

## FIUME PO

# REGIMAZIONE A CORRENTE LIBERA DELL'ALVEO DI MAGRA DEL PO PER LE NAVI DI CLASSE Va CEMT DA FOCE MINCIO FINO A VALLE DI FERRARA

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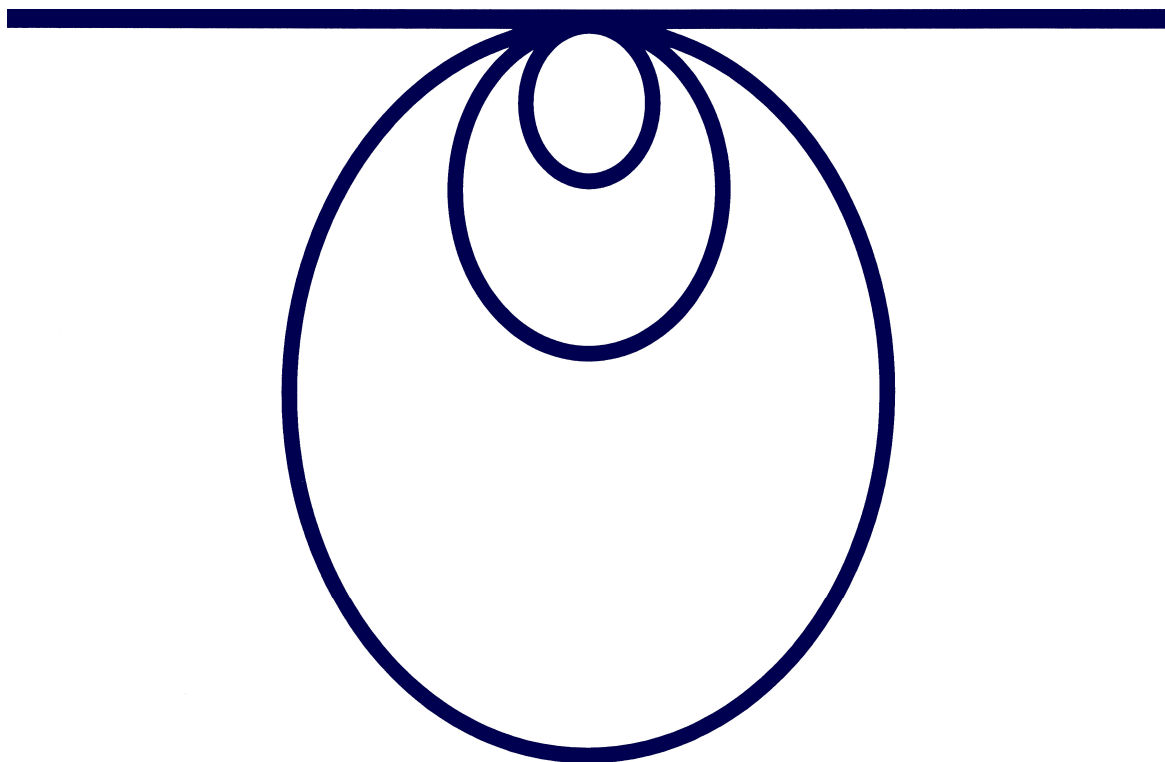




**ADEGUAMENTO DELLE CONDIZIONI DI NAVIGABILITA'  
DELL'ALVEO DI MAGRA DEL FIUME PO  
PER NAVI DI CLASSE V<sup>A</sup>**

**Tratto REVERE-FERRARA**

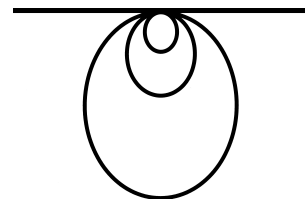
Relazione geologica  
Marzo 2019 – revisione Gennaio 2023





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## ADEGUAMENTO DELLE CONDIZIONI DI NAVIGABILITA' DELL'ALVEO DI MAGRA DEL FIUME PO PER NAVI DI CLASSE V<sup>A</sup>

### Tratto REVERE-FERRARA

Relazione geologica  
Marzo 2019 – revisione Gennaio 2023

GEOLOGIA APPLICATA

GEOFISICA

GEOTECNICA

IDROGEOLOGIA E  
IDROLOGIA

MODELLI MATEMATICI

### Indice

1	PREMESSA.....	2
2	QUADRO AMBIENTALE.....	2
2.1	Geologia di superficie.....	3
2.2	Morfologia.....	3
2.3	Idrogeologia.....	3
2.4	Modellazione geologico-tecnica.....	4
2.5	Pericolosità geologica e categorie vincolistiche. ....	4
2.6	Sismica.....	4
3	SONDAGGI .....	5
4	ARGOMENTI .....	5
5	CRITERI DI PARAMETRIZZAZIONE .....	6
6	CEDIMENTI .....	11
7	POTENZIALE DI LIQUEFAZIONE .....	13
8	STABILITA' .....	15

### Monografie allegate

Castelmassa  
Calto  
Felonica  
Ficarolo  
Gaiba  
Ravalle  
Stienta

## 1 PREMESSA

L'attività sedimentaria del Fiume Po nel tratto compreso tra Revere e Ferrara è limitata al deposito di granulometrie medie e fini.

Le modeste caratteristiche meccaniche di quelle terre facilitano l'erosione lungo l'estradosso dei meandri ed il conseguente sovralluvionamento degli intradossi.

Le escursioni stagionali del livello idrometrico, unitamente alla mobilità del fondo, creano ostacolo alla navigazione fluviale.

Il Progetto in corso si prefigge opportuni indirizzamenti del flusso, tali da regolarizzare il talweg e quindi consentire il transito delle navi di classe V<sup>a</sup> per buona parte dell'anno.

In pratica, si tratta d'installare pennelli repellenti e protezioni spondali nei siti strategici individuati dalla modellazione del Fiume.

Il compito affidatoci riguarda una prima definizione delle caratteristiche geomeccaniche dei terreni di fondo in corrispondenza di quelle posizioni e la disamina dei possibili riflessi sulle opere.

A tal fine, il Committente, in accordo col Progettista, predispose una serie di prove penetrometriche statiche, poi eseguite da Elletipi S.R.L. di Ferrara con l'ausilio di un pontone messo a disposizione da Flumar S.R.L. di Boretto (RE).

Il presente rapporto sintetizza i risultati e le elaborazioni estratte.

## 2 QUADRO AMBIENTALE

Il comparto padano è uno dei più studiati sotto il profilo geologico; sono agli atti diversi lavori specialistici riguardanti sia i volumi d'interesse geotecnico sia quelli profondi attinenti alla sismica ed alla ricerca d'idrocarburi.

Una particolare attenzione fu riservata alle arginature che difendono la Bassa Pianura dalle esondazioni.

A tal proposito si può ricordare il recente *“Progetto strategico per il miglioramento delle condizioni di sicurezza idraulica dei territori lungo l'asta medio inferiore del Fiume Po”* ottenuto dalla sinergia di diversi Enti nazionali e regionali con le Università di Bologna, Ferrara, Firenze, Milano e Siena.

Per quanto riguarda le strutture tettoniche sepolte, il lavoro *“Subsurface geological structure of the Po Plan”* (Pieri & Groppi, – Progetto finalizzato geodinamico CNR, 1981) costituisce il riferimento di base.

In sintesi, la piatta morfologia dei sedimenti continentali nasconde un basamento d'origine marina articolato in anticlinali/sinclinali, sovrascorrimenti e faglie che seguono grossomodo l'allineamento ONO-ESE della Catena appenninica: si tratta delle cosiddette *Pieghe emiliane-romagnole e ferraresi*.

Al loro culmine, esse determinano uno spessore relativamente ridotto del materasso alluvionale, mentre lo incrementano negli avvallamenti, così da creare una sorta di rilievo montuoso sepolto sotto l'ampia fascia pianeggiante che borda a Nord i contrafforti appenninici, dall'Adriatico alla Provincia di Reggio Emilia.

Notoriamente, quell'assetto regionale è un riflesso della collisione dei continenti africano ed europeo nell'incessante deriva di quelle zolle crostali.

La strizione dell'area mediterranea determinò il sollevamento delle Alpi e degli Appennini associando placche distensive, quali l'Avanfossa padano-adriatica.

La dinamica tettonica permane tuttora, come dimostrano i terremoti ricorrenti.

Giacché la materia è argomento d'innomerevoli pubblicazioni scientifiche e divulgative, ad esse si rimanda per i dettagli.

Ai fini del Progetto in corso, sono di maggiore interesse le problematiche ingegneristiche associate ai terreni di tetto.

## **2.1 Geologia di superficie**

Questa si limita alla Formazione delle alluvioni fluviali.

I meandri attuali, prevalentemente sabbiosi, si snodano sull'intreccio degli analoghi paleoalvei sepolti che il corso d'acqua si ritagliò a più riprese nei sedimenti limo-argillosi della Bassa Pianura.

Pertanto, nel substrato della fascia soggetta alle antiche divagazioni del Fiume si ritrova la coalescenza di depositi serpentiformi incoerenti variamente interdigitati a terre coesive.

Considerando tale assetto, si è ritenuto poco produttivo esporre una cartografia geologica priva di distinzioni formazionali.

## **2.2 Morfologia**

Le dinamiche del Fiume modellarono una pianura in lenta crescita per effetto degli apporti terrigeni, contrastando la generale subsidenza del fondo.

Dunque un vasto territorio originariamente aperto alle cicliche piene che poi fu bonificato con la costruzione delle arginature, riservando le aree golenali alle divagazioni del corso d'acqua.

Giacché i rilievi sono di origine antropica, una carta morfologica non aggiungerebbe informazioni alla semplice topografia.

## **2.3 Idrogeologia**

Il Po costituisce il livello di riferimento locale degli acquiferi superficiali, pertanto ne alterna il drenaggio e l'alimentazione.

Alla complessa tessitura del substrato si associano ovviamente permeabilità differenziate, ma non tali da produrre sostanziali variazioni alla soggiacenza media della falda idrica nella piana circostante.

In ogni caso, l'argomento non riguarda le opere da realizzarsi in alveo, pertanto sono da considerare i soli riflessi delle variazioni stagionali ai livelli idrometrici del Fiume.

D'altra parte, s'intende utilizzare materiali da costruzione permeabili, quindi sono da escludere gradienti, anche laddove l'appoggio comprenda orizzonti incoerenti e coesivi.

## **2.4 Modellazione geologico-tecnica**

I lunghi tratti di Fiume interessati dalle opere e gli sviluppi lineari delle medesime presentano un substrato sedimentario inevitabilmente articolato, il cui dettaglio potrebbe risolversi solo mediante un gran numero di sondaggi da effettuarsi in alveo.

Ritenendo da un lato improponibile una campagna geognostica del genere e considerando dall'altro l'utilità che riserverebbe, si sono volutamente evitate le ricostruzioni stratigrafiche di fantasia riferite a verticali alquanto distanziate.

E' sembrato più logico trattare i riflessi di maggior interesse geotecnico, vale a dire: resistenza a taglio degli strati, stabilità e cedimenti dei pennelli, potenziale di liquefazione delle eventuali sabbie di fondo, assumendo a riferimento ciascun sondaggio effettuato, così da consentire una visione statistica delle varie situazioni possibili.

I risultati sono espressi in alcune tabelle che, nel loro complesso, intendono presentare al Progettista modelli sintetici facilmente utilizzabili.

Giacché le prove penetrometriche possono fornire una serie limitata dei parametri d'interesse, quelli esclusi sono tratti dall'esperienza.

## **2.5 Pericolosità geologica e categorie vincolistiche.**

Per le opere in argomento non si prospetta alcuna pericolosità connessa alla Geologia.

La sede in alveo comporta tuttalpiù vincoli di carattere idraulico.

## **2.6 Sismica**

Si assume a riferimento il terremoto distruttivo che nel 2012 provocò anche fenomeni di liquefazione in una fascia della Bassa pianura padana prossima a quella in oggetto, nella considerazione che simili eventi possono prodursi nelle sabbie sciolte presenti in alveo e indurre cedimenti alle opere sovrainposte.

Le misure penetrometriche consentono di valutare quel potenziale.

Ad ogni buon conto, eventualità del genere si risolverebbero in deformazioni prive di un'oggettiva pericolosità.

La categoria stratigrafica C è sembrata la più opportuna per le verifiche normative.

### 3 SONDAGGI

Come detto più sopra, si sono premiate le prove penetrometriche statiche, in particolare quelle eseguite col Piezocono (CPTU), ritenendole sufficienti nell'attuale fase d'indagine.

Il numero elevato degli interventi singolari derivato dalla modellazione fluviale consigliò di procedere per gruppi, limitandosi a saggiare situazioni locali, dunque senza pretendere la risoluzione delle anisotropie stratigrafiche e batimetriche, verosimilmente da attendersi per opere di quello sviluppo lineare in un ambiente dinamico.

Va da sé che i successivi affinamenti richiederanno indagini più circostanziate.

Per il posizionamento del pontone si ricorse a semplici indicazioni GPS.

L'ubicazione dei siti di sondaggio fu programmata con riferimento a foto satellitari; l'attuazione della campagna in concomitanza al basso livello idrometrico richiese alcuni spostamenti per evitare i tiranti d'acqua preclusi al natante e le secche affioranti.

Analoghi spostamenti furono necessari per l'impossibilità di penetrare il pietrame di vecchie protezioni spondali finito sul fondo.

In ogni caso, le prove furono spinte al limite strumentale, dettato non tanto dalla potenzialità dello strumento o dalla resistenza opposta ad esso, quanto dalle variazioni indotte al galleggiamento del pontone, inevitabili quando s'alternano spinte in avanzamento e rilasci delle medesime per aggiungere nuove aste alla batteria di sondaggio.

Ad ogni buon conto, le profondità raggiunte consentono un approccio geotecnico, anche se non risolvono completamente i volumi significativi.

Furono eseguite 20 verticali in 7 sottozone classificate:

<b>Castelmassa</b>	(sondaggi 1A, 2A, 3B, 3C, 3D)
<b>Calto</b>	(sondaggi 4A, 4B)
<b>Felonica</b>	(sondaggi 6A, 7A)
<b>Ficarolo</b>	(sondaggi 8A, 9A))
<b>Gaiba</b>	(sondaggio 10A)
<b>Ravalle</b>	(sondaggi 11A, 12A, 12B)
<b>Stienta</b>	(sondaggi 13A, 14A, 15A, 15B, 15C)

ciascuna oggetto di una monografia posta in allegato.

### 4 ARGOMENTI

Le monografie trattano diversi aspetti, quali:

- l'ubicazione dei sondaggi,
- i diagrammi penetrometrici,

- le elaborazioni stratigrafiche e geomeccaniche ottenute dal software dedicato<sup>1</sup>,
- le interpretazioni relative al potenziale di liquefazione in regime sismico,
- gli outputs relativi al calcolo dei cedimenti,
- le verifiche di stabilità.

Nel seguito si riportano le giustificazioni ai calcoli e le sintesi dei risultati.

## 5 CRITERI DI PARAMETRIZZAZIONE

Considerando le finalità del lavoro, si è ritenuto di verificare il comportamento deformativo e la stabilità di generiche opere lineari per due sezioni tipo, rispettivamente d'altezza 4 e 6 m, con la possibilità di emergere in magra per 2 m.

Conformemente al Progetto preliminare, i paramenti sono inclinati 1/1 da un lato e 2/3 dall'altro; la sommità è larga 3 m, così da determinare forme trapezoidali con basi di 13 e 18 m.

La massa volumica media del pietrame e della sabbia che presumibilmente costituiranno le opere è stimata  $1.6 \text{ Mg/m}^3$  e, ovviamente,  $0.6 \text{ Mg/m}^3$  per la porzione che rimane costantemente immersa.

L'angolo di resistenza a taglio del manufatto generico è posto pari a  $45^\circ$  sulla scorta dell'esperienza d'analoghe opere fluviali, ritenendo che paramenti inclinati altrettanto siano risultati stabili all'atto pratico.

Giacché la pendenza del declivio pari al suo angolo di resistenza a taglio determina l'equilibrio limite, se s'intende conservare le suddette sezioni occorre introdurre una coesione fittizia sufficiente a garantire il fattore di stabilità desiderato.

Tale caratteristica aggiuntiva andrà ricercata in armature, quali le geomembrane o le reti metalliche.

Ovviamente, l'incidenza di tali ausili è via via maggiore quanto più le verifiche agli stati limite salgono la scala delle criticità.

Dunque, sarà la prestazione attesa a condizionare la scelta dei materiali da costruzione, le geometrie progettuali, le modalità realizzative e, in definitiva, il costo delle opere, fattori da prendere in esame nelle sedi opportune.

Segnatamente alle caratteristiche dei terreni d'appoggio, in figura 1 si riporta la serie degli algoritmi utilizzati dal software per generare i diagrammi in allegato.

Per agevolare l'analisi successiva, si apportano semplificazioni ed aggiunte suggerite dall'esperienza; nella fattispecie:

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<sup>1</sup> CpeT-IT, redatto da Geologismiki in collaborazione con Gregg Drilling & Testing Inc. e Peter Robertson.

- la massa volumica efficace delle sabbie è riferita alla resistenza penetrometrica  $q_c$  secondo la relazione empirica:

$$\gamma' = 0.55 + 0.0167 q_c$$

con  $q_c$  in MPa,

- quella delle terre coesive è posta pari a  $1 \text{ Mg/m}^3$ ;
- l'angolo efficace di resistenza a taglio delle sabbie deriva dagli outputs del software, operando linearizzazioni rispettose dei trends;
- ritenendo ottimistiche le stime per i termini coesivi, ad essi si è attribuito  $\phi' = 25^\circ$  con coesione intercetta nulla;
- i rapporti di compressibilità scelti per le terre argillose sono:

CR = 0.20; RR = 0.02; mentre OCR deriva dal software citato;

- ponendo le sabbie nell'ambito della normalconsolidazione, il rapporto di compressione delle medesime è stimato tramite la relazione empirica:

$$CR = 0.012 - 0.0007 q_c$$

con  $q_c$  in MPa.

Quanto al regime sismico, le velocità delle onde di taglio derivano dalle elaborazioni standard del software.

Le medie pesate di  $V_s$ , ottenute limitatamente alle profondità raggiunte dai sondaggi, porrebbero i suoli dell'area nelle categorie stratigrafiche comprese tra C e D di NTC 2018.

Sembra ragionevole considerare la prima, supponendo che il maggior addensamento degli strati sottostanti a quelli indagati abbia l'effetto d'incrementare la media nel pacco canonico di 30 m e quindi di condurre a C i suoli prossimi al limite superiore di D.

Tale escamotage mette in gioco un'unica accelerazione *free field* per ciascuno Stato limite, da scegliersi tra quelle indicate dalla Norma per i vari tempi di ritorno, fissando in 50 anni la Vita utile nella Condizione topografica T1 (pianura) e per la Classe d'uso 1 (presenza solo occasionale di persone).

Tuttavia, limitatamente alla liquefazione delle sabbie, fenomeno che non può verificarsi oltre i  $15 \div 20$  m di profondità, si sono mantenute le categorie stratigrafiche risultanti dalle interpretazioni delle prove penetrometriche nei tratti consentiti all'avanzamento.

Presented below is a list of formulas used for the estimation of various soil properties. The formulas are presented in SI unit system and assume that all components are expressed in the same units.

#### :: Unit Weight, $\gamma$ (kN/m<sup>3</sup>) ::

$$\gamma = \gamma_w \cdot \left( 0.27 \cdot \log(R_f) + 0.36 \cdot \log\left(\frac{q_t}{p_a}\right) + 1.236 \right)$$

where  $\gamma_w$  = water unit weight

#### :: Permeability, $k$ (m/s) ::

$$I_c < 3.27 \text{ and } I_c > 1.00 \text{ then } k = 10^{0.952 - 3.04 I_c}$$

$$I_c \leq 4.00 \text{ and } I_c > 3.27 \text{ then } k = 10^{-4.52 - 1.37 I_c}$$

#### :: $N_{SPT}$ (blows per 30 cm) ::

$$N_{60} = \left( \frac{q_c}{p_a} \right) \cdot \frac{1}{10^{1.1268 - 0.2817 I_c}}$$

$$N_{1(60)} = Q_{tn} \cdot \frac{1}{10^{1.1268 - 0.2817 I_c}}$$

#### :: Young's Modulus, $E_s$ (MPa) ::

$$(q_t - \sigma_v) \cdot 0.015 \cdot 10^{0.55 I_c + 1.68}$$

(applicable only to  $I_c < I_{c\_cutoff}$ )

#### :: Relative Density, $D_r$ (%) ::

$$100 \cdot \sqrt{\frac{Q_{tn}}{k_{DR}}} \quad \text{(applicable only to SBT}_n\text{: 5, 6, 7 and 8 or } I_c < I_{c\_cutoff}\text{)}$$

#### :: State Parameter, $\psi$ ::

$$\psi = 0.56 - 0.33 \cdot \log(Q_{tn,cs})$$

#### :: Peak drained friction angle, $\phi$ (°) ::

$$\phi = 17.60 + 11 \cdot \log(Q_{tn})$$

(applicable only to SBT<sub>n</sub>: 5, 6, 7 and 8)

#### :: 1-D constrained modulus, $M$ (MPa) ::

If  $I_c > 2.20$

$$\alpha = 14 \text{ for } Q_{tn} > 14$$

$$\alpha = Q_{tn} \text{ for } Q_{tn} \leq 14$$

$$M_{CPT} = \alpha \cdot (q_t - \sigma_v)$$

If  $I_c \leq 2.20$

$$M_{CPT} = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 I_c + 1.68}$$

#### :: Small strain shear Modulus, $G_0$ (MPa) ::

$$G_0 = (q_t - \sigma_v) \cdot 0.0188 \cdot 10^{0.55 I_c + 1.68}$$

#### :: Shear Wave Velocity, $V_s$ (m/s) ::

$$V_s = \left( \frac{G_0}{\rho} \right)^{0.50}$$

#### :: Undrained peak shear strength, $S_u$ (kPa) ::

$$N_{kt} = 10.50 + 7 \cdot \log(F_r) \text{ or user defined}$$

$$S_u = \frac{(q_t - \sigma_v)}{N_{kt}}$$

(applicable only to SBT<sub>n</sub>: 1, 2, 3, 4 and 9 or  $I_c > I_{c\_cutoff}$ )

#### :: Remolded undrained shear strength, $S_{u(rem)}$ (kPa) ::

$$S_{u(rem)} = f_s \quad \text{(applicable only to SBT}_n\text{: 1, 2, 3, 4 and 9 or } I_c > I_{c\_cutoff}\text{)}$$

#### :: Overconsolidation Ratio, OCR ::

$$k_{OCR} = \left[ \frac{Q_{tn}^{0.20}}{0.25 \cdot (10.50 + 7 \cdot \log(F_r))} \right]^{1.25} \text{ or user defined}$$

$$OCR = k_{OCR} \cdot Q_{tn}$$

(applicable only to SBT<sub>n</sub>: 1, 2, 3, 4 and 9 or  $I_c > I_{c\_cutoff}$ )

#### :: In situ Stress Ratio, $K_0$ ::

$$K_0 = (1 - \sin \phi') \cdot OCR^{\sin \phi'}$$

(applicable only to SBT<sub>n</sub>: 1, 2, 3, 4 and 9 or  $I_c > I_{c\_cutoff}$ )

#### :: Soil Sensitivity, $S_t$ ::

$$S_t = \frac{N_s}{F_r}$$

(applicable only to SBT<sub>n</sub>: 1, 2, 3, 4 and 9 or  $I_c > I_{c\_cutoff}$ )

#### :: Effective Stress Friction Angle, $\phi'$ (°) ::

$$\phi' = 29.5^\circ \cdot B_q^{0.121} \cdot (0.256 + 0.336 \cdot B_q + \log Q_t)$$

(applicable for  $0.10 < B_q < 1.00$ )

#### References


- Robertson, P.K., Cabal K.L., Guide to Cone Penetration Testing for Geotechnical Engineering, Gregg Drilling & Testing, Inc., 5<sup>th</sup> Edition, November 2012
- Robertson, P.K., Interpretation of Cone Penetration Tests - a unified approach., Can. Geotech. J. 46(11): 1337-1355 (2009)

*figura. 1*

Le tabelle che seguono compendiano il quadro geotecnico di riferimento per ciascuna verticale di sondaggio.


	Castelmassa					Calto		Felonica		Ficarolo		Gaiba	Ravalle			Stienta				
Numero CPTU	1A	2A	3B	3C	3D	4A	4B	6A	7A	8A	9A	10A	11A	12A	12B	13A	14A	15A	15B	15C
Battente acqua	2.20	2.62	2.40	2.90	2.30	2.30	2.78	3.00	2.50	2.50	2.30	2.50	4.06	2.20	2.20	3.10	4.50	2.20	2.00	2.00
Profondità indagata	15.60	15.58	15.10	15.74	15.20	20.20	15.86	15.86	16.00	16.00	15.50	15.40	14.98	15.80	15.80	14.90	12.52	13.80	15.54	16.72

	Castelmassa					Calto		Felonica		Ficarolo		Gaiba	Ravalle			Stienta				
Numero CPTU	1A	2A	3B	3C	3D	4A	4B	6A	7A	8A	9A	10A	11A	12A	12B	13A	14A	15A	15B	15C
Strato di 1 m	$\gamma$ (kN/m <sup>3</sup> )																			
I	15	20	20	20	20	15	15	15	15	15	14	15	20	15	14	15	15	15	15	14
II	16	16	15	15	15	15	16	20	16	16	15	16	20	16	14	16	16	20	15	16
III	17	16	16	16	16	16	17	17	16	16	15	16	20	16	16	17	17	20	17	16
IV	17	17	16	17	16	16	17	17	17	17	15	17	20	17	16	17	17	17	17	16
V	17	17	16	17	17	17	17	17	17	17	15	17	20	17	16	17	17	17	20	20
VI	17	17	17	17	17	17	17	17	17	17	20	17	20	17	17	18	17	17	20	20
VII	18	17	18	18	17	17	17	18	18	18	20	18	20	18	17	17	17	18	20	20
VIII	18	17	18	18	18	17	18	18	18	18	20	18	18	17	17	20	20	20	20	20
IX	18	17	18	20	18	20	20	20	18	18	20	18	18	17	17	19	18	20	20	20
X	18	17	20	20	20	20	20	20	18	18	20	19	19	18	17	18	18	20	20	20
XI	18	17	20	20	20	20	20	20	18	18	20	18	19	18	17	18	18	20	20	20
XII	20	17	20	20	20	20	17	20	20	20	19	20	18	18	17	18	18	20	20	17
XIII	20	18	18	18	18	18	18	20	20	20	19	20	20	17	20	18	19	20	19	18
XIV	18	18	19	18	19	19	18	20	20	20	19	18	18	20	18	19		18	20	18
XV	18	18	19	20	19	18	18	20	20	20	19	19	18	19	19	19			19	19
XVI	18	18	19	19	19	18	19	19	19	19	18	19		19	19				19	18
XVII						20														18
XVIII						20														
XIX						20														
XX						19														
XXI						19														

 terre coesive


 terre incoerenti

	Castelmassa					Calto		Felonica		Ficarolo		Gaiba	Ravalle			Stienta				
Numero CPTU	1A	2A	3B	3C	3D	4A	4B	6A	7A	8A	9A	10A	11A	12A	12B	13A	14A	15A	15B	15C
Strato di 1 m	$\phi'$ (°) per $c' = 0$																			
I	36	25	25	25	25	35	35	35	34	35	33	34	25	32	31	34	34	33	33	34
II	38	38	38	37	36	35	36	25	36	37	36	36	25	34	32	36	36	25	35	36
III	39	38	38	38	38	38	37	38	37	36	36	37	25	36	35	37	37	25	38	36
IV	37	38	37	39	37	37	38	39	38	37	35	38	25	35	35	36	34	37	38	35
V	37	38	36	38	37	38	39	38	38	38	35	38	25	35	37	38	36	34	25	25
VI	39	37	38	38	39	39	38	37	38	39	25	39	25	37	37	39	36	37	25	25
VII	39	38	40	37	39	38	37	36	39	40	25	39	25	38	37	38	35	39	25	25
VIII	39	39	42	38	40	37	38	39	39	40	25	39	38	34	35	25	25	25	25	25
IX	40	37	41	25	38	25	25	25	39	41	25	40	39	35	37	41	38	25	25	25
X	41	38	25	25	25	25	25	25	38	41	25	41	42	38	37	40	37	25	25	25
XI	41	35	25	25	25	25	25	25	38	41	25	40	40	38	35	39	37	25	25	25
XII	25	36	25	25	25	25	33	25	25	25	42	25	39	37	35	36	39	25	25	36
XIII	25	39	40	36	39	33	39	25	25	25	41	25	25	31	25	38	41	25	40	39
XIV	33	38	41	34	42	42	37	25	25	25	42	38	33	25	38	40		36	25	39
XV	36	38	41	25	40	39	35	25	25	25	40	40	36	41	41	39			41	39
XVI	37	39	41	38	39	32	37	39	39	40	37	40		41	42				41	36
XVII						25														36
XVIII						25														
XIX						25														
XX						39														
XXI						39														

 terre coesive


 terre incoerenti


	Castelmassa					Calto		Felonica		Ficarolo		Gaiba	Ravalle				Stienta				
Numero CPTU	1A	2A	3B	3C	3D	4A	4B	6A	7A	8A	9A	10A	11A	12A	12B	13A	14A	15A	15B	15C	
Strato di 1 m	CR																				
I	0.010	0.010	0.200	0.200	0.200	0.200	0.011	0.011	0.011	0.011	0.011	0.011	0.200	0.011	0.011	0.011	0.011	0.200	0.011	0.011	
II	0.010	0.010	0.011	0.010	0.011	0.011	0.010	0.010	0.010	0.010	0.011	0.011	0.200	0.011	0.011	0.010	0.010	0.200	0.011	0.011	
III	0.010	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.009	0.009	0.011	0.010	0.200	0.011	0.011	0.010	0.010	0.200	0.010	0.011	
IV	0.010	0.009	0.010	0.010	0.009	0.009	0.009	0.009	0.009	0.009	0.011	0.010	0.200	0.011	0.011	0.009	0.010	0.200	0.009	0.011	
V	0.009	0.009	0.009	0.009	0.009	0.009	0.008	0.009	0.009	0.008	0.011	0.009	0.200	0.011	0.011	0.009	0.010	0.200	0.009	0.011	
VI	0.008	0.009	0.009	0.009	0.008	0.008	0.008	0.008	0.007	0.007	0.200	0.009	0.200	0.010	0.010	0.008	0.010	0.200	0.200	0.011	
VII	0.007	0.009	0.008	0.008	0.007	0.008	0.007	0.007	0.007	0.006	0.200	0.008	0.200	0.010	0.010	0.007	0.009	0.005	0.200	0.200	
VIII	0.006	0.008	0.006	0.007	0.007	0.009	0.007	0.005	0.004	0.004	0.200	0.007	0.007	0.010	0.010	0.200	0.200	0.200	0.200	0.200	
IX	0.005	0.008	0.004	0.200	0.007	0.009	0.200	0.200	0.009	0.004	0.200	0.006	0.007	0.009	0.009	0.003	0.007	0.200	0.200	0.200	
X	0.004	0.008	0.200	0.200	0.010	0.200	0.200	0.200	0.009	0.004	0.200	0.004	0.002	0.008	0.009	0.004	0.007	0.200	0.200	0.200	
XI	0.003	0.009	0.200	0.200	0.200	0.200	0.200	0.200	0.009	0.004	0.200	0.004	0.004	0.007	0.010	0.006	0.007	0.200	0.200	0.200	
XII	0.200	0.009	0.200	0.200	0.010	0.200	0.009	0.200	0.200	0.200	0.003	0.004	0.006	0.007	0.010	0.007	0.007	0.200	0.200	0.200	
XIII	0.200	0.008	0.006	0.009	0.009	0.200	0.006	0.200	0.200	0.200	0.002	0.200	0.008	0.200	0.010	0.006	0.003	0.200	0.005	0.006	
XIV	0.009	0.007	0.005	0.009	0.001	0.002	0.008	0.200	0.200	0.200	0.000	0.200	0.010	0.008	0.006	0.004		0.200	0.007	0.006	
XV	0.008	0.005	0.003	0.200	0.003	0.005	0.009	0.200	0.200	0.006	0.000	0.003	0.009	0.004	0.003	0.004			0.002	0.005	
XVI				0.006	0.005	0.006	0.006	0.004	0.004	0.002	0.007	0.003		0.000	0.000				0.002	0.007	
XVII						0.010														0.007	
XVIII						0.200															
XIX						0.200															
XX						0.200															
XXI						0.004															

 terre coesive

 terre incoerenti

	Castelmassa					Calto		Felonica		Ficarolo		Gaiba	Ravalle			Stienta				
Numero CPTU	1A	2A	3B	3C	3D	4A	4B	6A	7A	8A	9A	10A	11A	12A	12B	13A	14A	15A	15B	15C
Strato di 1 m	RR																			
I	0.010	0.010	0.020	0.020	0.020	0.020	0.011	0.011	0.011	0.011	0.011	0.011	0.020	0.011	0.011	0.011	0.011	0.020	0.011	0.011
II	0.010	0.010	0.011	0.010	0.011	0.011	0.010	0.010	0.010	0.010	0.011	0.011	0.020	0.011	0.011	0.010	0.010	0.020	0.011	0.011
III	0.010	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.009	0.009	0.011	0.010	0.020	0.011	0.011	0.010	0.010	0.020	0.010	0.011
IV	0.010	0.009	0.010	0.010	0.009	0.009	0.009	0.009	0.009	0.009	0.011	0.010	0.020	0.011	0.011	0.009	0.010	0.020	0.009	0.011
V	0.009	0.009	0.009	0.009	0.009	0.009	0.008	0.009	0.009	0.008	0.011	0.009	0.020	0.011	0.011	0.009	0.010	0.020	0.009	0.011
VI	0.008	0.009	0.009	0.009	0.008	0.008	0.008	0.008	0.007	0.007	0.020	0.009	0.020	0.010	0.010	0.008	0.010	0.020	0.020	0.011
VII	0.007	0.009	0.008	0.008	0.007	0.008	0.007	0.007	0.007	0.006	0.020	0.008	0.020	0.010	0.010	0.007	0.009	0.005	0.020	0.020
VIII	0.006	0.008	0.006	0.007	0.007	0.009	0.007	0.005	0.004	0.004	0.020	0.007	0.007	0.010	0.010	0.020	0.020	0.020	0.020	0.020
IX	0.005	0.008	0.004	0.020	0.007	0.009	0.020	0.020	0.009	0.004	0.020	0.006	0.007	0.009	0.009	0.003	0.007	0.020	0.020	0.020
X	0.004	0.008	0.020	0.020	0.010	0.020	0.020	0.020	0.009	0.004	0.020	0.004	0.002	0.008	0.009	0.004	0.007	0.020	0.020	0.020
XI	0.003	0.009	0.020	0.020	0.020	0.020	0.020	0.020	0.009	0.004	0.020	0.004	0.004	0.007	0.010	0.006	0.007	0.020	0.020	0.020
XII	0.020	0.009	0.020	0.020	0.010	0.020	0.009	0.020	0.020	0.020	0.003	0.004	0.006	0.007	0.010	0.007	0.007	0.020	0.020	0.020
XIII	0.020	0.008	0.006	0.009	0.009	0.020	0.006	0.020	0.020	0.020	0.002	0.020	0.008	0.020	0.010	0.006	0.003	0.020	0.005	0.006
XIV	0.009	0.007	0.005	0.009	0.001	0.002	0.008	0.020	0.020	0.020	0.000	0.020	0.010	0.008	0.006	0.004		0.020	0.007	0.006
XV	0.008	0.005	0.003	0.020	0.003	0.005	0.009	0.020	0.020	0.006	0.000	0.003	0.009	0.004	0.003	0.004			0.002	0.005
XVI				0.006	0.005	0.006	0.006	0.004	0.004	0.002	0.007	0.003		0.000	0.000				0.002	0.007
XVII						0.010														0.007
XVIII						0.020														
XIX						0.020														
XX						0.020														
XXI						0.004														

 terre coesive

 terre incoerenti

	Castelmassa					Calto		Felonica		Ficarolo		Gaiba	Ravalle			Stienta				
Numero CPTU	1A	2A	3B	3C	3D	4A	4B	6A	7A	8A	9A	10A	11A	12A	12B	13A	14A	15A	15B	15C
Strato di 1 m	OCR																			
I	1	1	1	4	1	1	1	1	1	1	1	1	5	1	1	1	1	4	1	1
II	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	5	1	1
III	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	6	1	1
IV	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	7	1	1
V	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	8	1	1
VI	1	1	1	1	1	1	1	1	1	1	1	5	1	5	1	1	1	8	6	1
VII	1	1	1	1	1	1	1	1	1	1	1	4	1	5	1	1	1	1	7	5
VIII	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	1	5	5	4	5
IX	1	1	1	4	1	1	4	4	1	1	1	4	1	1	1	1	1	4	5	5
X	1	1	1	4	1	4	4	4	1	1	1	4	1	1	1	1	1	4	5	5
XI	1	1	1	5	3	4	4	4	1	1	1	4	1	1	1	1	1	4	5	4
XII	3	1	1	4	1	5	1	3	4	4	1	1	1	1	1	1	1	3	4	6
XIII	5	1	1	1	1	5	1	3	4	4	1	3	1	5	1	1	1	2	1	1
XIV	1	1	1	1	1	1	1	3	4	4	1	6	1	1	1	1	1	3	1	1
XV	1	1	1	6	1	1	1	3	4	1	1	1	1	1	1	1			1	1
XVI				1	1	1	1	1	1	1	1	1		1	1				1	1
XVII						1														1
XVIII						4														
XIX						4														
XX						3														
XXI						1														

terre coesive
 terre incoerenti

## 6 CEDIMENTI

Entrambe le sezioni in argomento riguardano rilevati lunghi 100 m.

Il calcolo è relativo ad alcuni punti disposti ortogonalmente a tale sviluppo presso la sua mezzeria, in modo da cogliere le differenze da attendersi in opere di lunghezza indefinita ed a rigidezza nulla.

La relazione applicata ad ogni strato di spessore  $h = 1$  m è la seguente:

$$\Delta h = h \cdot (RR \cdot \log(\sigma'_p / \sigma'_{v0}) + CR \cdot \log((\sigma'_{v0} + \Delta\sigma_z) / \sigma'_p))$$

con  $RR$  = rapporto di ricompressione,  $CR$  = rapporto di compressione,  $\sigma'_p$  = pressione di pre-consolidazione,  $\Delta\sigma_z$  = sovra-pressione indotta alla profondità  $Z$ , dove agisce la tensione litostatica efficace  $\sigma'_{v0}$ .

$\Delta\sigma_z$  è calcolata in accordo col modello elastico di Boussinesq tramite l'equazione (Steinbrenner, 1934) relativa al corpo di carico rettangolare flessibile di lunghezza  $L$  e larghezza  $B$ , uniformemente caricato  $\sigma$ ; nella fattispecie:

$$\Delta\sigma_z = \sigma/2\pi \cdot (\arctg(L \cdot B/Z / (L^2 + B^2 + Z^2))^{1/2} + (1/(L^2 + Z^2) + 1/(B^2 + Z^2)) \cdot L \cdot B \cdot Z \cdot (L^2 + B^2 + Z^2)^{1/2})$$

Questa fornisce il parametro alla profondità generica  $Z$  sotto lo spigolo.

Per ottenere le sovra-tensioni lungo la proiezione di punti diversi, interni o esterni alla pianta, si ricorre alla soluzione di *Ohde*, 1939, intesa a sovrapporre gli effetti di 4 riquadri con vertice comune ed algebricamente equivalenti all'elemento in considerazione.

Quanto alle  $\sigma$  variabili proprie di corpi a sezione trapezia, si opera una discretizzazione della medesima in prismi rettangolari, come mostra la figura 2; essa riporta anche le verticali prescelte per il calcolo dei cedimenti.

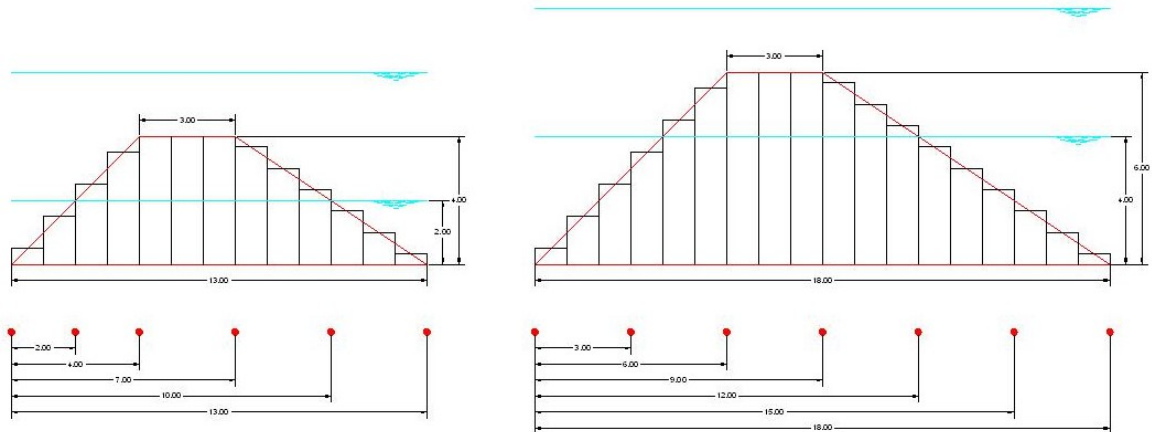


figura 2

Per entrambe e per ciascuna profondità vige la sommatoria delle diverse  $\Delta\sigma_z$ , prodotte da tutti i corpi di carico considerati.

Le tabelle seguenti compendiano i risultati; gli outputs per esteso sono nelle monografie allegate.

Come si vede, il massimo cedimento assoluto è intorno a 10 cm, valore che può ritenersi ammissibile per opere del genere.

Trattandosi di manufatti flessibili, le deformazioni differenziali tra l'asse e la periferia delle sezioni non appaiono critiche.

### Dati riassuntivi dei cedimenti espressi in cm

		SEZIONE PENNELLO 6m																				
		Castelmassa					Calto		Felonica		Ficarolo		Gaiba		Ravalle			Stienta				
VERTECALE		NUMERO CPTU																				
N.	Y (m)	1A	2A	3B	3C	3D	4A	4B	6A	7A	8A	9A	10A	11A	12A	12B	13A	14A	15A	15B	15C	
1	0	1.1	1.1	4.8	1.4	1.0	1.5	1.3	1.6	1.3	1.1	1.6	1.2	1.1	1.4	1.3	1.0	1.1	1.4	1.6	1.7	
2	3	2.4	2.4	7.7	2.7	2.2	2.9	2.7	3.0	2.6	2.3	3.3	2.5	2.9	2.9	2.9	2.3	2.5	3.3	3.3	3.5	
3	6	3.5	3.5	10.0	3.9	3.3	4.1	3.9	4.3	3.8	3.3	4.9	3.7	4.6	4.2	4.2	3.4	3.7	5.2	4.8	5.0	
4	9	3.6	3.6	10.3	4.0	3.4	4.2	4.0	4.4	3.8	3.4	5.0	3.7	4.7	4.3	4.3	3.5	3.8	5.3	4.9	5.1	
5	12	2.8	2.8	8.6	3.2	2.6	3.3	3.1	3.5	3.0	2.7	3.9	2.9	3.5	3.4	3.3	2.7	2.9	4.0	3.9	4.1	
6	15	1.8	1.8	6.2	2.1	1.7	2.2	2.1	2.3	2.0	1.8	2.5	1.9	2.1	2.2	2.2	1.7	1.9	2.4	2.5	2.7	
7	18	0.8	0.8	3.7	1.1	0.8	1.2	1.0	1.2	1.0	0.8	1.1	0.9	0.8	1.0	1.0	0.7	0.8	1.0	1.2	1.3	

		SEZIONE PENNELLO 4m																					
		Castelmassa					Calto		Felonica		Ficarolo		Gaiba		Ravalle			Stienta					
VERTECALE		NUMERO CPTU																					
N.	Y (m)	1A	2A	3B	3C	3D	4A	4B	6A	7A	8A	9A	10A	11A	12A	12B	13A	14A	15A	15B	15C		
1	0	1.1	1.1	4.1	1.3	1.0	1.4	1.3	1.4	1.2	1.0	1.5	1.1	1.1	1.3	1.3	1.0	1.1	1.4	1.6	1.7		
2	2	2.0	2.0	5.8	2.2	1.8	2.3	2.2	2.4	2.1	1.9	2.7	2.1	2.4	2.4	2.4	1.9	2.1	2.7	2.7	2.8		
3	4	2.7	2.7	7.1	2.9	2.5	3.0	3.0	3.2	2.9	2.6	3.7	2.9	3.6	3.3	3.3	2.7	2.9	3.9	3.7	3.8		
4	7	2.8	2.8	7.3	3.0	2.6	3.1	3.1	3.4	3.0	2.7	3.9	3.0	3.7	3.4	3.4	2.8	3.0	4.1	3.8	4.0		
5	10	1.9	1.9	5.7	2.1	1.7	2.2	2.1	2.4	2.1	1.8	2.6	2.0	2.3	2.3	2.3	1.9	2.0	2.6	2.6	2.8		
6	13	0.8	0.8	3.5	1.0	0.8	1.1	1.0	1.1	1.0	0.8	1.2	0.9	0.8	1.0	1.0	0.8	0.8	1.1	1.2	1.3		

## 7 POTENZIALE DI LIQUEFAZIONE

Questo è uno degli aspetti da considerare, giacché la probabilità che si verifichino eventi del genere è elevata per le sabbie dell'area, come già evidenziato nel citato studio relativo alla sicurezza idraulica del Po.

Tale evenienza può produrre deformazioni e fenomeni del tipo *lateral spread*, che tuttavia non è dato prevedere e nemmeno prevenire ricorrendo a fondazioni speciali, improponibili per opere di quel tipo.

Va comunque esclusa la pericolosità d'eventuali dissesti.

Le tavole allegate relative all'argomento sintetizzano la procedura di Robertson & Wride, 1997, ed il metodo di sintesi di Iwasaky et Al., 1982, la cui descrizione è rimandata alla bibliografia specialistica<sup>2</sup>.

I primi 8 diagrammi di ciascuna tavola riguardano l'elaborazione dei CPTU in chiave di liquefazione e sono prodromici al nono che sintetizza il rischio potenziale del fenomeno

La Magnitudo è assunta pari a 5.8, il picco registrato nella fascia di studio.

Conseguentemente, ad esso è associata l'accelerazione in campo libero attribuita dalla Norma allo Stato Limite di Collasso.

Le tabelle seguenti riportano i dati d'ingresso ed i risultati.

<sup>2</sup> Consigliabile il lavoro "CPT-based liquefaction hazard maps for an Italian coastal area" di T. Crespellani, C. Madiati e G. Vannucchi riportato sulla Rivista italiana di geotecnica, anno XXXVII, n.

**DATI ESTRATTI DAL CATALOGO ISIDE**

Time	Latitude	Longitude	Depth/Km	MagType	Magnitude	Event Location Name
20/05/2012	44.8955	11.2635	9.5	Mw	5.8	7 km NW Finale Emilia (MO)
20/05/2012	44.8737	11.2703	6.1	ML	5	5 km NW Finale Emilia (MO)
20/05/2012	44.8597	11.152	9.1	ML	5	2 km NE San Felice sul Panaro (MO)
29/05/2012	44.8417	11.0657	8.1	Mw	5.6	1 km SW Medolla (MO)
29/05/2012	44.8647	10.9475	7.9	ML	5	5 km SE Novi di Modena (MO)
29/05/2012	44.8652	10.9795	4.4	Mw	5.3	3 km SW San Possidonio (MO)
29/05/2012	44.866	10.9763	7.2	ML	5.1	3 km SW San Possidonio (MO)
29/05/2012	44.8558	10.941	8.7	ML	5	5 km SE Novi di Modena (MO)

						Accelerazioni espresse in (g) per T <sub>0</sub>							
						Orrizontale				Verticale			
Sottozona	PROVA N.	LAT.	LONG.	Media Vs (m/s)	Categoria suolo	SLO	SLD	SLV	SLC	SLO	SLD	SLV	SLC
Castelmassa	CPTU 1-A	45.01557	11.00287	173	D	0.060	0.063	0.148	0.191	0.008	0.009	0.032	0.046
	CPTU 2-A	45.00590	11.31928	165	D	0.059	0.062	0.150	0.193	0.008	0.009	0.032	0.048
	CPTU 3-B	44.99402	11.33531	166	D	0.059	0.062	0.152	0.197	0.008	0.009	0.033	0.049
	CPTU 3-C	44.99351	11.32670	162	D	0.059	0.062	0.152	0.197	0.008	0.009	0.033	0.049
	CPTU 3-D	44.98973	11.33445	165	D	0.059	0.063	0.153	0.198	0.008	0.009	0.033	0.049
Calto	CPTU 4-A	44.98346	11.35835	171	D	0.059	0.063	0.154	0.200	0.008	0.009	0.034	0.050
	CPTU 4-B	44.98116	11.36558	166	D	0.060	0.063	0.155	0.201	0.008	0.009	0.034	0.051
Felonica	CPTU 6-A	44.96962	11.39227	158	D	0.059	0.063	0.154	0.200	0.008	0.009	0.034	0.050
	CPTU 7-A	44.96788	11.41075	165	D	0.059	0.062	0.152	0.198	0.008	0.009	0.033	0.049
Ficarolo	CPTU 8-A	44.93782	11.42575	171	D	0.062	0.065	0.173	0.230	0.009	0.009	0.040	0.062
	CPTU 9-A	44.93349	11.45594	154	D	0.061	0.065	0.170	0.226	0.008	0.009	0.039	0.060
Gaiba	CPTU 10-A	44.94056	11.48464	173	D	0.061	0.064	0.166	0.220	0.008	0.009	0.038	0.058
Ravalle	CPTU 11-A	44.93534	11.49579	167	D	0.061	0.064	0.167	0.222	0.008	0.009	0.038	0.058
	CPTU 12-A	44.93572	11.51150	164	D	0.061	0.064	0.167	0.222	0.008	0.009	0.038	0.058
	CPTU 12-B	44.93593	11.51499	155	D	0.060	0.064	0.162	0.214	0.008	0.009	0.037	0.056
Stienta	CPTU 13-A	44.93638	11.53975	181	C	0.050	0.053	0.133	0.176	0.008	0.009	0.036	0.054
	CPTU 14-A	44.93020	11.55351	169	D	0.060	0.063	0.160	0.211	0.008	0.009	0.036	0.054
	CPTU 15-A	44.92265	11.56411	143	D	0.060	0.064	0.161	0.212	0.008	0.009	0.036	0.055
	CPTU 15-B	44.92053	11.55970	153	D	0.060	0.064	0.161	0.213	0.008	0.009	0.036	0.055
	CPTU 15-C	44.91879	11.56585	154	D	0.062	0.066	0.175	0.234	0.009	0.009	0.041	0.063

Sottozona	PROVA N.	RISCHIO DI LIQUEFAZIONE
Castelmassa	CPTU 1-A	ALTO
	CPTU 2-A	ALTO
	CPTU 3-B	ALTO
	CPTU 3-C	ALTO
Calto	CPTU 3-D	ALTO
	CPTU 4-A	ALTO
Felonica	CPTU 4-B	ALTO
	CPTU 6-A	ALTO
Ficarolo	CPTU 7-A	ALTO
	CPTU 8-A	MOLTO ALTO
Gaiba	CPTU 9-A	MOLTO ALTO
	CPTU 10-A	ALTO
Ravalle	CPTU 11-A	BASSO
	CPTU 12-A	MOLTO ALTO
	CPTU 12-B	MOLTO ALTO
Stienta	CPTU 13-A	MODERATO
	CPTU 14-A	ALTO
	CPTU 15-A	MODERATO
	CPTU 15-B	ALTO
	CPTU 15-C	MOLTO ALTO

## 8 STABILITA'

Si ricorre al programma Winstabl, una versione del classico STABL<sup>3</sup> della Purdue University – Indiana.

Per semplicità si è scelto il metodo noto come “*Bishop modificato*”<sup>4</sup> per superfici circolari, imponendo la ricerca di quelle più critiche nell’ambito di 4500 diversi tentativi richiesti per il paramento a maggiore inclinazione.

Lasciando la trattazione teorica alla Bibliografia specialistica, qui si procede in *back analysis*, giacché è d’interesse ottenere un fattore di stabilità accettabile, che, come si è detto, non può che derivare dall’associazione di una congrua coesione all’angolo di resistenza a taglio dell’opera nel suo complesso.

Con riferimento alle condizioni geometriche più critiche, riferibili al manufatto di maggiore altezza parzialmente emerso, quel fattore obiettivo è posto intorno a 1.1 in regime sia statico sia sismico.

Per quest’ultimo, si mettono in conto le accelerazioni previste dalla Norma per lo Stato Limite di Danno.

Tale assunzione sembra opportuna, giacché, volendo salvaguardare l’integrità per gli Stati limite superiori, le armature da introdurre nei manufatti diverrebbero particolarmente impegnative, col rischio di vanificare l’investimento qualora la crisi si trasferisse ai terreni d’appoggio per l’insorgere della liquefazione.

<sup>3</sup> Ronald A. Siegel, “*Computer analysis of general slope stability problems*”, 1975.

<sup>4</sup> Bishop A.W. ,1955, “*The use of slip circle in the stability analysis of slopes*” Geotechnique vol.5(1), 1955.

La vasta casistica assunta necessita di sfrondare quanto possibile gli outputs, così da evitare le ridondanze cartacee.

In quest'ottica, gli allegati specifici si limitano ai risultati grafici dei tentativi fruttuosi per ogni verticale di sondaggio; i disegni mostrano le 10 superfici più critiche (quando non si sovrappongono), i rispettivi fattori di stabilità ed i valori attribuiti alla coesione fittizia.

La tabella seguente riunisce questi ultimi.



Sottozona	PROVA N.	Coesione imposta c' in kPa	
		Senza sisma	Con sisma
Castelmassa	CPTU 1-A	0.6	2.0
	CPTU 2-A	0.6	3.0
	CPTU 3-B	0.6	3.0
	CPTU 3-C	0.6	3.0
	CPTU 3-D	0.6	3.0
Calto	CPTU 4-A	0.6	2.0
	CPTU 4-B	0.6	2.0
Felonica	CPTU 6-A	0.6	2.5
	CPTU 7-A	0.6	2.5
Ficarolo	CPTU 8-A	0.6	2.0
	CPTU 9-A	0.6	2.5
Gaiba	CPTU 10-A	0.6	2.5
Ravalle	CPTU 11-A	0.6	3.0
	CPTU 12-A	0.6	2.5
	CPTU 12-B	0.6	3.5
Stienta	CPTU 13-A	0.6	2.5
	CPTU 14-A	0.6	2.5
	CPTU 15-A	0.6	3.0
	CPTU 15-B	0.6	2.5
	CPTU 15-C	0.6	2.5



## CASTELMASSA



LEGENDA

-  PROVA PENETROMETRICA
-  OPERE IN PROGETTO



UBICAZIONE SONDAGGI CASTELMASSA 1



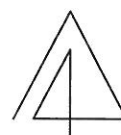
LEGENDA



PROVA PENETROMETRICA



OPERE IN PROGETTO



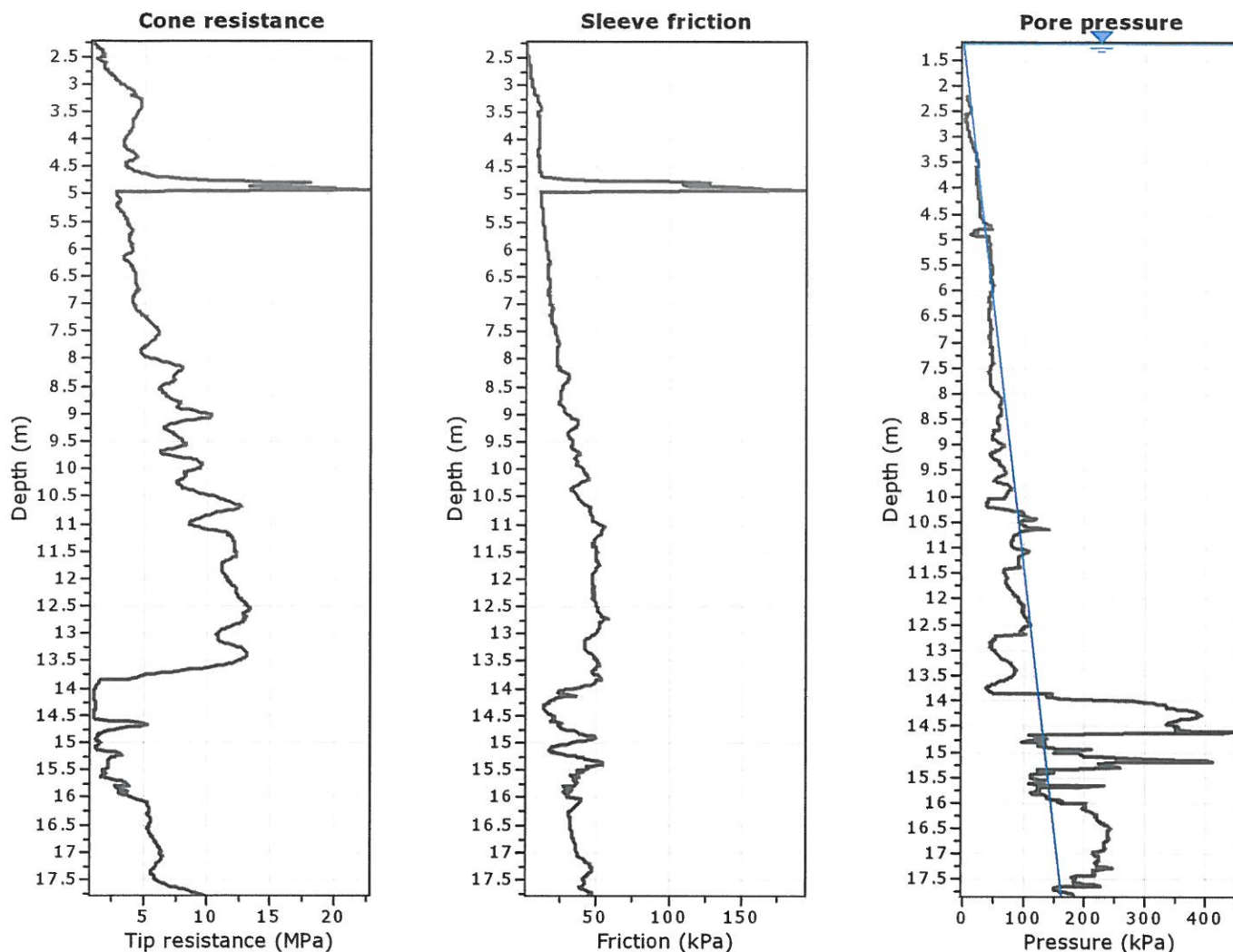
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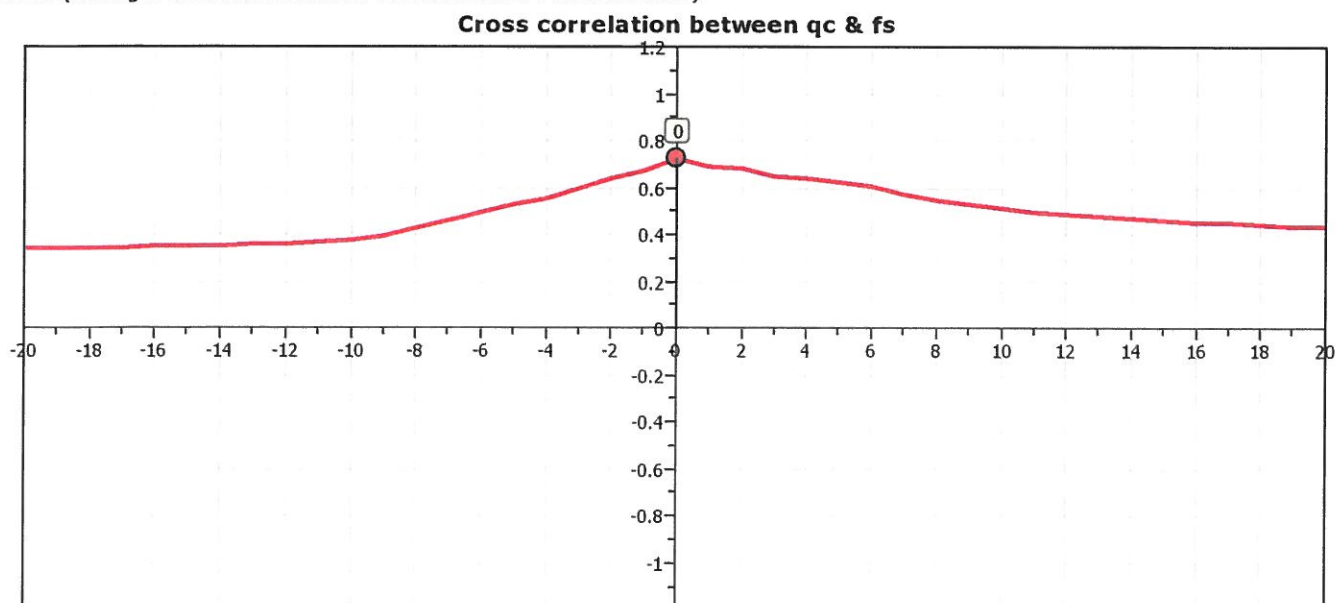
UBICAZIONE SONDAGGI CASTELMASSA 2 3

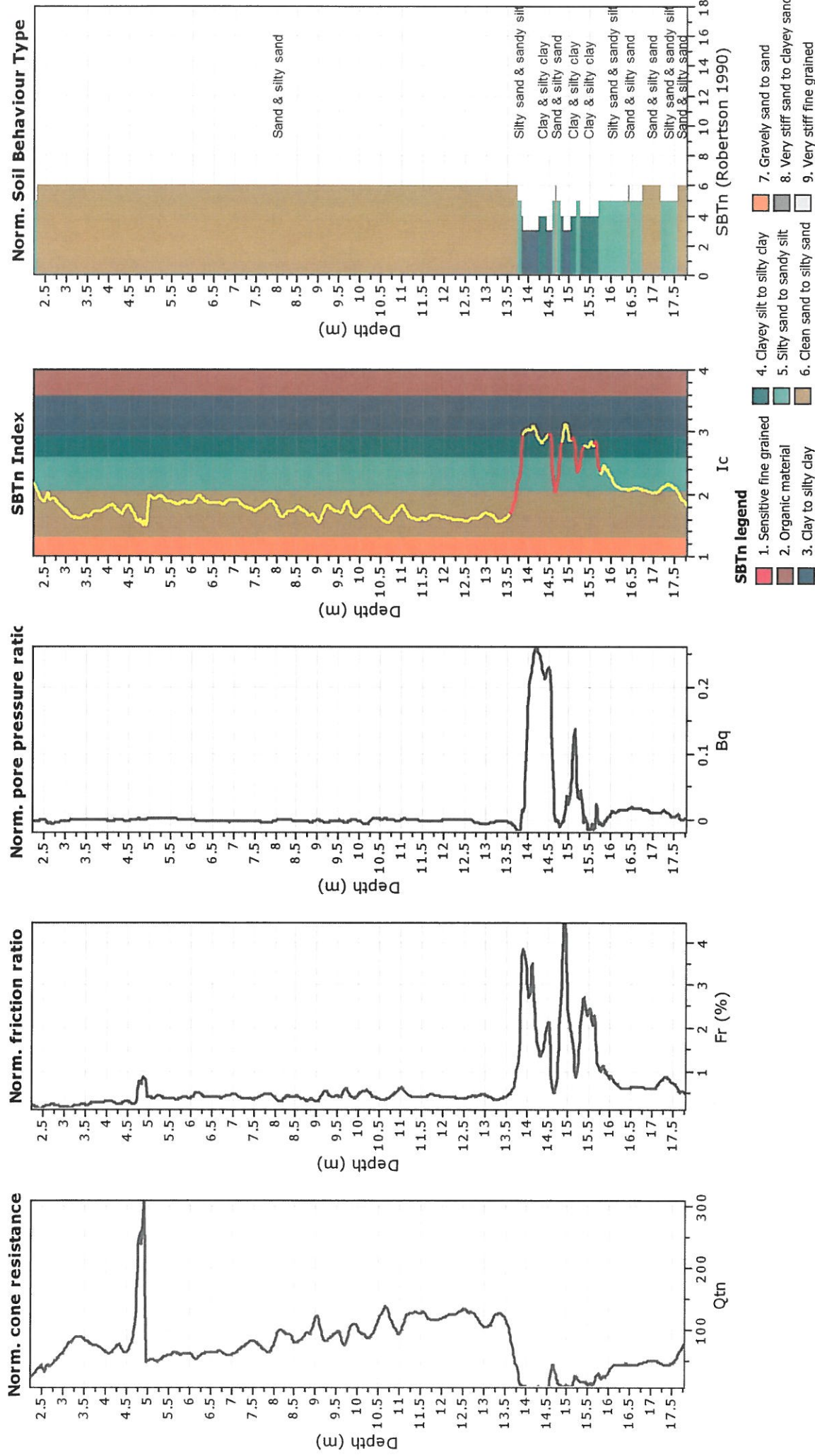
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

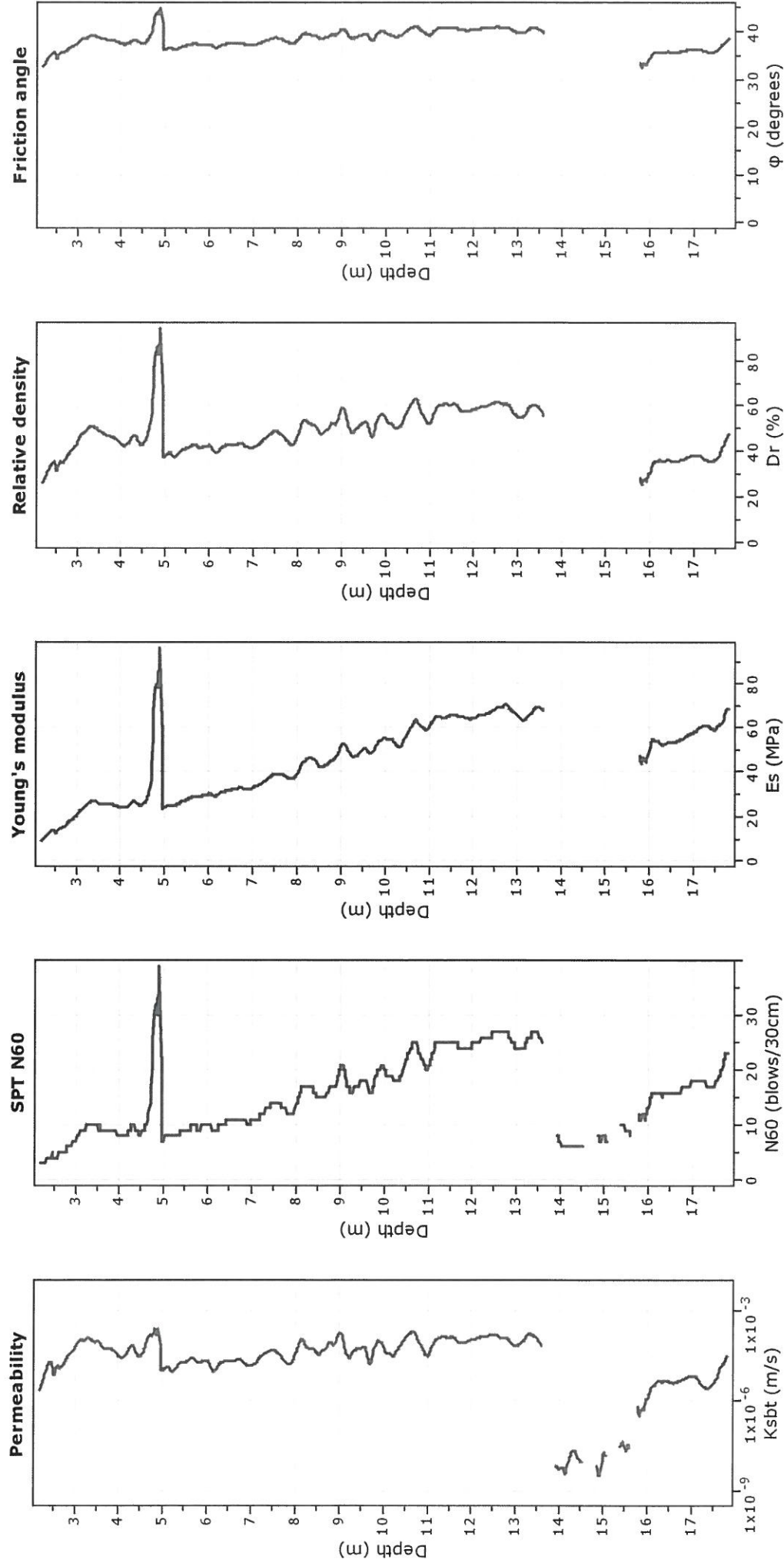
**Location: TRATTO CASTELMASSA - STIENTA**



The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).





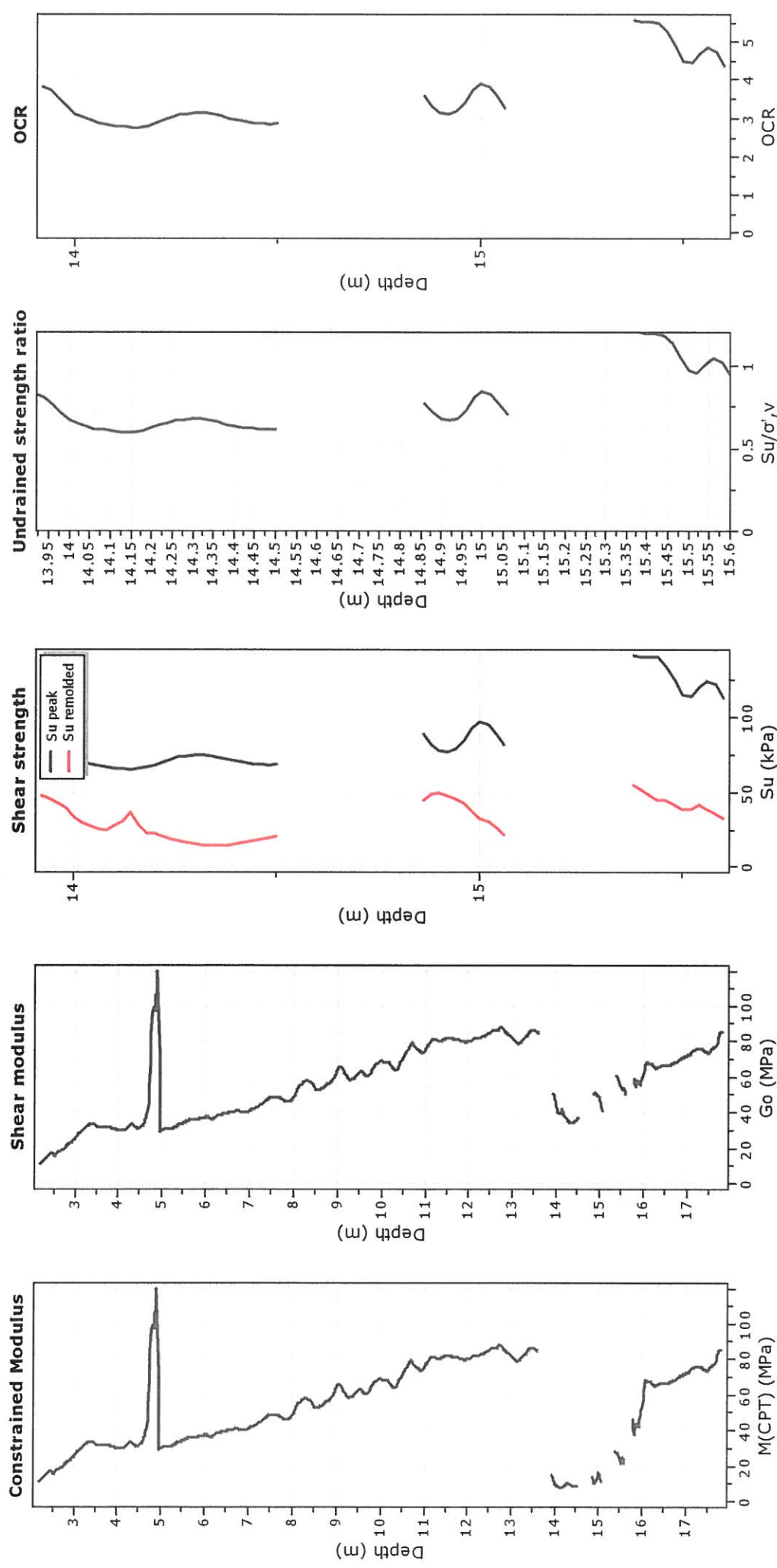


## Calculation parameters

Permeability: Based on  $SBT_n$   
SPT  $N_{60}$ : Based on  $I_c$  and  $q_t$   
Young's modulus: Based on variable  $\alpha$  using  $I_c$  (Robertson, 2009) —●— User defined estimation data  
Relative density constant,  $C_D$ : 350.0  
Phi: Based on Kulhawy & Mayne (1990)

Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE

Location: TRATTO CASTELMASSA - STIENTA



#### Calculation parameters

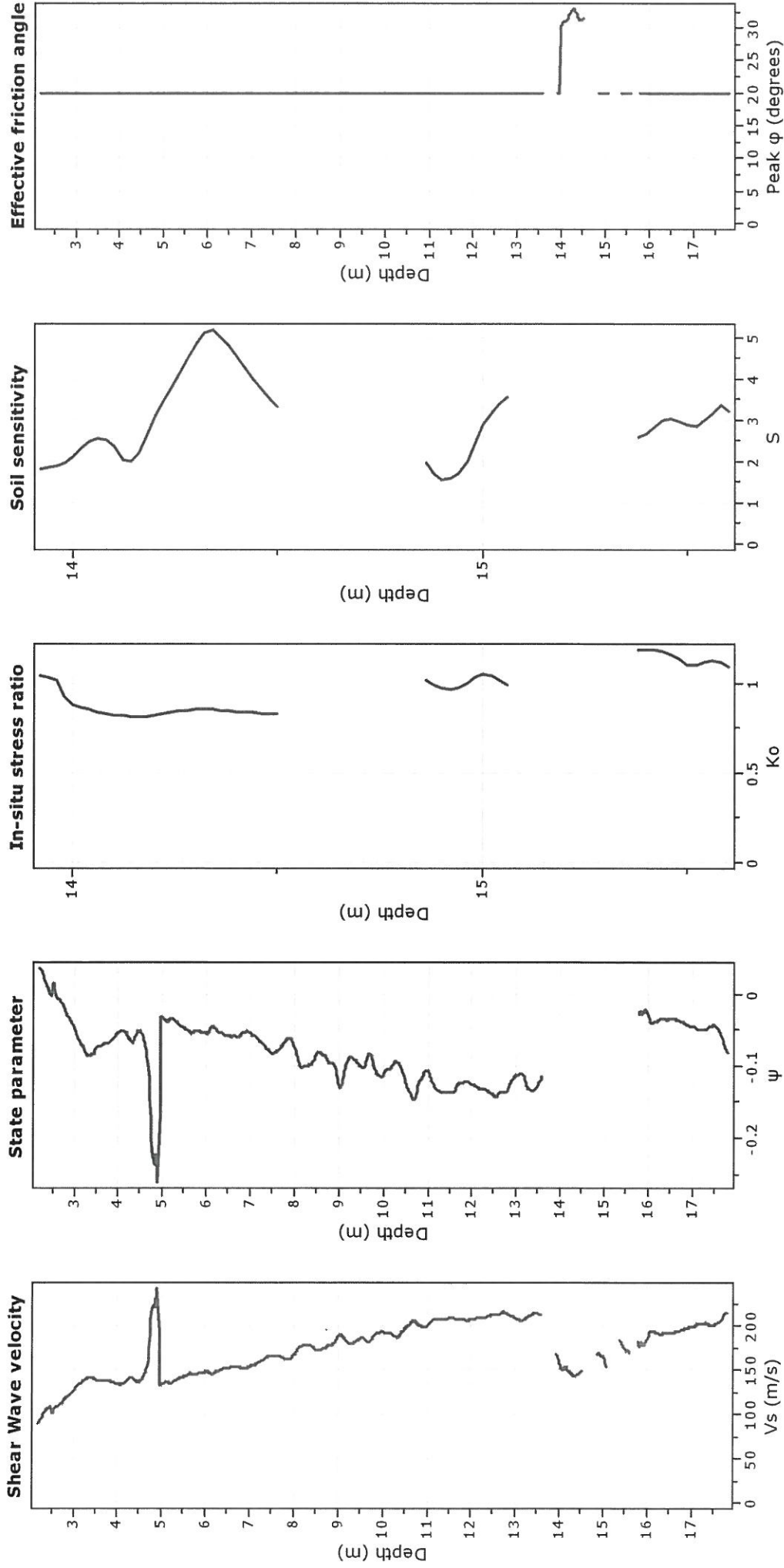
Constrained modulus: Based on variable  $\alpha/\beta$  using  $I_c$  and  $Q_m$  (Robertson, 2009)

Go: Based on variable  $\alpha/\beta$  using  $I_c$  (Robertson, 2009)

Undrained shear strength cone factor for clays,  $N_{kt}$ : 14

OCR factor for clays,  $N_{kt}$ : 0.33

—●— User defined estimation data



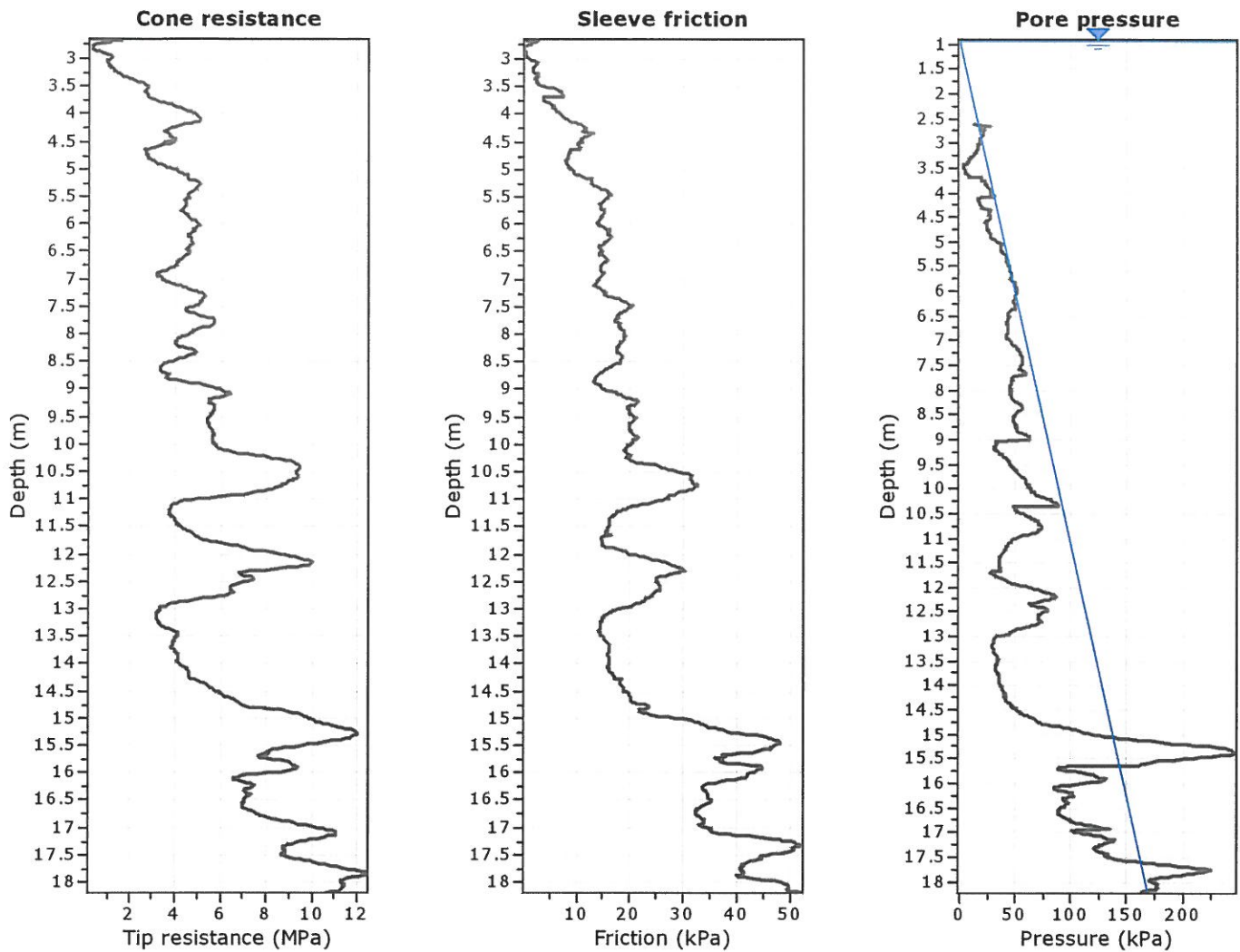
**Calculation parameters**

Soil Sensitivity factor,  $N_s$ : 7.00

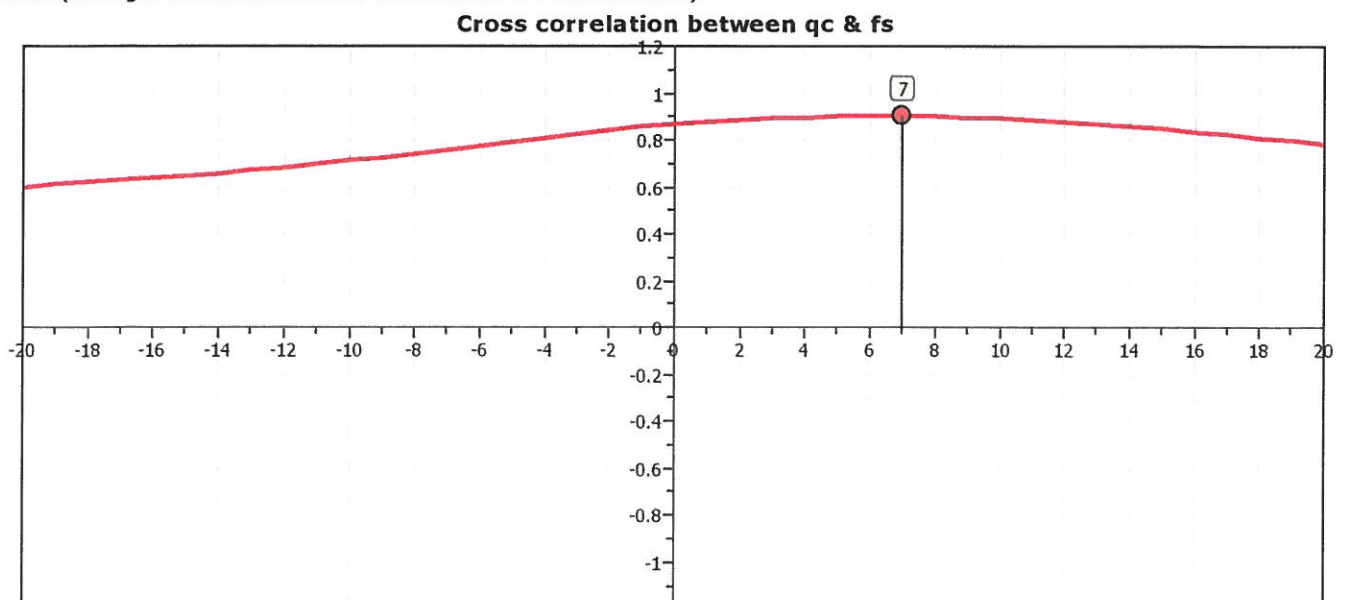
—●— User defined estimation data

**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

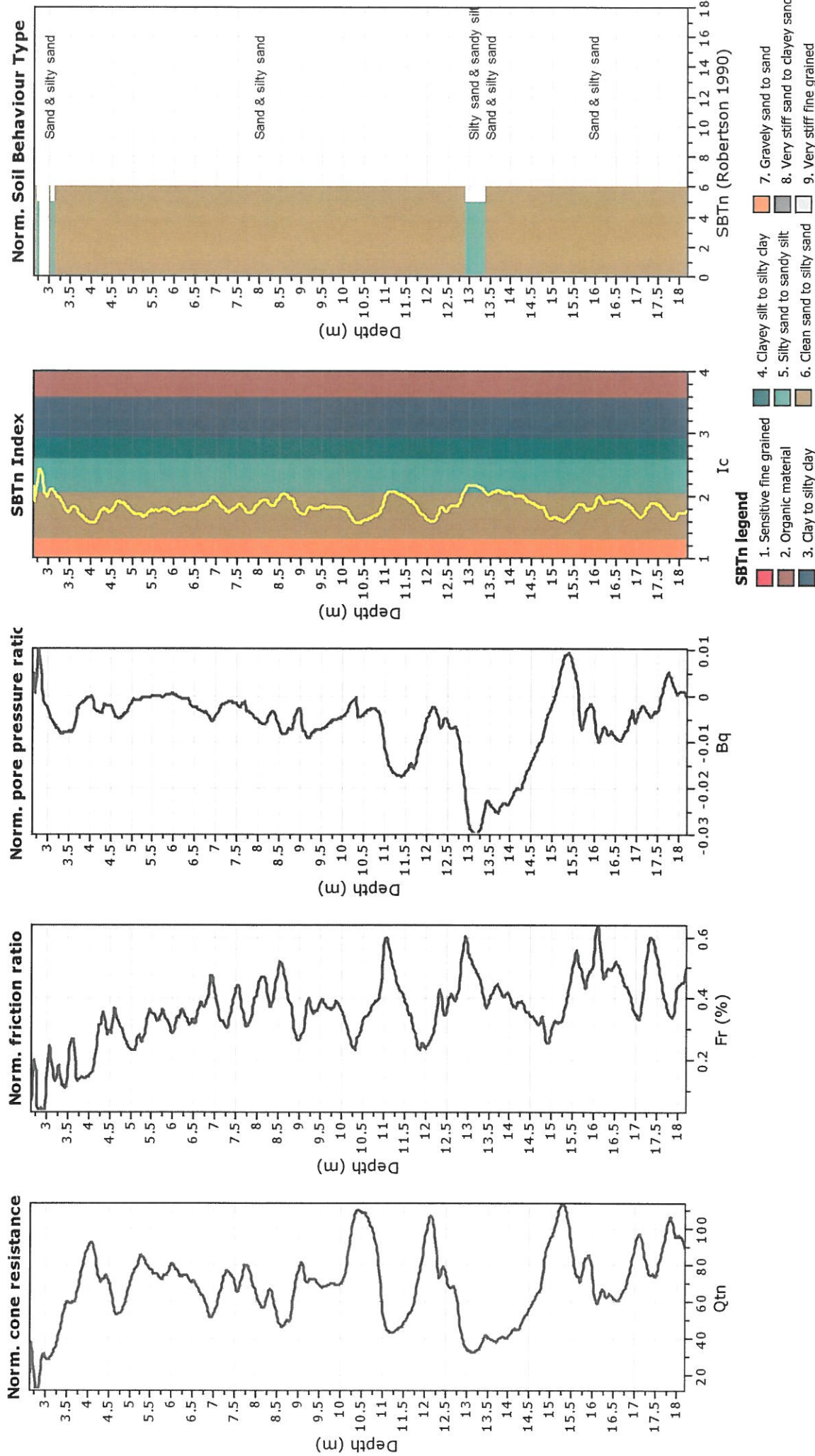
**Location: TRATTO CASTELMASSA - STIENTA**

