## 4.5 S5 – CHIN COULEE

**Background**

The Chin Coulee site is located on Highway 36:02, approximately 20 km south of Taber, AB and on the north approach slope to the highway bridge across the Chin Coulee Reservoir.

The following background information for this site is re-presented from the previous annual assessment reports:

- As shown on Figure S5-1 in Appendix S5, the highway is oriented northeast/southwest across the upper portion of the south facing valley slope on the north side of the Chin Coulee reservoir. The valley slope is approximately 60 m high above the reservoir level. This segment of the highway is on the north approach to the highway bridge across the reservoir.

- This site has been inspected and monitored by AIT and consultant personnel since 1979. The landslide most recently experienced significant movement in 1997. Additional instruments have been installed since that time and regular assessments and monitoring are ongoing. In 2002 the National Research Council (NRC) commenced InSAR satellite-based ground movement monitoring of this site, however it is understood that AIT did not receive any conclusive data from this work and that this monitoring is no longer active.

- The slope instability at this site consists of deep-seated landsliding in the north valley slope along with relatively shallower movements in the fill embankment immediately below the highway. Based on a review of historical airphotos of this site it is believed that the highway fill embankment may have in-filled a drainage gully in the valley slope.

- The overall landslide mass has an elevation difference of approximately 50 m from the reservoir level to the headscarp adjacent to the highway. The width of the landslide is approximately 350 m at the reservoir shoreline. The length of the landslide is approximately 200 m. The overall angle of the landslide is approximately 13°. The overall landslide is inferred to be deep seated with a failure surface at a depth of about 30 to 40 m near the highway (scarp) and 17 m near the reservoir (toe). Therefore, the overall toe of the landslide is likely below the reservoir level. The failure surface is thought to be along weak zones in the bedrock and overlying till. The exact position of the overall landslide crest relative to the highway is not clear, and it is judged that this landslide mechanism could potentially encompass the entire highway.

- The landslide has shown large scale movements on two known occasions since the 1950's, with some possible ongoing shallower movements contained within the overall landslide mass. The ongoing movements are impacting the south/downslope shoulder of the highway. There remains a risk of reactivation of the larger landslide mass, which could have a more significant impact on the road.

- The SI GA98-3 that was installed in the shallower movement area in the fill embankment immediately downslope of the highway has previously sheared off at a depth of approximately 15 m below ground surface.

- A functional planning study for this segment of the highway was completed by AMEC in December 2004. The functional planning study considered the possibility of realigning the highway through the landslide area and also the possibility of adding a climbing lane. The functional planning study concluded that a climbing lane was not warranted and that upslope relocation of the road away from the landslide area would be deferred. The functional planning study also concluded that the highway should be relocated approximately 30 m upslope in the future if deep-seated landsliding damaged the road. The study recommended additional geotechnical investigation and analyses for detailed design of any upslope shift of the road in order to optimize the amount of upslope shifting and provide a greater level of assurance as to the amount of benefit. The previous geotechnical investigation and analysis in 1998 only included preliminary analyses on the increase in Factor of Safety for various amounts of upslope shifting of the road that were based on limited borehole drilling and limited testing of bedrock samples.

Please refer to Section A of the site binder for a more detailed discussion of the site background.

**Site Assessment**

The site assessment was performed on June 21, 2006. The weather at the time of the site assessment was sunny with a light breeze.

Please refer to Appendix S5 for a site plan illustrating the layout of the site. The assessment covered the highway surface through the landslide area, the upslope ditch, and the downslope slope face.

**Observations**

The following points summarize the observations made during the site assessment. Please also refer to Appendix S5 for a site plan and annotated photographs illustrating key observations.

- The central portion of the headscarp of the shallow slumping immediately downslope of the road has retrogressed approximately 1 to 1.5 m since the May 2006 inspection, resulting in a loss of pavement along an approximately 7 m segment of the south shoulder of the road. Photos S5-1, 3 and 4 show this area. The undermined area is along and adjacent to the guardrail and lies outside of the white line along the south side of the pavement.

