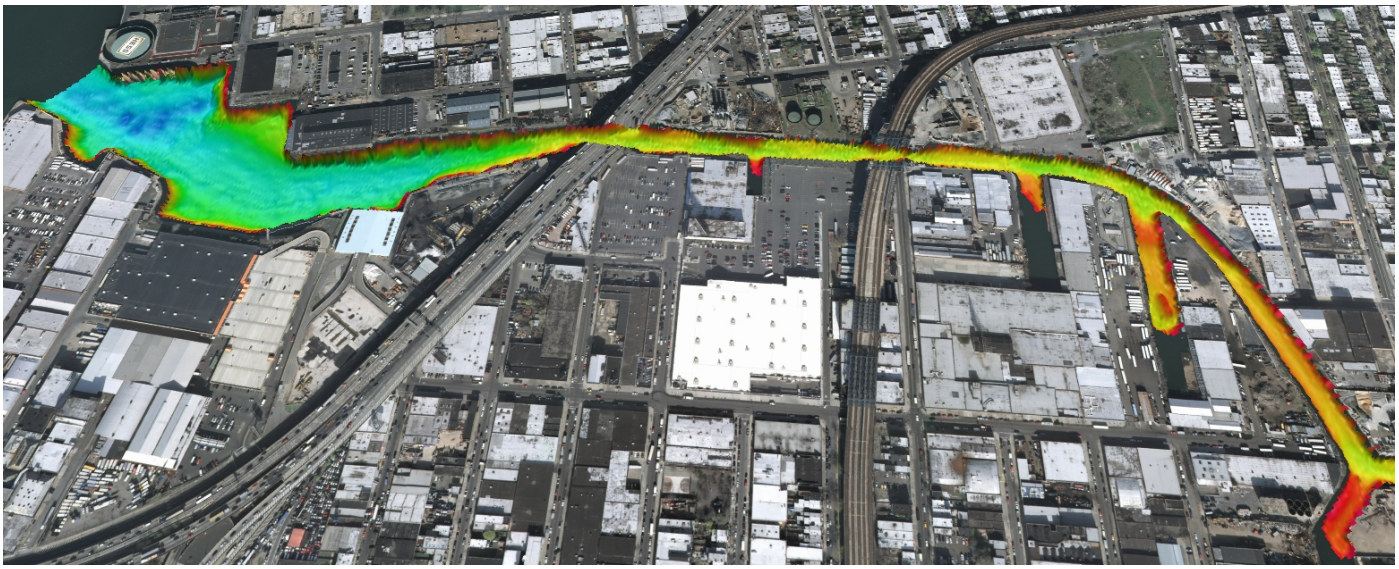
BATHYMETRIC SURVEY REPORT

GOWANUS CANAL

BROOKLYN, NEW YORK



3-D Visualization of a Portion of the Gowanus Canal Survey Area

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April 2010

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1.0 INTRODUCTION

CR Environmental, Inc. (CR) performed a bathymetric survey of part of Gowanus Bay and all navigable portions of the Gowanus Canal, located in Brooklyn, NY, on January 5, 2010 for Henningson, Durham and Richardson Architecture and Engineering, P.C. (HDR). The objective of the survey was to map seabed elevations within the Gowanus Canal Study Area in support of the ongoing Remedial Investigation/Feasibility Study (RI/FS). These data can be used to support volume calculations, estimates of changes in depth over time, and to assist in planning sediment sampling investigations.

This draft report summarizes the methods used for bathymetric data acquisition and the results obtained. Digital data products were transmitted electronically to HDR and CH2M Hill, Inc. on January 25, 2010 and also on a CD with the draft report submitted February 2010. Data are projected to New York State Plane (Long Island), NAD-83, U. S. Survey Feet. Seabed elevations are reported in U.S. Survey Feet relative to NAVD88 (estimated).

2.0 METHODS

The bathymetric survey was designed to meet or exceed the survey requirements specified by HDR in an August 2009 Request for Proposal. The executed survey methodology was in compliance with hydrographic survey standards promulgated by the U.S. Army Corps of Engineers (USACE, EM-1110-2-1003). Survey transects were designed using HYPACK 2009 hydrographic survey software. Background imagery including georeferenced orthophotos and USGS Quadrangles were obtained and imported to HYPACK to assist in the survey design.

Shore-parallel survey transects were spaced approximately 10 to 50 feet apart. Channel cross-sections were spaced 100 feet apart. Navigation for the survey was accomplished using Trimble AgGPS 132 and Trimble ProXRS 12-channel Differential Global Positioning Systems (DGPS) capable of receiving U.S. Coast Guard (USCG) Beacon corrections, and OmniStar subscription-based satellite differential corrections. Both systems provided real time digital positions accurate to less than 1 meter horizontally.

