

Geospatial data integration for geotechnical site characterisation

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Abstract

Smart data management is essential to comprehend the numerous, intricate datasets associated with offshore developments that cover large extents of potentially variable soil conditions. Integration of foundation zone data using ArcGIS Spatial Analysis culminates in an integrated engineering ground model. This presentation describes our approach to offshore site characterisation via the application of bespoke ArcGIS add-ins developed to enhance data access, integration, analysis and visualisation.

Keywords

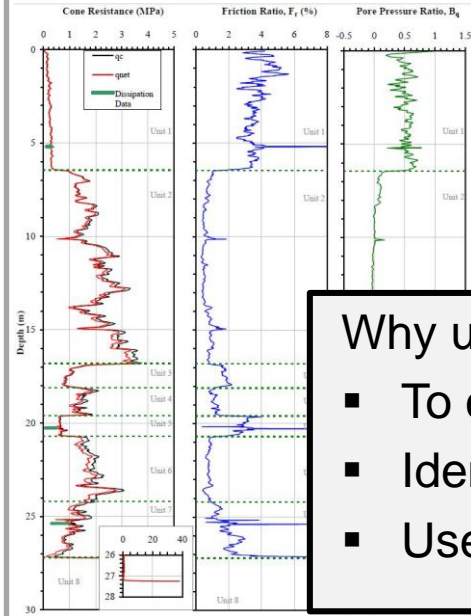
Data integration, Spatial analysis, Site characterisation, Ground model, GIS.

Outline

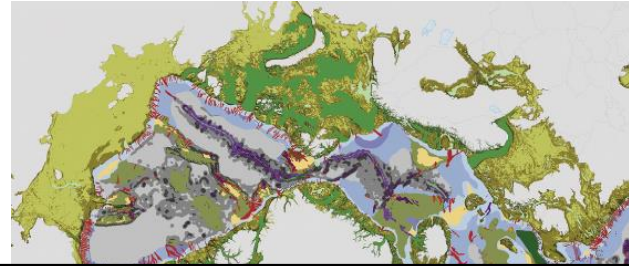
- Available datasets
- Site characterisation
- Case studies
- Geospatial analysis
- Conclusions

Available Datasets

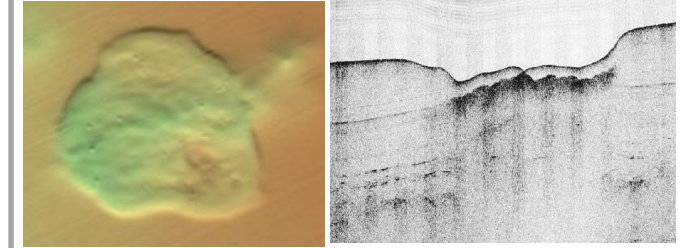
Geotechnical



Geological



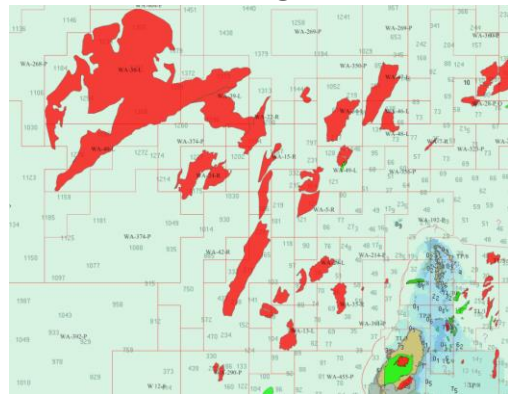
Geophysical



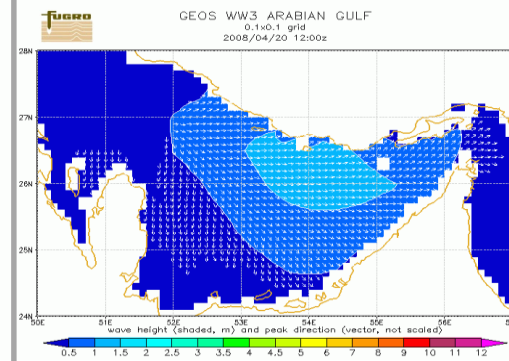
Why use GIS?

- To centralise all project data in single database
- Identify trends and anomalies to characterise the site
- Use GIS as correlation, analysis and manipulation tool

Cultural / Legislative



Metoccean



Environmental

petroleum GIS Conference 2017



- Available datasets
- **Site characterisation**
- Case studies
- Geospatial analysis
- Conclusions

