SOUTHERN REGION GEOHAZARD ASSESSMENT
ANNUAL ASSESSMENT REPORT
2007

Submitted to:

Alberta Infrastructure and Transportation
Calgary, Alberta

Submitted by:

AMEC Earth & Environmental,

a division of AMEC Americas Limited

Calgary, Alberta

November 2007

CG25263

November 6, 2007
CG25263

Mr. Roger Skirrow, M.Sc., P.Eng.
Alberta Infrastructure and Transportation
2nd Floor, Twin Atria Building
4999 – 98 Avenue
Edmonton, AB T6B 2X3

Dear Roger:

Re: Southern Region Geohazard Assessment
Annual Assessment Report, 2007

Please find enclosed one copy of the 2007 Annual Assessment Report. Also included is an unbound copy of the appendices for inclusion in the appropriate site binders and a CD containing electronic copies of the report files. Copies of these items have also been sent to Ross Dickson of Alberta Infrastructure and Transportation in Calgary.

If you have any questions or require any further information, please do not hesitate to contact the undersigned at (403) 569-6529.

Yours truly,
AMEC Earth & Environmental,
a division of AMEC Americas Limited

Andrew Bidwell, M.Eng., P.Eng.
Associate Geological Engineer

AB

c: Ross Dickson – AIT

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1.0 INTRODUCTION

AMEC Earth & Environmental (AMEC), a division of AMEC Americas Limited (AMEC), has been retained by Alberta Infrastructure and Transportation (AIT) to conduct annual assessments of identified geohazard sites in the Southern Region. This work is being done in conjunction with semi-annual instrumentation monitoring at several of the identified geohazard sites.

This report presents the results of the 2007 annual assessments along with recommendations for continued assessment, monitoring and additional work where required. The enclosed CD contains electronic copies of the report files.

This work has been authorized by AIT under Consulting Services Agreement CE044/2004.

2.0 BACKGROUND

AIT has implemented a Geotechnical Risk Management Plan (GRMP) in order to estimate the risk levels of geohazard events at specific sites and to assist AIT in the prioritization of mitigative works. This work has been conducted in the past by AIT personnel and since 2000 by outside geotechnical consultants with the work being awarded on a regional basis. AMEC has been awarded the assignment of conducting this work for the Southern Region since the spring of 2000.

The GRMP includes the estimation of a Risk Level for each site that is assessed. The estimated Risk Level is expressed as a number ranging from 1 to 200 that is calculated as the product of a Probability Factor and a Consequence Factor assigned to each site on the basis of annual site assessments, geotechnical instrumentation readings, and other information for each specific site. The descriptions for these factors are listed on Tables A1 to A3 in Appendix A. Table A1 lists general descriptions for these factors, as provided by AIT. Tables A2 and A3 list the sets of probability and consequence factors specific to rockfall hazards and debris flows, respectively, as developed by AMEC for AIT during a recent geohazards review of the Highway 40/Highway 541 corridor.

3.0 FIELD PROGRAM

The annual assessments were performed on June 18 to 21, 2007 for the following sites.

June 18, 2007
S2 – Priddis
S7 – Millarville
S10 – Highway 762 S10(C)
S8 – Fisher Creek
S22 – Highway 762 "S" Curve
S10 – Highway 762 S10(A)
S1 – Jumpingpound Creek
S3 – Cochrane

June 19, 2007
S12 – Spray Lakes Road
S17 – Highway 40 – Mount Baldy Rock Cut
S18 – Highway 40 – Galatea Creek Through-Cut
S19 – Highway 40 – King Creek
S20 – Highway 541 – Highwood House Rock Cut
S21 – Highway 541 – Highwood Base Road Creek
S16 – Chain Lakes Site

June 20, 2007
S15 – Crowsnest Lake Rockfall Barrier
S14 – Bellevue Sites
S27 – Highway 3 – Windmill
S28 – Highway 3A At Range Road 2-2A
S23 – Highway 507:02 – East Of Mill Creek
S24 – Highway 507 – Eastbound Lane Site and Westbound Lane Site
S4 – Willow Creek
S25 – Highway 3 – Monarch

June 21, 2007
S5 – Chin Coulee
S26 – Highway 41 – Elkwater
S29 – Highway 1 – Seven Persons Creek

Each site was visited by Andrew Bidwell of AMEC along with Roger Skirrow and Rocky Wang of AIT. Ross Dickson of AIT participated in the site visits on June 19 to 21, 2007.

Each site was assessed visually and measurements and notes of site features were recorded using field reconnaissance level techniques. Digital photographs of site features were also taken.

4.20 S23 – HIGHWAY 507:02 – EAST OF MILL CREEK

Site Description and Background

This site is located on Highway 507, immediately east of the bridge across Mill Creek and approximately 5 km eastbound (measured along the highway) from the junction between Highway 507 and Highway 774 near Beaver Mines, AB. Please refer to Figures S23-1 and S23-2 in Appendix S23 for an illustration of the site location and layout.

This site is on the east approach slope to the bridge over Mill Creek. The highway is oriented east/west on a cross-slope down towards the north. As shown in Photo S23-1 in Appendix S23, it appears that the highway is constructed in a slight cut, possibly with a small fill embankment along the north side of the right-of-way.

AMEC had previously inspected this site as a call-out request by AIT in September 2006. The purpose of the call-out request was to inspect a landslide in the slope above the south side of the highway. The landslide is approximately 200 m wide as measured along the south ditch line and has a semi-circular headscarp set back as far as approximately 70 m from the highway. A typical view of the landslide area is shown in Photo S23-1 in Appendix S23. The crest-to-toe slope angle through the landslide area is generally around 15°. The overall landslide geometry and appearance are consistent with rotational and translational landslide movement in the slope above (south of) the highway.

The review of AIT's files for this site after the September 2006 site inspection showed that geotechnical issues at this site have been documented since at least the mid-1980's and some repair work and mitigative measures were implemented by AIT in 1993. A summary of the site background is listed below. Please refer to AMEC's report[7] on the September 2006 site inspection for further details.

1. During the mid-1980's and early 1990's there was ongoing damage to the road surface along this segment of highway. The damage consisted of settlement, deformation and cracking of the highway surface that was attributed to landslide movement both upslope and downslope of the highway. Based upon photographs in AIT's files, it appears that the damage to the highway was adjacent to and also further west (downhill towards Mill Creek) of the currently-noted landslide area in the backslope.

2. Three SI's were installed in November 1990 at the locations marked as SI #4, SI #5 and SI #6 on the plan view of the site (see Figure S23-2 in Appendix S23). The SI data up to the fall of 1991 showed potential and confirmed movement in each of these SI's at the depths noted on Figure S23-2. These movement depths are within the native clay and clay till soils and possibly the underlying clay shale bedrock as well. There was no data after the fall of 1991 for these SI's in the AIT files that were reviewed.

[7] "Report On September 28, 2006 Call-Out Request, Highway 507:02, West of Pincher Creek, AB, Mill Creek – East Hill Slide Area", AMEC report submitted to AIT, October 2006, AMEC project number CG25239.

