Vita

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Universities Attended:
Memorial University (2016)
Bachelors of Science

University of New Brunswick (2021)
Masters of Science
Earth Science

Conference Presentations:

Boulay, D. E., and Butler, K. E. Electrical resistivity tomography to monitor for seepage at an embankment dam abutment. Atlantic Geoscience 45th Colloquium. Fredericton, NB, Canada. Feb 8-10, 2019.

Boulay, D. E., and Butler, K. E. Design of a 3D Electrical Resistivity Imaging System for Seepage Monitoring at an Embankment Dam Abutment. GAC-MAC-IAH Mtg. Quebec City, QC, Canada. May 13, 2019.

Butler, K. E, Grace, M., Boulay, D., and Black, A. Locating abandoned wells using ground and UAV magnetometry: examples from Stoney Creek Oil and Gas Field, New Brunswick, Canada. SAGEEP 2019 - 32nd Annual Symposium on the Application of Geophysics to Engineering and Environmental Problems, Environmental & Engingeering Geophysical Society, Portland, OR, 2019; 425.

Boulay, D. E., Butler, K. E., McLean B. D. & Campbell I. J. Implementation of a 3D Resistivity Imaging System for Seepage Reconnaissance at an Embankment Dam Abutment. Atlantic Geoscience 46th Colloquium. Truro, NS, Canada. Feb 7, 2020.

Butler, K. E. and Boulay, D. E. 3D Resistivity Monitoring for Seepage Assessment at an Earth Dam Abutment: System Design and Early Results. GELMON Virtual Conference. Nov 18-19, 2020.

Commissioning a three-dimensional electrical resistivity imaging system for seepage monitoring at an embankment dam abutment

UNIVERSITY OF NEW BRUNSWICK

THESIS DEFENCE AND EXAMINATION

in Partial Fulfillment

of the Requirement for the Degree of
Master of Science

by

Daniel Boulay

in the Department of Earth Science

U.N.B., Fredericton, N.B.

Tuesday, February 23rd, 2021
1:00 p.m.

Via MS TEAMS

Examining Committee

Dr. Karl Butler	Supervisor
Dr. Cliff Shaw	Internal Examiner
Dr. Peter Lelievre	External Examiner
Dr. Joseph C. White	Chair of Oral Examination

Abstract

The Mactaquac Generating Station is a large (660 MW) hydroelectric facility on the Saint John River, approximately 19 km upstream from Fredericton, New Brunswick. An alkali-aggregate reaction within the dam's concrete structures is causing their differential expansion. This has prompted the dam's operator, NB Power, to be proactive in monitoring for any signs of concentrated seepage that could arise where the dam's clay till core abuts a concrete diversion sluiceway. Seepage is a leading cause of dam failures. An emerging method to non-invasively investigate an embankment's interior is Electrical Resistivity Imaging (ERI). ERI is sensitive to changes in water saturation, temperature and ionic content, all of which can be indicators for localized seepage. In this work, a 100 electrode areal array is installed focused on the interface between the embankment and its concrete abutment.

Numerous hurdles and challenges were solved throughout this work. The installation of a durable and effective array which was achieved by drilling long (0.91 m) electrodes into the slope, using salted bentonite to keep contact resistances low. Limitations posed by the relatively short survey line lengths on the back of the dam were mitigated by implementing a pole-dipole survey geometry which yields relatively large depths of exploration and maintained sensitivity near the ends of the lines. An enigmatic current regulation issue, which affected repeatability, was solved by customization of measurement array geometries and by averaging many surveys over time with a smart-averaging processing routine designed to reject outlier measurements. Many necessary changes have been made to electrode array configuration over the course of the study and data quality has steadily improved.

Early results are encouraging, yielding repeatable resistivity models for the embankment that are consistent with its internal structure. Time lapse surveys were successful in observing localized resistivity changes in the embankment, interpreted as seasonal temperature change. Also observed were small resistivity change anomalies within and just outside the core, which are inferred to be consequences of changes in saturation and water temperature as well as road salt presence in the winter. Localized seasonal resistivity anomalies have been identified that are suggestive of two paths for elevated seepage: i) water passing through the concrete abutment and entering the rockfill on the downstream side of the core, and ii) a possibility of elevated seepage though the core adjacent to interface. Further seasonal monitoring, incorporating data from electrodes installed across the dam crest will be needed to confidently assess seepage through the core is anomalous next to the abutment.