Investigation and Design of Coal-Mine Mitigation below a Highway

Chris Grapel, M.Eng., P.Eng.

Tri-Party 2018

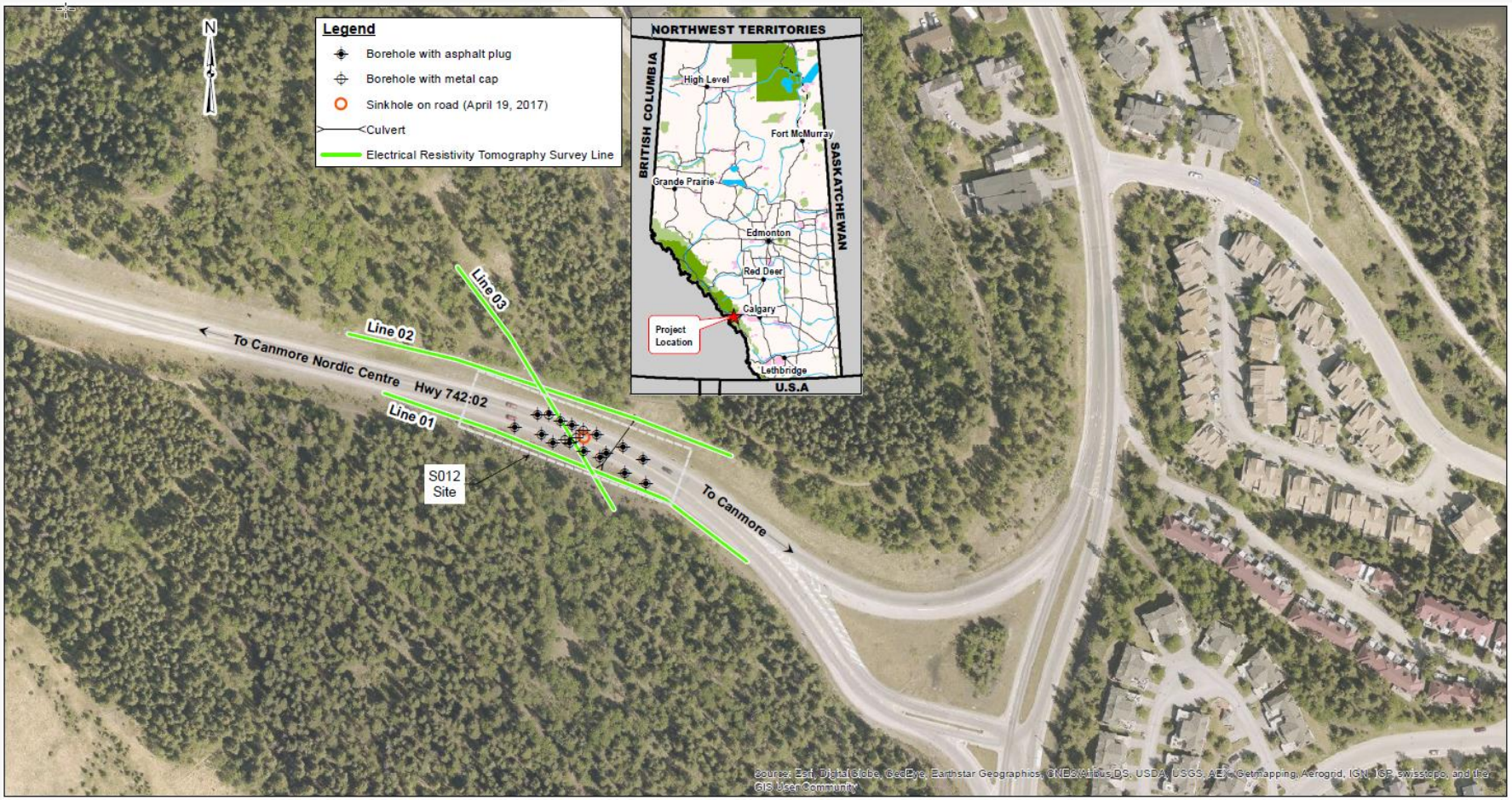
Acknowledgements

- Alberta Transportation (AT)
  - Roger Skirrow, P.Eng.
  - Ross Dickson
  - Mark Bajar (pavement LiDAR)
- Challenger Geomatics (surveying)
  - Renishaw Canada (downhole-LiDAR camera)
- TetraTech (geophysics)
- 3v Geomatics, Inc. (InSAR)
- Town of Canmore (LiDAR data)
- Gerry Stephenson (Canmore coal-mining expert)
- Previous work (AMEC, Norwest)

Geohazards affecting highway infrastructure

- Numerous geohazards affect the public highway system in Alberta, mostly landslides, but other geohazards have included: rockfalls, erosion, and subsurface voids.
- AT manages over 350 geohazards affecting the public highway system in Alberta
- The S012 Spray Lakes Road site in Canmore, AB crosses a shallow coal-mine void that is a remnant of the Canmore coal-mining industry.

