Standard for New Zealand Vertical Datum 2016

LINZS25009

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Tables

TERMS AND DEFINITIONS

For the purposes of this standard, the following terms and definitions apply.

Term/abbreviation	Definition
ellipsoid	a surface formed by the rotation of an ellipse about a main axis. For the purposes of this standard, the ellipsoids used are oblate to match the general shape of the Earth. An oblate ellipsoid is one in which the semi–minor axis of the ellipse is the axis of revolution.
ellipsoidal height	the distance from a reference ellipsoid to a point along the ellipsoidal normal.
equipotential surface	a surface that is always perpendicular to the force of gravity. An example is the static surface of the ocean, if disturbances caused by dynamic influences such as tides, currents, seawater density, wind, and atmospheric pressure are not considered.
geoid	an equipotential surface that is approximated by sea level in the open oceans and which is the reference surface for orthometric heights.
GRS80	Geodetic Reference System 1980 — a set of parameters adopted by the International Association of Geodesy (IAG) that includes a reference ellipsoid and a normal gravity field for the Earth (Moritz 2000).
LINZ	Land Information New Zealand.
LVD	local vertical datum
LVD relationship	the surface representing the variable difference between NZGeoid2016 and the surface of a LVD, realised through precise levelling and GNSS surveys at benchmarks.
LVD relationship grid	the grid file of LVD relationship values as provided on the LINZ web site.
normal height	the distance from the quasigeoid to a point along the curved normal gravity plumbline. Normal heights are calculated along levelling lines using actual gravity observations.
normal–orthometric height	the distance from the quasigeoid to a point along the curved normal gravity plumbline. Normal–orthometric heights are calculated along levelling lines using a normal gravity field rather than actual gravity observations.
NZGD2000	New Zealand Geodetic Datum 2000, a three-dimensional geocentric datum based on the International Terrestrial Reference Frame 1996 with ellipsoidal heights defined in terms of the GRS80 ellipsoid.
NZGeoid2016	New Zealand Quasigeoid 2016

Term/abbreviation	Definition
NZGeoid2016 grid	the grid file of NZGeoid2016 values as provided on the LINZ website.
NZVD2016	New Zealand Vertical Datum 2016
orthometric height	the distance from the geoid to a point along the plumbline. Orthometric heights can not be easily realised in practice because their calculation requires knowledge of density variations inside the local topography, as well as local gravity.
quasigeoid	a non–equipotential surface that coincides reasonably closely with the geoid and which is the reference surface used for normal and normal-orthometric heights.
quasigeoid height	the vertical distance from the reference ellipsoid to the quasigeoid.
vertical datum	a curved or level reference surface from which to determine elevations.

FOREWORD

Introduction

A national geodetic system is a fundamental component of a nation's infrastructure. The unique property of a geodetic system is its ability to allow the integration of multiple geographically dependent data sources into a single geographic reference frame.

One element of a geodetic system is a national vertical datum. Transformations are needed to enable spatial data held in terms of other vertical datums to be converted to the national vertical datum. This allows diverse spatial datasets to be correctly correlated and compared within a consistent framework.

A key benefit of the New Zealand Vertical Datum 2016 (NZVD2016) is the ability to readily determine heights in terms of it anywhere within New Zealand's territory without resorting to the cost and limitations of precise levelling. It also provides a single consistent vertical datum nationally across New Zealand.

NZVD2016 improves on NZVD2009 by including airborne gravity observations across New Zealand into the computation of the reference geoid model and by better modelling the spatially-variable relationships of the geoid to the existing local vertical datums.

Purpose of standard

The purpose of this standard is to specify a national vertical datum for New Zealand and to define its relationship to other commonly used height systems.

This standard contributes to the Surveyor-General's function under s 7 of the Cadastral Survey Act 2002 to maintain a national geodetic system.

Brief history of standard

This standard replaces LINZS25004 Standard for New Zealand Vertical Datum 2009.

References

Heck, B. 2003, *Rechenverfahren und Auswertemodelle der Landesvermessung*, 3rd edn, Wichmann, Karlsruhe, p. 473. ISBN-10: 3879073473

Moritz, H. 2000, *Geodetic Reference System 1980*, Journal of Geodesy, vol. 74, no. 1, pp. 128-133. doi:10.1007/S001900050278

1 Scope

(a) This standard describes the national vertical datum, NZVD2016.