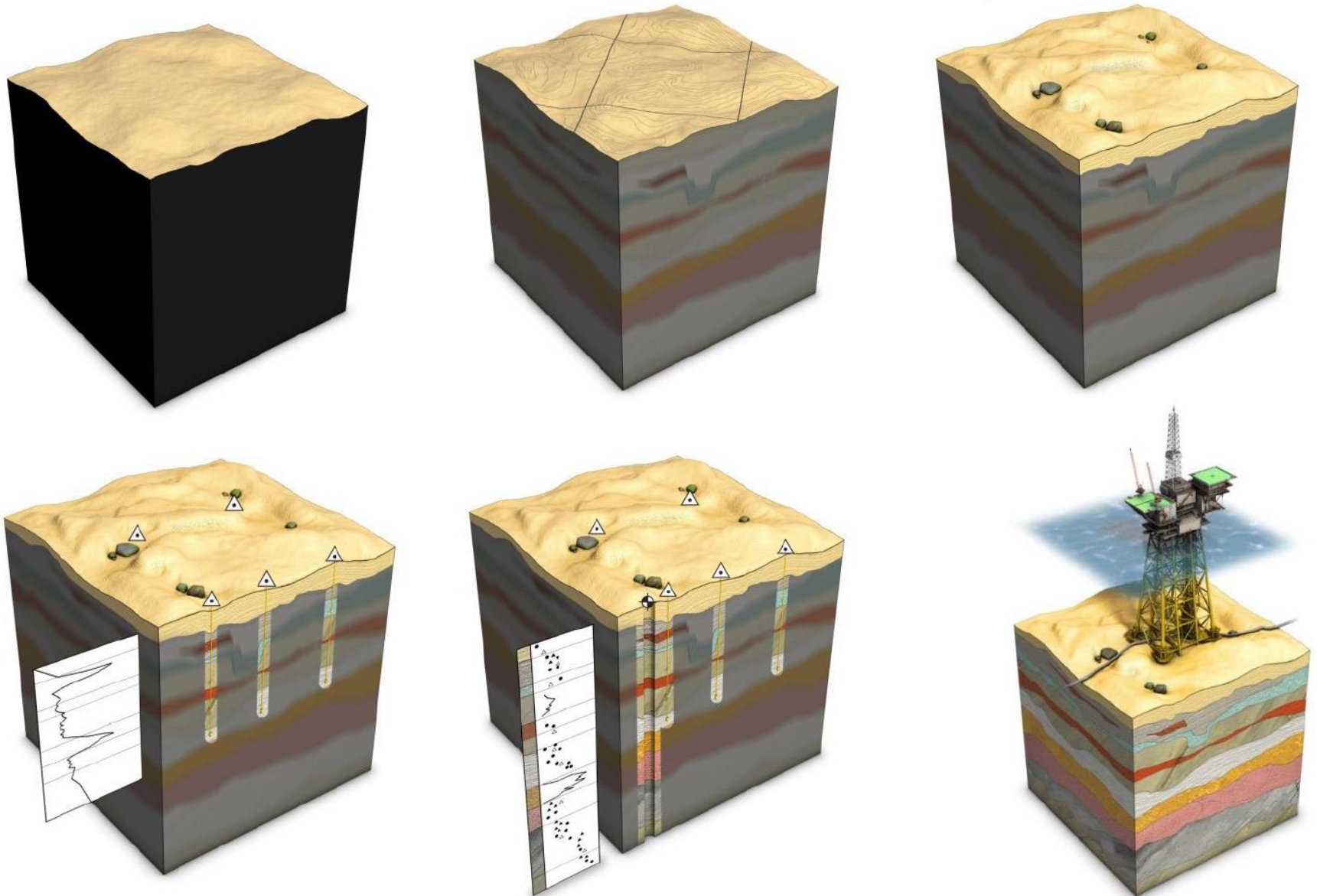
Traditional approach

- Datasets studied in isolation by each discipline
- Data handled in different software for very specific uses
- Can lead to incomplete and potentially conflicting conclusions

Modern (integrated) approach

- Integrate multiple large datasets to provide a predictive, flexible and accessible database of site conditions – Ground model
- Maximise use of site-specific geotechnical investigations, using geophysical surveys to optimise geotechnical acquisition, and making existing data more discoverable
- Identify data gaps, uncertainties and engineering constraints
- Assist with subsea infrastructure positioning and foundation concept selection

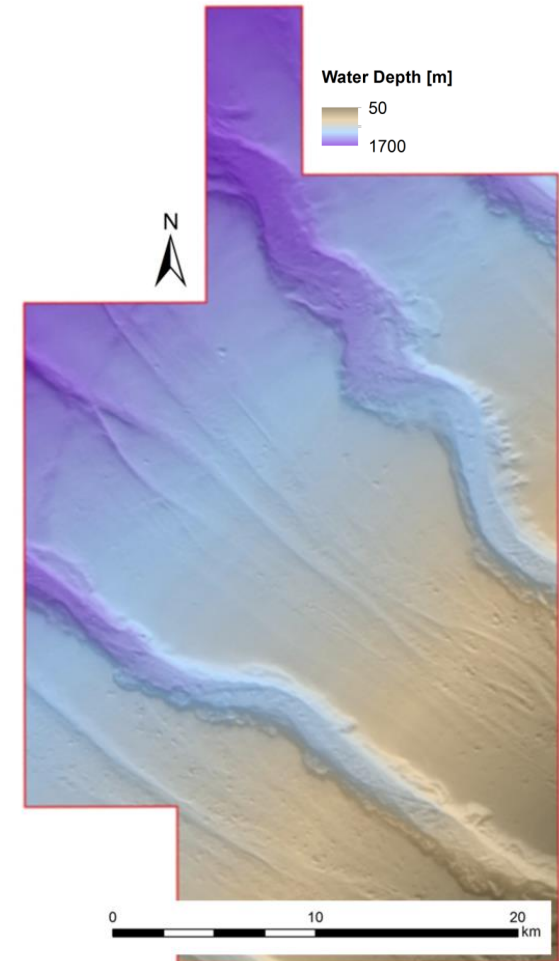
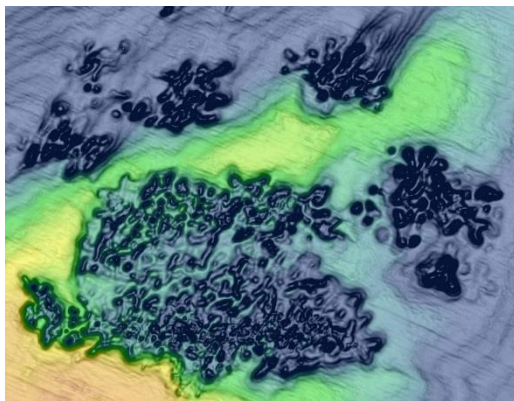
Site Characterisation: Objective



