Chapter 2
Civil Works Applications

2-1. General Scope

Hydrographic surveys are performed to support the Corps' dredging, navigation, and flood control missions. A wide range of hydrographic survey techniques, vessels, and equipment are required, depending on the nature and location of the survey, as illustrated in Figure 2-1. Nearly 100 in-house and contract survey crews are deployed surveying over 900 navigation projects and 12,000 miles of waterways. Thousands of drawings depicting these projects are produced annually. This chapter describes the requirements and types of hydrographic surveys, and some of the current processes used by districts to accomplish these tasks.

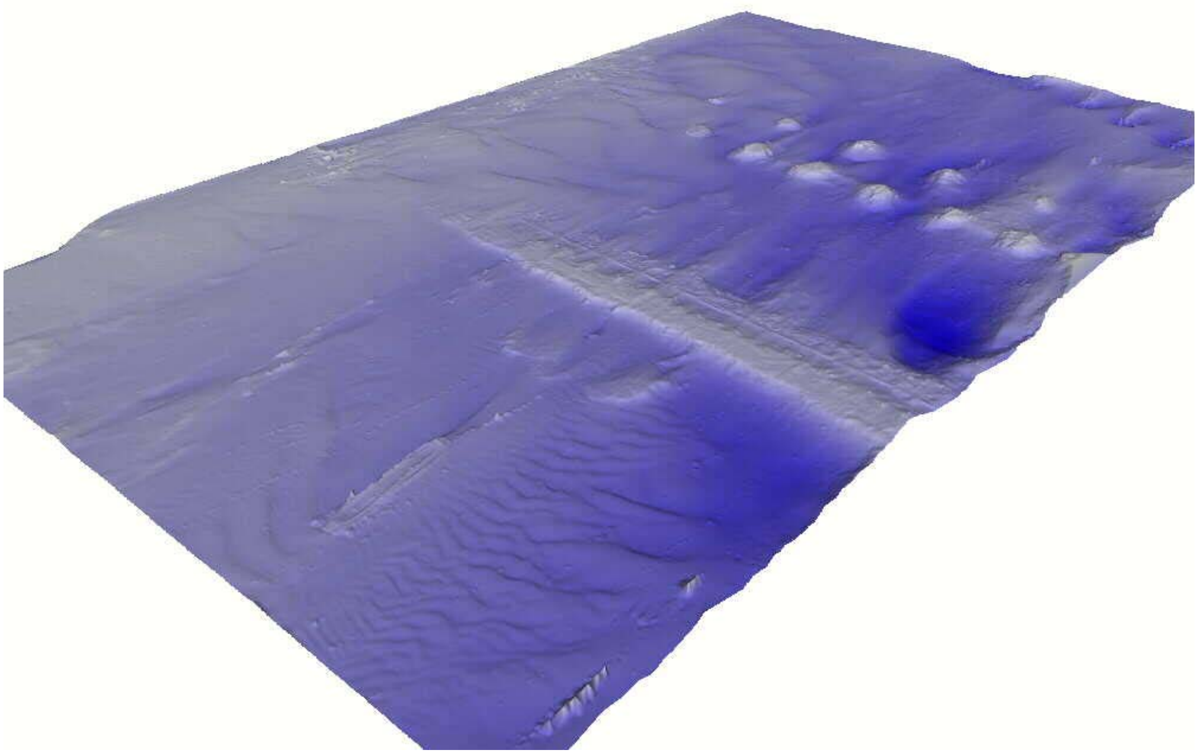


Figure 2-1. Old Lock and Dam 26, Mississippi River. DTM depicts old Lock and Dam 26, the old Alton Bridge piers, and a sunken barge just upstream of the old Lock and Dam 26 foundation. The scour holes below the old bridge piers are from the bridge piers of the new Alton Bridge. This is at River Mile 202.1 on the Upper Mississippi. The data file was collected on the M/V Boyer with a RESON 8125 Multibeam sonar. The 8125 is a 0.5 by 0.5 deg beam, 240 beams, and 120-degree swath. (St. Louis District)

2-2. Civil Works Program Surveying Requirements

Hydrographic surveying support is required throughout most phases of civil works water resource projects. During the early phases of a project, a comprehensive plan should be developed to integrate hydrographic surveying requirements throughout the various stages of a project's life. Procedures for accomplishing this are contained in ER 1110-2-1150, "Engineering and Design for Civil Works Projects." Hydrographic surveying may be required during any of the five project phases outlined in ER 1110-2-1150: Reconnaissance phase, Feasibility phase, Preconstruction Engineering and Design (PED) phase, Construction phase, and Operation and Maintenance phase. Most effort is required during the later three phases.

a. Reconnaissance phase. The reconnaissance phase is general in scope, and at this early stage of project development there is normally no requirement (or funding) for field survey effort. Existing maps or charts are normally adequate for developing the preliminary plans that will ultimately lead to an engineering solution.

b. Feasibility phase. The purpose of the feasibility phase is to formulate a solution to address a specific need. The work includes studying potential solutions, evaluating costs and benefits, preparing initial designs, and recommending a plan to solve the problem. Engineering effort during this phase may include hydrographic surveys of project sites. ER 1110-2-1150 contains the following guidance on surveying requirements:

> *Surveying, Mapping, and other Geospatial Data. Surveying, mapping, and other geospatial data information should be obtained to support all feasibility phase requirements. At this level, existing surveying, mapping, and other geospatial data available through in-house sources or through other federal, county, local, commercial, or private sources may be adequate. Additional information on finding these sources is available in EM 1110-1-2909. The data source, i.e., compilation scale, contour interval, control data and datum, etc., should be verified to assure it meets accuracy requirements to support the level of detail required. Otherwise, new surveying, mapping, and other geospatial data may need to be developed. If sufficiently scaled topography is not available to support the level of detail required, then it shall be developed during the feasibility phase to eliminate the possibility of large quantity errors (e.g., real estate, reservoir volumes, etc.). Detailed guidance on photogrammetric mapping surveys is provided in EM 1110-1-1000. Survey control methods and if possible the actual control points shall be established in the field at this phase of study to avoid rework and errors and to maintain continuity during subsequent phases of the project. Detailed site-specific mapping may be deferred and developed during the PED phase unless it is required to develop an accurate baseline cost estimate. The Geographic Information System (GIS) for the project should be established during this phase in accordance with EM 1110-1-2909 and ER 1110-1-8156.*

During the feasibility phase cost estimates for subsequent modeling requirements are made. These would include any tidal modeling requirements, such as on projects without an established MLLW reference. Also, projects requiring RTK DGPS observations will require geoid modeling during the PED phase.

c. Preconstruction engineering and design phase. The Preconstruction Engineering and Design Phase (PED) is the phase during which the design is finalized, the plans and specifications (P&S) are prepared, and the construction contract is prepared for advertising. A Design Documentation Report (DDR) is developed. This phase may involve physical model studies or development of water level or geoid reference models. Hydrographic surveys are a critical component of the P&S. P&S shall be prepared in accordance with ER 1110-2-1200, the Architect/Engineer/Construction CADD Standards and the CADD/GIS Technology Center (Tri-Service) Spatial Data Standards.

d. Construction phase. Hydrographic survey support is continuous throughout construction--especially for dredging and beach renourishment projects. The various surveys supporting construction are described later in this chapter and in subsequent chapters.

e. Operation and maintenance (O&M) phase. Maintenance of authorized navigation projects requires continuous condition surveys and construction surveys associated with maintenance dredging.

Support to O&M is by far the largest hydrographic surveying activity in the Corps--both in manpower and funding.

2-3. Hydrographic Survey Applications on Civil Works Activities

Hydrographic survey support is required for a wide range of civil works engineering and construction activities, ranging from navigation project dredging to topographic surveys of wetlands. This section describes some of the more common activities or projects requiring survey support.

a. Dredging measurement and payment surveys. Dredge measurement and payment surveys encompass all work associated with contracted construction activities of USACE, most particularly those surveys performed to measure the amount of excavated, deposited, and/or placed material in subsurface areas. These surveys also include investigative studies used for preparing contract bid documents and for directly monitoring and measuring subsequent contract performance, payment, and acceptance. These surveys require a high level of accuracy in both positioning and depth measurement so that payments will be equitable and consistent with the actual work performed. A significant portion of Corps survey resources are engaged in supporting dredging operations. A wide variety of vessels and equipment are used on dredging payment surveys, depending on water depth, inland or coastal location, and material being dredged. During FY 1999, some 328 MCY were excavated under 252 contracts and another 46 MCY by 12 Corps-owned dredges. Corps survey forces were responsible for monitoring most of this excavation in progress.

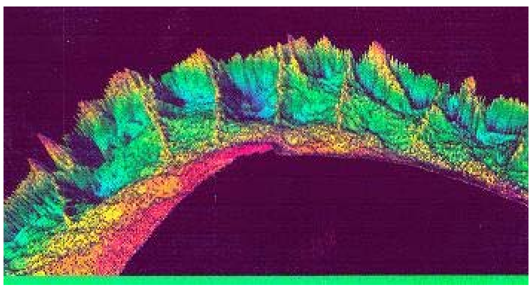
(1) Plans and specifications surveys. Surveys and investigative studies performed to gather terrain, bathymetric, and geophysical data and related site plan information in advance of a design effort are referred to as plans and specifications (P&S) surveys. These P&S surveys will be used to produce a set of engineering plans and specifications (and related cost estimates) for construction or dredging. These surveys support not only river and harbor dredging construction but also many other forms of marine construction in which detailed site plans are essential to the bid documents. This includes planned construction of offshore structures (jetties, groins, etc.), disposal areas, flood control structures (locks, dams, spillways, dikes, control structures, reservoirs, etc.), and beach/bank erosion protection. In rare instances where no substantive change is expected before the beginning of construction/dredging, these surveys can also serve as the before construction/dredging payment survey. Such a procedure, however, must be clearly allowed in the contract specifications.

(2) Before and after dredging surveys. Most USACE construction contracts structure a payment schedule on a unit price basis, with units, lengths, areas, or volumes determined by in-place surveys. Contracts with daily/hourly rate pay schedules may still require detailed in-place surveys to monitor production. Depending on the provisions of the measurement and payment clause in the construction contract specifications, before/after surveys for construction payment may be performed by government hired-labor forces, dredging contractor forces, or third-party forces contracted by the government, contractor, or local sponsor. These contract payment surveys shall be performed to the accuracy standards contained in this manual. Payment surveys include those surveys performed before, during, and after dredging or other marine construction activity to measure quantities for the determination of the proper (and equitable) payment to be made. Also included in payment surveys are final contract acceptance surveys, including all types of channel sweeping operations to verify project clearance for final contract acceptance and release. Since direct contract payment is involved, this type of survey represents one of the most critical functions performed by a hydrographic survey crew. Final as-built drawings of completed projects are furnished to local sponsors and other public and private entities. In addition, contract personnel evaluating payment, acceptance, and project clearance survey data must clearly and properly correlate these accuracy standards with the field survey data to ensure that data accuracy interpretations are technically sound.

