#### **KLOHN CRIPPEN BERGER**

2023 AWARD SUBMISSION



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## SPRAY LAKES ROAD COAL-MINE VOID REPAIR







### Klohn Crippen Berger

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PROJECT TITLE	Spray Lakes Road Coal-Mine Void Repair		
LOCATION OF PROJECT	Canmore, Alberta		
CATEGORY OF ENTRY	Transportation		
ROJECT OWNER / CLIENT	Alberta Transportation		
SUBSCONSULTANTS	Tetra Tech		
	Challenger Geomatics		
	3vGeomatics		
CONTRACTORS	DCL Construction Service	es Ltd.	
	Triton Environmental Con	sultants Ltd.	

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Highway 742 is a busy highway to popular recreational destinations in Canmore, Alberta. Following the discovery of a void below the highway at Spray Lakes Road, Klohn Crippen Berger (KCB) worked with Alberta Transportation (AT) to design a repair to address sinkhole risks to motorists while reducing construction impacts to the public and the environment with innovative investigation methods and monitoring techniques, 3D modelling of the coal-mine void, and an in-situ repair method conducted from the road surface. 0





Extensometer head plate installed at highway sub-base before gravel and asphalt placement



Downhole camera survey of coal-mine void in an investigation borehole

RST VWIE anchor head plate installed flush with ground level in the highway



# PROJECT HIGHLIGHTS

#### INNOVATION

Spray Lakes Road was constructed over the No. 2 seam of the old No. 1 mine which dipped steeply (45°) and was about 2.1 m thick. An open coal-mine void was located 4.2 m below the pavement. The mine entrance is on the south bank of Canmore Creek, 400 m from the void below Spray Lakes Road. Groundwater from the mine discharges into Canmore Creek. KCB prepared a design that factored in the unique conditions of the mine coal seams and mitigated a risk of void collapse affecting the highway surface and ensured early detection of future deformations below the highway.

The coal-mine void was investigated with geophysical investigations and drilling. Downhole video cameras were used in boreholes to view the mine void and a downhole LiDAR camera was used in the boreholes to survey the extent of the open coal mine void below the highway. This was the first time AT used a LiDAR camera to survey a coal mine void.

KCB combined the borehole and geophysical data with historic coal mine record drawings from the Canmore Geoscience Centre and created a three-dimensional model of the coal-mine void using Civil 3D software. The model included aerial LiDAR topographic data provided by the Town of Canmore (ToC) and borehole log and geophysical data. KCB also hired the last Chief Mine Engineer at Canmore Collieries to assist with understanding the spatial variability of the coal mine.

The pavement surface above the void was monitored for deformation for a year while investigation and design work was completed using satellitebased Interferometric-synthetic-



Spray Lakes Road Coal-Mine Void Repair won the 2023 CEA Award of Excellence – Transportation Infrastructure

aperture radar (InSAR) and compared to data collected in AT's annual pavement-surface LiDAR surveys.

KCB's design included placing concrete in the coal mine void to support the roof of the void where the void was close to the pavement. Due to the presence of groundwater in the mine and the coarseness of the collapse material in the mine void, a custom low-slump, low-bleed-water concrete mix was designed. The custom mix reduced the risk of concrete spreading beyond the limits of the highway and minimized the potential for contamination of groundwater and of Canmore Creek.

KCB's design also included vibrating wire inline extensometers (VWIE) for long-term monitoring



Historic mine plan from the Canmore Geoscience Centre. Red circle indicates project location.

of the mine roof below the highway. The use of VWIEs to monitor for ground deformations was a first-time installation for AT and allows for early detection of any roof collapse below the highway.

#### COMPLEXITY

Steeply dipping underground voids like those present at Spray Lakes Road have increased sinkhole potential: collapse materials can fall into the void and away from the void roof. Roof collapse at Highway 742 had already resulted in a large void below the highway and investigation results indicated roof collapse would continue and eventually create a sinkhole.

Hwy 742 is a busy highway that accesses Alberta's most popular mountain areas such as the Goat Valley, Ha Ling Peak, Grassi Lakes Provincial Park, and Canmore Nordic Centre. Construction work was completed in 2021 when recreational activity in Canmore increased during the COVID-19 pandemic. Traffic accommodation and allowable work hours were established collaboratively between AT, KCB, ToC, and the contractor, DCL.

