SURVEY GUIDE

For

ALABAMA ENGINEERING PROJECT ACTIVITIES

PLANNING

DESIGN

CONSTRUCTION

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
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SECTION 1

Introduction

Surveying is a vital link in the process of obtaining quality engineering in Natural Resources Conservation Work. It is the beginning and ending of a project and a strong reflection of the caliber work which we as professional employees portray. Every effort, therefore, should be made to conduct our engineering surveys in a professional manner.

This Guide includes procedures for planning, design, and construction surveys of watershed projects and RC&D structural measures. Primary emphasis is placed on surveys for floodwater retarding dams, channels, and gullies since these are the major types of structures usually encountered in project type activities; however, the procedures and principles outlined in the Guide are to be used with appropriate modification for survey work of regular conservation technical assistance at the field office.

The purposes of the Guide are to:

1. Establish concise, accurate, and uniform procedures for engineering surveys for project-type activities.

2. Serve as a reference for engineering consultants, engineers, survey technicians, and construction inspectors for information concerning required data, procedures, and criteria for engineering surveys.

3. Encourage professionalism and quality survey work in all NRCS activities.

4. Serve as a training aid to new employees.

This Guide is supplemented by survey textbooks and Service publications, including Part 540 of the National Engineering Manual; Technical Release No. 62; Section 10 of the National Engineering Handbook; and Alabama Engineering Field Manual, Chapter 2. Symbols used in drafting all surveys will be taken from the publication USDA-SCS, Standard Map Symbols.

SECTION 2

Planning Surveys

I. General - All planning surveys will be planned, scheduled, and directed by the planning engineer, hydrologist, and field engineer. All work will be coordinated with the field engineer assigned responsibility for the project.

The type and purpose of survey to be accomplished will determine the degree of accuracy required. All instruments used in surveying will be checked periodically according to the National Engineering Manual policy to assure they are adjusted to yield the required accuracy. Accuracy and plotting requirements for the various types of surveys are set forth in Appendix I.

Notes for Project-type surveys will be kept in accordance with Technical Release No. 62 dated January 1979. Survey notes will be kept in bound standard survey field books (SCS-191) or equivalent. The subject of the survey will be fully described on the front cover of each field book. The description should include, but is not limited to (1) the watershed or project name; (2) planning book, design book, or construction book, etc.; (3) the contents of the book, such as valley cross sections, baseline alignment, gully survey, landrights survey, bench level survey, and (4) the book number; i.e., 1 of 1, 1 of 4, etc.

Any items or sites of archaeological, historical, or environmental interest discovered during surveying that will affect planning or installing the project will be immediately brought to the attention of the planning engineer and the cultural resources specialist.

II. Investigation Surveys - Surveys which are required during preliminary planning to determine feasibility of a watershed will be conducted in such a manner that the survey data can be used during detailed watershed planning and final design. Planning surveys may include the following elements:

1. Vertical control surveys
2. Reference line and centerline surveys for dams
3. Valley and channel cross-section surveys
4. Reservoir area surveys
5. Embankment and emergency spillway site surveys
6. Gully surveys where appropriate

These elements of field surveys will be accomplished in accordance with the requirements stated in the Specifications for Survey Procedures (See Appendix I.)

United States Geological Survey 7.5 minute topographic maps, will be utilized for obtaining topographic information for preliminary investigations. Map information will be supplemented by field surveys as directed by the planning engineer. Information generally obtained from maps and/or field surveys for use in planning includes (1) estimated top of dam, (2) profile of the centerline of proposed structures (3) elevations of fixed improvements in the proposed reservoirs, and (4) key contours in the reservoir areas.

Floodplain data required may include (1) the width and slopes of the valley, (2) existing channel cross-sections, (3) roughness coefficients (Mannings “n”), (4) the location of the

fixed improvements in the floodplain, and (5) bridge size. Additional information may be needed on key and marginal sites in order to determine watershed feasibility.

III. Site Area Map Review - When the site area map has been completed, the planning engineer should select the best centerline for the structure (in many cases, this will be the reference line) and the best location for the principal spillway. The planning engineer will then schedule a field review of the structure and principal spillway centerlines with the district conservationists, the responsible engineer, and the state design engineer. During this review, attention should be given to the approximate location of the emergency spillway and borrow areas so that additional topographic survey information may be obtained if needed.

