Clean Water Act Section 319(h) Nonpoint Source Pollution Control Program Project

Lake Granger Watershed Planning and Implementation Project
TSSWCB Project # FY05-9

Quality Assurance Project Plan

Texas State Soil and Water Conservation Board

prepared by

Texas AgriLife Blackland Research and Extension Center
Water Quality

Effective Period: September 1, 2005 to August 31, 2010

Questions concerning this quality assurance project plan should be directed to:

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Section A1 Approval Sheet

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Texas AgriLife Blackland Research and Extension Center (BREC)

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Signature: ______________________________ Date:___________________

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Title: Quality Assurance Officer and Hydrographic Field Operations Manager

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Section A2: Table of Contents

List of Figures

List of Acronyms and Abbreviations

BMP	best management practices
BRA	Brazos River Authority
CAR	corrective action report
CPE	conservation pool elevation
CWA	Clean Water Act
DGPS	differential global positioning system
DTM	digital terrain model
DQO	data quality objectives
GIS	geographic information system
GPS	global positioning system
NAD83	North American Datum of 1983
NGS	National Geodetic Survey
NGVD29	National Geodetic Vertical Datum of 1929
NMAS	National Map Accuracy Standard
NPS	nonpoint source
NRCS-WRAT	Natural Resources Conservation Service – Water Resources Assessment Team
NTU	nephelometric turbidity units
PM	project manager
QA	quality assurance
QAO	quality assurance officer
QAPP	quality assurance project plan
QC	quality control
SONAR	sound navigation ranging
SOP	standard operating procedure
SWAT	Soil and Water Assessment Tool
TIFF	tagged image file format
TSSWCB	Texas State Soil and Water Conservation Board
TWDB	Texas Water Development Board
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency (Region 6 implied)
USGS	United States Geological Survey

Section A3: Distribution List

Organizations, and individuals within, which will receive copies of the approved QAPP and any subsequent revisions include:

United States Environmental Protection Agency (USEPA), Region VI

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Title: Research Scientist

Name: Jason McAlister
Title: Quality Assurance Officer and Hydrographic Field Operations Manager

Section A4: Project/Task Organization

A4.1 Project Organization

This project effort will be led by U.S. EPA Region VI. Primary participants will include Texas State Soil and Water Conservation Board (lead administrator for Texas Agricultural and Silvicultural Nonpoint Source Pollution Program), Brazos River Authority and Little River-San Gabriel Soil and Water Conservation District (who will serve as co-leads for project entitled "*Lake Granger Watershed Planning and Implementation Project*", and Blackland Research and Extension Center (who will perform work under the Survey of Lake Bottom Sediment Thickness and Distribution for Granger Lake, contract #05-09B. Responsibilities of specific individuals for quality assurance/quality control (QA/QC), and data reduction and reporting are given in subsequent relevant sections of the Quality Assurance Project Plan (QAPP). The following is an overview of individuals and organizations participating in the project with their specific roles and responsibilities:

USEPA – Provides project overview and funding at the Federal level.

Henry Brewer, USEPA Texas Nonpoint Source Project Officer
Responsible for overall performance and direction of the project at the Federal level. Ensures that the project assists in achieving the goals of the federal Clean Water Act (CWA). Reviews and approves the QAPP, project progress, and deliverables.

TSSWCB - Provides project overview and funding at the state level.

Pamela Casebolt, TSSWCB Project Manager
Responsible for ensuring that the project delivers data of known quality, quantity, and type on schedule to achieve project objectives. Provides the primary point of contact between the Texas State Soil and Water Conservation Board (TSSWCB) and the Brazos River Authority (BRA). Tracks and reviews deliverables to ensure that tasks in the work plan are completed as specified. Reviews and approves QAPP and any amendments or revisions and ensures distribution of approved/revised QAPPs to TSSWCB and USEPA participants. Responsible for verifying that the QAPP is followed by BRA and BREC participants. Notifies the TSSWCB Quality Assurance Officer (QAO) of significant project nonconformances and corrective actions taken.

Donna Long, TSSWCB QAO
Responsible for determining that the project meets the requirements for planning, quality control (QC), quality assessment, and reporting under the CWA Section 319 program. Assists the TSSWCB Project Manager (PM) on quality assurance (QA)-related issues. Reviews and approves the QAPP and any amendments or revisions. Conveys QA problems to appropriate TSSWCB management. Monitors implementation of corrective actions. Coordinates or conducts audits of field and laboratory systems and procedures.

BRA – Responsible for coordination, development, and delivery of quarterly reports and the final project report.

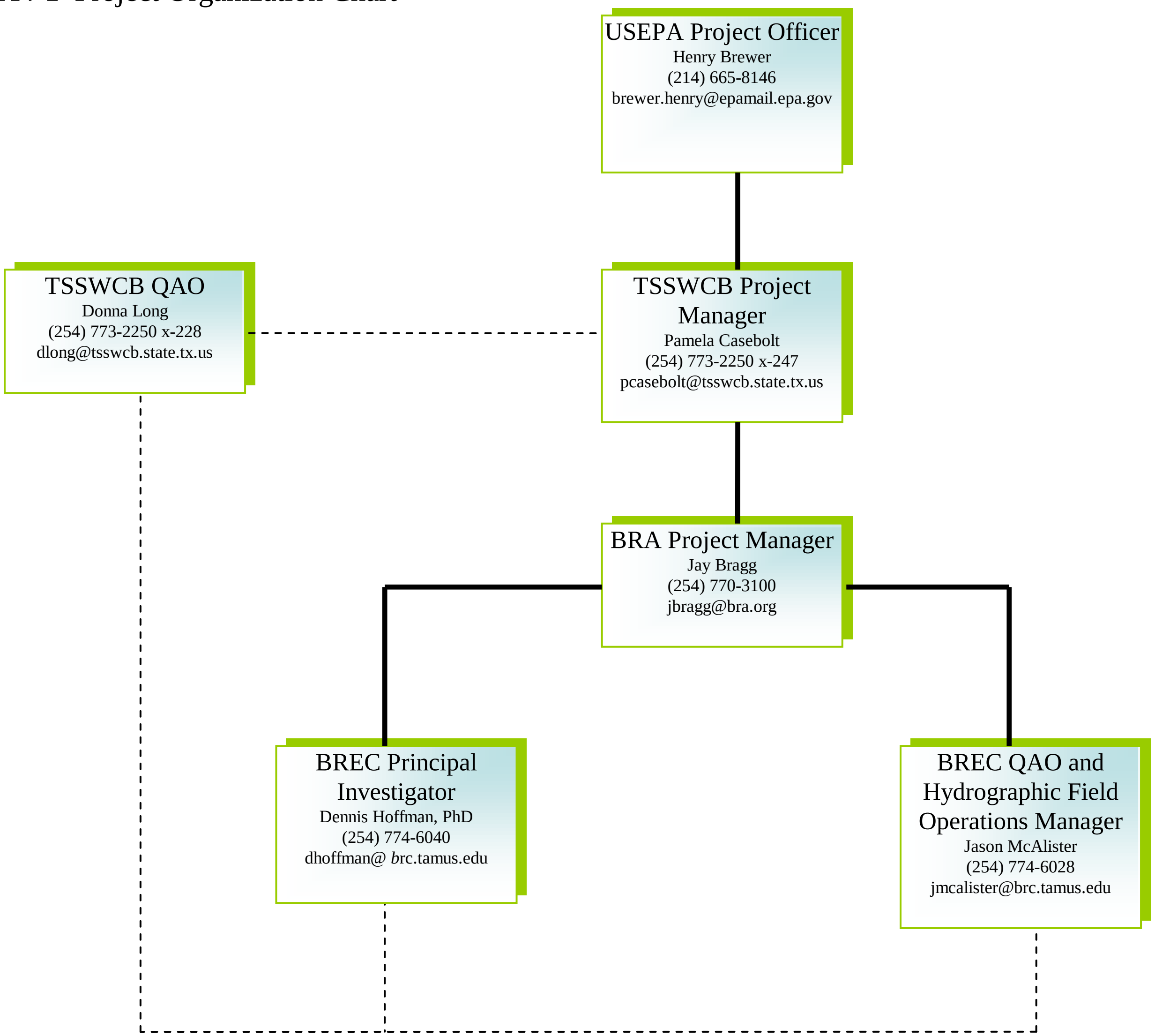
Jay Bragg, Regional Environmental Planner
Responsible for ensuring that tasks and other requirements in the contract are executed on time and with the QA/QC requirements in the system as defined by the contract work plan and in the QAPP; assessing the quality of sub-participant work; submitting accurate and timely deliverables to the TSSWCB PM; and coordinating attendance at conference calls, training, meetings, and related project activities with the TSSWCB. Responsible for overall supervision and technical direction for hydrographic and sediment mapping of Granger Lake. Responsible for verifying that the QAPP is distributed and followed by the BREC water quality staff, and that the data produced is of known and acceptable quality. Responsible for ensuring adequate training and supervision of all activities involved in generating analytical data by the BREC water quality staff. Responsible for the facilitation of audits and the implementation, documentation, verification and reporting of corrective actions. Responsible for coordination, review, and delivery of quarterly reports and the final project report.

