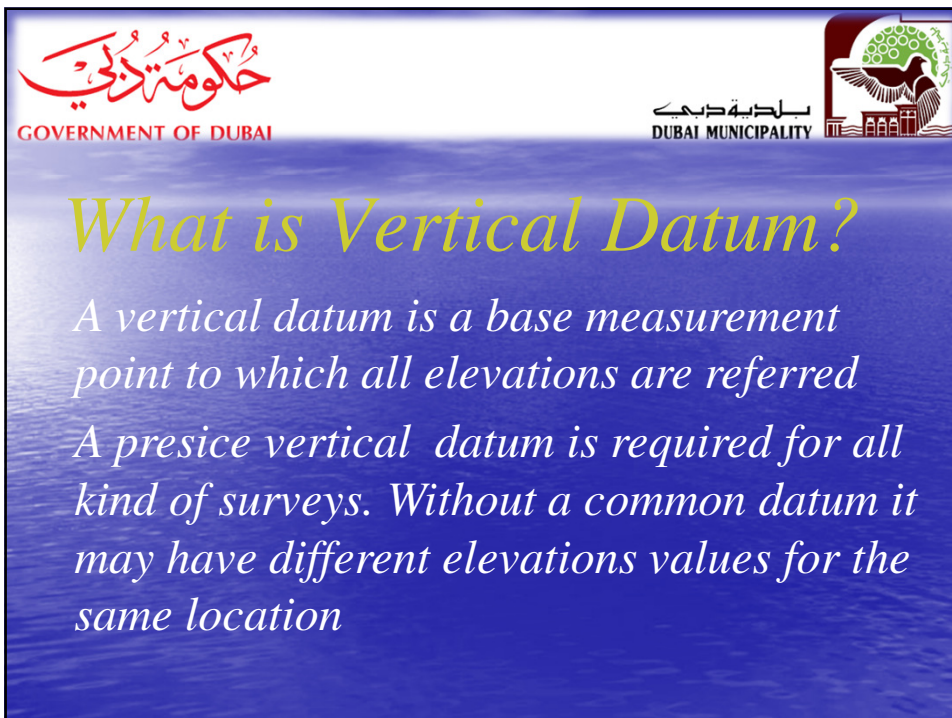


حكومة دبي  
GOVERNMENT OF DUBAI

بلدية دبي  
DUBAI MUNICIPALITY

## *Establishing and Updating Vertical Datum for Land and Hydrographic Surveying in Dubai Emirate*

Mustafa Mohammed Baqer  
Head of Hydrographic Unit  
Geodesy & Hydrographic Section  
Survey Department  
Dubai Municipality  
Email: MMBAQER@dm.gov.ae



حكومة دبي  
GOVERNMENT OF DUBAI

بلدية دبي  
DUBAI MUNICIPALITY

## *What is Vertical Datum?*

*A vertical datum is a base measurement point to which all elevations are referred*

*A precise vertical datum is required for all kind of surveys. Without a common datum it may have different elevations values for the same location*



*The vertical datum needs to be updated periodically because of the geologic changes to the surface of the earth due to the subsidence and uplift or gradual changes in sea level*



## Outlines

All Surveyors/Cartographers/GIS users are defining points in terms of X,Y,Z /E,N,H/ Lat. Long. H, which are the Geo-spatial factors.

Generally in the era of Global Navigation Satellite System (GNSS), defining a Horizontal position is easy. But defining a precise vertical reference level (Z) is complicated.

Traditionally the horizontal reference level taken for the land surveying is referred to MSL or Reference Ellipsoid and for Hydrographic Surveying the reference level is the Chart Datum, which is more or less close to the Lowest Astronomical Tide Level.



## Why to update Vertical datum

For transferring accurate vertical level to near shore & offshore constructions

For updating Land/Offshore Geoid Models

Creating numerical modeling for tide and tidal streams

For revising coastal boundary lines (coastline and shore line)

For precise surveying

For updating Dubai Virtual Reference System (a real time RTK DGPS system, now being converted to a GNSS System)



This paper explains the details of sea level change and the necessity to update the vertical datum of Dubai Emirate with respect to the tidal variations and other factors.





