State of Nevada Department of Transportation

CONSTRUCTION SURVEY MANUAL

2012

Brian Sandoval
Governor

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Rudy Malfabon, P.E.
Director

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
1263 S. Stewart Street
Carson City, Nevada 89712

BRIAN SANDOVAL
Governor

RUDY MALFABON, P.E., *Director*

In Reply Refer to:

The Nevada Department of Transportation (NDOT) has developed the *2012 Construction Survey Manual* to provide policies and guidelines for data setup, preliminary field work, construction staking and documentation of survey information for various NDOT projects. It is also to serve as a guide for local public agencies, service providers and others, both within and outside of NDOT, who are responsible for project survey.

The primary goal of the *2012 Construction Survey Manual* is to provide general guidance and standards for surveying. Guidelines within the newly revised manual now focus beyond construction staking by including standards for data setup, preliminary fieldwork, conventional survey, Robotic Total Stations, global positioning systems (GPS) and documentation.

A great team effort was necessary within NDOT to prepare this edition of the *Construction Survey Manual*. Key individuals that played instrumental working roles, beyond their normally assigned roles, are acknowledged below. The Construction Division wishes to express our appreciation to all who assisted in the development of this manual, specifically contributions and support from the Directors Office, Division Heads, Construction Staff, Location Staff, Roadway Design Staff, FHWA, Service Providers and other reviewers.

NDOT Survey Committee Members:

Monte Bliss	Greg Boggs	Mike Bridges	John Burgess
Steve Hale	Rob Liebherr	Sam Lompa	Todd Montgomery
	Gary Nelson	Nick Senrud	

The *2012 Construction Survey Manual* is approved for use and available on both the Headquarters Construction SharePoint site at

http://shptsrv1/040/Survey%20Manual/CONSTRUCTION%20SURVEY%20MANUAL.pdf

and the Department's internet site at

http://www.nevadadot.com/About_NDOT/NDOT_Divisions/OPERATIONS/CONSTRUCTION/Documents/Survey_Manual.aspx

The Headquarters Construction Office is charged with maintaining and updating this manual. Please direct any comments or recommendations to NDOT Headquarters Construction at (775) 888-7460.

Sincerely,

Jeff Shapiro, P.E.
Chief Construction Engineer

Table of Contents

Chapter 1

Analysis of Contract Plans

SECTION DESCRIPTION

SECTION 1.1

INTRODUCTION

The following chapter is an outline of the Analysis of Contract Plans as it relates to the identification of standard procedures from the Location Division at the Nevada Department of Transportation. Many of the citations within this chapter have been directly referenced from the Location Division's manual of *Special Instructions for Survey, Mapping or GIS Consultants*. The Location Division publishes this manual for the benefit of contractors wishing to provide consulting services for the Department, but it also serves as a guide for survey standards Department wide. The manual of *Special Instructions for Survey, Mapping or GIS Consultants* is available on SharePoint at \\datsrv1\017public\2007Consultants' Manual.pdf and on the Department's internet site at

http://www.nevadadot.com/Documents/Doing_Business/Special_Instructions_for_Survey,_Mapping_or_GIS_Consultants.aspx

SECTION 1.2

UNITS OF MEASUREMENT

Currently, the U.S. Survey Foot is the recognized unit of measurement at the Nevada Department of Transportation for all survey work, with sub units of tenths and hundredths of a foot. In years past, projects may have been designed in meters as well, with sub units of millimeters. Current projects that are to tie to legacy surveys in metric must also be in metric.

SECTION 1.3

ACCURACY

Accuracy for construction stakeout surveys should adhere to the standards set forth in the manual of *Special Instructions for Survey, Mapping or GIS Consultants*. The specific applicable reference in the manual is titled, "Minimum Engineering Survey Standards". An excerpt from that section concerning Positional Tolerance is shown on the following page:

Contract Stakeout Survey
Positional Tolerances

	Horizontal (+/-)		Vertical (+/-)	
Rough Grade Stakes	0.15m	0.50ft	0.05m	0.16ft
Sub grade Red Head Stakes	0.05	0.16	0.01	0.03
Finish Grade Blue Top Stakes	0.05	0.16	0.01	0.03
Building Offset Stakes	0.005	0.03	0.01	0.03
Sewer Offset Stakes	0.05	0.16	0.01	0.03
Waterline Offset stakes	0.05	0.16	0.02	0.07
Hydrant Offset stakes	0.05	0.16	0.01	0.03
Street Lights	0.05	0.16	0.03	0.10
Curb Offsets	0.01	0.03	0.01	0.03
Structural Concrete	0.01	0.03	0.01	0.03

SECTION 1.4

MONUMENT IDENTIFICATION

Survey Monuments at the Nevada Department of Transportation are to be set or located prior to construction by a Location Division Survey. These monuments may vary in character and location due to the type and age of the particular monument.

Construction Control Feno Monument

For a complete list of potential monument types that may be encountered in the field, refer to the manual of *Special Instructions for Survey, Mapping or GIS Consultants* under the sub-heading of "Instructions for Setting and Stamping of Control Monuments". Additional information can be obtained from the Location Information System or "LoIS" at:

http://www.nevadadot.com/reports_pubs/LoIS/

Any monuments pertinent to a project will be listed in the contract plans project control sheet, referred to as the "LC" sheet (see example on the next 8 pages). The project control sheet is prepared by the Geodesy Section of the Location Division and any questions concerning project control should be referred to them at (775) 888-7250.

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA	IM-080-2(053)	PERSHING	LC1

PROJECT ALIGNMENT
LPN 1116 - I-80 WEST BOUND
"LW" 100+00.00 PDT to "LW" 1081+07.81 PDT
CONTRACTS #1483,1919,1600 & 1097
MP PE 13.03 to MP PE 31.59
Horz = NAD83/94 Ft g(f) = .9997101703
11/06/2009

"CW" 686+38.25 PT =					
"LW" 100+00.00 POT			15086338.708	2642912.277	
	N 49°36'53" E - 4584.62'				
"LW" 145+84.62 PC			15089309.195	2646404.405	
	R = 11200.00'				
	D = 20°21'13" Lt				
PI			15090611.858	2647935.825	
CC			15097840.289	2639147.653	
	L = 3978.66'				
	T = 2010.52'				
"LW" 185+63.28 PT =			15092365.835	2648918.547	
"LW" 186+02.05 POT					
	N 29°16'40" E - 3754.30'				
"LW" 223+56.35 PC			15095641.091	2650753.612	
	R = 10000.00'				
	D = 5°04'48" Lt				
CC			15100528.995	2642029.600	
	L = 886.63'				
	T = 443.60'				
"LW" 232+42.98 PT =			15096432.773	2651152.152	
"LW" 232+50.42 POT					
	N 24°10'52" E - 3102.85'				
"LW" 263+53.27 PC			15099263.368	2652423.151	
	R = 3784.00'				
	D = 35°06'46" Rt				
PI			15100355.508	2652913.545	
CC			15097713.358	2655875.125	
	L = 2318.96'				
	T = 1197.19'				
"LW" 286+72.24 PT			15100966.833	2653942.884	
	N 59°17'38" E - 653.43'				
"LW" 293+25.66 PC			15101300.494	2654504.697	
	R = 3700.00'				
	D = 30°00'42" Lt				
PI			15101806.950	2655357.459	
CC			15104481.747	2652615.350	
	L = 1938.07'				
	T = 991.82'				
"LW" 312+63.73 PT =					
"LW" 313+07.74 PT			15102672.033	2655842.568	
	N 29°16'56" E - 1808.46'				
"LW" 331+16.20 POT =			15104249.412	2656727.108	
"CW" 918+46.27 POT =					
"CW" 3+49.00 POT					
	N 29°16'56" E - 2972.17'				
"LW" 360+88.37 PC			15106841.800	2658180.831	
	R = 3784.00'				
	D = 39°32'56" Rt				
PI			15108028.385	2658846.227	
CC			15104991.001	2661481.315	
	L = 2611.94'				
	T = 1360.42'				
"LW" 387+00.31 PT			15108519.657	2660114.844	
	N 68°49'52" E - 5344.60'				
"LW" 440+44.91 PC			15110449.689	2665098.789	
	R = 10000.00'				
	D = 32°34'51" Lt				
PI			15111505.017	2667823.975	
CC			15119774.889	2661487.606	
	L = 5686.43'				
	T = 2922.39'				
"LW" 497+31.34 PT =			15113861.753	2669552.023	
"LW" 498+14.33 POT					
	N 36°15'01" E - 22836.82'				
"LW" 726+51.15 PC			15132278.320	2683055.746	
	R = 10000.00'				
	D = 10°46'20" Lt				
PI			15133041.026	2683614.991	
CC			15138191.455	2674991.329	
	L = 1885.93'				
	T = 945.77'				
"LW" 745+37.07 PT =			15133895.054	2684021.331	
"LW" 745+66.21 POT					
	N 25°26'41" E - 12051.77'				
"LW" 866+17.98 PC			15144777.805	2689199.256	
	R = 20000.00'				
	D = 5°30'55" Rt				
PI			15145647.706	2689613.146	
CC			15136185.006	2707259.260	
	L = 1925.12'				
	T = 963.34'				
"LW" 885+43.17 PT =			15146473.797	2690108.727	
	N 30°57'36" E - 19564.63'				
"LW" 1081+07.80 POT =			15163250.990	2700173.547	
"BW" 754+01.03 PC					

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

LOCATION CONTROL

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA	IM-080-2(053)	PERSHING	LC2

VERTICAL DATUM: ELEVATIONS ARE BASED UPON NAVD88 HOLDING PUBLISHED USC & GS BENCH MARK AND NDOT CONTROL MONUMENTS: 846003M(3982.082), K 317X(3958.056), Q 297Z(4026.422), V 145X(4164.818) AS FIXED.

BEARING SOURCE: BEARINGS OF THIS MAP WERE DERIVED FROM NEVADA STATE PLANE COORDINATES NAD 83/94 DATUM WEST ZONE, WITH A MEAN CONVERGENCY OF 0°05'57". USING LOCAL CONTROL POINTS: 846003M, FAA LOL AZ, K 317X, Q 297Z, V 145X AS FIXED AND IS FURTHER ARCHIVED AT NDOT UNDER FILE LPN 1116. COORDINATES AND DISTANCES REFLECT A SINGLE COMBINATION GROUND TO GRID FACTOR OF 0.9997101703 AND HAVE BEEN CONVERTED TO FEET. MONUMENTS ARE STAMPED WITH "NDOT" AND MONUMENT NAME UNLESS NOTED IN DESCRIPTION.

SPECIAL NOTE: PLSS MONUMENTS LISTED IN THIS CONTRACT ARE REQUIRED TO BE PERPETUATED UNDER THE DIRECT SUPERVISION OF A PROFESSIONAL LAND SURVEYOR REGISTERED IN THE STATE OF NEVADA TO ASSURE COMPLIANCE WITH NEVADA REVISED STATUTES,CHAPTERS 329 & 625. ANY MONUMENTS FOUND DURING SURVEY, MAPPING, CONSTRUCTION OR MAINTENANCE PHASES OF NEVADA DEPARTMENT OF TRANSPORTATION PROJECTS NOT LISTED FOR PERPETUATION IN THE CONTRACT PLANS SHALL BE PERPETUATED IN ACCORDANCE WITH THE STATE OF NEVADA DEPARTMENT OF TRANSPORTATION, TRANSPORTATION POLICY (TP) 3-1-3, TITLED PERPETUATION OF SURVEY MONUMENTS, DATED JANUARY 13, 1999.

CONSTRUCTION CONTROL

NAME	NORTHING	EASTING	ELEVATION	EQUATION	OLD STATION	DIST(')	NEW STATION		DIST(')	NOTE
1116001M	15093590.81	2649758.41	3960.655				"LW" 200+81.24	POT	133.94	NDOT FENO
K_317X	15093788.86	2650003.95	3958.056				"LW" 203+74.03	POT	251.35	NGS BM
1116002M	15094851.03	2650481.66	3961.596				"LW" 215+34.17	POT	148.92	NDOT FENO
1116003M	15096793.88	2651440.47	3981.301				"LW" 236+97.94	POT	115.10	NDOT FENO
1116004M	15098737.62	2652374.36	3968.594				"LW" 258+53.85	POT	170.77	NDOT FENO
1116005M	15100039.18	2653067.90	3976.383				"LW" 273+74.37	POC	138.46	NDOT FENO
1116006M	15102222.30	2655701.34	3987.200				"LW" 308+16.34	POC	124.71	NDOT FENO
1116007M	15103676.47	2656725.28	3977.994				"LW" 326+15.58	POT	278.64	NDOT FENO
1116008M	15105221.92	2657470.56	3981.760				"LW" 343+26.08	POT	172.79	NDOT FENO
1116009M	15106562.23	2658213.68	3981.567				"LW" 358+60.59	POT	165.39	NDOT FENO
1116010M	15107968.28	2658984.84	3990.153				"LW" 374+57.95	POT	-101.43	NDOT FENO
1116011M	15108584.04	2660630.20	3989.123				"LW" 392+04.14	POT	126.07	NDOT FENO
1116012M	15109070.97	2662239.59	3987.453				"LW" 408+80.77	POT	253.17	NDOT FENO
1116013M	15109593.97	2663217.82	3992.088				"LW" 419+81.85	POT	118.72	NDOT FENO
1116014M	15109944.35	2664542.74	3993.483				"LW" 433+43.89	POT	270.44	NDOT FENO
1116015M	15110596.37	2666096.42	3991.862				"LW" 450+03.74	POC	270.66	NDOT FENO
1116016M	15111489.53	2667568.29	4004.739				"LW" 466+81.46	POT	277.25	NDOT FENO
1116017M	15112655.53	2668867.10	4007.836				"LW" 483+83.62	POT	253.89	NDOT FENO
1116018M	15113873.82	2669930.00	4011.908				"LW" 500+47.56	POT	297.68	NDOT FENO
1116019M	15115459.16	2670589.09	4014.018				"LW" 517+15.77	POT	-108.23	NDOT FENO
1116020M	15116684.42	2671956.84	4018.640				"LW" 535+12.64	POT	270.26	NDOT FENO
1116021M	15118080.61	2673068.88	4013.667				"LW" 552+96.15	POT	341.47	NDOT FENO
1116022M	15119399.41	2674022.74	4017.948				"LW" 569+23.72	POT	330.88	NDOT FENO
1116023M	15120671.95	2675015.29	4013.981				"LW" 585+36.86	POT	378.84	NDOT FENO
1116024M	15122011.73	2675973.17	4020.537				"LW" 601+83.72	POT	359.09	NDOT FENO
1116025M	15123221.17	2676870.87	4026.698				"LW" 616+89.88	POT	367.87	NDOT FENO
1116026M	15124539.85	2677826.57	4040.261				"LW" 633+18.44	POT	358.84	NDOT FENO
1116027M	15125765.65	2678746.87	4047.318				"LW" 648+91.32	POT	376.05	NDOT FENO
1116028M	15127178.91	2679652.62	4059.080				"LW" 665+26.46	POT	270.93	NDOT FENO
1116029M	15128647.47	2680316.61	4071.724				"LW" 681+03.39	POT	-61.98	NDOT FENO
1116030M	15129702.01	2681638.86	4099.979				"LW" 697+35.68	POT	380.77	NDOT FENO
1116031M	15131097.96	2682644.45	4111.252				"LW" 714+56.05	POT	366.28	NDOT FENO
1116032M	15132586.98	2683648.91	4123.909				"LW" 732+32.92	POC	313.29	NDOT FENO
1116033M	15134173.62	2684475.04	4132.305				"LW" 750+12.68	POT	290.02	NDOT FENO
1116034M	15135642.29	2685175.03	4146.442				"LW" 766+39.63	POT	291.11	NDOT FENO
1116035M	15137381.96	2685995.22	4161.393				"LW" 785+62.94	POT	284.31	NDOT FENO
1116036M	15138898.31	2686730.41	4172.111				"LW" 802+48.07	POT	296.70	NDOT FENO
1116037M	15140450.17	2687470.19	4214.457				"LW" 819+67.24	POT	297.98	NDOT FENO
1116038M	15142036.12	2688232.19	4251.967				"LW" 837+26.74	POT	304.68	NDOT FENO
1116039M	15143552.46	2688835.36	4192.639				"LW" 853+55.14	POT	197.86	NDOT FENO
1116040M	15145206.70	2689702.56	4155.973				"LW" 872+29.58	POC	260.98	NDOT FENO
1116041M	15146547.68	2690432.52	4155.953				"LW" 887+73.10	POT	239.65	NDOT FENO
1116042M	15147981.14	2691302.20	4157.629				"LW" 904+49.73	POT	248.00	NDOT FENO
1116043M	15149515.98	2692288.19	4166.035				"LW" 922+73.13	POT	303.93	NDOT FENO
1116044M	15150981.25	2693167.52	4175.638				"LW" 939+82.00	POT	304.18	NDOT FENO

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

LOCATION CONTROL

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA	IM-080-2(053)	PERSHING	LC3

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CADASTRAL CONTROL

NAME	NORTHING	EASTING	ELEVATION	OLD STATION	EQUATION	DIST(')	NEW STATION		DIST(')	NOTE
1116047H	15086272.23	2642968.88	3968.30GP	"OE"686+44.49PT		-44.71	"LW" 100+00.04	POT	87.31	NHD BRASS DISC
1116046H	15086300.80	2642944.64	3968.97GP	"OW"686+38.25PT=	"OW"686+44.49POT	49.94	"LW" 100+00.09	POT	49.84	NHD BRASS DISC
1116045H	15086380.11	2642877.28	3966.24GP	"OW"686+38.25PT=	"OW"686+44.49POT	54.11	"LW" 100+00.17	POT	-54.21	NHD BRASS DISC
1116048H	15089180.16	2646363.99	3960.49GP	"OE"731+14.16PC		-59.97	"LW" 144+70.23	POT	72.10	NHD BRASS DISC
270031H	15089085.94	2646444.23	3961.36GP	"OE"731+14.16PC		63.92	"LW" 144+70.30	POT	195.86	NHD BRASS DISC
1116050H	15089255.61	2646449.87	3960.04GP	"OW"732+28.44PC		-69.96	"LW" 145+84.53	POT	70.27	NHD BRASS DISC
1116049H	15089375.78	2646347.70	3965.91GP	"OW"732+28.44PC		87.64	"LW" 145+84.57	POT	-87.46	NHD BRASS DISC
1116051H	15092412.85	2648834.69	3957.89GP	"OW"772+45.94POT=	"OW"772+07.15PT	96.25	"LW" 186+02.08	POT	-96.14	NHD BRASS DISC
270038H	15092392.29	2648871.63	3957.62GP	"OW"772+45.94POT		53.91	"LW" 186+02.20	POT	-53.86	NHD BRASS DISC
270033H	15094330.09	2650188.95	3960.26GP	"OE"795+80.62POT		54.10	"LW" 209+36.63	POT	148.19	NHD BRASS DISC
1116052H	15095688.26	2650669.57	3961.79GP	"OW"3810+00.00PC=	"OW"810+00.00POT	96.47	"LW" 223+56.42	POC	-96.37	NHD BRASS DISC
270034H	15095568.13	2650883.99	3962.19GP	"OE"810+00.00POT		65.43	"LW" 223+56.42	POC	149.40	NHD BRASS DISC
1116053H	15095670.36	2650701.54	3962.65GP	"OW"3810+00.00PC=	"OW"810+00.00POT	59.73	"LW" 223+56.43	POC	-59.73	NHD BRASS DISC
1116054H	15097975.31	2651713.45	3966.31GP	"OE"835+31.27POT		116.67	"LW" 248+87.53	POT	-119.81	NHD BRASS DISC
270036H	15097858.33	2651974.07	3966.17GP	"OE"835+31.27POT		81.91	"LW" 248+87.57	POT	165.86	NHD BRASS DISC
1116056H	15097818.61	2652062.56	3965.53GP	"OE"3835+31.27POT		178.90	"LW" 248+87.58	POT	262.85	NHD BRASS DISC
1116055H	15097954.14	2651760.82	3965.87GP	"OE"835+31.27POT		67.95	"LW" 248+87.62	POT	-67.93	NHD BRASS DISC
1116058H	15099151.84	2652671.87	3967.84GP	849+97.30PC		188.63	"LW" 263+53.42	POC	272.58	NHD BRASS DISC
270037H	15099174.24	2652622.16	3967.48GP	"OW"849+97.30PC		134.06	"LW" 263+53.50	POC	218.06	NHD BRASS DISC
1116057H	15099312.75	2652314.21	3967.84GP	849+97.30		119.62	"LW" 263+53.68	POC	-119.61	NHD BRASS DISC
1116059H	15102464.32	2655646.55	3982.23GP	"RM" 00+00PC		36.97	"LW" 309+81.94	POC	-58.82	NHD BRASS DISC
1116060H	15102700.86	2655789.35	3979.41GP	"RM" 42+79.14PT		32.99	"LW" 312+62.83	POC	-60.52	NHD BRASS DISC
1116062H	15102607.49	2655957.40	3979.75GP	"OE"3898+99.61PT=	"OE"900+37.61POT	47.65	"LW" 312+63.60	POC	131.73	NHD BRASS DISC
1116063H	15102584.03	2655999.22	3976.41GP	"OE"3898+99.61PT	"OE"900+37.61POT	95.69	"LW" 312+63.60	POC	179.68	NHD BRASS DISC
1116061H	15102698.33	2655795.54	3981.15GP	"OW"3898+55.62PT=	"OW"900+37.61	54.06	"LW" 312+63.66	POC	-53.88	NHD BRASS DISC
1116064H	15102719.53	2656025.02	3979.59GP	"RM1"0+00.00POT		29.90	"LW" 314+38.41	POT	135.91	NHD BRASS DISC
1116065H	15102699.13	2656061.44	3976.41GP	"RM1"0+00.00POT		71.72	"LW" 314+38.43	POT	177.65	NHD BRASS DISC
1116066H	15103068.23	2655993.12	3979.33GP	"RM"16+99.08PC		25.48	"LW" 317+26.95	POT	-62.47	NHD BRASS DISC
1116067H	15103171.88	2656372.66	3977.27GP	"RM1"15+70.98PC		72.30	"LW" 320+02.99	POT	217.88	NHD BRASS DISC
1116068H	15103608.58	2656677.30	3977.51GP	"RM1"11+07.31PC		82.10	"LW" 325+32.89	POT	269.99	NHD BRASS DISC
1116069H	15104039.02	2656930.72	3978.36GP	"CM4"97+00POT=	"RM1"16+94.00POT	96.87	"LW" 330+32.28	POT	280.50	NHD BRASS DISC
1116070H	15104274.90	2656527.72	3978.38GP	"CM1"1+22.00POT=	"RM4"20+94.46POT	86.94	"LW" 330+40.91	POT	-186.38	NHD BRASS DISC
1116071H	15104286.37	2656547.06	3977.99GP	"CM1"1+22.00POT=	"RM4"20+94.46POT	64.42	"LW" 330+60.37	POT	-175.12	NHD BRASS DISC
1116073H	15104279.17	2656892.35	3992.04GP	"OE"919+53.01POT		45.55	"LW" 332+22.98	POT	129.57	NHD BRASS DISC
1116074H	15104206.30	2657022.40	3978.75GP	"OE"919+53.01POT		194.59	"LW" 332+23.03	POT	278.65	NHD BRASS DISC
1116072H	15104366.24	2656737.31	3991.76GP	"OW"919+53.01POT		48.30	"LW" 332+23.09	POT	-48.24	NHD BRASS DISC
1116075H	15105867.69	2657525.97	3978.88GP	"RM"339+00.69POT		72.76	"LW" 349+18.43	POT	-94.73	NHD BRASS DISC
1116076H	15105863.05	2657552.13	3980.31GP	"RM"339+00.69POT		42.71	"LW" 349+18.46	POT	-64.76	NHD BRASS DISC
1116077H	15106131.15	2657957.39	3983.20GP	"OE"940+89.03POT=	"RM2"39+33.17POT	68.50	"LW" 353+59.24	POT	152.70	NHD BRASS DISC
1116078H	15106118.53	2657979.89	3982.05GP	"OE"940+89.03POT=	"RM2"39+33.17POT	94.31	"LW" 353+59.24	POT	178.50	NHD BRASS DISC
1116082H	15106754.46	2658336.20	3979.99GP	"OW"948+18.37POT=	"OW3"948+18.37PC	94.11	"LW" 360+68.18	POT	178.24	NHD BRASS DISC
1116080H	15106878.47	2658115.14	3983.04GP	"OE"948+18.37POT=	"OW3"948+18.37PC	85.11	"LW" 360+68.23	POT	-75.23	NHD BRASS DISC
1116081H	15106777.99	2658294.36	3984.83GP	"OW"948+18.37POT=	"OW3"948+18.37PC	46.21	"LW" 360+68.24	POT	130.23	NHD BRASS DISC
1116084H	15107744.97	2658790.04	3983.71GP	"OW"3959+00.00POC		66.79	"LW" 371+69.99	POC	-66.62	NHD BRASS DISC
1116083H	15107787.50	2658748.59	3982.46GP	"OW"3959+00.00		126.19	"LW" 371+70.07	POC	-126.01	NHD BRASS DISC
1116085H	15107614.15	2659084.63	3982.35GP	"OE"960+00.00PC		146.50	"LW" 372+97.02	POC	230.83	NHD BRASS DISC
1116086H	15108480.56	2660129.92	3988.19GP	"OE"974+30.58POT=	973+92.74POT	22.00	"LW" 387+00.25	POC	41.90	NHD BRASS DISC
1116088H	15108290.78	2660203.44	3985.33GP	"OE"973+92.74POT=	973+72.59PT	161.44	"LW" 387+00.27	POC	245.43	NHD BRASS DISC
1116087H	15108361.94	2660175.93	3985.31GP	"OE"973+92.74POT=	"OE"973+72.59PT	85.22	"LW" 387+00.32	POT	169.13	NHD BRASS DISC
1116089H	15109671.80	2662584.69	3988.51GP	"OW"1001+12.32POT		182.39	"LW" 414+19.55	POT	-182.49	NHD BRASS DISC

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

LOCATION CONTROL

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA	IM-080-2(053)	PERSHING	LC4

NAME	NORTHING	EASTING	ELEVATION	OLD STATION	EQUATION	DIST(')	NEW STATION		DIST(')	NOTE
1116090H	15109572.12	2662623.34	3988.12GP	"OW"1001+12.32POT		75.47	"LW" 414+19.60	POT	-75.58	NHD BRASS DISC
1116092H	15110533.98	2665066.23	3991.12GP	"OW"37.49PC		90.25	"LW" 440+44.99	POC	-90.36	NHD BRASS DISC
1116091H	15110610.80	2665036.54	3990.92GP	"OW"1027+37.49PC		172.57	"LW" 440+45.04	POC	-172.72	NHD BRASS DISC
1116094H	15110279.87	2665421.82	3990.62GP	"OE"1029+77.47PC		191.04	"LW" 442+78.35	POC	277.81	NHD BRASS DISC
1116093H	15110369.38	2665387.20	3990.58GP	"OW"1029+77.47PC		95.09	"LW" 442+80.59	POC	181.87	NHD BRASS DISC
1116095H	15113946.29	2669437.00	4005.54GP	"OW"1084+87.47POT=	"OW"1084+87.47PT	142.72	"LW" 498+14.48	POT	-142.75	NHD BRASS DISC
1116096H	15113900.61	2669499.33	4005.88GP	"OW"1084+87.47POT=	"OW"1084+24.35PT	65.93	"LW" 498+14.50	POT	-65.47	NHD BRASS DISC
1116097H	15113820.56	2669873.90	4007.84GP	"OE"1086+44.45POT=	"OE"1086+64.33PC	83.91	"LW" 499+71.44	POT	283.93	NHD BRASS DISC
1116098H	15113777.30	2669932.95	4006.69GP	"OE"1086+44.45POT=	"OE"1086+64.33PC	157.10	"LW" 499+71.47	POT	357.13	NHD BRASS DISC
1116100H	15119805.63	2674360.68	4012.85GP	"OE"1161+23.64POT		103.14	"LW" 574+51.14	POT	383.21	NHD BRASS DISC
1116099H	15119854.23	2674294.63	4013.35GP	"OE"1161+23.64POT		81.14	"LW" 574+51.28	POT	281.20	NHD BRASS DISC
1116102H	15121006.72	2674692.41	4011.86GP	"OW"1172+88.32POT		79.67	"LW" 586+15.90	POT	-79.49	NHD BRASS DISC
1116101H	15121061.91	2674617.23	4011.83GP	"OW"1172+88.32POT		172.94	"LW" 586+15.96	POT	-172.76	NHD BRASS DISC
1116103H	15123254.55	2676783.13	4026.07GP	"OE"1203+37.25POT		77.23	"LW" 616+64.92	POT	277.38	NHD BRASS DISC
1116104H	15123202.98	2676853.50	4026.65GP	"OE"1203+37.25POT		164.52	"LW" 616+64.94	POT	364.62	NHD BRASS DISC
1116105H	15124287.45	2676968.84	4029.59GP	"OW"1212+79.99POT		183.86	"LW" 626+07.71	POT	-183.63	NHD BRASS DISC
1116106H	15124228.00	2677049.93	4029.82GP	"OW"1212+79.99POT		-83.26	"LW" 626+07.71	POT	-83.08	NHD BRASS DISC
1116108H	15126344.93	2678593.45	4044.09GP	"OW"1239+00.00POT		-90.28	"LW" 652+27.60	POT	-90.09	NHD BRASS DISC
1116107H	15126395.25	2678524.86	4043.92GP	"OW"1239+00.00POT		-175.36	"LW" 652+27.62	POT	-175.16	NHD BRASS DISC
1116109H	15126420.03	2679116.86	4048.65GP	"OE"1242+70.00POT		87.17	"LW" 655+97.66	POT	287.60	NHD BRASS DISC
1116110H	15126369.39	2679186.03	4049.24GP	"OE"1242+70.00POT		173.21	"LW" 655+97.72	POT	373.33	NHD BRASS DISC
1116111H	15128603.75	2680600.29	4076.94GP	"OE"1269+72.79POT		-64.78	"LW" 683+00.39	POT	145.34	NHD BRASS DISC
1116112H	15128565.93	2680761.01	4080.09GP	"OE"1269+72.79POT		144.65	"LW" 683+00.41	POT	344.62	NHD BRASS DISC
1116113H	15129396.77	2680739.16	4078.06GP	"OW"1276+30.00POT		-164.34	"LW" 689+57.52	POT	-164.29	NHD BRASS DISC
1116114H	15129350.08	2680802.93	4079.57GP	"OW"1276+30.00POT		-85.36	"LW" 689+57.57	POT	-85.26	NHD BRASS DISC
1116116H	15131684.65	2683068.19	4113.53GP	"OE"1308+51.76PC		161.13	"LW" 721+79.66	POT	361.14	NHD BRASS DISC
1116115H	15131709.10	2683034.75	4113.17GP	"OE"1308+51.76PC		119.71	"LW" 721+79.69	POT	319.66	NHD BRASS DISC
1116117H	15132384.21	2682912.30	4102.71GP	"OW"1313+23.74PC		173.21	"LW" 726+51.73	POC	-178.30	NHD BRASS DISC
1116118H	15132336.20	2682977.83	4109.10GP	"OW"1313+23.74PC		96.95	"LW" 726+51.76	POC	-97.06	NHD BRASS DISC
1116119H	15133356.13	2683986.97	4124.34GP	"OE"1327+37.15POT		92.60	"LW" 740+45.91	POC	212.83	NHD BRASS DISC
1116120H	15133324.58	2684053.24	4126.09GP	"OE"1327+37.15POT		165.01	"LW" 740+49.40	POC	286.14	NHD BRASS DISC
1116121H	15133674.37	2684162.60	4125.91GP	"OE"1330+99.93POT=	"OE"1330+93.52PT	114.46	"LW" 744+01.51	POC	223.32	NHD BRASS DISC
1116122H	15133642.30	2684229.96	4127.80GP	"OE"1330+99.93POT=	"OE"1330+93.52PT	189.11	"LW" 744+02.48	POC	297.92	NHD BRASS DISC
1116124H	15133927.62	2683951.97	4120.26GP	"OW"1332+31.82POT=	1332+09.13PT	76.54	"LW" 745+36.68	POC	-76.62	NHD BRASS DISC
1116123H	15133970.32	2683862.29	4116.86GP	"OW"1332+31.82POT=	1332+09.13PT	175.93	"LW" 745+36.70	POC	-175.95	NHD BRASS DISC
1116126H	15135487.78	2684689.90	4128.86GP	"OW"1349+57.50POT		80.54	"LW" 762+91.68	POT	-80.58	NHD BRASS DISC
1116127H	15135366.27	2684946.29	4140.72GP	"OE"1349+57.50POT		94.21	"LW" 762+91.68	POT	202.24	NHD BRASS DISC
1116125H	15135626.38	2684608.81	4125.33GP	"OW"1349+57.50POT		170.37	"LW" 762+91.69	POT	-170.39	NHD BRASS DISC
1116128H	15135337.08	2685006.73	4144.37GP	"OE"1349+67.50POT		162.22	"LW" 762+91.72	POT	270.26	NHD BRASS DISC
1116129H	15137715.57	2686041.78	4152.37GP	"OE"1375+50.00POT		74.95	"LW" 788+84.19	POT	183.02	NHD BRASS DISC
1116130H	15137674.37	2686128.50	4159.98GP	"OE"1375+50.00POT		171.11	"LW" 788+84.25	POT	279.03	NHD BRASS DISC
PEF001H	15138452.36	2686420.19	4162.48GP	"BF"470+15.00		100.00	"LW" 797+12.10	POT	208.17	NHD BRASS DISC
1116132H	15141906.38	2687700.81	4213.83GP	"BW"506+84.56POT		119.94	"LW" 833+81.28	POT	-119.42	NHD BRASS DISC
1116133H	15141776.60	2687973.70	4227.81GP	"BE"506+84.56POT		74.35	"LW" 833+81.34	POT	182.76	NHD BRASS DISC
1116135H	15144685.87	2689385.78	4164.03GP	"BE"539+18.38PC		100.00	"LW" 866+15.09	POT	207.93	NHD BRASS DISC
1116134H	15144830.26	2689082.47	4154.68GP	"BW"539+18.38PC		127.97	"LW" 866+15.16	POT	-127.99	NHD BRASS DISC
1116136H	15146546.36	2689992.49	4136.59GP	"BW"558+38.48POT=	558+48.91PT	137.04	"LW" 885+45.60	POT	-137.01	NHD BRASS DISC
1116137H	15146381.72	2690266.93	4141.49GP	"BE"558+38.48PT		75.04	"LW" 885+45.60	POT	183.03	NHD BRASS DISC
1116139H	15151859.93	2693565.28	4174.39GP	"BW"622+33.12POT		34.97	"LW" 949+40.11	POT	193.25	NHD BRASS DISC
1116138H	15151997.94	2693335.52	4170.55GP	"BW"622+33.12POT		75.00	"LW" 948+40.26	POT	-74.78	NHD BRASS DISC
1116140H	15157427.80	2696598.42	4142.46GP	"BW"685+68.03POT		69.98	"LW"1012+75.08	POT	-70.09	NHD BRASS DISC
1116141H	15157284.92	2696836.99	4157.49GP	"BE"685+68.03POT		100.00	"LW"1012+75.28	POT	208.00	NHD BRASS DISC
1116143H	15159626.44	2698212.48	4156.20GP	"BW"712+83.70POT		75.00	"LW"1039+90.80	POT	182.94	NHD BRASS DISC
1116142H	15159759.09	2697991.37	4156.97GP	"BW"712+83.70POT		75.00	"LW"1039+90.81	POT	-74.90	NHD BRASS DISC
1116145H	15163156.85	2700330.47	4167.18GP	"BW"754+01.03POT		75.00	"LW"1081+07.80	POT	182.99	NHD BRASS DISC

