TENNESSEE DEPARTMENT OF TRANSPORTATION

Survey Manual

Issued by the Design Division
Third Edition

May 3, 2011

TDOT

FOREWORD

This Manual establishes uniform policies and procedures for surveys within the Tennessee Department of Transportation. A legal standard for surveys is not established or intended. It is published solely for information, guidance, and training of the Department's employees and consultants.

The Manual does not establish any legal or administrative interpretations of the Department's contracts. In the event that the terms of a contract and the Manual are in conflict, the Manual is subordinate to the contract.

APPROVED FOR DISTRIBUTION

Carolyn A. Stonecipher — May 3, 2011

Director, Design Division — Date

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CHAPTER 1 - INTRODUCTION AND GENERAL INFORMATION

1.1 PURPOSE

This Manual has been developed to serve as a guide for all persons involved in the performance of engineering surveys for the Tennessee Department of Transportation (TDOT). The Manual establishes minimum acceptable standards of accuracy and completeness, and will help to assure uniformity of method and product statewide.

The Manual is intended as a reference, not as a textbook or contract document. The Manual is not intended as a substitute for surveying knowledge, experience, or judgment. Although portions include textbook material, the Manual does not attempt to completely cover any facet of surveying.

The hope is that the Manual will be used as a reference by field survey parties, a planning document and reference by consultant firms employed by TDOT, and as a training tool for new employee orientation.

1.2 ORGANIZATION

The following links illustrate the organization and reporting order of the survey function within the Design Division of the Department of Transportation. The Department is divided into four operational sections designated as Regions 1, 2, 3, and 4. The Regional Survey organization is the same statewide and reports directly to the Regional Director. The headquarters Survey and Design Office is divided into four sections, one responsible for Region 1, one for Region 2, one for Region 3, and one for Region 4. The Survey and Design Offices are part of the Design Division in the Bureau of Engineering.

Tennessee Department of Transportation:

http://www.tdot.state.tn.us/orgchart.htm

Design Division:

http://www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_design/design/index.htm

1.3 PUBLIC RELATIONS

1.3.1 GENERAL

Each employee is a representative of the Department of Transportation and is responsible for developing and maintaining public goodwill. The outdoor nature of surveying keeps personnel in the “public eye” much of the time. Work shall be accomplished efficiently and with a minimum of idle time. All direct contact with the public shall be pleasant, courteous, and businesslike. This includes answering questions, listening to criticism (justified or not) and listening to suggestions.

1.3.2 QUESTIONS FROM THE PUBLIC

All questions shall be referred to the Field Supervisor. He shall answer each question for which he knows the facts. If any doubt exists, he shall refer the person asking the question to the Regional Survey Office. Since exact alignment is determined during the design phase, conversation about possible route locations shall be avoided.

1.3.3 PROPERTY OWNERS

Dealing with property owners is a vital facet of public relations. The property owner will be directly affected by the survey and possible subsequent construction. The surveyor is usually the initial contact with the property owner and good relations developed by conscientious surveyors will carry over into all phases of the project.

1.3.4 RIGHT OF ENTRY

The Tennessee Code Annotated (Section 54-5-107) provides for entry to private property for the purpose of locating, laying out, or constructing any road to become a part of the state system of highways. There are certain steps, however, which shall be taken to secure permission for entry.

1.3.5 PRE-ENTRY CONTACTS

At least one week prior to commencing any survey activity on private property, contact letters shall be mailed to all property owners where entry is needed (Refer to Figures A-2, A-3, and A-4 in the Appendix). Property owner's names and addresses shall be obtained using the latest records available from the county Tax Assessor's Office. To promote good relationships, a diligent effort shall be made to contact each property owner or tenant prior to entering the property. However, personal contact is preferable in order to explain why entry is required, the purpose of the survey, the activities involved, and to determine facts pertinent to the survey. The Property Owner Contact Form (Refer to Figure A-1 in the Appendix) shall be used to document conversations with property owners (Refer to Section 3.6.3). Property owner information and contact method shall be entered into the CADD file (Refer to Section 3.4.2).

1.3.6 OBJECTION TO ENTRY

When a property owner or tenant objects to entry, DO NOT ENTER! If the property owner voices objection after the survey has begun, leave immediately. The Regional Survey Office shall be contacted and negotiations begun at that level. If entry cannot be gained, the Survey Coordinator shall be contacted. If efforts fail at that level, legal action can be taken.

1.4 LEGAL ASPECTS

1.4.1 RIGHT TO ENTER PRIVATE PROPERTY

The Tennessee Code Annotated (Section 54-5-107) authorizes the employees of the Department of Transportation, while engaged in locating, laying out, or constructing any road to become a part of the state system of highways, to do so without interference. In the event of such interference, an injunction to prohibit this conduct may be obtained. On entering property, the property must be protected from damage to the fullest extent possible. For additional information, refer to Section 1.3.4.

1.4.2 CLAIMS FOR DAMAGE TO PRIVATE PROPERTY

In the event a property owner feels he or she is due compensation for damage done to his or her property, he or she should seek restitution through the Division of Claims Administration, Treasury Department. The property owner is responsible for the contact. However, Field Supervisors shall cooperate fully in supplying information of their activities while on the property in question. The address of the State Claims Administration is:

Division of Claims Administration
Treasury Department
9th Floor - Andrew Jackson Building
Nashville, Tennessee 37243
Phone: (615) 741-2734

1.4.3 CITIZEN'S RIGHT TO VIEW DOCUMENTS

The Department maintains an open records policy and any citizen has the right to observe and copy most documents that are relative to his inquiry. However, most documents are public property, and possession is not to be surrendered without specific approval from the director of the Design Division.

1.4.4 RIGHT TO CONTROL TRAFFIC DURING SURVEY

There is no specific law authorizing members of a survey party to control traffic. However, state personnel are legally empowered to survey "without interference." All reasonable measures shall be used to preclude interference with vehicular movement, and lane closures shall not be considered until all other alternatives have been exhausted. In the event that traffic control measures are necessary, they shall be provided by Regional Maintenance personnel. The Regional Maintenance Supervisor shall be contacted for traffic control services. Very short closures or special situations may be handled by the survey party. In the event that traffic control measures are necessary, they shall be determined by the procedures outlined in the Manual on Uniform Traffic Control Devices (MUTCD). The MUTCD is distributed by the Traffic Engineering Office of the Maintenance Division, 400 James K. Polk Building, Nashville Tennessee and is available online at the following website:

http://mutcd.fhwa.dot.gov/

1.5 SAFETY

Survey personnel perform their work in many different hazardous environments including rugged terrain and high-speed traffic. The promotion of a safe atmosphere requires the acknowledgment of hazards and attention to safe practices by all employees. However, the Field Supervisor in charge of the party must assure safe conditions exist. As a part of this responsibility, he or she shall make sure all Personal Protection Equipment (PPE) and safety practices are maintained and in use.

Safe placement of vehicle, equipment and personnel shall be in compliance with the MUTCD. PPE shall be used any time employees are out of their vehicles. PPE includes, but is not limited to, a hard hat, a class III reflective safety vest, and substantial footwear. As with all TDOT vehicles, the use of seat belts by all parties in vehicles is mandatory. Any safety questions can be directed to the TDOT Safety Director, 400 James K. Polk Building, Nashville Tennessee or the Regional Safety Coordinators.

1.6 PROJECT NAMING CONVENTIONS

Project descriptions in any file and in all correspondence shall be in sequence as follows:

- FAI number (if an interstate)
- State route number (if a state route)
- U.S. route number (if a U.S. route)
- County name

- Local road name
- Project limits (from and to)

Examples:

- SR-6 (US-16, Thomasville Rd.), from 0.5 mi south of Thompsons Station, to 1.3 mi north of Turtle Dove Creek, Williamson County
- SR-6 (US-16, Thomasville Rd.), bridge and approaches over Turtle Dove Creek, LM 2.45, Williamson County
- The project number, PIN, and county shall be included in all correspondence.

Refer to Section 3.4.2 for Planimetric file naming procedure.

1.7 PROCEDURE FOR SUBMITTING SURVEYS

1.7.1 SUBMITTAL

The Field Office Supervisor or Consulting Engineer will submit all completed surveys to the Regional Survey Supervisor.

1.7.2 NEW SURVEYS

If the project is to be designed by the Regional Design Office, the Regional Survey Supervisor will submit the survey to the Regional Design Engineer. If the project is to be designed by Headquarters Design or by a Consultant, the survey will be submitted to Headquarters. Surveys may be sent directly to the Consultant if time is a factor.

1.7.3 ADDITIONAL INFORMATION AND SURVEY UPDATES

The completed additional information and / or survey updates should be forwarded to the appropriate design engineer with a copy of this transmittal to the Survey Coordinator.

1.7.4 FIELD AND OFFICE SURVEY CHECKLIST

An example of the survey checklists can be found in the Appendix on pages A-70 through A-77 and the most current checklists can be found at the following TDOT website:

http://www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_design/design/survey.htm

CHAPTER 2 - AERIAL SURVEYS AND MAPPING

2.1 INTRODUCTION

These guidelines shall be used as the standard for all computer-aided mapping produced by and for the Survey Office in the Design Division of the Tennessee Department of Transportation. Mapping submissions shall be in accordance with this manual and/or modifications contained in the consultant's contract or as prescribed by the Aerial Survey Manager.

2.2 CORRESPONDENCE

All correspondence for support should be addressed to:

Tennessee Department of Transportation
Office of Aerial Surveys
521 Olen Taylor Drive
Nashville, TN 37217-2512

2.3 STANDARD PARAMETERS

In order to establish standard parameters by which maps are to be created, the following guidelines have been established:

- The accuracy of a design file will be in direct correlation with the working units and the state plane coordinate system. This provides direct correlation of mapping and design data to the field control points.
- Standard level, color, style, and weight assignments of elements are assigned according to the type of map or sheet being generated. The user is referred to the CADD Guidelines published by the Design Division for these standards as well as other CADD standards such as font and cell files at the following website: http://www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_design/design/v8/V8design.htm.

  The user shall refer to the CADD Guidelines for the following standards:

  - File extensions to be used
  - Line styles to be used
  - Color tables to be used
  - Font files and font sizes to be used
  - Seed files to be used
- The standard cell library is STDS.CEL. Cells shall be scaled inversely proportional for mapping scales (i.e. AS=50 for 1"=50'; AS=100 for 1"=100'; and AS=200 for 1"=200'). The weight shown in the level structure is the weight at which the cell is drawn.
- Map features shall be digitized in a point-to-point mode.

  Standard mapping width is as follows:

  - 1"= 50' scale – 750' each side of proposed centerline
  - 1"= 100' scale – 1,500' each side of proposed centerline
  - 1"= 200' scale – 3,000' each side of proposed centerline

2.4 GROUND CONTROL PREPARATION

2.4.1 PRE-FLIGHT TARGETING

When a project is to be mapped photogrammetrically, targets shall be placed on the ground at predetermined strategic points, marked with a reinforcing bar or other suitable metallic material and driven flush with the ground.

All known and recovered horizontal and vertical control monuments that exist inside the band of mapping shall be targeted. These monuments shall have been generated by an accepted surveying agency, preferably National Geodetic Survey (NGS) or TDOT.

In most instances a pre-flight targeting diagram can be furnished by the Aerial Surveys Division that considers the scale, model gain and side-lap geometry of the exposed format. Target placement on the ground shall follow the diagram as close as feasibly possible.

Targets generally used by TDOT are constructed from unbleached muslin cloth and are placed on the ground to form a right angle with the point of observation being the inside corner of the target. On pavement, targets may be painted (Refer to Figure A-18 in the Appendix for an example).

The size of the targets varies with the scale of the photographs (Refer to Figure A-18 in the Appendix for examples). After the project has been flown the target material shall be removed but the reinforcing bar or other reference material shall remain.

2.4.2 HORIZONTAL CONTROL

Project control monuments, in addition to and between Tennessee Geodetic Reference Network (TGRN) tie monuments (Refer to Section 3.2.1), shall be established along the mapping band as close as possible to the proposed centerline. These points are to be used for positioning horizontal photo control and for projecting the proposed alignment. This monumentation for project control shall be semi-permanent, usually reinforcing bars with a stamped disk. An adequate description and “to-reach” shall then be written and retained for future needs. These monuments shall be in place before each project photo flight. They can be pre-flight targeted and will substantially strengthen the horizontal and vertical photo control survey.

The coordinate values of these monuments will be datum adjusted Tennessee State Plane Coordinates. Since TGRN tie monuments (with datum adjusted coordinates) are used for the origin and terminus of each leg of the project control traverse, no further datum adjustment is necessary.

The position of these monuments will be established by either total station traverse or Global Positioning System (GPS) methods.

All observations shall be performed with equipment whose specifications meet Federal Geodetic Control Committee (FGCC) standards for geodetic surveys.

All project control surveys shall originate and terminate at TGRN tie monuments (Refer to Section 3.2 and 3.3).

All project control surveys for photogrammetry shall meet Second (2nd) Order Class II Standards, 1:250.

After raw field data has been compiled, computed and minimum standards met, project control traverses between adjacent pairs of TGRN tie points shall be adjusted to those points by either least squares adjustment or compass rule adjustment methods.

Each leg of the project control survey (between adjacent pairs of TGRN tie points) shall be considered and adjusted independently.

When aerial photographs have been obtained, picture points are then selected. Often, these are the targets that were in place when the exposures were made. Picture points are chosen to form a geometric pattern suitable for orienting, leveling and scaling, and to rectify the aerial photograph. When the targets are not in place, natural images must be carefully selected instead. Natural images can be fence posts, parking stripes, etc. The horizontal picture points are enclosed by triangles on the front and back of the photos. The precise picture point is designated by a line pointer to the exact spot observed during the survey. An exact duplicate of each photograph shall be kept on file in the Regional Survey Office or the Consultant Firm's office to facilitate field checking for errors.

After picture points are chosen for the horizontal scheme, they are positioned by supplemental survey ties from the main scheme control network. These points shall be surveyed with Global Navigation Satellite System (GNSS) or Total Station standard procedures as directed by the Regional Survey Supervisor.

As stated in the paragraph above, all computed points, both project control monuments and picture points, are datum adjusted Tennessee State Plane Coordinate values and require no further adjustment. These coordinates are written on the back of selected photographs beside the designated number of the point. The points can be labeled as H-1, H-100, H-101 or HV-110 if, for example, both positions (horizontal and vertical) are known for a picture point.

2.4.3 VERTICAL CONTROL

Vertical survey control is as important to photogrammetric surveys as horizontal control. All known and acceptable Bench Marks, preferably NGS, TDOT, or Tennessee Valley Authority (TVA), which appears in the band of photography shall be pre-flight targeted.

If there are too few known Bench Marks appearing on the photos to satisfy the vertical photo control geometry, Bench Marks shall be established along the proposed alignment. The Bench Marks shall be horizontal control monuments as well as vertical control monuments. These Bench Marks can be used throughout the project survey and construction and shall be adequately described and referenced for future use. All vertical photo control points shall originate and terminate on, or be looped back to Bench Marks that have been established to Third (3rd) Order FGCC criteria (Refer to Table A-5 in the Appendix and Section 5.2 for additional information on accuracy).

Vertical control instruments shall meet specifications required by the FGCC for Third Order accuracy.

In some instances, vertical photo control may be established by trigonometric leveling with Total Station procedures. GNSS procedures may be allowed at the discretion of the Regional Survey Supervisor.

Vertical control points are marked on the front and back of selected photographs with a circle. Natural images for vertical photo control can be: corners of sidewalks, intersections of streets and roads, fence corners, etc. Vertical points shall be in a fairly level area and precisely designated and described on the back of the photo. Vertical photo points shall be designated with "V" as V-1, V-9, etc. The precise picture point is designated by a line pointer to the exact spot that was observed during the survey. If a point is both a horizontal and vertical control, it shall be designated HV.

2.5 AERIAL MISSION

In order to establish standard parameters by which aerial photography is to be obtained, the following parameters have been established:

- Aerial Photography shall be undertaken only when well-defined images can be obtained. Photography shall not be attempted when the ground is obscured by haze, smoke or dust, snow or ice, or when cloud or cloud shadows will occur on more than five percent of the area of any one photograph. Photography shall not contain shadows caused by topographic relief and sun angle except when these shadows fall on a portion of the photograph not in the area of interest, which will not prevent the use of the remainder of the photograph for photo interpretation, measuring and mapping. Photography will not be undertaken when the sun angle is less than thirty degrees above the horizon. Super-wide angle, convergent or low oblique photography will not be acceptable.
- Overlap on all photography in the direction of the line of flight shall be sixty percent, unless otherwise specified, and overlap in the direction of the line of flight of more than sixty-five percent or less than fifty-five percent shall be cause for rejection of the photography. In the case where parallel flights are necessary, the side lap of flights shall be thirty percent or more and any side lap less than fifteen percent shall be cause for rejection of the photography.
- Tip and tilt of the photography shall be kept to an absolute minimum. Tip and tilt in any case shall not exceed four degrees. Tip and tilt in excess of four degrees shall be cause for rejection of the photography.
- Crab of the photography in excess of three degrees is undesirable and crab in excess of five degrees in two or more of the photographs shall be cause for rejection of the photography.

The required ground sample distance for photography to be used for digital photogrammetric compilation shall be:

Airplane – Digital

Extreme Detail (Old 1” = 50’ scale mapping)

1.667 inch pixel size or GSD of 0.14’

Design Mapping Detail (Old 1” = 50’ scale mapping)

3 inch pixel size or GSD of 0.25’

Planning Detail (Old 1” = 100’ scale mapping)

6 inch pixel size or GSD of 0.41’

Wide Area Planning Detail (Old 1 = 200’ scale mapping)

12 inch pixel size or GSD of 0.82’

The aerial camera to be used in photography, unless otherwise specified, will be a Vexcel Ultracam X, Vexcel Ultracam Xp, Intergraph DMC, or any equally precise camera. The camera must feature a resolution across the flight path of no less than 13,500 pixels, and a resolution along the flight path of no less than 7,500 pixels. All cameras must be calibrated within a two-year period prior to the beginning of the project work order. If it is desired to use a camera or resolution different than above, it will be required that special permission be obtained in writing from the Office of Aerial Surveys. In order to obtain permission to use a camera other than those listed above, it will be required that the complete specifications, including a current calibration report of the camera be submitted to the Photogrammetry Supervisor at the Office of Aerial Surveys.

2.6 PHOTO PRODUCTS

After completion of the aerial mission, the CONSULTANT shall furnish the following to the Office of Aerial Surveys for final custody in the Aerial Surveys Office:

- All images collected as part of the flight, in both RGB color and in near-infrared (NIR) false-color imagery, unless otherwise specified by the Office of Aerial Surveys. Image color bit depth to be no greater than 8 bits per channel. Images to be provided in either TIF (.TIF) format with lossless (LZW) compression, TIF format with 100% quality JPEG compression, or JPEG (.JPG) format with 100% quality setting, on DVD(s) or non returnable external hard disk drive unit(s) if the number of DVDs necessary to hold the images exceeds 10 DVD(s) or external drives to be in a format compatible with the current version of the Microsoft® Windows operating system.
- An ASCII text file on the first DVD or external drive consisting of a list of geographic coordinates of the horizontal and vertical control points as specified in Sections 2.4.2 and 2.4.3.

Camera center information from airborne GNSS for the project on the first DVD or external drive, in ASCII text format should contain the following:

- Photograph #, Latitude and Longitude in degrees, minutes, and seconds.

2.7 ANALYTICAL AERIAL TRIANGULATION

Analytical Aerial Triangulation may be used to supplement horizontal and vertical controls where necessary. Either a strip adjustment program or bundle adjustment program may be used. Accuracy of these programs must meet National Map Accuracy Standards for the specified scale in the project work order. The Office of Aerial Surveys shall be provided with a CD or DVD compatible with the current version of the Microsoft® Windows operating system in ASCII text format.

2.8 DIGITAL MAPPING FILE REQUIREMENTS

In order to establish standard parameters by which digital mapping is to be obtained, the following parameters have been established:

- All digital data must be recorded directly as a function of stereoplotter operation. Post-compilation (board) digitizing of graphic compilation **will not** be permitted.
- All mapping data must be compiled directly in (or translated to) MicroStation® Design File Format. Production and delivery of 100% clean, edited digital data in MicroStation® Design File Format compatible with the Office of Aerial Surveys' Intergraph configuration is required. CONSULTANT's software must be compatible with the Office of Aerial Survey's current version of Microstation®.

Files shall be merged to contain a maximum of 15 megabytes of data. Individual stereomodels shall not be separated into more than one file, regardless of size. All design files shall be submitted to the Office of Aerial Surveys as 3 dimensional (3-D) files. The files shall be delivered as follows:

- Files containing planimetric feature information shall be left at the collected elevation with a file extension of .**MFC**.
- Files containing digital terrain model information with a file extension of **.DTM**.

- Files shall be compiled with coordinate values to the nearest one-thousandth (1/1000) of a foot. Coordinate values for all features shall be based on the ground coordinates indicated by the control data.
- A merged **.MFC** and **.DTM** file with the **.DTM** file triangulated with all information.
- All files shall be delivered on compact disc compatible with the current version of the Microsoft® Windows operating system.

2.9 MAP COMPILATION TECHNIQUES

In order to establish standard parameters for map compilation, the following parameters have been established:

- Features shall be identified with the following MicroStation® element types as appropriate: cell, line, line string, connected (complex) string, linear patterns, area patterns, simple shapes, complex shapes, ellipses (including circles) and text strings. The following element types shall not be used: **Arcs and Shared Cells**.
- Features are to be labeled only as required for clarification. Labels shall be oriented along linear features or parallel to the flight line of the stereomodel being compiled, so that the project beginning shall be at the left and the project end shall be at the right. The project beginning and end points are identified on the project work order.
- Road alignments shall be carefully compiled and consist of tangent line strings. Irregular curve compilation will be permitted only on meandering irregular alignments.
- Compilation on adjacent files shall butt match exactly.
- Each deliverable file shall be identified by the file name. The file names shall have the extension **.MFC** for the planimetric files and **.DTM** extension for the digital terrain model files.
- A Job Model Index shall be produced for each project. The CONSULTANT shall add each file name to the index.

2.10 MAP CONTENT

The following section parameters have been established for map content:

2.10.1 CONTROL POINTS

GNSS and Traverse Points shall be shown with their coordinate values, properly symbolized and labeled.

2.10.2 PLANIMETRIC DETAIL

All stereo compilation, whether planimetric only or topographic, shall show all planimetric features that are visible and identifiable or interpretable on the aerial photography and in accordance with the appropriate standards as outlined in Section 2.3.

Particular attention shall be given to include all transportation and transportation-related features such as roads, railroads, bridges, canals, streams, dams, utilities and drainage ditches, etc., as well as other features along transportation corridors.

The widths of roads and streets shall be shown as the separation between curb faces or hard surface edges (white fog lines) as appropriate.

2.10.3 TOPOGRAPHIC DETAIL

2.10.3.1 CONTOURS

Contours shall be generated from the DTM's at the interval specified in the project work order. No contours or spot elevations are required for planimetric only stereo compilation.

Contours shall accurately portray the shape of the terrain within specified accuracy standards. Special attention shall be given to contours at transportation and transportation-related features. Accuracy standards for contours notwithstanding, contours shall clearly reflect the crown or cross-slope of all paved areas, including roads, paved ditches, and curbs, and shall truly depict all drainage ways, sinkholes, and dikes.

In areas obscured by tree cover or heavy vegetation, contours shall be omitted and the area labeled "GROUND OBSCURED".

2.10.3.2 SPOT ELEVATIONS

Spot elevations shall be used to supplement elevation data provided by contours, generally where exact elevations are needed and in areas of relatively flat terrain where contours are widely spaced.

Spot elevations shall be shown at the following points and only in **.DTM** files:

- At all road and road/railroad intersections.
- On the road centerline at each end of bridges and similar structures.
- On the road centerline over all culverts.
- At the crest of all closed contours.
- At the lowest point of all closed depression contours, significant saddles, cuts, and depressions.

The surface elevation of all open water bodies shall be indicated by one or more water elevation readings near the center of the water body, or the portion of the water body shown on that map. **Show** only in the **.DTM** file.

Spot elevations shall also be shown in other areas with sufficient frequency so that there is a maximum map distance of two inches in any direction between contours and/or spot elevations.

All spot elevations shall be labeled with decimal values giving their elevation to the nearest one-tenth of a foot. Labels shall be placed parallel with the bottom of the sheet and positioned so that they do not obscure other map detail.

2.11 DIGITAL TERRAIN MODEL PRODUCTION

The following standard parameters are to be used for DTM production:

- DTM information should be contained in dedicated DTM files, which should contain **<u>nothing else!</u>** There should be **<u>no text at all</u>** in a DTM file. The points should be true points (lines of zero length), **not** symbols.
- DTM's shall be compiled in a format that is 100% compatible with the state's GEOPAK® design package.
- Generation of DTM's using previously collected contours will **not** be allowed.
- Information collected for the DTM's shall be stored in a standard MicroStation® 3D/DTM design file.

DTM's are to be collected from the stereomodel in the following forms:

- Break lines
- Ridges
- Drains
- Spot elevations
- X, y, & z coordinate points identified at regular intervals along parallel lines.

DTM's compiled from helicopter flights should pay particular attention to the following:

- Outside edge of paved shoulders
- Roadway white fog lines
- Center of lane white lines
- Any ruts in roadway, including tops and bottoms
- Top and bottom of curbs or curb and gutter
- Ramps, bridges and cross-roads
- Spot elevations at high points and low points

All DTM files must be able to be merged and triangulated together.

2.12 MAP ACCURACY STANDARDS

The following standard parameters for mapping accuracy have been established.

- Ninety percent of all planimetric features shall be collected so that their position on the completed map shall be accurate to within at least one fiftieth (1/50) of an inch of their true coordinate position as determined by the test survey. None of the features tested shall be misplaced on the final map by more than one twenty-fifth (1/25) of an inch from their true coordinate position.
- The position of GNSS points and traverse points shall be mathematically correct in the design file.
- Ninety percent of the elevations of contours generated from the DTM shall be accurate with respect to true elevation of one-half contour interval or better and the remaining ten-percent of such elevations shall not be in error of more than one contour interval. Contours shall not be generated in areas obscured by dense cover.
- Ninety percent of all spot elevations placed on the maps shall be accurate to within one-fourth contour interval, and the remaining 10 percent shall be accurate to within one-half contour interval.

Collection parameters for Digital Terrain Models are shown in the following table:

Map Scale	Contour Interval	Profile Distance	Station Distance
Airplane Flight			
1”=50’	2’	25’	25’
1”=100’	5’	25’	50’
1”=200’	10’	50’	100’
Helicopter Flight			
1”=50’	0.25’	10’	10’

Table 2-1
Collection Parameters for Digital Terrain Models

2.13 FEATURE DESCRIPTIONS

2.13.1 SPOT ELEVATION

Supplemental elevation used in conjunction with contour information should be embedded in the DTM file.

2.13.2 WATER ELEVATION

Elevation on the surface of the water.

2.14 SURVEY CONTROL INFORMATION & MANUSCRIPT DATA

2.14.1 TRAVERSE/ GNSS POINT

Place at coordinates and label with point name, coordinates, and elevation.

2.14.2 MAPPING LIMITS LINE

Digitize mapping boundary; pull all detail cleanly to line. Do not plot line on final plots.

2.14.3 TITLE BLOCK

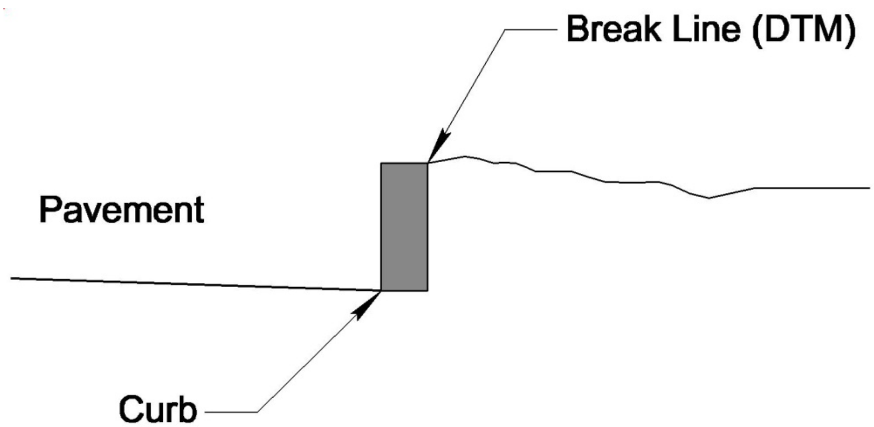
Place title block on each file and properly fill in required information.

2.14.4 EXISTING TRANSPORTATION FEATURES

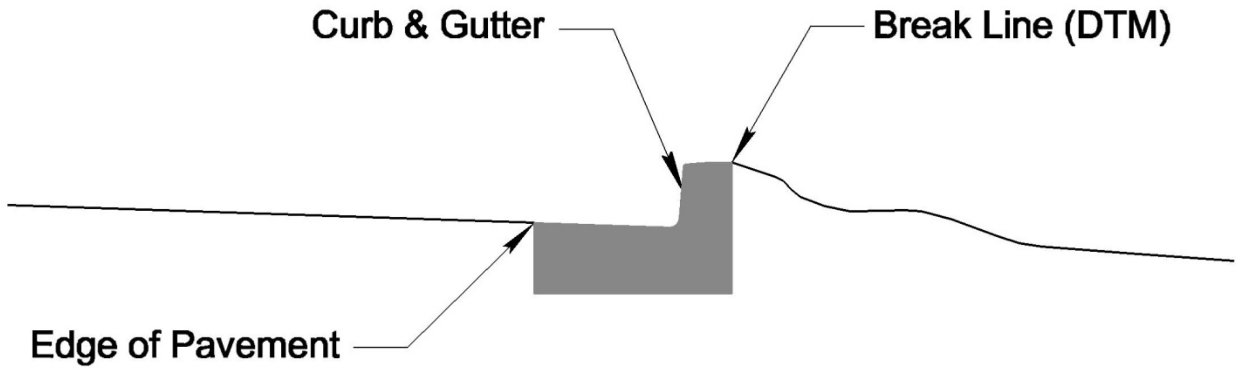
AIRPORT RUNWAY & HELIPORT - Airport pavement used for takeoff, landing, or taxiing of airplanes. The edges shall be digitized. "Runway" also includes heliports. Unpaved runways shall be shown.

BIKE PATH - If paved, digitize each edge. If unpaved digitize the centerline of the bike path. Label as “BIKE PATH”. All transportation features have precedence over bike paths.

CURB - Raised edge-defining edge of pavement, parking lot islands, etc. Digitize the lower edge of the curb. Label as "CURB". Curbs have precedence over edge of pavement lines. Retaining walls have precedence over curbs. **Do not** snap to the sides of curb.



CURB & GUTTER - Raised edge with gutter-defining edge of pavement. Digitize the edge of pavement and the lower edge of the curb. Label as "C&G". Retaining walls have precedence over curb and gutter. **Do not** snap to the sides of curb and gutter.



HANDICAP RAMP - Digitize a corner of the ramp in the sidewalk and place the cell to fit the actual handicap ramp. **Do not** label.

PAVED DRIVEWAY - Defined by the edge of pavement. Paved drives have precedence over unpaved roads, unpaved drives, sidewalks and slabs. Paved roads and retaining walls have precedence over paved drives. Paved shoulders should join cleanly with paved drives. Paved shoulders should not stop for unpaved drives. Cap the end of paved drives.

PAVED PARKING LOT - Digitize the edge of pavement of parking lots and parking lot islands. Curbs and retaining walls have precedence over paved parking. Paved drives shall join cleanly with paved parking. Paved parking has precedence over unpaved drives and unpaved parking lots.

PAVED ROAD - Defined by edge of pavement, excluding paved shoulders, curbs, and curb and gutter. Paved road edges have precedence over paved drives and paved parking lots, and the edge of pavement should remain unbroken where drives or parking lots intersect the road.

PAVED SHOULDER - Pavement between the edge of the paved road and the edge of total paved surface. Curbs and guardrails have precedence over paved shoulders. Paved shoulders should be broken for paved drives and paved parking lots. **Do not** show unpaved shoulders.

PUBLIC SIDEWALK - Show the edges of sidewalks. Sidewalks should not continue across paved drives unless they do so visibly on the photography. Paved drives, paved parking lots, and paved roads have precedence over sidewalks. Sidewalks have precedence over unpaved drives, unpaved parking lots and slabs. Show steps in sidewalks.

RAILROAD - Digitize the centerline of all rails (the line will be patterned to depict the railroad tracks). Show all sidings and spurs (tracks for storage etc.). **Do not** delineate old railroad grades with no tracks intact.

RAILROAD SWITCH STAND - Digitize the center of the switch stand. Orient the stand properly with the railroad tracks.

TRAIL - Dirt passageway that is permanent in nature. Digitize the centerline of trails. Label as "TRAIL". Trails are not maintained as well as dirt roads; field roads shall be shown as trails. All transportation features have precedence over trails.

TUNNEL - Concrete walls on each end of a tunnel. Digitize the outside edge of the tunnel wall. Label as “TUNNEL”.

UNPAVED DRIVEWAY - Defined by the edge of the graded surface or the edge of tire wear lines, whichever is appropriate. Edge of pavement of any kind has precedence over unpaved drives. **Do not** cap the end of unpaved drives.

UNPAVED PARKING LOT - Define unpaved parking lot by the edge of graded surface or the edge of tire wear lines, whichever is appropriate. Edge of pavement of any type has precedence over unpaved parking lots. Unpaved drives should join cleanly with unpaved parking lots. **Do not** show islands in unpaved parking lots. **Do not** open paved shoulder for unpaved parking lots.

UNPAVED ROAD - Dirt or gravel road maintained as a thoroughfare. Unpaved roads are frequently found in rural areas or in suburban areas. Unpaved alleys are depicted as unpaved roads. Define by the edge of the graded surface, or edge of tire wear lines, whichever is appropriate. Unpaved road edges have precedence over unpaved drives and unpaved parking lots. Where the unpaved road edge intersects a paved surface, the edge of pavement line has precedence, including slabs and sidewalks.

2.14.5 EXISTING ROADSIDE BARRIERS AND TEXT FOR LEVEL # 7 & 8

GUARDRAIL - Single beam, corrugated steel, wooden, or cable guardrails. Guardrails are usually located along road edges near hazards. Digitize the centerline of the rail in the direction of traffic (the line will be patterned to depict the guardrail).

IMPACT ATTENUATOR - An impact-absorbing device usually placed around solid objects near the roadway. Digitize around the outside edge of the impact attenuators. **Do not** label.

JERSEY BARRIER - Short wall erected between traffic lanes. Digitize each side of the wall (at bottom).

MEDIAN DIVIDER GUARDRAIL - Double-sided beam guardrails. These guardrails are located in medians of roads. Digitize the centerline of the rail (the line will be patterned to depict the guardrail).

RETAINING WALL (ROADWAY & NOISE) - Fixed structure either retaining earth or for noise pollution along thoroughfares. Digitize each side of the wall, and then close the ends. If the retaining wall has a fence, digitize the centerline of the fence (the line will be patterned to depict the fence). Label as "RW". Retaining walls have precedence over curbs, fences, edge of pavements, and/or residential and commercial retaining walls.

TEXT - Label as specified in these guidelines.

2.14.6 EXISTING NON-TRANSPORTATION FEATURES

AREA UNDER CONSTRUCTION - Digitize the outline of the entire area under construction as a closed shape. Show any roads under construction as unpaved roads. Digitize building outlines, including foundation slabs or basement remains under construction, and any feature that has been completed (e.g. curb or completed building). Label as "AREA UNDER CONSTRUCTION" or "AREA U/C". **Do not** show debris or storage within the area outline. **Do not** contour.

BOULDER - Digitize the center of identifiable large boulders sitting on the ground.

BUILDING (ODD SHAPED OR ORTHOGONAL) - "Buildings" includes barns, residential and commercial buildings, residential and commercial trailers, and well houses. Include covered porches, permanent overhangs, carport roofs, covered sidewalks, etc. as part of building. All buildings are to end at the mapping limit boundary. **Do not** show common rooflines (e.g., between townhouse) or interior rooflines (e.g., dormers).

CEMETERY - Delineate the cemetery boundary only if not bounded by a fence line. Show paved and unpaved drives and buildings. Label using the cemetery cell. **Do not** show headstones or sidewalks.

CHIMNEY - Outline industrial chimneys or smokestacks only when they standalone. **Do not** show ones attached to houses or businesses.

DAM OR SPILLWAY - Barrier across river, creek, or swamp to regulate or obstruct water flow. Visible beaver dams large enough to affect water flow shall be outlined. Label as "DAM". Spillways shall be outlined and labeled as such.

DEBRIS AND JUNKYARD - Debris is scattered or unsorted material covering the ground. Digitize the outline of the area as a closed shape and label as "DEBRIS". Outline junkyards and label as "JUNKYARD". **Do not** contour either feature.

FENCE POST - Digitize the center of the posts. Intended for use only for misplaced individual posts.

FLAG POLE - Digitize the center of the pole. Look for a slab at the base.

GOLF COURSE / ATHLETIC FIELD - Outline fields only if not depicted by a fence. Show permanent basketball goals, football goal posts, etc. as miscellaneous posts. Show paved or unpaved tracks as paved or unpaved drives. **Do not** show tennis court nets or posts for tennis court nets. Label as “ATHLETIC FIELD”. Show outline of golf courses only if not bounded by a fence. Show all paved and unpaved drives (cart paths) that are permanent in nature. Show all hydrology and natural features. Label as "GOLF COURSE" with only enough frequency for identification. **Do not** digitize tees, greens, sand traps or flags except upon special request.

LEVEE - Earth wall for fluid retention, usually found along rivers or canals. Digitize the outline of the levees on planimetric maps only (contours define levees on topographic maps). Label as "LEVEE".

LIQUID PROPANE TANK - Digitize the center of the tank. Orient the tank to correspond to its true position.

LONG FENCE LINE - Digitize the centerline of all visible cross-country fences (the line will be patterned to depict the fence). **Do not** differentiate between fence and gate. If the gate closes across the road, pull the fence across the road. **Do not** show individual fence posts in fence lines.

MAILBOX - Digitize the center of the mailbox. Orient the face of the mailbox to correspond to its true position.

MISCELLANEOUS POST, BASKETBALL GOAL, ETC. - Pole or post greater than 10 feet in height, including basketball goals and unidentifiable poles or posts. Digitize the center of pole or post.

PIER - Piers are structures extending into navigable water. Digitize the edge of the pier. Label as "PIER". **Do not** show private piers behind residential homes.

PIPELINE - Cross country above ground pipelines used for transportation of liquid, gas, or matter, usually found near industrial areas or public utility plants. Digitize edge; label as "PIPELINE". **Do not** show supporting structures. **Do not** show pipes that do not touch the ground, such as between buildings.

PIT OR QUARRY - Mining areas. No distinction is made between rock (consolidated) material mines and loose (unconsolidated) material mines. Show natural features present within quarries and pits. Digitize quarry and pit outlines as a closed shape and label as "QUARRY" or “PIT” with only enough frequency to identify the feature. **Do not** contour active quarries. Contour inactive quarries and pits only. Place spot elevations at lowest points of each.

PRIVATE SIDEWALK - Show the edges of sidewalks. Paved drives, paved parking lots, and paved roads have precedence over sidewalks. Sidewalks have precedence over unpaved drives, unpaved parking lots and slabs. Show steps in sidewalks.

RADIO, CELL PHONE, OR TV TOWER - Digitize the center of the tower.

RETAINING WALL (RESIDENTIAL & COMMERCIAL) - Fixed structure-retaining earth not located along a thoroughfare. Digitize each side of the wall, and then close the ends. If the retaining wall has a fence, digitize the centerline of the fence (the line will be patterned to depict the fence). Label as "RW". This retaining wall has precedence over curb, fence, edge of pavement, and hydrology. Roadway and noise retaining walls have precedence over residential and commercial retaining walls.

RIPRAP - Outline areas of riprap and close as a shape. Pattern using appropriate area pattern.

