BUREAU OF RIGHT OF WAY

Volume II

SURVEY MANUAL

2020 Edition

KANSAS DEPARTMENT OF TRANSPORTATION

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Summary of Revisions to the 2014 Edition

Section	Old Page	New Page	Revision Description
Table of Contents:			
TOC	All	All	Updated All Sections
List of Figures:			
Figure 1.2.3-1	1-4	1-4	Corrected Title and New Image
Figure 1.2.3-2	1-5	1-5	New Image
Figure 3.4-1	3-6	0-0	Deleted Figure
Section 1:			
Figure 1.2.3-2	1-4	1-4	Updated Figure
Section 2:			
2.2.2	2-8	2-8	Highlighted text
2.2.3	2-10	2-10	Added Project Control Overview Text
Figure 2.2.3-1	0-0	2-11	New Figure for Project Control Overview
Section 3:			
3.2	3-2	3-2	Delete old paragraphs and add new section on Horizontal Control for KDOT Projects.
3.3	3-3	3-3	Delete old paragraphs and add new section on Primary Horizontal Control
3.4	3-4	3-4	Delete old paragraphs and add new section on Monumentation
3.6	3-8	3-8	Delete entire section

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EXECUTIVE SUMMARY

This Kansas Department of Transportation (KDOT) Design Manual has been compiled for the Division of Engineering and Design from the existing design manuals of the Bureau of Road Design, Coordinating Section, Bureau of Structures and Geotechnical Services, and the Bureau of Right of Way. Although these manuals have been consolidated for consistency of style and format, the essential integrity of each volume has been maintained. This manual should allow each employee and consultant of the Division of Engineering and Design to contribute to a uniform and consistent application of KDOT procedures.

In all four volumes, many of the subjects simply highlight the design criteria and procedures; however, it is not intended that the manuals be all-inclusive. Personnel are responsible for the complete understanding of their functions with the goal of providing safe, economical, and maintainable roads and structures.

KDOT DESIGN MANUAL ORGANIZATION

The KDOT Design Manual is organized into the following four volumes:

- *Volume I, Bureau of Road Design*
- *Volume II, Bureau of Right of Way, Survey Manual*
- *Volume III, Bureau of Structures and Geotechnical Services*
- *Volume IV, Bureau of Right of Way*

Volume I, Bureau of Road Design, is divided into three parts: Part A, "Procedures for Preparation of Highway Plans"; Part B, "Instructions to Road Designers"; and Part C, "Elements of Drainage and Culvert Design." Part A addresses procedures for the preparation of Grading Plans or Grading and Surfacing Plans Combined and for the preparation of Surfacing Plans. The order of topic discussion of this part corresponds closely to the order of occurrence of the activities required in the process of plan preparation. The sections in Part B discuss General Instructions, Drafting, Grading, and Surfacing. Part C provides the technical information and procedures used in the design of culverts, median drains, channels, and erosion protection, which are necessary for the control of highway surface waters.

Volume II, Bureau of Right of Way, Survey Manual, provides general guidelines for survey practice when performing field surveys for KDOT funded projects. It covers such subjects as KDOT policy regarding employee conduct toward the general public; safety issues related to handling tools and the problems common to the outdoor work environment (exposure to the elements, insects, snakes, poison ivy, etc.); general surveys; and horizontal control surveys.

Volume III, Bureau of Structures and Geotechnical Services, provides general guidelines, including detailed procedures and instructions, for the design and preparation of bridge plans and specifications. The topics introduced in this volume include plans for Preliminary Design; Analysis and Design; Bridge Load Rating; and Falsework Design, Analysis, and Inspection.

Volume IV, Bureau of Right of Way, offers KDOT procedures and policy for acquisition of properties, whether by purchase, condemnation, or other forms of possession. This volume shows

example maps, plats, plans, computer programs, descriptions, and surveys to be used as guidance for personnel in the Bureau of Right of Way.

Over time, KDOT procedures and policies may change as a result of the introduction of new technologies, new findings in research, or the development of new products. Periodically, the KDOT Design Manual will be revised to reflect current conditions and practices.

KANSAS DEPARTMENT OF TRANSPORTATION ORGANIZATION

KDOT is a multi-modal transportation agency, with its primary objective being the planning, design, construction, and maintenance of Kansas highways. The Division of Engineering and Design plays an essential role in achieving that objective. Nevertheless, it must be recognized that the citizens of the state of Kansas possess ultimate authority over the Department of Transportation.

See Figure 1 (Page ES-3) for the organization of the Department of Transportation from the Secretary of Transportation through the Bureau level.

See Figure 2 (Page ES-4) shows the organization of the Division of Engineering and Design.

Figure 1 Organization Chart, Secretary of Transportation through Bureau level, Department of Transportation

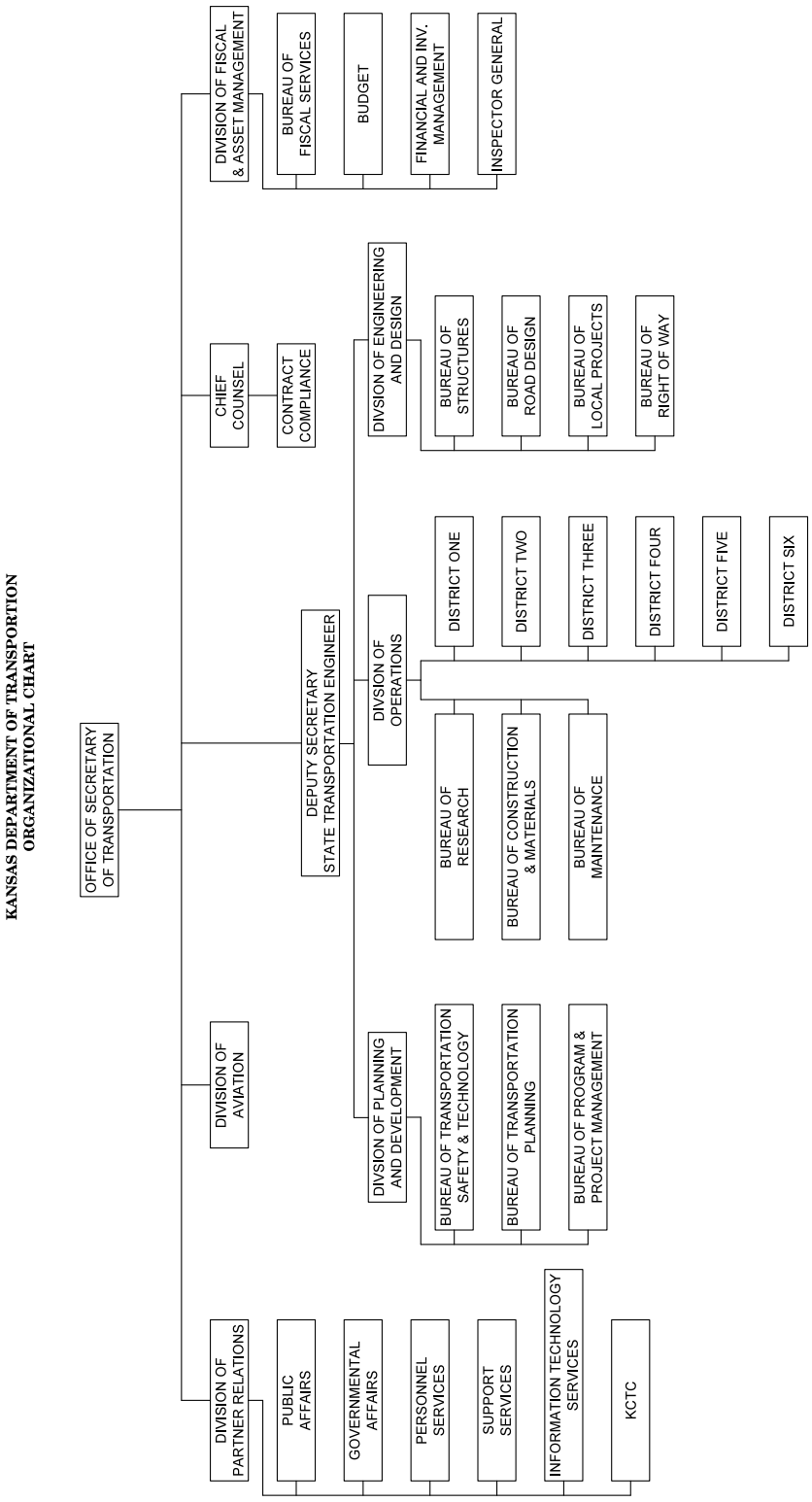
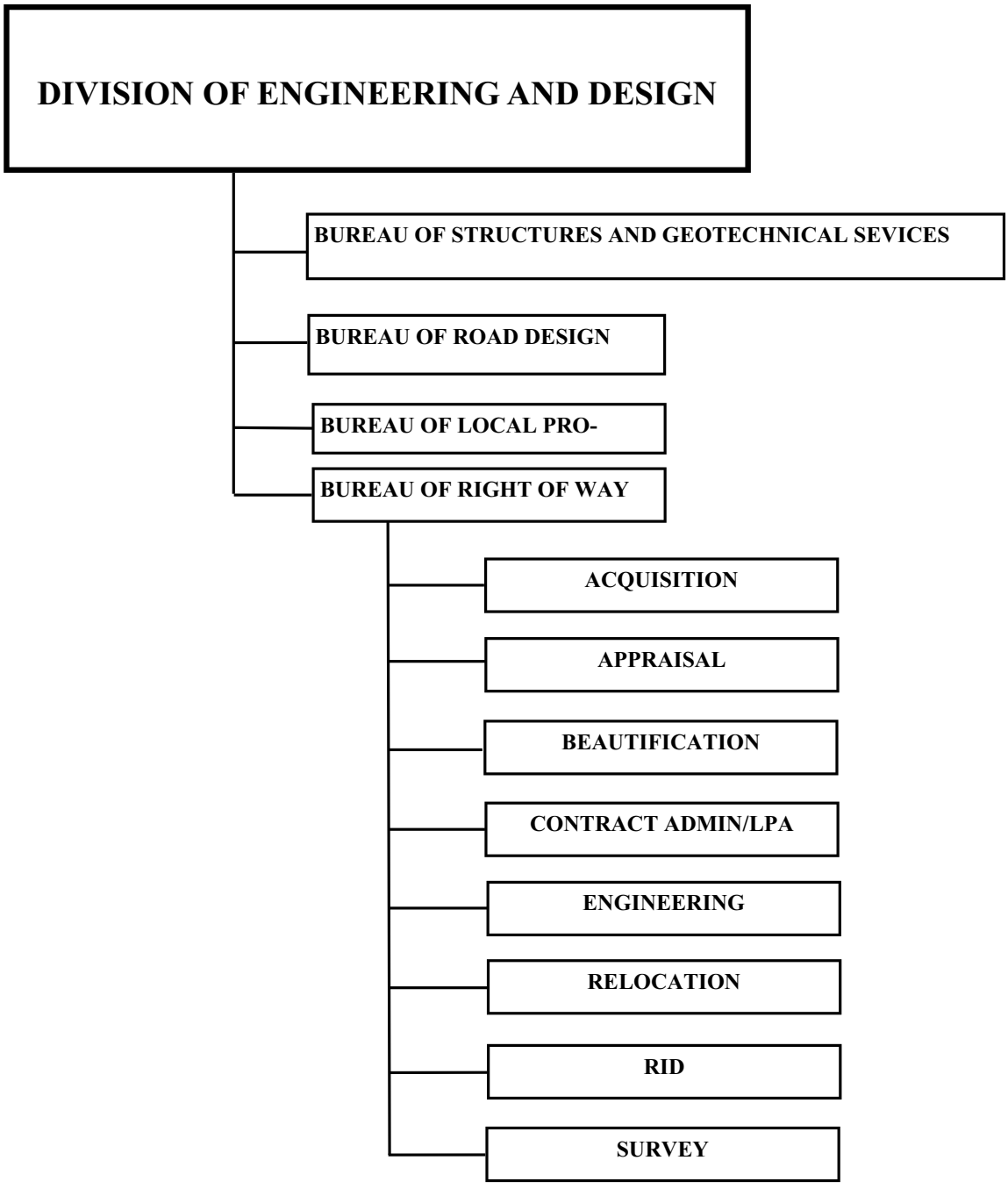


Figure 2 Organization Chart, Division of Engineering and Design, Department of Transportation



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ABBREVIATIONS/SYMBOLS

The following abbreviations may be used in this volume and subsequent volumes. The use of abbreviations shall be kept to a minimum and shall be used only where clarity and standard usage prevent confusion or misinterpretation.

abut.	Abutment
A/C	Access Control
Ac.	Acre
Ahd.	Ahead
Alum.	Aluminum
	Angle
Appr.	Approach
Ave.	Avenue
Avg.	Average
ADT	Average Daily Traffic
Azi.	Azimuth
Bar.	Barometer
Bk.	Back
	Base Line
Btry.	Battery
Brg.	Bearing
BM	Bench Mark
Blbd.	Billboard
Bit. Conc.	Bituminous Concrete
Bit Mat.	Bituminous Material
Blvd.	Boulevard
Bd.	Bound
Br.	Bridge
Bldg.	Building
BTC	Buried Telephone Cable
Calc.	Calculation
CI	Cast Iron

CIP	Cast Iron Pipe
CB	Catch Basin
Ctl. Gd.	Cattle Guard
Cem.	Cemetery
Ctr.	Center
℄	Center Line
Chs.	Chains
Ch. Ch.	Channel Change
CAF	Combined Adjustment Factor
Com.	Common
Conc.	Concrete
Const.	Construct
CJ	Construction Joint
Cont.	Continuous
CP	Contour Point
CR.	Creek
CL	Crop Line
Cor.	Corner
CMP	Corrugated Metal Pipe
CPP	Corrugated Plastic Pipe
X-Buck	Cross Buck
CTwd.	Cottonwood
Co.	County
+ Cut	Cross Cut
X-Sect	Cross Section
X-ing	Crossing
CRP	Cross Road Pipe
Cr. Gr.	Crown Grade
Cult.	Cultivated
C	Curb
C & G	Curb & Gutter
C.O.	Curb Opening

Culv.	Culvert
DM	Dead Man
D also °	Degree
∆ or Δ	Delta Angle
Dept.	Department
Dia.	Diameter
Diff.	Difference
Dt.	Ditch
DA	Drainage Area
Dr.	Drive
Esmt.	Easement
E	East
E. Bd.	East Bound
ENE	East Northeast
ESE	East Southeast
EM	Edge Mat
EP	Edge Pavement
ER	Edge Road
ET	Edge Timber
EDM	Electronic Distance Measure
EDMI	Electronic Distance Measuring Insturment
Elev.	Elevation
E. Sects.	End Section
Ent.	Entrance
Emb	Embankment
Estab.	Establishment
Exc.	Excavation
Exist.	Existing
Exp. Jt.	Expansion Joint
Extd.	Extended
Ext.	External
FAS	Federal Aid Secondary

Fc.	Fence
F.o.	Fiber Optic
FH	Fire Hydrant
Fl.	Floor
℄	Flow Line
Ftg.	Footing
Fwd.	Forward
Found.	Foundation
Fr.	Frame
Gar.	Garage
G.M.	Gas Meter
G.V.	Gas Valve
GLO	General Land Office
Govt.	Government
Gr.	Grade
Gr. Bld.	Grader Blade
Gnd.	Ground
Gd. Fc.	Guard Fence
Gd Stk.	Guard Stake
G	Gutter
G. Po.	Guy Post
Hack.	Hackberry
Hdrl.	Handrail
Hdwl.	Headwall
ha	Hectare
Hdg.	Hedge
H.D.	Horizontal Distance
H.W.	High Water
Horiz.	Horizontal
HCP	Horizontal Control Point
Ho.	House
Hub. Gd.	Hub Guard

Hyd.	Hydrant
Imp.	Improvement
Incl.	Inclusive
Isle	Island
Instr.	Instrument
Jct.	Junction
km.	Kilometer
Lat.	Latitude
L.B.	Layback Curb
Lt.	Left
L	Length of Curve
Lgt. Po.	Light Pole
Ls.	Limestone
lk. Or lks.	Link (Measure)
Log.	Logarithm
L.C.	Long Chord
Long.	Longitude
M.B.	Mail Box
MH	Man Hole
Mkr.	Marker
Msry.	Masonry
Max.	Maximum
Meas.	Measure
Med.	Median
MAC	Metal Arch Culvert
m	Meter (measure)
MOC	Midpoint of Curve
mi.	Mile
MPH	Miles per Hour
mm	Millimeter
min.	Minimum
'	Minute

NGS	National Geodetic Survey
NOAA	National Ocean & Atmospheric Administration
NOS	National Ocean Survey
N	North
N. Bd.	North Bound
NE	Northeast
NNW	North Northwest
NW	Northwest
No. or #	Number
Ⓢ	Offset
Orig.	Original
Orn.	Ornamental
Ovhd.	Overhead
O.P.	Over Pipe
Pg.	Page
past.	Pasture
pavt.	Pavement
perm.	Permanent
petro.	Petroleum
pt.	Point
P.C.C.	Point of Compound Curve
P.O.C.	Point on Curve
P.C.	Point of Curvature
P.I.	Point of Intersection
P.R.C.	Point of Reverse Curve
P.O.S.T.	Point on Sub-Tangent
P.T.	Point of Tangency
P.O.T.	Point on Tangency
Photo	Photograph
Po.	Post
Prelim.	Preliminary
Pres.	Present

Proj.	Project
℄	Property Line
Prop.	Proposed
Pub.	Public
R	Radius (or Range)
RR	Railroad
Ry.	Railway
RCAC	Reinforced Concrete Arch Culvert
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
Reinf.	Reinforcing
Rebar	Reinforcing Bar
Ref.	Reference
R.M.	Reference Mark
Reloc.	Relocation
Ret-wall	Retaining Wall
Ret.	Return (curb, valley, gutter, etc.)
Rt.	Right
R/W	Right of Way
Rd.	Road
Rdwy	Roadway
Ss.	Sandstone
San. Sew.	Sanitary Sewer
Sch.	School
"	Second
Sec.	Section
℄	Section Line
Serv. Sta.	Service Station
Sh.	Sheet
Shld.	Shoulder
SR	Side Road
S.W.	Sidewalk

Sig.	Signal
S	South
S. Bd.	South Bound
SE	Southeast
SSE	South Southeast
SSW	South Southwest
SW	Southwest
Sp. Dt.	Special Ditch
Spk.	Spike
S.C.	Spiral to Curve
S.T.	Spiral to Tangent
Sq.	Square
Sta.	Station
Stm. Sew.	Storm Sewer
S.B.	Stream Bed
St.	Street
surf	Surface
SI	System International
T	Tangent (length)
Tan.	Tangent
T.C.	Tangent to Curve
T.S.	Tangent to Spiral
TBM	Temporary Bench mark
Tel.	Telephone
Tel. Ped.	Telephone Pedestal
Temp.	Temporary
Ter.	Terrace
TR.	Top of Rail
TO	Top of Opening
Topog.	Topography
Tshp.	Township
Tr. Sig.	Traffic Signal

TW	Traveled Way
T.P.	Traverse or Transit Point

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1.0 GENERAL

1.1 INTRODUCTION

This manual was prepared as an outline of methods and procedures to develop and report survey information in a uniform manner. However, while this manual has been prepared as a guide, it is not intended to provide direction to every situation that may be encountered during the course of a survey.

English units of measure are noted within this manual. The U.S. survey foot conversion shall be utilized when converting from S.I. units to English, i.e. 1 meter equals 3.2808333333 feet.

1.2 PUBLIC RELATIONS

1.2.1 General

As a public service organization, the Kansas Department of Transportation is judged not only by its accomplishments, but by the actions of its employees on and off the job. KDOT employees have a responsibility to build public good will, and as such, should refrain at all times from loose talk, gossip, or comments concerning the Department or its policies. It is expected that employees will exhibit a courteous attitude, a clean and neat appearance, and behavior that is consistent with the social customs of the project location.

1.2.2 General Public

News releases will be issued by the Agency prior to the beginning of a survey activity. Since the location and schedule of a proposed improvement is subject to change, statements to the general public should be framed with that aspect in mind.

When operating state-owned vehicles, KDOT employees are expected to drive safely, courteously, and responsibly. When leaving vehicles unattended, do not obstruct movement of farm machinery or other vehicles. Avoid littering at all times. Refrain from careless markings with crayon, ink, or paint.

Care should be exercised to limit crop damage when working in cultivated areas. Do not step on fence wires or climb fences in urban areas, utilize gates when possible. Always take time to repair damage to a fence.

Do not cut or trim trees unnecessarily. The cuttings of brush or trees should be stacked neatly and out of the way**.** If an opening needs to be cut through a natural fence such as a hedge or tree row, close the opening by replacing some of the cuttings. Do not walk in flower beds or vegetable gardens.

In the event that a funeral procession passes, all activities shall cease and employees will stand at the roadside in a respectful manner until the procession has passed.

1.2.3 Property Owners

Access to property outside of the existing right of way is necessary for most highway design surveys. Each land owner or tenant shall be contacted prior to entry. This contact presents itself with a great opportunity to gather other information relative to the project that may be beneficial for the design. Examples of this would be highwater information, boundary corner history, or surveys that are not recorded, etc. Specific requests as to access, gates, frequency of contact, should also be noted.

Property owner contact is a great opportunity to build trust and good will for the Agency. It also presents an opportunity to create animosity and anger. Property owner contact should only be done by trained individuals, having an understanding of the project and the survey tasks ahead.

At the time permission for entry is requested, complete a Property Owner Log. It is most important to document the date of the contact, whom permission for entry was granted by, the legal description of the subject property, address of the contact person, and the survey crew member responsible for the contact. Additional project related information, plus any specific owner requests or concerns, shall be noted on the property owner log. The brochure, "KDOT SURVEYORS Mapping the Landscape", which describes the project development process, shall be offered to the property owner. On small surveys, with a limited number of owners, the description upon the Property Owner Log will be sufficient to track the ownership with the property. On surveys which contain multiple small tracts, a sketch correlating the property owner logs with the property along the survey will be required. The property owner logs are utilized by other Agency staff in the course of the project development.

Property owners or tenants usually grant permission of entry for survey purposes. However, if permission is denied, report to the Survey Coordinator the following information:
(1) name of the owner, and or tenant.
(2) address.
(3) phone number.
(4) legal description(s) of all effected property of owner, or tenant.
(5) reasons for denial, if available.

The Survey Coordinator will process the letter through the Agency. The letter will then be served upon the owner or tenant, either by certified mail or by local law enforcement personnel. After the statutory length of time in which notice has been met, the survey crew may enter the property. It is highly recommended that local law enforcement be advised of the survey activity, and render any assistance which may be necessary for safety of the survey crew.

See Figure 1.2.3-2 for a sample Property Owner Log.

Figure 1.2.3-1 Example Property Owner Log

Property Owner Log Sheet No._____

Project: _____ **Project Manager:** _____

County: _____ **Date Contacted:** _____

Contacted By/At: _____

Name: _____ **Phone:** _____

Address: _____ **Cell Phone:** _____

_____ **Email Address:** _____

_____ _____

House Located: _____

_____

Land owned or rented:_____

_____

Use of land:_____

_____

Reservations (driving on grounds, etc.):_____

_____

Remarks: (sanitary sewer, lateral lines, etc.):_____

_____

_____

High water information:_____

_____

Figure 1.2.3-2 Sample of a Completed Property Owner Log.

Property Owner Log

Sheet No. _____

Project: 99-99-KA-9999-01
County: Wabaunsee
Project Manager: R. Feldkamp
Date Contacted: 10/28/2020
Contacted By/At: J. Baker

Name: Fred Astaire
Address: 1234 Deadguy Ln. Alma, KS. 67654
Phone: (555) 867-5309
Cell Phone: (555) 555-1212
Email Address: beyondthegrave@gmail.com

House Located: at address

Land owned or rented: SW/4 section 12-T-9S-R3E

Use of land: Agriculture, Dance Studio

Reservations (driving on grounds, etc.): Please check in @ house when entering property

Remarks: (sanitary sewer, lateral lines, etc.): lateral lines are in front of the house (on the highway side) E. face of structure. Abandoned well on S. side of Studio

High water information: Owner spoke of water over the highway in 93' and 02'. He remarked that it washed out his Mailbox.

1.3 SAFETY

1.3.1 General

All employees will adhere to the traffic control policy of the Agency and as outlined in the current Manual on Uniform Traffic Control Devices. Employees have an obligation to the traveling public, as well as to themselves and coworkers, to ensure that adequate safety procedures are followed. It is of particular importance to instruct new employees in traffic safety. If necessary, contact the local KDOT Maintenance Supervisor for assistance in performing traffic control for the survey tasks.

Safety vests should be worn when working within the right of way limits of public roads. Advance warning signs and vehicle strobe lights shall be used whenever working within the right of way.

1.3.2 Hand Tool Safety

1.3.2.1 Brush Clearing Equipment

Employees should work clear of others and obstacles when cutting trees and brush with a brush axe or machete. Avoid holding brush with one hand while striking with the other. Always direct your swing away from yourself.

1.3.2.2 Sledge Hammer or Pick Axe

Rebar, steel fence posts, grader blades, and railroad spikes are usually driven with a sledge hammer. Make sure objects are well started and secure before heavy striking. Do not hold an object while someone else strikes with a sledge hammer. Protective eyewear shall be worn when using a sledge hammer or pick axe.

1.3.2.3 Gas Powered Equipment

Employees utilizing gas powered equipment, e.g. chain saws, jack hammers, hammer drills, shall be sufficiently trained in their operation. Manuals shall be reviewed as to the proper operation and maintenance of the equipment prior to use.

1.3.2.4 Snakes

There are several species of snakes found in Kansas that pose a threat to the safety of humans; i.e. cottonmouths, copperheads and rattlesnakes. All snakes should be left alone and avoided if possible. The unnecessary killing of snakes is discouraged, as the act in itself could be hazardous to the employee. In case of snake bite, obtain prompt treatment from a physician.

1.3.2.5 Poisonous Plants, Insects, Weather

Poison ivy, poison oak, poison sumac, and insects are encountered almost every working day. All personnel should be able to identify the poisonous plants, and take proper precautions. It is advisable to use insect repellent.

Sunburn, sunstroke, heatstroke, heat exhaustion, and frostbite are all serious conditions. These conditions can be avoided by sensible use of protective clothing, sunscreen, and by avoiding overexertion in hot, humid weather. A shirt shall be worn at all times. Shorts are not permitted.

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2.0 GENERAL SURVEYS

2.1 NOTES

The necessity of arranging notes accurately, legibly, and systematically cannot be overemphasized. Because accuracy is the most important consideration, the person recording the notes must be alert to potential errors and place themselves in a position to be able to observe the survey task taking place.

2.1.1 Standards

All field data, with the exception of drainage maps, will be on standard loose-leaf notepaper. Field notes should not be placed on the back side of a sheet. Avoid staples in the notes. Sketches should be kept to a maximum size of 11 inches in height to accommodate reproduction. Every attempt to use the following drafting techniques should be made:

- When looking at the sketch in hand the binding edge should be to your left. If stationing is detailed it should proceed from left to right, or bottom of page to top.
- Lettering should be legible with the binding edge to the left of the top of the sheet.