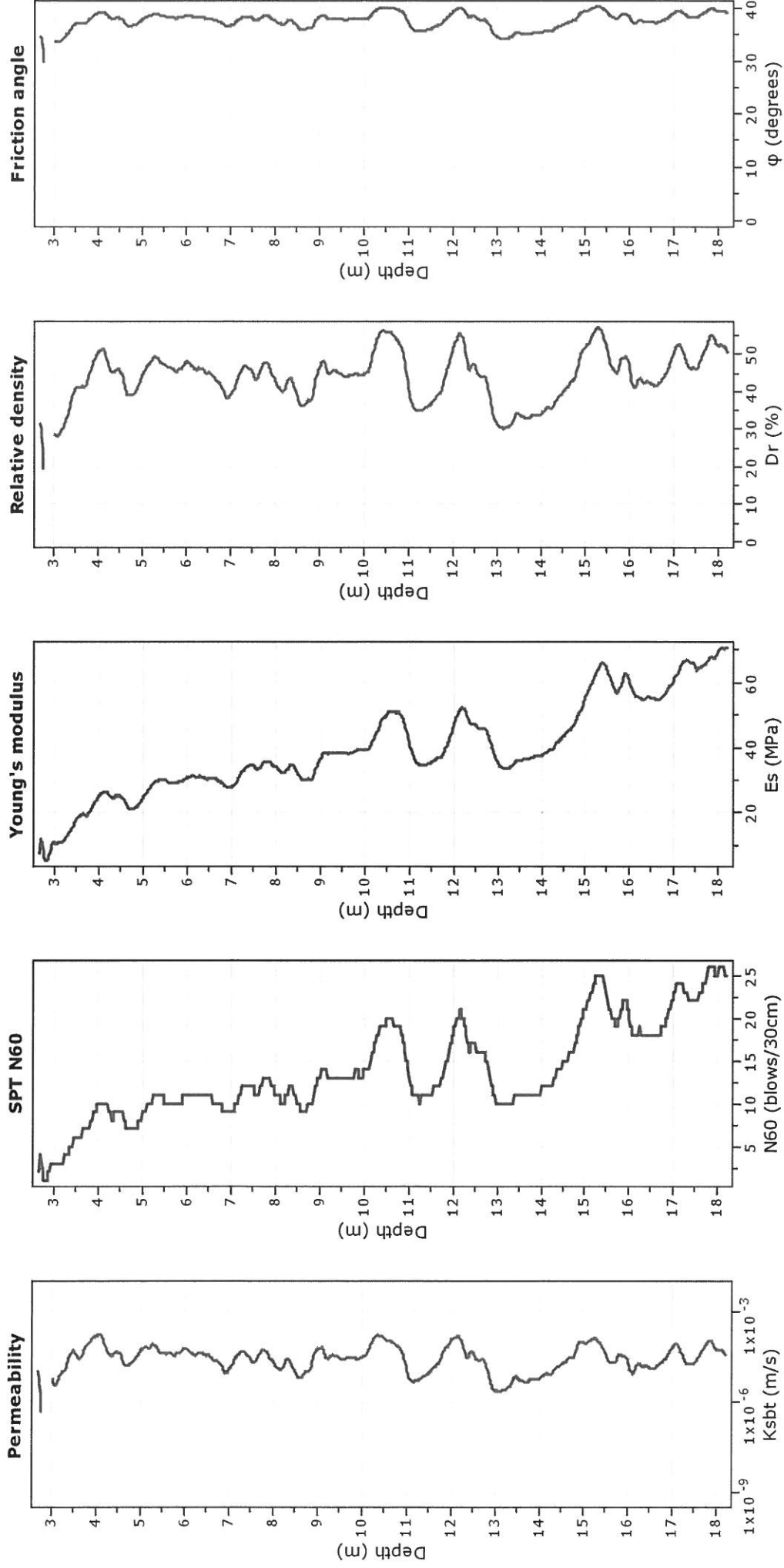


The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**





#### Calculation parameters

Permeability: Based on SBT<sub>n</sub>

SPT N<sub>60</sub>: Based on I<sub>c</sub> and q<sub>t</sub>

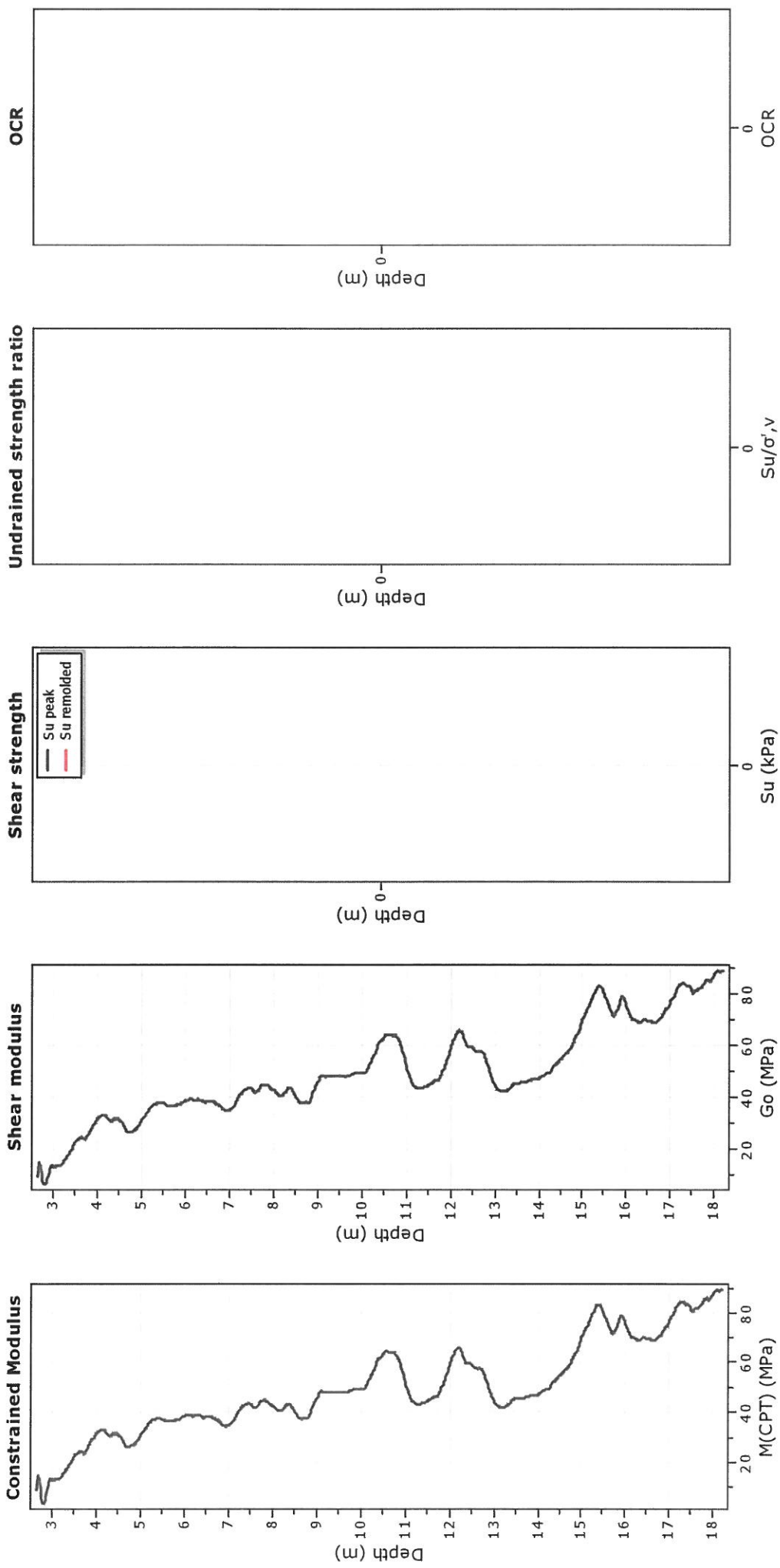
Young's modulus: Based on variable alpha using I<sub>c</sub> (Robertson, 2009)

Relative density constant, C<sub>Dr</sub>: 350.0

Phi: Based on Kulhawy & Mayne (1990)

—●— User defined estimation data

Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



**Calculation parameters**

Constrained modulus: Based on variable  $\alpha/p_h$  using  $I_c$  and  $Q_m$  (Robertson, 2009)

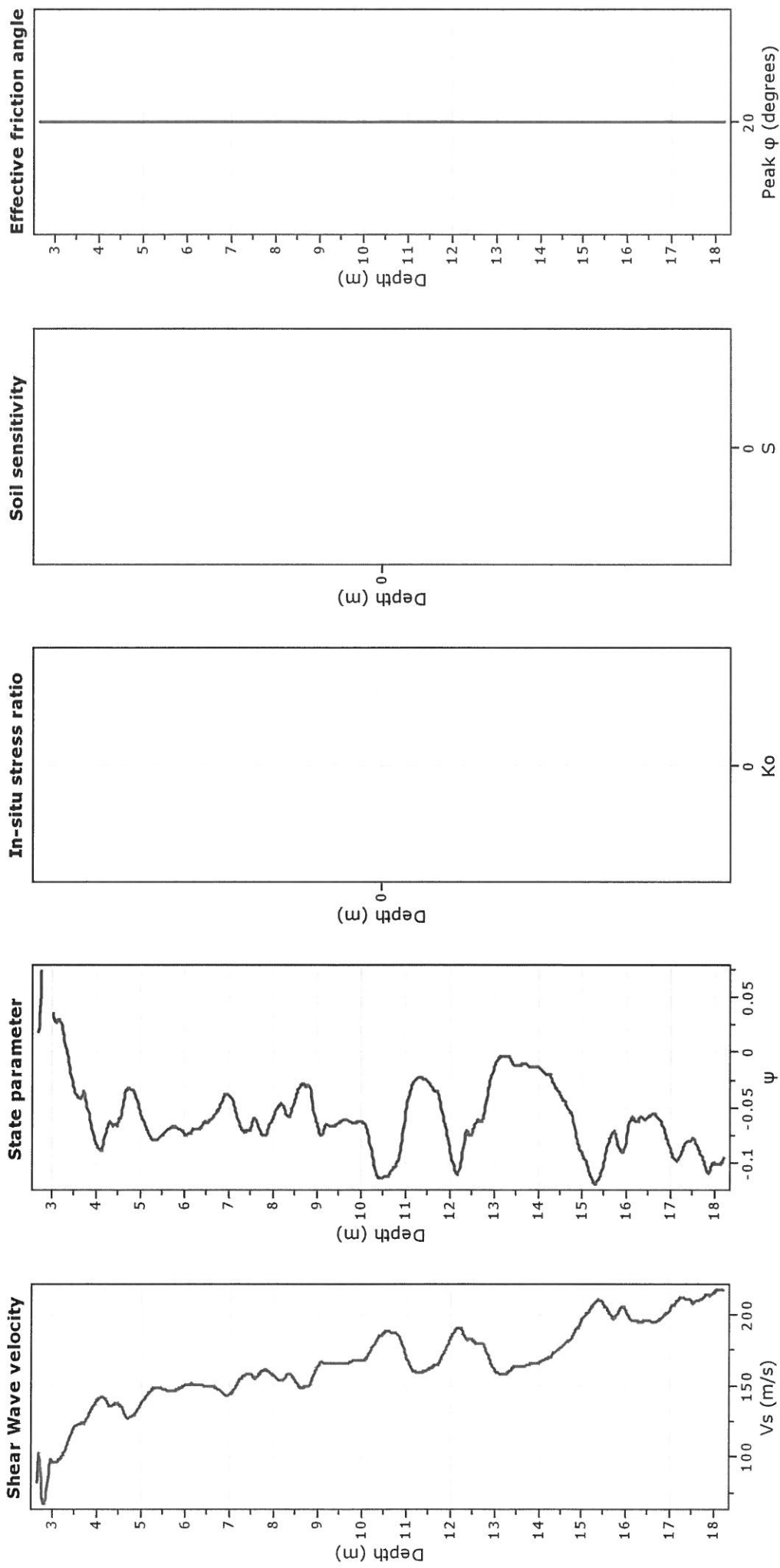
$G_o$ : Based on variable  $\alpha/p_h$  using  $I_c$  (Robertson, 2009)

Undrained shear strength cone factor for clays,  $N_{k\kappa}$ : 14

OCR factor for clays,  $N_{k\kappa}$ : 0.33

—●— User defined estimation data

**Project:** FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
**Location:** TRATTO CASTELMASSA - STIENTA



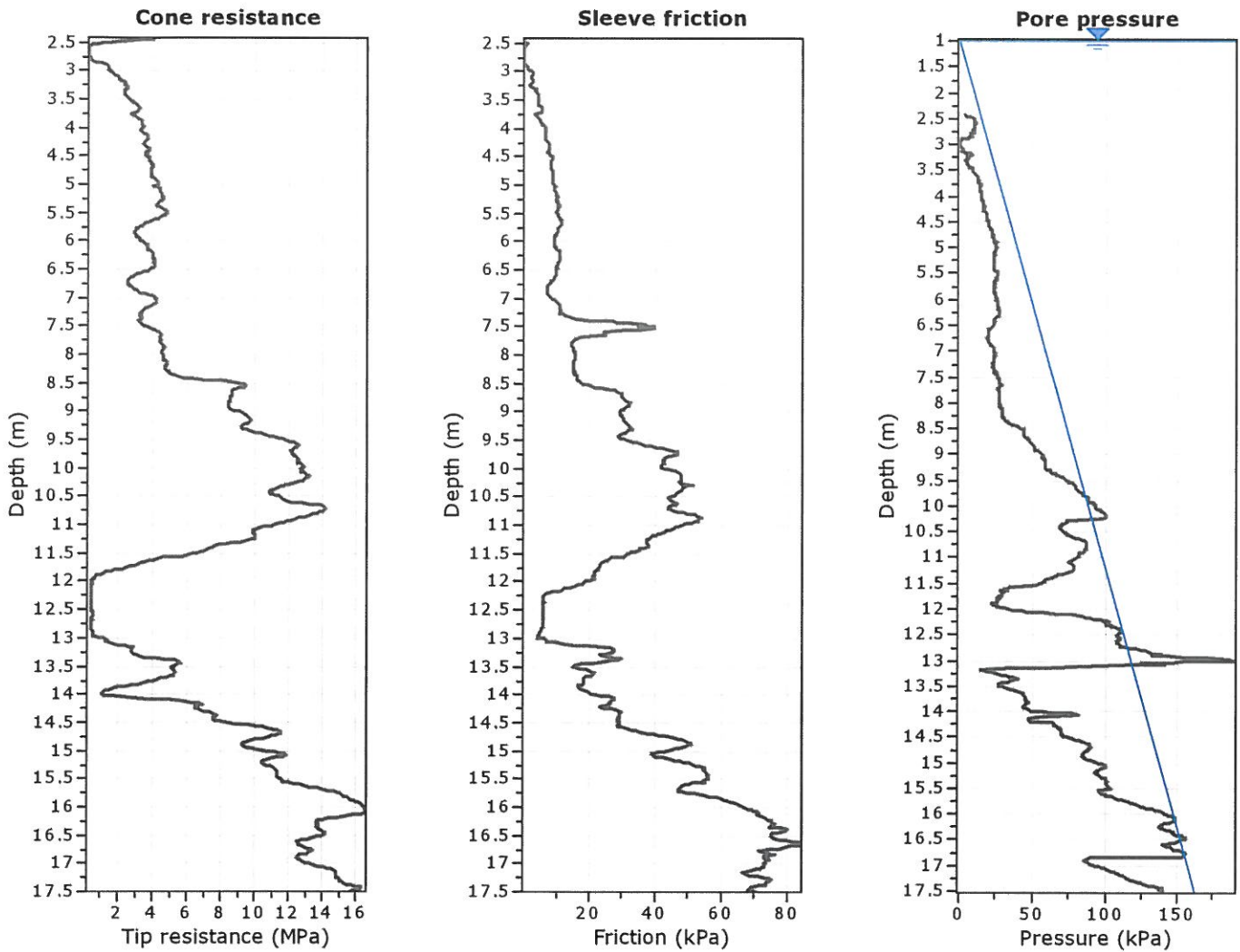
**Calculation parameters**

Soil Sensitivity factor,  $N_s$ : 7.00

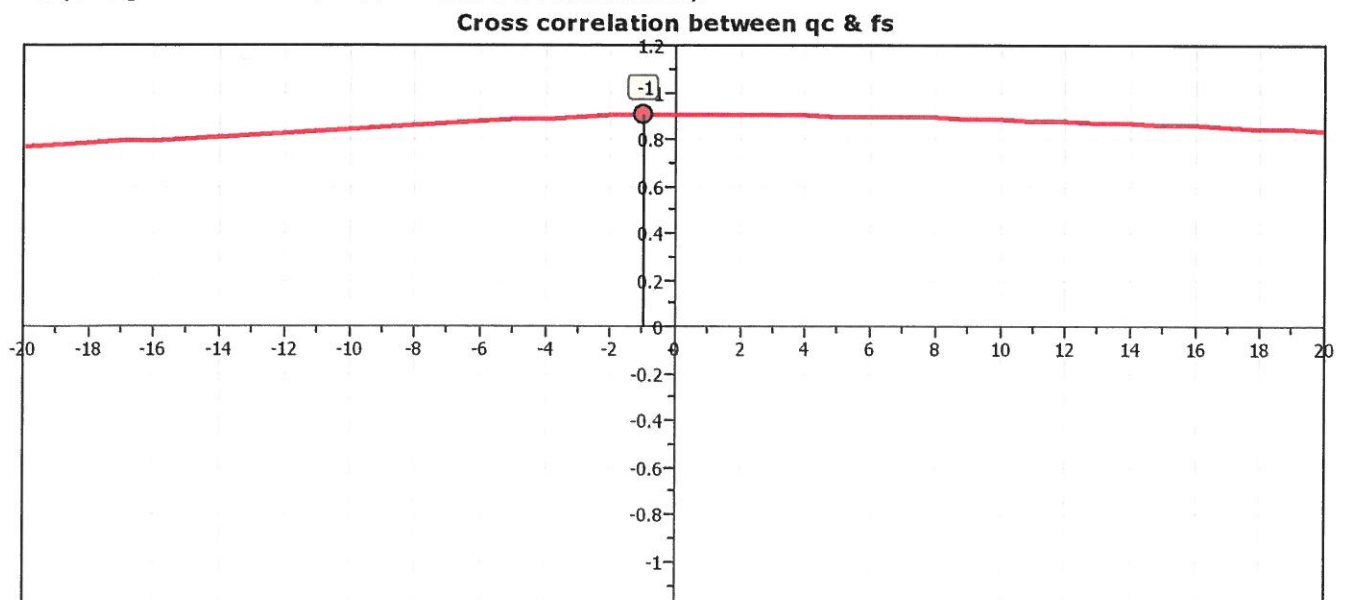
—●— User defined estimation data

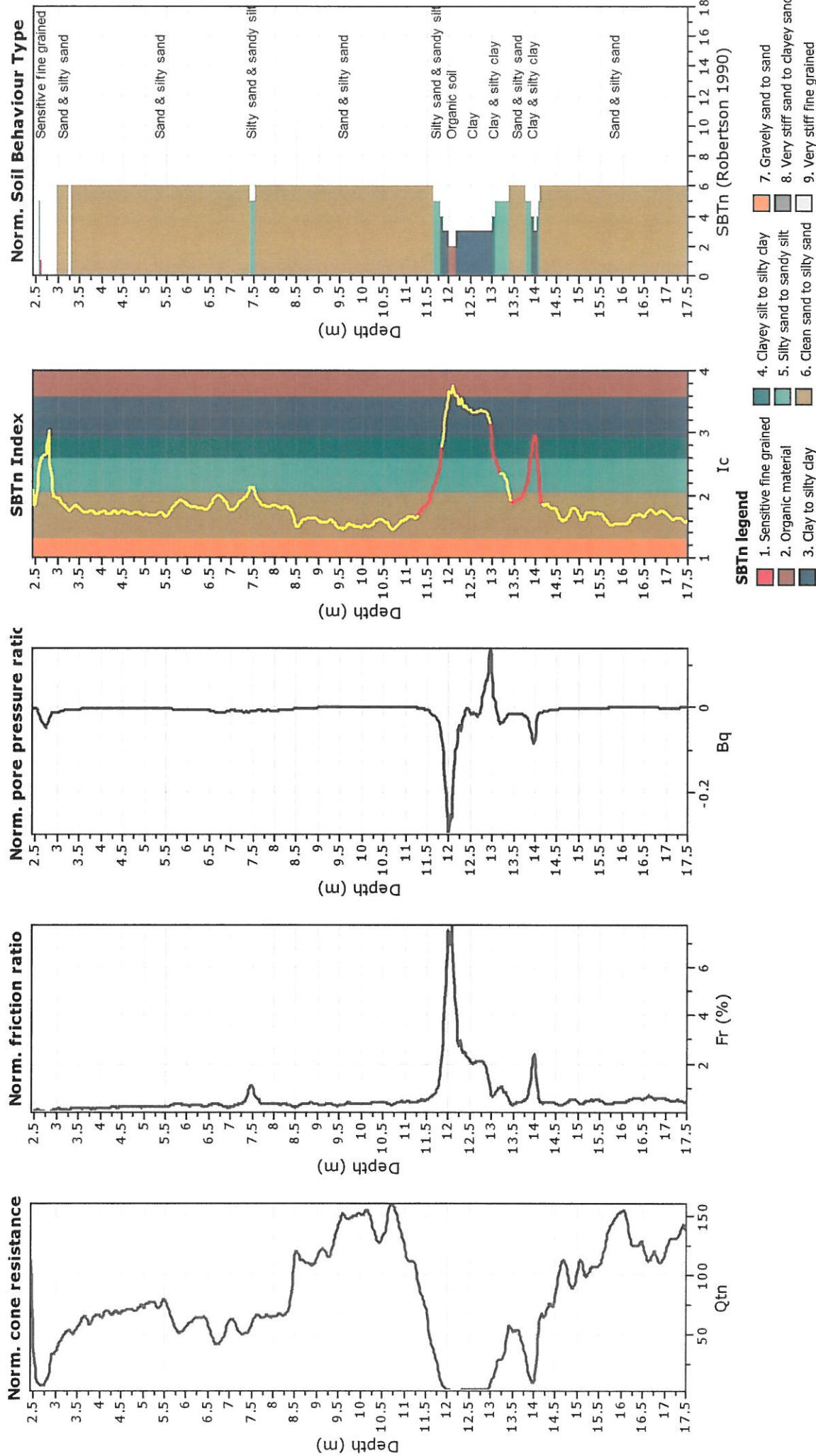
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

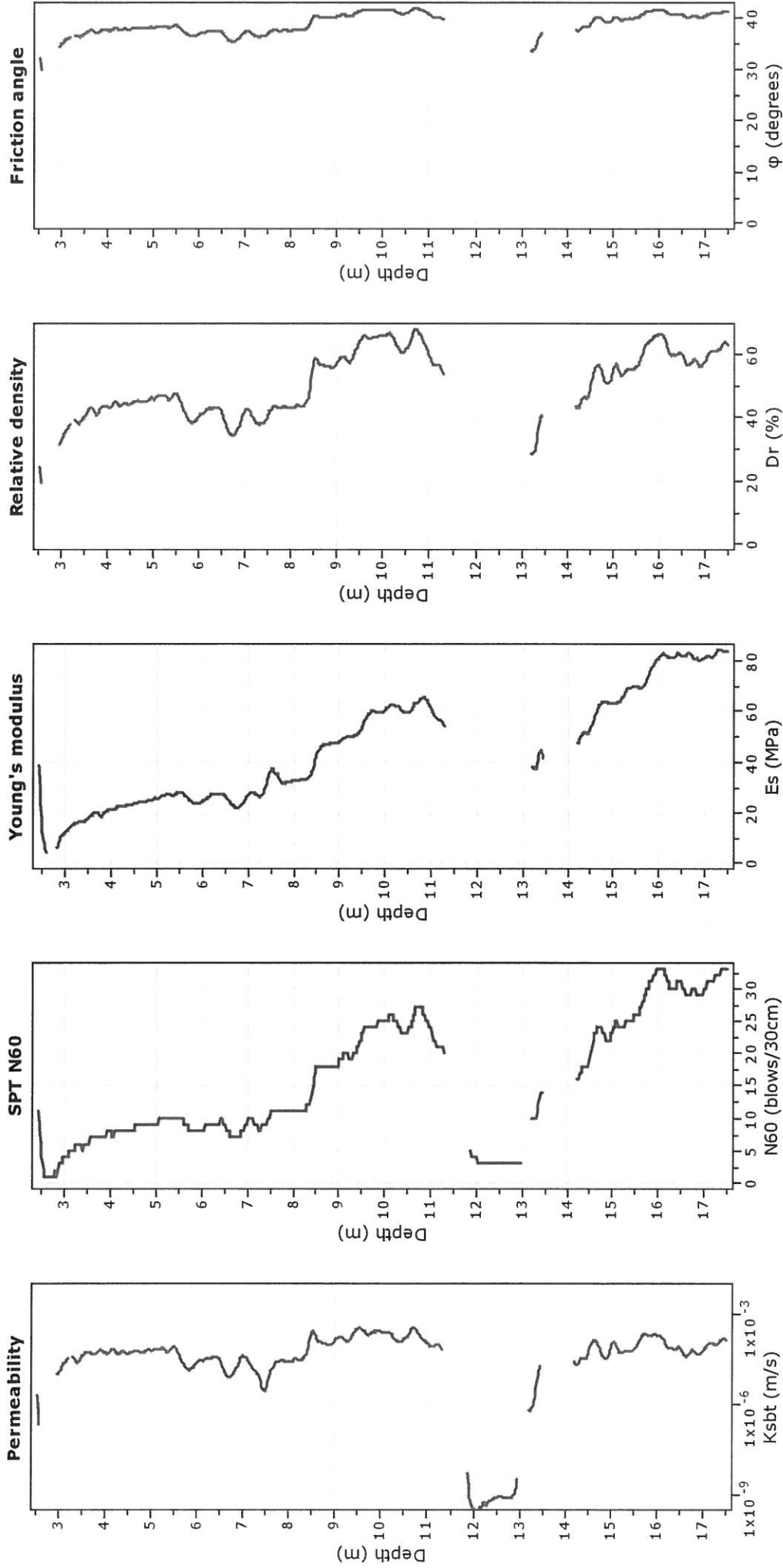
**Location: TRATTO CASTELMASSA - STIENTA**



The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



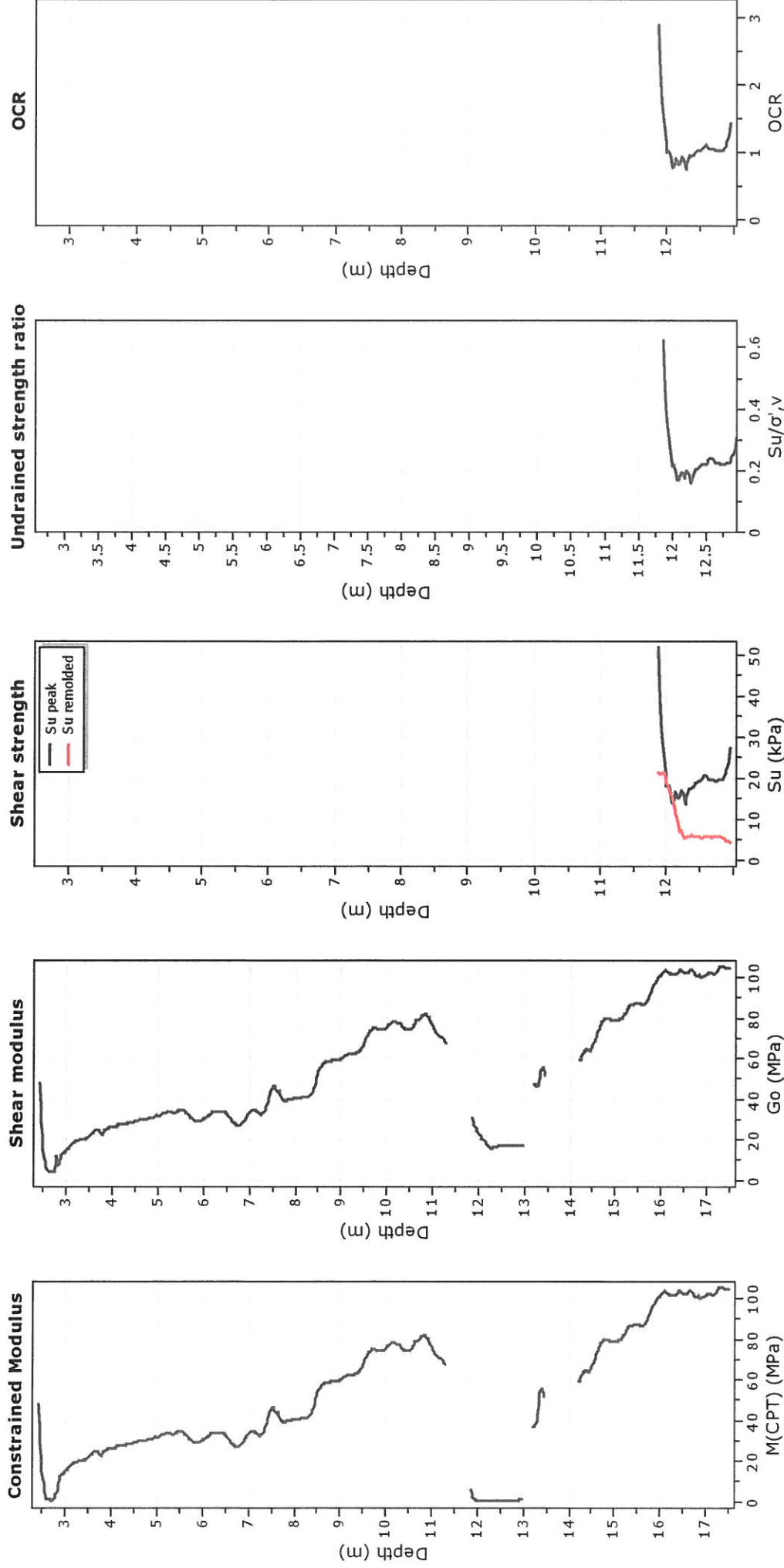




**Calculation parameters**

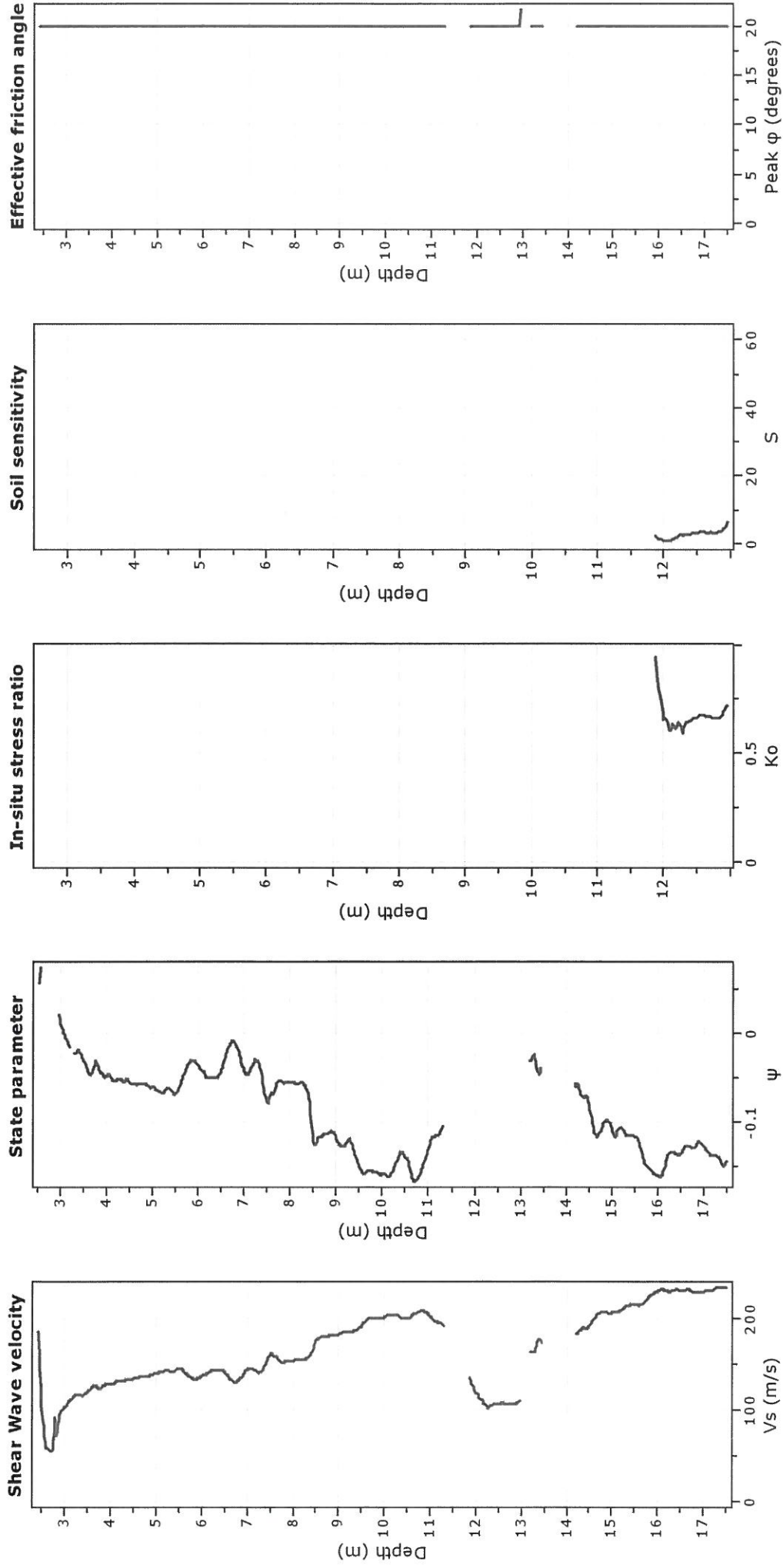
Permeability: Based on SBT<sub>n</sub>  
SPT N<sub>60</sub>: Based on I<sub>c</sub> and q<sub>t</sub>  
Young's modulus: Based on variable alpha using I<sub>c</sub> (Robertson, 2009) —●— User defined estimation data  
Relative density constant, C<sub>Dr</sub>: 350.0  
Phi: Based on Kulhawy & Mayne (1990)

**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**



#### Calculation parameters

Constrained modulus: Based on variable  $\alpha/p_h$  using  $I_c$  and  $Q_m$  (Robertson, 2009)  
Go: Based on variable  $\alpha/p_h$  using  $I_c$  (Robertson, 2009)  
Undrained shear strength cone factor for clays,  $N_{k1}$ : 14  
OCR factor for clays,  $N_{k2}$ : 0.33  
User defined estimation data



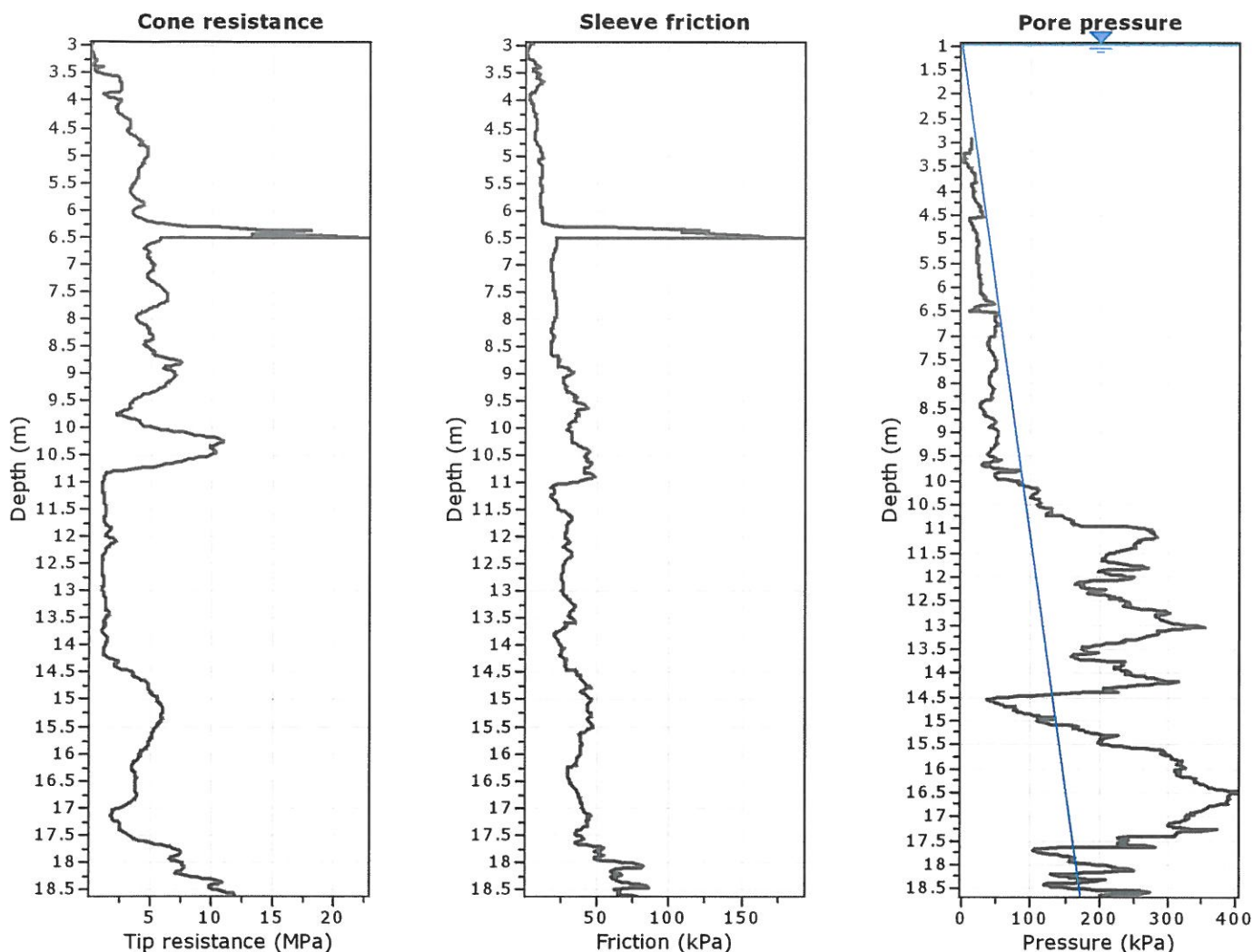
#### Calculation parameters

Soil Sensitivity factor,  $N_s$ : 7.00

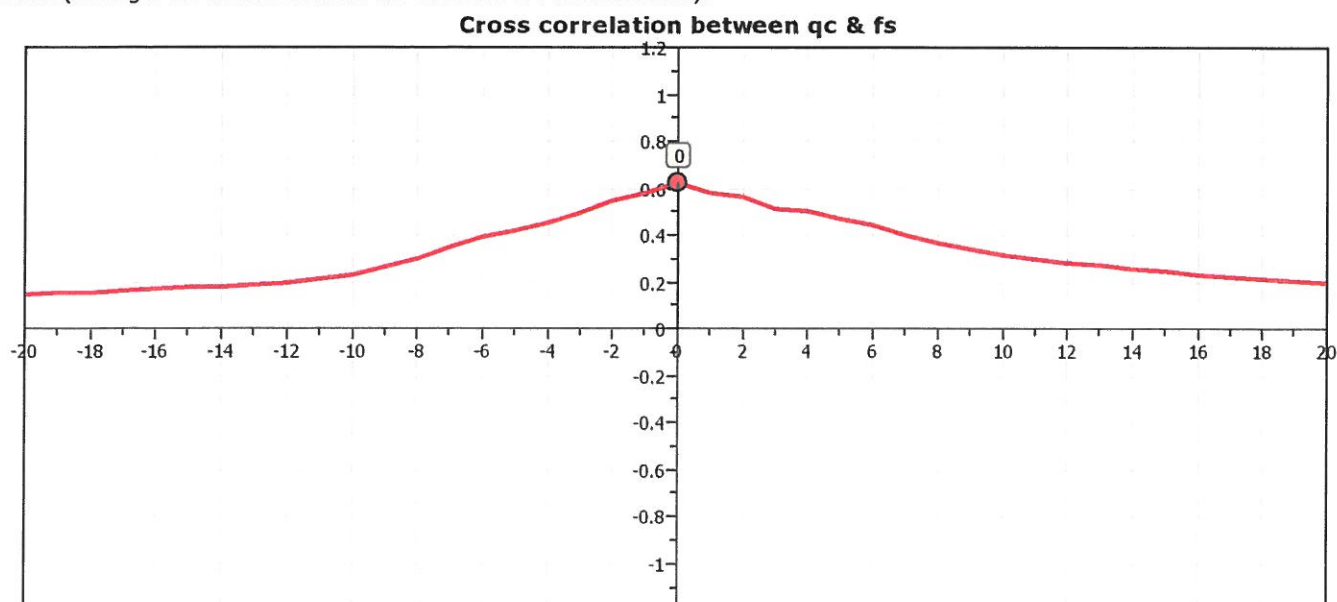
—●— User defined estimation data

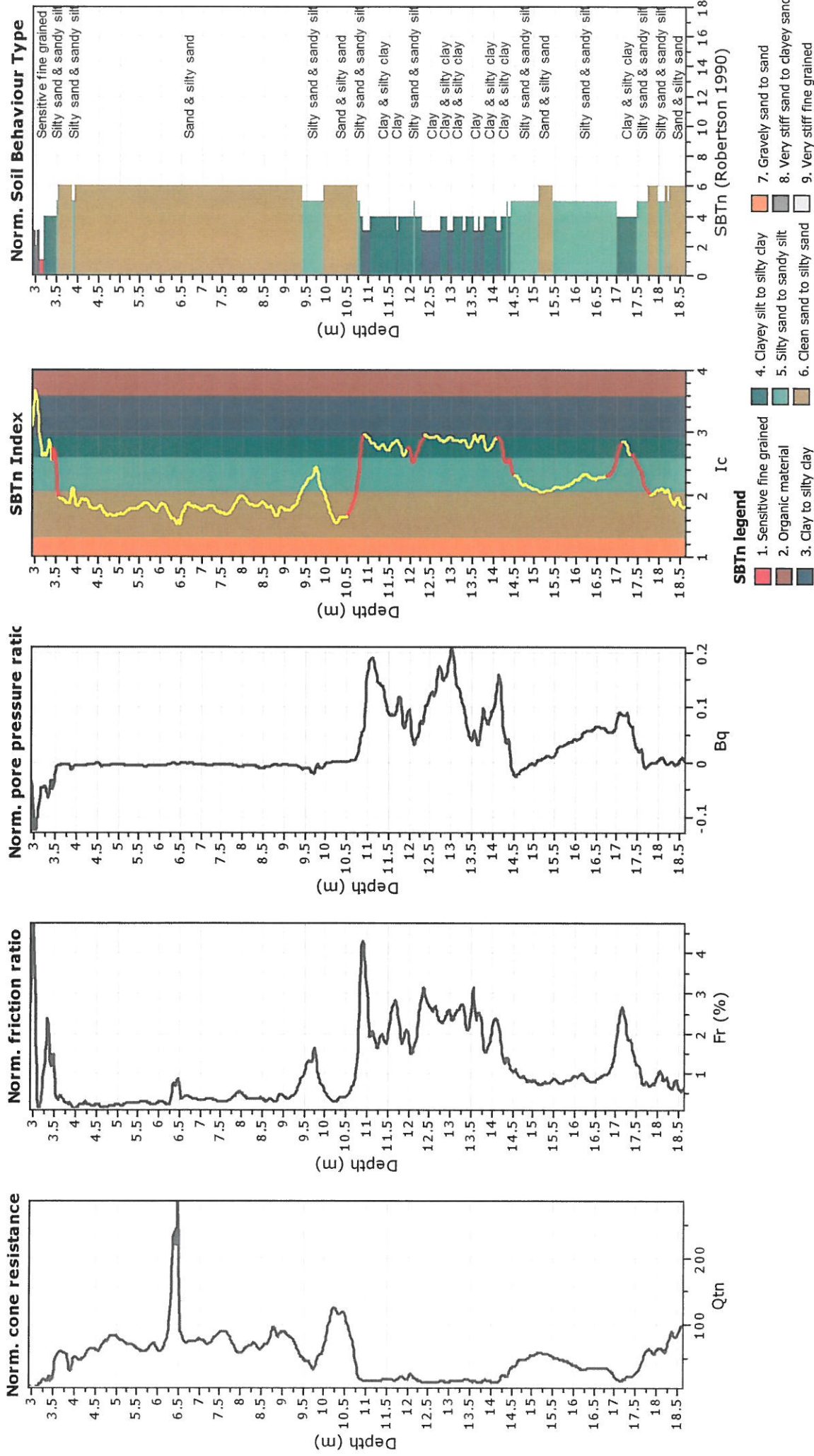
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

**Location: TRATTO CASTELMASSA - STIENTA**

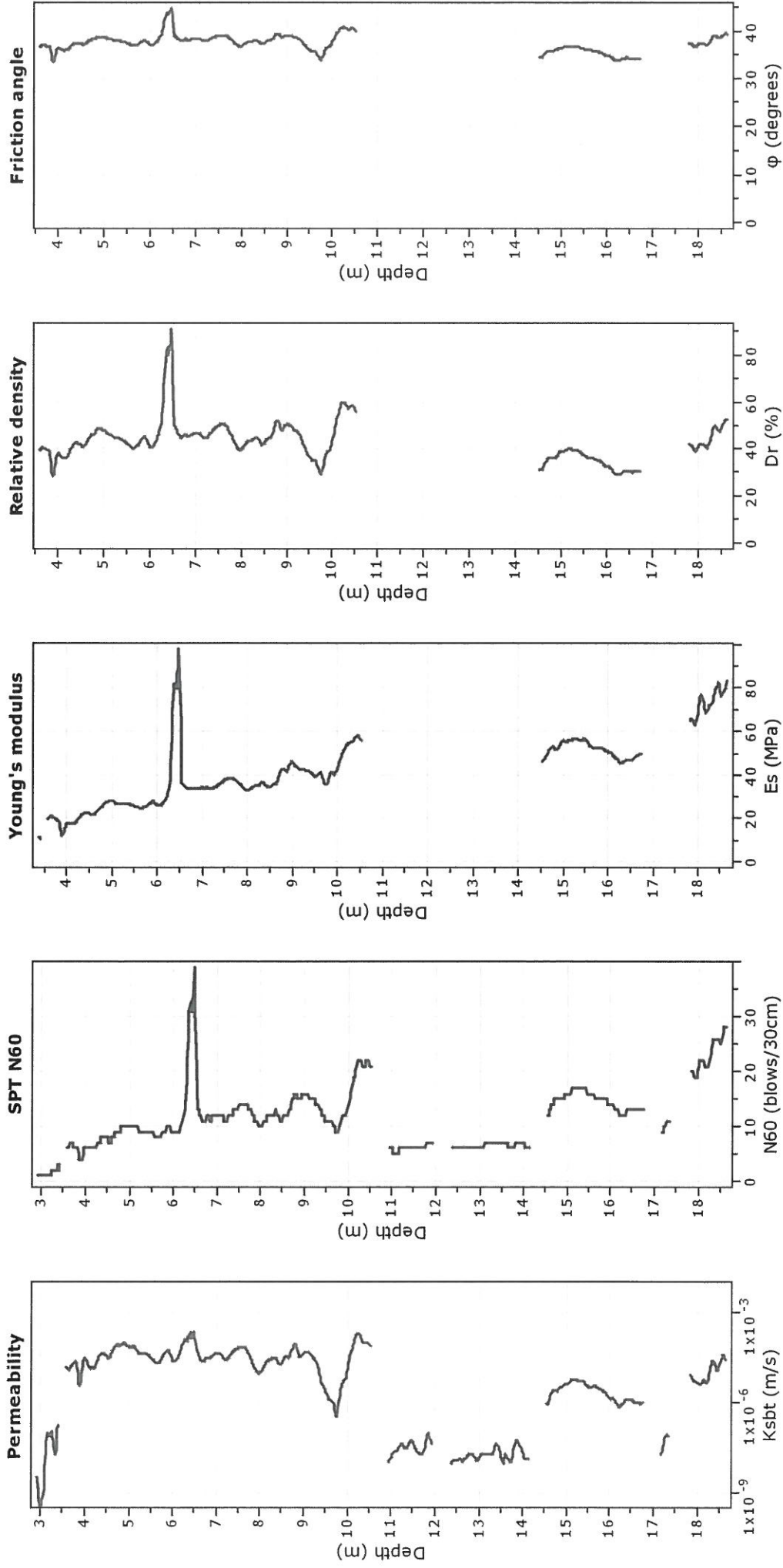


The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



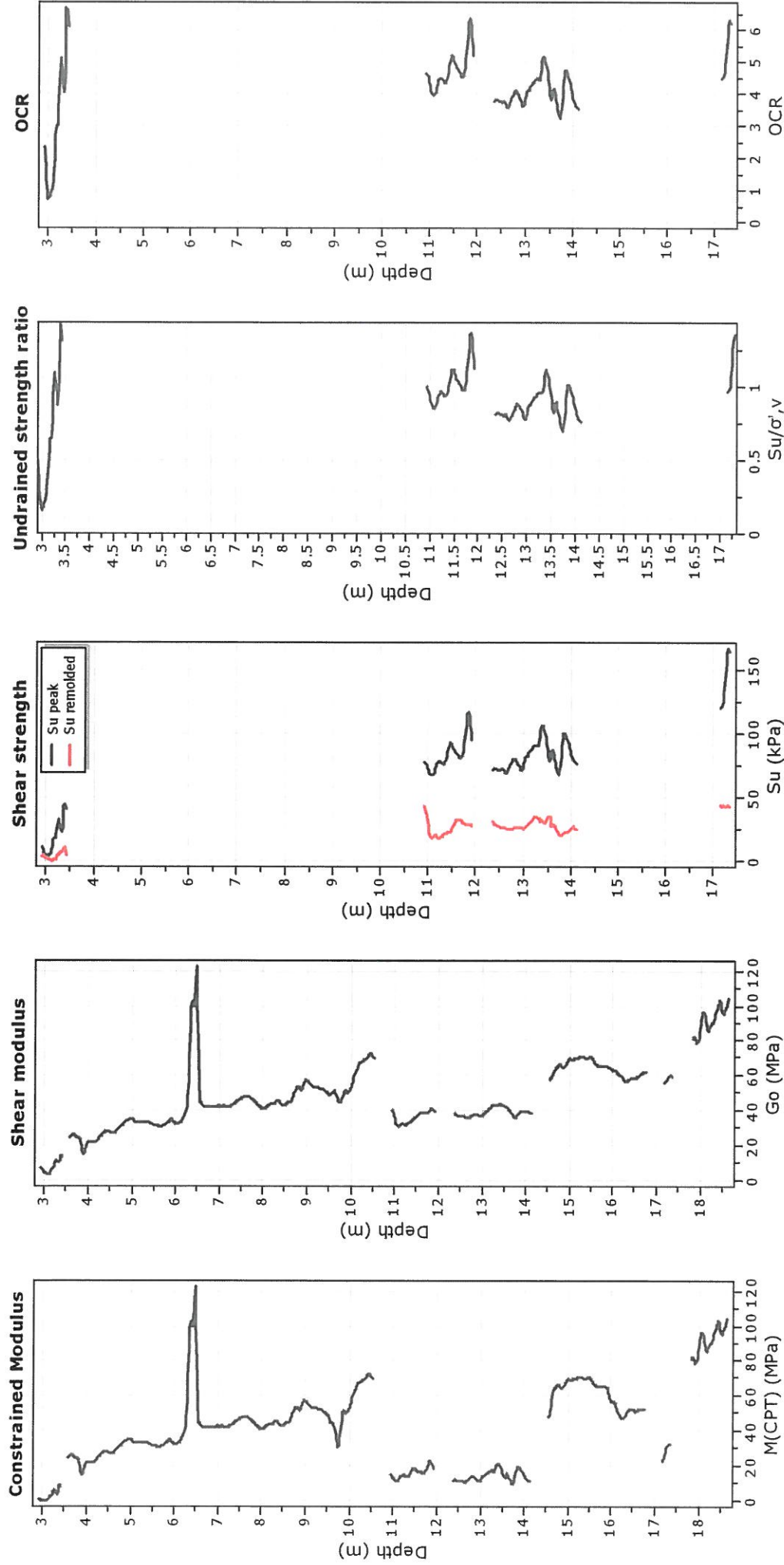


Project: Fiume Po - Sistemazione a corrente libera per la navigazione  
Location: Tratto Castelmasa - Stienta



Calculation parameters

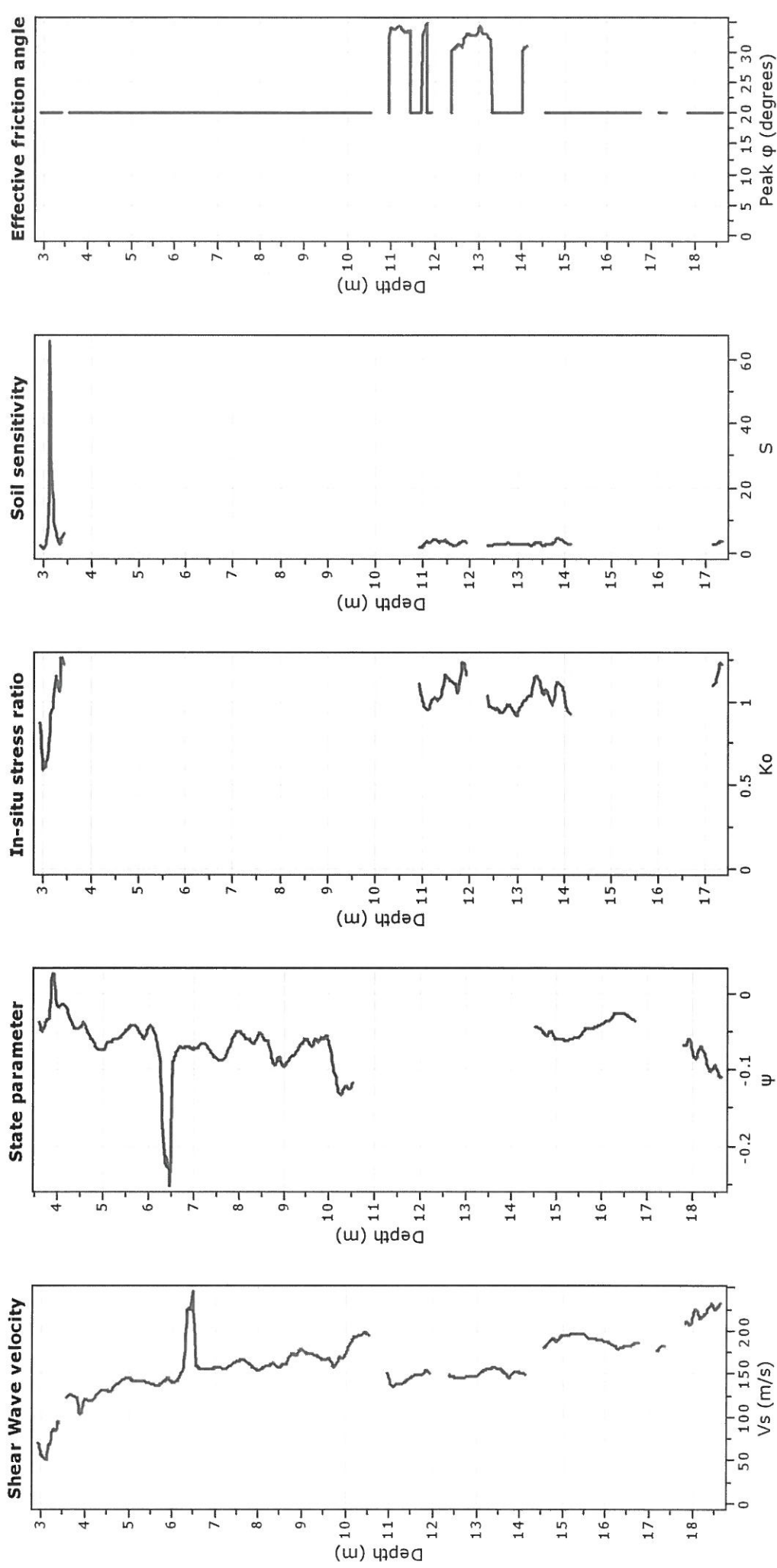
Permeability: Based on  $SBT_n$   
SPT  $N_{60}$ : Based on  $I_c$  and  $\alpha_c$   
Young's modulus: Based on variable  $\alpha$  using  $I_c$  (Robertson, 2009)  
Relative density constant,  $C_{Dr}$ : 350.0  
Phi: Based on Kulhawy & Mayne (1990)  
—●— User defined estimation data



## Calculation parameters

Constrained modulus: Based on variable  $\alpha/\rho$  using  $I_c$  and  $Q_m$  (Robertson, 2009)  
 Go: Based on variable  $\alpha/\rho$  using  $I_c$  (Robertson, 2009)  
 Undrained shear strength cone factor for clays,  $N_{kt}$ : 14  
 OCR factor for clays,  $N_{kt}$ : 0.33  
 —●— User defined estimation data

Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



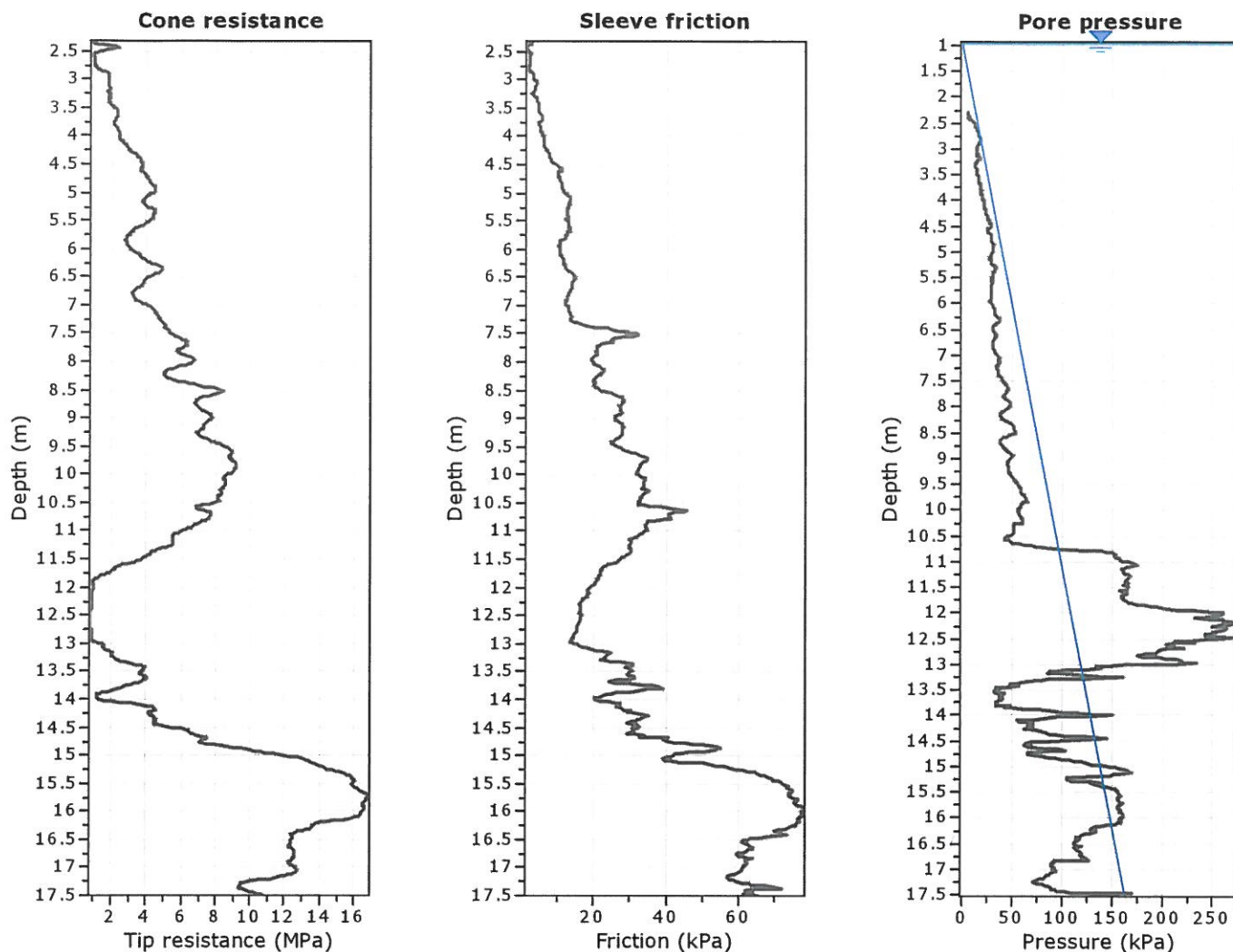
**Calculation parameters**

Soil Sensitivity factor,  $N_s$ : 7.00

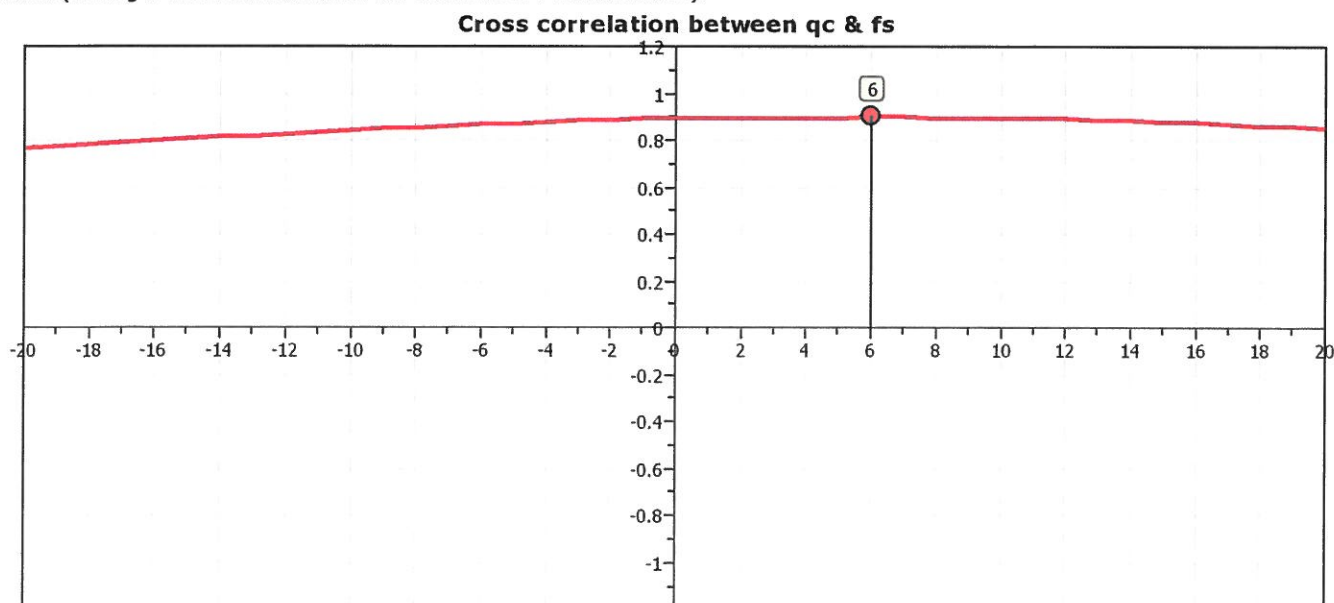
—●— User defined estimation data

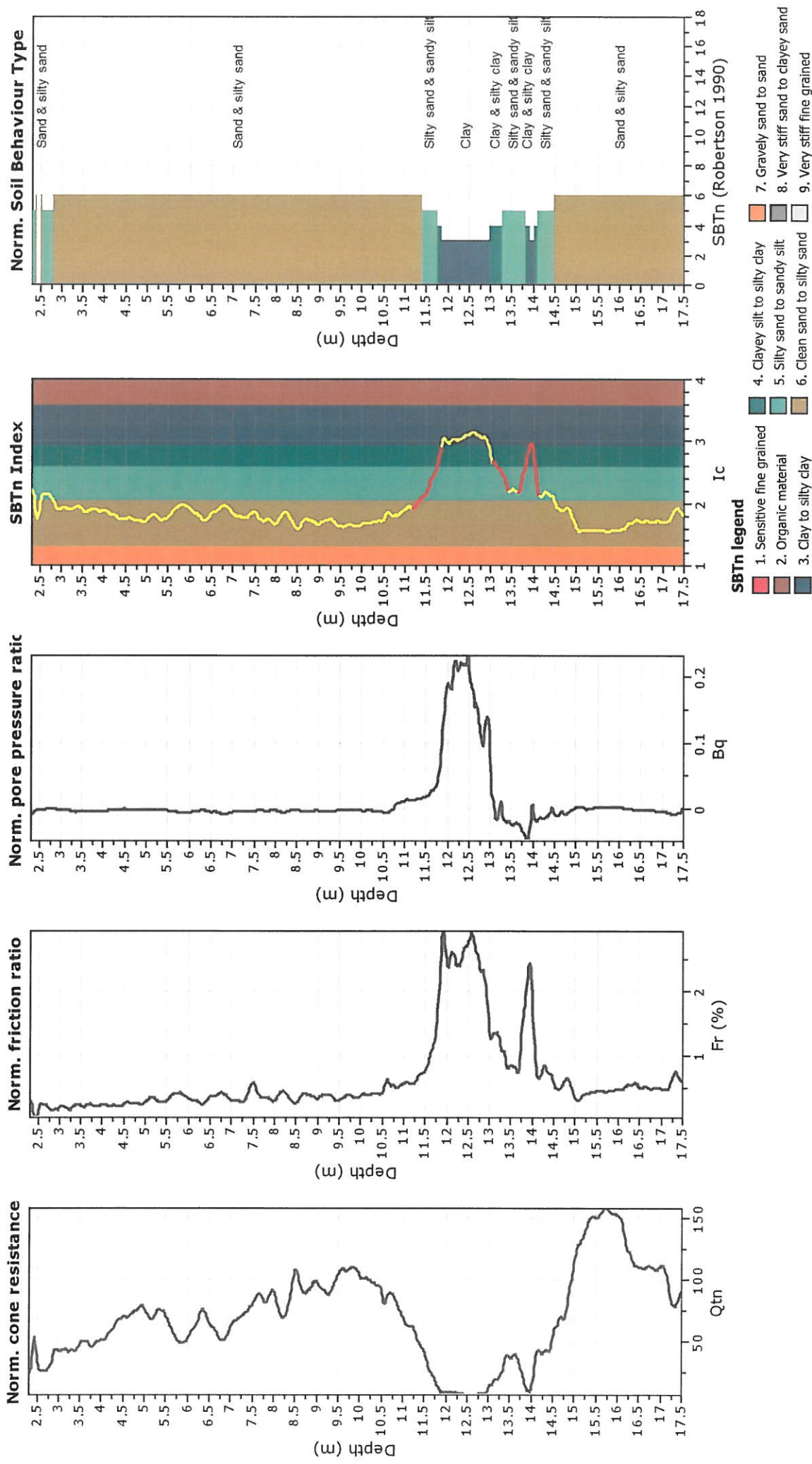
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

**Location: TRATTO CASTELMASSA - STIENTA**

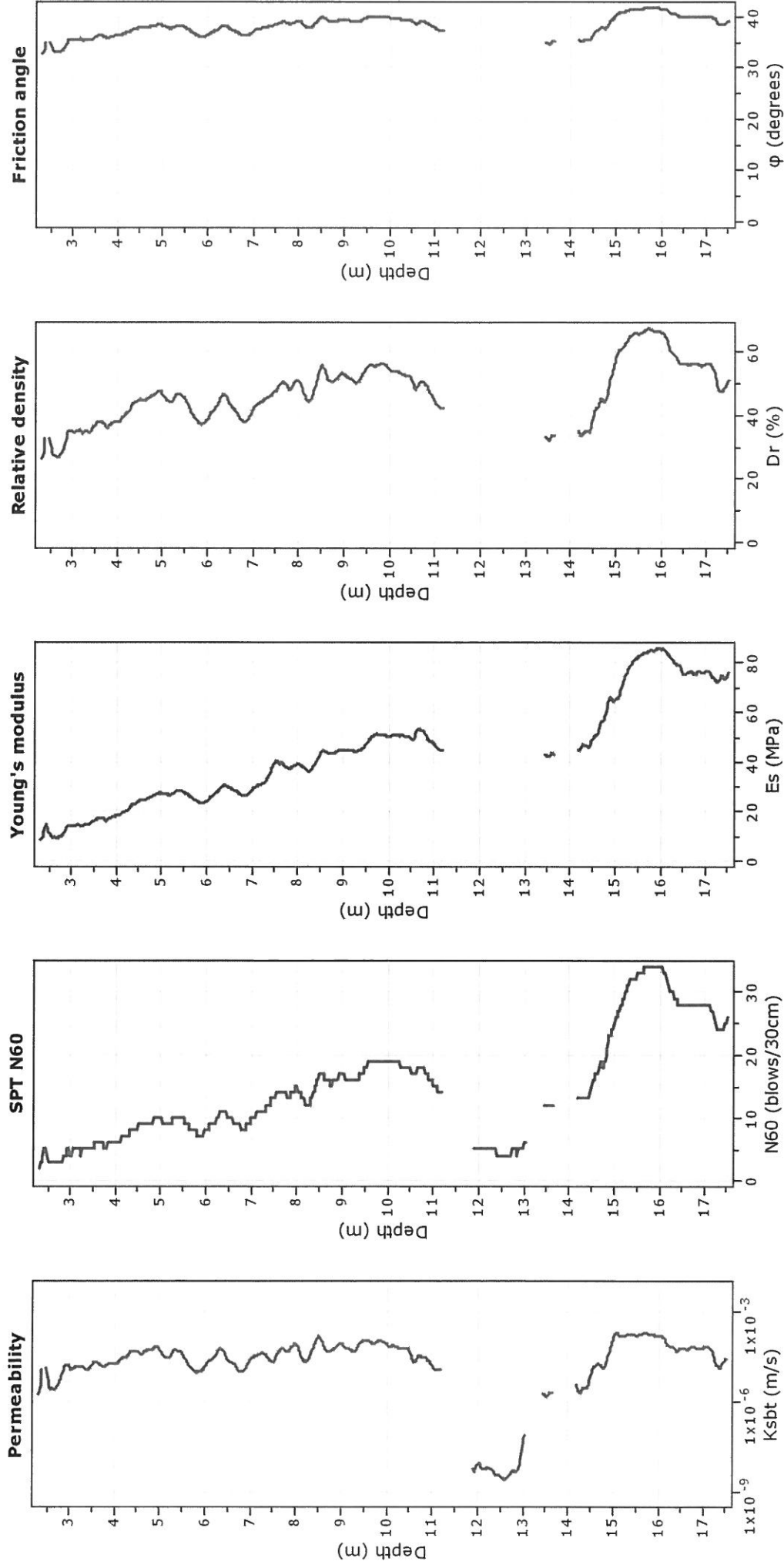


The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).





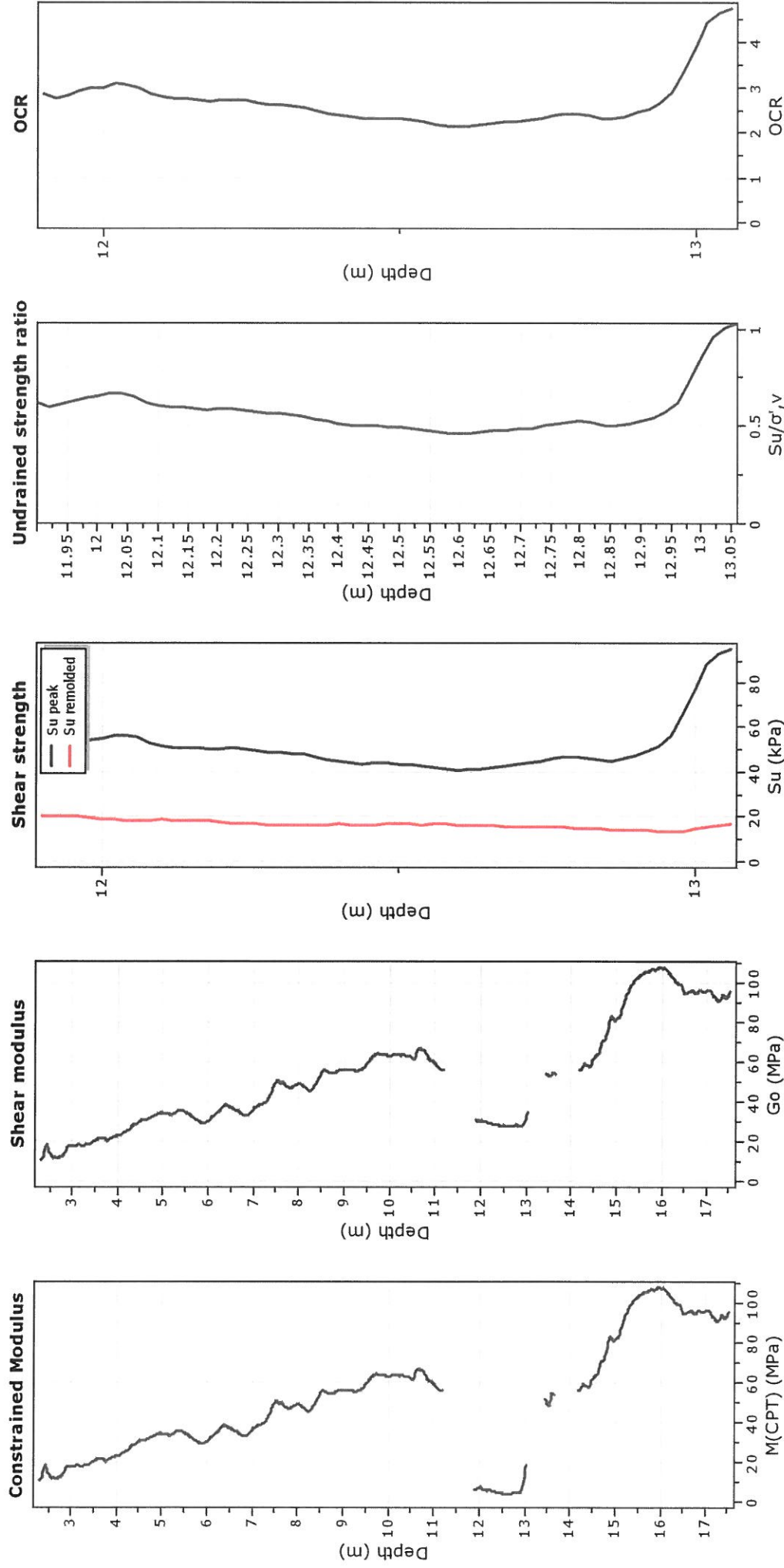
Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



## Calculation parameters

Permeability: Based on  $SBT_n$   
SPT  $N_{60}$ : Based on  $I_c$  and  $q_t$   
Young's modulus: Based on variable alpha using  $I_c$  (Robertson, 2009)  
Relative density constant,  $C_D$ : 350.0  
Phi: Based on Kulhawy & Mayne (1990)  
—●— User defined estimation data

Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



#### Calculation parameters

Constrained modulus: Based on variable  $\alpha/\beta$  using  $I_c$  and  $Q_m$  (Robertson, 2009)

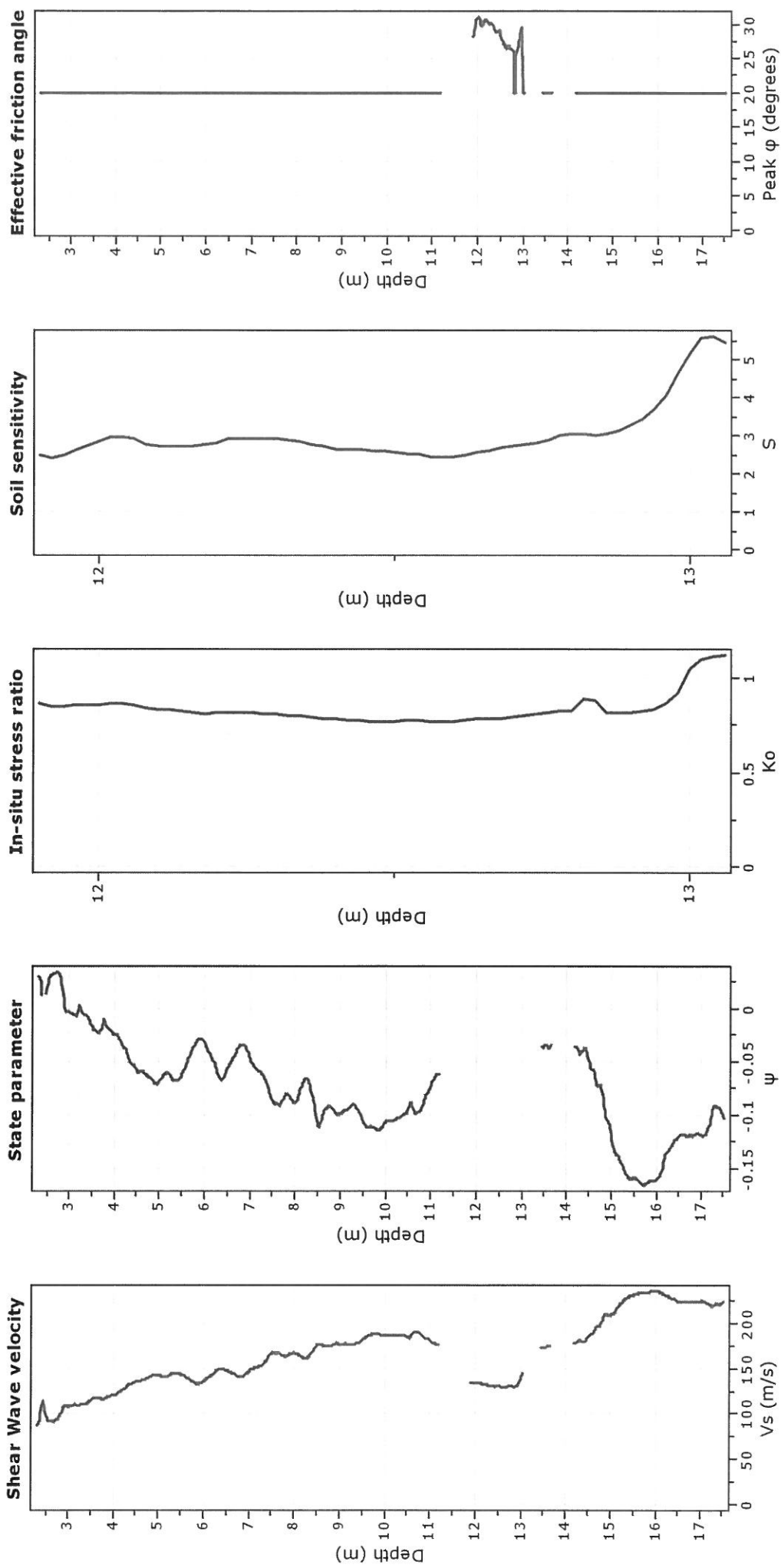
$G_0$ : Based on variable  $\alpha/\beta$  using  $I_c$  (Robertson, 2009)

Undrained shear strength cone factor for clays,  $N_{k1}$ : 14

OCR factor for clays,  $N_{k2}$ : 0.33

—●— User defined estimation data

Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



**Calculation parameters**

Soil Sensitivity factor,  $N_s$ : 7.00

—●— User defined estimation data

## CPTU 1A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

### COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

### CARATTERISTICHE DEGLI STRATI

### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	9.0	1	0.010	0.010	3.0	0.13	19.1	0.49	50.7	0.82	49.7	0.81	26.5	0.60
3	1.0	6	15.0	1	0.010	0.010	4.9	0.12	20.6	0.38	45.8	0.61	46.6	0.61	27.3	0.45
4	1.0	6	21.0	1	0.010	0.010	6.7	0.12	21.5	0.31	41.7	0.48	43.1	0.48	27.5	0.36
5	1.0	6	27.2	1	0.009	0.009	8.4	0.11	21.9	0.23	38.1	0.34	39.7	0.35	27.2	0.27
6	1.0	7	33.6	1	0.008	0.008	9.8	0.09	21.9	0.17	35.0	0.25	36.5	0.26	26.5	0.20
7	1.0	7	40.2	1	0.007	0.007	10.8	0.07	21.6	0.13	32.2	0.18	33.7	0.19	25.6	0.15
8	1.0	7	47.0	1	0.006	0.006	11.7	0.06	21.1	0.10	29.8	0.13	31.1	0.13	24.5	0.11
9	1.0	7	54.1	1	0.005	0.005	12.2	0.04	20.4	0.07	27.6	0.09	28.8	0.09	23.4	0.08
10	1.0	7	61.4	1	0.004	0.004	12.6	0.03	19.8	0.05	25.7	0.06	26.7	0.06	22.4	0.05
11	1.0	8	68.9	1	0.003	0.003	12.8	0.02	19.0	0.03	24.0	0.04	24.9	0.04	21.3	0.04
12	1.0	10	77.7	3	0.200	0.020	12.8	0.13	18.3	0.18	22.5	0.22	23.3	0.23	20.3	0.20
13	1.0	10	87.7	5	0.200	0.020	12.8	0.12	17.6	0.16	21.2	0.19	21.8	0.19	19.3	0.17
14	1.0	6	95.8	1	0.009	0.009	12.7	0.05	16.9	0.06	19.9	0.07	20.5	0.08	18.4	0.07
15	1.0	7	102.3	1	0.008	0.008	12.5	0.04	16.2	0.05	18.9	0.06	19.3	0.06	17.5	0.06
TOTALI (cm)								1.13	2.42	3.53	3.59	2.81				

### COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

### CARATTERISTICHE DEGLI STRATI

### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	9.0	1	0.010	0.010	12.0	0.37	2.0	0.09
3	1.0	6	15.0	1	0.010	0.010	12.6	0.27	3.2	0.08
4	1.0	6	21.0	1	0.010	0.010	13.4	0.21	4.4	0.08
5	1.0	6	27.2	1	0.009	0.009	14.2	0.16	5.6	0.07
6	1.0	7	33.6	1	0.008	0.008	14.9	0.13	6.6	0.06
7	1.0	7	40.2	1	0.007	0.007	15.3	0.10	7.6	0.05
8	1.0	7	47.0	1	0.006	0.006	15.6	0.07	8.4	0.04
9	1.0	7	54.1	1	0.005	0.005	15.7	0.06	9.1	0.03
10	1.0	7	61.4	1	0.004	0.004	15.7	0.04	9.6	0.03
11	1.0	8	68.9	1	0.003	0.003	15.5	0.03	10.0	0.02
12	1.0	10	77.7	3	0.200	0.020	15.3	0.16	10.3	0.11
13	1.0	10	87.7	5	0.200	0.020	15.0	0.14	10.5	0.10
14	1.0	6	95.8	1	0.009	0.009	14.6	0.06	10.6	0.04
15	1.0	7	102.3	1	0.008	0.008	14.2	0.05	10.6	0.03
TOTALI (cm)								1.83		0.84

[illegible]

# CPTU 2A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	9.0	1	0.010	0.010	3.0	0.13	19.1	0.50	50.7	0.82	49.7	0.82	26.5	0.60
3	1.0	6	15.1	1	0.009	0.009	4.9	0.11	20.6	0.34	45.8	0.55	46.6	0.55	27.3	0.40
4	1.0	6	21.3	1	0.009	0.009	6.7	0.11	21.5	0.27	41.7	0.42	43.1	0.43	27.5	0.32
5	1.0	6	27.5	1	0.009	0.009	8.4	0.10	21.9	0.23	38.1	0.34	39.7	0.35	27.2	0.27
6	1.0	6	33.8	1	0.009	0.009	9.8	0.10	21.9	0.20	35.0	0.28	36.5	0.29	26.5	0.23
7	1.0	6	40.1	1	0.009	0.009	10.8	0.09	21.6	0.17	32.2	0.23	33.7	0.24	25.6	0.19
8	1.0	6	46.5	1	0.008	0.008	11.7	0.08	21.1	0.13	29.8	0.17	31.1	0.18	24.5	0.15
9	1.0	7	52.9	1	0.008	0.008	12.2	0.07	20.4	0.11	27.6	0.15	28.8	0.15	23.4	0.13
10	1.0	7	59.4	1	0.008	0.008	12.6	0.07	19.8	0.10	25.7	0.12	26.7	0.13	22.4	0.11
11	1.0	6	65.8	1	0.009	0.009	12.8	0.07	19.0	0.10	24.0	0.12	24.9	0.13	21.3	0.11
12	1.0	6	72.0	1	0.009	0.009	12.8	0.06	18.3	0.09	22.5	0.11	23.3	0.11	20.3	0.10
13	1.0	7	78.4	1	0.008	0.008	12.8	0.05	17.6	0.07	21.2	0.08	21.8	0.09	19.3	0.08
14	1.0	7	85.0	1	0.007	0.007	12.7	0.04	16.9	0.06	19.9	0.06	20.5	0.07	18.4	0.06
15	1.0	7	92.0	1	0.005	0.005	12.5	0.03	16.2	0.04	18.9	0.04	19.3	0.04	17.5	0.04
TOTALI (cm)								1.12	2.39	3.50	3.56	2.78				

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'_{v0}$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	9.0	1	0.010	0.010	12.0	0.37	2.0	0.09
3	1.0	6	15.1	1	0.009	0.009	12.6	0.24	3.2	0.08
4	1.0	6	21.3	1	0.009	0.009	13.4	0.19	4.4	0.07
5	1.0	6	27.5	1	0.009	0.009	14.2	0.16	5.6	0.07
6	1.0	6	33.8	1	0.009	0.009	14.9	0.14	6.6	0.07
7	1.0	6	40.1	1	0.009	0.009	15.3	0.13	7.6	0.07
8	1.0	6	46.5	1	0.008	0.008	15.6	0.10	8.4	0.06
9	1.0	7	52.9	1	0.008	0.008	15.7	0.09	9.1	0.05
10	1.0	7	59.4	1	0.008	0.008	15.7	0.08	9.6	0.05
11	1.0	6	65.8	1	0.009	0.009	15.5	0.08	10.0	0.06
12	1.0	6	72.0	1	0.009	0.009	15.3	0.08	10.3	0.05
13	1.0	7	78.4	1	0.008	0.008	15.0	0.06	10.5	0.04
14	1.0	7	85.0	1	0.007	0.007	14.6	0.05	10.6	0.04
15	1.0	7	92.0	1	0.005	0.005	14.2	0.03	10.6	0.02
TOTALI (cm)								1.80	0.82	

[illegible]

### CPTU 3B PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	12.9	1	0.011	0.011	3.0	0.10	19.1	0.43	50.7	0.76	49.7	0.75	26.5	0.53
3	1.0	6	18.8	1	0.010	0.010	4.9	0.10	20.6	0.32	45.8	0.54	46.6	0.54	27.3	0.39
4	1.0	6	24.9	1	0.010	0.010	6.7	0.10	21.5	0.27	41.7	0.43	43.1	0.44	27.5	0.32
5	1.0	6	31.0	1	0.009	0.009	8.4	0.09	21.9	0.21	38.1	0.31	39.7	0.32	27.2	0.25
6	1.0	6	37.2	1	0.009	0.009	9.8	0.09	21.9	0.18	35.0	0.26	36.5	0.27	26.5	0.21
7	1.0	7	43.5	1	0.008	0.008	10.8	0.08	21.6	0.14	32.2	0.19	33.7	0.20	25.6	0.16
8	1.0	7	50.3	1	0.006	0.006	11.7	0.05	21.1	0.09	29.8	0.12	31.1	0.13	24.5	0.10
9	1.0	8	57.5	1	0.004	0.004	12.2	0.03	20.4	0.05	27.6	0.07	28.8	0.07	23.4	0.06
10	1.0	10	66.3	1	0.200	0.020	12.6	1.51	19.8	2.27	25.7	2.85	26.7	2.94	22.4	2.53
11	1.0	10	76.3	1	0.200	0.020	12.8	1.35	19.0	1.94	24.0	2.38	24.9	2.45	21.3	2.14
12	1.0	10	86.3	1	0.200	0.020	12.8	1.21	18.3	1.67	22.5	2.01	23.3	2.07	20.3	1.83
13	1.0	7	94.7	1	0.006	0.006	12.8	0.03	17.6	0.04	21.2	0.05	21.8	0.05	19.3	0.05
14	1.0	7	101.8	1	0.005	0.005	12.7	0.03	16.9	0.03	19.9	0.04	20.5	0.04	18.4	0.04
15	1.0	8	109.2	1	0.003	0.003	12.5	0.01	16.2	0.02	18.9	0.02	19.3	0.02	17.5	0.02

TOTALI (cm)

4.79

7.67

10.03

10.30

8.63

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	12.9	1	0.011	0.011	12.0	0.31	2.0	0.07
3	1.0	6	18.8	1	0.010	0.010	12.6	0.22	3.2	0.07
4	1.0	6	24.9	1	0.010	0.010	13.4	0.19	4.4	0.07
5	1.0	6	31.0	1	0.009	0.009	14.2	0.15	5.6	0.06
6	1.0	6	37.2	1	0.009	0.009	14.9	0.13	6.6	0.06
7	1.0	7	43.5	1	0.008	0.008	15.3	0.10	7.6	0.06
8	1.0	7	50.3	1	0.006	0.006	15.6	0.07	8.4	0.04
9	1.0	8	57.5	1	0.004	0.004	15.7	0.04	9.1	0.03
10	1.0	10	66.3	1	0.200	0.020	15.7	1.84	9.6	1.17
11	1.0	10	76.3	1	0.200	0.020	15.5	1.61	10.0	1.07
12	1.0	10	86.3	1	0.200	0.020	15.3	1.41	10.3	0.98
13	1.0	7	94.7	1	0.006	0.006	15.0	0.04	10.5	0.03
14	1.0	7	101.8	1	0.005	0.005	14.6	0.03	10.6	0.02
15	1.0	8	109.2	1	0.003	0.003	14.2	0.02	10.6	0.01

TOTALI (cm)

6.17

3.74

3.46

# CPTU 3C PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

### CARATTERISTICHE DEGLI STRATI

### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	13.0	1	0.010	0.010	3.0	0.09	19.1	0.39	50.7	0.69	49.7	0.68	26.5	0.48
3	1.0	6	18.9	1	0.010	0.010	4.9	0.10	20.6	0.32	45.8	0.53	46.6	0.54	27.3	0.39
4	1.0	6	25.0	1	0.010	0.010	6.7	0.10	21.5	0.27	41.7	0.43	43.1	0.44	27.5	0.32
5	1.0	6	31.1	1	0.009	0.009	8.4	0.09	21.9	0.21	38.1	0.31	39.7	0.32	27.2	0.25
6	1.0	6	37.3	1	0.009	0.009	9.8	0.09	21.9	0.18	35.0	0.26	36.5	0.27	26.5	0.21
7	1.0	7	43.8	1	0.008	0.008	10.8	0.08	21.6	0.14	32.2	0.19	33.7	0.20	25.6	0.16
8	1.0	7	50.3	1	0.007	0.007	11.7	0.06	21.1	0.11	29.8	0.14	31.1	0.15	24.5	0.12
9	1.0	10	58.6	4	0.200	0.020	12.2	0.16	20.4	0.26	27.6	0.34	28.8	0.35	23.4	0.29
10	1.0	10	68.6	4	0.200	0.020	12.6	0.15	19.8	0.22	25.7	0.28	26.7	0.29	22.4	0.24
11	1.0	10	78.6	5	0.200	0.020	12.8	0.13	19.0	0.19	24.0	0.23	24.9	0.24	21.3	0.21
12	1.0	10	88.6	4	0.200	0.020	12.8	0.12	18.3	0.16	22.5	0.20	23.3	0.20	20.3	0.18
13	1.0	6	96.8	1	0.009	0.009	12.8	0.05	17.6	0.07	21.2	0.08	21.8	0.08	19.3	0.07
14	1.0	6	103.0	1	0.009	0.009	12.7	0.05	16.9	0.06	19.9	0.07	20.5	0.07	18.4	0.06
15	1.0	10	111.1	6	0.200	0.020	12.5	0.09	16.2	0.12	18.9	0.14	19.3	0.14	17.5	0.13
16	1.0	7	119.5	1	0.006	0.006	12.3	0.03	15.6	0.03	17.9	0.04	18.3	0.04	16.7	0.03
TOTALI (cm)								1.39	2.72	3.92	3.99	3.15				