3. In October and November 1993 the following repair measures were constructed to mitigate the damage described in 1:

   a. An approximately 120 m segment of the highway was excavated and reconstructed. The approximate extent of the reconstruction is shown on Figure S23-2 in Appendix S23. The depth of excavation was typically 5.5 to 6 m with the objective of removing “buried trees” from the existing road subgrade. The road was reconstructed with a 2.5 m thick drainage layer of “gravel” at the base of the excavation, overlain by a “clay (silty, sandy)” borrow material.

   b. A trench drain was installed along the south ditch. The approximate extent of the trench drain relative to the landslide area is illustrated on Figure S23-2 in Appendix S23.

   c. A series of finger drains were installed by trenching into the slope in the landslide area with an excavator. The finger drains were supposed to be connected to the trench drain in the south ditch. However, the as-built locations and details of the finger drains are not known.

   d. Some drawings in the file also showed a cut-off ditch/drain to be installed along the treeline on the backslope and connected to the above-noted finger drains. However, it is not clear if this ditch/drain was actually installed.

AMEC understands that this site more recently came to attention in 2004 due to apparent renewed landslide movement upslope of the road with the toe of the backslope encroaching into the south ditch.

Aside from the description of the landslide area discussed above, the key observations from the September 2006 site inspection are summarized as follows:

- No damage to the highway surface was noted at the time of the inspection.

- Based on observations from the inspection, it was judged that the east side of the landslide is relatively active with numerous rotational landslide blocks visible in the slope profile and delineated by numerous open tension cracks and areas of uniformly back-tilted trees. The west side of the landslide area appeared to be relatively inactive.

The June 2007 site inspection by AMEC and AIT personnel was the first since September 2006 and the first annual inspection as part of the Southern Region GRMP. It was added to the annual site inspection list to follow-up from the September 2006 site inspection.

Site Assessment

The site assessment was performed on June 20, 2007. The weather at the time of the site assessment was clear and warm.

The site assessment consisted of a visual review of the landslide area from the highway, a traverse along the south ditch to the east abutment of the bridge over Mill Creek, and a traverse of the north ditch and area north of the fenceline to (unsuccessfully) search for the previously-installed SI #6 in this area.

Observations

The following points summarize the key observations made during the site assessment. Please also refer to Appendix S23 for a site plan and annotated photographs.

- The site conditions and the appearance of the landslide area in the slope above (south) of the highway did not appear to have changed significantly since the September 2006 inspection. Photo S23-1 shows a general view of the landslide area. Photos S23-2 to 5 show closer views of the toe bulge of the landslide along the south road ditch and a well-defined portion of the landslide headscarp above the road.

- There was no visible damage to the highway surface adjacent to the landslide area at the time of the inspection.

- Geotextile was exposed in several "steps" in the profile of the south ditch. The geotextile appeared to have been placed as a separation layer and/or liner during construction of the steps in the ditch profile. The south ditch was dry at the time of the inspection, however it appeared that it carried erosive flows at times.

- A drain outlet was noted near the crest of the east abutment slope at the bridge over Mill Creek (west of the landslide area) and appeared to be in the right location to correspond to the outlet of the trench drain reported to have been installed along the south ditch. The location of the drain outlet is marked on Figure S23-2. This drain was dry at the time of the inspection and only very minor erosion was visible in the slope face below the outlet, which suggests that the drain does not carry significant flows.

- The north ditch was dry at the time of the inspection. However, some minor surface erosion from ditch flow was noted in the segment of the ditch opposite the landslide toe bulge.

- Two drain outlets were noted in the north ditch, opposite the landslide area. The drains were dry at the time of the site inspection. The position of these drain outlets suggests that they might be diagonal take-off drains from the trench drain that is understood to have been installed along the south ditch. However, there was no reference to any such take-off drains in AIT's files for this site that were reviewed after the September 2006 site inspection.

Discussion and Assessment

Based on the observations from the June 2007 site inspection, the landslide conditions do not appear to have changed significantly since the September 2006 inspection. There continues to be no visible damage to the highway surface.

The current landslide activity at this site appears to be a recent reactivation (i.e. over the past two to three years) of movement at the east end of the landslide area above (south of) the road surface only. Based on the visual inspections of the site and the highway condition, it does not appear that more widespread landslide movement extending onto the slope north of the highway and consistent with the landslide movement that damaged the highway prior to the 1993 repairs is currently occurring. It is possible that the recently reactivated landslide movement includes movement along failure surfaces that extend below the highway (e.g. along the potential deeper-seated, bedrock failure surface noted in the SI #4 data up to the fall of 1991), but to date there has not been damage to the highway surface.

As noted in the report on the September 2006 site inspection, the reactivated landslide movement is likely being driven by relatively high groundwater levels in recent years causing movement along weak layers in the clay/clay till soil and possibly along pre-sheared weak layers in the underlying clay shale bedrock. The south ditch trench drain and finger drains into the landslide body that were installed during the 1993 repairs should be beneficial to some degree in relieving groundwater pressure in the landslide area, but the east portion of the landslide appears to have reactivated nonetheless. It should also be noted that if the current landslide activity is seated in the clay shale bedrock, then the shallow drainage measures in the upslope ditch and slope area above the highway would not provide complete relief of the piezometric pressures at the depths of landslide movement.

The geotechnical risks at this site are as follows:

- The current main geotechnical risk at this site appears to be the potential loss of capacity of the south road ditch due to the active landslide toe encroaching into the ditch. The buried trench drain that was installed along the south ditch in 1993 may serve to mitigate any loss of surface capacity in the south ditch, provided that any ditch flow is able to percolate downwards into the trench drain.

- There is also a risk that future landslide movements will eventually push the toe of the landslide area into the eastbound lane of the highway.

- It is also possible that the landowner to the south of the highway may contact AIT with concerns regarding the encroachment of the landslide headscarp into the cleared field south of the highway.

The most practical measure to reduce the landslide risk to the south ditch and highway would likely be to drill a series of sub-horizontal drain pipes into the landslide area above the road to attempt to relieve groundwater pressures in the landslide mass. The concept and intent of the sub-horizontal drain pipes would be the same as the finger drains that were installed into the slope during the 1993 repairs. However, by being drilled at a near-horizontal inclination the new drain pipes would effectively penetrate further into the slope than the finger drains trenched into the slope face in 1993 (if they were actually done) and greatly improve the drainage from the landslide area. The drains could be installed from the south ditch and discharge into the south ditch (and presumably into the buried trench drain along the south ditch). Prior to installing the drains, a series of auger boreholes should be drilled in the slope above the highway to confirm the profile of the underlying bedrock surface and thereby determine the required inclination for the drains. Piezometers and SI's could also be installed in these boreholes to allow for monitoring of groundwater levels and landslide movement after the horizontal drains are installed.

Other options to reduce the landslide risk such as earthworks to repair the landslide (e.g. slope regrading, toe buttress) are likely not practical or cost-competitive with drainage measures because the slope angle in the landslide area is already relatively gentle and it would be preferable to avoid disturbing the treed area above the highway. A retaining wall or pile wall to hold back the landslide above the road and/or support the highway alignment are likely not practical or cost-effective in comparison to other options.

Risk Level

The Risk Level recommended after the September 2006 site inspection should be maintained:

- Probability Factor of 10 to reflect the apparent active landslide movement rate above the road with uncertainty as to whether or not the movement rate is increasing, decreasing or holding steady.

- Consequence Factor of 3 to reflect the potential for continued landslide movement to block the south ditch and possibly encroach onto the eastbound lane of the highway.

