Determination of GDA94 coordinates for eighty-four stations of GPSnet in Victoria using the October 2012 GPS data set

Geoscience Australia  
Record 2014/08

G. Hu, J. Dawson



Accredited for compliance with ISO/IEC 17025. Accreditation No. 15002.

Department of Industry

Minister for Industry: The Hon Ian Macfarlane MP  
Parliamentary Secretary: The Hon Bob Baldwin MP  
Secretary: Ms Glenys Beauchamp PSM

Geoscience Australia

Chief Executive Officer: Dr Chris Pigram  
This paper is published with the permission of the CEO, Geoscience Australia



© Commonwealth of Australia (Geoscience Australia) 2014

With the exception of the Commonwealth Coat of Arms and where otherwise noted, all material in this publication is provided under a Creative Commons Attribution 3.0 Australia Licence. (<http://www.creativecommons.org/licenses/by/3.0/au/deed.en>)

Geoscience Australia has tried to make the information in this product as accurate as possible. However, it does not guarantee that the information is totally accurate or complete. Therefore, you should not solely rely on this information when making a commercial decision.

Geoscience Australia is committed to providing web accessible content wherever possible. If you are having difficulties with accessing this document please email [clientservices@ga.gov.au](mailto:clientservices@ga.gov.au).

ISSN 2201-702X (PDF)

ISBN 978-1-922201-97-3 (PDF)

GeoCat 78746

Bibliographic reference: Hu, G. & Dawson, J. 2014. Determination of GDA94 coordinates for eighty four stations of GPSnet in Victoria using the October 2012 GPS data set. Record 2014/08. Geoscience Australia, Canberra. <http://dx.doi.org/10.11636/Record.2014.008>

Contents

[Introduction 5](#_Toc382461700)

[Measurand 5](#_Toc382461701)

[Measurand Traceability 5](#_Toc382461702)

[Measurand Uncertainty 5](#_Toc382461703)

[GPS Data 6](#_Toc382461704)

[GPS Data Irregularities 6](#_Toc382461705)

[Method 10](#_Toc382461706)

[Results 11](#_Toc382461707)

## Name of NATA approved facility

Geoscience Australia – National Geospatial Reference Systems Section

Corner Jerrabomberra Ave and Hindmarsh Drive

Symonston ACT 2609 Australia

Telephone: (02) 6249 9111 Facsimile: (02) 6249 9969

Email: [geodesy@ga.gov.au](mailto:geodesy@ga.gov.au)

## Client Detail

Peter Oates

Department of Environment and Primary Industries

Level 3, 402 Mair Street Ballarat Victoria 3350

Telephone: (03) 5336 6779 Facsimile: (03) 5336 6772

Email: [Peter.Oates@dse.vic.gov.au](mailto:Peter.Oates@dse.vic.gov.au)

Date of request: 30 May 2013

## Expiry of this Report

5 years after authorisation date.

## Abbreviations

AFN Australian Fiducial Network

ARGN Australian Regional GNSS Network

CORS Continuously Operating Reference Station(s)

GDA94 Geocentric Datum Australia 1994

GNSS Global Navigation Satellite System(s)

GPS Global Positioning System

GRS80 Geodetic Reference System 1980

IGS International GNSS Service

ITRF International Terrestrial Reference Frame

ITRF92 International Terrestrial Reference Frame 1992

ITRF2008 International Terrestrial Reference Frame 2008

# Introduction

An application dated 11 February 2013 for verification of a reference standard of measurement under Regulation 12 of the National Measurement Regulations 1999 was received from Department of Environment and Primary Industries, for verification of GDA94 position on their owned or managed station monument. This report documents the processing and analysis of GPS data observed by the Department of Environment and Primary Industries during a 7-day period for eighty-four stations to satisfy the position verification requirements.

# Measurand

Station position, at the time of measurement and stated instrumentation, of a GPS monument with respect to the Geocentric Datum of Australia (GDA94) referred to the GRS80 ellipsoid being in the ITRF92 reference frame at the epoch 1994.0.

# Measurand Traceability

Measurement traceability was ensured by comparing the computed solution against the recognised value standard for position of the Australian Fiducial Network stations. Additionally, the computed solution was checked against the ITRF based solutions computed by the IGS and the individual global analysis centres of the IGS. The validity and traceability of the entire GPS system was ensured via its link to the global Satellite Laser Ranging (SLR) and Very Long Baseline Interferometry (VLBI) observing networks through the ITRF. The validity and traceability of our internal computation processes were ensured by undertaking standard benchmark analysis prior to this analysis.

