

# Proposal for GPS Monitoring Stations in Yarmouth and North Sydney

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## Introduction

The tectonic subsidence of Nova Scotia is a fundamental phenomenon that contributes to the net rise in sea level along the coastlines of Nova Scotia. Assessments of coastal risk, therefore, benefit from measuring tectonic subsidence at various locations around the province. This can be done using data from continuous or campaign-mode global position system (GPS) monitoring. Presently, there is only a single continuous GPS station in Nova Scotia, located at the Bedford Institute of Oceanography in the Halifax Regional Municipality. These data are supplemented by campaign-mode GPS monitoring at a handful of Canadian Base Network (CBN) monuments throughout the province by the Canadian Geodetic Service.

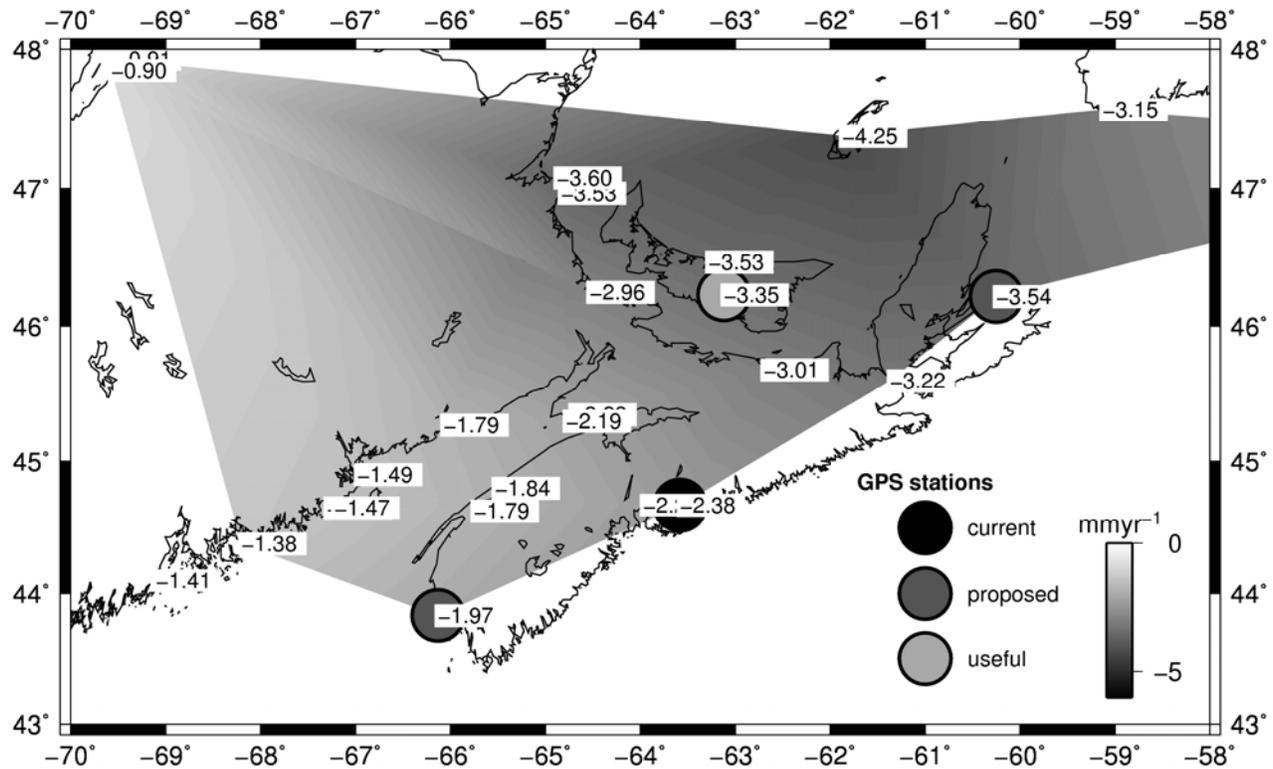
A proposal was developed to install continuous GPS stations on tide gauges in Yarmouth and North Sydney that would help to improve subsidence estimates for the entire province because subsidence appears to be greatest in the northeast and least in the southwest ends of the province. Deployment partnerships with the Canadian Geodetic Service and the Canadian Hydrographic Service were lined up in which these partners would maintain and operate the sites and station data as part of the Canadian Active Control System. Unfortunately, the Nova Scotia Department of Natural Resources was unsuccessful in identifying and securing funds for purchase and installation of the monitoring equipment, either externally from the Atlantic Climate Adaptation Solutions federal funding vehicle or internally in the division budget. Consequently, the proposed project is on hold indefinitely until such time as necessary funding is identified and secured. Identified implementation costs and partnerships will need to be re-determined at that later date, but are reported here for future reference.

## Background

The Geological Services Division of the Nova Scotia Department of Natural Resources is charged with producing coastal risk assessments for the Yarmouth, Lunenburg and Oxford/Pugwash municipalities in a currently funded project with the Atlantic Climate Adaptation Solutions program (Government of Canada, 2010). Candidate formats for delivering these assessments to the municipalities will be detailed maps of coastal materials and probable rates of erosion and/or levels of risk (D. Utting, personal communication). These maps will be referenced to the present level of the sea, which determines the present coastline of Nova Scotia.