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

### CARATTERISTICHE DEGLI STRATI

### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'_{v0}$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	13.0	1	0.010	0.010	12.0	0.28	2.0	0.06
3	1.0	6	18.9	1	0.010	0.010	12.6	0.22	3.2	0.07
4	1.0	6	25.0	1	0.010	0.010	13.4	0.19	4.4	0.07
5	1.0	6	31.1	1	0.009	0.009	14.2	0.15	5.6	0.06
6	1.0	6	37.3	1	0.009	0.009	14.9	0.13	6.6	0.06
7	1.0	7	43.8	1	0.008	0.008	15.3	0.10	7.6	0.06
8	1.0	7	50.3	1	0.007	0.007	15.6	0.08	8.4	0.05
9	1.0	10	58.6	4	0.200	0.020	15.7	0.21	9.1	0.12
10	1.0	10	68.6	4	0.200	0.020	15.7	0.18	9.6	0.11
11	1.0	10	78.6	5	0.200	0.020	15.5	0.16	10.0	0.10
12	1.0	10	88.6	4	0.200	0.020	15.3	0.14	10.3	0.10
13	1.0	6	96.8	1	0.009	0.009	15.0	0.06	10.5	0.04
14	1.0	6	103.0	1	0.009	0.009	14.6	0.05	10.6	0.04
15	1.0	10	111.1	6	0.200	0.020	14.2	0.10	10.6	0.08
16	1.0	7	119.5	1	0.006	0.006	13.9	0.03	10.6	0.02
TOTALI (cm)								2.08	1.05	

[illegible]

# CPTU 3D PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	12.9	1	0.011	0.011	3.0	0.10	19.1	0.43	50.7	0.76	49.7	0.75	26.5	0.53
3	1.0	6	18.8	1	0.010	0.010	4.9	0.10	20.6	0.32	45.8	0.54	46.6	0.54	27.3	0.39
4	1.0	6	24.9	1	0.009	0.009	6.7	0.09	21.5	0.24	41.7	0.38	43.1	0.39	27.5	0.29
5	1.0	6	31.2	1	0.009	0.009	8.4	0.09	21.9	0.21	38.1	0.31	39.7	0.32	27.2	0.25
6	1.0	6	37.5	1	0.008	0.008	9.8	0.08	21.9	0.16	35.0	0.23	36.5	0.24	26.5	0.19
7	1.0	7	44.0	1	0.007	0.007	10.8	0.07	21.6	0.12	32.2	0.17	33.7	0.17	25.6	0.14
8	1.0	7	50.7	1	0.007	0.007	11.7	0.06	21.1	0.11	29.8	0.14	31.1	0.15	24.5	0.12
9	1.0	7	57.4	1	0.007	0.007	12.2	0.06	20.4	0.09	27.6	0.12	28.8	0.12	23.4	0.10
10	1.0	6	63.8	1	0.010	0.010	12.6	0.08	19.8	0.12	25.7	0.15	26.7	0.15	22.4	0.13
11	1.0	10	71.8	3	0.200	0.020	12.8	0.14	19.0	0.20	24.0	0.25	24.9	0.26	21.3	0.23
12	1.0	6	79.8	1	0.010	0.010	12.8	0.06	18.3	0.09	22.5	0.11	23.3	0.11	20.3	0.10
13	1.0	6	85.9	1	0.009	0.009	12.8	0.05	17.6	0.07	21.2	0.09	21.8	0.09	19.3	0.08
14	1.0	8	93.2	1	0.001	0.001	12.7	0.01	16.9	0.01	19.9	0.01	20.5	0.01	18.4	0.01
15	1.0	8	101.1	1	0.003	0.003	12.5	0.02	16.2	0.02	18.9	0.02	19.3	0.02	17.5	0.02
16	1.0	7	108.5	1	0.005	0.005	12.3	0.02	15.6	0.03	17.9	0.03	18.3	0.03	16.7	0.03
TOTALI (cm)								1.04	2.23	3.30	3.36	2.60				

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

## CARATTERISTICHE DEGLI STRATI

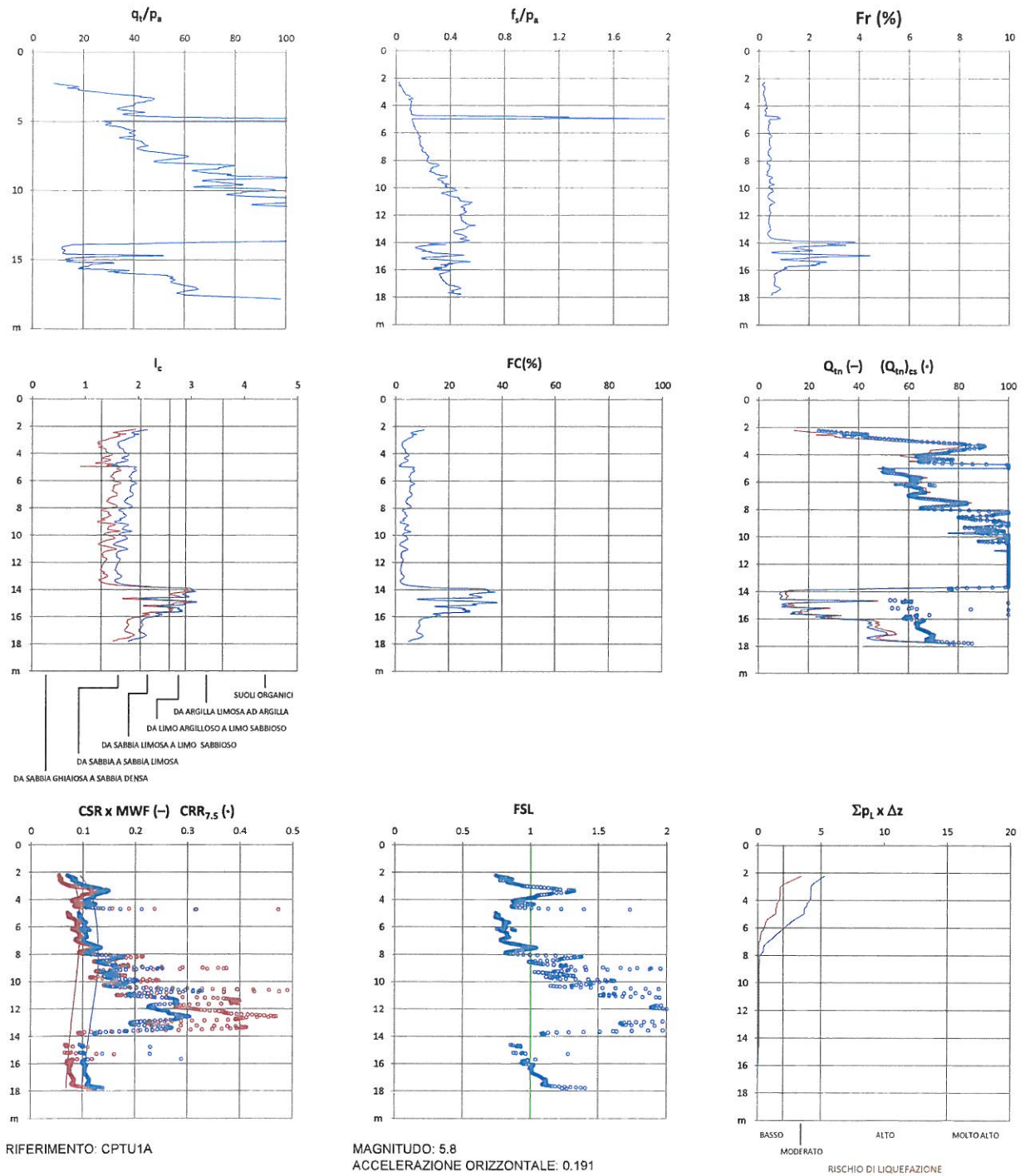
## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	12.9	1	0.011	0.011	12.0	0.31	2.0	0.07
3	1.0	6	18.8	1	0.010	0.010	12.6	0.22	3.2	0.07
4	1.0	6	24.9	1	0.009	0.009	13.4	0.17	4.4	0.06
5	1.0	6	31.2	1	0.009	0.009	14.2	0.15	5.6	0.06
6	1.0	6	37.5	1	0.008	0.008	14.9	0.12	6.6	0.06
7	1.0	7	44.0	1	0.007	0.007	15.3	0.09	7.6	0.05
8	1.0	7	50.7	1	0.007	0.007	15.6	0.08	8.4	0.05
9	1.0	7	57.4	1	0.007	0.007	15.7	0.07	9.1	0.04
10	1.0	6	63.8	1	0.010	0.010	15.7	0.10	9.6	0.06
11	1.0	10	71.8	3	0.200	0.020	15.5	0.17	10.0	0.11
12	1.0	6	79.8	1	0.010	0.010	15.3	0.08	10.3	0.05
13	1.0	6	85.9	1	0.009	0.009	15.0	0.06	10.5	0.04
14	1.0	8	93.2	1	0.001	0.001	14.6	0.01	10.6	0.00
15	1.0	8	101.1	1	0.003	0.003	14.2	0.02	10.6	0.01
16	1.0	7	108.5	1	0.005	0.005	13.9	0.03	10.6	0.02
TOTALI (cm)								1.67	0.77	

[illegible]

## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



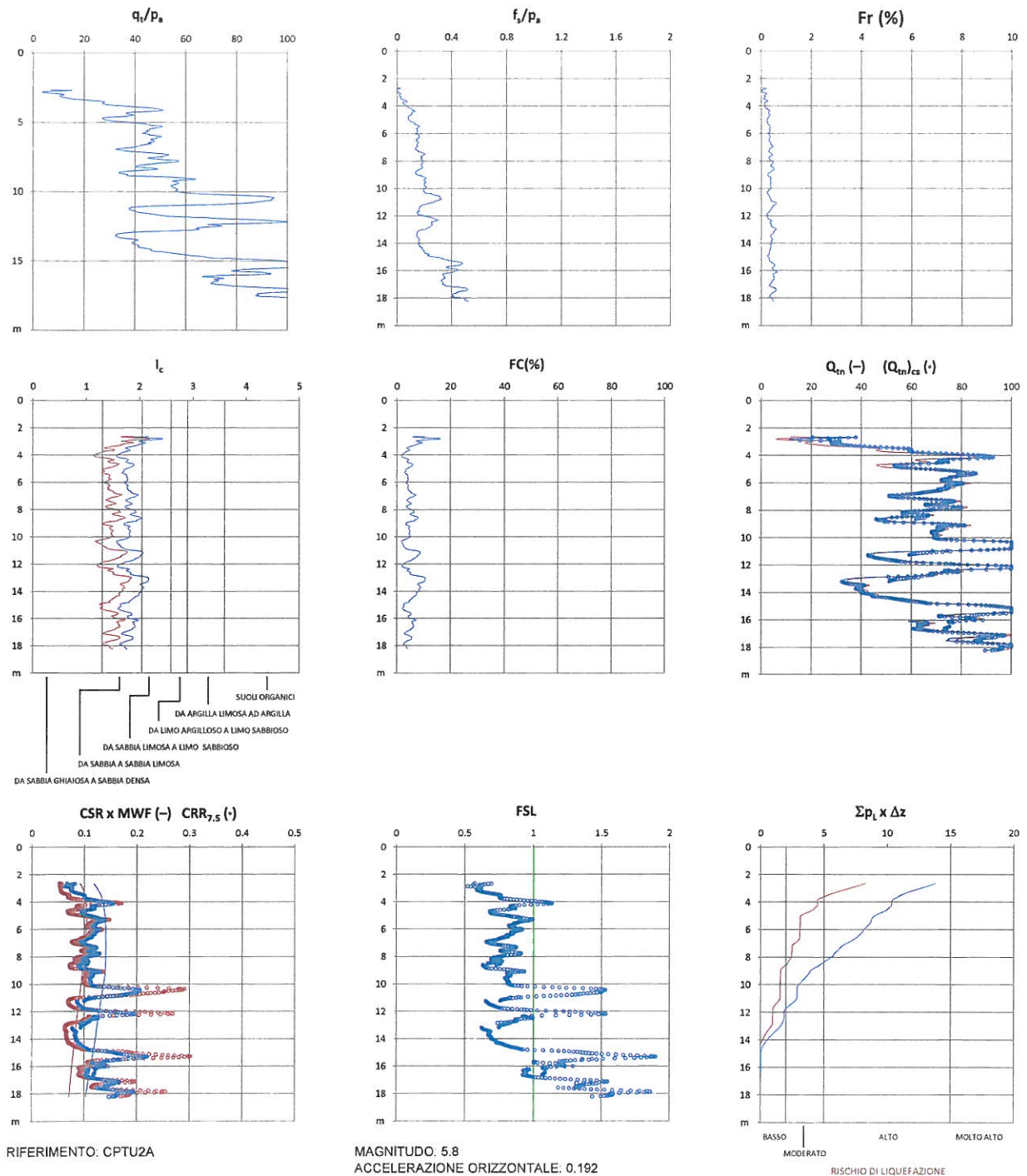
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MAGNITUDO: 5.8  
ACCELERAZIONE ORIZZONTALE: 0.191

SOFTWARE GIANVITO CASSINADRI 2014

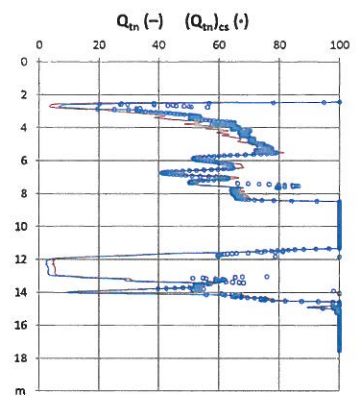
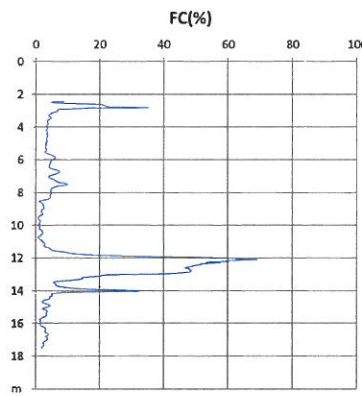
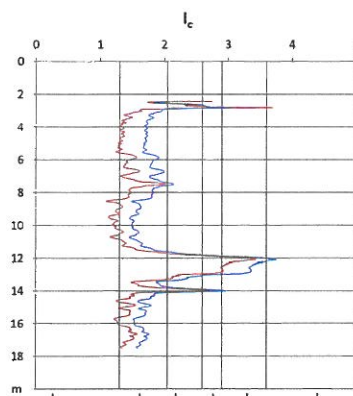
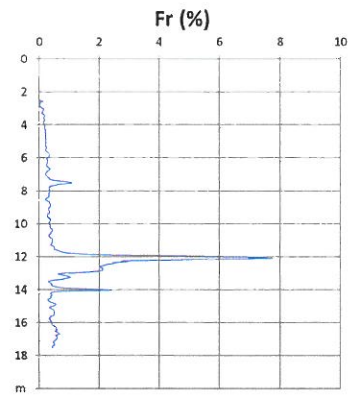
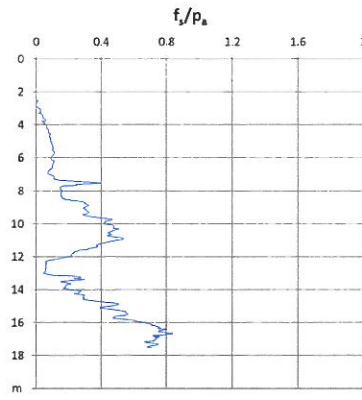
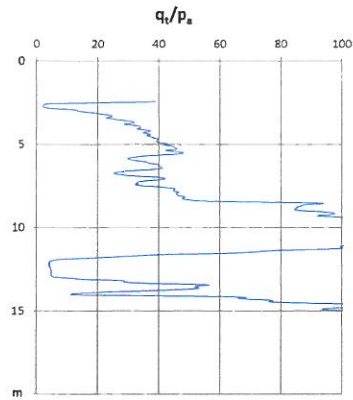
## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)

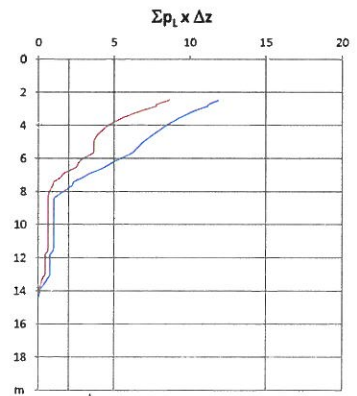
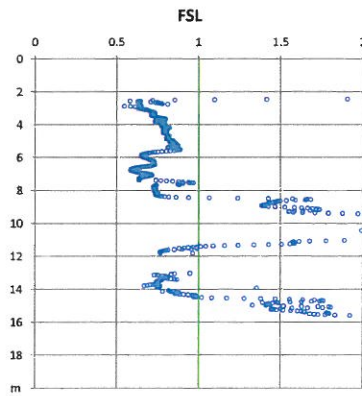
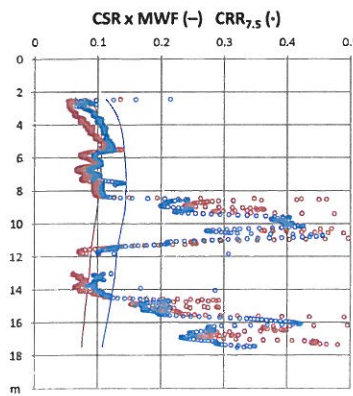


## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



DA SABBIA GHIAIOSA A SABBIA DENSA  
DA SABBIA A SABBIA LIMOSA  
DA SABBIA LIMOSA A LIMO SABBIOSO  
DA LIMO ARGILLOSO A LIMO SABBIOSO  
DA ARGILLA LIMOSA AD ARGILLA  
SUOLI ORGANICI



RIFERIMENTO: CPTU3B

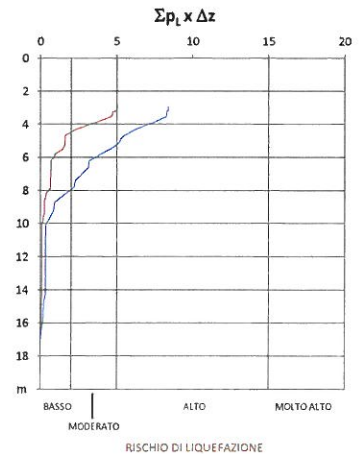
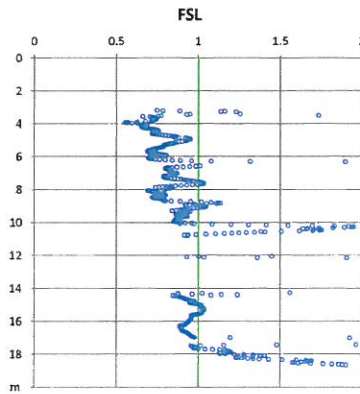
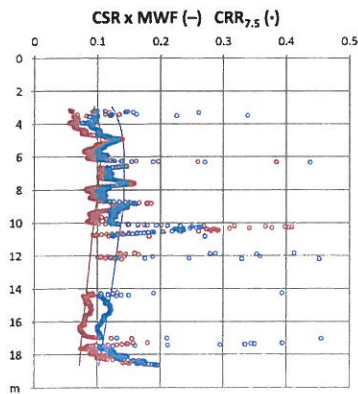
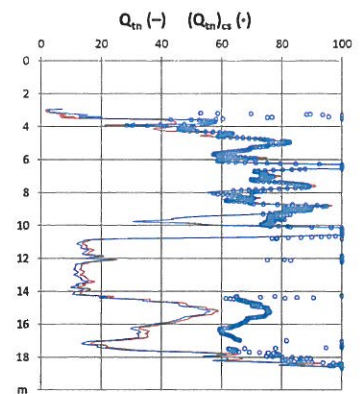
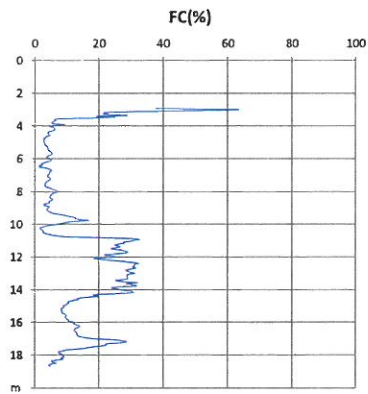
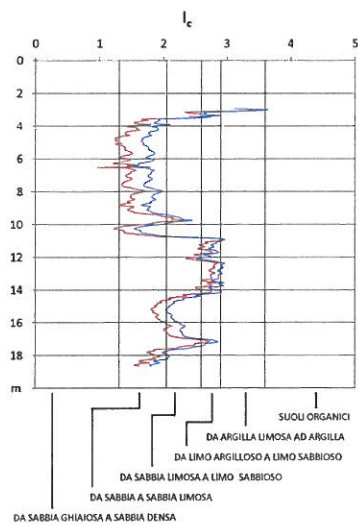
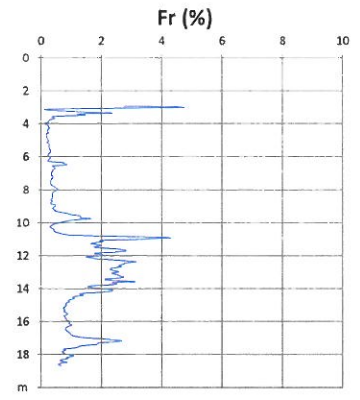
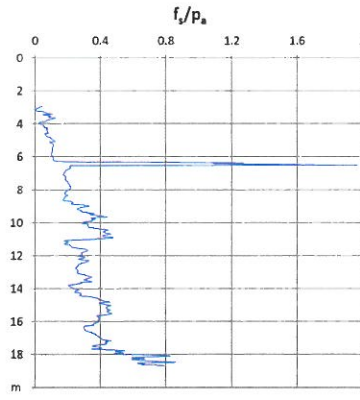
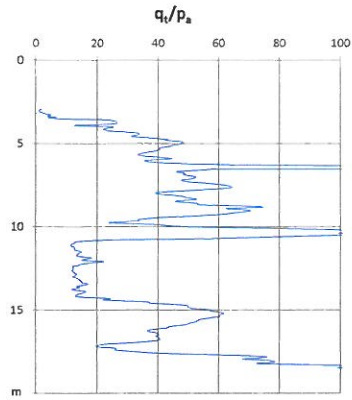
MAGNITUDO: 5.8  
ACCELERAZIONE ORIZZONTALE: 0.197

RISCHIO DI LIQUEFAZIONE

SOFTWARE GIANVITO CASSINADRI 2014

## RISCHIO LIQUEFAZIONE

(Robertson & Wride, 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



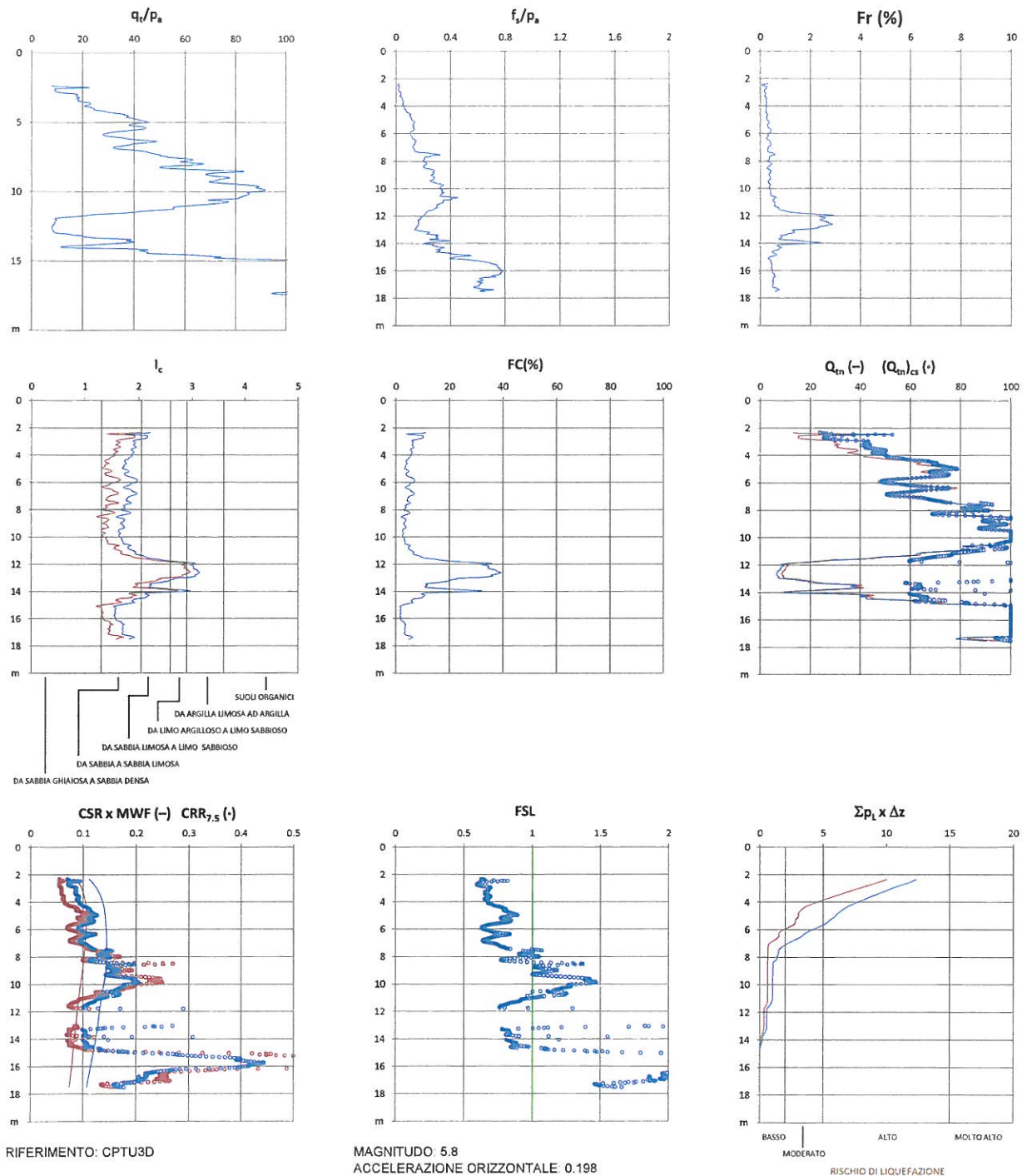
RIFERIMENTO: CPTU3C

MAGNITUDO: 5.8  
ACCELERAZIONE ORIZZONTALE: 0.197

SOFTWARE GIANVITO CASSINADRI 2014

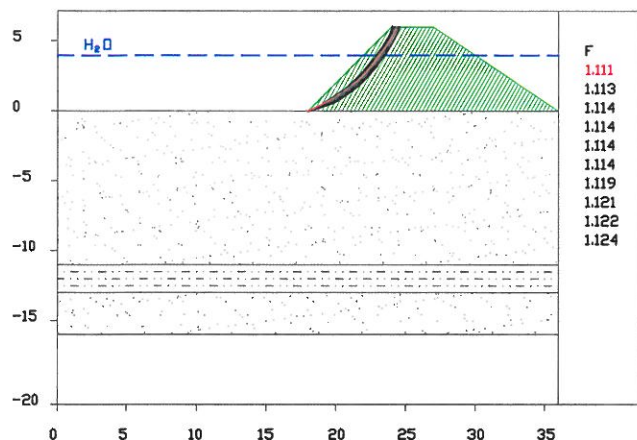
## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)

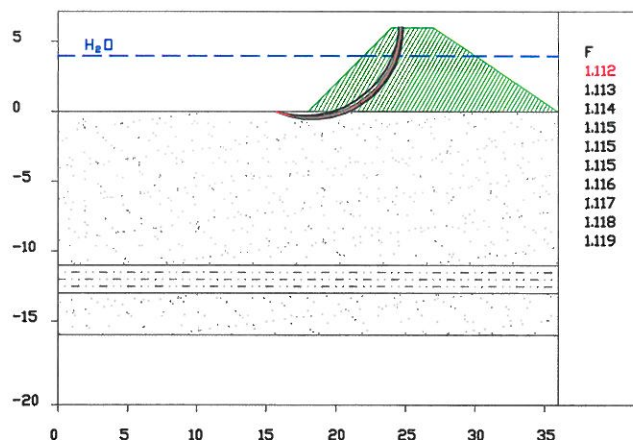


## VERIFICHE DI STABILITÀ

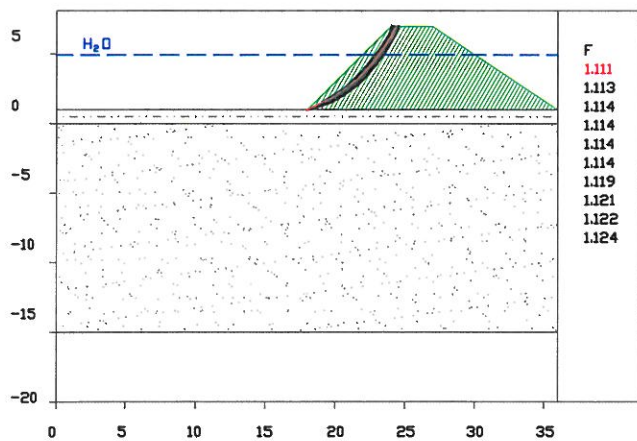
CPTU 1A - SENZA SISMA E COESIONE = 0.6 kPa



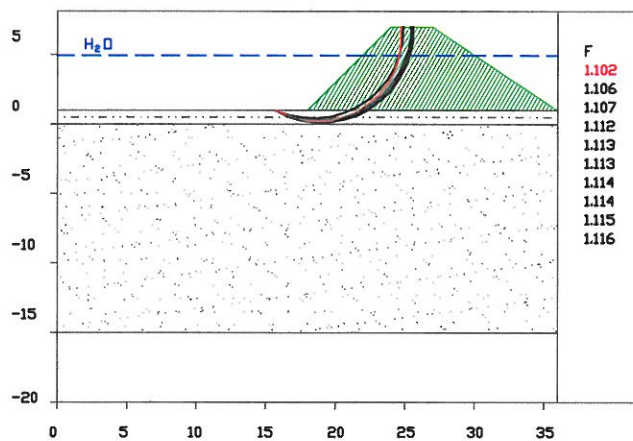
CPTU 1A - CON SISMA E COESIONE = 2 kPa



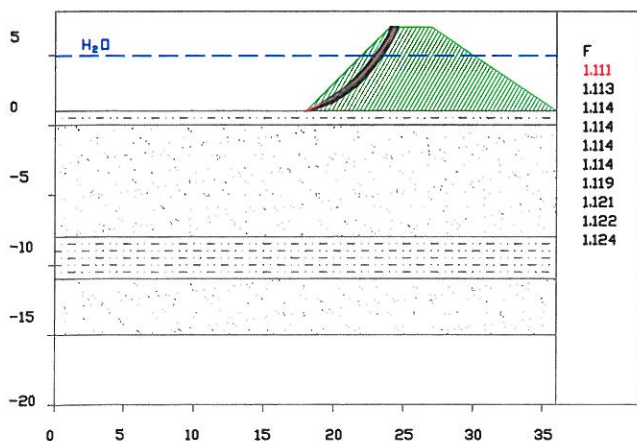
CPTU 2A - SENZA SISMA E COESIONE = 0.6 kPa



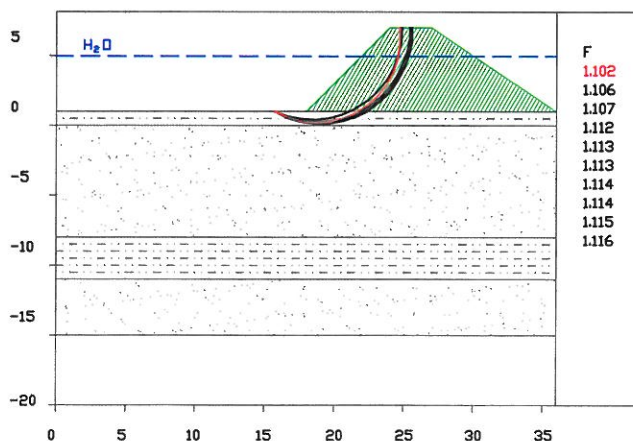
CPTU 2A - CON SISMA E COESIONE = 3 kPa



CPTU 3B - SENZA SISMA E COESIONE = 0.6 kPa

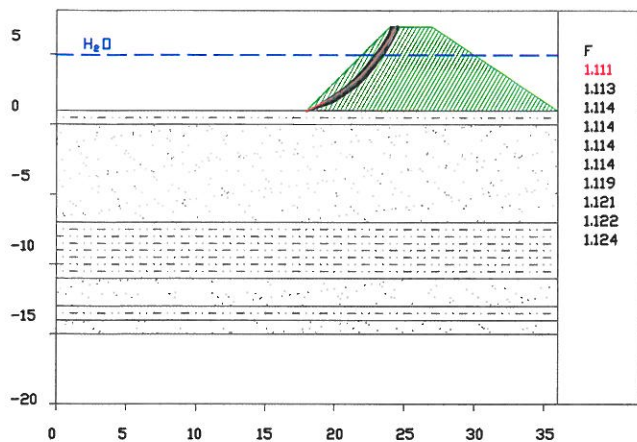


CPTU 3B - CON SISMA E COESIONE = 3 kPa

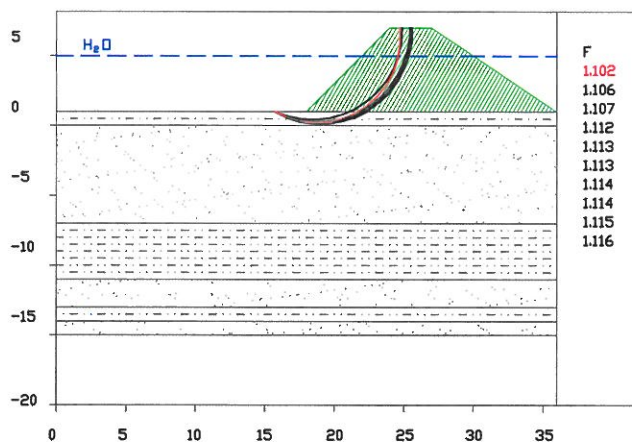


## VERIFICHE DI STABILITÀ

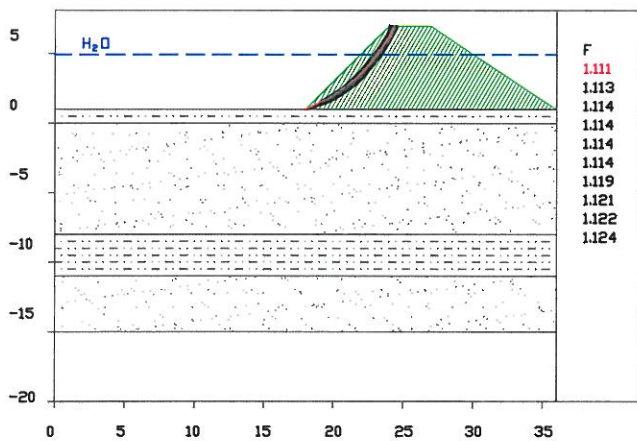
CPTU 3C - SENZA SISMA E COESIONE = 0.6 kPa



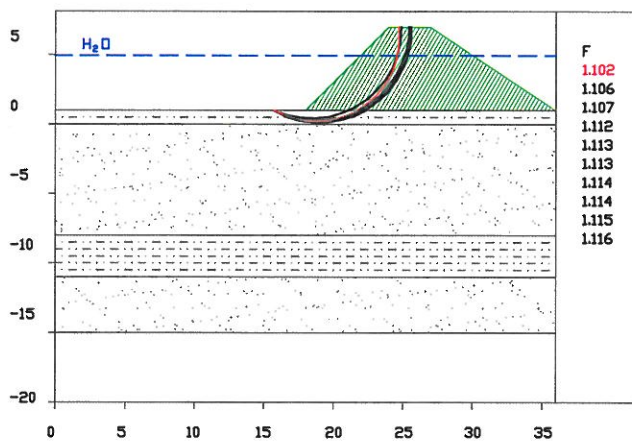
CPTU 3C - CON SISMA E COESIONE = 3 kPa



CPTU 3D - SENZA SISMA E COESIONE = 0.6 kPa



CPTU 3D - CON SISMA E COESIONE = 3 kPa





**CALTO**

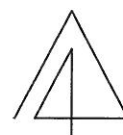


PROVA PENETROMETRICA



OPERE IN PROGETTO

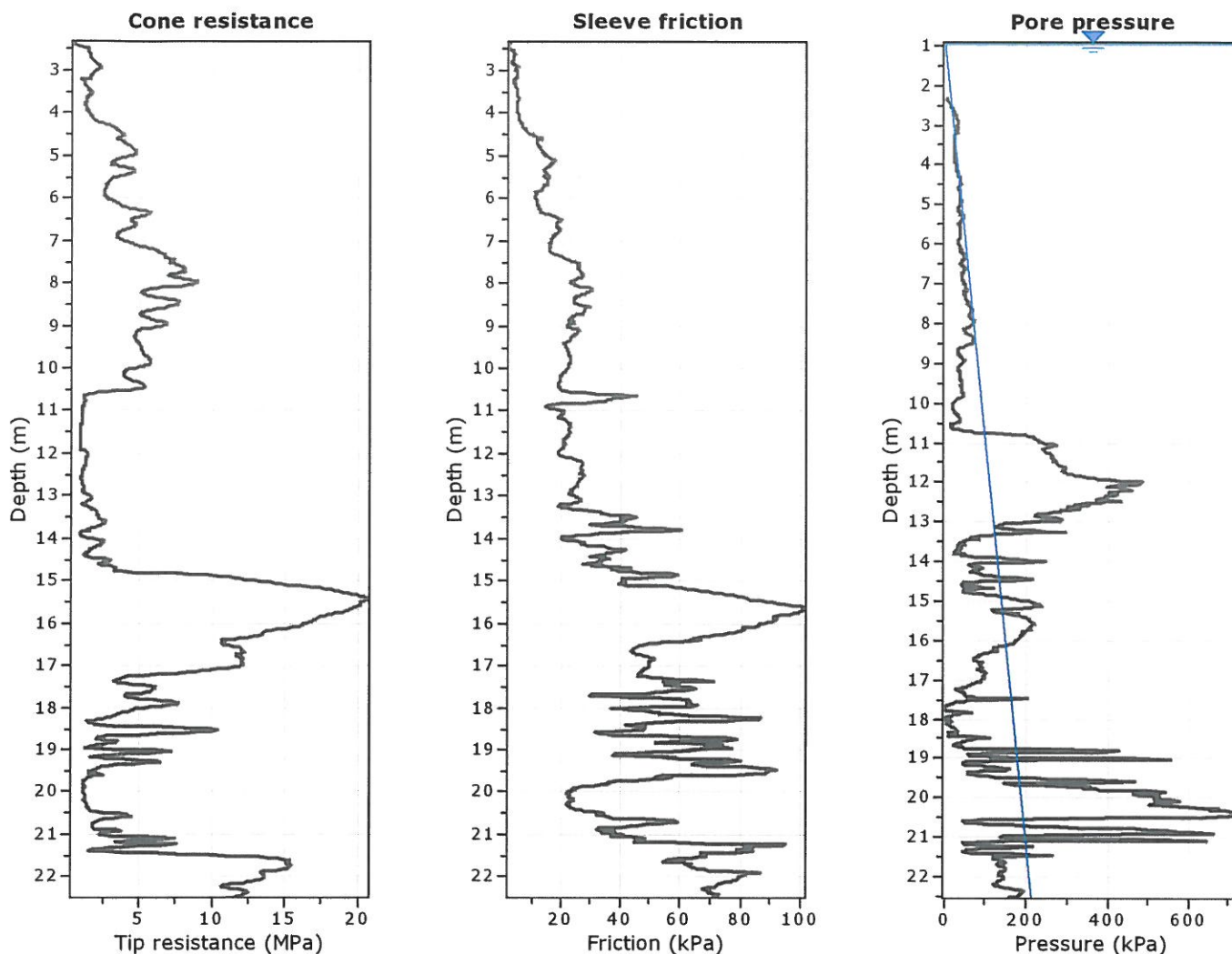
LEGENDA



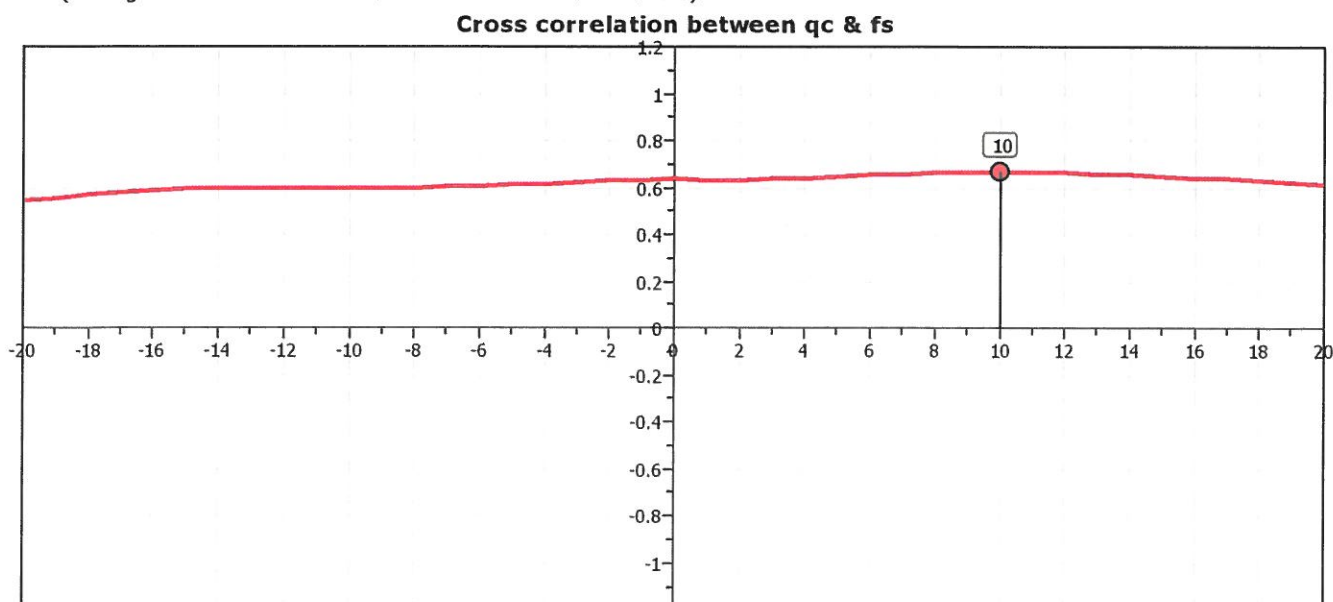
NORD

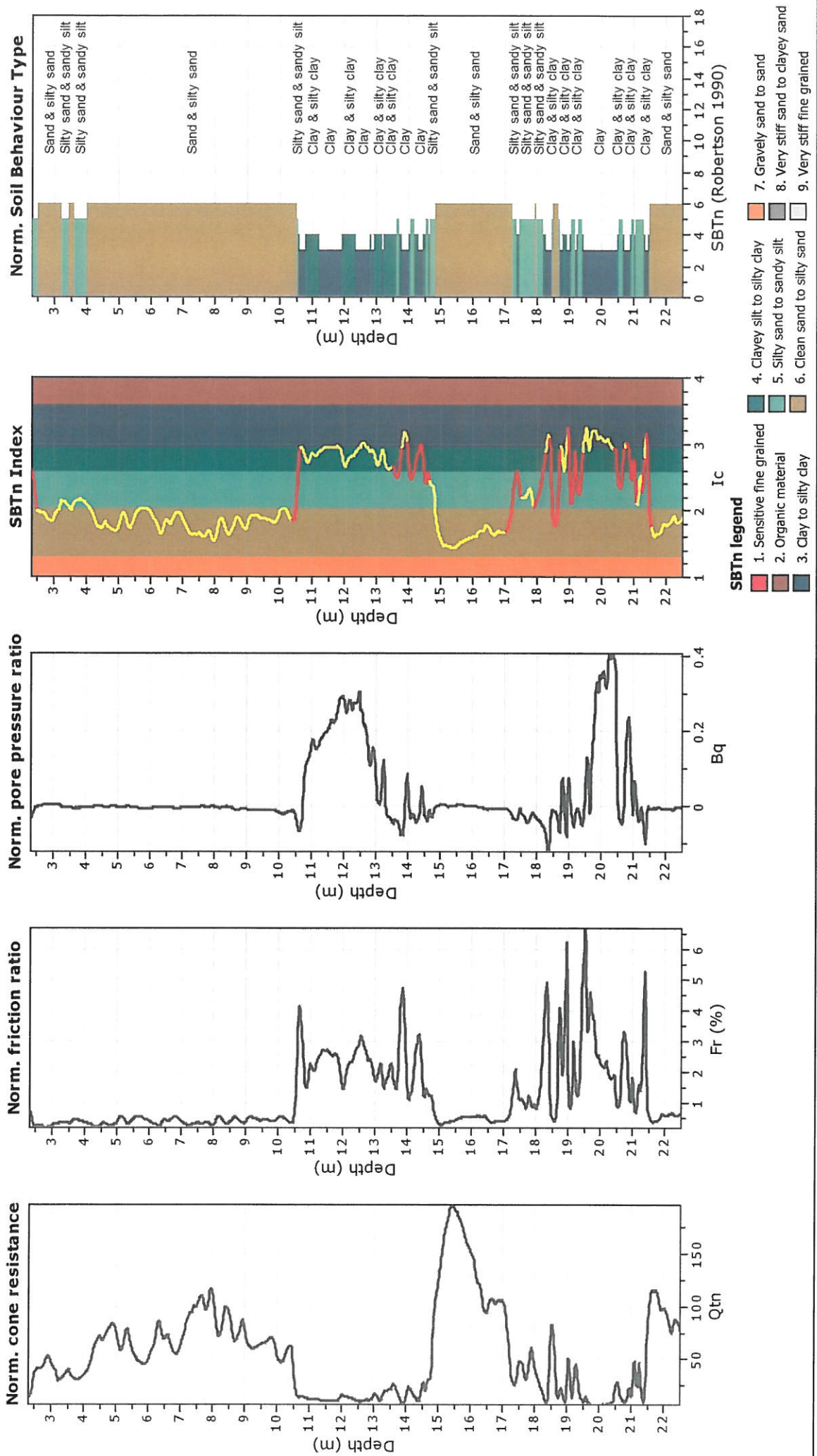


UBICAZIONE SONDAGGI CALTO



The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



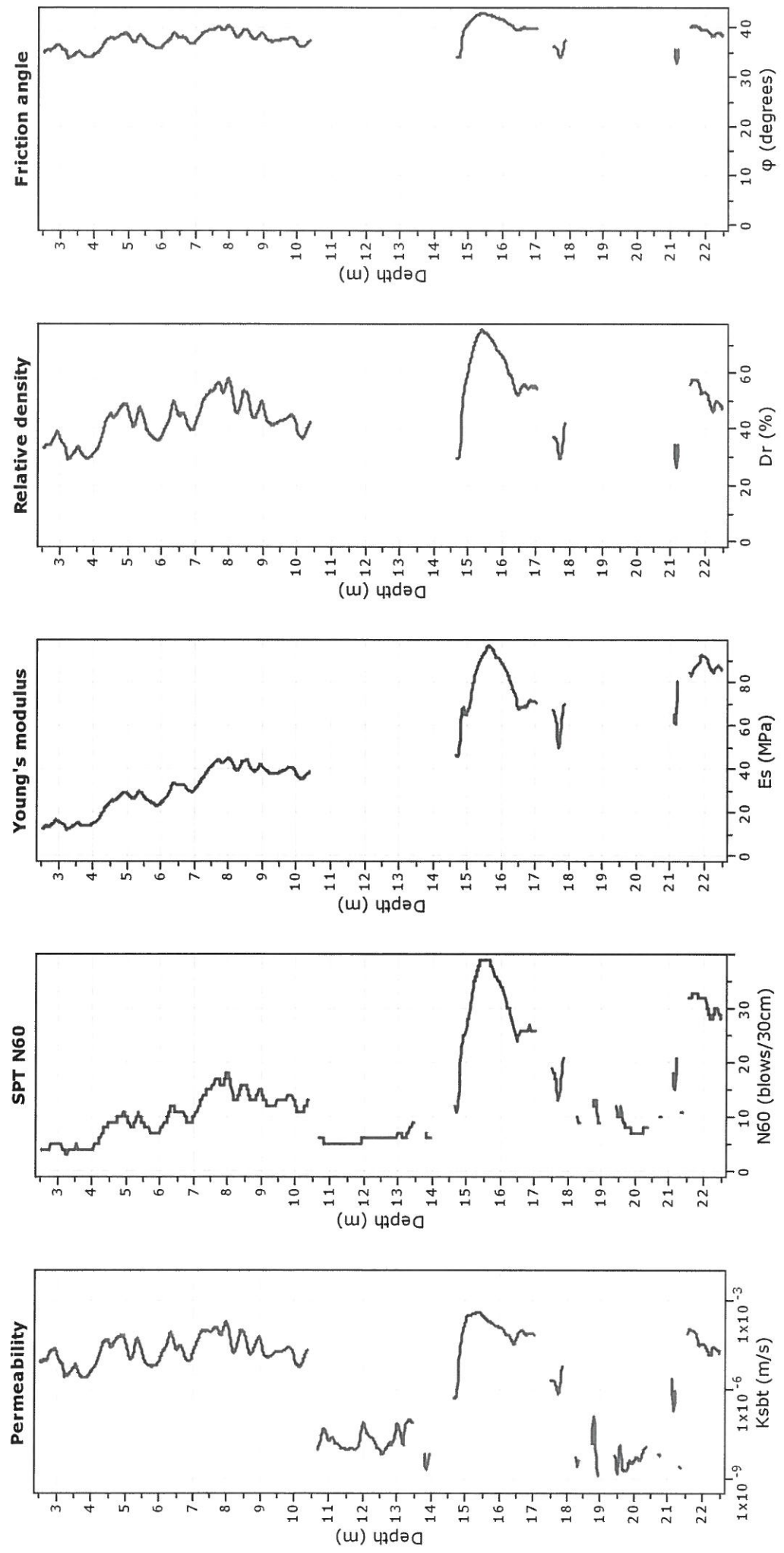




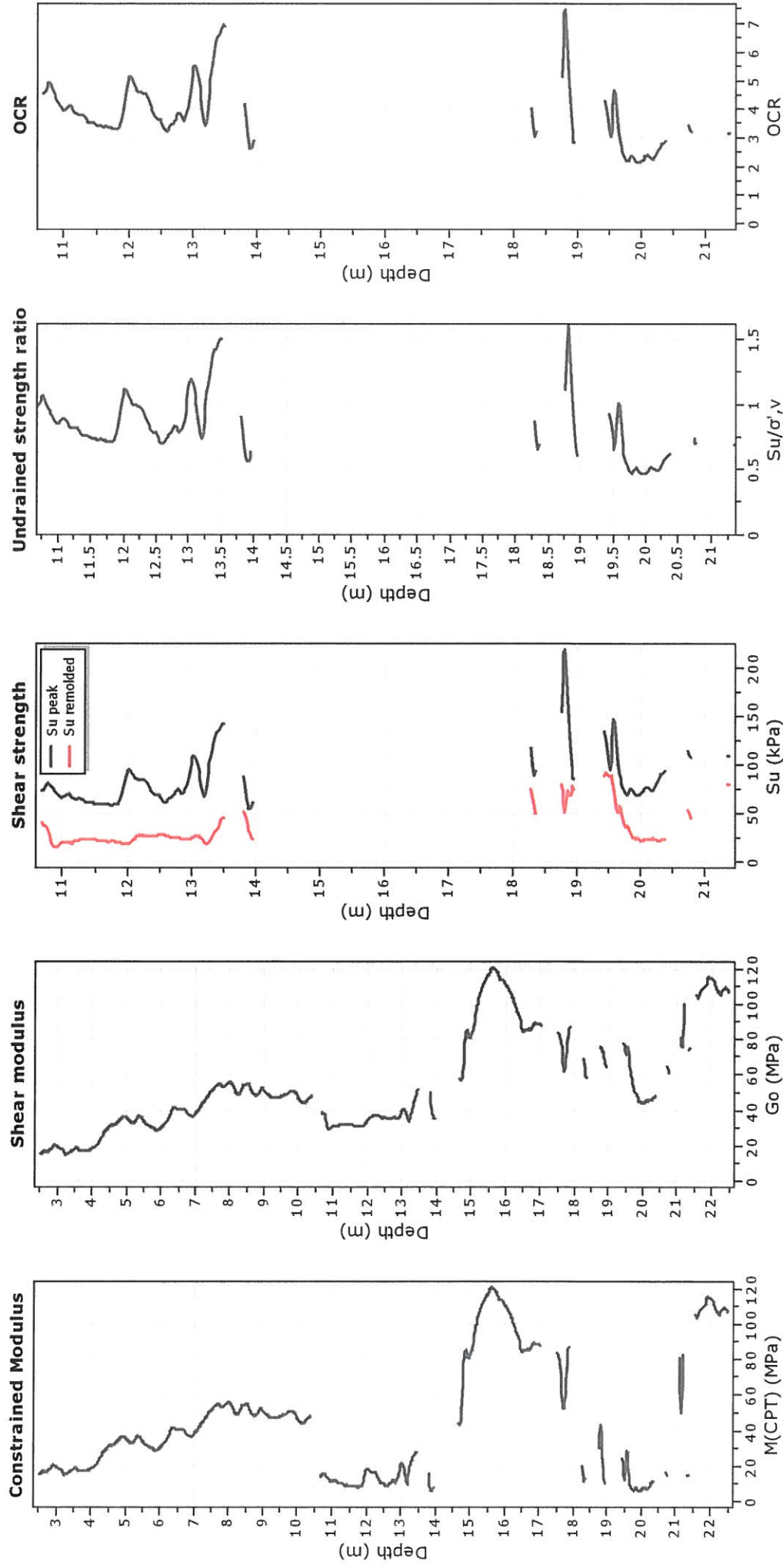
Studio Geologi Associati  
Via Emilia all'Angelo 14  
42124 Reggio Emilia

CPT: CPTU\_4A  
Total depth: 22.50 m, Date: 01/02/2019  
Coords: lat 44.981791° lon 11.357152°  
Cone Type: TECNOPENTA G1-CPL2IN  
Cone Operator: L. ZANIRATO

Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



**Calculation parameters**  
Permeability: Based on SBT<sub>n</sub>  
SPT N<sub>60</sub>: Based on I<sub>c</sub> and q<sub>t</sub>  
Young's modulus: Based on variable alpha using I<sub>c</sub> (Robertson, 2009) —●— User defined estimation data  
Relative density constant, C<sub>Dr</sub>: 350.0  
Phi: Based on Kulhawy & Mayne (1990)



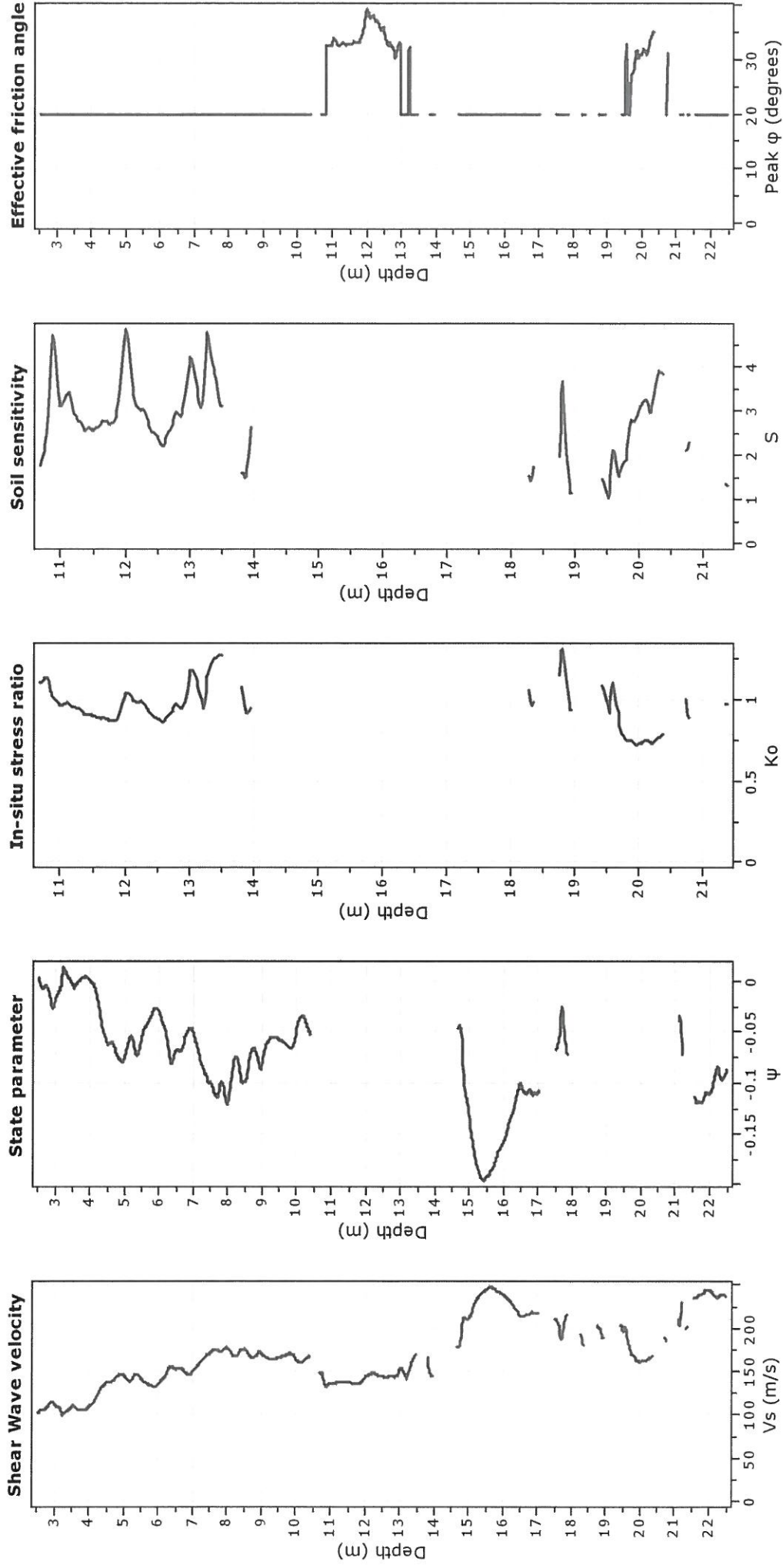
#### Calculation parameters

Constrained modulus: Based on variable  $\alpha/\rho/\eta$  using  $I_c$  and  $Q_m$  (Robertson, 2009) OCR factor for clays,  $N_{kc}$ : 0.33

Go: Based on variable  $\alpha/\rho/\eta$  using  $I_c$  (Robertson, 2009)

Undrained shear strength cone factor for clays,  $N_{ks}$ : 14

—●— User defined estimation data



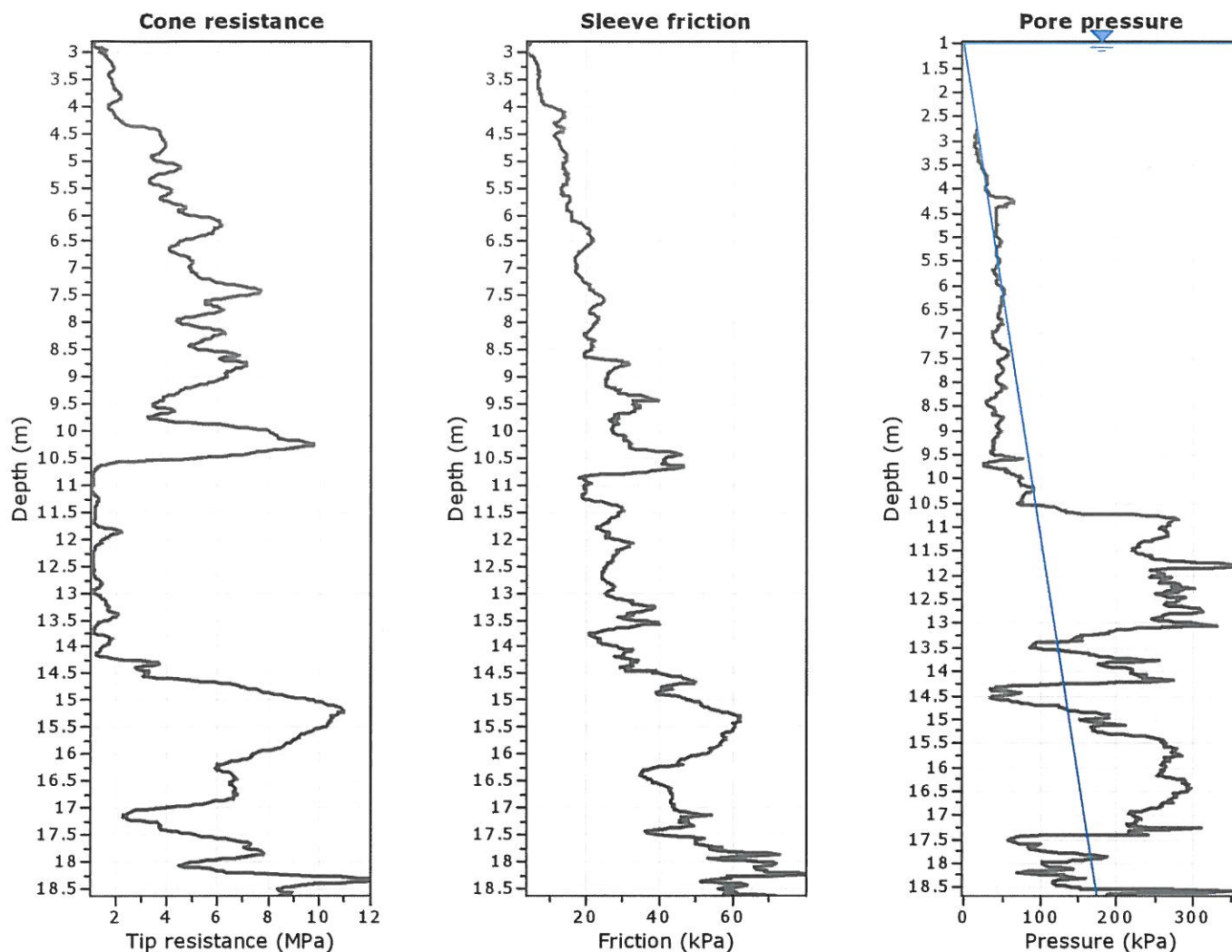
#### Calculation parameters

Soil Sensitivity factor,  $N_s$ : 7.00

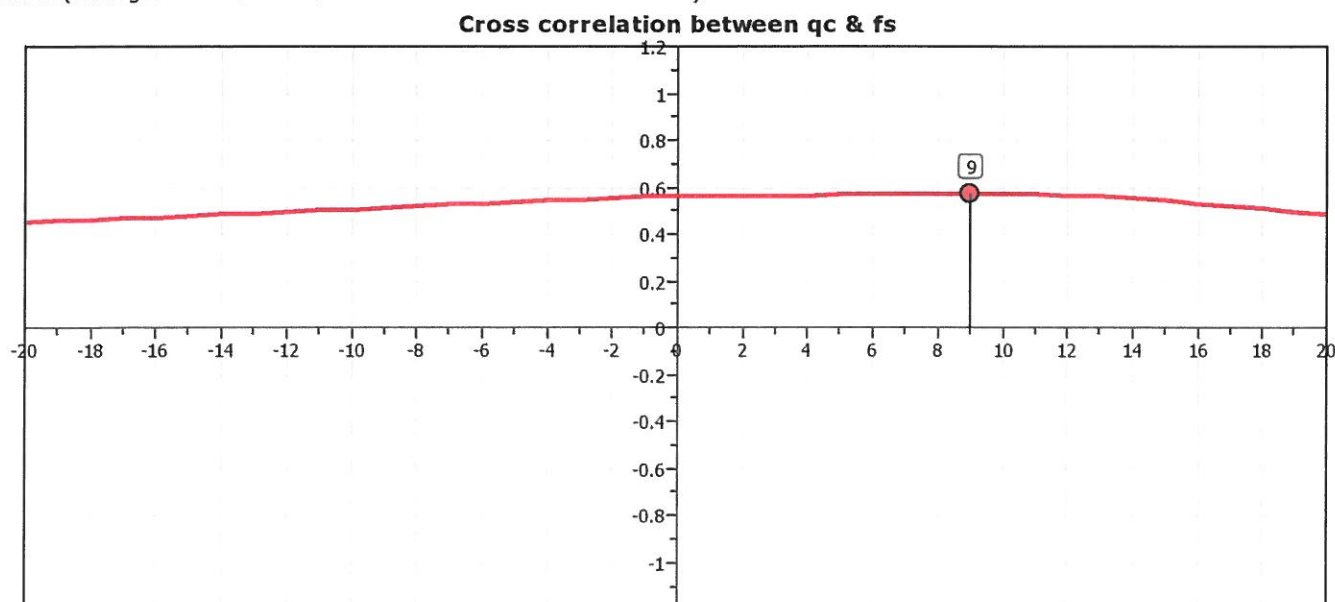
—●— User defined estimation data

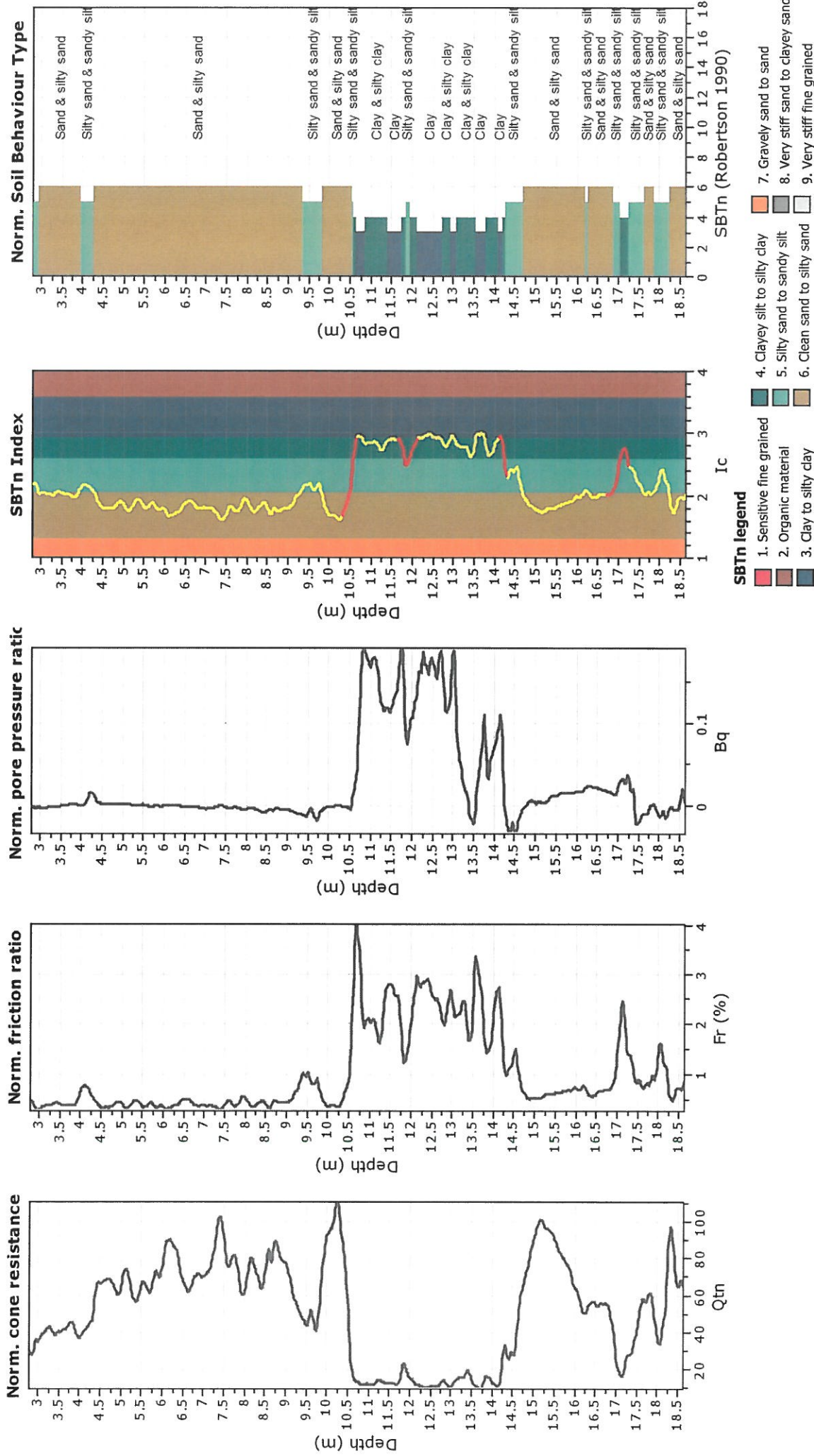
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

**Location: TRATTO CASTELMASSA - STIENTA**

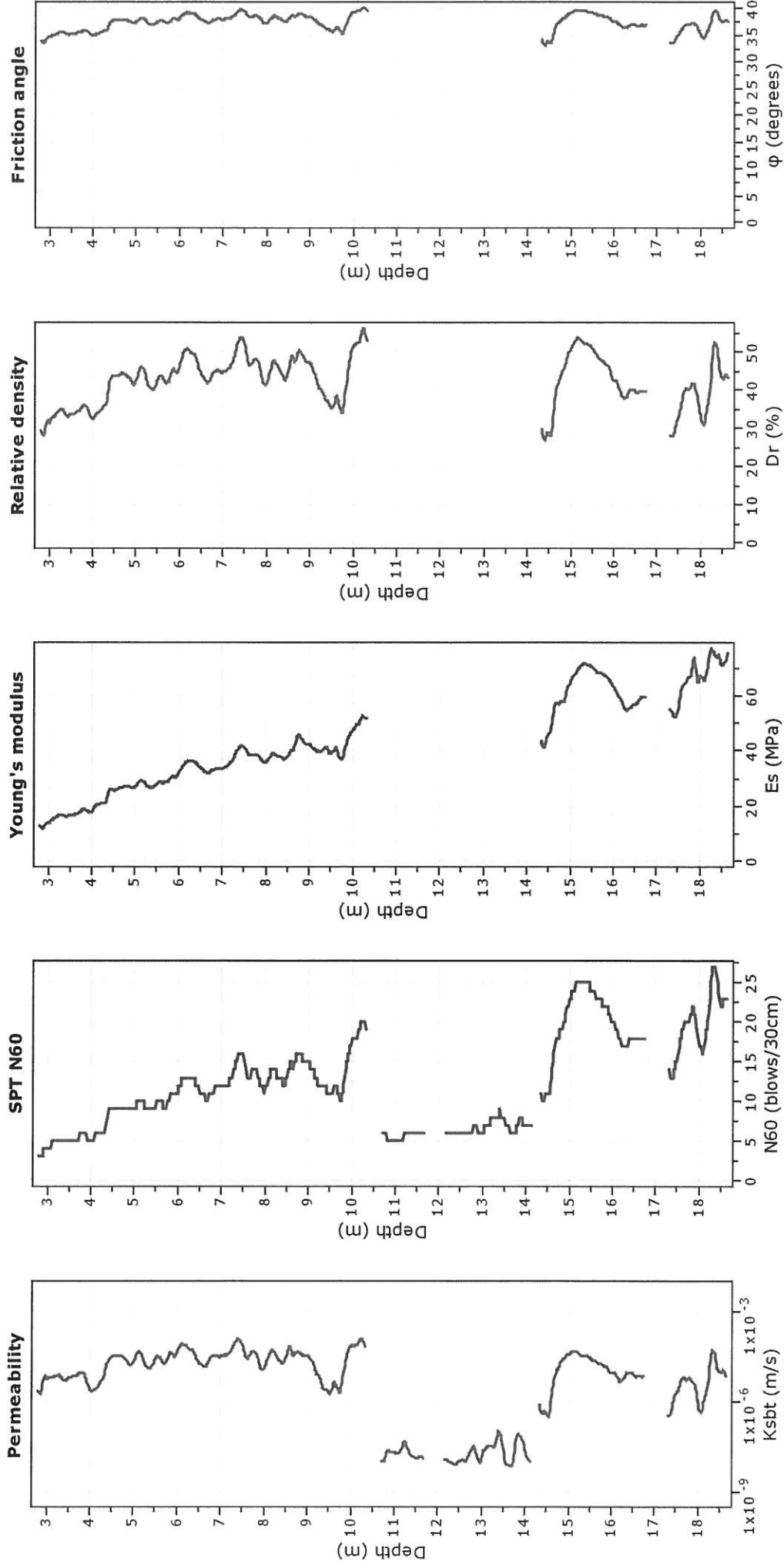


The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



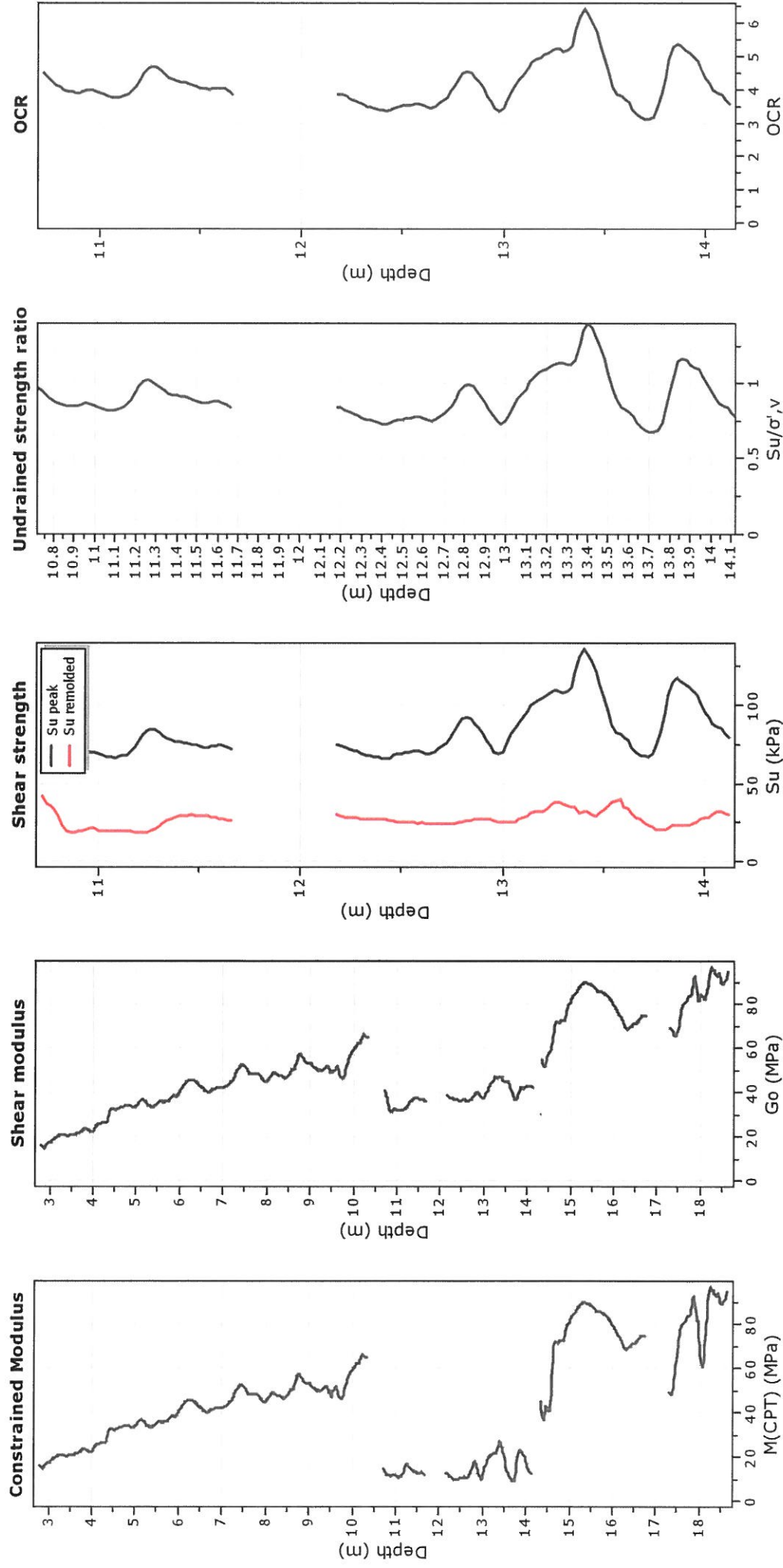


**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**



## Calculation parameters

Permeability: Based on  $SBT_n$   
SPT  $N_{60}$ : Based on  $I_c$  and  $q_t$   
Young's modulus: Based on variable  $\alpha$  using  $I_c$  (Robertson, 2009) —●— User defined estimation data  
Relative density constant,  $C_{Dr}$ : 350.0  
Phi: Based on Kulhawy & Mayne (1990)



#### Calculation parameters

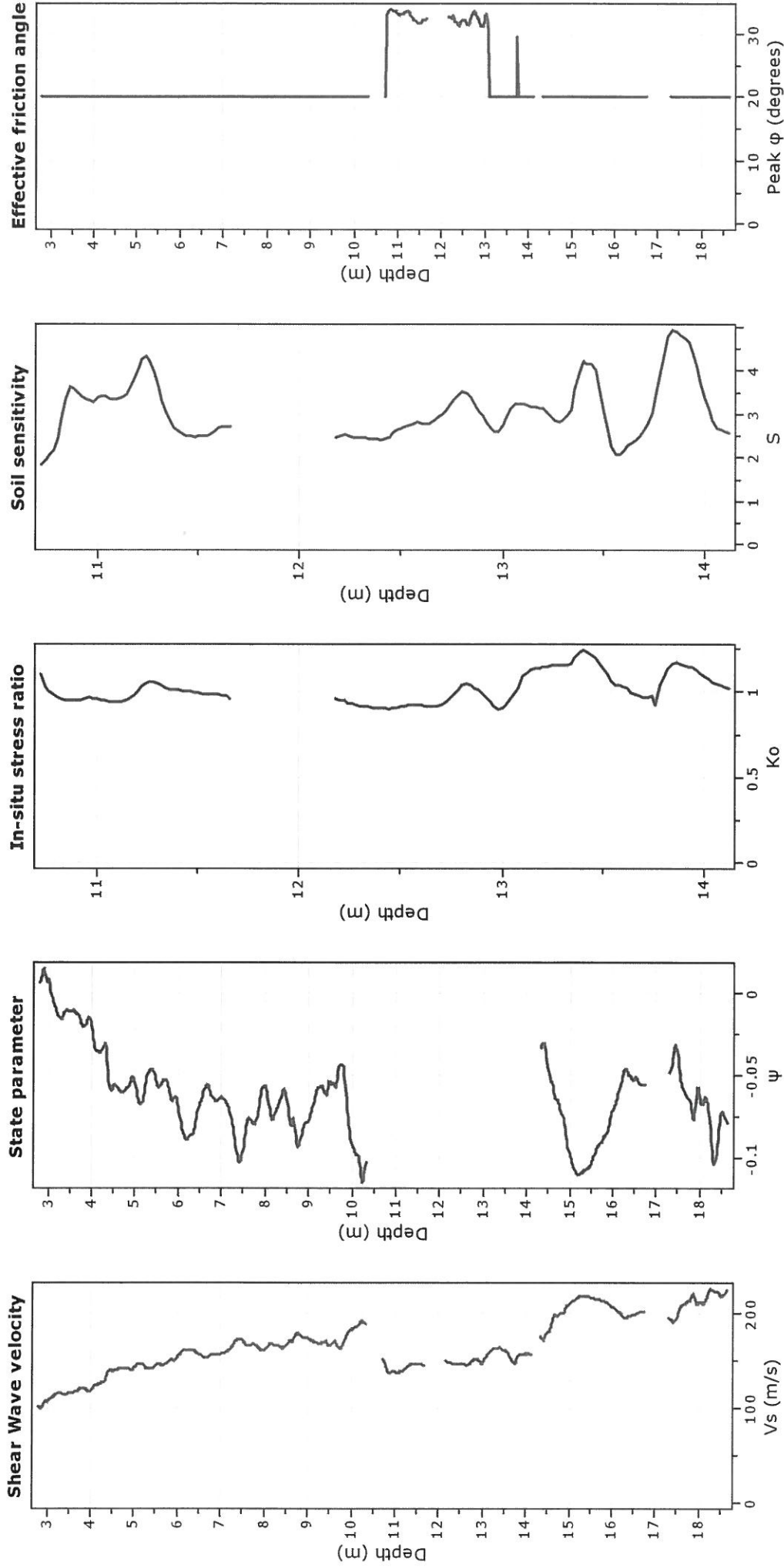
Constrained modulus: Based on variable  $\alpha/\rho\alpha$  using  $I_c$  and  $Q_m$  (Robertson, 2009)

Go: Based on variable  $\alpha/\rho\alpha$  using  $I_c$  (Robertson, 2009)

Undrained shear strength cone factor for clays,  $N_{kt}$ : 14

OCR factor for clays,  $N_{kt}$ : 0.33

—●— User defined estimation data



**Calculation parameters**

Soil Sensitivity factor,  $N_s$ : 7.00

—●— User defined estimation data

# CPTU 4A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	12.9	1	0.011	0.011	3.0	0.10	19.1	0.43	50.7	0.76	49.7	0.75	26.5	0.53
3	1.0	6	18.8	1	0.010	0.010	4.9	0.10	20.6	0.32	45.8	0.54	46.6	0.54	27.3	0.39
4	1.0	6	24.9	1	0.009	0.009	6.7	0.09	21.5	0.24	41.7	0.38	43.1	0.39	27.5	0.29
5	1.0	6	31.2	1	0.009	0.009	8.4	0.09	21.9	0.21	38.1	0.31	39.7	0.32	27.2	0.25
6	1.0	7	37.6	1	0.008	0.008	9.8	0.08	21.9	0.16	35.0	0.23	36.5	0.24	26.5	0.19
7	1.0	7	44.1	1	0.008	0.008	10.8	0.08	21.6	0.14	32.2	0.19	33.7	0.20	25.6	0.16
8	1.0	6	50.5	1	0.009	0.009	11.7	0.08	21.1	0.14	29.8	0.18	31.1	0.19	24.5	0.15
9	1.0	6	56.8	1	0.009	0.009	12.2	0.08	20.4	0.12	27.6	0.15	28.8	0.16	23.4	0.14
10	1.0	10	64.8	4	0.200	0.020	12.6	0.15	19.8	0.23	25.7	0.29	26.7	0.30	22.4	0.26
11	1.0	10	74.8	4	0.200	0.020	12.8	0.14	19.0	0.20	24.0	0.24	24.9	0.25	21.3	0.22
12	1.0	10	84.8	5	0.200	0.020	12.8	0.12	18.3	0.17	22.5	0.20	23.3	0.21	20.3	0.19
13	1.0	10	94.8	5	0.200	0.020	12.8	0.11	17.6	0.15	21.2	0.17	21.8	0.18	19.3	0.16
14	1.0	8	103.8	1	0.002	0.002	12.7	0.01	16.9	0.01	19.9	0.02	20.5	0.02	18.4	0.01
15	1.0	7	111.4	1	0.005	0.005	12.5	0.02	16.2	0.03	18.9	0.03	19.3	0.03	17.5	0.03
16	1.0	7	118.4	1	0.006	0.006	12.3	0.03	15.6	0.03	17.9	0.04	18.3	0.04	16.7	0.03
17	1.0	6	124.8	1	0.010	0.010	12.1	0.04	15.0	0.05	17.0	0.06	17.3	0.06	16.0	0.05
18	1.0	10	132.8	4	0.200	0.020	11.9	0.07	14.4	0.09	16.1	0.10	16.5	0.10	15.3	0.09
19	1.0	10	142.8	4	0.200	0.020	11.6	0.07	13.9	0.08	15.4	0.09	15.7	0.09	14.7	0.08
20	1.0	10	152.8	3	0.200	0.020	11.3	0.06	13.3	0.07	14.7	0.08	14.9	0.08	14.1	0.08
TOTALI (cm)								1.53	2.87		4.07		4.15		3.30	

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	12.9	1	0.011	0.011	12.0	0.31	2.0	0.07
3	1.0	6	18.8	1	0.010	0.010	12.6	0.22	3.2	0.07
4	1.0	6	24.9	1	0.009	0.009	13.4	0.17	4.4	0.06
5	1.0	6	31.2	1	0.009	0.009	14.2	0.15	5.6	0.06
6	1.0	7	37.6	1	0.008	0.008	14.9	0.12	6.6	0.06
7	1.0	7	44.1	1	0.008	0.008	15.3	0.10	7.6	0.06
8	1.0	6	50.5	1	0.009	0.009	15.6	0.11	8.4	0.06
9	1.0	6	56.8	1	0.009	0.009	15.7	0.10	9.1	0.06
10	1.0	10	64.8	4	0.200	0.020	15.7	0.19	9.6	0.12
11	1.0	10	74.8	4	0.200	0.020	15.5	0.16	10.0	0.11
12	1.0	10	84.8	5	0.200	0.020	15.3	0.14	10.3	0.10
13	1.0	10	94.8	5	0.200	0.020	15.0	0.13	10.5	0.09
14	1.0	8	103.8	1	0.002	0.002	14.6	0.01	10.6	0.01
15	1.0	7	111.4	1	0.005	0.005	14.2	0.03	10.6	0.02
16	1.0	7	118.4	1	0.006	0.006	13.9	0.03	10.6	0.02
17	1.0	6	124.8	1	0.010	0.010	13.5	0.04	10.5	0.04
18	1.0	10	132.8	4	0.200	0.020	13.1	0.08	10.4	0.07
19	1.0	10	142.8	4	0.200	0.020	12.7	0.07	10.3	0.06
20	1.0	10	152.8	3	0.200	0.020	12.3	0.07	10.1	0.06
TOTALI (cm)								2.23	1.18	

[illegible]

# CPTU 4B PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

### CARATTERISTICHE DEGLI STRATI

### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.010	0.010	3.0	0.13	19.1	0.50	50.7	0.83	49.7	0.82	26.5	0.60
3	1.0	6	14.9	1	0.010	0.010	4.9	0.12	20.6	0.38	45.8	0.61	46.6	0.62	27.3	0.45
4	1.0	6	21.0	1	0.009	0.009	6.7	0.11	21.5	0.28	41.7	0.43	43.1	0.44	27.5	0.33
5	1.0	6	27.4	1	0.008	0.008	8.4	0.09	21.9	0.20	38.1	0.30	39.7	0.31	27.2	0.24
6	1.0	7	33.8	1	0.008	0.008	9.8	0.09	21.9	0.17	35.0	0.25	36.5	0.25	26.5	0.20
7	1.0	7	40.4	1	0.007	0.007	10.8	0.07	21.6	0.13	32.2	0.18	33.7	0.18	25.6	0.15
8	1.0	7	47.1	1	0.007	0.007	11.7	0.07	21.1	0.11	29.8	0.15	31.1	0.15	24.5	0.13
9	1.0	10	55.5	4	0.200	0.020	12.2	0.17	20.4	0.27	27.6	0.35	28.8	0.36	23.4	0.31
10	1.0	10	65.5	4	0.200	0.020	12.6	0.15	19.8	0.23	25.7	0.29	26.7	0.30	22.4	0.26
11	1.0	10	75.5	4	0.200	0.020	12.8	0.14	19.0	0.20	24.0	0.24	24.9	0.25	21.3	0.22
12	1.0	6	83.6	1	0.009	0.009	12.8	0.06	18.3	0.08	22.5	0.09	23.3	0.10	20.3	0.08
13	1.0	7	90.1	1	0.006	0.006	12.8	0.03	17.6	0.05	21.2	0.05	21.8	0.06	19.3	0.05
14	1.0	7	96.8	1	0.008	0.008	12.7	0.04	16.9	0.06	19.9	0.07	20.5	0.07	18.4	0.06
15	1.0	6	103.1	1	0.009	0.009	12.5	0.04	16.2	0.06	18.9	0.07	19.3	0.07	17.5	0.06
TOTALI (cm)								1.32	2.71	3.90	3.97	3.13				

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

### CARATTERISTICHE DEGLI STRATI

### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m³	$\sigma'_{v0}$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.010	0.010	12.0	0.37	2.0	0.09
3	1.0	6	14.9	1	0.010	0.010	12.6	0.27	3.2	0.08
4	1.0	6	21.0	1	0.009	0.009	13.4	0.19	4.4	0.07
5	1.0	6	27.4	1	0.008	0.008	14.2	0.15	5.6	0.06
6	1.0	7	33.8	1	0.008	0.008	14.9	0.13	6.6	0.06
7	1.0	7	40.4	1	0.007	0.007	15.3	0.10	7.6	0.05
8	1.0	7	47.1	1	0.007	0.007	15.6	0.09	8.4	0.05
9	1.0	10	55.5	4	0.200	0.020	15.7	0.22	9.1	0.13
10	1.0	10	65.5	4	0.200	0.020	15.7	0.19	9.6	0.12
11	1.0	10	75.5	4	0.200	0.020	15.5	0.16	10.0	0.11
12	1.0	6	83.6	1	0.009	0.009	15.3	0.07	10.3	0.05
13	1.0	7	90.1	1	0.006	0.006	15.0	0.04	10.5	0.03
14	1.0	7	96.8	1	0.008	0.008	14.6	0.05	10.6	0.04
15	1.0	6	103.1	1	0.009	0.009	14.2	0.05	10.6	0.04
TOTALI (cm)								2.06	0.98	

