ASSISTING IN THE MANAGEMENT OF QUEENSLAND'S WATERWAYS

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28th November 2012
8th FIG Regional Conference
Montevideo, Uruguay

Introduction

- About Maritime Safety Queensland (MSQ)
- Introduction to the CARIS Bathy DataBASE Suite
  - Bathy DataBASE
  - BASE Editor
  - Engineering Analysis Module
- Different methods for Volume Calculations
  - End Area Volumes
  - Triangular (TIN) Volumes
  - Rectangular Volumes
  - Hyperbolic Volumes
- Volume Case Study: Port of Weipa
- Volume Case Study: Lake Lyndon Baines Johnson (LBJ)
- Data Visualization

Maritime Safety Queensland

- Division of Transport and Main Roads within Queensland State Government
- Responsible for protecting Queensland's waterways
- Within MSQ, Hydrographic Services section carry out hydrographic surveys on behalf of clients
  - North Queensland Bulk Ports (Hay Point, Weipa, Abbot Point, Mackay)
  - Ports North (Cape Flattery, Thursday Island)
  - Gladstone Ports Corporation
  - Boating Infrastructure and Waterways Management
- Coverage for over 1700 Nm of coastline

Maritime Safety Queensland

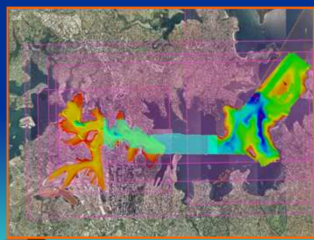
Hydrographic Surveying

- Utilize a variety of survey equipment in operations
  - Simrad EM3002D MBES
  - Klein 3000 Sidescan
  - Starfish 452f sidescan
  - SEA Swath Plus 234 kHz interferometry system
  - Echotrak MK III dual frequency single beam
  - Deso 300 single beam
  - Applanix POS MV 320 and Wavemasters
  - Leica RTK
- Permanent and mobile installations

Maritime Safety Queensland

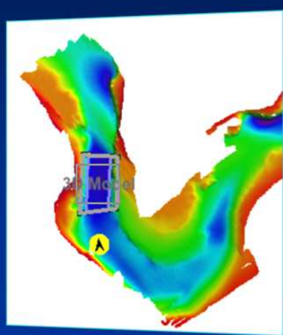
CARIS Bathy DataBase

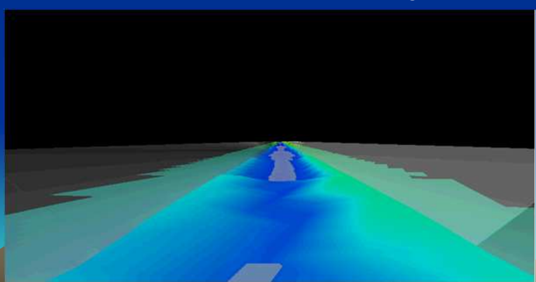
- **BASE Editor**
  - Standalone Desktop Application
    - Processed bathymetry import
    - Data validation and visualization
    - Bathymetry model operations
    - Bathymetry product creation (e.g. Depth Contours)
- **BASE Manager + DataBASE Server**
  - All the functionality of BASE Editor plus…
    - Data Storage / Management
      - Load bathymetry models and metadata into DataBASE Server
      - Access stored data using configured queries
    - Execute processes on the DataBASE Server
      - Utilize Server processors for Depth Contour creation, etc.
    - Manage users, their roles, data back-ups, etc.



CARIS Bathy DataBase

- **Engineering Analysis Module**
  - Extra functionality for BASE Editor/Manager applications
    - Volume Calculations
    - Conformance Analysis
    - Shoal Management
    - Reference Model Creation/Editing





Methods for Volume Calculation in Hydrographic Surveys

Volumes

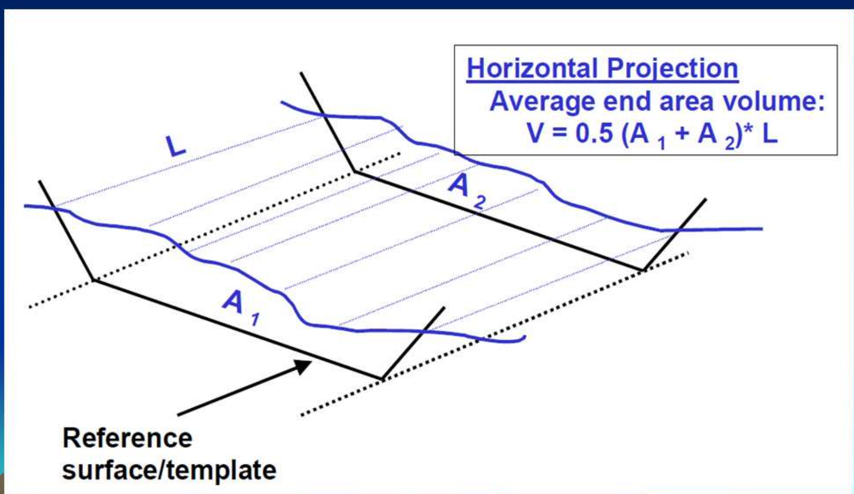
"Accurate volume estimates are important for the choice of dredging plant, production estimates, times of execution and ultimately project costs."

