ISSMGE TC209 Workshop
on
Challenges of Offshore Geotechnical Engineering

25 September 2019

Bodrum - Turkey

Offshore Site Investigation and Site Characterization

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Challenges of Offshore Geotechnical Engineering
Bodrum, Turkey – September 2019

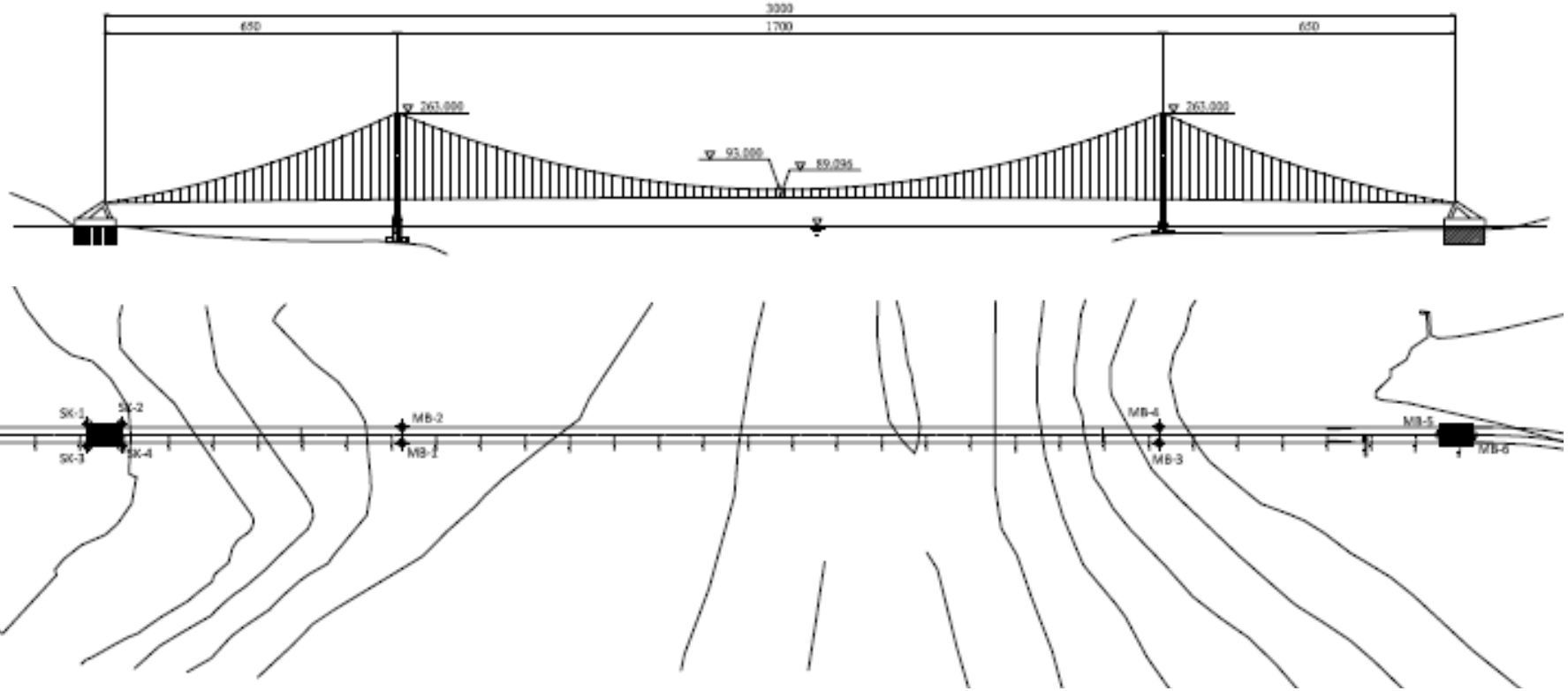
Offshore Projects

- Transportation Projects
  - Railway Projects
  - Highway Projects
- Pipeline Projects
  - Water transmission
  - Oil and Gas Pipelines
- Oil and Gas offshore platform
- Port, Jetty and Break Water Projects
- Offshore Wind Farms

Owner's Goals

- Reduce project related uncertainties;
- Reduce bid contingencies ;
- Reduce schedule and cost risks;
- Provide a robust bid basis to contractors;
- Facilitate project financing.

Project Challenges



What are the surface/subsurface conditions

What are the primary geohazards

Deep Soft and Liquefiable Soils Present At Site?

Integrated Site Characterization

Work Sequence

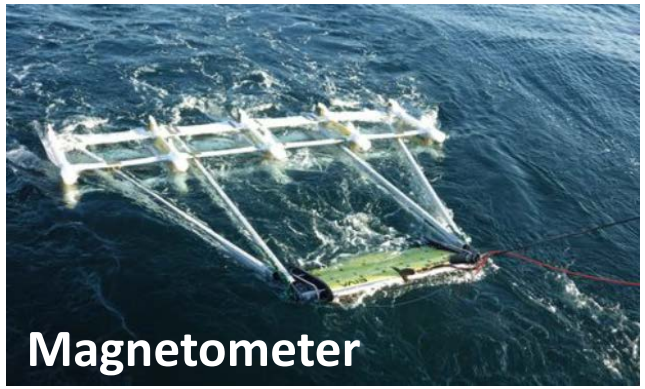
1. Existing Information/ Desktop Study
2. Area-wide Bathy / Geophysical Surveys
3. Develop and Execute Project-Specific Geotechnical Exploration Program
4. Data Integration and Interpretation
5. Project GIS database
6. 3D Model of the Subsurface

Bathymetric and Geophysical Surveys

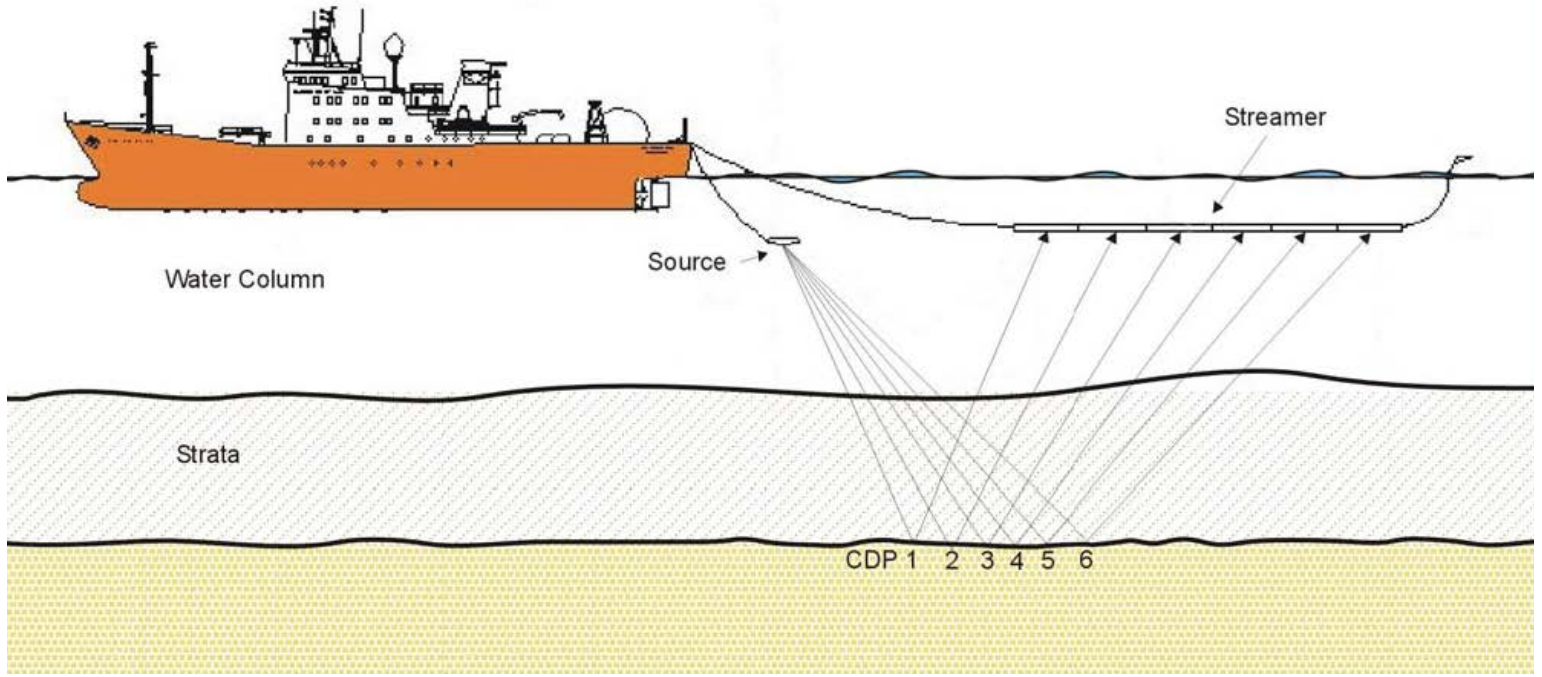
Bathy – Geophysical Surveys

- Bathymetry – Multibeam Echosounder (MBES)
- Seabed Features - Side Scan Sonar (SSS)
- Buried metallic objects (UXO, cables, etc.) - Magnetometer
- Shallow Stratigraphy – Sub-bottom Profiler
- Deeper Stratigraphy – Ultra high Resolution Seismic (Multichannel Seismic Survey)

