September 2, 2016

Alberta Transportation
2nd Floor, Willowglen Business Park
803 Manning Road NW
Calgary, Alberta
T2E 7M8

Ross Dickson
Project Services Technologist - Construction

Dear Mr. Dickson:

CON0017609 Southern Region GRMP - Call-Out Reports
S047 - Hwy 3:02 Coleman Bin Wall (km 13.283)
S048 - Hwy 3:04 Castle Back Slopes (km 23.567)

1 INTRODUCTION

As part of the Geohazard Risk Management Plan (GRMP) Contract for Southern Region, Klohn Crippen Berger Ltd. (KCB) was requested by Alberta Transportation (AT) to conduct a call-out inspection of an embankment back slope failure site along Highway 3 east of the Oldman Reservoir (Castle Back Slopes) as well as a corroded bin retaining wall between Highway 3:02 and 19 Avenue in Coleman (Coleman Bin Wall). At AT's request, these two sites have been combined into one Call-Out report.

Both sites are located in Contractor Maintenance Area (CMA) 26, where Volker Stevin is the maintenance contractor (MC). Specific location details of the sites are as follows:

- The Castle Back Slopes failure, was located with a hand held GPS (49° 32.629' N, 114° 1.158' W, WGS 84). The legal land description of the site is LSD SW 12-7-1-W5.
- The Coleman Bin Wall, was located with a hand held GPS (49° 38.095' N, 114° 31.242' W, WGS 84). The legal land description of the site is LSD NW 8-8-4-W5.

The sites were inspected on June 15, 2016 by Mr. Chris Gräpel, P.Eng., Mr. Tim Keegan, P.Eng., and Andy Brunsdon, P.Eng. of KCB, and Roger Skirrow, P.Eng. and Ross Dickson of AT. Photographs from the inspections of both sites are attached in Appendix I for reference. Overall site plans of the Castle Back Slopes and Coleman Bin Wall are presented in Figures 1 and 2 respectively.

This call-out report represents the first documented engineering site visit to the Coleman Bin Wall. The Castle Back Slopes were the subject of a call-out report inspection dated prior to 2015. This report was prepared by KCB for AT Southern Region under Contract No. CON0017609. The results of

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our site inspections, assessments, and our recommendations for remediation works are presented herein.

2 BACKGROUND

2.1 Coleman Bin Wall

Highway 3:02 at this site is located within the Municipality of Coleman. The base of the binwall structure is located adjacent to 19 Avenue. There is a small valley north of the site, on the opposite side of Highway 3. The bin wall is approximately 2.5 to 3 m tall and 70 m long. Of this, approximately 35 m (11 sections) of the bin wall are corroded.

A review of readily available topographic, geologic, and surficial soil maps indicates that the highway is constructed in an area of moraine colluvial deposits, with glacialfluvial deposits in nearby valleys. The moraine includes till with a mixture of clay, silt, and sand, as well as minor pebbles, cobbles, and boulders. (Alberta Geological Survey, 2013). The glacialfluvial deposits contain poor to well-sorted coarse to fine grained sediment, including till in some places.

The Coleman area is the site of historic coal mining activities. Review of the online Alberta Energy regulator coal mine listings indicate that the subject site is underlain by historic coal mine workings. The presence or extent of coal seams, adits/slopes, coal mining waste or fine coal refuse (slack) piles in the vicinity of the subject site is unknown.

The average annual daily traffic (AADT) along Highway 3 east of the site at the intersection of Hwy 3 and Hwy 40 at is 8200 westbound and 9240 eastbound (reference No. 70060). Traffic counts on 19 Avenue are not available for our review on the AT website.

2.2 Castle Back Slopes

Highway 3:04 at this site is constructed in a double cut section east of a bridge crossing (BF 75529) over the Castle River where it discharges into the Oldman Reservoir. The cut slopes on both sides of the highway are approximately 8 m in height, and sloped at about 3H:1V. A Canadian Pacific Railway (CPR) rail line and bridge crossing over the Castle River is located approximately 120 m north of the highway.

A review of readily available topographic, geologic, and surficial soil maps indicates that the highway is constructed in an area of glaciolacustrine deposits which includes fine sand, silt, clay sediment, and local debris. The area also contains well-sorted silty sand, pebbly sand, and minor gravel (Alberta Geological Survey, 2013).

The average annual daily traffic (AADT) along Highway 3 east of the site at the intersection of Hwy 3 and Hwy 6 is 4200 westbound (reference No. 81080).

