Comune di Rimini

PA
2025

PIANO DELL'ARENILE

ai sensi dell'art.72 - L.R. 24/2017

Assunzione:
Delibera di G.C. n.465 del 12/12/2023

Adozione:
Delibera di C.C. n. 36 del 21/05/2024 e n. 47 del 13/06/2024

Approvazione:
Delibera di C.C. n.59 del 07/08/2025

Pubblicazione BURERT:
Bollettino n.235 del 10/09/2025

QUADRO CONOSCITIVO

B3_REL	Studio di risposta sismica locale, micro zonazione sismica, verifiche alla liquefacibilità
	Relazione

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COMUNE DI RIMINI

PIANO DELL'ARENILE

ai sensi dell'art. 72 - LR 24/2017

QUADRO CONOSCITIVO

B3_REL	**Studio di risposta sismica locale, di microzonazione sismica, verifiche alla liquefacibilità.** **Analisi di III Livello di Approfondimento.**
	Relazione

COMMITTENTE: AMMINISTRAZIONE COMUNALE DI RIMINI.

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DATA: NOVEMBRE 2023

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1 VALUTAZIONI DI MICROZONAZIONE SISMICA.

1.1 Premesse normative e generali.

Con obiettivo di riduzione del rischio sismico, così come specificato nell'art. 2, comma 4, dell'allegato alla L.R. 20/2000, la Regione Emilia-Romagna con Delibera di Assemblea Legislativa n.112 del 02/05/07 ha approvato il seguente documento: *"Atto di indirizzo e coordinamento tecnico ai sensi dell'art. 16, comma 1, della L.R. 20/2000 – Disciplina generale sulla tutela e l'uso del territorio", in merito a "Indirizzi per gli studi di microzonazione sismica in Emilia Romagna per la pianificazione territoriale e urbanistica",* seguita successivamente da una nota esplicativa redatta dai Servizi della Regione Emilia - Romagna con prot. n. 2007.0166430 del 22/06/07.
Nello specifico, la normativa di cui sopra stabilisce che, lo strumento urbanistico potrà essere approvato solo successivamente alla valutazione sull'eventuale necessità di eseguire approfondimenti tecnici che la rendano conforme all'atto di indirizzo di cui sopra ed alla successiva nota regionale.
In sostanza occorre valutare se l'area oggetto di Pianificazione debba contenere le analisi tecniche e gli approfondimenti di cui al terzo livello dell'allegato "A", capitolo 4.2, della Delibera di Assemblea Legislativa n.112 del 02/05/07, ricadendo nelle situazioni qui di seguito elencate:

a) Aree soggette a liquefazione e densificazione.
b) Aree instabili e potenzialmente instabili.
c) Aree in cui le coperture hanno spessori fortemente variabili, come ad esempio nelle aree pedemontane e di fondovalle a ridosso dei versanti.
d) Aree in cui è prevista la realizzazione di opere di rilevante interesse pubblico.

La DAL 112/2007 è rimasta come norma regionale di riferimento per la riduzione del rischio sismico la norma di riferimento per la riduzione di riferimento sino al 2015 dopodiché, rispettivamente con DGR 2193/2015, DGR 630/2019, DGR 476/2021 e DGR 564/2021, la Regione Emilia Romagna ha deciso di approvare nuovi documenti contenenti importanti aggiornamenti tecnici sui temi trattati nonché in adeguamento alla recente normativa urbanistica LR 24/2017.
Pertanto l'ultimo ed integrale aggiornamento è rappresentato dall'atto di coordinamento tecnico denominato INTEGRAZIONE DELLA PROPRIA DELIBERAZIONE N. 476 DEL 12 APRILE 2021 MEDIANTE APPROVAZIONE DELL'ALLEGATO A, "ATTO DI COORDINAMENTO TECNICO SUGLI STUDI DI MICROZONAZIONE SISMICA PER LA PIANIFICAZIONE TERRITORIALE E URBANISTICA (ARTT. 22 E 49, L.R. N. 24/2017)", di cui alla Delibera di Assemblea Legislativa n. 564 del 26/04/21 che deve essere osservato per gli atti di programmazione territoriale. Tale recente norma, necessaria a conformarsi ai requisiti della LR 24/2017, è da ritenersi, pertanto, sostitutiva della precedente DAL 112/2007.
Anche in questo caso, in ossequio al paragrafo 2.1, lettera c) di tale delibera occorre valutare se il sito oggetto di studio debba contenere le analisi tecniche e gli approfondimenti di cui al terzo livello, ricadendo nelle situazioni qui di seguito elencate:

c) 1. Aree soggette di liquefazione o densificazione.
c) 2. Aree di versante instabili e potenzialmente instabili.
c) 3. Aree con rapide variazioni della profondità del bedrock sismico, come ad esempio le valli strette e profondamente incise, nelle quali il modello geologico non può essere assimilato ad un modello fisico monodimensionale; in questo caso sono raccomandate analisi bidimensionali;
c) 4. Aree suscettibili di effetti differenziali (zone di contatto laterale tra litotipi con caratteristiche fisico – meccaniche molto diverse, zone di faglia attiva e capace, zone con cavità sepolte).

Nella situazione specifica in cui si trova il PSC/RUE del Comune di Rimini, dove lo studio di microzonazione sismica è stato redatto sulla base della DAL 112/2007 e assunto negli aspetti normativi delle NTA, è necessario fornire risposta al punti a), b), c) e d) sia della DAL112/2007 che della DGR 564/2021. Ciò in quanto di fatto nella attuale fase di esistenza del PSC/RUE entrambe le norme coesistono.

1.2 Verifica sulla necessità di produrre approfondimenti di terzo livello di microzonazione sismica ai sensi dell'allegato "A", capitolo 4.2, punto a) sia della DAL 112/2007 che della DGR 564/2021.

Per la verifica in oggetto circa la presenza di aree soggette a liquefazione e densificazione, come da punto a) dell'allegato "A", punto 4.2, della DAL 112/2007 e punto c)1. del paragrafo 2.1, lettera c) della DGR 564/2021, ci si è avvalsi delle seguenti informazioni e dati analitici:

1. Esecuzione di indagini geognostiche in sito estese su tutta l'area in studio, con distribuzione areale ritenuta significativa per la conoscenza litostratigrafica.
2. Analisi granulometriche su campioni prelevati negli ambiti in studio.
3. Verifica cartografica con la Tavola del PTCP 2007 della Provincia di Rimini denominata "S.A. 11 – SISTEMA AMBIENTALE – Rischio sismico e carta delle zone suscettibili degli effetti locali" ed in particolare con il punto 6: aree suscettibili di liquefazione.
4. Verifica cartografica con le tavole del Sistema Ambientale e Naturale del Quadro Conoscitivo del PSC di Rimini denominate: "Tav.e 9a/b – Microzonazione sismica. Primo livello di approfondimento. Carta delle aree suscettibili di effetti locali in caso di evento sismico"; "Tav.e 10a/b – Microzonazione sismica. Primo livello di approfondimento. Carta di sintesi della pericolosità sismica"; "Tav.e 17a/b – Carta dei livelli di approfondimento per gli studi di micro zonazione sismica".
5. valutazione della presenza di caratteri predisponenti alla liquefazione, con riferimento all'allegato A3, punto A1 della DGR 564/2021, sulla possibilità di escludere l'occorrenza di tale fenomeno.

Per quanto riguarda le verifiche cartografiche di cui ai punti 3 e 4 l'intera area in studio risulta ricadere tra le zone suscettibili di effetti locali per liquefazione in condizioni sismiche e che necessitano di analisi di III Livello di approfondimento.
Invece ai fini delle valutazioni di cui al punto 5) sono stati utilizzati i dati stratigrafici e litologici provenienti dalle campagne geognostiche di nuova realizzazione e dai dati di laboratorio reperiti.

Al proposito le evidenze storiche in termini di effetti sul territorio vengono riportate nel recente catalogo di Galli P. (2000) e nel web-gis *Catalogo italiano degli Effetti Deformativi del suolo Indotti dai forti Terremoti (CEDIT) - CERI* dell'Università "Sapienza" di Roma, che censisce gli effetti indotti sul terreno da terremoti storici verificatisi in un arco temporale che va dall'anno 1000 d.C. al 2016; in figura 1, viene riportato uno stralcio del catalogo di Galli (2000) raffigurante gli eventi principali geolocalizzati lungo la costa romagnola, con particolare riferimento agli eventi della Provincia Riminese e nei tratti costieri limitrofi.

Epicentral parameters of the seismic events								Sites with indication of liquefaction					
Ref.	Date	Latitude	Longitude	I_o	M_e	M_s	Area	Site[a]	Latitude	Longitude	d (km)	I_s	Type
136	1786.12.25	43.980	12.580	8.0	5.59	5.5	Rimini	Rimini	44 04	12 34	10	8.0	A1 E
177	1875.03.17	44.070	12.550	8.0	5.72	5.2	Rimini	Cervia	44 16	12 21	27	7.0	A1
178	1875.03.17	44.070	12.550	8.0	5.72	5.2	Rimini	Cesenatico	44 12	12 24	19	8.0	A1–2
230	1916.05.17	44.000	12.630	8.0	5.72	6	Rimini area	Rimini	44 03	12 34	8	8.0	A1
231	1916.08.16	43.970	12.670	8.0	5.59	6.1	Rimini urea	Cattolica	43 58	12 44	5	8.0	A1–2 A4–5
232	1916.08.16	43.970	12.670	8.0	5.59	6.0	Rimini area	Ghetto delle Fontanelle	43 59	12 40	2	8.0	A4–5
233	1916.08.16	43.970	12.670	8.0	5.59	6.0	Rimini urea	Pesaro	43 55	12 55	20	8.0	A1
234	1916.08.16	43.970	12.670	8.0	5.59	6.0	Rimini urea	Riccione	44 01	12 39	5	8.0	A1 A4
235	1916.08.16	43.970	12.670	8.0	5.59	6.0	Rimini area	Rimini	44 04	12 34	14	8.0	C

- A = ground fissuring and related phenomena
  - A1 = only ground fissures
  - A2 = water emission
  - A3 = mud, sand and gravel venting
  - A4 = mixed water and sand venting (sand boils)
  - A5 = mud volcanoes
- B = surface deformation
  - B1 = local settlement
  - B2 = local swelling
- C = differential settlement of building
- D = liquefaction evidence s.l. or without description.

Figura 1 – Stralcio da "New empirical relationships between magnitude and distance for liquefaction" – Table 4, Galli, 2000.

Una prima valutazione sul comportamento/stabilità atteso per i terreni costieri in condizioni sismiche, di tipo prettamente qualitativo, può essere desunta applicando il criterio geologico di Youd e Perkins (1978), basato su natura ed età del deposito, presentano una moderata-alta suscettibilità alla liquefazione (vedi fig. 2).
Un' ulteriore indicazione in merito alla suscettibilità a liquefazione in condizioni sismiche di tali terreni si può ottenere attraverso la sovrapposizione delle curve di distribuzione granulometrica delle sabbie con i campi di potenziale liquefacibilità proposti da Tsuchida H. (1970) (analoghi a quelli proposti in figura 1 dell'Allegato A3 della DAL 112/2007 e DGR 564/2021). Come evidenziato anche in Merli A. (Tesi di dottorato, 2019), sulla base di campioni prelevati lungo tutta la costa, è evidente come le sabbie litorali di entrambe le unità A e B, sia a nord che a sud del porto canale (rispettivamente RNN e RNS), ricadano significativamente entro i fusi granulometrici di potenziale liquefazione (vedi Fig. 3).
Pertanto dalle indagini in sito, unitamente al raffronto con campioni prelevati in aree vicine e situazioni litostratigrafiche analoghe (nel medesimo ambito deposizionale), è possibile stabilire come i terreni superficiali appartenenti alle Unità A e B presentino distribuzioni granulometriche ricadenti entro le fasce granolometriche di cui alla figura 1) dell'Allegato A3 della DAL 112/2007 e DGR 564/2021, per terreni con coefficiente di uniformità sia Uc< 3.5 che Uc>3.5, ritenendo in particolare che i sedimenti sabbiosi costieri rientrino per la quasi totalità all'interno del campo di "possibilità di liquefazione".
Diversamente i terreni presenti a maggior profondità, al di sotto del cuneo sabbioso costiero (Unità C), risultano significativamente esterni alle fasce granulometriche di cui sopra, presentando generalmente un contenuto in fine "FC" (passante al vaglio 200 ASTM) superiore al 90%, un contenuto in argilla superiore al 20% e, oltretutto, un indice di plasticità IP>20%, quest'ultimo tale da considerarli non liquefacibili anche secondo quanto espresso da Boulanger (2008), Seed et Al. (2003) e Bray e Sancio (2006).
La presenza di eventuali orizzonti ghiaiosi (Lit. G) all'interno o al tetto dell'Unità C, a profondità inferiori a 20 m, risulta tuttavia non significativa in virtù dell'elevata conducibilità idraulica (in grado di dissipare le sovrappressioni sismicamente indotte) e resistenza meccanica degli stessi, sufficiente ad inibire lo sviluppo e/o propagazione di eventuali fenomeni di liquefazione (vedi Tavola n. 7.1 e 7.2).
Quindi al di sotto dei terreni appartenenti alle Unità A e B non si rinvengono ulteriori depositi incoerenti sabbiosi di significativo spessore e continuità sino ad almeno 20.0 mt di profondità, considerata quest'ultima la massima profondità in cui si possono manifestare in modo significativo eventuali fenomeni di liquefazione (vedi Tavola n. 7.1 e 7.2).

Tipo di deposito	Probabilità di liquefazione di depositi sedimentari durante terremoti Strong Motion			
	< 500 anni	Olocene	Pleistocene	Pre-Pleistocene
a) Depositi continentali				
Canale fluviale	Molto alta	Alta	Bassa	Molto bassa
Pianura di esondazione	Alta	Moderata	Bassa	Molto bassa
Pianura e conoidi alluvionali	Alta	Moderata	Bassa	Molto bassa
Spiagge e terrazzi marini		Bassa	Bassa	Molto bassa
Deltaici	Alta	Moderata	Bassa	Molto bassa
Lacustri	Alta	Moderata	Bassa	Molto bassa
Dune	Alta	Moderata	Bassa	Molto bassa
Loess	Alta	Alta	Alta	Sconosciuta
Terreni residuali	Bassa	Bassa	Molto bassa	Molto bassa
b) Zone costiere				
Deltaici	Molto alta	Alta	Bassa	Molto bassa
Di estuario	Alta	Moderata	Bassa	Molto bassa
Di spiaggia	Alta	Moderata	Bassa	Molto bassa
Lagunari	Alta	Moderata	Bassa	Molto bassa
c) Riempimenti artificiali				
Non compattati	Molto alta			
Compattati	Bassa			

Figura 2 -. Criterio geologico di verifica della suscettibilità alla liquefazione secondo Youd e Perkins (1978).

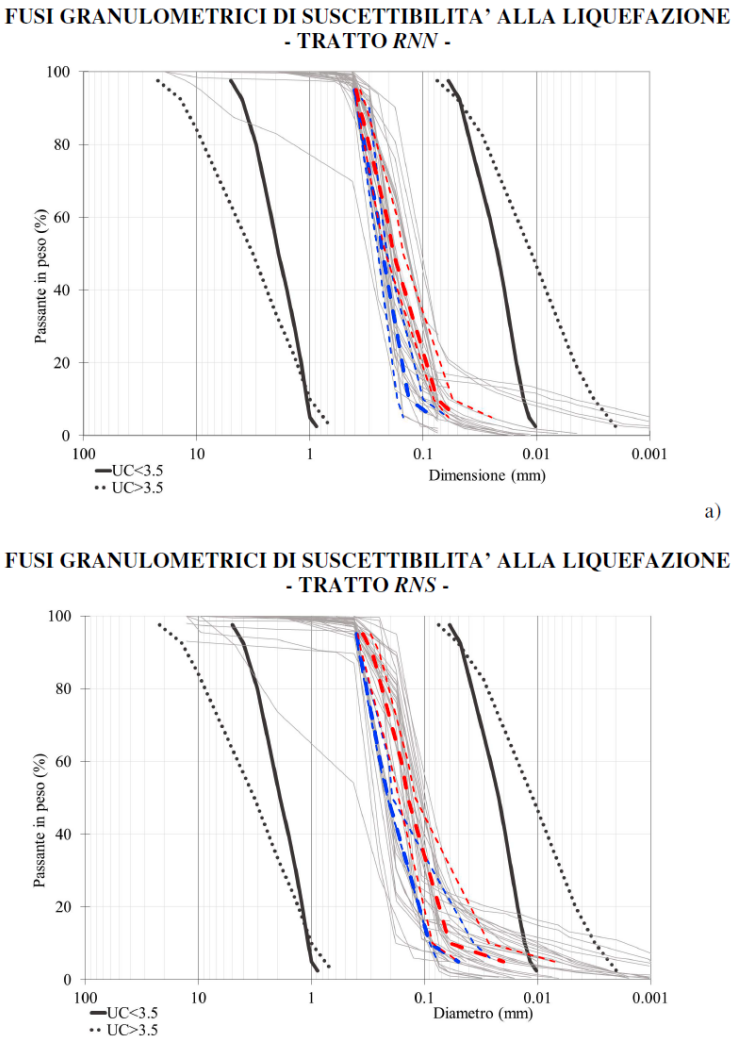


Figura 3 - Fusi granulometrici di suscettibilità alla liquefazione (Tsuchida, 1970) per le zone RNN (a) e RNS (b) Merli A. (Tesi di dottorato, 2019).

Pertanto, poiché l'area oggetto di studio presenta un potenziale rischio circa la possibilità di verificarsi del fenomeno di liquefazione, in ottemperanza alla normativa regionale di riferimento, è necessario eseguire una "Analisi approfondita – terzo livello di approfondimento".

1.3 Verifica sulla necessità di produrre approfondimenti di terzo livello di microzonazione sismica ai sensi dell'allegato "A", capitolo 4.2, punto b) sia della DAL 112/2007 che della DGR 564/2021.

Per le aree instabili e potenzialmente instabili di cui al punto b) dell'allegato "A", punto 4.2 , della DAL 112/2007 che del punto c)2. del paragrafo 2.1, lettera c) della DGR 564/2021, le valutazioni e verifiche si sono articolate considerando le situazioni di:

- Aree instabili: aree direttamente interessate da fenomeni franosi attivi.
- Aree potenzialmente instabili: aree in cui sono possibili riattivazioni (frane quiescenti) o attivazioni di movimenti franosi (tutti gli accumuli detritici incoerenti indipendenti dalla genesi, con acclività > 15°, pendii costituiti da terreni prevalentemente argillosi e/o intensamente fratturati con acclività >15°, versanti con giacitura degli strati a franapoggio con inclinazione minore o uguale a quella del pendio, aree prossime a zone instabili che possono essere coinvolte dalla riattivazione del movimento franoso, scarpate subverticali, accumuli detritici incoerenti prossimi all'orlo di scarpate).

A seguito di quanto sopra le valutazioni e verifiche sono state articolate come segue:

1. Esame della condizione geologica, geomorfologia e litostratigrafica del territorio attraverso rilevamento diretto di superficie.
2. Confronto con le Tavole *"S.A. 9 – SISTEMA AMBIENTALE – Carta del dissesto", "S.A. 10 – RISCHIO SISMICO – Carta delle zone suscettibili di effetti di sito", "S.A. 11 - RISCHIO SISMICO – Carta delle zone suscettibili degli effetti locali"* del PTCP 2007 adottato della Provincia di Rimini ai fini della verifica della condizione di instabilità e potenziale instabilità gravitativa delle aree oggetto di pianificazione urbanistica.
3. Verifica con la Cartografia Regionale CTR 1:5.000 ai fini della valutazione dell'acclività dei versanti, così come specificato in Allegato A2.2 di entrambi gli atti normativi regionali.
4. Verifica cartografica con le tavole del Sistema Ambientale e Naturale del Quadro Conoscitivo del PSC di Rimini denominate: "Tav.e 2a/b – Carta geomorfologica"; "Tav.e 8a/b – Carta delle pericolosità, vulnerabilità e tutele ambientali".
5. Verifica delle condizioni stratigrafiche di giacitura degli strati dalla Cartografia Geologica e dei Suoli della Regione Emilia - Romagna redatta dal Servizio Geologico Sismico e dei Suoli della medesima Regione.

Al termine delle analisi effettuate secondo lo schema sopra indicato, emerge quanto segue:

- Il sito è subpianeggiante e pertanto gli effetti topografici di amplificazione sismica possono essere trascurati.
- La zona oggetto di pianificazione non risulta direttamente interessata da fenomeni franosi.
- La zona, infine, non risulta essere potenzialmente instabile in quanto non si prevedono riattivazioni di frane quiescenti o attivazioni di movimenti franosi (pendio con acclività inferiore a 15°, versanti con giacitura degli strati a traversopoggio, non coinvolgimento di aree prossime a zone instabili, assenza di scarpate subverticali e accumuli detritici incoerenti).

Pertanto l'area oggetto di pianificazione non presenta alcun rischio né di instabilità gravitativa, né di potenziale instabilità gravitativa e di effetti di sito a seguito della topografia.

1.4 Verifica sulla necessità di produrre approfondimenti di terzo livello di microzonazione sismica ai sensi dell'allegato "A", capitolo 4.2, punto c) sia della DAL 112/2007 che della DGR 564/2021.

Nel merito del punto c) dell'allegato "A", punto 4.2, sia della Delibera di Assemblea Legislativa n.112 del 02/05/07 sia del punto c)3. del paragrafo 2.1, lettera c) della DGR 564/2021, è opportuno precisare che sostanzialmente esprimono la stessa valenza tecnica anche se formulate con espressioni leggermente diverse. In sostanza richiedono di valutare se il sito è riconducibile ad un modello geologico monodimensionale, quindi senza importanti variazioni geologiche laterali, piuttosto che un modello geologico che imponga analisi bidimensionali.

A tal fine si sono condotte le opportune valutazioni nel modo seguente:

1. Esame della condizione geologica e geomorfologia delle singole aree direttamente in sito e più in generale della conoscenza geologica del territorio.
2. Verifica della condizioni litostratigrafiche locali direttamente attraverso le campagne geognostiche e geofisiche eseguita e indirettamente mediante l'utilizzo della banca dati geologici reperibile presso il Servizio Geologico, Sismico e dei Suoli della Regione Emilia-Romagna.
3. Confronto con la Tavola "S.A. 10 – RISCHIO SISMICO – Carta delle zone suscettibili di effetti di sito", e con la Tavola "S.A. 11 - RISCHIO SISMICO – Carta delle zone suscettibili degli effetti locali" del PTCP 2007 della Provincia di Rimini.
4. Verifica cartografica con le tavole del Sistema Ambientale e Naturale del Quadro Conoscitivo del PSC di Rimini denominate: "Tav.e 3a/b – Carta litologica"; "Tav.e 9a/b –

Microzonazione sismica. Primo livello di approfondimento. Carta delle aree suscettibili di effetti locali in caso di evento sismico"; "Tav.e 12a/b/c/d – Sezioni idrostratigrafiche".

Al termine delle analisi effettuate secondo lo schema sopra indicato, emerge come il sito presenti una successione stratigrafica alquanto omogenea e comunque lo spessore della copertura alluvionale al di sopra del substrato sia piuttosto consistente.

Pertanto a conclusione delle valutazioni sopra esperite si può affermare che l'area oggetto di pianificazione non presenta caratteristiche geologiche in alcun modo riconducibili alla situazione di "*aree in cui le coperture hanno spessori fortemente variabili, come ad esempio nelle aree pedemontane e di fondovalle a ridosso dei versanti*" o per cui siano necessarie *"analisi geologiche bidimensionali".*

1.5 Verifica sulla necessità di produrre approfondimenti di terzo livello di microzonazione sismica ai sensi dell'allegato "A", capitolo 4.2, punto d) della della DAL 112/2007 che della DGR 564/2021.

Per quanto concerne il punto d) dell'allegato "A", punto 4.2, Delibera di Giunta Regionale n. 112 del 2007 e punto c)4. del paragrafo 2.1, lettera c) della DGR 564/2021, nel formulare le dovute valutazioni si terrà conto di:

1) Esame della condizione geologica e geomorfologia dell'area direttamente in sito e più in generale della conoscenza geologica del territorio.
2) Verifica delle condizioni stratigrafiche e dei rapporti laterali tra corpi sedimentari attraverso la Cartografia Geologica e le Sezioni Geologiche della Regione Emilia-Romagna redatta dal Servizio Geologico Sismico e dei Suoli della medesima Regione.
3) Verifica cartografica con le tavole del Sistema Ambientale e Naturale del Quadro Conoscitivo del PSC di Rimini denominate: "Tav.e 9a/b – Microzonazione sismica. Primo livello di approfondimento. Carta delle aree suscettibili di effetti locali in caso di evento sismico"; "Tav.e 10a/b – Microzonazione sismica. Primo livello di approfondimento. Carta di sintesi della pericolosità sismica".
4) Ricerca nel catalogo "ITHACA" dell'ISPRA delle faglie attive e capaci e dello stato delle conoscenza scientifica in merito.

In particolare i punti 1 e 2 sono stati già trattati nelle situazioni precedenti.
Per soddisfare i successivi punti 3 – 4 ai fini della ricostruzione del quadro di pericolosità sismica dell'area per fagliazione ci si avvale del database ITHACA (ITHACA Working Group (2019). ITHACA (ITALY HAZARD FROM CAPABLE FAULTING), A DATABASE OF ACTIVE CAPABLE FAULTS OF THE ITALIAN TERRITORY. VERSION DECEMBER 2019. ISPRA GEOLOGICAL SURVEY OF ITALY. WEB PORTAL HTTP://SGI2.ISPRAMBIENTE.IT/ITHACAWEB/MAPPATURA.ASPX) creato per la raccolta e la consultazione di tutte le informazioni disponibili riguardo le strutture tettoniche attive in Italia, con particolare attenzione ai processi tettonici che potrebbero generare rischi naturali. Il progetto si occupa in modo particolare delle faglie capaci, definite come faglie attive che potenzialmente possono creare deformazione in superficie.
Il database delle faglie capaci (vedi figure successiva) è uno strumento fondamentale sia per analisi di pericolosità ambientale / sismica che per la pianificazione territoriale ed, al proposito, in figura 4 viene riportato un dettaglio dell'area.

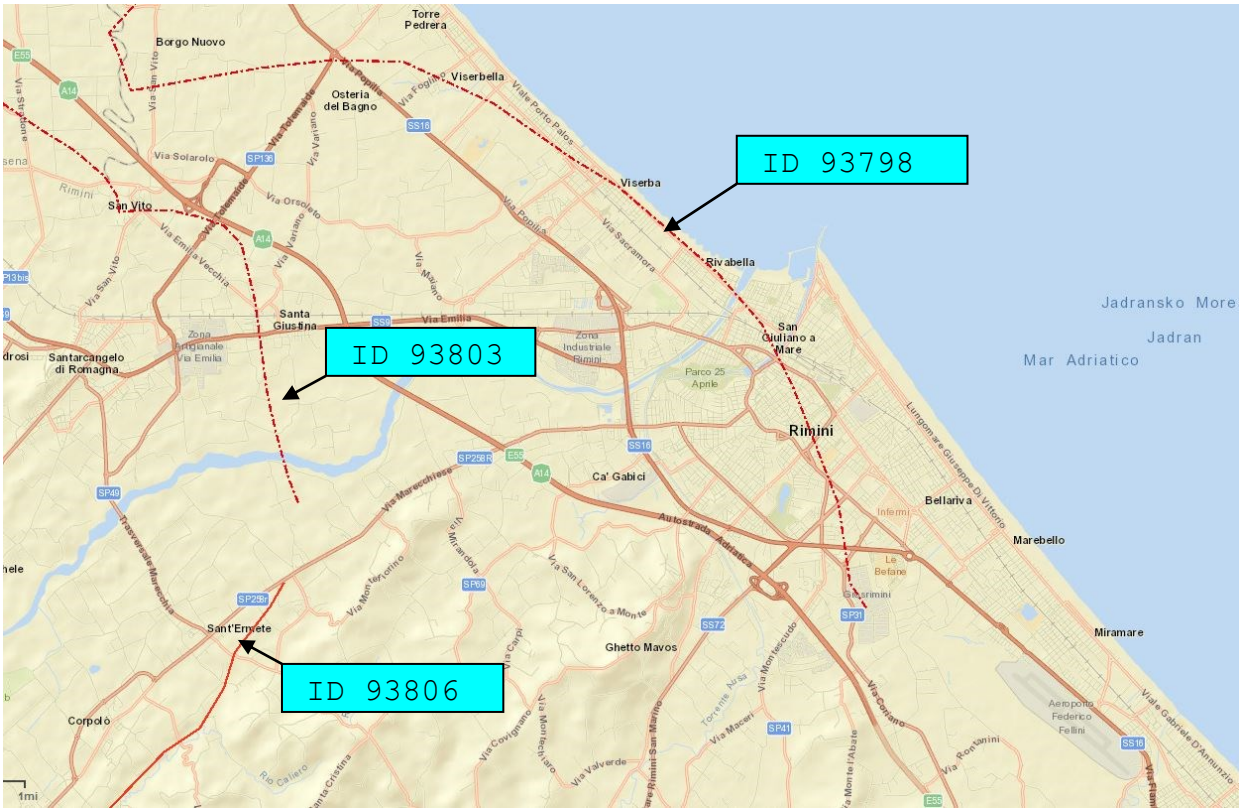


Figura 4 – Dettaglio catalogo ITHACA delle faglie attive e capaci e relativo codice identificativo.

Dalla figura 4 si evince come il territorio in studio possa essere interessato da una struttura di faglia con cinematismo "inverso", con direzione NW-SE, denominata "Rimini-Ravenna" (*Fault code 93798*); tuttavia i dati disponibili nel catalogo ITHACA e le schede di censimento relative riportano una scarsa conoscenza di tali strutture, trattandosi di sovrascorrimenti profondi post-tortoniani dedotti (secondo carta geologica Web-Gis Emilia Romagna), così come non ci sono evidenze superficiali ne elementi noti su recenti attività, per cui la qualità delle informazioni è ritenuta bassa.
Pertanto sulla base di questi dati si può affermare che nell'area oggetto di pianificazione, allo stato della conoscenza scientifica attuale, non si rinviene la presenza certa di faglie attive e capaci sepolte legate all'orogenesi appenninica certe di una certa rilevanza, che possano essere segnalate negli studi di Microzonazione Sismica, come previsto negli I.C.M.S. (gruppo di lavoro MS 2008), nella versione 1.0 a titolo "Linee guida per la gestione del territorio in aree interessate da faglie attive e capaci FAC".
In conseguenza di ciò anche in questo caso si può affermare che nel territorio oggetto di studio non vi sono situazioni accertate riconducibili a "zone di faglia attiva e capace" in grado di condizionare in maniera consistente la pericolosità sismica locale soprattutto in termini di deformazioni/fagliazioni superficiali. Allo stesso modo sono da escludere effetti differenziali quali zone di contatto laterale tra litotipi con caratteristiche fisico – meccaniche molto diverse e zone con cavità sepolte.

1.6 Verifica sulla necessità di produrre approfondimenti di terzo livello di microzonazione sismica ai sensi dell'allegato "A", capitolo 4.2, punto d) della DAL 112/2007.

Nel presente studio non viene preso in esame il punto d) dell'allegato "A", punto 4.2, della Delibera di Assemblea Legislativa n.112 del 02/05/07 (opere di rilevante interesse pubblico), in quanto non di competenza del sottoscritto.

2. APPROFONDIMENTI DI MICROZONAZIONE SISMICA DI III LIVELLO

2.1 SISMICITA' STORICA E PERICOLOSITA' SISMICA DI BASE

Per la definizione della sismicità storica del territorio in studio è stato consultato il Database Macrosismico Italiano DBMI15 (Locati M., Camassi R., Rovida A., Ercolani E., Bernardini F., Castelli V., Caracciolo C.H., Tertulliani A., Rossi A., Azzaro R., D'Amico S., Antonucci A. (2021). Database Macrosismico Italiano (DBMI15), versione 3.0. Istituto Nazionale di Geofisica e Vulcanologia (INGV). *https://doi.org/10.13127/DBMI/DBMI15.3*). La successiva Tabella 1 riporta i principali eventi sismici (scosse principali "mainshock") risentiti nel comune in esame. Per ogni evento sismico sono riportate: data, area epicentrale, intensità epicentrale I_0 (valori in scala MCS), magnitudo momento MW (stimata da correlazioni empiriche o misurata) e intensità al sito IS (MCS).



Figura- 5: Evidenziato in rosso il territorio appartenente al comune di Rimini, sul cui fronte mare si colloca l'ambito dell'arenile.

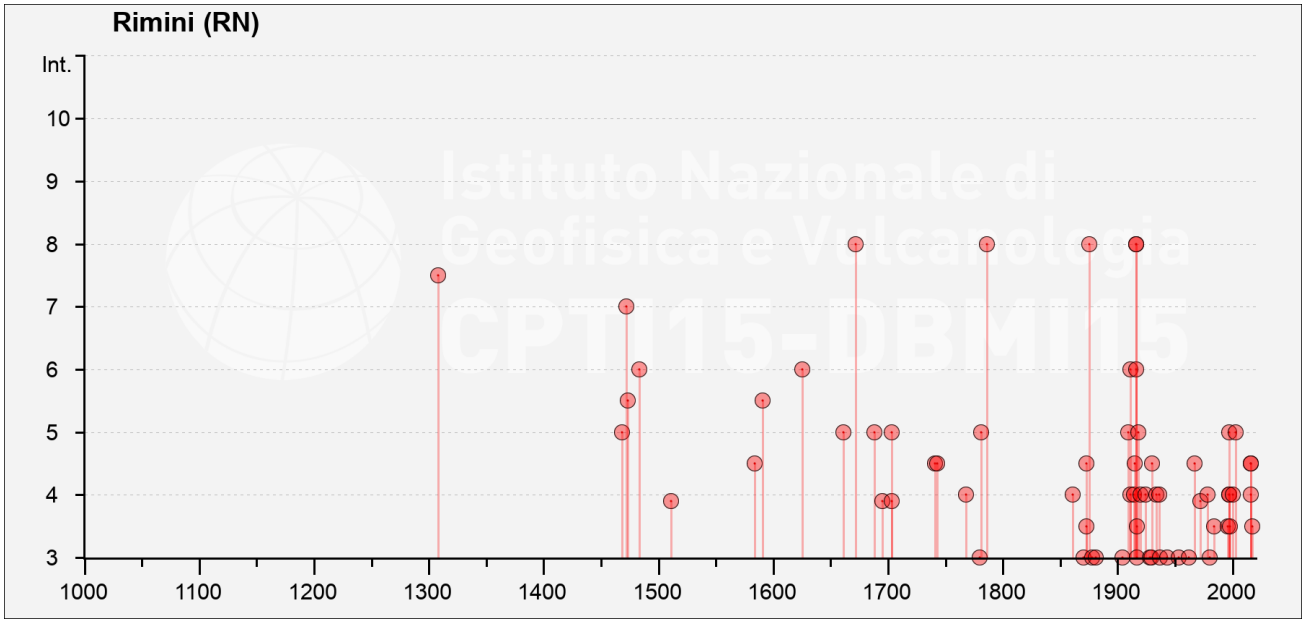
*Tabella 1 – Storia sismica del Comune di **RIMINI** (estratta dal DBMI15).*

Effetti	In occasione del terremoto del				
Int.	**Anno Me Gi Ho Mi Se**	**Area epicentrale**	**NMDP**	**Io**	**Mw**
7-8	1308 01 25 17 15	Rimini	1	7-8	5.33
5	1468 06 06 10 30	Romagna	3	4	3.70
7	1472	Rimini	1	7	5.10
5-6	1473 02 02	Rimini	1	5-6	4.40
6	1483 08 11 19 40	Romagna	14	8	5.69
F	1511 03 26 15 30	Friuli-Slovenia	120	9	6.32
4-5	1584 09 10 20 30	Appennino forlivese	17	9	5.97
5-6	1591 07 10	Romagna	6	6-7	5.13
6	1625 12 05	Rimini	1	6	4.63
5	1661 03 22 12 50	Appennino forlivese	79	9	6.05
8	1672 04 14 15 45	Riminese	92	8	5.59
5	1688 04 11 12 20	Romagna	39	8-9	5.84
F	1695 02 25 05 30	Asolano	107	10	6.40
F	1703 01 14 18	Valnerina	197	11	6.92
5	1703 02 02 11 05	Aquilano	69	10	6.67
4-5	1741 04 24 09 20	Fabrianese	135	9	6.17
4-5	1743 02 20	Ionio settentrionale	84	9	6.68
4	1768 10 19 23	Appennino forlivese	45	9	5.99
3	1780 05 25	Romagna	5	5-6	4.40
5	1781 04 04 21 20	Faentino	96	9-10	6.12
8	1786 12 25 01	Riminese	90	8	5.66
4	1861 10 16	Romagna	10	6-7	5.13
3	1870 10 30 18 34	Forlivese	41	8	5.61
4-5	1873 03 12 20 04	Appennino marchigiano	196	8	5.85
3-4	1873 06 29 03 58	Alpago Cansiglio	197	9-10	6.29
NF	1874 10 07	Imolese	60	7	4.96
8	1875 03 17 23 51	Costa romagnola	144	8	5.74
3	1878 03 12 21 36	Bolognese	31	6	4.84
3	1881 09 28	Cesena	24	6-7	4.71
3	1904 11 17 05 02	Pistoiese	204	7	5.10
5	1909 01 13 00 45	Emilia Romagna orientale	867	6-7	5.36
NF	1909 08 25 00 22	Crete Senesi	259	7-8	5.34
4	1911 02 19 07 18 30	Forlivese	181	7	5.26
6	1911 03 26 13 51	Riminese	9	5	5.04
NF	1913 11 25 20 55	Appennino parmense	73	4-5	4.65
4	1914 10 27 09 22	Lucchesia	660	7	5.63
4-5	1915 01 13 06 52 43	Marsica	1041	11	7.08
8	1916 05 17 12 50	Riminese	132	8	5.82
6	1916 06 16 01 27	Riminese	17	6	4.82
8	1916 08 16 07 06 14	Riminese	257	8	5.82
2	1916 11 16 06 35	Alto Reatino	40	8	5.50
3	1917 04 26 09 35 59	Alta Valtiberina	134	9-10	5.99
3-4	1917 12 02 17 39	Appennino forlivese	32	6-7	5.09

Effetti Int.	In occasione del terremoto del Anno Me Gi Ho Mi Se	Area epicentrale	NMDP	Io	Mw
5	1918 11 10 15 12 28	Appennino forlivese	187	9	5.96
4	1920 09 07 05 55 40	Garfagnana	750	10	6.53
4	1924 01 02 08 55 13	Senigallia	76	7-8	5.48
2	1926 01 01 18 04 03	Carniola interna	63	7-8	5.72
3	1928 05 30 20 01	Senigallia	17	5	5.02
3	1929 04 10 05 44	Bolognese	87	6	5.05
4-5	1930 10 30 07 13	Senigallia	268	8	5.83
4	1934 11 30 02 58 23	Adriatico settentrionale	51	5	5.30
4	1936 10 18 03 10	Alpago Cansiglio	269	9	6.06
3	1937 11 26 21 58 30	Costa pesarese	7	5	4.16
3	1943 10 03 08 28 29	Ascolano	170	8	5.67
3	1953 12 14 07 11 06	Appennino forlivese	48	5-6	4.70
2	1961 05 08 22 45 51	Forlivese	40	5	4.37
3	1962 01 23 17 31	Costa pesarese	49	5	4.35
NF	1962 08 30 06 27 07	Montefeltro	23	6-7	4.76
4-5	1967 12 30 04 19	Emilia Romagna orientale	40	6	5.05
F	1972 11 30 11 25 2	Costa pesarese	30		4.52
4	1978 12 05 15 39 04	Romagna	34	4-5	4.61
3	1980 11 23 18 34 52	Irpinia-Basilicata	1394	10	6.81
2	1983 11 09 16 29 52	Parmense	850	6-7	5.04
3-4	1984 04 29 05 02 59	Umbria settentrionale	709	7	5.62
NF	1986 12 06 17 07 1	Ferrarese	604	6	4.43
NF	1993 11 07 23 21 1	Cesenate	36	4-5	3.95
3-4	1996 10 15 09 55 5	Pianura emiliana	135	7	5.38
4	1997 09 26 00 33 1	Appennino umbro-marchigiano	760	7-8	5.66
5	1997 09 26 09 40 0	Appennino umbro-marchigiano	869	8-9	5.97
4	1997 10 14 15 23 1	Valnerina	786		5.62
3-4	1998 04 05 15 52 2	Appennino umbro-marchigiano	395		4.78
2	1999 01 25 22 45 5	Appennino forlivese	97	5	4.36
2-3	2000 05 08 12 29 0	Faentino	126	5	4.67
2-3	2000 05 10 16 52 0	Faentino	151	5-6	4.82
4	2000 08 01 02 34 31	Montefeltro	84	5-6	4.27
2	2001 11 26 00 56 5	Casentino	211	5-6	4.63
5	2003 12 07 10 20 3	Forlivese	165	5	4.18
NF	2006 10 21 07 04 1	Anconetano	287	5	4.21
4-5	2016 08 24 01 36 32	Monti della Laga	221	10	6.18
4	2016 10 26 19 18 0	Valnerina	77		6.07
4-5	2016 10 30 06 40 1	Valnerina	379		6.61
3-4	2017 01 18 10 14 9	Aquilano	280		5.70

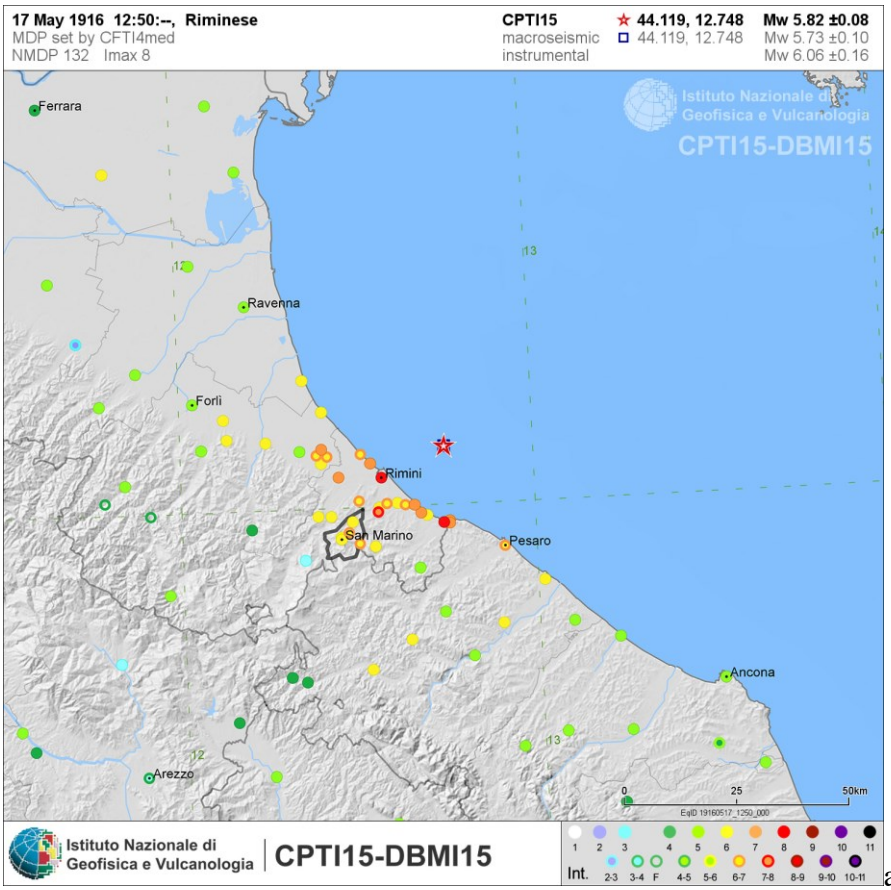
Estratto della tabella esplicativa riportante i parametri che costituiscono il formato sintetico del database:

Field Description	
N Record number (in chronological order)	**Se** Origin time: seconds
Year Origin time: year	**EpicentralArea** Epicentral area or area of the largest macrsoseismic effects
Mo Origin time: month	**Mw** moment magnitude
Da Origin time: day	**NMDP** Number of macroseismic data point
Ho Origin time: hour	**Imax** Maximum intensity
Mi Origin time: minutes	**Io** Epicentral intensity
	*N.F (not felt-non avvertito)

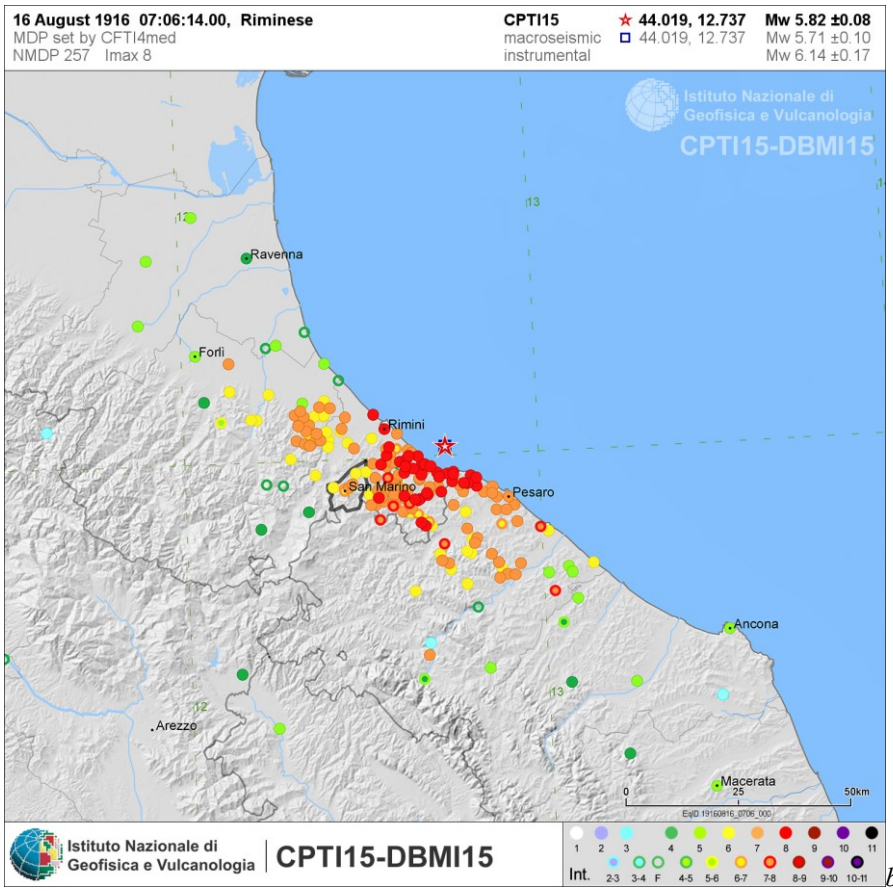


Distribuzione temporale degli eventi sismici considerati

L'esame della storia sismica indica quali eventi di maggior rilevanza: il terremoto “Riminese” del 1308, 1472, 1672, 1786, 1875 e del 1916. Tali sismi hanno generato in prossimità della zona epicentrale il massimo risentimento e danno (VII ≤ I_S ≤ VIII MCS); l’ultimo evento, in termini temporali, di maggior risentimento significativo è stato quello del Riminese 1916, di cui in fig. 6 a) e b) viene riproposto lo stralcio della carta dei risentimenti macrosismici INGV rispettivamente per gli eventi principali del 17 maggio e 16 agosto 1916. Inoltre in fig. 7 si propongono le carte delle isosisme ricostruite da INGV per i maggiori terremoti storici della Romagna.

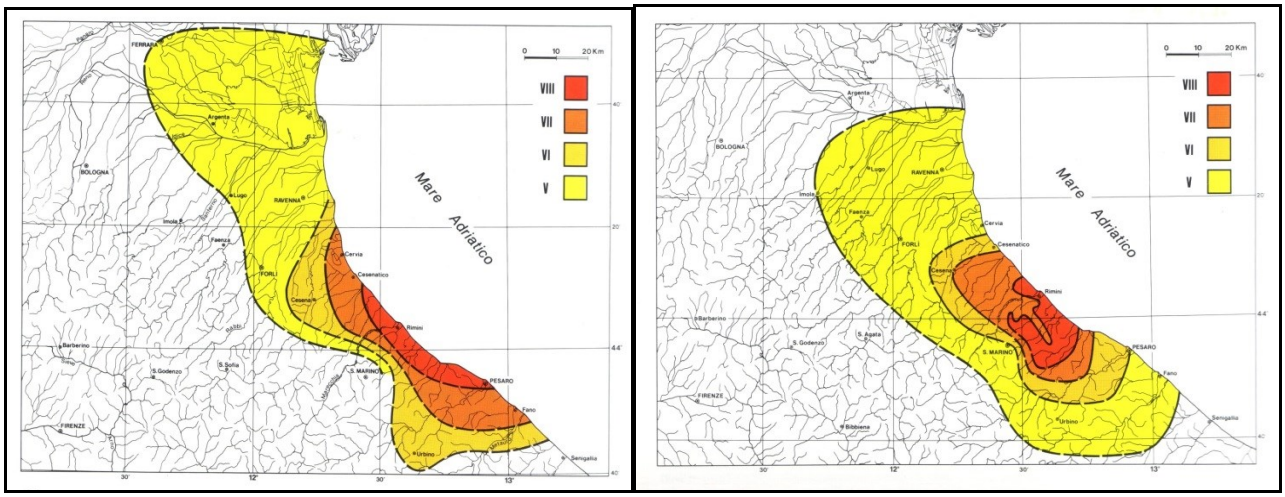


a)



b)

Figura- 6: Carta del risentimento macrosismico – terremoto Riminese eventi maggio/agosto 1916 - DBMI15 (a e b)



Terremoto del 14 aprile 1672 **Terremoto del 25 dicembre 1786**

Terremoto del 17 marzo 1875 **Terremoto del 17 maggio – 16 agosto 1916**

Figura - 7: Carte delle isosisme in cui le aree colorate dal rosso al verde corrispondono a parti di territorio colpite da effetti di severità decrescente. (DISS3/INGV).

In base alla disposizione degli epicentri, nonché da una verifica sul database DISS 3.2 (Database of Individual Seismogenic Sources) realizzato dal'INGV, è possibile risalire alle aree sismogenetiche che hanno particolarmente contribuito alla sismicità storica della zona in studio ed alla pericolosità sismica dell'area (vedi fig. 8); in tal caso si tratta di sistemi di faglia appenninici e costieri prevalentemente di natura compressiva.

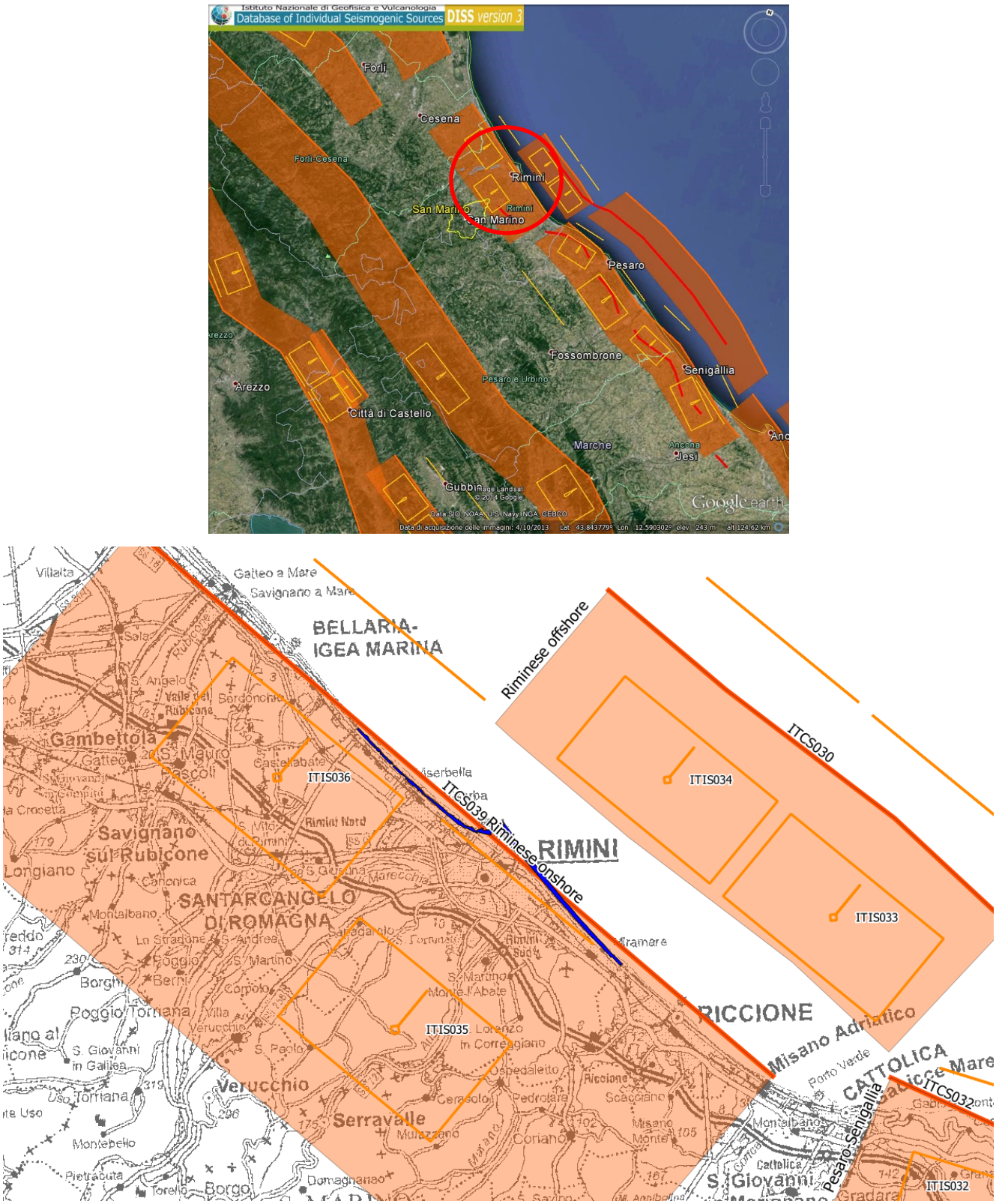


Figura – 8: Sorgenti sismogenetiche (Id-Nome-Max Magnitudo) individuate dal catalogo DISS (Database of Individual Seismogenic Sources) dell'Istituto Nazionale di Geofisica e Vulcanologia. In blu viene evidenziata l'area in studio.

Come riportato da "La sismicità della zona costiera adriatica nord-marchigiana di Stefano Mazzoli e Chiara Macchiavelli" si trae che studi effettuati in tempi recenti da gruppi di ricerca (Borraccini et alii, 2002, 2005; Di Bucci et alii, 2003; Santini et alii, 2011; Macchiavelli et alii, 2012), la sismicità della zona costiera e delle Marche settentrionali mostra un comportamento complesso, caratterizzato da una notevole variabilità delle orientazioni degli assi di massima e minima compressione (Fig. 9)

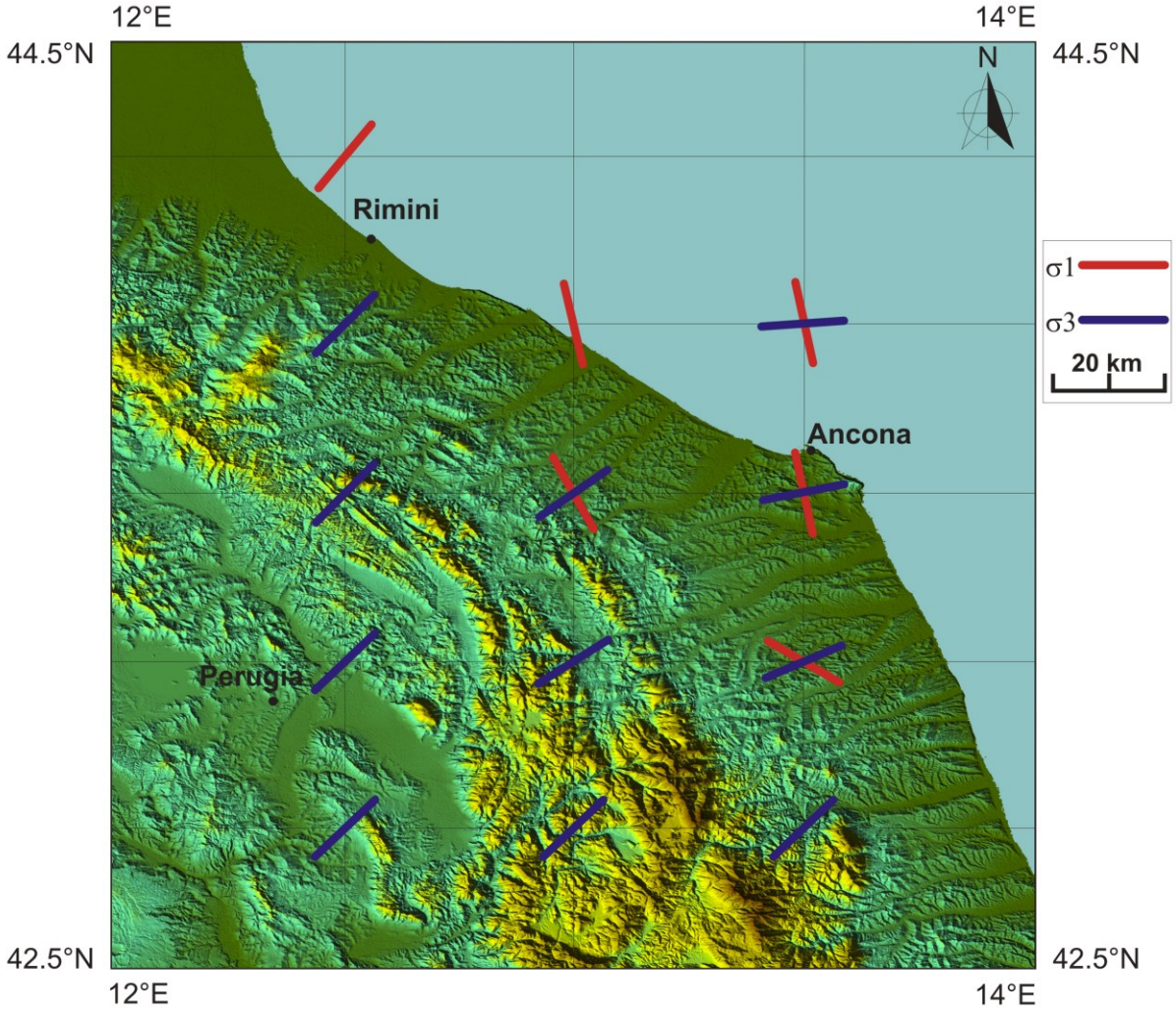


Figura 9 – Proiezione in mappa degli assi di massima compressione (σ1) e minima compressione (σ3) per l'area umbro-marchigiano-romagnola (da Macchiavelli et alii, 2012).

Nonostante un notevole dibattito scientifico esista circa la cinematica delle faglie attive ed campo di stress attualmente dominante nell'area d'interesse (Frepoli & Amato, 1997, 2000; Montone et alii, 1999, 2004, 2012; Boncio et alii, 2000; Di Bucci & Mazzoli, 2002; Vannoli et alii, 2004; Chiarabba et alii, 2005; Pondrelli et alii, 2006; Basili et al., 2007; Boncio & Bracone, 2009; Piccinini et alii, 2009; Pierdominici et alii, 2012; Macchiavelli et alii, 2012), tutti gli Autori concordano sul fatto che le faglie attive principali che controllano la sismicità dell'area siano rappresentate da strutture con direzione circa parallela alla costa e immersione dominante verso sud-ovest (costituite, almeno originalmente, da faglie inverse).

Inoltre dai diagrammi di disaggregazione per magnitudo (M) e distanza (R) in Figura 10 (Tr 475 anni), desunti dal Progetto DPC-INGV-S1 (2006) e Iervolino et Al. 2011, si osserva come i maggiori contributi alla pericolosità dell'area siano legati al sistema di faglie costiere adriatiche (onshore e offshore) entro i 20 Km di distanza (valore medio R< 10 km). In maniera minore sembrano intervenire, quindi, i grandi sistemi appenninici conosciuti in letteratura come Etrurian Fault System (EFS) e Umbria Fault System.

