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Infrastructure Supporting Mapping of Tidal Planes and Lines

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Outline

- **Discuss Chart Datum**
- **Extend to Tidal Planes and Lines**



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Introduction

- **Global Positioning System (GPS) as an hydrographic survey tool is now at the point where it is possible to locate the survey vessel and the soundings in three dimensions relative the WGS84.**
- **Reduction of GPS derived soundings to chart datum is dependent on a knowledge of the height of chart datum relative to the zero ellipsoidal surface.**
- **The AUSHYDROID provides that link.**



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Chart Datum

- **Is the base elevation used as a reference to reckon depths and heights:-**
 - ◆ **Depths are below datum; and,**
 - ◆ **Drying heights are above it**
- **Is referred to a fixed point – the Tide Gauge Benchmark – for stability checks & long term maintenance;**
- **Is the reference for tidal heights & tidal planes**
- **Lowest Astronomical Tide (LAT) has been adopted by the Hydrographic Service RAN as the chart datum for Australian waters.**



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Chart Datum - Cont

- **It is particularly important to note that chart datum has been used for a long time;**
- **The height of chart datum is related to the range of tide;**
- **It is necessary to retain chart datum at its established elevation irrespective of the technique used to:-**
 - ◆ **Realize the datum surface; or,**
 - ◆ **Obtain the depths to be shown on the chart.**



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Chart Datum - Cont

- **The tidal range varies spatially;**
- **Accordingly the elevation of the tidal planes, such as Mean High Water Spring Tide and chart datum (LAT) varies spatially;**
- **The range of the tide, the height of tide and chart datum are known only at the tidal stations where observations are available.**



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Chart Datum - Cont

- **Tidal planes are not geometric planes;**
- **All tidal planes, including chart datum, are curved undulating surfaces that are not parallel to the conventional vertical reference surfaces such as the geoid, Australian Height Datum or ellipsoid.**
- **There is no theory available to determine the height of tide or chart datum at places other than tidal stations.**



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Chart Datum - Cont

- **The AUSHYDROID is the geodetic realisation of chart datum;**
- **“L” is the height separation between the WGS84 ellipsoid and chart datum;**
- **The AUSHYDROID and “L” are the hydrographic equivalent of the geodetic AUSGEOID and “N”.**



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Tidal Range Variation

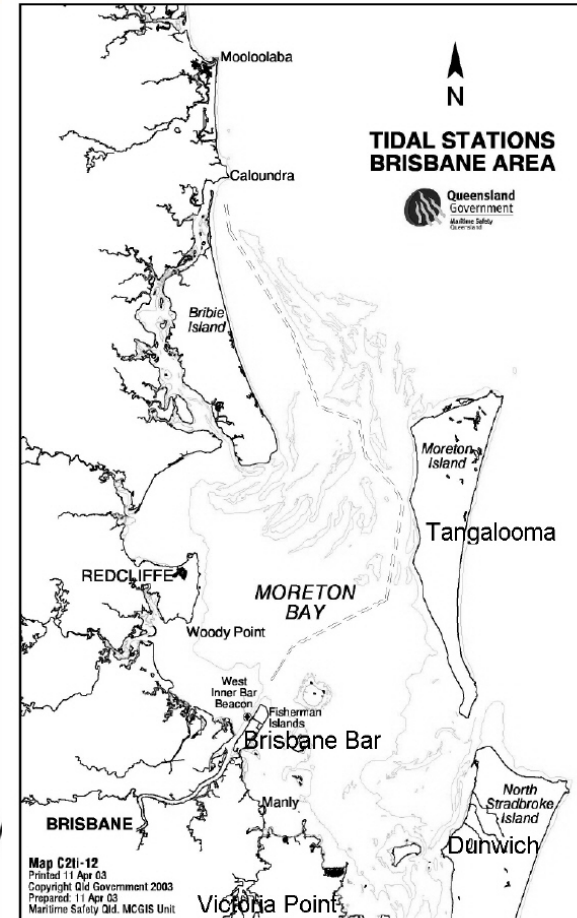
| Tidal Station | Range | “L” |
|---------------------------|--------------|----------------|
| Victoria Point | 2.93m | 39.733m |
| Dunwich | 2.68m | 39.964m |
| Manly Boat Harbour | 2.78m | 40.107m |
| Brisbane Bar | 2.71m | 40.253m |
| Woody Point | 2.58m | N/a |
| Tangalooma | 2.49m | N/a |
| Mooloolaba | 2.13m | N/a |



