CHS National Project:
Continuous Vertical Datums for Canadian Waters
(Status Summary Feb. 2013)

J. Bartlett [1], M. Craymer [2], B. de Lange Boom [1], A. Godin [1], T. Herron [1], D. Lefaivre [1], P. MacAulay [1], L. Maltais [1], S. Nudds [1], C. Robin [1,2], M. Véronneau [2]
[1] DFO-CHS, [2] NRCan-GSD

1. Introduction

Since the 1990's the Canadian Hydrographic Service (CHS), in some cases in collaboration with other agencies, have developed and employed a number of regionally-based continuous vertical separation surfaces. These separation surfaces model the difference between the CHS's primary vertical datum 'Chart Datum' (CD) and either Canadian orthometric datum or Ellipsoidal references. Examples of early successful efforts are: 1) a continuous vertical separation model for the St. Lawrence River; 2) a stepped separation solution to CGVD28 for the Fraser River; 3) continuous separation solutions for both the Bay of Fundy and the Northumberland Strait; 4) continuous transformation solutions for Welland Canal, Lake Simcoe, and 5) the International Great Lakes Datum 1985 (IGLD1985).

In 2010 the CHS recognized the need to create a common national framework from which to re-develop, extend, maintain, and evolve these early efforts in order to provide consistent solutions for all Canadian waters. The national "Continuous Vertical Datums for Canadian Waters (CVDCW) Project" was established to address this need.

2. Project Goals

The CVDCW project's primary goal is to develop continuous separation surfaces (SEPs) between traditional Hydrographic datums, for example CD, and Canadian Spatial Reference Systems, for example NAD83(CSRS). These SEPs will interconnect the CHS's existing array of individual datums already established at all CHS tide stations. However, for these new SEPs to be accurate representations their behaviours must reflect the variations in the geoid, tidal dynamics, and dynamic ocean topography that exist throughout the space between the tide stations (Figure 1).

Given the size and complexity of Canada's coastline, the CHS has chosen to adopt/build a national, common set of procedures and tools to develop and maintain the SEP surfaces. Nonetheless, flexibility has been designed into the methods to accommodate regional differences in geography and hydrographic requirements.

3. Present Status

Progress for the CVDCW Project has been ongoing since 2010, based on both incremental regional and national support. Several national strategy and methods development workshops have been held, as well as regular conference calls and online meetings. Collection and validation of the necessary common basic input data sets, shore control links and model generated surfaces is continuing at an accelerated pace.

Particular attention has been paid to optimizing methods for integrating input data into the solutions, for example, to avoid datum contamination across land, and to honour the observed datum separations at the tide stations.

There are on-going efforts to re-analyse and validate existing tidal data sets and to fill gaps in the tidal station network data. Tide station constituent sets based on shorter observed water level time-series are being enhanced by incorporation of long-period constituents derived from nearby tide stations with multi-year observations. Through partnerships with Department of Fisheries and Oceans (DFO) Oceanographers, new hydrodynamic ocean and coastal models are being developed at both regional and sub-regional scales, validated and modified for use in the creation, management and maintenance of CVDCW SEPs.

Figure 2 summarises CHS's expanding network of shore control links (presently at 437 individual tide stations) between tidal datums and both ellipsoidal and geodetic references. This figure also illustrates the unstructured grids of the ocean models being used in the regional SEP solutions. All shore control links in Figure 2 are based on 24 hour precision GPS occupations of tidal station benchmarks, starting in 1999 but primarily over the last 5 years. New tide stations are being established or better data sets collected at existing sites in order to address gaps in the existing shore control geospatial coverage. In many areas the coverage necessary to support initial solutions has been achieved. However, additional work is still required particularly for remote areas, especially in the Arctic.

The CVDCW project's first priority is to develop the Chart Datum (CD) to NAD83(CSRS) SEPs, and the associated spatially dependent uncertainties, necessary to undertake 'survey to the ellipsoid' hydrographic operations. In the future, additional SEPs providing the transformations between other CHS vertical datums will be developed (for example, Datum for Elevations/Clearances, LAT, LLWLT, HHWLT, HAT) and Canadian reference systems (e.g. NAD83(CSRS), CGVD28 and CGVD2013). An important goal will be to coordinate with the American VDatum project in order to connect border waters through a common datum surface and reference frame.

Significant progress on the development of computational tools and methods has been made in the past year. Preliminary first-cut SEP solutions between CD and the NAD83 reference frame have been generated for all regions, Pacific, Atlantic, Gulf, and Arctic. These solutions were developed principally to demonstrate methods, test and compare alternative approaches and to develop common tools. Both Pacific and Quebec regions have already tested certain aspects of their initial solutions in finite small areas.

4. Next Steps

New test versions of the CD to NAD83 SEP surfaces using the latest methods and tools will be available for field testing in the summer of 2013. Methods for the assessment and inter-comparison of the existing CHS vertical control strategies with those utilizing the new SEPs are under development in coordination with CHS hydrographic managers. Results from field tests will be used to refine the SEPs and their spatially dependent uncertainty estimates. These test SEPs will also help guide efforts to improve the geospatial coverage of existing shore control links and to improve the observational data upon which these links rely. A national SEP data management system is under development.