Site Characterisation: Challenges

Features of offshore developments that can present an engineering or data management challenge with respect to site characterisation include:

- Large spatial extent, particularly pipelines
- Greater potential for encountering variable soil conditions
- Numerous foundation locations
- Potential for requiring multiple foundation concepts
- Large and intricate geotechnical and geophysical datasets
- Unique engineering considerations

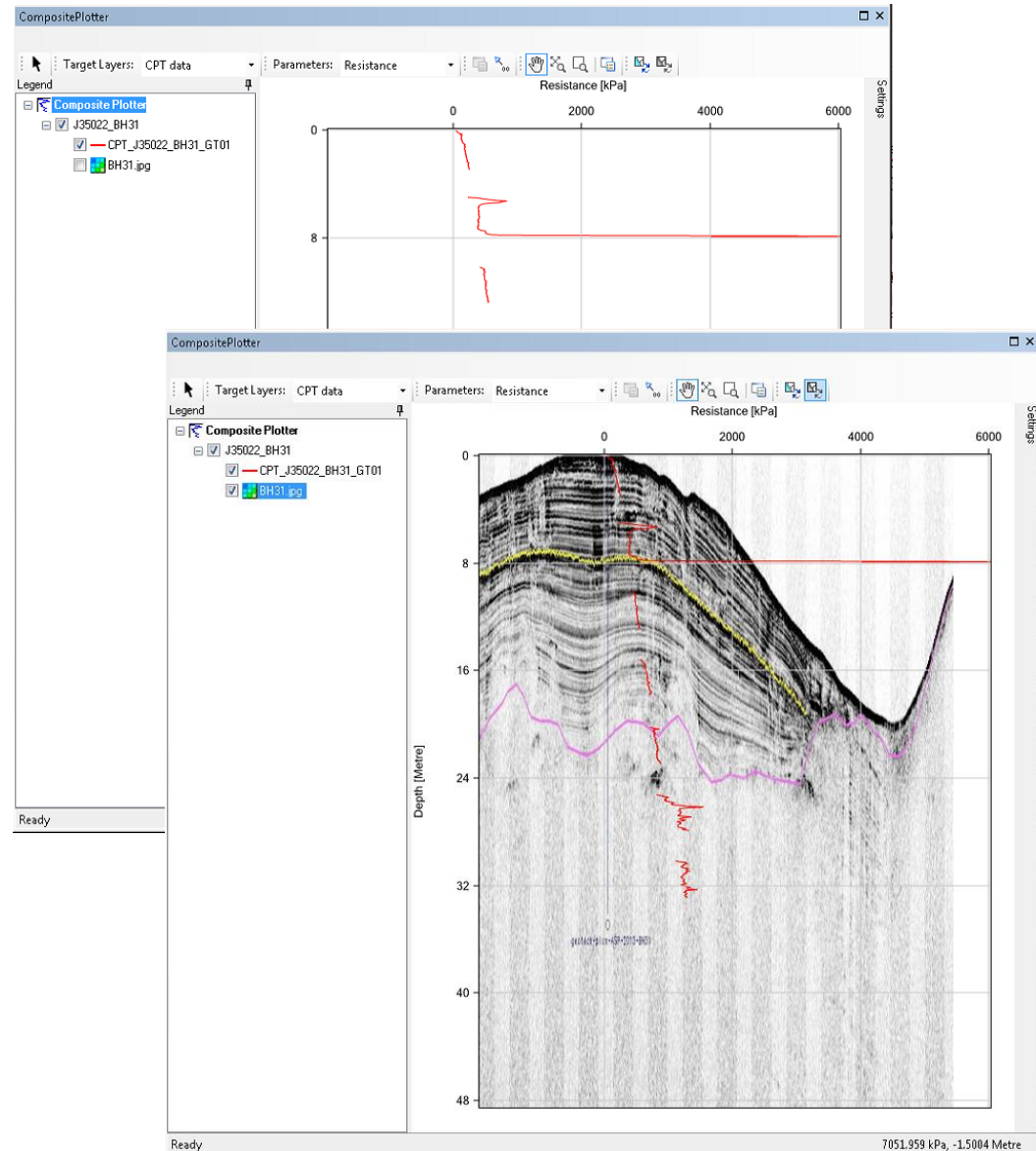


Outline

- Available datasets
- Site characterisation
- **Case studies**
- Geospatial analysis
- Conclusions