S012 – Spray Lakes Road site



Klohn Crippen Berger

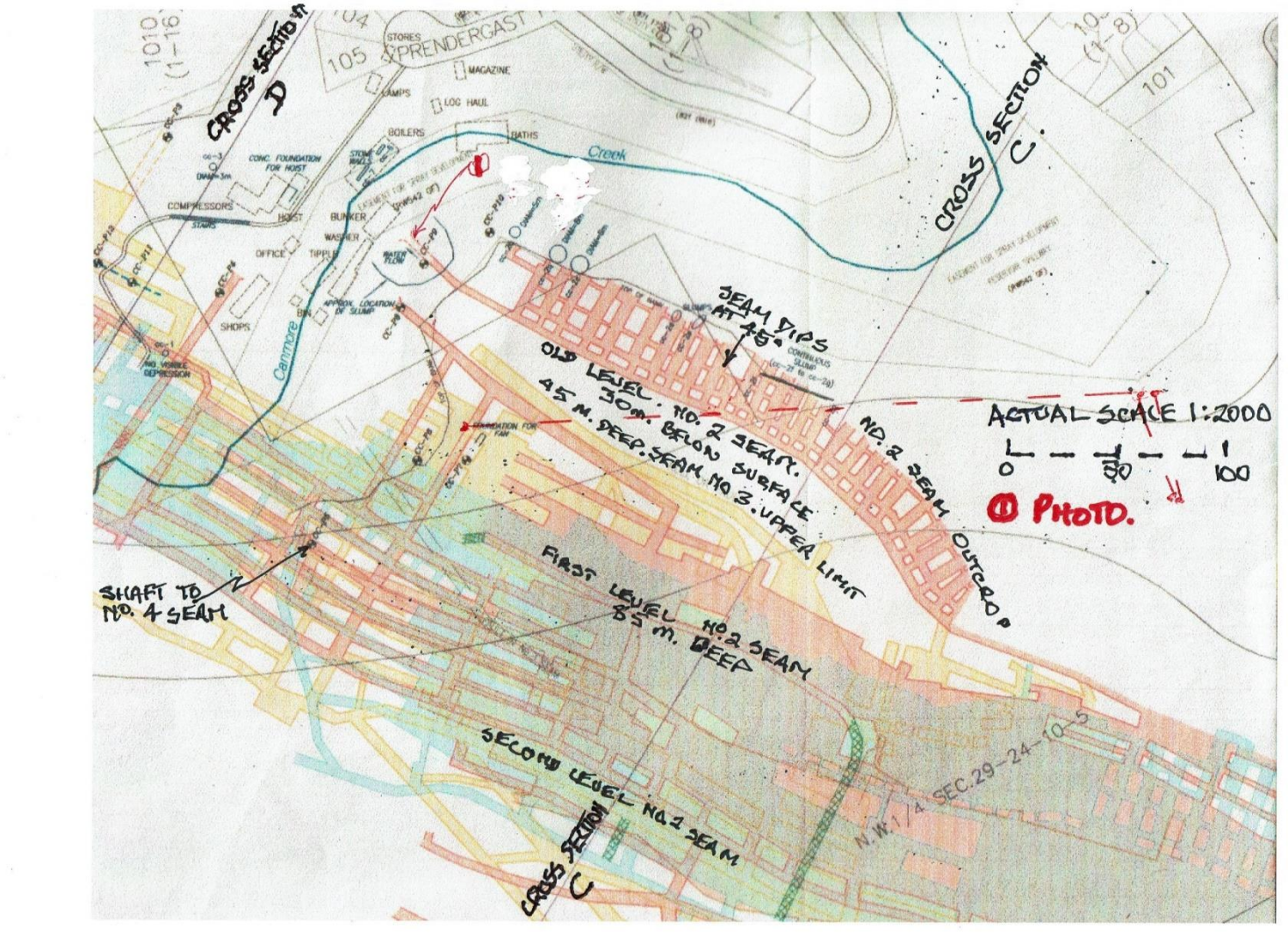
CANADA'S BEST MANAGED COMPANIES Platinum member