CPTU 4B PENNELLO 4 m

COORDINATE  $(x, y, z)$  E PRESSIONI  $(\sigma'v)$  RELATIVE AI RETTANGOLI DI CARICO

N.	x1	y1	x2	y2	x3	y3	x4	y4	z	σ'v
	m	m	m	m	m	m	m	m	m	kPa
1	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+2
2	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+6
3	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+10
4	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+17
5	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+28
6	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+38
7	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+43
8	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+43
9	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+43
10	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+35
11	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+20
12	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
13	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,2.0	50.0,4.0	50.0,7.0	50.0,10.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma$ kN/m <sup>3</sup>	$\sigma'_{v0}$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.010	0.010	3.3	0.14	16.0	0.45	35.6	0.70	37.7	0.72	14.8	0.43
3	1.0	6	14.9	1	0.010	0.010	5.5	0.14	17.1	0.33	32.1	0.50	34.3	0.52	15.9	0.32
4	1.0	6	21.0	1	0.009	0.009	7.4	0.12	17.5	0.24	28.9	0.34	31.0	0.35	16.4	0.23
5	1.0	6	27.4	1	0.008	0.008	8.9	0.10	17.3	0.17	26.1	0.23	27.9	0.24	16.5	0.16
6	1.0	7	33.8	1	0.008	0.008	9.8	0.09	16.9	0.14	23.7	0.18	25.1	0.19	16.3	0.14
7	1.0	7	40.4	1	0.007	0.007	10.4	0.07	16.2	0.10	21.5	0.13	22.8	0.14	15.8	0.10
8	1.0	7	47.1	1	0.007	0.007	10.7	0.06	15.5	0.09	19.7	0.11	20.7	0.11	15.2	0.08
9	1.0	10	55.5	4	0.200	0.020	10.7	0.15	14.8	0.21	18.1	0.25	18.9	0.25	14.5	0.20
10	1.0	10	65.5	4	0.200	0.020	10.7	0.13	14.1	0.17	16.7	0.20	17.4	0.20	13.9	0.17
11	1.0	10	75.5	4	0.200	0.020	10.5	0.11	13.4	0.14	15.5	0.16	16.1	0.17	13.2	0.14
12	1.0	6	83.6	1	0.009	0.009	10.3	0.05	12.7	0.06	14.5	0.06	14.9	0.06	12.6	0.05
13	1.0	7	90.1	1	0.006	0.006	10.0	0.03	12.0	0.03	13.5	0.04	13.9	0.04	12.0	0.03
14	1.0	7	96.8	1	0.008	0.008	9.7	0.03	11.4	0.04	12.7	0.04	13.0	0.04	11.4	0.04
15	1.0	6	103.1	1	0.009	0.009	9.4	0.03	10.9	0.04	11.9	0.04	12.2	0.04	10.8	0.04
TOTALI (cm)								1.25		2.20		2.98		3.09		2.13

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6  
50.0, 13.0

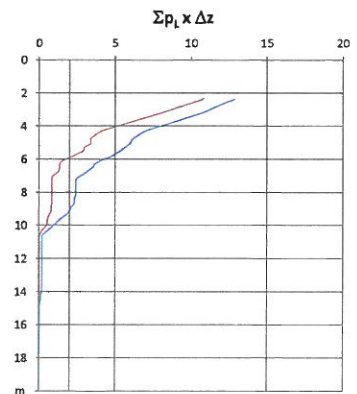
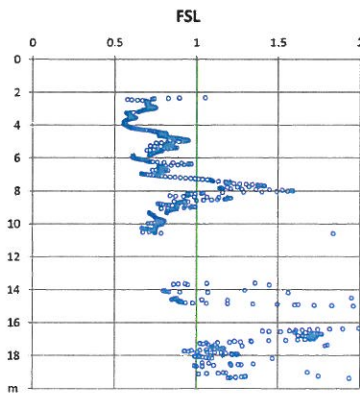
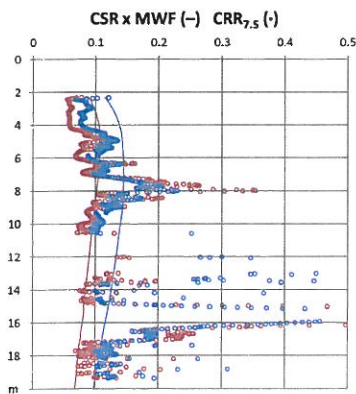
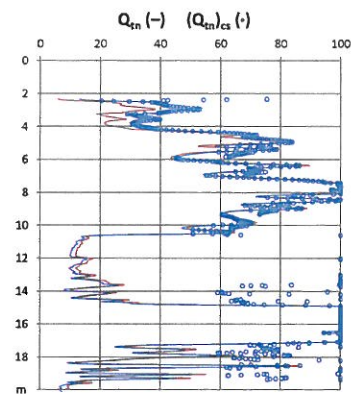
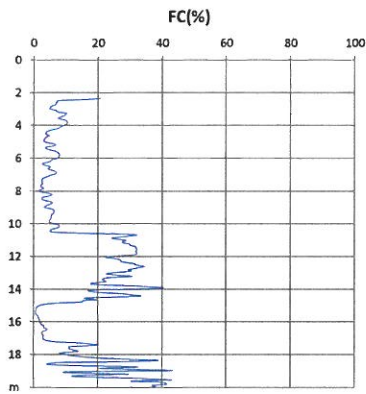
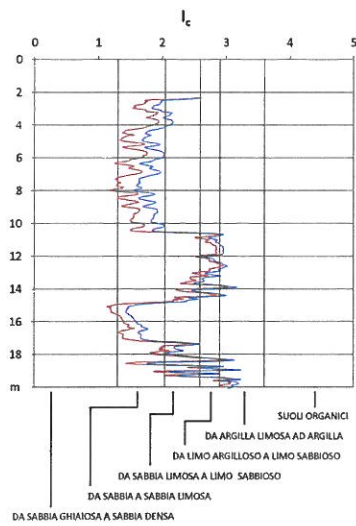
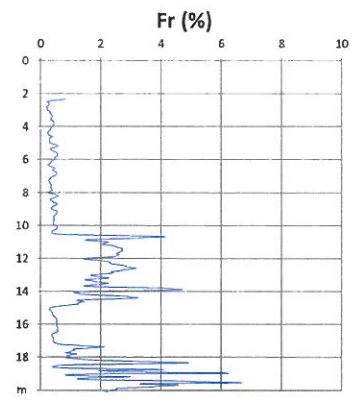
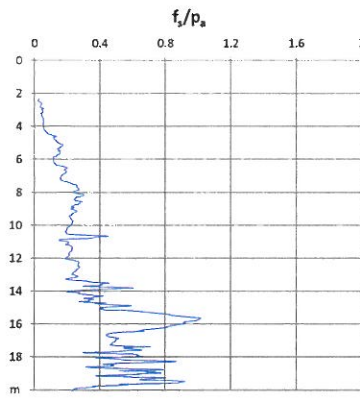
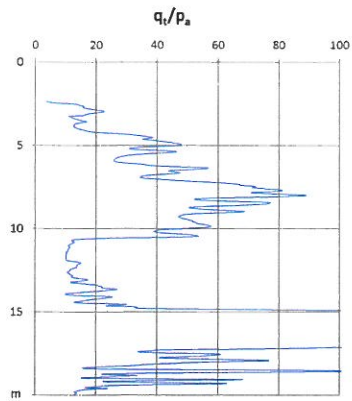
## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

[illegible]

## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



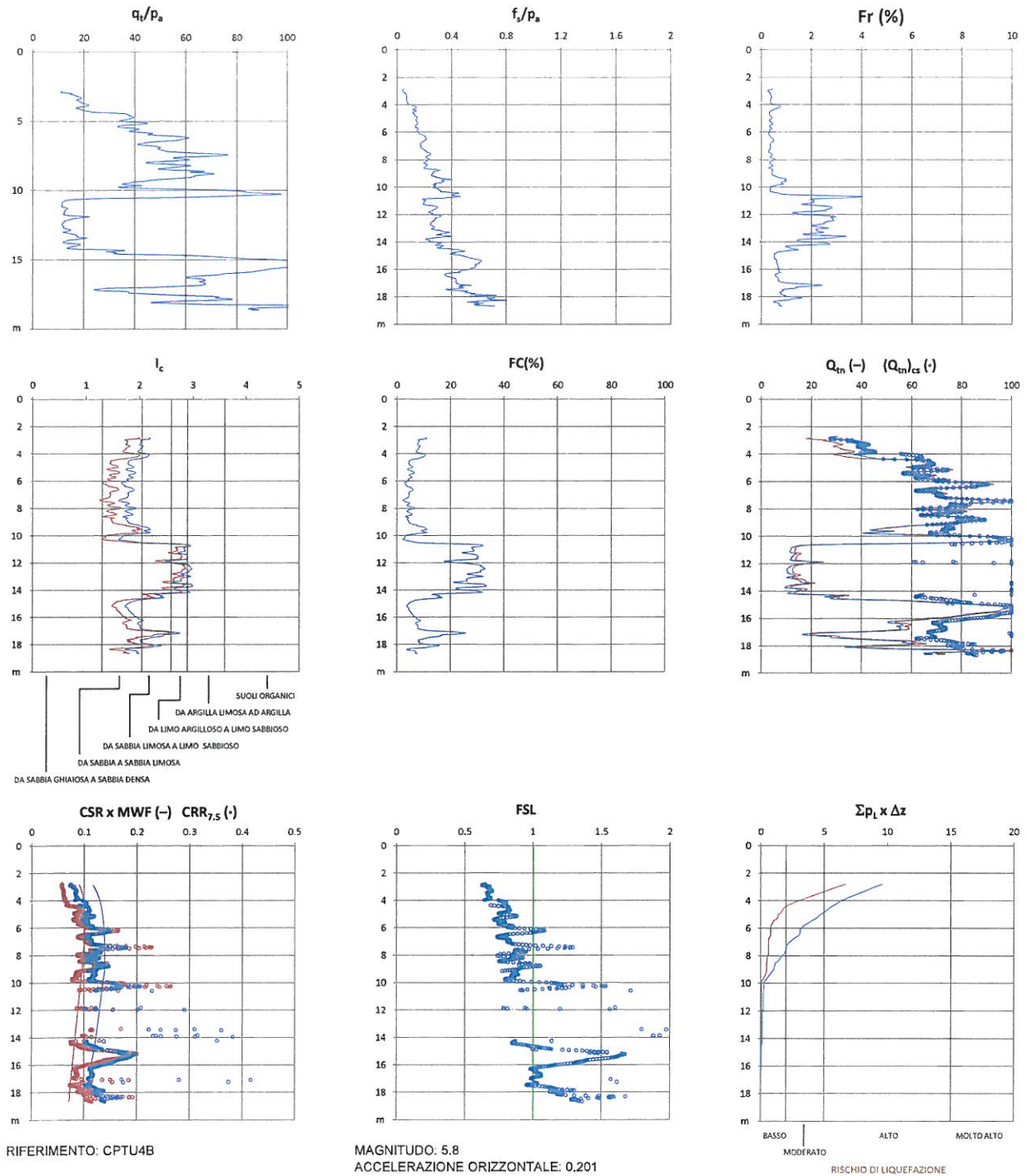
RIFERIMENTO: CPTU4A

MAGNITUDO 5.8  
ACCELERAZIONE ORIZZONTALE: 0.2

SOFTWARE GIANVITO CASSINADRI 2014

## RISCHIO LIQUEFAZIONE

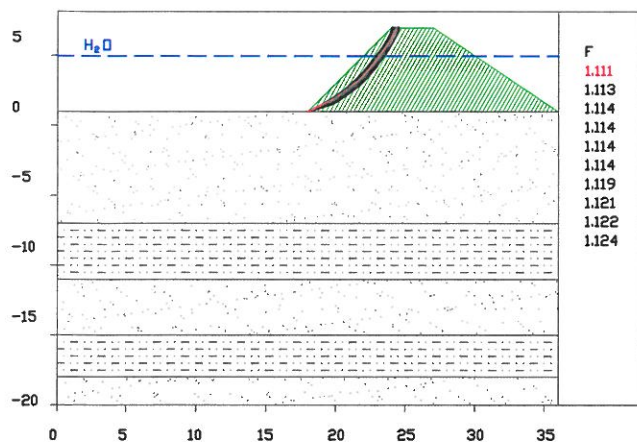
(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



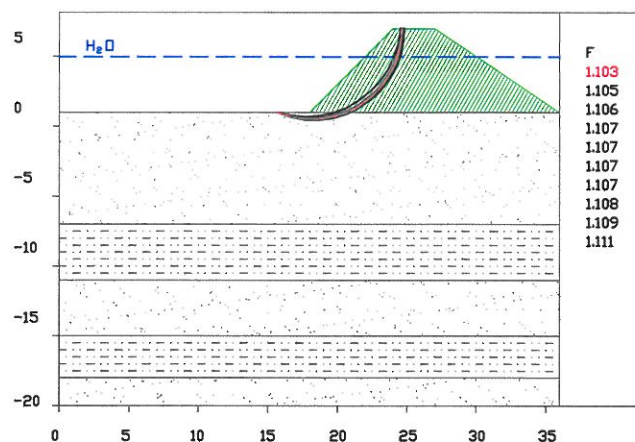
SOFTWARE GIANVITO CASSINADRI 2014

## VERIFICHE DI STABILITÀ

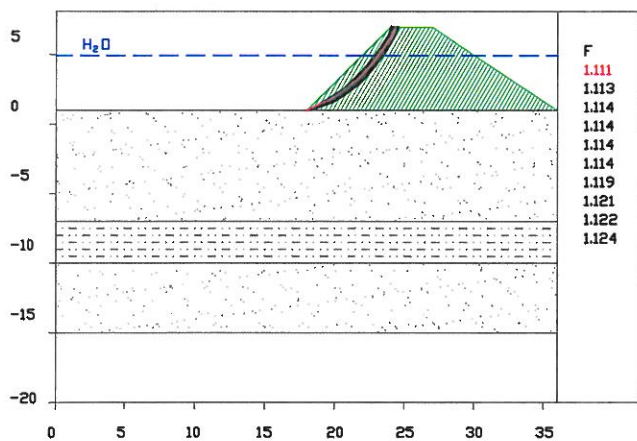
CPTU 4A - SENZA SISMA E COESIONE = 0.6 kPa



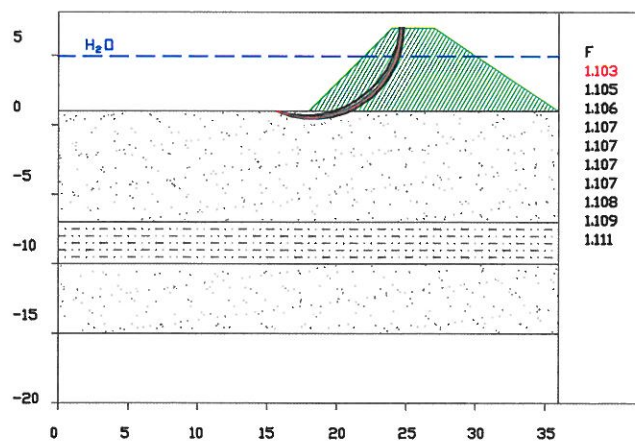
CPTU 4A - CON SISMA E COESIONE = 2 kPa



CPTU 4B - SENZA SISMA E COESIONE = 0.6 kPa

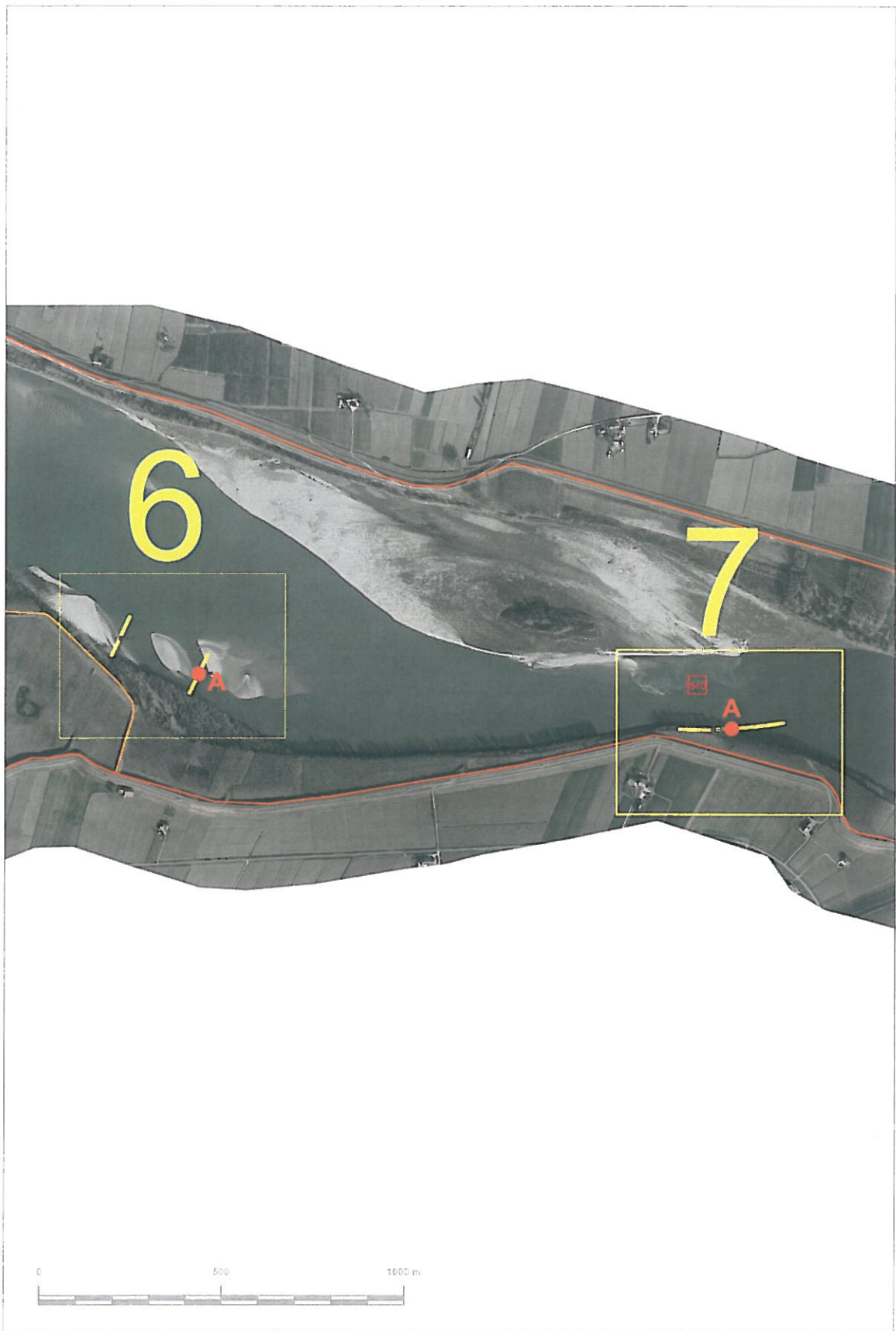


CPTU 4B - CON SISMA E COESIONE = 2 kPa





**FELONICA**

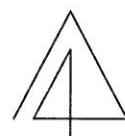


PROVA PENETROMETRICA



OPERE IN PROGETTO

LEGENDA



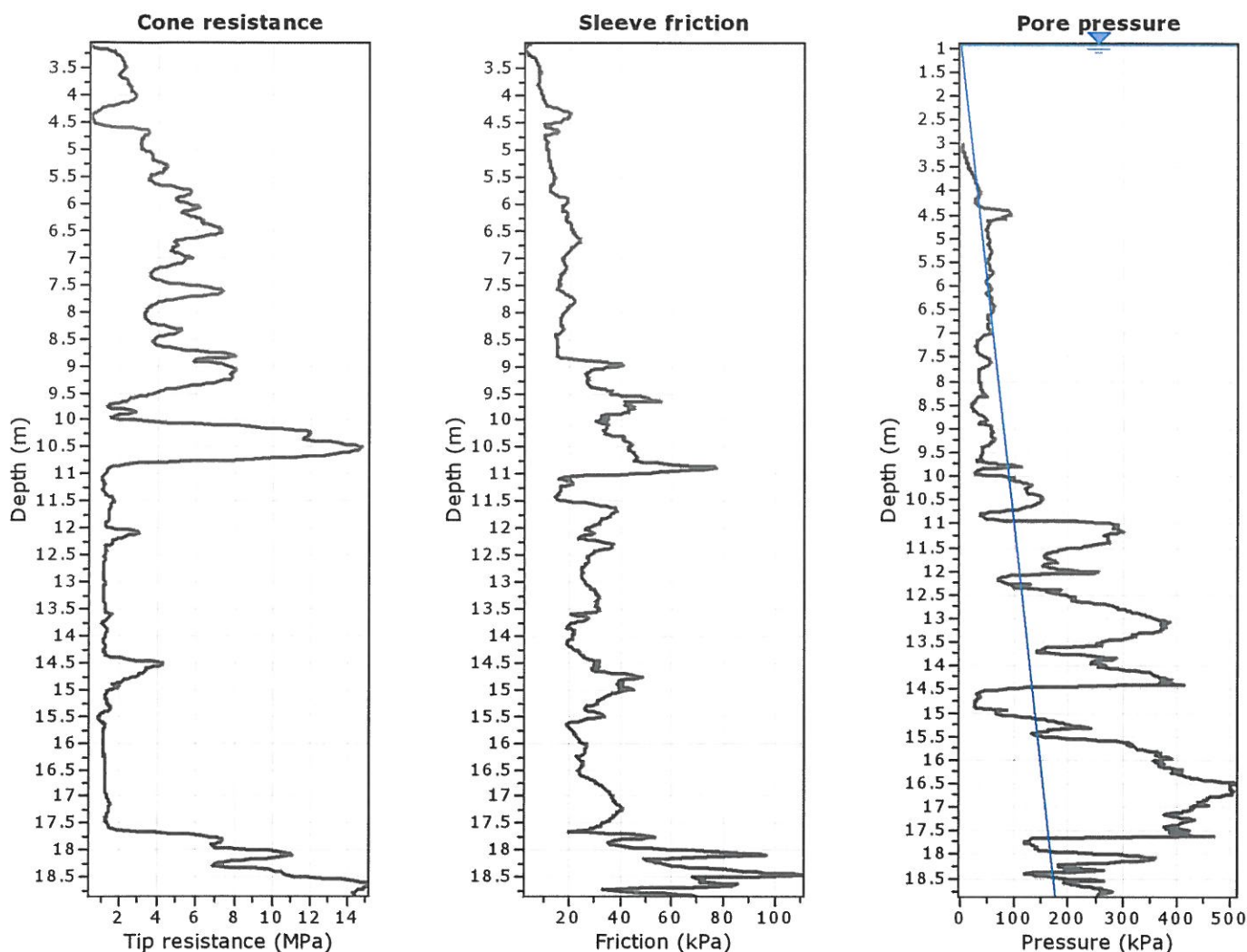
NORD



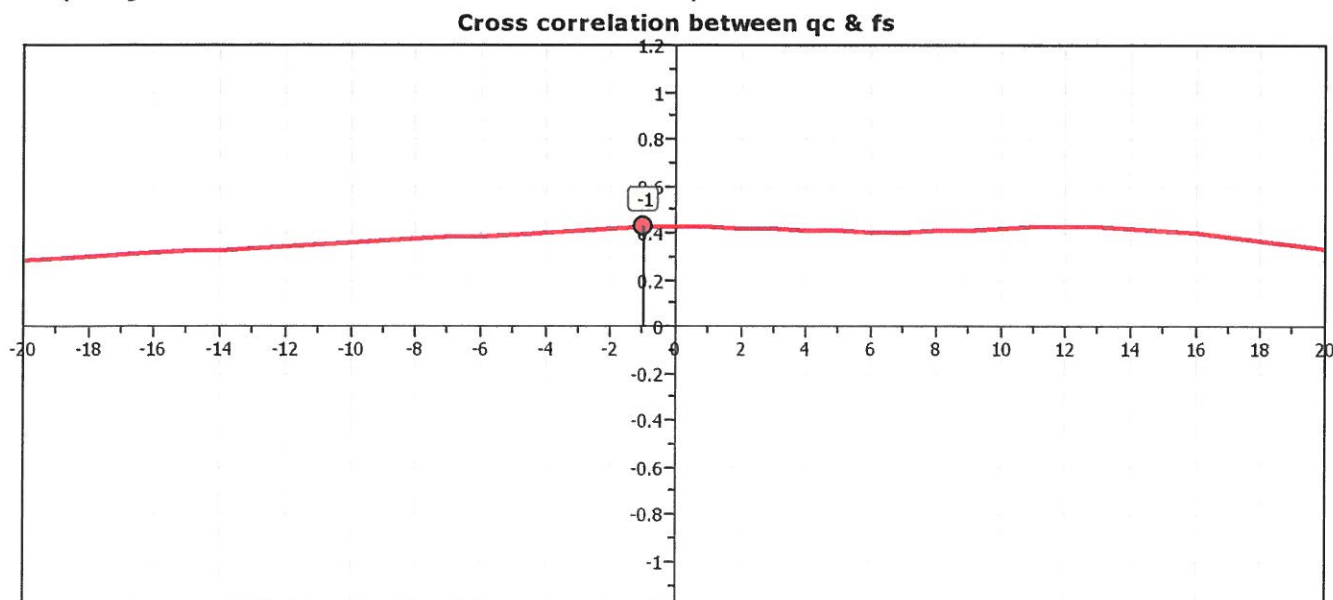
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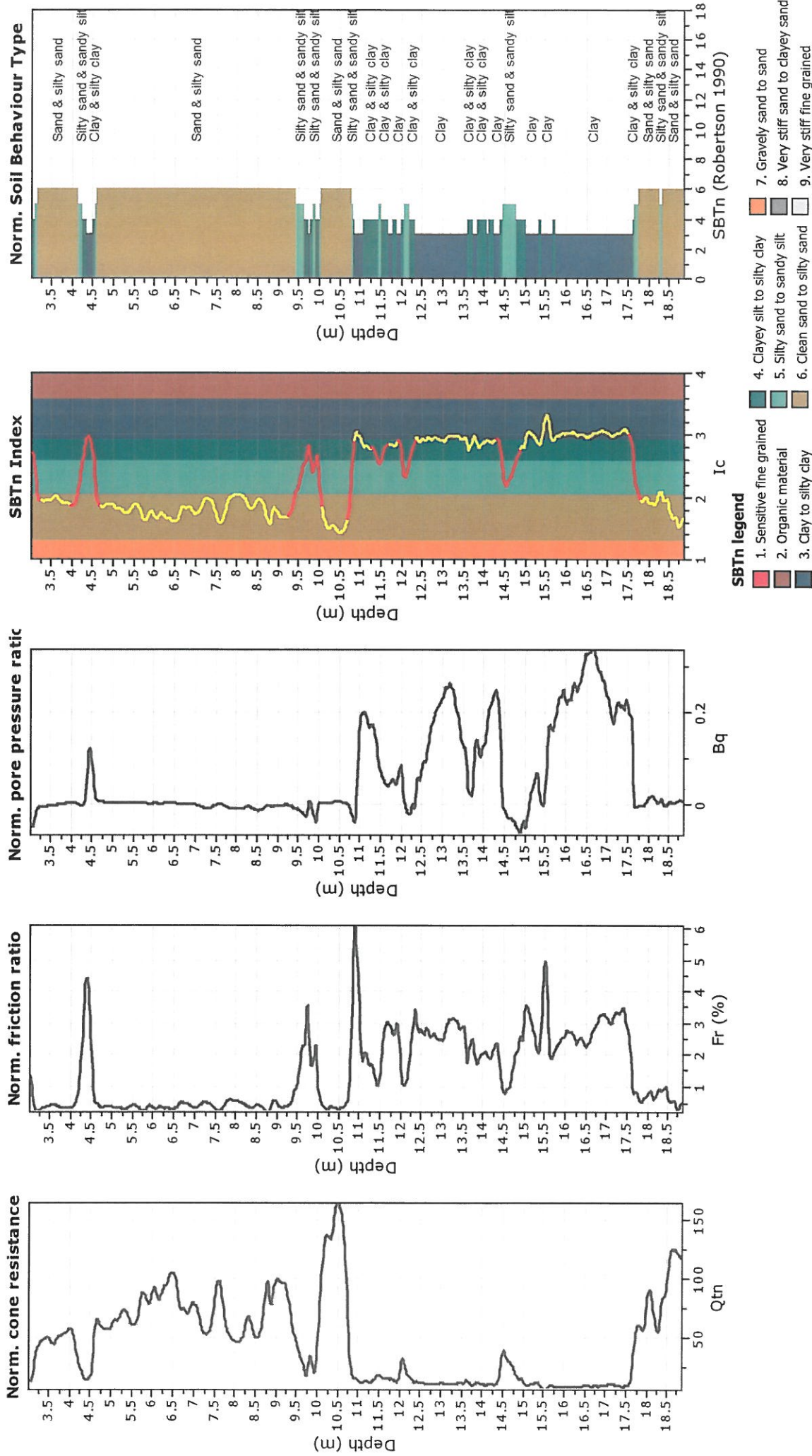
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

**Location: TRATTO CASTELMASSA - STIENTA**

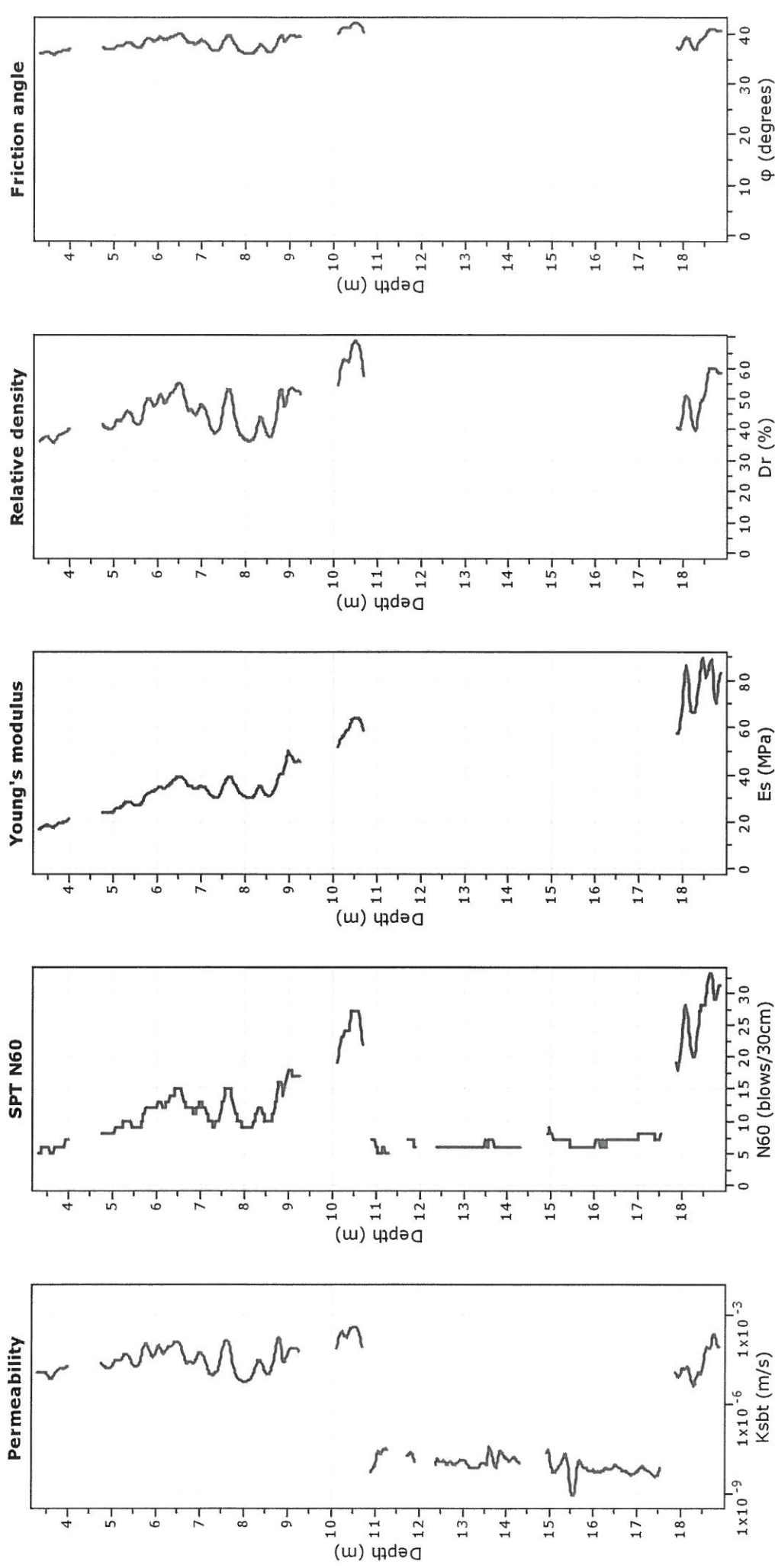


The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



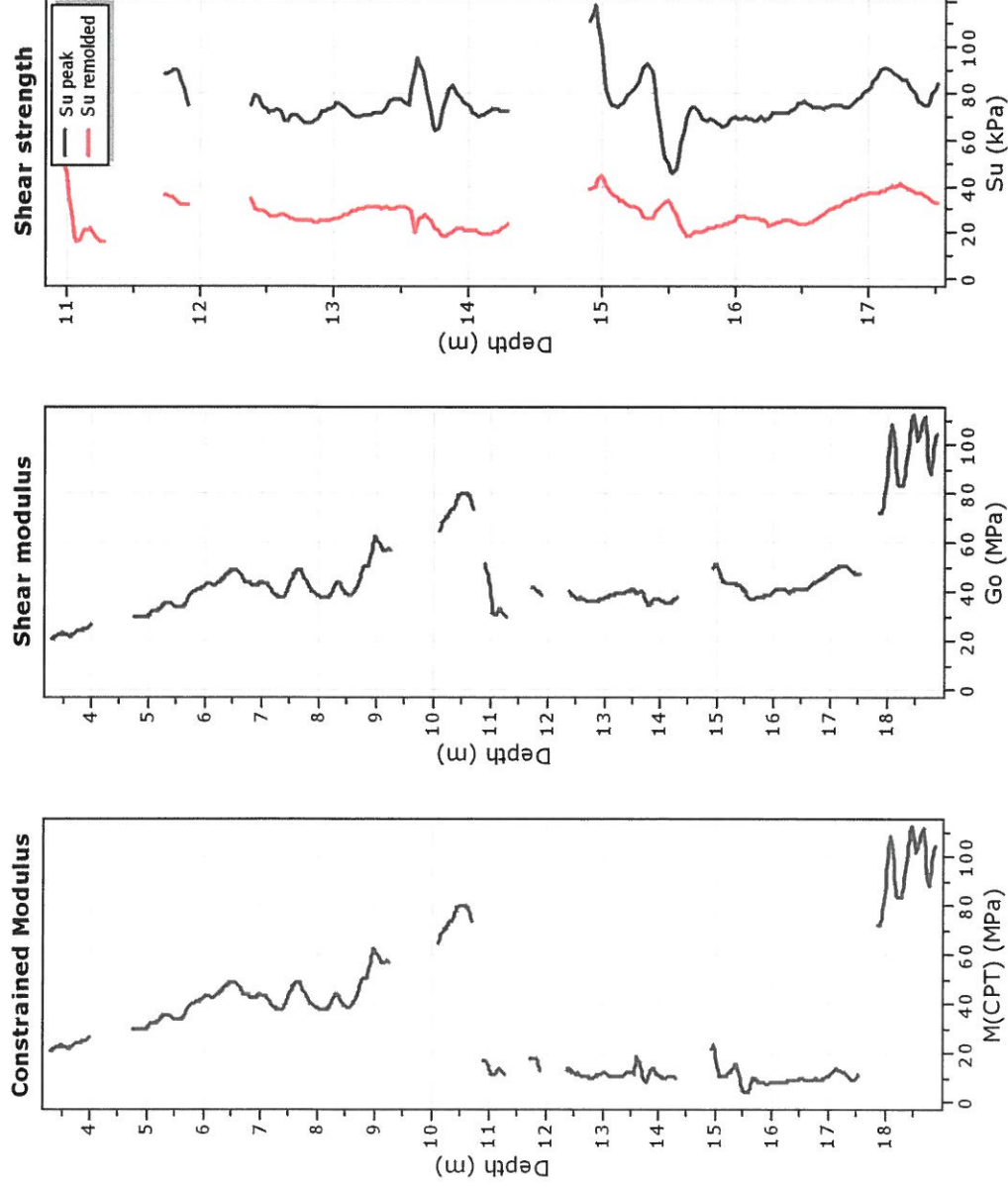


Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



**Calculation parameters**

Permeability: Based on SBT<sub>n</sub>  
SPT N<sub>60</sub>: Based on I<sub>c</sub> and q<sub>t</sub>  
Young's modulus: Based on variable alpha using I<sub>c</sub> (Robertson, 2009)  
Relative density constant, C<sub>or</sub>: 350.0  
Phi: Based on Kulhawy & Mayne (1990)  
—●— User defined estimation data



#### Calculation parameters

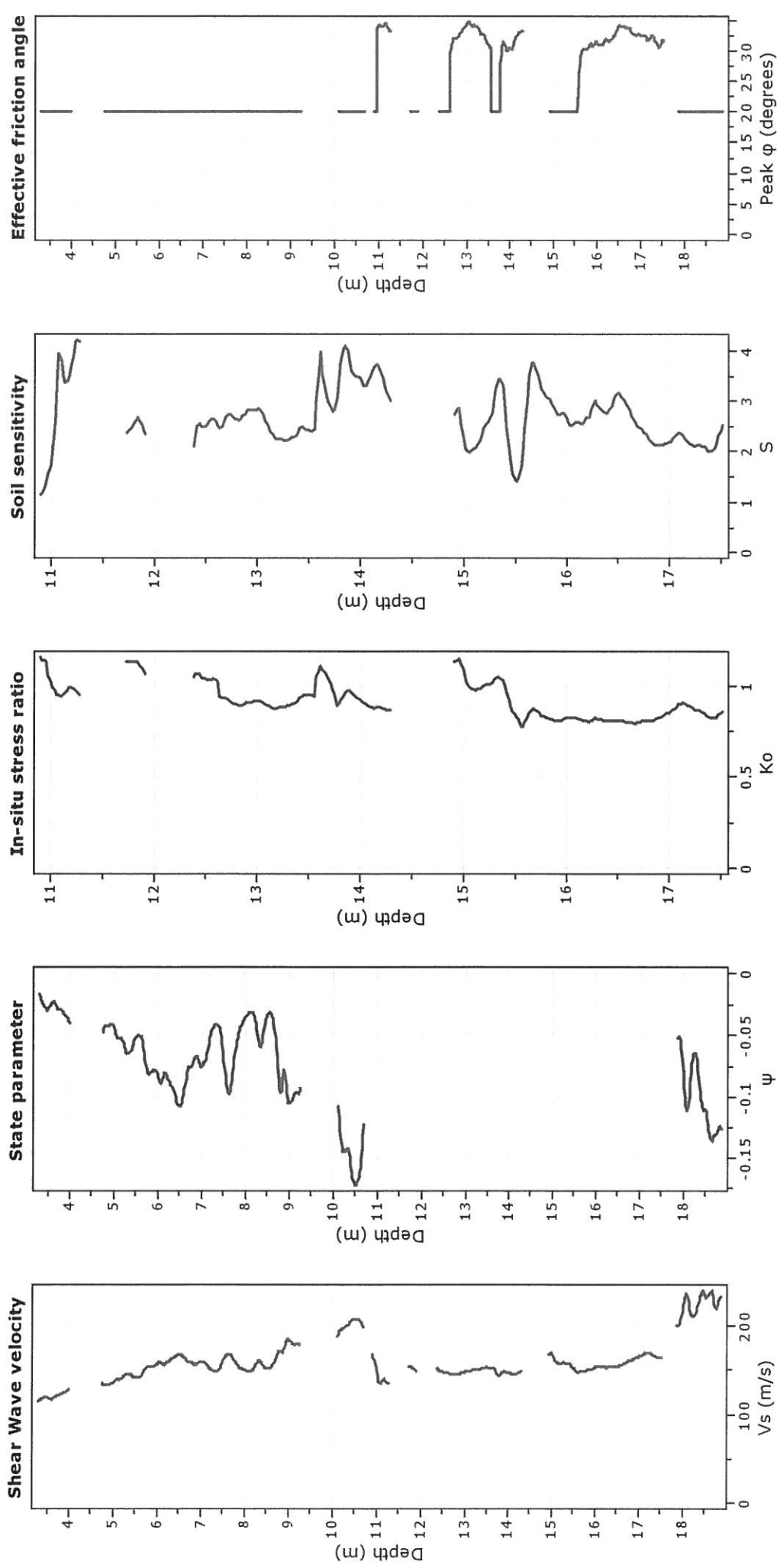
Constrained modulus: Based on variable  $\alpha/\rho$  using  $I_c$  and  $Q_m$  (Robertson, 2009)

Go: Based on variable  $\alpha/\rho$  using  $I_c$  (Robertson, 2009)

Undrained shear strength cone factor for clays,  $N_{kt}$ : 14

OCR factor for clays,  $N_{kt}$ : 0.33

—●— User defined estimation data



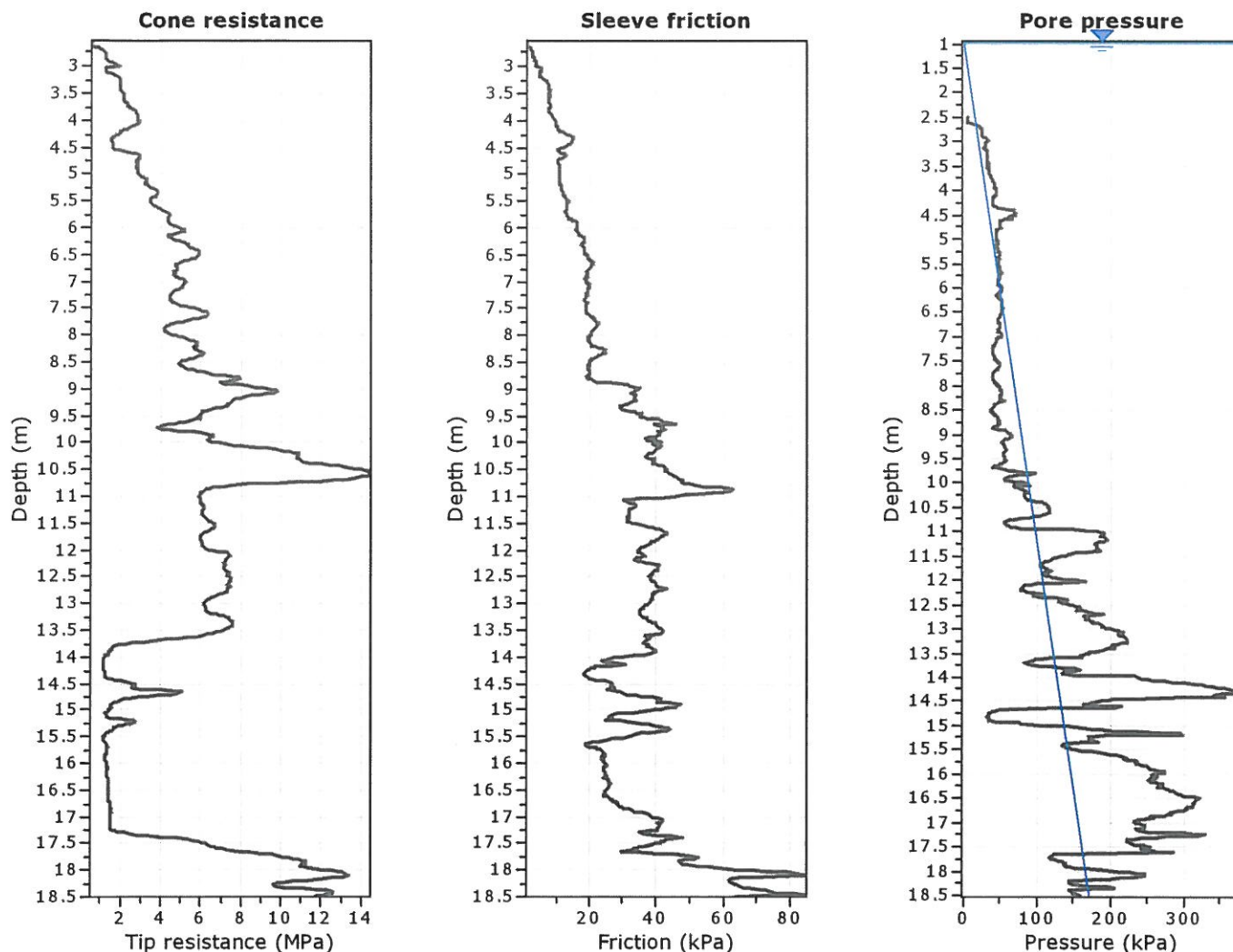
#### Calculation parameters

Soil Sensitivity factor,  $N_s$ : 7.00

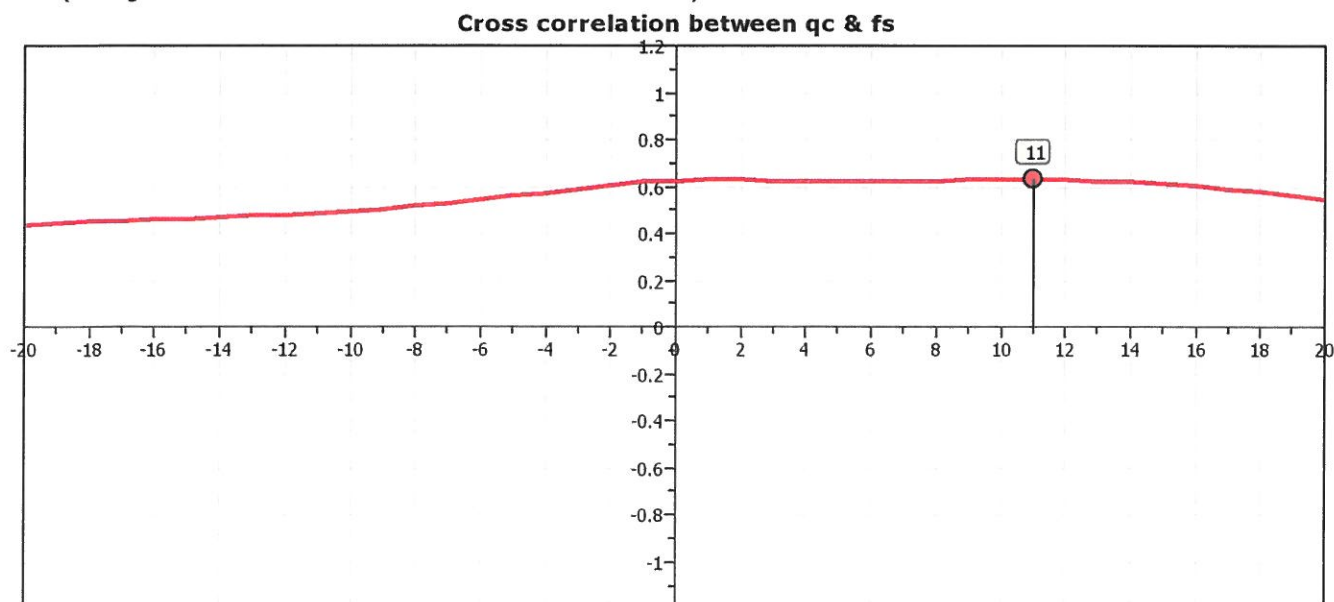
—●— User defined estimation data

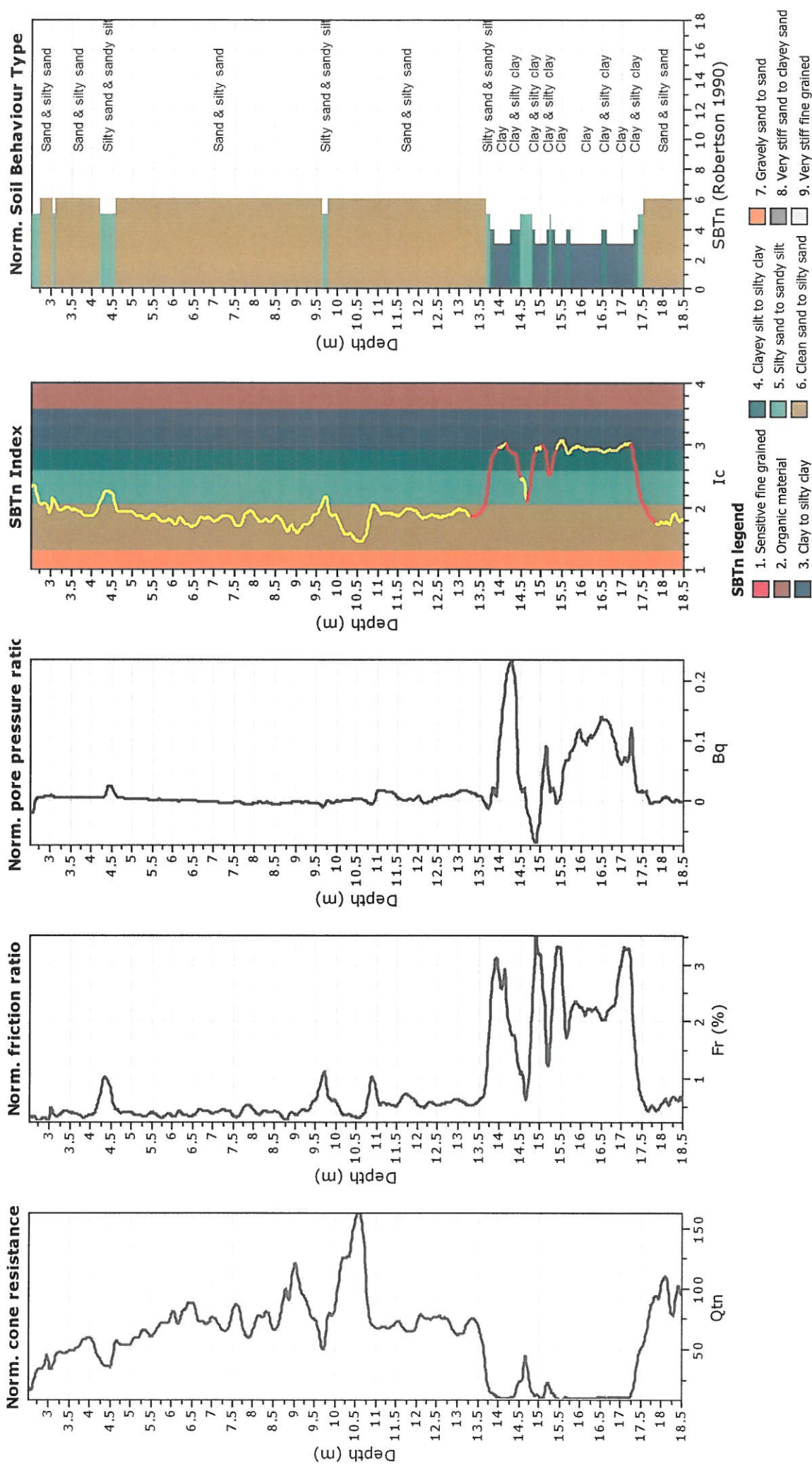
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

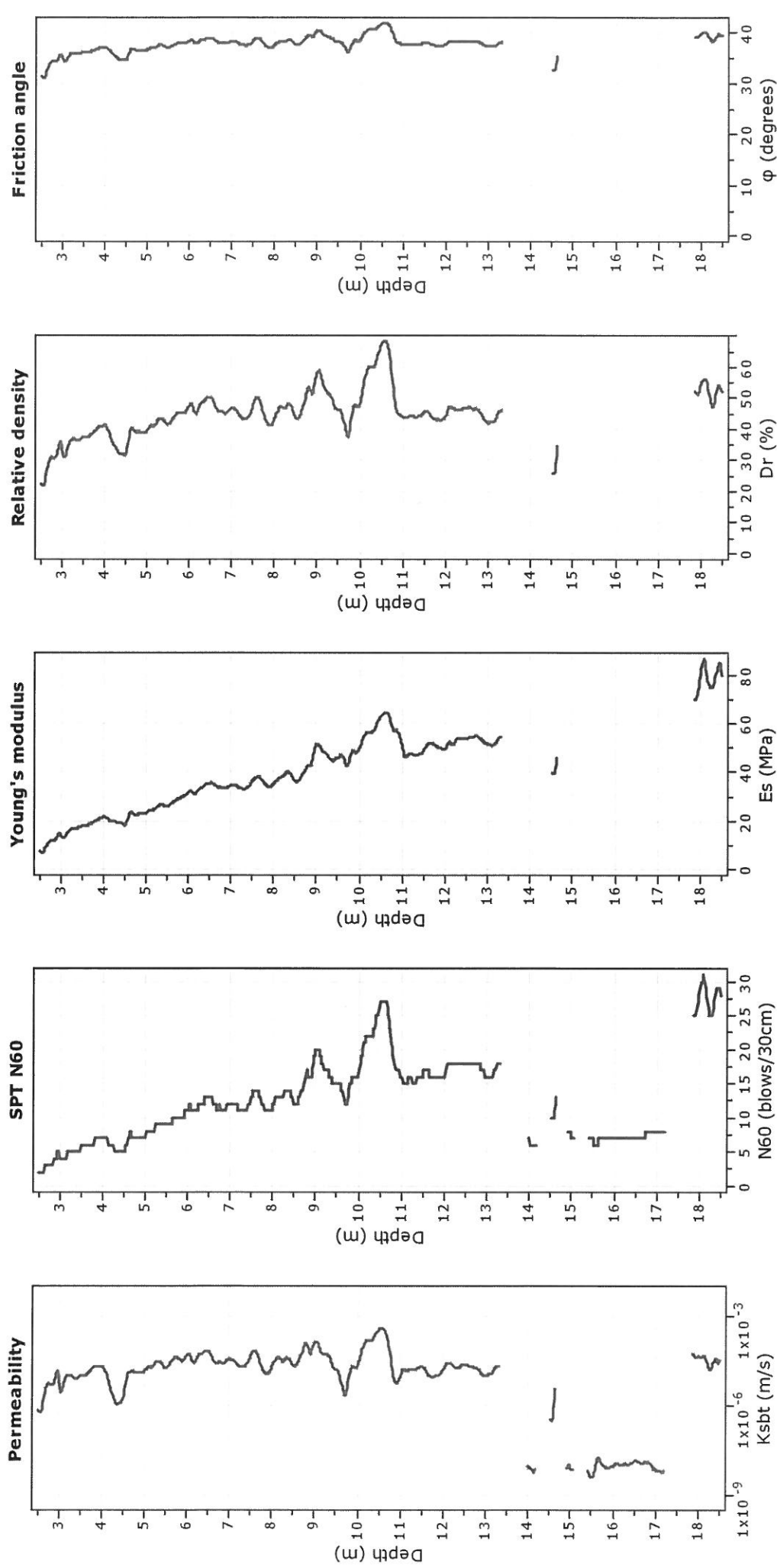
**Location: TRATTO CASTELMASSA - STIENTA**



The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



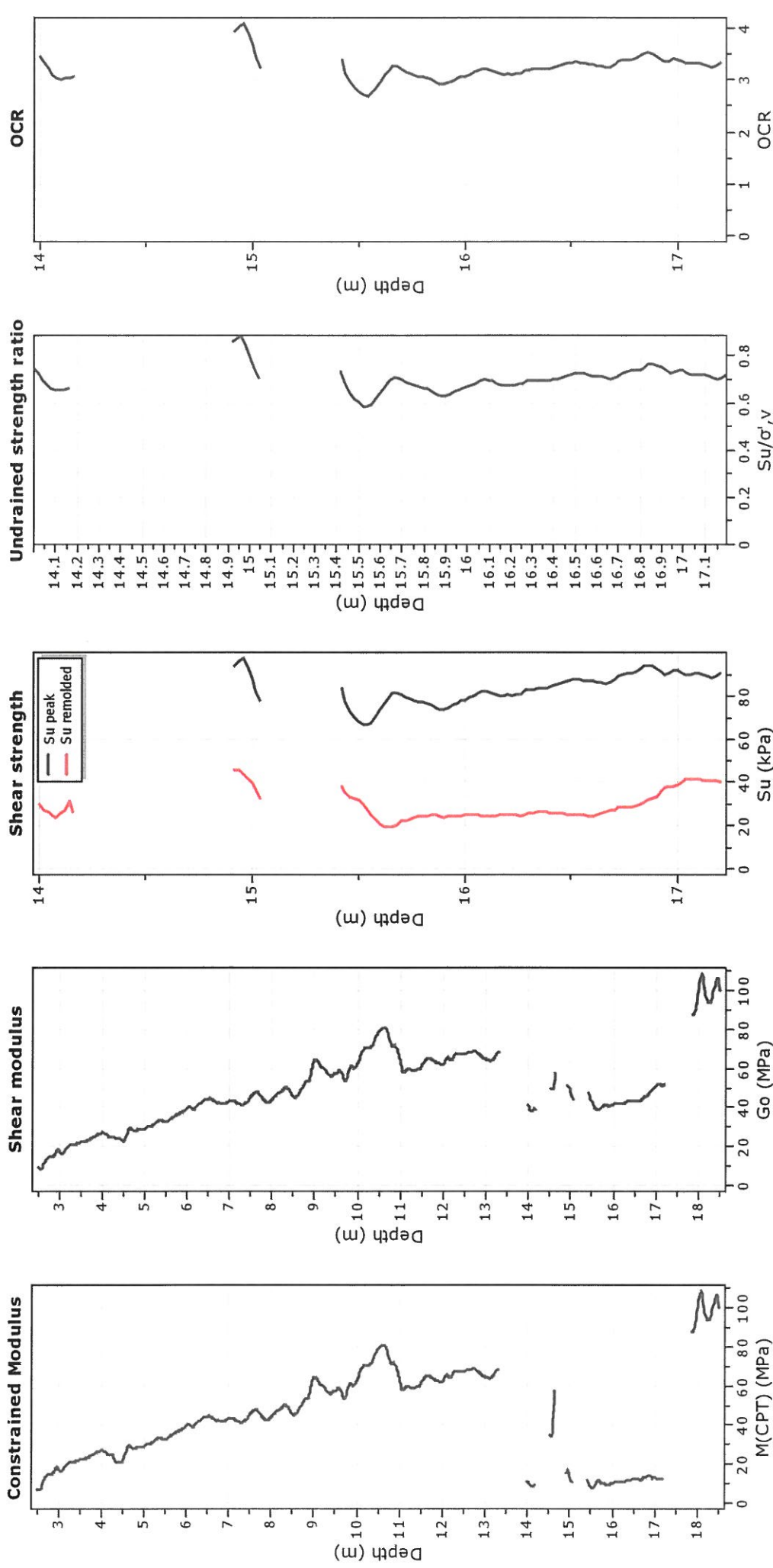




#### Calculation parameters

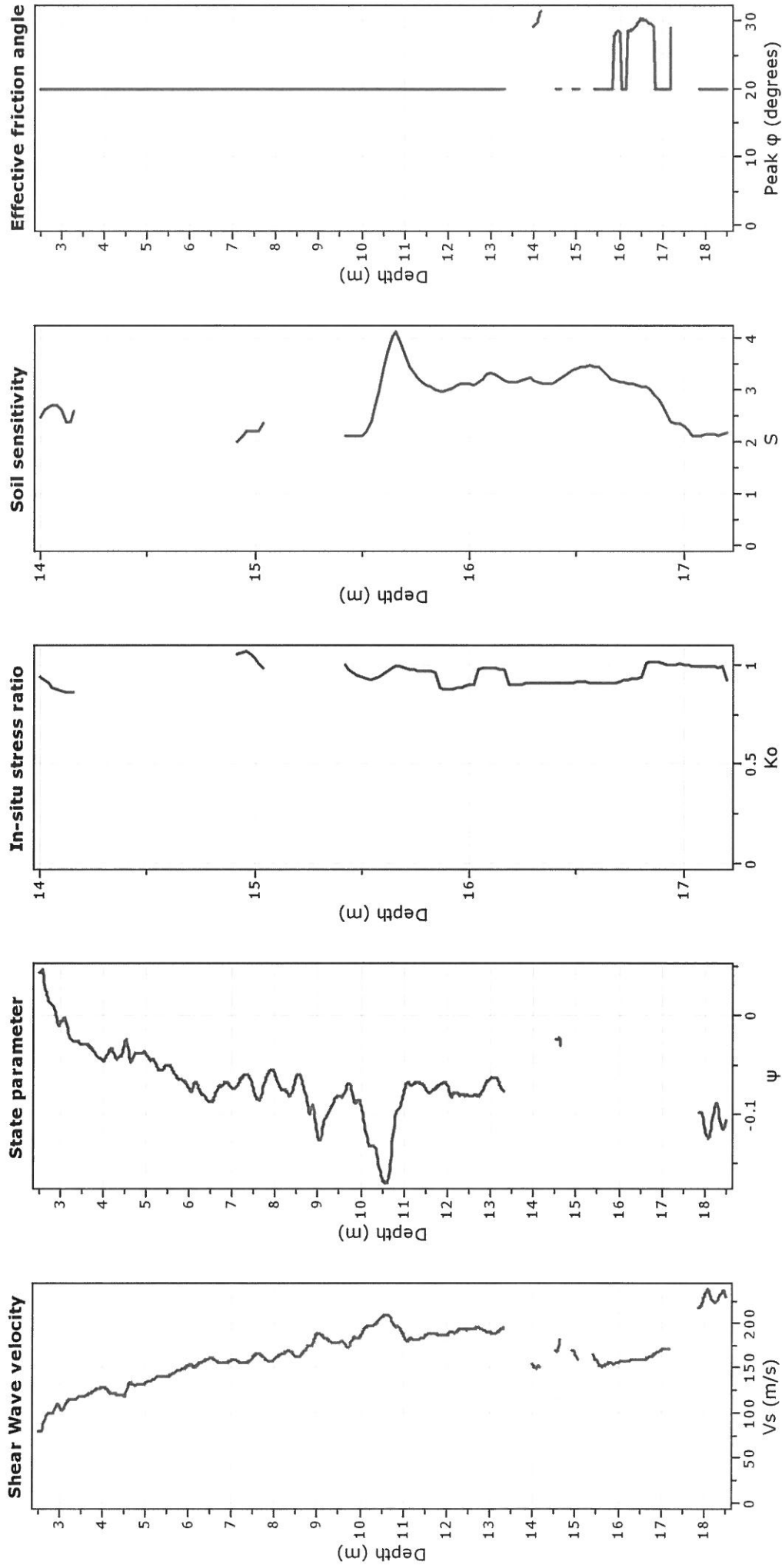
Permeability: Based on SBT<sub>n</sub>  
SPT N<sub>60</sub>: Based on I<sub>c</sub> and q<sub>t</sub>  
Young's modulus: Based on variable alpha using I<sub>c</sub> (Robertson, 2009)  
Relative density constant, C<sub>or</sub>: 350.0  
Phi: Based on Kulhawy & Mayne (1990)  
—●— User defined estimation data

Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



**Calculation parameters**

Constrained modulus: Based on variable  $\alpha$  using  $I_c$  and  $Q_m$  (Robertson, 2009)      OCR factor for clays,  $N_{kt}$ : 0.33  
Go: Based on variable  $\alpha$  using  $I_c$  (Robertson, 2009)      —●— User defined estimation data  
Undrained shear strength cone factor for clays,  $N_{kt}$ : 14



#### Calculation parameters

Soil Sensitivity factor,  $N_s$ : 7.00

—●— User defined estimation data

# CPTU 6A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.010	0.010	3.0	0.13	19.1	0.50	50.7	0.83	49.7	0.82	26.5	0.60
3	1.0	6	14.8	1	0.010	0.010	4.9	0.12	20.6	0.38	45.8	0.61	46.6	0.62	27.3	0.45
4	1.0	6	20.9	1	0.009	0.009	6.7	0.11	21.5	0.28	41.7	0.43	43.1	0.44	27.5	0.33
5	1.0	6	27.2	1	0.009	0.009	8.4	0.11	21.9	0.23	38.1	0.34	39.7	0.35	27.2	0.27
6	1.0	6	33.5	1	0.008	0.008	9.8	0.09	21.9	0.17	35.0	0.25	36.5	0.26	26.5	0.20
7	1.0	7	40.0	1	0.007	0.007	10.8	0.07	21.6	0.13	32.2	0.18	33.7	0.19	25.6	0.15
8	1.0	7	47.0	1	0.005	0.005	11.7	0.05	21.1	0.08	29.8	0.11	31.1	0.11	24.5	0.09
9	1.0	10	55.6	4	0.200	0.020	12.2	0.17	20.4	0.27	27.6	0.35	28.8	0.36	23.4	0.31
10	1.0	10	65.6	4	0.200	0.020	12.6	0.15	19.8	0.23	25.7	0.29	26.7	0.30	22.4	0.25
11	1.0	10	75.6	4	0.200	0.020	12.8	0.14	19.0	0.20	24.0	0.24	24.9	0.25	21.3	0.22
12	1.0	10	85.6	3	0.200	0.020	12.8	0.12	18.3	0.17	22.5	0.20	23.3	0.21	20.3	0.18
13	1.0	10	95.6	3	0.200	0.020	12.8	0.11	17.6	0.15	21.2	0.17	21.8	0.18	19.3	0.16
14	1.0	10	105.6	3	0.200	0.020	12.7	0.10	16.9	0.13	19.9	0.15	20.5	0.15	18.4	0.14
15	1.0	10	115.6	3	0.200	0.020	12.5	0.09	16.2	0.11	18.9	0.13	19.3	0.13	17.5	0.12
TOTALI (cm)								1.56	3.03	4.28	4.36	3.48				

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m³	$\sigma'_{v0}$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.010	0.010	12.0	0.37	2.0	0.09
3	1.0	6	14.8	1	0.010	0.010	12.6	0.27	3.2	0.09
4	1.0	6	20.9	1	0.009	0.009	13.4	0.19	4.4	0.07
5	1.0	6	27.2	1	0.009	0.009	14.2	0.16	5.6	0.07
6	1.0	6	33.5	1	0.008	0.008	14.9	0.13	6.6	0.06
7	1.0	7	40.0	1	0.007	0.007	15.3	0.10	7.6	0.05
8	1.0	7	47.0	1	0.005	0.005	15.6	0.06	8.4	0.04
9	1.0	10	55.6	4	0.200	0.020	15.7	0.22	9.1	0.13
10	1.0	10	65.6	4	0.200	0.020	15.7	0.19	9.6	0.12
11	1.0	10	75.6	4	0.200	0.020	15.5	0.16	10.0	0.11
12	1.0	10	85.6	3	0.200	0.020	15.3	0.14	10.3	0.10
13	1.0	10	95.6	3	0.200	0.020	15.0	0.13	10.5	0.09
14	1.0	10	105.6	3	0.200	0.020	14.6	0.11	10.6	0.08
15	1.0	10	115.6	3	0.200	0.020	14.2	0.10	10.6	0.08
TOTALI (cm)								2.34	1.18	

1.14

# CPTU 7A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.010	0.010	3.0	0.13	19.1	0.50	50.7	0.83	49.7	0.82	26.5	0.60
3	1.0	6	14.9	1	0.009	0.009	4.9	0.11	20.6	0.34	45.8	0.55	46.6	0.55	27.3	0.41
4	1.0	6	21.1	1	0.009	0.009	6.7	0.11	21.5	0.27	41.7	0.43	43.1	0.43	27.5	0.33
5	1.0	6	27.4	1	0.009	0.009	8.4	0.10	21.9	0.23	38.1	0.34	39.7	0.35	27.2	0.27
6	1.0	7	33.9	1	0.007	0.007	9.8	0.08	21.9	0.15	35.0	0.22	36.5	0.22	26.5	0.18
7	1.0	7	40.5	1	0.007	0.007	10.8	0.07	21.6	0.13	32.2	0.18	33.7	0.18	25.6	0.15
8	1.0	7	47.5	1	0.004	0.004	11.7	0.04	21.1	0.06	29.8	0.08	31.1	0.09	24.5	0.07
9	1.0	6	54.3	1	0.009	0.009	12.2	0.08	20.4	0.12	27.6	0.16	28.8	0.17	23.4	0.14
10	1.0	6	60.7	1	0.009	0.009	12.6	0.07	19.8	0.11	25.7	0.14	26.7	0.14	22.4	0.12
11	1.0	6	67.0	1	0.009	0.009	12.8	0.07	19.0	0.10	24.0	0.12	24.9	0.12	21.3	0.11
12	1.0	10	75.2	4	0.200	0.020	12.8	0.14	18.3	0.19	22.5	0.23	23.3	0.23	20.3	0.21
13	1.0	10	85.2	4	0.200	0.020	12.8	0.12	17.6	0.16	21.2	0.19	21.8	0.20	19.3	0.18
14	1.0	10	95.2	4	0.200	0.020	12.7	0.11	16.9	0.14	19.9	0.17	20.5	0.17	18.4	0.15
15	1.0	10	105.2	4	0.200	0.020	12.5	0.10	16.2	0.12	18.9	0.14	19.3	0.15	17.5	0.13
TOTALI (cm)								1.33	2.64	3.77	3.83	3.04				

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

## CARATTERISTICHE DEGLI STRATI

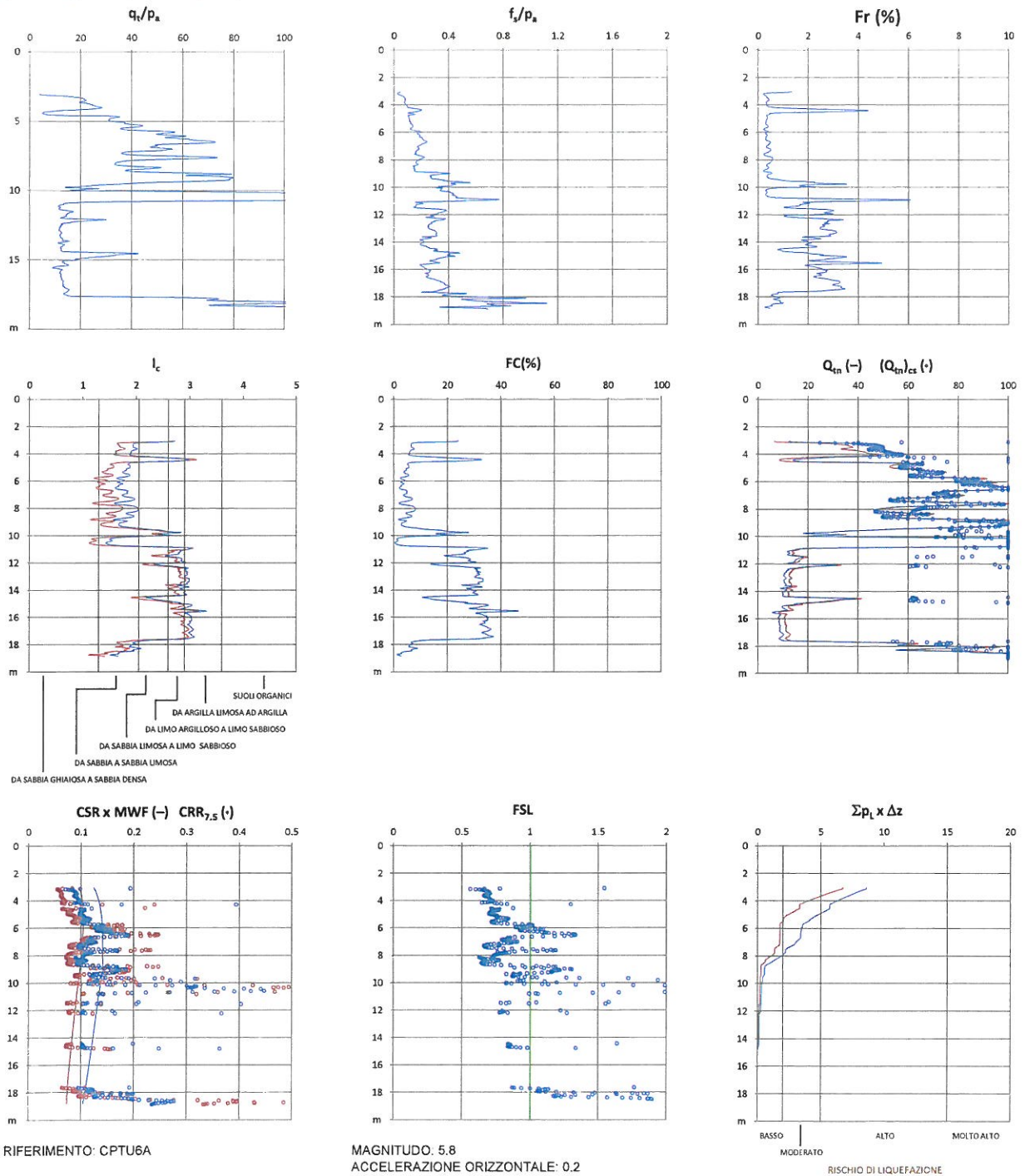
## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m³	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.010	0.010	12.0	0.37	2.0	0.09
3	1.0	6	14.9	1	0.009	0.009	12.6	0.24	3.2	0.08
4	1.0	6	21.1	1	0.009	0.009	13.4	0.19	4.4	0.07
5	1.0	6	27.4	1	0.009	0.009	14.2	0.16	5.6	0.07
6	1.0	7	33.9	1	0.007	0.007	14.9	0.11	6.6	0.05
7	1.0	7	40.5	1	0.007	0.007	15.3	0.10	7.6	0.05
8	1.0	7	47.5	1	0.004	0.004	15.6	0.05	8.4	0.03
9	1.0	6	54.3	1	0.009	0.009	15.7	0.10	9.1	0.06
10	1.0	6	60.7	1	0.009	0.009	15.7	0.09	9.6	0.06
11	1.0	6	67.0	1	0.009	0.009	15.5	0.08	10.0	0.05
12	1.0	10	75.2	4	0.200	0.020	15.3	0.16	10.3	0.11
13	1.0	10	85.2	4	0.200	0.020	15.0	0.14	10.5	0.10
14	1.0	10	95.2	4	0.200	0.020	14.6	0.12	10.6	0.09
15	1.0	10	105.2	4	0.200	0.020	14.2	0.11	10.6	0.08
TOTALI (cm)								2.03		1.00

[illegible]

## RISCHIO LIQUEFAZIONE

(Robertson & Wride, 1997 - Iwasaki et al. 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)

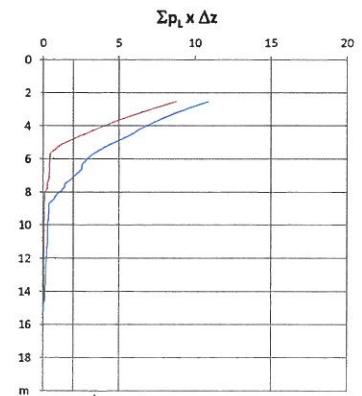
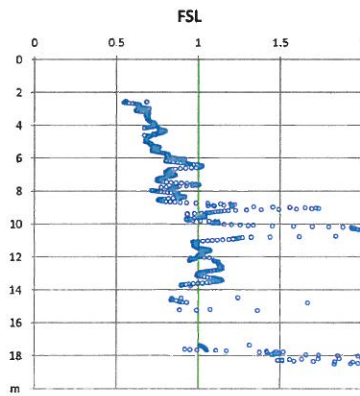
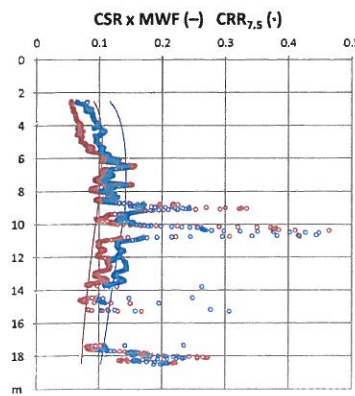
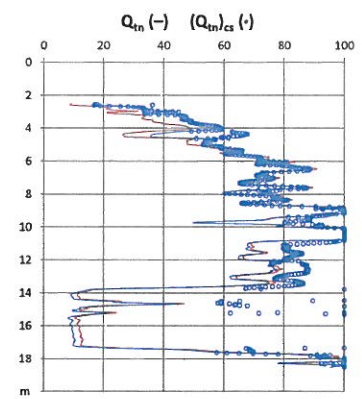
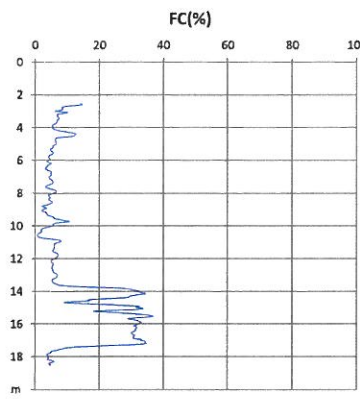
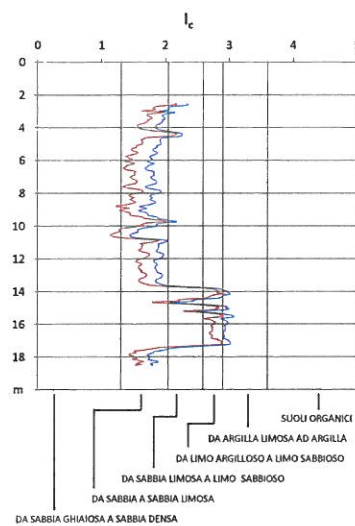
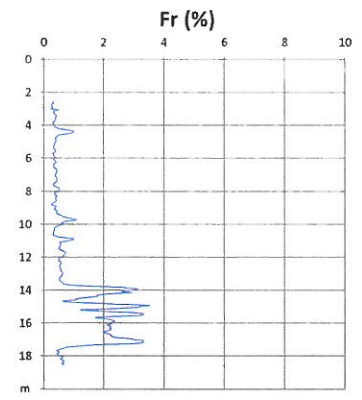
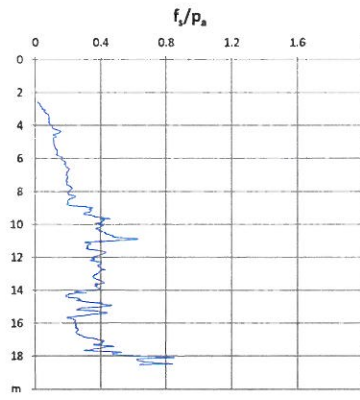
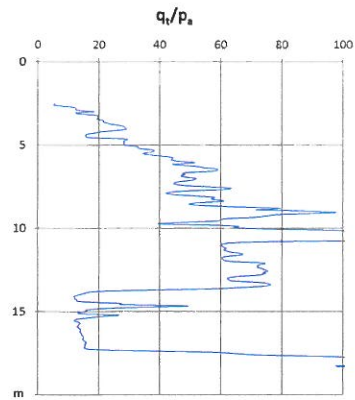


RIFERIMENTO: CPTU6A

MAGNITUDO: 5.8  
ACCELERAZIONE ORIZZONTALE: 0.2

## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



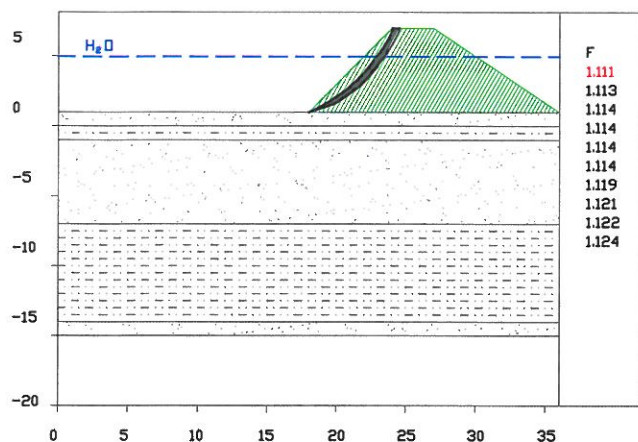
RIFERIMENTO: CPTU7A

MAGNITUDO: 5.8  
ACCELERAZIONE ORIZZONTALE: 0.198

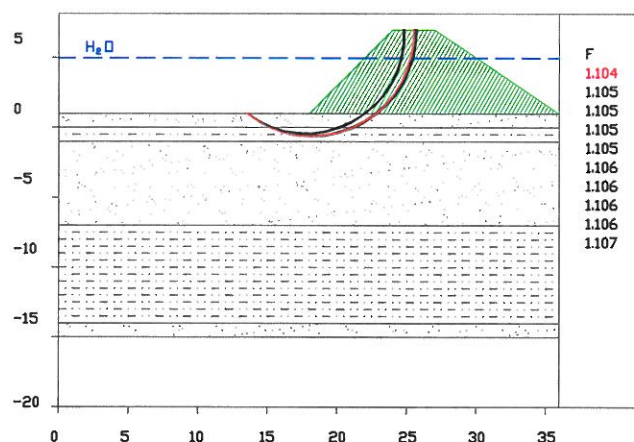
SOFTWARE GIANVITO CASSINADRI 2014

## VERIFICHE DI STABILITÀ

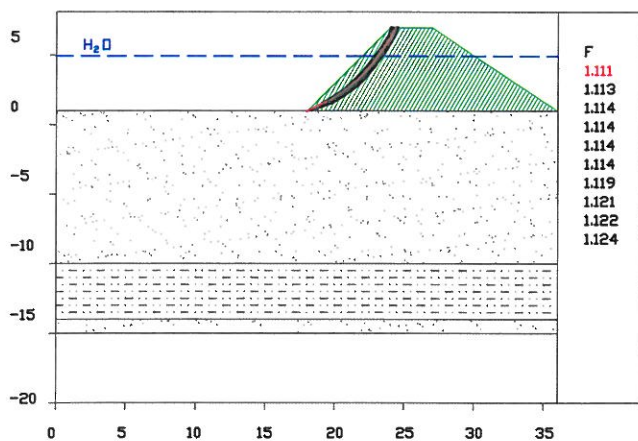
CPTU 6A - SENZA SISMA E COESIONE = 0.6 kPa



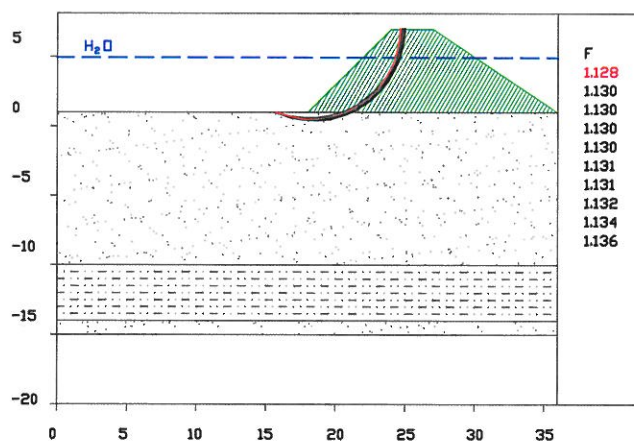
CPTU 6A - CON SISMA E COESIONE = 2.5 kPa



CPTU 7A - SENZA SISMA E COESIONE = 0.6 kPa



CPTU 7A - CON SISMA E COESIONE = 2.5 kPa





## FICAROLO

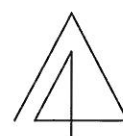


PROVA PENETROMETRICA



OPERE IN PROGETTO

LEGENDA



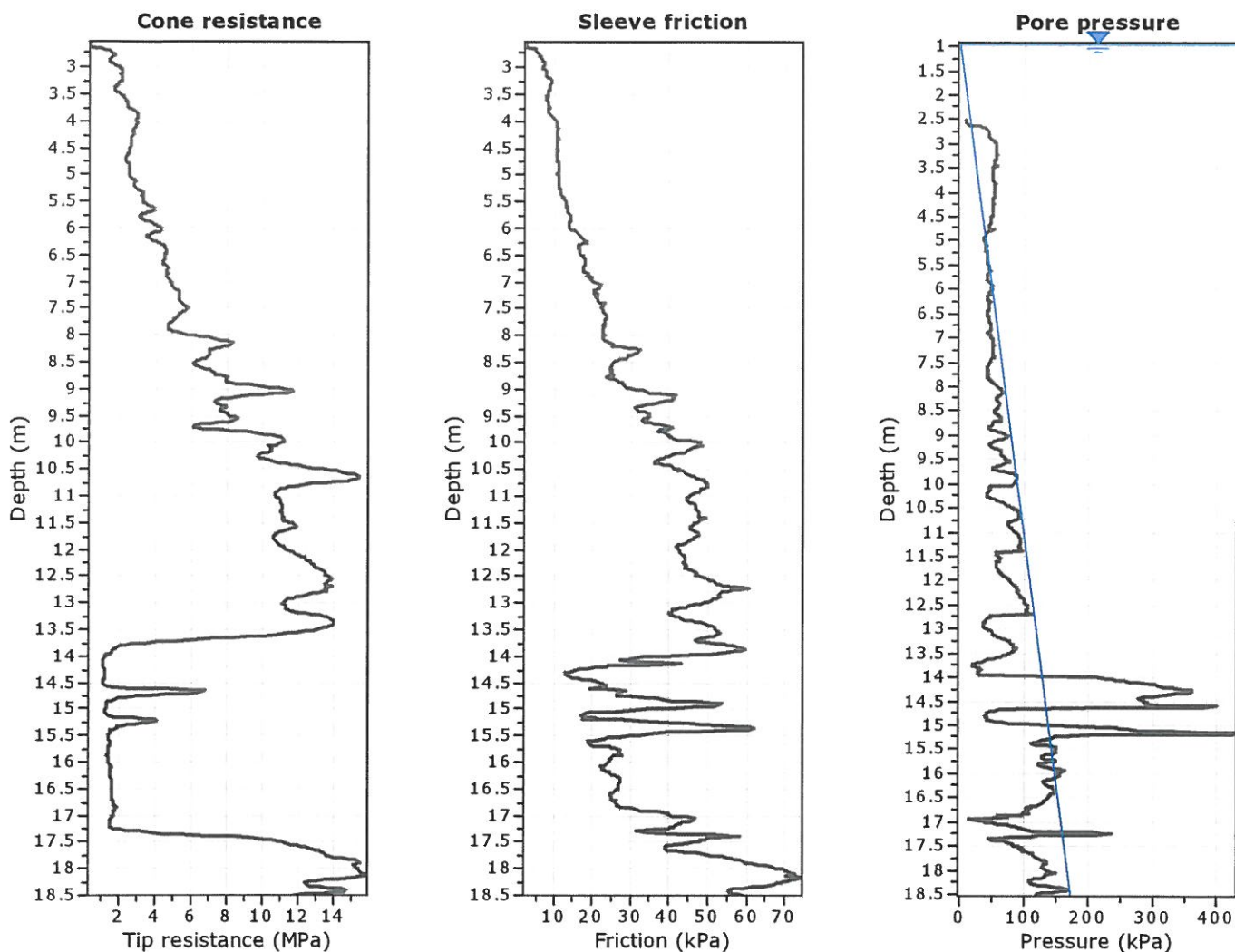
NORD



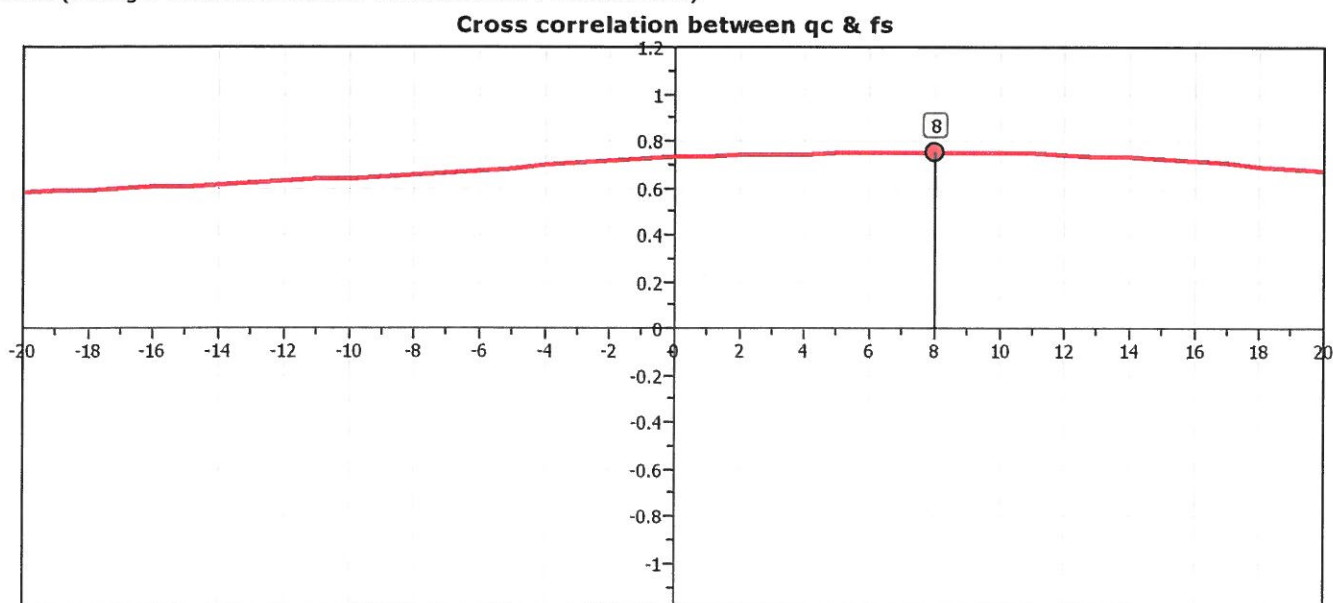
UBICAZIONE SONDAGGI FICAROLO

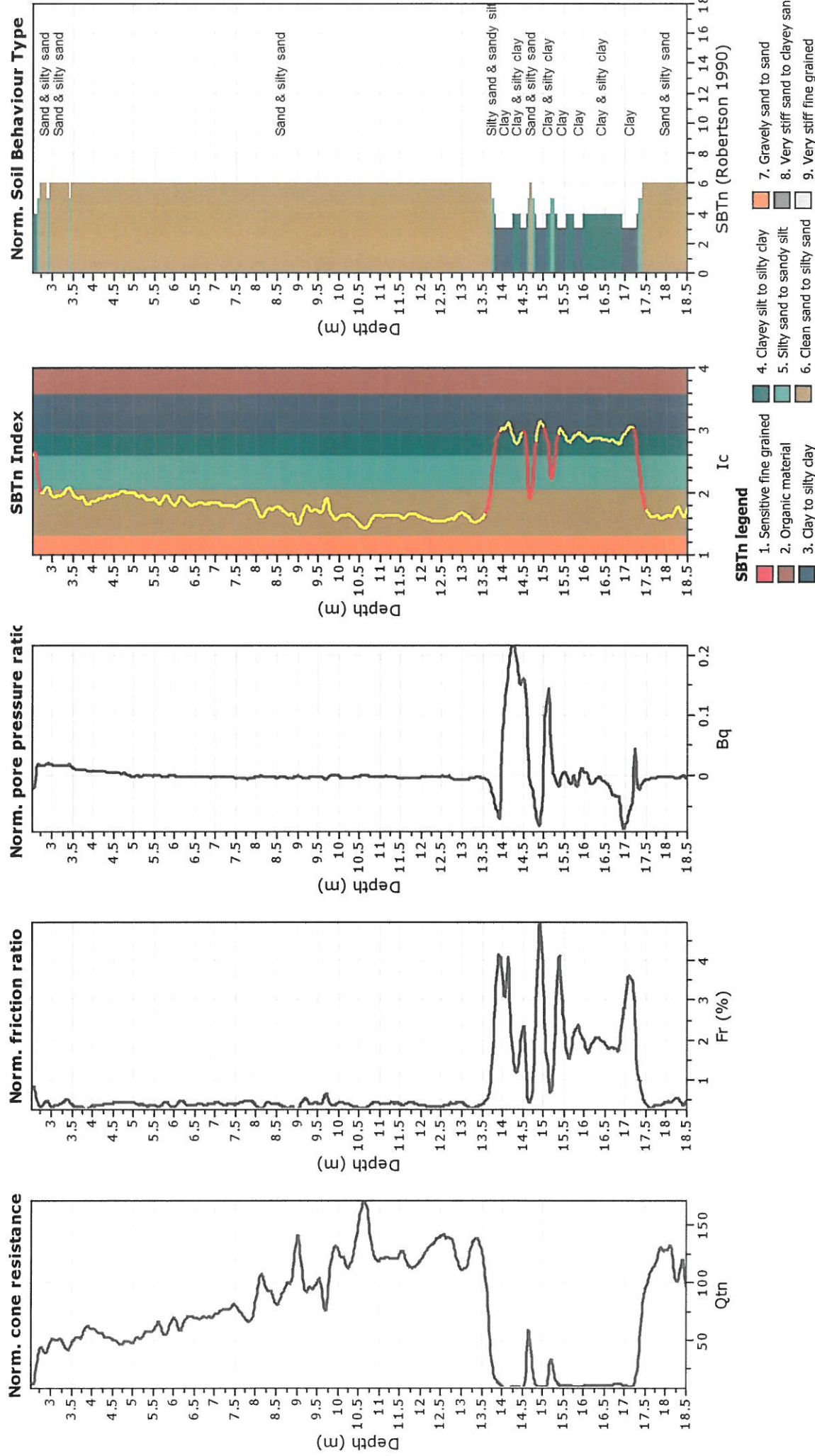
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

