

July 28, 2017

Alberta Transportation
2nd Floor, 803 Manning Road NE
Calgary, Alberta
T2E 7M8

Ross Dickson
Project Services Technologist - Construction

Dear Mr. Dickson:

Southern Region GRMP - Call – Out Report
Site S012; Hwy 742:02, km 4.319 Spray Lake Road

1 HWY 742:02, KM 4.319 CALL-OUT REPORT 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 the S012 site on Hwy 742:02 (Spray Lakes Road), km 4.319 to inspect the voids that have formed beneath the highway from old coal mines. The site is located in Canmore, Alberta. Volker Stevin Contracting Ltd. is the Maintenance Contractor (MC) for the site located in Contractor Maintenance Area (CMA) 28. The site was located with a hand-held GPS (51° 4.661' N, 115° 22.102' W). The legal land description of the site is NW 29-24-10 W5. A site plan is presented in Figure 1.

The site was inspected on April 19, 2017 by Mr. Chris Gräpel, P.Eng. of KCB. AT operations staff from CMA 28 also attended the call-out site visit. Mr. Perry Roberts, the Maintenance Contract Inspector (MCI), and Mr. Paul Prout, the Field Support Technologist (FST), attended on behalf of AT. Photographs from the site inspection are attached in Appendix I.

This call-out report was prepared by KCB for AT Southern Region under Contract No. CON0017609. The site was last inspected by KCB June 14, 2016 as part of the GRMP annual inspection program. KCB's site observations, assessments, and recommendations for short- and long-term remediation works are presented herein.

2 BACKGROUND

The S012 site has been investigated and inspected annually by AT and their consultants since 2000 to assess the risk to Hwy 742 from underlying, abandoned coal mine workings. The annual site inspections indicate there is a risk of future subsidence or collapse over voids and cavities associated with the old mine workings known to underlie this area. The site investigation work has consisted of Ground Penetrating Radar (GPR) surveys along with borehole drilling and downhole camera

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inspections conducted to locate voids associated with the mine workings and estimate their depth and lateral extent relative to the highway right-of-way. Based on review of a coal mine map in the GRMP binder, the coal mine workings across the Hwy are approximately 40 m wide, crossing the Hwy diagonally over an 80 m to 100 m highway length.

The S012 site is underlain by one of four steeply inclined coal seams that were excavated during the life of the mine. Three of these four seams were encountered by the 2002 drilling program that was described in Norwest Corporation's (Norwest) 2003 report. A summary of that report is presented in this section.

Norwest reported that, in the late-1980s, a sinkhole developed near the shoulder of the road at or near the S012 site. The sinkhole was not investigated and the feature was reported as being backfilled. In 1993 the Rundle Water Main Trunk was constructed in the ditch at the south side of the road. A site investigation conducted to support the water-main construction indicated that the No. 2 seam was within 4 m of ground surface. A small void (1.0 m diameter by 1.5 m deep) was encountered during water main construction.

Drilling investigations conducted by Norwest (2003) encountered voids at 3.5 m to 6.0 m depths below asphalt. Boreholes drilled at the site in December 2002 encountered up to approximately 1 m of overburden, which was underlain by a sequence of mudstone over voids interspaced with coal deposits/seams. The voids were typically in the order of 2 m to 5 m in vertical thickness (measured in the boreholes). Downhole camera surveys were conducted through multiple boreholes. The downhole camera videos were reported by AT to indicate that the voids intersected by the various boreholes were interconnected as light could be seen from one borehole to the other. The boreholes were capped with flush-mounted head boxes. The 2003 Norwest report indicates that the area of investigation did not span the entire length of the highway overlying the No. 1 Mine.

KCB conducted the 2016 Section B annual inspection of the S012 site on June 14, 2016. The inspection included visiting sinkholes associated with collapse of coal-mine workings located to the south of the S012 site. At that time, AT remarked that the extent and depth of the sinkholes had increased in the past five years. The flush-mounted head boxes on the highway surface were still visible. The extent and depth to coal-mining voids at the S012 site has not been assessed since 2002.

A proposal for assessing the extent of the coal-mine voids beneath Spray Lakes Road was prepared by KCB and submitted to AT on March 6, 2017. KCB's proposed scope of work included creating a three-dimensional model of ground surface details and the underlying coal-mine void using topographic survey, geophysics, and downhole LiDAR camera. The downhole LiDAR camera would be lowered downhole using the remaining boreholes capped with flush-mounted head boxes. KCB's proposal also included conducting monitoring of surface deformations using InSAR, a satellite-based ground-deformation-monitoring system.