3 SITE OBSERVATIONS

3.1 Coleman Bin Wall

The following observations were made during the site visit and verified with review of Google Earth Street Level View imagery:

- The site is located south and downslope of Highway 3, along the north side of 19 Avenue in Coleman (which is parallel to Highway 3 at the site location).
- There is a small valley on the opposite (north) side of the highway, generally north of the corroded bin walls.
- The bin walls in this location are approximately 1.5 to 2.5 m tall and are constructed with 22 binwall sections to form a retaining wall approximately 70 m long (Photos 1, 2, and 3).
- 11 sections (approximately 35 m) of the binwall structure have experienced corrosion visible from 19 Avenue. Granular fill material has started coming out of the eight western most bin walls (Photo 1). Rust stains are present on the remaining 3 bin walls showing evidence of corrosion.
- In general, there appeared to be no visible sign of global instability of the binwalls, aside from the rupture and loss of backfill materials in 8 binwalls.

3.2 Castle Back Slopes

The following observations were made during the site visit:

- An approximately 200 m length of the 8 m high back slope has failed on the north facing south slope (Photos 2, 3, 4, and 5). The slope on the south side is approximately 3H:1V. The failed slope is sporadically vegetated as a result of the failure and sloughing. The south-facing north slope has not failed.
- The slide appears to be a result of surface water and possibly groundwater drainage toward and out of the south or north-facing slope. The north-facing south slope has a larger catchment area to the southeast draining towards it. By contrast, regional surface water drainage appears to be draining away from the crest of the south-facing slope.
- The failed back slope has undermined a fence line beside the adjacent field over a length of approximately 10 m (Photos 4, 6, and 7). Four fence posts have been undermined by the slope failure. Other than the four fence posts that have been undermined, in general, the fence line appears to be relatively straight along the crest of the slope (Photo 10).
- The zone of accumulation at the toe of the slide has extended into the ditch and has caused some partial ditch blockage and some erosion (Photo 5).
- The sloughing has resulted in a near vertical slope at the crest of the slope near the fence (Photos 8 and 9).

- Some minor erosion and rills can be seen on the failed slope material (Photo 9).

4 ASSESSMENT

4.1 Coleman Bin Wall

The call-out inspection can only assess the external condition of the bin wall. The condition of the buried structural members is unknown. However, corrosion of the buried structural elements should be expected.

The observation of corrosion being located only on the binwall segments located adjacent to a valley suggest that groundwater seepage may be more corrosive and aggressive near the valley. The reasons for this are not clear; however, the cause of the corrosion failure of the wall could include, but not be limited to:

- drainage from abandoned mine workings or piles of slack coal upslope of the binwalls could be acidic; and
- the soil backfill placed in the binwalls could have variable geochemical properties which would result in varying degrees of corrosion potential.

There is potential for brittle failure of the retaining wall caused by a collapse failure of buried and corroded structural elements in tension. In the absence of any observations that could refute this and given the proximity of 19 Avenue to the toe of the wall, repairs should be implemented immediately. Failure of the wall will impact the Hwy 3 embankment slope above the binwall and could lead to retrogression of the backscarp to the edge of the pavement or into the eastbound lane.

4.2 Castle Back Slopes

It appears that the root cause of the back slope failure of the south slope is primarily related to surface runoff with an unknown contribution from regional groundwater seepage. The south slope gets less sunlight than the slope on the north side of Highway 3 because it is oriented facing north, and therefore there is less evapotranspiration occurring on the south slope which will support wetter conditions. Review of the imagery presented in Figure 1 indicates a lighter color on the north slope which indicates drier conditions. The zones of failure on the south slope are also lighter colored which indicates that the failed materials may dry out due to loss of grass cover or disrupted surface drainage.

It is KCB's opinion that if left unaddressed, the slide will continue expanding to the east and west along the highway embankment. It is also likely that the slope will continue to expand to the south and encroach on the adjacent private property with further undermining of the fence line and disruption of farmland.

5 RISK LEVEL

5.1 General

Risk levels have not been prepared for the site to date. Risk levels for AT GRMP sites are determined according to the following:

Risk Level = Probability Factor X Consequence Factor

where the AT risk level is defined as follows:

- Probability Factor varies from 1 (inactive, very low probability of slide occurrence) to 20 (catastrophic slide occurring).
- Consequence Factor varies from 1 (minor consequence, no impact to driver safety, maintenance issue) to 10 (safety of public at risk, loss of infrastructure, rapid mobilization of large slides).