S012 site

By contrast…

Canmore Creek, now and then

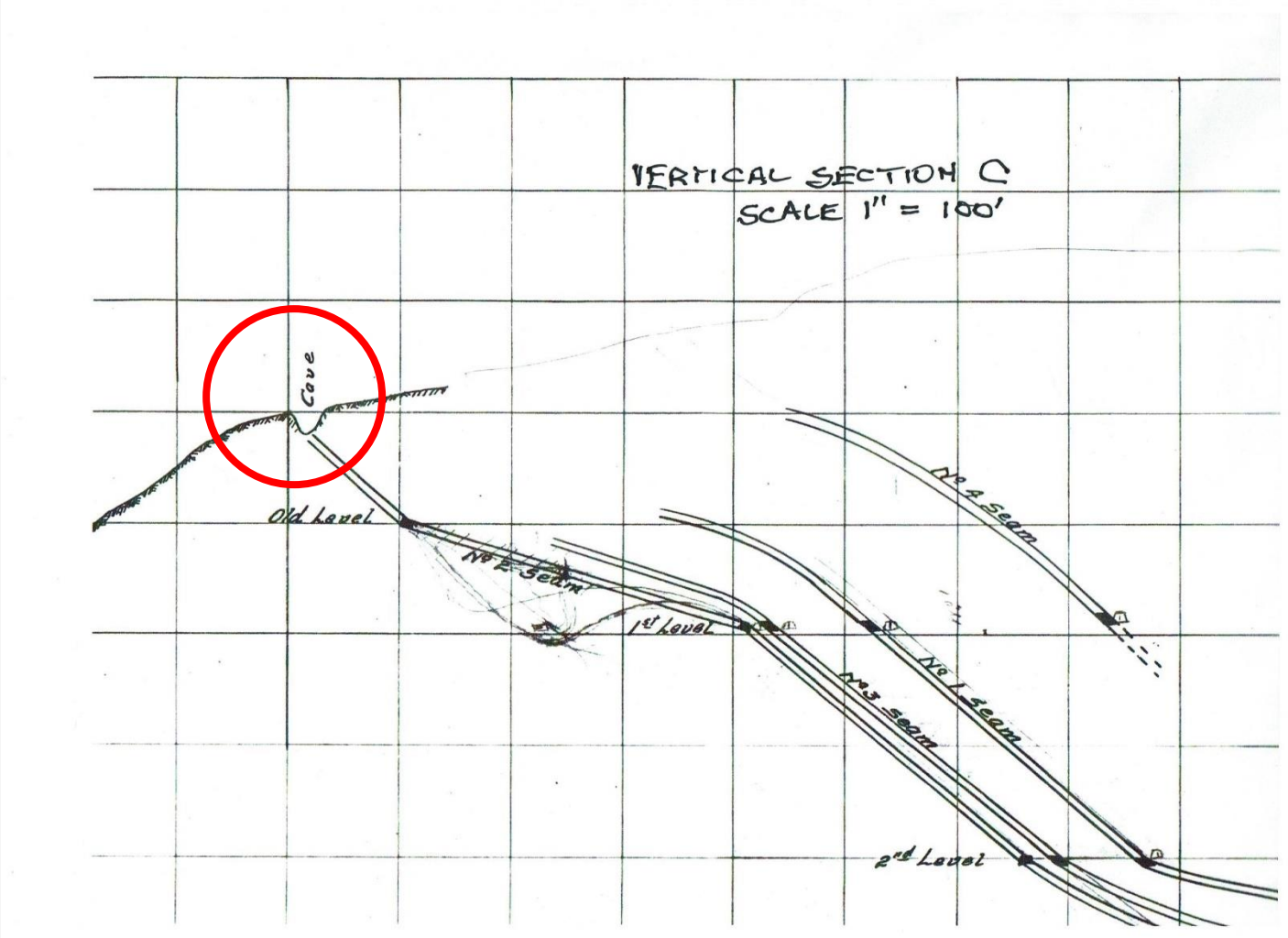
Plan of S012 site with coal mine



Klohn Crippen Berger

CANADA'S BEST MANAGED COMPANIES Platinum member

Mine section through S012 site



Klohn Crippen Berger

CANADA'S BEST MANAGED COMPANIES Platinum member

Portal to No. 2 Seam Adit

Seepage from mine into Canmore Creek

Nearby foundation for coal-mine fan

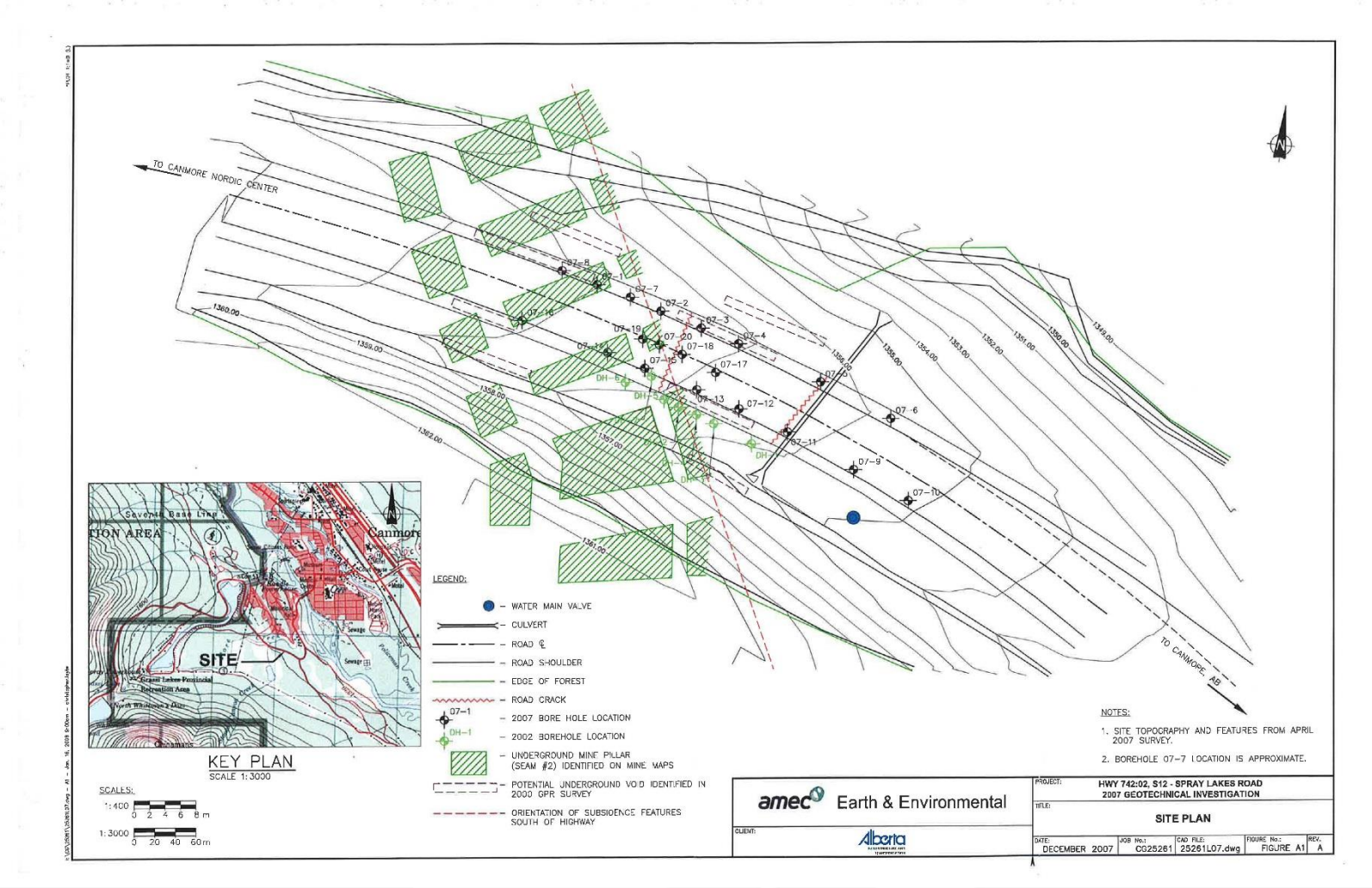
Nearby coal-mine-collapse features

Nearby coal-mine-collapse features

Previous work

- Two drilling investigations
  - Norwest 2003
  - AMEC 2007
- One geophysical investigation (ground –penetrating radar)