# Measurand Uncertainty

Position uncertainties were calculated in accordance with the principles of the ISO Guide to the Expression of Uncertainty in Measurement (1995), with an interval estimated to have a confidence level of 95% at the time of verification. The combined standard uncertainty was converted to an expanded uncertainty using a coverage factor, k, of 2.

Type A uncertainty sources were evaluated by adopting an a priori sigma of 0.001 metre for the precision (1 sigma) of the L1-frequency, one-way, phase observation, at zenith. The corresponding uncertainties of all parameters were determined, by standard error propagation theory, in the least-squares estimation process used in the GPS analysis. Since the formal (internal) precision estimates of GPS solutions are well known to be optimistic, a factor of 10 (i.e. variance scale factor of 100) was subsequently applied to the variance-covariance matrix of the computed GDA94 coordinates.

Type B uncertainty sources, which in practice contribute to position uncertainty, cannot be estimated from the statistical analysis of short-period (i.e. 7-day) observations; these include environmental effects, such as long-period station loading (deformation) processes. Table 1 shows the major type B uncertainty sources for GPS analysis.

Table Type B uncertainty sources (95% C.L.) for position, determined from GPS, and the total uncertainty, assuming the normal distribution of the uncertainty sources, high degrees of freedom and a coverage factor, k, of 2.

| Uncertainty Source | Position Uncertainty Horizontal (mm) | Position Uncertainty Vertical (mm) |
| --- | --- | --- |
| Antenna phase centre | 3 | 10 |
| Monument stability | 1 | 1 |
| Other sources including un-modelled crustal loading, satellite orbit variations, atmosphere, tectonics, signal multi-path | 6 | 10 |

# GPS Data

GPS RINEX data was supplied for spanning a 7-day period from 07 October 2012 to 13 October 2012 (day of year 281 to 287) for the eighty-four stations of GPSnet in Victoria. Figure 1 shows the locations of the stations. The AFN/ARGN/IGS network sites used in the GPS data processing are also plotted in Figure 1. Table 2 lists the GPS receiver and antenna type used in the GPS data processing for each of the AFN/ARGN/IGS network sites. The GPS receiver and antenna types at the GPSnet sites in Victoria are listed in Table 3. An antenna height of 0.000 m to the Antenna Reference Point (ARP) has been adopted for the stations of GPSnet in Victoria for the GPS data processing. The ARP is the reference point as defined by IGS and the RINEX specifications. Table 4 lists the GPS antenna heights to the Antenna Reference Point (ARP) used in the GPS data processing for the AFN/ARGN/IGS stations.

# GPS Data Irregularities

The updated data set and meta data on 11 December 2013 have been adopted for the GPS data processing. Note that data of the site ALBU was invalid since the antenna was changed after submitting the data.

Due to the complexity of this document and the niche scientific target audience, no alternative description has been provided. Please email Geoscience Australia at clientservices@ga.gov.au for an alternative description.

Figure Stations of GPSnet in Victoria (circle) and AFN/ARGN/IGS (black triangles) stations used in GPS data processing.

Table GPS receiver and antenna types for the AFN/ARGN/IGS sites.

| Station | GPS receiver type | GPS antenna serial number | IGS antenna type and dome type |
| --- | --- | --- | --- |
| ALIC | LEICA GRX1200GGPRO | 09370001 | LEIAR25.R3 NONE |
| CEDU | TRIMBLE NETR8 | 194 | AOAD/M\_T AUST |
| DARW | GRX1200GGPRO | CR13354 | ASH700936D\_M NONE |
| HOB2 | LEICA GRX1200GGPRO | 203 | AOAD/M\_T NONE |
| KARR | TRIMBLE NETR8 | 4938353444 | TRM59800.00 NONE |
| MAC1 | LEICA GRX1200+GNSS | 308 | AOAD/M\_T AUST |
| MOBS | LEICA GRX1200GGPRO | CR20020709 | ASH701945C\_M NONE |
| STR1 | LEICA GRX1200GGPRO | CR620023911 | ASH701945C\_M NONE |
| SYDN | JPS E\_GGD | CR519994908 | ASH701945C\_M NONE |
| TIDB | ASHTECH UZ-12 | 205 | AOAD/M\_T JPLA |
| TOW2 | LEICA GRX1200GGPRO | 09310016 | LEIAR25.R3 NONE |
| YARR | LEICA GRX1200PRO | 103314 | LEIAT504 NONE |

