

**Minimum Technical Standards Report  
Control Survey &  
Specific Purpose Survey for LiDAR**



**PREPARED FOR:  
UNITED STATES GEOLOGICAL SURVEY  
& FEDERAL EMERGENCY MANAGEMENT AGENCY**



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2011 FEMA VI-UPPER BLACK WATERSHED LIDAR  
DATE: 10 APRIL 2012

**Technical Standards Report  
Control Survey & Specific Purpose Survey for LiDAR**

2011 FEMA VI-Upper Black Watershed

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## **Introduction & Specification**

The purpose of this project was to provide ground truth data which will be used to validate LiDAR data of the Upper Black Watershed LiDAR project located in North East Arkansas. The ground surveys were conducted utilizing the CORS network to collect checkpoints of 10% of the predominant vegetation within the AOI. The vertical accuracy requirements meet or exceed the required RMSEz of 12.5cm and the vertical accuracy of 24.5cm at the 95% confidence level as specified by the SOW using NSSDA accuracy standards.

## **Ground Truth Survey**

Ground Truth data was collected of the five major land cover classes representing 10% of the predominate vegetation dispersed within the area of interest. 20 points were collected in each of the five predominate vegetation classes, bare earth, urban, tall weeds/ crops, brush lands, and forested/fully grown, all were collected with a Total Station. A pair of points was surveyed using the CORS network once completed the total station is used to collect the all vegetation ground classes. A Leica 1103 TCR+ total station was used to collect all the shots collected in all the classes surveyed, due to the limited GPS signal when working in and around tree canopy.

## **Datum & Coordinate Systems**

The survey data and coordinate values associated with this project are referenced to the Universal Transverse Mercator Coordinate System, Zone 15 units of Meters, North Americas Datum of 1983, in units of Meters. Geoid 09 was used to determine the NAVD88 heights.

## **Survey Area**

The project area is approximately 154 square miles and the AOI lies in a portion of Clay, Greene and Randolph Counties in Arkansas.

## **Control Survey**

The GPS survey was tied into the CORS Network located in Arkansas, Missouri and Oklahoma. The CORS network is a network of continuously operating GPS reference stations. This allows post processing of the GPS points. Five (5) CORS stations were used (ARBT, ARPG, MODX, MOKE, MOVB)

As a quality control measure differential levels using a Leica DNA 10 level were run between the pair of GPS points used to collect field data, also random points were collected to confirm that the project will meet the 5cm local network accuracy at the 95% confidence level.

Survey field work was performed on 2-23-12 thru 2-25-12 by Maptech Inc. field crews using Leica 1203 Global Positioning System with Leica ATX1230 and Leica ATX1230GG antennas.

## Vertical Accuracy Analysis

Data analysis was accomplished by comparing ground truth checkpoints with LIDAR points from the edited data set, which were within 1 meter horizontally from the ground truth points. Based on the number of returns and the density of points in this project, it was not necessary to compare to anything further away than 1 meter horizontally from the ground truth points. Vertical accuracy requirements follow the NSSDA specifications based on RMSE of 12.5 cm in open terrain land cover category. This assessment verifies the vertical accuracy of the LiDAR derived DEM shall be calculated and reported in three ways. 1. FVA 2.SVA 3.CVA. Additionally the FVA points were assessed against the TIN derived from the LAS LiDAR point cloud controlled and calibrated swath data to ensure they met the required accuracy of 12.5cm RMSEz and 24.5cm at the 95% confidence interval. The results can be found within Table 1.

Table 1- shows the complete results from the RMSE calculations. The required accuracies of the FVA and the CVA are within the required specifications.