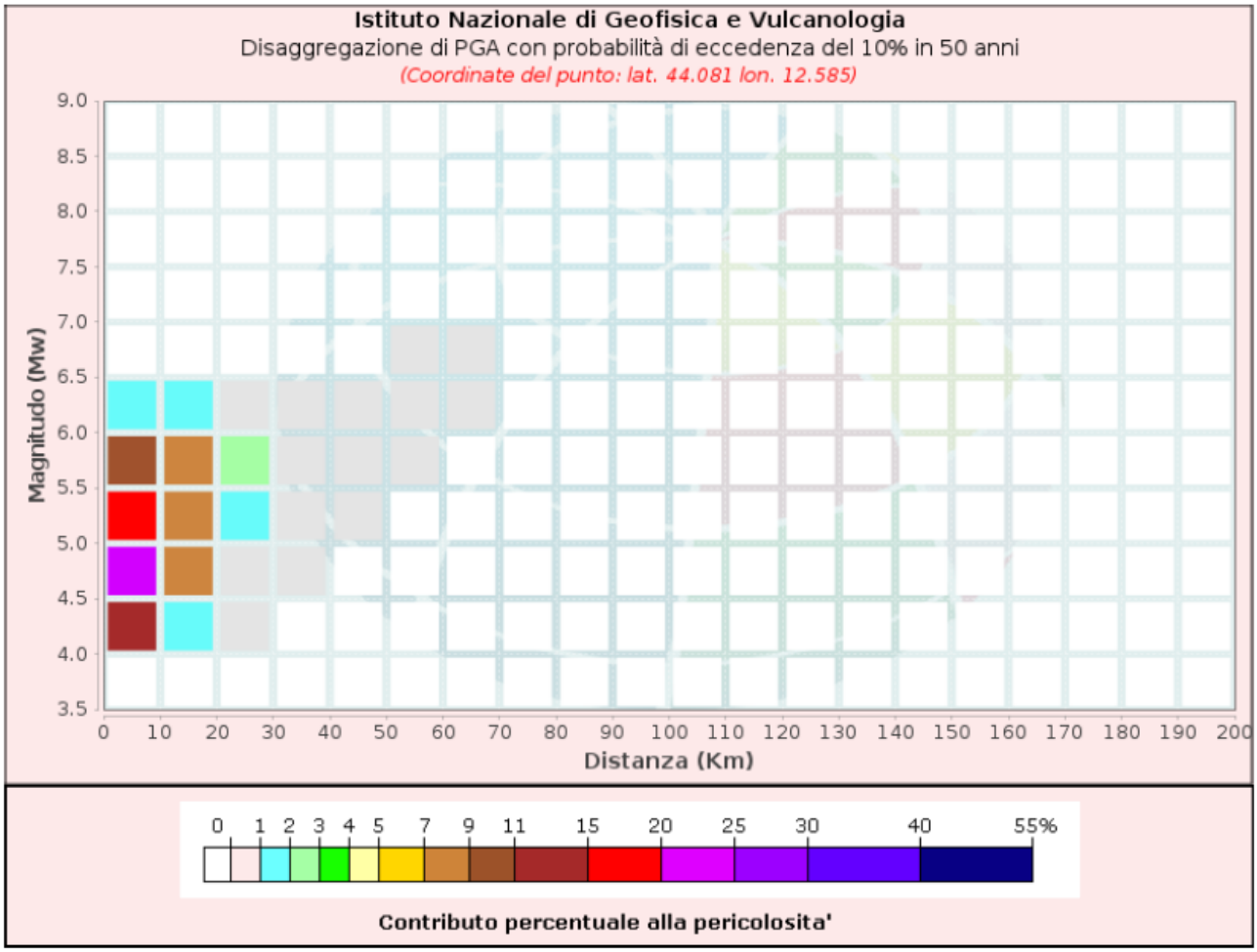
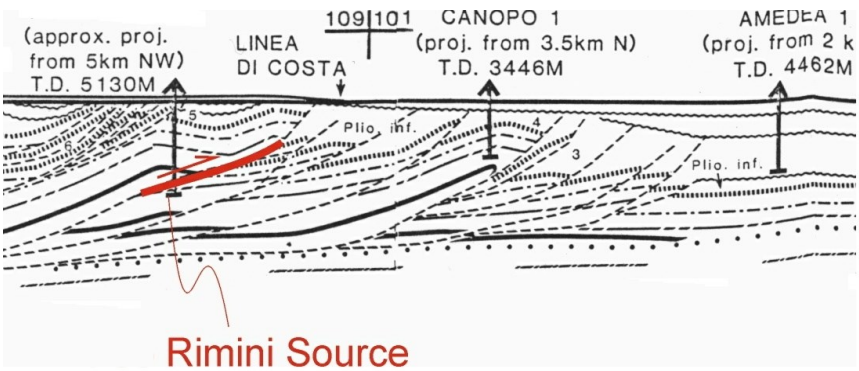


Figura 10 – Diagramma di disaggregazione riferito alla zona baricentrica dell'area in studio

Nelle tabelle 2, 3 e 4 vengono indicate le caratteristiche generali dei principali sistemi sismogenetici compositi **ITCS030-032-039** sulla base di evidenze empiriche e dati di letteratura da catalogo DISS 3.2:

Tabella 2 Principali parametri della sorgente sismogenetica ITCS039 (da DISS 3.2).

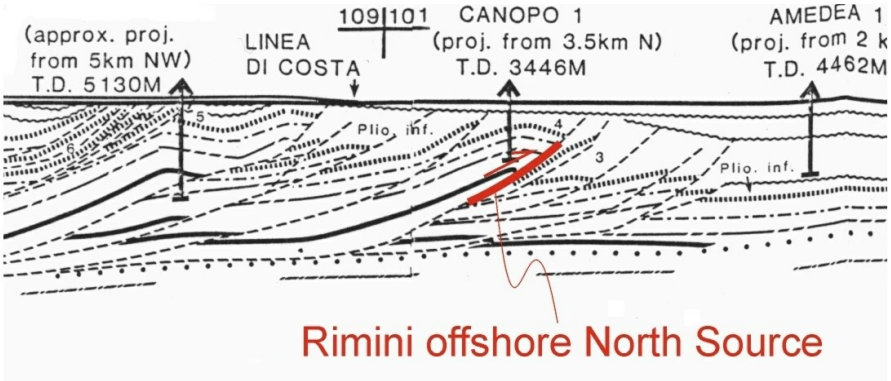
ITCS039 – RIMINESE ONSHORE	
Min Depth (km)	2
Max Depth (km)	10
Strike (deg)	120 - 140
Dip (deg)	25 - 35
Rake (deg)	80 - 100
Slip Rate (mm/y)	1.0 - 1.07
Max Magnitude (Mw)	5.9



Sorgente sismogenetica ITC039 - Riminese "on-shore" proiettata su Sezione Amedea-M.te.Amiata di Bally et al. [1986]. Basili, R., U. Fracassi and S. Mariano 2006

Tabella 3 Principali parametri della sorgente sismogenetica ITCS030 (da DISS 3.2).

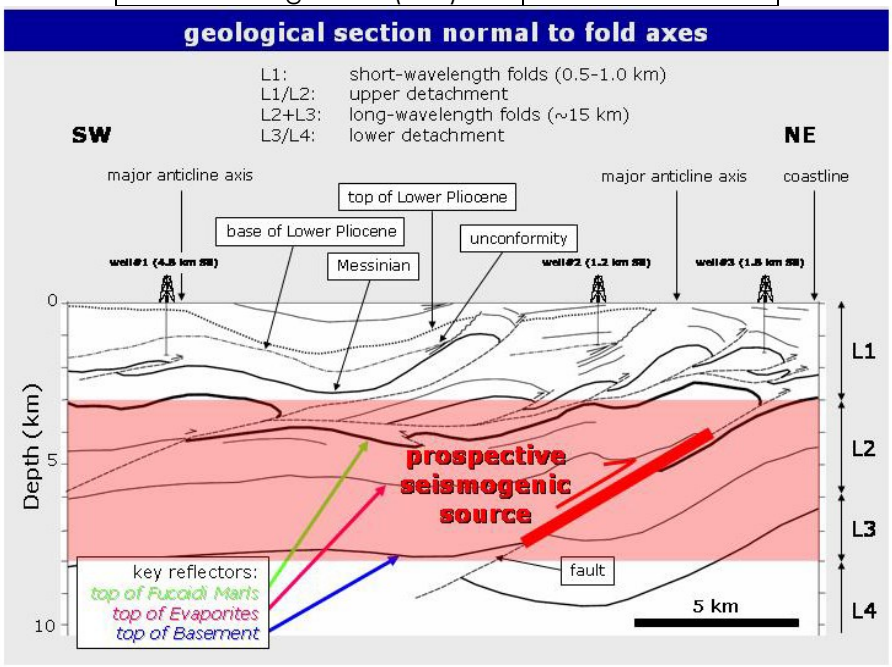
ITCS030 – RIMINESE OFFSHORE SOUTH	
Min Depth (km)	3
Max Depth (km)	7
Strike (deg)	120 - 140
Dip (deg)	25 - 35
Rake (deg)	80 - 100
Slip Rate (mm/y)	0.2 – 0.52
Max Magnitude (Mw)	6.1



Sorgente sismogenetica ITC030 - Riminese "off-shore" proiettata su Sezione Amedea-M.te.Amiata di Bally et al. [1986]. Basili, R., U. Fracassi and S. Mariano 2006.

Tabella 4 Principali parametri della sorgente sismogenetica ITCS032 (da DISS 3.2).

ITCS032 – PESARO-SENIGALLIA	
Min Depth (km)	3
Max Depth (km)	7.5
Strike (deg)	105 - 145
Dip (deg)	25 - 35
Rake (deg)	80 - 100
Slip Rate (mm/y)	0.2 – 0.52
Max Magnitude (Mw)	6.1



Hypotetical location of the Senigallia earthquake suorce based on a seismic reflection profile. The correlative fault is a main thrust which generates long-wavelenght folds, (From Basili et al. [2004]).

Infine per quanto attiene la stima dei valori di Mw attesi nell'area può essere utilizzato lo studio ZS9 del 2004 ("Gruppo di Lavoro per la redazione della Mappa della Pericolosità Sismica" dell'INGV), il quale è una rielaborazione della precedente sismozonazione ZS4 (Meletti et al, 2000), ripensata in base sia a nuove valutazioni del potenziale sismogenetico sia rispetto a nuove analisi eseguite sui terremoti storici e considerazioni statistiche.
La zona di studio ricade interamente entro la zona "Rimini-Ancona" definita come ZS n. 917 "Rimini – Ancona", come evidenziato in figura 11.

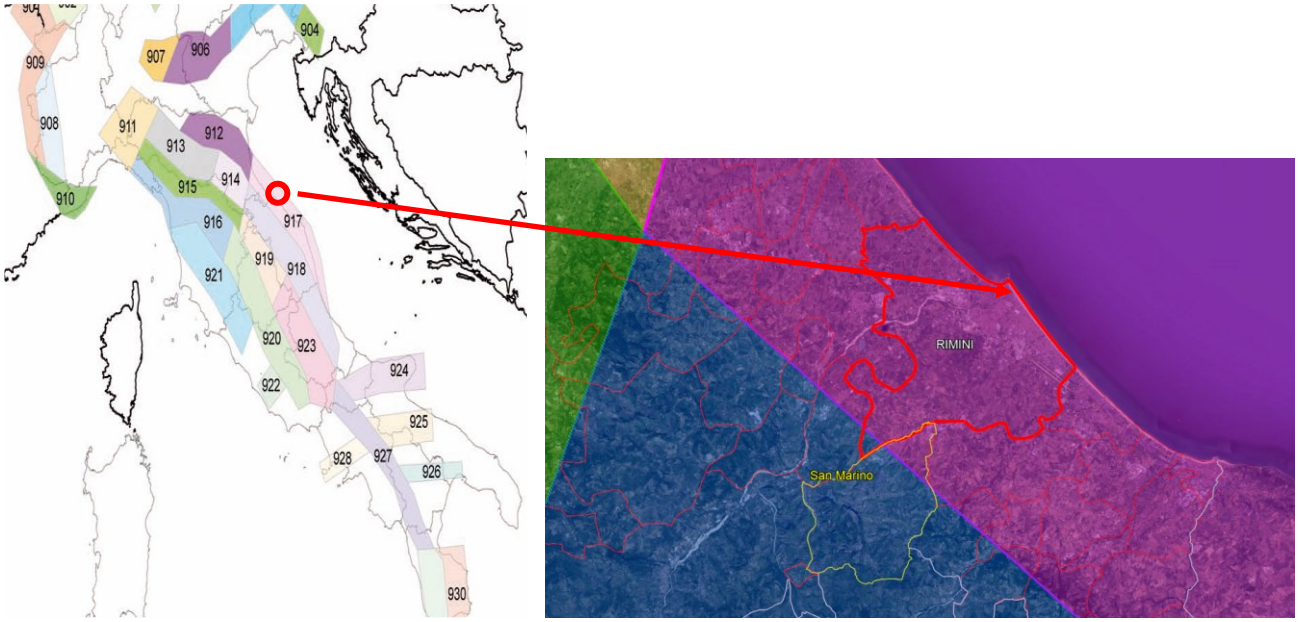


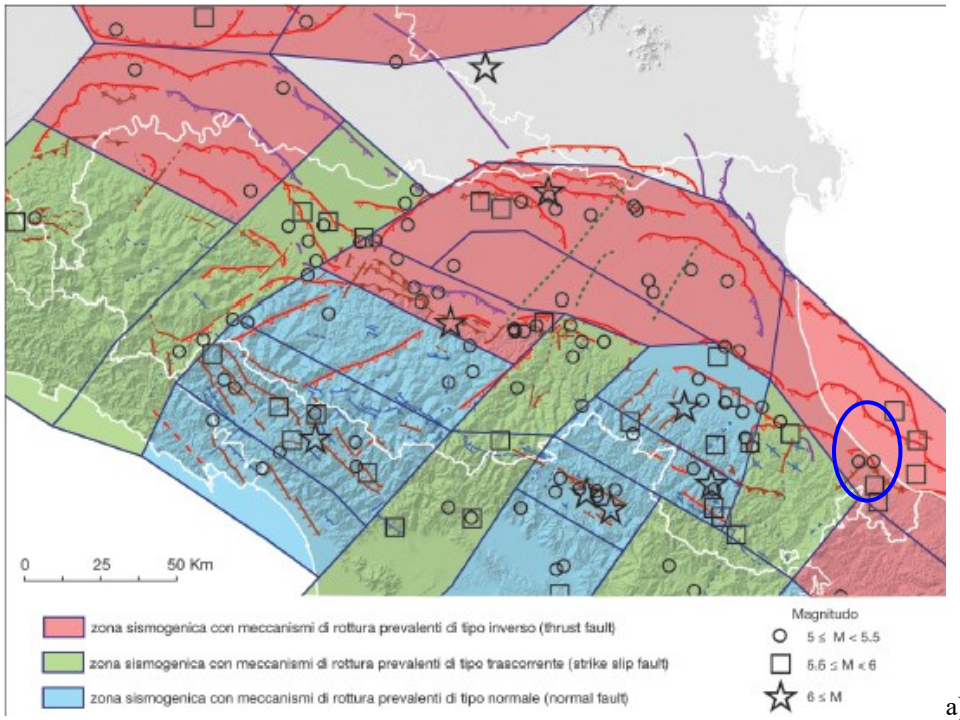
Figura 11–Dettaglio della Zonazione Sismogenetica ZS9 ("Gruppo di Lavoro per la redazione della Mappa della Pericolosità Sismica" dell'INGV, 2004). Evidenziata in viola la ZS n. 917 "Rimini-Ancona" ed in celeste la ZS n. 918 "Medio-Marchigiana/Abruzzese".

Le caratteristiche associate a tale zona prevede:

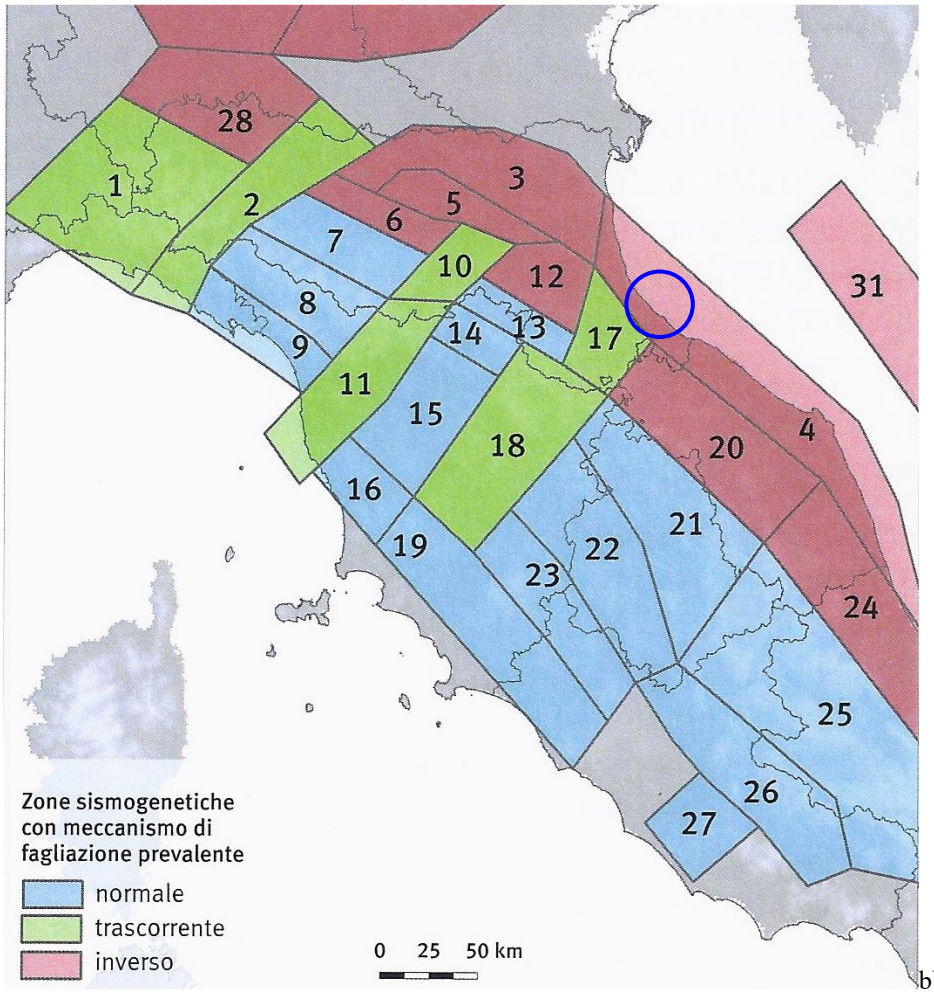
- Un meccanismo focale prevalente.
- Una Magnitudo Momento Massima "Osservata" (Mw-max1) definita sia dalle analisi legate agli eventi storici sia su basi geologiche legate al Database of Individual Seismogenic Sources (DISS).
- Una Magnitudo Momento Massima "Cautelativa" (Mw-max2) definita aggiungendo un margine di sicurezza rispetto alla Mw-max1 in relazione alle conoscenze strutturali, geofisiche e sismologiche.

Zona	**917**
Meccanismo focale	**inverso**
Mw-Max	**6.14**

Tali valori risultano sostanzialmente in linea con la recente carta sismotettonica della Regione Emilia Romagna – Edizione 2016, di cui in figura 12a e 12b se ne riporta uno stralcio illustrativo.
Anche in quest'ultima zonazione proposta dalla regione le aree in studio ricadono pienamente nella Zona 4, per la quale i meccanismi focali associabili alle principali faglie attive risultano prevalentemente di tipo inverso, con una orientazione caratteristica SW/30 (direzione di immersione) e profondità ipocentrali comprese fra 5-15 km; la magnitudo massima ivi osservata storicamente risulta pari a Mw=6.1, mentre quella massima calcolata per scenari futuri, sulla base dei modelli di analisi adottati, porta a valori pari a Mwmax= 6.16±0.21.



a)



b)

Fig. 12 - Stralcio cartografia zonazione carta sismotettonica 2016 Emilia Romagna (a-b)

In conclusione si può osservare come ben pochi dei terremoti significativi verificatisi nella storia sismica del riminese e lungo la costa del Comune di Rimini abbiano presentato delle magnitudo inferiori a 5/5.5 e grado di intensità MCS<7-8. Pertanto, considerati i cataloghi storici e le relative incertezze, gli studi dell'INGV, la zonazione ZS9 e le indicazioni I.C.M.S. nonché la recente Carta Sismotettonica della Regione Emilia Romagna, in relazione alle finalità e tipologia di studio, si ritiene adeguata una magnitudo momento massima di riferimento pari a **Mw=6.16**.

Per completare l'inquadramento sismico dell'area, in accordo con quanto descritto nell'Allegato A4 alla Delibera di G.R. 630/2019, come aggiornata dalla DGR 476/2021 e successiva integrazione DGR 564/2021, per ciascuna zona significativa interna al Comune in studio è possibile, infine, calcolare lo spettro di risposta elastico a probabilità uniforme che descrive le caratteristiche del moto sismico atteso per un periodo di ritorno di 475 anni (con smorzamento pari al 5%) a partire da un moto di riferimento al bedrock (a_{refg}).
La definizione del moto sismico di riferimento (in termini di PGA_0 al bedrock) si basa sui valori di pericolosità elaborati da INGV per il territorio nazionale resi disponibili per il territorio regionale sui punti di una griglia con passo 0.05 gradi (circa 5.5 km) nel sito web del Servizio Geologico, Sismico e dei Suoli, tema "Sismica Microzonazione Sismica".
Il valore di a_{refg} (PGA_0) relativo a ciascun sito analizzato si ottiene interpolando i valori di a_{refg} definiti nei punti della griglia più prossimi al sito o utilizzando il valore del punto della griglia più vicino. Tale valore corrisponde all'accelerazione di ancoraggio prevista al bedrock per lo spettro elastico normalizzato e per cui:

- la forma dello spettro di risposta normalizzato è rappresentativo del moto sismico atteso per un periodo di ritorno di 475 anni (con smorzamento pari al 5%);
- i valori di a_{refg} di ogni comune sono riferiti al 10% di probabilità di superamento in 50 anni;

In figura 13 viene illustrato uno stralcio di insieme della griglia di punti con i valori di arefg di riferimento sostanzialmente derivato dal progetto DPC-INGV-S1, mentre in figura 14 viene illustrato un particolare ingrandito dei punti prossimi alla costa, utilizzabili in modo specifico per le analisi di RSL di III Livello presso ciascuna zona omogenea.
Da tale disamina si evince che, muovendosi nell'ambito del territorio, il valore arrotondato di arefg (PGA_0) può variare localmente ed in misura modesta da a_{refg} = 0.183 (ag/g) a arefg = 0.184 (ag/g).

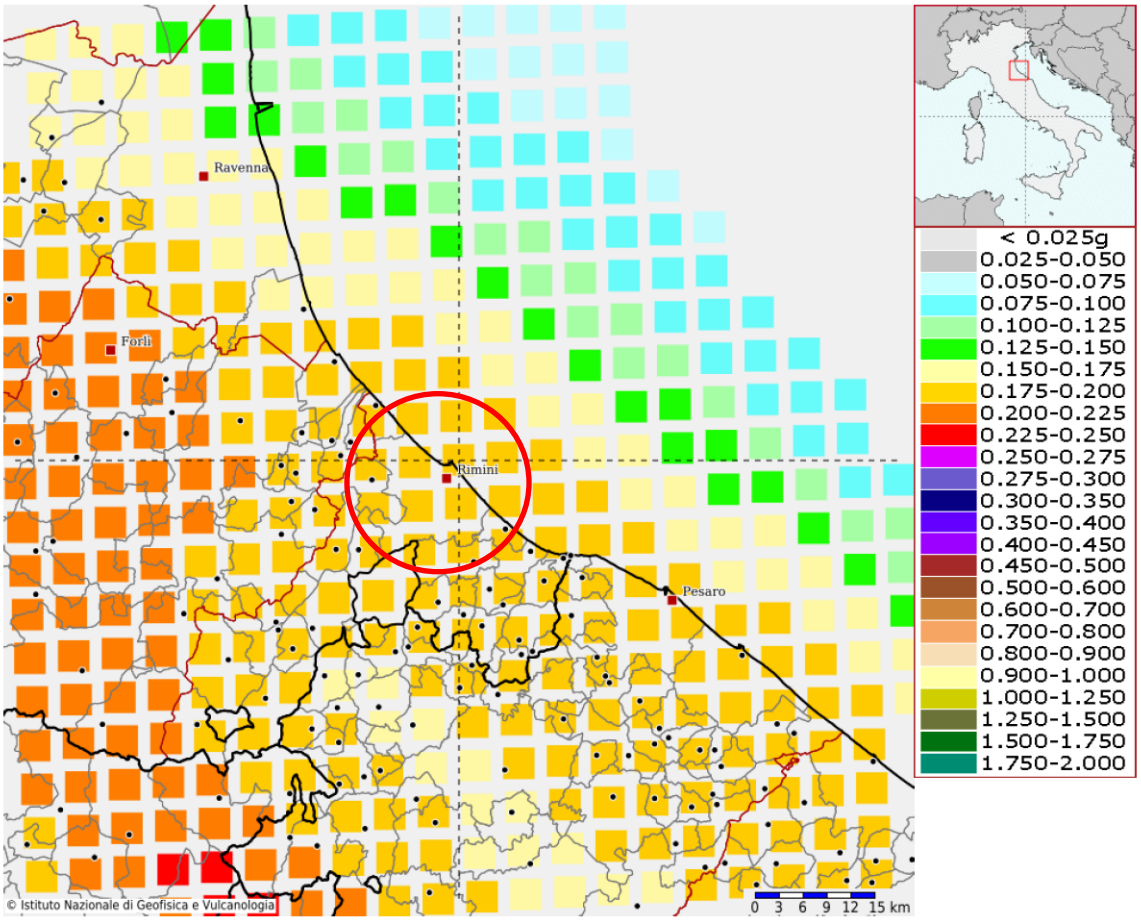


Figura 13 – Stralcio griglia punti di analisi PGA0 attraverso disaggregazione, progetto DPC-INGV-S1 Web-Gis.



Figura 14 – Dettaglio griglia punti di analisi PGA_0 utilizzabili per le analisi di MS3 lungo le zone costiere (nodi cerchiati in rosso).

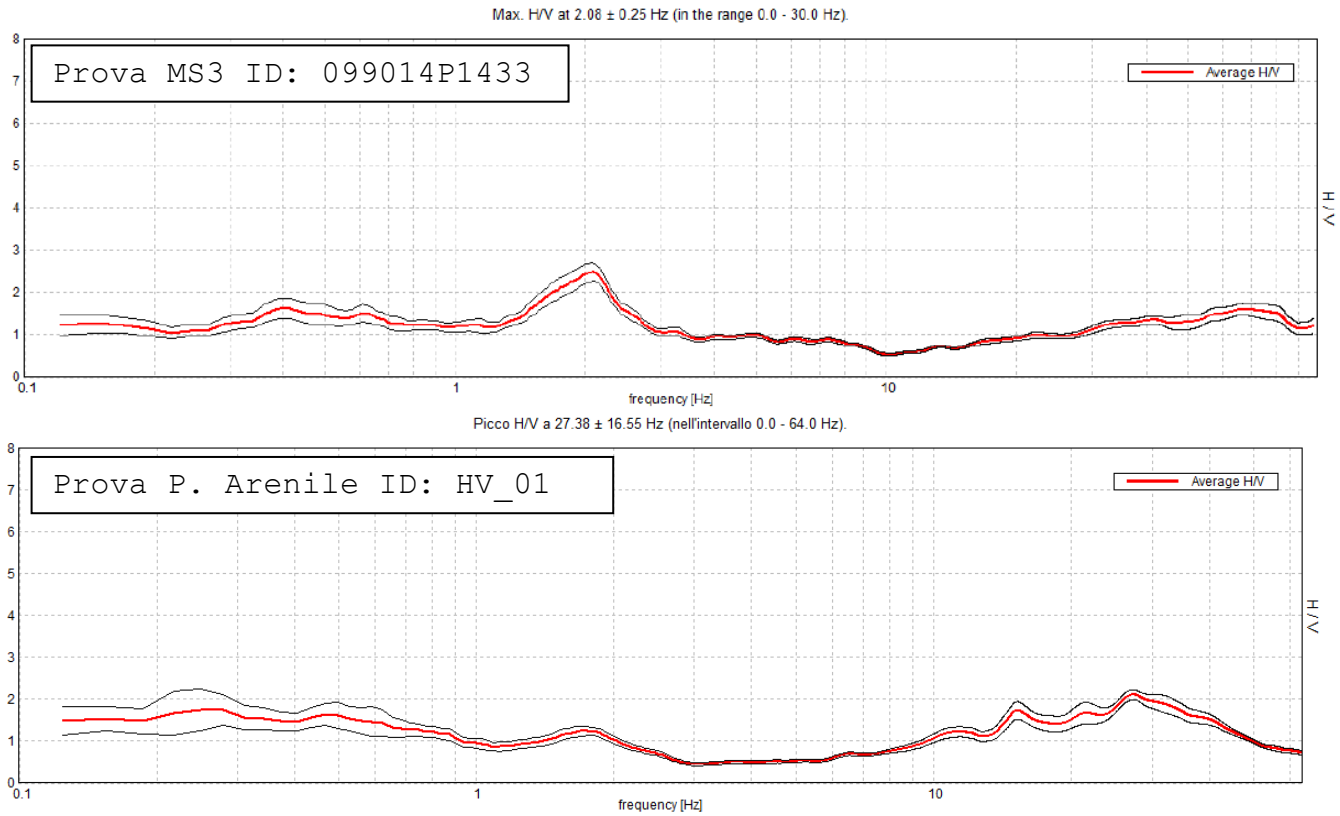
2.2. MODELLO DI SOTTOSUOLO

2.2.1. *Comportamento dinamico del sottosuolo*

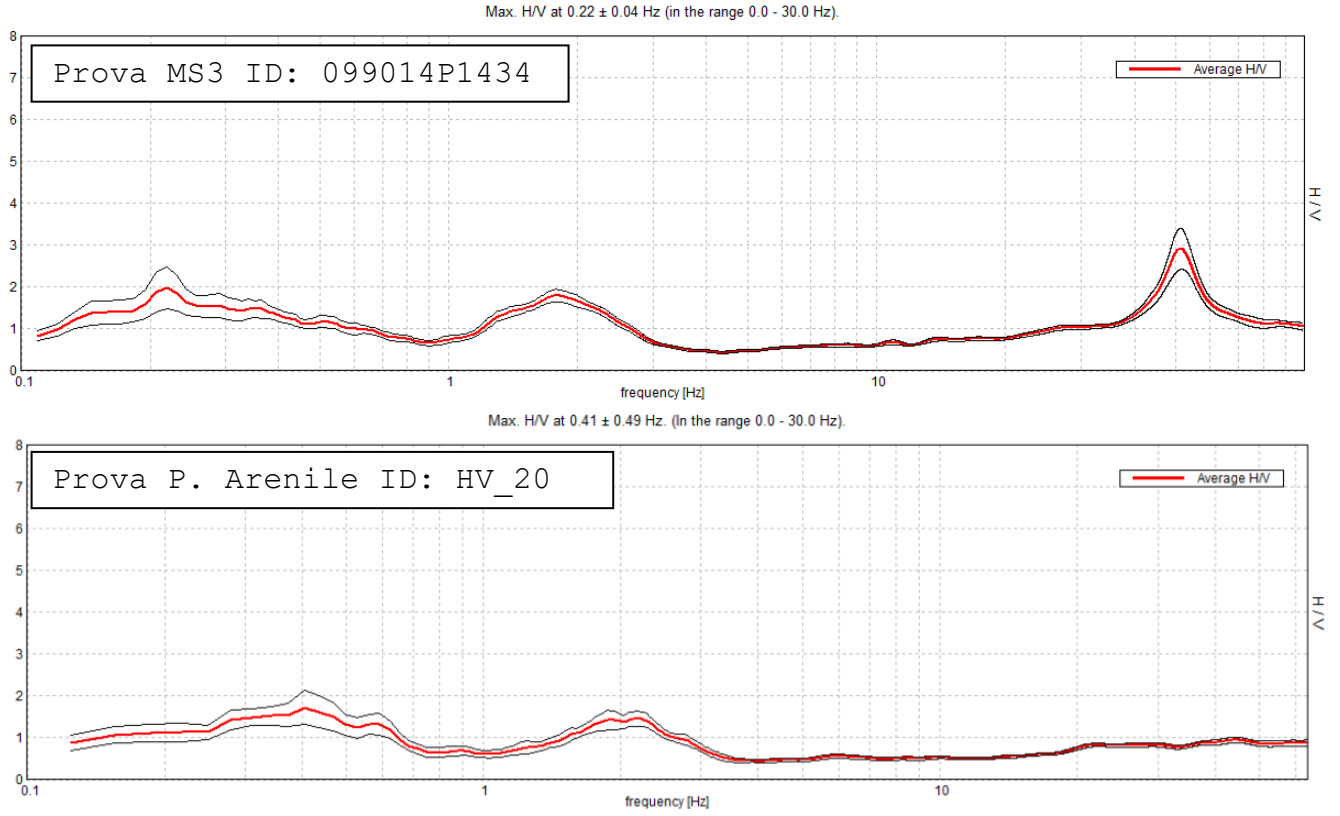
Come evidenziato nell'inquadramento geologico (Capitolo 2 e 3 Relazione Geologica) le profondità del substrato geologico attese per l'area di studio vanno dall'ordine delle diverse decine di metri sino a centinaia di metri di profondità nella zona più profonda della conoide del Marecchia. Data la quantità di informazioni geofisiche distribuite sul territorio si sono sfruttate le prove HVSR congiuntamente ai dati geognostici e geofisici profondi di bibliografia utili ad individuare i picchi di frequenza di maggior rilevanza per la risposta sismica locale, tra cui quelli associabili ad interfacce compatibili con un bedrock geofisico.

A titolo di esempio in figura 15 si ripropongono alcune coppie comparate di registrazioni tromografiche con relativa elaborazione HVSR, tratte dall'archivio del recente studio di MS3 del Comune di Rimini e di nuova realizzazione, effettuate in siti vicini lungo l'arenile, presso le zone di Rimini Nord (RNN), Marina centro (in prossimità del portocanale) ed in corrispondenza del tratto centro meridionale dell'arenile (loc. Miramare). Il raffronto spettrale di tali prove consente di poter apprezzare e constatare l'analogia e coerenza di comportamento dinamico dei siti in studio lungo i vari tratti di arenile e di lungomare con le zone a comportamento dinamico omogeneo in cui è stato suddiviso l'ambito costiero nell'ambito degli studi di MS3 effettuati dal Comune di Rimini (vedi figura 16).

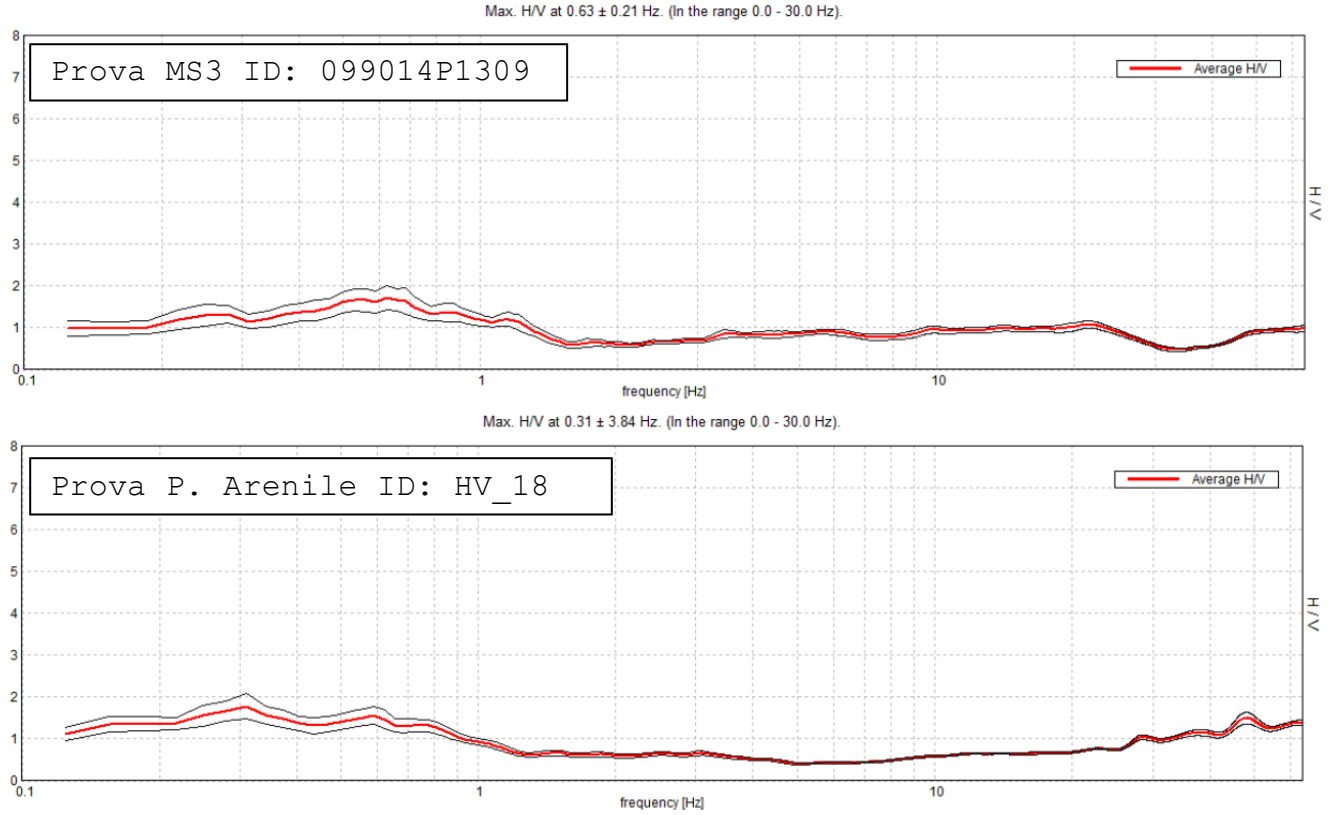
Si ribadisce come le coppie registrazioni, per quanto vicine, comunque siano state eseguite in periodi differenti e, quindi, con condizioni al contorno parzialmente differenti, le quali possono determinare differenti fluttuazioni nella forzante ambientale, es. vento, maree, mareggiate, condizioni meteo e turbolenze atmosferiche, tremori indotti da attività antropiche, ecc..; talora, inoltre, sono state condotte con strumenti differenti e/o a diversa sensibilità di acquisizione, per cui i valori in ampiezza dei massimi di ampiezza H/V vanno apprezzati prevalentemente dal punto di vista qualitativo (valori di frequenza a cui sono centrati i massimi di ampiezza H/V) e in minor misura quantitativo (altezza del picco H/V). Tali valori, in funzione della deviazione standard (dispersione dei valori) e delle modalità di misura, vanno considerati sempre potenzialmente suscettibili di una variabilità pari ad "almeno" il 25% e talora superiore.


Max. H/V at 2.08 ± 0.25 Hz (in the range 0.0 - 30.0 Hz).
Prova MS3 ID: 099014P1433
Average H/V
H / V
frequency [Hz]
Picco H/V a 27.38 ± 16.55 Hz (nell'intervallo 0.0 - 64.0 Hz).
Prova P. Arenile ID: HV_01
Average H/V
H / V
frequency [Hz]

a)


Max. H/V at 0.22 ± 0.04 Hz (in the range 0.0 - 30.0 Hz).
Prova MS3 ID: 099014P1434
Average H/V
H / V
frequency [Hz]
Max. H/V at 0.41 ± 0.49 Hz. (In the range 0.0 - 30.0 Hz).
Prova P. Arenile ID: HV_20
Average H/V
H / V
frequency [Hz]

b)



c)

Figura 15 – Comparazione di coppie di spettri HVSR ottenuti da registrazioni recenti e da archivio MS3 lungo le zone costiere presso Rimini Nord (a), Marina Centro (b) e Rimini Sud (c .

I massimi di ampiezza H/V, in assenza di particolari configurazioni geometriche/morfologiche e/o strutture risonanti, identificano quindi specifici modi di vibrare prevalentemente determinati dagli assetti geologico/stratigrafici e contrasti di rigidezza significativi presenti nel sottosuolo.
La coerenza dei modi di vibrare fondamentali e di quelli superiori maggiormente significativi, verificata con le prove pregresse lungo i vari tratti di costa, consente quindi di adottare la medesima schematizzazione di modello di sottosuolo già definito per la fascia costiera in sede di studi di I-II e III Livello, già realizzati per conto del Comune di Rimini ed attualmente in fase di validazione presso il Dipartimento di Protezione Civile. Tali studi sono stati sviluppati ed elaborati seguendo le più recenti e vigenti Linee Guida nazionali (ICMS, 2008) e regionali (DGR 564/2021).
Al proposito si ritiene coerente ed adeguato adottare il modello di sottosuolo di riferimento e la zonazione sismica definiti in tale recente microzonazione sismica, calibrata anche sulla scorta di prove geofisiche, di laboratorio ciclico/dinamico e sondaggi profondi realizzati proprio in corrispondenza degli arenili e delle aree limitrofe, pienamente rappresentativi dell'area in studio.
Sulla scorta di tali valutazioni ed elaborazioni il tratto costiero è stato suddiviso secondo 10 zone a comportamento dinamico omogeneo e rappresentativo (vedi figura 16), individuando altresì le relative profondità del bedrock geofisico e sviluppando specifici modelli di sottosuolo con profili di Vs caratteristici, utilizzati poi per le modellazioni di RSL, al fine di definire le azioni sismiche di progetto ed i fattori di amplificazione attesi. Una rappresentazione di riferimento delle zone così definite per questo Piano ed a scala maggiore, viene illustrata in Allegato n. 1.
In particolare muovendosi lungo costa da N verso S, l'interfaccia con il bedrock sismico è stata individuata circa al contatto tra la copertura deposizionale del Sintema AEI ed il substrato geologico formazionale IMO, generalmente correlabile ai massimi di frequenza H/V significativi compresi tra 0.4-0.6 Hz; solamente in corrispondenza delle zone RNS_04 e 05 il contrasto di impedenza significativo risulta individuabile a profondità maggiori di tale interfaccia, all'interno dello stesso substrato formazionale.

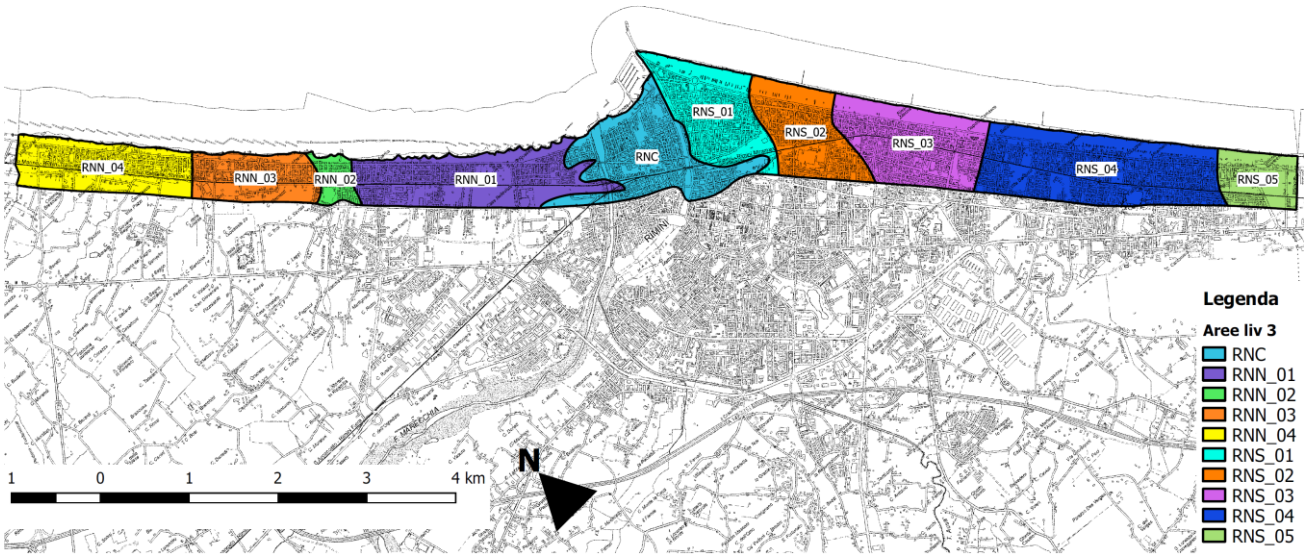


Figura 16- Zone a comportamento dinamico omogeneo e rappresentativo per le RSL lungo il tratto costiero studiato – Studio MS3 Rimini, 2021.

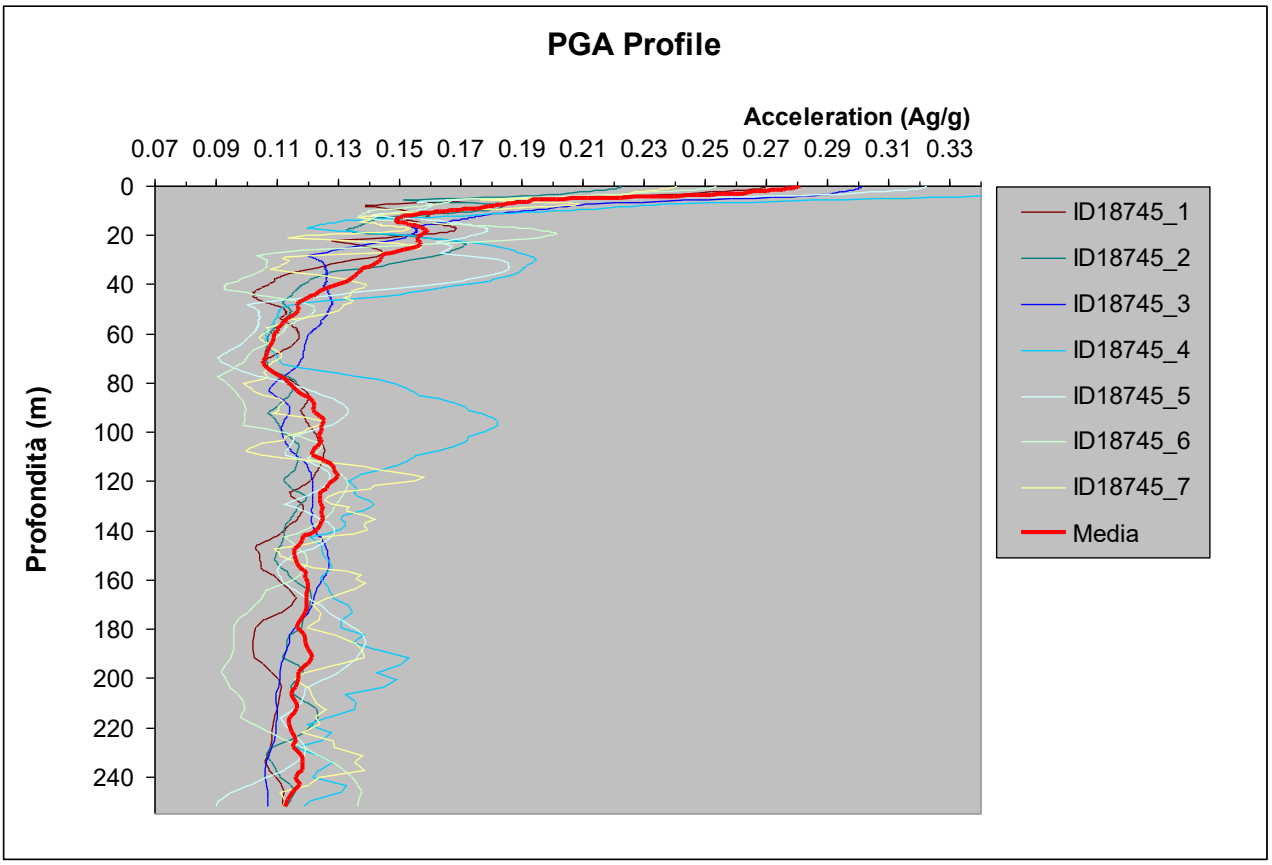
2.3 MOTO SISMICO DI RIFERIMENTO

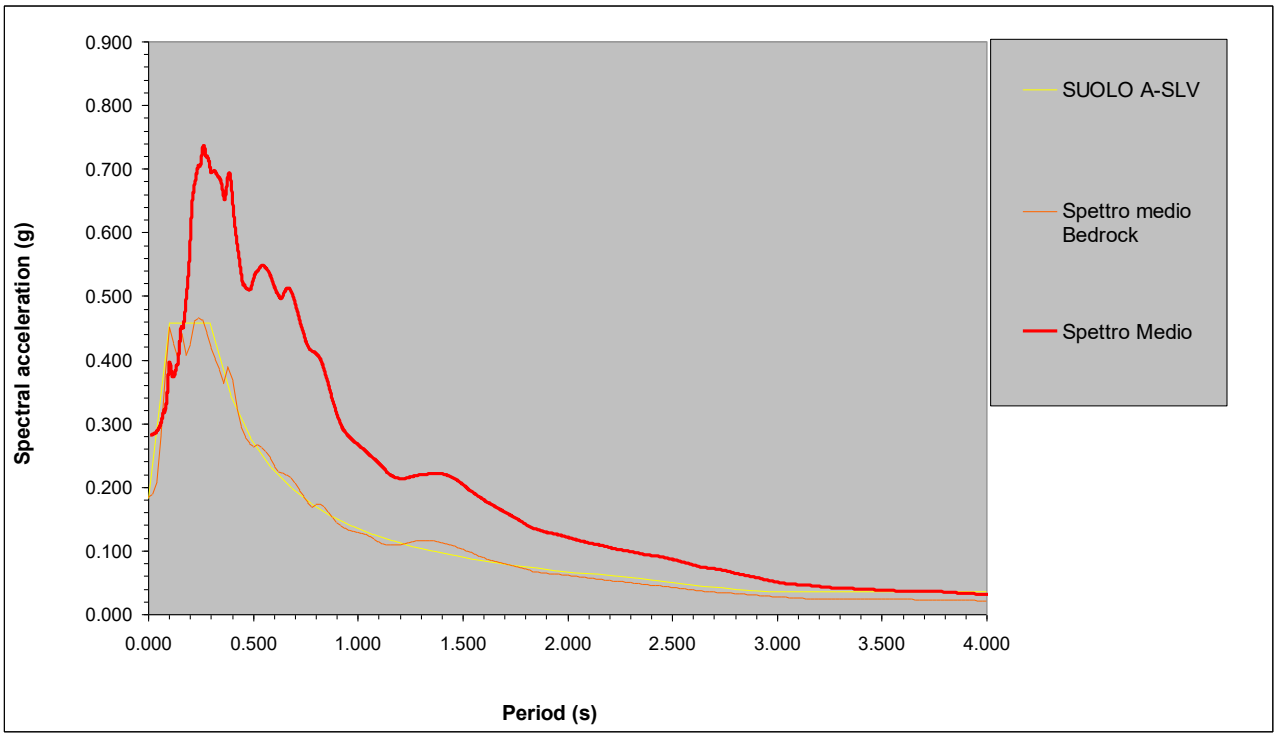
Oltre alla suddivisione in zone a comportamento dinamico omogeneo si ritiene coerente ed adeguato attenersi anche ai relativi modelli sottosuolo sviluppati per ciascuna di esse ed ai relativi valori di azione sismica ottenuti nello studio di III Livello di approfondimento, tramite puntuali elaborazioni di Risposta Sismica Locale con metodo di analisi lineare equivalente.