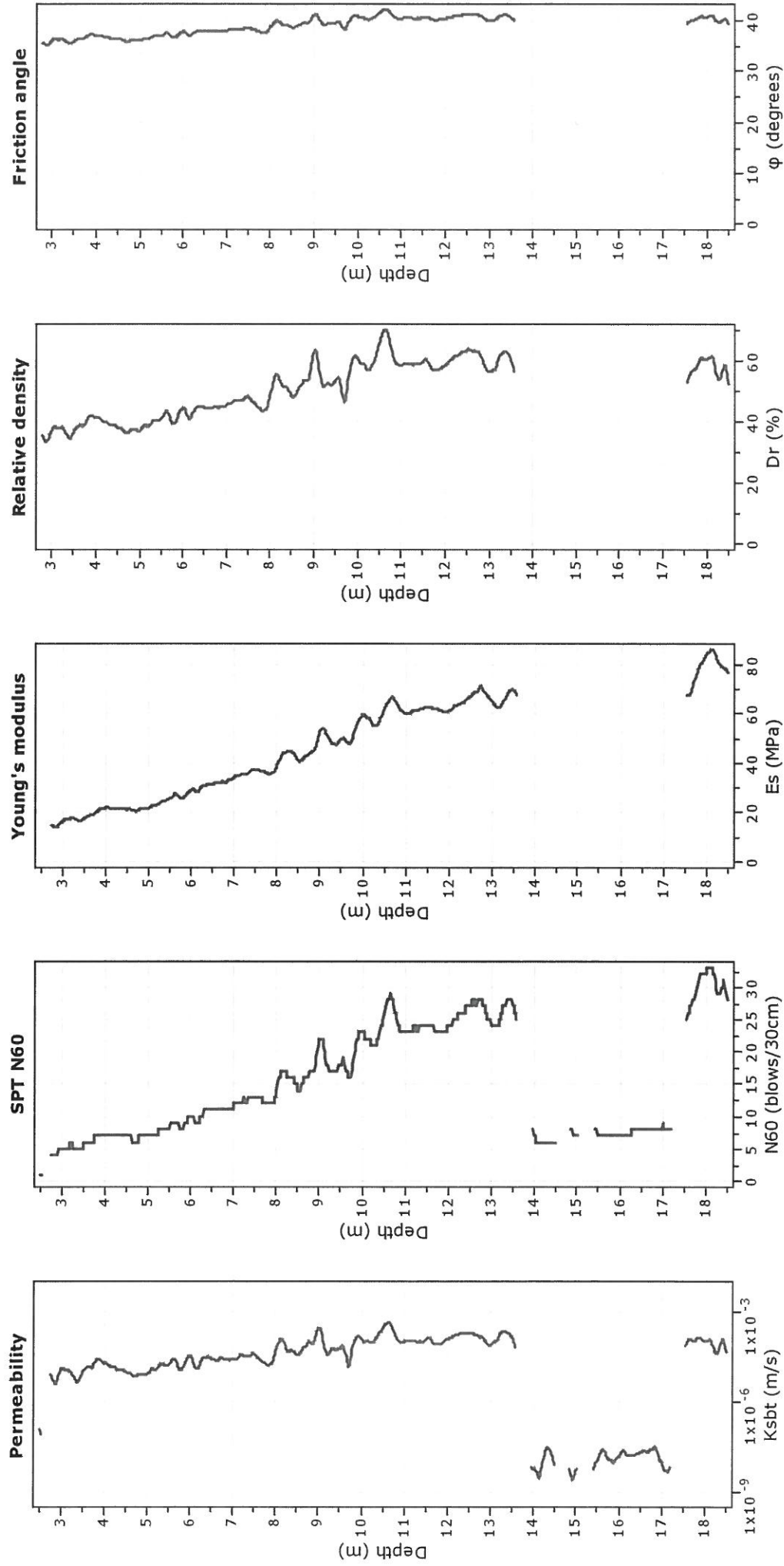
**Location: TRATTO CASTELMASSA - STIENTA**



The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



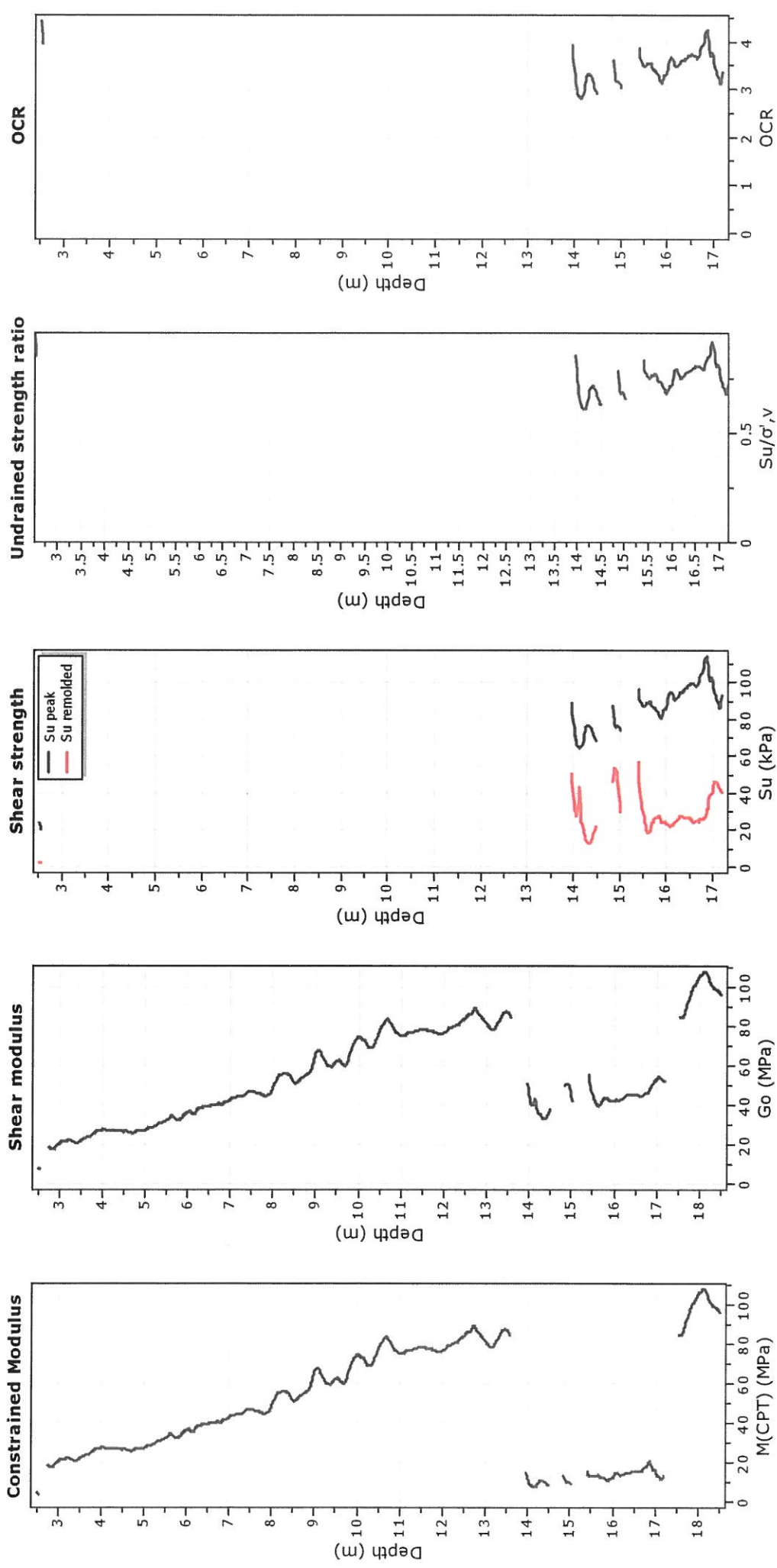




#### Calculation parameters

Permeability: Based on  $SBT_n$   
SPT  $N_{60}$ : Based on  $I_c$  and  $q_t$   
Young's modulus: Based on variable alpha using  $I_c$  (Robertson, 2009)  
Relative density constant,  $C_{Dr}$ : 350.0  
Phi: Based on Kulhawy & Mayne (1990)  
—●— User defined estimation data

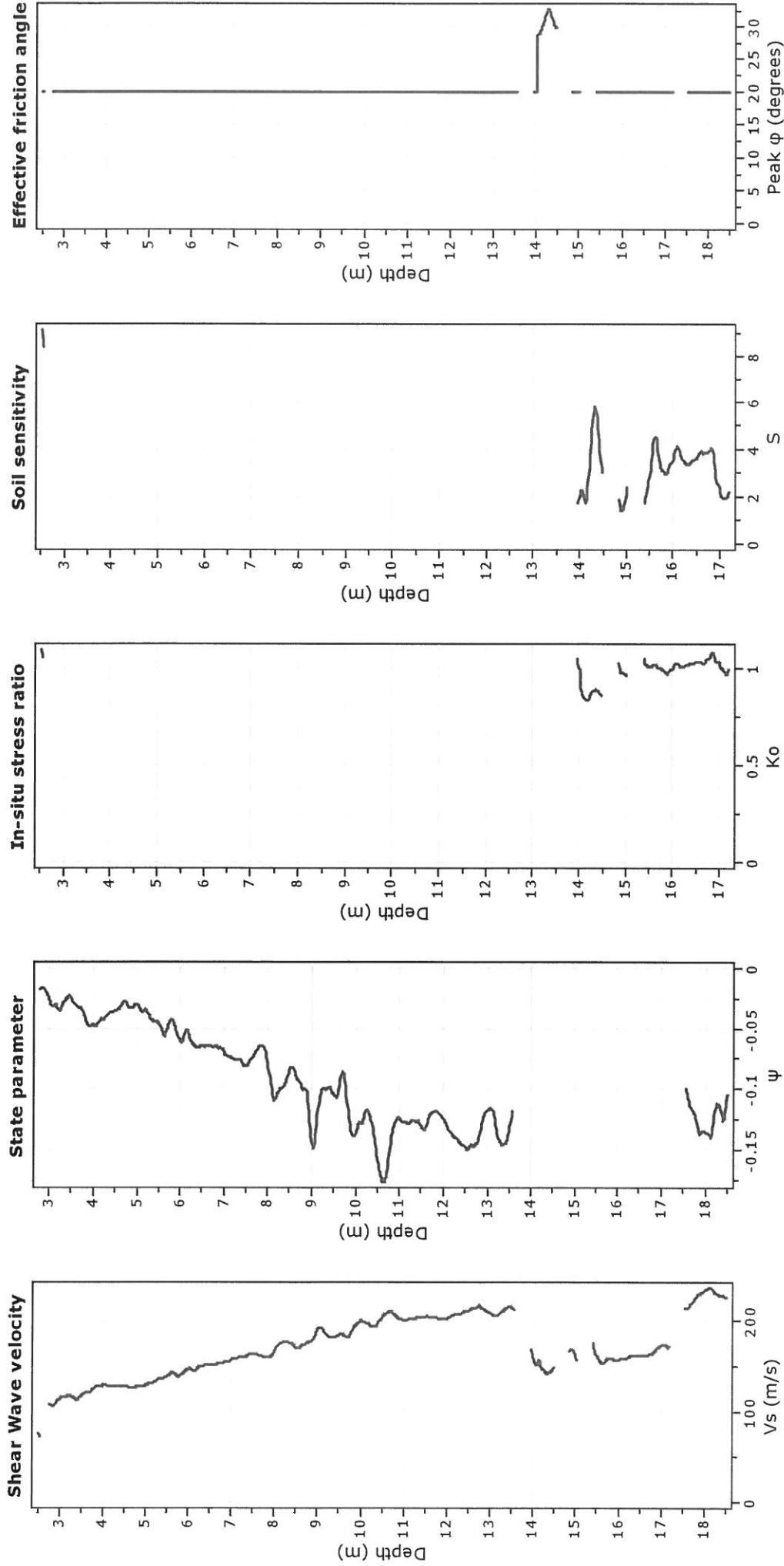
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**



#### Calculation parameters

Constrained modulus: Based on variable  $\alpha/\beta$  using  $I_c$  and  $Q_m$  (Robertson, 2009)  
Go: Based on variable  $\alpha/\beta$  using  $I_c$  (Robertson, 2009)  
Undrained shear strength cone factor for clays,  $N_{kt}$ : 14  
OCR factor for clays,  $N_{kt}$ : 0.33  
—●— User defined estimation data

Project: Fiume Po - Sistemazione a corrente libera per la navigazione  
Location: Tratto Castelmasa - Stienta



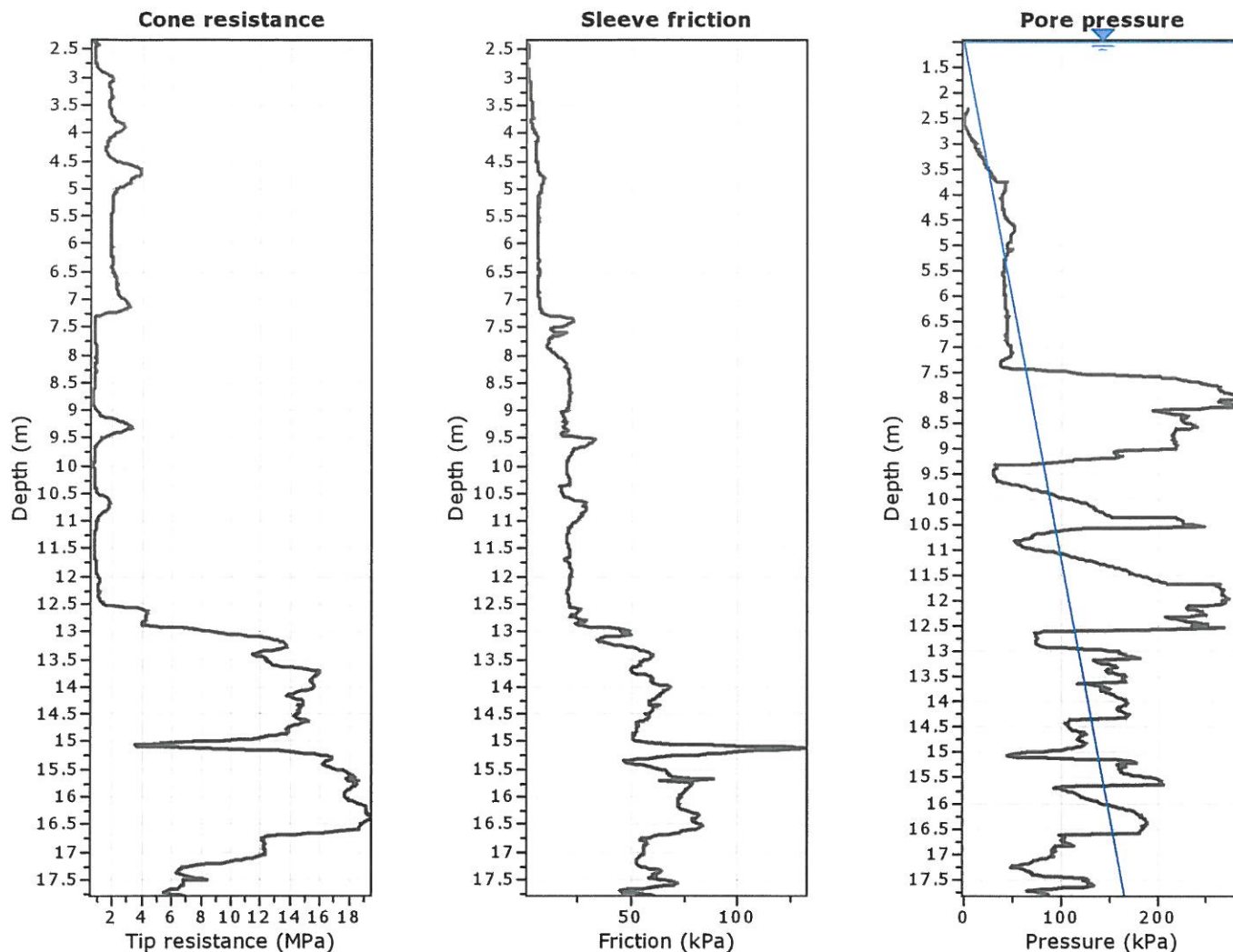
**Calculation parameters**

Soil Sensitivity factor,  $N_s$ : 7.00

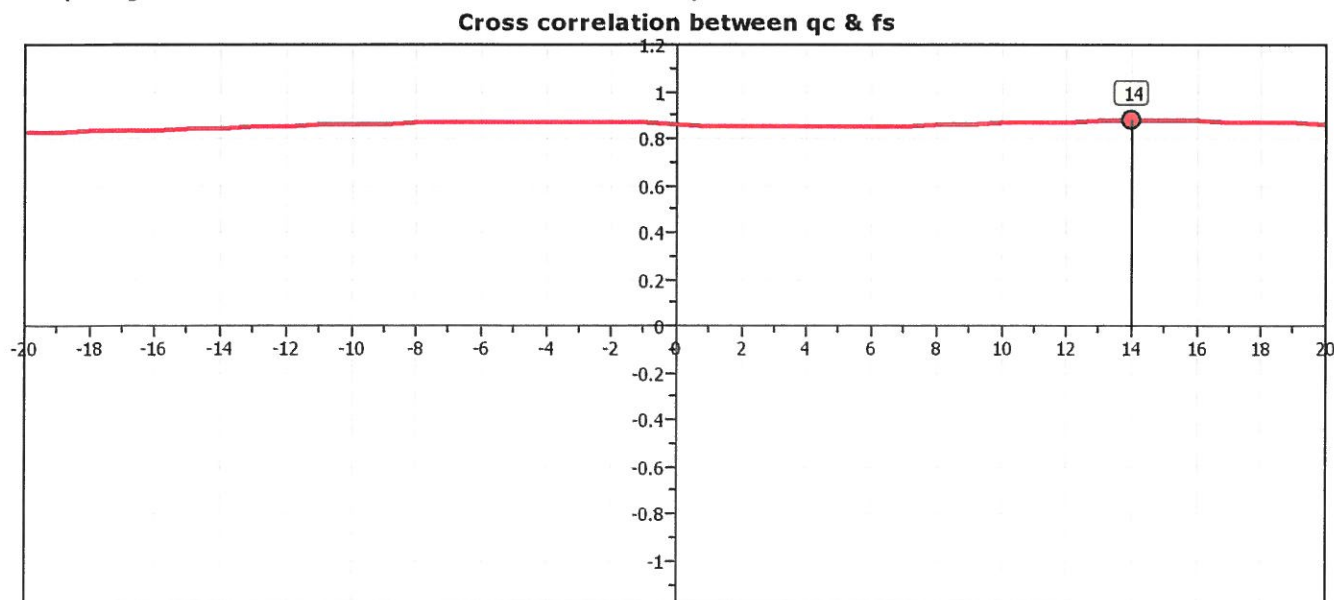
—●— User defined estimation data

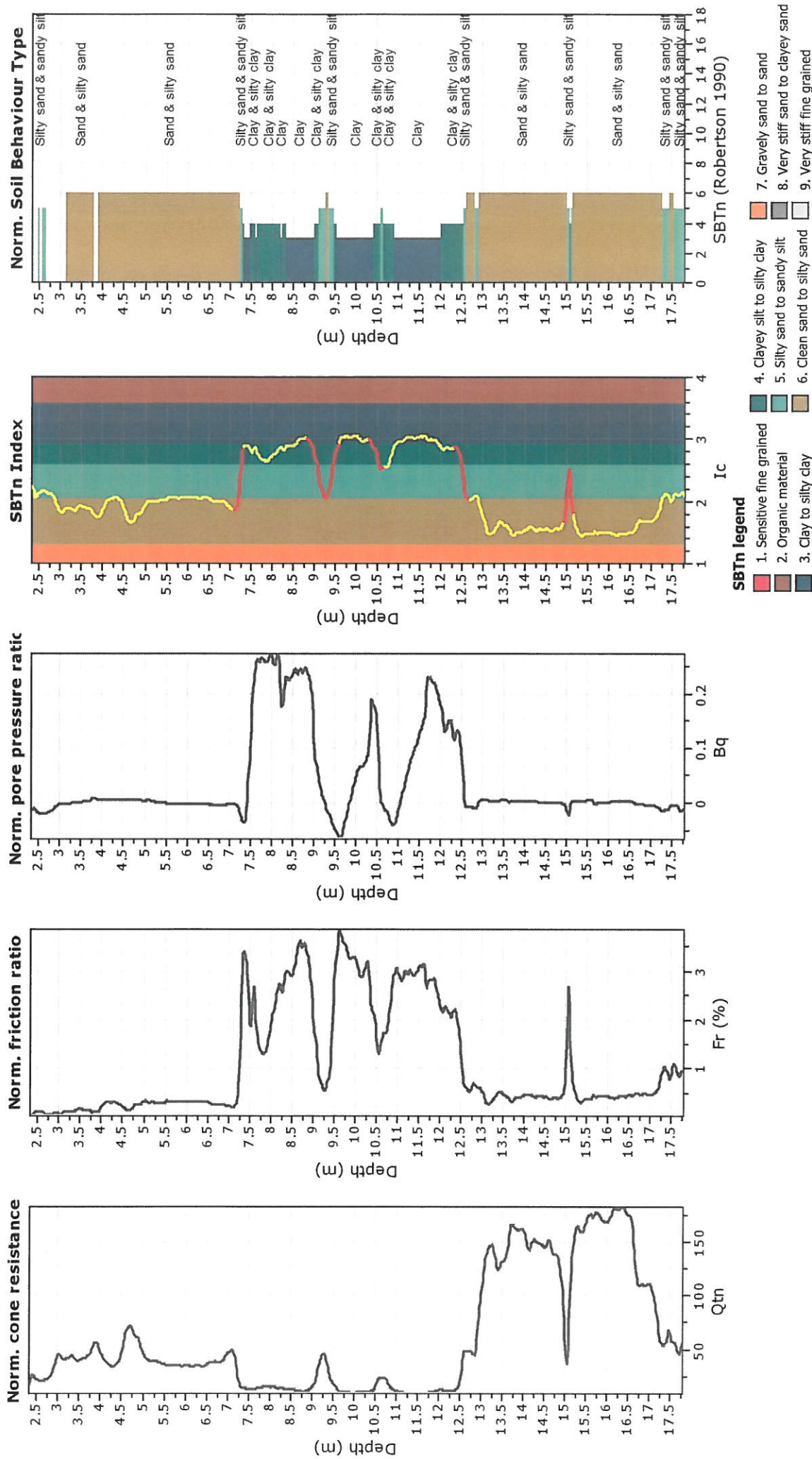
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

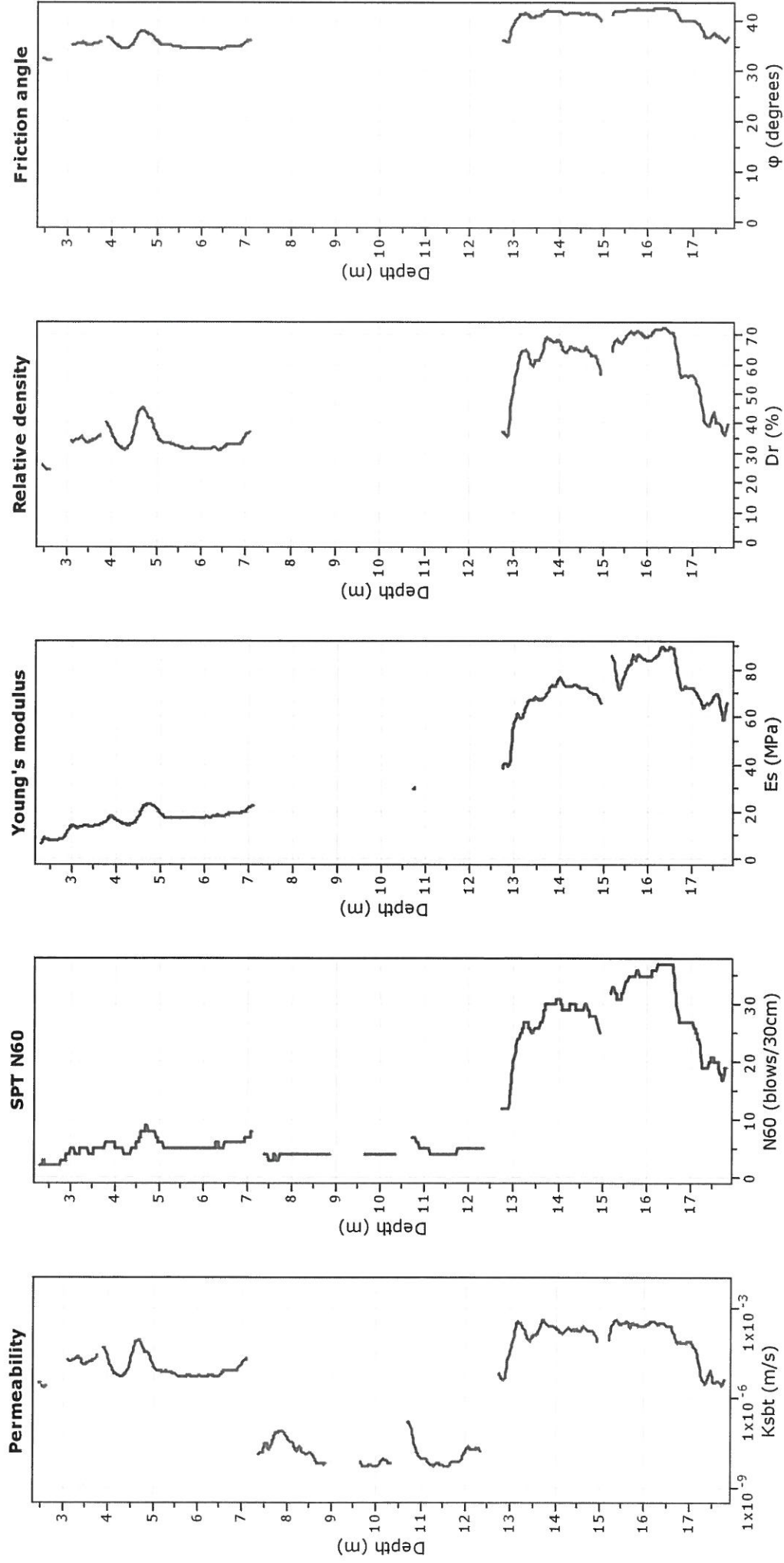
**Location: TRATTO CASTELMASSA - STIENTA**



The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



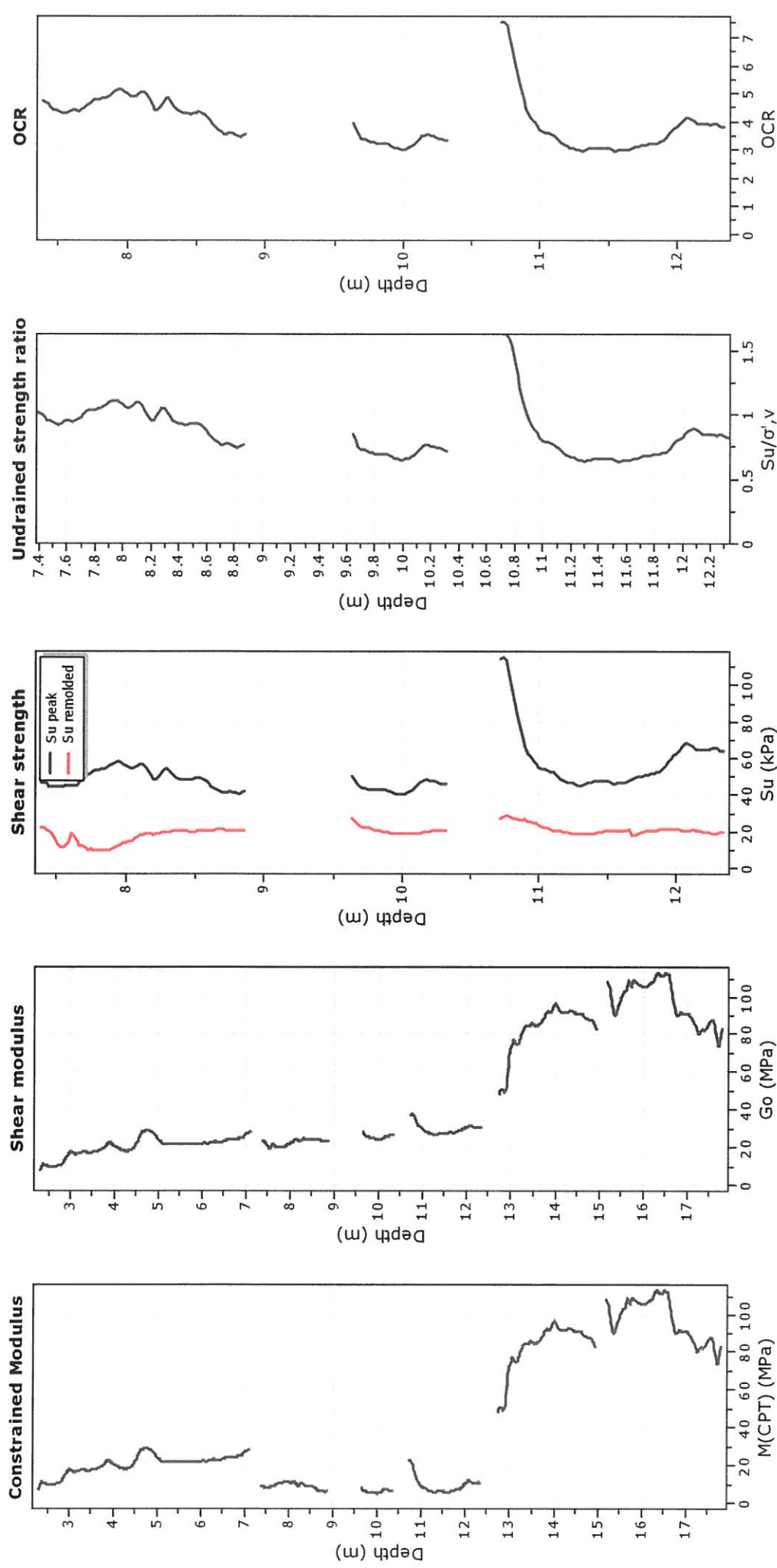




#### Calculation parameters

Permeability: Based on  $SBT_n$   
SPT  $N_{60}$ : Based on  $I_c$  and  $q_t$   
Young's modulus: Based on variable  $\alpha$  using  $I_c$  (Robertson, 2009) —●— User defined estimation data  
Relative density constant,  $C_{Dr}$ : 350.0  
Phi: Based on Kulhawy & Mayne (1990)

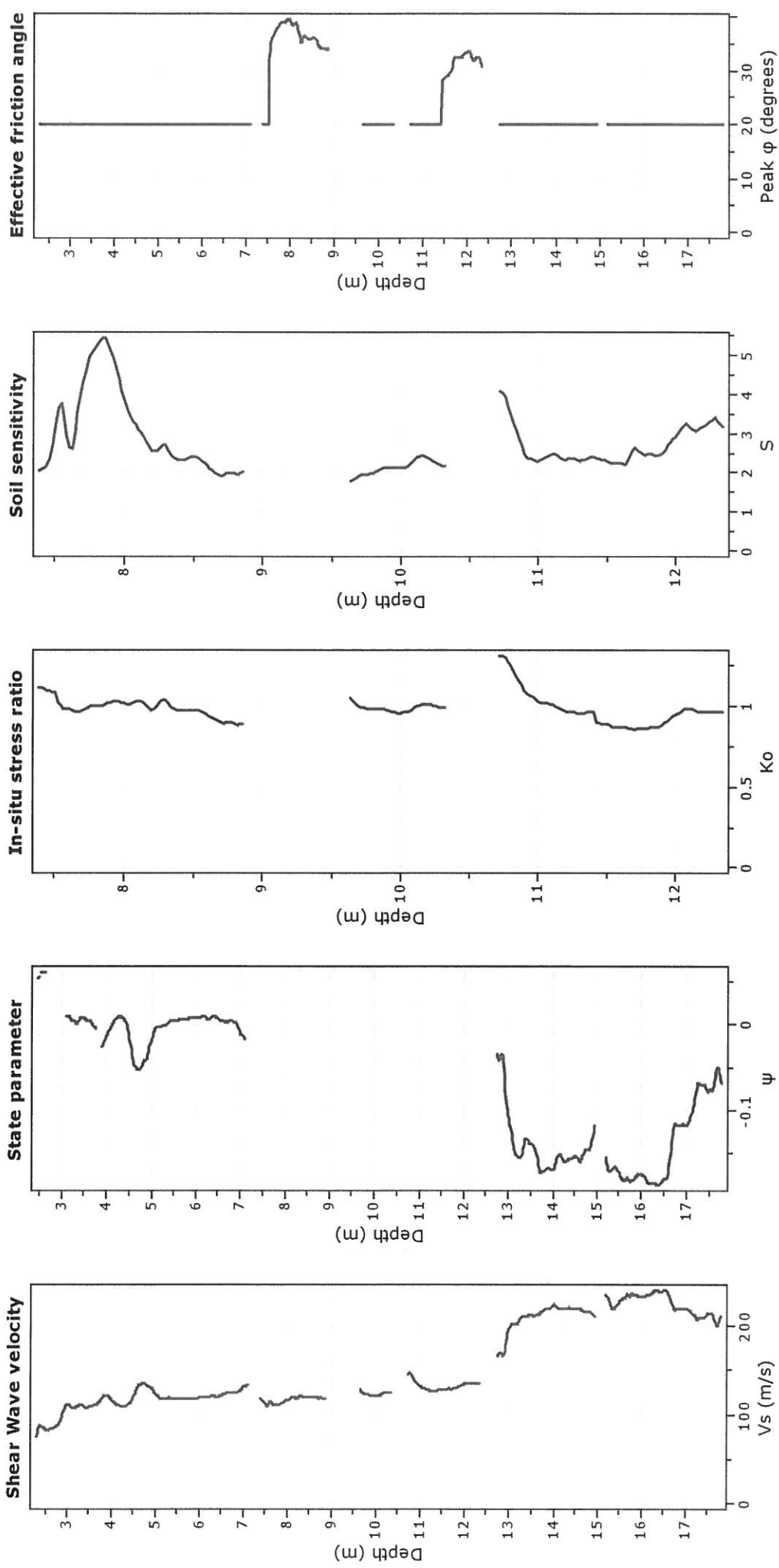
Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



#### Calculation parameters

Constrained modulus: Based on variable  $\alpha/\rho$  using  $I_c$  and  $Q_n$  (Robertson, 2009)  
Go: Based on variable  $\alpha/\rho$  using  $I_c$  (Robertson, 2009)  
Undrained shear strength cone factor for clays,  $N_{kt}$ : 14  
OCR factor for clays,  $N_{kc}$ : 0.33  
—●— User defined estimation data

**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**



#### Calculation parameters

Soil Sensitivity factor,  $N_s$ : 7.00

—●— User defined estimation data

# CPTU 8A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

### CARATTERISTICHE DEGLI STRATI

### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.010	0.010	3.0	0.13	19.1	0.50	50.7	0.83	49.7	0.82	26.5	0.60
3	1.0	6	14.9	1	0.009	0.009	4.9	0.11	20.6	0.34	45.8	0.55	46.6	0.55	27.3	0.41
4	1.0	6	21.2	1	0.009	0.009	6.7	0.11	21.5	0.27	41.7	0.43	43.1	0.43	27.5	0.33
5	1.0	7	27.6	1	0.008	0.008	8.4	0.09	21.9	0.20	38.1	0.30	39.7	0.31	27.2	0.24
6	1.0	7	34.2	1	0.007	0.007	9.8	0.08	21.9	0.15	35.0	0.21	36.5	0.22	26.5	0.17
7	1.0	7	40.9	1	0.006	0.006	10.8	0.06	21.6	0.11	32.2	0.15	33.7	0.16	25.6	0.13
8	1.0	7	48.0	1	0.004	0.004	11.7	0.04	21.1	0.06	29.8	0.08	31.1	0.09	24.5	0.07
9	1.0	7	55.3	1	0.004	0.004	12.2	0.03	20.4	0.05	27.6	0.07	28.8	0.07	23.4	0.06
10	1.0	7	62.7	1	0.004	0.004	12.6	0.03	19.8	0.05	25.7	0.06	26.7	0.06	22.4	0.05
11	1.0	7	70.0	1	0.004	0.004	12.8	0.03	19.0	0.04	24.0	0.05	24.9	0.05	21.3	0.05
12	1.0	10	78.7	4	0.200	0.020	12.8	0.13	18.3	0.18	22.5	0.22	23.3	0.23	20.3	0.20
13	1.0	10	88.7	4	0.200	0.020	12.8	0.12	17.6	0.16	21.2	0.19	21.8	0.19	19.3	0.17
14	1.0	10	98.7	4	0.200	0.020	12.7	0.11	16.9	0.14	19.9	0.16	20.5	0.16	18.4	0.15
15	1.0	7	107.1	1	0.006	0.006	12.5	0.03	16.2	0.04	18.9	0.04	19.3	0.04	17.5	0.04
TOTALI (cm)								1.09	2.30	3.34	3.39	2.66				

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

### CARATTERISTICHE DEGLI STRATI

### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m³	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.010	0.010	12.0	0.37	2.0	0.09
3	1.0	6	14.9	1	0.009	0.009	12.6	0.24	3.2	0.08
4	1.0	6	21.2	1	0.009	0.009	13.4	0.19	4.4	0.07
5	1.0	7	27.6	1	0.008	0.008	14.2	0.14	5.6	0.06
6	1.0	7	34.2	1	0.007	0.007	14.9	0.11	6.6	0.05
7	1.0	7	40.9	1	0.006	0.006	15.3	0.08	7.6	0.04
8	1.0	7	48.0	1	0.004	0.004	15.6	0.05	8.4	0.03
9	1.0	7	55.3	1	0.004	0.004	15.7	0.04	9.1	0.03
10	1.0	7	62.7	1	0.004	0.004	15.7	0.04	9.6	0.02
11	1.0	7	70.0	1	0.004	0.004	15.5	0.03	10.0	0.02
12	1.0	10	78.7	4	0.200	0.020	15.3	0.15	10.3	0.11
13	1.0	10	88.7	4	0.200	0.020	15.0	0.14	10.5	0.10
14	1.0	10	98.7	4	0.200	0.020	14.6	0.12	10.6	0.09
15	1.0	7	107.1	1	0.006	0.006	14.2	0.03	10.6	0.02
TOTALI (cm)								1.75	0.82	

CPTU 8A PENNELLO 4 m

COORDINATE  $(x, y, z)$  E PRESSIONI  $(\sigma'v)$  RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	σ'v kPa
1	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+2
2	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+6
3	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+10
4	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+17
5	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+28
6	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+38
7	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+43
8	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+43
9	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+43
10	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+35
11	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+20
12	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
13	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,2.0	50.0,4.0	50.0,7.0	50.0,10.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma^*$ kN/m <sup>3</sup>	$\sigma^*v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.010	0.010	3.3	0.14	16.0	0.45	35.6	0.70	37.7	0.72	14.8	0.43
3	1.0	6	14.9	1	0.009	0.009	5.5	0.12	17.1	0.30	32.1	0.45	34.3	0.47	15.9	0.28
4	1.0	6	21.2	1	0.009	0.009	7.4	0.12	17.5	0.24	28.9	0.34	31.0	0.35	16.4	0.22
5	1.0	7	27.6	1	0.008	0.008	8.9	0.10	17.3	0.17	26.1	0.23	27.9	0.24	16.5	0.16
6	1.0	7	34.2	1	0.007	0.007	9.8	0.08	16.9	0.12	23.7	0.16	25.1	0.17	16.3	0.12
7	1.0	7	40.9	1	0.006	0.006	10.4	0.06	16.2	0.09	21.5	0.11	22.8	0.12	15.8	0.08
8	1.0	7	48.0	1	0.004	0.004	10.7	0.03	15.5	0.05	19.7	0.06	20.7	0.06	15.2	0.05
9	1.0	7	55.3	1	0.004	0.004	10.7	0.03	14.8	0.04	18.1	0.05	18.9	0.05	14.5	0.04
10	1.0	7	62.7	1	0.004	0.004	10.7	0.03	14.1	0.04	16.7	0.04	17.4	0.04	13.9	0.03
11	1.0	7	70.0	1	0.004	0.004	10.5	0.02	13.4	0.03	15.5	0.03	16.1	0.04	13.2	0.03
12	1.0	10	78.7	4	0.200	0.020	10.3	0.11	12.7	0.13	14.5	0.15	14.9	0.15	12.6	0.13
13	1.0	10	88.7	4	0.200	0.020	10.0	0.09	12.0	0.11	13.5	0.12	13.9	0.13	12.0	0.11
14	1.0	10	98.7	4	0.200	0.020	9.7	0.08	11.4	0.10	12.7	0.11	13.0	0.11	11.4	0.09
15	1.0	7	107.1	1	0.006	0.006	9.4	0.02	10.9	0.03	11.9	0.03	12.2	0.03	10.8	0.03
TOTALI (cm)								1.03		1.88		2.58		2.67		1.81

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

50.0, 13.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

[illegible]

# CPTU 9A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.011	0.011	3.0	0.14	19.1	0.55	50.7	0.91	49.7	0.91	26.5	0.67
3	1.0	6	14.6	1	0.011	0.011	4.9	0.14	20.6	0.42	45.8	0.68	46.6	0.68	27.3	0.50
4	1.0	6	20.4	1	0.011	0.011	6.7	0.14	21.5	0.34	41.7	0.53	43.1	0.54	27.5	0.41
5	1.0	6	26.3	1	0.011	0.011	8.4	0.13	21.9	0.29	38.1	0.43	39.7	0.44	27.2	0.34
6	1.0	10	34.2	5	0.200	0.020	9.8	0.22	21.9	0.43	35.0	0.61	36.5	0.63	26.5	0.50
7	1.0	10	44.2	4	0.200	0.020	10.8	0.19	21.6	0.35	32.2	0.48	33.7	0.49	25.6	0.40
8	1.0	10	54.2	4	0.200	0.020	11.7	0.17	21.1	0.29	29.8	0.38	31.1	0.39	24.5	0.32
9	1.0	10	64.2	4	0.200	0.020	12.2	0.15	20.4	0.24	27.6	0.31	28.8	0.32	23.4	0.27
10	1.0	10	74.2	4	0.200	0.020	12.6	0.14	19.8	0.21	25.7	0.26	26.7	0.27	22.4	0.23
11	1.0	10	84.2	4	0.200	0.020	12.8	0.12	19.0	0.18	24.0	0.22	24.9	0.23	21.3	0.20
12	1.0	8	93.0	1	0.003	0.003	12.8	0.02	18.3	0.02	22.5	0.03	23.3	0.03	20.3	0.03
13	1.0	8	100.8	1	0.002	0.002	12.8	0.01	17.6	0.01	21.2	0.02	21.8	0.02	19.3	0.02
14	1.0	8	108.8	1	0.000	0.000	12.7	0.00	16.9	0.00	19.9	0.00	20.5	0.00	18.4	0.00
15	1.0	8	117.2	1	0.000	0.000	12.5	0.00	16.2	0.00	18.9	0.00	19.3	0.00	17.5	0.00
TOTALI (cm)								1.57	3.33		4.85		4.95		3.87	

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

CARATTERISTICHE DEGLI STRATI

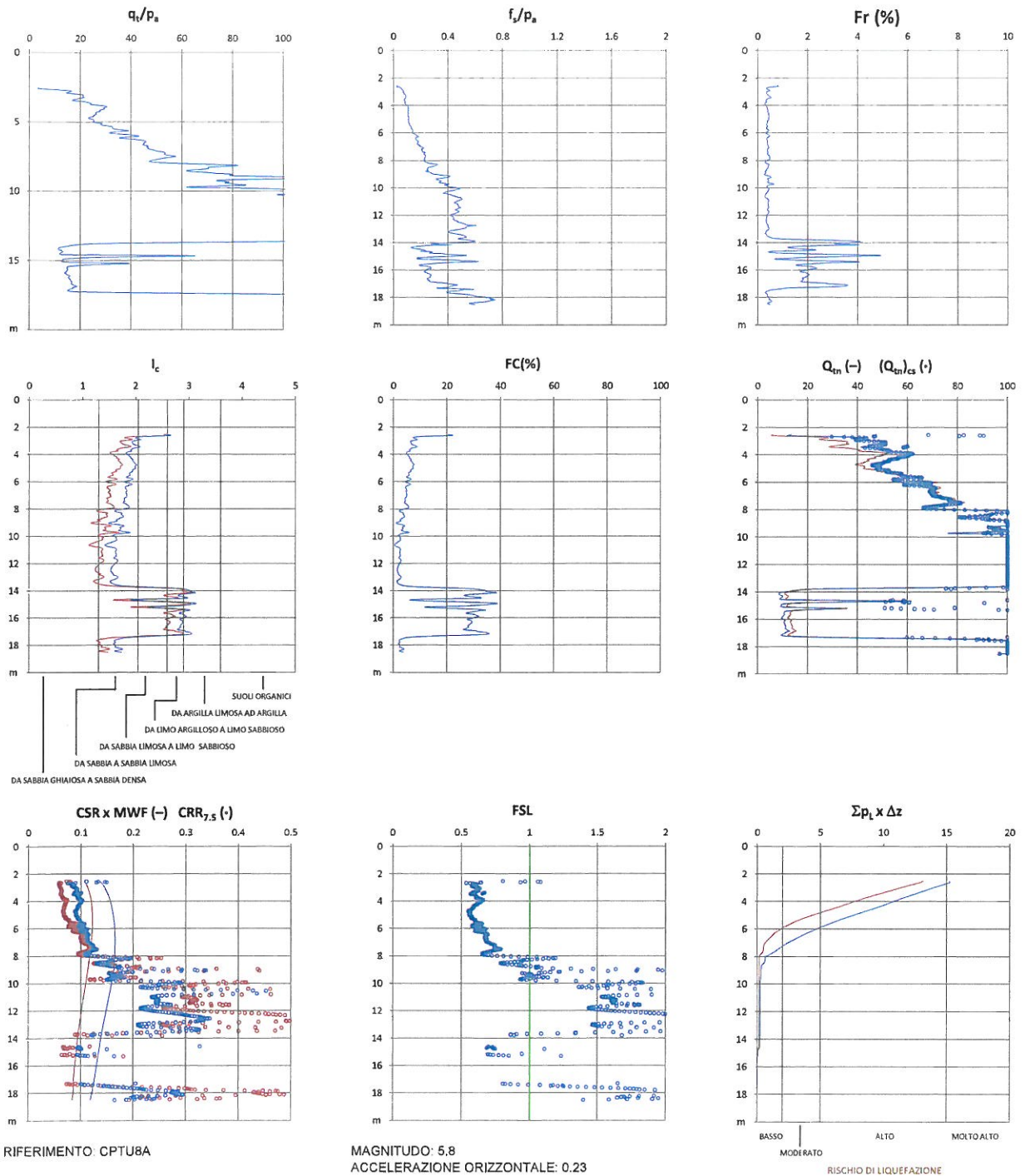
TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.011	0.011	12.0	0.41	2.0	0.10
3	1.0	6	14.6	1	0.011	0.011	12.6	0.30	3.2	0.09
4	1.0	6	20.4	1	0.011	0.011	13.4	0.24	4.4	0.09
5	1.0	6	26.3	1	0.011	0.011	14.2	0.21	5.6	0.09
6	1.0	10	34.2	5	0.200	0.020	14.9	0.31	6.6	0.15
7	1.0	10	44.2	4	0.200	0.020	15.3	0.26	7.6	0.14
8	1.0	10	54.2	4	0.200	0.020	15.6	0.22	8.4	0.13
9	1.0	10	64.2	4	0.200	0.020	15.7	0.19	9.1	0.11
10	1.0	10	74.2	4	0.200	0.020	15.7	0.17	9.6	0.11
11	1.0	10	84.2	4	0.200	0.020	15.5	0.15	10.0	0.10
12	1.0	8	93.0	1	0.003	0.003	15.3	0.02	10.3	0.01
13	1.0	8	100.8	1	0.002	0.002	15.0	0.01	10.5	0.01
14	1.0	8	108.8	1	0.000	0.000	14.6	0.00	10.6	0.00
15	1.0	8	117.2	1	0.000	0.000	14.2	0.00	10.6	0.00
TOTALI (cm)								2.49	1.14	

1.16

## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al. 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



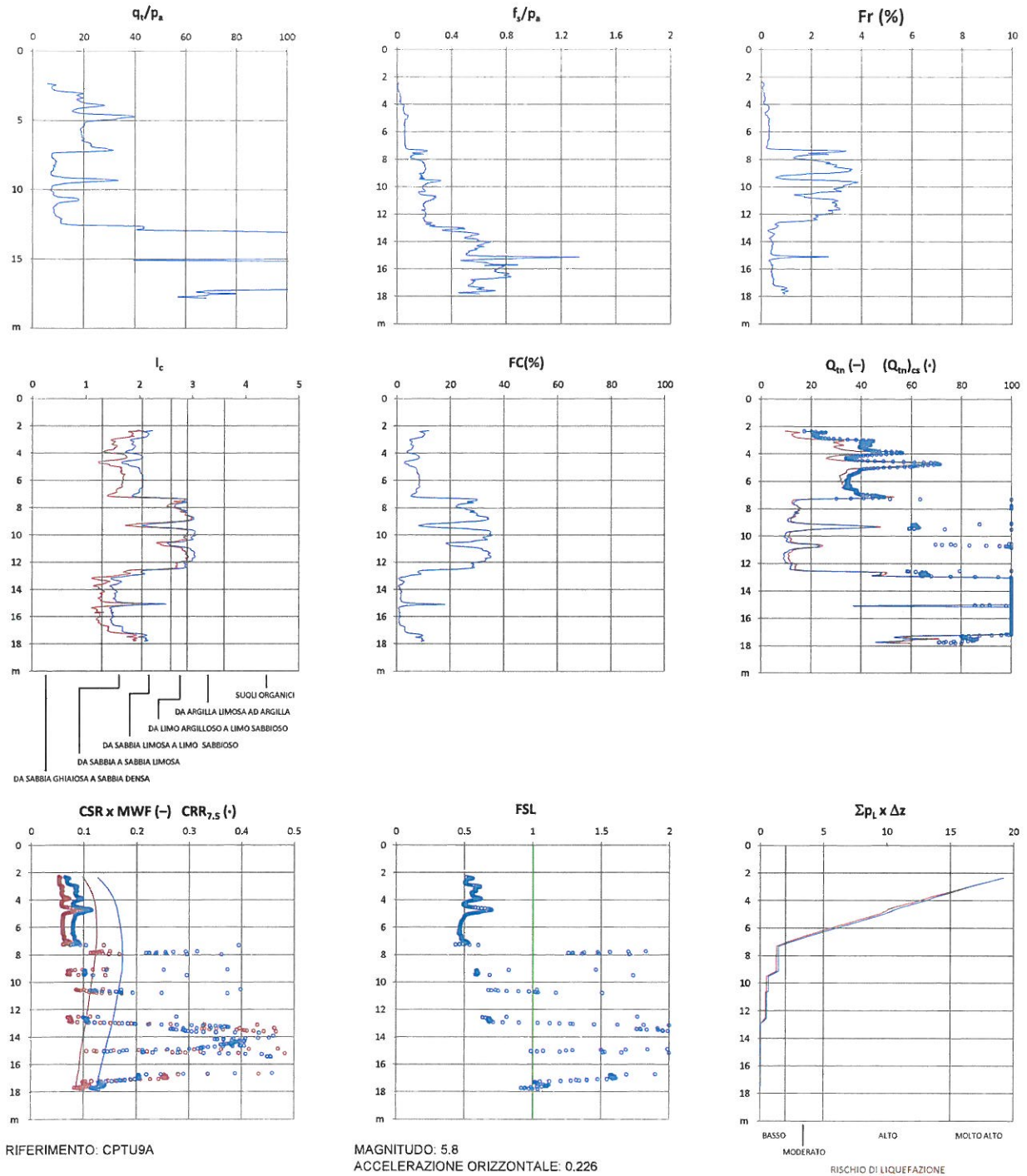
RIFERIMENTO: CPTU8A

MAGNITUDO: 5,8  
ACCELERAZIONE ORIZZONTALE: 0.23

SOFTWARE GIANVITO CASSINADRI 2014

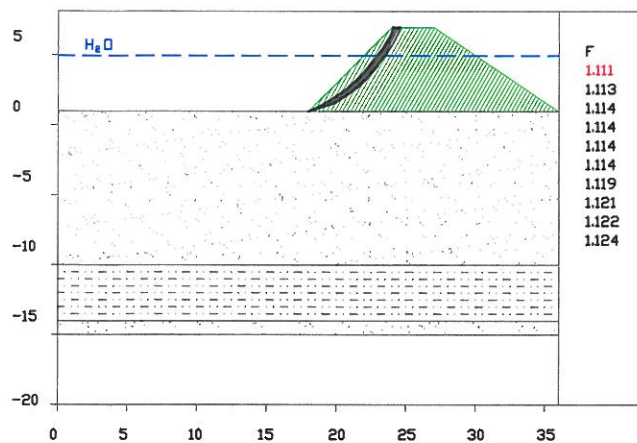
## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)

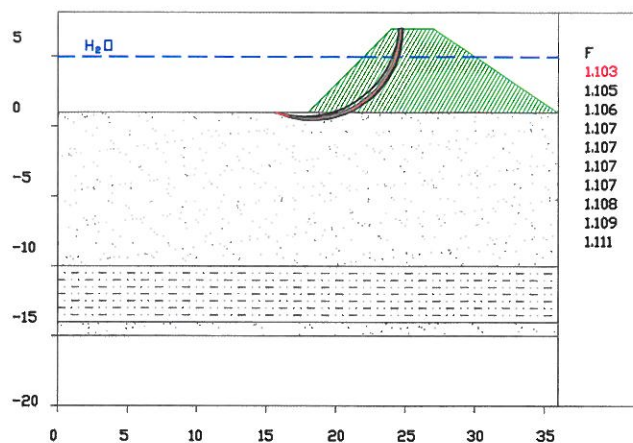


## VERIFICHE DI STABILITÀ

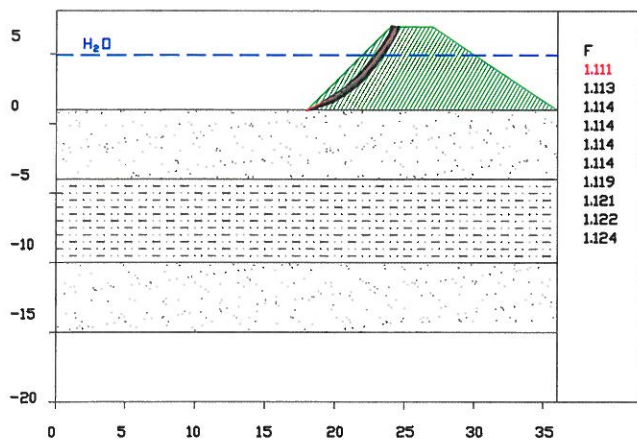
CPTU 8A - SENZA SISMA E COESIONE = 0.6 kPa



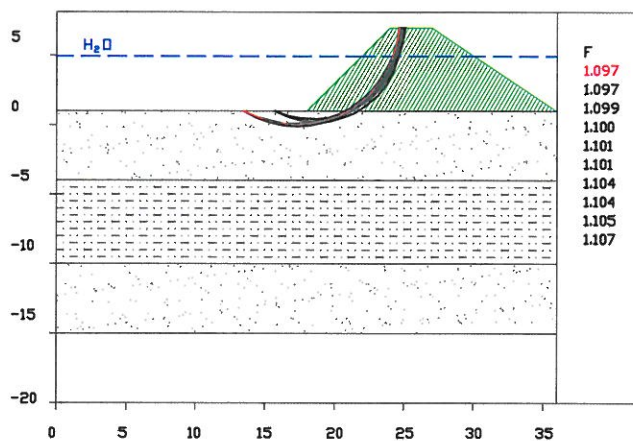
CPTU 8A - CON SISMA E COESIONE = 2 kPa



CPTU 9A - SENZA SISMA E COESIONE = 0.6 kPa



CPTU 9A - CON SISMA E COESIONE = 2.5 kPa



Pennello



Terreni coesivi

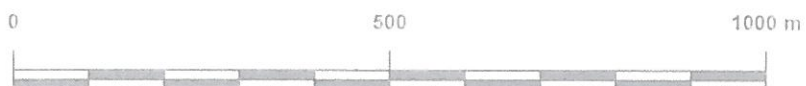
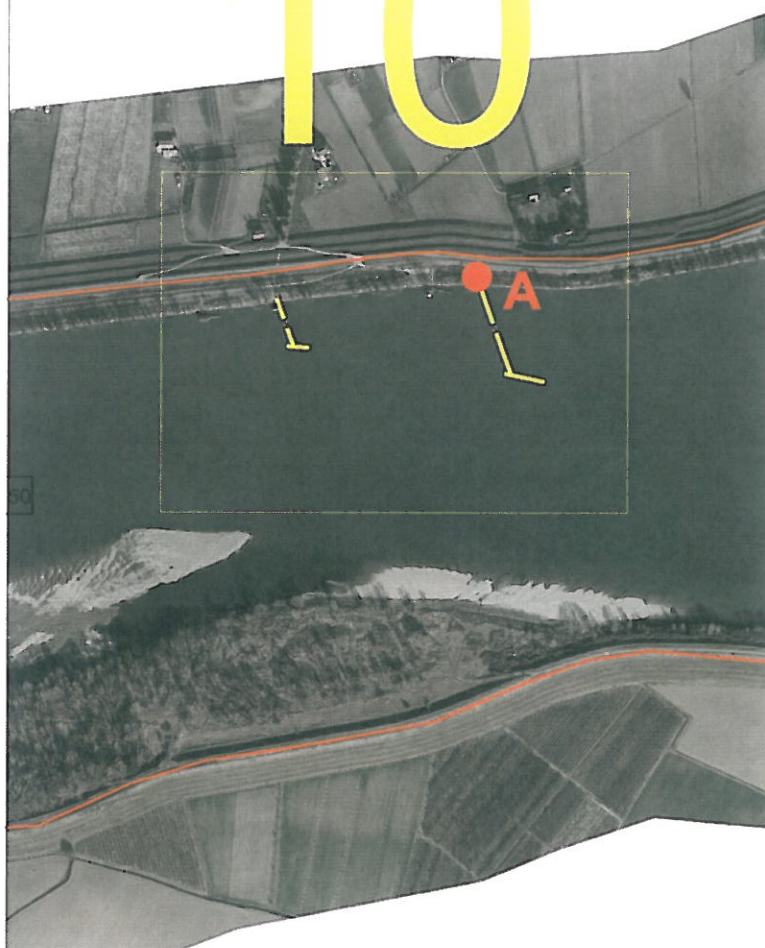


Terreni non coesivi





**GAIBA**

# 10



## LEGENDA

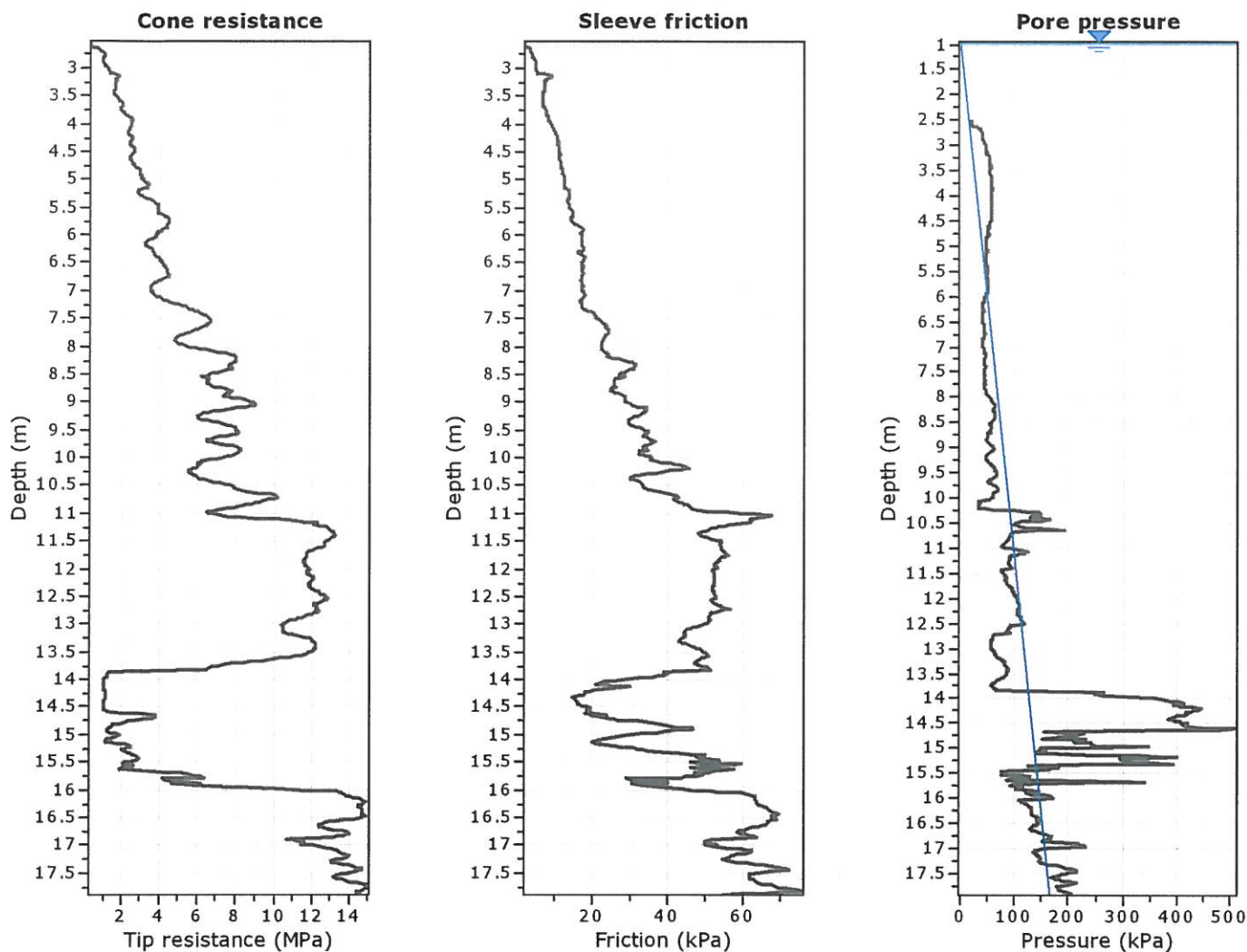
-  PROVA PENETROMETRICA
-  OPERE IN PROGETTO



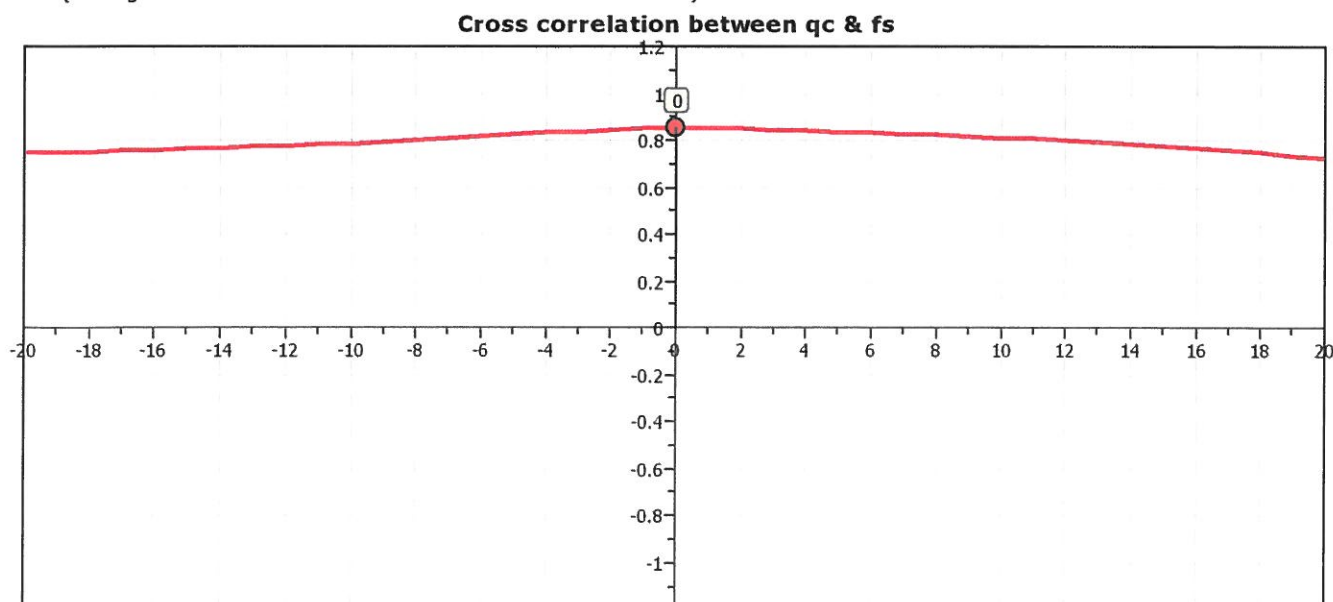
UBICAZIONE SONDAGGI GAIBA

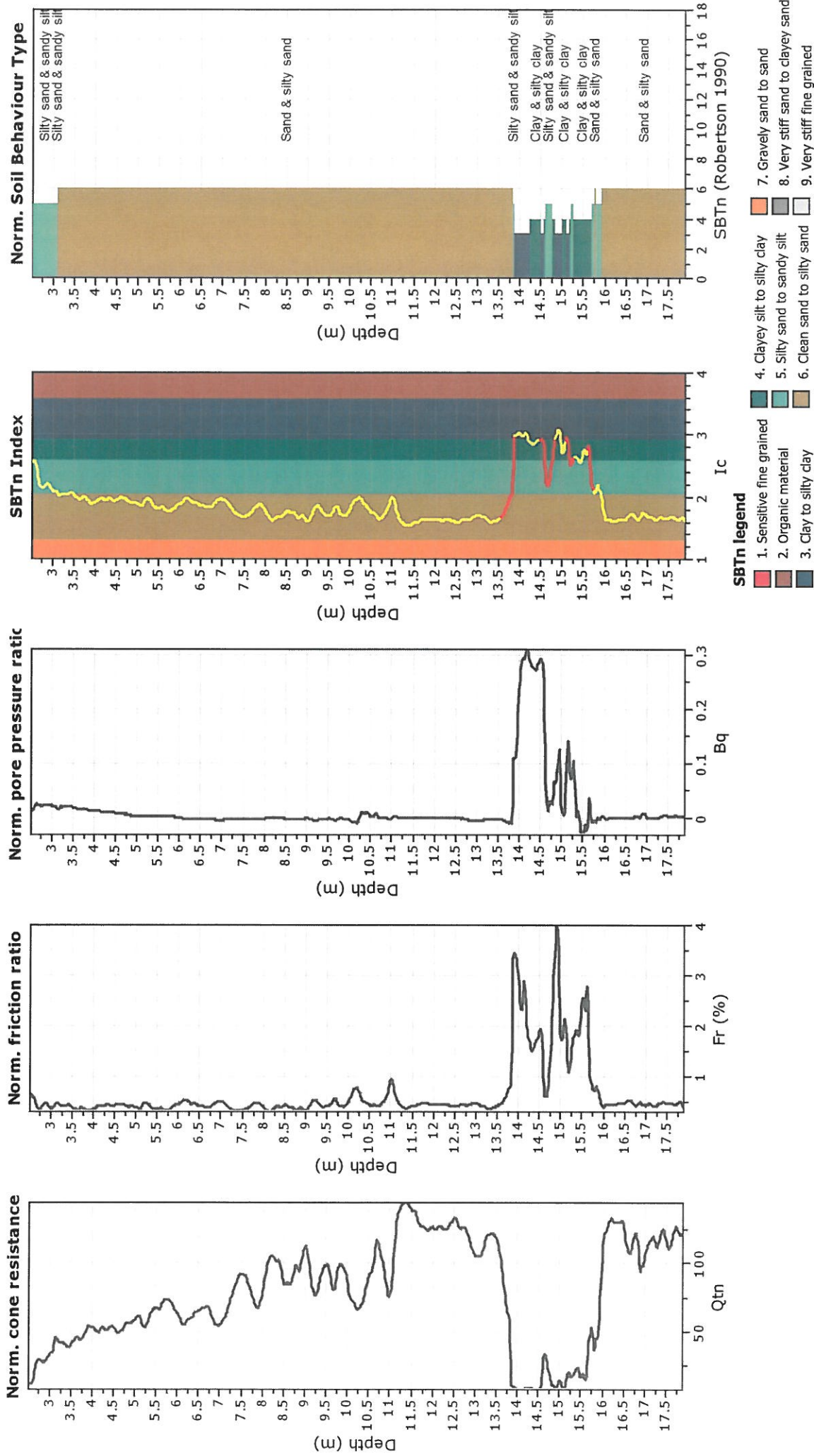
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

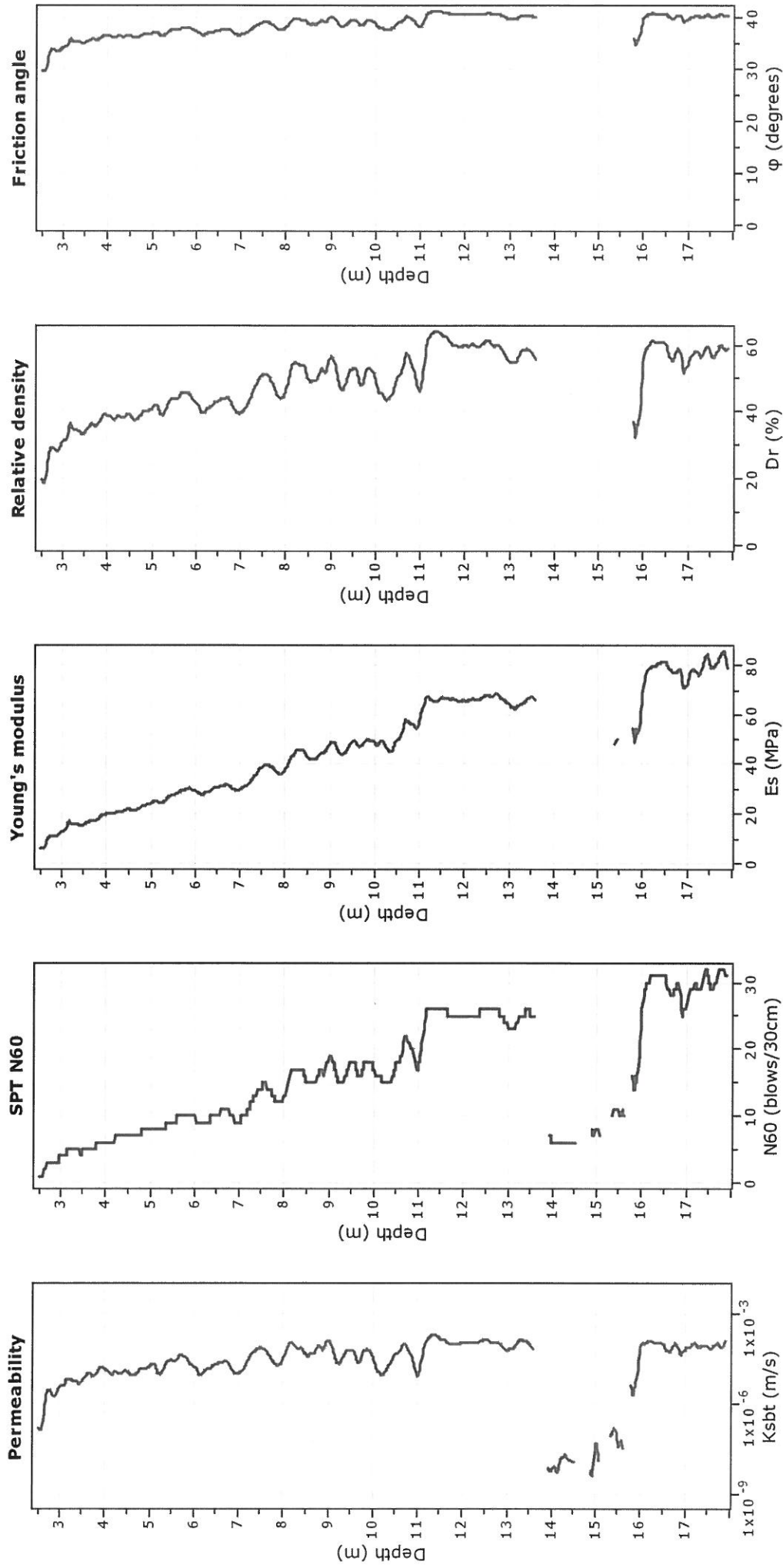
**Location: TRATTO CASTELMASSA - STIENTA**



The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).

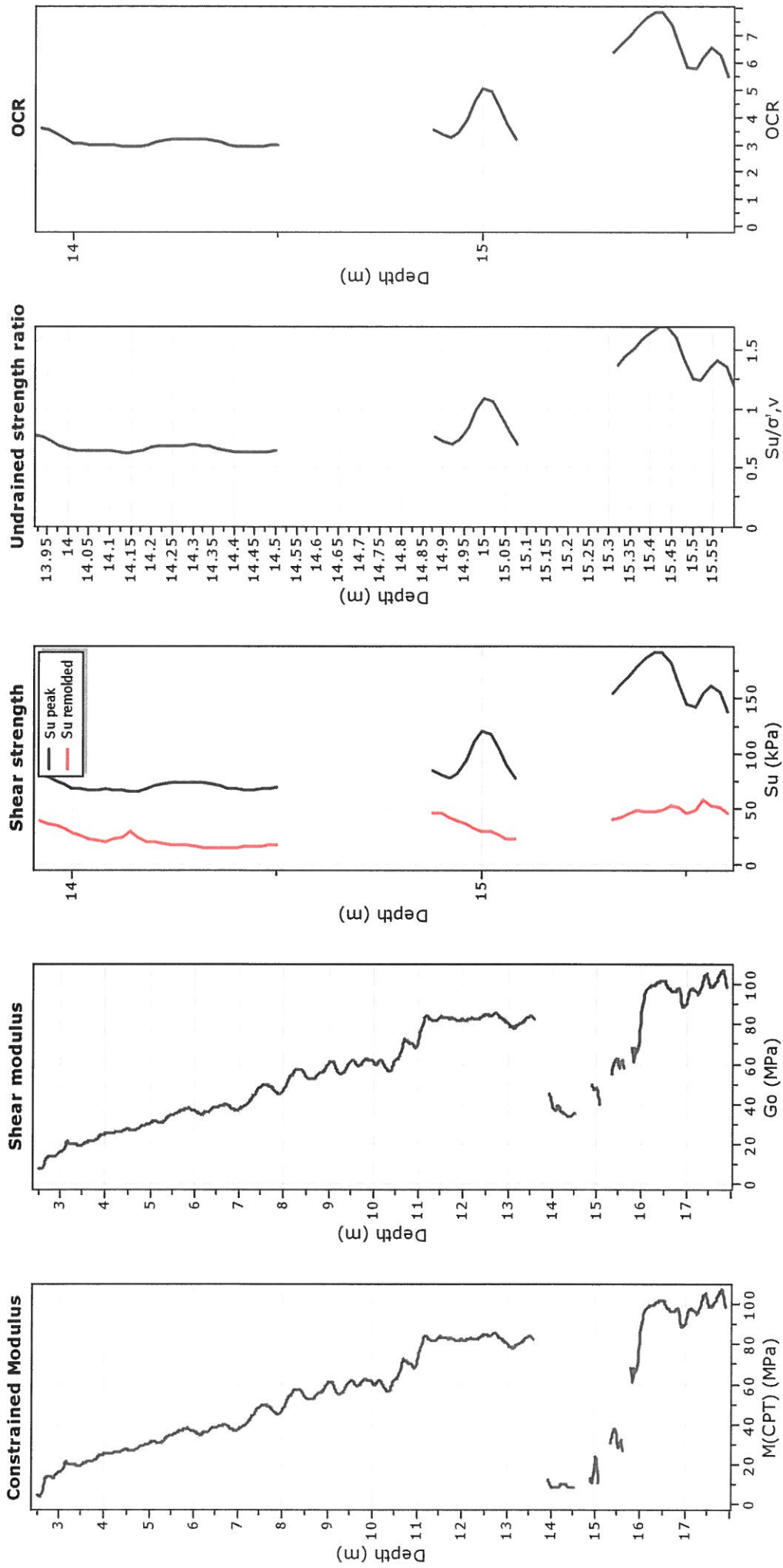






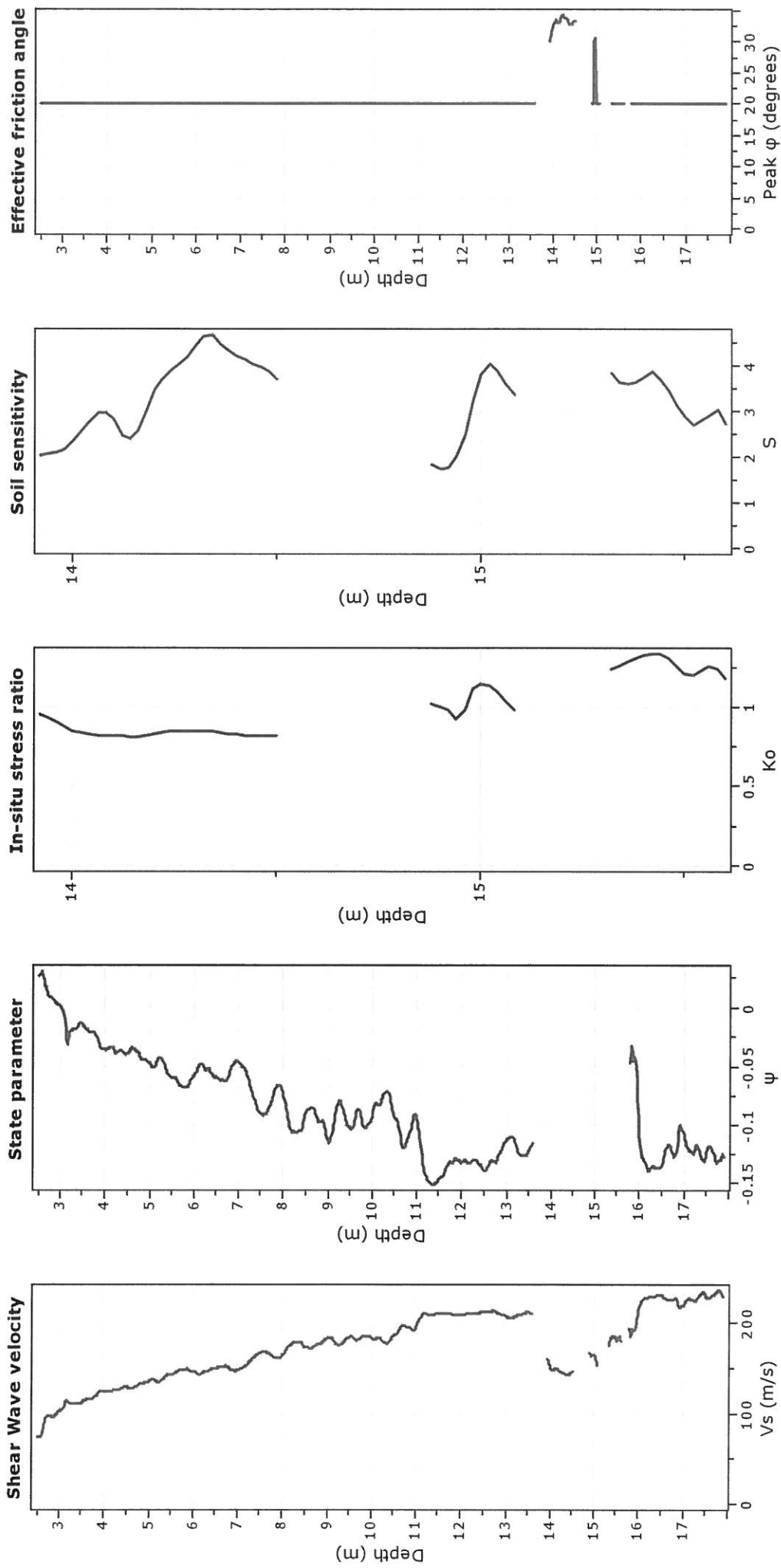
### Calculation parameters

Permeability: Based on  $SBT_n$   
 $SPT N_{60}$ : Based on  $I_c$  and  $q_c$   
 Young's modulus: Based on variable alpha using  $I_c$  (Robertson, 2009)  
 Relative density constant,  $C_{ur}$ : 350.0  
 Phi: Based on Kulhawy & Mayne (1990)  
 User defined estimation data



#### Calculation parameters

Constrained modulus: Based on variable  $\alpha/\phi$  using  $I_c$  and  $Q_m$  (Robertson, 2009)  
Go: Based on variable  $\alpha/\phi$  using  $I_c$  (Robertson, 2009)  
Undrained shear strength cone factor for clays,  $N_{kt}$ : 14  
OCR factor for clays,  $N_{kt}$ : 0.33  
—●— User defined estimation data



#### Calculation parameters

Soil Sensitivity factor,  $N_s$ : 7.00

—●— User defined estimation data

# CPTU 10A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

### CARATTERISTICHE DEGLI STRATI

### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.6	1	0.011	0.011	3.0	0.15	19.1	0.56	50.7	0.92	49.7	0.92	26.5	0.67
3	1.0	6	14.5	1	0.010	0.010	4.9	0.13	20.6	0.38	45.8	0.62	46.6	0.63	27.3	0.46
4	1.0	6	20.5	1	0.010	0.010	6.7	0.12	21.5	0.31	41.7	0.48	43.1	0.49	27.5	0.37
5	1.0	6	26.6	1	0.009	0.009	8.4	0.11	21.9	0.24	38.1	0.35	39.7	0.36	27.2	0.28
6	1.0	6	32.8	1	0.009	0.009	9.8	0.10	21.9	0.20	35.0	0.28	36.5	0.29	26.5	0.23
7	1.0	7	39.3	1	0.008	0.008	10.8	0.08	21.6	0.15	32.2	0.21	33.7	0.22	25.6	0.17
8	1.0	7	45.8	1	0.007	0.007	11.7	0.07	21.1	0.12	29.8	0.15	31.1	0.16	24.5	0.13
9	1.0	7	52.6	1	0.006	0.006	12.2	0.05	20.4	0.09	27.6	0.11	28.8	0.11	23.4	0.10
10	1.0	7	59.7	1	0.004	0.004	12.6	0.03	19.8	0.05	25.7	0.06	26.7	0.06	22.4	0.06
11	1.0	7	67.0	1	0.004	0.004	12.8	0.03	19.0	0.04	24.0	0.05	24.9	0.05	21.3	0.05
12	1.0	7	74.3	1	0.004	0.004	12.8	0.03	18.3	0.04	22.5	0.05	23.3	0.05	20.3	0.04
13	1.0	10	83.0	3	0.200	0.020	12.8	0.12	17.6	0.17	21.2	0.20	21.8	0.20	19.3	0.18
14	1.0	10	93.0	6	0.200	0.020	12.7	0.11	16.9	0.15	19.9	0.17	20.5	0.17	18.4	0.16
15	1.0	8	101.8	1	0.003	0.003	12.5	0.02	16.2	0.02	18.9	0.02	19.3	0.02	17.5	0.02
TOTALI (cm)								1.16	2.51	3.68	3.73	2.92				

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

### CARATTERISTICHE DEGLI STRATI

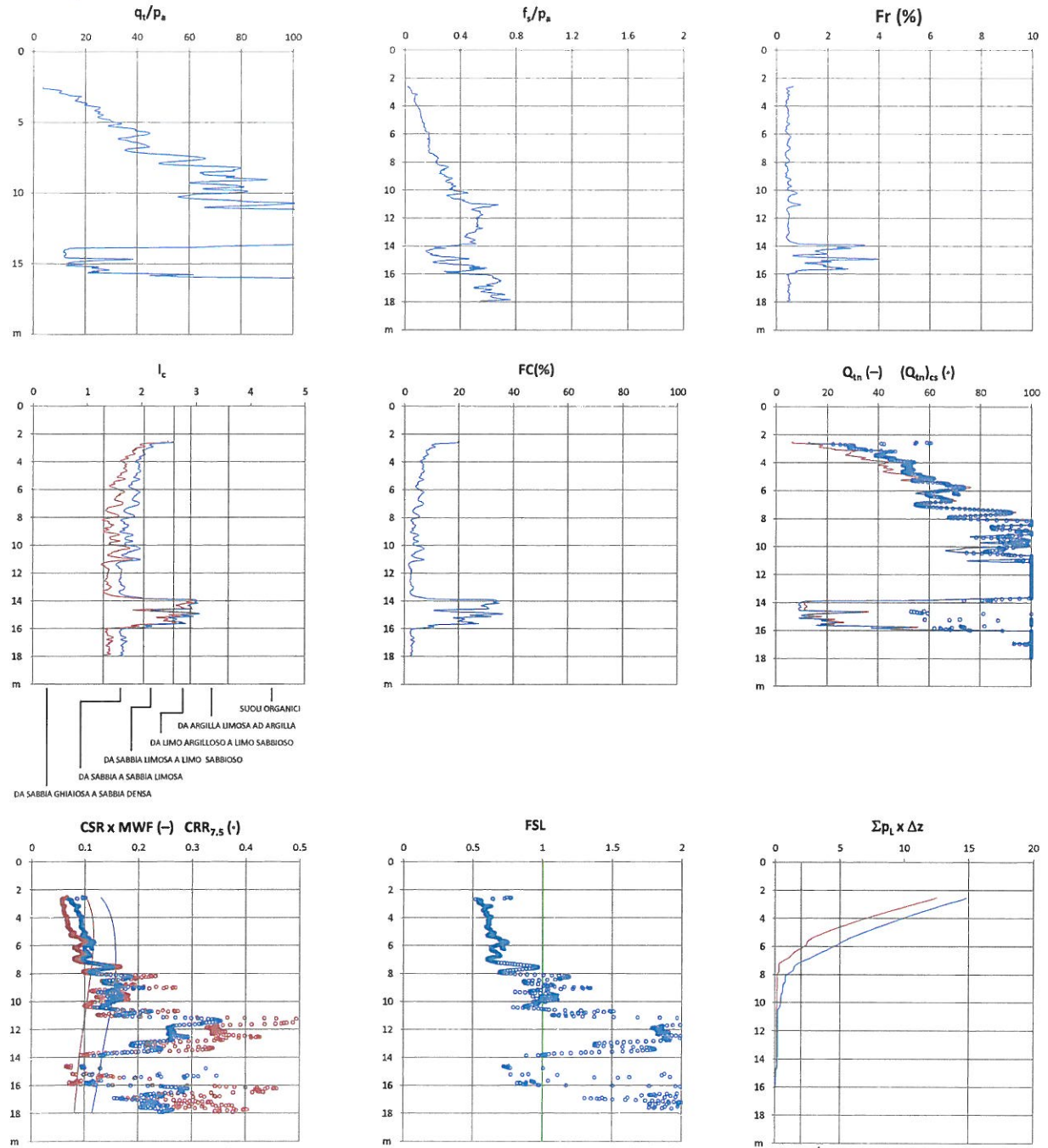
### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m³	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.6	1	0.011	0.011	12.0	0.42	2.0	0.10
3	1.0	6	14.5	1	0.010	0.010	12.6	0.27	3.2	0.09
4	1.0	6	20.5	1	0.010	0.010	13.4	0.22	4.4	0.08
5	1.0	6	26.6	1	0.009	0.009	14.2	0.17	5.6	0.07
6	1.0	6	32.8	1	0.009	0.009	14.9	0.15	6.6	0.07
7	1.0	7	39.3	1	0.008	0.008	15.3	0.11	7.6	0.06
8	1.0	7	45.8	1	0.007	0.007	15.6	0.09	8.4	0.05
9	1.0	7	52.6	1	0.006	0.006	15.7	0.07	9.1	0.04
10	1.0	7	59.7	1	0.004	0.004	15.7	0.04	9.6	0.03
11	1.0	7	67.0	1	0.004	0.004	15.5	0.04	10.0	0.02
12	1.0	7	74.3	1	0.004	0.004	15.3	0.03	10.3	0.02
13	1.0	10	83.0	3	0.200	0.020	15.0	0.14	10.5	0.10
14	1.0	10	93.0	6	0.200	0.020	14.6	0.13	10.6	0.09
15	1.0	8	101.8	1	0.003	0.003	14.2	0.02	10.6	0.01
TOTALI (cm)								1.89		0.85

