Klohn Crippen Berger

Alberta Transportation

Central Region GRMP

Hwy 570:01, km 8.8 (Near Dorothy)
Call-Out Report

A05116A02

October 2022

Klohn Crippen Berger

October 11, 2022

Alberta Transportation
4th Floor, Provincial Building
4920 – 51st Street
Red Deer, AB, T4N 6K8

Tony Penney, P.Eng.
Construction Engineer

Dear Mr. Penney:

Central Region GRMP
Hwy 570:01, km 8.8, Call-Out Report
Draft

1 INTRODUCTION

As part of the Geohazard Risk Management Program (GRMP) contract for central region, Klohn Crippen Berger Ltd. (KCB) was requested by Alberta Transportation (AT) to conduct a call-out inspection of a deep-seated landslide site on Hwy 570:01, km 8.8 (the site). The site is located on the north lane of Hwy 570:01 along the Red Deer River Valley, 4 km west of Dorothy, Alberta. The legal land description of the site is 4-17-027-17 W4M, 3-17-027-17 W4M, 13-8-027-17 W4M, and 14-8-027-17 W4M. A site plan is presented in Figure 1.

The site was inspected on May 31, 2022, by Mr. Chris Gräpel, P.Eng. and Mr. James Lyons, P.Eng. of KCB and Mr. Rocky Wang, P.Eng. of Alberta Transportation (AT). The site features were visually observed and documented using pictures and drone video capturing. Photographs from the site inspection are included in Appendix I. The call-out report inspection was conducted during the 2022 Central Region GRMP section B site inspection tour. The call-out inspection was triggered by observation of the barbed wire fence being buried with rockfall material and evidence of deep-seated sliding observed at the toe of the slope near the highway.

This call-out report was prepared for AT Central Region under Contract No. CON0017608. KCB's site observations, assessments, and recommendations for short-term and long-term remedial actions are presented herein.

This call-out report was prepared after the actions made on June 28 and 29, 2022 by KCB and AT to reduce the potential risk of a large rock fall onto the highway (not included in this report).

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2 BACKGROUND

Hwy 570 is a paved, two-lane highway orientated in the northwest-southeast direction at the site. The site of the sliding and rockfall hazard is on private land owned by Adams Ranch Ltd., located in Special Area No 2. The contractor maintenance area (CMA) at the site is 519, and Emcon Services Inc. (Emcon) is the Highway Maintenance Contractor (HMC).

The alignment of Hwy 570 at the site is at the former location of the original railway constructed into Drumheller during the start of the coal-mining era of the Drumheller area. The highway was constructed over the former railway right of way.

The 2021 Average Annual Daily Traffic (AADT) was 510 vehicles per day going west on Hwy 570 at the intersection with Hwy 848, approximately 3.3 km east of the site (Traffic Counts Reference No. 116220, West) and 410 vehicles per day going east on Hwy 570 at the intersection with Hwy 10, approximately 8.8 km west of the site (Traffic Counts Reference No. 997198, East).

The slope height is 100 m from the highway to the crest and the active zone is 82 m from the highway to the upper scarp. The horizontal distance from the highway to the crest is 290 m and the active zone from the highway to the upper scarp is 190 m. The slope angle can be discretized in three sections, the back slope is 29° up to 35 m above the highway, next, the angle reduces to 20° up to the upper scarp, and at the top 18 m, the angle is 9°. Also, there is a 31 m high rock scarp with a 52° angle on the west side of the landslide. The slope is bounded by two gullies that are 20 m apart at the top and 264 m at the toe, with a side angle of approximately 30°.

The surficial geology and the bedrock stratigraphy have been identified using geological maps provided by Alberta Geological Survey. The bedrock units at the site are part of the Horseshoe formation and Bearpaw formation (Prior et al., 2013). These formations are composed generally by horizontally oriented bedding layers of sandstone, siltstone, bentonite, mudstone, and coal seams. The surficial geology at the site is composed by colluvial deposits that may contain bedrock, till, glaciolacustrine, glaciofluvial, and eolian sediments that are generally poorly sorted (Fenton et al., 2013).

The geology at this valley has a history of being very sensitive to weathering processes allowing for the development of deep erosion gullies, sinkholes, weak runoff marks, with pipe or tunnel erosion features (Roustaei et al. 2020). These weathering processes are mostly associated with water erosion from precipitation events, water seepage, ice accumulation and snow melt that can result in differential disintegration of the rock mass. The landslide area appears to be bounded by two deep gullies incised into the valley slope that are approximately 135 m apart at the crest of the landslide.

Review of historic air photos obtained from Alberta Environment and Parks (see Figure 2 and 3) indicates that

- The railway appeared to be in place in 1950 and the highway was constructed by 1986. The scale of the air photos does not permit assessment on if highway construction involved excavating the toe of the natural valley slope at the site;

- The earliest evidence of cracking and slope deformation in the upper part of the slope is from 1963.

Discussions with the now-retired MCI, Mr. Gord Wilton indicated that the "pad" of fill across the highway was a former ridge that was used as a borrow area for the railway embankment and for construction of the highway. The railway at Drumheller was built in 1911 (FJHS, 2022). The railway initially constructed a double cut through the ridge, and gradually fill borrowing reduced the ridge to its current level on the south side of the highway. However, the air photos from 1963 and 1975 show the development of tension cracks on the back slope and landslide material being deposited on the "pad."

3 SITE OBSERVATIONS

The site was visited on May 31, 2022. The weather during the site visit was 12°C, sunny. KCB's observations made during the site visits are as follows:

- KCB and AT noticed that a wire fence along the highway and at the toe of the slope had been covered by the eroded material for the slope (See Photos 2 and 3 in Appendix I). The regional AT Maintenance Contract Inspector (MCI), Carson Elliot, noticed the accumulation of failed material at the toe of the slope about two weeks before.
- At the site the differential erosion process of the bedrock and the displacement of the landslide mass allowed for the formation, distortion and fracturing of quasi-vertical rock blocks. The rock blocks located approximately at mid-slope height have released rock blocks and debris that have reached the ditch and rolled across the highway. The rock blocks at mid-slope were visible from the highway (See Figure 4).
- The failed material accumulated at the toe of the slope includes fine-grained soils in two talus fans, a portion of the slope that appeared to have bulged out towards the highway in a manner consistent with deep-seated sliding, and an accumulation of cobble- to boulder-sized angular particles at various locations across the toe of the slope. The length of the zone of accumulation of failed materials was estimated to be approximately 120 m along the highway.
- The material in the ditch has buried a barbed-wire fence that was unburied when KCB last visited this area in 2021. The ditch is now blocked and water is ponded at the east end of the site.
- One boulder (approximately dimensions 0.8 m x 0.8 m x 0.8 m) was observed to have crossed the highway (See Photo 4 in Appendix I).
- No payment cracks or dents or other evidence of large rock blocks striking and damaging the pavement were observed along the highway below the slope.
- There was a large pad of bedrock fill material located across from the landslide and KCB believes that the pad is failed material from the slope that has been placed over the years as the highway was cleared of slope failure materials (See Photo 5 in Appendix I). We have contacted the previous, now retired, MCI to request additional background information on

the site and any possible operational maintenance work such as removing landslide mass material from the highway.