SATELLITE DISH - Digitize the center of commercial and private satellite dishes. Broadcast antennas have precedence over satellite dishes. **Do not** show satellite dishes on the top of buildings.

SHORT FENCE LINE - Digitize the centerline of all visible fences enclosing houses, barns, etc. (the line will be patterned to depict the fence). **Do not** differentiate between fence and gate. If the gate closes across the road, pull the fence across the road. **Do not** show individual fence posts in fence lines.

SLAB, PATIO, OR DECK - Any miscellaneous concrete slab, such as a flag pole base or concrete around a swimming pool. Also, use slab for patios and decks. If slab is imbedded in a paved surface, outline as change of pavement. Slab has precedence over unpaved roads.

STAIRWAY - Outline stairways and show individual steps which are built of concrete, stone, etc. **Do not** show wooden steps unless they are the main entrances to a building.

STONE FENCE & ROCK WALL - Digitize the centerline of stone fences and rock walls (the line will be patterned to depict the fence or wall).

STORAGE PILE - Stacked material or piles of dirt, sand, gravel, salt, etc. Digitize the outline of the area as a closed shape and label as "STORAGE". Retaining wall symbology has precedence over storage outline. **Do not** contour storage piles or areas stacked so that the ground is not visible.

STREAM GAUGE - Stream gauges shall be outlined as a building and labeled.

SWIMMING POOL - Digitize interior edge of concrete around built in pools, and centerline of walls in above ground pools. Label as “POOL”. Also, use pool for aeration pools in industrial areas. Pool has precedence over slab and sidewalk symbology.

TANK/SILO (FIXED) - Outline fixed public utility tanks, industrial storage tanks, and silos. Label as "TANK”, "TANKS" if grouped together or “SILO” or “SILOS” if grouped together.

TEXT - Label as specified in these guidelines.

WELL - Digitize the center of the well.

2.14.7 EXISTING NATURAL DRAINAGE FEATURES

IRRIGATION DITCH - Digitize the centerline of irrigation ditches (remember this is also a break line).

LAKE - A large inland body of fresh water. Show manmade reservoirs as lakes. Digitize the shoreline. Join the lake outline cleanly with rivers or creek lines. Label with name.

POND - A body of standing water much smaller than a lake, often manmade. Digitize the shoreline. Join the pond outline cleanly with streams.

RAPID OR WATERFALL - Place the cell representing waterfalls and rapids as necessary to depict these areas.

RIVER - Navigable stream. Digitize the shorelines. Label with name.

SPRING - Place cell at the apparent origin of flowing water. Let arrow point in the direction of flow. Continue from arrowhead with stream symbology.

STREAM - Navigable stream. Digitize the shorelines. Digitize the shorelines of streams wider than 5 feet, and digitize the centerlines of streams narrower than 5 feet. Join creeks cleanly with ponds, rivers, and lakes.

SWAMP CELL - Place swamp cells within the swamp area.

SWAMP LINE - Area of spongy, wet ground, usually harboring vegetation. Digitize any river, lake, pond, or creek outline within the swamp. Digitize the outline of swamps and place swamp cells in the swamp area. No distinction is made between a swamp, marsh, or inundated area. Show all vegetation within the swamp area.

TEXT - Label as specified in these guidelines.

2.14.8 EXISTING VEGETATION FEATURES

BRUSH LINE - Group of brush too close together to allow individual plotting. Digitize the edge of brush mass by following outline along the outer edge of the brush (the line will be patterned to depict the brush). Brush lines cannot cross over any double wide linear feature (e.g. vehicular trail, creek over 10 feet) or any railroad line, regardless of canopy spread. If ground cannot be seen, label as "GROUND OBSCURED".

BUSH - Single bush less than 10 feet tall. Digitize the center of the bush. If many bushes are aligned together, use hedge line symbology. The bush cell does not reflect width of the bush. **Do not** show single bushes within a hedge line. **Do not** show groups of flowers that may be interspersed with decorative bushes.

GROUND OBSCURED LINE - In areas where ground cannot be seen, outline area by digitizing points on ground (must be a closed shape) and label as “GROUND OBSCURED”.

HEDGE LINE - Line of bushes close together, usually neatly maintained. Digitize the center of the hedge line (the line will be patterned to depict the hedge).

TEXT - Label as specified in these guidelines.

TREE - Single tree over 10 feet tall. Digitize the center of the tree trunk. No distinction is made between coniferous and deciduous trees. Tree cell does not reflect extent of tree canopy. **Do not** plot single trees within an area outlined as woods.

WOODS LINE - Group of trees too close together to allow individual plotting. Digitize the edge of tree mass by following outline along the outer edge of the tree trunks (the line will be patterned to depict the woods). Woods lines cannot cross over any double wide linear feature (e.g. vehicular trail, creek over 10 feet wide) or any railroad line, regardless of canopy spread. If ground cannot be seen, label as "GROUND OBSCURED".

2.14.9 EXISTING BRIDGES & DRAINAGE STRUCTURES

BOX CULVERT - Digitize the outside edge of culvert endwalls and label as "EW".

BRIDGE - Structures erected over an obstacle or depression. "Bridge" includes automotive bridges, railroad bridges, footbridges, and viaducts. Digitize the edge of the bridge. Stop the edge of paved roads at bridge ends. Carry guardrail across bridge if it continues on the bridge. **Do not** contour bridges.

ENDWALL & CONCRETE APRON - Concrete wall on the end of a pipe culvert or box culvert. Digitize the outside edge of endwalls and label as "EW". Digitize the outside edges of concrete aprons and label as “CONC. APRON”. **Do not** digitize the ends of pipes, which have no endwalls.

PAVED DITCH FOR ROADWAYS - Digitize each side of the paved ditch, and then cap the ends or join cleanly with endwalls. Label as "CONC. DITCH". Retaining walls have precedence over paved ditches. Paved ditches have precedence over sidewalks and slabs. **Do not** show the water lines inside the ditches.

TEXT - Label as specified in these guidelines.

2.14.10 EXISTING STORM DRAINAGE

BOX CULVERT - Digitize the outside edge of culvert endwalls and label as "EW".

CATCH BASIN & DROP INLET - Small rectangular or square drainage grate. Digitize the center of the grate and align it properly with the curb or edge of pavement. Label as “CB” or “DI”.

MANHOLE - A hole through which one can enter a sewer, conduit, etc. Manholes can be located on paved or unpaved surfaces. Digitize the center of the manhole. Label as “MH”.

TEXT - Label as specified in these guidelines.

2.14.11 EXISTING SIGNS & TRAFFIC CONTROL

BILLBOARD & OVERHEAD SIGN - Digitize the center of each post, regardless of number of posts, and show the billboard face. Label as "BB". Overhead signs can be single or multi-post signs. Digitize the center of each post and show the sign face. Label as "OH”.

PAD MOUNTED CONTROLLER - Digitize the center of the controller for traffic lights. Orient the cell to face its true position.

POLE MOUNTED CONTROLLER - Digitize the center of the controller for traffic lights. Orient the cell to face its true position.

RAILROAD CROSSING SIGNAL (GATES LOWER AND LIGHTS FLASH) - Signal along railroad tracks to warn vehicles of railroad track intersections with roads. Digitize the center of the signal post. Orient the cell to face its true position.

RAILROAD CROSSING SIGNAL (NO GATES WHICH LOWER BUT HAS LIGHTS THAT FLASH) - Signal along railroad tracks to warn vehicles of railroad track intersections with roads. Digitize the center of the signal post. Orient the cell to face its true position.

SIGN (1 POST) - Digitize the center of the signpost. Orient the face of the sign to correspond to its true position.

SIGN (2 POSTS) - Digitize the center of the sign. Orient the face of the sign to correspond to its true position.

SIGN (DOUBLE SIDED) - Sign with a face on each side. Digitize the center of the signpost. Orient the sign to correspond to its true position.

STRAIN POLE FOR TRAFFIC SIGNAL SUPPORT - Digitize the center of the metal post supporting the traffic lights. Traffic signal symbology has precedence over light pole symbology if post has a dual purpose. **Do not** show signals suspended over roads.

TEMPORARY BARRICADE - Temporary concrete barriers used in areas of road construction. Digitize the center of the barrier and orient the face of the barrier to correspond to its true position.

TEXT - Label as specified in these guidelines.

WOOD POLE FOR TRAFFIC SIGNAL SUPPORT - Digitize the center of the wood pole supporting the traffic lights. Traffic signal symbology has precedence over light pole symbology if post has a dual purpose. **Do not** show signals suspended over roads.

2.14.12 EXISTING UTILITIES (GROUND & UNDERGROUND)

CABLE TV BOX - Digitize the center of the box. Orient the cell to correspond to its true position.

FIRE HYDRANT - Digitize the center of the hydrant. Orient the face of the hydrant to correspond to its true position.

GAS METER - Digitize the center of the meter.

GAS VALVE - Digitize the center of the valve.

LIGHTING CONTROL CENTER - Control box on a pad for lights or luminaries (usually located at directional interchanges). Orient the cell to correspond to its true position.

PULL BOX - Digitize the center of the in ground circuitry box. Orient the cell to correspond to its true position.

TELEPHONE BOOTH - Digitize the center of the booth. Orient the cell to correspond to its true position.

TELEPHONE BOX - Digitize the center of the post holding the telephone box. Orient the cell to correspond to its true position.

TELEPHONE PEDESTAL - Digitize the center of the above ground circuit box. Orient the cell to correspond to its true position.

TEXT - Label as specified in these guidelines.

UTILITY BOX - Digitize the center of the utility box.

WATER METER - Digitize the center of the meter.

WATER VALVE - Digitize the center of the valve.

2.14.13 EXISTING UTILITIES (OVERHEAD)

GUY WIRE - Place the cell so that it points to the pole to which it is attached.

HIGH MAST POLE LUMINAIRE (FULL CIRCLE OF LIGHTS) - Utility pole from which full luminaries are suspended (usually located in directional interchanges). Digitize the center of the pole.

HIGH MAST POLE LUMINAIRE (HALF CIRCLE OF LIGHTS) - Utility pole from which half luminaries are suspended (usually located in directional interchanges). Digitize the center of the pole and orient it to the direction in which the luminaries are facing.

LIGHT POLE - Pole from which a light is suspended (usually located in yards or close to houses for security purposes). Digitize the center of the pole and orient it to the direction in which the light arm is facing.

LIGHT POLE WITH POWER - Utility pole from which power and a light are suspended. Digitize the center of the pole and orient it to the direction in which the light arm is facing. Traffic signal poles have precedence over light poles with power.

LIGHT STANDARD (SINGLE & DOUBLE) - Pole supporting a street light or light in parking lots, business areas, etc. Digitize the center of the pole and orient it to the direction in which the light arm (or arms) is facing.

OFFSET LUMINAIRE POLE - Utility poles which have an offset for the luminaire are suspended in the direction of the interchange. Digitize the center of the pole and orient it to the direction in which the luminaire is facing.

POWER & TELEPHONE POLE - Utility pole from which electrical and telephone lines are suspended. Digitize the center of the pole and orient it to the direction in which the major power supply is running. Traffic signal poles have precedence over power and telephone poles.

POWER POLE - Utility pole from which electrical lines are suspended. Digitize the center of the pole and orient it to the direction in which the major power supply is running. Traffic signal poles have precedence over power poles.

SUBSTATION - High voltage units grouped together, usually within a fence. Digitize the outline if not enclosed by a fence. Show large structures within substations as miscellaneous buildings. The substation outline has precedence over slabs, unpaved drives, and trails. Label as "SUBSTATION". **Do not** show individual poles, pipes, or transformers within substation boundary.

TEXT - Label as specified in these guidelines.

TRANSMISSION LINE TOWER - Large structure for supporting power lines across long distances. Digitize around the base of the tower and place diagonal lines from corner to corner.

CHAPTER 3 - SURVEYING PROCEDURES AND PRACTICES

3.1 GENERAL SURVEY PROCEDURES

This chapter details the various activities involved in the survey process, including data requirements and procedures for gathering and presenting the data. Recent developments in surveying technology have made many methods obsolete. In general, it is assumed that the surveyor is using total stations, data collectors, GNSS equipment, network real time kinematic (RTK), data reduction software, and a computer aided drafting system. The requirements specified in this manual are intended to control the end product rather than intermediate activities, e.g., data collector formats. The required end product will be a complete survey in electronic format, certain check plots and required notes, and documentation. This manual, instructions from the Regional Survey Supervisor, and, in the case of surveys performed by consultant firms, the contract, will define requirements for each separate project. Because of rapidly changing technology, data transfer methods will not be defined here. They will be a part of the Regional Survey Supervisor's instructions. A Survey Checklist for field and office procedures has been developed to assure completeness. They must be completed and turned in with the survey. The checklist can found at the following link:

http://www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_design/design/survey.htm

3.2 PROJECT CONTROL (GENERAL)

3.2.1 HORIZONTAL

All survey projects shall be tied to the Tennessee Geodetic Reference Network (TGRN). Section 5.1 will provide a more detailed discussion of the TGRN.

Ties shall consist of intervisible monuments along the length of the project. Spacing will depend on the type project, terrain, etc. and will be determined by the Regional Survey Supervisor (usually about 500 to 1000 ft).

Semi-permanent monuments will be used (reinforcing bars with metal caps or better). Also, an adequate description and "to-reach" shall be prepared (Refer to Figure A-5 in the Appendix for an example). A route description from a nearby landmark, a taped distance and azimuth to the witness post, and at least two other reference points should be shown. Points along an existing route should be tied to the log mile.

TGRN ties, in most cases, will be supplied by TDOT Ground Control Crews.

Coordinate values for the monuments will be "Tennessee State Plane Grid Coordinates". These coordinates will be datum adjusted before being supplied to field crews for surveying and / or mapping. A more complete discussion of datum adjustment may be found in Section 5.1.

All ties to the TGRN will be made utilizing GNSS techniques. All GNSS surveys will be according to the publication "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques", Version 5.0, May 1988, distributed by the Federal Geodetic Control Committee. GNSS Surveys shall meet First Order (1:100000) accuracy standards as an absolute minimum. One part in one million closure for GNSS control work is preferred.

Project control traverses will be required where GNSS coverage is not available (generally wooded areas). The traverse will commence and end at pairs of TGRN tied control points. Since these surveys originate and terminate at points with datum adjusted Tennessee

State Plane Coordinates, all computed coordinates will be datum adjusted Tennessee State Plane Coordinates. No further datum adjustment is required.

Project control traverses shall meet Second Order Class II Standards (1:20000) or better, (Refer to Section 5.2 and Appendix Tables A-4 and A-5).

After the raw field data for project control has been compiled, computed, and minimum standards met, traverses shall be adjusted using the least squares method.

Each leg of the project control survey (between adjacent pairs of TGRN tie points) shall be considered and adjusted independently.

All TGRN tie points (control pairs) and project control traverse points shall be clearly shown and labeled in the planimetrics file (Refer to Section 3.4.2).

Coordinates will be listed with current notation plus the year of the upgrade in parentheses, immediately following. Therefore, reference to current coordinate values will be NAD 83 (1995) for geographic coordinates and SPCS 83 (1995) for state plane coordinates.

3.2.2 VERTICAL

GNSS methods may be used for vertical control for projects provided approved procedures are followed.

Please check with the TDOT Regional Survey Supervisor for a recommendation as to the appropriate geoid model to utilize. Known third order or better North American Vertical Datum of 1988 (NAVD 88) benchmarks are occupied in the project control sessions and used for vertical ties and adjustment.

TDOT ground control crews will normally provide vertical control.

3.3 PROJECT CONTROL (GNSS PROCEDURES)

3.3.1 PRE-PLANNING

Assemble TVA / United States Geological Survey (USGS) quad maps, the Transportation Planning Report (TPR), photos, etc. for the project. Locate the project on the quad map and read the approximate latitude and longitude of the project.

Based upon the map, the surveyor can get a rough idea of the number of points that will be required, and how long it might take to establish control for the project. Estimate point placement, manpower needs, and potential problems with satellite blockage from this map also. The surveyor can also get an idea of how much of the project will be accessible by vehicle and where walking to the point will be required.

Check satellite predictions based upon satellite almanacs. Use this information to plan occupation times.

3.3.2 RECONNAISSANCE

Contact any property owners in accordance with requirements in Chapter 1.

Determine control point placement as follows:

- Place points in the clear, away from trees, buildings and potential multi-path structures. Maximum obstruction angle shall be 20º.
- Nominal control point spacing of 500 ft to 1000 ft.

- Points should be intervisible when possible. Exceptions will be large wooded areas. Note the example in Appendix Figure A-26 shows a wooded area. The surveyor would simply skip this area and start placing points again on the other side.
- Place points close to the projected centerline so that they will be of the most use to the surveyors (i.e. on hilltops). However, some thought should also be given to placing these points so that at least some of them will survive construction.
- Document blockage problems on the site log. A site log form is shown in Appendix Figure A-24. If there are blockage problems, place the control point to the south of the blockage since the satellite path never crosses due north.

3.3.3 RECEIVER SETUP PROCEDURES

3.3.3.1 STATIC METHOD

- Improper instrument setup (human error) accounts for the most and the largest errors when performing GNSS surveys. Therefore, care must be exercised during setup.
- Use extra care to assure correct set up on the point.
- Make sure to properly focus the plummet and cross-hairs. Check to assure the instrument is on the point during the session and before breaking down the tripod to move. Triple checking the setup will greatly reduce the human error during the session.
- Check and record the height of instrument (HI) reading on the site log when setting up. Check the HI again during the recording session and once more before breaking down the instrument to move. This again aids in reducing human error during the session.
- Set the tripod so that the receiver is at or above head height.
- Set the tripod legs wide enough to prevent the tripod from being blown over.
- Press the tripod feet firmly into the ground.
- If sent to retrieve another receiver, check the setup before breaking it down.
- Do not be afraid to report possible errors to the party chief. It is better to reoccupy the point while the survey crew is still in the field, than to try and determine what went wrong back in the office.

3.3.3.2 RTK METHOD WITH A BASE STATION

- TDOT control points should be located on the job and the base should be setup on one of the control points (preferably one that has the best visibility of the sky and is located in a relatively safe place).
- The surveyor should try to prevent the base from being disturbed or being an obstruction to traffic.
- The surveyor should use a fixed tripod to set the base on, as this is the most stable.

3.3.4 OBSERVATION METHODS

The three methods of observations are discussed below:

- Static Traverse
- Static Wing Point
- RTK

3.3.4.1 STATIC METHODS

There are two basic methods used by TDOT using static GNSS procedures to bring control into a project from the TGRN reference points. For this discussion, we will refer to them as the Traverse Method and the Wing Point Method. Table 3-1 shows advantages and disadvantages of each method.

A diagram of both methods is shown in Appendix Figures A-25, A-26, and A-27.

	Advantages	Disadvantages
Traverse Method	Uses similar leapfrog methodology as the conventional traverse. Is more efficient for projects with five or fewer control points.	Due to inherent possible errors in GNSS baselines, error can accumulate rapidly. Requires high degree of coordination between survey crew. Requires higher degree of sophistication from all crew members.
Wing Point Method	Baselines are longer, minimizing error. Points are measured from two base points giving a check. Wing points are likely to survive construction for later use. Less coordination is required between receiver operators. Base stations require little supervision for inexperienced operators. A true network is formed, giving stronger checks and adjustments. Wing points can be existing NGS benchmarks giving a vertical check on the network.	Time and effort are required to locate and set the wing points. Wing points are only useful for GNSS work because they have no Azimuth points.

Table 3-1
Summary of Static GNSS Methods

3.3.5 TRAVERSE METHOD

- Use this method if the project requires five (5) points or less, or if terrain conditions are non-conducive to the Wing Point Method. Refer to Appendix Figure A-25 for an example.
- Reconnoiter the project and set points at 500 ft to 1000 ft spacing.
- Choose the **two** closest TGRN points for tie points. **Never tie back to the same point.**
- On the first session, occupy TGRN A, TGRN B, and the first and last points on the project. Occupy these points for three (3) hours minimum using a 5-second epoch rate.
- After the long line observations are complete, change the receivers to a 1-second epoch rate for the remaining short lines.
- Short lines (lines less than 20 km (12 mi.) should be observed for 5 minutes plus 1 minute per km of baseline length. A minimum of 20 minutes of data is recommended on all lines, to allow for clipping bad segments of data. This allows for flexibility in computations during post processing when problems are discovered.

3.3.6 WING POINT METHOD

- This is the preferred method for all projects because of the greater accuracy that can be obtained (Refer to Appendix Figure A-26 for an example).
- Set the wing points near the midpoint of the project, approximately 2 km (1 mi.) to 5 km (3 mi.) left and right of the proposed centerline. The maximum length of any measured line, from the wing points to the project control points, should be less than 10 km (6 mi.). Two or more pairs of wing points may be needed to accomplish this. Place wing points in the clear, away from trees, buildings, and potential multi-path structures.
- Place the wing points on or near NGS NAVD 1988 benchmarks for a vertical tie.
- Reconnoiter the project and set points at 500 ft to 1000 ft spacing.
- Choose the **two** closest TGRN points for tie points. **Never tie back to the same point.**
- In the first session, occupy TGRN A, TGRN B, and the two wing points. Occupy these points for three (3) hours minimum using a 5-second epoch rate. If there are more than two wing points on the project, perform the above mentioned procedure for each pair of wing points.
- On subsequent missions, set base stations on the wing points and two rovers on the project. The base units will run continuously. The rovers will collect a minimum of 20 minutes of data for each of the project points and also any photo control points. It is advised that each rover have a list of points that he will occupy rather than just going to whichever point is next. This will eliminate duplicate or omitted points.
- **NOTE: Modified Wing Point Method for small two point projects –** Often, on a two point project (bridge or intersection) the surveyor will have severe blockage on the site which makes collecting 3 hours of data very difficult. Using a modified wing point method, go up and down the road from the project a mile or two and chose a location with no blockages. Set one point up the road and one down the road from the actual project site. Occupy TGRN A, TGRN B, and these two modified wing points for a minimum of three (3) hours using a 5-second epoch rate (Refer to Appendix Figure A-27). Then use 1-second epoch data collection on a short line from the modified wing points into the project and choose the best 20 minutes of data.

Problem	Remedy
PDOP goes above 6.0	Note the time in site log. Restart time count.
Loss of lock	Note in site log. If frequent, the user may need to start over with a higher HI.
Cycle slips	Note in site log. If frequent, start over with a higher HI.
Thunderstorm or other atmospheric event	Note time and azimuth in site log.
Receiver is disturbed	Notify party chief. Restart point observation.
Forgot to begin recording	Notify party chief. Restart point observation.

Table 3-2
GNSS Field Problems and Remedies

3.3.7 RTK METHOD

- Set up the base on a known TDOT GPS marker.
  - Make sure the base is recording static data at 1-second epoch data. In the event that additional post-processing is needed, this data will be available for use.
- Establish the radio connection between the base and rover.
- Locate a known TDOT GPS marker with the rover as a check that assures the scale factor and project settings are correct in the controller.
  - TDOT recommends using a tripod to perform this initial check.
  - The surveyor may stake out this point and store it as a stake point.
  - The surveyor may survey this point and store it as a topo point in the controller.
- The surveyor will want to take more data on this point than a typical RTK shot.
  - The surveyor shall change the settings (number of epochs) on the controller necessary to develop a tighter position on the check shot.
  - TDOT typically uses 60 epochs for this procedure.
- If the point's calculated coordinates are within tolerances, then survey work may ensue. If not, then steps should be taken to determine this error. This is a good indicator that a setting is incorrect. If the check point position is off vertically, then perhaps the wrong Geoid Model was selected for this job. If it is off horizontally, then perhaps an incorrect Scale factor / Datum Adjustment factor was used.
- Record this check in the file by taking a shot on the control point (number and coded correctly) and store it as an observation to the raw file for later reference. **Do not** overwrite the control point in the data collector. If the check point is coded and numbered correctly, a screen telling that this point already exists will require a response. The surveyor has 3 options: overwrite, use new number, or store in raw data. The surveyor should store in raw data only. This verifies the coordinates and can be reviewed later, but does not create or overwrite the control. It is recommended to do this when first starting and before ending a session.
- The surveyor should periodically perform this control check during the survey session.
- Once the setup procedure has been completed and the tolerances are in check, the surveyor may proceed to collect data using the rover.
- Assure that the rover is plumb when collecting data.
- Always monitor satellite coverage to assure the accuracy has not decreased due to being near an obstruction.
- The procedure described above shall be repeated when using the TDOT GNSS Reference Network; however, the surveyor will connect to the network and will not use a portable base. Once a connection has been established to the TDOT GNSS Reference Network, the surveyor will perform checks on known TDOT control markers as described in this section before beginning the survey.

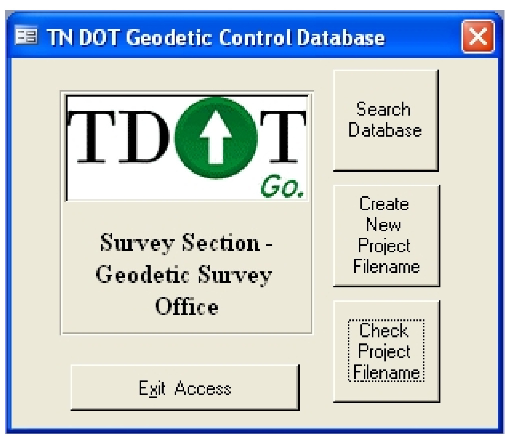
3.3.8 POST-PROCESSING STATIC DATA

- Check the field data as it is inserted into the post-processing software. Be sure to check the HI, antenna offset, and point names. Be sure that control point names are always identical, or two different points which cannot be combined will be shown.

- Always calculate all lines for which there is sufficient data. This will make the network stronger.
- Always check the log file for calculated lines for the items indicated in Appendix Figure A-24.
- Always check the log file for the network adjustment for the items listed in Appendix Figure A-24.
- When performing the network adjustment, be sure to fix benchmarks in height only. This is ellipsoid height not orthometric height.
- After network adjustment, process the final geographic coordinates to compute state plane coordinates and orthometric heights. The geoid model published by the National Geodetic Survey is the only approved model for computing orthometric heights. TN Lambert map projection information is available in the appendix.
- Process the state plane coordinates through an approved method to compute an average datum adjustment factor for the project. This factor will be applied to all project control points to compute final published coordinates. Control information shall be supplied to Regional Survey Supervisor in a suitable format for adding the information to the control point database maintained by TDOT. The geodetic control point database was created by TDOT using the Microsoft® Access software.

3.3.9 TDOT CONTROL POINT DATABASE USE

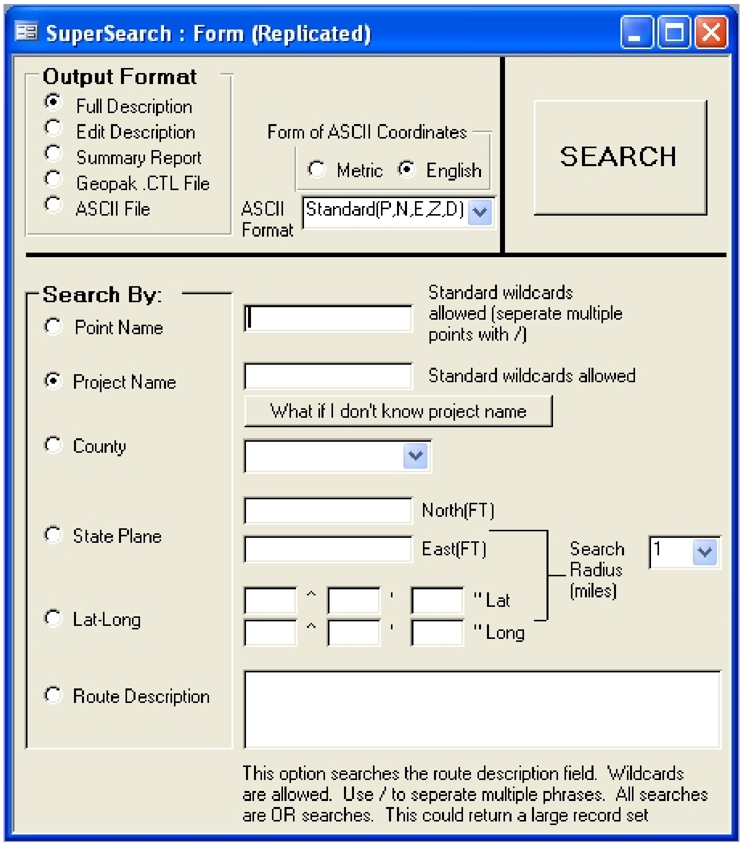
Refer to the Appendix Figure A-5 for a sample control point description sheet. The following menu opens when the database is opened. Select Search Database to retrieve data regarding TDOT control points.



Create New Project Filename is used by Regional Survey Supervisor in assigning project names but can be used by the database user to find the project name associated with a particular project. The user is prompted for a county-route code. This is a two-character code for the county, followed by three numbers for the route. County codes are documented in the CADD Guidelines. A link to these guidelines can be found in Section 3.4. Append an asterisk to find all projects in the database in the county, and on that route. The user can cycle through the choices to find the appropriate project. Then search for the control on this project as shown below.

Check Project Filename is used to search for project names given a county and route.

Various output formats are available and the user may search by various inputs.



- Search by Point Name allows a wildcard asterisk if only part of the name is known.
- Search by Project Name allows the user to enter a project name, if known.
- Search by County
- Search by State Plane and Lat-Long allow the user to input a search radius.
- Search by State Plane Coordinates searches a 1.5 mi radius based on Northing and Easting input.
- Search by Route Description allows the user to enter part of a know route description.
- Output Full Description places the points on a description sheet, complete with all information, as shown in the sample in Appendix Figure A-5.
- Output Summary Report creates a summary report (example below) which list all the points in a table (usually 1-2 sheets) including only coordinates (in feet) and Datum Adjustment factors.
- Output GEOPAK® .CTL File creates a file that can be imported directly into GEOPAK® containing all of the GPS control information for the project.
- Output ASCII File creates a text file for input into a CADD program to eliminate the need for retyping.

Geodetic Survey Control Project Summary

Tennessee Dept. of Transportation - Geodetic Survey Section

Project Filename: EMORY

County KNOX	North: (ft.)	East: (ft.)	Elev.: (ft.)	D.A. Factor:	Horz. Datum:	Vert. Datum:
EM-1	630817.6396	2559599.9201	1030.07	1.00009538	NAD83(1995)	1988
EM-10	635349.8028	2565915.1021	1031.77	1.00009538	NAD83(1995)	NAVD 1988
EM-11	636001.7231	2566874.8708	1048.72	1.00009538	NAD83(1995)	NAVD 1988
EM-12	636399.1048	2567305.4434	1057.05	1.00009538	NAD83(1995)	NAVD 1988
EM-13	637165.0662	2568118.7397	1057.91	1.00009538	NAD83(1995)	NAVD 1988
EM-14	638059.9890	2569209.4521	1049.37	1.00009538	NAD83(1995)	NAVD 1988
EM-15	638658.2965	2569639.8154	1054.89	1.00009538	NAD83(1995)	NAVD 1988

3.4 DEVELOPMENT OF SURVEY CADD FILES

In the following discussion, the surveyor is advised that CADD standards are maintained by the Design Division, CADD Section, and periodically revised. The surveyor is referred to the latest version of these standards, hereinafter referred to as the CADD Guidelines, for questions regarding colors, level structure, and other file format items. The CADD Section also maintains all files such as cell and font libraries that the surveyor may need. The Regional Survey Supervisor can direct the surveyor to the appropriate contact person. Note: All CADD files shall be in MicroStation® format, shall conform to the standards set forth in the CADD Guidelines, and shall be of manageable size as set by the Regional Survey Supervisor. The Design Division's CADD standards and downloads can be found at the following link:

http://www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_design/design/v8/V8design.htm

3.4.1 GENERAL

3.4.1.1 TNDOT.SMD

The TNDOT.smd feature table file shall be used on all TDOT surveys. This file can be downloaded from the TDOT web site. This download also contains a list of these features.

http://www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_design/design/survey.htm

The completed survey will consist, at a minimum, of the following items:

- A MicroStation® (.DGN) file containing all planimetrics
- A GEOPAK® (.TIN) file containing the digital terrain model (DTM)
- A GEOPAK® (.GPK) file containing: points, lines, curves, spirals, chains, survey chains and parcels. Refer to TDOT CADD Guidelines for COGO element naming conventions.
- A Microsoft® Excel (.xls) file containing the R.O.W. acquisition table
- Other documentation or paper plots as set forth in the remainder of this manual
- Other computer files or paperwork as required

3.4.2 THE PLANIMETRICS FILE

3.4.2.1 FILENAME

This file shall have the form 11222-33Filetype.DGN where:

- 11 = the county code (Refer to Table A-7), and as shown in the CADD Guidelines
- 222 = the route number (if not a state route the surveyor's discretion is allowed)
- 33 = GNSS project number (Contact the Regional Survey Supervisor for this number)
- Filetype = Survey (Survey Topography and Profile data)
  - Example: DV155-01Survey.DGN
- Filetype = SurveySUE (Survey Subsurface Utility Engineering data)
  - Example: DV155-01SurveySUE.DGN

Refer to Section 1.6 for project naming procedure.

3.4.2.2 CONTENT

This file shall contain the following items within the limits of the project as specified by the Regional Survey Supervisor or set forth in the survey contract.

- A survey centerline (as required)
- All existing right-of-way and property with owners shall be shown in the CADD file (Refer to Section 3.6.6, 3.6.7 and 3.13). This file will be used to create the acquisition table. The Microsoft® Excel file (RowAcqTable.EXE) can be downloaded from the following TDOT web site:

http://www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_design/design/survey.htm

- All existing topography (Refer to Section 3.6)
- Profiles of all survey centerlines with underground and overhead utilities shown shall be included in the survey file (Refer to Section 3.8)
- Drainage Information as required (Refer to Section 3.10, 3.11 and 3.12)
- Other survey data such as various notes and other items as set forth elsewhere in this manual.

3.4.2.3 NOTES

Refer to Figure A-6 through Figure A-13 and Table A-3 in the Appendix for examples of the above information. The surveyor is advised that the survey will not consist of finished sheets but will be in a CADD file. The CADD file will consist of a single long map with coordinate integrity maintained. Also, the examples show only certain levels plotted in order to indicate the information required. The CADD file will actually contain all the information shown on all the examples on the levels as specified in the CADD Guidelines.

The surveyor shall make every effort to assure the readability and usability of the completed survey for design work. This shall include checking for text overlaps. The surveyor shall consider which data will be displayed simultaneously as the design process continues and make allowances for placement of text and other data. It is understood that all contingencies cannot possibly be considered, but a reasonable effort shall be required.

It shall be noted that any file format conversions required and any problems realized therefrom are the responsibility of the surveyor and that the end result of the turn-in files must be in a form in compliance with the CADD Guidelines.

3.4.3 THE DIGITAL TERRAIN MODEL

3.4.3.1 DEFINITIONS

The following definitions apply to all other discussions within this manual:

- Digital Terrain Model (DTM) – a set of three dimensional random points and breaklines used to model the surface of the earth both horizontally and vertically.
- Breakline – Also known as a fault line, is defined as a discontinuity in the earth's surface such as the edge of pavement or shoulders. Other examples are the top of a sharply defined stream channel or the bottom of a man-made ditch. Breaklines are generally indicated by a sharply defined line on the ground surface rather than a smooth or rolling appearance.
- Random Point (Spot) – Those points which are not connected with any breakline but stand alone.
- Link Lines (Triangle) – Also known as triangle lines are the imaginary lines stored internally in a computer connecting the points used to interpolate information about the ground surface where no actual point exists.
- Edge Lines (Boundary Lines) – A line placed around the edge of data in an attempt to keep link lines from forming in areas where no data exists.

3.4.3.2 FILENAME

The DTM file shall be a binary .TIN file in GEOPAK® format.

3.4.3.3 NOTES

A DTM is interpreted by the computer as a set of points connected by a series of link lines. The algorithms used to create the lines connect points to their nearest neighbor. However, in some instances the nearest point may not be the proper link connection. For example, the nearest point to a point on the top of a ditch cut may be a point on the opposite top. The proper link is in the bottom of the ditch, though, hence the need for breaklines. The computer algorithm will not allow a link line to cross a breakline. So a breakline in the bottom of the ditch forces the links into the bottom instead of short circuiting across the top.

Breaklines may be required even when the ground shows no obvious discontinuity. The surveyor shall show adequate random points and breaklines to assure that the DTM accurately reflects the surface of the earth. Great care shall be taken in the development of breaklines in the area of bridges or other structures, in a stream, under bridges, etc. At bridge abutments, wing walls, ends of pipes and culverts, curbs, retaining walls and any other vertical-type situation, breaklines at both the top and bottom of the feature shall be developed.

Random points are generally collected in a gridded manner with a nominal spacing of about 25 to 50 feet. This spacing can vary widely, from much smaller or much larger, depending on the regularity of the surface being modeled. The spacing and placement of random points shall be such as to assure the accuracy of the DTM (Refer to Figure A-13 in the Appendix for an example of a DTM).

3.5 FINAL ALIGNMENT AND TOPOGRAPHY

3.5.1 ALIGNMENT

3.5.1.1 GENERAL

The final alignment shall be computed as nearly as possible to that specified in the TPR. The Regional Survey Supervisor will furnish the Field Supervisor with all design criteria, the TPR, any available preliminary maps, TVA quad maps, control monuments, etc., and provide any needed assistance to establish the final alignment. If it is discovered that the alignment falls close to a wetland or “blue line stream” a line change shall be considered. Any significant deviation shall be approved by the Regional Survey Office. Alignments or portions thereof may or may not be field staked at the discretion of the Regional Survey Supervisor. If staked, all route surveys shall meet Second Order, Class II accuracy standards, and be tied to the TGRN (Refer to Section 3.2).

3.5.1.2 STATIONING

Stationing of the mainline will always be shown in the direction of increasing log mile. Log miles are available for all Interstates and State Routes, and for almost all County and City Roads / Streets. If log miles are not available, stationing will be shown from South to North and from West to East. Interstates and State Routes crossing or intersecting with the mainline shall be stationed with their existing log mile. County and City Roads / Streets crossing or intersecting with the mainline shall be stationed left to right looking forward along the alignment. Stationing of cross roads shall be staggered to prevent any two cross roads from having the same or overlapping station value.

3.5.2 CURVES

All curves shall adhere to the latest TDOT standard drawings and Design Guidelines. Exceptions shall be approved by the Regional Survey Office. The standard drawings and design guidelines are accessible through the following TDOT website:

http://www.tdot.state .tn.us/Chief_Engineer/assistant_engineer_design/design/Des_Resources.htm

Circular Curves - All data is to be computed by the arc definition.

Curve data shall be rounded to three decimal places.

3.5.3 TANGENTS

All bearings are to be calculated from the initial bearing from P.I. to P.I. P.I. coordinates shall be computed to four decimal places, then bearings re-computed to even seconds. Bearings and beginning coordinate point are then held constant and P.I.’s and ending coordinates re-computed to four decimal places. These new coordinates and even bearings will be labeled on present layout sheets. Coordinates at the beginning and ending of all alignments, at all P.I.’s, and at intersection station equations shall be labeled.

3.5.4 STAKING FINAL ALIGNMENT

3.5.4.1 ALIGNMENT POINTS

Iron pins, spikes, nails, or other material that can be located with a metal detector shall be used for curve points and significant POT’s. Other points may be marked with stakes. All alignment points in cultivated fields shall be buried below the depth of cultivation and all points in yards or pastures shall be driven flush with the ground. Alignment points shall be staked at the discretion of the Regional Survey Supervisor.

3.5.4.2 STAKING

The final alignment may be staked and marked at the discretion of the Regional Survey Supervisor, with the station number at least every 100 feet. Intervals for staking will be at the discretion of the Regional Survey Supervisor. When staking on existing pavement, all stations will be marked with a nail and the station painted on the pavement near the point. All stakes shall be removed from cultivated fields and hay fields when the survey is complete, or when requested by a property owner or tenant.

3.5.5 REFERENCE POINTS

Project control survey points (Refer to Section 3.2) will serve as reference points for each project. They are to be referenced with permanent type material and documented in the planimetrics file. A table shall be placed in the planimetrics file, listing data for GNSS project control points, and total station (traverse closed and adjusted) project control points. The table lists point-number, northing, easting, elevation, station, and offset for each point. Station and offset refer to the mainline alignment only. Refer to Table A-1 in the Appendix for examples.

