CORPS IMPLEMENTATION OF NAUTICAL DEPTH IN CHANNELS WITH FLUID MUD

ERDC
Engineer Research and Development Center

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Mobile District
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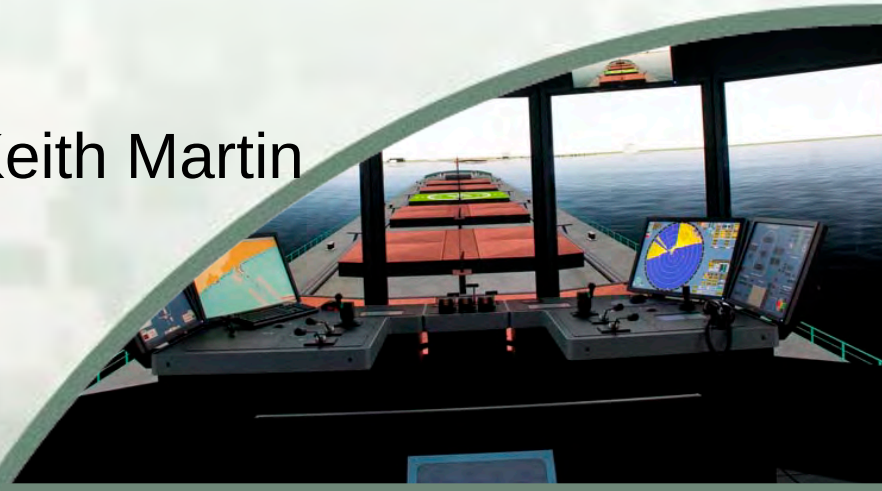
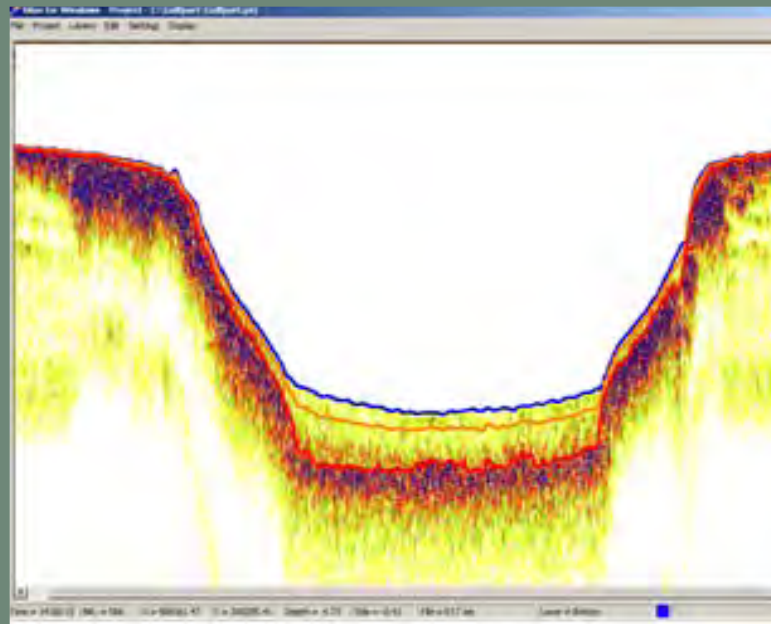




US Army Corps of Engineers®

Outline

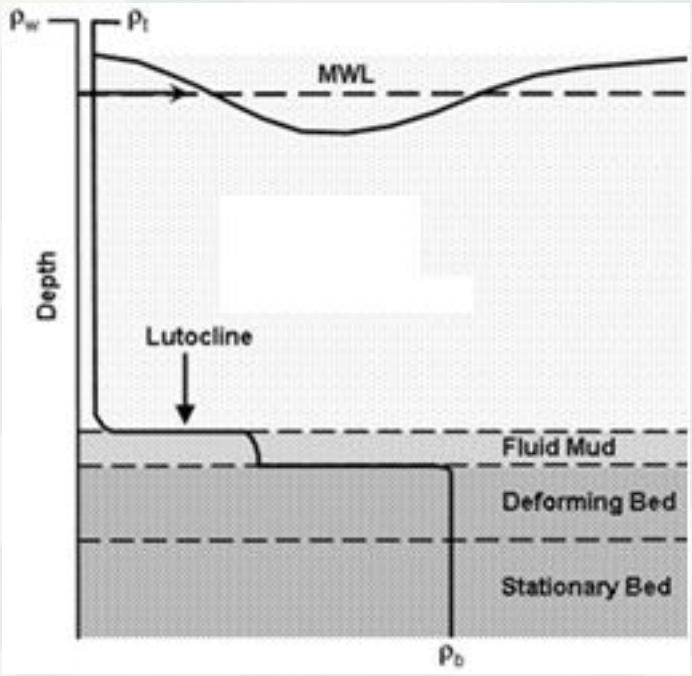
- What is fluid mud?
- Fluid mud hydro surveying considerations
- What is nautical bottom/depth and what's needed to implement?
- Corps past/present/future implementation activities

Definition of Fluid Mud

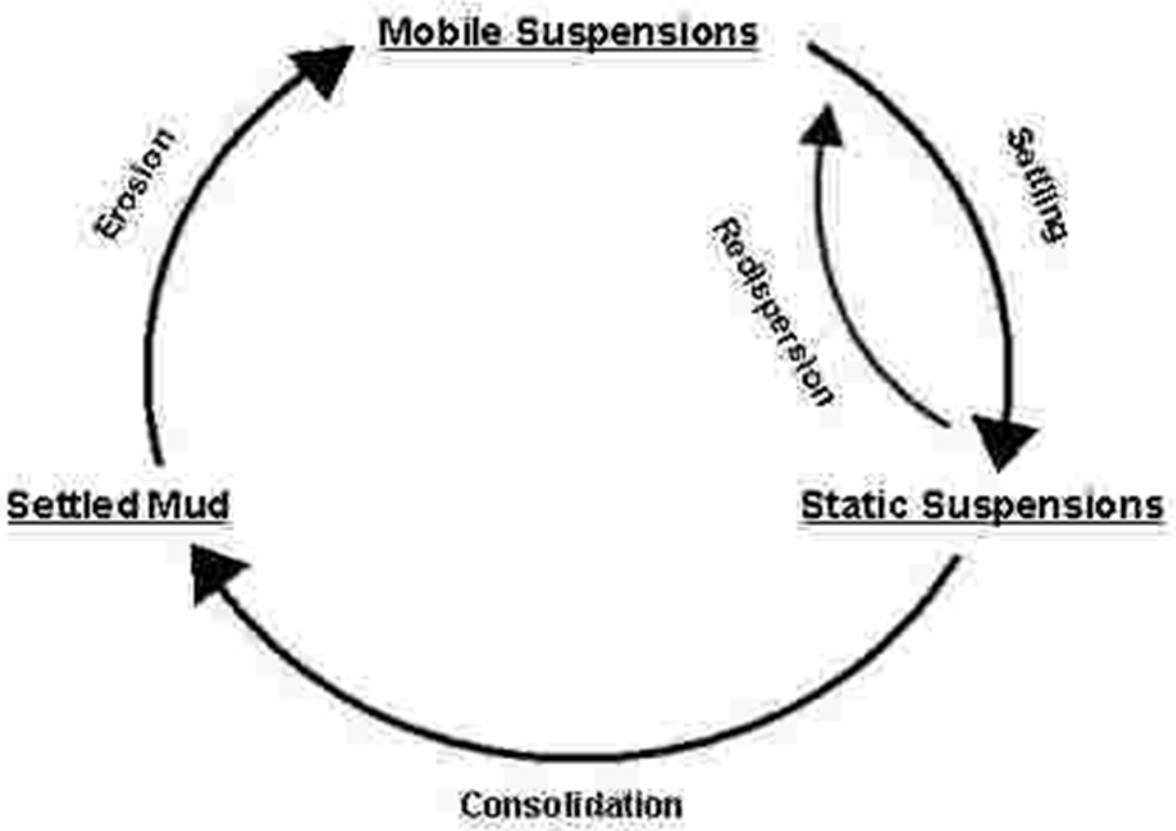
"Fluid mud is a high concentration aqueous suspension of fine-grained sediment in which settling is substantially hindered by the proximity of sediment grains and flocs, but which has not formed an inter-connected matrix of bonds strong enough to eliminate the potential for mobility, leading to a persistent suspension."