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Locality Maps





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Modeling Chart Datum

- **Because of the lack of theory concerning the height of chart datum, we are left with the following choice of technique to undertake the estimation:-**
 - ◆ **Create an analogue of the natural system, i.e. a carefully validated hydrodynamic model; or**
 - ◆ **Use an arbitrary mathematical process, such as interpolation or extrapolation**



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Hydrodynamic Models

- **Link the physics of the water movement induced by the rise and fall of tide and the bathymetry to derive the height of the water level at any point in the waterway;**
- **The elevation of LAT and thus chart datum may then be deduced for any point;**
- **Detailed, high precision hydrodynamic models are costly to build and validate;**
- **There are so few models available that to consider them further does not advance our cause in realizing chart datum.**



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Mathematical Processes

- **In the absence of any attempt to relate cause and effect, the arbitrary nature of extrapolation is intuitively dangerous;**
- **Interpolation seems a little less so;**
- **Even interpolation between places each with known tidal heights only yields an approximation of the elevation at intermediate points.**



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Co-Tidal Zones

- **In order to represent the curved chart datum surface, the chart is divided into a number of zones (polygons) which we call co-tidal zones;**
- **The zones are created small enough for the curved surface within each zone to be regarded as a geometric plane;**
- **This approximation simplifies the estimation of the elevation of chart datum and thus the “L” value at any point.**



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Tidal Heights

- **Tidal heights within each co-tidal zone are based on:-**
 - ◆ **The tidal readings at one or more tidal stations; and,**
 - ◆ **Some interpolating technique together with associated assumptions.**
- **The estimate of the ellipsoidal height of chart datum (“L”) within each co-tidal zone is based on:-**
 - ◆ **Its value at the tidal stations; and,**
 - ◆ **The tidal interpolation techniques and assumptions used to estimate the tidal heights**



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Tidal Height Estimation

- **Accept that the tide is the same at all places in the zone:-**
 - ◆ **Assumption – there is no appreciable change in the tidal times or height**
- **Interpolate the tidal height within the zone from readings at a number of stations. The two commonly accepted techniques are:-**
 - ◆ **Linear; and,**
 - ◆ **Planar**



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Linear Interpolation

- **The tidal stations are aligned with the direction of the tidal flow;**
- **The tidal height at a point along the line joining the two stations is interpolated by distance using simultaneous readings at each**
 - ◆ **Assumption – the change in tidal height (and the related elevation of the datum) occurs along the line of flow and that any cross slope (and cross slope in the datum) is minimal.**
All points on a line at right angles to this point are assumed to have the same tidal height.



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Planar Interpolation

- **The tidal height at a point in the zone is interpolated from simultaneous readings from each of three stations;**
 - ◆ **Assumption – The water surface is assumed to be a geometric plane between three tidal stations and that any cross slope in the water surface (and any cross slope in the datum) is incorporated into the interpolation.**



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Co-Tidal Information

- **The information attached to each co-tidal zone is:-**
 - ◆ **The spatial extent**
 - ◆ **The chart datum in use (always LAT)**
 - ◆ **The applicable tidal station or stations**
 - ◆ **The applicable interpolation technique**



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Example Zone Definition

- **Zone 0304 Manly Boat Harbour - use tides as recorded at the Manly Boat Harbour tidal station 007105B.**
- **The datum is LAT**
- **(27° 30' - 153° 21'), (27° 30 S - 153° 25'), (27° 35' - 153° 25'), (27° 35' - 153° 21'), (27° 34.5 - 153° 20')**



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Co-Tidal Zones





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Interpolation of Chart Datum

- **The method used to interpolate the tidal heights defines the height of chart datum at places in between the tidal stations;**
- **The ellipsoidal height of chart datum (“L”) is know at each tidal station.**
- **“L” is interpolated for any place on the chart using the tidal height interpolation technique designated for the co-tidal zone.**



