

Final Technical Report

Award #G10AC00081

**USGS Earthquake Hazards Program External Research
and Monitoring Support**

ARRA Real-time Upgrade of the Pacific Northwest Geodetic Array

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Abstract

As part of the 2009 American Recovery and Reinvestment Act, Central Washington University's Pacific Northwest Geodetic Array (PANGA) has been funded to upgrade a network of continuously operating GPS sites throughout Washington and Oregon. The overall scope of this project entailed much more than simply upgrading existing equipment. In addition to replacing GPS-only receivers with Global Navigation Satellite System (GNSS) capable equipment, PANGA has increased reliability of the northwest geodetic network by: installment of back-up power systems, construction of an independent radio communications backbone, and finally, replacement of poor quality mounts with solid drill-brace geodetic monuments. The monument and radio communication upgrades were specifically chosen for sites of key geologic interest. Extensive planning was required to accomplish each of these goals. Permits with many separate government and private organizations were required at many sites. Each component involved a combination of electrical and mechanical design and engineering. In addition, a large amount of construction equipment and supplies had to be purchased and stored.

With guidance and oversight by PANGA Director and Principal Investigator, Tim Melbourne, the groundwork of this project was tasked to staff geologists Rex Flake and Andrew Miner. Aaron Mayfield, a CWU graduate student, was also employed to assist in constructing and permitting the radio network.

Receiver Upgrades

Accuracy of geodetic measurements are directly affected by the number of satellites in view of the ground-based antennae. This is of particular concern in the Pacific Northwest due to numerous trees and foliage limiting sky visibility. Many existing geodetic receivers utilizing the L1/L2 band in the U.S. are limited to measurements relative to the Global Positioning System (GPS) constellation. At any given time there are at least 24 working satellites in this constellation. A similar satellite population exists within the Russian equivalent constellation, GLONASS. Combining coverage of these two systems doubles the number of satellites viewed from the ground and therefore increases the accuracy of position measurements. The receiver upgrade component of this project involved replacing existing GPS only systems with receivers capable of utilizing both the GPS and GLONASS constellations, together called the Global Navigation Satellite System (GNSS).

The Topcon Net-3GA receivers chosen for this purpose were supplied to PANGA as government furnished equipment (GFE). Manufacturer problems followed by numerous firmware issues delayed arrival of this equipment until well past the first project quarter. Finally in the fall of 2010, CWU PANGA received 61 Topcon Net-3GA GNSS capable receivers with antennae. Regardless of these delays and subsequent programming issues, our PANGA group was able to install 53 of these receivers (two more than proposed).

Receiver Upgrades: Codes and Locations

Site code	Site Location	Site code	Site Location
BIGD	Coulee City, WA	NWBG	Newburg, OR
BDRY	Boundary, WA	NWPT	Newport, WA
CATH	Cathlamet, OR	OCC1	Bellevue, WA
CHCM	Chimacum, WA	OKNG	Okanagon, WA
CHEL	Chelan, WA	OLAR	Tumwater, WA
COLV	Colville, WA	OLMP	Olympia, WA
COUG	Cougar, WA	OTHL	Othello, WA
COUP	Coupville, WA	PDTN	Pendleton, OR
CROK	Castle Rock, WA	PKWD	Packwood, WA
CSKI	Kent, WA	PLMN	Pullman, WA
DEEJ	Amanda Park, WA	PNCL	Port Angeles
DVPT	Davenport, WA	PNDL	Pendleton, OR
ELSR	Bremerton, WA	PRSR	Prosser, WA
EPHR	Euphrata, WA	PTAA	Port Angeles, WA
GLWD	Glenwood, WA	RDK1	Oroville, WA
GOLY	Goldendale, WA	RPUB	Republic, WA
GRCK	Grouse Creek, WA	RYMD	Raymond, WA
GRMD	Grand Mound, WA	SKMA	Skamania, WA
KENI	Keniwick, WA	SPKN	Spokane, WA
KLTS	Kahlotus, WA	SSHO	Snohomish, WA
LINH	Ellensburg, WA	TOPP	Toppenish, WA
LTAH	Latah, WA	VCWA	Vancouver, WA
LWCK	Ilwaco, WA	WEEZ	Everett, WA
MKAH	Makah, WA	WNTH	Winthrop, WA
MONT	Gray's Harbor, WA	XANE	Wenatchee, WA
LNII	Badger Pocket, WA	HAHD	Palmer, WA