McAnally et al. 2007

What is Fluid Mud?



COHESIVE SEDIMENT DYNAMICS



Source: Kirby and Parker

Fluid Mud Mobility

- Tidal currents and river flows can move the “upper portions” of the fluid mud around.
- Deep draft vessel pressure wave and propeller wash can also move/modify fluid mud.

Problem Statement

Why Is It A Problem?

Sounding pole, lead line, and acoustic echo sounding will generally not correlate with one another, or give consistent readings from one time to the next when the same type of instrument is used in fluid mud (Hydro EM).

Measurement ambiguity has hindered optimization of Corps management of channels with fluid mud.

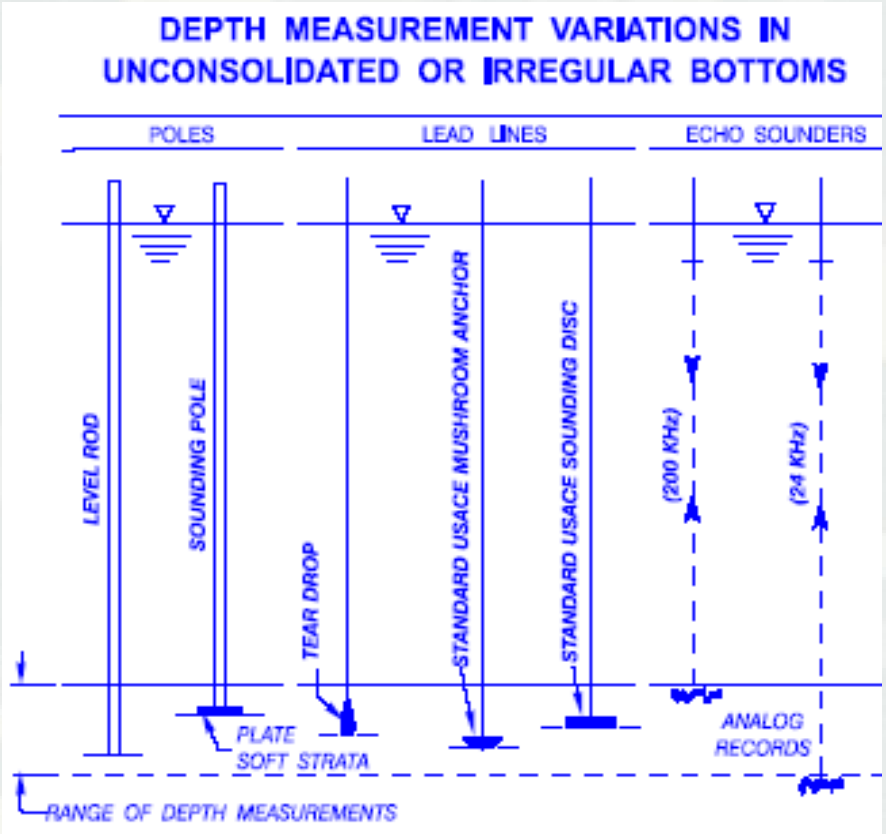
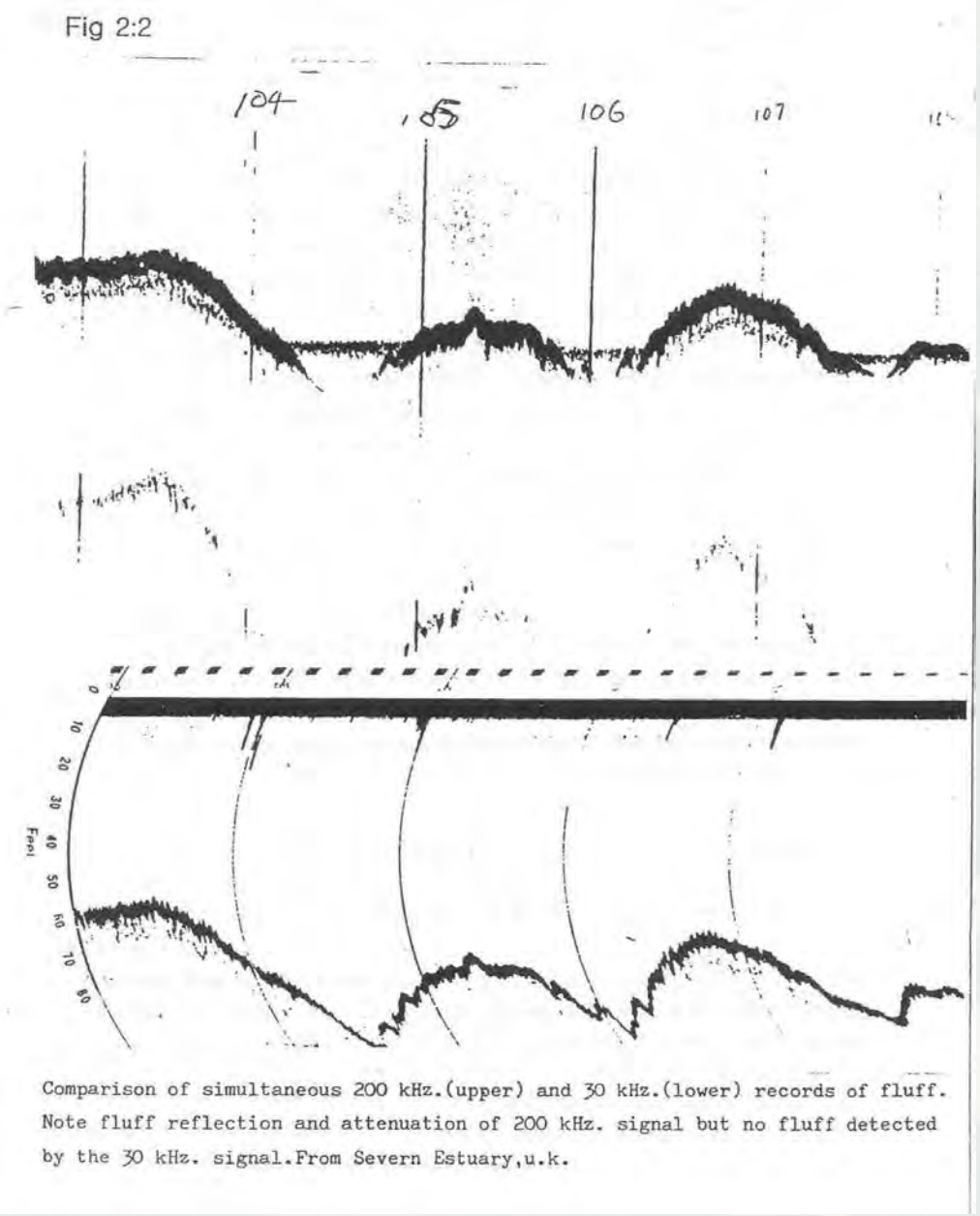
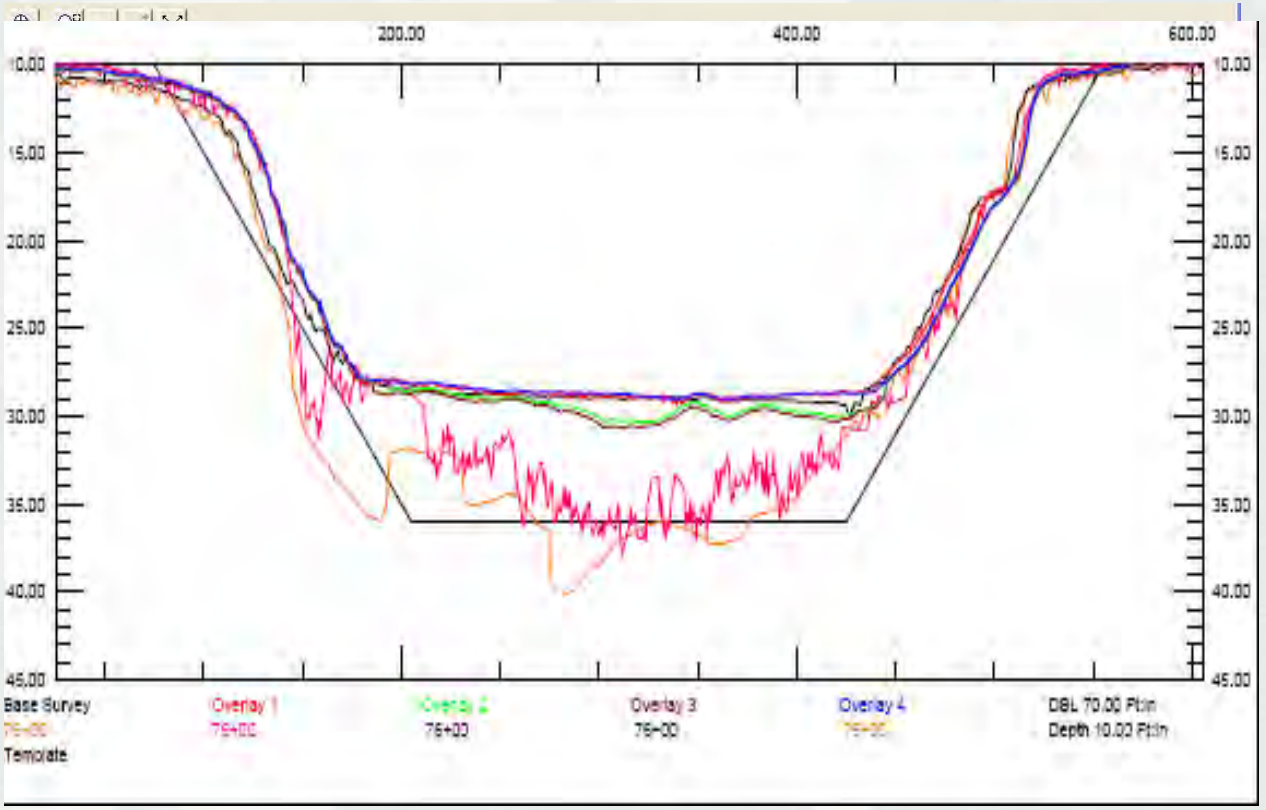