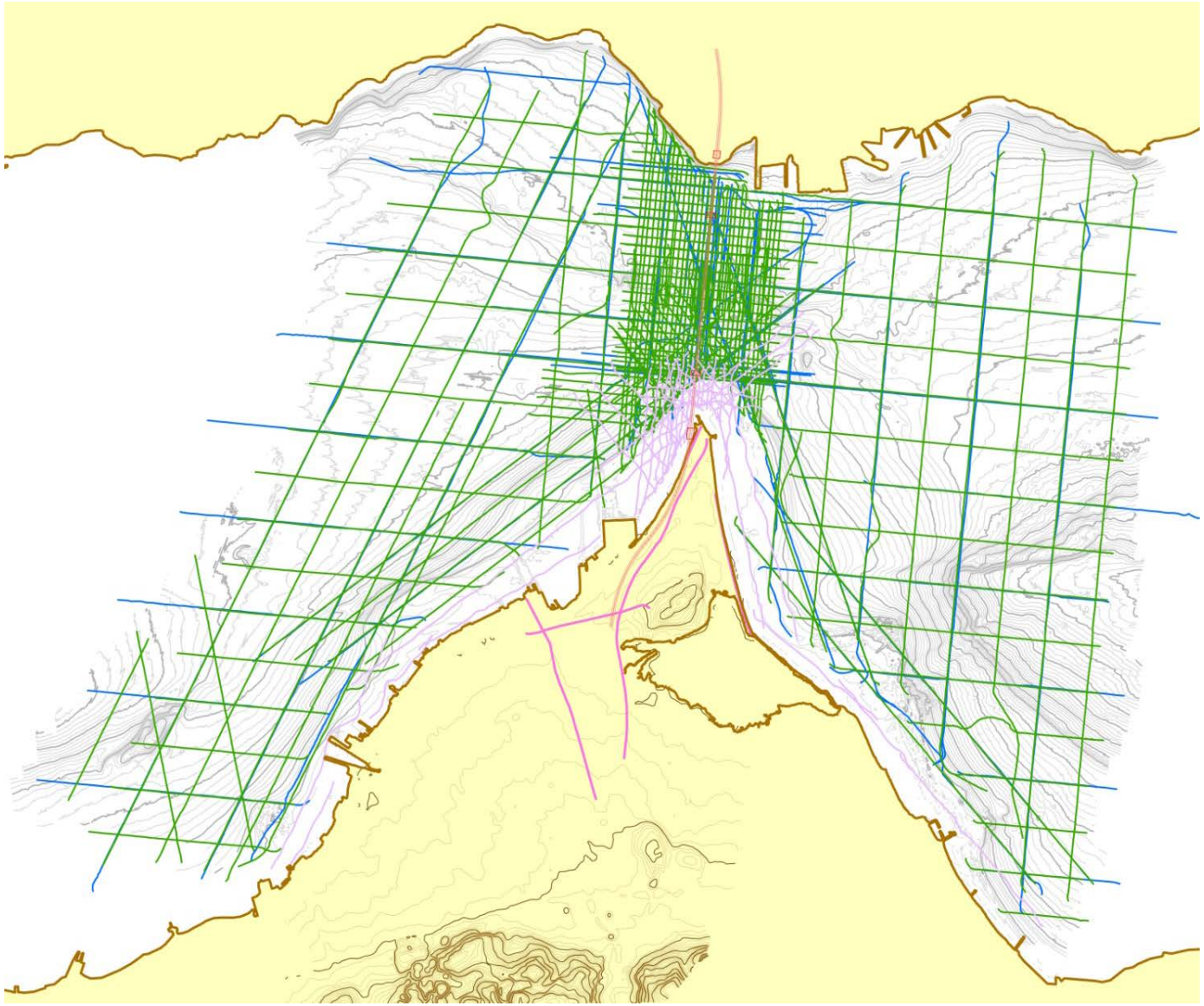
Bathy – Geophysical Surveys



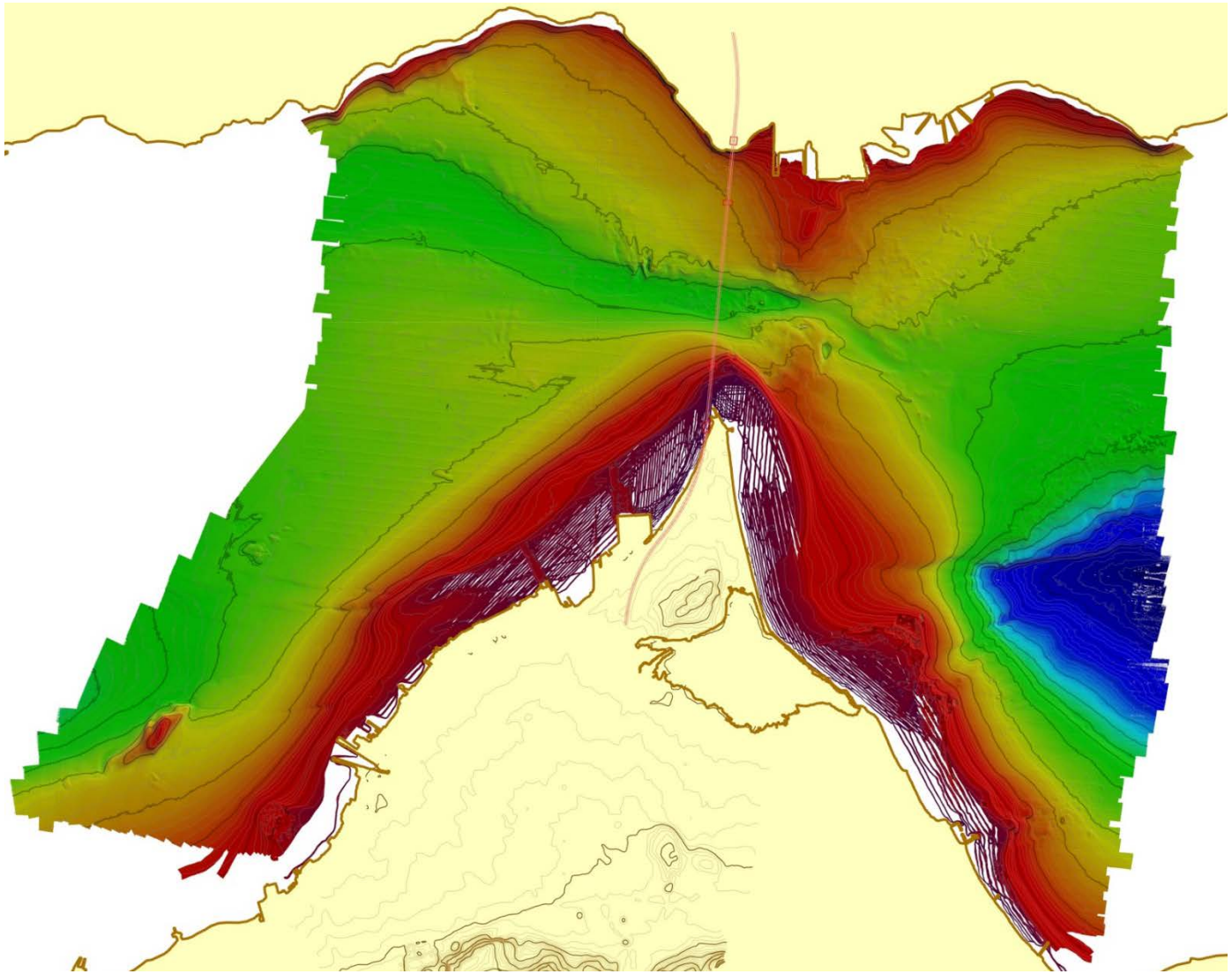
Multi-channel Seismic



Bathy – Geophysical Surveys



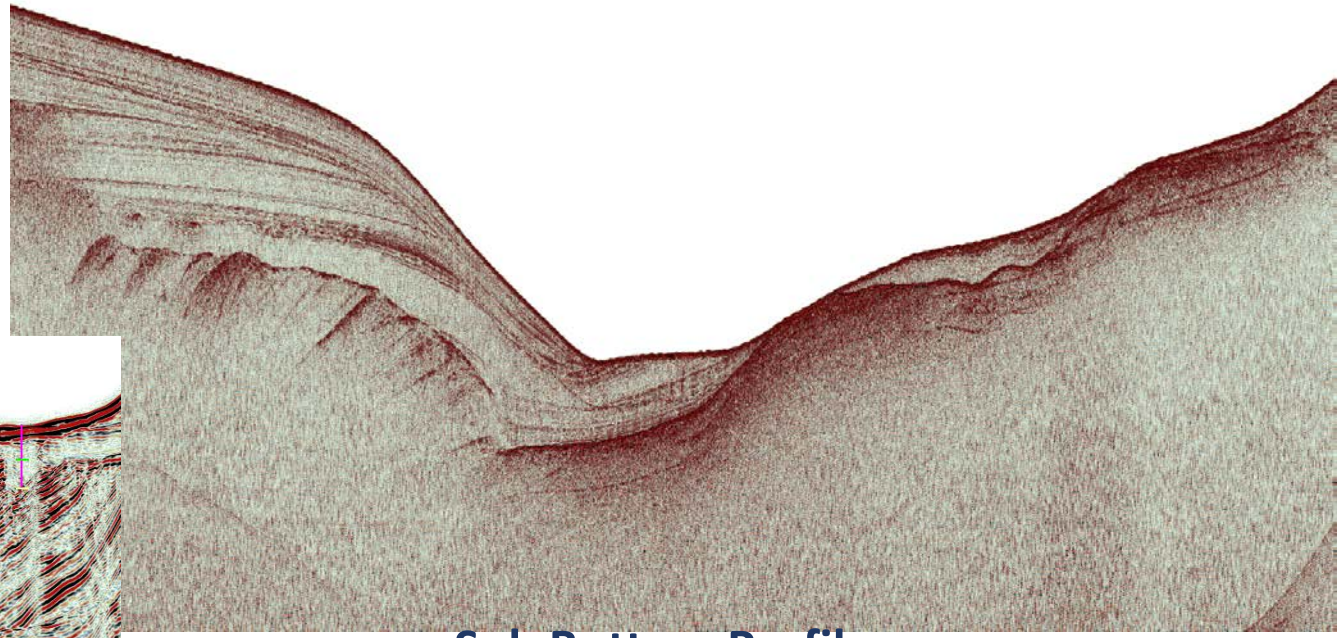
Bathy – Geophysical Surveys



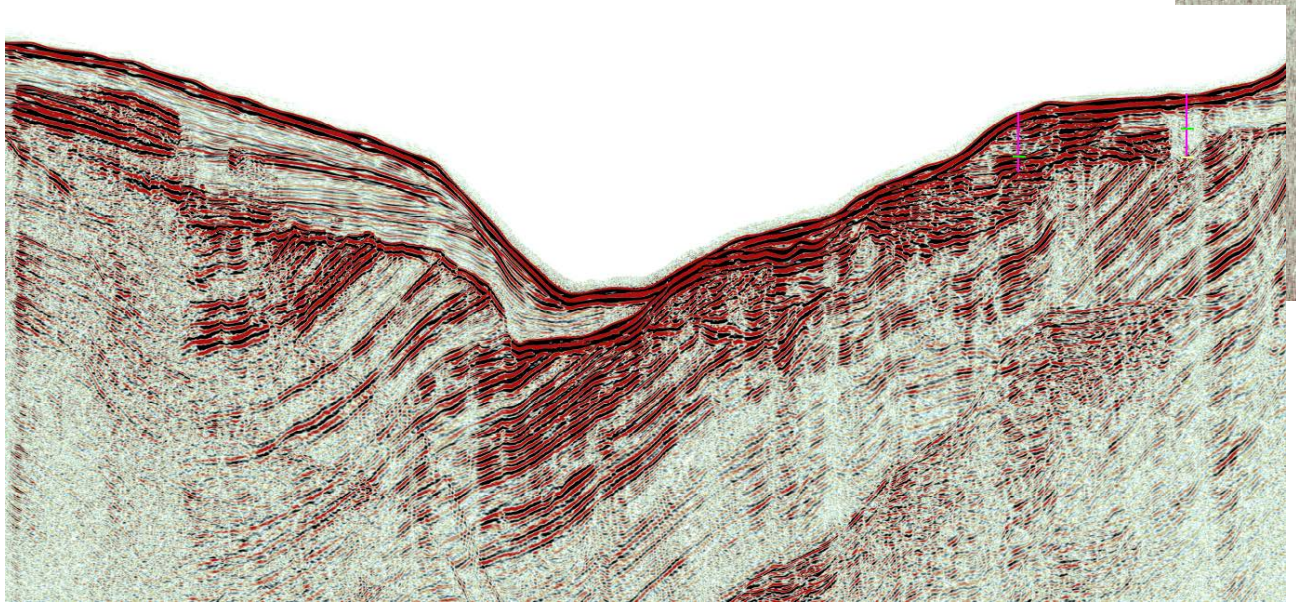
- Multibeam Echo Sounder
- Side Scan Sonar
- Laser Line scanner

UHR Seismic Reflection Geophysical Survey

Different sources: Boomer, Sparker, Airgun, Chirp
Different Receivers: single/ multi channel/ digital/ analogue



