

## **ALLEGATI**

### **ALLEGATO 1**

Prove Penetrometriche Statiche (CPT)

### **ALLEGATO 2**

Tabelle parametri

### **ALLEGATO 3**

Sismica a rifrazione

### **ALLEGATO 4**

Modello Geologico

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**SUBSOIL**  
Via Morandi 3, - Quattro Castella (RE)  
Tel. 0522/887268 – Fax. 0522/ 249540

Relazione geologica e sismica *a supporto del progetto di recupero dell'edificio "Ex Scuole Elementari" di Puianello*

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## ALLEGATO 1

Prove Penetrometriche Statiche (CPT)

CPT1

CPT2



**CERTIFICATO DI PROVA n.° 017PS/2014**  
emessa in data 31/03/2014

**SETTORE DI PROVA: 3 – “Prove in sito” – settore “C” Circolare 349/99/STC**

**3.3 PROVE DI DEFORMABILITA' E RESISTENZA MECCANICA:**

CODICE PROVA	DESCIZIONE PROVA	N. PROVE DA ESEGUIRE	NORMATIVA DI RIFERIMENTO
3.3.1.a	Prove penetrometriche statiche con punta meccanica		- <i>Raccomandazioni A.G.I. 1977</i> - <i>ASTM D 3441/86</i>

Committente: EDIL4 SpA

Cantiere: Ex Scuola Elementare di Puianello

N.° commessa: 01808213\_FG

Nome prova: CPT1

Data esecuzione prova: 5 Marzo 2014

**Allegato 1 (risultato della prova):**

	Relazione
X	Diagramma
X	Documentazione fotografica

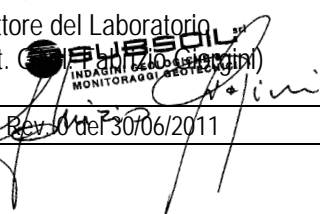

**Allegato 2 (ubicazione del punto di indagine):**

	Corografia in scala opportuna con indicazione ubicazioni
X	Indicazione planoaltimetrica dei punti di indagine
	Coordinate geografiche

Eventuali anomalie riscontrate:.....

Note:  
Falda assente

Tecnico del Laboratorio  
(Dott. Roberto Spagni)

Direttore del Laboratorio  
(Dott.   


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**CERTIFICATO DI PROVA n.° 017PS/2014**  
emessa in data 31/03/2014

**ALLEGATO 1**  
Risultato della prova

**NOME PROVA**  
**CPT1**



Tecnico del Laboratorio  
(Dott. Roberto Spagni)

Direttore del Laboratorio  
(Dott.   
INDAGINI GEOLOGICHE & MONITORAGGI GEOTECNICI

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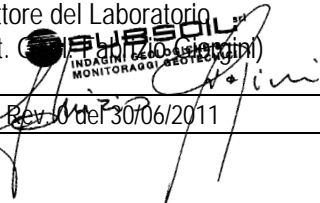
## PROVA PENETROMETRICA STATICA

## CPT 1

Committente:	EDIL4 SpA	Data:	5/03/2014
Località:	Puianello di Quattro Castella (RE)	quota inizio:	Piano campagna
Cantiere:	Ex Scuole Elementari di Puianello	prof. falda:	Assente
Note:			

Prof. m.	LP Kg/cm <sup>2</sup>	LL Kg/cm <sup>2</sup>	RP Kg/cm <sup>2</sup>	RL Kg/cm <sup>2</sup>
0,20	0	0	0	0
0,40	0	0	0	0,4
0,60	12	18	12	0,73
0,80	14	25	14	0,6
1,00	11	20	11	0,6
1,20	17	26	17	0,67
1,40	17	27	17	1,07
1,60	22	38	22	1,67
1,80	25	50	25	2,53
2,00	29	67	29	2,53
2,20	37	75	37	2,93
2,40	38	82	38	3,8
2,60	36	93	36	3,8
2,80	38	95	38	3,4
3,00	39	90	39	3,2
3,20	37	85	37	2,93
3,40	33	77	33	2,8
3,60	30	72	30	3
3,80	33	78	33	3,2
4,00	30	78	30	2,33
4,20	75	110	75	2,67
4,40	38	78	38	2,6
4,60	33	72	33	1,87
4,80	28	56	28	1,93
5,00	28	57	28	1,07
5,20	27	43	27	1,33
5,40	21	41	21	1
5,60	22	37	22	1,13
5,80	28	45	28	1
6,00	30	45	30	1,07
6,20	20	36	20	1,2
6,40	14	32	14	1
6,60	38	53	38	1,27
6,80	65	84	65	2
7,00	70	100	70	2,33
7,20	75	110	75	3
7,40	85	130	85	8,67
7,60	160	290	160	5,33
7,80	280	360	280	0

Tecnico del Laboratorio  
(Dott. Roberto Spagni)

Direttore del Laboratorio  
(Dott.   
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CERTIFICATO DI PROVA n.° 017PS/2014  
emessa in data 31/03/2014

ALLEGATO 2  
Ubicazione della prova

NOME PROVA  
**CPT1**



Legenda:

● CPT1

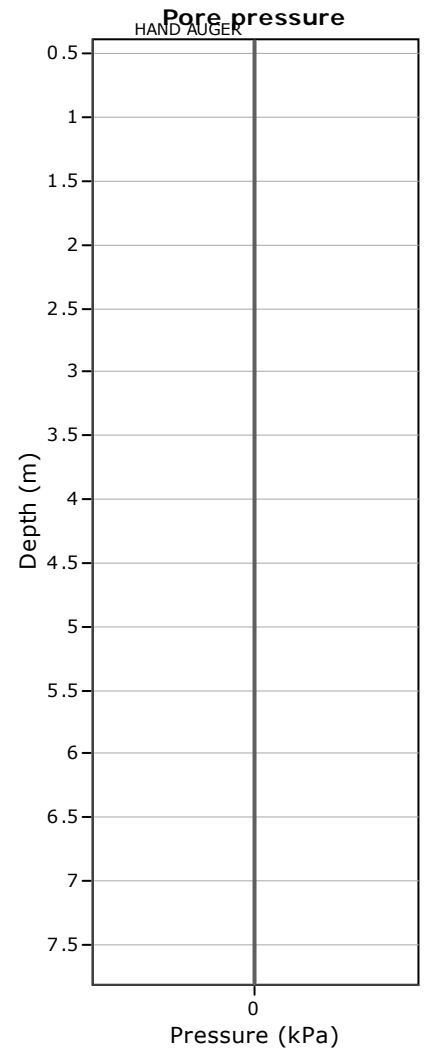
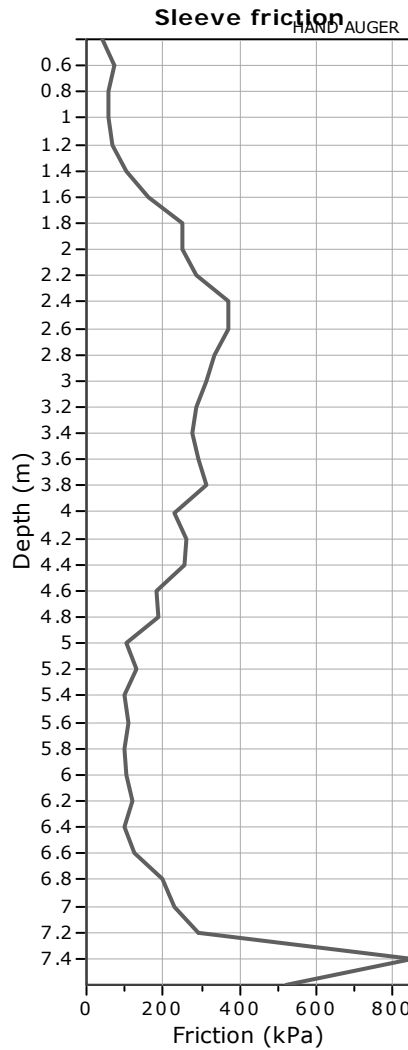
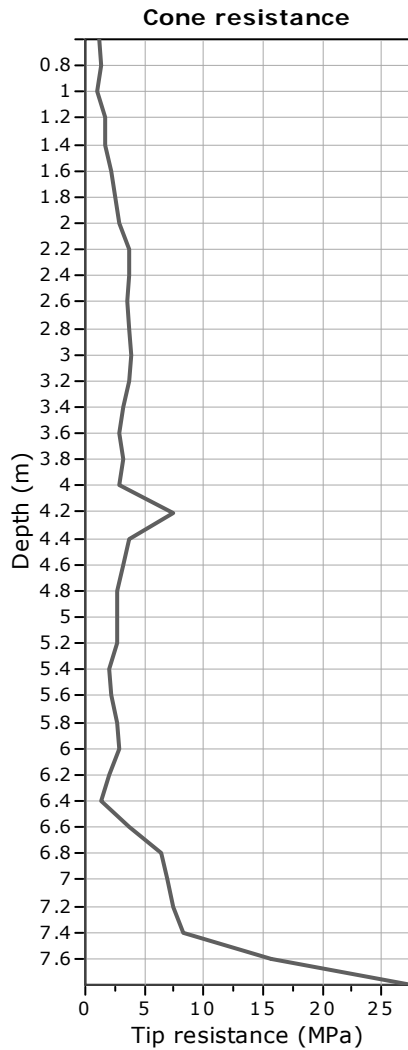
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(Dott. Roberto Spagni)

Direttore del Laboratorio  
(Dott.   
SUBSOIL  
INDAGINI GEOLOGICHE  
MONITORAGGI GEOTECNICI

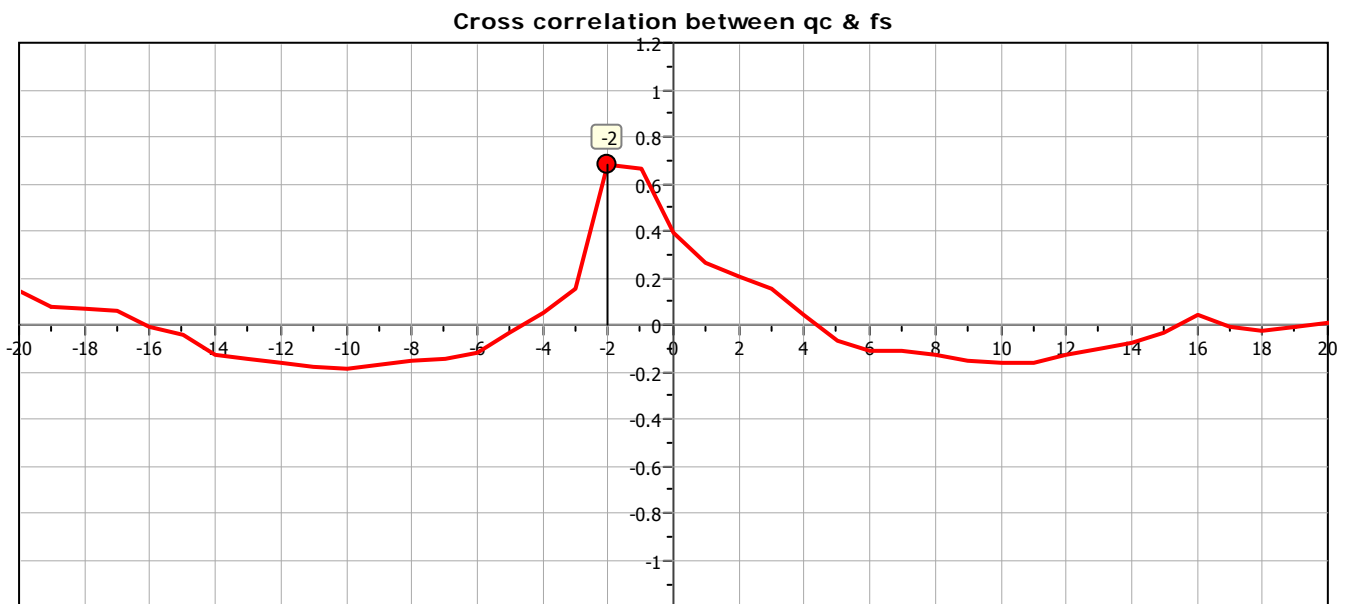
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**Project:**

**Location:**



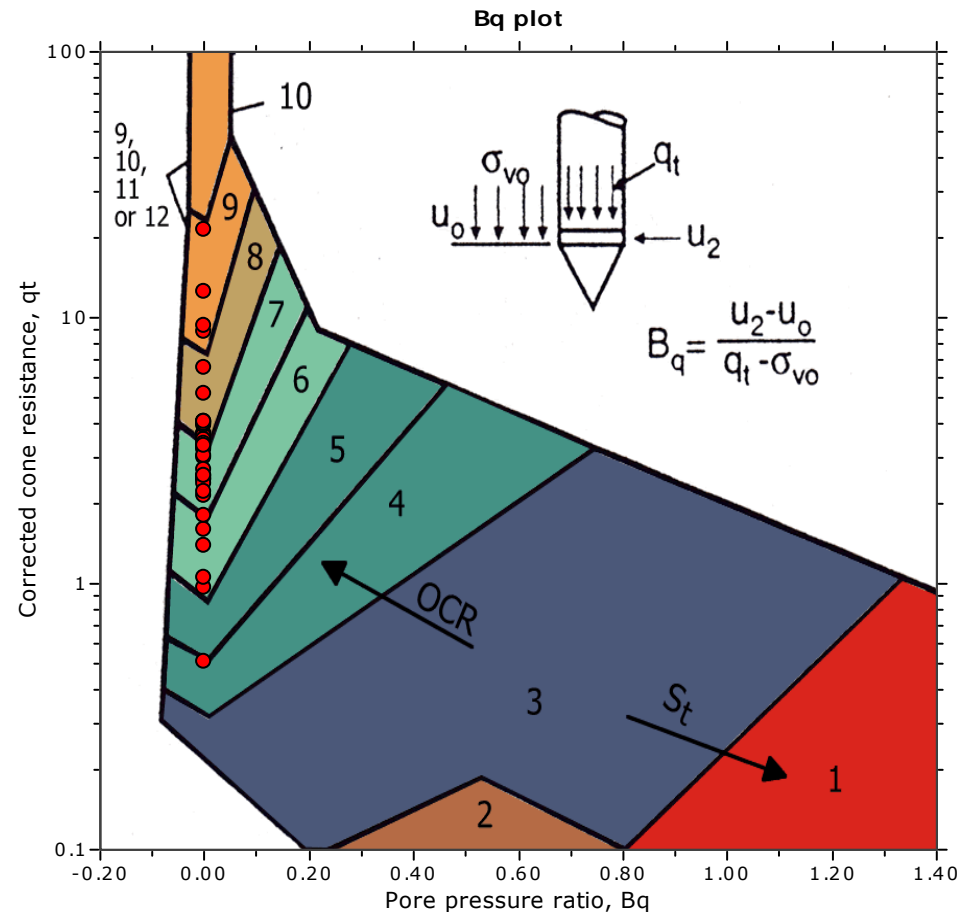
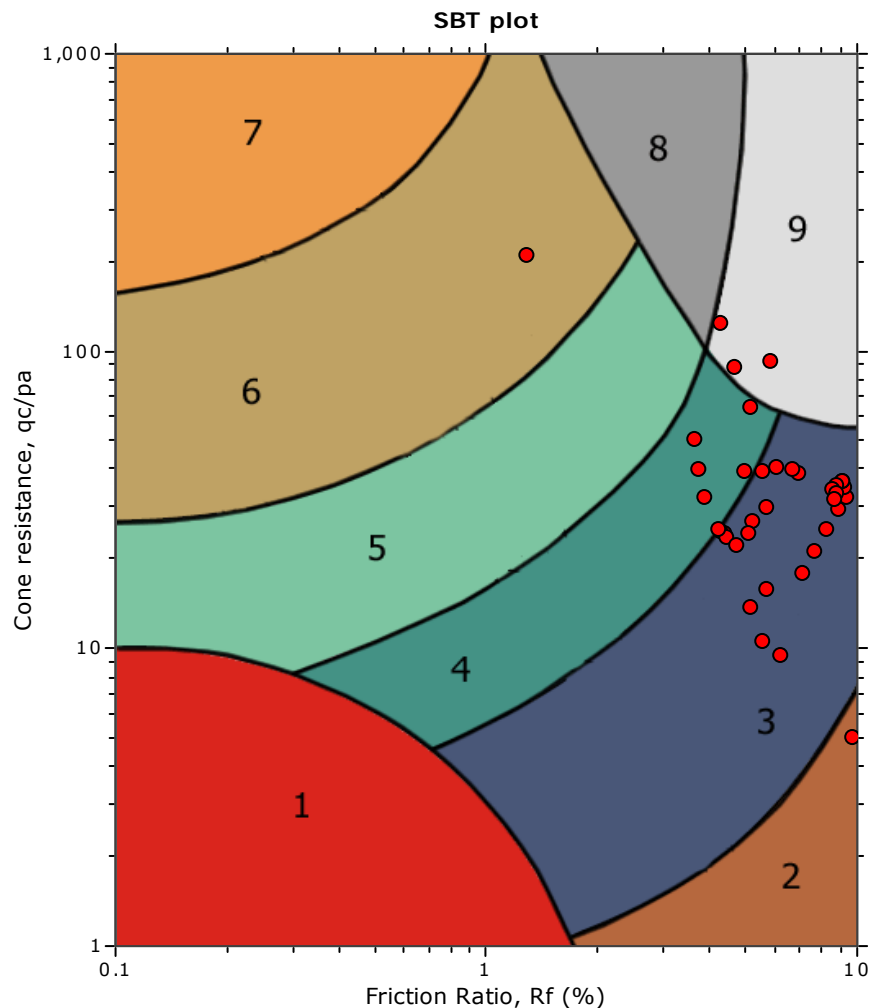
The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