IV. Channel Alignment Surveys - The planning engineer and/or hydrologist will develop a proposed alignment for all channel improvement based on a detailed study of maps, photos, valley cross-sections, and onsite examination. Generally, field surveys for channel alignment will be conducted only to the extent necessary to meet requirements for channel design in the planning stage of project development. The proposed channel alignment should be located on contact prints using the distances between sections along the proposed alignment to establish the hydraulic gradient. These prints should show sufficient detail to provide a sound basis for delineating the easement requirements for development of the landrights work map.

SECTION 3

Design Surveys

I. General - After a watershed has been approved for operations and design priorities have been established, the state design engineer will review all survey data available and discuss additional surveys needed with the responsible field engineer. After survey needs have been established, the field engineer will plan, schedule, and direct all design surveys. In order to avoid duplication, the field engineer should be familiar with surveys completed during the planning phase of watershed development.

   Vertical control surveys needed for design will be a continuation of the vertical control survey made during watershed planning. Temporary Bench Mark (TMB's) numbering will continue in the same sequence begun during planning surveys. All additional surveys needed for design will be performed in accordance with the requirements in the Specifications for Survey Procedures (See Appendix I).

II. Structure Site Surveys - Reservoir area and structure site surveys will generally be made during detailed planning; however, in those cases where they must be made during final design, the different elements of the survey will be completed in accordance with the requirements stated in Appendix I.

   When site surveys are made by stereoplotter, additional information may be needed for final design. The field engineer will verify the accuracy of the stereoplotted map. Where the ground slopes are gentle or contour intervals are wide it may be necessary to survey top-of-dam and normal pool contours after final elevations are determined.

III. Structure Layout for Geologic Investigation - Preliminary design drawings will be furnished to the field engineer and geologist by the Engineering Design Section prior to the time the site is scheduled for geologic investigation. The field engineer, in consultation with the geologist, will direct layout of the centerline of the dam, the centerline of the principal spillway, the centerline and outside edges of the emergency spillway and will set horizontal and vertical control hubs in the borrow areas and any other areas requiring geologic investigation. The survey crew will establish the location and elevation of the individual drill holes from reference hubs.

   Any discrepancies in topography or structure layout noted during survey of geologic investigation will be reported to the design engineer.

IV. Channel Surveys - Channel plan surveys will be plotted on black line prints or transparencies of half-tone aerial photographs. The plan will be transferred to a reproducible medium in the Engineering Design Section during final design. This will provide final drawings with a photographic background.

   Black line photographic prints for channel surveys will be procured by the design engineer and furnished to the field engineer. Field engineers should coordinate the procurement of prints with the design engineer as soon as channel surveys are scheduled. The proposed channel alignment developed during planning will be used unless subsequent developments require alignment changes.

A baseline and centerline shall be established as stated in Appendix I, Specifications for Survey Procedures, Section 3B. Sketches should be made in the notes that will locate channel banks, wood lines, etc. The baseline should be located accurately on the print and any scale discrepancies noted.

Cross-section the existing channel and the area in the vicinity of the probable channel location at sufficient intervals to provide a sound basis for channel design and quantity computations. The distance from the baseline to the existing channel at intermediate stations between cross-sections should be measured and recorded so the channel alignment can be located accurately. TBM's should be established approximately every quarter mile along the channel and located just outside the probable work area. TBM locations should be selected carefully and described in detail so that they can be relocated without difficulty. Planning TBM's that are relocated for use in design surveys should be referenced and described in the design survey notebook in the same detail as TBM's established during design surveys.

Plot the location of the existing channel on the photograph, using the baseline as a reference. Locate both banks of this channel where scale permits. Establish the proposed channel centerline on the base map, locate tangents with respect to the centerline, and compute curve design.

Locate on the base map all property lines, TBM's, fixed improvements, utility Rights-of-Way (R.O.W.), access routes, proposed side drains requiring pipe installation or rock structures, rock outcrops in existing channels, and any other physical features affecting design. Show changes in wood lines and changes in other identifiable features since the photograph was made.

Check planning survey information for adequacy of bridge and culvert information pertinent to design. Obtain additional data at road crossing if necessary. Give particular attention to the location of all utility lines crossing proposed channels.

The field engineer will schedule and conduct a joint field review of channel alignment involving the district conservationist, geologist, and design engineer. After agreed-upon alignment changes are incorporated, the base map will be thoroughly checked for completeness and forwarded to the state conservation engineer's office for preliminary design.