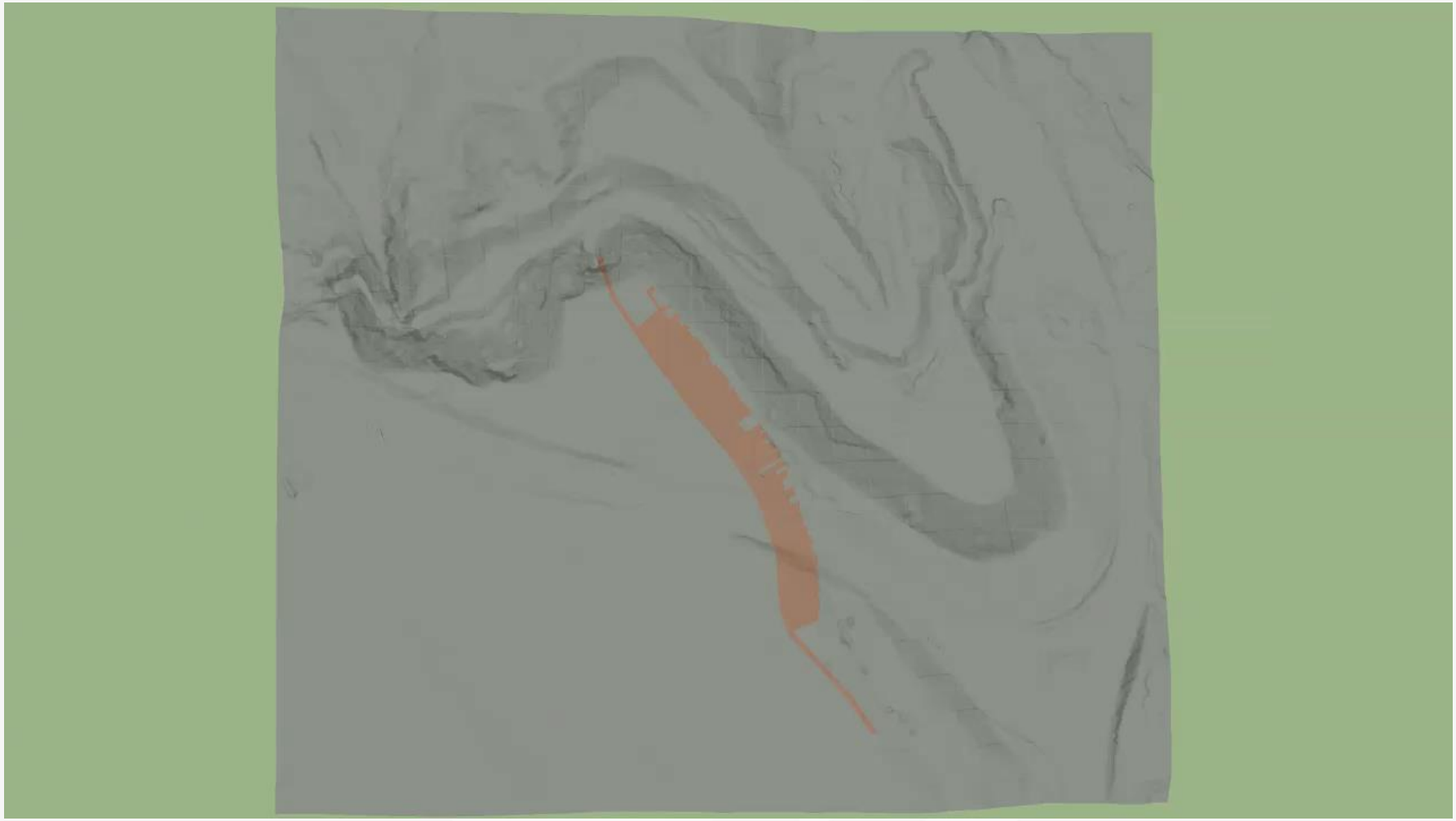
Previous investigations by Norwest and AMEC



