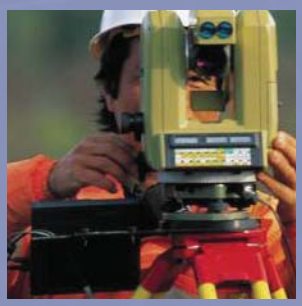

TENNESSEE DEPARTMENT OF TRANSPORTATION

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

TABLE OF CONTENTS

CHAPTER 1 - INTRODUCTION AND GENERAL INFORMATION 1-1
1.1 Purpose 1-1
1.2 Organization 1-1
1.3 Public Relations 1-1
1.3.1 General 1-1
1.3.2 Questions from the Public 1-1
1.3.3 Property Owners 1-2
1.3.4 Right of Entry 1-2
1.3.5 Pre-Entry Contacts 1-2
1.3.6 Objection to Entry 1-2
1.4 Legal Aspects 1-2
1.4.1 Right to Enter Private Property 1-2
1.4.2 Claims for Damage to Private Property 1-2
1.4.3 Citizen's Right To View Documents 1-3
1.4.4 Right to Control Traffic During Survey 1-3
1.5 Safety 1-3
1.6 Project Naming Conventions 1-3
1.7 Procedure for Submitting Surveys 1-4
1.7.1 Submittal 1-4
1.7.2 New Surveys 1-4
1.7.3 Additional Information and Survey Updates 1-4
1.7.4 Field and Office Survey Checklist 1-4

CHAPTER 2 - AERIAL SURVEYS AND MAPPING 2-1
2.1 Introduction 2-1
2.2 Correspondence 2-1
2.3 Standard Parameters 2-1
2.4 Ground Control Preparation 2-2
2.4.1 Pre-Flight Targeting 2-2
2.4.2 Horizontal Control 2-2
2.4.3 Vertical Control 2-3
2.5 Aerial Mission 2-4
2.6 Photo Products 2-5
2.7 Analytical Aerial Triangulation 2-5
2.8 Digital Mapping File Requirements 2-5
2.9 Map Compilation Techniques 2-6
2.10 Map Content 2-6
2.10.1 Control Points 2-6
2.10.2 Planimetric Detail 2-6
2.10.3 Topographic Detail 2-7
2.10.3.1 Contours 2-7
2.10.3.2 Spot Elevations 2-7
2.11 Digital Terrain Model Production 2-7
2.12 Map Accuracy Standards 2-8
2.13 Feature Descriptions 2-9
2.13.1 Spot Elevation 2-9
2.13.2 Water Elevation 2-9
2.14 Survey Control Information & Manuscript Data 2-9

2.14.1 Traverse/ GNSS Point 2-9
2.14.2 Mapping Limits Line 2-9
2.14.3 Title Block 2-9
2.14.4 Existing Transportation Features 2-9
2.14.5 Existing Roadside Barriers and Text For Level # 7 & 8 2-11
2.14.6 Existing Non-Transportation Features 2-11
2.14.7 Existing Natural Drainage Features 2-13
2.14.8 Existing Vegetation Features 2-14
2.14.9 Existing Bridges & Drainage Structures 2-14
2.14.10 Existing Storm Drainage 2-15
2.14.11 Existing Signs & Traffic Control 2-15
2.14.12 Existing Utilities (Ground & Underground) 2-16
2.14.13 Existing Utilities (Overhead) 2-16

