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February 27, 2015

File: R715-0299-00

Associated Engineering Alberta Ltd.
#400, 600 Crowfoot Crescent NW
Calgary AB T3G 0B4

Attention: Mr. Russell Martin, P.Eng.

Project: Canyon Church Camp Bridge Replacement, Waterton Lakes National Park, Alberta

Subject: Site Review and Preliminary Foundation Recommendations

Dear Mr. Martin,

Levelton Consultants Ltd. (Levelton) was retained by Associated Engineering Alberta Ltd. (Associated) to complete a site visit on January 28, 2015, at the site of the existing Canyon Camp Church Bridge over Blakiston Creek in Waterton Lakes National Park, Alberta. The purpose of the site visit was to review site conditions in order to determine the condition of the existing bridge foundations and to develop preliminary foundation recommendations to assist in the design of a replacement structure. A bridge has existed across Blakiston Creek at this location for approximately the past 100 years, consisting of a timber structure with intermediate piers that have been damaged during flooding events. The replacement structure will be designed as a single span structure supported on abutments that will be located near the existing abutments. The existing abutments are to be re-used if practical. Recent discussions with Associated indicate that the condition of the abutment concrete is poor and the most likely scenario will be removal and replacement of the abutments with new concrete.

This letter report provides site observations and preliminary geotechnical design and construction recommendations in accordance with the scope of work described in your email dated January 21, 2015. Levelton was provided with a series of site photographs taken by Parks Canada staff in the summer of 2014, as well as a summary of information regarding the bridge history and reports during previous flooding events, including photographs of the bridge during flood conditions. Site geologic observations were correlated with published geologic information[1]. Photographs taken by Levelton at time of our January 28, 2015 site visit are included in Appendix A, and are referenced in the report text as appropriate. The letter is subject to the Terms of Reference following the report text, which form an integral part of this letter.

[1] Lebel, D., Douglas, R.J.W. and Norris, D.K. 1994. Waterton Lakes (82H/4), Alberta-Geology (preliminary); Geologic Survey of Canada. Open File Map 2855, scale 1:50,000.

Site Observations

The bridge site occupies a portion of Blakiston Creek flowing from approximately west to east with a relatively uniform cross section (Photo 1). The creek bed is aligned following the strike of a local bedrock outcrop that consists of medium bedded limestone with a dip in the order of 28 degrees down towards the north. The south bank of the channel consists of the exposed dip slope of the bedrock (Photo 2) while the north bank is steeper, exposing approximately 3 to 5 m of outcrop perpendicular to the dip slope (Photo 3). In the vicinity of the bridge crossing, the exposed bedrock structure is relatively uniform and planar. The local soil cover is not well developed and consists of granular colluvium with a thin veneer of organic topsoil.

The existing bridge consists of a three span timber structure with a total span length between abutments of approximately 25 m. The piers bear directly on the site bedrock. The abutments are constructed approximately at uniform elevation, with minor cut into the top of slope at the south abutment approach. The north abutment is located at a relatively flat area adjacent to the creek channel and appears to bear directly on bedrock, given the proximity and orientation of the exposed outcrop bedding. During our site visit we did not excavate the soils adjacent to the north abutment to confirm actual bearing conditions. The north abutment is well above the creek channel and did not show evidence of any erosion of soil cover around the abutment (Photo 4).

The south abutment is surrounded by soils that have eroded from under the front face (Photo 5). The surface drainage at the south abutment appears to concentrate runoff along the east side that has eroded backfill leading down to the front face (Photo 6). This runoff may contribute to undermining along the front face of the abutment. The south abutment is located above an exposed bedrock bedding plane; however, it is unknown if any portion of the abutment bears directly on outcrop at some point farther into the slope. During the site visit, bedrock outcrop was observed to be exposed just below the front face of the abutment along the east half of the abutment (Photo 7) and along the west half (Photo 8). The depth to bedrock along the western portion of the face of the south abutment was measured at approximately 30 cm below the exposed underside of abutment (Photo 9). Based on the orientation of the bedrock surface, it is reasonable to assume that bedrock would be expected to be present within 30 to 50 cm along the front face of the abutment footing and that portions of the south abutment may bear directly on bedrock. The specific bearing conditions at the south abutment would need to be confirmed through further exploration or through direct observations during demolition and removal of the existing abutment.

