Explanatory Notes on Geodetic Datums in Hong Kong

Survey and Mapping Office
Lands Department

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Minor Revision (小修訂) 2018
<table>
<thead>
<tr>
<th>Rev.</th>
<th>Details of Change</th>
<th>Effective Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Initial Release</td>
<td>14-Nov-1995</td>
</tr>
<tr>
<td>1.1</td>
<td>Page A1, A4, A5, C2 and C9 revised.</td>
<td>5-Sep-2018</td>
</tr>
</tbody>
</table>
A1
<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data 1</td>
<td>Data 2</td>
</tr>
<tr>
<td>Data 3</td>
<td>Data 4</td>
</tr>
</tbody>
</table>

Please note that the text is not readable due to the quality of the image.
Based on the tide data recorded by Quarry Bay tide gauge station in Victoria Harbour during the recent 19-year cycle (1997 to 2015), the mean sea level is about 1.30m above HKPD.
HK80 Geodetic Datum
Reference Ellipsoid: International Hayford (1910)

Latitude 22° 18’ 12.82” N
Longitude 114° 10’ 18.75” E
Origin: Trig “Zero”

WGS84 Datum
Reference Ellipsoid: WGS 84
Rifleman’s Bolt
5.435m

Mean Sea Level
HKPD
Chart Datum
Chart depth

Vertical Datum

Central Meridian
Longitude
Latitude

N
Earth
S

3° 3°

The Transverse Mercator Projection
<table>
<thead>
<tr>
<th>Stage</th>
<th>Geodetic Datum</th>
<th>Projection and Local Grid System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre – 1963</td>
<td>Reference Ellipsoid: Clark 1880</td>
<td>Projection : Cassini</td>
</tr>
<tr>
<td></td>
<td>Origin: Trig “Zero” 38.4 feet south of Hong Kong</td>
<td>Origin : Victoria Peak</td>
</tr>
<tr>
<td></td>
<td>Observatory</td>
<td>Co-ord : 5.18 ft N  0.38 ft E</td>
</tr>
<tr>
<td></td>
<td>Grid Origin : Trig No. 1</td>
<td>False Grid Origin : southwest Lantau Island</td>
</tr>
<tr>
<td>1963 Re-triangulation</td>
<td>Reference Ellipsoid: Clark 1858</td>
<td>Projection : Cassini</td>
</tr>
<tr>
<td></td>
<td>Origin: Trig “Zero”</td>
<td>Origin : Victoria Peak</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Co-ord : 50000 ft N  120000 ft E</td>
</tr>
<tr>
<td>1976 Metrification and co-ordinates transformation</td>
<td>Reference Ellipsoid: Clark 1858</td>
<td>False Grid Origin : 3550m east of false origin</td>
</tr>
<tr>
<td></td>
<td>Origin: Trig “Zero”</td>
<td>of HK 1963 Grid</td>
</tr>
<tr>
<td></td>
<td>Origin: Trig “Zero”</td>
<td>Origin : Trig No. 2 at Patridge Hill</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Co-ord : 819069.80 mN   836694.05 mE</td>
</tr>
<tr>
<td>1990 GPS observation</td>
<td>No change in definitions of the local geodetic datum.</td>
<td>False Grid Origin : Same as HK1976 Grid</td>
</tr>
<tr>
<td></td>
<td>Latitude, longitude and UTM Grid on WGS84 Datum are added to small scale maps for users’ convenience.</td>
<td>No change of map projection, projection origin and grid origin for local rectangular grid system.</td>
</tr>
</tbody>
</table>
SCHEMATIC DIAGRAM SHOWING
TRANSFORMATION OF CO-ORDINATES OF GEODETIC DATUMS

UTM Grid
N_{WGS84}, E_{WGS84}

Projection Formulae
equation (1) to (3)
equation (3) to (5)

Geographic Co-ordinate
\( \Phi_{WGS84}, \lambda_{WGS84} \)

WGS 84 DATUM

UTM Grid
N_{HK80}, E_{HK80}

Projection Formulae
equation (1) to (3)
equation (3) to (5)

Geographic Co-ordinate
\( \Phi_{HK80}, \lambda_{HK80} \)