BREC – Responsible for reporting tasks for the contracted work (hydrographic and sediment mapping of Lake Granger) including development of data quality objectives (DQOs) and a QAPP. Responsible for sound navigation ranging (sonar) data collection, data analysis and QA procedures for that task. BREC will contribute to the development of quarterly reports and the final project report.

Dr. Dennis Hoffman, BREC Water Quality Research Scientist
Responsible for verifying that the QAPP is followed by the BREC water quality staff, and that the data produced is of known and acceptable quality. Responsible for ensuring adequate training and supervision of all activities involved in generating analytical data by the BREC staff. Responsible for the facilitation of audits and the implementation, documentation, verification and reporting of corrective actions. Responsible for submitting accurate and timely data analyses and contributions for progress and final reports to the BRA PM. Responsible for ensuring that tasks and other requirements in the contract are executed on time and as defined by the grant work plan; assessing the quality of work by staff; submitting accurate and timely deliverables and costs to the BRA PM; and coordinating attendance at conference calls, training, meetings, and related project activities with the BRA.

Jason McAlister, QAO and Hydrographic Field Operations Manager
Responsible for technical direction and implementation of hydrographic data collection/generation of analytical data, analysis, modeling, and mapping. Responsible for submitting accurate and timely contributions for progress and final analysis to the BREC Water Qualtiy Research Scientist and BRA PM. Responsible for ensuring that tasks and other requirements in the contract are executed on time and with the QA/QC requirements in the system as defined by the contract work plan and in the QAPP.

Figure A4-1 Project Organization Chart



Section A5: Problem Definition/Background

The Natural Resources Conservation Service Water Resource Assessment Team (NRCS-WRAT) conducted the Volumetric Survey of Lake Granger in 1995 for the Brazos River Authority. The purpose of the survey was to determine the capacity of the lake at the conservation pool elevation (CPE) and to establish a baseline for future surveys. In 1980 when Granger Lake first started impounding water, initial storage calculations estimated that the volume of the lake at CPE to be 65,510 acre/feet. The October 1995 survey determined the volume of the lake to be 54,280 acre/feet. The loss of 11,230 acre/feet over the 15 year life of the lake represented 17% of total storage at a rate of 748.67 acre/feet per year (1,343,095 tons of sediment /year).

In 2002 the Texas Water Development Board (TWDB) conducted a similar survey to determine the sediment loadings from October 1995 to April 2002. Results indicate a loss of 1,319 acre/feet in the 6 and ½ years between the surveys representing a loss of 202.92 acre/feet per year (364,033 tons of sediment/year). There is a distinct difference in the annual loss of volume in the lake between 1980-1995 and 1995-2002. These differences are directly related to rainfall and storm intensity.

In 1999 the NRCS-WRAT, at the request of the BRA, conducted a separate study of the Granger Lake watershed using the Soil and Water Assessment Tool (SWAT) basin model to assess flow and sediment loads and the effects of various Best Mangement Practices (BMPs) to those sediments. Modeling results indicated that a combination of conventional conservation practices has the potential to reduce sediment loads by 20-30%. Other practices such as stream bank restoration and created wetlands were not taken into account in the study.

Williamson County is currently the fourth fastest growing county in the country. Lake Granger currently serves as a drinking water supply reservoir for approximately 20,000 residents of Williamson County. The public drinking water demands on the lake are expected to increase to exceed 100,000 residents in the next five to ten years. As the population continues to grow in this area, it becomes increasingly important to protect and preserve the water quality of Lake Granger. 1999 land use photography indicated that approximately 33% of the watershed is Brushy rangeland, 24.5% is open rangeland, 20.5% is row crop agriculture, and 11% is pasture and hayland, and the remaining 11% is Urban. While only 20.5% of the watershed is row crop, the soils and proximity of the cropland to the lake make it the main contributor to sediment loadings. Technical and financial assistance are needed to assist landowners with implementing best management practices that will reduce agricultural runoff.

The BRA owns and operates the East Williamson County Regional Water System that treats water from Lake Granger. Sedimentation into the reservoir not only threatens to reduce the firm yield of the reservoir but also causes significant problems in treating the water. Turbidities above 200 ntu (Nephelometric turbidity units) are common with turbidity spikes exceeding 5000 ntu. Treating these high levels of turbidity to achieve the 0.1 ntu drinking water standard results in increased treatment costs that must be passed on to customers.

Section A6: Project/Task Description

This project will provide the Little River-San Gabriel Soil and Water Conservation District (SWCD) and the Taylor SWCD with funding for technical assistance and financial assistance to implement best management practices through conservation planning. To better direct these efforts in the future, and to help quantify impact of these measures, the Brazos River Authority has contracted with BREC to conduct a high resolution hydrographic and sediment mapping survey of Granger Lake (BRA, 2005); this, to determine current lake capacity and quantity/distribution of lacustrine sediments.

Survey of Lake Bottom Sediment Thickness and Distribution for Granger Lake

BREC will conduct a high-resolution hydrographic survey of Granger Lake using a Knudsen Engineering, Ltd. Model 320 B/P dual frequency (28/200 kHz) Echo Sounding System. The hydrographic survey and modeling of Granger Lake will begin in spring of 2007. A follow-up survey will be performed prior to project completion. Digital echo sounder profiles will be obtained on overlapping grids in order to provide high-resolution lake bathymetry and sediment distribution coverage. The objective of the survey is to produce an accurate, up-to-date hydrographic dataset containing bank-to-bank data (where possible) for Granger Lake, as part of the Lake Granger Watershed Assessment and Implementation Project. From this, current holding capacity at CPE will be identified. A second objective of this survey is to assess and quantify the amount of sediment currently in Granger Lake. Digital echo sounder profiles will be obtained on overlapping grids in order to provide high-resolution sediment distribution coverage.