## Topics of Discussion

- Various definitions of Height
- Tides
- Need to measure the water levels?
- Measuring water levels
- Status of Dubai Tidal-Met stations
- Analysis and Prediction of water level
- Application of water level / vertical datum
- Future Plans for updating water levels.
- Conclusion



## Orthometric Height ( $H$ )

Height from the geoid to the Earth's surface

Usually derived from leveling using spirit levels

Frequently called "height above mean sea level"

e.g. The Height of Mount Everest is "8848 meters"



## Ellipsoidal Height ( $h$ )

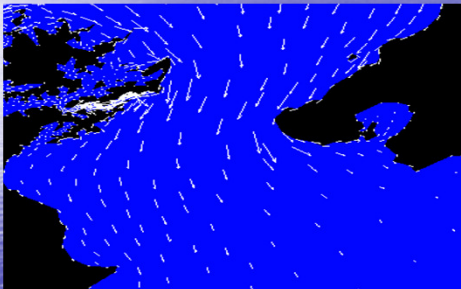
Height from the Ellipsoid to the Earth's surface

WGS -84 ellipsoid is used by GPS

To convert ellipsoidal height to orthometric height one needs gravity measurements



## What is TIDE?

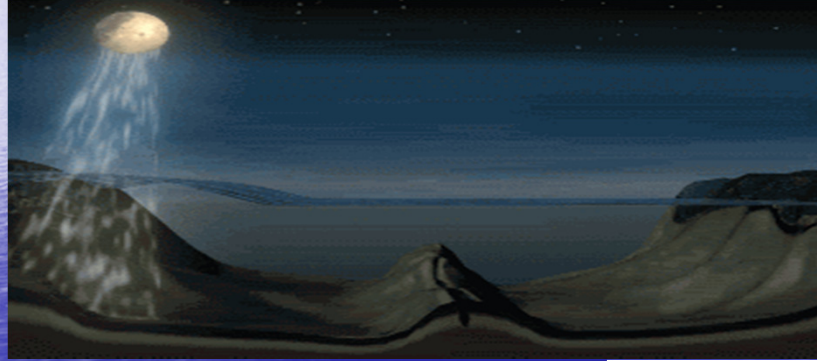


The tide is the regular rising and falling of the ocean's surface caused by changes in gravitational forces external to the Earth.

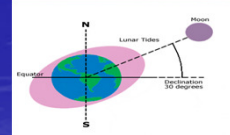




## How does gravitational force generate Tide?



The Moon's gravity imparts tremendous energy to earth, making raising of water level throughout the global oceans.



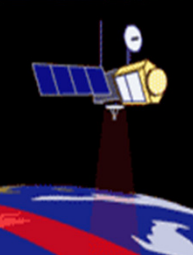
## How water level can be measured

### In-Shore Tide Gauge

- Manual Measurement (Tide Gauges)
- Pressure Transducers
- Acoustic Transducers
- RADAR
- RTK DGPS

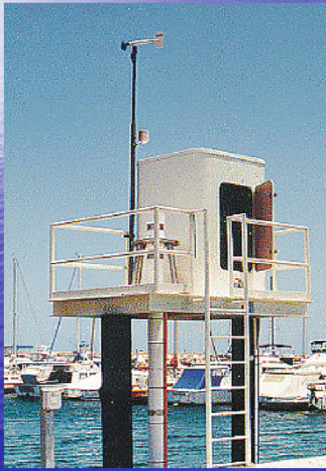
### Off-Shore Tide Gauge

- Offshore Buoy with ADCP/Pressure Sensors
- Satellite Altimetry





## Why Tide Gauges are needed in the “Age of Satellite Altimetry”?



- Altimeters need to be calibrated using tide gauges
- Continuity in reading and low cost. The altimeter record may have lots of data gaps
- Continuous mean sea level (MSL) records for a long duration are needed for water rise studies
- Accuracy of the Altimeters in the coastal area are not precise.