HK80 DATUM

Transformation Accuracy

\[
\begin{align*}
\text{UTM}_{WGS} & \leftrightarrow \text{UTM}_{HK80} & \pm 5m \\
\Phi, \lambda_{WGS} & \leftrightarrow \Phi, \lambda_{HK80} & \pm 0.2" \\
\text{UTM} & \leftrightarrow \Phi, \lambda & \pm 5m/0.2" \\
N, E & \leftrightarrow \Phi, \lambda_{HK80} & \pm 5m/0.2"
\end{align*}
\]

HK1980 GRID
N, E

HK80 DATUM
UTM Grid Zone in Hong Kong (WGS84 Datum)

<table>
<thead>
<tr>
<th>Geodetic Datum</th>
<th>HK80</th>
<th>WGS84</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 49Q</td>
<td>GQ</td>
<td>GE</td>
</tr>
<tr>
<td></td>
<td>HQ</td>
<td>HE</td>
</tr>
<tr>
<td>Zone 50Q</td>
<td>JV</td>
<td>JK</td>
</tr>
<tr>
<td></td>
<td>KV</td>
<td>KK</td>
</tr>
</tbody>
</table>
Contour Map Showing the Difference between Heights of WGS84 and Principal Datum

Conversion of Heights

\[ H_{\text{WGS84}} = H_{\text{HKPD}} + \text{diff} \]

\( H_{\text{WGS84}} = 282.2 \text{ m} \)

\( H_{\text{HKPD}} = 283.7 \text{ m} \)
DEFINITIONS OF TERMS

Let P be the point to be converted.

N, E = Northing, Easting of P
N₀, E₀ = Northing, Easting of projection origin O
Φ, λ = Latitude, Longitude of P
Φ₀, λ₀ = Latitude, Longitude of projection origin O
m₀ = scale factor on the central meridian
Δλ = longitude of P measured from central meridian in radian (i.e. λ - λ₀)
t = tan Φ
M = meridian distance measured from the Equator to P
M₀ = meridian distance measured from the Equator to origin of projection
υₛ = radius of curvature in the prime vertical = a / (1 - e²sin²Φ)⁷⁄₂
ρₛ = radius of curvature in the meridian = a(1 - e²) / (1 - e²sin²Φ)³⁄₂
ψₛ = isometric latitude = υₛ / ρₛ
a = semi-major axis of the reference ellipsoid
f = flattening of the reference ellipsoid
e² = first eccentricity of the reference ellipsoid = 2f - f²
**Projection Formulae**

**Φ, λ to Grid co-ordinates**

\[
N = N_0 + m_0[(M - M_0) + \upsilon_s (\sin \Phi) \left( \frac{\Delta \lambda^2}{2} \right)(\cos \Phi)]
\]  
--(Eq. 1)

\[
E = E_0 + m_0\left[\upsilon_s \Delta \lambda \cos \Phi + \upsilon_s \frac{\Delta \lambda^3}{6} (\cos^3 \Phi)(\psi_s - t^2)\right] \}
\]  
--(Eq. 2)

**Meridian distance, M**

\[
M = a [A_0' \Phi - A_2' \sin (2 \Phi) + A_4' \sin (4 \Phi)]
\]  
--(Eq. 3)

where

\[
A_0' = 1 - \frac{e^2}{4} - \frac{3 e^4}{64}
\]

\[
A_2' = \frac{3}{8}(e^2 + \frac{e^4}{4})
\]

\[
A_4' = \frac{15}{256} e^4
\]

Notes: 1. \(M_0\) is computed using Eq. 3 by putting \(\Phi = \Phi_0\) (Latitude of the projection origin.)

2. \(\lambda, \Phi\) are in radian.

**Grid Co-ordinates to Φ, λ**

\[
\lambda = \lambda_0 + \sec \Phi_p \left( \frac{\Delta E}{m_0 \nu_\rho} \right) - \sec \Phi_p \left( \frac{\Delta E^3}{6 m_0^3 \nu_\rho^3} \right)(\psi_p + 2t_p^2)
\]  
--(Eq. 4)

\[
\Phi = \Phi_p - \left( \frac{t_p}{m_0 \rho_\rho} \right) \left( \frac{\Delta E^2}{2 m_0 \nu_\rho} \right)
\]  
--(Eq. 5)

where

\[
\Delta N = N - N_0
\]

\[
\Delta E = E - E_0
\]

and \(\Phi_p\) is the latitude for which \(M = (\Delta N + M_0) / m_0\)

Notes: 1. \(\Phi_p\) must be computed by iteration using Eq. 3.