Standard abbreviations, symbols, and terminology will be used at all times. Each page of the notes will have the project number, county, Field Survey Project Manager, and date of the survey in the upper right margin of the page. The date of the survey shall be the begin month and year in which the survey was started. Project stamps are recommended for this purpose.

A notation as to the person(s), their duties, and the work date should be entered at the upper left margin of each page of the field notes. This will aid in responding to concerns relative to the field work.

The notes should be recorded using a pencil dark enough to facilitate reproduction of the notes. All computations must be checked and initialed for accuracy. Cross references should appear when needed.

2.1.2 Submitting the Field Notes

When completed, the field notes will be submitted in folders. Staples shall be removed from the notes. Include the project Survey Request Form in the first project folder. A detailed index shall be included in the front of each folder to aid in the retrieval of information. Location maps shall be included in the front of each project folder, detailing the project site.

On smaller projects, the field notes may be submitted in one folder. For projects that includes property ownership information, the property owner deed sketch and copies of the deeds will always be submitted in a separate folder. The project deed folder is transmitted solely to the

Bureau of Right of Way Engineering Section. Do not combine this information into other survey information.

On larger projects the notes should be placed in folders with a logical sequence. The number of pages is generally limited to 125 pages per folder. The following provides a general outline of survey information which should be included and submitted on larger projects:

Geodetic Horizontal Control Folder –

- County Map
- Index
- Review of Survey/Project Control Overview
- Project Calibration Report/Residuals
- NGS data Sheets, or Basis of Coordinate Information
- State Plane and Project Coordinate Information
- Control Point References
- GPS Observation Information

Topography and Vertical Control Folder –

- Survey Submittal Sheet
- County Map
- Survey Request
- Index
- Location of Project
- Alignment Information and Coordinates
- Offset Control Point Information and Coordinates
- Vertical Control Information
- Drainage Structures
- Utility Information

Bridge Information Folder –

- County Map

Index

High Water Questionnaire

Historic High Water and Ordinary High Water Information

Waterway Openings and Elevations

Streambed Profiles

Channel Sections

Valley Sections

Land Survey Folder –

County Map

Index

Property Owner Logs with Index Map if Needed

Land Survey Tie Drawings

Coordinates

Land Survey Reference Reports

Record Road Right of Way Information

Copies of Record Surveys

Deed Folder –

County Map

Index

Deed Index Sketch

Project Deeds

Other items generally submitted that cannot be placed in folders e.g., drainage maps, subdivision plats, large scale survey drawings, railroad strip maps, etc., may be folded and placed in envelopes. An index of these items shall be placed on front of the envelope, identifying the types of instruments and, if applicable, the location of the record document. It is important to know and document those items which have been submitted. Record information furnished to the survey crew from the office shall be returned upon completion of the survey.

The survey information being submitted shall be listed on the K.D.O.T. Form No.1121, Survey Notes Transmittal Sheet. Additionally, K.D.O.T. Form No.1119, Project Completion Sheet, shall be included with the notes submission. The field notes shall be delivered to the office by a Design Survey employee.

See Figure 2.1.2-1 for a sample K.D.O.T. form No.1119 Project Completion Sheet.

See Figure 2.1.2-2 for a sample K.D.O.T. Form No.1121 Survey Transmittal Sheet.

Figure 2.1.2-1 Form 1119

KANSAS DEPARTMENT OF TRANSPORTATION

Date: 4-13-98

MEMORANDUM TO: William J. Haverkamp, R.L.S.
Survey Coordinator

We are furnishing the following project information:

Project Number: 69-11-X2016-01

Description: Railroad Crossing approximately 2 1/2 miles South of K-96 & K-7 Jct on K-7 Highway

Date that the work began: April 9, 1998

Date that the work was completed: April 9, 1998

T.J.
Party Chief

Rev. 11-90

D.O.T. FORM NO. 1119

Figure 2.1.2-2 Sample K.D.O.T. Form 1121 Survey Transmittal Sheet

SURVEY NOTES

No. _____

Date of Survey Beginning _____ Completion _____ Notes Rec'd. _____

Project No. _____ County _____

Chief of Party _____ Recorder _____

Location of Project _____

_____

_____

_____ Length _____

_____

_____

Record of Field Books and Notes

Classification	No. of Books or Sheets	Remarks

D.O.T. Form No. 1121

2.2 ALIGNMENT

2.2.1 General

The Survey Coordinator will provide the survey crew with instructions regarding the type of improvement being considered. Information in the form of existing highway plans, USGS contour maps, and horizontal control information and record survey notes will be provided to begin the survey. Additional research information may be found at K.D.O.T. District Offices, or county offices.

2.2.2 Alignment Development Procedure

A preliminary design survey will require the retracement of an existing project alignment. The majority of existing projects will be found to have been constructed to conform to the record plans. In the event a material difference is discovered during the course of a survey, it shall be documented in the field notes in a clear and concise manner for the design and right of way staff.

Recovery of the original alignment points should be the primary consideration in the retracement of an existing project alignment. The process in attempting to recover the alignment would be to utilize a plan reference position, e.g., bridge, culvert, etc., to identify the location to search with a magnetic locator. Evaluate the plan profile to gauge an approximate depth. There is no need to attempt to recover an alignment beneath concrete pavement. In the event the monuments of the alignment cannot be recovered, the following order of priority should be considered to retrace the alignment:

- Section corner monuments matching the original plan description.
- Existent horizontal control points of the original project.
- Centerline of bridges.
- Centerline of concrete pavement.
- Centerline of box culverts.
- Right of way monuments.

At times you may determine that a deflection may exist on the ground which is not reflected on the plans, or that the measured P.I. delta angle does not conform to the plan deltas. This is not uncommon and could be attributed to either the methods or instruments used on the original survey, or by post construction alignment perpetuation. One should be especially aware of this potential condition at locations of crests on tangents greater than one mile in length, or at the beginning or end of a project.

The alignment notes shall contain an overview of the methods utilized to retrace each individual tangent line on the project. This overview shall be indexed as the Procedure to Establish Alignment. It shall include a reference listing of the plan(s) utilized in the alignment development. This is an ideal location to further explain instances of material difference for other design staff working with the project alignment. When completed, the Procedure to Establish

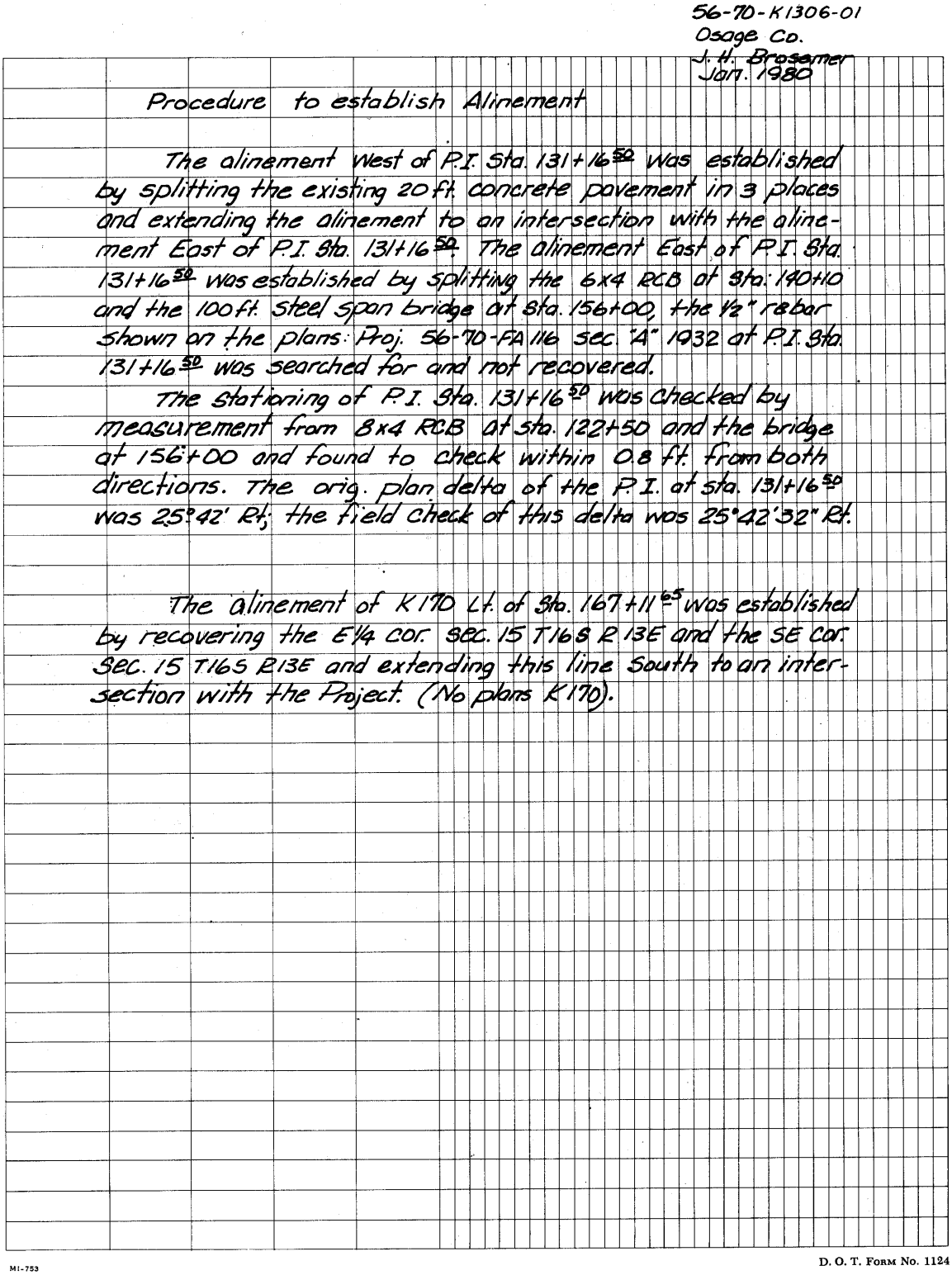
Alignment should afford enough clarity that a third party may be able to understand the evidence and methods utilized by the survey crew.

When a survey is along or adjacent to an existing project, it is necessary to note the stationing relationship between the survey and the existing project stationing. This shall be noted at the beginning and end of a project, and also at all found alignment points which are located on the survey alignment. This is to be done within the alignment references, and should note the stationing of the current project, a description of the found monument, and the plan stationing and plan project number.

Stationing equations, which can be found on existing highway plans prior to 1970, are different than stationing relationship noted in the previous paragraph. These were previously utilized to possibly isolate errors discovered in chaining, or differing stations utilized in the course of the plan development. The surveyor should be aware of these situations as they will have some effect on alignment recovery and the recovery or reestablishment of land survey monuments from the project plans. **Projects alignments being surveyed at present should not include stationing equations.** The stationing should be developed in a seamless chain.

See Figure 2.2.2-1 for the format of a Procedure to Establish Alignment.

Figure 2.2.2-1 Procedure to Establish Alignment.



56-70-K1306-01
Osage Co.
J. H. Brosemer
Jan. 1980

Procedure to establish Alinement

The alinement West of P.I. Sta. 131+16.50 was established by splitting the existing 20 ft. concrete pavement in 3 places and extending the alinement to an intersection with the alinement East of P.I. Sta. 131+16.50. The alinement East of P.I. Sta. 131+16.50 was established by splitting the 6x4 RCB at Sta. 140+10 and the 100 ft. steel span bridge at Sta. 156+00, the ½" rebar shown on the plans Proj. 56-70-FA 116 sec. "A" 1932 at P.I. Sta. 131+16.50 was searched for and not recovered.

The stationing of P.I. Sta. 131+16.50 was checked by measurement from 8x4 RCB at Sta. 122+50 and the bridge at 156+00 and found to check within 0.8 ft. from both directions. The orig. plan delta of the P.I. at Sta. 131+16.50 was 25°42' Rt; the field check of this delta was 25°42'32" Rt.

The alinement of K170 Lt. of Sta. 167+11.65 was established by recovering the E¼ Cor. Sec. 15 T16S R13E and the SE Cor. Sec. 15 T16S R13E and extending this line South to an intersection with the Project. (No plans K170).

M1-753

D. O. T. Form No. 1124

2.2.3 Coordinates and Basis of Bearings

The basis of bearings, and the coordinate basis for the project, should be noted in the alignment notes. This can be summarized in the Review of Survey/Project Control Overview. See Figure 2.2.3-1 Project Control Overview. Include both the horizontal and vertical control. This will be utilized on the plan development in the General Notes. The availability of GPS equipment has enhanced the opportunity to utilize state plane coordinates and grid bearings on each project. The use of assumed coordinates and assumed bearings must be approved by the Bureau of Right of Way Survey Coordinator, prior to beginning a survey. The content and format of the notes, relative to geodetic type horizontal control, may be found further in this Manual titled as "Geodetic Horizontal Control Surveys Section ".

The alignment coordinate input file, listing the coordinates, stationing and curve information, will be generated by the office staff for in house projects. A copy of this information will be included in the field notes.

The preliminary design survey group is allocated point numbers 1 to 500 for use in the point numbering of the alignment and offset control points. A listing of the point numbers and coordinates will be submitted on each project.

Figure 2.2.3-1 Project Control Overview

75-7 KA 4798-03
Brown County
Joseph L Bowen L.S.
June 2018

2.

Horizontal and Vertical Project Control Overview

Horizontal Control:

Horizontal Datum: KRCS Zone 10 Atchison (NAD83)

Project Control is based on 3 Opus solution points on the project. The Latitude and Longitude provided by OPUS were used and converted with the KRCS Zone 10 Atchison for project coordinates.

Vertical Control:

North American Vertical Datum of 1988 (NAVD 88)

The vertical control was determined by using (2) 4 hour static observations and then submitted to the NGS OPUS website.

Datum Benchmark: Base 2 = 1175.241

NGS Mark Reamer PID KE1268 was observed for a vertical check.
NAVD 88 Elevation = 1149.561
OPUS SHARED GPS Elevation = 1149.481

A double set of level runs were run from BASE 2 though the Benchmarks and Traverse Points for the final elevations on these control points.

2.2.4 Alignment Control Monuments

Alignment monuments are found or established for construction related purposes in the project development process. The construction time line may be several years after the preliminary design survey crew has completed their work. Therefore, the location, references and permanence of the points is of great importance.

Since projects differ widely in terrain and land use across the state, it is difficult to set hard and fast rules for the establishment of alignment monuments on a project. The Bureau of Right of Way Survey Coordinator will outline the level in which the project alignment monuments will be established. In all instances, alignment monuments will be found or established that define the tangent(s) on a project. Avoid the establishment of alignment points that may be interpreted to represent a land survey corner monument. If the monument of the land survey corner is existent, include reference witness ties in the alignment references and on the applicable land survey reference report.

The safety of the survey crew and the traveling public are very important. On projects in which conditions allow to safely monument the entire project centerline alignment, the following guidelines will be used:

On rural projects monuments will be set at 1200 foot intervals along the project, at each crest, each side of a bridge or stream crossing, each fence crossing, each side road crossing, and other locations that are deemed as favorable prospects for future recovery. Set all curve points, i.e. P.C., P.I., P.T. A P.O.C. will be necessary on curves greater than 1200 feet in length. When completed, the alignment monuments shall allow for a continual line of sight through the project.

On urban projects the alignment monuments shall be placed at each crest and at each street intersections, and no further than 500 feet apart. All curve points, i.e., P.C., P.I. and P.T. will be set. A P.O.C. will be necessary on curves greater than 500 feet in length.

On projects in which conditions exist that hinder, or prohibit, the establishment of the entire project centerline alignment, the following guidelines will be used to monument the basic alignment network of the project:

The beginning centerline alignment monument will be established on the project, along with all subsequent curve points, i.e. P.C., P.I., and P.T., and an ending centerline alignment monument. Offset points shall supplement this basic alignment network in the same manner as described for establishing monuments for an entire centerline alignment in the previous paragraphs.

The alignment monument shall be a ½" rebar of sufficient length so as to remain stable and in true position. It is not necessary to place an identification cap on an alignment point. Monuments shall be placed at a sufficient depth so as to be preserved during routine maintenance. The following guidelines are presented for that effort:

• Concrete Surfaces	Flush
• Asphalt Surfaces	0.25 feet deep.
• Pastures/ Other Highway Right of Way locations	0.50 feet deep.

• Cultivated Fields	1.50 feet deep.
• Crossing Fences	Projecting 0.2 feet.

Offset points to be utilized for the alignment control shall be ½" rebar of sufficient length so as to remain stable and true in position. A KDOT identification cap shall be placed on the rebar. These shall be set at a depth to prevent being disturbed by maintenance or farm equipment. Do not leave them flush with the ground line within the right of way.

Alignment monument references will be included in the field survey note submittal. The monument calls and reference ties are included on the project plans by the design staff. The process is to incorporate them verbatim from the field notes. Keep in mind that abbreviations must conform to the standard practice of the Agency. The design staff cannot be expected to guess, or assume, the intent of the field notes. Clarity, and accuracy are essential. The following considerations should be made when developing the alignment monument references:

- The alignment reference notes shall be listed sequentially by stationing.
- If it is a found monument you must describe the type of point, depth, the existing plan stationing, project number and date of the plans. Reference ties shall be noted with the cardinal directions and measured slope distance.
- Monuments at P.I. locations shall include the field measure delta angle, the survey curve data, and the existing plan delta angle for comparison.
- A description of all set monuments shall note the depth of the monument, and several locative reference ties. The reference ties should note a general cardinal direction and measured slope distance. Always include a tie to the center of an existing roadway.
- If horizontal distances are used, note with an H.D.
- If the alignment point is an intersection of another alignment, include the cross stationing and the angle of the intersection.

Several reference ties should be used for alignment points. These may include spikes and KDOT washers in top of fence posts, or flush in the side of utility pole or gate post.

Obtain approval from the land owner prior to placing reference nails in trees.

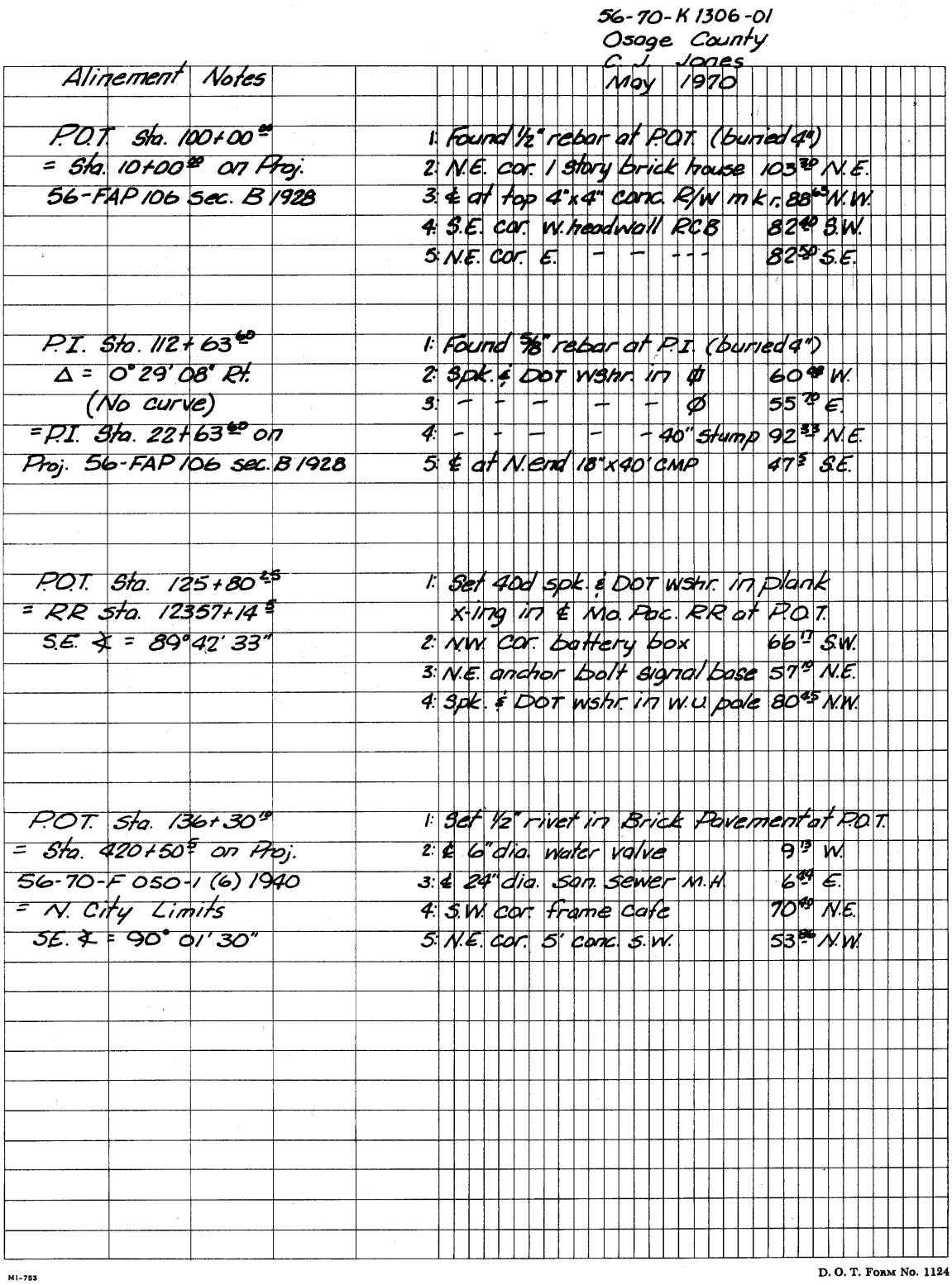
Do not place spikes in yard trees, pecan, walnut or fruit trees, or trees that may be harvested for firewood. These types of trees may be utilized as a reference to the centerline of the tree.

Other types of references would be corners of sidewalks, retaining walls, building, etc. Any physical object, readily described within 200 feet of the alignment monument, is beneficial.

Alignment points should be witnessed by using stakes, flags, or paint for future recovery. The points should be identified by a project stationing, or by its point number.

See Figure 2.2.4-1 for a sample format of alignment reference notes.

Figure 2.2.4-1 Sample Format of Alignment Reference Notes



2.2.5 Horizontal Simple Curves

A survey alignment may consist of several straight lines, known as tangents, which are connected by curves. Horizontal curves used by KDOT on new projects will be simple curves of radius definition. This is based upon the principal that the degree of curve, D, is the angle at the radius point, or center subtended by an arc of 100 feet.

On some past highway projects the chord definition was utilized, based upon the degree being the angle at the center subtended by a chord of 100 ft. When chord definition curves are encountered it will be the practice to develop an arc definition curve in its place. The field measured delta will be utilized with the plan radius to calculate the curve data.

It is the practice to include curve information for all P.I. delta angles exceeding 30 minutes. In the event an existing alignment does not reflect curve information for a P.I. with greater than 30 minute delta angle, the survey crew shall retrace the existing plan alignment. The Bureau of Road Design will determine an appropriate curve and detail this as an office relocation to the survey alignment.

Some definitions of common horizontal curve elements are as follows:

- The Point of Intersection, (P.I.), is the point at which two tangent lines intersect.
- The Back Tangent is the tangent line in the direction of the beginning of the project as reckoned from the P.I.
- The Forward Tangent is the tangent in the direction of the end of the project as reckoned from the P.I.
- The delta angle at the P.I. is the angle that measures the change in direction between the back and forward tangent.
- The Point of Curve (P.C.), is the beginning of the simple curve or the point where the back tangent is tangent to the curve.
- The Point of Tangent (P.T.) is the end of the simple curve or the point where the forward tangent is tangent to the curve.
- The Tangent Distance (T) is the distance from the P.I. to either the P.C. or the P.T.
- Point on Sub-Tangent, (P.O.S.T.) is a point on either the forward or back tangent between the P.I. and the P.C. or P.T.
- The External Distance (E) is the distance from the P.I. to the midpoint of the curve.
- The Long Chord (LC) is the straight line distance between two points on an arch.
- Length of Curve, (L), is the distance from the P.C. to the P.T. along the arc.
- Radius (R) is the distance from the center or radius point to all points on the curve.
- Mid Point of the Curve (M.O.C.) is the point where the external is measured, also the point that is equal distance along the arc from the P.C. or the P.T.
- Deflection Angle is the angle turned from a point on the curve to any other point on the curve.
- Arc is the term used to define the curve or a part of the curve.

- Degree of Curve (D) is the angle at the radius point or center subtended by an arc of 100 feet.

The general process is for the field survey crew to determine the coordinate values of the alignment points controlling the project. A listing of the point numbers and the existing plan curve data are then submitted to the office staff for processing. The office staff will then generate an alignment input file based upon the field measure delta and existing plan radius with the current design software and forward it back to the survey crew.

Occasionally it may be necessary to field calculate curve information on the project site. It is recommended that two persons working independently calculate the curve and curve stationing to avoid errors. This will be predominantly accomplished with computer based software. However, it is suggested that new employees be given training on calculating curve data with a handheld calculator in order to emphasize the basic math principles with which we work. An outline of the stationing solutions is as follows;

The P.C. station is determined by subtracting the tangent length, T, from the P.I. back stationing.

The P.T. stationing is determined by adding the length of curve, L, to the stationing of the P.C.

The M.O.C. stationing is determined by adding one half the length of curve to the P.C. stationing.

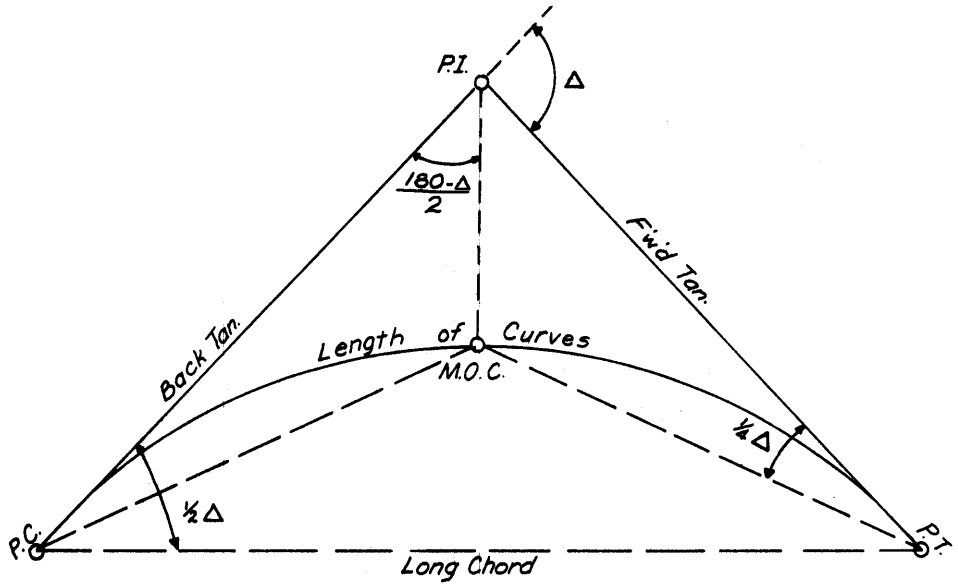
The P.I. ahead stationing is determined by subtracting the tangent length, T, from the stationing of the P.T.