2.1 Survey Vessel

Two vessels were utilized for the survey. The primary survey vessel was the *M/V Donna Miller*, chartered from Miller's Launch in Staten Island, NY. This 25-ft aluminum work boat was used to conduct the survey in Gowanus Bay, and a portion of the work in the lower Gowanus Canal. The 12-ft survey *skiff* was utilized in the shallower portions of the Canal, and to conduct the survey work above the Carroll Street Bridge. Both vessels were outfitted with over-the-side transducer mounts, DGPS antenna brackets, and data acquisition computers. Neither vessel was equipped with ice breaking equipment, and because of this, the surveys were limited by the extent of any ice encountered in the Canal and turning basins.

2.2 Bathymetric Data Acquisition

The bathymetric data acquisition systems consisted of laptop computers running HYPACK 2009 hydrographic survey software, precision single-beam echo sounders and a Trimble DGPS. The echo sounders and DGPS were interfaced to the survey computers via RS-232 serial and Ethernet ports. Most depth measurements on the *Donna Miller* were acquired by simultaneous deployment of two survey-grade echo sounders in order to increase data density, productivity, and usability. The two echo sounders on the *Donna Miller* were an ODOM CV-100 precision echo sounder equipped with an 8-degree 200-kHz transducer, and a SyQwest Bathy500 precision echo sounder equipped with a 3-degree 200-kHz transducer. Depth measurements on the *skiff* were collected using a SyQwest HydroBox precision echo sounder equipped with an 8-degree 200-kHz transducer. The echo sounders digitized and recorded the seabed and exported depth values to HYPACK. The echo sounder transducers were mounted to the rails of the survey vessels amidships using high-strength adjustable booms. The DGPS antenna on the *skiff* was mounted directly over the transducer, eliminating the need to account for horizontal offsets. The DGPS antenna on the *Donna Miller* was mounted directly over the CV-100 transducer, and a precise horizontal offset was measured and entered into HYPACK to account for the offset from the Bathy500 transducer. The depth of each transducer below the water surface was measured both at the start and end of the survey.

The accuracy of the CV-100, HydroBox, and Bathy500 was approximately 0.1% of the water depth with a resolution of 0.1 foot. System accuracy was checked at the start and end of the survey day by comparing each echo sounder's water depth measurements to known water depths obtained using the bar check method, in which a metal plate is lowered beneath the echo sounder's transducer to several known distances (e.g., 5, 10, 15 and 20 ft below the water surface). Based on these comparisons, the systems were calibrated for shallow water conditions. Bar check calibrations for all three systems were consistently accurate to within 0.1 foot throughout the survey.

Additional calibrations were conducted in-situ by collecting water column profiles of sound velocity. Sound velocity in water can be determined based on measurements of temperature and conductivity. Measurements of water column temperature and conductivity were performed using a YSI, Inc. Model 6600 EDS-V2 water quality sonde, and a YSI, Inc. Model 85 Handheld Water Quality Meter.

2.3 Vertical Control

Vertical control for this survey was accomplished by using a cost-effective combination of techniques. GEOD Corporation, a NY Licensed Land Surveying firm, had established three vertical control points in support of CR's 2003 bathymetric surveying effort of the Canal (see Attachment 1). One benchmark was located in outer Gowanus Bay at the Columbia Street pier, one was located in the central reach of the Gowanus Canal at Bayside Fuel Corporation (537 Smith Street), and one was near the head of the Canal at the Carroll Street Bridge. GEOD was contacted and they conducted a site reconnaissance

which concluded that only the benchmark in the Bay and the benchmark at Carroll Street were still in existence and usable.

CR set two time-synchronized water level recorders, one near the upstream extent of the survey area and one near the downstream extent of the survey area in order to evaluate time and range offsets in water surface elevation during the survey. A new temporary benchmark (TBM-1) was established near the downstream limit of the survey area, adjacent to 629 Smith Street, and an In Situ, Inc. LevelTroll 500 water level recorder was suspended beneath this benchmark. An In Situ, Inc. LevelTroll 100 water level recorder was suspended beneath the upstream Carroll Street Bridge control point (BM-1). After the survey was completed, data from the two synchronized tide recorders were compared. CR determined that there was no quantifiable difference in tidal range or timing between the two locations during the survey (both flood and ebb around high tide). Thus, for the purposes of this survey, occupation of TBM-1 by a land survey firm was not required. Note, however, that the tidal gradient in the Canal surrounding low tide or under different wind conditions is unknown. The TBM-1 benchmark was clearly marked, and could be surveyed at any time if needed.

Per the request of Project advisors from CH2M Hill, Inc., the elevations from the January 2010 survey have been reported as "estimated" NAVD88 elevations. The Carroll Street benchmark elevation was reported by GEOD relative to NGVD29 (Attachment 1), and three methods were used to convert the benchmark elevation to NAVD88. First, the U.S. Army Corps of Engineers' (ACOE) datum conversion routine, Corpscon, was run to determine the offset between the two datums. Corpscon gave a result of -1.109 U.S. Survey Feet between NGVD29 and NAVD88. CR then contacted GEOD Corporation, and they confirmed that the separation between NGVD29 and NAVD88 was -1.11 feet. This value has been used to convert the soundings to estimated NAVD88 seabed elevations. The accuracy of the conversion was verified by comparing the NAVD88 adjusted tide data to NOAA's Battery tide series (Station ID: 8518750), adjusted for Gowanus Bay. This comparison suggested a -1.19 foot separation between datums.