(b) This standard enables the transformation of NZVD2016 heights to and from the 13 major precise levelling–based local vertical datums (LVDs) and the New Zealand Geodetic Datum 2000 (NZGD2000).

2 Intended use of standard

Any person using or referring to NZVD2016 must comply with this standard.

> **COMMENTARY**
>
> **Spatial extent of NZVD2016**
>
> NZVD2016 should only be used within the area defined by 160°E to 170°W and 25°S to 60°S.

3 New Zealand Vertical Datum 2016

3.1 Official reference surface

(a) NZVD2016 heights must be measured in relation to the official reference surface.

(b) The official reference surface of NZVD2016 is the New Zealand Quasigeoid 2016 (NZGeoid2016).

3.2 Official height system[1]

(a) NZVD2016 heights must be provided in the normal–orthometric height system in relation to the official reference surface.

(b) The value of the NZGeoid2016 in relation to the Geodetic Reference System 1980 (GRS80) ellipsoid at a specific location must be bi–linearly interpolated from the NZGeoid2016 grid using its NZGD2000 position.

(c) The grid values for the NZGeoid2016 are provided on the LINZ website.

[1] For more information about height systems, see Appendix A: Height systems.

3.3 Normal–orthometric correction

(a) NZVD2016 normal–orthometric heights must be calculated using the GRS80 normal gravity field specified in Table 1.

(b) NZVD2016 normal–orthometric heights determined by precise levelling must be reduced using the normal–orthometric correction (NOC) equation (Heck 2003) and GRS80 parameters from Moritz (2000) specified in Table 1:

$$\text{NOC} = -\frac{f^*}{R} H_{avg} \sin 2\phi \cos\alpha \, \delta s \qquad \text{expressed in metres}$$

where

f^*	is the GRS80 normal gravity flattening constant
R	GRS80 mean Earth radius, expressed in metres
H_{avg}	average normal-orthometric height of benchmarks either end of a single levelling line or traverse, expressed in metres
ϕ	mid–latitude between benchmarks, expressed in negative degrees when south of the equator
α	azimuth between benchmarks, in degrees reckoned positive in a clockwise direction from north
δs	horizontal distance between benchmarks, expressed in metres.

Table 1: GRS80 gravity field parameters (Moritz 2000)

Parameter	Symbol	Value
normal gravity flattening constant	f^*	0.005 302 440 112
mean Earth radius	R	6 371 000 m

(c) Where NZVD2016 normal-orthometric heights are determined by precise levelling the NOC must be calculated in relation to a mark with an existing NZVD2016 height that is included in the levelling line.

4 Local Vertical Datums

(a) The official LVDs defined in Table 2 may be used with NZVD2016.

(b) The LVD relationship grids described in Table 2 must be used to relate NZVD2016 to the official LVDs.

(c) The value of the LVD relationship with respect to the NZGeoid2016 at a specific location must be bi–linearly interpolated from the appropriate LVD relationship grid using its NZGD2000 position.

(d) The 13 LVD relationship grids listed in Table 2 are available on the LINZ website.

Table 2: Official local vertical datums and relationship grids [2]

Local vertical datum	LVD relationship grid
One Tree Point 1964	OTP64-NZVD16
Auckland 1946	AUK46-NZVD16
Moturiki 1953	MOT53-NZVD16
Gisborne 1926	GSB26-NZVD16
Napier 1962	NPR62-NZVD16
Taranaki 1970	TNK70-NZVD16
Wellington 1953	WGN53-NZVD16
Nelson 1955	NSN55-NZVD16
Lyttelton 1937	LTN37-NZVD16
Dunedin 1958	DUN58-NZVD16
Dunedin-Bluff 1960	DBL60-NZVD16
Bluff 1955	BLF55-NZVD16
Stewart Island 1977	STI77-NZVD16

COMMENTARY

Computation of LVD relationship grid

The relationship grids have been computed using the difference between normal-orthometric and ellipsoidal heights for GNSS-Levelling marks within the LVD region. The result is a spatially variable surface which models the relationship between the datums.