Fig 2:2



Comparison of simultaneous 200 kHz.(upper) and 30 kHz.(lower) records of fluff. Note fluff reflection and attenuation of 200 kHz. signal but no fluff detected by the 30 kHz. signal.From Severn Estuary,u.k.

Source:
Kirby and
Parker 1978



STEMA - Silas - Bottom	347,701 yd^3	265,000 m^3
ODOM - mkIII - HI Freq 200Khz	346,632 yd^3	265,000 m^3
HI Freq 200Khz	338,620 yd^3	260,000 m^3
STEMA - Silas - Low density	314,407 yd^3	240,000 m^3
STEMA - Silas - High density	304,582 yd^3	233,000 m^3
ODOM - mkIII - LO Freq 28Khz	139,989 yd^3	107,000 m^3
LO Freq 41 Khz	60,482 yd^3	46,000 m^3

$1,000,000

$180,000

Nautical Bottom

Definiton PIANC-IAPH 1997:

“the level where physical characteristics of the bottom reach a critical limit beyond which contact with a ship’s keel causes either damage or unacceptable effects on controllability and manoeuvrability”

Nautical Bottom Approach Requires:

- practical fluid mud criterion & critical value
- practical, continuous survey method
- minimum underkeel clearance value
- knowledge about ship behaviour

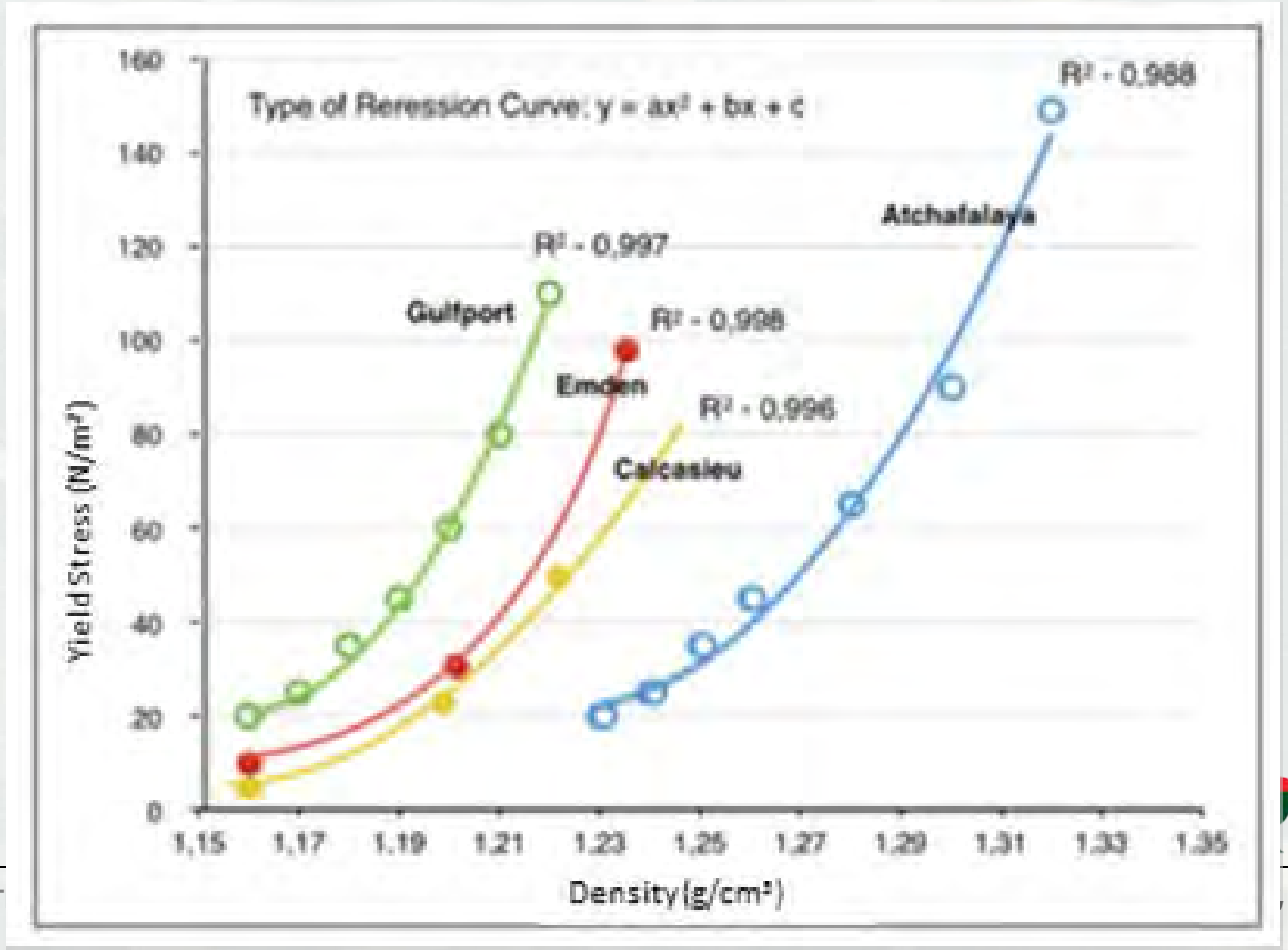
Practical Fluid Mud Criterion & Critical Value