5.2 Coleman Bin Wall

The risk level associated with the Coleman Bin Wall was determined using AT's earth slides and debris flow risk level system and is presented as follows:

- Probability Factor – A rating of 8 was selected due to the extent of the corrosion on the bin walls and granular fill material eroding and falling out of the corrosion holes.
- Consequence Factor – A rating of 8 was selected due to the height of fill and close proximity of the bin wall to 19 Avenue in Coleman which could cause public safety issues. Partial closure of Hwy 3 is not considered likely in the short term after a failure, but 19 Avenue would be closed in the event of failure.

A total Risk Level of 64 was assigned for the subject site.

5.3 Castle Back Slopes

The risk level associated with the Castle Back Slopes instability was determined using AT's earth slides and debris flow risk level system and is presented as follows:

- Probability Factor – A rating of 9 was selected due to the evidence of ongoing movement possibility of additional portions of the slope failing.
- Consequence Factor – A rating of 2 was selected for the slide as it does not appear that the back slope failing will cause a road closure.

A total Risk Level of 18 was assigned for the subject site for slope instability.

6 RECOMMENDATIONS

6.1 Short Term

6.1.1 Coleman Bin Wall

A jersey barrier should be installed in front of the failing sections of the wall with signage installed indicating a speed reduction, narrow lane and hazard indication. The rate of backfill loss through the voids and short term failure of the binwalls could be reduced by placement of temporary steel plating over the face of the walls braced with concrete jersey barricades and/or granular fill placed at the toe of the binwalls. The cost of this work should be between $10,000 and $20,000. However, the drilling investigation described in section 6.2.2 should be completed first.

Recommended long-term actions are discussed in Section 6.2.

6.1.2 Castle Back Slopes

For the short term, the ditch should be re-graded to allow for positive surface water drainage. This will require removal of slide toe materials from the ditch. The amount of slide material should be limited to the minimum required to re-establish drainage without initiating additional slope movements. The cost of this work is estimated to be between $5,000 and $10,000.

Recommended long-term actions are discussed in Section 6.2.

6.2 Long Term Slope Stabilization

6.2.1 Coleman Bin Wall

The extent of repair required cannot be assessed at this time. Based on the degree of deterioration visible from 19 Avenue, it appears that the corroded sections of the binwall need to be replaced. However, the extent of corrosion of buried structural elements is unknown. While adjacent, apparently good condition binwalls can be exposed to have their buried structural elements exposed and assessed, it will not be possible to completely assess the condition of all buried elements of the binwall without excavating the entire wall. Therefore, AT the following options:

- partial or complete binwall removal, depending on conditions of exposure of buried structural elements, with replacement with a reinforced earth retaining wall system; and
- rehabilitate the wall in situ without removal of the bin walls with:
  - corrosion protected tied back pre-cast or cast-in-place concrete panels placed over the front of the binwalls; and
  - A tied back driven steel h-pile and timber lagging retaining wall.

Replacement of the binwalls with another reinforced earth wall could result in the crest of the excavation extending into the east bound land or the use of temporary excavation stabilization such as soil nails to limit the impact on Hwy 3 traffic. Additionally, due to the potential for continued

corrosion due to upslope sources of aggressive groundwater, replacement reinforced earth walls will need to incorporate structural elements that do not corrode (such as plastic strips or grids).

A geotechnical investigation should be completed to assess wall backfill materials, foundation materials and groundwater level and chemical composition. Samples of the backfill behind the wall could be taken through the corroded holes in the wall for chemical testing and geotechnical index testing. One or two boreholes could be drilled at the toe of the wall, subject to a buried service sweep, with 50 mm diameter standpipes installed in flush mounted road head boxes. Soil samples would be taken from Standard Penetration Testing and grab samples for geotechnical index testing, The 50 mm diameter standpipes would be installed to permit water sampling and testing to assess corrosion potential of groundwater. It is expected that a downhole hammer, ODEX, Becker, sonic or other drilling method suited to cobbly, gravelly soils and the local bedrock would be required to complete the boreholes. One borehole should be completed through the eastbound lane behind the corroded section of the binwall. All borehole should be drilled a depth of 5 m below the current toe of the wall. The rough order of magnitude cost estimate for the drilling investigation, including buried utility sweep, traffic accommodation/control, lab testing and reporting, including preliminary assessment of the repair options described herein is between $20,000 and $30,000.