Table GPS receiver and antenna types for the stations of GPSnet in Victoria.

| Station | GPS receiver type | GPS antenna serial number | IGS antenna type and dome type |
| --- | --- | --- | --- |
| ADEL | Trimble NetR5 | 30518790 | TRM55971.00 NONE |
| ANGL | Trimble NetR5 | 11909802 | TRM41249.00 NONE |
| ANTW | Trimble NetR5 | 1440932115 | TRM57971.00 NONE |
| APSL | Trimble NetR5 | 1440929138 | TRM57971.00 NONE |
| BALL | Trimble NetR9 | 1441107493 | TRM57971.00 NONE |
| BALM | Trimble NetR5 | 1441004065 | TRM57971.00 NONE |
| BCUS | Leica GRX1200GG Pro | 08090150 | LEIAX1202GG NONE |
| BEUA | Trimble NetR5 | 1441004198 | TRM57971.00 NONE |
| BIGG | Trimble NetR5 | 1441004019 | TRM57971.00 NONE |
| BIRC | Trimble NetR5 | 1440932191 | TRM57971.00 NONE |
| BNDC | Trimble NetR5 | 1440929178 | TRM57971.00 NONE |
| BNLA | Trimble NetR9 | 1441112323 | TRM57971.00 NONE |
| BOLC | Leica GRX1200+GNSS | 10321034 | LEIAS10 NONE |
| BOOL | Trimble NetR5 | 1440932111 | TRM57971.00 NONE |
| BORT | Trimble NetR5 | 1441009481 | TRM57971.00 NONE |
| BUCH | Trimble NetR5 | 1440932029 | TRM57971.00 NONE |
| BUXT | Trimble NetR5 | 1440932171 | TRM57971.00 NONE |
| CANR | Trimble NetR5 | 1440921023 | TRM57971.00 NONE |
| CLAC | Trimble NetR3 | 30767584 | TRM57971.00 NONE |
| CLBN | Trimble NetR5 | 1440932055 | TRM57971.00 NONE |
| CRSY | Leica GRX1200+GNSS | 10321003 | LEIAS10 NONE |
| EBNK | Trimble NetR5 | 31050722 | TRM57971.00 NONE |
| ECHU | Trimble NetR5 | 30882659 | TRM57971.00 NONE |
| EPSM | Trimble NetR5 | 31050429 | TRM57971.00 NONE |
| EURO | Trimble NetR5 | 1440932134 | TRM57971.00 NONE |
| GEES | Trimble NetR5 | 30767586 | TRM57971.00 NONE |
| GELA | Trimble NetR5 | 1440932044 | TRM57971.00 NONE |
| GLDN | Trimble NetR5 | 1440929147 | TRM57971.00 NONE |
| GLEN | Trimble NetR5 | 1440929158 | TRM57971.00 NONE |
| GNOA | Trimble NetR5 | 1441004040 | TRM57971.00 NONE |
| GORO | Trimble NetR5 | 1440929099 | TRM57971.00 NONE |
| HATT | Trimble NetR5 | 1440921294 | TRM57971.00 NONE |
| HMLT | Trimble NetR5 | 1440932157 | TRM57971.00 NONE |
| HOTH | Trimble NetR5 | 1441009222 | TRM57971.00 NONE |
| HRSM | Trimble NetR5 | 31050729 | TRM57971.00 NONE |
| IRYM | Trimble NetR5 | 30473532 | TRM55971.00 NONE |
| KRNG | Trimble NetR9 | 1441112008 | TRM57971.00 NONE |
| LALB | Trimble NetR5 | 1440925066 | TRM57971.00 NONE |
| LCLA | Trimble NetR5 | 1440929125 | TRM57971.00 NONE |
| LIPO | Trimble NetR5 | 1440932034 | TRM57971.00 NONE |