Density

Country	Port	Criterion Critical Limit Density (g/cm^3)
The Netherlands	Rotterdam	1.2
Thailand	Bangkok	1.2
Surinam	Paramaribo	1.2
Belgium	Zeebrugge	1.2
China	Yangtze	1.2
China	Liang yungang	1.25 – 1.3
China	Tianjing xingang	1.2 – 1.3
UK	Avonmouth	1.2
France	Dunkirk	1.2
France	Bordeaux	1.2
France	Nantes - Saint Nazaire	1.2
French Guyana	Cayenne	1.2
UK	Bristol	1.2

Practical Fluid Mud Criterion & Critical Value

Yield Stress




Mobile
Baton Rouge
Cat Island
Dauphin Island
Petit Bois Island
New Orleans
Gulfport Ship Channel
Mississippi-Alabama Shelf
Marsh Island
Calcasieu Bar Channel
Mississippi Delta
Atchafalaya Bar Channel
Ship Shoal
Dorsey Canyon
Sackett Bank
N
Google earth
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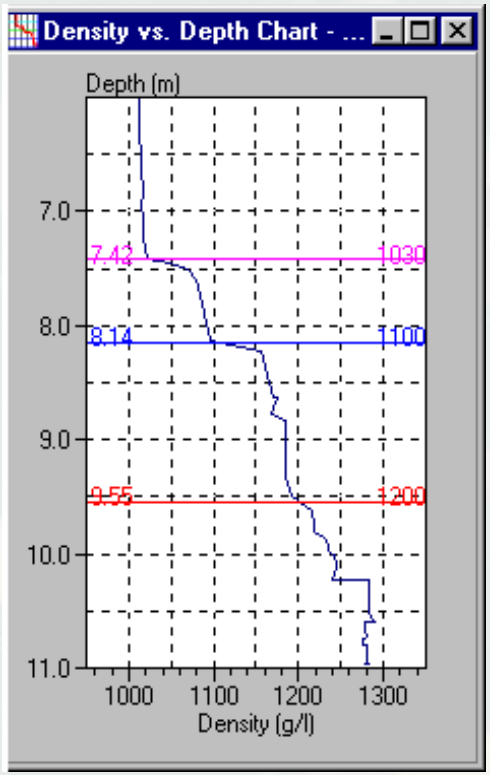
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