- During the May 31, 2022, inspection, an unmanned air vehicle (UAV) flight was made by KCB to inspect the upper sections of the slope. The video and images taken from the UAV flight made by KCB revealed that:
  - There are a series of backscarps behind the rock blocks at mid-slope and open ground cracks are visible in the upper slope. The observations of the open cracks combined with the bulging at the intact slope at highway level indicate there is a deep-seated landslide failure underway;
  - There are potential graben features visible in the upper part of the slope which could indicate translational sliding on a weak horizontal layer.
  - Three rock blocks perched at the brow of the slope have been distorted and fractured by ongoing slope movements. Two of the rock blocks to the east of the slope were isolated near vertical blocks of rock. The slope and rock blocks at the brow of the slope above the highway have been weathering over time and have the potential to topple or disaggregate into smaller blocks as indicated by recent slope movements (See Figure 4, 5, and Photos 6, 7 and 8 in Appendix I);
  - There is a vertical rock outcrop, very fractured and weathered, located on the west side of the slope that has the potential of releasing large rock blocks onto the highway (See Photo 9 in Appendix I).
- Upon review of the UAV footage the day after the inspection, KCB contacted AT and advised them of the magnitude of the landslide event and severity of the risk to the public travelling on Hwy 570. AT's initial response included augmenting existing rockfall hazard signage with additional signage and an automated message board stating there is an active landslide and no stopping signs. The fill pad across the highway is reported by the MCI to be a popular stopping location for tourists.

4 ASSESSMENT

KCB's assessment of the site is as follows:

- Overall, historic tension cracks well above the brow of the slope appear to indicate that the slope is failing due to deep-seated sliding, most likely on a weak plane in the bedrock. The depth to the failure plane is unknown but appears to be horizontal based on the cracking and deformation pattern observed near the crest of the slope. The removal of lateral confinement on either side of the sliding mass in the two gullies would tend to reduce the stability of the valley slope by removing three-dimensional stabilizing effects. An additional destabilizing effect could be the excavation of the slope toe during highway construction when the railway right of way at this site was converted to a highway right of way;
- The deformation of the slope has left some blocks of bedrock mid slope that present rockfall hazards to the public travelling on Hwy 570;

- The disaggregated material and rock blocks that fell previously have accumulated and filled up most of the catchment ditch at the toe of the slope, impeding highway drainage and ponding water near the toe of the landslide where there appears to be a weak horizontal layer. Softening and saturation of the weak layer could trigger more deep-seated movements that could accelerate rockfall occurrence;
- The material deposited at the toe of the slope appears to be associated with failure modes that include sliding of relatively intact bedrock, rock fall of large and small intact bedrock blocks, and debris from weathered bedrock/soil; and
- The three blocks that are of most pressing concern to the safe operation of Hwy 570 are located on the east side of the slope approximately 50 m above the highway, as shown in Photos 6, 7 and 8 in Appendix I. Weathering processes around the blocks have left the sides with a vertical dip as shown in Figure 5. KCB believes that continuing and eventual weathering processes of the three blocks will result in the potential release and fall of large rock blocks that would reach Hwy 570, creating a hazard to road users.

5 RISK LEVEL

Risk levels have not been previously prepared for the subject site to date. Two hazard types were considered at the site: the mobilization of rock falls, and the mobilization of the deep-seated earth slide. Risk levels for AT GRMP sites for earth slides, debris flow, and rock fall are determined according to the following:

Risk Level = Probability Factor X Consequence Factor

Where the AT risk level is defined as follows:

- Probability Factor on:
  - Earth slides vary from 1 (inactive, very low probability of slide occurrence) to 20 (catastrophic slide is occurring).
  - Rock falls vary from 1 (inactive very low probability of rock fall occurrence) to 20 (active, large volume of rock is surrounded by open cracks, toppling or sliding is accelerating).
- Consequence Factor on:
  - Earth slides vary from 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) to 10 (safety of public and significant loss of infrastructure facilities or privately owned structures will occur if a slide occurs; slides where rapid mobilization of the large-scale slide is possible).
  - Rock falls vary from 1 (rock fall contained by ditch if cleaned to maintain catchment capacity) to 10 (individual or total volume of rock damage/destroy vehicles, cause a complete closure, or require a complete reconstruction of the road).

The risk level for the Hwy 570 site was assessed using AT's risk level system. The values selected for the Hwy 570 site are as follows:

- Probability Factor
  - Earth Slides: A rating of 8 was selected because the tension cracks on the landslides, recent cracking and building of the lower slope face and recent material accumulated at the ditch indicated an active movement.
  - Rock falls: An initial rating of 20 was selected before the removal of the three large rock blocks on the east side of the slope and the vertical rock slab on the west side of the slope. This initial rating was selected because the slope is active with several rock falls occurring as indicated by rock fall material accumulating in the highway ditch. Additionally, the mid-slope rock masses were surrounded by active, open ground cracking (indicating ongoing deep-seated landslide movement) and were also distorted and fractured, indicating high potential for additional rock falls;
    - A revised rating of 11 was selected after the work carried out on June 28 and 29, 2022, which included the controlled removal of the rock blocks and rock slab from the slope, the details of which will be submitted in a separate report. The work removed the blocks that were at imminent risk of falling. Additional rainfall and/or slope movement could create conditions where rockfall risk is heightened again.
- Consequence Factor
  - Earth Slides: A rating of 6 was selected for the site because there is potential for the road to be closed would be a direct and unavoidable result of slide occurrence if the earth slide occurs. There are limited detour options for Hwy 570 without routing traffic long distances over roads that are not designed to handle sustained heavy traffic.
  - Rock falls: A rating of 6 was selected for the site because the slope generates large size rock blocks that have been found along the ditch and across the highway; which, if they struck a vehicle, could cause severe damage to the vehicles or severely injure or kill a vehicle occupant or cyclist on Highway 570.