Power System Back-up and Radio Telemetry Network

Independent data communication and back-up power is essential for geodetic networks; as learned from the Mw=9.1 Sendai Earthquake in which much of the 1 second data was lost due to power failure and interruptions in communications infrastructure. Furthermore, inclement weather of the US Pacific Northwest causes unreliable power that can hinder continuous data streams. To smooth power interruptions, and ensure data continuity, PANGA has developed a system of redundant power and radio data communications for existing GNSS stations across the northwest. For this project, CWU installed these power systems at 72 separate sites. Each power system is composed of a deep cycle 12V 100 ampere-hour "Lifeline" battery and 15A "Samlex" battery charger (see Appendix D). This system will power a typical GNSS receiver for up to two weeks without external power. In the case of a catastrophic event in which these power systems will be utilized, interruptions in regional communications networks that terminate transmission of data streams is also expected. To avoid losing this most important data, all receivers

are set to locally record 1Hz data on a ring buffer with key geological sites connected to the PANGA laboratory via independent radio.

In addition to power back-up systems, PANGA procured permits with the Department of Natural Resources, Washington State Parks, and various county/city municipalities to install an independent radio data communications backbone. As stated above, it's expected that during large earthquake events standard data networking relying on public infrastructure will fail due to increase cellular usage and/or actual damage to hardware equipment. One of our goals here at PANGA is to measure earthquake activity in real-time via these GNSS networks. To ensure data flow, we constructed a radio network that operates separately from existing communication grids. Construction of radio towers and installation of radio telemetry at 16 separate sites linking the west coast data streams directly to CWU has been completed. These systems are composed of one to two radios per site with solar power, battery power back up and various towers depending on location (see *Site Photos: Radio Network* below). These sites connect data streams from the coast to the PANGA lab in Ellensburg via 900MHz radio transmission from the Olympic Mountains to the Cascades, then onto the ridge systems of central Washington and finally ending at the science building at Central Washington University. These radio towers are constructed at Burnt Hill, Striped Peak, Blyn Mountain, McDonald Mountain, Manastash Ridge, Umptanum Ridge, Science Building (CWU), with end-point nodes at Ilwaco, Oroville, Kahlotus, Diamond Lake, Wenatchee, Badger Pocket and Olympia.

Drill-brace Monument Installations

Some of the existing GPS sites analyzed by PANGA are of poor geodetic quality. For example, some have large error due to high multipathing and/or poor mounting hardware such as those on top of wood-frame buildings. CWU has purchased a drill-rig, trailer and necessary installation equipment and hardware supplies to replace these unreliable mounts with solid geodetic ground monuments. For this project, PANGA constructed 13 of these solid drill-brace monuments each complete with GNSS capable receivers, power system back-ups and radio telemetry. The drill-brace monuments are drilled to approximately 15-20ft deep and emplaced with drilling grout. All four legs, one center and three symmetrically angled braces are welded solid. We used SCIGN type mounts on all these monuments and provided cover protection for the GNSS GR3A Topcon antennae with SCIGN domes and base-plates (see *Site Photos: Constructed Drill-Brace Monuments* below).

Project Map of Power Systems, Receiver Upgrades, and Monuments



Site Photos: Constructed Drill-Brace Monuments



HAHD: Howard Hansen Ridge



DEEJ: Amanda Park



GLNW: Glenwood



KLTS: Kahlotus



LNIH: Badger Pocket



LWCK: Ilwaco/Lewis and Clark Interpretive Center



OCEN: Ocean Shores



OLAR: Olympia Airport



PDTN: Pendleton



PTAA: Port Angeles



RDK1: Oroville



XANE: Wenatchee



DMND: Diamond Lake

Site Photos: Independent Communication Network Radio Sites



Umptanum Ridge



Manastash Ridge



Blyn Mountain



Radar Ridge



Badger Pocket



William Fairchild Airport



McDonald Mountain



Striped Peak



Cape Disappointment



Wenatchee Foothills



Oroville



Tumwater

Appendix A: Site Information of ARRA Constructed Monuments

1. PTAA Site Identification of the GNSS Monument

Site Name : PORT ANGELES
Four Character ID : PTAA
Monument Inscription :
IERS DOMES Number : (A9)
CDP Number : (A4)
Monument Description : Wyatt/Agnew drilled-braced
Height of the Monument : 2 m
Monument Foundation : STEEL RODS
Foundation Depth : 10 m
Marker Description : Divot in center post of SCIGN D3 antenna
Date Installed : 2011-10-20
Geologic Characteristic : GRAVEL
Bedrock Type : SEDIMENTARY

2. Site Location Information

City or Town : Port Angeles
State or Province : Washington
Country : USA
Tectonic Plate : North American
Approximate Position (ITRF)
X coordinate (m) : -2354268.021
Y coordinate (m) : -3557671.864
Z coordinate (m) : 4725608.595
Latitude (N is +) : +480700.58
Longitude (E is +) : -1232939.69
Elevation (m,ellips.) : 66.8
Additional Information : ARP ITRF00 POSITION (EPOCH 1997.0)
: Computed in Feb 2012 using 12 days of data.

