Bathymetric Survey of the Guadalupe River

December 2010 Survey

Prepared by:

The Texas Water Development Board

May 2011

Prepared for:

Rebecca Creek Municipal Utility District

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Published and Distributed by the
Texas Water Development Board
P.O. Box 13231
Austin, TX 78711-3231

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Note: References to brand names throughout this report do not imply endorsement by the Texas Water Development Board

Introduction

The Hydrographic Survey Program of the Texas Water Development Board (TWDB) was authorized by the 72nd Texas State Legislature in 1991. The Texas Water Code authorizes TWDB to perform surveys to determine reservoir storage capacity, sedimentation levels, rates of sedimentation, and projected water supply availability.

In December 2010, TWDB entered into agreement with Rebecca Creek Municipal Utility District, to perform a bathymetric survey of a section of the Guadalupe River, Texas (TWDB, 2010). This report describes the methods used to conduct the bathymetric survey, including data collection and processing techniques. This report serves as the final contract deliverable from TWDB to the Rebecca Creek Municipal Utility District and includes a contour map of the river-bottom surface in the surveyed area.

Bathymetric survey of the Guadalupe River

General Information

The section of the Guadalupe River designated for study by the Rebecca Creek Municipal Utility District is located near the upper reaches of Canyon Lake (Figure 1). The area was defined as a section of the river starting with the downstream coordinates 29º 53’ 51.30” N 98º 18” 43.95” W and ending at the upstream coordinates 29º 54’ 19.32” N 98º 19’ 54.39” W. Canyon Lake is located about 12 miles northwest of the city of New Braunfels in Comal County, Texas. The U.S. Government owns Canyon Lake, including the dam, appurtenant structures, and flowage easments (lands surrounding the lake up to elevation 948.0 feet) (TWDB, 1971, TWDB, 2001). The U.S. Army Corps of Engineers, Fort Worth District, operates and maintains the facility. Construction on Canyon Lake began on June 27, 1958. Deliberate impoundment began on June 16, 1964, and the dam was completed on August 22, 1964 (TWDB, 1971). Canyon Dam was built for water supply storage for local municipalities, flood protection for those downstream, and recreational uses (USACE, 2011). Water rights to the conservation pool of the reservoir, below 909.0 feet, are appropriated to the Guadalupe-Blanco River Authority through Certificate of Adjudication No. 18-2074 and its amendments. The certificates are on file in the Records Division of the Texas Commission on Environmental Quality.