**Project:**

**Location:**

**SBT - Bq plots**



**SBT legend**

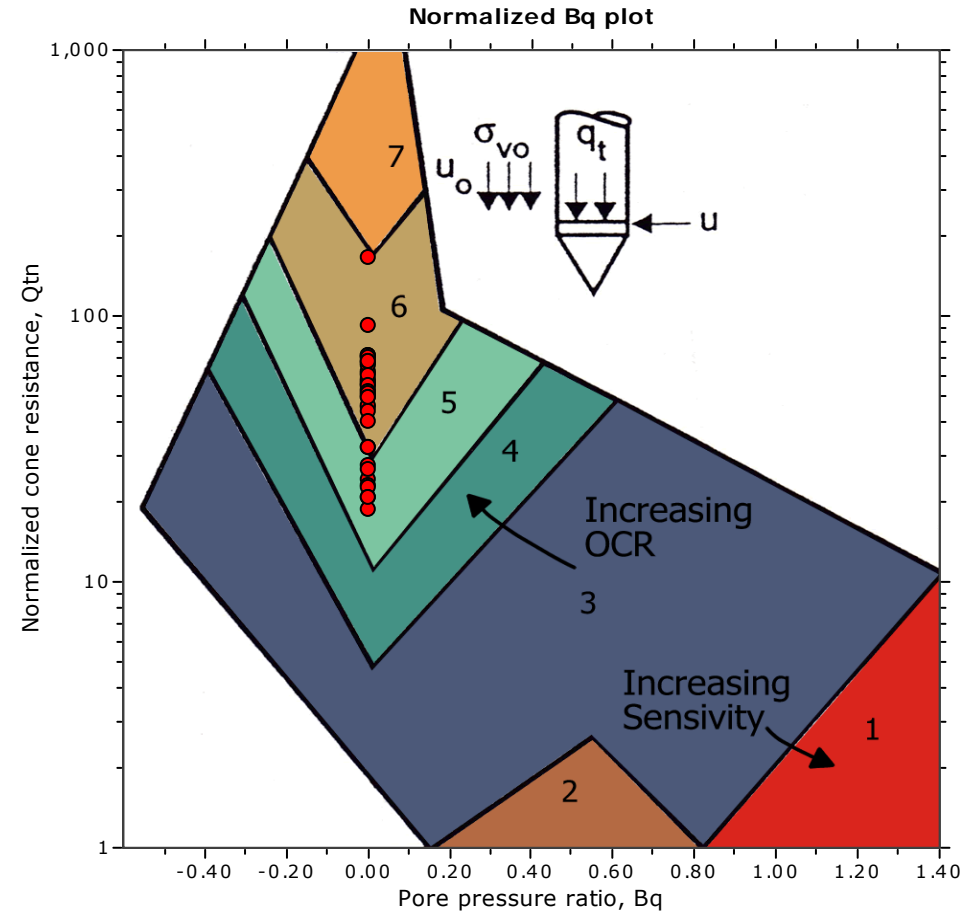
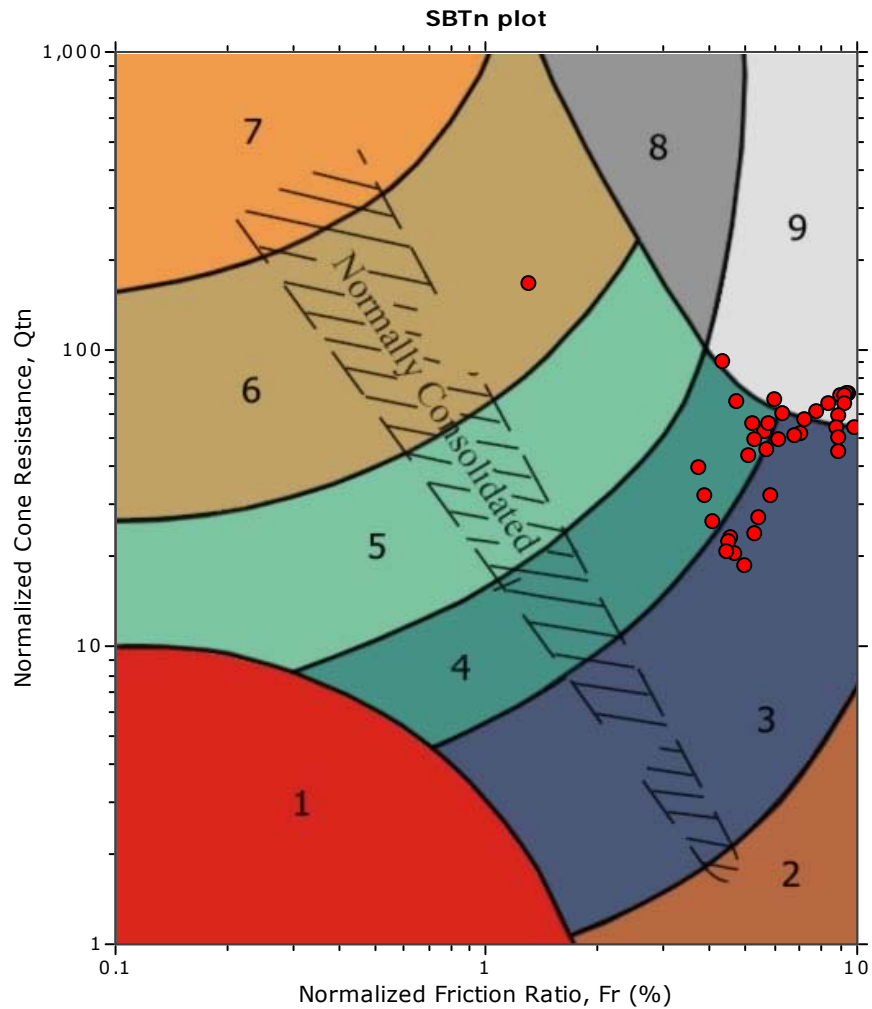
- |  |   |   |
|--|---|---|
| <span style="color: red;">■</span> 1. Sensitive fine grained | <span style="color: teal;">■</span> 4. Clayey silt to silty clay      | <span style="color: orange;">■</span> 7. Gravely sand to sand         |
| <span style="color: brown;">■</span> 2. Organic material     | <span style="color: lightgreen;">■</span> 5. Silty sand to sandy silt | <span style="color: grey;">■</span> 8. Very stiff sand to clayey sand |
| <span style="color: blue;">■</span> 3. Clay to silty clay    | <span style="color: tan;">■</span> 6. Clean sand to silty sand        | <span style="color: lightgrey;">■</span> 9. Very stiff fine grained   |



Project:

Location:

**SBT - Bq plots (normalized)**



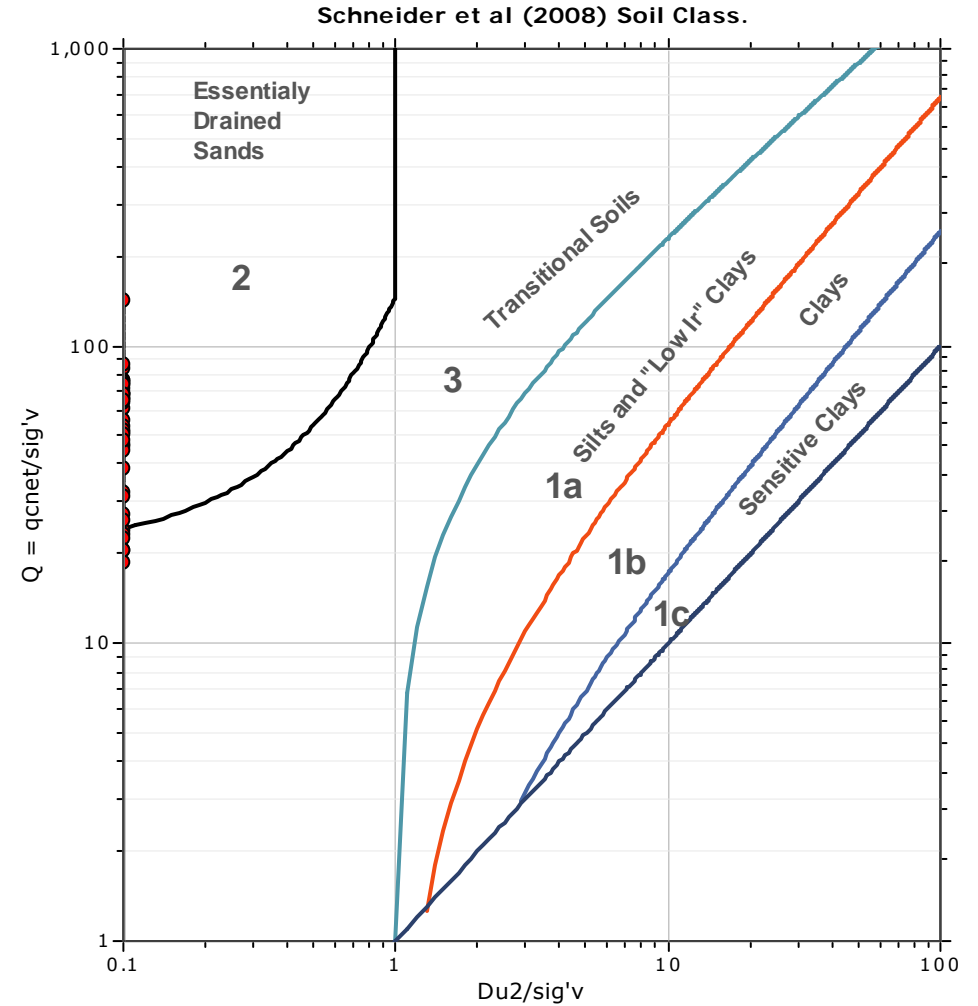
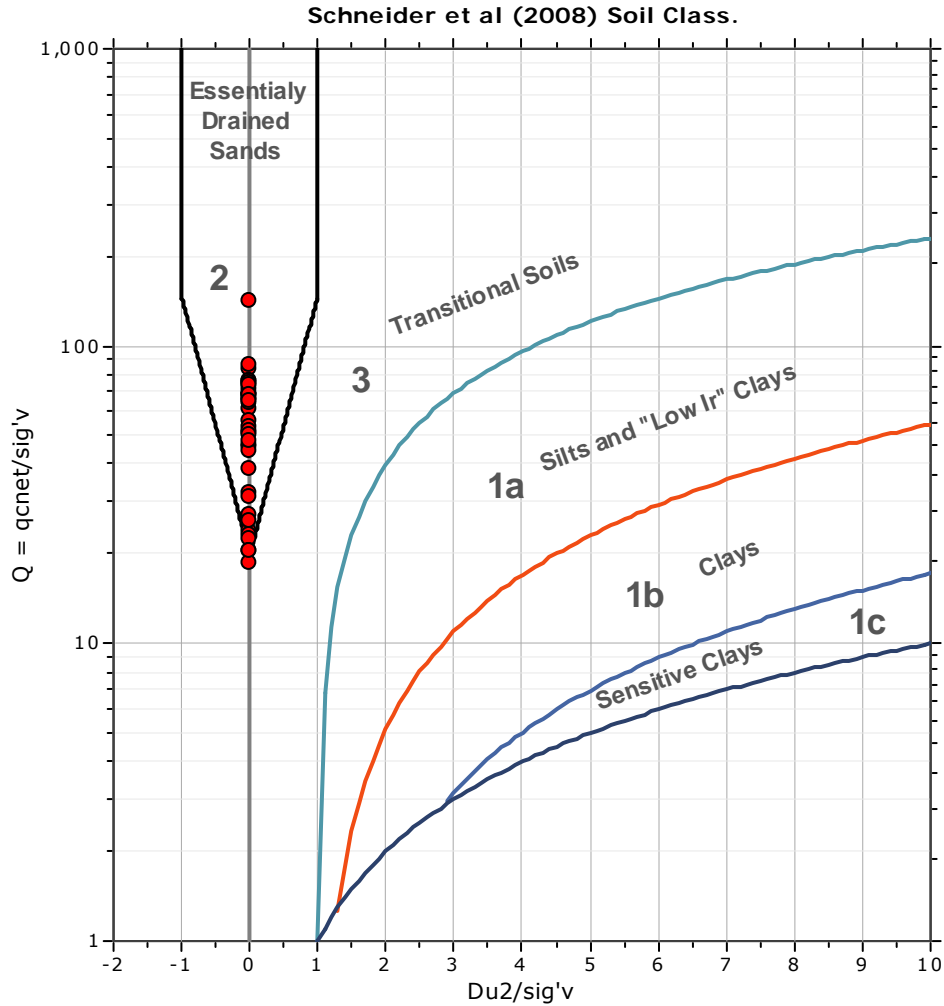
**SBTn legend**

- |  |   |   |
|--|---|---|
| <span style="color: red;">■</span> 1. Sensitive fine grained | <span style="color: teal;">■</span> 4. Clayey silt to silty clay      | <span style="color: orange;">■</span> 7. Gravely sand to sand         |
| <span style="color: brown;">■</span> 2. Organic material     | <span style="color: lightgreen;">■</span> 5. Silty sand to sandy silt | <span style="color: grey;">■</span> 8. Very stiff sand to clayey sand |
| <span style="color: blue;">■</span> 3. Clay to silty clay    | <span style="color: tan;">■</span> 6. Clean sand to silty sand        | <span style="color: lightgrey;">■</span> 9. Very stiff fine grained   |



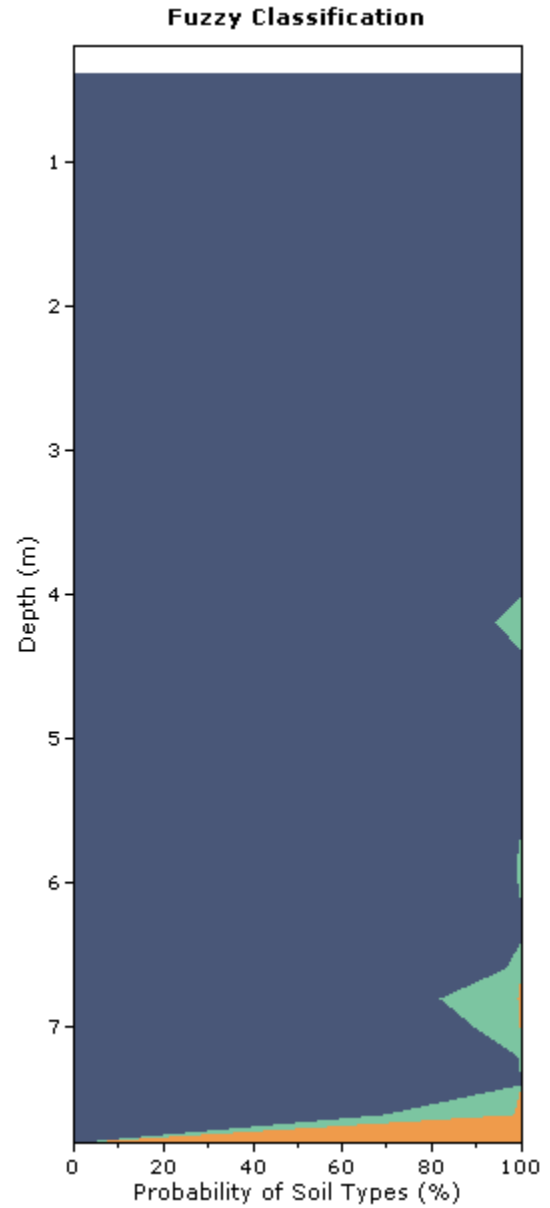
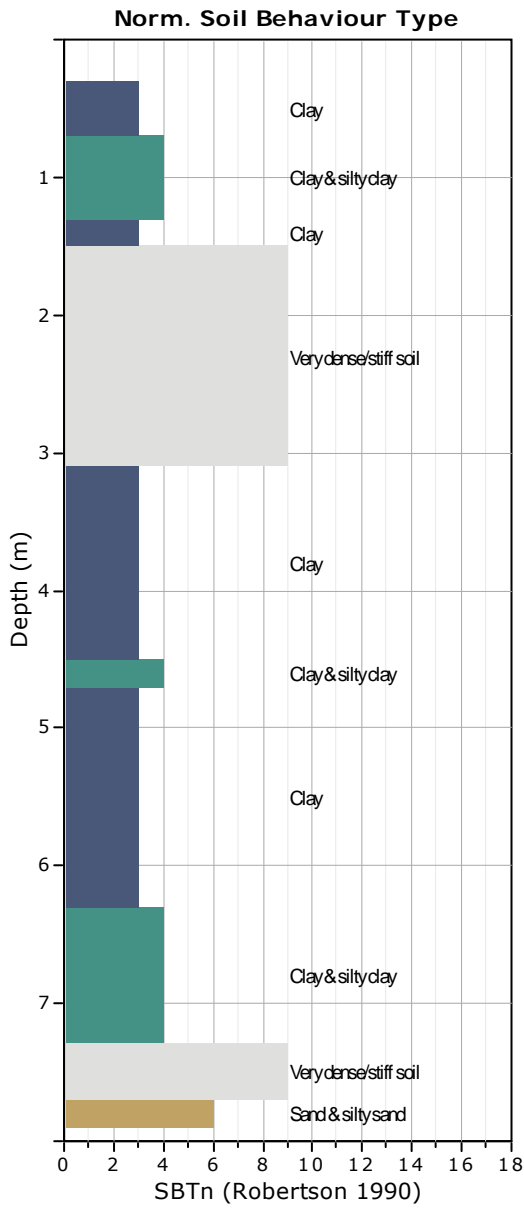
**Project:**  
**Location:**