3.6 TOPOGRAPHY

3.6.1 GENERAL

It is important that all topography likely to be affected by, or that will affect, the proposed road be accurately located. This shall include all houses on properties that are in some way affected by the project. It is the responsibility of the Field Supervisor to determine limits of the topography. The limits shall include the proposed width of R.O.W. and possible limits of construction. Occasionally a building or drainage structure outside the construction limits will affect or be affected by the project; therefore these shall also be located.

3.6.2 DATA COLLECTION (TOTAL STATION AND RTK)

Topography may be accurately located with total stations using angle and distance method. A minimum of two points shall always be tied and all buildings measured so they can be accurately plotted. A minimum of two points shall be tied on each property line, preferably each corner if possible. This method assures that any point or property line can be calculated using coordinate geometry. There are different methods of recording field data from different instruments. A method approved by the Regional Survey Office shall be used.

3.6.3 PROPERTY OWNER CONTACT

As discussed in other sections of this manual, the first step of any survey involving private property shall be the personal contact of the property owner or tenant. At this meeting, the Field Supervisor shall request from the property owner information concerning the location of property lines, property corners, septic tanks, overflow fields and wells. In the case of commercial property, an inquiry shall be made as to the existence of underground storage tanks. The Property Owner Contact Form (Appendix Figure A-1) shall be used for this purpose. A completed form for each tract shall be submitted as part of the completed survey. This procedure will also be applied to all railroad property.

3.6.4 AT GRADE ROAD CROSSINGS

Alignment, DTM, topography, and present R.O.W. shall be recorded for a minimum of 500 ft for State Routes and 300 ft for other roads. Exceptions to the minimum may be made at the discretion of the Regional Survey Office. The DTM shall be extended as necessary to assure proper information for grade ties of proposed to existing roadways. Bearings of centerlines and stations of the intersection shall also be shown.

3.6.5 AT GRADE RAILROAD CROSSINGS

A 90 degree crossing is desirable, and in no case shall tracks be skewed less than 70 degrees.

Field Data Required:

- Plus and bearing of each set of rails
- Alignment of all tracks, 600 ft each direction with curve information (if any) computed and recorded in the planimetrics file
- All topography within the railroad R.O.W. for 600 ft each direction, including switching devices, signal devices, control boxes, and utilities (especially fiber optic cables)
- Name of the railroad
- Present railroad R.O.W., the term “Charter R.O.W.” does not indicate that the railroad owns the property and charter R.O.W. shall not be shown. Railroad R.O.W. shall include only the property owned by deed or being used and maintained
- Distance and direction to the nearest mile post and description of same
- Profile of the top of rail 600 ft each direction
- Develop the DTM 200 ft in each direction along the tracks within the railroad R.O.W. If the road R.O.W. extends beyond 200 ft, the outermost limits of the DTM shall be taken at the limits of the R.O.W.
- Size, type, invert elevation, and condition (if required) of all existing drainage structures with the direction of flow in field drains and channels indicated by arrows
- Plotting – Refer to Section 3.15.2 for additional plotting information

3.6.6 PROPERTY LINES

The bearing, distance, and station of intersection shall be shown along each property line in the planimetrics file. If the property line does not cross the survey line, the right angle station and offset distance shall be shown for the property corner at the affected area. All angles to property lines will be tied with a total station, as directed in Section 3.6.2, and the bearings calculated from the survey line. Deed bearings shall not be shown.

Riparian Owners - Title to Stream Beds - Whether the stream is navigable or not determines how much of the stream bed a private individual can own. In Tennessee, an individual can own to the ordinary low water lines, but no farther if the stream is navigable. Title to the stream bed that lies between the ordinary low water lines in a navigable stream is vested in the State for the use and enjoyment of the public at large. It is not susceptible to private ownership even when the deed calls for center of the stream. Title to stream beds in non-navigable streams is vested in the adjacent riparian proprietors.

Navigability - Where the Corps of Engineers has declared certain waters to be “Navigable Waters of the United States” pursuant to the Rivers and Harbors Act of 1899, those will be accepted as navigable. A list of waters so designated by the Corps is shown on pages

A-8 through A-10 of the Appendix. On all other streams, a determination of navigability must be made. The Tennessee Supreme Court has defined navigability this way: “A stream is navigable in a legal sense when it is capable, in the ordinary stage of water, of being navigated, both ascending and descending by such vessels as are usually employed for purposes of commerce.” Holbert vs. Edens, 73 Tenn. 204 (1880).

It is not navigable in a legal sense when: “as where, in certain stages of the water, it may have insufficient depth for flatboats, rafts, or small vessels of light draft.” Holbert vs. Edens, 73 Tenn. 204 (1880).

So, if a stream can float “flatboats, rafts, or small vessels of light draft” at all times of the year, it is navigable in the legal sense. If it can float such vessels only during flood time, it is not navigable in the legal sense. The fact that a stream has never been used for navigation is no bar to navigability if the potential for navigation is present.

Property Lines on Navigable Waters - The Tennessee Supreme Court has said: “--the owners of land upon navigable streams have title to the ordinary low water mark--.” Martin vs. Nance, 40 Tenn. 649 (1859).

Ordinary low water mark was defined in another case: “The ordinary low water mark is the usual and common or ordinary stage of the river, when the volume of water is not increased by rains or freshets, occasioned by melted snow on one hand, or diminished below such usual stage or volume by long continued drought to extreme low water mark.” Goodall vs. Herbert & Sons, Inc., 8 Tenn. App. 265 (1928).

Property Lines on Non-navigable Waters - When the stream is not navigable, private ownership extends to the center of the stream even if the deed calls for the edge or water line, unless there is a metes and bounds description or other intent not to extend to the center of stream.

Property Lines on TVA Lakes - TVA property extends to the “Maximum Shoreline Contour” (Refer to Table A-2 of the Appendix). A “Flowage Easement” around lakes, such as Norris, Cherokee, and Douglas may also be owned and shall be indicated. Easements may be investigated at the TVA property office closest to the lake in question.

Surveying Riparian Property Lines - Enough data must be taken to enable the Designer to calculate the area of take. This means that the riparian property lines must be traversed, or located by offsets from base lines, by angle and distance with a total station or located by other suitable means.

Overlapping Deeds - Adjacent owners shall be consulted to determine if they can agree to a common line. If so, it shall be shown as an agreed property line. Discussions with the owners shall be documented on the Property Owner Contact Form (Refer to Figure A-1). If the owners cannot agree to a common line, both deed lines bounding the overlapped area shall be shown and the area labeled as “disputed” in the planimetric file.

Noncontiguous Deeds - If no one claims the area between the deeds, the deed lines shall be shown and the area labeled “owner unknown”. Discussions with the owners shall be documented on the Property Owner Contact Form.

Deed Search - It is the responsibility of the surveyor to locate a deed for each piece of property affected by the project.

Subdivisions - The recorded plats provide information, but are not substitutes for locating property lines.

Evidence of Property Lines - Tennessee Courts will try to determine from a deed the land which the parties intended to include in the conveyance. Evidence is generally given this order of preference:

- Agreed line between adjacent owners
- Natural objects
- Man-made objects
- Boundary lines of abutting property
- Courses and distances

Example: If a boundary is the center of a creek but the stream has naturally shifted, the boundary shifts with the creek unless the deed has metes and bounds calls that would otherwise show the intent of the parties.

Example: A deed calls for 350 ft to John Smith's eastern boundary, but the line measures 342 ft to Smith's boundary. The true distance is 342 ft, because a boundary line takes precedence over a course and distance. All physical evidence shall be recorded (iron pins, monuments, fences, etc.).

3.6.7 PRESENT RIGHT-OF-WAY

3.6.7.1 GENERAL

There are only six (6) situations in which the State can successfully claim ownership of present R.O.W.:

- There is a recorded deed executed between the State, County, or Municipality and the present or prior owner.
- There is an unrecorded deed that can be located, executed between the State, County or Municipality and the present owner who is still living.
- There is a plat recorded by the present or prior owner which shows a R.O.W. width.
- There is an unrecorded petition between the present owner and the County.
- There is a R.O.W. monument on the property.
- Failing all five of the above, the State can only claim to the user's line, or if the user's line cannot be established, there is a presumption that the unascertained R.O.W. is 25 feet on either side of the centerline of the traveled portion of the road.

3.6.7.2 USER'S LINE

Determination will be a matter of judgment, and only property being used by the State may be claimed.

For rural sections, evidence shall be given the following order of preference:

- Marked property corners
- Fence paralleling the road

The widest of the following:

- Limit of maintenance
- A line of utility poles
- Toe of slope and back of ditch
- Edge of Shoulder

- Edge of Pavement

For urban sections, evidence shall be given the following order of preference:

- Marked property corners
- Back of sidewalk

The widest of the following:

- Limit of maintenance
- A line of utilities
- Toe of slope or back of ditch
- Back of curb or edge of pavement

The orders of preference given above for the user's line can be disregarded only if there is good reason therefore.

When necessary, the Regional R.O.W Supervisor may be contacted for assistance in locating a user's line.

The user's line shall be labeled as "Pres. R.O.W." in the planimetrics file.

3.6.7.3 OLD RIGHT-OF-WAY PLANS

Old plans sometimes exist for which there are no R.O.W. deeds. In this case, without physical evidence, the old plans are only circumstantial evidence of present R.O.W. and only the user's line may be claimed. Areas to the user's line shall be calculated.

In the event that the present R.O.W. cannot be identified and a user's line cannot be established for a two (2) lane undivided public road, there shall be a presumption that the unascertained R.O.W. is 25 feet on either side of the centerline of the traveled portion of the road.

Information necessary for a complete description of R.O.W. lines (metes and bounds or coordinates) shall be recorded. All present R.O.W. metes and bounds, station and offset distances for all break points, the beginning and end of curve points, and property line intersection points along the present R.O.W. line shall be labeled in the planimetrics file.

3.6.8 UTILITIES

All existing utilities within the project area shall be shown.

3.6.8.1 OWNERS

The owner of each utility shall be shown. Include name, address, contact person, and phone number.

3.6.8.2 LIMITS

When more than one utility company supplies the same service, the limits of each owner's service area shall be indicated.

3.6.8.3 LOCATION AND PROFILE

The location and depth of underground utilities shall be determined as best as possible. Profiles on gas lines and gravity-flow sewer lines are especially critical. However, gas lines shall never be sounded with a steel rod.

3.6.8.4 UNDERGROUND

All underground utilities which may be affected by roadway or structure construction (as determined by the Regional Survey Supervisor) will be shown in the planimetrics file and plotted with present layout and profile. Other utilities within the proposed R.O.W. will be shown in the planimetrics file and plotted only on the present layout with approximate depth noted. In both cases, the utility representative's name and the date the utility was located shall be recorded in the field book. Service lines will not be shown.

3.6.8.5 OVERHEAD

Overhead utility lines between poles will not be shown on present layout plots. The direction of the lines will be indicated by a short line through the circle representing the pole. However, any wire, or low wire of a line group, crossing the centerline shall be shown with the station and elevation recorded and shown on the profile. A temperature reading shall be recorded and shown on the profile for all high-tension lines.

3.6.8.6 SIGNALS

At signalized intersections, the signal heads, span wires, poles, and controller shall be recorded and shown on present layout plots.

3.6.8.7 POLE OR TOWER NUMBER

The pole or tower number shall be recorded, if available, for major transmission lines.

3.6.8.8 TYPE OF UTILITY

The type of service for each underground line and for each utility pole shall be noted using symbols shown on standard drawing RD-L-1, RD-L-2, and RD-L-3. The standard drawings can be accessed through the following TDOT website:

http://www.tdot.state.tn.us/Chief_Engineer/engr_library/design/Std_Drwg_Eng.htm

3.6.8.9 STORM SEWERS AND SANITARY SEWERS

Elevations shall be taken on the top and bottom of each manhole or catch basin and on the invert at each end of every pipe, including pipes that terminate in manholes. This information may be taken during development of the DTM or as part of a separate level run. It is advisable to develop a table of elevations and numbering system for the pipes of a sewer system.

3.6.8.10 SEPTIC TANKS AND DRAIN FIELDS

In areas where there are no municipally owned sewer and water systems, information shall be shown on all developed property regarding sewage disposal and water supply. All septic tanks and field lines near the proposed roadway shall also be located. However, a note indicating the location of facilities a considerable distance from the proposed roadway (or behind a building) will suffice.

3.6.8.11 WELLS

Any drilled wells (gas, oil, or water) that will be inside the proposed roadway or that will be abandoned shall be shown. The name and address of the driller, the date drilled, the depth of the well and the name of the property owner at the time the well was drilled shall also be noted. If this information is available, it shall be listed in the planimetrics file adjacent to the well site.

3.6.8.12 LOCATION FOR PAY ITEM PURPOSE

Responsibility for payment (Utility Co. or State) to relocate a utility is determined by its location within or without of present R.O.W. When utilities are close to the present R.O.W. or user's line, care shall be taken when developing the planimetrics file to indicate whether the utility is inside or outside of the present R.O.W. The Regional Utility Engineer shall be consulted when there is confusion about information to be shown.

3.6.8.13 PROBLEMS

Occasionally problems are encountered in the coordinating of the location of underground utilities. Any such problems shall be recorded in the project field book.

3.6.9 LAND CHARACTER

The land character of rural areas such as pasture, second growth, cultivated, swampy, etc., shall be noted. There shall be no attempt to show boundaries of each character except for fences and tree lines.

3.6.9.1 STOCK AND EQUIPMENT PASSES

As implied in the TDOT Design Guidelines, it is the responsibility of survey parties to recommend locations where stock and / or equipment passes shall be placed for proposed highways. The primary indicator for a stock pass is the dividing of a large area specifically used for pasture. Therefore, all pasture lands shall be carefully noted in the planimetrics file. Also, field personnel shall be cautioned against discussing possible locations with property owners. The assurance that a stock and / or equipment pass will be considered during the design process is usually the best response.

3.6.9.2 TREES

Trees which may be affected by construction shall be recorded. The edges of wooded areas shall also be identified.

3.6.10 EXISTING DRAINAGE STRUCTURES

- The direction of flow shall always be shown.
- The size, type, length, invert elevations, type of foundation material (if determinable), and condition (if required) of existing drainage structures shall be noted in the planimetrics file.
- Channel Changes
- The alignment shall be tied to the survey line.
- The DTM shall encompass any area affected by a channel change.
- Material used for channel lining shall be identified.
- Storm Sewers - The size and location of all pipes shall be shown. A recommended method is to give each catch basin and manhole a number so that each pipe can be identified. Example: 71 in x 47 in from 3 to 4.

3.6.11 BUILDINGS

The number of stories shall be shown, such as:

- 1 F (one story frame)
- 2 B (two story brick)

Only the floors above ground shall be counted, and the abbreviations shown on Standard Drawing RD-A-1 shall be used. Additional identification such as res., barn, shed, etc., shall be used. All commercial property shall be noted in the planimetrics file by name, e.g., “McDonald’s Restaurant”. Standard Drawing RD-A-1 can be accessed through the following TDOT website:

http://www.tdot.state.tn.us/Chief_Engineer/engr_library/design/Std_Drwg_Eng.htm

At least two corners on all buildings shall be located and measurements of the buildings shall be obtained so they can be plotted accurately. In business districts, all doors and loading docks shall be shown with floor elevations noted. Also, the floor elevation shall be shown for all buildings near drainage structures in flood prone areas.

3.6.12 RAMPS AND DRIVEWAYS

All existing ramps and driveways shall be accurately located.

3.6.13 UNDERGROUND PETROLEUM STORAGE TANKS

The disposition of property containing underground petroleum storage tanks is of utmost importance to TDOT. Environmental requirements call for expensive procedures to assure that leakage does not occur during any activity affecting the property. Because of the expense involved, TDOT must carefully consider such property when planning or constructing a roadway project. The ideal solution would be to avoid such property. This, however, is not always possible.

An attempt will be made to locate and identify all such property during development of the TPR. Proposed alignments will then be located so that the property can be avoided if possible. All such tanks, currently in use, shall have a certificate (or tank identification) number issued by the Tennessee Department of Environment and Conservation (TDEC).

In the event that such property is unavoidable, all tanks shall be located as accurately as possible and recorded in the planimetrics file. The Facility Identification Number shall also be shown. Accurate location of the underground tanks is often difficult. However, all possible sources of information shall be investigated (conversation with tenants, request for plans from owners, etc.). TDEC personnel can also be contacted and may be aware of additional information (including the Facility Identification Number) in their files. They may be reached at (615) 532-0945 in Nashville.

Occasionally property with tanks not identified in the TPR will be encountered. This is more likely when the tanks are not in use. The property and existing tanks shall be brought to the attention of the Regional Survey Supervisor for consideration of moving the survey line to avoid the property. If this is not possible, the property and tanks shall be located as discussed above. If the tanks are in use, the TDEC office shall be contacted as mentioned above, for a Facility Identification Number.

3.6.14 OTHER TOPOGRAPHIC FEATURES

Ornamentation on private properties such as signs, raised planters, etc. shall be shown and labeled in the planimetrics file. Parking lots and parking spaces (within or adjacent to proposed R.O.W.) shall also be located in the planimetrics file. These items affect the appraisal of the property.

3.6.15 FIELD NOTES

Field notes are not a required part of the survey. However, a field book shall be kept to record information which would be of use during data analysis and editing, development of plots, and review of activities. Examples: conversations with property owners, utility company employees, etc.; sketches of unusual locations or situations; descriptions of potential problems or locations; descriptive data to be entered into files later.

3.6.16 PLOTTING

3.6.16.1 GENERAL

The alignment and topography shall be plotted to check the planimetrics file.

3.6.16.2 SCALE

A scale of 1”=50’ shall be used unless otherwise directed by the Regional Survey Office or Design Division.

3.6.16.3 HORIZONTAL AND VERTICAL DATUM

The horizontal and vertical datum used (Refer to Sections 3.2, 3.7 and 5.1) shall be noted in the planimetrics file and on the check plot. Examples: “Coordinates are Datum Adjusted NAD 83 (1995) by the factor of 1.000XXX”. The “1995” refers to the year of the most recent adjustment of coordinate values in Tennessee and “1.000XXX” refers to the actual datum adjustment factor used for the project. And, “All elevations are referenced to the NAVD 1988”. Datum adjustment factors will be accurate to at least six decimal places.

3.6.16.4 COORDINATE VALUES FOR P.I.’S

Coordinate values for all P.I.’s shall be shown in the planimetrics file as part of each curve data table. Coordinate values shall also be listed for the beginning and ending points of all alignments and intersection station equations.

3.6.16.5 COMPLETE NAMES

Complete names as shown on deed shall be used on present layout sheets and property tables. The term “ETUX” shall be avoided.

3.7 BENCH LEVELS AND CHECK LEVELS

3.7.1 VERTICAL DATUMS

All vertical datums shall be tied to monuments established by the National Geodetic Survey (NGS). Note: Assumed datums or the use of GNSS to establish vertical control will be used only when authorized by the Regional Survey Supervisor.

3.7.2 METHODS AND ACCURACY

Bench marks will be set and check levels run before they are used for development of the DTM. Third order accuracy shall be obtained before adjustments are made (Refer to Table A-5 in the Appendix for definition). Check level calculations shall be shown in the notes of the field book (Refer to Figure A-14 through Figure A-17 in the Appendix for examples of field notes).

3.7.3 BENCH MARK LOCATION

Bench Marks shall be set at least every 1,000 ft along the survey and near all major structure sites and major intersections. All Bench Marks will be permanent in nature. Usually, GNSS project control points will be used as bench marks. Avoid using nails or spikes in trees or poles. Trees are injured and also lose their value with nails in them. Typically, utility companies prohibit placing nails in their poles.

3.7.4 DESCRIPTIONS

All Bench Marks are to be fully described. Example: B.M. No. 35, elev. 594.68, Aluminum disk atop 5/8” rebar stamped “HV-4” driven flush to the ground, 160 ft right, Sta. 24+45.00.

3.8 PROFILE AND CROSS SECTIONS

3.8.1 PROCEDURES

3.8.1.1 GENERAL

Profiles, including drive and ramp profiles, are typically generated from the DTM and no separate procedures are required in the field. However, there may be an occasional situation for which the Regional Survey Supervisor would require a conventional profile. It is for that reason profile methods and procedures are outlined below. Many of the methods described below shall be observed when developing profile plots from the DTM. Cross sections are no longer used by TDOT as a method of gathering field data and they are not plotted as part of the survey function. Therefore, cross sections procedures are not considered in this manual.

3.8.1.2 REQUIREMENTS

Profile shots shall be taken at the beginning and ending stations, and at every 50 ft station. The profile shall also be taken at all breaks or abrupt changes in ground elevation.

3.8.1.3 METHODS

The Direct Rod Reading Method shall be used when taking a profile with a surveyor’s level. Readings shall be made to the nearest 0.1 ft on soil, rock, or gravel surfaces, and to the nearest 0.01 ft on asphalt or concrete surfaces.

3.8.1.4 DRIVEWAY AND RAMP PROFILES

Driveway and ramp profiles shall be taken at 25 ft intervals for a distance sufficient to accommodate ties to proposed grades. All profiles shall be tied to the centerline of survey, not some physical object such as edge of pavement.

3.8.1.5 SIDE ROADS

Profiles shall be taken for the limit of the alignment at 25 ft intervals with additional profile, if required, to accommodate ties to existing grades.

3.8.1.6 TRIGONOMETRIC METHODS

Trigonometric profiling may be used when the terrain is rough or elevation differences are great. The field notes must be in such form that they are easily interpreted by others.

3.8.1.7 NOTES

An example of profile notes is included as Figure A-17 in the Appendix. Notes must be checked and initialed in the field book.

3.8.1.8 DATA COLLECTORS

When field data collectors are used, a tabulated list of offsets and elevations must be produced.

3.8.2 PROFILE PLOTTING

Refer to Figure A-9 through Figure A-11 in the Appendix for examples.

3.8.2.1 GENERAL

Profile plots shall be generated to check data in the planimetrics file and turned in with the survey. Standard GEOPAK® Road profile tools shall be used with the horizontal scale the same as that used for present layout plots. The desirable ratio is one (1) vertical to ten (10) horizontal.

3.8.2.2 ITEMS TO BE PLOTTED

- Profile of the survey centerline or baseline
- Profiles of all side road centerlines or baselines
- Profiles of the tops of each rail for a railroad crossing for a minimum of 600 ft in each direction
- Profiles of all ramps and driveways, if not included in the DTM
- Profiles of storm and sanitary sewer lines within the roadway (back of shoulders or sidewalks)
- Storm and sanitary sewers and major utilities, e.g., gas transmission lines which may be affected by roadway or structure construction
- Bench Mark descriptions and elevations or control point descriptions and elevations, if they are used for vertical control
- All intersection equations
- Drainage information, including structure plotted, station, size of drainage area, skew and direction of flow
- Low wire crossing information, including wire type, clearance, station, and temperature if a high tension line
- High water marks and normal water marks at stream crossings or at intervals when the centerline parallels streams
- Vertical datum and stationing properly shown (example: “All elevations are referenced to NAVD 1988”)
- Labeling for each item shown
- Profile plot labeled with project description

The survey file shall contain the following disclaimer within the survey seed file, that depths to some utilities are approximate, and profiles shall not be considered as accurate representations of their locations:

THIS SURVEYOR HAS NOT PHYSICALLY LOCATED THE UNDERGROUND UTILITIES. ABOVE GRADE AND UNDERGROUND UTILITIES SHOWN WERE TAKEN FROM

VISIBLE APPURTENANCES AT THE SITE, PUBLIC RECORDS AND / OR MAPS PREPARED BY OTHERS. THEREFORE, RELIANCE UPON THE TYPE, SIZE AND LOCATION OF UTILITIES SHOWN SHOULD BE DONE SO WITH THIS CIRCUMSTANCE CONSIDERED. DETAILED VERIFICATION OF EXISTANCE, LOCATION, AND DEPTH SHOULD ALSO BE MADE PRIOR TO ANY DECISION RELATIVE THERETO IS MADE. AVAILABILITY AND COST OF SERVICE SHOULD BE CONFIRMED WITH THE APPROPRIATE UTILITY COMPANY. IN TENNESSEE, IT IS A REQUIREMENT, PER "THE UNDERGROUND UTILITY DAMAGE PREVENTION ACT", THAT WHO ENGAGES IN EXCAVATION MUST NOTIFY ALL KNOWN UNDERGROUND UTILITY OWNERS, NO LESS THAN (3) THREE OR NO MORE THAN (10) TEN WORKING DAYS PRIOR TO THE DATE OF THEIR INTENT TO EXCAVATE AND ALSO TO AVOID ANY POSSIBLE HAZARD OR CONFLICT. TENNESSEE ONE CALL 1-800-351-1111.

3.9 DRAINAGE SURVEYS

3.9.1 DRAINAGE MAP

An example is included as Figure A-12 in the Appendix.

3.9.1.1 METHODS

A drainage map will be prepared for every project that has drainage crossing the survey centerline, unless instructed otherwise by the Regional Survey Office. Large areas may be run on quad sheets or aerial mapping. Smaller areas shall be surveyed in the field. Mapping shall be digitized and entered in the planimetrics file if possible. Any drainage structures which control flow into or away from the immediate project area (where flow crosses the centerline) shall be located and their size noted.

3.9.1.2 NOTES

Field notes shall be recorded in a standard field book if a data collector is not used, and shall include the following information:

- Any necessary traverse notes with ties to the centerline and other drainage areas.
- Drainage area features such as ground cover, buildings, roads, etc. and any change in the drainage area that might affect the runoff, such as urban development or watershed projects.

3.9.1.3 PLOTTING

Drainage map check plots shall be developed on bond paper and submitted with the survey if not included with the submitted MicroStation® planimetric file. The scale for maps (usually 1 in = 200 ft) shall be determined by the Regional Survey Office (Refer to Figure A-12 in the Appendix for an example). The following information shall be shown on plots:

- Centerline of survey with stationing
- Each complete area and cross reference to other maps for large areas
- North arrow, title block, area in acres, centerline ties, ground cover, buildings with floor elevations, roads, the elevation of and distance to the farthest point along the flow path, and the size, location and inlet and outlet invert elevations of existing drainage structures

- In the event a TVA lake is shown on the drainage map the Full Pool Contour Elevation and the Maximum Shoreline Contour Elevation shall be noted (Refer to Table A-2 in the Appendix).

3.9.2 GENERAL REQUIREMENTS FOR BRIDGE AND CULVERT SURVEYS

3.9.2.1 SECTION 404 PERMIT INFORMATION

Under Section 404 of the Federal Water Pollution Control Act, the Survey and Design Office must provide certain information to the Corps of Engineers and obtain permits to dredge or fill in any channel conveying minimum constant average flows of 5 cfs. The requirement applies to any stream shown as a solid blue line on USGS maps.

3.9.2.2 DEFINITIONS

- EXTREME HIGH WATER: the highest elevation to which evidence can be found that water has ever risen (If the drainage basin has been altered, the highest elevation since that time)
- NORMAL POOL: this elevation is identical to ordinary high water, but is applied to lakes and wetlands.
- NORMAL WATER: the water surface elevation during normal weather conditions (no flood runoff).
- ORDINARY HIGH WATER: the water surface elevation of the vegetation line.

3.9.2.3 FIELD DATA

The extreme high water, normal water, and ordinary high water elevations are required.

3.9.2.4 NAMES AND ADDRESSES

The names and addresses of property owners adjacent to streams that require 404 permits shall be recorded in the field book and in the planimetrics file.

3.9.2.5 SIZING DRAINAGE STRUCTURES

Sizing is not required by survey personnel. The size or type of structures is usually indicated in the TPR, or will be determined by the Structures Division during the design.

3.10 DRAINAGE SITE SURVEYS

Unless directed otherwise by the Regional Survey Office, the following two (2) types of drainage site surveys will be made:

- BRIDGE SURVEYS: survey for sites with Q_{50} greater than 500 cfs or any structure whose length along the roadway is 20 feet or greater
- PIPE AND BOX CULVERT SURVEYS: survey for sites with Q_{50} up to and including 500 cfs

The drainage area will be used in conjunction with the Hydrologic Areas Chart (Appendix Figure A-28) to determine if a bridge or culvert survey is performed.

3.11 BRIDGE SURVEYS

(Q_{50} = GREATER THAN 500 CFS OR ANY STRUCTURE WHOSE LENGTH ALONG THE ROADWAY IS 20 FT OR GREATER) - Each bridge survey shall have a corresponding

Bridge Survey Notes block submitted with the project data. This block is included in the MicroStation® standard seed file survseed.dgn.

3.11.1 FLOOD PLAIN SECTIONS

A flood plain section perpendicular to flood flow shall be taken upstream and downstream each looking downstream. Each section shall be a distance from the proposed structure equal to four times the typical distance between top of banks or a minimum of 50 feet. The flood plain section shall extend completely across the flood plain from extreme high water to extreme high water and be tied accurately to the centerline of survey.

Additional flood plain sections will be necessary at points where the valley constricts or significantly changes within the area of study (length of stream profile above or below the structure).

Flood plain sections at great distances from the structure may be located on a quad sheet or other mapping rather than the site plan. If it is determined from examination of topographic maps that a representative flood plain section can be observed closer to the survey centerline, the objective of the survey will be met.

The flood plain section shall be described in segments as shown below (Figure 3-1). Land character shall be described using terms such as: pasture, no brush, high grass, cultivated area, row crops, heavy weeds, scattered brush, light brush and trees, heavy stand of timber, etc.

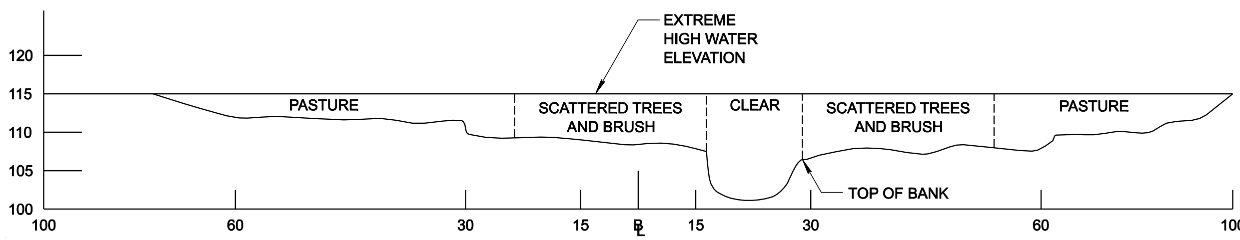


Figure 3-1
Example Floodplain Section

3.11.2 STREAM PROFILE

The DTM shall be generated such that a stream bed, water surface and top of one bank profile can be developed for a distance equal to six times the typical distance between top of banks or a minimum of 50 feet, upstream and downstream of the proposed structure. DTM shots shall be taken at regular intervals (depending on the size and uniformity of the stream) and at any point the water velocity changes. The type of material in the stream bed shall be described and it shall be noted if banks are subject to scour. Depth-finders may be used on major streams and rivers. The top of bank data is required only for those streams with well defined stream channels.

3.11.3 ROADWAY PROFILE

The DTM shall be generated such that a survey centerline profile can be developed completely through the flood plain. In the event that the survey centerline does not coincide with the existing road (when the structure is to be relocated), the DTM shall include the existing road completely through the flood plain. The DTM shall also include any other road in the study area.

3.11.4 DTM DEVELOPMENT

In the immediate area of the structure, the DTM shall be developed such that accurate 6-inch contours may be produced. The area must be wide enough to cover the limits of construction, and long enough to cover the proposed structure and approaches. This will simplify design of slope protection for approach fills. Existing bridges and the TPR may be used as a guide for length.

3.11.5 TOPOGRAPHY

Complete topography shall be taken to include stream meanders. Meanders of bank tops, bottom of banks, and water surfaces shall be recorded and topography extended the greater of 300 ft, one structure length or the length of the stream profile upstream and downstream. On large flood plains, the topography can be spotted on USGS quadrangle sheets, aerial photographs, or other suitable mapping. Such maps will be submitted as part of the bridge survey. A stream baseline shall be shown generally following the stream meanders. This baseline shall be treated the same as a horizontal alignment except they are placed on CADD levels as noted for stream information. Alignments will also be shown for stream cross sections.

3.11.5.1 BUILDINGS AND OTHER STRUCTURES SUBJECT TO FLOODING

The structure shall be located and floor elevation recorded along with structure type and use (i.e. business, residence, etc.).

It will be necessary to document any structure that is replaced. The existing structure shall be located and described with dimensions of waterway openings shown. Also, wingwall geometry, retaining walls, rock ledges, or previously abandoned structures in the area shall be located and defined.

3.11.5.2 CONSTRUCTION CLEARANCE FOR BRIDGE PROJECTS

When the proposed bridge will be located near the present structure, the offset distance shall be noted from the proposed centerline to the corners of the existing structure. Offsets shall be recorded to the nearest 0.1 ft. Also, an offset line or any method that will show the designer his working clearances, may be used.

3.11.5.3 EXISTING STRUCTURES

Each bridge or culvert along the existing route within the flood plain shall be located with beginning and ending stations shown for the bridges. An elevation view sketch of each shall also be developed and may be in the planimetrics file or a paper plot (Refer to Figure A-20 through Figure A-23 in the Appendix). They shall be drawn to scale or have all dimensions of the waterway opening shown. The low beam elevation shall be recorded for bridges and the inlet and outlet invert elevations for culverts. Pier and deck elevations may also be required.

3.11.5.4 HIGH WATER AND NORMAL WATER

The elevations of extreme high water and normal water levels shall be recorded with a description of how the extreme high water was determined (including date). If the extreme high water level is backwater the name of the river or lake shall also be noted.

Any significant collected material on the upstream entrance to the structure shall be noted in the planimetrics file.

3.11.5.5 QUESTIONS

Questions concerning a particular bridge survey shall be directed to the Regional Survey Office.

3.11.6 PLOTTING

Information must be provided, in the planimetrics file, DTM, and on paper plots such that a plotted bridge survey complete within itself can be produced. The Road Designer will develop the following plots and forward them to the structures Division, Hydraulics Design Section along with electronic files (.dgn, .gpk, and .tin).

3.11.6.1 TOPOGRAPHY

Text - Project name, stream name, comments, and descriptive data.

Data - Present layout, 6-inch contours in the immediate area of the structure, stream meanders with top and bottom of banks shown, survey centerline, location of flood plain sections if practical, existing structures, buildings subject to flooding with floor elevations.

3.11.6.2 PROFILES (GENERATED FROM DTM)

Text - normal water elevation, extreme high water elevation with a description of how it was determined, vertical datum used, and description of channel bottom material.

Data - profiles of centerline, other existing roads, bottom of stream, water surface, top of bank, and flood plain sections with type of vegetation shown.

3.11.6.3 SKETCHES

Drawings of existing structures may be shown separately or with the topography plot. They shall include all data described in Section 3.11.5.3 (Refer to Figure A-20 through Figure A-23 in the Appendix for examples).

3.11.6.4 DRAINAGE MAP

The drainage map shall be provided as described in Section 3.9.1 (Refer to Figure A-12 in the Appendix for an example).

3.11.6.5 QUAD SHEET

If required as noted previously.

3.12 PIPE AND BOX CULVERT SURVEYS

(Q_{50} = 0 cfs to 500 cfs) - Separate surveys for these structures are not required. However, certain data must be gathered during the topographic survey and measures taken during DTM development to assure information is provided to allow for proper design.

3.12.1 TOPOGRAPHIC SURVEYS

Data gathered during topographic surveys will be shown in the planimetrics file and includes: stream and / or ditch meanders, and existing structure details such as endwalls, wingwalls, etc.

3.12.2 DTM

The DTM shall be developed in greater detail in the area of the existing structure and flow. Spot elevation shots and breaklines shall be recorded at the bottom of ditches or center of stream and the DTM shall be extended far enough to determine the natural profile of the stream or ditch.

3.12.3 TEXT

Certain descriptive information shall be recorded in the area of the pipe or structure, including:

- Condition and other comments
- Foundation material
- Invert elevations
- Extreme high water and normal water elevations

3.12.4 EROSION CONTROL

Retention ponds and other special drainage features will be designated by the designer and may require additional field information at the time of design. Other data shall be provided as part of usual drainage surveys. A contour map of the area (scale no smaller than 1:5000) will supply required drainage information and is the designer's best source of information for erosion control (Refer to Section 3.10).

3.13 PROPERTY MAP

3.13.1 PROCEDURES

Information will be gathered and shown in the planimetrics file such that a property map can be prepared for every project which requires R.O.W. and / or easement acquisition.

3.13.2 SOURCES OF INFORMATION

- Deeds and plats
- Field Information (Refer to Section 3.6.6)
- Tax maps
- Aerial mapping
- Planning commissions, agency engineer
- Private survey firms

3.13.3 MAP LIMITS

Each affected property shall be shown in its entirety, including all access roads. However, very large tracts do not need the entire boundary surveyed in the field. A field survey shall be performed and labeled with metes and bounds on the property to a width that will show on the present layout sheet. Outside this width, the area may be scaled or digitized from tax maps or deeds and shall not be labeled.

3.13.4 TRACT NUMBERS

Each tract shall be numbered consecutively from the beginning of the project, crisscrossing the road as necessary. A separate tract number shall be assigned for each separate deed, even though adjoining tracts may have the same owner.

3.13.5 R.O.W. ACQUISITION TABLE

The table shall be as shown in Table A-3 (consistent with the Acquisition Table in the Design Guidelines), and as called for in Section 3.4.2.2.

The following will be recorded unless the Regional Survey Office directs otherwise:

- Deed area right and left of survey centerline unless there is an obvious difference in deed area versus tax assessor data or calculated area. Then the tax assessor data or calculated area will be used. Deed area is the preferred method.
- Areas to the nearest square foot
- Deed book and page number
- Tax Map and Parcel Numbers

3.14 GRADE SEPARATIONS (ROADWAY)

When it is proposed to construct, widen, or replace a bridge over a road, the following procedures apply:

3.14.1 FIELD DATA REQUIRED

- The station of intersection shall be noted.
- Alignment and topography shall be taken 500 ft right and left on rural roads and 1,000 ft right and left on state routes. Deviation from these limits shall be approved by the Regional Survey Office.
- The DTM of crossroads shall be recorded for the limits of the alignment.
- A detailed DTM suitable for development of a 6-inch contour interval map for separation structures shall be taken.
- When the proposed bridge will be located near the present structure, the vertical clearance and offset distance from the proposed centerline to the existing structure shall be recorded to the nearest 0.1 ft.

3.14.2 PLOTTING

Data shall be recorded in the planimetrics and DTM files necessary to prepare the following plots:

- Proposed roadway and crossroad profile
- Ground line contour map (6-inch intervals)
- As-built survey if needed
- Topography and alignment of bridge approaches, crossroad approach with any drainage structures, and flowline elevations

3.15 GRADE SEPARATIONS (RAILROAD)

When it is proposed to construct, widen, or replace a bridge over a railroad, the following procedures apply:

3.15.1 FIELD DATA REQUIRED

- Station of intersection of each set of rails and spacing between tracks
- Alignment of all tracks, 600 ft each direction with curve information (if any) computed and recorded in the planimetrics file

- All topography within the railroad R.O.W. for 600 ft each direction, including switching devices, signal devices, control boxes, and utilities (especially fiber optic cables)
- Name of the railroad
- Present railroad R.O.W.; the term "Charter R.O.W." does not indicate that the railroad owns the property and charter R.O.W. shall not be shown. Railroad R.O.W. shall include only the property owned by deed or being used and maintained.
- Distance and direction to the nearest milepost and description of same
- Profile of the top of rail 600 ft each direction
- Develop the DTM 200 ft in each direction along the tracks within the railroad R.O.W. If the road R.O.W. extends beyond 200 ft, the outermost limits of the DTM shall be taken at the limits of the R.O.W.
- DTM data required to develop a contour map (6-inch intervals) in the area of the proposed structure
- Size, type, invert elevation and condition (if required) of all existing drainage structures with the direction of flow in field drains and channels indicated by arrows
- When the proposed bridge will be located near the present structure, the offset distance from the proposed centerline to the existing structure (to nearest 0.1 ft) and the location and vertical clearance from top of rail to bottom of beam

3.15.2 PLOTTING

Data shall be recorded in the planimetrics and DTM files as necessary to prepare the following plots:

- Roadway profile
- Ground line contour map (6-inch intervals)
- As-built survey, if needed
- Profile of top of rail(s) 600 ft each direction
- Topography and alignment of proposed centerline of bridge approaches and tracks 600 ft each direction including any drainage structures (with flowline elevation), distance and direction to the nearest milepost and description of same, and present railroad R.O.W.