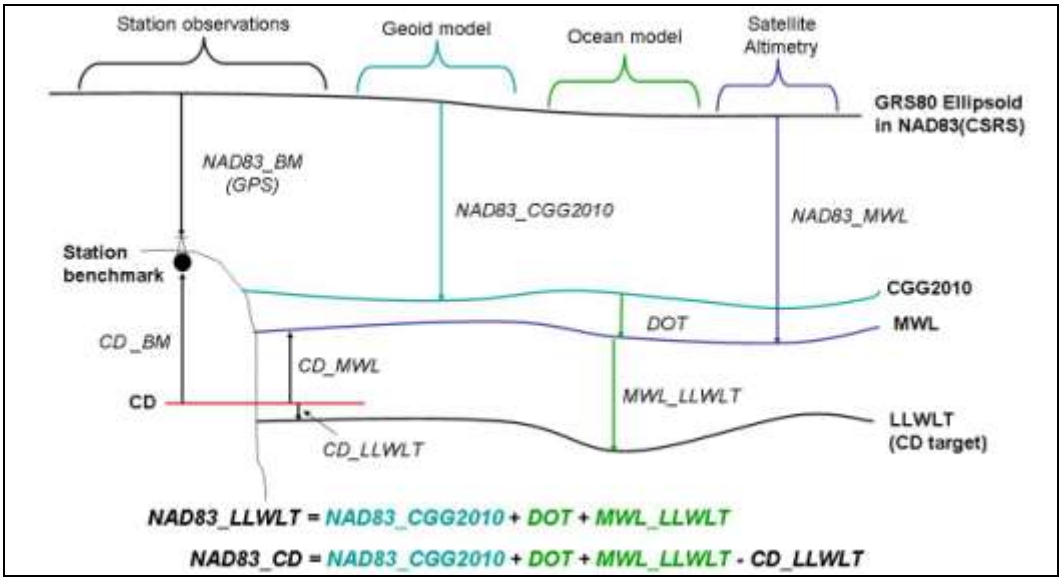

Figure 1. The relationship between the various vertical reference surfaces used in the CVDCW project.

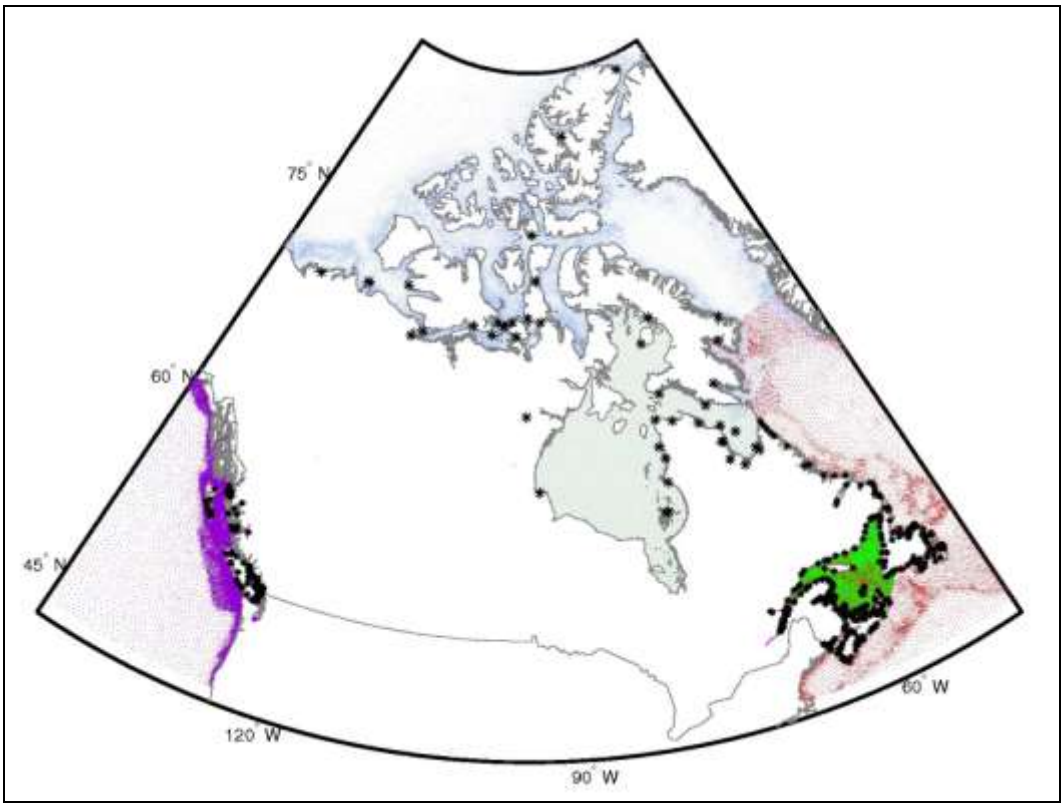

Figure 2. Existing (as of 2012 December) shore control links (*) between vertical datums defined at water level stations and both the ellipsoidal and geodetic datums. The 96 sites in the St. Lawrence Seaway are not shown. Coloured dots indicate the coverage of various tidal models (Arctic9, Hudson's Bay, NWATL, G5, STLE, NEP28/NEP35).