Sites 33, 34 and 35 – Mount Armstrong Viewpoint Cut Slope and Retaining Walls

The Mount Armstrong viewpoint is located approximately 2 km west of the junction between Highways 40, 541 and 940 at Highwood House. There is an approximately 200 m long pullout lane on the downslope (south) side of the two lane highway at this site. This site was inspected in September 2005 and three areas with potential hazards were noted.

Slumping in the cut slope above the highway at the viewpoint.
The cut slope above the highway is approximately 25 to 30 m in height at a crest-to-toe angle of around 21°. There are numerous arcuate slump scarps in the cut slope with vertical downdrops typically ranging between 0.5 and 1.5 m. Photos 1 to 4 show various views of this slope. In general, the slump scarps on the lower half of the slope are more well-defined in the slope profile than the scarps further upslope. Many of the slump scarps coincide with areas of seepage discharge on the slope. The natural slope face above the crest of the cut slope has an inclination of approximately 10°. The slump scarps visible on the cut slope face did not extend upslope of the crest of the cut.

It is not clear when the slump blocks first formed. It is judged that they have been present for many years. None of the slump blocks appear to have undergone significant movement in recent years, however it is possible that there may be ongoing movement at low rates.

The slumping does not appear to have affected the upslope ditch or northbound lane of the highway.

AMEC recommends the following Risk Level factors for this site using AIT's general geohazard frequency-severity matrix:

- Probability Factor of 6 based on the presence of well-defined slump scarps in the slope profile but uncertainty regarding the level of activity and movement rate.

- Consequence Factor of 2 based on a scenario where one of the slump blocks on the lower portion of the slope moved and filled the ditch with debris that encroached into the northbound lane of the highway. The highway would not have to be closed, although the pullout lane along the downslope edge of the highway might need to be used to maintain two-way traffic under a reduced speed limit until the debris was cleared.

Therefore, the recommended Risk Level for this site is 12.

AMEC recommends the following to manage the Risk Level at this site:

1. A follow-up site inspection in July 2006 in order to check the slope conditions and further estimate whether or not the slump blocks are actively moving and verify

the applicable Risk Level. Note that this portion of the highway is closed between December 1st and June 15th of each year. It may be possible to reduce the Probability Factor if future observations of the cut slope suggest that the slump blocks are not actively moving.

2. Given the recommended Consequence Factor, additional geotechnical characterization and more involved monitoring of the slumping are not judged to be warranted at this time. However, if it is judged after future inspections that the slump blocks are actively moving and quantitative monitoring of the movement is required, then the installation of simple surface extensometers spanning the slump scarps could be considered as a reasonably effective and economical alternative to slope inclinometers (SI's). The simple extensometers could consist of metal rods hammered into the ground on either side of a slump scarp. Follow-up readings are taken by using a tape measure to measure the distance between these reference points. Changes in the distance over time can be used to estimate any lateral deformation that is occurring, notwithstanding any disturbance to the reference points and the level of precision achieved while using the tape measure.

A retaining wall below the Mount Armstrong viewpoint sign along the highway.
There is a vertical retaining wall below the highway, roughly centered around the Mount Armstrong viewpoint sign on the south side of the highway (Photo 5). The length of the wall is approximately 220 m. The maximum height of the retaining wall is approximately 9 to 10.5 m. The wall appears to be a "reinforced earth" style wall with a series of metal retaining straps connected to the concrete face panels and extending into the backfill behind the wall. The wall itself appears to be in good condition, with no visual signs of significant deformation or movement.

The east end of the wall is above a steep (approximately 36°) slope between the highway and the Highwood River (Photos 6 and 7). The toe of this slope is exposed to erosion along the river channel, and there are also several erosion gullies in the slope face that have formed due to surface runoff. It was not possible to safely access the gullies to check if there was bedrock exposed in the gully walls. The gully headslopes are close to the toe of the retaining wall in several locations, with a minimum offset from the toe of the wall in the order to 3 m. Some short lengths of metal strips of the type used in retaining wall backfill were exposed in one of these gully headwalls, however it is not clear if these strips were waste material from when the wall was constructed or were perhaps buried in an attempt to stabilize the soil around the head of the gully.

AMEC recommends the following Risk Level factors for this site using AIT's general geohazard frequency-severity matrix:

- Probability Factor of 5 based on the proximity of the erosion gullies to the east toe of the wall. Based on the visual observations during the site inspection, the

wall does not appear to have moved or deformed to date, however it would be prudent to check if the wall design accounted for having such a slope close to the toe of the wall.

- Consequence Factor of 4 based on the possibility of instability of the east end of the wall impacting on the eastbound lane of the highway and requiring partial closure of the highway.

Therefore, the recommended Risk Level for this site is 20.

AMEC recommends the following to manage the Risk Level at this site:

1. Check the design and construction records for the wall to see if the steep slope adjacent to the east toe of the wall was accounted for in the design. If not, check how this might affect the stability of the wall.

2. Future visual inspections of the slope crest along the toe of the east end of the retaining wall to monitor for retrogression of the erosion gullies and potential destabilization of the wall.