3.16 BRIDGE WIDENING

3.16.1 BRIDGE WIDENING PROJECTS

In the event a structure is to be widened, the following information will be required in addition to that indicated in Section 3.14 or 3.15:

- An as-built survey is needed for the existing structure. Dimensions and elevations shall be recorded to the nearest 0.01 ft, since new concrete must be tied to old. Attention shall be given to details of elevation on low girder, top of footings, abutments, piers and beam seats.
- The thickness of paving added to the structure shall be estimated.
- Existing plans or sketches prepared by bridge inspection teams shall be requested (if available) and may be used for checking and / or recording as-built dimensions. Specific requests for survey information may be made by Structures Division personnel.

3.17 SPECIAL SURVEYS

3.17.1 STAKING RIGHT-OF-WAY

R.O.W. staking is usually requested by Regional R.O.W. Offices and is used by appraisers and buyers to field locate property parcels.

Stakes shall be set so that an observer can easily see from one stake to the other. When an obstruction is encountered (building, large tree, boulder, etc.), a stake shall be set adjacent to and on each side.

When possible, a standard 1” x 2” x 36” stake with the top 12 inches painted red shall be used or as directed by the Regional Survey Supervisor. When a R.O.W. corner falls on pavement, a nail shall be set and painted. Since these points can be expected to be semi-permanent the same degree of accuracy used on the survey will apply.

The method used to establish R.O.W. shall be based on sound engineering principles.

Iron pins and / or R.O.W. stakes will be set as follows:

- At R.O.W. angle points (stakes and pins)
- At the beginning and end of each radius (stakes and pins)
- At the intersection of property lines and R.O.W. lines (stakes only)
- Near all structures which are positioned close to the margin, so that the relationship of the R.O.W. limit to the object can be determined visually (stakes only)
- When stakes are hidden by vegetation (e.g., cultivated areas, weed cover, thicket, etc.), they shall be marked with a witness flag which will protrude above the expected growth of vegetation.

R.O.W. stakes will be marked with description / station / offset. The following standard abbreviations shall be used (Reference Standard Drawing RD-A-1):

- PRES – Present
- PROP – Proposed
- R.O.W. or R/W – Right-of-Way
- ESMT – Easement
- BEG R – Begin Radius
- END R – End Radius
- PERM – Permanent
- COR – Corner

Present R.O.W. shall not be staked unless so directed by the Regional Survey Office.

The point at which the centerlines of the proposed alignment and any existing roads cross shall be marked when staking R.O.W. The marking shall consist of a pavement nail, with flagging, circled by pavement marking paint with the centerline station painted on the pavement nearby.

Easements - Permanent easements shall be staked using the same procedures used in R.O.W. staking. Temporary easements shall be staked as accurately as supplied information permits (stakes only).

3.17.2 STAKING SOUNDING HOLES

The location for soil samples is selected by the Geotechnical Operations Section. Two copies of the proposed Layout Sheet will be sent with the desired drilling site marked in red and labeled numerically. All field work necessary to obtain ground elevations will be recorded on one of these sheets and maintained in the project file. The other will be returned to the Geotechnical Operation Section with the elevation of the ground shown at each hole site (Refer to Figure A-19 in the Appendix for an example).

The actual field staking may be done with a cloth tape or other method giving similar or greater accuracy, and marked with a standard 1" x 2" x 36" stake, or as directed by the Regional Survey Supervisor. The identifying labels on the stakes shall agree with those shown on the layout sheets.

Points which fall in water too deep to wade shall be referenced so drill crews can locate them with tape or chain. An appropriate sketch shall be recorded on the sounding hole sheet showing reference points and reference elevation (Refer to Figure A-19 in the Appendix for an example).

3.17.3 ADDITIONAL INFORMATION

The methods and procedures used for gathering, recording, and editing additional information are generally the same as those used for the original survey. The primary problem encountered is the difficulty in separating additional data from original data. Procedures to be used for submitting additional survey information are outlined in the TDOT CADD Standards. Refer to the TDOT website below for the most current documented procedures.

http://www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_design/design/v8/V8design.htm

3.17.4 UPDATES

The old survey shall be carefully checked to determine where changes have occurred and new data exists. If changes are minor, plans can be marked. Otherwise, procedures would be the same as for additional information in Section 3.17.3.

3.17.5 NOISE ANALYSIS SURVEYS

3.17.5.1 NOISE SENSITIVE AREAS

Exterior - These are areas which have frequent human use and where noise levels affecting communication or aesthetic quality are undesirable (yards, playgrounds, sports areas, recreation areas, hospital grounds, church grounds, etc.).

Interior - These buildings house areas where noise levels affecting communication, aesthetic quality, or sleep are undesirable (schools, churches, hospitals, motels, hotels, nursing homes, residency, office buildings, libraries, etc.).

3.17.5.2 CRITICAL DISTANCES

The critical distance from the proposed centerline to a noise sensitive external area (D_E) and to a noise sensitive interior area (D_I) are determined by the Environmental Division and are based on projected traffic. D_E and D_I are provided prior to the survey.

3.17.5.3 SURVEY

A noise analysis survey involves extending the DTM and topography to any noise sensitive area that falls within $4D_E$ or $4D_I$. Refer to Figure 3-2 and Figure 3-3 for examples.

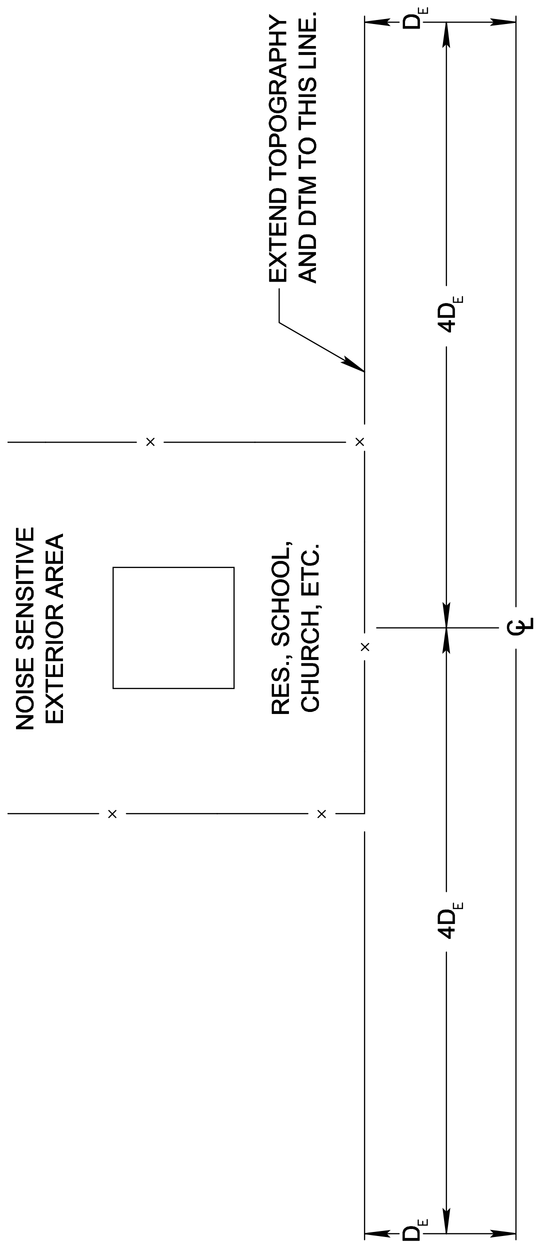


Figure 3-2
Noise Survey Information

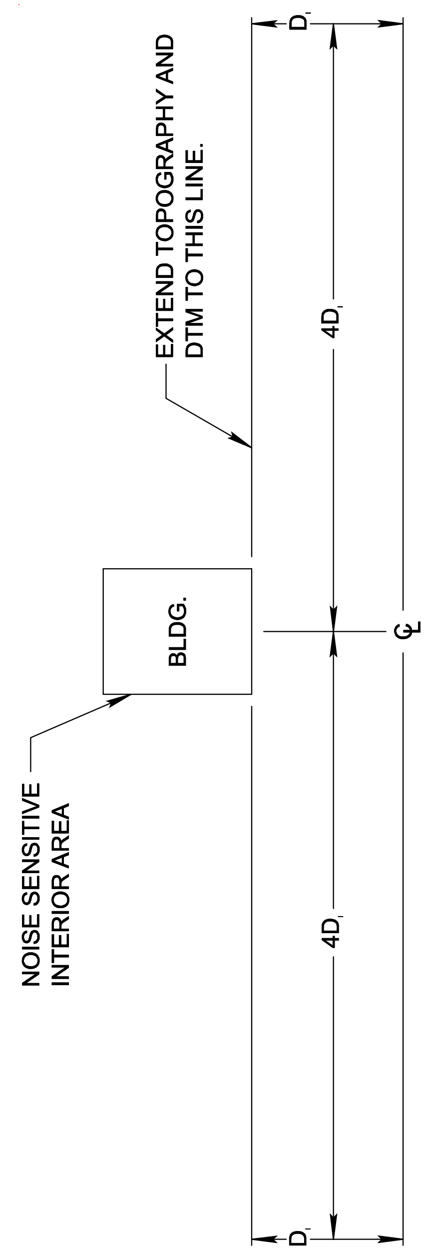


Figure 3-3
Noise Survey Information

CHAPTER 4 - CARE AND MAINTENANCE

4.1 CARE AND MAINTENANCE

4.1.1 GENERAL

TDOT has a large investment in surveying equipment and survey parties are expected to protect that investment by exercising proper care. Surveying equipment is made to withstand normal use, but it cannot be expected to perform accurately if it is misused. Therefore, every piece of equipment shall be used only for the purpose it was designed. The person in charge of the survey crew is personally responsible for the care and maintenance of survey equipment assigned to his work unit. Any employee who does not at all times show proper regard and care for survey equipment may be suspended or dismissed. The following are guidelines for use, care, and everyday maintenance:

4.1.2 TOTAL STATIONS AND LEVELS

- The instrument should be attached to the tripod snugly, but not so tight that the tripod head or spring plate becomes warped.
- The instrument should be held by the standards and tribrach (if applicable) when placing it on the tripod, not by the telescope or other parts.
- Lenses should not be touched with fingers. Lens cleaning fluid and eyeglass tissue, or a camel's hair brush should be used for cleaning.
- The instrument should be kept free of dirt and grease. If foreign matter is allowed to accumulate, it will eventually penetrate into the motions and cause sticking. The plastic hood should be used to protect the instrument in dusty conditions.
- The instrument should be kept dry. However, if it does get wet, it should be air-dried.
- An instrument should never be left unattended.
- The instrument should be in its carrying case when transported in a vehicle or when walking long distances, and never transported in a vehicle on one's lap or left on the tripod. Transporting equipment mounted on tripods can cause maladjustment and damage.
- When using the motions of the instrument, they should be clamped just enough that rotation about the axis will not occur with slight pressure. Motions shall never be forced. The instrument should be rotated gently with the fingertips rather than forcefully with a grip. If screws or motions operate too tightly, adjustments should be made. No part of an instrument should be removed, or adjustments made, without thorough knowledge of the procedures involved.
- When placing the instrument back in its case, it should be positioned and secured properly with the motions clamped lightly.

4.1.3 TOTAL STATIONS

- Total Stations should be loaded in vehicles so movement and jarring is minimized.
- Required maintenance is minimal on most instruments. However, protection from the elements and routine external cleaning are necessary.
- A total station should never be pointed directly at the sun. The focused rays of the sun can damage receiving elements.
- Prisms should be kept in their cases when not in use.

- Prisms must be kept clean to assure maximum reflection.
- When prisms are set up near a high-speed road or in a strong wind, they must be secured so they will not blow over.
- Between setups, total stations should be transported in their storage / carrying cases.

4.1.4 TRIPODS, LEVEL RODS AND OTHER EQUIPMENT

- Tension should be kept on tripod legs so they will just fall freely.
- Mud shall be cleaned from tripod shoes and legs at the end of each workday, and dirt and mud cleaned from level rods and range poles as needed.
- Tripods, level rods, or other equipment should never be thrown into a vehicle or leaned against vehicles, trees, or buildings. Level rods should be laid flat or held vertically. Tripods should rest with the legs spread and firmly set in the ground.
- Clamps on extendable leg tripods should be just tight enough to avoid slippage.
- Other material (stakes, axes, etc.) should not be loaded on top of tripods, level rods, range poles and other such equipment.
- When walking, level rods should be carried with the numbers facing in or out (not up or down), so the rod does not bounce or bend while being carried.
- Level rods, range poles or other equipment should not be used for unauthorized purposes such as prying, vaulting, hammering, digging, prodding, etc.
- The moving parts and clamps of tripods, level rods and other equipment shall be oiled occasionally. Also, screws and bolts shall be checked periodically for tightness to assure rigidity.

4.1.5 GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) EQUIPMENT

- Refer to manufacturer’s recommendations for detailed care and maintenance.
- Most GNSS equipment is water resistant and not waterproof.
- Over charging protection is typically built into the equipment.
- If using an RTK base station, place the base station on a point that is not likely to be in danger of being hit by a vehicle.
- When relocating to a different project area to work, take care in placing the rover rod with GNSS receiver in the vehicle to avoid damage.
- Occasionally, the receiver’s NVRAM may need to be cleared to eliminate communications or tracking problems.
- The moving parts and clamps of tripods, rover rods, and other equipment shall be oiled occasionally. Also, screws and bolts shall be checked periodically for tightness to assure rigidity.

4.1.6 OFFICE EQUIPMENT

Calculators, computers, etc., should be covered when not in use. Instruments such as planimeters, thermometers, hand levels, etc. should be kept in their boxes in a safe place.

4.2 ADJUSTMENTS

All survey equipment, including hand levels, planimeters, rods, etc., should be checked at frequent intervals to assure accuracy.

As a general rule, TDOT personnel should not attempt instrument repairs. However, competent and qualified personnel may perform minor repairs.

Adjustments can be classified as field or shop adjustments. Shop adjustments are made at the time of manufacture or during shop repairs.

The person in charge of the survey crew and Instrument Person shall know how to make field adjustments on levels and other equipment. This includes peg testing the level, leveling bubbles and centering cross hairs in the level.

When field adjustments become necessary, refer to the manufacturer's instructions for testing and adjusting.

Shop repairs or adjustments requiring expenditure of funds shall have prior approval by the Regional Survey Supervisor.

Instruments may be tested for distance and angle measuring accuracies by occupying points of known location.

4.3 SUPPLIES

The TDOT Limited Version of the Standard Financial Procedures Manual explains in detail the available sources and required procedures to obtain supplies. The following is offered as an aid in using that manual:

- Claims for incidental and emergency expenses (Refer to Form DT-0108 on page A-29 of the Appendix).
- Transfer or disposition of fixed assets (Refer to Form DT-0302 on page A-30 of the Appendix).
- Requisition for Garage Stock Room (Refer to Form DT-0125 on page A-32 of the Appendix).
- Requisition for Office and Engineering Supplies - from the Regional Stock Room (Refer to Form DT-0124 on page A-33 of the Appendix).
- Form DT-0607 is used for returning materials and supplies to inventory (Refer to form on page A-34 of the Appendix).
- In the event equipment is destroyed, lost or stolen, the proper form (F-303) may be obtained from the Regional Office to report the event and process the removal of these items from the fixed assets inventory report (DT-302). All thefts should be reported to the police. Sample forms may be found on pages A-35 and A-36 of the Appendix, respectively.

Specific companies to the State supply certain items under contract. These items must be purchased from the specified vendor. Any question as to whether an item is on contract shall be directed through the Regional Surveys Office to the Procurement Officer in the Region.

The purchase of supplies from outside vendors, requisitions from the Regional Garage Stockroom, requisitions from the Regional Stock Room or the transfer or disposition of fixed assets shall have prior approval by the Regional Survey Supervisor.

CHAPTER 5 - GENERAL SURVEY INFORMATION AND CONSULTANT COORDINATION

5.1 SURVEY DATUMS AND THE TENNESSEE GRID SYSTEM

5.1.1 ORIGIN OF DATUMS

The North American Datum of 1927, established by the United States Coast and Geodetic Survey (USC & GS), has recently been adjusted and republished by the National Geodetic Survey (NGS). This new North American Datum of 1983 (NAD 83) has been adopted for reference of control for all TDOT projects. The reference for vertical control, the Sea Level Datum of 1929 established by the USC & GS, has also been adjusted by NGS. This new North American Vertical Datum of 1988 (NAVD 88) has been adopted for reference of vertical control for all TDOT projects.

5.1.2 VERTICAL DATUM

Vertical datum is mean sea level. A network of monuments has been established throughout the United States and a listing has been published by NGS. An assumed vertical reference will **not** be used unless authorized by the Regional Survey Supervisor.

5.1.3 HORIZONTAL DATUM

All route survey projects shall be tied to the Tennessee Geodetic Reference Network (TGRN). This will allow all surveys to be correlated to a single reference framework. Point locations will be fixed and cannot be considered legally lost. Overlapping projects will be consistent and plane surveying will be possible over large areas without the introduction of significant error. Also, a uniform computational base will be established and fewer errors will go undetected.

5.1.4 TENNESSEE GEODETIC REFERENCE NETWORK (TGRN)

To more easily and accurately provide for ties to NAD 83, the TGRN has been developed. It is a highly accurate network of three dimensional monuments designed for use with GNSS equipment. The TGRN was tied to and is consistent with NAD 83. The sixty network monuments (Refer to Figure 5-1) are evenly spaced throughout the state so that no project shall be more than 15 miles from a network station. The internal accuracy of $1{:}10^7$ makes the network ideally suited for ties with highly accurate GNSS equipment. Network monument locations were also chosen with attention to visibility and accessibility desirable for GNSS equipment. Additional information concerning the TGRN is available through the State Survey Coordinators Office, any Regional Survey Office, or by referring to the TGRN manual developed by TDOT. The TGRN manual is accessible through the following website:

http://www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_design/design/field_surveys.htm

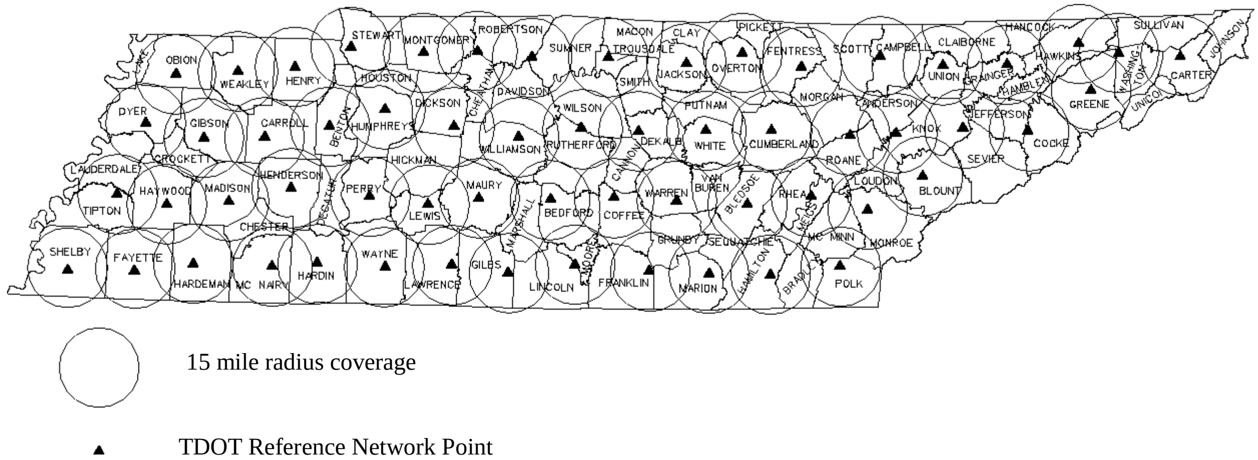


Figure 5-1
TGRN Network

5.1.5 TENNESSEE GRID SYSTEM

The Tennessee Grid System is derived from the Lambert Conformal Conic Projection. The Lambert projection is used in approximately 31 states in the United States and is best suited for states with East-West elongation, such as Tennessee.

Conformal means that the configuration of the area projected is maintained. Conic implies that the projection is extended to the surface of a large cone, as shown in Figure 5-2. Assume that the cone intersects the spheroid (slightly flattened sphere) or the mean earth's surface along two lines known as standard parallels of latitude [B-C and D-E in Fig. 5-2 (a)]. Parallels of latitude [F-G and H-I] are the limits of the projection. The apex of the cone of projection is point "A". Line J-K is the central meridian line. The central meridian for Tennessee is longitude 86°-00'. Fig. 5-2 (b) shows a portion of the plane surface developed from the cone of projection. If the limits of the projection do not exceed 158 miles, the North-South distortions are one part in 10,000 or less. The scale, defined as the ratio of a length on the projection grid distance to a corresponding geodetic distance on the sphere's sea-level surface, varies in the North-South direction. The scale is exact along the parallels in an East-West direction.

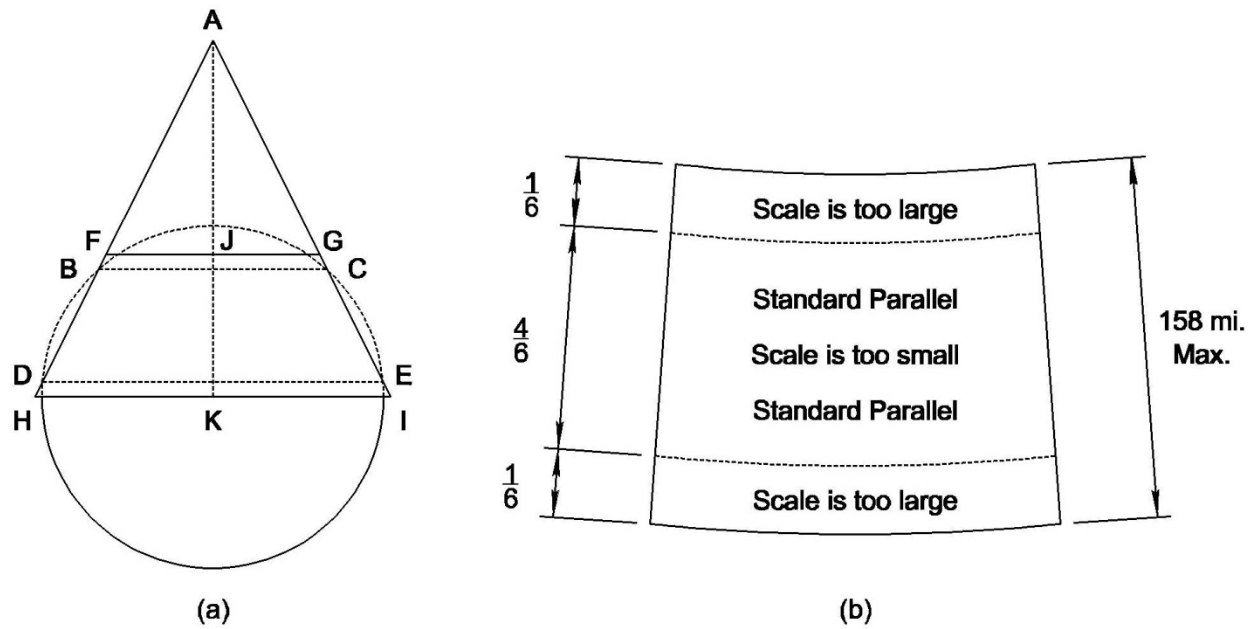


Figure 5-2
Lambert Conformal Map Projection

The Appendix of this manual (beginning on page A-37) contains excerpts from NOAA Manual NOS NGS 5, "State Plane Coordinate System of 1983" by James E. Stem. The manual, distributed by the U.S. Department of Commerce, gives a more detailed look at SPCS and computations involved. Most surveying software on the market today provides for easy conversion of coordinates from one datum to another. Therefore, details of the computations are not included in the body of this manual.

All TDOT surveys that relate to the grid system shall be datum adjusted to raise or lower the plane of projection of the surveyed points to the earth's surface. This facilitates staking of centerline, R.O.W., and construction points. Procedures used by GNSS crews, when establishing project control (Refer to Section 3.2), provide for this required datum adjustment. Each datum adjustment factor is project specific and is computed by TDOT personnel with the assistance of computer software developed specifically for this purpose.

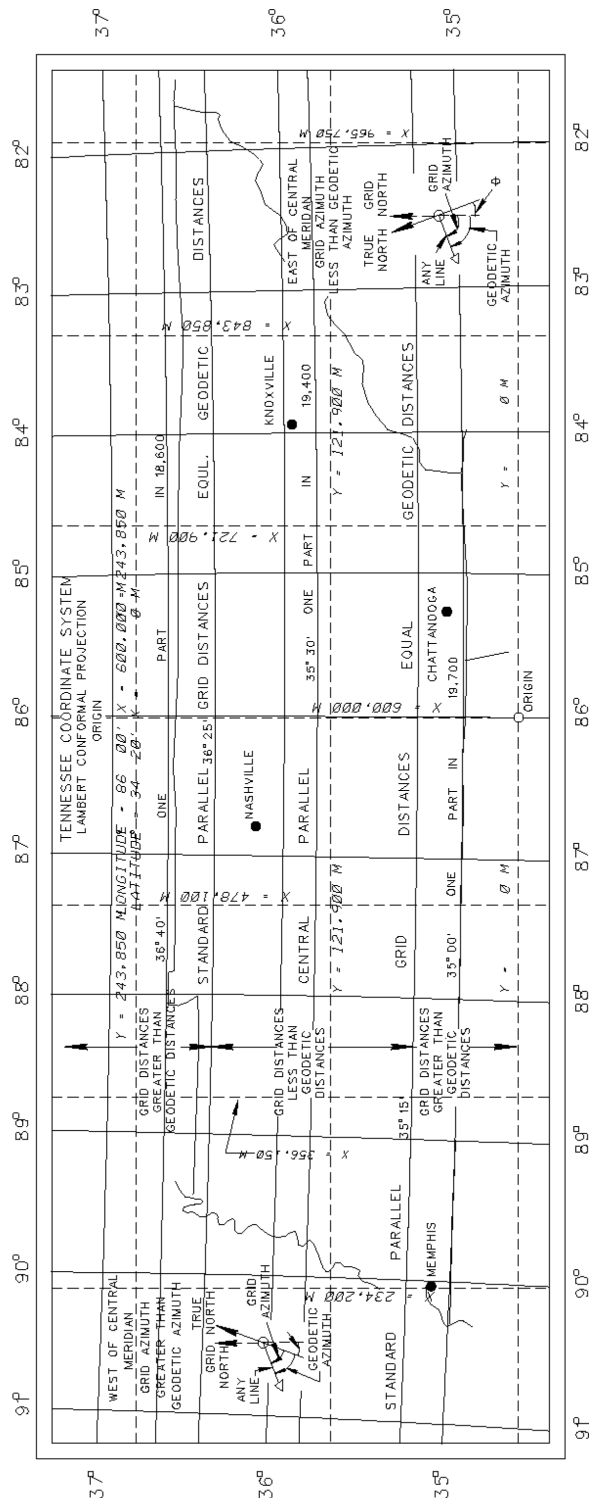


Figure 5-3
Tennessee Lambert Map Projection

5.2 ACCURACY AND ERRORS

5.2.1 ACCURACY AND PRECISION

The accuracy of a field survey depends directly upon its precision. Accuracy is the degree of conformity with a standard or a measure of closeness to a true value. Precision is the degree of refinement in the performance of an operation or in the statement of a result. Accuracy relates to the quality of the result obtained when compared to a standard. Precision relates to the quality of the operation used to attain the result.

Surveys with high order accuracies could be attained (through luck) without high order precision, therefore making such accuracies meaningless. All measurements and results shall be quoted in terms that are commensurate with the precision used to attain the results. Similarly, all surveys must be performed with a precision which assures that the desired accuracy is attained.

Precision is indicated by the number of decimal places to which a computation is carried and a result stated. Actual precision is governed by the accuracy of the source data and the number of significant figures, rather than by the number of decimal places.

5.2.2 SIGNIFICANT FIGURES

5.2.2.1 DEFINITION

Significant figures are those digits that are known plus one doubtful digit.

5.2.2.2 EXAMPLES

16.423	5 significant figures (such as reading a steel chain to the nearest thousandth of a foot)
21.63	4 significant figures (such as reading a steel chain to the nearest hundredth of a foot)
12.1	3 significant figures (such as reading a cloth tape to the nearest tenth of a foot)
0.4	2 significant figures (such as reading a level rod or cloth tape to the nearest tenth of a foot)
38	2 significant figures (such as reading a cloth tape to the nearest foot)
5	1 significant figure (such as reading a cloth tape to the nearest foot)

5.2.2.3 FIELD NOTES

Recorded field measured values shall never indicate a precision greater than that used in the actual survey.

Method Used	Recorded Value Not To Exceed
Stadia	Nearest 1 foot
Cloth tape	Nearest 0.1 foot
Steel tape or chain	Nearest 0.01 foot
Transit or theodolite	Least count
Level	Nearest 0.01 foot
Hand level	Nearest 0.1 foot
Total Station	As recommended by manufacturer
GNSS	As recommended by manufacturer

5.2.3 CALCULATIONS

The result must not reflect a greater accuracy than the methods used to gather field data.

Addition and Subtraction - The answer can contain no more significant figures to the right of the decimal than that of the least accurate number in the calculation.

Example: 24.1 + 16.32 = 40.4, not 40.42

Multiplying and Dividing - The answer must not contain more significant figures than the term with the least number of significant figures.

Example: 12.182 x 11.1 = 135 (three significant figures)

Exception: When one term has a beginning numeral that is close to a double digit number, such as 8 or 9, another significant number may be used.

Example: 9.2 x 2.11 = 19.4, not 19.

When calculations involve several steps, it is advisable to use one extra significant figure throughout the intermediate steps. However, the final result must always be rounded off to the appropriate number of significant figures.

5.2.4 ORDER OF ACCURACY

Table A-4 and Table A-5 in the Appendix give the standards of accuracy for horizontal and vertical control. GNSS control parties shall maintain First Order as a minimum. All other survey parties shall maintain Second Order - Class II.

5.2.5 DEFINITION OF ERROR

Error is the difference, after blunders have been eliminated, between a measured or calculated value of a quantity and the true or established value of the quantity.

A blunder (also called a mistake) is an unpredictable, human mistake and is not, by definition, an error. Examples of blunders are: transposition of two numbers, neglecting to level an instrument, misplacing a decimal point or misunderstanding a spoken number. Blunders are caused by carelessness, misunderstanding, confusion or poor judgment. All blunders must be eliminated prior to correcting and adjusting a survey for errors.

5.2.6 TYPES OF ERRORS

5.2.6.1 SYSTEMATIC

A systematic error is one which will always have the same magnitude and same algebraic sign under the same conditions.

Examples - Thermal contraction and expansion of a steel tape, refraction, or a particular chainman's tendency to always overpull a tape.

Effect - A systematic error, of a single kind, is cumulative. However, several kinds of systematic errors occurring in any one measurement could compensate each other.

Detecting and Minimizing - Since systematic errors can be difficult to detect, one must recognize the conditions (instrument imperfections, atmospheric pressure and temperature, personal habits, etc.) that cause such errors. Once the conditions are known, the effect of these errors can be minimized as follows:

- Use procedures that will automatically eliminate systematic errors, such as: balancing level foresights and backsights, turning angles direct and reverse, and using standardized tapes.
- When systematic errors cannot be eliminated by procedures, corrections are applied to the measurements. An example would be temperature correction applied to a taped measurement. All systematic errors must be eliminated prior to any adjustment of a survey for accidental errors.

5.2.6.2 ACCIDENTAL

An accidental error (also called a random error) is one which does not follow any fixed relation to the conditions or circumstances of the observation.

Example - An instrument man's inability to point a total station exactly. However, if his personal habits make him consistently point off to the same side of the sight line, this error becomes a systematic error.

Effect - Theoretically, an accidental error has an equal chance of being negative or positive. Thus, these errors tend to be compensating. However, since the magnitude is also a matter of chance, accidental error to a small degree remains in every measurement.

Compensating - Corrections cannot be computed for accidental errors, therefore, they must be compensated by adjustments.

Least Squares Adjustment - This method provides the most probable values. All systematic errors must first be eliminated because any adjustment method is applicable only to truly random error.

Adjustment Results - Any adjustment only provides what one believes to be the best solution for the total survey. Even after proper adjustment, each individual value (such as a point position) is in error by an amount depending on the precision of the survey. Possibly, an adjustment could increase the error for a specific point. Collectively, however, the errors have been reduced and the total survey is improved.

5.2.7 SOURCE OF ERRORS

5.2.7.1 PERSONAL

These errors are caused by the physical limitations of the observer and by his personal observing habits. They can be either systematic or accidental.

Personal Systematic Errors - These errors are caused by the observer’s tendency to react the same way under the same conditions, e.g., a chainman measuring slightly long each time because of a peculiarity of his stance. Everyone makes a personal systematic error to some degree on each individual observation. Fortunately, such errors are minimized by proper procedures.

Personal Accidental Errors - These errors are caused by the physical limitations of the observer. Absolutely correct observations are impossible because of these human limitations.

5.2.7.2 INSTRUMENTAL

These errors are caused by imperfections in the design, construction, and adjustment of instruments and other equipment.

Examples:

- Eccentricity of theodolite circles

- A chain which is too short or too long
- Misadjustment of level vials

Type - In an individual observation, instrumental errors are systematic because they will be of the same magnitude and sign under the same observing conditions. However, if several observations are made of the same value (such as observing an angle at different positions of the circle), the error of each observation could have the effect of an accidental error on the resulting value.

Eliminating or Minimizing - Most instrumental errors are eliminated by using proper procedures such as observing angles direct and reverse, balancing level foresights and backsights, and repeating measurements. Instrumental errors that are not eliminated by procedures must be minimized by maintaining a regular program of periodically checking, adjusting, or calibrating instruments and other equipment.

5.2.7.3 NATURAL

These errors result from natural physical conditions such as atmospheric pressure, temperature, humidity, gravity, wind, and atmospheric refraction.

Type - These external errors are systematic. But if undetected and thus not eliminated, or if incorrectly determined, they can have the same effect as accidental errors.

Correction - Natural errors are removed by determining corresponding corrections from known relationships between an error and the natural phenomena. Example: The atmospheric pressure and temperature correction applied to EDM measurements and temperature corrections applied to chain measurements.

Eliminating or Minimizing - Sometimes the effect of natural errors can be eliminated by using proper procedures. For example, the effect of curvature and refraction can be eliminated by balancing level foresights and backsights. Natural errors can be minimized by making observations only when natural conditions are most favorable. For example, chaining at night or in cloudy weather and turning vertical angles other than in early morning or late afternoon when refraction is changing most.

5.3 DESIGN CRITERIA AND STANDARD DRAWINGS PERTAINING TO SURVEYS

5.3.1 GENERAL

Design criteria for each type of road are found in the TDOT Standard Roadway and Structure Drawings under the heading “Roadway Design Standards”. When a design speed is given, it is considered a minimum. A lower design speed shall not be used without the consent of the Regional Survey Supervisor. The highest feasible design speed is desirable. However, the mixing of design speeds shall be avoided (produces unsafe conditions).

5.3.2 ALIGNMENT CRITERIA GIVEN

Knowing the minimum design speed, the tables in the TDOT Standard Roadway and Structure Drawings will yield the required radius, spiral length of runoff, grades, sight distance, etc.

5.3.3 DESIGN CRITERIA

The TPR will be given to the Field Office Supervisor before starting the survey and will provide the following information:

- Proposed typical section
- Design speed
- Current ADT and projected ADT
- General route location

Environmental Impact Statements (EIS) may contain items which shall be addressed during the survey.

The "TDOT Roadway Design Guidelines" have been developed as a reference for Road Design Engineers. Some of the sections directly affect the survey function and may be referenced in this survey manual.

5.4 REPORTS AND CORRESPONDENCE

5.4.1 WEEKLY REPORT

The report is prepared by the Field Office Supervisor and shall be received in the Regional Survey Supervisor's Office the first workday of each week. The percent complete and estimated completion date is shown for each active project.

5.4.2 MAN-DAY REPORT

The report is prepared by the Field Office Supervisor and submitted to the Regional Survey Supervisor with each completed survey. It is optional at the discretion of the Regional Survey Supervisor.

5.4.3 SURVEY TRANSMITTAL LETTER

The letter is prepared by the Field Office Supervisor transmitting the survey to the Regional Survey Supervisor. The Regional Survey Supervisor uses it in transmitting the survey to the appropriate agency or office.

5.4.4 SURVEY CHECK SHEET

The check sheet is prepared by the Field Office Supervisor or Consulting Engineer, submitted to the Regional Survey Supervisor with each completed survey, and kept as part of the regional survey project file. Each survey shall be checked for completion by using the survey check sheet item by item. It is not required for additional information and update surveys.

5.5 FIELD BOOKS

5.5.1 GENERAL

The primary method of recording data for field surveys is the electronic data collector. However, field books are frequently used to supplement recorded data or for narrative information, e.g., record of discussions with property owners or utility company representatives. The front cover of each book shall be labeled with project number, county, survey route, project location (from and to), and book number. The pages of each book shall be numbered. Notes must be legible and written with clarity.

5.5.2 BENCH MARK LEVELS

Bench Mark level notes are recorded in the field book and must be reduced and checked. Refer to Figure A-14 and Figure A-15 in the Appendix.

5.5.3 PROFILE NOTES

Usually profiles are developed from the Digital Terrain Model. However, conventional profile runs are sometimes required by the Regional Survey Supervisor. An example of profile notes may be found in Figure A-17 in the Appendix.

5.6 HORIZONTAL AND VERTICAL MEASUREMENTS

5.6.1 LINEAR MEASUREMENT

Electronic distance measuring equipment shall be used whenever possible to obtain linear measurements. Total stations shall be used to measure the distances between P.O.T.'s or between P.I.'s on the centerline of a survey.

Horizontal distances are to be used in the preparation of maps and plans, in deed descriptions, and in centerline stationing.

5.6.2 ANGULAR MEASUREMENT

A horizontal angle, such as a delta angle turned at a P.I., shall be turned in accordance with Table A-4 of the Appendix. A "position" is the act of making one direct and one reverse observation on each backsight and foresight point, and averaging the angles.

Vertical angles shall be read in both direct and reverse positions of the scope, and the angles averaged.

For extending straight lines, "double-centering" of the transit or theodolite shall be used.

5.6.3 VERTICAL MEASUREMENT

When an engineer's level and level rod are used, the turning points shall be "balanced", and the level run tied to a known bench mark.

When an EDM is used, vertical angles shall be read in both direct and reverse positions of the scope, and angles averaged.

5.7 COORDINATION OF CONSULTANT SURVEY PROJECTS

5.7.1 GENERAL

Consultant firms providing surveying services for the Department will be considered an extension of state forces and will be subject to controls and procedures specified within this manual. Exceptions to this policy will include some reporting procedures and specific exclusions stipulated in the contract or directed by the Regional Survey Supervisor or other appropriate Department representative. The Department has developed an estimate form using the computer software Microsoft® Excel. This current form will be used on all survey projects and on survey and design projects where applicable at the discretion of the Survey Coordinator.

5.7.2 CONTACTS

5.7.2.1 CONTRACTUAL MATTERS

The Consultant shall contact the appropriate Civil Engineering Manager 2, Survey and Design on all matters pertaining to contract interpretation, billing procedures, payments, extensions to contracts, future projects, etc.

5.7.2.2 WORK RELATED MATTERS

The Regional Survey Office shall be consulted on matters pertaining to scope of work, procedures, and requests for supplies and assistance.