2.4 Bathymetric Data Processing

Bathymetric data were processed using the HYPACK Single Beam Processor Module. Individual transect data were visually inspected in profile format, and components of processing included:

- Removal of outlying soundings associated with water column interference (e.g., fish, vegetation, or mid-water column debris);
- Adjustments of soundings for variations in sound velocity;
- Filtering of DGPS position data; and
- Conversion of soundings to estimated NAVD88 elevations based on a benchmark surveyed by GEOD Corporation in 2003, located near the Carroll Street Bridge. See Section 2.3 for a discussion of the vertical control for this project.

Neither water column interference nor sound velocity gradients influenced data quality, likely due to the cold dry weather which preceded the survey. However, DGPS position uncertainty was substantially increased by overhead obstruction and signal multipath near each of the bridge overpasses. Position data were filtered to retain only differentially corrected fixes with low dilution of position values. The locations of soundings beneath bridges were estimated based on interpolation between high-confidence DGPS fixes on either side of each bridge.

After performing data adjustments, the processed bathymetric data were combined into comma-delimited ASCII text files including fields for Northing, Easting, and Elevation. The data were imported to Golden Software, Inc. Surfer V.9.3 Surface Modeling Software and a digital elevation model (DEM) of seabed elevations was created using triangulation interpolation methods. A contour map depicting bottom elevations using a 0.5-foot contour interval was created from the DEM and the map was exported in DXF and SHP formats. A surface map of the bathymetric data was created using conventional hydrographic shading, artificial illumination, and a 2x vertical exaggeration to better illustrate bottom morphology. The surface map was exported as a georeferenced TIF image file.

3.0 BATHYMETRIC RESULTS AND DELIVERABLES

Processed bathymetric data, map layers, figures, and a copy of this report are attached on the project CD. Occupied survey transects (i.e., sounding tracklines) are depicted on Figures 1A and 1B. The increased data density afforded through simultaneous use of two echo sounders is readily apparent. Access to inner portions of all four turning basins was precluded by ice. DGPS signal quality was compromised near all bridges. This degradation was most severe beneath the 9th Street Bridge.

Elevations reported during the survey ranged from approximately -0.13 feet to -38 feet NAVD88, as illustrated by the contour and DEM layers presented on Figures 2A and 2B. Prop scours from tug boat operations are visible on the seabed near the downstream limit of the survey area.

Although single-beam bathymetry is not considered an effective tool for identifying underwater obstructions, wreckage is clearly visible in data collected from the turning basin between 5th Street and 6th Street. This feature extends above the water surface at all tides and is clearly visible from shore and in aerial photographs. Submerged wreckage or large debris is also suggested near the mouth of the upstream turning basin. Data suggests the widespread presence of other debris throughout the survey area. Mapping of these features will require side scan or multibeam sonar surveys.

Bathymetric data quality was assessed by comparing approximately co-located soundings along perpendicular transects. These “cross-tie” comparisons were conducted on the final merged data set, and included points collected using all three sounding systems on both vessels over a tidal range of 2.6 feet. Examination of 337 of these co-located soundings revealed a negligible arithmetic mean difference (depth bias) of -0.025

feet, and a standard deviation (SD) of the residuals of ±0.30 feet. Considering cross-tie comparisons across the full project depth range (38 feet), the root mean squared (RMS) error was 0.62 feet at the 95% Confidence Interval (CI), less than the most stringent Army Corps of Engineers (ACOE) requirement of 1.0 foot for navigation and dredging projects in water depths of 15 to 40 feet. Data collected from the *skiff* in water depths less than 15 feet had a RMS at the 95% CI of 0.27 feet, less than the 0.5-foot ACOE specification for this water depth.

International Hydrographic Organization (IHO) Special Order specifications for a survey in depths of 5 meters (16.4 feet) would call for a 95% CI of 0.8 feet (max SD = 0.42). IHO Special Order specifications for a survey in depths of 10 meters (32.8 feet) calls for a 95% CI of 0.9 feet (max SD = 0.44).

We, therefore, conclude that the quality of data generated by this survey is compliant with ACOE and IHO guidelines. Some of the variation in "cross-tie" comparisons is associated with the steep slopes and engineered headwalls which dominate the Canal margins. These slopes and headwalls cause vertical discontinuity between soundings run in different directions. In addition, the slight variation between some soundings suggests the presence of a surficial floc layer on the seabed which was intermittently penetrated by the ODOM and SyQwest sounding systems.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The January 2010 bathymetric survey of the Gowanus Canal generated an accurate database and map of seabed elevations and morphometry. Ice prevented access to small sections of the Canal's turning basins, and active and derelict barges and other vessels hindered navigation in some portions of the Canal's main channel. Further bathymetric survey work will be required to characterize these areas, and additional soundings should be collected in the vicinity of the 9th Street Bridge using a smaller vessel which does not require Bridge openings for access. Finally, the use of side scan sonar to accurately locate and characterize submerged debris which could pose a danger to sediment sampling or potential future dredging efforts is recommended.