V. Channel Layout for Geologic Investigation - The design engineer will furnish preliminary design drawings to the field engineer and geologist. The geologist will develop and coordinate geologic investigation plans with the field and design engineers. During the investigation, the field engineer will locate the designed channel centerline and will establish elevation of drill holes.

SECTION 4

Construction Surveys

I. General - All personnel involved in construction surveys should be thoroughly familiar with the surveying and note-keeping procedures contained in Chapter 2 - Construction Surveys, Section 19, National Engineering Handbook (NEH 19) and Technical Release 62. Personnel should be thoroughly familiar with all surveys conducted during the planning and design stages of the project's development and make maximum use of the available data. Prior to beginning the construction surveys, the field engineer, and the construction inspector should discuss and reach a complete understanding on the staking methods and procedures to use. The engineer field book, SCS-ENG-191B, (duplicating book) should be used for all construction surveys. All elements of construction surveys will be plotted and surveyed to meet the requirements set forth in Appendix I.

II. Surveys to Establish or Verify Vertical Control - Prior to beginning construction, all TBM's located within the construction area should be adjusted, following the procedure set forth in Chapter 2, NEH 19. Additional TBM's should be established and their elevations verified at locations where they will not be disturbed but will be accessible to the construction area. Each individual survey should be tied to at least two TBM's as this provides a quick elevation check.

It may not be practical to verify the elevations of all established TBM's adjacent to a channel, prior to beginning construction. However, during construction the elevations of all TBM's that are used should be verified.

A complete description should always be written in the engineer's field book for each TBM on a construction site. The first time that a particular TBM is used for a survey in a new field book, a complete description should be written rather than making a reference to a field book that has been previously used.

Not less than two permanent markers should be set on, or referenced to, the centerline or some other identifiable reference line on all structures (embankments and major channel projects) to establish a reference line from which all elements of the structure can be established, as well as elevations obtained. These markers should be established according to procedures set forth in Chapter 2, NEH, Section 19.

III. Surveys to Locate and Measure Areas to be Cleared - On all construction projects, the boundaries of areas to be cleared should be marked far enough in advance of the clearing operation to allow the landowner time to salvage all merchantable timber. The boundaries of all areas to be cleared should be marked with flagging or paint. If paint is used, it should be put on the side of the trees facing the area to be cleared, and if flagging is used, the tied know should be facing the area to be cleared. Individual trees to be left undisturbed should be clearly marked by a method (either by color or by type of marking) distinctly different from the clearing boundary markings. Areas to be cleared which are adjacent to an embankment should be marked with a different color paint or flagging to clearly distinguish these areas from the ones marked for clearing and grubbing. All boundaries, and markings for trees to be left in place, should be carefully and thoroughly explained to each landowner and the contractor prior to beginning the clearing operations.

When and wherever conditions permit, the survey to establish the limits of the areas to be cleared should be performed in such a manner that it will suffice as the survey for payment. Where no open areas exist within an area to be cleared, the area may be measured more efficiently after all the clearing has been completed for payment purposes. Where there may be doubt as to the area to be measured for payment after the clearing is completed, the area should be measured before the clearing begins and any open areas to be excluded should be explained to the contractor. The most accurate and efficient survey methods and procedures should be used for each individual job.

The limits of the areas to be cleared for a channel or an embankment, and the areas to be cleared and grubbed for the construction of an embankment, may be located and measured by establishing the distance from the centerline of the channel or the embankment, at each station, to the clearing boundary shown on the construction drawings by using a chain or shooting stadia. The areas to be cleared in a sediment pool on an embankment site may be marked most efficiently and accurately by running a level circuit to establish the clearing limits and measured by running a closed traverse. This survey method is applicable for areas to be cleared for borrow areas and emergency spillways.

IV. Embankment Surveys - The centerline of the embankment should be offset and referenced outside the work area using iron pins or hubs and tacks. Stakes should be set along the centerline at each station (a maximum of 100 feet apart) where a cross section of the embankment foundation or keyway area will be needed. Attention should be given at this time to the stations where the side slopes and the designed bottom of the keyway will intersect the principal spillway trench and the existing channel so that these stations can be noted for accurate quantity computations.

After the embankment foundation area has been cleared and grubbed, the centerline should be reestablished and the embankment area cross-sectioned perpendicular to the centerline at the predetermined stations, with sufficient elevations being established to permit accurate quantity computations. Simultaneously with this cross-section survey, the keyway slope stakes and the embankment slope stakes, berm stakes, and guard stakes should be set at each station following the procedure set forth in Chapter 2, NEH, Section 19 for surveying and notekeeping.