A follow-up survey will compare the amount of actual sediment deposition between subsequent surveys to help determine the success of the BMP implementation efforts by the local Soil and Water Conservation Districts and others. Results of both surveys may be used to support the following watershed activities: 1) evaluation of potential sediment transport conditions within the watershed, and 2) assist in selection of watershed land areas where additional erosion reducing BMPs may effectively address these conditions.

Project Deliverables:

Hardcopies and digital maps of Granger Lake complete with depth contours and capacity information derived from hydrographic digital terrain modeling (DTM).

Hardcopy and digital maps showing unconsolidated sediment distribution and thickness in Granger Lake derived from hydrographic DTM.

Quantitative estimate of total unconsolidated sediment within the lake derived from hydrographic DTM.

Figure A6-1. Coverage for hydrographic survey of Granger Lake

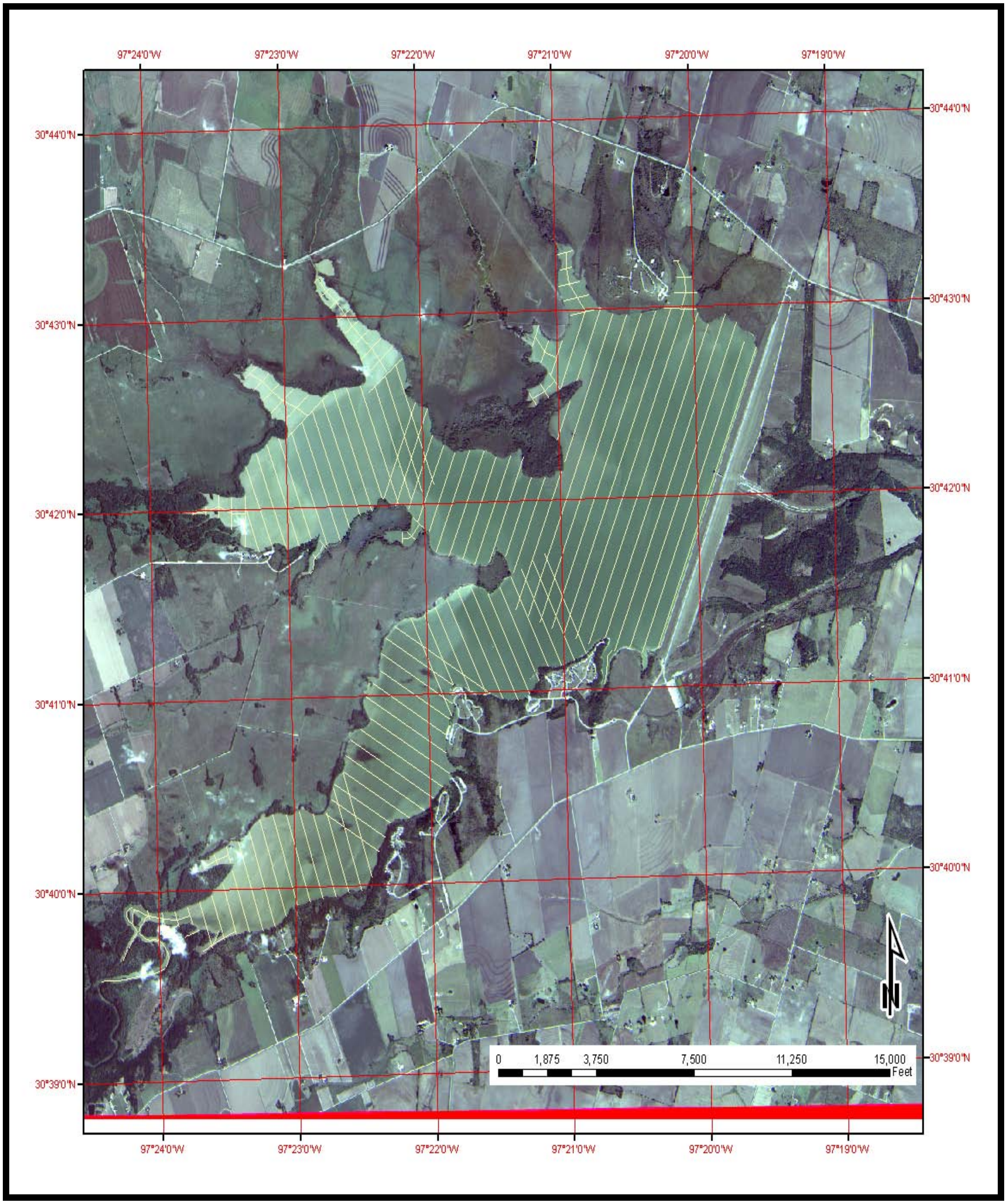


Table A6-1. Project Plan Milestones

TASK	PROJECT MILESTONES	AGENCY	START	END
1.1	BRA will assemble a stakeholder group that will provide input and assist in the development of a WPP.	BRA	Sep-05	Aug-10
1.2	After the completion of the WPP, the stakeholder group will meet annually or as needed to discuss the progress of implementation and identify alternative management measures and funding sources	BRA	Aug-10	Aug-10
2.1	Determine the most appicable and cost effective BMPs to reduce sediment loadings into Granger Lake	LR-SG SWCD	Sep-05	Aug-10
2.2	Notify producers and landowners within the Granger Lake watershed of the project and post an initial sign-up period	LR-SG SWCD	Sep-05	Aug-10
2.3	Accept applications for cost-share assistance, meet with landowners/producers, and rank applications.	LR-SG SWCD	Sep-05	Aug-10
2.4	Assist landowners and producers with implementing conservation practices.	LR-SG SWCD	Sep-05	Aug-10
3.1	Develop a QAPP for monitoring that will be evaluated and approved by the TSSWCB and EPA	BREC	Jul-10	Oct-10
3.2 *	The BRA will conduct routine monitoring at 4 sites.	* (not covered in the scope of this QAPP)		
3.3	The BRA will contract with the Blackland Research and Extension Center (BREC)	BREC	Jan-06	Aug-10
3.3.1	BRC conducts Bathymetric Survey	BREC	Jan-07	Feb-07
3.3.2	BRC conducts follow-up survey - upon completion of major implementation activities	BREC	Jun-10	Jul-10
4.1	LR-SG SWCD will provide BRA with information regarding total BMPs implemented in each sub-watershed and a compliation of RULSE calculations so the data can be included in the final report	LR-SG SWCD	Jun-10	Aug-10
4.2	BRA will compare water quality data to implementation data in an attempt to quantify the benefits of the projects	BRA	Jun-10	Aug-10
4.3	Prepare and distribute a final report	BRA	Jun-10	Aug-10

Section A7: Quality Objectives And Criteria For Measurement Data

The primary objectives of this project are to quantify current capacity at CPE for Granger Lake, and to identify, quantify, and accurately map the areas of sediment deposition in Granger Lake. Achievement of these objectives will support decisions on how to best target implementation and/or management measures to reduce sediment loadings into Granger Lake.