The results of the drilling investigation should be reviewed before a design concept is selected for final design. A detailed proposal for design services can be prepared at that time. In the interim, design of a replacement retaining wall with final design drawings, specification and tender and construction monitoring and post construction services is estimated to cost between $80,000 and $120,000.

The rough order of magnitude construction cost to replace the bin wall is estimated to be between $50,000 and $100,000 to replace the visibly corroded length (22 m) of wall, and between $150,000 and $300,000 to replace the entire 70 m length of the bin wall. A rough order of magnitude cost for insitu rehabilitation of the wall with anchored panels a tied back h-pile and timber lagging wall over the entire length of the binwall is between $500,000 and $900,000. Drilled soil nails were considered but their applicability to this site would need to be assessed based on the results of corrosion testing.

6.2.2 Castle Back Slopes

The long term solution for this site should include establishing a crest ditch to intercept surface water drainage and divert it downslope in an armoured channel. The area where the slide has retrogressed behind the fence line should either be re-established with fill or have the fence line relocated. The entire failed back slope area should be hydro-seeded to re-establish grass cover.

Constructing the ditch and repair to the crest of the slope or revision of the fence line will require discussions and an agreement with the owner of the adjacent private property.

Designing the drainage ditch on the crest of the hill will require a hydrologic assessment by a hydrotechnical engineer. The assessment would include a site reconnaissance, as well as a review of available LiDAR data of the area to determine the catchment size and volume of runoff reporting to the ditch. The definition of the design storm and runoff event would be required from AT; it is

anticipated that a 1:10 year storm would be the required design event. It is expected that the diversion ditch will need to be protected with grass near the crest of the slope but armored with geocell and gravel or rip rap where it discharges over the steeper cut slope.

If AT requests a design to be completed, rough order of magnitude costs for ditch design and repair, preparation of one or two drawings showing plan and section details and preparing Special Provisions to assist in sole sourcing the work to the maintenance contractor with 2 one day site visits (kick off and part way through construction) would be in the order of $10,000 to $20,000. It is assumed that limited site presence would be required during construction. If additional time on site is required, additional costs would apply. Additional costs would also apply if a tender and tendering process is required or if land acquisition and related negotiations are required. A more detailed proposal can be provided if AT decides to proceed with engineering design of ditch and erosion repairs.

The rough order of magnitude construction cost for the diversion ditch construction, fence repair, and re-vegetating the slope is between $80,000 and $150,000.

7 CLOSING

This is a draft report only and we solicit your review and comments within 4 weeks of submission. Upon issue of the final report, we request that all draft reports be destroyed or returned to Klohn Crippen Berger Ltd. This draft report should not be relied upon as a final document for design and/or construction.

This report is an instrument of service of Klohn Crippen Berger Ltd. The report has been prepared for the exclusive use of Alberta Transportation (Client) for the specific application to the Hwy 3:04 and Hwy 3:02 Call-Out Reports. The report's contents may not be relied upon by any other party without the express written permission of Klohn Crippen Berger. In this report, Klohn Crippen Berger has endeavoured to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

Please do not hesitate to contact the undersigned for any questions, comments or concerns.

Yours Truly,

KLOHN CRIPPEN BERGER LTD.

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

Attachments
Figures
Appendix I Photographs

REFERENCES

Alberta Transportation (AT). 2015. Traffic Counts Reference No. 81080. Retrieved August 23, 2016 from: < http://www.transportation.alberta.ca/mapping/>

Alberta Transportation (AT). 2015. Traffic Counts Reference No. 70060. Retrieved August 23, 2016 from: < http://www.transportation.alberta.ca/mapping/>

Alberta Geological Survey (AGS). 2013. Map 601 Surficial Geology of Alberta. Published March 25, 2013.

FIGURES

715,400 715,500 715,600 715,700 715,800 715,900 716,000

5,492,300

5,492,200

5,492,100

N

Old Man Reservoir

To Cowley

Hwy 3:04

CPR Rail Line

Castle River

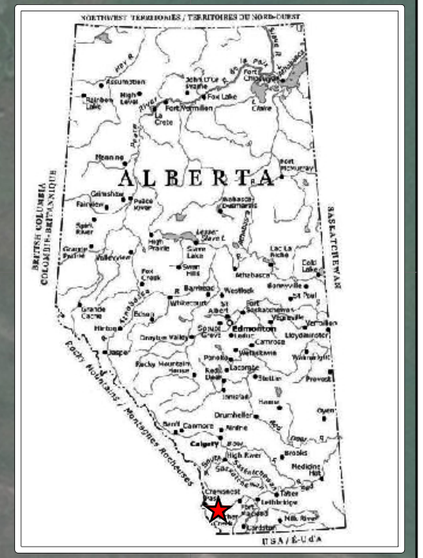
No sign of instability on south facing slope