Sub Bottom Profiler



Ultra High Resolution

Geotechnical Investigations

Geotechnical Survey - Vessels

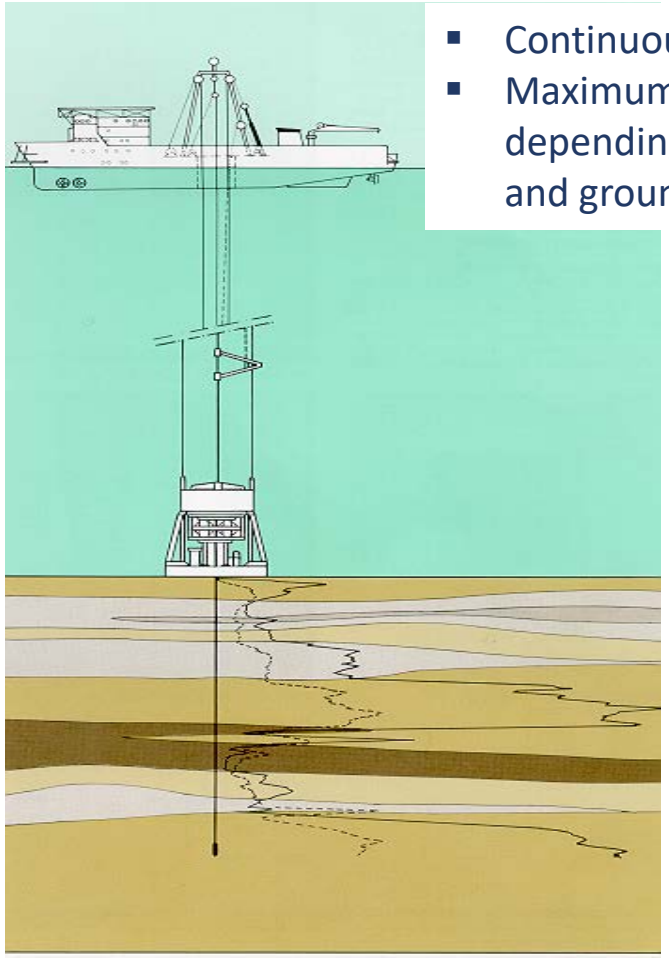
Dynamically Positioned (DP2) Vessels

Jack-ups (Lift-Barges)

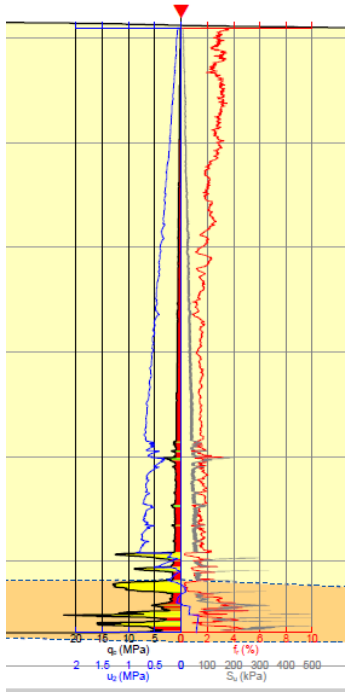
Semi-Submersible Drilling Vessels

Geotechnical Survey – Seabed vs Downhole

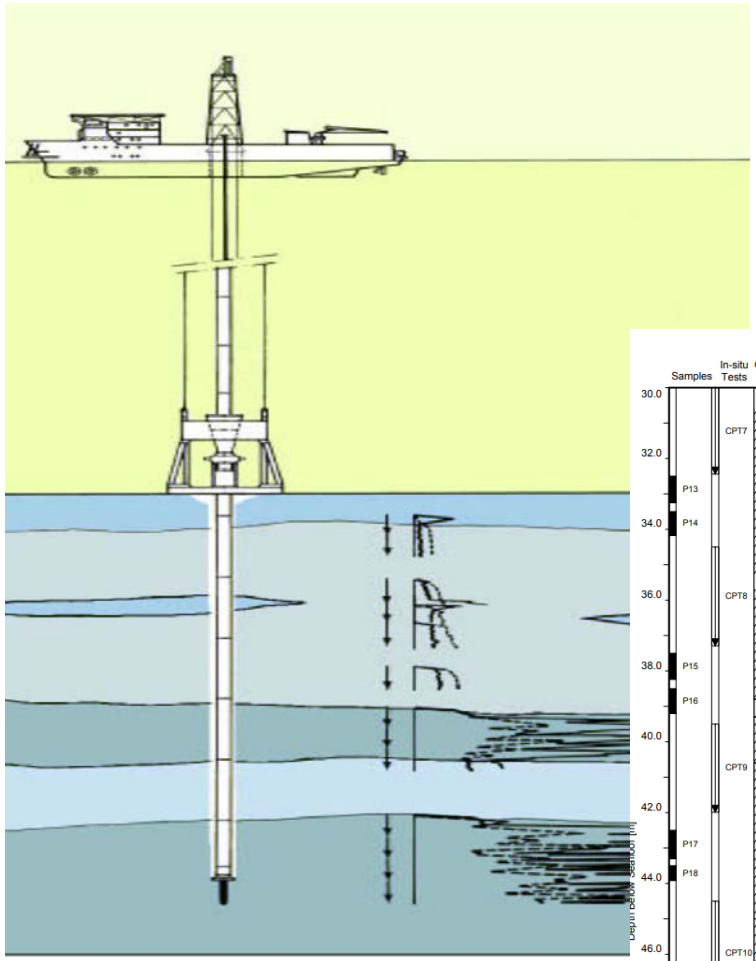
Seacalf: Seabed CPT



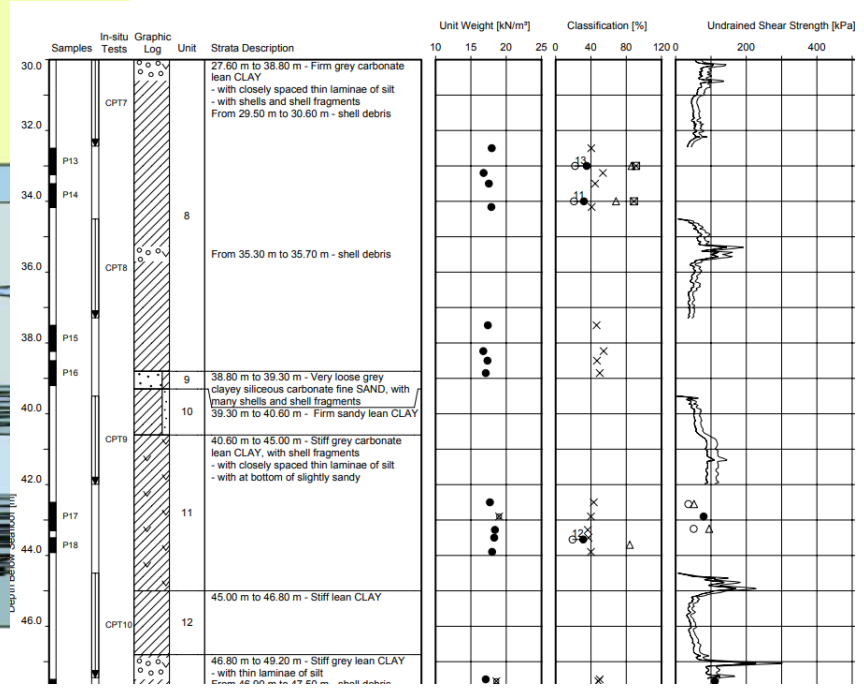
- Continuous data
- Maximum depths 40m depending on water depth and ground conditions



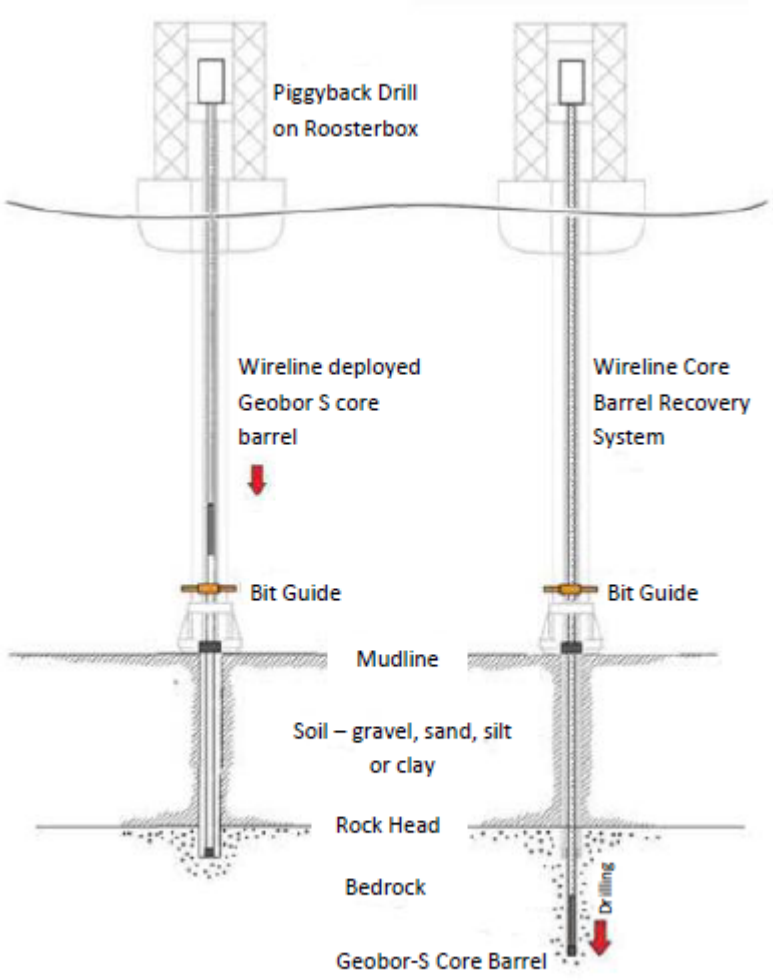
Wison XP : Downhole CPT/ undisturbed sampling



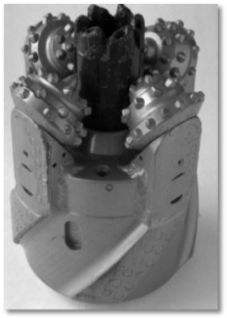
- Discontinuous data – 3m strokes
- Much higher penetration depths
- Alternation between in situ testing and sampling