Therefore, the recommended Risk Level is 30.

This Risk Level is also judged to be appropriate to reflect the uncertainty regarding:

- The potential for the current active landslide area to expand towards or beyond the lateral limits of the landslide area from the 1980's and early 1990's as described in AIT's files,

and/or

- Reactivation of the potential movement surface in the bedrock underlying and north of the highway as shown in the data for SI #4 up to the spring of 1991.

If the depth and extent of landslide movement increases there is the potential for future damage to the highway, despite the 1993 repair measures that appear to have been effective to date in preventing damage to the highway.

Recommendations

AMEC recommends the following work for this site:

1. Short-term maintenance along the south ditch if required. If the landslide toe encroaches further into the south ditch it would be possible to excavate and remove landslide debris from the south ditch to restore full ditch capacity without significantly further destabilizing the landslide area or increasing the Risk Level at this site. However, such excavation would spur continued landslide movement that would "re-fill" the excavated area along the south ditch.

2. Continue with annual inspections of this site as part of the Southern Region GRMP.

It is judged that the other recommendations in the September 2006 report for a site survey, recovery and readings of SI #6 and installing new instrumentation (e.g. SI's, reference stakes ("simple extensometers"), piezometers) can be deferred for the time being if the maintenance and inspection recommendations above are implemented.

4.21 S24 – HIGHWAY 507 – EASTBOUND AND WESTBOUND LANE SITES

The S24 site consists of two separate sites along Highway 507 between Beaver Mines and Pincher Creek, AB.

4.21.1 Eastbound Lane Site

Site Description and Background

This site is located on Highway 507, west of Pincher Creek, AB and approximately 4 km west of the junction between Highway 6 and Highway 507. Please refer to Figures S24-1 to S24-3 in Appendix S24 for an illustration of the site location, the site layout and a typical cross-section.

The highway is located approximately 500 m north of the channel of Pincher Creek and along the crest of the north Pincher Creek valley slope. This valley is a broad, relatively flat-bottomed valley incised approximately 30 m into a flat upland plain to the west of the town of Pincher Creek, AB. The local segment of the highway is straight along an east/northeast bearing of 074/254 and is approximately tangent to the curving crest of the north valley slope as shown on the plan view of the site, attached as Figure S24-2 in Appendix S24.

AMEC had previously inspected this site as a call-out request by AIT in September 2006. The purpose of the call-out request was to inspect cracking and settlement areas on the road surface at the site and develop geotechnical recommendations to mitigate the damage to the highway. A summary of the observations from the September 2006 site inspection is as follows:

- The settlement and cracking area is along an approximately 52 m long segment of the highway and encompasses the entire eastbound lane. This segment consists of a fill embankment approximately 3 to 4 m high that was placed to maintain the road grade across an area where the highway alignment crosses below the crest of the north valley slope and is across the uppermost portion of the valley slope.

- Figure S24-3 in Appendix S24 shows a cross-section through the damaged portion of the highway.

- Based on the road surface appearance at the time of the September 2006 site inspection, it appeared that the maximum vertical settlement prior to patching could have been in the order of 100 mm.

The report on the September 2006 site inspection concluded that the damage to the road surface was due to settlement of and/or shallow sliding/shearing in the embankment fill. This was supported by the location of the damage to the road as well as the semi-circular pattern of the boundary of the cracking and settlement.

The June 2007 site inspection by AMEC and AIT personnel was the first since September 2006 and the first annual inspection as part of the Southern Region GRMP.

Site Assessment

5.0 SUMMARY

A list of the sites, ranked by current recommended Risk Level, is presented in Table A4 in Appendix A for reference. This table also shows:

- Which sites have been recommended for further assessment (e.g. site investigation).
- Which sites have been recommended for repair work, and whether or not the recommended repair work is pending.

6.0 CLOSURE

This report has been prepared for the exclusive use of Alberta Infrastructure and Transportation for the specific project described herein. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it are the responsibility of such third parties. AMEC Earth & Environmental, a division of AMEC Americas Limited cannot accept responsibility for such damages, if any, suffered by any third party as a result of decisions made or actions based on this report. This report has been prepared in accordance with accepted geotechnical engineering practices. No other warranty, expressed or implied, is made.

We trust that this meets your needs at this time. Please contact the undersigned if you have any questions or require any further information.

Respectfully Submitted,

AMEC Earth & Environmental,
a division of AMEC Americas Limited

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Associate Geological Engineer

APEGGA Permit To Practice No. P-04546

Reviewed by:

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Principal Geotechnical Engineer

APPENDIX A

Tables

Table A1 – Geohazard Risk Level Factors

Risk Level = (Probability Factor, PF) x (Consequence Factor, CF)	
Probability Factor (ranked on a scale of 1 to 20)	
1	Inactive, very low probability of slide occurrence.
3	Inactive, low probability of remobilization.
5	Inactive, moderate probability of remobilization, uncertainty level moderate, or active but very slow rate of movement or indeterminate movement pattern.
7	Inactive, high probability of remobilization or additional hazards, uncertainty level high, or active with perceptible movement rate and defined zone(s) of movement.
9	Active with moderate steady, or decreasing, rate of ongoing movement.
11	Active with moderate but increasing rate of movement.
13	Active with high rate of movement, steady or increasing.
15	Active with high rate of movement with additional hazards.
20	Catastrophic slide is occurring.
Consequence Factor (ranked on a scale of 1 to 10)	
1	Shallow cut slope where slide may spill into ditches or fills where slide does not impact pavement, minor consequence of failure, no immediate impact to driver safety, maintenance issue.
2	Moderate fills and cuts, not including bridge approach fill or headslopes, loss of portion of the roadway or slide onto road possible, small volume. Shallow fills where private land, waterbodies or structures may be impacted. Slides affecting use of roadways and safety of motorists, but not requiring closure of the roadway. Potential rock fall hazard sites.
4	Fills and cuts associated with bridges, intersectional treatments, culverts and other structures, high fills, deep cuts, historic rock fall hazards areas. Sites where partial closure of the road or significant detours would be a direct and unavoidable result of a slide occurrence.
6	Sites where closure of the road would be a direct and unavoidable result of a slide occurrence.
10	Sites where the safety of public and significant loss of infrastructure facilities or privately owned structures will occur if a slide occurs. Sites where rapid mobilization of large scale slide is possible.

Table A2 – Rock Fall Risk Level Factors

Probability Factor – Rock Falls
(For Each Rock Cut or Rock Slope)

Weight	Description
1	Inactive, very low probability of fall occurrence.
3	Inactive, low probability of fall occurrence.
5	Inactive, moderate probability of fall occurrence.
7	Inactive, high probability of fall occurrence (e.g. seasonal, following freeze/thaw cycles) and/or a fall has occurred in the historic past.
9	Active, falls occur after exceptional weather (e.g. the melting of greater than average snow accumulations or exceptionally intense precipitation), fall frequency is in the order of once a decade.
11	Active, one or two falls occur each year triggered by annually recurring weather conditions.
13	Active, several falls occur each year and/or the frequency of falls is increasing in comparison to equivalent time periods in previous years.
15	Active, many falls occur each year and/or the area producing rock falls is expanding. Ongoing or persistent rock falls during specific times of the year.
20	Active, a large volume of rock is surrounded by open cracks. Toppling or sliding of the displacing mass is accelerating. Sites where rapid movement of a large fall is possible.

