

## Introduction to the Chart Project

The Charles River in Massachusetts is an urban river that is also one of the most active recreational rivers in the country. Unfortunately, sediment deposition has been a long-standing problem in the Charles River. It was recently highlighted in articles published by the Boston Globe in 2011 and WGBH in 2016. In recent years, sediment deposits have caused several incidents that have resulted in damage to watercraft and personal injury. While the sediment appears to be a larger problem where major tributaries - Laundry Brook, Hyde Brook, Faneuil Brook, Muddy River, Stony Brook - empty into the Charles, once the sediment is in the river, it can spread to other areas, causing further problems, especially where it is already shallow. This problem is not limited to the areas upstream of the BU Bridge. A significant bar upriver of the Massachusetts Avenue Bridge is shallow enough and large enough to be a navigation hazard to both sailboats and motorboats. There are also extraordinary events, such as the 1996 flood of the Muddy River and the water main breaks in Weston in May 2010 and near the Anderson Bridge in August 2015, each of which caused large amounts of sediment to be moved.

It has been difficult to marshal the resources to remediate areas impacted by sedimentation since much of the knowledge about the shallows and bars has been anecdotal, coming from the daily experiences of the boaters on the river but not backed up by quantitative data. To address this issue, the Charles River Alliance of Boaters (CRAB) has developed a partnership with the MIT Sea Grant College Program to create a chart of the river depth between Science Park and the Watertown Dam, and to monitor changes in the river bottom in the future. Based upon some feasibility studies done in late 2015, more detailed and extensive measurements were undertaken in 2016 and 2017. To date, most of the river between Newton Yacht Club and the New Charles River Dam has been surveyed for depth and relative hardness of the river bottom.

The initial scope of the project is described below:

### 1. **Depth Measurement**

The project team used a Lowrance HDS-7 chartplotter/fishfinder with Point-1 GPS, HST-WSBL broadband, and LSS-2 sidescan sonar transducers for depth measurements. In areas of the river that are wide, survey lines were spaced between 30 and 65 feet apart and driven at speeds generally between 3 and 4.8 knots. Where the river is narrow, several passes were made up and down the river over multiple weeks. Broadband sonar was used during the entire survey, resulting in recordings of both depth and relative hardness of the river bottom, as well as time and position of each sonar reading. In addition, sidescan sonar was used downriver of the BU Bridge to capture images of the river bottom and objects of interest.

### 2. **Influence of Daily Water Releases**

As part of flood control measures, water from the river is released from the Charles River Dam into Boston Harbor at low tide

and held in the river at high tide. This causes the water level in the river to change several inches over the course of a day. A USGS [gauge](#) at the First Street Bridge in Cambridge records this variation in the height of the watersheet. While this gauge is a good measure of the river level downstream of the BU Bridge, there were no gauges between this location and the Watertown Dam.

In order to better understand the variation in watersheet over the entire survey area, the project team installed Crain 4 ft. stream gauges and Onset HOBO Model #U20L-04 Water Level Data Loggers at Riverside Boat Club, Herter Park, and Community Rowing facilities. These additional gauges provided insight into how the height of the watersheet varies along the length of the river. During the 2016 summer, the gauges indicate that the river acted as a lake, with the height of the watersheet varying uniformly along its gauged length within .1 ft. If there had been more rainfall or more substantial dam releases, it was expected that the height of the watersheet would have varied along the length of the river. We plan to keep the additional gauges installed for a few years and to monitor how the height of the watersheet changes during periods of significant rainfall.

In order to more accurately determine the depth of the river, all raw depth measurements have been adjusted to account for the variation in the height of the watersheet, and referenced to a First Street Bridge gauge height of 107.5 ft.



Sacarny and Yoder on Charles during survey. Note GPS visible above transom.

### 3. Development of Digital Charts

The raw sonar data gathered in the field was first processed using ReefMaster PRO mapping software. This generated two-dimensional contours of both depth and relative hardness that were then exported as ESRI shapefiles. ReefMaster was also used to construct sidescan sonar mosaics of the river bottom. ArcGIS ArcMap was used to organize additional geospatial data, including landmarks, elevated structures, detailed shorelines, and contour annotation into completed charts.

The web version of the chart is the product of a simplified workflow combining the best of ArcGIS and open-source web mapping frameworks. The refined, multi-layer map package developed in ArcMap is uploaded to ArcGIS Online, where the individual layers are made available as Web Map Services (WMSs). WMSs is then used to import the ArcGIS Online layers into a mobile-friendly, highly-customizable web environment coded in Leaflet and CartoDB javascript frameworks.

To enable public to access this data, the following formats have been developed:

- Chart Booklet: A printable PDF file that includes an overview of the river from Watertown to Charles River Dam, and more detailed charts of each section of the river. There are variants of the booklet for water depth and river bottom hardness.
- Large Format Overview: Intended for poster-sized printout, it presents a view of the entire river from Watertown to the Charles River Dam, showing river bottom depths and contours. This format is suitable to be displayed on the wall of every boathouse.
- Google Earth and Google Map: Online versions of the depth and relative hardness data using both Google Earth and Google Maps.
- Online GIS: Additional representations of the river data are openly available on the Sea Grant website at <http://seagrant.mit.edu/charleschart/>.

## Statement of Accuracy

**Vertical Uncertainty:** This chart represents depths as determined by fishfinder sonar and is based on echo from the top layers of sediments. Given these readings, transducer uncertainty, and related factors, the depth accuracy is stated as +/-5%. In areas of loose sediments, manual measurements could result in depths several tenths of a foot greater than those based on fishfinder sonar.

**Horizontal Uncertainty:** Based on specifications of the GPS used in the survey, horizontal accuracy is stated as 3m. except in areas where GPS satellite signal is degraded, such as under bridges, especially the Zakim Bridge. Uncertainty in lateral position may give rise to additional uncertainty in depth. Also, as an artifact of chart processing, depths immediately adjacent to walled sections above the BU Bridge are depicted as sloped contours rather than discrete steps.

## Project Personnel

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