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Treatment of Tidal Planes

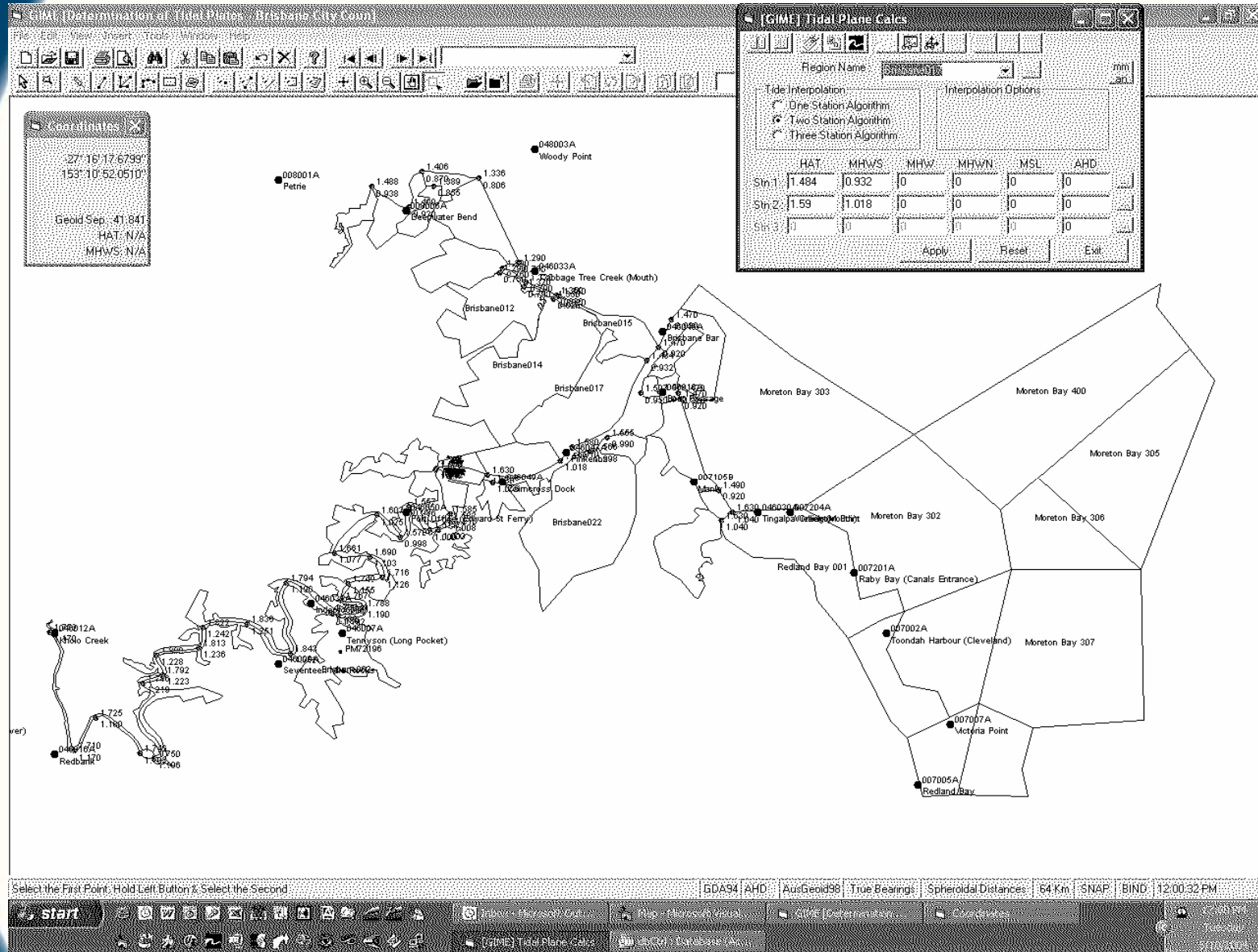
- **Chart datum is one of many tidal planes the height of which are known at each tidal station;**
- **The height of chart datum is interpolated across the chart using co-tidal zoning;**
- **The height of other tidal planes may be interpolated in the same way as the chart datum.**



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The Infrastructure





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Determination of Tidal Lines

- **Once the elevation of a tidal plane can be determined for any point, it becomes a relatively trivial matter to intersect the tidal surface with the bathymetry or topography to obtain a tidal line (mark).**
- **In this way it is possible to map the tidal lines**
 - ◆ **MHWS (High Water Mark in Queensland);**
 - ◆ **Low Water Mark, and so on.**
- **The following figure illustrates this development of our proposal.**



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Line of Mean High Water Spring Tide

Western Section of the
Fisherman Island Complex
Port of Brisbane

Blue - MHWS

Red - Uncertainty estimate





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Conclusion

- **The work reported here is very much “work in progress”.**
- **The principles to establish the elevation of the tidal planes have been set out.**
- **All that remains is to implement these principles and build the infrastructure to support the mapping of the tidal planes and lines.**



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Questions

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