**Bq plots (Schneider)**





**Project:**  
**Location:**





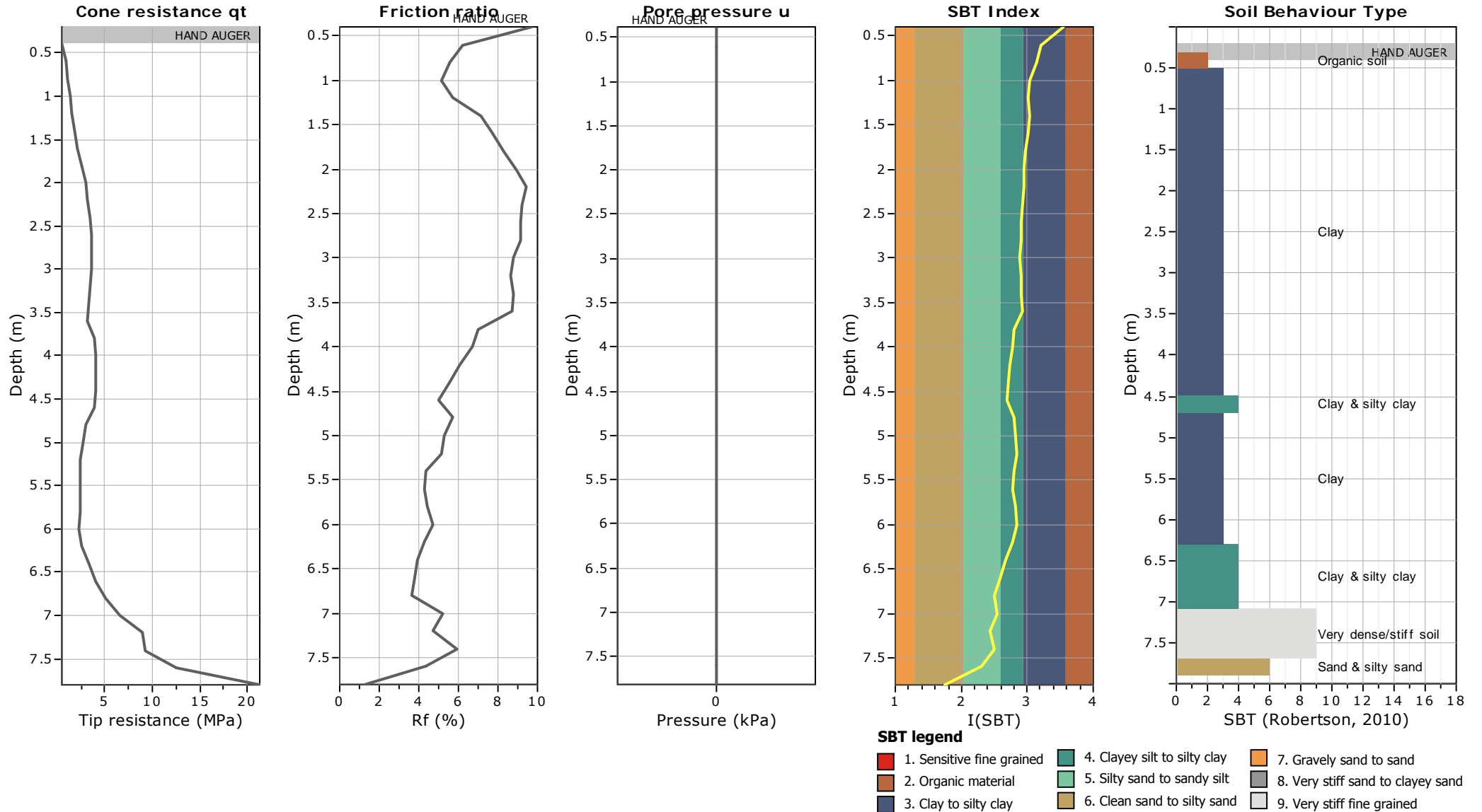
**SUBSOIL Srl**

Indagini Geologiche Monitoraggi Geotecnici  
 Via Morandi 3, 42020 Quattro Castella (RE)  
 Tel. 0522/887268 Fax: 0522/249540

**CPT: CPT-01**

Total depth: 7.80 m, Date: 05/03/2014  
 Surface Elevation: 0.00 m  
 Coords: X:0.00, Y:0.00  
 Cone Type: Unknown  
 Cone Operator: Unknown

**Project:**  
**Location:**





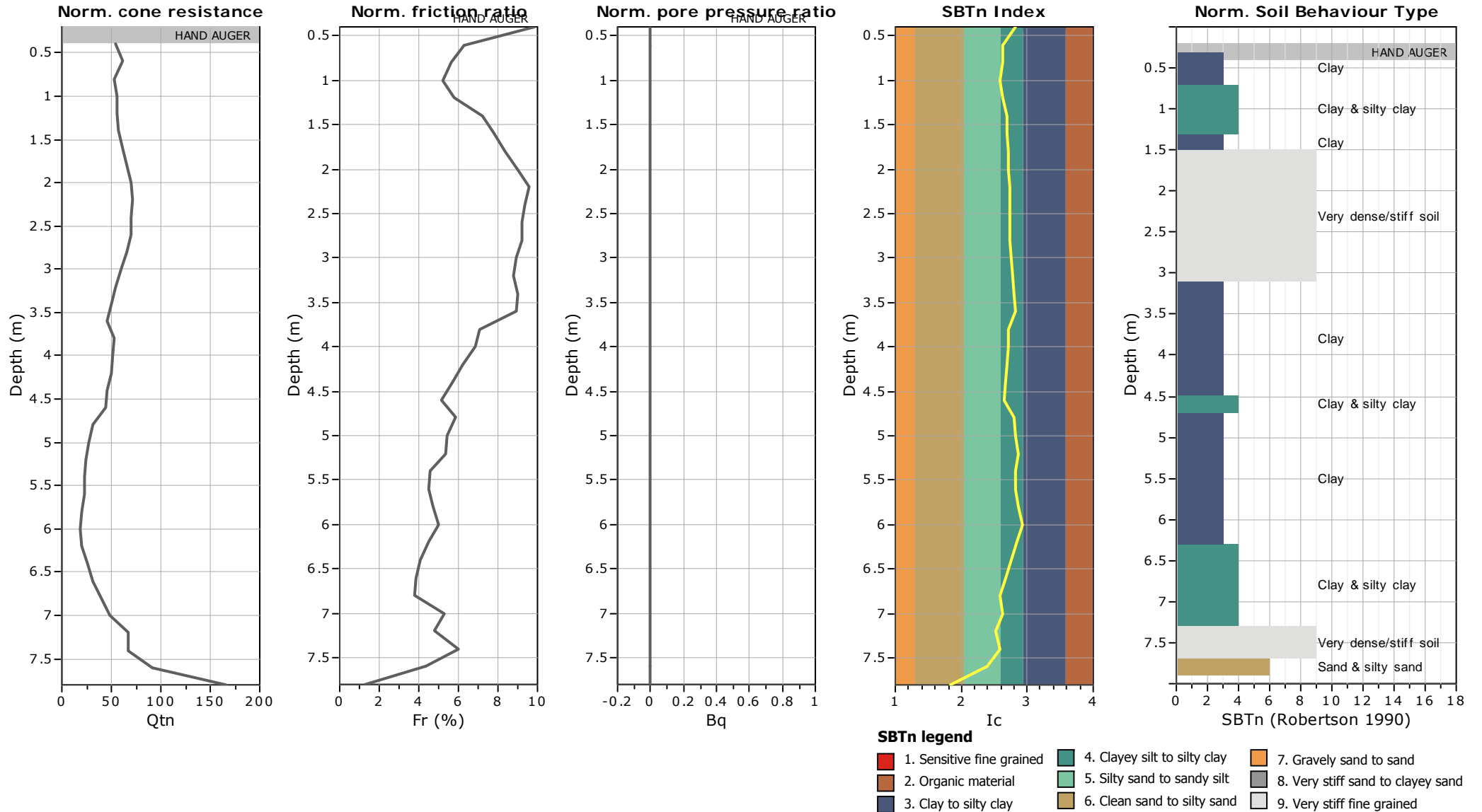
**SUBSOIL Srl**

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 Tel. 0522/887268 Fax: 0522/249540

**CPT: CPT-01**

Total depth: 7.80 m, Date: 05/03/2014  
 Surface Elevation: 0.00 m  
 Coords: X:0.00, Y:0.00  
 Cone Type: Unknown  
 Cone Operator: Unknown

**Project:**  
**Location:**





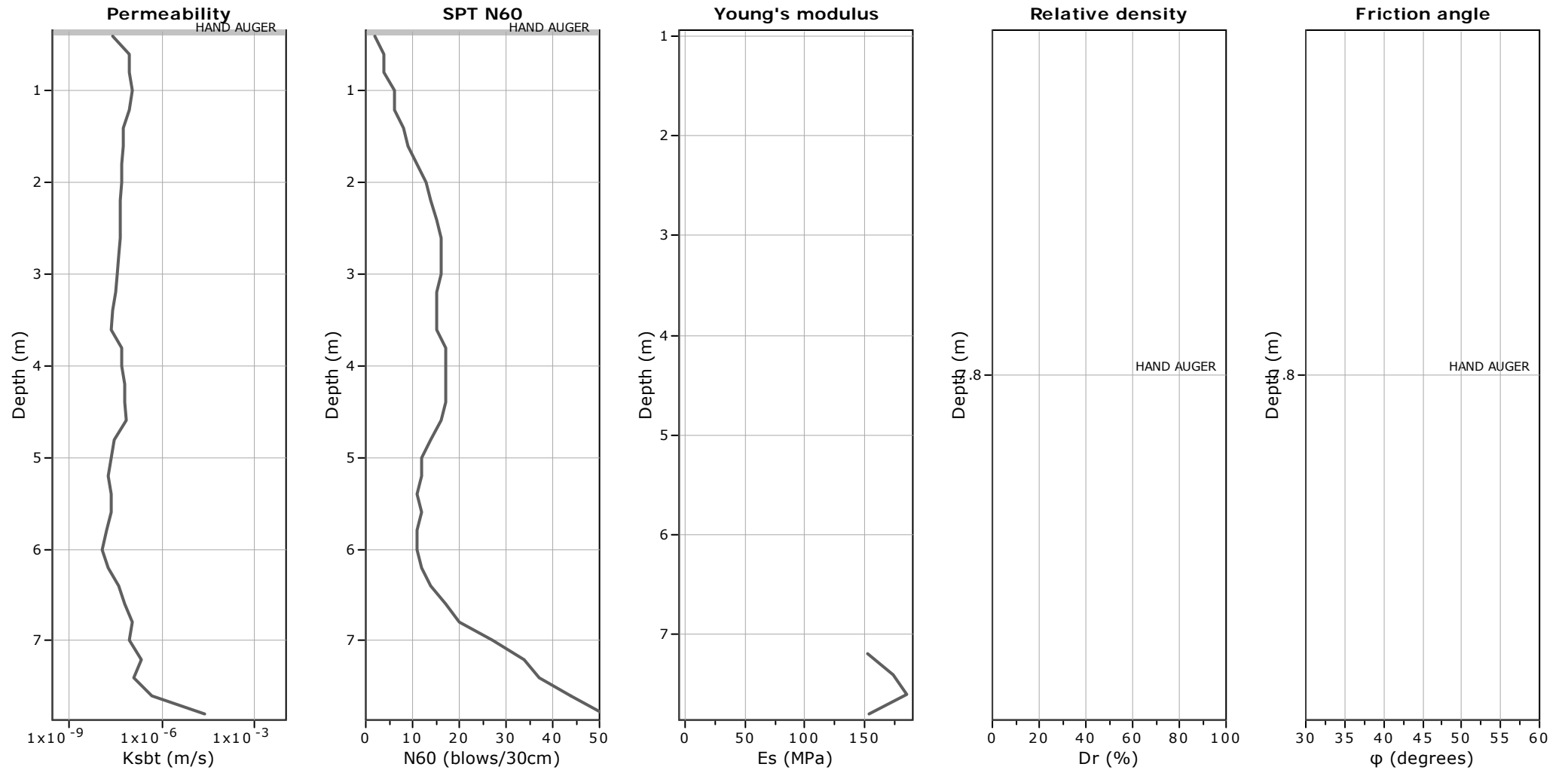
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Indagini Geologiche Monitoraggi Geotecnici  
 Via Morandi 3, 42020 Quattro Castella (RE)  
 Tel. 0522/887268 Fax: 0522/249540

**CPT: CPT-01**

Total depth: 7.80 m, Date: 05/03/2014  
 Surface Elevation: 0.00 m  
 Coords: X:0.00, Y:0.00  
 Cone Type: Unknown  
 Cone Operator: Unknown

**Project:**  
**Location:**



**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



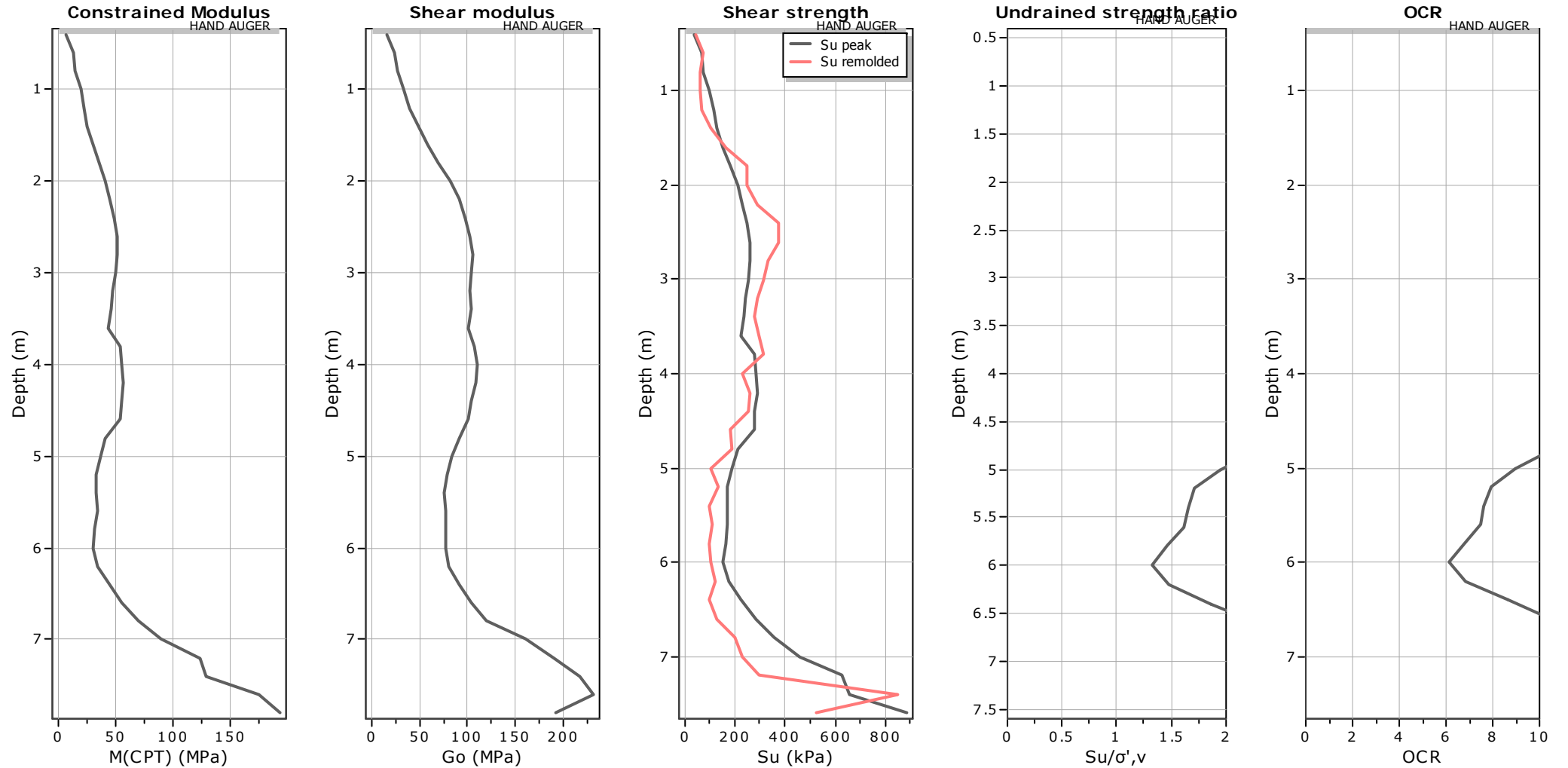
**SUBSOIL Srl**

Indagini Geologiche Monitoraggi Geotecnici  
 Via Morandi 3, 42020 Quattro Castella (RE)  
 Tel. 0522/887268 Fax: 0522/249540

**CPT: CPT-01**

Total depth: 7.80 m, Date: 05/03/2014  
 Surface Elevation: 0.00 m  
 Coords: X:0.00, Y:0.00  
 Cone Type: Unknown  
 Cone Operator: Unknown

**Project:**  
**Location:**



**Calculation parameters**

Constrained modulus: Based on variable *alpha* using  $I_c$  and  $Q_{tn}$  (Robertson, 2009)