If a higher level of monitoring for wall deformation and movement is required in the future, it should be possible to install a series of survey targets on the wall face. The installation of an SI behind the wall would also be helpful, but likely not practical because the borehole could hit some of the retaining strips in the wall backfill.

A second retaining wall below the highway, approximately 300 m west of the Mount Armstrong viewpoint sign.

The vertical retaining wall to the west of the viewpoint sign has a maximum height of approximately 6 to 7.5 m. The length of the wall is approximately 60 m. Photo 8 shows an overall view of this wall, which also appears to be a "reinforced earth" style of retaining wall with a series of metal retaining straps connected to the concrete face panels and extending into the backfill behind the wall.

The eastern end of the wall face appears to be tilting downslope. This may be an optical illusion, however if the downslope tilt is real it may have occurred during or shortly after construction when the retaining strips for the wall were first loaded or it could indicate post-construction movement of the wall face.

AMEC recommends the following Risk Level factors for this site using AIT's general geohazard frequency-severity matrix:

- Probability Factor of 5 based on the apparent tilting of the wall and the uncertainty regarding whether or not the tilting indicates active deformation of the wall.

- Consequence Factor of 4 based on the possibility of instability of the east end of the wall impacting on the eastbound lane of the highway and requiring partial closure of the highway.

Therefore, the recommended Risk Level for this site is 20.

AMEC recommends the following to clarify the Risk Level for this retaining wall:

1. After this segment of the highway re-opens in June 2006, using a plumb bob to determine if the wall face is off vertical, and if so measure the horizontal offset of the top of the wall relative to the toe. This survey could be repeated in the fall of 2006 in order to check if the tilt is increasing.

Photo 1 (top) – Cut slope above the highway. Total height estimated to be 25 to 30 m and the crest-to-toe slope angle is approximately 21°. There are numerous arcuate slump scarps in the cut slope with vertical downdrops typically ranging between 0.5 and 1.5 m. The slump scarps often coincide with areas of seepage discharge on the slope. There appears to be little to no impact to the ditch or northbound lane of the highway from the slumping.

Photo 2 (middle) – Facing east along one of the visible slump scarps near the crest of the cut slope above the road. The slump scarp and vertical downdrop of the slump block is well-defined in the slope profile, however the overall visual appearance does not indicate recent significant movement of the slump block.

The natural slope above the cut slope (in the trees off the left background of this photo) has an inclination of approximately 10° and appeared to be stable.

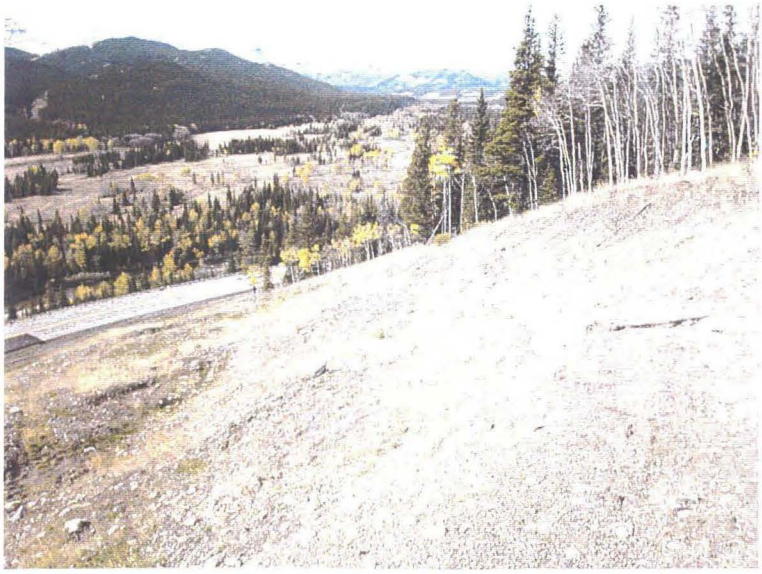

Photo 3 (bottom) – Facing west across the area shown in Photo 2, illustrating the relative position of the slump scarps in the upper portion of the cut slope and the highway.

Photo 4 (top) – Facing west across the lower to middle portions of the cut slope above the highway. A slump scarp is visible in the right foreground of the photo. A number of similar scarps were noted a various locations on the cut slope, however they generally did not appear to have experienced significant movement in recent years.