Klohn Crippen Berger

CANADA'S BEST MANAGED COMPANIES Platinum member

3D modelling for a 3D problem

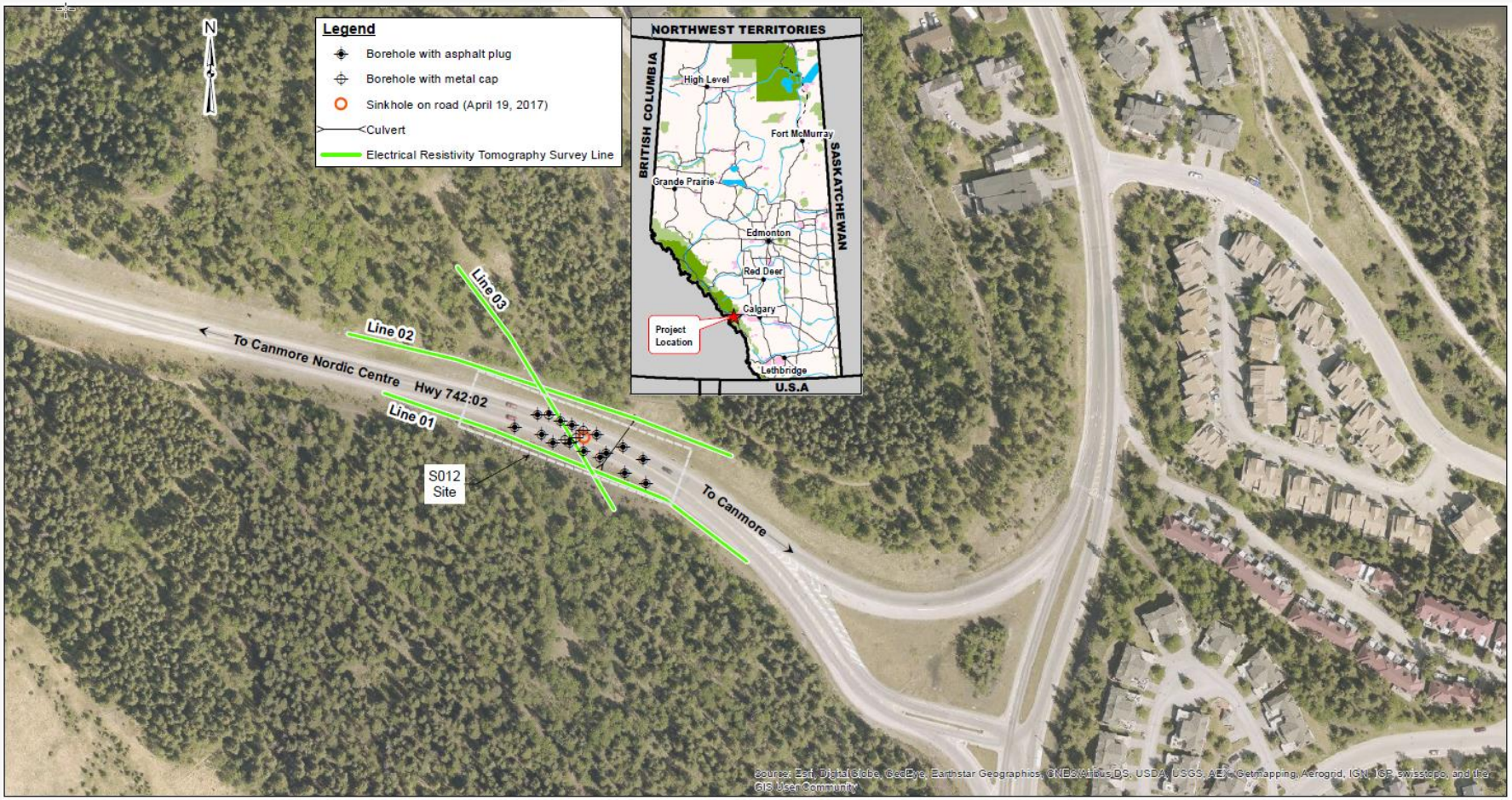


2017 Investigation

2017 investigation work

- Downhole video camera
- Topographic survey (Challenger Geomatics), with
  - Downhole-LiDAR-camera survey (Renishaw Canada Ltd.)
  - 2013 LiDAR data provided by Town of Canmore
- Electrical-resistive tomography (TetraTech)
- InSAR monitoring (3v Geomatics)
- AT pavement LiDAR data review