- The guardrail post in the central portion of the retrogression area is completely unsupported, and the next post to the west is only marginally supported. Aside from these posts, the conditions along the guardrail are largely unchanged since the 2006 inspection.

- Aside from the loss of pavement noted above, the road surface adjacent to the shallow slumping area and across the site in general is in good condition and does not show any visual indication on landslide disturbance.

The Spring 2007 readings of the slope inclinometers at this site showed that the active slope instability along the downslope edge of the road had not expanded to the west of the visible scarp. The inclinometer in the upslope road ditch also showed no deep-seated valley slope landslide movement encompassing the existing road alignment, consistent with previous years.

**Assessment and Risk Level**

Based on the observations from the current inspection, the assessment of the geotechnical risk at this site is unchanged. In summary:

Shallow Slumping

- The active, shallow slumping immediately downslope of the guardrail continues to undermine a segment of the guardrail and the central portion of the slumping headscarp has retrogressed into the paved road surface since the 2006 inspection. Without mitigative measures, this retrogression into the road surface will continue over time. It is not considered likely that significant portions of the road would be taken out of service by a sudden increment of retrogression of the shallow slumping, however this cannot be entirely ruled out.

Deep-Seated Landsliding

- There is a potential for reactivation of the overall deep-seated landslide at this site that could result in the loss of a large portion of the road alignment. This risk has been managed by the planning and preliminary design (during the Functional Planning Study) for an upslope shift of the road alignment if required due to landslide movement. However, in the event of a future deep-seated landslide event, a portion of the highway could be out of service until a temporary detour lane is added in the upslope road ditch.

On the basis that two separate modes of failure could affect the highway at this site, two recommended Risk Levels are provided:

- For the shallow modes of failure, the Probability Factor is taken as 10 since the rate of movement is moderate and ongoing. A Consequence Factor of 2 is assigned to this slide type on the basis that only a portion of the road would be lost. Based on the

above, the Risk Level for the relatively shallow movements at this site is calculated as 20. These values are unchanged from the 2005 and 2006 assessments.

- For a deep-seated mode of failure, the Probability Factor is taken as 4 since the movement appears to be inactive and with a low to moderate probability of remobilization based on the instrument data from recent years. This is a reduction from the value of 5 recommended after the 2006 inspection on the basis of the Spring 2007 instrument readings continuing to show no significant movement. A Consequence Factor of 5 is assigned to this slide type on the basis that a large portion of the road would likely be lost during a reactivation of the deep-seated failure mode. Based on the above, the Risk Level for the deep-seated movements at this site is calculated as 20.

**Recommendations**

AMEC recommends the following future work for this site:

1. **The slope face along the south shoulder of the road should be repaired in order to restore the lost pavement area and support the guardrail posts.** The options of using a geogrid reinforced backfill or launched soil nails to restore and stabilize the slope face have been discussed during previous site inspections and reports. The use of launched soil nails may be the more effective option and would be implemented as follows:

    a. Install soil nails along an approximately 45 m segment of the slope crest adjacent to the guardrail, extending approximately 17 m eastwards and 28 m westwards from the point where the slumping has retrogressed into the pavement. The oversteepened segment of the slope crest is approximately 2 to 2.5 m high at an angle of 60 to 80°. The soils exposed in the crest consist of sand and silt, with trace amounts of gravel and isolated cobbles.

    b. Three rows of soil nails would likely be used at roughly 1 m horizontal and vertical spacing. This would result in a total of approximately 130 to 140 soil nails.

    Based on discussions on site during the inspection, AMEC understands that AIT may decide to instruct the maintenance contractor to subcontract this work to a soil nailing company without the preparation of a detailed design. If requested by AIT, AMEC could prepare conceptual sketches of the soil nail repair option for use in presenting the work to the maintenance contractor.

2. **The annual assessments and semi-annual instrumentation monitoring should be continued.** As noted in previous reports, the geotechnical risk management strategy for this site is to continue monitoring the instruments and apply the existing design for the upslope realignment of the highway only if it becomes required due to reactivation of

slope movement encompassing the road alignment. Continued visual and instrumentation monitoring is required to implement this strategy.