Go: Based on variable *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



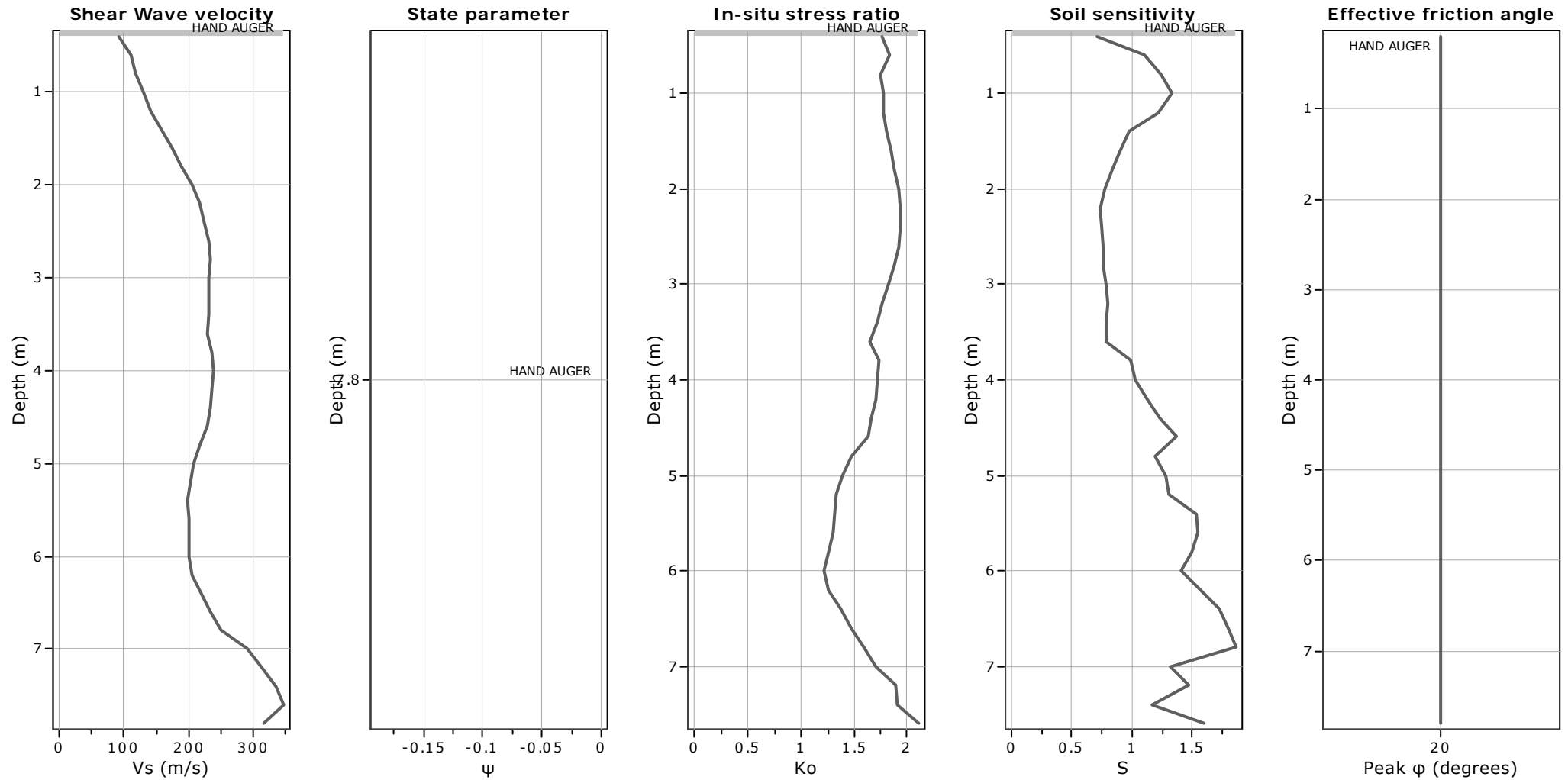
### SUBSOIL Srl

Indagini Geologiche Monitoraggi Geotecnici  
Via Morandi 3, 42020 Quattro Castella (RE)  
Tel. 0522/887268 Fax: 0522/249540

### CPT: CPT-01

Total depth: 7.80 m, Date: 05/03/2014  
Surface Elevation: 0.00 m  
Coords: X:0.00, Y:0.00  
Cone Type: Unknown  
Cone Operator: Unknown

**Project:**  
**Location:**



#### Calculation parameters

Soil Sensitivity factor,  $N_s$ : 7.00

—●— User defined estimation data



**CERTIFICATO DI PROVA n.° 018PS/2014**  
emessa in data 31/03/2014

**SETTORE DI PROVA: 3 – “Prove in sito” – settore “C” Circolare 349/99/STC**

**3.3 PROVE DI DEFORMABILITA' E RESISTENZA MECCANICA:**

CODICE PROVA	DESCIZIONE PROVA	N. PROVE DA ESEGUIRE	NORMATIVA DI RIFERIMENTO
3.3.1.a	Prove penetrometriche statiche con punta meccanica		- <i>Raccomandazioni A.G.I. 1977</i> - <i>ASTM D 3441/86</i>

Committente: EDIL4 SpA

Cantiere: Ex Scuola Elementare di Puianello

N.° commessa: 01808213\_FG

Nome prova: CPT2

Data esecuzione prova: 5 Marzo 2014

**Allegato 1 (risultato della prova):**

	Relazione
X	Diagramma
X	Documentazione fotografica

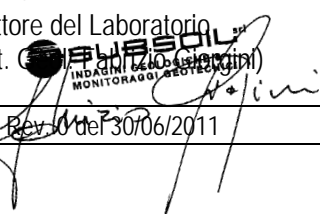
**Allegato 2 (ubicazione del punto di indagine):**

	Corografia in scala opportuna con indicazione ubicazioni
X	Indicazione planoaltimetrica dei punti di indagine
	Coordinate geografiche

Eventuali anomalie riscontrate:.....

Note:  
Falda assente

Tecnico del Laboratorio  
(Dott. Roberto Spagni)

Direttore del Laboratorio  
(Dott.   
SUBSOIL  
INDAGINI GEOLOGICHE & MONITORAGGI GEOTECNICI

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**CERTIFICATO DI PROVA n.° 018PS/2014**  
emessa in data 31/03/2014

**ALLEGATO 1**  
Risultato della prova

**NOME PROVA**  
**CPT2**



Tecnico del Laboratorio  
(Dott. Roberto Spagni)

Direttore del Laboratorio  
(Dott.   


All. 09/09 Certificato di prova Rev. 0 del 30/06/2011

## PROVA PENETROMETRICA STATICA

## CPT 2

Committente: EDIL4 SpA  
Località: Puianello di Quattro Castella (RE)  
Cantiere: Ex Scuole Elementari di Puianello  
Note:

Data:  
quota inizio:  
prof. falda:

5/03/2014  
Piano campagna  
Assente

Prof. m.	LP Kg/cm <sup>2</sup>	LL Kg/cm <sup>2</sup>	RP Kg/cm <sup>2</sup>	RL Kg/cm <sup>2</sup>
0,20	0	0	0	0
0,40	0	0	0	0
0,60	0	0	0	0
0,80	0	0	0	0
1,00	0	0	0	1,13
1,20	20	37	20	1,13
1,40	23	40	23	1,67
1,60	27	52	27	1,67
1,80	25	50	25	2,47
2,00	27	64	27	2,33
2,20	35	70	35	2,8
2,40	36	78	36	3,2
2,60	35	83	35	3,4
2,80	37	88	37	3,4
3,00	37	88	37	3,47
3,20	38	90	38	3,07
3,40	36	82	36	3
3,60	34	79	34	3,07
3,80	35	81	35	2,87
4,00	34	77	34	3,13
4,20	38	85	38	2,53
4,40	33	71	33	2,6
4,60	30	69	30	1,8
4,80	27	54	27	1,8
5,00	29	56	29	1,27
5,20	28	47	28	1,33
5,40	24	44	24	1,07
5,60	25	41	25	1,13
5,80	30	47	30	1,07
6,00	28	44	28	3,33
6,20	75	125	75	3,2
6,40	87	135	87	2,8
6,60	93	135	93	6
6,80	160	250	160	6,67
7,00	250	350	250	0

Tecnico del Laboratorio  
(Dott. Roberto Spagni)

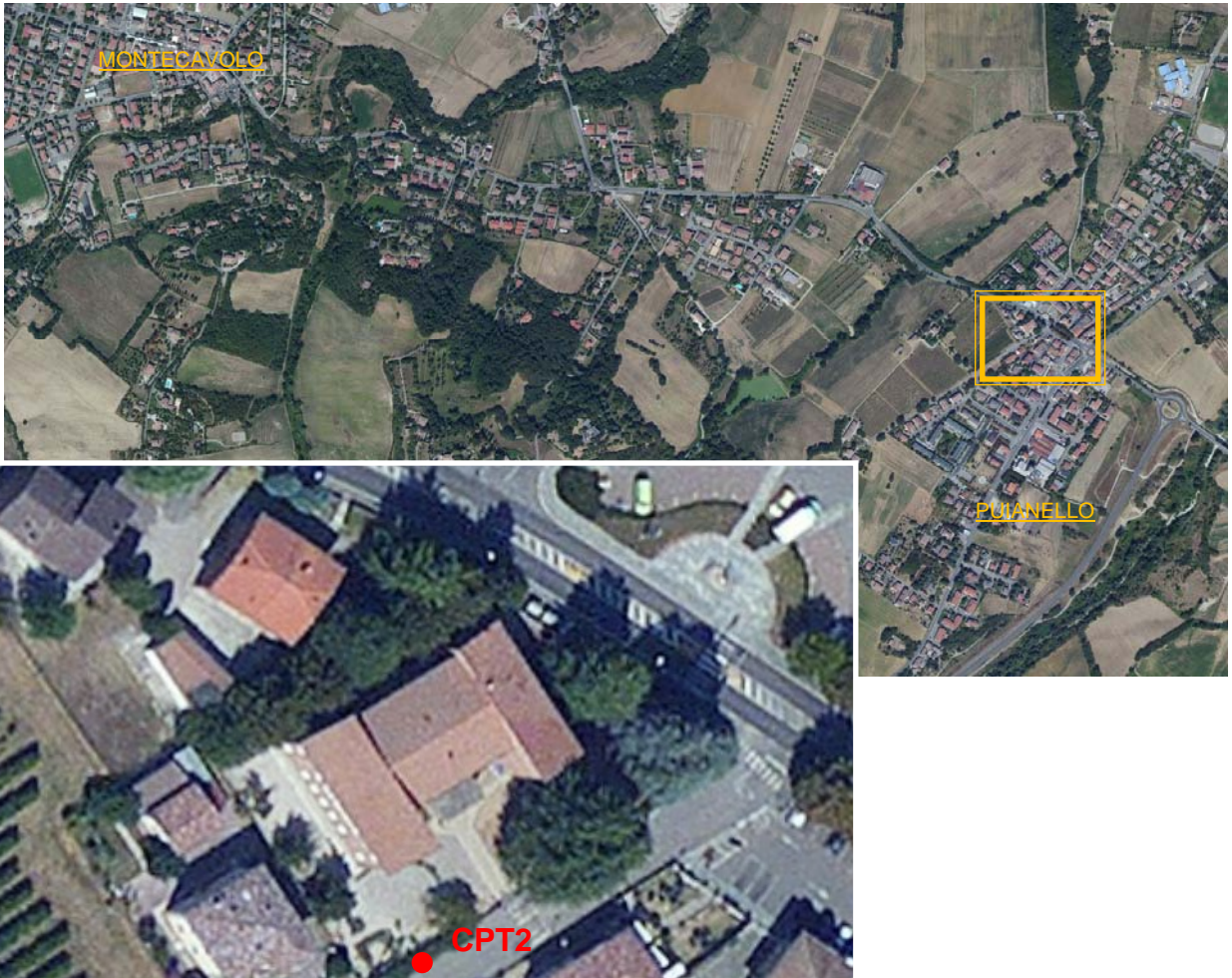
Direttore del Laboratorio  
(Dott.   
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CERTIFICATO DI PROVA n.° 018PS/2014  
emessa in data 31/03/2014

ALLEGATO 2  
Ubicazione della prova

NOME PROVA  
CPT1



Legenda:

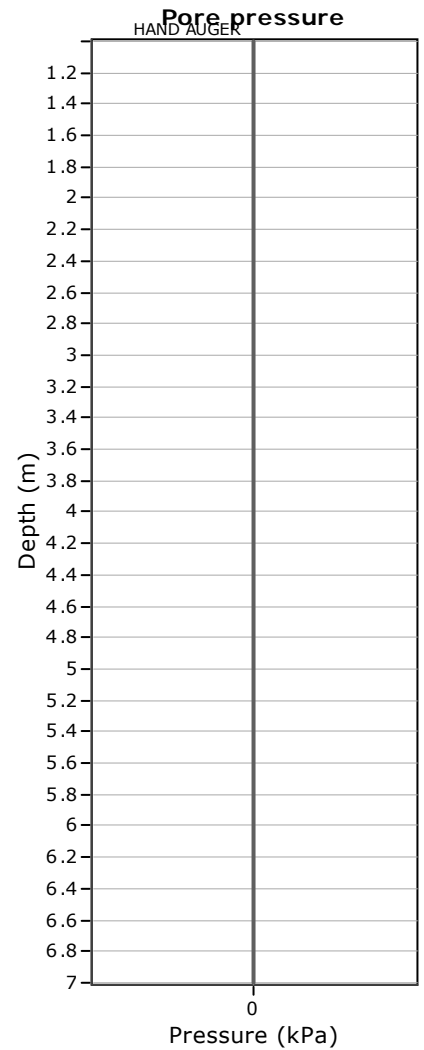
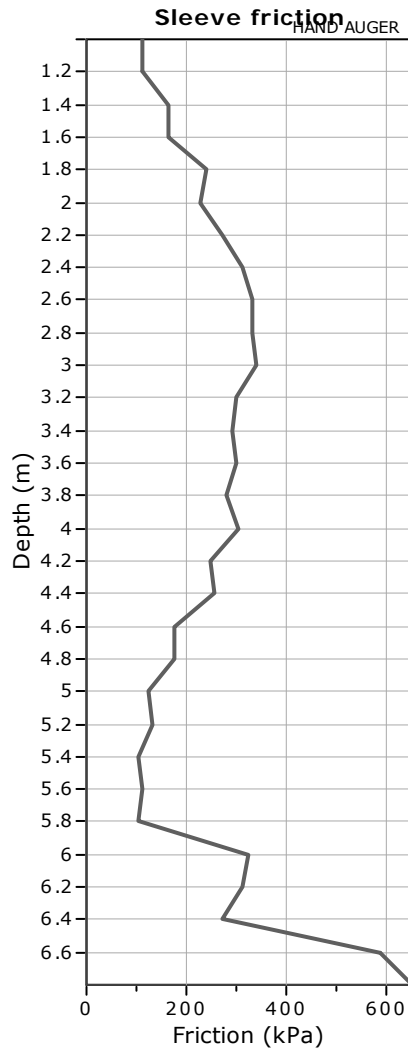
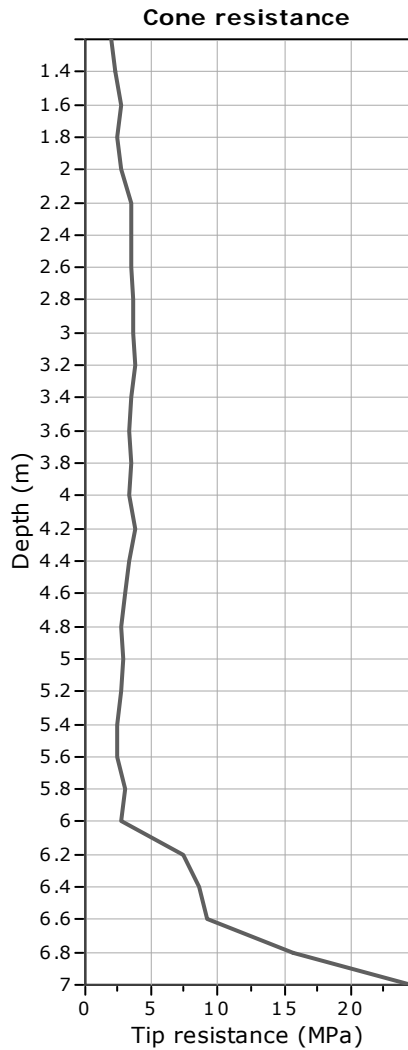
● CPT2

Tecnico del Laboratorio  
(Dott. Roberto Spagni)

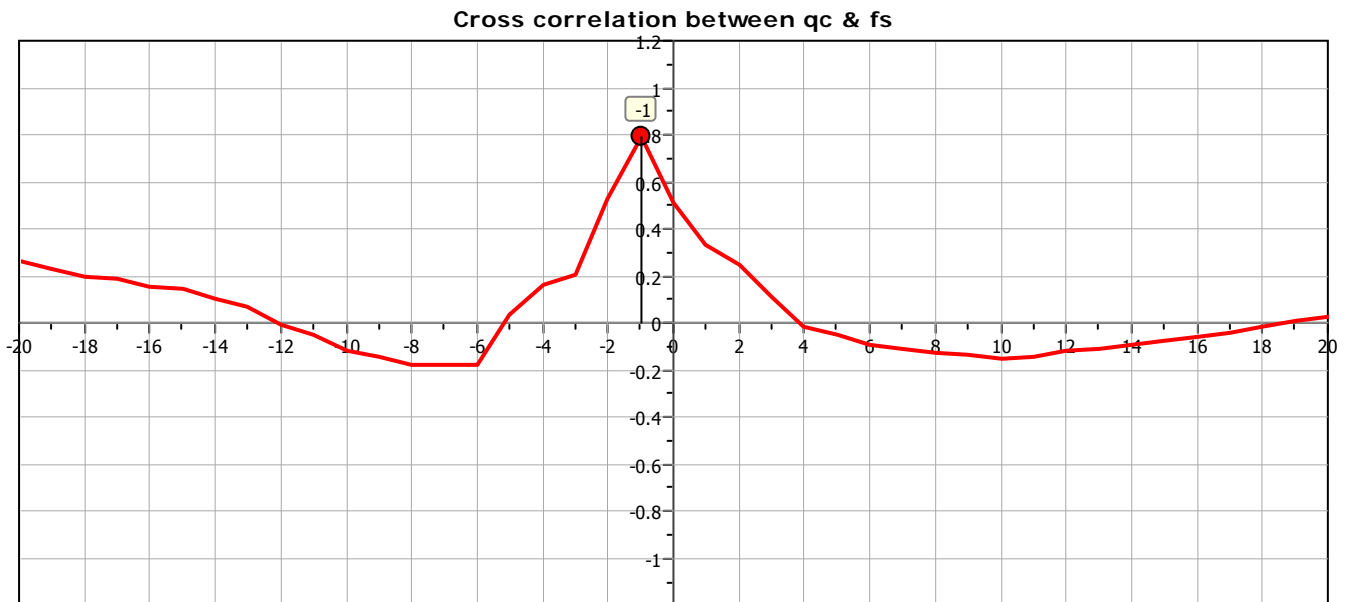
Direttore del Laboratorio  
(Dott.   
SUBSOIL  
INDAGINI GEOLOGICHE  
MONITORAGGI GEOTECNICI