The data quality and targeted methods selected for this survey will be obtained using state-of-the-art equipment and technology, and will meet the data needs presented in Section A6. After data processing, the completeness of final data (i.e., bathymetric coverage) will be evaluated in consultation with BRA to determine if there are data gaps requiring alternative surveying methods. The overall data quality objective for this project is to develop and implement procedures that will ensure the collection of representative data of known, acceptable, and defensible quality. Parameters used to assess data quality include precision, accuracy, representativeness, comparability, completeness, and sensitivity. These data quality parameters are discussed as follows:

Precision: The measure of agreement among repeated measurements will be evaluated during data processing using the HyPack® Cross Check Statistics by comparing vertical measurements of intersecting survey lines. The program provides a statistical report showing the standard deviation distribution and average error. The output report contains detailed information for every intersecting point. For horizontal accuracy, a latency test will be performed using a redundant survey line to compare and correct time lag between GPS and sonar communication/data logging. During post processing and editing of collected data., tracklogs for each survey line are displayed; from this, planned survey lines (constructed in advance of actual survey) are compared to the actual recorded location at time of survey, or to previous data collection locations.

Accuracy: The target horizontal accuracy is 3 ft at a 95% confidence level and target vertical accuracy is +/- 0.5 ft at a 95% confidence level. These accuracy levels meet the minimum performance standards for soft bottom material navigation and dredging support surveys in the USACE hydrographic surveying engineering manual (USACE 2002), and further described in Section B2 (Positioning). Accuracy will be demonstrated in the cross-check analysis, which provides a confidence level for each sonar frequency.

Representativeness: The overall degree to which the data appropriately reflect the Granger Lake environment will be evaluated through visual analysis of the resulting digital terrain model (DTM) to identify data anomalies or artifacts, manual lead line sounding and sediment probing of lake bottom, and through comparison to prior surveys.

Comparability: Differences in data collection methodologies between earlier TWDB volumetric surveys, Baylor Univeristy Department of Geology sediment surveys, and this dual frequency hydrographic survey may result in limitations in data comparisons. However, comparability should be within 0.5 ft in areas with no significant change in bottom elevation between surveys (i.e., sediment scour or deposition).

Completeness: The objective of the survey is to provide bank-to-bank coverage where the survey vessel can safely navigate. The following factors will affect the ability to collect bank-to-bank data: 1) satellite geometry (the number of satellites and their location will impact the accuracy of global positioning system [GPS] data), 2) obstructions along the shoreline such as docks, tree stumps, or pilings (which may restrict vessel operations or block sonar signals), and 3) bank slope (a long shallow bank will not be mapped as close to shore as a steep bank). It is expected that there will be data gaps that cannot be avoided, such as those caused by obstructions or shallow areas. These areas will be evaluated on a case-by-case basis and an assessment will be made, in consultation with BRA, to determine if alternative methods are required to fill data gaps.

Section A8: Special Training Requirements/Certifications

The staff involved in data collection of bathymetric data collection have received the appropriate education and training required to adequately perform their duties. No special certifications are required, except that personnel involved in use sonar and Global Positioning System (GPS) instruments have been trained in the appropriate use of this equipment.

Section A9: Documentation and Records

Dual frequency hydrographic data will be exported into an ASCII format for use in a geographic information system (GIS). Within ArcGIS, data will be transformed into a triangulated irregular network (TIN) for analysis. Data will then be interpolated as a raster grid, onto which a series of contours can be overlaid. Finished raster grid maps will be projected in North American Datum (NAD) 83 Texas State Plane Central FIPS 4203. These maps will include 2-ft contours, represented as feet (ft) above mean sea level (msl) relative to National Geodetic Vertical Datum of 1929 (NGVD29) elevations. These contours represent a full coverage survey over Granger Lake and will provide detail of lakebed elevation and sediment deposition. Sediment thickness grids will be produced in color.

The following product and information will be provided:

- Contour maps at a mutually agreed upon scale
- Elevation and sediment thickness grid maps at same scale and layout as contour maps
- Electronic versions of data products, which will include PDF files for field records and documentation, ArcGIS shape files of contours, raster datasets of bathymetry, and georeferenced tagged image file format (TIFF) files of imagery
- ASCII files of binned data set
- Field records of the Geodetic Control Survey
- Documentation of QC checks and identification of QC issues (including trackline plot with tracklines identified by name
- Metadata for digital data

The project data, including ASCII files and QC information, will be provided to BRA, and subsequently to TSSWCB and USEPA for review.

Section B1: Sampling Process Design (Data Generation and Acquisition)

The hydrographic survey of Granger Lake will collect precision data in the primary survey area covering the entirety of the waterbody, as shown in Figure A6-1.

The survey will be conducted using dual frequency sonar, which allows for the collection of data which covers a single track directly below the survey vessel. The 200 kHz acoustic impulse provides approximately 1 cm vertical resolution and is used primarily to acquire detailed hydrographic (depth) data. The 28 kHz acoustic impulse can penetrate up to 10 meters of fine-grained lacustrine sediment to provide an indication of sediment thickness. Dual frequency track lines will be designed/spaced to provide high-resolution coverage. The resulting data set will be used to create digital terrain models of the lakebed morphology from which current lake capacity and sediment thickness can be derived.

Data will be collected by running survey lines perpendicular to the shoreline. Several cross-check lines will also be surveyed to confirm system calibration and document accuracy.

The survey will be conducted on an established coordinate system, referenced by monuments with published positions. The horizontal datum for this survey is North American Datum of 1983, Texas State Plane Central FIPS 4203, measured in US Survey Feet. The vertical datum used during this survey is that used by the United States Geological Survey (USGS) for the lake elevation gage at Granger Lake. The station number and name is 08105600 GRANGER LAKE NEAR GRANGER, TX. The datum for this gage is reported as mean sea level (msl) NGVD29 (USGS, 2002). Thus, elevations are reported here in feet (ft) above mean sea level (msl) NGVD29. Volume and area calculations in this report are referenced to water levels provided by the USGS gage.

Section B2: Sampling Method Requirements (Survey Methods)

This section describes the survey vessel and crew, control network, positioning, and acquisition of multibeam data.

Survey vessel and crew
The survey vessel will be the a 18 foot pontoon survey boat owned and operated by BREC. This vessel is equipped with an integrated navigation and data acquisition system and a custom over-the-side mount for the Knudsen Engineering dual-frequency transducer, and is ideal for shallow-water survey operations. The hydrographic survey crew will consist of a lead hydrographer and an assistant from BREC.

Positioning
Horizontal positions will be acquired with a Trimble® differential global positioning system (DGPS). This system integrates a Trimble® GPS receiver with a Trimble GeoBeacon® radio beacon receiver. With this system, Coast Guard radio signals are input from an array of base stations to improve horizontal positioning accuracy to better than 0.5 m (1.6 ft). This system is preferred because beacon corrections are not subject to the same line-of-sight limitations that satellite-based correction sources have in difficult terrain (coves, high tree-lines, etc.); satellite signals may be blocked and/or reflected from these obstacles (multi-path), resulting in position jumps or large drifts in position, which can exceed survey tolerances. A geodetic control survey will be conducted by static GPS techniques from monuments with published positions. A series of observations will be made with redundant comparisons to document accuracy of the survey. Position verification of the GPS will be performed using monument BZ0824 (SOP in Appendix D). Field logs will be provided for the geodetic control survey.