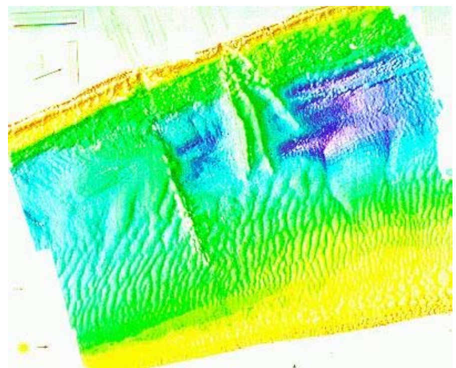
b. Project Condition Surveys. The Corps is responsible for maintaining over 900 shallow- and deep-draft navigation projects plus another 12,000 miles of inland navigation system channels. In FY 1998, some 680,321 vessels moved 2.182 billion tons through inland navigation locks. Project condition surveys are performed over project areas to determine the present condition of these coastal and inland navigation channels, navigation locks, underwater features, river or flood control structures, or beach/bank erosion protection structures. These surveys are variously referred to as project condition surveys, channel condition surveys, condition surveys, or examination surveys, and are used to determine if project conditions have changed enough to warrant future construction or maintenance activities, if additional condition surveys are required at more frequent intervals, or if a greater survey coverage density is necessary. The most prevalent types of project condition surveys are those performed on authorized river and harbor navigation projects. Drawings and/or project condition reports derived from these surveys are usually furnished to local sponsors, commercial navigation interests, and to other federal agencies, such as the U.S. Coast Guard (USCG) and the National Ocean Survey (NOS). For coastal areas charted by NOS, Corps regulations require that condition survey drawings and reports must be furnished within 60 days after completion. These critical submittal requirements are detailed in ER 1130-2-520, EP 1130-2-520 and Section 554 of WRDA 2000. Survey procedures are usually designed to maximize coverage along critical channel navigation points. This is accomplished by surveying a limited number of lines either perpendicular to or parallel with the project alignment. Navigation projects without defined channel limits, e.g., inland waterway projects, may have a broader coverage. This limited density of data provides a good general project condition; however, it is insufficient for accurate quantity take-off computations. In some instances, shoal areas encountered during a condition survey will be immediately surveyed to a density and accuracy suitable for a plans and specifications.

c. Elapsed time between condition surveys. Shipper's reports and USCG Notice to Mariners are indicators of possible shoaling in waterways. Typically each project is assessed and funded on an annual basis. Changes in annual weather patterns may alter scheduled condition surveys. Some projects may require a condition survey every 10 years; other high shoaling areas, such as Southwest Pass, Mississippi River (New Orleans District), require condition surveys on a daily basis. Every project contains unique dredging parameters that require engineering judgment to predict the correct elapsed time between condition surveys. Unless unique circumstances are present, condition schedules should not be more frequent than dredging maintenance work for a given project. For example, if maintenance dredging were required every 18 months, a similar condition survey frequency would be warranted.

d. River stabilization project surveys. Surveys of revetments, dikes, levees, and other river control structures are performed to assess the condition of these control structures--see Figure 2-2. They are often referred to as overbank surveys when hydrographic coverage is extended above the water surface level using conventional topographic survey techniques. These surveys are often performed at regular intervals to determine the condition of the structures, scour, shoaling, revetment voids, etc. They are used to support a variety of engineering requirements--e.g., to develop guidance for minimum sill depth in locks to reduce lock cost, minimum under keel allowance for deep draft vessels in inland channels, and channel width and depth requirements for mixed fleets; to provide improved guidance for the design and layout of lock approach guard and guide walls - resulting in improved safety and efficiency; to develop guidance for evaluating hydraulic and sedimentation characteristics for underwater hydraulic structures and to use results to better design these structures; and to develop design guidance for bendway weirs that considers the effects of the weirs on vessels navigating the waterway. Surveys are also performed during levee grading or during placement of articulated concrete mats.



Surveys of Bendway Weirs
St. Louis District



Surveys of Sand waves & Pipeline crossings -- Lower Mississippi

Figure 2-2. River engineering support surveys

e. Underwater obstruction or condition surveys. Surveys performed to detect the existence and extent of obstructions to the safe use of waterways are referred to as underwater obstruction surveys. Side-scan and multibeam sonar are the tools best suited to detect exposed obstructions on the channel bottom made of concrete or steel. Considerable success in locating possible obstructions (targets) has been established using side-scan coupled to a suitable positioning system. Divers may be needed to verify an underwater obstruction in some cases. Magnetometers register magnetic perturbations in the local magnetic field (which usually occur in the vicinity of metallic objects) and are often used to trace buried cables. Unlike side-scan, this equipment can detect unexposed metal. Both systems are used as qualitative tools to find underwater objects. Locations must be verified by survey equipment, and possibly divers, to meet survey standards. Condition surveys are also performed adjacent to bridge piers, locks, and below hydroelectric power plants to assess scour or other conditions. Both acoustic and visual methods may be deployed.

f. Coastal engineering surveys. Coastal engineering surveys are performed for a variety of purposes. In coastal areas, these surveys determine the condition of beach renourishment and hurricane protection projects or to support coastal engineering research studies. Surveys are also performed to study the effects of offshore protection structures (jetties, breakwaters, groins), harbor entrances, estuaries, and coastlines in areas of suspected accretion, erosion, or other material movement or transport. Surveys are also performed to develop, evaluate, and calibrate physical and numerical models used for planning and design of projects.

g. Reservoir sedimentation surveys. The Corps maintains some 390 flood control reservoirs. Many of these are periodically surveyed to assess sedimentation and update area-capacity curves.

h. Inland navigation charting surveys. Surveys are performed to update maps and charts of the Corps inland navigation projects--about 12,000 miles of waterways. Corps-wide, these charts involve hundreds of drawings. Updates are performed every 5 to 10 years. Hydrographic, topographic and facility features are updated.

i. Wetland surveys. Hydrographic surveys are often performed in shallow wetlands or water conservation pools. Different equipment and techniques are required due to the shallow depth and vegetation effects on acoustic signals. Small skiffs or airboats are often used for these surveys.

j. Miscellaneous surveys. Various other marine surveys are performed to support civil works water resources activities. These include: environmental/HTRW surveys/studies of underwater areas, periodic disposal area monitoring surveys during placement of material, offshore drill barge location, subsurface probings (wash or dry), tidal boundary surveys (e.g., MHW demarcation), and underwater archeological surveys. Some of these surveys are illustrated in Figure 2-3.