3 SITE OBSERVATIONS

The weather during the site visit was sunny and 10°C. KCB's site representative was Mr. Chris Gräpel, P.Eng.. The following observations were made during the site visit:

- A small pavement dip at the site appears to have increased in depth, based on the smoothness of vehicle ride across the site and visual inspection. The difference since last year is subtle. A view of the pavement dip is shown in Photo 1.
- Pavement surface did not have any fresh cracking and the cracks present at site in the spring of 2016 did not appear to be wider. Subtle depression noted at outlet of culvert to east of site, may indicate infiltration of culvert discharge into an underlying void.
- The area of the sinkhole was delineated with traffic cones and an inverted cone was placed in the sinkhole as shown in Photos 2, 3 and 4.
- The edges of the hole are uniform and circular with a uniform diameter of approximately 250 mm as shown in Photo 5. The hole below the pavement was of uniform diameter and appeared to be an old borehole.
- The depth to the bottom of the coal-mine void was recorded by AT and Volker Stevin to be 10.7 m (35 feet). The depth to the roof of the coal-mine void could not be measured.
- A faint smell of rotten eggs was noted once during a period of no wind. This could indicate hydrogen sulphide gas escaping from the coal-mine void.
- The sinkhole reported by AT is a former location of a metal-capped borehole (flush-mounted headbox) located in the eastbound lane, close to centreline. A photo of the sinkhole site in June 2016 is included as Photo 6. The boreholes capped with a flush-mounted head box were used for downhole camera surveys in 2002. Footage captured during the 2002 downhole camera surveys shows that the boreholes were not cased. The remaining boreholes drilled during the 2002 investigation were capped with asphalt.
- It was KCB's opinion that it was surprising that the headbox and casing fell from surface into the void without hanging up within the borehole. It is unclear if the headbox fell into the borehole or was removed from ground surface.
- Settlement of the remaining flush-mounted head boxes was observed. The MCI indicated that there have been no recent pavement overlays at the site. The settlement of the flush-mounted head boxes may indicate seepage of water from pavement surface into the coal-mine void. Seepage into the coal mine void could promote settlement of road surface and deformation of asphalt around boreholes.
- Collapse features to the southeast were visited. A series of coal-mine-collapse features are located in-line with the S012 site, consistent with the site plan in the S012 binder, shown in Figure 2. The rims of the collapse features have exposed bare earth that could indicate that settlement of the ground surface is slowly occurring due to ongoing collapse of the coal-mine voids. In June 2016, AT commented that the collapse features to the southeast of the site had increased in depth and size since AT's last inspection several years before.

4 ASSESSMENT

The collapse of one of the flush-mounted head boxes into the coal-mine void combined with the observation of a subtle dip in the asphalt and observations of continued coal-mine void collapse to the southeast indicates that deformation of the soil and rock above the coal-mine void is continuing. The actual depth to the roof of the coal-mine void is unknown.

It is KCB's opinion that continued deformation of the coal-mine-void roof could result in collapse of the mine. The time to collapse, rate of collapse, and magnitude and extent of ground subsidence is unknown.

5 RISK LEVEL

A risk level of 77 was assigned to the site in 2016 according to the following:

$$\text{Risk Level} = \text{Probability Factor} \times \text{Consequence Factor}$$

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).

The 2016 risk level was determined using AT's risk level system and is presented as follows:

- Probability Factor – A rating of 11 was selected in 2016 because of the probability of road subsidence/collapse with uncertainty of timing, extent and duration of collapse. The rate of movement was described as “active, with moderate but increasing rate of movement” based on the increase in depth and extent of the coal-mine-void-collapse features to the southeast observed by AT since their previous inspection.
- Consequence Factor – A rating of 7 was selected because collapse of coal-mine workings would result in a temporary closure of the highway.

KCB reviewed the 2016 risk level and concluded that the risk rating should remain at 77. The probability descriptor “active, with moderate but increasing rate of movement” is judged by KCB to still be applicable to the site. The recent collapse of a flush-mounted head box confirms that movements are active at the site.