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

LOCATION CONTROL

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA	IM-080-2(053)	PERSHING	LC5

PROJECT ALIGNMENT
LPN 1116 - I-80 EAST BOUND
"LE" 100+00.00 POT to "LE" 1081+07.81 POT
CONTRACTS #1483,1919,1600 & 1097
MP PE 13.03 to MP PE 31.59
Horz = NAD83/94 Ft g(f) = .9997101703
11/06/2009

"OE" 686+44.49 PT =				
"LE" 100+00.00 POT			15086238.163	2642997.803
	N 49°36'53" E - 4470.31'			
"LE" 144+70.31 PC			15089134.586	2646402.861
	R = 11200.00'			
	D = 20°21'13" Lt			
PI			15090437.249	2647934.281
CC			15097665.680	2639146.109
	L = 3978.66'			
	T = 2010.52'			
"LE" 184+48.97 PT			15092191.227	2648917.003
	N 29°15'40" E - 3907.38'			
"LE" 223+56.35 PC			15095600.032	2650826.894
	R = 10084.00'			
	D = 5°04'48" Lt			
CC			15100528.995	2642029.600
	L = 894.07'			
	T = 447.33'			
"LE" 232+50.43 PT			15096398.364	2651228.782
	N 24°10'52" E - 3102.86'			
"LE" 263+53.29 PC			15099228.961	2652499.781
	R = 3700.00'			
	D = 35°06'46" Rt			
PI			15100296.856	2652979.289
CC			15097713.358	2655875.125
	L = 2267.48'			
	T = 1170.61'			
"LE" 286+20.76 PT =				
"LE" 286+72.25 PT			15100894.610	2653985.777
	N 59°17'38" E - 653.43'			
"LE" 293+25.67 PC			15101228.272	2654547.591
	R = 3784.00'			
	D = 30°00'42" Lt			
PI			15101746.225	2655419.712
CC			15104481.747	2652615.350
	L = 1982.07'			
	T = 1014.33'			
"LE" 313+07.74 PT			15102630.947	2655915.834
	N 29°16'56" E - 1808.46'			
"LE" 331+16.21 POT =			15104208.327	2656800.375
"OE" 918+46.27 POT =				
"CM" 2+65.00 POT				
	N 29°16'56" E - 2972.17'			
"LE" 360+88.37 PC			15106800.715	2658254.098
	R = 3700.00'			
	D = 39°32'56" Rt			
PI			15107960.959	2658904.723
CC			15104991.001	2661481.316
	L = 2553.96'			
	T = 1330.22'			
"LE" 386+42.33 PT =			15108441.325	2660145.179
"LE" 387+00.31 POT				
	N 68°49'52" E - 5584.56'			
"LE" 442+84.86 PC			15110458.013	2665352.896
	R = 10000.00'			
	D = 32°34'51" Lt			
PI			15111513.341	2668078.082
CC			15119783.213	2661741.713
	L = 5686.43'			
	T = 2922.39'			
"LE" 499+71.29 PT			15113870.078	2669806.130
	N 36°15'01" E - 22208.04'			
"LE" 721+79.33 PC			15131779.568	2682938.045
	R = 10000.00'			
	D = 10°48'20" Lt			
PI			15132542.274	2683497.290
CC			15137692.703	2674873.628
	L = 1885.92'			
	T = 945.77'			
"LE" 740+65.26 PT			15133396.302	2683903.630
	N 25°26'41" E - 12552.72'			
"LE" 866+17.97 PC			15144731.407	2689296.780
	R = 19892.00'			
	D = 5°30'55" Rt			
PI			15145596.607	2689708.435
CC			15136185.006	2707259.260
	L = 1914.80'			
	T = 958.14'			
"LE" 885+32.77 PT =			15146418.237	2690201.3400
"LE" 885+43.18 POT				
	N 30°57'36" E - 19564.63'			
"LE" 1081+07.80 POT =			15163195.431	2700266.160
"BE" 754+01.03 PC				

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

LOCATION CONTROL

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA	IM-080-2(053)	PERSHING	LC6

VERTICAL DATUM: ELEVATIONS ARE BASED UPON NAVD88 HOLDING PUBLISHED USC & GS BENCH MARK AND NDOT CONTROL MONUMENTS: 846003M(3982.082), K 317X(3958.056), Q 297Z(4026.422), V 145X(4164.818) AS FIXED.

BEARING SOURCE: BEARINGS OF THIS MAP WERE DERIVED FROM NEVADA STATE PLANE COORDINATES NAD 83/94 DATUM WEST ZONE, WITH A MEAN CONVERGENCY OF 0°05'57". USING LOCAL CONTROL POINTS: 846003M, FAA LOL AZ, K 317X, Q 297Z, V 145X AS FIXED AND IS FURTHER ARCHIVED AT NDOT UNDER FILE LPN 1116. COORDINATES AND DISTANCES REFLECT A SINGLE COMBINATION GROUND TO GRID FACTOR OF 0.9997101703 AND HAVE BEEN CONVERTED TO FEET. MONUMENTS ARE STAMPED WITH "NDOT" AND MONUMENT NAME UNLESS NOTED IN DESCRIPTION.

SPECIAL NOTE: PLSS MONUMENTS LISTED IN THIS CONTRACT ARE REQUIRED TO BE PERPETUATED UNDER THE DIRECT SUPERVISION OF A PROFESSIONAL LAND SURVEYOR REGISTERED IN THE STATE OF NEVADA TO ASSURE COMPLIANCE WITH NEVADA REVISED STATUTES,CHAPTERS 329 & 625. ANY MONUMENTS FOUND DURING SURVEY, MAPPING, CONSTRUCTION OR MAINTENANCE PHASES OF NEVADA DEPARTMENT OF TRANSPORTATION PROJECTS NOT LISTED FOR PERPETUATION IN THE CONTRACT PLANS SHALL BE PERPETUATED IN ACCORDANCE WITH THE STATE OF NEVADA DEPARTMENT OF TRANSPORTATION, TRANSPORTATION POLICY (TP) 3-1-3, TITLED PERPETUATION OF SURVEY MONUMENTS, DATED JANUARY 13, 1999.

CONSTRUCTION CONTROL

NAME	NORTHING	EASTING	ELEVATION	EQUATION	OLD STATION	DIST(')	NEW STATION		DIST(')	NOTE
1116001M	15093590.81	2649758.41	3980.655				"LE" 200+81.24	POT	49.94	NDOT FENCE
K_317X	15093788.86	2650003.95	3958.056				"LE" 203+74.04	POT	167.35	NGS BM
1116002M	15094851.03	2650481.66	3961.596				"LE" 215+34.18	POT	64.92	NDOT FENCE
1116003M	15096793.88	2651440.47	3981.301				"LE" 236+97.95	POT	31.10	NDOT FENCE
1116004M	15098737.82	2652374.36	3968.594				"LE" 258+53.86	POT	86.77	NDOT FENCE
1116005M	15100039.18	2653067.90	3976.383				"LE" 273+51.72	POC	54.46	NDOT FENCE
1116006M	15102222.30	2655701.34	3987.200				"LE" 308+50.20	POC	40.71	NDOT FENCE
1116007M	15103676.47	2656725.28	3977.994				"LE" 326+15.58	POT	194.64	NDOT FENCE
1116008M	15105221.92	2657470.56	3981.760				"LE" 343+28.08	POT	88.79	NDOT FENCE
1116009M	15106562.23	2658213.68	3981.567				"LE" 358+60.59	POT	81.39	NDOT FENCE
1116010M	15107968.28	2658984.84	3990.153				"LE" 374+27.55	POC	-185.43	NDOT FENCE
1116011M	15108584.04	2660630.20	3989.123				"LE" 392+04.13	POT	42.07	NDOT FENCE
1116012M	15109070.97	2662239.59	3987.453				"LE" 408+80.76	POT	169.17	NDOT FENCE
1116014M	15109593.97	2663217.82	3992.088				"LE" 419+81.84	POT	34.72	NDOT FENCE
1116015M	15109944.35	2664542.74	3993.483				"LE" 433+43.88	POT	186.44	NDOT FENCE
1116016M	15110596.37	2666096.42	3991.862				"LE" 450+16.64	POC	166.69	NDOT FENCE
1116013M	15111489.53	2667568.29	4004.739				"LE" 467+14.43	POC	135.79	NDOT FENCE
1116017M	15112655.53	2668867.10	4007.836				"LE" 484+42.57	POC	78.44	NDOT FENCE
1116018M	15113873.82	2669930.00	4011.908				"LE" 500+47.56	POT	97.68	NDOT FENCE
1116019M	15115459.16	2670589.09	4014.018				"LE" 517+15.77	POT	-306.23	NDOT FENCE
1116020M	15116684.42	2671956.84	4018.640				"LE" 535+12.64	POT	70.26	NDOT FENCE
1116021M	15118080.61	2673068.88	4013.667				"LE" 552+96.15	POT	141.47	NDOT FENCE
1116022M	15119399.41	2674022.74	4017.948				"LE" 569+23.72	POT	130.88	NDOT FENCE
1116023M	15120671.95	2675015.29	4013.981				"LE" 585+36.85	POT	178.84	NDOT FENCE
1116024M	15122011.73	2675973.17	4020.537				"LE" 601+83.71	POT	159.09	NDOT FENCE
1116025M	15123221.17	2676870.87	4026.898				"LE" 616+89.88	POT	167.87	NDOT FENCE
1116026M	15124539.85	2677826.57	4040.261				"LE" 633+18.44	POT	158.84	NDOT FENCE
1116027M	15125765.85	2678746.87	4047.318				"LE" 648+51.32	POT	176.05	NDOT FENCE
1116028M	15127178.91	2679652.62	4059.080				"LE" 665+26.45	POT	70.93	NDOT FENCE
1116029M	15128647.47	2680316.61	4071.724				"LE" 681+03.39	POT	-261.98	NDOT FENCE
1116030M	15129702.01	2681638.86	4099.979				"LE" 697+35.68	POT	180.77	NDOT FENCE
1116031M	15131097.96	2682644.45	4111.252				"LE" 714+56.05	POT	166.28	NDOT FENCE
1116032M	15132586.98	2683648.91	4123.909				"LE" 732+36.68	POC	152.54	NDOT FENCE
1116033M	15134173.62	2684475.04	4132.305				"LE" 750+12.68	POT	182.02	NDOT FENCE
1116034M	15135642.29	2685175.03	4146.442				"LE" 766+39.63	POT	183.11	NDOT FENCE
1116035M	15137381.96	2685995.22	4161.393				"LE" 785+62.94	POT	176.31	NDOT FENCE
1116036M	15138858.31	2686730.41	4172.111				"LE" 802+48.07	POT	188.70	NDOT FENCE
1116037M	15140450.17	2687470.19	4214.457				"LE" 819+67.24	POT	189.98	NDOT FENCE
1116038M	15142036.12	2688232.19	4251.967				"LE" 837+26.74	POT	196.68	NDOT FENCE
1116039M	15143552.46	2688835.36	4192.639				"LE" 853+55.14	POT	89.86	NDOT FENCE
1116040M	15145206.70	2689702.55	4155.973				"LE" 872+26.27	POC	152.98	NDOT FENCE
1116041M	15146547.68	2690432.52	4155.953				"LE" 887+73.10	POT	131.65	NDOT FENCE
1116042M	15147981.14	2691302.20	4157.629				"LE" 904+49.73	POT	140.00	NDOT FENCE
1116043M	15149515.98	2692286.19	4166.035				"LE" 922+73.13	POT	195.93	NDOT FENCE
1116044M	15150981.25	2693167.52	4175.638				"LE" 939+62.00	POT	196.18	NDOT FENCE

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NEVADA	IM-080-2(053)	PERSHING	LC7

VERTICAL DATUM: ELEVATIONS ARE BASED UPON NAVD88 HOLDING PUBLISHED USC & GS BENCH MARK AND NDOT CONTROL MONUMENTS: 846003M(3982.082), K 317X(3958.056), Q 297Z(4026.422), V 145X(4164.818) AS FIXED.

BEARING SOURCE: BEARINGS OF THIS MAP WERE DERIVED FROM NEVADA STATE PLANE COORDINATES NAD 83/94 DATUM WEST ZONE, WITH A MEAN CONVERGENCY OF 0°05'57". USING LOCAL CONTROL POINTS: 846003M, FAA LOL AZ, K 317X, Q 297Z, V 145X AS FIXED AND IS FURTHER ARCHIVED AT NDOT UNDER FILE LPN 1116. COORDINATES AND DISTANCES REFLECT A SINGLE COMBINATION GROUND TO GRID FACTOR OF 0.9997101703 AND HAVE BEEN CONVERTED TO FEET. MONUMENTS ARE STAMPED WITH "NDOT" AND MONUMENT NAME UNLESS NOTED IN DESCRIPTION.

SPECIAL NOTE: PLSS MONUMENTS LISTED IN THIS CONTRACT ARE REQUIRED TO BE PERPETUATED UNDER THE DIRECT SUPERVISION OF A PROFESSIONAL LAND SURVEYOR REGISTERED IN THE STATE OF NEVADA TO ASSURE COMPLIANCE WITH NEVADA REVISED STATUTES,CHAPTERS 329 & 625. ANY MONUMENTS FOUND DURING SURVEY, MAPPING, CONSTRUCTION OR MAINTENANCE PHASES OF NEVADA DEPARTMENT OF TRANSPORTATION PROJECTS NOT LISTED FOR PERPETUATION IN THE CONTRACT PLANS SHALL BE PERPETUATED IN ACCORDANCE WITH THE STATE OF NEVADA DEPARTMENT OF TRANSPORTATION, TRANSPORTATION POLICY (TP) 3-1-3, TITLED PERPETUATION OF SURVEY MONUMENTS, DATED JANUARY 13, 1999.

CADASTRAL CONTROL

NAME	NORTHING	EASTING	ELEVATION	OLD STATION	EQUATION	DIST(')	NEW STATION		DIST(')	NOTE
1116047H	15086272.23	2642968.88	3968.30GP	"OE"686+44.49PT		-44.71	"LE" 100+00.04	POT	-44.69	NHD BRASS DISC
1116046H	15086300.80	2642944.64	3968.97GP	"OW"686+38.25PT=	"OW"686+44.49POT	49.94	"LE" 100+00.09	POT	-82.16	NHD BRASS DISC
1116045H	15086380.11	2642877.28	3966.24GP	"OW"686+38.25PT=	"OW"686+44.49POT	54.11	"LE" 100+00.17	POT	-186.21	NHD BRASS DISC
1116048H	15089180.16	2646363.89	3960.49GP	"OE"731+14.16PC		-59.97	"LE" 144+70.23	POT	-59.90	NHD BRASS DISC
270031H	15089085.94	2646444.23	3961.36GP	"OE"731+14.16PC		63.92	"LE" 144+70.30	POT	63.86	NHD BRASS DISC
1116050H	15089255.61	2646449.87	3960.04GP	"OW"732+28.44PC		-69.96	"LE" 145+85.16	POC	-61.14	NHD BRASS DISC
1116049H	15089375.78	2646347.70	3965.91GP	"OW"732+28.44PC		87.64	"LE" 145+66.85	POC	-218.86	NHD BRASS DISC
1116051H	15092412.85	2648834.69	3957.89GP	"OW"772+45.94POT=	"OW"772+07.15PT	96.25	"LE" 186+02.08	POT	-180.14	NHD BRASS DISC
270038H	15092392.29	2648871.63	3957.62GP	"OW"772+45.94POT		53.91	"LE" 186+02.20	POT	-137.86	NHD BRASS DISC
270033H	15094330.09	2650188.95	3960.26GP	"OE"795+80.62POT		64.10	"LE" 209+36.63	POT	64.19	NHD BRASS DISC
1116052H	15095688.26	2650669.57	3961.79GP	"OW3"810+00.00PC=	"OW"810+00.00POT	96.47	"LE" 223+56.43	POC	-180.37	NHD BRASS DISC
270034H	15095568.13	2650883.99	3962.19GP	"OE"810+00.00POT		65.43	"LE" 223+56.43	POC	65.40	NHD BRASS DISC
1116053H	15095670.36	2650701.54	3962.65GP	"OW3"810+00.00PC=	"OW"810+00.00POT	59.73	"LE" 223+56.44	POC	-143.73	NHD BRASS DISC
1116054H	15097975.31	2651713.45	3966.31GP	"OE"835+31.27POT		116.67	"LE" 248+87.54	POT	-203.81	NHD BRASS DISC
270036H	15097858.33	2651974.07	3966.17GP	"OE"835+31.27POT		81.91	"LE" 248+87.58	POT	81.86	NHD BRASS DISC
1116056H	15097818.61	2652062.56	3965.53GP	"OE3"835+31.27POT		178.90	"LE" 248+87.59	POT	178.85	NHD BRASS DISC
1116055H	15097954.14	2651760.82	3965.87GP	"OE"835+31.27POT		67.95	"LE" 248+87.63	POT	-151.93	NHD BRASS DISC
1116058H	15099151.84	2652671.87	3967.84GP	849+97.30PC		188.63	"LE" 263+53.43	POC	188.58	NHD BRASS DISC
270037H	15099174.24	2652622.16	3967.48GP	"OW"849+97.30PC		134.06	"LE" 263+53.50	POC	134.06	NHD BRASS DISC
1116057H	15099312.75	2652314.21	3967.84GP	849+97.30		119.62	"LE" 263+53.69	POC	-203.61	NHD BRASS DISC
1116059H	15102464.32	2655646.55	3982.23GP	"RM" 00+00PC		36.97	"LE" 310+19.55	POC	-142.82	NHD BRASS DISC
1116060H	15102700.86	2655789.35	3975.41GP	"RM" 42+79.14PT		32.99	"LE" 313+06.82	POC	-144.52	NHD BRASS DISC
1116063H	15102584.03	2655999.22	3976.41GP	"OE3"898+99.61PT	"OE"900+37.61POT	95.69	"LE" 313+07.61	POC	95.68	NHD BRASS DISC
1116062H	15102607.49	2655957.40	3975.75GP	"OE3"898+99.61PT=	"OE"900+37.61POT	47.65	"LE" 313+07.62	POC	47.73	NHD BRASS DISC
1116061H	15102698.33	2655795.54	3981.15GP	"OW3"898+55.62PT=	"OW"900+37.61	54.06	"LE" 313+07.68	POC	-137.88	NHD BRASS DISC
1116064H	15102719.53	2656025.02	3975.59GP	"RM1"0+00.00POT		29.90	"LE" 314+38.41	POT	51.91	NHD BRASS DISC
1116065H	15102699.13	2656061.44	3976.41GP	"RM1"0+00.00POT		71.72	"LE" 314+38.43	POT	93.65	NHD BRASS DISC
1116066H	15103068.23	2655993.12	3978.33GP	"RM1"6+89.08PC		26.48	"LE" 317+26.95	POT	-146.47	NHD BRASS DISC
1116067H	15103171.88	2656372.66	3977.27GP	"RM1"16+70.98PC		72.30	"LE" 320+03.00	POT	133.88	NHD BRASS DISC
1116068H	15103608.58	2656677.30	3977.51GP	"RM1"11+07.31PC		82.10	"LE" 325+32.90	POT	185.99	NHD BRASS DISC
1116069H	15104039.02	2656930.72	3978.36GP	"CM4"97+00POT=	"RM1"16+94.00POT	96.87	"LE" 330+32.29	POT	196.50	NHD BRASS DISC
1116070H	15104274.90	2656527.72	3978.38GP	"CM1"1+22.00POT=	"RM4"20+94.46POT	86.94	"LE" 330+40.91	POT	-270.38	NHD BRASS DISC
1116071H	15104286.37	2656547.06	3977.99GP	"CM1"1+22.00POT=	"RM4"20+94.46POT	64.42	"LE" 330+60.38	POT	-259.12	NHD BRASS DISC
1116073H	15104279.17	2656892.35	3992.04GP	"OE"919+53.01POT		45.55	"LE" 332+22.98	POT	45.57	NHD BRASS DISC
1116074H	15104206.30	2657022.40	3978.75GP	"OE"919+53.01POT		194.58	"LE" 332+23.03	POT	194.65	NHD BRASS DISC
1116072H	15104366.24	2656737.31	3991.76GP	"OW"919+53.01POT		48.30	"LE" 332+23.10	POT	-132.24	NHD BRASS DISC
1116075H	15105867.69	2657525.97	3978.86GP	"RM3"39+00.69POT		72.76	"LE" 349+18.43	POT	-178.73	NHD BRASS DISC
1116076H	15105853.05	2657552.13	3980.31GP	"RM3"39+00.69POT		42.71	"LE" 349+18.46	POT	-148.76	NHD BRASS DISC
1116077H	15106131.15	2657957.39	3983.20GP	"OE"940+89.03POT=	"RM2"39+33.17POT	68.50	"LE" 353+59.24	POT	68.70	NHD BRASS DISC
1116078H	15106118.53	2657979.89	3982.05GP	"OE"940+89.03POT=	"RM2"39+33.17POT	94.31	"LE" 353+59.24	POT	94.49	NHD BRASS DISC
1116082H	15106754.46	2658336.20	3979.99GP	"OW"948+18.37POT=	"OW3"948+18.37PC	94.11	"LE" 360+88.19	POT	94.24	NHD BRASS DISC
1116080H	15106678.47	2658115.14	3983.04GP	"OE"948+18.37POT=	"OW3"948+18.37PC	85.11	"LE" 360+88.23	POT	-159.23	NHD BRASS DISC
1116081H	15106777.99	2658294.36	3984.83GP	"OW"948+18.37POT=	"OW3"948+18.37PC	46.21	"LE" 360+88.25	POT	46.23	NHD BRASS DISC
1116084H	15107744.97	2658790.04	3983.71GP	"OW3"959+00.00PCC		66.79	"LE" 371+45.98	POC	-150.62	NHD BRASS DISC
1116083H	15107787.50	2658748.59	3982.46GP	"OW3"958+00.00		126.19	"LE" 371+46.06	POC	-210.01	NHD BRASS DISC

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NAME	NORTHING	EASTING	ELEVATION	OLD STATION	EQUATION	DIST(')	NEW STATION	POC	DIST(')	NOTE
1116085H	15107614.15	2659084.63	3982.35GP	"OE"960+00.00PC		146.50	"LE" 372+70.19	POC	146.83	NHD BRASS DISC
1116086H	15108480.56	2660129.92	3988.19GP	"OE"974+30.58POT=	973+92.74POT	22.00	"LE" 386+42.27	POC	-42.10	NHD BRASS DISC
1116088H	15108290.78	2660203.44	3985.33GP	"OE"973+92.74POT=	973+72.59PT	161.44	"LE" 386+42.29	POT	161.43	NHD BRASS DISC
1116087H	15108361.94	2660175.93	3985.31GP	"OE"973+92.74POT=	"OE"973+72.59PT	85.22	"LE" 386+42.34	POT	85.13	NHD BRASS DISC
1116089H	15109671.80	2662584.69	3988.51GP	"OW"1001+12.32POT		182.39	"LE" 414+19.54	POT	-266.49	NHD BRASS DISC
1116090H	15109572.12	2662623.34	3988.12GP	"OW"1001+12.32POT		75.47	"LE" 414+19.59	POT	-159.58	NHD BRASS DISC
1116092H	15110533.98	2665066.23	3991.12GP	"OW"37.49PC		90.25	"LE" 440+44.98	POT	-174.36	NHD BRASS DISC
1116091H	15110610.80	2665036.54	3990.92GP	"OW"1027+37.49PC		172.57	"LE" 440+45.03	POT	-256.72	NHD BRASS DISC
1116094H	15110279.87	2665421.82	3990.62GP	"OE"1029+77.47PC		191.04	"LE" 442+84.81	POT	191.01	NHD BRASS DISC
1116093H	15110369.38	2665387.20	3990.58GP	"OE"1029+77.47PC		95.09	"LE" 442+84.85	POC	95.04	NHD BRASS DISC
1116095H	15113946.29	2669437.00	4005.54GP	"OW"1084+87.47POT=	"OW"1084+87.47PT	142.72	"LE" 498+08.93	POC	-341.47	NHD BRASS DISC
1116096H	15113900.61	2669499.33	4005.88GP	"OW"1084+87.47POT=	"OW"1084+24.35PT	65.93	"LE" 498+10.24	POT	-264.21	NHD BRASS DISC
1116097H	15113820.56	2669873.90	4007.84GP	"OE"1086+44.45POT=	"OE"1086+64.33PC	83.91	"LE" 499+71.43	POT	83.93	NHD BRASS DISC
1116098H	15113777.30	2669932.95	4006.69GP	"OE"1086+44.45POT=	"OE"1086+64.33PC	157.10	"LE" 499+71.46	POT	157.13	NHD BRASS DISC
1116100H	15119805.63	2674360.68	4012.85GP	"OE"1161+23.64POT		103.14	"LE" 574+51.14	POT	163.21	NHD BRASS DISC
1116099H	15119854.23	2674294.63	4013.35GP	"OE"1161+23.64POT		81.14	"LE" 574+51.27	POT	81.20	NHD BRASS DISC
1116102H	15121006.72	2674692.41	4011.86GP	"OW"1172+88.32POT		79.67	"LE" 586+15.90	POT	-279.49	NHD BRASS DISC
1116101H	15121061.91	2674617.23	4011.83GP	"OW"1172+88.32POT		172.94	"LE" 586+15.95	POT	-372.76	NHD BRASS DISC
1116103H	15123254.55	2676783.13	4026.07GP	"OE"1203+37.25POT		77.23	"LE" 616+64.92	POT	77.38	NHD BRASS DISC
1116104H	15123202.98	2676853.50	4026.65GP	"OE"1203+37.25POT		164.52	"LE" 616+64.94	POT	164.62	NHD BRASS DISC
1116105H	15124287.45	2676968.84	4029.59GP	"OW"1212+79.99POT		183.86	"LE" 626+07.70	POT	-383.63	NHD BRASS DISC
1116106H	15124228.00	2677049.93	4029.82GP	"OW"1212+79.99POT		-83.26	"LE" 626+07.71	POT	-283.08	NHD BRASS DISC
1116108H	15126344.93	2678593.45	4044.09GP	"OW"1239+00.00POT		-90.28	"LE" 652+27.60	POT	-290.09	NHD BRASS DISC
1116107H	15126395.25	2678524.86	4043.92GP	"OW"1239+00.00POT		-175.36	"LE" 652+27.62	POT	-375.16	NHD BRASS DISC
1116109H	15126420.03	2679116.86	4048.65GP	"OE"1242+70.00POT		87.17	"LE" 655+97.66	POT	87.60	NHD BRASS DISC
1116110H	15126369.39	2679186.03	4049.24GP	"OE"1242+70.00POT		173.21	"LE" 655+97.72	POT	173.33	NHD BRASS DISC
1116111H	15128683.75	2680600.29	4076.94GP	"OE"1269+72.79POT		-54.78	"LE" 683+00.39	POT	-54.66	NHD BRASS DISC
1116112H	15128565.93	2680761.01	4080.09GP	"OE"1269+72.79POT		144.65	"LE" 683+00.41	POT	144.62	NHD BRASS DISC
1116113H	15129396.77	2680739.16	4078.06GP	"OW"1276+30.00POT		-164.34	"LE" 689+57.51	POT	-364.29	NHD BRASS DISC
1116114H	15129350.08	2680802.93	4079.57GP	"OW"1276+30.00POT		-85.36	"LE" 689+57.57	POC	-285.26	NHD BRASS DISC
1116116H	15131684.55	2683066.19	4113.53GP	"OE"1308+51.76PC		161.13	"LE" 721+79.66	POC	161.14	NHD BRASS DISC
1116115H	15131709.10	2683034.75	4113.17GP	"OE"1308+51.76PC		119.71	"LE" 721+79.68	POC	119.66	NHD BRASS DISC
1116118H	15132336.20	2682977.83	4109.10GP	"OW"1313+23.74PC		96.95	"LE" 726+65.83	POC	-285.57	NHD BRASS DISC
1116117H	15132384.21	2682912.30	4102.71GP	"OW"1313+23.74PC		173.21	"LE" 726+69.90	POC	-366.71	NHD BRASS DISC
1116120H	15133324.58	2684053.24	4126.09GP	"OE"1327+37.15POT		165.01	"LE" 740+64.78	POT	165.91	NHD BRASS DISC
1116119H	15133356.13	2683986.97	4124.34GP	"OE"1327+37.15POT		92.60	"LE" 740+64.79	POT	92.52	NHD BRASS DISC
1116122H	15133642.30	2684229.96	4127.80GP	"OE"1330+99.93POT=	"OE"1330+93.52PT	189.11	"LE" 744+27.60	POT	188.99	NHD BRASS DISC
1116121H	15133674.37	2684162.60	4125.91GP	"OE"1330+99.93POT=	"OE"1330+93.52PT	114.46	"LE" 744+27.62	POT	114.38	NHD BRASS DISC
1116124H	15133927.62	2683951.97	4120.26GP	"OW"1332+31.82POT=	1332+09.13PT	76.54	"LE" 745+65.81	POT	-184.62	NHD BRASS DISC
1116123H	15133970.32	2683862.29	4116.86GP	"OW"1332+31.82POT=	1332+09.13PT	175.93	"LE" 745+65.83	POT	-283.95	NHD BRASS DISC
1116126H	15135487.78	2684689.90	4128.86GP	"OW"1349+57.50POT		80.54	"LE" 762+91.68	POT	-188.58	NHD BRASS DISC
1116127H	15135366.27	2684945.29	4140.72GP	"OE"1349+57.50POT		94.21	"LE" 762+91.68	POT	94.24	NHD BRASS DISC
1116125H	15135526.38	2684608.81	4125.33GP	"OW"1349+57.50POT		170.37	"LE" 762+91.69	POT	-278.39	NHD BRASS DISC
1116128H	15135337.08	2685006.73	4144.37GP	"OE"1349+57.50POT		162.22	"LE" 762+91.72	POT	162.26	NHD BRASS DISC
1116129H	15137715.57	2686041.78	4152.37GP	"OE"1375+60.00POT		74.95	"LE" 788+64.19	POT	75.02	NHD BRASS DISC
1116130H	15137674.37	2686128.50	4159.98GP	"OE"1375+60.00POT		171.11	"LE" 788+64.25	POT	171.03	NHD BRASS DISC
PEF001H	15138452.36	2686420.19	4162.48GP	"BF"470+15.00		100.00	"LE" 797+12.09	POT	100.17	NHD BRASS DISC
1116132H	15141906.38	2687700.81	4213.83GP	"BW"506+84.56POT		119.94	"LE" 833+61.28	POT	-227.42	NHD BRASS DISC
1116133H	15141776.60	2687973.70	4227.81GP	"BF"506+84.56POT		74.35	"LE" 833+61.33	POT	74.76	NHD BRASS DISC
1116135H	15144685.87	2689385.78	4164.03GP	"BE"539+18.38PC		100.00	"LE" 866+15.09	POT	99.93	NHD BRASS DISC
1116134H	15144830.26	2689082.47	4154.68GP	"BW"539+18.38PC		127.97	"LE" 866+15.16	POT	-235.99	NHD BRASS DISC
1116136H	15146546.36	2689992.49	4136.59GP	"BW"558+30.48POT=	558+48.91PT	137.04	"LE" 885+45.60	POT	-245.01	NHD BRASS DISC
1116137H	15146381.72	2690266.93	4141.49GP	"BE"558+30.48PT		75.04	"LE" 885+45.60	POT	75.03	NHD BRASS DISC
1116139H	15151859.93	2693565.28	4174.39GP	"BW"622+33.12POT		34.97	"LE" 949+40.11	POT	85.25	NHD BRASS DISC
1116138H	15151997.94	2693335.52	4170.55GP	"BW"622+33.12POT		75.00	"LE" 949+40.25	POT	-182.78	NHD BRASS DISC
1116140H	15157427.80	2696598.42	4142.46GP	"BW"685+68.03POT		69.98	"LE" 1012+75.05	POT	-178.09	NHD BRASS DISC
1116141H	15157284.92	2696836.99	4157.49GP	"BE"685+68.03POT		100.00	"LE" 1012+75.26	POT	100.00	NHD BRASS DISC
1116143H	15159526.44	2698212.48	4156.20GP	"BW"712+83.70POT		75.00	"LE" 1039+90.80	POT	74.94	NHD BRASS DISC
1116142H	15159759.09	2697991.37	4156.97GP	"BW"712+83.70POT		75.00	"LE" 1039+90.81	POT	-182.90	NHD BRASS DISC
1116145H	15163156.85	2700330.47	4167.18GP	"BW"754+01.03POT		75.00	"LE" 1081+07.80	POT	75.00	NHD BRASS DISC

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

LOCATION CONTROL

SECTION 1.5

DATA INPUT-LoIS FILE RESEARCH

Data input for project control is extremely important in today's age of GPS Surveying. Most information needed to set up a new project can be found on the Location Information System or "LoIS" as mentioned above. The information contained in this database can be queried either by map or by attributes. The attributes can be queried by Point Name, LPN Name, UTM Coordinates/Radius, Lat-Long/Radius and PLSS Sections. LoIS is a valuable resource, because it provides essential information concerning a monument's Ground and Grid coordinates, Ortho and Ellipsoidal Elevations, Horizontal and Vertical Datum, State Plane Zone, Units, Area Combination Factor and descriptions and pictures of the monument. Questions concerning LoIS and its contents should be directed to the Geodesy Section of the Location Division.