Historical photos and reports from Parks Canada indicate that the maximum water level during flood events did not reach the abutment bearing elevations. Given the extent of clean scouring of bedrock observed adjacent to the stream channel and the existing vegetation present above and on the outcrop, there was no obvious evidence of scour from high water. The extent of flooding and scour potential is beyond the geotechnical scope and should be determined through hydrologic review.

Preliminary Geotechnical Recommendations

Based on our site observations and the reviewed Parks Canada Bridge History and photos, we provide the following preliminary geotechnical recommendations pertinent to design and construction of the proposed bridge replacement:

- The site bedrock consists of medium bedded dolomitic limestone with layers typically 30 to 50 cm thick between bedding planes. The rock quality appeared in generally sound condition. The site bedrock has a local strike direction parallel to Blakiston Creek with a dip of approximately 28 degrees down to the north.
- It is anticipated that the existing abutments bear directly on or within approximately 30 to 50 cm above bedrock. The exact elevation of bedrock and bearing conditions of the existing abutments would need to be confirmed through further exploration or through direct observation during demolition and removal of the existing abutments.
- The new bridge abutment foundations should be constructed bearing directly on suitably prepared bedrock consisting of sound limestone.
- The new abutment foundations may consist of either a pre-cast concrete abutment dowelled into a concrete levelling pad, or a new cast-in-place concrete abutment.
- Foundations bearing directly on rock should be designed using an Ultimate Limit State (ULS) bearing resistance of 3000 kPa and Serviceability Limit State (SLS) bearing pressure of 1,000 kPa. A geotechnical resistance factor of 0.5 should be used to determine the factored ultimate bearing resistance at ULS in accordance with Table 8.2 of the Canadian Foundation Engineering Manual (CFEM)[2].
- The bridge abutment walls should be designed to resist to resisting lateral earth pressures using "at-rest" earth pressure conditions. The lateral pressure applied to subgrade walls is calculated using the following formula:

$$P = K_o (\gamma_b H + q)$$

Where:
- P = lateral earth pressure (kPa)
- K_o = at-rest earth pressure coefficient, use 0.45 for sands and gravels.
- γ_b = unit weight of soils and bedrock, use 21.0 kN/m^3 for sands and gravels.
- H = height of wall or depth of retained fill (m)
- q = surcharge load at ground level

- Where abutment wall backfill will consist of imported clean granular backfill and the abutments are not rigidly held in place, a wall movement of 0.001 to 0.002 times the height of retained fill would be adequate to mobilise the "active" earth pressure condition. For the "active" case, an earth pressure coefficient (K_a) of 0.30 and a bulk unit weight of 21 kN/m^3 should be used to calculate the lateral earth pressure for imported granular abutment backfill using the above expression and substituting K_a for K_o.
- The above expressions assume drained conditions behind the abutment walls and a horizontal backfill surface. The buildup of water behind a wall or an upward sloping backfill surface will increase the lateral pressures on the abutments and the design pressures should be re-evaluated if that is the case.
- A friction factor of 0.7 should be used for evaluating sliding friction between the concrete and sound bedrock. A geotechnical resistance factor of 0.8 should be used to determine the factored sliding resistance at ULS in accordance with Table 8.2 of CFEM.

[2] Canadian Geotechnical Society; Canadian Foundation Engineering Manual, Fourth Edition; 2006

- The foundations should be designed to incorporate dowelling into the bedrock below bearing elevation to maintain contact and to reduce the potential for ice-jacking, as well as to provide sufficient sliding resistance. Dowelling should be grouted full-length and extend a minimum of 1 m beneath bearing elevation.
- The proposed abutment pads must be properly cleaned, with removal of loose rock, weathered material and debris to expose sound rock. The base of the pad should be cut and keyed into the rock to create a roughly horizontal surface.
- The abutment pads and exposed bedrock must be reviewed by Levelton prior to concrete placement to confirm that actual bearing conditions are consistent with the above mentioned design assumptions.
- Backfill behind the abutment walls should not commence before the concrete has reached a minimum of 2/3 of its 28-day strength. Only hand operated compaction equipment should be used within 600 mm of the abutment walls.

