INFORMING FLOOD DYKE RESILIENCY STRATEGIES THROUGH ELECTICAL RESISTIVITY IMAGING

A Case Study from the Upper Bay of Fundy

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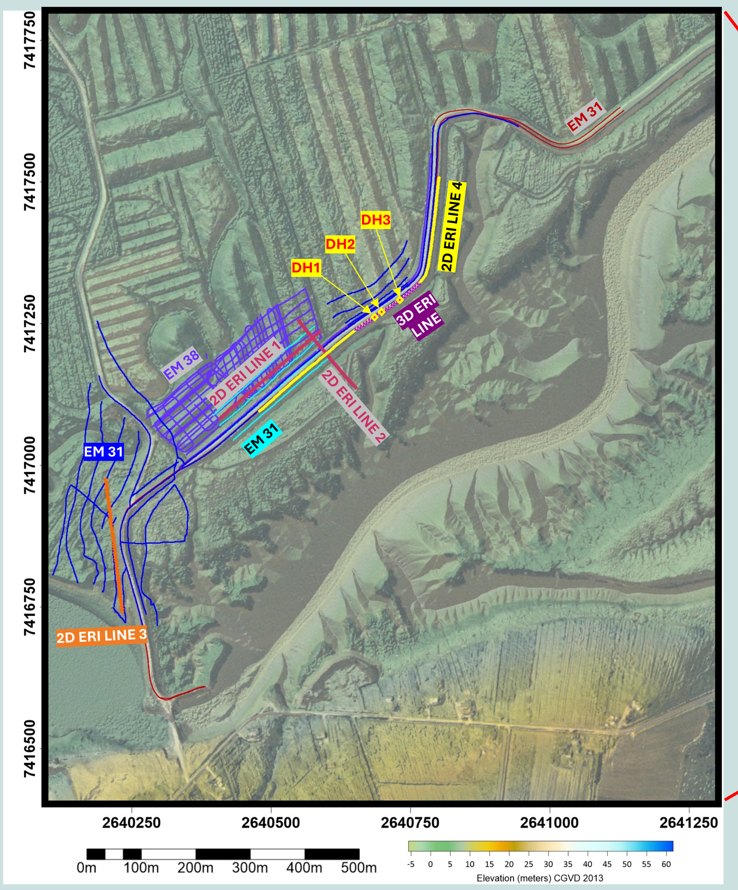
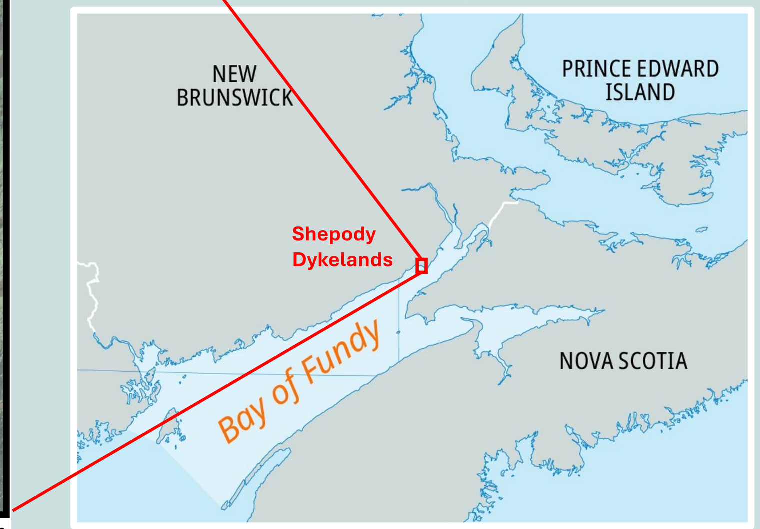
BACKGROUND

Coastal dykes of the macro-tidal Bay of Fundy are facing increasing risks from escalating effects of climate change. Mitigation may require comprehensive engineering intervention. **This research aims to evaluate the applicability of geophysical imaging methods for guiding dyke rehabilitation** and informing re-engineering efforts.



