Chapter 8
Manual Depth Measurement Techniques

8-1. General Scope and Applications

Manual depth measurement techniques are used for many under water engineering and construction applications. These methods include use of hand lead lines, topographic level rods, and sounding poles. Manual methods are generally used where more efficient acoustic methods cannot provide adequate depth data or sufficient detail. Examples include: surveys of areas adjacent to piers, bulkheads, and offshore pile structures; near locks, dams, power plants, and river control structures subject to turbulence; detailed surveys of rock jetties and breakwaters; beach and dune profile surveys; surveys in shallow detention or retention ponds or water conservation pools; surveys in shallow wetland areas with thick bottom vegetation or mangrove; and surveys in areas where unconsolidated sediments are present. Manual depth measurement techniques are simply a variation of conventional topographic survey methods. However, unlike land-based topographic surveys, the geophysical properties of the bottom are not always visible or consistent. Any type of positioning method may be used to locate the depth measurement device--total stations and DGPS now being the most common. This chapter provides general guidance and procedural criteria for manual hydrographic survey depth measurements on engineering and construction projects.

8-2. Lead Line or Sounding Disk Measurement

Prior to the accepted use of acoustic depth sounding methods in the 1950s, lead lines were the Corps standard for hydrographic survey depth measurement, as illustrated in Figure 8-1. At one time they were used as the calibration reference for acoustic soundings. Lead lines are simply surveyor tapes (chains) with a weight attached to the end. The length of these lines was usually less than 100 ft, or near project depth; however, much longer lines were used for deep-water surveys. Lead lines may be operated by hand, suspended from a bicycle wheel, or operated by a power winch apparatus--see Figure 8-2. The water surface is used as the reference datum for the observations, as shown in Figure 8-1.

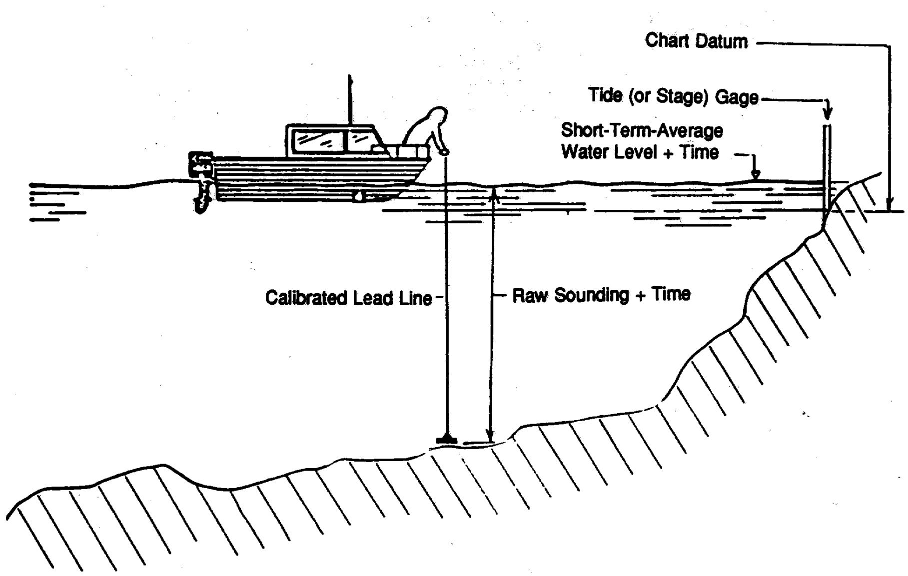

Figure 8-1. Lead-line depth measurement

a. General uses. Lead lines are to be used in situations where use of electronic sounding would be impractical, impossible, or give faulty results. Lead line sounding is especially suited for underwater investigation of rock or concrete placement; on the slopes of jetties, groins, and revetments; and near bulkhead construction. In such areas, echo sounding may be inaccurate or contaminated with noise from side echoes. Lead lines are to be used in conjunction with acoustic or nuclear density techniques to corroborate echo soundings. Also, for silty bottoms containing “fluff” that would give questionable echo sounding readings, a lead line may be required in a construction contract.