Coal-mine collapse at the S012 site could occur rapidly with little or no warning, and could occur under vehicle loading. The S012 site will be visited during the 2017 southern region GRMP spring tour.

6 RECOMMENDATIONS

The following subsections discuss the recommended short- and long-term remediation works for the subject site.

6.1 Short-Term

The MCI was advised to backfill the sinkhole as quickly as possible to minimize the potential for water to run into the void during rainfall events and further destabilize the coal-mine-void roof. KCB recommended that a foam backfill be used to fill the hole, with some manner of hole plug inserted a few meters down the borehole to hold the liquid foam in place until it expanded and cured. The asphalt could then be patched to seal the sinkhole and restore the smoothness of the pavement surface. At the end of the call-out visit the MCI advised KCB that the borehole would be backfilled with foam and patched with asphalt by Friday April 21, 2017. As a result, there was insufficient time to bring the downhole LiDAR camera subcontractor to site, even if our proposal dated March 6, 2017 was approved in-part or in-principle by AT.

6.2 Long-Term

KCB verbally recommended in a de-brief telecon held after the call-out inspection that AT approve the scope of work for the S012 site described in our proposal dated March 6, 2017. The S012 portion of our March 6, 2017 proposal was approved by AT on May 4, 2017. Pavement LiDAR data supplied by AT will be reviewed during our recently approved S012 coal-mine-void-investigation assignment.

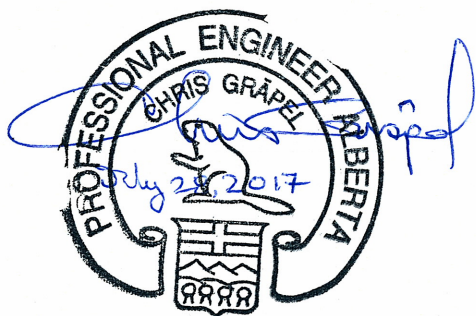
7 CLOSING

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 Southern Region GRMP. 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 endeavored to comply with generally-accepted professional practice common to the local area. Klohn Crippen Berger makes no warranty, express or implied.

We look forward to continuing a constructive and successful working partnership with Alberta Transportation. Please do not hesitate to contact the undersigned at 780.733.4580 if you have any questions, comments, or concerns regarding this report.

Yours truly,

KLOHN CRIPPEN BERGER LTD.