Surveys should be performed periodically on the embankment during construction to insure that it is being constructed to grade. Upon its completion, the embankment should be cross-sectioned at selected intervals (a minimum of three) and a profile run on the centerline to verify that the embankment was constructed according to the specified requirements.

V. Principal Spillway Surveys - The centerline of the principal spillway should be established from the point of intersection with the embankment centerline. Sufficient iron pins, or hubs and tacks, should be set outside the work area to permit easy relocation of the principal spillway centerline. Stakes should be set at 50-feet intervals or less along the principal spillway centerline. The centerline will be cross-sectioned at each station, and slope stakes set for the principal spillway excavation in accordance with the procedures set forth in Chapter 2, NEH, Section 19.

When the principal spillway trench excavation is completed, the trench should be cross-sectioned at the stations selected previously to verify that the excavation is to grade.

Grade hubs should then be set for the invert elevation of each joint of the principal spillway pipe. As the pipe is installed in the trench, the alignment, invert grade, and top of pipe grade should be checked at each joint and the elevations recorded in the field book.

VI. Existing Channel Survey, Embankment Area - A baseline should be established in the best location to cross-section the existing channel. The existing channel should be cross-sectioned perpendicular to the baseline at 50-feet intervals (more frequently if necessary) prior to beginning the channel excavation. At this same time, the necessary slope stakes for channel excavation should be set. After the excavation is completed, the channel should be cross-sectioned at the previously selected stations to establish the excavated grade for payment.

VII. Plunge Basin and Outlet Channel Surveys - The plunge basin should be staked as shown on the construction drawings and at least three cross-sections taken. All of the stations necessary for accurate quantity computations should be located. After the excavation is completed, the excavated grade should be checked with cross-sections. The centerline of the outlet channel should be established, cross-sections taken from the centerline at 100-feet intervals (more frequently if necessary) and channel slope stakes set. After the excavation is completed, cross-sections should be taken at the previously selected stations to verify the construction.

VIII. Emergency Spillway Surveys - The emergency spillway centerline, or the inside and outside bottoms if they can be established easier, should be established as shown in the construction drawings. The spillway should be cross-sectioned at the selected intervals to verify accurate quantity computations. Slope stakes should be set in accordance with procedures set forth in Chapter 2, NEH, Section 19. After the excavation is completed, the spillway should be cross-sectioned at the previously selected stations to establish the constructed grades.

IX. Channel Surveys - The centerline of the channel will be established, using the arc definition and laid out with appropriate chord lengths. Adequate centerline locations should be established from the iron pins set during design survey to satisfactorily mark the clearing limits. Guard stakes should be set to protect the horizontal control points, or these points should be relocated outside the work area prior to the beginning of the clearing operations.

After the clearing operations are completed, the centerline should be reestablished and the cleared area measured by the most efficient method. The areas to be excavated should be cross-sectioned at 100-feet intervals (more frequently, if necessary) and slope stakes should be set in accordance with procedures as set forth in Chapter 2, NEH, Section 19. Once the channel excavation is completed, the channel should be cross-sectioned at 500-feet intervals (more frequently, if needed). The average bottom grade should be checked and recorded at the intermediate 100-feet stations and the spoil should be cross-sectioned in each representative reach.

APPENDIX I

Specifications for Survey Procedures

1. Scope

   This specification shall determine the procedures and accuracy for conducting and plotting the different elements of project surveys for Natural Resources Conservation Service work in Alabama

2. Vertical Control Surveys

   Vertical control surveys will be referenced to mean sea level elevation. Surveys will begin at United States Coast and Geodetic Survey or other weel-established bench marks.

   Set temporary bench marks (TBM's) in conspicuous places such as on bridge abutments or large trees which are unlikely to be disturbed. Give a detailed description of the TBM in the field book; locate the TBM on photographs, prints, or maps used in plotting the survey; and record its number and elevation on the print or map. Number and elevation should be recorded on the back of photographs. If TBM is established on a tree, it should be marked by making a triangular blaze on the tree about 5 feet above the ground.

   Make turns on all TBM's and close the traverse. The allowable error of closure in feet is $\pm 0.05 \sqrt{M}$, where M is the length of the traverse in miles.