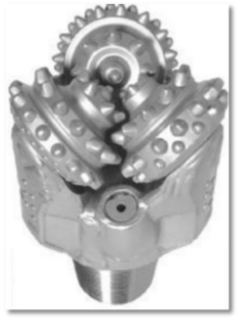
Geotechnical Survey – Drilling



Drag Bits

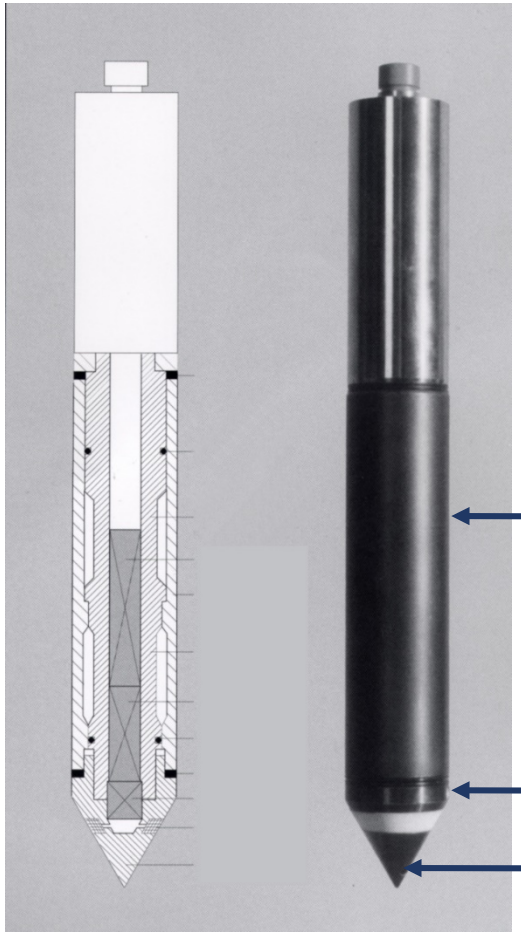


Roller Bits



Full Face Bits

Geotechnical Survey – In situ testing



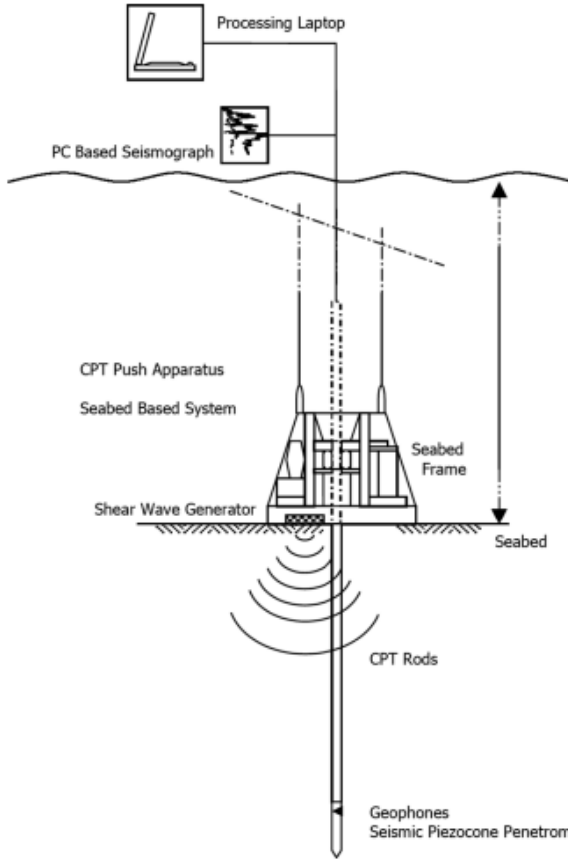
Marine CPT

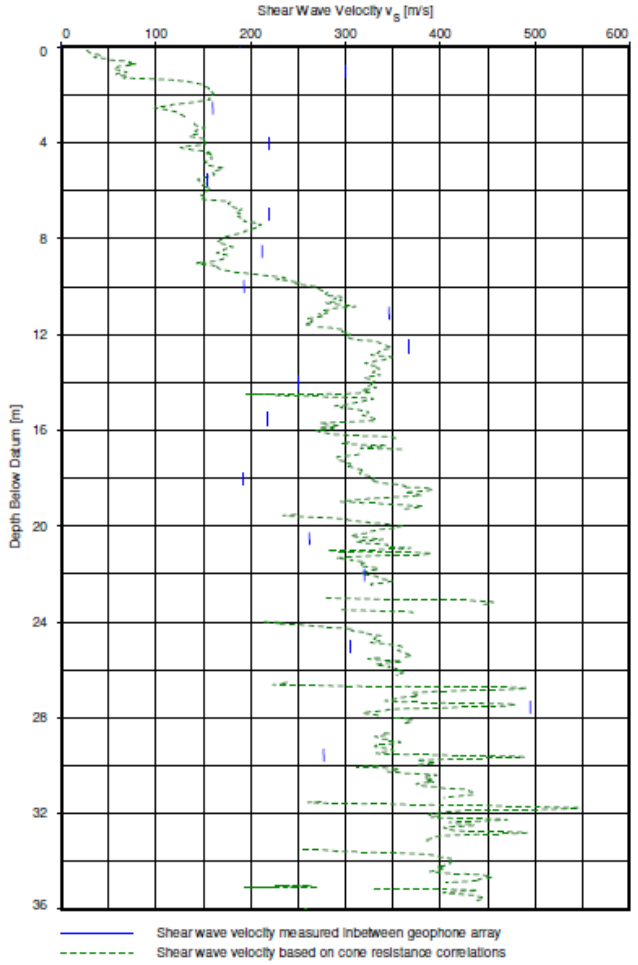
- Downhole and Seabed Techniques
- Isolation from Vessel Movement
- Superior Penetration Capability
- High Production Rate

In situ Shear Vane Test

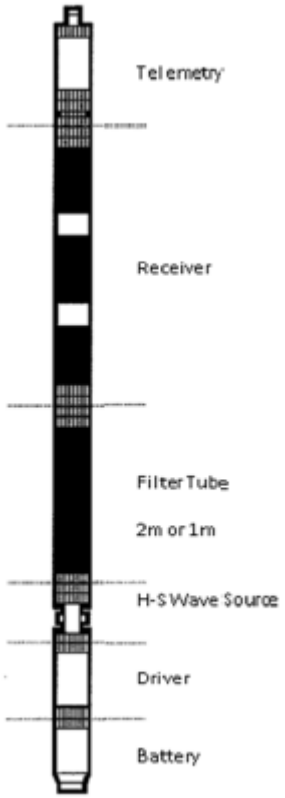
Geotechnical Survey – In situ testing

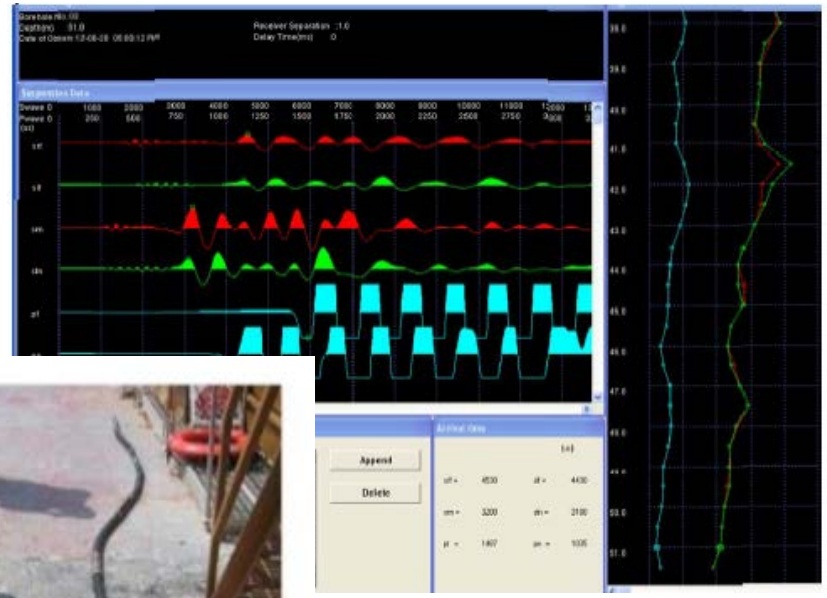
Seismic CPT – S wave velocity profile





P-S Suspension Logging



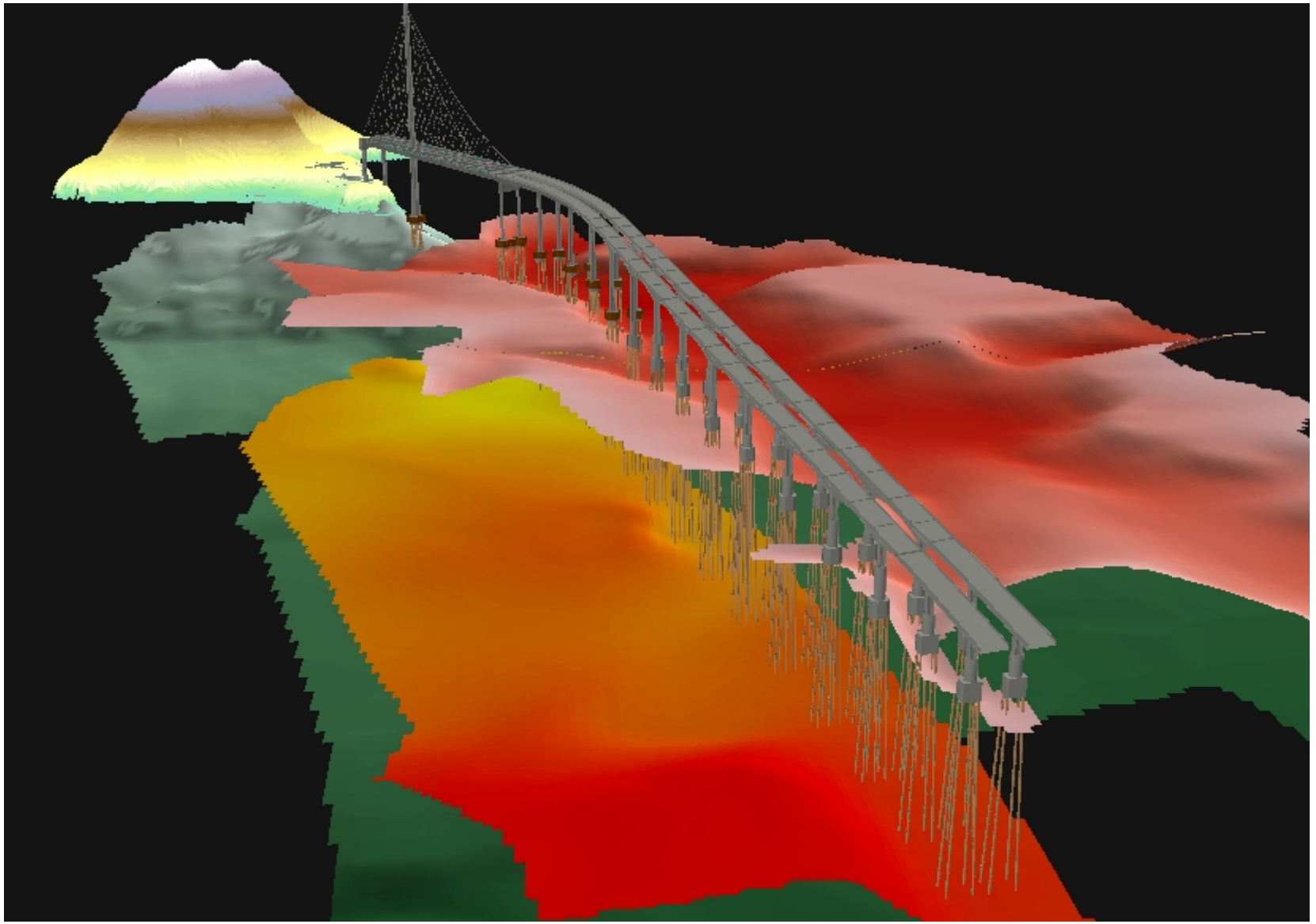


Onboard Core Logging and Laboratory Testing

Onboard Soils Testing Laboratory:

- expedites investigation results
- improves quality of test results, and
- provides real time QC of drilling program