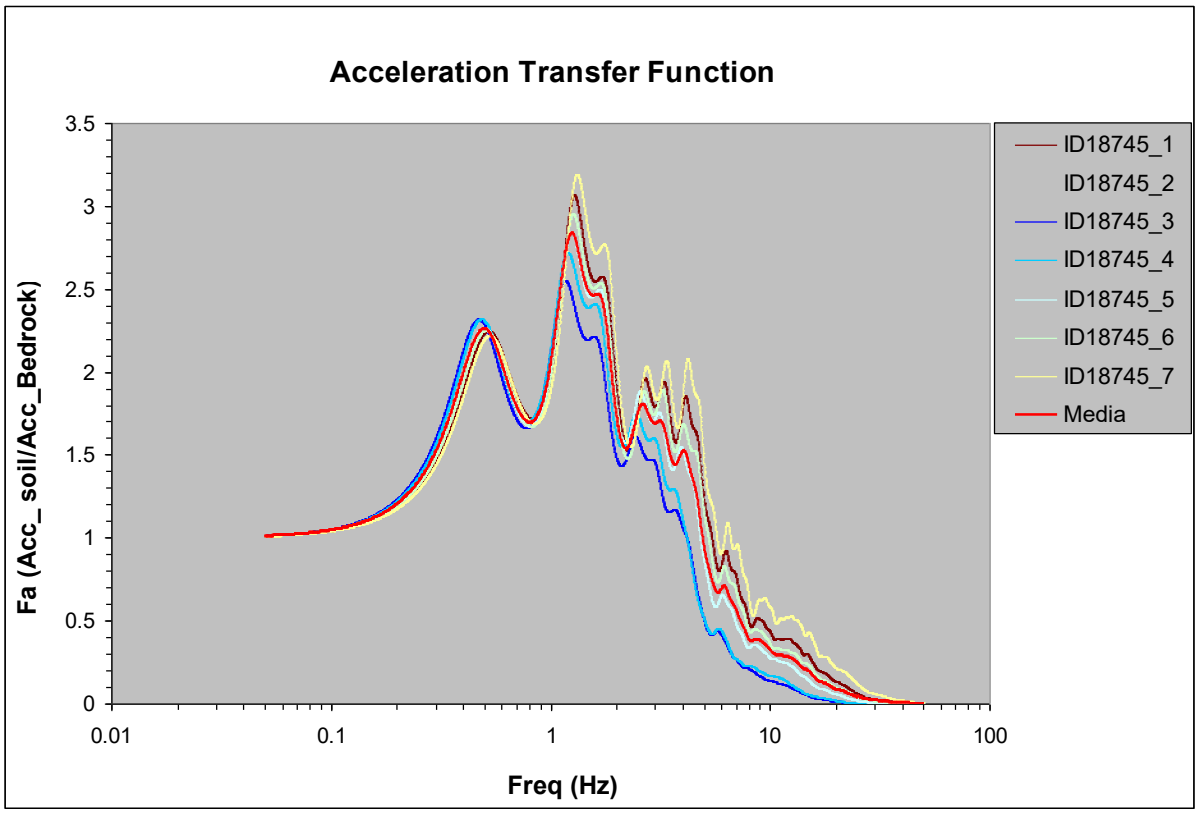
Di seguito si riportano, quindi, i dati di sintesi (in forma grafica e tabellare) di ciascuna zona sismicamente rappresentativa identificata lungo costa, partendo da N verso S; in coda ai grafici di ciascun ambito di verifica viene riportato anche il relativo valore di V_{SH} (nel caso specifico riferibile a Vs30 in virtù della significativa profondità del bedrock sismico) onde consentire un eventuale confronto con i parametri tabellari proposti negli abachi regionali (DGR 564/2021) e/o degli ICMS.
I valori/parametrici sismici sono riferibili alle condizioni di free field e, in ossequio alle direttive approvate con 630/2019, come aggiornata dalla *DGR 476/2021 e successiva integrazione DGR 564/2021*, per ciascuna area di verifica sono state calcolate le relative "*PGA*" (peak ground acceleration) al suolo libero (media di 7 segnali) ed i fattori di amplificazione e di intensità spettrale determinati sulla base di:

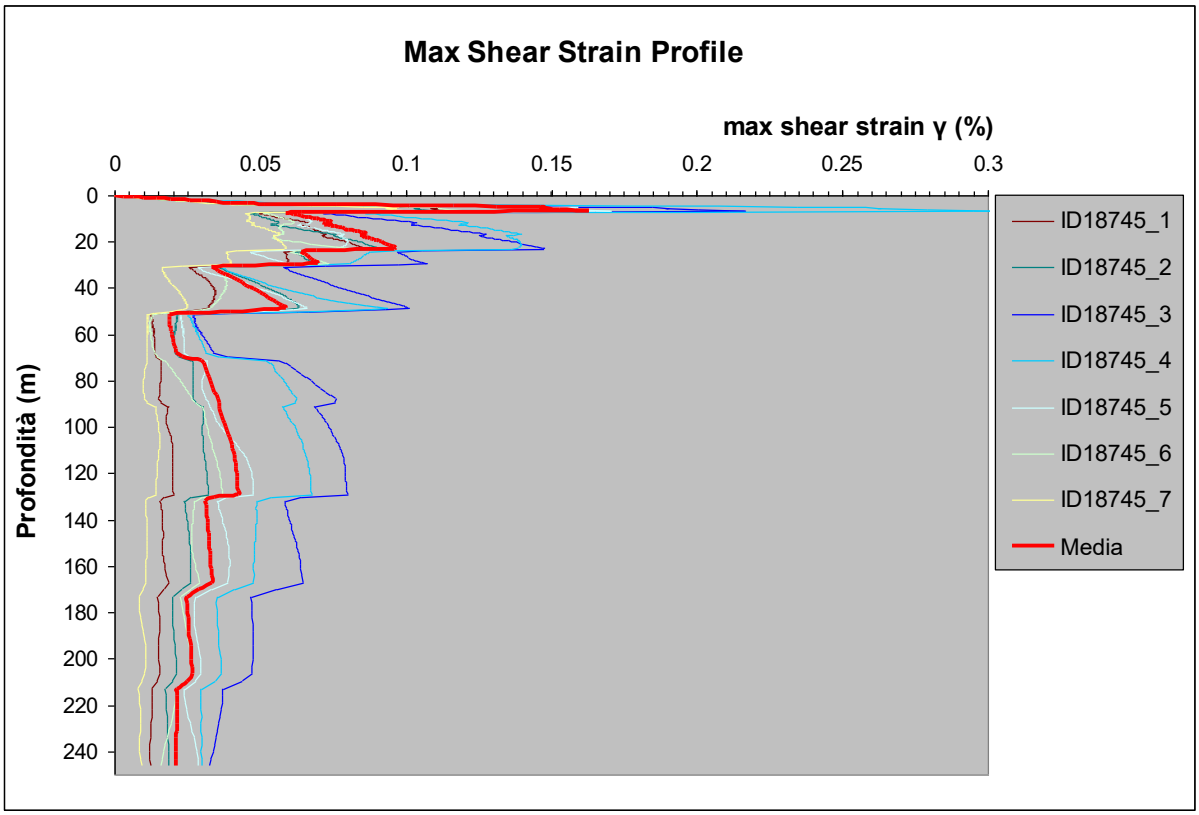
- ***F_{PGA} = PGA/PGA0 (ove PGA0=$ag_{bedrock}$)***
- ***FA = SA/SA0, ovvero rapporti spettrali in accelerazione fra i seguenti periodi T(s) di riferimento: SA1 per 0,1s≤T≤0,5s, SA2 per 0,4s≤T≤0,8s, SA3 per 0,7s≤T≤1,1s, SA4 per 0,5s≤T≤1,5s;***
- ***FH = SI/SI0, ovvero rapporti spettrali in pseudovelocità (Intensita di Housner) fra i seguenti periodi T(s) di riferimento: SI1 per 0,1s≤T≤0,5s, SI2 per 0,5s≤T≤1,0s, SI3 per 0,5s≤T≤1,5s;***
- ***Parametro di scuotimento assoluto H_{SM} (cm/s^2) (Naso et al., 2019), calcolato per l'intervallo di periodi 0,1s≤T≤0,5s ed H_{0408}, H_{0711}, H_{0515}, ovvero lo scuotimento in accelerazione (cm/s^2) atteso al sito per gli intervalli di periodi 0,4s≤T≤0,8s, 0,7s≤T≤1,1s e 0,5s≤T≤1,5s;***

ZONA RNN_04


PGA Profile
Acceleration (Ag/g)
0.07 0.09 0.11 0.13 0.15 0.17 0.19 0.21 0.23 0.25 0.27 0.29 0.31 0.33
Profondità (m)
0 20 40 60 80 100 120 140 160 180 200 220 240
ID18745_1
ID18745_2
ID18745_3
ID18745_4
ID18745_5
ID18745_6
ID18745_7
Media


Spectral acceleration (g)
0.900 0.800 0.700 0.600 0.500 0.400 0.300 0.200 0.100 0.000
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000
Period (s)
SUOLO A-SLV
Spettro medio Bedrock
Spettro Medio





VsH (0-30)=193 (m/s)

PGA=0.281

F_{PGA}=1.529

Fattori SA:

		Periodo(s)	Bedrock		Soil		FA
INT SPETT.	SA1	0.1-0.5	0.163954		0.236425		1.442
INT SPETT.	SA2	0.4-0.8	0.102997		0.203486		1.976
INT SPETT.	SA3	0.7-1.1	0.064537		0.135347		2.097
INT SPETT.	SA4	0.5-1.5	0.157940		0.326703		2.069

Fattori SI:

		Periodo(s)	Bedrock		Soil		FA
INT SPETT.	SI1	0.1-0.5	7.003158		11.415441		1.630
INT SPETT.	SI2	0.5-1.0	11.043347		24.752059		2.241
INT SPETT.	SI3	0.5-1.5	22.057859		46.560792		2.111

ASIpu/ΔT= 404.950669

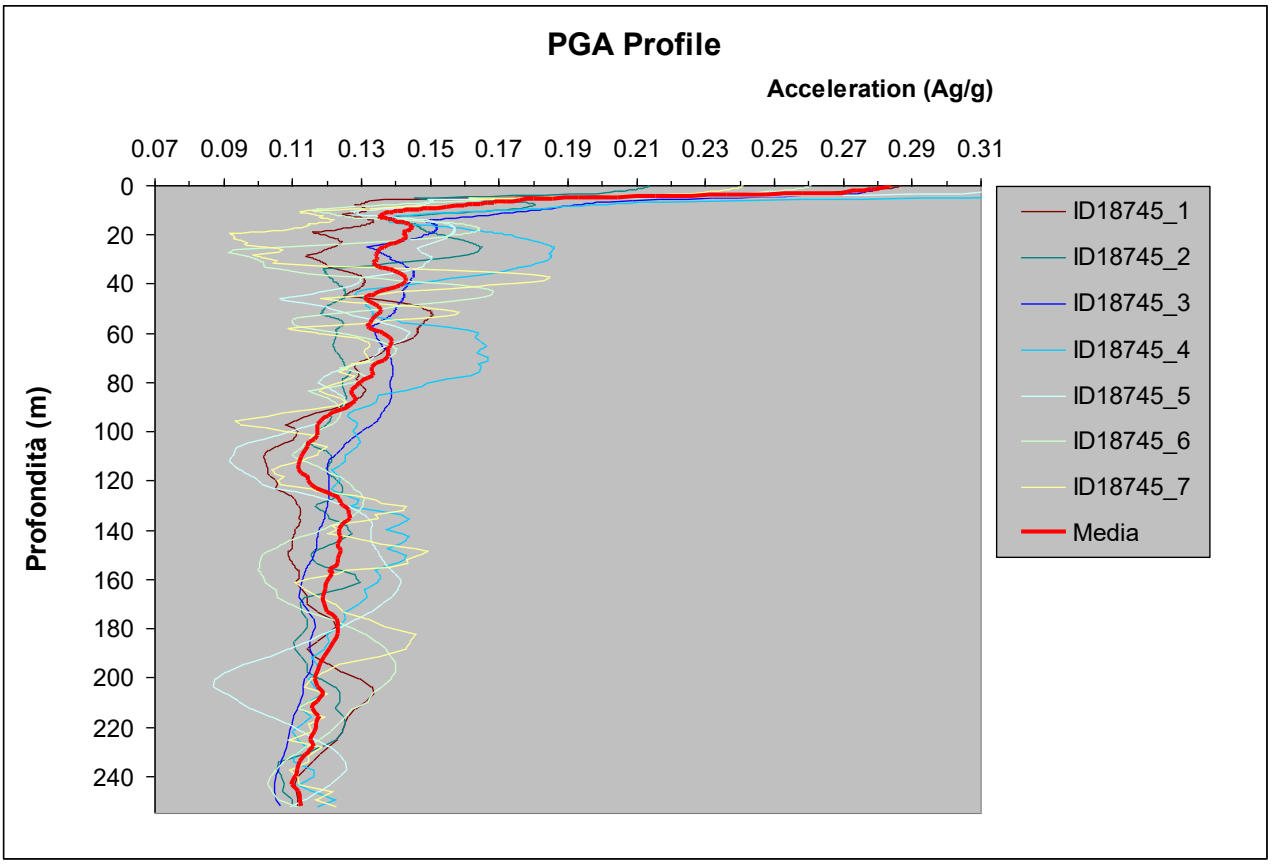
H_{SM}= 583.947

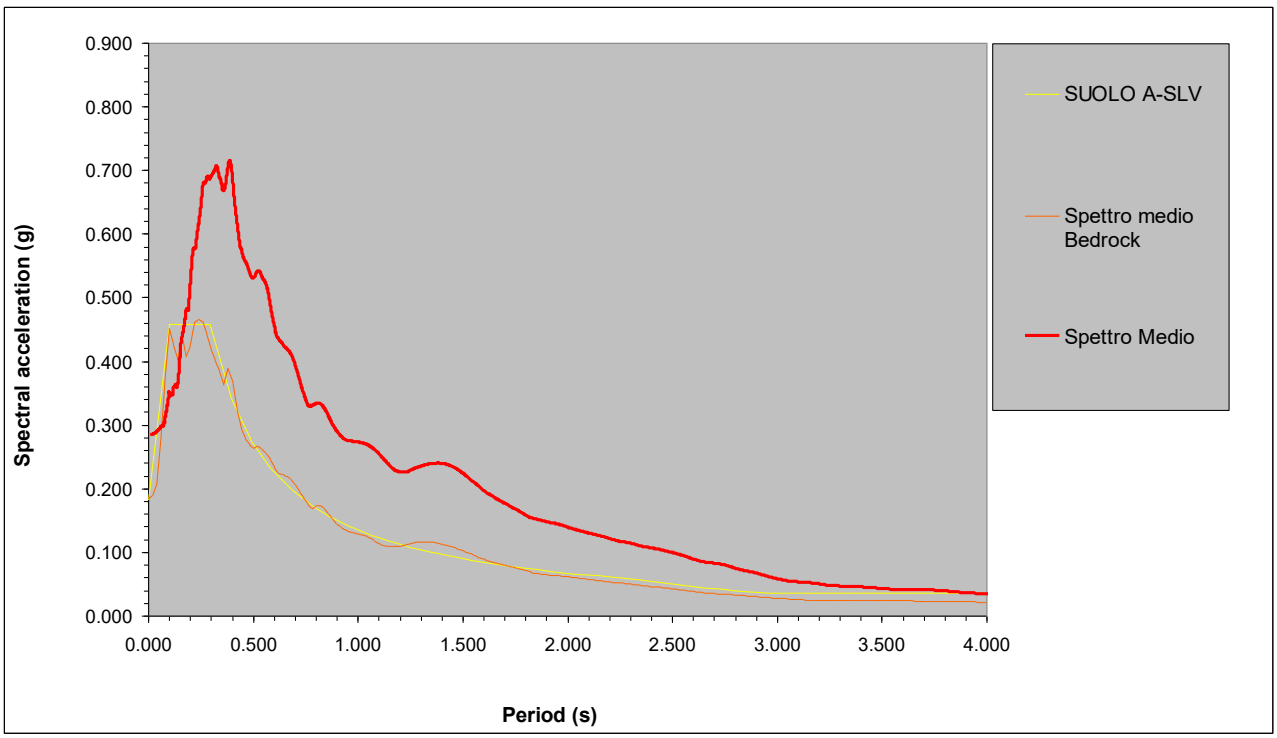
H_{0408}= 498.880

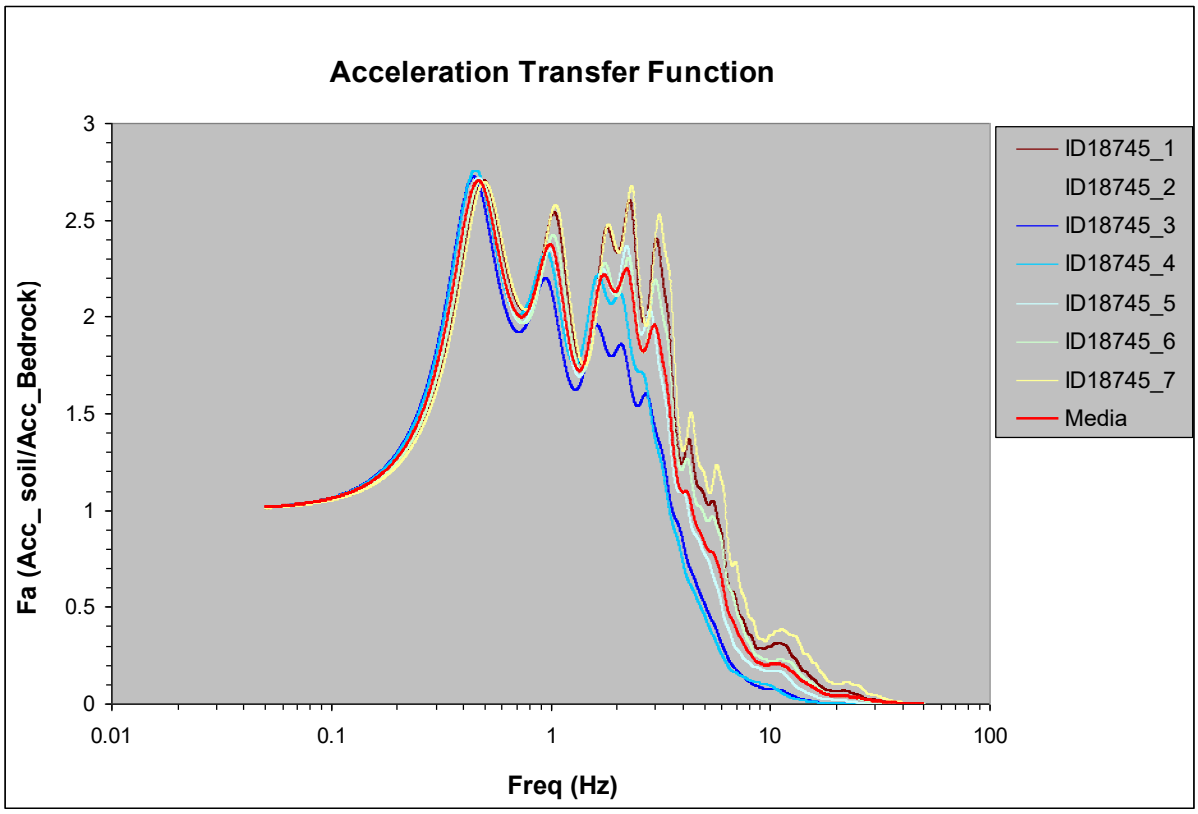
H_{0711}= 331.824

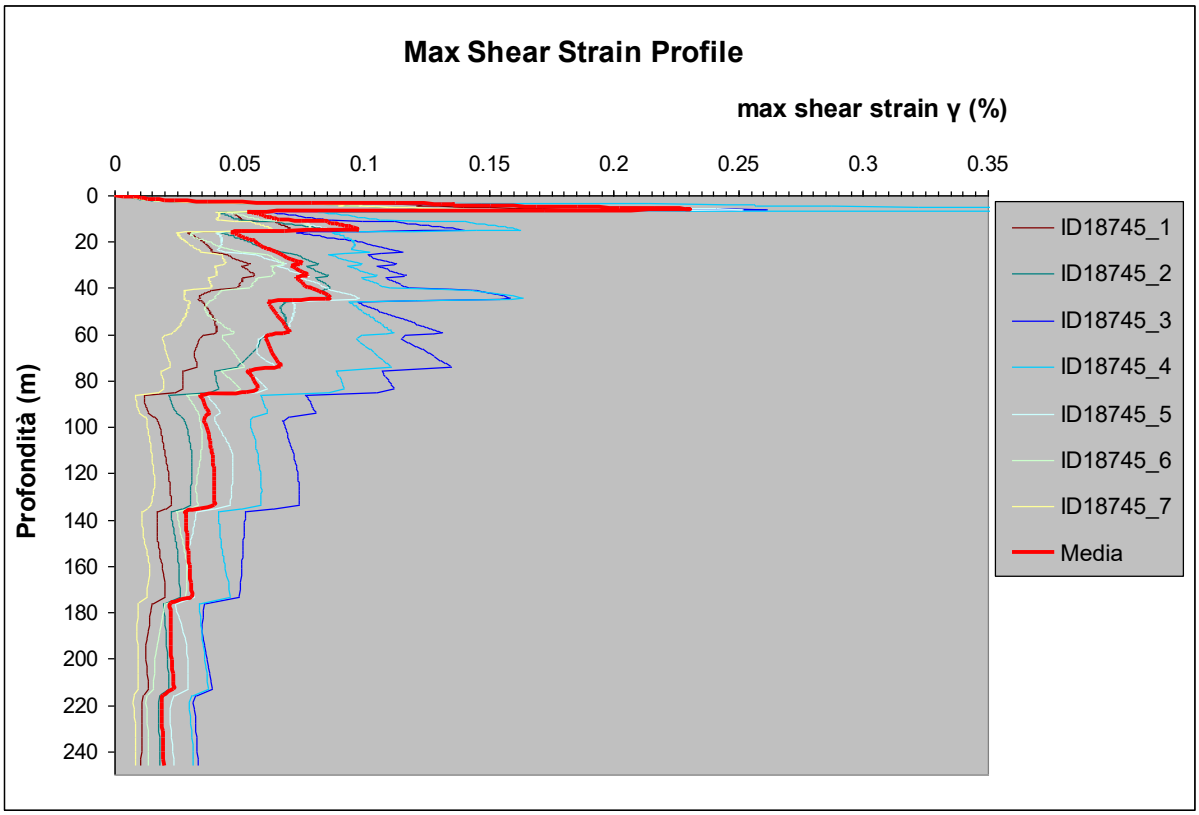
H_{0515}= 320.386

ZONA RNN_03


PGA Profile
Acceleration (Ag/g)
0.07 0.09 0.11 0.13 0.15 0.17 0.19 0.21 0.23 0.25 0.27 0.29 0.31
Profondità (m)
0 20 40 60 80 100 120 140 160 180 200 220 240
ID18745_1
ID18745_2
ID18745_3
ID18745_4
ID18745_5
ID18745_6
ID18745_7
Media


Spectral acceleration (g)
0.900 0.800 0.700 0.600 0.500 0.400 0.300 0.200 0.100 0.000
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000
Period (s)
SUOLO A-SLV
Spettro medio Bedrock
Spettro Medio





VsH (0-30)=213 (m/s)

PGA=0.284

F_{PGA}=1.546

Fattori SA:

		Periodo(s)	Bedrock		Soil		FA
INT SPETT.	SA1	0.1-0.5	0.163954		0.231935		1.415
INT SPETT.	SA2	0.4-0.8	0.102997		0.187944		1.825
INT SPETT.	SA3	0.7-1.1	0.064537		0.121843		1.888
INT SPETT.	SA4	0.5-1.5	0.157940		0.309767		1.961

Fattori SI:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SI1	0.1-0.5	7.003158	11.404615	1.628
INT SPETT.	SI2	0.5-1.0	11.043347	21.945506	1.987
INT SPETT.	SI3	0.5-1.5	22.057859	45.340564	2.056

ASIpu/ΔT= 404.950669

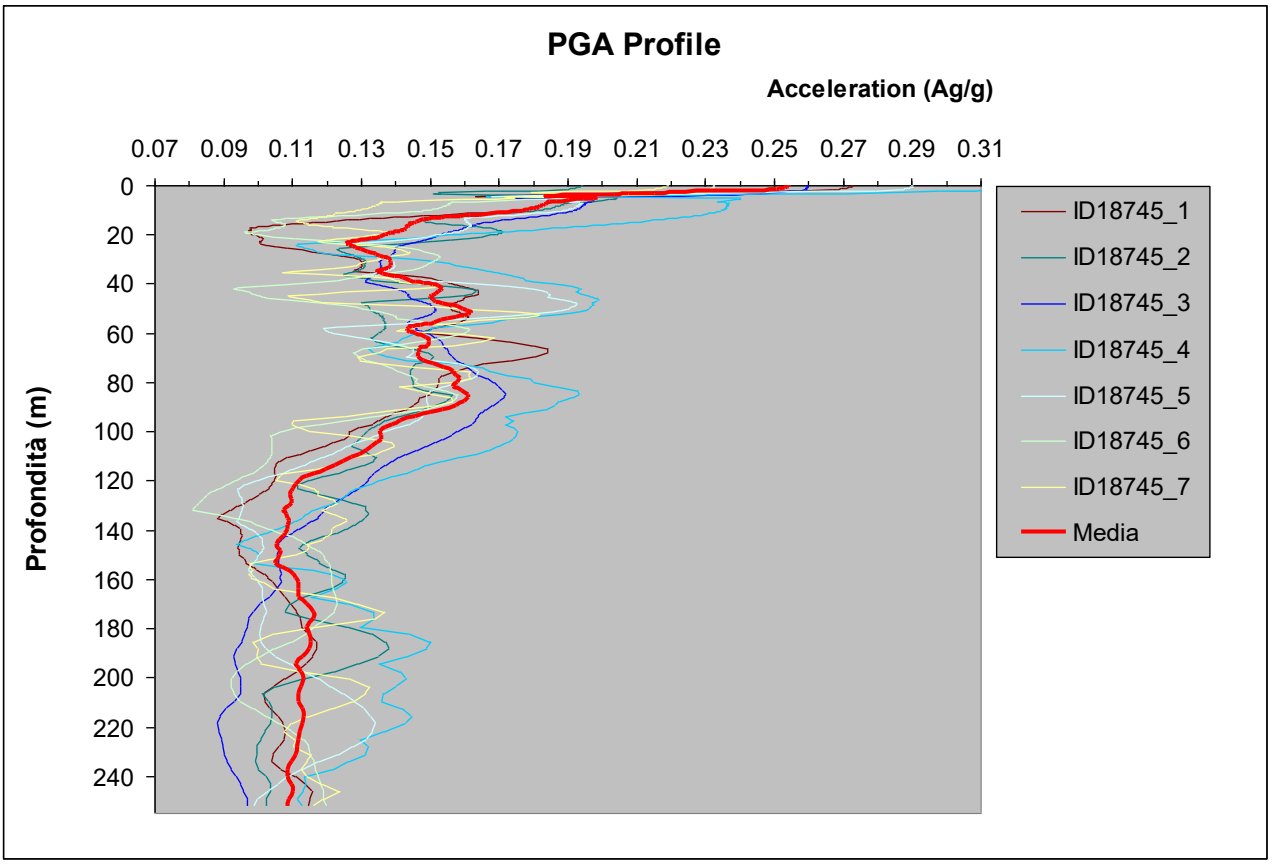
H_{SM}= 572.857

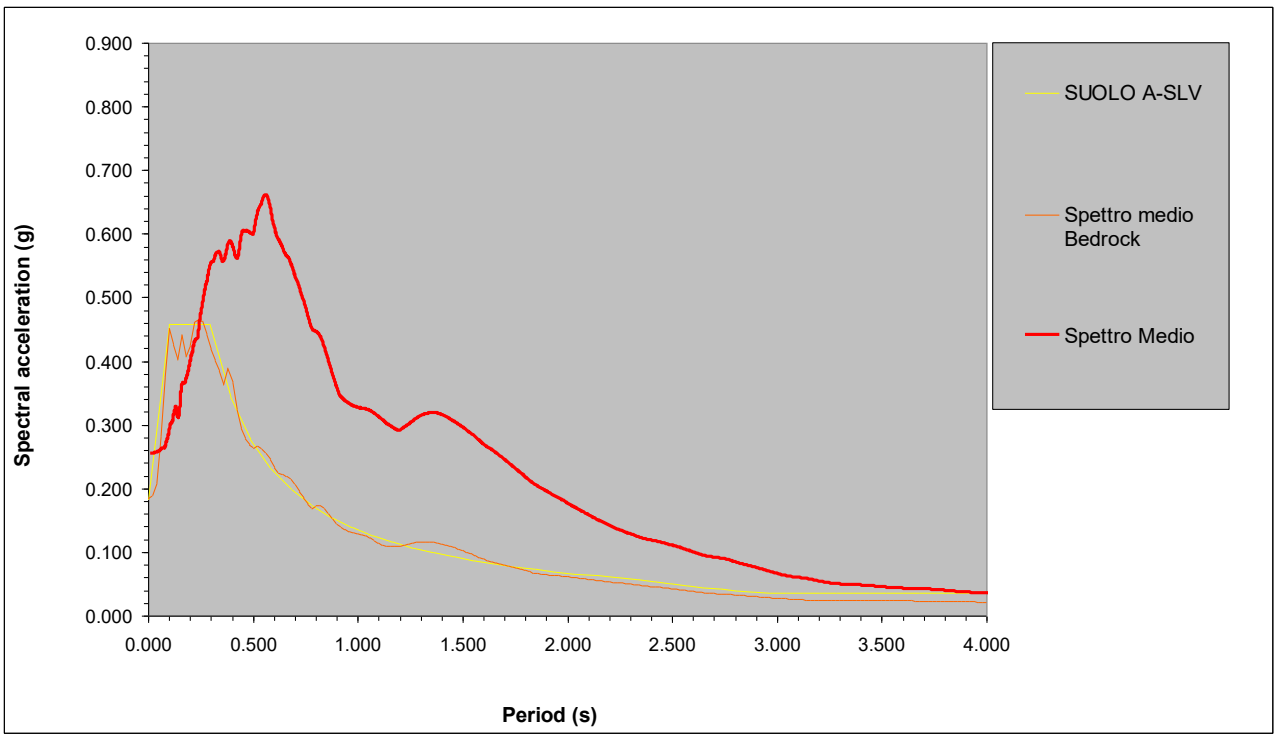
H_{0408}= 460.775

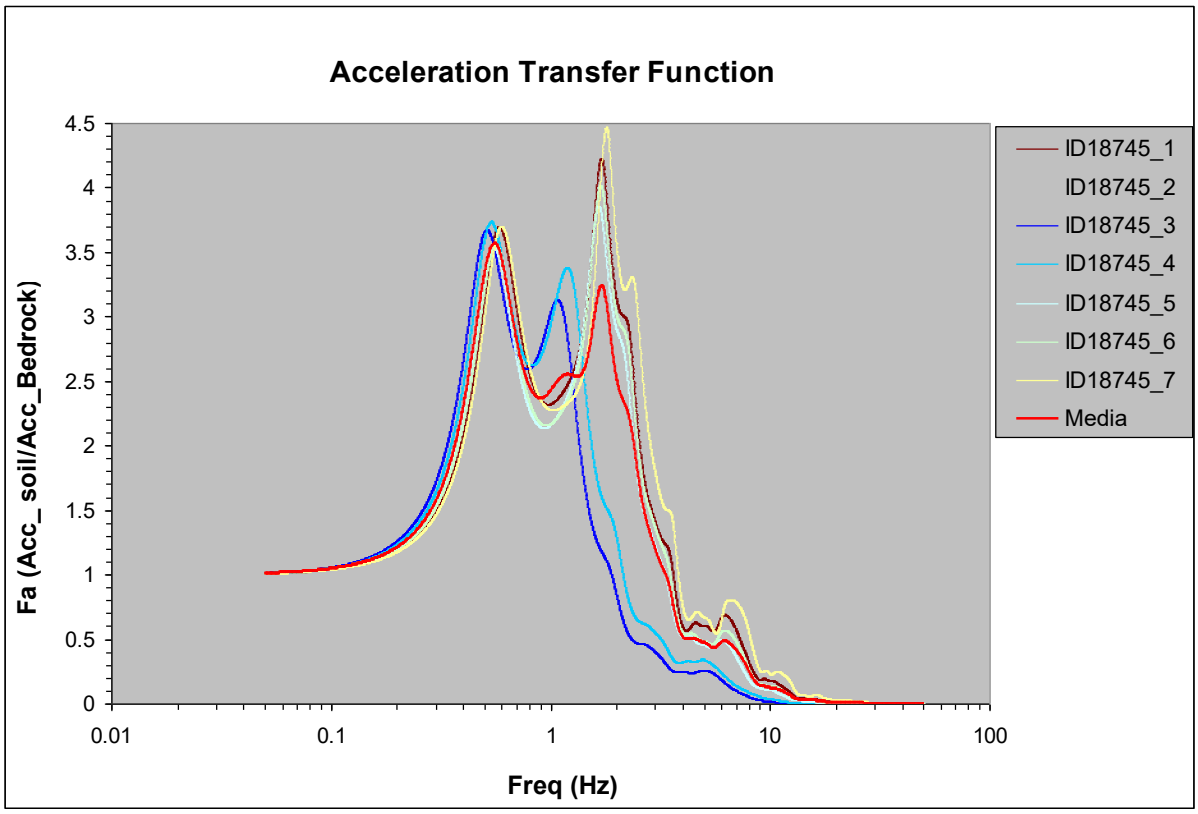
H_{0711}= 298.718

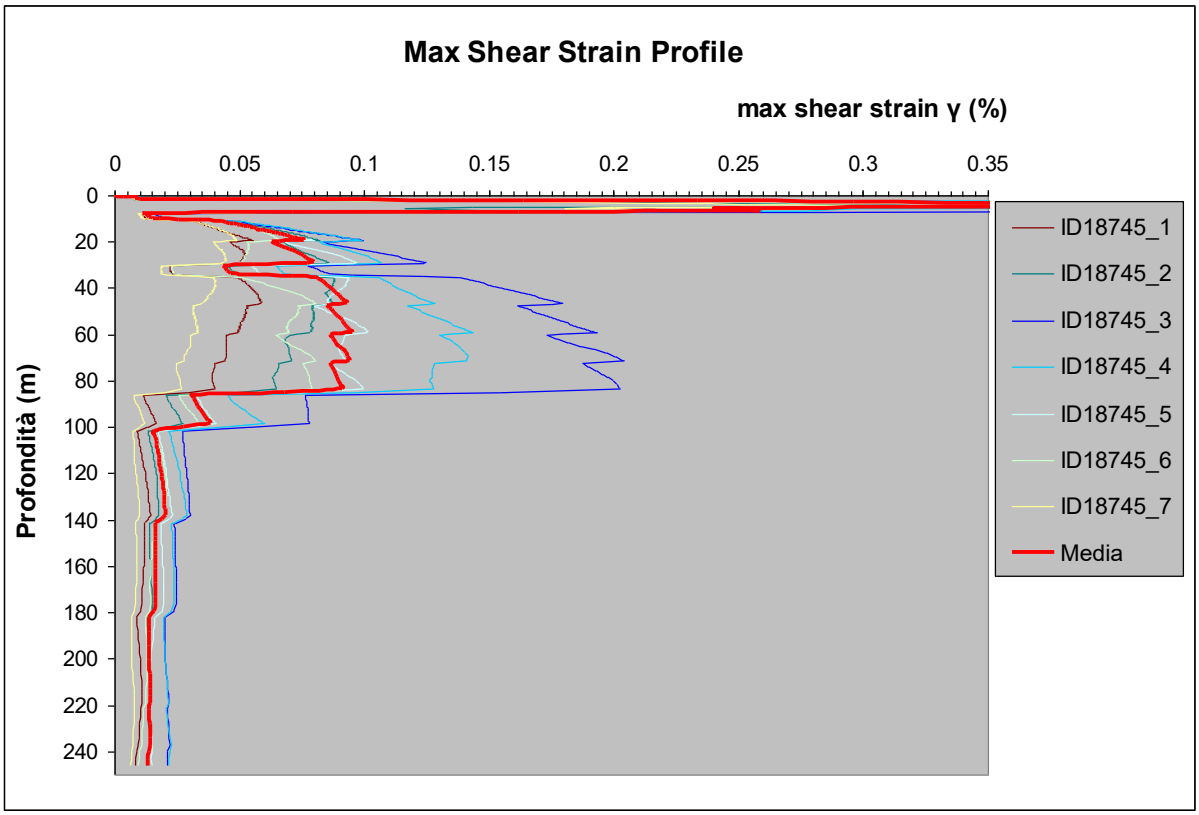
H_{0515}= 303.778

ZONA RNN_02


PGA Profile
Acceleration (Ag/g)
0.07 0.09 0.11 0.13 0.15 0.17 0.19 0.21 0.23 0.25 0.27 0.29 0.31
Profondità (m)
0 20 40 60 80 100 120 140 160 180 200 220 240
ID18745_1
ID18745_2
ID18745_3
ID18745_4
ID18745_5
ID18745_6
ID18745_7
Media


Spectral acceleration (g)
0.900 0.800 0.700 0.600 0.500 0.400 0.300 0.200 0.100 0.000
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000
Period (s)
SUOLO A-SLV
Spettro medio Bedrock
Spettro Medio





VsH (0-30)=193 (m/s)

PGA=0.255

F_{PGA}=1.384

Fattori SA:

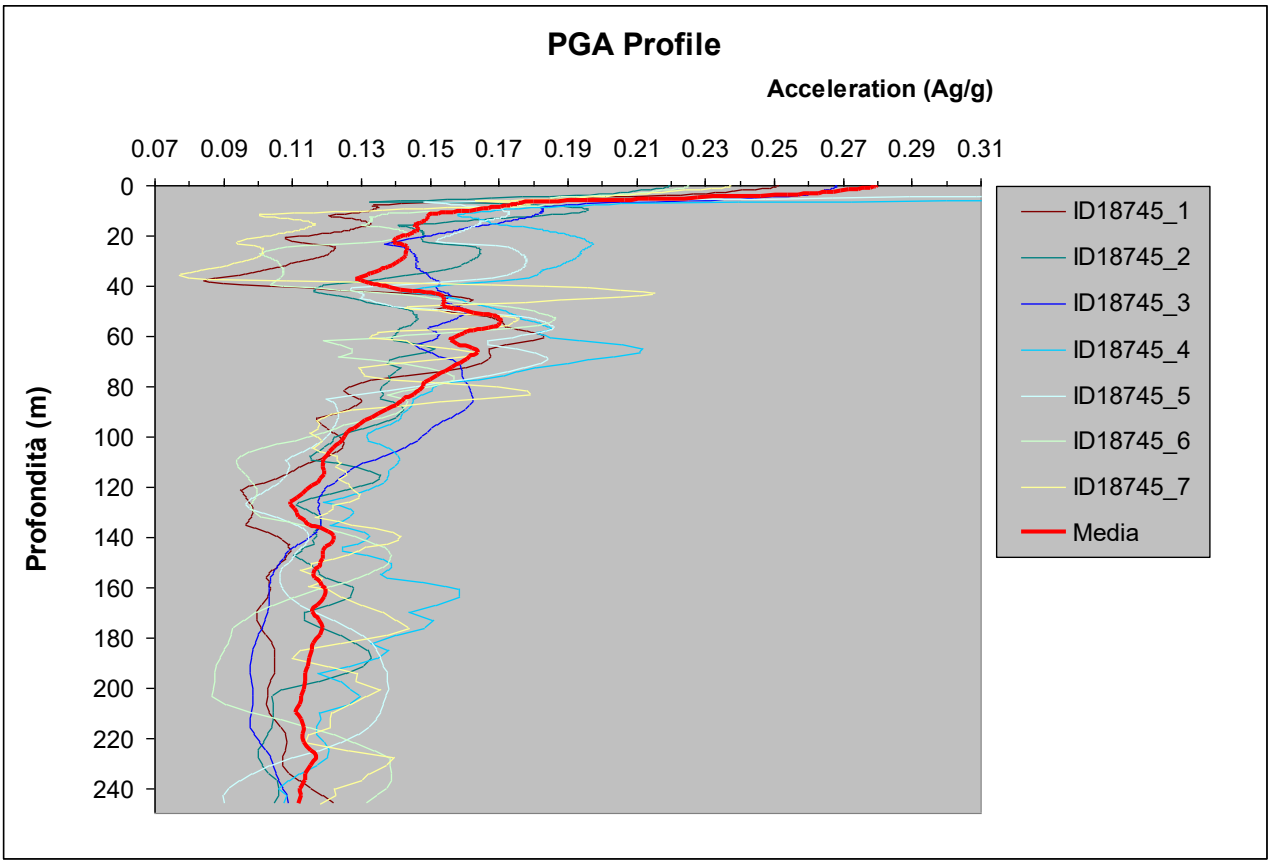
		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SA1	0.1-0.5	0.163954	0.197593	1.205
INT SPETT.	SA2	0.4-0.8	0.102997	0.229168	2.225
INT SPETT.	SA3	0.7-1.1	0.064537	0.156368	2.423
INT SPETT.	SA4	0.5-1.5	0.157940	0.400161	2.534

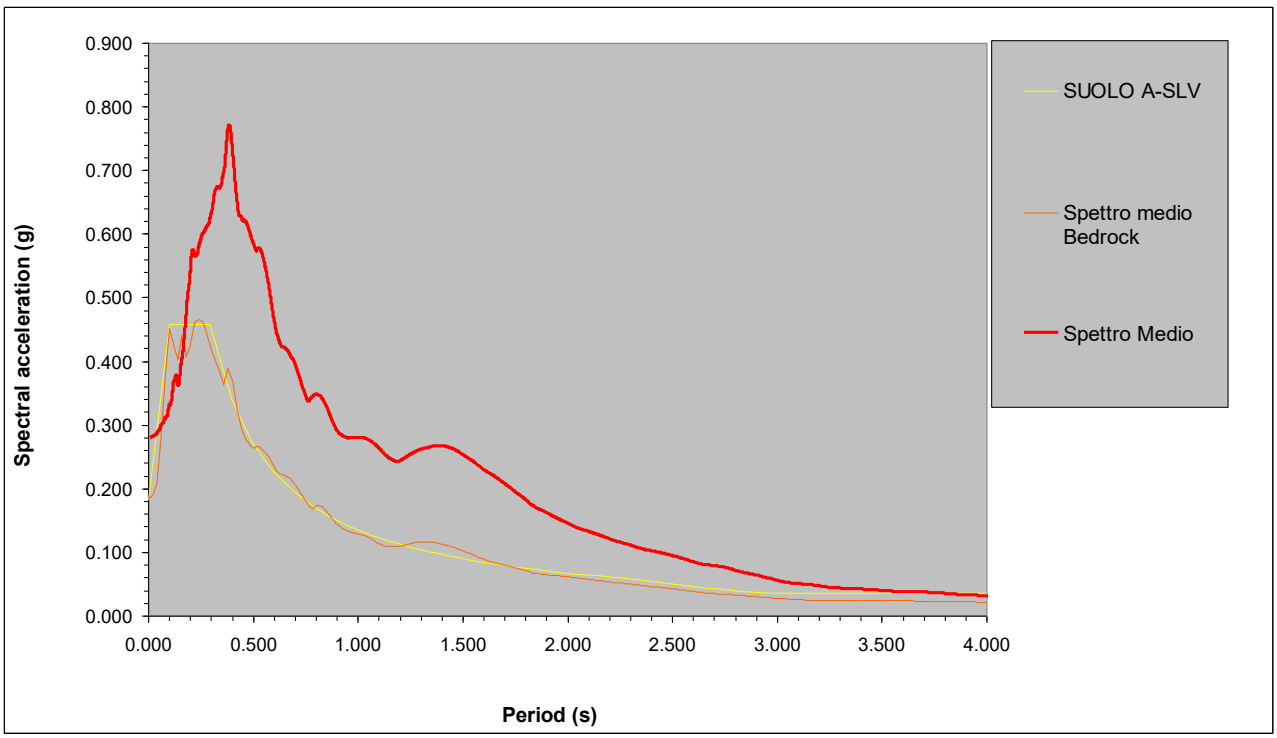
Fattori SI:

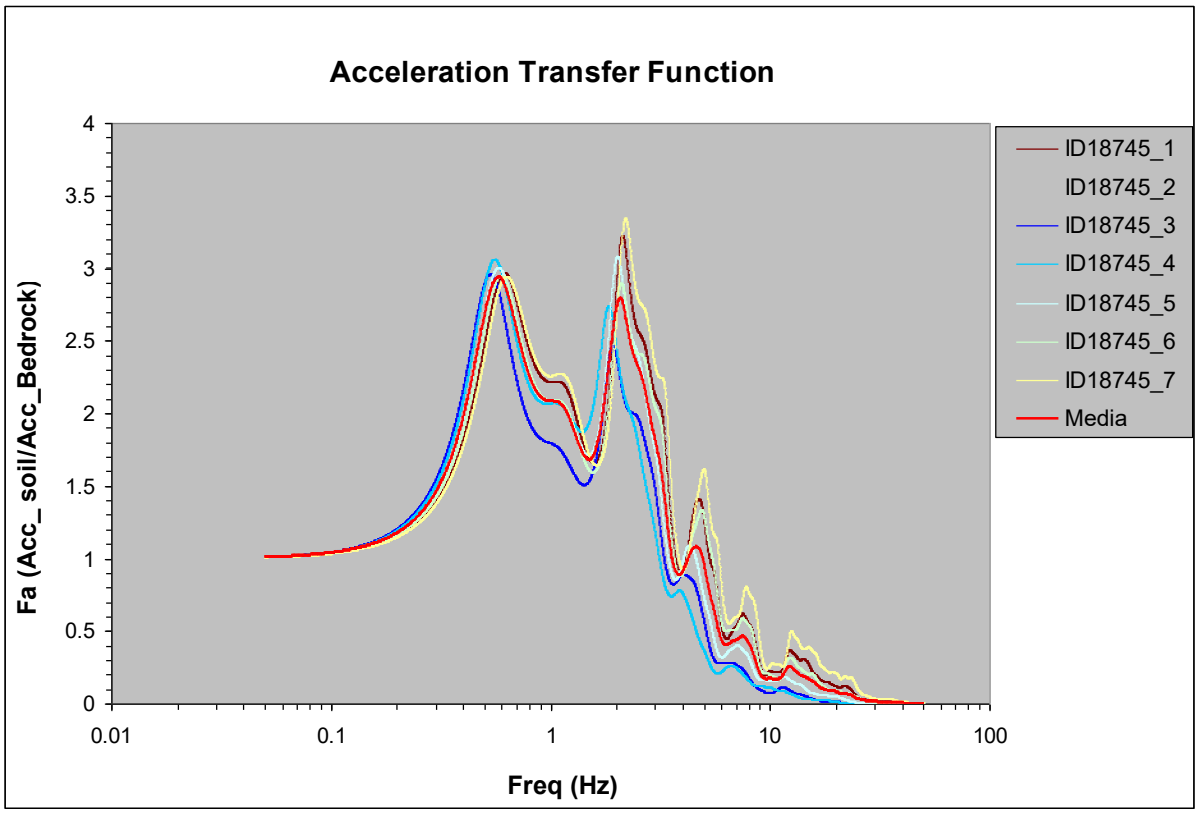
		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SI1	0.1-0.5	7.003158	10.016537	1.430
INT SPETT.	SI2	0.5-1.0	11.043347	28.295502	2.562
INT SPETT.	SI3	0.5-1.5	22.057859	58.502846	2.652

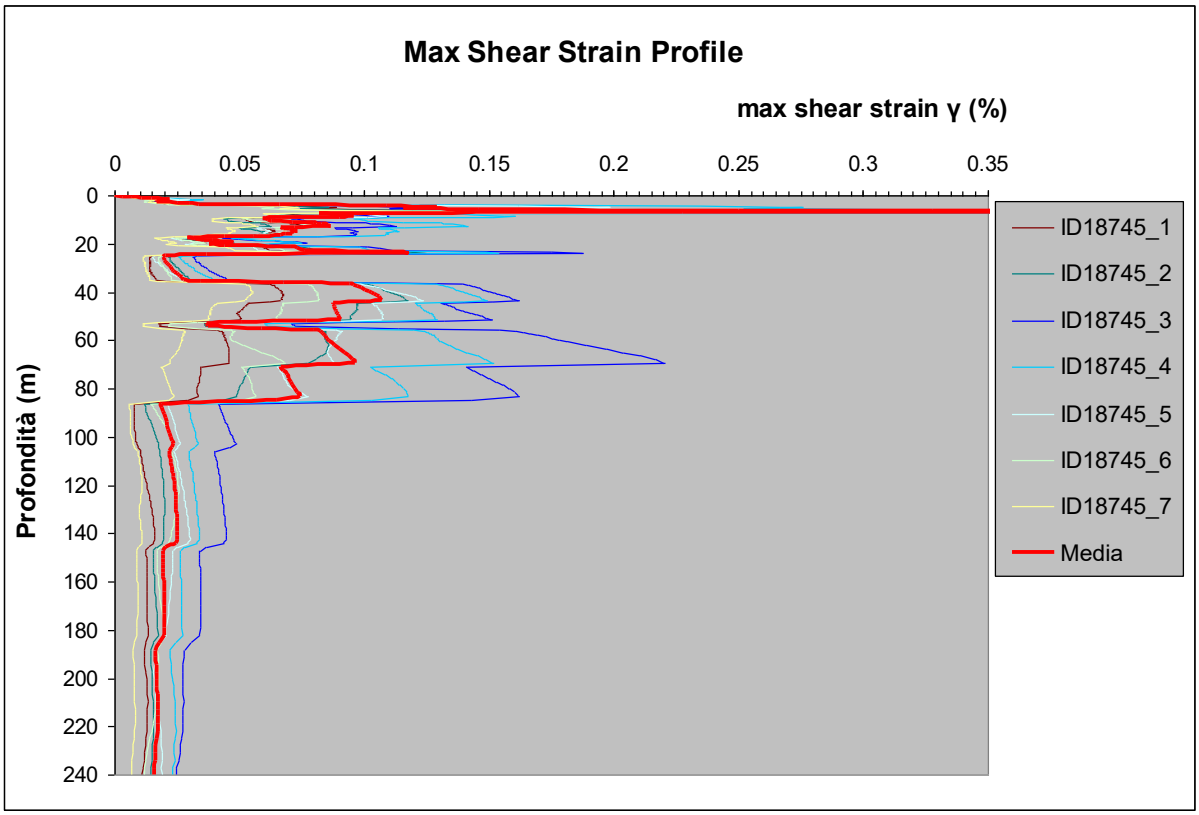
ASIpu/ΔT= 404.950669
H_{SM}= 488.036
H_{0408}= 561.844
H_{0711}= 383.362
H_{0515}= 392.424

ZONA RNN_01


PGA Profile
Acceleration (Ag/g)
0.07 0.09 0.11 0.13 0.15 0.17 0.19 0.21 0.23 0.25 0.27 0.29 0.31
Profondità (m)
0 20 40 60 80 100 120 140 160 180 200 220 240
ID18745_1
ID18745_2
ID18745_3
ID18745_4
ID18745_5
ID18745_6
ID18745_7
Media


Spectral acceleration (g)
0.900 0.800 0.700 0.600 0.500 0.400 0.300 0.200 0.100 0.000
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000
Period (s)
SUOLO A-SLV
Spettro medio Bedrock
Spettro Medio





VsH (0-30)=229 (m/s)

PGA=0.280

F_{PGA}=1.524

Fattori SA:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SA1	0.1-0.5	0.163954	0.232936	1.421
INT SPETT.	SA2	0.4-0.8	0.102997	0.196660	1.909
INT SPETT.	SA3	0.7-1.1	0.064537	0.124661	1.932
INT SPETT.	SA4	0.5-1.5	0.157940	0.324482	2.054

Fattori SI:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SI1	0.1-0.5	7.003158	11.634198	1.661
INT SPETT.	SI2	0.5-1.0	11.043347	22.520730	2.039
INT SPETT.	SI3	0.5-1.5	22.057859	47.940286	2.173

ASIpu/ΔT= 404.950669

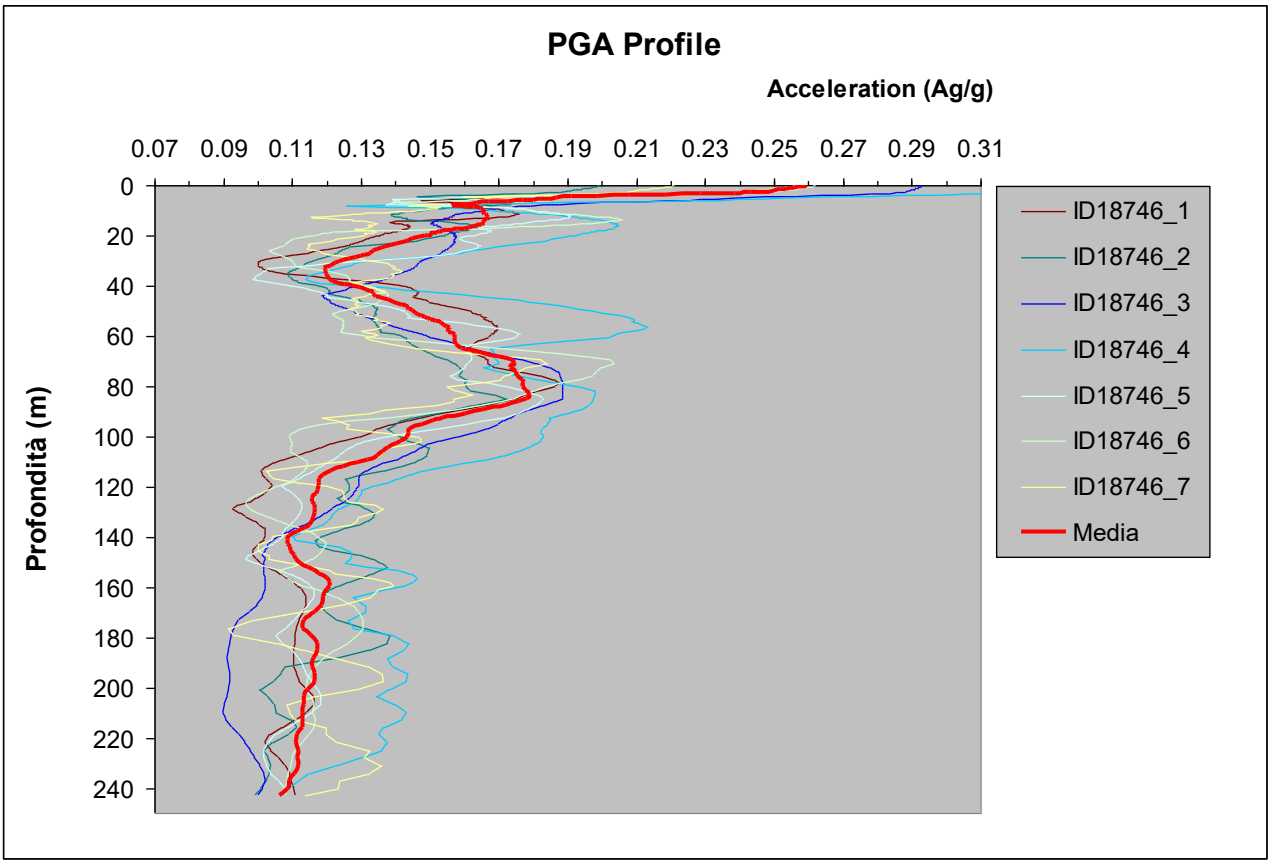
H_{SM}= 575.330

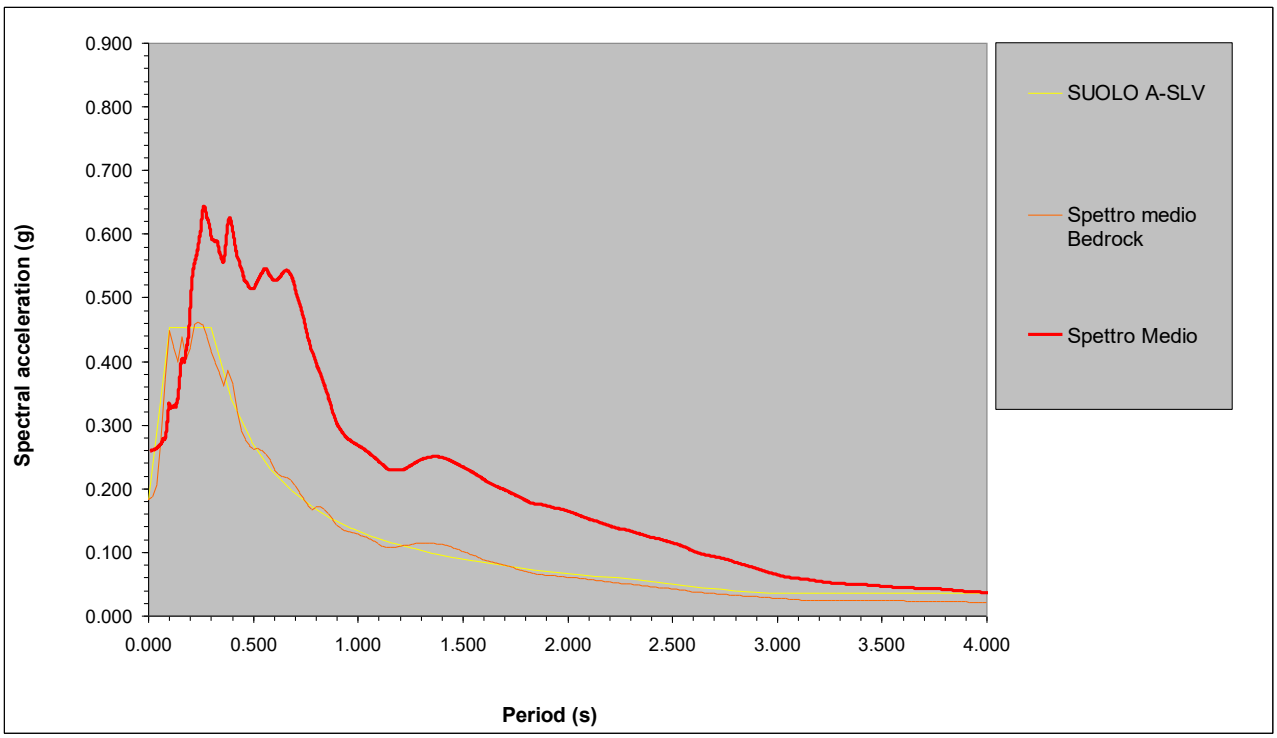
H_{0408}= 482.143

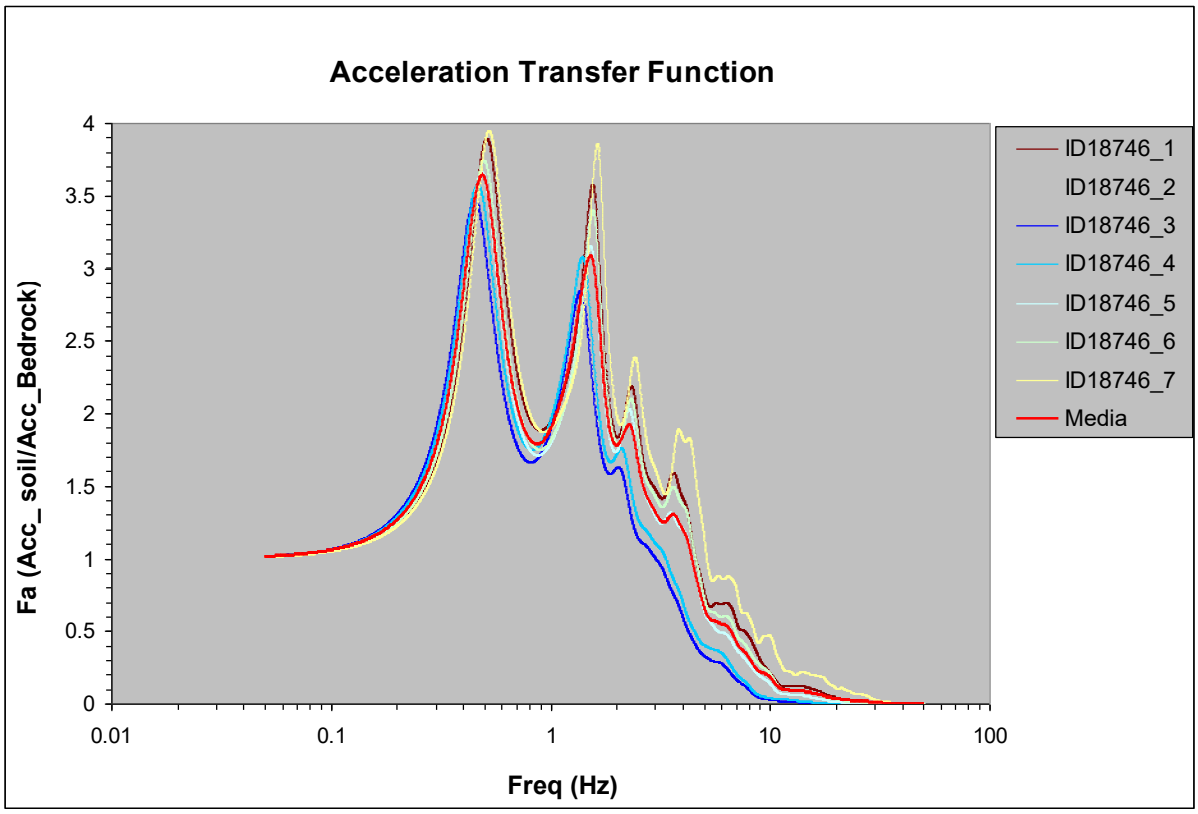
H_{0711}= 305.627

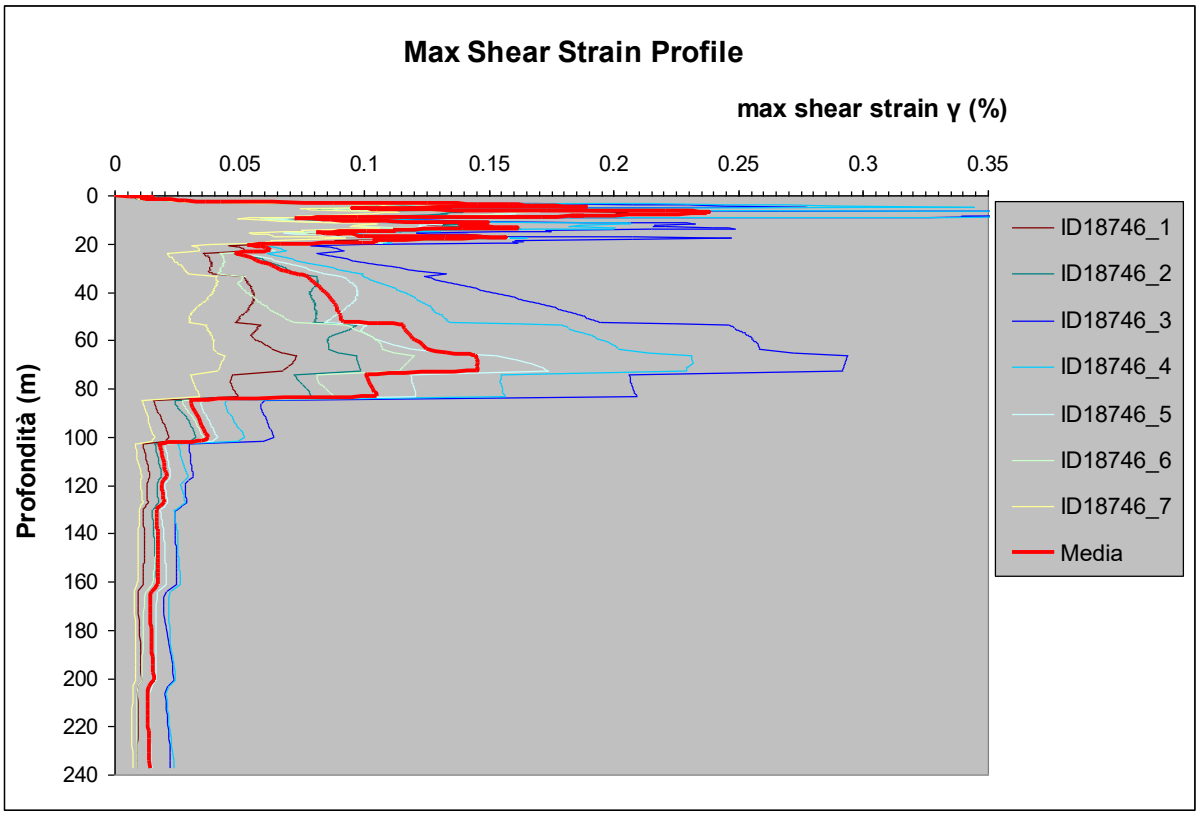
H_{0515}= 318.209

ZONA RNC


PGA Profile
Acceleration (Ag/g)
0.07 0.09 0.11 0.13 0.15 0.17 0.19 0.21 0.23 0.25 0.27 0.29 0.31
Profondità (m)
0 20 40 60 80 100 120 140 160 180 200 220 240
ID18746_1
ID18746_2
ID18746_3
ID18746_4
ID18746_5
ID18746_6
ID18746_7
Media


Spectral acceleration (g)
0.900 0.800 0.700 0.600 0.500 0.400 0.300 0.200 0.100 0.000
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000
Period (s)
SUOLO A-SLV
Spettro medio Bedrock
Spettro Medio





VsH (0-30)=177 (m/s)

PGA=0.259

F_{PGA}=1.416

Fattori SA:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SA1	0.1-0.5	0.162582	0.209880	1.291
INT SPETT.	SA2	0.4-0.8	0.102135	0.207056	2.027
INT SPETT.	SA3	0.7-1.1	0.063997	0.135249	2.113
INT SPETT.	SA4	0.5-1.5	0.156617	0.337442	2.155

Fattori SI:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SI1	0.1-0.5	6.944532	10.299370	1.483
INT SPETT.	SI2	0.5-1.0	10.950898	24.899033	2.274
INT SPETT.	SI3	0.5-1.5	21.873204	48.559624	2.220