3. GNSS Receiver Information

3.1 Receiver Type : TPS NET-G3A
Satellite System : GPS+GLONASS
Serial Number : 618-00942
Firmware Version : 3.5
Elevation Cutoff Setting : 5 deg
Date Installed : 2011-10-20

4. GNSS Antenna Information

4.1 Antenna Type : TPSCR.G3
Serial Number : 383-1945
Antenna Reference Point : BPA
Marker->ARP Up Ecc. (m) : 0.0083
Marker->ARP North Ecc(m) : 0.0000
Marker->ARP East Ecc(m) : 0.0000
Alignment from True N : 0 deg
Antenna Radome Type : SCIT
Antenna Cable Type : LMR-400

Antenna Cable Length : 15 m
Date Installed : 2011-10-20
Date Removed : 2011-11-29T21:00Z

1. **RKD1** Site Identification of the GNSS Monument

Site Name : OROVILLE AIRPORT
Four Character ID : RKD1
IERS DOMES Number : (A9)
CDP Number : (A4)
Monument Description : DRILLED AND BRACED STEEL RODS
Height of the Monument : 2 m
Monument Foundation : STEEL RODS
Foundation Depth : 4.6 m
Marker Description : (CHISELLED CROSS/DIVOT/BRASS NAIL/etc)
Date Installed : 2011-10-14
Geologic Characteristic : CLAYEY SAND
Bedrock Type : SEDIMENTARY
Bedrock Condition : N/A
Fracture Spacing : N/A

2. Site Location Information

City or Town : Oroville
State or Province : Washington
Country : USA
Tectonic Plate : North American
Approximate Position (ITRF)
X coordinate (m) : -2060482.333
Y coordinate (m) : -3654823.907
Z coordinate (m) : 4788193.227
Latitude (N is +) : +485751.66
Longitude (E is +) : -1192446.89
Elevation (m,ellips.) : 313.2
Additional Information : ARP ITRF00 POSITION (EPOCH 1997.0)
: Computed in Feb 2012 using 12 days of data.
:

3. GNSS Receiver Information

3.1 Receiver Type : TPS NET-G3A
Satellite System : GPS+GLONASS
Serial Number : 618-00963
Firmware Version : 3.5
Elevation Cutoff Setting : 5 deg
Date Installed : 2011-10-14

4. GNSS Antenna Information

4.1 Antenna Type : TPSCR.G3
Serial Number : 383-1737
Antenna Reference Point : BPA
Alignment from True N : 0 deg
Antenna Radome Type : SCIT
Radome Serial Number :

Antenna Cable Type : LMR400
Antenna Cable Length : 20 m
Date Installed : 2011-10-14

1. **PDTN** Site Identification of the GNSS Monument

Site Name : PENDLETON
Four Character ID : PDTN
Monument Description : STEEL RODS
Height of the Monument: 2 m
Monument Foundation : STEEL RODS DRILLED AND SET IN BEDROCK
Foundation Depth : 4.57 m
Marker Description : (CHISELLED CROSS/DIVOT/BRASS NAIL/etc)
Date Installed : 2011-09-02
Geologic Characteristic : Highly compacted loess deposits
Bedrock Type : sedimentary

2. Site Location Information

City or Town : Pendleton
State or Province : Oregon
Country : USA
Tectonic Plate : North American
Approximate Position (ITRF)
X coordinate (m) : -2148198.265
Y coordinate (m) : -3914526.065
Z coordinate (m) : 4539659.844
Latitude (N is +) : +453957.41
Longitude (E is +) : -1184524.93
Elevation (m,ellips.) : 394.4
Additional Information : ARP ITRF00 POSITION (EPOCH 1997.0)
: Computed in Feb 2012 using 12 days of data.
:

3. GNSS Receiver Information

3.1 Receiver Type : TPS NET-G3A
Satellite System : GPS+GLONASS
Serial Number : 618-00943
Firmware Version : 3.5
Elevation Cutoff Setting: 5 deg
Date Installed : 2011-09-02
Date Removed : (CCYY-MM-DDThh:mmZ)
Temperature Stabiliz. : (none or tolerance in degrees C)
Additional Information : (multiple lines)