[2] For more information about the local vertical datums, and relationship grids see LINZ website

5 Height Transformations

5.1 Introduction

The following paragraphs define the transformations between official New Zealand height systems. The transformations defined are between:

(a) NZGD2000 ellipsoidal heights and NZVD2016,

(b) LVDs and NZVD2016,

(c) different LVDs, and

(d) LVDs and NZGD2000 ellipsoidal heights.

5.2 Transformation between NZGD2000 ellipsoidal heights and NZVD2016

When transforming between NZGD2000 ellipsoidal heights and NZVD2016 normal-orthometric heights, the following equations must be used:

$$H_{NZVD} = h - N$$

$$h = H_{NZVD} + N$$

where

H_{NZVD} is the NZVD2016 normal–orthometric height in metres

h is the NZGD2000 ellipsoidal height in metres

N is the NZGeoid2016 value in metres at the NZGD2000 position of h.

5.3 Transformation between a local vertical datum and NZVD2016

When transforming between normal–orthometric heights in terms of a LVD listed in Table 2 and NZVD2016 normal–orthometric heights, the following equations must be used:

$$H_{NZVD} = H_A - o_A$$

$$H_A = H_{NZVD} + o_A$$

where

H_{NZVD} is the NZVD2016 normal–orthometric height in metres

H_A is the LVD A normal–orthometric height in metres

o_A is the LVD A offset in metres evaluated from the relationship grid in Table 2 at the NZGD2000 position of the specific location.

5.4 Transformation between local vertical datums

When transforming normal–orthometric heights between the LVDs listed in Table 2, the following equation must be used:

$$H_B = H_A - o_A + o_B$$

where

H_A	is the LVD A normal–orthometric height in metres
H_B	is the LVD B normal–orthometric height in metres
o_A	is the LVD A offset in metres evaluated from the LVD relationship grid in Table 2 at the NZGD2000 position of the specific location .
o_B	is the LVD B offset in metres evaluated from the LVD relationship grid in Table 2 at the NZGD2000 position of the specific location.

5.5 Transformation between a local vertical datum and NZGD2000 ellipsoid heights

When transforming between normal–orthometric heights in terms of a LVD listed in Table 2 and NZGD2000 ellipsoidal heights, the following equations must be used:

$$h = H_A + N - o_A$$

$$H_A = h - N + o_A$$

where

h	is the NZGD2000 ellipsoidal height in metres
H_A	is the LVD A normal–orthometric height in metres
N	is the NZGeoid2016 value in metres at the NZGD2000 position of h
o_A	is the LVD A offset in metres evaluated from the LVD relationship grid in Table 2 at the NZGD2000 position of h.

Appendix A: Height systems

A.1 Introduction

A height is a vertical distance above a reference surface. The type of reference surface used has an impact on the type of height that can be measured from it. Normal-orthometric and ellipsoidal are the two types of height that are commonly used in New Zealand.

A.2 Normal–orthometric heights

(a) Normal–orthometric heights correspond to what most users understand as heights above mean sea level[3].

(b) Normal-orthometric heights are approximations of true orthometric heights within the limits of approximation of the normal gravity field to the actual gravity field.

(c) The flow of fluids is more realistically predicted by spatial changes in normal-orthometric heights than by ellipsoidal heights.

A.3 Ellipsoidal heights

(a) Ellipsoidal heights are measured above a reference ellipsoid.

(b) The GRS80 ellipsoid is a simple geometric approximation of the shape of the geoid that varies from mean sea level by up to about ±100 m globally.

(c) Ellipsoidal heights cannot reliably predict the flow of fluids because the ellipsoid does not relate to the Earth's gravity field.

(d) Ellipsoidal heights are provided in Global Navigation Satellite System (GNSS) positions because of their geometrically simple definition of the Earth's shape.

(e) NZGD2000 uses ellipsoidal heights based on the GRS80 ellipsoid.

[3] Note: most of the LVDs were established using sea level measurements in the early half of last century. Due to the rising sea level, the present mean sea level is approximately in the range 0.1–0.2 m above the relevant LVD