0.85

## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



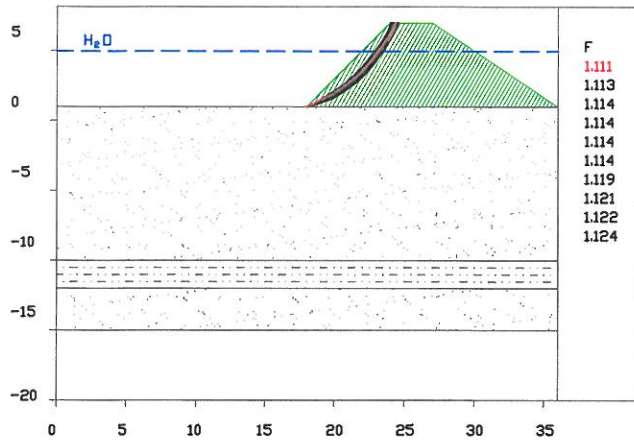
RIFERIMENTO: CPTU10A

MAGNITUDO: 5.8  
ACCELERAZIONE ORIZZONTALE: 0.22

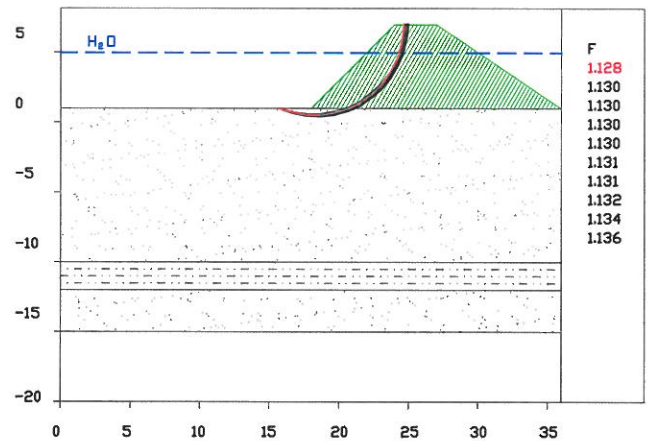
SOFTWARE GIANVITO CASSINADRI 2014

## VERIFICHE DI STABILITÀ

CPTU 10A - SENZA SISMA E COESIONE = 0.6 kPa



CPTU 10A - CON SISMA E COESIONE = 2.5 kPa





**RAVALLE**

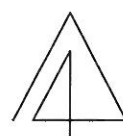


PROVA PENETROMETRICA



OPERE IN PROGETTO

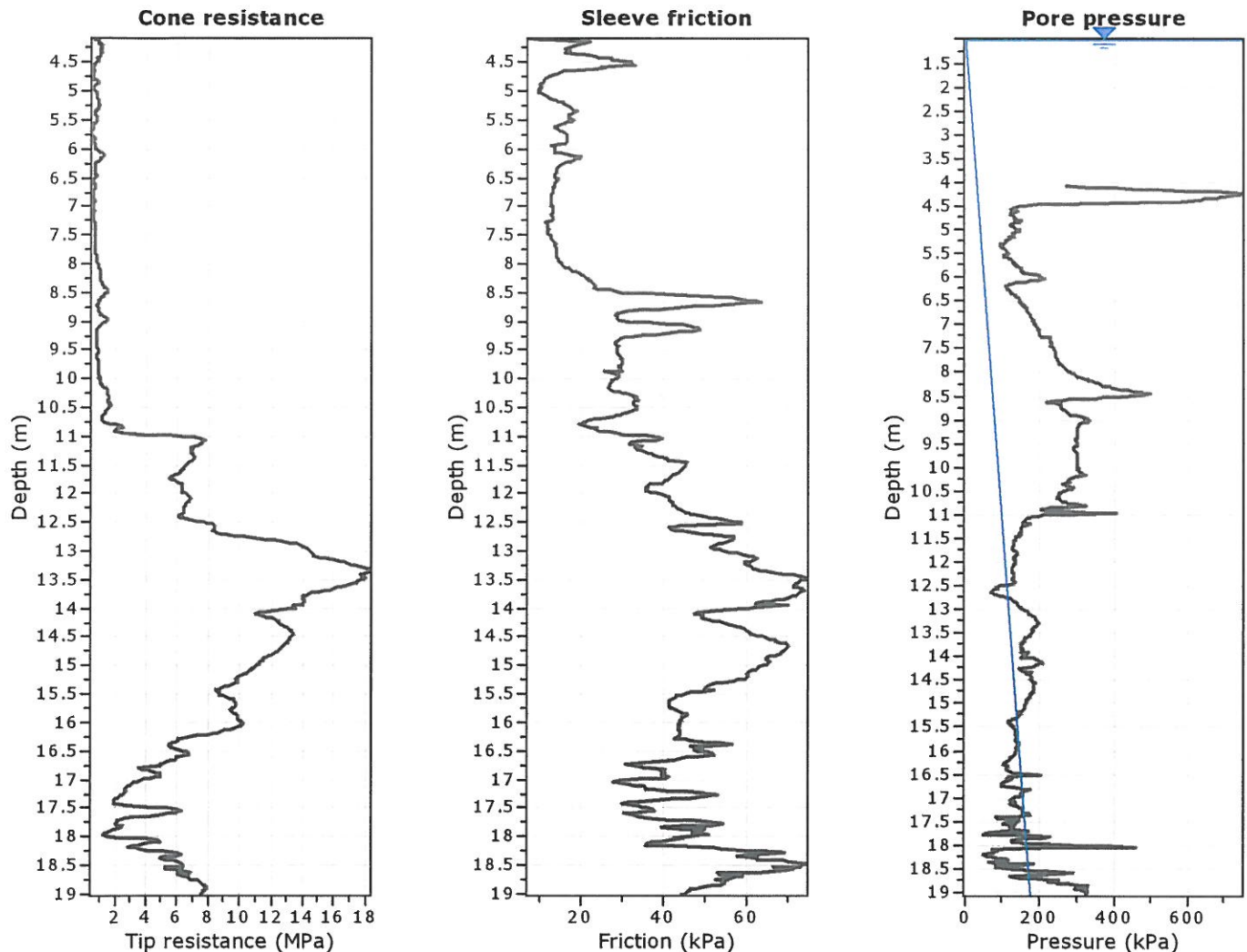
LEGENDA



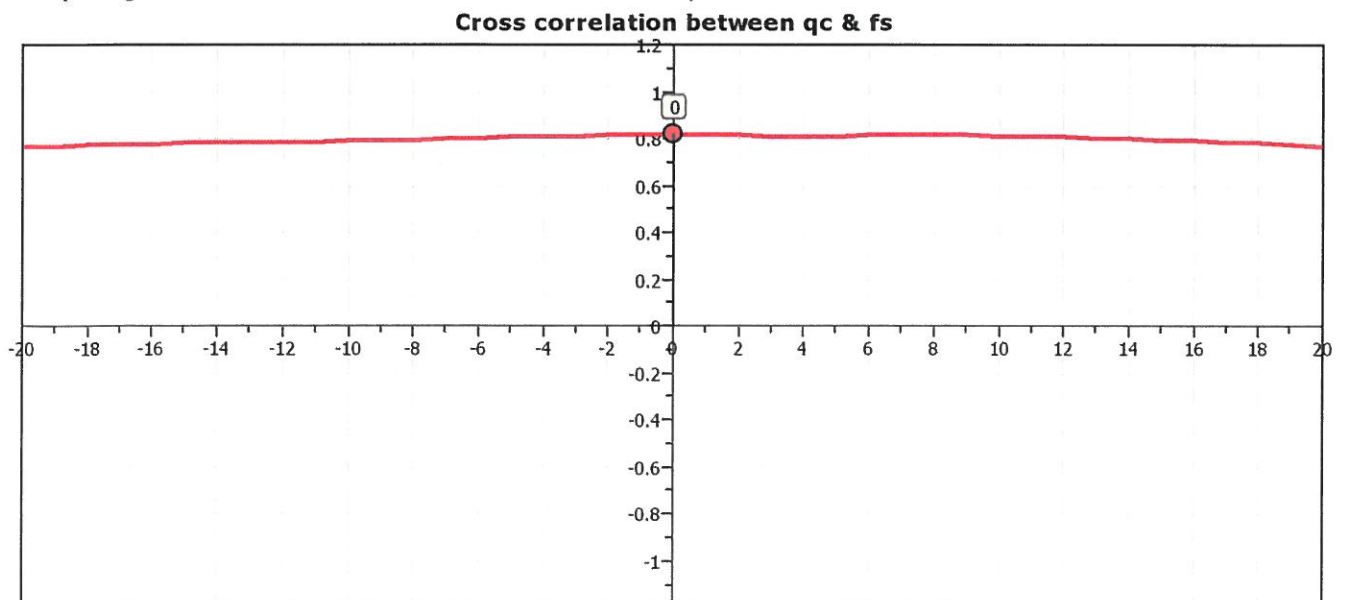
NORD



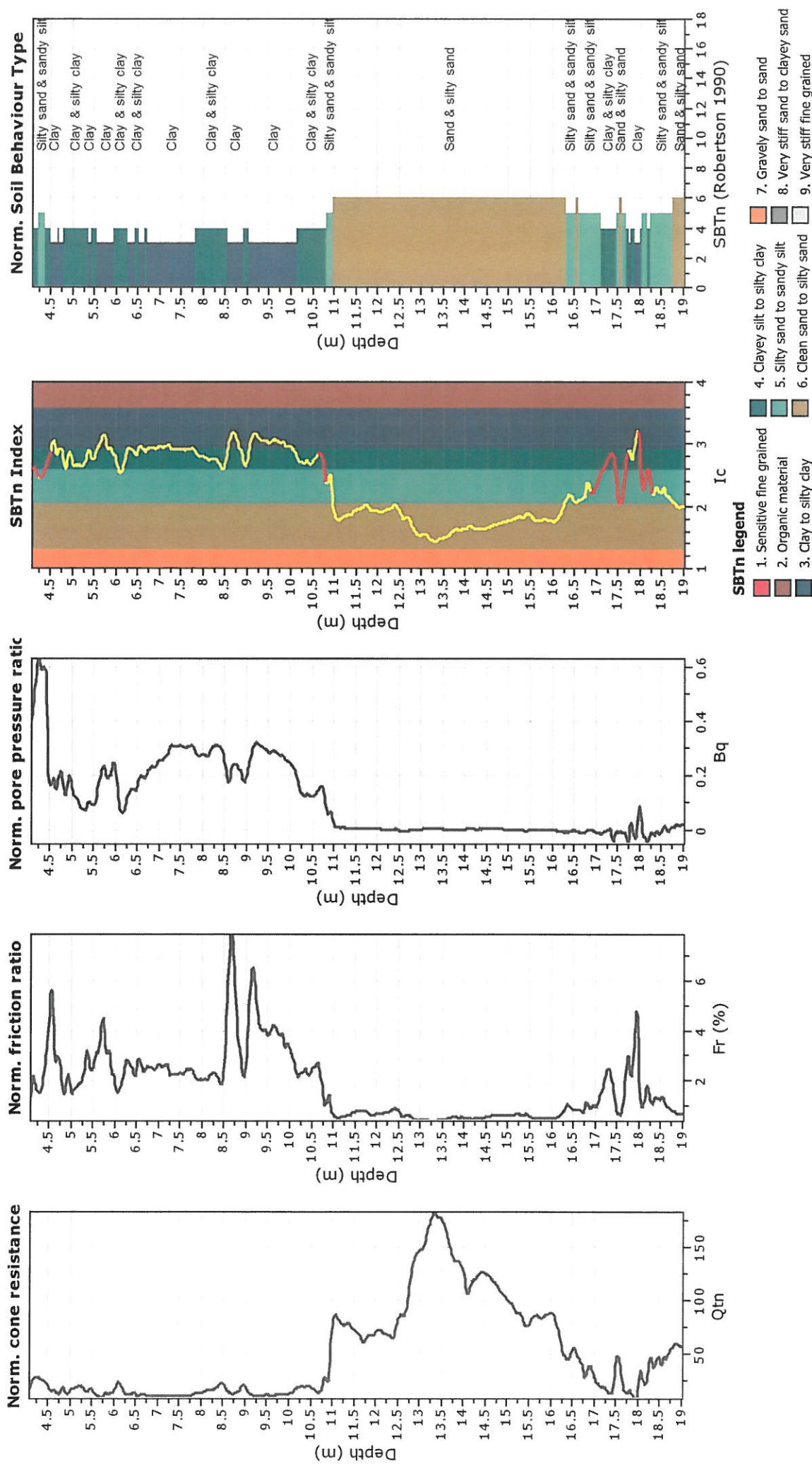
UBICAZIONE SONDAGGI RAVALLE

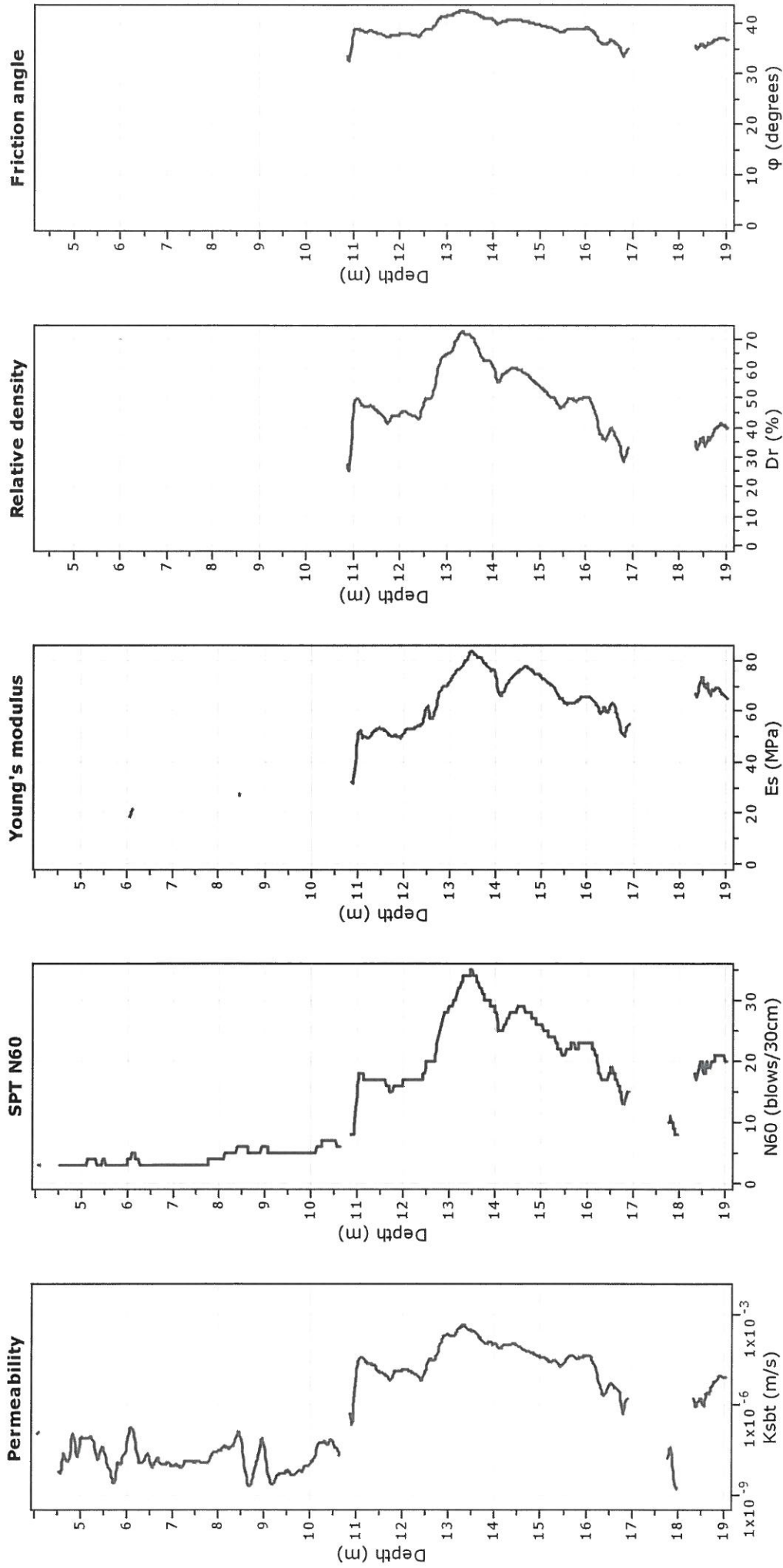


The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



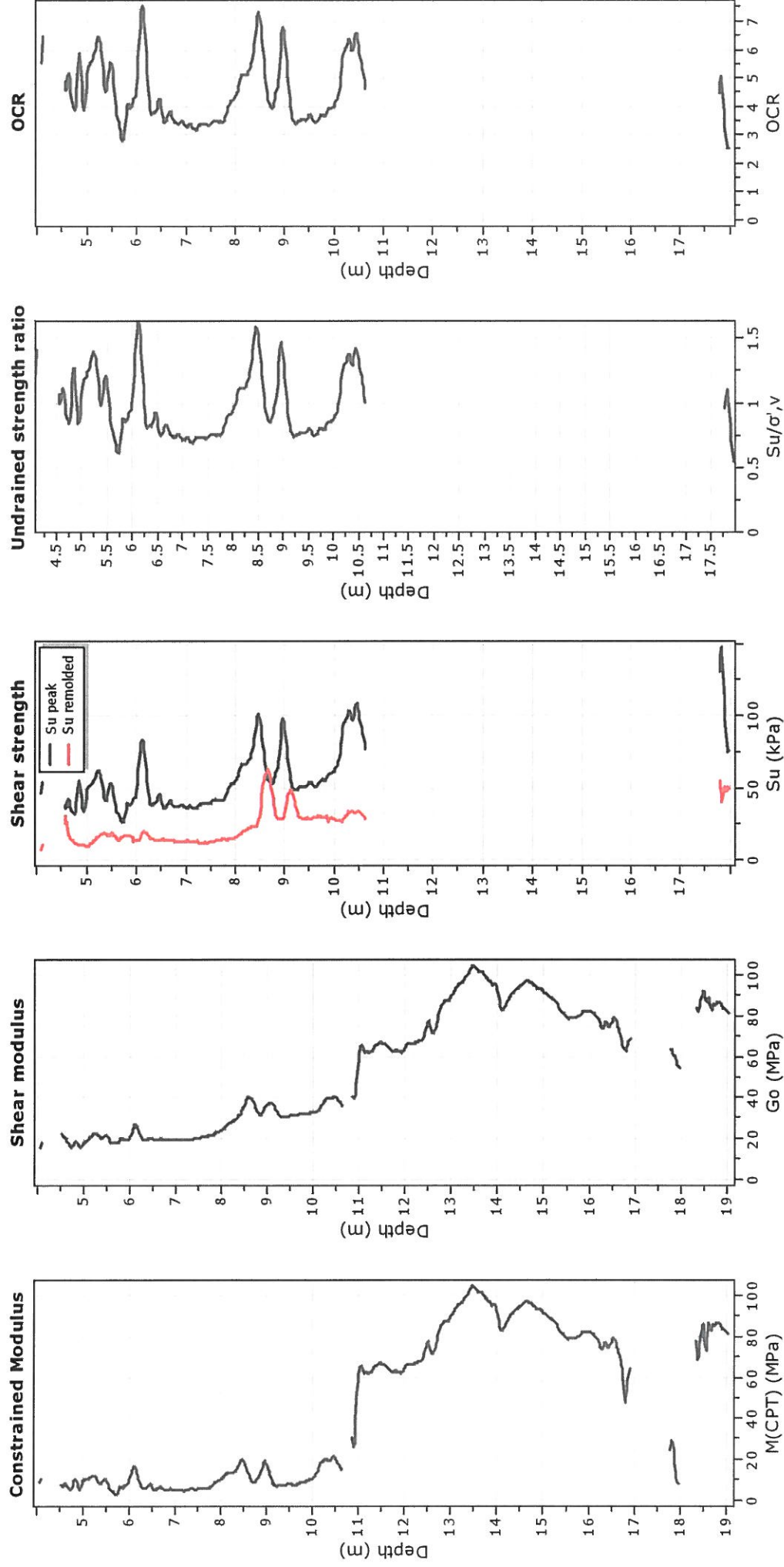
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**





#### Calculation parameters

Permeability: Based on SBT<sub>n</sub>  
SPT N<sub>60</sub>: Based on I<sub>c</sub> and q<sub>t</sub>  
Young's modulus: Based on variable alpha using I<sub>c</sub> (Robertson, 2009)  
Relative density constant, C<sub>dr</sub>: 350.0  
Phi: Based on Kulhawy & Mayne (1990)  
—●— User defined estimation data



#### Calculation parameters

Constrained modulus: Based on variable  $\alpha$  using  $I_c$  and  $Q_m$  (Robertson, 2009)

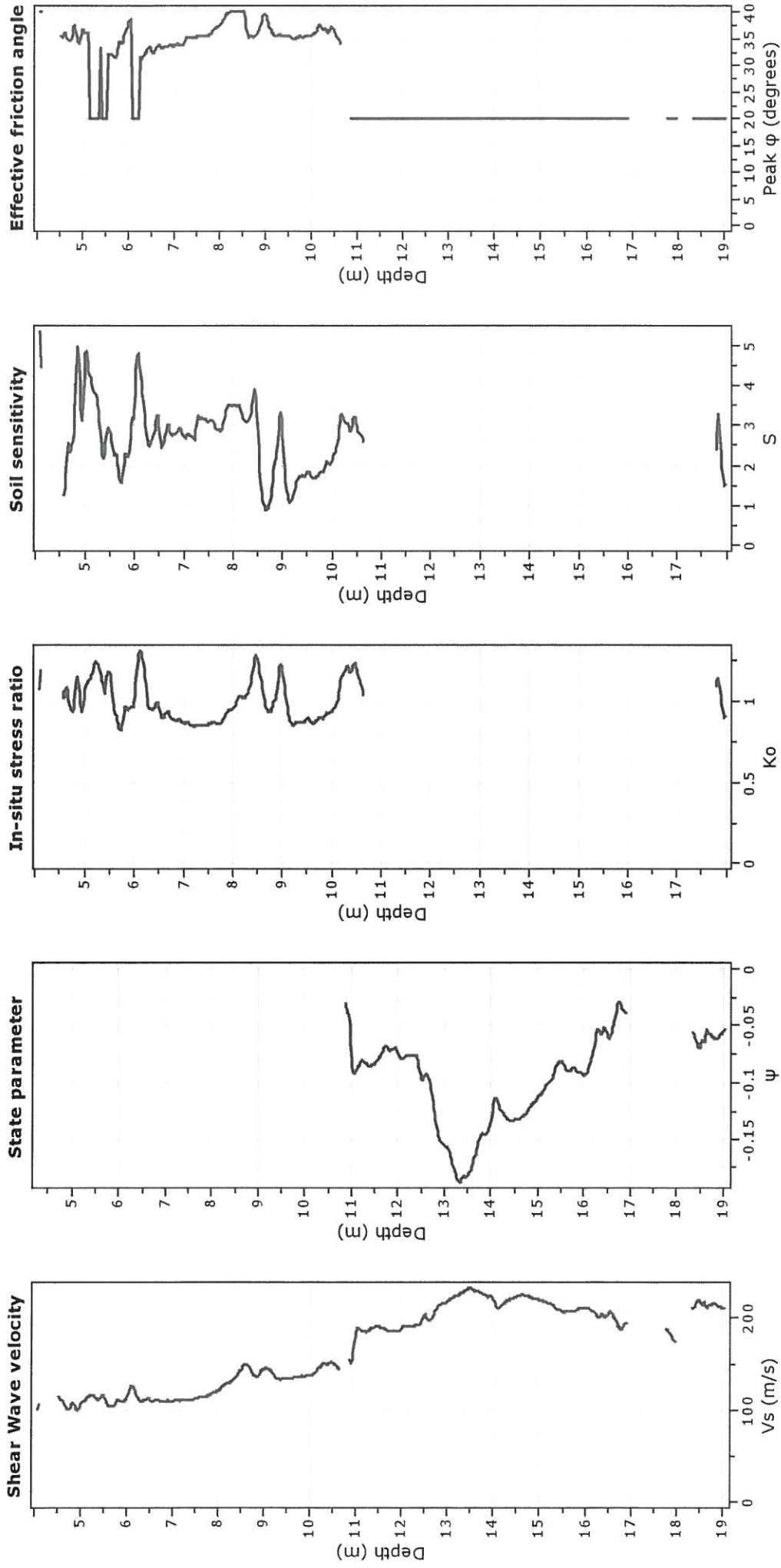
OCR factor for clays,  $N_{kk}$ : 0.33

Go: Based on variable  $\alpha$  using  $I_c$  (Robertson, 2009)

—●— User defined estimation data

Undrained shear strength cone factor for clays,  $N_{kk}$ : 14

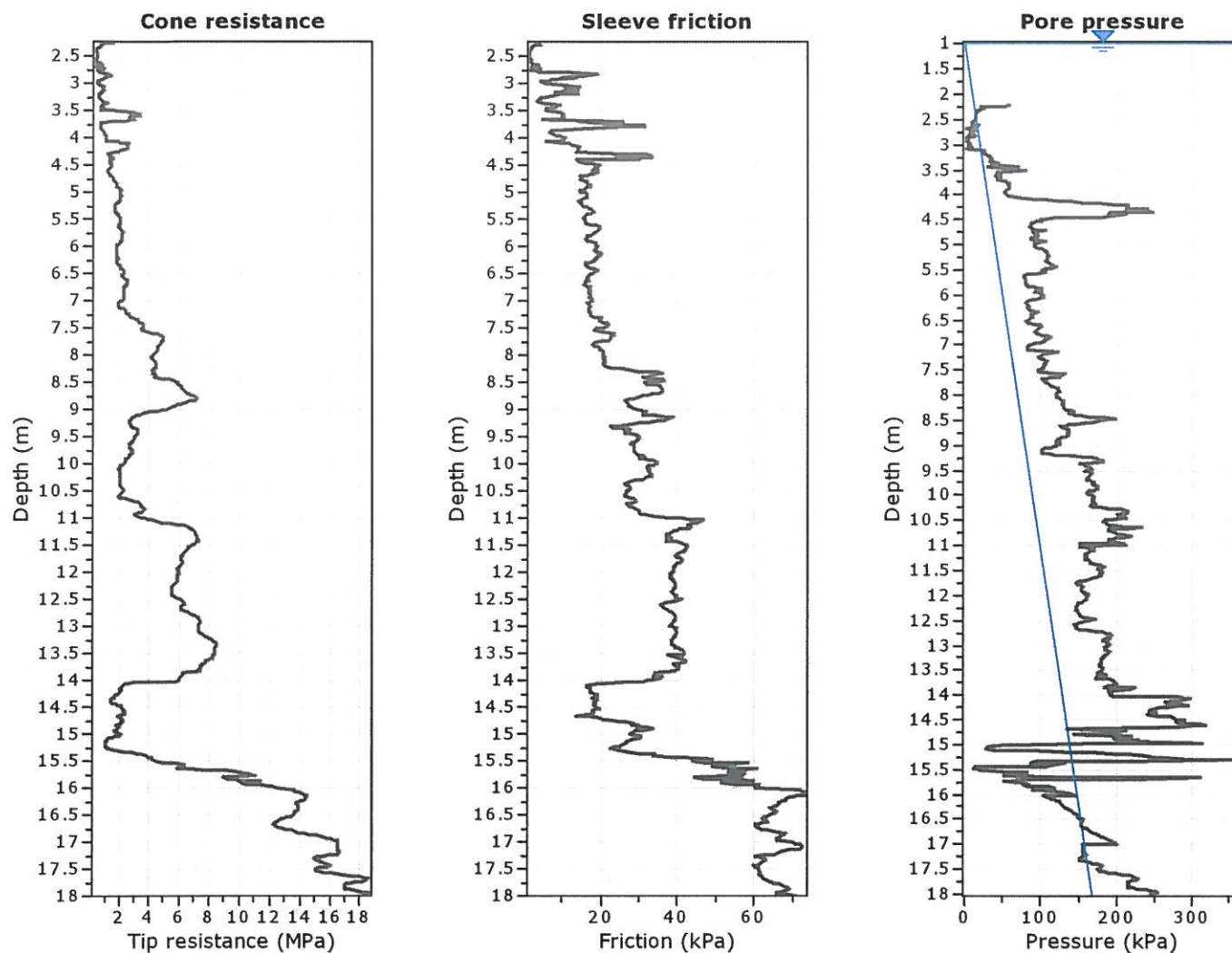
Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



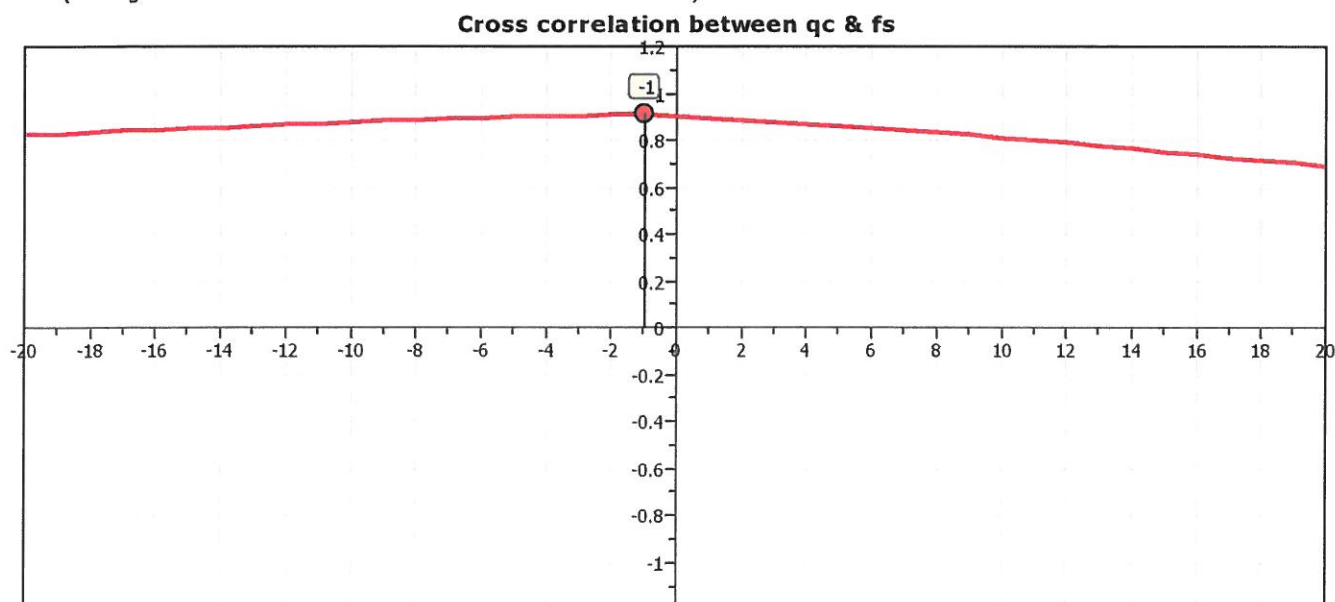
**Calculation parameters**

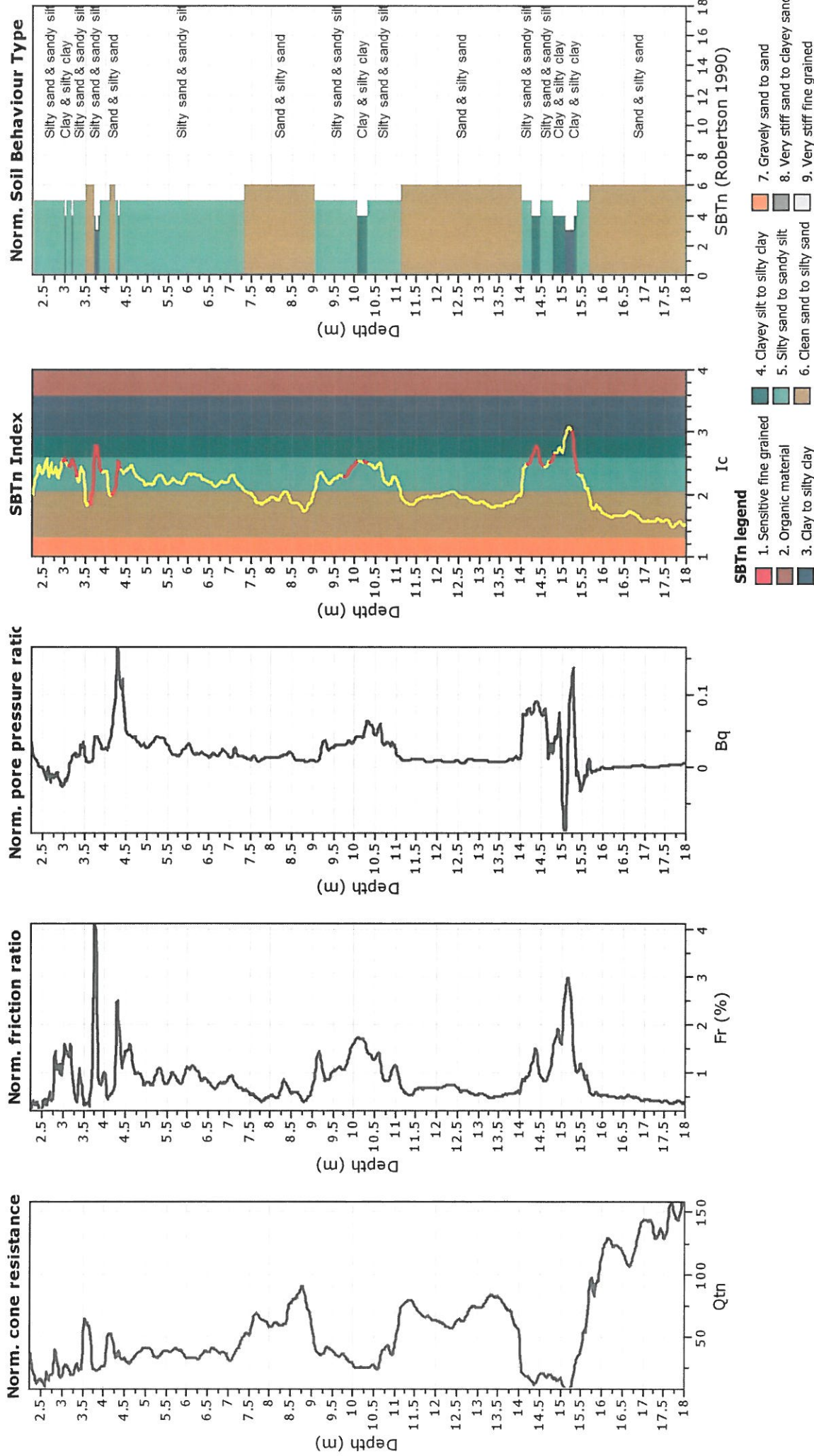
Soil Sensitivity factor,  $N_s$ : 7.00

—●— User defined estimation data

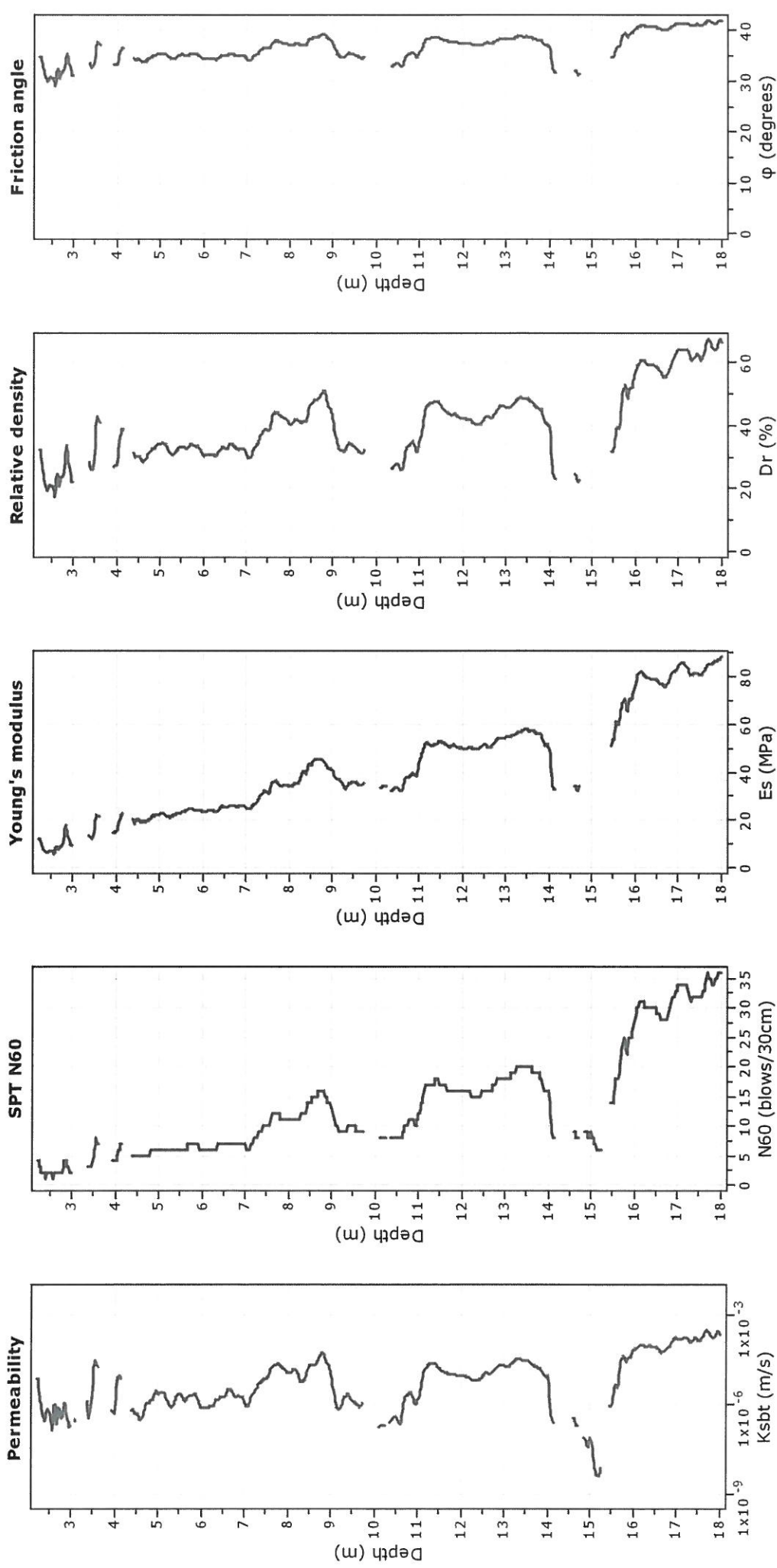


The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).





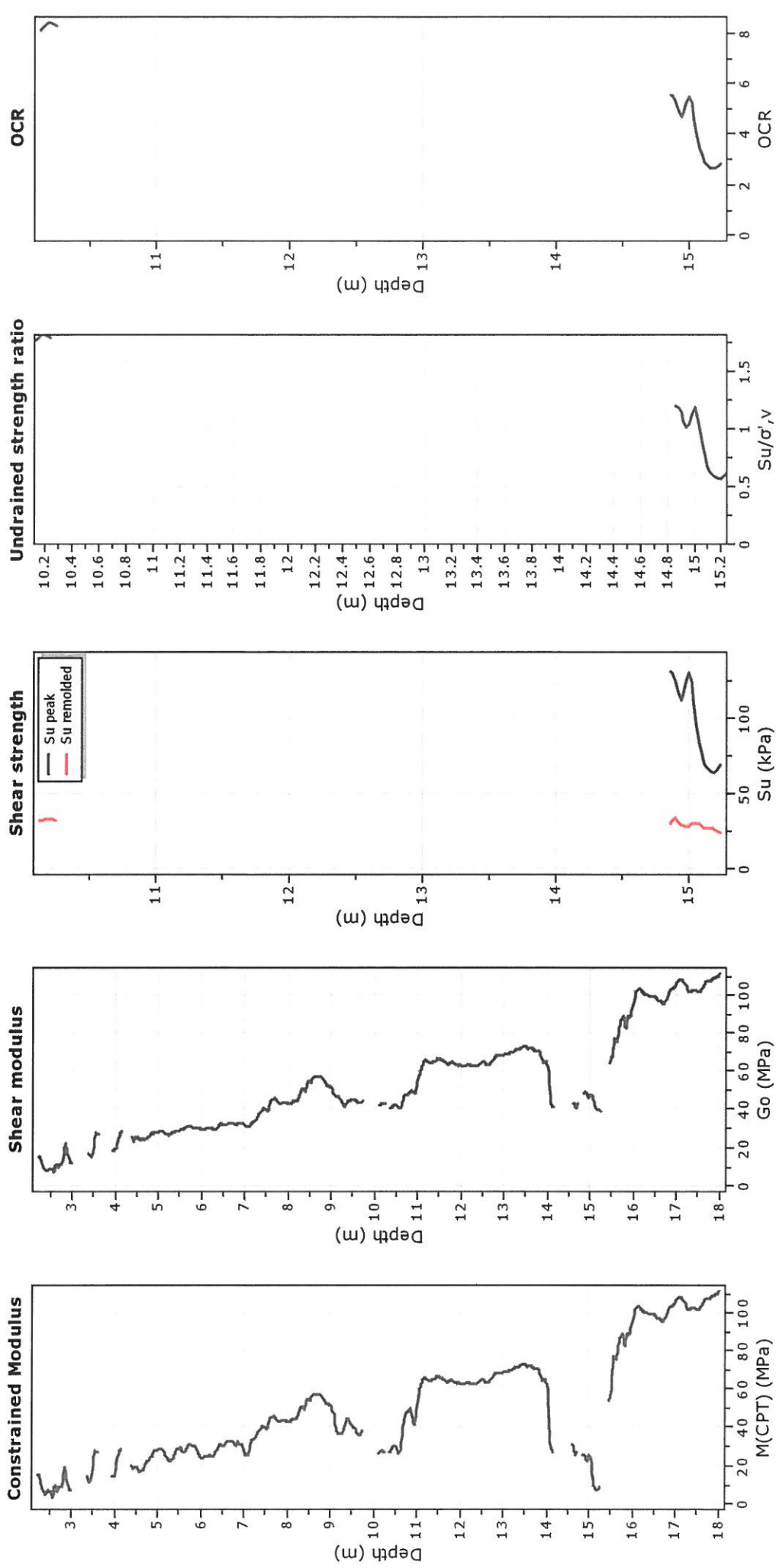
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**



#### Calculation parameters

Permeability: Based on SBT<sub>n</sub>  
SPT N<sub>60</sub>: Based on I<sub>c</sub> and q<sub>t</sub>  
Young's modulus: Based on variable alpha using I<sub>c</sub> (Robertson, 2009)  
Relative density constant, C<sub>dr</sub>: 350.0  
Phi: Based on Kulhawy & Mayne (1990)  
—●— User defined estimation data

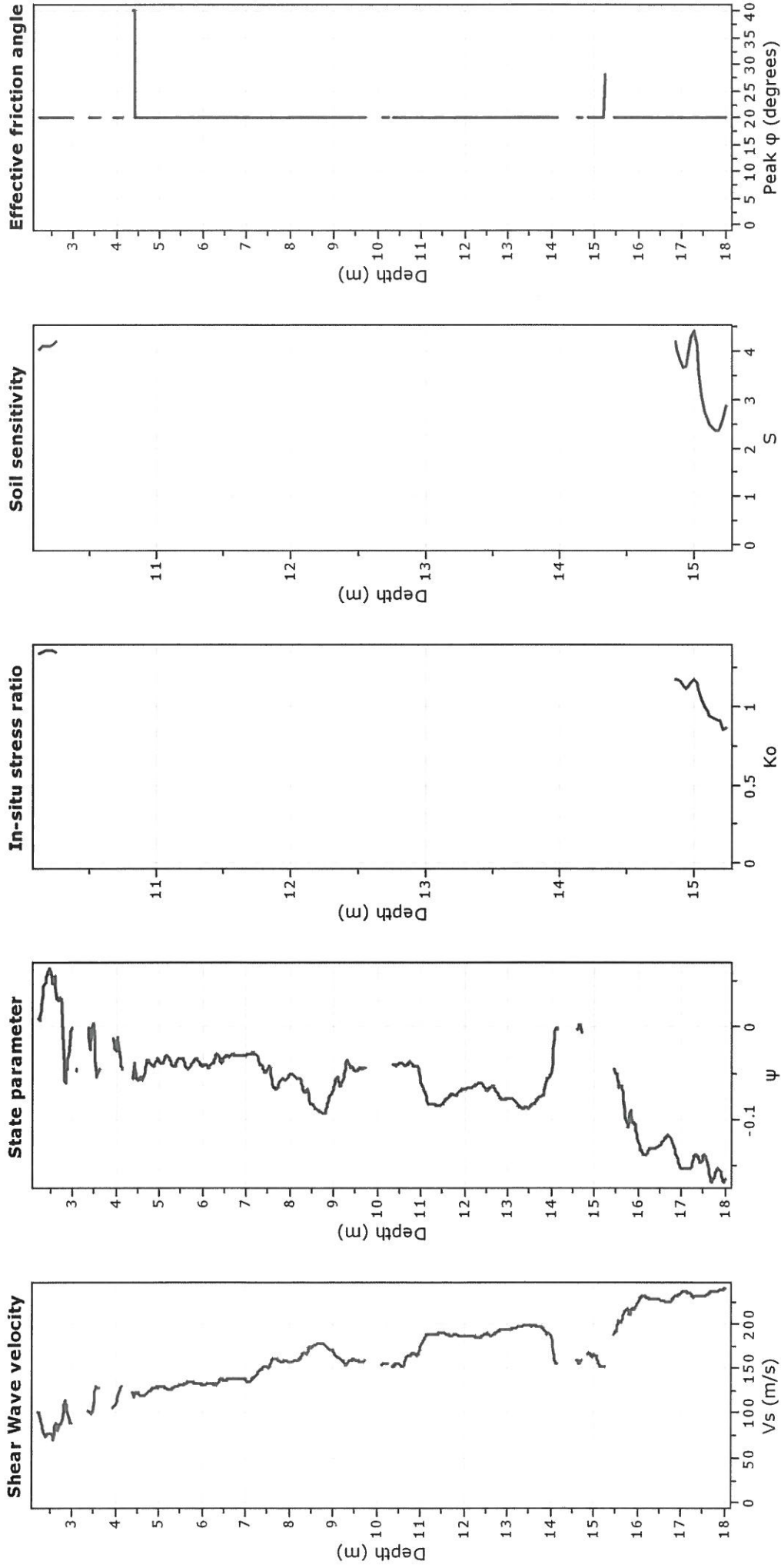
**Project:** FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
**Location:** TRATTO CASTELMASSA - STIENTA



#### Calculation parameters

Constrained modulus: Based on variable  $\alpha$  using  $I_c$  and  $Q_m$  (Robertson, 2009) OCR factor for clays,  $N_{kt}$ : 0.33  
Go: Based on variable  $\alpha$  using  $I_c$  (Robertson, 2009)  
Undrained shear strength cone factor for clays,  $N_{kt}$ : 14  
—●— User defined estimation data

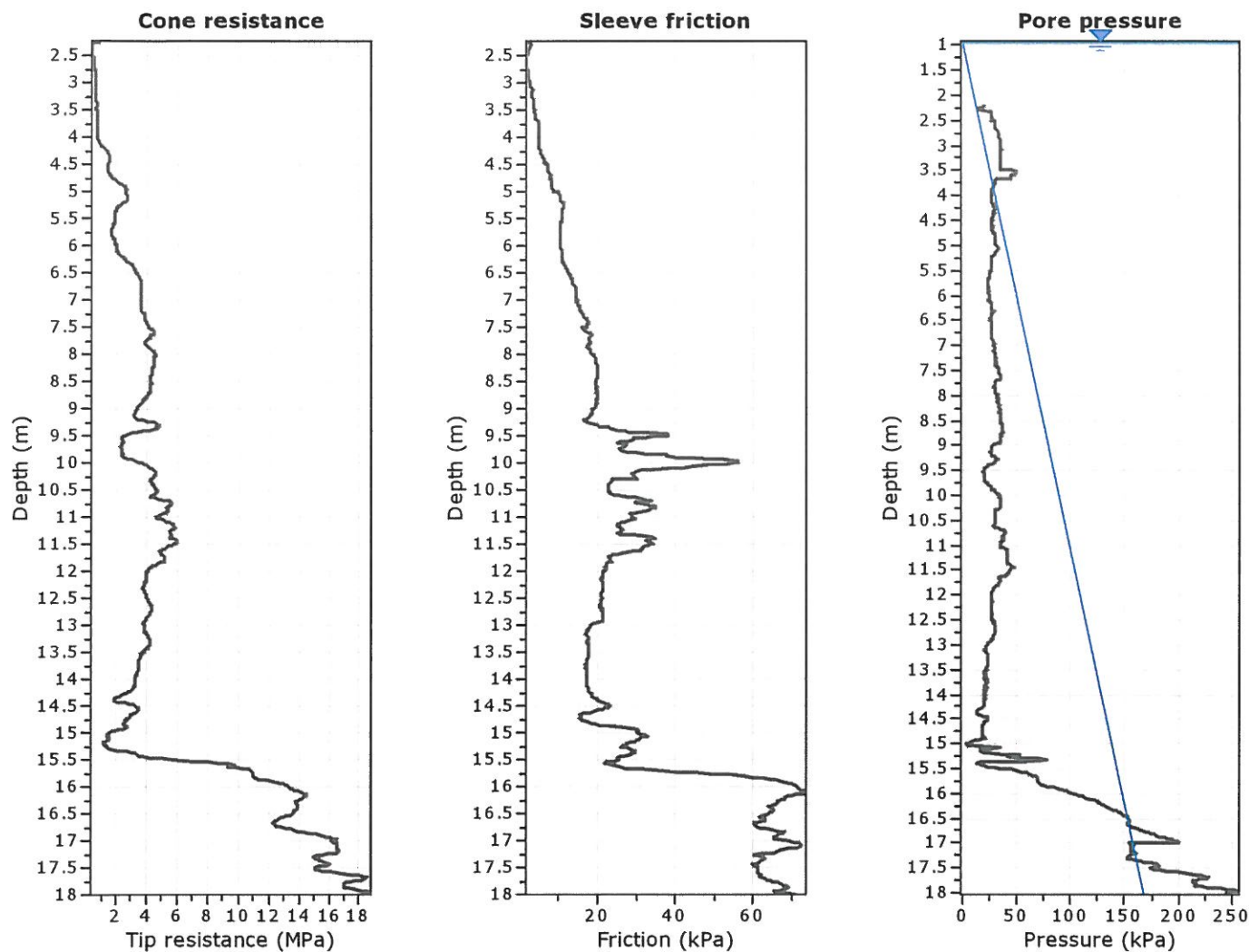
Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



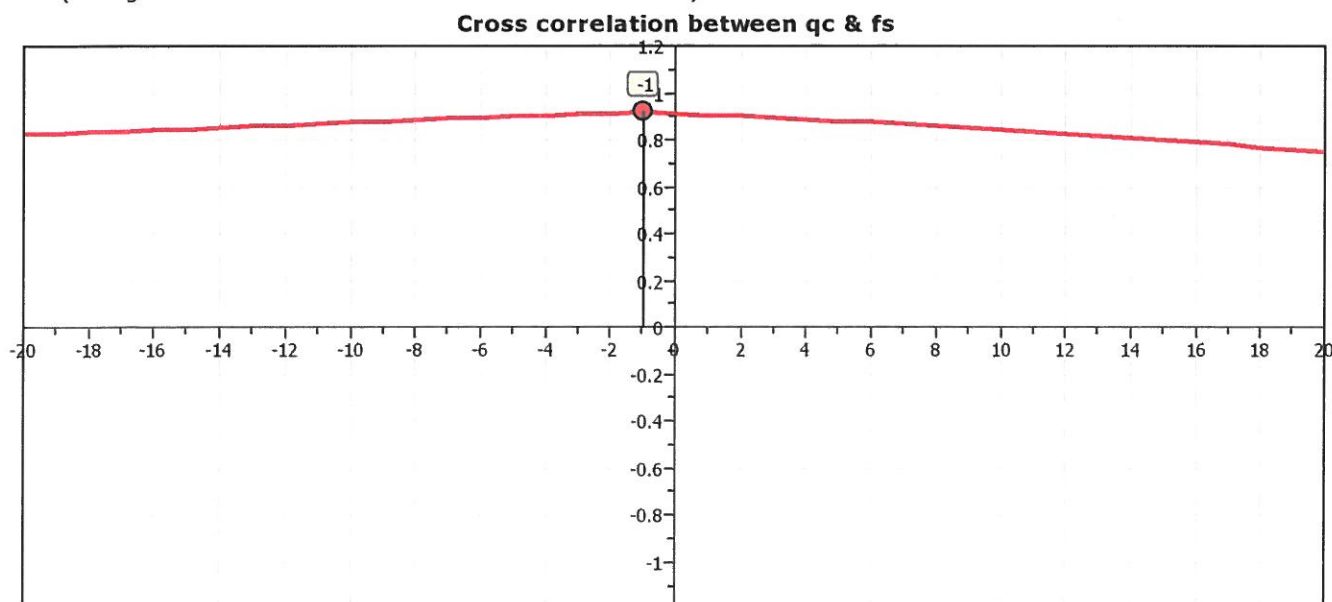
**Calculation parameters**

Soil Sensitivity factor,  $N_s$ : 7.00

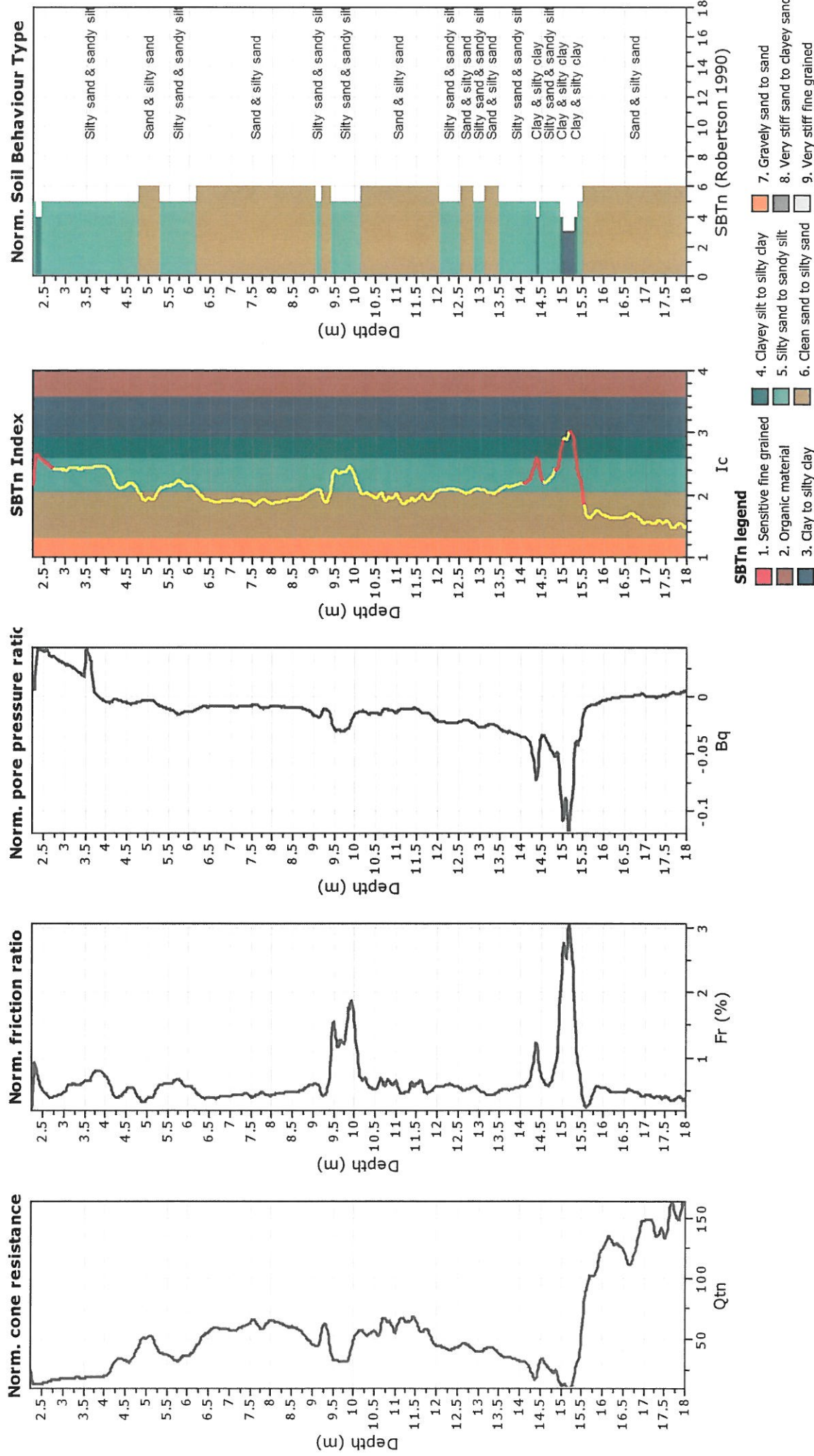
—●— User defined estimation data

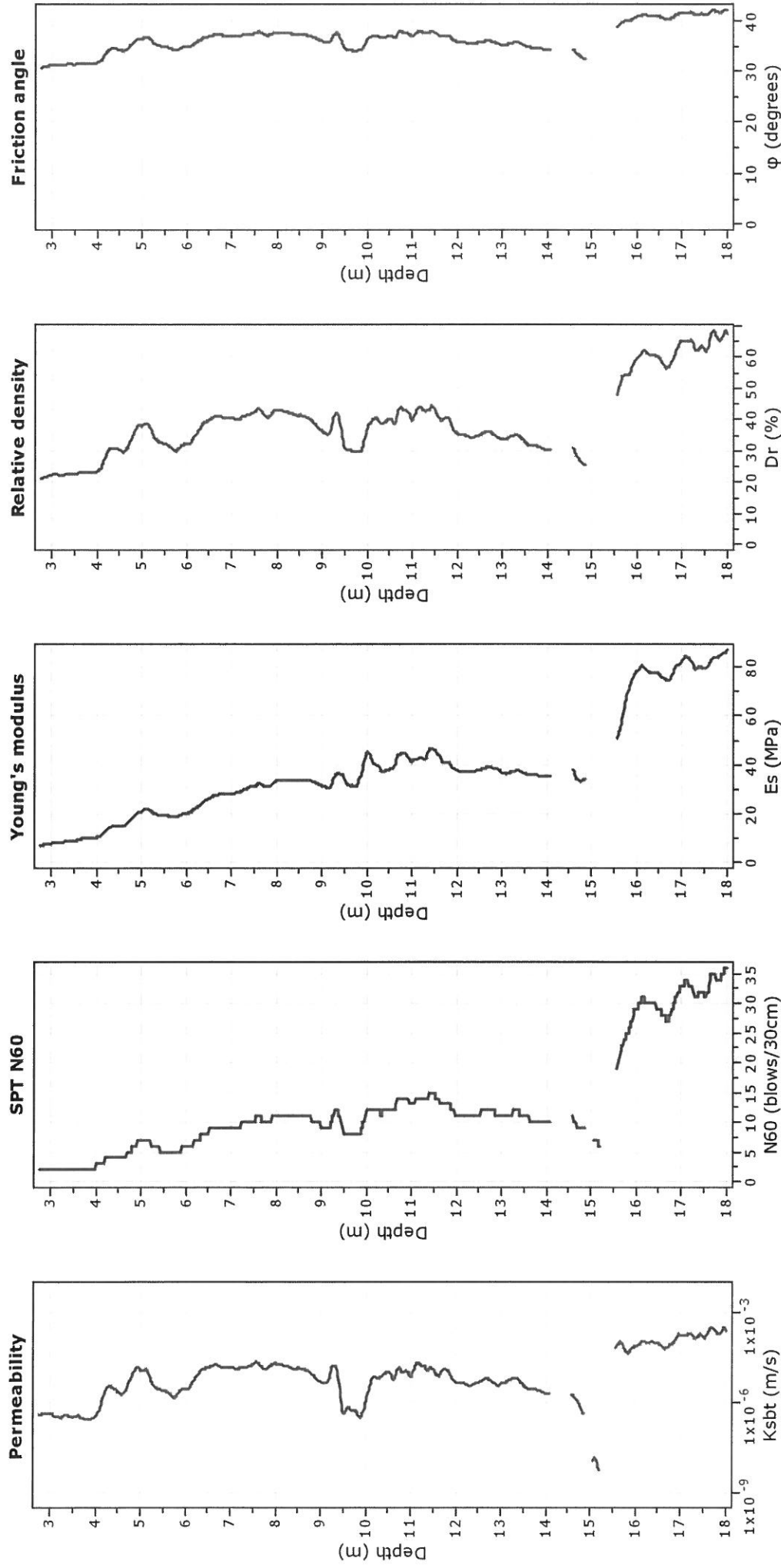


The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**

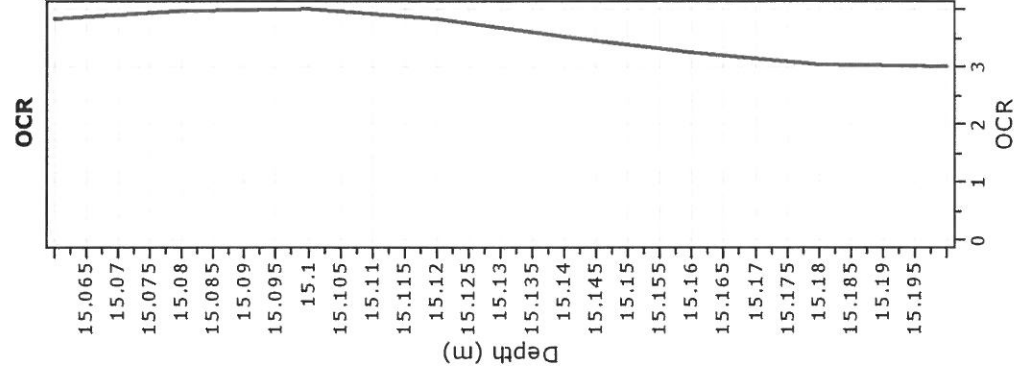
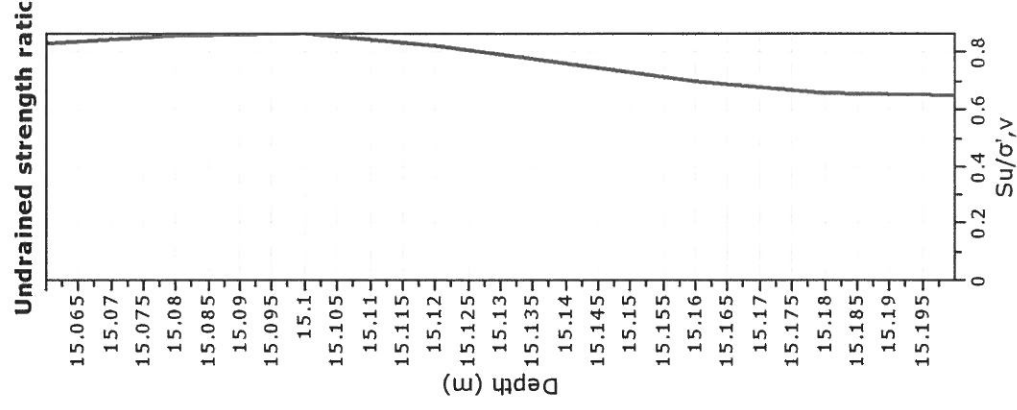
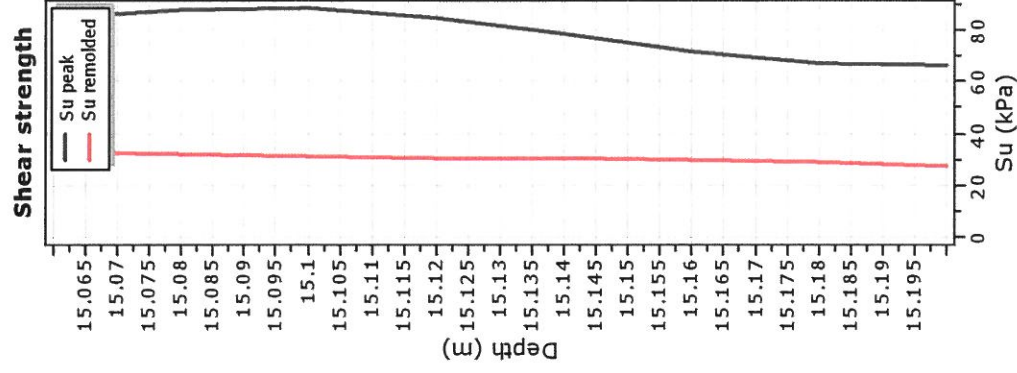
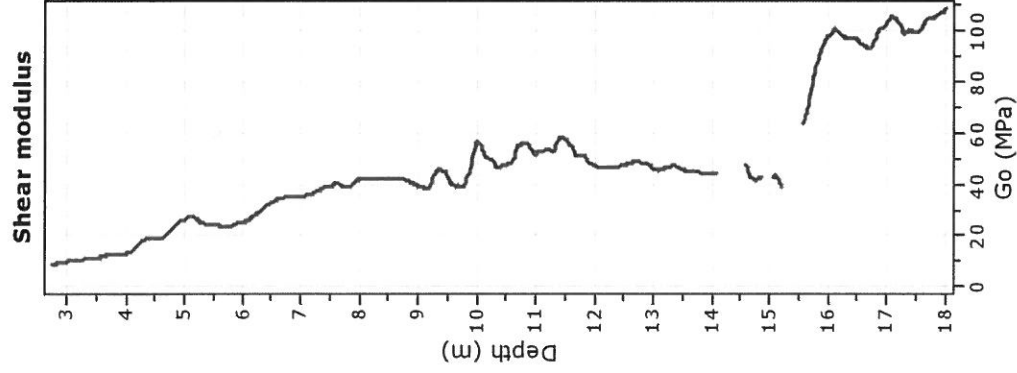
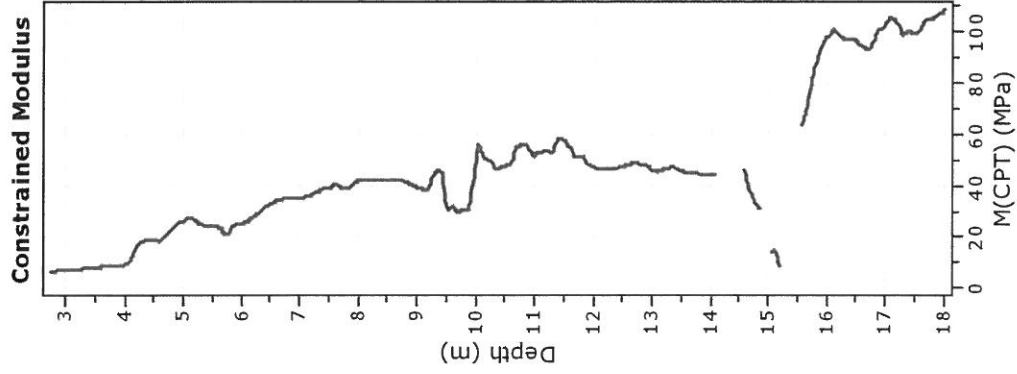




## Calculation parameters

Permeability: Based on  $SBT_n$   
 $SPT_{N60}$ : Based on  $I_c$  and  $q_t$   
 Young's modulus: Based on variable  $\alpha$  using  $I_c$  (Robertson, 2009) ● User defined estimation data  
 Relative density constant,  $C_{Dr}$ : 350.0  
 $\Phi$ : Based on Kulhawy & Mayne (1990)

**Project:** FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
**Location:** TRATTO CASTELMASSA - STIENTA



#### Calculation parameters

Constrained modulus: Based on variable  $\alpha$  using  $I_c$  and  $Q_m$  (Robertson, 2009)

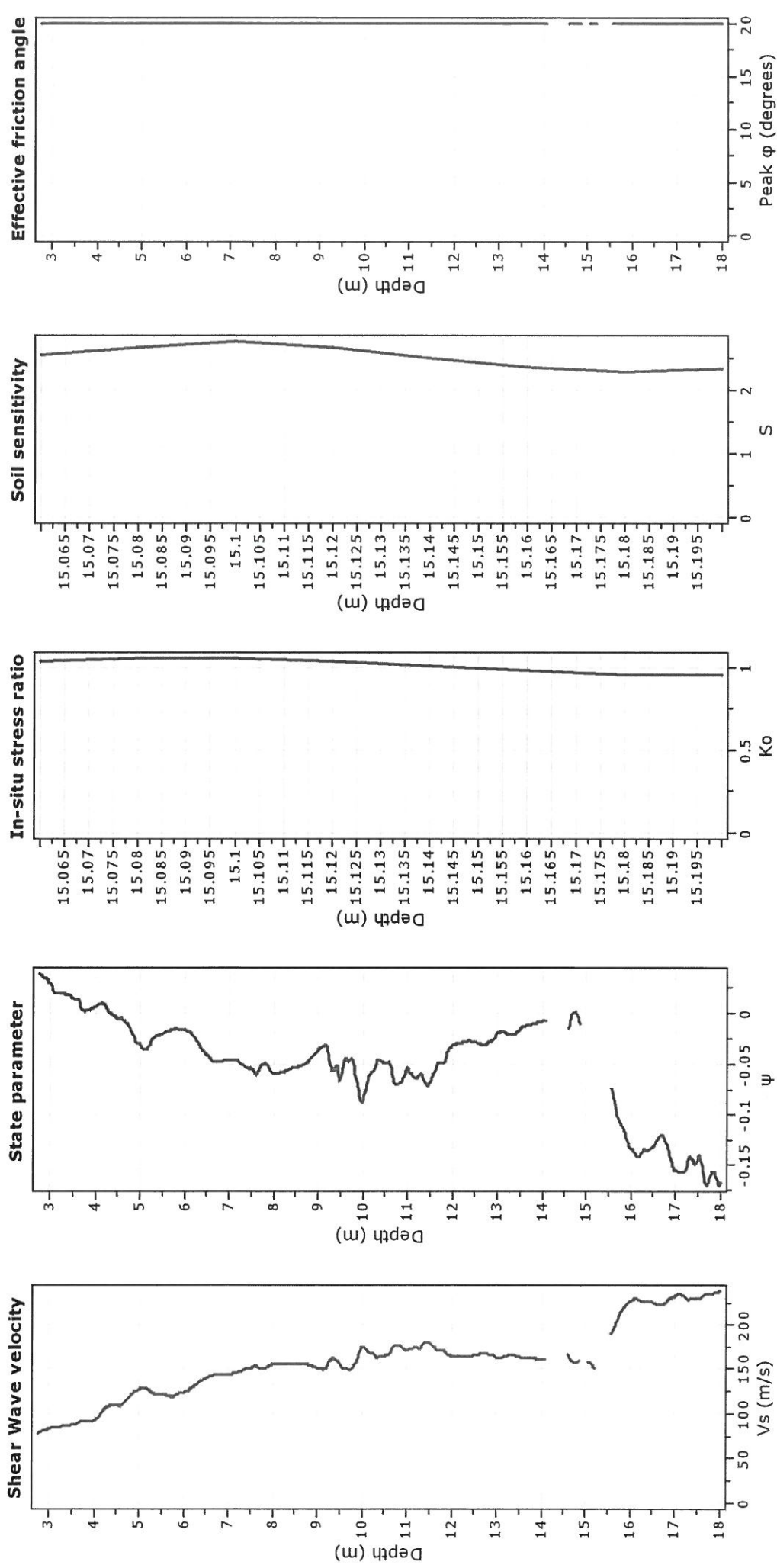
OCR factor for clays,  $N_{kt}$ : 0.33

Go: Based on variable  $\alpha$  using  $I_c$  (Robertson, 2009)

—●— User defined estimation data

Undrained shear strength cone factor for clays,  $N_{kt}$ : 14

**Project:** FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
**Location:** TRATTO CASTELMASSA - STIENTA



**Calculation parameters**

Soil Sensitivity factor,  $N_s$ : 7.00

—●— User defined estimation data

# CPTU 11A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	10	15.0	5	0.200	0.020	3.0	0.16	19.1	0.71	50.7	1.28	49.7	1.27	26.5	0.88
3	1.0	10	25.0	5	0.200	0.020	4.9	0.16	20.6	0.52	45.8	0.90	46.6	0.91	27.3	0.64
4	1.0	10	35.0	5	0.200	0.020	6.7	0.15	21.5	0.42	41.7	0.68	43.1	0.70	27.5	0.50
5	1.0	10	45.0	5	0.200	0.020	8.4	0.15	21.9	0.34	38.1	0.53	39.7	0.55	27.2	0.41
6	1.0	10	55.0	5	0.200	0.020	9.8	0.14	21.9	0.29	35.0	0.43	36.5	0.44	26.5	0.34
7	1.0	10	65.0	5	0.200	0.020	10.8	0.13	21.6	0.25	32.2	0.35	33.7	0.36	25.6	0.29
8	1.0	7	73.3	1	0.007	0.007	11.7	0.04	21.1	0.08	29.8	0.10	31.1	0.11	24.5	0.09
9	1.0	7	80.0	1	0.007	0.007	12.2	0.04	20.4	0.07	27.6	0.09	28.8	0.09	23.4	0.08
10	1.0	8	87.3	1	0.002	0.002	12.6	0.01	19.8	0.02	25.7	0.02	26.7	0.02	22.4	0.02
11	1.0	8	94.9	1	0.004	0.004	12.8	0.02	19.0	0.03	24.0	0.04	24.9	0.04	21.3	0.04
12	1.0	7	102.2	1	0.006	0.006	12.8	0.03	18.3	0.04	22.5	0.05	23.3	0.05	20.3	0.05
13	1.0	7	108.9	1	0.008	0.008	12.8	0.04	17.6	0.05	21.2	0.06	21.8	0.06	19.3	0.06
14	1.0	6	115.2	1	0.010	0.010	12.7	0.05	16.9	0.06	19.9	0.07	20.5	0.07	18.4	0.06
TOTALI (cm)								1.13	2.89		4.62		4.69		3.46	

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	10	15.0	5	0.200	0.020	12.0	0.51	2.0	0.11
3	1.0	10	25.0	5	0.200	0.020	12.6	0.36	3.2	0.10
4	1.0	10	35.0	5	0.200	0.020	13.4	0.28	4.4	0.10
5	1.0	10	45.0	5	0.200	0.020	14.2	0.24	5.6	0.10
6	1.0	10	55.0	5	0.200	0.020	14.9	0.21	6.6	0.10
7	1.0	10	65.0	5	0.200	0.020	15.3	0.18	7.6	0.10
8	1.0	7	73.3	1	0.007	0.007	15.6	0.06	8.4	0.03
9	1.0	7	80.0	1	0.007	0.007	15.7	0.05	9.1	0.03
10	1.0	8	87.3	1	0.002	0.002	15.7	0.01	9.6	0.01
11	1.0	8	94.9	1	0.004	0.004	15.5	0.03	10.0	0.02
12	1.0	7	102.2	1	0.006	0.006	15.3	0.04	10.3	0.02
13	1.0	7	108.9	1	0.008	0.008	15.0	0.04	10.5	0.03
14	1.0	6	115.2	1	0.010	0.010	14.6	0.05	10.6	0.04
TOTALI (cm)								2.07	0.80	

[illegible]

# CPTU 12A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

### CARATTERISTICHE DEGLI STRATI

### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.5	1	0.011	0.011	3.0	0.15	19.1	0.56	50.7	0.93	49.7	0.92	26.5	0.68
3	1.0	6	14.2	1	0.011	0.011	4.9	0.14	20.6	0.43	45.8	0.69	46.6	0.69	27.3	0.51
4	1.0	6	20.0	1	0.011	0.011	6.7	0.14	21.5	0.35	41.7	0.54	43.1	0.55	27.5	0.41
5	1.0	6	25.8	1	0.011	0.011	8.4	0.13	21.9	0.29	38.1	0.43	39.7	0.44	27.2	0.34
6	1.0	6	31.7	1	0.010	0.010	9.8	0.12	21.9	0.23	35.0	0.32	36.5	0.33	26.5	0.26
7	1.0	6	37.7	1	0.010	0.010	10.8	0.11	21.6	0.20	32.2	0.27	33.7	0.28	25.6	0.23
8	1.0	6	43.7	1	0.010	0.010	11.7	0.10	21.1	0.17	29.8	0.23	31.1	0.23	24.5	0.19
9	1.0	6	49.8	1	0.009	0.009	12.2	0.09	20.4	0.13	27.6	0.17	28.8	0.18	23.4	0.15
10	1.0	7	56.2	1	0.008	0.008	12.6	0.07	19.8	0.10	25.7	0.13	26.7	0.14	22.4	0.12
11	1.0	7	62.8	1	0.007	0.007	12.8	0.06	19.0	0.08	24.0	0.10	24.9	0.10	21.3	0.09
12	1.0	7	69.4	1	0.007	0.007	12.8	0.05	18.3	0.07	22.5	0.09	23.3	0.09	20.3	0.08
13	1.0	10	77.8	5	0.200	0.020	12.8	0.13	17.6	0.18	21.2	0.21	21.8	0.21	19.3	0.19
14	1.0	7	86.0	1	0.008	0.008	12.7	0.05	16.9	0.06	19.9	0.07	20.5	0.07	18.4	0.07
15	1.0	8	93.0	1	0.004	0.004	12.5	0.02	16.2	0.03	18.9	0.03	19.3	0.03	17.5	0.03
TOTALI (cm)								1.36	2.89	4.20	4.28	3.35				

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

### CARATTERISTICHE DEGLI STRATI

### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m³	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.5	1	0.011	0.011	12.0	0.42	2.0	0.10
3	1.0	6	14.2	1	0.011	0.011	12.6	0.30	3.2	0.10
4	1.0	6	20.0	1	0.011	0.011	13.4	0.25	4.4	0.10
5	1.0	6	25.8	1	0.011	0.011	14.2	0.21	5.6	0.09
6	1.0	6	31.7	1	0.010	0.010	14.9	0.17	6.6	0.08
7	1.0	6	37.7	1	0.010	0.010	15.3	0.15	7.6	0.08
8	1.0	6	43.7	1	0.010	0.010	15.6	0.13	8.4	0.08
9	1.0	6	49.8	1	0.009	0.009	15.7	0.11	9.1	0.07
10	1.0	7	56.2	1	0.008	0.008	15.7	0.09	9.6	0.05
11	1.0	7	62.8	1	0.007	0.007	15.5	0.07	10.0	0.04
12	1.0	7	69.4	1	0.007	0.007	15.3	0.06	10.3	0.04
13	1.0	10	77.8	5	0.200	0.020	15.0	0.15	10.5	0.11
14	1.0	7	86.0	1	0.008	0.008	14.6	0.05	10.6	0.04
15	1.0	8	93.0	1	0.004	0.004	14.2	0.02	10.6	0.02
TOTALI (cm)								2.18	1.00	

[illegible]

# CPTU 12B PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

### CARATTERISTICHE DEGLI STRATI

### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.5	1	0.011	0.011	3.0	0.15	19.1	0.56	50.7	0.93	49.7	0.92	26.5	0.68
3	1.0	6	14.2	1	0.011	0.011	4.9	0.14	20.6	0.43	45.8	0.69	46.6	0.70	27.3	0.51
4	1.0	6	19.9	1	0.011	0.011	6.7	0.14	21.5	0.35	41.7	0.54	43.1	0.55	27.5	0.41
5	1.0	6	25.8	1	0.011	0.011	8.4	0.13	21.9	0.29	38.1	0.43	39.7	0.45	27.2	0.34
6	1.0	6	31.6	1	0.010	0.010	9.8	0.12	21.9	0.23	35.0	0.32	36.5	0.33	26.5	0.26
7	1.0	6	37.6	1	0.010	0.010	10.8	0.11	21.6	0.20	32.2	0.27	33.7	0.28	25.6	0.23
8	1.0	6	43.6	1	0.010	0.010	11.7	0.10	21.1	0.17	29.8	0.23	31.1	0.23	24.5	0.19
9	1.0	6	49.8	1	0.009	0.009	12.2	0.09	20.4	0.13	27.6	0.17	28.8	0.18	23.4	0.15
10	1.0	6	56.0	1	0.009	0.009	12.6	0.08	19.8	0.12	25.7	0.15	26.7	0.15	22.4	0.13
11	1.0	6	62.1	1	0.010	0.010	12.8	0.08	19.0	0.12	24.0	0.14	24.9	0.15	21.3	0.13
12	1.0	6	68.2	1	0.010	0.010	12.8	0.07	18.3	0.10	22.5	0.12	23.3	0.13	20.3	0.11
13	1.0	6	74.1	1	0.010	0.010	12.8	0.07	17.6	0.09	21.2	0.11	21.8	0.11	19.3	0.10
14	1.0	7	80.5	1	0.006	0.006	12.7	0.04	16.9	0.05	19.9	0.06	20.5	0.06	18.4	0.05
15	1.0	8	87.8	1	0.003	0.003	12.5	0.02	16.2	0.02	18.9	0.03	19.3	0.03	17.5	0.02
TOTALI (cm)								1.34	2.87	4.19	4.26	3.33				

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

### CARATTERISTICHE DEGLI STRATI

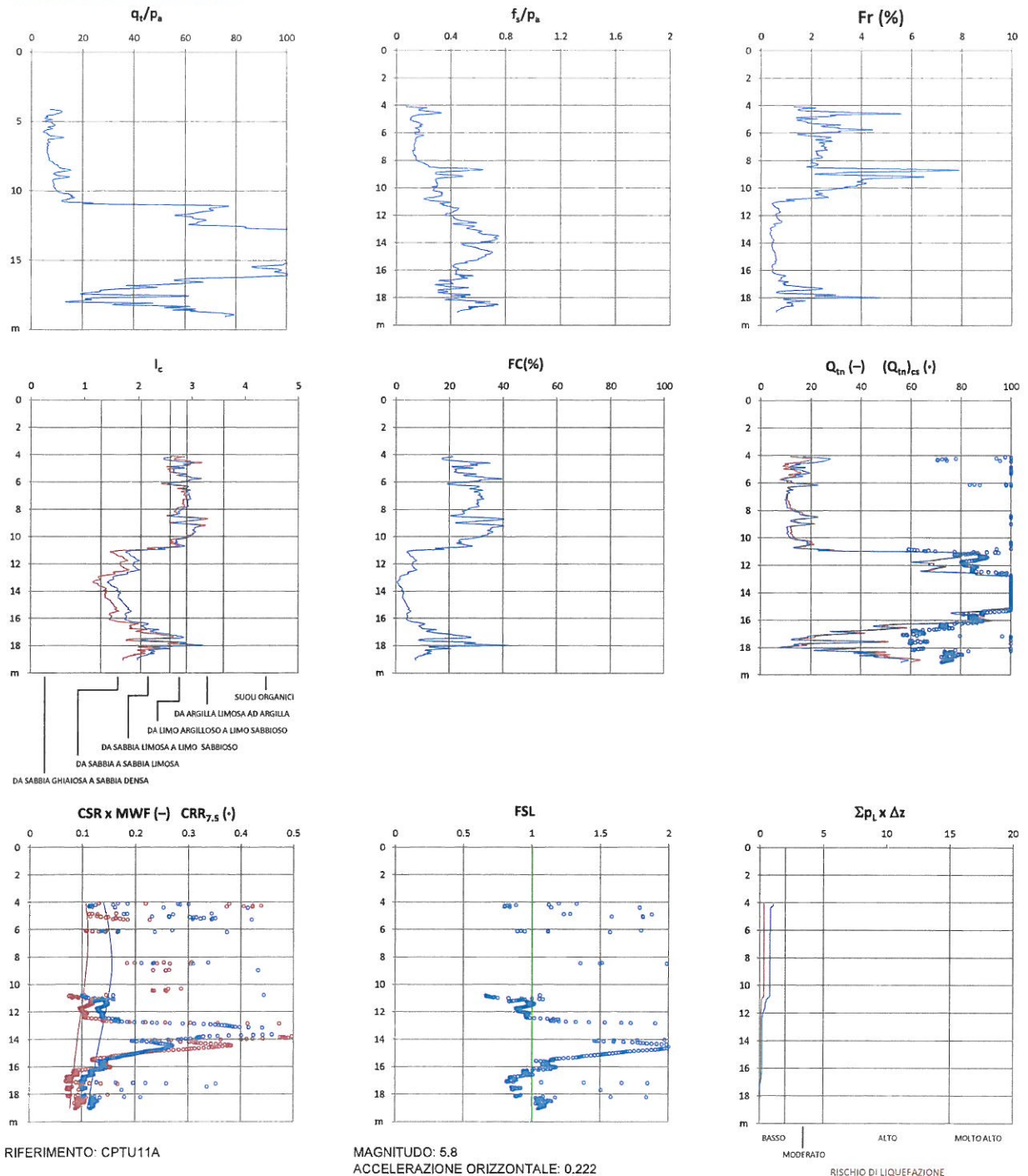
### TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m³	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.5	1	0.011	0.011	12.0	0.42	2.0	0.10
3	1.0	6	14.2	1	0.011	0.011	12.6	0.30	3.2	0.10
4	1.0	6	19.9	1	0.011	0.011	13.4	0.25	4.4	0.10
5	1.0	6	25.8	1	0.011	0.011	14.2	0.21	5.6	0.09
6	1.0	6	31.6	1	0.010	0.010	14.9	0.17	6.6	0.08
7	1.0	6	37.6	1	0.010	0.010	15.3	0.15	7.6	0.08
8	1.0	6	43.6	1	0.010	0.010	15.6	0.13	8.4	0.08
9	1.0	6	49.8	1	0.009	0.009	15.7	0.11	9.1	0.07
10	1.0	6	56.0	1	0.009	0.009	15.7	0.10	9.6	0.06
11	1.0	6	62.1	1	0.010	0.010	15.5	0.10	10.0	0.06
12	1.0	6	68.2	1	0.010	0.010	15.3	0.09	10.3	0.06
13	1.0	6	74.1	1	0.010	0.010	15.0	0.08	10.5	0.06
14	1.0	7	80.5	1	0.006	0.006	14.6	0.04	10.6	0.03
15	1.0	8	87.8	1	0.003	0.003	14.2	0.02	10.6	0.01
TOTALI (cm)								2.16	0.98	

0.99

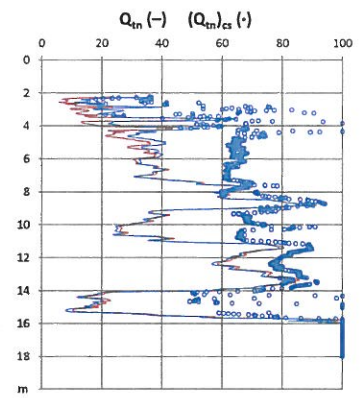
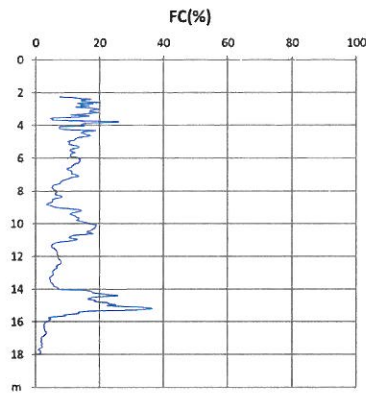
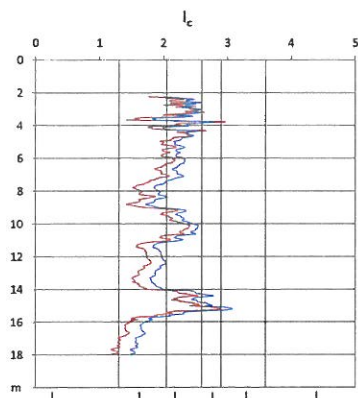
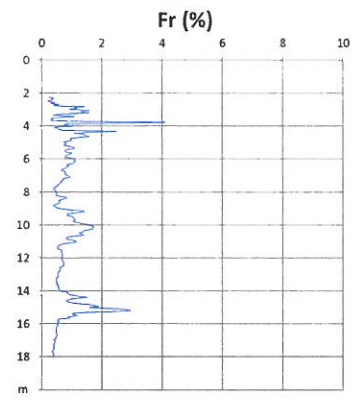
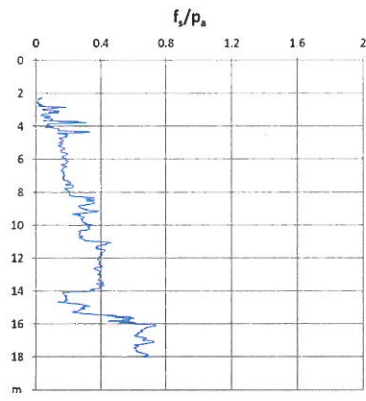
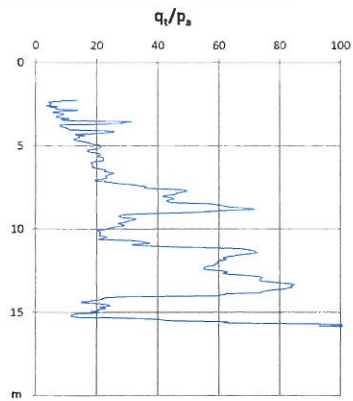
## RISCHIO LIQUEFAZIONE