A total Risk Level of 48 was designated for the earth slides and for the rock falls a total Risk Level of 66 was selected (initially rated 120 before the removal of the rock blocks and rock slab) at the subject site.

6 RECOMMENDATIONS

Recommended short-term and long-term remedial actions for the site are discussed in the following subsections.

6.1 Short Term

The following recommendations were made to AT to reduce the short-term hazard of the slope:

- Jersey barriers to reduce the potential for material to roll across the highway should be installed (this was completed within two days of our site inspection, one day after we spoke to AT about the risk to the public at the site).
- The three blocks located on the east end of the slope should be removed (this was completed on June 27 and 28, 2022).
- The vertical rock slab located on the west rock outcrop should be removed (this was completed on June 27 and 28, 2022).
- The ledge along the slope should be reshaped removing vertically standing rock or soil blocks (this was completed on June 27 and 28, 2022).
- Drainage along the ditch next to the highway shall be re-established.
- The MCI should monitor the site for increased movement and rock fall hazard during or after high-runoff events.

6.2 Long Term

The following recommendations are to minimize the long-term hazard of the slope:

- Establish the Hwy 570 site as a new monitoring site for GRMP in the Central Region;
- Implement spring and fall change detection surveys using a UAV to assess if slope movements continue in response to periods of wet weather, including complete the change detection assessment that will be submitted in a separate report;
- Continue monitoring of the site during the spring and fall with change detection methods to evaluate the rate of movement and active zones of the earth slide;
- Removal of rockfall materials should not excavate the toe of the intact slope. Excavating the toe of the slope could accelerate deep-seated movements which could correspondingly increase the rockfall hazard; and
- Re-establish ditch drainage to eliminate water ponding at the toe of the slope.

7 CLOSING

This report is an instrument of service of Klohn Crippen Berger Ltd. (KCB). The report has been prepared for the exclusive use of Alberta Transportation (Client) for the specific application to the central region GRMP, and it may not be relied upon by any other party without KCB's written consent.

KCB has prepared this report in a manner consistent with the level of care, skill, and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered. KCB makes no warranty, express or implied.

Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

1. The report is to be read in full, with sections or parts of the report relied upon in the context of the whole report.
2. The observations, findings, and conclusions in this report are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.
3. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the report.

Please contact the undersigned if you have questions or comments about this report.

Yours truly,

KLOHN CRIPPEN BERGER LTD.

October 11 2022
I.D. # 58463

Jorge Rodriguez, M.Sc. Ph.D.
Geotechnical Engineer in Training

Chris Gräpel, M.Eng., P.Eng.
Senior Civil Engineer, Associate

JR:CG:bb

PERMIT TO PRACTICE
KLOHN CRIPPEN BERGER LTD.
RM SIGNATURE: _____
RM APEGA ID #: 187607
DATE: 11 Oct. 2022
PERMIT NUMBER: P009196
The Association of Professional Engineers and Geoscientists of Alberta (APEGA)

ATTACHMENTS

Figures
Appendix I Photographs

REFERENCES

Alberta Transportation (AT). 2020a. Traffic Counts Reference No. 116220. Retrieved July 05, 2022 from: http://www.transportation.alberta.ca/mapping/ .

Alberta Transportation (AT). 2020b. Traffic Counts Reference No. 997198. Retrieved July 05, 2022 from: http://www.transportation.alberta.ca/mapping/

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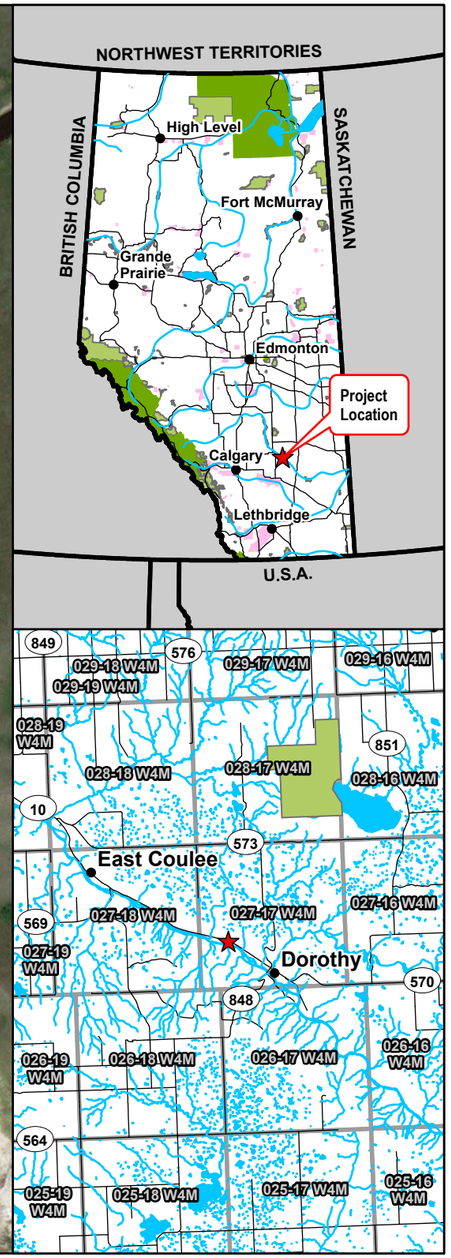
FIGURES



Legend

- Scarp
- Drainage Route
- Active Zone Extent
- Vertical Rock Block
- Rock Fall and Debris Deposition

0 125 Metres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM ZONE 12N
3. IMAGE SOURCE: 2022 MICROSOFT CORPORATION, 2022 MAXAR, CNES, DISTRIBUTION AIRBUS DS

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Site Plan
Section D Call-Out Response
Hwy 570