STUDY LOCATION

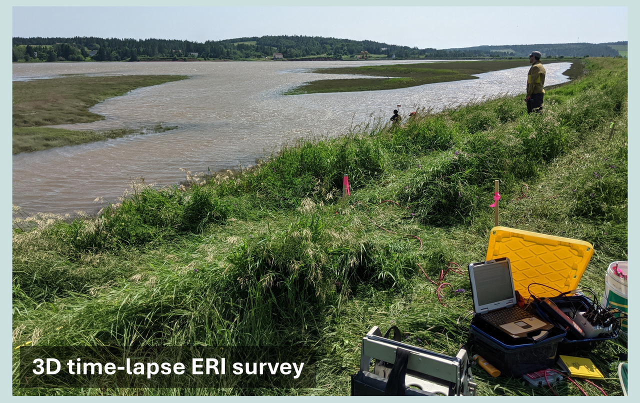
Location map, ERI and EM geophysical survey lines, and drillholes.



METHODOLOGY

We performed electrical resistivity imaging (ERI), electromagnetic (EM) apparent conductivity surveying, and standard penetration tests (SPT) with split-spoon sampling, in the Shepody dykelands, near Riverside Albert, New Brunswick, Canada.

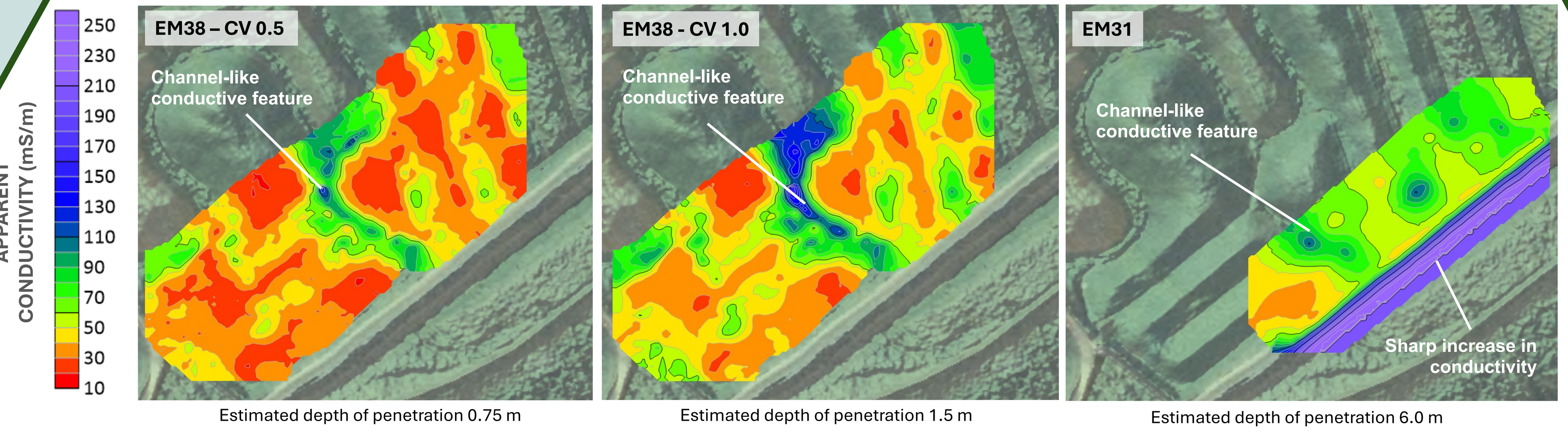

2D ERI survey


3D time-lapse ERI survey

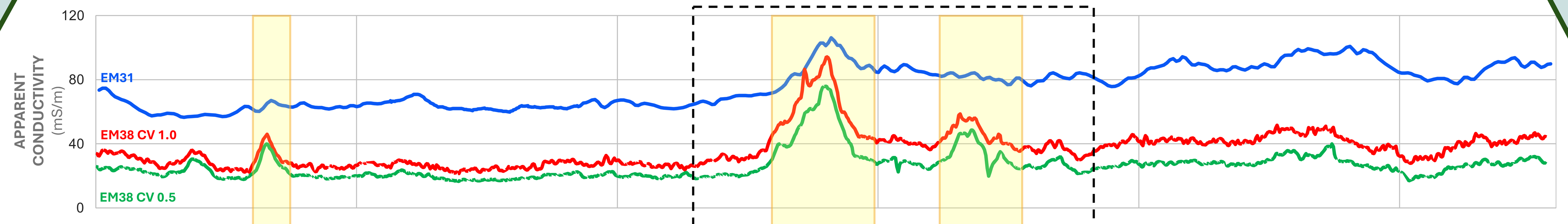
RESULTS AND DISCUSSION

EM APPARENT CONDUCTIVITY MAPS

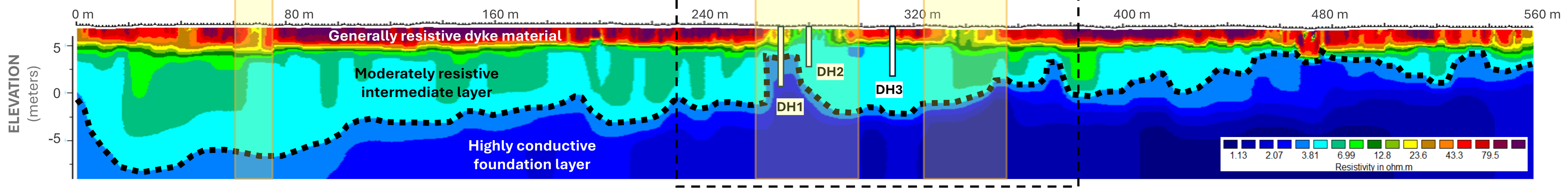
EM mapping responsive to varying depths successfully highlighted resistivity variations.