| MAFF | Trimble NetR5 | 1440932308 | TRM57971.00 NONE |
| MANY | Trimble NetR5 | 144092930 | TRM57971.00 NONE |
| MARY | Trimble netR5 | 1441004127 | TRM57971.00 NONE |
| MENO | Trimble NetR5 | 1440929027 | TRM57971.00 NONE |
| MIMI | Trimble NetR5 | 1441004561 | TRM57971.00 NONE |
| MITT | Trimble NetR5 | 1440932067 | TRM57971.00 NONE |
| MLAK | Trimble NetR5 | 1440931111 | TRM57971.00 NONE |
| MNSF | Trimble NetR5 | 1440929203 | TRM57971.00 NONE |
| MOOR | Trimble NetR5 | 1441009157 | TRM57971.00 NONE |
| MRNO | Trimble NetR5 | 1440925245 | TRM57971.00 NONE |
| MRNT | Trimble NetR9 | 1441107709 | TRM57971.00 NONE |
| MURR | Trimble NetR5 | 1440921049 | TRM57971.00 NONE |
| MYRT | Trimble NetR5 | 1441004145 | TRM57971.00 NONE |
| NELN | Trimble NetR5 | 1440932073 | TRM57971.00 NONE |
| OMEO | Trimble NetR5 | 1441004037 | TRM57971.00 NONE |
| ORBO | Trimble NetR5 | 1440929187 | TRM57971.00 NONE |
| PIAN | Trimble NetR5 | 1440932243 | TRM57971.00 NONE |
| PKVL | Leica GRX1200GG Pro | 6400046 | LEIAX1202GG NONE |
| POCA | Trimble NetR5 | 1441004593 | TRM57971.00 NONE |
| PRTF | Trimble NetR5 | 1441004411 | TRM57971.00 NONE |
| RNBW | Trimble NetR5 | 1440932241 | TRM57971.00 NONE |
| RUTH | Trimble NetR5 | 1440929104 | TRM57971.00 NONE |
| SEAL | Trimble NetR5 | 1440932026 | TRM57971.00 NONE |
| SEMR | Trimble NetR5 | 31171731 | TRM57971.00 NONE |
| SKIP | Trimble NetR5 | 1441004137 | TRM57971.00 NONE |
| SRVC | Trimble NetR5 | 1440921084 | TRM57971.00 NONE |
| STAR | Leica GRX1200+GNSS | 10321032 | LEIAS10 NONE |
| STRH | Trimble NetR5 | 1441004206 | TRM57971.00 NONE |
| TATU | Trimble NetR5 | 30874021 | TRM57971.00 NONE |
| TELO | Trimble NetR5 | 1440932188 | TRM57971.00 NONE |
| THOM | Trimble NetR5 | 30767549 | TRM57971.00 NONE |
| UNDE | Trimble NetR5 | 1440929069 | TRM57971.00 NONE |
| WALW | Trimble NetR5 | 1440929149 | TRM57971.00 NONE |
| WEDD | Trimble NetR5 | 1441004384 | TRM57971.00 NONE |
| WHTL | Trimble NetR5 | 30966067 | TRM57971.00 NONE |
| WORI | Trimble NetR9 | 1441107808 | TRM57971.00 NONE |
| WOTG | Trimble NetR5 | 31051061 | TRM57971.00 NONE |
| WYCH | Trimble NetR5 | 1440932252 | TRM57971.00 NONE |
| YALL | Trimble NetR5 | 30132034 | TRM55971.00 NONE |
| YANK | Leica GRX1200GG Pro | 7120090 | LEIAX1202GG NONE |
| YARS | Trimble NetR5 | 1440929122 | TRM57971.00 NONE |
| YIEL | Trimble NetR5 | 1440929077 | TRM57971.00 NONE |
| YRRM | Trimble NetR5 | 1440929089 | TRM57971.00 NONE |