Position data will be used in real-time to provide navigation information to the vessel operator. The helmsman will be presented with a plan view of the survey area with the vessel position and track. A color-coded track-line of the sonar coverage will be painted to the screen and used to navigate the survey vessel along a pre-planned route. To check the accuracy of the positioning system and confirm that the geodetic parameters used in the real-time projection to the NAD83, Texas State Plane Central Zone coordinate system are correct, a position check will be conducted daily on an established monument with a known position. Water surface measurements will be documented daily by referencing the USGS lake elevation gage at Granger Lake. Lake level elevations will be based on United States Geological Survey (USGS) lake elevation gage at Granger Lake. The station number and name is 08105600 GRANGER LAKE NEAR GRANGER, TX. The datum for this gage is reported as mean sea level (msl) NGVD29 (USGS, 2002). All soundings will be reduced to feet (ft) above mean sea level (msl) NGVD29 elevations in the delivered data set.

Single Beam (Dual-Frequency) data acquisition
Soundings, or precision water depth measurements, will be acquired with Knudsen Engineering B/P 320 dual-frequency sonar. Using frequencies of 200 and 28 kHz, sonar data will be collected

by running lines perpendicular to the shoreline. In addition to those survey lines run perpendicular to the banks, crosstie lines will be run over the main scheme lines to confirm system calibration and document the accuracy of the survey. Sonar data will be acquired running Knudsen Engineering Ltd. Sounder Suite®, as well as Coastal Oceanographics HYPACK MAX software. The navigation system provides navigation output to the vessel operator's monitor and manages the survey. The acquisition system can also be used to replay the survey so that the coverage and quality of the data can be reviewed prior to demobilization from the site.

To verify and correct for delay times applied to the time-tagged sensor data, a latency test will be conducted. A latency test is a series of lines run in a redundant pattern, perpendicular to bottom slope. A bar check and lead line check will be conducted to confirm draft of the sonar head and adjustment of sound velocity. These tests will be conducted at the beginning and end of the survey and any time there are changes in the instrument configuration.

Data acquisition involves setting the running slow, uniform lines in a systematic pattern. Adjustments will be made to scale and gain settings, as required, to maximize resolution of the survey.

During the survey, preliminary hydrographic data will be displayed in realtime on the HyPack computer. Pixels color-coded by depth will be drawn on screen, showing the coverage and agreement between adjacent survey tracks. At the end of the survey, screen grabs of the preliminary coverage will be forwarded to BRA for review, to determine if additional lines should be run to fill gaps in coverage. These coverage maps are preliminary and additional data gaps may not become apparent until after data processing.

Survey schedule

The first hydrographic survey will be conducted in spring of 2007. The second survey will be conducted in June 2010. It is expected that each survey will take approximately 5 days to complete. A project data report will be provided by BREC to BRA no more than 60 working days following completion of each field survey.

Section B3: Sample Handling and Custody Requirements

No physical samples will be collected as part of this survey. All location and depth data will be logged automatically in real-time through HyPack Survey® software. Manual sediment depth measurements (sediment probing) will be taken as necessary to confirm low frequency sonar data according to SOP (appendix B). As well, these measurements, and associated field notes will be logged electronically through HyPack® software, albeit, manually by computer interface.

Section B4: Analytical Methods (Data Processing Methods)

Post-processing of sonar data will be conducted utilizing HyPack® Single Beam Max. The HyPack® Single Beam Max software allows for simultaneous viewing of the dual-frequency sonar data to analyze anomalies on the lake bottom during post-processing. Water-level data will be applied to adjust all depth measurements to conservation pool elevation.

Processing will begin with review of each survey line using Single Beam Max. Verified water surface elevation will be applied to the data set at this time. Position and sensor data will be reviewed and accepted, if no outliers are present, or rejected if erroneous data are observed. Sounding data will be reviewed and edited for anomolies such as bottom multiples, and returns from submerged trees or debris. These data points will be flagged as rejected and will not be used as part of the final data set. Sounding data, including sonar beams reflecting from sediment in the water column, noise due to aeration in the water column, or air trapped in sediment layers will be carefully reviewed to determine if data should be flagged as rejected. In each case, data will not be eliminated and can be re-accepted during the subset editing process. Data may be re-accepted if they are needed to fill data gaps and they meet accuracy standards based on comparison to adjacent data. The cross-check statistical analysis for soundings will be performed on the data set at this stage.

To take advantage of the level of detail the survey will provide an x, y (location), z (depth) data set will be exported from HyPack® for further analysis and generation of a DTM from which contours will be created in ArcGIS. This will allow for comparisons with previous hydrographic surveys that were conducted with similar high-resolution methods, in order to further interpret/analyze any shoaling or scouring that may be occurring. All original data will be archived at full resolution. If required at a later date, specific areas of interest can readily be remodeled.

A TIN will be constructed and reviewed for survey coverage and analyzed to determine if subtle artifacts remain in the data set, which may require further processing. From the TIN model, ArcGIS 3D Analyst extension will be used to calculate sediment and reservoir volume. The final TIN model will be converted to a raster grid and exported as a georeferenced TIFF file that can be imported into AutoCAD® or any GIS program for final presentation and plotting.

Section B5: Quality Control Requirements

The acquisition system and survey protocols are designed with some redundancy to demonstrate that the required accuracy is being achieved during the survey and to provide a backup to primary systems. Data integrity will be monitored throughout the survey by redundant system comparisons and checks against known values. All raw data are recorded to allow for adjustments to be made to any of the data during processing based on the results of comparisons and checks. During HyPack® post-processing of the data, the software allows for date- and time-stamped changes of any system bias, squat correctors, static draft, or instrument offsets in the event of any changes during the survey. Lake elevation can be modified at any time during processing. Data rejected manually or through filtering are flagged as rejected and not deleted. This approach allows for review of all data to confirm or disprove anomalies.

Positioning: Positions will be recorded and archived in WGS84 geographic coordinates and projected onto NAD83 Texas State Plane Central Zone (FIPS 4203) coordinate system. A position confidence check will be conducted daily on a monument that is accessible from the water. The obtained published position will be compared to the surveyed value to assure the target horizontal accuracy is being obtained. Position verification of the GPS will be performed using monument BZ0824 (SOP in Appendix D).

Lake Level: USGS lake elevation gauge observations will be documented and used during post-processing of sonar data. Lake level elevations will be based on United States Geological Survey (USGS) lake elevation gage at Granger Lake. The station number and name is 08105600 GRANGER LAKE NEAR GRANGER, TX. The datum for this gage is reported as mean sea level (msl) NGVD29 (USGS, 2002).

Sonar draft:

- A bar check will be conducted at the beginning and end of the project to confirm sonar draft below the water line. A bar will be lowered below the sonar to specific intervals below the water surface using calibrated marks on the steel cable.
- Sonar draft marks will be observed with the vessel trimmed to zero roll angle to confirm the static draft of the sonar.
- Leadline and sediment probing depth observations will be made at the beginning and end of the sampling event to confirm sonar draft and sound velocity observations.

Documented changes in draft can be accounted for in the HyPack® hardware configuration file.

Positioning System Latency: A latency test will be conducted at the beginning of each survey to confirm that the timing bias are correctly applied to sonar data.