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

CM:kc

Attachments

Figure

Appendix I Photographs

REFERENCES

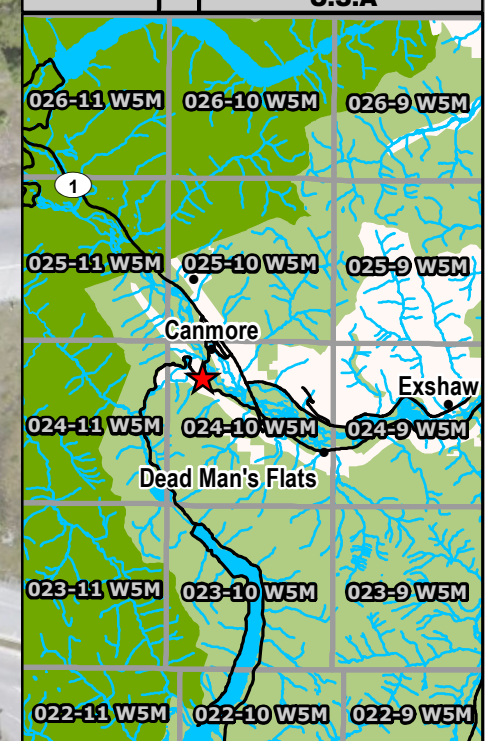
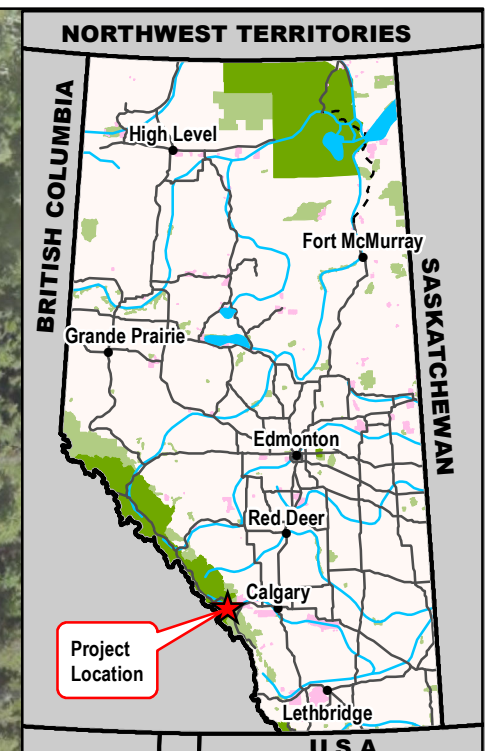
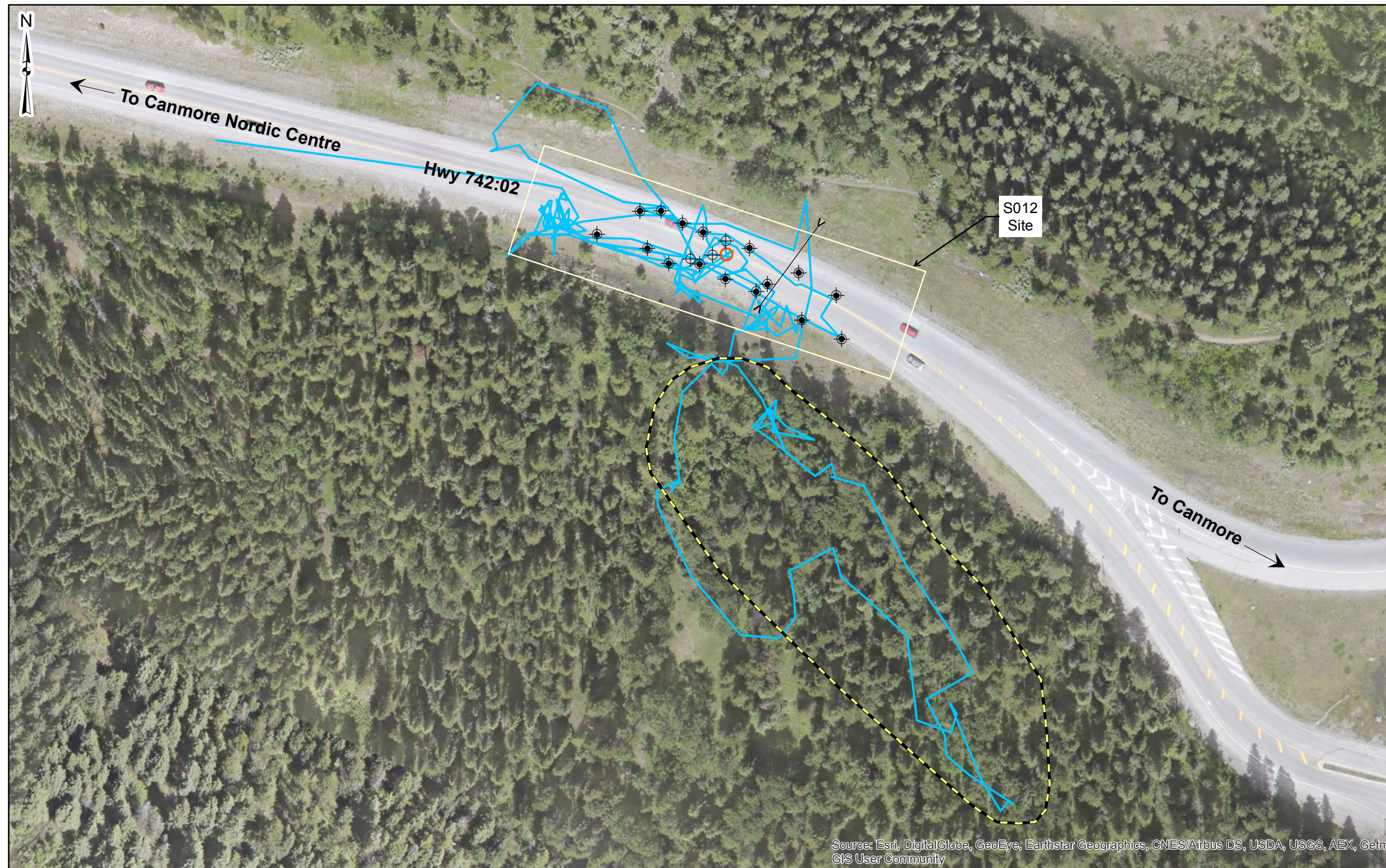
AMEC Environment and Infrastructure (AMEC). 2012. Southern Region Geohazard Assessment. Retrieved May 1, 2017 from:

<http://www.transportation.alberta.ca/Content/docType372/Production/s1212report.pdf>

Norwest Corporation, 2003. Spray Lakes Road, Canmore. Undermining Investigation. Report submitted to Alberta Transportation.