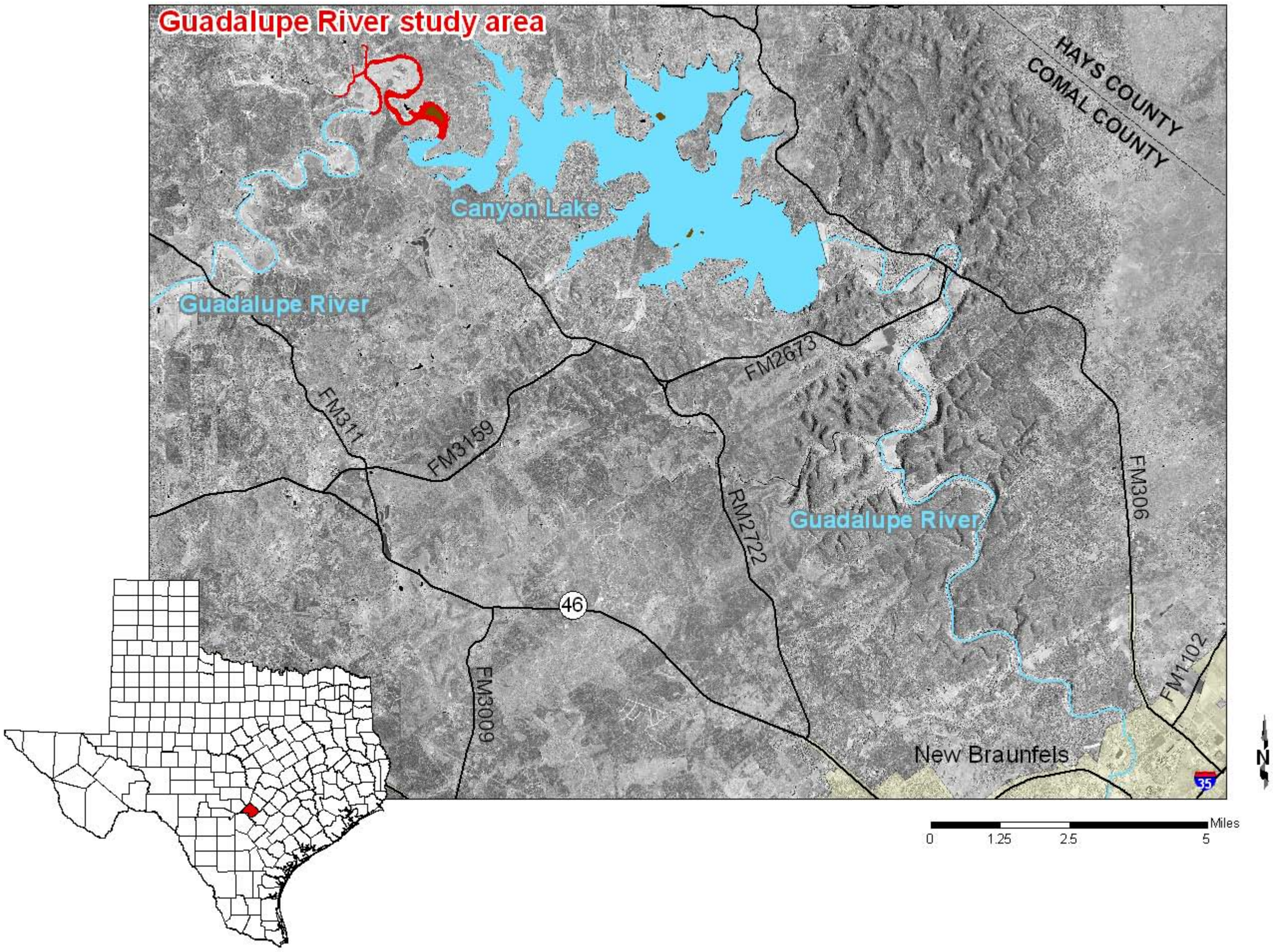

Figure 1. **Location Map - Guadalupe River study**

Datum

The vertical datum used during this survey is that used by the United States Geological Survey (USGS) for the reservoir elevation gage USGS 08167700 Canyon Lake near New Braunfels, TX (USGS, 2010). The datum for this gage is reported as National Geodetic Vertical Datum 1929 (NGVD29). Elevations reported here are in feet above mean sea level. Volume and area calculations in this report are referenced to water levels provided by the USGS gage. The horizontal datum used for this report is North American Datum 1983 (NAD83), and the horizontal coordinate system is State Plane Texas South Central Zone (feet).

TWDB bathymetric data collection

TWDB collected bathymetric data on the Guadalupe River on December 22 and 23, 2010. The water surface elevation of Canyon Lake during that time ranged between 907.87 feet and 907.84 feet above mean sea level (NGVD29). TWDB used a Specialty Devices, Inc., single-beam, multi-frequency, (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with differential global positioning system (DGPS) equipment, but only the 200 kHz returns representing the current bottom surface were processed for this study. Data collection occurred while navigating along pre-planned range lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 250 feet apart. Many of the survey lines were those originally surveyed by TWDB during the 2000 volumetric survey of Canyon Lake (TWDB, 2001). The depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. During the 2010 survey, team members collected nearly 27,300 data points over cross-sections totaling approximately 28 miles in length. Figure 2 illustrates locations of data collection during the 2010 TWDB survey.

