#19

GPS Project Control
For
Portions of Cascade Lakes Highway and Burgess Road
Under FHWA Contract No. DTFH70-95-C-00002

Located West of LaPine, OR
in
Deschutes and Klamath Counties, Oregon

Prepared At The Request Of

Transportation Utilities
W&H PACIFIC
Land Development

8405 S.W. Nimbus Avenue
Beaverton, OR 97008-7120
(503) 626-0455

Prepared By

OrbiTech
GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305
(541) 383-2715
orbitech@transport.com

Project Numbers 98018 and 98019
August, 1998

GPS Project Control
For
Portions of Cascade Lakes Highway and Burgess Road
Under FHWA Contract No. DTFH70-95-C-00002

Located West of LaPine, OR
in
Deschutes and Klamath Counties, Oregon

Table of Contents

Prepared By

OrbiTech
GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305

(541) 383-2715
orbitech@transport.com

Project Numbers 98018 and 98019

I Scope of Project

This project was performed at the request of *W&H Pacific, Inc.,* Beaverton, Oregon.

The purpose of this project was to provide GPS project control as a basis for topographic mapping of a corridor survey along Cascade Lakes Highway and Burgess Road. Both of these projects were performed for the Federal Highway Administration (FHWA) under Contract No. DTFH70-95-C-00002. The Cascade Lakes Highway portion extends from the Davis Lake area near the Deschutes / Klamath County line northerly for approximately 31 miles, ending near Elk Lake Resort. The Burgess Road portion extends from approximately the Deschutes River at Pringle Falls westerly for approximately four miles to the terminus of Burgess Road at South Century Drive. Ultimately, the control work and the topographic data collected by *W&H Pacific, Inc.* will be used by the FHWA for a widening and overlay project on the surveyed portions of these roads. The projects lie within Townships 18-23 South and Ranges 7-9 East, Willamette Meridian.

II Description of Methods Employed

The project required NAD 83(91) State Plane Coordinates (SPC) plus Local Datum Plane (LDP) coordinates and NAVD 88 elevations to be established on 16 points, four on the Burgess Road portion and 12 on the Cascade Lakes Highway portion. The points were configured on the Burgess Road portion to have an azimuth pair on either end of the project and were configured on the Cascade Lakes Highway portion to have an azimuth pair on each end and in the middle of the project section as well as a single GPS control point at approximately four mile intervals. For this report, only the SPC values are shown, as the LDP coordinates were only used internally to reduce subsequent ground traverses. The survey was performed using static GPS methods on tripods and all measurements are in the metric system per the FHWA contract.

All measurements for determining the positions established by this survey were made using two Leica System 300 dual frequency Global Positioning System (GPS) receivers. The manufacturer's stated accuracy of this equipment is 5 mm ± 1 ppm for static surveys. Each of the projects were treated as an independent network in order to facilitate the flow of field work and will be treated as separate networks throughout the remainder of this report with respect to the reported data.

GPS baseline data was processed utilizing the NGS precise ephemeris with Leica SKI, version 2.2. All measurements were simultaneously adjusted using the SKI adjustment software, and then translated to the final coordinates using the SKI Datum/Map module.

III Level of Accuracy

Burgess Road

The GPS baselines were combined in a minimally constrained least squares adjustment, holding Station WICKIUP fixed, to check the validity of the GPS measurements within themselves, with the largest error ellipse (2σ / 95% confidence level) having a semi major axis of 0.06 feet (18 mm) at Station 98125, with the largest vertical residual being 0.06 feet (20 mm) at

Station GIS 42. The network was then constrained to Deschutes County Control Survey stations GIS 39 and GIS 42 and NGS HARN Station WICKIUP (holding the latitude, longitude and ellipsoid height) with the largest error ellipse having a semi major axis of 0.06 feet (20 mm) at Station 98125, with the largest vertical residual being 0.06 feet (19 mm) also at Station 98125. The adjusted WGS84 coordinates were then transformed to NAD 83(91) SPC Oregon South Zone (3602) by applying the zone parameters to the GPS measurements. LDP coordinates were obtained by dividing each SPC northing and easting by the average combined grid factor of 0.99973895.

Orthometric heights were determined by a combination of leveling and geoid modeling. *W&H Pacific, Inc.* provided leveled elevations on the following stations: 98101, 98125 and GIS 39. Elevations were based on USC&GS benchmark P 370 (NAVD 88 elevation 1304.018 meters) and were obtained through closed differential level loops using a Leica digital level. The elevations were derived at stations 98126 and 98127 by modeling the geoid of the area by holding the stations listed above. The modeling method used was the Leica Stepwise Transformation Approach. This approach uses a local interpolation for the height values using an affine transformation approach in combination with a modeling of the local geoid separations. Once this local model was developed, it was applied to stations 98126 and 98127. The elevations at stations GIS 42 and WICKIUP for this portion of the project and as shown in this report are the published values by their respective source, either Deschutes County or the NGS.

Cascade Lakes Highway

The GPS baselines were combined in a minimally constrained least squares adjustment, holding Station CREST fixed, to check the validity of the GPS measurements within themselves, with the largest error ellipse (2σ / 95% confidence level) having a semi major axis of 0.12 feet (36 mm) at Station 98308, with the largest vertical residual being 0.15 feet (45 mm) at Station 98286. The network was then constrained to Deschutes County Control Survey stations GIS 42 and GIS 62 and NGS HARN stations CREST and WICKIUP (holding the latitude, longitude and ellipsoid height except for Station CREST, where the ECEF Cartesian coordinates were held) with the largest error ellipse having a semi major axis of 0.10 feet (30 mm) at Station 98127, with the largest vertical residual being 0.12 feet (37 mm) at Station 98286. The adjusted WGS84 coordinates were then transformed to NAD 83(91) SPC Oregon South Zone (3602) by applying the zone parameters to the GPS measurements. LDP coordinates were obtained by dividing each SPC northing and easting by the average combined grid factor of 0.99973802.

Orthometric heights were determined by a combination of leveling and geoid modeling. *W&H Pacific, Inc.* provided leveled elevations on the following stations: 98101, 98127, 98152, 98183, 98188, 98205, 98233, 98264 and 98286. Elevations were based on USGS benchmark P 10 (NAVD 88 elevation 1331.836 meters) and were obtained through closed differential level loops using a Leica digital level. The elevations were derived at stations 98100, 98308 and 98309 by using the NGS Geoid 96 model. The elevations at stations GIS 42, GIS 62, CREST and WICKIUP for this portion of the project and as shown in this report are the published values by their respective source, either Deschutes County or the NGS.

IV GPS Heights and Orthometric Elevations

Orthometric height elevations are not to be confused with GPS heights. GPS heights are based upon a mathematical surface called the *ellipsoid*, while orthometric elevations are based upon a surface called the *geoid*. Both of the surfaces are the "zero" points for their respective heights.

To convert the GPS ellipsoidal height to an orthometric height elevation, we need to know the difference in height between the two systems. This difference is not constant and changes gradually from point to point in any given area. It also varies due to changes in gravity associated with changing terrain, e.g. mountains. This change is referred to as the *geoidal undulation.*

Differential leveling measures the difference in height above the geoid between two benchmarks. GPS, on the other hand, measures the difference in height above the ellipsoid between the two marks. The relationship between the two systems can be represented by the following formula:

$N + H = h$ where N is the geoidal separation, which varies
H is the orthometric height
h is the ellipsoidal height

To convert h to H, you need N. The accuracy of GPS derived elevations depends upon how well N is known.