<b>Land Cover Category Calculated against the DEM</b>	<b># of Points</b>	<b>FVA Required 24.5</b>	<b>SVA Target 36.3</b>	<b>CVA Required 36.3</b>	<b>FVA Calculated Against the TIN derived from the Swath Data Required 24.5</b>
Consolidated All Classes	100			0.29	
Bare earth (Open Terrain)	20	0.06			0.07
Urban	20		0.08		
Tall Weeds Crops	20		0.25		
Brush Low Trees	20		0.36		
Forested	20		0.30		

## Horizontal Accuracy Analysis

There is not a systematic method of testing when testing horizontal accuracy in LiDAR. The horizontal accuracy is checked by collecting building corners during the survey. Lines are then digitized while viewing the intensity images representing the building outline and the differences are measure from each individual survey point to the corner of the building outline. Stats are calculated to ensure horizontal tolerances are met. These measurements resulted in an RMSEr of 0.25 meters and a horizontal accuracy of 0.44 meter horizontal accuracy at the 95 % confidence interval. Method used was the NSSDA standard for horizontal accuracy assessment.

FGDC-STD-007.3-1998

$$RMSE_{northing} = \sqrt{[\sum (CONTROL_{northing} - MEASURED_{northing})^2/n]}$$

$$RMSE_{easting} = \sqrt{[\sum (CONTROL_{easting} - MEASURED_{easting})^2/n]}$$

$$RMSE_r = \sqrt{[RMSE_{easting}^2 + RMSE_{northing}^2]}$$

$$RMSE \text{ accuracy} = 1.7308 * RMSE_r$$

## **Appendix A**

# The NGS Data Sheet

See file [dsdata.txt](#) for more information about the datasheet.

```

DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.87.5
1      National Geodetic Survey,  Retrieval Date = FEBRUARY 14, 2012
DH8992 *****
DH8992  CORS           -   This is a GPS Continuously Operating Reference Station.
DH8992  DESIGNATION  -   BATESVILLE CORS ARP
DH8992  CORS_ID      -   ARBT
DH8992  PID          -   DH8992
DH8992  STATE/COUNTY-   AR/INDEPENDENCE
DH8992  USGS QUAD    -   JAMESTOWN (1981)
DH8992
DH8992                      *CURRENT SURVEY CONTROL
DH8992
DH8992  _____
DH8992*  NAD 83(CORS)-   35 42 35.52897(N)    091 37 42.73873(W)    ADJUSTED
DH8992*  NAVD 88      -                   ** (meters)                ** (feet)
DH8992  _____
DH8992  EPOCH DATE   -           2002.00
DH8992  X            -   -147,353.295 (meters)                        COMP
DH8992  Y            -   -5,182,836.019 (meters)                      COMP
DH8992  Z            -   3,702,154.503 (meters)                       COMP
DH8992  ELLIP HEIGHT-           93.161 (meters)                      (03/??/06) ADJUSTED
DH8992  GEOID HEIGHT-          -27.48 (meters)                       GEOID09
DH8992  HORZ ORDER  -   SPECIAL (CORS)
DH8992  ELLP ORDER  -   SPECIAL (CORS)
DH8992
DH8992. ITRF positions are available for this station.
DH8992
DH8992. The coordinates were established by GPS observations
DH8992. and adjusted by the National Geodetic Survey in March 2006.
DH8992
DH8992. The datum tag of NAD 83(CORS) is equivalent to NAD 83(CORS96).
DH8992
DH8992. The coordinates are valid at the epoch date displayed above
DH8992. which is a decimal equivalence of Year/Month/Day.
DH8992
DH8992. The PID for the CORS L1 Phase Center is DH8993.
DH8992
DH8992. The XYZ, and position/ellipsoidal ht. are equivalent.
DH8992
DH8992. The ellipsoidal height was determined by GPS observations
DH8992. and is referenced to NAD 83.
DH8992
DH8992. The geoid height was determined by GEOID09.
DH8992
DH8992;
DH8992;          North          East          Units Scale Factor Converg.
DH8992; SPC AR N    -   152,778.808   433,612.430   MT   0.99993833   +0 12 58.2
DH8992; SPC AR N    -   501,241.81   1,422,610.11   sFT  0.99993833   +0 12 58.2
DH8992
DH8992!
DH8992! SPC AR N    -   Elev Factor  x  Scale Factor =  Combined Factor
DH8992! SPC AR N    -   0.99998538  x  0.99993833 =  0.99992371
DH8992
DH8992                      SUPERSEDED SURVEY CONTROL