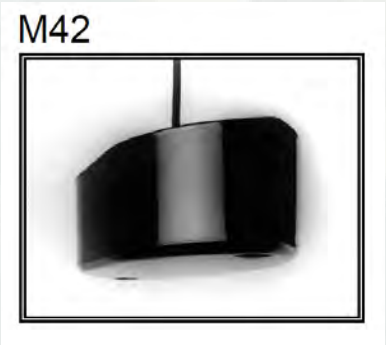
Practical Continuous Survey Method

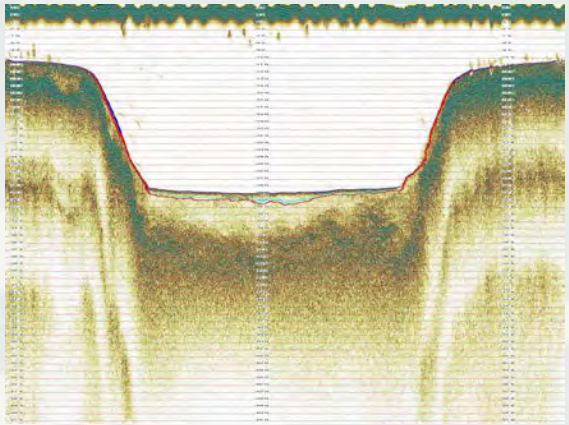
Gulfport Ship
Channel, Mississippi

Practical Continuous Survey Method



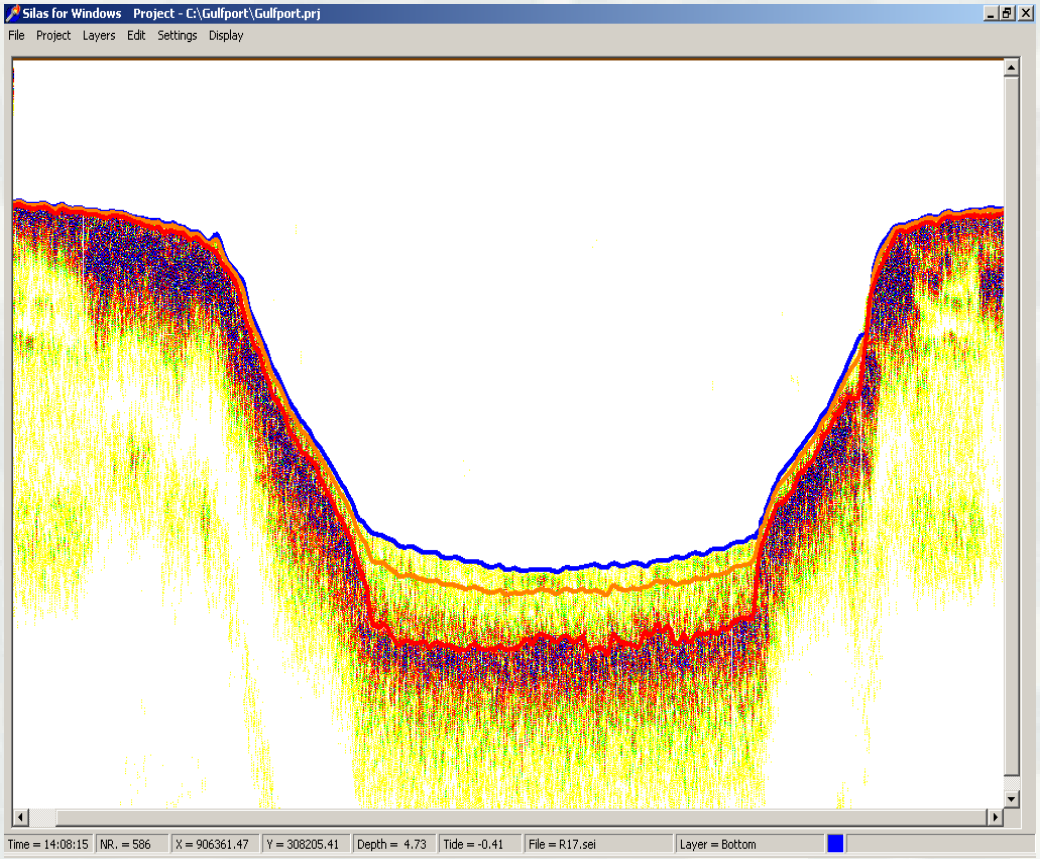
Densitune Density Probe





SILAS

Practical Continuous Survey Method



SILAS DIGITAL RECORDING LINE 17

LEGEND

TOP SILT LAYER

1.200kg\liter DENSITY LEVEL

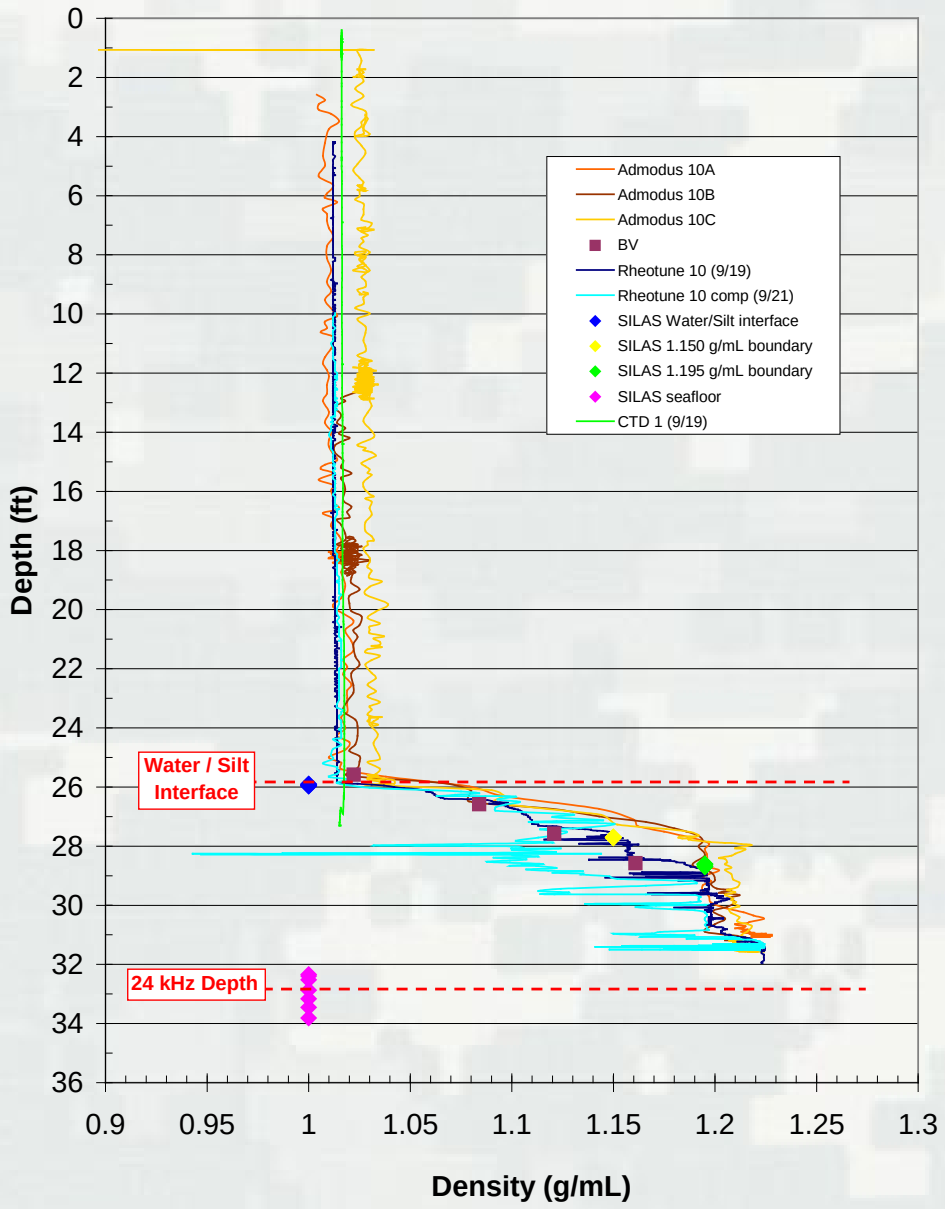
TOP CONSOLIDATED MATERIAL

SILAS SURVEY GULF PORT

DIGITAL RECORDING OF ODOM ECHOTRACK MK III
24 kHz FEQUENCY


13A
13B
13C
13D

Fluid Mud Field Drop 10



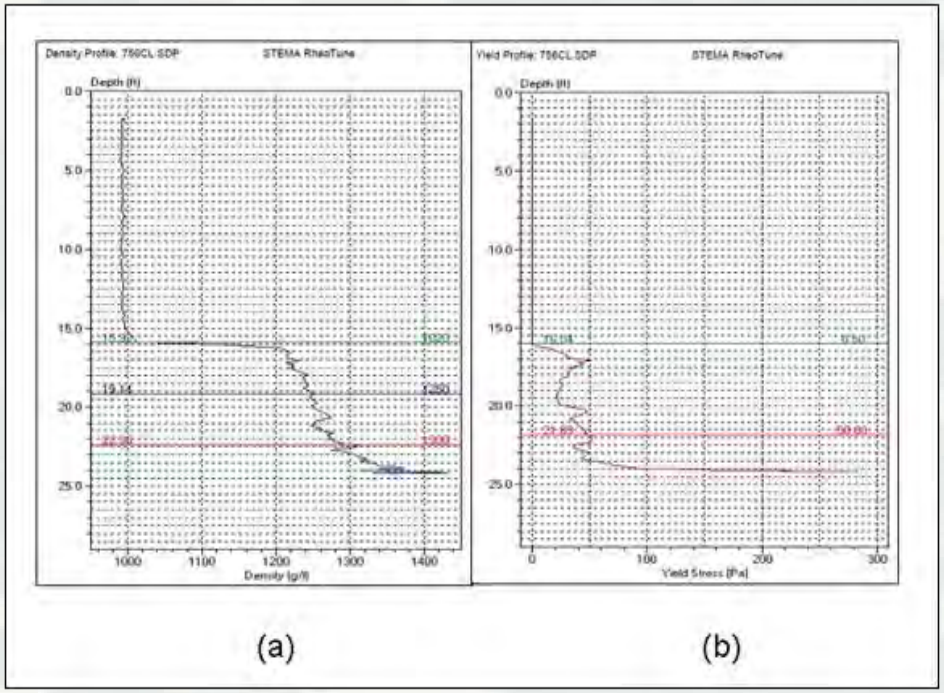
Atchafalaya (Louisiana) Bar Channel

Vicksburg Mississippi Densitune Testing

Vicksburg Mississippi Densitune Testing

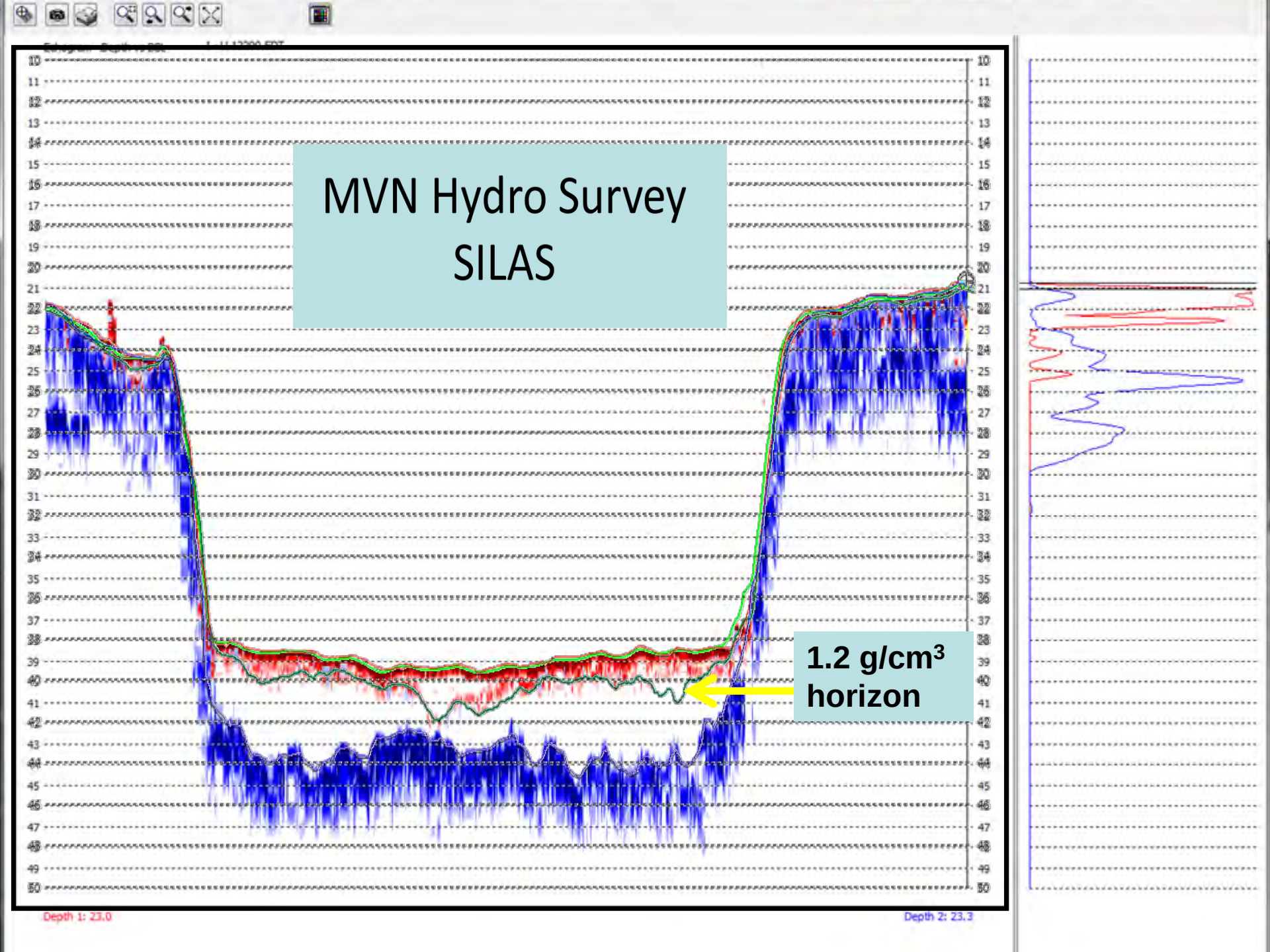
Depth Above Bottom	Ball Valve Sample Density	Densitune Density	Relative Difference %
40 cm	1.008	1.022	1.2
30 cm	1.256	1.319	5.0
20 cm	1.284	1.361	6.0
10 cm	1.289	1.362	5.6