Our firm employs the GEOID96 model developed by the National Geodetic Survey to determine the value of N. This model was computed using nearly 1.8 million gravity values, and is accurate to roughly 3 cm (0.1 feet) over distances of 100 km (62 miles) or one part-per-million, with better accuracy over shorter distances.

Because GEOID96 is only a model and could contain small errors, we do not currently consider geoid-corrected heights to be a substitute for geodetic leveling in meeting Federal Geodetic Control Committee (FGCC) standards for vertical control networks. Work is under way on improving the model, and at present, many less stringent requirements can be met using the current model.

V Data Presentation

The final survey data is presented in the following format:

NAD 83(91) Horizontal State Plane Coordinates
NAVD 88 Vertical

The horizontal control for the adjustment of the survey networks was based upon the published positions for the following stations.

Burgess Road

Station Description	Latitude	Longitude	Source
GIS 39	43°44'27.99122" N	121°36'24.15555" W	Deschutes County
GIS 42	43°50'14.63685" N	121°41'16.16163" W	Deschutes County
WICKIUP	43°40'56.59981" N	121°41'15.57620" W	NGS

Cascade Lakes Highway

Station Description	Latitude	Longitude	Source
CREST	43°31'48.72590" N	121°56'37.59576" W	NGS
GIS 42	43°50'14.63685" N	121°41'16.16163" W	Deschutes County
GIS 62	43°59'36.76943" N	121°39'32.43139" W	Deschutes County
WICKIUP	43°40'56.59981" N	121°41'15.57620" W	NGS

The vertical control for the adjustment of the survey networks was based upon the published elevations of the following stations.

Burgess Road

Station Description	NAVD 88 Elevation	Source
98101	1321.584 Meters	*W&H Pacific, Inc.*
98125	1306.696 Meters	*W&H Pacific, Inc.*
GIS 39	1297.790 Meters	*W&H Pacific, Inc.*

Cascade Lakes Highway

GPS derived elevations were based on the NGS Geoid96 model holding the ellipsoid heights at the following stations.

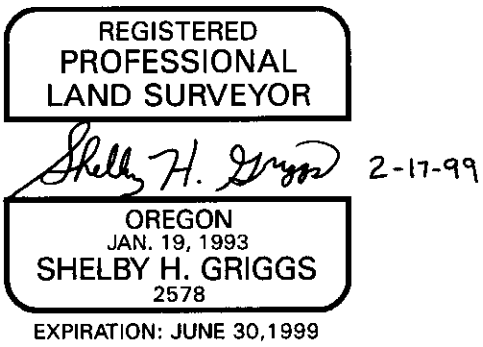
Station Description	NAD 83 Ellipsoid Height	Source
CREST	1433.203 Meters	NGS
GIS 42	1432.856 Meters	Deschutes County
GIS 62	1931.526 Meters	Deschutes County
WICKIUP	1307.409 Meters	NGS

Control Notes

See the vertical control discussion under the "Level of Accuracy" and "GPS Heights and Orthometric Elevations" sections above.

The remainder of this report consists of control placement diagrams, a summary of station data and station description sheets.

I hereby certify that this survey was conducted by me during August, 1998, at the request of *W&H Pacific, Inc.*, Beaverton, Oregon.



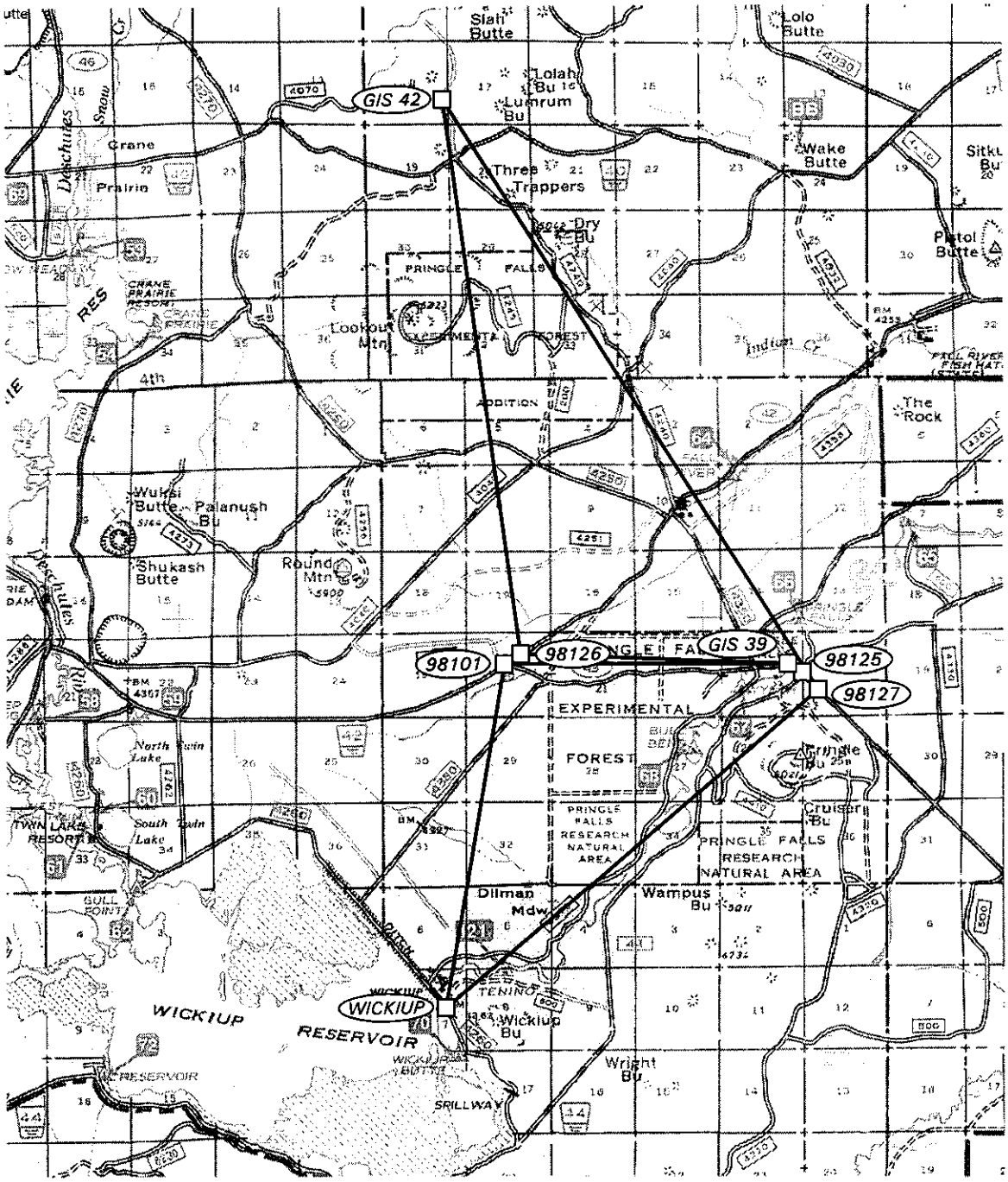
GPS Project Control
For
Portions of Cascade Lakes Highway and Burgess Road
Under FHWA Contract No. DTFH70-95-C-00002