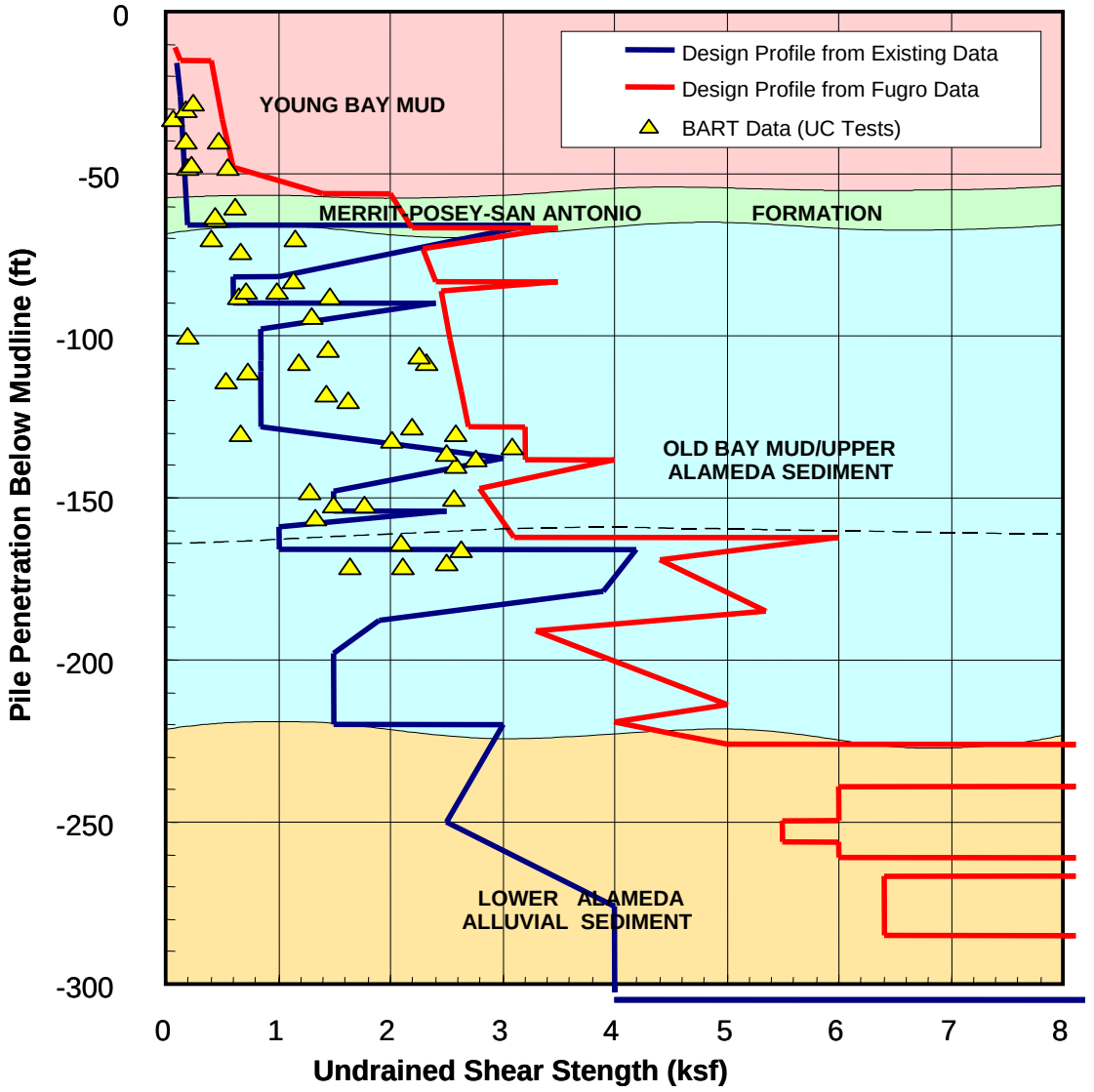
New San Francisco Oakland Bay Bridge



Site Characterization

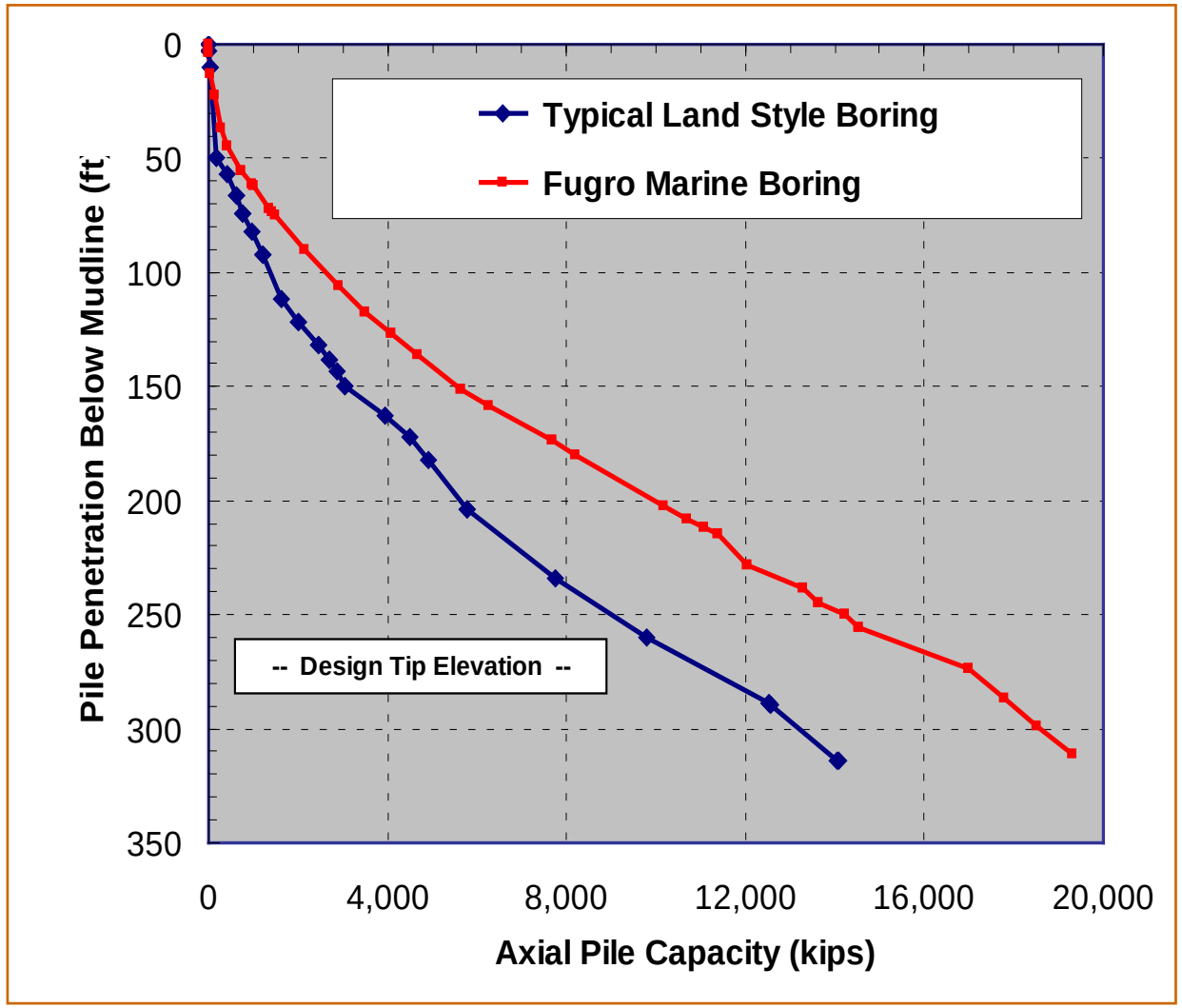
New San Francisco Oakland Bay Bridge

Application of Standard Land-based Techniques Can Result in Underprediction of Shear Strengths by on the order of 25 to 50 percent!

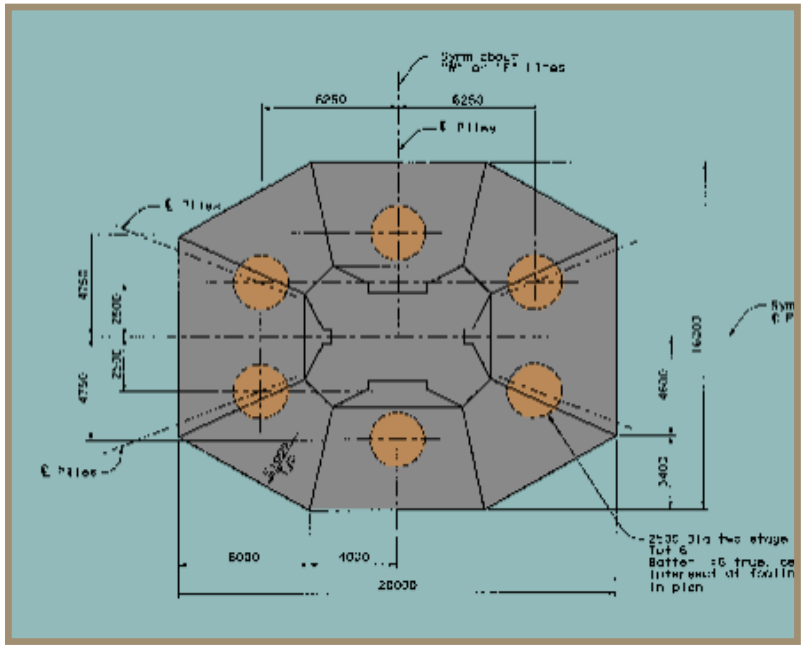


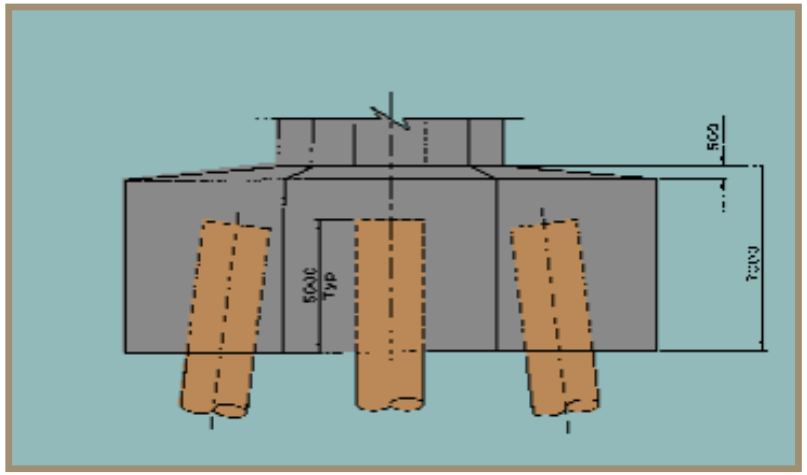
New San Francisco Oakland Bay Bridge

Comparison of Computed Pile Capacity Standard "Land" vs "Marine"



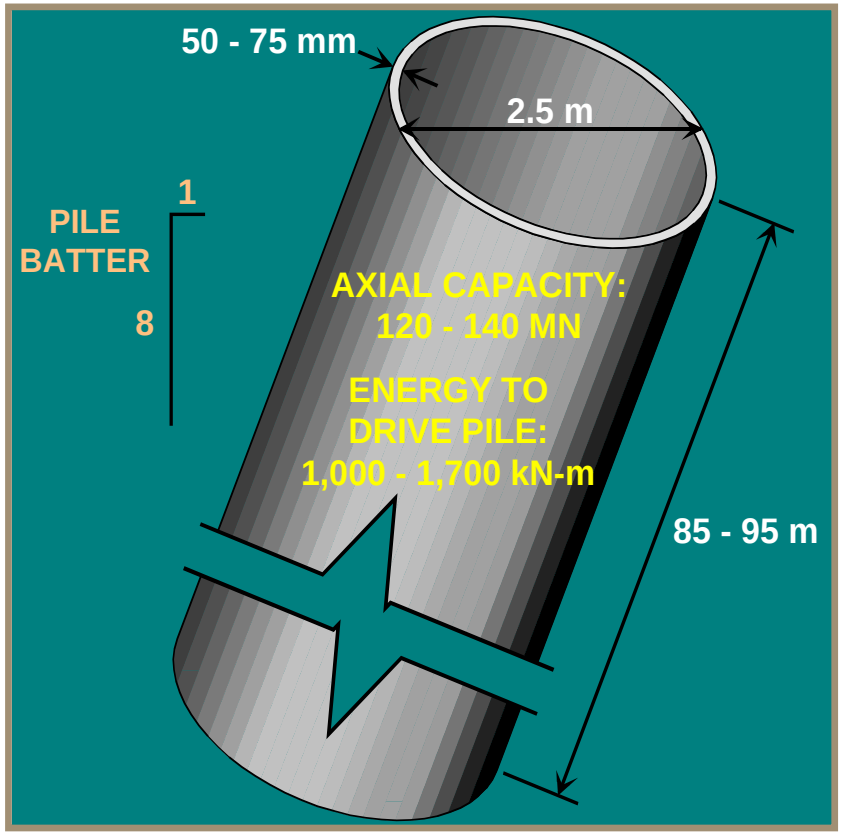
New San Francisco Oakland Bay Bridge





Skyway Foundation:

- 28 Footing Locations
- 160 piles



The savings decrease in pile length alone exceeds the additional costs for the offshore SI

Site Investigation Challenges

- Site Conditions
  - Boat Traffic (Bosporus, Çanakkale Straits)
  - Currents
  - Weather
  - Shallow Gas
  - Seabed Conditions (UXO, Cables, Shipwrecks etc)

Site Investigation Challenges

- Logistics - Multidisciplinary projects, work sequence limitations
- Schedule - Very tight schedules especially for BOT and EPC projects.
- Costs - High costs due to mobilization and using most modern techniques and equipment. High returns due to saving time and obtaining good quality data.