Consequence Factor – Rock Falls
(For Each Rock Cut or Rock Slope)

Weight	Description
1	Rock fall contained by ditch if cleaned as required to maintain capacity.
2	Rock fall onto roadway removable by maintenance crews by hand or with shovels. Road closure not required. Minor damage to the road surface that can be repaired during annual patching and sealing of the road. Minor to no damage to vehicles being struck by falling rocks or striking rocks deposited onto road.
3	Rock fall onto road that could damage a vehicle (e.g. flat tire, dent body of vehicle). Rocks bounce or roll onto the road surface but likely not with a trajectory that would pass through the windows or windshield of a passing vehicle.
4	Individual rocks or the total volume of rocks deposited on the road large enough to: Damage vehicles or cause accidents if struck by traffic or damage vehicles and injure occupants if they strike a moving vehicle. o Cause partial closure of the road or require a detour lane prior to cleanup. Damage to the road surface may require temporary repair in order to re-open road.
6	Individual rocks or the total volume of rocks deposited on the road large enough to: o Damage/destroy vehicles and severely injure occupants if struck by traffic or damage/destroy vehicles and severely injure/kill occupants if they strike a moving vehicle. o Cause complete closure of the road, with a rough detour/diversion possible within hours to days. o Require days to weeks required to restore the road to normal service. Possibly significant damage to the road surface that requires immediate repair.
8	Same as weighting of 6, but with several days required to develop a rough detour/diversion around the rockfall site.
10	Individual rocks or the total volume of rocks deposited on the road large enough to: o Damage/destroy vehicles and severely injure occupants if struck by traffic. o Bury vehicles if they strike a moving vehicle. o Cause complete closure of the road, with a temporary, rough detour or diversion possible in days to weeks. o Require complete reconstruction or rerouting of the road after the rockfall.

Table A3 – Debris Flow Risk Level Factors

Probability Factor – Debris Flows
(For Each Fan)

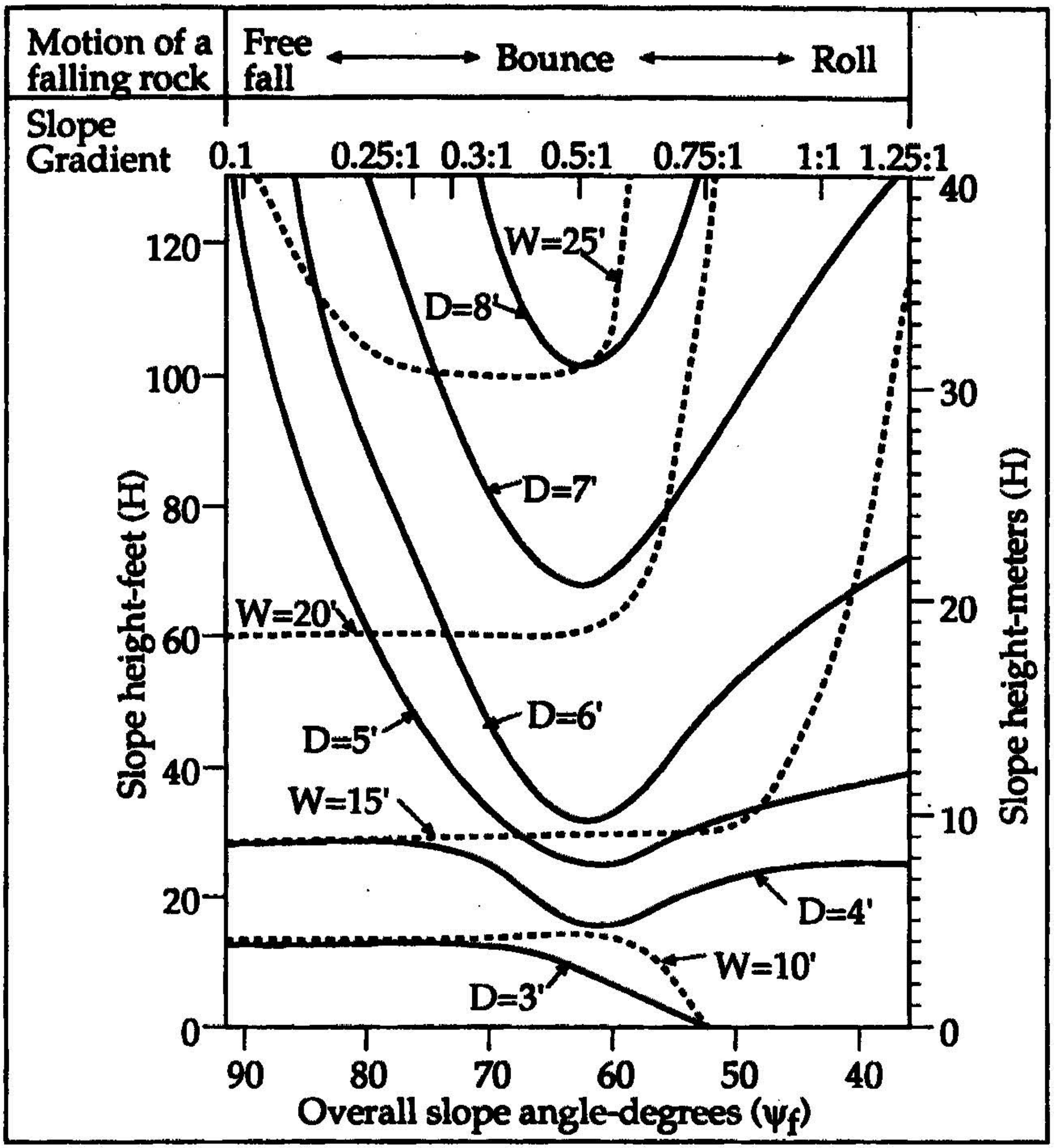
Weight	Description
1	Inactive, very low probability of a flow. No historical or current visual evidence of debris flow activity.
3	Inactive, low probability of a flow.
5	Inactive, moderate probability of a flow based on channel morphology and presence of debris in the potential source zone.
7	Inactive, high probability of a flow; a flow has occurred in the historic past and/or debris buildup in the channel/source area is considered to be ongoing.
9	Debris accumulation normally present in the source area. Fan is considered to be active, with flows occurring after the melting of an exceptional snow accumulation or an exceptionally intense rainfall.
11	Active, one or two flows per year triggered by annually recurring weather conditions.
13	Active, several flows each year.
15	Active, many flows each year, the area producing flows is expanding.
20	Active, a large volume of debris is impounding a large and rising reservoir of water upstream. Overtopping and dam-break is expected.

Consequence Factor – Debris Flows
(For Each Fan)

Weight	Description
1	Debris flow contained by the ditch or able to be conveyed past the road alignment via a sufficiently sized culvert or clear span bridge.
2	Debris flow onto roadway easily removable by maintenance crews. No damage to the road surface. Road closure not required and/or road still passable without damage to vehicles provided reduced speed limit established.
4	Partial closure of the road or significant detours would result from a debris flow. Debris flow onto roadway that requires partial closure of the road or significant detours while maintenance crew uses heavy equipment to clear debris and restore road surface. Damage to the road surface possible.
6	Complete closure of the road would result from debris flow while maintenance crew uses heavy equipment to clear the roadway and/or remove debris flow deposits plugging culvert or ditch. Geotechnical inspection required to assess post-event stability of road fills. Damage to the road surface likely.
10	Sites where the safety of the public is threatened by a debris flow, where there will be significant loss of infrastructural facilities or privately-owned structures if a flow occurs.