SCALE 1:4,000 | PROJECT No. A05116E02 | FIG No. 1

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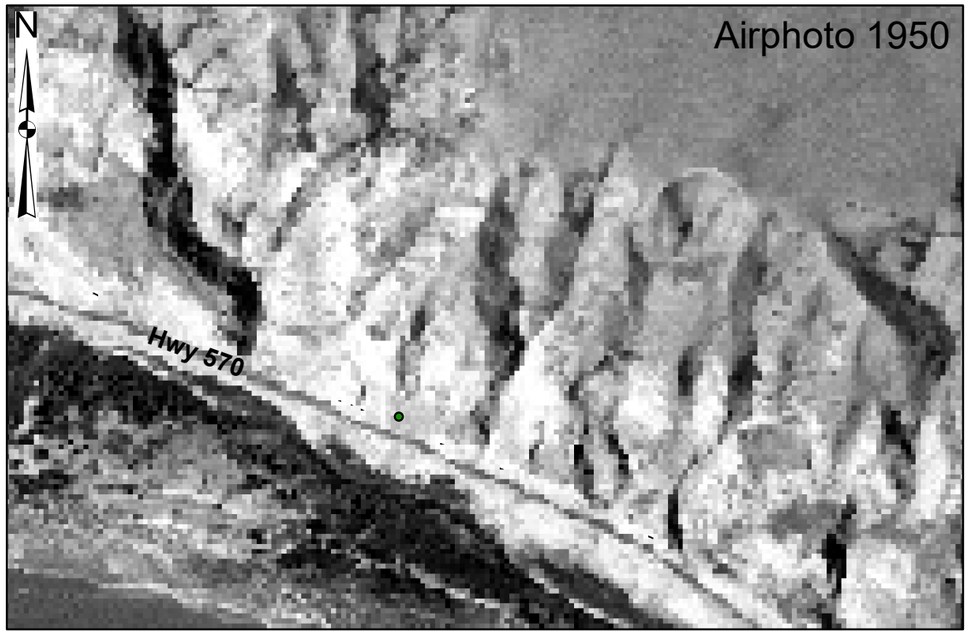