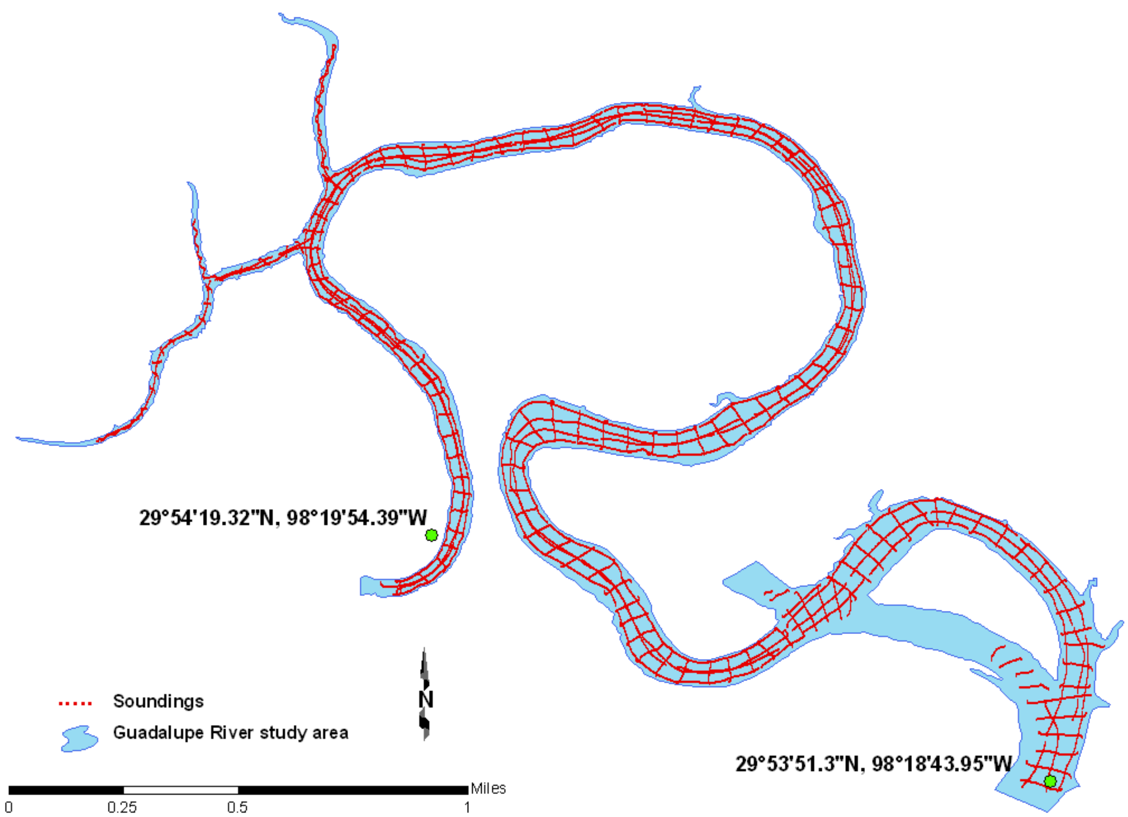

Figure 2. **Survey data collected during 2010 TWDB survey**

Data processing

Model boundary

The river boundary of the reach surveyed was digitized from digital orthophoto quarter-quadrangle images (DOQQs), obtained from the Texas Natural Resources Information System (TNRIS), using Environmental Systems Research Institute's (ESRI) ArcGIS 9.3.1 software (NAIP, 2006, TNRIS, 2009). The DOQQs that cover the study section of the Guadalupe River are Fischer SW and Fischer SE. The DOQQs were photographed on May 2, 2010, while the water surface elevation measured 909.89 feet above mean sea level. The 2010 DOQQs have a resolution of 1-meter. The river's boundary was digitized from the land water interface visible in the photos and assigned the elevation 909.89 feet.

Triangulated Irregular Network model

Following completion of data collection, the raw data files collected by TWDB were edited using the software DepthPic to remove data anomalies. DepthPic is used to display, interpret, and edit the multi-frequency data and to manually identify the river-bottom surface. The water surface elevations at the times of each sounding were used to convert sounding depths to corresponding river-bottom elevations. For processing outside of DepthPic, the sounding coordinates (X,Y,Z) were exported. Using the self-similar interpolation technique (described below), TWDB created additional mass points files of interpolated bathymetric elevation data located between surveyed cross sections. The points file resulting from data interpolation was used in conjunction with the sounding and boundary files to create a Triangulated Irregular Network (TIN) model with the 3D Analyst Extension of ArcGIS. The 3D Analyst algorithm uses Delaunay's criteria for triangulation to create a grid composed of triangles from non-uniformly spaced points, including the boundary vertices (ESRI, 1995).

The TIN model was then converted to a raster representation using a cell size of 1 foot by 1 foot. The bathymetric contours of the river were extracted from this raster and presented in 5 feet intervals in the attached contour map.

Self-similar interpolation

The 3D Analyst extension utilizes the Delaunay method for triangulation. A limitation of the Delaunay method for triangulation when creating TIN models results in artificially-curved contour lines extending into the river where the river channel banks are steep and the river is relatively narrow. These curved contours are likely a poor representation of the true river bathymetry in these areas. Also, if the surveyed cross sections are not perpendicular to the centerline of the submerged river channel (the location of which is often unknown until after the survey), the TIN model is not likely to represent the true channel bathymetry well.