```

DH8992  
DH8992.No superseded survey control is available for this station.  
DH8992  
DH8992\_U.S. NATIONAL GRID SPATIAL ADDRESS: 15SXV2406152636(NAD 83)  
DH8992  
DH8992\_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA  
DH8992  
DH8992 STATION DESCRIPTION  
DH8992  
DH8992'DESCRIBED BY NATIONAL GEODETIC SURVEY 2006  
DH8992'STATION IS A GPS CORS. LATEST INFORMATION INCLUDING POSITIONS AND  
DH8992'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE  
DH8992'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.  
DH8992' ftp://cors.ngs.noaa.gov/cors/README.txt  
DH8992' ftp://cors.ngs.noaa.gov/cors/coord/coord\_08  
DH8992' ftp://cors.ngs.noaa.gov/cors/station\_log  
DH8992' http://geodesy.noaa.gov/CORS

\*\*\* retrieval complete.  
Elapsed Time = 00:00:02



# The NGS Data Sheet

See file [dsdata.txt](#) for more information about the datasheet.

```

DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.87.5
1      National Geodetic Survey,   Retrieval Date = FEBRUARY 14, 2012
DH7109 *****
DH7109 CORS          - This is a GPS Continuously Operating Reference Station.
DH7109 DESIGNATION - PARAGOULD CORS ARP
DH7109 CORS_ID      - ARPG
DH7109 PID          - DH7109
DH7109 STATE/COUNTY- AR/GREENE
DH7109 USGS QUAD    - PARAGOULD WEST (1984)
DH7109
DH7109                      *CURRENT SURVEY CONTROL
DH7109
DH7109* NAD 83(CORS)- 36 03 32.78725(N)    090 31 07.62532(W)    ADJUSTED
DH7109* NAVD 88      -                      ** (meters)          ** (feet)
DH7109
DH7109 EPOCH DATE   -      2002.00
DH7109 X            -      -46,740.492 (meters)                    COMP
DH7109 Y            -     -5,161,985.668 (meters)                  COMP
DH7109 Z            -      3,733,536.623 (meters)                  COMP
DH7109 ELLIP HEIGHT-      69.584 (meters)                        (11/??/05) ADJUSTED
DH7109 GEOID HEIGHT-     -28.21 (meters)                          GEOID09
DH7109 HORZ ORDER  - SPECIAL (CORS)
DH7109 ELLP ORDER  - SPECIAL (CORS)
DH7109
DH7109. ITRF positions are available for this station.
DH7109
DH7109. The coordinates were established by GPS observations
DH7109. and adjusted by the National Geodetic Survey in November 2005.
DH7109
DH7109. The datum tag of NAD 83(CORS) is equivalent to NAD 83(CORS96).
DH7109
DH7109. The coordinates are valid at the epoch date displayed above
DH7109. which is a decimal equivalence of Year/Month/Day.
DH7109
DH7109. The PID for the CORS L1 Phase Center is DH7110.
DH7109
DH7109. The XYZ, and position/ellipsoidal ht. are equivalent.
DH7109
DH7109. The ellipsoidal height was determined by GPS observations
DH7109. and is referenced to NAD 83.
DH7109
DH7109. The geoid height was determined by GEOID09.
DH7109
DH7109;
DH7109; SPC AR N      -      North      East      Units Scale Factor Converg.
DH7109; SPC AR N      -      192,467.643  533,443.083  MT  0.99997020  +0 51 42.9
DH7109; SPC AR N      -      631,454.26  1,750,137.85  sFT 0.99997020  +0 51 42.9
DH7109
DH7109!
DH7109! SPC AR N      -      Elev Factor x Scale Factor = Combined Factor
DH7109! SPC AR N      -      0.99998908 x 0.99997020 = 0.99995928
DH7109
DH7109                      SUPERSEDED SURVEY CONTROL