- 1- To establish a unique vertical reference (Z)
- 2- To define the coastal boundary
- 3- To design inshore/offshore structures
- 4- For coastal monitoring
- 5- For geoid modeling for VRS
- 6- For safe navigation on the Sea

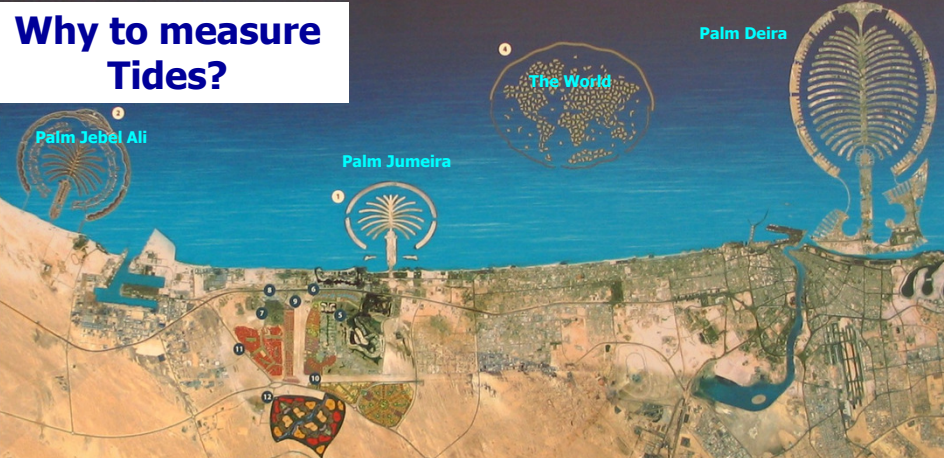
## Why to measure Tides?







**Why to measure Tides?**

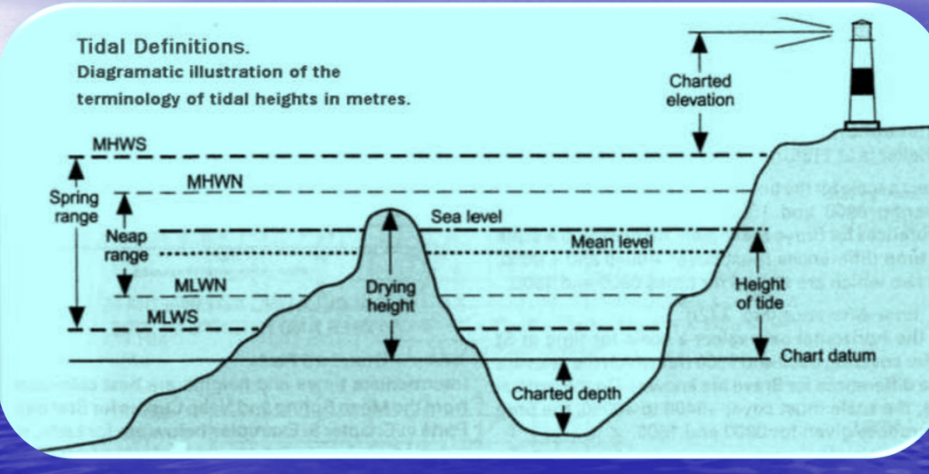


**To monitor the sea level variation and its effects over the near shore and offshore manmade islands and to transfer a precise vertical datum to offshore islands**

**Various Tide levels and Chart Datum**

**Tidal Definitions.**  
Diagrammatic illustration of the terminology of tidal heights in metres.

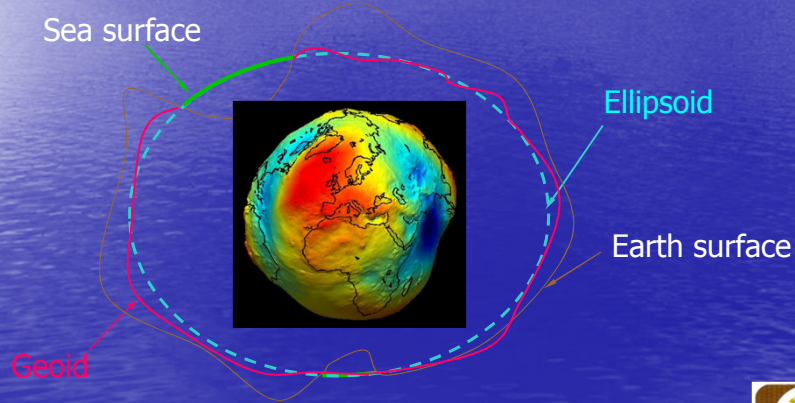






### GEOID Determination by MSL and Gravity Metering

For Defining a precise geoid precise Orthometric heights from a vertical datum is required



### Why do we study GEOID?

The easy explanation is this - by using the geoid model and GPS, we can determine elevations faster and cheaper.