Table A4 – Summary of Recommended Risk Levels for Southern Region Sites

Site	Recommended Risk Level Value		Recommendations		
	Current	2006	Annual Inspection In 2008	Further Assessment	Design and Repair or Maintenance Work, With Notes On Schedule Where Applicable
S15 – Crowsnest Lake Rockfall Barrier	90	15	Yes	No	Repairs to net required ASAP.
S14 – Bellevue Sites (Potential sinkhole site)	72	72	No	Borehole drilling to follow-up and supplement 2004 GPR survey.	Nothing planned. To be confirmed once borehole information available.
S12 – Spray Lakes Road	54	63	Yes	No	Develop list of repair options for AIT review and decision.
S26 – Highway 41 - Elkwater	52	n/a	Yes	Boreholes to assess applicability of horizontal drains to reduce landslide movement.	Horizontal drain design, pending information from boreholes. Boreholes not scheduled yet. Ongoing road maintenance as required.
S19 – Highway 40 – King Creek (worst case scenario)	50	50	Yes	No	Design/cost estimate for secondary culvert, for AIT review and decision.
S2 – Priddis	45	45	Yes	New piezometers.	Maintenance of road surface as required.
S17 – Highway 40 – Mount Baldy Rock Cut - East Cut Slope	45	45	Yes	No	Scaling – as soon as practical. Ditch cleaning – ongoing.
S18 – Highway 40 – Galatea Creek Through-Cut - East Cut Slope	45	45	Yes	No	Ditch cleaning – ongoing. Increase capacity of East Ditch (if possible while maintaining clear width requirements).
S20 – Highway 541 – Highwood House Rock Cut	45	45	Yes	Track and assess required effort for ditch cleaning to verify if it is cost-effective vs. other measures.	Ditch cleaning – ongoing.
S10 – Highway 762 S10(A)	44	44	Yes	No	Develop list of repair options for AIT review and decision.
S21 – Highway 541 – Highwood Base Road Creek	33	33	Yes	No	Excavate and haul away debris from upslope side of road. Clean out debris from existing culvert or install second culvert.
S1 – Jumpingpound Creek	30	40	Yes	No	Surface drainage improvements and apply creek bank erosion protection measures.
S23 – Highway 507:02 – East Of Mill Creek	30	30	Yes	No	Excavation to maintain south ditch capacity – if required. Maintenance work if/when required.
S7 – Millarville	30	24	Yes	Install SI's and piezometer in new cracking area. Locate and mark shear key drain outlet for future visual monitoring.	Nothing planned. To be confirmed once new instrument data available.
S3 – Cochrane	27	27	Yes	No	Repairs to ditch berm. Develop list of repair options for AIT review and decision.
S24 – Highway 507 – Westbound Lane Site	27	27	No (unless recommended further assessment work performed)	Boreholes to check subsurface conditions and investigate causes of damage to road surface.	Depends on findings from boreholes, otherwise continue with road surface maintenance as required.
S10 – Highway 762 S10(C)	27	n/a	Yes	Overexcavate existing sinkhole in west embankment slope to further assess its cause.	Nothing planned. To be confirmed once further assessment completed.
S8 – Fisher Creek	24	32	Yes	No	Shear key design previously completed. Defer repair work until if/when more significant damage occurs.
S28 – Highway 3A At Range Road 2-2A	24	n/a	Yes	Airphoto review, site survey, and borehole drilling/instrumentation to characterize slope instability.	Design work based on further assessment data. In the meantime, road surface maintenance as required.
S5 – Chin Coulee	20	25	Yes	No	Install soil nails to stabilize downslope shoulder of road.
S22 – Highway 762 "S" Curve	20	10	Yes	No	Maintain road surface as necessary. Develop list of repair options for AIT review and decision.
S19 – Highway 40 – King Creek ('typical' year)	10	n/a	Yes	No	Design/cost estimate for secondary culvert, for AIT review and decision.
S4 – Willow Creek	18	18	Yes	No	Repair work to be tendered, late 2007. Planned to be completed in spring 2008.
S24 – Highway 507 – Eastbound Lane Site	18	18	No	No	Road surface maintenance as required.
S14 – Bellevue Sites (Rock cut site)	15	15	No	No	n/a
S18 – Highway 40 – Galatea Creek Through-Cut - West Cut Slope	12	12	Yes	No	Ditch cleaning in conjunction with east ditch at this site.
S27 – Highway 3 – Windmill	7.5	n/a	Yes	No	Nothing planned.
S16 – Chain Lakes Site	5	n/a	Yes	Instrument readings in 2008.	n/a
S25 – Highway 3 – Monarch	5	n/a	Yes	Not recommended.	Road surface maintenance as required.
S29 – Highway 1 – Seven Persons Creek	5	n/a	Yes	No	n/a



NOTES:

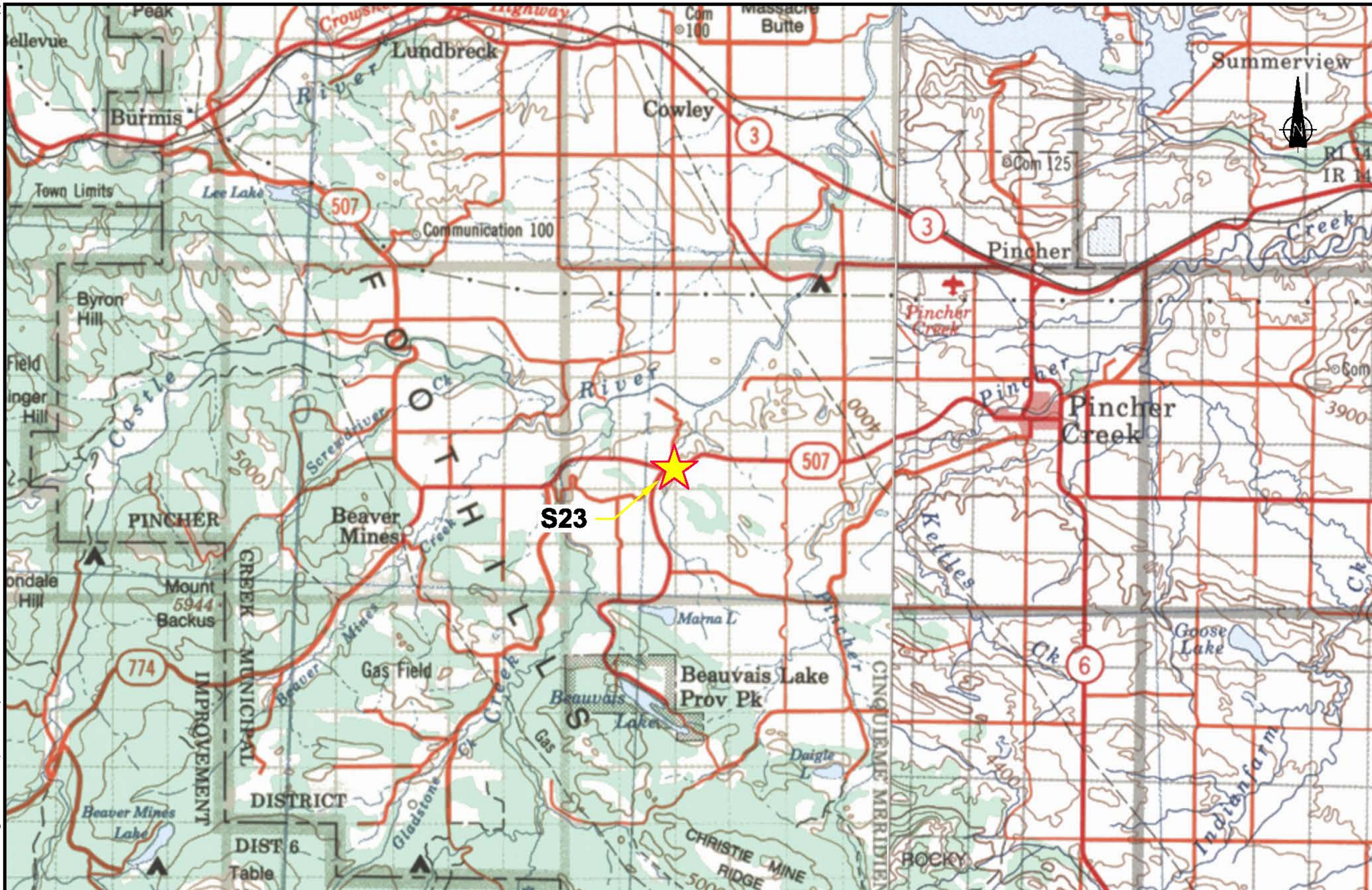
1. AFTER RITCHIE (1963), AS SHOWN IN TRANSPORTATION RESEARCH BOARD SPECIAL REPORT 247 (1996).