S012 – Spray Lakes Road site



Klohn Crippen Berger

CANADA'S BEST MANAGED COMPANIES Platinum member

Downhole-Video Camera

Downhole-Video Camera

Downhole-LiDAR-Camera Survey

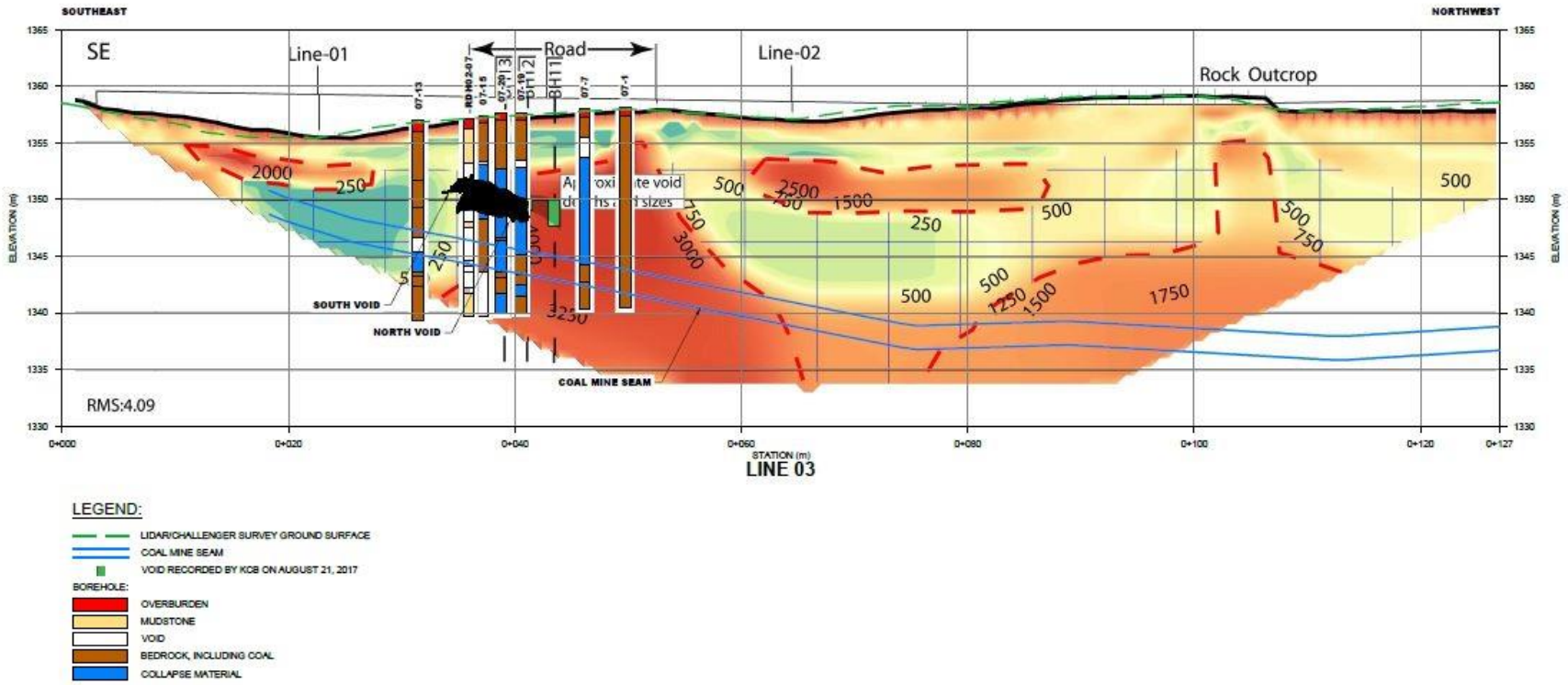
Downhole-LiDAR-Camera Survey

Electrical-Resistive Tomography

Electrical-Resistive Tomography

Electrical-Resistive Tomography

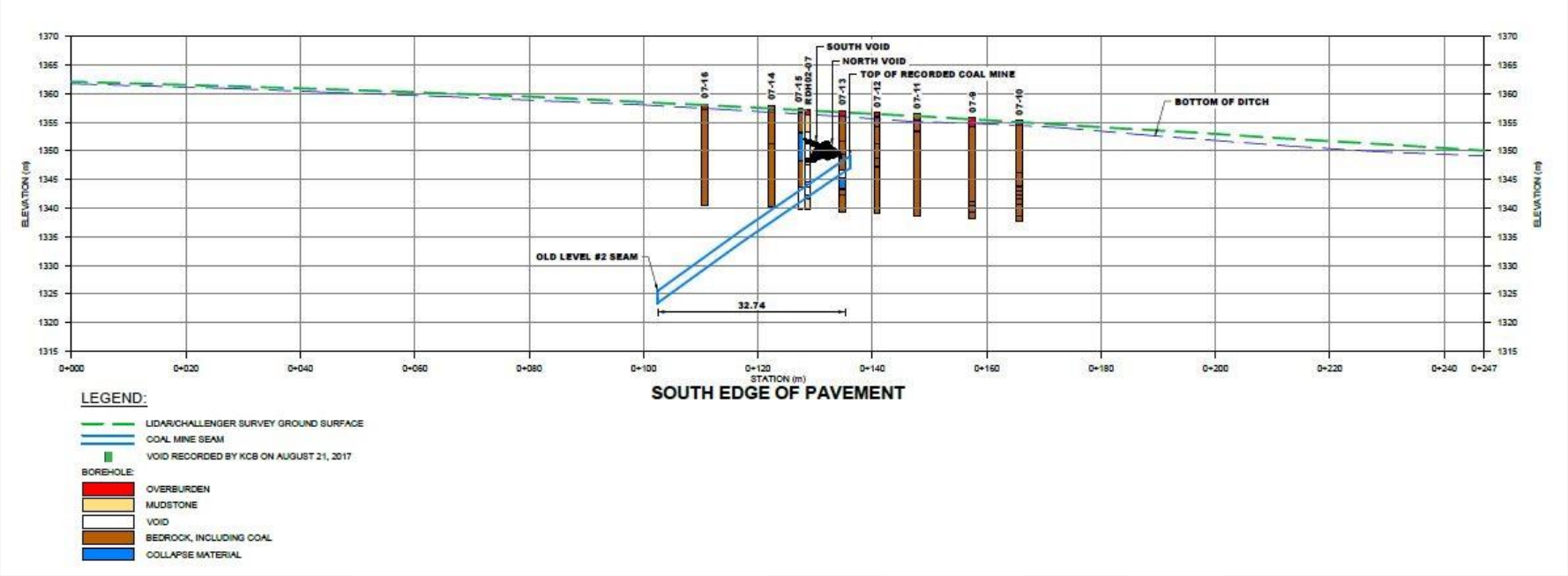
Cross-Highway ERT Data



Klohn Crippen Berger

CANADA'S BEST MANAGED COMPANIES Platinum member

Profile along south edge of pavement

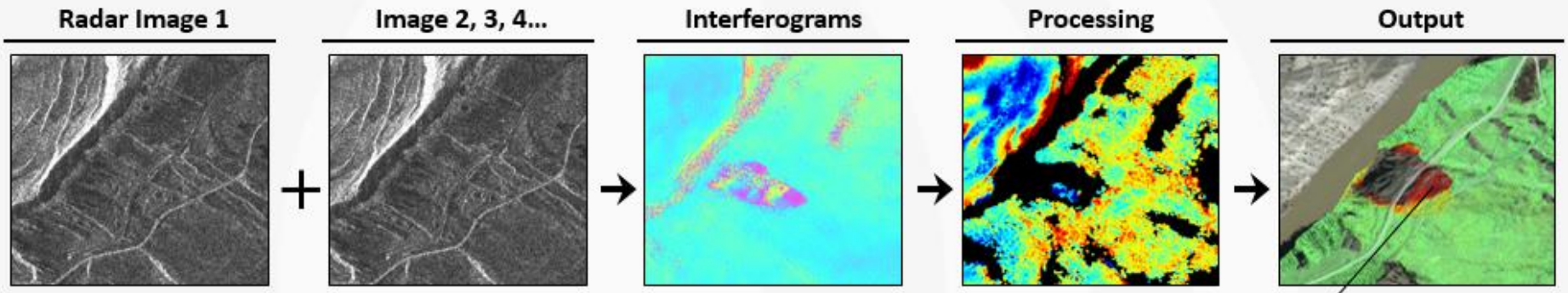


Klohn Crippen Berger

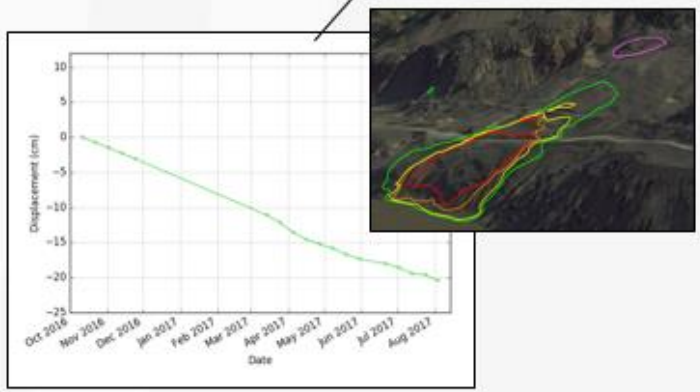
CANADA'S BEST MANAGED COMPANIES Platinum member