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Chapter 2

Data Setup

SECTION 2.1

INTRODUCTION

The modern Total Station, in advance of theodolites, chain measurements and the sizable labor required to make use of both tools, offers a new standard with servo-driven laser-measuring robotic tools that automate data collection and reduce the labor requirements to a single operator. Combined with Global Positioning Satellite (GPS), the Robotic Total Station completes a dynamic approach to construction survey. That twofold approach allows the surveyor some flexibility and convenient transitions between two methods of survey, all the while maintaining dependable accuracy.

The Total Station lacks the sophistication of GPS, in consideration of the complex computations for terrestrial solutions from orbiting satellites, but delivers efficient results with accuracy that is solely dependent on the equipment condition and user input. Simply put, the equipment will yield varying results based on the preparatory effort of the operator.

In this section of the manual, the user will find reference to essential quick-start routines that hasten the startup time of the Total Station and reduce prospective operational errors. The limited routines in this manual do not represent the entire arsenal of techniques offered by the Total Station. Therefore, the user is encouraged to explore their manufacturer's operating manuals and collector help screens to realize the full potential of these instruments.

SECTION 2.2

DATA SETUP

For Desktop Software-Project Design Input: The central computer (office or notebook) is the hub for importing and exporting design data, or project data built from contract plans, into the data collector, which the surveyor then uses to stake or measure information in the field.

Monuments are typically taken from the contract plans under referenced datum, then researched in the NDOT Location Information System (LoIS) LPN files, and verified in the field.

997117 S Geodetic = 36-10-54.38842 -115-8-34.85322 UTM - 11 = 4005708.09 666989.67 State Plane = 26768083.37 786106.02 kf = 0.99991931 hf = 0.99990854 Ground = 26772821.32 786245.16	Ortho Elev = 2004.26 Ellp Elev = 1912.4 Geoid Ht = -91.86 Conv = 0-15-35.8 Sf = 0.99982786 Area CF = 0.9998230313	Display on Map V Datum = NAVD 88 H Datum = NAD 83/94 Zone = East(2701) Units = Feet Date = 6/26/2006	LPN 997 H-Acc = 0.05 H-Rel = GA V-Acc = 0.1 V-Rel = GP
FOUND 2" ALUM CAP REFERENCE MONUMENT, STAMPED: "RM, 11.64', 265.23' PLS 2002". LOCATED IN THE TOP OF CURB ON THE EAST SIDE OF "A" ST. AT THE NORTH SIDE OF THE DRIVEWAY AT 950 "A" ST.			

The typical LoIS monument description contains the information above. The essential data is the Geodetic coordinates, Ground coordinates, and Ortho and "Elip" (Ellipsoidal) elevations. The V&H Datum references obviously need to fit the project datum. The user is encouraged to explore these LPN folders and seek the "help" sections for further explanations.

The Survey software typically has a "Points Management" function that allows the user to insert northing, easting, and elevation data. Those points, when entered as such, usually display on the software's main screen, where "view" functions render point labeling for easier screen identification. To reduce entry errors, the use of the "cut and paste" entry method is highly suggested in comparison to the tedious keypad entry.

In concern of GPS points for calibrations, LoIS Longitude and Latitude (Geodetic) data can be copied and pasted with minor alterations to the Longitude and Latitude, where in LoIS they display as: Latitude; 36-10-54.38842, but enter as 36.105438842 and Longitude; -115-8-34.85322 but enter as 115.083485322 (note the 8 in the longitude minutes are entered "08" when less than 10).

- Road Alignment and Vertical Profile: The software typically allows for horizontal and vertical alignment
- information input, where either electronic design files are imported into the routine or the user manually inputs alignment data from the contract plans.

- Typical Section Template Data: The vertical profile information adds the dimensional aspect of a surface relative to the planned or existing roadway. Using the contract plans, cross sectional templates are built using subgrade depth, cross slope, shoulder cuts or fills, shoulder width, ditch elevation, and back slope data. With this information in the data collector, the surveyor will have instantaneous cut or fill information and the preparatory slope staking effort is minimal.

- Surface Datum: Surface data for the project is obtained by two main methods. First, the project may have design information derived from aerial mapping which contains accuracy to within .3 to .4 ft. The second method is by cross section, where the survey crew performs a preliminary grid collection of elevations within the roadway limits.

- Stakeout Data Input: Once all roadway alignment information and design surface data has been input into the desktop software, the data then must be downloaded to the data collector for field staking and compilation.

- Drainage Stakeout Data: Alignment, culvert dimensions, and flow line elevation data in the contract plans can build a drainage model that, when staked, yields accurate quantities of drainage excavation.

- Special Survey Data: Geographical Information Systems (GIS) data can be merged into survey data, where satellite imagery can be overlaid to show a road alignment in its actual environment.

Note: Refer to your equipment manufacturer's owner's manual for actual input methods. Software compatibility issues may require additional research and updates for accurate data management.

SECTION 2.3

DATA COLLECTOR SETUP

Data Collector Setup (depends on the manufacturer)

- Connectivity: The typical method of connecting the data collector and the central system includes USB/ USB mini-B, Bluetooth, and Wi-Fi. The user will need to ascertain the most effective way to transfer files within the environment provided.

- Memory and File Considerations:

    - Memory of late is readily available, but the user should consider collector capacity in heavy staking and collection conditions.

    - Roadway sections, as in the plans, need different file associations. Slope staking, drainage items, aggregate base section staking (redheads and blue-tops), curb-and-gutter, asphalt, PCCP, electrical items, and even permanent striping all need file names that isolate daily stakeouts and collection.

    - On-board data collector operating systems typically allow for temporary project information storage. Your collector file system centers on the limits of the operating software, the survey standards for project data storage, and ultimate compatibility for differing users.

- Download Daily Stakeout: The central computer being the hub for project data manipulation is the starting point for the surveyor's workload. To prevent recovery issues, the tasks for the day should be downloaded and uploaded accordingly for minimal memory usage.

- Collection of Data: Feature codes and terrain strategies lend to the methodology the user employs into data collection (e.g., a cross-section of a road may involve original ground, curb and gutter, utility accesses, and asphalt. The user may want to survey one component at a time, and thus reduce constant and error-prone toggling of feature code selections).

- Backup, Protection, and Uploading Data to Desktop: The user is cautioned that all electronic devices are prone to catastrophic failure and that a backup system should be in place for daily protection of data files.

SECTION 2.4

TOTAL STATION CONFIGURATION

The electronic manipulation of any survey equipment starts with the data collector. The Total Station is configured by the data collector through specific setup routines that reside in the collector's software. Permanent survey style settings such as model type, communication frequencies, laser specifications, prism specifications, and instrument properties are typical data collector inputs. Setup information regarding atmospheric conditions, setup point coordinates, backsight coordinates, instrument height, and prism height are data collector settings made upon the onsite initialization of the instrument.

A significant instrument setting is the Direct Reflex (prismless) configuration that involves reflected laser measurements to any surface that has sufficient characteristics of reflection. The resulting rectangular coordinates can be used to model the surface irregularities. In this situation, the operator is controlling the survey solely through the data collector and without a need to leave the instrument. See the appendix for the *Trimble* data collector and instrument Direct Reflex settings.

The operating manuals and help screens will always be the definitive source for the information regarding the configuration of the Total Station.

SECTION 2.5

TOTAL STATION SETUP

The Total Station will be used in a variety of setup situations. In order to ensure efficient results, some key elements such as the tripod used, the power sources, and cable connections need to be addressed.

Tripod - Out of the case, the immediate requirements for the Total Station center on the platform that the instrument will be mounted. A sturdy tripod is an essential piece for the operation of the equipment, where fluctuations in the leveling of the instrument will be problematic. Most instruments will cease operation, shutdown the instrument, and require a re-initialization if the leveling is out of balance.

Power - A typical Total Station lists a multitude of battery requirements for their equipment, such as the instrument, the prism pole, the radio, and for any long-range transistorized prisms. Most manufacturers offer a variety of ways to power the instrument by means of close proximity connections to a vehicle or by batteries in remote areas away from road access. Recharging of remote power sources can be completed either in the vehicle or in the field office. Strict adherence to the

manufacturer's requirements will yield the most usage out of these expensive batteries. It is recommended that backup batteries be on hand for all equipment and for any unforeseen remote operations.

Connections - Manufacturers are compelled to realize profit through accessories. The cables required to connect a Total Station to various components represents a myriad of specificity. Seldom do the data cables of one manufacturer fit the data ports of another. With that added uniqueness, having connection problems in remote terrain is not a pleasant experience for anyone. The protection of these specialized cables is paramount, as replacement cables, due to their specialty, carry robust pricing.

Beyond the elements mentioned above, Total Stations are delicate optical equipment that will always need periodic recalibration. These recalibrations are best handled through a local manufacturer's repair center. Internal batteries often need changing as well. The repair center is the best source for the restoration needs of your individual equipment, as warranties can be voided if the user attempts an unauthorized repair.

Finally, the appendix has distinct references to the *Trimble* Total Station setup routine. The operating manuals and help screens will always be the definitive source of information for the user, but the following list is a basic approach to the instrument setup in the field.

The Instrument Setup in General:

- Set and rough-level the tripod
- Mount and bubble-level the instrument (or tri-bracket)
- Rough center the instrument over the control point (plumb bob)
- Connect power to the instrument
- Connect the data collector and initialize the instrument
- While in sync with the collector, fine-level and then re-center the instrument
- Set the local atmospheric conditions (temperature, barometric pressure, etc.)
- Initialize the station setup
- Initialize a robotic survey
- Disconnect the data collector
- Reconnect the data collector to the prism pole mounted radio
- Establish remote radio communications with the instrument radio
- Begin the survey under robotic conditions
- Open a project file in the collector and stake points or accumulate data as needed

SECTION 2.6

TOTAL STATION ROBOTIC SURVEYS

During stakeout, the robotic operation of the Total Station is controlled remotely via radio communications to the instrument from the prism pole-mounted data collector. Line of sight obstructions and long distant operations will affect the distance measuring and reception abilities of the communication equipment. The surveyor needs to assess his operating environment and plan for obstructions accordingly. The plan of attack may include the setting of additional construction control to avoid obstructions and reduce extensive distances between the prism and instrument.

The operator is reminded that Total Stations are not fool proof and when operating at great distances in robotic mode, the instrument can lose track of the prism target. Electronic “long-range” prisms help in target relocks by signaling their location when the telescope is within a few degrees of the target. Another search feature allows the operator to engage the instrument into a predefined scan to relocate a lost target. If all else fails, the operator can have the instrument return to the previously staked point for relock or have the instrument turn a certain angle to relock.

During robotic operations, the data collector provides basic audible and symbolic instructions that readily indicate direction and walking distance to reach the intended stakeout point. The typical data collector has several icons of significance during a remote operation. The operating manuals and help screens will always be the definitive source for the information on these collector screens.

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Chapter 3

Preliminary Fieldwork

SECTION 3.1

INTRODUCTION

The following chapter is an outline of preliminary fieldwork as it relates to the identification of project control and construction limits. The Location Division at the Nevada Department of Transportation is responsible for the location and determination of project control prior to construction. Many of the citations within this chapter have been directly referenced from the Location Division's manual of *Special Instructions for Survey, Mapping or GIS Consultants*. The Location Division publishes this manual for the benefit of contractors wishing to provide consulting services for the Department, but it also serves as a guide for survey standards Department wide.

SECTION 3.2

FIELD ASSESSMENT OF IN-PLACE ERRORS

A preliminary jobsite visit and exploratory field survey should be conducted prior to the start of construction. This includes a cursory review of any plans or data received to verify that existing features and facilities are correctly depicted. Any errors found in the field should be reported to the Resident Engineer and the Designer of Record to avoid impacts to the contract's schedule and budget.

SECTION 3.3

FIELD IDENTIFICATION OF MONUMENTS IN LoIS

Information concerning the type and character of specific project control can be found in LoIS or the "Location Information System" at the following link: http://www.nevadadot.com/reports_pubs/LoIS/

The database, maintained by the Geodesy Section in the Location Division, contains pertinent information regarding controlling attributes for a particular monument. The type of information that can be found in LoIS is described in Chapter 1 of this manual under "Monument Identification" and "Data Input-LoIS File Research".

Field identification of monuments in LoIS requires an understanding of the point types that are used for control and their character. This information can be found in the manual of *Special Instructions for Survey, Mapping or GIS Consultants* in the Survey Section. The various types of monuments used are shown on the following page.

	Basic	Construction	Cadastral	Aerial
Wooden Hub				X
Washer Disc				X
Rebar Marker			X	
Feno Monument		X	X	
Concrete Marker	X			

Additional attention must be paid to the point types and their naming convention in order to properly reference the specific monument in LoIS. An example of the naming convention typically found on NDOT control is shown below:

EXAMPLE: LPN1012, first station point number, section corner
Designation = **1012001L**

- Numbers 1, 2, 3 & 4 designate the Location Project Number (LPN) assigned by NDOT
- Numbers 5,6, & 7 designate the sequential station number assigned
- Number 8 indicates the point type assigned

Based on project specifications, various point types have been established with differing degrees of control reliability. The letter designations appear on the monument at the end of the point number to differentiate the type of monument found in the field. The list of available point types used is shown below.

SECTION 3.4

POINT TYPES

A = Traverse point
X = Permanent basic control point
M = Construction control point
K = Construction control point / no spirit level elevations
L = Section corner (PLSS)
H = Highway reference monument
S = Local street monument
P = Property corner
Z= Fixed NGS control (X, Y, & Z)
B= Boundary Control Point
R= Railroad or Reset

For further identification, LoIS contains a field which often includes pictures of the monument in question. You can access this image by clicking on the “View Monument” icon in the LoIS control report for the specific monument. A few examples are shown on the next five pages:

A-Traverse Point

X-Permanent Basic Control Point

M-Construction Control Feno Monument

K-Construction Control Point / No Spirit Level Elevations

L-Section Corner (PLSS)

H-Highway Reference Monument

S- Local Street Monument

P-Property Corner

Z-Fixed NGS Control (X, Y, & Z)

SECTION 3.5

HORIZONTAL CONTROL & VERTICAL DATUMS

Horizontal control and vertical datum information pertinent to a project will be listed in the contract plans project control sheet, referred to as the "LC" sheet. The project control sheet is prepared by the Geodesy Section of the Location Division. This portion of the contract plans contains valuable metadata concerning specific control for the project. This includes the control located by station and offset, Horizontal datum, Vertical datum and the area combined ground to grid factor. Any monuments found in the field not included in the project control sheet should be examined by the Location Division prior to use to verify its compatibility with the established control network for the project.

SECTION 3.6

CONSTRUCTION LIMITS

Construction limits can be verified through the contract plans for a particular project. Additionally, project limits can also be loaded to the data collectors from *Inroads* or as a text file. Construction limits are not always the same as the Right of Way limits for a project. Right of Way limits should always be determined prior to construction to avoid potential trespass onto adjacent property.

Note: Determination of legal boundaries must be performed by the Location Division or a licensed and authorized Land Surveyor in the State of Nevada.

Right-of-Way Fencing

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Chapter 4

Robotic Total Station

SECTION 4.1

INTRODUCTION

If necessity is the mother of invention, then the invention of the Total Station robotic instrument truly fits the requirements of the necessity. This powerful engineering tool performs the work of a five-man survey crew, is twice as accurate, and reduces tedious errors in time-consuming data collection. Unlike Global Positioning Satellite (GPS), the equipment offers pinpoint precision in severe environmental conditions, where satellite radio crosstalk interference and overhead obstructions commonly renders a GPS useless.

The instrument is based on older theodolite technology that was eventually enhanced by laser or electronic distance measurement (EDM) and internal motor driven components that made remote operation possible through local radio control. That remote operation allows the instrument operator the luxury of hands on survey, where a physical presence at the point of stakeout had always been desired.

Trimble 5600 Robotic Total Station

The advances in distance measurement capabilities have led the surveyor to the world of "Prismless Survey", where the instrument can now perform measurements from afar and out of the hazards of heavy traffic conditions. Prismless survey is a great tool for surface scans, where the extremities of an existing surface are input through the data collector software, and the instrument takes robotic observations in a grid pattern. Those collected observations can be used to create 3D surface models.

SECTION 4.2

LIMITATIONS

The limitations of the Total Station are based on the manufacturer's model specifications and the geographical nature of the intended survey location.

Manufacturers build differing features into their equipment, where degree of accuracy, distance measuring, robotic controls, communication features, convenience features, telescopic options, durability, and battery life are options the user needs to consider prior to the final purchase. The daily needs, future needs, and equipment upgrade capabilities to meet those needs are all parameters the consumer should consider prior to committing to one piece of equipment.

Geographical limitations, such as physical obstructions, will limit the user's production. A construction survey conducted in rugged well-vegetated terrain will force tedious breakdowns and setups of the equipment to remain clear of obstructions. Telescopic limitations in this type of terrain and the effects of heat shimmer make long observations difficult.

The Total Station also has minor measurement limitations, where the distance between the prism target and instrument, prism configurations, temperature, common foliage, weather conditions, and prism characteristics all effect measurement characteristics. Long-range prisms have expanded the length of observation capabilities. The overall range is determined by the manufacturer's specifications, where the *Trimble* 5600 and a single long-range prism yields distances to 16,400 US ft maximum.

Power options in relation to the locations of the planned instrument setup are another concern. In rural areas, where the user's vehicle is nearby, DC connections can power the equipment from a simple cigarette lighter or alligator clips to the vehicle battery. In remote areas, portable rechargeable power packs or gel batteries are transported to the setup site and the day's survey production is based on that collective stored power.

The time of day is typically not a problem for a Total Station. Many models come with illumination features that allow nighttime usage. The data collectors are backlit as well, so the surveyor can operate twenty-four hours a day if the power is available.

SECTION 4.3

ESTABLISH LOCALIZED CONSTRUCTION CONTROL

In relation to geographical limitations, the establishment of localized construction control can aid greatly in the reduction of numerous equipment movements.

The Total Station has the edge over GPS in elevation precision, so the surveyor will want construction control in the areas of ditch work, culvert pipe, reinforced concrete boxes, traffic signals, curbs, valley-gutters, stockpiles, and any area of redundant surveys. The prudent surveyor performs a

reconnaissance of these areas of construction and physically walks the project to assess where the Total Station setups will yield the most productive shots.

To maintain accurate coordinates and elevations, the surveyor most likely will field-calculate and traverse in these points from project monuments. Their locations will be in areas of extreme activity, so protection is a priority and is enhanced through conspicuous delineation by means of bold colored ribbons and brightly painted lath. The preferred location for these points is near existing utility poles or in areas designated as "Not to be Disturbed".

Time saving efforts, made early in the project, will help avoid the ever-wandering contractor's penchant to mysteriously find and destroy your construction control points.

All data collected can be uploaded and processed in the respective office software for further distribution to field personnel, the contractor, various engineering factions, or Designer's of Record.

SECTION 4.4

LOCALIZED DRAINAGE CONTROL

As previously mentioned, the presence of control near drainage construction provides the surveyor a reference to quickly check initial offset stakeout points, flow line grade, drainage excavation quantities, elevations of existing connection sections for tie-in, potential utility conflicts, and as-built conditions. The Total Station is an invaluable tool for these areas of need. All data collected can be uploaded and processed in the respective office software for further distribution to field personnel, the contractor, various engineering factions, or Designer's of Record.

SECTION 4.5

MISCELLANEOUS CONSTRUCTION CONTROL

This topic essentially reminds the surveyor that rare circumstances may dictate the need for control outside the normal lines of stationing and elevation references. Items like existing utility locations, where manhole covers, valve covers, and junction boxes may be in need of relocation after construction and paving operations. Control may be simple ties to undisturbed curb and gutter or extensive coordinate references topographically depicted in a 3D model.

Either process involves a preliminary or detailed walk of the roadway, with thorough identification or inventory of the facilities (utilities) in place. The Total Station can be setup in intersections, and with robotics, the remote operator can be physically at the utility and enter feature codes (description) data accordingly.

SECTION 4.6

MATERIAL PIT CROSS SECTIONS

Prior to the start of the contract, the survey crew typically accesses the material pit of intent and performs a cross section for a model of existing pit conditions. The pit model is based off construction control from the roadway monuments, section corner monuments, or a surveyor placed take-off point with an assumed elevation and coordinates. The problem with the latter control is the data lacks a true reference to existing topography.

Once a protected control point is established, the Total Station can be set to use either remote or scan shots. The surface scan feature (see appendix A.4) is an invaluable tool in pit assessment conditions. The surveyor cross sections the pit for a 3D model and after material production is ceased, the surveyor can re-cross section the identical grid patterns and compare the original surface to the excavated surface. The office software can create an instantaneous report that represents a comprehensive volumetric account of quantities used.

The scanning feature is also a great tool for stockpile assessment. Accuracy is dependent on the shape of the material piles, and the contractor should be made aware that uniformity in his stockpile would aid in any payment resolution.

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Chapter 5

Global Positioning System (GPS)

SECTION **DESCRIPTION**

SECTION 5.1

INTRODUCTION

GPS (G*lobal Positioning System)* is a tool that the construction industry has adopted from the US Military. It is a constellation of at least 24 satellites that provide accurate position coordinates. GPS uses satellites and computers to compute positions anywhere on the Earth.

There are three main segments to the GPS. The first being *space*. This medium encompasses a minimum of 24 satellites that orbit the earth every 12 hours at an altitude of about 12,551 miles. The second segment is *control*. There is a master station located at Schriever Air Force Base in Colorado Springs, Colorado. Each satellite passes over one of 4 monitoring stations twice a day. The master station calculates corrections and synchronizes the atomic clocks aboard the satellites. The third and final segment is the *user*. The user is, simply put, anyone who has a GPS receiver and can access the signal.

GPS survey methods include, but are not limited to:

Static GPS surveys
Fast-static GPS surveys
Real-Time GPS surveys (RTK)
Post-Processed kinematic GPS surveys

The type of GPS survey you will mostly use for construction is Real-Time GPS survey (RTK). RTK is similar to a Total Station radial survey. RTK surveys measure the baselines from the reference station to the roving receivers point. A radio at the reference station broadcasts the position of the reference point to the rovers and the system processes the baselines in "Real Time" allowing for project coordinate information to be gathered and analyzed during the actual field survey. RTK surveying provides centimeter-level precision without post-processing. There are three types of survey methods in RTK surveys: topo points, continuous surveys, and stakeouts. Topo points are short (usually 3-15 second) occupations, e.g. over a sample site or survey marker. Continuous survey mode allows ongoing data collection at a specified logging interval, e.g. every 5 seconds, or a specified distance interval, e.g. 1 meter. Continuous mode is used for mapping. Stakeout mode allows navigation to predetermined coordinates.

The following are some of the items that will affect the accuracy of a GPS survey:

Satellite Geometry

A minimum of four satellites are required to survey with GPS. A minimum of five satellites is recommended. The configuration of the visible satellites the receiver is able to track in relation to each other will make a significant difference in the data that is being collected. Satellite geometry is expressed as a numeric value known as Dilution of Precision (DOP). Good satellite geometry will have

small DOP values while poor satellite geometry will have large DOP values. As a guideline, DOP values of six or lower are required for NDOT GPS surveys. The ideal satellite geometry is one which has the visible satellites distributed throughout the sky. Good satellite geometry will yield a higher precision. Satellite geometry factors that must be considered when planning a GPS survey are:

1. Number of satellites available

2. Minimum elevation angle above the horizon (elevation mask)

3. Obstructions limiting satellite visibility

4. Position Dilution of Precision (PDOP)

5. Vertical Dilution of Precision (VDOP)

6. Horizontal Dilution of Precision (HDOP)

7. Geometric Dilution of Precision (GDOP)

Weather Conditions

Generally, weather conditions do not affect GPS surveying; however, the following conditions must be considered when planning a GPS survey:

1. GPS observations should never be conducted during an electrical storm.

2. Significant changes in weather or unusual weather conditions should be noted either in the field notes, data collector, or receiver.

3. Horizontal and vertical GPS observations can at times be affected by severe snow, hail and rain storms. Therefore, high accurate GPS surveys should not be conducted during these periods.

4. Sunspots or magnetic storms can affect GPS observations; care needs to be taken to avoid GPS surveying during these periods.

Elevation Mask Angle

Nearly all GPS receivers, inexpensive or expensive, have a *"Mask Angle"* setting. This means that the receiver can be set to ignore any satellite signals that come from below a user-definable angle above the horizon, or "mask" them out. The most typical mask angle is usually somewhere between 10 and

15 degrees. The drawback here is that setting the mask angle too high might exclude satellites needed to acquire the necessary minimum of four. It's a trade-off. Are you so desperate for a position at that exact time that you're willing to accept a degraded signal? It does happen. In that case, the mask angle could be set to maybe 5 degrees, or even to zero if there's a clear view of the horizon, such as at sea, and simply accept a degraded signal and possibly (probably) a poorer accuracy as a result. In most cases, it's better to keep the mask angle at that upper end of around 15 to (at most) 20 degrees and just wait for a sufficient number of satellites to become available above the mask. Now that the full GPS constellation is complete, there will rarely be times with too few satellites sufficiently high in the sky to get a good position. Another potential source of error is receiver noise, or electronic noise produced by the receiver itself that interferes with the very weak incoming signal. While this error is highly variable among receiver brands, most have some kind of internal filtering designed to minimize the problem some better than others. Elevation mask also helps to minimize the atmospheric noise in the data. Satellites that are high in the sky will have less atmospheric noise than satellites low in the sky and very close to the observer's horizon. By having an elevation mask set, the noise in the GPS satellite signal is kept to a minimum.

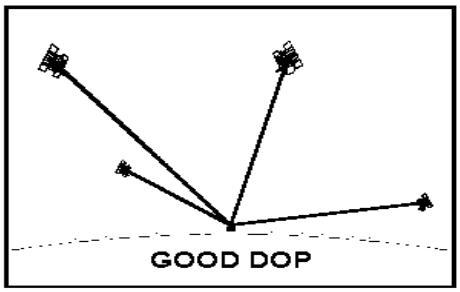
Multi-Path Errors

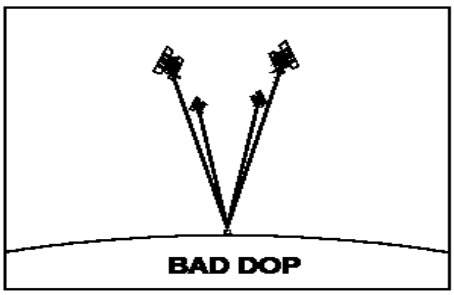
Another potential, though relatively minor, source of signal error is Multi-Path. Multi-Path is simply the reception of a reflected satellite signal. With multi-path reception, the receiver collects both the direct signal from the satellite and a fractionally delayed signal that has bounced off of some nearby reflective surface then reached the receiver. This is the same kind of thing seen in television "ghosts." The problem is that the path of the signal that has reflected off some surface is longer than the direct line to the satellite. This can "confuse" some lower-end receivers resulting in an incorrect range measurement and, consequently, an incorrect position. Most receivers have some way of "seeing" and comparing the correct and incorrect incoming signal. Since the reflected multi-path signal has traveled a longer path, it will arrive at a fraction of a second later, and a fraction weaker than the direct signal. By recognizing that there are two signals one right after another, and that one is slightly weaker than the other, the receiver can reject the later, weaker signal, minimizing the problem. This ability is referred to as the receiver's multi-path rejection capability.

Dilution of Precision (DOP)

The DOP is a measure of the geometry of the visible satellite. The ideal orientation of four or more satellites would be to have them equally spaced all around the receiver, including one above and one below. Because we're taking our position from only one side of the Earth, that's really not possible since that part of space is blocked by the planet itself. The next best orientation is to have one satellite directly above and the other three evenly spaced around the receiver and elevated to about 25 to 30 degrees (to help minimize atmospheric refraction). This would result in a very good DOP value. If all the satellites are clustered together, it would result in a poor DOP value and your readings could be

suspect. A low numeric DOP value represents a good satellite configuration, whereas a higher value represents a poor satellite configuration. The DOP at any given moment will change with time as the satellites move along their orbits. When the satellites are widely spaced, the overlap area of the two zones of possible satellite range error is relatively small. The diagram below on the left illustrates a pair of widely spaced satellites which would result in a good or low DOP value. The diagram below on the right illustrates poor satellite geometry resulting in poor or high DOP.





A DOP value of less than 2 is considered excellent-about as good as it gets, but it doesn't happen often, usually requiring a clear view of the sky all the way to the horizon. DOP values of 2 to 3 are considered very good. DOP values of 4 or below are frequently specified when equipment accuracy capabilities are given. DOP values of 4 to 5 are considered fairly good and would normally be acceptable for all but the highest levels of survey precision requirements. A DOP value of 6 would be acceptable only in low precision conditions, such as in coarse positioning and navigation. Position data should not be recorded when the DOP value exceeds 6.

It's important to carefully consider where the data is to be collected. Is the area of interest on Main Street of a large city? If so, the receiver is likely to be surrounded by tall buildings that restrict satellite visibility resulting in poor DOPs, since the only satellites that the receiver can see will be nearly straight up. That is, provided it's even possible to see enough satellites to get a position at all. In addition, the glass-sided structures all around the receiver act as nearly perfect multi-path reflectors. It's possible that, because of the efficiency of the buildings to reflect the incoming satellite signal, the receiver's multi-path rejection capability may actually be overloaded. These are very difficult problems to overcome, particularly in dense urban areas with many tall buildings. And the problems aren't just in the cities. Even out in the country with wide open spaces there are conditions to be considered. Close proximity to high-power lines is a problem. The electromagnetic radiation surrounding the lines can interfere with the satellite signal, contributing an error that is nearly impossible to compensate for or model. Forests with dense canopy cover can obscure the sky and interfere with the incoming satellite signal. The problem is even worse if the vegetation is wet, since the liquid water itself can also interfere with the signal.

Human Error

The greatest contributor to error in GPS measurement is human error. Care must be taken while performing any GPS survey to keep human error to a minimum by proper procedures, redundant checks, repeat measurements and GPS observation log reports. The following are some common examples of human error:

- Misreading antenna height measurements
- Transposing numbers entered electronically
- Rushing observations
- Poor centering and leveling over points
- Observing the wrong survey point (for example, observing a reference mark instead of the actual mark itself)
- Incorrect equipment configuration settings

SECTION 5.2

Equipment

NDOT is currently using GPS equipment from various manufacturers such as *Leica* and *Trimble* and also various generations of old and new. Therefore, you will need to refer to the operating manuals on the actual setup and operation of your equipment. This chapter is just a general guide to help you through the process.

Receivers

RTK surveys utilize two or more receivers. One is used as a reference or base station over a control monument. The other receiver or (rover) is moved from point to point collecting data. Additional receivers can be employed to achieve better productivity.

Base radio

A radio or cellular link between the receiver and the rover is required. Some receivers utilize an internal radio while others need an external base radio to transmit to the rovers. The rover has a built in radio to receive data from the base. Most external base radios include an antenna that mounts on a

standard tripod and are powered by its own battery. The rover units have a small whip antenna and do not require an external power source.

Survey Controller (Data Collector)

The survey controller is needed for running the rover receiver. The survey controller gives control over the survey and records data. It communicates with the rover by either cable or by *Bluetooth*. Most survey controllers work exclusively on their manufacturer's equipment and will not communicate with other brands. Most Survey controllers have an internal battery. Each manufacturer has its own menu's and procedures. Therefore, the operator's manual must be referenced.

Software

Each manufacturer has its own version of software for downloading data from the survey controller and receiver. Data can then be manipulated from your personal computer and transferred back to the survey controller for stakeout.

Miscellaneous

Precautions that are recommended:

- Use a fixed height rod for both the base and the rover to eliminate height of instrument mistakes.
- Use bi-pod leg attachments when performing calibration shots.
- Check "fish eye" level bubbles frequently for plumb.
- Always take caution when winding up cords as they have glass encasements inside that if kinked will break and malfunction.

Batteries and battery chargers

Supply the electricity required to run GPS equipment. Plan ahead to keep your batteries in the best condition and fully charged. Each supplier that delivers your GPS units include chargers that correspond with that equipment. Do not mix and match chargers and/or cables not meant for each particular unit. The life of the batteries can be affected by temperature. During very cold conditions, place hand warmers or other suitable devices inside the base/radio case. Keep rover batteries in a heated truck or in an inside pocket to keep them warm until needed. Conversely, when surveying in very hot conditions, keep the equipment off the direct surface of the ground by using a blanket and make sure to keep the equipment shaded as much as possible. It may be necessary to adjust your surveying times to reflect the coolest possible times.

There is one other issue with batteries that might need to be mentioned. This is the slow deterioration that occurs over time. When battery life declines by half, get rid of the batteries and replace them with new ones. The lost time and maneuvering in the field to keep changing batteries is not cost effective.

Equipment Maintenance

At the beginning of any survey and at least every 6 months, all survey equipment should be checked and adjusted if needed. Checks and adjustments shall include but are not limited the following:

- Tripods - nuts and bolts are tight, no loose or broken legs, tripod head is tight, flat, and not damaged.
- Fixed Height Tripods - level bubbles are in adjustment, rod is not bent or damaged, height of rod is correct as reportedly measured, and legs are secure.
- Rods - level bubbles are in adjustment, rod is not bent or damaged, height of rod is correct as reportedly measured, and adjustable rod height clamps are secure.
- Tribrachs - optical plummets are in adjustment, level bubble is in adjustment, no loose legs, no loose or missing screws, bottom head is flat and not damaged.
- Cables - no cuts, breaks, pinch marks or damage.
- Receivers - no cracks or visible signs damage.
- Receiver Antennas - if equipped with a ground plane, it is not bent or warped, no cracks or visible signs of damage.

Follow the manufacturers' recommendations on the care and storage of your equipment. Store the equipment in a secure area and do not store the equipment in a wet case.

SECTION 5.3

Procedures

Proper planning is an important step in an RTK survey. The first step in beginning a survey is to locate control monuments in your project area. These can be found in the contract plans project control sheets (see Chapter 1 sec. 1.4). Use at least 6 to 8 control points for a site calibration (the minimum is 3 for horizontal and 4 vertical). Place the calibration points around the perimeter of the job site. Do not survey outside of the area enclosed by the calibration points as the calibration is not valid beyond this perimeter.

