LANDSLIDE RISK ASSESSMENT
SOUTHERN REGION

SITE S5: CHIN COULEE LANDSLIDE

LEGAL LOCATION:	**LSD 10-36-07-17 W4M**	
REFERENCE LOCATION ALONG HIGHWAY		
UTM COORDINATES:	**N 5495250 E 414900** (NAD27) NTS Map Sheet 82 H/9 (Chin Coulee)	
AI FILE:	**H36:02**	
AI PLAN & PROFILE:		
Date of Initial Observation:	Fall 1978	
Date of Last Inspection:	July 2003 Instruments read May 2003	
Instruments Installed:	1981 - 4 Slope Inclinometers 1998 – 2 Slope Inclinometers, 2 Piezometers	
Instruments Operational:	1 Slope Inclinometers (1998), 2 Piezometers (1988)	
Risk Assessment:	Overall Slide	PF(6) * CF(5) = **30**
	Ongoing shallower slides	PF(10) * CF(2) = **20**
Last updated by:	AMEC, August 2003	
Comments:		

Location

The slide is located on the north bank of the Chin Coulee Reservoir, adjacent to Highway 36. The site is about 20 km south of the town of Taber in Southern Alberta.

General Description of Instability

The Chin Coulee Reservoir is estimated to be 60 to 70 m in height from the original valley bottom to the prairie level. The slide itself has an elevation difference of approximately 50 m from the reservoir level to the headscarp adjacent to the highway. The toe of the slide is not visible and is believed to be below the water level in the reservoir. The width of the slide is approximately 350 m at the shoreline. The length of the slide is approximately 200 m. The overall angle of the slide is about 13 degrees.

The slide has shown large scale movements on two known occasions since the 1950's, with some possible ongoing smaller/shallower movements contained within the overall slide mass. The ongoing movements appear to be having a slight impact on the road. There remains a risk of reactivation of the larger slide mass, which could have a more significant effect on the road.

The overall slide 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). The failure surface is though to be along weak zones in the bedrock and overlying till. This mechanism could affect the entire road cross section.

There are shallower more active mechanisms, which are continuing to affect the south road shoulder. One slope indicator in this area has sheared off at a depth of about 15 m, demonstrating shallower, more active portion of the slide.

Geologic Setting

The site geology generally consists of a silty clay till overlying shale/siltstone bedrock. The thickness of the overburden was in the order of 10 m near the reservoir (toe of the slide) and 37 m below the highway. The surface of the bedrock appears to dip in the direction of the slide, although the bedrock bedding is reported to dip to the north. Fill thicknesses in excess of 5 m appear to have been placed during highway construction.

Groundwater levels measured in standpipes indicate that water levels range from the ground surface to depths of about 15 m. It has been speculated that water levels lower in the slope are associated with the reservoir, and those higher in the slope are in a perched water table, primarily associated with flow along sand layers in the till.

Chronological Background

Table A1 provides the Chronological Background of the slide.

Past Investigations

The site was investigated by AT in 1979, however little information is available from that study. Golder Associates conducted an investigation in 1998. Golder's report concluded that the slide was the site of an historic landslide, which was reactivated by a number of factors, including the presence of the reservoir, natural fluctuations in overall groundwater levels and, to a smaller degree, the presence of Highway 36. The report provided recommendations for various courses of action, including minor improvements and observation, highway relocation and major stabilization.

An additional slope inclinometer and two pneumatic piezometers were installed by AMEC in March 2002. These instruments were installed in the upslope road ditch opposite the portion of road being undermined by ongoing slope movement.

Mitigative Measures Taken

No major mitigative measures undertaken.

AMEC submitted a design package for upslope relocation of the road through the slide area to AT in May 2002. It is understood that this design will be implemented if necessary in the future due to additional slope movement undermining the road surface.

Monitoring Overview

Monitoring conducted to date appears to indicate decreasing movement of a deep slip surface about 40 m below the road surface. One slope inclinometer was sheared off at a depth of 15.5 m and continues to show significant surface movements.

The SI installed in AMEC Borehole 2002-1 in March, 2002 will be used to monitor for movement beneath the existing road.