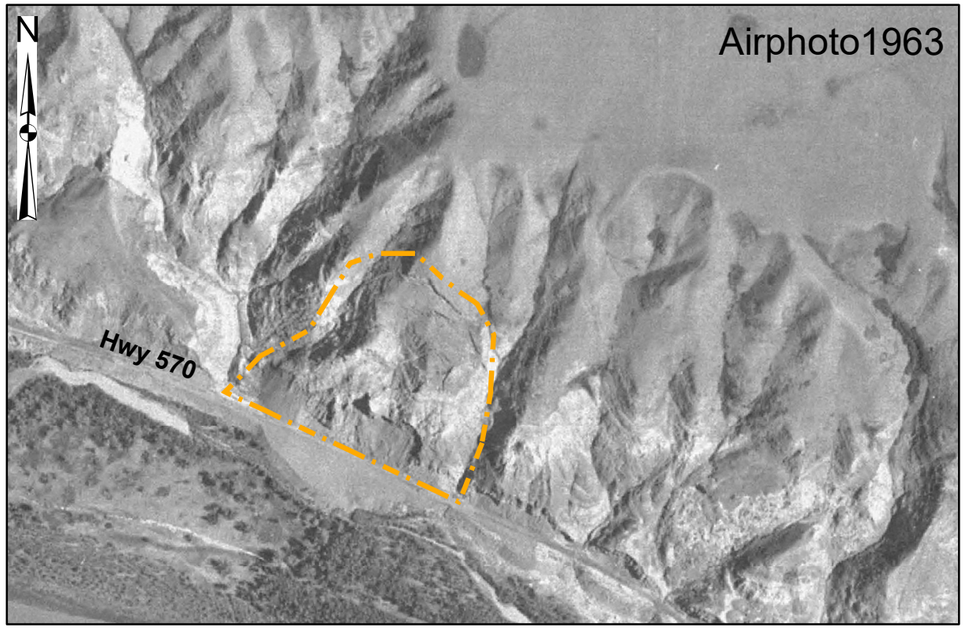

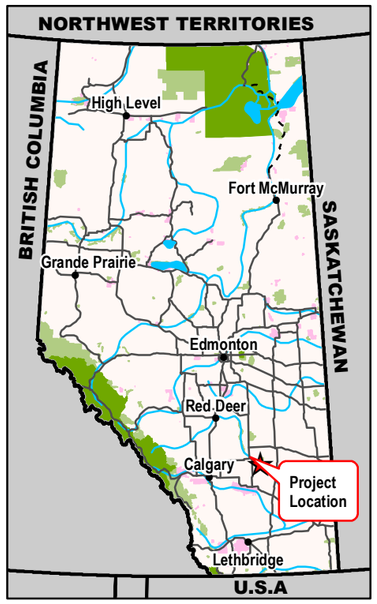

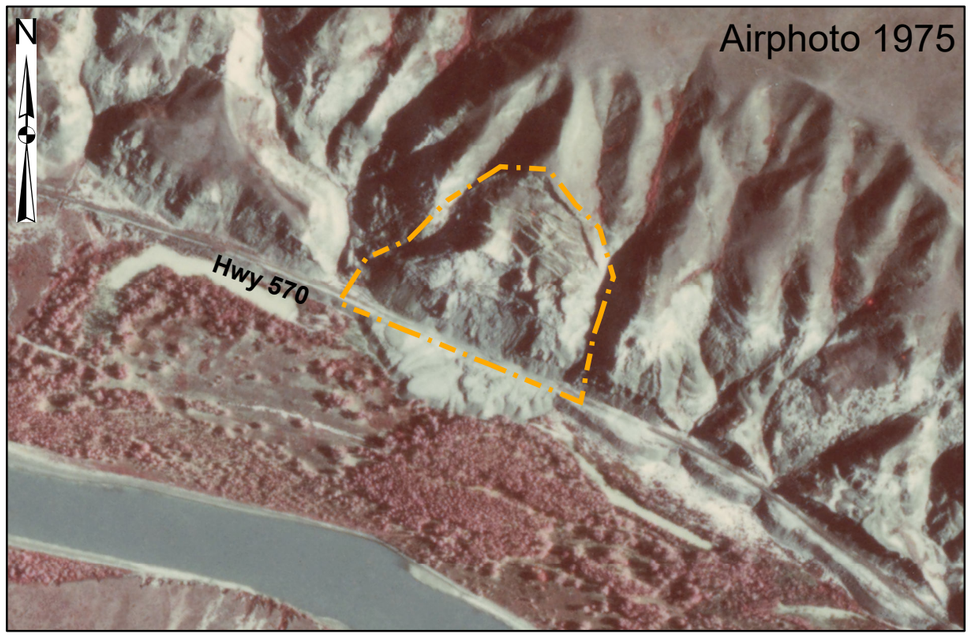

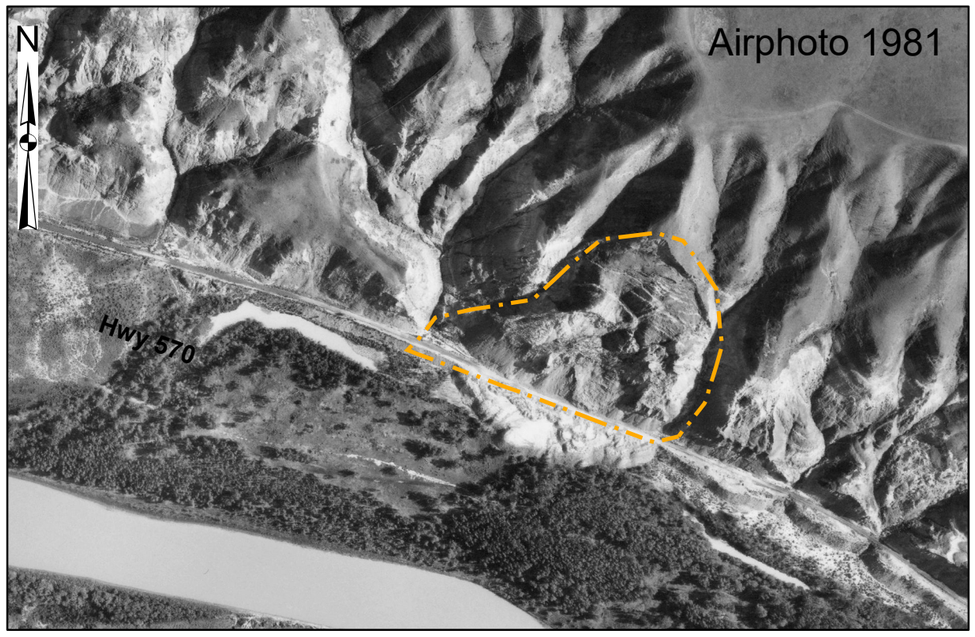

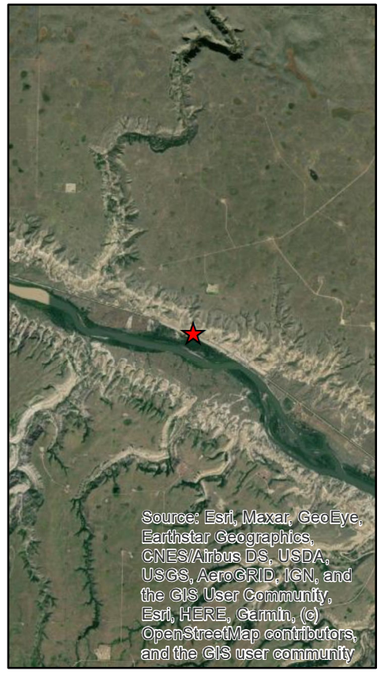

0 45 90 180 270 360

Meters

Legend

Active Zone Extent

NOTES:

1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM Zone 12N
3. IMAGE SOURCE: Bing Maps, Microsoft Corporation 2019

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Airphoto Comparison 1950, 1963, 1975, 1981
Hwy 570 Response
Hwy 570:01, km 8.8

SCALE	PROJECT No.	FIG No.
1:6,000	A05116E02	2

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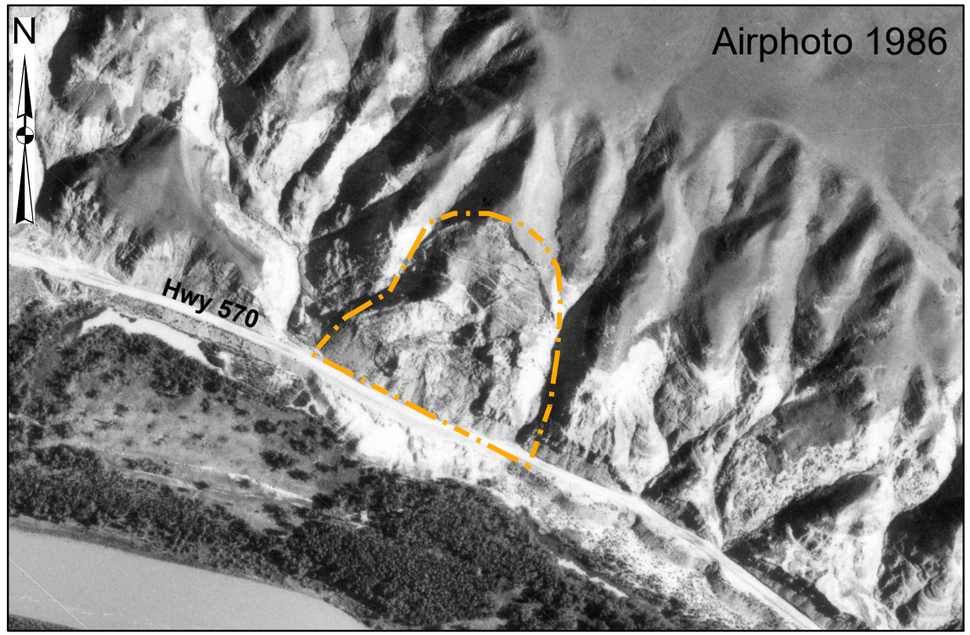