Located West of LaPine, OR

in

Deschutes and Klamath Counties, Oregon

Burgess Road Control Placement Diagram



Portion of U.S.F.S. Deschutes National Forest Map
Oregon, 1988
Approximate Scale: 1/2" = 1 Mile

OrbiTech

GPS Surveying, Consulting and Training

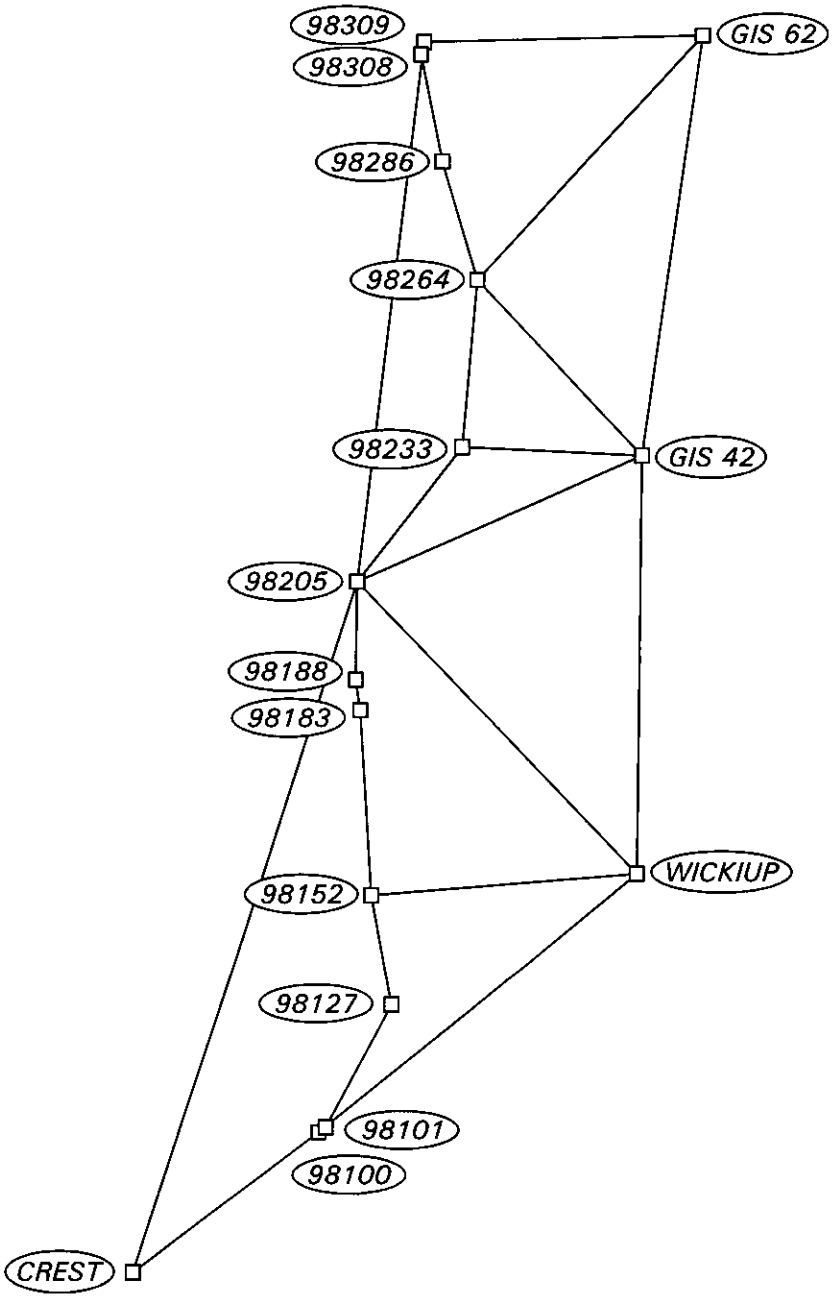
GPS Project Control
For
Portions of Cascade Lakes Highway and Burgess Road
Under FHWA Contract No. DTFH70-95-C-00002

Located West of LaPine, OR

in

Deschutes and Klamath Counties, Oregon

Cascade Lakes Highway Overall Control Placement Diagram



Scale: 1" = 8000 Meters

OrbiTech

GPS Surveying, Consulting and Training

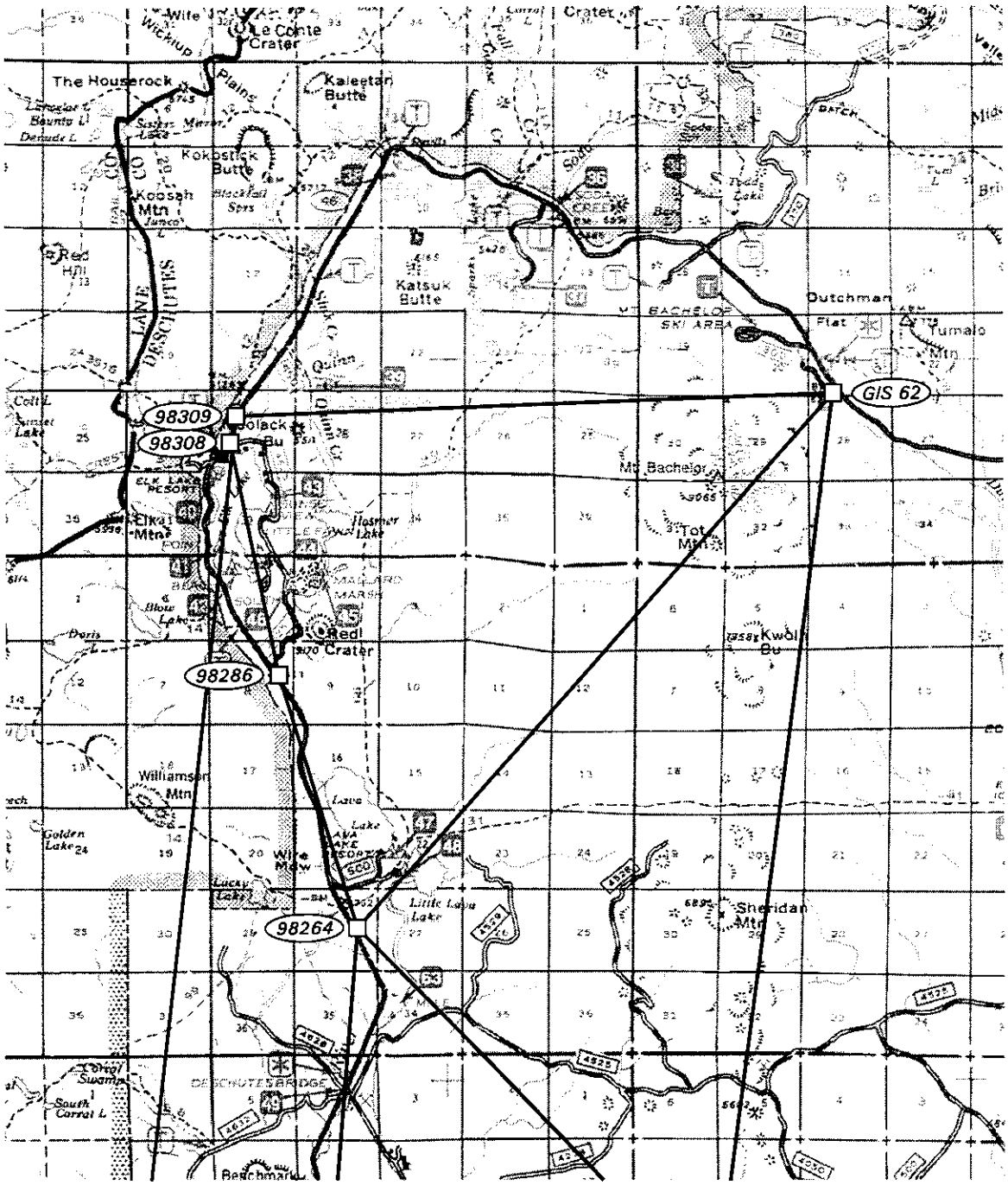
GPS Project Control
For
Portions of Cascade Lakes Highway and Burgess Road
Under FHWA Contract No. DTFH70-95-C-00002