Table A1 –S5 - Chin Coulee - Chronological Background

YEAR	MONTH	DESCRIPTION
1950's		The Chin Coulee Reservoir was constructed. Current alignment of Highway 36 constructed.
1960's		Highway paved. Re-surfaced at least once since that time.
1978	Fall	Movement of the slide was first noticed after a period of heavy rainfall and runoff. A scarp of up to 1 m in height was formed at that time and the head of the slide was reported to have affected the shoulder of the highway for a distance of about 45 m. The slide was reported to be 500 m across at the water line, with the toe of the slide not visible.
1979	May	Inspected by geotechnical personnel. No further movements noted.
1979	Sept.	Inspected by geotechnical personnel. No further movements noted.
1981	Nov.	Slope inclinometers installed by ATU (?).
1981	Dec.	4 boreholes drilled and slope inclinometers installed. Very limited information available on drilling and followup monitoring.
1997	Spring	Re-activation of slide following a period of wet weather. The amount of movement that took place appears to be similar to the 1978 movements and the headscarp of the slide again developed adjacent to the shoulder of the road for a distance of about 40 m. Relatively minor deflection of the paved surface (mostly in the shoulder) also occurred at that time.
1998	June	A detailed investigation of the slide was conducted by Golder Associates. This included drilling 5 boreholes, installing one standpipe piezometer, two pneumatic piezometers and two slope inclinometer casings
1999	May	Instrumentation read. One slope indicator sheared off at 15.5 m depth. Significant movements noted in sheared SI. Little definitive movement in deeper SI
	June	Annual Inspection – No signs of significant additional movement.
	Sept.	Instrumentation read. Further significant movements noted in sheared SI. Slight distress to pavement. Little definitive movement in deeper SI
2000	May	Instrumentation read by AMEC.
	Sept.	Instrumentation read by AMEC.
2001	May	Instrumentation read by AMEC. Annual site inspection by AMEC and AT personnel.
	Sept.	File and airphoto review completed by AMEC. Report submitted to AT recommending installation of additional instrumentation upslope of the existing road and preparation of a design for upslope relocation of the existing road.
	October	Instrumentation read by AMEC.
2002	March	Slope inclinometer installed by AMEC in upslope road ditch, across from the portion of the road being undermined by the ongoing slope movement. Two pneumatic piezometers also installed in adjacent borehole.
	May	Instrumentation read by AMEC. No significant movement noted. Annual inspection by AMEC and AT personnel.
2003	May	Instrumentation read by AMEC.
	July	Annual site inspection by AMEC and AT personnel.

S5 – Chin Coulee

The Chin Coulee site was visited on July 9, 2003. Photographs from this site visit are included in Appendix S5, along with a site plan, air photograph, and a detailed discussion of the visit. This discussion has also been submitted in separate unbound sheets for inclusion in Appendix B of the Chin Coulee binder. The following is a brief summary of the assessment.

This site is a major landslide complex, with the highway located directly adjacent to the active scarp area. No significant movement has been noted in the two slope inclinometers at this site over the last 2 to 3 years, however slope inclinometer AMEC 2002-1 in the upslope road ditch has shown potential downslope movement zones around 25 and 40 m depth. Therefore retrogression of significant movement into the present road alignment is possible, and is considered likely in the long term.

Recent, shallow slumping of the scarp of the landslide at the south edge of the road at the guardrail was noted to have occurred since the May 2002 instrument readings. One of the guardrail posts was undermined by the slumping, and the two adjacent guardrail posts were very close to becoming undermined as well. At the time of the inspection, there was an approximately 4 m long segment of the scarp that had worked its way back to the line of the guardrail. Aside from this recent instability at the guardrail, the overall slope condition has not changed significantly since the previous inspections.

The Risk Levels at this site were kept at 20 for shallower movements, and 30 for a possible deep seated movement. These values are unchanged from the previous assessments. AMEC recommends that the annual assessments and semi-annual monitoring at this site be continued. Please refer to Appendix S5 for further discussion.

APPENDIX S5
Chin Coulee

1.0 Site Visit

The Annual Inspection site visit was conducted on July 9, 2003. At the time of the visit, the weather was clear with a light breeze.

2.0 Significant Observations

The following observations, considered to be relevant to the stability of the slope were made:

- The scarp area of the slide that is directly adjacent to the south shoulder of the road showed signs of recent, shallow slumping along the guardrail (Photos 1, 2, 4 and 5). This shallow slumping had occurred since the May 2003 instrument readings. One of the guardrail posts was undermined by the slumping, and the two adjacent guardrail posts were very close to becoming undermined as well. At the time of the inspection, there was an approximately 4 m long segment of the scarp that had worked its way back to the line of the guardrail.
- Despite the recent slumping, the guardrail alignment did not appear to have been affected.
- The northeast flank of the slide, located downslope and away from the road, showed numerous open tension cracks and appeared to have experienced slightly more recent movement in comparison to observations during the previous annual inspections.
- The road surface did not show any signs of settlement or cracking related to the landslide.