New Orleans District Hydro Survey Rheotune & SILAS

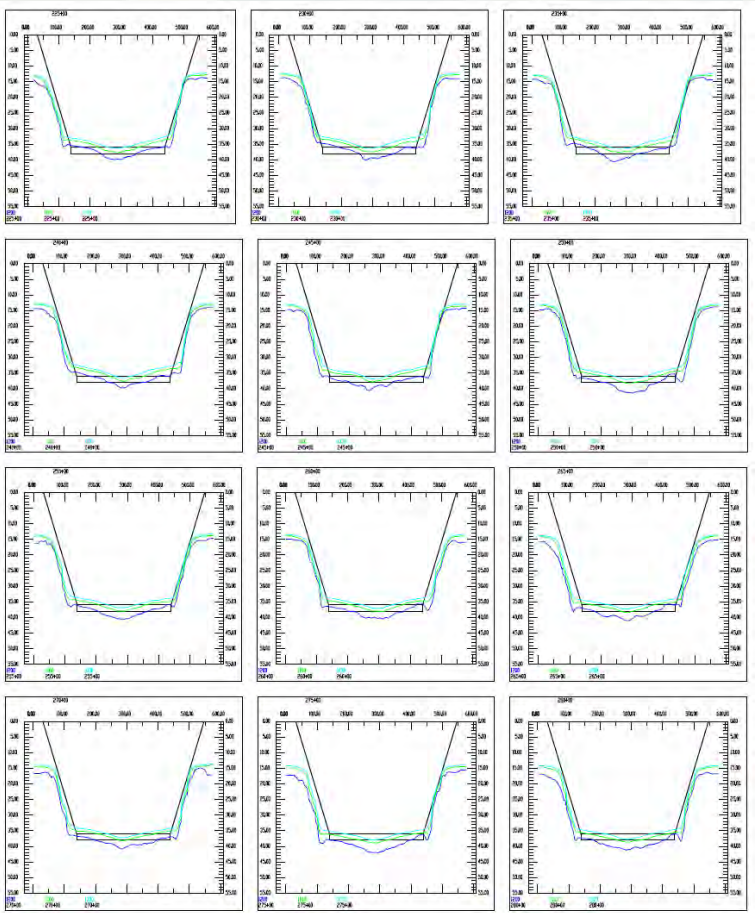


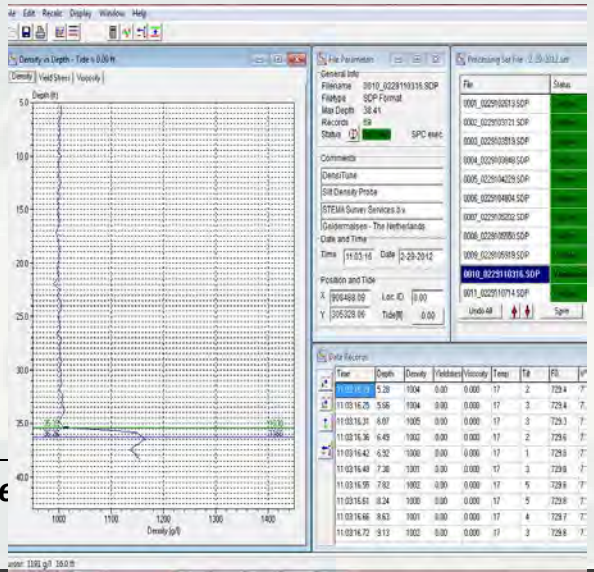
Rheotune

Port of Morgan City


MVN Hydro Survey
SILAS
1.2 g/cm3
horizon
Depth 1: 23.0
Depth 2: 23.3

Mobile District Hydro Survey
SILAS & Rheotune





Innovative

Nautical Bottom

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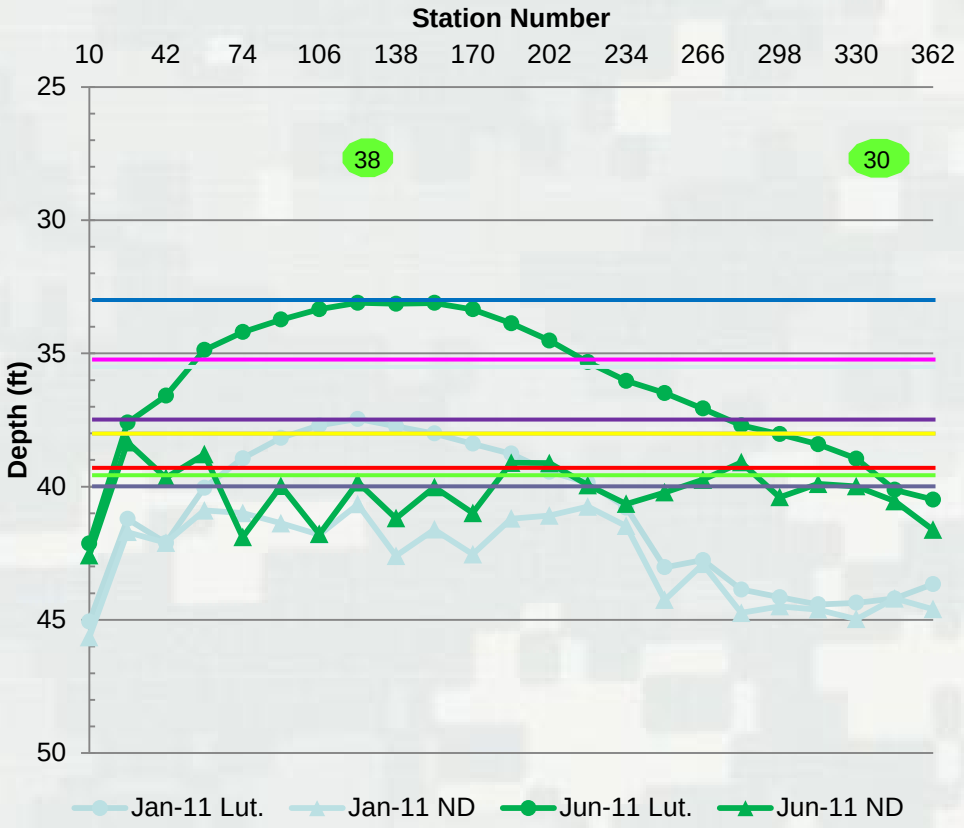
- practical, continuous survey method
- minimum underkeel clearance value
- knowledge about ship behaviour

Knowledge of Ship Behavior

- Observe ship behavior relative to density/yield stress horizons
- Develop Calcasieu Bar Channel hydrodynamic model for ERDC ship simulator w/o fluid mud effects.
- Modify ship simulator with Ghent University/Flemish Hydraulics Institute fluid mud/ship maneuverability hydraulic coefficients.
- Have Calcasieu Pilots “drive” simulator with differing fluid mud conditions.
- Achieve a common understanding of nautical depth.