-Sciortino J.A, (2011)

End Area Volumes

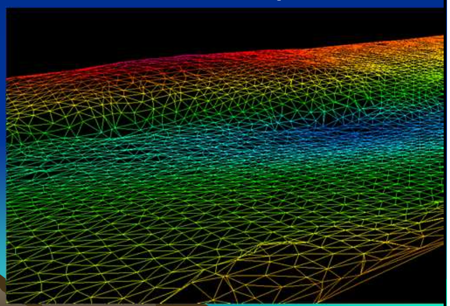
- Derived from methods used in railroad and roadway construction
- Cross sections of channel are taken at a constant interval
- Computation based on volumes between cross sections
- Assumption is that cross sectional area relatively constant between two successive cross sections
- Otherwise, just an approximation

End Area Volumes



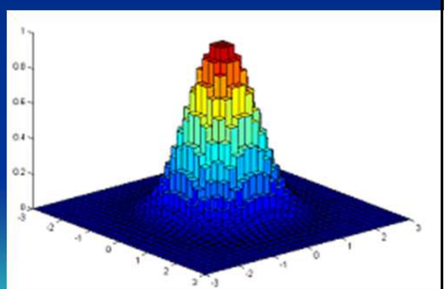
TIN Volumes

- Suitable for point data (i.e. point cloud)
- Could also be derived from a grid
- Uses true positions of depths
- Surface is modelled as collection of small planes
- Fast computation (can depend on software package)
- Quite accurate results



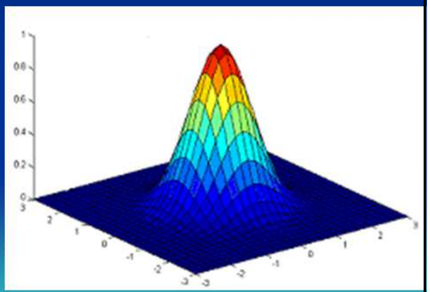
Rectangular Volumes

- Simple volume calculation based on a grid
- Assigns a rectangular prism for each cell
- Single depth value for each cell
- Fast processing times
- Degradation of accuracy
- Cannot be calculated against a sloped surface (i.e. bank of a channel)



Hyperbolic Volumes

- More sophisticated than other volume methods
- Hyperbolic cell created from centres of adjacent grid nodes
- Surface is modelled as collection of hyperbolic paraboloids
- Most accurate results
- Computationally intensive
- Can only be used on a grid