Located West of LaPine, OR

in

Deschutes and Klamath Counties, Oregon

Cascade Lakes Highway Control Placement Diagram 1 of 3



Portion of U.S.F.S. Deschutes National Forest Map
Oregon, 1988
Approximate Scale: 1/2" = 1 Mile

OrbiTech

GPS Surveying, Consulting and Training

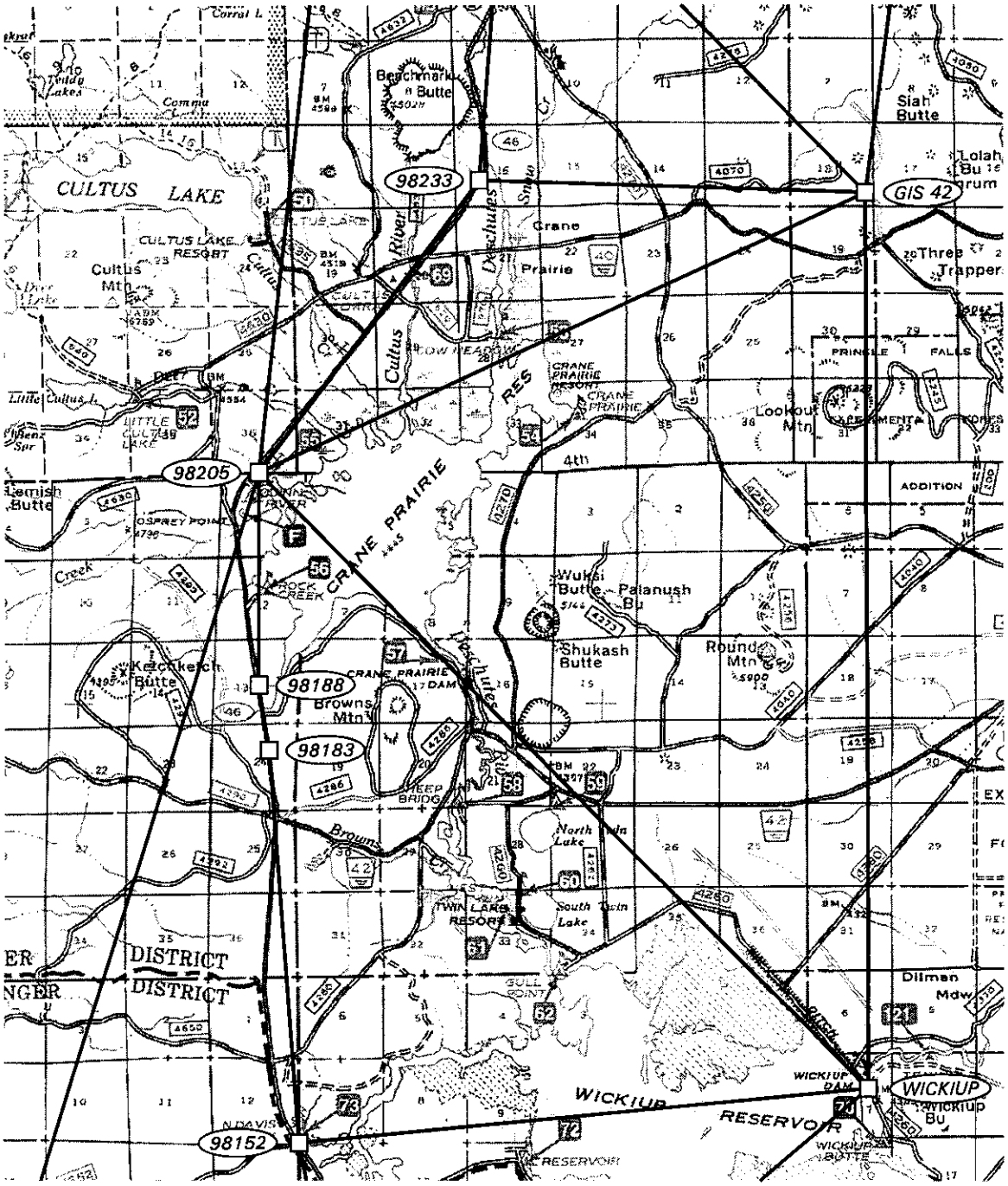
GPS Project Control
For
Portions of Cascade Lakes Highway and Burgess Road
Under FHWA Contract No. DTFH70-95-C-00002

Located West of LaPine, OR

in

Deschutes and Klamath Counties, Oregon

Cascade Lakes Highway Control Placement Diagram 2 of 3



Portion of U.S.F.S. Deschutes National Forest Map
Oregon, 1988
Approximate Scale: 1/2" = 1 Mile