Closure

This letter has been prepared by Levelton Consultants Ltd. exclusively for Associated Engineering Alberta Ltd. and its appointed agents. The report reflects our judgement in light of the information available to us at the time when it was prepared. Any use of the report by third parties, or any reliance on or decisions made based on it, are the responsibility of such third parties. Levelton Consultants Ltd. does not accept responsibility for damages suffered, if any, by a third party as a result of their use of this report. The attached Terms of Reference are an integral part of this letter.

We trust the information contained in this report meets your present requirements. Should you require any inspection services or any further information regarding the geotechnical aspects of this project, please contact our office.

Levelton Consultants Ltd.

PROFESSIONAL ENGINEER ALBERTA DAVID A. FIELD

27 FEB 2015

PERMIT TO PRACTICE LEVELTON CONSULTANTS LTD. Signature Date 2015/Feb/27 APEGA PERMIT NUMBER: P8696

Per: David A. Field, MSCE, P.Eng.
Senior Geotechnical Engineer
dfield@levelton.com

Reviewed by: Jens Hornbruch, P.Eng.
Division Manager, Geotechnical Engineering

DF/JH/ycr

Attachments: Terms of Reference
Appendix A Site Photos

TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS ISSUED BY LEVELTON CONSULTANTS LTD.

LEVELTON

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TERMS OF REFERENCE FOR GEOTECHNICAL REPORTS ISSUED BY LEVELTON CONSULTANTS LTD. (continued)

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b. **Reliance on information**: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site investigation and field review and on the basis of information provided to Levelton. Levelton has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Levelton cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the report as a result of misstatements, omissions, misrepresentations or fraudulent acts of persons providing information.

c. **Additional Involvement by Levelton**: To avoid misunderstandings, Levelton should be retained to assist other professionals to explain relevant engineering findings and to review the geotechnical aspects of the plans, drawings and specifications of other professionals relative to the engineering issues pertaining to the geotechnical consulting services provided by Levelton. To ensure compliance and consistency with the applicable building codes, legislation, regulations, guidelines and generally-accepted practices, Levelton should also be retained to provide field review services during the performance of any related work. Where applicable, it is understood that such field review services must meet or exceed the minimum necessary requirements to ascertain that the work being carried out is in general conformity with the recommendations made by Levelton. Any reduction from the level of services recommended by Levelton will result in Levelton providing qualified opinions regarding adequacy of the work.

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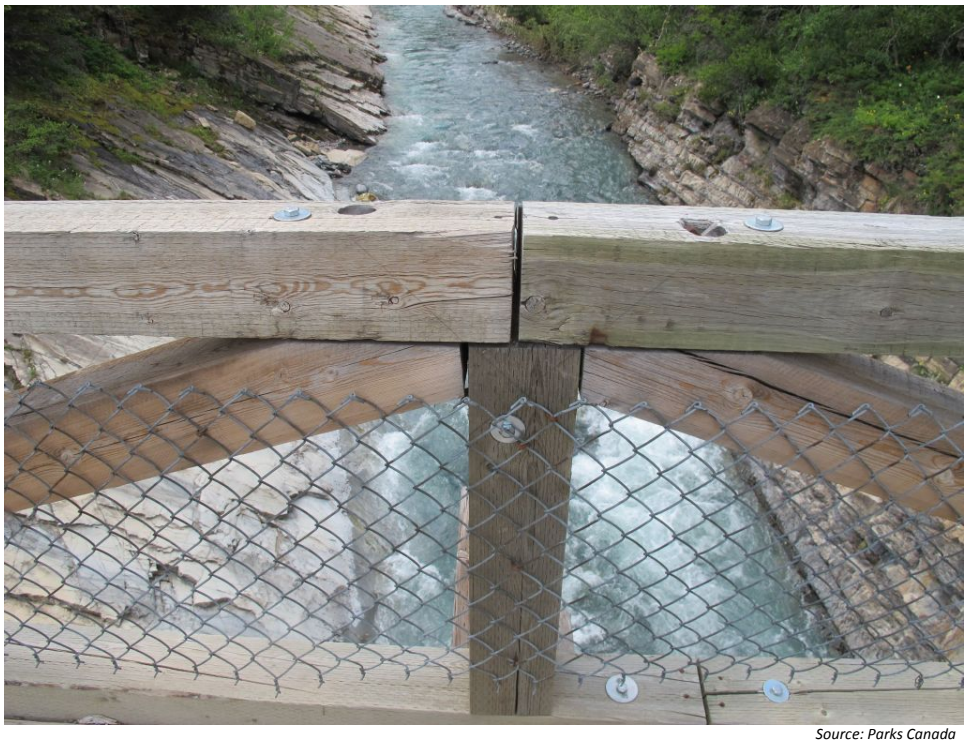
When Levelton submits both electronic and hard copy versions of the Instruments of Professional Services, the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding upon Levelton. The hard copy versions submitted by Levelton shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancy, the hard copy versions shall govern over the electronic versions; furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed and sealed versions of the Instruments of Professional Services maintained or retained, or both, by Levelton shall be deemed to be the overall originals for the Project.