Cross-line analysis: A cross-check statistical analysis will be conducted across the full width of the survey, when there is sufficient water depth, to confirm that the frequencies used meet target accuracy.

TIN Analysis: A TIN will be generated from the accepted hydrographic data set. The raster grid image will then be generated and reviewed for anomalous data and consistency between adjacent planned survey lines.

Section B6: Instument/Equipment Testing, Inspection, & Maintenance Requirements

Prior to mobilization, the survey vessel and equipment will be inspected and confirmed to be in operating order according to manufacturer's specifications. The vessel is inspected and maintained daily by BREC staff.

During mobilization, instrumentation will be tested and system performance testing will be conducted. Performance testing will include a bar check, latency test, leadline and sediment probing comparison to digital readings, as well as a position confidence check according to SOPs (appendices B,C,D, and E).

Section B7: Instrument/Equipment Calibration and Frequency

Equipment calibration is verified through system performance testing (bar checks, position checks, automated gauging station observation, latency test, leadline and probing comparison to digital record, and cross-line analysis according to SOPs [appendices B,C,D, and E]).

Frequency of observations is as follows:

- Bar check, sonar draft mark observations, leadline and sediment probing to digital record comparison: beginning and end of sampling event or any change in sonar mounting
- Position checks: daily
- automated gauging station observation: daily
- Latency test: beginning of project or any change in instrumentation
- Cross-line analysis: once per survey.

Section B8: Inspection/Acceptance Requirments for Supplies and Consumables

No significant consumables are required because all data are digitally recorded. The survey vessel is equipped with survey log forms for any additional survey documentation and a supply of rewritable compact discs (CD-RW).

Section B9: Data Acquisition Requirements (Non-direct Measurements)

The horizontal control survey will be based on existing monuments with published National Geodetic Survey (NGS) positions and elevations (NGS, 2006). Position verification of the GPS will be performed using monument BZ0824 (SOP in Appendix D). Lake level elevations will be based on United States Geological Survey (USGS) lake elevation gage at Granger Lake. The station number and name is 08105600 GRANGER LAKE NEAR GRANGER, TX. The datum for this gage is reported as mean sea level (msl) NGVD29 (USGS, 2002).

Section B10: Data Management

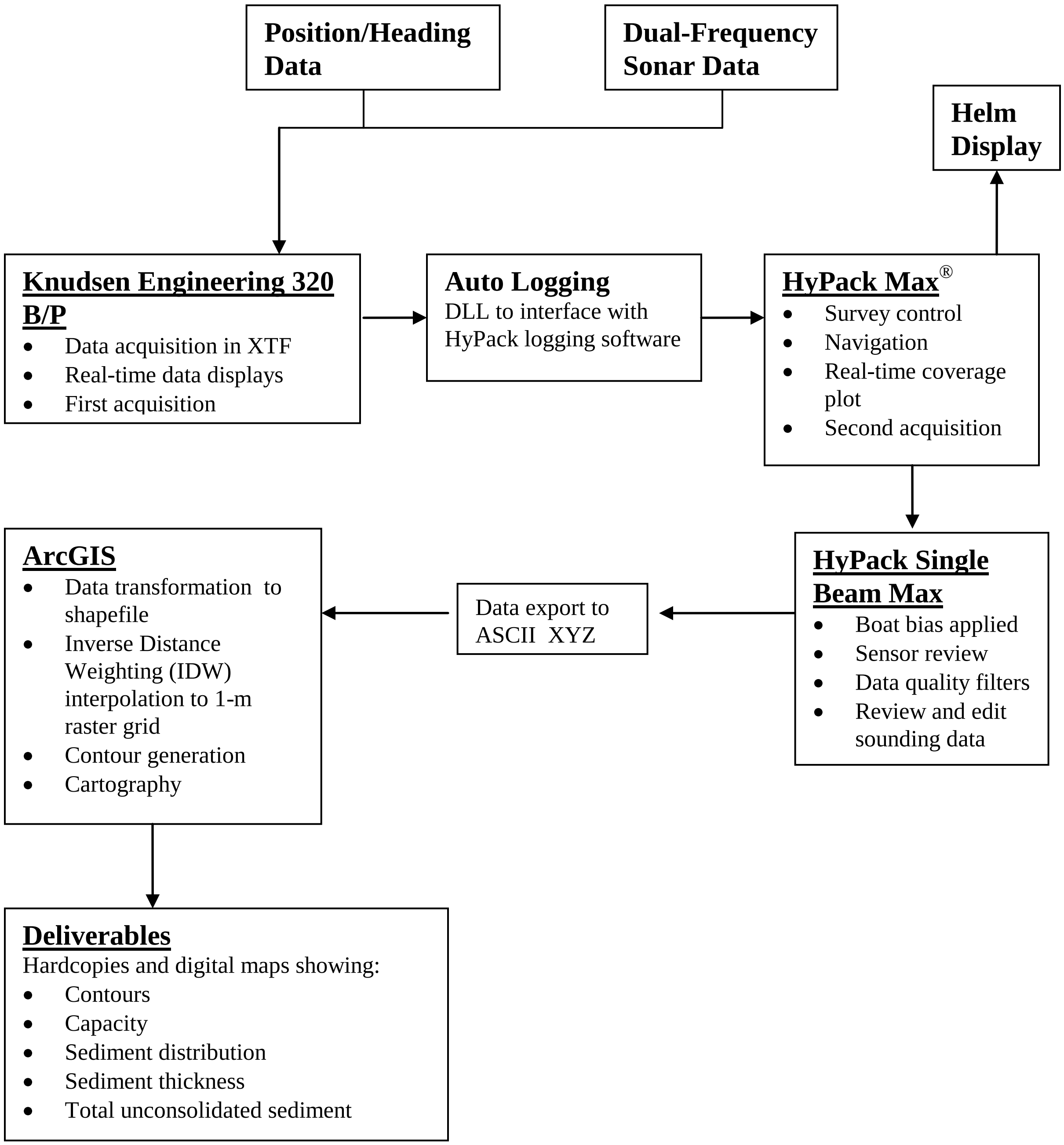
Data from the survey vessel will be backed up to CD-RW at the end of each survey day. Data will not be removed from the acquisition computers until they have been loaded and verified to backup hard drive on desktop computer at BREC. Altered files are backed up to disk daily, with full backups to CD-RW weekly along with offsite storage. At the completion of the project, data are archived on two sets of CD-RW, and archived in two separate locations.

Figure B10-1 presents a flowchart illustrating the data flow from acquisition to production of deliverables.

Archives and Data Retention

Original data recorded on paper files are stored for at least five years. Data in electronic format are stored on hard drives and CD-RW in a climate controlled room at BREC.

Figure B10-1. Hydrographic data acquisition and processing flowchart



Section C1: Assessments and Response Actions

The BREC Hydrographic Field Operations Manager will audit system checks and DTM raster imagery during post-processing. TSSWCB will conduct at least one QA field audit during the life of the project.

Section C2: Reports to Management

Primary communications will be through the BREC project manager and BRA. BRA will provide all project communications to TSSWCB and USEPA Region VI. During field operations, communications between BREC and BRA will be through BREC's Hydrographic Field Operations Manager, with copies of correspondence forwarded to BREC's Project Manager. This correspondence will primarily consist of e-mails sent during survey operations, which will include general overview of survey progress, coverage images, and any problems encountered during surveying. BRA will forward these e-mails as necessary to TSSWCB and USEPA Region VI for review.