OrbiTech

GPS Surveying, Consulting and Training

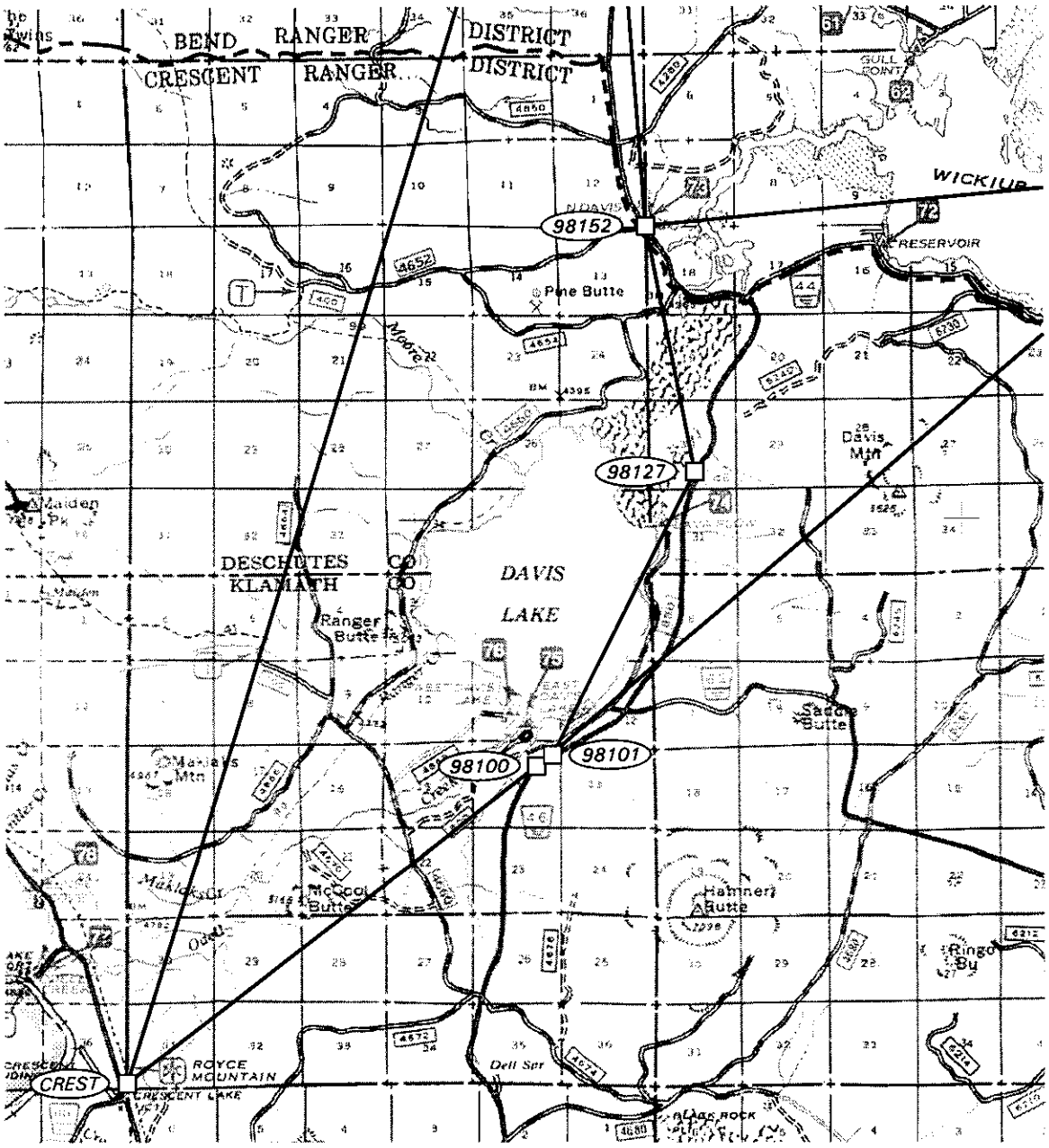
GPS Project Control
For
Portions of Cascade Lakes Highway and Burgess Road
Under FHWA Contract No. DTFH70-95-C-00002

Located West of LaPine, OR

in

Deschutes and Klamath Counties, Oregon

Cascade Lakes Highway Control Placement Diagram 3 of 3



Portion of U.S.F.S. Deschutes National Forest Map
Oregon, 1988
Approximate Scale: 1/2" = 1 Mile

OrbiTech

GPS Surveying, Consulting and Training

GPS Project Control
For
Portions of Cascade Lakes Highway and Burgess Road
Under FHWA Contract No. DTFH70-95-C-00002

Located West of LaPine, OR
in
Deschutes and Klamath Counties, Oregon

Horizontal Datum: NAD 83(91)
State Plane Coordinates (Zone 3602, Oregon South)

Vertical Datum: NAVD 88
All units are in Meters

Burgess Road

Station	Latitude	Longitude	Northing (m)	Easting (m)	Elevation (m)	Convergence	Grid Factor	Elevation Factor	Combined Factor
98101	43°44'28.40204" N	121°40'25.22879" W	231114.311	1405464.178	1321.584	-0°48'10.679"	0.99994453	0.99979613	0.99974067
98125	43°44'22.65072" N	121°36'11.81904" W	230859.756	1411131.324	1306.696	-0°45'17.310"	0.99994425	0.99979845	0.99974272
98126	43°44'34.52508" N	121°40'11.29294" W	231298.896	1405778.600	1319.560	-0°48'01.145"	0.99994483	0.99979644	0.99974128
98127	43°44'12.14119" N	121°35'58.48620" W	230531.522	1411425.369	1307.503	-0°45'08.188"	0.99994374	0.99979833	0.99974209
GIS39	43°44'27.99122" N	121°36'24.15555" W	231028.199	1410857.491	1297.790	-0°45'25.750"	0.99994451	0.99979985	0.99974437
GIS42	43°50'14.63685" N	121°41'16.16163" W	241814.777	1404476.227	1453.659	-0°48'45.525"	0.99996274	0.99977542	0.99973817
WICKIUP	43°40'56.59981" N	121°41'15.57620" W	224594.403	1404245.081	1328.3	-0°48'45.124"	0.99993478	0.99979507	0.99972987

OrbiTech
GPS Surveying, Consulting and Training

GPS Project Control
For
Portions of Cascade Lakes Highway and Burgess Road
Under FHWA Contract No. DTFH70-95-C-00002

Located West of LaPine, OR
in
Deschutes and Klamath Counties, Oregon

Horizontal Datum: NAD 83(91)
State Plane Coordinates (Zone 3602, Oregon South)

Vertical Datum: NAVD 88
All units are in Meters

Cascade Lakes Highway (1 of 2)

Station	Latitude	Longitude	Northing (m)	Easting (m)	Elevation (m)	Convergence	Grid Factor	Elevation Factor	Combined Factor
98100	43°35'00.80097" N	121°50'58.23456" W	213813.437	1391020.122	1357.980	-0°55'23.748"	0.99992080	0.99979043	0.99971125
98101	43°35'07.48963" N	121°50'45.26166" W	214015.139	1391314.422	1359.047	-0°55'14.873"	0.99992103	0.99979026	0.99971131
98127	43°37'56.54332" N	121°48'46.77207" W	219189.310	1394053.867	1395.518	-0°53'53.809"	0.99992733	0.99978455	0.99971190
98152	43°40'22.98225" N	121°49'27.27684" W	223722.215	1393217.522	1330.102	-0°54'21.520"	0.99993333	0.99979480	0.99972815
98183	43°44'29.35513" N	121°49'53.25406" W	231333.802	1392756.582	1374.846	-0°54'39.292"	0.99994457	0.99978778	0.99973237
98188	43°45'09.74749" N	121°50'02.30899" W	232583.435	1392573.860	1357.621	-0°54'45.487"	0.99994655	0.99979048	0.99973704
98205	43°47'21.79225" N	121°50'02.26180" W	236658.031	1392639.823	1358.678	-0°54'45.455"	0.99995330	0.99979031	0.99974362
98233	43°50'22.76390" N	121°46'50.70390" W	242175.711	1397007.394	1375.129	-0°52'34.401"	0.99996320	0.99978772	0.99975094

OrbiTech
GPS Surveying, Consulting and Training

GPS Project Control
For
Portions of Cascade Lakes Highway and Burgess Road
Under FHWA Contract No. DTFH70-95-C-00002

Located West of LaPine, OR
in
Deschutes and Klamath Counties, Oregon

Horizontal Datum: NAD 83(91)
State Plane Coordinates (Zone 3602, Oregon South)

Vertical Datum: NAVD 88
All units are in Meters

Cascade Lakes Highway (2 of 2)