A sharp increase in conductivity on the water side of the dyke suggests saline water infiltration.



EMI APPARENT CONDUCTIVITY MEASUREMENTMENTS ALONG DYKE CREST



2D ERI INVERSION ALONG DYKE CREST, LINE 4

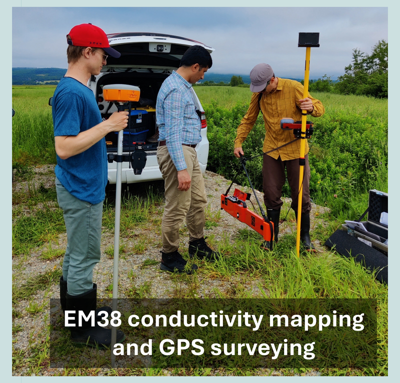


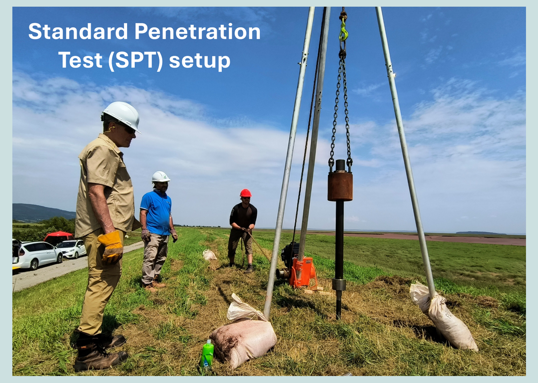
Initial 2D ERI inversion results from Line 4 (along dyke crest) reveal localized resistivity lows that align with high EM apparent conductivities (see orange boxes above). These anomalies may be **potential zones of abnormally high saline water seepage or higher clay content**. Laboratory work confirms that saline water content is the dominant influence (see below), suggesting **these conductive regions are more hydraulically conductive.**