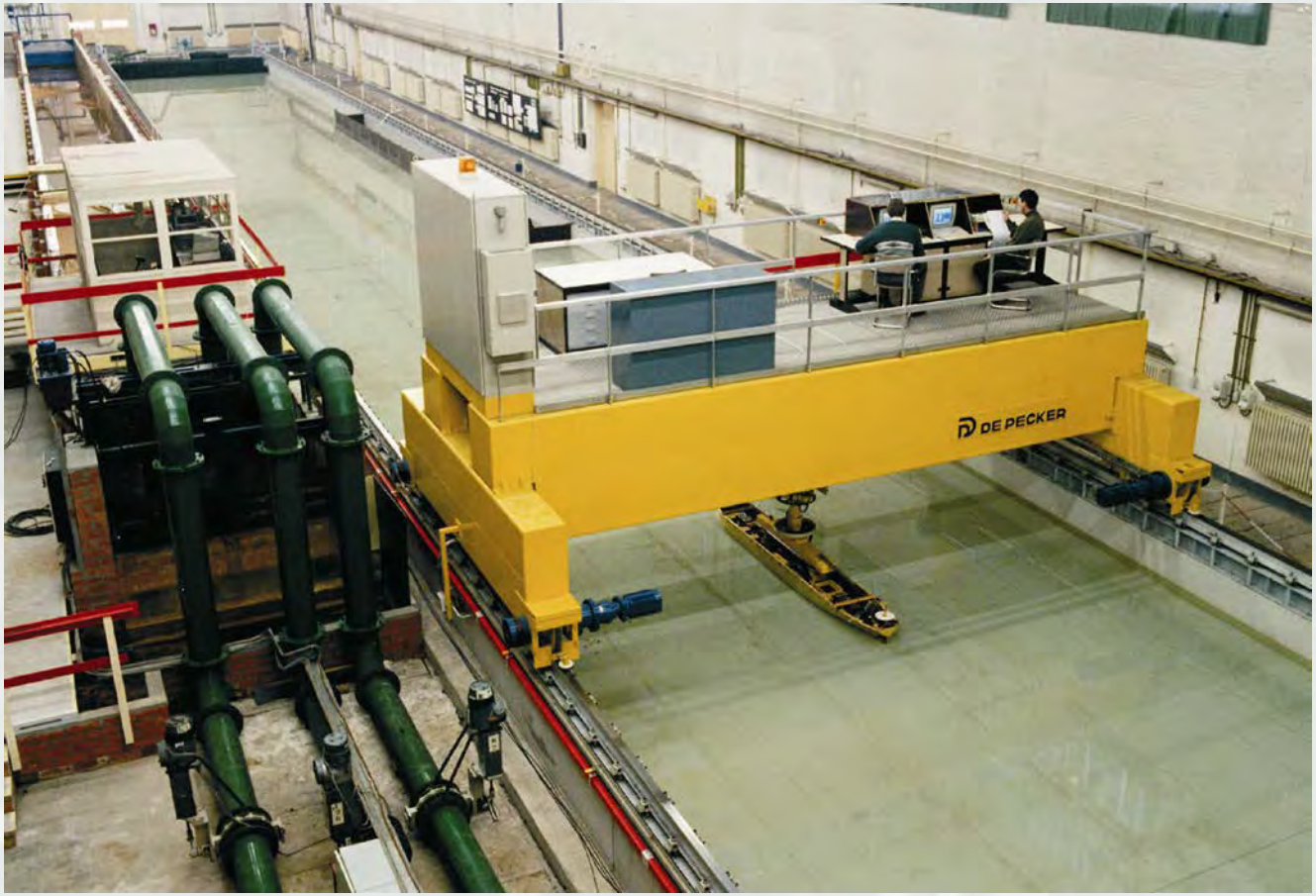
Calcasieu Bar Channel Speed Reductions Reported by Bar Pilots

Lutocline and Nautical Depth



Date	Draft (ft)	Reduction (knots)
10/16/2010	37.5	1.2
12/18/2010	39.3	2.2
12/18/2010	33	0
12/26/2010	35.5	1.5
2/1/2011	40	1.8
5/4/2011	38	2
5/5/2011	39.5	3.2
5/12/2011	35.3	3.3
6/9/2011	38	3.2
Average	37.3	2.04
Average of 35'+ draft	37.9	**2.30**

Several vessels over 35' in draft showed a consistent reduction in speed with constant RPM from buoys 30-38.



Source: Dr. Marc Vantorre 2005

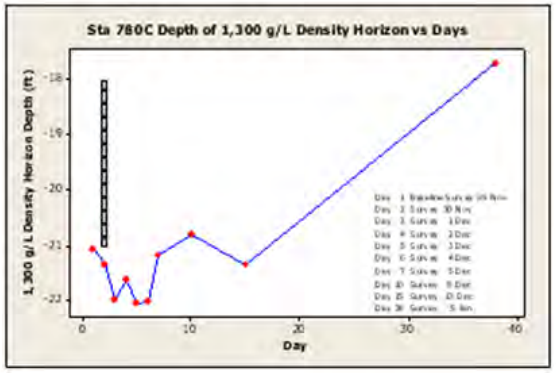
Dr. Marc Vantorre

Towing tank for maneuvers in shallow water co-operation Flanders Hydraulics Laboratory & Belgium Ghent University, Belgium

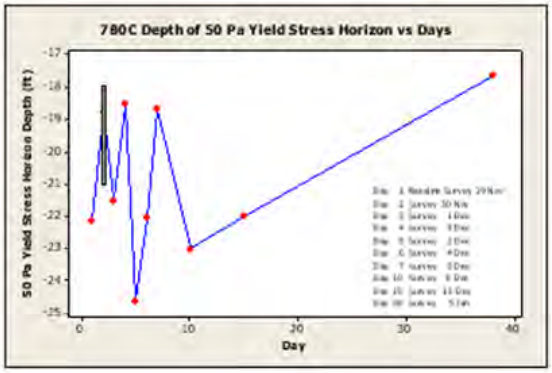
ERDC Ship Simulator

Emden Germany
“Sediment Conditioning”

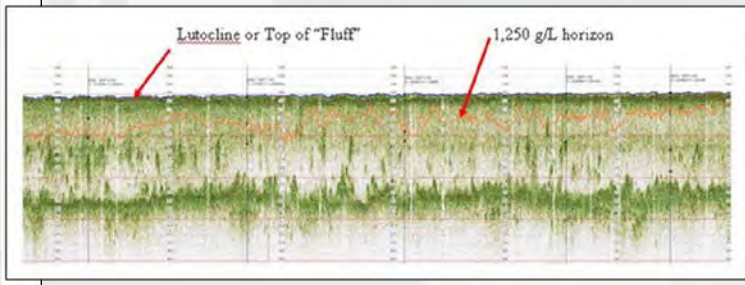
Atchafalaya Bar Channel Bed-leveler (Modified) Sediment Conditioning Demo



(a)



(b)