Site Characterization

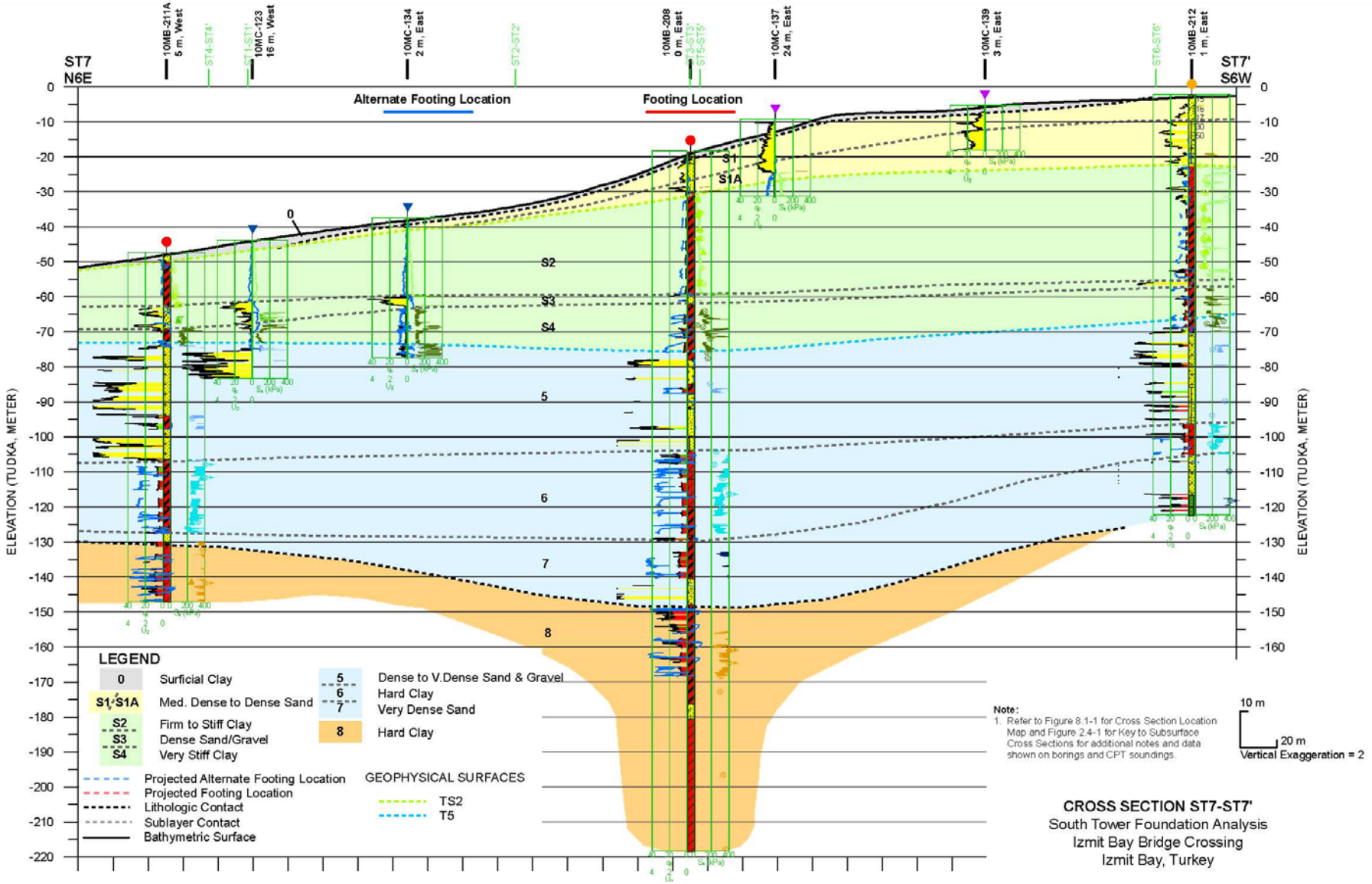
Integrated Site Characterization

Available Information:

- Geology of the Project Area
- Bathymetry (MBES, SSS)
- Geophysics (UHRS, SBP)
- Geotechnical Survey (Downhole Drilling/ Sampling and Testing, Seabed CPT, Seismic CPT)
- Borehole Geophysics (P-S Logging)
- Laboratory Tests (Onboard and in external Laboratories, conventional and advanced)

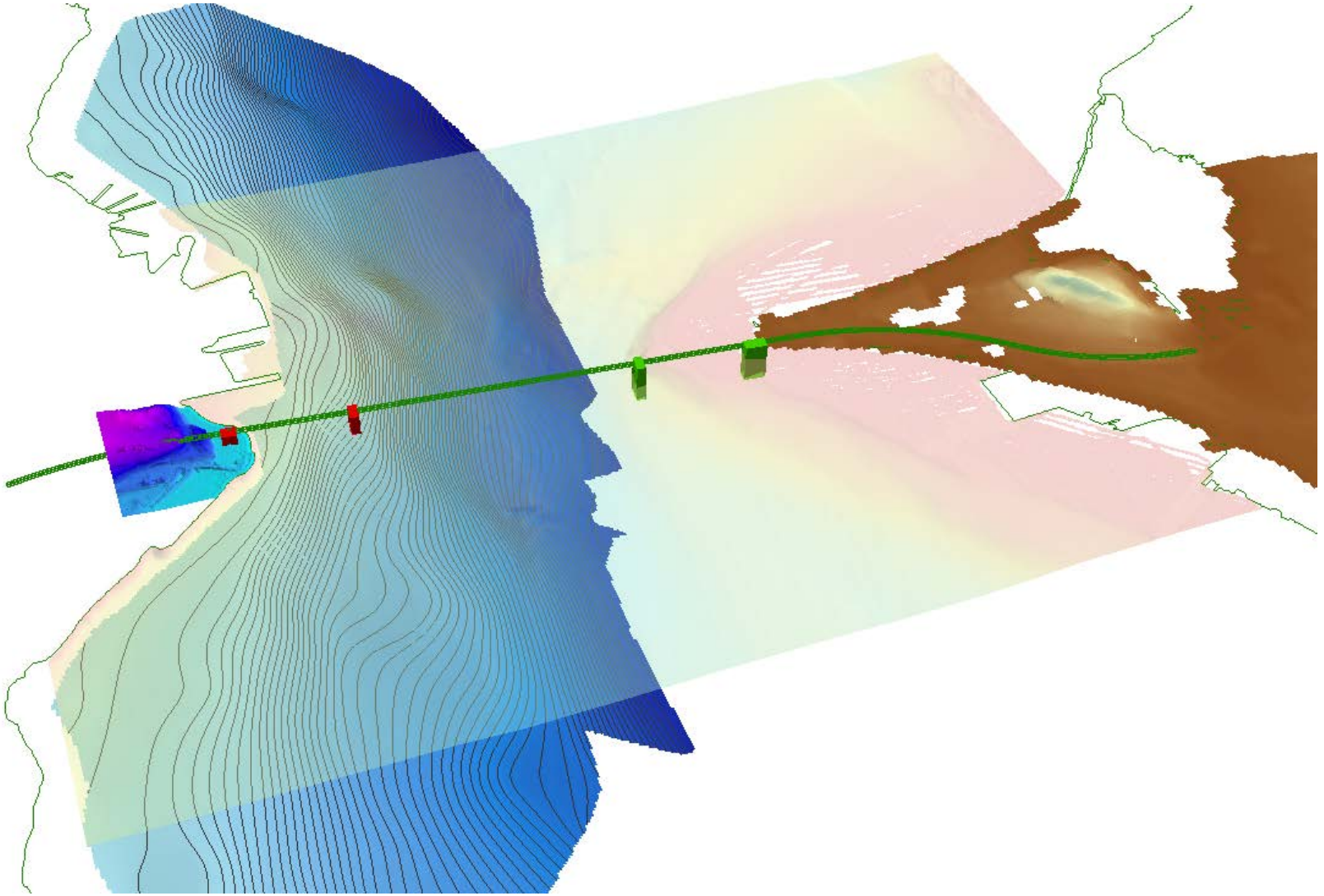
A very large GIS database that allows synthesis, comparison, analyses and output of the data.