METHODOLOGY *(continued)*

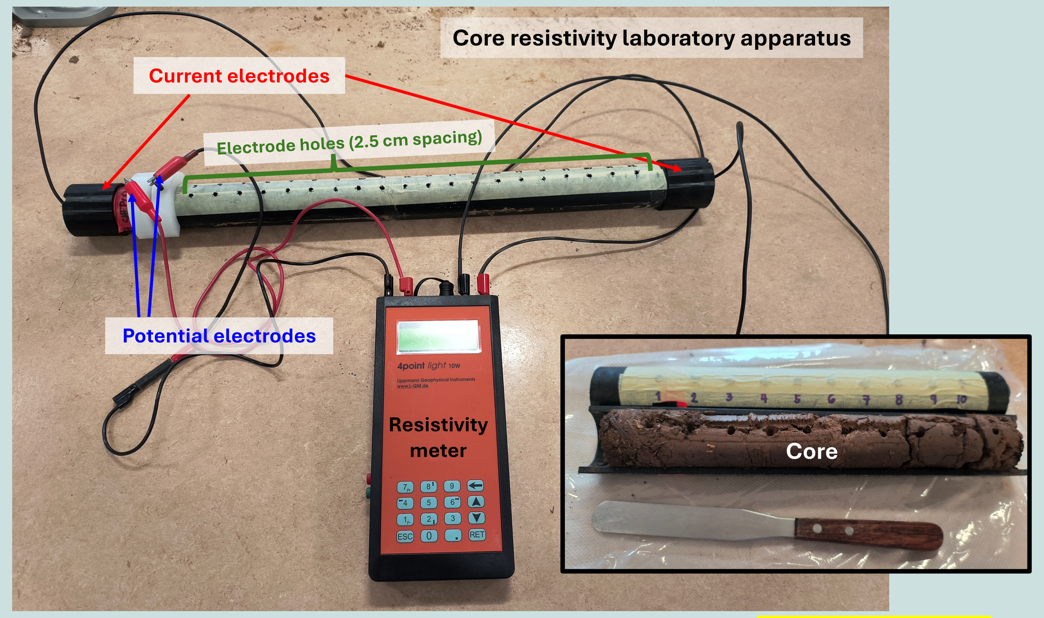
ERI and EM surveys covered the dyke and adjacent farmlands. We used 2D ERI and EM mapping to locate prominent resistivity anomalies and target subsequent SPT split-spoon sampling, from which we obtained soil core samples and geotechnical data.


EM31 conductivity mapping

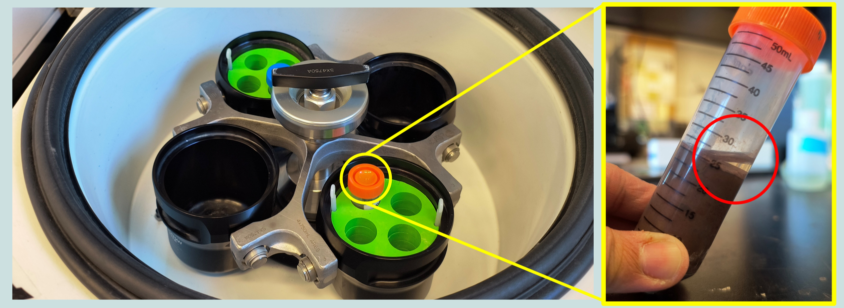

EM38 conductivity mapping and GPS surveying


Standard Penetration Test (SPT) setup

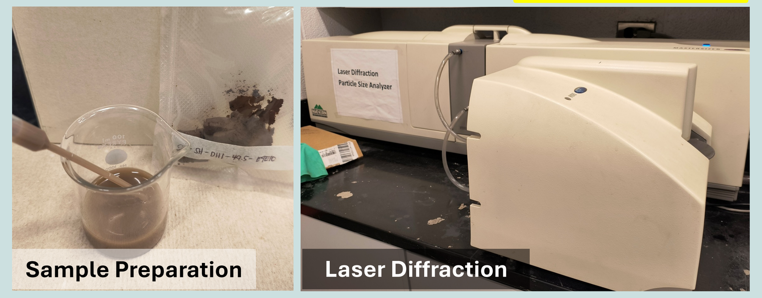
We measured core sample resistivities using a resistivity meter. Copper plate current electrodes were attached at each end of the core and steel potential electrodes were inserted into dilled holes.