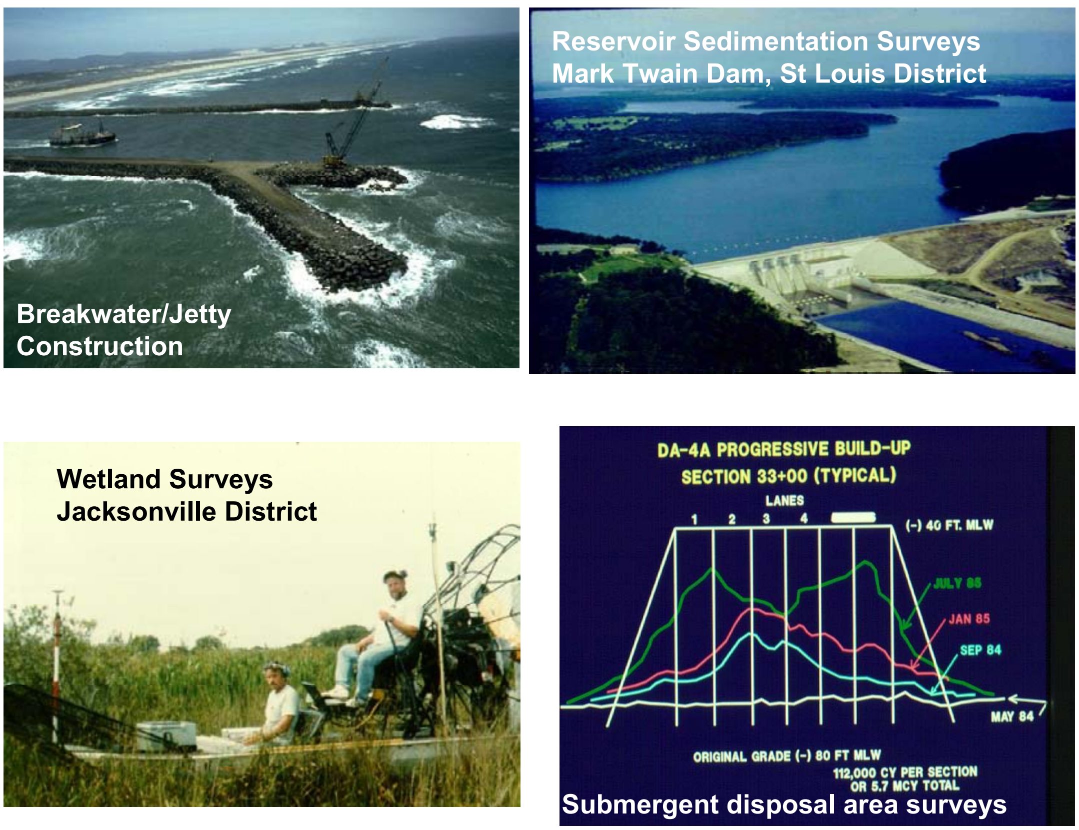


Figure 2-3. Wetland, disposal area, and sedimentation surveys

2-4. Overview of Hydrographic Survey Techniques in Corps--Field to Finish

The following sections are intended to provide an overview of a typical USACE hydrographic survey operation, from the initial planning stages, through the field data acquisition phase to the final processing and finished product stage. It is written to describe the more common navigation dredging and project condition surveys; however, it is applicable to most other types of surveys as well. This overview covers the survey equipment and instrumentation currently used on engineering and construction surveys. It is applicable to both in-house and A-E survey forces. This overview was developed by the Baltimore District.

a. Topographic survey methods. A hydrographic survey is basically a topographic survey of underwater areas. In many cases hydrographic surveys for Corps engineering and construction projects are performed using the same equipment and methods used in topographic site plan surveys. For example, a total station can be set up over a known control point on the shoreline to observe X-Y-Z points on a hand-held rod placed in underwater locations--i.e., an open-end traverse technique. Cross-sections of river or canal projects are run identically with those performed on highway construction. Data points may be recorded in a standard field survey book or electronically logged on a data recorder connected to the total station.

b. Hydrographic variations. When data points are required in areas out of range of a total station, or in water depths deeper than the range of a hand-held rod, hydrographic survey techniques must be employed. This includes use of a floating platform, locating that platform, and measuring the bottom elevation off the platform. Since the platform must be positioned, then the bottom elevation measured relative to that platform, the measurement process is, in effect, a double-leg open-end traverse.

c. Hydrographic positioning. Positioning the platform is performed using a variety of topographic or geodetic survey methods. These include resection (sextant), triangulation (transit/theodolite), trilateration (range-range or GPS), or traverse (total station or differential GPS). The positional accuracy may degrade as a function of distance from the shore-based reference point.

d. Elevation of subsurface points. The major difference between topographic and hydrographic methods involved the methods of determining the elevation of an underwater point, and the reference used to measure the elevation. Perhaps most unique to hydrographic surveys, the water surface is used to measure and reference the elevation of an underwater point, which is then termed a depth or sounding. The water surface is, in effect, the "level bubble" in a level or total station. Since this water surface is not stable (i.e., it is subject to river slope, tides, waves) elevations measured relative to this surface must be corrected. In addition, the required depth is often referenced to a nominal water surface (i.e., a datum) which in itself can vary from point to point. Hydrographic surveys can use mechanical methods to measure the depth of a point relative to the water surface. These include level rods and hand-held lead lines. More commonly, acoustic depth measurement methods are employed to measure depths relative to the floating platform. Single acoustic depths directly under the platform may be recorded as in conventional topographic survey methods. Alternatively, swath array depths may be recorded (i.e., multibeam survey system) which is the hydrographic equivalent of a photogrammetric mapping survey. X-Y-Z point data are recorded and processed similarly to topographic survey methods.