3.0 Changes from Previous Visits

The only significant changes from the previous annual inspection is the recent, shallow slumping along the guardrail and the possibly greater rate of movement in the northeast flank of the slide in the area downslope and away from the road.

The potential for additional deep-seated movement encompassing the road is still present, but no such movements have been noted since the previous inspection.

4.0 Discussion

As noted in the previous annual inspections, this site is a major landslide complex with the highway located directly adjacent to the active scarp area. No significant movement has been measured in the slope inclinometer GA98-2, which is located adjacent to the downslope edge of the road but west of the active slide area. The new slope inclinometer (AMEC 2002-1) that was installed to approximately 45 m depth in the upslope road ditch in March 2002 has shown potential downslope movement zones around 25 and 40 m depth, therefore retrogression of significant movement into the present road alignment is possible, and is considered likely in the long term. The slope inclinometer 2002-1 will be valuable for monitoring for deeper-seated movement encompassing the road.

As part of a separate scope of work, AMEC has submitted a design package to AT for upslope relocation of the road through the slide area. The intent was to have a design package ready for immediate tendering and implementation in the event of future retrogression of the landslide through the existing road. The decision on whether or not to relocate the road should be based on continued monitoring of the existing instruments. The design includes shifting the centerline of the road upslope by approximately 10 m through the slide area. This design was developed with input from AT in order to somewhat minimize the design excavation volumes required for upslope relocation of the road, with the understanding that the design package may need to be updated if the amount of crest retrogression is greater than approximately 10 m.

5.0 Assessment

The area downslope of the highway is a large active slide area. This includes a significant portion of the highway embankment. It is not considered feasible to mitigate this entire slide area due to its size.

The recent, shallow movements along the guardrail along the downslope edge of the road have undermined some of the guardrail posts. This type of slope movement is likely to continue in the future and will continue to damage the guardrail and possibly cause settlement and cracking of the road surface. If the movement accelerates, it is possible that the guardrail, shoulder and portions of the eastbound lane could be lost in single events. However, it is considered less likely that the entire road would be lost in a single event.

A deeper seated failure, encompassing the entire road surface, is considered to be possible but less likely. Slope inclinometer 2002-1 installed in the upslope ditch of the road will be used to monitor for such movement.

On the basis of the above assessment and the observations from the current site inspection, the risk levels for this site have not been changed. As before, on the basis that two separate modes of failure could affect this highway, two 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.

- For a deep-seated mode of failure, the Probability Factor is taken as 6 since the movement appears to be inactive, but with some uncertainty. A Consequence Factor of 5 is assigned to this slide type on the basis that a large portion of the road would be lost. Based on the above, the Risk Level for the deep-seated movements at this site is calculated as 30.

6.0 Recommendations

The slope face along the south shoulder of the road should be regraded in order to restore support to the guardrail posts. The regrading of the slope face in this area will also help by closing up any open tension cracks that could receive water during rain events.

The exposed soils on the slope face along the south shoulder of the road should be covered with a rolled erosion control product (RECP). This will provide a physical barrier to reduce the amount of surface erosion and infiltration of runoff into the unstable slope face immediately downslope of the guardrail. Given the steepness and dryness of the exposed soils on the slope face, it will be difficult to permanently revegetate this area. A typical drawing for the use of an RECP (taken from AT's Design Guidelines For Erosion and Sediment Control For Highways, March 2003 edition) is attached for general illustration (Figure 2-S5). Modifications from this generic illustration would be required for application at this site. AMEC could prepare a site-specific design for this work if requested by AT.

The monitoring programs currently in place should be continued. Particular attention should be paid to the future data from the slope inclinometer at 2002-1, as this will provide an indication of whether or not deep-seated slope movement encompassing the existing road is occurring.

If any further data from the NRC INSAR satellite based ground movement monitoring project becomes available, it should be incorporated into the monitoring program. AMEC understands that limited data is available to date, and that further readings are required in order to provide input to the monitoring of slope movement.

The Annual Inspections should be continued as planned.

Maintenance personnel should carefully monitor the surface condition of the road as well as the guardrail alignment. This would be in conjunction with slope indicator and piezometer monitoring to provide as early detection of potential problems below the road as possible.