amec Earth & Environmental	PROJECT: SOUTHERN REGION GEOHAZARD ASSESSMENT				
CLIENT: Alberta INFRASTRUCTURE AND TRANSPORTATION	TITLE: ROCKFALL CATCHMENT DITCH SIZING CHART				
	DATE: AUGUST 2007	JOB No.: CG25263	CAD FILE: 25263X04.dwg	FIGURE No.: FIGURE A1	REV. A

APPENDIX S23
Highway 507:02 – East of Mill Creek

*PLOT 1:1=A (P)

J:\CG\25263\25263L01.dwg - FIG S23-1 - Aug. 23, 2007 2:20pm - scott.peters



SCALE

1:150 000

0 1 2 3 km

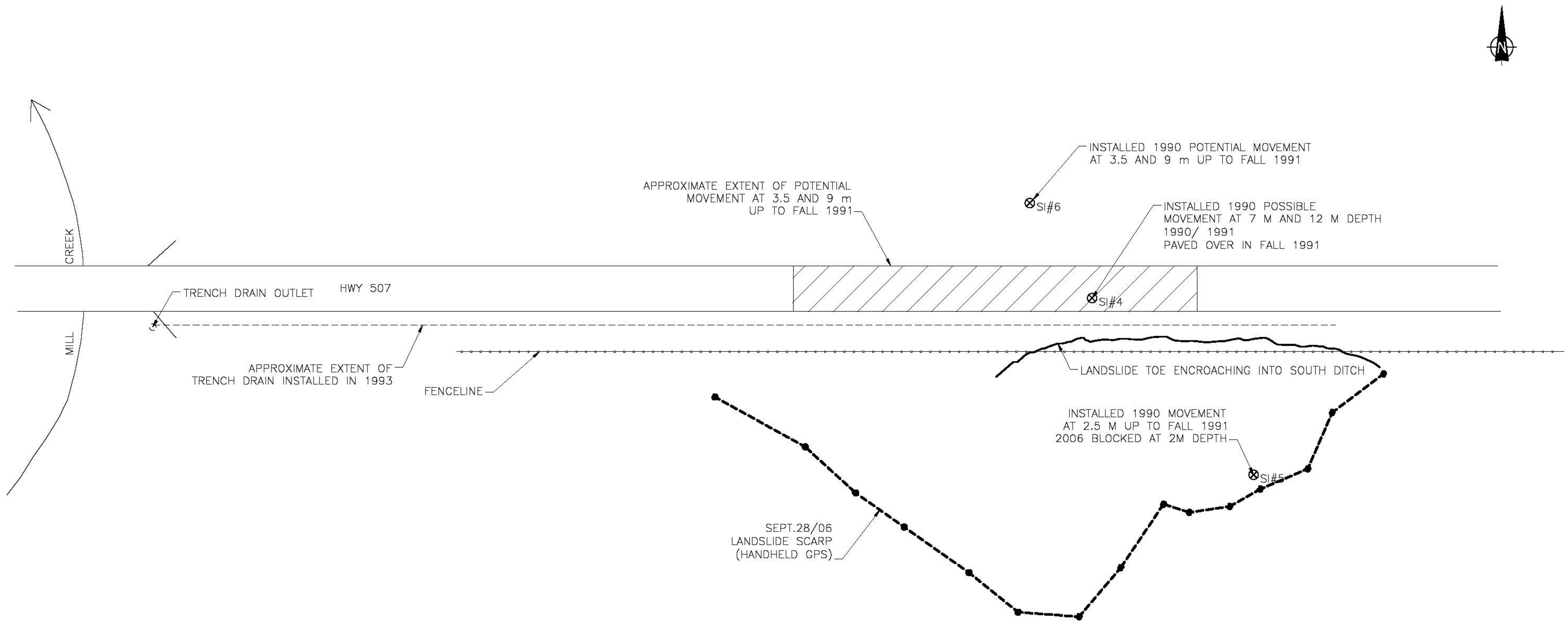
amec Earth & Environmental

CLIENT: Alberta INFRASTRUCTURE AND TRANSPORTATION

PROJECT: SOUTHERN REGION GEOHAZARD ASSESSMENT

TITLE: LOCATION PLAN
S23 - EAST OF MILL CREEK

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
AUGUST 2007	CG25263	25263L01.dwg	S23-1	A



NOTES:

1. SCHEMATIC SITE PLAN BASED ON SITE RECON ON SEPTEMBER 28, 2006. ALL SITE FEATURES LOCATION AND DIMENSIONS ARE APPROPRIATE.