ASIpu/ΔT= 401.835994

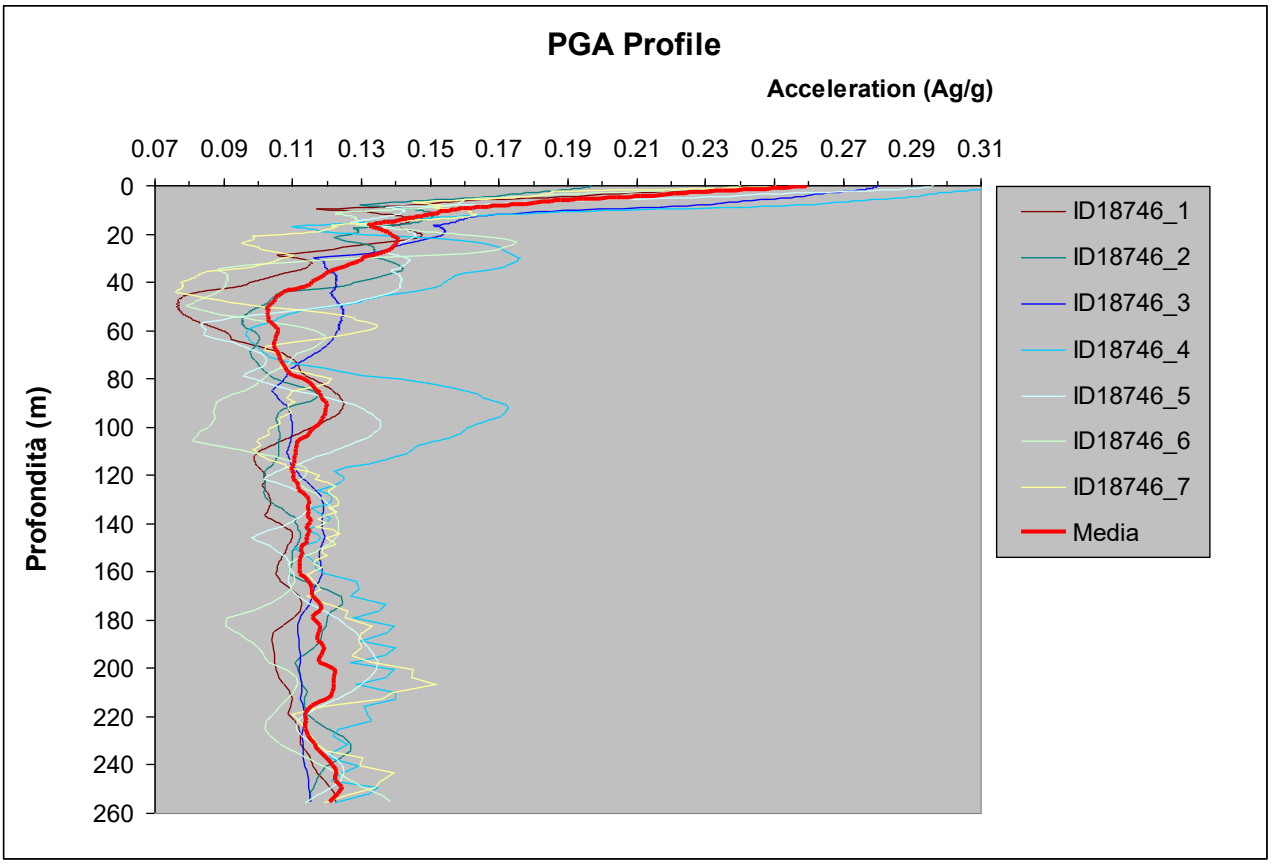
H_{SM}= 518.738

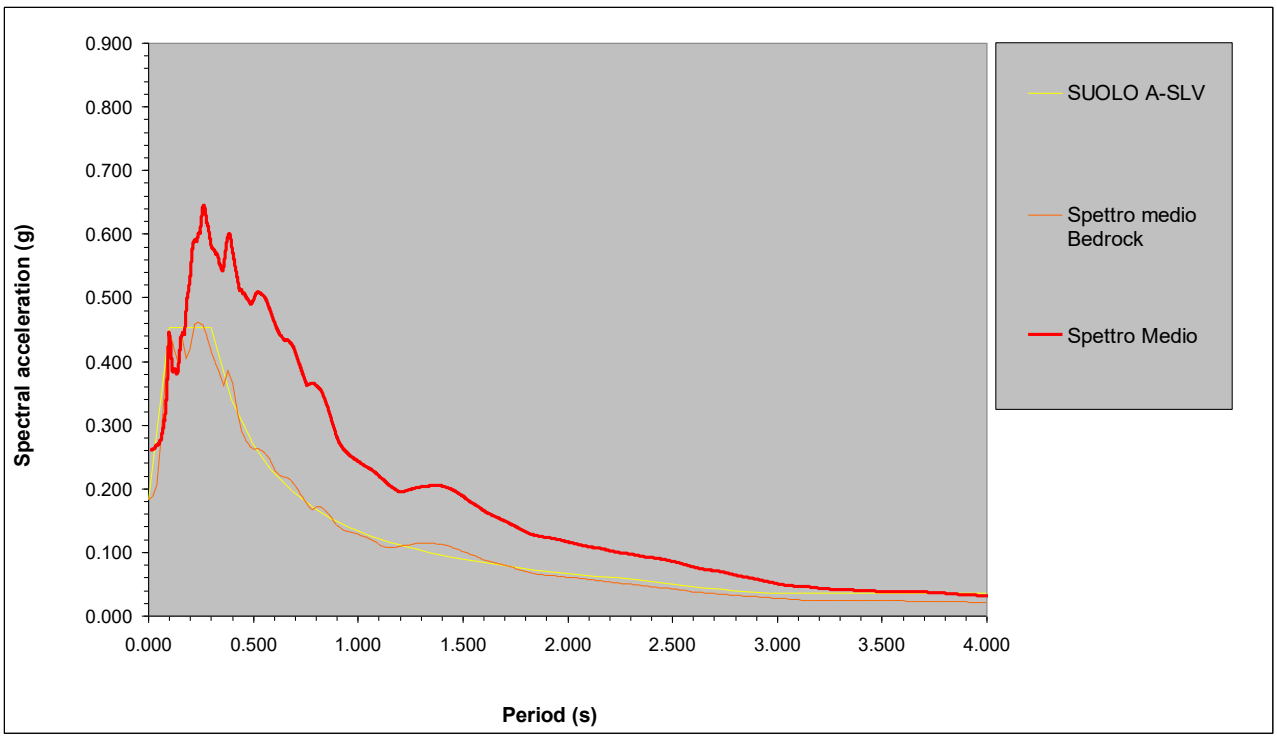
H_{0408}= 507.631

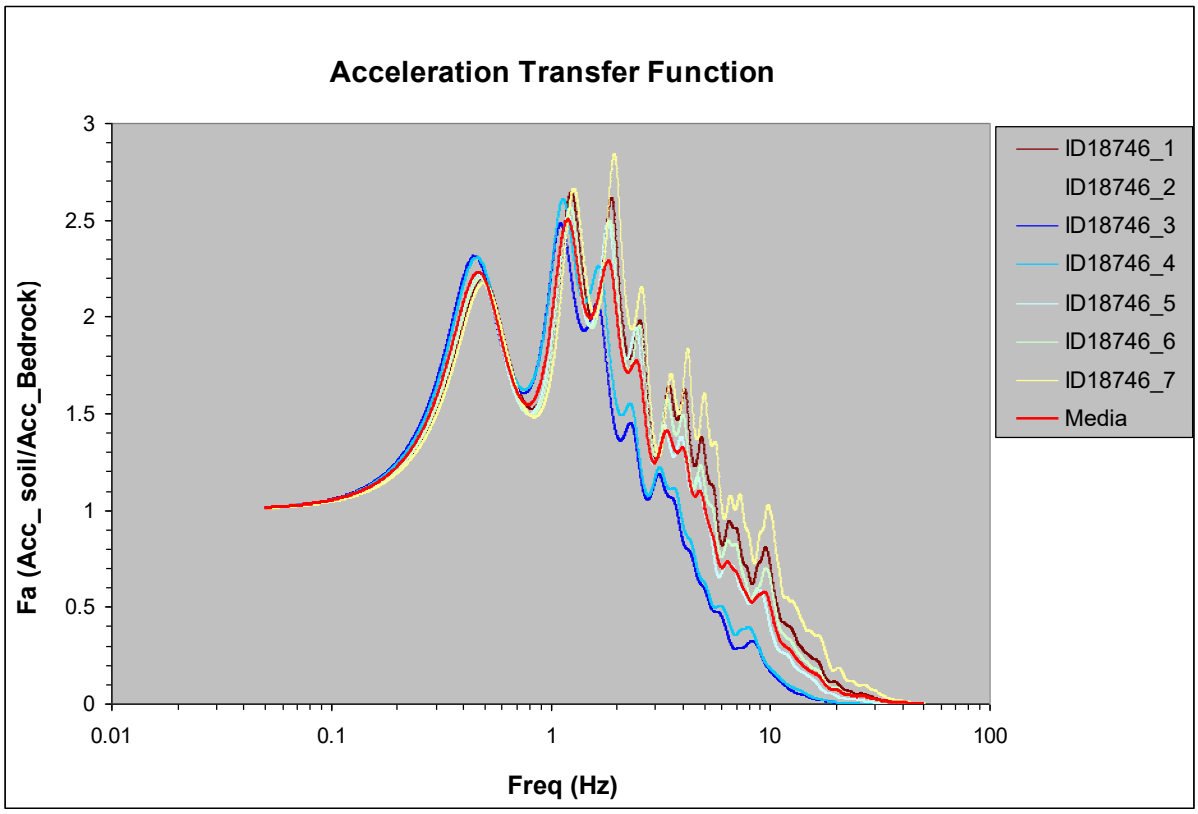
H_{0711}= 331.584

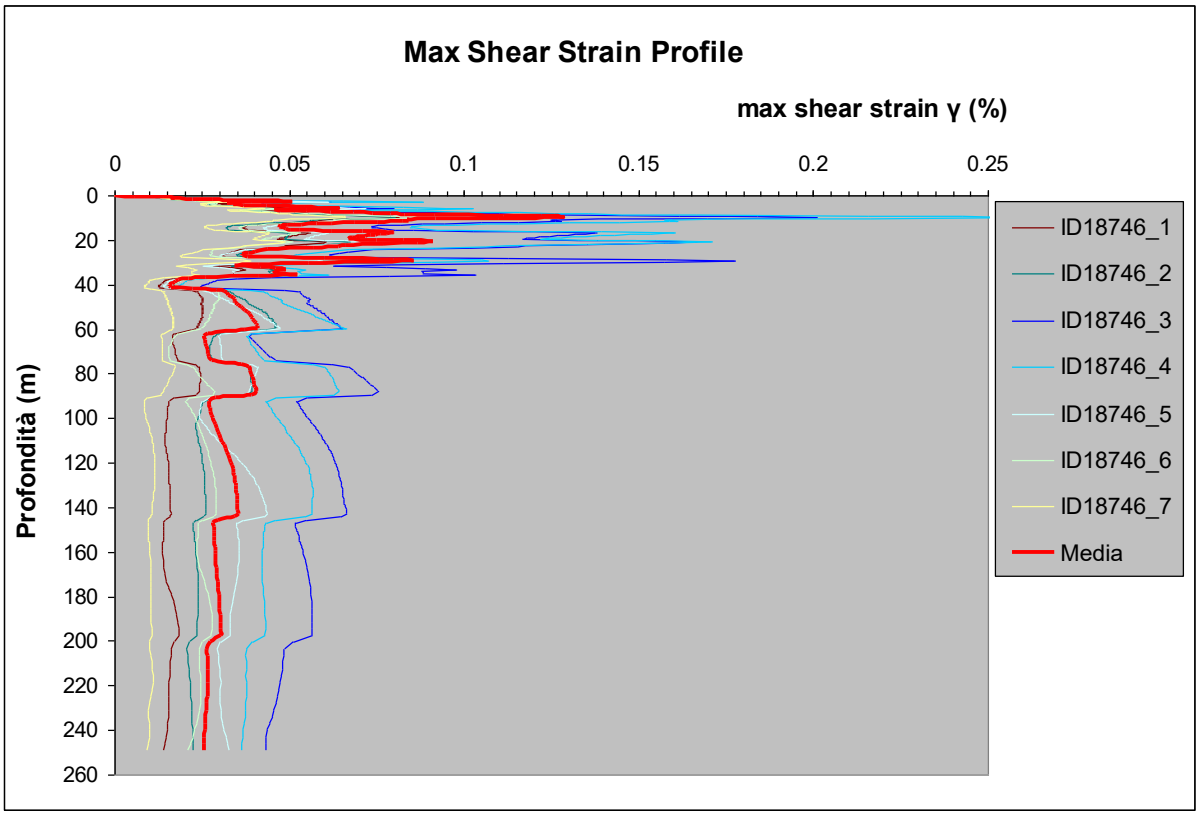
H_{0515}= 330.917

ZONA RNS_01


PGA Profile
Acceleration (Ag/g)
0.07 0.09 0.11 0.13 0.15 0.17 0.19 0.21 0.23 0.25 0.27 0.29 0.31
Profondità (m)
0 20 40 60 80 100 120 140 160 180 200 220 240 260
ID18746_1
ID18746_2
ID18746_3
ID18746_4
ID18746_5
ID18746_6
ID18746_7
Media


Spectral acceleration (g)
0.900 0.800 0.700 0.600 0.500 0.400 0.300 0.200 0.100 0.000
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000
Period (s)
SUOLO A-SLV
Spettro medio Bedrock
Spettro Medio





VsH (0-30)=227 (m/s)

PGA=0.260

F_{PGA}=1.421

Fattori SA:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SA1	0.1-0.5	0.162582	0.212364	1.306
INT SPETT.	SA2	0.4-0.8	0.102135	0.182999	1.792
INT SPETT.	SA3	0.7-1.1	0.063997	0.120375	1.881
INT SPETT.	SA4	0.5-1.5	0.156617	0.293923	1.877

Fattori SI:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SI1	0.1-0.5	6.944532	10.204992	1.470
INT SPETT.	SI2	0.5-1.0	10.950898	22.003084	2.009
INT SPETT.	SI3	0.5-1.5	21.873204	42.112490	1.925

ASIpu/ΔT= 401.835994

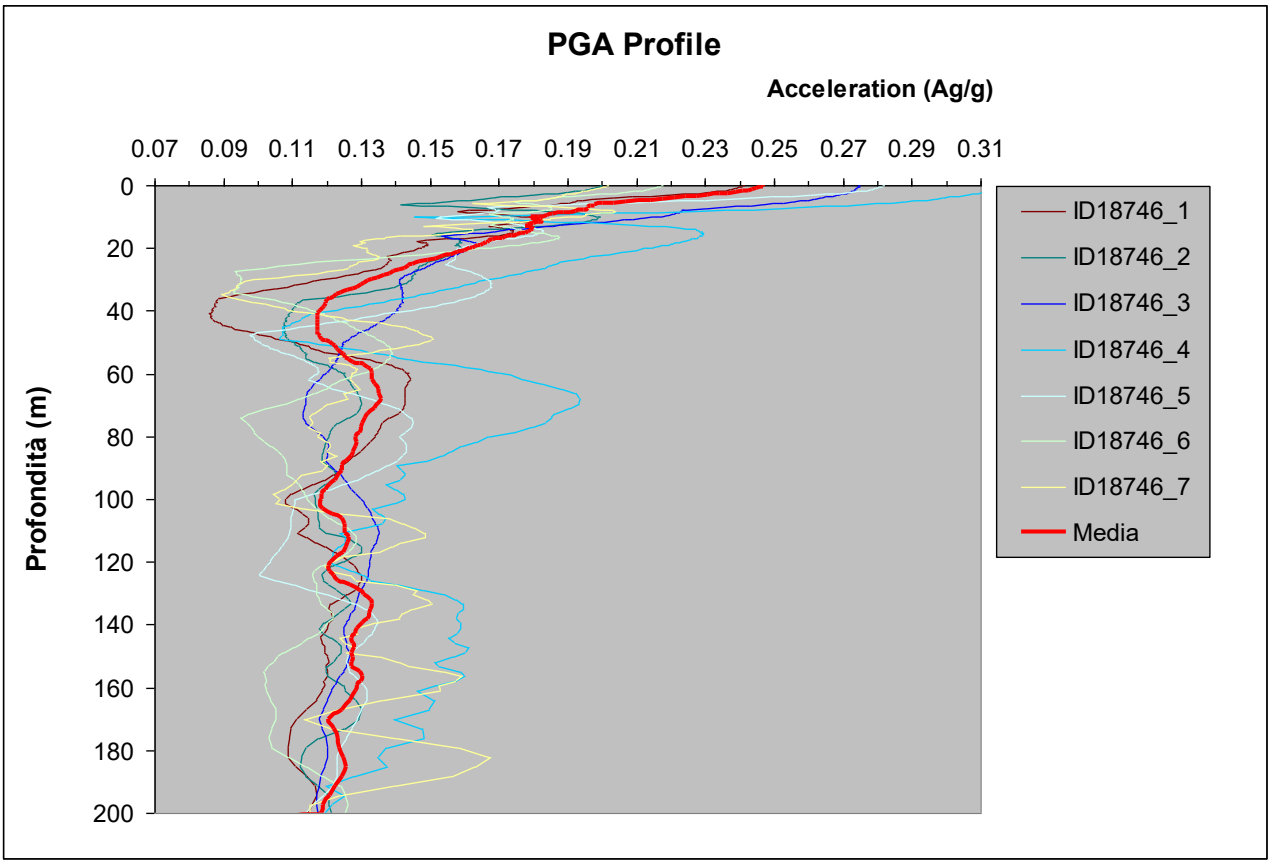
H_{SM}= 524.878

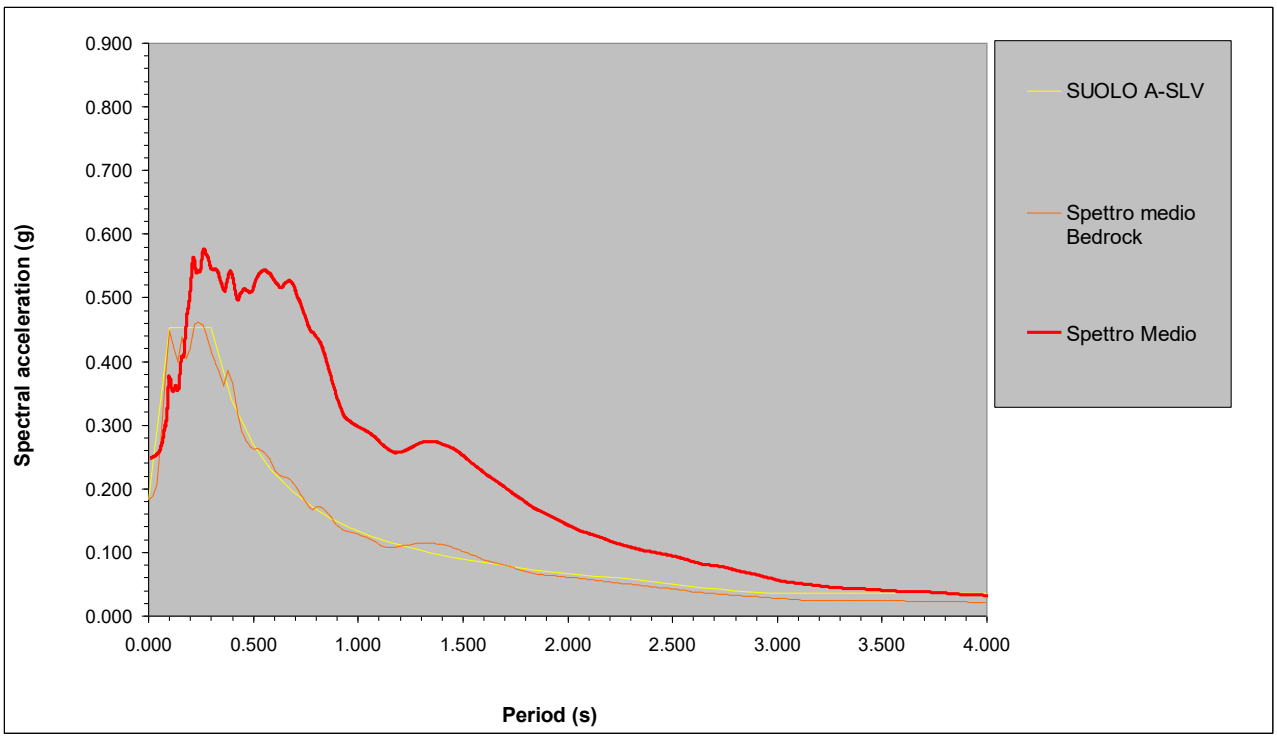
H_{0408}= 448.653

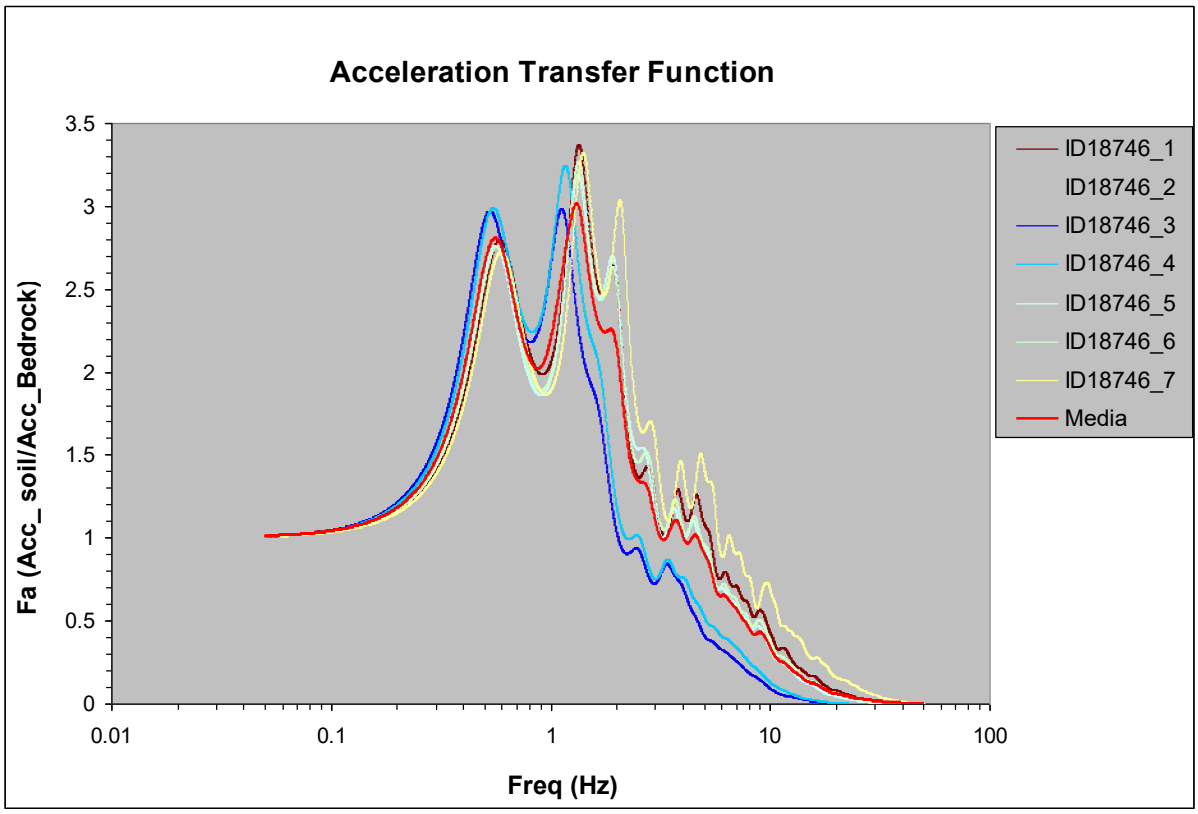
H_{0711}= 295.119

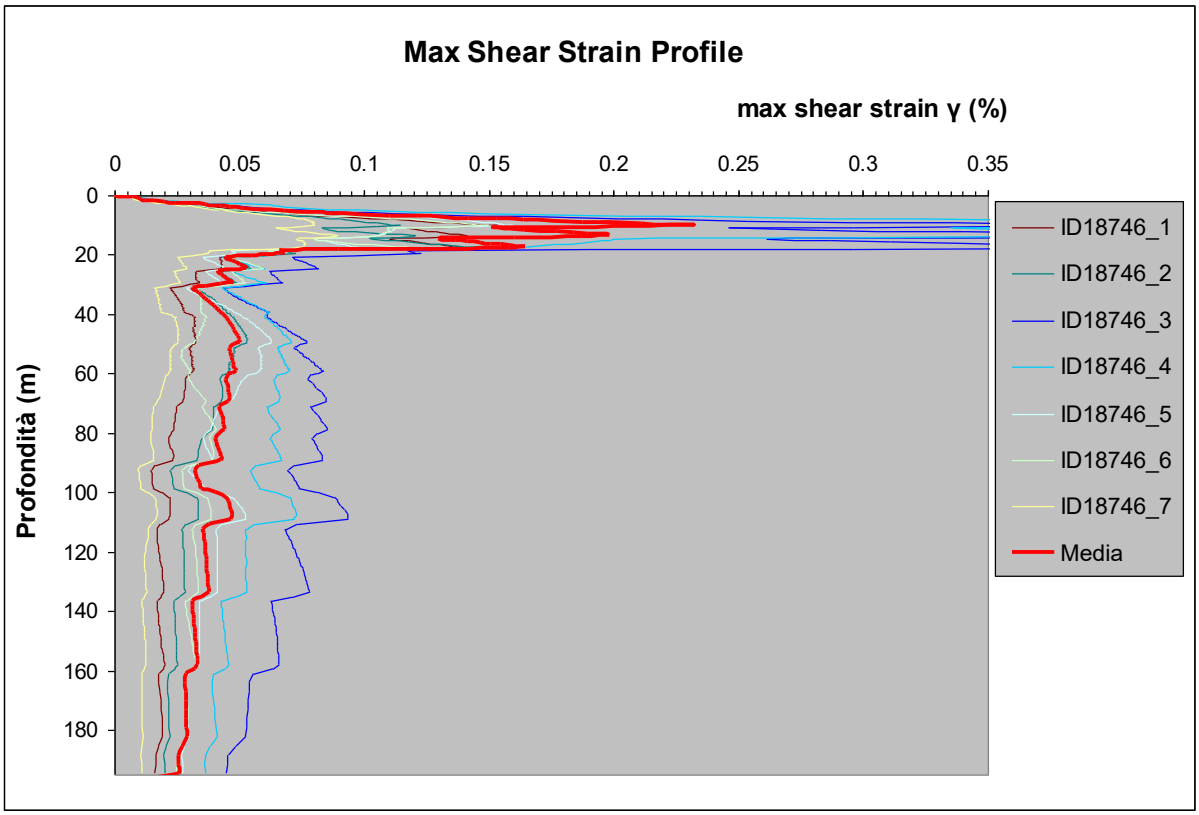
H_{0515}= 288.240

ZONA RNS_02


PGA Profile
Acceleration (Ag/g)
0.07 0.09 0.11 0.13 0.15 0.17 0.19 0.21 0.23 0.25 0.27 0.29 0.31
Profondità (m)
0 20 40 60 80 100 120 140 160 180 200
ID18746_1
ID18746_2
ID18746_3
ID18746_4
ID18746_5
ID18746_6
ID18746_7
Media


Spectral acceleration (g)
0.900 0.800 0.700 0.600 0.500 0.400 0.300 0.200 0.100 0.000
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000
Period (s)
SUOLO A-SLV
Spettro medio Bedrock
Spettro Medio





VsH (0-30)=209 (m/s)

PGA=0.247

F_{PGA}=1.352

Fattori SA:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SA1	0.1-0.5	0.162582	0.199557	1.227
INT SPETT.	SA2	0.4-0.8	0.102135	0.204044	1.998
INT SPETT.	SA3	0.7-1.1	0.063997	0.147774	2.309
INT SPETT.	SA4	0.5-1.5	0.156617	0.359237	2.294

Fattori SI:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SI1	0.1-0.5	6.944532	9.688517	1.395
INT SPETT.	SI2	0.5-1.0	10.950898	26.053639	2.379
INT SPETT.	SI3	0.5-1.5	21.873204	52.288060	2.391

ASIpu/ΔT= 401.835994

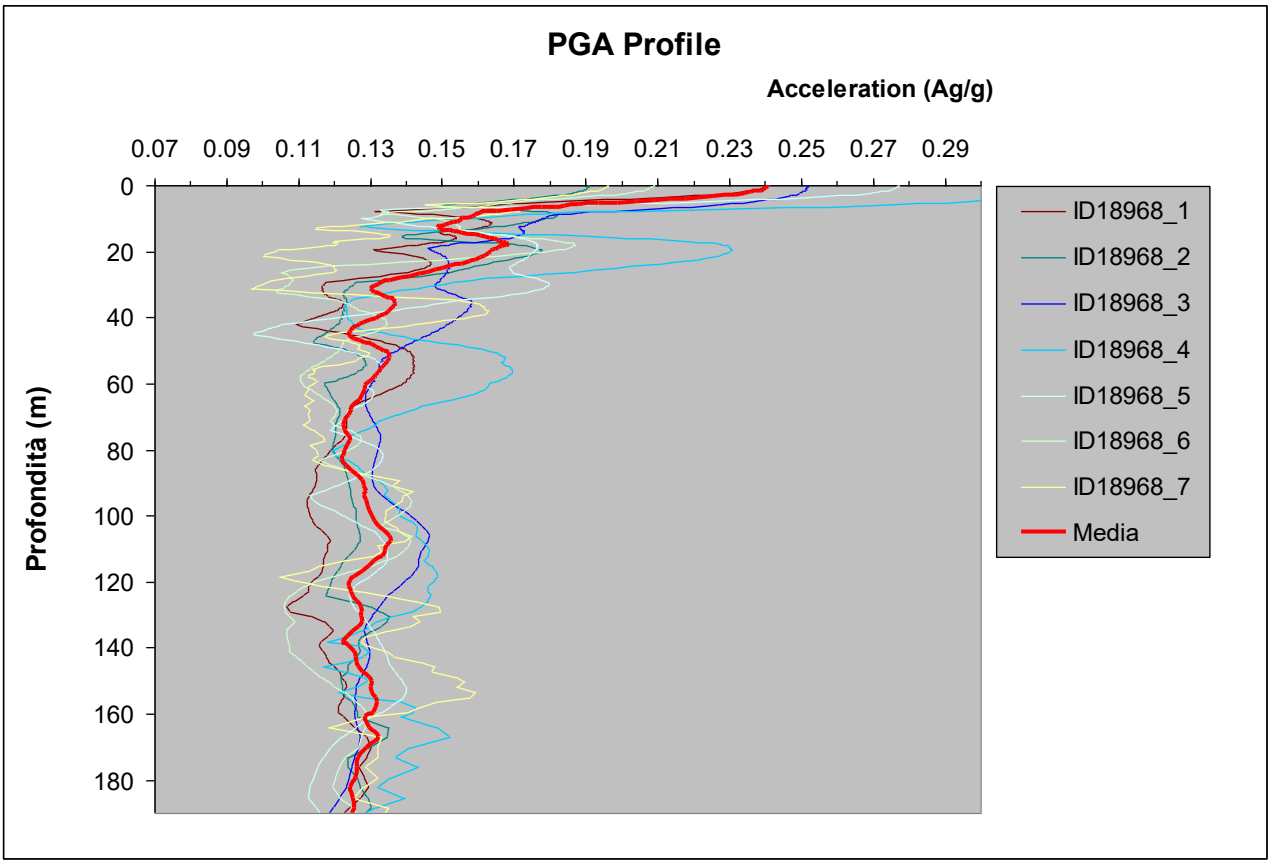
H_{SM}= 493.225

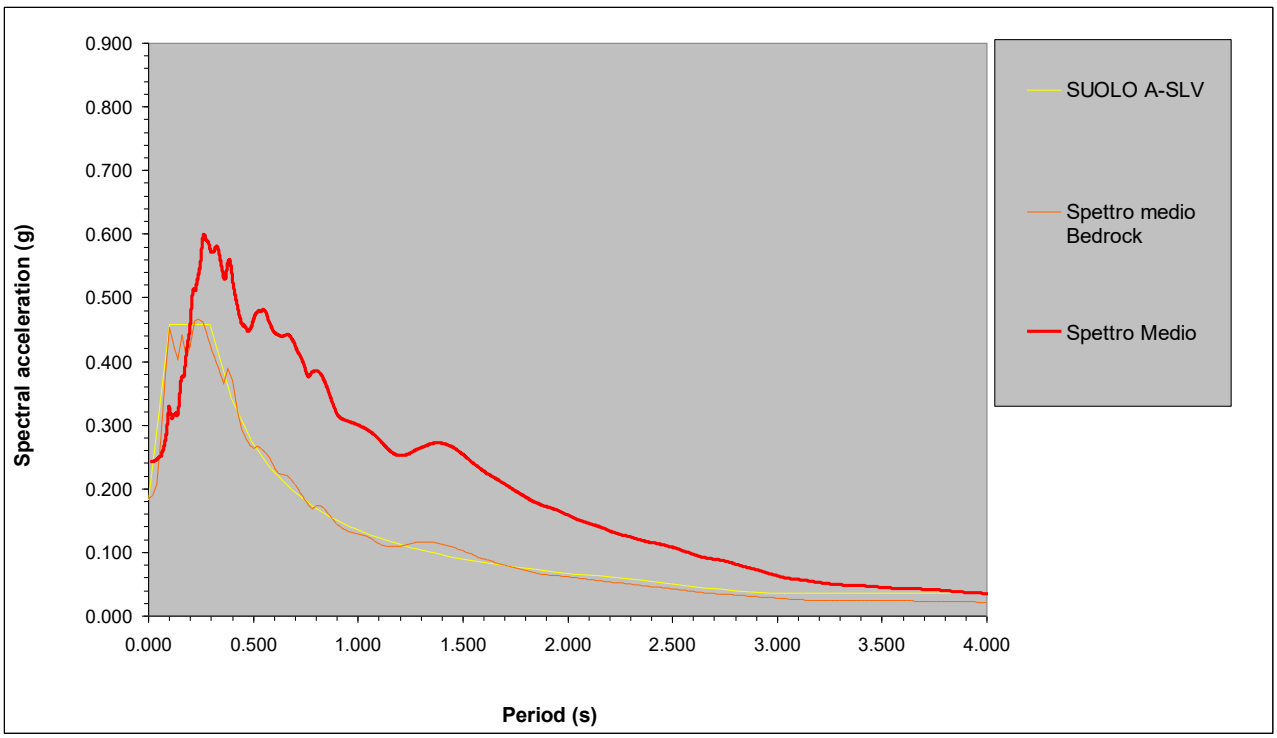
H_{0408}= 500.248

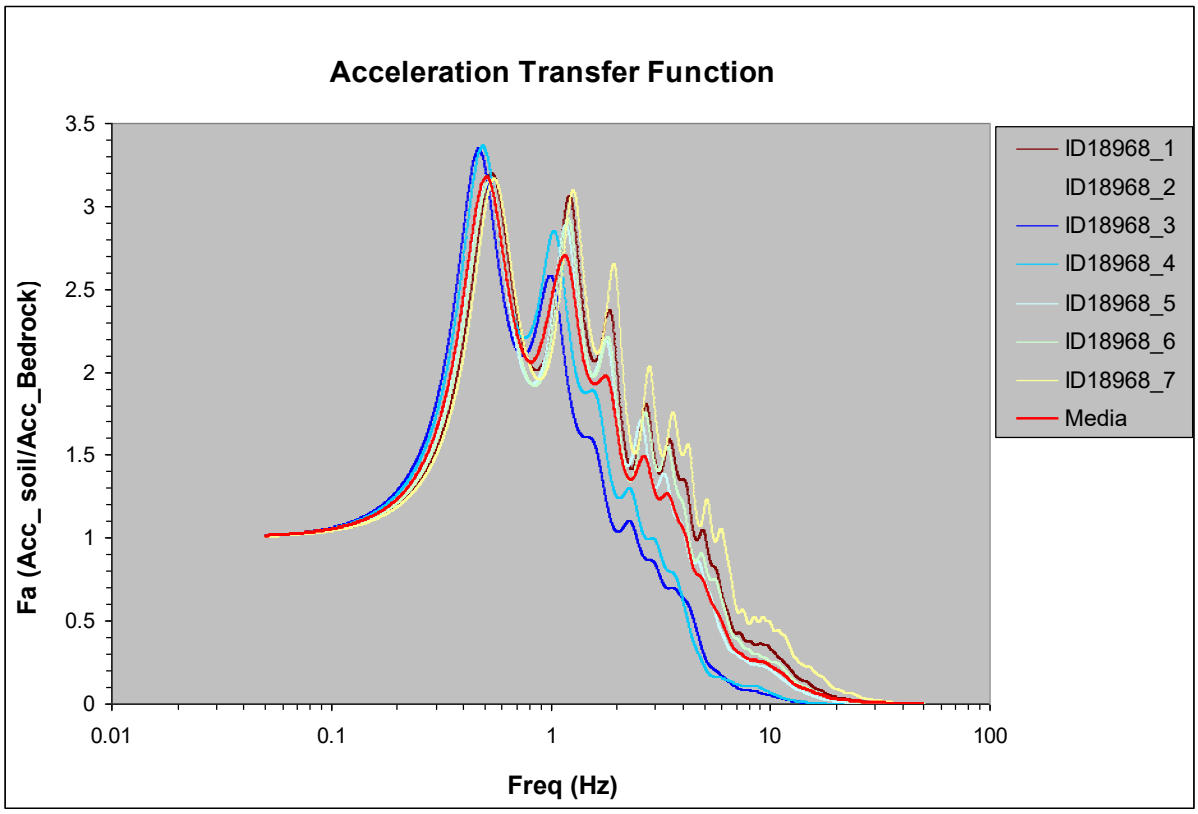
H_{0711}= 362.293

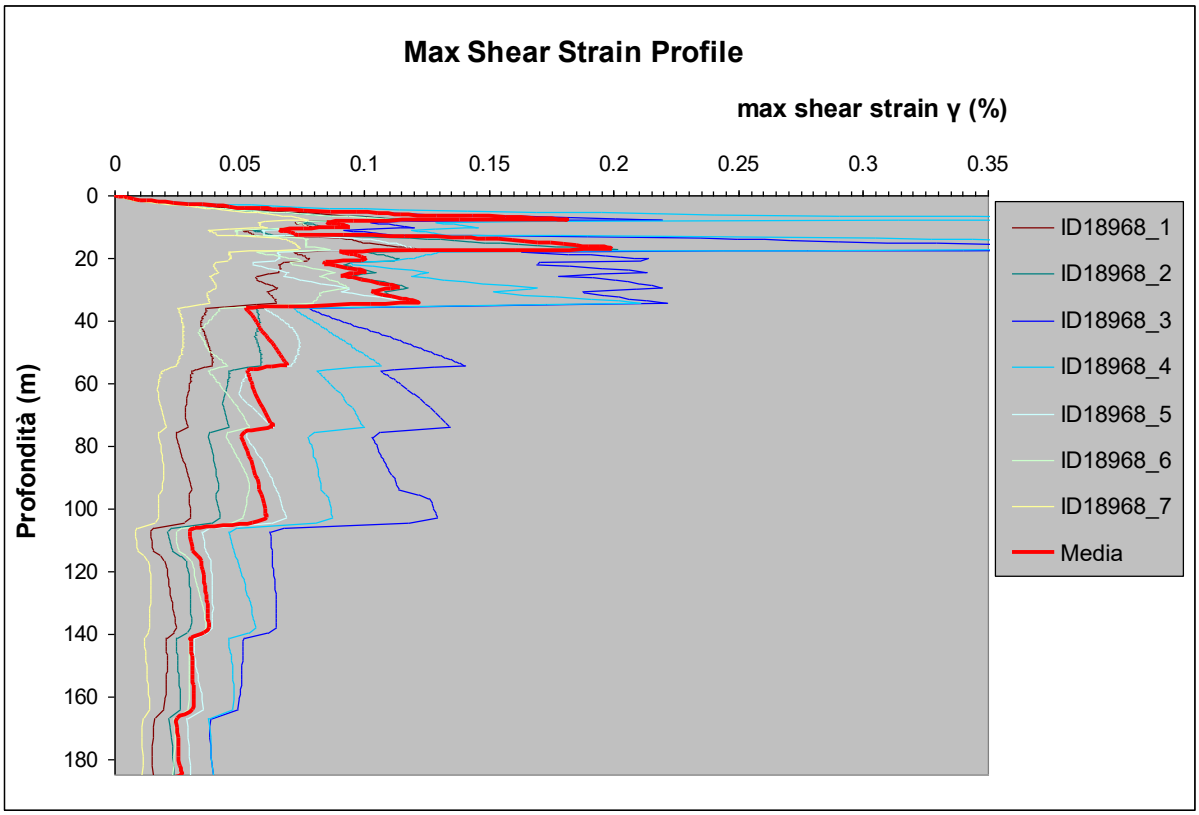
H_{0515}= 352.291

ZONA RNS_03


PGA Profile
Acceleration (Ag/g)
0.07 0.09 0.11 0.13 0.15 0.17 0.19 0.21 0.23 0.25 0.27 0.29
Profondità (m)
0 20 40 60 80 100 120 140 160 180
ID18968_1
ID18968_2
ID18968_3
ID18968_4
ID18968_5
ID18968_6
ID18968_7
Media


Spectral acceleration (g)
0.900 0.800 0.700 0.600 0.500 0.400 0.300 0.200 0.100 0.000
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000
Period (s)
SUOLO A-SLV
Spettro medio Bedrock
Spettro Medio





VsH (0-30)=196 (m/s)

PGA=0.241

F_{PGA}=1.312

Fattori SA:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SA1	0.1-0.5	0.164043	0.193710	1.181
INT SPETT.	SA2	0.4-0.8	0.103053	0.177763	1.725
INT SPETT.	SA3	0.7-1.1	0.064573	0.135652	2.101
INT SPETT.	SA4	0.5-1.5	0.158026	0.331439	2.097

Fattori SI:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SI1	0.1-0.5	7.006972	9.430273	1.346
INT SPETT.	SI2	0.5-1.0	11.049362	23.057416	2.087
INT SPETT.	SI3	0.5-1.5	22.069873	49.142392	2.227

ASIpu/ΔT= 404.5644

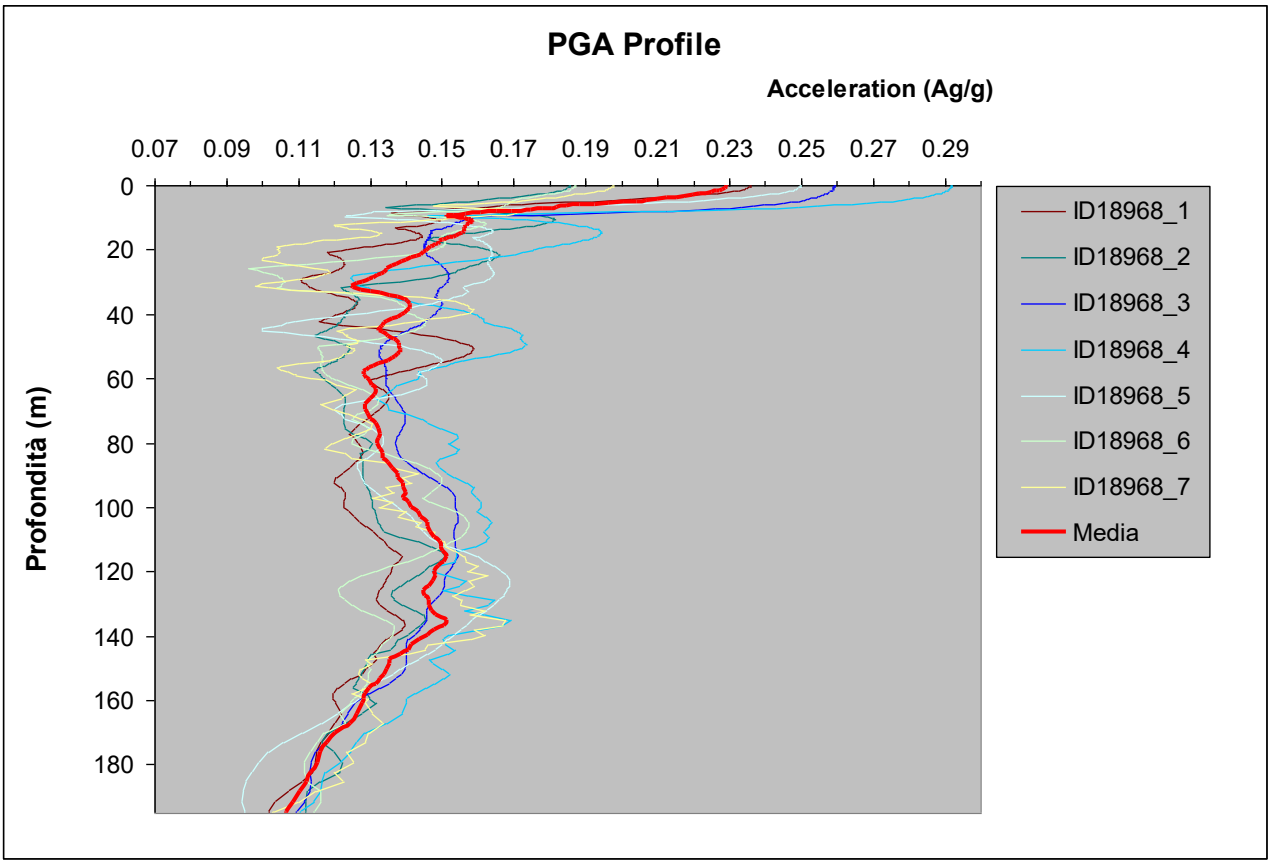
H_{SM}= 477.730

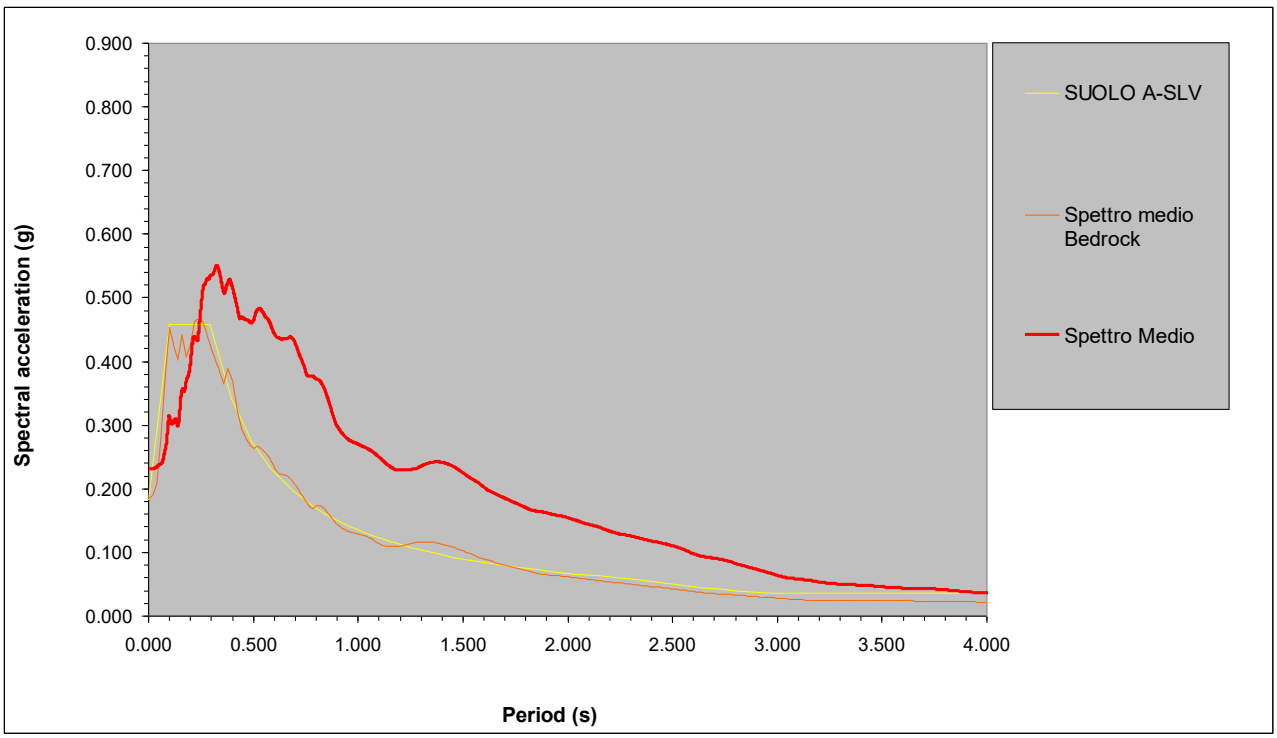
H_{0408}= 435.816

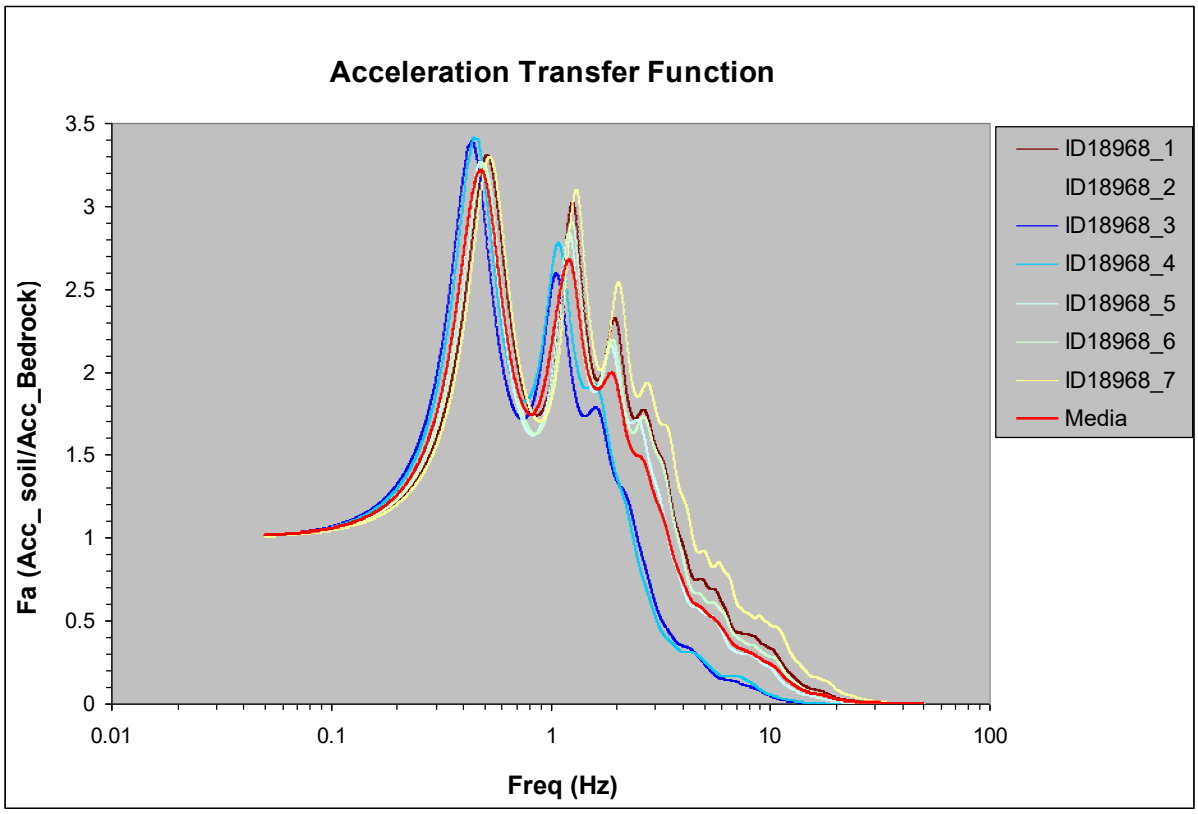
H_{0711}= 332.574

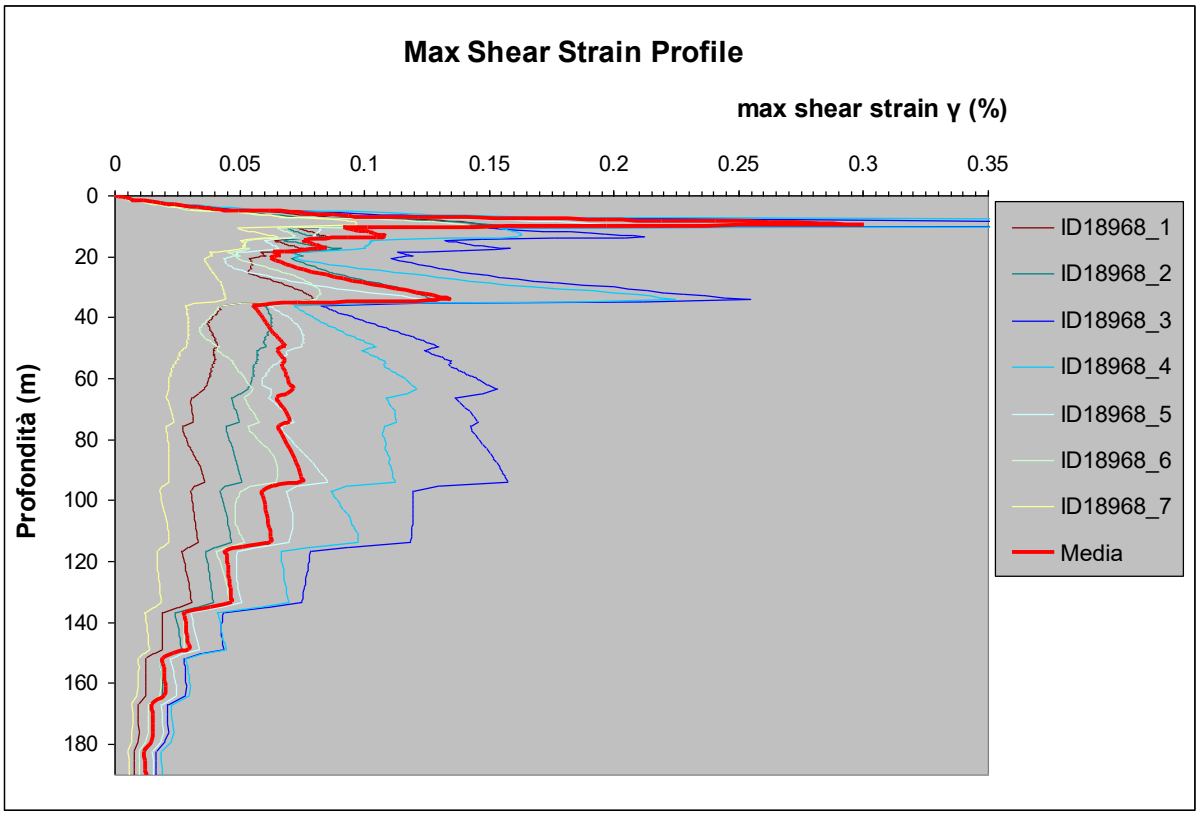
H_{0515}= 325.031

ZONA RNS_04


PGA Profile
Acceleration (Ag/g)
0.07 0.09 0.11 0.13 0.15 0.17 0.19 0.21 0.23 0.25 0.27 0.29
Profondità (m)
0 20 40 60 80 100 120 140 160 180
ID18968_1
ID18968_2
ID18968_3
ID18968_4
ID18968_5
ID18968_6
ID18968_7
Media


Spectral acceleration (g)
0.900 0.800 0.700 0.600 0.500 0.400 0.300 0.200 0.100 0.000
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000
Period (s)
SUOLO A-SLV
Spettro medio Bedrock
Spettro Medio





VsH (0-30)=195 (m/s)

PGA=0.229

F_{PGA}=1.249

Fattori SA:

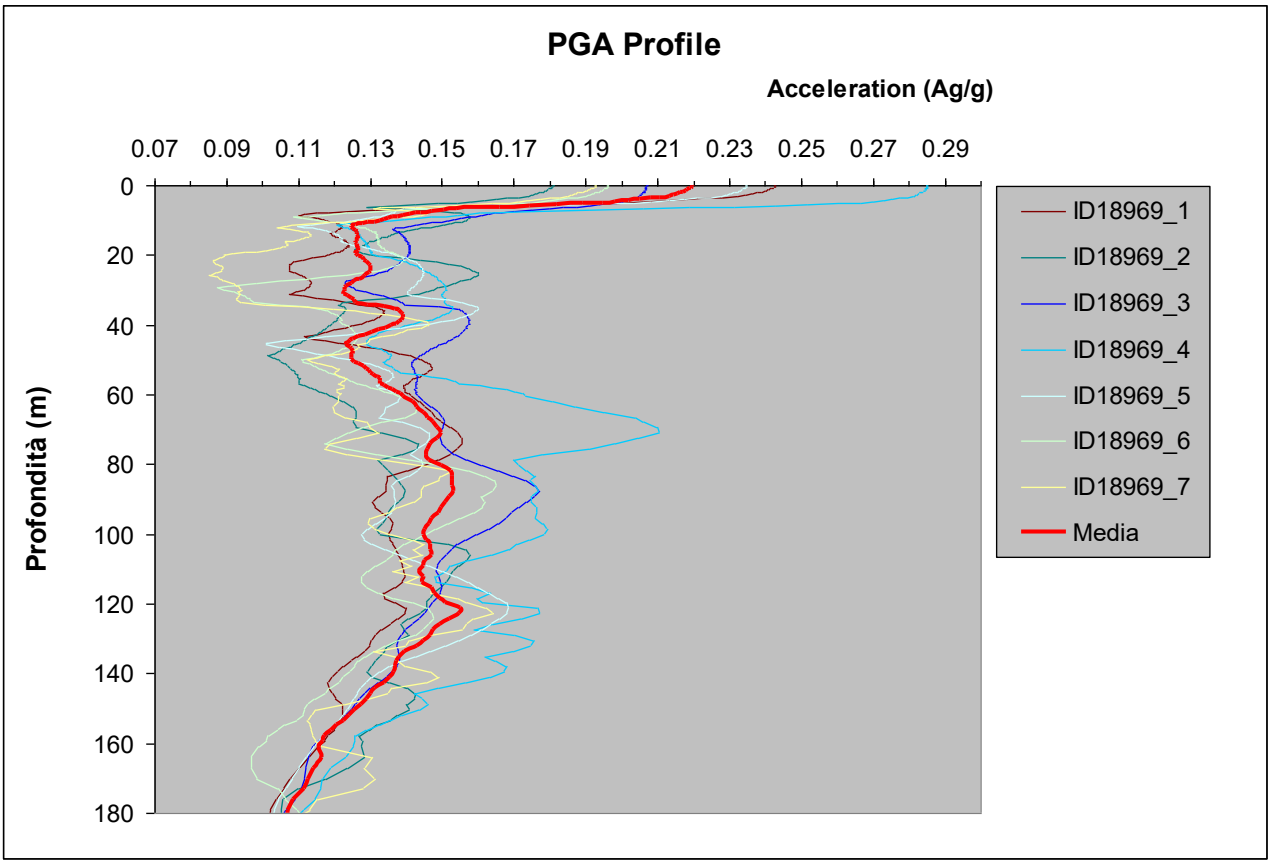
		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SA1	0.1-0.5	0.164043	0.181532	1.107
INT SPETT.	SA2	0.4-0.8	0.103053	0.177616	1.724
INT SPETT.	SA3	0.7-1.1	0.064573	0.128403	1.989
INT SPETT.	SA4	0.5-1.5	0.158026	0.312864	1.980

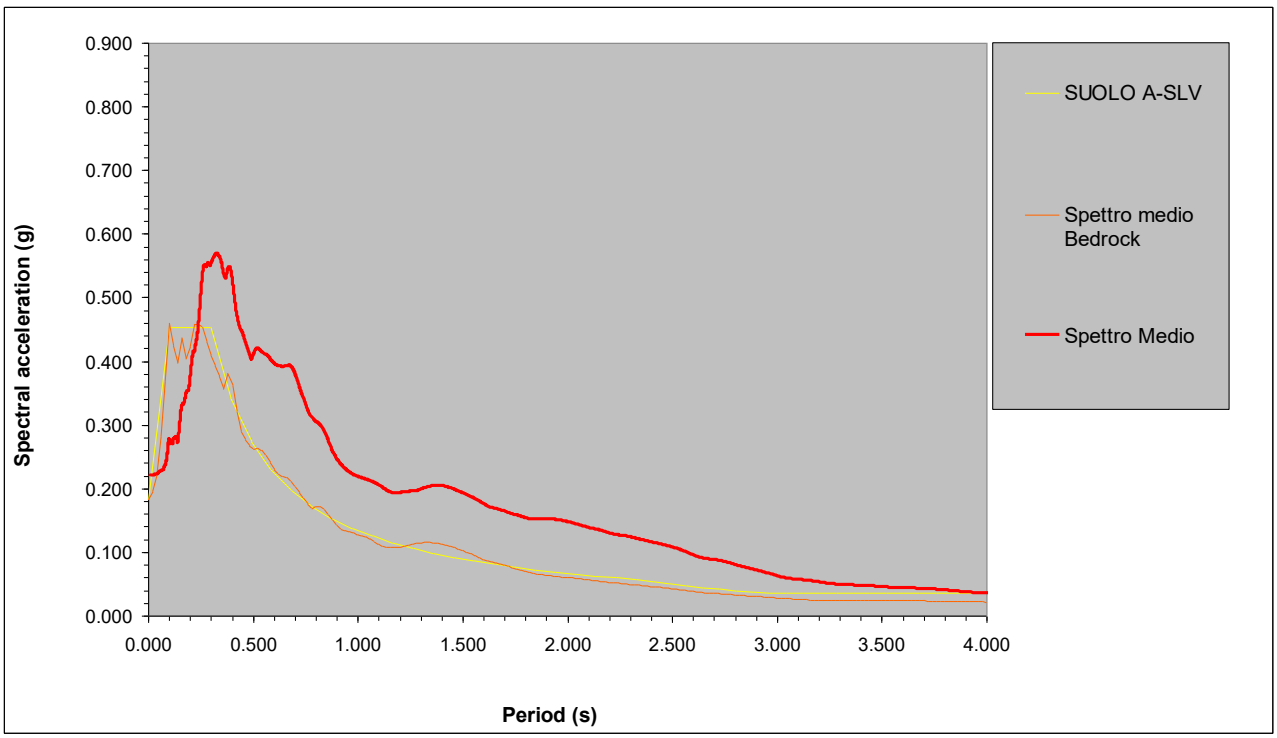
Fattori SI:

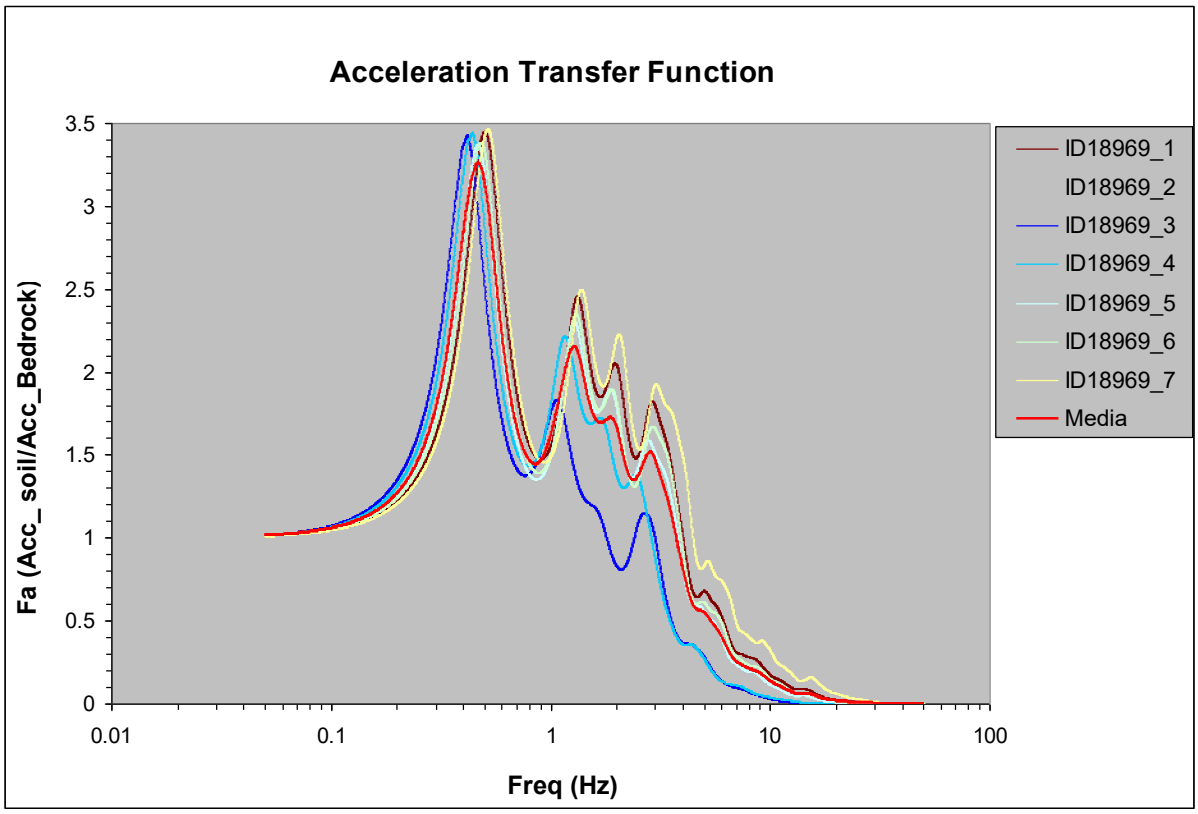
		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SI1	0.1-0.5	7.006972	8.962644	1.279
INT SPETT.	SI2	0.5-1.0	11.049362	22.426016	2.030
INT SPETT.	SI3	0.5-1.5	22.069873	45.784273	2.075

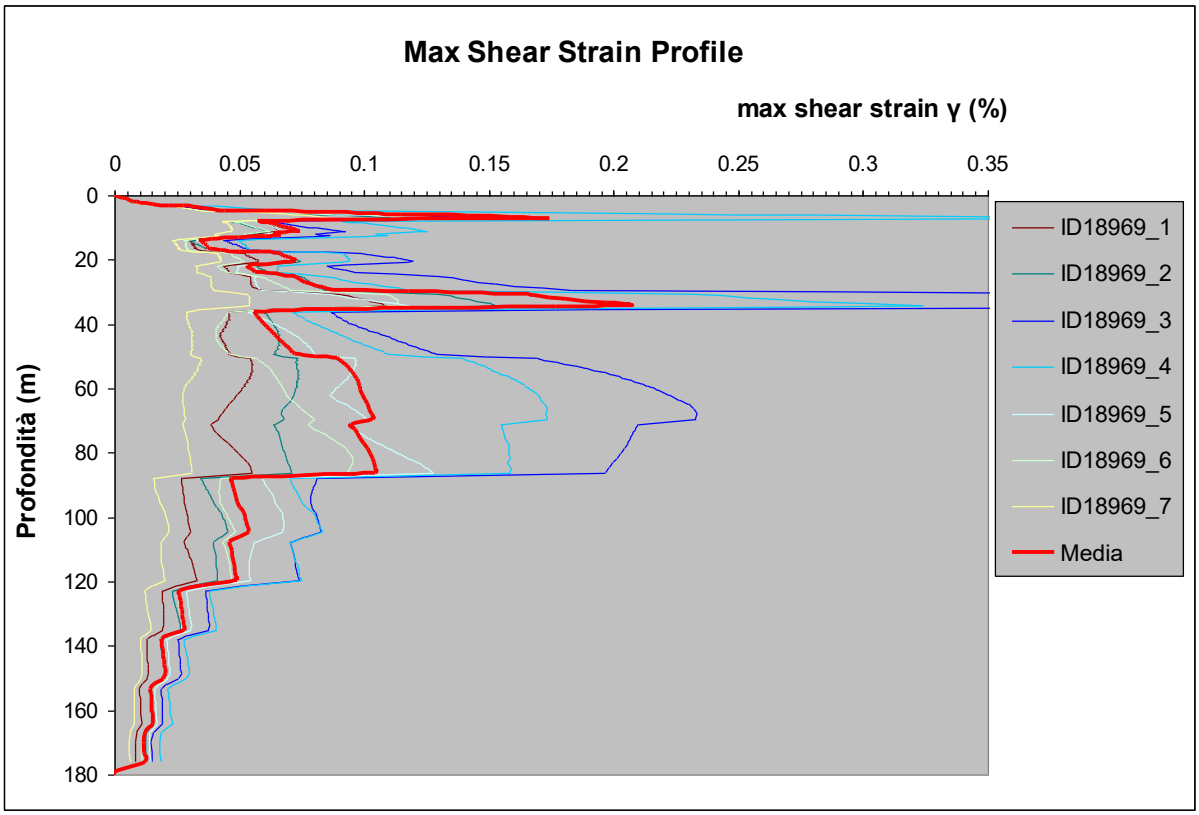
ASIpu/ΔT= 404.5644
H_{SM}= 447.695
H_{0408}= 435.454
H_{0711}= 314.801
H_{0515}= 306.814

ZONA RNS_05


PGA Profile
Acceleration (Ag/g)
0.07 0.09 0.11 0.13 0.15 0.17 0.19 0.21 0.23 0.25 0.27 0.29
Profondità (m)
0 20 40 60 80 100 120 140 160 180
ID18969_1
ID18969_2
ID18969_3
ID18969_4
ID18969_5
ID18969_6
ID18969_7
Media


Spectral acceleration (g)
0.900 0.800 0.700 0.600 0.500 0.400 0.300 0.200 0.100 0.000
0.000 0.500 1.000 1.500 2.000 2.500 3.000 3.500 4.000
Period (s)
SUOLO A-SLV
Spettro medio Bedrock
Spettro Medio





VsH (0-30)=221 (m/s)

PGA=0.220

F_{PGA}=1.202

Fattori SA:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SA1	0.1-0.5	0.161864	0.179793	1.111
INT SPETT.	SA2	0.4-0.8	0.101911	0.159118	1.561
INT SPETT.	SA3	0.7-1.1	0.063921	0.106549	1.667
INT SPETT.	SA4	0.5-1.5	0.156511	0.266252	1.701

Fattori SI:

		Periodo(s)	Bedrock	Soil	FA
INT SPETT.	SI1	0.1-0.5	6.902271	8.863661	1.284
INT SPETT.	SI2	0.5-1.0	10.936045	19.158128	1.752
INT SPETT.	SI3	0.5-1.5	21.870432	38.790141	1.774

ASIpu/ΔT= 402.498169
H_{SM}= 447.082
H_{0408}= 390.104
H_{0711}= 261.221
H_{0515}= 261.104

Il trend osservabile è un graduale e progressivo approfondimento del bedrock sismico procedendo da S verso N così come un generale decremento di rigidezza sismica degli orizzonti alluvionali e marini nelle prime decine di m superficiali. In particolare, le zone RNN_01, 02, 03, 04, sono caratterizzate da una più cospicua presenza di orizzonti ghiaiosi e dai relativi contrasti di impedenza sismica; in corrispondenza di questi ultimi, soprattutto quelli più superficiali, talora si evidenzia lo sviluppo di deformazioni di taglio significative, potenzialmente determinanti condizioni di non linearità. Coerentemente la PGA presenta la medesima tendenza generale di incremento da S verso N.
Talora i livelli deformativi (max shear strain) stimabili in corrispondenza degli orizzonti potenzialmente liquefacibili e/o di significativi contrasti di rigidezza, tramiti i moti di input e condizioni al contorno adottati, risultano pari o superiori ai limiti di generale applicabilità dei metodi di analisi EQL, suggerendo all'occorrenza l'opportunità di un eventuale approccio anche tramite metodi di analisi non lineare, generalmente più adeguati nel campo delle medie-grandi deformazioni.
Le azioni sismiche così definite si ritiene possano essere adottate per le verifiche a liquefazione tramite metodi semplificati.

2.4 VERIFICHE DI III LIVELLO DI APPROFONDIMENTO PER LIQUEFAZIONE

2.4.1 Suscettibilità a liquefazione ed analisi tramite metodi semplificati

Preso atto di quanto già illustrato e valutato al precedente Par. 1.2, una stima di pericolosità per fenomeni di liquefazione dei terreni in condizioni sismiche, può essere determinata in modo puntuale e quantitativo tramite l'adozione di metodi numerici semiempirici, basati sull'elaborazione di dati ottenibili in sito da prove geognostiche es. tipo CPT, SPT, DMT o geofisiche tipo Vs.
Il comportamento non drenato dei terreni incoerenti superficiali soggetti ad elevate deformazioni cicliche (con ridotta capacità di drenaggio in relazione alla velocità di applicazione dei carichi), per la natura sostanzialmente incompressibile dell'acqua, può indurre la generazione di sovrappressioni interstiziali in grado di portare il terreno a liquefazione.
Dai dati della campagna geognostica risulta che lo spessore del corpo sedimentario sabbioso costiero (rappresentato in loco dalle Unità A e B), costituito da sabbie prevalenti e alternanze di livelli sabbiosi con sottili orizzonti limosi ed argillosi ma a comportamento generale prettamente incoerente, risulta variabile fra i valori di circa 6.5-12.5 mt (con locali anomalie in corrispondenza delle foci dei corsi d'acqua principali, secondari e delle derivazioni antropizzate es. deviatore, darsena, ecc.) (vedi

sezioni litotecniche in Tavola n. 7.1 e 7.2); tuttavia alla base del prisma sabbioso, talora, sono presenti orizzonti metrici di sabbie limose alluvionali e/o ghiaietto di barra di foce, determinando un'ulteriore spessore locale di materiali incoerenti potenzialmente liquefacibili. Data l'estensione dell'area in studio, si sono adottate le azioni sismiche derivate dalla suddivisione in 10 settori omogenei in relazione agli assetti geologici e stratigrafici adottati per la modellazione di RSL.
La stima del potenziale di liquefazione può essere effettuata in condizioni "free-field" con i "metodi semplificati" indicati in Allegato A3 della DGR 630/2019, come aggiornata dalla *DGR 476/2021 e successiva integrazione DGR 564/2021* e, a tal fine, per ogni verticale si è utilizzato il picco di accelerazione massima in superficie a_{max} (*PGA*) desunto per ciascuna zona a risposta dinamica omogenea.
Per il caso in esame risulta possibile analizzare la potenziale liquefacibilità dei terreni attraverso metodi basati sullo stato tensionale in cui il fattore di sicurezza alla liquefazione viene definito tramite il rapporto tra resistenza ciclica *CRR* e azione simica di progetto *CSR* (Cyclic Stress Ratio) per cui *FS=CRR/CSR*; in particolare ci si può avvalere di metodologie di tipo storico – empirico fra cui quelle basate su prove CPT come raccomandato nelle Linee Guida AGI 2005 e ICMS 2008.
Le CPT di riferimento utilizzate sono state selezionate fra quelle di nuova realizzazione e quelle appartenenti alla base dati degli studi di MS3 recentemente realizzati per il Comune di Rimini ed a cui è anche riferito il relativo codice identificativo (ID) (vedi Allegato n. 1). Alcune prove di riferimento anche se ricadenti esternamente ai perimetri urbanistici sono ritenute ugualmente rappresentative delle zone in studio.
Per quanto riguarda la scelta del metodo si è adottata la formulazione di Robertson 2009-2015 (*R09*), ritenuta particolarmente idonea e riconosciuta per affidabilità e diffusione a livello internazionale e nel mondo accademico; in particolare la stima in continuo del contenuto in fine % *FC* (Robertson & Fear, 1995) risulta ben calibrata sulla situazione litostratigrafica e granulometrica dei sedimenti in posto. Tale metodo, in assenza di puntuali e diffuse prove di laboratorio, consente una stima della resistenza ciclica di riferimento sulla scorta della resistenza alla punta in funzione del parametro di comportamento del terreno *Ic* (soil behavior index), in quanto il valore di resistenza ciclica finale dei terreni è influenzato da diversi fattori genetici e costitutivi oltre al solo "contenuto in fine apparente".
Fra gli altri metodi altrettanto riconosciuti quali ad es. quello proposto Idriss-Boulanger (2014), nonostante abbia comportato un ulteriore aggiornamento di alcuni parametri e delle case-history di riferimento, a parere dello scrivente risulta molto sensibile alle valutazioni/stime del contenuto in fine dei terreni e, il modello di interpretazione dell'*FC* insito nel metodo, richiederebbe un'approfondita e specifica calibrazione basata su di un vasta base di dati di laboratorio.
In tal senso per l'analisi di tipo areale ed in base ai riscontri ottenuti da studi pregressi in aree limitrofe del medesimo ambito costiero, al grado di conoscenza della stratigrafia, di affidabilità delle prove e dei dati utilizzati, si è scelto quindi di utilizzare il metodo di Robertson 2009-2015 (*R09*) secondo un adeguato fattore di sicurezza di riferimento FS (FS=CRR/CSR), al fine di garantire lo stesso livello di confidenza, in termini probabilistici, proprio degli altri metodi CPT maggiormente diffusi in letteratura (*IB2014*, *IB08*, *Moss 2006*), adottando una curva limite che discrimini gli ambiti di liquefazione/non liquefazione secondo un livello di confidenza minimo pari all'85% (curva con probabilità di liquefazione PL=15%).

A attraverso la formulazione di Ku et al. (2012), per cui $P_L = 1 - \Phi\left[\frac{0.102 + \ln(F_s)}{0.276}\right]$ (con Φ = distribuzione standard normale), si evince come l'adozione di ***FS=1.2*** garantisca il livello di confidenza richiesto (*PL*=15%).
Tale scelta appare suffragata anche da un confronto con i dati sperimentali di laboratorio ciclico (vedi valutazioni MS3 Rimini), opportunamente rapportati alle condizioni di campo (taglio semplice) attraverso la relazione di Seed H.B. e Peacock W.H. (1971), da cui si evince come le resistenze normalizzate ($CRR_{7.5}$) stimabili con il metodo R09 con fattore di sicurezza limite FS=CRR/CSR=1.2, in corrispondenza degli orizzonti campionati, appaiano coerenti e commisurate alle resistenze cicliche rilevabili dai test di laboratorio per un numero di cicli pari a N=15.
Inoltre secondo un approccio prettamente deterministico, tale soglia di *FS=1.2* viene altresì raccomandata dall'autore stesso per valutazioni inerenti opere ordinarie, in quanto il metodo mantiene insito, comunque, un certo grado di conservatività (comunicazione personale).
L'adozione dei metodi semplificati di verifica a liquefazione, in relazione alle condizioni di pericolosità sismica generale ed alla stima dei carichi ciclici ipotizzabili, richiede l'adozione di una *Mw* (magnitudo momento) di riferimento che, per il caso in esame, viene assunta pari a ***Mw=6.16***.

La verifica di calcolo, riportata in allegato n. 2, è stata effettuata come da normativa attraverso l'utilizzo del software CLiq vers. 2.3.1.15 della software house Geologismiki, utilizzando le prove Cpte/u identificate nella "Carta di inquadramento" in allegato n. 1, la cui stratigrafia è stata discretizzata mediando i valori ottenibili secondo orizzonti di 3 e 5 cm.
Il metodo *R09* è basato su un proprio fattore caratteristico di scalatura della magnitudo (*MSF*) e specifici coefficienti riduttivi (*Rd-Kα-Kσ*) atti a determinare i valori di *CRR* (cyclic resistance ratio) e *CSR* (cyclic stress ratio) necessari a definirne il *FS* (fattore di sicurezza) per ciascuno strato rispetto ad una soglia limite di riferimento prefissata. Essendo uno studio di tipo areale ed in assenza di specifiche indicazioni progettuali il calcolo è stato effettuato assumendo condizioni di free-field ed un livello di falda ipotizzabile in condizioni di massimo innalzamento medio stagionale.
Ai fini dell'azione sismica, trattandosi di ampie aree di studio nonché in riferimento alle indicazioni contenute nel NASEM Report-2016, si è optato per l'utilizzo della sola *PGA* ricavata per ciascuna delle zone a comportamento dinamico omogeneo, per cui i rispettivi valori (arrotondati), muovendosi da N a S, risultano pari a:

ZONE RSL	**PGA (ag/g)**
RNN_04	0.28
RNN_03	0.28
RNN_02	0.25
RNN_01	0.28
RNC	0.26
RNS_01	0.26
RNS_02	0.25
RNS_03	0.24
RNS_04	0.23
RNS_05	0.22

Il piano/quota di riferimento utilizzato per le verifiche è pari al piano campagna attuale (p.c.).
Come indicatore di rischio complessivo, oltre al valore di *FS* per ciascun singolo strato, viene stimato anche il potenziale di liquefazione "*IPL*" o "IL" lungo la colonna stratigrafica fino alle profondità sondate secondo il metodo di Iwasaki et Al. 1982, come recentemente rivisto ed aggiornato da Sonmez (2003), integrando in modo pesato il potenziale di liquefazione di ciascuno strato su tutto il profilo stratigrafico indagato (vedi allegato n. 2) e per cui:

IWASAKI 1982
IPL=0 Rischio liquefazione molto basso
0<IPL≤5 Rischio liquefazione basso
5<IPL≤15 Rischio liquefazione alto
IPL>15 Rischio liquefazione molto alto

SONMEZ 2003
IPL=0 Rischio liquefazione molto basso
0<IPL≤2 Rischio liquefazione basso
2<IPL≤5 Rischio liquefazione moderato
5<IPL≤15 Rischio liquefazione alto
IPL>15 Rischio liquefazione molto alto

La distribuzione areale dei valori ottenuti viene illustrata in Tavola 2.

In funzione del *FS* calcolato sono stati determinati, altresì, le deformazioni massime (*γmax - LDI*) ed i cedimenti attesi (*εv - ∆Si*) nei terreni sia in falda che fuori falda (Zhang, 2002, Priebe, 1998), siano essi incoerenti che coesivi (rispettivamente per deformazione volumetrica/riaddensamento e riconsolidazione; Robertson metodo "All Soil, 2009").
In allegato n. 2-3 viene altresì illustrata l'entità dei cedimenti post-sismici attesi ∆*S*, cumulativa sia per terreni incoerenti che coesivi i quali, all'interno di ciascuna zona, presentano una modesta variabilità areale (vedi Tavola 3).
A titolo di riferimento Ishihara e Yoshimine (1992), in relazione ai cedimenti stimati ed al grado di danneggiamento/effetti attesi al suolo, identificano tre ambiti di pericolosità per cui:

Cedimento (cm)	Grado/severità di danneggiamento
∆S < 10	Assente - Lieve
10<∆S < 30	Medio
∆S > 30	Esteso - Severo

Inoltre, in relazione al rapporto di spessore fra strati liquefacibili/non liquefacibili) e la relativa profondità, altri autori (Crespellani et. al. 1988; Ishihara, 1985; Youd e Garri 1994, 1995) schematizzano la possibilità di propagazione verso l'alto e/o di avere manifestazioni superficiali in funzione del moto sismico atteso (vedi figura 17). I risultati grafici di tale valutazione vengono sintetizzati in coda al report di ciascuna prova (vedi allegato n. 3).
In ultimo, a supporto del giudizio complessivo e sui potenziali effetti sulla stabilità del terreno e delle strutture ivi insistenti, è opportuno valutare anche altri indicatori di pericolosità quale il parametro *LSN* (Van Ballegooy et al., 2013) (vedi allegato 3 e Tavola 4).
Il valore di *LSN* viene ricavato tramite l'integrazione, su tutta la colonna stratigrafica, del coefficiente di riconsolidazione verticale ε_v calcolato con il metodo di Zhang et al. (2002). In tal modo vengono definiti i seguenti valori e scenari di riferimento:

$$LSN = 1000 \cdot \int \frac{\varepsilon_v}{z} \cdot dz$$

LSN Range	*Predominant performances*
0 ÷ 10	Little to no expression of liquefaction, minor effects
10 ÷ 20	*Minor expression of liquefaction some sand boil*
20 ÷ 30	*Moderate expression of liquefaction, with sand boil and structural damage*
30 ÷ 40	*Moderate to severe expression of liquefaction, settlement can cause structural damage*
40 ÷ 50	*Major expression of liquefaction, undulations and damage to ground surface, severe total and differential settlement of structure*
>50	*Severe damage, extensive evidence of liquefaction at surface, severe total and defferential settlement affetting structure, damage to services*

Gli scenari di danno stimabili con il parametro *LSN* risultano significativamente condizionati dal rapporto tra strati liquefacibili/non liquefacibili, la loro posizione e la relativa deformabilità, cosa che il metodo, sulla scorta di prove ad alta risoluzione (quali CPTe/u), riesce a discriminare con buona attendibilità.
Questi indicatori, infatti, portano a stimare rispettivamente la probabilità di sviluppo del fenomeno in relazione all'IPL e gli scenari di deformazione/danno attesi in superficie sulla base dell'assetto stratigrafico rilevato e del rapporto fra orizzonti liquefacibili/non liquefacibili; ciò consente un giudizio più approfondito sul potenziale di danneggiamento e sulla severità delle manifestazioni superficiali attese.
In linea generale, in zone omogenee, lungo l'arenile si può stimare un aumento generale della pericolosità per liquefazione procedendo dal lungomare (storicamente zona di massima altezza della duna principale e con depositi superficiali maggiormente addensati) verso la battigia; ciò è imputabile alla progressiva riduzione della soggiacenza avvicinandosi alla linea di riva (con falda stabile al piano campagna), contestualmente all'incremento di gradiente topografico ed al maggiore rimaneggiamento degli orizzonti superficiali per azione del mare. Inoltre osservando la "Carta delle isopotenziali di liquefazione" (Tavola 2), è possibile apprezzare trend generali per cui i valori di IPL e, quindi, di pericolosità per liquefazione, tendano ad aumentare progressivamente verso le zone costiere centrali e verso l'estremità di Rimini Nord. Nel primo caso i valori più significativi si rilevano presso Marina Centro, soprattutto in corrispondenza delle zone RNS_01 e parte di RNS_02, ove gli spessori del prisma sabbioso tendono a valori massimi. Un'anomalia nei trend generali è rappresentata dai depositi presenti nella zona centrale di "interdigitazione" (RNC) ricompresa fra il Deviatore Marecchia ed il Portocanale, ove l'assetto stratigrafico risulta più articolato e maggiormente influenzato dall'interazione con le dinamiche e depositi fluviali e, localmente, anche dalla attività antropiche ivi realizzate. Ciò porta a rilevare maggiori intercalazioni con livelli ghiaiosi/addensati e/o coesivi con conseguente riduzione dei valori di pericolosità, conducendo comunque sempre a valori di IPL≥5. Dagli studi di MS3 a monte del Lungomare, tuttavia, i valori di pericolosità risultano aumentare nuovamente nell'ambito di un'ampia zona a potenziale elevato/molto elevato per liquefazione.
Diversamente presso Rimini Nord, sebbene gli spessori di sabbia risultino minori (vedi sezioni litotecniche in Tavola n. 7.1 e 7.2), gli orizzonti superficiali (Unità A - Lit. S) risultano di esiguo spessore e mai particolarmente addensati, riducendo quel potenziale effetto di confinamento attribuibile ad una crosta superficiale stabile; oltretutto anche gli orizzonti maggiormente critici dell'Unità B (Lit. H-AL) presentano generalmente un minor stato di addensamento.

Anche l'osservazione dei laboratori ciclici su campioni rappresentativi prelevati nell'ambito dello studio di MS3 del Comune di Rimini porta ad evidenziare una modesta differenza di comportamento tra i depositi costieri di RNN e RNS ove, nel campo dei cicli di riferimento, il CRR rappresentativo per l'Unità A risulta lievemente più alto di quello corrispondente alla stessa unità presso RNN. Di contro dai provini propri dell'Unità B si evince un comportamento differente e per cui, quelli rappresentativi degli ambiti RNS, risultano moderatamente più resistenti allo sforzo ciclico rispetto a quelli prelevati presso RNN. Tale modesta differenza di comportamento può essere condizionata in qualche misura dalle differenze granulometriche, di tessitura e mineralogiche che contraddistinguono i depositi costieri a Sud e a Nord della foce del Marecchia.
I provini di terreno prelevati nell'ambito nell'Unità C (depositi alluvionali limo-argillosi alla base del cuneo sabbioso) presso RNS, in occasione del recente studio di MS3 di Rimini, evidenziano una significativa resistenza ciclica, sensibilmente superiore a quella delle sabbie costiere e, in particolare, di entità superiore ad almeno il 40% di quella propria dell'Unità A stimata nello stesso sito. Una verifica di resistenza residua post-ciclica (tramite prove TRX_CIU) condotta su alcuni provini di tale Unità C, dopo aver superato raggiunto la deformazione assiale in doppia ampiezza pari al 5%, ha portato ad osservare una perdita di resistenza non drenata pari a circa il 25% della resistenza originaria.

In ultimo, lo studio di MS3 sopracitato, tramite le formulazioni semplificate di Harzibaba 2005 (FCth-H05) e Rahman 2012 (FCth-R12), per i terreni delle Unità A e B ha condotto ad una stima di prima approssimazione della soglia di contenuto in fine (FCth) oltre la quale il comportamento del deposito non è più governato dai contatti intergranulari dello scheletro solido grossolano ma dalla sempre maggiore prevalenza di matrice fine. I valori riscontrati con tali metodologie per ciascuna Unità (A e B) presso RNN e RNS sono riportati in Tabella 5:

Tabella 5 Stima approssimativa della soglia di contenuto in fine (FCth) per le Unità A e B presso RNN ed RNS

Parametro	RNN_A	RNN_B	RNS_A	RNS_B
FCth-H05	0.27	0.28	0.28	0.28
FCth-R12	0.40	0.40	0.39	0.40

Pertanto entro i range di FCth rilevati i metodi di verifica semplificati CPT risultano trovare una coerente applicabilità. L'analogia dei risultati conferma la modesta differenza tessiturale e granulometrica tra le sabbie del litorale a N e S di Rimini; ciò avvalora il fatto per cui il differente comportamento fra i terreni dell'Unità A e B presso ciascuna zona, data la stessa natura litologica, possa essere prevalentemente imputabile al diverso rapporto nelle alternanze fra orizzonti di sabbie cernite e livelli maggiormente limosi (in termini di frequenza e spessore) nonché al relativo stato di addensamento.
Lungo il tratto costiero di RNC e RNN assume importanza la presenza locale di orizzonti ghiaiosi ad elevata resistenza ciclica e capacità di drenaggio talora presenti in corrispondenza degli orizzonti basali del cuneo sabbioso marino o, talvolta, la presenza di strutture di paleoalveo anche nell'ambito dei livelli più superficiali (es. in prossimità del Portocanale, in località San Giuliano Mare, Rivabella o Viserba), con maggior spessore e persistenza soprattutto nelle aree a monte dell'arenile.

Quindi, per un giudizio complessivo circa i parametri di pericolosità stimati, osservando comparativamente i rispettivi risultati per ciascuna prova, si rileva quanto segue:

- In corrispondenza di zone o prove a medesimo grado di pericolosità per IPL, i valori di cedimento post-sismico atteso risultano sostanzialmente correlabili allo spessore dei materiali potenzialmente liquefacibili, fornendo un valore conservativo senza contemplare il rapporto fra strati liquefacibili/non liquefacibili e la relativa profondità; tale aspetto talora può comportare valori di cedimento non sempre direttamente proporzionali agli andamenti di IPL.
- IPL offre una stima pesata con la profondità del grado di pericolosità in funzione della presenza e spessore lungo la verticale dei vari orizzonti liquefacibili/non liquefacibili (discretizzati secondo le situazioni FS<1 o FS>1), consentendo di discriminare specifiche soglie di rischio secondo valori di riferimento riconosciuti nella comunità scientifica e professionale, a livello nazionale ed internazionale (IPL=0, 2, 5, 15, >15).
- LSN essendo un estimatore della severità di danno atteso in superficie risulta maggiormente sensibile allo spessore della crosta superficiale, al rapporto fra strati liquefacibili/non

liquefacibili e alla relativa profondità. LSN segue generalmente i trend di pericolosità evidenziati da IPL ma rispetto a quest'ultimo, poiché ε_v varia in modo maggiormente progressivo in funzione dell'entità del fattore di sicurezza alla liquefazione, talora risulta esaltare maggiormente (in eccesso o in difetto di pericolosità) situazioni stratigrafiche specifiche.

- A fronte di valori di IPL generalmente caratterizzanti un rischio Alto (5<IPL≤15) ed a tratti Molto Alto (IPL>15), le caratteristiche geomeccaniche e stratigrafiche dei depositi costieri di Rimini in tali zone determinano valori di LSN e di cedimento massimo generalmente riconducibili a manifestazioni con grado/severità di danneggiamento atteso da basso a medio, quest'ultimo soprattutto nei casi di maggior spessore dei depositi. Solo in corrispondenza delle zone con maggior spessore delle sabbie congiuntamente a bassi valori di resistenza ciclica si perviene alla stima di possibili significative manifestazioni di liquefazione (particolarmente in corrispondenza di alcuni settori presso RNN_01-02-03-04 e RNS_01-02).
- In corrispondenza di RNC, in virtù della particolare situazione litostratigrafica locale, si rilevano i minori valori di LSN, con possibilità di minime - modeste espressioni di liquefazione, sebbene i cedimenti complessivi attesi risultino poco inferiori a 10 cm e con IPL>5 Lungo.
- Talora in corrispondenza dei lungomari e delle zone immediatamente limitrofe e retrostanti è possibile stimare valori di IPL inferiori alle medie della zona di appartenenza in quanto tali settori generalmente risultano morfologicamente corrispondenti alla posizione della "duna principale", topograficamente un poco più rilevati rispetto alle prospicienti zone a mare e monte della stessa e, quindi, caratterizzati da una maggiore soggiacenza della falda (da pochi decimetri ad oltre 1 m) nonché da orizzonti sabbiosi superficiali dell'Unità A un poco più addensati rispetto alle aree limitrofe.
- In prossimità del portocanale, all'altezza delle aree di piano lungo via destra del porto, si rilevano strutture di paleolaveo/barra di foce individuabili come corpi ghiaiosi metrici localizzati, in grado di mitigare moderatamente il potenziale di liquefazione locale; in tali situazione andrà attentamente valutato l'assetto stratigrafico locale in relazione anche alle modalità di intervento ed alla possibilità di manifestazione di fenomeni di lateral spreading.

Chiaramente gli scenari attesi e derivabili dai metodi semplificati possono essere significativamente influenzati da ulteriori variabili sito specifiche e sismogenetiche quali:

- Fenomeni di direzionalità dell'azione sismica e tipologia di faglia
- Distanza epi/ipocentrale, contenuto in frequenza, durata della fase forte, ecc.
- condizioni idrogeologiche e/o di drenaggio locale
- configurazioni geomorfologiche particolari e/o mancanza di contenimento laterale dei terreni (es. presenza di declivio, corsi d'acqua di significative dimensioni e profondità, banchine portuali, strutture arginali, ecc.)
- presenza di carichi piezometrici e/o falde in pressione
- presenza di gas nel sottosuolo
- fenomeni di interazione terreno struttura e/o presenza di sovraccarichi o carichi concentrati
- preesistenza di sforzi di taglio in condizioni statiche

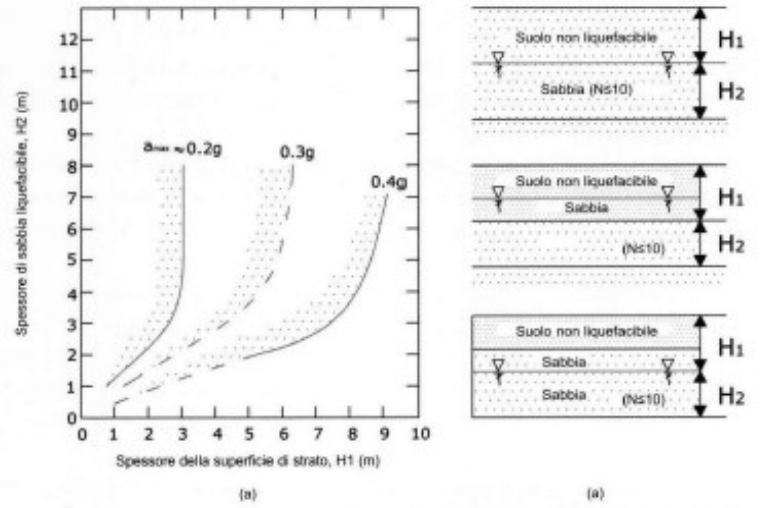
In allegato n. 2 si riportano i report sintetici delle verifiche a liquefazione effettuate su ciascuna area, mentre in allegato n. 3 vengono illustrate le tabelle parametriche riepilogative di tutti i corrispondenti valori di IPL, LSN e cedimento calcolati per ciascuna zona a comportamento dinamico omogeneo ed in condizioni di campo libero (free-field).

Tutte le aree analizzate hanno presentato un IPL>5. *Qualora opere edilizie, infrastrutture o aree di previsione urbanistica ricadano a cavallo dei limiti di potenziale di liquefazione di riferimento (es. IPL=15) e/o di zone caratterizzate da differente fattore di amplificazione sismica, sarà opportuno associare ad esse il parametro di pericolosità più conservativo nell'ambito di variazione; nel caso le aree o infrastrutture interessate da tale intersezione risultino di significativa estensione, tale approccio andrà adottato per un congruo tratto od estensione funzionale al mantenimento delle prestazioni attese per l'infrastruttura e/o area interessata.*

Le valutazioni sopra effettuate rappresentano un utile inquadramento sull'andamento del pericolo di liquefazione e dei fattori parametrici ad esso correlabili. Tuttavia in sede progettuale esecutiva sarà opportuno valutare puntualmente la compatibilità e la ricaduta delle risultanze di ulteriori verifiche in relazione al grado di rischio connesso, i piani di posa dei manufatti, le caratteristiche delle strutture (geometriche, in elevazione e fondazionali) e realizzative (dimensionamento geotecnico, modalità operative, eventuali interventi di mitigazione, drenaggio, miglioramento dei terreni, ecc.), le prestazioni attese dalle opere e la relativa funzionalità.

Valutazione delle manifestazioni superficiali in funzione del rapporto fra lo spessore dello strato superficiale non liquefacibile e quello sottostante liquefacibile

Accelerazione [gal] 1 gal = 1 cm/s²	Condizione	Propagazione della liquefazione verso l'alto	Manifestazioni superficiali
200	$h_1 \geq 3$ m e $h_2 < 3$ m	IMPEDITA	NO
	$h_1 \leq 3$ m e $h_2 > 3$ m	NON IMPEDITA	SI
300	$h_1 < 5$ m e $h_2 > 4$ m	NON IMPEDITA	SI
	$h_1 > 5$ m e $h_2 < 4$ m	IMPEDITA	NO
400 - 500	$h_1 < 7$ m e $h_2 > 3$ m	NON IMPEDITA	SI
	$h_1 > 7$ m e $H_2 < 3$ m	IMPEDITA	NO



Relazione fra lo spessore dello strato liquefacibile e lo spessore dello strato sovrapposto (Ishihara, 1985)

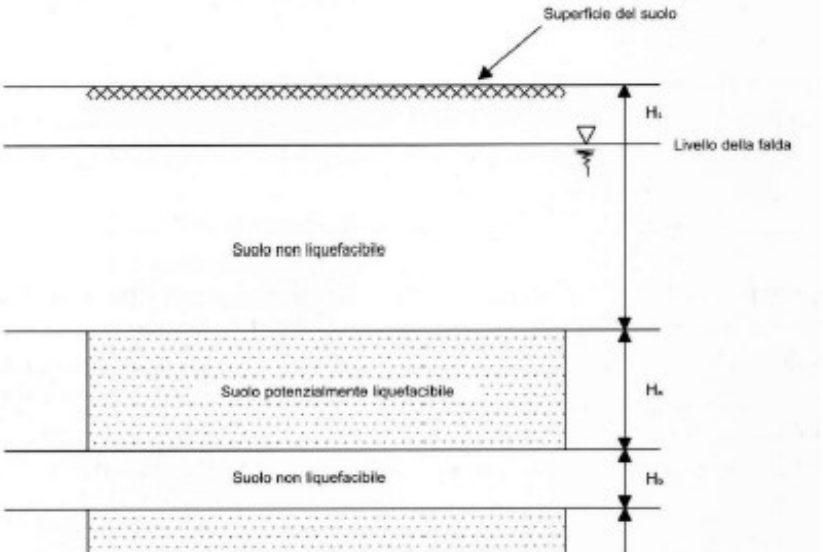


Figura 17 – Schema per la valutazione delle manifestazioni superficiali per liquefazione (Crespellani et. al. 1988; Ishihara, 1985; Youd e Garri 1994, 1995)

3. CONCLUSIONI E INDICAZIONI REALIZZATIVE

Come inquadramento generale l'area in studio si sviluppa lungo l'intera fascia costiera di Rimini, comprendendo la zona urbanizzata dei lungomari e relative aree accessorie nonché tutta l'area di arenile a mare degli stessi, che si sviluppano con sostanziale continuità dal confine con Bellaria – Igea Marina sino al confine sud con Riccione.

I terreni sabbiosi e le alternanze presenti nell'area (piana costiera) si presentano, in condizioni statiche, generalmente come discreti terreni di fondazione, tuttavia va considerata la significativa estensione lineare delle opere e la variabilità laterale dei depositi alla base del cuneo sabbioso marino per via della frequente ed irregolare interdigitazione con occasionali depositi alluvionali fluviali limo-argillosi.

L'analisi di III° livello di approfondimento nell'ambito della verifica dei rischi sismici ex DGR 564/2021, ha riguardato da un lato la definizione delle azioni sismiche attese sull'area in studio (in termini di valori nominali e fattori di amplificazione) e dal dell'altro le connesse stime del potenziale di liquefazione in condizioni di *free field con riferimento al p.c. attuale* (Vedi Tav. 1, Tav. 5 e Tav. 6).

Rimini e la costa romagnola più in generale presentano una storia sismica caratterizzata da numerosi terremoti di intensità significativa, che hanno prodotto storicamente danneggiamenti e manifestazioni superficiali importanti, compresi casi documentati di liquefazione, cedimento e fessurazione. L'area ricade nella Zona Sismogenetica n. 4 della nuova Carta Sismotettonica 2016 R.E.R., corrispondente alla zona 917 della ZS9 INGV, leggermente modificata nei limiti nord-occidentali. Le caratteristiche sismotettoniche assunte sono quelle già indicate per la zona 917 della ZS9, vale a dire deformazione lungo thrust attivi immergenti verso SW. Evidenze geomorfologiche indicano la presenza di anticlinali di crescita attive lungo la costa adriatica (Vannoli et al., 2014). La magnitudo storica massima è Mw=5,82±0.08; tuttavia in tale recente zonazione alla Zona n. 4 viene associata una magnitudo momento massima stimabile pari a Mw=6.16±0.21. Per i fini del presente studio si è assunto quindi il valore centrale pari a Mw=6.16.

In ragione della natura dei terreni e delle necessità di pianificazione urbanistica, sulla base delle informazioni geologico/stratigrafiche nonché della comparazione con dati sperimentali geognostici e geofisici di nuova acquisizine, per la stima delle azioni sismiche attese si è ritenuto coerente ed adeguato riferirsi ai recenti studi di I-II e III Livello, già realizzati per conto del Comune di Rimini ed attualmente in fase di validazione presso il Dipartimento di Protezione Civile. Tali studi sono stati sviluppati anche sulla scorta di prove geofisiche, di laboratorio ciclico/dinamico e sondaggi profondi realizzati proprio in corrispondenza degli arenili e delle aree limitrofe e, quindi, pienamente rappresentativi dell'area in studio, nonché restituiti ed elaborati seguendo le più recenti e vigenti Linee Guida nazionali (ICMS, 2008) e regionali (DGR 564/2021).

In tal senso il tratto costiero è stato suddiviso secondo 10 zone a comportamento dinamico omogeneo e rappresentativo (vedi figura 16 e Tavola 1), i cui parametri sismici caratteristici, vengono riferiti a condizioni di pericolosità attese per un periodo di ritorno di 475 anni e sono sinteticamente riepilogati al Par. 2.3 della presente relazione.

Si ricorda infatti che le analisi di RSL a fini di progettazione esecutiva dovranno essere condotte in ottemperanza alle specifiche indicazioni/prescrizioni della normativa sismica vigente (NTC2018), adottando idonei parametri di riferimento e set di accelerogrammi specificamente spettro-compatibili agli spettri elastici di riferimento per le tipologie, classi di rischio e tempi di ritorno relativi alle opere in progetto.

Un utile riferimento in fase di decisionale e di progettazione risultano essere al proposito le indicazioni ed aspetti procedurali previsti con DGR 1814/2020 in relazione alle analisi contenute nella presente relazione ed a quanto sintetizzato in Tav. 1, Tav. 5 e Tav. 6.

Nell'ambito del presente studio sono inoltre state condotte analisi/valutazioni di approfondimento inerenti il potenziale di liquefazione dei terreni incoerenti sabbiosi appartenenti al cuneo deposizionale marino, evidenziando in condizioni di *free field (con riferimento al p.c. attuale)* un potenziale di liquefazione IPL (Iwasaki 1982-85 / Sonmez 2003) generalmente **"Alto" (IPL>5). In alcuni tratti di arenile, coerentemente agli studi di MS3 realizzati dal Comune di Rimini, si rilevano zone contraddistinte da IPL≥15 (potenziale molto alto). Gli andamenti generali di tale parametro vengono illustrati in Tavola 2. Altri indicatori utilizzabili per stimare la pericolosità dei fenomeni di liquefazione attesi riguardano i cedimenti post-sismici ed LSN (liquefaction severity number) rispettivamente riportati sia nei report di calcolo agli allegati 2 e 3 che in Tavola 3 e 4.**

L'assetto litostratigrafico generale rilevato lungo la fascia costiera viene riportato in Tavola n. 7.1 e 7.2. In linea generale, nell'ambito di ciascuna zona omogenea, si può stimare un aumento tendenziale della pericolosità per liquefazione procedendo dal lungomare (storicamente zona di massima altezza della duna principale e con depositi superficiali maggiormente addensati) verso la battigia; ciò è imputabile alla progressiva riduzione della soggiacenza avvicinandosi alla linea di riva (con falda stabile al piano campagna), contestualmente all'incremento di gradiente topografico ed al maggiore rimaneggiamento degli orizzonti superficiali per azione del mare. Inoltre osservando la "Carta delle isopotenziali di liquefazione" (Tavola 2), è possibile apprezzare trend generali per cui i valori di IPL e, quindi, di pericolosità per liquefazione, tendano ad aumentare progressivamente verso le zone costiere centrali e verso l'estremità di Rimini Nord. Nel primo caso i valori più significativi si rilevano presso Marina Centro, soprattutto in corrispondenza delle zone RNS_01 e parte di RNS_02, ove gli spessori del prisma sabbioso tendono a valori massimi. Un'anomalia nei trend generali è rappresentata dai depositi presenti nella zona centrale di "interdigitazione" (RNC) ricompresa fra il Deviatore Marecchia ed il Portocanale, ove l'assetto stratigrafico risulta più articolato e maggiormente influenzato dall'interazione con le dinamiche e depositi fluviali e, localmente, anche dalla attività antropiche ivi realizzate. Ciò porta a rilevare maggiori intercalazioni con livelli ghiaiosi/addensati (strutture di paleocanale/barra di foce) e/o coesivi con conseguente riduzione locale dei valori di pericolosità, conducendo comunque sempre a valori di IPL≥5. Dagli studi di MS3 a monte del Lungomare, tuttavia, i valori di pericolosità risultano aumentare nuovamente nell'ambito di un'ampia zona a potenziale elevato/molto elevato per liquefazione. Anche in prossimità del portocanale, all'altezza delle aree di piano lungo via destra del porto, si rilevano strutture di paleolaveo/barra di foce individuabili come corpi ghiaiosi metrici localizzati, in grado di mitigare moderatamente il potenziale di liquefazione locale; in tali situazioni andrà attentamente valutato l'assetto stratigrafico locale in relazione anche alle modalità di intervento ed alla possibilità di manifestazione di fenomeni di lateral spreading.

Diversamente presso Rimini Nord, sebbene gli spessori complessivi del cuneo sabbioso risultino inferiori, gli orizzonti superficiali (Unità A - Lit. S) presentano uno spessore esiguo ed un minor grado di addensamento, riducendo quel potenziale effetto di confinamento attribuibile ad una crosta superficiale stabile; oltretutto anche gli orizzonti maggiormente critici dell'Unità B (Lit. H-AL) evidenziano generalmente un minor stato di addensamento.

Per le finalità del presente studio, ai fini di pianificazione urbanistica e per le indicazioni realizzative generali, si ritiene che la campagna geognostica eseguita, unitamente alla base dati di archivio, risulti di ottima qualità ed esaustiva sia per la densità di verticali d'indagine che per la tipologia delle prove effettuate, oltretutto coerente anche con gli esiti di precedenti studi condotti sull'arenile a fini di pianificazione urbanistica (es. Parco del Mare, Piano Arenile 2004).
Le verifiche di calcolo, estese su tutto il territorio, condotte su verticali selezionate e ritenute rappresentative, forniscono un quadro complessivo degli andamenti riscontrati su scala areale; in tali verifiche, nel rapporto CRR/CSR (tra resistenza e domanda ciclica), coerentemente al metodo utilizzato (Robertson 2009-2015), si adotta un fattore di sicurezza di base FS=1,2, mantenuto intrinsecamente per la stima di tutti gli indicatori di rischio correlati (IPL, ΔS ed LSN,).

Si ribadisce come gli scenari attesi e derivabili dai metodi semplificati possono, comunque, essere significativamente influenzati da ulteriori variabili sito specifiche e sismogenetiche quali:

- Fenomeni di direzionalità dell'azione sismica e tipologia di faglia
- Distanza epi/ipocentrale, contenuto in frequenza, durata della fase forte, ecc.
- condizioni idrogeologiche e/o di drenaggio locale
- configurazioni geomorfologiche particolari e/o mancanza di contenimento laterale dei terreni (es. presenza di declivio, corsi d'acqua di significative dimensioni e profondità, banchine portuali, strutture arginali, ecc.)
- presenza di carichi piezometrici e/o falde in pressione
- presenza di gas nel sottosuolo
- fenomeni di interazione terreno struttura e/o presenza di sovraccarichi o carichi concentrati
- preesistenza di sforzi di taglio in condizioni statiche

In allegato n. 2 si riportano i report sintetici delle verifiche a liquefazione effettuate su ciascuna area, mentre in allegato n. 3 vengono illustrate le tabelle parametriche riepilogative di tutti i corrispondenti valori di IPL, LSN e cedimento calcolati per ciascuna zona a comportamento dinamico omogeneo ed in condizioni di campo libero (free-field).

Tutte le aree analizzate hanno presentato un IPL>5. *Qualora opere edilizie, infrastrutture o aree di previsione urbanistica ricadano a cavallo dei limiti di potenziale di liquefazione di riferimento (es. IPL=15) e/o di zone caratterizzate da differente fattore di amplificazione sismica, sarà opportuno associare ad esse il parametro di pericolosità più conservativo nell'ambito di variazione; nel caso le aree o infrastrutture interessate da tale intersezione risultino di significativa estensione, tale approccio andrà adottato per un congruo tratto od estensione funzionale al mantenimento delle prestazioni attese per l'infrastruttura e/o area interessata.*

Le valutazioni sopra effettuate rappresentano un utile inquadramento sull'andamento del pericolo di liquefazione e dei fattori parametrici ad esso correlabili. Tuttavia in sede progettuale esecutiva sarà opportuno valutare puntualmente la compatibilità e la ricaduta delle risultanze di ulteriori verifiche in relazione al grado di rischio connesso, i piani di posa dei manufatti, le caratteristiche delle strutture (geometriche, in elevazione e fondazionali) e realizzative (dimensionamento geotecnico, modalità operative, eventuali interventi di mitigazione, drenaggio, miglioramento dei terreni, ecc.), le prestazioni attese dalle opere e la relativa funzionalità.

Considerati l'entità dei fenomeni e gli aspetti di non linearità ipotizzabili circa il comportamento dinamico/ciclico dei terreni, all'occorrenza e/o in fase di progettazione esecutiva, soprattutto per opere strategiche e/o di rilevanza, potrà essere opportuno un approfondimento di studio tramite analisi della risposta sismica di sito con metodi di calcolo non lineari ed in tensioni efficaci, opportunamente calibrati con prove di laboratorio cicliche, in grado di stimare con maggior precisione i fenomeni deformativi e le sovrappressioni interstiziali attesi in condizioni sismiche.

Pertanto in base alle valutazioni complessive sopra citate, considerate le tipologie degli interventi previsti ed in merito agli effetti di sito inerenti il potenziale di liquefazione (IPL>5), è ragionevolmente ipotizzabile utilizzare le risultanze delle analisi sismiche, definendo due tipologie d'intervento per le opere da realizzare:

- **Per manufatti precari, per manufatti permanenti di modeste dimensioni e ritenuti di scarsa rilevanza strutturale, per percorsi ciclo-pedonali e passeggiate, per attrezzature di spiaggia, per la normale attività balneare di spiaggia, per attrezzature dedicate ad attività ludico-sportive-ricreative, per modesti rilevati stradali, per infrastrutture tecnologiche ordinarie (non strategiche), per opere di rinaturalizzazione e di tutela delle aree a verde si ritiene ammissibile intervenire tramite fondazioni dirette. L'incastro ed il corretto dimensionamento delle opere fondali sarà determinato in sede di progettazione esecutiva tenendo conto oltre che della tipologia dell'opera anche dei cedimenti potenziali. In ogni caso una idonea valutazione circa le metodologie di intervento più appropriate a garantire un grado di sicurezza adeguato per il sistema opera/terreno dovrà essere condotta dal Progettista incaricato in fase esecutiva in funzione del grado di rischio/classe d'uso connessi all'opera ed al suo utilizzo nonché del relativo tempo di vita nominale.**

- **Per manufatti permanenti, di maggiori dimensioni e ritenuti di rilevanza strutturale, per infrastrutture tecnologiche strategiche e/o condizioni di significativo rischio connesso all'opera ed al suo utilizzo (in virtù della classe d'uso, del livello di presenza/permanenza delle persone o di situazioni di affollamento), al fine di inibire/mitigare la suscettibilità alla liquefazione dei depositi incoerenti e di omogeneizzarne il comportamento geomeccanico, occorrerà valutare l'approntamento di interventi preliminari di stabilizzazione, miglioramento e/o di drenaggio dei terreni di fondazione nel volume di interesse. In tal caso potranno essere adottate fondazioni superficiali di tipo diretto da dimensionare in funzione delle prestazioni attese e del grado di stabilizzazione/miglioramento ottenuto nel volume di terreno di interesse per le specifiche opere. In mancanza di altre soluzioni percorribili e/o come precisa scelta progettuale nella fase esecutiva, si potrà ricorrere all'utilizzo di fondazioni profonde adeguatamente dimensionate alle azioni di taglio ed alla mancanza di adesione laterale negli orizzonti dell'Unità A e B; andranno tenuti in debito conto possibili effetti di attrito negativo/trascinamento a seguito del riaddensamento dei terreni potenzialmente liquefacibili e/o coesivi soggetti a degradazione ciclica.**

Soluzioni alternative potranno essere ammissibili solo se adeguatamente motivate sotto il profilo tecnico-realizzativo, previo significativo approfondimento di indagine (in sito ed in laboratorio)

e di analisi della risposta sismica di sito tramite metodi di calcolo avanzati di tipo non lineare ed in tensioni efficaci, opportunamente calibrati con prove di laboratorio cicliche, in grado di stimare con maggior precisione i fenomeni deformativi e le sovrappressioni interstiziali attesi nelle condizioni sismiche di progetto. In tale contesto dovrà altresì essere adeguatamente valutato il comportamento atteso per il sistema opera-terreno al fine di garantire le necessarie condizioni prestazionali e di sicurezza.

Naturalmente in fase esecutiva rimane in ambito discrezionale del progettista l'adozione dei parametri di pericolosità e di azione sismica ai fini delle verifiche di calcolo ed analisi geotecniche in funzione della tipologia di opera e delle relative classi d'uso, vita nominale, grado di rischio connesso all'opera. In ogni caso le valutazioni andranno approfondite puntualmente in relazione alle quote dei piani di posa, ai carichi insistenti nonché alle modalità realizzative delle opere in progetto e delle prestazioni attese dalle stesse e, pertanto, anche in base a quanto espresso al paragrafo 7.11.3.4.3 delle NTC *"L'adeguatezza del margine di sicurezza nei confronti della liquefazione deve essere valutata e motivata dal progettista".*

Anche la scelta delle tipologie fondazionali e dei relativi piani di posa, nonchè degli approcci metodologici corretti per gli eventuali sbancamenti, le opere di drenaggio e/o di contenimento, saranno effettuati in sede di progettazione esecutiva, tenendo conto di quanto sopra riportato e di quanto già illustrato e prescritto nella relazione Geologica redatta dagli scriventi, datata Novembre 2023.