To ameliorate these problems, a self-similar interpolation routine developed by TWDB was used to interpolate the bathymetry between many survey lines. The self-similar interpolation technique increases the density of points input into the TIN model, and directs the TIN interpolation to better represent the river topography between cross sections (Furnans, 2006). In the case of the Guadalupe River, the application of self-similar interpolation helped represent the lake morphology near the banks and improved the representation of the submerged river channel (Figure 3). In areas where obvious geomorphic features indicate a high-probability of cross-sectional shape changes (e.g. incoming tributaries, significant widening/narrowing of channel, etc.), the assumptions used in applying self-similar interpolation are not likely to be valid. Therefore, interpolation was not used in areas of the Guadalupe River where a high probability of change between cross-sections exists. Figure 3 illustrates typical results from the self-similar interpolation routine for the Guadalupe River. In Figure 3A, the higher elevation contour lines near the river's bank extend inward towards the center of the river channel, producing irregular channel topography. This is an undesired effect of the TIN generation routine, rather than an accurate representation of the physical bathymetric surface. Inclusion of self-similar points (3B) corrects and smoothes the bathymetric contours and the bathymetry shown in Figure 3C was used to produce the final contour map of the study area.

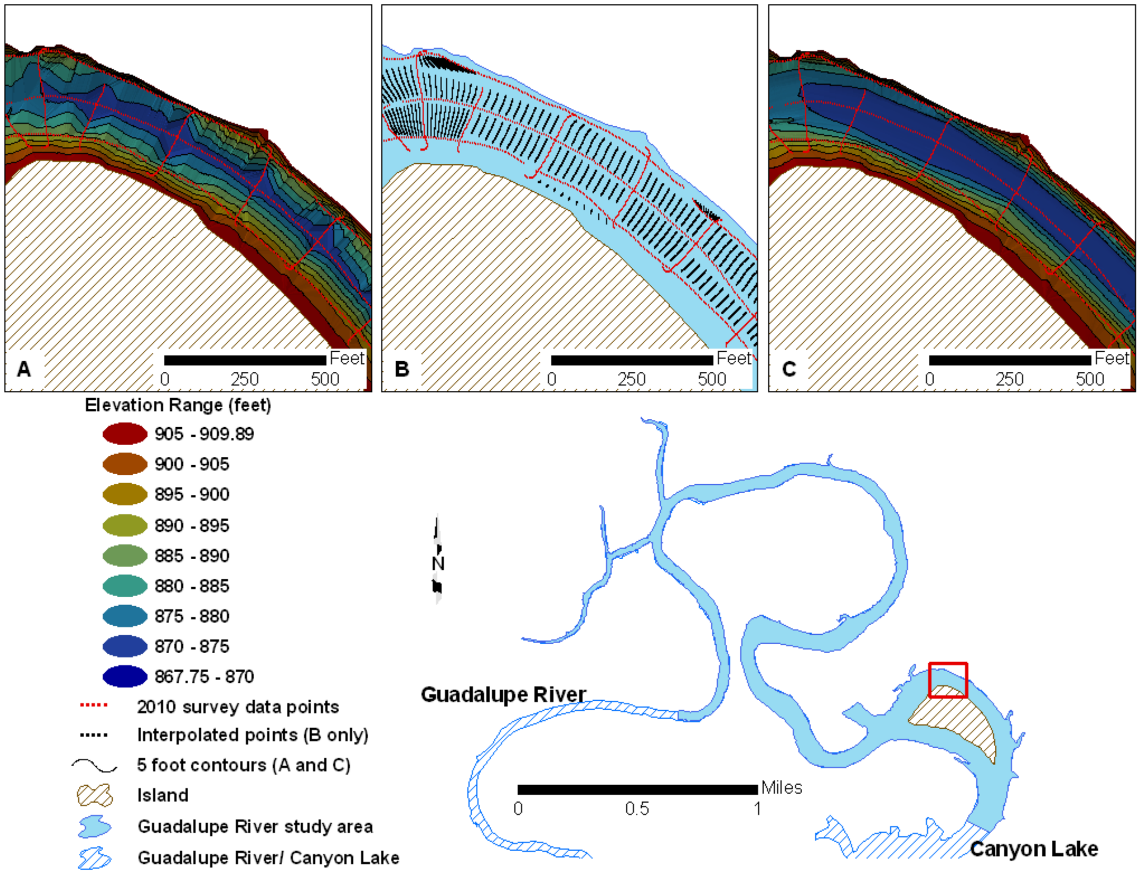

Figure 3. **Application of the self-similar interpolation technique to the Guadalupe River sounding data – A) bathymetric contours without interpolation, B) sounding points (red) and interpolated points (black) with river boundary at elevation 909.89 feet, C) bathymetric contours with interpolation.**