5.7.3 ESTIMATES

5.7.3.1 CONTACTS

The Consultant shall contact the Regional Survey Office to discuss scope of work, procedures, difficulty factors, etc. before an estimate for cost of services is prepared. The Regional Survey Office will provide TPRs, location sketches, etc. as required. It is recommended that a meeting at the job-site or in the Regional Survey Office serve as this contact. In the case of extremely small or simple projects, phone contact may suffice. This contact will allow for negotiations on all activity difficulty factors as well as items entered on the project summary sheet.

5.7.3.2 PREPARATION

The proposal for services shall use the current Microsoft® Excel form for Survey and Design estimates. The most current version of this form may be found at the following internet address:

http://www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_design/design/survey.htm

Proposals not submitted in this manner cannot be properly evaluated and may be deemed unacceptable. The form is designed to be used for most types of surveys; therefore, all items will probably not apply to a particular survey.

5.7.3.3 DEPARTMENT

A separate estimate of man-days required will be made by the Regional Survey Supervisor or the Survey Coordinator using the most recent version of the TDOT survey and design estimate form created in Microsoft® Excel. This estimate will be identical to the consultant's, since the project data and difficulty have been negotiated.

5.7.3.4 SUBMITTAL

Consultant - The "Manday Proposal" and any other supporting documents included in the proposal will be submitted to the Survey Coordinator.

Department - An "Estimate for Field Surveys" and a "Project Summary Form" are completed by the Regional Survey Supervisor and submitted to the Survey Coordinator.

5.7.3.5 PROCEDURES

The Consultant shall notify the Regional Survey Office when work has begun and report progress at the end of each second week thereafter. This notification may be in the form of a letter, e-mail, or by phone at the discretion of the Regional Survey Supervisor.

The completed survey will not be reviewed if the project is to be designed by the same firm performing the survey. The following procedures apply for projects for which Department personnel will develop R.O.W. and Construction Plans:

- Completed surveys will be submitted to the Regional Survey Office.
- The Regional Survey Office will be responsible for review of completed projects to assure that all required information is present and in acceptable format. In the event

that additional information is required or other problems exist, necessary arrangements with the Consultant will be made by the Regional Survey Office.

- Upon successful completion of the survey, (all necessary information submitted and approved), the appropriate Civil Engineering Manager 2, Survey and Design shall be notified. This notification (in writing) shall indicate that the project is complete and additional comments made as to the quality of the product, cooperation and competency of the Consultant, and any other information pertinent to the project. The Survey Coordinator shall receive a copy of the letter.
- Submitting of the survey, after checking, will be according to usual procedures (Refer to Section 1.7).

5.8 COORDINATION OF CONSULTANT SURVEY AND DESIGN PROJECTS

5.8.1 GENERAL

The development of surveys by agencies outside the Department for their use in the design of bridge or roadway projects will be consistent with the directions of this manual. No special information, reduction in necessary information, or change of format shall be required. The Consultant shall coordinate all phases of the survey with the Regional Survey Office including matters of scope, control, etc. Refer to Section 1.7 for transmittal requirements.

5.8.2 BRIDGE SURVEY / SETTING GRADES

Firms responsible for survey and design of bridge replacement projects shall submit a copy of survey data including: present layout sheet, plotted stream profiles, suggested structure grade, etc., and request for hydraulic analysis directly to:

Engineering Director
Structures Division
1200 James K. Polk Building
Nashville, Tennessee 37243-0339

A copy of the request shall be forwarded to the Regional Survey Office. Personnel of the Structures Division will provide a direct response in regards to setting the grades and sizing the structure.

Appendix

Tract:
Name:
Names:
Address: Box No.:
City: State: Zip Code:
Tax Map No.: Parcel:
Deed Book: Page:
Remarks:
State Project No.:
Description:

Person Contacted: Owner ☐ Renter ☐
By:
Date:

The following exists on the property:

Wells: UG Utilities:
Septic Tanks: Graves:
Field Lines: Property Corners:
UG Fuel Tanks:

Make sketch of location of all above.

High Water Marks: Date:
Well Dug By: For: Date:
Building Types:

Comments:

Sketch:

Continue on back if necessary

Figure A-1
Property Owner Contact Form

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
REGION 3 SURVEY & DESIGN OFFICE
6601 Centennial Boulevard, 2nd Floor
Nashville, TN 37243-0360
February 11, 2009

John Doe
1234 Doe Road
Example, TN 12345

Re: Project Identification Number: xxxxxx.00
SR 123
OVER EXAMPLE CREEK L.M. 1.23
XXXXX County

Dear John Doe:

As you may have heard, TDOT is continuing its public involvement process for the above mentioned project, and we want to alert you about activities you may be seeing shortly in your neighborhood.

In order to insure that we have the most accurate, complete, and current information possible, TDOT survey crews will begin gathering data to supplement existing aerial photographs of the area. This will involve ground surveys, which will investigate property lines, underground utilities, detailed stream information, environmental surveys, and more.

These ground surveys will begin within the next one (1) to four (4) weeks, and will continue for twelve (12) to eighteen (18) months.

The survey crews may need to gain access to your property, located on this project, in order to gather the necessary information, and we will appreciate your cooperation in that effort. The surveyors will attempt to contact you personally prior to entering your property. If there are specific times during the work week we should avoid, please let us know. Surveys will not be required on all properties.

If you have specific questions, you may contact Ms. Melissa Portell (phone: (615) 350-4485, email: melissa.portell@state.tn.us), or Mr. Dave Marshall at (615) 350-4252, or Mr. Larry Binion at (615) 350-4254. TDOT thanks you in advance for your cooperation.

Very truly yours,
David Marshall
David Marshall

cc: Mr. J. Kelly Henshaw
Ms. B J Doughty
Mr. Dave Marshall
Mr. Larry Binion
File

Figure A-2
Property Owner Contact Letter – Survey

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
REGION 3 SURVEY & DESIGN OFFICE
6601 Centennial Boulevard, 2nd Floor
Nashville, TN 37243-0360
February 11, 2009

John Doe
1234 Doe Road
Example, TN 12345

Re: Project Identification Number: xxxxxx.00
SR 123
OVER EXAMPLE CREEK L.M. 1.23
XXXXX County

Dear John Doe:

As you may have heard, TDOT is continuing its public involvement process for the above mentioned project, and we want to alert you about activities you may be seeing shortly in your neighborhood.

In order to insure that we have the most accurate, complete, and current information possible, TDOT survey crews will begin staking the Geotechnical boring locations on the project. A representative from TDOT's Geotechnical Engineering Section of the Materials and Tests Division will be contacting you to discuss Geotechnical needs on your property.

These ground surveys will begin within the next one (1) to four (4) weeks, and will continue for twelve (12) to eighteen (18) months.

The survey crews may need to gain access to your property, located on this project, in order to gather the necessary information, and we will appreciate your cooperation in that effort. The surveyors will attempt to contact you personally prior to entering your property. If there are specific times during the work week we should avoid, please let us know. Surveys will not be required on all properties.

If you have specific questions, you may contact Ms. Melissa Portell (phone: (615) 350-4485, email: melissa.portell@state.tn.us), or Mr. Dave Marshall at (615) 350-4252, or Mr. Larry Binion at (615) 350-4254. TDOT thanks you in advance for your cooperation.

Very truly yours,
David Marshall
David Marshall

cc: Mr. J. Kelly Henshaw
Ms. B J Doughty
Mr. Dave Marshall
Mr. Larry Binion
File

Figure A-3
Property Owner Contact Letter – Geotechnical Staking

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
REGION 3 SURVEY & DESIGN OFFICE
6601 Centennial Boulevard, 2nd Floor
Nashville, TN 37243-0360
February 11, 2009

John Doe
1234 Doe Road
Example, TN 12345

Re: Project Identification Number: xxxxxx.00
SR 123
OVER EXAMPLE CREEK L.M. 1.23
XXXXX County

Dear John Doe:

As you may have heard, TDOT is continuing its public involvement process for the above mentioned project, and we want to alert you about activities you may be seeing shortly in your neighborhood.

In order to insure that we have the most accurate, complete, and current information possible, TDOT survey crews will begin staking the proposed right-of-way and easements on the project. A representative from TDOT's ROW Division will be contacting you in the near future regarding the proposed right-of-way and easements.

These ground surveys will begin within the next one (1) to four (4) weeks, and will continue for twelve (12) to eighteen (18) months.

The survey crews may need to gain access to your property, located on this project, in order to gather the necessary information, and we will appreciate your cooperation in that effort. The surveyors will attempt to contact you personally prior to entering your property. If there are specific times during the work week we should avoid, please let us know. Surveys will not be required on all properties.

If you have specific questions, you may contact Ms. Melissa Portell (phone: (615) 350-4485, email: melissa.portell@tn.gov), or Mr. Dave Marshall at (615) 350-4252, or Mr. Larry Binion at (615) 350-4254. TDOT thanks you in advance for your cooperation.

Very truly yours,
David Marshall
David Marshall

cc: Mr. J. Kelly Henshaw
Ms. B J Doughty
Mr. Dave Marshall
Mr. Larry Binion
File

Figure A-4
Property Owner Contact Letter – ROW Staking

Geodetic Survey Control Data

Project Name: EMORY

County: KNOX | Year: 1998 | Point Name: EM-1

Latitude(N): 36° 02' 58.471849" | Longitude(W): 84° 00' 04.022711"

	(m)	(Ft)
D.A. Northing	192273.601	630817.6396
D.A. Easting	780167.616	2559599.9201
Elevation	313.965	1030.07

Horz. Datum: NAD83(1995) | D.A. Factor: 1.00009538

Vert. Datum: 1988 | Scale Factor: 0.99995545

Vertical Order: GPS | Geoid Model:

Ellipsoid Ht: 0

Party Chief: H.Garland | Described By: B.Solomon

Backsights

EM-2	N85-01-08.6E	248.224	meter
			meter

Type of Monument: DISK ATOP 5/8" REBAR STAMPED "EM-1", "1998", AND DRIVEN FLUSH WITH GROUND.

Route Description: Beginning at Emory Road I-75 Interchange, LOCATED ON I-75 NORTH OF THE BRIDGE OVER EMORY ROAD.

References: 72.54 m NORTH OF THE NORTHEAST CORNER OF BRIDGE 1.83 m EAST OF THE EDGE OF PAVEMENT ON NORTHBOUND LANE 0.55 m WEST OF WITNESS POST.

Tennessee Dept. of Transportation - Geodetic Survey Offices

7366 Region Lane, Knoxville, TN 37914

4004 Cromwell Road, Chattanooga, TN 37422

6601 Centennial Blvd, Nashville, TN 37243

300 Benchmark Place, Jackson, TN 38302

Note: These points have been set for the express use of the Tennessee Department of Transportation and its agents. No warranty, either express or implied, is granted to any individual and/or entity that makes use of this data for any other purpose.

Figure A-5
Example of Control Point Description Sheet

CONTROL POINTS					
POINT	NORTH	EAST	ELEV.	STATION	OFFSET
S1	460,512.0120	1,417,231.8940	520.7730	100+76.50	253.5824
S2	461,350.7600	1,417,172.0970	538.4500	108+74.06	-12.8205
S3	462,446.8280	1,417,446.0830	557.0590	120+03.83	-19.8765
S4	462,785.4470	1,417,328.7590	557.8100	123+02.66	-217.6868
S5	462,218.7960	1,417,385.1590	558.8310	117+67.82	-22.2078
S56	462,724.3300	1,417,773.8720	555.1660		
S101	462,751.2340	1,417,834.9240	552.9990		
S168	462,768.3990	1,417,518.0770	558.9040	123+33.21	-30.0730
S598	462,098.0210	1,417,360.0870	553.1960	116+44.60	-16.4726
S702	461,969.7530	1,417,435.2430	542.8950	115+39.04	88.2074
S703	461,965.0580	1,417,341.7330	544.0990	115+11.25	-1.2008
S755	461,813.7480	1,417,314.5920	535.6530	113+57.94	10.1202
S756	462,509.1290	1,417,461.4790	556.6760	120+68.01	-20.4495
S770	462,613.5110	1,418,737.5120	497.9230		
S771	462,823.9260	1,417,066.7250	554.6490	122+74.80	-481.0615
S776	461,372.5600	1,416,845.3620	536.6770	108+13.96	-334.7197
S779	461,156.6620	1,417,186.8740	530.0850	106+89.73	49.7386
S780	461,310.9110	1,417,479.7350	511.2280	109+11.93	295.0675
S802	461,555.6070	1,417,260.3260	530.9610	110+94.41	21.7219
S808	461,635.7310	1,417,281.4760	531.0160	111+77.28	22.2922
S978	460,968.0820	1,417,155.1260	524.0090	104+99.18	65.8612
S988	460,671.4170	1,417,149.4370	521.9000	102+10.41	134.0909
S996	460,638.7590	1,416,905.0140	525.9170	101+18.02	-94.5433
S1119	461,156.6490	1,417,186.8490	530.0850	106+89.71	49.7176
S1120	461,310.8250	1,417,479.7280	511.2000	109+11.85	295.0821
S1195	461,595.0120	1,417,330.5160	527.8030	111+50.03	79.9144

Table A-1
Control Points (Tabular Format)

NAVIGABLE WATERS OF THE UNITED STATES

Pursuant to the Rivers and Harbor Act of 1899, the U.S. Corps of Engineers has declared certain waters to be Navigable Waters of the United States.

The Nashville District

Regulates waters in the Cumberland River and Tennessee River watersheds. For further information, call the Corps Permit Section at 615-251-5181.

The Memphis District

Regulates waters in the Mississippi River watershed. For further information call the Corps Regulatory Control Branch at 901-521-3468.

The Nashville District, Corps of Engineers, has declared the following waterways to be "Navigable Waters of the United States".

CUMBERLAND RIVER AND TRIBUTARIES

I. *Cumberland River (CR)--Mouth* to Mile 694.2 (head of river, confluence of Poor Fork and Clover Fork, at Harlan, Kentucky).

  A. *Little River* (CRM 59.0)--Mouth to Mile 25.0.

  B. *Red River* (CRM 125.3)--Mouth to Mile 50.8 (Tennessee-Kentucky State Line).

  C. *Harpeth River* (CRM 152.9)--Mouth to Mile 88.9 (Franklin, Tennessee at Highway 96).

  D. *Stones River* (CRM 205.6)--Mouth to Mile 38.7 (Confluence of East and West Fork, Stones River).

    1. *East Fork, Stones River--Mouth* to Mile 10.0 (Waterhill Dam).

    2. *West Fork, Stones River--Mouth* to Mile 14.5 (US Highways 41 and 70-S bridge near Murfreesboro, Tennessee).

  E. *Caney Fork River* (CRM 308.9)--Mouth to Mile 111.1.

  F. *Obey River* (CTM 380.9)--Mouth to Mile 58.2 (Confluence of East Fork and West Fork Obey River).

    1. *East Fork Obey River* (Obey River Mile 58.2)--Mouth to Mile 47.2.

    2. *West Fork Obey River* (Obey River Mile 58.2)--Mouth to Mile 4.9.

    3. *Wolf River* (Obey River Mile 31.1)--Mouth to Mile 24.0.

  G. *Big South Fork Cumberland River* (CRM 516.0)--Mouth to Mile 77.0 (Confluence of Clear Fork River and New River).

    1. *New River--Mouth* to Mile 36.0 (Mouth of Smokey Creek).

    2. *Clear Fork River--Mouth* to Mile 19.9 (at Peter's Bridge).

  H. *Rockcastle River* (CRM 546.4)--Mouth to Mile 13.1

I. *Laurel River* (CRM 552.1)--Mouth to Mile 21.5.

J. *Poor Fork of Cumberland River* (CRM 694.2)--Mouth to Mile 30.6 (Letcher-Harlan County Line).

K. *Clover Fork of Cumberland River* (CRM 694.2)--Mouth to Mile 10.8 (Mouth of Yocum Creek).

1. *Martins Fork of Cumberland River* (Clover Fork of Cumberland River Mile 1.6)--Mouth to Mile 19.5.

TENNESSEE RIVER AND TRIBUTARIES

II. *Tennessee River* (TR)--Mouth to Mile 652.1 (head, confluence of French Broad and Holston Rivers).

A. *Clarks River* (TRM 4.3)--Mouth to Mile 13.0.

B. *Blood River* (TRM 50.7)--Mouth to Mile 9.7.

C. *Big Sandy River* (TRM 67.0)--Mouth to Mile 15.1.

D. *Duck River* (TRM 110.8)--Mouth to Mile 210.3 (Warner Bridge, Fishing Ford Road).

1. *Buffalo River* (Duck River Mile 15.4)--Mouth to Mile 65.0 (Flatwoods, Tennessee).

E. *Beech River* (TRM 135.7)--Mouth to Mile 17.0.

F. *Yellow Creek* (TRM 215.1)--Mouth to Mile 32.1 (head, Tennessee Valley Divide).

G. *Bear Creek* (TRM 224.7)--Mouth to Mile 27.3 (Bishop Bridge at Maude, Alabama).

H. *Cypress Creek* (TRM 255.0)--Mouth to Mile 10.2 (Mouth of Little Cypress Creek).

I. *Shoal Creek (TRM* 264.3)--Mouth to Mile 13.5.

J. *Elk River (TRM* 284.3)--Mouth to Mile 153.6 (Boiling Fork Creek).

1. *Richland Creek* (Elk River Mile 42.6)--Mouth to Mile 24.3 (Mill Street Bridge).

K. *Flint River* (TRM 339.1)--Mouth to Mile 35.9 (L & N Railroad Bridge at Bell Factory, Alabama).

L. *Paint Rock River* (TRM 343.2)--Mouth to Mile 60.0 (Confluence of Estill Fork and Hurricane Creek).

M. *Town Creek* (TRM 360.8)--Mouth to Mile 14.0 (High Falls).

N. *Crow Creek* (TRM 401.1)--Mouth to Mile 20.4 (Confluence of Little Crow Creek).

O. *Sequatchie River* (TRM 422.7)--Mouth to Mile 80.0 (Pikeville, Tennessee).

P. *Hiwassee River* (TRM 500.3)--Mouth to Mile 42.5.

1. *Ocoee River* (Hiwassee River Mile 34.4)--Mouth to Mile 11.9 (Ocoee Dam No.1).

Q. *Clinch River* (TRM 567.7)--Mouth to Mile 317.3 (Bridge 0.35 mile above Town Hill Creek).

1. *Emory River* (Clinch River Mile 4.4)–Mouth to Mile 28.4 (Confluence of Obed River).
   a. *Obed River* (Emory River Mile 28.4)–Mouth to Mile 5.0
2. *Powell River* (Clinch River Mile 88.8)–Mouth to Mile 156.7.
   a. *North Fork Powell River* (Powell River Mile 156.7) Mouth to Mile 7.0.

R. *Little Tennessee River* (TRM 601.3)–Mouth to Mile 114.7 (Franklin, North Carolina).

1. *Tellico River* (Little Tennessee River Mile 19.2)--Mouth to Mile 28.0 (Tellico Plains).
2. *Tuckasegee River* (Little Tennessee River Mile 76.2)–Mouth to Mile 33.6 (mouth of Savannah Creek, two miles southwest of Sylva, North Carolina).

S. *Little River* (TRM 635.6)–Mouth to Mile 41.0 (Blount and Sevier County line).

T. *Holston River* (TRM 652.1)–Mouth to Mile 142.2 (head, confluence of North and South Fork Holston River).

1. *North Fork Holston River* (Holston River Mile 142.2)–Mouth to Mile 92.5 (Juncture of Laurel Creek).
2. *South Fork Holston River* (Holston River Mile 142.2–Mouth to Mile 74.0.
   a. *Watauga River* (South Fork Holston River Mile 19.9)–Mouth to Mile 53.0.

U. *French Broad River* (TRM 652.1)–Mouth to Mile 196.5 (Wilson Bridge crossing Highway 276).

1. *Little Pigeon River* (French Broad River Mile 27.4)--Mouth to Mile 9.6 (mouth of East Fork (Prong) Little Pigeon River).
2. *Nolichucky River* (French Broad River Mile 69.1)–Mouth to Mile 110.8 (Juncture of Cane Creek).
3. *Pigeon River* (French Broad River Mile 73.8)–Mouth to Mile 42.7.

In addition, embayments and tributary streams of all impounded reservoirs are considered navigable water of the United States to the extent of slack water, and jurisdiction will be exercised accordingly.

The Memphis District, Corps of Engineers, has declared the following waterways to be "Navigable Waters of the United States".

I. *Hatchie River--Mouth* to Bolivar.

II. *Forked Deer River,* North Fork--Mouth to Dyersburg.

III. *Forked Deer River--Mouth* to junction, North and South Forks.

IV. *Forked Deer River,* South Fork--Mouth to Jackson.

V. *Obion River--Mouth* to Obion, Tennessee.

VI. *Wolf River--Mouth* to Jackson Ave. Bridge in Memphis.

MAINSTREAM	FULL POOL CONTOUR ft (m)	MAXIMUM SHORELINE CONTOUR ft (m)
Kentucky	359 (109.4)	375 (114.3)
Guntersville	595 (181.4)	600 (182.9)
Nickajack	634 (193.2)	640 (195.1)
Chickamauga	682.5 (208.03)	690 (210.3)
Watts Bar	741 (225.9)	750 (228.6)
Fort Loudon	813 (247.8)	820 (249.9)

TRIBUTARY RESERVOIRS	FULL POOL CONTOUR ft (m)	MAXIMUM SHORELINE CONTOUR ft (m)
Boone	1385 (422.1)	1390 (423.7)
Cherokee	1073 (327.1)	1080 (329.2)
Douglas	1000 (304.8)	1007 (306.9)
Ft. Patrick Henry	1263 (385.0)	1268 (386.5)
Great Falls1	805.3 (245.46)	812 (247.5)
Melton Hill	795 (242.3)	800 (243.8)
Nolichucky	1241 (378.3)	1246 (379.8)
Normandy	875 (266.7)	885 (269.7)
Norris	1020 (310.9)	1044 (318.2)
Ocoee No. 1	837.65 (255.317)	842.6 (256.8)
Ocoee No. 3	1435 (437.4)	1440 (438.9)
South Holston	1729 (527.0)	1747 (532.5)
Tellico	813 (247.8)	820 (249.9)
Tims Ford	888 (270.7)	895 (272.8)
Watauga	1959 (597.1)	1980) (603.5)

[1] Outside Tennessee River drainage area. Section 26a does not apply. TVA land or landrights may be involved.

Table A-2
Tennessee Reservoirs

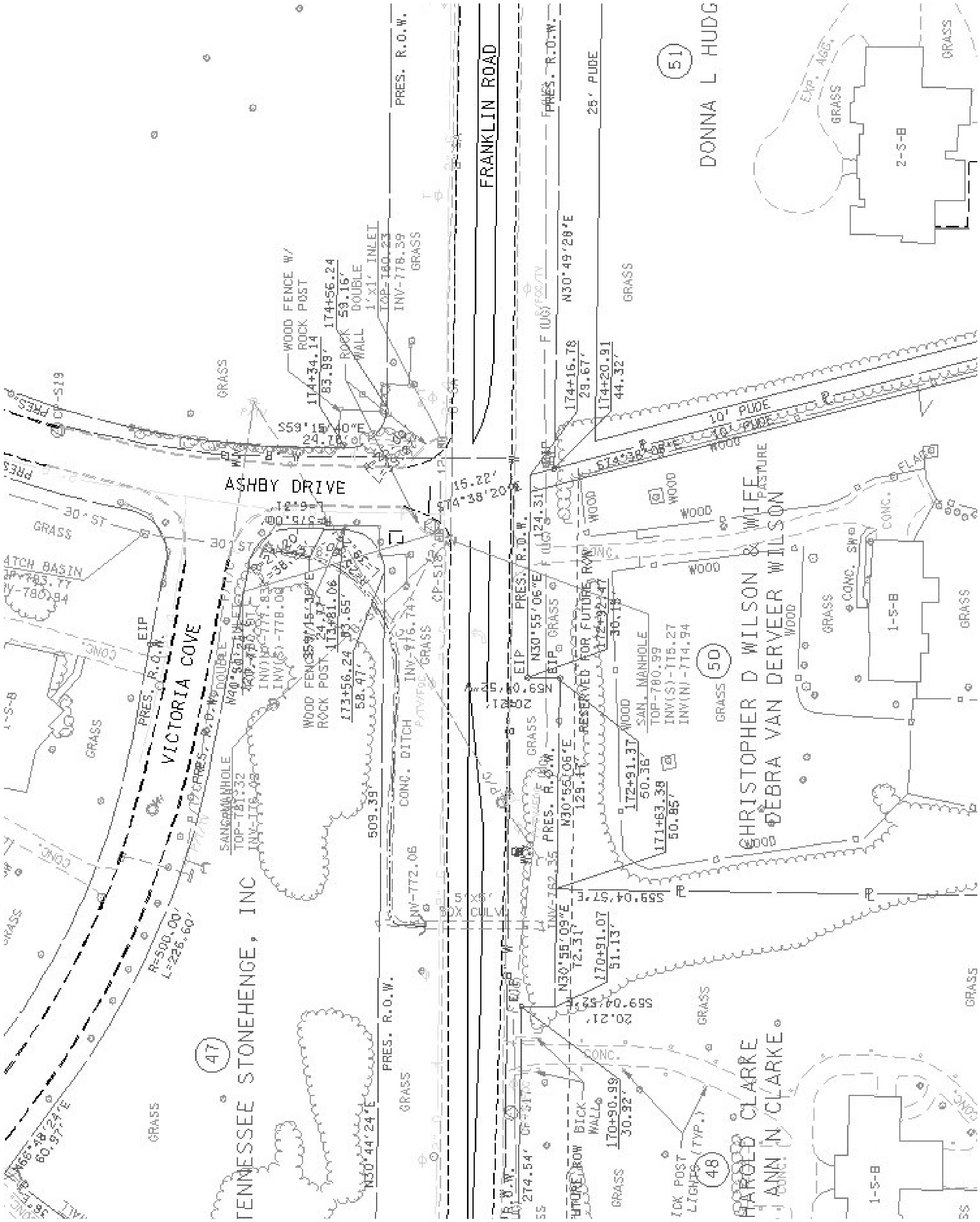


Figure A-6
Example of Present Layout Sheet

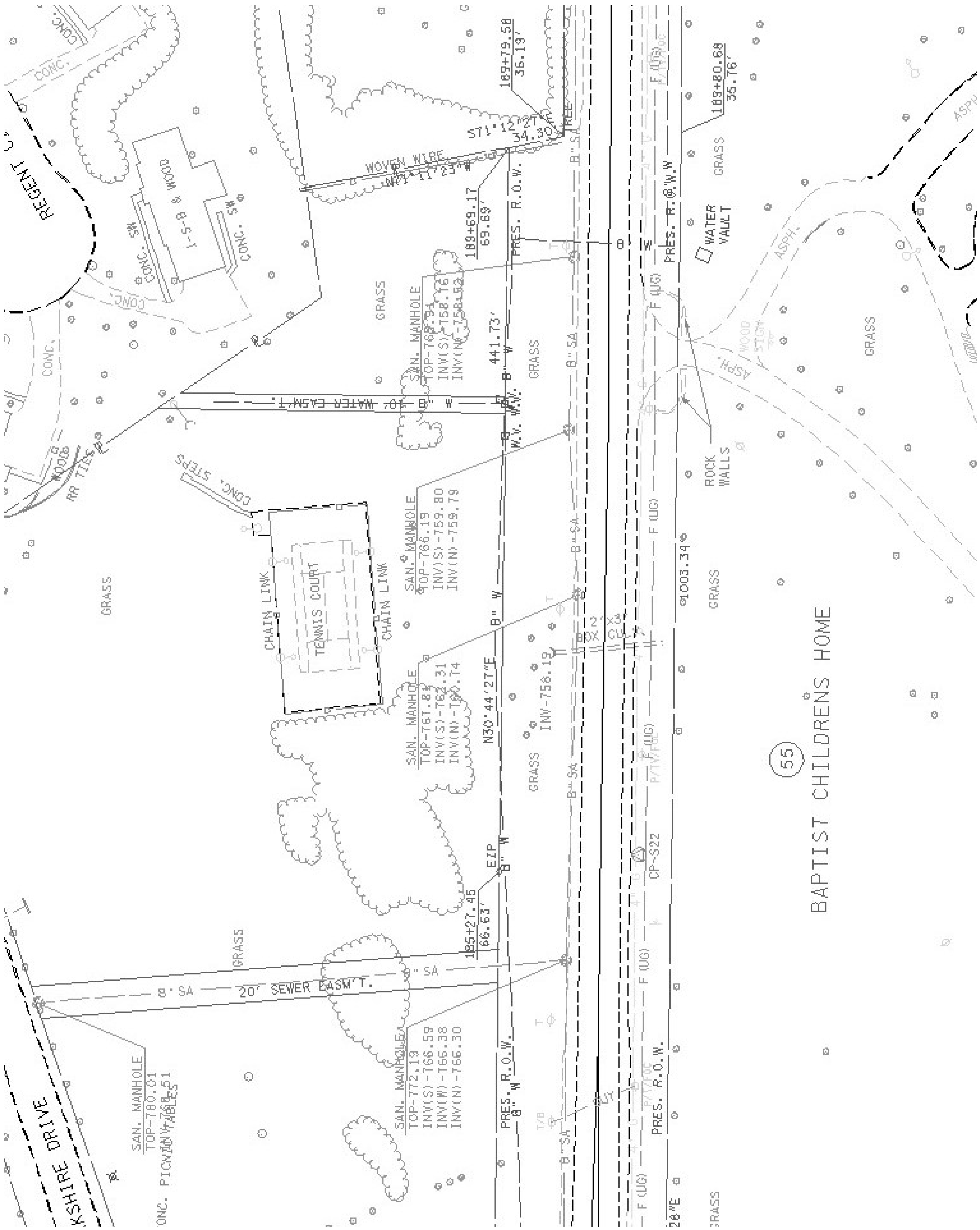


Figure A-7
Example of Present Layout Sheet

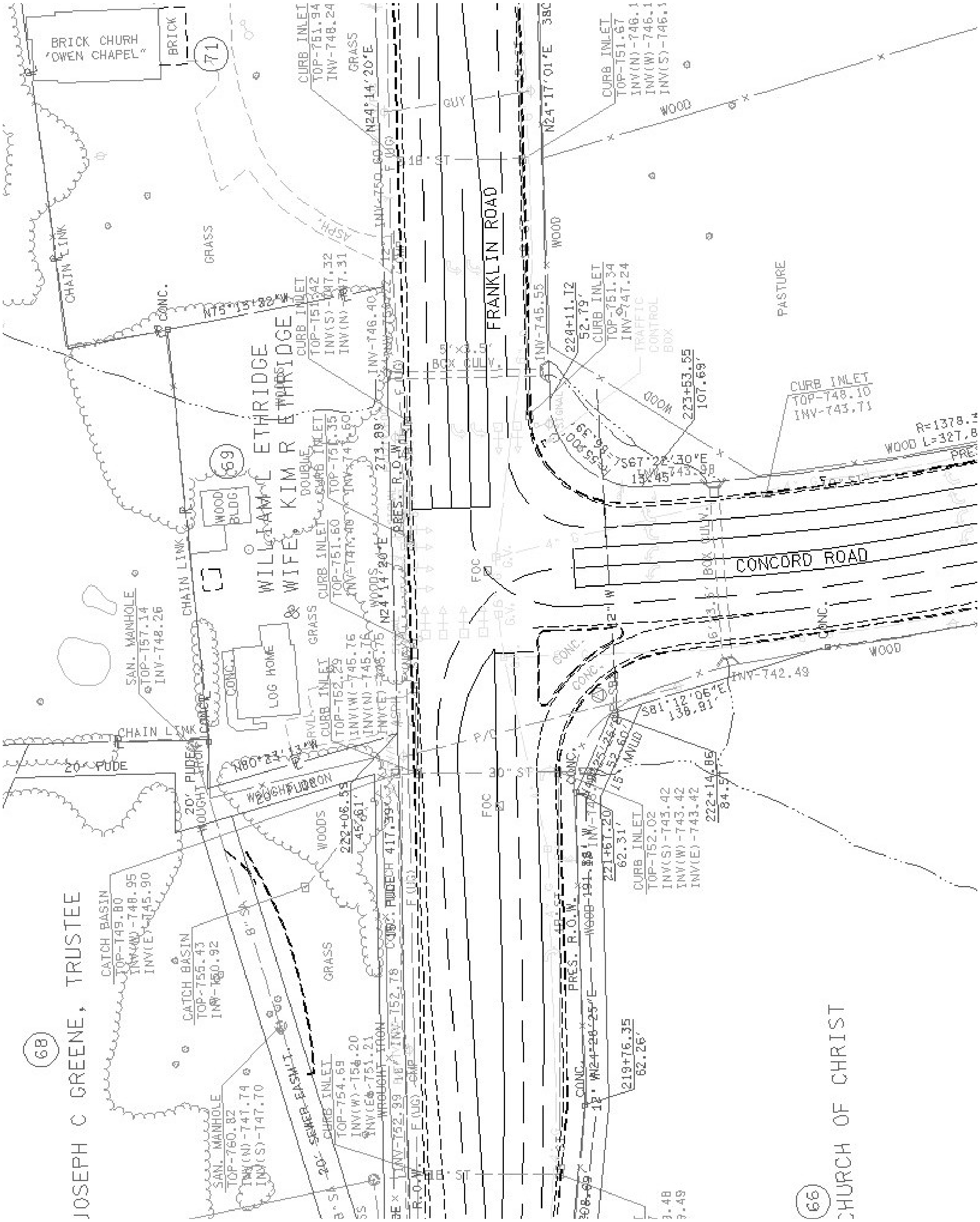


Figure A-8
Example of Present Layout Sheet

R.O.W. ACQUISITION TABLE

TRACT NO.	PROPERTY OWNERS	COUNTY RECORDS				TOTAL AREA ACRES			AREA TO BE ACQUIRED ACRES			AREA REMAINING ACRES		EASEMENT (SQUARE FEET)		
		TAX MAP NO.	PARCEL NO.	DEED DOCUMENT BK.	DEED DOCUMENT PAGE	LEFT	RIGHT	TOTAL	LEFT	RIGHT	TOTAL	LEFT	RIGHT	PERM. DRAINAGE	SLOPE	CONST.
1	BERT C. NICHOLSON	42	8	16	142											(1) 0.138 AC
2	GINGER BURCHETT	42	9	24	216											(2) 807 (3) 97
3	GLENN LADD	42	10	30	123	42.006		42.006	3.279		3.279	38.727				
4	IRENE S. MONK	42	11	77	289		52.098	52.098		2099 S.F.	2099 S.F.		52.052			
5	ROBERT L. BRYANT	42	12	83	352	36.699	58.966	95.665	10.146	9.244	19.39	26.553	49.721			

(1) FOR CONSTRUCTION OF DETOUR
(2) FOR CONSTRUCTION OF DRAINAGE DITCH
(3) FOR CONSTRUCTION OF RETAINING WALL

NOTE: EASEMENT AREAS SHOULD BE SHOWN IN ACRES AND NOTED AS SUCH WHEN GREATER THAN 0.1 ACRES AREAS ACQUIRED AND REMAINING SHOULD BE SHOWN IN SQUARE FEET AND NOTED AS SUCH WHEN LESS THAN 0.1 ACRES. IN URBAN PROJECTS THE PREDOMINANT UNITS FOR AREA ACQUIRED AND REMAINING SHOULD BE SHOWN IN SQUARE FEET.