   TBM's at the structure sites will be given the number of the structure suffixed by a number designating the order in which the TBMs were established at the site. For example, TBM 7-3 would be the third TBM established at Site No. 7. Set a minimum of three TBM's at each structure site (one in the flood plain and one at each end of the dam).

   TBM's along channels will be numbered by the same procedure as is used for structure sites except that the site number will be replaced by an abbreviation of the channel name. For example, TBM S-3 or TBM SAL-3 would be the third TBM established in Salamander Creek Channel.

3. Reference Lines and Centerlines for Dams and Channels

   A. Reference Lines and Centerlines for Dams - A reference line will be established as a reference for all future surveys. The reference line will be located at the proposed centerline of dam. Iron pins should be set in both abutments on the reference line beyond the expected end of the dam and emergency spillway. Another iron pin should be set in the floodplain on the reference line. Each iron pin should be referenced by angle or magnetic bearing and distance to three nearby permanent reference points. The station numbers on the reference line shall increase from left to right looking downstream.

      The beginning station should be designated 10+00. Sufficient treated hubs should be set along the reference line to facilitate horizontal measurement to an accuracy of 1 foot per 5000 feet and to provide vertical control points for the reservoir area survey.

The reference line will be used as the centerline of the dam unless a new centerline is established.

The reference line will be profiled and the bench level traverse closed. The profile survey will include establishing the elevations of all pins and hubs along the line and additional ground elevations at intermediate points to accurately portray the surface of the land. The vertical error of closure in feet will not exceed $\pm$ 0.05 $\sqrt{M}$.

If the established reference line is not selected as the structure centerline, the centerline should be staked, referenced, and profiled in the same manner and to the same degree of accuracy as the reference line. The centerline should be tied to the reference line by recording appropriate angles, distances, and stations. The centerline should be part of a closed traverse which includes the reference line.

The reference and/or centerline profiles will be plotted on standard grid paper SCS-ENG-315 (21" x 30" sheet) or equivalent. The scale should be selected to fit the sheet and be easily readable. Ample space shall be provided below the plotted profile to allow plotting of geologic borings. If the reference line or centerline has an angle or a curve, a plan view of the alignment will be plotted to the same scale as the profile. The bearing, angles, and iron pins will be shown.

B. Reference Lines and Centerlines for Channels - A baseline shall be established close to the probable centerline of the new channel. Record double deflection angles and the bearing of the baseline. Iron pins or treated hubs should be set along this baseline at all P.I.'s, P.O.T.'s, and other identifiable points.

For channels in urban areas, the baseline shall be a closed traverse with the maximum error of angular closure N x (1.0 minutes), where N is the number of angles turned. The maximum error of horizontal closure shall be 1 foot per 5000 feet.

In rural areas, the traverse should be checked either by closure, cutoff lines between nonsuccessive stations which break the traverse into a series of loops, or by observing the angle to some distant landmark from each of several stations. In some cases, the traverse may begin and end at points whose locations have been accurately determined by previous surveys. In rural areas, the maximum error of angular closure shall be the same as for urban areas and the maximum error of horizontal closure shall be 1 foot per 3000 feet.

Channel centerlines should be run as separate lines from baselines. The centerline should be tied to the baseline at both ends of the channel and may serve as the closing leg of the baseline survey. Centerline stations should increase in the downstream direction. The upstream station number will be large enough so that any possible channel extension will not require negative stationing. Curve computations should be based on the arc definition of curvature and should be so stated.

4. Valley and Channel Sections

Locations for valley cross-sections will be selected by the designated engineer and will be marked on maps and or photographs for use by the survey party.

Sections are intended to be representative of flood plain and channel conditions. If it is necessary to move a valley section to a more representative location, the engineer should be consulted. Changes in channel sections from the original locations will be shown on the maps or photographs and noted on the plotted section and in the field book.

All horizontal measurements should be accurate to $\pm$ 1 foot per 100 feet. All vertical measurement will be a closed traverse and should be accurate to $\pm$ 0.8 $\sqrt{M}$.

Any reliable floodmarks should be marked on the ground and then located on the map or photograph. The date of the flood producing the mark and the name and address of the person giving floodmark information should be recorded on the back of the photograph and in the engineering field book on the page of the nearest valley cross section. The floodmark should be described in sufficient detail to enable a survey party to relocate it at a later date and determine its elevation.

Valley cross sections shall be surveyed vertically well beyond the apparent flood elevations. Vertical extent of valley cross sections will vary depending on topography and location in the watershed and will be coordinated with the hydrologist.