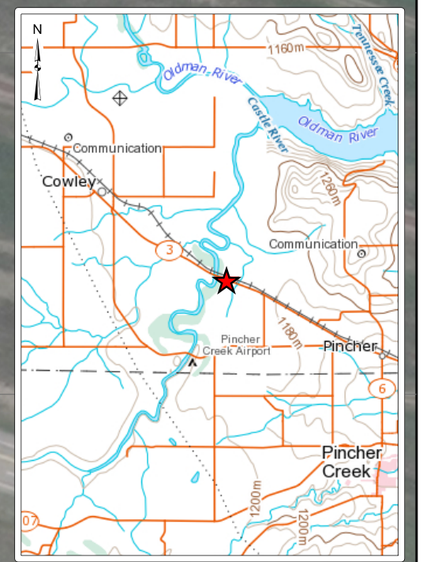
Toe of slide partially blocking ditch

This distance is 4 fence posts

To Brocket

bing™





© 2010 DigitalGlobe © 2010 GeoEye © 2015 Microsoft Corporation

Legend

Main Scarp

Fence

0 100 Metres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM Zone 11N
3. IMAGE SOURCE: Bing Maps 2016, Microsoft Corporation Image dated July 2013

CLIENT: Alberta Transportation

Klohn Crippen Berger

PROJECT: SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE: Call-Out Site Plan
S047 - Castle Back Slopes
Hwy 3:04, km 23.567

SCALE	PROJECT No.	FIG No.
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Date: August 29, 2016
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678,900 679,000 679,100 679,200

5,501,100

5,501,000

5,500,900

N

To B.C. border

Hwy 3:02

19 Ave

To Jct Hwy 22

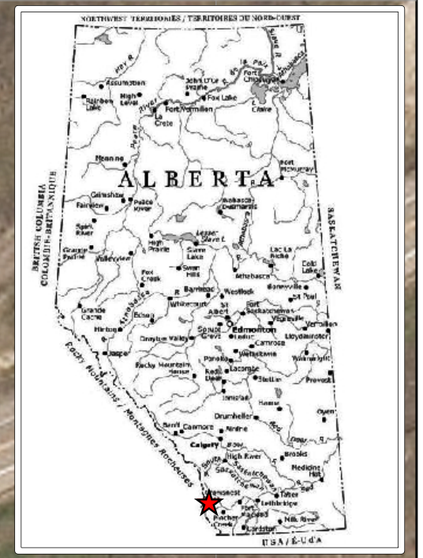
22 m

Corroding sections

Bin wall

68 m

67 St.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

0 50 Metres

NOTES:
1. HORIZONTAL DATUM: NAD83
2. GRID ZONE: UTM Zone 11N
3. IMAGE SOURCE: World Imagery from ESRI ArcGIS Online. Image dated July 15, 2012

CLIENT
Alberta Transportation

Klohn Crippen Berger

PROJECT
SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM

TITLE
Call-Out Site Plan
S047 - Coleman
Hwy 3:02, km 13.283

SCALE	PROJECT No.	FIG No.
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Date: August 29, 2016
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APPENDIX I

Photographs

Appendix I
Photographs

Photo 1 **Corroded and failing Bin Wall. Photo was taken facing northeast on June 15, 2016.**

Photo 2 **Looking south at the north-facing failing back slope. The photo was taken on June 15, 2016.**

Photo 3 **Looking east at the failing back slope. The photo was taken on June 15, 2016.**

Photo 4 **Looking southeast at the failing back slope. The photo was taken on June 15, 2016.**

Photo 5 **Looking west at the failing back slope. The photo was taken on June 15, 2016.**

Photo 6 **A closer look at the failing back slope. The fence has failed as a result of the failing slope. The photo was taken on June 15, 2016.**

Photo 7 **Fence posts that have failed and sloughed as a result of the failing back slope. The photo was taken on June 15, 2016.**

Photo 8 **Looking east at the failing back slope approximately 200 m on the south side. Rills on the slope were present. Photo taken on June 15, 2016.**

Photo 9 **Entire back slope is moving and eroding due to a water runoff from the field. Photo taken on June 15, 2016.**

Photo 10 **Looking west at the slope and drainage grade in the field adjacent to the south side (crest) of the slope. The photo was taken on June 15, 2016.**