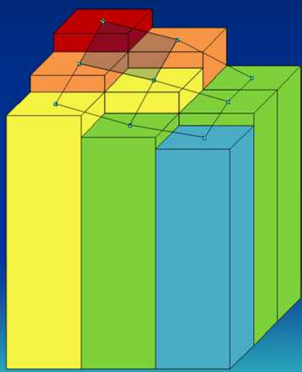
Hyperbolic Volumes

- **Display of grid nodes (plan view)**

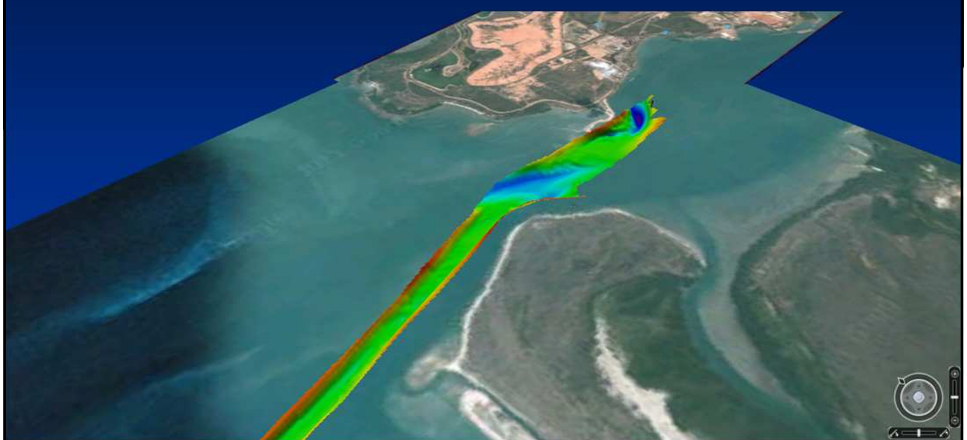
9	8	6
8	7	6
7	6	5

Hyperbolic Volumes

- Constructing the Hyperbolic Paraboloid



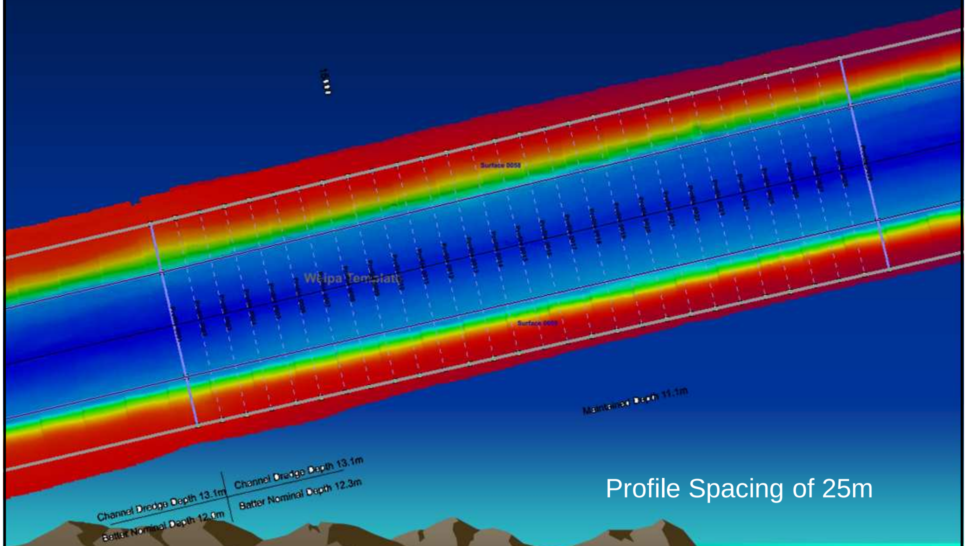
Case Study – Weipa



Case Study – Weipa

- Pre dredge survey October 2011
- Post dredge survey November 2011
- Section of Channel chosen to compare results between volumes
  - End Area Volumes
  - TIN Volumes
  - Rectangular Volumes
  - Hyperbolic Volumes

Case Study – Weipa

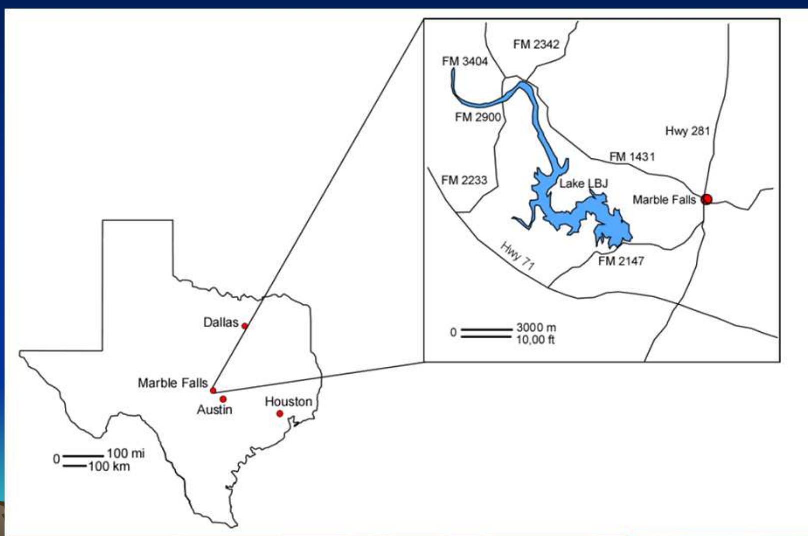


Profile Spacing of 25m

Case Study – Weipa

Method	Volume (m³)	Difference (m³)	Volume Error (%)
Hyperbolic Volume	794,912.5 m³	0	0
Rectangular Volume	805,090.2 m³	10177.7 m³	1.280%
TIN Volume	798,654.4 m³	3,741.9 m³	0.471%
End Area (25m)	803,019.1 m³	8106.5 m³	1.020%
End Area (50m)	802,755.3 m³	7842.7 m³	0.987%
End Area (100m)	802,022.8 m³	7110.2 m³	0.894%