CHAPTER 3 - SURVEYING PROCEDURES AND PRACTICES 3-1
3.1 General Survey Procedures 3-1
3.2 Project Control (General) 3-1
3.2.1 Horizontal 3-1
3.2.2 Vertical 3-2
3.3 Project Control (GNSS Procedures) 3-2
3.3.1 Pre-Planning 3-2
3.3.2 Reconnaissance 3-2
3.3.3 Receiver Setup Procedures 3-3
3.3.3.1 Static Method 3-3
3.3.3.2 RTK Method With a Base Station 3-3
3.3.4 Observation Methods 3-3
3.3.4.1 Static Methods 3-4
3.3.5 Traverse Method 3-4
3.3.6 Wing Point Method 3-5
3.3.7 RTK Method 3-6
3.3.8 Post-Processing Static Data 3-6
3.3.9 TDOT Control Point Database Use 3-7
3.4 Development of Survey CADD Files 3-9
3.4.1 General 3-9
3.4.1.1 TNDOT.smd 3-9
3.4.2 The Planimetrics File 3-10
3.4.2.1 Filename 3-10
3.4.2.2 Content 3-10
3.4.2.3 Notes 3-10
3.4.3 The Digital Terrain Model 3-11
3.4.3.1 Definitions 3-11
3.4.3.2 Filename 3-11
3.4.3.3 Notes 3-11
3.5 Final Alignment and Topography 3-12
3.5.1 Alignment 3-12
3.5.1.1 General 3-12
3.5.1.2 Stationing 3-12
3.5.2 Curves 3-12
3.5.3 Tangents 3-12
3.5.4 Staking Final Alignment 3-12

3.5.4.1 Alignment Points 3-12
3.5.4.2 Staking 3-13
3.5.5 Reference Points 3-13
3.6 Topography 3-13
3.6.1 General 3-13
3.6.2 Data Collection (Total Station and RTK) 3-13
3.6.3 Property Owner Contact 3-13
3.6.4 At Grade Road Crossings 3-14
3.6.5 At Grade Railroad Crossings 3-14
3.6.6 Property Lines 3-14
3.6.7 Present Right-of-Way 3-16
3.6.7.1 General 3-16
3.6.7.2 User's Line 3-16
3.6.7.3 Old Right-of-Way Plans 3-17
3.6.8 Utilities 3-17
3.6.8.1 Owners 3-17
3.6.8.2 Limits 3-17
3.6.8.3 Location and Profile 3-17
3.6.8.4 Underground 3-18
3.6.8.5 Overhead 3-18
3.6.8.6 Signals 3-18
3.6.8.7 Pole or Tower Number 3-18
3.6.8.8 Type of Utility 3-18
3.6.8.9 Storm Sewers and Sanitary Sewers 3-18
3.6.8.10 Septic Tanks and Drain Fields 3-18
3.6.8.11 Wells 3-18
3.6.8.12 Location For Pay Item Purpose 3-19
3.6.8.13 Problems 3-19
3.6.9 Land Character 3-19
3.6.9.1 Stock and Equipment Passes 3-19
3.6.9.2 Trees 3-19
3.6.10 Existing Drainage Structures 3-19
3.6.11 Buildings 3-19
3.6.12 Ramps and Driveways 3-20
3.6.13 Underground Petroleum Storage Tanks 3-20
3.6.14 Other Topographic Features 3-20
3.6.15 Field Notes 3-21
3.6.16 Plotting 3-21
3.6.16.1 General 3-21
3.6.16.2 Scale 3-21
3.6.16.3 Horizontal and Vertical Datum 3-21
3.6.16.4 Coordinate Values for P.I.'s 3-21
3.6.16.5 Complete Names 3-21
3.7 Bench Levels and Check Levels 3-21
3.7.1 Vertical Datums 3-21
3.7.2 Methods and Accuracy 3-21
3.7.3 Bench Mark Location 3-22
3.7.4 Descriptions 3-22
3.8 Profile and Cross Sections 3-22
3.8.1 Procedures 3-22