Table GPS antenna heights to ARP used in GPS processing for the minimally constrained AFN/ARGN/IGS stations.

| Station | Domes number | Antenna height to ARP (m) | Station | Domes number | Antenna height to ARP (m) |
| --- | --- | --- | --- | --- | --- |
| ALIC | 50137M001 | 0.0015 | MOBS | 50182M001 | 0.0000 |
| CEDU | 50138M001 | 0.0060 | STR1 | 50119M002 | 0.0040 |
| DARW | 50134M001 | 0.0025 | SYDN | 50124M003 | 0.0300 |
| HOB2 | 50116M004 | 0.0000 | TIDB | 50103M108 | 0.0614 |
| KARR | 50139M001 | 0.0010 | TOW2 | 50140M001 | 0.0033 |
| MAC1 | 50135M001 | 0.0280 | YARR | 50107M006 | 0.0045 |

# Method

Analysis was undertaken following the procedures detailed in Geoscience Australia’s GPS Analysis Manual for the Verification of Position Issue 1.15.

In summary, daily solutions of the stations of GPSnet in Victoria and AFN/ARGN/IGS/other site data were processed using Bernese GPS Processing Software version 5.0. The Bernese GPS Software conforms to the IERS2003 conventions. IGS final GPS satellite ephemerides and earth orientation parameters were used in the computations. The double difference carrier phase observables at 30-second epoch intervals were used for GPS data processing. Other measurement modelling and parameter estimation included:

* Receiver clock corrections.
* Absolute antenna elevation-dependent phase centre variation corrections.
* Solid earth tide displacements.
* Ocean tide loading displacements.
* Elevation cutoff of 10° for all observations.
* QIF integer ambiguity resolution strategy.
* Elevation dependent observation weighting.
* Troposphere zenith delays estimated at 1-hour intervals for all stations.
* Minimum constraint condition for daily network solution in terms of the ITRF2008 using subset of the IGS08 reference stations.

This solution was transformed to GDA94 using the transformation approach detailed in: ITRF to GDA94 coordinate transformation, John Dawson and Alex Woods, Journal of Applied Geodesy 4 (2010), no. 4, pp. 189-199, available online at <http://www.reference-global.com/loi/jag>.

# Results

Table 5 and Table 6 list the Root Mean Square (RMS) of the daily station coordinate values. Table 7 lists the station coordinates resulting from the combination of the daily ITRF solutions and their subsequent transformation to GDA94.

Table Root Mean Square (RMS) of daily station coordinates for the minimally constrained AFN/ARGN/IGS.

| Station | North  (mm) | East  (mm) | Up  (mm) | Station | North  (mm) | East  (mm) | Up  (mm) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ALIC | 0.7 | 0.9 | 2.5 | MOBS | 0.9 | 0.7 | 2.9 |
| CEDU | 0.4 | 1.1 | 3.1 | STR1 | 0.8 | 0.7 | 2.4 |
| DARW | 1.7 | 1.6 | 4.4 | SYDN | 0.5 | 1.3 | 4.5 |
| HOB2 | 1.4 | 0.8 | 2.2 | TIDB | 0.8 | 1.2 | 2.4 |
| KARR | 0.6 | 1.1 | 2.8 | TOW2 | 1.3 | 3.0 | 3.3 |
| MAC1 | 1.3 | 1.7 | 5.4 | YARR | 0.8 | 1.4 | 1.9 |

Table Root Mean Square (RMS) of daily station coordinates for the stations of GPSnet in Victoria.