Length of Curve (L) is the distance from the P.C. to the P.T. along the arc.

In most instances the curve points will be established by the coordinate values generated. The curve may be checked from other points, or by occupying the P.C., or P.T. and checking the curve. This can be done by measuring the observed deflection angle and long chord distance to the between from either the P.C., P.I. or P.T.. Tolerances should be within the 0.04 feet of the intended position.

See Figures 2.2.5-1 for a Horizontal Curve Schematic and Formula's.

Figure 2.2.5-1 Horizontal Curve Schematic and Formulas.



Curve Formula

$$T = R \times \tan. \frac{\Delta}{2} \qquad L = \frac{\Delta}{D} \times 100$$

$$E = T(\tan 1/4\,\Delta)$$

$$\text{Deflection Angles} = \frac{\frac{D}{2} \times \text{arc length}}{100}$$

2.2.6 Curves with Spiral Transitions

Spiral transition curves are occasionally used to retrace projects that cannot be altered from the original construction due to the scope. The Road Squad Leader will identify those instances in which spiral curves will be necessary. Knowledge of this type of curve is therefore necessary. As with simple curves, the field survey crew will submit the coordinates of the field observed alignment monuments available. The office will calculate the spiral curve points based upon the field measured delta and the base existing project spiral curve criteria.

A spiral transition curve is a simple curve with transitions on one or both ends that provides a uniform change from the beginning of the spiral to the beginning of the simple curve. It is seldom required to locate the ten points on a spiral. There are tables in most reference books and software to aid in the computations. The curve points may be established by the coordinate values generated by the alignment input file, then checked from another control point. The tolerance of error should be within 0.04 feet of the intended position.

Spiral Curve Formula:

$$Ts = (Rc + p) \tan 1/2\ \Delta + k$$

$$Es = (Rc + p) \text{exsec } 1/2\ \Delta + p$$

$$\Delta_C = \Delta - 2\varnothing s$$

$$L_C = \Delta_C \frac{(100)}{D_C}$$

The project stationing is determined in the following manner:

T.S. = Subtract Ts length from P.I. stationing.

S.C. = Add length of spiral Ls to T.S. stationing.

C.S. = Add length of simple Curve to S.C. stationing.

S.T. = Add length of spiral Ls to C.S. stationing.

P.I. Ahead = Subtract Ts from S.T. stationing.

Definitions of Spiral Curve Elements

- Central Angle of the Simple Curve (Δ_c) - The angle at the center between the radial lines through the S.C. and C.S. It is equal to the delta measured at the P.I. minus 2 ($\varnothing_s$)
- Curve to Spiral (C.S.) - The point where the simple curve and spiral hold a common tangent. The end of the simple curve and the beginning of the spiral.

- Degree of Curve (D_c) - The degree of the simple curve and the maximum degree of the spiral.
- External Distance (E_s) - The distance from the P.I. to the midpoint of the simple curve.
- Spiral to Curve (S.C.) - The point where the spiral and simple curve hold a common tangent. The end of the spiral and beginning of the simple curve.
- Spiral to Tangent (S.T.) - The point where the forward tangent is tangent to the spiral.
- Length of Simple Curve (L_c) - The length of the simple curve.
- Length of Spiral (L_s) - The arc length of the spiral.
- p and k - Values taken from the tables.
- Radius (R_c) - The radius of the simple curve and the minimum radius of the spiral.
- Spiral Angle ($\varnothing_s$) - The total spiral angle subtended by the length of the spiral.
- Tangent Distance (T_s) - The distance from the P.I. to the S.T. or T.S.
- Tangent to Spiral (T.S.) - The point where the back tangent is tangent to the spiral.
- Total Spiral Deflection Angle ($\varnothing_c$) - The deflection angle from tangent at the T.S. or S.T. measured to the S.C. or C.S. and very nearly 1/3 ($\varnothing_s$)
- X_c = Distance from T.S. or S.T. along the tangent to the offset point to locate the S.C. or C.S.
- Y_c = Offset distance from forward or back tangent to the S.C. or C.S.
- Spiral Transition Curve - A simple curve with transitions on one or both ends that provides a uniform change from the beginning of the spiral to the beginning of the simple curve.

See Figure 2.2.6-1 Spiral Curve Schematic.

See Figure 2.2.6-2 for a sample of Spiral Curve computations.

Figure 2.2.6-1 Spiral Curve Schematic.

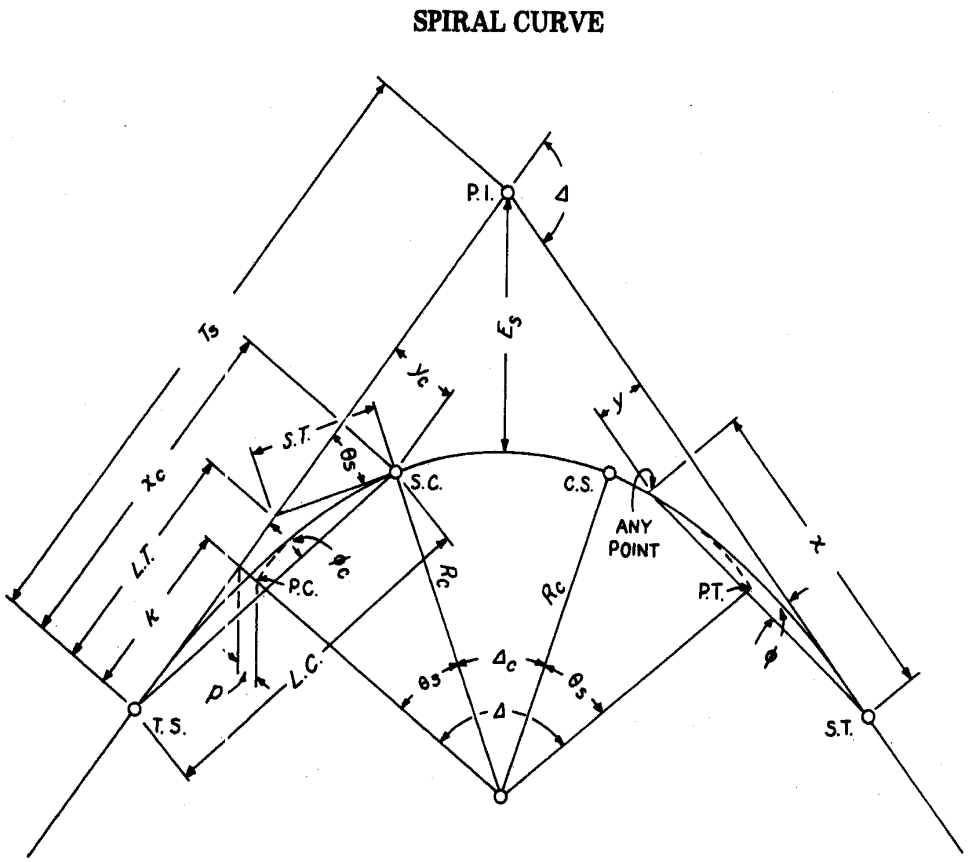
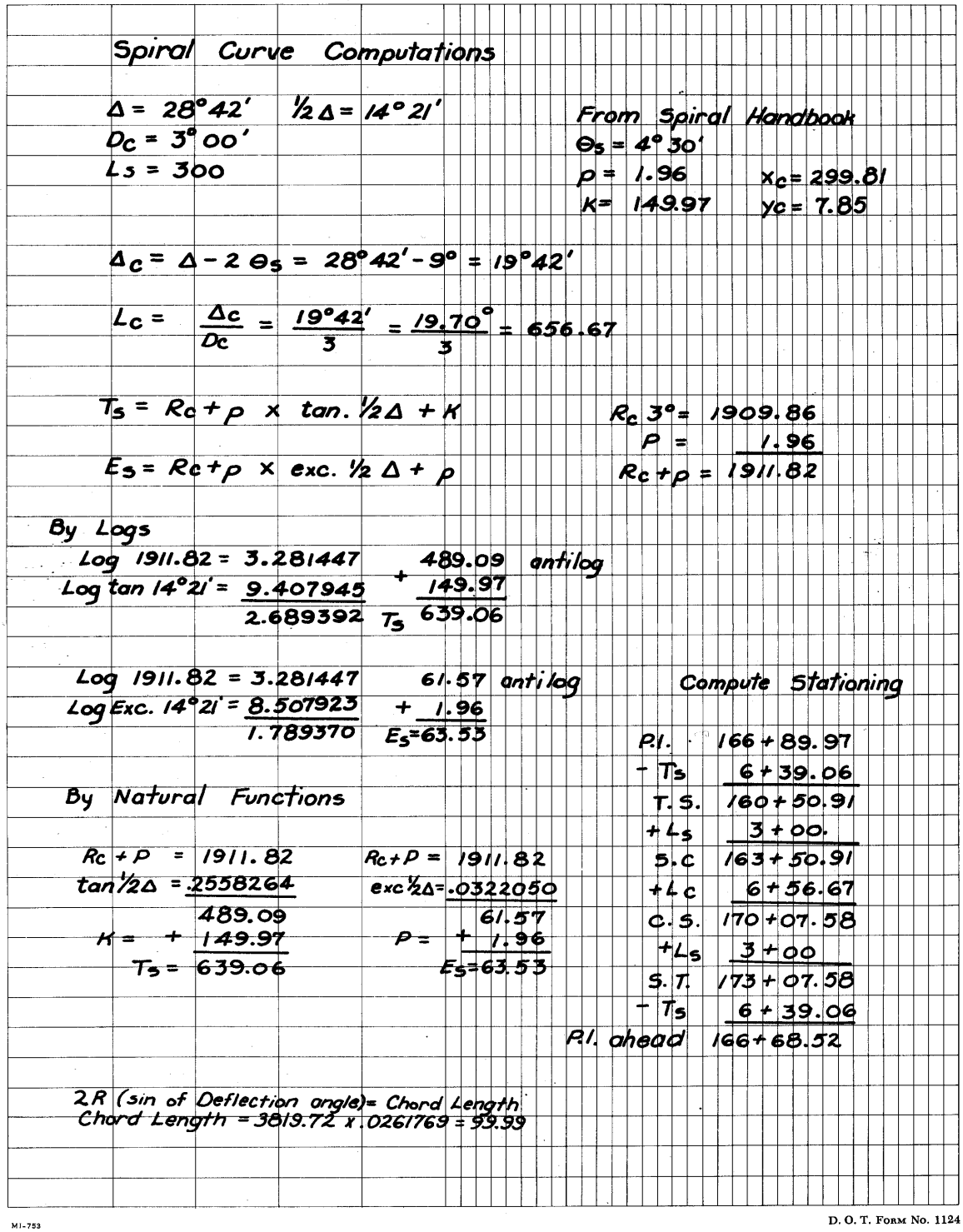


Figure 2.2.6-2 Sample of Spiral Curve Computations.



Spiral Curve Computations

Δ = 28°42′ ½Δ = 14°21′
Dc = 3°00′
Ls = 300

From Spiral Handbook
θs = 4°30′
p = 1.96 xc = 299.81
k = 149.97 yc = 7.85

Δc = Δ − 2 θs = 28°42′ − 9° = 19°42′

Lc = Δc/Dc = 19°42′/3 = 19.70°/3 = 656.67

Ts = Rc + p × tan. ½Δ + K

Es = Rc + p × exc. ½ Δ + p

Rc 3° = 1909.86
p = 1.96
Rc + p = 1911.82

By Logs

Log 1911.82 = 3.281447
Log tan 14°21′ = 9.407945
2.689392

489.09 antilog
+ 149.97
Ts 639.06

Log 1911.82 = 3.281447
Log Exc. 14°21′ = 8.507923
1.789370

61.57 antilog
+ 1.96
Es = 63.53

By Natural Functions

Rc + P = 1911.82
tan ½Δ = .2558264
489.09
K = + 149.97
Ts = 639.06

Rc + P = 1911.82
exc ½Δ = .0322050
61.57
P = + 1.96
Es = 63.53

Compute Stationing

P.I.	166 + 89.97
− Ts	6 + 39.06
T.S.	160 + 50.91
+ Ls	3 + 00.
S.C	163 + 50.91
+ Lc	6 + 56.67
C.S.	170 + 07.58
+ Ls	3 + 00
S.T.	173 + 07.58
− Ts	6 + 39.06
P.I. ahead	166 + 68.52

2R (sin of Deflection angle) = Chord Length
Chord Length = 3819.72 x .0261769 = 99.99

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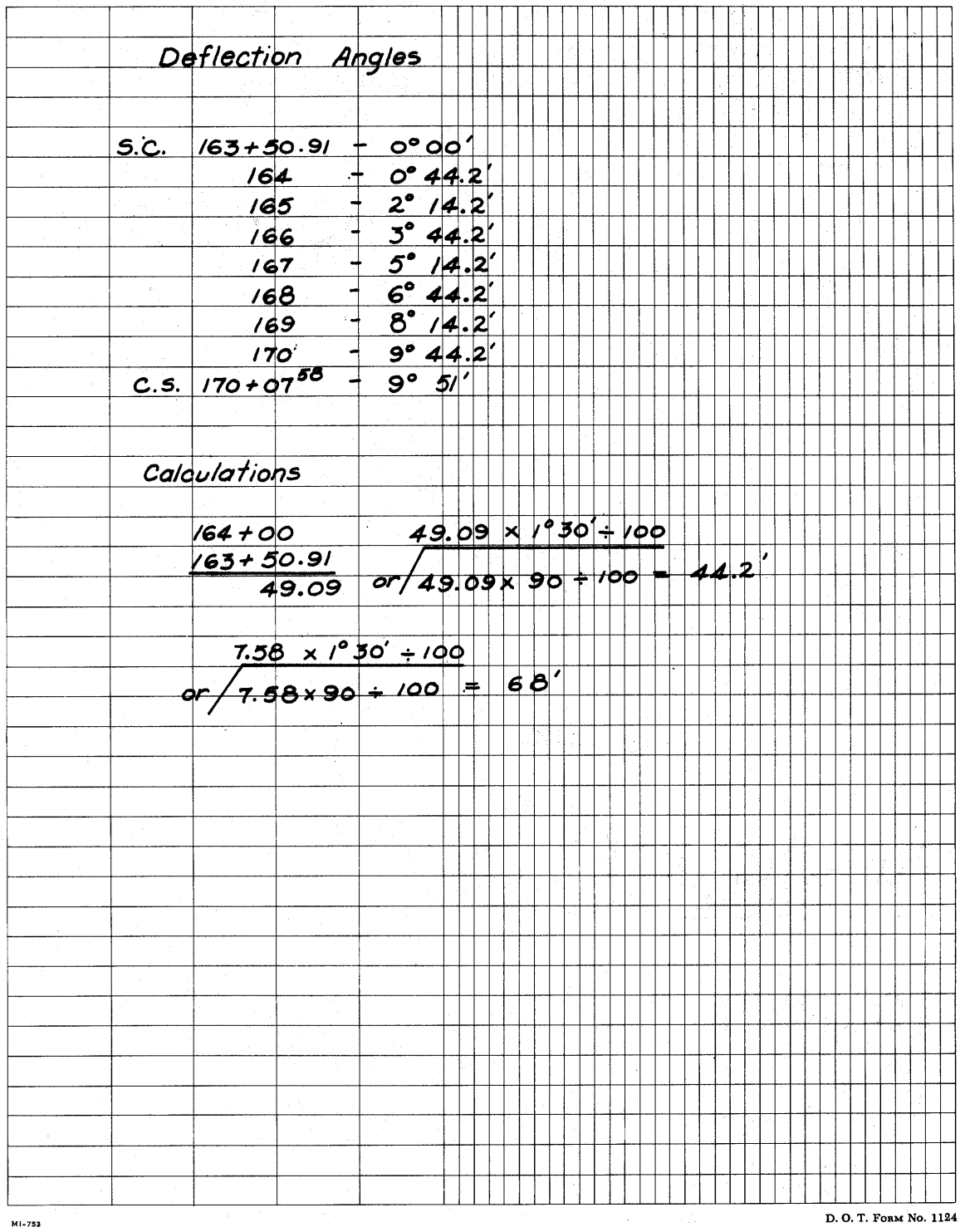
D. O. T. Form No. 1124

Figure 2.2.6-2a Sample of Spiral Curve Computations (Continued)



Deflection Angles

S.C.	163+50.91	-	0°00′
	164	-	0°44.2′
	165	-	2°14.2′
	166	-	3°44.2′
	167	-	5°14.2′
	168	-	6°44.2′
	169	-	8°14.2′
	170	-	9°44.2′
C.S.	$170+07^{58}$	-	9°51′

Calculations

164+00
163+50.91
49.09

$\frac{49.09 \times 1°30' \div 100}{\text{or } 49.09 \times 90 \div 100} = 44.2'$

$\frac{7.58 \times 1°30' \div 100}{\text{or } 7.58 \times 90 \div 100} = 68'$

M1-753

D. O. T. Form No. 1124

2.3 BENCH MARKS

2.3.1 General

The Survey Coordinator will provide record available published vertical data to the survey crew. This data may include elevations and descriptions published by the National Geodetic Survey (NGS), United States Geological Survey (USGS), or record KDOT permanent bench marks in the vicinity of the project. The published elevations will be listed as first, second, or third order leveling based on the National Geodetic Vertical Datum. It is important to identify the particular datum, e.g., 1929 or 1988, so that an allowance for the difference between the datum's may be made in project elevations. When using a datum other than 1929, note the difference on the datum bench mark sheet between the current datum and the 1929 datum. This will allow the design staff to correlate current elevations to record elevations.

2.3.2 Setting Bench Marks

The most important considerations in establishing bench marks along a project are permanence and ease of use. Bench marks should be placed on each major drainage structure, at each side road or street intersection, every 39 feet in elevation difference, every 1500 feet or three "turns" on a rural project, and at least every 1000 feet or two turns on an urban project. Bench marks should be placed in protected areas, and if possible, at locations beyond the limits of construction. The location of the project may not permit the bench marks to conform to all of the general statements on spacing. Sound judgment and common sense will dictate spacing, number of turns, and bench mark locations.

Some commonly used bench mark monuments are as follows:

- Railroad spikes in trees or solid stumps, or utility poles. Utility poles shall not be used more often than once in every third bench. Do not set railroad spikes in walnut, pecan, fruit or yard trees, or trees that may be harvested for firewood. Obtain permission from the land owner prior to setting railroad spikes in trees.
- Rivets or bolts placed in a drilled hole, or square/cross cuts chiseled on concrete structures, such as headwalls of RCB, abutments of bridges, large highway concrete sign bases, gas pump islands. Avoid the setting of bench marks on curbs, or the hubguard of a bridge.
- Steel fence posts, grader blades, or rebar greater than 1 inch in diameter and of adequate length to be firm in the ground. They should be of a size so as not to be subject to movement due to freeze and thaw conditions. These types of marks should be set in well protected areas, near the right of way line, flush with the ground. Be aware of any underground utilities while setting this type of mark. Do not set this type of mark in the path of vehicular travel.
- Tops of concrete right of way markers, setting in a protected location, may be utilized. Refrain from using this type of mark more often than once every third mark.

Consideration should be given to available overhead clearance. If needed, make sure that the bench mark will accommodate an extended and plumb rod. Avoid setting bench marks on curb

and gutter, sidewalks or near large trees. Avoid using fire hydrants or utility poles for bench marks since utility lines and poles are subject to relocation to clear construction, prior to the letting.

Bench marks are to be numbered in succession with the direction of the project stationing, beginning with BM #10. The bench marks shall be marked with a stake and flagged in a conspicuous manner. Do not use paint to identify bench marks on private property, nor any object which stands vertically on public property. It is permissible to paint the tops of headwalls or abutments of structures used as bench marks in rural areas.

Bench marks which are established on side roads will be numbered in relation to the mainline bench mark at the intersection, e.g. if the bench at the mainline was #12, then the first side road bench mark would be designated #12A, the next #12B, progressing ahead with the side road stationing.

The level crew will consist of an instrument operator and two rod persons. The instrument operator will observe and record the level notes as they proceed. It is recommended that the notes be taken on standard notepaper to eliminate the need for copying of the runs. The bench marks are double run, i.e., there is a difference in elevation obtained in the bench marks in the direction of the project stationing, called the forward run. A difference in elevation is then obtained in the opposite direction called the back run. The forward and back run shall be done independently. The practice of operating two levels side by side shall be allowed if there is a check datum bench mark at the end of the loop.

The rod readings are to be observed and recorded to the nearest hundredth. The allowable differences between forward and back runs are as follows:

- One Turn between Bench Marks Zero
- Two Turn's, or more, between Bench Marks 0.02'

Bench runs which exceed these differences must be rerun until they meet the desired accuracy.

Before beginning a line of levels, and periodically as to need, the level should be checked for adjustment. Sights must be balanced in length and should not exceed 250 feet. A rod person must use solid turns and hold the rod plumb, or make sure that the rod is breaking plumb on a "wave". It is recommended that the same instrument operator does not run both the forward and back runs.

The following is a list of common causes of errors in bench mark runs:

- Misreading of the rod.
- Distance between back and forward rod are not balanced in distance.
- Tripod legs are loose.
- Weather conditions such as wind (or traffic), thermal interference, or freezing and thawing conditions that do not permit stable setups.
- Rods are not fully extended, or rods that have worn foot plates or loose screws.

The project bench marks shall be tied to published bench marks at each available location on a project. These ties should be at the beginning and end of the project. The level runs to the published bench marks (called datum benches) will be with the same accuracy, distance, and turn factors as the project bench marks. When using a datum bench mark which is distant from the project, the level party shall establish permanent bench marks on bridges and culverts on the level

run to the project and note their location by an approximate distance to section corners for future use.

When an published bench mark is recovered, examine the monument for signs of damage or disturbance. If it is believed that the mark has been disturbed, make a check run to another bench. Recovery conditions of NGS benchmarks will be reported on line to the NGS website.

Once the level loop has been completed and the runs checked for accuracy, the bench marks are ready for adjustment. The calculations of the adjustment will be as follows: Divide the total error of closure by the total number of turns in the loop, which will obtain the correction per turn. This correction should not be more than 0.003 per turn. The average differences between bench marks are then adjusted by multiplying the number of turns by the correction per turn and either adding or subtracting that value from the average difference between bench marks to obtain the corrected difference. The elevations are then calculated for each bench mark in the loop using the corrected average differences. The bench marks are then rounded to the nearest hundredth.

All level notes and computations will be checked for accuracy. The notes will include the following:

- Datum bench mark sheet containing descriptions, elevations, particular datum, and elevation of bench marks used on the project. Type and make of level and rods used on project.
- A recap sheet with the bench mark number, elevation, description, and station and offset from the survey alignment.
- An abstract of bench marks with the bench number, number of turns between bench marks, forward and back runs, average difference, correction, corrected differences and elevations.
- Level runs.

In the event that a published bench mark elevation is deemed in error, a cross note shall be made on the datum bench mark sheet and on the bench mark recap documenting the observed elevation and the published elevation.

See Figure 2.3.2-1 represents a sample Datum Bench Mark Sheet.

See Figure 2.3.2-2 represents a sample Bench Mark Recap.

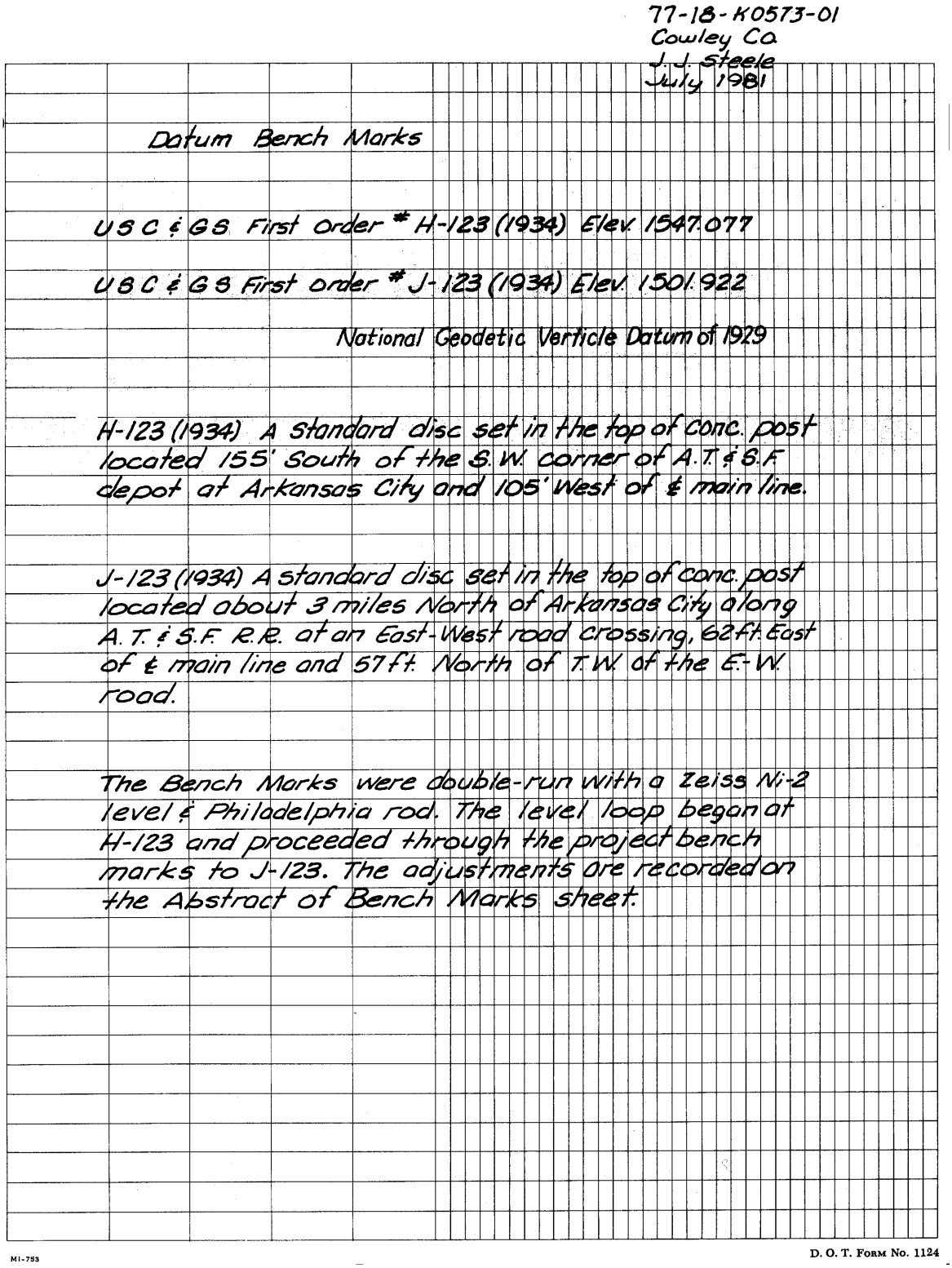
See Figure 2.3.2-3 represents a sample Abstract of Bench Marks on a closed level run.

See Figures 2.3.2-4 represents sample level run notes.