There are times of the day when the number of satellites available will vary. The positions of the satellites at various times of the day are also a factor. Planning your work around these times greatly increases productivity and the quality of your results. The selection of the base station sites will also affect the success of the RTK observations. The base should be situated in a location that minimizes obstructions. A problem at the base will affect all rovers. In general, a clear view of the sky above 15 degrees is desired. At least 5 healthy satellites must be observed and the PDOP shall not exceed 6 during any GPS survey observations. The following considerations should be taken into account when choosing a site.

- Sites should be free of vertical obstructions blocking the horizon such as buildings, overhangs, terrain, trees, fences, utility poles, overhead lines, or any other visible obstructions. Non-obstructed skies 15 degrees above the horizon are best.

- Sites should not be located close to radio transmitters including cellular phone equipment, because they may disrupt satellite signal reception.

- Sites close to large flat surfaces such as signs, fences, glass, or utility boxes should be avoided.

- If feasible, sites should not be disturbed by future construction activities and should be outside the design construction limits and top of cuts for the project.

Preparing the Data Collector

- Set up the data collector for an RTK survey. The methods will vary depending on the manufacturer. Therefore, the operator's manual should be referenced. *Trimble* uses a feature called a "survey style" which is a template of settings for different types of surveys. Each style contains dozens of settings for receivers, base and rover radios, etc.

- A feature code library should be loaded into the data collector.

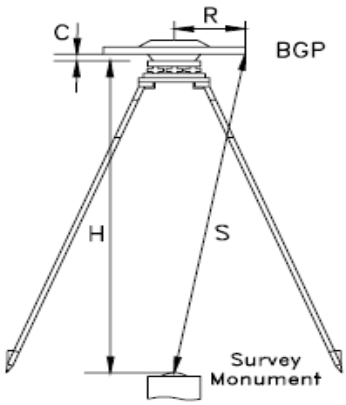
- Set up a job on the data collector.

- Enter the names, coordinates and ortho elevations of the control points that were selected. When naming points, use different names for Grid and WGS-84 coordinates with grid being keyed in from the project control sheets and WGS-84 from 3 minute field observations. For example, a point named 997117 S use 997117 S for grid coordinates and G997117 S for WGS-84 coordinates.

To set up the base station for RTK survey

1. Select a location over a control point where there is a clear and unobstructed view of the sky and preferably this location is higher than the area to be surveyed.

2. Set the GPS receiver antenna over the control point and face it to the north. GPS antennas should be set up over the points using fixed-height antenna tripods. When using standard tripods with a tribrach, the antenna slope-height will be measured multiple times (per manufacturer's directions) and the average recorded.



H = True height of fixed height tripod rod

S = Slant height field measeurment

C = Distance for addition of ground plane

R = Radius from antenna phase center to edge of ground plane

BGP = Bottom of ground plane (or antenna)

3. Attach the GPS antenna cable to the GPS antenna and then into the GPS receiver. (In some units, the receiver is built into the antenna. Therefore, this step is unnecessary).

4. Attach the data cable to the receiver.

5. Attach the battery to the base receiver.

6. Set up a tripod and place the radio antenna on it approximately 20 feet away from your GPS antenna.

7. Plug the radio antenna cable into the antenna port on the *Trimmark 3* or other radio.

8. Attach the power cable to the external radio battery and plug the other end into the radio.

9. Plug one end of the radio cable into the base receiver and then the other into the radio.

10. Turn on the receiver

To start a *Trimble* base receiver

1. Start a file in your data collector by selecting **Files** from the main menu. Select **New Job**. Name your job and then tap coordinate system. Four choices will come up. For this time, select **no projection/no datum**. The screen will change and make sure the coordinates are selected **Ground**. Enter in the project height (can be found on the LPN sheet) and select **Use Geoid Model**. Select the proper geoid model and hit **Store**. Make sure your feature code library is selected and US survey feet is in the units category. Enter in the LPN number and your name and hit **Accept**.

2. Connect the data collector to the data cable already attached to the *Trimble* base receiver and select **Survey**. Then select the appropriate RTK survey style. Then select **START BASE RECEIVER**.

3. It will ask for a point number. Key in the point name and code. Select the **Here** button down on the bottom. This will give you a general location of your base station and allow you to calibrate on the control points.

4. Disconnect data cable and key in Grid Coordinates and ortho elevations of the control points that were selected. Use the point names from the project control sheets.

5. Turn on the rover and wait for it to initialize before you leave the base.

To perform a calibration

1. Attach the bipod legs to your rover rod (this is mandatory).

2. Face the antenna to the North for each measurement.

3. Go to control points that are outside the limits of your job usually before, after, in the middle and outside of the Right-of-Way if possible. You want to try and surround your jobsite if possible. Shoot at least 6 to 8 control points for the calibration and remember that you should only shoot within 6 miles of your base. Always remember to name the shots you do in the calibration the number that is in the LPN sheet with a “G” placed in front of it to keep the points straight.

4. At the occupied point, face your predetermined direction and place the rod tip in the divet, firmly step on the bipod feet to sink them into the ground, level up, select **Start Survey**, then wait for the rover to initialize. Select **Measure Points** and select **Observed Control Point** for your choice of shot type.

5. After the 3 minute shot, you can collapse the legs and pick up and go to the other monuments for their shots.

6. Once you have completed all of the shots you want to do, you may start the field calibration in your data collector.

7. Select **Key in / Points** from the main menu. Set the type field to **Coordinates**. Check that the coordinate fields are North, East, and Elevation. Enter in any control points that have not been entered already.

8. Select the point pairs that you want to use for the calibration by selecting the LPN coordinates number and then your survey shots with the same name and the "G" prefix.

9. Once you select the point pairs, evaluate the vertical and horizontal residuals. You want to do the horizontal first. Try to hold the furthest points out from the job to get the widest calibration possible. Toggle on/off the horizontal portion of the selections on each of the pairs to determine if you get better residuals. Once you get the horizontal residual to be .03 or less, work on getting the vertical as low as possible. Once you get both as good as you can get them, fix the scale factor to 1 and then hit **Apply.**

10. Once the calibration is complete and you accept the results, never re-calibrate on this area as you do not want to change the relationship between all of the control points and the subsequent points you shoot. Multiple calibrations along a roadway should be connected at the ends by using one or two of the same control points in each of the associated calibrations. This enables the two calibrated surfaces to be held together at this point and removes the possibility of elevation breaks that can plague some projects.

11. Once you have a calibrated site, you should be able to set up your base receiver on any of your control points you have in your data collector.

Field Observation

RTK GPS surveying is similar to a Total Station radial survey. The protocols used in point collection are the same in both methods of surveying.

Once the gear is set up and you have started the base receiver, you can initialize and start the survey. It is generally best to make sure you have a radio signal from the base, and the rover is initialized before leaving the area.

Measuring points can take a couple of different forms.

- Topo Point method is a shot that takes approximately three seconds to take once you hit measure. This is a very accurate shot and should be taken when shooting concrete and/or plantmix bituminous surfaces, flow lines of pipe or drop inlets, and basically any time that good elevation is required.

- Continuous Topo is another option where the vehicle or rod mounted rover can take a shot in a selected time or distance interval.

- Rapid Point has the least quality of the methods. It only takes about a second to take one of these shots, and this method should only be used on cross sections for borrow pits and original surfaces on dirt.

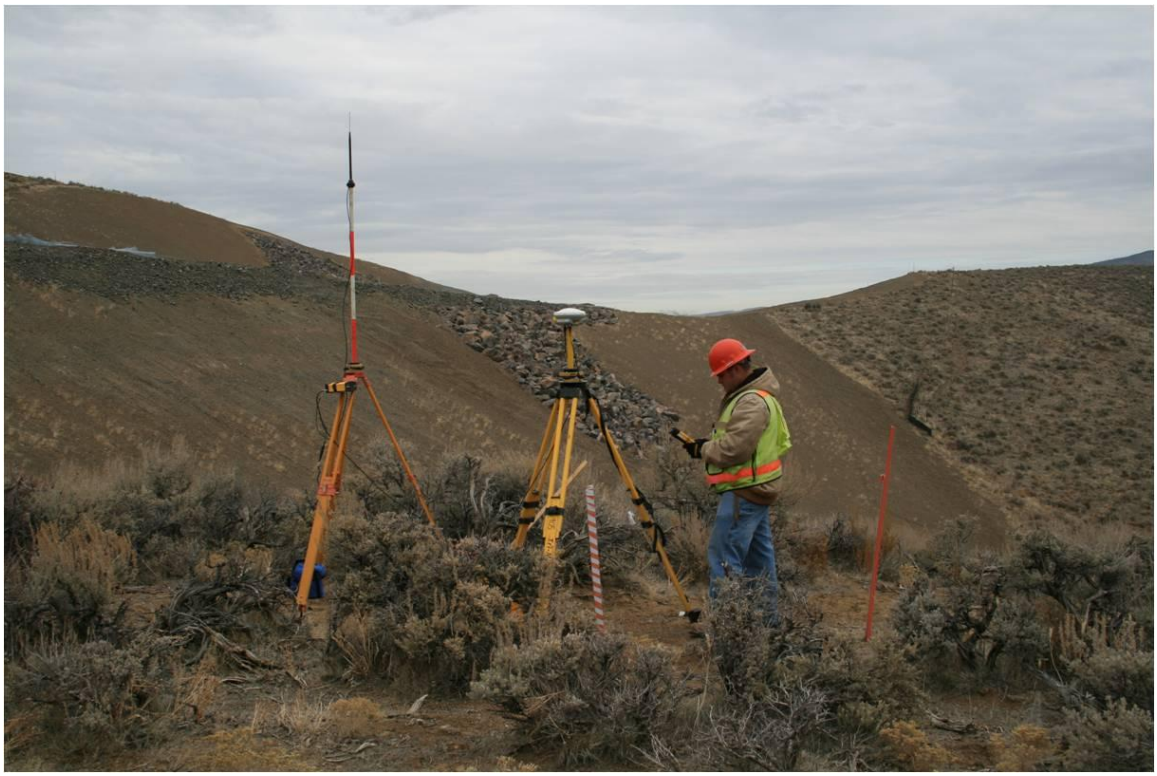
- Stake out. Once calibrated, the project's alignment can be entered into the data collector or downloaded from a personal computer in the office. Any point on the alignment can be staked out and offset as long as it is inside the calibrated area.

Feature Codes

Always remember to use the proper feature code on your points. There is a feature code library included in this Manual (see appendix A.2). Improper coding is the number one problem when trying to create breaklines and surfaces and can lead to costly mistakes. Features should be shot sequentially whenever possible to reduce the amount of editing on breaklines in the office.

SECTION 5.4

Troubleshooting



Trimble R8 GPS

Getting set up for RTK surveys can be quite finicky. If you are having trouble getting your base and rover to communicate via radio link, consider the following:

- Are both the base and the rover set to CMR+ (in "Broadcast format" in the survey style on the controller)?
- Is the correct antenna type in the survey style for both the base and the rover?
- Is the correct radio type in the survey style for both the base and the rover?
- Is the power setting for the base radio appropriate for the distance between the base and rover?
- Does the base radio frequency and wireless mode settings match on the base and the rover?
- Is the coordinate system appropriate for the region?

- Is the base radio in the right broadcast mode?
- Check that all cables are correct.
- Check batteries.
- Power the receivers and survey controller off and then back on and restart the base with the survey controller. Sometimes a power cycle is all that is needed.

Note: Different manufacturers may refer to these methods by different names so read through the operator's manual for the correct procedures for your equipment. This guide was created with *Trimble* GPS equipment in mind.

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Chapter 6

Construction Stakeout and Stakeout Documentation

SECTION 6.1

INTRODUCTION

The construction surveys for a roadway consist essentially in (1) staking out earthwork and structures preparatory to, and during the process of, grading and construction, and (2) making the measurements necessary to determine the volume of work actually performed up to a given date, as a basis for payment to the Contractor.

Construction survey parties are under the direction of the Resident Engineer, and it is necessary that they be familiar with effective methods of staking. The Resident Engineer is directly responsible for survey marks and stakes set. Regardless of how the survey parties are organized, the Resident Engineer must have full knowledge of the methods used and results accomplished.

Detailed planning, with the coordination of the Contractor, and timely start of staking is required. The Resident Engineer should instruct his Surveyor to anticipate as near as possible the Contractor's needs in regard to staking or taking measurements. Under no circumstances shall any delay in staking be permitted that will hinder the construction operation. A survey request form is a valuable tool to assist the contractor in communicating their direction and needs (see appendix A.8).

Survey operations on a project may consist of any or all of the following:

Reproducing centerline
Referencing control points
Setting clearing and grubbing limits
Setting slope stakes
Staking culverts and structures
Data collection (pre and post construction)
Signs and electrical
Staking permanent survey monuments
Setting construction bench marks
Staking Right of Way fences
Cross sectioning and measuring borrow pits, etc.
Preserving monuments and markers
Staking curb/gutter, barrier rail, and guardrail

Survey field notes shall be made in a standard field book using a sharp pencil (hard lead to prevent smudging). Notes shall be clear and in sufficient detail to be thoroughly understood by anyone not familiar with the project. **TOO MUCH DETAIL IS BETTER THAN TOO LITTLE!!!!!!** Field books shall be handled in such a manner so as not to break the binding or cause other damage to them.

Field Office Preparation

The Resident Engineer must rely to a large extent upon crew personnel to prepare the necessary stakeout data prior to the start of construction on a project. For this reason, it is essential that the Resident Engineer select and train competent personnel for utilization in the field office.

Preliminary plans are generally submitted to the project prior to award of the project. Most stakeout calculations can be started and some may even progress to a completion stage before the final plans are received. If this occurs, all data should be checked for accuracy before any field stakeout begins.

As in all phases of construction engineering, a general order for stakeout computation completion can be created, but the sequence will not apply in all instances. The following list will provide a very brief overview of some of the initial computations which must be made prior to the start of construction.

1. Alignment – Construction alignment books should be compiled as soon as possible. In most cases, the original alignment must be reproduced and any changes in length noted and necessary distance measurements adjusted. All curve deflections, tangent lengths, etc., should be calculated and checked prior to sending the book to the field.

2. Slope stake – Slope stake data for the roadways must be prepared and checked. The slope stake books should include all of the information necessary for the construction crew to accurately set the slope stakes in the field. Stations, grade percent, vertical curve information, elevations, shoulder distance, ditch, and slope information must all be indicated in the slope stake book.

3. Structures – Structure books must be completed for the culvert and bridge structures if required. Care should be exercised when calculating structures as they have a definite bearing on the durability of the finished roadway.

4. Grade books – Grade books should be completed by the time subgrade is complete to aid the construction crew in setting “red heads” or grade stakes.

It should be stressed that the above stakeout computations should be accurate and complete. All computations and all other stakeout data must be checked and verified.

Note: If mistakes are made, line them out and write the correction above or below. Never erase or use correction fluid, ink, or tape.

SECTION 6.2

COMMON STAKES AND MARKERS

Hub

Wood (1 1/2” x 1 1/2” x 12”) to be used (with a “hub tack”) for all control points.

Guinea

Wood (3/4” x 3/4” x 6” or 8”) to be used for all non-control points (centerline, slope stakes, fence points, guide posts, etc.)

Long stake

Wood (1 1/2” x 3/4“ x 16”) to be written on with “lumber crayon” or “paint pen” to provide information about the “Hub”, “Guinea”, or any other point which it is witness to. It should be driven near (6 to 12 inches) the point it describes (leaning slightly toward it) and far enough away as to not disturb the point.

Short Stake

Wood (1 1/2” x 3/4“ x 8”) to be used for grade stakes (redheads), level loops, etc.

“PK” Nail, Boat Nail, and Railroad Spike

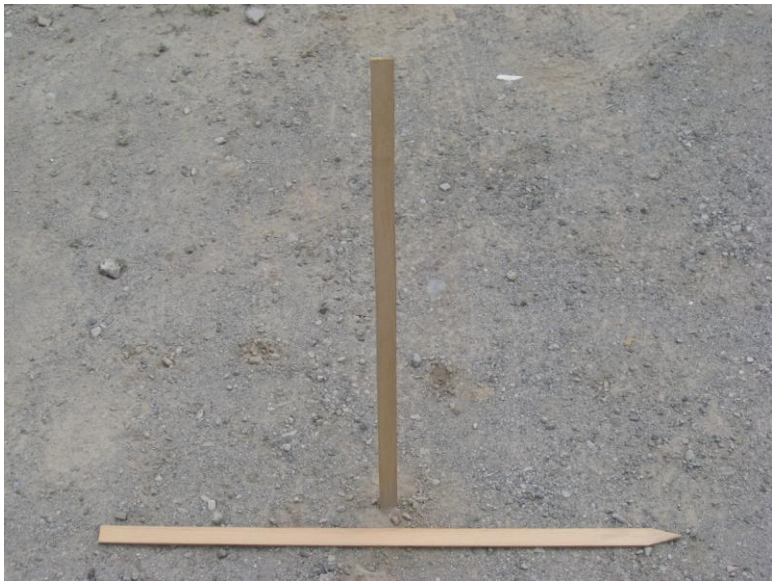
Metal (various sizes) to be used as a hub in surfaces to hard for wood.

Concrete Nail and Shiner

Metal (various sizes) to be used as a Guinea in surfaces such as asphalt or concrete.

Lath

Wood (3/8“ x 1 1/2” x 36”) to be used to mark all points of importance. Care should be taken as not to cover any information on the stake nor disturb the “Hub” or “Guinea” when setting the lath. When cut into thirds or quarters, they are used to guard “redheads”.

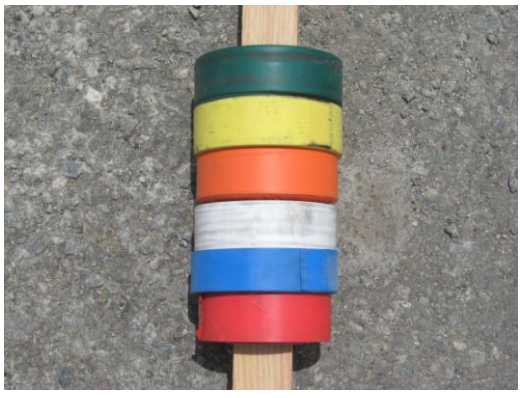


Flagging

Plastic ribbon. To be tied onto lath in order to help identify just what the point is that the lath is set next to.

Control points should be color coded as follows:

- Orange with White – Centerline control and reference points (alignment)
- Red with White – Reserved for Bench Marks (usually “barber-poled” around lath)
- Blue with White – Drainage, Pipe, Drop Inlets, RCB stakeout
- Yellow with White – Electrical stakeout
- Green with Orange – Slope stakes
- Red with Blue – Right-of-Way Fence stakeout, Temporary Easements



Combinations of flagging are used in order for our points not to be confused with the Standard Flagging being used by utility companies.

Note: Other combinations should be used to mark points which are not covered above.

SECTION 6.3

ALIGNMENT AND HORIZONTAL CONTROL

The centerline of construction shall be reproduced from the plans and shall be marked by witness stakes driven on centerline facing the initial station of the survey.

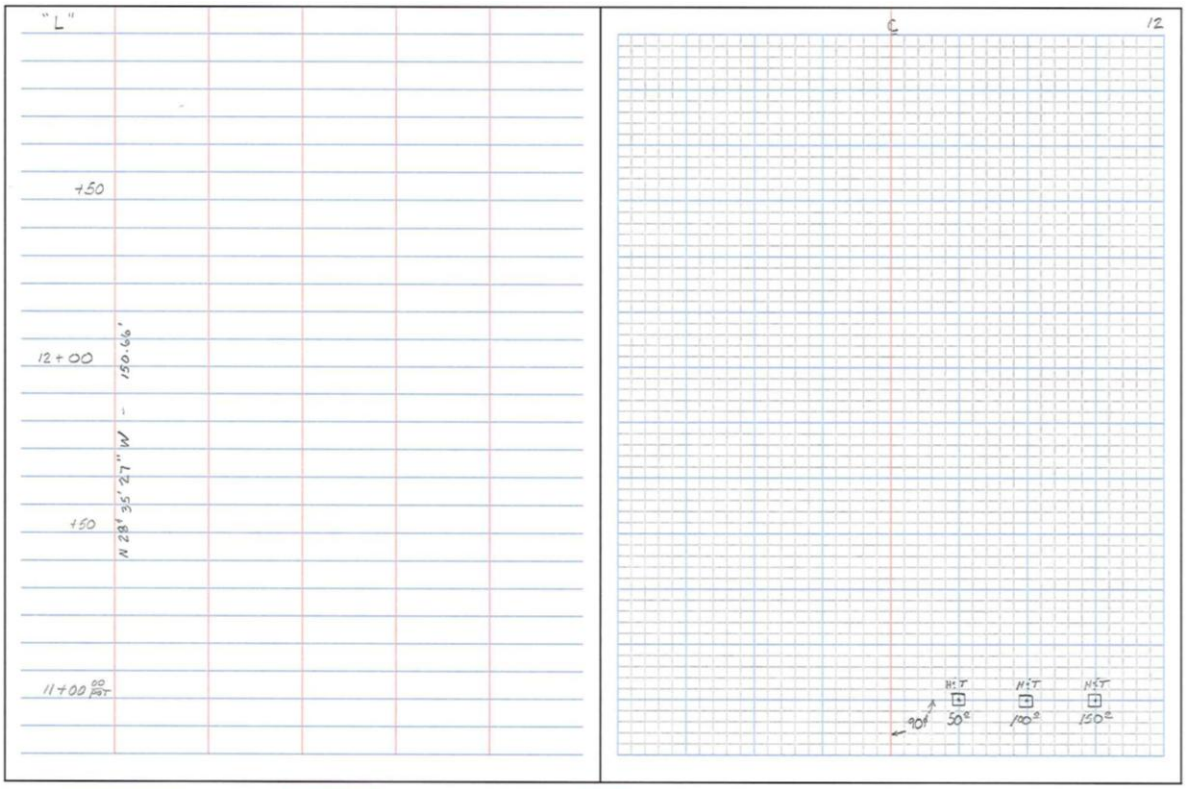
In case the line to be constructed differs from the line originally staked, the line to be constructed shall be established to connect with adjacent portions of the centerline. In staking these revisions, care should be exercised to ensure that the relationship is maintained between the original and revised line. An accurate tie shall be made to the original line at the end of the revision.

When reproducing centerline and a discrepancy is found with that shown on the plans, the work shall be checked until the Resident Engineer is satisfied that a discrepancy exists and the location and amount of discrepancy is known. At the point where the discrepancy is found, an equation shall be made and the plan station shall then be carried forward from that point. This must be done so that construction records will agree closely as possible to the plans and estimates designed for the project.

Reference points may be set at the same time that the centerline is being reproduced, or immediately thereafter. A sufficient number of control points shall be referenced so that the centerline can be reproduced at any time without retracing any great length when only a short section is required.

Reference points should be placed in such places so that they are protected from any construction operation. They should be set so that the point referenced can be reestablished in the same manner as the original. The angle of intersection between the reference line and the centerline shall be measured and noted in the transit book along with the horizontal measurements to the reference hubs. As far as possible, the measurements should be made without the benefit of slope chaining or breaking chain.

The planned location of Right-of-Way monuments should be reviewed prior to referencing, as it is entirely possible that staking of the Right-of-Way monuments and the referencing of centerline points may be accomplished at the same time.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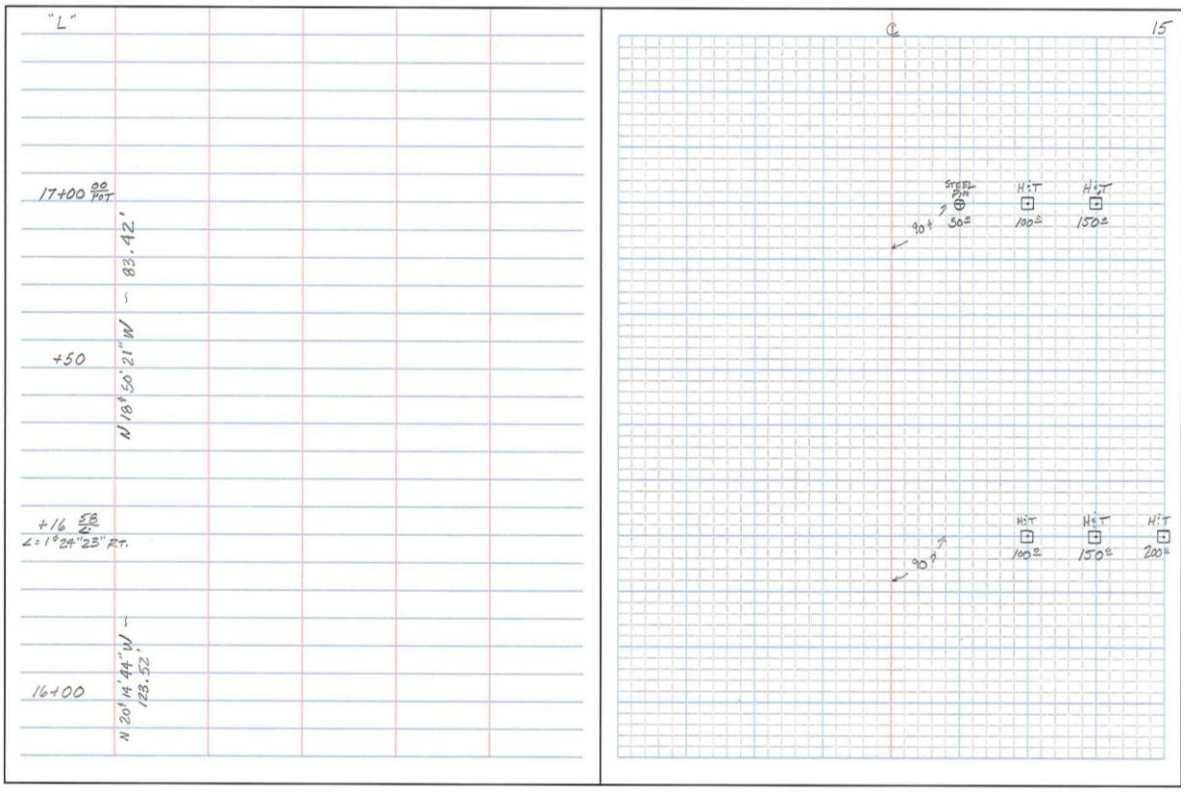
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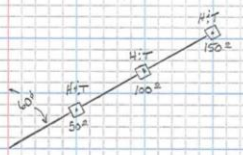
14+00		2° 08' 21"	
			Δ = 6° 56' 39"
			$\frac{\Delta}{2}$ = 3° 28' 19.5"
			R = 2000'
			L = 242.40'
			T = 121.35'
+50		1° 25' 23"	Defl./ft. = 0.85942657'
13+00		0° 42' 34"	
12+50 PC		0° 00' 00"	
L = 1° 24' 04" Ft.			

℄ 13

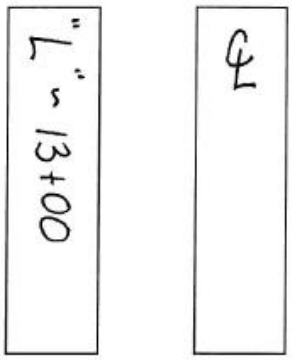
"L"		Defl. Rt.	
+50	N 20° 19' 44" W - 123.52'		
15+00			
+93 PT		3° 28' 19"	
14+50		2° 51' 19"	

℄ 14



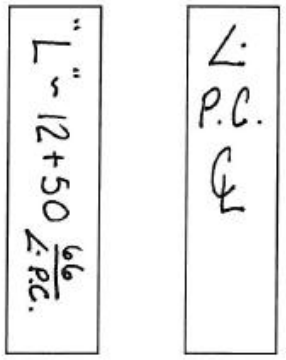
STAKE PLACEMENT FOR CENTERLINE AND REFERENCE POINTS

Face | Back



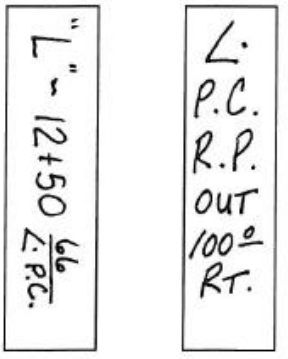
CENTERLINE STATIONING

To be used with a guinea. The stake should be set ahead on line, facing toward the guinea.



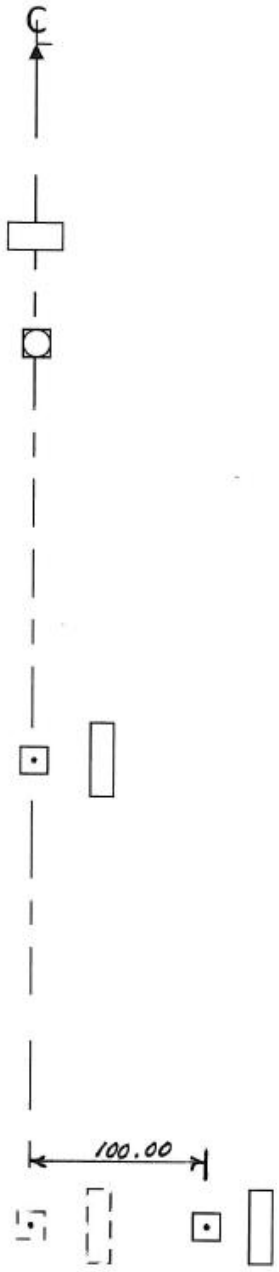
CENTERLINE CONTROL POINT

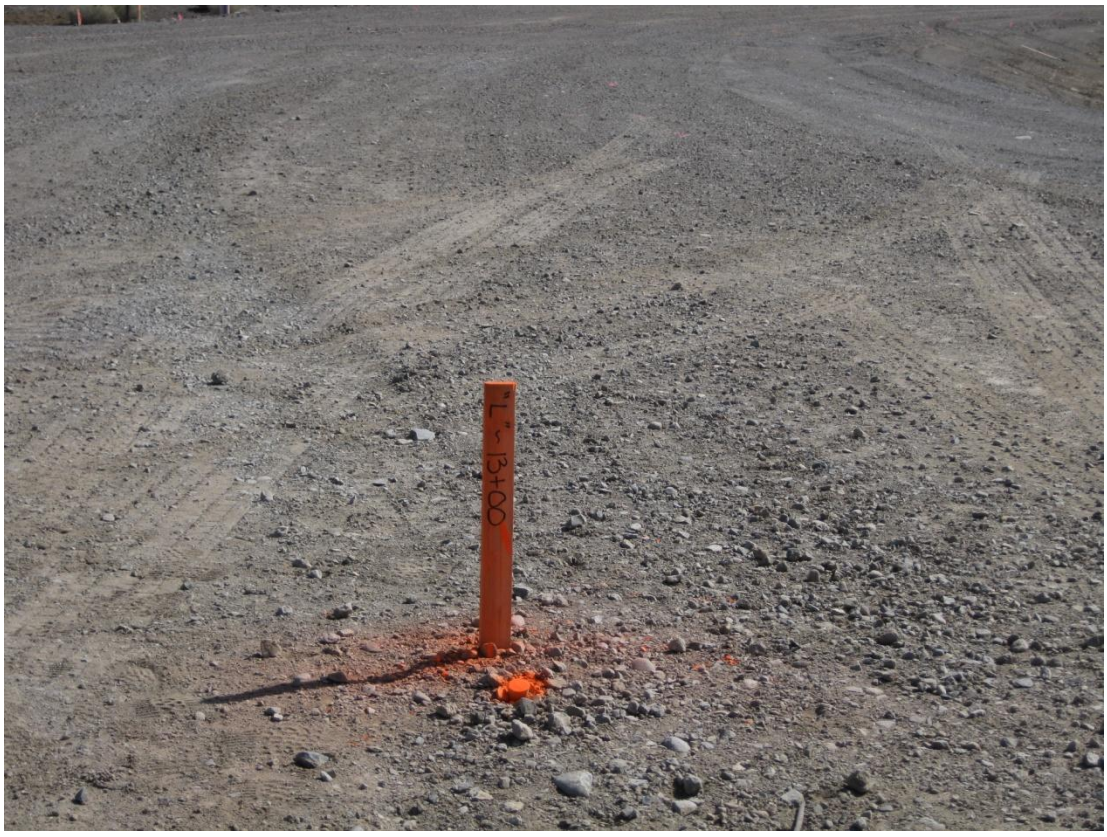
To be used with a hub. The stake should be set to the side, facing toward the hub.



REFERENCE POINT

To be used with a hub. The stake should be set to the outside of the hub, facing the hub.





Centerline Stake

Reference Point

SECTION 6.4

VERTICAL CONTROL

Construction bench marks should be set to avoid running level circuits a considerable distance to establish an elevation. Construction bench marks are usually required near major structures, special construction areas, or where the terrain is rugged and preliminary bench marks are difficult to reach. Construction bench marks shall be established by the same procedure and to the degree of accuracy as required for preliminary bench marks set by the Location Division. All bench marks, whether they are Line Designated ("X" BM) or Construction Designated (Con. BM), should be numbered to coincide with the stationing. (i.e. Con. BM #1^3 would be located either left or right of station 13+00.)

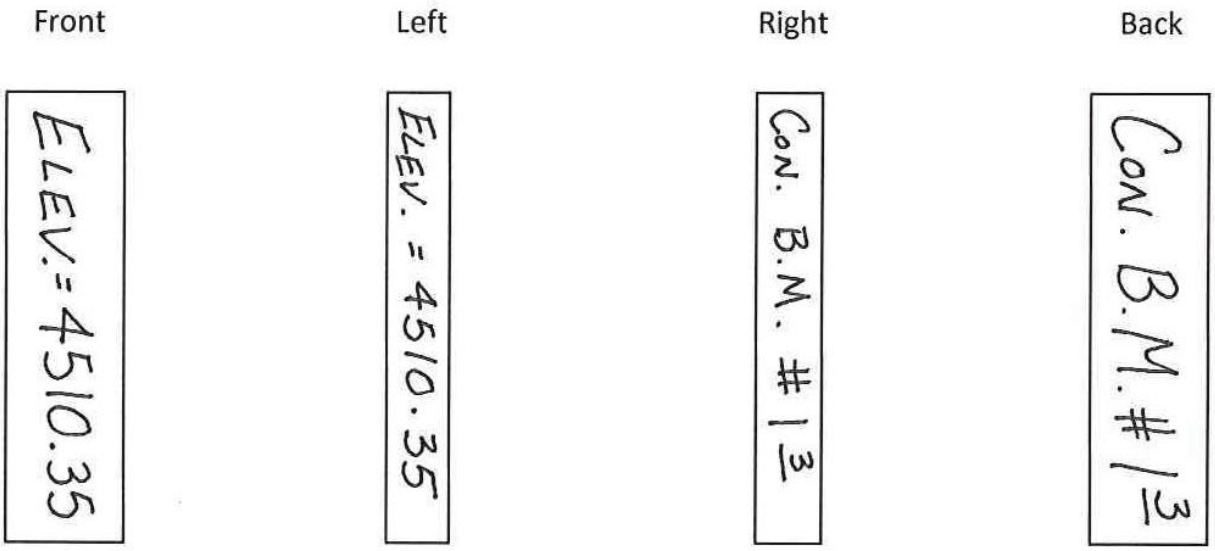
DEGREE OF ACCURACY

Closed Circuit Accuracy – 0.02 ft between established bench marks

Structures, Culverts, Bridges, Etc. – 0.02 ft between bench marks

Bench Mark Stakes

To be used as a witness stake to a steel pin or any other object designated to be the bench mark. The stake should be driven far enough away from the bench (front facing centerline) so as not to disturb it.