3.8.1.1 General ... 3-22
3.8.1.2 Requirements ... 3-22
3.8.1.3 Methods ... 3-22
3.8.1.4 Driveway and Ramp Profiles ... 3-22
3.8.1.5 Side Roads ... 3-22
3.8.1.6 Trigonometric Methods ... 3-22
3.8.1.7 Notes ... 3-23
3.8.1.8 Data Collectors ... 3-23
3.8.2 Profile Plotting ... 3-23
3.8.2.1 General ... 3-23
3.8.2.2 Items to be Plotted ... 3-23
3.9 Drainage Surveys ... 3-24
3.9.1 Drainage Map ... 3-24
3.9.1.1 Methods ... 3-24
3.9.1.2 Notes ... 3-24
3.9.1.3 Plotting ... 3-24
3.9.2 General Requirements For Bridge and Culvert Surveys ... 3-25
3.9.2.1 Section 404 Permit Information ... 3-25
3.9.2.2 Definitions ... 3-25
3.9.2.3 Field Data ... 3-25
3.9.2.4 Names and Addresses ... 3-25
3.9.2.5 Sizing Drainage Structures ... 3-25
3.10 Drainage Site Surveys ... 3-25
3.11 Bridge Surveys ... 3-25
3.11.1 Flood Plain Sections ... 3-26
3.11.2 Stream Profile ... 3-26
3.11.3 Roadway Profile ... 3-26
3.11.4 DTM Development ... 3-27
3.11.5 Topography ... 3-27
3.11.5.1 Buildings and Other Structures Subject to Flooding ... 3-27
3.11.5.2 Construction Clearance For Bridge Projects ... 3-27
3.11.5.3 Existing Structures ... 3-27
3.11.5.4 High Water and Normal Water ... 3-27
3.11.5.5 Questions ... 3-28
3.11.6 Plotting ... 3-28
3.11.6.1 Topography ... 3-28
3.11.6.2 Profiles (Generated from DTM) ... 3-28
3.11.6.3 Sketches ... 3-28
3.11.6.4 Drainage Map ... 3-28
3.11.6.5 Quad Sheet ... 3-28
3.12 Pipe and Box Culvert Surveys ... 3-28
3.12.1 Topographic Surveys ... 3-28
3.12.2 DTM ... 3-29
3.12.3 Text ... 3-29
3.12.4 Erosion Control ... 3-29
3.13 Property Map ... 3-29
3.13.1 Procedures ... 3-29
3.13.2 Sources of Information ... 3-29
3.13.3 Map Limits ... 3-29
3.13.4 Tract Numbers ... 3-29

3.13.5 R.O.W. Acquisition Table ... 3-30
3.14 Grade Separations (Roadway) ... 3-30
3.14.1 Field Data Required ... 3-30
3.14.2 Plotting ... 3-30
3.15 Grade Separations (Railroad) ... 3-30
3.15.1 Field Data Required ... 3-30
3.15.2 Plotting ... 3-31
3.16 Bridge Widening ... 3-31
3.16.1 Bridge Widening Projects ... 3-31
3.17 Special Surveys ... 3-32
3.17.1 Staking Right-of-Way ... 3-32
3.17.2 Staking Sounding Holes ... 3-33
3.17.3 Additional Information ... 3-33
3.17.4 Updates ... 3-33
3.17.5 Noise Analysis Surveys ... 3-33
3.17.5.1 Noise Sensitive Areas ... 3-33
3.17.5.2 Critical Distances ... 3-33
3.17.5.3 Survey ... 3-33

CHAPTER 4 - CARE AND MAINTENANCE ... 4-1
4.1 Care and Maintenance ... 4-1
4.1.1 General ... 4-1
4.1.2 Total Stations and Levels ... 4-1
4.1.3 Total Stations ... 4-1
4.1.4 Tripods, Level Rods and Other Equipment ... 4-2
4.1.5 Global Navigation Satellite System (GNSS) Equipment ... 4-2
4.1.6 Office Equipment ... 4-2
4.2 Adjustments ... 4-2
4.3 Supplies ... 4-3

CHAPTER 5 - GENERAL SURVEY INFORMATION AND CONSULTANT COORDINATION 5-1
5.1 Survey Datums and the Tennessee Grid System ... 5-1
5.1.1 Origin of Datums ... 5-1
5.1.2 Vertical Datum ... 5-1
5.1.3 Horizontal Datum ... 5-1
5.1.4 Tennessee Geodetic Reference Network (TGRN) ... 5-1
5.1.5 Tennessee Grid System ... 5-2
5.2 Accuracy and Errors ... 5-5
5.2.1 Accuracy and Precision ... 5-5
5.2.2 Significant Figures ... 5-5
5.2.2.1 Definition ... 5-5
5.2.2.2 Examples ... 5-5
5.2.2.3 Field Notes ... 5-5
5.2.3 Calculations ... 5-6
5.2.4 Order of Accuracy ... 5-6
5.2.5 Definition of Error ... 5-6
5.2.6 Types of Errors ... 5-6
5.2.6.1 Systematic ... 5-6
5.2.6.2 Accidental ... 5-7
5.2.7 Source of Errors ... 5-7