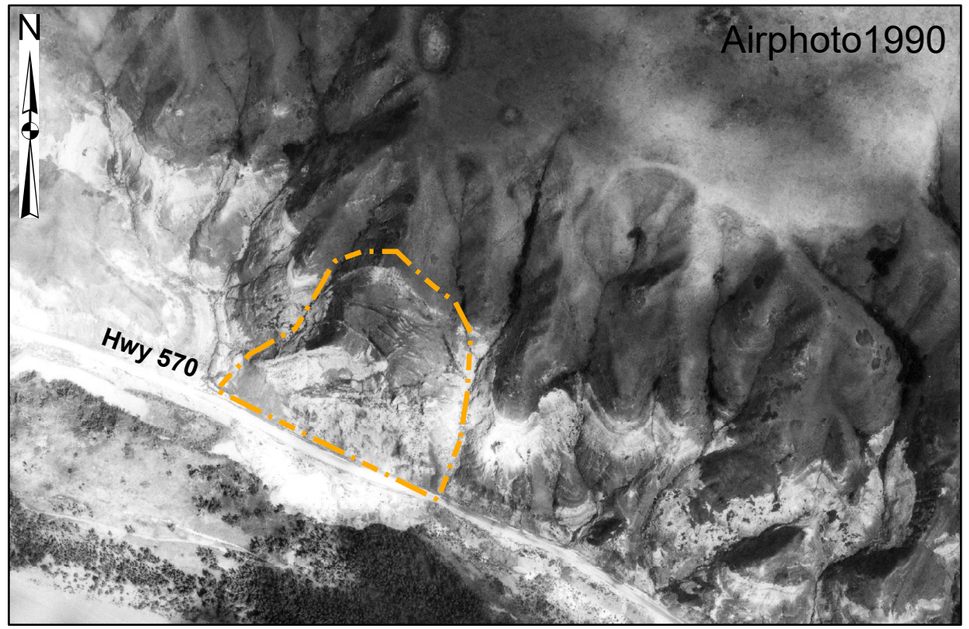

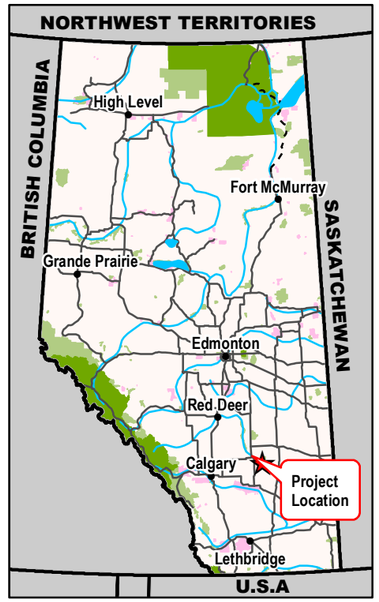

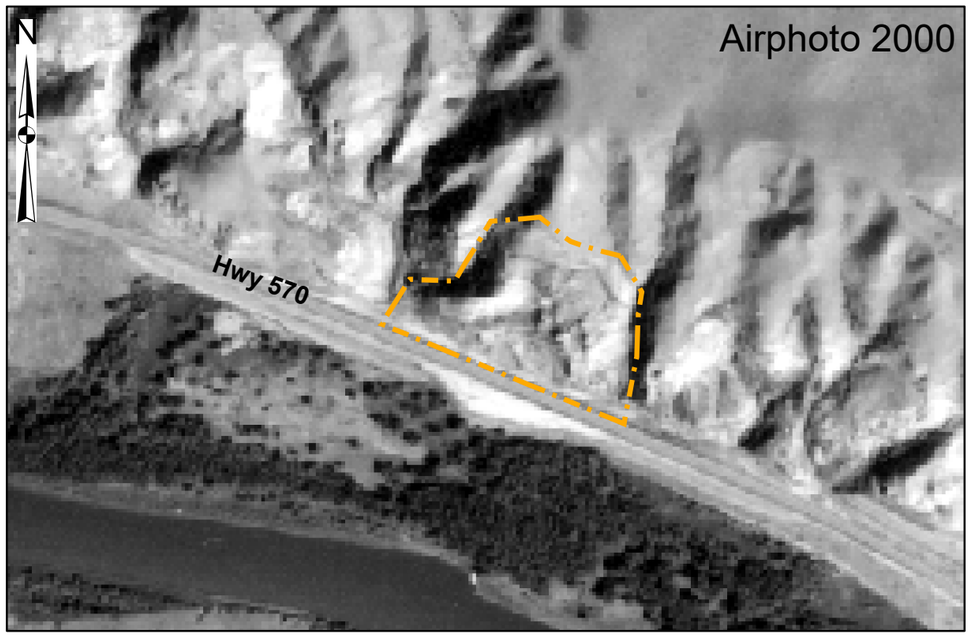

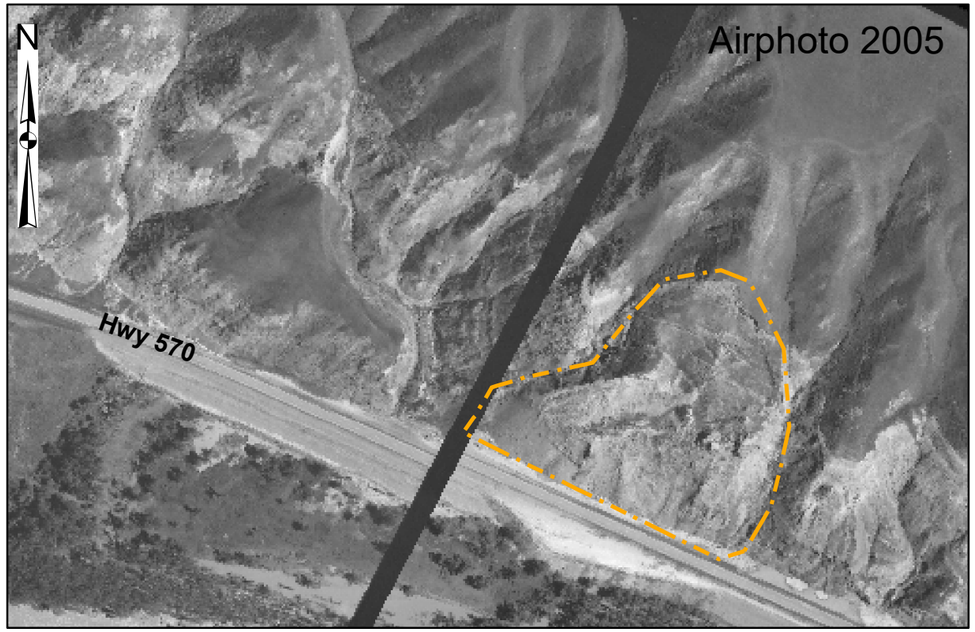

0 45 90 180 270 360

Meters

Legend

Active Zone Extent

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM Zone 12N
3. IMAGE SOURCE: Bing Maps, Microsoft Corporation 2019

CLIENT: Alberta

Klohn Crippen Berger

PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Airphoto Comparison 1986, 1990, 2000, 2005
Hwy 570 Response
Hwy 570:01, km 8.8