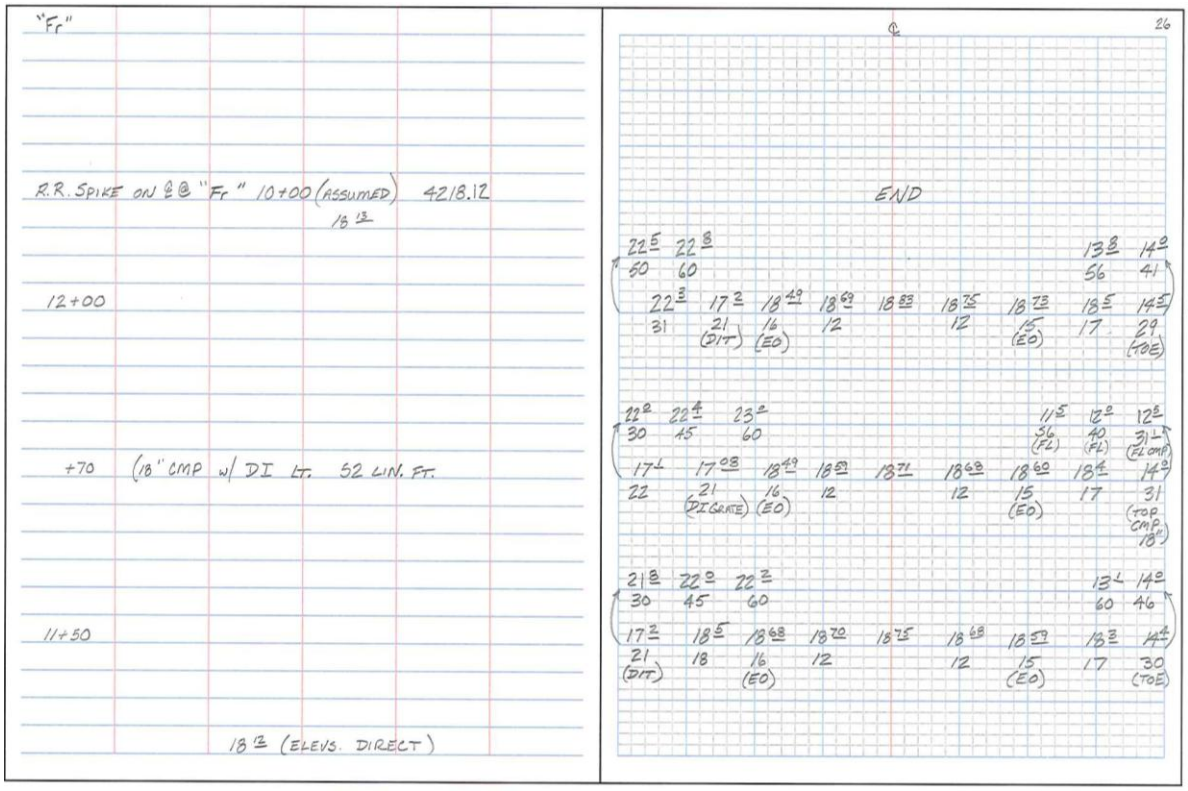


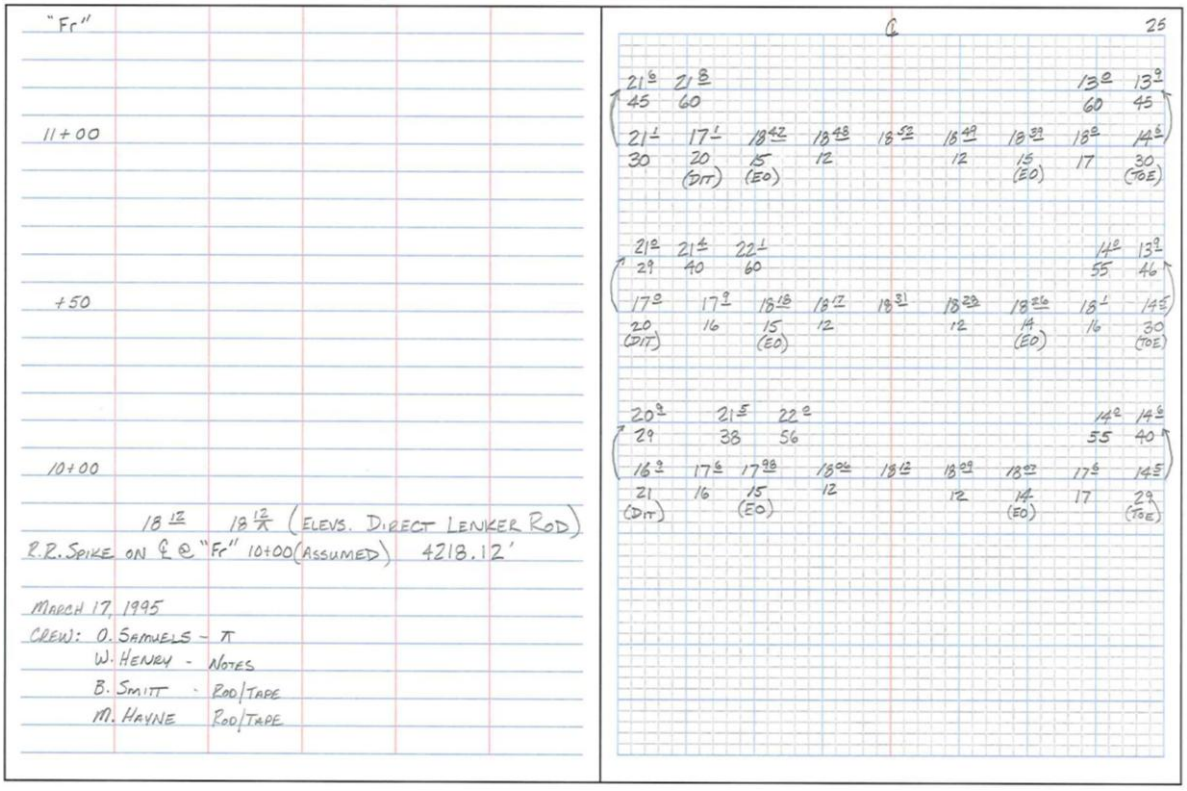
SECTION 6.5

CROSS SECTIONS

Cross sections may be required in some cases due to alignment change, insufficient cross sections taken during original survey, or for various other reasons. When this is required, the same minimum requirement as set out for location surveys will be followed.

Cross sections shall normally be taken on stations, plus 50's and equations. Additional plus stations shall be added as necessary to show such things as drainage, slip outs, drop-offs, etc. Cross sections shall be taken at right angles to the centerline on tangents and on radial lines on curves. If this is not possible due to physical limitations or obstacles, the reason for deviating, and the angle that it was taken on, shall be entered in the Cross Section book.




"Fr"
11+00
+50
10+00
18 12/12 18 12/A (ELEVS. DIRECT LENKER ROD)
R.R. SPIKE ON ℄ @ "Fr" 10+00 (ASSUMED) 4218.12'
MARCH 17, 1995
CREW: O. SAMUELS - π
W. HENRY - NOTES
B. SMITT - ROD/TAPE
M. HAYNE ROD/TAPE
℄
25
21 6/45 21 8/60
21 1/30 17 1/20 (DIT) 18 42/15 (EO) 18 48/12 18 52/ 18 49/12 18 39/15 (EO) 18 2/17 14 8/30 (TOE)
13 2/60 13 9/45
21 2/29 21 4/40 22 1/60
17 0/20 (DIT) 17 9/16 18 18/15 (EO) 18 17/12 18 3/ 18 23/12 18 26/14 (EO) 18 1/16 14 5/30 (TOE)
14 2/55 13 9/46
20 2/29 21 5/38 22 2/56
16 3/21 (DIT) 17 6/16 17 98/15 (EO) 18 04/12 18 12/ 18 09/12 18 07/14 (EO) 17 6/17 14 5/29 (TOE)
14 2/55 14 6/40

SECTION 6.6

SLOPE STAKES

Slope Stake with Guard Lath

Slope stakes are set at locations where the top of cut slopes and the toes of fill slopes meet the original ground and shall be known as the “catch point”. The markings on slope stakes pertaining to the cut or fill and the distance shall be large enough to be easily read, and the back of the slope stake shall have the station of the section staked. The sides of the slope stake should contain all pertinent information necessary, such as subgrade shoulder distance, slopes, depth of roadway ditches, etc.

A guinea shall be set at the catch point and at the same elevation as the catch point was computed. The cut or fill information shall be written on the slope stake, and it shall be driven far enough beyond the guinea so as not to disturb it. The cut or fill information shall face centerline of the roadway. A guard lath shall be placed 6 to 8 inches back on-line from the guinea to protect it.

The use of a guinea has a two-fold purpose. The guinea shows the contractor where the rod reading (shot) was taken, and that he has a definite take-off point to begin construction. Also, if the slope stake is accidentally knocked out or moved during construction, the catch point can be recovered. If a slope stake has been stuck in the ground and no guinea is present, the contractor and the engineering personnel will know immediately that it is not a catch point.

Slope stakes shall be set at right angles to the centerline on tangents and on the radial lines of curves. Use an instrument for this if necessary. Stations, plus 50's and equations shall be slope staked and any other pluses that will be helpful to the contractor to produce a well contoured roadway.

Elevations and distances are measured and recorded to the nearest tenth of a foot. Only cloth tapes that are in good shape shall be used.

Slope stakes may be set by several different methods, depending upon the terrain of the area. The most efficient method shall be used. The selection shall be based on the judgment of the Resident Engineer.

The following methods are briefly discussed:

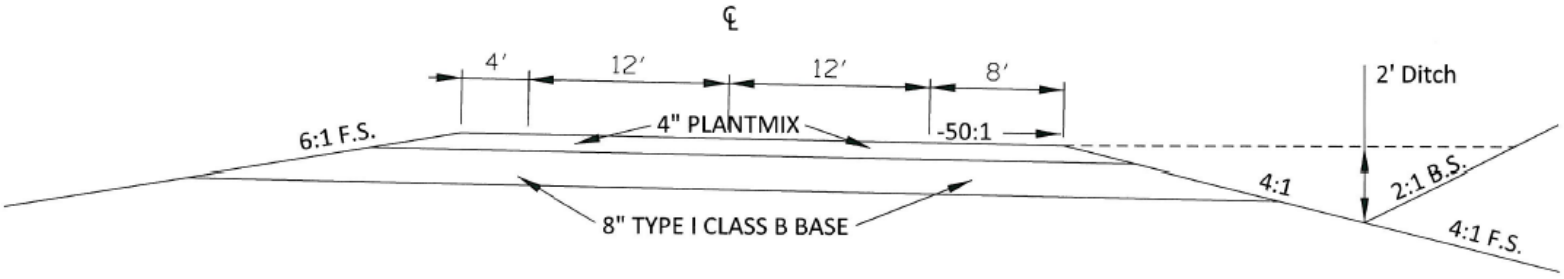
1. The use of level, tripod, level rod, and cloth tape. This method is generally best suited to relatively flat terrain where it is possible to run the profile of centerline and set the slope stakes while at the same instrument set up. It is often supplemented by use of the hand level to establish slope stakes when it is not possible to set the stakes from the instrument set up.

2. Use of a hand level, level rod, and cloth tape. Prior to use of this method of slope staking, it is necessary to run a centerline elevation and determine the cut or fill. From the centerline data, it is then possible to set the slope stakes by use of the hand level. This method is suited to locations where visibility with an instrument is restricted, or where the terrain is moderately rough.
3. Use of instrument, level rod, and tape or electronic measurement. This method is employed in any terrain but especially mountainous country where it is more expedient to transfer elevations and distances by means of slope measuring than by hand leveling.

4. Due to advancements made in technology, especially with the advent of the Total Station and GPS, there is now the "radial method" of slope staking. This is one of the most expedient methods in use today. However, as with any method used, care must be exercised in establishing all points being occupied.

Note: No matter what method is employed to slope stake, all work (calculations, angles, distances, etc.) must be recorded in the appropriate field book so that it may be checked in the field office.

SLOPESTAKES

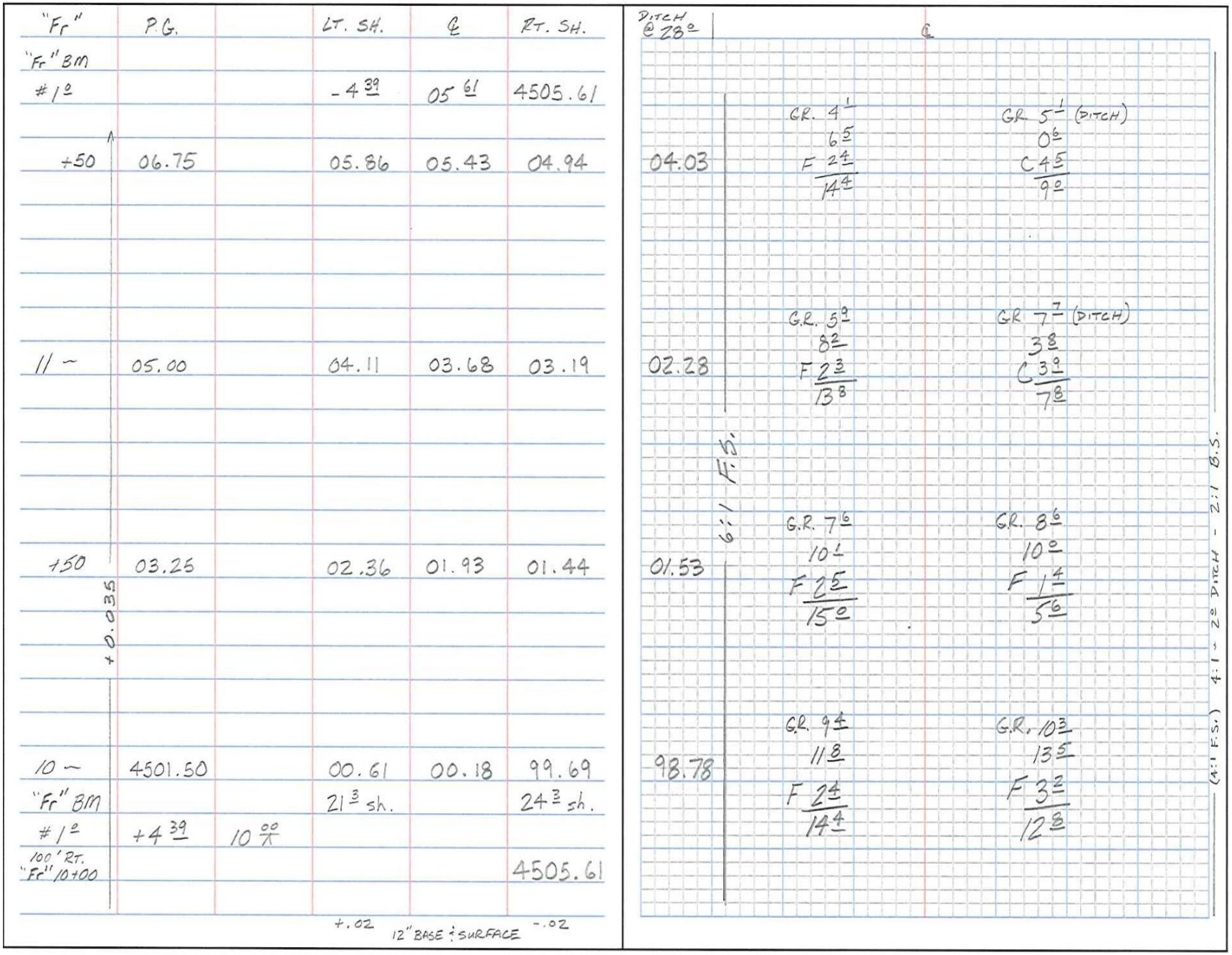


SECTION OF IMPROVEMENT

"Fr" 0+00.00 to "Fr" 20+00.00

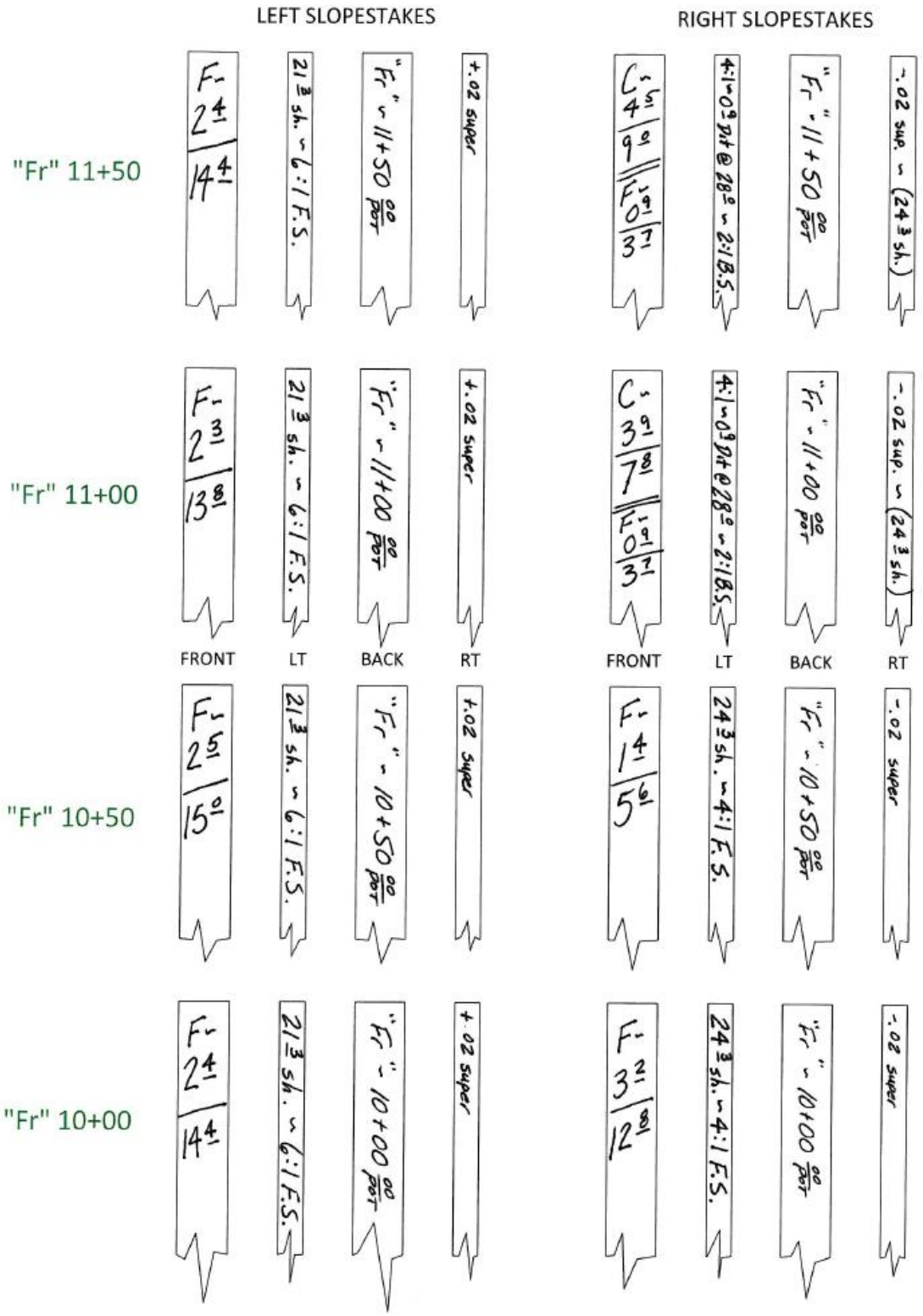
* The following examples are based on this 'Section of Improvement' *

+


"Fr" P.G. LT. SH. ℄ RT. SH.
"Fr" BM
#1 Pt 4505.61
+50 06.75 05.86 05.43 04.94
11 + 05.00 04.11 03.68 03.19
+150 03.25 02.36 01.93 01.44
+0.035
10 + 4501.50 00.61 00.18 99.69
"Fr" BM +4.39 21.3 sh. 24.3 sh.
#1 Pt 10.00
100' RT. "Fr" 10+00 4505.61
+.02 12" BASE & SURFACE -.02
DITCH @ 28°
℄
04.03
GR. 4.1 6.5 F 2.4 14.4
GR. 5.1 (DITCH) 0.6 C 4.5 9.0
02.28
G.R. 5.9 8.2 F 2.3 13.8
GR 7.7 (DITCH) 3.8 C 3.9 7.8
6:1 F.S.
01.53
G.R. 7.6 10.4 F 2.5 15.0
G.R. 8.6 10.0 F 1.4 5.6
98.78
G.R. 9.4 11.8 F 2.4 14.4
G.R. 10.3 13.5 F 3.2 12.8
(4:1 F.S.) 4:1 → 2° DITCH - 2:1 B.S.

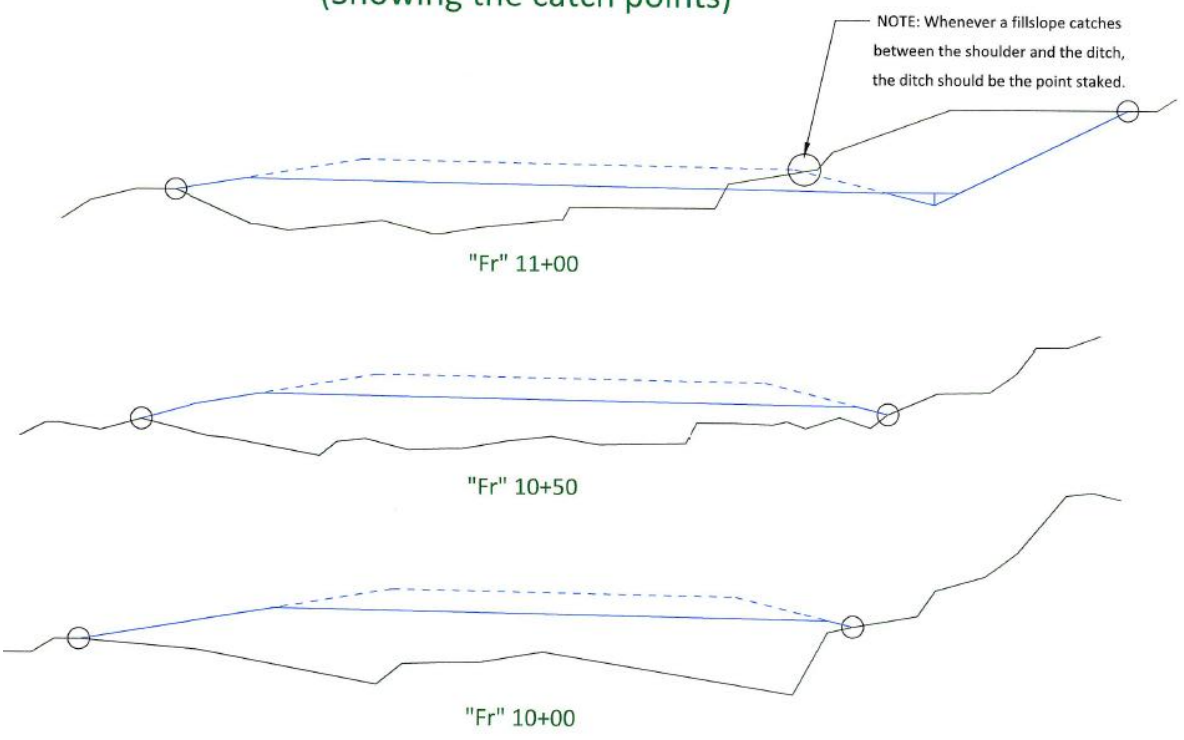
WRITING SLOPESTAKES

* NOTE: THE FRONT ON THE STAKE IS TO FACE CENTERLINE *

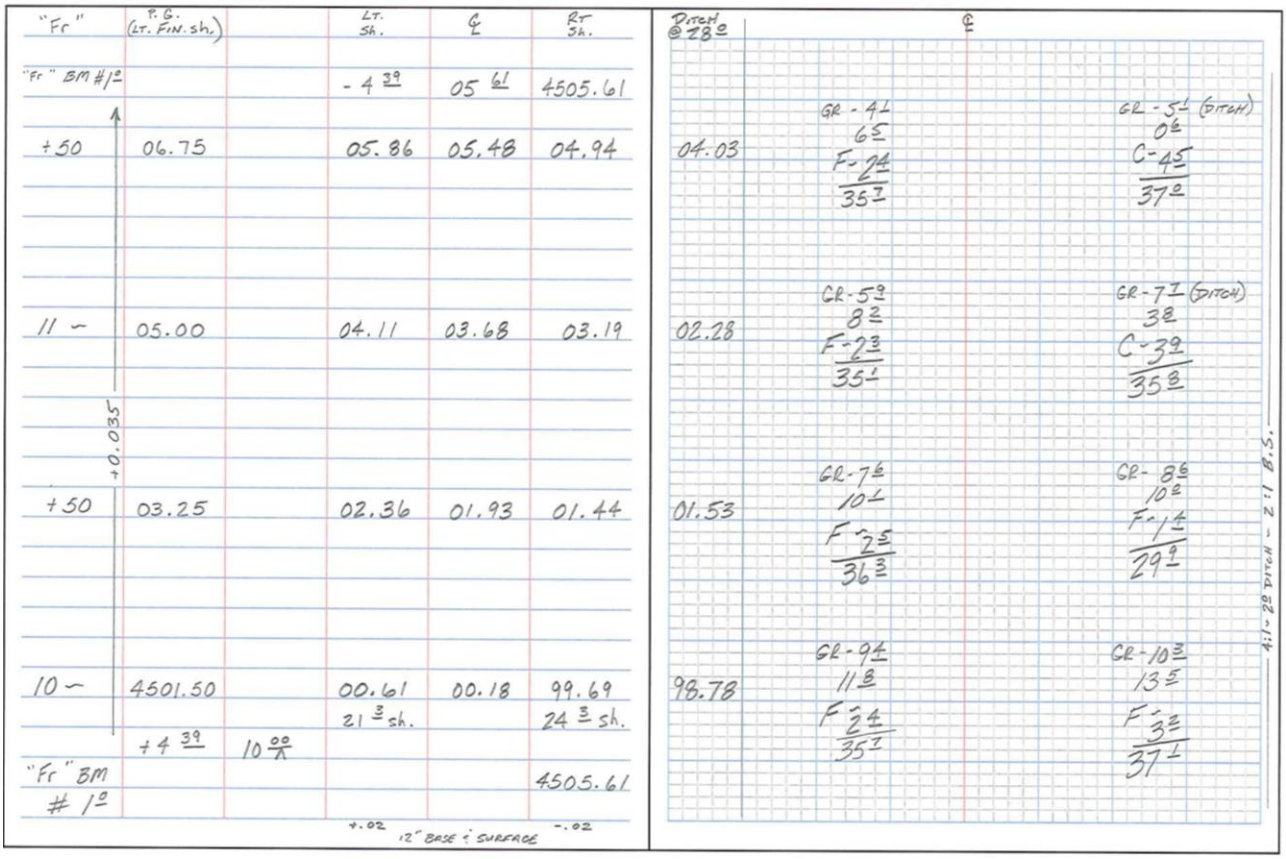


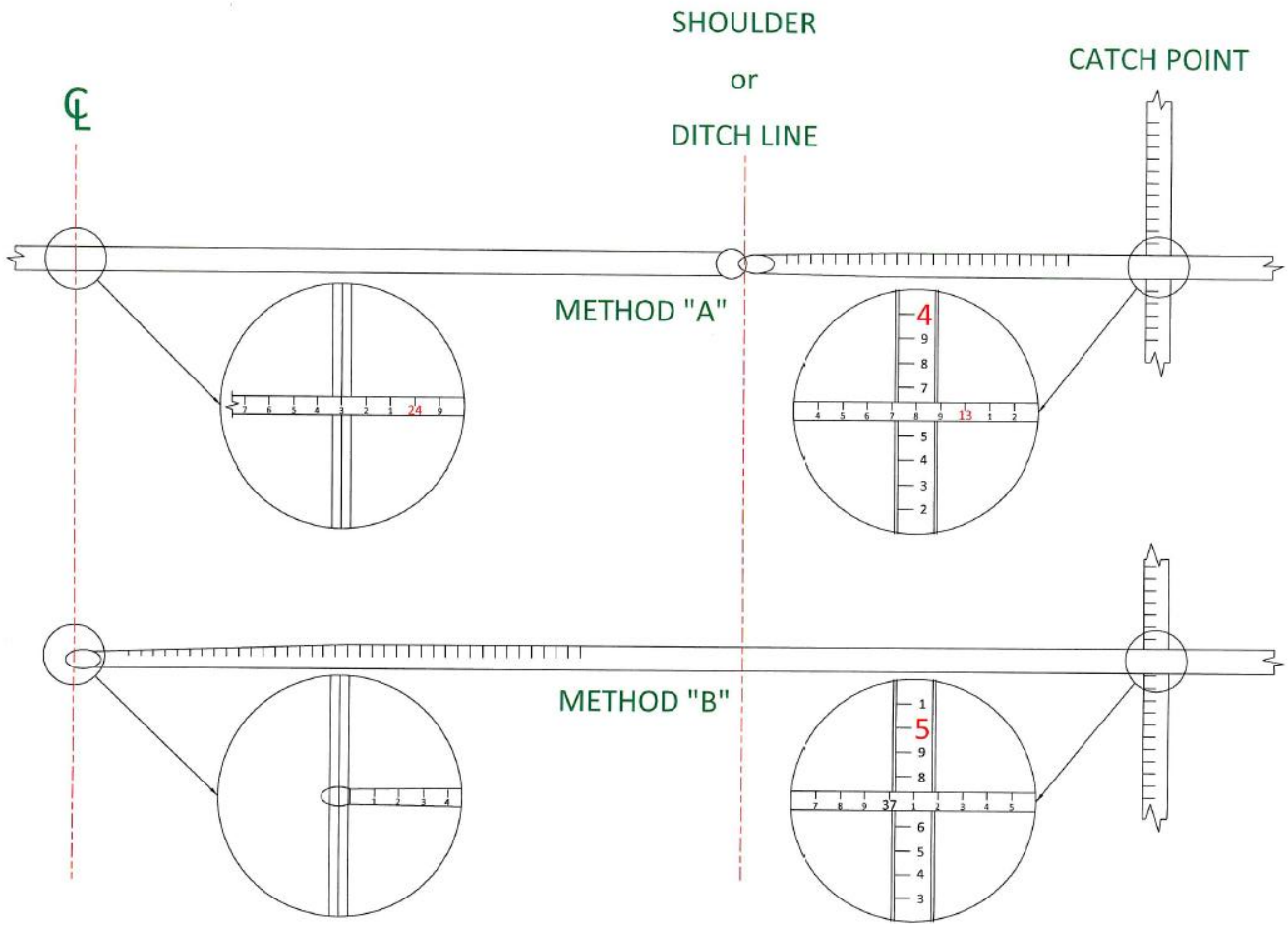
CROSS SECTIONS

(Showing the catch points)



◯ - CATCH POINT




SHOULDER
or
DITCH LINE
CATCH POINT
℄
METHOD "A"
METHOD "B"

Contract #	Description of Feature: "FR" Centerline Subgrade	Staked By: Lompa/Hurlbut	Date Staked: 6/24/09

Pt. #	C/L Station (Roadway)	Offset to C/L (Roadway)	Feature Offset	O.G. Elevation (Guinea)	Feature Design Elevation	Cut(-) or Fill(+) to Feature	Horizontal Distance to Feature	Stake Information			
								Side	Front	Side	Back
FR6460Lt.	64+60.000	-13.824	0	1559.123	1557.799	-1.324	13.824	1:2.97~0.8Ditch@8.22~1:3B.S.	To S.G.	+.02 sup. (6.44 sh.)	"FR" 64+60.000P.O.T.

Notes / Calculations:

+.02 / .337 / 100 mm / 200 mm — ℄

-.337 - (+.02) = -.357

-.300 / -.357 = .840 = HD

.840 x .02 = .017

-.300 + .017 = -.283 = VD

	-12.806	1558.961
	-12.109	1558.627
Ditch BS.	-10.616	1558.130
Ditch Btm.	-8.216	1557.330
Lt Hinge	-5.601	1558.211
	-.840	-.283
Lt Sysh	-6.441	1557.928
℄	0.000	1558.099
		-.300
℄ S.G.	0.000	1557.799

1558.961 - 1559.123 = -0.162
-12.806 - - 13.824 = 1.018
1558.627 - 1558.961 = -0.334
-12.109 - - 12.806 = 0.697
1558.130 - 1558.627 = -0.497
-10.616 - - 12.109 = 1.493
1557.330 - 1558.130 = -0.800
-8.216 - - 10.616 = 2.400
1557.928 - 1557.330 = 0.598
-6.441 - - 8.216 = 1.775
1557.799 - 1557.928 = -0.129
0.000 - - 6.441 = 6.441

Pt. #	C/L Station (Roadway)	Offset to C/L (Roadway)	Feature Offset	O.G. Elevation (Guinea)	Feature Design Elevation	Cut(-) or Fill(+) to Feature	Horizontal Distance to Feature	Stake Information			
								Side	Front	Side	Back
FR6480Lt.	64+80.000	-12.704	0	1559.276	1557.749	-1.527	12.704	1:3~0.8Ditch@8.00~1:3B.S.	To S.G.	+.02 sup. (6.45 sh.)	"FR" 64+80.000P.O.T.