Section D1: Data Review, Validation and Verification

Data will be reviewed and verified by evaluation of DTM raster imagery, cross-line analysis, comparison of sonar data to redundant depth measurement techniques and comparison to adjacent and previous soundings.

Section D2: Validation and Verification Methods

Verification of sonar data will be performed by comparison to intersecting and overlapping soundings, leadline soundings, and sediment probing. A cross-check statistical analysis will be performed to document the system performance.

TIN models and raster grid images will be reviewed for anomalous data and inconsistency between adjacent sonar tracks. Artifacts in the image will be investigated in HyPack® Single Beam Max sonar data editor by comparing the data to adjacent soundings.

Section D3: Reconciliation with Data Quality Objectives (User Requirements)

Data quality objectives for accuracy will be achieved by meeting the target horizontal and vertical accuracies at a 95% confidence level for the survey. Methods outlined in Sections B5, B7, and D2, will verify that the target accuracies are being obtained. Other data quality indicators, including completeness, representativeness, and precision, will be evaluated with a color-by-depth presentation in HyPack; as well as TIN and raster grid coverage image generated in ArcGIS. Final review by the lead hydrographer will include the evaluation of TINs and raster grid images for artifacts from system bias, and comparison to prior surveys.

References

Brazos River Authority (BRA). 2005. 05-09 Scope of Work. Prepared for Texas State Soil and Water Conservation Board for submittal to US Environmental Protection Agency, Region VI, Dallas, TX

National Geodetic Survey (NGS). 2006. "NGS Data Sheet Page," http://www.ngs.noaa.gov/cgi-bin/datasheet.prl.

United States Army Corps of Engineers (USACE). 2002. Engineering design: hydrographic surveying. EM 1110-2-1003. Department of the Army, US Army Corps of Engineers, Washington, DC.

United States Environmental Protection Agency (USEPA). 2002. Guidance for quality assurance project plans. EPA/240/R-02/009. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

United States Geological Survey (USGS). 2002. Water Resources Data, Texas, Water Year 2001. Water-Data Report TX-01-3, Volume 3.

APPENDIX A

Corrective Action Report

CAR #:______________

Date:_____________________ Area/Location:______________________

Reported by:_____________________ Activity:___________________________

State the nature of the problem, nonconformance or out-of-control situation:

Possible causes:

Recommended Corrective Actions:

CAR routed to:__________________________________
Received by:____________________________________

Corrective Actions taken:

Has problem been corrected?: YES NO

Immediate Supervisor:_________________________________

Project Manager:____________________________________

Quality Assurance Officer:____________________________

APPENDIX B

STANDARD OPERATING PROCEDURES FOR SEDIMENT PROBING

1. Using the on-board GPS system, maneuver the sampling vessel to within 5 ft of the preprogrammed target coordinates for each sample location. Secure the vessel in place using spuds and/or anchors.

2. Use a 1 in. steel rod or equivalent to probe the sediment. The probe will be sharpened at one end, and calibrated in 1/10 ft intervals.

3. Advance the probe into the lake bottom, noting the depth of penetration and type of resistance met by the probe.

4. Move the probe laterally several feet (while maintaining the maximum 3 ft distance from the target location) and repeat the probing at least a total of 3 times.

5. Record the approximate average sediment thickness (to the nearest .1 ft.) and estimated sediment type (e.g., rock, fine-grained, coarse-grained) in the field database. If results of probing are inconsistent between the three attempts; record the inconsistency in the manual description of the field database. Record the estimated sediment type as the most representative one of the three attempts.

APPENDIX C

STANDARD OPERATING PROCEDURES FOR BAR CHECK

1. A "bar check" is a test procedure used to set-up the appropriate speed of sound and draft settings for a sounding session. Typically, a bar check would be performed as follows.
2. A "bar" (a target which will return a distinct echo) is lowered to a known short distance below the surface.
3. The draft is then adjusted until the depth return from the bar equals the known value.
4. After the draft has been adjusted, the bar is then lowered to a deeper known depth.
5. The sound speed is then adjusted until the depth return from the bar equals the known value.
6. This procedure must be repeated several times until both elements are calibrated.
7. After this procedure, the system will calibrated for the current water conditions and can be left unmodified for the remainder of the sounding session.

APPENDIX D

STANDARD OPERATING PROCEDURES FOR POSITION CHECK

The purpose of this document is to address instrument settings, field operation, and data processing for GPS data collection and to make recommendations for standards in recording of positional data.

Definition of the Global Positioning System
GPS (Global Positioning System) is currently a constellation of 25 Department of Defense satellites that orbit the earth approximately every 12 hours, emitting signals to Earth at precisely the same time. The position and time information transmitted by these satellites is used by a GPS receiver to trilaterate a location coordinate on the earth using three or more satellites.

The satellites broadcast on two carrier frequencies in the L-band of the electromagnetic spectrum. One is the "L1" or 1575.42MHz and the other is "L2" or 1227.6MHz. On these carrier frequencies are broadcast codes, much like a radio or television station broadcast information on their channels (frequencies). The satellites broadcast two codes, a military-only encrypted Precise Position Service (PPS) code and a civil-access or Standard Position Service (SPS) code.

Positional Data

Accuracy is dependent on a number of factors. Several factors that can significantly impact data accuracy can be monitored in the field: the number of satellite vehicles, Positional Dilution of Precision (PDOP), signal-to-noise (SNR) and Estimated Horizontal Error (EHE). One should always acquire at least 4 satellites. This gives you a 3D position. More satellites are better than fewer. PDOP relates to satellite geometry at a given time and location. Keep the PDOP as low as possible (ideally, maximum PDOP=4) when collecting mapping data.

Differential corrections should be used whenever possible. This removes the greatest source of errors remaining in the GPS error budget. Real-time differential corrections are available through the NDGPS/Coast Guard Beacon System, the WAAS (FAA) satellite based differential system, OmniStar, or a variety of paid private differential services.

Receiver-Specific Recommended Settings:
Trimble GeoExplorer:

1. PDOP: less then or equal to 6 (we recommend starting with a PDOP maximum of 4 and shifting to 5 if data collection is not successful at 4; this will keep you around the NMAS for a 1:5,000 map).

2. Minimum of 4 satellites (3D) for every position.
3. SNR: less then or equal to 5.
4. Elevation Mask: 15.
5. Antenna height: be sure to check for correct antenna height setting. This setting should be the typical height at which the antenna will be carried. If the antenna is attached to a pole, it must be located above the user's head and the antenna height setting should be the height of the top of the pole. Wherever possible, the antenna should be clear of any obstructions.
6. Position Type: Must be post-processed or real-time differentially corrected.

At the beginning of each survey, a position verification of the GPS will be performed using monument BZ0824, X, Y coordinate 31 04 04.18773 (N), 097 27 53.90621 (W), NAD 83. The unit will be positioned directly on the monument while collecting X, Y coordinates. When the points are averaged, they are to be within 3 ft of the monument. The X, Y coordinates and map of the GPS monument are shown in below.

Collected X, Y coordinates for GPS verification

Identification #	Date	Time	X	Y

APPENDIX E

STANDARD OPERATING PROCEDURES FOR LATENCY TEST

Before surveying with single beam systems, you should first confirm that the GPS Latency offset entered in Hardware is as accurate as possible.