See Figure 2.3.2-5 represents a sample Bench Mark Recap and Abstract of Bench Marks on an open level run.

See Figure 2.3.2-5a represents a sample Bench Mark Recap and Abstract of Bench Marks on an open level run.

Figure 2.3.2-1 Sample Datum Bench Mark Sheet.



77-18-K0573-01
Cowley Co.
J.J. Steele
July 1981

Datum Bench Marks

U S C & G S First order # H-123 (1934) Elev. 1547.077

U S C & G S First order # J-123 (1934) Elev. 1501.922

National Geodetic Verticle Datum of 1929

H-123 (1934) A standard disc set in the top of conc. post located 155' South of the S. W. corner of A. T. & S. F. depot at Arkansas City and 105' West of ℄ main line.

J-123 (1934) A standard disc set in the top of conc. post located about 3 miles North of Arkansas City along A. T. & S. F. R. R. at an East-West road crossing, 62 ft. East of ℄ main line and 57 ft. North of T. W. of the E.-W. road.

The Bench Marks were double-run with a Zeiss Ni-2 level & Philadelphia rod. The level loop began at H-123 and proceeded through the project bench marks to J-123. The adjustments are recorded on the Abstract of Bench Marks sheet.

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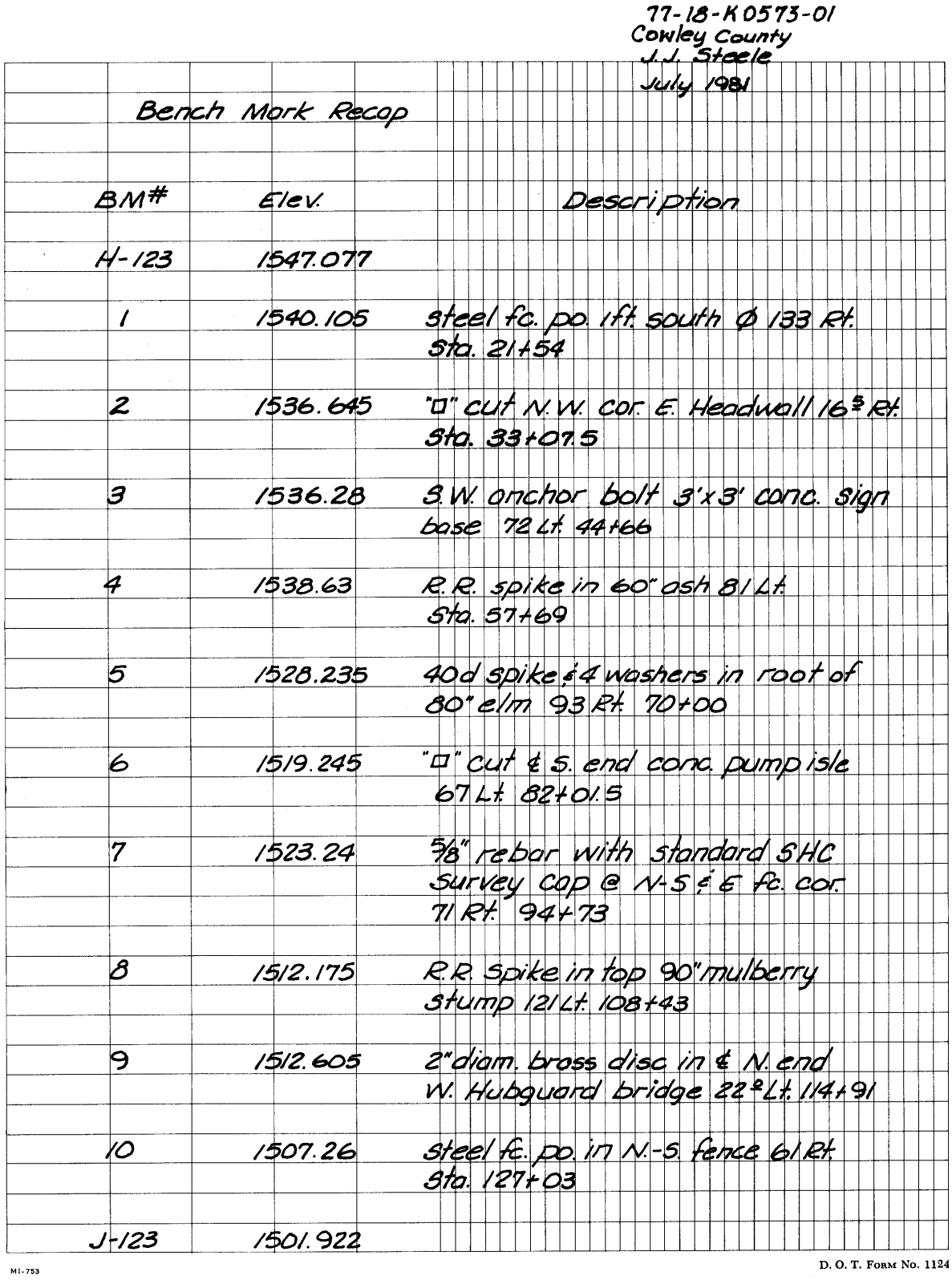
Figure 2.3.2-2 Sample Bench Mark Recap.



77-18-K0573-01
Cowley County
J.J. Steele
July, 1981

Bench Mark Recap

BM#	Elev.	Description
H-123	1547.077	
1	1540.105	steel fc. po. 1ft. south Ø 133 Rt. Sta. 21+54
2	1536.645	"□" cut N.W. cor. E. Headwall 16$ Rt. Sta. 33+07.5
3	1536.28	S.W. anchor bolt 3'x3' conc. sign base 72 Lt. 44+66
4	1538.63	R.R. spike in 60" osh 81 Lt. Sta. 57+69
5	1528.235	40d spike & 4 washers in root of 80" elm 93 Rt. 70+00
6	1519.245	"□" cut ℄ S. end conc. pump isle 67 Lt. 82+01.5
7	1523.24	5/8" rebar with standard SHC survey cap @ N-S & E fc. cor. 71 Rt. 94+73
8	1512.175	R.R. Spike in top 90" mulberry stump 121 Lt. 108+43
9	1512.605	2" diam. brass disc in ℄ N. end W. Hubguard bridge 22° Lt. 114+91
10	1507.26	steel fc. po. in N-S fence 61 Rt. Sta. 127+03
J-123	1501.922	

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Figure 2.3.2-3 Sample Abstract of Bench Marks on a Closed Level Run.

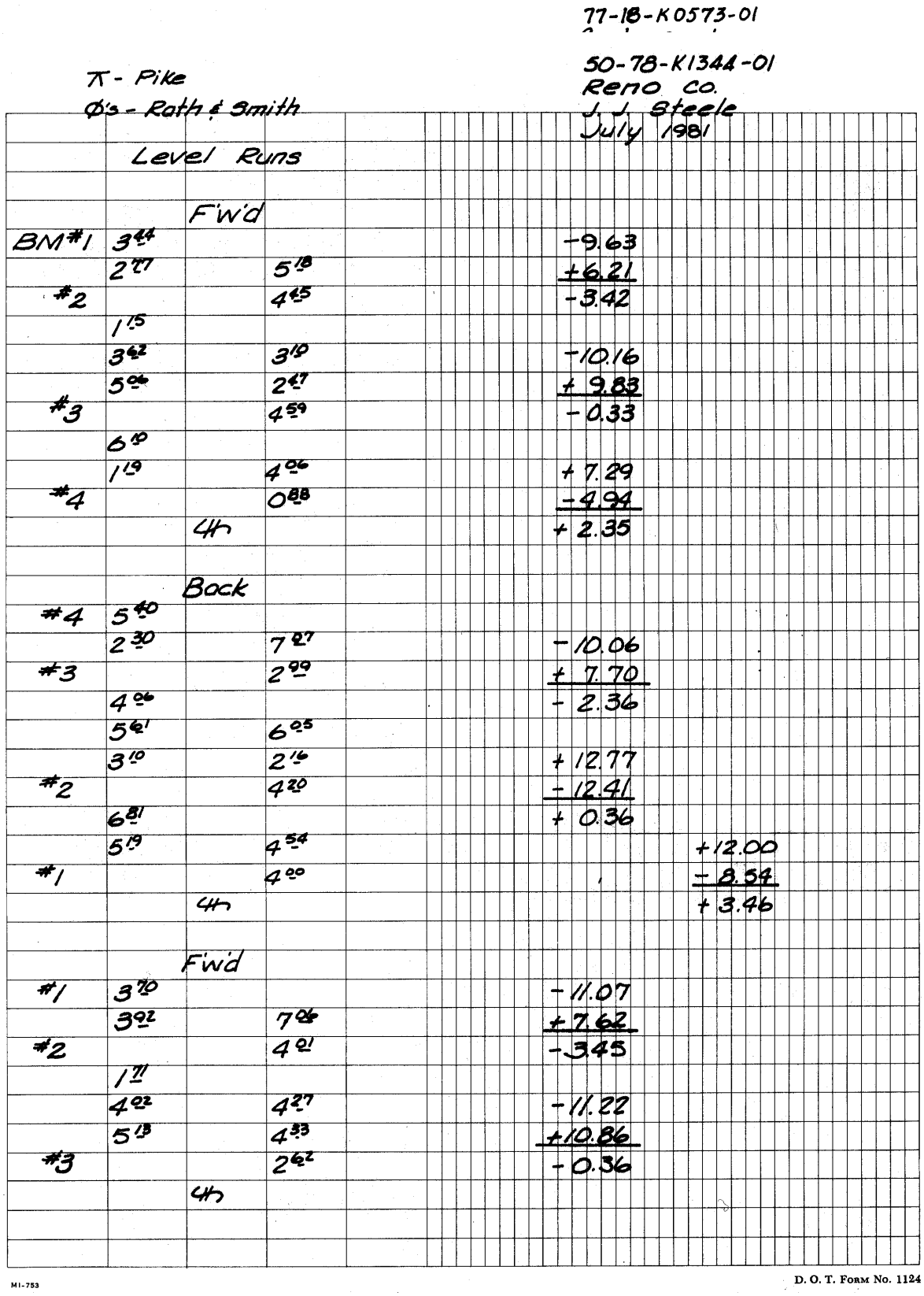

Figure 2.3.2-4 Sample Level Run Notes.

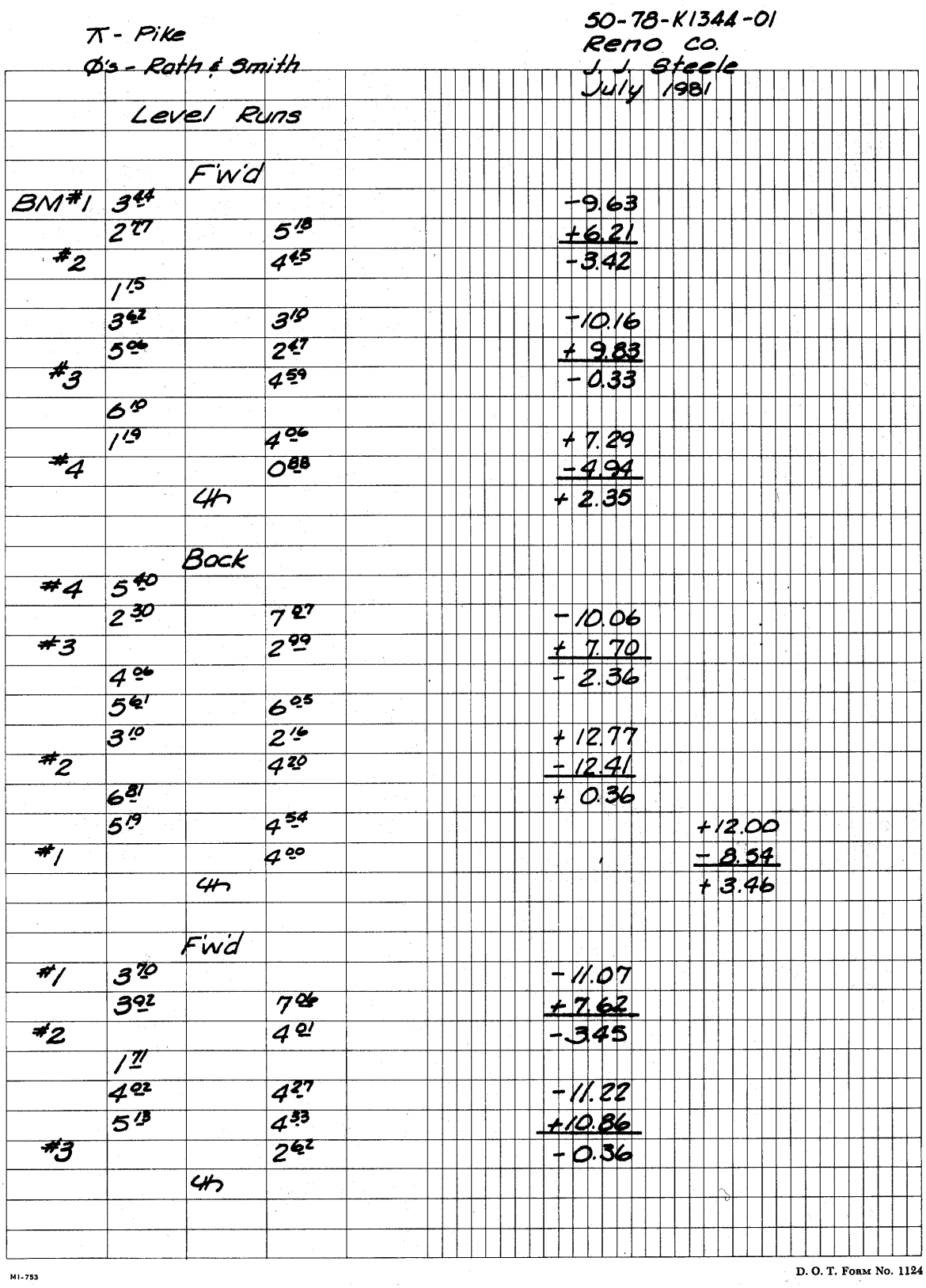

Figure 2.3.2-5 Sample Bench Mark Recap and Abstract of Bench Marks on an Open Level Run

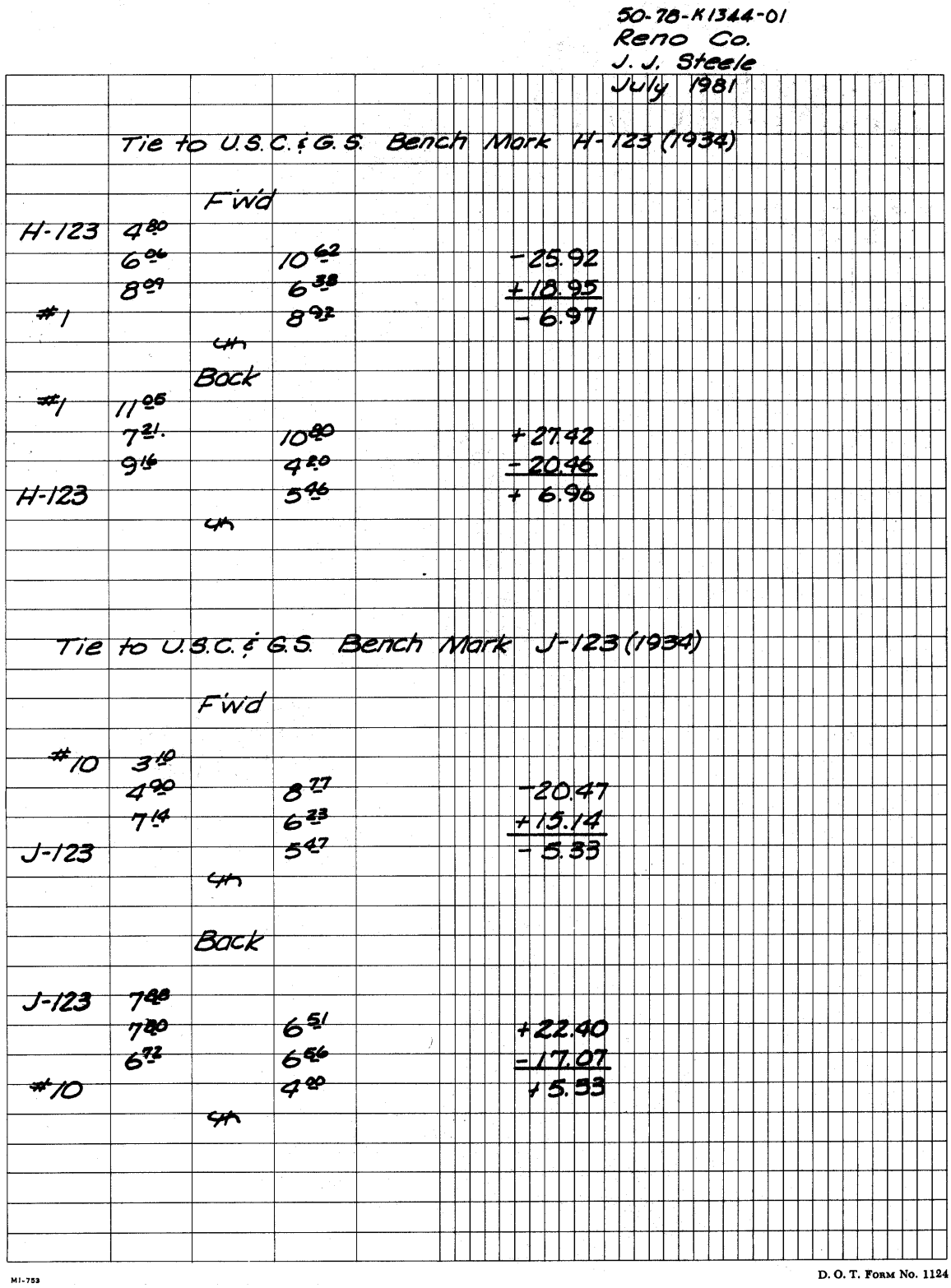

Figure 2.3.2-5a Sample Bench Mark Recap and Abstract of Bench Marks on an Open Level Run (Continued).

54-1-K0101-01
Allen Co.
J. H. Brosemer
Sept. 1980

Example Recap sheet un-adjusted Bench Marks
(Tied to one datum Bench)

Recap Bench Marks

BM #	Fwd Run	Back Run	Re-run	Avg. diff.	Elevation	Description
1					1310.055	40d spike 4 washers in root
	+1.06	-1.05		+1.055		90" elm 72 Lt. 101+15
2					1311.11	"□" cut N.E. Cor. West headwall
	-3.21	+3.21		-3.21		RCB 16° Lt. 112+92 ±
3					1307.90	Steel fence po. 2 Ft. N. fc.
	+5.80	-5.78		+5.79		Cor. N-S ± E 60 Rt. 122+88
4					1313.69	N.E. anchor bolt conc. base
	+7.10	-7.13	-7.10	+7.10		Texaco sign 76 ± Rt. 133+15
5					1320.79	R.R. spike in top 90" stump
	-4.62	+4.61		-4.615		103 Lt. 144+73
6					1316.175	"□" cut N.E. cor. N.W. wing
						Bridge 17 ± Lt. 151+91

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2.4 THE DIGITAL TERRAIN MODEL SURVEY

2.4.1 General

The digital terrain model survey (hereafter called DTM survey) will contain the necessary information to develop computer generated, two and three dimensional models of the topography of the job area. The DTM survey is gathered using Agency designated feature codes for topographic and elevation features.

2.4.2 Setting of Offset Points

A DTM survey will be conducted with the use of RTK GPS equipment, a conventional total station, or both. To support mapping efforts with a total station, a network of offset points will be established from which the necessary features may be measured and collected. The importance of care and checks in establishing the offset points cannot be overstated. these points should be set in a manner consistent with the offset points described in Section 2.2.4.

The horizontal position of offset points established by RTK GPS shall be check measured. Horizontal position of offset points established by an electronic theodolite should be either by closed traverse, or checked by radial measurements from two independent instrument setups. A hard copy listing of the point numbers, coordinates, station and offsets, and elevations are to be included in the field notes.

The elevations of offset points should be obtained by use of a level. The offset points are then submitted in an electronic file to the office for post processing of the survey data into complete design files.

2.4.3 The Collecting of Data by Total Station

After setting up the instrument it will be necessary to program the instrument or data collector for the operation. It will be necessary to enter the job number, the instrument occupied point number, and a backsight point.

An accurate height of instrument will need to be obtained. This is done with a steel tape by measuring from the offset point to the horizontal axis of the telescope. This height of instrument will be entered into the instrument or data collector.

An accurate height of prism is also required. This will be obtained by measuring from the bottom of the plumbing pole to the sighting position on the prism. This prism height will be entered into the instrument or data collector.

When training new instrument operators it is advisable that an additional member of the crew be kept with the instrument operator to insure that all the information has been entered into the instrument, and perhaps kept on hard copy for later reference.

Prior to ending an instrument setup an independent check measurement shall be made to another offset point.

Data collected during a DTM survey will include the location of all physical features in the project site, and will ultimately reflect the surface elevations of the project.

Break lines within a DTM model can be described as a barrier. A data point measured on one side of a break line will not cross a break line and connect to another point. The correct inclusion of break lines will increase the accuracy of the ground surface derived from the model. Examples of break lines are the travel way (center) of roadways, the edge of a roadway, shoulder lines, base of roadway drainage, top of back slope, left and right banks of streams, center of streambed, left streambed and the right streambed, and any other defined ground line that is observed by the rod person. Measurements should be taken frequently enough along the break lines to build an accurate model. Typically every 50 to 100 feet is sufficient. When working in urban locations in which there is curb and gutter and other hard pavement elevations, the measurement intervals will be in the 20 to 30 feet range. It is important that break lines not cross one another. The data collection crew must be alert and methodical in this task.

Regular contour point shots will supplement break lines. These shots should be taken at an interval of 50 to 80 feet in between the break lines, or in undefined open areas of the survey not depicted by a break line, e.g. a level field or parking lot.

The DTM survey will include measurements to all topography features within the limits of the project. These may include the travel ways of any side roads or private entrances, all underground utility lines, telephone pedestals, power poles, meters, valves, drainage structures, the headwalls and wings of any concrete drainage structures, trees, edges of timber, buildings or houses, fences, inlets, manholes, bridge rails, railroads, signs, streambeds, etc.

When doing a DTM survey each rod person should carry either a can of spray paint, a colored marking crayon (for urban work), or flags so that he is able to mark the progress of the survey.

There are some features that will need to be measured in a particular manner to allow for correct plotting. A couple of examples are guard rail fence and signs. The rod person should become familiar with these instances by studying the K.D.O.T. features table code list.

The feature code list is included in Figure 2.4.3-1.

After all the data has been collected (or at the end of each day) the data should be transferred from the data collector to a computer, where it can be printed out and edited. Special care should be taken when editing the data so as to guard against the deletion of necessary information or the insertion of incorrect data.

Some important data collection tips….

- On paved side roads - locate the breakline down the center and each edge of the road as needed. Use feature code 3001 for public roads, and features code 3002 for private roads.
- On entrances – locate breakline as needed, map the edge entrance with features code 3002 for plotting purposes.
- Use feature Code 3507 to map drainage culverts.

- The feature code for a shoulder line (3004) is to be used as a paved shoulder of a roadway.
- Always use feature code 3022 along the EWS of bridges.
- Always locate a breakline around culvert wings and bridge abutments. The 3d model of a bridge site will display without the bridge. Therefore the survey crew must keep the concept in mind as they measure and locate the features at a bridge or culvert site.
- Use "0" degrees, "0" minutes, "0" seconds as a backsight initial.

Figure 2.4.3-1 Feature Code List.

## Barrier ##		****=Included in DTM**
Fence (Barbed Wire)	3201	
Fence (Chain Link)	3202	
Fence (Wooden)	3203	
Fence (Woven Wire)	3204	
Fence Post 'X'	3205	Center of Post
Retaining Wall	3206	Center of Wall
Stone Wall	3207	Center of Wall
** Curb	3208	BK of Curb W/TW on right
** Curb and Gutter	3209	BK of Curb W/TW on right
Guardrail	3214	Shoot Rail side W/TW on Rt.
Cemetery Graveline	3218	
Guard Fence Post	3217	Center of Post
Guardrail (Top)	3220	Shoot on Top of Rail
** Guardrail (Ground)	3221	Shoot @ Ground next to Rail
## Mapping Features ##		
Railroad Crossbucks	3903	
Mailbox	3917	Center of Base
## Roads and Rails ##		
** Public Road	3001	
** Private Road	3002	Use for Ent.
** Shoulder Line (Paved)	3004	
T.W. of Bridge	3005	
** Parking Lot (Paved)	3007	Closed Figure
** Sidewalk	3009	Edge of SW-Closed Figure
Gutter of Bridge	3010	
Bridge Rail	3012	
Railroad	3014	Shoot Center of Tracks
** R. R. Planking	3015	Closed Figure
Top of Rail Elev	3021	
** E.W.S. of Bridge	3022	
** Approach Slab	3023	Closed Figure
## Utilities (Above Ground) ##		
Manhole	3301	Center of Top
Catch Basin-Square	3302	Center of Top
Catch Basin-Round	3303	Center of Top
Fire Hydrant	3304	Center of Top
Gas Well	3305	Center of Top
Oil Well	3306	Center of Top
Water Hydrant	3307	Center of Top
Well	3315	Center of Top
Vent Pipe	3316	
Fill Cap	3317	For Underground Tanks
Irrigation Pivot Point	3318	
Irrigation End Point	3319	
## Utilities (Underground) ##		
Gas Line	4101	
Oil Line	4102	
Power Cable	4103	
Sanitary Sewer	4104	
Water Line	4105	
Telephone Cable	4106	
Utilities Marker Sign	4107	Center
Top of Valve	4108	Spot Elev. Top Valve
TV Cable	4109	
Fiber Optic Cable	4111	
Transformer Box	4112	Center of Top
## Vegetation ##		
Tree Row	3401	Center of Row
Evergreen Shrub	3402	2 Shots-Center & Radius
Mixed Trees	3403	Keep Trees to the Right
Bush	3404	2 Shots-Center & Radius
Orchard	3405	Keep Trees to the Right
Tree	3406	2 Shots-Center & Radius
Evergreen	3407	2 Shots-Center & Radius
Edge of Timber	3408	Keep Trees to the Right
Hedge Row	3409	Center of Row
Tree Trunk	3410	Center of Trunk
Tree Stump	3411	Center of Stump
Bushes-Deciduous	3412	Keep Bushes to the Right
Cropline	3413	
## Digital Terrain Model ##		
** Breaklines	4301	
** Regular Contour Points	4304	
** Spot Elevation	4305	Top of Hill-Bottom of Hole
** High Spot	4306	

## Irrigation Wheel Path	3320	
## Irrigation End Path	3321	
## EPA Monitoring Well	3314	

## Surveys and Boundaries ##		
Right of Way Marker	3813	Center of Top
Section Corner	3812	
Bench Mark	3814	
Default	4214	Use for Targets
## Drainage ##		
** Stream	3502	Start Upstream-Work Down
** Waters Edge	3504	Keep Water on Right
** Slope/Dam	3506	Shoot with Slope to the Rt.
Culvert	3507	Use for Pipes also
** Streambed Lt or Rt.	3508	
Culvert Wings	3512	Use for Headwalls Also
** Terrace Line	3514	Center of Terrace
Guter Inlet	3516	Gutter then Lip
Ditch Plug	3518	2 Shots-Near Point then Far
** Rip Rap Edge	3519	
Top of Opening	3521	Spot Elev. on TO
Flowline Elev.	3522	Spot Elev on FL
Streambed Elev.	3523	Spot Elev. on SB
Hubguard	3524	Spot Elev. on Hubguard
## Signs ##	**Face sign when shooting**	
Sign (one post)	4001	2 Shots-Shoot Rt.-then Lt
Sign (two posts)	4002	2 Shots-Shoot Rt.-then Lt
Billboard	4003	2 Shots-Shoot Rt.-then Lt
Billboard (lighted)	4005	2 Shots-Shoot Rt.-then Lt
## Structures ##		
Building-Orthogonal	3101	Closed Figure
Building-Irregular	3102	Closed Figure
Building-Church	3103	Closed Figure
Building-School	3104	Closed Figure
Building-Commercial	3105	Closed Figure
Building-Foundation	3106	Closed Figure
Building-House	3112	Closed Figure
Building-Mobile Home	3115	Closed Figure
Building-Garage	3114	Closed Figure
Deck	3121	Closed Figure
Tank-Square	3107	Closed Figure
Tank-Round	3108	2 shots-Both sides
Silo	3109	2 shots-Both sides
Propane Tank	3110	2 shots-End to End
Building Overhang	3111	Closed Figure
Building-Out Building	3113	Closed Figure
Grain Bin	3116	2 shots-Both sides
Floor Elevation Point	3117	
Ground Elevation Point	3118	
Flag Pole	3120	
Swimming Pool	3122	Closed Figure
** Concrete Area	3130	Closed Figure
** Bituminous Area	3131	Closed Figure
## Utility Poles ##		
Power Pole	4201	
Light Pole	4202	Center
Light Tower	4204	Center
Dead Man	4205	
Guy Pole	4206	
Telephone Pedestal	4207	
Telephone Pole	4208	
Power and Tel Pole	4209	
Water Meter	4210	Center of Top
Gas Meter	4211	Center of Top
Gas Valve	4212	Center of Top
Water Valve	4213	Center of Top
Cable TV Pedestal	4215	
F.O. Junc. Box	4216	
High Power Elec. Tower	4217	Center
##ITS Equipment ##		
Dynamic Message Sign (single post)	4401	
Dynamic Message Sign (dual post)	4402	
Dynamic Message Sign (dual face)	4403	
ITS Equipment Cabinet	4404	

Revised 10/14/13

2.5 BRIDGE SURVEYS

2.5.1 General

Each bridge survey location presents a unique situation. The survey crew will be advised by the Survey Coordinator if, and when, additional survey information has been requested.