Notes / Calculations:

+.02 / .333 / 100 mm / 200 mm — ℄

-.333 - (+.02) = -.353

-.300 / -.353 = .850 = HD

.850 x .02 = .017

-.300 + .017 = -.283 = VD

	-12.463	1559.193
Ditch BS.	-10.400	1558.161
Ditch Btm.	-8.000	1557.361
Lt Hinge	-5.600	1558.161
	-.850	-.283
Lt Sysh	-6.450	1557.878
℄	0.000	1558.049
		-.300
℄ S.G.	0.000	1557.749

1559.193 - 1559.276 = -0.083
-12.463 - - 12.704 = 0.241
1558.161 - 1559.193 = -1.032
-10.400 - - 12.463 = 2.063
1557.361 - 1558.161 = -0.800
-8.000 - - 10.400 = 2.400
1557.878 - 1557.361 = 0.517
-6.450 - - 8.000 = 1.550
1557.749 - 1557.878 = -0.129
0.000 - - 6.450 = 6.450

Pt. #	C/L Station (Roadway)	Offset to C/L (Roadway)	Feature Offset	O.G. Elevation (Guinea)	Feature Design Elevation	Cut(-) or Fill(+) to Feature	Horizontal Distance to Feature	Stake Information			
								Side	Front	Side	Back
FR6500Lt.	65+00.000	-12.749	0	1558.96	1557.624	-1.336	12.749	1:3~0.8Ditch@8.00~1:3B.S.	To S.G.	+.02 sup. (6.45 sh.)	"FR" 65+00.000P.O.T.

Notes / Calculations:

+.02 / .333 / 100 mm / 200 mm — ℄

.850 = HD

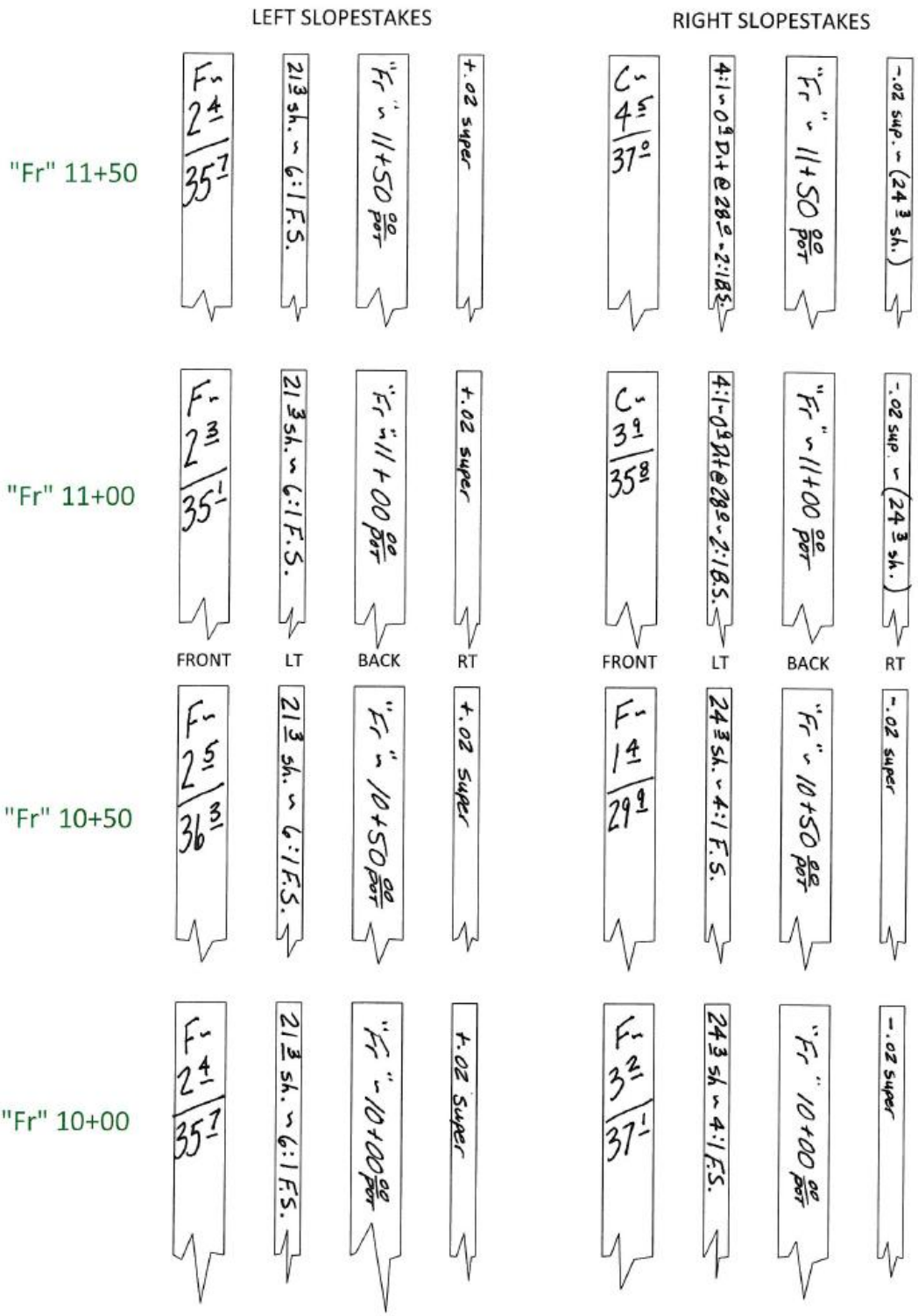
-.283 = VD

	-12.078	1558.875
Ditch BS.	-10.400	1558.036
Ditch Btm.	-8.000	1557.236
Lt Hinge	-5.600	1558.036
	-.850	-.283
Lt Sysh	-6.450	1557.753
℄	0.000	1557.924
		-.300
℄ S.G.	0.000	1557.624

1558.875 - 1558.960 = -0.085
-12.078 - - 12.749 = 0.671
1558.036 - 1558.875 = -0.714
-10.400 - - 12.078 = 1.678
1557.236 - 1558.036 = -0.800
-8.000 - - 10.400 = 2.400
1557.753 - 1557.236 = 0.517
-6.450 - - 8.000 = 1.550
1557.624 - 1557.753 = -0.129
0.000 - - 6.450 = 6.450

WRITING SLOPESTAKES

* NOTE: THE FRONT ON THE STAKE IS TO FACE CENTERLINE *

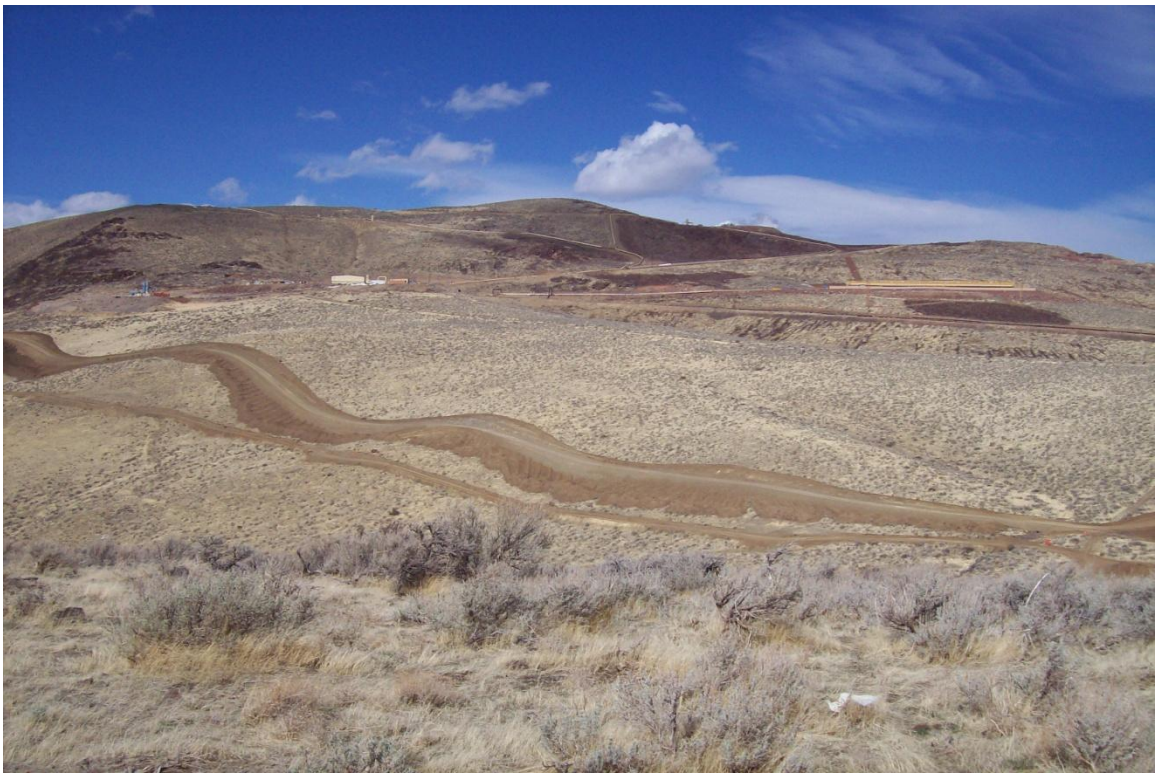


Slope Stake Showing Cut/Fill Information, Backslope, Ditch, and Foreslope

Slope Stake Showing Station, Superelevation, and Shoulder

Slope Stake on the I-580 Project (Contract 3292)

Slope Stake on the I-580 Project (Contract 3292)



I-580 Freeway Prior to Construction

I-580 Freeway Under Construction

SECTION 6.7

DRAINAGE

RCP Stakeout

Pipe and storm drain should be staked as soon as possible and the "pipe list" prepared. Delay in staking of pipe can cause delay in the contractor's operation, which may lead to delay of the project and/or a claim against the Department. Construction bench marks (Con. BM's) set near the pipe, as well as preparing a pipe book with all pertinent information, will expedite the staking and also give better control for installing the same. Further aid in the staking of pipe can be accomplished by having the pipe stations located at the same time the centerline is being reproduced.

The centerline of pipe shall be indicated by hubs driven on the centerline produced at such a distance from the end of pipes (or headwall) to protect them from disturbance. Elevations should be taken on the hubs and the cut or fill to flow-line of the pipe determined, and the necessary information plainly marked on the stakes. Designers typically add additional length to culverts depending on fill slope. Be sure to reference the minimum culvert installation detail in the *NDOT Standard Plans for Road and Bridge Construction* if additional length of culvert is necessary.

RCP Stakeout

RCP Stakeout

Reinforced Concrete Box Stakeout

Reinforced Concrete Boxes should be staked as soon as possible also. This information is very important to you as well as the contractor. If there are any changes, such as length or skew, all concrete and reinforcing steel will require recalculation.

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION
CALCULATION SHEET

PAGE NO. 3 of 5

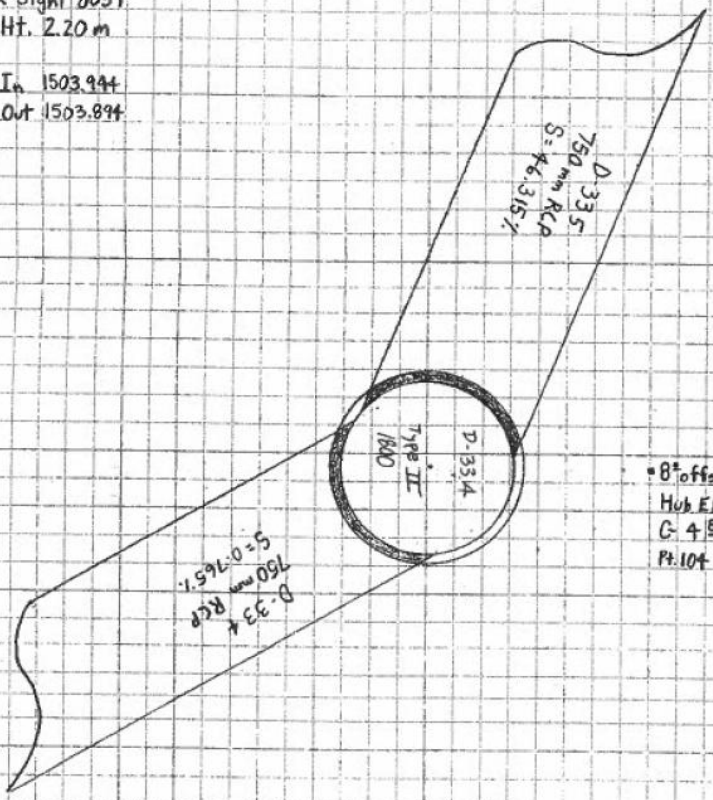
CONTRACT NO. 3292 CALCS BY B. Hurlbut CHECKED BY J. Read DATE 4-19-07
DESCRIPTION D-334 Type II 1800 Manhole Staked on 4-16-07
LOCATION P3' 110+86.227 89.011 Rt.

REFERENCE FIELD BOOK NO. _____ PAGE(S) _____

Staked By
Beck Hurlbut
Joel Read
Mike Brown

Occ. Pt Temp 100
Back Sight 8039
Rod Ht. 2.20 m

Inv. In 1503.994
Inv. Out 1503.894



* 8' offset to Cntr. MH.
Hub Elev. 1508.786
C- 4 892 to Inv Out F/L
Pt 104

* 10' offset to Cntr. M.H.
Hub Elev. 1509.811
C- 5 917 to Inv. Out F/L
Pt 105

DOT
-034
88

"D" 30+00 - NEW 24" x 86' CMP

X-SECTIONS (CONTINUED)

"D" BM #3		-1 53	72 04	6172.04
1+				
+96 = INLET END OF CMP				
+80				
	73 87			

CMP ℄

10

3 2 3 2 4 0 4 2 5 0 6 1 6 0 6 1 5 2
20 15 10 5 3 7 15 22

4 0 4 1 4 2 5 1 5 2 6 0 5 2 6 0 5 2
20 12 8 4 4 8 12 20

"D" 30+00 - NEW 24" x 86' CMP

NEW END SECTION RT.

~ STAKEOUT DATA ~

	LT.	℄	RT	
P.G.		6181.11		
FINISH SH.	81.77		80.45	
INLET ELEV.			68.30	
OUTLET ELEV.	65.60			
DIAM. PIPE	2.00		2.00	
TOP OF PIPE ELEV.	67.60		70.30	
FILL OVER PIPE	14.17		10.15	
FILL x SLOPE 1½:1	21.26		20.30	2:1
DIAM x SLOPE 1½:1	3.00		—	
½ ROADWAY	18.00		18.00	
ADTL. FOR FILL HGT.	2.5		1.67	
LENGTH REQ'D.	44.76		39.97	
LENGTH USED	46.00		40.00	
TOTAL USED		86'		
"D" BM #3		-1 83	72 04	6172.04
	+1 83	73 87		
"D" BM #3				

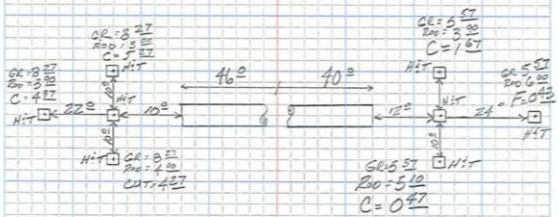
"D" ℄

8

CREW:
O. SAMUELS - T
W. HENRY - NOTES
B. SMITH - CHAIN/ROD
M. HAYNE - CHAIN/ROD

T = 73.87
F.L. = 65.60
G.R. = 8.27

T = 73.87
F.L. = 68.30
G.R. = 5.57



"D" 30+00 - NEW 24" x 86' CMP
X-SECTIONS (PERPENDICULAR TO CMP ℄)

+60

+35

+10 = OUTLET END OF CMP

0+00 = HIT 10' FROM OUTLET END OF CMP ℄

+1 83 73 87 A

"D" BM #3 6172.04

CMP ℄ 9

2E 19 3C 16 3J 12 4I 6 7E 1 9C 7B 2 4C 5 4L 11 4G 15 4I 21

2C 20 3C 15 3E 10 4C 5 7C 2 7G 2 7E 2 3G 6 4C 10 4C 15 4E 20

"JP" 6+95 CONSTRUCT 10'x4'x161' RCB
X-SECTIONS (CONTINUED)

CON. BM #07 -4 15 11 35 4511.35

END X-SECTS. +76

1+61 BEGIN RCB

15 50 A

RCB ℄ 46

5E 30 5B 20 6C 9 11G 5 FL 12C FL 11C 6 FL 6C 10 5G 15 6C 30

5B 30 5B 15 6L 10 11B 6 FL 12J 3 FL 12C FL 11I 5 FL 6L 11 6B 20 6C 30

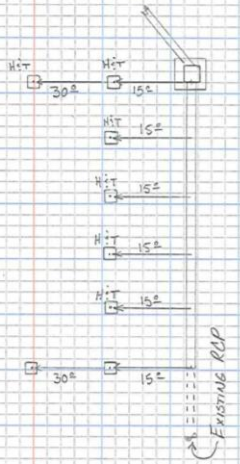
"L" 10+60 to "L" 11+80 - Construct 24" x 120' RCP Storm Drain 50' Rt. - Connect to Existing 24" RCP 50' Rt. of "L" 10+60 (I.E.=4500.20) and to a New Type 2A Drop Inlet 50' Rt. of "L" 11+80 (I.E.=4499.65 - Grate Elev. = 4506.15)

- Stakeout -

"L" BM #1			-3 12	06 81	4506.81
		Invert Elev.	Rod	@ 15' Elev.	C/F to Invert
+20 = Cntr. of D.I. 50' Rt. of "L" 11+80		4499 65	5 10	04 83	C 5 18
1+00		99 74	5 21	04 72	C 4 98
+75	↑	99 85	5 37	04 56	C 4 71
+50	24400'	99 96	5 48	04 45	C 4 49
+25	↓	00 08	5 59	04 34	C 4 26
0+00 = 50' Rt. of "L" 10+60		4500 20	5 71	4504 22	C 4 02
	+3 12	09 93			
"L" BM #1					4506 81

"L" 35

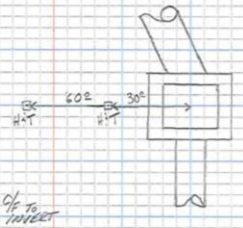
Crew:
O. Samuels - T
W. Henry - Notes
B. Smith - Stakes
M. Hayne - Stakes
March 23, 2006
T - "L" BM #1



"L" 11+80 - Construct Type 2A Drop Inlet 50' Rt.
(I.E.=4499.65 - Grate Elev. = 4506.15)

"L" BM#1		-3 12	06 81	4506.81
	+3 12	09 93		
"L" BM #1				4506.81

"L" 36

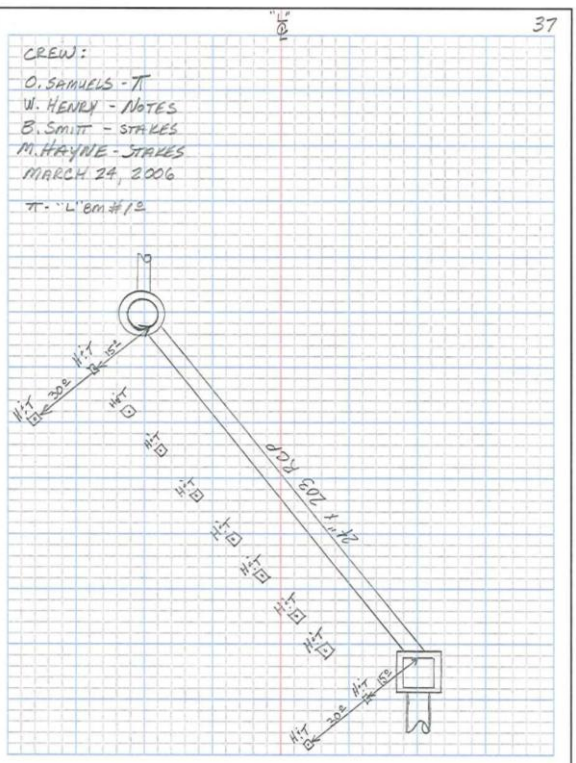


Hub	Rod	Elev.	C/F to Invert
30°	4 71	05 22	C-5 51
60°	4 60	05 33	C-5 68

"L" 11+80 to "L" 13+60 - Construct 24" x 206' RCP Storm Drain 50' Rt to 50' Lt - Connect to a new Type 2A Drop Inlet 50' Rt of "L" 11+80 (I.E.= 4499.65 - Grate Elev. = 4506.15) and a new Type 2 Manhole 50' Lt of "L" 13+60 (I.E.= 4497.00 - Cover Elev.= 4505.25)

~ Stakeout ~

		Invert Elev.	Rod	@ 15° Elev.	C/F to Invert
+25		98 02	6 60	05 38	C- 7 36
1+00		98 24	6 46	05 52	C- 7 18
+75	.01854	98 67	6 52	05 46	C- 6 79
+50		99 00	6 48	05 50	C- 6 50
+25		99 32	6 51	05 47	C- 6 15
0+00 = 50' Rt of "L" 11+81		4499 65	6 75	05 23	C- 5 58
	+5 17	11 98			
"L" BM #12					4506.81



37

"L" 11+80 to "L" 13+60 - RCP Storm Drain

~ Stakeout (Continued) ~

"L" BM #12			-5 17	06 81 -5 17	4506.81
		Invert Elev.	Rod	@ 15° Elev.	C/F to Invert
2+03 = 50' Lt of "L" 13+58		4497 00	6 75	05 23	C- 8 23
+75		97 37	6 69	05 29	C- 7 92
1+50		97 70	6 71	05 27	C- 7 57
		11 98			

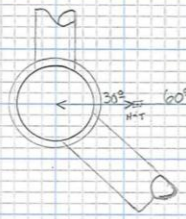
38

"L" 13+60 - CONSTRUCT TYPE 2 MANHOLE 50' LT
(I.E. = 4497.00 - COVER ELEV. = 4505.25)

"L" BM #12		-5 17	06 81	4506.81
	+5 17	11 98		
"L" BM #12				4506.81

"L" ℄

39



H.I.T	ROD	ELEV.	C/F TO INVERT
30°	6 41	05 57	C-8 57
60°	6 50	05 48	C-8 48

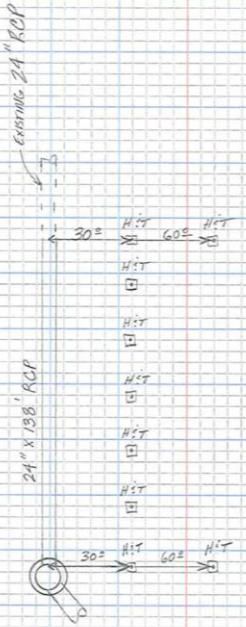
"L" 13+60 TO "L" 15+00 - CONSTRUCT 24" x 140' RCP STORM DRAIN 50' LT - CONNECT TO A NEW TYPE 2 MANHOLE 50' LT OF "L" 13+60 (I.E. = 4497.00 - COVER ELEV. = 4505.25) AND AN EXISTING 24" RCP 50' LT. OF "L" 15+00 (I.E. = 4495.15)

~ STAKEOUT ~

		INVERT ELEV.	ROD	@ 15° ELEV.	C/F TO INVERT
+38 = 50' LT OF "L" 15+00		4495 15	5 91	05 40	C-10 25
+25		95 32	5 67	05 64	C-10 32
1+00		95 66	5 86	05 45	C-9 79
+75	-.013406	96 00	5 91	05 40	C-9 40
+50		96 33	6 00	05 51	C-8 98
+25		96 66	5 75	05 56	C-8 90
0+00 = 50' LT. OF "L" 13+62		4497 00	5 70	05 61	C-8 61
	+4 50	11 31			
"L" BM # 12					4506.81

"L" ℄

40



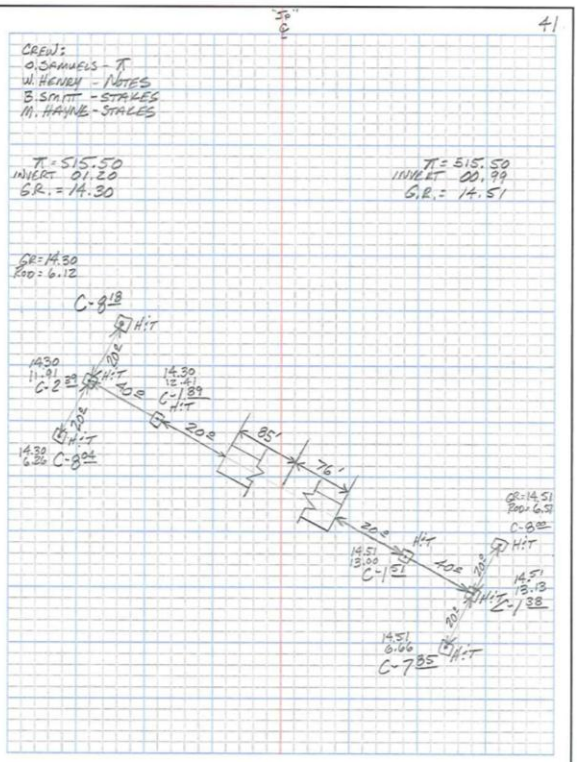
"Jp" 6+95 - CONSTRUCT 10'x4'x161' RCB - 29° SKEW LT AHEAD - TYPE I HEADWALLS LT : RT (UNSKEWED) MIN COVER UNDER ROADWAYS 7' - (U.I.E. 90' LT = 4501.20, L.I.E. 71' RT = 4500.99, S = 0.00129) PLACE RIP RAP AT INLET : OUTLET

~ STAKEOUT DATA ~

	LT	℄	RT	
P.G.		4509.49		
FINISH SH.	08.54		10.39	
U.I.E.	4501.20			
L.I.E.			4500.99	
H:T.	4.67		4.67	
TOP OF DECK ELEV.	05.87		05.66	
FILL OVER BOX	2.67		4.73	
FILL X SLOPE	*		21.29	4½:1
½ ROADWAY	49.00		45.00	
EFF. LENGTH	|		66.29	
29° SKEW	|		75.79	
ADD. FOR FILL HGT.	|		0.00	
LENGTH REQ'D.	|		75.79	
LENGTH USED	85.00		76.00	
TOTAL LENGTH		161'		
CON. BM #07		-4 15	11 35	4511.35
+4 15	15 50			
CON. BM #07				4511.35

* RCB EXTENDED FOR FUTURE LANE

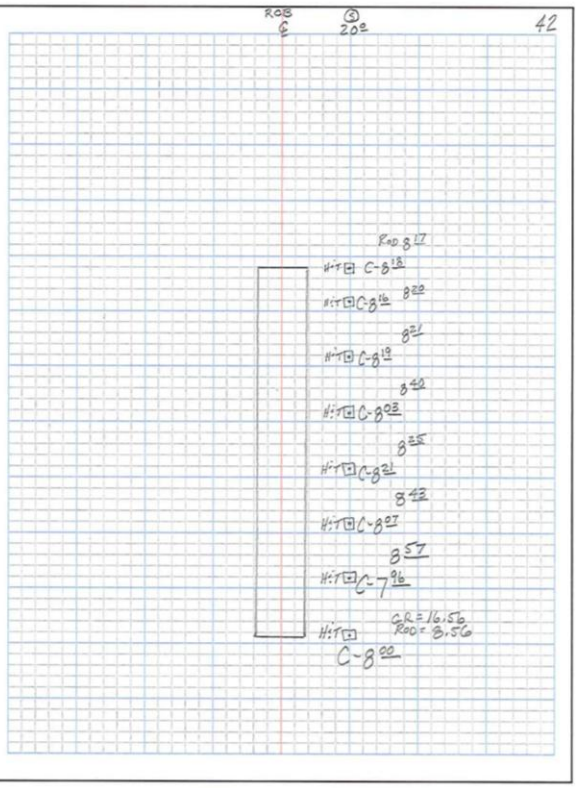
RR SPIKE IN POWER POLE #493021



"Jp" 6+95 CONSTRUCT 10'x4'x161' RCB

~ STAKEOUT (CONTINUED) ~

	INVERT ELEV.	G.R.		
CON. BM #07		-6 20	11 35	4511.35
RCB ℄				
INLET OF RCB +61 =	01.20	16 35		
+50	01.19	16 36		
+25	01.15	16 40		
1+00	01.12	16 43		
+75	01.09	16 46		
+50	01.05	16 50		
+25	01.02	16 53		
0+00 = OUTLET END OF RCB	4500.99	16 56		
+6 20	17 55			
CON. BM #07				4511.35

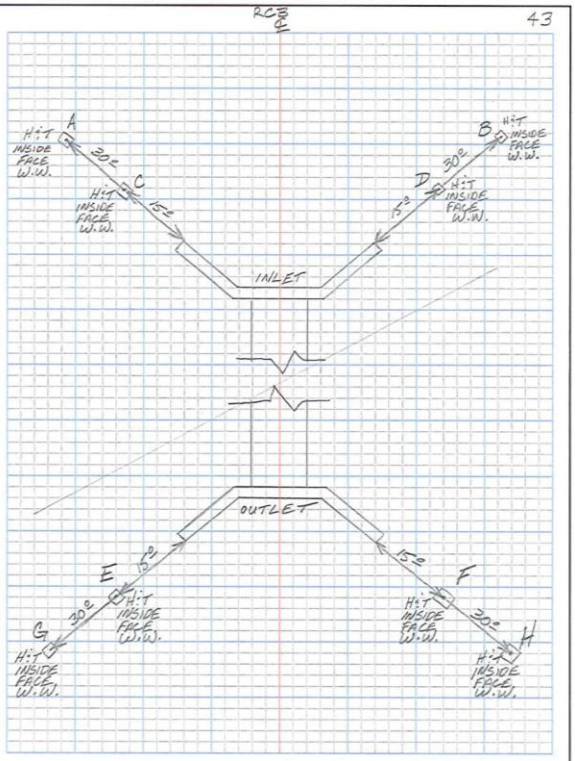


"Jp" 6+95 CONSTRUCT 10'x4'x16½' RCB ~ 29° SKEW
LT. AHEAD - TYPE I HEADWALLS LT & RT (UNSKEWED)
"HEADWALL STAKEOUT"

	LT	RT
U.I.E.	4501.20	
L.I.E.		4500.99
	-2.00	-2.00
	4499.20	4498.99

CON. BM #07			-6 20	11 35	4511.35
H.I.T	ROD	ELEV.	BTM. FTG. ELEV.	C/F TO BTM. FTG.	
A	6 05	4511 50	4499.20	C-12 30	
B	6 20	11 35	4499.20	C-12 15	
C	6 31	11 24	99.20	C-12 04	
D	6 45	11 10	99.20	C-11 90	
E	7 25	10 30	4498.99	C-11 31	
F	6 29	11 26	98.99	C-12 27	
G	8 00	9 55	98.99	C-10 56	
H	6 52	11 03	98.99	C-12 04	
	+6 20	17 55			
CON. BM #07					4511.35

R.R. SPIKE IN POWER POLE # 493021



"Jp" 6+95 CONSTRUCT 10'x4'x16½' RCB
X-SECTIONS - PERPENDICULAR TO RCB ℄

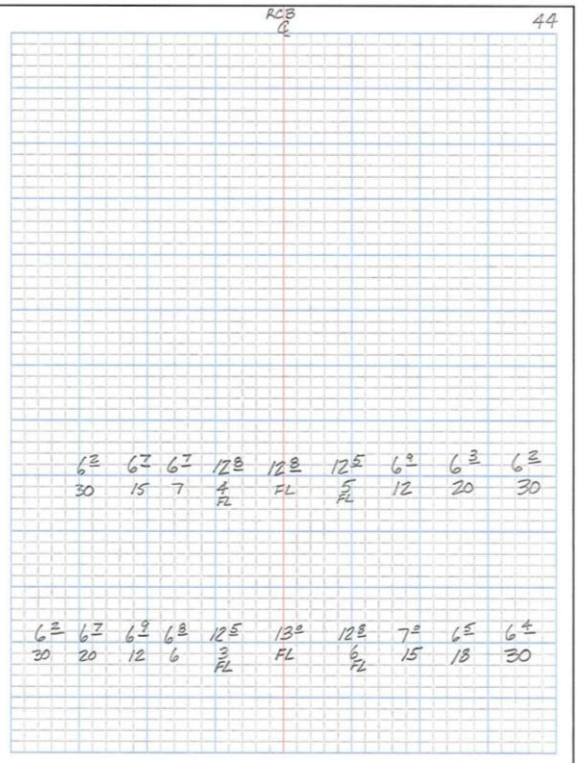
+60

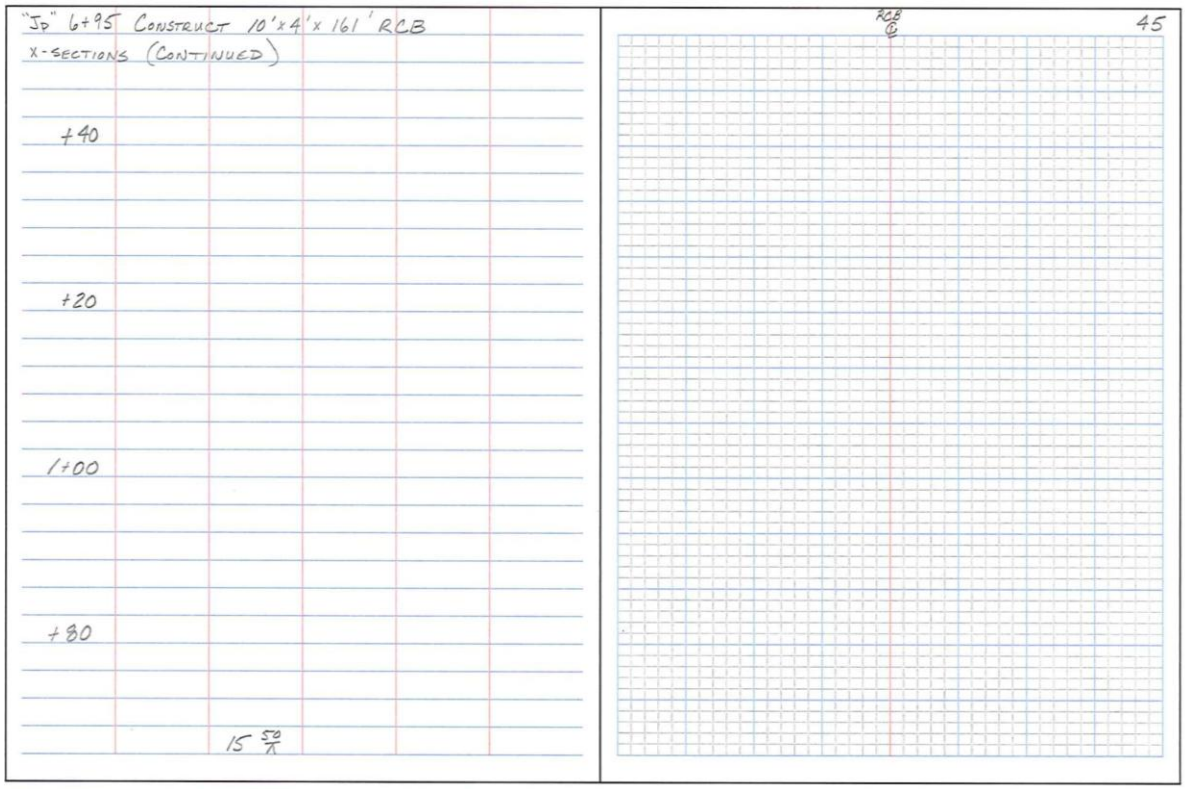
+40

+20
END RCB

0+00 =
HUB 20° RT.
OF OUTLET ON RCB ℄

+4 15	15 50	
CON. BM #07		4511.35




"Jo" 6+95 Construct 10'x4'x 161' RCB
X-sections (Continued)
+40
+20
1+00
+80
15 50/A
RCB
45

SECTION 6.8

BORROW PITS

Mira Loma Borrow Pit (WA 71-01)

The reason for layout and cross sectioning a borrow pit is usually to enable us to determine the cubic yards of Borrow Excavation used on a particular project.