InSAR Monitoring

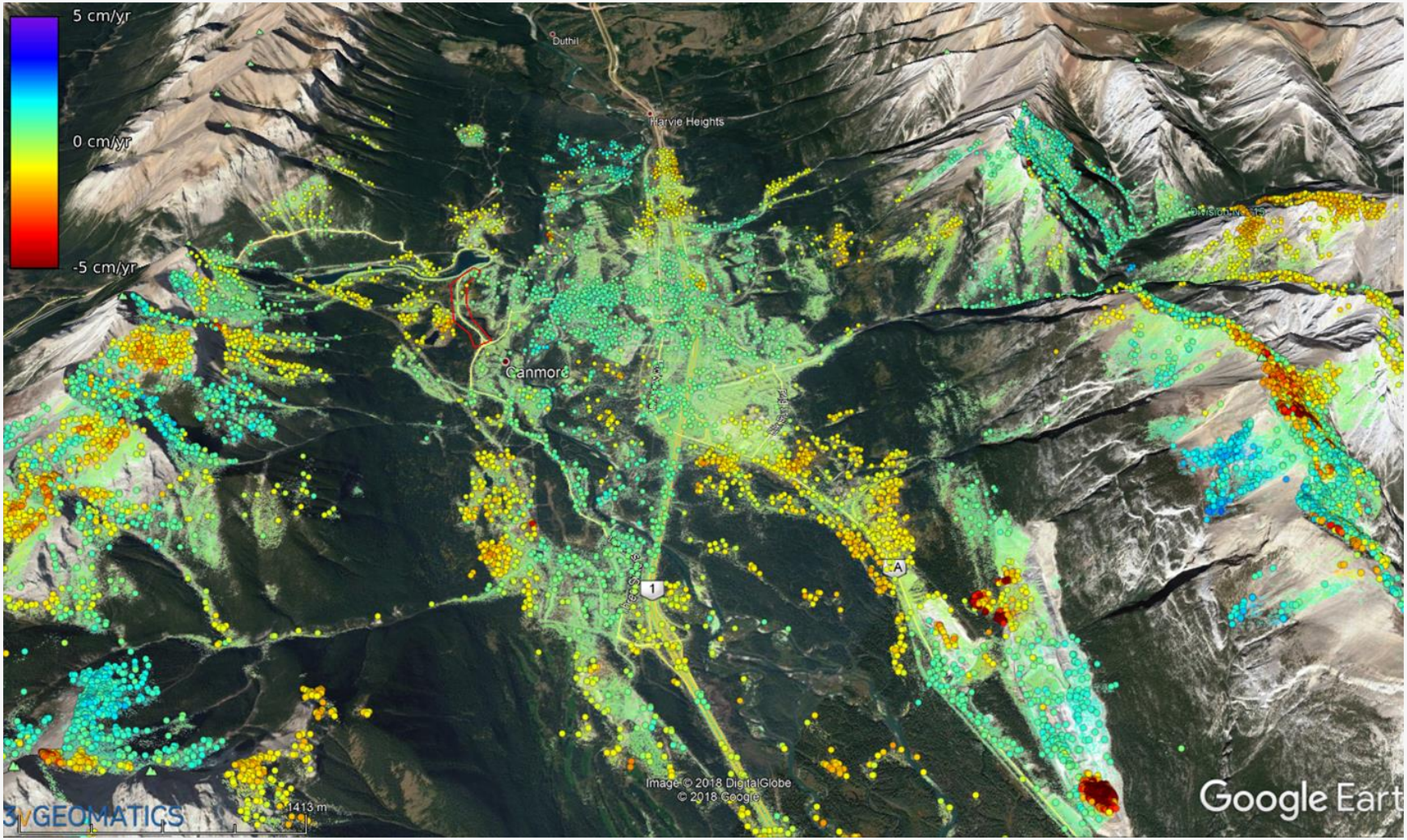
- **In**terferometric-**s**ynthetic-**a**perture **r**adar (InSAR)



Area of Coverage:	1,500 – 42,000 square kilometers
Resolution:	3 – 20 meters
Data Density:	40,000 data points per square kilometer
Precision / Detection Limit:	2 – 3 millimeters of displacement
Measurement Frequency:	Every 4 – 12 days (i.e., orbit frequency)
On-site Requirements:	Remote sensing, no site visit required



InSAR Measurements April – October 2017

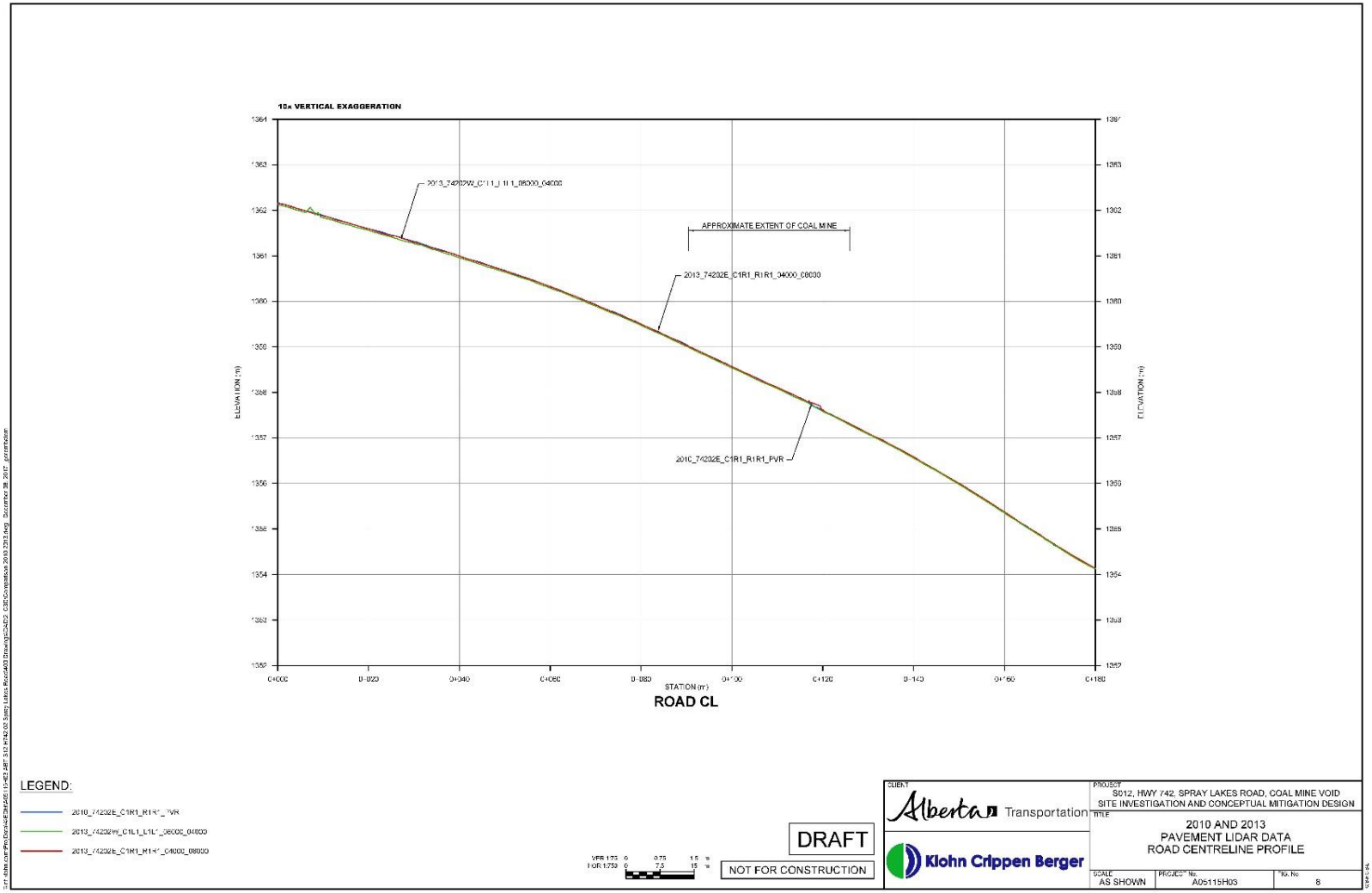


Klohn Crippen Berger

CANADA'S BEST MANAGED COMPANIES Platinum member

AT Pavement-LiDAR Data (2010 to 2013)