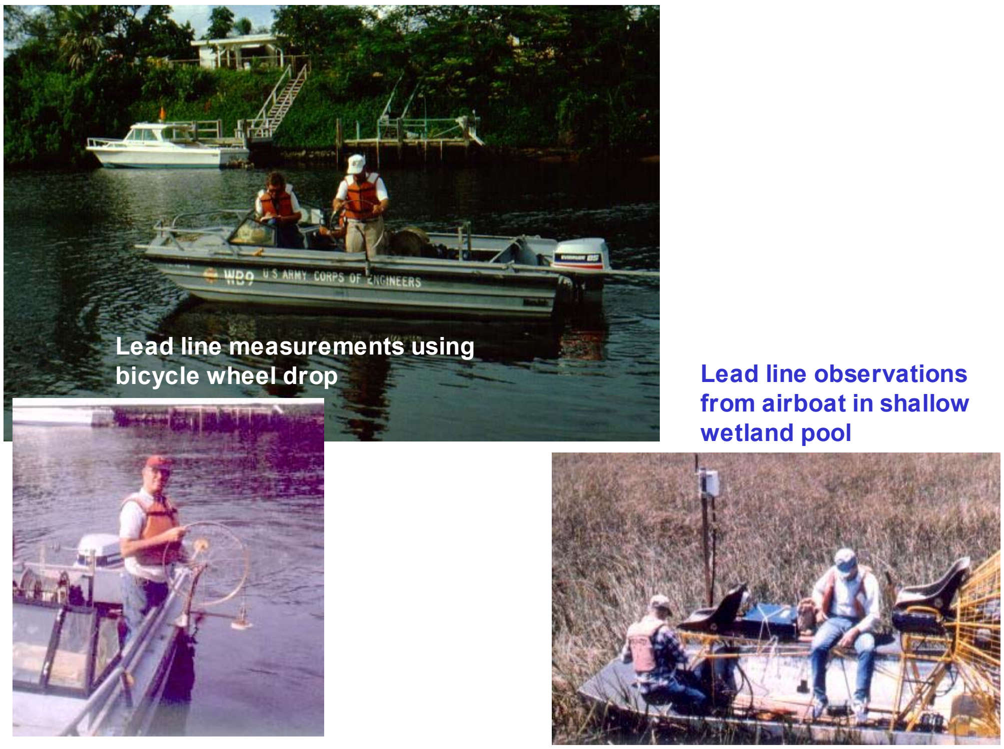

Figure 8-2. Lead line measurements (Jacksonville District)

b. Line materials and dimensions. A variety of flexible metallic materials can be used to suspend a sounding lead. All must exhibit minimal stretch while under tension. Braided rope is never used for this reason. Standard 100-ft surveyor's chains/tapes have been configured into lead lines. Stainless steel wire rope, piano wire, and rubber-shielded electrical wire are often used. Since a lead line is rarely used in depths exceeding 50 ft, line stretching due to tension should be minimal. However, this should be checked when any type of braided material is used. For most USACE applications, lines need not be made any longer than 50 to 75 ft. Shorter lines may be made when used primarily on shallow-draft projects.

(1) The Coast and Geodetic Survey recommends use of a mahogany-colored tiller rope with a phosphor-bronze wire center (size 8 line --0.24-in. diameter). This type of braided line is suitable for continuous hand operation since the tightly woven cotton shroud prevents broken wire strands from protruding and causing hand injury. Procedures for seasoning and calibrating this type of line are covered in the NOAA Hydrographic Manual (1976).

(2) Flexible wire lines are best suited for mechanically reeled lead lines. A bicycle wheel rim (Figure 8-2) or other large-diameter drum provides a rapid line payout velocity. A thin braided or solid core flexible wire is used for such devices.

c. Line marking. For Corps applications, lines are marked at 0.1-ft intervals throughout their length. The zero reference is the bottom crown of the mushroom anchor or sounding disk, and the marking interval begins above the connection to the sounding line. The anchor/disk shank is not marked. Marking the 0.1-ft intervals is performed using a standard 100-ft surveyor's chain. These marks must be easily read. Care must be taken to ensure that the ring/swivel and shackle connection is free and clear and that the line is under adequate tension. Types of marks used depend on the line. Marks may be seized onto the line with small cord. Seizings should penetrate the wire braids to prevent slippage. Marks may be directly crimped onto braided or solid wire using standard wire rope crimping equipment, and identified by color-coded seizing cord or seized leather flags.

d. Lead type and dimensions. A Corps-wide standard lead line weight shall be either a mushroom anchor or a flat sounding disk. A standardized weight will help ensure uniformity of contract payment, especially in areas subjected to high-suspended sediment concentrations. These two optional standardized weights should not be interchanged on the same project.

(1) *Mushroom anchor.* The USACE standard mushroom anchor type lead weighs 7-lbs. and has a 6-in. diameter crown. This type of anchor may be purchased at most marine supply outlets. The lower end of the line should be attached to the anchor ring with a freely pivoting shackle. In some cases, a permanent bight in the line may be end-spliced around the anchor ring's eye. Any variation from this standard lead weight shall be indicated in construction contract specifications. In some high-turbulence areas, a heavier lead may be required. Lead weights in excess of 100 lb. have been used to investigate scour rates below control structures.