SCALE
1:1250
0 10 20 25 m

amec Earth & Environmental

CLIENT: Alberta INFRASTRUCTURE AND TRANSPORTATION

PROJECT: SOUTHERN REGION GEOHAZARD ASSESSMENT				
TITLE: S23 - EAST OF MILL CREEK SITE PLAN				
DATE: AUGUST 2007	JOB No.: CG25263	CAD FILE: 25263X00.dwg	FIGURE No.: S23–2	REV. A

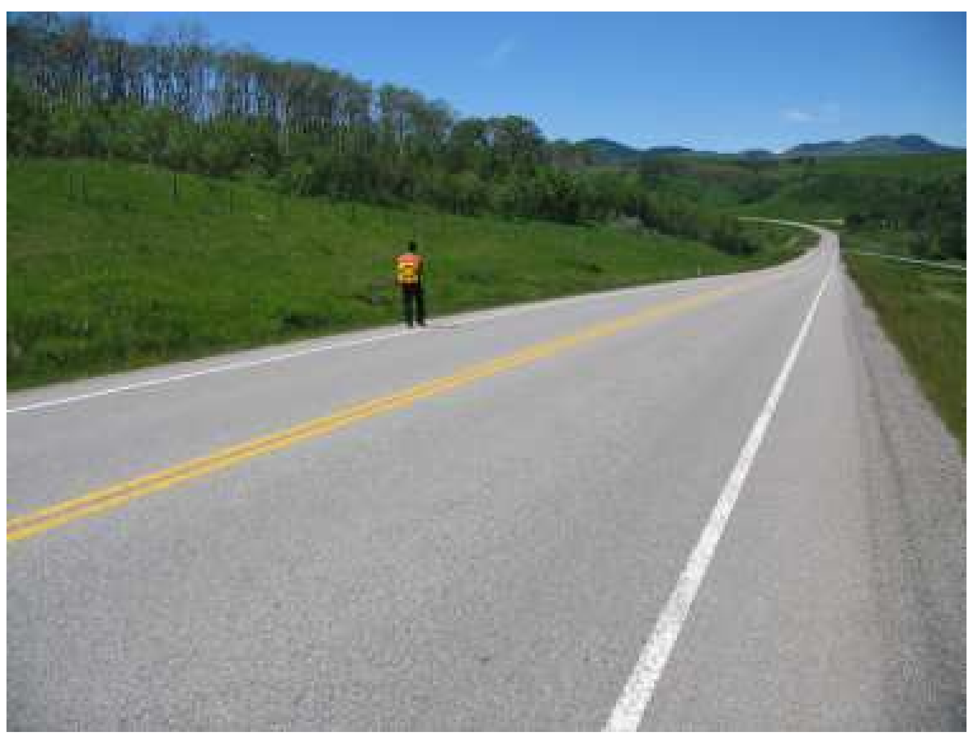


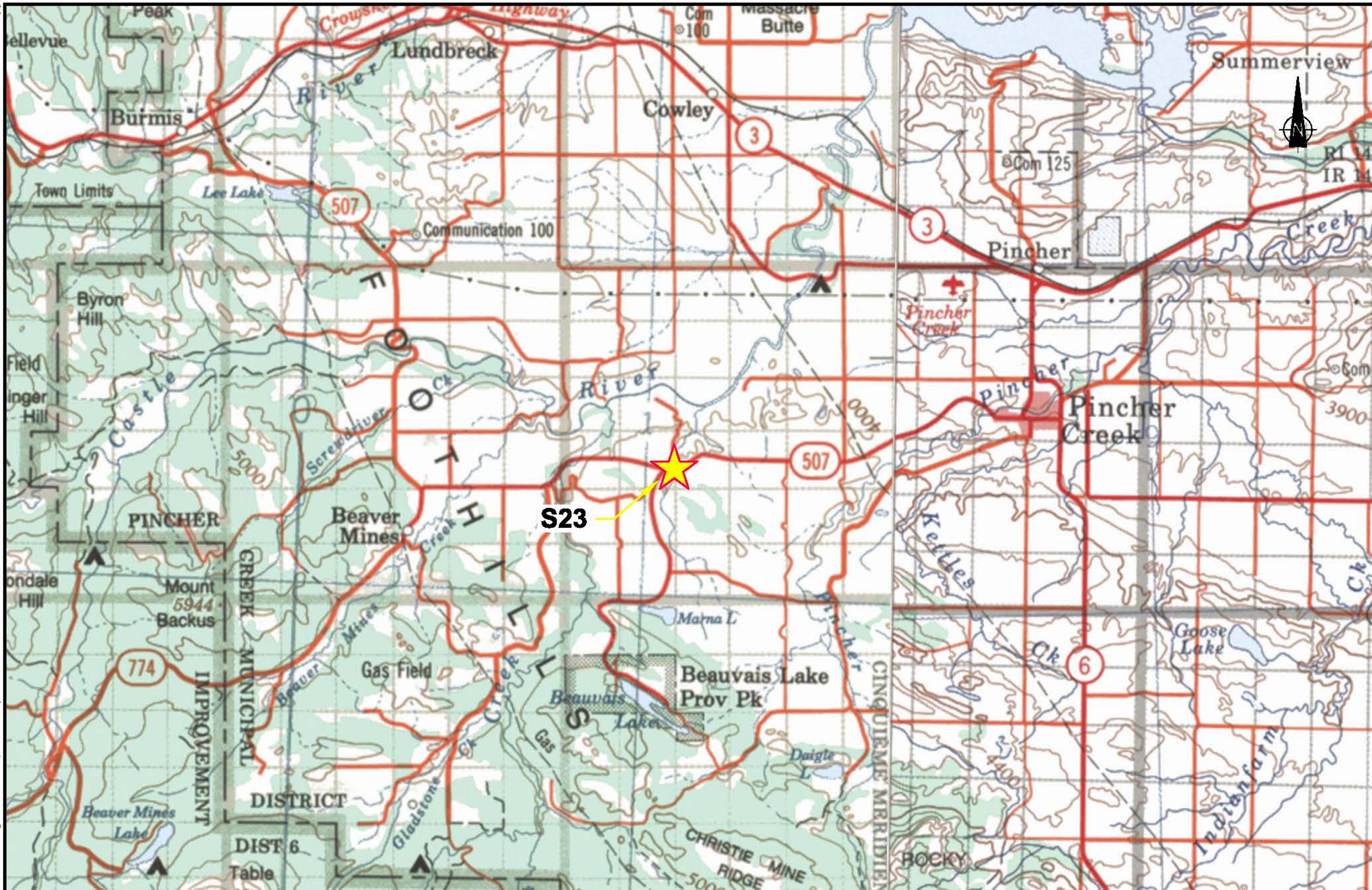
Photo S23-1 – June 2007 (top)
Facing south across the highway towards the landslide area. The visible east flank of the landsliding is labelled along with the location shown in more detail on Photo S23-5.

Photo S23-2 – June 2007 (lower left)
Facing west along the highway across the toe of the landslide area.

Photo S23-3 – June 2007 (lower right)
Facing east along the highway across the toe of the landslide area. The toe bulge of the landslide that encroaches into the ditch is visible.

Photo S23-4 – June 2007 (left)
Closer view, facing west, across one of the visible toe bulges in the landslide.

Photo S23-5 – September 2006 (right)
Landslide scarp in the vicinity of SI #5 around the upper east flank of the landslide area (see Figure S23-2 for an illustration of this location). This 2 to 2.5 m high, near-vertical scarp has presumably formed since SI #5 was installed in 1990 because the SI is located at the base of the scarp at a location that would not be accessible for the drilling equipment with the scarp in place.