2. All other quantities, such as \(t_p, \rho_\rho, \upsilon_\rho, \psi_p\) have their usual meanings but are computed using \(\Phi_p\).
Parameters for Projection Formulae

<table>
<thead>
<tr>
<th>Para.</th>
<th>WGS84 Datum (UTM ↔ Φ, λ)</th>
<th>HK80 Datum (UTM ↔ Φ, λ)</th>
<th>HK80 Datum (HK1980 Grid ↔ Φ, λ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₀</td>
<td>0m N</td>
<td>0m N</td>
<td>819 069.80m N</td>
</tr>
<tr>
<td>E₀</td>
<td>500 000m E</td>
<td>500 000m E</td>
<td>836 694.05m E</td>
</tr>
<tr>
<td>Φ₀</td>
<td>Zone 49Q: 0°</td>
<td>Zone 49Q: 0°</td>
<td>22°18’43.68”N</td>
</tr>
<tr>
<td></td>
<td>Zone 50Q: 0°</td>
<td>Zone 50Q: 0°</td>
<td></td>
</tr>
<tr>
<td>λ₀</td>
<td>Zone 49Q: 111°E</td>
<td>Zone 49Q: 111°E</td>
<td>114°10’42.80”E</td>
</tr>
<tr>
<td></td>
<td>Zone 50Q: 117°E</td>
<td>Zone 50Q: 117°E</td>
<td></td>
</tr>
<tr>
<td>m₀</td>
<td>0.9996</td>
<td>0.9996</td>
<td>1</td>
</tr>
<tr>
<td>M₀</td>
<td>0m</td>
<td>0m</td>
<td>2 468 395.728m</td>
</tr>
<tr>
<td>υₛ</td>
<td>6381215.957m</td>
<td>6381480.502m</td>
<td>6381480.502m</td>
</tr>
<tr>
<td>ρₛ</td>
<td>6344618.793m</td>
<td>6344727.809m</td>
<td>6344727.809m</td>
</tr>
<tr>
<td>ψₛ</td>
<td>1.005768221</td>
<td>1.005792635</td>
<td>1.005792635</td>
</tr>
<tr>
<td>a</td>
<td>6 378 137m</td>
<td>6 378 388m</td>
<td>6 378 388m</td>
</tr>
<tr>
<td>e²</td>
<td>6.69437999x 10⁻³</td>
<td>6.722670022x 10⁻³</td>
<td>6.722670022x 10⁻³</td>
</tr>
</tbody>
</table>

Notes: υₛ, ρₛ, ψₛ are parameters of a point near the centroid of Hong Kong and given to simplify the transformation.

Reference Example

<table>
<thead>
<tr>
<th>Datum</th>
<th>Input Data</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>WGS84</td>
<td>Φ 22° 26’ 01.26”N  λ 114° 10’ 29.31” E</td>
<td>UTM 2 483 566m N 209 194m E</td>
</tr>
<tr>
<td></td>
<td>Φ 22° 26’ 01.16” N  λ 114° 10’ 29.24” E</td>
<td>HK1980 832 699m N 836 055m E</td>
</tr>
<tr>
<td>HK80</td>
<td>Φ 22° 26’ 06.76” N  λ 114° 10’ 20.46” E</td>
<td>HK1980 832 699m N 836 055m E</td>
</tr>
<tr>
<td></td>
<td>Φ 22° 26’ 06.89” N  λ 114° 10’ 20.39” E</td>
<td>HK1980 832 699m N 836 055m E</td>
</tr>
<tr>
<td></td>
<td>Φ 22° 26’ 06.76” N  λ 114° 10’ 20.45” E</td>
<td>HK1980 832 699m N 836 055m E</td>
</tr>
</tbody>
</table>