Station	Latitude	Longitude	Northing (m)	Easting (m)	Elevation (m)	Convergence	Grid Factor	Elevation Factor	Combined Factor
98264	43°54'04.19925" N	121°46'26.72100" W	249000.880	1397647.042	1458.059	-0°52'17.993"	0.99997639	0.99977470	0.99975109
98286	43°56'42.99501" N	121°47'34.63328" W	253924.518	1396207.357	1498.526	-0°53'04.455"	0.99998655	0.99976835	0.99975490
98308	43°59'07.15604" N	121°48'16.64981" W	258387.903	1395339.825	1513.262	-0°53'33.201"	0.99999630	0.99976604	0.99976235
98309	43°59'23.66980" N	121°48'11.46180" W	258895.727	1395463.356	1527.131	-0°53'29.651"	0.99999745	0.99976387	0.99976132
CREST	43°31'48.72590" N	121°56'37.59576" W	208013.917	1383306.124	1454.3	-0°59'15.921"	0.99991449	0.99977536	0.99968987
GIS42	43°50'14.63685" N	121°41'16.16163" W	241814.777	1404476.227	1453.659	-0°48'45.525"	0.99996274	0.99977542	0.99973817
GIS62	43°59'36.76943" N	121°39'32.43139" W	259129.991	1407033.368	1951.789	-0°47'34.558"	0.99999837	0.99969731	0.99969568
WICKIUP	43°40'56.59981" N	121°41'15.57620" W	224594.403	1404245.081	1328.3	-0°48'45.124"	0.99993478	0.99979507	0.99972987

GPS Surveying, Consulting and Training

Station Control Data Sheet

Prepared By:

OrbiTech

GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305
(541) 383-2715
orbitech@transport.com

Station Designation: 98101

Station Location: Burgess Rd / S Century Drive

Horiz. Method: GPS
Vert. Method: Leveled
Error Ellipse Semi major axis
(95% Confidence Level)
± 0.013 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°44'28.40204" N
Longitude: 121°40'25.22879" W
Ellipsoid Height: 1,300.646 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

Northing: 231,114.311 Meters
Easting: 1,405,464.178 Meters

Northing: 758,249.05 Int. Feet
Easting: 4,611,102.95 Int. Feet

θ: -0°48'10.679"
Scale Factor: 0.99994453
Elevation Factor: 0.99979613
Combined Factor: 0.99974067

NAVD 88 Orthometric Elevation

1,321.584 Meters 4,335.90 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Point is located at the intersection of Burgess Road and South Century Drive, 2.2 meters west of the westerly fog stripe of the drive. This point is intervisible with point 98126.

FHWA
·
CP

REGISTERED
PROFESSIONAL
LAND SURVEYOR

OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578

EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech

GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305
(541) 383-2715
orbitech@transport.com

Station Designation: 98125

Station Location: Burgess Rd / USFS Rd 44

Horiz. Method: GPS
Vert. Method: Leveled
Error Ellipse Semi major axis
(95% Confidence Level)
± 0.020 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°44'22.65072" N
Longitude: 121°36'11.81904" W
Ellipsoid Height: 1,285.804 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

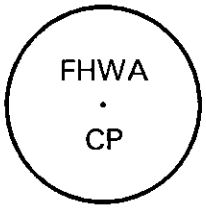
Northing:	230,859.756	Meters
Easting:	1,411,131.324	Meters
Northing:	757,413.90	Int. Feet
Easting:	4,629,695.95	Int. Feet

θ: -0°45'17.310"
Scale Factor: 0.99994425
Elevation Factor: 0.99979845
Combined Factor: 0.99974272

NAVD 88 Orthometric Elevation

1,306.696 Meters 4,287.05 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Point is located at the intersection of Burgess Road and USFS Road 44 to southwest and USFS Road to Pringle Falls Campground to northeast, 5.0 meters north of the north edge of pavement of Burgess Road and 1.6 meters east of the east edge of pavement of the road to the campground. References: a 20 cm Pine bears N 22° E, 6.30 meters and a 28 cm Pine bears N 86°E, 16.30 meters. Bearings are magnetic (0° declination). This point is intervisible with point 98127.



REGISTERED
PROFESSIONAL
LAND SURVEYOR

Shelby H. Griggs

OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578

EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech

GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305
(541) 383-2715
orbitech@transport.com

Station Designation: 98126

Station Location: S Century Drive

Horiz. Method: GPS
Vert. Method: GPS Derived
Error Ellipse Semi major axis
(95% Confidence Level)
± 0.015 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°44'34.52508" N
Longitude: 121°40'11.29294" W
Ellipsoid Height: 1,298.637 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

Northing: 231,298.896 Meters
Easting: 1,405,778.600 Meters

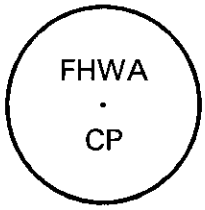
Northing: 758,854.64 Int. Feet
Easting: 4,612,134.51 Int. Feet

θ: -0°48'01.145"
Scale Factor: 0.99994483
Elevation Factor: 0.99979644
Combined Factor: 0.99974128

NAVD 88 Orthometric Elevation

1,319.560 Meters 4,329.26 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Point is located 365 meters northeast of the intersection of Burgess Road and South Century Drive on the southeast side of the drive. This point is intervisible with point 98101.



REGISTERED
PROFESSIONAL
LAND SURVEYOR

OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578

EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech

GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305
(541) 383-2715
orbitech@transport.com

Station Designation: 98127

Station Location: Burgess Road

Horiz. Method: GPS
Vert. Method: GPS Derived

Error Ellipse Semi major axis
(95% Confidence Level)
± 0.012 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°44'12.14119" N
Longitude: 121°35'58.48620" W
Ellipsoid Height: 1,286.593 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

Northing:	230,531.522	Meters
Easting:	1,411,425.369	Meters
Northing:	756,337.01	Int. Feet
Easting:	4,630,660.66	Int. Feet

θ: -0°45'08.188"
Scale Factor: 0.99994374
Elevation Factor: 0.99979833
Combined Factor: 0.99974209

NAVD 88 Orthometric Elevation

1,307.503 Meters 4,289.70 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Point is located 441 meters southeast of the intersection of Burgess Road and USFS Road 44 on the southwest side of the road. This point is intervisible with point 98125.

FHWA
·
CP

REGISTERED
PROFESSIONAL
LAND SURVEYOR

OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578

EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech
GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305

(541) 383-2715
orbitech@transport.com

Station Designation: 98100

Station Location: Cascade Lakes Hwy

Horiz. Method: GPS
Vert. Method: GPS Derived

Error Ellipse Semi major axis
(95% Confidence Level)
± 0.018 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°35'00.80097" N
Longitude: 121°50'58.23456" W
Ellipsoid Height: 1,337.002 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

Northing: 213,813.437 Meters
Easting: 1,391,020.122 Meters

Northing: 701,487.65 Int. Feet
Easting: 4,563,714.31 Int. Feet

θ: -0°55'23.748"
Scale Factor: 0.99992080
Elevation Factor: 0.99979043
Combined Factor: 0.99971125

NAVD 88 Orthometric Elevation

1,357.980 Meters 4,455.31 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Point is located approximately 412 meters southwest along the Cascade Lakes Highway from the northerly terminus of road maintenance by Klamath County of the highway and is located on the northwest side of the highway. This point is intervisible with point 98101.

