Mapping of Dynamic Beach, Flood Hazard Limit, Nearshore Bathymetry and Biodiversity for the Wasaga Beach and Collingwood Shoreline

Mapping of the near shore bathymetry from water's edge to 5 m depth.

Existing bathymetry for the Collingwood and Wasaga Beach coastal area is available through the Canadian Hydrographic Service at a scale of 1:50,000 - 150,000 and the onshore OBM mapping is at a scale of 1:2000 with 1 m contours. These scales are too coarse to accurately model coastal processes and hazard lands.

Bathymetric mapping of the near shore zone will be undertaken by staff from the NVCA and WILD Canada using rental boats. Using a Garmin Chartplotter/Sonar Combo, bathymetry will be collected from 0.9m (the minimum depth for the Garmin chartplotter) to 5m depth. The goal is to provide near shore bathymetry to approximately 0.25 m vertical accuracy. The Garmin unit tracks the boat's position and transects will be taken perpendicular to the shoreline at approximately 25 m intervals. Collingwood has a much more diverse shoreline pattern and we will attempt to capture all accessible areas. The Garmin units also will provide information on bottom structure and we will attempt to map out vegetation beds by marking way points as they are encountered.

All bathymetry data will be post processed by NVCA staff to correct for lake level and provide a seamless product across the waterfront. Cost for the bathymetric survey is based on a larger boat to capture the 2m – 5m depth with a crew of 2 and a smaller boat to capture the 0 - 2m depth each for 3 weeks of data collection. In total approximate 36 km of shoreline will be collected.

Background and Definitions

Bathymetry

- "Bathymetry" originally referred to the ocean's depth relative to sea level, although it has come to mean "submarine topography," or the depths and shapes of underwater terrain.
- In the same way that topographic maps represent the three-dimensional features (or relief) of overland terrain, bathymetric maps illustrate the land that lies underwater. Variations in sea-floor relief may be depicted by color and contour lines called depth contours or isobaths.
- Bathymetry is the foundation of the science of <u>hydrography</u>, which measures the physical features of a water body. Hydrography includes not only bathymetry, but also the shape and features of the shoreline; the characteristics of tides, currents, and waves; and the physical and chemical properties of the water itself

Sample Images:



Bathymetric Survey mass points, interpolated contours, and derived sub-surface model



Lake bed surface

Data Availability

Bathymetry of Lake Huron

Bathymetry of Lake Huron has been compiled as a component of a NOAA project to rescue Great Lakes lake floor geological and geophysical data and make it more accessible. This project was a cooperative effort between investigators at the NOAA National Geophysical Data Center's Marine Geology and Geophysics Division (NGDC/MGG), the NOAA Great Lakes Environmental Research Laboratory (GLERL) and the Canadian Hydrographic Service(CHS). Through NOAA and CHS, a spatial data set is available (**contours 5m intervals**) or as an Imagery Grid). While this data set is available, the resolution is too course for this project's purposes.



Interpolate contours from this product (with DEM 3D shoreline) for representative depths



Bathymetry through Third Party "Navigation" Charts

Navionics:

- Navionics integrates the sonar logs from individual users with existing data to ensure the SonarChart becomes more and more precise, even in the ever-changing conditions of sea, lake and river bottoms. Navionics accepts sonar logs from all major plotter/sounder brands and mobile devices
- bathymetry map featuring extraordinary bottom contour detail, great for increasing awareness of shallow waters

DFO / CHS – Canadian Hydrographic Services has another product (circa 2014), Bathymetric **LiDAR** along Georgian Bay Shorelines; however has not been made available to-date.

LIDAR (Light Detection and Ranging)

- LiDAR systems can gather digital elevation data to be used in mass point data sets, and in DEMs. LiDAR is composed of an airborne GPS with a GPS base station, an Inertial Measurement Unit (IMU), and light-emitting scanning laser. The airborne GPS determines the in-flight three-dimensional position of the sensor, and the IMU determines the attitude of the sensor, i.e., the roll, pitch and heading.
- Topographic LiDAR can measure elevations on land using the travel time of a red laser pulse. Airborne LiDAR mapping (ALM) uses a large number of near-vertical laser pulses to develop a digital elevation model (DEM) of the terrain. As topographic LiDAR also uses backscattered energy to determine distance, multiple travel times are possible for each beam in areas with tree cover. Many LiDAR applications require "bare-earth" DEM to be developed, so one task of LiDAR analysis involves identifying and removing the objects that sit on the ground, such as trees and buildings.
- Bathymetric LiDAR uses a blue-green laser, which penetrates clear water easily.
 Airborne LiDAR Bathymetry (ALB) deploys two lasers from the aircraft: the red laser measures the height of the sea surface since it does not penetrate the water; and the blue-green laser measures the distance to the seabed (provided enough backscatter energy returns to the aircraft). The time difference between the two laser returns gives the depth of water.
- Bathymetric LiDAR works very well in depths up to about 50 metres, when the water is clear and the seabed is light-coloured. It is not suitable for measuring depth if the

water is turbid or if there are suspended materials in the water column, such as air bubbles, fish or kelp.