TWDB contact information

More information about the Hydrographic Survey Program can be found at:

http://www.twdb.state.tx.us/assistance/lakesurveys/volumetricindex.asp

Any questions regarding the TWDB Hydrographic Survey Program may be addressed to:

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References

ESRI (Environmental Systems Research Institute), 1995, *ARC/INFO Surface Modeling and Display, TIN Users Guide*, ESRI, 380 New York Street, Redlands, CA 92373.

Furnans, Jordan., 2006, *HydroEdit User's Manual*, Texas Water Development Board.

NAIP (National Agriculture Imagery Program), 2010, http://www.fsa.usda.gov/FSA/apfoapp?area=home&subject=prog&topic=nai, accessed February 2011.

TNRIS (Texas Natural Resources Information System), 2009, http://www.tnris.state.tx.us/, accessed January 2011.

TWDB (Texas Water Development Board), 2010, Contract No. 1148011205 with the Rebecca Creek Municipal Utility District.

TWDB (Texas Water Development Board), 2001, Volumetric Survey of Canyon Lake, http://www.twdb.state.tx.us/hydro_survey/Canyon2001/CanyonLake.pdf., accessed January 2011.

TWDB (Texas Water Development Board), 1971, *Canyon Dam and Canyon Reservoir*, Report 126, Engineering Data on Dams and Reservoirs in Texas, Part III.

USACE (United States Army Corps of Engineers, Fort Worth District), 2011, Canyon Lake Official Web Page, http://www.swf-wc.usace.army.mil/canyon/, accessed February 10, 2011.

USGS (United States Geological Survey), 2010, U.S. Geological Survey National Water Information System: Web Interface, *USGS Real-Time Water Data for USGS 08167700 Canyon Lk nr New Braunfels, TX*, http://waterdata.usgs.gov/tx/nwis/uv/?site_no=08167700&PARAmeter_cd=00062,72020,00054, accessed January 4, 2011.

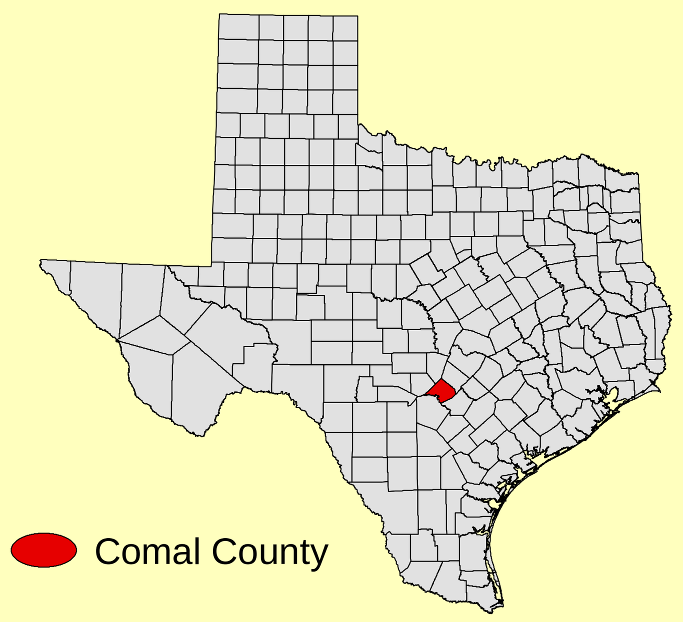
Figure 4

Elevations
(feet above mean sea level)

- 905.1 - 909.89
- 900.1 - 905
- 895.1 - 900
- 890.1 - 895
- 885.1 - 890
- 880.1 - 885
- 875.1 - 880
- 870.1 - 875
- 867.8 - 870
- Island
- Guadalupe River/ Canyon Lake
- 5' Contours

Conservation Pool Elevation of Canyon Lake:
909.0 feet above mean sea level
River modeled to elevation:
909.89 feet above mean sea level

Projection: NAD83
State Plane
Texas South Central Zone



This map is the product of a survey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the bathymetry of a section of the Guadalupe River. The Texas Water Development Board makes no representations nor assumes any liability.