Integrated Site Characterization - Stratigraphy

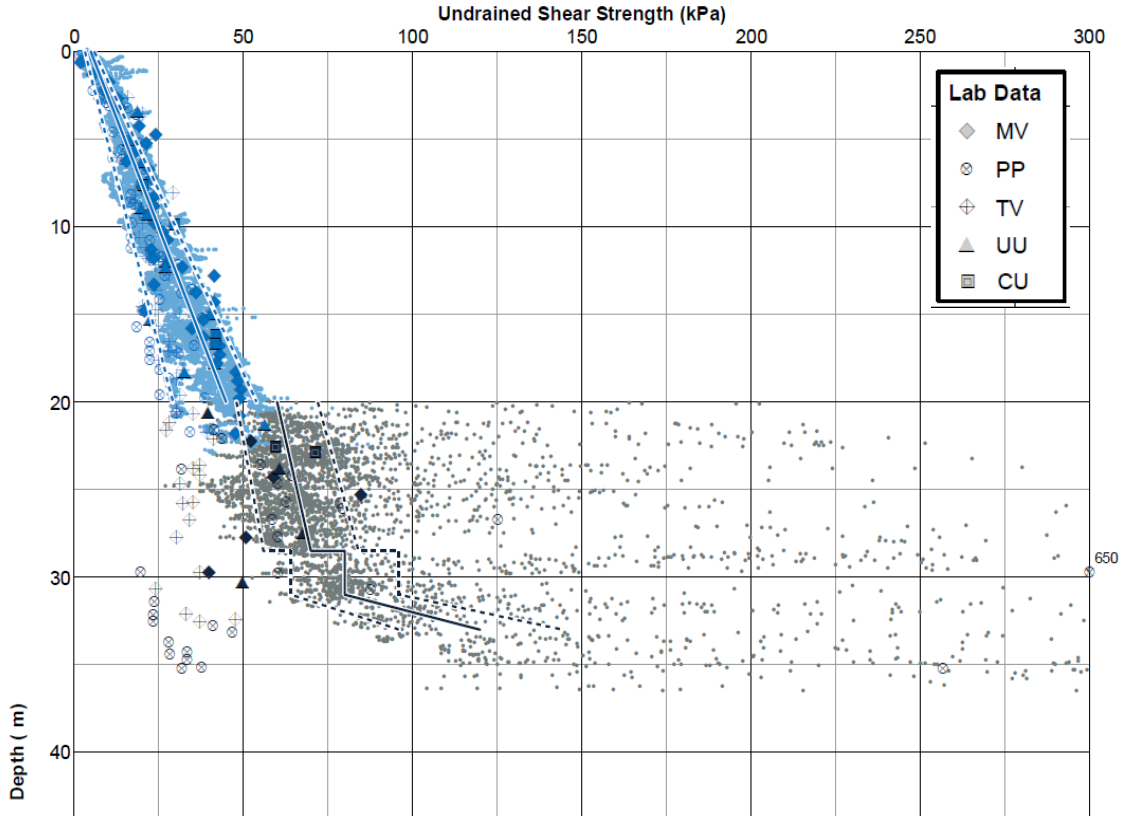


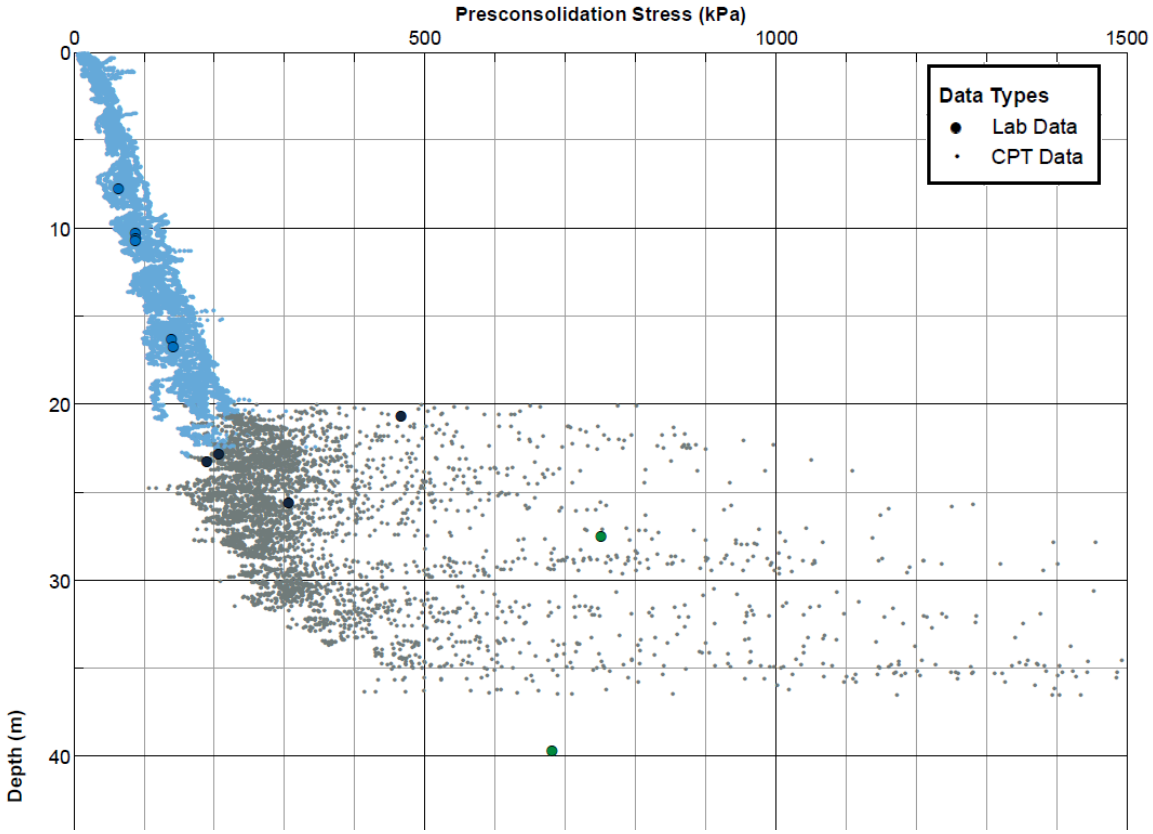
CROSS SECTION ST7-ST7'
South Tower Foundation Analysis
Izmit Bay Bridge Crossing
Izmit Bay, Turkey