2-5. Survey Scheduling

The primary purpose for most hydrographic surveying done within the USACE is to support a wide variety of navigation-related projects. Most USACE districts routinely conduct periodic project condition surveys (PCS) on all active navigation projects to evaluate their current condition and to determine if any future dredging may be required. If maintenance dredging is necessary, then a plans and specifications (P&S) survey, a before dredge (BD) survey, and an after dredge (AD) survey must also be conducted during the dredging cycle. Because the dredge-related surveys are used to accurately determine the extent of dredge work necessary and also as the basis for final dredge contractor payment, they must meet strict accuracy standards and they need to be fully processed in near real-time. In addition to the navigation-related projects, other sources both inside and outside of the USACE may periodically require some type of hydrographic survey in order to proceed with a project. Some of these other types of projects may include structural assessment surveys, general pre-construction and as-built site surveys, natural resource reconnaissance surveys, or submerged obstruction surveys. Within a district, survey priorities tend to evolve on an almost continual basis. Generally, any contract-related surveying requirements would take priority over other less time-sensitive projects. Most districts will maintain a backlog of PCS work that can be completed during periods when there are no contract-related requirements to address. While survey priorities are an important factor when actually scheduling and conducting the survey data acquisition, many other factors also impact when a particular job may be completed. Whether the work will be conducted by an in-house survey crew or an A-E survey contractor will need to be considered when determining time requirements for completing the work. Generally, the A-E survey work will require more lead time to initiate because a delivery order scope of work will need to be prepared and survey time and cost negotiations will need to be completed. The weather can also be an important consideration when attempting to develop short-term survey schedules. For instance, high priority work in open, unprotected areas may need to be delayed because of rough sea conditions. During this time, lower priority work in more sheltered areas could be scheduled. Similarly, water level or tide conditions may also be an important consideration when scheduling hydrographic survey work. For instance, some shallow-water projects can only be efficiently addressed when water levels are running higher than normal.

2-6. Pre-Survey Planning

Before actual field surveying can begin, it is generally necessary to prepare some type of pre-survey package to assist the field surveyor. For an A-E contract survey, a scope of work must be prepared that outlines all the work required and also provides all relevant background information (e.g., channel or project coordinates, local control information, prior survey information, local contacts and rights of entry requirements, etc.). A similar scope of work may also be developed for in-house survey work, though it is not required. The pre-survey package is generally prepared in the area where most of the required background information is maintained – generally within the main data processing area or within the field office. For repeat surveys to project areas where the surveyor has frequently worked in the past, it is likely that the surveyor will have most of the prior survey information that he may need. For surveys within new project areas or areas that are unfamiliar to the surveyor, there is some pre-survey information that will need to be supplied. For new project areas, the required survey and coverage limits should be clearly indicated on a nautical chart, a quad map, or some other map that accurately depicts the area. Also, a listing of available local horizontal and vertical control information should be provided, as well as a clear indication of the required horizontal and vertical datums for the project. The control listing may represent a combination of historical USACE control, NOAA control, USGS control, or control from some other state or local agency, and should include the reference or relationship that is needed to establish the local water level-based vertical datum (e.g., Mean Lower Low Water).

2-7. Pre-Survey Field Set-up and Calibration

Before hydrographic data acquisition can begin, the field survey crew must complete a number of field set-up tasks. The local control points that will be used to establish the project datum should be recovered and verified. If control points have been destroyed or are not available in the project area, then new control may have to be established. With the strong reliance on differential GPS for survey control, there may no longer be a need to maintain an extensive horizontal control network within the immediate project site. However, If DGPS is being used for survey control, then it is a good idea to have at least one strong control point within the immediate survey that can be used to verify the performance of the positioning system.

a. Horizontal and vertical datums. Most Corps-related projects in coastal waters will use Mean Lower Low Water (MLLW) as the vertical datum. For inland navigation projects or reservoirs, a variety of reference planes may be used for the vertical datum. There are a variety of techniques for establishing a water-level related datum. Whatever vertical datum is selected, there must be a mechanism in place for recording the actual water level relative to this datum during all periods of a survey. A staff or staffs may be installed in the project area by running differential levels from the vertical datum benchmarks; this staff can then be observed and then manually recorded during the survey. Similarly, a recording water-level gauge can also be installed that will automatically record (and possibly transmit) the observed water level at a user-specified time interval. Within some project areas, NOAA or some other agency may maintain a water-level station that can be accessed to obtain the necessary water-level data. If kinematic DGPS is being used to control the hydrographic survey and adequate ellipsoidal height/water-level relationships have been developed, then the required water level information can be extracted from the DGPS data.

b. Data acquisition systems. The most common survey conducted within the USACE is a channel cross-section survey, using a single-beam acoustic echo sounder to measure depth, a differential GPS to provide accurate position, and a PC-based data acquisition system to time-tag and record the depth and position data. Multiple transducer sweep systems or multibeam swath systems may also be used. Prior to beginning this type of survey, the data acquisition system needs to be configured to reflect the particular survey vessel and the types of sensors being used and also the area being surveyed. Accurate sensor offsets must be measured between the echo sounder and the positioning antenna and then applied within the acquisition system. If the GPS antenna is mounted directly over the echo sounder transducer, then no horizontal offsets need to be applied. However, if RTK DGPS is being used to measure vertical movement during the survey, then the vertical offset would need to be measured and applied. Also, any transmit latencies (or delays) in the sensor data output must be accurately measured and also applied within the acquisition system. Finally, the pre-planned survey lines must be laid out within the acquisition system to provide the necessary coverage over the specified survey area. The pre-planned lines should include sufficient cross-check lines so that some comparisons can be made between overlapping soundings from different survey lines.