The actual cross sectioning is very similar to that shown in Section 5 of this chapter; the layout however is somewhat more involved. As you are taking the "original" cross sections, you should keep in mind the fact that you really do not know exactly how the contractor is going to mine the withdrawal area. Consequently, you must be sure to catch all "breaks" which lie within the withdrawal limits.

By using a Total Station or GPS, it is possible to data collect the borrow pit before and after to get a total withdrawal for the area by comparing the two surfaces.

— CREW —

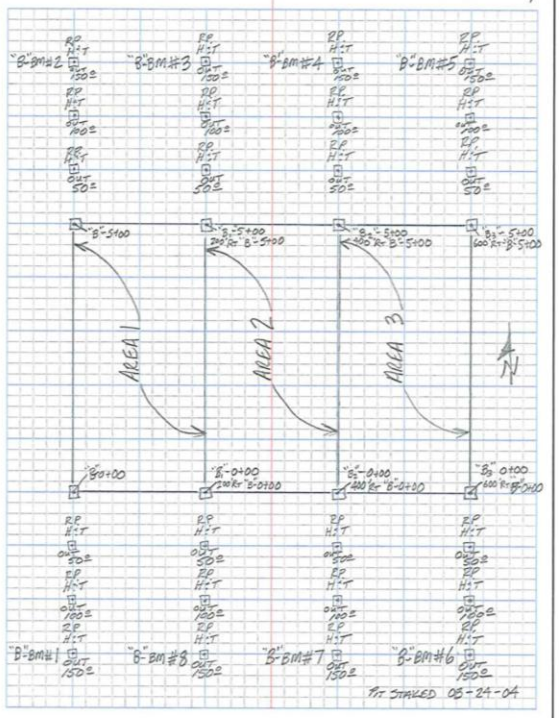
O. SAMUELS - NOTES
W. HENRY - T
B. SMITT - STAKES
M. HAYNE - STAKES

— BENCHMARK DATA —

(SEE PAGE NO. 2 FOR LEVEL NET.)

BM No.	DESCRIPTION	ELEV.
"B"-BM#1	R.P. HUB 150' SOUTH "B"-0+00	1000.00
"B"-BM#2	R.P. HUB 150' NORTH "B"-5+00	1001.00
"B"-BM#3	R.P. HUB 150' NORTH "B_1"-5+00	1003.55
"B"-BM#4	R.P. HUB 150' NORTH "B_2"-5+00	1003.19
"B"-BM#5	R.P. HUB 150' NORTH "B_3"-5+00	1004.90
"B"-BM#6	R.P. HUB 150' SOUTH "B_3"-0+00	1003.77
"B"-BM#7	R.P. HUB 150' SOUTH "B_2"-0+00	1001.32
"B"-BM#8	R.P. HUB 150' SOUTH "B_1"-0+00	1001.48

1

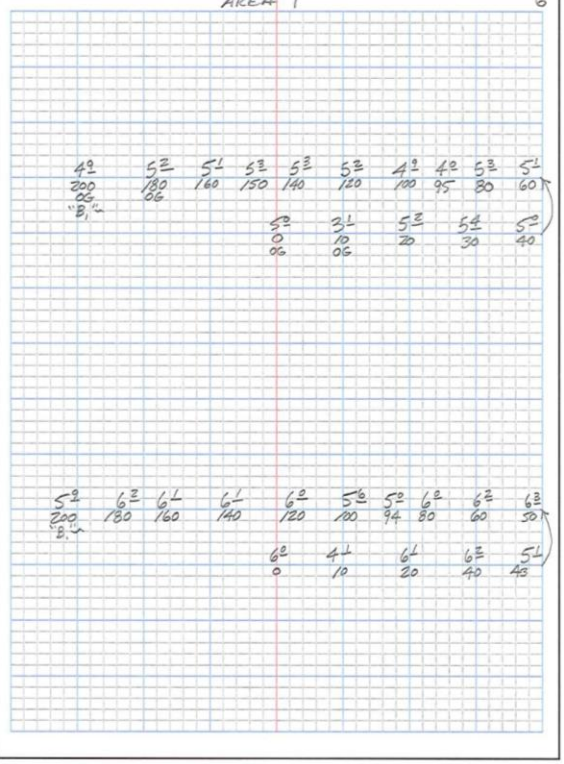


"B" —

"B"-BM#2 HUB 150' North of "B"-5+00		+8.00	+001.00	1001.00
* FINALS 5+00				*
"B"-BM#2 HUB 150' North of "B"-5+00		-9.00	001.00	1001.00
5+00				
	+009.00 A			
	010.00 A			

AREA 1

6



	+	⊼	−	ELEV.	B.M. ELEV
"B"-BM #1 HUB 150 SOUTH OF "B"+00			-8 34	00 00	1000.00
	+6 86	08 34 ⊼			
"B"-BM #8 HUB 150' SOUTH OF "B"-0+00			-6 01	01 48	1001.48
	+6 17	07 49 ⊼			
"B"-BM #7 HUB 150' SOUTH OF "B2"-0+00			-10 67	01 32	1001.32
	+8 22	11 99 ⊼			
"B"-BM #6 HUB 150' SOUTH OF "B3"-0+00			-8 14	03 77	1003.77
	+5 56	11 91 ⊼			
			-7 11	06 35	
	+8 56	13 46 ⊼			
"B"-BM #5 HUB 150' NORTH OF "B3"-5+00			-5 42	04 90	1004.90
	+7 13	10 32 ⊼			
"B"-BM #4 HUB 150' NORTH OF "B2"-5+00			-9 62	03 19	1003.19
	+9 26	12 81 ⊼			
"B"-BM #3 HUB 150' NORTH OF "B1"-5+00			-5 22	03 55	1003.55
	+7 77	08 77 ⊼			
"B"-BM #2 HUB 150' NORTH OF "B"-5+00			-6 16	01 00	1001.00
	+6 87	07 16 ⊼			
			-6 13	00 29	
	+6 42	06 42 ⊼			
"B"-BM #1 HUB 150' SOUTH OF "B"-0+00					ASSUMED ELEV. 1000.00

2

- CREW -
O. SAMUELS - NOTES
W. HENRY - ⊼
B. SMITT - STAKES
M. HAYNE - STAKES

"B" -

* FINALS 0+00					*
"B"-BM #1 HUB 150' SOUTH OF "B"-0+00	* +9 00	* 009 00 ⊼			1000.00
	+10 00	010 00 ⊼			
"B"-BM #1 HUB 150' SOUTH OF "B"-0+00					1000.00

AREA 1

3

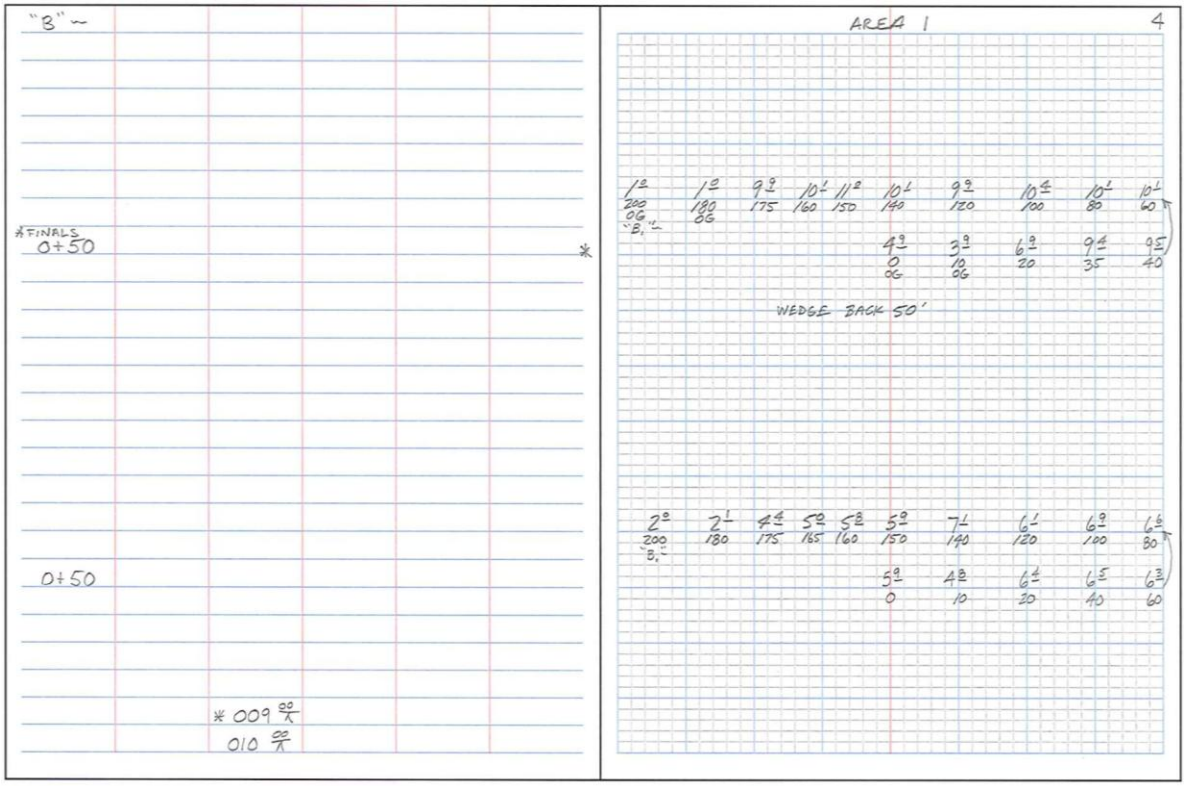
1 1 / 200 "B1" OG
1 1 / 190 OG
3 6 / 175 OG
4 9 / 160 OG
6 0 / 140 OG
6 1 / 0 OG
1 6 / 130 OG
5 0 / 10 OG
6 1 / 100 OG
5 6 / 25 OG
5 8 / 90 OG
5 9 / 35 OG
5 4 / 60 OG
4 8 / 40 OG

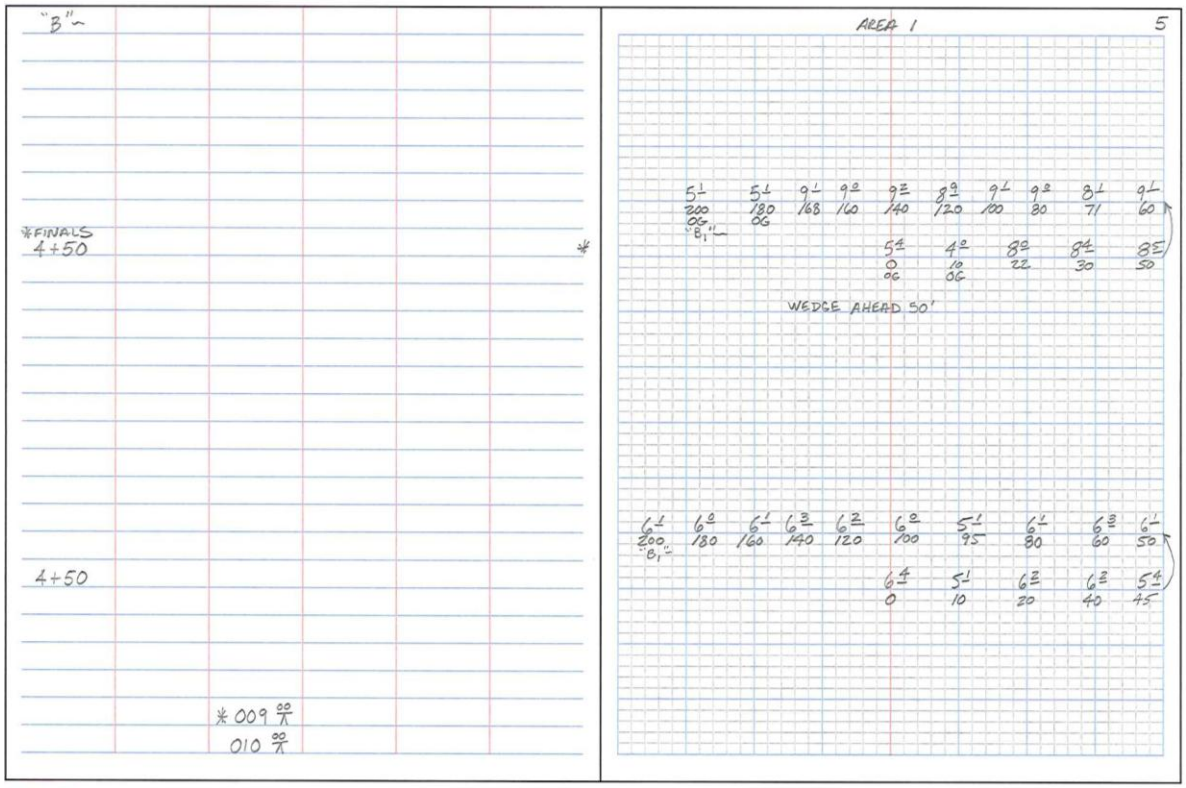
* FINALS TAKEN 10-07-08

2 1 / 200 "B1"
2 1 / 180
4 6 / 175
5 1 / 125
5 1 / 130
6 7 / 135
7 0 / 140
7 0 / 145
5 9 / 150
5 9 / 160
4 1 / 165
2 6 / 120
5 2 / 115
6 1 / 110
7 1 / 100
6 6 / 90
6 1 / 0
6 5 / 80
5 9 / 10
6 7 / 70
6 3 / 20
6 6 / 60
6 6 / 30
5 9 / 50
5 9 / 40

- CREW -
O. SAMUELS - NOTES
W. HENRY - ⊼
B. SMITT - ROD
M. HAYNE - TAPE

ORIGINALS TAKEN 08-24-04


"B" ~
*FINALS
0+50
*
0+50
* 009 00 A
010 00 A
AREA 1
4
1 2 200 06 "B" ~
1 2 180 08
9 2 175
10 1 160
11 2 150
10 1 140
9 3 120
10 4 100
10 1 80
10 1 60
4 3 0 06
3 3 10 06
6 3 20
9 4 35
9 5 40
WEDGE BACK 50'
2 2 200 "B" ~
2 1 180
4 4 175
5 2 165
5 2 160
5 2 150
7 1 140
6 1 120
6 2 100
6 1 80
5 3 0
4 2 10
6 1 20
6 5 40
6 3 60


"B" ~
*FINALS
4+50
*
4+50
* 009 00 A
010 00 A
AREA 1
5
5 1 200 06 "B" ~
5 1 180 06
9 1 168
9 2 160
9 2 140
8 3 120
9 1 100
9 2 80
8 1 71
9 1 60
5 4 0 06
4 2 10 06
8 2 22
8 4 30
8 3 50
WEDGE AHEAD 50'
6 1 200 "B" ~
6 2 180
6 1 160
6 3 140
6 2 120
6 2 100
5 1 95
6 1 80
6 3 60
6 1 50
6 4 0
5 1 10
6 2 20
6 2 40
5 4 45

SECTION 6.9

CURB/GUTTER AND SIDEWALK

Curb and Gutter Stakeout

As when staking anything, extreme care must be taken when staking curb or curb and gutter. Not only is it highly visible, but it is almost always designed to carry drainage away from roadways. Additionally, many times it is placed prior to paving. Consequently, it becomes the control for placement of the plantmix bituminous surface. Good communication with the contractor is essential so that distances along lay out line and lay out line offsets are most effective, yet will not be disturbed.

Note: Again, as with all stakeout, all information (including date and crew) must be neatly entered into the stakeout book.

"L"-6+00 TO "L"-8+50 - CONSTRUCT TYPE 5 CURB & GUTTER RT. ~ STAKEOUT (CONTINUED) ~

"L" ℄ — (41) 5^{0} TO F.F.C. — 20

F.F.C.			F.F.C. FL	G.R.		
"L"-BM #1^{0}			-6^{30}	10^{20}	4510.20	
+50 = 36' RT OF "L"-8+50			10.50	6^{00}		H.I.T 5^{10} ⊡ C-0^{90}
+25		-.004	10.60	5^{90}		H.I.T 5^{30} ⊡ C-0^{60}
2+00			10.70	5^{80}		H.I.T 5^{40} ⊡ C-0^{40}
		16^{50}				

"L"-6+00 TO "L"-8+50 - CONSTRUCT TYPE 5 CURB & GUTTER RT. ~ STAKEOUT ~

"L" ℄ — (41) 5^{0} TO F.F.C. — 19

F.F.C.			F.F.C. FL	G.R.		
+75			10.80	5^{70}		H.I.T 5^{40} ⊡ C-0^{30}
+50			10.90	5^{60}		H.I.T 5^{50} ⊡ C-0^{10}
+25			11.00	5^{50}		H.I.T 5^{60} ⊡ F-0^{10}
1+00			11.10	5^{40}		H.I.T 5^{90} ⊡ F-0^{50}
+93 = CTR. OF 40' DRIVEWAY		-.004	11.13	5^{37}		H.I.T ~~6.40~~ 5^{90} ⊡ ~~F-0.80~~ F-0^{53}
+75			11.20	5^{30}		H.I.T ~~6.50~~ 6^{10} ⊡ ~~F-1.30~~ F-0^{80}
+50			11.30	5^{20}		H.I.T 6^{50} ⊡ F-1^{30}
+25			11.40	5^{10}		H.I.T 6^{00} ⊡ F-0^{90}
0+00 = 36' RT OF "L"-6+00 - F.F.C.			4511.50	5^{00}		H.I.T 6^{00} ⊡ F-1^{00}
	$+6^{30}$	16^{50}				
"L"-BM #1^{0}					4510.20	

SECTION 6.10

BARRIER RAIL AND GUARDRAIL

Barrier Rail Stakeout

Barrier rail and guardrail are typically staked to the front face of rail. The beginning, end, terminals, transitions or angle points are some examples of items which need stakes. As noted before, good communication with the contractor is essential so that distances along lay out line and lay out line offsets are most effective, yet will not be disturbed.

Guardrail Stakeout

SECTION 6.11

SIGNS AND ELECTRICAL

Electrical Stakeout

Signs, pull boxes, transformers, cabinets, lights, etc. are typically staked out to the center of the installation. In some cases, offset stakes will be necessary to assist with proper alignment of the installation. Refer to the *NDOT Standard Plans for Road and Bridge Construction* to ensure proper stakeout and placement.

Chapter 7

Equipment

SECTION 7.1
INTRODUCTION

The following chapter is an outline for requesting and purchasing equipment, inventory responsibilities and repair request procedures.

SECTION 7.2
PURCHASING AUTHORITY

Purchasing of budget items for construction survey will need to be directed through the Headquarters Construction office. In the spring of each year, the Chief Construction Engineer will send out the budgetary requests for equipment over $5,000 for the fiscal year. This will be the Resident Engineer's opportunity to request new equipment for the next fiscal year. Your request must be returned to the chief for review and approval.

Purchasing of non budget items for construction also need to be requested through Headquarters Construction over the phone, by e-mail or with a completed 51 form. This will ensure timely delivery of parts and services and less confusion for our vendors.

For repairs, Headquarters Construction requests that all repairs be coordinated through Construction. Headquarters Construction suggests that all *Trimble* equipment be sent to Carson City for distribution. If you are close to Reno, please directly deliver to Monsen Engineering. All *Leica* equipment will need to be serviced by H&S Survey and Laser. If delivered directly, remember to notify Headquarters Construction. This will better facilitate repair of survey equipment and provide a single point of contact, so the Department can improve the tracking and documentation of repair for future equipment replacement and repairs. Please consider the use of the construction sample runner for shipping. This approach will save the state money and ensure safe arrival of equipment. If you should have any questions, please feel free to contact the following:

Rob Liebherr
NDOT Headquarters Construction Administration, Equipment purchasing, Repairs, Parts, and Shipping
775-888-7284

Martin Crook
Monsen Engineering, *Trimble* Repair and Software
1140 Financial Blvd # 400 Reno Nevada 89502
775-359-6671

Tom Mason
H & S Laser and Survey, *Leica* Sales and Service
4445 S. Valley View #2 Las Vegas Nevada 89103
702-777-2030 Cell 702-604-1872

SECTION 7.3

INVENTORY RESPONSIBILITIES

All survey inventory items over $5,000 will receive a blue asset tag attached to that piece of equipment; this tag is issued by state purchasing and is recorded in the state inventory records. Please make sure the tag is installed on your equipment in a permanent place on a non removable part.

Each construction crew has the responsibility of keeping their inventory intact. If a piece of equipment is to be traded, moved or decommissioned, proper paper work must be completed to remove that equipment from crew inventory before the beginning of a state inventory inspection. Once a calendar year, Headquarters Construction will perform a state wide survey equipment inventory inspection with construction crews. The inventory review will ideally be scheduled during the slower part of the construction season and will be announced. Survey equipment will be inspected for asset tags, condition and age; this would be an ideal time to obtain the necessary service, parts or small equipment.

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Appendix

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A.1

TP 1-9-3 Perpetuation of Survey Monuments

STATE OF NEVADA DEPARTMENT OF TRANSPORTATION

January 13, 1999 — TP 1-9-3 Formerly TP 3-1-3

Approved Jeffrey Fontana — Perpetuation of Survey Monuments

1. PURPOSE:

To establish standards and procedures for the perpetuation of survey monuments to assure compliance with Nevada Revised Statues (NRS) 329, 408 and 625.

2. POLICY:

Monuments found during survey, mapping, construction, or maintenance phases of Nevada Department of Transportation (NDOT) projects are to be perpetuated under the direction of the Chief Land Surveyor.

3. SCOPE:

This policy applies to all monuments placed in NDOT rights-of- way and construction zones.

4. RESPONSIBILITY:

a. The Location Division is responsible for:

(1) Initiation and revision of this TP.

(2) Administration of the perpetuation of monuments found in NDOT rights-of-way.

b. All Divisions/Districts are responsible for:

(1) Following the procedures in this TP.

5. DEFINITIONS:

a.	Corner	A geographic point on the surface of the earth which is on and a part of a line and which controls the location of such line.
b.	Monument	A physical structure that occupies the exact position of a corner.
c.	NDOT Reference Monument	A special monument placed by NDOT which does not occupy the same geographical position as a corner, whose spatial relationship to a corner, line or centerline is recorded at NDOT and which serves

1

		to witness the alignment of the roadway center lines, rights-of-way corridor boundaries, and the location of found monuments.
d.	Property Corner or Property Controlling Corner Monument	A stamped or tagged monument set by a professional land surveyor used to control the location of property.
e.	Tie Monument	A special monument placed outside the construction zone of the roadway but within one hundred feet of a found Public Land Survey Corner or Property Corner or Property Controlling Corner with a measured distance to the found monument established and stamped on the surface with the letters "TM" and PLS and the license number of the land surveyor that established the tie monument.
f.	Public Land Survey Corner	Any corner established and monumented in an original survey or resurvey used as a basis of legal description for issuing a patent for the land to a private person from the United States Government.
g.	Corner Record	A written record of the spatial relationship of a found monument to reference monuments or the reconstruction of a Public Land Survey Corner or Property Corner or Property Controlling Corner as described in NRS 329.
h.	Construction Zone	Any area within established rights-of-way or easements that may be disturbed during any construction or major maintenance activity, not including emergency projects.

6. PROCEDURE:

All visible stamped or tagged survey monuments and Public Land Survey Corners found in NDOT rights-of-way that may be destroyed by construction or maintenance activities must be perpetuated under the supervision of a licensed Nevada professional land surveyor. This will be achieved for each found monument by the following:

a. **Prior to the development of all construction or major maintenance contracts**

(1) The Design Division shall request the Location Division to verify the presence of any Public Land Survey Corners within the construction zone.

(2) The Location Division will conduct an in-house record search to determine if there are any Public Land Survey Corners within the right-of-way. If so, they will be verified in the field.

(3) All found Public Land Survey Corners will be listed in the contract by the Design Division for perpetuation.

(a) They must be perpetuated according to Nevada Revised Statutes Chapter 329 by a Nevada licensed professional land surveyor then tied to two (2) existing NDOT reference monuments utilizing NDOT's *Special Instruction for Survey or Mapping Consultant's Manual* which is distributed by the Location Division. Public Land Survey Corners in the construction zone are to be set in a survey well and referenced by four (4) tie monuments set outside the construction zone. A copy of the recorded Corner Record for each monument with a written report identifying the character, location, description, and ties of the new monument and NDOT Reference Monuments shall be sent by the land surveyor to the Chief Land Surveyor, Headquarters Building, 1263 South Stewart Street, Carson City, Nevada 89712.

(4) At the discretion of the Chief Land Surveyor, any Public Land Survey Corner found in the roadway will be tied to two (2) NDOT Reference Monuments set by the Location Division. A Corner Record will be sent by the Chief Land Surveyor to the appropriate County to be recorded.

(5) Copies of the construction plans will be maintained in NDOT headquarters as well as the District Offices including Ely, Winnemucca, and Tonopah.

(6) The Chief Land Surveyor will maintain a record of all perpetuated Public Land Survey Corners in the Geodesy Section.

b. **Prior to staking a construction project**

(1) The Resident Engineer, under the direction of the Chief Land Surveyor, will follow the provisions in the Construction Manual (Sec.2-102.8) and field verify the presence of all visible monuments.

(2) Any Public Land Survey Corners found and which are not listed in the contract plans for perpetuation will be added to the contract for perpetuation as defined in Procedure a.(3)(a).

(3) All visible stamped or tagged Property Corner or Property Controlling Corner Monuments that may be disturbed will be tied by the Resident Engineer. The ties will be to two (2) existing inter-visible NDOT Reference Monuments or two (2) set inter-visible NDOT Reference Monuments which will not be disturbed during construction activities. Instruction on procedures used to tie a Property Corner or Property Controlling Corner Monument or to construct a Reference Monument will be available from the Chief Land Surveyor.

(4) Found monuments will be noted in the as-built construction plans and a written report identifying the character, location, description, and ties of the monument and NDOT Reference Monuments will be sent to the Chief Land Surveyor, Location Division, Carson City.

(5) After review and acceptance of the written report, monuments used to reference a Public Land Survey Corner or Property Corner or Property Controlling Corner shall be approved to be stamped with the Chief Land Surveyor's registration number by memo from the Chief Land Surveyor to the Resident Engineer.

(6) The Chief Land Surveyor will maintain a record of all tied Property Corner or Property Controlling Corner Monuments in the Geodesy Section and a Corner Record

will be sent by the Chief Land Surveyor to the appropriate County to be recorded.

c. **Prior to District maintenance activities that will cover or destroy monuments**

(1) The District Engineer, under the direction of the Chief Land Surveyor, will follow the provisions in the Construction Manual (Sec.2-102.8) and field verify the presence of any monuments.

(2) Any Public Land Survey Corners found will be reported to the Location Division with a request that the monument be perpetuated prior to maintenance activities.

(3) All visible stamped or tagged Property Corner or Property Controlling Corner Monuments that may be disturbed will be tied by the District Engineer. The ties will be to two (2) existing inter-visible NDOT Reference Monuments or two (2) set inter-visible NDOT Reference Monuments which will not be disturbed during maintenance activities. Instruction on procedures used to tie a Property Corner or Property Controlling Corner or to construct a NDOT Reference Monument will be available from the Chief Land Surveyor.

(4) Found and tied monuments will be noted in the latest as-built construction plans and a written report identifying the character, location, description, and ties of the monument and NDOT reference monuments will be sent to the Chief Land Surveyor, Location Division, Carson City.

(5) After review and acceptance of the written report, monuments used to reference a Public Land Survey Corner or Property Corner or Property Controlling Corner shall be approved to be stamped with the Chief Land Surveyor's registration number by memo from the Chief Land Surveyor to the Resident Engineer.

(6) The Chief Land Surveyor will maintain a record of all tied Property Corner or Property Controlling Corner Monuments in the Geodesy Section and a Corner Record will be sent by the Chief Land Surveyor to the appropriate County to be recorded.