2.5.2 Channel Sections

Channel sections are cross sections measured perpendicular to the streambed. These are derived from the digital terrain model. Therefore the data collection must provide sufficient coverage 400 feet up and down stream for one half the bridge length each direction from the high bank for channel sections. Refer to Figures 2.5.2-1 and 2.5.2-2, the Hydrology Guide Sketch for a graphic representation at a typical site.

2.5.3 Streambed Profiles

Streambed profiles are taken to determine the gradient of the stream. Streambed profiles are measured along the thread of the stream. Elevations are measured at the lowest part of the streambed in increments of 100 feet upstream and downstream, and additionally at any location of riffles, scour, dams, spillways, and other streambed junctions. The elevation of the water is taken at the centerline, locations of riffles, scours and dams, and at each end of the profile. Typically the streambed profile should be obtained for a distance of 1000 feet each direction from the bridge site. This should be collected electronically so that it may be included in the modeling with the valley sections and channel sections.

Figure 2.5.2-1 Channel Cross Section Guideline Sketch.

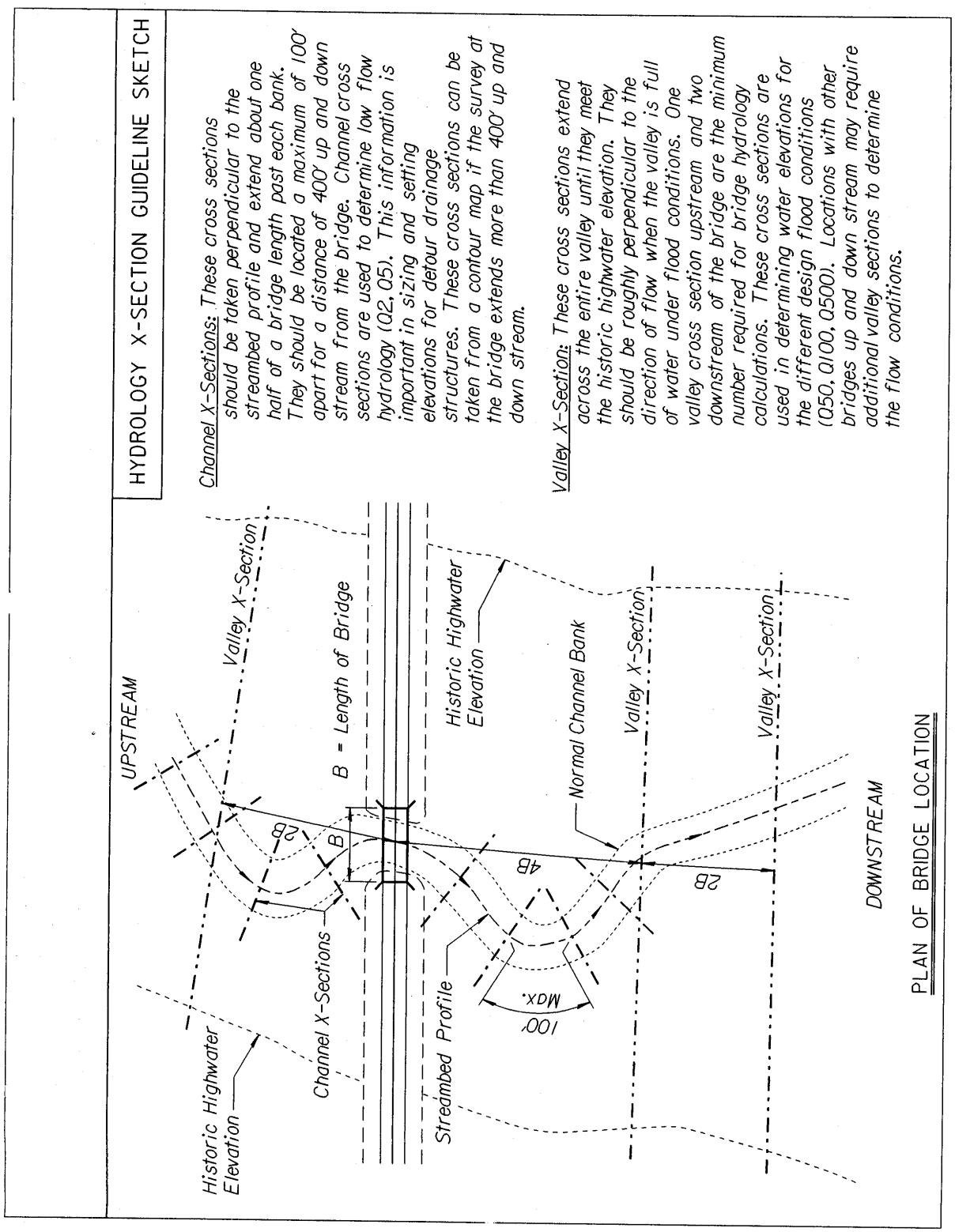
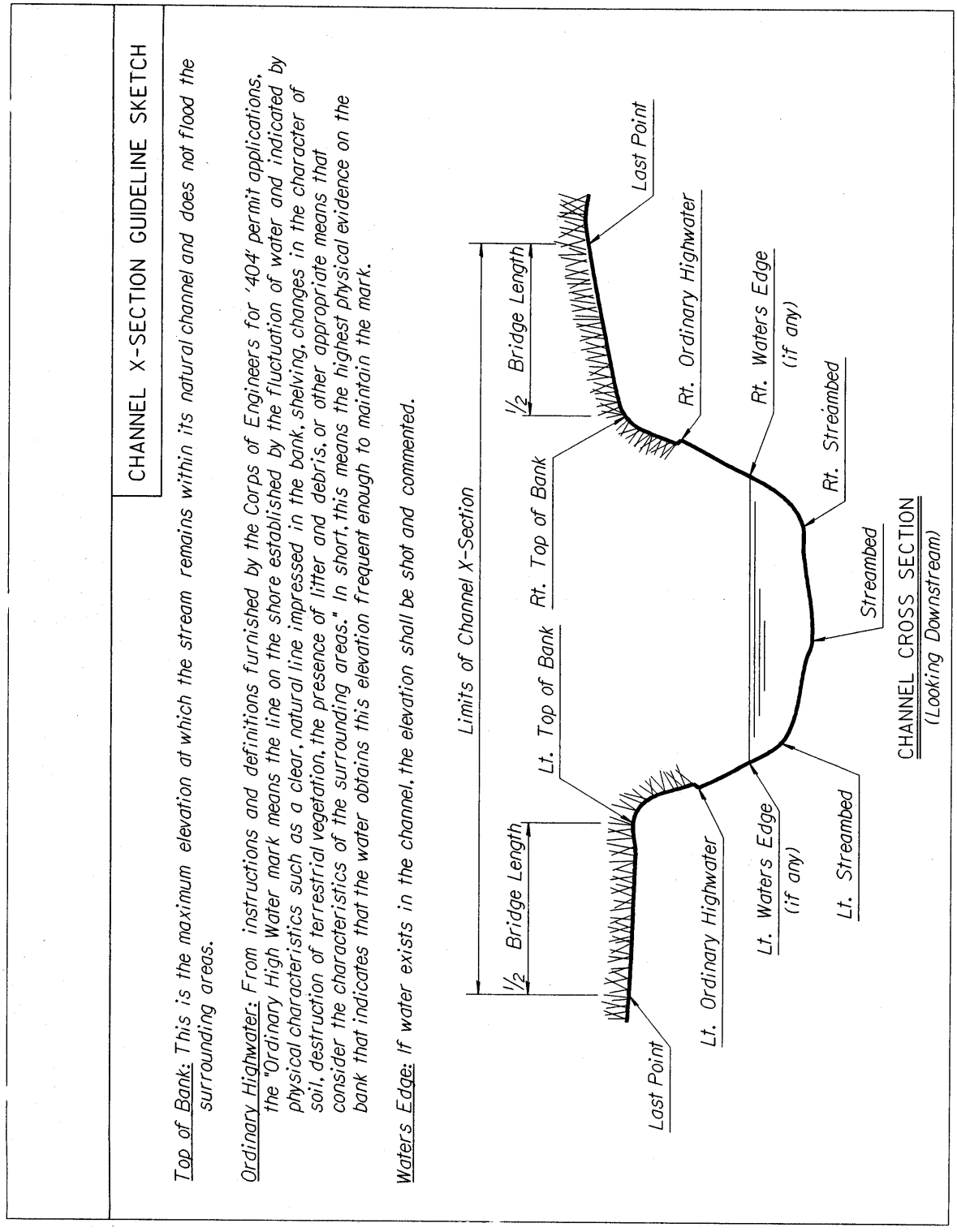


Figure 2.5.2-2 Hydrology Cross Section Guideline Sketch.



2.5.4 Waterway Openings

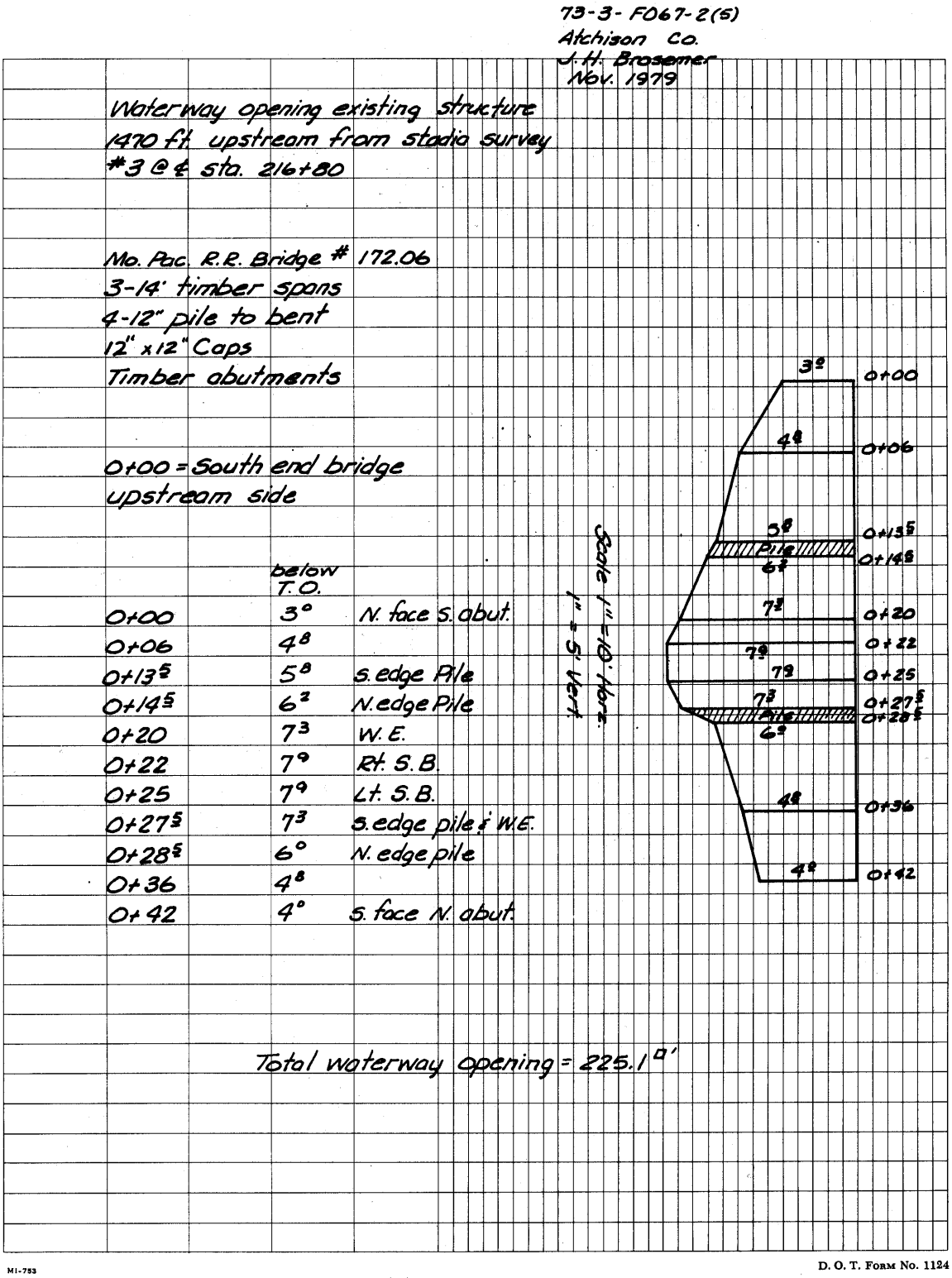
A waterway opening will reflect the unobstructed area that will allow water to pass under a bridge. This information will be included for all span structures in the vicinity of the bridge location, and may include railroad or adjacent side road bridges one mile upstream or downstream. Waterway openings are taken by assuming the face of abutment on the upstream side of the bridge to be station 0+00, then measuring the distances down from the top opening of the structure to the ground. Measurements are taken at succeeding points along the opening wherever changes in ground elevation occur, sufficient to determine the area of the opening, to the opposite bridge abutment. If there are plans for the structure then an alternative to the aforementioned would be to profile the ground line at the upstream face, and note the T.O. elevations. The bridge designer will then process the information required.

Check the bridge opening of the piers and total bridge with any available construction layouts for conformity. If different, verify the field information, and document the difference for the bridge design staff.

If there are not any plans for the subject structure then a sketch, drawn to scale, will be included to depict the opening. Information to be noted on the sketch will include the location of the structure, description, elevation on the top opening, and the area of the opening. If a roadway or railroad structure, then also note the roadway or top of rail elevation.

See Figure 2.5.4-1 for an example of a waterway opening sketch.

Figure 2.5.4-1 Sample Waterway Opening Sketch.



M1-753

D. O. T. Form No. 1124

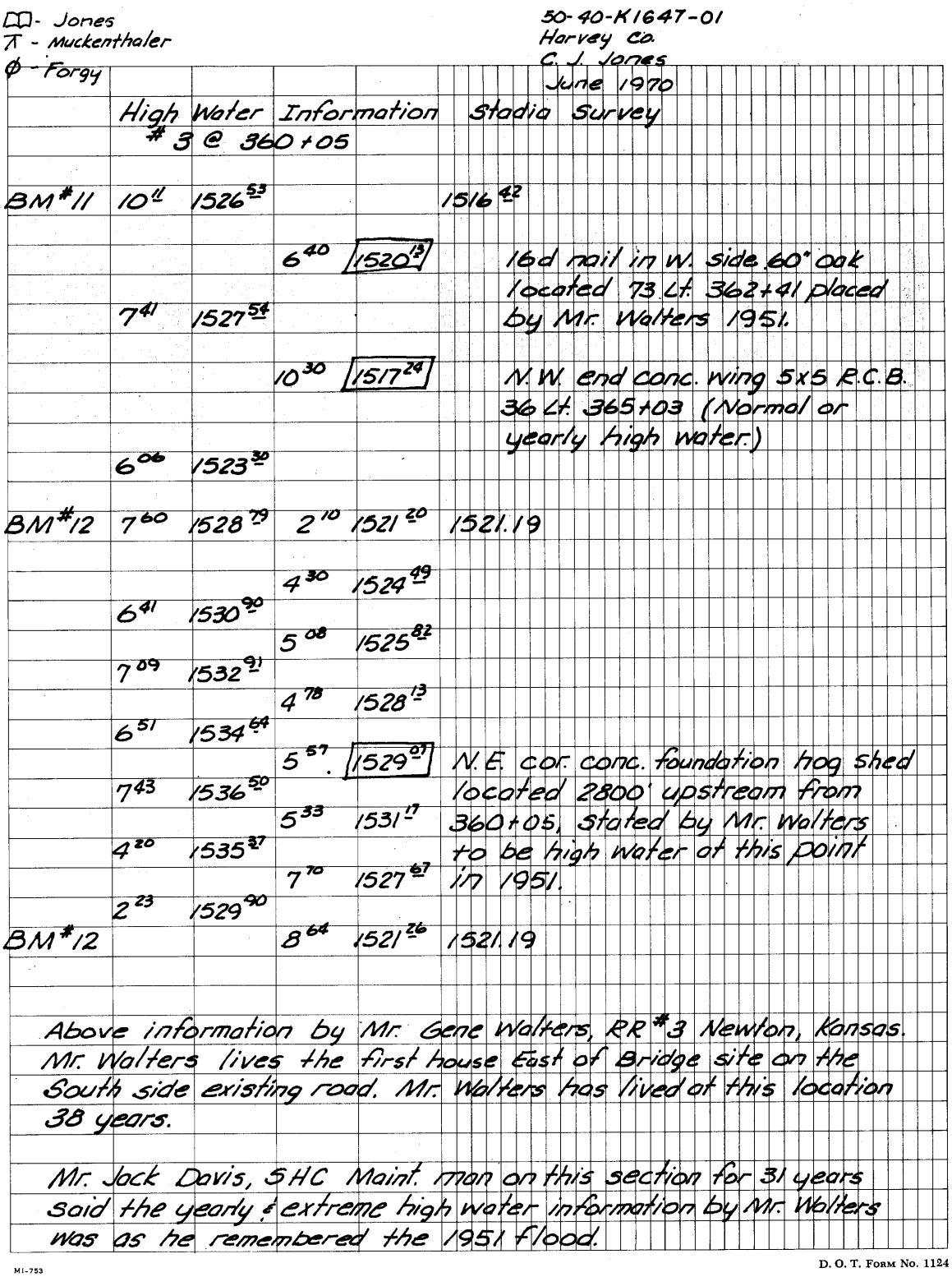
2.5.5 High Water Elevation and Ordinary High Water Elevation Information

The history of the elevation of high water occurrence is an important element in the design of a bridge structure. Sources of information are local residents, KDOT maintenance personnel, Railroad Roadmaster, Corps of Engineers, and State Board of Water Resources. A determined effort should be made to obtain more than one opinion. To aid in this documentation, have each witness complete the Bridge Hydraulic Information sheets and incorporate these into the project notes. A sample of a high water elevation sheet can be seen in Figure 2.5.5-1.

Once the high water elevation marks have been determined, a level run is made through the high water marks and tied to project bench marks. The location of the high water, with a description of the mark, will be included in the notes, as well as the source of information.

Ordinary high water is defined as the elevation a stream reaches often enough during the year to prevent sustaining permanent wooded vegetation from growing below that elevation. Often it is a well-defined line on the banks and is easily determined, while other times it can be most difficult to determine. Ordinary high water elevations near right of way line in a normal channel setting should be obtained. Include the elevation and location by station and offset to the survey alignment. Ordinary high water elevations are required for all bridge replacement survey sites and at all drainage structure locations that are detailed with a "blue line" stream crossing on a USGS quadrangle map.

Figure 2.5.5-1 High Water Elevation Sheet.



□ - Jones
⊼ - Muckenthaler
ϕ - Forgy

50-40-K1647-01
Harvey Co.
C. J. Jones
June 1970

	High Water Information # 3 @ 360+05				Stadia Survey	
BM #11	10.11	1526.53			1516.42	
			6.40	1520.13		16d nail in W. side 60" oak located 73 Lt. 362+41 placed by Mr. Walters 1951.
	7.41	1527.54				
			10.30	1517.24		N.W. end conc. wing 5x5 R.C.B. 36 Lt. 365+03 (Normal or yearly high water.)
	6.06	1523.30				
BM #12	7.60	1528.79	2.10	1521.20	1521.19	
			4.30	1524.49		
	6.41	1530.90				
			5.08	1525.82		
	7.09	1532.91				
			4.78	1528.13		
	6.51	1534.64				
			5.57	1529.07		N.E. cor. conc. foundation hog shed located 2800' upstream from 360+05, stated by Mr. Walters to be high water of this point in 1951.
	7.43	1536.50				
			5.33	1531.17		
	4.20	1535.37				
			7.70	1527.67		
	2.23	1529.90				
BM #12			8.64	1521.26	1521.19	

Above information by Mr. Gene Walters, RR #3 Newton, Kansas. Mr. Walters lives the first house East of Bridge site on the South side existing road. Mr. Walters has lived at this location 38 years.

Mr. Jack Davis, SHC Maint. man on this section for 31 years said the yearly & extreme high water information by Mr. Walters was as he remembered the 1951 flood.

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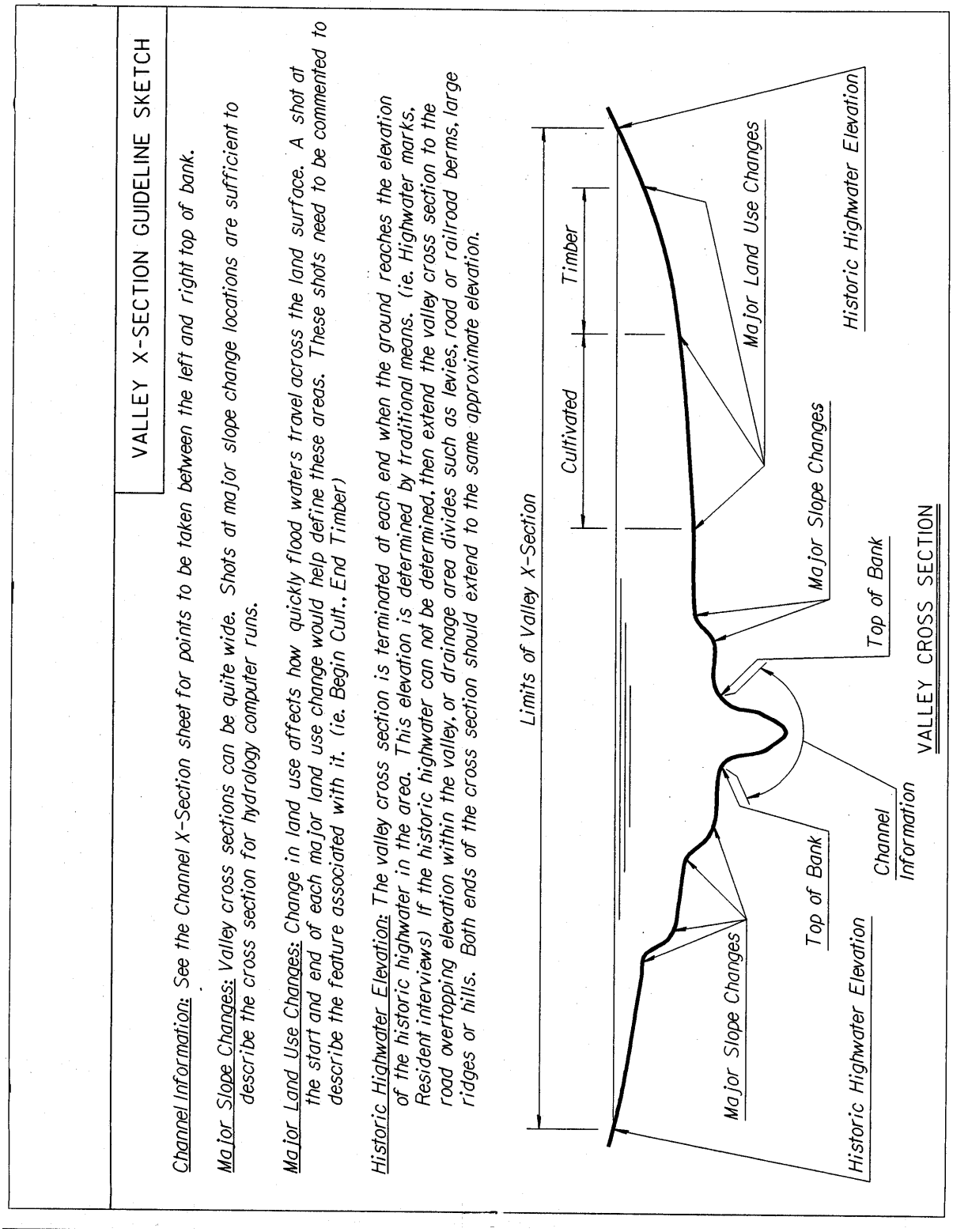
2.5.6 Valley Sections

The amount of water flowing down the valley and passing through the bridge site is also an important factor in determining the size of structure required. The bridge designer will review the survey site to determine any special needs for that particular location. A valley section is basically a profile, on a determined line, below the historic high water elevation. Figure 2.5.6-1 reflects a schematic of the general locations of a valley section.