All. 09/09 Certificato di prova Rev. 0 del 30/06/2011

**Project:**  
**Location:**



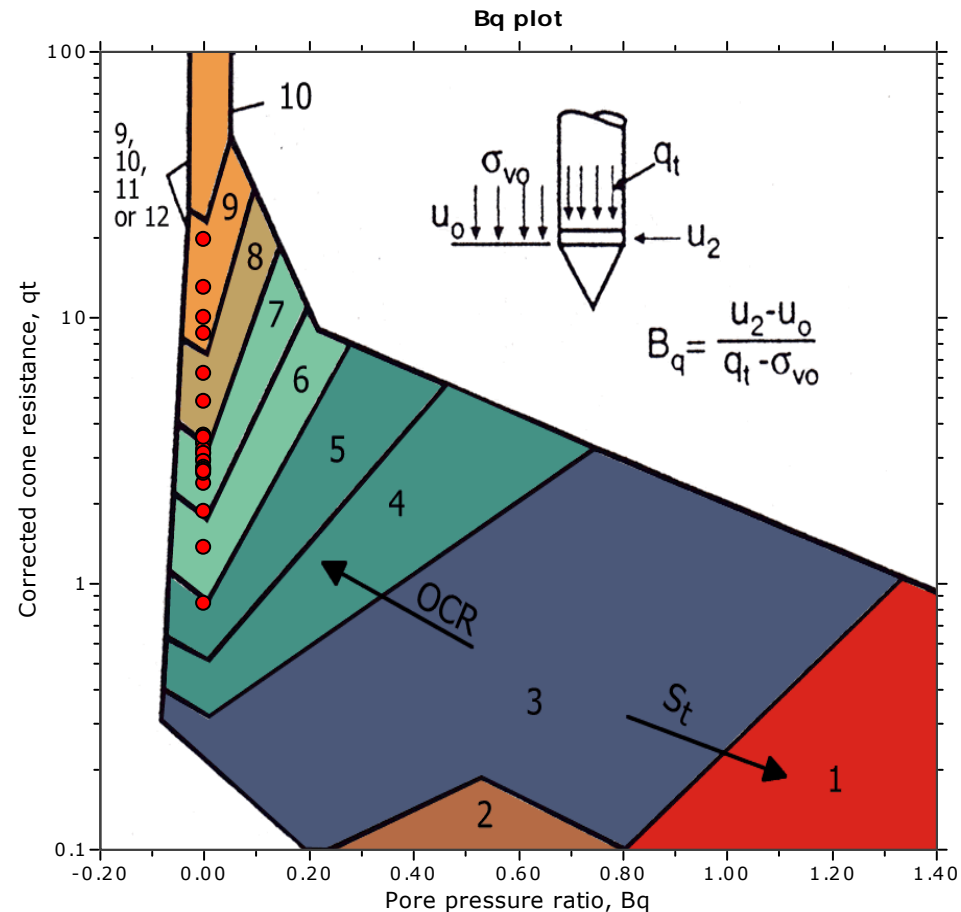
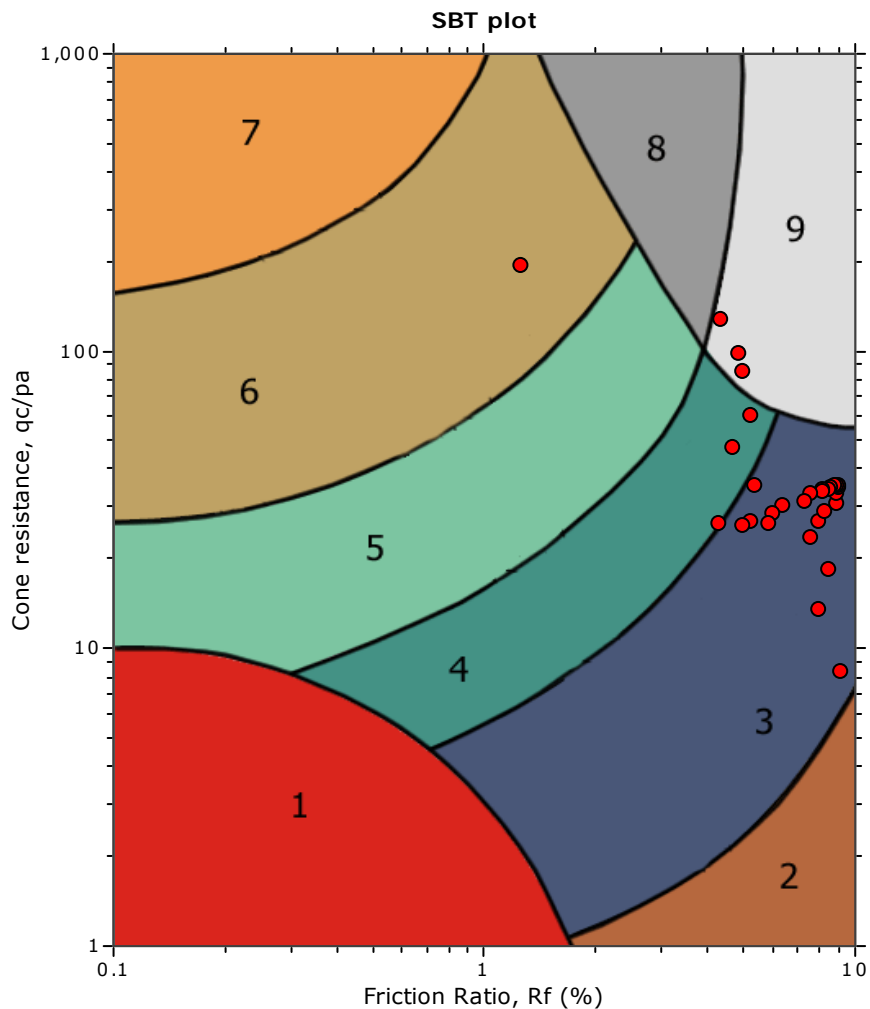
The plot below presents the cross correlation coefficient between the raw  $q_c$  and  $f_s$  values (as measured on the field). X axes presents the lag distance (one lag is the distance between two successive CPT measurements).



**Project:**

**Location:**

**SBT - Bq plots**



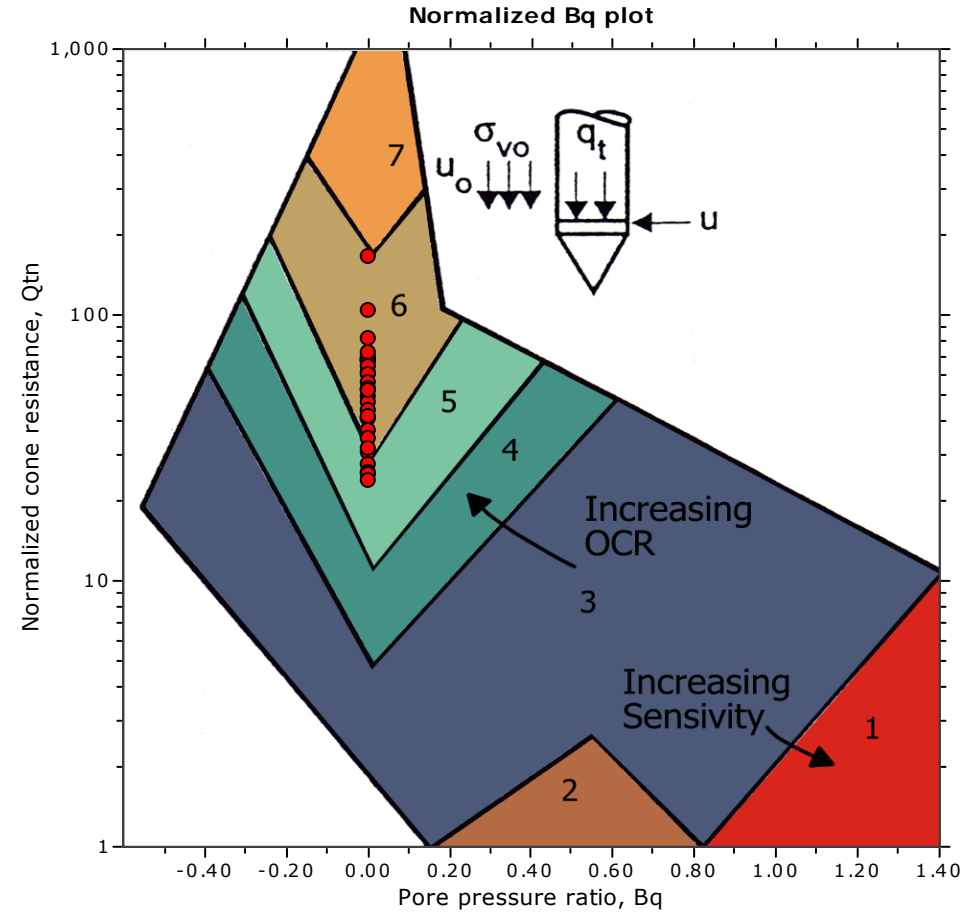
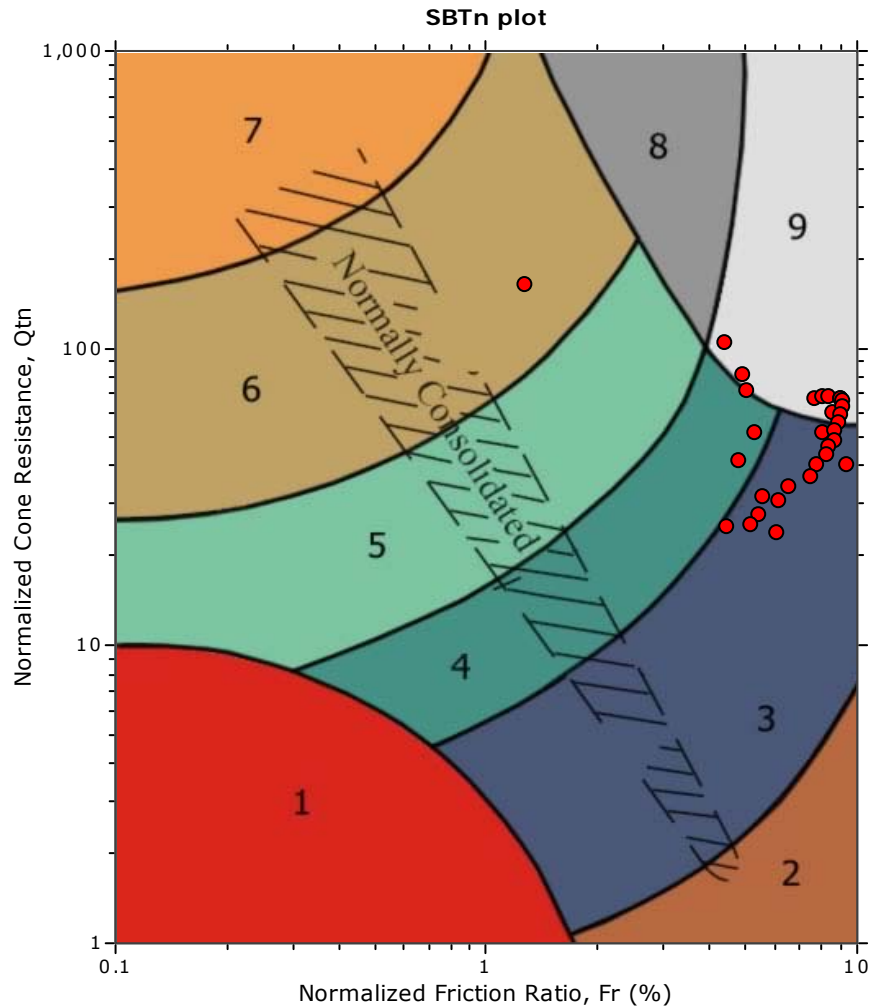
**SBT legend**

- |  |   |   |
|--|---|---|
| <span style="color: red;">■</span> 1. Sensitive fine grained | <span style="color: teal;">■</span> 4. Clayey silt to silty clay      | <span style="color: orange;">■</span> 7. Gravely sand to sand         |
| <span style="color: brown;">■</span> 2. Organic material     | <span style="color: lightgreen;">■</span> 5. Silty sand to sandy silt | <span style="color: grey;">■</span> 8. Very stiff sand to clayey sand |
| <span style="color: blue;">■</span> 3. Clay to silty clay    | <span style="color: tan;">■</span> 6. Clean sand to silty sand        | <span style="color: lightgrey;">■</span> 9. Very stiff fine grained   |

**Project:**

**Location:**

**SBT - Bq plots (normalized)**



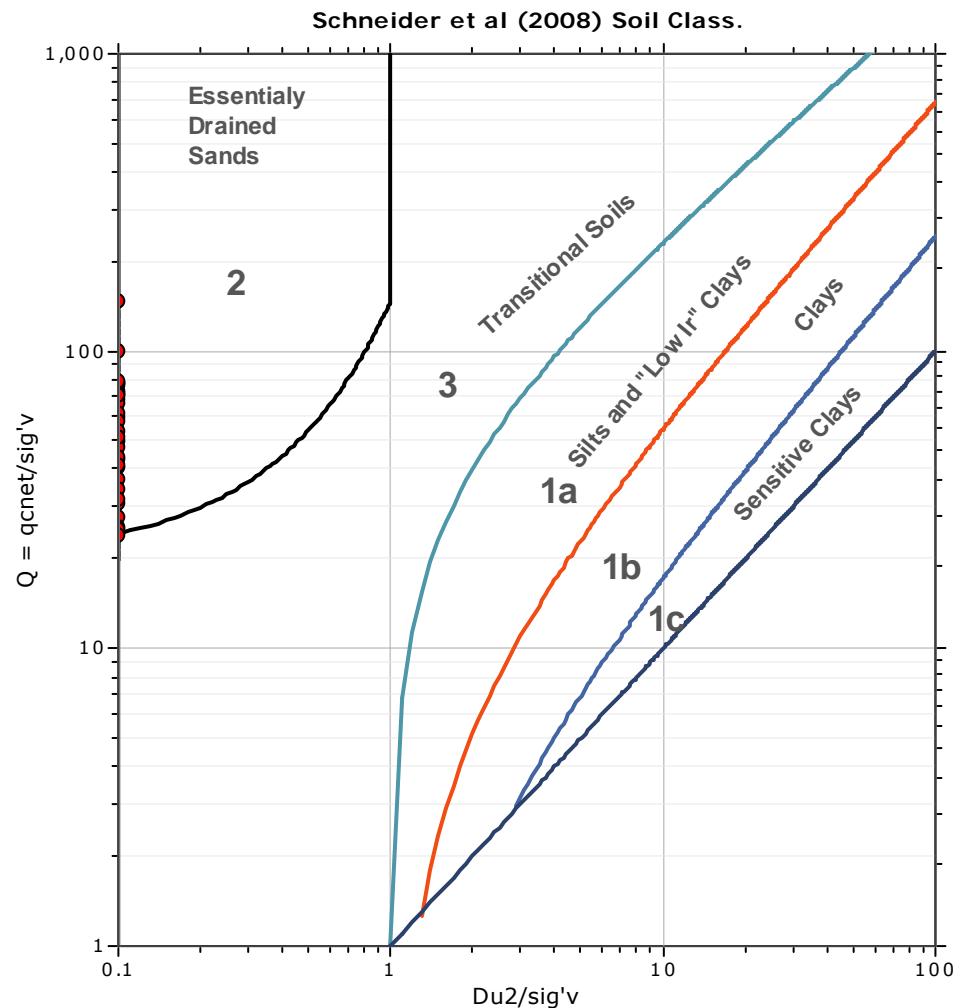
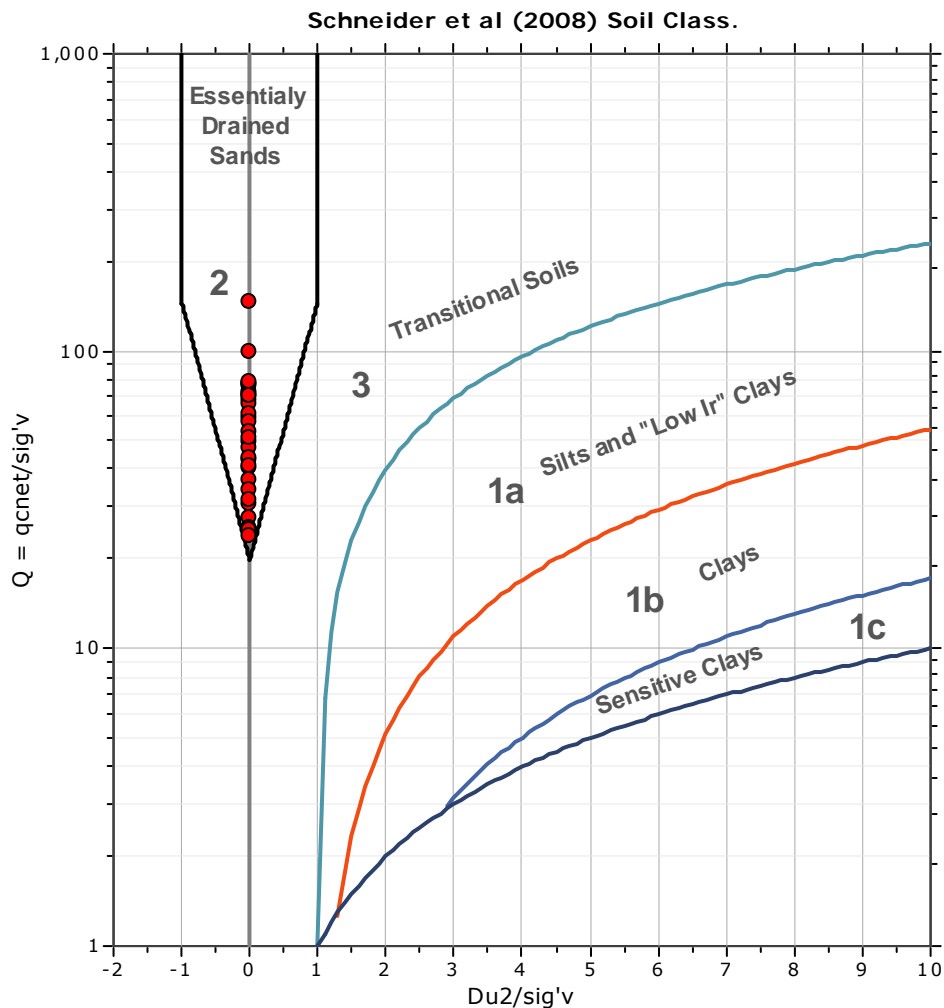
**SBTn legend**