c. Speed of sound in water calibrations. Before on-line survey data acquisition can begin, the surveyor must properly measure and account for the speed of sound in the water column and the draft of the survey boat, and possibly verify the operation of the positioning system. To account for the speed of sound of the water column, the surveyor could obtain direct readings using a calibrated speed of sound profiler. An assumed speed of sound can be entered into the echo sounder during data acquisition and then the actual speed of sound profile can be applied during post-processing to correct the soundings. The surveyor can also conduct a bar-check calibration of the echo sounder to obtain an average speed of sound that can be entered directly into the echo sounder during data acquisition. Although it does not provide as complete a picture of the water column as an automatic speed of sound profile, a well-calibrated bar-check does provide verifiable proof of the proper operation of the echo sounder. It takes into account both the static draft of the transducer and the speed of sound in the water column, and can be used to provide the optimum echo sounder performance at a desired project depth. In shallow-water project areas, it may also be possible to check the echo sounder using a calibrated rod or sounding pole.

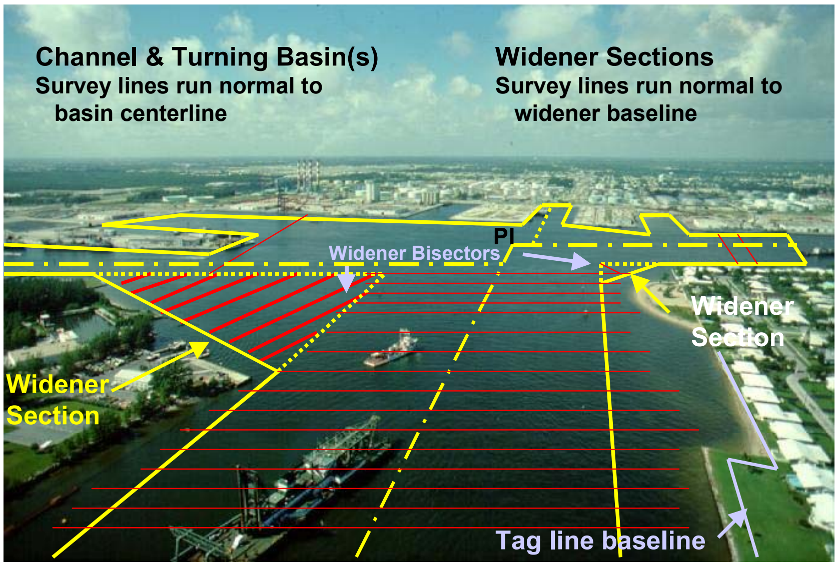
d. Vessel draft corrections. The static draft of the survey boat transducer is physically measured while the boat is out of the water and may be annotated with hash marks on the hull of the boat. The hash marks enable the surveyor to verify the static draft or to note any changes due to vessel loading. Because the draft of the boat may change considerably when underway, it is important to know the dynamic draft of the boat. The dynamic draft is usually measured through periodic settlement and squat tests that track the vertical movement of the transducer as the survey boat moves through various engine speeds. Because the dynamic draft can vary greatly with boat speed, it is usually a good idea to run the boat at a consistent speed throughout the survey. However, because dynamic draft is more a function of boat engine speed (i.e., RPMs) rather than actual speed over water, winds and current may have an effect on how the dynamic draft is applied. Most data acquisition systems measure and record the boat speed over water (based on position), but they do not record engine RPMs. The dynamic draft must either be entered during data acquisition or applied during final post-processing.

e. Positioning system calibration. Although DGPS has proven to be a very reliable system for providing accurate survey positioning data, it may still be reasonable to perform periodic system checks to verify the performance of the system. The performance check can be a straightforward procedure of placing the positioning system antenna alongside a well-known control point (e.g., a PK nail in a piling) and verifying the observed DGPS position. The positioning system performance check would be essential in project areas where a local differential base station had to established, or in wide-open, non-descript areas away from any recognizable cultural or natural features.

2-8. Survey Data Acquisition

After the data acquisition system has been properly configured and all of the necessary calibrations have been completed, on-line data acquisition can begin. For most operations, this generally entails a boat coxswain steering the boat along the pre-planned survey lines, while the surveyor monitors the data acquisition system and the sensor data to ensure that the necessary survey coverage is being obtained. As discussed earlier, tide or water level readings must be recorded during all periods of data acquisition. The water-level data can be applied on the boat during data acquisition or it can be recorded and then applied during data processing.

a. Channel section surveys. During a typical Corps channel cross-section survey, numerous lines (spaced 50, 100, or 200 feet apart) must be run across the channel alignment for the entire length of the defined project--see Figure 2-4. Because these surveys may be conducted in areas with heavy recreational and/or commercial boat traffic, it is important that the boat coxswain is attentive to local channel conditions as he steers the pre-planned survey lines. In addition to the channel cross-sections, survey data should also be acquired along the channel centerline and each of the channel toes. These channel profile lines will provide the overlapping sounding data needed to perform cross-check comparisons, and also may indicate potential shoal areas that exist between the cross-section sounding lines. In addition to the sounding lines, the surveyor should also ensure that all prominent features within the project area have been properly positioned and well described. The list of features should include all fixed and floating aids to navigation, any shoreline features such as docks or bulkheads that extend close or into the project limits, and any visible submerged or partially submerged obstructions.