```

DH7109  
DH7109.No superseded survey control is available for this station.  
DH7109  
DH7109\_U.S. NATIONAL GRID SPATIAL ADDRESS: 15SYV2348093353(NAD 83)  
DH7109  
DH7109\_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA  
DH7109  
DH7109 STATION DESCRIPTION  
DH7109  
DH7109'DESCRIBED BY NATIONAL GEODETIC SURVEY 2005  
DH7109'STATION IS A GPS CORS. LATEST INFORMATION INCLUDING POSITIONS AND  
DH7109'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE  
DH7109'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.  
DH7109' ftp://cors.ngs.noaa.gov/cors/README.txt  
DH7109' ftp://cors.ngs.noaa.gov/cors/coord/coord\_08  
DH7109' ftp://cors.ngs.noaa.gov/cors/station\_log  
DH7109' http://geodesy.noaa.gov/CORS

\*\*\* retrieval complete.  
Elapsed Time = 00:00:02

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See file [dsdata.txt](#) for more information about the datasheet.

```

DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.87.5
1      National Geodetic Survey,  Retrieval Date = FEBRUARY 14, 2012
DM4672 *****
DM4672  CORS          -  This is a GPS Continuously Operating Reference Station.
DM4672  DESIGNATION -  MODOT DEXTER CORS ARP
DM4672  CORS_ID     -  MODX
DM4672  PID         -  DM4672
DM4672  STATE/COUNTY-  MO/STODDARD
DM4672  USGS QUAD   -  DEXTER (1979)
DM4672
DM4672                      *CURRENT SURVEY CONTROL
DM4672
DM4672*  NAD 83(CORS)-  36 48 24.82031(N)    089 58 42.95945(W)    ADJUSTED
DM4672*  NAVD 88      -                      *(meters)          *(feet)
DM4672
DM4672  EPOCH DATE   -          2002.00
DM4672  X            -          1,909.696 (meters)                COMP
DM4672  Y            -        -5,112,932.119 (meters)            COMP
DM4672  Z            -        3,800,310.023 (meters)            COMP
DM4672  ELLIP HEIGHT-          89.055 (meters)                (12/??/10) ADJUSTED
DM4672  GEOID HEIGHT-         -28.44 (meters)                GEOID09
DM4672  HORZ ORDER  -  SPECIAL (CORS)
DM4672  ELLP ORDER  -  SPECIAL (CORS)
DM4672
DM4672. ITRF positions are available for this station.
DM4672
DM4672. The coordinates were established by GPS observations
DM4672. and adjusted by the National Geodetic Survey in December 2010.
DM4672
DM4672. The datum tag of NAD 83(CORS) is equivalent to NAD 83(CORS96).
DM4672
DM4672. The coordinates are valid at the epoch date displayed above
DM4672. which is a decimal equivalence of Year/Month/Day.
DM4672
DM4672. The PID for the CORS L1 Phase Center is DM4673.
DM4672
DM4672. The XYZ, and position/ellipsoidal ht. are equivalent.
DM4672
DM4672. The ellipsoidal height was determined by GPS observations
DM4672. and is referenced to NAD 83.
DM4672
DM4672. The geoid height was determined by GEOID09.
DM4672
DM4672;          North          East          Units Scale Factor Converg.
DM4672; SPC MO E  -   108,150.802   296,524.882   MT   0.99995999   +0 18 44.6
DM4672
DM4672!          -  Elev Factor  x  Scale Factor =  Combined Factor
DM4672! SPC MO E  -   0.99998602  x   0.99995999  =   0.99994601
DM4672
DM4672                      SUPERSEDED SURVEY CONTROL
DM4672

```

DM4672.No superseded survey control is available for this station.

DM4672

DM4672\_U.S. NATIONAL GRID SPATIAL ADDRESS: 16SBF3427377591(NAD 83)

DM4672

DM4672\_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA

DM4672

DM4672

STATION DESCRIPTION

DM4672

DM4672'DESCRIBED BY NATIONAL GEODETIC SURVEY 2010

DM4672'STATION IS A GPS CORS. LATEST INFORMATION INCLUDING POSITIONS AND

DM4672'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE

DM4672'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.