The Client agrees that the electronic file and hard copy versions of Instruments of Professional Services shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Levelton. The Client warrants that the Instruments of Professional Services will be used only and exactly as submitted by Levelton.

The Client recognizes and agrees that Levelton prepared and submitted electronic files using specific software or hardware systems, or both. Levelton makes no representation about the compatibility of these files with the current or future software and hardware systems of the Client, the Approved Users or any other party. The Client further agrees that Levelton is under no obligation, unless otherwise expressly specified, to provide the Client, the Approved Users and any other party, or any or all of them, with specific software and hardware systems that are compatible with any electronic submitted by Levelton. The Client further agrees that should the Client, an Approved User or a third party require Levelton to provide specific software or hardware systems, or both, compatible with the electronic files prepared and submitted by Levelton, for any reason whatsoever included but not restricted to an order from a court, then the Client will pay Levelton for all reasonable costs related to the provision of the specific software or hardware systems, or both. The Client further agrees to indemnify and hold harmless Levelton, its officers, directors, employees, agents, representative or sub-consultant, or any or all of them, against any claim or any nature whatsoever brought against Levelton, whether in contract or in tort, arising or related to the provision or use or any specific software or hardware provided by Levelton.

APPENDIX A
SITE PHOTOS



Source: Parks Canada

Photo 1 Blakiston Creek Bed Looking West

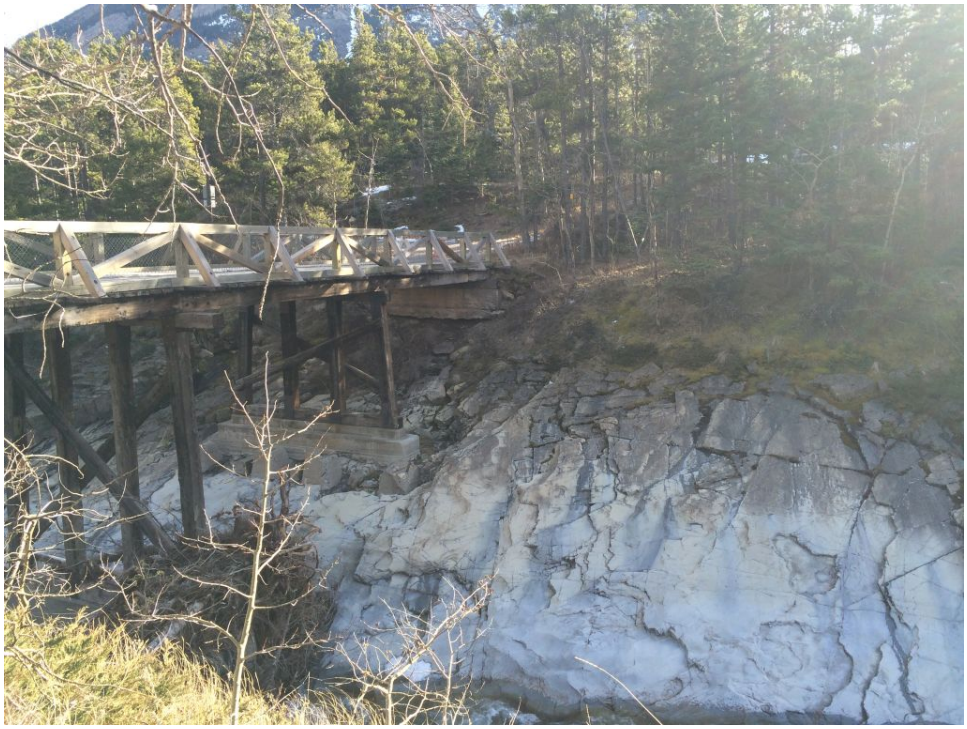
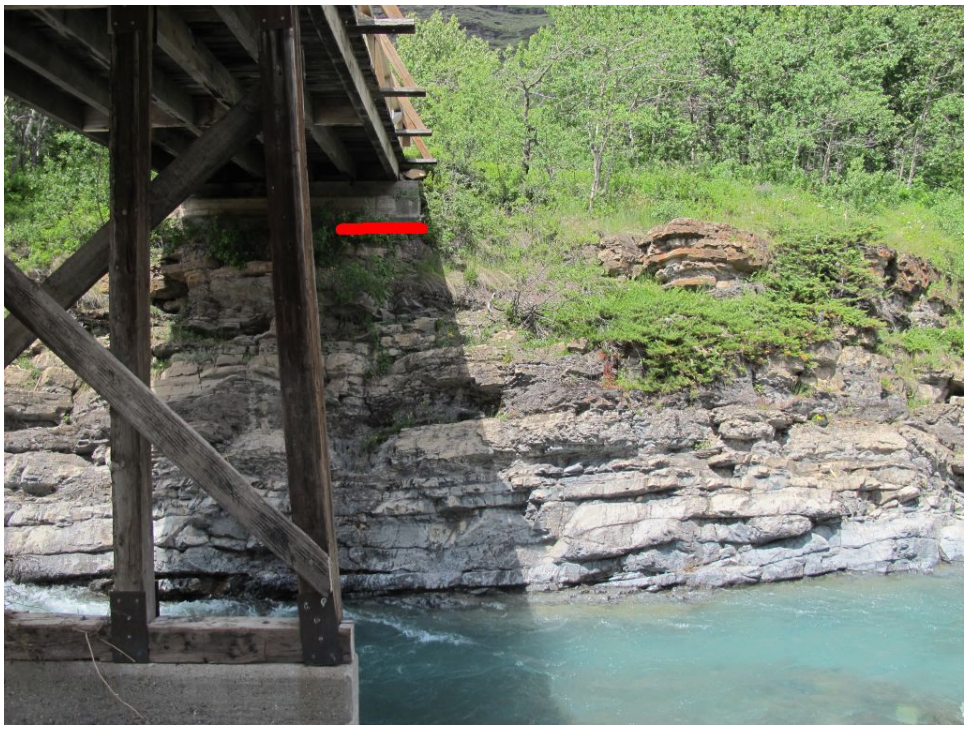