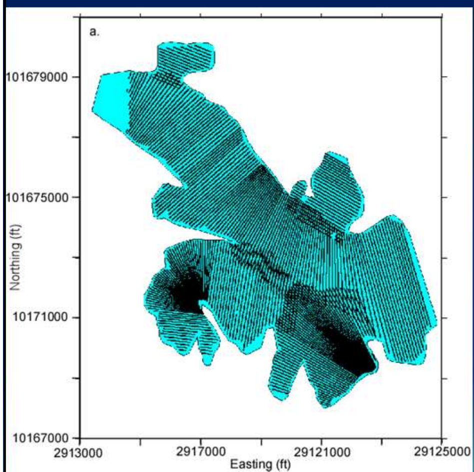
Case Study – Lake LBJ



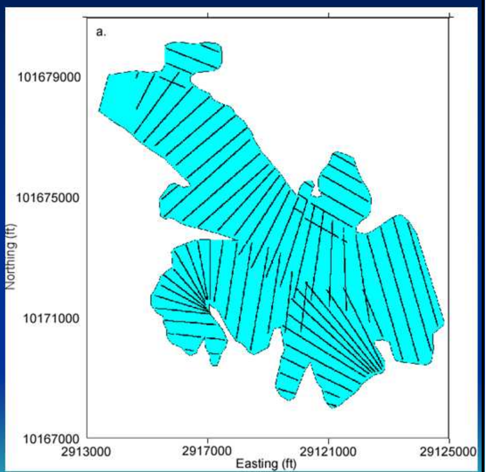
Case Study – Lake LBJ

- Study conducted by Baylor University (BU) and Texas Water Development Board (TWDB)
- Studying methods for hydrographic surveying
- In particular, computing sedimentation volumes in a reservoir
- Influence of profile spacing on volume accuracy
- Simulated end area volumes by extracting profiles from MBES data set
- Comparison of ‘simulated volumes’ and volume computed on full MBES data set

Case Study – Lake LBJ

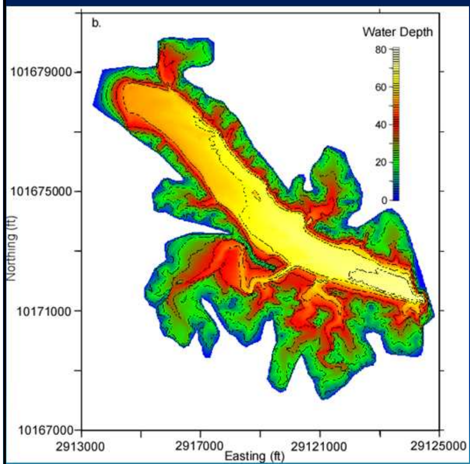


Simulated profiles
(100 ft spacing)

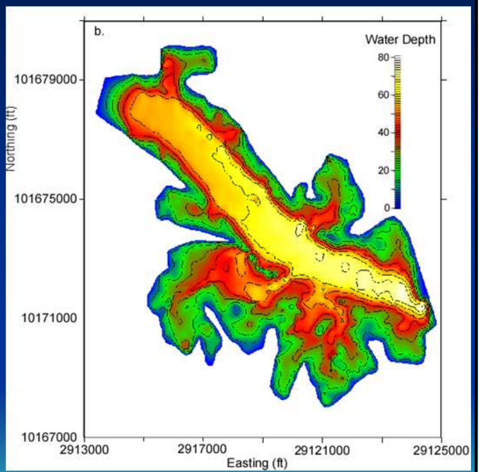


Simulated profiles
(500 ft spacing)

Case Study – Lake LBJ



Bathymetry based on 100 ft Profiles



Bathymetry based on 500 ft Profiles

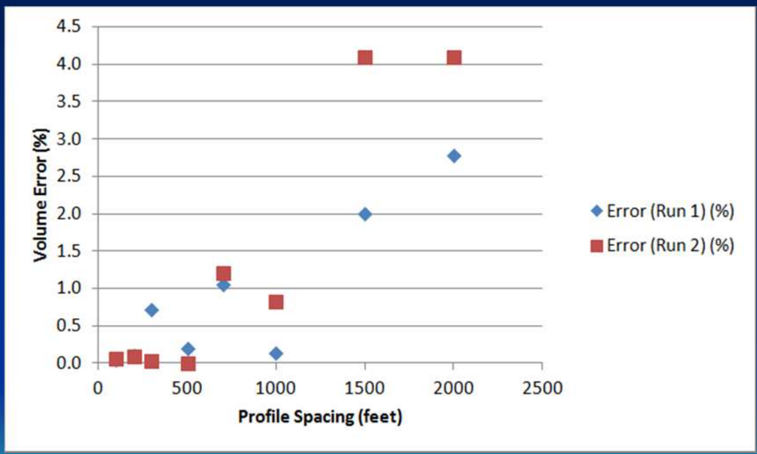
Case Study – Lake LBJ

- Results

Simulated Profile Spacing	Run 1 Volume (acre-ft)	Run 1 Volume Error (%)	Run 2 Volume (acre-ft)	Run 2 Volume Error (%)
Full Multi-Beam	51,701.5	0.0	51,701.5	0.0
100 ft	51,726.6	0.048	52,020.9	0.062
200 ft	51,646.9	0.106	51,746.4	0.087
300 ft	52,072.8	0.718	51,712.7	0.022
500 ft	51,803.2	0.196	51,703.9	0.005
700 ft	52,247.2	1.06	51,076.0	1.21
1000 ft	51,775.6	0.14	51,277.4	0.82
1500 ft	52,712.5	2.00	49,581.3	4.10
2000 ft	53,141.1	2.78	49,584.5	4.10