Rimini, Novembre 2023



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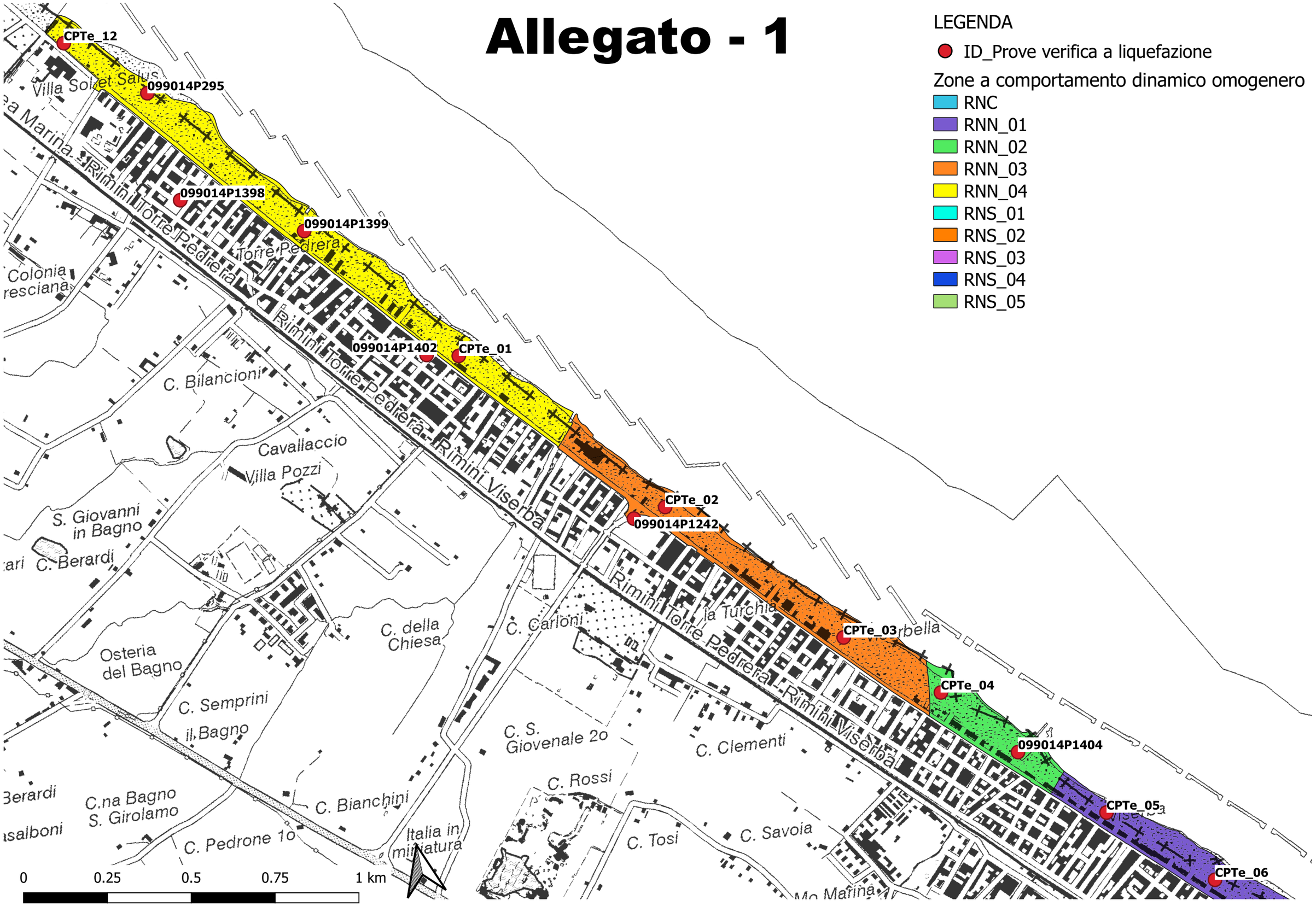
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A L L E G A T I

Allegato - 1



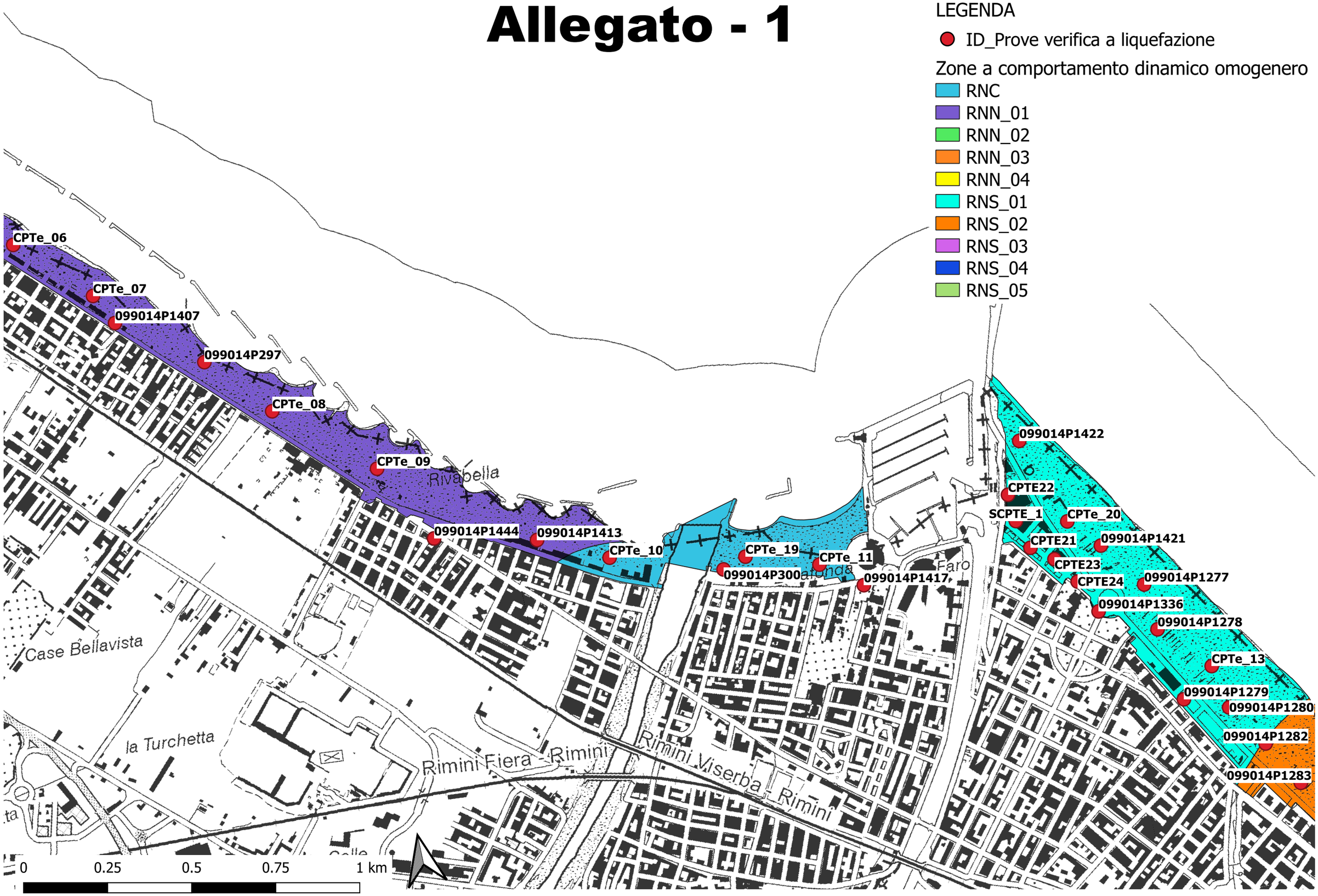
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ID_Prove verifica a liquefazione

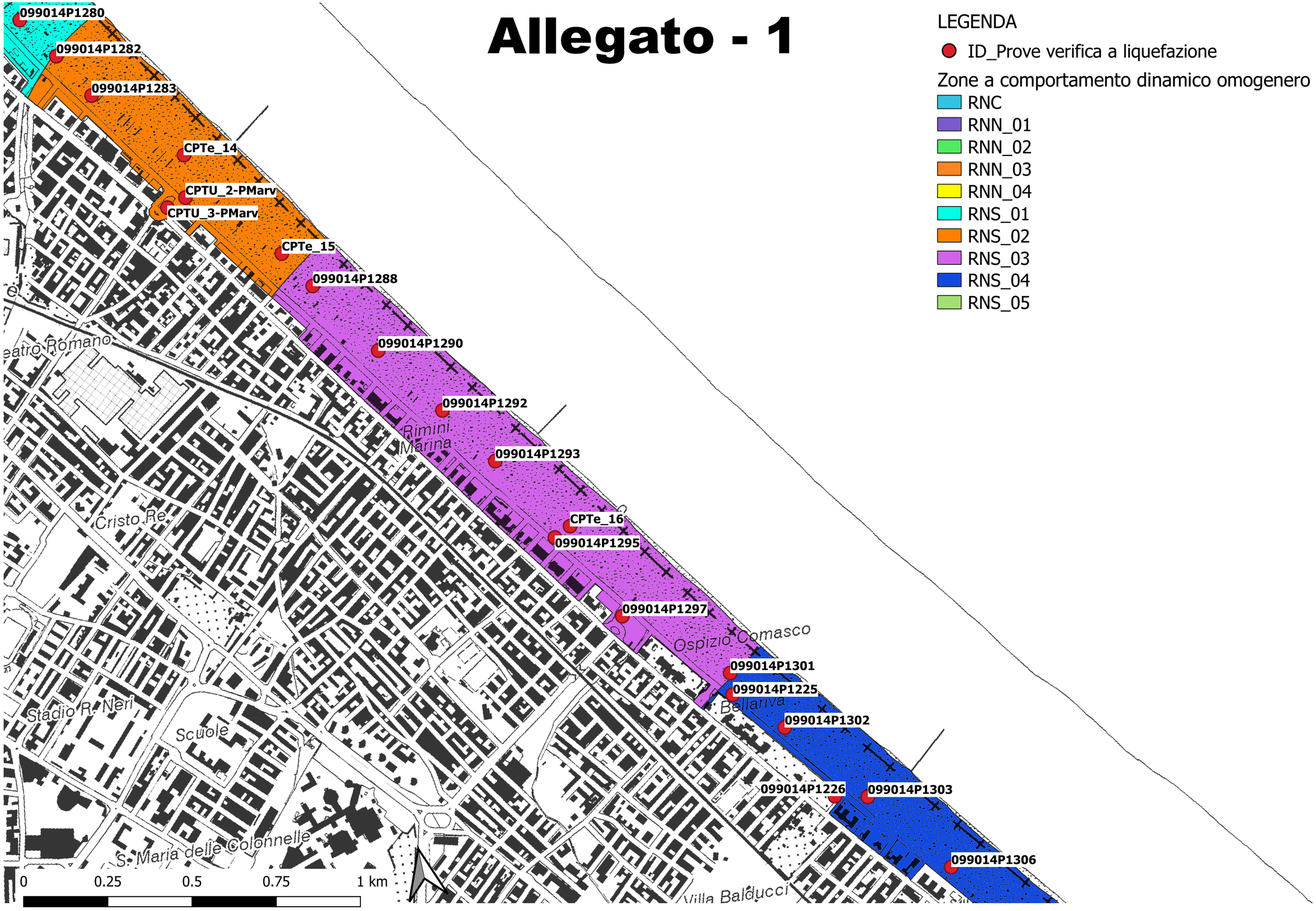
Zone a comportamento dinamico omogenero

- RNC
- RNN_01
- RNN_02
- RNN_03
- RNN_04
- RNS_01
- RNS_02
- RNS_03
- RNS_04
- RNS_05

Allegato - 1


LEGENDA
ID_Prove verifica a liquefazione
Zone a comportamento dinamico omogenero
RNC
RNN_01
RNN_02
RNN_03
RNN_04
RNS_01
RNS_02
RNS_03
RNS_04
RNS_05
CPTe_06
CPTe_07
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099014P1413
CPTe_10
CPTe_19
CPTe_11
099014P300
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099014P1422
CPTE22
SCPTE_1
CPTe_20
CPTE21
099014P1421
CPTE23
CPTE24
099014P1277
099014P1336
099014P1278
CPTe_13
099014P1279
099014P1280
099014P1282
099014P1283
Rivabella
Case Bellavista
la Turchetta
Rimini Fiera
Rimini
Rimini Viserba
Rimini
Marina Centro
Faro
0
0.25
0.5
0.75
1 km

Allegato - 1



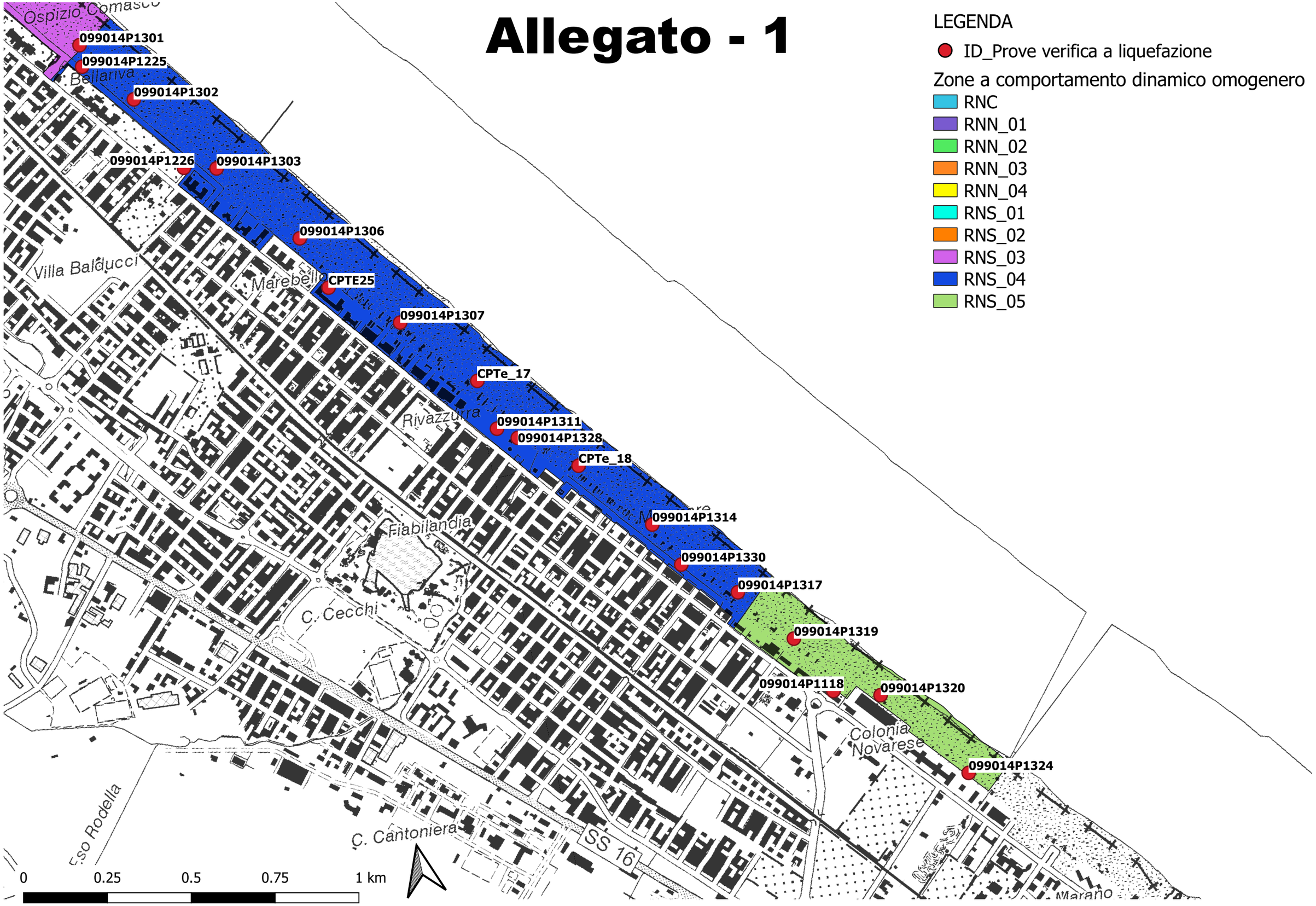
LEGENDA

ID_Prove verifica a liquefazione

Zone a comportamento dinamico omogenero

- RNC
- RNN_01
- RNN_02
- RNN_03
- RNN_04
- RNS_01
- RNS_02
- RNS_03
- RNS_04
- RNS_05

Allegato - 1



LEGENDA

- ID_Prove verifica a liquefazione

Zone a comportamento dinamico omogenero

- RNC
- RNN_01
- RNN_02
- RNN_03
- RNN_04
- RNS_01
- RNS_02
- RNS_03
- RNS_04
- RNS_05

ALLEGATO N. 2

REPORT VERIFICHE DI LIQUEFAZIONE

REPORT - ZONA RNN_04

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

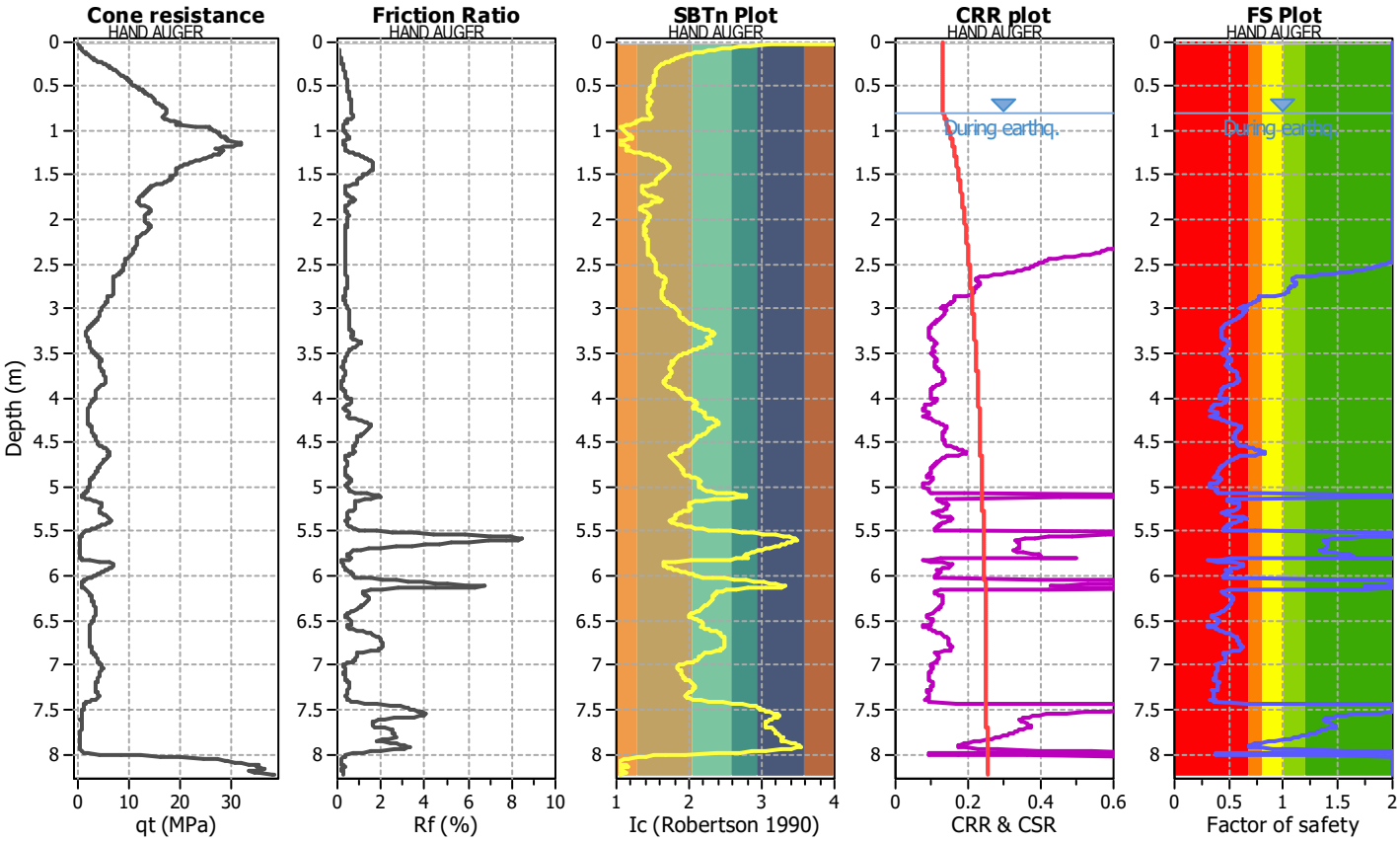
LIQUEFACTION ANALYSIS REPORT

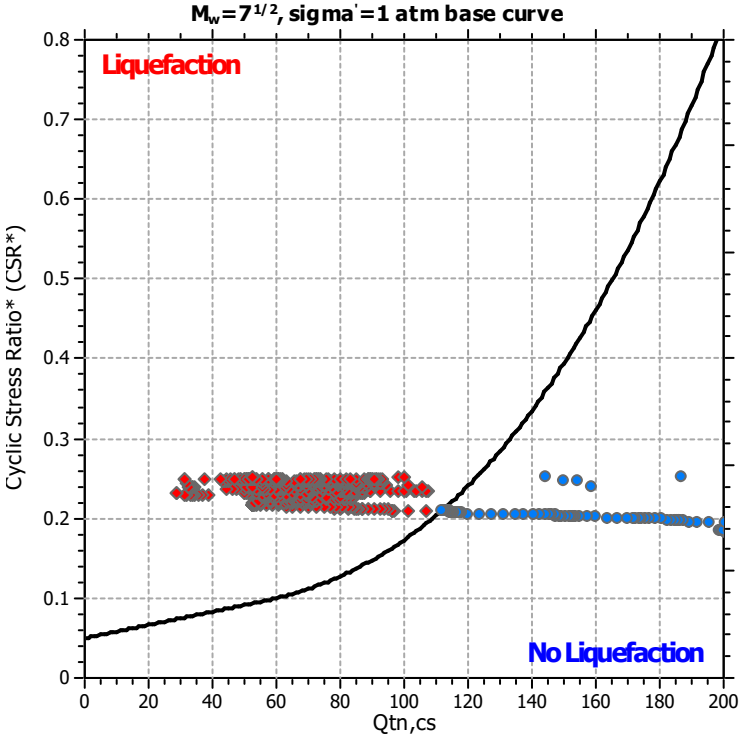
Project title : MS3 Rimini_RNN_04 **Location : Rimini**

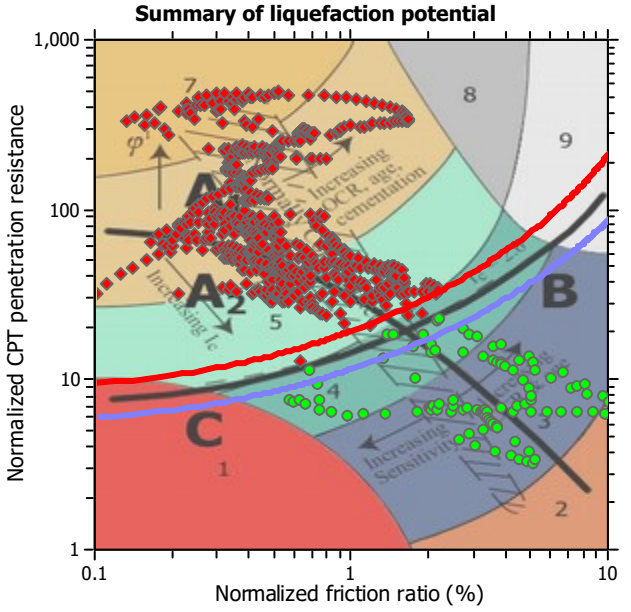
CPT file : CPTe_12

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.10 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

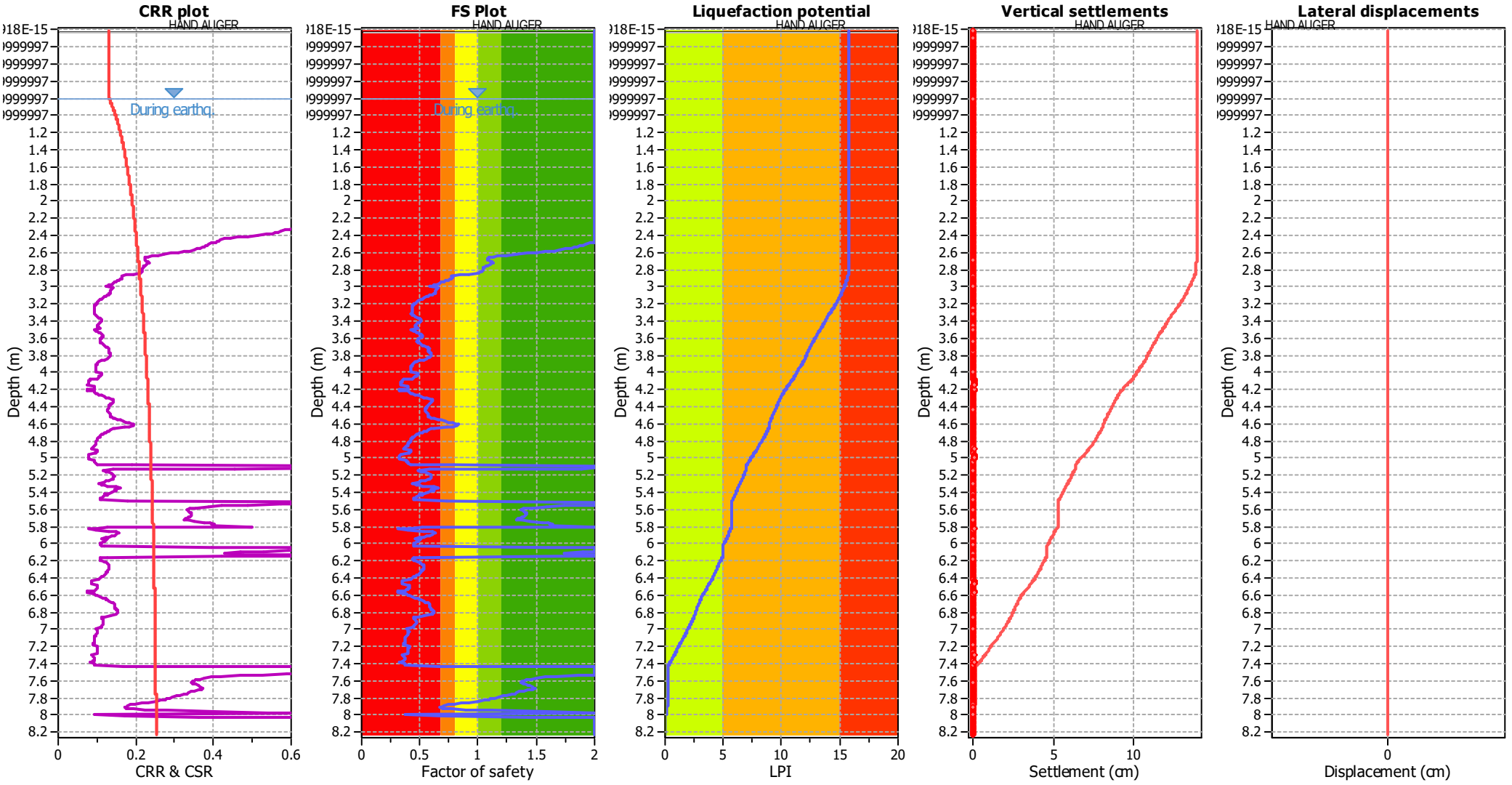






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.10 m	Fill height:	N/A	Limit depth:	20.00 m

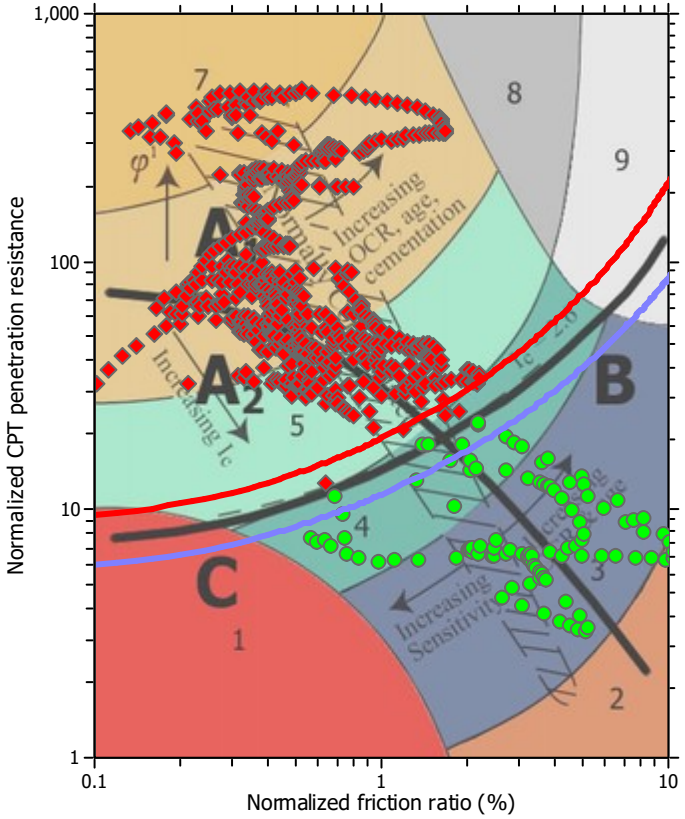
F.S. color scheme

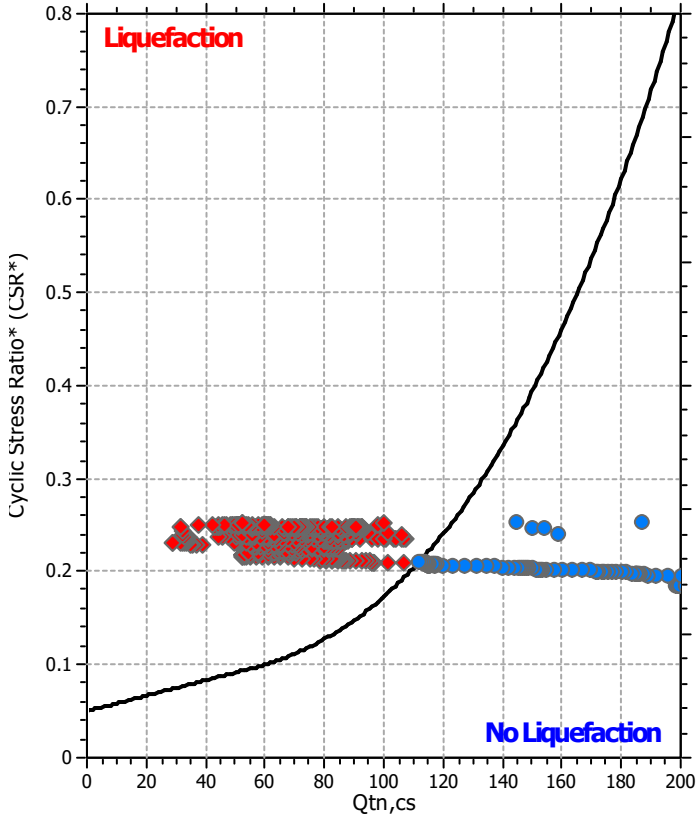
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

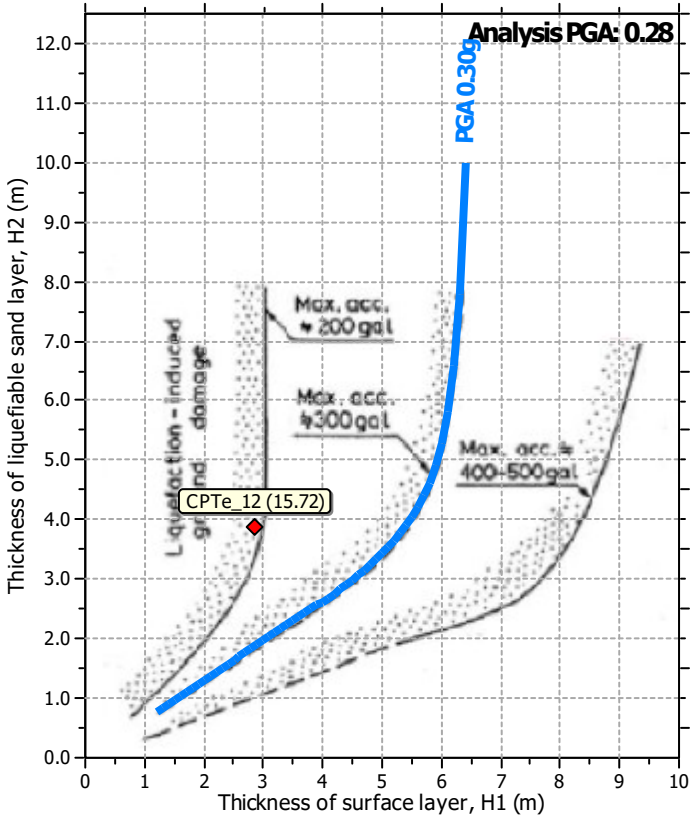
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.10 m	Fill height:	N/A	Limit depth:	20.00 m

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

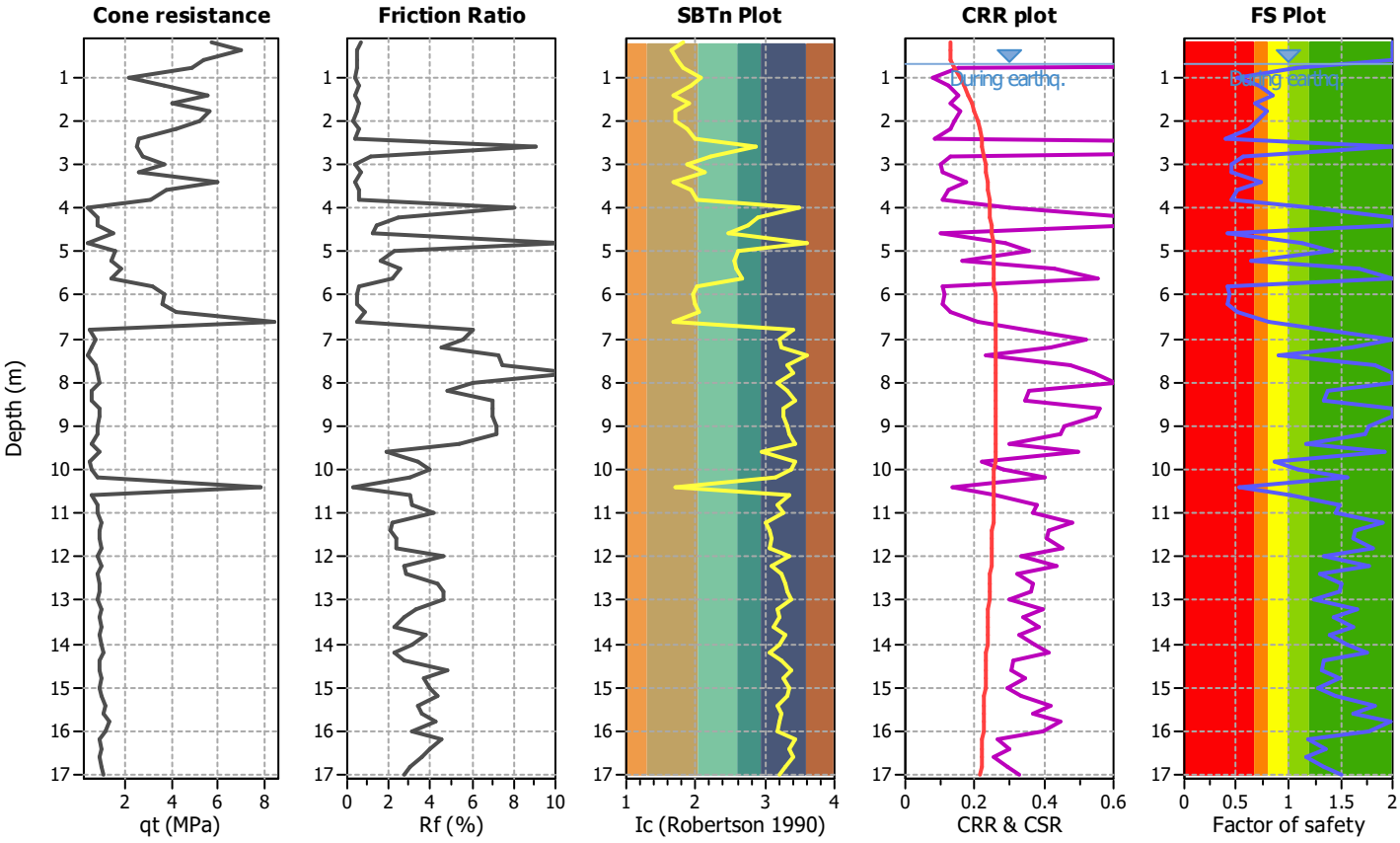
LIQUEFACTION ANALYSIS REPORT

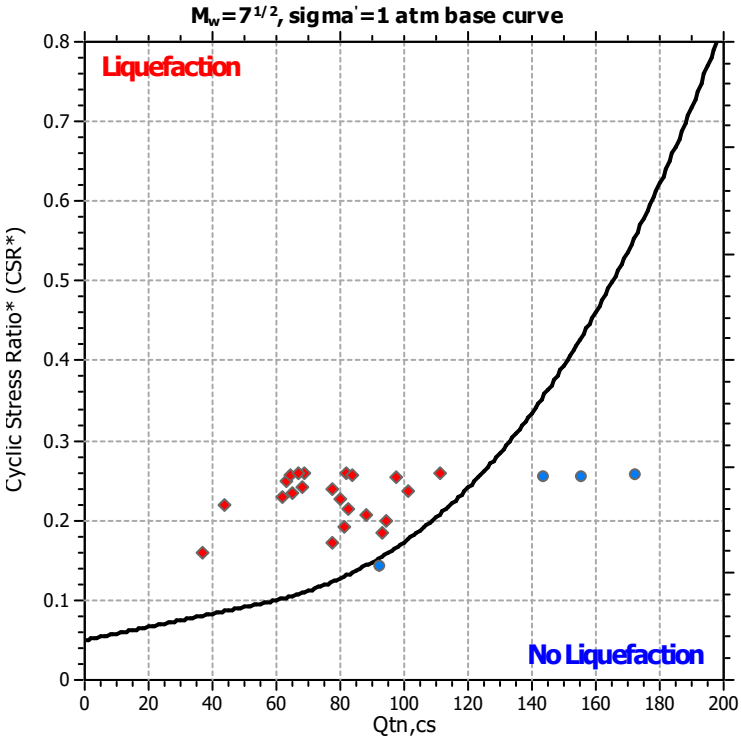
Project title : MS3 Rimini_RNN_04 **Location : Rimini**

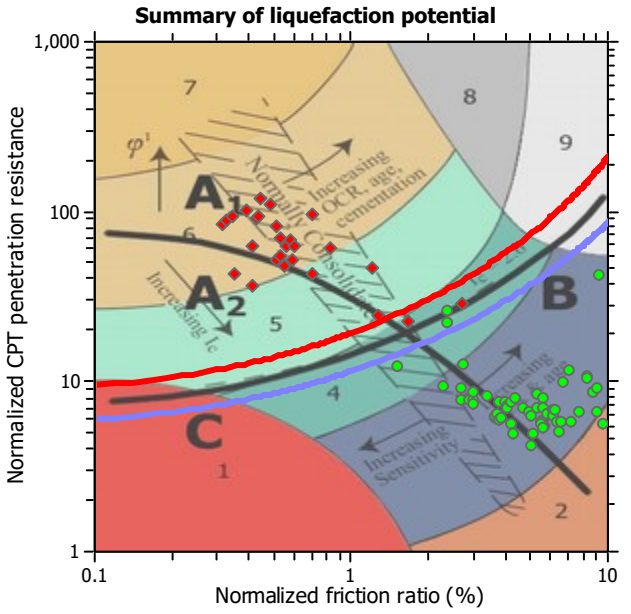
CPT file : 099014P295

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.70 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	1	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

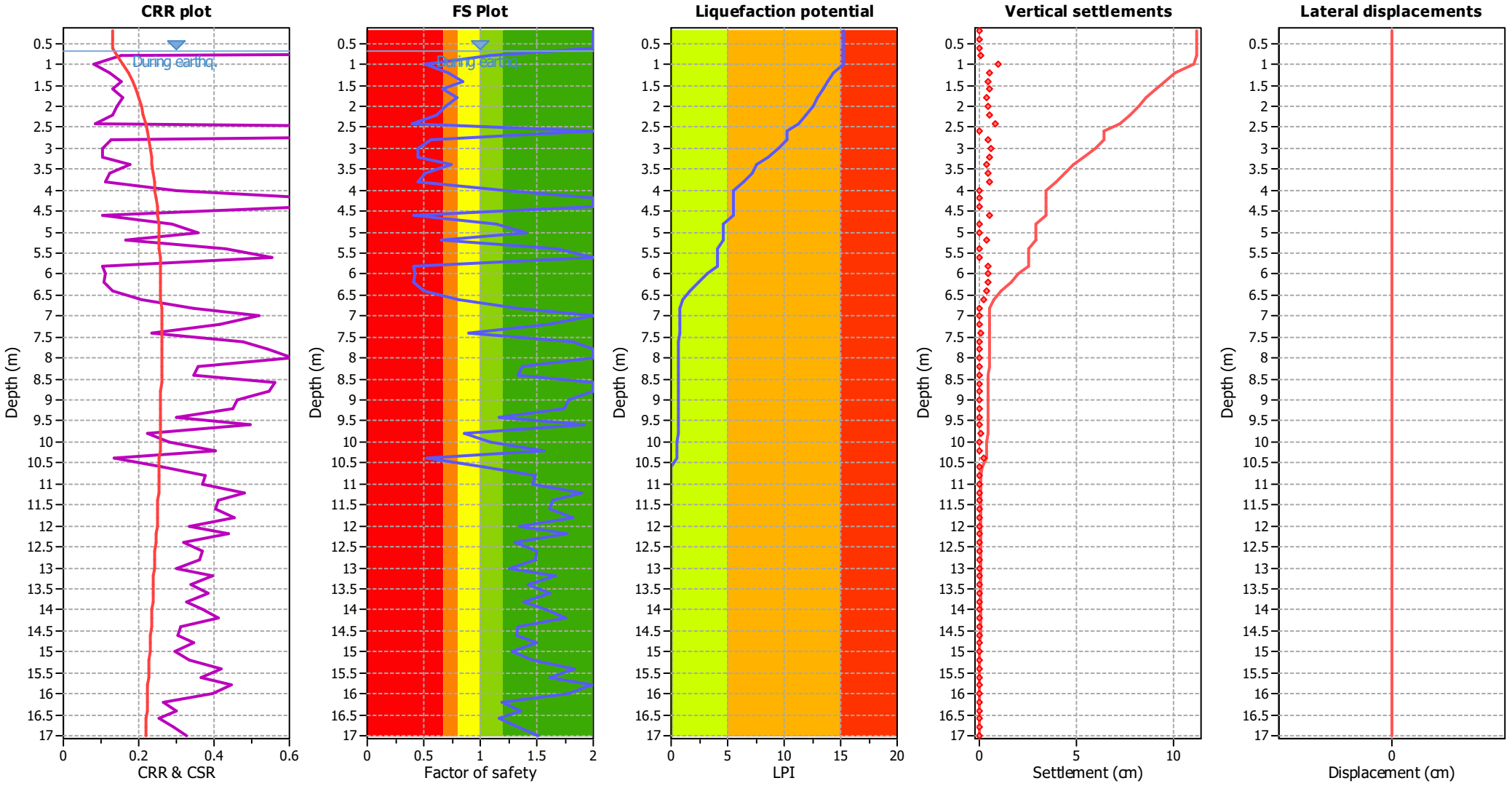






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	1	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

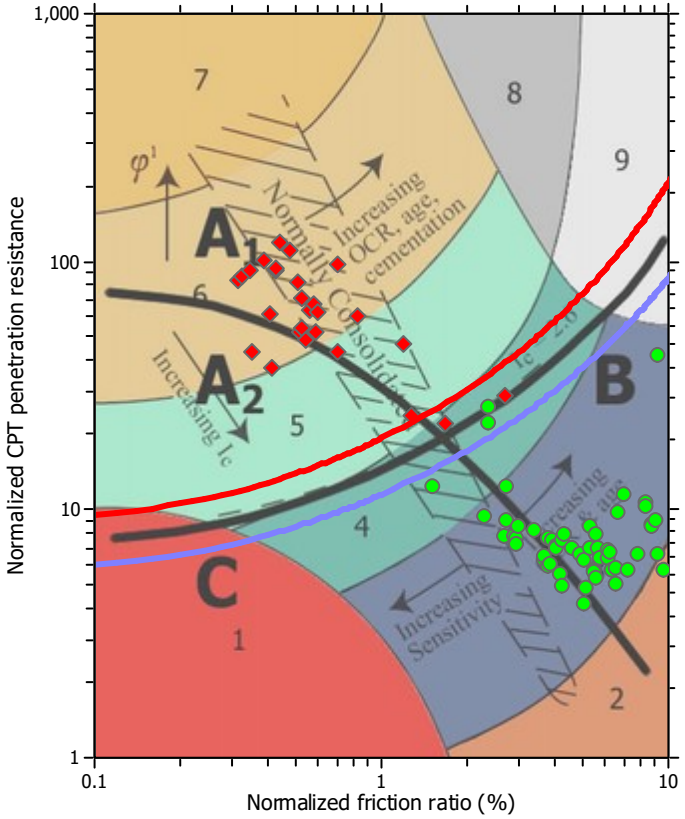
F.S. color scheme

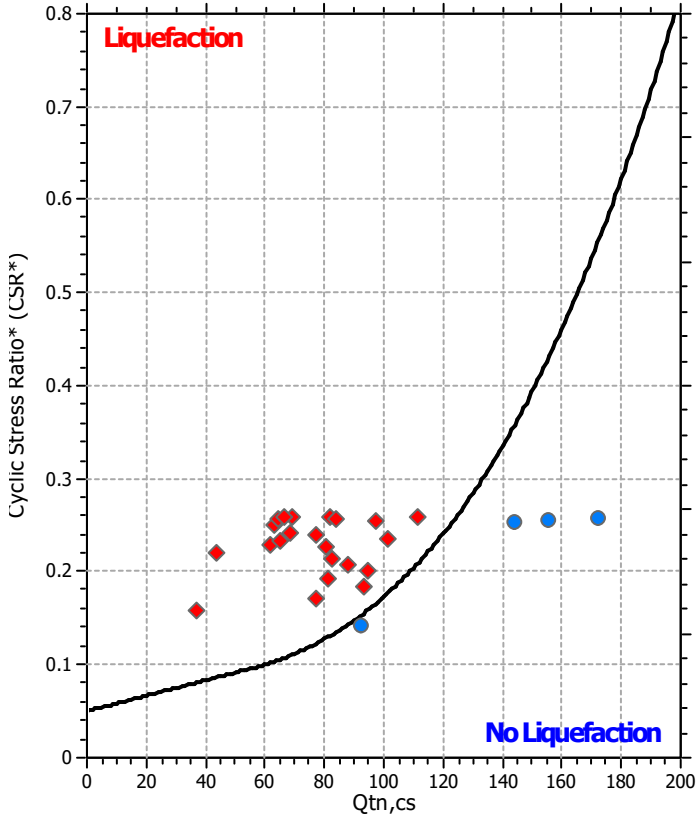
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

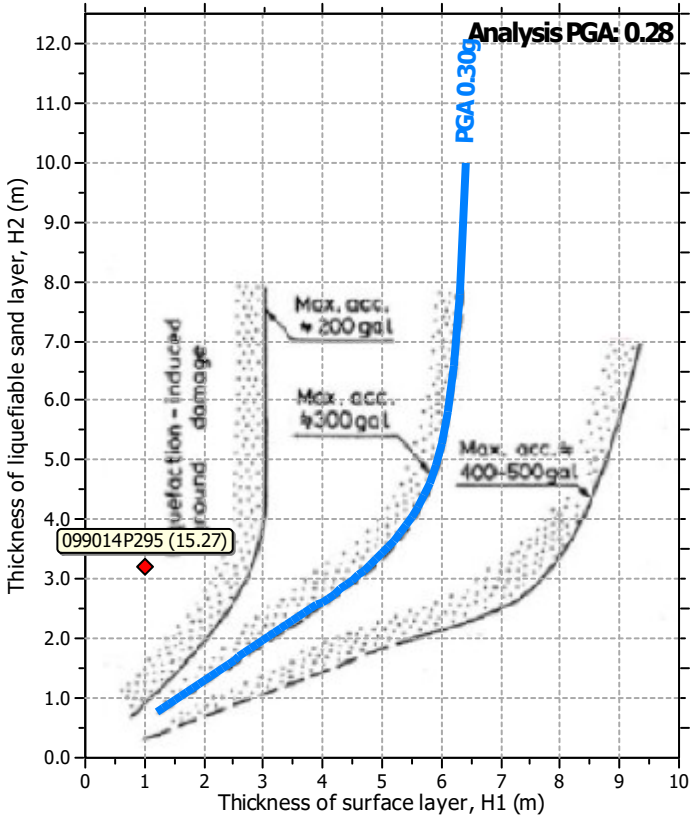
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	1	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

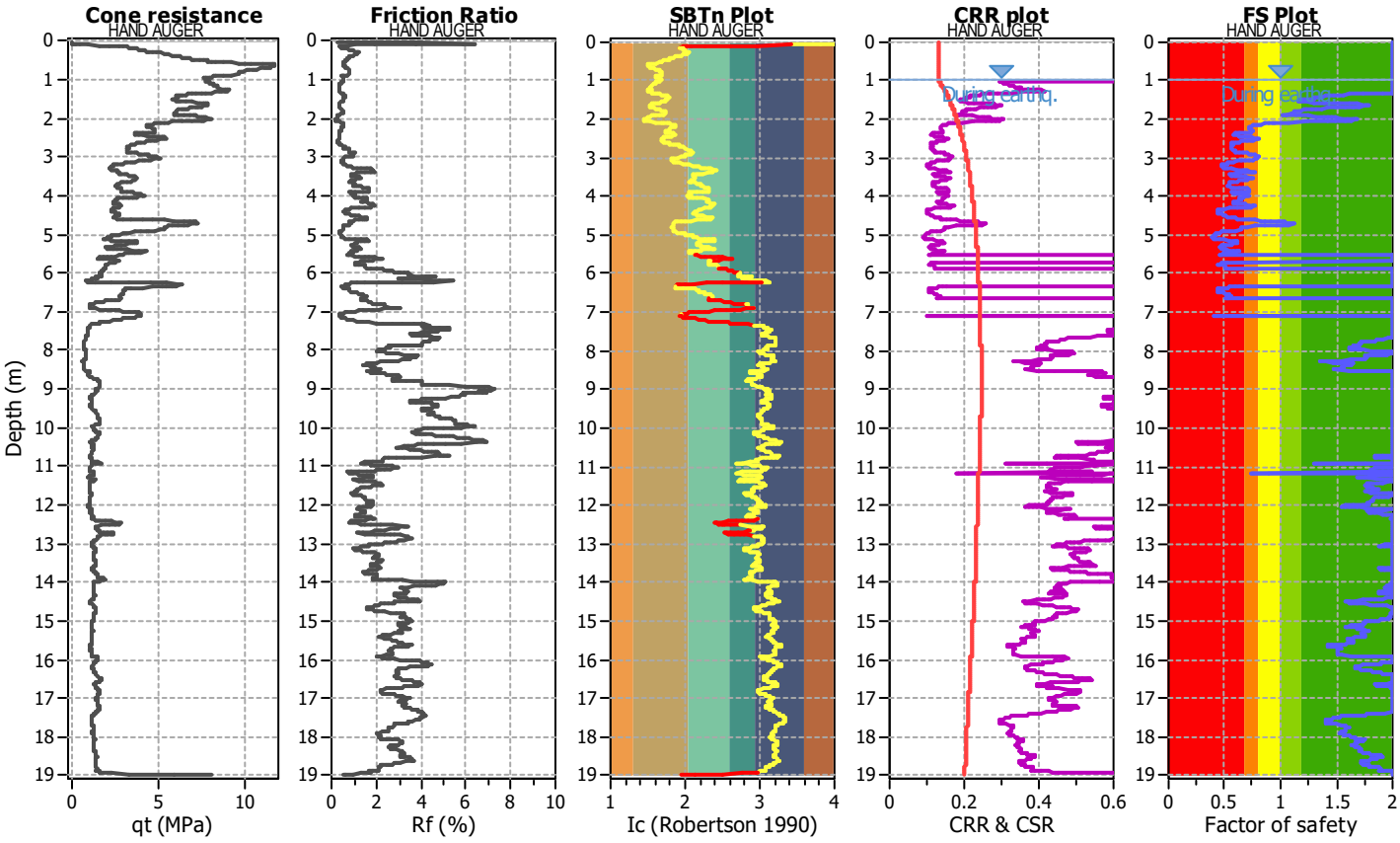
LIQUEFACTION ANALYSIS REPORT

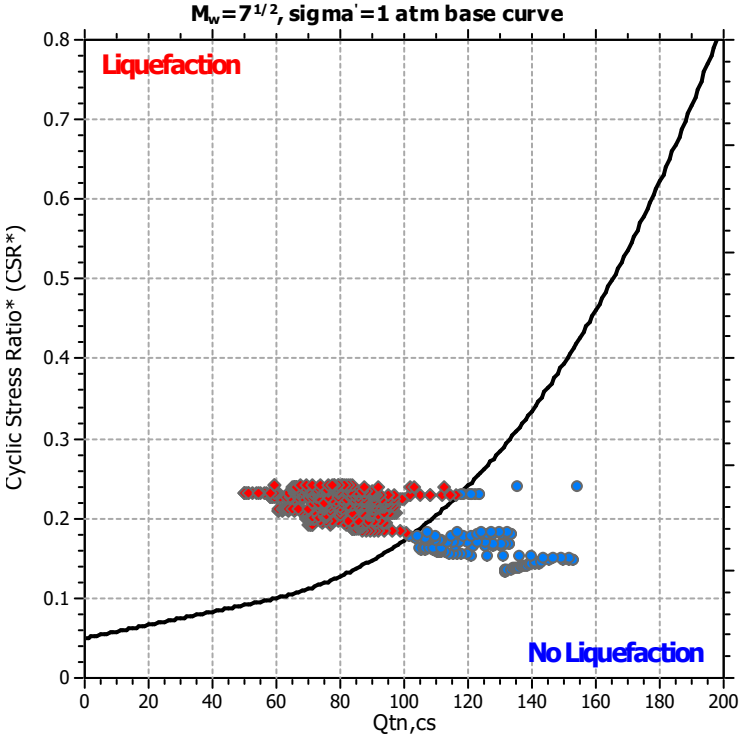
Project title : MS3 Rimini_RNN_04 **Location : Rimini**

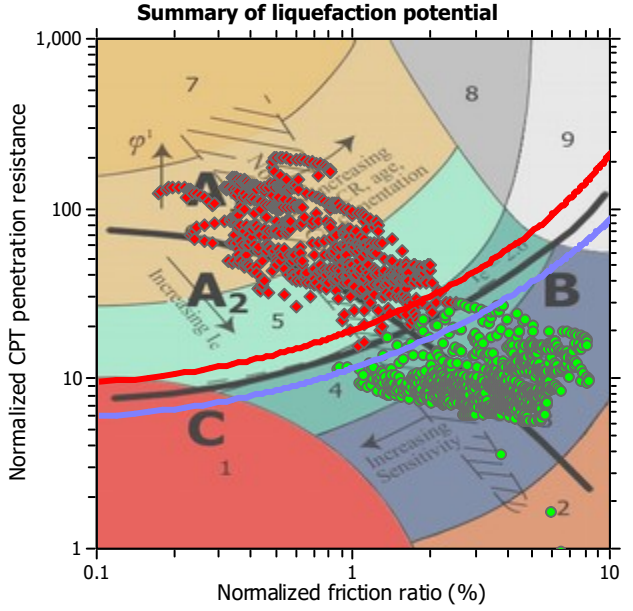
CPT file : 099014P1398

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.30 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

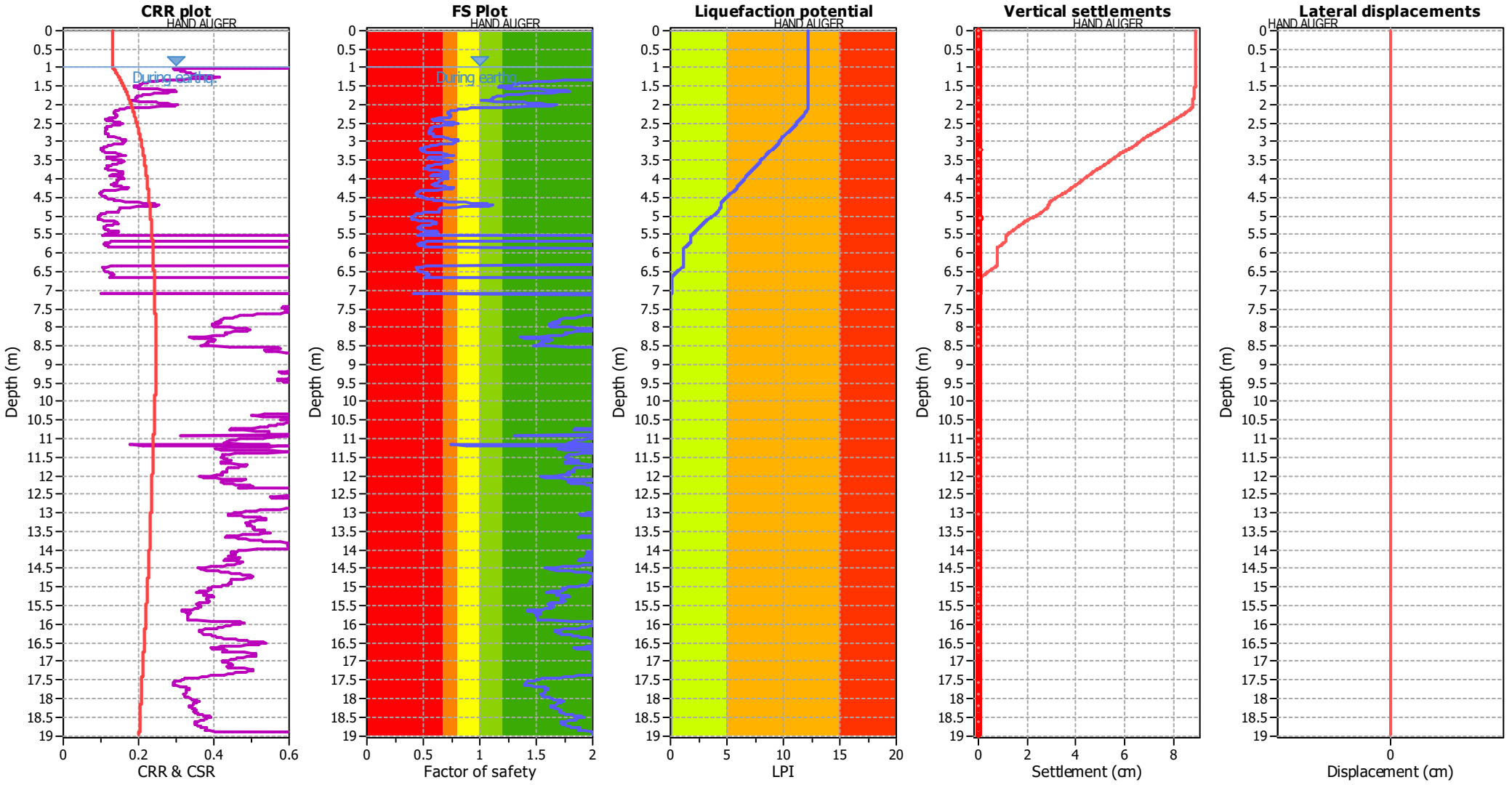






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.30 m	Fill height:	N/A	Limit depth:	N/A

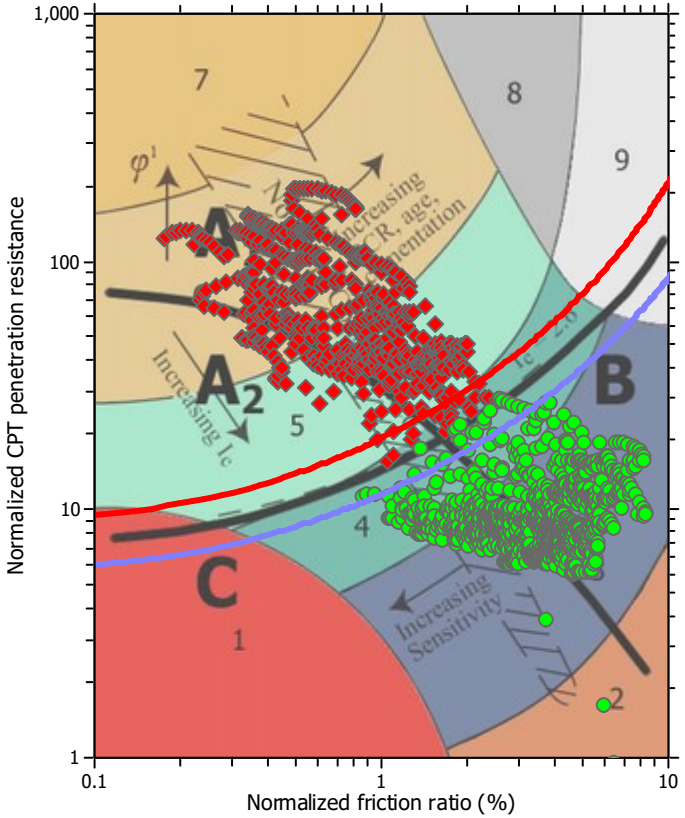
F.S. color scheme

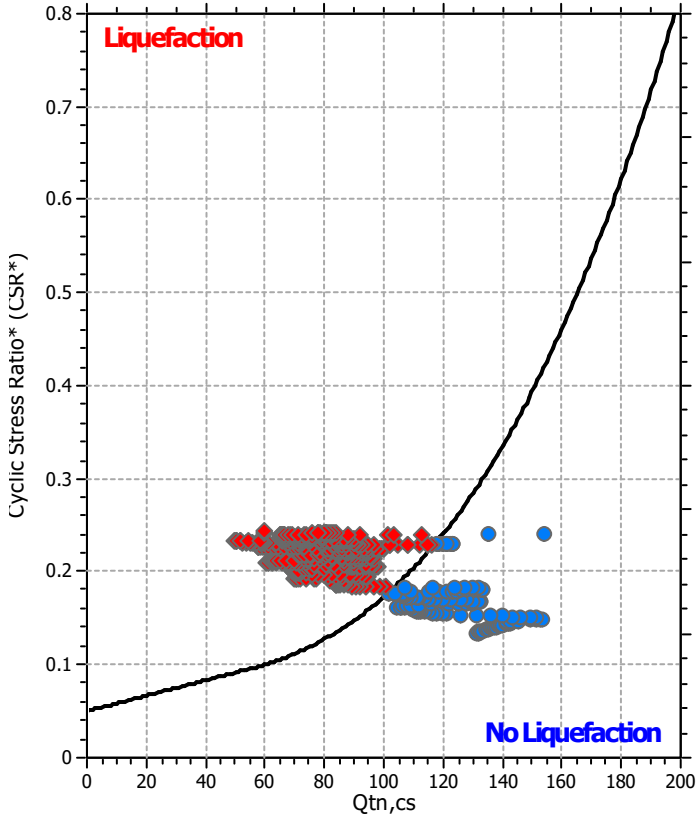
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

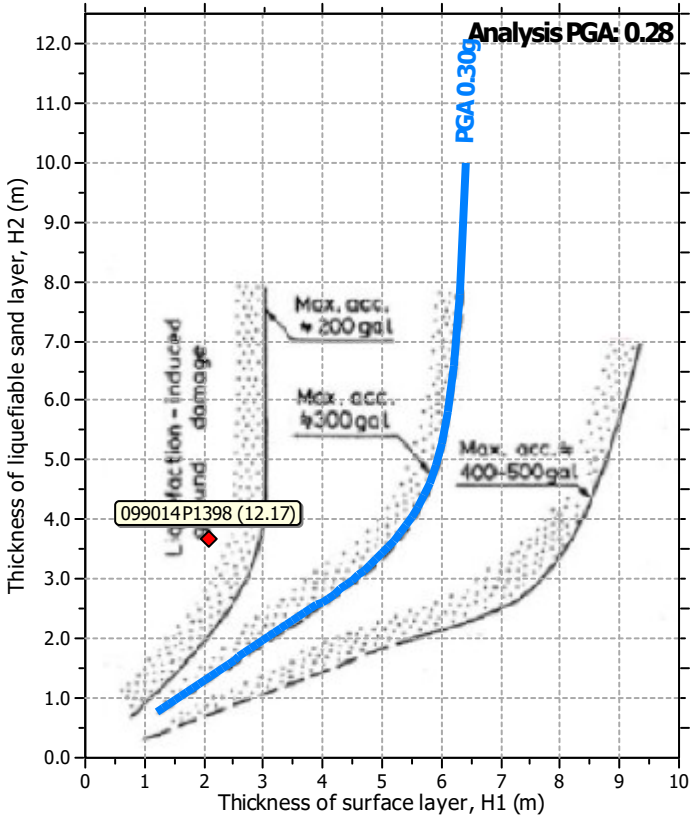
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.30 m	Fill height:	N/A	Limit depth:	N/A