DM4672' ftp://cors.ngs.noaa.gov/cors/README.txt

DM4672' ftp://cors.ngs.noaa.gov/cors/coord/coord\_08

DM4672' ftp://cors.ngs.noaa.gov/cors/station\_log

DM4672' http://geodesy.noaa.gov/CORS

\*\*\* retrieval complete.

Elapsed Time = 00:00:02

# The NGS Data Sheet

See file [dsdata.txt](#) for more information about the datasheet.

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DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.87.5
1      National Geodetic Survey,  Retrieval Date = FEBRUARY 14, 2012
DL6892 *****
DL6892  CORS          -   This is a GPS Continuously Operating Reference Station.
DL6892  DESIGNATION -   MODOT KENNETT CORS ARP
DL6892  CORS_ID      -   MOKE
DL6892  PID          -   DL6892
DL6892  STATE/COUNTY-   MO/DUNKLIN
DL6892  USGS QUAD    -   KENNETT SOUTH (1983)
DL6892
DL6892                      *CURRENT SURVEY CONTROL
DL6892
DL6892 * NAD 83(CORS)-   36 13 17.10477(N)    090 04 24.46878(W)    ADJUSTED
DL6892 * NAVD 88      -                   ** (meters)                ** (feet)
DL6892
DL6892 EPOCH DATE   -           2002.00
DL6892 X           -           -6,605.233 (meters)                    COMP
DL6892 Y           -          -5,151,558.596 (meters)                  COMP
DL6892 Z           -           3,748,072.203 (meters)                  COMP
DL6892 ELLIP HEIGHT-           54.028 (meters)                      (04/??/10) ADJUSTED
DL6892 GEOID HEIGHT-          -28.45 (meters)                        GEOID09
DL6892 HORZ ORDER  -   SPECIAL (CORS)
DL6892 ELLP ORDER  -   SPECIAL (CORS)
DL6892
DL6892. ITRF positions are available for this station.
DL6892
DL6892. The coordinates were established by GPS observations
DL6892. and adjusted by the National Geodetic Survey in April 2010.
DL6892
DL6892. The datum tag of NAD 83(CORS) is equivalent to NAD 83(CORS96).
DL6892
DL6892. The coordinates are valid at the epoch date displayed above
DL6892. which is a decimal equivalence of Year/Month/Day.
DL6892
DL6892. The PID for the CORS L1 Phase Center is DL6893.
DL6892
DL6892. The XYZ, and position/ellipsoidal ht. are equivalent.
DL6892
DL6892. The ellipsoidal height was determined by GPS observations
DL6892. and is referenced to NAD 83.
DL6892
DL6892. The geoid height was determined by GEOID09.
DL6892
DL6892;
DL6892; SPC MO E      -           North           East           Units Scale Factor Converg.
DL6892; SPC MO E      -           43,143.159      288,347.858      MT  0.99995145  +0 15 07.4
DL6892
DL6892!
DL6892! SPC MO E      -           Elev Factor   x   Scale Factor =   Combined Factor
DL6892! SPC MO E      -           0.99999152   x   0.99995145 =   0.99994297
DL6892
DL6892                      SUPERSEDED SURVEY CONTROL
DL6892

```

DL6892.No superseded survey control is available for this station.

DL6892

DL6892\_U.S. NATIONAL GRID SPATIAL ADDRESS: 15SYA6305712479(NAD 83)

DL6892

DL6892\_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA

DL6892

DL6892

STATION DESCRIPTION

DL6892

DL6892'DESCRIBED BY NATIONAL GEODETIC SURVEY 2010

DL6892'STATION IS A GPS CORS. LATEST INFORMATION INCLUDING POSITIONS AND

DL6892'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE

DL6892'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.

DL6892' ftp://cors.ngs.noaa.gov/cors/README.txt

DL6892' ftp://cors.ngs.noaa.gov/cors/coord/coord\_08

DL6892' ftp://cors.ngs.noaa.gov/cors/station\_log

DL6892' http://geodesy.noaa.gov/CORS

\*\*\* retrieval complete.

Elapsed Time = 00:00:01

# The NGS Data Sheet

See file [dsdata.txt](#) for more information about the datasheet.