Port Everglades, Florida   Jacksonville District

Figure 2-4. Cross-section surveys of a typical deep-draft navigation project

b. Annotation of depth data records. During data acquisition, the surveyor should maintain an accurate and detailed written record of the overall survey operation. This written record could be entered within a separate field book and/or entered directly on the echo sounder trace. This written record should include the basic project start-up information (e.g., date, personnel, survey project, weather, sea conditions, etc.), a record or summary of all calibration results, a summary of all survey lines run and any unusual conditions encountered on these lines, and a description of all point features that were positioned during data acquisition. In many congested project areas it is also useful to obtain photographs (regular or digital) to help describe local project conditions. If photographs are obtained, then the written record should also contain a brief description of what these pictures are depicting. A survey position should also be taken to document the point from where the photo was taken.

2-9. Initial Field Data Review and Editing

After field data acquisition is complete, the data must be initially processed and edited in the field. This is typically performed by manual processes described hereafter; however, software is rapidly being developed that will automatically adjust, filter, smooth, edit, and thin hydrographic survey data. The recorded or downloaded tide or water-level information must be properly applied to all sounding data. Each individual sounding line must also be reviewed for both position and depth accuracy. Generally, bad positioning data can either be smoothed over or rejected depending upon the extent of the bad data. If there is only a short positioning gap or "bust" (i.e., less than 15 seconds) then generally the bad positioning data could be smoothed between the adjacent good positioning data. For longer positioning busts, the data must usually be rejected and then re-run if necessary to provide the required survey coverage.

a. Editing depth data. Generally, bad depth data can either be rejected or edited, but should not be smoothed. During depth editing, the digital depth record should be compared to the analog echo sounder trace. In addition to checking for incorrect digital depths (i.e., "spikes"), the surveyor should also ensure that the critical strikes or shoals have been digitized. For instance, if the peak of a shoal or obstruction was not digitized, then the surveyor must scale this depth off of the analog trace and then insert it into the proper location within the digital record. For standard channel cross-section surveys, there is usually not a lot of depth data editing or inserting that must be done. However, for surveys conducted over irregular or varying bottoms, it may take a careful review of the records to ensure that the digital data accurately depicts the true bottom. In these types of areas, the accuracy of the digital data can be improved by increasing the record rate of the echo sounder and/or running the survey boat at slower speeds.

b. Depth interpretation in unconsolidated materials. Other types of bottom conditions can also impact the extent to which the depth data must be reviewed and edited. In naturally soft bottom areas or in dredge areas with unconsolidated materials, it may be difficult to detect or even define the true bottom. A low frequency transducer signal (e.g., 10 – 50 kHz) can usually penetrate a soft bottom layer and can help identify the first hard bottom return. However, even if a dual frequency echo sounder is used, it can still be a somewhat subjective decision as to what constitutes the true bottom. This can become a major point of contention during dredge payment surveys and must be resolved in a consistent and equitable manner. Frequently, the surveyor must prove to the project manager and the dredge contractor that the depths they are using provide the "best" and most consistent representation of the bottom. In shallow water projects, random pole soundings or lead-line soundings can be obtained to verify the accuracy of the echo sounder depths. This is more difficult in deeper projects, though lead-line soundings may still be possible in ideal conditions. The surveyor can also highlight the comparisons of overlapping survey data outside of the dredged or disturbed areas to prove the consistency of the overall survey operations.

c. Surveys in shallow waters or wetlands. Echo sounder depth readings must also be closely reviewed for operations conducted in shallow water areas. Extensive hydrographic surveying over shallow water is often required to support some type of shoreline engineering or wetland creation project and the hydrographic data will frequently be merged with adjacent topographic survey data. Because of the required signal send and receive time delays, most digital echo sounders are unable to effectively sound any shallower than two feet below the transducer. However, most of these echo sounders will still output an incorrect digital depth, even as the transducer is dragging along the bottom. In these cases, the digital depths will be off by up to two feet, but the errors will not be obvious to those who may be reviewing or using the data in the future. For shallow-water surveying, it is important that the surveyor know the limitations of the echo sounder, and either schedule the survey during high-water periods or supplement the echo sounder depths with periodic pole soundings. In order to avoid discrepancies with the overlapping topographic data, it is important that any invalid shallow-water echo sounder depths be rejected during data editing.

d. Insufficient data coverage. While editing the depth data, the surveyor should also be alert for any unusual or questionable features indicated within the echo sounder data. For instance, a slight rise or depression on a normally flat bottom may be the indication of a side echo or scour hole associated with a nearby obstruction. Any echo sounder features that cannot be adequately resolved or defined should be noted; additional data may have to be acquired in the areas immediately around these unresolved features.

e. Final review. After all necessary position and depth edits have been completed, the surveyor should review the overall edited survey package to ensure that adequate coverage has been obtained.

Ideally, this initial editing and review of the data should take place in the field so that any additional field work that may be required can be quickly addressed. This is particularly true for projects that are distant from the area where the survey party is based. During this data review, the surveyor should also check the consistency of the present survey data by comparing any overlapping sounding data. If the survey area is part of a dredging project or has been surveyed in the recent past, then the current survey data can also be compared against any prior survey data to provide another measure of the reliability of this data. Any additional field data that is required to fill in coverage holes caused by rejected data, to better define a potential bottom feature, or to resolve some other discrepancy should be acquired as soon as possible. This additional data should be edited as discussed above and then combined with the prior survey data.