4. GNSS Antenna Information

4.1 Antenna Type : TPSCR.G3
Serial Number : 383-1798
Antenna Reference Point : BPA
Marker->ARP Up Ecc. (m) : 0.0083
Marker->ARP North Ecc(m): 0.0000
Marker->ARP East Ecc(m) : 0.0000
Alignment from True N : 0 deg

Antenna Radome Type : SCIT
Radome Serial Number :
Antenna Cable Type : LMR-400
Antenna Cable Length : 50 m
Date Installed : 2011-09-02
Date Removed : (CCYY-MM-DDThh:mmZ)
Additional Information : (multiple lines)

1. HAHD Site Identification of the GNSS Monument

Site Name : HOWARD HANSON
Four Character ID : HAHD
Monument Inscription : NONE
IERS DOMES Number : (A9)
CDP Number : (A4)
Monument Description : DRILLED AND BRACED STEEL RODS
Height of the Monument : 2 m
Monument Foundation : STEEL RODS
Foundation Depth : 4.57 m
Marker Description : (CHISELLED CROSS/DIVOT/BRASS NAIL/etc)
Date Installed : 2011-07-06
Geologic Characteristic : CONGLOMERATE
Bedrock Type : (IGNEOUS/METAMORPHIC/SEDIMENTARY)
Bedrock Condition : (FRESH/JOINTED/WEATHERED)
Fracture Spacing : (1-10 cm/11-50 cm/51-200 cm/over 200 cm)
Fault zones nearby : (YES/NO/Name of the zone)
Distance/activity : (multiple lines)
Additional Information : (multiple lines)

2. Site Location Information

City or Town : Ravensdale
State or Province : Washington
Country : USA
Tectonic Plate : North American
Approximate Position (ITRF)
X coordinate (m) : -2283358.762
Y coordinate (m) : -3684391.676
Z coordinate (m) : 4664380.849
Latitude (N is +) : +471726.88
Longitude (E is +) : -1214717.09
Elevation (m,ellips.) : 853.9
Additional Information : ARP ITRF00 POSITION (EPOCH 1997.0)
: Computed in Feb 2012 using 12 days of data.
:

3. GNSS Receiver Information

3.1 Receiver Type : TPS NET-G3A
Satellite System : GPS+GLONASS
Serial Number : 618-00944
Firmware Version : 3.5
Elevation Cutoff Setting : 5 deg
Date Installed : 2011-07-06
Date Removed : (CCYY-MM-DDThh:mmZ)

Temperature Stabiliz. : (none or tolerance in degrees C)
Additional Information : (multiple lines)

4. GNSS Antenna Information

4.1 Antenna Type : TPSCR.G3
Serial Number : 383-1815
Antenna Reference Point : BPA
Marker->ARP Up Ecc. (m) : 0.0083
Marker->ARP North Ecc(m) : 0.0000
Marker->ARP East Ecc(m) : 0.0000
Alignment from True N : 0 deg
Antenna Radome Type : SCIT
Radome Serial Number : UNKNOWN
Antenna Cable Type : LMR-400
Antenna Cable Length : 10 m
Date Installed : 2011-07-06
Date Removed : (CCYY-MM-DDThh:mmZ)
Additional Information : (multiple lines)

1. **GLWD** Site Identification of the GPS Monument

Site Name : Glenwood (102)
Four Character ID : GLWD
Monument Description : Drilled and braced steel rods
Height of the Monument:
Monument Foundation : STEEL RODS
Foundation Depth : 4m
Marker Description : (CHISELLED CROSS/DIVOT/BRASS NAIL/etc)
Date Installed : 2011-09-12
Geologic Characteristic : Compact sandy gravel
Bedrock Type : SEDIMENTARY/ Alluvium

2. Site Location Information

City or Town : Glenwood
State or Province : Washington
Country : USA
Tectonic Plate : North America
Approximate Position (ITRF)
X coordinate (m) : -2304417.4146
Y coordinate (m) : -3791795.3127
Z coordinate (m) : 4567177.4327
Latitude (N is +) : +460111.36723
Longitude (E is +) : -1211718.92773
Elevation (m,ellips.) : 561.421 m
Additional Information : Reference frame used is (ITRF2000_V2).
: Coordinate system used is (WGS84).