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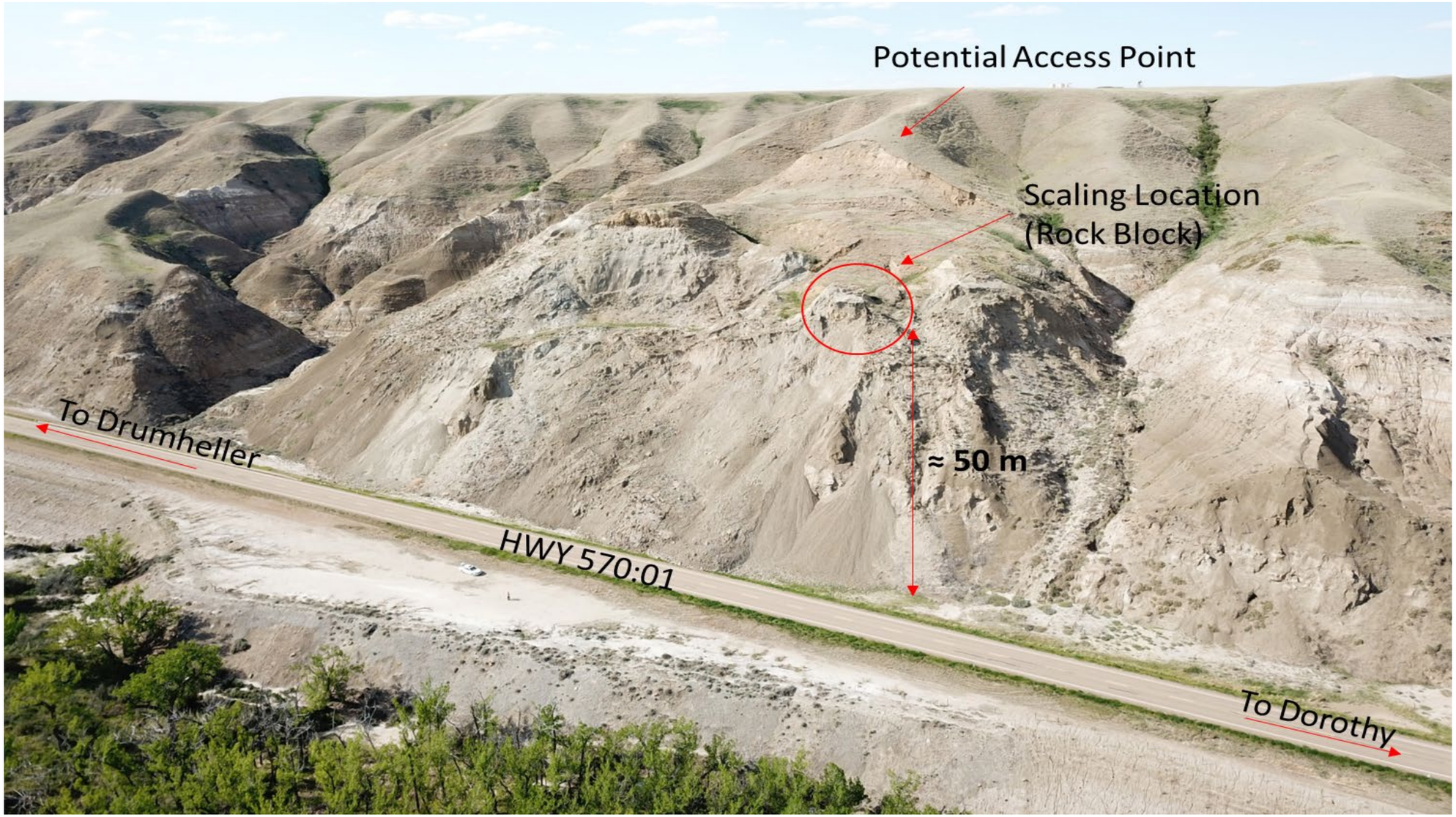

Convention:

Scaling Work Area

CLIENT
Alberta Transportation
Klohn Crippen Berger

PROJECT
CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Panoramic View and Height of Rock Blocks
Section D Call-Out Response
Hwy 570:01 km 8.8

SCALE	PROJECT No.	FIG No.
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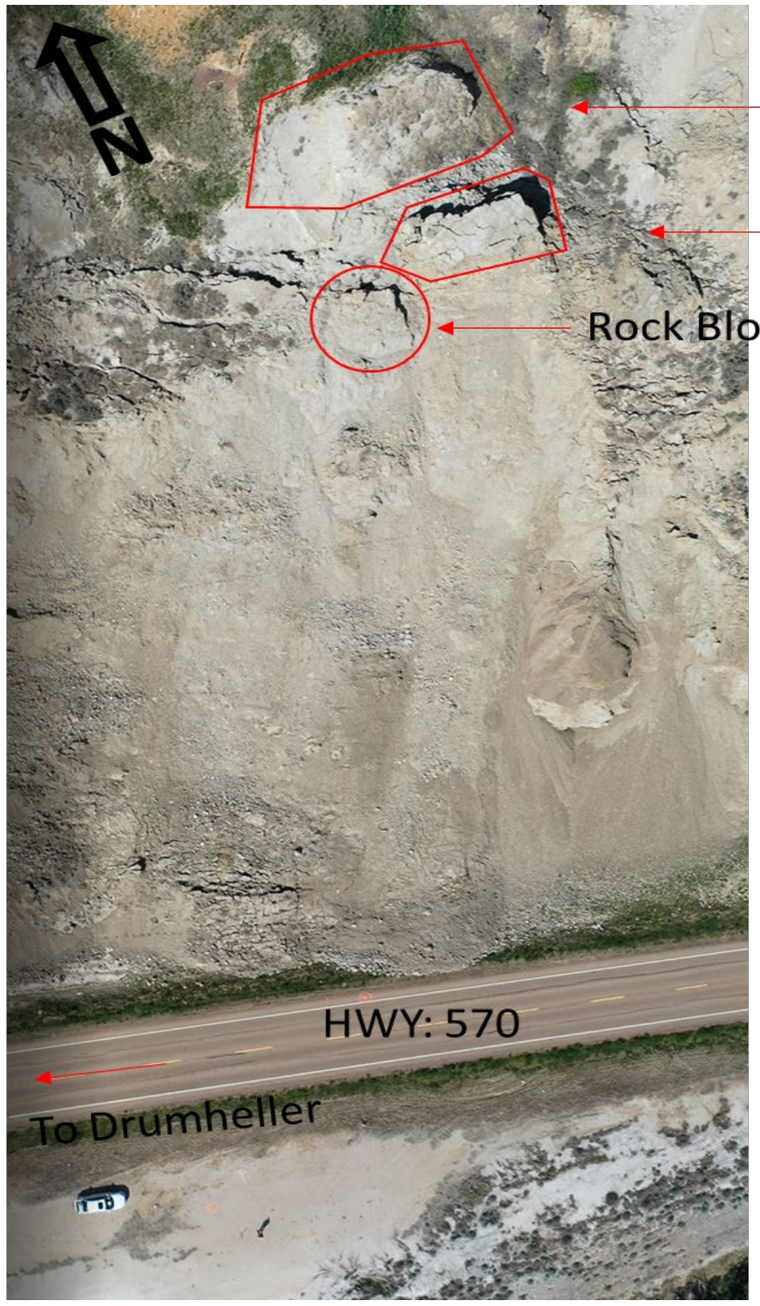