FIGURES

Time: 12:11:08 PM
 Date: May 23, 2017
 File: Z:\A\EDM\A05115A03 ABT Southern Region GRMP\400 Drawings\2017\S012_Hwy742_EmergCallout\170523_S12Callout_Fig1.mxd



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

Legend

- Borehole with asphalt plug
- Borehole with metal cap
- Sinkhole on road (April 19, 2017)
- GPS Track (April 19, 2017)
- Culvert
- Approximate area of coal-mine sinkholes near Hwy 742



NOTES:
 1. HORIZONTAL DATUM: NAD83
 2. GRID ZONE: UTM Zone 11N
 3. IMAGE SOURCE: World Imagery from ESRI
 ArcGIS Online. Image date unknown.

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PROJECT SOUTHERN REGION GEOHAZARD RISK MANAGEMENT PROGRAM		
TITLE April 19, 2017 Emergency Call-out S012 - Canmore Spray Lakes Road Hwy 742:02, km 4.319		
SCALE 1:1,000	PROJECT No. A05115A03	FIG No. 1

APPENDIX I

Photographs

Appendix I Photographs

Photo 1 S012 site location with traffic cones in place. Photo taken west of S012 site, facing south east. Note dip at edge of road in westbound lane.



Photo 2 S012 sinkhole location (red arrow) with culvert to east of site in foreground. Photo taken facing northwest.



Photo 3 S012 site with sinkhole location marked with a red arrow. Note boreholes drilled as part of historic investigations at this site. Photo taken facing northeast.



Photo 4 Inverted traffic cone marks location of sinkhole. Photo taken facing southeast.