2-10. Field Data Submittal to District Office

After data acquisition and initial field editing are complete, the finished field data package should be submitted for office review and final data processing. Many of the specific procedures used for submitting data and also the office where the final data processing actually occurs will likely vary a great deal between Corps districts. However, in most cases the same basic requirements for data submittal will need to be met. Generally, both raw and edited digital survey data, any applicable digital parameter files, all echo sounder traces, all survey notes or field books, any supplementary tide or GPS data, any digital or regular photographs taken, and any other relevant survey information should be submitted to the final data processing office. In addition to the field survey items outlined above, the field unit may also be responsible for creating and submitting the initial metadata file that will be used to describe and track this data set as it moves through the final data processing phases.

a. District office review of incoming field data package. If the field performed most of the editing and processing of data on board the survey boat, then the amount of district office review will be minimal; and will be primarily a quality assurance check on the adequacy of the field data processing. A cursory scan of cross-sections is usually adequate to pick up any editing deficiencies. A cross line check run in the field may also be rerun to verify data adequacy. Comparisons with any recent surveys should be performed. For contract surveys pre- and post- dredge sections may be compared. Data are then sorted for subsequent volume computations and/or plotting. The type of processing for volumes will depend on the type of collected data and if TIN or average-end-area volumes will be computed. After quantities are computed, they should be quality checked against estimated quantities or progress payment quantities. Data are then sorted at proper increments for eventual plotting. Thinning of data must follow Corps-wide guidelines. Multiple sorts may be required if different plot scales are needed.

b. Convert data to CADD format and distribute to users. Hydrographic data is incorporated with other related information such as digital quad data, aerial mapping data, and digital photos. Data files are merged within a CADD package--e.g., MicroStation/Inroads--and drawings are adjusted to the desired plot scale. Although most surveys are distributed in plan format, other display options are available. Figure 2-5 depicts a condition survey report in which controlling depths are shown by profile lines along the channel. The entire database should be reviewed prior to electronic transmittal to the requesting district function. Project Managers receiving data should be requested to red-line any corrections and provide other comments. Where applicable, controlling depths are determined for project condition reports. Final drawing files are created and raw and edited data and map files are archived. Metadata files are generated and placed on applicable public servers. Project condition survey data is distributed to Federal and local agencies, and posted directly on servers for public access. Digital Project Notebook data are updated if needed to reflect new survey information.

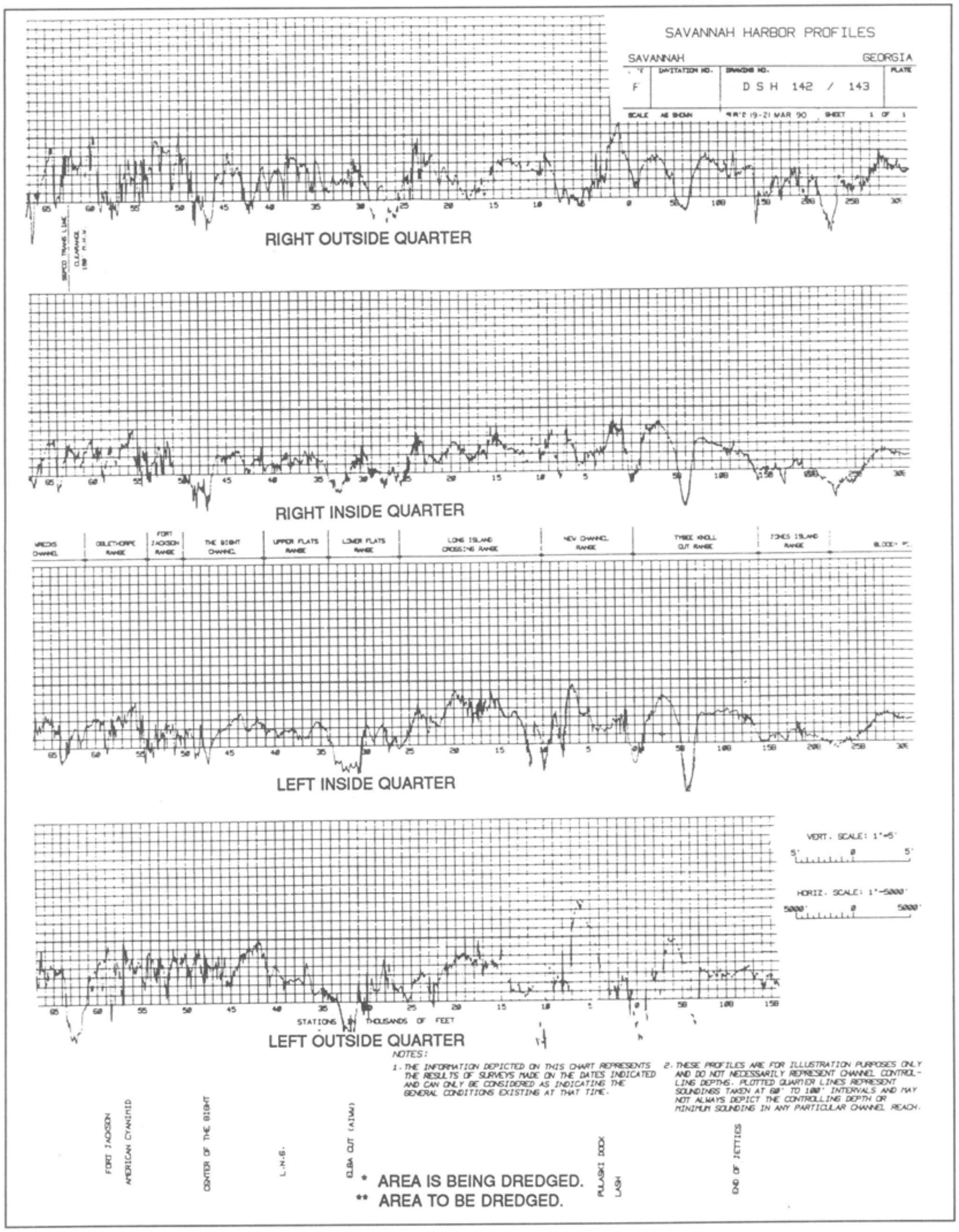


Figure 2-5. Savannah Harbor profile lines (Savannah District)

2-11. Mandatory Requirements

There are no mandatory requirements in this chapter.