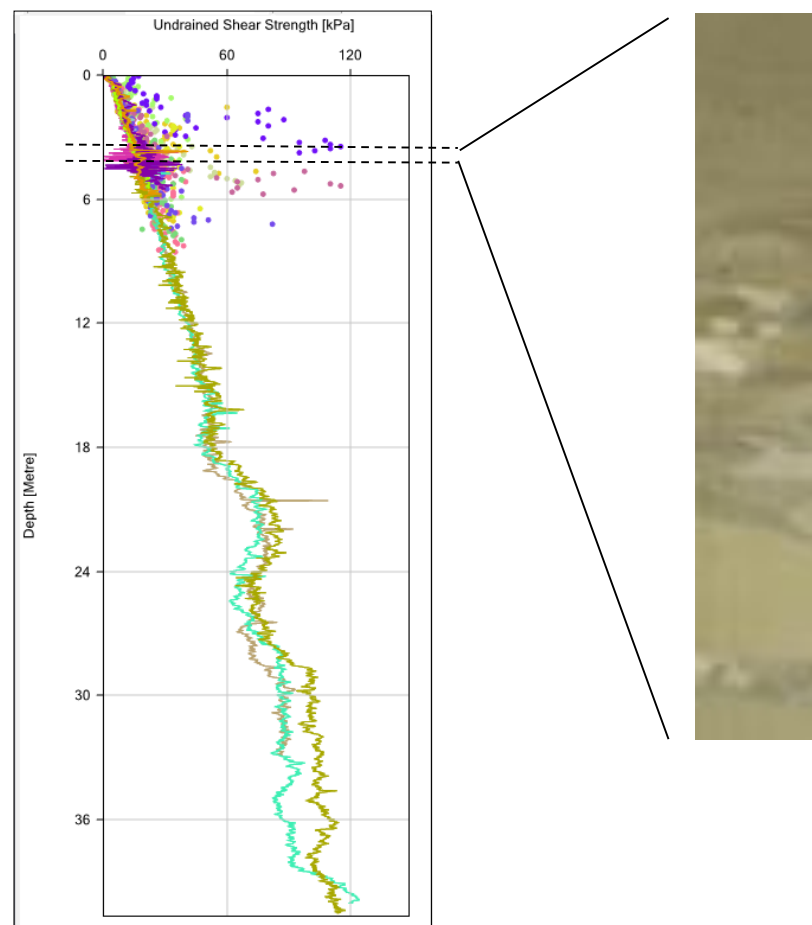
Case Study 1 (geotechnical and geophysical)

- CPT at single location showing large unexplained spike at 8m
- When complimented with continuous sub-bottom-profiler data it is apparent that the geotechnical spike is driven by intersecting a particular geophysical horizon
- Sub-bottom-profiler data rationalises high resistance spike allowing that geotechnical observation to be extrapolated laterally across that geophysical horizon.



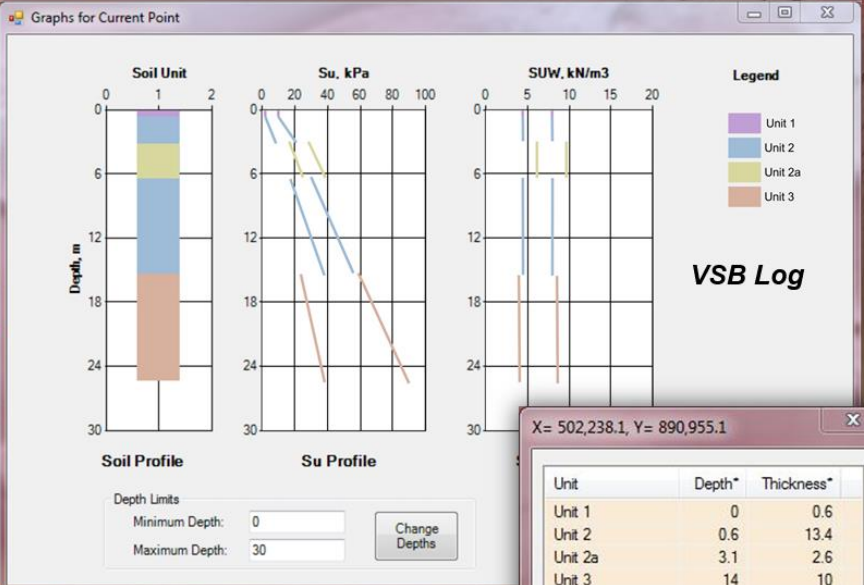
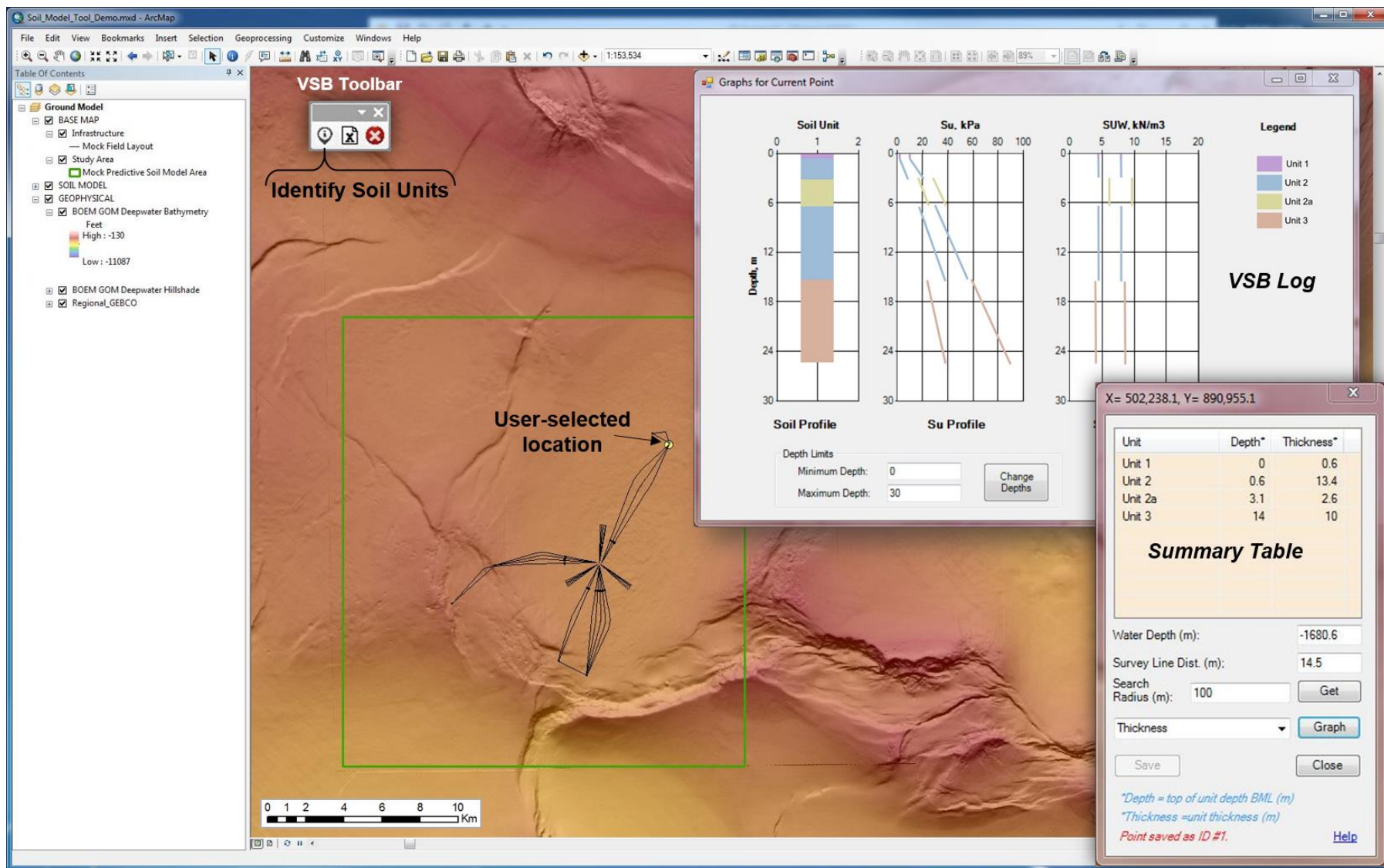
Case Study 2 (geotechnical and geohazard)