Construction projects can be completed faster and for less cost - so, we all benefit.

### Who use GEOID?

Anyone who wishes to use GPS to determine elevations above Mean sea level will definitely need to use the Geoid.



## *History of Dubai Vertical datum*



- In 1954 first vertical datum was established in Dubai by the Royal British Navy with reference to the Lowest Water.
- In 1978 first national bench mark was established by M/s. Halcrow in Port Rashid with reference to lowest water
- In 2004, Dubai Municipality had established five tidal-meteorological stations along the coastal area to finalize the discrepancies existed between different datum
- In 2011, Dubai started construction of a series of permanent tidal stations along the coastal area of Dubai to update the vertical datum. The first one will be completed this year



In 2003 the Geodesy and hydrographic Survey Section of Dubai Municipality had decided to establish a unique vertical Datum in Dubai

In the first phase, DM established five Tidal-Met stations in the Coastal area of Dubai and started collecting water levels at two minutes interval



**حكومة دبي**  
 GOVERNMENT OF DUBAI

**بلدية دبي**  
 DUBAI MUNICIPALITY

## The reasons for establishing 5 Tidal Stations

- Defining an accurate vertical datum
- Determination the Mean Sea Level, HAT, LAT
- Prediction the Water level
- Launching the Real time data to users
- Storm Surges Detection
- Establishment of Warning System in case of Abnormal High water




**حكومة دبي**  
 GOVERNMENT OF DUBAI

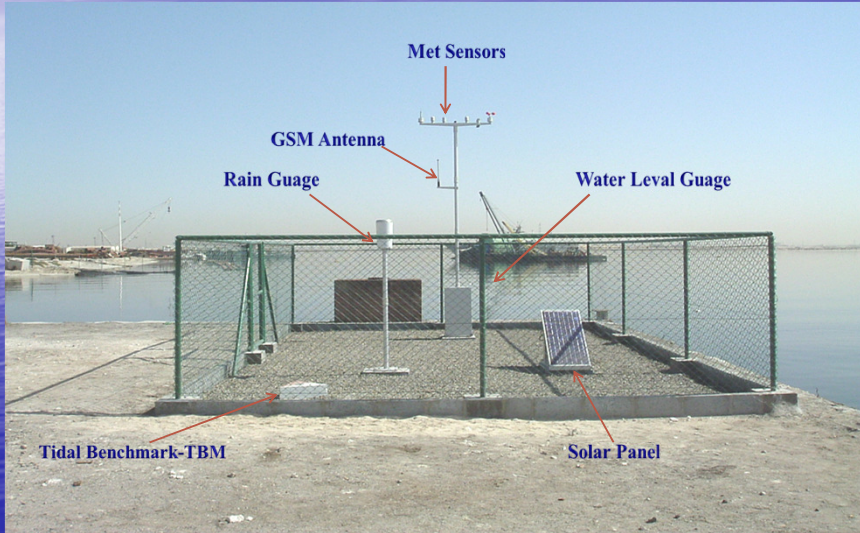
**بلدية دبي**  
 DUBAI MUNICIPALITY

### DUBAI Tidal-Meteorological Network- COASTAL STATIONS



All the stations are located inside the Harbours or Basins

## Dubai Tidal-Meteorological Station (At Al Jadaf)



## OFFSHORE BUOY



The Survey Department of Dubai Municipality has deployed an offshore buoy fitted with meteorological sensors and an ADCP (Acoustic Doppler Current Profiler) in the offshore area of Dubai Emirate for updating the vertical datum in the offshore area considering the massive construction taking place in the offshore area of Dubai. The WAVESCAN buoy is a wave directional buoy measuring waves, meteorological and other environmental parameters.