(2) *Sounding disk.* The standard sounding disk is a 6-in.-diameter circular stainless steel plate. A connecting shank (4- to 8-in. length) and swivel shall be welded to the center of the plate. Four 1-in.-diameter holes shall be drilled symmetrically around the plate. Total weight, including shank and attachment swivel, shall be 8 lb. Again, any variation from this standard lead weight shall be indicated in construction contract specifications.

e. Operational procedures. Normally, measurement is made upon free-fall to apparent refusal on the bottom. Proper care shall be taken to minimize line angle from the vertical due to strong currents or tidal flow. A bicycle wheel should be employed when rapid drops are necessary such as in project depths exceeding 40 ft with strong surface or subsurface currents are present. In soft-bottomed materials, the reading should be taken at apparent refusal or within some specified time (normally 5-sec) after apparent initial penetration. In payment areas where a lead continues to fall under its own weight, it is essential that contract specifications (or subsequent agreement) indicate the elapsed time before reading. To ensure consistency and equity of payment, the same lead line and leadsman operator should be used for both pre-construction and post-construction surveys. Leads should be thrown or mechanically dropped adjacent to the tag line mark or positioning reference. If lead casts are made to port/starboard and/or forward/aft of the positioning reference, an eccentric correction must be applied. The lead line is held taut for sufficient time to visually mean any sea state variation. Observed depths are recorded to the nearest 0.1 ft either in a surveyor's field book, on a worksheet, or directly into a portable data-logging device. Buffalo District has developed a system whereby lead line observations are input into HYPACK along with observed DGPS positions. Subsequent corrections are made for river/pool stage or tidal datum. Corrections resulting from periodic calibrations are also applied.

f. Calibration. Each lead line should be calibrated at intervals of time not exceeding those listed in Table 8-1. Contractors are free to request that the lead line be checked before any payment survey. Calibration should be performed by comparison of marked intervals with a steel tape. Calibration data should be recorded in a standard field survey book or on a worksheet. Differences between true and marked intervals should be computed. Measurements in the interval band should be corrected accordingly. Maximum errors should not exceed the indicated allowable values. If so, marks exceeding this value shall be reset. If a constant index error is present, the line-anchor connecting assembly should be modified to remove the error.

8-3. Sounding Pole

a. Uses. A sounding pole is basically a level rod which uses the water surface instead of a differential leveling instrument for reference. Depths are observed relative to the water surface. If a total station is used, direct absolute elevations may be observed and reduced to the water surface datum. Standard expandable level rods are often used for sounding poles. Sounding poles, like lead lines, are useful in certain situations in which an electronic echo sounding system is not practical or accurate. For example, areas with dense bottom vegetation or irregular jetty stone may give false signals electronically and must be sounded by hand. Next to instrumental leveling, a sounding pole is perhaps the most accurate hydrographic measuring device in shallow water depths. It is especially suitable for subsurface rock and concrete placement. Its light weight is useful in fluff areas where free-fall penetration must be minimized. Its uses are generally restricted to depths not exceeding 15 to 20 ft. Figures 8-3 and 8-4 are illustrations of the use of a sounding pole.

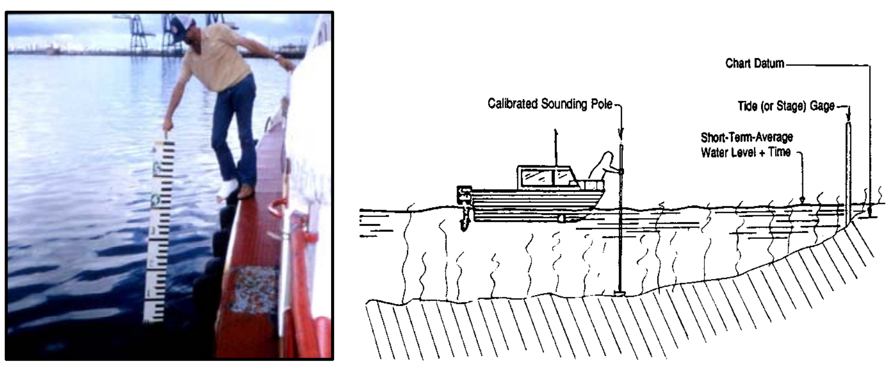

Figure 8-3. Sounding pole depth measurement

b. Dimensions. Poles should generally not exceed 20 ft in length. A 12- to 15-ft-long pole is optimal for ease in handling and maintaining verticality. Wood or square tubular aluminum poles (1-in. dimension) are commonly used. Standard wooden/metallic and fiberglass level rods are also employed as sounding poles. For other than subsurface rock, packed sand, concrete, or other hard bottom material depth measurement, the pole should have a 6-in.-diameter circular plate attached to the base of the pole. Overall weight of the pole (including base plate) should be less than 8 lb. As with a lead line, use of a particular pole should remain consistent throughout the duration of a contract/project. When conventional level rods or fiberglass rods are used, the base plate characteristics and overall weight should conform to the above standard. Any deviation for a particular project shall be noted in the contract specifications.