FHWA
·
CP

REGISTERED
PROFESSIONAL
LAND SURVEYOR

Shelby H. Griggs

OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578

EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech

GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305
(541) 383-2715
orbitech@transport.com

Station Designation: 98101

Station Location: Cascade Lakes Hwy

Horiz. Method: GPS
Vert. Method: Leveled
Error Ellipse Semi major axis
(95% Confidence Level)
± 0.021 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°35'07.48963" N
Longitude: 121°50'45.26166" W
Ellipsoid Height: 1,338.091 Meters

NAD 83 (91) State Plane Coordinates Zone 3602, Oregon South

Northing:	214,015.139	Meters
Easting:	1,391,314.422	Meters
Northing:	702,149.40	Int. Feet
Easting:	4,564,679.86	Int. Feet

θ: -0°55'14.873"
Scale Factor: 0.99992103
Elevation Factor: 0.99979026
Combined Factor: 0.99971131

NAVD 88 Orthometric Elevation

1,359.047 Meters 4,458.81 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Point is located approximately 55 meters southwest along the Cascade Lakes Highway from the northerly terminus of road maintenance by Klamath County of the highway and 2.1 km southwest of the junction with USFS Road 62. Station is located 2.20 meters northwest of the westerly edge of pavement of the highway. References: a 16 cm Pine bears N 82° W, 12.88 meters and a 20 cm Pine bears N 36°W, 8.85 meters. Bearings are magnetic (0° declination). This point is intervisible with point 98100.

FHWA
•
CP

REGISTERED
PROFESSIONAL
LAND SURVEYOR

OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578

EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech
GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305

(541) 383-2715
orbitech@transport.com

Station Designation: 98127

Station Location: Cascade Lakes Hwy

Horiz. Method: GPS
Vert. Method: Leveled
Error Ellipse Semi major axis
(95% Confidence Level)
± 0.030 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°37'56.54332" N
Longitude: 121°48'46.77207" W
Ellipsoid Height: 1,374.534 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

Northing:	219,189.310	Meters
Easting:	1,394,053.867	Meters
Northing:	719,125.03	Int. Feet
Easting:	4,573,667.54	Int. Feet

θ: -0°53'53.809"
Scale Factor: 0.99992733
Elevation Factor: 0.99978455
Combined Factor: 0.99971190

NAVD 88 Orthometric Elevation

1,395.518 Meters 4,578.46 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Station is located 1.06 meters west of the westerly edge of pavement of Cascade Lakes Highway and on the west side of a guardrail. References: a 33 cm Pine bears S 62° W, 18.80 meters and an 18 cm Pine bears N 46°W, 21.60 meters. Bearings are magnetic (0° declination).

FHWA
·
CP

REGISTERED
PROFESSIONAL
LAND SURVEYOR
Shelby H. Griggs
OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578
EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech

GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305
(541) 383-2715
orbitech@transport.com

Station Designation: 98152

Station Location: Cascade Lakes Hwy

Horiz. Method: GPS
Vert. Method: Leveled
Error Ellipse Semi major axis
(95% Confidence Level)
± 0.022 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°40'22.98225" N
Longitude: 121°49'27.27684" W
Ellipsoid Height: 1,309.130 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

Northing:	223,722.215	Meters
Easting:	1,393,217.522	Meters
Northing:	733,996.77	Int. Feet
Easting:	4,570,923.63	Int. Feet

θ: -0°54'21.520"
Scale Factor: 0.99993333
Elevation Factor: 0.99979480
Combined Factor: 0.99972815

NAVD 88 Orthometric Elevation

1,330.102 Meters 4,363.84 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Station is located 3.22 meters northeast of the easterly edge of pavement of Cascade Lakes Highway, approximately 60 meters southerly of the intersection with USFS Road 4652 and North Davis Creek Campground. References: a 24 cm Pine bears N 88° E, 11.05 meters and a 12 cm Pine bears N 14°W, 5.30 meters. Bearings are magnetic (0° declination).

FHWA
·
CP

REGISTERED
PROFESSIONAL
LAND SURVEYOR

Shelby H. Griggs

OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578

EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech

GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305
(541) 383-2715
orbitech@transport.com

Station Designation: 98183

Station Location: Cascade Lakes Hwy

Horiz. Method: GPS
Vert. Method: Leveled

Error Ellipse Semi major axis
(95% Confidence Level)
± 0.028 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°44'29.35513" N
Longitude: 121°49'53.25406" W
Ellipsoid Height: 1,353.922 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

Northing:	231,333.802	Meters
Easting:	1,392,756.582	Meters
Northing:	758,969.17	Int. Feet
Easting:	4,569,411.36	Int. Feet

θ: -0°54'39.292"
Scale Factor: 0.99994457
Elevation Factor: 0.99978778
Combined Factor: 0.99973237

NAVD 88 Orthometric Elevation

1,374.846 Meters 4,510.64 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Station is located 2.56 meters east of the easterly edge of pavement of Cascade Lakes Highway. References: a 17 cm Pine bears N 31° E, 6.58 meters and a 19 cm Pine bears S 46° E, 9.52 meters. Bearings are magnetic (0° declination). This point is intervisible with point 98188.

FHWA
·
CP

REGISTERED
PROFESSIONAL
LAND SURVEYOR

OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578

EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech

GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305
(541) 383-2715
orbitech@transport.com

Station Designation: 98188

Station Location: Cascade Lakes Hwy

Horiz. Method: GPS
Vert. Method: Leveled

Error Ellipse Semi major axis
(95% Confidence Level)
± 0.028 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°45'09.74749" N
Longitude: 121°50'02.30899" W
Ellipsoid Height: 1,336.714 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

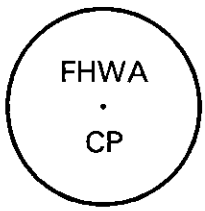
Northing:	232,583.435	Meters
Easting:	1,392,573.860	Meters
Northing:	763,069.01	Int. Feet
Easting:	4,568,811.88	Int. Feet

θ: -0°54'45.487"
Scale Factor: 0.99994655
Elevation Factor: 0.99979048
Combined Factor: 0.99973704

NAVD 88 Orthometric Elevation

1,357.621 Meters 4,454.13 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Station is located 2.82 meters west of the westerly edge of pavement of Cascade Lakes Highway and across the highway from a large unpaved pullout in a fill section of the highway that passes through a slough section of Crane Prairie Reservoir. References: a 10 cm Pine bears S 6° E, 2.75 meters and a 9 cm Pine bears S 50° W, 3.71 meters. Bearings are magnetic (0° declination). This point is intervisible with point 98183.



REGISTERED
PROFESSIONAL
LAND SURVEYOR

Shelby H. Griggs

OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578

EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech

GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305
(541) 383-2715
orbitech@transport.com

Station Designation: 98205

Station Location: Cascade Lakes Hwy

Horiz. Method: GPS
Vert. Method: Leveled
Error Ellipse Semi major axis
(95% Confidence Level)
± 0.012 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°47'21.79225" N
Longitude: 121°50'02.26180" W
Ellipsoid Height: 1,337.794 Meters

NAD 83 (91) State Plane Coordinates Zone 3602, Oregon South

Northing:	236,658.031	Meters
Easting:	1,392,639.823	Meters
Northing:	776,437.11	Int. Feet
Easting:	4,569,028.29	Int. Feet

θ: -0°54'45.455"
Scale Factor: 0.99995330
Elevation Factor: 0.99979031
Combined Factor: 0.99974362

NAVD 88 Orthometric Elevation

1,358.678 Meters 4,457.60 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Station is located 4.27 meters east of the easterly edge of pavement of Cascade Lakes Highway. References: a 5 cm Pine bears S 84° E, 11.78 meters and a 7 cm Pine bears S 26° E, 13.83 meters. Bearings are magnetic (0° declination).