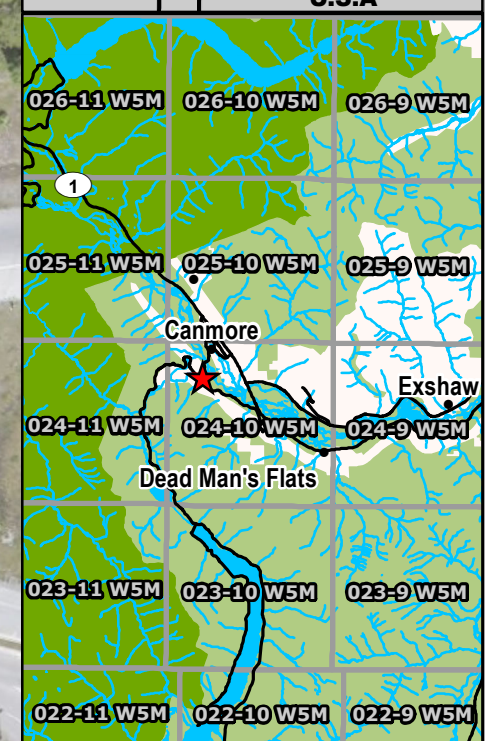
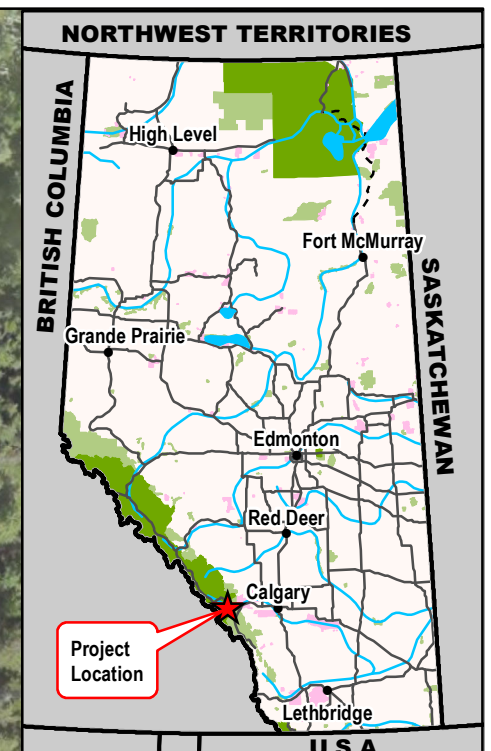
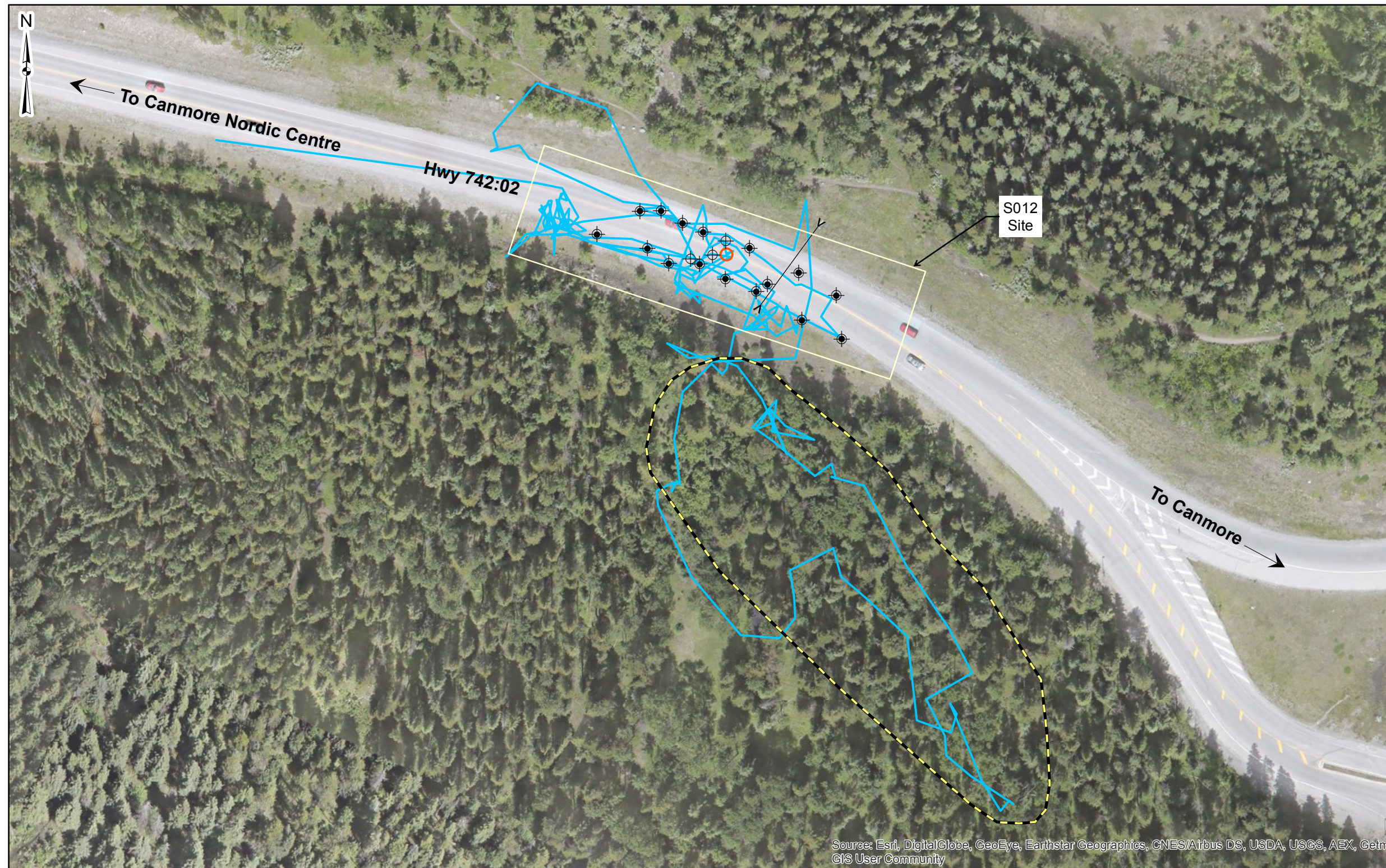
Photo 5 Sinkhole is uniform and appears to be a borehole location from previous investigations.



Photo 6 Photo of sinkhole site taken during 2016 Section B inspection. Note that borehole at the location of the sinkhole had a removeable metal cap.



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