Station all valley cross sections from left to right looking downstream with the beginning station at 10+00. Make enough readings to show the actual surface of the land.

Make the channel portion of the cross sections perpendicular to the channel. If the channel is not representative where a valley section crosses the channel, move upstream or downstream to a representative channel section, and then resume the valley section along the original line. Extend the channel cross section beyond any secondary channels, alluvial berms, or spoil banks. Record the elevation of the flood plain at each channel section.

Manning's "n" value will be determined for each channel and valley section. Values of "n" for valley sections will be subdivided into segments for left and right flood plains and the channel. Determination of Manning's "n" values will be based on Supplement B, Section 5, NEH and on Geological Survey Water Supply Paper 1849, "Roughness Characteristics of Natural Channels." One member of the survey party shall be assigned responsibility for determining all "n" values within a watershed in order to lend consistency throughout the project.

Survey and index bridge and culvert sections, showing relationship of the bridge or culvert to roadbed and stream. Record a flood plain elevation at each section.

Enough channel cross sections should be taken to make reliable estimates of quantities and to delineate the existing channel conditions. Cross sections for detailed design should normally be taken at intervals not exceeding 300 feet. The sections should extend far enough to permit improved channel alignment and to cover the expected right-of-way limits.

Channel sections should normally be located perpendicular to the baseline and referenced to baseline stations. If sections are needed which are not perpendicular to the baseline, the angle the section makes with the baseline should be recorded.

Valley and channel sections will be plotted on station grid paper SCS-ENG-315 (21" x 30" sheets) or equivalent. The valley cross section profiles will be plotted to a horizontal scale 1"=200' and a vertical scale 1"=10'. In addition, a separate plot of the channel portion of the sections will be plotted to a horizontal and vertical scale 1" = 10', preferably to the right of the total section using a common vertical scale. Plot the channel section using the same horizontal stationing. All sections will be plotted from left to right looking downstream and in numerical order starting at the bottom of the sheet. Indicate on each section the location of any rock outcrops that are encountered. Also plot the elevations and describe any fixed improvements that could be affected by the works of improvement.

Culvert and bridge sections will be plotted on the same type of paper as the valley sections, to a horizontal and vertical scale 1"=10'. These sections will be fully identified. Identification for all sections will be centered below each plotted section.

5. Reservoir Area Survey

When the reservoir is to be surveyed by conventional methods, the embankment reference line will be the reference for all other grid lines, cross-sections, contours, and other lines. If the reservoir area at the estimated top-of-dam elevation exceeds about 100 acres, a closed traverse should be run around the perimeter of the area with the reference line or centerline of dam as a segment of the traverse. The traverse will be used as control points for the plane table survey. When the reservoir area map is prepared by aerial surveying methods, or by CADD generated topographies, the embankment reference line may be selected after the contours are completed. The reference line will be tied to the contour map by field measurement to identifiable objects on the photographs. Contour will be verified by field survey at selected locations. All contours in the vicinity of the embankment centerline will be checked by field surveys and adjusted as necessary.

Corrected-scale aerial photographs may be used as the base map for reservoir areas to be surveyed by conventional surveying methods. CADD generated topographies using electronically recorded survey points will not require a photographic base map. The scale of the reservoir area map will be selected on the basis of the estimated size of the reservoir at the designated top contour. A scale of 1"=200', 300' or 400' will be selected to fit the reservoir area to be a standard size sheet. A scale smaller than 1"=400' will not be used unless approved by the state conservation engineer. A contour interval will be selected for each reservoir area based on the topography of the area to be mapped as follows: 2 feet when the average slope is 2 percent or less, 5 feet when the topography is rolling to hilly, and 10 feet in mountainous country. When a 10-foot contour interval is used, locate all intermediate 5-foot contours across the valley floor but discontinue these partial contours on the abutments.

The reservoir area map will extend from a point 300 to 500 feet downstream from the reference line to the point upstream where the top contour designated by the planning engineer crosses the valley floor. The location of all fixed improvements and unusual topographic fractures; i.e., buildings, cemeteries, wells, power lines, pipe lines, fences, sinks, springs, rock outcrops, etc., shall be clearly shown on the reservoir area map.