| Station | North  (mm) | East  (mm) | Up  (mm) | Station | North  (mm) | East  (mm) | Up  (mm) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ADEL | 0.9 | 0.8 | 2.1 | MARY | 0.5 | 0.8 | 1.8 |
| ANGL | 0.9 | 0.6 | 4.9 | MENO | 2.3 | 0.9 | 2.3 |
| ANTW | 0.6 | 0.4 | 2.7 | MIMI | 1.3 | 2.2 | 5.8 |
| APSL | 2.7 | 2.9 | 5.6 | MITT | 0.4 | 0.6 | 2.8 |
| BALL | 0.7 | 0.6 | 2.3 | MLAK | 0.7 | 0.7 | 1.7 |
| BALM | 0.7 | 0.6 | 2.6 | MNSF | 0.7 | 0.6 | 3.9 |
| BCUS | 0.6 | 0.7 | 3.7 | MOOR | 0.6 | 0.6 | 1.8 |
| BEUA | 0.3 | 0.3 | 2.5 | MRNO | 1.6 | 1.3 | 1.9 |
| BIGG | 1.0 | 1.1 | 1.9 | MRNT | 0.8 | 0.8 | 3.7 |
| BIRC | 0.6 | 0.5 | 1.2 | MURR | 0.4 | 0.8 | 1.6 |
| BNDC | 0.8 | 0.8 | 3.3 | MYRT | 0.6 | 0.8 | 3.4 |
| BNLA | 0.5 | 1.0 | 3.9 | NELN | 0.5 | 0.8 | 2.7 |
| BOLC | 1.0 | 0.7 | 5.1 | OMEO | 1.2 | 0.9 | 3.3 |
| BOOL | 1.0 | 0.4 | 2.5 | ORBO | 0.7 | 0.8 | 2.5 |
| BORT | 1.1 | 1.0 | 3.4 | PIAN | 0.5 | 2.0 | 2.6 |
| BUCH | 1.1 | 0.8 | 3.7 | PKVL | 0.6 | 0.9 | 3.0 |
| BUXT | 1.1 | 0.9 | 4.6 | POCA | 1.0 | 0.7 | 2.8 |
| CANR | 0.4 | 0.7 | 3.0 | PRTF | 0.9 | 0.7 | 3.1 |
| CLAC | 0.6 | 0.5 | 2.6 | RNBW | 0.5 | 0.4 | 1.8 |
| CLBN | 0.4 | 0.7 | 2.1 | RUTH | 0.6 | 0.4 | 2.9 |
| CRSY | 1.0 | 1.0 | 3.8 | SEAL | 0.6 | 0.7 | 2.3 |
| EBNK | 0.8 | 0.9 | 3.2 | SEMR | 0.5 | 0.7 | 4.4 |
| ECHU | 0.9 | 0.6 | 3.1 | SKIP | 0.4 | 0.7 | 2.7 |
| EPSM | 1.1 | 0.7 | 2.7 | SRVC | 0.7 | 0.5 | 2.2 |
| EURO | 0.7 | 0.8 | 1.7 | STAR | 0.5 | 0.7 | 0.9 |
| GEES | 0.9 | 0.6 | 3.8 | STRH | 0.7 | 0.6 | 2.1 |
| GELA | 0.6 | 0.7 | 3.6 | TATU | 0.5 | 0.5 | 3.1 |
| GLDN | 0.6 | 1.0 | 3.1 | TELO | 0.4 | 0.6 | 1.7 |
| GLEN | 0.7 | 0.6 | 2.0 | THOM | 1.4 | 1.1 | 7.3 |
| GNOA | 0.8 | 1.2 | 3.9 | UNDE | 0.6 | 0.5 | 2.0 |
| GORO | 0.6 | 0.5 | 2.2 | WALW | 0.9 | 0.8 | 3.9 |
| HATT | 0.3 | 0.6 | 3.0 | WEDD | 0.6 | 0.6 | 2.2 |
| HMLT | 0.6 | 0.7 | 2.7 | WHTL | 1.0 | 0.7 | 3.3 |
| HOTH | 1.2 | 1.3 | 4.4 | WORI | 0.9 | 0.9 | 3.0 |
| HRSM | 1.0 | 0.5 | 2.9 | WOTG | 0.8 | 0.6 | 3.6 |
| IRYM | 0.5 | 0.4 | 1.9 | WYCH | 0.5 | 0.5 | 1.7 |
| KRNG | 0.5 | 0.3 | 2.8 | YALL | 1.2 | 1.0 | 4.1 |
| LALB | 0.3 | 0.4 | 1.7 | YANK | 0.6 | 0.7 | 3.1 |
| LCLA | 0.9 | 0.7 | 9.9 | YARS | 0.5 | 1.4 | 2.5 |
| LIPO | 0.4 | 0.5 | 2.3 | YIEL | 0.7 | 0.5 | 1.3 |
| MAFF | 1.2 | 0.7 | 4.1 | YRRM | 0.8 | 0.8 | 2.3 |
| MANY | 0.4 | 0.6 | 2.2 |  |  |  |  |

Table Computed Geocentric Datum of Australia (GDA94) geodetic coordinates and their uncertainty for the stations of GPSnet in Victoria. The uncertainties are calculated in accordance with the principles of the ISO Guide to the Expression of Uncertainty in Measurement (1995), with an interval estimated to have a confidence level of 95% at the time of verification. The combined standard uncertainty was converted to an expanded uncertainty using a coverage factor, k, of 2.