Table A-3
Example of R.O.W. Acquisition Table

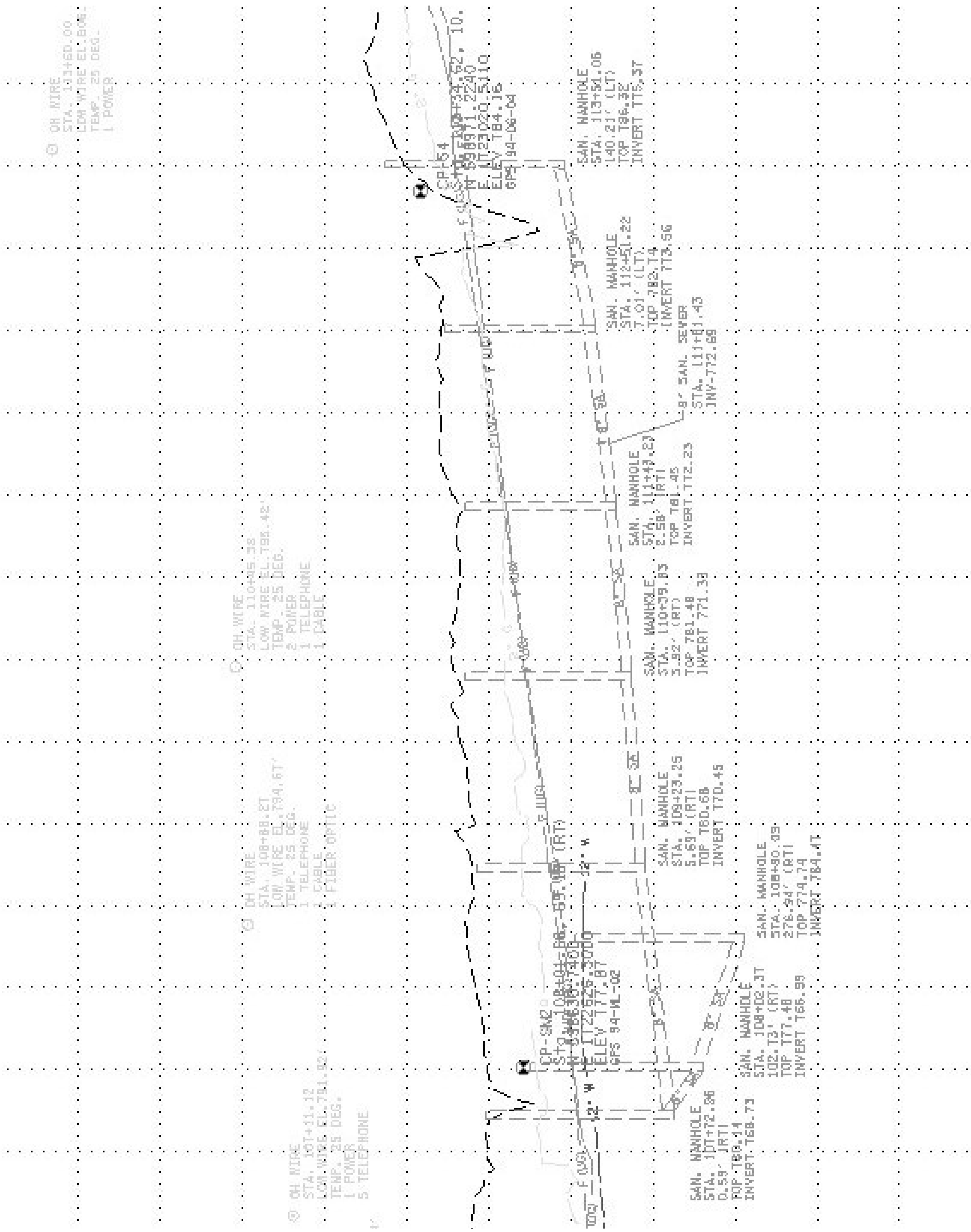


Figure A-9
Example of Profile

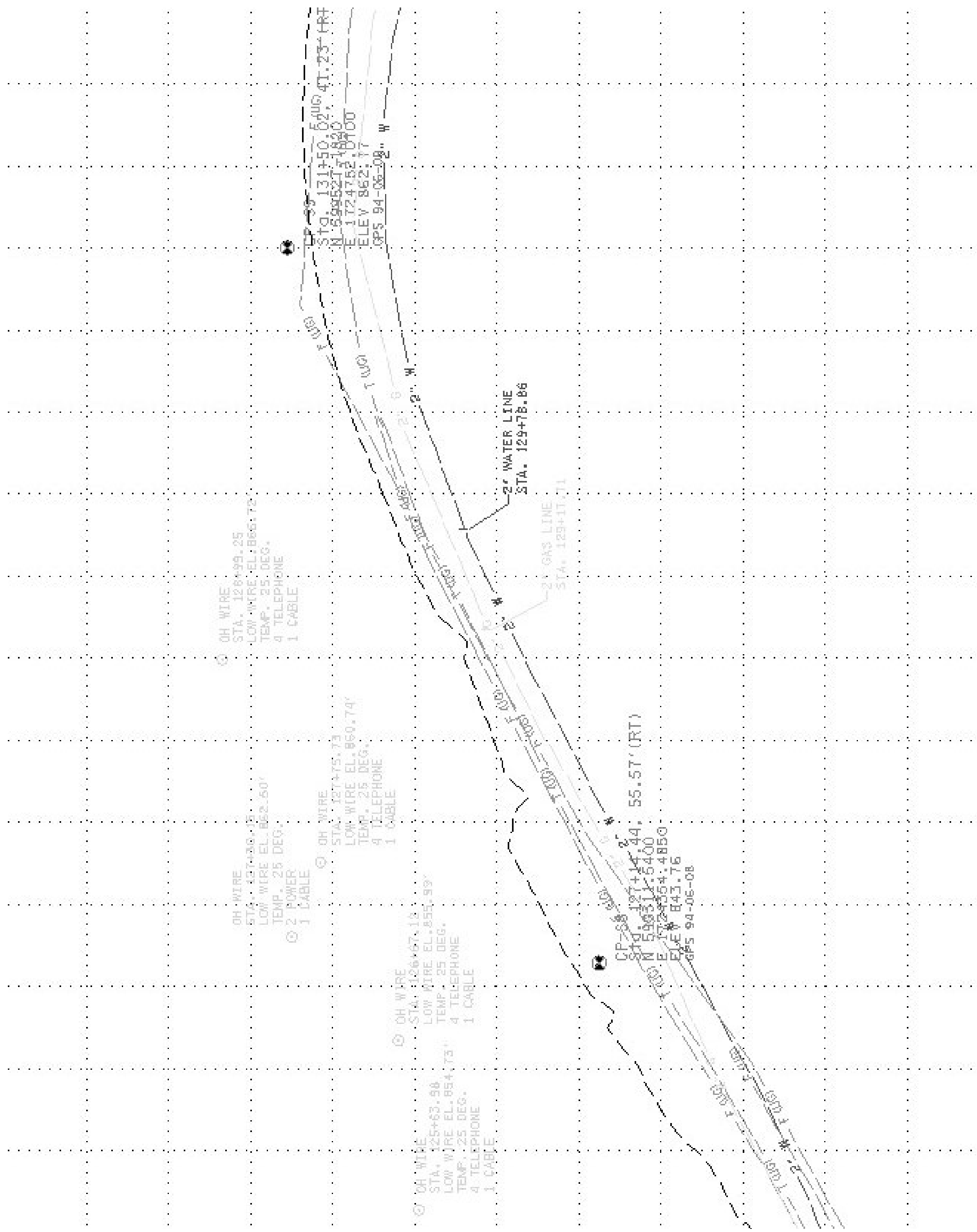


Figure A-10
Example of Profile

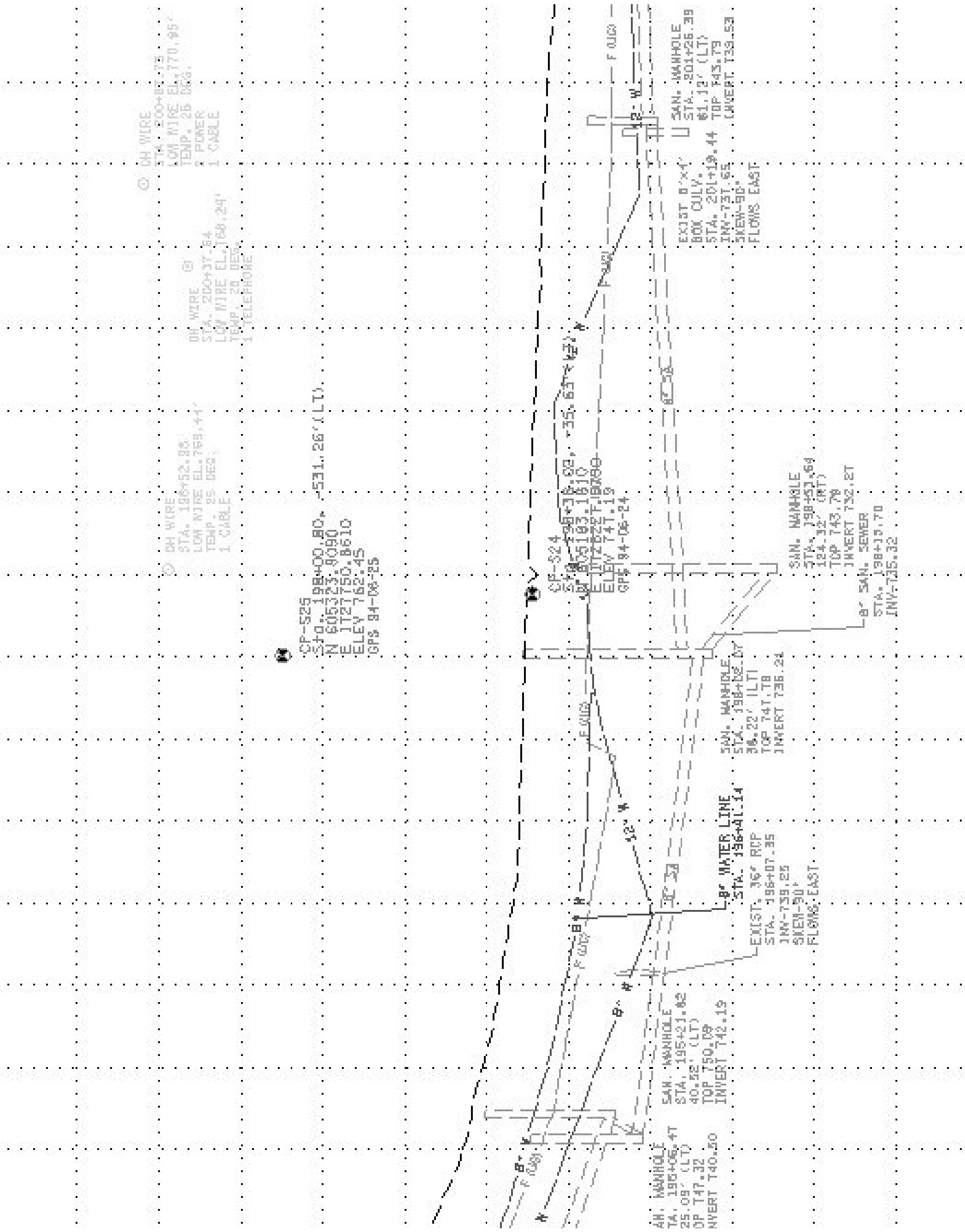


Figure A-11
Example of Profile

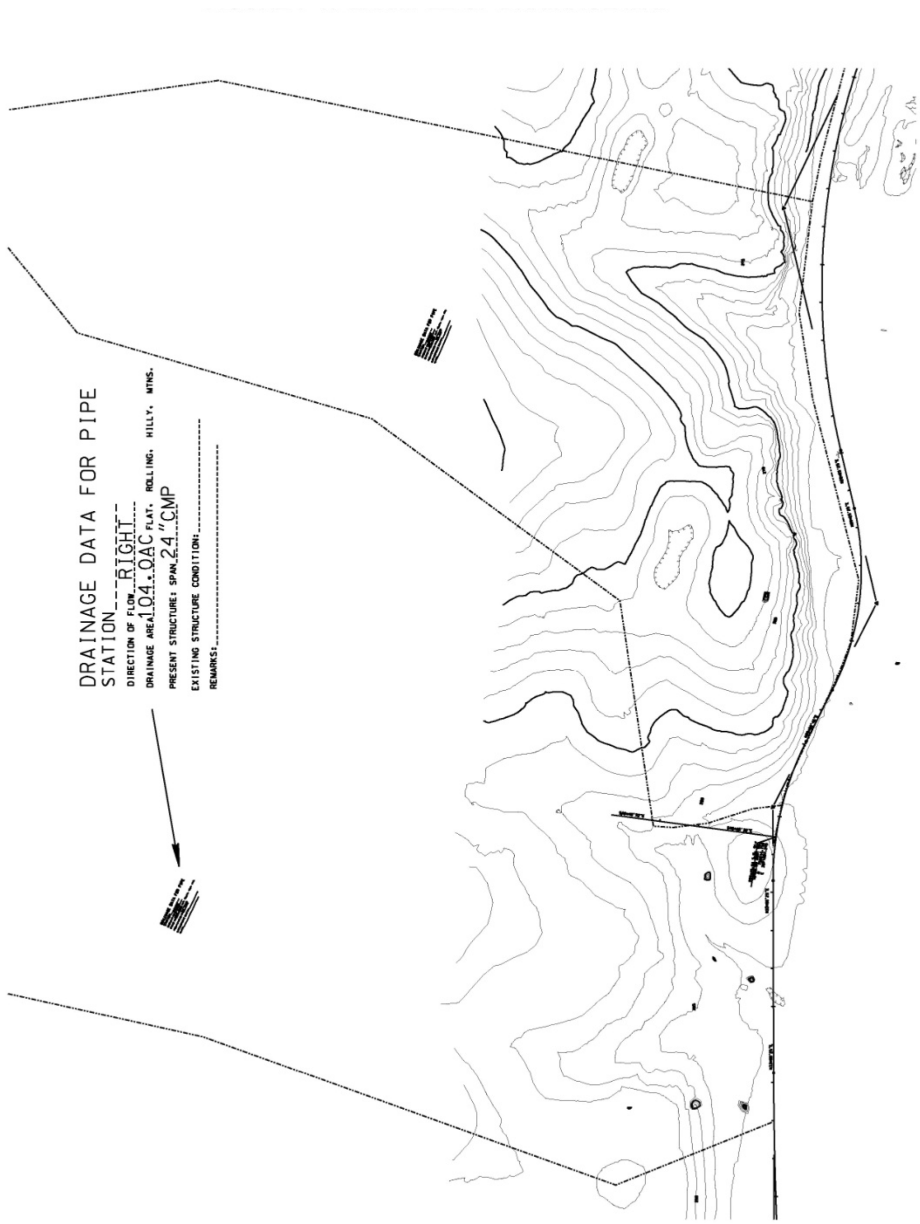


Figure A-12
Example of Drainage Map

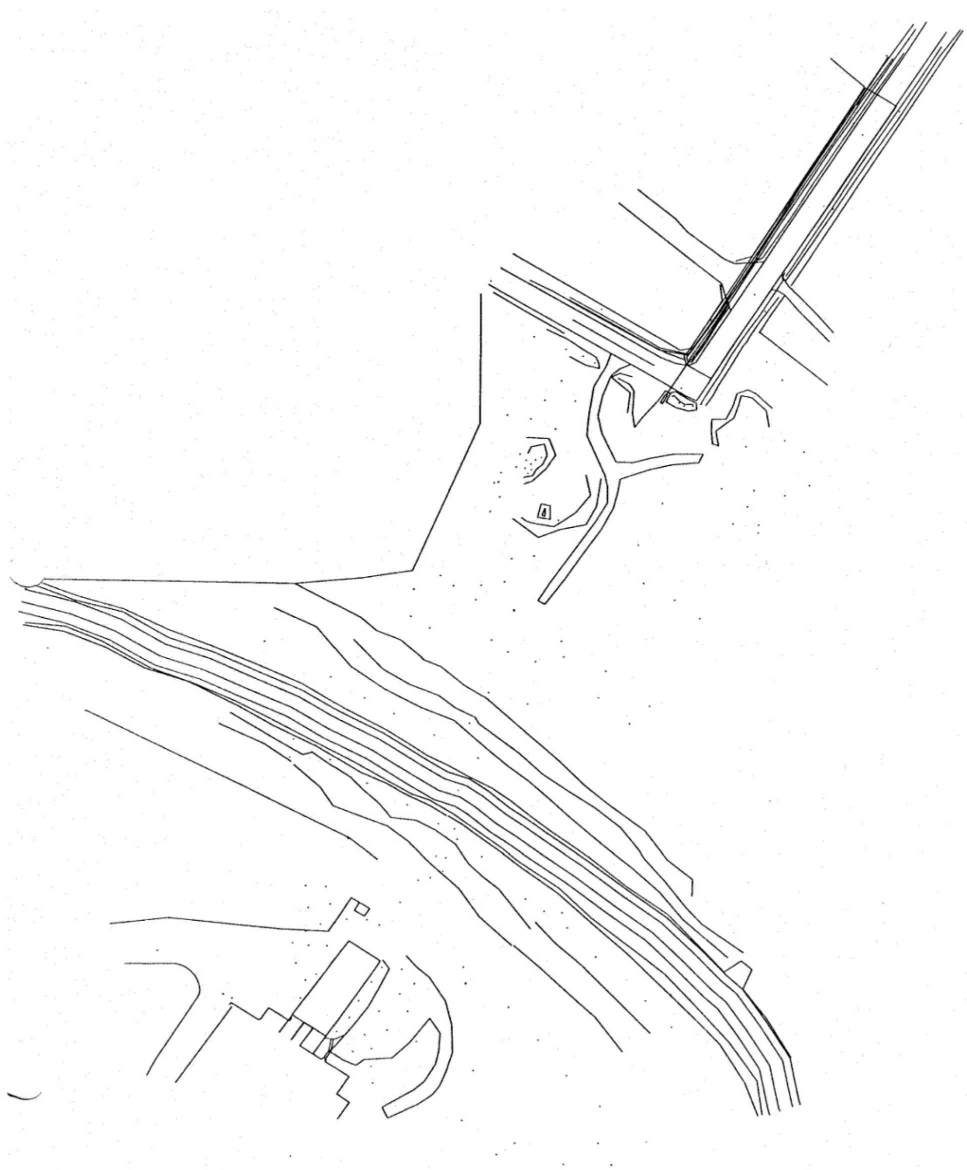


Figure A-13
Example of DTM (Aerial Surveys, MicroStation® Format)

SURVEY STANDARDS HORIZONTAL

	FIRST ORDER	SECOND ORDER		THIRD ORDER	
		Class I	Class II	Class I	Class II
POSITION CLOSURE	1:100,000 or 0.17 ft. $\sqrt{M}$	1:50,000 or 0.33 ft. $\sqrt{M}$	1:20,000 or 0.83 ft. $\sqrt{M}$	1:10,000 or 1.66 ft. $\sqrt{M}$	1:5,000 or 3.33 ft. $\sqrt{M}$
NUMBER OF COURSES BETWEEN AZIMUTH CHECKS	5-6	10-12	15-20	20-25	30-40
AZIMUTH CLOSURE AT AZIMUTH CHECKPOINT NOT TO EXCEED	1.0" per traverse point or 2" $\sqrt{N}$	1.5" per traverse point or 3" $\sqrt{N}$ Urban 2" per traverse point or 3" $\sqrt{N}$	2.0" per traverse point or 6" $\sqrt{N}$ Urban 4" per traverse point or 8" $\sqrt{N}$	3.0" per traverse point or 10" $\sqrt{N}$ Urban 6" per traverse point or 15" $\sqrt{N}$	8.0" per traverse point or 30" $\sqrt{N}$

N = The number of traverse points for carrying azimuth.
M= Distance in miles
In expressions for closing errors, use the formula that gives the smallest permissible closure.

Table A-4
Survey Standards Horizontal

SURVEY STANDARDS VERTICAL

	FIRST ORDER		SECOND ORDER		THIRD ORDER
	Class I	Class II	Class I	Class II	
Closure error not to exceed	0.017 ft.$\sqrt{M}$	0.021 ft.$\sqrt{M}$	0.025 ft.$\sqrt{M}$	0.035 ft.$\sqrt{M}$	0.050 ft. $\sqrt{M}$

M = Distance in miles

Table A-5
Survey Standards Vertical

STA.	FORWARD		BACK		ELEV.		
✓	+	-	+	-			
USC & GS BM K 212	4.94				618.41 ✓		
TP	3.86	10.22					
TP	2.16	9.76					
TP	4.51	11.31					
TP	5.53	6.83					
TP	4.37	5.42					
BM NO. 1		5.51	5.47		594.70 ✓		
			5.41	4.61			
			7.01	4.86			
			10.95	4.63			
			9.82	2.25			
			10.11	3.96			
				4.78			
USC & GS BM K 212	25.34 ✓	49.05 ✓	48.77 ✓	25.09 ✓			
		25.34	25.09				
		23.71 ✓ 23.68	23.68 ✓				
		0.03 DIFF.	✓				
		LINE APPROX. 1.1 MI. ✓					
		12.0√1.1 =	12.6 VS. 1		✓		
			CHECK ✓				

SETTING FIRST BENCH

11-5-09 2

FAIR & COLD
ASHMORE
SOLOMON
PARIS

MON & DISC. IN S.W. CORNER OF S.R. 22 & JONES ROAD ELEV.
OBTAINED FROM TN. DOT AERIAL SURVEY DIV. NASHVILLE. TN.

ALUMINUM DISK 75' RT. STA. 0+45

MON. & DISC. IN S. W. CORNER OF S.R. 22 & JONES ROAD

REDUCED BY R.A.J.
CHECKED BY S.M.R.

Figure A-14
Example of Field Notes

BENCH LEVELS

3

STA.	FORWARD		BACK		ELEV.			
	+	-	+	-				
BM NO. 1	1.48				594.71 ✓	ADJUSTED		ALUMINUM DISK 75' RT. STA. 0+45
TP	3.22	11.36						
TP	2.91	10.55						
BM NO. 2	1.31	8.16						TAG BOLT FIRE HYDRANT 40' LT. 10+15
TP	2.65	6.43						
TP	2.01	5.85						
BM NO. 3	5.15	7.43						X ON CURB 22' LT. 20+07
TP	5.71	5.50						
TP	6.82	5.48						
BM NO. 4		7.12	10.05					NW CORNER OF BLDG. FOUNDATION 65' RT. 25+50
TP			11.66	7.41				
TP			8.21	6.20				
TP			10.95	7.08				
TP			9.92	2.31				
TP			11.48	3.57				
TP			7.82	4.81				
BM NO. 1				2.12				ALUMINUM DISK 75' RT. STA. 0+45
	31.26	67.88 ✓	70.09 ✓	33.50 ✓				
		31.26	33.50					
		36.62 ✓	36.59 ✓					
		0.03 DIFF.	✓					
		LINE APPROX. 0.5 MI. ✓						
		0.05√0.5 = 0.035 VS. 0.03 ✓						
			CHECK ✓					
								REDUCED BY R.A.J.
								CHECKED BY S.M.R.

SETTING SUBSEQUENT BENCHES

Figure A-15
Example of Field Notes

ADJUSTED ELEVATIONS

BM		ELEV.
NO. 1		594.71
NO. 2		572.21
NO. 3		558.47
NO. 4		558.06

BENCH MARK LIST

4

ALUMINUM DISK 75' RT. STA. 0+45
TAG BOLT FIRE HYDRANT 40' LT. 10+15
X ON CURB 22' LT. 20+07
NW CORNER OF BLDG. FOUNDATION 65' RT. 25+50

REDUCED BY R.A.J.

Figure A-16
Example of Field Notes

ROADWAY PROFILE

STA.	+	HI	-	PRO.	ELEV.		
BM NO. 6	5.42	536.01 ✓			530.59 ✓		
30				6.1	529.9 ✓		
+22				8.2	527.8 ✓		
+50				5.8	530.2 ✓		
+81				4.7	531.3 ✓		
31				7.5	528.5 ✓		
+17				7.7	528.3 ✓		
+50				9.2	526.8 ✓		

PROFILE

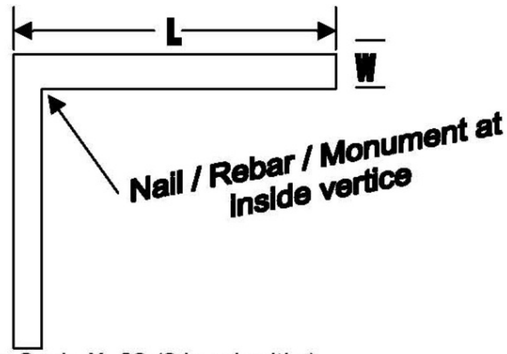
11-5-09 7

CLOUDY
SMITH
JONES
KELLY
WHITE

ALUMINUM DISK 75' RT. 29+50

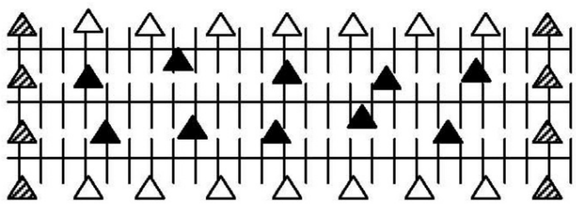
REDUCED BY M.G.D
CHECKED BY S.M.R.

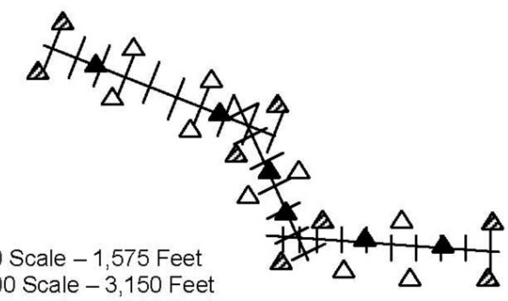
Figure A-17
Example of Field Notes



(L) Length of Leg = Photo Scale X .02 (2 hundredths)

(W) Thickness of Leg = 12 inches for below 1"=800' Photo Scale
18 inches for above 1"=800' Photo Scale





Distance between flight lines for block photography

50 Scale – 1,575 Feet
100 Scale – 3,150 Feet
200 Scale – 6,300 Feet

▲ Can be moved any direction a distance equal to the photo scale. Preference to be equal distance between flight lines on block photography. Move back and forth along flight line for strip photography.

△ Can be moved back and forth along the flight line a distance equal to one half of the photo scale. Can be moved away from the flight line a distance of one eight of the photo scale.

Can be moved back and forth along the flight line a distance equal to one half of the photo scale. Can be moved away from the flight line a distance of one eight of the photo scale.

Target spacing is 2,700 feet in the direction of the flight line and 750 feet from the centerline of flight for 1"=50' scale mapping.

Target spacing is 5,400 feet in the direction of the flight line and 1,500 feet from the centerline of flight for 1"=100' scale mapping.

Target spacing is 10,800 feet in the direction of flight line and 3,000 feet from the centerline of flight for 1"=200' scale mapping.

Figure A-18
Example Aerial Survey Target, Block Photography, and Strip Photography

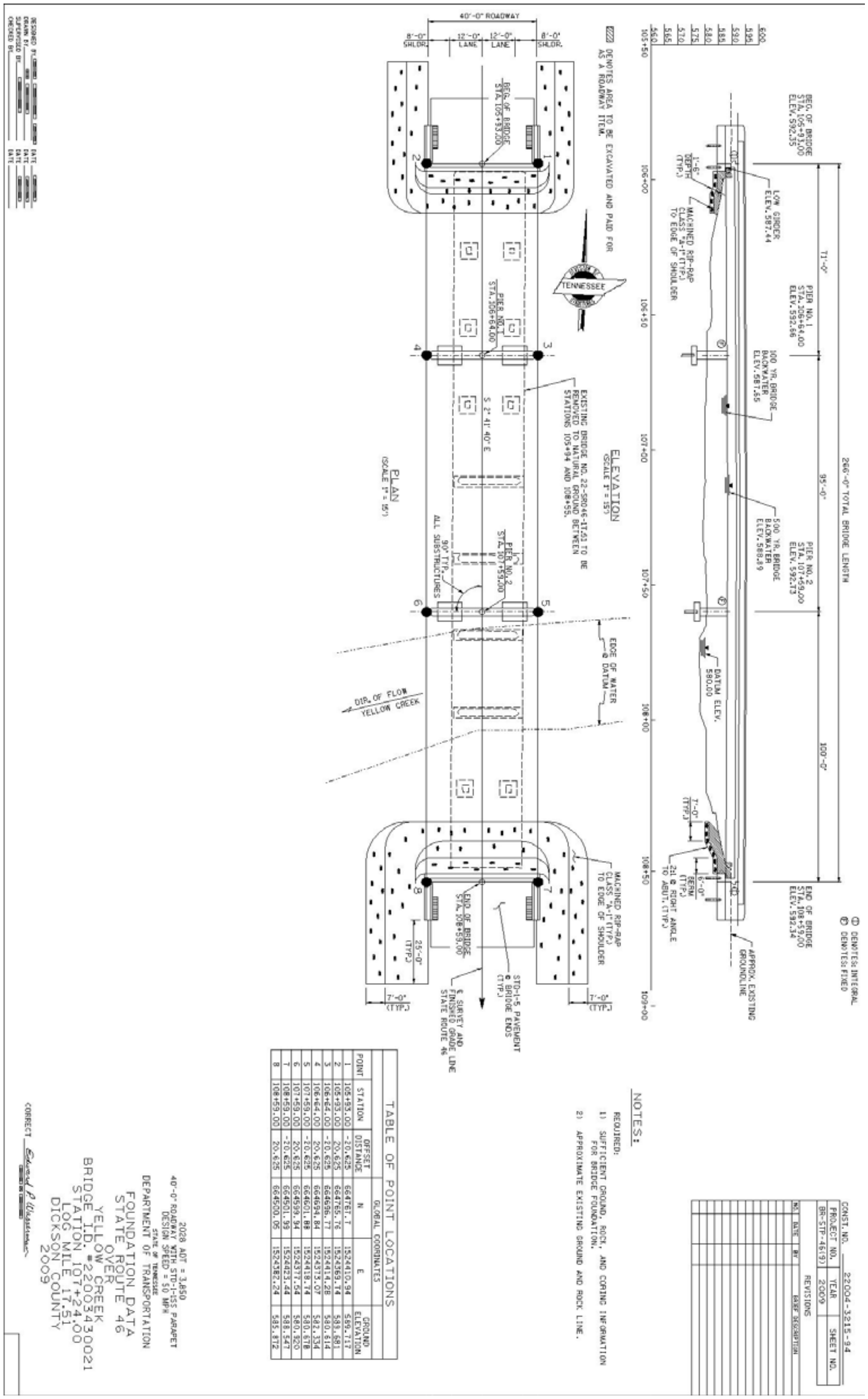


Figure A-19
Example of Preliminary Bridge Drawing

DT – 0108
F – 108
Z – 84

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

CLAIM FOR INCIDENTAL AND EMERGENCY EXPENSES

(LIMITED TO UNDER $10.00)

This form is to be completed when an employee of the Department of Transportation personally incurs the following incidental/emergency expenses while performing official State business: gasoline, oil, minor vehicular repair, ice, etc.

This form will be prepared by the employee incurring the incidental/emergency expense. The original and two copies of this form must be submitted along with the supporting paid receipts attached. (The supporting paid receipts must show the name and address of the vendor and must be marked Paid. The employee will sign and date the forms. The employee's authorized supervisor will approve these expenses by signing and dating these forms.

The forms will be submitted to: DOT FINANCE - ACCOUNTING
SUITE 800
JAMES K. POLK BUILDING
NASHVILLE, TENNESSEE 37219

QUANTITY	DESCRIPTION	AMOUNT	VENDOR	REASON FOR PURCHASE
	TOTAL	**$**		

I CERTIFY THAT THIS CLAIM IS TRUE AND CORRECT

CLAIMANT ADDRESS DATE

TITLE

APPROVED DIVISION HEAD DATE

TITLE

FOR DOT ACCOUNTS USE ONLY

NAME

DATE

CO.	SECTION	JOB OR DOT NUMBER	FUND F	FUND S	*	ACCOUNT NUMBER CONTROL	REG	FUNC.	* OBJECT	APPROP. CODE	AMOUNT	* CLAIMANT NUMBER

*TO BE CODED BY DOT ACCOUNTING ONLY.

DT-0302
Rev 02/04

Tennessee Department of Transportation

TR 000001

Transfer of Fixed Assets

__ / __ / __
(Document Date)

Send the white copy of this form to:
TDOT Finance
Attn: Fixed Asset Accountant
Suite 800, J.K. Polk Bldg
Nashville, TN 37243-0329

Distribution:
White - TDOT Finance Office
Canary - Releasing Unit Files
Pink - Receiving Unit Files

Please record the permanent transfer of the Fixed Asset(s) identified below to the unit number(s) shown. The Section Head or Unit Supervisor receiving the items(s) has acknowleged receipt below.

TDOT Tag Number	Serial Number	Cnty	Standard Description
F 0			
F 0			
F 0			
F 0			
F 0			
F 0			
F 0			
F 0			
F 0			
F 0			
F 0			
F 0			
F 0			
F 0			
F 0			
F 0			
F 0			

Remarks:

Signature of Section Head or Unit Supervisor Releasing Item(s)	Date	Releasing Unit Number:
Signature of Section Head or Unit Supervisor Receiving Item(s)	Date	Receiving Unit Number:

TENNESSEE DEPARTMENT OF TRANSPORTATION
FINANCIAL PROCEDURES MANUAL

DESCRIPTION TRANSFER of FIXED ASSETS FORM INSTRUCTIONS

PURPOSE To provide instructions for the proper completion of form DT-0302. This form is used to report the reassignment of fixed assets from one unit to another.
NOTE: Send the completed DT-0302 form to:

TDOT Finance Office
Attn: Fixed Asset Accountant
Suite 800 James K. Polk Building
505 Deaderick Street
Nashville, TN 37243-0329

ITEM NO.	NAME	REQ	INSTRUCTION / VALUE
1	Document Number	N/A	Use only forms of the 02/04 revision, or later, in sets of three, with preprinted document numbers.
2.	Document Date	R	Enter the date the document is prepared, using mm/dd/yy format.
3.	Mail To Address	R	When form is complete, to include both signatures, mail the white copy to DOT Finance.
4.	Distribution	R	Separate the sheets of the completed form; mail the **white** copy to Finance, provide the **pink** copy to the receiving unit, and retain the **canary** copy in the releasing unit files. Retain completed forms for not less than three years.
5.	Fixed Asset Tag Number	R	Enter the last five digits of the tag number of the fixed asset to be transfered.
6.	Serial Number	R	If the asset has a serial number, enter the last 8 digits of that serial number.
7.	County	R	Enter the two digit county number where the item will be located after the transfer.
8.	Standard Description	R	Enter the description of the item.
9.	Remarks	O	Use this space to provide any additional explanation considered necessary.
10.	Releaser's Signature	R	The Section Head or Unit Supervisor of the unit releasing the listed item(s) MUST sign the form. The form is not complete without this signature.
11.	Releasing Unit Number	R	Enter the six-digit unit number of the unit releasing the item(s).
12.	Receiver's Signture	R	The Section Head or Unit Supervisor of the unit receiving the item(s) listed MUST sign the form. The form is not complete without this signature.
13.	Receiving Unit Number	R	Enter the six-digit unit number of the unit receiving the item(s).

DT – 0125
F – 125
Z – 74

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION

NO. 50362

REQUISITION TO GARAGE STOCKROOM

DATE ____________, 19_____

STOCK NUMBER OR LICENSE NUMBER	PART NUMBER OR SIZE	STD. UNIT	STANDARD DESCRIPTION	QUANTITIY ORDERED	QUANTITY SHIPPED	NUMBER BACK-ORDERED

COST DISTRIBUTION							
CO.	SEC.	JOB NO.	FUND F	FUND S	CONTROL	R	FUNCTION

DELIVER TO ____________________
LOCATION

DISTRIBUTION: WHITE, PINK, BLUE COPIES TO STOCKROOM
YELLOW COPY IS RETAINED BY ORIGINATOR

REQUESTED BY ____________________
NAME AND TITLE

APPROVED ____________________
DME OR AUTHORIZED PERSONNEL

ORDER FILLED BY ____________________

REQUISTION FOR OFFICE & ENGINEERING SUPPLIES

CREDIT ACCOUNT			NUMBER	
1510				9909

STATE OF TENNESSEE

DEPARTMENT OF TRANSPORTATION

REQUISITION FOR OFFICE & ENGINEERING SUPPLIES 28141

____________ DATE

____________ REQUESTED BY   FROM DIVISION OF ____________ APPROVED ____________ REGION ____________

DELIVER TO D.O.T. IN CARE OF ____________ NAME ____________ SHOW EXACT LOCATION OF DELIVERY

COST DISTRIBUTION								STANDARD DESCRIPTION	STD. UNIT	QUANTITY ORDERED	QUANTITY ISSUED	STOCK NUMBER
CO.	SEC.	DOT-JOB	FUND	C	CONTROL	R	FUNCT					

FILLED BY: ____________

DATE		
MO.	DAY	YR

RECEIVED BY: ____________ DATE: ____________

DT-0607
F-607
REVISION 9-74

THE MATERIALS AND SUPPLIES LISTED BELOW HAVE BEEN RECEIVED INTO THIS INVENTORY LOCATION.

____
STOREKEEPER

State of Tennessee
Department of Transportation
MATERIALS AND SUPPLIES RETURNED TO INVENTORY

DATE______________________,19______

LOCATION

DEBIT ACCOUNT	NUMBER	
15	06371	1 9 9 0 9

PROJECT NUMBER						ACCOUNT									
CO.	SEC.	JOB OR DOT	FUND F	FUND S	C B	CONTROL	R	FUNCT	STANDARD DESCRIPTION	QUANTITY	STD. UNIT	UNIT PRICE	AMOUNT	STOCK NUMBER

Tennessee Department of Transportation

DT-0308
Rev 02-04

LSR 000001

LOST OR STOLEN PROPERTY REPORT

Distribution:

White	- TDOT Finance Office	Blue	- Unit File (permanent)	Pink	- Unit File (suspense)
Canary	- TDOT Finance Office	Green	- Region or Division File		

TO BE COMPLETED IMMEDIATELY UPON DISCOVERY OF LOSS BY PERSON TO WHOM PROPERTY IS ASSIGNED

DOT TAG NUMBER ____________________ DATE ____________

SERIAL NUMBER ____________________ COMPLETED BY:

PROPERTY DESCRIPTION ____________________ NAME ____________

____________________ TITLE ____________

____________________ UNIT LOC & SUB-LOC ____________

ESTIMATED VALUE $ ____________________ SUPERVISOR:

DATE OF LOSS ____________________ NAME ____________

PLACE OF LOSS ____________________ TITLE ____________

DETAILS OF LOSS (CIRCUMSTANCES, CAUSE, ETC.): ____________________

IF STOLEN, WHAT LAW ENFORCEMENT AGENCIES WERE NOTIFIED? ____________________

DOES TDOT HAVE A CLAIM AGAINST ANY EMPLOYEE OR OTHER PERSON FOR LOSS OF THIS ITEM (DUE TO NEGLIGENCE, ETC.)? ________ *IF YES, GIVE NAME, ADDRESS AND BASIS FOR CLAIM ON SEPARATE MEMORANDUM ATTACHED.*

APPROVED ____________________ (REGIONAL DIRECTOR OR DIVISION HEAD)

TO BE COMPLETED BY FIXED ASSET ACCOUNTANT

DOT TAG NUMBER	STANDARD DESCRIPTION	SERIAL NUMBER
F 0		

ORIGINAL COST $ ____________________ DATE PURCHASED ____________

REVIEWED BY ____________________ DATE ____________
INTERNAL AUDITOR

FORM NOT VALID WITHOUT REGIONAL DIRECTOR or DIVISION HEAD'S SIGNATURE

TENNESSEE DEPARTMENT OF TRANSPORTATION
FINANCIAL PROCEDURES MANUAL

DESCRIPTION LOST OR STOLEN PROPERTY REPORT INSTRUCTIONS

PURPOSE To provide instructions for the proper completion of form DT-0303. This form is used to report the loss of fixed assets, sensitive items, mobile equipment and inventory items. (Inventory lost as result of normal shrinkage need not be reported in this manner.) This form may also be used to report the loss or theft of "untagged assets."

NOTE: Send the white and yellow copies of the completed DT-0303 form to:

TDOT Finance Office
Cost Accounting Section
Suite 800 James K. Polk Building
505 Deaderick Street
Nashville, TN 37243-0329

ITEM NO.	NAME	REQ	INSTRUCTION / VALUE
1.	Document Number	N/A	Use only forms of the 02/04 revision, or later, printed in sets of five and with preprinted document numbers.
2.	Distribution Director	N/A	From the back of the packet to the front, the **pink** copy is retained in the unit as a suspense item, while the rest of the document is sent to the Regional or Division Head for signature; Once signed, the **green** copy is retained at the Region or Division level for file, and the rest of the signed packet is returned to the originating unit; At the unit, the **blue** copy is retained for permanent file and the remainder of the packet (**white** and **canary** copies) are mailed to DOT Finance, at the address above.
3.	DOT Tag Number	R	Enter the fixed asset tag number (or license number of mobile equipment). Use one form per tag number.
4.	Serial number	R	Serial number or VIN.
5.	Property Description	R	List a detailed description of item. Include manufacturer name and model if known.
6.	Estimated Value	O	Best estimate of the item's value at time of loss.
7.	Date of Loss	R	Date item was discovered missing.
8.	Place of Loss	R	Enter where the loss occurred.
9.	Date	R	Date report is filled out.
10.	Name	R	Signature of person reporting loss.
11.	Title	R	Job title of person reporting loss.

EXCERPT FROM NOAA MANUAL NOS NGS 5

This discussion is taken from NOAA Manual NOS NGS 5, "State Plane Coordinate System of 1983". References to the tranverse Mercator and oblique Mercator projections have been omitted. Any cross references printed in this section refer only to Sections and Tables from NOAA Manual NOS NGS 5, not to other sections in the Survey Manual.

3. CONVERSION METHODOLOGY

This chapter addresses both "manual" and "automated" methods for performing "conversions" on any Lambert conformal conic projections. Included is conversion from NAD 83 latitude/longitude to SPCS 83 northing/easting, plus the reverse process. For these processes this manual uses the term "conversion," leaving the term "transformation" for the process of computing coordinate values between datums, for example, transforming from NAD 27 to NAD 83 or transforming from SPCS 27 to SPCS 83. In addition to converting point coordinates, methods for conversion of distances, azimuth, and angles are also given.

The "automated" methods for conversions given in Section 3.1 are equations that have been sequenced and structured to facilitate programming. "Manual" methods are generally a combination of simple equations, tables, and intermediate numerical input, requiring only a calculator capable of basic arithmetic operations. Section 3.4 provides such a manual method for the Lambert projection where the intermediate numerical input is polynomial coefficients. Table 3.0 summarizes the conversion computational methods that were used for SPCS 27 and the methods discussed in this manual for SPCS 83.

TABLE 3.0 Summary of Conversion Methods

Datum	Mode	Projection	Method
SPCS 27	Manual	Lambert and Transverse Mercator	Projection tables
		Oblique Mercator	Intersection tables
	Automated	Lambert, transverse Mercator, and Oblique Mercator	Equations and constants described in C&GS Publication 62-4 (Claire 1968)
SPCS 83	Manual	Lambert	Polynomial coefficients (Sec. 3.4)
		Tranverse Mercator	New projection tables (future)
		Oblique Mercator	Automated only
	Automated	Lambert	Polynomial coefficients or new mapping equations (Sec. 3.1)
		Tranverse Mercator	New mapping equations (Sec. 3.2)
		Oblique Mercator	New mapping equations (Sec. 3.3)

The mapping equations given in Section 3.1 are not really "new" and may differ little from equations found in geodetic literature. However, they are new in the sense that they are not in the same form as the equations published or programmed by NGS or its predecessors in connection with SPCS 27. Whereas the SPCS 27 equations given in C&GS Publication 62-4 were designed to reproduce exactly the numerical results of an earlier manual method using logarithmic computations and projection tables, the equations here were designed for accuracy and computational efficiency.

Because the mapping equations of the automated approach apply equally to mainframe computers and programmable hand-held calculators, the availability of sufficient significant digits warrants consideration. For the Lambert projection, the method of polynomial coefficients (Sec. 3.4) was developed for machines with only 10 significant digits. With less than 12 digits, the general mapping equations could not guarantee millimeter accuracy in all Lambert zones, particularly in Florida, Louisiana, Texas, South Carolina, Nebraska and Montana. However, the polynomial coefficient method may also prove to be the most efficient for any machine. The general mapping equations will produce submillimeter accuracy when adequate significant digits are available for the computation.

Since the equations are not difficult, the polynomial coefficient method also fills the requirement for a manual method for the Lambert projection.