3. GPS Receiver Information

3.1 Receiver Type : Rtcn 3.1 NETG3

Satellite System : GPS+GLONASS
Serial Number : 618-00968
Firmware Version : UNKNOWN
Elevation Cutoff Setting: 5 deg
Date Installed : 2011-09-12

4. GPS Antenna Information

4.1 Antenna Type : TPSCR.G3 SCIT
Serial Number : 383-1954
Antenna Reference Point : BPA
Date Installed : 2011-09-12

1. **LWCK** Site Identification of the GPS Monument

Site Name : Ilwaco (117)
Four Character ID : LWCK
Monument Description : STEEL MAST
Height of the Monument: 1 meter
Monument Foundation : CONCRETE BLOCK
Foundation Depth : Unknown - WWII reinforced concrete bombing bunker
Marker Description : (CHISELLED CROSS/DIVOT/BRASS NAIL/etc)
Date Installed : 2011-11-10
Geologic Characteristic :
Bedrock Type : IGNEOUS
Bedrock Condition : JOINTED/WEATHERED
Fracture Spacing : unknown

2. Site Location Information

City or Town : Ilwaco
State or Province : Washington
Country : USA
Tectonic Plate : North America
Approximate Position (ITRF)
X coordinate (m) : -2470676.8503
Y coordinate (m) : -3657499.3788
Z coordinate (m) : 4588790.1951
Latitude (N is +) : +461821.156
Longitude (E is +) : -1240221.889
Elevation (m,ellips.) : -13.834 m
Additional Information : Reference frame used is (ITRF2000_V2).
: Coordinate system used is (WGS84).

3. GNSS Receiver Information

3.1 Receiver Type : TPSCR.G3
Satellite System : GPS+GNSS
Serial Number : 618-XXXX
Firmware Version :
Elevation Cutoff Setting: 5 deg
Date Installed : 2011-11-10
Date Removed : (CCYY-MM-DDThh:mmZ)

4. (GPS / GNSS) Antenna Information

4.1 Antenna Type : TPSCR.G3 TPSH
Serial Number : 383-1942
Antenna Reference Point : BPA
Antenna Cable Type : LMR-400
Antenna Cable Length : 3 meters
Date Installed : 2012-11-10

1. OCEN Site Identification of the GNSS Monument

Site Name : Ocean Shores (50)
Four Character ID : OCEN
Monument Description : Wyatt/Agnew drilled-braced
Height of the Monument: 3 m
Monument Foundation : STEEL RODS
Foundation Depth : 6 m
Marker Description : divot in center post of SCIGN D3 antenna
Date Installed : 2009-07-28T00:00Z
Geologic Characteristic : Sand bar
Bedrock Type : SEDIMENTARY
Bedrock Condition : N/A
Fracture Spacing : N/A
Fault zones nearby : (YES)
Distance/activity : (ACTIVE Juan De Fuca)
Additional Information : (multiple lines)

2. Site Location Information

City or Town : Ocean Shores
State or Province : Washington
Country : USA
Tectonic Plate : North America
Approximate Position (ITRF)
X coordinate (m) : -2449015.2912
Y coordinate (m) : -3609074.6491
Z coordinate (m) : 4638139.2206
Latitude (N is +) : +465708.519181
Longitude (E is +) : -1240934.913879
Elevation (m,ellips.) : -17.071
Additional Information : Reference frame used is (ITRF2000_V2).
: Coordinate system used is (WGS84).

3. GNSS Receiver Information

3.1 Receiver Type : TRIMBLE NETR5
Satellite System : GPS+GLONASS
Serial Number : 4750K11528
Firmware Version : NAV 3.5
Elevation Cutoff Setting: 5 DEG
Date Installed : 2009-07-28T00:00Z

4. GNSS Antenna Information

4.1 Antenna Type : TRM55971.00 SCIT
Serial Number : 30569125
Antenna Reference Point : BPA
Alignment from True N : 0
Antenna Radome Type : SCIT
Radome Serial Number : UNKOWN
Antenna Cable Type : Trimble
Antenna Cable Length : 50 m
Date Installed : 2009-07-28T00:00Z

1. **KLTS** Site Identification of the GPS Monument

Site Name : Kahlotus (311)
Four Character ID : KLTS
Monument Inscription :
IERS DOMES Number : (A9)
CDP Number : (A4)
Monument Description : Drilled Brace Steel Rod
Height of the Monument: 2m
Monument Foundation : Steel Rod
Foundation Depth : 4m
Date Installed : 2011-07-01
Geologic Characteristic : CLAYEY Sand
Bedrock Type : SEDIMENTARY
Bedrock Condition : N/A
Fracture Spacing : N/A

2. Site Location Information

City or Town : Kahlotus
State or Province : Washington
Country : USA
Tectonic Plate : North America
Approximate Position (ITRF)
X coordinate (m) : -2097128.6414
Y coordinate (m) : -3853240.5419
Z coordinate (m) : 4614651.7763
Latitude (N is +) : +463835.52863
Longitude (E is +) : -1183329.34969
Elevation (m,ellips.) : 257.693 m
Additional Information : Reference frame used is (ITRF2000_V2).
: Coordinate system used is (WGS84).