Photo 2 South Abutment



Source: Parks Canada

Photo 3 North Abutment (outcrop marked)

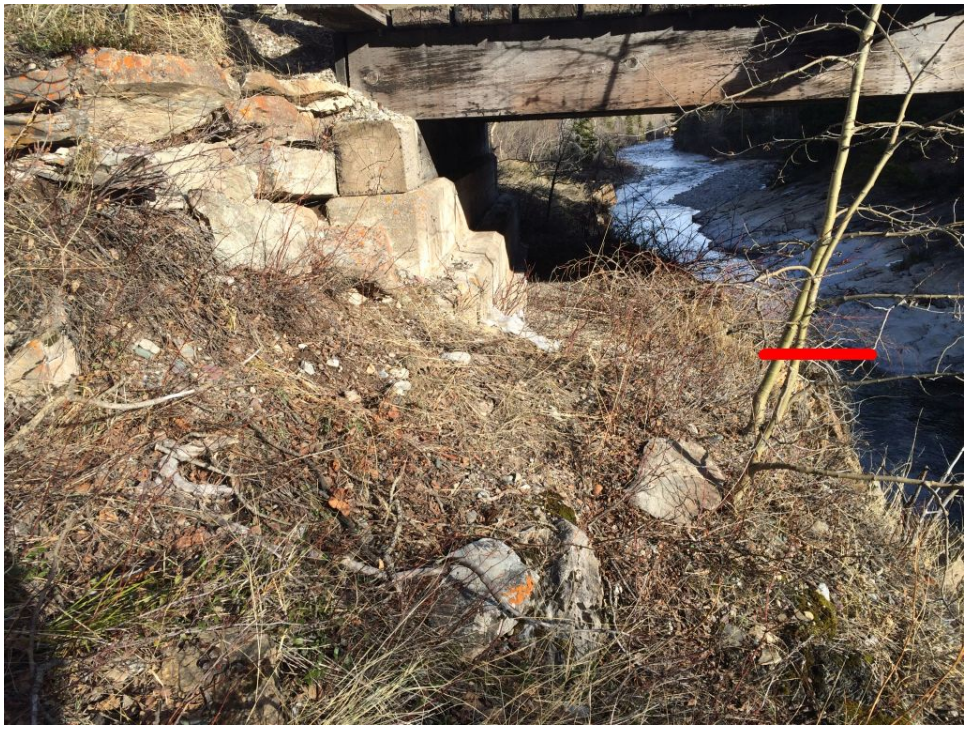
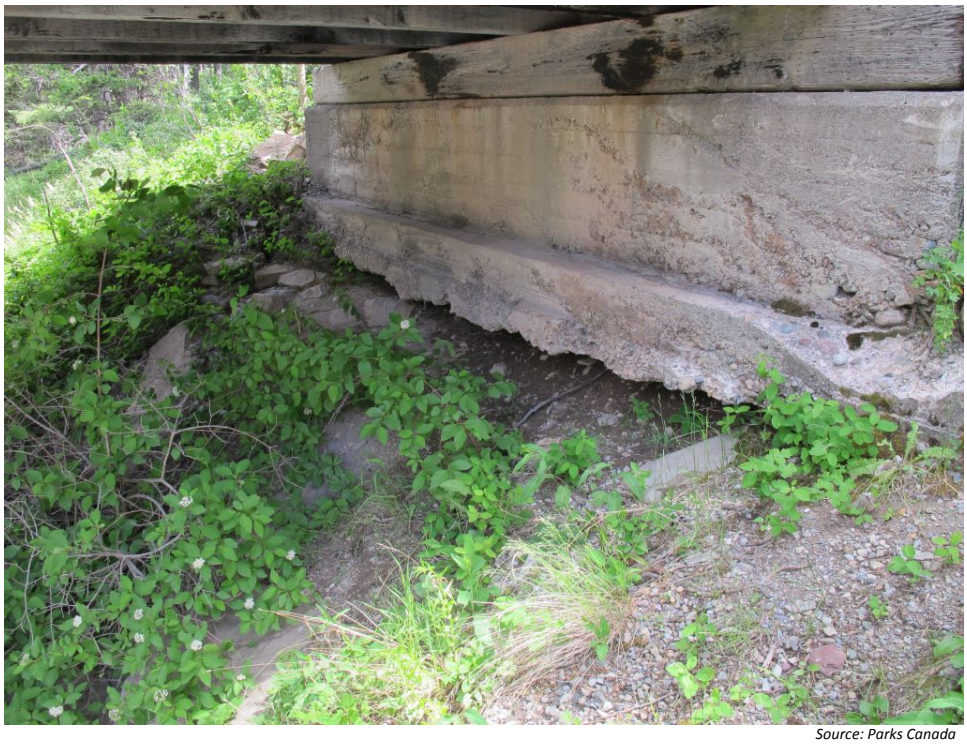
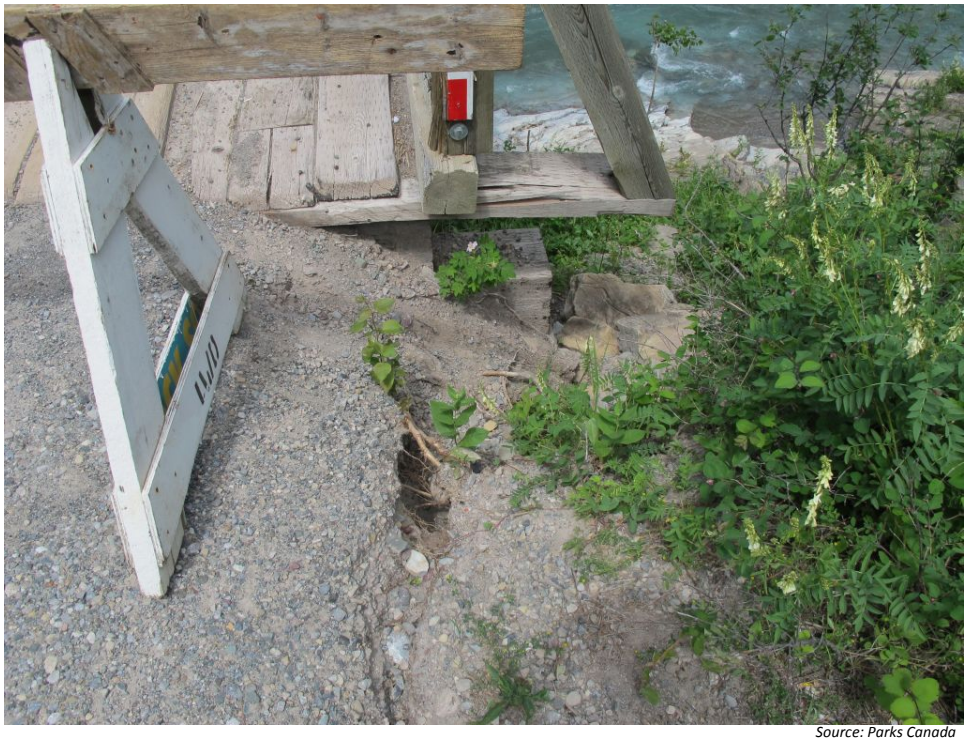