While it is easy to visualize map projections by considering them a perspective projection of the meridians and parallels of the datum surface onto a surface that develops into a plane, in this age of coordinate plotters a graticule is generally not constructed by these means. Although a set of mechanical procedures can sometimes be defined by which meridians and parallels can be geometrically constructed on the grid using a ruler, compass, and scale, a pair of functions, $N = f_1(\phi,\lambda)$ and $E = f_2(\phi,\lambda)$, always exist. That is, for a point of given latitude (ϕ) and longitude (λ), there exist equations to yield the northing coordinate and equations to yield the easting coordinate when ϕ and λ are substituted into the equations. Likewise, equations must exist to compute the convergence angle, $\gamma = f_3(\phi,\lambda)$, and grid scale factor, $k = f_4(\phi,\lambda)$. These four functions, or equations, comprise the direct conversion process.

Furthermore, it must be possible to perform the inverse computation, requiring another pair of formulas, latitude $(\phi) = f_5(N,E)$ and longitude $(\lambda) = f_6(N,E)$. Similarly needed are convergence and grid scale factor as a function of the plane coordinates, $\gamma = f_7(N,E)$ and $k = f_8(N,E)$. Because these are one-to-one mappings, the inverse computation must reproduce the original values.

This chapter provides these eight "mapping equations" for the Lambert conformal conic projection (Sec. 3.1). The definition of the adopted symbols will be given first. Two sets of symbols are listed, the conventional set which incorporates the Greek alphabet and a set available on standard keyboards. The equations in this chapter will use the conventional notation. The entries in the notation section flagged with an asterisk are the constants required to uniquely define one specific zone of that general type of map projection. The values of those zone-defining constants as adopted and legislated by the States are listed in Appendix A.

EXCERPT FROM APPENDIX A - Zone Defining Constants

State/Zone/Code		Projection	Central Meridian And Scale Factor (T.M.) or Standard Parallels (L.)	Grid Origin Longitude Latitude	Easting Northing
Tennessee TN	4100	L	35 15	86 00	600000
			36 25	34 20*	0

* This represents a change from the defining constant used for the 1927 State Plane Coordinate System. All metric values assigned to the origins also are changes.

Included within the notation section are the symbols and definitions of ellipsoid constants. Although several geometric ellipsoid constants are used within the mapping equations, only two geometric constants are required to define an ellipsoid. The SPCS 83 uses the GRS 80 ellipsoid. Those constants are discussed in Section 1.7. All other geometric ellipsoid constants are then derived from the two defining constants, usually for the purpose of eliminating repeated computations.

A section on computation of zone constants follows each section on notation and definitions. Within this section are equations to compute intermediate quantities derived from the zone-defining constants of Appendix A. These need only to be derived once. The derived "intermediate computing constants" of this section that need to be saved for future computations are flagged with an asterisk. The advantage of segmenting the general mapping equations is to eliminate repeated computations.

Subsequent sections list the equations of the direct and inverse coordinate conversion process. The solution of the ultimate mapping equations will require the values of the asterisked terms of the first two sections (defining constants plus intermediate constants).

3.1 Lambert Conformal Conic Mapping Equations

3.11 Notation and Definitions

For some terms an optional symbol appears in parentheses. This optional symbol available on all keyboards is used exclusively in Section 3.4 and Appendix C. Asterisked terms define the projection. Their values are listed in Appendix A. These terms are the "zone defining constants" included within State SPCS legislation where enacted.

	ϕ	(B)	Parallel of geodetic latitude, positive north
*	ϕ_s	(B_s)	Southern standard parallel
*	ϕ_n	(B_n)	Northern standard parallel
	ϕ_o	(B_o)	Central parallel, the latitude of the true projection origin
*	ϕ_b	(B_b)	Latitude of the grid origin
	λ	(L)	Meridian of geodetic longitude, positive west

*	λ_o	(L_o)	Central meridian, longitude of the true and grid origin
	k		Grid scale factor at a general point
	k_{12}		Grid scale factor of a line (between point 1 and point 2)
	k_o		Grid scale factor at the central parallel ϕ_o
	γ	(C)	Convergence angle
	δ	(t-T)	Arc-to-chord or second-term correction
	N		Northing coordinate (formerly y)
*	N_b		The northing value for ϕ_b at the central meridian (the grid origin). Sometimes identified as the false northing.
	N_o		Northing value at the intersection of the central meridian with the central parallel (the true projection origin)
	E		Easting coordinate (formerly x)
*	E_o		The easting value at the central meridian λ_o. Sometimes identified as the false easting.
	R		Mapping radius at latitude ϕ
	R_b		Mapping radius at latitude ϕ_b
	R_o		Mapping radius at latitude ϕ_o
	K		Mapping radius at the equator
	Q		Isometric latitude
*	a		Semi-major axis of the geodetic ellipsoid
	b		Semi-minor axis of the geodetic ellipsoid
*	f		Flattening of the geodetic ellipsoid = (a-b)/a
	e		First eccentricity of the ellipsoid = $(2f-f^2)^{1/2}$

3.12 Computation of Zone Constants

In this section the zone defining constants, ellipsoid constants, and parts of the Lambert mapping equations are combined to form several intermediate computing constants that are zone specific. These intermediate constants, flagged with an asterisk, will be required within the working equations of Sections 3.13 through 3.15. <u>All angles are in radian measure</u> where 1 radian equals 180/π degrees. Linear units are identical to the units of the ellipsoid (a and b) and grid origin (N_b and E_o).

$$Q_s = \tfrac{1}{2}\left[\ln\frac{1+\sin\phi_s}{1-\sin\phi_s} - e\ln\frac{1+e\sin\phi_s}{1-e\sin\phi_s}\right]$$

$$W_s = (1 - e^2\sin^2\phi_s)^{1/2}$$

Similarly for Q_n, W_n, Q_b, Q_o and W_o upon substitution of the appropriate latitude

$$* \quad \sin \phi_o = \frac{\ln [W_n \cos \phi_s / (W_s \cos \phi_n)]}{Q_n - Q_s}$$

$$* \quad K = \frac{a \cos \phi_s \exp (Q_s \sin \phi_o)}{W_s \sin \phi_o} = \frac{a \cos \phi_n \exp (Q_n \sin \phi_o)}{W_n \sin \phi_o}$$

NOTE: $\exp(x) = \epsilon^x$

where $\epsilon = 2.718281828...$ (the base of natural logarithms)

$$* \quad R_b = K / \exp (Q_b \sin \phi_o)$$

$$* \quad R_o = K / \exp (Q_o \sin \phi_o) \qquad (R_o \text{ used in } \delta \text{ computation})$$

$$* \quad k_o = (W_o \tan \phi_o R_o) / a$$

$$* \quad N_o = R_b + N_b - R_o$$

3.13 Direct Conversion Computation

This computation starts with the geodetic coordinates of a point (ϕ,λ) from which the Lambert grid coordinates (N, E) are to be computed, with convergence angle (γ), and grid scale factor (k).

$$Q = ½ \left[\ln \frac{1 + \sin \phi}{1 - \sin \phi} - e \ln \frac{1 + e \sin \phi}{1 - e \sin \phi} \right]$$

$$R = K / \exp (Q \sin \phi_o)$$

$$\gamma = (\lambda_o - \lambda) \sin \phi_o$$

$$N = R_b + N_b - R \cos \gamma$$

$$E = E_o + R \sin \gamma$$

$$k = (1 - e^2 \sin^2 \phi)^{½} (R \sin \phi_o) / (a \cos \phi)$$

3.14 Inverse Conversion Computation

In this computation the Lambert grid coordinates of a point (N, E) are given and the geodetic coordinates (ϕ,λ), convergence (γ), and grid scale factor (k) are to be computed.

$$R' = R_b - N + N_b$$

$$E' = E - E_o$$

$$\gamma = \tan^{-1} (E'/R')$$

$$\lambda = \lambda_o - \gamma / \sin \phi_o$$

$$R = (R'^2 + E'^2)^{1/2}$$

$$Q = [\ln (K/R)] / \sin \phi_o$$

Computation of latitude is iterative. Starting with the approximation

$$\sin \phi = \frac{\exp (2Q) - 1}{\exp (2Q) + 1}$$

solve for sin ϕ three times, as follows:

$$f_1 = ½ \left[\ln \frac{1 + \sin \phi}{1 - \sin \phi} - e \ln \frac{1 - e \sin \phi}{1 + e \sin \phi} \right] - Q$$

$$f_2 = \frac{1}{1 - \sin^2 \phi} - \frac{e^2}{1 - e^2 \sin^2 \phi}$$

Add a correction of ($-f_1 / f_2$) to sin ϕ and iterate two times before obtaining ϕ.

$$k = (1 - e^2 \sin^2 \phi)^{1/2} (R \sin \phi_o)/(a \cos \phi)$$

If only k is desired from the grid coordinates, an approximate ϕ will suffice and its computation shortened. After computing Q, compute

$$\sin \theta = \frac{\exp (2Q) - 1}{\exp (2Q) + 1}$$

$$\phi = \theta + (A \sin \theta \cos \theta) (1 + B \cos^2 \theta)$$

in which $A = e^2 (1 - e^2 / 6)$ and $B = 7e^2 / 6$. For the GRS 80 ellipsoid A = 0.0066869 and B = 0.0078.

The grid scale factor may be approximated by the equation

$$k = k_o + (N-N_o)^2 / 2r_o^2 + (N-N_o)^3 (\tan \phi_o) / 6r_o^3$$

The quantity r_o is defined in Section 3.15. Values of r_o, k_o and N_o are given in Appendix C.

A further approximation is given by the equation:

$$k = k_o + (N-N_o)^2 (1.231 \times 10^{-14}) + (N-N_o)^3 (\tan \phi_o) (6.94 \times 10^{-22})$$

These approximations may not be sufficiently accurate in the States with a single Lambert zone, such as Tennessee.

To derive the grid scale factor at a point directly from the grid coordinates, the method given in Section 3.4, the method of polynomial coefficients, also warrants consideration.

3.15 Arc-to-Chord Correction "δ" (alias "t-T")

The relationship among grid azimuth (t), geodetic azimuth (α), convergence angle (γ), and arc-to-chord correction (δ) at any given point is

$$t = \alpha - \gamma + \delta$$

To compute δ requires knowledge of the coordinates of both ends of the line to which δ is to be applied. If geodetic coordinates of the endpoints are available (ϕ_1, λ_1 and ϕ_2, λ_2), the δ from point 1 to point 2 can be computed from

$$\delta_{12} = (\sin \phi_3 - \sin \phi_o)(\lambda_1 - \lambda_2) / 2$$

where $\phi_3 = (2\phi_1 + \phi_2) / 3$ and ϕ_o is the computed constant for the zone. In normal practice, however, δ is desired as a function of the grid coordinates. To that end the following sequence of equations will produce the best possible determination of δ_{12}, given points N_1, E_1 and N_2, E_2:

$$p_1 = N_1 - N_o \qquad p_2 = N_2 - N_o$$
$$q_1 = E_1 - E_o \qquad q_2 = E_2 - E_o$$
$$R'_1 = R_o - p_1 \qquad R'_2 = R_o - p_2$$
$$\Delta N = N_2 - N_1$$

$$M_o = k_o a (1 - e^2) / (1 - e^2 \sin^2 \phi_o)^{3/2}$$

NOTE: M_o is the scaled radius of curvature in the meridian at ϕ_o scaled to the grid. The value of M_o for each zone appears in Appendix 3 as a "computed constant."

$$u_1 = p_1 - q_1^2 / 2R'_1$$

$$\phi_3 = \phi_o + (u_1 + \Delta N/3) / M_o$$

$$\delta_{12} = (\sin \phi_3 / \sin \phi_o - 1)(q_2/R'_2 - q_1/R'_1) / 2 \qquad (1)$$

For most applications a less accurate determination of ϕ will suffice. For example, the original Coast and Geodetic Survey formula (Adams and Claire 1948) should be adequate for all applications except the most precise surveys in the largest Lambert zones.

$$\delta_{12} = (p_1 + \Delta N/3) \Delta E / 2r_o^2 \qquad (2)$$

where

$$p_1 = N_1 - N_o$$

$$\Delta N = N_2 - N_1 \qquad\qquad \Delta E = E_2 - E_1$$

$$r_o = k_o a(1 - e^2)^{1/2} / (1 - e^2 \sin^2 \phi_o)$$

The quantity r_o is the geometric mean radius of curvature at ϕ_o scaled to the grid and is constant for any one zone. The value of r_o has been included with the computed constants in Appendix C. A single value of $1 / (2r_o^2)$ is often used and combined with the constant to convert radians to seconds (1 radian = $648000/\pi$ seconds).

Hence, $\delta_{12} = 25.4 \ (p_1 + \Delta N / 3) \ (\Delta E) \ 10^{-10}$ seconds, where the coordinates are in meters. Sometimes the notation (ΔN) replaces $(p_1 + \Delta N/3)$. Then the above equation is analogous to the expression often used in connection with NAD 27:

$$\delta_{12} = 2.36 \ \Delta x \ \Delta y \ 10^{-10} \text{ seconds}$$

where the coordinates are in feet. This expression also serves for NAD 83 coordinates that have been converted to feet.

For the SPCS 27 Lambert systems NGS suggested two other appropriate methods that provided more accurate (t-T) corrections at the zone extremities. One was similar to Equation 3.15 (1) and gave essentially the same results. Since the computing effort was somewhat greater than for 3.15 (1) it is not given here. The second, while not as accurate as 3.15 (1), may be simpler for manual calculations because it uses the SPCS 83 zone constants and readily understood rotation and translation formulas.

$$\delta_{12} = (e_2 - e_1)\ (2n_1 + n_2) / 6r_o^2 \qquad \text{(in radian measure)}$$

where

$n = D + E' \sin \gamma + N' \cos \gamma$
$e = E' \cos \gamma - N' \sin \gamma$

" γ " is the average convergence angle for the survey area and is considered positive. γ to minutes is sufficient.

$D = 2R_o \sin^2 \gamma / 2$
$N' = N - N_o$
$E' = E - E_o$

The size of δ varies linearly with the length of the ΔE $(\Delta\lambda)$ component of the line and with the distance of the standpoint from the central parallel. It does not vary with distance of standpoint from the central meridian. Hence the size of δ depends on the direction of the line, varying from a zero value between points on the same meridian to maximum values over east-west lines.

Table 3.1 gives an overview of the true numeric value of the arc-to-chord correction (δ) and of the computational errors expected from Equations (1) and (2). The examples were computed for a hypothetical zone with central parallel of approximately 42° (standard parallels 41° and 43°), on the GRS 80 ellipsoid. Two cases, 1° and 2°, are illustrated for the distance of the standpoint from the central parallel ϕ_o. Two cases, 5° and 10°, are given for the distance of the standpoint from the central meridian. Although the magnitude of δ is not a function of the distance of the standpoint from the central meridian, Equation (2) becomes less accurate as this distance increases. Table 3.1 also gives three cases for the orientation of the line, in azimuths of 90°, 135°, and 180°. Again note that although the true δ equals zero in an azimuth of 180°, the equations only approximate zero.

The final assumption in Table 3.1 is that the length of the line for which δ is being computed is 20 km. Dividing the line into several traverse legs results in a proportional decrease in the required correction to a direction. It does nothing to diminish the closure error in azimuth because errors due to omission of δ are cumulative.

From data given in Table 3.1 the persons performing the computing must decide which reduction formula is appropriate for their needs, remembering that the accuracy of the formula should exceed the expected accuracy of the field work by one order of magnitude and that an error of 1" direction corresponds to a linear error of about 1:200 000, or 5 ppm.

TABLE 3.1 True Values of (t-T)

And Computational Errors in Their Determination (in seconds of arc)

$\phi_1 - \phi_o$	1°	2°	1°	2°
$\lambda_1 - \lambda_o$	5°	5°	10°	10°
Azimuth	90°	90°	90°	90°
True δ	5.67	11.44	5.67	11.44
Error by (1)	0.00	0.02	0.03	0.11
Error by (2)	0.53	0.38	2.28	2.07
Azimuth	135°	135°	135°	135°
True δ	3.83	7.91	3.83	7.91
Error by (1)	0.00	0.01	0.02	0.08
Error by (2)	0.14	-0.20	0.99	0.38
Azimuth	180°	180°	180°	180°
True δ	0.00	0.00	0.00	0.00
Error by (1)	0.00	0.00	0.00	0.00
Error by (2)	-0.34	-0.67	-0.90	-1.55

3.4 Polynomial Coefficients for the Lambert projection

Conversion of coordinates from NAD 83 geodetic positions to SPCS 83 plane coordinate positions, and vice versa, can be greatly simplified for the Lambert projection using precomputed zone constants obtained by polynomial curve fitting. NGS developed the Lambert "polynomial coefficient" approach as an alternative to the rigorous mapping equations given in Section 3.1. For many zones the solution of the textbook mapping equations for the Lambert projection requires the use of more than 10 significant digits to obtain millimeter accuracy, and in light of the programmable calculators generally in use by surveyors/engineers, an alternative approach was warranted. For the polynomial coefficient method of the Lambert projection, 10 significant digits will produce millimeter accuracy in all zones.

Given the precomputed polynomial coefficients, the conversion process by this method reduces to the solution of simple algebraic equations, requiring no exponential or logarithmic functions. It is therefore very efficient for hand calculators and small computers. In addition, the conversion is not too difficult to apply manually without the aid of programming. For this reason, the polynomial coefficient approach has also been listed as a manual approach in Table 3.0. When programmed, this approach may be more efficient than the mapping equations of Section 3.1.

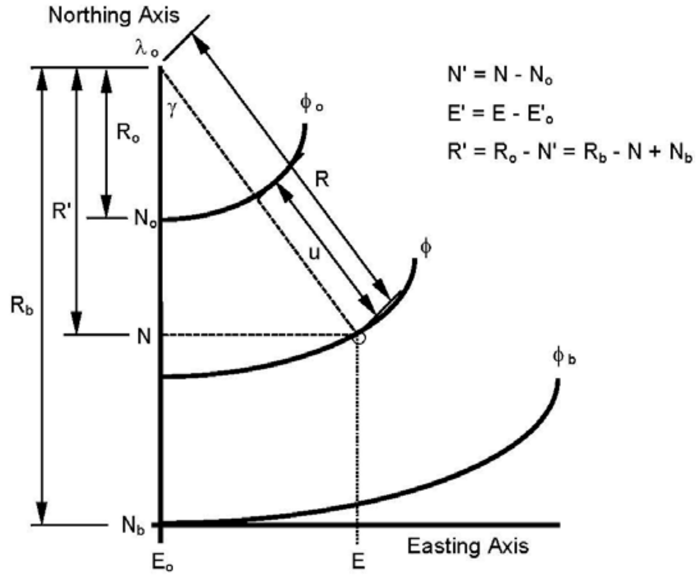


FIGURE 3.4 The Lambert Grid

The equations in this section are similar to those in Section 3.1, with the symbols representing the same quantities. Four new symbols are introduced, three of which are for polynomial coefficients--L's, G's, and F's--and the fourth is the symbol "u". From the equations and Figure 3.4, it will be discovered that "u" is a distance on the mapping radius "R" between the central parallel and a given point. The "L" coefficients (L_1, L_2, L_3, etc.) are used in the forward conversion process (Section 3.41), the "G" coefficients (G_1, G_2, G_3, etc.) are used in the inverse conversion process (Section 3.42), and the "F" coefficients are used in the computation of grid scale factor. For the computation of (t-T), the methods in Section 3.15 are applicable.

The fundamental polynomial equations of this method are

$$u = L_1\Delta\phi + L_2\Delta\phi^2 + L_3\Delta\phi^3 + L_4\Delta\phi^4 + L_5\Delta\phi^5 \quad \text{(forward conversion)}$$

$$\Delta\phi = \phi - \phi_o = G_1u + G_2u^2 + G_3u^3 + G_4u^4 + G_5u^5 \quad \text{(inverse conversion)}$$

The determination of "u" in meters on a plane by a polynomial, given point (ϕ,λ) in the forward conversion, and the determination by a polynomial of $\Delta\phi$ in radians on the ellipsoid given point (N,E) in the inverse conversion, is the unique aspect of this method. The L-coefficients perform the functions: (1) computing the length of the meridian arc between ϕ and ϕ_o, and (2) converting that length to (R_o - R) which is its equivalent on the mapping radius. The G-coefficients serve the same two-stage process, but in reverse. The polynomial coefficients of these equations, L's and G's, were separately determined by a least squares curve fitting program that also provided information as to the accuracy of the fit. Ten data points were used for each Lambert zone and the model solved for the fewest number of coefficients possible that provided 0.5 mm coordinate accuracy in the conversion. Consequently, some small zones required only three coefficients, three L's and three G's, whereas a few large zones required five coefficients for each the forward and inverse conversion.

Appendix C discusses the computed constants and coefficients required for this method, which are defined as follows:

The Defining Constants of a Zone:

ϕ_s or B_s	Southern standard parallel
ϕ_n or B_n	Northern standard parallel
ϕ_b or B_b	Latitude of grid origin
λ_o or L_o	Central meridian - longitude of true and grid origin
N_b	Northing value at grid origin (B_b)
E_o	Easting value at grid and projection origin (L_o)

The Derived Constants:

ϕ_o or B_o	Central parallel - Latitude of the projection origin
N_o	Northing value at projection origin (B_o)
k_o	Grid Scale Factor at the central parallel
R_o	Mapping radius at (B_o)
R_b	Mapping radius at (B_b)
M_o	Scaled radius of curvature in the meridian at B_o used in Section 3.15

The Polynomial Coefficients:

L_1 through L_5 used in the forward conversion
G_1 through G_5 used in the inverse conversion
F_1 through F_3 used in the grid scale-factor computation

EXCERPT FROM APPENDIX C

Constants for the Lambert Projection By the Polynomial Coefficient Method

TN TENNESSEE ZONE # 4100

Defining Constants			Coefficients for GP to PC		
B_s	=	35:15	L(1)	=	110950.2019
B_n	=	36:25	L(2)	=	9.25072
B_b	=	34:20	L(3)	=	5.64572
L_o	=	86:00	L(4)	=	0.017374
N_b	=	0.0000			
E_o	=	600000.0000			

Computed Constants			Coefficients for PC to GP		
B_o	=	35.8340607459	G(1)	=	9.013052490E-06
sin B_o	=	0.585439726459	G(2)	=	-6.77268E-15
R_b	=	9008631.3113	G(3)	=	-3.72351E-20
R_o	=	8842127.1422	G(4)	=	-9.2828E-28
N_o	=	166504.1691			
K	=	13064326.2967	Coefficients for Grid Scale Factor		
k_o	=	0.999948401424			
M_o	=	6356978.3321	F(1)	=	0.999948401424
r_o	=	6371042.	F(2)	=	1.23188E-14
			F(3)	=	4.54E-22

3.41 Direct Conversion Computation

The computation starts with the geodetic position of a point (ϕ,λ), and computes the Lambert grid coordinates (N,E), convergence angle (γ), and grid scale factor (k).

$\Delta\phi = \phi - B_o$ ($\Delta\phi$ in decimal degrees)
$u = L_1 \Delta\phi + L_2 \Delta\phi^2 + L_3 \Delta\phi^3 + L_4 \Delta\phi^4 + L_5 \Delta\phi^5$

NOTE: The only required terms are those for which polynomial coefficients are provided in Appendix C. Either three, four, or five L's are required depending on the size of the zone.

Suggestion: Use nested form.

$u = \Delta\phi\,[\,L_1 + \Delta\phi\,\{\,L_2 + \Delta\phi\,(\,L_3 + \Delta\phi\,(\,L_4 + L_5 \Delta\phi\,))\}]$
$R = R_o - u$
$\gamma = (\,L_o - \lambda\,) \sin (\,B_o\,)$ convergence angle
$E' = R \sin\gamma$

$N' = u + E' \tan(\gamma / 2)$	
$E = E' + E_o$	easting
$N = N' + N_o$	northing
$k = F_1 + F_2u^2 + F_3u^3$	grid scale factor

3.42 Inverse Conversion Computation

This computation starts with the Lambert grid coordinates (N,E) from which are computed the geodetic coordinates (ϕ,λ), convergence angle (γ), and grid scale factor (k):

$N' = N - N_o$	
$E' = E - E_o$	
$R' = R_o - N'$	
$\gamma = \tan^{-1}(E' / R')$	convergence angle
$\lambda = L_o - \gamma / \sin(B_o)$	longitude
$u = N' - E' \tan(\gamma / 2)$	
$\Delta\phi = \phi - B_o = G_1u + G_2u^2 + G_3u^3 + G_4u^4 + G_5u^5$	($\Delta\phi$ in decimal degrees)

NOTE: The only required terms are those for which polynomial coefficients are provided in Appendix C. Either three, four, or five G's are required depending on the size of the zone.

Suggestion: Use factored form.

$$\Delta\phi = u\,[\,G_1 + u\,\{\,G_2 + u\,(\,G_3 + u\,(\,G_4 + G_5\,u\,))\}]$$

$\phi = B_o + \Delta\phi$	latitude
$k = F_1 + F_2u^2 + F_3u^3$	grid scale factor

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
FIELD ENGINEERS PROJECT TIME REPORT IN MAN-DAYS

Project No.: ______________________________ County: ____________________
Route No.: ______________________________ Length: ________________ Miles
Description: ____
____

Type of Survey: Urban ______ Rural ______
Function Code: __________

	MAN-DAYS		
	FIELD	OFFICE	TOTAL
Alignment			
B. M.'s and Cross Sections			
Topography and Utilities			
Drainage			
Property			
Lost Time (travel, weather, etc.)			
Control Traverses			
Grand Total			

Remarks: ____
____
____
____
____
____

This form will be turned in with each survey.

Prepared by: ______________________________
Field Supervisor Date

TENNESSEE DEPARTMENT OF TRANSPORTATION

MANDAY ESTIMATE AND FEE PROPOSAL

For Survey Only

SR-22

from SR-314 to 0.75 Miles South of Old Bridge Road

Humphreys County

Project Identification Number (PIN): <100000.00>

General Comments:

ABC Engineering

Mr. Surveyor

2112 Benchmark Place

615-555-5555

615-555-5556

mrsurveyor@emailserver.net

Prepared By:

IMA Surveyor

Date prepared:

4/5/2011

Project No.:

43065-1241-04

TDOT

Version 2.22

TDOT

Survey Summary

Route: SR-22 4/5/2011

Description: from SR-314 to 0.75 Miles South of Old Bridge Road

County: Humphreys

Consultant: ABC Engineering

Prepared By: IMA Surveyor

Project No.: 43065-1241-04

Mainline Project Length: **4.00** (miles)

Number of Sideroads: 10 Length: **3500** (feet)

Office Travel Time per day (hrs): 2.00

Crew Travel Time per day (hrs): 1.00

Crew Work per day (hrs): 8

Number of Existing Lanes: 2 Proposed: 4

Number of Driveways/Ramps: 36

Location:

Existing Road: 100% Rural: 50%

New Alignment: 0% Urban: 50%

Business: 0%

Rural Land Character: Woods: 50% Terrain: Flat 50%

Pasture: 50% Rolling: 25%

Cultivated: 0% Hilly: 0%

Mountains: 25%

Distance to Nearest Benchmark: 0.6 miles

Number of Survey Updates 0

R.O.W. Staking:

Iron Pins 0

1 Stake Points 0

2 Stake Points 0

Aerial Mapping Available: ◉ YES ○ NO

Approximate Obscured Area: 10% Use 100% if no mapping is available.

Proposed DTM Width: **300** (ft)

Geotechnical Staking:

Points 0

Drainage:

Approx. Number of Culvert Sites: 42

Number of Bridges: Small: 0 Medium 0 Large: 0

Approx. Number of Property Tracts: 30 Number of Railroad Crossings: 0

Indicate Utilities Present: Elect.: ☑ Telephone: ☑ Cable TV: ☑

Water: ☑ Sewer: ☑ Gas: ☐

Fiber Optic: ☐ Petroleum Pipeline: ☐

Comments on Difficulty, Conditions or Other Considerations:

INPUT SIDEROADS LT & RT OF CENTERLINE

Sideroad Name	Length (feet)
Side Road 1	400
Side Road 2	400
Side Road 3	500
Side Road 4	300
Side Road 5	300
Side Road 6	300
Side Road 7	300
Side Road 8	1000
Total Length	3500

ESTIMATE FOR FIELD SURVEYS

PROJECT DESCRIPTION: Version 2.22

Route: SR-22
Description: from SR-314 to 0.75 Miles South of Old Bridge Road
County: Humphreys Prepared By: IMA Surveyor
Consultant: ABC Engineering Date Prepared: 4/5/2011
Project No.: 43065-1241-04
TOTAL LENGTH(miles): 4.38
OFFICE TRAVEL TIME PER DAY(hrs): 2.00
CREW TRAVEL TIME PER DAY(hrs): 1.00

ACTIVITY	PROJECT MANAGER	OFFICE CADD TECH.	PARTY CHIEF	INSTRUMENT MAN	RODMAN	RODMAN	FLAGGER	FLAGGER	
	PM	O	P	I	R	R	F	F	Total
1.Establish & Stake Alignments	0.9	0.6	4.4	4.4	4.4	4.4			19.1
2. Update Survey									
3. Control Traverses	2.3	0.7	2.9	2.9	2.9	2.9			14.6
4. Set Aerial Control									
5. Bench Levels	0.7	0.7	2.3	2.3	2.3	2.3			10.6
6. Develop Digital Terrain Model	3.1	4.6	5.6	5.6	5.6	5.6			30.1
7. R.O.W.,Deed & Utility Research	1.5	1.0							2.5
8. Property Owner Contact	2.0		2.0						4.0
9. Locate Property & Pres. R.O.W. Lines	3.0	3.0	5.0	5.0	5.0	5.0			26.0
10. Obtain Topo/Verify Aerial	1.7	3.4	16.9	16.9	16.9	16.9			72.7
11. Drainage Surveys (Culverts)	2.8	2.8	10.6	10.6	10.6	10.6			48.0
12. Bridge Surveys (bridge details, stream alignment, topo, profile, flood plain sections, high water, etc.									
13. Railroad Surveys									
14. Utilities	0.7	1.8	11.7	11.7	11.7	11.7			49.3
15. Stake R.O.W. & Easements									
16. Stake Sounding Holes									
17. Note Reduction & other Calculations	4.4								4.4
18. Plot Plan, Profiles, Property Map, Drainage Map, Bridge Survey, Control Point Table, etc.	1.8	7.0							8.8
19. Supervision	4.4								4.4
20. Travel Time (8 HOUR MAN-DAYS)	0.8	0.3	8.8	8.5	8.5	8.5			35.4
TOTALS (8 HOUR MAN-DAYS)	30.1	25.9	70.2	67.9	67.9	67.9			**329.9**

Description: from SR-314 to 0.75 Miles South of Old Bridge Road
County: Humphreys
Consultant: ABC Engineering
Project No.: 43065-1241-04
TOTAL LENGTH(miles): 4.38
Date Prepared: 4/5/2011 Prepared By: IMA Surveyor

	OFFICE DIFFICULTY	FIELD DIFFICULTY	REMARKS
Align.	0.5	0.5	
Update	1.0	1.0	0 Survey Updates
Control	1.0	1.0	
Aerial	0.0	0.0	0 0 NUMBER HORIZONTAL & NUMBER VERTICAL POINTS
Levels	1.0	1.0	ZERO IF NOT REQUIRED
DTM	1.3	1.3	10% PERCENT SKIPS 300 DTM WIDTH(feet)
Research	1.0	1.0	30 NUMBER OF TRACTS
Contacts	1.0	1.0	
Property	1.0	1.0	DO NOT EDIT THESE CELLS
Topo	1.2	1.2	
Culverts	1.0	1.0	
Bridges	1.0	1.0	0 0 0 NUMBER OF SMALL, MEDIUM, LARGE BRIDGES
RR	1.0	1.0	0 NUMBER OF RR CROSSINGS
Utilities	1.0	1.0	5 Number of Different Utilities Involved
R.O.W.	1.0	1.0	DO NOT EDIT THESE CELLS
Geotech.	1.0	1.0	
	1.0		0 0 0 Number of IP's, 1-stake, 2-stakes
Plotting	1.0		0 Number of Geotechnical Staking Points
	1.0		**73.6** 8 - Hr MD/MILE not including travel
	1.0	1.0	**82.5** 8 - Hr MD/MILE

SURVEY DIRECT LABOR COST

PROJECT DESCRIPTION:
ROUTE: SR-22
DESCRIPTION: from SR-314 to 0.75 Miles South of Old Bridge Road
COUNTY: Humphreys
CONSULTANT: ABC Engineering
TOTAL LENGTH (miles): 4.66

Prepared By: IMA Surveyor
Date Prepared: 4/5/2011

TDOT

	Abbrv.	Personnel Classification	8 - Hr Man-Days		Approved Hours	Rate Per Hr	Direct Labor	
1	PM	PROJECT MANAGER	30.1		8.0	$ 38.00	$ 9,150.40	
2	O	OFFICE CADD TECH.	25.9		8.0	$ 22.00	$ 4,558.40	
3	P	PARTY CHIEF	70.2		8.0	$ 20.00	$ 11,232.00	
4	I	INSTR. MAN	67.9		8.0	$ 15.00	$ 8,148.00	
5	R	RODMAN	67.9		8.0	$ 11.00	$ 5,975.20	
6	R	RODMAN	67.9		8.0	$ 11.00	$ 5,975.20	
7	F	FLAGGER	0.0		8.0	$ -	$ -	
8	F	FLAGGER	0.0		8.0	$ -	$ -	
		TOTALS	329.9				$ 45,039.20	

Direct Labor Cost Per 8 - Hour Man-Day	$ 136.52

Version 2.22

SURVEY DIRECT EXPENSES

PROJECT DESCRIPTION:
ROUTE: SR-22
DESCRIPTION: from SR-314 to 0.75 Miles South of Old Bridge Road
COUNTY: Humphreys
CONSULTANT: ABC Engineering
TOTAL LENGTH (miles): 4.66

Prepared By: IMA Surveyor
Date Prepared: 4/5/2011
Project No.: 43065-1241-04

TDOT

Reproduction Costs

Item Description	Number / Unit	Unit Price	Item Subtotal	Item Total Cost
Xerographic Bond	0	$ 0.25	$ -	
Blueline Fullsize	10	$ 0.25	$ 2.50	
Photo-Copies	60	$ 0.25	$ 15.00	
Deeds	30	$ 0.50	$ 15.00	
			Subtotal	$ 32.50

Travel

Survey Crew Travel Calculations

From:
To:

	Number of Trips	No. of Miles/No. of People	* RATE	Item Subtotal	Item Total Cost
Travel Day Per Diem	14.00 Man-Days	X 4.00 People X	$ 34.50 Per Day	= $ 1,932.00	
Non Travel Day Per Diem	57.00 Man-Days	X 4.00 People X	$ 46.00 Per Day	= $ 10,488.00	
Transportation	71.00 Man-Days	X 50.00 Miles X	$ 0.46 Per Mile	= $ 1,633.00	
Lodging	57.00 Nights	X 4.00 People X	$ 77.00 Per Person	= $ 17,556.00	
				Subtotal	= $ 31,609.00

Office Personnel Travel Calculations

From:
To:

	Number of Trips	No. of Miles/No. of People	* RATE	Item Subtotal	Item Total Cost
Travel Day Per Diem	2.00 Man-Days	X 1.00 People X	$ 34.50 Per Day	= $ 69.00	
Non Travel Day Per Diem	0.00 Man-Days	X 1.00 People X	$ 46.00 Per Day	$ -	
Transportation	1.00 Round Trips	X 130.00 Miles X	$ 0.46 Per Mile	= $ 59.80	
Lodging	1.00 Nights	X 1.00 People X	$ 77.00 Per Person	= $ 77.00	
				Subtotal	$ 205.80

Other Expenses

Item Description	Number / Unit	Unit Price	Item Subtotal	Item Total Cost
	0	$ -	$ -	
	0	$ -	$ -	
	0	$ -	$ -	
	0	$ -	$ -	
	0	$ -	$ -	
	0	$ -	$ -	
	0	$ -	$ -	
			Subtotal	$ -

TOTAL DIRECT EXPENSES	$ 31,847.30

FEE PROPOSAL

ROUTE:	SR-22	Project No.:	43065-1241-04
DESCRIPTION:	from SR-314 to 0.75 Miles South of Old Bridge R	PIN No.:	<100000.00>
COUNTY:	Humphreys		
CONSULTANT:	ABC Engineering		
Prepared By:	IMA Surveyor		
Date Prepared:	4/5/2011		

COMPLETE SURVEY SHEETS FIRST IF SURVEY IS INCLUDED IN THE CONTRACT.
PROCEED WITH FEE PROPOSAL IF SURVEY IS NOT INCLUDED.

This sheet computes percent net fee and performs fee proposal calculations for each phase of the project and total project.
Enter the appropriate overhead rate & fill in shaded boxes that apply for each phase.

Version 2.22

Data For Fee Calculations

Overhead Rate = **1.4500** **

** **(State Project Maximum overhead rate = 1.45)**
** **(Federal Project Maximum overhead rate per External Audit Report)**

Design Direct Labor =	$	-
Survey Direct Labor =	$	45,039.20
Total Direct Labor =	$	45,039.20
Cost for net fee basis =	$	110,346.04 *
Net Fee = (Rounded to Nearest Tenth)		**12.5%** *

NOTE: Net Fee for Supplements shall be the same as the original contract. It may be necessary to modify net fee calculated on supplement requests.

* Net fee is based on cost of contract not including direct cost and net fee as follows:

Survey & Design / Design Only Rates		Survey Only Rates	
$ 0 - $ 100,000 =	13.0%	$ 0 - $ 50,000 =	13.0%
$100000 - $ 500,000 =	12.5%	$ 50,000 - $ 200,000 =	12.5%
> $ 500,000 =	12.0%	> $200,000 =	12.0%

(Place X in adjacent box to remove instructions prior to printing.)