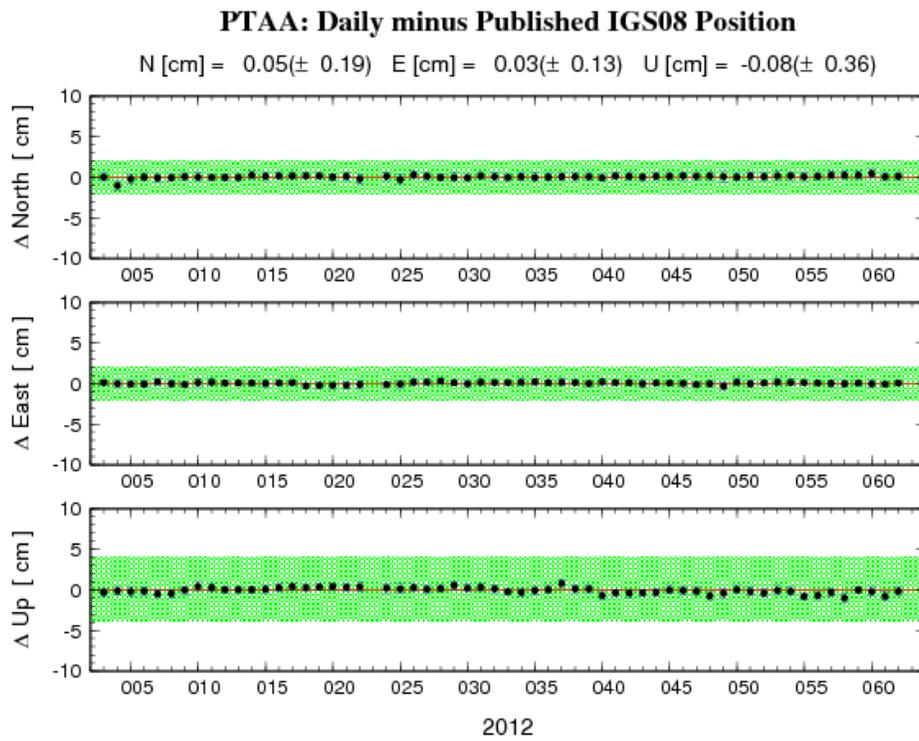
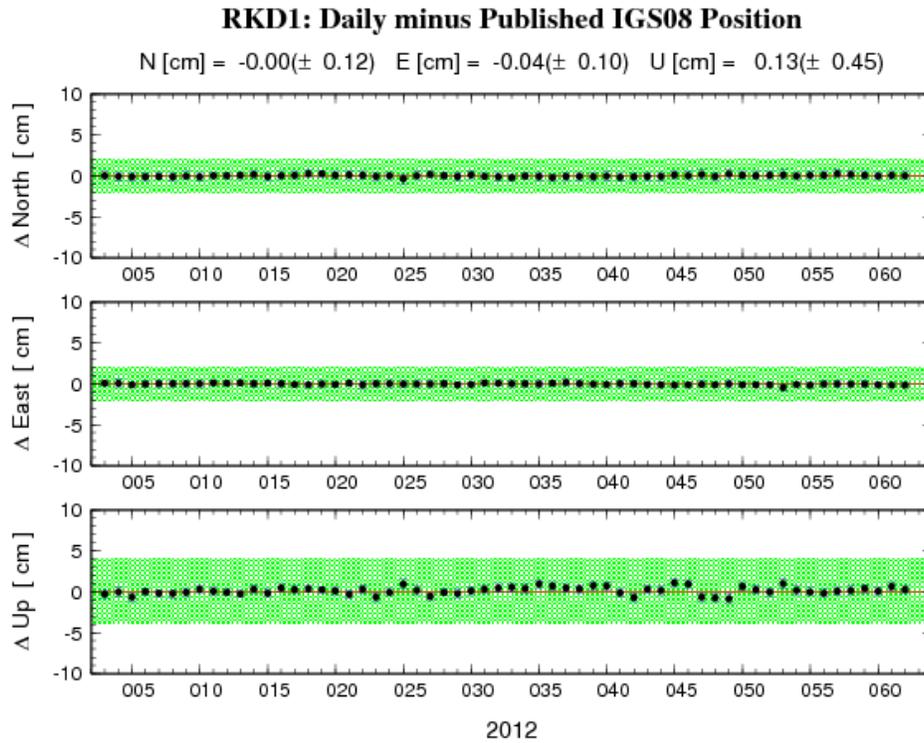
3. GNSS Receiver Information