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A.2

FEATURE CODE LIST

DATA COLLECTOR FEATURE CODES

NAME	STYLE	DESCRIPTION
BB	: ZZDTM	: Bench Back
BD	: EXSTR	: Bridge Deck
BF	: ZZDTM	: Bench Front
BLD	: EXTPO	: Building
BOB	: EXSTR	: Bottom of Beam
BNCH	: EXTPO	: Bench
BRDS	: EXTPO	: Barrier Rail Double Sided
BRFL	: EXSTR	: Bottom of Bridge Deck
BRK	: ZZDTM	: Ground Breaks
BRPP	: EXTPO	: Barrier Rail Port Precast
BRR	: EXSTR	: Top of Bridge Rail
BRSS	: EXTPO	: Barrier Rail Single Sided
BRWN	: EXSTR	: Abutment and Wing Wall
CAN	: EXSTR	: Canopies and Carports
CB	: EXTPO	: Catch Basin
CBR	: EXTPO	: Cable Rail
CGF	: EXTPO	: Curb and Gutter Flow Line
CGTB	: EXTPO	: Curb and Gutter Top Back
CGTF	: EXTPO	: Curb and Gutter Top Front
CHG	: EXTPO	: Drainage Check Gate
CLRW	: EXROW	: Right of Way Line
CMAP	: EXTPO	: Corrugated Metal Arch Pipe
CMP	: EXTPO	: Corrugated Metal Pipe
CNTY	: EXROW	: Political County Line
CONC	: EXTPO	: Concrete
CPP	: EXTPO	: Corrugated Plastic Pipe
CRWN	: ZZDTM	: Pavement Crown
CTMH	: EXUTL	: Cable TV Manhole
CTOH	: EXUTL	: Cable TV OH
CTPB	: EXUTL	: Cable TV Pull Box
CTUG	: EXUTL	: Cable TV UG
CTY	: EXROW	: Political City Line
CUGA	: EXUTL	: Common Ground Guy Anchor
CUGP	: EXUTL	: Common Guy Pole Anchor
CUMH	: EXUTL	: Common Utility Manhole
CUOH	: EXUTL	: Common Utility OH
CUPB	: EXUTL	: Common Utility Box
CUT	: ZZDTM	: Catch Point Cut
CUUG	: EXUTL	: Common Utility UG
MONPS	: EXGSY	: Mon Set Property Cntrl
MP	: EXTPO	: Milepost
MSH	: EXTPO	: Veg. Marsh
OG	: ZZDTM	: Random Ground Shots
PDK	: EXTPO	: Plant Mix Dike
PIERB	: EXSTR	: Pier Cap Bottom
PKRB	: EXROW	: Political Park Line
PL	: EXROW	: Property Line
PLH	: EXTPO	: Plant Hedge Line
PLT	: EXTPO	: Veg. Shrub
POLE	: EXUTL	: Common Utility Pole-0 Ray
POLI	: EXUTL	: Common Utility Pole-1 Ray
POLII	: EXUTL	: Common Utility Pole-2 Ray
POLIII	: EXUTL	: Common Utility Pole-3 Ray
POLIV	: EXUTL	: Common Utility Pole-4 Ray
POST	: EXTPO	: Post
PPR	: EXSTR	: Perimeter of Pier
PRKL	: ZZDTM	: Edge of Parking Lot
PRR	: EXTPO	: Pipe Riser Round
PRS	: EXTPO	: Pipe Riser Square
PTNK	: EXTPO	: Propane Tank
PTST	: EXUTL	: Petroleum Structure
PTUG	: EXUTL	: Petroleum UG
PTVL	: EXUTL	: Petroleum Valve
RCAP	: EXTPO	: Reinforced Conc Arch Pipe
RCB	: EXTPO	: Reinforced Concrete Box
RCK	: EXTPO	: Rock
RCKO	: EXTPO	: Rock Outline
RCP	: EXTPO	: Reinforced Concrete Pipe
RR	: EXTPO	: Top of Rail
RRCL	: EXTPO	: Railroad Centerline
RRG	: EXTPO	: Railroad Gate Arm
RRLT	: EXTPO	: Railroad Crossing Light
RRP	: EXTPO	: Rip Rap Basin
RRST	: EXTPO	: Railroad Switch
RVR	: EXTPO	: Edge of Water
RWCA	: EXROW	: ROW C/A Without Fence
RWCF	: EXROW	: ROW C/A With Fence
RWUG	: EXUTL	: Reclaimed Water UG

DATA COLLECTOR FEATURE CODES

NAME	STYLE	DESCRIPTION
DI	: EXTPO	: Drop Inlet
DISH	: EXTPO	: Satellite Dish
DK	: ZZDTM	: Earth Dike
ELBL	: EXUTL	: Electric Lumin Pull Box
ELGA	: EXUTL	: Electric Guy Grnd Anchor
ELGP	: EXUTL	: Electric Guy Pole Anchor
ELMH	: EXUTL	: Electric Manhole
ELOH	: EXUTL	: Electric OH
ELOM	: EXUTL	: Electric OH Transmission
ELPB	: EXUTL	: Electric Pull Box
ELPS	: EXUTL	: Electric Signal Pull Box
ELTP	: EXUTL	: Electric Light Pole
ELTR	: EXUTL	: Electric Transformer
ELUG	: EXUTL	: Electric UG
ELVT	: EXUTL	: Electric Vault
EMBP	: EXTPO	: Embankment Protector
EO	: EXTPO	: Edge of Asphalt
EOC	: EXTPO	: Edge of Concrete
EOG	: ZZDTM	: Edge of Gravel Roadway
EP	: EXUTL	: Electric Pole - 0 Ray
EPI	: EXUTL	: Electric Pole - 1 Ray
EPII	: EXUTL	: Electric Pole - 2 Ray
EPIII	: EXUTL	: Electric Pole - 3 Ray
EPIV	: EXUTL	: Electric Pole - 4 Ray
ESP	: NWROW	: Easements Permanent
EST	: NWROW	: Easements Temporary
FDN	: EXSTR	: Foundations and Ruins
FG	: ZZDTM	: Finish Grade Random Shots
FILL	: ZZDTM	: Catch Point Fill
FL	: EXTPO	: Flowline
FLM	: EXTPO	: Man Made Flowline
FLP	: EXTPO	: Flag Pole
FLVG	: ZZDTM	: Valley Gutter Flow Line
FN	: EXTPO	: Fence
FNG	: EXTPO	: Fence Gate
FOBP	: EXUTL	: Fiber Optic Pull Box
FOOH	: EXUTL	: Fiber Optic OH
FOUG	: EXUTL	: Fiber Optic UG
GR	: EXTPO	: Guardrail
GSMT	: EXUTL	: Gas Meter
GSUG	: EXUTL	: Gas UG
GSVL	: EXUTL	: Gas Valve
HCP	: EXTPO	: Accessibility Parking
RWVL	: EXUTL	: Reclaimed Water Valve
SBD	: EXROW	: Property Subdivision Line
SC	: EXROW	: Landnet Sec Cnr Fnd
SCC	: EXROW	: Landnet Sec Cnr Clos Fnd
SCCN	: EXROW	: Landnet Sec Cnr Clos
SCN	: EXROW	: Landnet Sec Cor
SDMH	: EXUTL	: Storm Drain Manhole
SDUG	: EXUTL	: Storm Drain UG
SGN	: EXTPO	: Sign
SGNS	: EXTPO	: Street Sign
SGP	: EXTPO	: Signal Pole
SGPL	: EXTPO	: Signal Pole With Light
SLD	: EXTPO	: Slotted Drain
SNC	: EXTPO	: Major Sign Commercial
SNSO	: EXTPO	: Major Sign State Owned
SOIL	: EXGTL	: Boring Test Holes
SPR	: EXGTL	: Artesian Spring
SQC	: EXROW	: Landnet Sec Qtr Cnr Fnd
SQCN	: EXROW	: Landnet Sec Qtr Cor
SSMH	: EXUTL	: Sanitary Sewer Manhole
SSUG	: EXUTL	: Sanitary Sewer UG
STL	: EXROW	: Political State Line
STLP	: EXGTL	: Settlement Plates
STR	: EXSTR	: Stairs
STRIPE	: EXTPO	: Pavement Marking
TAC	: EXGSY	: Temporary Aerial Control
TBM	: EXGSY	: Temporary Bench Mark
TLB	: EXUTL	: Telephone Booth
TLGA	: EXUTL	: Telephone Guy Ground Anchr
TLMH	: EXUTL	: Telephone Manhole
TLOH	: EXUTL	: Telephone OH Line
TLPA	: EXUTL	: Telephone Guy Pole Anchr
TLPB	: EXUTL	: Telephone Pull Box
TLUG	: EXUTL	: Telephone UG
TLVT	: EXUTL	: Telephone Vault
TP	: EXUTL	: Telephone Pole-0 Ray
TPI	: EXUTL	: Telephone Pole-1 Ray
TPII	: EXUTL	: Telephone Pole-2 Ray
TPIII	: EXUTL	: Telephone Pole-3 Ray
TPIV	: EXUTL	: Telephone Pole-4 Ray
TREEC	: EXTPO	: Veg. Tree Non-Deciduous
TREED	: EXTPO	: Veg. Tree Deciduous
TREEL	: EXTPO	: Veg. Tree Line

DATA COLLECTOR FEATURE CODES

NAME	STYLE	DESCRIPTION
HDW	: EXTPO	: Drainage Headwall
HP	: ZZDTM	: Hinge
HWM	: EXTPO	: High Water Mark
IMPA	: EXTPO	: Barrier Impact Attenuator
LK	: EXTPO	: Lake
LUM	: EXUTL	: Luminaire on Arm
MB	: EXTPO	: Mailbox
MBC	: EXTPO	: Mailbox Cluster
MINE	: EXTPO	: Rock Mining
MON	: EXGSY	: Mon No Designation
MONB	: EXGSY	: Mon Fnd Basic Cntrl
MONBM	: EXGSY	: Mon Fnd Bench Mark
MONBS	: EXGSY	: Mon Set Basic Cntrl
MONC	: EXGSY	: Mon Fnd Const Cntrl
MONCD	: EXGSY	: Mon Fnd Cadastral Cntrl
MONCDS	: EXGSY	: Mon Set Cadastral Cntrl
MONCS	: EXGSY	: Mon Set Const Cntrl
MONH	: EXGSY	: Mon Fnd Ham Cntrl
MONHS	: EXGSY	: Mon Set Harn Cntrl
MONP	: EXGSY	: Mon Fnd Property Cntrl
TREEP	: EXTPO	: Veg. Tree Palm
TRPB	: EXTPO	: Traffic Signal Pull Box
TSL	: EXTPO	: Traffic Signal Loop
UTMH	: EXUTL	: Unknown Utility Manhole
UTOH	: EXUTL	: Unknown Utility OH
UTPB	: EXUTL	: Unknown Utility Pull Box
UTUG	: EXUTL	: Unknown Utility UG
VOID	: ZZDTM	: Misc. Void Areas
WALF	: EXTPO	: Wall Free Standing
WALR	: EXTPO	: Wall Retaining
WALS	: EXTPO	: Wall Sound
WELL	: EXTPO	: Domestic Water Well
WH	: EXUTL	: Water Hydrant
WLK	: EXTPO	: Edge of Sidewalk
WM	: EXUTL	: Water Meter
WMH	: EXUTL	: Water Manhole
WST	: EXTPO	: Water Stock Tank
WUG	: EXUTL	: Water UG
WV	: EXUTL	: Water Valve

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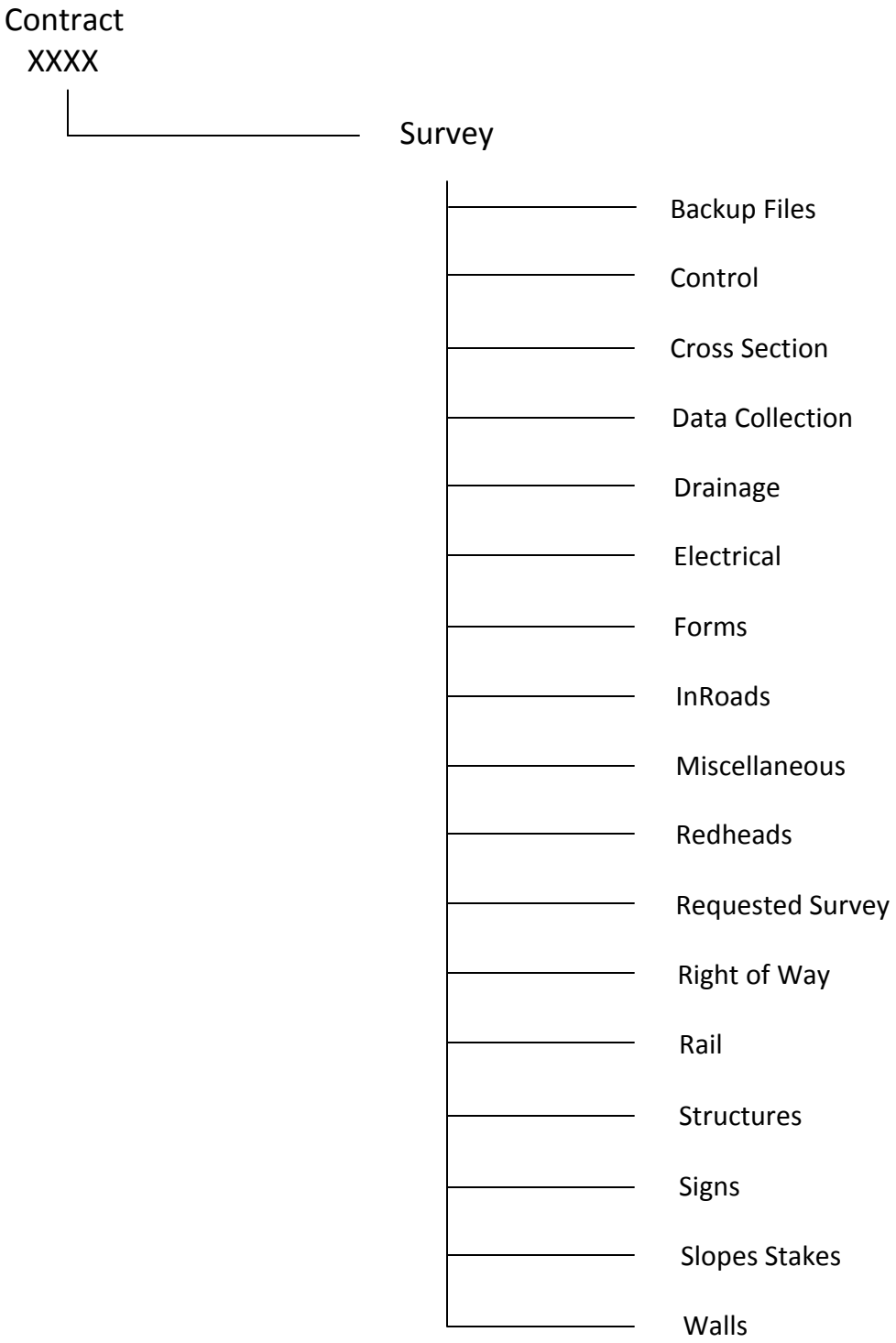
A.3

DATA FILE MANAGEMENT



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A.4

5600 TOTAL STATION CONFIGURATION

Configuration

1) Set-up and level your backsight and the 5600 on their appropriate tripods.

2) Connect the Power Carriage to the 5600 and TSCe Data Collector (recommend both on the same side). Note: There are several ways to provide power, see your user's manual.

3) Turn on the 5600 by powering up the TSCe Data Collector and running Survey Controller software. Warning: Wait for the fisheye level screen to appear on the TSCe prior to pressing any keys or selecting screen functions. A failure to do so could result in a system lockup, which requires a hard reset of the data collector*.

4) Fine tune the leveling of the 5600 and accept the conditions.

5) Parameter settings appear on the next screen, where you can enter the temperature, barometric pressure, and prism constant. These settings need a onetime entry from the data collector.

6) The basic screen then displays. At this point, you can zero the 5600 on your backsight, measure a quick distance, and turn an angle from this screen, without entering a project/job file. Otherwise, you may escape from this screen.

7) The Main Screen appears for Survey Controller.

8) Create a new job by selecting: **Files**/**New Job**/type in job name/Select **Coordinate System**/**Scale Factor=1.00** (always)/Select **Units (meters or US feet)**/**Accept**. Accept should return you to the main screen for the job you just created.

   Open an existing job by selecting: **Files**/**Open Job**/tap on desired job.

Note: Refer to your equipment manufacturer's owner's manual for actual input methods. Software compatibility issues may require additional research and updates for accurate data management.

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A.5

5600 TOTAL STATION SETUP

Station Setup

1) Connect to the 5600 Total Station using the “Configuration” steps 1-5 shown on the previous page.

2) From the Survey Controller main screen, select: **Survey**/**5600**/**Station Setup**/**Enter**;

- Occupied point (from either the point list or shoot the point)
- Backsight point (from either the point list or shoot the point)
- 5600 height
- Backsight height

Measure 

the point/**Accept**/**Store** (only if residuals are accurate)

Once you have established the setup, you may perform topography-shots, stakeouts, 2-person mode surveys, and robotic surveys.

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A.6

5600 TOTAL STATION ROBOTIC SURVEYS

Robotic Surveys

1) After station setup, select **Survey**/**End Survey**/. You will be prompted to Shutdown 5600 to which you enter, **No**/**Survey**/**Start Robotic**/**Auto Centered is fine?**/**Ok**/**Yes**

2) The 5600 will shutdown.

3) You then disconnect the TSCe cable from the 5600 battery pack and connect the cable to the bottom port on the side of the pole-mounted radio. It takes approximately thirty (30) seconds for the radio to power on and render a beep, which indicates a remote connection is established. During the wait time, you can turn on your prism on top of the pole (green LED's will flash) and set your prism height on the telescoping pole.

4) At this point, the TSCe screen will display the same leveling screen, and you can adjust the bubble accordingly. However, remember heavy level adjustments will force a new station setup. Proceed to the station setup screen and use your last setup if no large leveling adjustments were performed, which will save you redundant entries.

5) You are now ready to perform Topographic Surveys, Measure Points, Measure Rounds, or Stakeouts.

6) The next step is to lock your 5600 on to your remote pole prism. Walk away in-line from the telescope approximately 15 feet while holding the pole and towards the 5600. If your prism is on the 5600, it should "Autolock". If the Autolock fails, select the instrument icon  on the right side of the screen and select **Autolock**, where the  icon appears while the 5600 searches for the prism. Once locked on, the lights should be solid   .

7) Once locked, you can commence performing the previously mentioned surveys.

As usual, all of these procedures are in the help section on the TSCe and in PDF versions on your *Trimble* Survey Controller disk that came with the data collector.

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A.7

5600 TOTAL STATION SURFACE SCAN

Surface scanning is an automated direct reflex (DR) measuring process where measurements are automatically stored along a remote surface that you have defined.

To perform a surface scan using *Trimble* Survey Controller:

1. Start a conventional survey.

2. From the Survey menu, select **Surface Scan**.

3. Enter the Start point name and code (if necessary).

4. In the Method field, select a measurement method.

5. Define the area for the scan and grid interval.

6. Tap the ***Trimble* functions** button and set the EDM method (TRK is fastest). The total number of points to scan, scan grid dimensions, and estimated scan time are displayed.

7. Change the scan size, step sizes or EDM method to increase or decrease the number of points and scan time.

8. Tap **Start**.

To define the scan area, do one of the following:

- If the point already exists, enter the point name, or use menu arrow to select it from the list.

- From the pop−up menu in the *Top left* and *Bottom right* fields, select **Fast fix** or **Measure** to measure and store points that define the limits of the search.

Define the scan area with one of the following methods:

HA VA interval − Use this method on complex surfaces, when you cannot use a rectangular plane to approximate the surface you are scanning (see diagram on the following page):

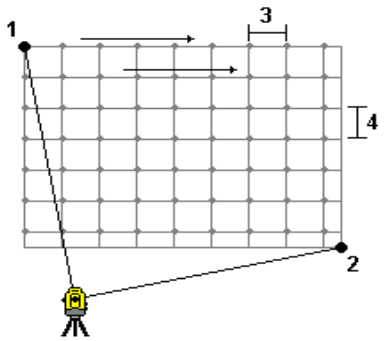
1. Aim to the top left corner of the scan area (1) and measure a point.

2. Aim to the bottom right corner of the scan area (2) and measure another point.

3. Define the angular grid interval, where:

   3 is the Horizontal angle

   4 is the Vertical angle



Tip − To define a Horizontal only scan of a 360° scan area, set the Top left and Bottom right points to the same name and set the VA interval to null.

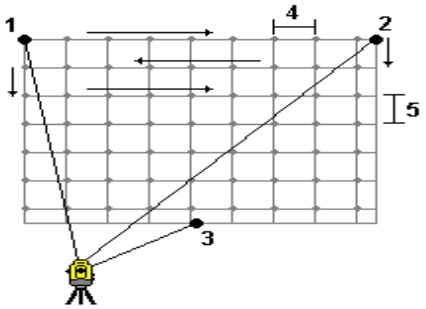
Rectangular plane − Use this method on a plane surface where you need a regular grid interval.

Trimble Survey Controller determines the angle of the plane and uses this and the grid interval to approximate how far to turn the instrument for each subsequent point.

1. Aim to the first corner of the scan area (1) and measure a point.

2. Aim to the second corner of the scan area (2) and measure another point.

3. Aim to the third point on the opposite side of the plane (3) and measure a point.



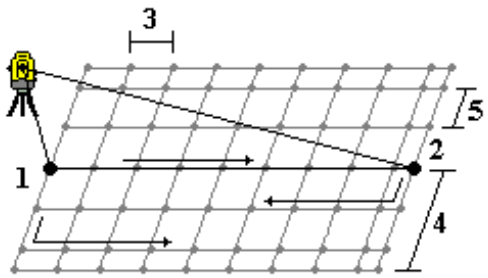
4. Define the distance and grid interval, where:

   4 is the Horizontal distance

   5 is the Vertical distance

Line and offset − Use this method to define the area to scan from a center line that has equal offsets to the left and right. *Trimble* Survey Controller defines the surface using horizontal offsets perpendicular to the center line. The software then uses this definition and the station interval to determine approximately how far to turn the instrument for each subsequent point (see diagram on the following page):

1. Perform one of the following:



   Two point method:

   - Aim to the start point of the center line (1) and measure a point.
   - Aim to the end point of the center line (2) and measure another point. These two points (1 and 2) define the center line.

   Access the pop−up menu in the Start point field. Change the method and then define the line by a start point with azimuth and length.

2. Define the station interval (3).

3. Define the maximum offset distance (4).

4. Define the offset interval (5).

Trimble Survey Controller scans the center line first, then the points on the right−hand side, and finally the left−hand side.

Note: With all of the above methods, the defined scan area may not exactly fit the grid interval. There may be an area left over along the scan extents that is smaller than the grid interval. If the width of this area is less than one−fifth of the grid interval, the points along this scan area will not be measured. If the width is more than one−fifth of the grid interval, then an extra point is scanned.

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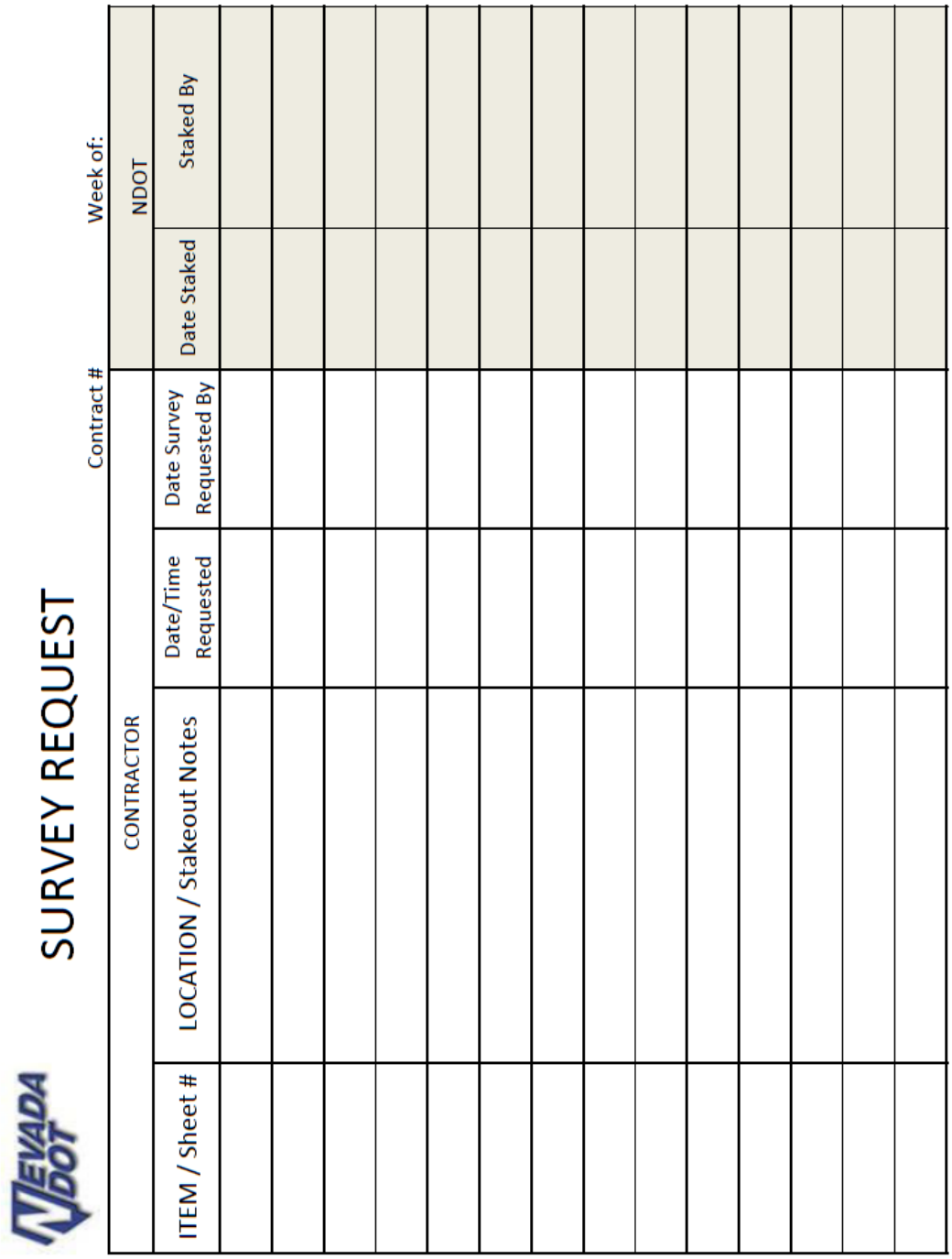
A.8

Survey Request Form



SURVEY REQUEST

Contract #

Week of:

CONTRACTOR			NDOT	
ITEM / Sheet #	LOCATION / Stakeout Notes	Date/Time Requested	Date Survey Requested By	Date Staked	Staked By

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Glossary of Terms

Aerial Mapping or Aerial Surveying - A geomatics method of collecting information by using aerial photography, LiDAR or from remote sensing imagery using other bands of the electromagnetic spectrum, such as infrared, gamma, or ultraviolet. It can also refer to the chart or map made by analyzing a region from the air. This is typically done using aero planes, helicopters, UAVs such as the InView Unmanned Aircraft System and in history with balloons. Aerial survey should be distinguished by satellite imagery technologies because of its better resolution, quality and atmospheric conditions.

Aerial Photography - The taking of photographs of the ground from an elevated position. The term usually refers to images in which the camera is not supported by a ground-based structure. Cameras may be hand held or mounted, and photographs may be taken by a photographer, triggered remotely or triggered automatically. Platforms for aerial photography include fixed-wing aircraft, helicopters, balloons, blimps and dirigibles, rockets, kites, poles, parachutes, and vehicle mounted poles.

Angle of Intersection - The angle between two lines.

Atmospheric Pressure - The force per unit area exerted into a surface by the weight of air above that surface in the atmosphere of Earth (or that of another planet).

Azimuth - The angle of horizontal deviation, measured clockwise, of a bearing from a standard direction, as from north or south.

Barometric Pressure - The value of standard or normal atmospheric pressure, equivalent to the pressure exerted by a column of mercury 29.92 in. (760 mm) high, or 1013 millibars (101.3 kilopascals).

Backsight - Point with known coordinates or known azimuth from the instrument point that is used to orientate the instrument during a station setup.

Back Slope - The slope from the back of the ditch to existing ground beyond the ditch.

Base Grade- The layer of material immediately beneath the pavement. It may be composed of crushed stone, crushed or uncrushed sand and gravel, or combinations of these materials known as aggregate base.

Bench Mark - A surveyor's mark on a permanent object of predetermined position and elevation used as a reference point.

Bluetooth - A proprietary open wireless technology standard for exchanging data over short distances (using short-wavelength radio transmissions in the ISM band from 2400–2480 MHz) from fixed and mobile devices, creating personal area networks (PANs) with high levels of security.

Borrow Pit (Quarry) - A quarry is a type of open-pit mine from which rock or minerals are extracted. Quarries are generally used for extracting building materials, such as dimension stone, construction

aggregate, riprap, sand, and gravel. They are often co-located with concrete and asphalt plants due to the requirement for large amounts of aggregate in those materials.

Breaklines - A surface feature consisting of a collection of spatial coordinates that have an implied linear relationship.

Calibration - The act of checking or adjusting (by comparison with a standard) the accuracy of a measuring instrument.

Catch Point - The point at which a fill slope intercepts the original surface.

Centerline - A line that bisects something into equal parts. Typically a painted line running along the center of a road or highway.

Clearing and Grubbing - The stage of construction in which vegetation is cleared from land (clearing) and a root rake or similar device employed to remove roots remaining in the soil (grubbing).The next stage is cutting and filling.

Constellation - An assemblage, collection, or group of usually related persons, qualities, or things.

Contour - Defined line of equal elevation on a map or plat.

Control - A system of points whose relative positions have been determined from survey data.

Control Point - A point whose position (horizontal or vertical) has been determined from survey data, and is used as a base for a dependent survey.

Coordinates - Linear or angular quantities, or both, which designate the position of a point in relation to a given reference frame.

Cross Section - The creation of a DTM from collecting grid elevations in a predetermined area or roadway section.

Cross Slope - A geometric feature of pavement surfaces; the transversal slope [%] with respect to the horizon.

Culvert Pipe - A conduit to convey a stream or runoff through an embankment.

Cut Slope - The cut which is created when a roadway is lower than the surrounding terrain.

Data Collector - Electronic Field Notebook.

Datum - A reference element such as a line or plane, in reference to which the positions of other elements are determined. See: Horizontal Datum and Vertical Datum.

Digital Terrain Model (DTM) - The DTM is considered as a continuous, usually smooth surface which, in addition to height values, also contains other elements that describe a topographic surface: slope, aspect, curvature, gradient, skeleton (pits, thalwegs, saddles, ridges, peaks), and others.

Dilution of Precision (DOP) - An indicator of the quality of a GPS position. DOP takes into account the location of each satellite relative to other satellites in the constellation, as well as their geometry relative to the GPS receiver. A low DOP value indicates a higher probability of accuracy. Standard DOPs for GPS applications are PDOP - Position (three coordinates), RDOP - Relative (Position, averaged over time), HDOP - Horizontal (two horizontal coordinates), VDOP - Vertical (height only), and TDOP-Time (Clock offset only).

Direct Reflex - Enables surveyors to accurately measure remote points without first locating a physical target at each point.

Easement - The right to use the real property of another for a specific purpose. The easement is itself a real property interest, but legal title to the underlying land is retained by the original owner for all other purposes.

Easting - One of the two values indicating the position of a point on a grid system. The easting coordinate is abbreviated: E. A term used in plane surveying that corresponds to the x-position on a Cartesian plane. See: Grid Coordinates

Electromagnetic Radiation - Energy in the form of electromagnetic waves.

Electromagnetic Spectrum - The range of all possible frequencies of electromagnetic radiation.

Electronic Distance Measurement (EDM) - A surveying instrument that utilizes an infrared or laser beam to measure the distance from the source point to.

Elevation - The distance of any point above or below a reference level (datum).

Elevation Mask - Filters out signals from satellites below a certain angle of elevation above the horizon.

Fast-Static GPS Survey - Similar to static GPS surveys, but with shorter observation periods (approximately 5 to 10 minutes). Fast-static GPS survey procedures require more advanced equipment and data reduction techniques than static GPS methods.

Feature Codes - The abbreviation used to define an object collected during a radial survey.

Fill Slope - The fill which is created when a roadway is higher than the surrounding terrain.

Foreslope - The segment of the ditch between the hinge and the ditch bottom.

Geodetic Coordinates - Refers to a location on earth defined by its latitude, longitude and elevation.

Geoid - The gravity model set up for the earth that closely approximates mean sea level.

Geoid Model - Separation between the Geoid and the WGS-84 datum.

Geomatics - The discipline of gathering, storing, processing, and delivering geographic information, or spatially referenced information.

Global Positioning Satellite (GPS) - A system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver.

Grade - Surface level of ground or rate/degree of slope.

Grid - A network composed of two sets of equidistant parallel lines intersecting at right angles.

Grid Coordinates - The numbers of a coordinate system that designate a point on a grid.

Heat Shimmer - Caused by temperature differences at varying heights in air. The different air layers have a different index of refraction causing light to bend as it passes from one layer to another, causing a shimmer.

Horizontal Alignment - Consists of straight sections of roadway, known as tangents, connected by horizontal curves.

Horizontal Control - Control stations whose grid coordinates are known.

Horizontal Datum - In plane surveying, the grid system of reference used for the horizontal control of an area; defined by the easting and northing of one station in the area, and the azimuth from this selected station to an adjacent station.

Hub - A wooden stake set in the ground, with a tack or other marker to indicate the exact position. A guard stake protects and identifies the hub.

InRoads - Enables you to transfer data from electronic fieldbooks (EFBs) to the MicroStation or AutoCAD environment, reducing time from field to finished drawings with interactive data editing capabilities. It produces plot-ready graphics immediately upon reading the data. Contours can be displayed, surveys adjusted and results visually verified before you leave the site. InRoads Survey's Fieldbook Data Editor helps you interactively edit your raw survey data.

Kinematic GPS Surveys - Make use of two or more GPS units. At least one GPS unit is set up over a known (reference) station and remains stationary, while other (rover) GPS units are moved from station to station. All baselines are produced from the GPS unit occupying a reference station to the rover units. Kinematic GPS surveys can be either continuous or “stop and go”. Stop and go station observation periods are of short duration, typically under two minutes. Kinematic GPS surveys are employed where third-order or lower accuracy standards are applicable.

Laser - A device that produces an intense, coherent, directional beam of light by stimulating electronic or molecular transitions to lower energy levels.

Latitude - In plane surveying, the amount that one end of a line is north or south of the other end. As the plane coordinates of a point are known as the easting and northing of the point, the latitude is the difference between the northings of the two ends of the line, which may be either plus or minus.

Level Circuit – Using a level and rod to transfer an elevation from one point to another and back to the original.

Lois - Source for Survey Monument Control Points (LPN Sheets).

Longitude - A measure of relative position east or west on the earth's surface, given in degrees from a certain meridian, usually the prime meridian at Greenwich, England, which has a longitude of 0°.

Magnetic Storm - A disturbance or fluctuation in the earth's magnetic field, associated with solar flares.

MicroStation - A CAD software product for 2- and 3-dimensional design and drafting, developed and sold by Bentley Systems.

Monument - A permanently placed survey marker such as a stone shaft sunk into the ground.

NGS - National Geodetic Survey

Northing - One of the two values indicating the position of a point on a grid system. The northing coordinate is abbreviated: N. A term used in plane surveying that corresponds to the y-position on a Cartesian plane. See: Grid Coordinates.

Offset - Perpendicular interval; to parallel and continue a preceding course, line or boundary.

PCCP - Portland Cement Concrete Pavement

Perpendicular - A straight line at an angle of 90 degrees to a given line, plane, or surface.

Plantmix Bituminous Surface - Consists of a surface course composed of mineral aggregate and bituminous material mixed in a central mixing plant and placed on a prepared course.

Positional Tolerance - The allowable tolerance of how much something may deviate from its true location.

Prism - A transparent polygonal solid, often having triangular bases, used for dispersing light into a spectrum or for reflecting rays of light.

Prism Constant - A dimension on a prism which is an offset from the back of the glass to the center of the point.

Project Control - A set of known survey monuments for use on a particular project.

Propagate - To travel through space or a material - used of wave energy (as light, sound, or radio waves).

Radial Line - A line passing through the center of a circle or sphere.

Real Time GPS Survey (RTK) - A position location process whereby signals received from a reference device (such as a GPS receiver) can be compared using carrier phase corrections transmitted from a reference or base station to the user's roving receiver.

Reinforced Concrete Box (RCB) - A structure used to convey a stream or runoff through an embankment.

Remote Sensing - The acquisition of information about an object or phenomenon, without making physical contact with the object. In modern usage, the term generally refers to the use of aerial sensor technologies to detect and classify objects on Earth (both on the surface, and in the atmosphere and oceans) by means of propagated signals.

Residuals - The difference between the mean of a set of observations and one particular observation.

Right of Way - A parcel of land, granted by deed or easement, for construction and maintenance according to a designated use. This may include highways, streets, canals, ditches or other uses.

Riprap - Embankment protection adjacent to a stream or lake, the bank is lined with broken concrete or rock to prevent erosion.

Roadway - The portion of a highway, including shoulders, for vehicular use.

Robotic Total Station - A multi-purpose electronic surveying instrument with a built in EDM capable of measuring horizontal distances, slope distances, angles, vertical height differences, and three-dimensional coordinates.

Satellite - A manufactured object or vehicle intended to orbit the earth, the moon, or another celestial body.

Slope Staking - A special form of leveling to determine the point at which the proposed slope intersects the existing ground.

Static GPS Survey - Static GPS survey procedures allow various systematic errors to be resolved when high-accuracy positioning is required. Static procedures are used to produce baselines between stationary GPS units by recording data over an extended period of time during which the satellite geometry changes.

Station - A numerical designation for points on a project centerline which denote the distance of that point from another point on the project.

Subgrade - A surface of native material upon which a road is laid.

Survey Monuments - A reference point marked by a permanently fixed marker.

Tangent - A straight line or plane that touches a curve or curved surface at a point, but if extended does not cross it at that point.

Terrestrial - The comparison of field survey between two known points to true values.

Theodolite - An optical surveying instrument with a rotating telescope for measuring horizontal and vertical angles.

Tie - A survey connection from a point of known position to a point whose position is desired.

Total Station - A Total Station is an electronic/optical instrument used in modern surveying. The Total Station is an electronic theodolite (transit) integrated with an electronic distance meter (EDM) to read distances from the instrument to a particular point.

Traverse - To travel or pass through, over, or across a point.

Tri-Bracket - An instrument attachment plate with three leveling screws used to attach a theodolite or surveyor's level to its tripod, level the instrument, and center it precisely over a point.

***Trimble* Survey Controller and *Trimble* Access** - Are field software used in *Trimble* TSC2 and TSC3 data collectors. The older TSC2 uses *Trimble* Survey Controller and the newer TSC3 uses *Trimble* Access. *Trimble* has included on board help documentation in both versions that can be used by crews in the field.

Tripod - An adjustable three-legged stand which is the support for theodolite or level.

Vertical Alignment - A change in elevation along a roadway.

Vertical Curve - A curve on the longitudinal profile of a road to provide for change of gradient.