- |  |   |   |
|--|---|---|
| <span style="color: red;">■</span> 1. Sensitive fine grained | <span style="color: teal;">■</span> 4. Clayey silt to silty clay      | <span style="color: orange;">■</span> 7. Gravely sand to sand         |
| <span style="color: brown;">■</span> 2. Organic material     | <span style="color: lightgreen;">■</span> 5. Silty sand to sandy silt | <span style="color: grey;">■</span> 8. Very stiff sand to clayey sand |
| <span style="color: blue;">■</span> 3. Clay to silty clay    | <span style="color: tan;">■</span> 6. Clean sand to silty sand        | <span style="color: lightgrey;">■</span> 9. Very stiff fine grained   |

Project:

Location:

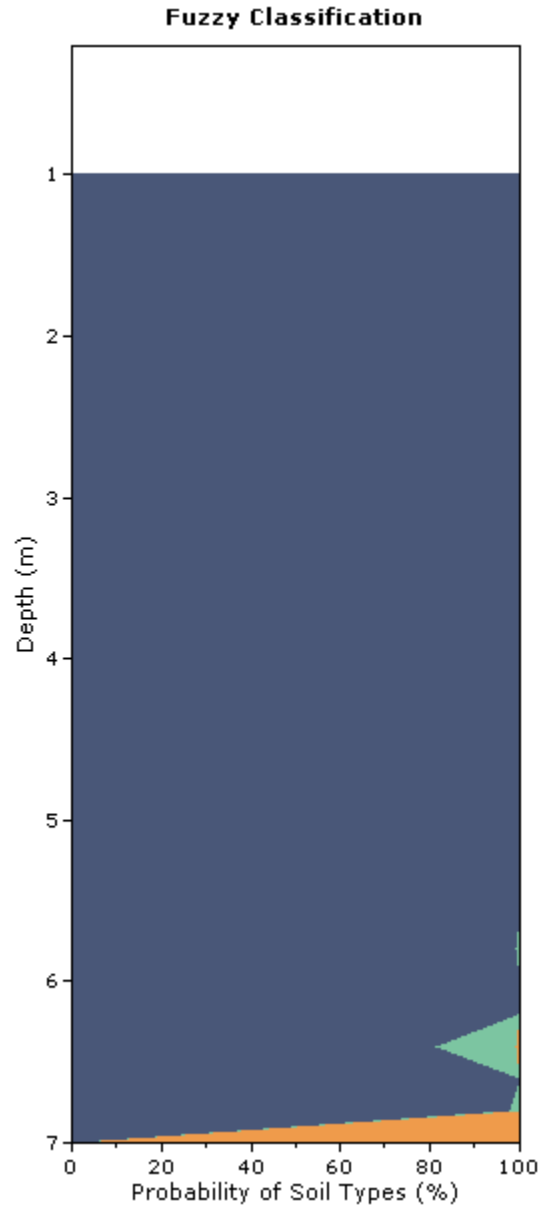
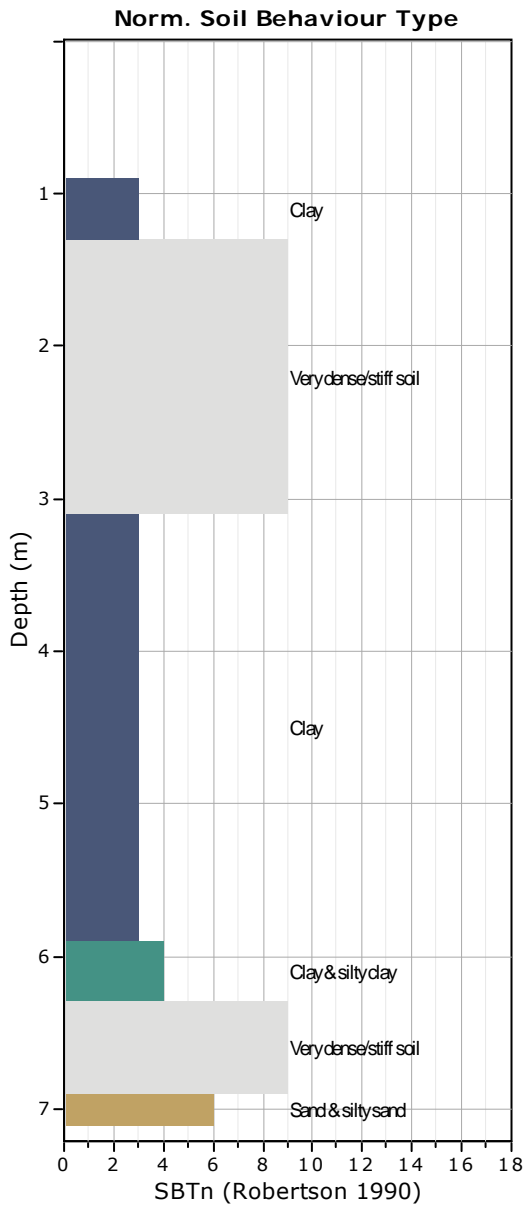
**Bq plots (Schneider)**







**Project:**  
**Location:**





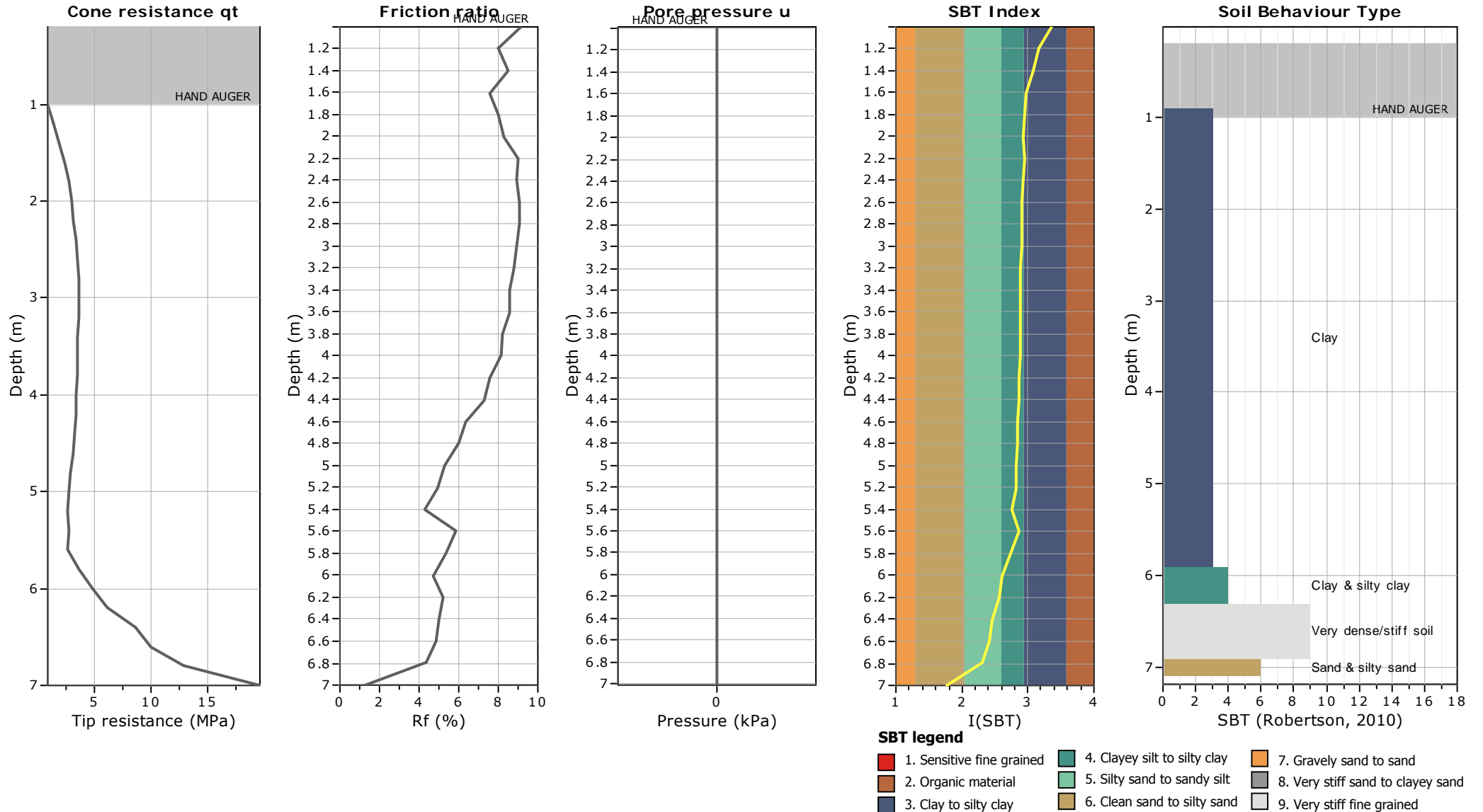
**SUBSOIL Srl**

Indagini Geologiche Monitoraggi Geotecnici  
 Via Morandi 3, 42020 Quattro Castella (RE)  
 Tel. 0522/887268 Fax: 0522/249540

**CPT: CPT-02**

Total depth: 7.00 m, Date: 05/03/2014  
 Surface Elevation: 0.00 m  
 Coords: X:0.00, Y:0.00  
 Cone Type: Unknown  
 Cone Operator: Unknown

**Project:**  
**Location:**





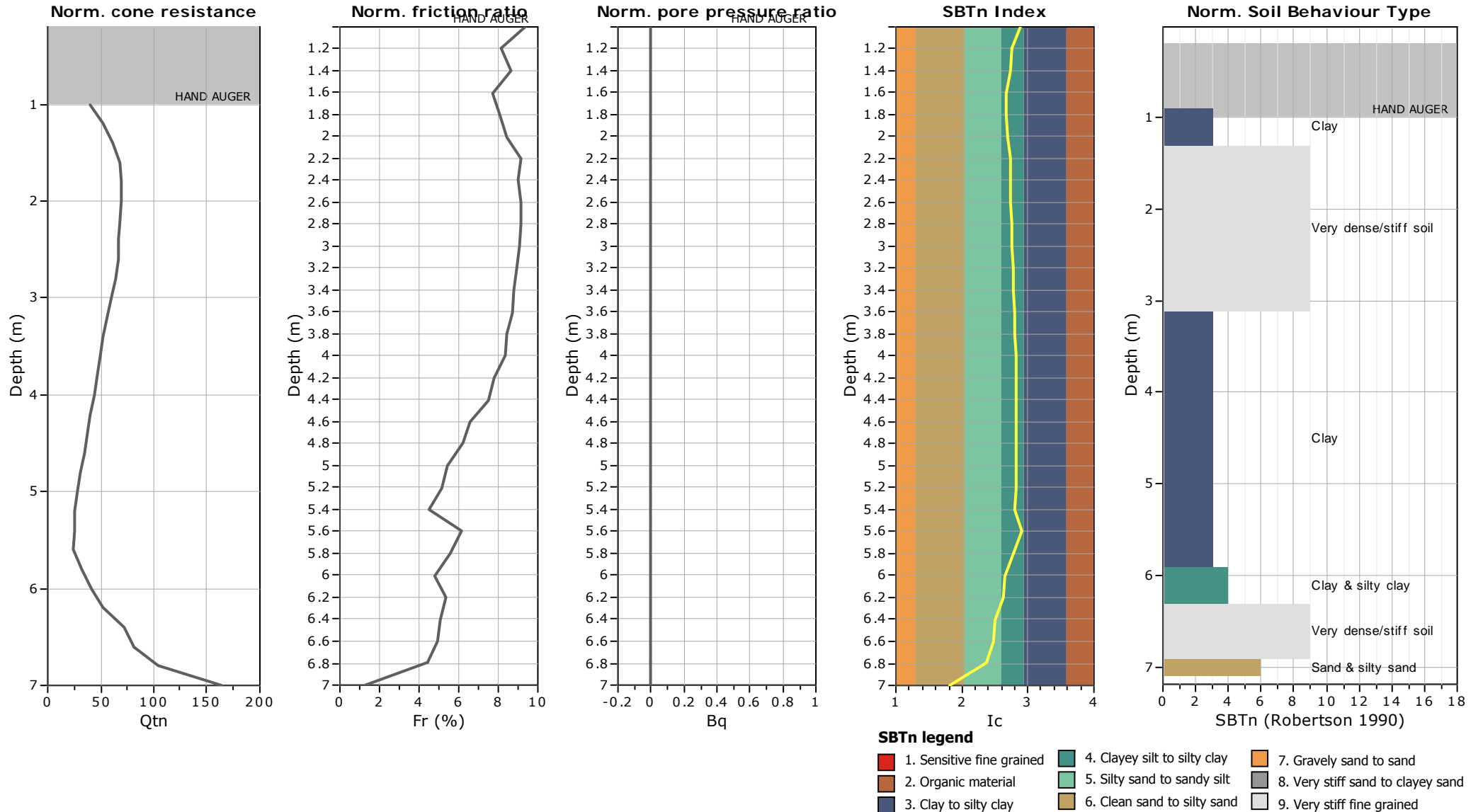
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 Via Morandi 3, 42020 Quattro Castella (RE)  
 Tel. 0522/887268 Fax: 0522/249540

**CPT: CPT-02**

Total depth: 7.00 m, Date: 05/03/2014  
 Surface Elevation: 0.00 m  
 Coords: X:0.00, Y:0.00  
 Cone Type: Unknown  
 Cone Operator: Unknown

**Project:**  
**Location:**





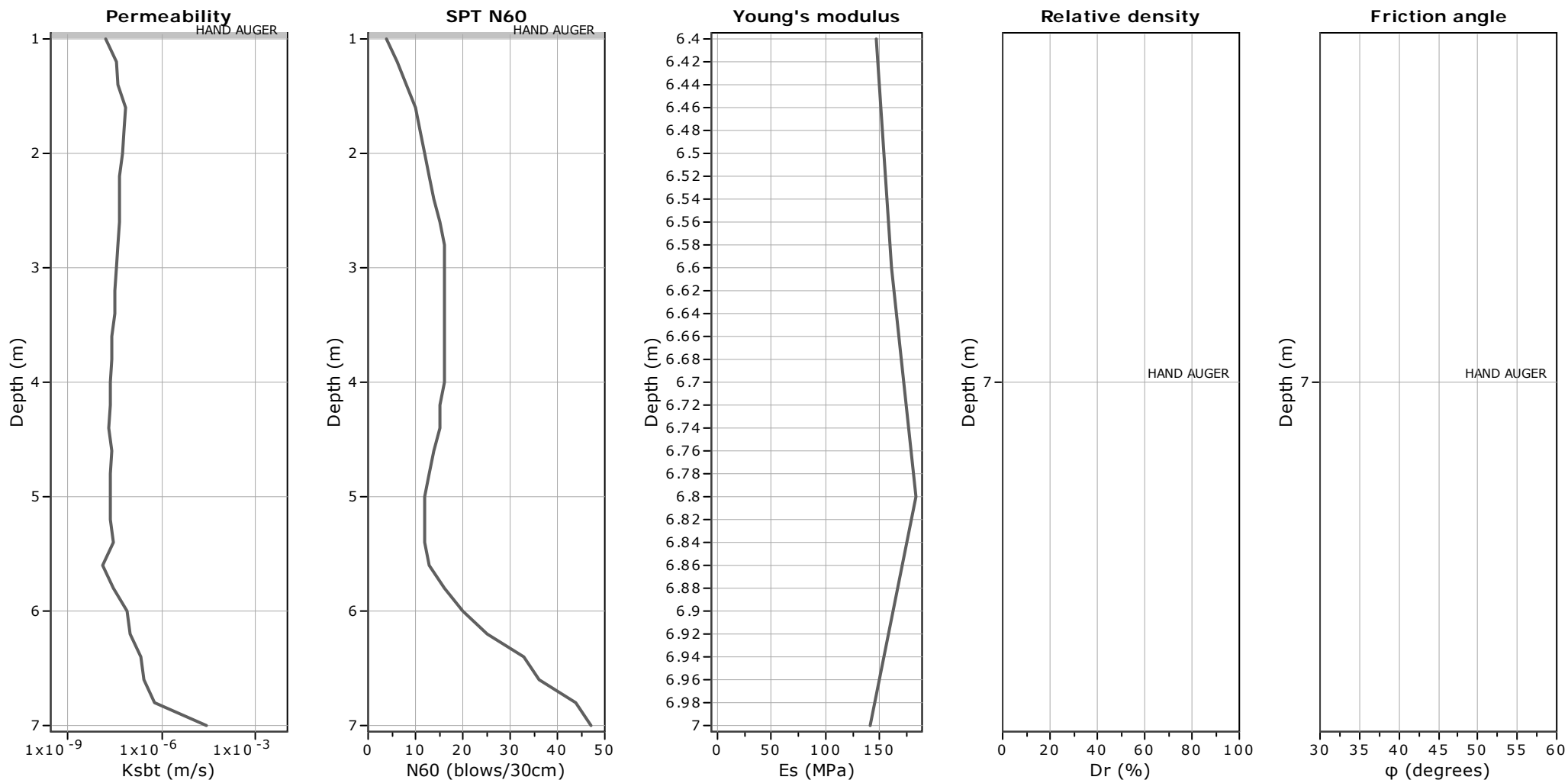
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 Tel. 0522/887268 Fax: 0522/249540