(Robertson & Wride, 1997 - Iwasaki et al. 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)

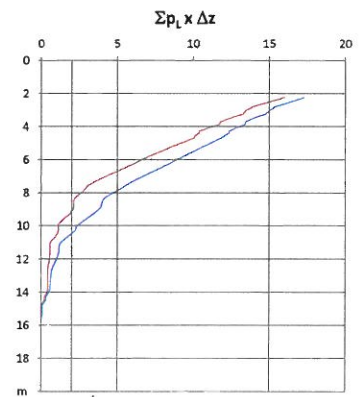
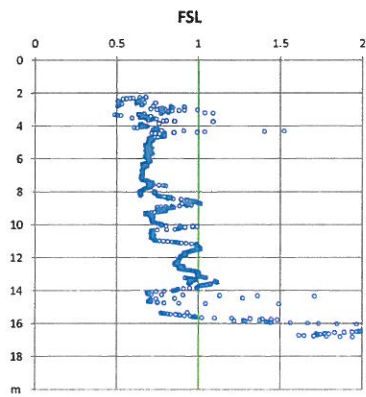
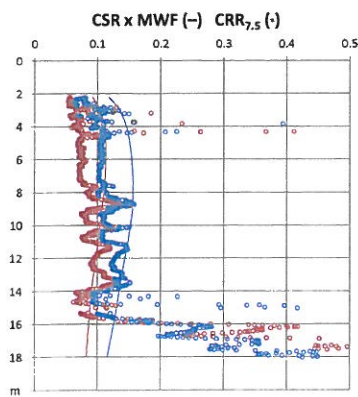


## RISCHIO LIQUEFAZIONE

(Robertson & Wride, 1997 - Iwasaki et al. 1982 - Robertson, 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



DA SABBIA GHIAIOSA A SABBIA Densa  
DA SABBIA A SABBIA LIMOSA  
DA SABBIA LIMOSA A LIMO SABBIOSO  
DA LIMO ARGILLOSO A LIMO SABBIOSO  
DA ARGILLA LIMOSA AD ARGILLA  
SUOLI ORGANICI



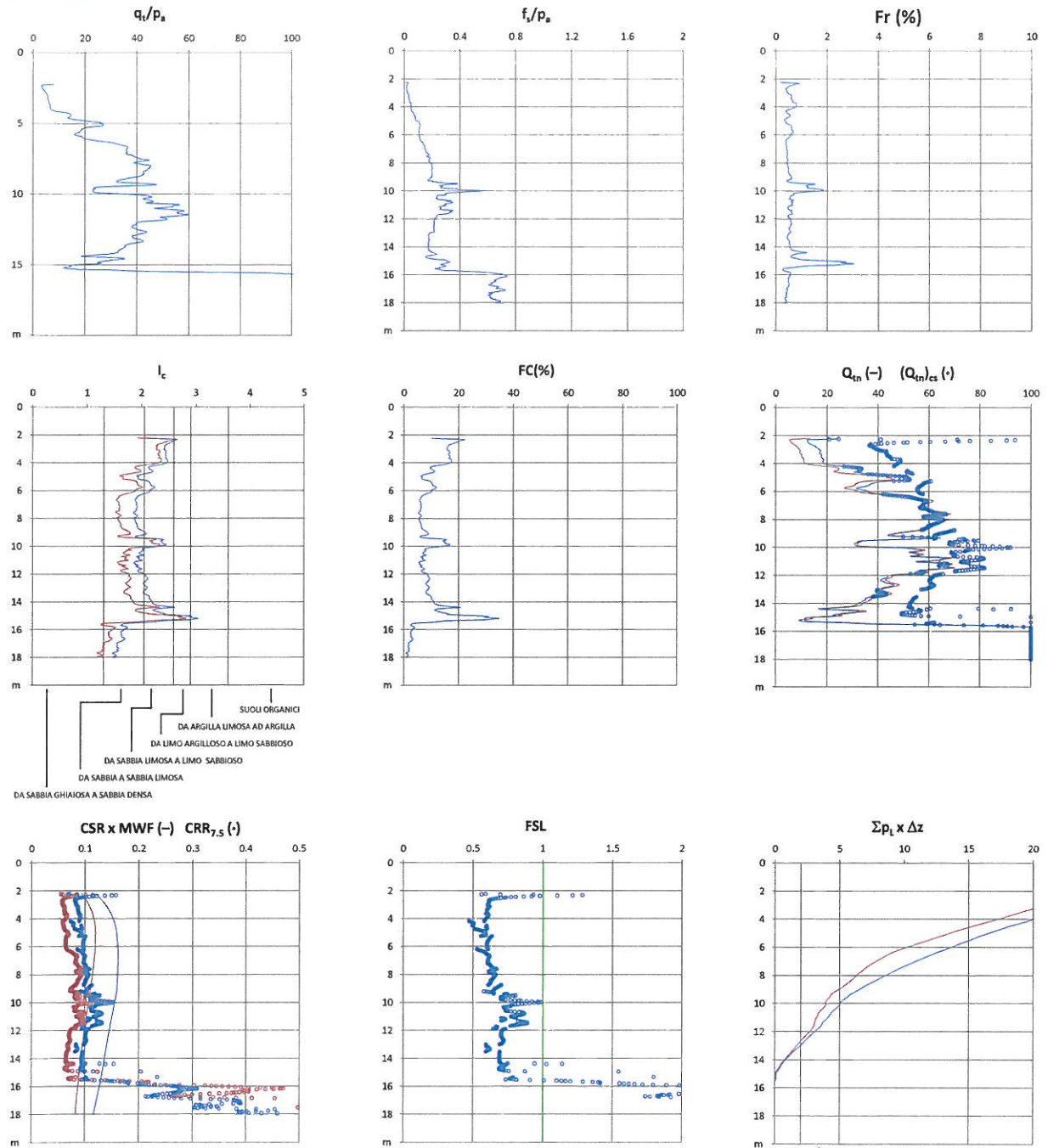
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ACCELERAZIONE ORIZZONTALE: 0.222

SOFTWARE GIANVITO CASSINADRI 2014

## RISCHIO LIQUEFAZIONE

(Robertson & Wride, 1997 - Iwasaki et al, 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



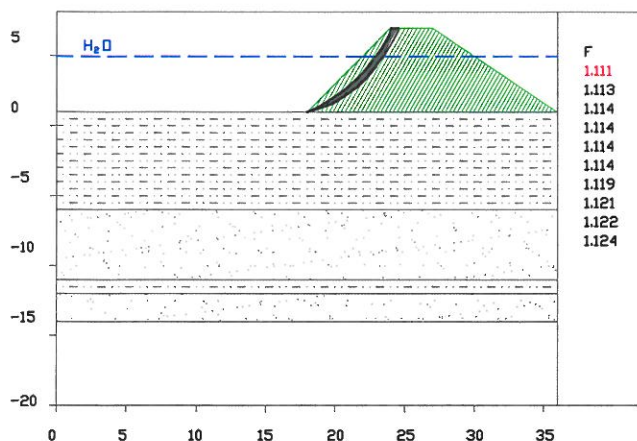
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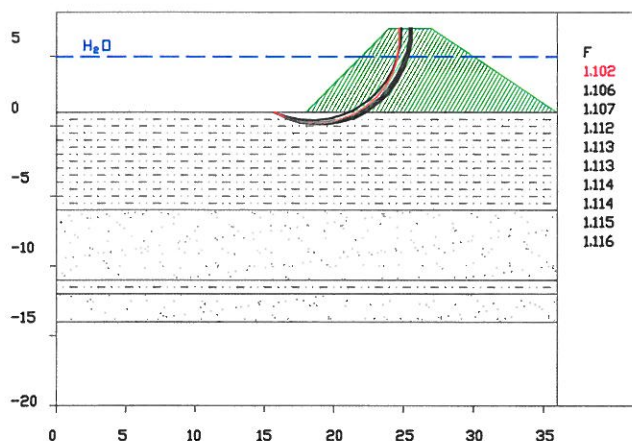
SOFTWARE GIANVITO CASSINADRI 2014

## VERIFICHE DI STABILITÀ

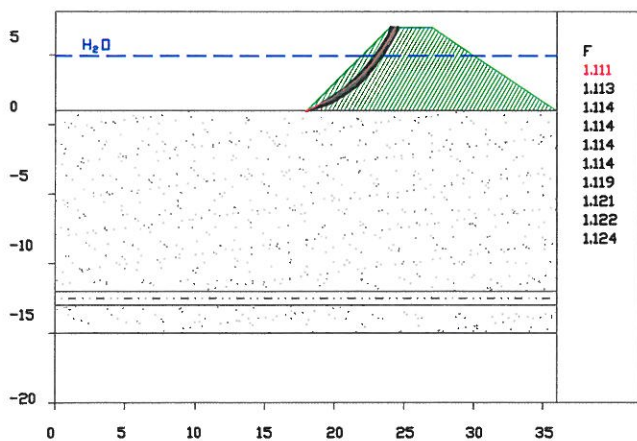
CPTU 11A - SENZA SISMA E COESIONE = 0.6 kPa



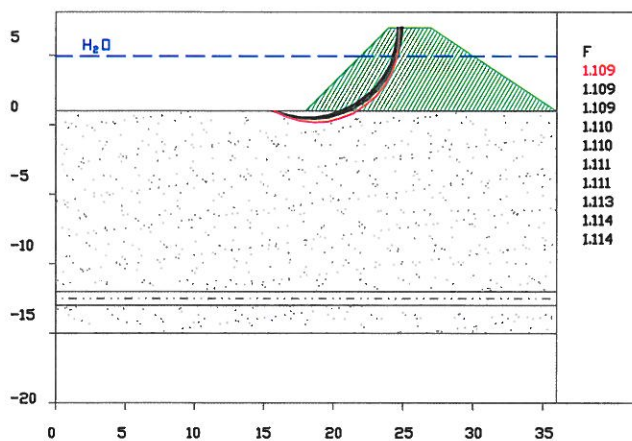
CPTU 11A - CON SISMA E COESIONE = 3 kPa



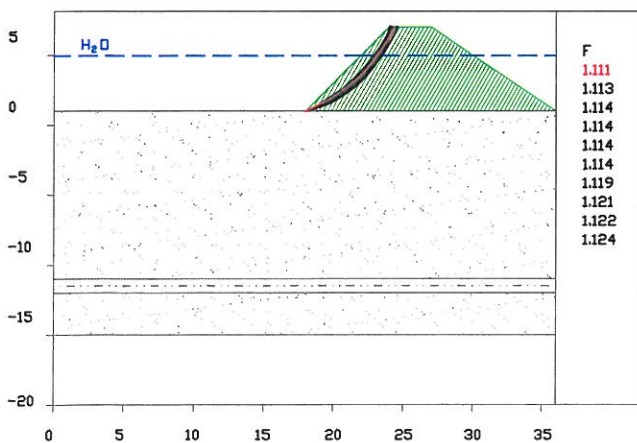
CPTU 12A - SENZA SISMA E COESIONE = 0.6 kPa



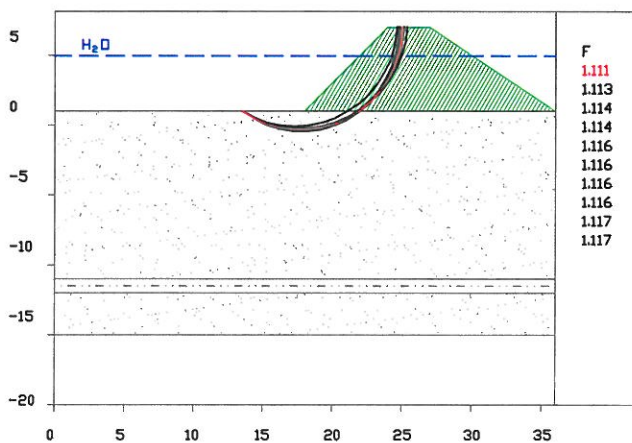
CPTU 12A - CON SISMA E COESIONE = 2.5 kPa



CPTU 12B - SENZA SISMA E COESIONE = 0.6 kPa



CPTU 12B - CON SISMA E COESIONE = 3.5 kPa





**STIENTA**

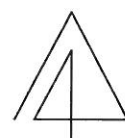


PROVA PENETROMETRICA



OPERE IN PROGETTO

LEGENDA



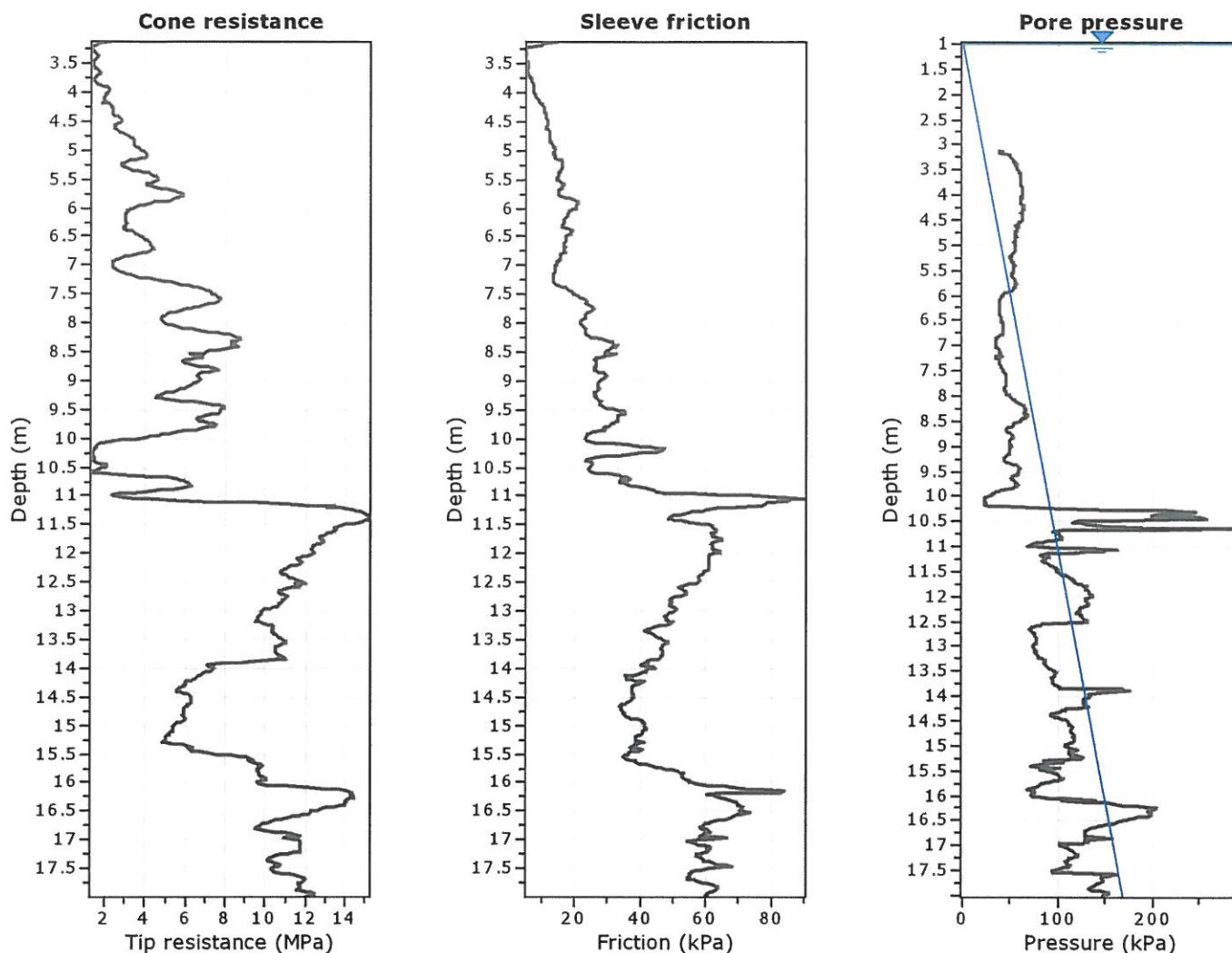
NORD



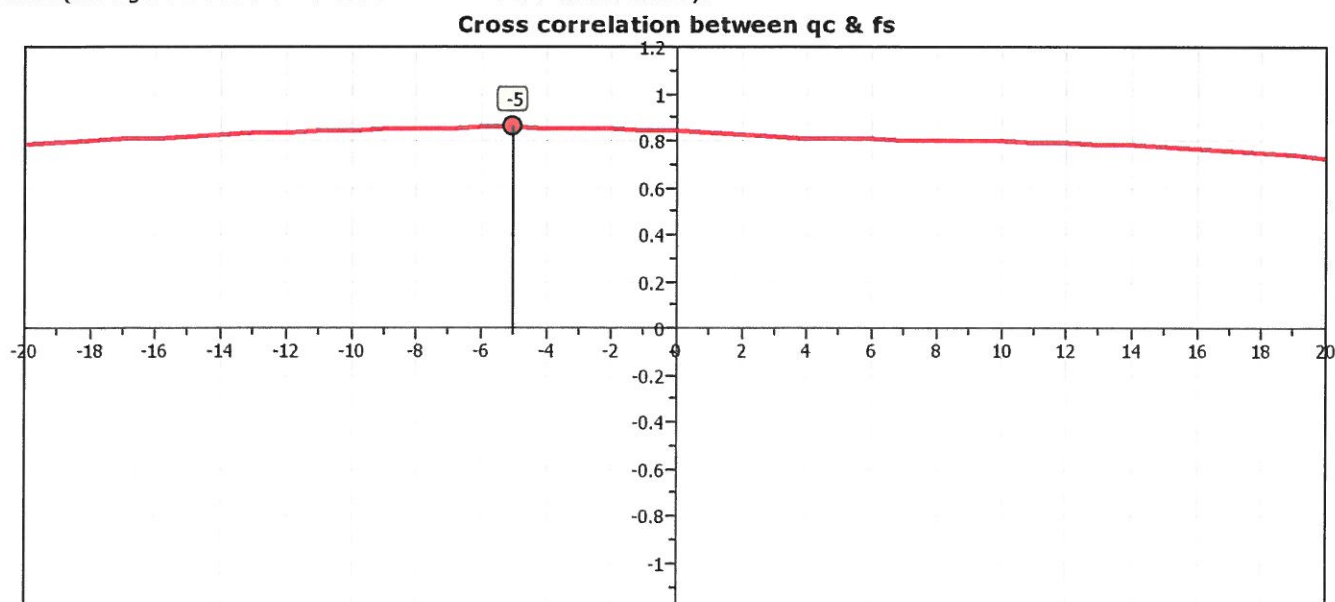
UBICAZIONE SONDAGGI STIENTA

**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

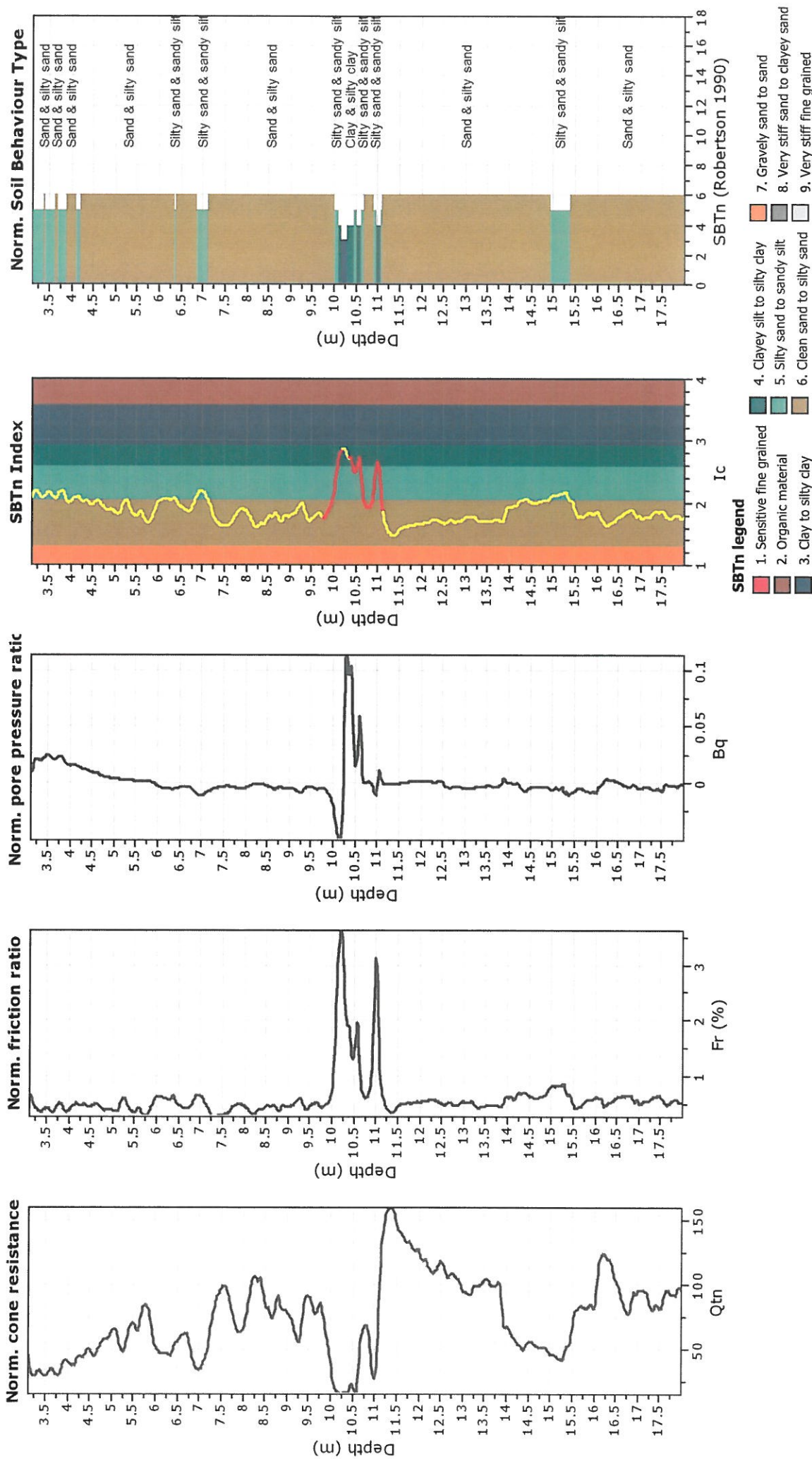
**Location: TRATTO CASTELMASSA - STIENTA**



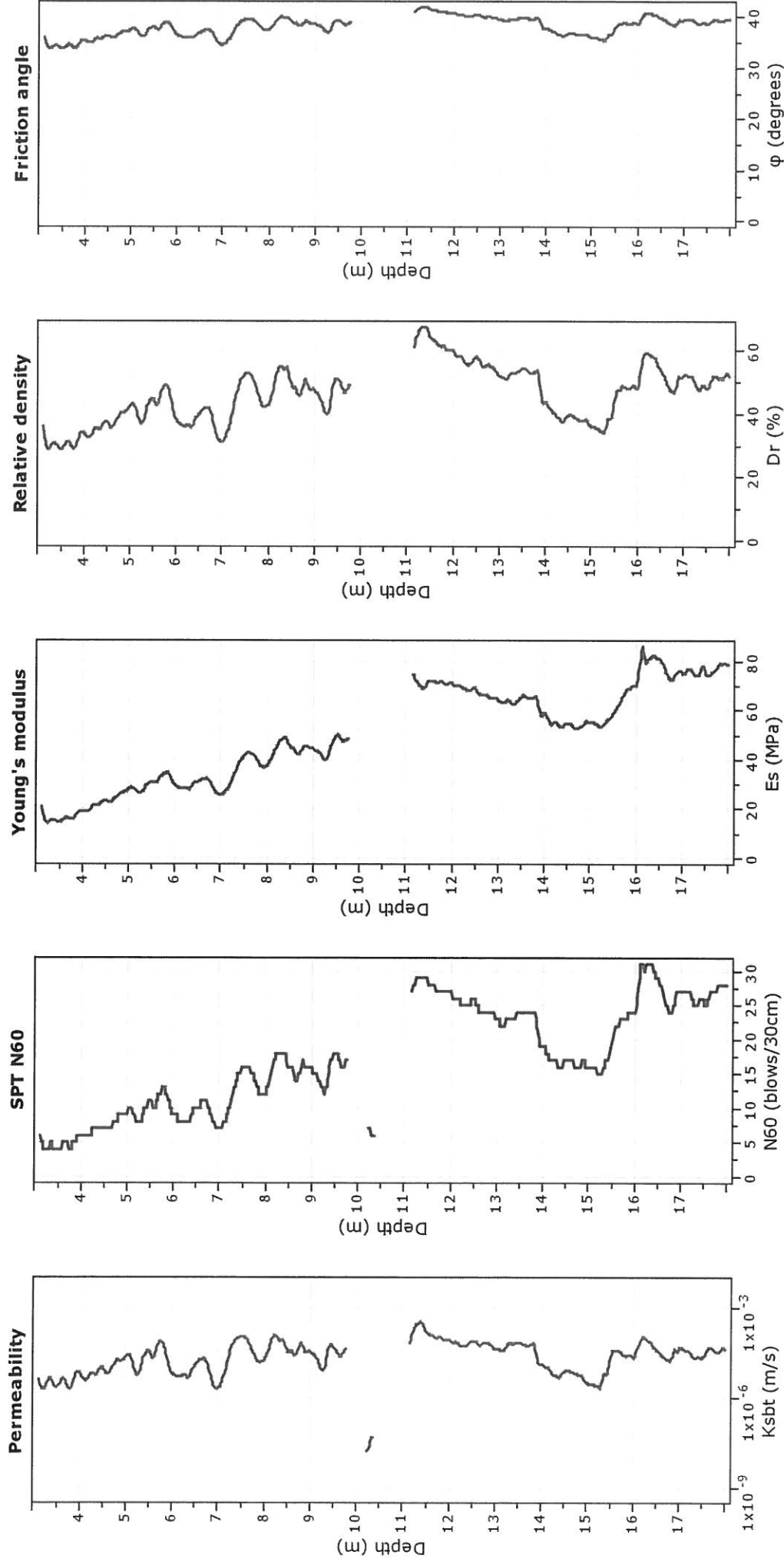
The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**



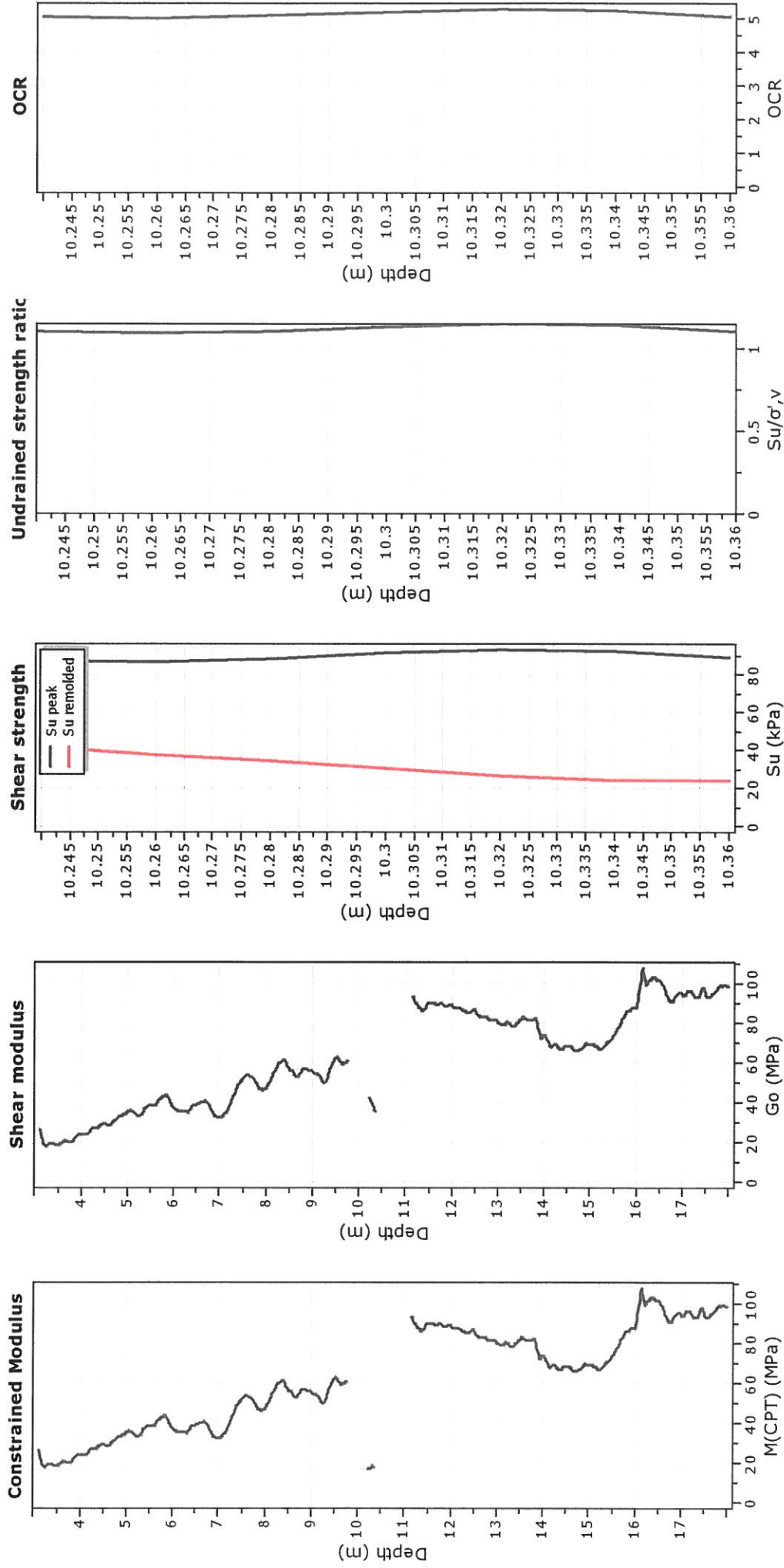
Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



#### Calculation parameters

Permeability: Based on SBT<sub>n</sub>  
SPT N<sub>60</sub>: Based on I<sub>c</sub> and q<sub>c</sub>  
Young's modulus: Based on variable alpha using I<sub>c</sub> (Robertson, 2009) —●— User defined estimation data  
Relative density constant, C<sub>Dr</sub>: 350.0  
Phi: Based on Kulhawy & Mayne (1990)

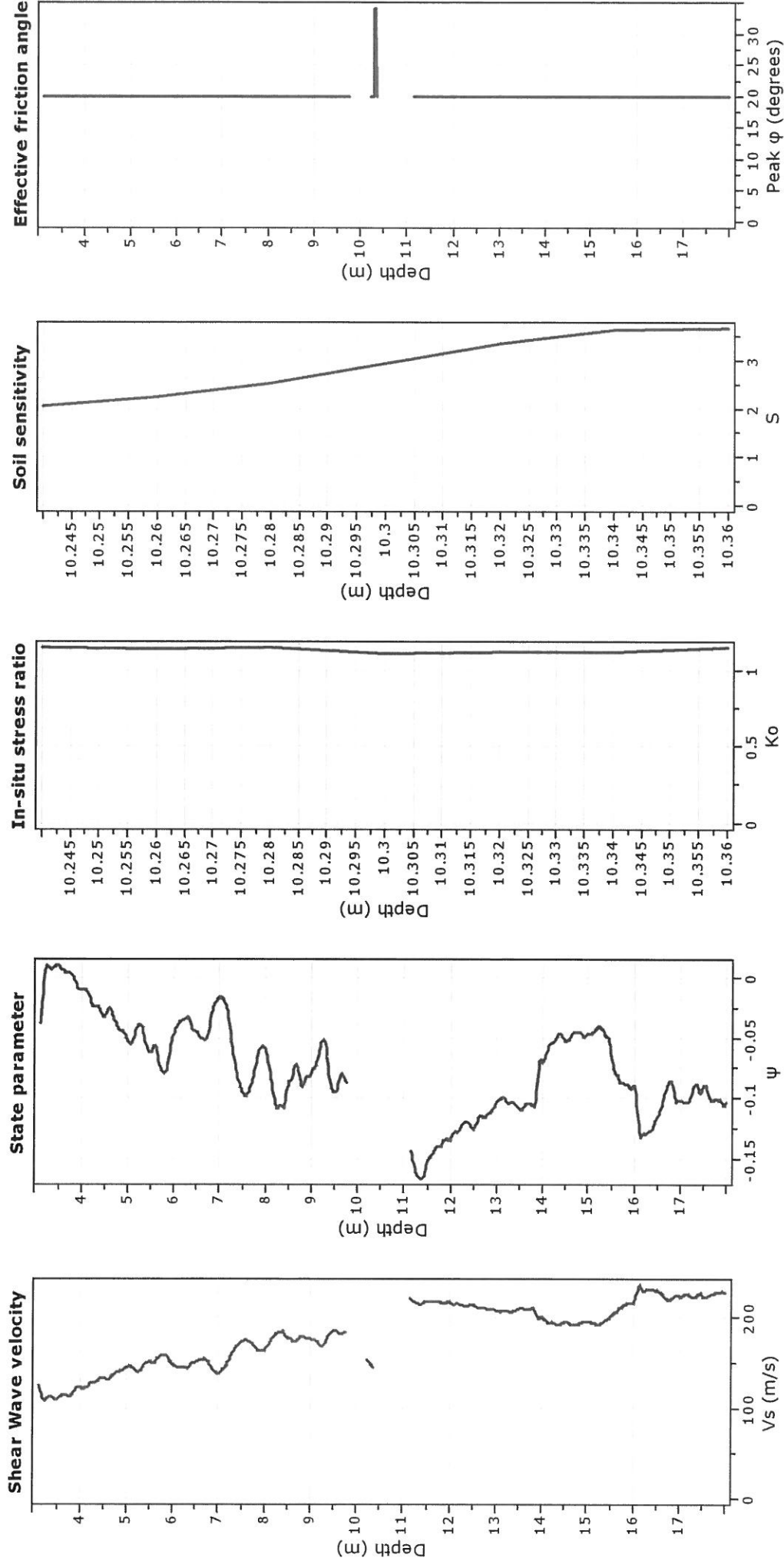
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**



#### Calculation parameters

Constrained modulus: Based on variable  $\alpha$  using  $I_c$  and  $Q_n$  (Robertson, 2009) OCR factor for clays,  $N_{kt}$ : 0.33  
Go: Based on variable  $\alpha$  using  $I_c$  (Robertson, 2009)  
Undrained shear strength cone factor for clays,  $N_{kt}$ : 14

Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



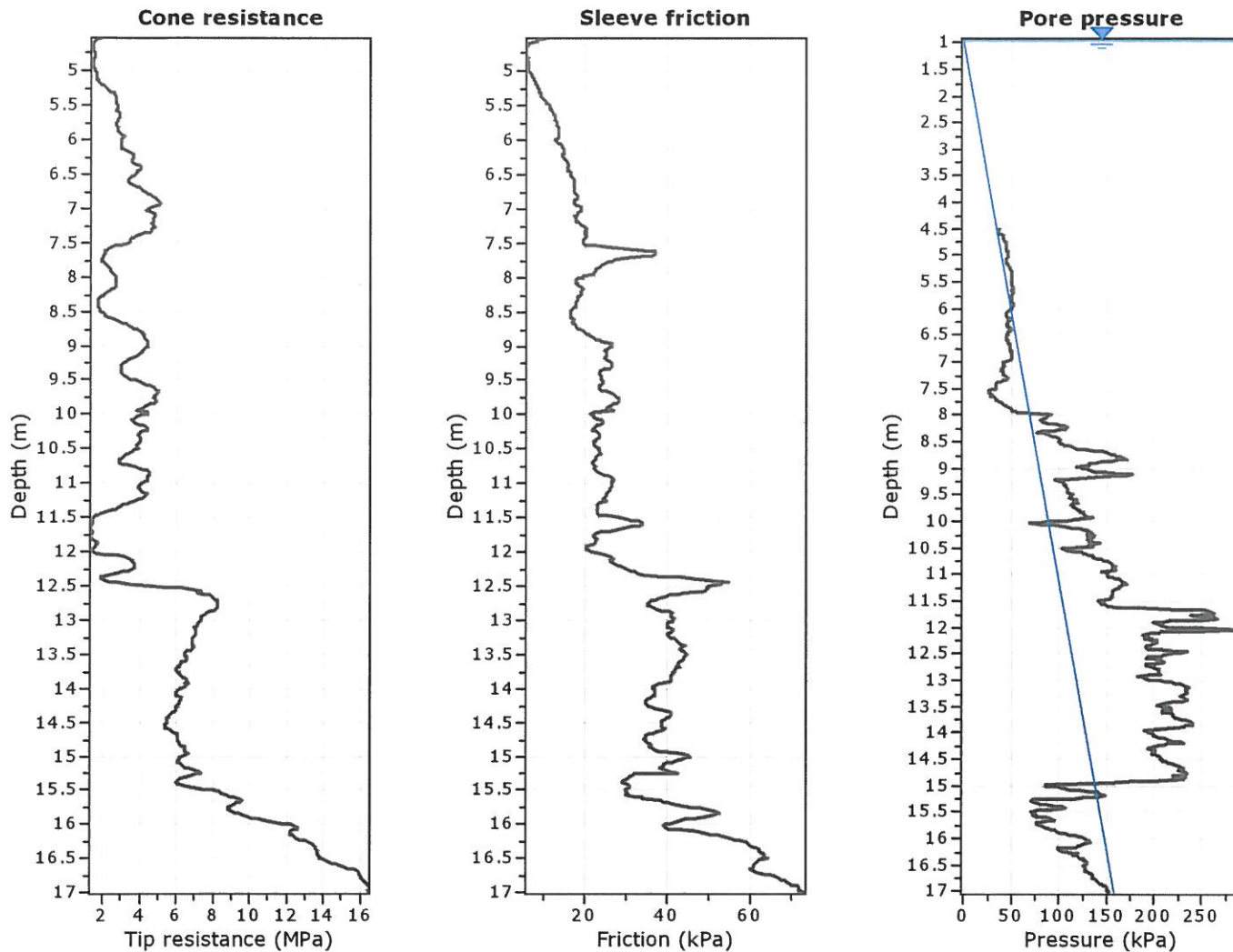
#### Calculation parameters

Soil Sensitivity factor,  $N_s$ : 7.00

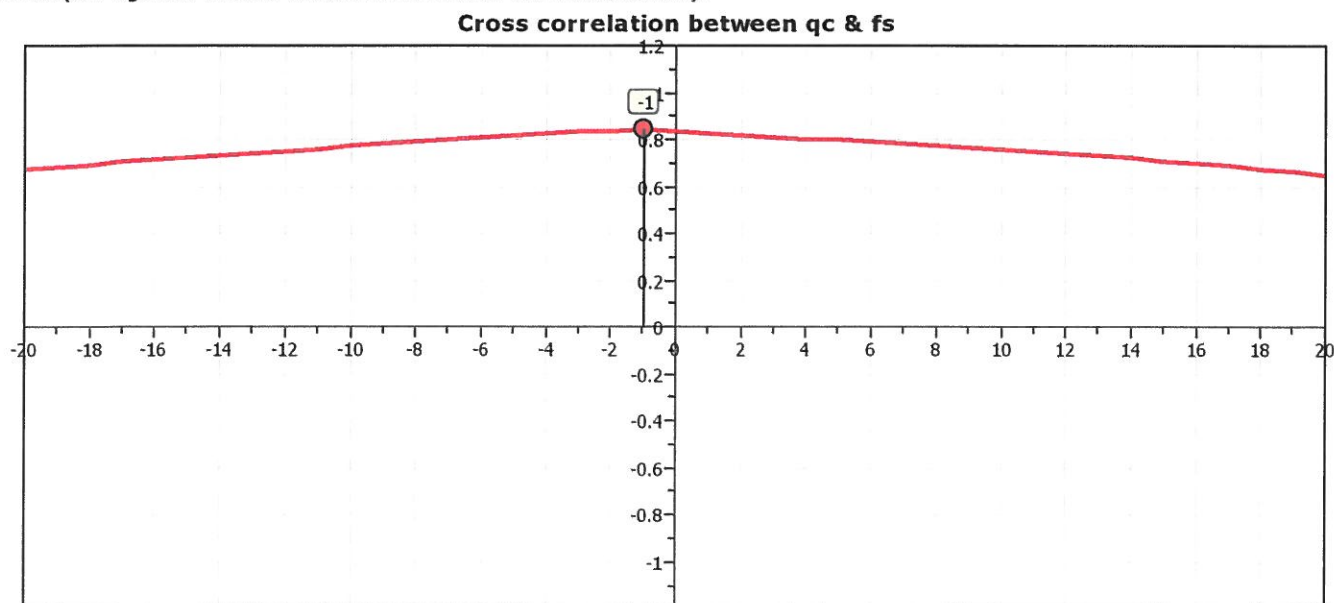
—●— User defined estimation data

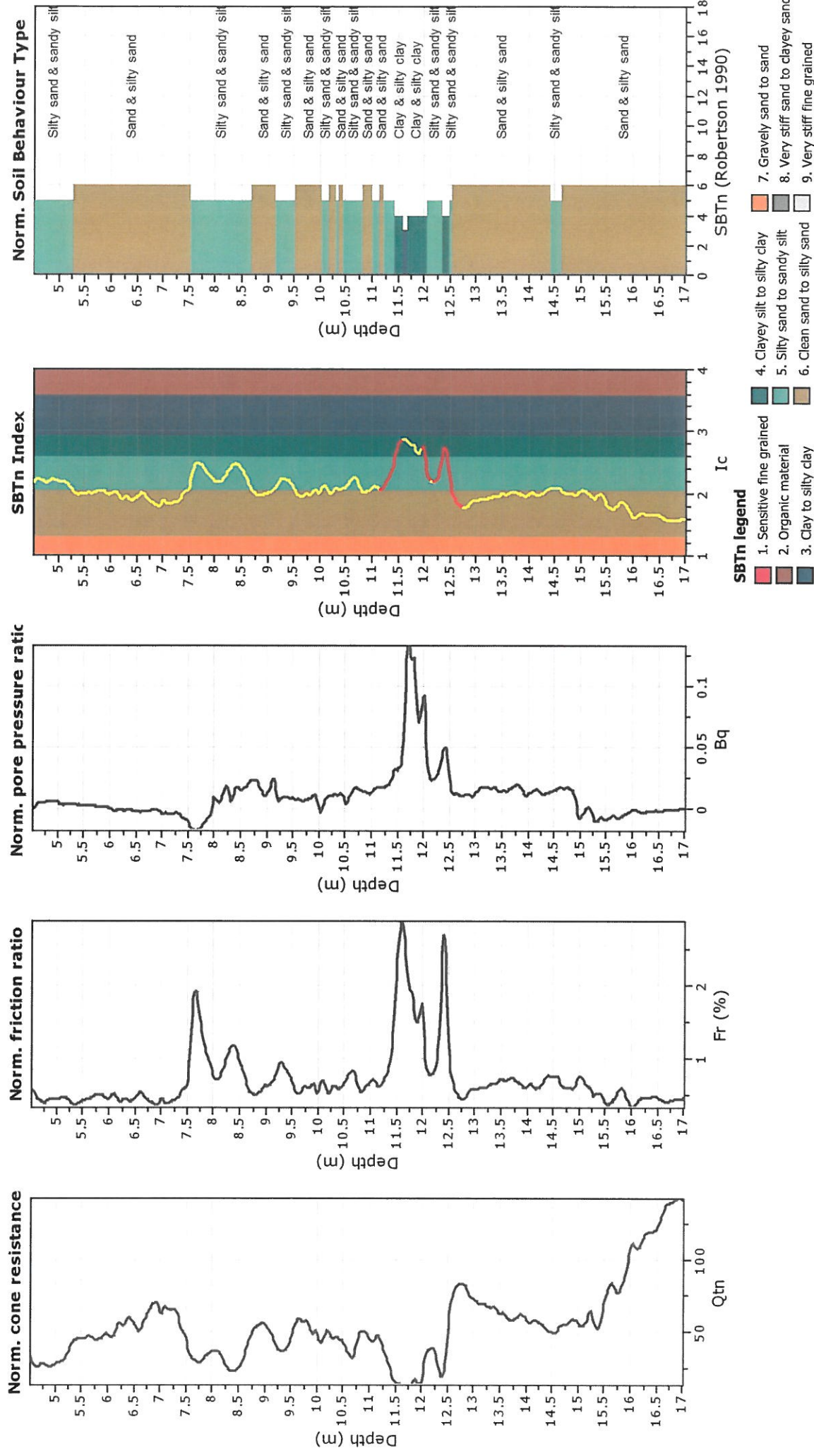
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

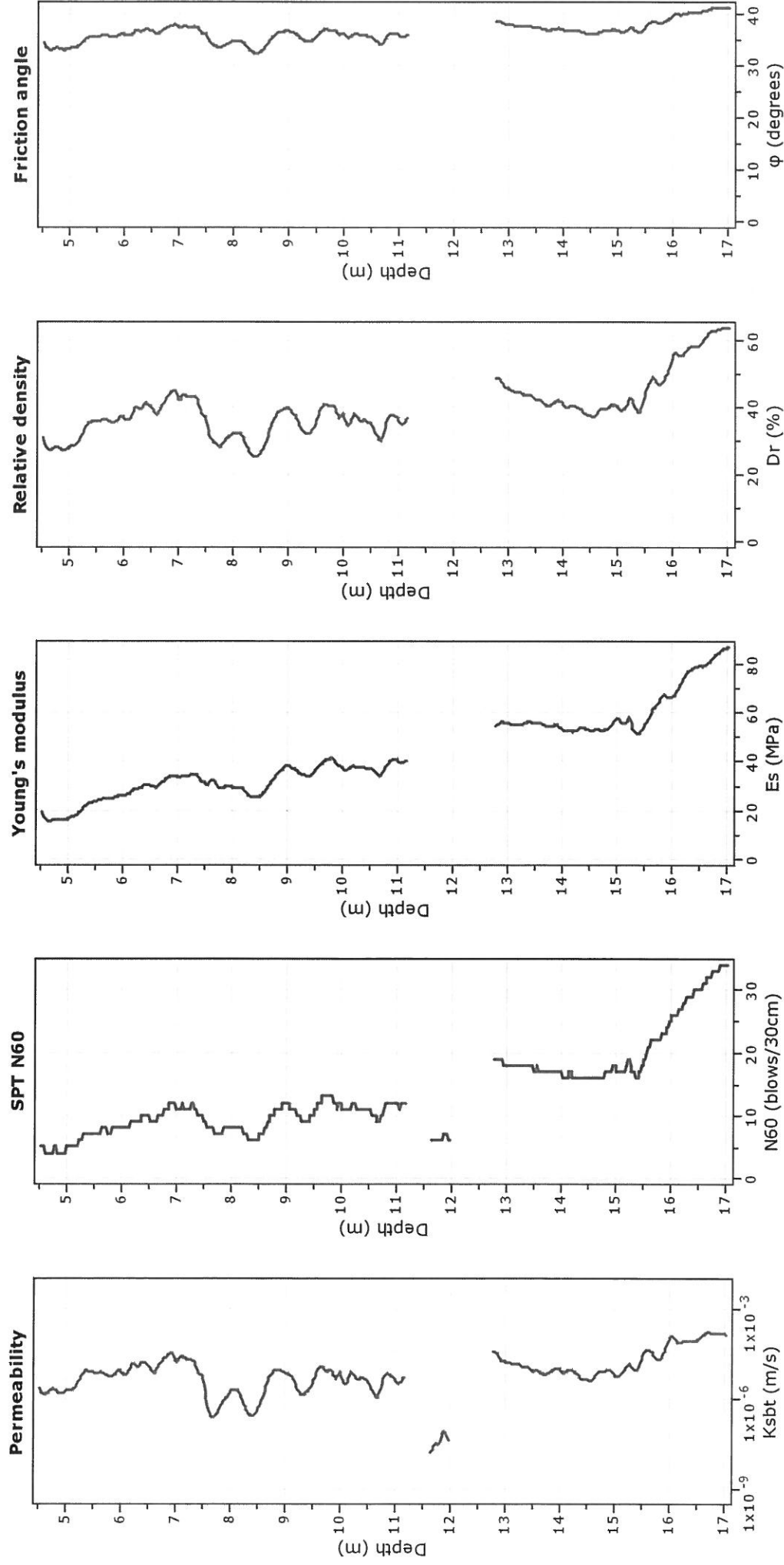
**Location: TRATTO CASTELMASSA - STIENTA**



The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



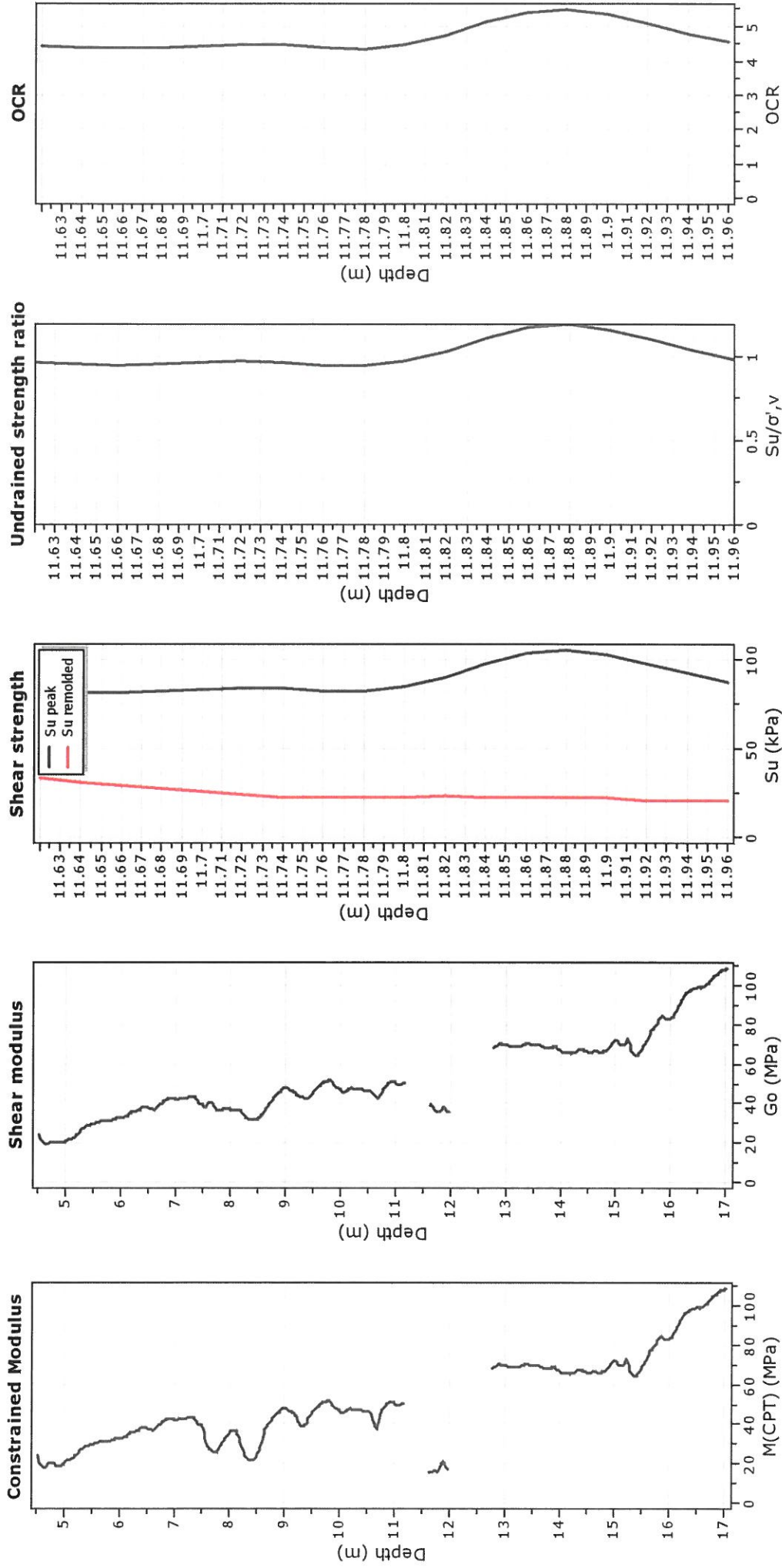




**Calculation parameters**

Permeability: Based on  $SBT_n$   
SPT  $N_{60}$ : Based on  $I_c$  and  $q_c$   
Young's modulus: Based on variable alpha using  $I_c$  (Robertson, 2009) —●— User defined estimation data  
Relative density constant,  $C_{Dr}$ : 350.0  
Phi: Based on Kulhawy & Mayne (1990)

**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**



#### Calculation parameters

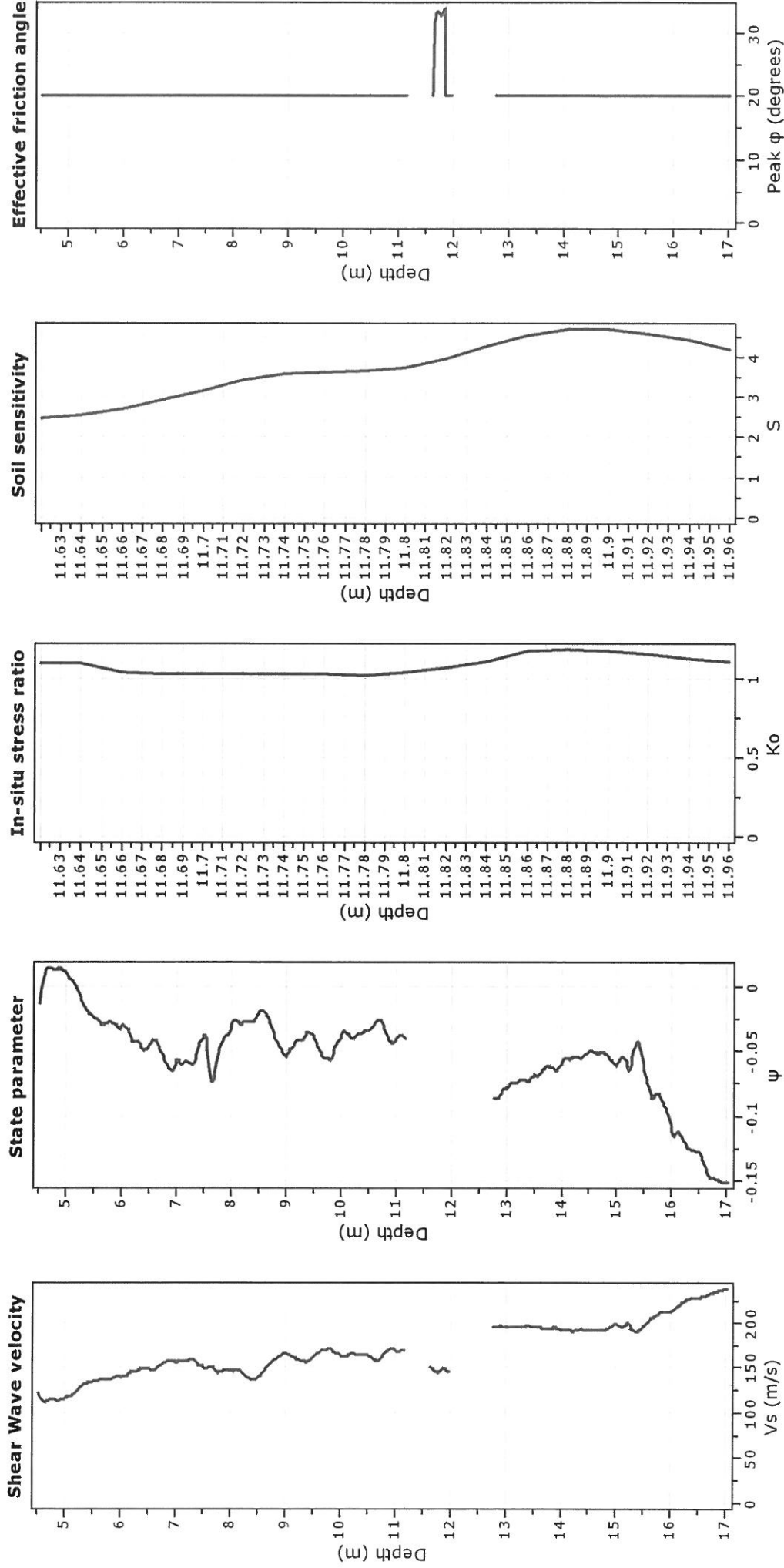
Constrained modulus: Based on variable  $\alpha/\rho$  using  $I_c$  and  $Q_m$  (Robertson, 2009)

Go: Based on variable  $\alpha/\rho$  using  $I_c$  (Robertson, 2009)

Undrained shear strength cone factor for clays,  $N_{kt}$ : 14

OCR factor for clays,  $N_{kt}$ : 0.33

—●— User defined estimation data



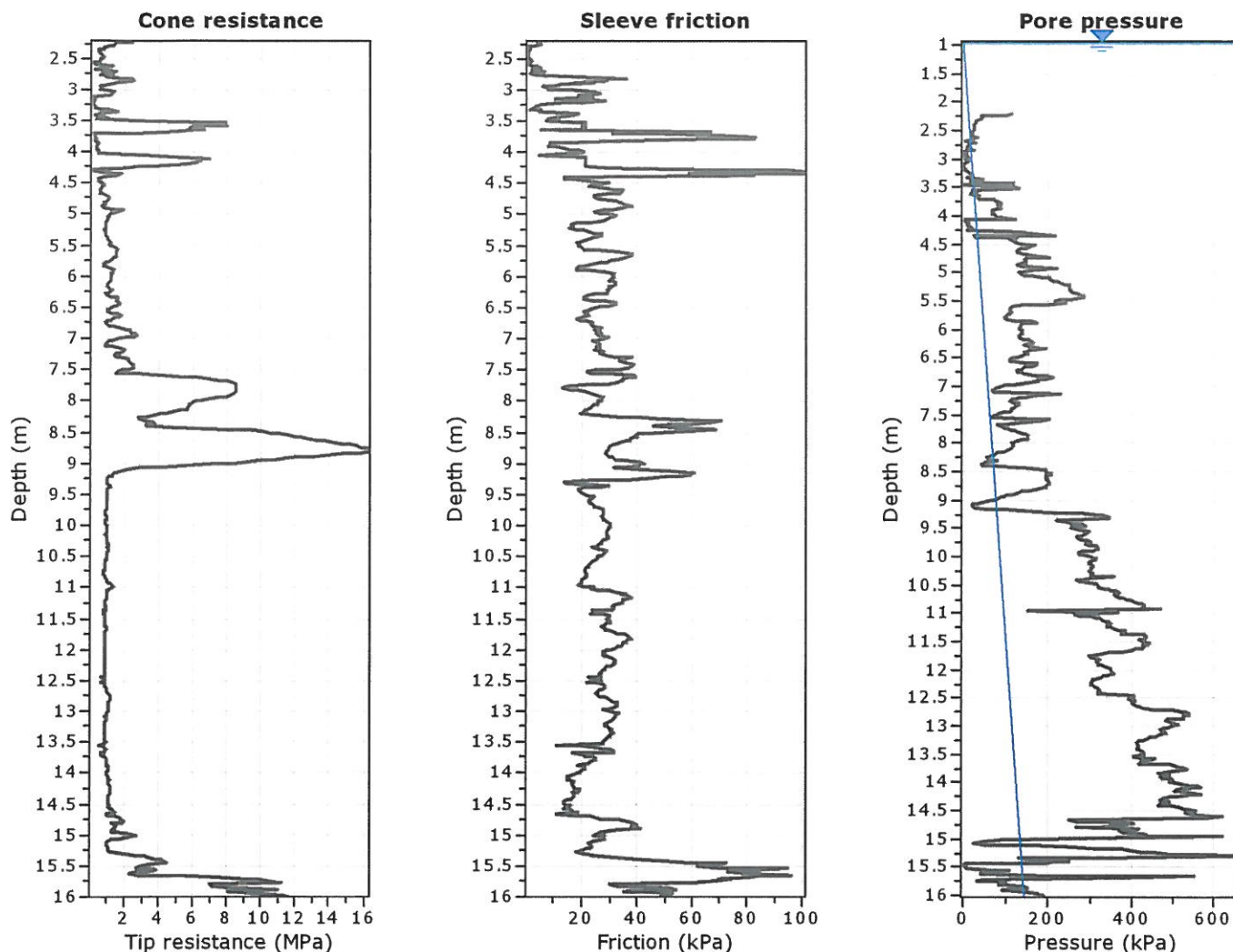
**Calculation parameters**

Soil Sensitivity factor,  $N_s$ : 7.00

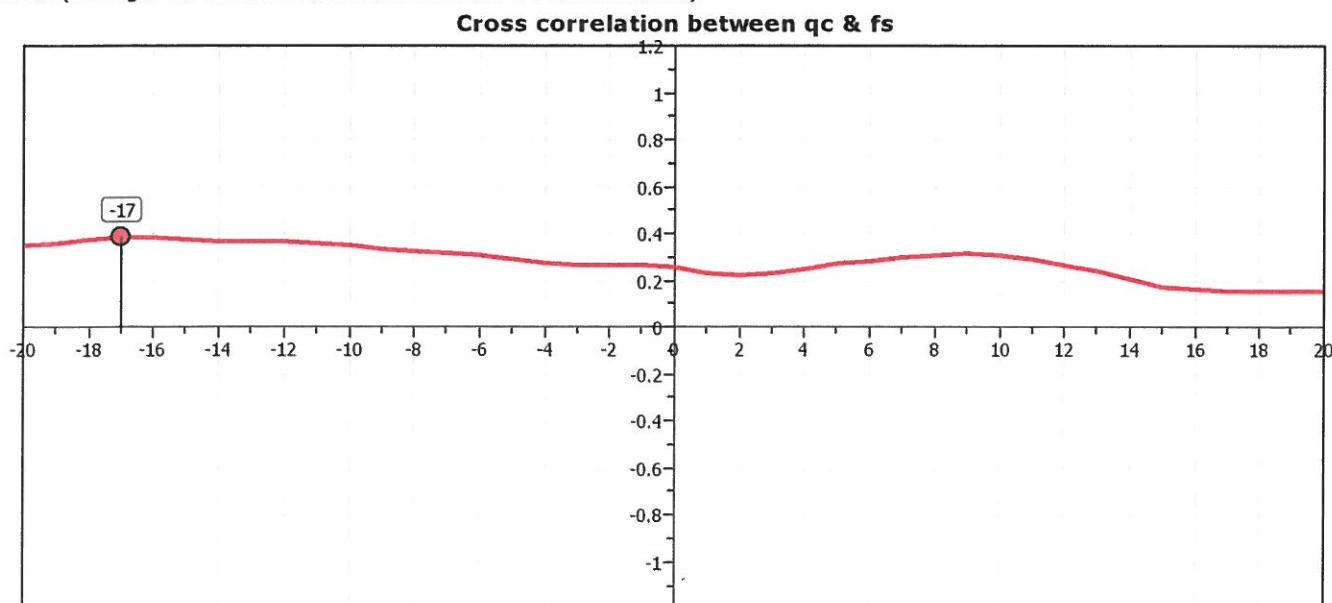
—●— User defined estimation data

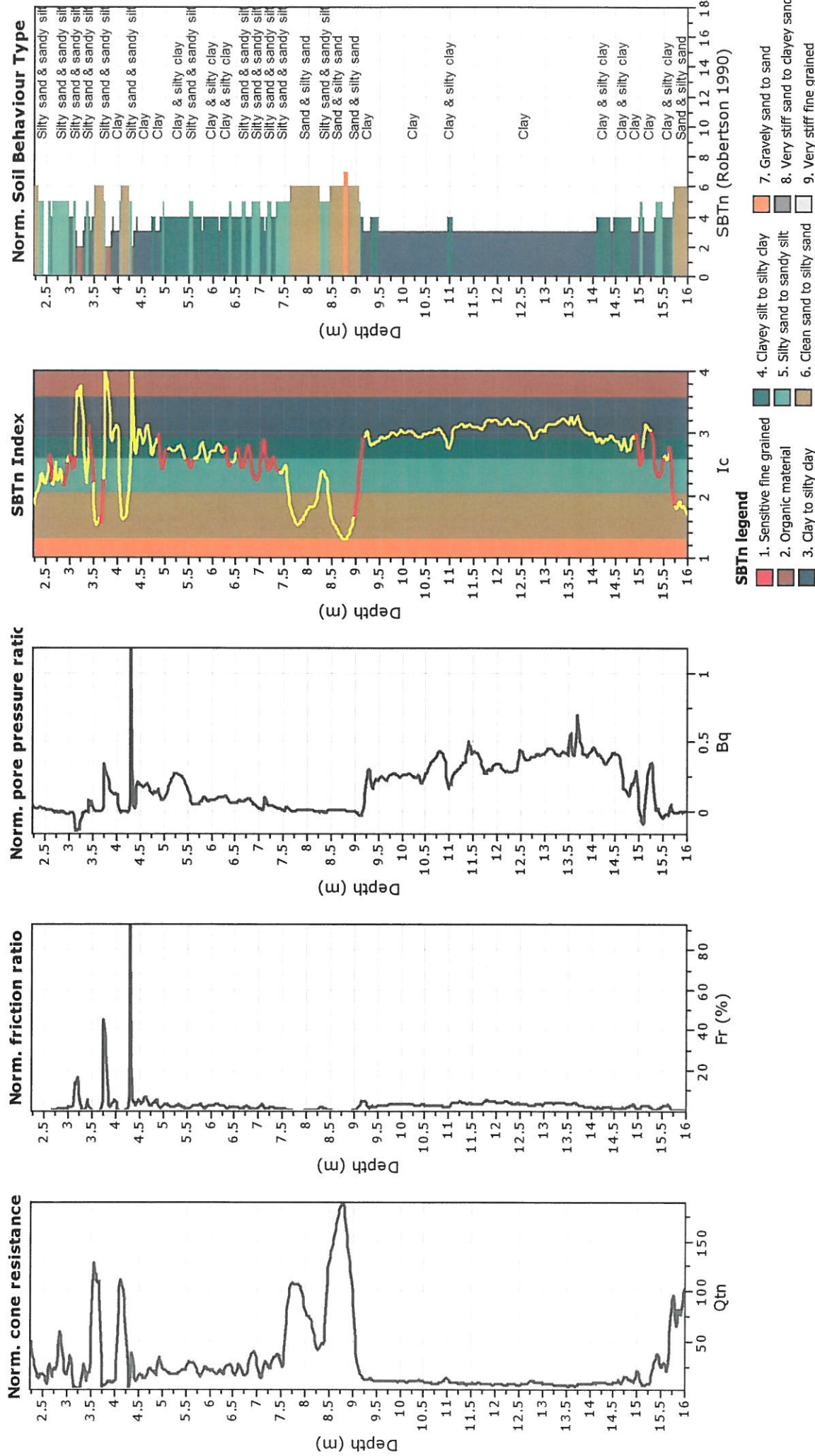
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

**Location: TRATTO CASTELMASSA - STIENTA**

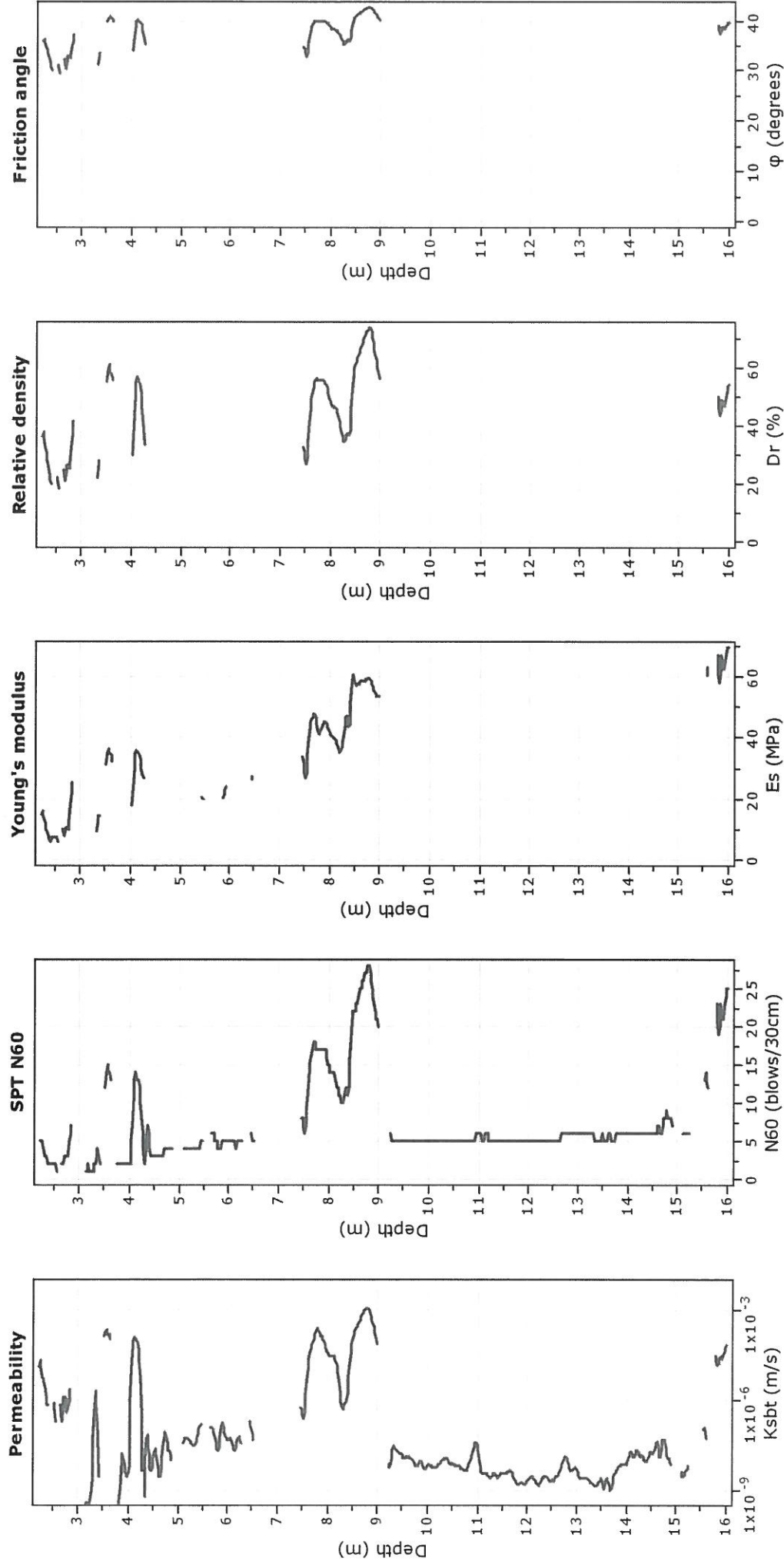


The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



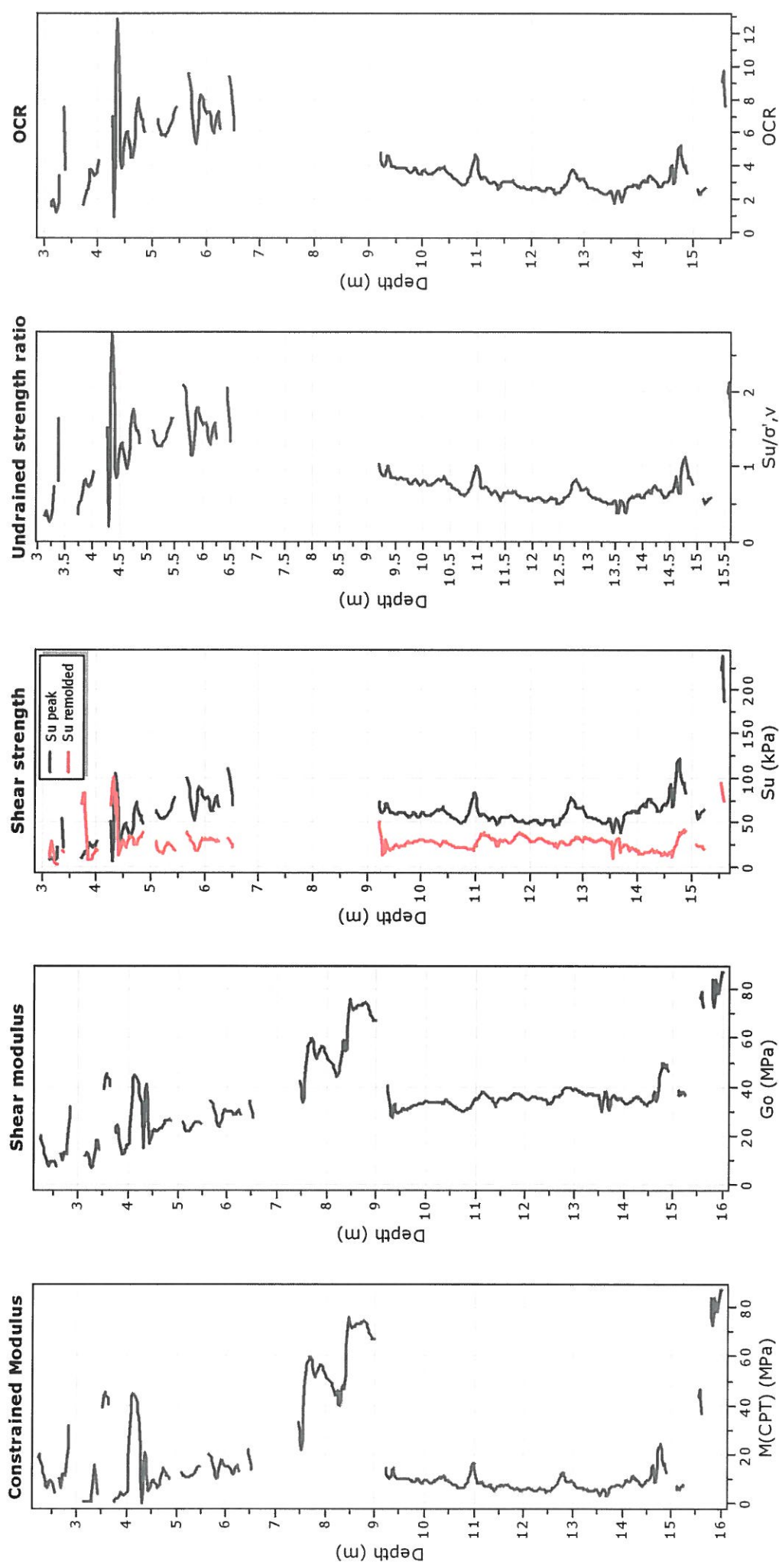


Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



#### Calculation parameters

Permeability: Based on  $SBT_n$   
SPT  $N_{60}$ : Based on  $I_c$  and  $q_t$   
Young's modulus: Based on variable  $\alpha$  using  $I_c$  (Robertson, 2009) —●— User defined estimation data  
Relative density constant,  $C_{Dr}$ : 350.0  
Phi: Based on Kulhawy & Mayne (1990)



## Calculation parameters

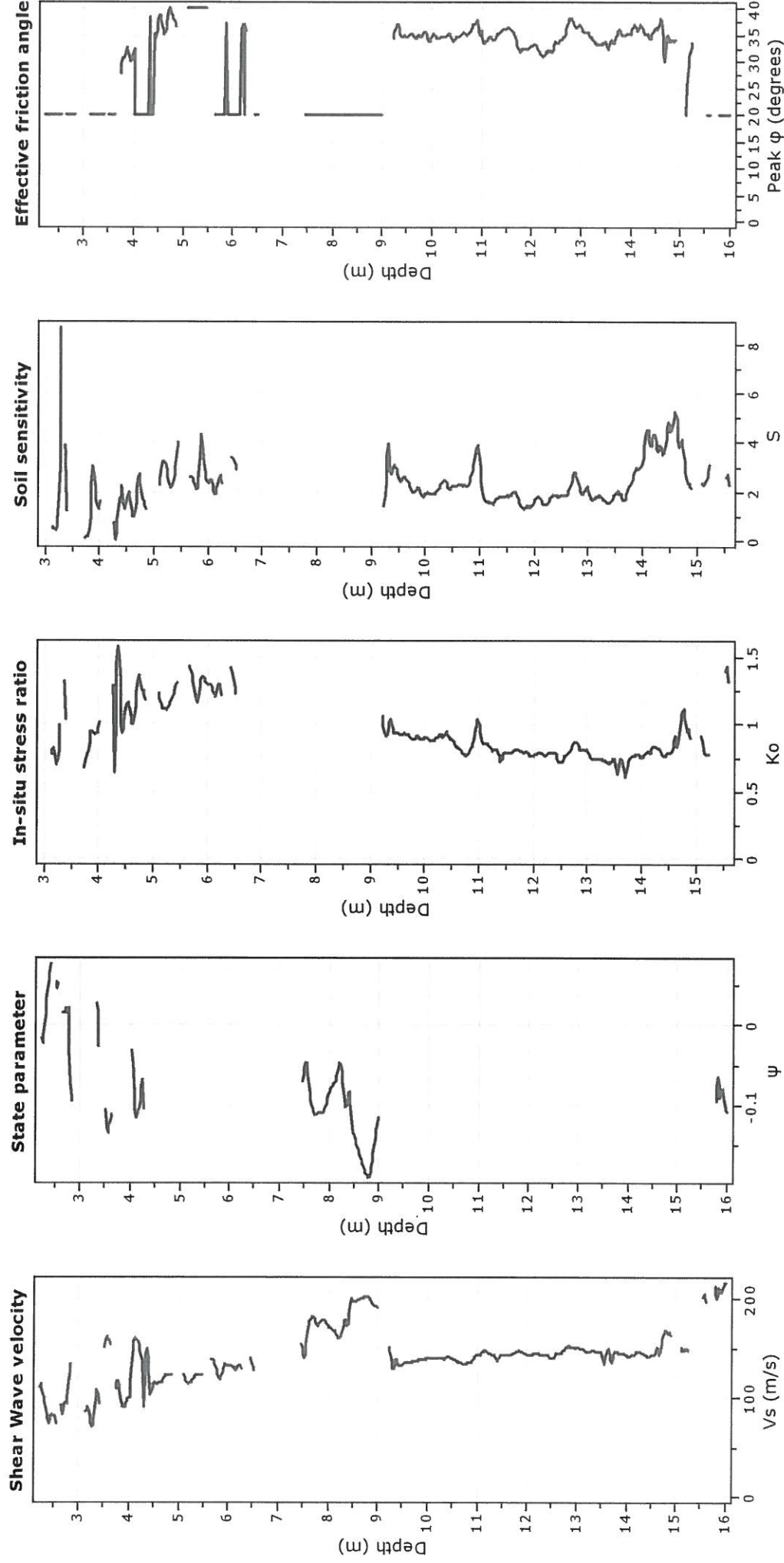
Constrained modulus: Based on variable  $\alpha/p$  using  $I_c$  and  $Q_m$  (Robertson, 2009)

Go: Based on variable  $\alpha/p$  using  $I_c$  (Robertson, 2009)

Undrained shear strength cone factor for clays,  $N_{kt}$ : 14

OCR factor for clays,  $N_{kt}$ : 0.33

—●— User defined estimation data



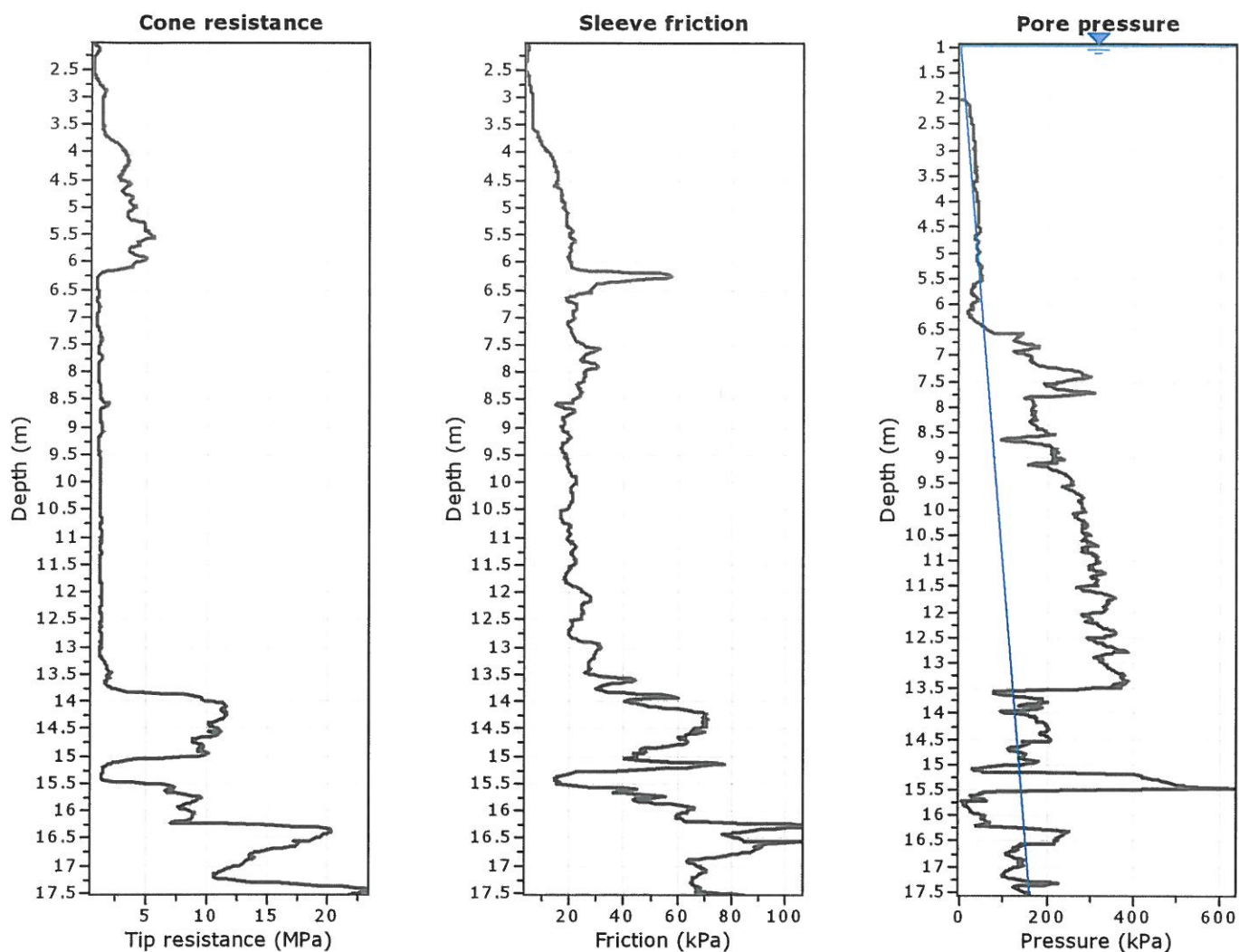
#### Calculation parameters

Soil Sensitivity factor,  $N_s$ : 7.00

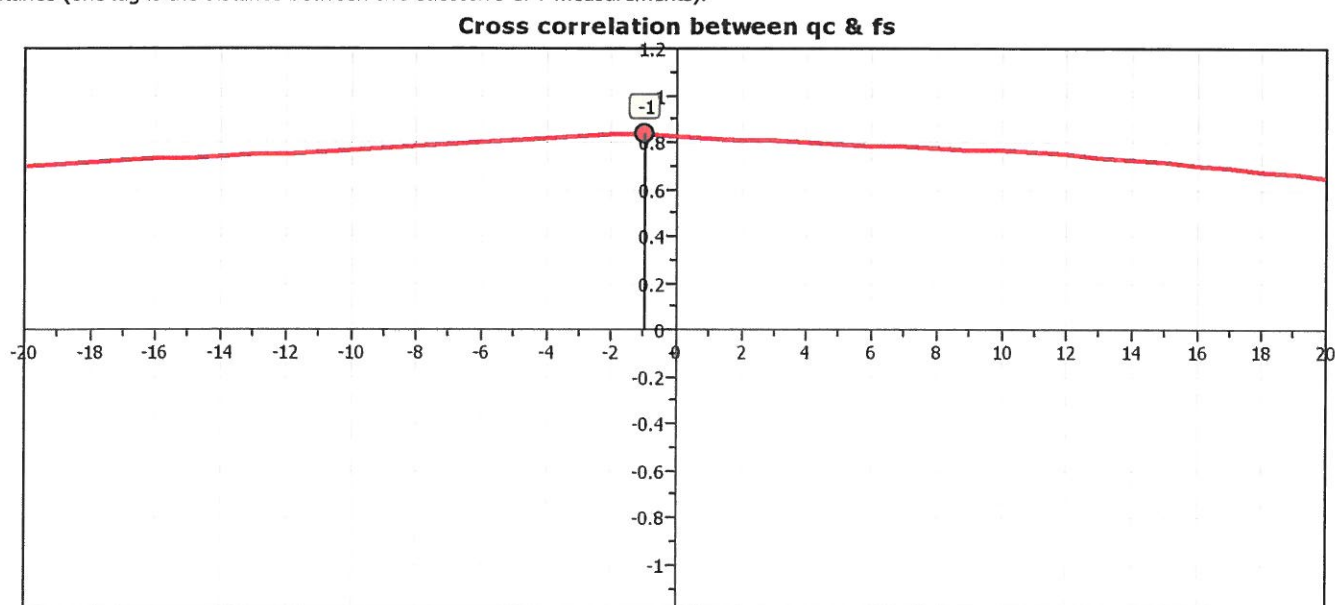
—●— User defined estimation data

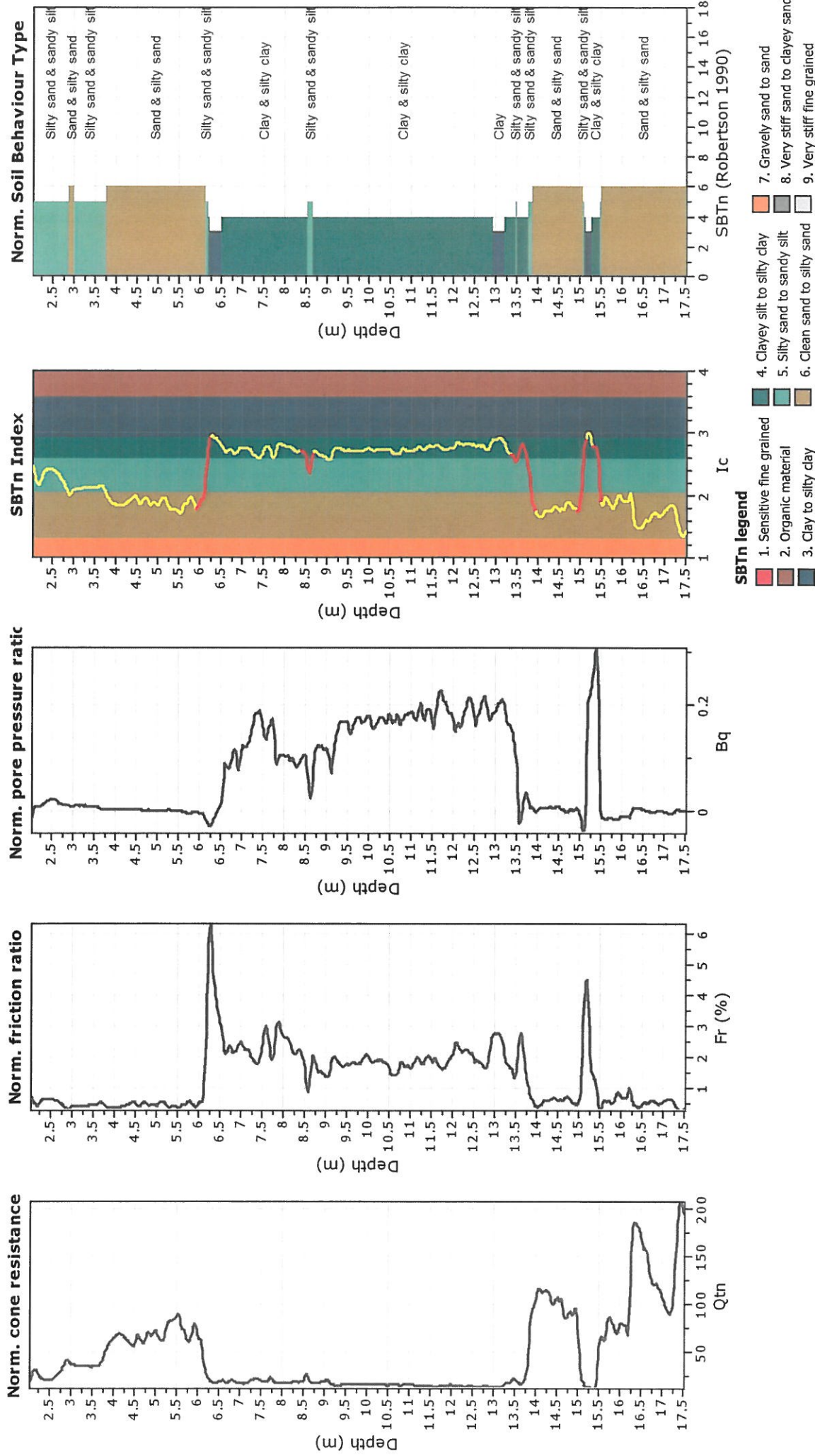
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**