The **Latency Test** is used to determine the "fixed" delay time between the GPS and singlebeam echosounder. This value is typically positive. The latency correction is used in HARDWARE to adjust the "Latency" time in the Offsets dialog for the positioning device. It represents a combined delay time between the GPS and echosounder. This method works well on GPS systems that have a constant latency time and for surveys at scales of 1:5,000 to 1:100,000.

In the event that you have collected data with incorrect Latency settings, you can:

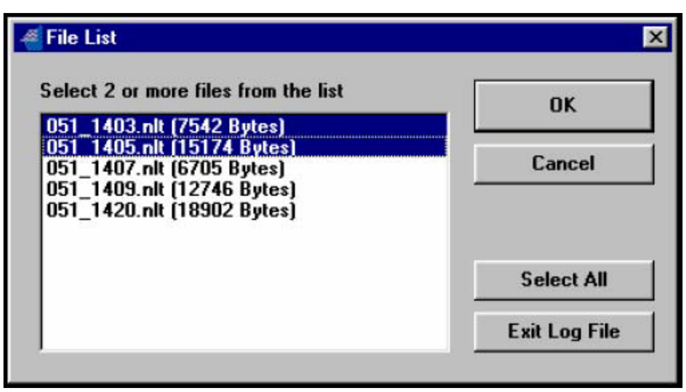
• Correct your raw data in the DATA ADJUSTMENTS program
• Adjust the latency in the SINGLE BEAM EDITOR which will correct the resultant edited data, but the raw data will remain the same.

1. **Run reciprocal lines over a changing bottom**. Run the same line up and down over a sloping bank or over a prominent bottom feature. For the best results:

- **Follow the planned line** as exactly as possible.
- **Monitor the number of satellites read by your GPS.**

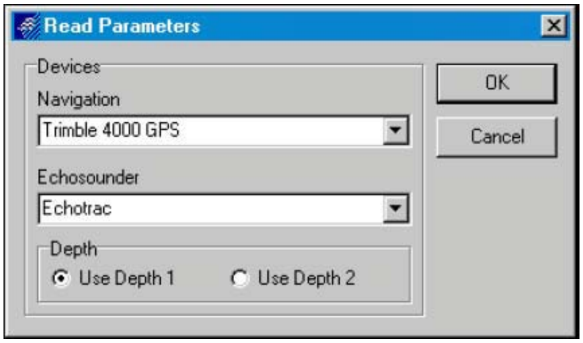
You can set your system to log data based on the HDOP or number of satellites in the Alarm tab of the driver setup dialog for the kinematic.dll or GPS.dll.
Open the program by clicking UTILITIES– CALIBRATION-LATENCY TEST.
Select FILE-OPEN SOUNDING CATALOG and select the .LOG file containing your latency test lines.
Click [OK]. A list of files will appear.

Sounding Catalog in LATENCY TEST



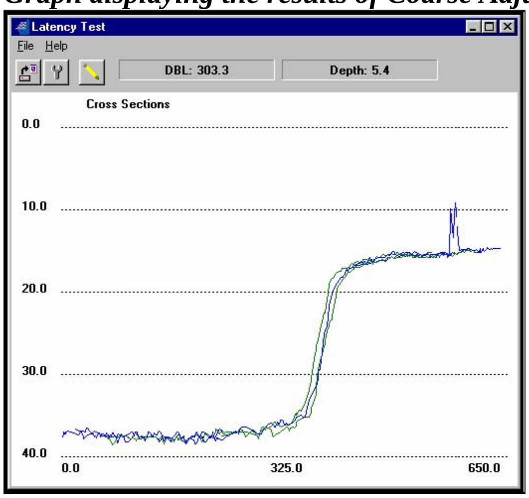
5. **Click on the two files to be used for the latency calculation and click [OK].** After the first file header is read, the Read Parameters dialog appears.

Latency Read Parameters Dialog



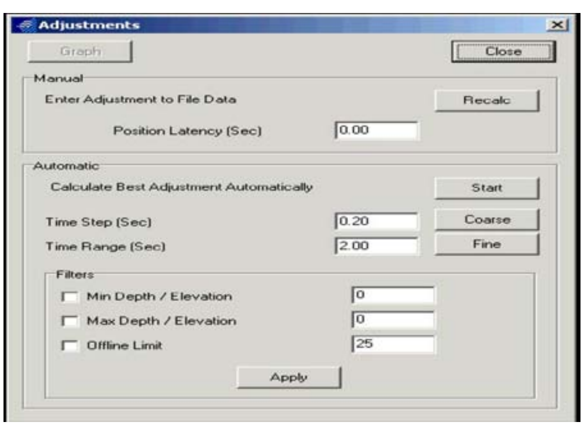
6. **Select the devices you are using.** Make sure you have selected the single beam echosounder. If your data files were collected over an area of fluff, use Depth 2 for the calculation. Click [OK] to continue. A cross section graph will display the profiles of your two survey lines. You may notice the sections are not "aligned" meaning there is an error in the latency time setting.

Graph displaying the results of Coarse Adjustments



7. **Select FILE -ADJUSTMENTS** (or click the wrench icon) to display the Adjustments dialog.

Latency Adjustments Dialog

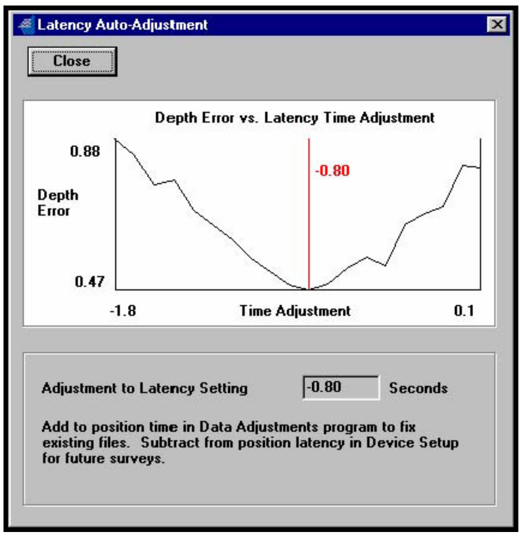


8. **Set Filters to omit obvious bad soundings**. You can set filters for minimum and maximum depth or elevation, and for soundings farther off line than the user-defined limit.

9. **Perform Coarse Adjustments**.
    - Click [Coarse] to select Coarse Adjustment Settings. The settings will be automatically calculated.
    - Click [Start] to begin calculations. When they are completed, a graph will appear showing the results.
    - Click [Close] to return to the Adjustments dialog.

10. **Perform Fine Adjustments**.
    - Click [Fine].
    - Click [Start] to test using the Fine settings. When the soundings are redrawn, the banded pattern is gone, giving you a value to be used as your latency setting as in the following figure.

Latency Value



B. Correcting Latency Time in the Hardware Program

The value calculated by the LATENCY TEST should be entered into the GPS Offset–Latency in the HARDWARE program to correct timing errors in the system.

In the HARDWARE program:

1. Click on the DEVICE menu and select your position device.
2. **Click [Offsets] and enter your latency** in seconds (be sure to invert your value as instructed in the Latency Test program).
3. **Click [OK]** to exit Offsets, and [OK] again to exit Device Setup.

The change will be saved automatically when you exit the HARDWARE program.