| Station | Longitude (DMS east)  Uncertainty (m) | | | Latitude (DMS south)  Uncertainty (m) | | | Ellipsoidal height (m)  Uncertainty (m) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ADEL | 138 | 36 | 13.16945 | 34 | 55 | 52.38328 | 55.0844 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| ANGL | 144 | 11 | 35.43956 | 38 | 23 | 46.77762 | 19.6401 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| ANTW | 142 | 1 | 36.44658 | 36 | 17 | 43.49006 | 103.6394 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| APSL | 141 | 4 | 59.63343 | 36 | 58 | 3.26075 | 112.1993 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| BALL | 143 | 51 | 17.69940 | 37 | 33 | 32.00110 | 463.2764 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.019 |
| BALM | 141 | 50 | 32.04109 | 37 | 14 | 55.65671 | 191.4208 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| BCUS | 144 | 26 | 31.61397 | 37 | 40 | 36.49391 | 112.4911 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| BEUA | 142 | 24 | 52.93604 | 35 | 56 | 24.04745 | 97.2693 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| BIGG | 148 | 1 | 34.41441 | 36 | 16 | 50.73779 | 330.1672 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| BIRC | 142 | 54 | 46.21161 | 35 | 59 | 7.62093 | 117.3899 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| BNDC | 148 | 53 | 5.66055 | 37 | 8 | 50.97644 | 848.2105 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| BNLA | 146 | 0 | 21.48938 | 36 | 32 | 37.89799 | 187.4521 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| BOLC | 142 | 50 | 27.36935 | 37 | 42 | 41.64097 | 220.0917 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| BOOL | 142 | 40 | 4.81891 | 36 | 20 | 24.67964 | 129.4854 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| BORT | 143 | 43 | 21.25793 | 36 | 8 | 9.34478 | 113.9003 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| BUCH | 148 | 10 | 4.04689 | 37 | 29 | 52.84584 | 184.4777 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| BUXT | 145 | 42 | 44.16516 | 37 | 25 | 34.01526 | 300.6269 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| CANR | 149 | 9 | 26.96702 | 37 | 33 | 53.52666 | 137.1798 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| CLAC | 143 | 35 | 6.49625 | 38 | 20 | 32.55330 | 144.6686 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.019 |
| CLBN | 144 | 47 | 53.51928 | 36 | 35 | 30.69388 | 129.8312 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| CRSY | 143 | 38 | 23.06955 | 38 | 1 | 41.50784 | 157.8815 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| EBNK | 145 | 56 | 9.72899 | 38 | 14 | 36.66394 | 181.9500 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| ECHU | 144 | 45 | 12.89162 | 36 | 8 | 25.15456 | 112.1753 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| EPSM | 144 | 18 | 52.56012 | 36 | 43 | 5.12667 | 206.9679 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| EURO | 145 | 34 | 22.19257 | 36 | 45 | 11.41580 | 195.4428 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| GEES | 144 | 21 | 42.24742 | 38 | 9 | 34.01064 | 29.4864 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| GELA | 148 | 15 | 53.20691 | 37 | 13 | 6.95221 | 779.4738 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| GLDN | 147 | 24 | 9.87586 | 38 | 12 | 31.94948 | 25.2768 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| GLEN | 142 | 39 | 42.76508 | 36 | 54 | 32.29991 | 180.6824 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| GNOA | 149 | 35 | 22.14037 | 37 | 28 | 36.85228 | 32.0430 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| GORO | 141 | 28 | 21.95260 | 36 | 43 | 5.51731 | 170.7658 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| HATT | 142 | 20 | 22.28051 | 34 | 45 | 20.53316 | 61.6548 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| HMLT | 142 | 1 | 29.06849 | 37 | 44 | 42.73915 | 197.6385 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| HOTH | 147 | 8 | 30.63382 | 36 | 58 | 55.47383 | 1774.0086 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| HRSM | 142 | 10 | 29.50331 | 36 | 43 | 21.93764 | 144.3036 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| IRYM | 142 | 11 | 28.35568 | 34 | 13 | 11.01469 | 72.2685 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| KRNG | 143 | 55 | 20.28205 | 35 | 44 | 7.45755 | 90.5449 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| LALB | 143 | 22 | 31.17145 | 35 | 40 | 24.48023 | 97.7915 |