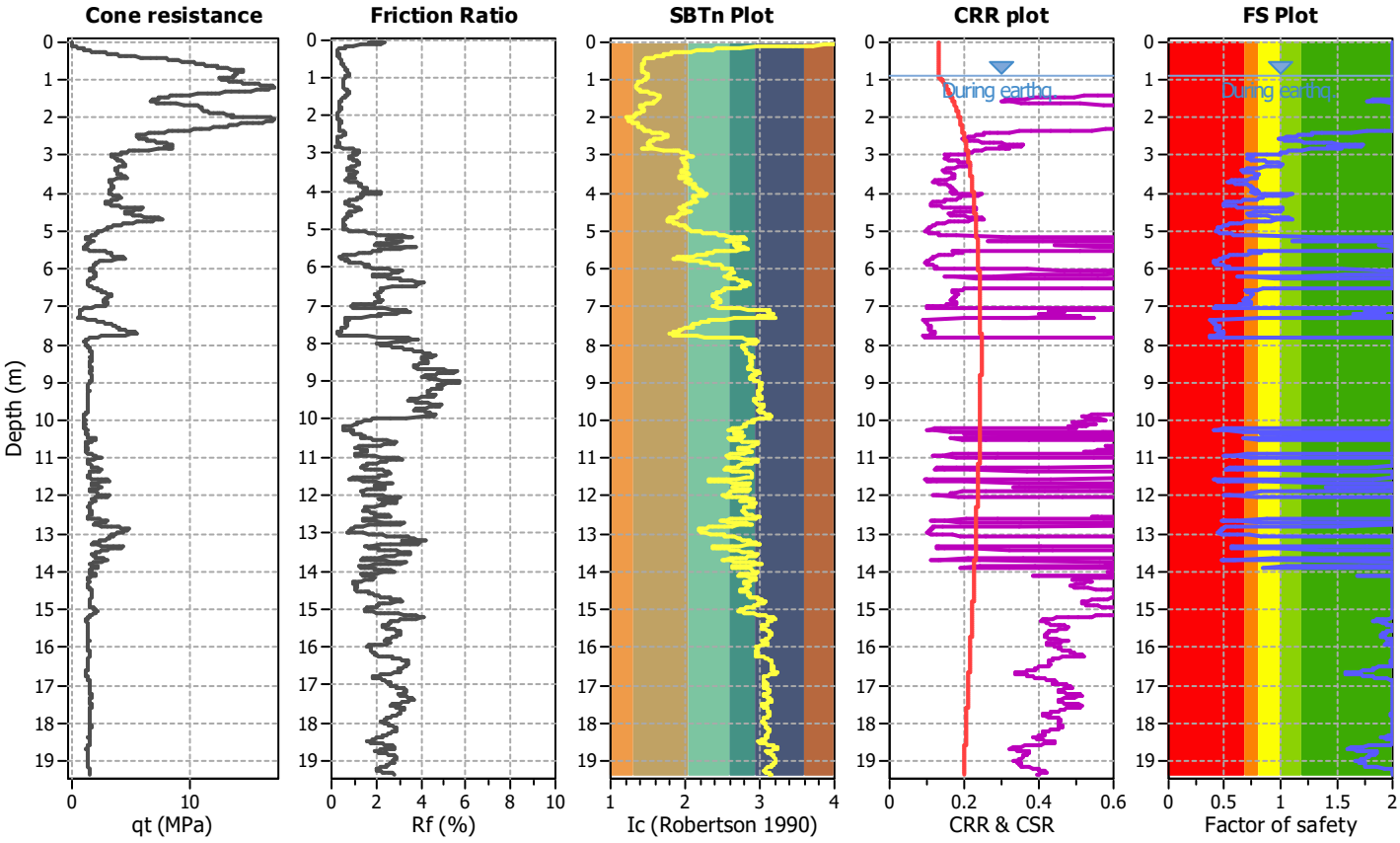
LIQUEFACTION ANALYSIS REPORT

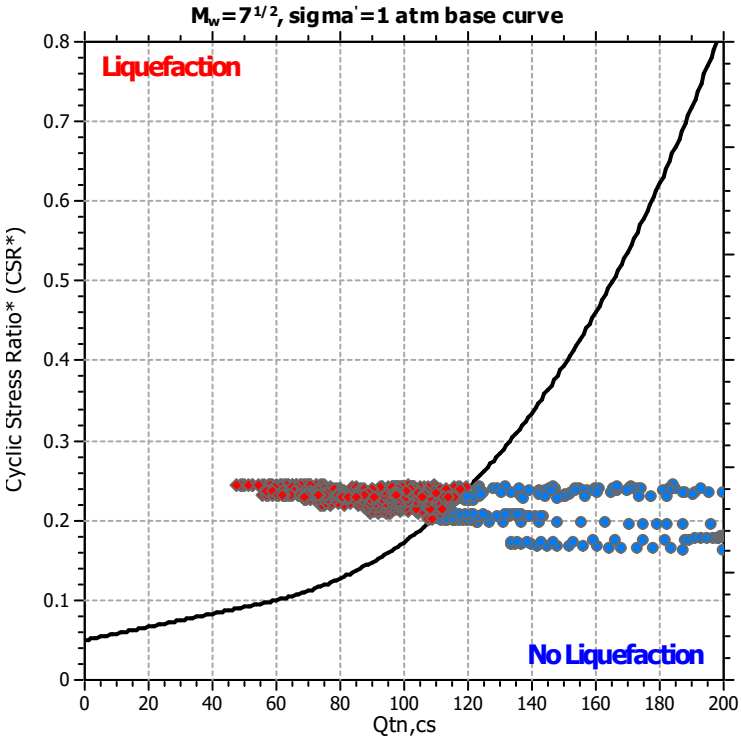
Project title : MS3 Rimini_RNN_04 **Location : Rimini**

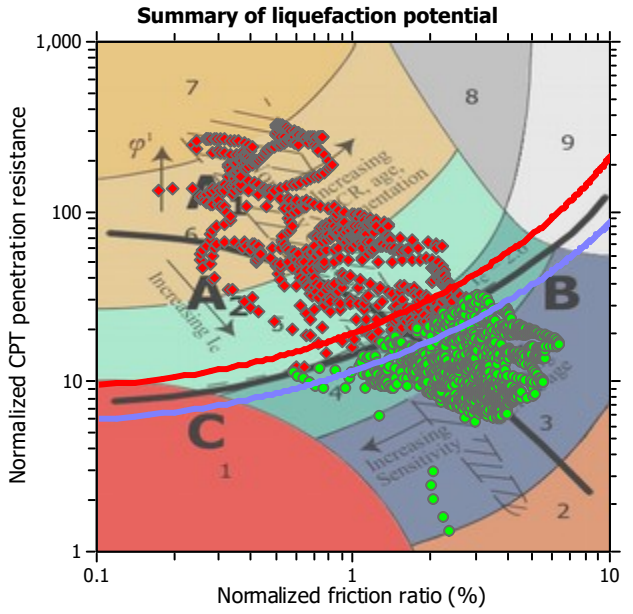
CPT file : 099014P1399

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.90 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

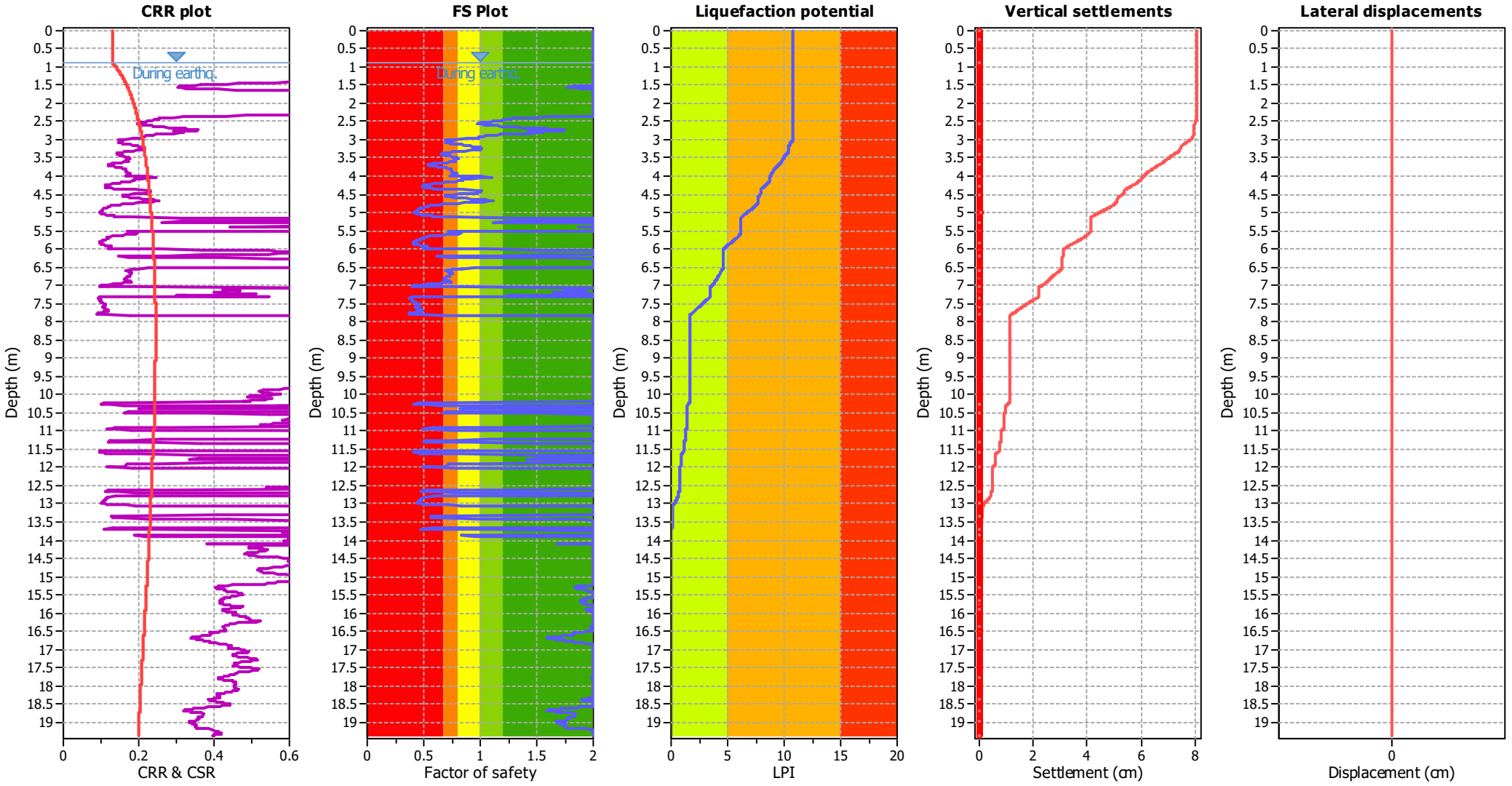






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.90 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

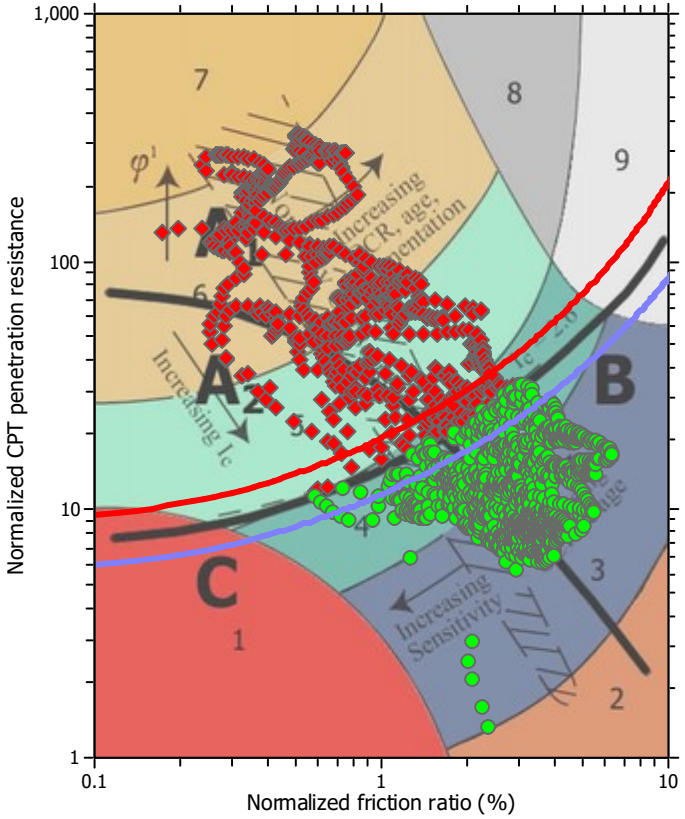
F.S. color scheme

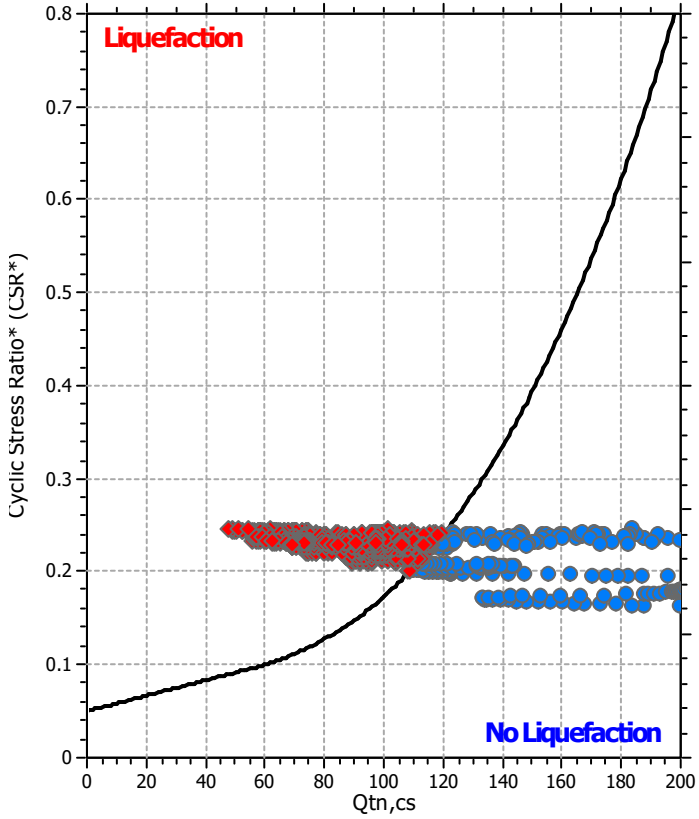
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

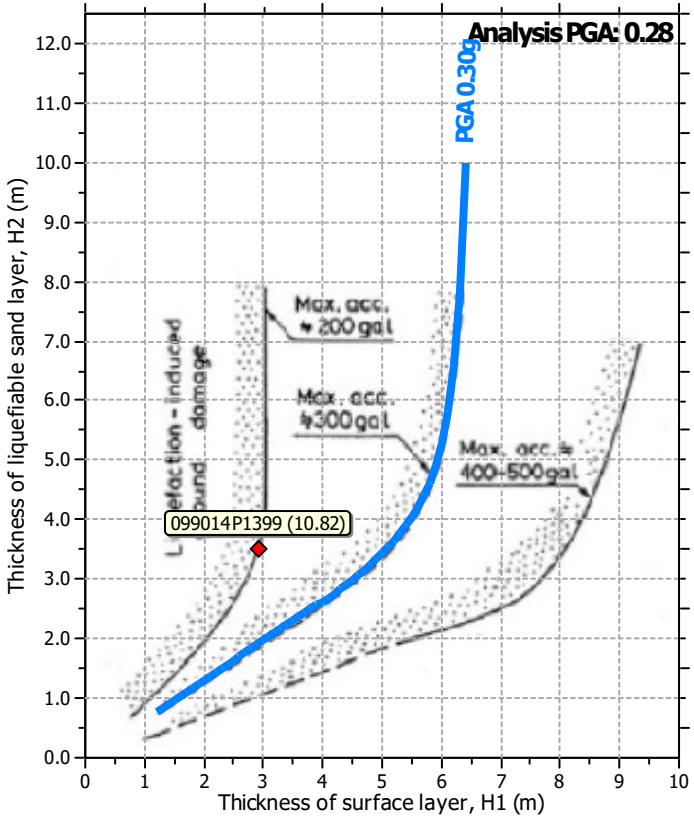
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.90 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

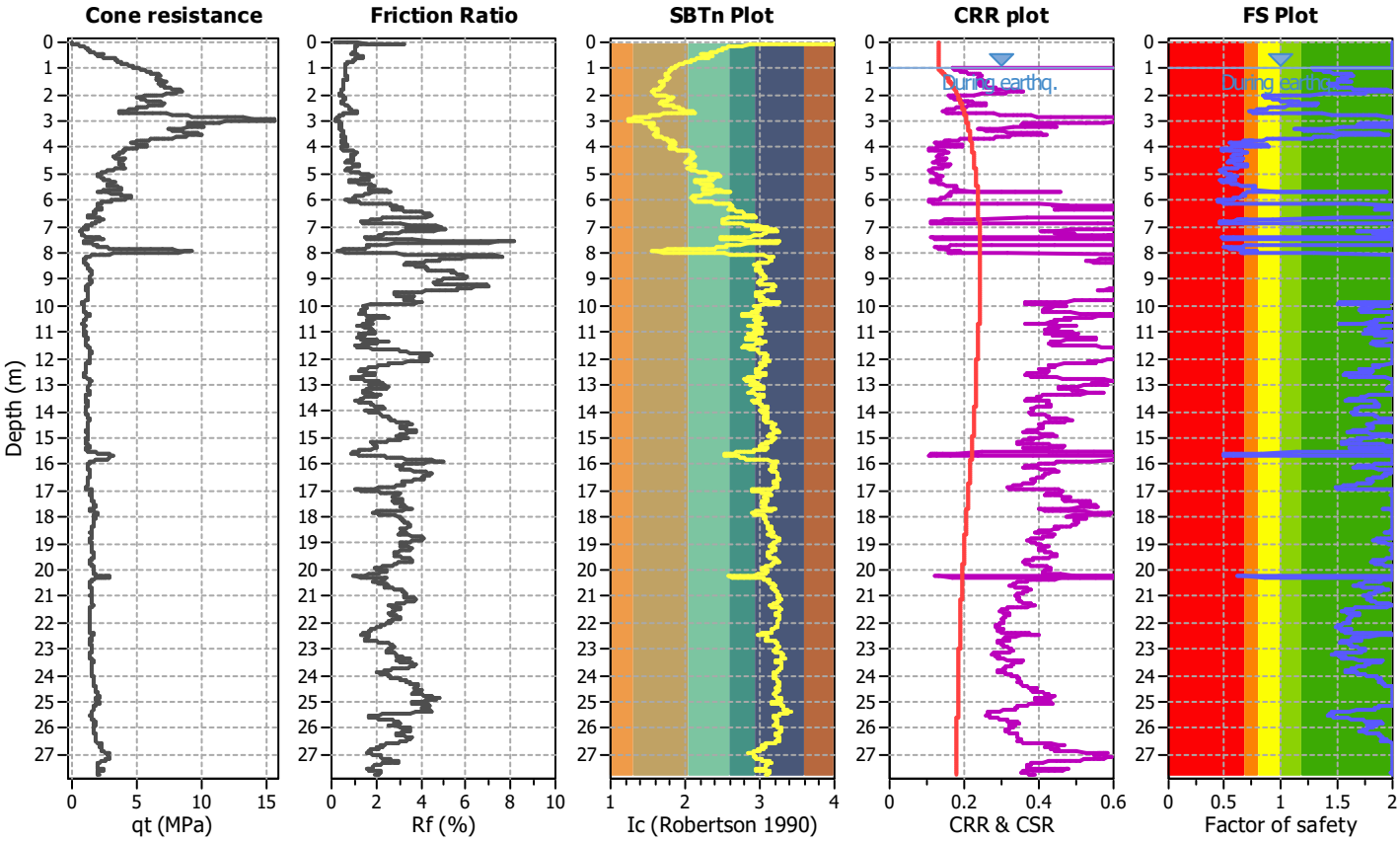
LIQUEFACTION ANALYSIS REPORT

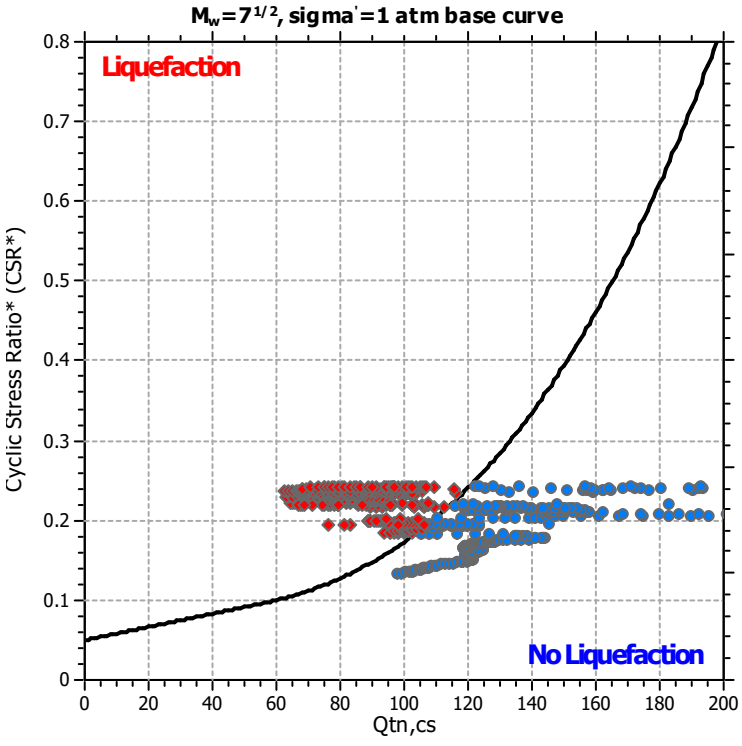
Project title : MS3 Rimini_RNN_04 **Location : Rimini**

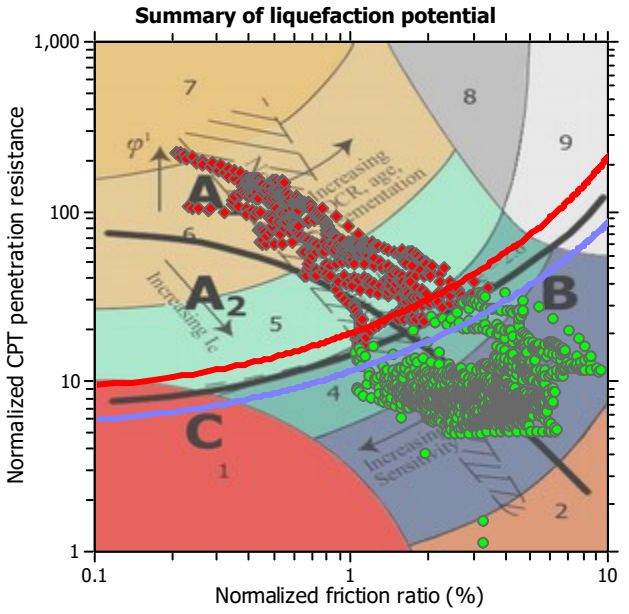
CPT file : 099014P1402

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.20 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

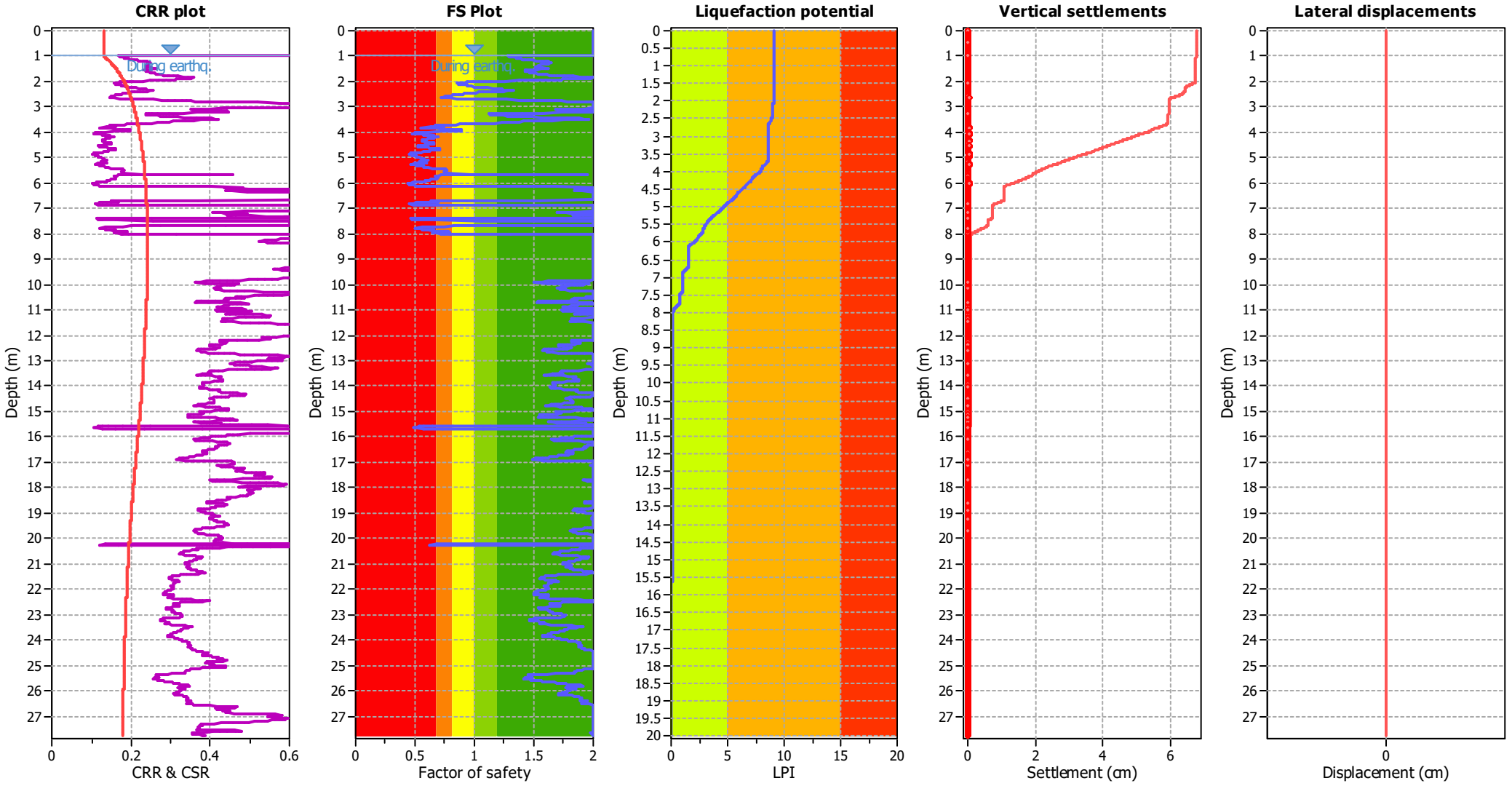






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	N/A

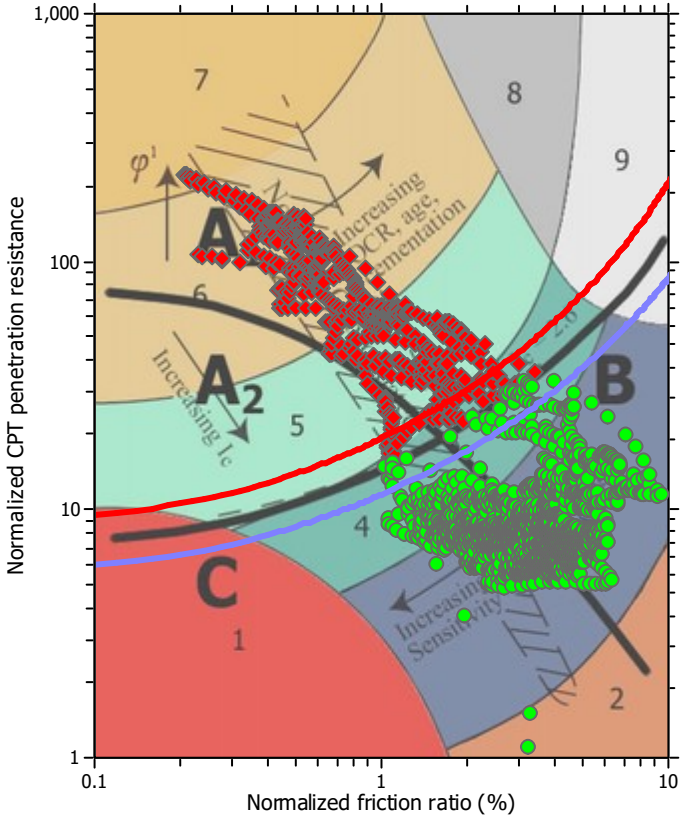
F.S. color scheme

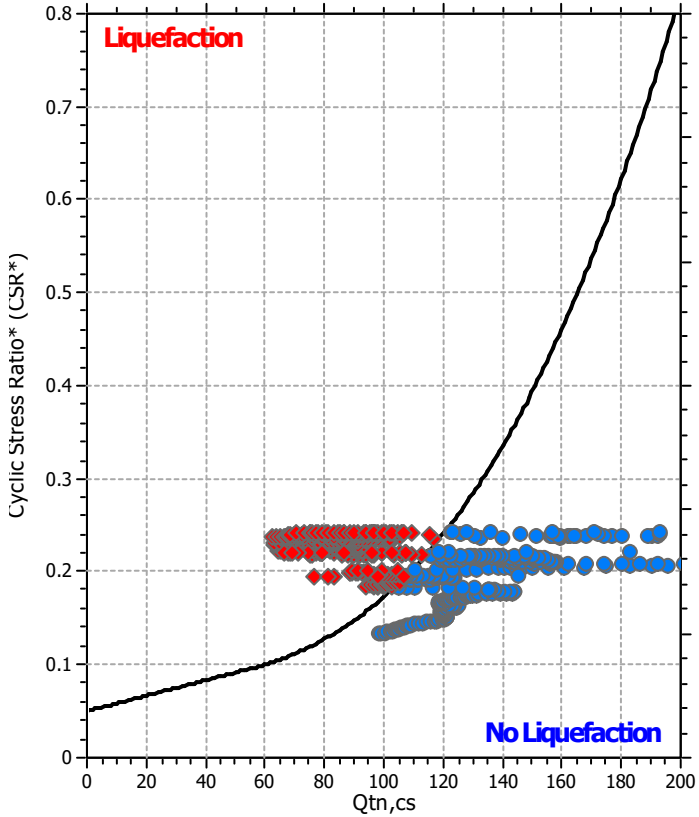
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

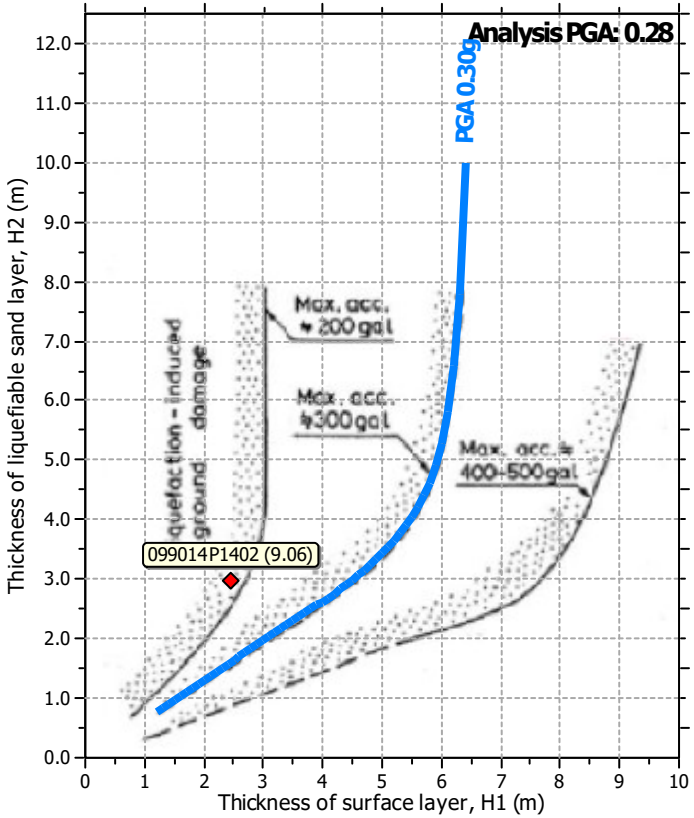
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	N/A

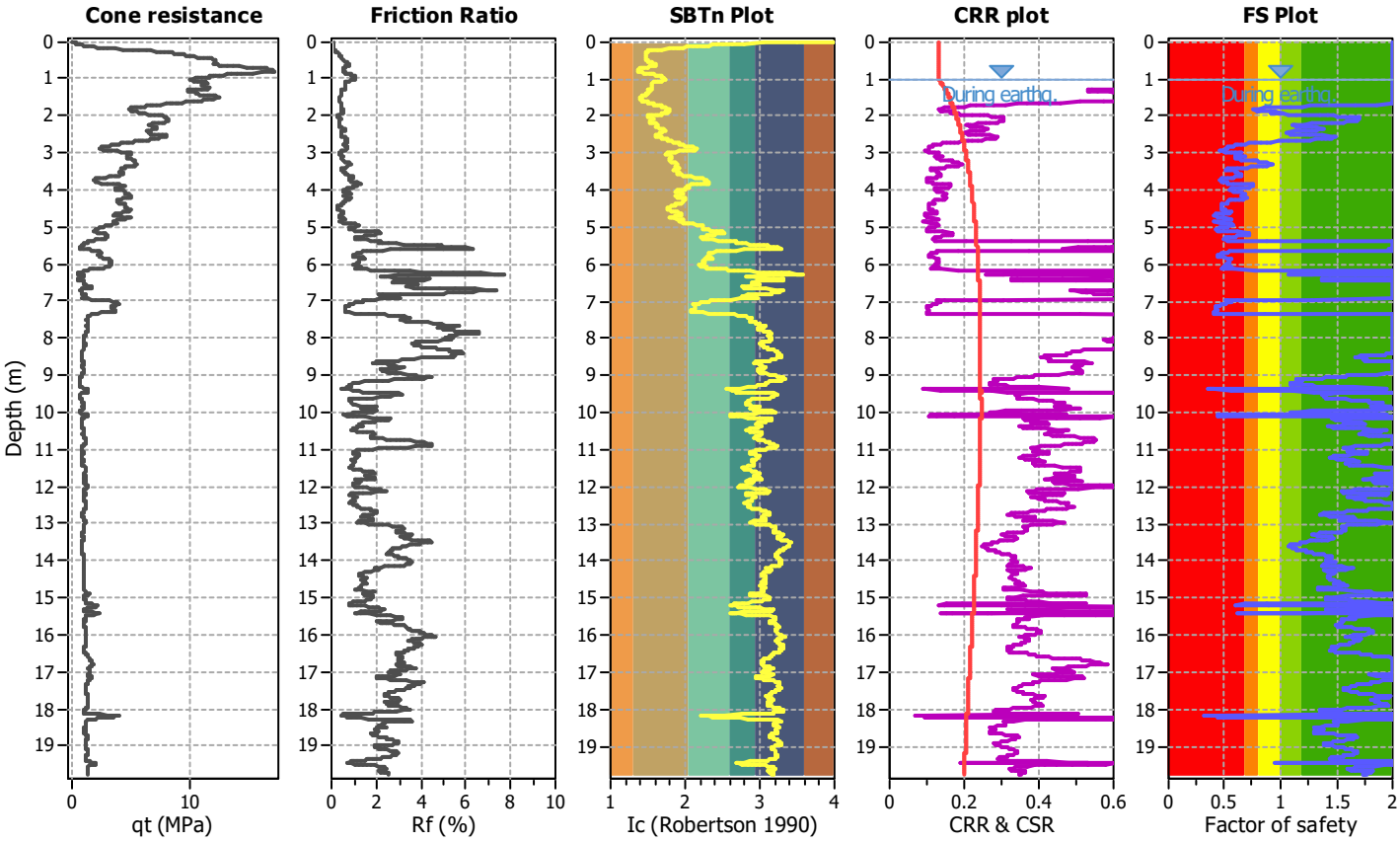
LIQUEFACTION ANALYSIS REPORT

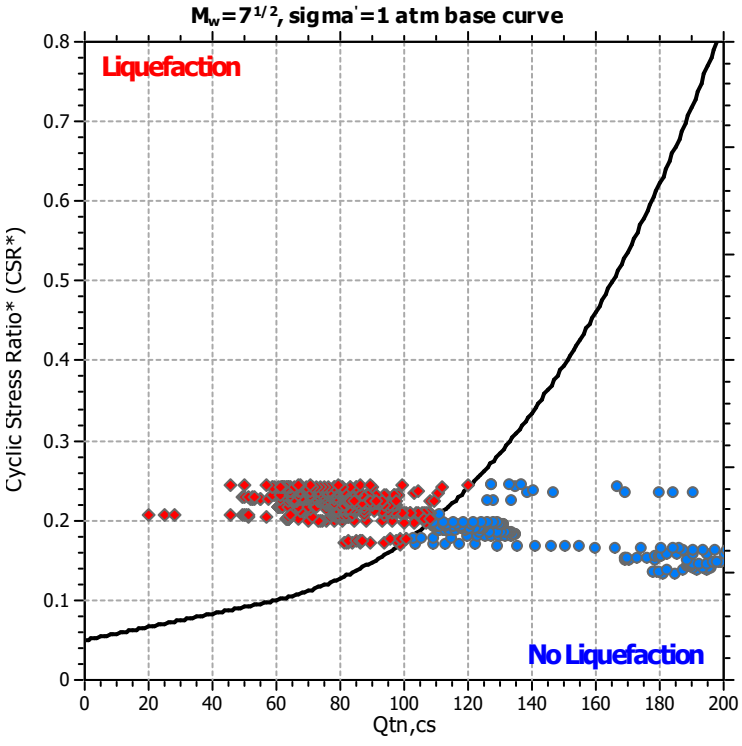
Project title : MS3 Rimini_RNN_04 **Location : Rimini**

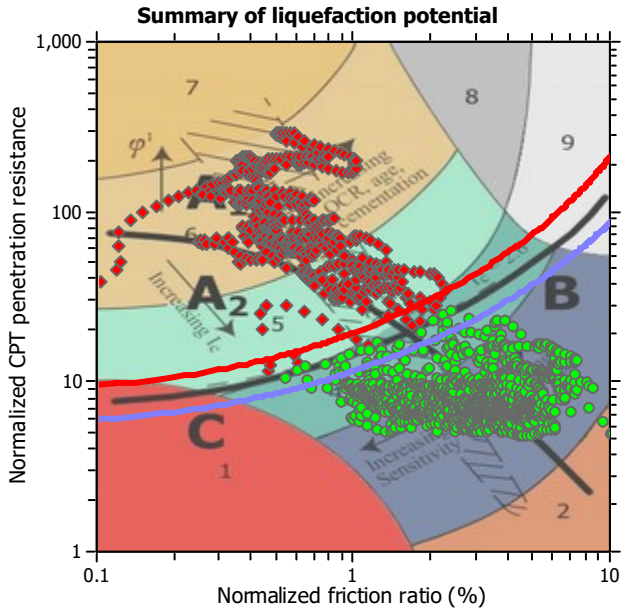
CPT file : CPTe_01

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.60 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

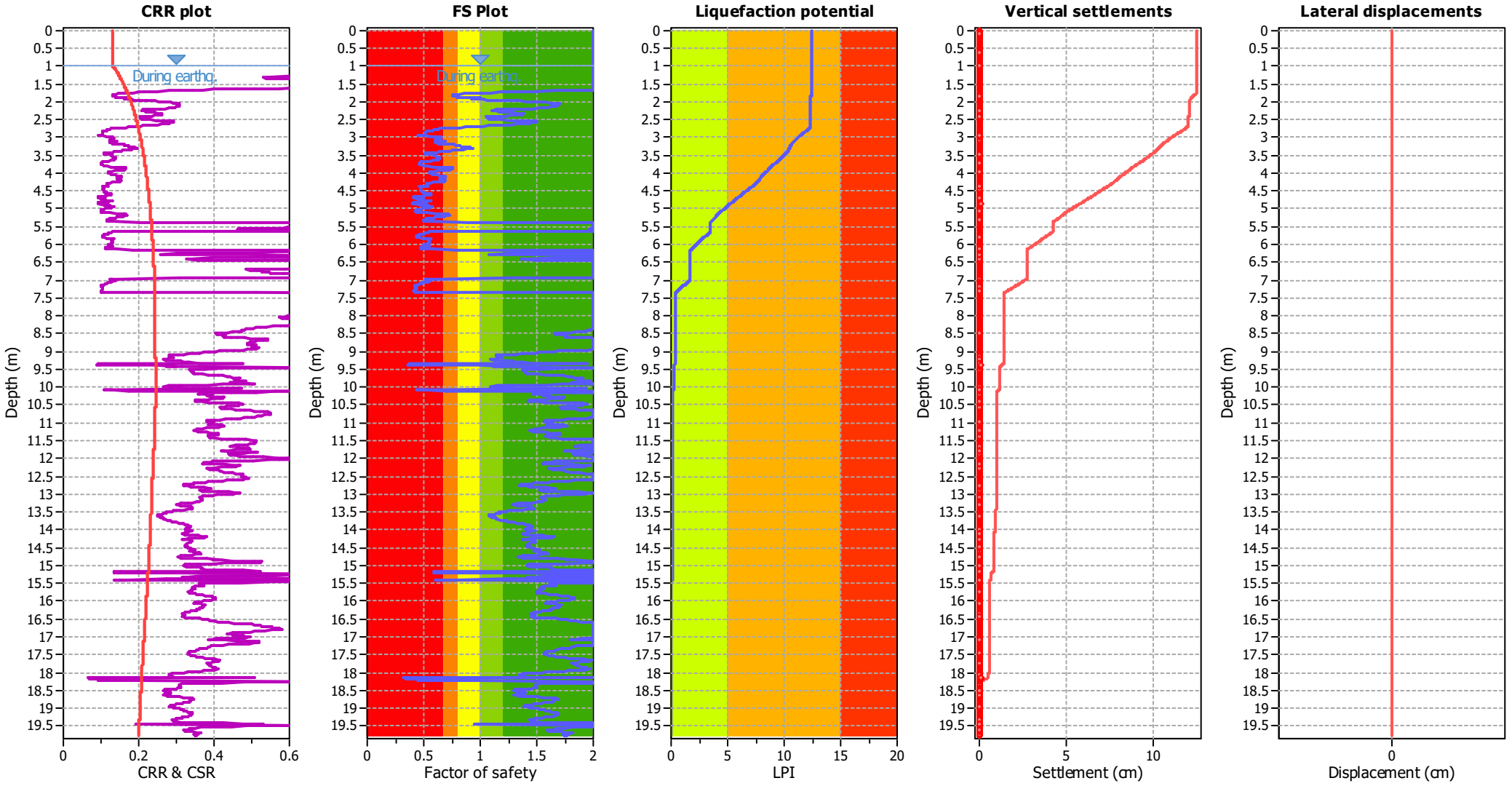






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.60 m	Fill height:	N/A	Limit depth:	20.00 m

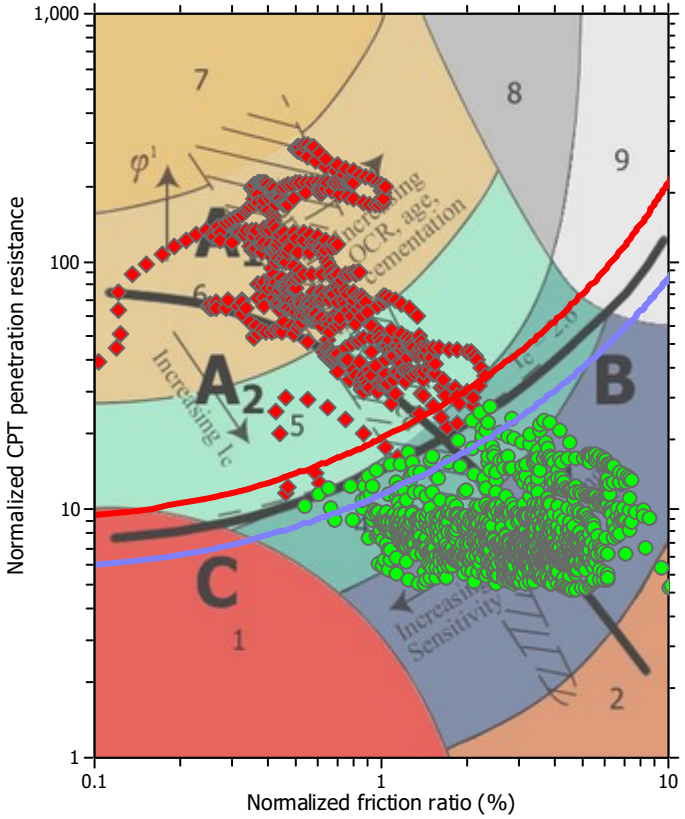
F.S. color scheme

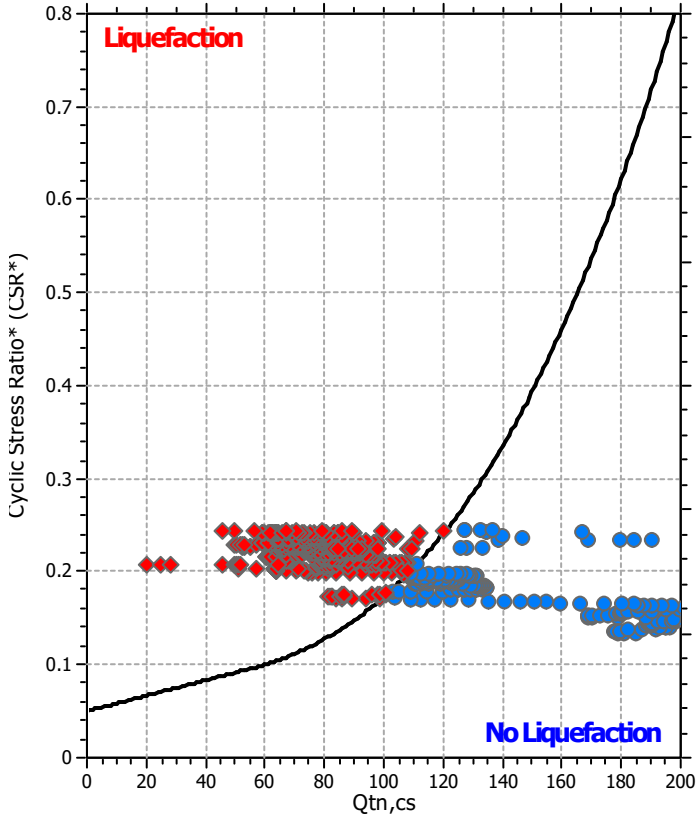
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

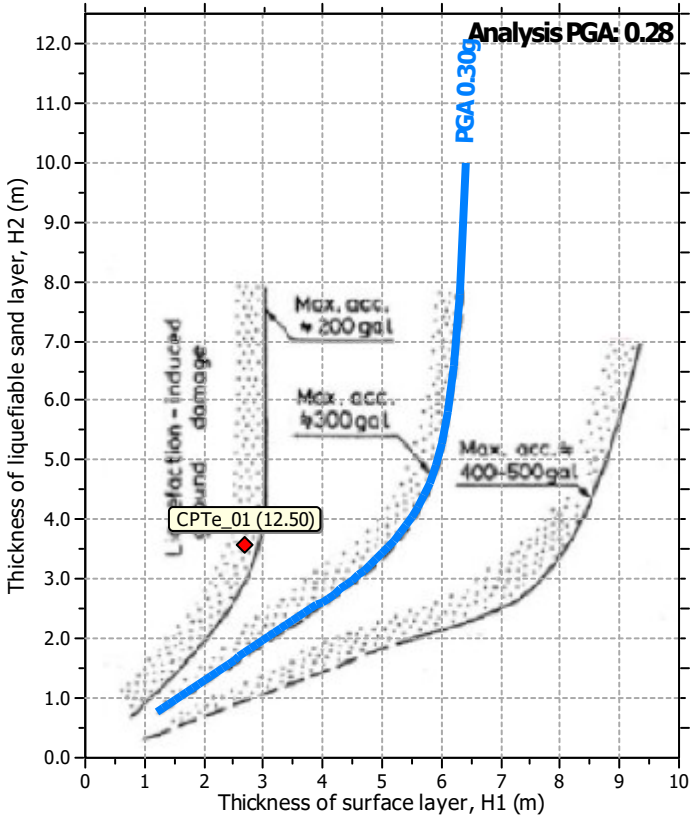
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.60 m	Fill height:	N/A	Limit depth:	20.00 m

REPORT - ZONA RNN_03

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

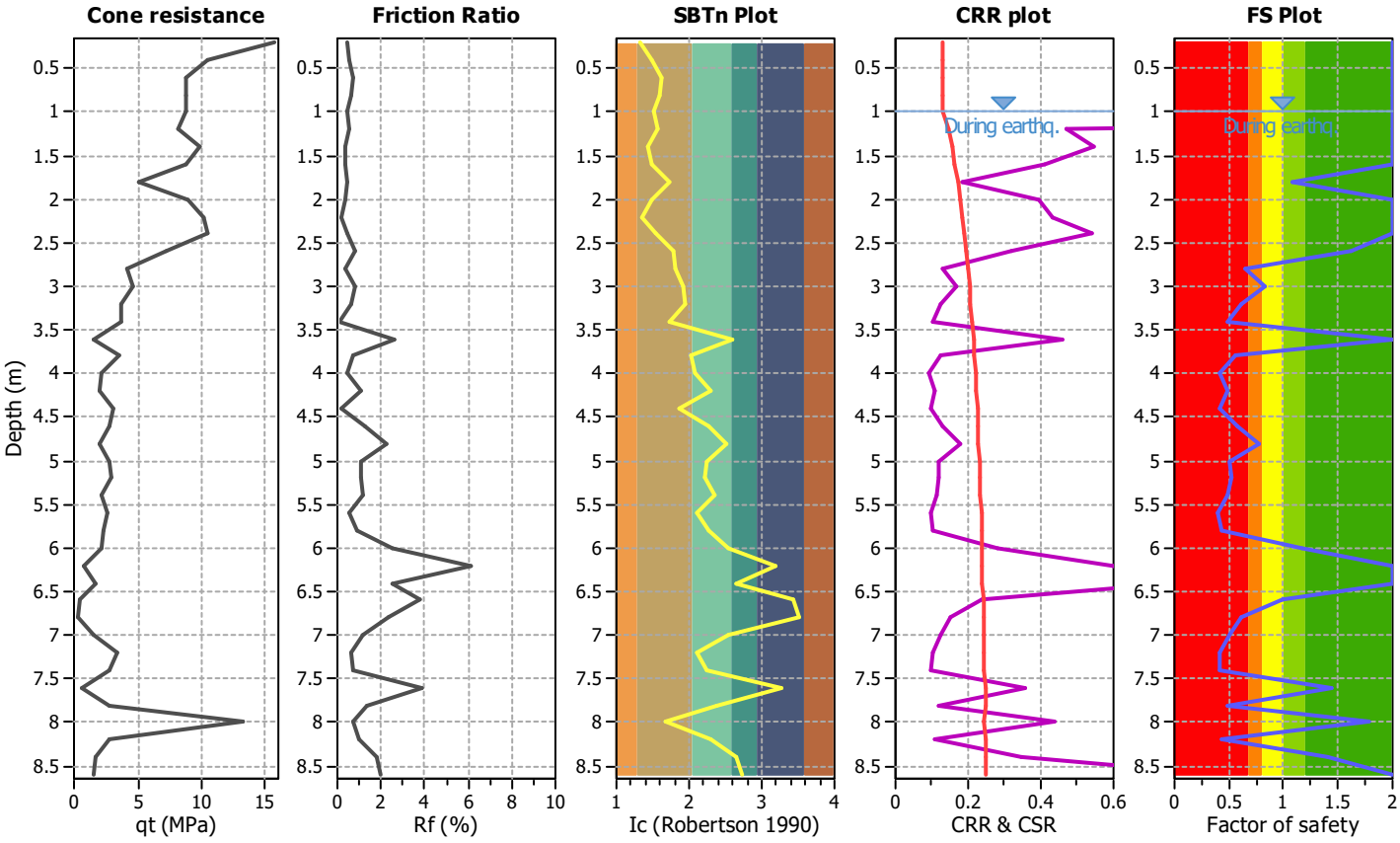
LIQUEFACTION ANALYSIS REPORT

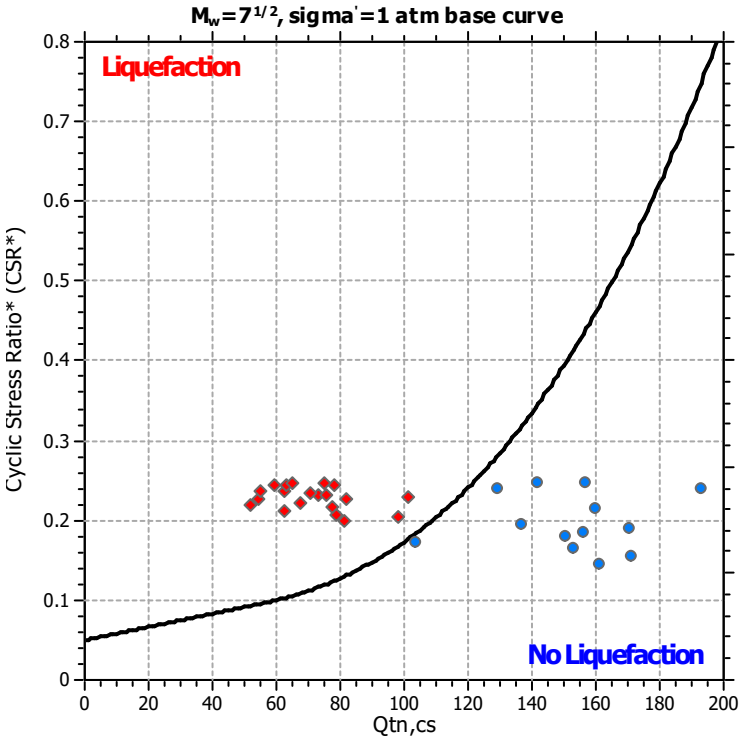
Project title : MS3 Rimini_RNN_03 **Location : Rimini**

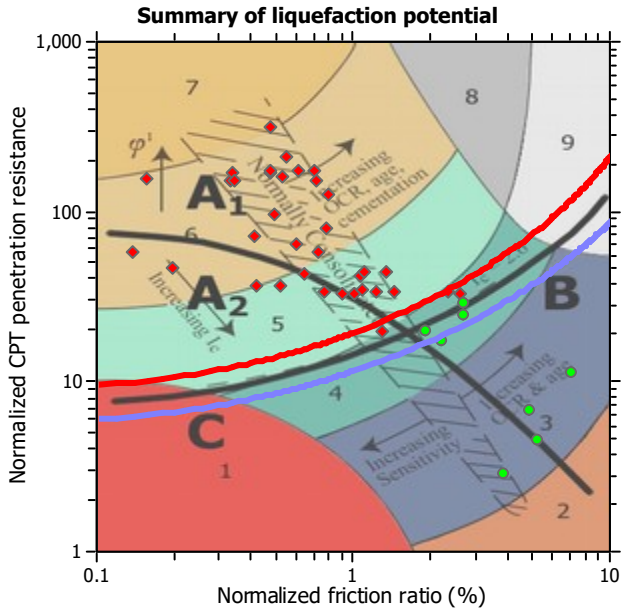
CPT file : 099014P1242

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.40 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	1	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

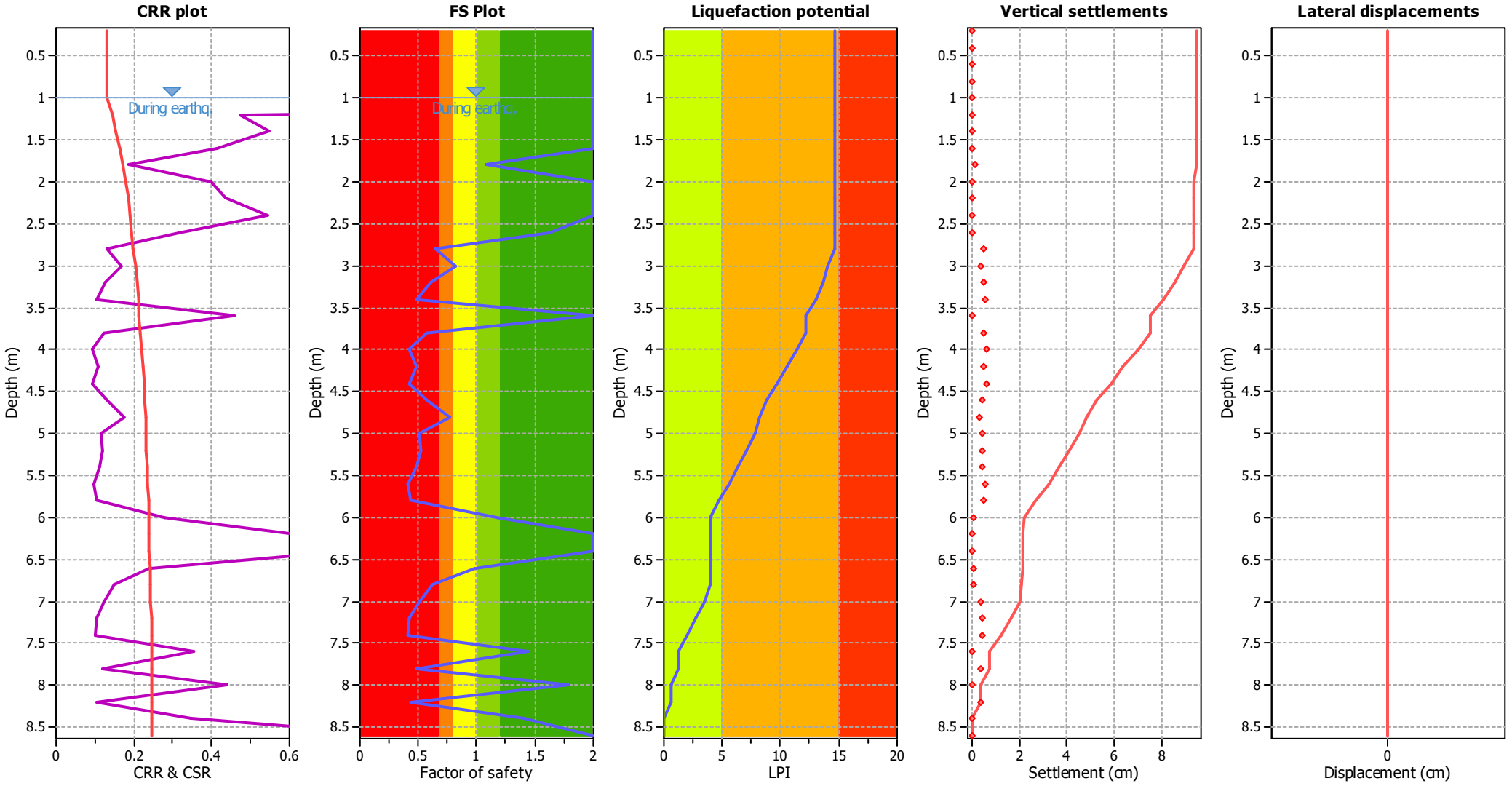






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	1	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.40 m	Fill height:	N/A	Limit depth:	N/A