Photo 4 North Abutment (outcrop marked)



Source: Parks Canada

Photo 5 South Abutment Showing Erosion at Face



Source: Parks Canada

Photo 6 South Abutment Showing Erosion at Backfill

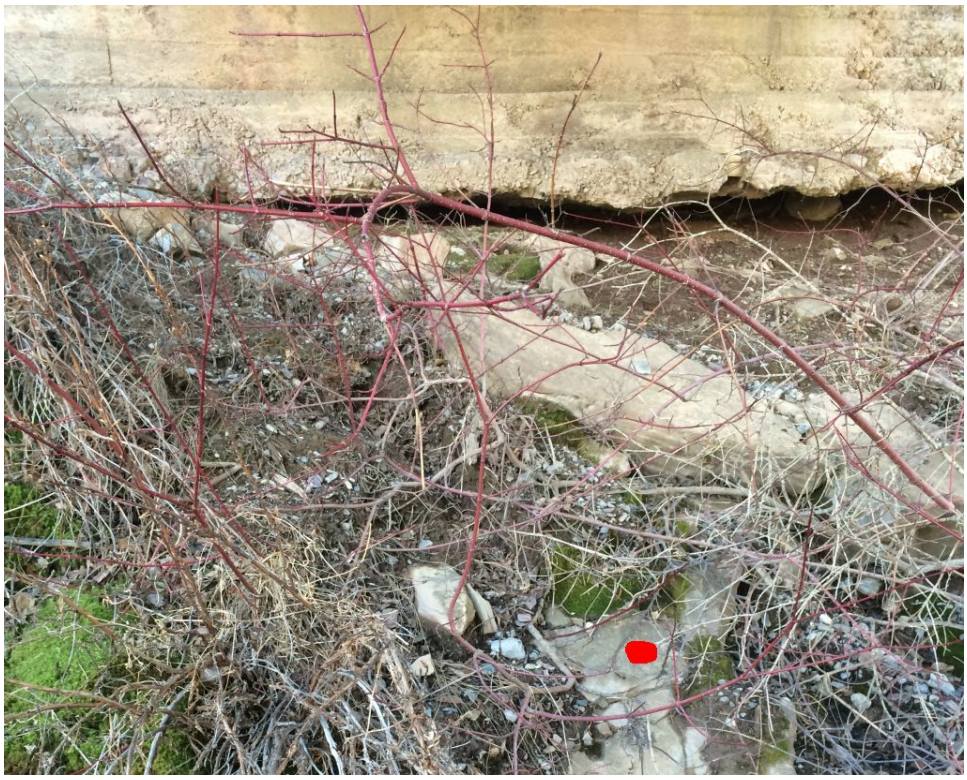


Photo 7 South Abutment East Side (outcrop marked)