SURVEYS

1	Direct Labor	=	$	45,039.20
2	Overhead (Overhead Rate = 1.4500) (Overhead rate X direct labor)	=	$	65,306.84
3	**Subtotal 1 + 2**	=	$	110,346.04
4	Net Fee = 12.5% (Rounded to nearest $10.) (Direct labor X 2.35 X 0.NF)	=	$	13,230.00
5	**Subtotal 3 + 4**	=	$	123,576.04
6	Direct Expense	=	$	31,847.30
7	Premium Labor (Premium Labor is only eligible if the survey crew works greater than a 40 hour work week.)	=	$	-
8	**Total Survey** (Total 5 + 6 + 7)	=	$	155,423.34

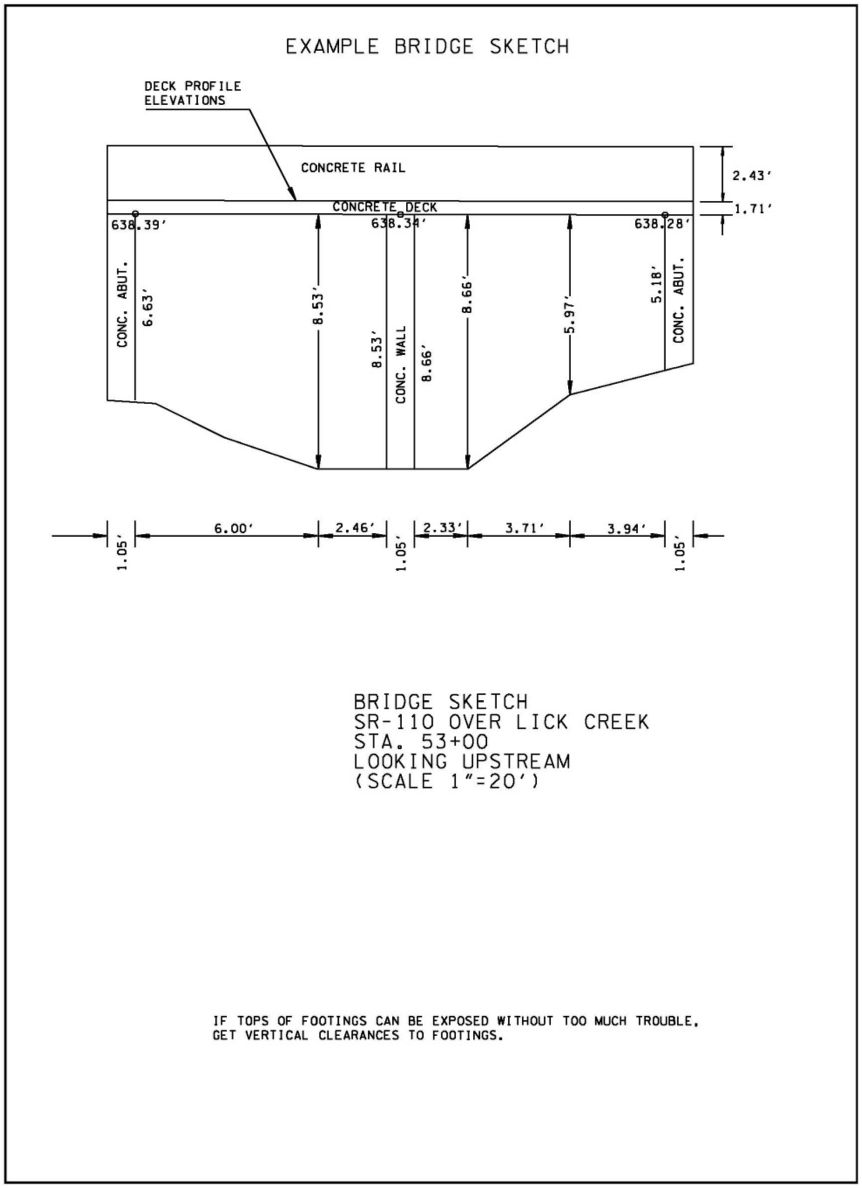


Figure A-20
Example Bridge Sketch

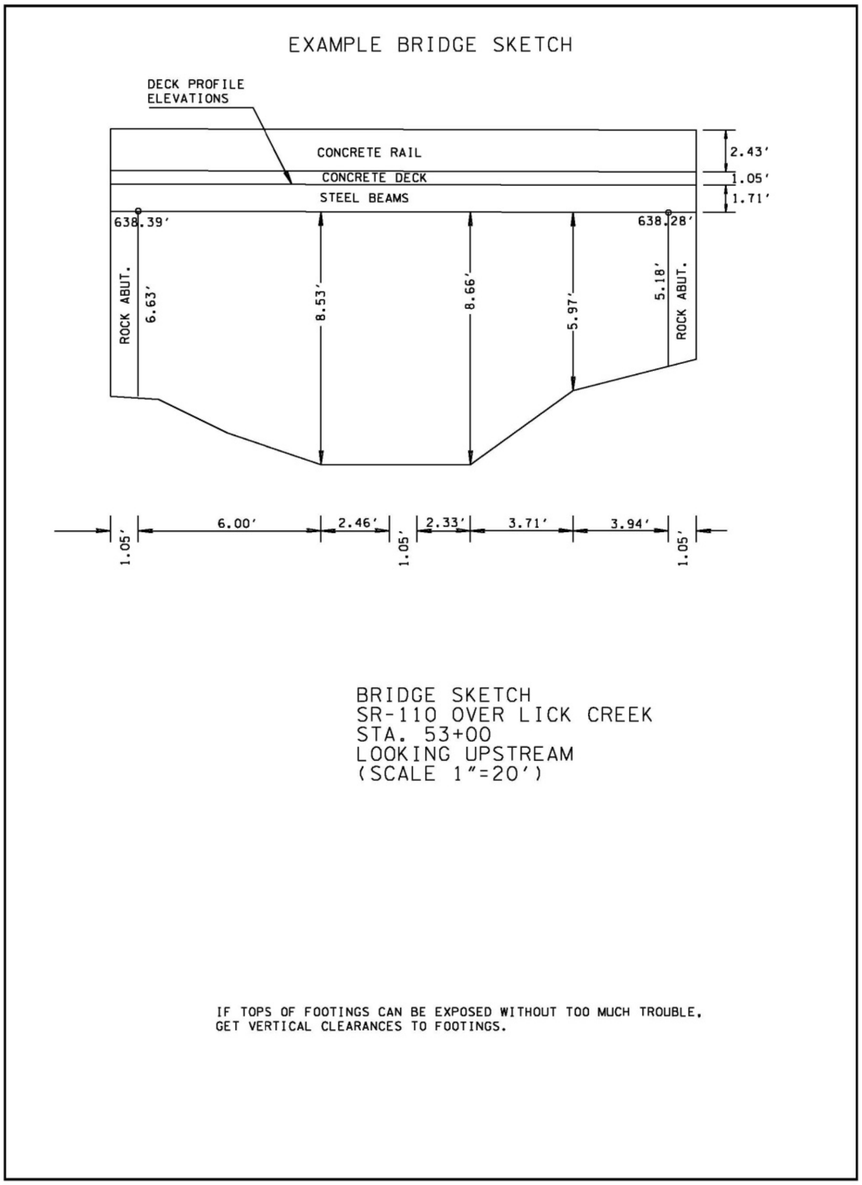


Figure A-21
Example Bridge Sketch

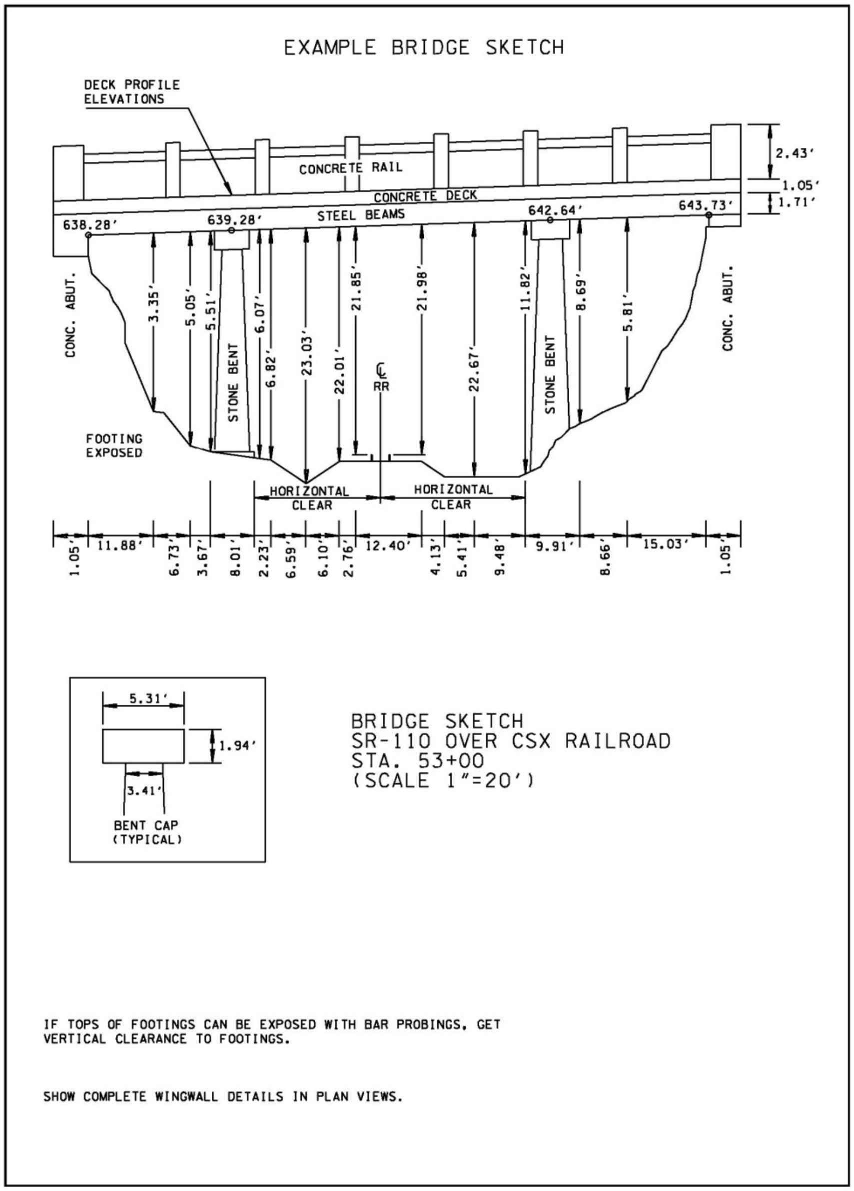


Figure A-22
Example Bridge Sketch

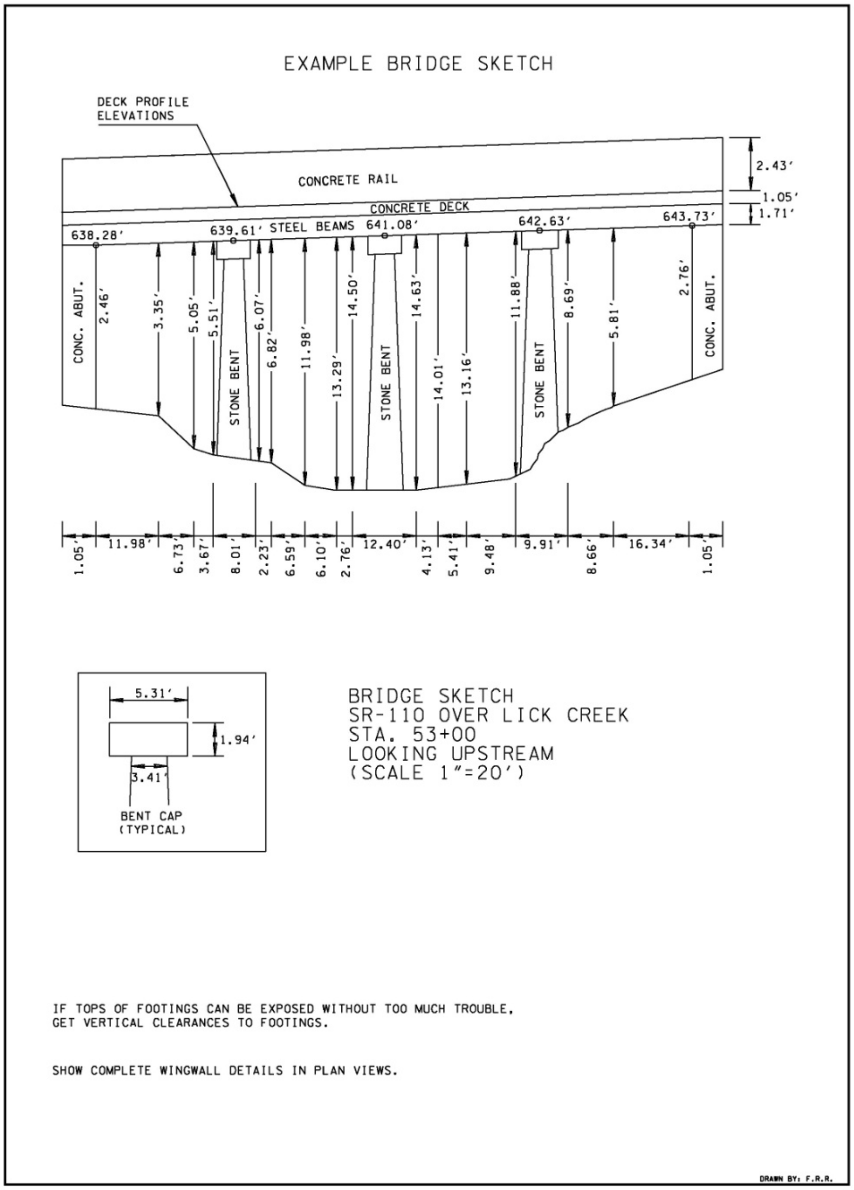


Figure A-23
Example Bridge Sketch

Tennessee Department of Transportation
Geodetic Survey Section

Project Name: ___________ Point Name: ____________Operator: ____________

Date: __________________ County: ___________________

Project Description (Include Termini): _______________________________________

Setup Type: (Circle one): 5" data 15" data stop-go rover stop-go base

Receiver SN: ____________ Controller SN: ____________ Card No: ______________

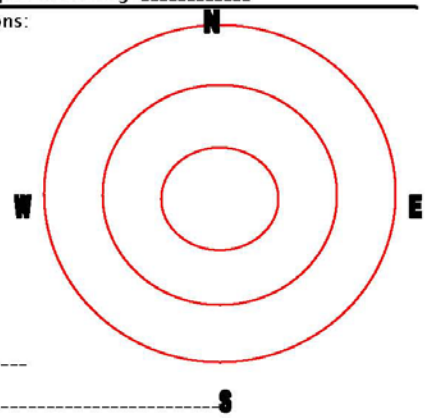
Antenna Offset = 0.441 m
Scale H.I. Reading = _____ m
Total Height = -____ m

Time Started Measuring: ____________

Time Stopped Measuring: ____________

Checklist:
Are tripod legs firm? ----
Is receiver head high? ----
Is Antenna oriented North? ----
Have you pressed measure? ----

Obstructions:



Comments: (Gdop, Errors, Etc.)

____

____

____

____

____

____

____

____

____

ALT KEYS

Alt-A = Audio Alarm on/off	Alt M = Message history	Alt L = Locks Keyboard
Alt B = Battery Status	Alt R = Help for alt keys	Alt U = Unlocks Keyboard
Alt I = Illumination on/off	Alt + = Increase contrast	Alt W = Warnings help
Alt K = Keyboard on/off	Alt - = Reduce contrast	

Figure A-24
Site Log

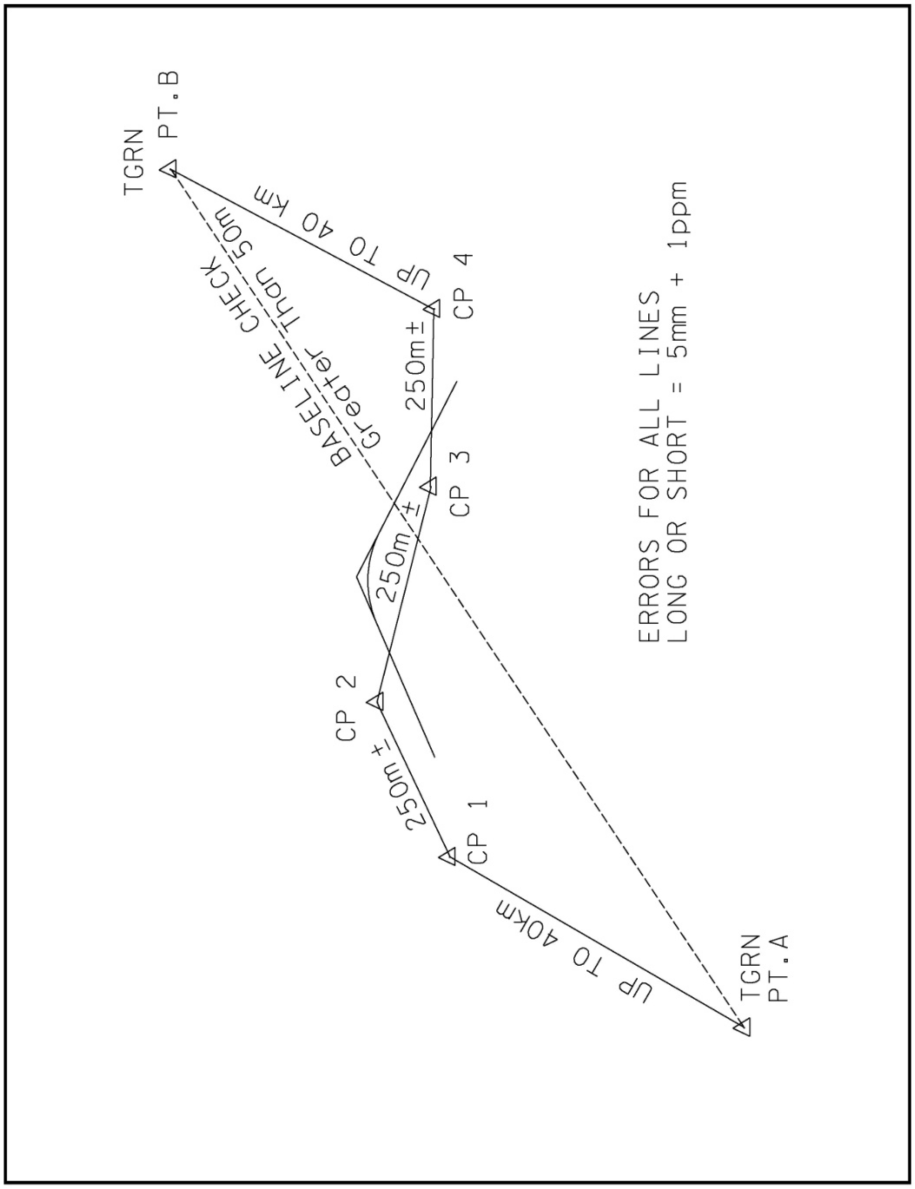


Figure A-25
Example of Traverse Method

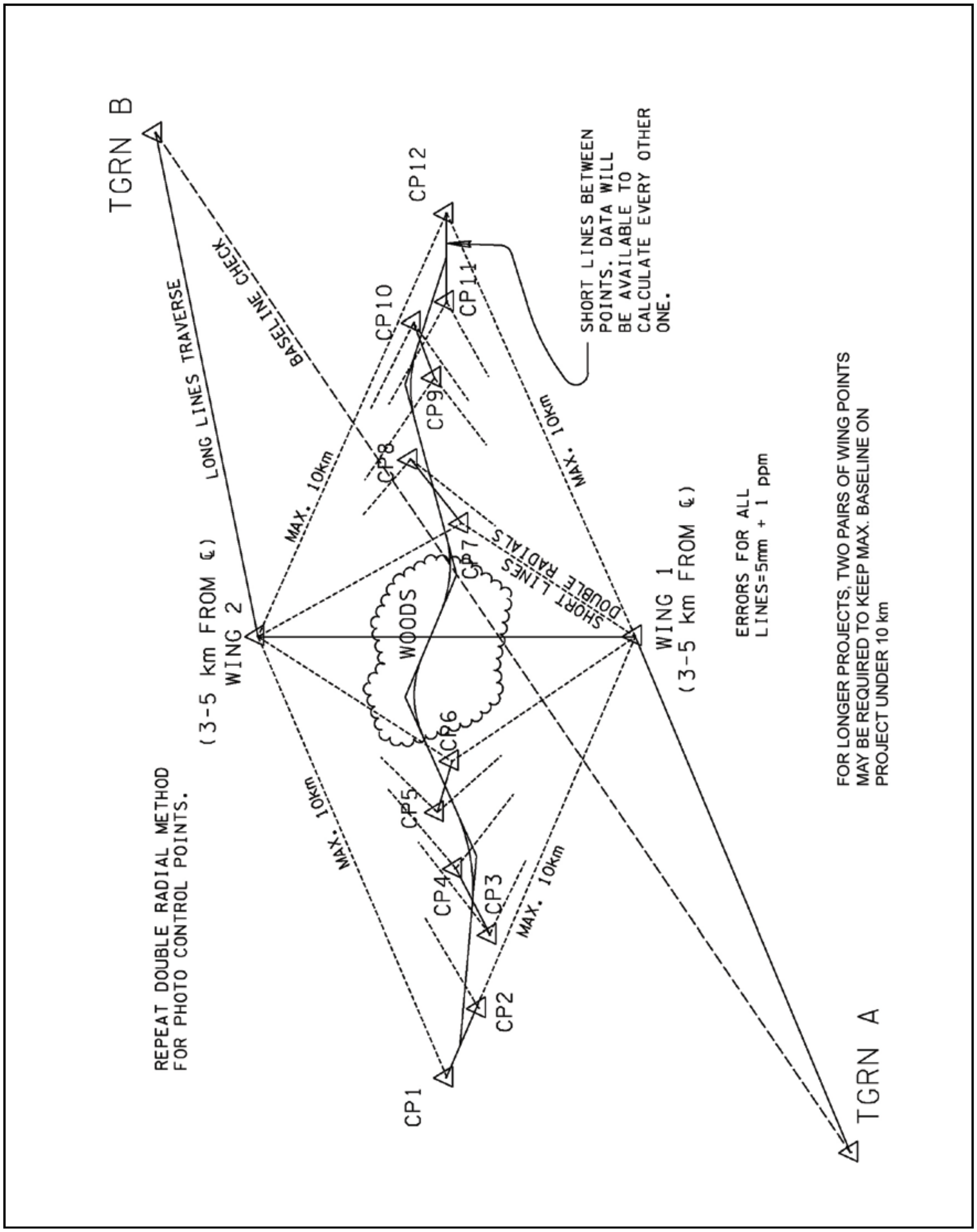


Figure A-26
Example of Wing Point Method

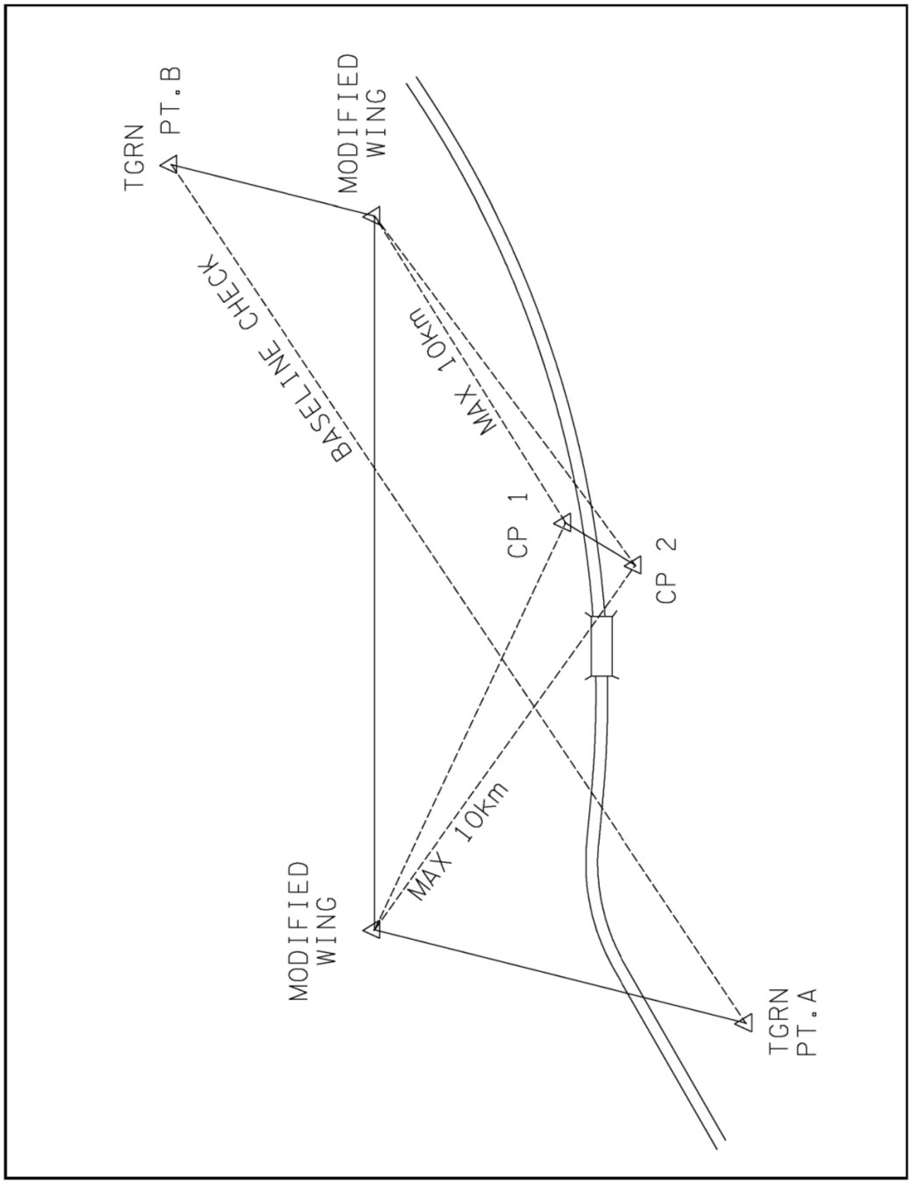


Figure A-27
Example of Modified Wing Point Method

COUNTY CODES			
REGION 1	**REGION 2**	**REGION 3**	**REGION 4**
ANDERSON – AN	BLEDSOE – BS	BEDFORD – BD	BENTON – BN
BLOUNT - BT	BRADLEY – BR	CHEATHAM – CT	CARROLL – CA
CAMPBELL - CM	CANNON - CN	DAVIDSON - DV	CHESTER - CH
CARTER - CR	CLAY - CL	DICKSON - DS	CROCKETT - CK
CLAIBORNE - CB	COFFEE - CF	GILES - GI	DECATUR - DE
COCKE - CO	CUMBERLAND -CU	HICKMAN - HI	DYER - DY
GRAINGER - GG	DEKALB – DK	HOUSTON – HO	FAYETTE – FA
GREENE - GR	FENTRESS - FE	HUMPHREYS - HU	GIBSON - GB
HAMBLEN - HB	FRANKLIN - FR	LAWRENCE - LW	HARDEMAN - HM
HANCOCKE - HC	GRUNDY - GD	LEWIS - LE	HARDIN - HD
HAWKINS - HK	HAMILTON - HT	LINCOLN - LI	HAYWOOD - HW
JEFFERSON - JF	JACKSON - JK	MACON - MC	HENDERSON - HS
JOHNSON - JN	McMINN - MM	MARSHALL - MS	HENRY – HY
KNOX - KN	MARION - MA	MAURY - MU	LAKE - LK
LOUDON - LO	MEIGS - ME	MONTGOMERY - MT	LAUDERDALE - LD
MONROE - MR	OVERTON - OV	MOORE - MO	McNAIRY - MN
MORGAN – MG	PICKETT - PI	PERRY - PE	MADISON - MD
ROANE - RO	POLK - PO	ROBERTSON - RB	OBION - OB
SCOTT - SC	PUTNAM – PU	RUTHERFORD – RF	SHELBY - SH
SEVIER - SE	RHEA – RH	SMITH - SM	TIPTON - TI
SULLIVAN – SL	SEQUATCHIE - SQ	STEWART - ST	WEAKLEY - WE
UNICOI - UC	VAN BUREN - VB	SUMNER - SU	
UNION – UN	WARREN – WR	TROUSDALE – TR	
WASHINGTON - WS	WHITE - WH	WAYNE - WA	
		WILLIAMSON - WM	
		WILSON – WI	

Table A-6
County Codes

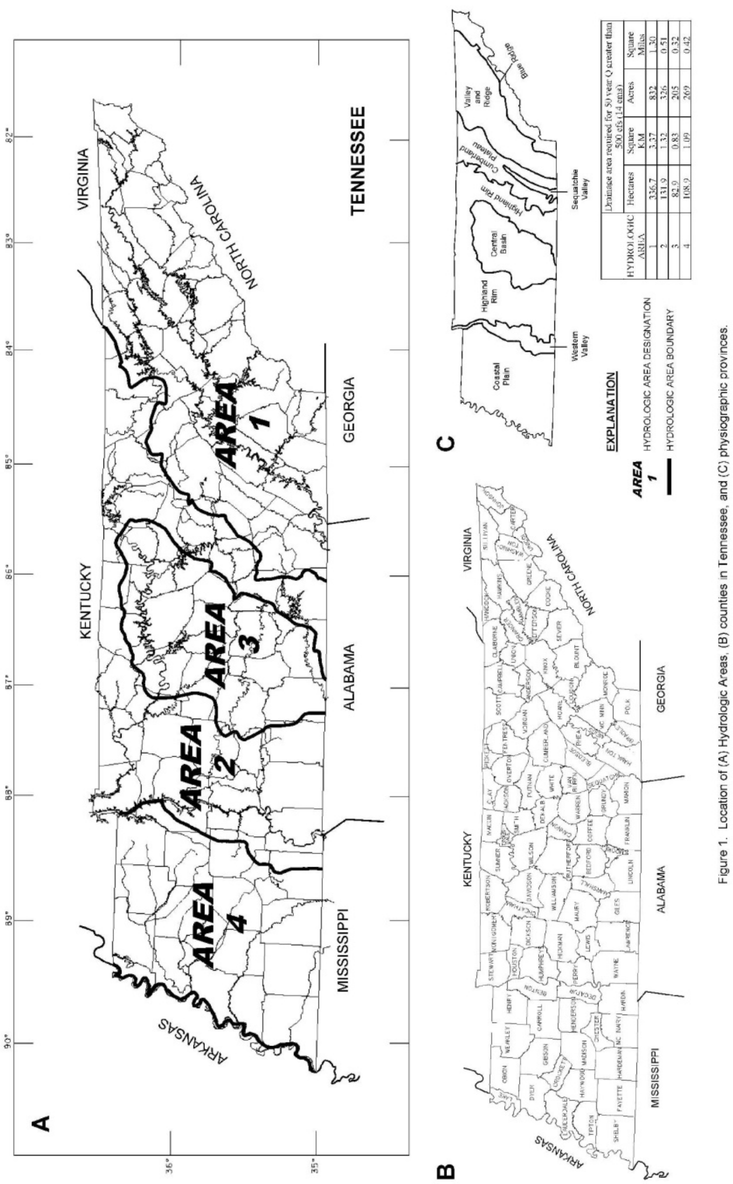


Figure A-28
Hydrologic Areas

FIELD - SURVEY CHECKLIST

PROJECT NO.:	
COUNTY:	
ROUTE NO.:	
DESCRIPTION:	
SURVEY CHECKLIST SHALL BE COMPLETED BY TDOT REGIONAL SURVEY OFFICE AND PLACED IN THE PROJECT FOLDER	

GENERAL:
Note: When locating features, MOST of them will require a comment. Examples are:

Buildings: type & description	**1-S-F RES, 2-S-B BILL'S PIZZA**	
Poles: utility lines on the poles	**P/T/C**	
Streams, lakes, etc.: names	**LITTLE GOOSE CREEK,**	**REELFOOT LAKE**
Pipes: size & type	**24" RCP,**	**30" CMP**
Roads: name & type of surface	**MAIN STREET**	**(ASP.)**

____ Property owners contacted & contact forms filled out
____ Railroad right-of-entry obtained

CONTROL

____ Additional, main control points set & located. Traverse closures as needed.
____ Bench marks set and located (if applicable)

PROPERTY

____ Property corners (front, side, and back) located
____ Present R.O.W. monuments or other R.O.W. evidence located

TOPO

____ Comments added to all possible points
____ (no aerial) Topo located
____ (w/aerial) Topo that is not on the aerial survey located
____ (w/aerial) Label aerial survey topo on a paper plot
____ Septic tanks & field lines located
____ Wells located
____ Fuel tanks located and get size, owner ID #, and facility # of them
____ Historical features located
____ Environmental features located
____ Log mile posts located on state routes and interstates. Comment example: LM-8

DTM

____ (no aerial) DTM within the project length & width.
____ (w/aerial) DTM: obscure areas filled in, within the project width.
____ (w/aerial) DTM: densify around drainage structures and in ditches.
____ (w/aerial) DTM & Locate all pavement ties on mainline and sideroads (crown, edges of pavement, shoulders, ditches).

1

FIELD - SURVEY CHECKLIST

BRIDGE SURVEYS

____ Locate the existing bridge and wingwalls.
Comment example: 3-SPAN CONC. & STEEL BRIDGE.
____ Obtain ordinary water and high water elevations.
The very bottom flow-line of the stream, top of water, and top of bank located.
____ The length up and down stream is approx. 6 times the typical distance between top of banks.
Upstream and downstream flood plain sections, taken to above the high water elevation, perpendicular to the stream flow.
____ The location is approximately 4 times the typical distance between top of banks
____ Bridge sketch (put in a separate data collector file).
____ Existing roads located and DTM taken to above the high water elevation.
____ Locate a center line (feature code DECK) on bridge decks (abutment to abutment)

UTILITIES

____ All Poles located. Comment example: P/T/C
____ Water lines, valves, and meters located.
____ Gas lines, valves, and meters located.
____ UG Telephone lines and pedistals located.
____ UG Fiber Optic lines and pedistals located.
____ UG Cable and pedistals located.
____ UG Electric lines and junction boxes located.
____ Manholes located.
____ TVA towers located (get tower numbers).
____ Signal heads & span wires located
____ Traffic control devices located.
____ Low Wire crossings (locate the lines pole-to-pole).
____ Low Wire crossing point located (list numbers of each type of wire and temperature).
____ Sanitary Sewer lines and Manholes (top, bottom, inverts) located.

DRAINAGE

____ Pipes & Box Culverts located (size & type).
____ Storm Sewer lines and catch basins / manholes (top, bottom, inverts) located.
____ Floor elevations of buildings subject to flooding.
____ Wetlands (notify the office if wetlands are possible).
____ Wetlands (locate them after they are flagged).
____ Springs located.
____ Sink holes located.

RAILROADS

____ Tracks, and all features located 600' each way from centerline, within the RR Row.
____ Locate any evidence of railroad ROW.
____ For at grade crossings, DTM 200' each way from centerline, within the RR ROW width.
For grade separation crossing, DTM width is the same as the roadway's.
____ Distance to nearest mile post, and get the mile number.

FIELD - SURVEY CHECKLIST

COMMENTS:	

SIGNATURE OF PARTY LEADER

SIGNATURE OF FIELD SUPERVISOR

3

OFFICE - SURVEY CHECKLIST

PROJECT NO.:	
COUNTY:	
ROUTE NO.:	
DESCRIPTION:	
SURVEY CHECKLIST SHALL BE COMPLETED BY TDOT REGIONAL SURVEY OFFICE AND PLACED IN THE PROJECT FOLDER	

PRELIMINARY

____ Get copies of tax maps, owners' names & addresses & phone numbers.
____ Get copies of deeds and plats.
____ Property owner contact letters written and mailed.
____ Railroad right-of-entry obtained.
____ Get quad maps.
____ Get old railroad ROW plans, if required.
____ Get copies of old highway plans.
____ Utility companies contacted for marking.

PLANIMETRIC

GENERAL:
____ Mainline survey length (also starting and ending points) correct.
____ Sideroads' survey length (also starting and ending points) correct.
____ Project description.
____ Drawing scale.
____ North arrow, placed near the planimetrics area.
____ Ties to prior surveys.
____ Plot all field data.

CONTROL:
____ Reference Datum noted (Horizontal & Vertical).
____ Control points table (Point #, North, East, Elevation, Station, Offset).
____ Survey tied at the beginning to existing log mile marker (if available).

TOPO:
____ All topography located and labeled.
____ Septic tanks & field lines shown, or location noted, on tracts not served by a sanitary sewer.
____ Underground fuel tanks (size, owner ID #, facility #).
____ Historical features.
____ Environmental features.
____ Ground cover labeled.
____ Wells shown, or water source noted, on tracts not served by a public water utility company. List the name & address of driller, date drilled, depth, property owner at the time of drilling.

OFFICE - SURVEY CHECKLIST

CENTERLINES:

____ Alignment and Base Chains named descriptively, such as a road or stream name.
____ Stationing on the mainline is in the direction of increasing log mile. If no log mile is available, stationing is south-to-north and west-to-east.
____ Stationing on sideroads left-to-right looking forward on the mainline, except for Interstates or State Routes, which are stationed by their log mile direction.
____ Bearings on curve tangents agree with bearings on adjoining centerline tangent sections.
____ Centerlines shown.
____ Curve tangents, PI symbol, point circles.
____ Station tics shown correctly.
____ Full tics at 500' stations.
____ Even 5 stations shown in figures.
____ Bearings.
____ Complete curve data.
____ Side roads' centerline intersection station equations.
____ Coordinates for all centerline PI's.
____ Coordinates for all centerline begin & end points.

PROPERTY:

____ Property lines.
____ Each tract shown in its entirety (where scale will allow).
____ Property lines' metes & bounds.
____ If a centerline crosses a property line or curve, show station of intersection and divide the property line or curve, and metes & bounds, in two.
____ Property owners' names.
____ Property tracts numbered.
____ Use separate tract #'s if property is disconnected.
____ Tracts numbered consecutively from the beginning of the project, crisscrossing the centerline as necessary.
____ Property overlaps and unclaimed property noted.
____ City, County, & State boundary lines.
____ All access to properties.

PRESENT ROW AND EASEMENTS:

____ Present ROW shown.
____ Present ROW labeled as such, along mainline and along sideroads.
____ Present ROW metes & bounds.
____ If a centerline crosses a present ROW line or curve, show station of intersection and divide the ROW line or curve, and metes & bounds, in two.
____ Present easements shown.
____ Station/offset flags on present ROW (end & bend pts, curve points, property intersections).

OFFICE - SURVEY CHECKLIST

UTILITIES:

____ All utilities shown (sizes & types).
____ Utility owners' list (names, addresses, contact person, and phone).
____ Limits of service shown when 2 utility owners supply the same service.
____ Utility easements.
____ Easements shown for any utility line outside the present R.O.W.
____ Elevations (top) of manholes, plus bottom and inverts for sanitary sewer manholes.
____ TVA towers & tower numbers.
____ Signal heads.
____ Major utilities shown (sizes & types).

DRAINAGE:

____ Boundary lines shown completely for each area.
____ Drainage information blocks filled in for every area.
____ Copy of quad map used to mark boundary lines.
____ Size, type, & length of existing drainage structures.
____ Elevations (top, bottom, inverts) of catch basins and manholes.
____ Elevations (inverts) of pipes & boxes.
____ Floor elevations of buildings subject to flooding.
____ Wetlands (with areas).

RAILROAD SURVEYS

____ RR centerline geometry (labeled the same as a road centerline).
____ All railroad topography within RR ROW for 600' each direction
____ RR centerline intersection station equations.
____ Distance to nearest mile marker, and the milepost number.
____ Profile of tops of each rail of railroad crossing.
____ Add the railroad company to the utility owners' list.

BRIDGE SURVEYS

____ Stream baseline & flood plain section lines shown and labeled (like horizontal alignments).
____ Profile flood plain sections (plans scale) (show type vegetation and high water).
____ Profile of centerlines of existing roads, completely through the floodplain (show highwater).
____ Profile of stream bed, top-of-water, top-of-bank, (plans scale).
____ Sketch of existing bridge opening. (scale: 1"=10' or 1"=20')
____ Stream data block filled in.

OFFICE - SURVEY CHECKLIST

DIGITAL TERRAIN MODEL AND TIN

____ Mainline DTM length and width (also starting and ending points) correct.
____ Sideroads' DTM length and width (also starting and ending points) correct.
____ Non-ground-surface points and points off project limits removed from DTM.
____ Break line crossings resolved.
____ Obscure areas within limits of project filled in.
____ Check for elevation errors (by contouring or rendering).
____ (w/aerial) DTM: densify around drainage structures and in ditches where needed
____ (w/aerial) DTM & Locate all pavement ties on mainline and sideroads (crown, edges of pavement, shoulders, & ditches).

PROFILE

GENERAL:

____ Each separate profile labeled with the road name.
____ Stations & Elevations to proper scale.
____ Groundline profiles have "grn" in their names.

CENTERLINES:

____ All centerline ground line profiles plotted.
____ Bridge deck profile (when applicable).
____ Centerline intersection station equations.
____ Stations & elevations of each railroad rail crossing.
____ Bench marks.
____ Underground utilities profiles (parallel to centerline).
____ Underground utilities (crossing the centerline).
____ Low wires (station, elevation, type) shown (add temperature for high-tension lines).
____ Existing drainage structures that cross a centerline (bridges, pipes, box culverts) (show size, type, station, invert, direction of flow).
____ Storm & sanitary sewers profiles (parallel to centerline).
____ Storm & sanitary sewers (crossing the centerline).
____ High water & normal water elevations at stream crossings.

ROW ACQUISITION TABLE

____ Tract numbers agree with planimetrics.
____ Owners' names correct as taken from the deed.
____ All columns filled out properly.

FINALIZE

____ All features match TDOT features.
____ Text and other drafting element overlaps resolved
____ Text, lines, and symbols rotated to the mainline alignment.
____ Check each individual Microstation level for correct color, weight, linestyle & element type.
____ Detach all files that are not turned in with the survey.

4

OFFICE - SURVEY CHECKLIST

COMMENTS:	

SIGNATURE OF FIELD SUPERVISOR

SIGNATURE OF REGIONAL SUPERVISOR

5