Repair work was conducted from highway surface while maintaining traffic flow using a single-lane closure, reducing impact to the public by avoiding a full road closure, and decreasing construction costs and environmental impacts by avoiding a large excavation. The design involved placing concrete into the coal mine void through large diameter boreholes drilled through the highway surface.

Groundwater outflows from the mine into Canmore Creek were monitored throughout construction, with no measured impact on water quality. A portable water treatment plant was set up at the mine entrance as a contingency measure. Drilling safety procedures were developed by DCL and their subcontractor to mitigate air quality and explosion risks from coal mine gases. Downhole camera surveys were conducted to view the coal-mine void and to assess the extent of concrete placement.

#### SOCIAL AND/OR ECONOMIC BENEFITS

AT provides a safe and efficient transportation system to support Alberta's economic, social, and environmental vitality. The site required risk mitigation due to the assessed risk of a sinkhole affecting the highway and causing the loss of highway use, damage to public infrastructure, private property damage, injury, or death.

Canmore is a thriving tourism and recreational hub, and Hwy 742 has high traffic volume all year with an average of 3400 cars per day, which peaked to about 4900 vehicles per day during the pandemic. The repair design concept and associated traffic accommodation strategy was a critical aspect of the project in minimizing impact to the public. During construction there were no reported traffic incidents due to construction activity.

In addition to recreational value, the Spray Valley is also the site of a major hydroelectric development. Loss of the highway due to a sinkhole, or prolonged shutdown of the highway for more intrusive repair methods would create a longer traffic diversion for the public and industry to access the Spray Valley. Loss or closure of Hwy 742 for a more intrusive repair would have resulted in a 130 km long traffic diversion to access popular recreational amenities 10 km away (or less) from Canmore (e.g., provincial parks trails, world-class Canmore Nordic Centre) that saw increased use during the COVID-19 pandemic.





II Channel from mine entrance entering into Canmore Cree

#### **ENVIRONMENTAL BENEFITS**

Although Canmore Creek was impacted by coal mining, the creek and the surrounding valley environment have recovered and are now valued natural habitat. The repair method selected was the least-intrusive method of all repair options considered.

KCB recognized that contact of concrete or concrete bleed water with groundwater in the coal mine void could result in elevated pH levels and suspended solids in the groundwater which would impact Canmore Creek. A customized, project-specific concrete mix design was prepared so that the concrete would have minimal bleed, reducing the chance of impact to the groundwater in the mine. The contractor's team was required to carry out a trial mix design and trial field placement to verify concrete behaviour before construction started.

Continuous monitoring of water quality was a contract requirement. Monitoring locations included the outflow from the mine entrance and Canmore Creek, with water quality monitoring conducted before and during construction. Due to the potential for pH to increase after concrete placement, the contractor was contractually required to respond to changes in water quality at the time of occurrence to meet regulatory requirements. DCL's team selected a portable water treatment plant as their mitigation scheme in the unlikely event that mine discharge water became impacted by concrete placement in the coal mine void. Due to the measures included in the design (i.e., not placing concrete below water table, use of custom mix design for concrete) changes to water quality were not detected during construction, with no adverse impacts to Canmore Creek.

#### MEETING CLIENT'S NEEDS

AT's objectives focused on maintaining public and worker safety while avoiding environmental impact and reducing the social and economic impacts associated with construction work while pursuing the best value for taxpayers.

The risk of sinkhole formation and impact to motorists was mitigated. Shallow voids were backfilled so that the risk associated with a sinkhole suddenly forming on the highway surface was eliminated. Deeper voids below water level were not backfilled and were instrumented to monitor for future roof collapse.

Environmental regulations were followed. KCB obtained a Water Act permit in recognition that the work area was directly connected to Canmore Creek through the mine void. Canmore Creek was not impacted.

Traffic flow was safely maintained during construction and the road was fully open on the weekends and holidays.

Project costs were managed using a custom concrete mix design and a repair method conducted from the road surface. AT only mitigated the risk of sinkhole formation below the highway, areas beyond the highway surface were not mitigated.

KCB maintained good relationships with ToC. Frequent discussions were held with the ToC during design, tendering and construction with ToC requirements being included in the contract, including limitations on hours of work and the requirement for the road to be fully open on the weekends and on holidays.

The project had no negative impacts on neighbouring landowners. Managing groundwater flow out of the mine maintained the regional groundwater drainage which, if impacted, could have exacerbated sinkhole formation on adjacent land. // SPRAY LAKES ROAD COAL-MINE VOID REPAIR





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