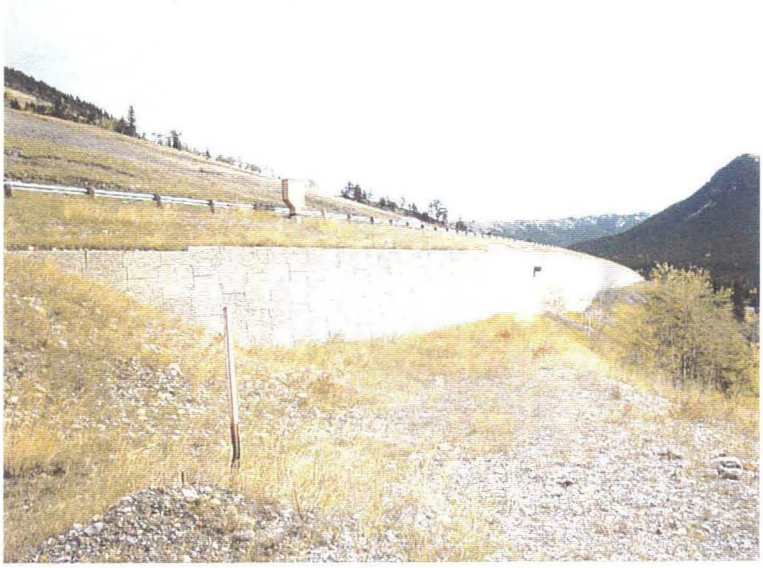

Photo 5 (middle) – Facing east across the retaining wall along the downslope edge of the highway. The red/brown signpost along the guardrail is the "Mount Armstrong Viewpoint" sign along the highway. The maximum height of the retaining wall is approximately 9 to 10.5 m. The wall appears to be in good condition, however there is a steep slope in close proximity to the base of the wall at the eastern end of the wall (right background of this photo) – see Photos 6 and 7.

Photo 6 (bottom) – Facing east along the toe of the retaining wall below the highway. The natural slope below the eastern portion of the wall is steep (approximately 36°) and the heads of several erosion gullies in this slope were within 3 m of the toe of the wall. The toe of this slope is exposed to erosion by the Highwood River, as shown in Photo 7.

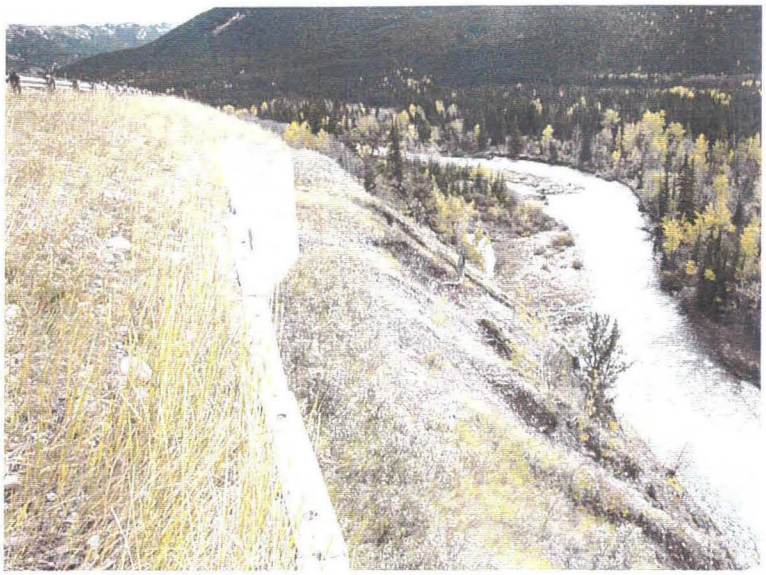

Photo 7 (top) – Eastern end of the retaining wall below the Mount Armstrong viewpoint. This view illustrates the relative position of the erosion gullies in the steep slope below the wall and the toe of the wall. The minimum offset between the toe of the wall and the head of one of the erosion gullies was approximately 3 m. Some short lengths of metal strips used in retaining wall backfill were exposed in one of these gully heads, however it is not clear if these strips were waste material from when the wall was constructed or if they had been placed in an attempt to stabilize the soil around the head of the gully.

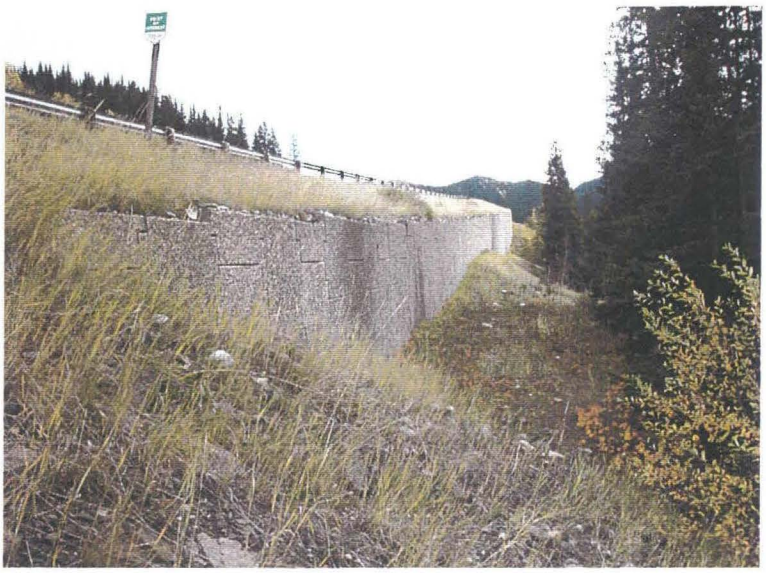

Photo 8 (bottom) – Facing east along a second retaining wall below the highway, approximately 300 m west of the Mount Armstrong viewpoint sign along the highway. The maximum vertical height of this wall was approximately 6 to 7.5 m. This wall had a distinct visual appearance of tilting outwards, especially at the east end.