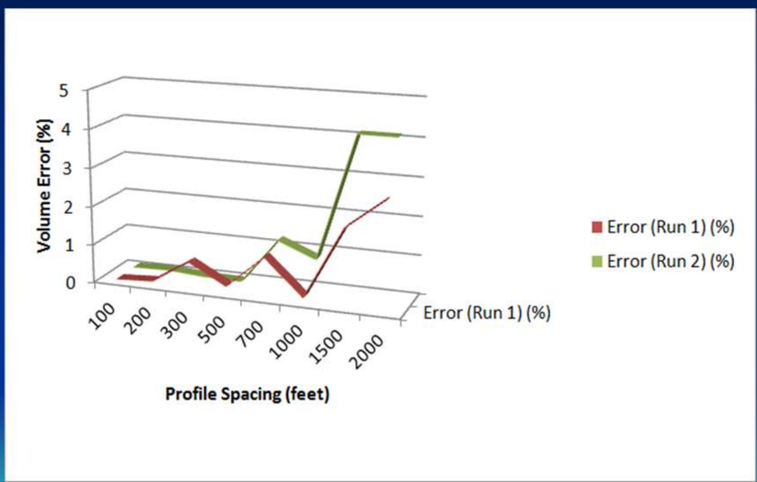
Table courtesy of Dunbar et al (2009)

Case Study – Lake LBJ



- Coefficient of Correlation
  - 0.884 *(Run 1)* and 0.936 *(Run 2)*

Case Study – Lake LBJ



Volumes at MSQ

	CARIS Engineering Analysis Module		Existing capability	
Area	**Time to Process (hh:mm:ss)**	**Volume to Dredge (m³)**	**Time to Process (hh:mm:ss)**	**Volume to Dredge (m³)**
Whole Channel	0:47:00	116,724	Not enough memory to compute	Not enough memory to compute
BN16 - BN18 (Toe to Toe)	0:01:57	2,234	0:03:14	2,233.8
BN6 - BN 8	0:05:50	31,015	0:19:34	31,016.2
BN 8 - CH15500	0:02:00	19,049	0:02:45	19,048.8
BN2 - BN4	0:05:52	10,492	> 1 hr	9867

Method Comparison

- End Area Volumes
  - Required profile spacing depends on bathymetric variability
  - Prior knowledge of survey area
  - Monitor changes between profiles and adjust spacing if necessary
  - Accuracy of volumes is down to ‘luck’
  - Decrease in profile spacing may not lead to significant increase in accuracy, just more survey time!
  - Suitable for uniform areas (i.e. Channel), not designed for areas such as bends

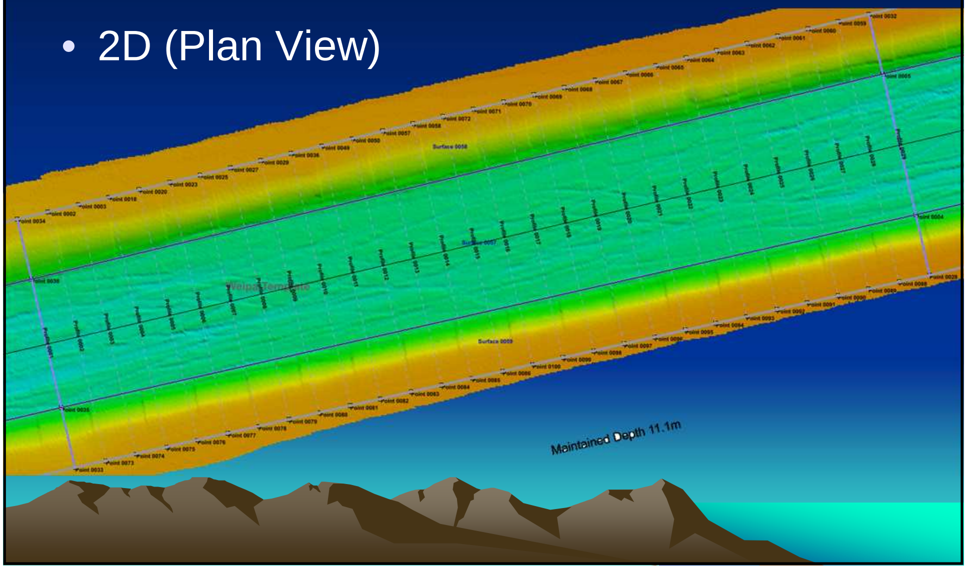
Method Comparison

- TIN Volumes
  - Suitable for point data
  - Good results (depending on density of input data)
- Hyperbolic Method
  - Suitable for dense multibeam data (especially when gridded)
  - Model produced for seabed is ‘smooth’
  - Not suitable for point data (needs to be grid)