3.1 Receiver Type : Trimble NetR5
Satellite System : GPS+GLONASS
Serial Number : Unknown
Firmware Version : Unknown
Elevation Cutoff Setting: 5 deg
Date Installed : 2011-07-01

4. GNSS Antenna Information

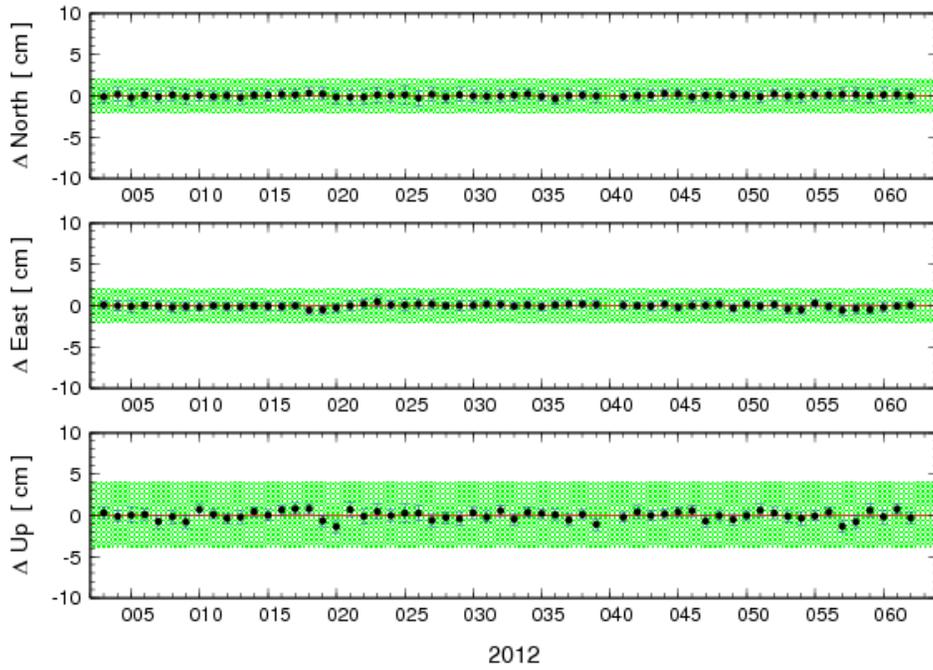
4.1 Antenna Type : TRM55971.00
Serial Number : 1440921022
Antenna Reference Point : BPA
Alignment from True N : 0
Antenna Cable Type : LMR-400
Antenna Cable Length : 30m
Date Installed : 2011-07-01

Appendix B: Timeseries of National CORS Accepted ARRA Constructed Monuments



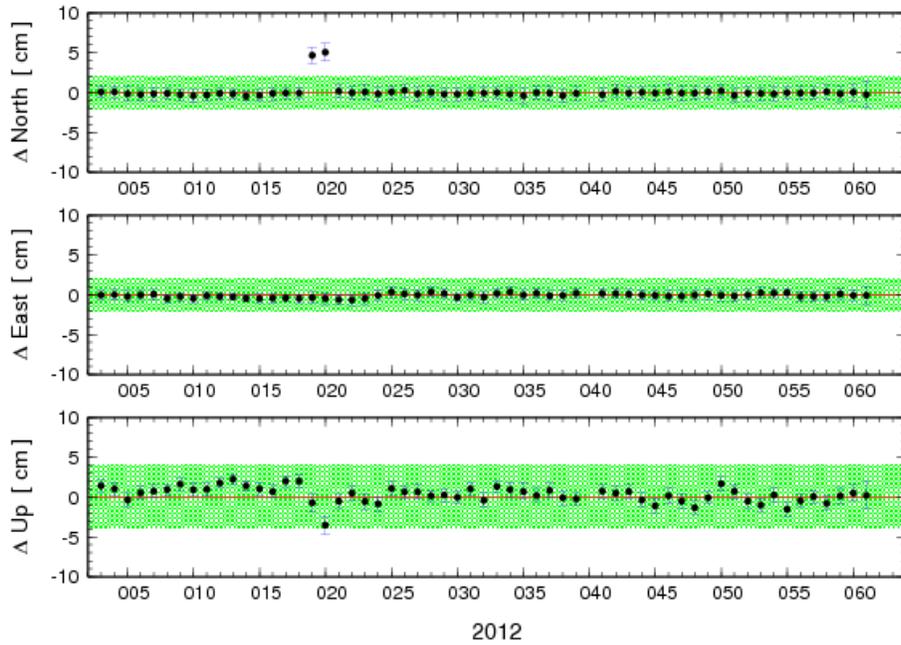
PDTN: Daily minus Published IGS08 Position