- Start with continuous geotechnical data
- Supplement with discrete test data which reinforces trend
- Further integration of geohazard core log data rationalises the high scatter as this depth range is within a debris flow deposit



Caption: Shear strength variation between 2m and 6m attributed to the differing properties of constituent clasts in the debris flow deposit. (Note geohazard core only ~40cm length).

Case Study 3 (Predictive Soil Model)



X= 502,238.1, Y= 890,955.1

Unit	Depth*	Thickness*
Unit 1	0	0.6
Unit 2	0.6	13.4
Unit 2a	3.1	2.6
Unit 3	14	10

Summary Table

Water Depth (m): -1680.6

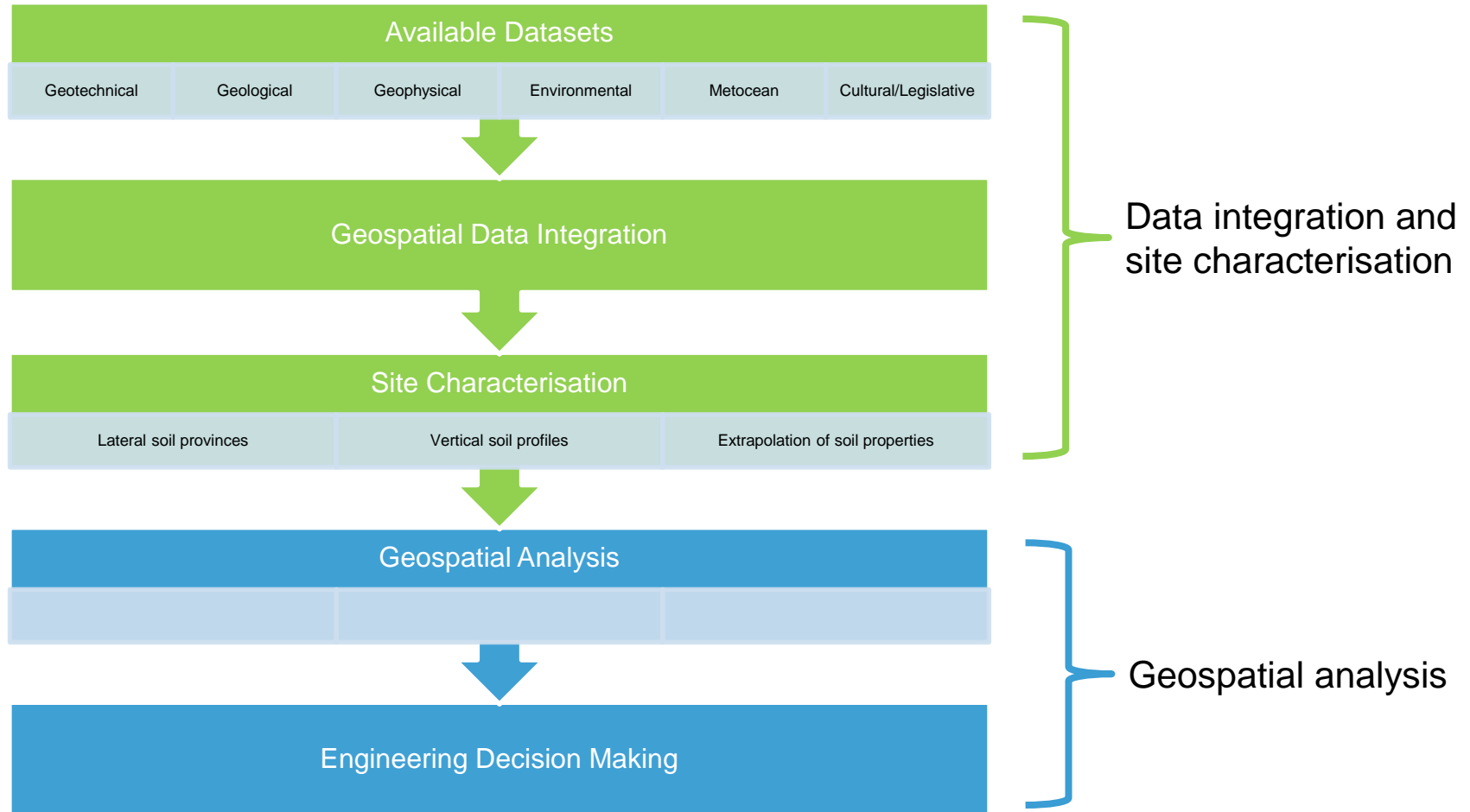
Survey Line Dist. (m): 14.5

Search Radius (m): 100

Thickness

*Depth = top of unit depth BML (m)
 *Thickness = unit thickness (m)
 Point saved as ID #1. [Help](#)

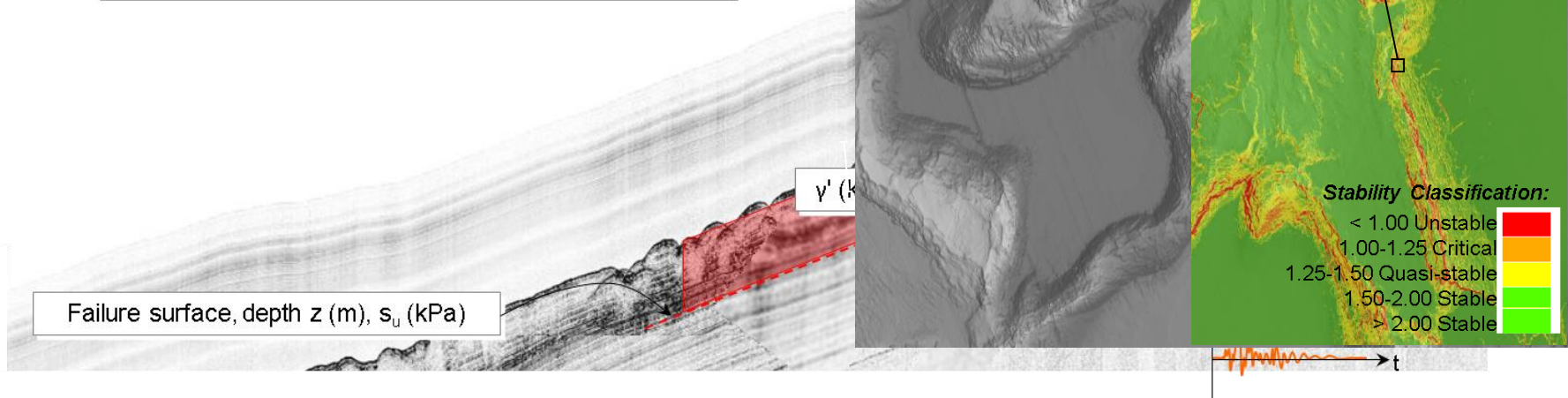
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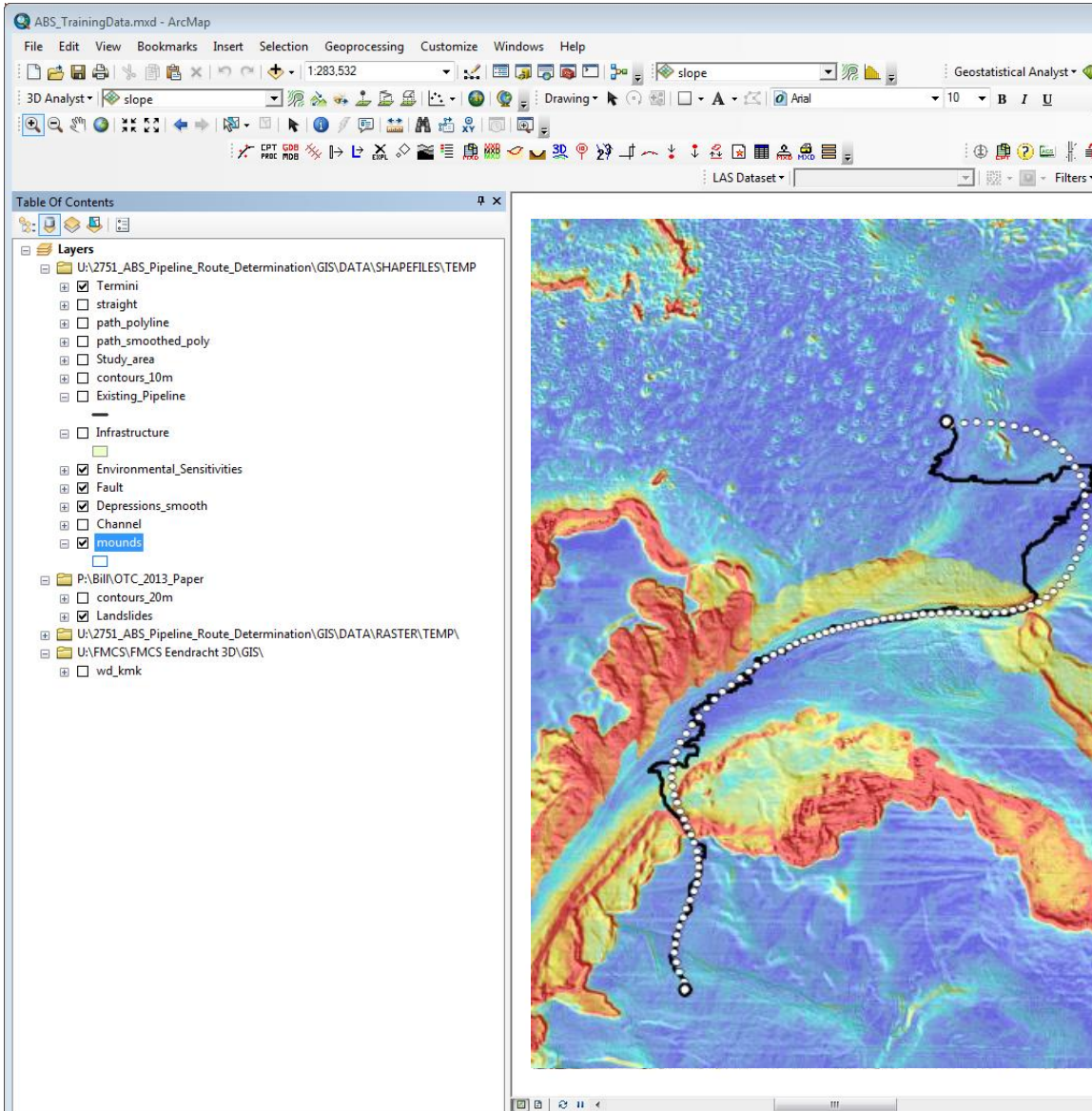
Geospatial Analysis: Slope Stability