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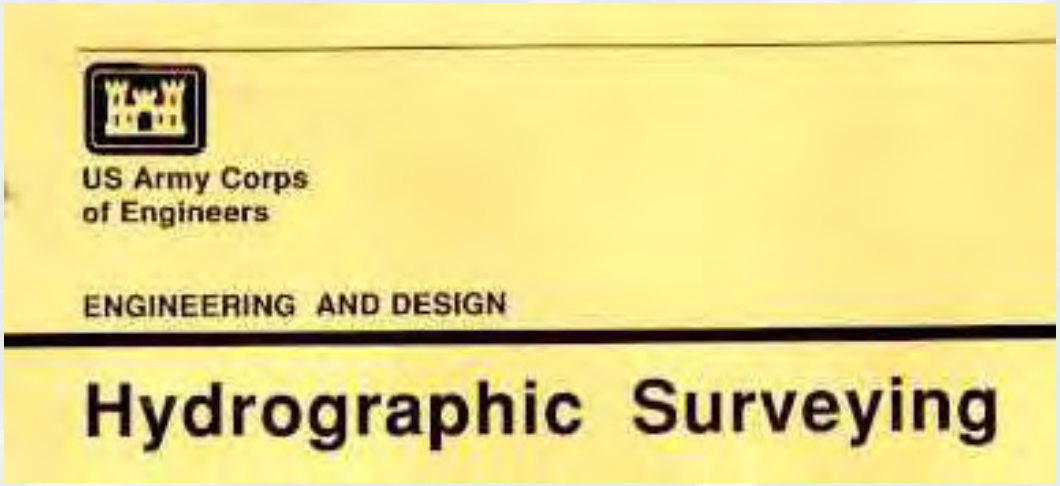
Corps Nautical Depth Implementation

Hydrographic Surveying Engineer Manual



http://www.publications.usace.army.mil/USACEPublications/EngineerManuals.aspx?udt_43544_param_page=4

Corps Nautical Depth Implementation

Hydrographic Surveying Engineer Manual

Figure P-14. GraviProbe Kit.

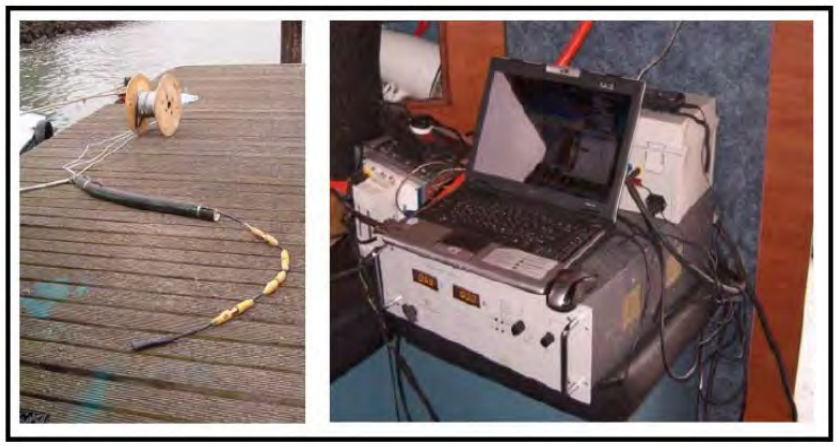
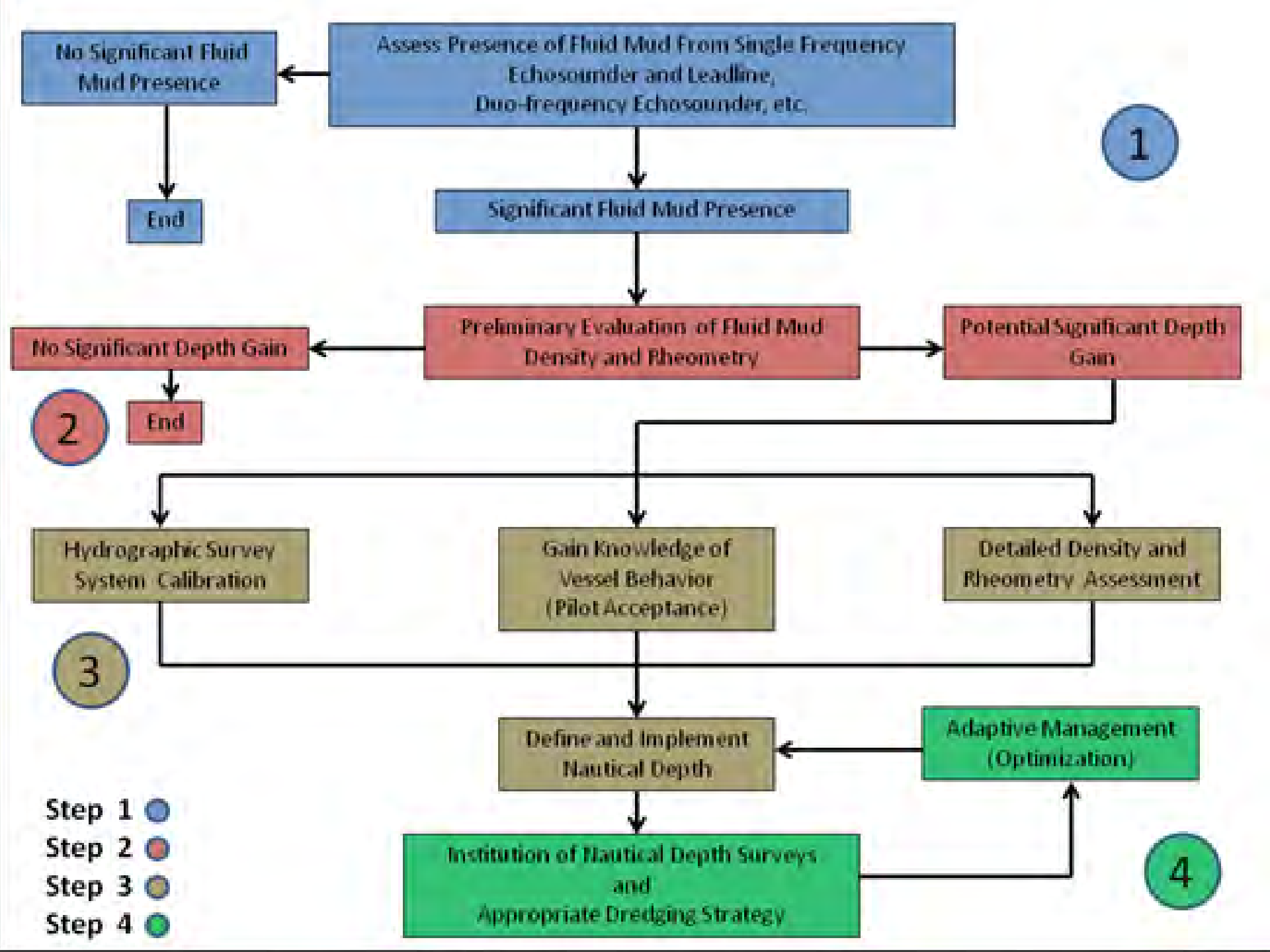


Figure P-16. Rheocable Method towed array and deck unit.


No Significant Fluid Mud Presence
Assess Presence of Fluid Mud From Single Frequency Echosounder and Leadline, Duo-frequency Echosounder, etc.
1
End
Significant Fluid Mud Presence
Preliminary Evaluation of Fluid Mud Density and Rheometry
No Significant Depth Gain
Potential Significant Depth Gain
2
End
Hydrographic Survey System Calibration
Gain Knowledge of Vessel Behavior (Pilot Acceptance)
Detailed Density and Rheometry Assessment
3
Define and Implement Nautical Depth
Adaptive Management (Optimization)
Institution of Nautical Depth Surveys and Appropriate Dredging Strategy
4
Step 1
Step 2
Step 3
Step 4

Corps Nautical Depth Implementation

Engineering Technical Letter?
Engineering Regulation?

QUESTIONS?