I've contacted various other agencies (MNRF, EC - Great Lakes Issue Management and Reporting Section, Severn Sound Environmental Association) regarding this data, comments include:

- Data captured near shore is not reliable or available as ice formations existed during time
- Product is not ready for release

Data (New) Acquisition:

The scope of this project is to collect near shore Bathymetric data (up to 5 metres depth). Retaining a vendor to collect ALB or to use Large Airborne equipment (Planes / Helicopters) was not be feasible for this exercise.

With the advancement in Sonar and GPS technology, data collection sensors have become readily available in a cost effective manner to the consumer.

Sensors can be attached to small boats, remote controlled vessels, floatation devices, to capture the information.

- Can run very shallow
- Single and Mulitple-beam depth sounding and acoustic bottom tracking
- Blue Tooth and Windows integration
- Data gridding and interpolation
- Some units do not require specialized complex software, saving you time and money
- Water sound speed corrections are interpolated in both space and time
- Water column velocity (currents) mapping can be captured
- Interface for customer-supplied GPS and/or heading sensor
- Can be coupled with RTK (Real Time Kinematic) GPS for position accuracy

Sample Products:



The **HydroLite MILspec** system represents the ultimate in portable ruggedised hydrographic surveying equipment, based around the integration of sub-meter handheld GPS with the Ohmex 'SonarMite' portable DSP echo sounder.



The **HyDrone™ RCV** is a hand-portable, remote controlled hydrographic survey platform. HyDrone RCV conducts bathymetric surveys in ponds, lakes, rivers, and streams. It accomplishes the same results as much more expensive RC survey systems, has a wide profile to avoid tipping, and watertight construction. It's rugged, lightweight, and is manufactured from high quality marine components. The system is easily disassembled for transport and shipping. Work environments include mines, sewage treatment plants, contaminated lakes, harbors, and rivers.



The **HydroSurveyorTM** is a system designed to collect bathymetric, water column velocity profile, and acoustic bottom tracking data as part of a hydrographic survey. The two key components of the system are the HydroSurveyor Acoustic Doppler Profiler (ADP®) platform, and the powerful, yet user-friendly, data collection software. With the HydroSurveyor platform, SonTek is able to offer an exclusive 5-beam depth sounding device, with built-in navigation, full water column velocity (currents) profiling, full compensation for speed of sound (with the CastAway-CTD), and integrated positioning solution.

Sonar/GPS Fish Finder

The technology in portable fish finders have also advanced in recent years. Many models have high quality transducers providing a clear representation of the surface bottom. In addition, some scanning sonars give you nearly photographic, wide images of what's below and to the sides of your boat. You clearly see structure, vegetation, and other features. The built in technology allows for separation and definition of the lake's surface.

Coupled with the transducer, may units have a built in GPS allowing for accurate positioning and navigation. A separate antenna can be attached to improve the horizontal positioning. These receivers track more satellites by utilizing GLONASS and WAAS for GPS signal correction.



A nearly photographic sonar view of structure from a **Sonar/GPS Fish Finder** unit. An excellent tool for scoping out the lake bottom, In addition some units provide a wide view of what lies off to either side of your boat (known as "Side View"). You see a crystal clear image that makes it easy to identify wrecks, structure, and rocks).

Some Portable units have the ability to use a memory card. With the study area being quite large (28 sq km), pre-planned tracks are essential. These routes can be surveyed on an external platform then uploaded to the unit. In addition, once data is collected, the data would need to be download for post processing. For this exercise, the ability to upload and download data is required.

Study Area

Nearshore area up to 5 metres depths along the shores of the Town of Wasaga Beach and the Town of Collingwood. This area lies on the southern shores of Georgian Bay, in Lake Huron.



Methodology

The area to be survey extended over an area of approximately 30 sq km. Conducting a reconnaissance exercise through aerial imagery, Navigation data, and field observation was desired (to plan a schedule for the data capture). Once the observations were compiled, the study area was divided into quadrants. This allowed for data/file management and, scheduling, and ensures all areas were captured. (see above)

Our approach defined two depths zones (0-2 m and 2-5m). The deeper zone data was captured parallel to the shore, and the inner zone was captured along a perpendicular path. By running perpendicular to the shore for the inner zone, a safe operation of the boat's outboard (and hull) from coming into contact to bottom structure was achieved.



The survey tracks (or paths) were generated in GIS, then uploaded to the Sonar unit. The tracks were set as 50 metres apart and covered the maximum are for each quadrant. To ensure no data gaps occurred, an overlap was implemented.

With a speed limit assumed and a total distance to cover, the exercise was estimated to require approximately 10 survey days on the water. However wind conditions and weather are two variables that impacted ideal conditions and time per day on the water.

With a travel speed set at 10 km/hr and a ping setting (when a sonar sound reading is recorded) for every 3 metres travelled, and depth reading is stored. In addition SideView technology on the Garmin unit captured an image of the surface. The Garmin unit has a built in GPS unit, however by attaching a WASS capable antenna, greater accuracy of the boats positioning was achieved. (WASS, a system of satellites and ground stations that provide GPS signal corrections, better than 3 m accuracy 95% of the time).