**CPT: CPT-02**

Total depth: 7.00 m, Date: 05/03/2014  
 Surface Elevation: 0.00 m  
 Coords: X:0.00, Y:0.00  
 Cone Type: Unknown  
 Cone Operator: Unknown

**Project:**  
**Location:**



**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



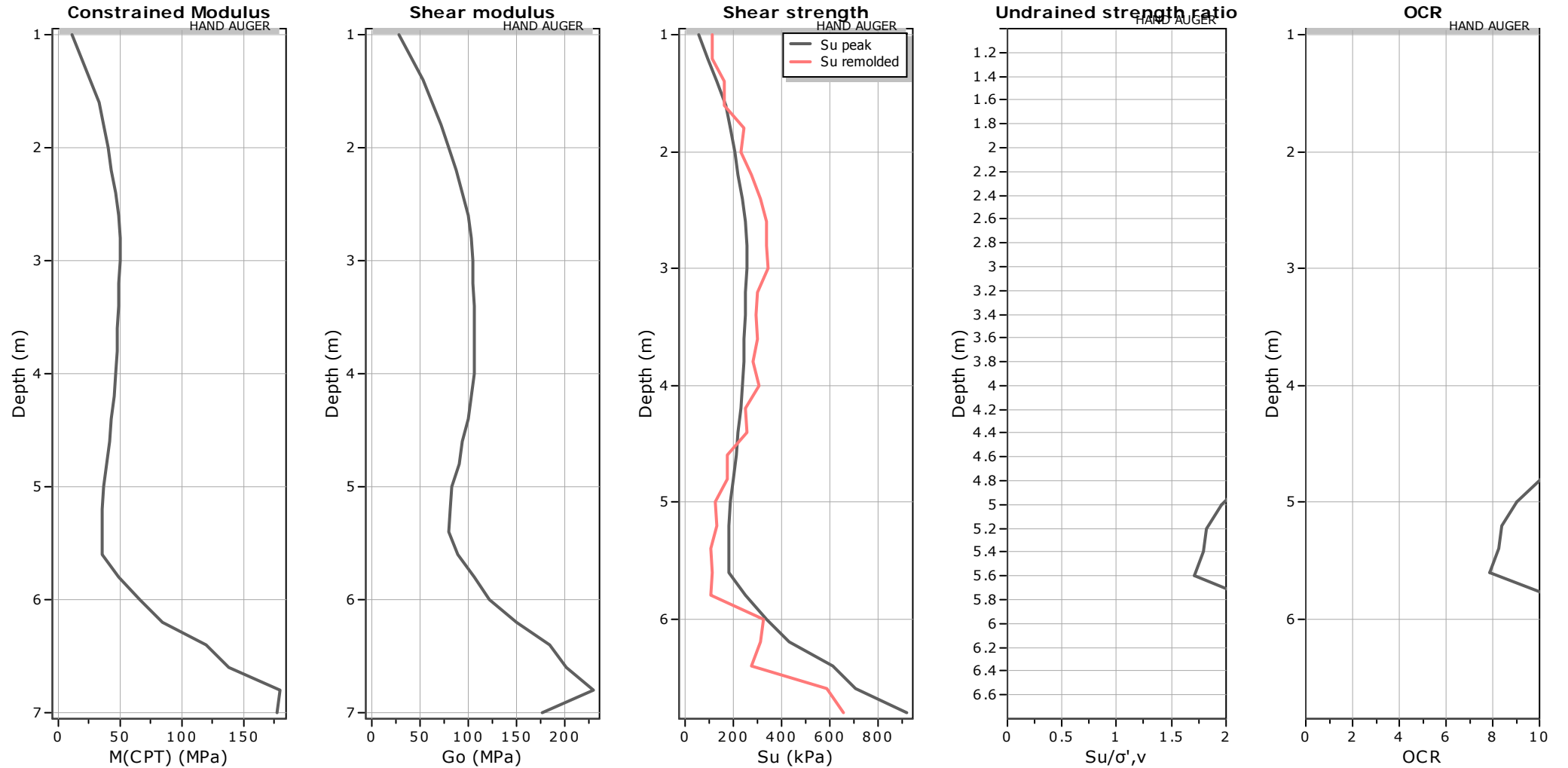
**SUBSOIL Srl**

Indagini Geologiche Monitoraggi Geotecnici  
 Via Morandi 3, 42020 Quattro Castella (RE)  
 Tel. 0522/887268 Fax: 0522/249540

**CPT: CPT-02**

Total depth: 7.00 m, Date: 05/03/2014  
 Surface Elevation: 0.00 m  
 Coords: X:0.00, Y:0.00  
 Cone Type: Unknown  
 Cone Operator: Unknown

**Project:**  
**Location:**



**Calculation parameters**

Constrained modulus: Based on variable *alpha* using  $I_c$  and  $Q_{tn}$  (Robertson, 2009)

Go: Based on variable *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



### SUBSOIL Srl

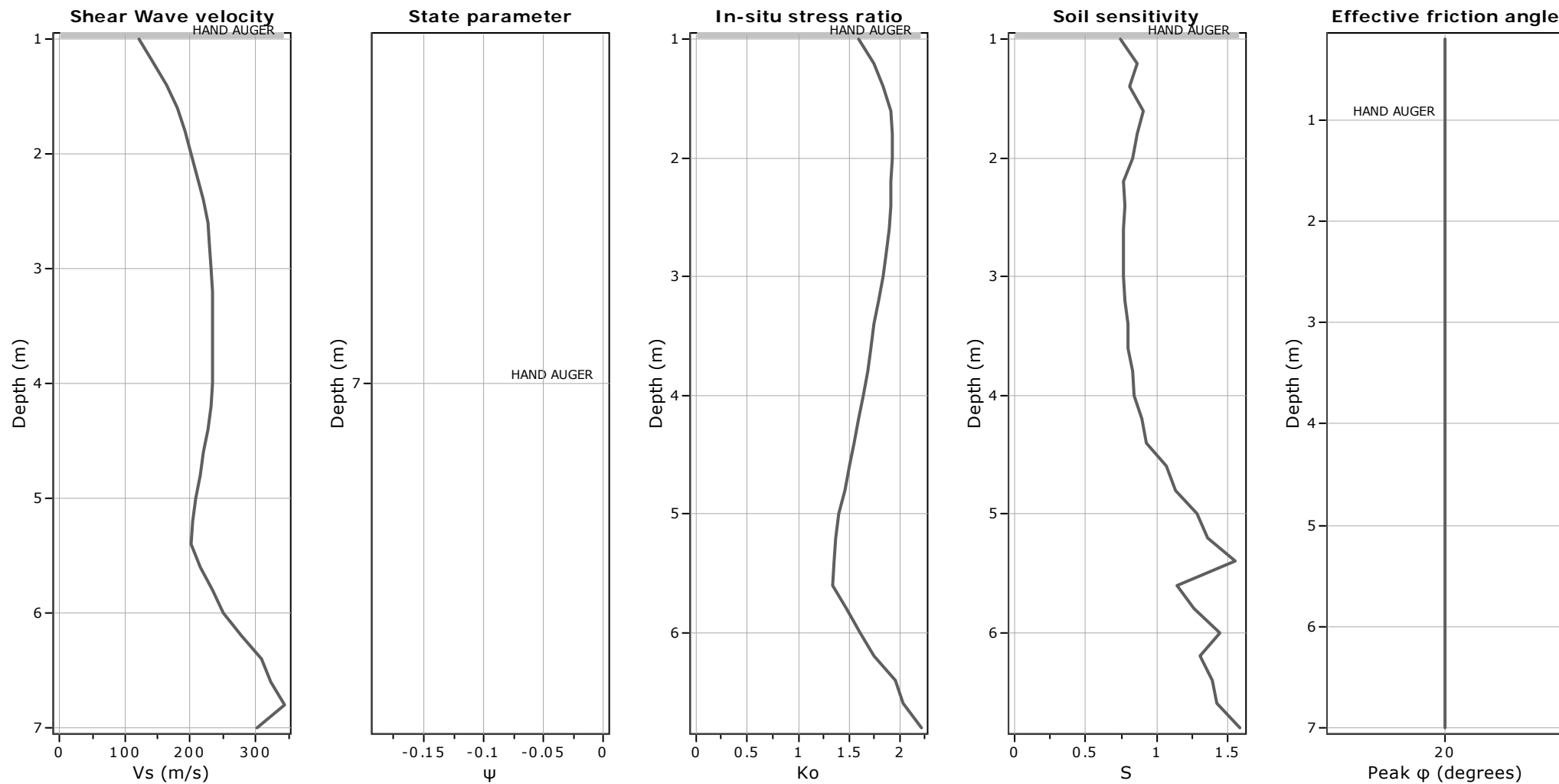
Indagini Geologiche Monitoraggi Geotecnici  
Via Morandi 3, 42020 Quattro Castella (RE)  
Tel. 0522/887268 Fax: 0522/249540

### CPT: CPT-02

Total depth: 7.00 m, Date: 05/03/2014  
Surface Elevation: 0.00 m  
Coords: X:0.00, Y:0.00  
Cone Type: Unknown  
Cone Operator: Unknown

Project:

Location:



#### Calculation parameters

Soil Sensitivity factor,  $N_s$ : 7.00

—●— User defined estimation data

## ALLEGATO 2

Tabelle parametri

CPT1

CPT2

Depth (m)	In situ data						Estimations													
	qc (MPa)	fs (kPa)	SBTn	Ksbt (m/s)	SPT N60 (blows/30cm)	Constrained Mod. (MPa)	Dr (%)	Friction angle (°)	Es (MPa)	Go (MPa)	Nkt	Su (kPa)	Su ratio	Kocr	OCR	Vs (m/s)	State parameter	Ko	Sensitivity	Peak phi (°)
0,2	-9999	-9999	0	0,00E+00	0	0	0	0	0	0	0	0	0	0,33	0	0	0	0	0	20
0,4	0	39,22662	3	2,51E-08	2	7,03284	0	0	0	15,93943	14	35,88184	3,88127	0,33	17,93148	90,71812	0	1,76593	0,70865	20
0,6	1,1768	71,58858	3	8,98E-08	4	13,29512	0	0	0	23,92405	14	67,83226	4,35302	0,33	20,11096	111,14119	0	1,83659	1,10762	20
0,8	1,37293	58,83993	4	8,78E-08	4	14,61485	0	0	0	26,40726	14	74,56559	3,76718	0,33	17,40438	116,76679	0	1,74801	1,24192	20
1	1,07873	58,83993	4	1,17E-07	6	19,22962	0	0	26,3179	32,9851	14	98,11031	4,00156	0,33	18,48719	130,50185	0	1,78446	1,33575	20
1,2	1,66713	65,70459	4	9,35E-08	6	21,92228	0	0	0	39,16622	14	111,84838	3,9946	0,33	18,45508	142,20456	0	1,7834	1,21228	20
1,4	1,66713	104,93121	3	5,91E-08	8	24,88953	0	0	0	48,30877	14	126,9874	4,11691	0,33	19,02011	157,93221	0	1,80189	0,97019	20
1,6	2,15746	163,77114	9	5,57E-08	9	29,77888	0	0	0	58,42127	14	151,93307	4,40217	0,33	20,33804	173,67735	0	1,84366	0,89628	20
1,8	2,45166	248,10837	9	5,36E-08	11	35,21741	0	0	0	69,58263	14	179,68064	4,70685	0,33	21,74563	189,54315	0	1,88634	0,83671	20
2	2,84393	248,10837	9	4,99E-08	13	40,93052	0	0	0	81,931	14	208,82916	5,00515	0,33	23,12381	205,67516	0	1,92641	0,77521	20
2,2	3,62846	287,33499	9	4,41E-08	14	44,72152	0	0	0	91,53629	14	228,17104	5,05882	0,33	23,37174	217,3974	0	1,93345	0,73129	20
2,4	3,72653	372,65289	9	4,61E-08	15	48,23794	0	0	0	97,93943	14	246,11196	5,03737	0,33	23,27263	224,87257	0	1,93064	0,7471	20
2,6	3,53039	372,65289	9	4,62E-08	16	50,93061	0	0	0	103,34365	14	259,85003	4,94967	0,33	22,86746	230,99342	0	1,91908	0,75795	20
2,8	3,72653	333,42627	9	4,11E-08	16	50,87741	0	0	0	105,47568	14	259,5786	4,64485	0,33	21,45922	233,364	0	1,87781	0,75716	20
3	3,82459	313,81296	9	3,76E-08	16	49,45127	0	0	0	104,15149	14	252,30242	4,2521	0,33	19,64468	231,8945	0	1,82192	0,78156	20
3,2	3,62846	287,33499	3	3,30E-08	15	47,75056	0	0	0	103,01233	14	243,62529	3,88448	0,33	17,9463	230,62283	0	1,76643	0,79406	20
3,4	3,23619	274,58634	3	2,71E-08	15	46,32443	0	0	0	103,55609	14	236,34911	3,5798	0,33	16,53867	231,23073	0	1,71777	0,78053	20
3,6	2,94199	294,19965	3	2,22E-08	15	43,79995	0	0	0	101,46247	14	223,46914	3,22114	0,33	14,88166	228,88136	0	1,65685	0,78302	20
3,8	3,23619	313,81296	3	5,07E-08	17	54,18103	0	0	0	108,11488	14	276,43381	3,72994	0,33	17,23234	236,26558	0	1,74208	0,98659	20
4	2,94199	228,49506	3	5,30E-08	17	55,50076	0	0	0	109,8868	14	283,16713	3,64425	0,33	16,83644	238,1938	0	1,72828	1,02527	20
4,2	7,35499	261,83769	3	6,23E-08	17	56,27132	0	0	0	108,18708	14	287,09855	3,52725	0,33	16,29588	236,34445	0	1,7091	1,13222	20
4,4	3,72653	254,97303	3	6,50E-08	17	54,84518	0	0	0	104,64184	14	279,82237	3,29475	0,33	15,22175	232,43974	0	1,6697	1,22646	20
4,6	3,23619	183,38445	4	7,39E-08	16	54,24281	0	0	0	101,12565	14	276,74904	3,12698	0,33	14,44665	228,50113	0	1,64012	1,36371	20
4,8	2,74586	189,26844	3	2,82E-08	14	41,00947	0	0	0	91,0138	14	209,23201	2,28602	0,33	10,56139	216,77606	0	1,47349	1,18801	20
5	2,74586	104,93121	3	2,35E-08	12	36,28831	0	0	0	83,21568	14	185,14444	1,94618	0,33	8,99136	207,28137	0	1,39457	1,28485	20
5,2	2,6478	130,42851	3	1,85E-08	12	33,21466	0	0	0	79,51221	14	169,46256	1,71495	0,33	7,92309	202,61641	0	1,33553	1,31074	20
5,4	2,0594	98,06655	3	2,33E-08	11	33,16146	0	0	0	76,1701	14	169,19113	1,65	0,33	7,62301	198,31244	0	1,31801	1,52872	20
5,6	2,15746	110,8152	3	2,29E-08	12	33,65743	0	0	0	77,55323	14	171,7216	1,61592	0,33	7,46557	200,10487	0	1,30863	1,55158	20
5,8	2,74586	98,06655	3	1,71E-08	11	31,68213	0	0	0	76,99146	14	161,64352	1,46711	0,33	6,77804	199,3788	0	1,2661	1,49568	20
6	2,94199	104,93121	3	1,20E-08	11	29,70683	0	0	0	76,96875	14	151,56544	1,32952	0,33	6,14239	199,3494	0	1,22416	1,40243	20
6,2	1,96133	117,67986	3	1,90E-08	12	34,04701	0	0	0	81,16889	14	173,70921	1,47556	0,33	6,8171	204,71634	0	1,26859	1,56671	20
6,4	1,37293	98,06655	4	3,92E-08	14	44,1535	0	0	0	92,29445	14	225,27294	1,86772	0,33	8,62889	218,29585	0	1,37508	1,7211	20
6,6	3,72653	124,54452	4	6,72E-08	17	55,08374	0	0	0	104,46804	14	281,03951	2,27641	0,33	10,51703	232,24663	0	1,47137	1,80031	20
6,8	6,37432	196,1331	4	1,18E-07	20	70,13278	0	0	95,8934	120,1864	14	357,82033	2,83959	0,33	13,11892	249,10667	0	1,58692	1,86238	20
7	6,86465	228,49506	4	8,79E-08	27	89,5752	0	0	0	161,82822	14	457,01635	3,51528	0,33	16,2406	289,05789	0	1,70712	1,32225	20
7,2	7,35499	294,19965	4	2,07E-07	34	123,02152	0	0	151,82034	190,28149	14	627,66082	4,77075	0,33	22,04087	313,44113	0	1,89506	1,47031	20
7,4	8,33565	850,23699	9	1,24E-07	37	128,46005	0	0	173,97402	218,04743	14	655,40839	4,81438	0,33	22,24243	335,53143	0	1,90097	1,16958	20
7,6	15,69064	522,69471	9	4,66E-07	44	173,71357	0	0	185,1923	232,10769	14	886,29371	6,52059	0,33	30,12511	346,18039	0	2,1088	1,60103	20
7,8	27,45862	0	6	2,47E-05	51	192,70459	69	42	153,75366	192,70459	0	0	0	0,33	0	315,43054	-0,18951	0	0	20