Integrated Site Characterization

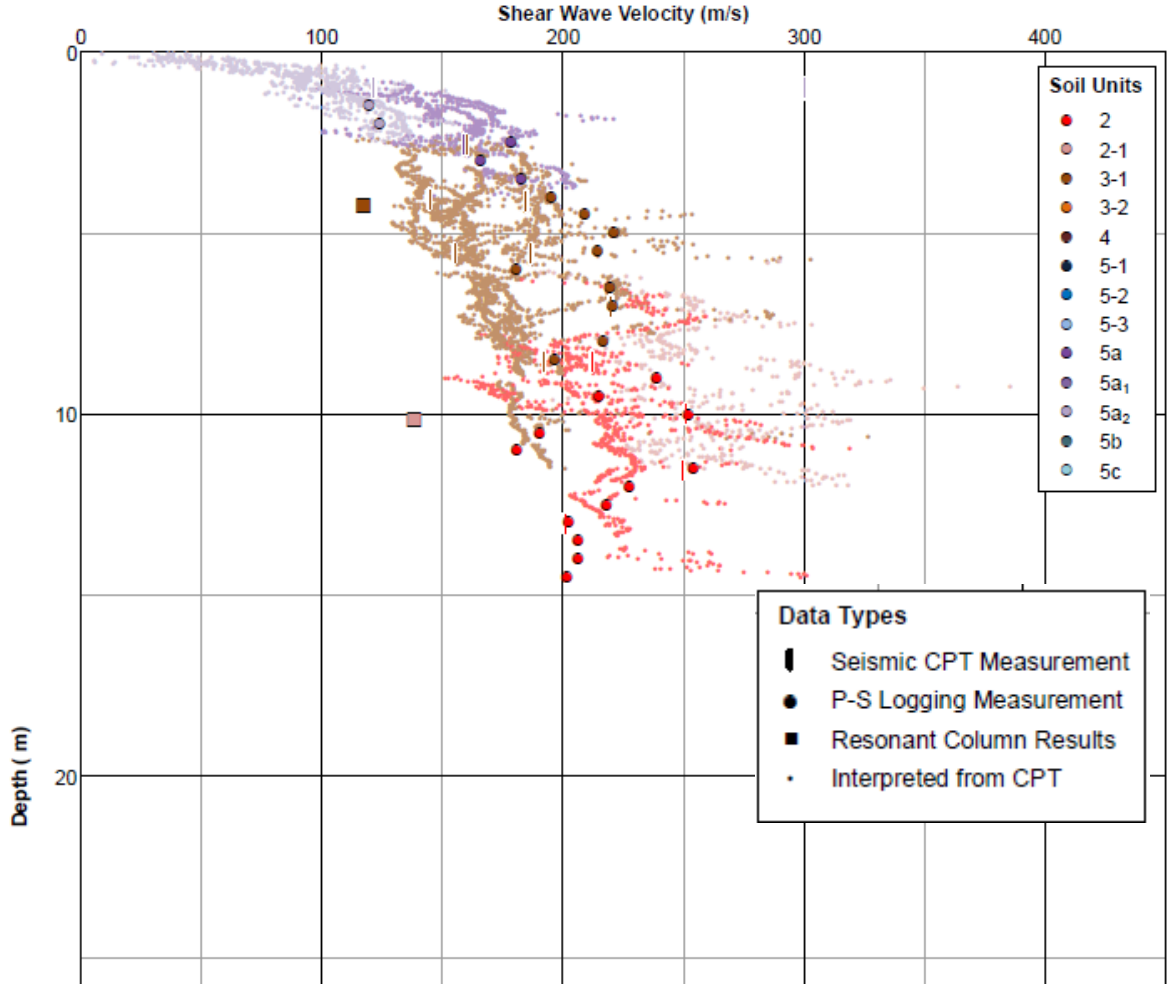


Integrated Site Characterization – Engineering Properties



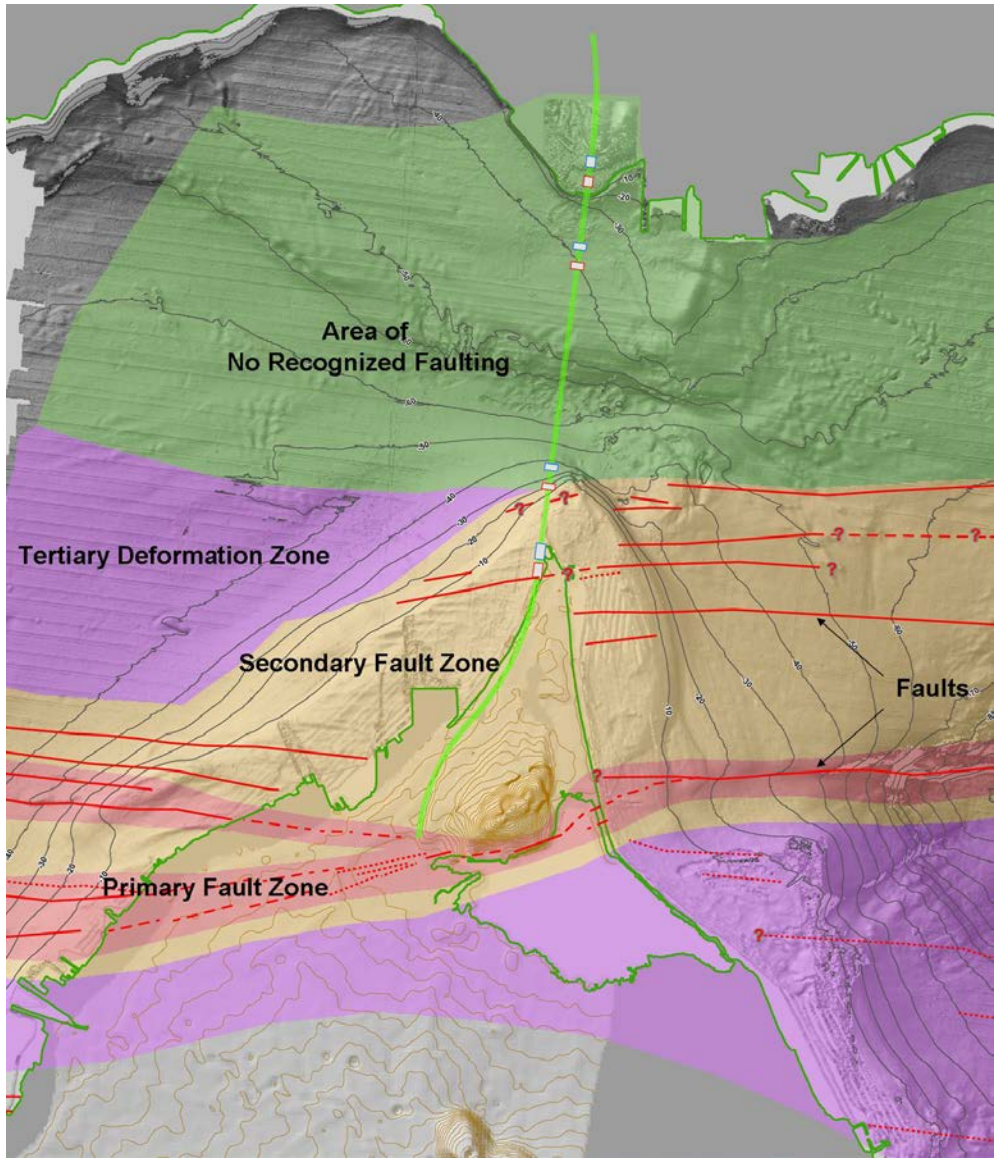


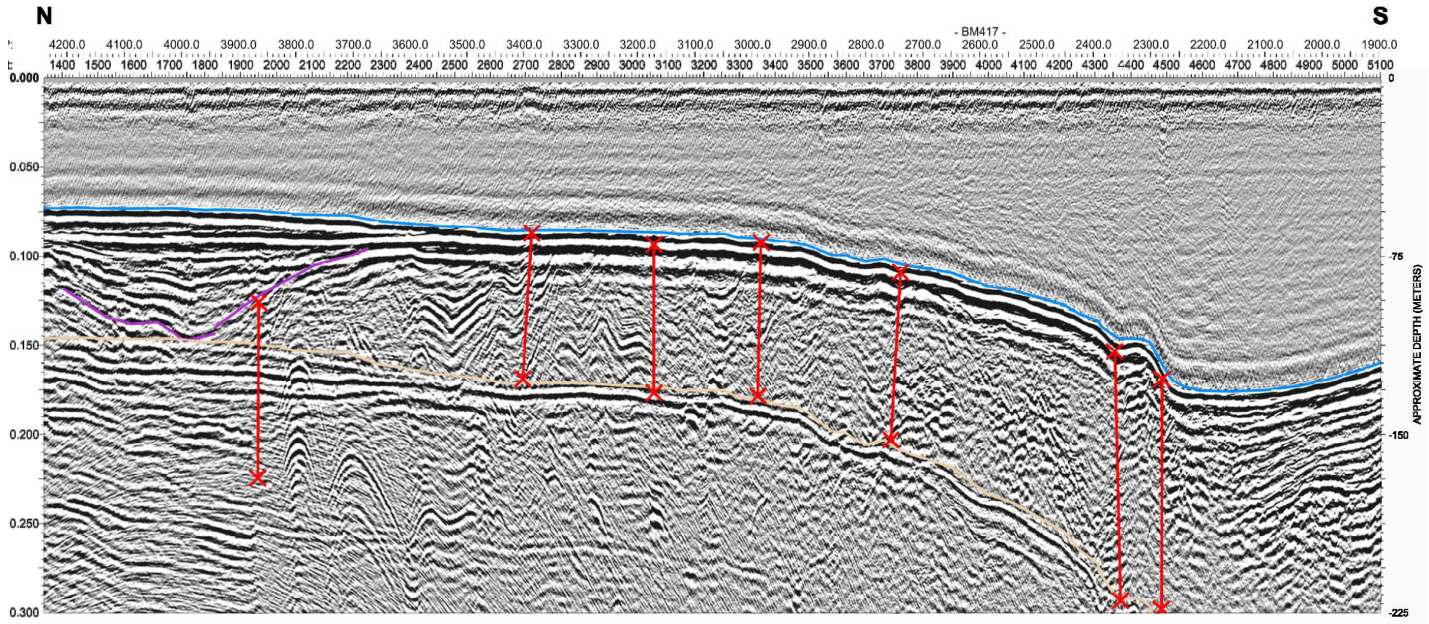
Integrated Site Characterization – Engineering Properties



Geohazards

Geohazard Identification - Faults





Notes:

1) Line BM417 is approximately 3.5km east of Hersek Peninsula.

2) Faults are interpreted only to depth of seafloeer multiple reflection except at north end.

3) Note buried channel and inactive fault.

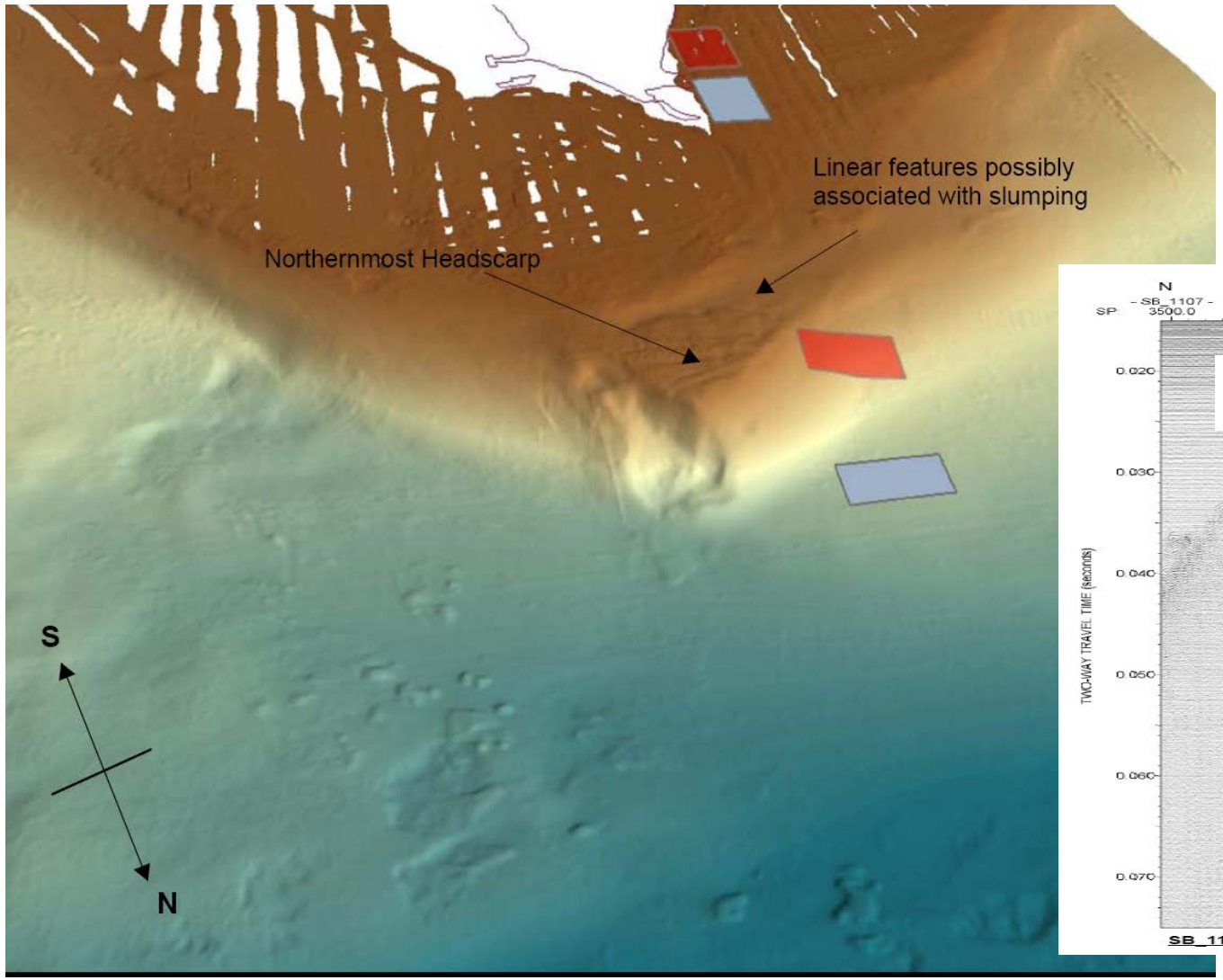
Scales:
H 1cm = 100m
V 1cm = 15m
VE ~ 6.7

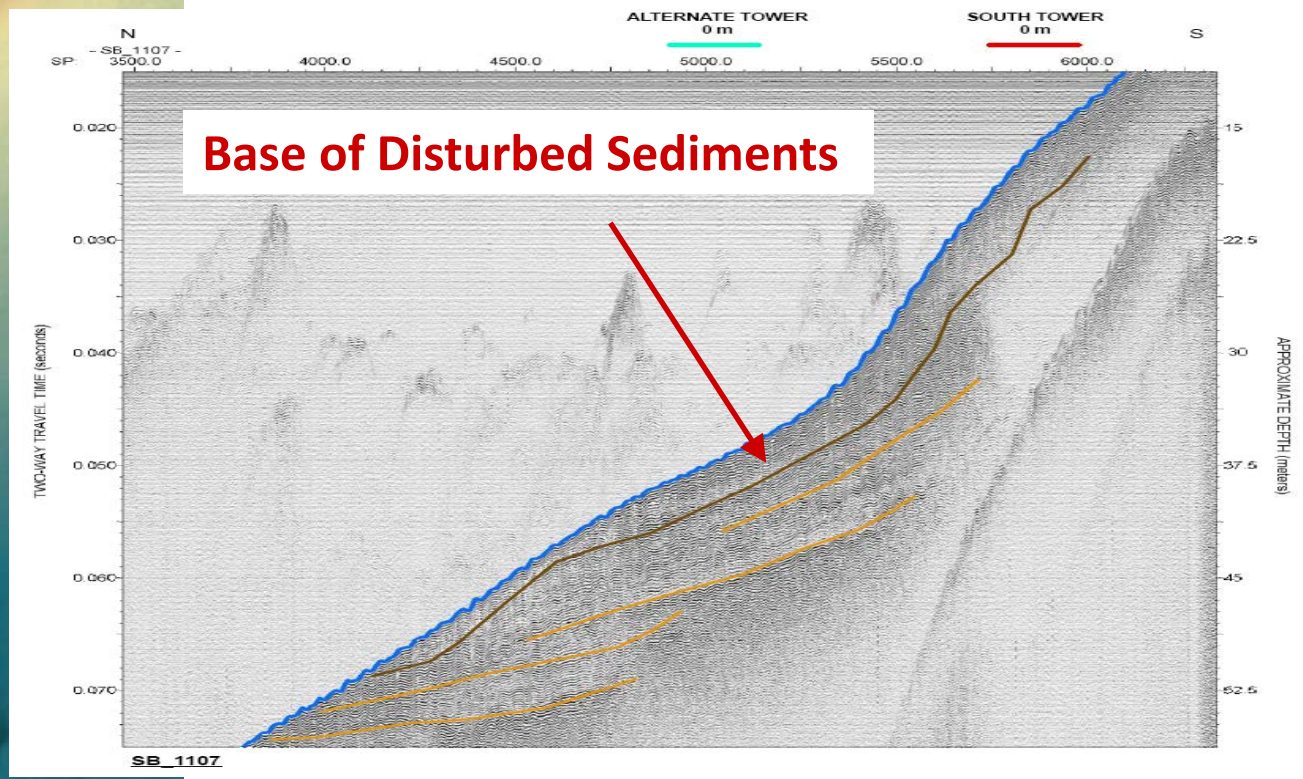
Legend:

Blue = Seafloor
Violet = Base of buried channel
Tan = Seafloor Multiple Reflection
Red = Interpreted faults

DATA EXAMPLE - LINE BM417
Izmit Bay Bridge Crossing
Izmit Bay, Turkey

Geohazard Identification – Slope Instabilities





Mega Offshore Projects in Turkey

- Izmit Bay Bridge – 3000m long suspension bridge spanning the plate boundary between the Anatolian and the Eurasian plates (4 months for SI, Lab testing and SC)
- Marmaray – the deepest immersed tube tunnel in the world: 1600m (3 months for SI, Lab testing and SC)
- Eurasia Tunnel – 5400m twin deck bored motorway tunnel
- Turkstream Project – Nearshore section of the Southstream pipeline in Turkey (2 months)
- 1915 Çanakkale Bridge - the world's longest suspension bridge: main span: 2023 m, total length: 4608 m
- Sinop Nuclear Power Plant – Identification of faults and age dating
- Bosporus 3-Storey Tunnel – Feasibility Study

Conclusions

Use of specialized marine techniques and equipment developed for the offshore industry

Collection of high-quality data

Execution in very short time-frame

High mobilization cost is overcome by schedule savings and data quality improvement

Thank You!
Questions?