FHWA
·
CP

REGISTERED
PROFESSIONAL
LAND SURVEYOR

Shelby H. Griggs

OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578

EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech
GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305

(541) 383-2715
orbitech@transport.com

Station Designation: 98233

Station Location: Cascade Lakes Hwy

Horiz. Method: GPS
Vert. Method: Leveled

Error Ellipse Semi major axis
(95% Confidence Level)
± 0.015 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°50'22.76390" N
Longitude: 121°46'50.70390" W
Ellipsoid Height: 1,354.302 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

Northing: 242,175.711 Meters
Easting: 1,397,007.394 Meters

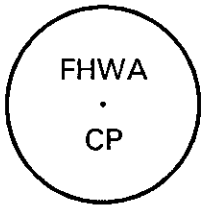
Northing: 794,539.73 Int. Feet
Easting: 4,583,357.59 Int. Feet

θ: -0°52'34.401"
Scale Factor: 0.99996320
Elevation Factor: 0.99978772
Combined Factor: 0.99975094

NAVD 88 Orthometric Elevation

1,375.129 Meters 4,511.57 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Station is located 2.62 meters east of the easterly edge of pavement of Cascade Lakes Highway. References: a 13 cm Pine bears N 12° E, 3.17 meters and a 10 cm Pine bears S 38° E, 9.64 meters. Bearings are magnetic (0° declination).



EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech
GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305

(541) 383-2715
orbitech@transport.com

Station Designation: 98264

Station Location: Cascade Lakes Hwy

Horiz. Method: GPS
Vert. Method: Leveled

Error Ellipse Semi major axis
(95% Confidence Level)
± 0.013 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°54'04.19925" N
Longitude: 121°46'26.72100" W
Ellipsoid Height: 1,437.436 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

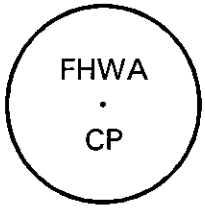
Northing:	249,000.880	Meters
Easting:	1,397,647.042	Meters
Northing:	816,932.02	Int. Feet
Easting:	4,585,456.17	Int. Feet

θ: -0°52'17.993"
Scale Factor: 0.99997639
Elevation Factor: 0.99977470
Combined Factor: 0.99975109

NAVD 88 Orthometric Elevation

1,458.059 Meters 4,783.65 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Station is located 3.15 meters northeast of the easterly edge of pavement of Cascade Lakes Highway and on the north side of a gravel drive to a trail head parking area. References: a 17 cm Pine bears N 62° E, 13.56 meters and a 15 cm Pine bears N 26° W, 9.77 meters. Bearings are magnetic (0° declination).



Station Control Data Sheet

Prepared By:

OrbiTech
GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305

(541) 383-2715
orbitech@transport.com

Station Designation: 98286

Station Location: Cascade Lakes Hwy

Horiz. Method: GPS
Vert. Method: Leveled

Error Ellipse Semi major axis
(95% Confidence Level)
± 0.022 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°56'42.99501" N
Longitude: 121°47'34.63328" W
Ellipsoid Height: 1,478.006 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

Northing:	253,924.518	Meters
Easting:	1,396,207.357	Meters
Northing:	833,085.69	Int. Feet
Easting:	4,580,732.80	Int. Feet

θ: -0°53'04.455"
Scale Factor: 0.99998655
Elevation Factor: 0.99976835
Combined Factor: 0.99975490

NAVD 88 Orthometric Elevation

1,498.526 Meters 4,916.41 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Station is located 2.51 meters northeast of the easterly edge of pavement of Cascade Lakes Highway. References: a 19 cm Pine bears N 6° E, 7.36 meters and a 12 cm Pine bears N 86° E, 8.52 meters. Bearings are magnetic (0° declination).

FHWA
·
CP

REGISTERED
PROFESSIONAL
LAND SURVEYOR

OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578

EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech

GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305
(541) 383-2715
orbitech@transport.com

Station Designation: 98308

Station Location: Cascade Lakes Hwy

Horiz. Method: GPS
Vert. Method: GPS Derived

Error Ellipse Semi major axis
(95% Confidence Level)
± 0.022 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°59'07.15604" N
Longitude: 121°48'16.64981" W
Ellipsoid Height: 1,492.712 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

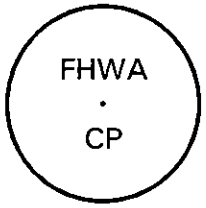
Northing:	258,387.903	Meters
Easting:	1,395,339.825	Meters
Northing:	847,729.34	Int. Feet
Easting:	4,577,886.56	Int. Feet

θ: -0°53'33.201"
Scale Factor: 0.99999630
Elevation Factor: 0.99976604
Combined Factor: 0.99976235

NAVD 88 Orthometric Elevation

1,513.262 Meters 4,964.76 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Station is located on the easterly side of Cascade Lakes Highway at its intersection with USFS Road 4625 (East Elk Lake Loop). The station is located at the northeast side of the intersection in the borrow ditch and 1.64 meters northeast from the edge of pavement on the return curve of the intersection. References: a 13 cm Pine bears N 18° E, 18.60 meters and a 25 cm Pine bears N 64° E, 14.40 meters. Bearings are magnetic (0° declination). This point is intervisible with point 98309.



EXPIRATION: JUNE 30,1999

Station Control Data Sheet

Prepared By:

OrbiTech

GPS Surveying, Consulting and Training

P.O. Box 5305
Bend, Oregon 97708-5305
(541) 383-2715
orbitech@transport.com

Station Designation: 98309

Station Location: Cascade Lakes Hwy

Horiz. Method: GPS
Vert. Method: GPS Derived

Error Ellipse Semi major axis
(95% Confidence Level)
± 0.018 Meters

NAD 83 (91) Geodetic Coordinates

Latitude: 43°59'23.66980" N
Longitude: 121°48'11.46180" W
Ellipsoid Height: 1,506.593 Meters

NAD 83 (91) State Plane Coordinates
Zone 3602, Oregon South

Northing: 258,895.727 Meters
Easting: 1,395,463.356 Meters

Northing: 849,395.43 Int. Feet
Easting: 4,578,291.85 Int. Feet

θ: -0°53'29.651"
Scale Factor: 0.99999745
Elevation Factor: 0.99976387
Combined Factor: 0.99976132

NAVD 88 Orthometric Elevation

1,527.131 Meters 5,010.26 US Feet

Set a 1/2" diameter X 18" long rebar with a 1" diameter yellow plastic cap marked "FHWA CP". Station is located 2.14 meters west of the westerly edge of pavement of Cascade Lakes Highway. References: a 15 cm Pine bears S 38° W, 12.65 meters and a 12 cm Pine bears N 38° W, 9.70 meters. Bearings are magnetic (0° declination). This point is intervisible with point 98308.

FHWA
·
CP

REGISTERED
PROFESSIONAL
LAND SURVEYOR

Shelby H. Griggs

OREGON
JAN. 19, 1993
SHELBY H. GRIGGS
2578

EXPIRATION: JUNE 30,1999