Final Technical Report

Award #G10AC00081

USGS Earthquake Hazards Program External Research and Monitoring Support

ARRA Real-time Upgrade of the Pacific Northwest Geodetic Array

March 1st, 2010 to December 31st, 2011

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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 that proposed).
Receiver Upgrades: Codes and Locations

<table>
<thead>
<tr>
<th>Site code</th>
<th>Site Location</th>
<th>Site code</th>
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<td>BIGD</td>
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<td>Newburg, OR</td>
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<td>Boundary, WA</td>
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<td>Newport, WA</td>
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<td>OKNG</td>
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<td>Packwood, WA</td>
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<td>Prosser, WA</td>
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<td>PTAA</td>
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<td>RDK1</td>
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<td>RPUB</td>
<td>Republic, WA</td>
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<td>RYMD</td>
<td>Raymond, WA</td>
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<td>Makah, WA</td>
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<td>Gray's Harbor, WA</td>
<td>XANE</td>
<td>Wenatchee, WA</td>
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<td>LNIH</td>
<td>Badger Pocket, WA</td>
<td>HAHD</td>
<td>Palmer, WA</td>
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</table>

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
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Final Technical Report: Award #G10AC00081

LNIH: Badger Pocket

LWCK: Ilwaco/Lewis and Clark Interpretive Center
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
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 +) : +48°07'00.58"
   Longitude (E is +) : -123°29'39.69"
   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  : CLAY/EY 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  

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

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<th>City or Town</th>
<th>Pendleton</th>
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<td>Country</td>
<td>USA</td>
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<td>Z coordinate (m)</td>
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<td>Latitude (N is +)</td>
<td>+453957.41</td>
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<td>Longitude (E is +)</td>
<td>-1184524.93</td>
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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

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<td>IERS DOMES Number</td>
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<td>CDP Number</td>
<td>(A4)</td>
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<td>Monument Description</td>
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<tr>
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<td>Geologic Characteristic</td>
<td>CONGLOMERATE</td>
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<td>(IGNEOUS/METAMORPHIC/SEDIMENTARY)</td>
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<td>Fault zones nearby</td>
<td>(YES/NO/Name of the zone)</td>
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<td>Distance/activity</td>
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<td>Additional Information</td>
<td>(multiple lines)</td>
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2. Site Location Information

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3. GNSS Receiver Information

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<td>Elevation Cutoff Setting</td>
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<td>Date Installed</td>
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<td>Date Removed</td>
<td>(CCYY-MM-DDThh:mmZ)</td>
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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 : Rtcm 3.1 NETG3
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

RKD1: Daily minus Published IGS08 Position

\[
\begin{align*}
N [\text{cm}] & = -0.00 (\pm 0.12) \\
E [\text{cm}] & = -0.04 (\pm 0.10) \\
U [\text{cm}] & = 0.13 (\pm 0.45)
\end{align*}
\]

PTAA: Daily minus Published IGS08 Position

\[
\begin{align*}
N [\text{cm}] & = 0.05 (\pm 0.10) \\
E [\text{cm}] & = 0.03 (\pm 0.13) \\
U [\text{cm}] & = -0.08 (\pm 0.36)
\end{align*}
\]
PDTN: Daily minus Published IGS08 Position

\[ N \text{ [cm]} = 0.02(\pm 0.14) \quad E \text{ [cm]} = -0.06(\pm 0.21) \quad U \text{ [cm]} = -0.03(\pm 0.52) \]

HAHD: Daily minus Published IGS08 Position

\[ N \text{ [cm]} = 0.06(\pm 0.93) \quad E \text{ [cm]} = -0.11(\pm 0.26) \quad U \text{ [cm]} = 0.31(\pm 1.00) \]
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

Bedrock Monument

Cable Routing

All Connections Coped and Welded
# Appendix D: Power Back-up Systems

![Typical Power Back-up System with Receiver](image)

## Lifeline Deep Cycle Battery Specifications:

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

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