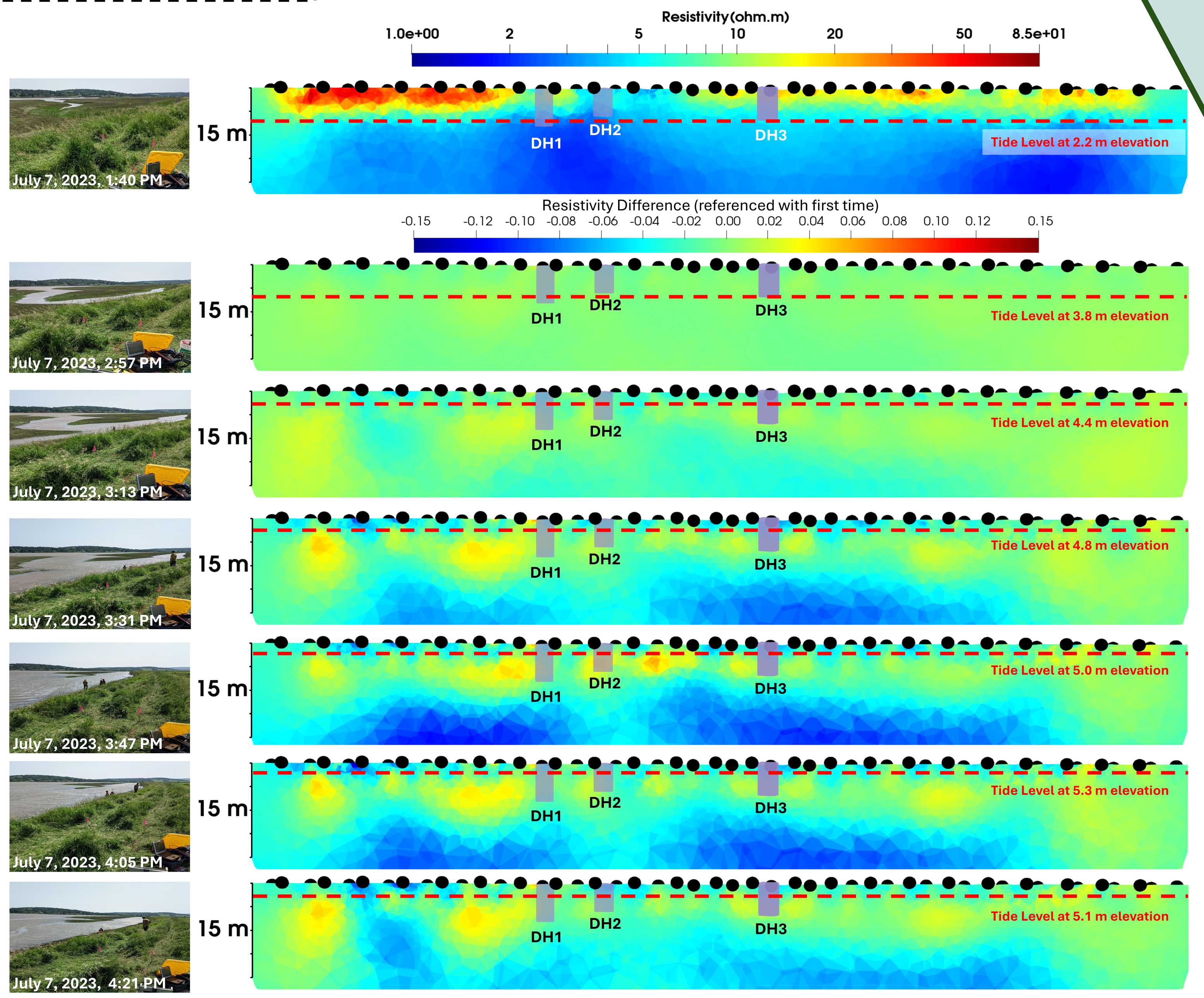


Pore fluid samples were extracted by centrifuge and measured with a conductivity meter.



Grain size analysis was performed using laser diffraction.