Standard criteria for valley sections require that a section be obtained 2 bridge lengths upstream and also at 4 and 6 bridge lengths downstream. These will be taken perpendicular to the valley and should extend to just above the record high water elevation. Contour maps and aerial photos are an ideal reference in determining the valley location. The valley section will be taken as a profile, with an assumed stationing for the beginning of the valley. Station and elevations will be determined along the valley sufficient to properly reflect the terrain. Additionally, a station and elevation where land use changes occur will be noted. The beginning and end of the valley section shall be tied to the project, with the coordinates, station and offset from the project included with the survey data.

Figure 2.5.6-1 Schematic of the general locations of a valley section.



2.5.7 Bridge Hydraulic Questionnaire

The Bureau of Structures and Geotechnical Services has developed a questionnaire to quantify the historic hydraulic condition at a bridge site. This questionnaire is self explanatory. This survey crew shall submit a minimum of two completed questionnaires at each location of a bridge survey. One questionnaire should be completed by KDOT Maintenance staff, and another (or more) questionnaires should be submitted by local residents familiar with the history of the site. The form should include the name of the crew member completing the form in the event additional detail is warranted.

Care should be taken in analyzing the information which is obtained, and seeking corroborative information when conflicting information is noticed.

Figure 2.5.8-1 reflects the content of the Bridge Hydraulic Questionnaire.

Figure 2.5.7-1 Bridge Hydraulic Questionnaire.

Proj. No. Pg.
County
Survey Party Chief

BRIDGE HYDRAULIC INFORMATION:

Bridge No._____ **Date**_____

Information for Structure at Station_____+_____

Stream Name:_____

Information obtained from Who?_____

Property Location (Twn,Rng,Sec)_____

Address_____

Phone Number_____

Length of residency or knowledge of site_____

How often does water go over the highway / sideroad?_____

_____

Depth over road & elevation?_____ **Elev:**_____

Project station overtopping location:_____+_____

How often does water reach the following locations?

Shoulder of roadway?_____

Project Sta/Location?_____

Top of opening of bridge or minimum clearance observed?_____

_____

Other locations (Dikes, levees, outbuildings, first floor of house, etc.)

_____

Project Sta/Location_____

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Page 1

Figure 2.5.7-1a Bridge Hydraulic Questionnaire (Continued).

Proj. No. Pg.
County
Survey Party Chief

HIGHWATER INFORMATION:

What was the record highwater event?_____

_____

Date: (Month & Year)_____

How long did the highwater event last? _____

How long was water over the roadway? _____

What was the second highwater event?_____

_____

Date: (Month & Year)_____

How long did the highwater event last? _____

How long was water over the roadway? _____

Are there any high-water marks or stains evident?
(Description, Owner-USGS /US COE/DWR/KDOT, location and elevation)

_____

Does the highwater run Slow, Moderate or Fast out of the bridge or RCB?

_____

Does the highwater cut across or remain with the main flow of the channel?

_____

Does the highwater appear to backup from downstream?

_____

What amount of trees or debris was observed in the highwater event?

_____

Rev. 3-2002

Page 2

2.6 TOPOGRAPHY

2.6.1 General

Although the limits and details of the information required will vary with the type of project, in general, this information will include the physical features that are within the digital terrain model survey.

2.6.2 Drainage Structures

The accurate location, description and elevations of drainage structures within a survey is important. In most instances, the existing plans will contain information of the structures along the corridor. The survey crew shall verify the field information with the record plan. Take special care in evaluating culvert sizes and types vs. the information noted by the survey crew. In instances where there is a substantial difference from the plan information, a check measurement shall be made. If a structure is found to be different than the existing plan, a note shall be included with the particular structure, documenting the difference and further noting that a check has been made. Field notes shall be reduced to reflect the elevations of the drainage structures. Elevations of drainage structures shall be determined by optical type survey equipment, by either a level or an electronic theodolite.

The survey crew should also note any special conditions found at a structure. Some items to be aware of would be a plugged structure, signs of scour, broken wing walls or headwall, and separation within the structure. These are to be noted in the structure information, or on a special sheet. Include photographs that best reflect the condition.

Reinforced Concrete Boxes - A complete description of the RCB is required, and will generally include the following items:

- Size of opening, perpendicular to the barrel. The width is listed first, the depth listed second, and the length listed last.
- Either roadway length or overall length (indicate which).
- Width and length of headwalls and wing walls.
- The angles of the wing walls.
- The skew, or rotation angle of the structure.
- Length of aprons.
- Dimension and location of soil savers.

Concrete Bridges - A complete description of the bridge is required, and will generally include the following items:

- Bridge number if available.
- The number and length of spans.
- The type of structure.

•Roadway width.

•Size of hubguards.

•Size of handrails.

Culverts- A completed description of the culvert to include the following as applicable:

- Inside diameter and length.
- Composition of culvert, i.e., metal, concrete, vcp…
- Width and length of headwalls, or soil savers.
- The length of pipes with headwalls should be listed as overall length, outside to outside of the headwalls.
- Length of end sections.

Arch Structures - A detailed description of arch structures would usually be shown by a sketch. If a sketch is not included, then the span and rise of the arch should be indicated.

Curb Inlets & Catch Basins- A location and description of the inlet and catch basin shall be noted. The location of the offset shall be noted. The elevation of the gutter, top opening, individual flow lines and sizes of the structures entering and exiting the catch basin shall be shown, along with the flow line of the catch basin. The survey notes may refer to a plan type, e.g, Type I Median Inlet, rather than a description, if the reference plans of a previous project contain the schematic of the inlet. Care in evaluating the project plans must be exercised so that a special condition has not been overlooked. In all cases the station and offset shall be noted to either the catch basin, outside headwall, or curb opening.

See Figures 2.6.2-1 through Figure 2.6.2-4 for sample structure description notes.

Figure 2.6.2-1 Sample Structure Description Notes.

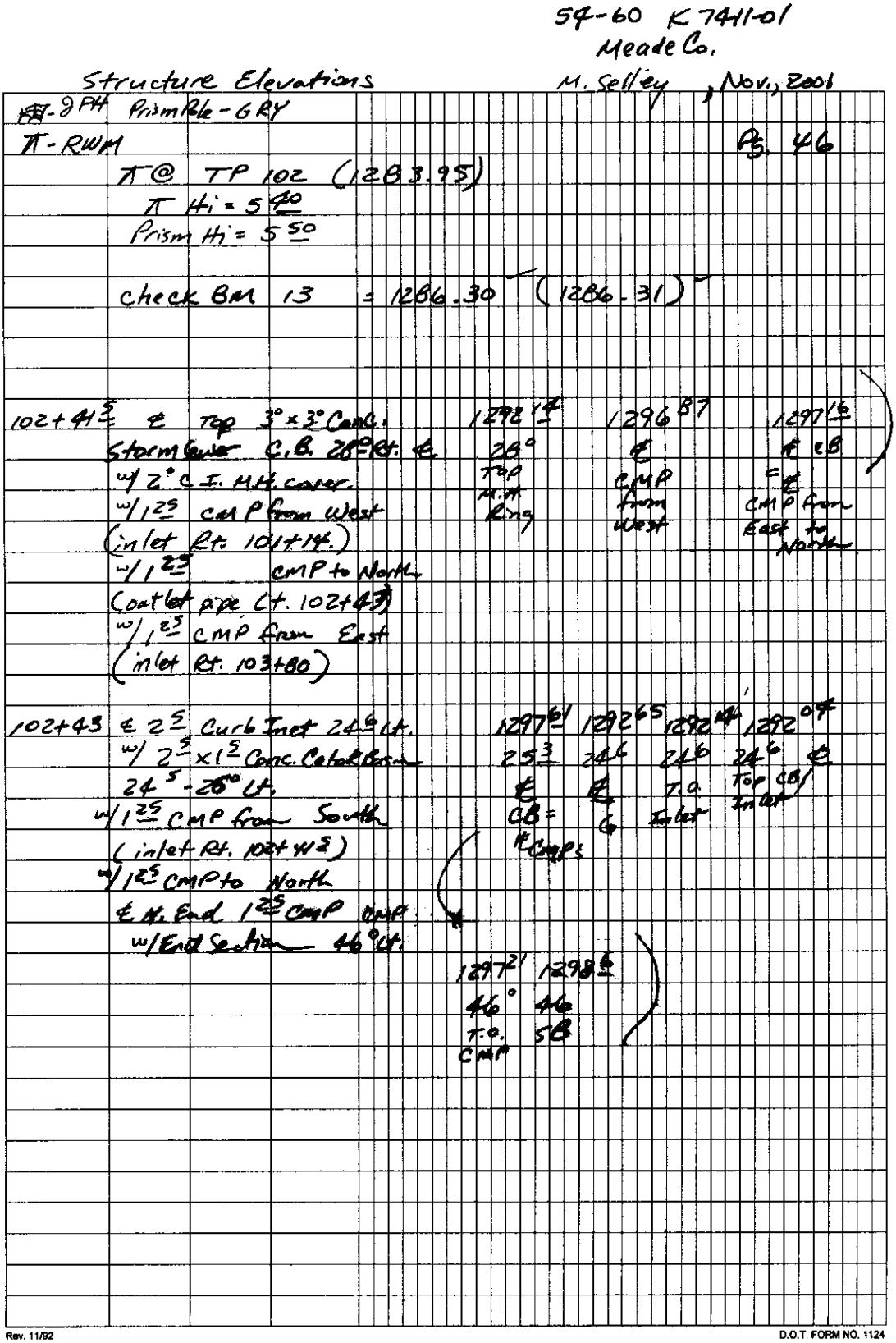

Figure 2.6.2-2 Sample Structure Description Notes.

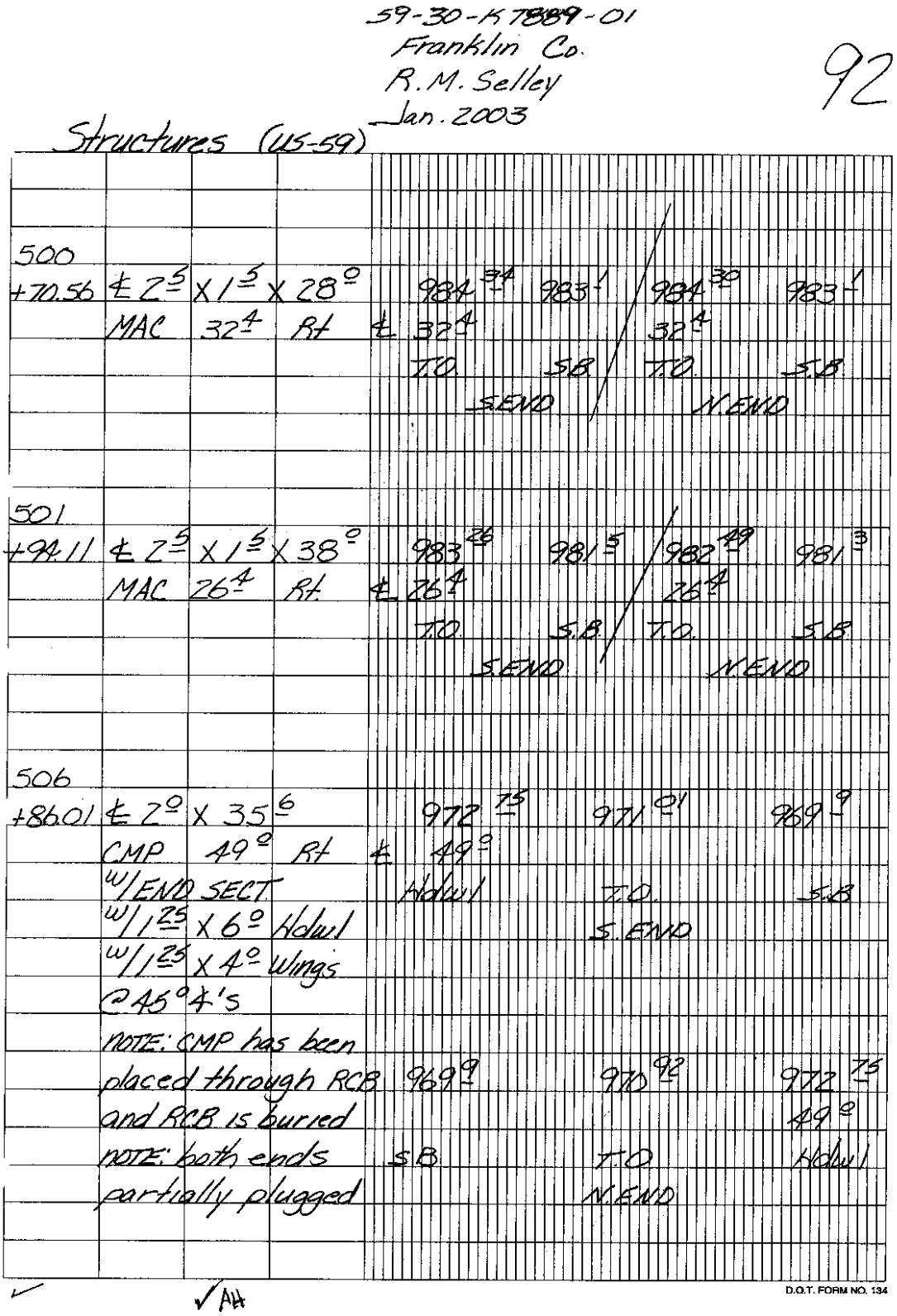

Figure 2.6.2-3 Sample Structure Description Notes.

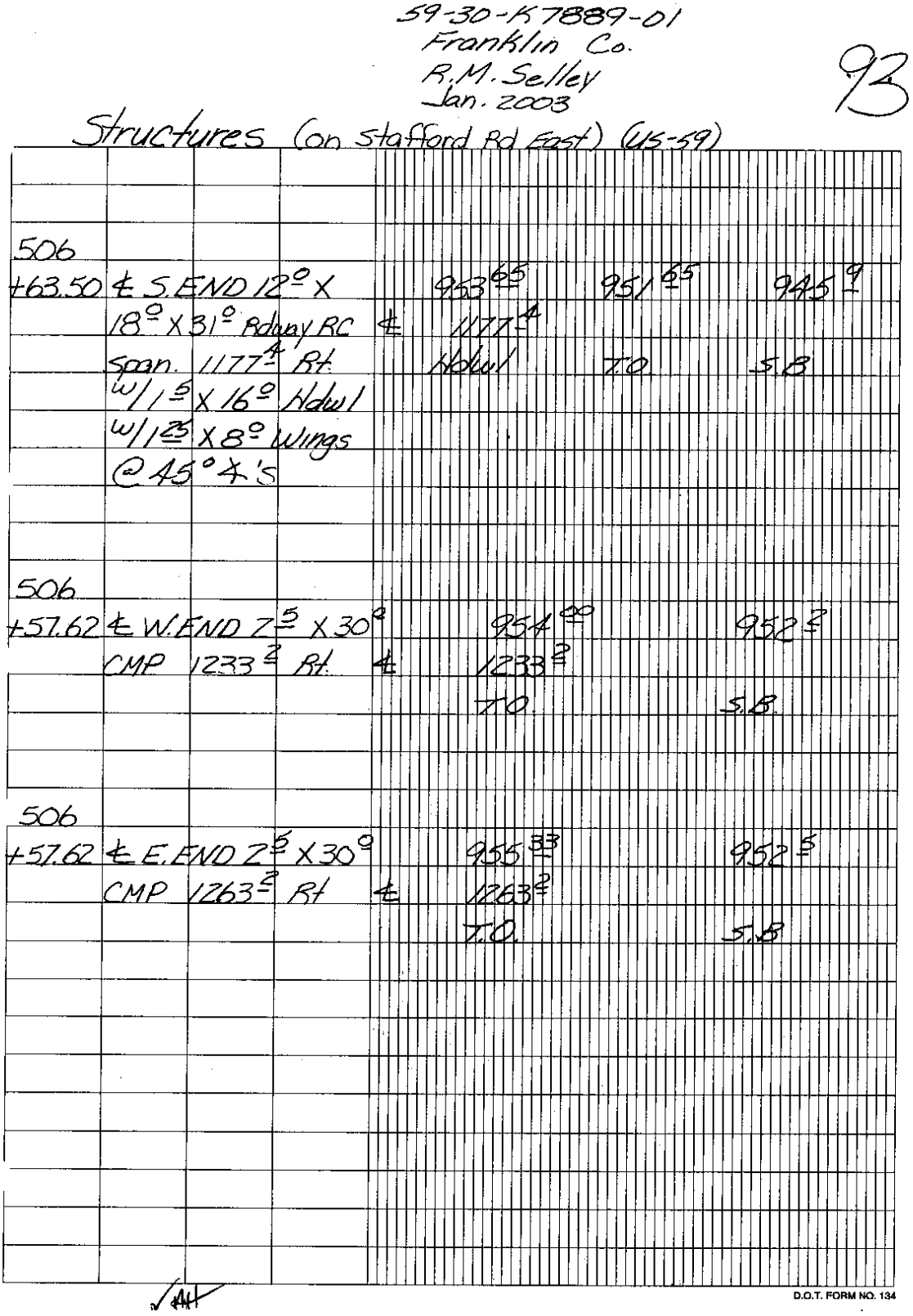

Figure 2.6.2-4 Sample Structure Description Notes.

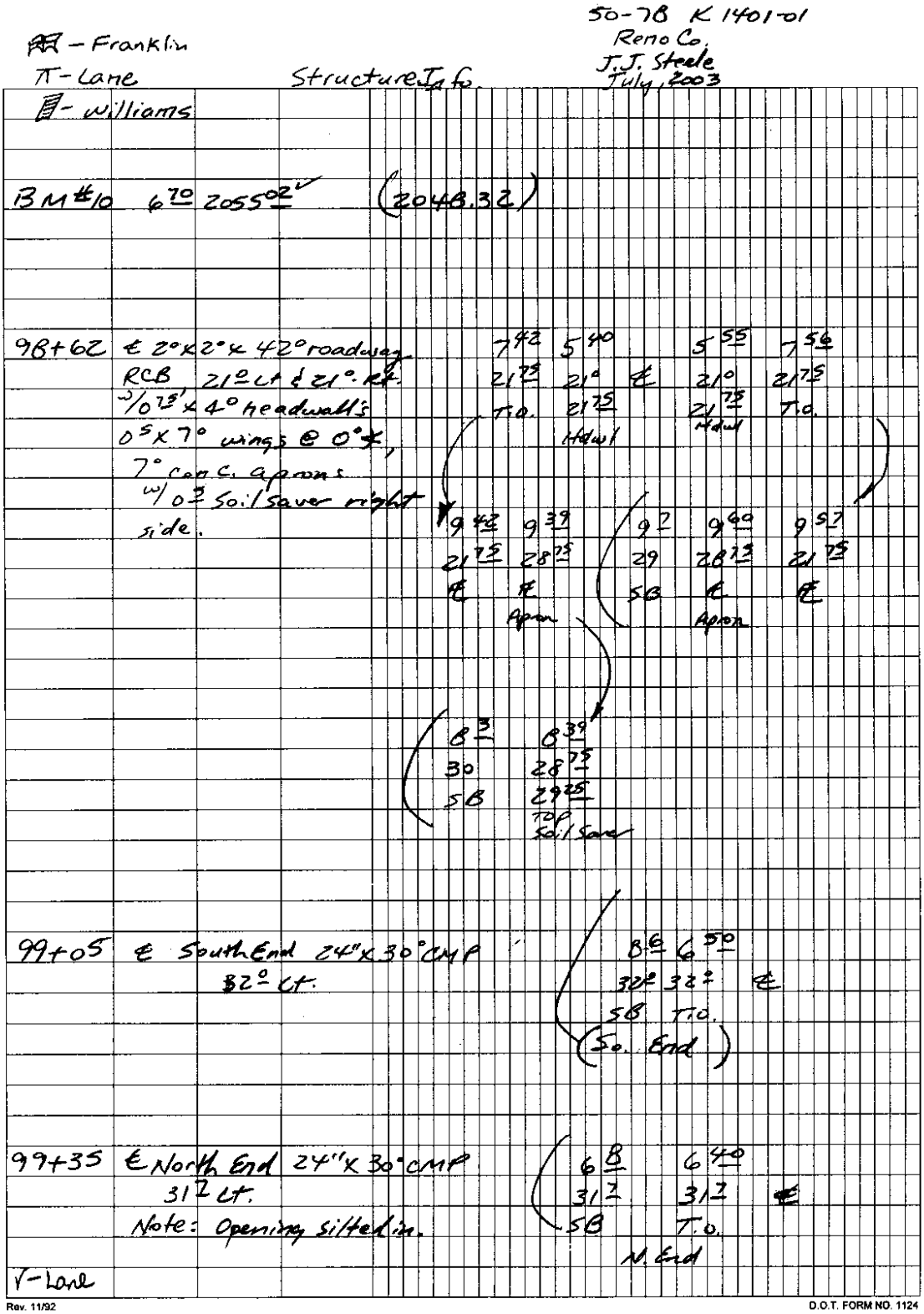

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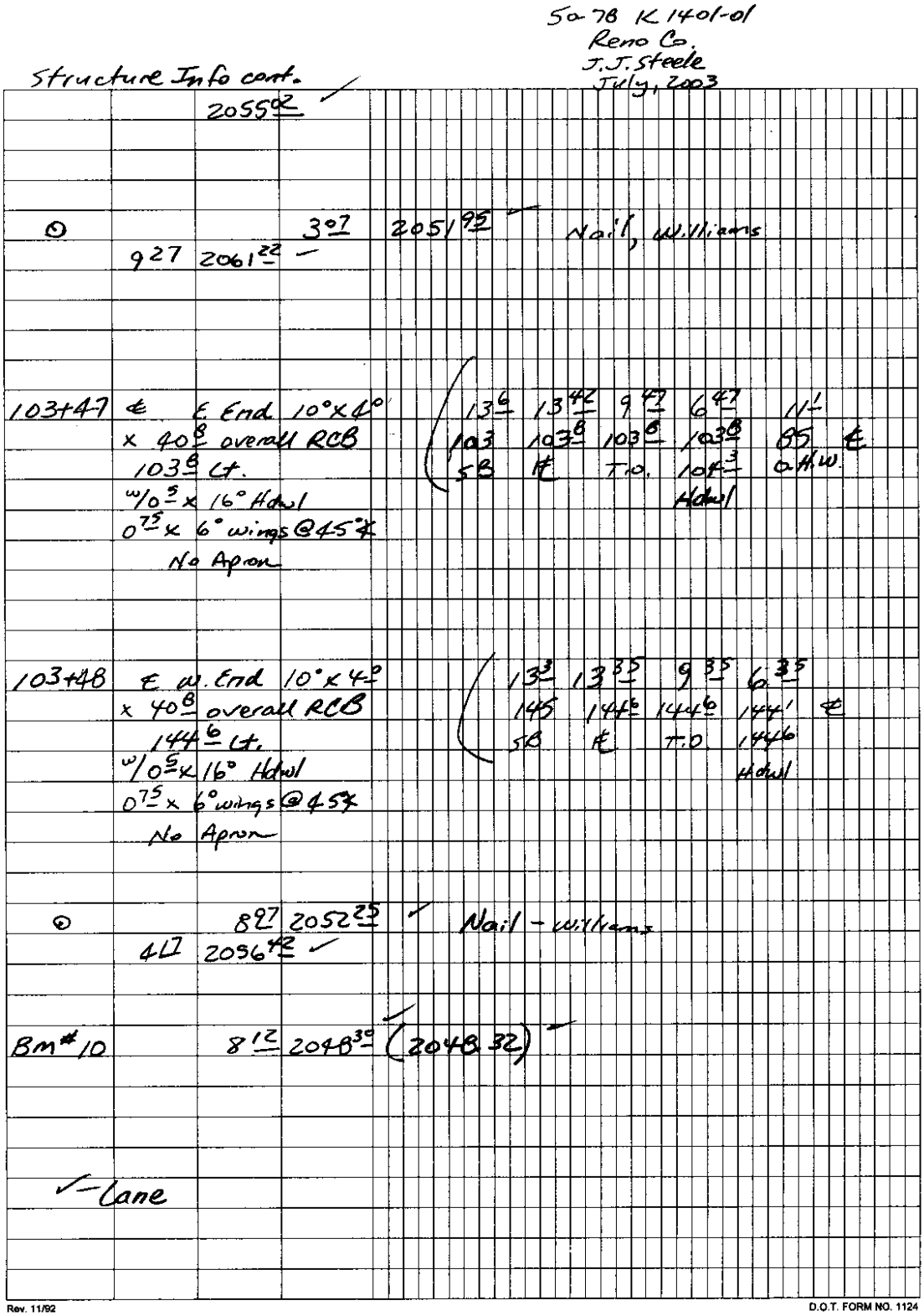
Figure 2.6.2-5 Sample Structure Description Notes.



2.6.3 Photograph of the Project Site

Photos of specific areas on a project are a definite benefit to the Designer. It will be customary to provide photos at locations along the project which will best show areas of erosion at culvert locations, bridge sites (both looking at the stream from the bridge location, and also up and down stream with a view of the bridge opening), intersections, etc. A Register of Photographs (DOT Form 1125) is to be submitted for each project, identifying the location and theme of the photo.

2.7 DRAINAGE AREAS

2.7.1 General

The design of a drainage structure requires an accurate, graphic representation of the surface drainage area upstream of a structure for proper sizing. Drainage area maps are required for all drainage areas less than 2 square miles. The project designer shall note on the Survey request if drainage maps will be required.

Standard KDOT drainage sheets will be utilized to map areas adjacent to the project. The scale of these maps are 1" to 500'. Aerial photographs should be examined to aid in the decision as to where to place the project alignment on the sheet. The centerline should be placed on the sheet so as to eliminate the need for additional or match sheets. The printed lines on the standard sheets represent section and quarter section lines. The centerline of the project is plotted on the sheets in respect to the section and quarter section lines with the "0" and "5" stations numbered. Note the station and plus of the section and quarter section lines placed on the respective lines. The section, township, and range may be conveniently placed in a circle at the center of the section being represented. A north arrow, scale, project number, date, and name of the person completing the sheet shall be placed in the space which is provided.

The true size of the fractional sections shall be indicated on the drainage sheet. It is good practice to place fractional sections at the top, bottom, or sides of a sheet.

Once the base format of the drainage sheet has been set, the next step is to transfer information relative to the crests, streambeds, entrances, ponds, terraces, waterways, dikes, and drainage structures and pipes from the survey notes to the sheet. Note the land use and locations of change in land use upon the sheet. This will aid in the determination of the drainage runoff speed in the course of the structure design.

The federal offices that support rural agriculture farm programs have aerial photos and light table's which may aid in the mapping of large scale drainage areas. Additionally, county mapping professionals and the county engineers office may have available aerial photos to aid in these efforts. These should be placed lightly on the drainage area sheets for field review and modification as needed.

The main crests are usually checked and plotted first. Crests are checked with odometer readings or by walking and pacing. Be alert for man-made alterations of drainage patterns and land use changes. A general rule is to "stay inside the drainage area." This means that when checking crests, to stay on the centerline side of the crests. Errors and confusion sometimes occur when one has to approach the crests from outside the drainage area being determined.

Drainage areas must be determined for entrance pipes as well as any drainage that intersects or is near to the centerline of the project. Smaller drainage areas require more accurate mapping.