The buoy is equipped with a sophisticated array of sensors which report half hourly data on

1. Wind speed and direction
2. Atmospheric pressure and humidity
3. Significant wave height and period
4. Air and Sea temperature
5. Sea water quality parameters



# The Complete Solution

**Labels:** GSM Antenna, Mooring Buoy, Argonaut-SL, Dead weight anchors, Argonaut-RR

- 1-Water Level
- 2-ADCP (Current Profiler)
- 3-Wave Information
- 4-Water Temperature
- 5-Conductivity
- 6-Salinity
- 5-Data Logger
- 6-Transmitter
- 7-Solar Panel

30 m. depth

**OFF-SHORE Tidal-Met Station**

**Telemetry:**  
Data collected from the offshore buoy is transmitted using GSM/GPRS technology.

**GOVERNMENT OF DUBAI**

**DUBAI MUNICIPALITY**

No.	Date	Time	Ref.	W.S	W.G	W.D	Vis.	A.T	Hum.	A.P	W.L	W.T	R.F
1	01-Dec-10	12:00:00	617	0.78	1.55	165.96	3000.04	19.04	75.66	1015.91	0.68	25.87	0
2	01-Dec-10	12:02:00	617	0.7	1.24	162.44	3000.04	18.95	75.16	1015.91	0.67	25.87	0
3	01-Dec-10	12:04:00	617	1.01	1.86	156.81	3000.04	18.86	74.65	1015.91	0.66	25.87	0
4	01-Dec-10	12:06:00	617	0.93	1.55	160.33	3000.04	18.86	74.65	1015.91	0.65	25.87	0
5	01-Dec-10	12:08:00	617	0.62	1.55	170.17	3000.04	18.95	75.36	1015.91	0.65	25.87	0
6	01-Dec-10	12:10:00	617	0.31	0.93	169.47	3000.04	18.86	75.46	1015.91	0.65	25.87	0
7	01-Dec-10	12:12:00	617	0.93	1.86	157.17	3000.04	18.86	74.75	1015.91	0.65	25.87	0

## Tide Analysis and its results.

Data collected from the tide/meteorological stations at 2 minute interval

Comparison of observed and predicted tides

## Tide Analysis and Its Results

Month	MSL	Correction	Corrected Level
Jan	1.06	0	0.97
Feb	1.05	0.1	1.06
Mar	1.06	0.1	1.07
Apr	1.12	0	1.12
May	1.19	-0.1	1.18
Jun	1.23	-0.1	1.22
Jul	1.29	-0.2	1.27
Aug	1.21	-0.1	1.20
Sep	1.19	-0.1	1.18
Oct	1.12	0	1.12
Nov	1.21	-0.1	1.20
Dec	1.03	0	1.03
Average=1.16m			1.15

Constituents	Dubai Municipality (2009)	
Sa	0.0809	
Ssa	0.0330	
Mm	0.0068	
Msf	0.0048	
O1	0.1709	
K1	0.2471	
M2	0.4545	
S2	0.1770	
Z0	1.1119	
Number of derived Constituents		62
Based on one and fiveyears data from Umm Sequim station		

Water Levels computed at each Station

Location	LAT	MLLW	MHLW	MSL	MLHW	MHHW	HAT	Year
Umm Suqeim	-0.16	+0.43	+0.78	+1.11	+1.32	+1.66	+2.30	2006-2009

MSL of UMM Sequim Station calculated for 2010

### Details of Vertical datum



Publishing Dubai  
Tide Table





By updating of our precise vertical datum, we are able to perform

- 1-Modelling the level of water (Offshore)
- 2-Preparing accurate Co-Tidal charts
- 3-Calibration of Satellite Altimeters readings in our region
- 4-Determination of Offshore Geoid model
- 5-Prediction of offshore water levels
- 6-Monitoring offshore constructions
- 7-Environmental Investigations



## Conclusion

Use of proper vertical elevation is required in surveying & mapping especially for overlaying the bathymetric data and land survey data.

Progress towards a unique vertical reference for whole UAE is going on.

We are sharing the information regarding a precise vertical datum with other line departments especially with the GIS Dept. for ocean modeling.