Data Visualization Techniques

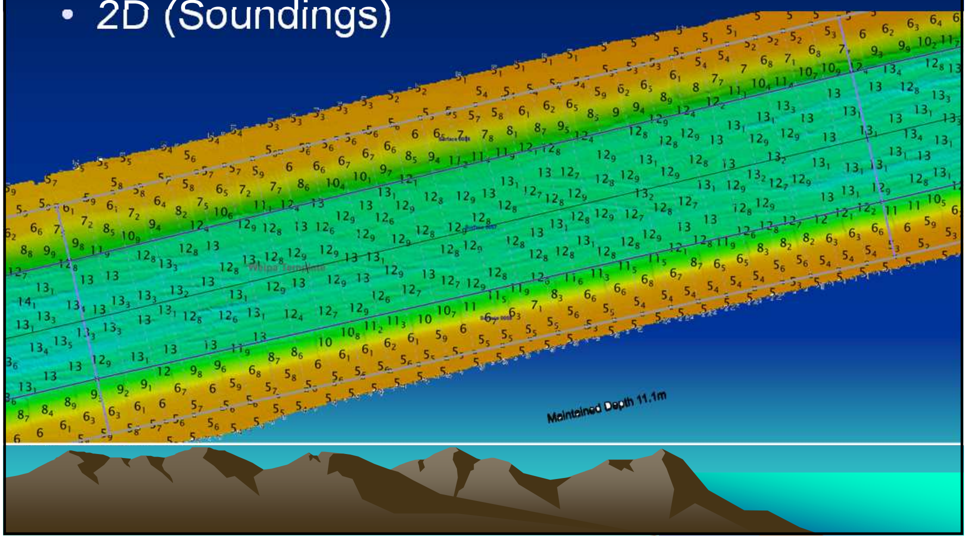
Data Visualization

- 2D (Plan View)



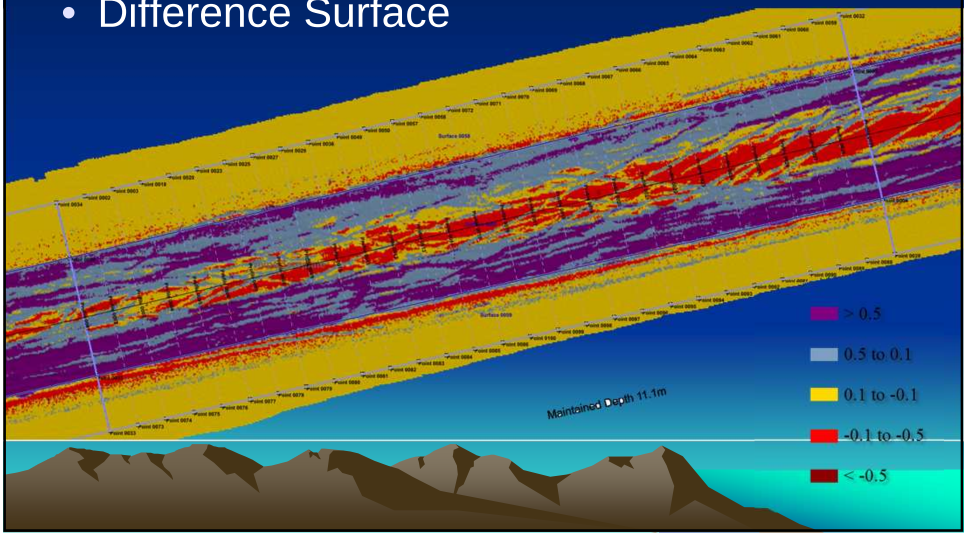
Data Visualization

- 2D (Soundings)