- One dimensional slope stability screening performed using GIS to rapidly assess wide areas
- The aim is to quantitatively assess the likelihood of failure of every slope across an entire site

$$FOS = \frac{s_u}{\left(\int_0^z \gamma' dz \right) \sin(\theta) \cos(\theta) + Ck_{seis} \left(\int_0^z (\gamma' + \gamma_w) dz \right) \cos^2(\theta)}$$



Geospatial Analysis: Cable & Pipeline Routing



OTC-26940-MS

A Sensible Approach to Subsea Pipeline Route Determination – Moving from Hand-Drawn Routes to Geologically-Constrained, Least-Cost Optimized Paths

OTC-25785

Stochastic Incorporation of Uncertainty and Subjectivity in Deepwater Pipeline Route Optimization
William C. Haneberg, Fugro GeoConsulting, Inc.

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A Modern Approach to Subsea Pipeline Route Determination

David Rushton, Fugro GeoConsulting, Wallingford, UK
William C. Haneberg¹, Fugro GeoConsulting, Houston, USA
Christine A. Devine, Fugro GeoConsulting, Houston, USA
James Brown, Fugro Advanced Geomechanics, Perth, Australia

Introduction

Selecting a subsea pipeline route, especially in deep or ultra-deep water, is a challenging job in which both primary criteria such as the locations of the pipeline termini must be honoured and secondary criteria such as water depth, seafloor slope and roughness, geohazards, environmental restrictions, and existing infrastructure must be evaluated (Tootill et al, 2004). Some traditional pipeline routing software applications are limited to span-only assessments based on rigid seabeds and give no consideration to the wider context of probabilistic geohazards, sediment mobility, slope stability, pipe-embedment etc. which present a plethora of constraints so often neglected in basic routing exercises. Route selection has historically been undertaken using generalized bathymetric information, simple geometric rules like minimizing gradient along the route, and qualitative evaluation of secondary criteria while trying to minimize route length (Tootill et al, 2004; Campbell & MacDonald, 2006). A route-specific bathymetric survey is then typically performed to confirm conditions along the proposed route, typically using an AUV (autonomous underwater vehicle) if the route is in deep water. With traditional methods selection of the final route, even when best practices, such as initial desktop studies using existing data and acquisition of high quality route-specific data, are followed, is a highly subjective and experience-based procedure that is not easily replicated or amenable to sensitivity analysis. Early stage mistakes in route selection, however, can have

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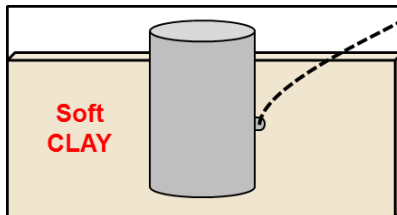
OPT 2016
Rushton et al.