```

DATABASE = NGSIDB , PROGRAM = datasheet95, VERSION = 7.87.5
1      National Geodetic Survey,   Retrieval Date = FEBRUARY 14, 2012
DM4694 *****
DM4694  CORS           -   This is a GPS Continuously Operating Reference Station.
DM4694  DESIGNATION  -   MODOT VAN BUREN CORS ARP
DM4694  CORS_ID      -   MOV8
DM4694  PID          -   DM4694
DM4694  STATE/COUNTY-   MO/CARTER
DM4694  USGS QUAD    -   VAN BUREN SOUTH (1997)
DM4694
DM4694                      *CURRENT SURVEY CONTROL
DM4694
DM4694* NAD 83(CORS)-   36 57 36.45577(N)      091 03 37.81109(W)      ADJUSTED
DM4694* NAVD 88      -                      ** (meters)          ** (feet)
DM4694
DM4694  EPOCH DATE   -           2002.00
DM4694  X            -           -94,443.051 (meters)              COMP
DM4694  Y            -          -5,101,890.210 (meters)            COMP
DM4694  Z            -           3,813,940.504 (meters)            COMP
DM4694  ELLIP HEIGHT-           136.821 (meters)                  (12/??/10) ADJUSTED
DM4694  GEOID HEIGHT-           -29.76 (meters)                   GEOID09
DM4694  HORZ ORDER  -   SPECIAL (CORS)
DM4694  ELLP ORDER  -   SPECIAL (CORS)
DM4694
DM4694. ITRF positions are available for this station.
DM4694
DM4694. The coordinates were established by GPS observations
DM4694. and adjusted by the National Geodetic Survey in December 2010.
DM4694
DM4694. The datum tag of NAD 83(CORS) is equivalent to NAD 83(CORS96).
DM4694
DM4694. The coordinates are valid at the epoch date displayed above
DM4694. which is a decimal equivalence of Year/Month/Day.
DM4694
DM4694. The PID for the CORS L1 Phase Center is DM4695.
DM4694
DM4694. The XYZ, and position/ellipsoidal ht. are equivalent.
DM4694
DM4694. The ellipsoidal height was determined by GPS observations
DM4694. and is referenced to NAD 83.
DM4694
DM4694. The geoid height was determined by GEOID09.
DM4694
DM4694;
DM4694; SPC MO E      -           North           East           Units Scale Factor Converg.
DM4694; SPC MO E      -           125,174.635     200,085.749     MT   0.99996401   -0 20 13.3
DM4694
DM4694!
DM4694! SPC MO E      -           Elev Factor   x   Scale Factor =   Combined Factor
DM4694! SPC MO E      -           0.99997853   x   0.99996401 =   0.99994254
DM4694
DM4694                      SUPERSEDED SURVEY CONTROL
DM4694

```

DM4694.No superseded survey control is available for this station.

DM4694

DM4694\_U.S. NATIONAL GRID SPATIAL ADDRESS: 15SXA7266892206(NAD 83)

DM4694

DM4694\_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA

DM4694

DM4694

STATION DESCRIPTION

DM4694

DM4694'DESCRIBED BY NATIONAL GEODETIC SURVEY 2010

DM4694'STATION IS A GPS CORS. LATEST INFORMATION INCLUDING POSITIONS AND

DM4694'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE

DM4694'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.

DM4694' ftp://cors.ngs.noaa.gov/cors/README.txt

DM4694' ftp://cors.ngs.noaa.gov/cors/coord/coord\_08

DM4694' ftp://cors.ngs.noaa.gov/cors/station\_log

DM4694' http://geodesy.noaa.gov/CORS

\*\*\* retrieval complete.

Elapsed Time = 00:00:02



## **Appendix B**