Sample Preparation
Laser Diffraction



3D ERI TIME-LAPSE INVERSION DURING RISING TIDE *(left)*

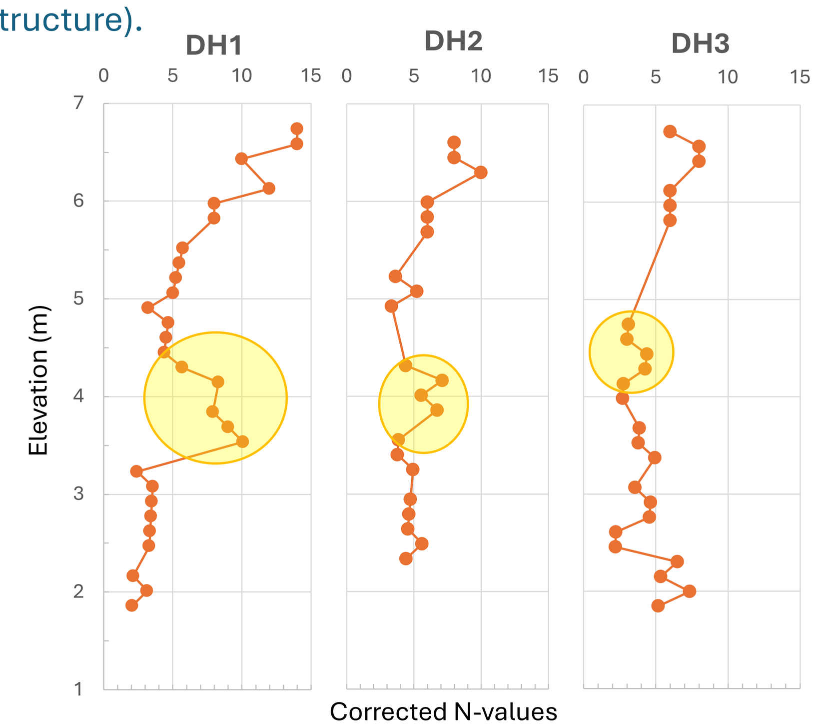
Results show increasing conductivity (reduced resistivity) at depth concurrent with rising tide levels, suggesting increased fluid saturation in the dyke materials. The potential impact of saltwater rising against the side of the dyke has yet to be assessed so cannot yet be ruled out.

CONCLUSIONS

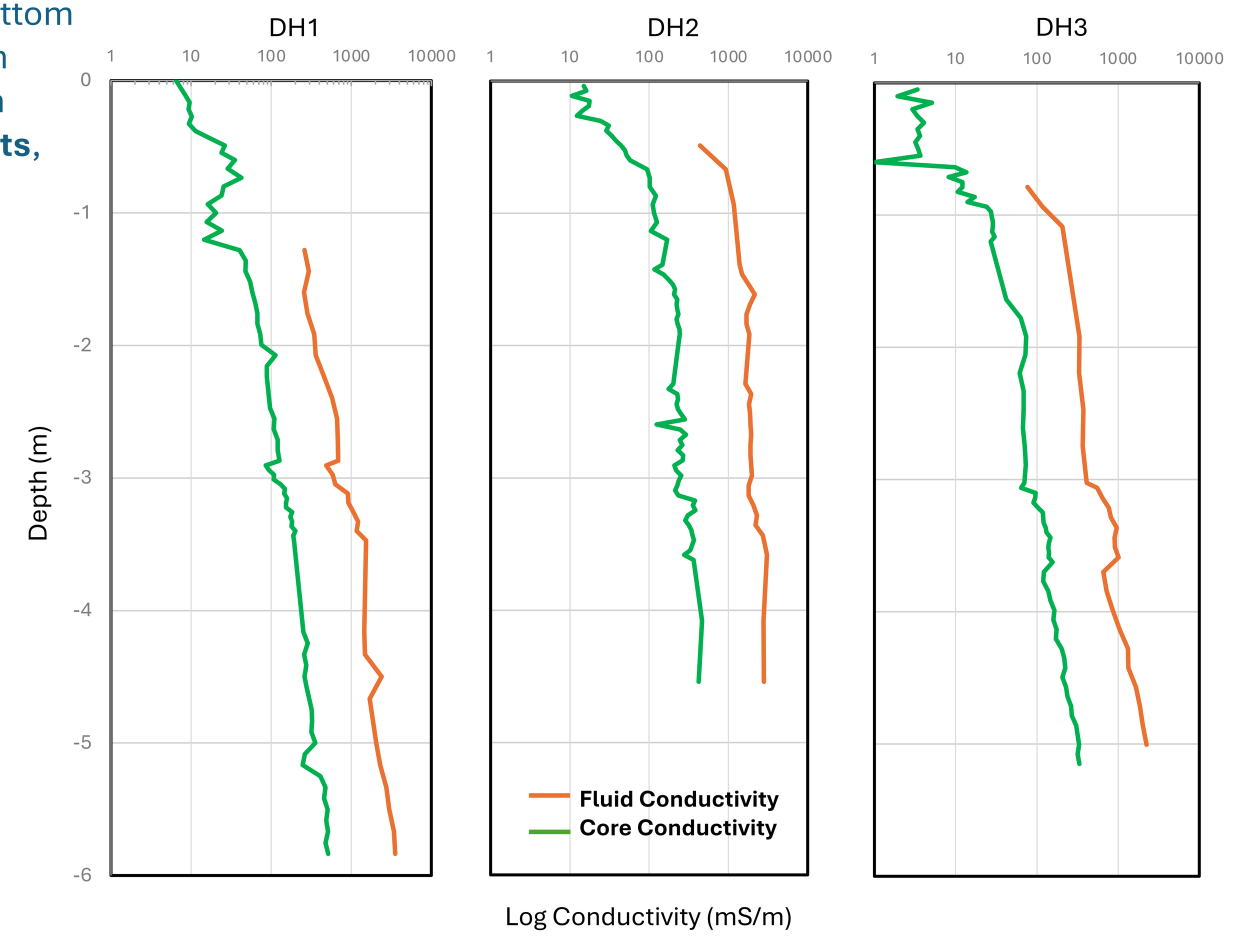
Results highlight the effectiveness of ERI and EM in assessing coastal flood embankments. EM can successfully differentiate surface materials. ERI can identify anomalies within flood dykes that may be indicative of potential zones of vulnerability. Geotechnical investigations indicate resistivity variations are primarily influenced by pore fluid conductivity. 3D time-lapse ERI results show increased conductivity at depth during rising tide levels.