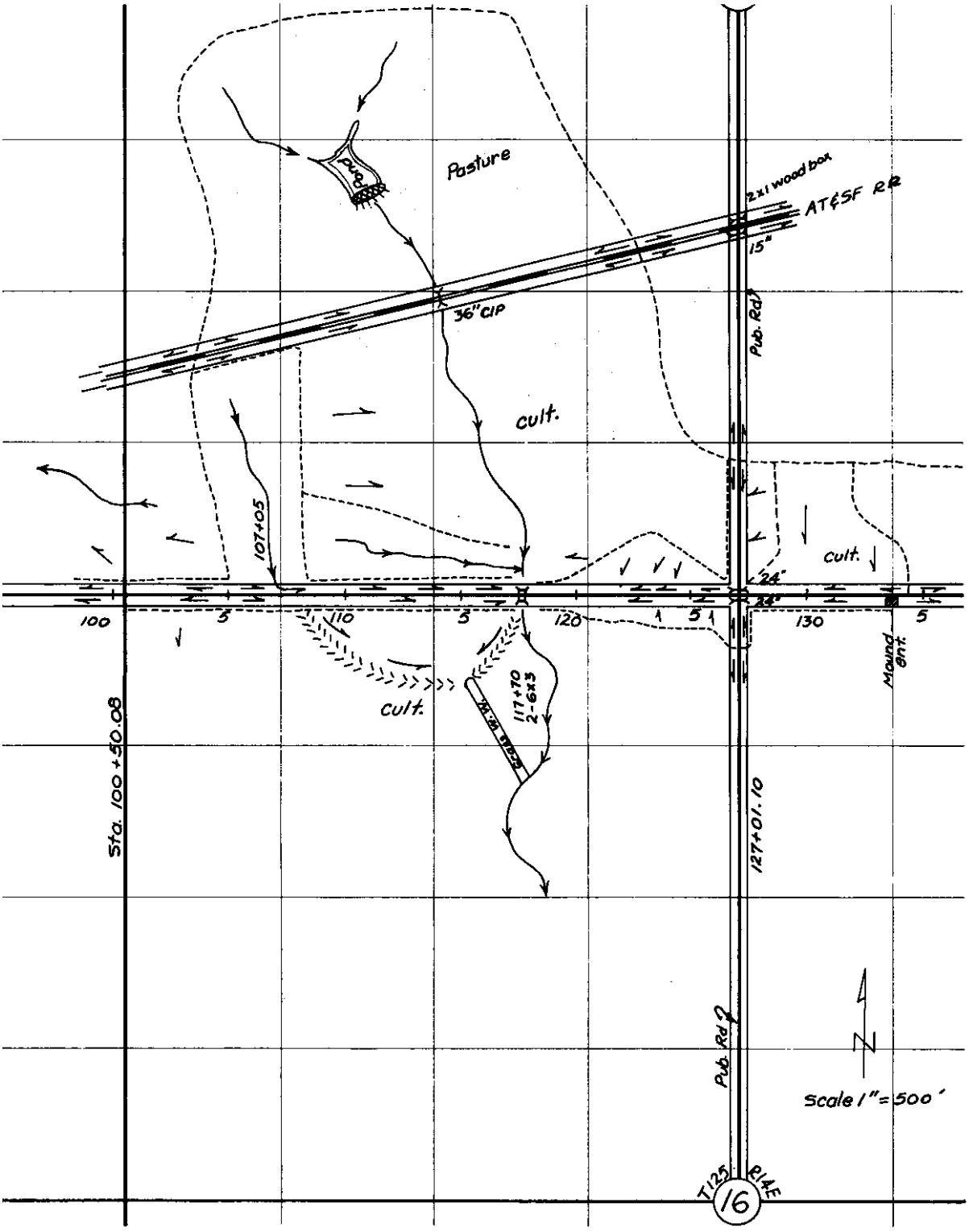
In level terrain, determining crests and drainage patterns can be very difficult. Lagoons and lagoon areas are common in flat terrain and should be accurately indicated on the drainage map. A good policy is to question property owners concerning drainage in more level areas. Often it becomes necessary to use an instrument to determine the drainage patterns.

Vertical drainage occurs in the sand hill regions of the state and is common along the Arkansas River in western Kansas. Sand hills that have vertical drainage should be indicated on the

drainage sheet. Irrigated areas with the type (flood or sprinkle) and tail water disposal should also be indicated.

Figure 2.7.1-1 depicts the format of a full scale drainage map.

Figure 2.7.1-1 Full Scale Drainage Map.



2.7.2 Urban Drainage Mapping

City plats are usually available from a city clerk and may be used to map city drainage. In case the scale of the city map is not adequate for use, then our regular drainage sheets may be used. The streets, alleys, and block lines should be indicated on the sheet. The center of the project is placed as previously outlined. Inlets, outlets, storm sewers, drainage structures, curb and gutter, valley gutters, land use (paved parking areas and large buildings etc.) should be indicated on the map. Curb and gutter are usually indicated on the map in red pencil, with the direction of flow indicated by red arrows. Unpaved streets with open ditches are indicated by black pencil for the direction of flow. Crests may be indicated with the dashed red lines. Care should be exercised when mapping city drainage with attention to building drains, storm sewer locations, siphons, and land use. In cities with flat terrain it is usually necessary to determine drainage with an instrument.

2.8 UTILITY INFORMATION

2.8.1 General

The existence of utilities may affect the design or location of a proposed improvement. It is important to locate and report utility information in such a manner that the type, size, location, and ownership is not in doubt.

2.8.2 Aboveground Utilities

Aboveground utilities cause few if any problems in identification, location, or ownership. All overhead utilities that cross the centerline will be indicated with the station plus, the number of wires or cables, and the approximate height. There are cases when the height of wires, both low and high, is very critical. These instances will be addressed upon specific request from the design staff.

2.8.3 Underground Utilities

The types of underground utilities encountered are sanitary sewers, water lines, natural gas lines, product lines, telephone cable, fiber optic cable, cable television lines, and electrical lines. The distinction between public and privately owned utility lines must be noted.

In Kansas there exists a statewide utility location service, Kansas One Call. This service presently notifies member utility firms of locate requests in Kansas. Prior to contacting Kansas One Call, compile a list of the legal descriptions for the project. The utility owner information is cataloged by the legal description. The phone number for Kansas One Call is 811. It is best to cross check with all utility companies in the area, especially rural water districts, to insure complete utility information.

The utility companies are responsible for locating their facilities along the project. While approximate depths are suitable for service lines, actual elevations are required on transmission type lines. If an offset alignment or detour has been indicated, utility line elevations will need to be obtained in those areas.

Sanitary sewers are located by recovering the necessary manholes. The size of sanitary sewer lines are to be obtained from the owner. Maps and other record information will be sufficient. Do not enter sanitary sewer manholes for the verification of line sizes. Obtain the flow line elevations from the manhole by the use of a level rod or tape. Survey crew members shall not enter sanitary sewer manholes or catch basins. The owner of the utility shall be requested to assist in obtaining the required information. Obtain locations and elevations of manholes each direction from the project to allow the determination of grade as needed.

Water lines usually have valves that are at or just below the surface, which will aid in obtaining location and elevation information.

2.8.4 Utility Owner Information Sheet

The survey notes shall contain a listing of all utility owners, including their address, phone, and contact person.

In instances of multiple utility lines of the same type, e.g., two water districts on a project, the locations of their individual lines must be identified. The method of a line location is also of benefit to the design staff, e.g.,

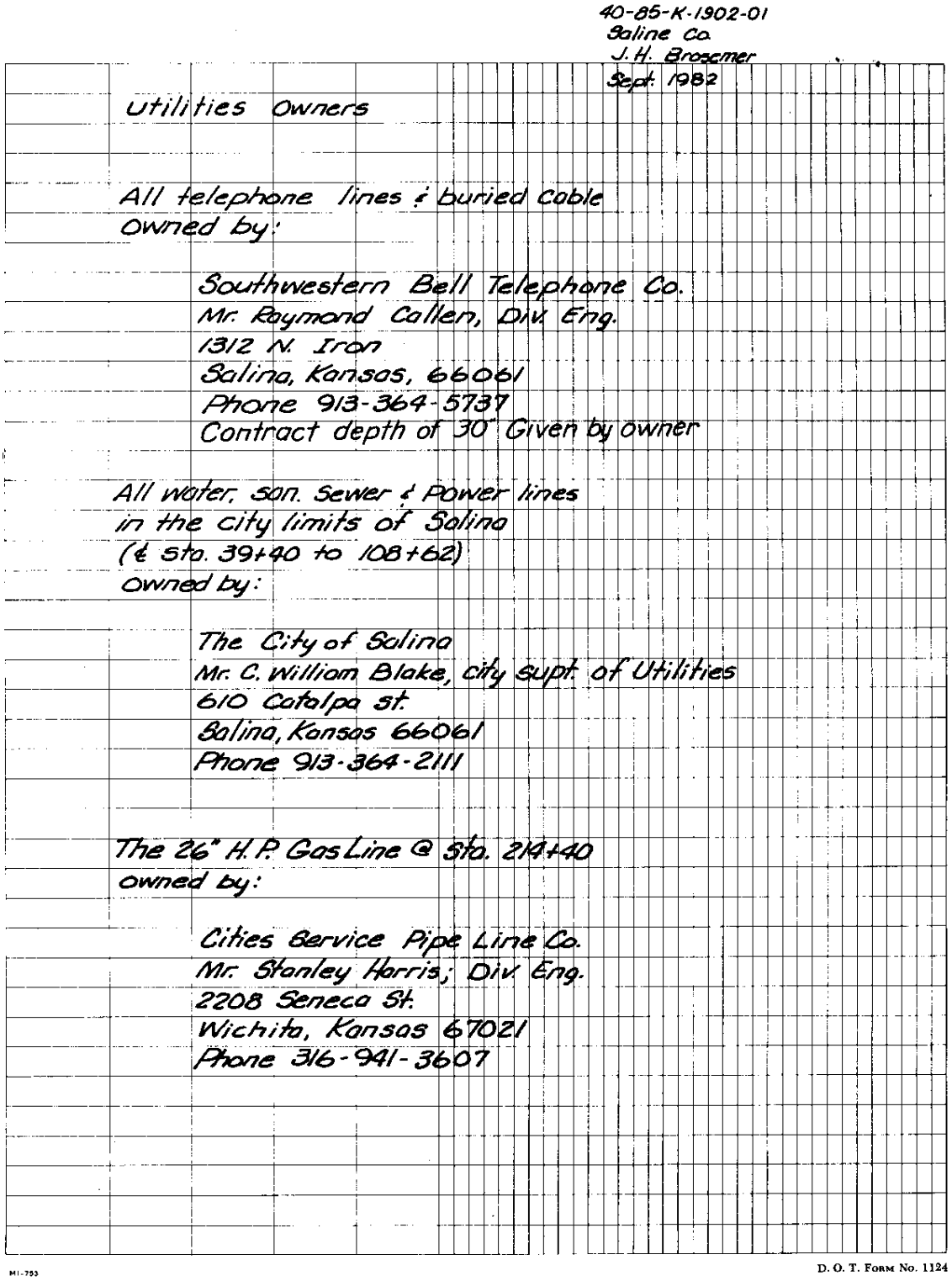
"The location of the plastic water lines from Sta. 110+00 to 124+75 were determined by a visible ditch. The location of the plastic water lines left of station 110 to 162 was determined by the owner using a hand held witching device."

"The location of buried telephone cables, gas lines and C.I. water lines on the project were spotted by the individual utilities owners using electronic devices."

In the event that a utility company will not locate their facilities, contact the Bureau of Design Survey Coordinator for assistance.

Figure 2.8.4-1 reflects a sample Utility Owner Information Sheet.

Figure 2.8.4-1 Utility Owner Information Sheet.



2.9 LAND SURVEY BOUNDARY INFORMATION

2.9.1 General

Land survey boundary monument ties are necessary so that KDOT may determine the existing right of way, and prepare the necessary legal descriptions to acquire new right of way for a highway improvement.

It is of extreme importance that the land surveyor be complete and accurate in conducting this survey activity.

The Survey Coordinator and the Field Survey Project Manager assigned the project will review and discuss the necessary land survey monuments which may be necessary for the project.

2.9.2 Public Land Survey System Monuments

In Kansas, section corners, 1/4 section corners, and meander corners were established by deputy government surveyors beginning in 1854 and continuing until the State was subdivided in the late 1870's. The subdivision was done under the instructions set out in the Manual of 1855 issued by the General Land Office (GLO). Each field survey party has a copy of the GLO Manual of 1855. The GLO Manual shall be reviewed and studied by each member of the field crew.

Additionally there are Kansas Minimum Standards, adopted by the Kansas State Board of Technical Professions, and Kansas Statutes which describe methods and procedures pertaining to re-establishing corners and the subdivision of sections. Each member of the survey crew should be familiar with the laws and regulations relative to land surveying in the State of Kansas. Survey methods and the monuments utilized shall be in compliance with State law and Kansas Minimum Standards.

The Survey Coordinator will provide the record KDOT information to the Party Chief at the onset of a project. This will include the Land Survey Reference Reports and GLO field notes and plats obtained from the Kansas State Historical Society.

Further research will then be required of local county offices at the project site. Research must be completed prior to searching for monuments in the field. It is suggested that as the property owners are being contacted for right of entry, they be asked of any knowledge they may have relative to boundary corner monuments or land surveys having been accomplished.

If there is any possibility that the corner monument could be there, excavate. It is just as important to know the monument has been destroyed as it is to recover the monument. Any monument recovered that is near the surface of a road or in a location where it could be deemed as endangered shall be lowered to a sufficient depth as to protect the monument, and witness ties established to perpetuate its position. Prior to excavating for corner monuments with mechanical equipment, e.g., backhoes or road graders, a search with a magnetic locator should be made. The position of all monuments should be determined prior to disturbing the location. Document the excavation efforts for all corners on the Land Survey Reference Report(s), including those that are unresolved at the completion of the survey.

Most counties, if requested to do so, will provide equipment to excavate for corner monuments. If the county will not provide this service, the local KDOT Maintenance Office shall be contacted for assistance.

Monuments at corner positions that are recovered or reestablished shall adhere to the requirements of Kansas Minimum Standards. Stone or concrete type monuments shall be enhanced with a rebar for future recovery. Shallow stones shall be lowered and a rebar placed with the stone, and over the centerline if possible. An aluminum cap, stamped KDOT, shall be placed on the rebar. If necessary to identify the monument, stamp the corner identity upon the aluminum cap. Monuments within an asphalt roadway of a state highway shall be placed at a depth to clear maintenance operations, with a surface monument (Nail and KDOT Washer) over top.

The references shall be reported and submitted in the notes on the Land Survey Reference Report Form of the Kansas State Historical Society. References to physical evidence, e.g., lines of fence, hedge rows, center of roadway, shall be noted, along with definitive locative ties similar to the format of alignment note references.

The Land Survey Reference Reports shall detail the origin of all found monuments, or shall have a complete explanation as to the methods and monuments used in the course of determining the position of set monuments. Reference surveys and supporting documentation shall be noted with the name of the previous land surveyor, date of the survey, and the location of the record instrument. The intersecting station of the section line and survey alignment, offset distance, and the angle of intersection shall be noted on all adjacent corner's. The office staff will note this information. The survey crew shall allow the first line of a Land Survey Reference Report reference to be "blank" for this information. Additionally, note the KDOT coordinate point number above the KSHS Location Code.

Figures 2.9.2-1 and 2.9.2-2 reflects a sample Land Survey Reference Report.

Figure 2.9.2-1 Sample Land Survey Reference Report.

LAND SURVEY REFERENCE REPORT
Department of Archives
Kansas State Historical Society
6425 SW Sixth Avenue, Topeka, KS 66615-1099
(785) 272-8681 Ext. 322 FAX (785) 272-8682

FOR OFFICIAL USE ONLY

12

Surveyor Kim L. Huxman
Company Ks. Dept. of Transportation-Design Survey
Address Docking State Office Building – Rm. B-50
Topeka, Kansas 66612-1568

L.S. Reg. No. 975
Job No. K7393-01
Telephone (785) 296-5100
Date of Survey SEPT, 2003

This report is for MITCHELL County, Kansas

This report is filed as a (check only one):

☑ SURVEY REFERENCE REPORT (K.S.A. 58-2011a). ☐ NOTICE OF ENDANCERMENT ACTIVITY (K.S.A. 58-2011b).
There is a $2.00 per corner filing fee which must accompany the Land Survey Reference Report.
☐ NOTICE OF COMPLETION OF ENDANGERMENT ACTIVITY AND REPORT OF RESTORATION (K.S.A. 58-2011c).
This may only be filed after filing a NOTICE OF ENDANGERMENT ACTIVITY. There is no filing fee.
Endangerment report filed _____.

LOCATION CODE OF MARKER IN TOWNSHIP (see illustration on back): 0 3 R 30408

Legal Description: NORTH 1/4 CORNER Sec. 30 Twp. 8-S Rng. 10-W
Survey Datum (if known): _____ North _____ East _____
Corner status prior to survey: _____ Existent _____ Obliterated ✓ Lost _____ Endangered
Monument Condition: _____ Found ✓ Set _____ Reset _____ Found Record
Monument Description: SET 5/8" x 24" REBAR WITH KDOT ALUM. CAP
0.5 Ft DEEP

REFERENCE MARKS AND MEASUREMENTS: (Please, no symbols or abbreviations.) * NOTE: SLOPE TIES.

R1 2672.55 Lt. (west) & Sta. 36+39.59 · SW ∠ = 89°41'38"
R2 IN LINE WITH OLD TREE LINE & CROP LINE SOUTH
3 TRAVEL-WAY OF EAST-WEST K-181 HIGHWAY 40.2 Ft N.
R4 N.A.R.A.
R5 _____
R6 CORNER DESTROYED BY ROAD CONSTRUCTION

METHOD OF RECOVERY OR ESTABLISHMENT: SET ON LINE AND PROPORTIONATE DISTANCE BETWEEN N.W. COR. SEC 30 AND N.E. CORNER 30. THIS CORNER POSITION FITS POSITION SET ON KDOT PROJ. # 181-62-K2263(2), DATED 1964.

SURVEYOR'S CERTIFICATE: This is to certify that I, Kim L. Huxman, have found evidence of the corner hereon described and that the statements contained hereon correctly represent the evidence, corner, monuments and accessories for the corner.

KIM LOUIS HUXMAN REGISTERED LS-975 11-13-03 KANSAS LAND SURVEYOR

Signed _____ Date 11-13-03

This blank form may be photocopied

* Slope tie's, unless noted H.D. for horizontal distance.

Figure 2.9.2-2 Sample Land Survey Reference Report.

LAND SURVEY REFERENCE REPORT
Department of Archives
Kansas State Historical Society
6425 SW Sixth Avenue, Topeka, KS 66615-1099
(785) 272-8681 Ext. 322 FAX (785) 272-8682

FOR OFFICIAL USE ONLY

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Surveyor Kim L. Huxman
Company Ks. Dept. of Transportation-Design Survey
Address Docking State Office Building – Rm. B-50
Topeka, Kansas 66612-1568

L.S. Reg. No. 975
Job No. K-7393-01
Telephone (785) 296-5100
Date of Survey SEPT., 2003

This report is for MITCHELL County, Kansas

This report is filed as a (check only one):

☑ SURVEY REFERENCE REPORT (K.S.A. 58-2011a). ☐ NOTICE OF ENDANCERMENT ACTIVITY (K.S.A. 58-2011b).
There is a $2.00 per corner filing fee which must accompany the Land Survey Reference Report.
☐ NOTICE OF COMPLETION OF ENDANGERMENT ACTIVITY AND REPORT OF RESTORATION (K.S.A. 58-2011c).
This may only be filed after filing a NOTICE OF ENDANGERMENT ACTIVITY. There is no filing fee.
Endangerment report filed _____.

LOCATION CODE OF MARKER IN TOWNSHIP (see illustration on back): 0 3 7 30008

Legal Description: CENTER CORNER Sec. 30 Twp. 8-S Rng. 10W
Survey Datum (if known): _____ North _____ East _____
Corner status prior to survey: ✓ Existent _____ Obliterated _____ Lost _____ Endangered
Monument Condition: ✓ Found _____ Set _____ Reset _____ Found Record
Monument Description: 18"X12"X8" LIMESTONE ON SOUTH SIDE OF BROKEN OFF LIMESTONE POST – 0.8 Ft DEEP * NOTE: SLOPE TIES

REFERENCE MARKS AND MEASUREMENTS: (Please, no symbols or abbreviations.)

R1 2661.90' Lt (West) & Sta. 10+00 NWX = 90°17'44"
R2 SET 5/8"X24" REBAR w/KDOT ALUM. CAP — 0.5 Ft N. & STONE
3 SET EXISTING T-POST ON SOUTH SIDE OF STONE
R4 IN LINE WITH FENCE REMNANTS NORTH & SOUTH
R5 IN LINE WITH EAST-WEST CROP LINE
R6 _____

METHOD OF RECOVERY OR ESTABLISHMENT: IDENTIFIED STONE SET BY A.D. MOOD, ON RECORDED COUNTY SURVEY IN BK 3, Pg 97, DATED MAR 10, 1880.

SURVEYOR'S CERTIFICATE: This is to certify that I, Kim L. Huxman, have found evidence of the corner hereon described and that the statements contained hereon correctly represent the evidence, corner, monuments and accessories for the corner.

KIM LOUIS HUXMAN REGISTERED LS-975 11-13-03 KANSAS LAND SURVEYOR

Signed _____ Date 11-13-03

This blank form may be photocopied

* Slope tie's, unless noted H.D. for horizontal distance.

2.9.3 Monument Ties in Platted Subdivisions

The survey shall include copies of all recorded subdivision plats relative to the project. The plats must be complete. The necessary monuments shall either be recovered, or reestablished to fix the positions of the subdivision.

An index sketch, describing the monument found and the position it controls, along with a point number, shall be included with the notes.

2.9.4 Record Legal Descriptions

The Bureau of Right of Way requires one copy of the last deed or instrument of transfer of all property adjacent to the project. This is to allow for depiction of preliminary property lines upon the plans. A Certificate of Title will be ordered by the Bureau of Right of Way as the project develops. Title to property is transferred in several ways, usually by a form of deed. Title may be transferred by Court decisions, which could be probate proceedings, divorce proceedings, condemnation proceedings, or other civil proceedings. Court proceedings are obtained from the Clerk of the District Court. Deeds are obtained from the Register of Deeds.

In areas of multiple tracts, a quick aid is to obtain the name of the owner from the County Clerk's office or from the County Appraisers Office.

Once in the Register of Deeds Office the process is to search the index beginning at the last entry and proceed backward in time until the instrument is located. When the instrument is located, the book and page should be verified and the copy requested.

The index should be checked from the last entry to the first entry for any instruments that may pertain to the property and effect your decision relative to corner monuments. Examples of this are right of way agreements, surveys, both recorded and legal, condemnation proceedings, court actions, easements, contracts, vacation proceedings, addition plats, etc. When reviewing deeds, particular attention should be directed to monument calls in the deeds. Monument calls are calls for a monument that could be a stone, a 3-in. pipe, the thread of a stream, an oak tree, the center of the road, etc.

All controlling monument calls within the survey limits of a project must be addressed in the course of the work of the Land Survey Party Chief. The solutions must be available for the Bureau of Right of Way to ascertain the deed line.

After the copies of the instruments have been obtained, the instruments are numbered consecutively through the project on a deed ownership sketch. Copies of subdivision plats may be used as a deed index sketch in platted areas to save the time of drawing them out. The deed sketch should include an abbreviated legal, name of the owner, and the type and location of the instrument by book and page.

The latest ordinance defining the city or corporate limits must be included with the notes.

2.9.5 Land Survey Monument Point Numbering

A system of numbering section corners and traverse points has been in use by KDOT for several years. The system assigns a three-digit number to sections 1 through 9, and a four-digit number for sections 10 through 36. The first digit refers to the section number in sections 1 through 9. The first two digits refer to the section number in sections 10 through 36. The last two digits in all sections refer to the section corner number or to the traverse point number. The section corners have the same number regardless of the section. The numbers are: the Southwest corner is 10; the West 1/ 4 corner is 20; the Northwest corner is 30; the North 1/4 corner is 40; the Northeast corner is 50; the East 1/4 corner is 60; the Southeast corner is 70; the South 1/4 corner is 80; the center corner is 00; the number 5 is reserved for 1/16 corners; traverse points are 1, 2, 3, 4, 6, 7, 8, or 9. Examples of the numbering system follows: A traverse point between the west 1/4 corner and the northwest corner section 15 would be 1521 and if two points were between the corners stated, the next traverse point would be 1522. The northwest corner of the southwest 1/4 of the northwest 1/ 4 section 15 would be 1525. The numbering system starts at the beginning of the project and proceeds from west to east or from south to north, as the case may be. As the use of electronic files has become more common, survey crews have been required to utilize a five digit number for section corner identification.

Utilizing the numbering system outlined above, the township number should be added to the section corner for projects running south to north and the range number should be added to the section corner for projects running west to east.

Corners originally numbered with four digits will include the last number of the township or range as follows:

E 1/4 cor. Section 26, Township 4 South, Range 17 East

- On a south to north project, the section corner identification = 26604
- On a west to east project, the section corner identification = 26607

Corners originally numbered with three digits will include the last number of the township or range. If the township or range is a single number, the number nine will be used between the corner number and the township or range as follows:

NE cor. Section 3, Township 8 S, Range 17 East

- On a south to north project, the section corner identification = 35098
- On a west to east project, the section corner identification = 35017

Figure's 2.9.5-1 and Figure 2.9.5-2 depicts the point numbering scheme.

Figure 2.9.5-1 Example of a Point Numbering Scheme.