**Location: TRATTO CASTELMASSA - STIENTA**



The plot below presents the cross correlation coefficient between the raw qc and fs values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



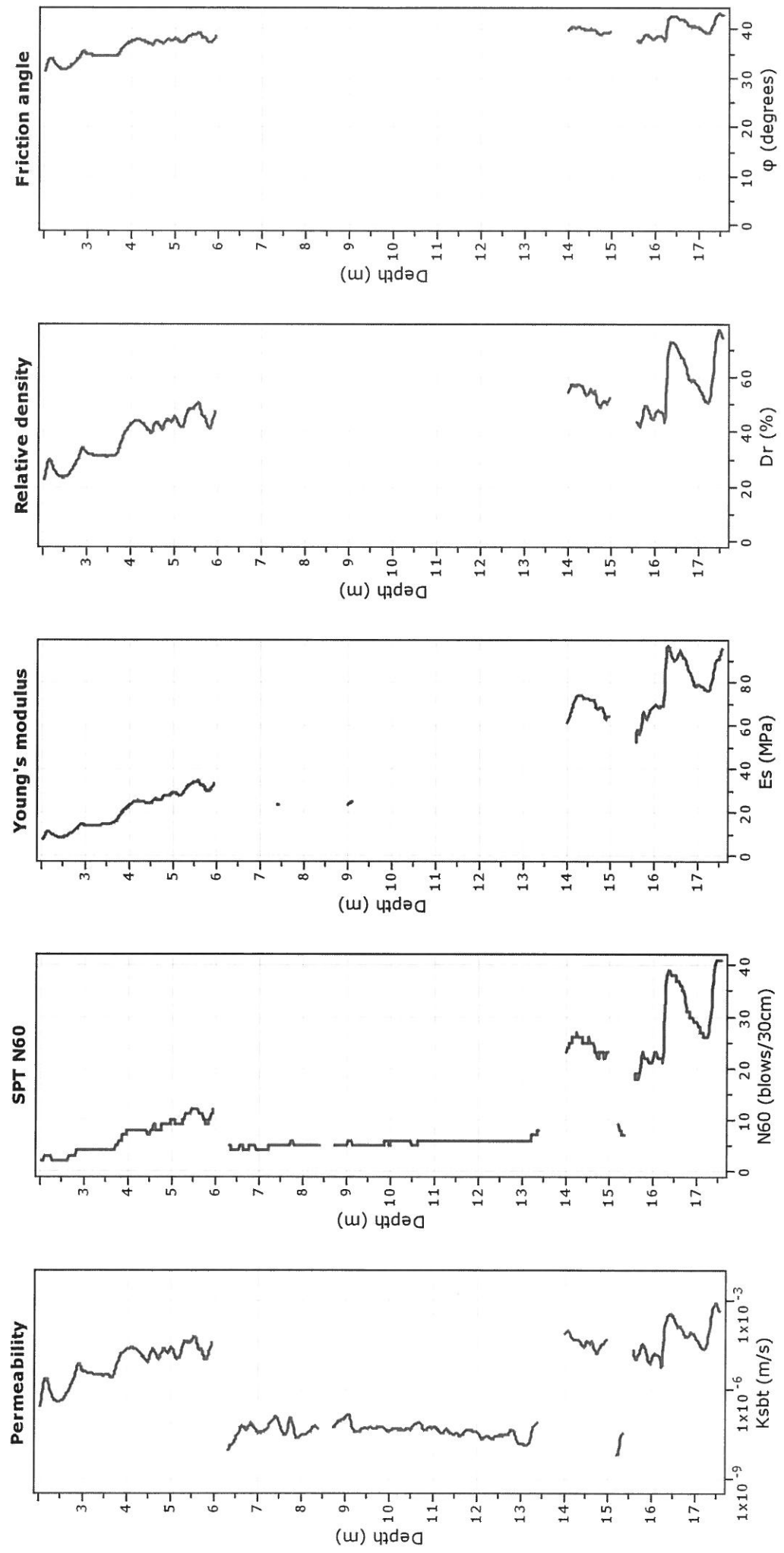




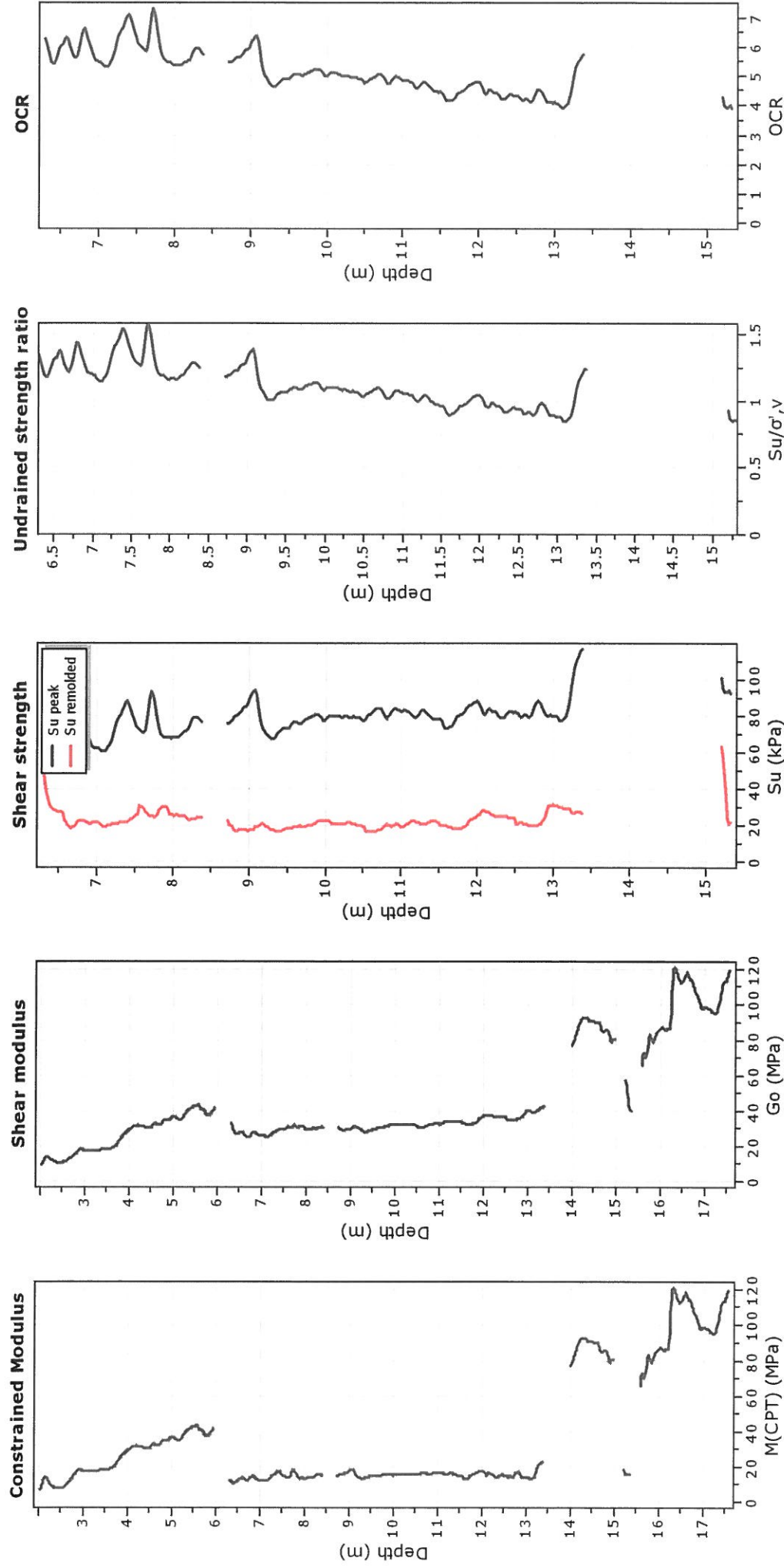
Studio Geologi Associati  
Via Emilia all'Angelo 14  
42124 Reggio Emilia

Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA

CPT: CPTU\_15B  
Total depth: 17.54 m, Date: 01/02/2019  
Coords: lat 44.919008° lon 11.558552°  
Cone Type: TECNOPENTA G1-CPL2IN  
Cone Operator: L. ZANIRATO



**Calculation parameters**  
Permeability: Based on SBT<sub>n</sub>  
SPT N<sub>60</sub>: Based on I<sub>c</sub> and q<sub>t</sub>  
Young's modulus: Based on variable alpha using I<sub>c</sub> (Robertson, 2009) —●— User defined estimation data  
Relative density constant, C<sub>Dr</sub>: 350.0  
Phi: Based on Kulhawy & Mayne (1990)



## Calculation parameters

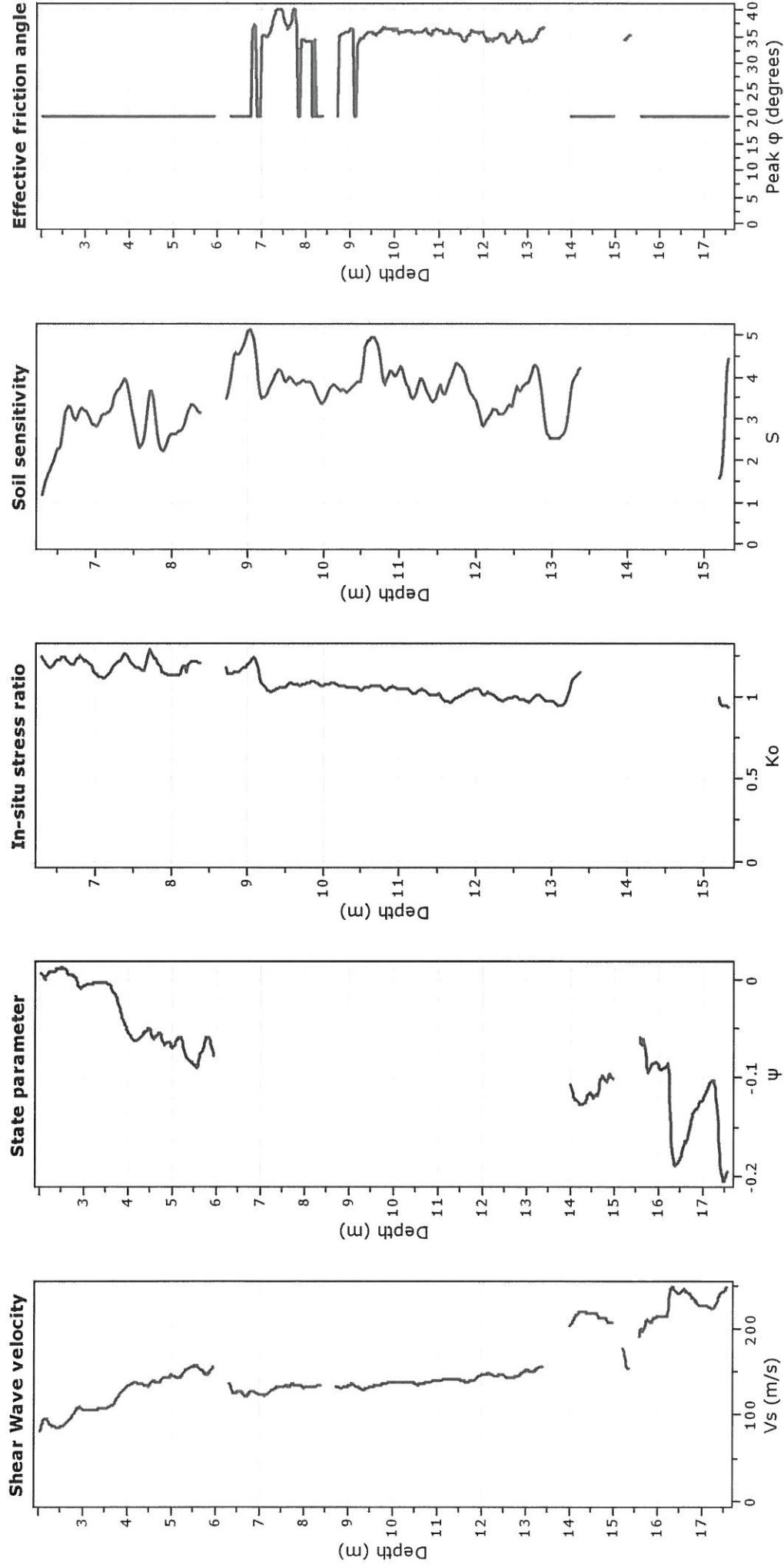
Constrained modulus: Based on variable  $\alpha/\rho/\eta$  using  $I_c$  and  $Q_m$  (Robertson, 2009)  
Go: Based on variable  $\alpha/\rho/\eta$  using  $I_c$  (Robertson, 2009)

Undrained shear strength cone factor for clays,  $N_{k\kappa}$ : 14

OCR factor for clays,  $N_{k\kappa}$ : 0.33

—●— User defined estimation data

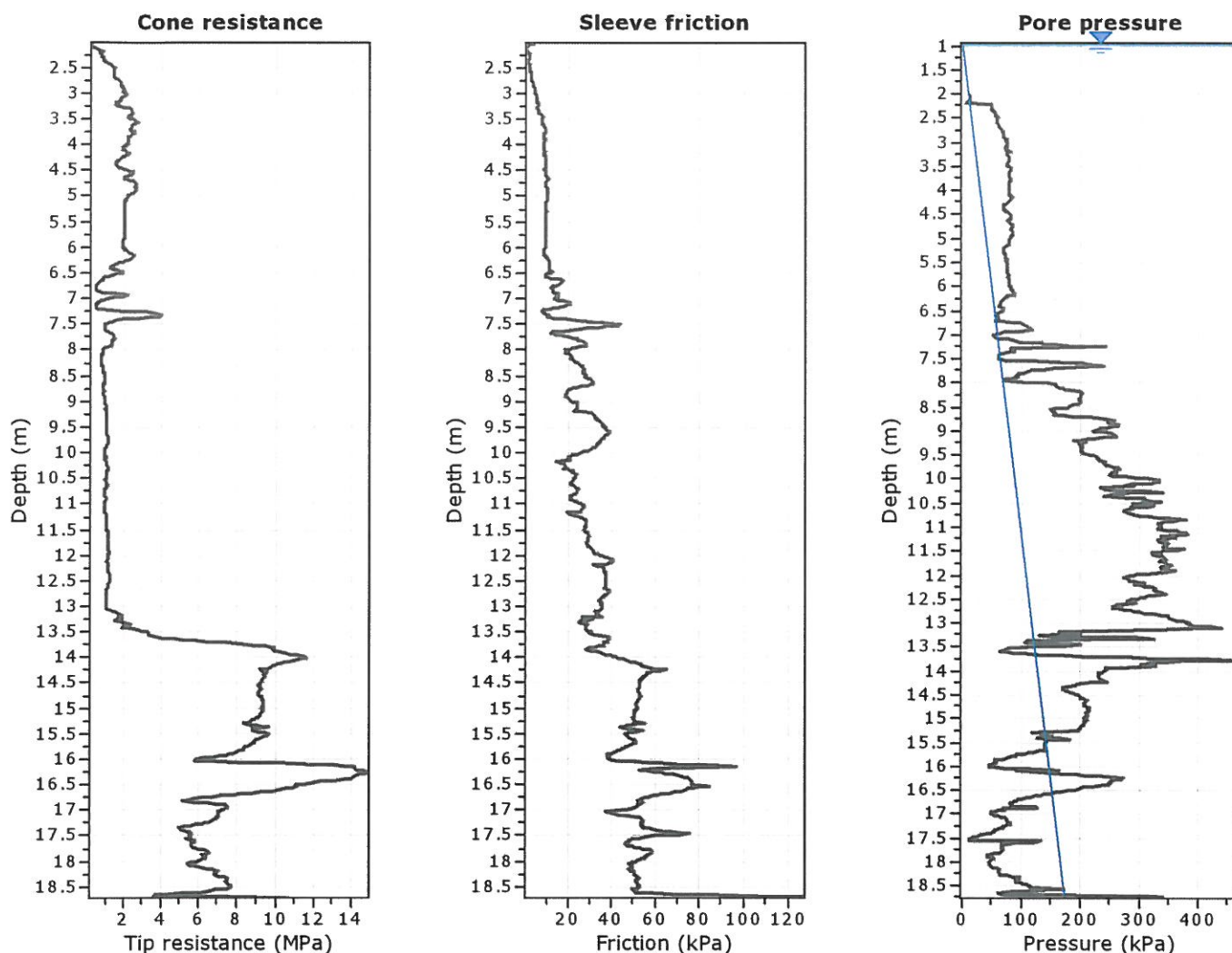
**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**



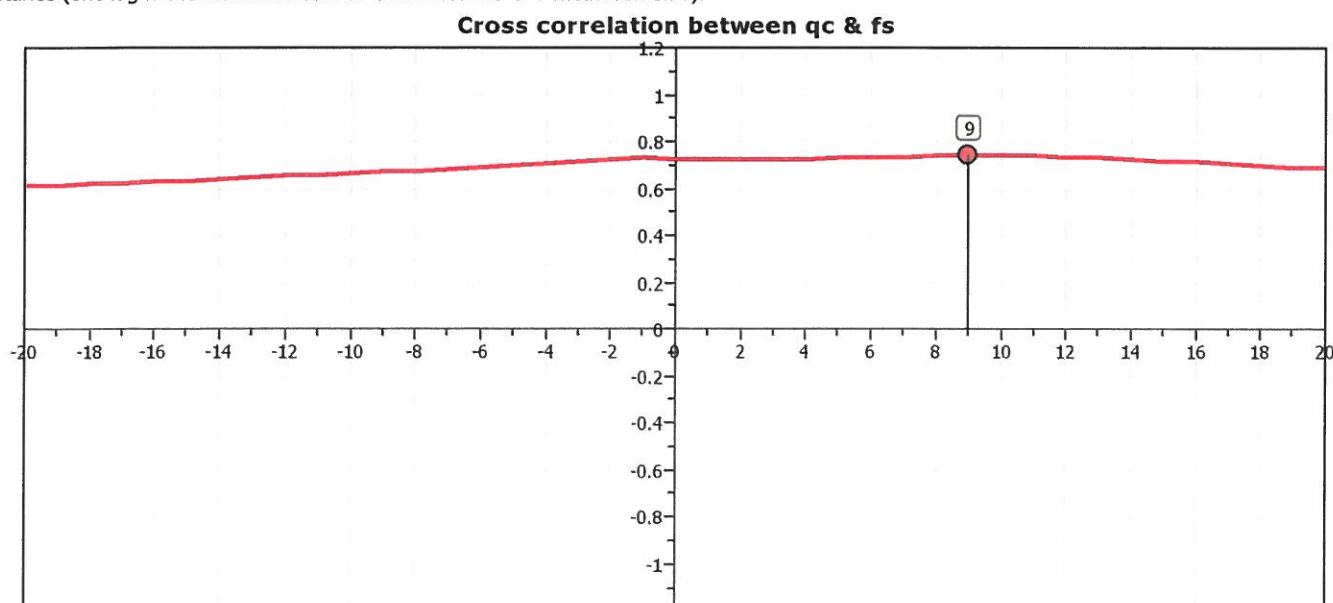
#### Calculation parameters

Soil Sensitivity factor,  $N_s$ : 7.00

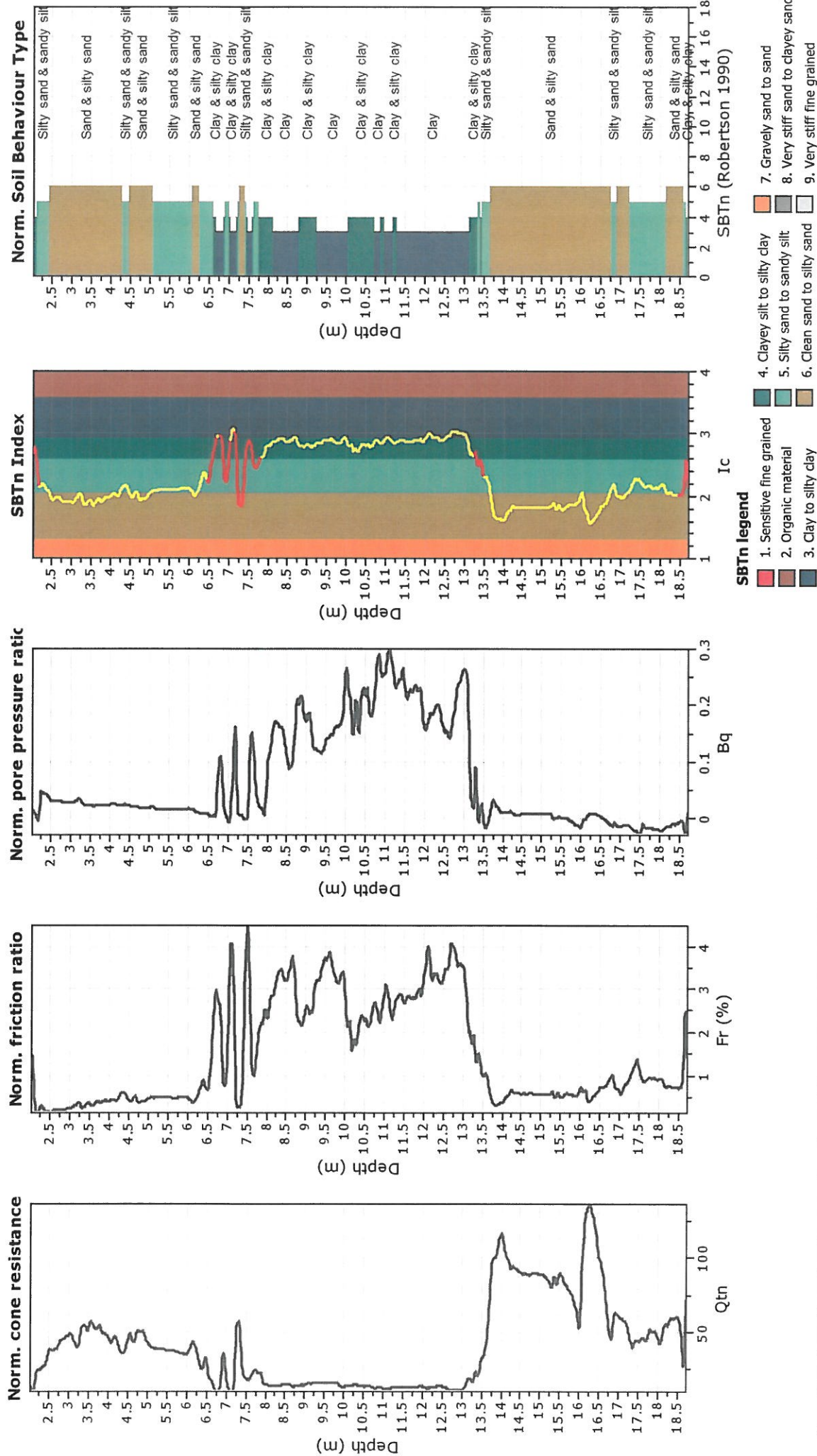
—●— User defined estimation data

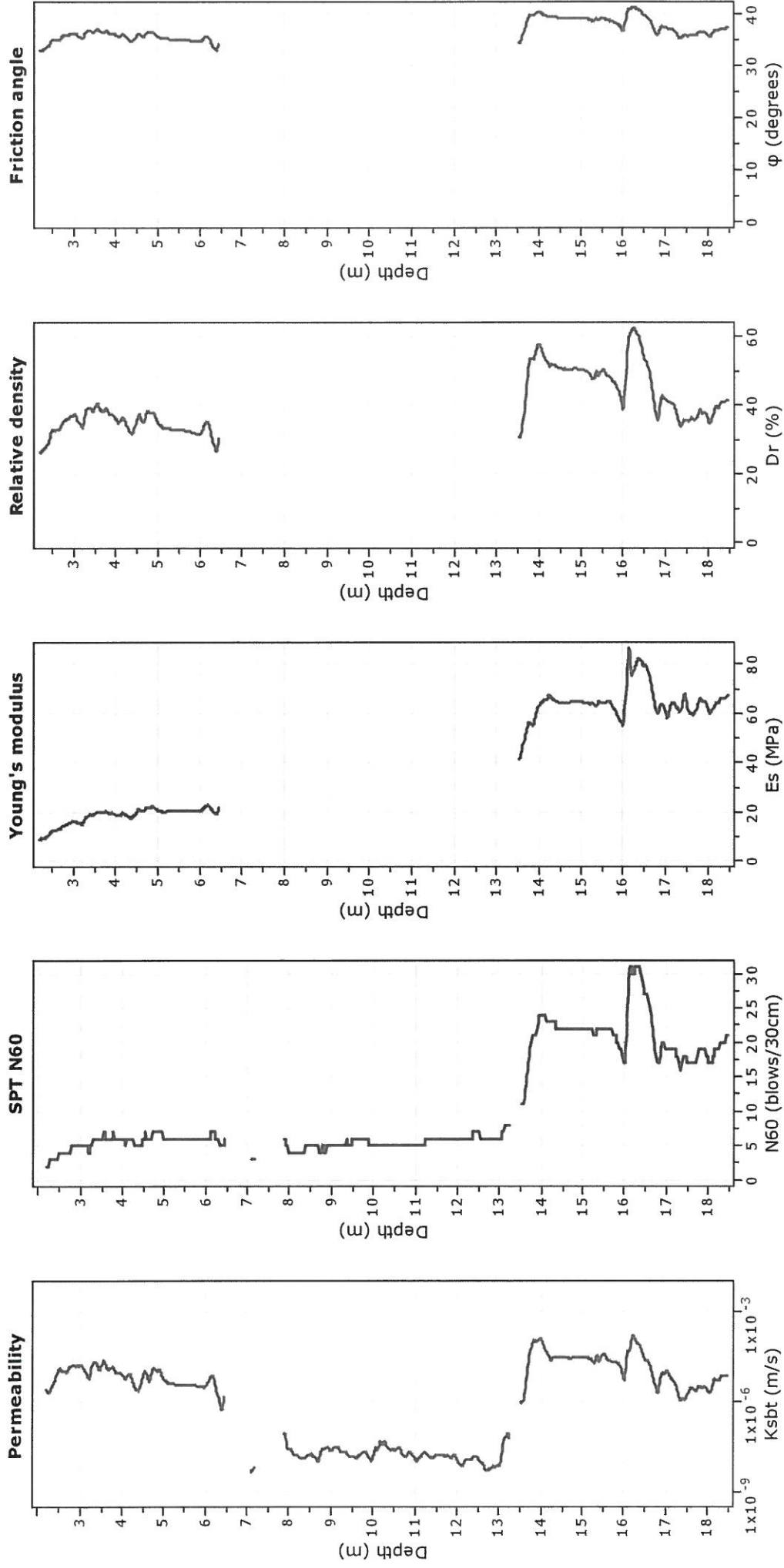


The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA

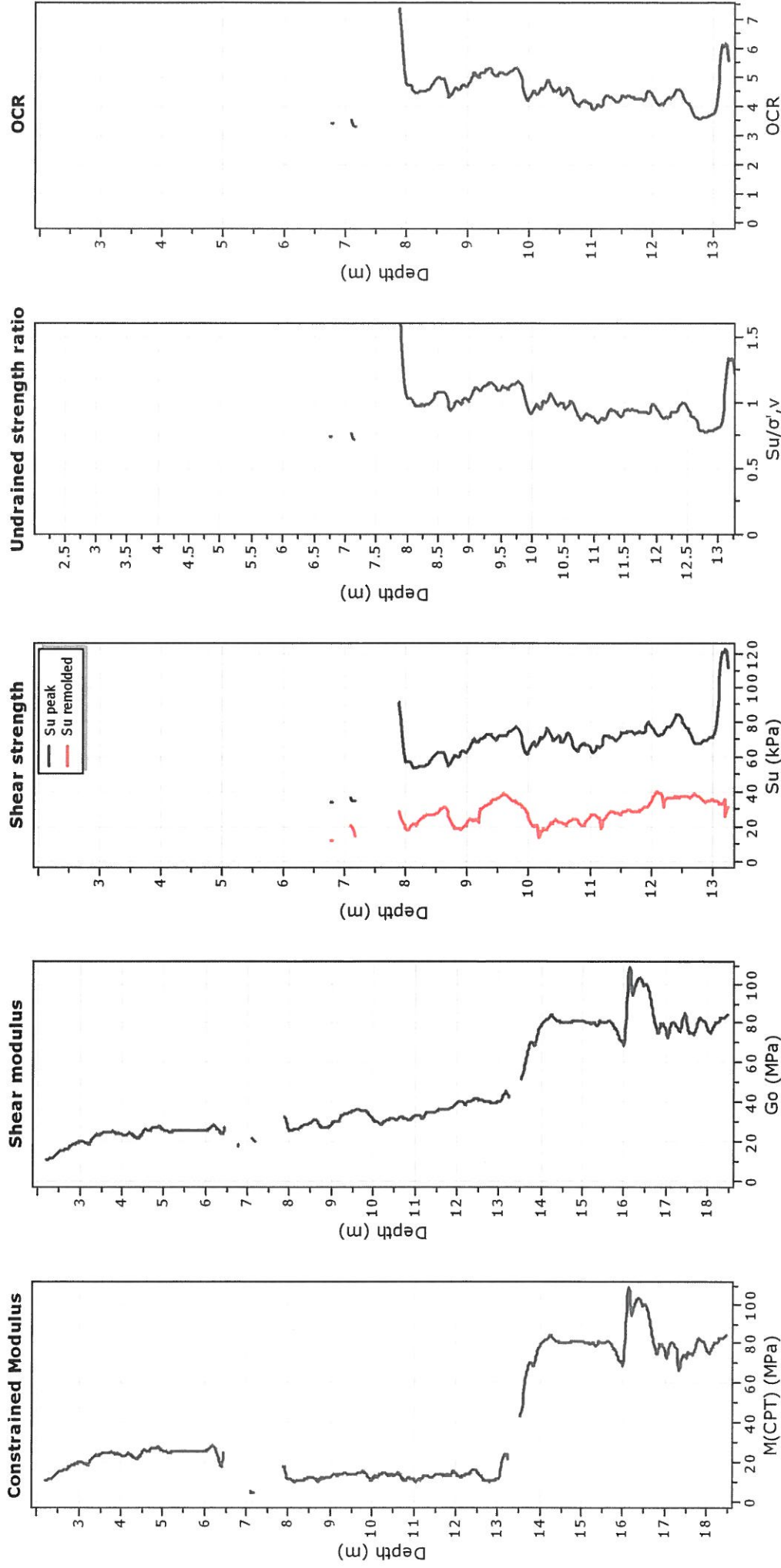




**Calculation parameters**

Permeability: Based on SBT<sub>n</sub>  
SPT N<sub>60</sub>: Based on I<sub>c</sub> and q<sub>t</sub>  
Young's modulus: Based on variable alpha using I<sub>c</sub> (Robertson, 2009) —●— User defined estimation data  
Relative density constant, C<sub>Dr</sub>: 350.0  
Phi: Based on Kulhawy & Mayne (1990)

Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE  
Location: TRATTO CASTELMASSA - STIENTA



#### Calculation parameters

Constrained modulus: Based on variable  $\alpha/\rho$  using  $I_c$  and  $Q_m$  (Robertson, 2009)

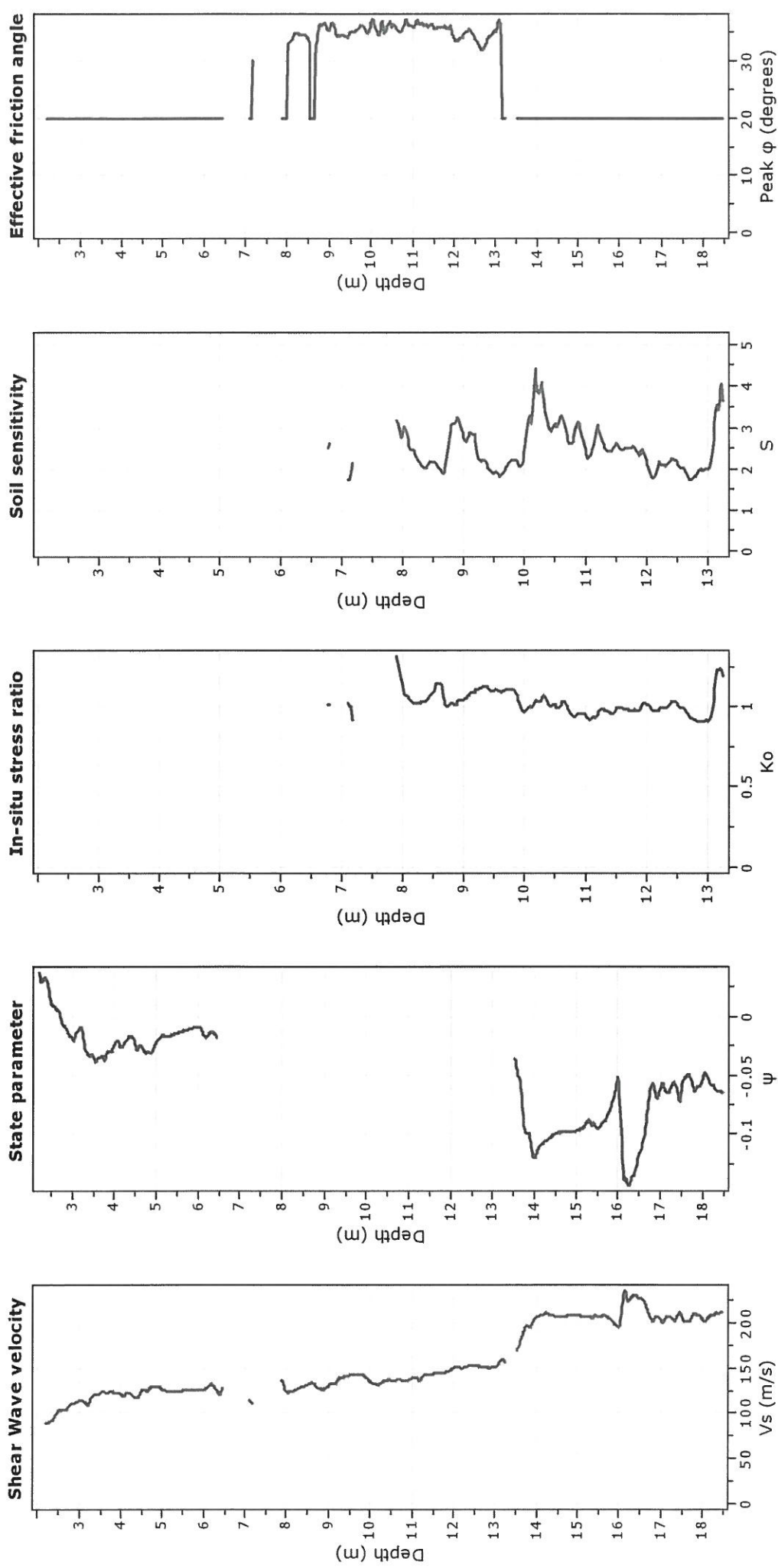
Go: Based on variable  $\alpha/\rho$  using  $I_c$  (Robertson, 2009)

Undrained shear strength cone factor for clays,  $N_{kt}$ : 14

OCR factor for clays,  $N_{kt}$ : 0.33

—●— User defined estimation data

**Project: FIUME PO - SISTEMAZIONE A CORRENTE LIBERA PER LA NAVIGAZIONE**  
**Location: TRATTO CASTELMASSA - STIENTA**



#### Calculation parameters

Soil Sensitivity factor,  $N_s$ : 7.00

—●— User defined estimation data

## CPTU 13A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.7	1	0.010	0.010	3.0	0.13	19.1	0.50	50.7	0.83	49.7	0.83	26.5	0.61
3	1.0	6	14.7	1	0.010	0.010	4.9	0.13	20.6	0.38	45.8	0.61	46.6	0.62	27.3	0.46
4	1.0	6	20.8	1	0.009	0.009	6.7	0.11	21.5	0.28	41.7	0.43	43.1	0.44	27.5	0.33
5	1.0	6	27.1	1	0.009	0.009	8.4	0.11	21.9	0.23	38.1	0.34	39.7	0.35	27.2	0.27
6	1.0	7	33.5	1	0.008	0.008	9.8	0.09	21.9	0.17	35.0	0.25	36.5	0.26	26.5	0.20
7	1.0	7	40.0	1	0.007	0.007	10.8	0.07	21.6	0.13	32.2	0.18	33.7	0.19	25.6	0.15
8	1.0	10	48.3	5	0.200	0.020	11.7	0.19	21.1	0.31	29.8	0.42	31.1	0.43	24.5	0.36
9	1.0	8	57.2	1	0.003	0.003	12.2	0.03	20.4	0.04	27.6	0.05	28.8	0.05	23.4	0.04
10	1.0	7	64.7	1	0.004	0.004	12.6	0.03	19.8	0.05	25.7	0.06	26.7	0.06	22.4	0.05
11	1.0	7	71.9	1	0.006	0.006	12.8	0.04	19.0	0.06	24.0	0.08	24.9	0.08	21.3	0.07
12	1.0	7	78.8	1	0.007	0.007	12.8	0.05	18.3	0.06	22.5	0.08	23.3	0.08	20.3	0.07
13	1.0	7	85.5	1	0.006	0.006	12.8	0.04	17.6	0.05	21.2	0.06	21.8	0.06	19.3	0.05
14	1.0	7	92.6	1	0.004	0.004	12.7	0.02	16.9	0.03	19.9	0.03	20.5	0.03	18.4	0.03
TOTALI (cm)								1.02	2.30	3.42	3.47	2.69				

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'_{v0}$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.7	1	0.010	0.010	12.0	0.38	2.0	0.09
3	1.0	6	14.7	1	0.010	0.010	12.6	0.27	3.2	0.09
4	1.0	6	20.8	1	0.009	0.009	13.4	0.19	4.4	0.08
5	1.0	6	27.1	1	0.009	0.009	14.2	0.17	5.6	0.07
6	1.0	7	33.5	1	0.008	0.008	14.9	0.13	6.6	0.06
7	1.0	7	40.0	1	0.007	0.007	15.3	0.10	7.6	0.05
8	1.0	10	48.3	5	0.200	0.020	15.6	0.24	8.4	0.14
9	1.0	8	57.2	1	0.003	0.003	15.7	0.03	9.1	0.02
10	1.0	7	64.7	1	0.004	0.004	15.7	0.04	9.6	0.02
11	1.0	7	71.9	1	0.006	0.006	15.5	0.05	10.0	0.03
12	1.0	7	78.8	1	0.007	0.007	15.3	0.05	10.3	0.04
13	1.0	7	85.5	1	0.006	0.006	15.0	0.04	10.5	0.03
14	1.0	7	92.6	1	0.004	0.004	14.6	0.03	10.6	0.02
TOTALI (cm)								1.72	0.74	

[illegible]

# CPTU 14A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.7	1	0.010	0.010	3.0	0.13	19.1	0.51	50.7	0.84	49.7	0.83	26.5	0.61
3	1.0	6	14.7	1	0.010	0.010	4.9	0.13	20.6	0.38	45.8	0.62	46.6	0.62	27.3	0.46
4	1.0	6	20.7	1	0.010	0.010	6.7	0.12	21.5	0.31	41.7	0.48	43.1	0.49	27.5	0.37
5	1.0	6	26.7	1	0.010	0.010	8.4	0.12	21.9	0.26	38.1	0.39	39.7	0.40	27.2	0.30
6	1.0	6	32.8	1	0.010	0.010	9.8	0.11	21.9	0.22	35.0	0.32	36.5	0.33	26.5	0.26
7	1.0	6	38.9	1	0.009	0.009	10.8	0.10	21.6	0.17	32.2	0.24	33.7	0.24	25.6	0.20
8	1.0	10	47.0	5	0.200	0.020	11.7	0.19	21.1	0.32	29.8	0.43	31.1	0.44	24.5	0.36
9	1.0	7	55.3	1	0.007	0.007	12.2	0.06	20.4	0.10	27.6	0.12	28.8	0.13	23.4	0.11
10	1.0	7	62.0	1	0.007	0.007	12.6	0.06	19.8	0.08	25.7	0.11	26.7	0.11	22.4	0.09
11	1.0	7	68.7	1	0.007	0.007	12.8	0.05	19.0	0.07	24.0	0.09	24.9	0.09	21.3	0.08
12	1.0	7	75.3	1	0.007	0.007	12.8	0.05	18.3	0.07	22.5	0.08	23.3	0.08	20.3	0.07
TOTALI (cm)								1.12	2.49	3.69	3.76	2.91				

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m³	$\sigma'_{v0}$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.7	1	0.010	0.010	12.0	0.38	2.0	0.09
3	1.0	6	14.7	1	0.010	0.010	12.6	0.27	3.2	0.09
4	1.0	6	20.7	1	0.010	0.010	13.4	0.22	4.4	0.08
5	1.0	6	26.7	1	0.010	0.010	14.2	0.19	5.6	0.08
6	1.0	6	32.8	1	0.010	0.010	14.9	0.16	6.6	0.08
7	1.0	6	38.9	1	0.009	0.009	15.3	0.13	7.6	0.07
8	1.0	10	47.0	5	0.200	0.020	15.6	0.25	8.4	0.14
9	1.0	7	55.3	1	0.007	0.007	15.7	0.08	9.1	0.05
10	1.0	7	62.0	1	0.007	0.007	15.7	0.07	9.6	0.04
11	1.0	7	68.7	1	0.007	0.007	15.5	0.06	10.0	0.04
12	1.0	7	75.3	1	0.007	0.007	15.3	0.06	10.3	0.04
TOTALI (cm)								1.85		0.81

CPTU 14A PENNELLO 4 m

COORDINATE  $(x, y, z)$  E PRESSIONI  $(\sigma'v)$  RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	σ'v kPa
1	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+2
2	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+6
3	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+10
4	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+17
5	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+28
6	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+38
7	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+43
8	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+43
9	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+43
10	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+35
11	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+20
12	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
13	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,2.0	50.0,4.0	50.0,7.0	50.0,10.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'_{v0}$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.7	1	0.010	0.010	3.3	0.14	16.0	0.45	35.6	0.71	37.7	0.73	14.8	0.43
3	1.0	6	14.7	1	0.010	0.010	5.5	0.14	17.1	0.34	32.1	0.50	34.3	0.52	15.9	0.32
4	1.0	6	20.7	1	0.010	0.010	7.4	0.13	17.5	0.27	28.9	0.38	31.0	0.40	16.4	0.25
5	1.0	6	26.7	1	0.010	0.010	8.9	0.12	17.3	0.22	26.1	0.30	27.9	0.31	16.5	0.21
6	1.0	6	32.8	1	0.010	0.010	9.8	0.11	16.9	0.18	23.7	0.24	25.1	0.25	16.3	0.17
7	1.0	6	38.9	1	0.009	0.009	10.4	0.09	16.2	0.14	21.5	0.17	22.8	0.18	15.8	0.13
8	1.0	10	47.0	5	0.200	0.020	10.7	0.18	15.5	0.25	19.7	0.30	20.7	0.32	15.2	0.24
9	1.0	7	55.3	1	0.007	0.007	10.7	0.05	14.8	0.07	18.1	0.09	18.9	0.09	14.5	0.07
10	1.0	7	62.0	1	0.007	0.007	10.7	0.05	14.1	0.06	16.7	0.07	17.4	0.08	13.9	0.06
11	1.0	7	68.7	1	0.007	0.007	10.5	0.04	13.4	0.05	15.5	0.06	16.1	0.06	13.2	0.05
12	1.0	7	75.3	1	0.007	0.007	10.3	0.04	12.7	0.05	14.5	0.05	14.9	0.05	12.6	0.05
TOTALI (cm)								1.11		2.07		2.87		2.99		2.00

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6  
50.0, 13.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

[illegible]

## CPTU 15A PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	10	15.0	5	0.200	0.020	3.0	0.16	19.1	0.71	50.7	1.28	49.7	1.27	26.5	0.88
3	1.0	10	25.0	6	0.200	0.020	4.9	0.16	20.6	0.52	45.8	0.90	46.6	0.91	27.3	0.64
4	1.0	10	35.0	7	0.200	0.020	6.7	0.15	21.5	0.42	41.7	0.68	43.1	0.70	27.5	0.50
5	1.0	10	45.0	8	0.200	0.020	8.4	0.15	21.9	0.34	38.1	0.53	39.7	0.55	27.2	0.41
6	1.0	10	55.0	8	0.200	0.020	9.8	0.14	21.9	0.29	35.0	0.43	36.5	0.44	26.5	0.34
7	1.0	7	63.6	1	0.005	0.005	10.8	0.03	21.6	0.06	32.2	0.09	33.7	0.09	25.6	0.07
8	1.0	10	72.2	4	0.200	0.020	11.7	0.13	21.1	0.22	29.8	0.30	31.1	0.31	24.5	0.25
9	1.0	10	82.2	4	0.200	0.020	12.2	0.12	20.4	0.19	27.6	0.25	28.8	0.26	23.4	0.22
10	1.0	10	92.2	4	0.200	0.020	12.6	0.11	19.8	0.17	25.7	0.21	26.7	0.22	22.4	0.19
11	1.0	10	102.2	4	0.200	0.020	12.8	0.10	19.0	0.15	24.0	0.18	24.9	0.19	21.3	0.16
12	1.0	10	112.2	3	0.200	0.020	12.8	0.09	18.3	0.13	22.5	0.16	23.3	0.16	20.3	0.14
13	1.0	10	122.2	2	0.200	0.020	12.8	0.09	17.6	0.12	21.2	0.14	21.8	0.14	19.3	0.13
TOTALI (cm)								1.44		3.33		5.16		5.25		3.95

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

CARATTERISTICHE DEGLI STRATI

TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	10	15.0	5	0.200	0.020	12.0	0.51	2.0	0.11
3	1.0	10	25.0	6	0.200	0.020	12.6	0.36	3.2	0.10
4	1.0	10	35.0	7	0.200	0.020	13.4	0.28	4.4	0.10
5	1.0	10	45.0	8	0.200	0.020	14.2	0.24	5.6	0.10
6	1.0	10	55.0	8	0.200	0.020	14.9	0.21	6.6	0.10
7	1.0	7	63.6	1	0.005	0.005	15.3	0.05	7.6	0.02
8	1.0	10	72.2	4	0.200	0.020	15.6	0.17	8.4	0.10
9	1.0	10	82.2	4	0.200	0.020	15.7	0.15	9.1	0.09
10	1.0	10	92.2	4	0.200	0.020	15.7	0.14	9.6	0.09
11	1.0	10	102.2	4	0.200	0.020	15.5	0.12	10.0	0.08
12	1.0	10	112.2	3	0.200	0.020	15.3	0.11	10.3	0.08
13	1.0	10	122.2	2	0.200	0.020	15.0	0.10	10.5	0.07
TOTALI (cm)								2.43		1.04

[illegible]

# CPTU 15B PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.011	0.011	3.0	0.14	19.1	0.55	50.7	0.91	49.7	0.91	26.5	0.67
3	1.0	6	14.7	1	0.010	0.010	4.9	0.13	20.6	0.38	45.8	0.62	46.6	0.62	27.3	0.46
4	1.0	6	20.8	1	0.009	0.009	6.7	0.11	21.5	0.28	41.7	0.43	43.1	0.44	27.5	0.33
5	1.0	6	27.0	1	0.009	0.009	8.4	0.11	21.9	0.23	38.1	0.34	39.7	0.35	27.2	0.27
6	1.0	10	35.1	6	0.200	0.020	9.8	0.21	21.9	0.42	35.0	0.60	36.5	0.62	26.5	0.49
7	1.0	10	45.1	7	0.200	0.020	10.8	0.19	21.6	0.34	32.2	0.47	33.7	0.48	25.6	0.39
8	1.0	10	55.1	6	0.200	0.020	11.7	0.17	21.1	0.28	29.8	0.38	31.1	0.39	24.5	0.32
9	1.0	10	65.1	5	0.200	0.020	12.2	0.15	20.4	0.24	27.6	0.31	28.8	0.32	23.4	0.27
10	1.0	10	75.1	5	0.200	0.020	12.6	0.13	19.8	0.20	25.7	0.26	26.7	0.26	22.4	0.23
11	1.0	10	85.1	5	0.200	0.020	12.8	0.12	19.0	0.18	24.0	0.22	24.9	0.22	21.3	0.19
12	1.0	10	95.1	4	0.200	0.020	12.8	0.11	18.3	0.15	22.5	0.18	23.3	0.19	20.3	0.17
13	1.0	7	103.7	1	0.005	0.005	12.8	0.03	17.6	0.03	21.2	0.04	21.8	0.04	19.3	0.04
14	1.0	7	110.6	1	0.007	0.007	12.7	0.03	16.9	0.04	19.9	0.05	20.5	0.05	18.4	0.05
15	1.0	8	118.0	1	0.002	0.002	12.5	0.01	16.2	0.01	18.9	0.01	19.3	0.01	17.5	0.01
TOTALI (cm)								1.63	3.34	4.82	4.92	3.88				

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m³	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.011	0.011	12.0	0.41	2.0	0.10
3	1.0	6	14.7	1	0.010	0.010	12.6	0.27	3.2	0.09
4	1.0	6	20.8	1	0.009	0.009	13.4	0.20	4.4	0.08
5	1.0	6	27.0	1	0.009	0.009	14.2	0.17	5.6	0.07
6	1.0	10	35.1	6	0.200	0.020	14.9	0.31	6.6	0.15
7	1.0	10	45.1	7	0.200	0.020	15.3	0.25	7.6	0.14
8	1.0	10	55.1	6	0.200	0.020	15.6	0.22	8.4	0.12
9	1.0	10	65.1	5	0.200	0.020	15.7	0.19	9.1	0.11
10	1.0	10	75.1	5	0.200	0.020	15.7	0.16	9.6	0.10
11	1.0	10	85.1	5	0.200	0.020	15.5	0.15	10.0	0.10
12	1.0	10	95.1	4	0.200	0.020	15.3	0.13	10.3	0.09
13	1.0	7	103.7	1	0.005	0.005	15.0	0.03	10.5	0.02
14	1.0	7	110.6	1	0.007	0.007	14.6	0.04	10.6	0.03
15	1.0	8	118.0	1	0.002	0.002	14.2	0.01	10.6	0.01
TOTALI (cm)								2.53	1.20	

TOTAL I (cm)	1.21
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# CPTU 15C PENNELLO 6 m

COORDINATE (x,y,z) E PRESSIONI ( $\sigma'v$ ) RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	$\sigma'v$ kPa
1	0.0	17.0	100.0	17.0	100.0	18.0	0.0	18.0	0.0	+2
2	0.0	16.0	100.0	16.0	100.0	17.0	0.0	17.0	0.0	+6
3	0.0	15.0	100.0	15.0	100.0	16.0	0.0	16.0	0.0	+10
4	0.0	14.0	100.0	14.0	100.0	15.0	0.0	15.0	0.0	+14
5	0.0	13.0	100.0	13.0	100.0	14.0	0.0	14.0	0.0	+18
6	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+22
7	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+29
8	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+39
9	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+50
10	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+55
11	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+55
12	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+65
13	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+47
14	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+31
15	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+21
16	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+15
17	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
18	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,3.0	50.0,6.0	50.0,9.0	50.0,12.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.011	0.011	3.0	0.14	19.1	0.55	50.7	0.91	49.7	0.91	26.5	0.67
3	1.0	6	14.6	1	0.011	0.011	4.9	0.14	20.6	0.42	45.8	0.68	46.6	0.68	27.3	0.50
4	1.0	6	20.4	1	0.011	0.011	6.7	0.14	21.5	0.34	41.7	0.53	43.1	0.54	27.5	0.41
5	1.0	6	26.3	1	0.011	0.011	8.4	0.13	21.9	0.29	38.1	0.43	39.7	0.44	27.2	0.34
6	1.0	6	32.1	1	0.011	0.011	9.8	0.13	21.9	0.25	35.0	0.35	36.5	0.36	26.5	0.29
7	1.0	10	40.0	5	0.200	0.020	10.8	0.21	21.6	0.37	32.2	0.51	33.7	0.53	25.6	0.43
8	1.0	10	50.0	5	0.200	0.020	11.7	0.18	21.1	0.31	29.8	0.41	31.1	0.42	24.5	0.35
9	1.0	10	60.0	5	0.200	0.020	12.2	0.16	20.4	0.25	27.6	0.33	28.8	0.34	23.4	0.29
10	1.0	10	70.0	5	0.200	0.020	12.6	0.14	19.8	0.22	25.7	0.27	26.7	0.28	22.4	0.24
11	1.0	10	80.0	4	0.200	0.020	12.8	0.13	19.0	0.19	24.0	0.23	24.9	0.24	21.3	0.20
12	1.0	10	90.0	6	0.200	0.020	12.8	0.12	18.3	0.16	22.5	0.19	23.3	0.20	20.3	0.18
13	1.0	7	98.5	1	0.006	0.006	12.8	0.03	17.6	0.04	21.2	0.05	21.8	0.05	19.3	0.05
14	1.0	7	105.5	1	0.006	0.006	12.7	0.03	16.9	0.04	19.9	0.05	20.5	0.05	18.4	0.04
15	1.0	7	112.6	1	0.005	0.005	12.5	0.02	16.2	0.03	18.9	0.03	19.3	0.03	17.5	0.03
16	1.0	7	119.5	1	0.007	0.007	12.3	0.03	15.6	0.04	17.9	0.04	18.3	0.04	16.7	0.04
TOTALI (cm)								1.73	3.50		5.02		5.12		4.05	

## COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6	7
50.0,15.0	50.0,18.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'v0$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.011	0.011	12.0	0.41	2.0	0.10
3	1.0	6	14.6	1	0.011	0.011	12.6	0.30	3.2	0.09
4	1.0	6	20.4	1	0.011	0.011	13.4	0.24	4.4	0.09
5	1.0	6	26.3	1	0.011	0.011	14.2	0.21	5.6	0.09
6	1.0	6	32.1	1	0.011	0.011	14.9	0.18	6.6	0.09
7	1.0	10	40.0	5	0.200	0.020	15.3	0.28	7.6	0.15
8	1.0	10	50.0	5	0.200	0.020	15.6	0.24	8.4	0.13
9	1.0	10	60.0	5	0.200	0.020	15.7	0.20	9.1	0.12
10	1.0	10	70.0	5	0.200	0.020	15.7	0.18	9.6	0.11
11	1.0	10	80.0	4	0.200	0.020	15.5	0.15	10.0	0.10
12	1.0	10	90.0	6	0.200	0.020	15.3	0.14	10.3	0.09
13	1.0	7	98.5	1	0.006	0.006	15.0	0.04	10.5	0.03
14	1.0	7	105.5	1	0.006	0.006	14.6	0.03	10.6	0.02
15	1.0	7	112.6	1	0.005	0.005	14.2	0.03	10.6	0.02
16	1.0	7	119.5	1	0.007	0.007	13.9	0.03	10.6	0.03
TOTALI (cm)								2.66	1.28	

CPTU 15C PENNELLO 4 m

COORDINATE  $(x, y, z)$  E PRESSIONI  $(\sigma'v)$  RELATIVE AI RETTANGOLI DI CARICO

N.	x1 m	y1 m	x2 m	y2 m	x3 m	y3 m	x4 m	y4 m	z m	σ'v kPa
1	0.0	12.0	100.0	12.0	100.0	13.0	0.0	13.0	0.0	+2
2	0.0	11.0	100.0	11.0	100.0	12.0	0.0	12.0	0.0	+6
3	0.0	10.0	100.0	10.0	100.0	11.0	0.0	11.0	0.0	+10
4	0.0	9.0	100.0	9.0	100.0	10.0	0.0	10.0	0.0	+17
5	0.0	8.0	100.0	8.0	100.0	9.0	0.0	9.0	0.0	+28
6	0.0	7.0	100.0	7.0	100.0	8.0	0.0	8.0	0.0	+38
7	0.0	6.0	100.0	6.0	100.0	7.0	0.0	7.0	0.0	+43
8	0.0	5.0	100.0	5.0	100.0	6.0	0.0	6.0	0.0	+43
9	0.0	4.0	100.0	4.0	100.0	5.0	0.0	5.0	0.0	+43
10	0.0	3.0	100.0	3.0	100.0	4.0	0.0	4.0	0.0	+35
11	0.0	2.0	100.0	2.0	100.0	3.0	0.0	3.0	0.0	+20
12	0.0	1.0	100.0	1.0	100.0	2.0	0.0	2.0	0.0	+9
13	0.0	0.0	100.0	0.0	100.0	1.0	0.0	1.0	0.0	+3

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

1	2	3	4	5
50.0,0.0	50.0,2.0	50.0,4.0	50.0,7.0	50.0,10.0

## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

N.	h m	$\gamma'$ kN/m <sup>3</sup>	$\sigma'_{v0}$ kPa	OCR	CR	RR	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm	$\Delta\sigma$ kPa	$\Delta h$ cm
2	1.0	6	8.8	1	0.011	0.011	3.3	0.15	16.0	0.50	35.6	0.78	37.7	0.80	14.8	0.47
3	1.0	6	14.6	1	0.011	0.011	5.5	0.15	17.1	0.37	32.1	0.56	34.3	0.58	15.9	0.35
4	1.0	6	20.4	1	0.011	0.011	7.4	0.15	17.5	0.30	28.9	0.42	31.0	0.44	16.4	0.28
5	1.0	6	26.3	1	0.011	0.011	8.9	0.14	17.3	0.24	26.1	0.33	27.9	0.35	16.5	0.23
6	1.0	6	32.1	1	0.011	0.011	9.8	0.13	16.9	0.20	23.7	0.26	25.1	0.28	16.3	0.20
7	1.0	10	40.0	5	0.200	0.020	10.4	0.20	16.2	0.30	21.5	0.37	22.8	0.39	15.8	0.29
8	1.0	10	50.0	5	0.200	0.020	10.7	0.17	15.5	0.24	19.7	0.29	20.7	0.30	15.2	0.23
9	1.0	10	60.0	5	0.200	0.020	10.7	0.14	14.8	0.19	18.1	0.23	18.9	0.24	14.5	0.19
10	1.0	10	70.0	5	0.200	0.020	10.7	0.12	14.1	0.16	16.7	0.19	17.4	0.19	13.9	0.16
11	1.0	10	80.0	4	0.200	0.020	10.5	0.11	13.4	0.13	15.5	0.15	16.1	0.16	13.2	0.13
12	1.0	10	90.0	6	0.200	0.020	10.3	0.09	12.7	0.11	14.5	0.13	14.9	0.13	12.6	0.11
13	1.0	7	98.5	1	0.006	0.006	10.0	0.03	12.0	0.03	13.5	0.03	13.9	0.03	12.0	0.03
14	1.0	7	105.5	1	0.006	0.006	9.7	0.02	11.4	0.03	12.7	0.03	13.0	0.03	11.4	0.03
15	1.0	7	112.6	1	0.005	0.005	9.4	0.02	10.9	0.02	11.9	0.02	12.2	0.02	10.8	0.02
16	1.0	7	119.5	1	0.007	0.007	9.1	0.02	10.4	0.03	11.3	0.03	11.5	0.03	10.3	0.03
TOTALI (cm)								1.65		2.84		3.82		3.97		2.75

COORDINATE (X,Y) DELLE VERTICALI DI CALCOLO

6  
50.0, 13.0

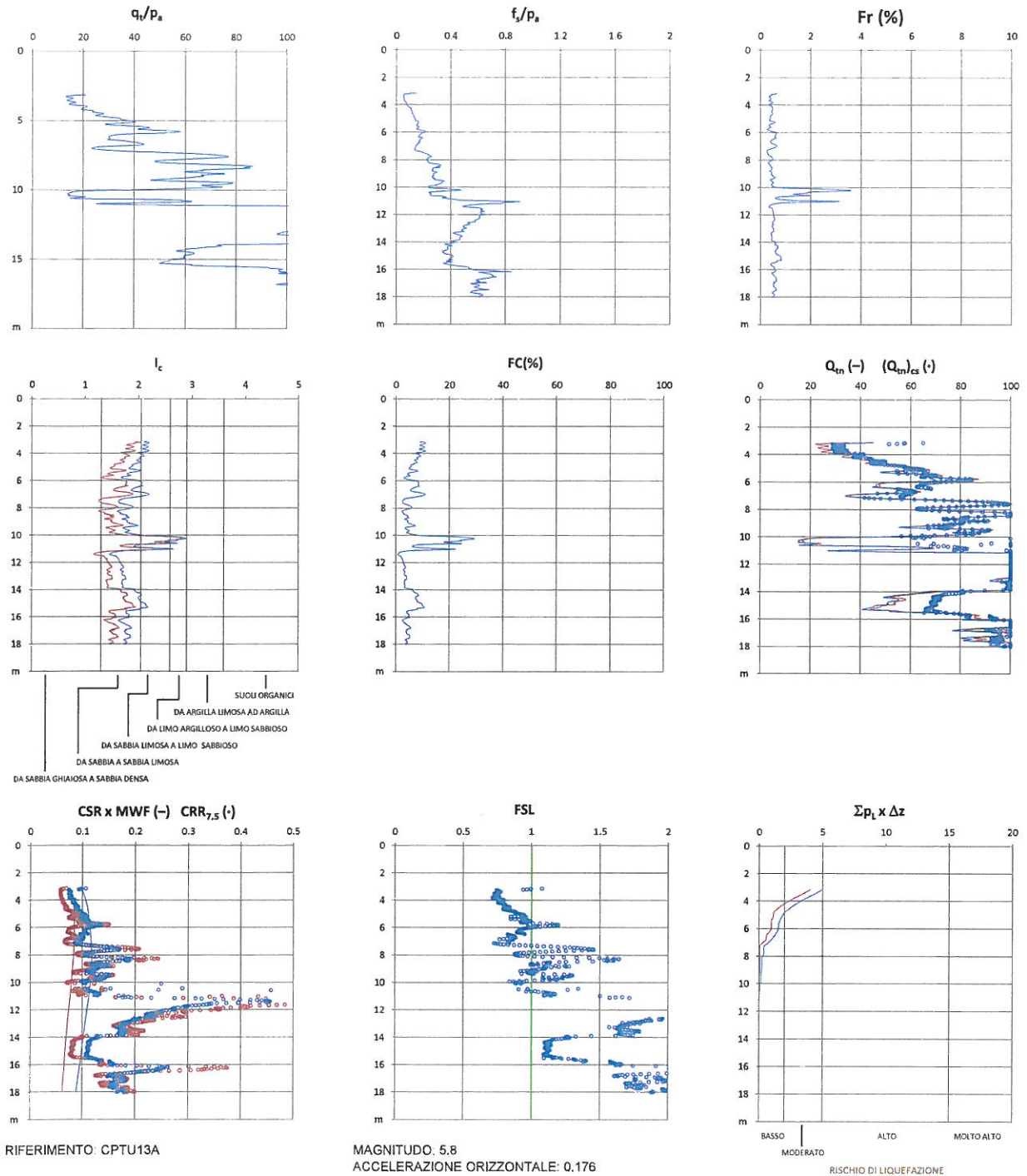
## CARATTERISTICHE DEGLI STRATI

## TENSIONI (kPa) E CEDIMENTI (cm)

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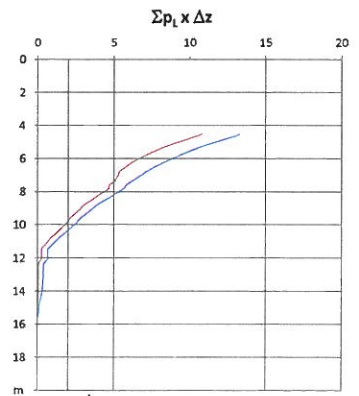
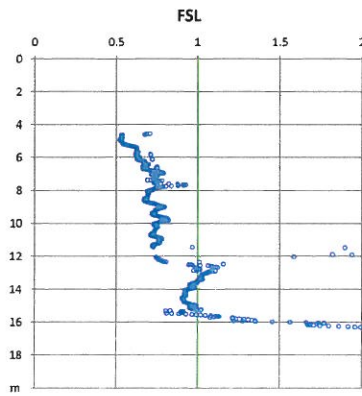
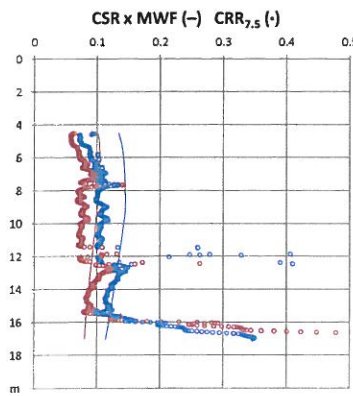
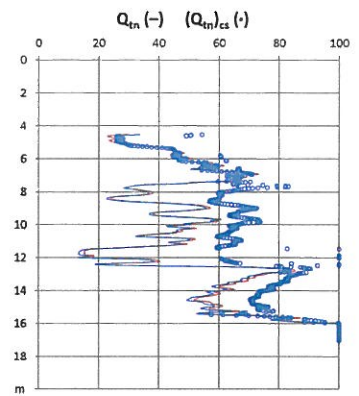
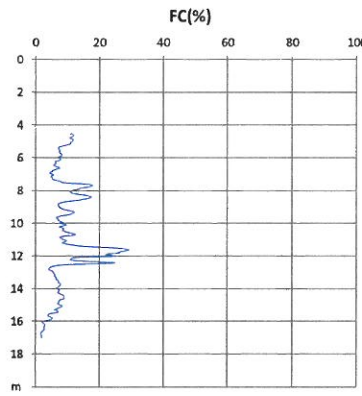
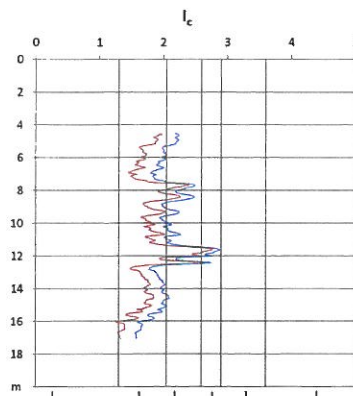
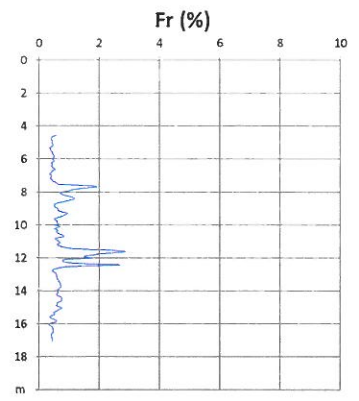
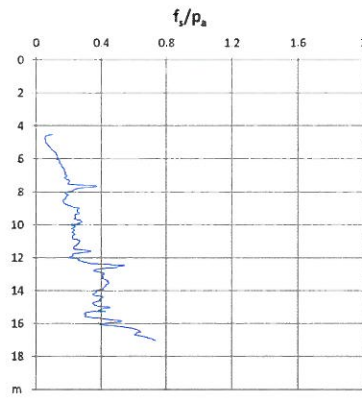
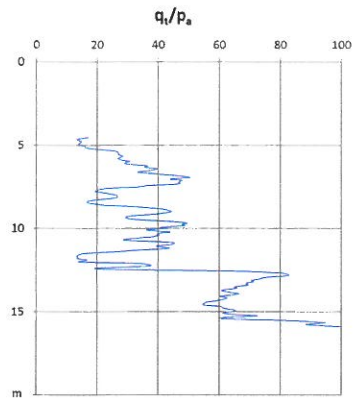
## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al. 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



RIFERIMENTO: CPTU14A

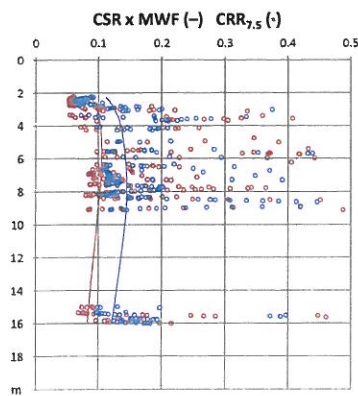
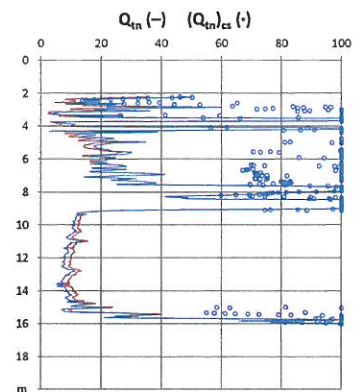
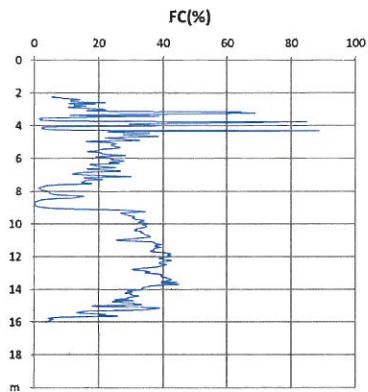
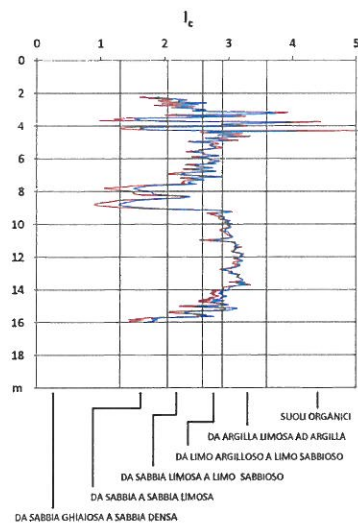
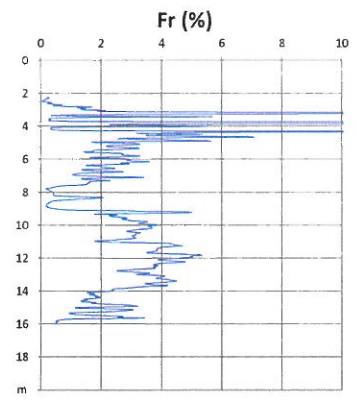
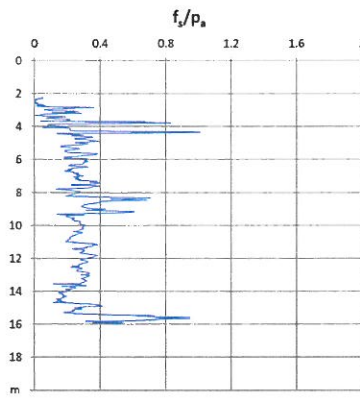
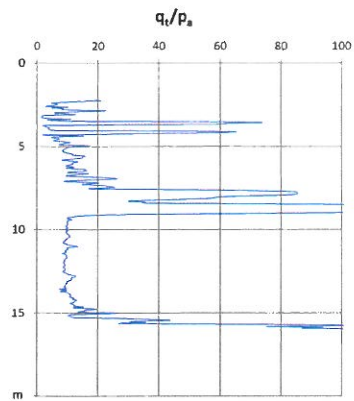
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ACCELERAZIONE ORIZZONTALE: 0.211

RISCHIO DI LIQUEFAZIONE

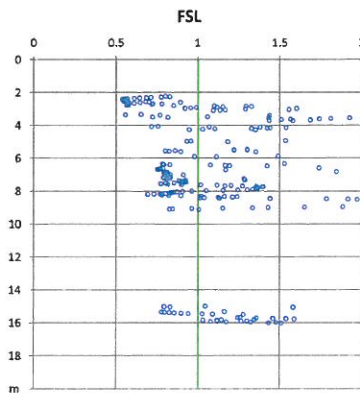
SOFTWARE GIANVITO CASSINADRI 2014

## RISCHIO LIQUEFAZIONE

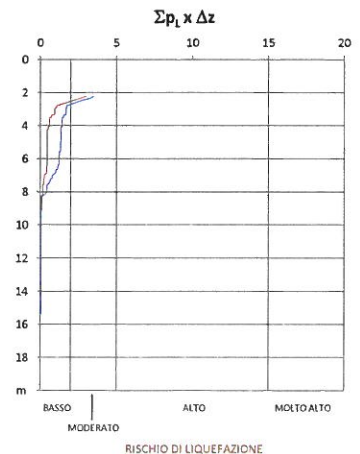
(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



RIFERIMENTO: CPTU15A



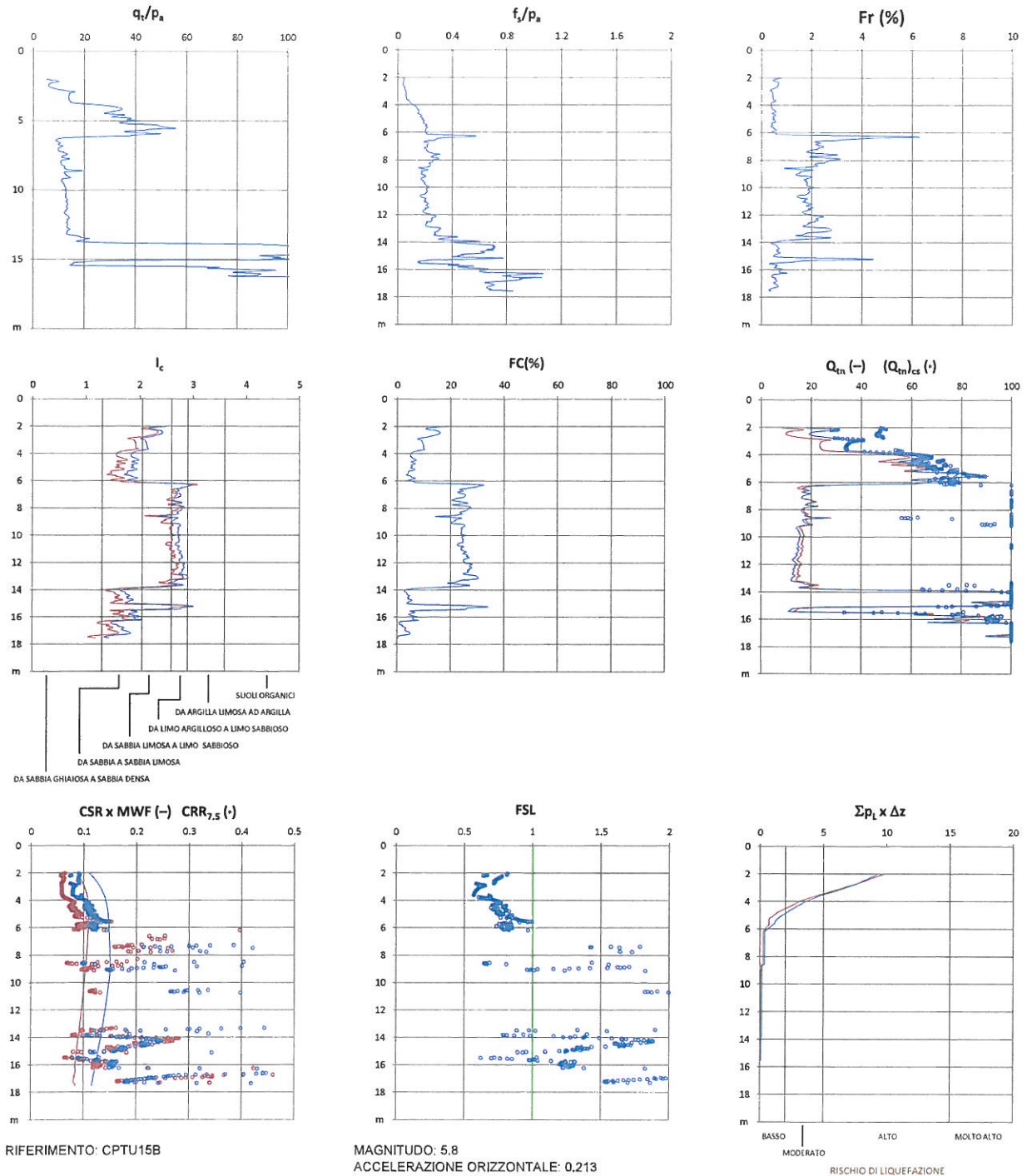
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ACCELERAZIONE ORIZZONTALE: 0.212



SOFTWARE GIANVITO CASSINADRI 2014

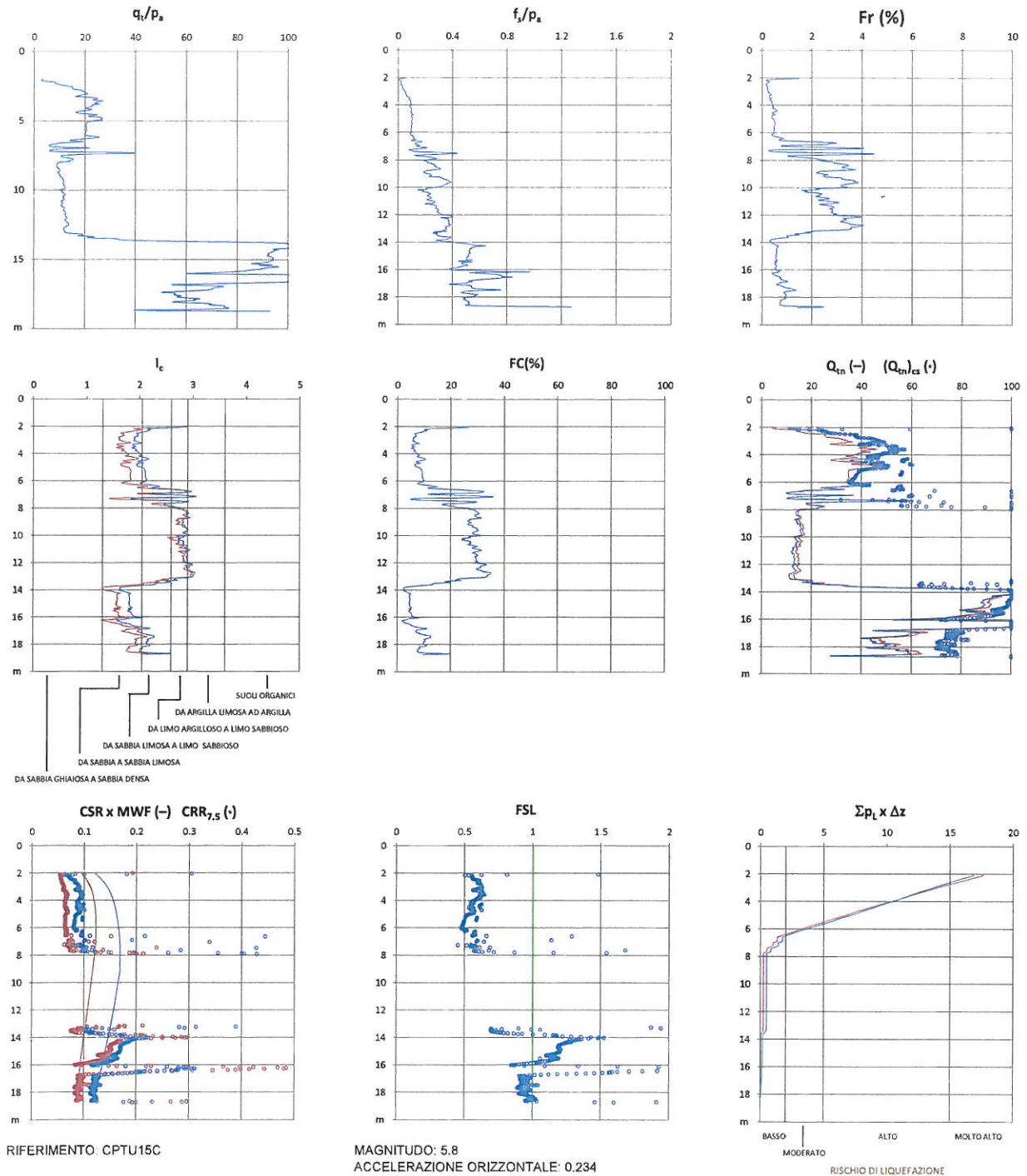
## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



## RISCHIO LIQUEFAZIONE

(Robertson & Wride 1997 - Iwasaki et al 1982 - Robertson 2009)  
(C.H. Juang, C.S. Ku, C.C. Chen, 2010)



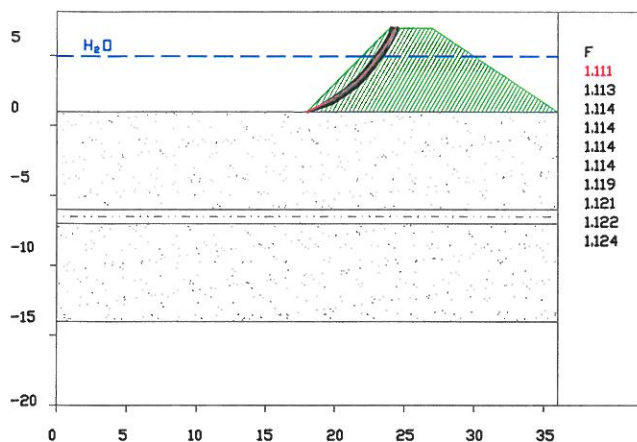
RIFERIMENTO: CPTU15C

MAGNITUDO: 5.8  
ACCELERAZIONE ORIZZONTALE: 0.234

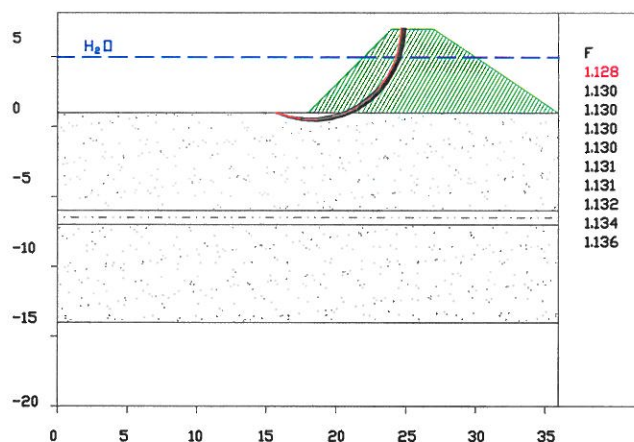
SOFTWARE GIANVITO CASSINADRI 2014

## VERIFICHE DI STABILITÀ

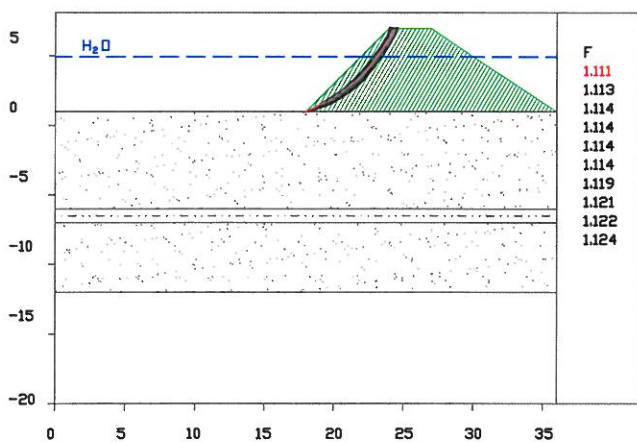
CPTU 13A - SENZA SISMA E COESIONE = 0.6 kPa



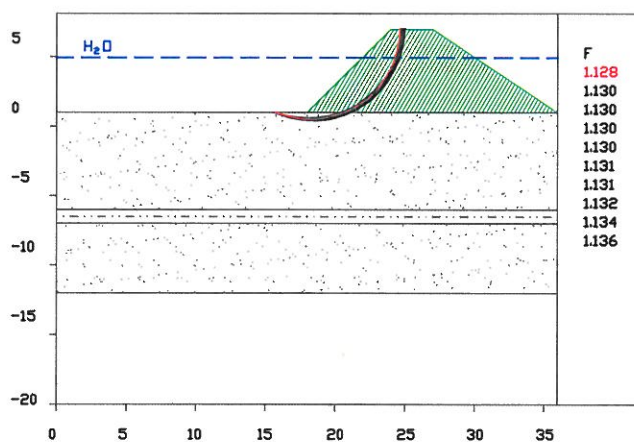
CPTU 13A - CON SISMA E COESIONE = 2.5 kPa



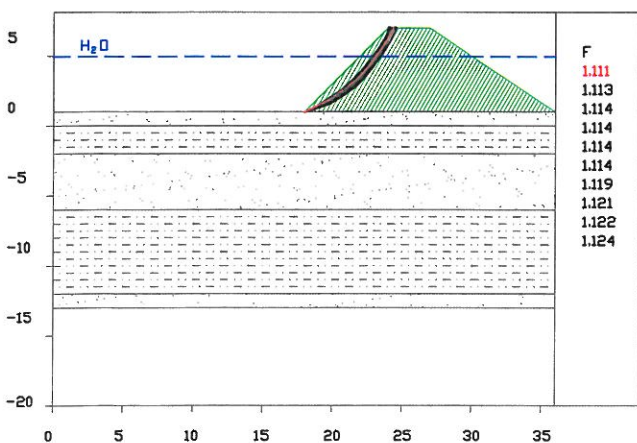
CPTU 14A - SENZA SISMA E COESIONE = 0.6 kPa



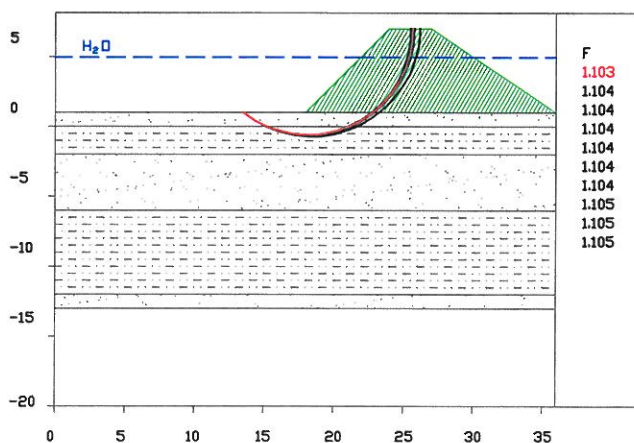
CPTU 14A - CON SISMA E COESIONE = 2.5 kPa



CPTU 15A - SENZA SISMA E COESIONE = 0.6 kPa

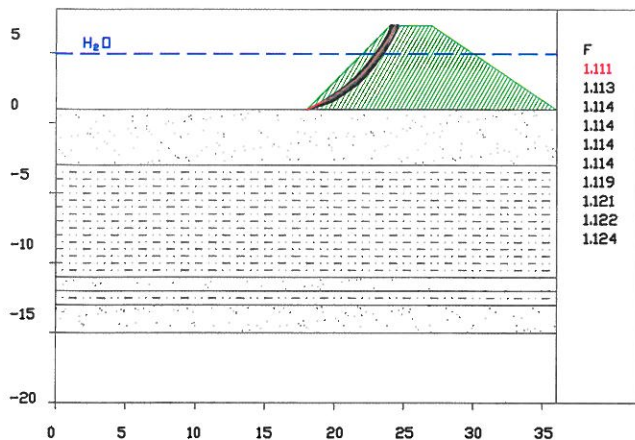


CPTU 15A - CON SISMA E COESIONE = 3 kPa

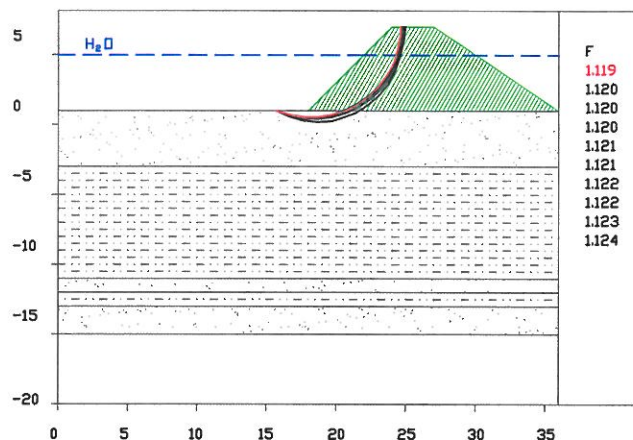


## VERIFICHE DI STABILITÀ

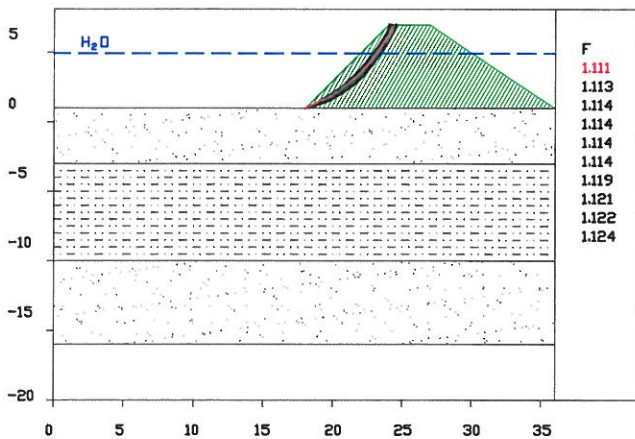
CPTU 15B - SENZA SISMA E COESIONE = 0.6 kPa



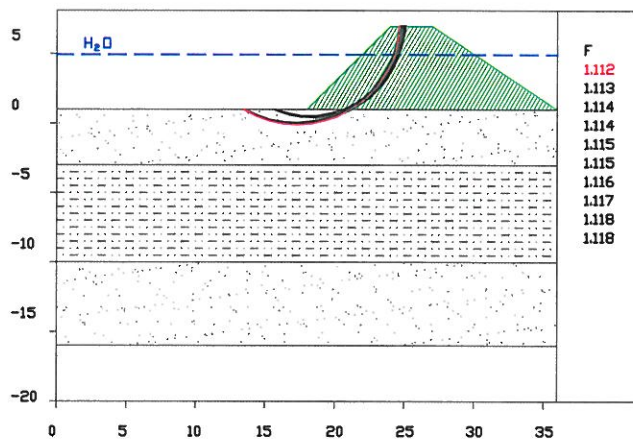
CPTU 15B - CON SISMA E COESIONE = 2.5 kPa



CPTU 15C - SENZA SISMA E COESIONE = 0.6 kPa



CPTU 15C - CON SISMA E COESIONE = 2.5 kPa



Pennello



Terreni coesivi



Terreni non coesivi