STANDARD PENETRATION TEST

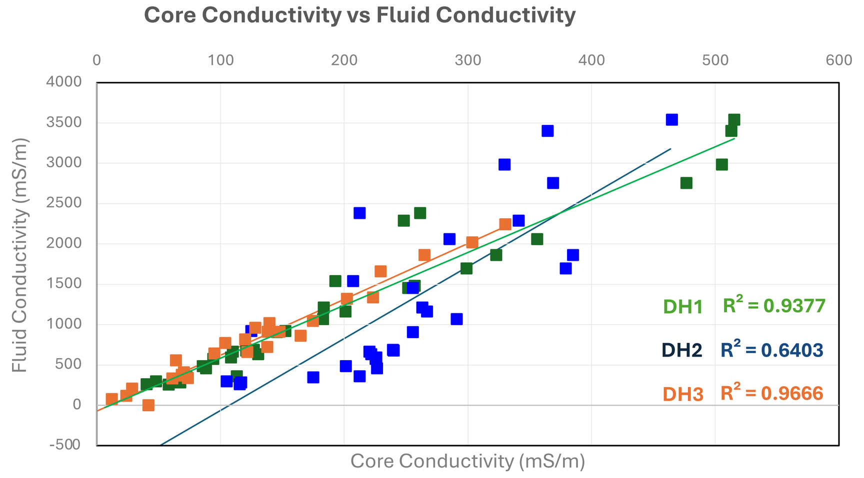
Decrease in N-values coinciding the with the expected bottom of the dyke at ~5 m elevation. Noticeable peaks below 5 m (circled). At ~3.7 m elevation, **water was heard flowing in DH2**. At ~3.5 m elevation, **DH1 contained wood fragments**, possibly part of an old abioideaux (water flow control structure).



LABORATORY MEASURED CORE AND PORE FLUID CONDUCTIVITIES



No direct relationship between clay content and core conductivity was found. However, pore fluid conductivity is well correlated with laboratory-measured conductivity. This suggests **pore fluid has a stronger influence on core conductivity than percent clay content.**



ACKNOWLEDGEMENTS

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