5.2.7.1 Personal 5-7
5.2.7.2 Instrumental 5-7
5.2.7.3 Natural 5-8
5.3 Design Criteria and Standard Drawings Pertaining to Surveys 5-8
5.3.1 General 5-8
5.3.2 Alignment Criteria Given 5-8
5.3.3 Design Criteria 5-8
5.4 Reports and Correspondence 5-9
5.4.1 Weekly Report 5-9
5.4.2 Man-Day Report 5-9
5.4.3 Survey Transmittal Letter 5-9
5.4.4 Survey Check Sheet 5-9
5.5 Field Books 5-9
5.5.1 General 5-9
5.5.2 Bench Mark Levels 5-9
5.5.3 Profile Notes 5-10
5.6 Horizontal and Vertical Measurements 5-10
5.6.1 Linear Measurement 5-10
5.6.2 Angular Measurement 5-10
5.6.3 Vertical Measurement 5-10
5.7 Coordination of Consultant Survey Projects 5-10
5.7.1 General 5-10
5.7.2 Contacts 5-10
5.7.2.1 Contractual Matters 5-10
5.7.2.2 Work Related Matters 5-11
5.7.3 Estimates 5-11
5.7.3.1 Contacts 5-11
5.7.3.2 Preparation 5-11
5.7.3.3 Department 5-11
5.7.3.4 Submittal 5-11
5.7.3.5 Procedures 5-11
5.8 Coordination of Consultant Survey and Design Projects 5-12
5.8.1 General 5-12
5.8.2 Bridge Survey / Setting Grades 5-12

LIST OF FIGURES

Figure 3-1 Example Floodplain Section 3-26
Figure 3-2 Noise Survey Information 3-34
Figure 3-3 Noise Survey Information 3-35
Figure 5-1 TGRN Network 5-2
Figure 5-2 Lambert Conformal Map Projection 5-3
Figure 5-3 Tennessee Lambert Map Projection 5-4
Figure A-1 Property Owner Contact Form A-2
Figure A-2 Property Owner Contact Letter – Survey A-3
Figure A-3 Property Owner Contact Letter – Geotechnical Staking A-4
Figure A-4 Property Owner Contact Letter – ROW Staking A-5
Figure A-5 Example of Control Point Description Sheet A-6
Figure A-6 Example of Present Layout Sheet A-12
Figure A-7 Example of Present Layout Sheet A-13
Figure A-8 Example of Present Layout Sheet A-14
Figure A-9 Example of Profile A-16
Figure A-10 Example of Profile A-17
Figure A-11 Example of Profile A-18
Figure A-12 Example of Drainage Map A-19
Figure A-13 Example of DTM (Aerial Surveys, MicroStation® Format) A-20
Figure A-14 Example of Field Notes A-23
Figure A-15 Example of Field Notes A-24
Figure A-16 Example of Field Notes A-25
Figure A-17 Example of Field Notes A-26
Figure A-18 Example Aerial Survey Target, Block Photography, and Strip Photography A-27
Figure A-19 Example of Preliminary Bridge Drawing A-28
Figure A-20 Example Bridge Sketch A-58
Figure A-21 Example Bridge Sketch A-59
Figure A-22 Example Bridge Sketch A-60
Figure A-23 Example Bridge Sketch A-61
Figure A-24 Site Log A-62
Figure A-25 Example of Traverse Method A-63
Figure A-26 Example of Wing Point Method A-64
Figure A-27 Example of Modified Wing Point Method A-65
Figure A-28 Hydrologic Areas A-67

LIST OF TABLES

Table 2-1 Collection Parameters for Digital Terrain Models 2-8
Table 3-1 Summary of Static GNSS Methods 3-4
Table 3-2 GNSS Field Problems and Remedies 3-5
Table A-1 Control Points (Tabular Format) A-7
Table A-2 Tennessee Reservoirs A-11
Table A-3 Example of R.O.W. Acquisition Table A-15
Table A-4 Survey Standards Horizontal A-21
Table A-5 Survey Standards Vertical A-22
Table A-6 County Codes A-66