| LCLA | 146 | 37 | 20.25947 | 37 | 37 | 41.57267 | 210.1032 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| LIPO | 141 | 0 | 40.37412 | 34 | 6 | 19.40241 | 64.1339 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| MAFF | 146 | 59 | 7.05199 | 37 | 58 | 19.88874 | 42.7458 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| MANY | 141 | 3 | 42.84088 | 35 | 2 | 55.13689 | 85.0741 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| MARY | 143 | 45 | 35.35732 | 37 | 0 | 19.52805 | 219.5896 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| MENO | 141 | 48 | 23.85393 | 34 | 16 | 20.49011 | 62.3628 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| MIMI | 147 | 22 | 23.61652 | 36 | 31 | 56.00338 | 290.6877 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| MITT | 142 | 39 | 27.56427 | 35 | 9 | 21.54247 | 72.7514 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.022 |
| MLAK | 142 | 48 | 30.27445 | 38 | 4 | 53.65984 | 140.2558 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| MNSF | 146 | 5 | 11.25604 | 37 | 3 | 55.78802 | 356.8299 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| MOOR | 142 | 7 | 52.86794 | 37 | 24 | 7.75654 | 279.5167 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| MRNO | 141 | 32 | 55.47721 | 37 | 43 | 10.91257 | 88.0554 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| MRNT | 145 | 3 | 58.81938 | 38 | 13 | 45.40305 | 60.2524 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| MURR | 141 | 10 | 52.01293 | 35 | 15 | 45.32319 | 77.6132 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| MYRT | 146 | 43 | 19.91180 | 36 | 33 | 28.68936 | 227.2737 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| NELN | 141 | 0 | 22.34801 | 38 | 2 | 52.52317 | 9.4840 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| OMEO | 147 | 36 | 2.03200 | 37 | 6 | 7.19055 | 712.4388 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| ORBO | 148 | 27 | 18.48137 | 37 | 42 | 14.80722 | 45.5475 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| PIAN | 143 | 19 | 39.79941 | 35 | 3 | 15.61268 | 78.7928 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| PKVL | 144 | 57 | 39.28752 | 37 | 47 | 59.36171 | 67.4993 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| POCA | 142 | 59 | 49.27266 | 38 | 37 | 2.74412 | 12.6309 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.019 |
| PRTF | 142 | 14 | 17.79037 | 38 | 23 | 6.17130 | 12.7214 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| RNBW | 141 | 59 | 34.58950 | 35 | 54 | 35.18276 | 116.3619 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| RUTH | 146 | 30 | 32.00837 | 36 | 5 | 54.50817 | 211.2163 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| SEAL | 142 | 50 | 55.47909 | 35 | 30 | 16.32213 | 70.9662 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| SEMR | 145 | 8 | 21.05465 | 37 | 1 | 27.23715 | 156.5902 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| SKIP | 143 | 21 | 34.21947 | 37 | 41 | 5.50972 | 302.2185 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| SRVC | 140 | 59 | 21.01245 | 36 | 22 | 40.42621 | 127.3437 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| STAR | 143 | 15 | 26.55824 | 36 | 36 | 55.02287 | 258.6759 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| STRH | 141 | 8 | 11.53982 | 37 | 43 | 43.63873 | 70.4046 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| TATU | 145 | 16 | 13.58403 | 36 | 26 | 22.74077 | 129.6814 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| TELO | 141 | 6 | 39.39192 | 36 | 7 | 33.66475 | 144.4255 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| THOM | 146 | 23 | 53.63608 | 37 | 50 | 36.75721 | 479.7833 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| UNDE | 141 | 48 | 45.49627 | 35 | 10 | 16.47370 | 68.5999 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| WALW | 147 | 44 | 3.04239 | 35 | 57 | 57.65815 | 242.2879 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| WEDD | 143 | 36 | 50.49530 | 36 | 25 | 31.88755 | 199.1411 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| WHTL | 145 | 4 | 3.45311 | 37 | 38 | 42.06222 | 163.1799 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| WORI | 145 | 31 | 48.10106 | 37 | 46 | 37.48052 | 117.9546 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| WOTG | 145 | 35 | 27.07614 | 38 | 36 | 29.15956 | 51.8838 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| WYCH | 143 | 13 | 33.36049 | 36 | 4 | 38.88950 | 120.4808 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| YALL | 146 | 20 | 56.47624 | 38 | 10 | 55.58417 | 64.8755 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| YANK | 146 | 12 | 24.80635 | 38 | 48 | 44.19894 | 29.9040 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |
| YARS | 141 | 27 | 16.55853 | 34 | 31 | 40.73059 | 97.0803 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| YIEL | 145 | 14 | 8.99434 | 35 | 55 | 40.60728 | 117.1364 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.021 |
| YRRM | 146 | 40 | 30.68066 | 38 | 33 | 54.61070 | 35.7743 |
|  |  |  | ±0.008 |  |  | ±0.008 | ±0.020 |

END OF REPORT