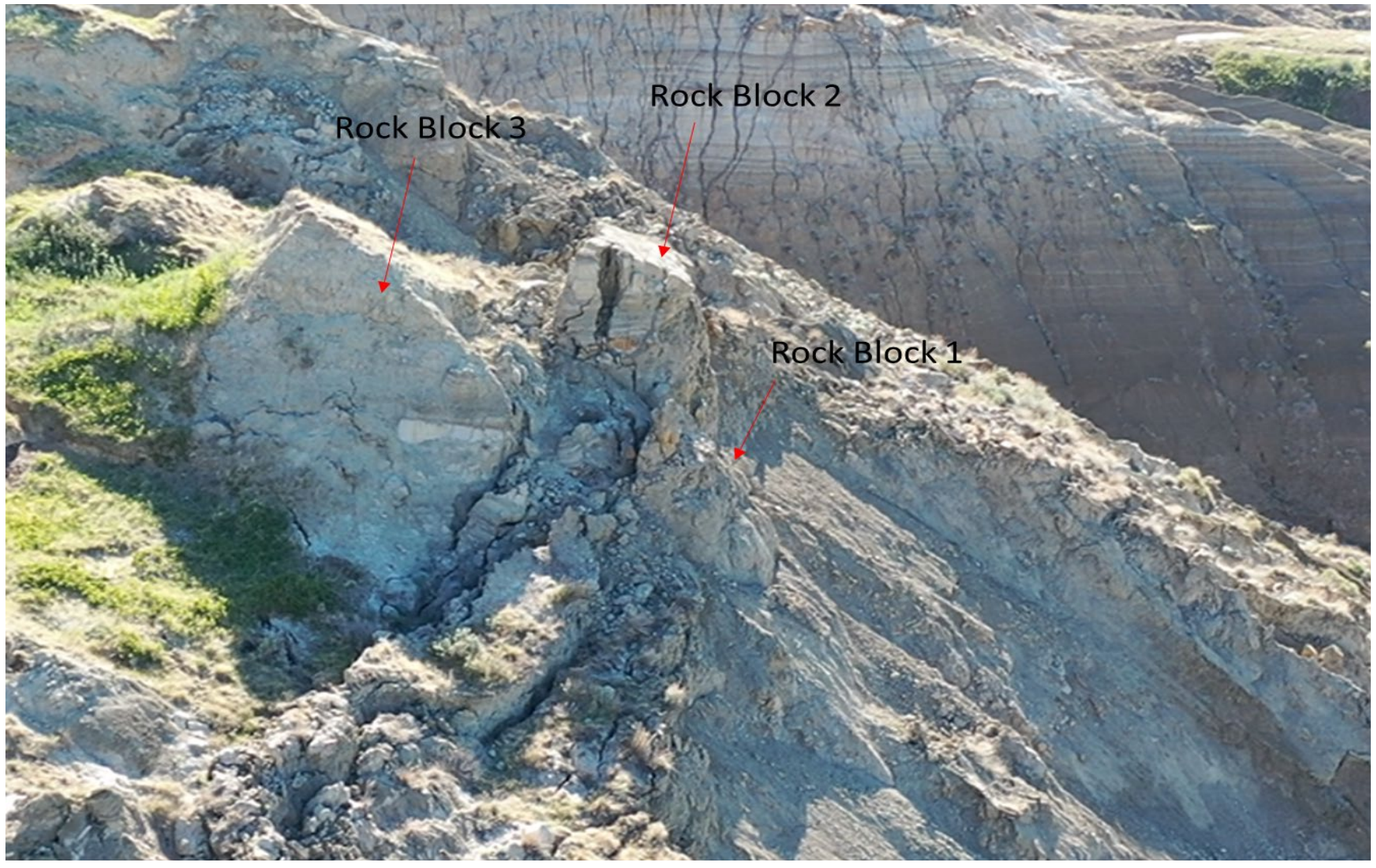

Convention:

Scaling Work Area

CLIENT: Alberta Transportation

Klohn Crippen Berger

PROJECT: CENTRAL REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Close Up View of the Three Blocks
Section D Call-Out Response
Hwy 570:01 km 8.8

SCALE	PROJECT No.	FIG No.
	A05116E02	5

APPENDIX I

Photographs

Appendix I
Photographs

Photo 1 **Oblique photo of the site: Hwy 570:01 km 8.8, west of Dorothy. Photo taken from the UAV on May 31, 2022, facing northeast.**

Photo 2 **Barbed wire fence covered with talus material along the highway. Photo taken May 31, 2022, facing north.**

Photo 3 Failed material accumulated in the ditch. Photo taken May 31, 2022, facing east.

Photo 4 Boulder found across the Highway. Photo taken May 31, 2022, facing north.

Photo 5 **Former natural ground area (ridge) that was excavated for railway and highway construction. Photo taken May 31, 2022, facing northeast.**

Photo 6 Rock blocks on the east side of the slope. Photo taken May 31, 2022, facing north.

Photo 7 **Oblique photo behind the three weathered rock blocks. Photo taken from the UAV on May 31, 2022, facing south.**

Photo 8 **Oblique photo of the three rock blocks on the east side of the slope. Photo taken from the UAV on May 31, 2022, facing east.**

Photo 9 **Rock outcrop on the west side of the slope. Photo taken May 31, 2022, facing north.**