For planning purposes, however, it is useful to be able to project into the future where Nova Scotia's coastline will be and what coastal risk will look like in the future. Nova Scotia is currently subsiding due to isostatic effects (Peltier, 2004) and global sea level is currently rising (Woppelmann et al., 2007). These effects constrain the total rise in sea level observed at tide gauges sited along the coast of Nova Scotia, and, in conjunction with topography, the landward migration of the coastline (Forbes et al., 2009). The primary data source currently used to constrain the subsidence of Nova Scotia is the single continuous GPS receiver at the Bedford Institute of Oceanography in Dartmouth, (Forbes et al., 2009). Campaign GPS data have also been collected recently from survey monuments in the Canadian Base Network (Henton et al., 2006; M. Craymer, personal communication).

Models of isostatic subsidence show that the rate of subsidence varies through the province (Fig. 1; Peltier, 2004). Two main trends are predicted: (1) an increase in subsidence rate from ca. 2.0 mm/yr in Yarmouth (southwest) to ca. 3.5 mm/yr in Sydney (northeast), and (2) an increase in



**Figure 1.** Predicted radial subsidence (mm/yr) from ICE-5G isostatic response model (Peltier et al., 2009).

subsidence rate from ca. 2.4 mm/yr in Halifax (southeast) to ca. 3.0 mm/yr along the North Shore (northwest). The proposal is to fund the installation of GPS stations in Yarmouth and Sydney. These stations, in complement with the current station in Dartmouth, will provide continuous data control for the increase in subsidence from southwest to northeast Nova Scotia.

In consultation with Dr. Don Forbes (Bedford Institute of Oceanography, Geological Survey of Canada), and Dr. Michael Craymer (Geodetic Survey Division, Geological Survey of Canada), the Geological Services Division verified the following. First, survey grade positioning data at tide gauges in Yarmouth and Sydney would greatly improve data constraints for isostatic response models for the entire province of Nova Scotia. Second, well-constrained isostatic response models can be used to better model the risk of flooding and erosion along the coastal regions of Nova Scotia due to long-term climate change. Third, GPS data from these sites will also contribute to the determination of global and regional sea level rise and would, therefore, contribute to a matter of

international interest. Specifically, the proposed stations would become part of the International Global Navigation Satellite System Service Tide Gauge Benchmark Monitoring project (Schone et al., 2009).

## Proposal

The Geological Services Division tried to identify and secure funding first from the Atlantic Climate Adaptation Solutions federal funding vehicle and second from their internal budget, without success. This funding would have covered the purchase and installation of the GPS monitoring equipment at Yarmouth and North Sydney (Fig. 1) as outlined in Table 1. Estimated purchase prices for the GPS equipment reflects membership of the Geodetic Service Division, Natural Resources Canada, in the University NAVSTAR Consortium and is substantially less than the normal price of these units (M. Craymer, personal communicator).

Upon installation, The Geodetic Service Division of Natural Resources Canada agreed to cover the

**Table 1.** Estimated costs and targeted responsibilities for the proposed GPS monitoring project.

<b>Project Stage</b>	<b>Tentative Costs</b>	<b>Potential funding source(s)</b>	<b>Partner responsibilities</b>
Site Installation (purchase two receivers, install two monuments, associated travel)	\$26,500 (total) \$15,000 (receivers) \$7,000 (monuments) \$4500 (travel)	Atlantic Climate Adaptation Solutions federal funding; Geological Services Division, NSDNR internal budget	The Geodetic Survey Division, NRCAN, team installs stations to national standards
Site Maintenance	Tbd	Canadian Hydrographic Service	Normal maintenance of tide gauges if GPS receivers installed at these sites
Data Maintenance	Ongoing, \$1200/yr	Geodetic Survey Division, NRCAN, operating budget	The sites will become part of the Canadian Active Control System maintained by the Geodetic Survey Division, NRCAN
Data Use	<ul style="list-style-type: none"> <li>• The time horizon for useful vertical motion data is after 3 years.</li> <li>• Subsidence data will be published by the Canadian Geodetic Service (and other groups since data is public).</li> <li>• Subsidence and climate change models will be developed by academic groups.</li> <li>• Subsidence data and models will become part of coastal change maps produced by NSDNR.</li> <li>• Flood risk maps can be developed by NSDNR in collaboration with different municipalities.</li> </ul>		

costs and fulfill the duties needed to operate, maintain and collect and process the data from the new stations. If installed at Canadian Hydrographic Service tide gauges, the Canadian Hydrographic Service had informally agreed to help ensure the housing and safety of the GPS equipment (M. Craymer, personal communicator). Initial data would come online in short order and subsidence estimates with reasonable error limits would likely become available within three to five years of the start of data collection (D. Forbes and M. Craymer, personal communicator).

## Acknowledgments

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(Bedford Institute of Oceanography, Natural Resources Canada) and Mr. Allen Flemming (Nova Scotia Geomatics Centre) for their help in preparing this proposal. Dr. Michael Craymer is especially thanked for bringing the resources of the Geodetic Survey Division, Natural Resources Canada to the table as the partner able to keep the new stations in operation, if installed.

## References

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