6. Embankment, Emergency Spillway, and Borrow Area Site Surveys

The embankment site survey will consist of establishing the centerline and developing a detailed topographic map of the embankment area, emergency spillway and borrow areas. The embankment site should be mapped using the most efficient combination of surveying methods and procedures for the particular site. A scale of 1"=50' or 1"=100' should be used except where topography is very flat. A scale smaller than 1"=200' should not be used, even if the site area must be mapped on more than one sheet. Contour intervals should be 2 feet or 5 feet, depending on topography. Sufficient area should be mapped to include all reasonable alternative locations for the emergency spillway and the borrow areas. Location of all fixed improvements should be shown, also the location of existing channels, wood lines, obvious property lines, and other topographic features. Several points common to the reservoir area map, including stations along the reference line, should be located on the site area map so that the two maps can be properly oriented.

If the site is mapped by aerial survey, the map will be field checked for accuracy. All pertinent information not found on the aerial survey map will be added during field checking.

The centerline of the principal spillway should be staked, references with pins outside the work area, and profiled. Principal spillway station 5+00 shall be established on the centerline of the dam. The station numbers on the principal spillway centerline should increase downsream. The existing channel should be cross-sectioned at selected intervals both upstream and downstream from the centerline of the structure. Sufficient data should be obtained, particularly downstream, to permit an accurate rating of channel capacity and to provide a basis for outlet channel design.

7. Gully Surveys

Vertical Control will be measured from an assumed elevation unless the gully is convenient to some MSL datum. One or two TBM's will be set depending on the size and depth of the gully. The TBM's will be set so no bench level circuit exceeds 2000 feet or over 30 feet of relief.

Usually the baseline will be an open-end survey and will parallel either the major portion of the gully or the structure to be planned. Horizontal measurements will have an accuracy of 1 foot per 5000 feet.

Vertical error of closure in feet will not exceed $\pm$ 0.1 $\sqrt{M}$. Stakes, with tacks, will be set at 100-foot intervals and/or at key locations along the baseline. The baseline stations will start at 10+00 at the upper end of the gully and increase toward the outlet end of the gully.

Elevations will be established on the top of each stake. Cross sections will be made from each baseline station. If the cross section is to be over 300 feet, a transit should be used for alignment, usually turned at 90° angles from the baseline. The degree of accuracy of these cross sections should be the same as for valley sections described in the Section 3 of the specifications.

Where surveys are performed using total station instruments, a baseline may not be required for the planning and design surveys. A minimum of two iron pins from which the survey may be referenced will be established on the ground. An assumed northing and

eastering orientation will be referenced to the iron pins. All future surveys and layout will be referenced to the iron pins.

Wood lines, fence lines, gully rim, and other objects that could affect planning, design, or installation will be surveyed. Many of the distances to the gully edges will be taken from the cross sections. The survey should fill in the intermediate points along gully edges.

From the survey and the plotted cross sections, a contour map of the gully and adjacent area can be prepared. The cross sections and contour map should cover enough area to fully describe the conditions for planning, designing, and installing the grade stabilization structure.

SUGGESTED ABBREVIATIONS FOR SURVEY NOTE KEEPING

	Notes (note keeper)
	Rod (rodman)
	Chain (chainman)
	Instrument (instrument man)
	Plane table
	Triangulation station
	Transit traverse station
	Stadia station
F. S.	Foresight
B. S.	Backsight
H. I.	Height of instrument
T. P.	Turning point
∡	Angle
Bear.	Bearing
Obs.	Observed
Cal.	Calculated
T. B. M.	Temporary Bench Mark
B. M.	Permanent Bench Mark
Sta.	Station
Stad.	Stadia
B. A.	Beaman Arc
Mon.	Monument
Stk.	Stake
Spk.	Spike
Na.	Nail
C. M.	Corrugated metal
cb.	Curb
M. H.	Man hole
tk.	Tack
Ref.	Reference
R. H.	Reference hub
O. S.	Offset
℄	Centerline
P. I.	Point of intersection
P. C.	Point of curve
P. T.	Point of tangent
△	Central angle
D.	Degree of curve
L	Length of curve
R.	Radius of curve
T.	Tangent distance
c.	Cord
dh.	Drill hole
U. S.	Upstream
D. S.	Downstream
W. S.	Water surface
W. E.	Waters edge
P. P.	Power pole
Tel. P.	Telephone pole
sb.	Start bridge
eb.	End bridge
I. S.	Invert bridge stringer (opening)
P.	Piling
R. C.	Reinforced concrete
C. B.	Catch basin
S. S.	Side slope

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