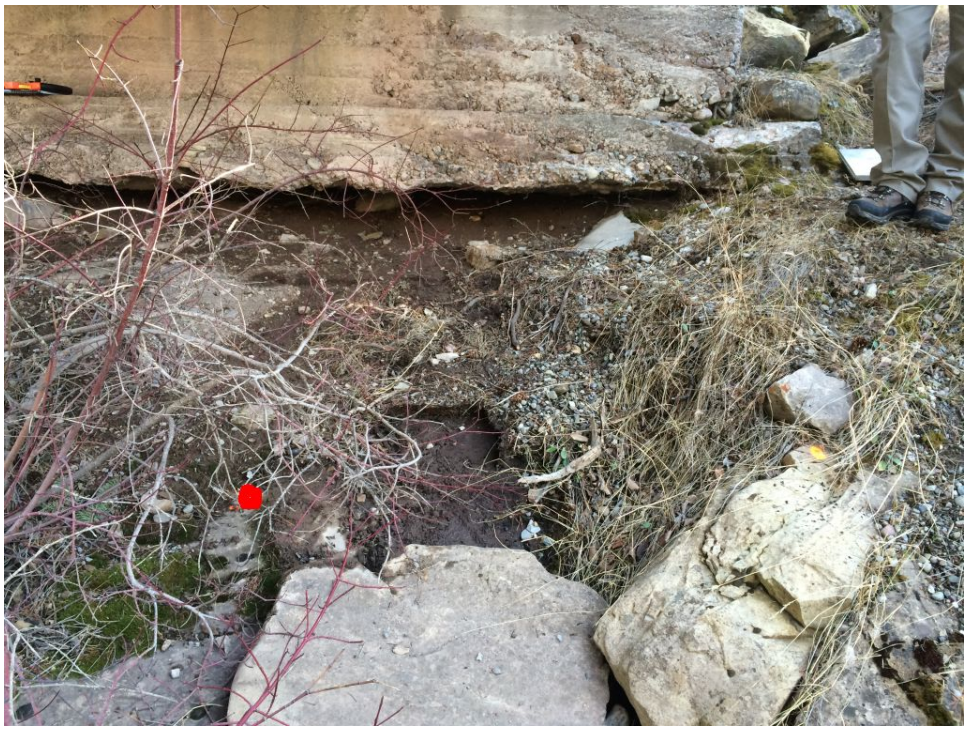


Photo 8 South Abutment West Side (outcrop marked)

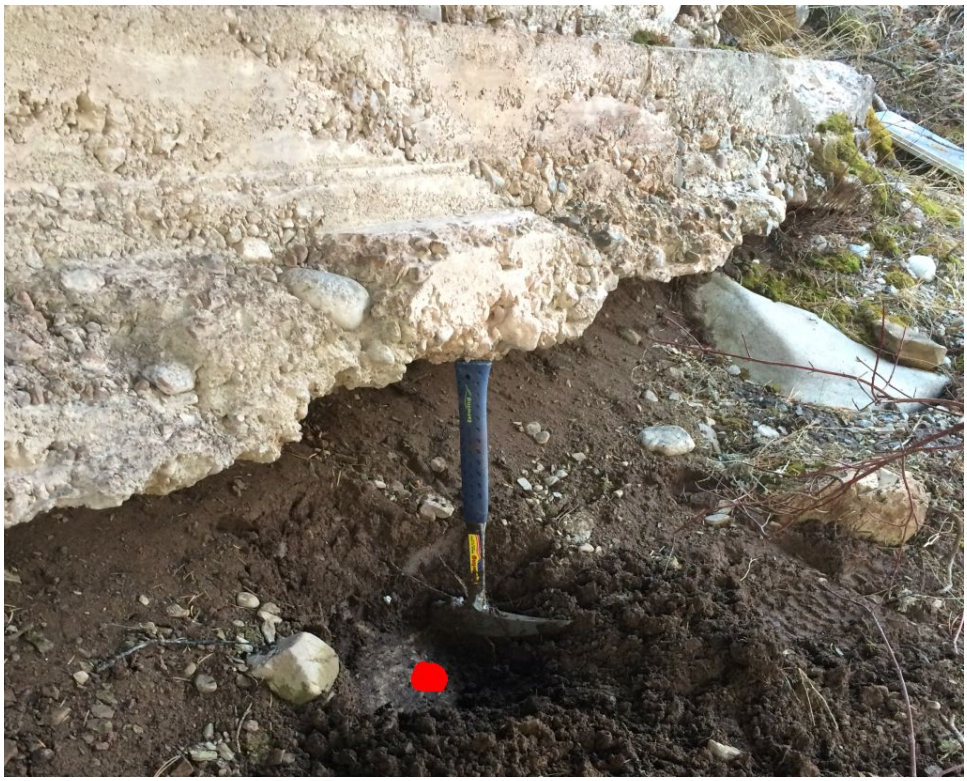


Photo 9 South Abutment West Side (outcrop at face marked)