At the end of each survey outing, the data was uploaded to a microSD drive for post processing. It is important to note that data captured on one day was not combined with another until post processing occurred. Adjustments for observed Great Lake water level (Collingwood Station), depth below transom height, and wave height were considered in the elevation calculation.

As mentioned, the Garmin units were set to capture a SideView image of the water column. Through third party software (SonarTRX), the distance from the surface to the lake's bottom can be extracted. This elevation was compare to the ping depth sounding reading to for Quality assurance.

In total there was 15 surveys conducted for this exercise. The Garmin GPX files were brought into a spreadsheet for post-processing and compiled into a master table.

Date	Longitude	Latitude	Depth	GL_WL	Transom	Elev
Sep_2	-79.995485	44.560696	0.2395	176.58	0.1	176.44
Sep_2	-79.995484	44.560693	0.2395	176.58	0.1	176.44
Sep_2	-80.007366	44.538634	0.2395	176.58	0.1	176.44
Oct_11	-80.052313	44.497342	0.2395	176.65	0.1	176.51
Oct_11	-80.064523	44.488503	0.2395	176.65	0.1	176.51
Oct_11	-80.06452	44.488497	0.2395	176.65	0.1	176.51
Sep_2	-80.006678	44.541215	0.243	176.58	0.1	176.44
Sep_2	-80.006683	44.541212	0.243	176.58	0.1	176.44
Oct_12	-80.084793	44.477309	0.243	176.64	0.1	176.5
Oct 12	-80 084793	44 477303	0.243	176 64	0 1	176.5

Sample Garmin GPX output into GIS with adjustment values

With the Longitude and Latitude coordinates, data can be brought into a GIS for surface/DEM creation. The X, Y, and Z values from the Nearshore survey, coupled with the onshore Terrestrial Surface model (see Aerial/Topographic Survey Report) mass points and

break lines were compiled to create a TIN (Triangle Irregular Network). The next section of this document provides a general overview of the TIN process.



Once a TIN surface is generated, a GRID is generated for the analysis.

The GRID defines geographic space as an array of equally sized square grid points arranged in rows and columns. Each grid point stores a numeric value that represents a geographic attribute (such as elevation or surface slope) for that unit of space. Each grid cell is referenced by its x, y coordinate location.

The consultants modeling he wave uprush, dynamic beach require an ASCII file for the elevations. We were able to achieve this requirement by creating the GRID surface.



The above figure illustrates an Elevation GRID of the Terrestrial and Nearshore surveys.

Mapping of the onshore topography from water's edge to elevation 180.0m

A second task involved obtaining high resolution topographic mapping along the waterfront. The mapping needs to be at a scale to be able to identify dune features and map the flood hazard limit.

HighEye Aerial Imaging Inc. will be contracted to provide high quality aerial surveying and orthomosaics across 36 km of Georgian Bay coastline from water's edge to the 180 m contour line or to the first road inland. A fixed winged airplane flying at 1000 ft above ground level and equipped with a high resolution camera and accurate GPS positioning sensors will be used to take high resolution aerial photogrammetry.

Approximately 300 control points are positions by ground surveyors across the project area to be used in the processing of the imagery. After flying, a specialized computer and state of the art software is used to generate ortho-rectified GIS

Terrestrial DEM

Several elevation products can be derived from collected terrain data. The elevation products can include a Triangular Irregular Network (TIN), contour lines, and Digital Elevation Models (DEM). The elevation products are generated from a Digital Terrain Model (DTM) that is a combination of mass points and breaklines. There are many ways to create contours and DEMs that are required as input to the hydraulic models. Each product will have its own level of accuracy.

DEMs represent the elevation of bare earth at regularly spaced intervals in eastings and northings. DEMs are usually displayed as uniformly spaced grids. DEM data is suitable for automated analyses where breakline information is not important. DEMs may neglect breakline information as the DEM is grid based. DEMs are normally produced from irregularly spaced mass points. DEMs are slightly less accurate than TINs, or mass points from which they are averaged or interpolated. DEMs can be produced by a variety of methods

<u>Breaklines</u> - are linear features that describe a change in the slope, smoothness, or continuity of a surface. Breaklines should be produced using either stereo photogrammetric procedures or digital Ortho-photography, where breakline features are digitized as two-dimensional features. Breaklines are created for stream centerlines, drainage ditches, tops and bottoms of streambanks, ridge lines, road crowns, levees, bulkheads, seawalls, road/highway embankments, and features that constrict the flow of water.

<u>DTM (Digital Terrain Model)</u> - is the combination of mass points and breaklines that can be used to generate a TIN.

<u>TIN (Triangulated Irregular Networks)</u> - a TIN is a set of adjacent, non-overlapping triangles computed from point, line, and polygon data interpreted from mass points and breaklines. The TIN model stores the topological relationship between triangles and their adjacent neighbors. A TIN allows for the efficient generation of surface models for the analysis and display of terrain surfaces. A TIN model can be used to generate contour lines and DEMs.



DTM, Interpolated Mass Point and Breaklines



TIN generation from Mass points and Breakline with generated contours