Figure 8-4. Sounding pole measurement from small work boat (Jacksonville District)

c. Marking. Sounding poles are marked at 0.1-ft intervals. Rod divisions are referenced to the bottom of the base plate. Marks are usually painted and annotated in a manner identical with that used to paint and annotate conventional level rods.

d. Calibration requirements. Each sounding pole should be calibrated at periodic intervals and recorded in a standard field survey book. Pole calibration should be done by comparison with a steel tape or level rod whereby marked intervals are measured and recorded.

e. Operational procedures. In projects with hard bottom material, readings shall be taken at apparent refusal. In soft-bottomed materials, the reading shall be taken at apparent refusal or within some specified time (normally 5 seconds) after apparent initial penetration. In extreme low-density areas where the pole continues to fall under its own weight, it is essential that contract specifications (or subsequent agreement) indicate the time of reading. It is critical that no pressure be exerted in areas of highly suspended sediments. Observations are referred to the water surface and are corrected to the final datum by applying appropriate corrections, including calibration corrections, if any. The pole must be kept as nearly vertical as possible especially in strong currents. A standard bulls-eye rod level may be attached to the pole if necessary. Depth measurements must be reduced for any horizontal eccentricities as described for lead line measurements.

8-4. Manual Depth Measurement Accuracy and Quality Control Criteria

Manual depth measurement accuracy depends on a number of factors: water depth, currents, sea state, and bottom consistency. In general, these devices are highly accurate in calm, shallow water where the device can quickly reach the bottom and depth readings can be easily interpolated from the water surface undulations. Accurate measurements require rapid estimation of the average wave action. Where feasible, direct total station elevation observations on the rod can eliminate the water surface interpolation error. However, this is usually not practical at distances beyond 500 ft from the instrument, and the water surface must be used as the reference elevation. Currents can adversely effect both lead line and sounding pole measurements, causing slope distances to be observed. In soft sediments, the reading accuracy is dependent on the ability to judge a point of refusal. This is likewise true in dense bottom vegetation or where mangrove roots are present.

a. Depth limitations. In general, the accuracy of manual depth measurement methods is limited to water depths of approximately 15 to 20 ft. This is based on the performance standards shown in Table 3-1 for mechanical observations at these depths--i.e., ± 0.25 ft RMS (95%). Deeper measurements may be justified only in extremely calm, current-free, protected waters, with a nearby reference gage.

b. Quality control and assurance. QC techniques are basically limited to periodic calibrations of the line or rod intervals, restricting observation conditions (depth, current, sea state, etc.), and verifying tide/stage gage readings. Independent QA testing is not usually performed on manual survey methods; thus, adequate QC is essential. If distances from the reference tide/staff gage are significant, then comparisons and/or interpolations should be made from a second gage. A "significant" difference in gage observations would be water surface slope errors exceeding 50% of the required elevation accuracy--i.e., approximately ± 0.12 ft for dredging and navigation surveys in less than 15 ft of water. Refer to Table 3-1.

c. Criteria. Table 8-1 describes general criteria for depth measurement observing, recording, and accuracy evaluation.

Table 8-1. Manual Depth Measurement Quality Control Criteria

	PROJECT CLASSIFICATION Navigation & Dredging Support Surveys Bottom Material Classification Hard	 Soft	 Other General Surveys & Studies (Recommended Standards)
Recommended maximum depth	15 ft	20 ft	50 ft
Read/record/plot soundings to nearest	0.1 ft	0.1 ft	0.1 ft
Maximum currents generally NTE	1-3 kts	4-5 kts	N/A
Reference water surface accuracy for depths < 15 ft	± 0.12 ft	± 0.12 ft	± 0.25 ft
Calibrate line/pole/rod to tape every read to nearest	week 0.05 ft	month 0.05 ft	annually 0.05 ft
Standard lead line weight	[7 lb mushroom anchor] [8 lb -- 6-in sounding disc]		optional optional
Standard pole/rod disc size Total weight	6-in diam 8 lbs	6-in diam 8 lbs	optional optional

8-5. Mandatory Requirements

The criteria in Table 8-1 are considered mandatory.