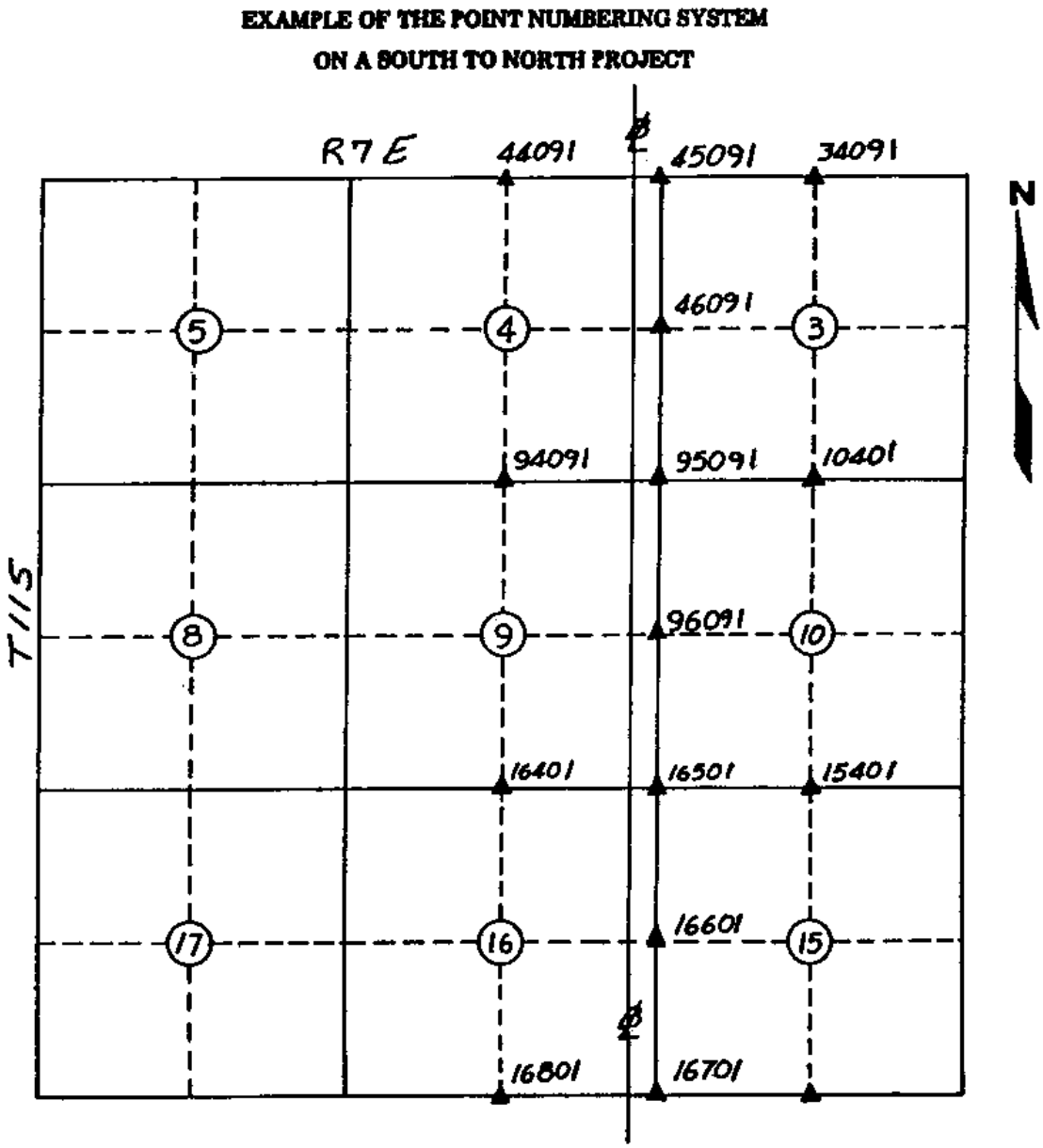
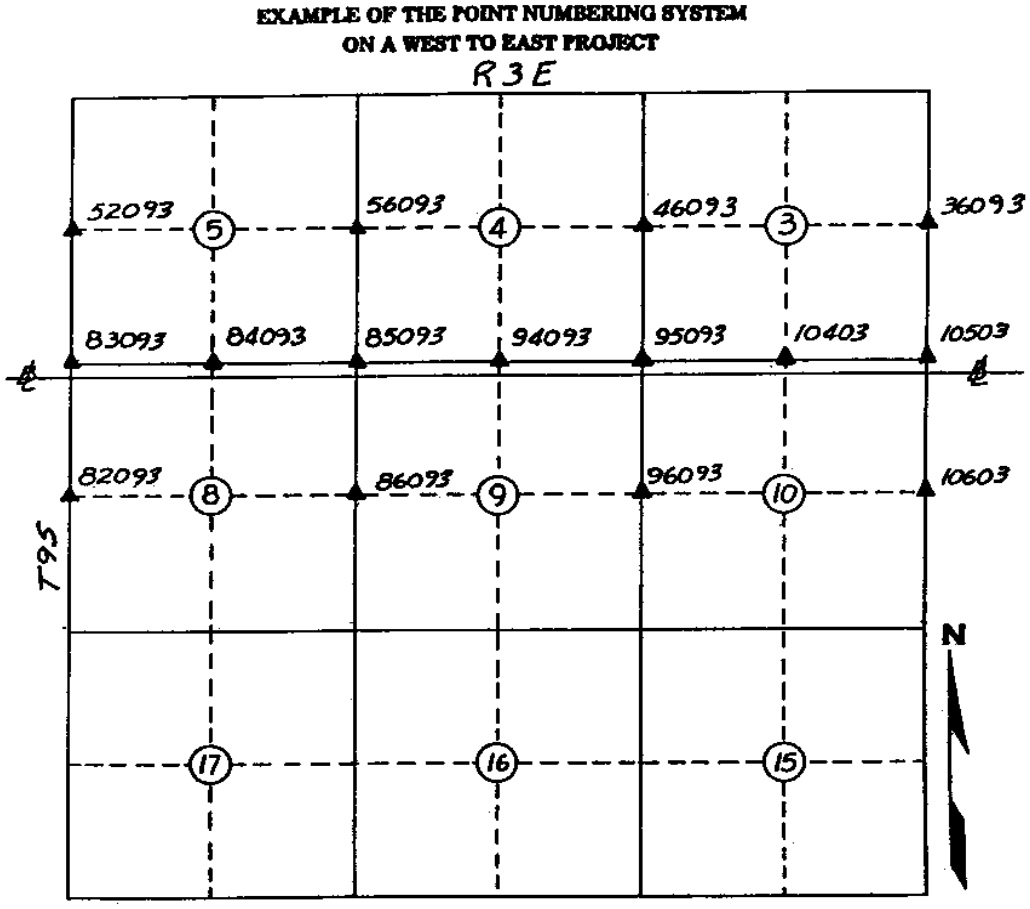


Figure 2.9.5-2 Example of a Point Numbering Scheme.



2.9.6 Record Road Right of Way Information

On most surveys, the project centerline will be adjacent to or intersected by public roads. It is necessary to obtain the following information on public roads:

- Road Location.
- Road Width.
- Road Record Source, i.e., Book and Page.
- Date of Opening or Vacation.
- Copy of the Road Record, if available.

State statutes place the responsibility of storing and maintaining county road records to the County Clerk; however, road record books may be found in the County Engineer's office or the Register of Deeds' office.

Road record books are special books that have a standard form to record the proceedings to open or vacate roads. The road records show the principal petitioner, the description of the road, the type of action (opening or vacation), the appointment of viewers, the viewer's report to the commissioners, the road survey in written and plat form by the County Surveyor, the action taken by the County Commissioners, the date, and the width.

There are some counties where all the sections lines in the county were opened as public roads of a designated width by an act of the State Legislature.

If the width is not set out in the road records the County Engineer may have knowledge of resolutions by the County Commissioners covering this situation. If a resolution does not exist, then a field measurement of the road should be made and this information included with the notes. There are times when a road was opened with a dedicated official width, but the existing fenced right of way measures differently. If this situation exists, it should be so noted. In many instances property owners have donated right of way to the county and no records exist of the donation of additional right of way. For this reason existing right of way should always be measured for comparison to the record.

When public roads are not on section or subdivision lines or are meandering in alignment, a copy of the survey that sets out the courses and bearings of the road is required. When a meandering road is a property division, or is adjacent to or intersects the centerline of the project, the center of the meandering road should be established and tied by distance and angles to the centerline of the project. A sketch of the road with ties must be included with the section line tie notes.

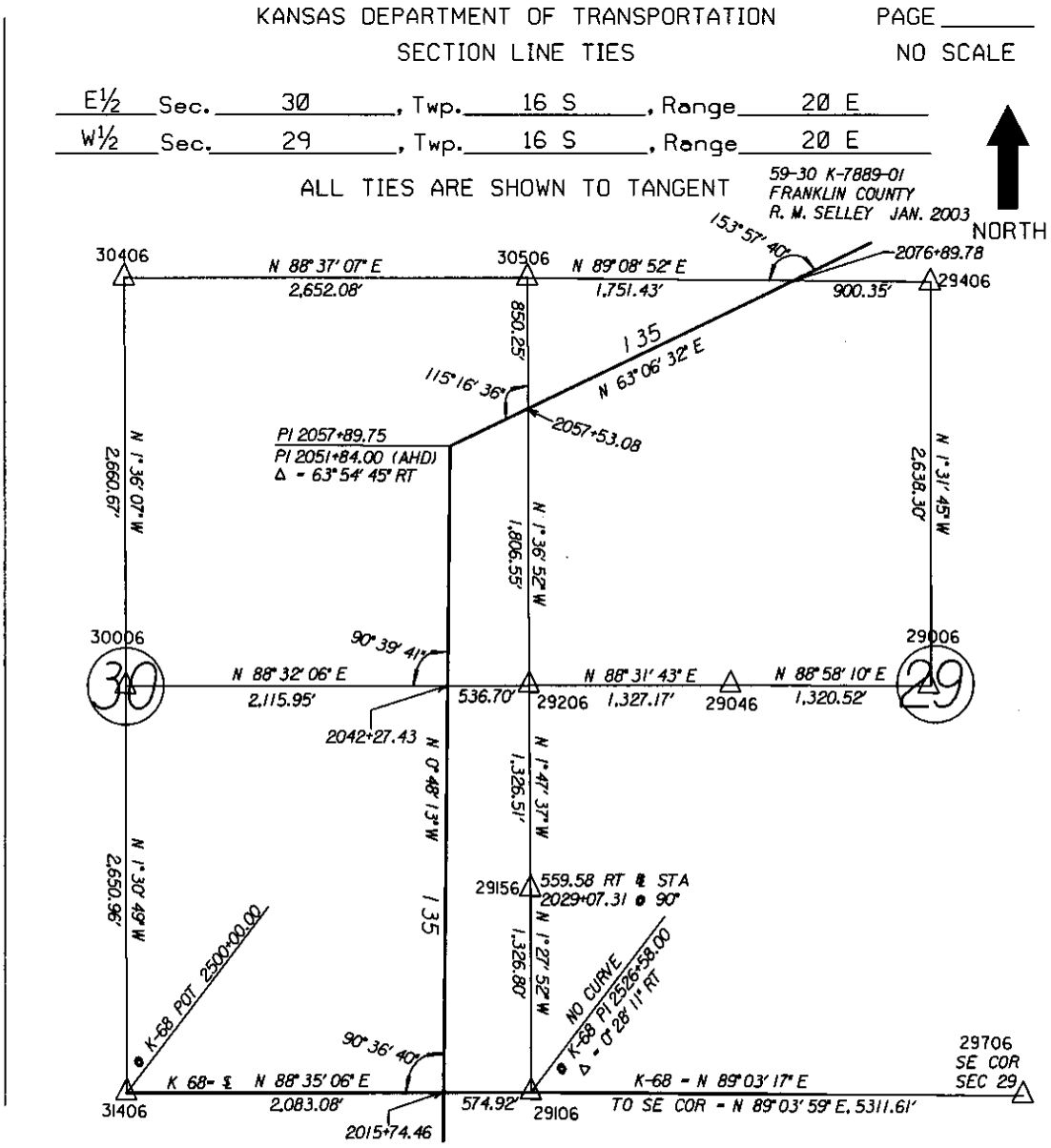
2.9.7 Land Survey Monument Ties

The positions of land survey monuments shall be measured by either RTK GPS, or by total station. In all instances, the position shall be checked by independent means.

An electronic file shall be submitted which lists the monuments and coordinates being submitted with the project. A hard copy shall be included in the notes.

Positions established by traverse methods shall be substantiated with the software printouts of the traverse operation.

2.9.8 Land Monument Tie Sketch's



REMARKS:
FOR ROAD RECORDS SEE ROAD RECORDS FOLDER OF THE FIELD SURVEY NOTES

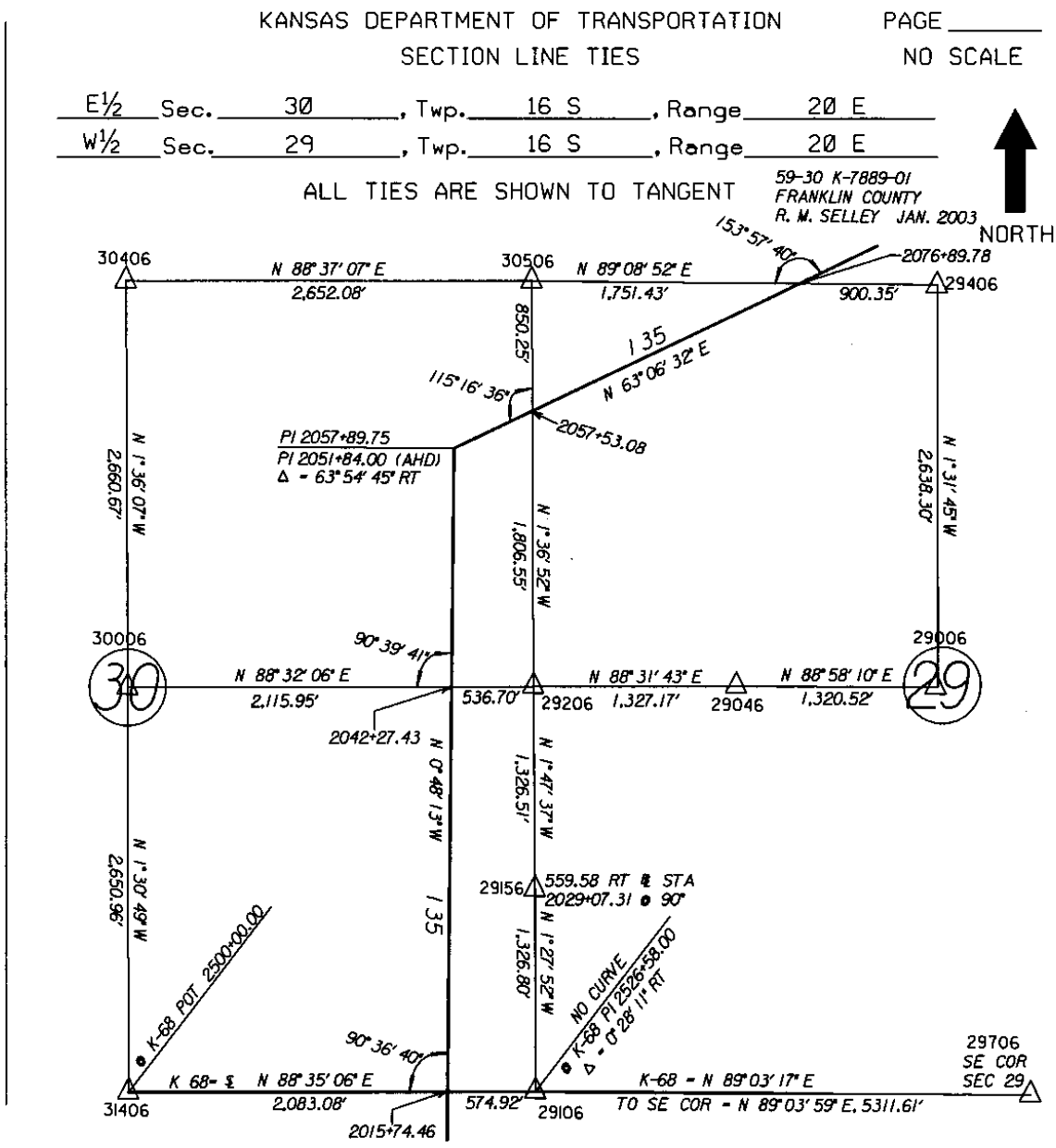
The field survey notes shall include a tie sketch, detailing the relationship of the land boundary monuments to the alignment of the project. This relationship should also be noted on the Land Survey Reference Report for the adjacent survey monuments on each side of an intersecting line.

The tie sketch shall note the alignment stationing, PI back and ahead stationing and delta angles, stations of intersects to the hundredth and dimensions to the adjacent corners. These sketch's shall be developed by the survey office support staff.

Additionally a sketch depicting the dimensions between the corners of the PLSS shall be developed by the survey office support staff and incorporated into the project notes.

Figure 2.9.8-1 reflects information found on a Section Tie Sketch.

Figure 2.9.8-1 Information Found on a Section Tie Sketch.



REMARKS:
FOR ROAD RECORDS SEE ROAD RECORDS FOLDER OF THE FIELD SURVEY NOTES

3.0 GEODETIC HORIZONTAL CONTROL SURVEYS

3.1 GENERAL

The Federal-Aid Highway Act of 1956 initiated two significant firsts in the engineering of highways, which have been continued in all subsequent Federal-Aid Highway Acts.

First, the term "construction" was amended to include "the establishment of temporary and permanent geodetic markers in accordance with specifications of the Coast and Geodetic Survey."

Second, the Act provided that "the Secretary of Commerce may, wherever practicable, authorize the use of photogrammetric methods in mapping, and the utilization of commercial enterprise for such services."

The recognition and authorization by law of two fundamental acts of efficiency and economy in accomplishing highway surveys is noteworthy and commendable. Highway engineers were, by this act, provided with effective and reliable methods to obtain accurate results in route surveying, right of way acquisition, and construction lay-out of complicated bridges and interchanges.

The National Geodetic Survey (hereafter referred to as NGS) of the National Oceanic and Atmospheric Administration (hereafter referred to as NOAA) of the U.S. Department of Commerce is responsible for the maintenance, adjustments, and establishing horizontal and vertical control in the United States. There is, at present, a network of horizontal control stations that span the continent. The horizontal control network consists of a framework of arcs of triangulation extending North to South and East to West and crisscrossing each other at intervals of about 60 miles. The areas between the arcs are subdivided with networks of single triangles, supplemental arcs, or traverses.

Historically horizontal control was established by triangulation, trilateration, and traverse procedures. GPS is now the primary method utilized by KDOT in developing geodetic horizontal control networks and project coordinates.

3.2 HORIZONTAL CONTROL FOR KDOT PROJECTS

KDOT has adopted the Kansas Regional Coordinate System (KRCS). The KRCS is a 20-zone statewide system of low-distortion projections referenced to the North American Datum of 1983 (NAD 83).

KRCS has been submitted to the National Geodetic Survey (NGS) for the SPCS2022 Zone Design. The National Spatial Reference System (NSRS) will change in 2022, including the State Plane Coordinate System (SPCS). The KRCS system has been set up for a coordinate change that will differ substantially from the original KRCS coordinates due to the change in 2022. For more information on the KRCS please see the link below.

https://www.kansasgis.org/initiatives/kdot_ldp/index.cfm

Horizontal control for KDOT projects will be surveyed in the KRCS coordinate system unless otherwise noted by the KDOT Survey Coordinator.

3.3 PRIMARY HORIZONTAL CONTROL

Primary horizontal control, OPUS Static if used for control it will contain two 4-hour sessions. A minimum of three horizontal control monuments will required on most projects. Opus solutions will be submitted along with the field notes.

3.4 MONUMENTATION

A ½ rebar at least 2 feet in length with a cap is sufficient for the monuments. The horizontal control points are referenced in the manner as described for alignment points. Additionally, a "how to locate" narrative, similar to that in the NGS recovery notes is beneficial for stations off the project.

The following are examples:

> "About 1320 feet east of the SW corner sec. 26 T18S R20E, 3 feet north of an E-W wire fence, on the north side of an E-W public road and 40 feet west of an entrance to the residence of O. M. Taylor."

> "The horizontal control point is located in the NE 1/4 sec. 13 T16S R16E from the intersection of U.S. 75 and K-268 go East on K-268 for 1.5 miles, turn south on a rock road that meanders south and southwesterly for 1000 feet to a crest in the road and the horizontal control point that is in the north ditch of the road."

3.5 DETERMINING THE PROJECT COMBINED ADJUSTMENT FACTOR (CAF)

The published coordinates of NGS stations are based upon State Plane Coordinates. Projects developed within the Agency utilize project coordinates, derived from the state plane values. This is based upon a factor determined by the average latitude scale factor multiplied by the average project elevation factor, which is termed the Combined Adjustment Factor (CAF).

The procedures are as follows:

Determine the elevation factor.

The formula to determine the elevation factor is:

$$1 - \frac{(h)}{R} = \text{elev. factor}$$

$$\text{then } 1 - \frac{1940}{20906000} = 0.9990724 \text{ Elevation Factor}$$

Where h is the elevation in feet. R = 20,906,000 feet, which is the mean radius of the earth for the United States. The geoid height must be added to the elevation (h) prior to division by the R.

Determine the latitude factor.

This can be obtained either from Plane Coordinate Projection Tables, special NGS publication No. 285 for Kansas, or by reviewing the NGS Data Sheets for the stations used for the control basis.

Once the control station coordinates have been projected to the project plane a site calibration can be accomplished. There is only one CAF for a project.

The overview of the horizontal control, outlining the monuments and datum used for the project control will be detailed on the Review of Survey/Project Control Overview. This information will be incorporated into the General Note of the project construction plans. It shall include the CAF factor to translate from State Plane to Project Coordinates.

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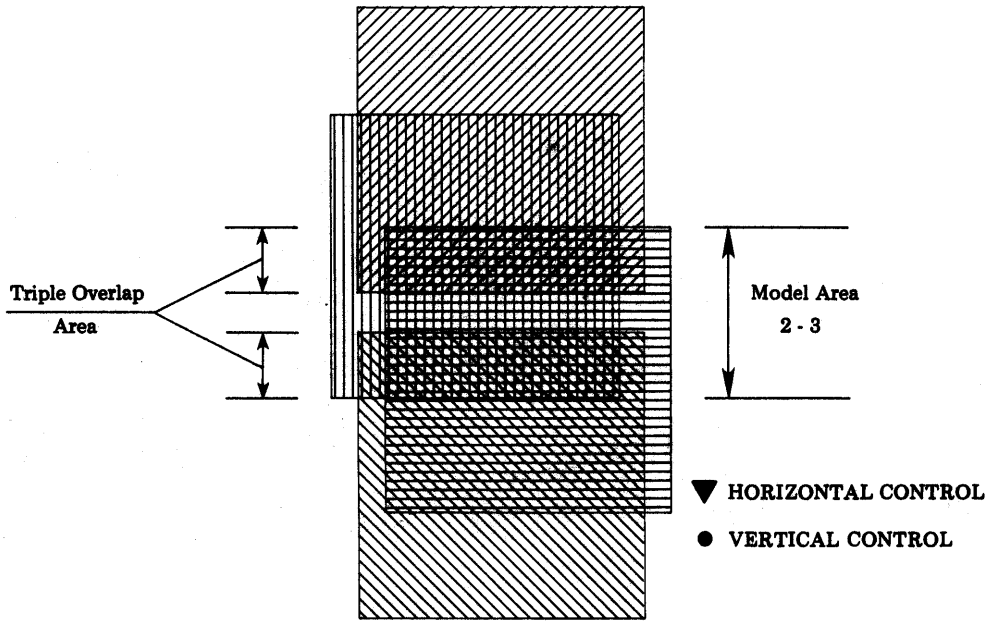
4.0 PHOTOGRAMMETRY SURVEYS

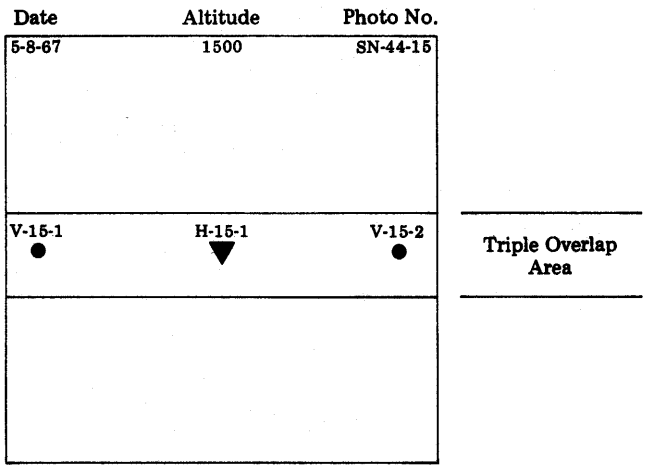
The development of photogrammetry greatly increased the scope of surveying and mapping, and made it possible to do these surveys in the office, free from adverse weather conditions. A skilled technician can view the terrain involved with a thoroughness and a perspective of the entire project denied him on the ground. The area between two successive pictures is considered the overlap. Figure 4.0-1 depicts this scenario.

To obtain and disseminate the information available on an aerial photograph there must be control established on the ground by the survey crew.

These control surveys involve obtaining the correct positions and elevations of objects on the ground that appear on the aerial photographs as sharp, well defined images. This may be accomplished in two manners, either by placing a target on points of known position and elevation, or by use of existing photo-image points.

Figure 4.0-1 Triple Overlap Area of Images.





4.1 PHOTOGRAMMETRIC CONTROL WITH PRIOR TARGETING

4.1.1 General

Targeting for aerial mapping may be defined as the placement of specially prepared targets on ground control stations prior to the taking of the aerial photography. By the placement of such targets prior to the taking of aerial photographs, a built-in image point on the photography is established and greatly increases the accuracy of the final product.

Placement of targets may be broken down into two parts: placement of horizontal control targets and placement of vertical control targets.

For every target placed upon the ground some type of survey must be run through this point. To ensure sufficient photogrammetric control over the entire project, the first target should be placed a sufficient distance before the beginning of the project and the last target a sufficient distance beyond the end of the project to map the limits required. Each project is unique and the coverage is dependent upon the flight height.

4.1.2 Vertical Control Targets

Vertical control points are used to level the aerial photo model and can be done two ways. Either a physical target with an elevation, or an x,y, z measured position.

For side road control place two vertical points on the side road with distances of 500 and 1000 feet, with x, y, and z coordinates. Wing targets to left of centerline will be identified by adding a number 7 to the front of the mainline targets, while targets to the right will be identified by adding the number 8 to
front of the mainline target number. "Double" targets as necessary will be flagged with "77" or "88" dependent on the side. Additionally when measuring the x, y, and z coordinates for the aerial targets with conventional electronic survey equipment, the distance from the instrument should not exceed 1500 feet. Vertical control points should be selected in an area where the ground is flat. Care should be taken not to place these points in shadows, well away from ground obstruction and in an open area. Remember, if you can't see up, the plotter will not be able to discern the target.

4.1.3 Horizontal Control Targets

The targets established along the project centerline are utilized to control the aerial photo horizontally and vertically. These targets are established typically at 800 feet intervals, and can be either plastic material or painted. The target interval may be altered by the flight height. These are typically placed or painted in the form of a "T" for identification purposes. Generally a stripe will be painted perpendicular to the fog line, or edge line of a highway, 18” – 24” in length. The targets are numbered sequentially along the project, beginning with target number 6101. As with the vertical control targets described in Section 4.1.2 the centerline targets also need to be located

for position and elevation. This will be reported as an x, y, z coordinate and elevation, with the location being the center of the open target area between the paint lines.

If the target station should fall in an area of dense growth an area around the target station should be cleared so as to provide visibility above the target. Care should be taken so that the target is not located in a shadow area at the time the aerial imagery is captured.

A recap of all targets on the project should be furnished with the field notes.

4.1.4 Target Material

Maximum contrast between the target and its background is a primary consideration. Best results are obtained with a white target on a black background. When the survey follows an existing black top road, white paint (fast drying) may be used. In other areas, a white material should be used such as white plastic or cloth strips.

This material should be of a durable nature for these targets may remain on the ground for some time before the photography can be obtained. If time permits, target material will be obtained from the Survey Coordinator.

All target material fasteners (nails, wire, etc.) are to be removed as soon as you are notified by the Survey Coordinator that the aerial imagery has been obtained and reviewed.