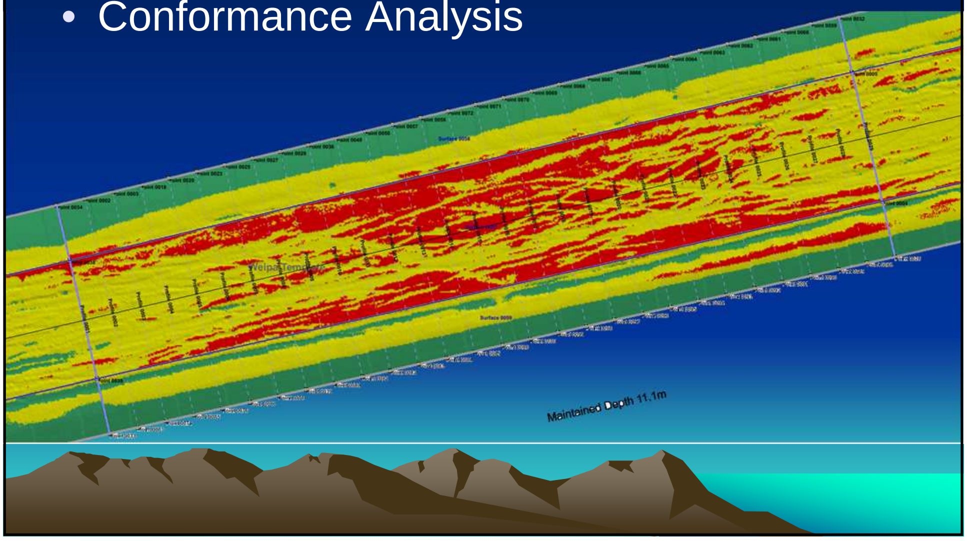
Data Visualization

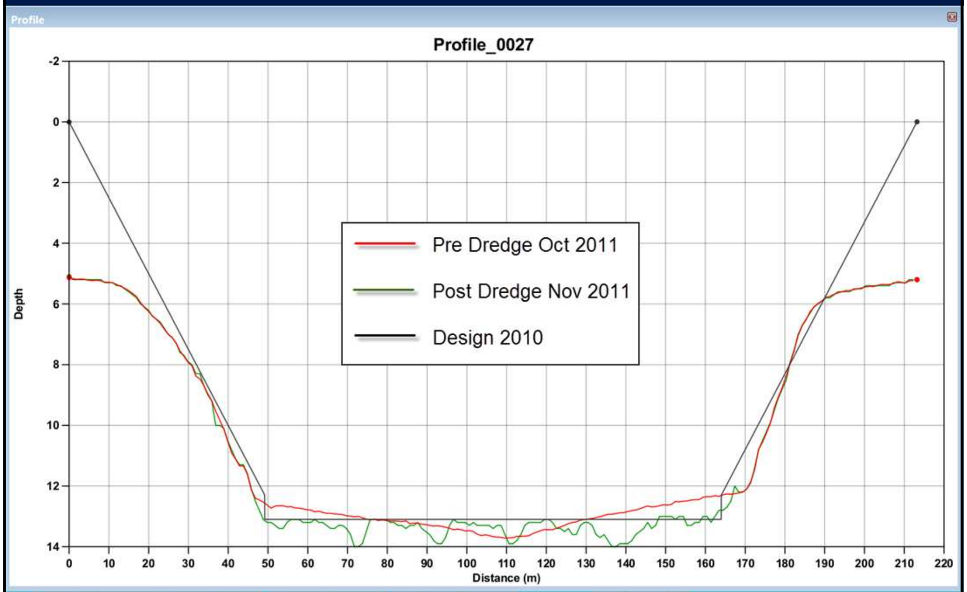
- Difference Surface



Data Visualization

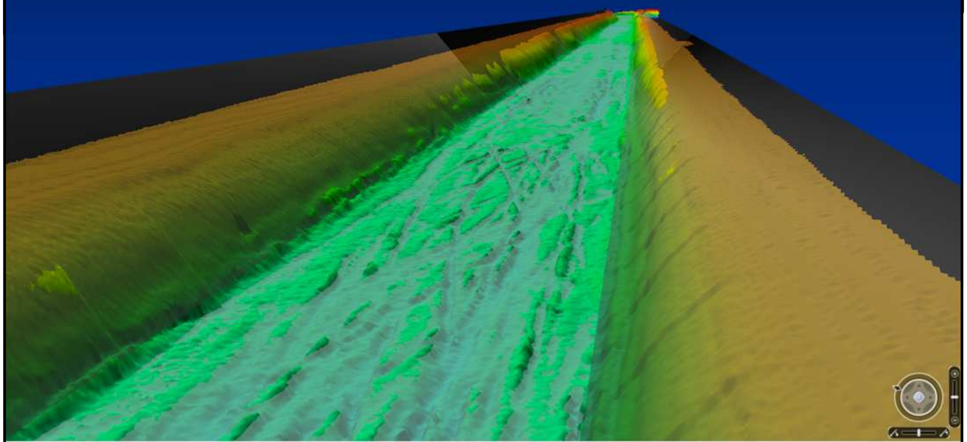
- Conformance Analysis

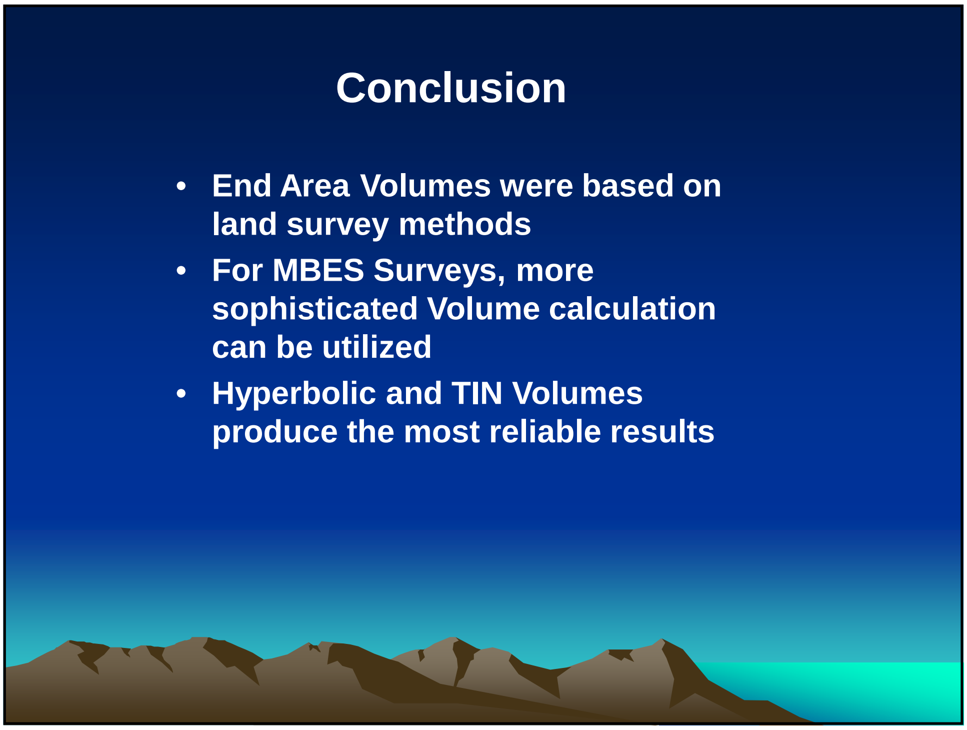


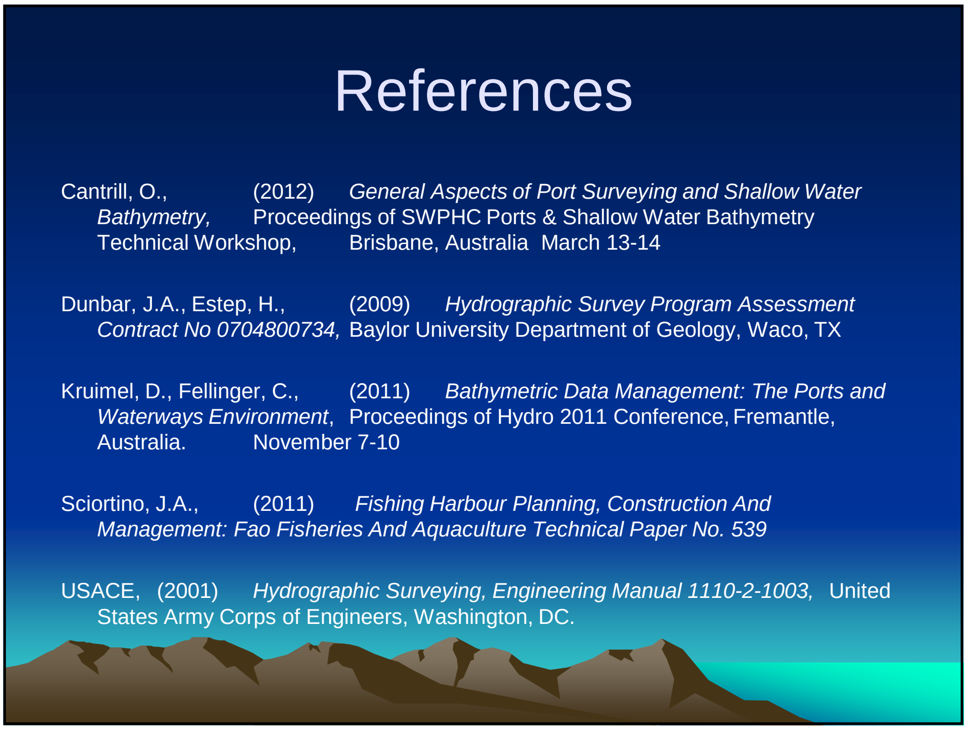


Data Visualization

- 3D




Conclusion
• End Area Volumes were based on land survey methods
• For MBES Surveys, more sophisticated Volume calculation can be utilized
• Hyperbolic and TIN Volumes produce the most reliable results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USACE, (2001) Hydrographic Surveying, Engineering Manual 1110-2-1003, United States Army Corps of Engineers, Washington, DC.


Thank You!


Any Questions
Thank You!