In situ data										Estimations										
Depth (m)	qc (MPa)	fs (kPa)	SBTn	Ksbt (m/s)	SPT N60 (blows/30cm)	Constrained Mod. (MPa)	Dr (%)	Friction angle (°)	Es (MPa)	Go (MPa)	Nkt	Su (kPa)	Su ratio	Kocr	OCR	Vs (m/s)	State parameter	Ko	Sensitivity	Peak phi (°)
0,2	0	0	0	0,00E+00	0	0	0	0	0	0	0	0	0	0,33	0	0	0	0	0	20
0,4	0	0	0	0,00E+00	0	0	0	0	0	0	0	0	0	0,33	0	0	0	0	0	20
0,6	0	0	0	0,00E+00	0	0	0	0	0	0	0	0	0	0,33	0	0	0	0	0	20
0,8	0	0	0	0,00E+00	0	0	0	0	0	0	0	0	0	0,33	0	0	0	0	0	20
1	0	110,8152	3	1,62E-08	4	11,54121	0	0	28,32838	14	58,88371	2,88557	0,33	13,33135	120,93961	0	1,59567	0,74865	20	
1,2	1,96133	110,8152	3	3,66E-08	6	18,90183	0	0	40,01393	14	96,43793	3,71572	0,33	17,16662	143,73526	0	1,7398	0,86047	20	
1,4	2,25553	163,77114	9	4,31E-08	8	25,71329	0	0	52,8432	14	131,19025	4,35157	0,33	20,10426	165,17802	0	1,83638	0,81228	20	
1,6	2,6478	163,77114	9	6,85E-08	10	33,07392	0	0	62,4989	14	168,74447	4,824	0,33	22,28687	179,63622	0	1,90227	0,90955	20	
1,8	2,45166	242,22438	9	6,30E-08	11	37,13951	0	0	71,25762	14	189,48729	4,91687	0,33	22,71594	191,81094	0	1,91472	0,86544	20	
2	2,6478	228,49506	9	5,75E-08	12	40,65593	0	0	79,30224	14	207,42821	4,93421	0,33	22,79606	202,34871	0	1,91703	0,83114	20	
2,2	3,43233	274,58634	9	4,58E-08	13	42,79942	0	0	87,0065	14	218,36439	4,83289	0,33	22,32796	211,95006	0	1,90347	0,76837	20	
2,4	3,53039	313,81296	9	4,64E-08	14	46,04125	0	0	93,37156	14	234,90436	4,80673	0,33	22,20708	219,56596	0	1,89994	0,77576	20	
2,6	3,43233	333,42627	9	4,36E-08	15	48,73392	0	0	99,93521	14	248,64243	4,74677	0,33	21,93006	227,15222	0	1,8918	0,76359	20	
2,8	3,62846	333,42627	9	3,99E-08	16	49,50447	0	0	103,18559	14	252,57385	4,52414	0,33	20,90154	230,8167	0	1,86097	0,76301	20	
3	3,62846	340,29093	9	3,66E-08	16	49,45127	0	0	104,70591	14	252,30242	4,2559	0,33	19,66226	232,51089	0	1,82247	0,77152	20	
3,2	3,72653	301,06431	3	3,35E-08	16	49,12349	0	0	105,6478	14	250,63004	3,99432	0,33	18,45377	233,55434	0	1,78336	0,7822	20	
3,4	3,53039	294,19965	3	3,11E-08	16	48,52112	0	0	105,79434	14	247,55671	3,7373	0,33	17,26633	233,71625	0	1,74325	0,79906	20	
3,6	3,33426	301,06431	3	2,75E-08	16	47,64416	0	0	106,22224	14	243,08244	3,48858	0,33	16,11724	234,18843	0	1,70267	0,80224	20	
3,8	3,43233	281,451	3	2,70E-08	16	47,59096	0	0	106,45246	14	242,81101	3,31309	0,33	15,30648	234,44208	0	1,67288	0,83098	20	
4	3,33426	306,9483	3	2,42E-08	16	46,714	0	0	106,53993	14	238,33673	3,10329	0,33	14,33721	234,53838	0	1,63586	0,83864	20	
4,2	3,72653	248,10837	3	2,46E-08	15	45,56245	0	0	103,63407	14	232,4615	2,88874	0,33	13,346	231,31775	0	1,59627	0,89831	20	
4,4	3,23619	254,97303	3	2,20E-08	15	43,31256	0	0	100,49162	14	220,98247	2,62951	0,33	12,14832	227,78369	0	1,54575	0,931	20	
4,6	2,94199	176,51979	3	2,55E-08	14	41,88643	0	0	94,66664	14	213,70629	2,43357	0,33	11,24307	221,08342	0	1,50535	1,06781	20	
4,8	2,6478	176,51979	3	2,30E-08	13	39,08737	0	0	90,01257	14	199,42536	2,1811	0,33	10,07669	215,5804	0	1,45	1,13233	20	
5	2,84393	124,54452	3	2,38E-08	12	36,5629	0	0	83,66453	14	186,54539	1,96084	0,33	9,05909	207,83965	0	1,39815	1,28211	20	
5,2	2,74586	130,42851	3	2,26E-08	12	35,13676	0	0	81,1692	14	179,26921	1,81396	0,33	8,3805	204,71674	0	1,36141	1,35718	20	
5,4	2,3536	104,93121	3	2,91E-08	12	35,90732	0	0	79,24436	14	183,20063	1,78718	0,33	8,25677	202,27486	0	1,3545	1,55942	20	
5,6	2,45166	110,8152	3	1,38E-08	13	35,57954	0	0	89,85937	14	181,52825	1,70609	0,33	7,88215	215,39687	0	1,33316	1,14379	20	
5,8	2,94199	104,93121	3	3,09E-08	16	48,43189	0	0	105,70697	14	247,10147	2,2498	0,33	10,39407	233,61972	0	1,46546	1,25987	20	
6	2,74586	326,56161	4	7,61E-08	20	65,67762	0	0	121,78049	14	335,08989	2,97095	0,33	13,72577	250,75325	0	1,61166	1,45214	20	
6,2	7,35499	313,81296	4	9,60E-08	25	84,29628	0	0	149,88918	14	430,08306	3,70653	0,33	17,12415	278,19086	0	1,73833	1,31034	20	
6,4	8,53179	274,58634	9	2,13E-07	33	119,93929	0	0	147,30662	14	611,93514	5,16565	0,33	23,86528	308,74655	0	1,94732	1,38982	20	
6,6	9,12018	588,3993	9	2,81E-07	36	137,73419	0	0	160,8661	14	702,72546	5,79329	0,33	26,76499	322,64377	0	2,02521	1,42328	20	
6,8	15,69064	654,10389	9	5,84E-07	44	179,41809	0	0	183,5903	14	915,39843	7,42848	0,33	34,31957	344,67984	0	2,20495	1,5876	20	
7	24,51663	0	6	2,54E-05	47	177,22645	68	42	141,40408	177,22645	0	0	0	0,33	0	302,49762	-0,18787	0	0	20

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,  $g$  (kN/m<sup>3</sup>) ::**

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

where  $g_w$  = water unit weight

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

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

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

**:: N<sub>SPT</sub> (blows per 30 cm) ::**

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

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

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

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

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

**:: Relative Density,  $Dr$  (%) ::**

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

**:: 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  $I_c > 2.20$

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

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

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

If  $I_c \leq 2.20$

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

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

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

**:: 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)



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Relazione geologica e sismica *a supporto del progetto di recupero dell'edificio "Ex Scuole Elementari" di Puianello*

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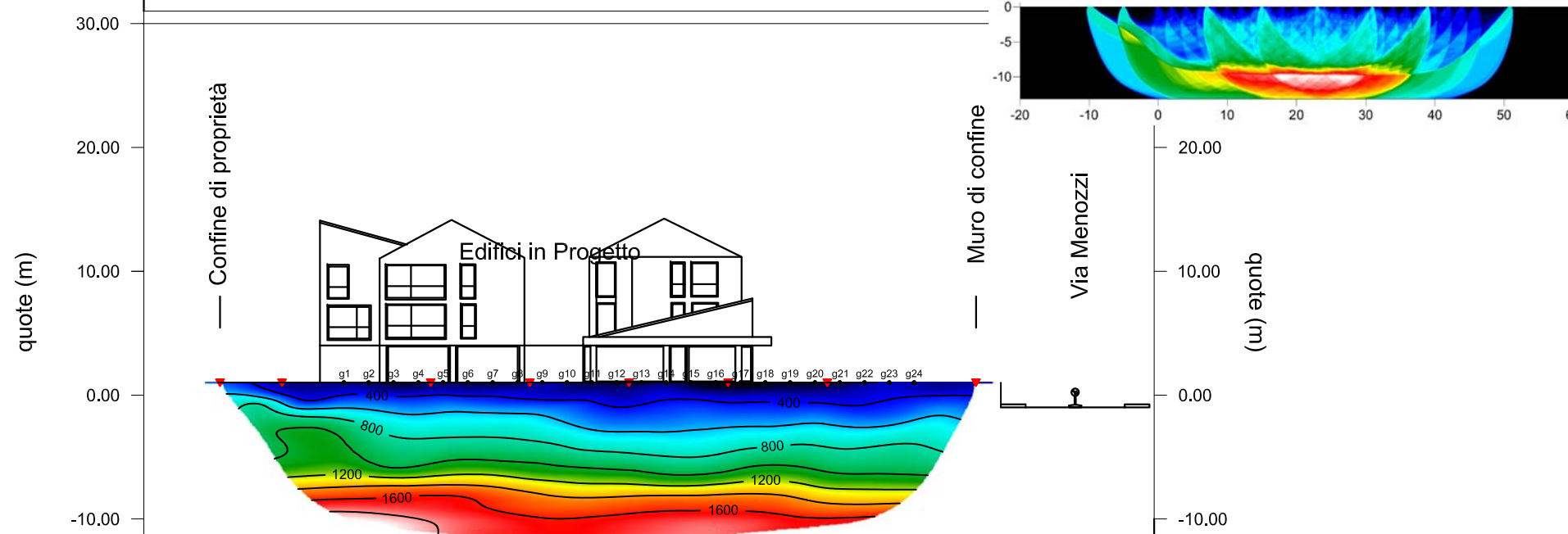
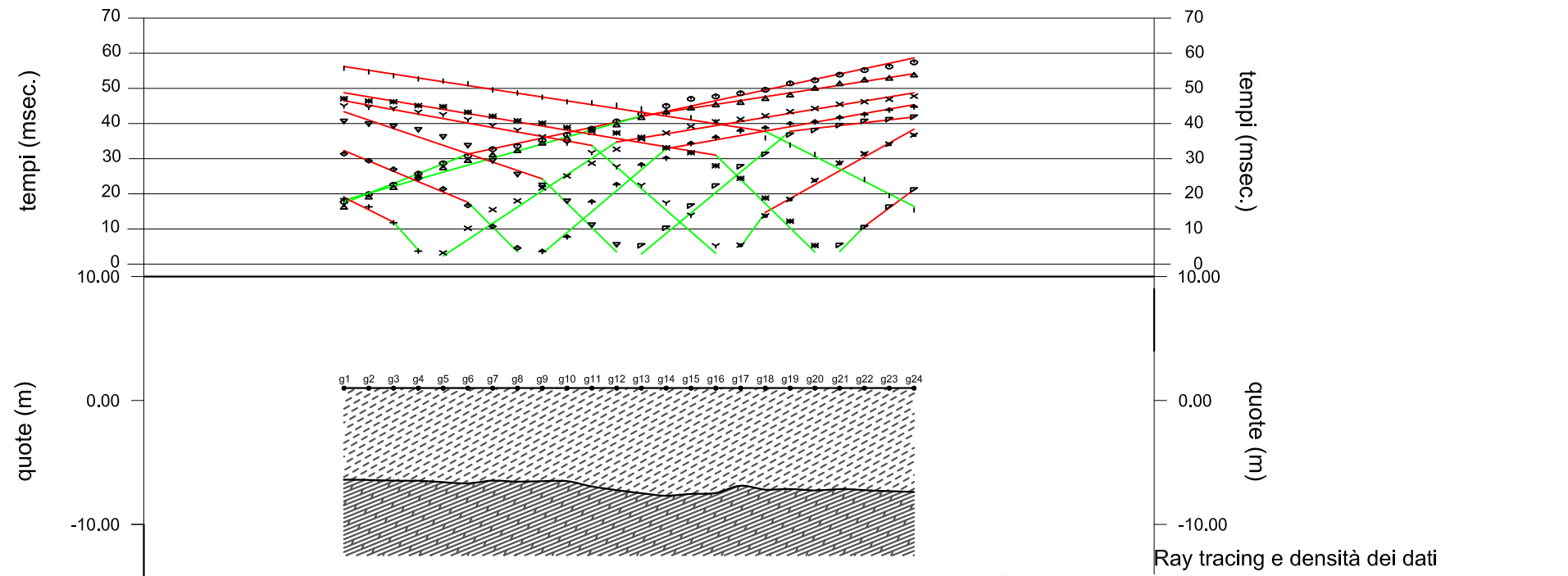
## **ALLEGATO 3**

Sismica a rifrazione

RIFRA1



# RIFRA 1



QUOTE GEOFONI (DA PIANO DI RIF)	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00			
DISTANZE PROGRESSIVE RELATIVE ALL'ANDAMENTO DEL TERRENO	0,00	5,00	10,00	12,00	14,00	18,00	17,00	20,00	22,00	25,00	24,00	28,00	30,00	32,00	34,00	36,00	38,00	41,00	42,00	44,00	46,00	48,00	50,00	52,00	54,00	56,00	61,00

Profilo su via Valentini



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REGIONE EMILIA ROMAGNA  
PROVINCIA DI REGGIO EMILIA  
COMUNE DI QUATTRO CASTELLA  
LOCALITA' PUIANELLO

**Relazione geologica e sismica a supporto del progetto di recupero dell'edificio "Ex Scuole Elementari" di Puianello**

COMMITTENTE:  
EDIL4 SpA

TAVOLA N. 01	DATA: 5 Marzo 2014
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OGGETTO:  
RIFRAZIONE SISMICA - Rifra1

REDAATTO <b>Dott. R.Spagni</b>	APPROVATO <b>Dott. geol. F. Giorgini</b>
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**LEGENDA**

Legenda elaborazione GRM  
(Generalized Reciprocal Method)

339 m/s (dotted pattern)    1352 m/s (hatched pattern)

Scala tomografia  
Velocità onde P (m/s)

200 400 600 800 1000 1200 1400 1600 1800 2000

**SCALA: 1:500**



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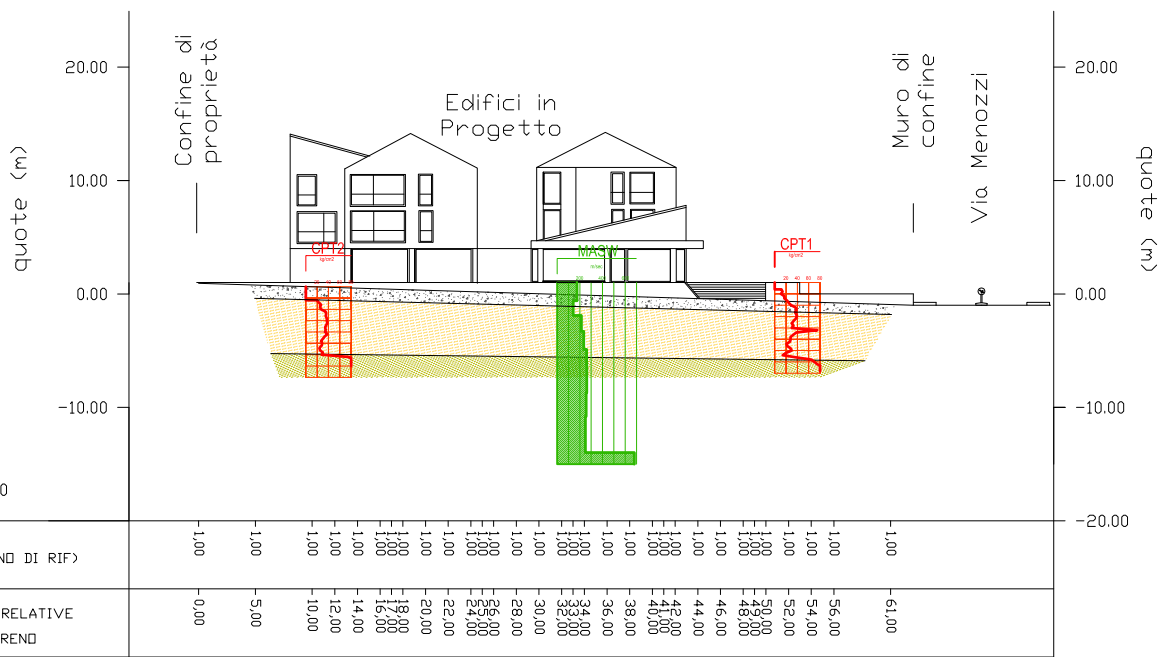
## ALLEGATO 4

Modello Geologico

**UBICAZIONE**



**A** **PROFILO SU VIA VALENTINI** **A'**



**Legenda:**



Pacchetto stradale di via Valentini



Argille



Argille e argille limose



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Relazione geologica e sismica a supporto del progetto di recupero dell'edificio "Ex Scuole Elementari" di Puianello

**COMMITTENTE:**

EDIL4 SpA

**TAV. N.**

02

**DATA:**

30 Marzo 2014

**OGGETTO:**

MODELLO GEOLOGICO

**REDATTO**

**Dott. R.Spagni**

**APPROVATO**

**Dott. geol. F. Giorgini**