N [cm] = $0.02(\pm 0.14)$ E [cm] = $-0.06(\pm 0.21)$ U [cm] = $-0.03(\pm 0.52)$



HAHD: Daily minus Published IGS08 Position

N [cm] = $0.06(\pm 0.93)$ E [cm] = $-0.11(\pm 0.26)$ U [cm] = $0.31(\pm 1.00)$



Appendix C: Construction Photos



Stainless Steel Rod Drilled w/ Mud



Drilling Angle Brace



Drilling Mud Routed Through Grout Swivel



Trenching for Conduit



Final Angle Brace Drilling



Cable Routing



Bedrock Monument



All Connections Coped and Welded



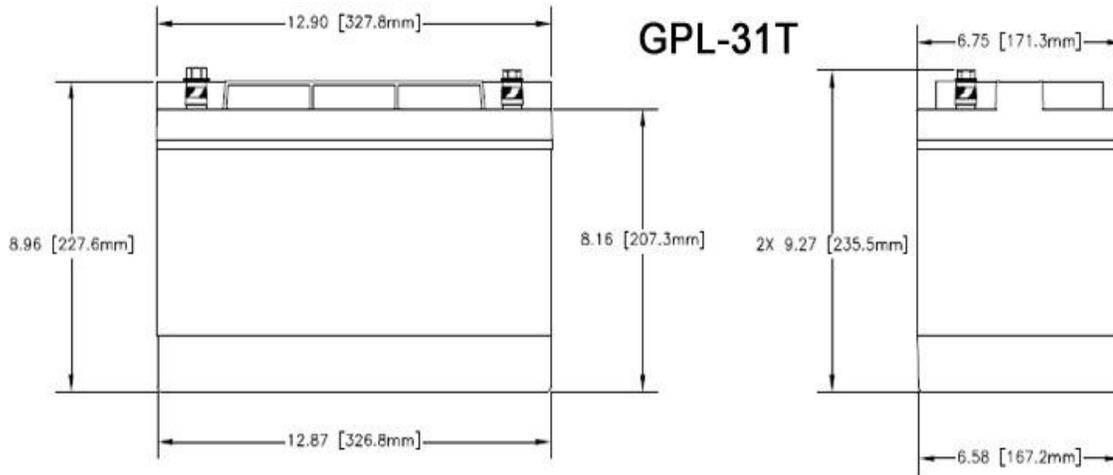
Appendix D: Power Back-up Systems



Typical Power Back-up System w/ Receiver

Lifeline Deep Cycle Battery Specifications:

Nominal Voltage _____ 12 volts
Amp hour capacity at 20 hour rate _____ 105 amp hour
Reserve Capacity at 25 amp discharge rate _____ 195 minutes
Reserve Capacity at 15 amp discharge rate _____ 340 minutes
Reserve Capacity at 8 amp discharge rate _____ 688 minutes
Dimensions (inches) _____ Length=12.90*, Width= 6.75, Height= 9.27*
Dimensions (mm) _____ Length=328, Width=172, Height=236
Weight _____ 69 pounds / 31.4 kilograms
Recommended charge voltage _____ Bulk Charge 14.2 – 14.6 volts
_____ Absorption/Acceptance Charge 14.2 - 14.6 volts
_____ Float Charge 13.1 to 13.4 volts
Recommended Charge Amperage _____ Up to 100% of the rated amp hour capacity
Self Discharge Rate _____ 2% per month at 77°F (25°C)
Operating Temperature _____ -50° to 150° F (-45 to 65.5 C)
Cycle life _____ 1,100 cycles to 50% DOD, 500 cycles to 100% DOD
Warranty _____ Refer to manual for warranty information by application



Samlex Charger Specifications:

MODEL NO.	SEC-1215A
PRE-SET INPUT VOLTAGE	120 VAC, 60 Hz
USER SELECTABLE INPUT VOLTAGE	230 VAC, 50 Hz
INPUT FREQUENCY	50 - 60 Hz
OUTPUT VOLTAGE-BOOST	14 VDC, or 14.4 VDC or disabled
DIP SWITCH SELECTABLE	
OUTPUT VOLTAGE-FLOAT	13.5 VDC
OUTPUT AMPS	15 A
OPERATING TEMPERATURE RANGE	0 - 40° C
WEIGHT, LBS	4.8
WEIGHT, KG	2.2
DIMENSIONS, INCHES (L x W x H)	8.5 x 8.4 x 3.3
DIMENSIONS, MM (L x W x H)	215 x 214 x 82
PROTECTIONS	Short circuit, over current, reverse battery connection
OUTPUT BANKS	3