February 24 & 25, 2016
Page 1

Geospatial Analysis: Optimized Infrastructure Sighting

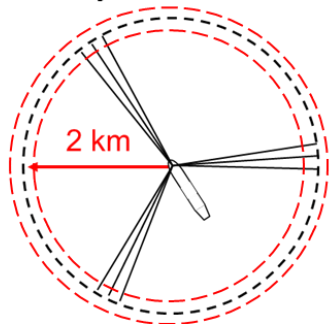
Select optimal FPSO anchor locations

- Variable seafloor
- Holding Capacity

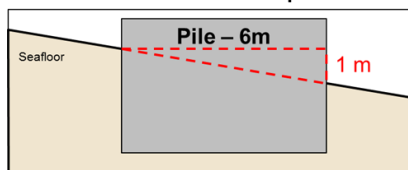


Rapidly evaluate multiple criteria

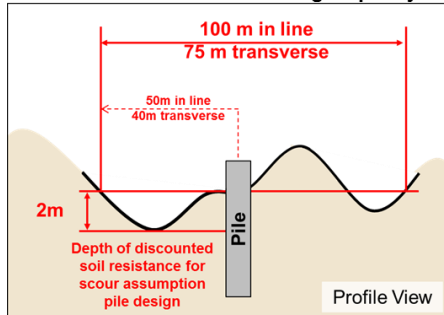
Proximity to nominal location



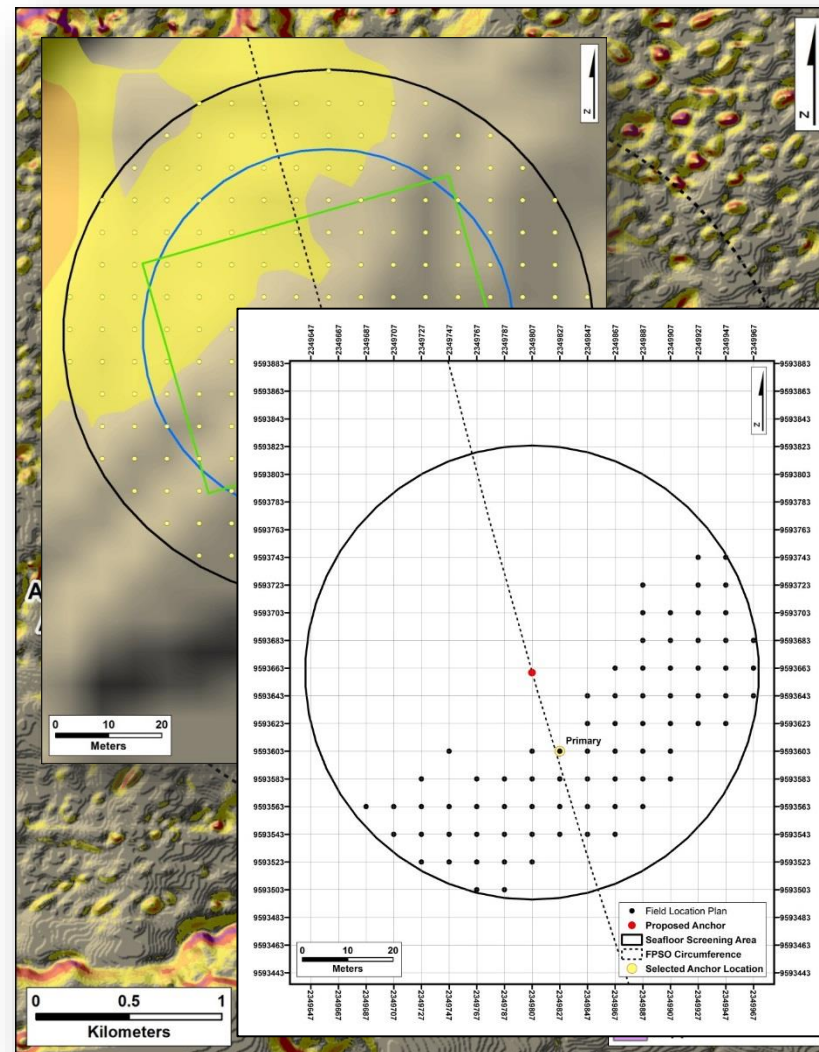
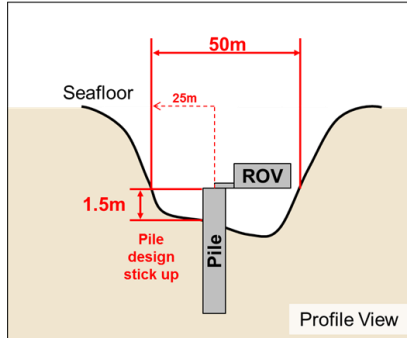
Seafloor slope



Soil Resistance – Holding Capacity



Installation Tolerance



Geospatial Analysis: Site Favourability Mapper

- Consolidating multiple data layers of varying complexity into useful information for decision making support
- Heat mapping to present favourability



Outline

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- Case studies
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- **Conclusions**

- The benefits of robust site characterisation are now well established throughout the industry to help in:
 - Survey and site investigation planning
 - Subsequent engineering analyses and decision making
- Site characterisation reduces uncertainty and minimises risk
- Failure to integrate can lead to inconclusive or conflicting conclusions
- The level of integration required for thorough site characterisation is not possible without a highly functional spatial platform such as ArcGIS with which to perform this data integration.

References and Further Reading

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Thank you