AT Pavement-LiDAR Data (2010 to 2013)



Klohn Crippen Berger

CANADA'S BEST MANAGED COMPANIES Platinum member

Conclusions

- No evidence of pavement movement noted in InSAR data or pavement LiDAR data
- Some previous observations of new pavement cracks
- Downhole video camera survey noted cracking in the bedrock exposed in the borehole walls above the open void
- ERT data indicates higher resistivity above void, below highway, which could indicate dilating (i.e. opening) bedrock joints
- Continued monitoring of S012 site without repair not recommended

Candidate Repair Options

- Two types of repair considered
  - Bridge the void
    - Construct reinforced embankment fill over void
    - Buried bridge over void
    - Expose the void and place a geogrid “bean-bag” of rockfill at the head of the void
  - Backfill the void
    - Expose void and backfill with rockfill
    - Urthane foam injection through boreholes
    - Concrete or grout/Cematrix backfill through boreholes

Portal to No. 2 Seam Adit

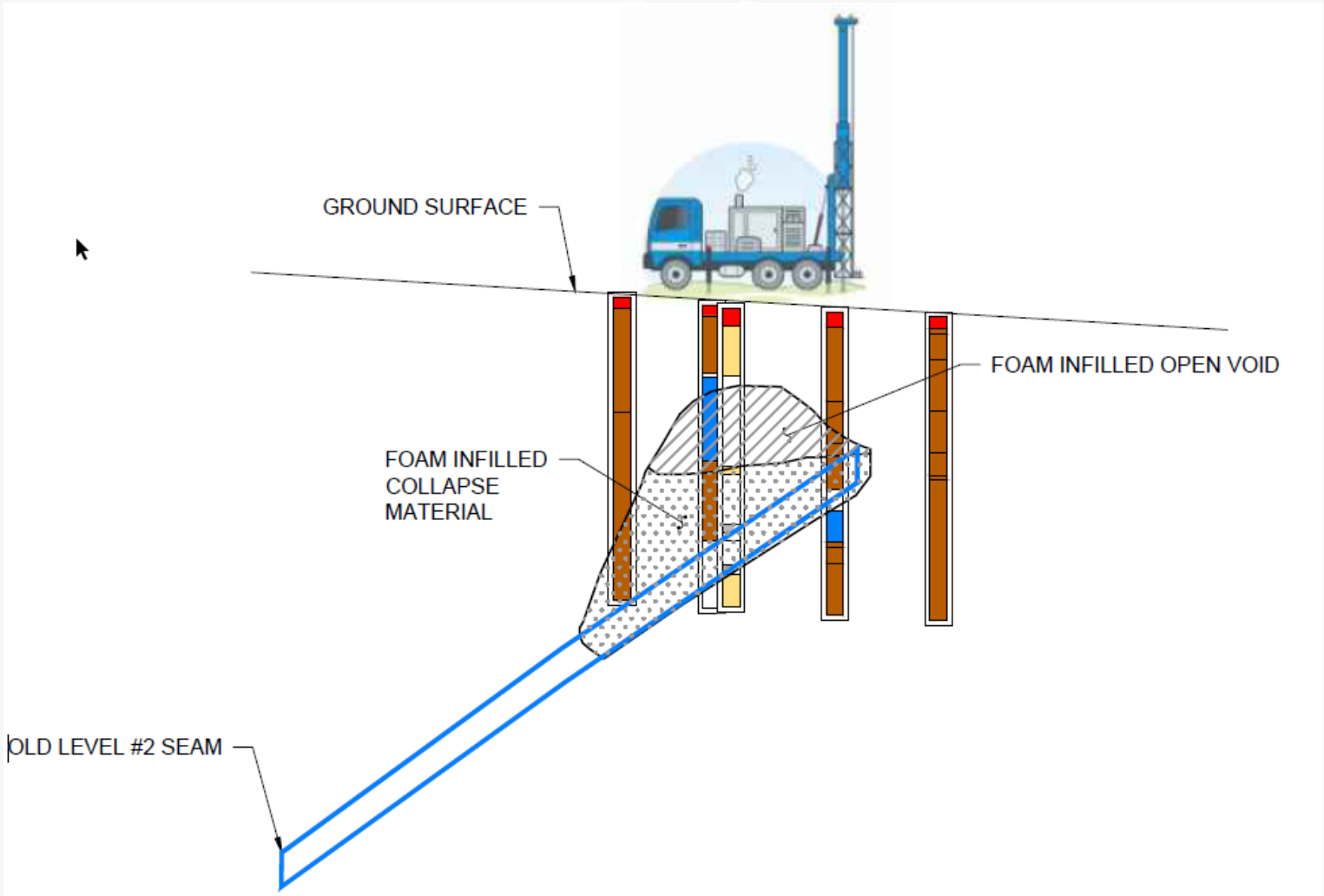
Seepage from mine into Canmore Creek

Selected Repair Option

- Urethane foam injection
  - Upper portion of mine to be backfilled with urethane foam injected through boreholes drilled from road surface into coal-mine void
  - Open voids and voids in collapse material to be backfilled with urethane foam
  - Extent of foam injection will be limited to upper portions of mine so foam does not impede groundwater discharge from mine
  - Additional drilling conducted in early spring 2018 to assess mine conditions at depth
  - Final design underway for tendering for 2019 construction

Sample of foam-injected coarse gravel

Foam injection method



Thank you for your attention

Questions?