SCALE

1:150 000

0 1 2 3 km

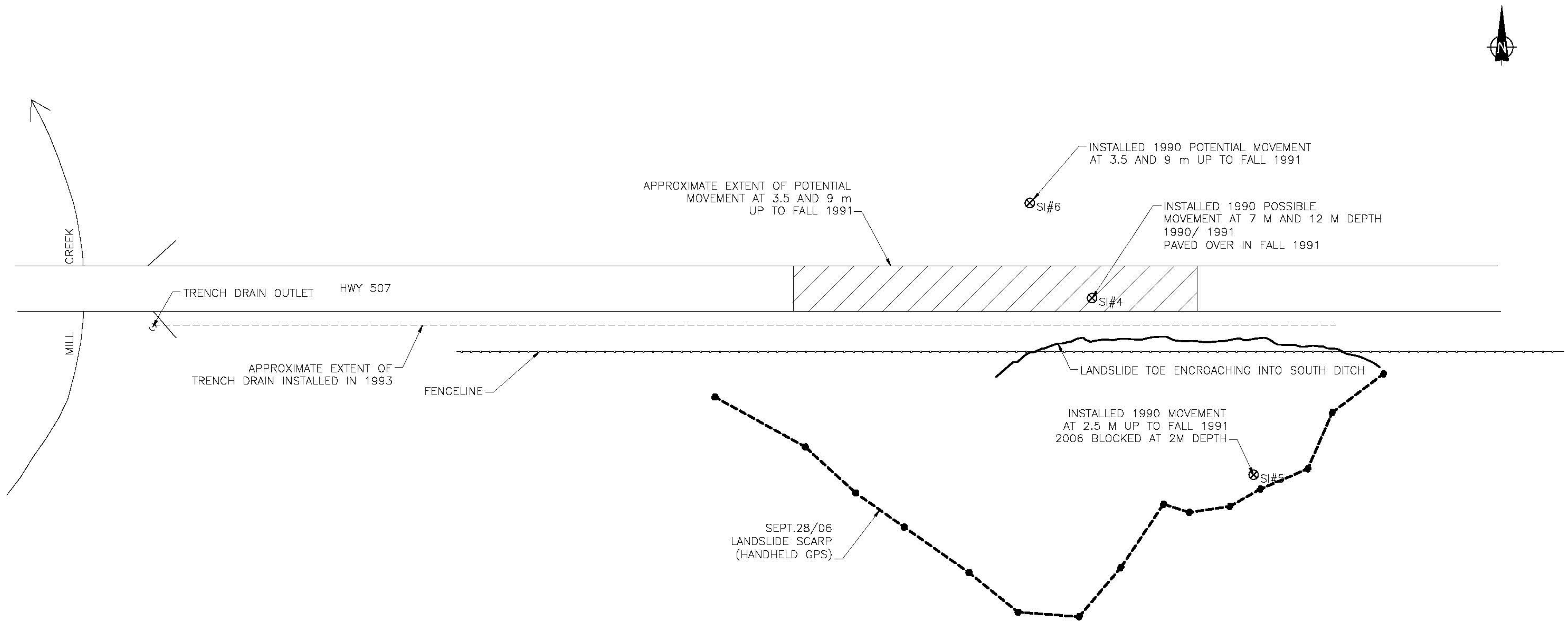
amec Earth & Environmental

CLIENT: Alberta INFRASTRUCTURE AND TRANSPORTATION

PROJECT: SOUTHERN REGION GEOHAZARD ASSESSMENT

TITLE: LOCATION PLAN
S23 - EAST OF MILL CREEK

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
AUGUST 2007	CG25263	25263L01.dwg	S23-1	A



NOTES:

1. SCHEMATIC SITE PLAN BASED ON SITE RECON ON SEPTEMBER 28, 2006. ALL SITE FEATURES LOCATION AND DIMENSIONS ARE APPROPRIATE.

SCALE

1:1250

0 10 20 25 m

amec Earth & Environmental

CLIENT: Alberta INFRASTRUCTURE AND TRANSPORTATION

PROJECT: SOUTHERN REGION GEOHAZARD ASSESSMENT

TITLE: S23 - EAST OF MILL CREEK SITE PLAN

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
AUGUST 2007	CG25263	25263X00.dwg	S23–2	A

*PLOT 1:1=B (L)

I:\CG\25263\25263X00.dwg – FIGURE S23-2 – Aug. 23, 2007 2:30pm – scott.peters

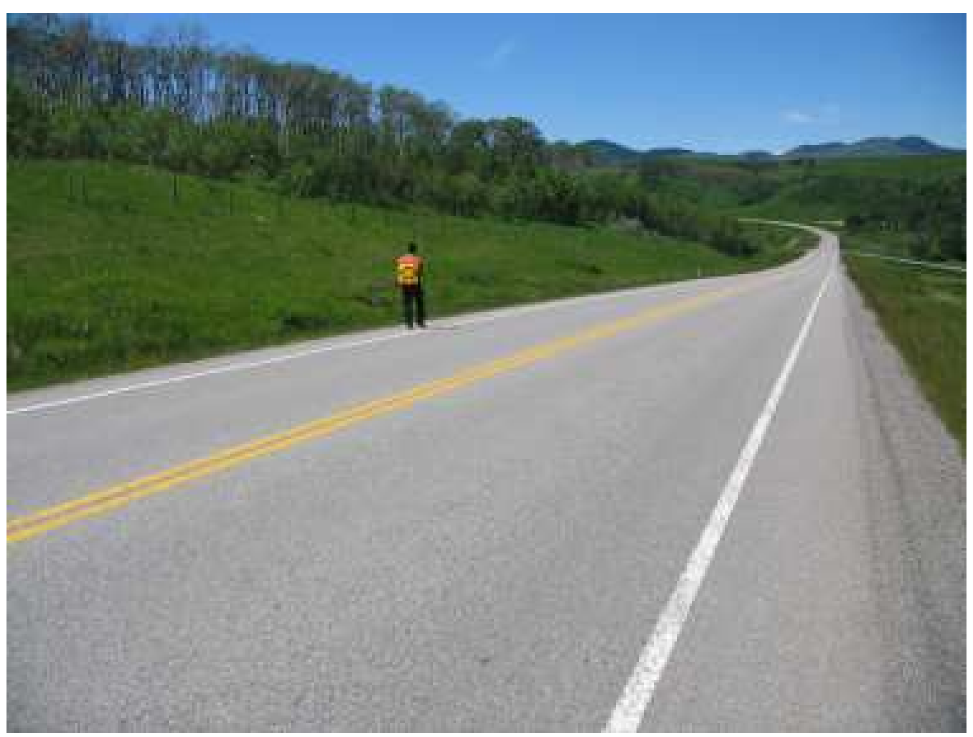


Photo S23-1 – June 2007 (top)
Facing south across the highway towards the landslide area. The visible east flank of the landsliding is labelled along with the location shown in more detail on Photo S23-5.

Photo S23-2 – June 2007 (lower left)
Facing west along the highway across the toe of the landslide area.

Photo S23-3 – June 2007 (lower right)
Facing east along the highway across the toe of the landslide area. The toe bulge of the landslide that encroaches into the ditch is visible.

Photo S23-4 – June 2007 (left)
Closer view, facing west, across one of the visible toe bulges in the landslide.

Photo S23-5 – September 2006 (right)
Landslide scarp in the vicinity of SI #5 around the upper east flank of the landslide area (see Figure S23-2 for an illustration of this location). This 2 to 2.5 m high, near-vertical scarp has presumably formed since SI #5 was installed in 1990 because the SI is located at the base of the scarp at a location that would not be accessible for the drilling equipment with the scarp in place.