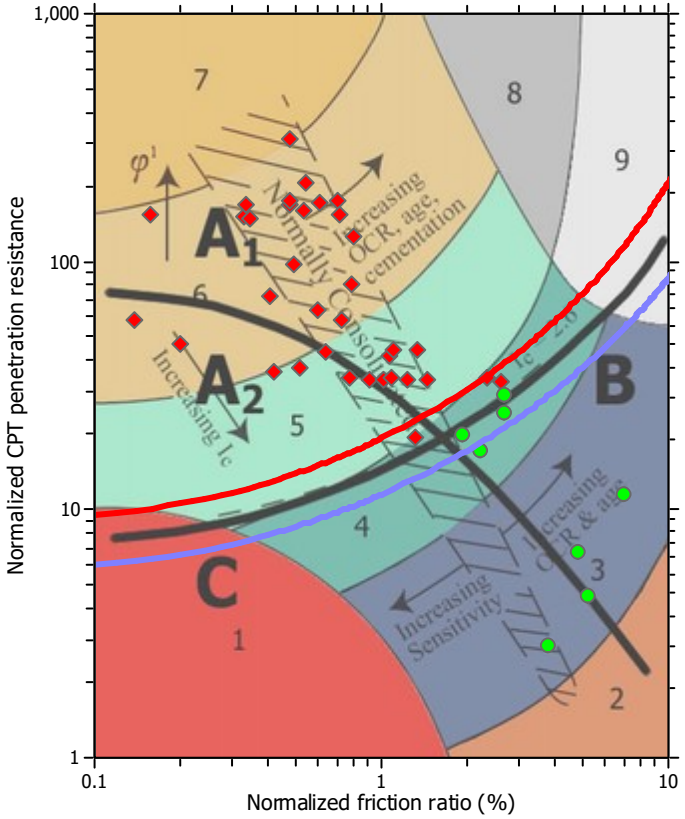
F.S. color scheme

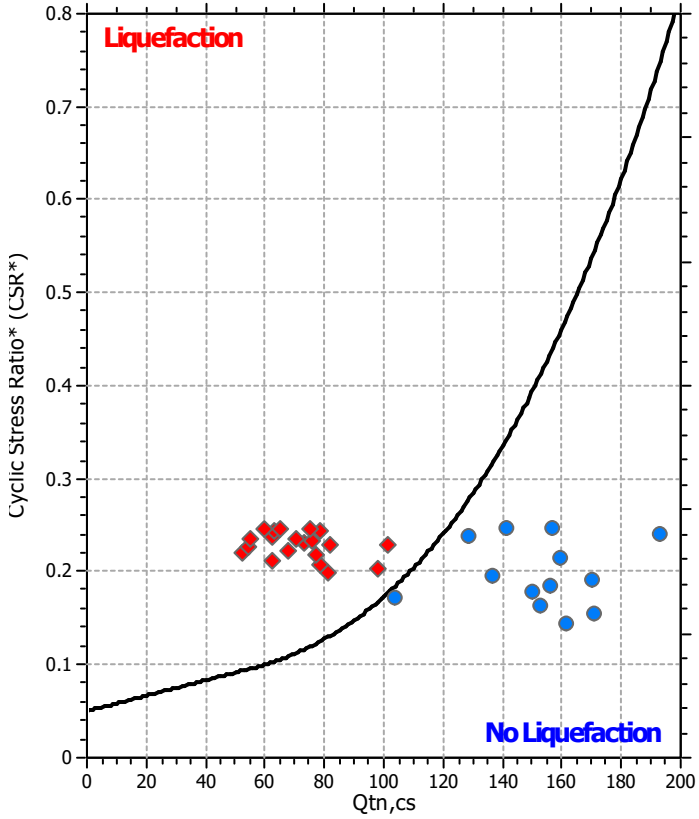
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

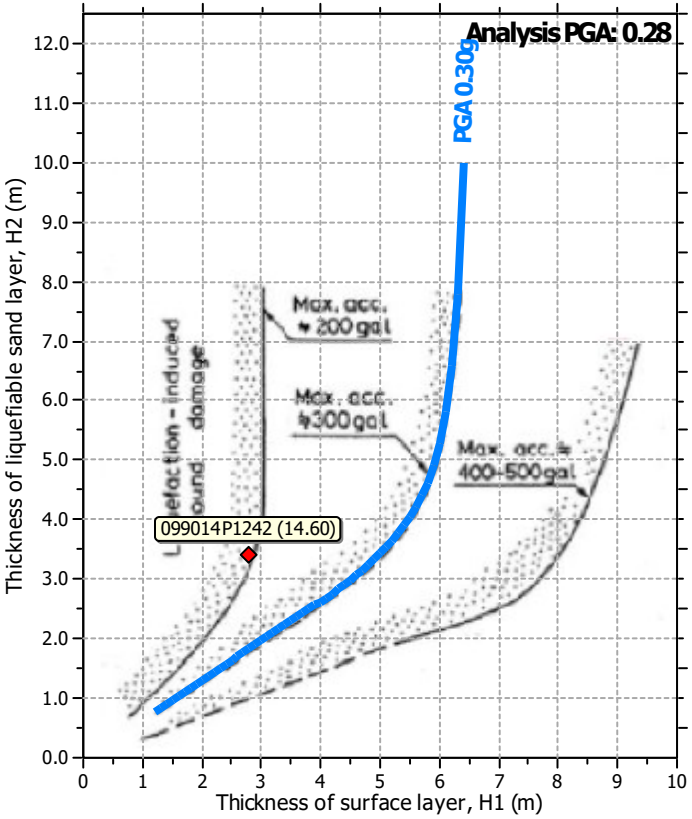
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	1	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.40 m	Fill height:	N/A	Limit depth:	N/A

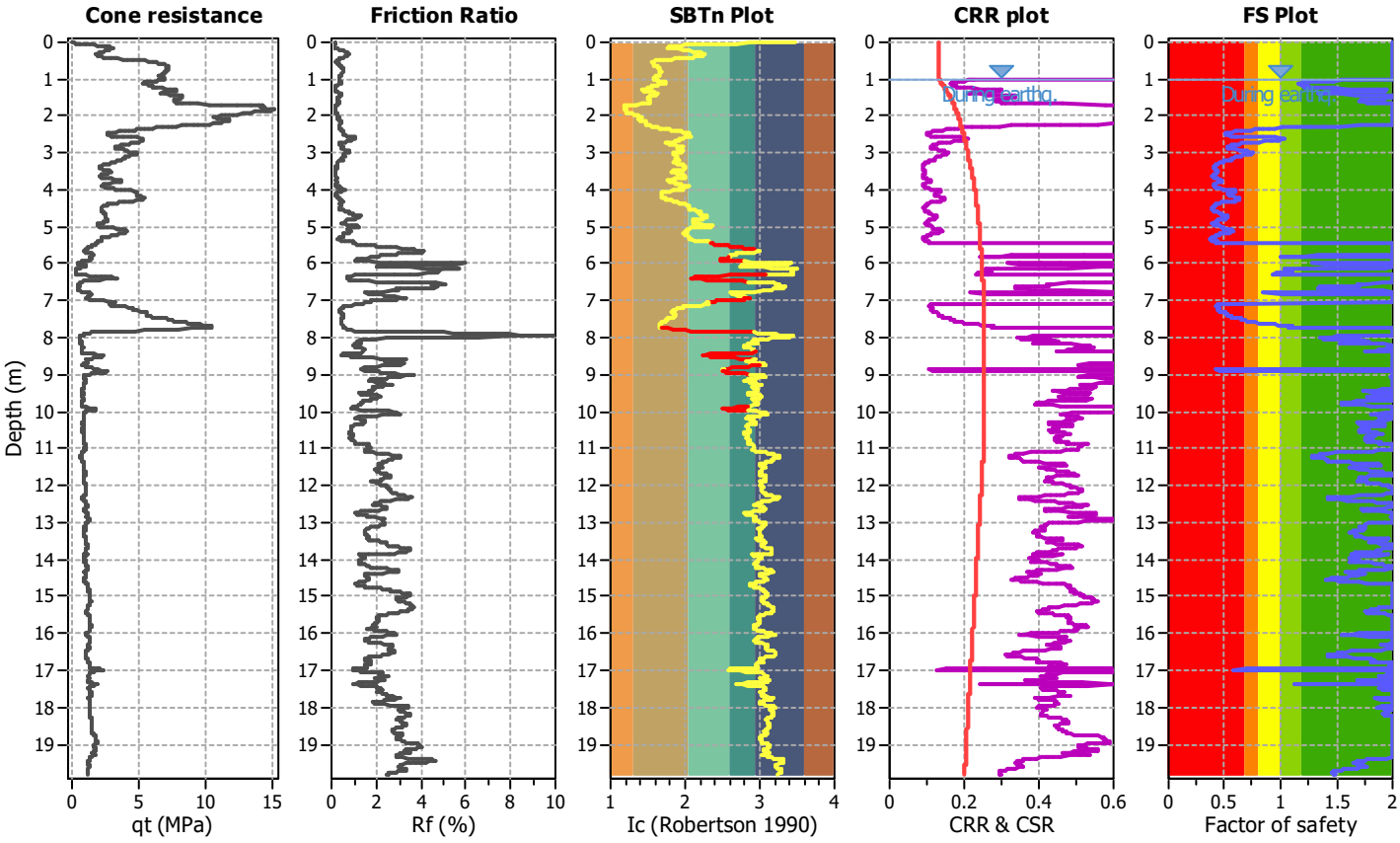
LIQUEFACTION ANALYSIS REPORT

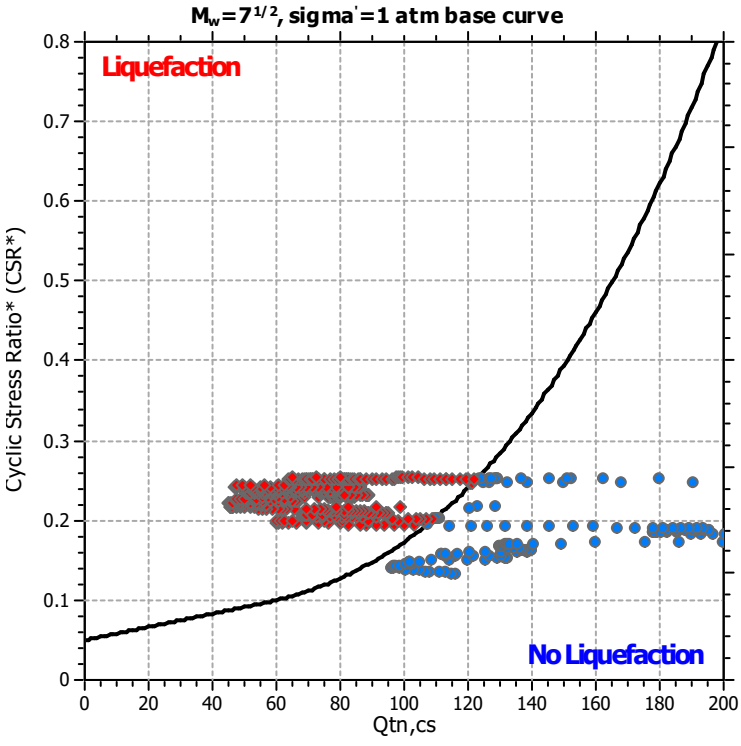
Project title : MS3 Rimini_RNN_03 **Location : Rimini**

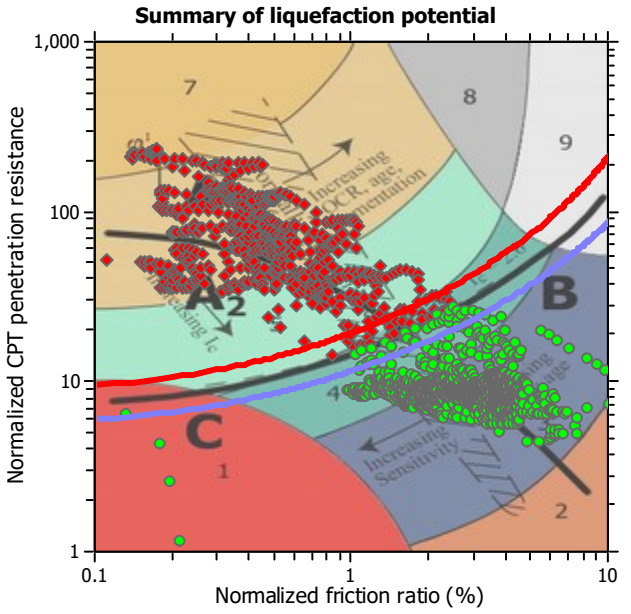
CPT file : CPTe_02

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.30 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

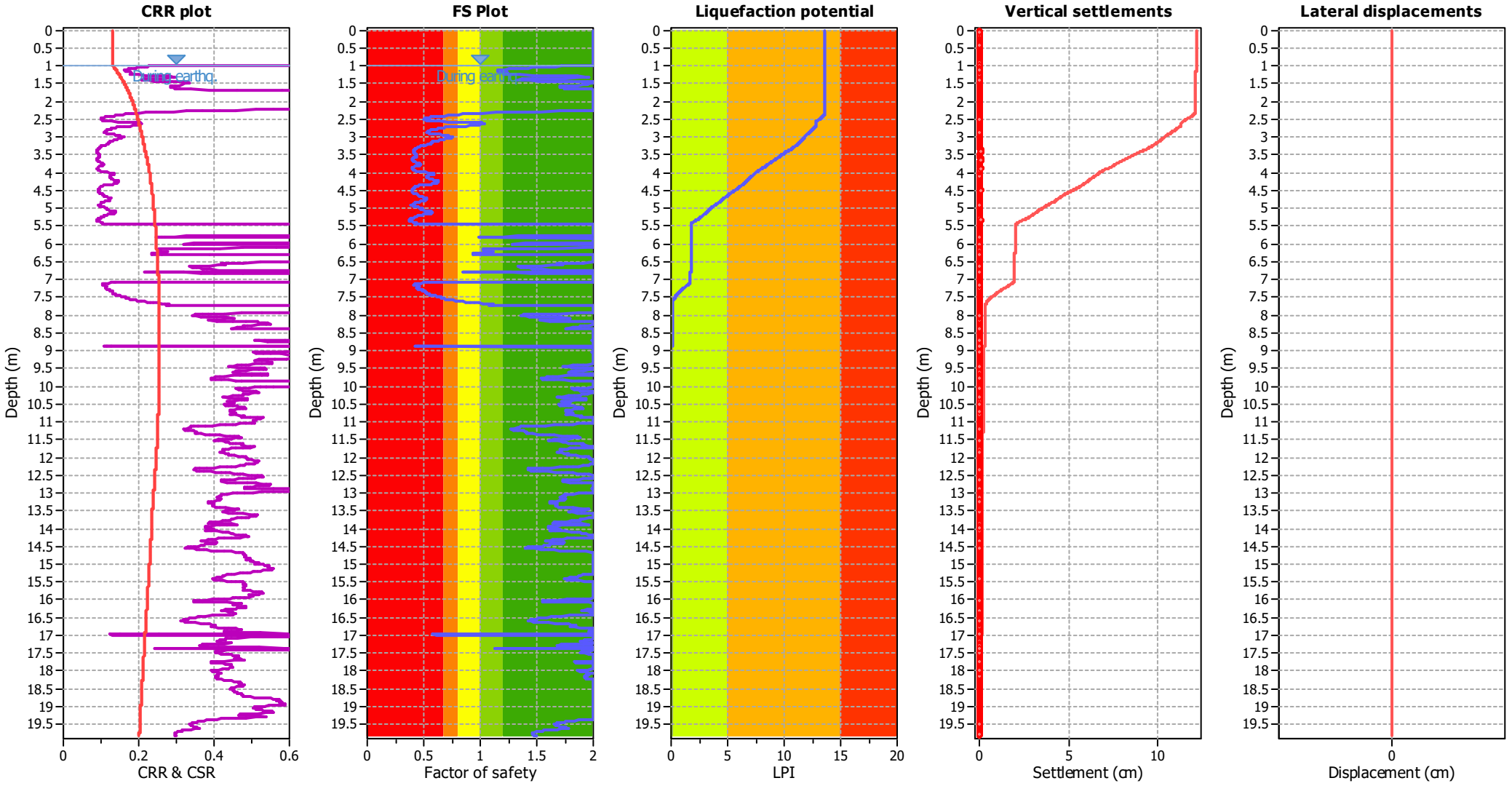






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.30 m	Fill height:	N/A	Limit depth:	N/A

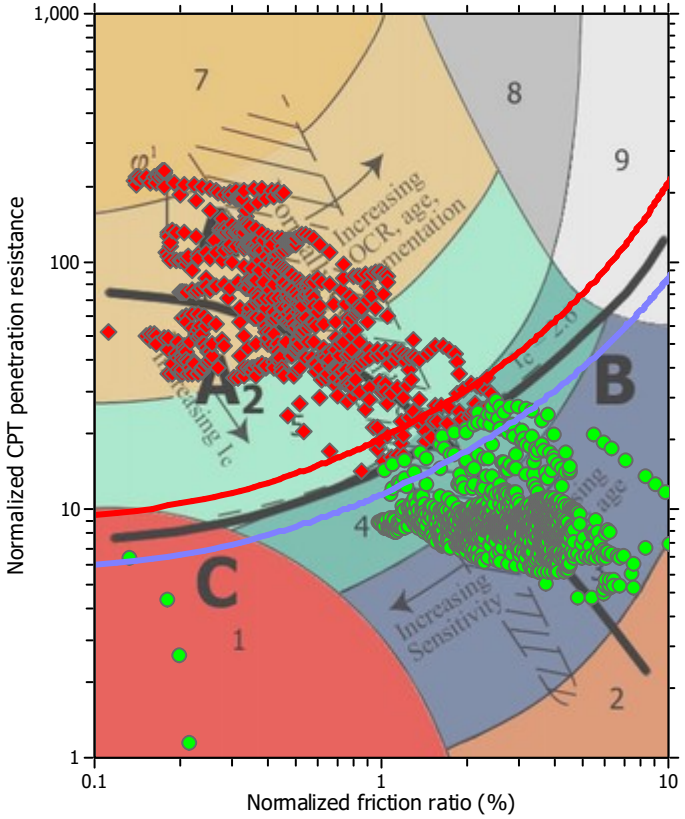
F.S. color scheme

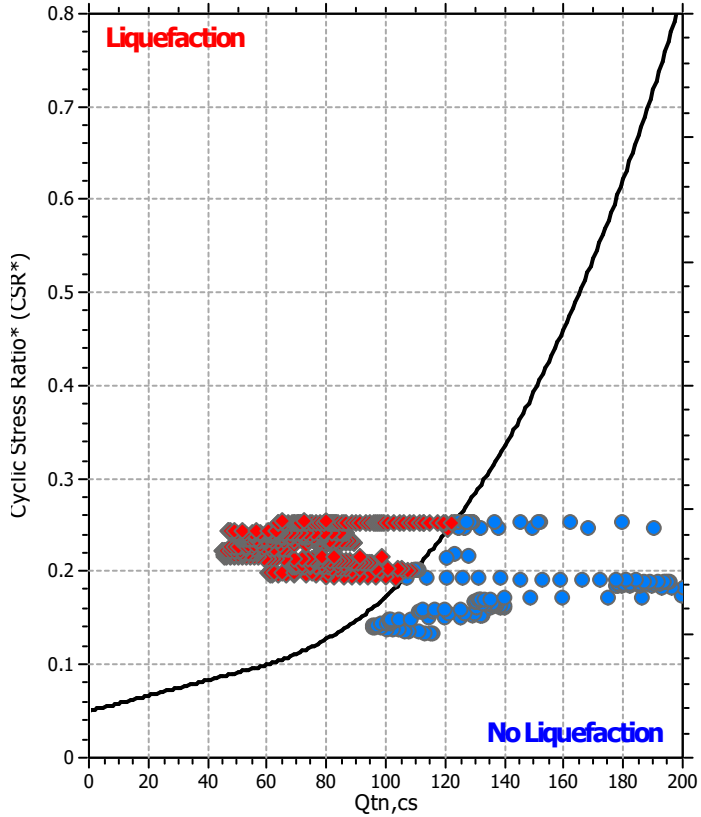
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

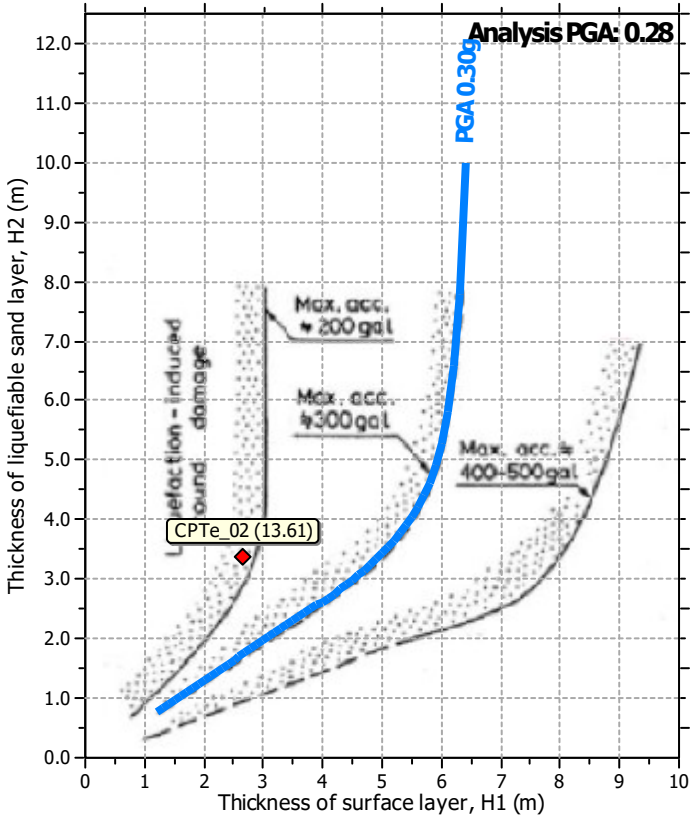
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.30 m	Fill height:	N/A	Limit depth:	N/A

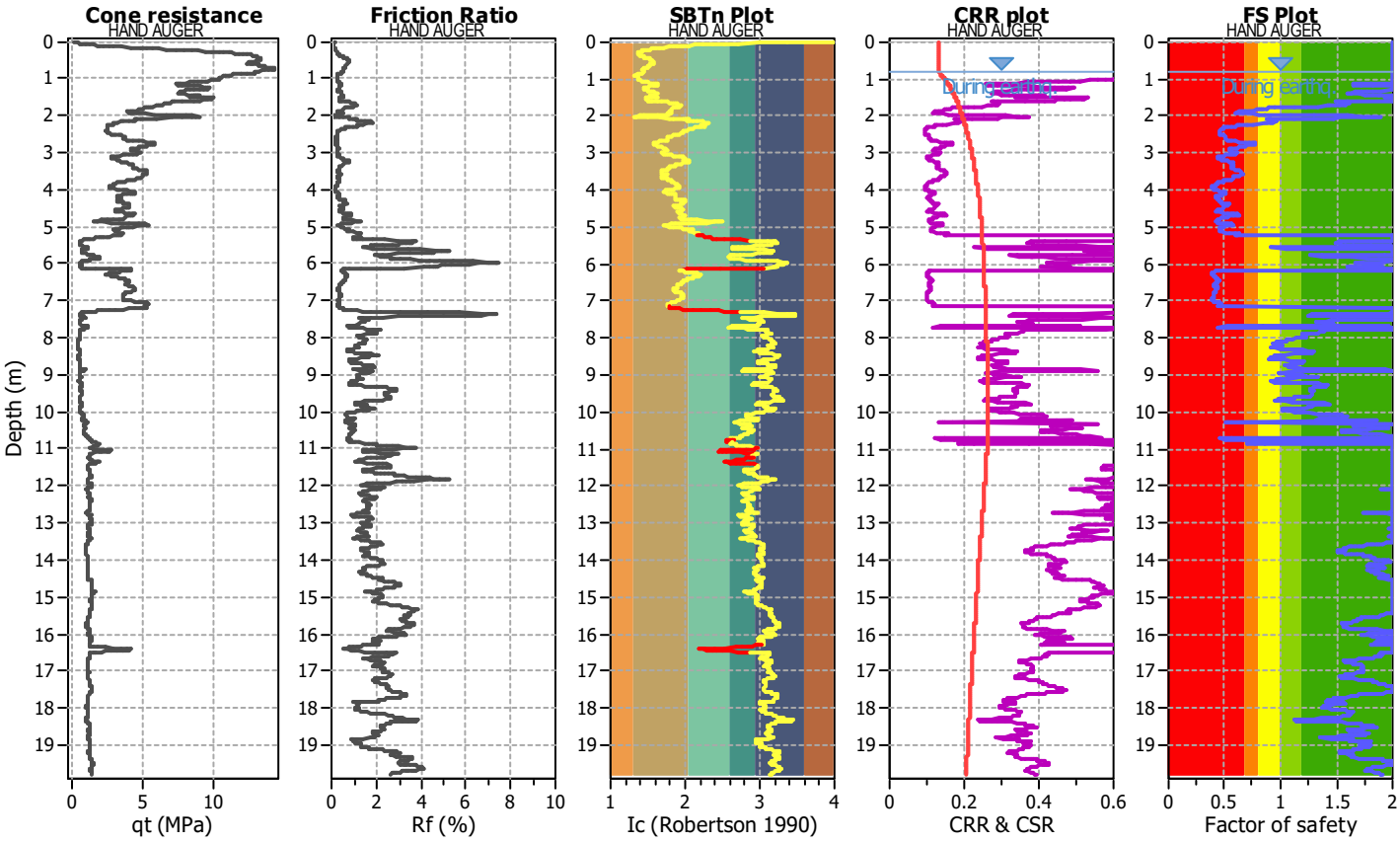
LIQUEFACTION ANALYSIS REPORT

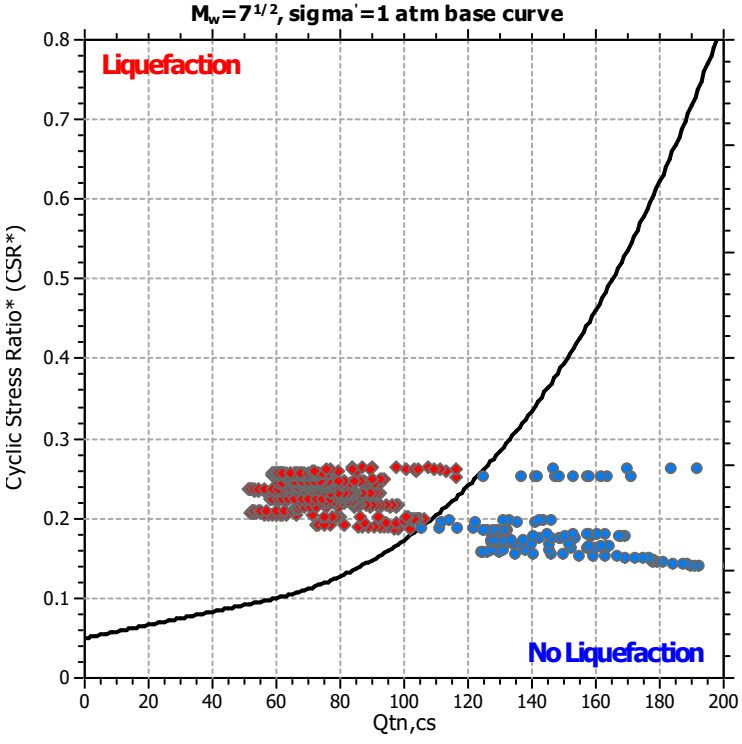
Project title : MS3 Rimini_RNN_03 **Location : Rimini**

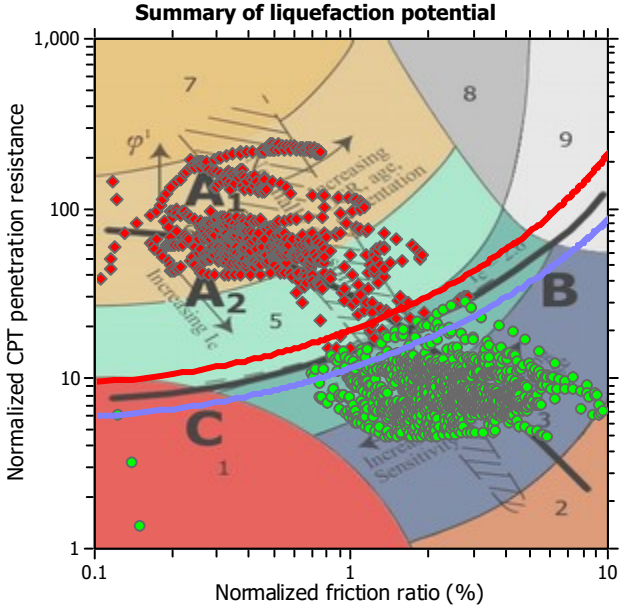
CPT file : CPTe_03

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

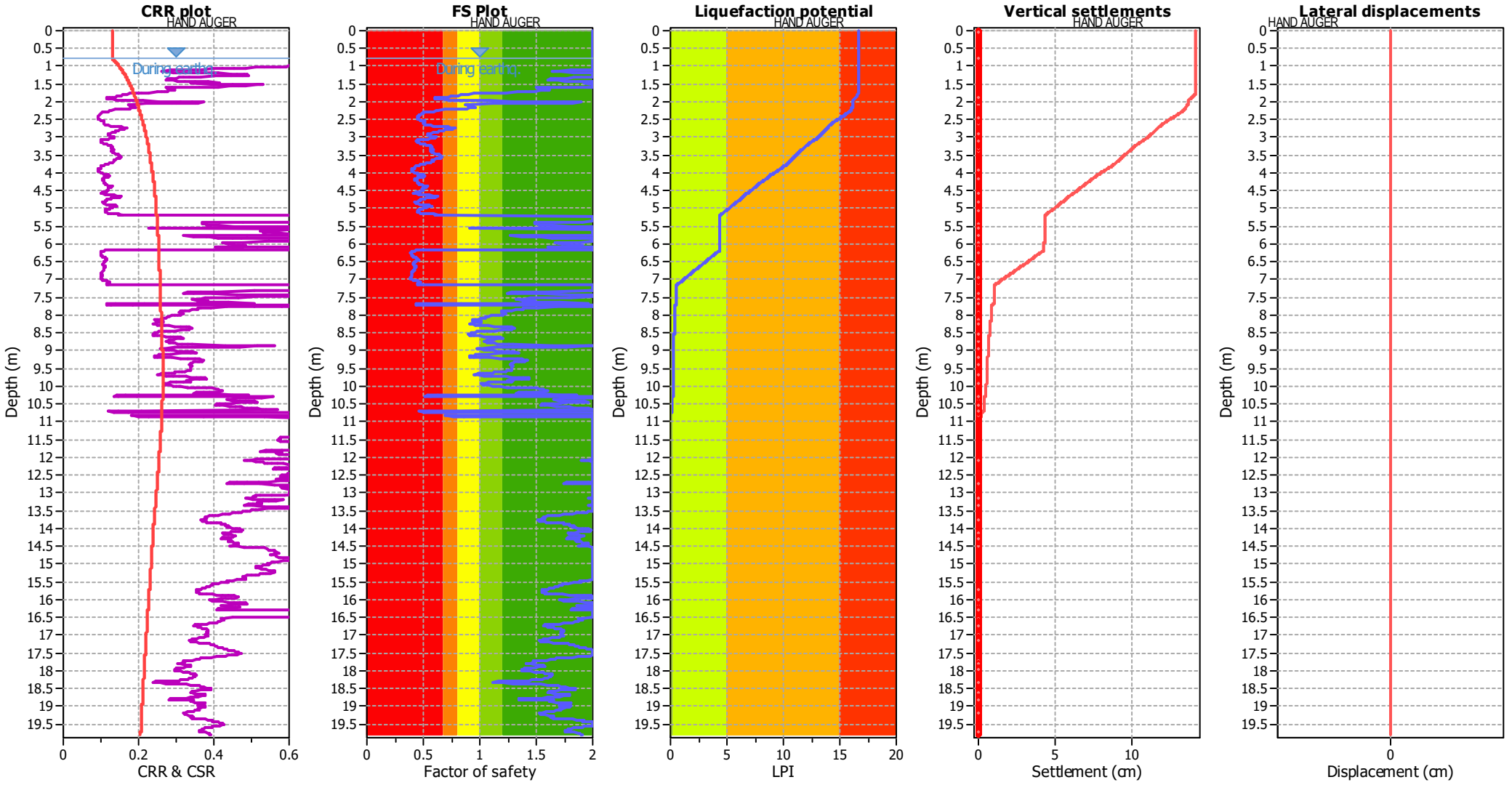






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

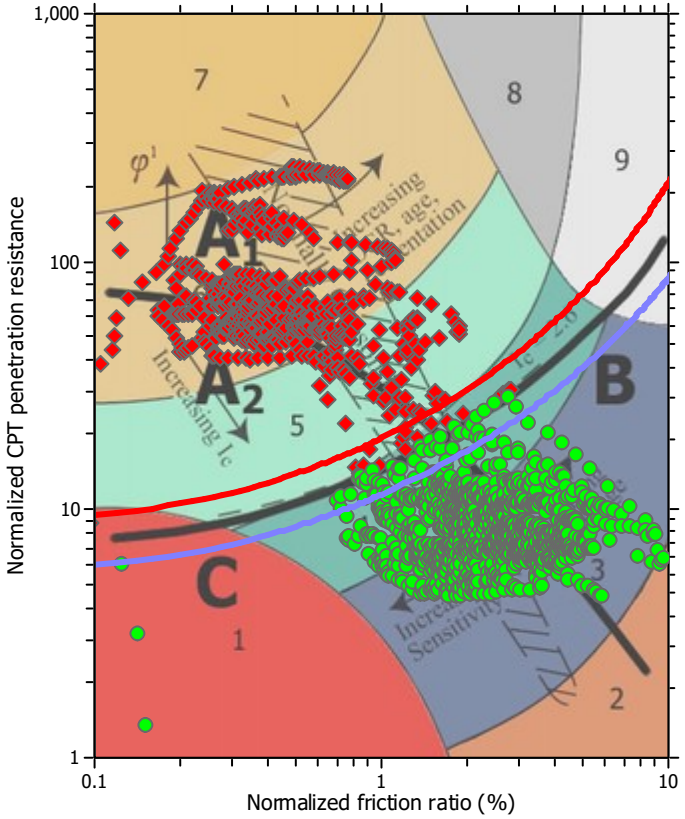
F.S. color scheme

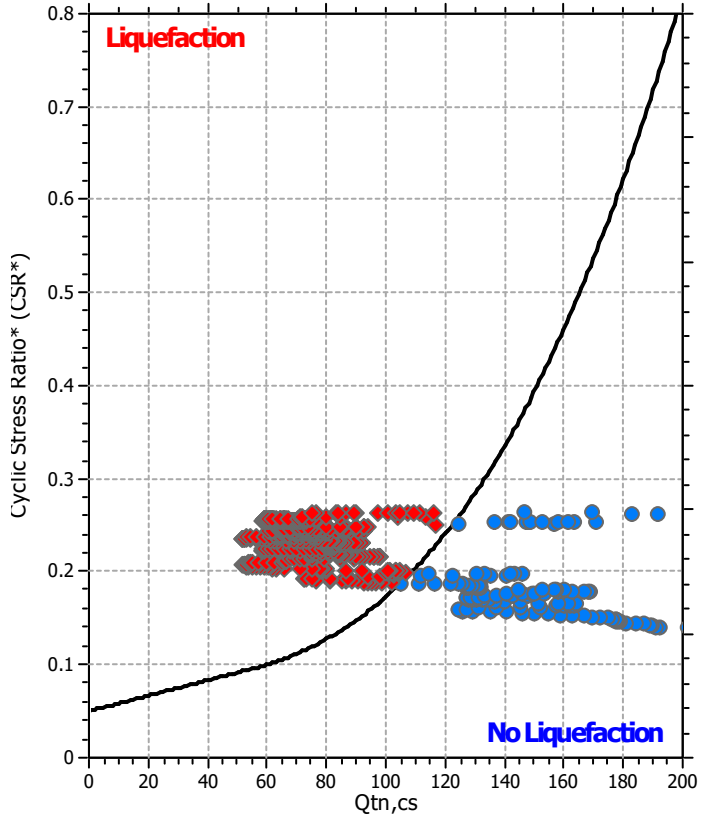
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

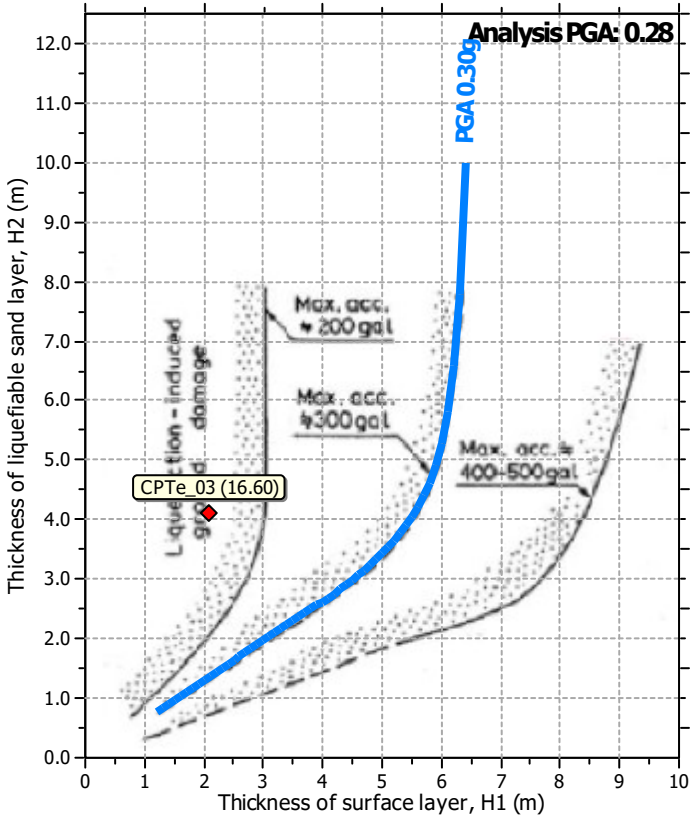
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

REPORT - ZONA RNN_02

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Dott. Geol. Alessandro Merli

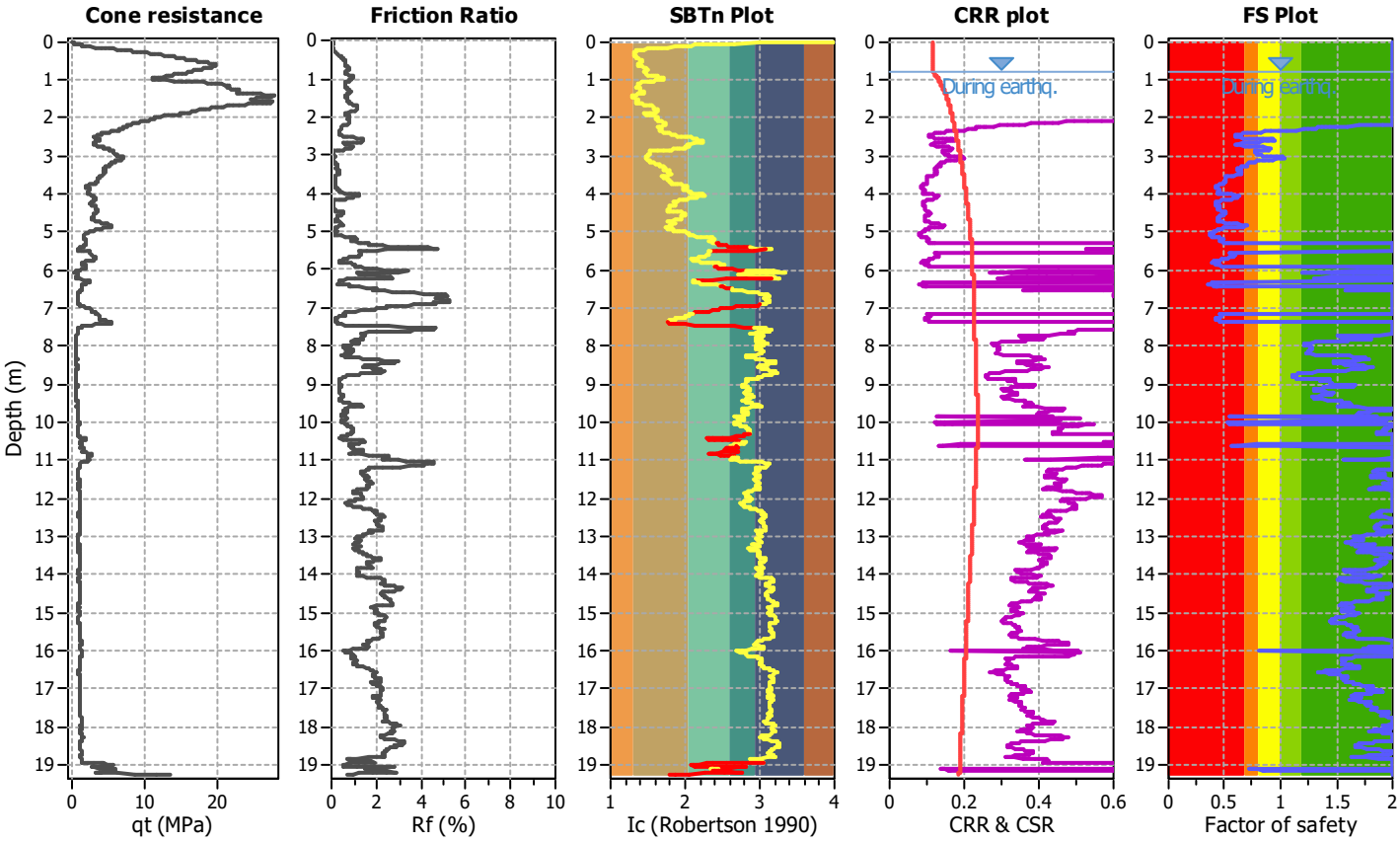
LIQUEFACTION ANALYSIS REPORT

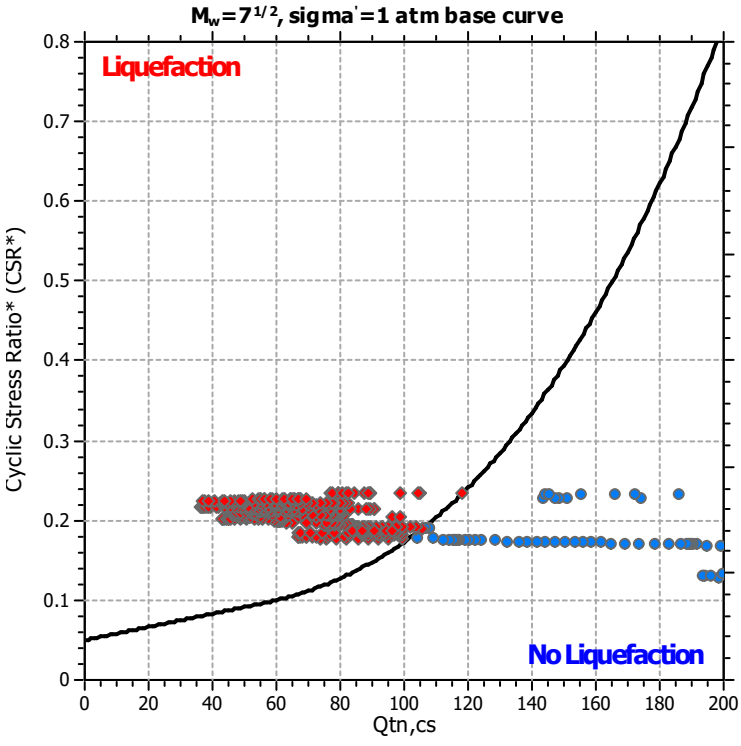
Project title : MS3 Rimini_RNN_02 **Location : Rimini**

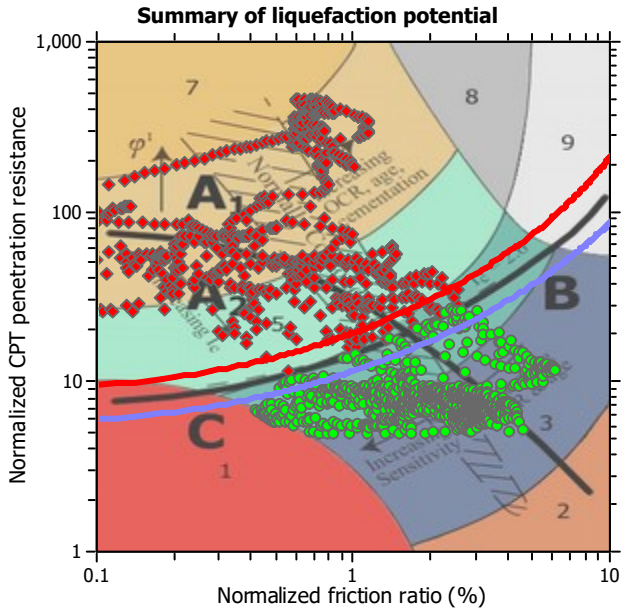
CPT file : CPTe_04

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.10 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

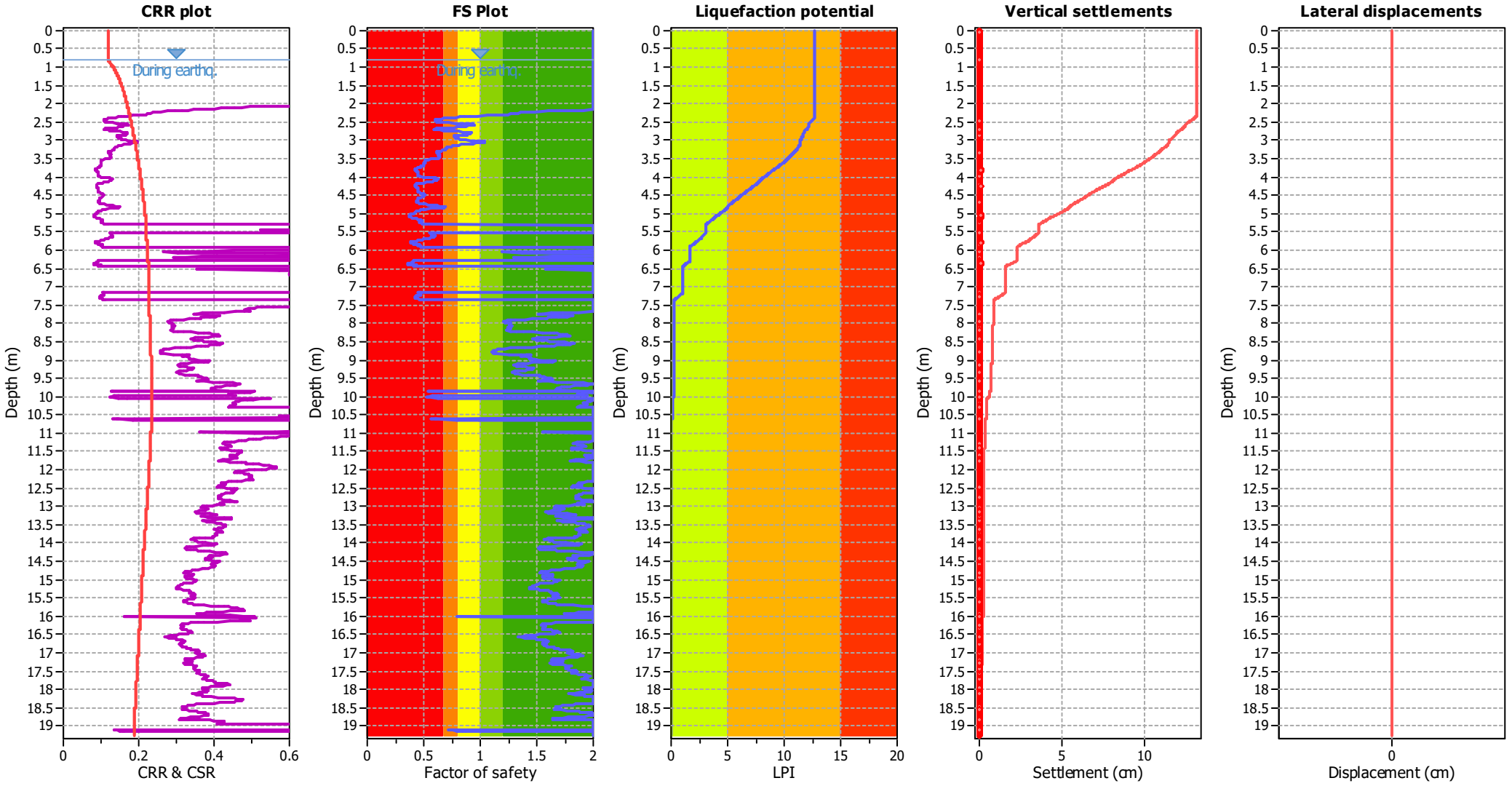






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.10 m	Fill height:	N/A	Limit depth:	N/A

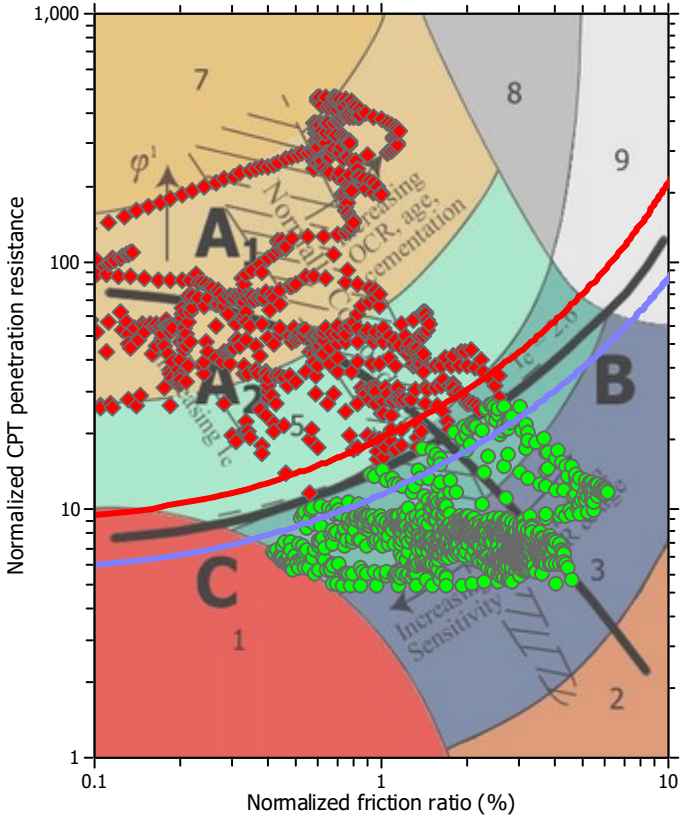
F.S. color scheme

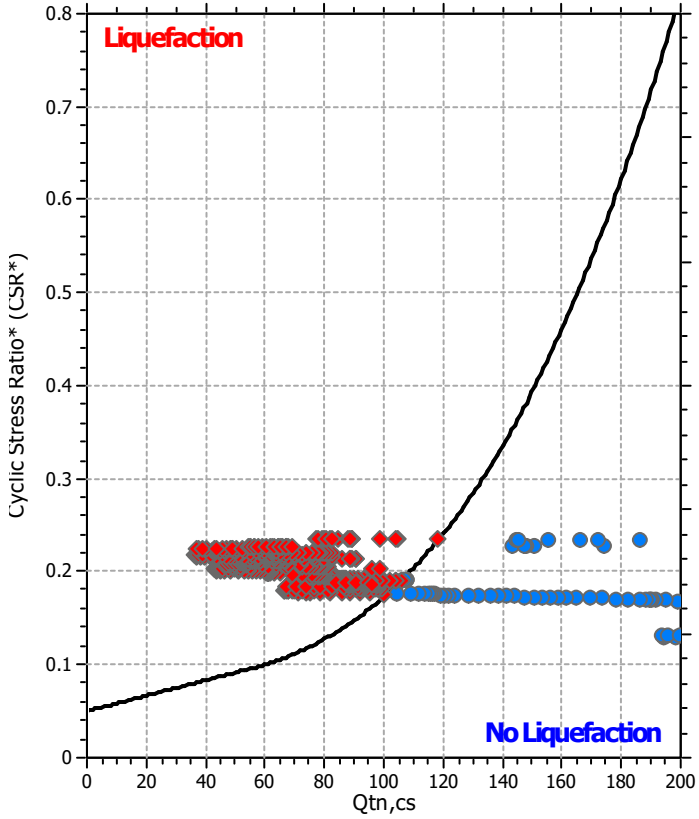
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

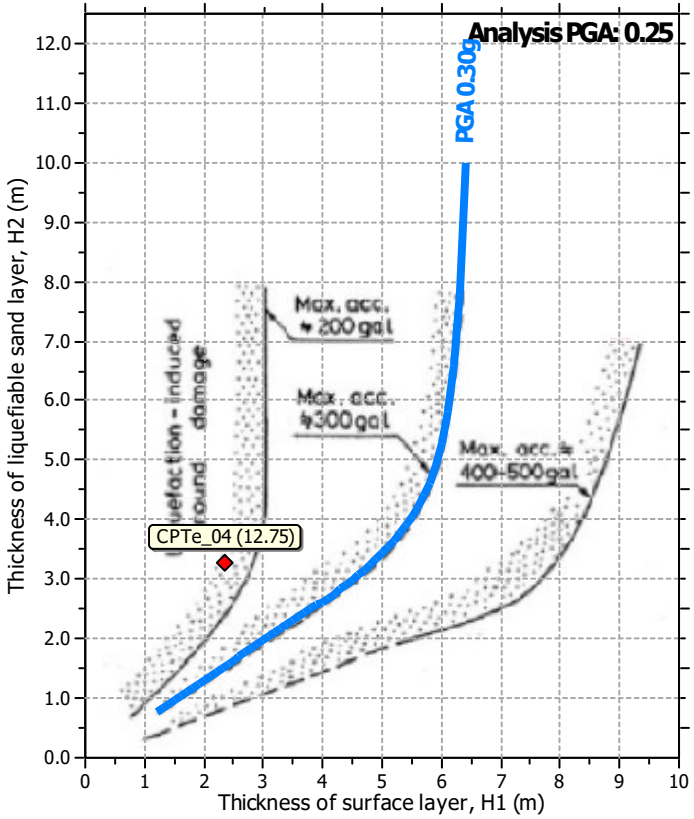
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.10 m	Fill height:	N/A	Limit depth:	N/A

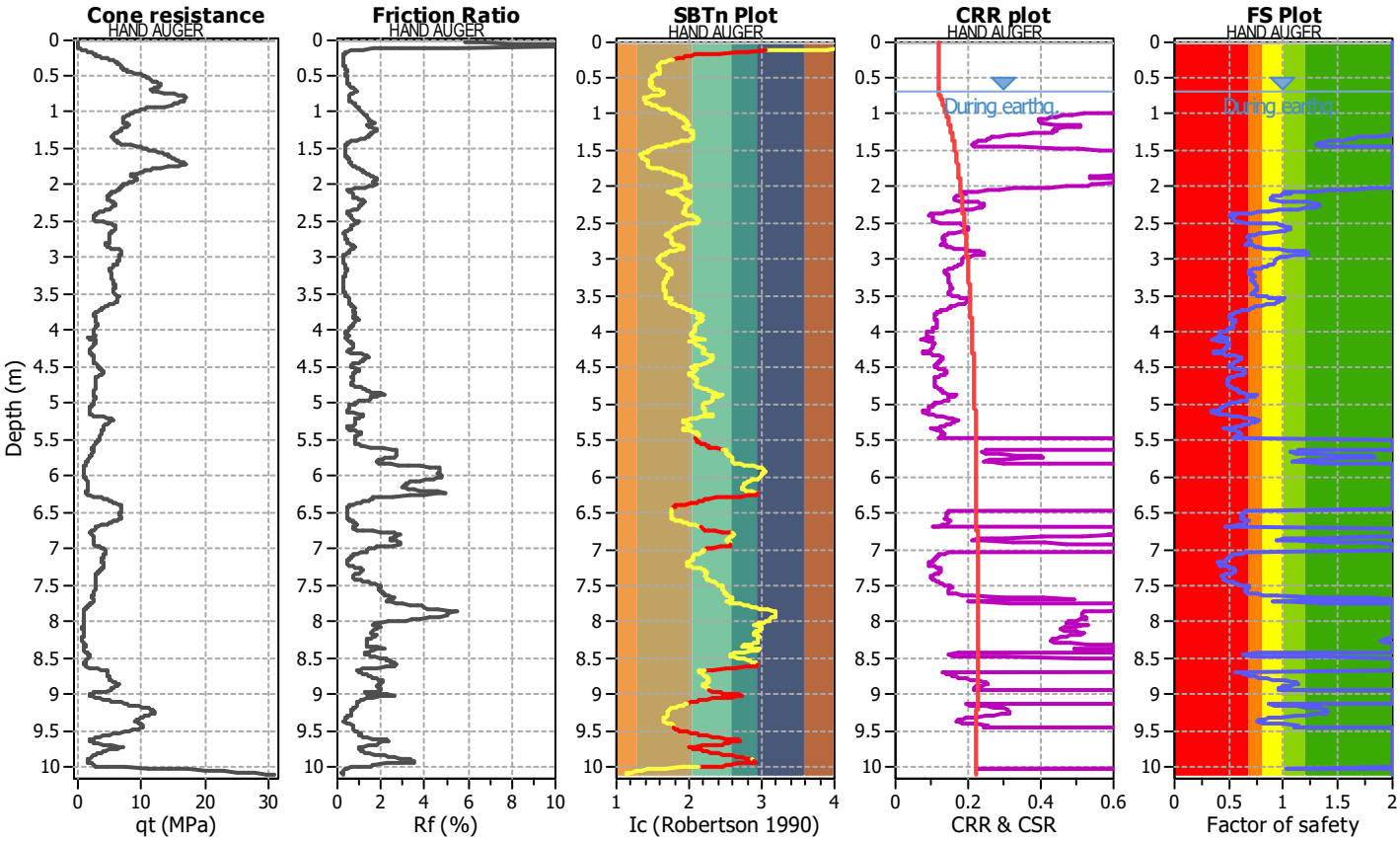
LIQUEFACTION ANALYSIS REPORT

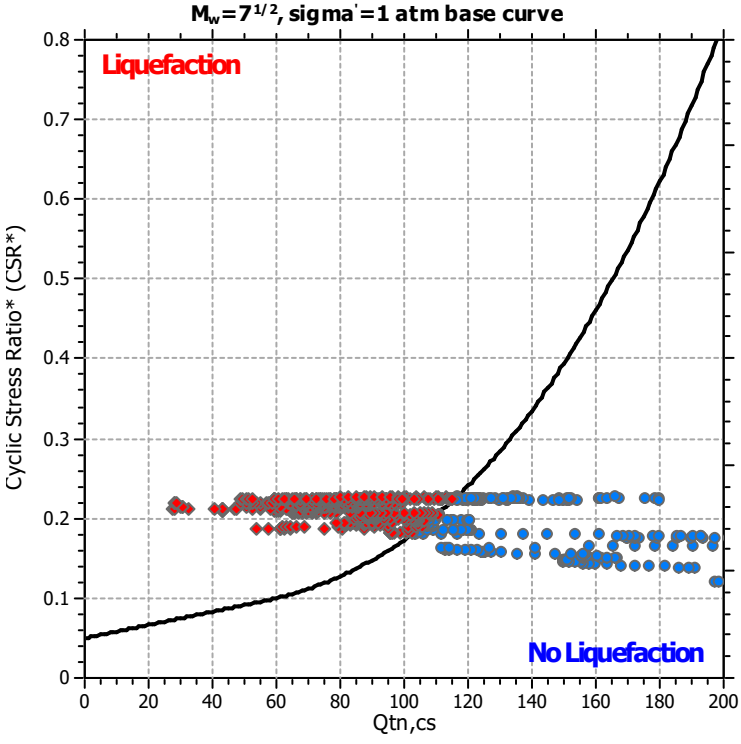
Project title : MS3 Rimini_RNN_02 **Location : Rimini**

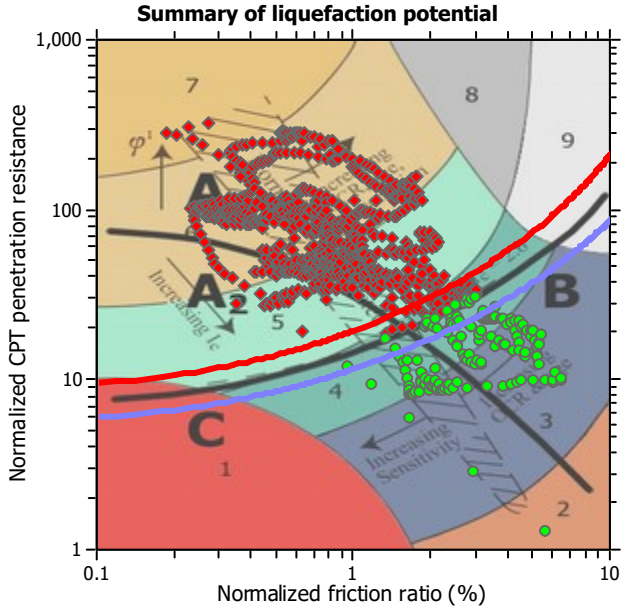
CPT file : 099014P1404

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.70 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

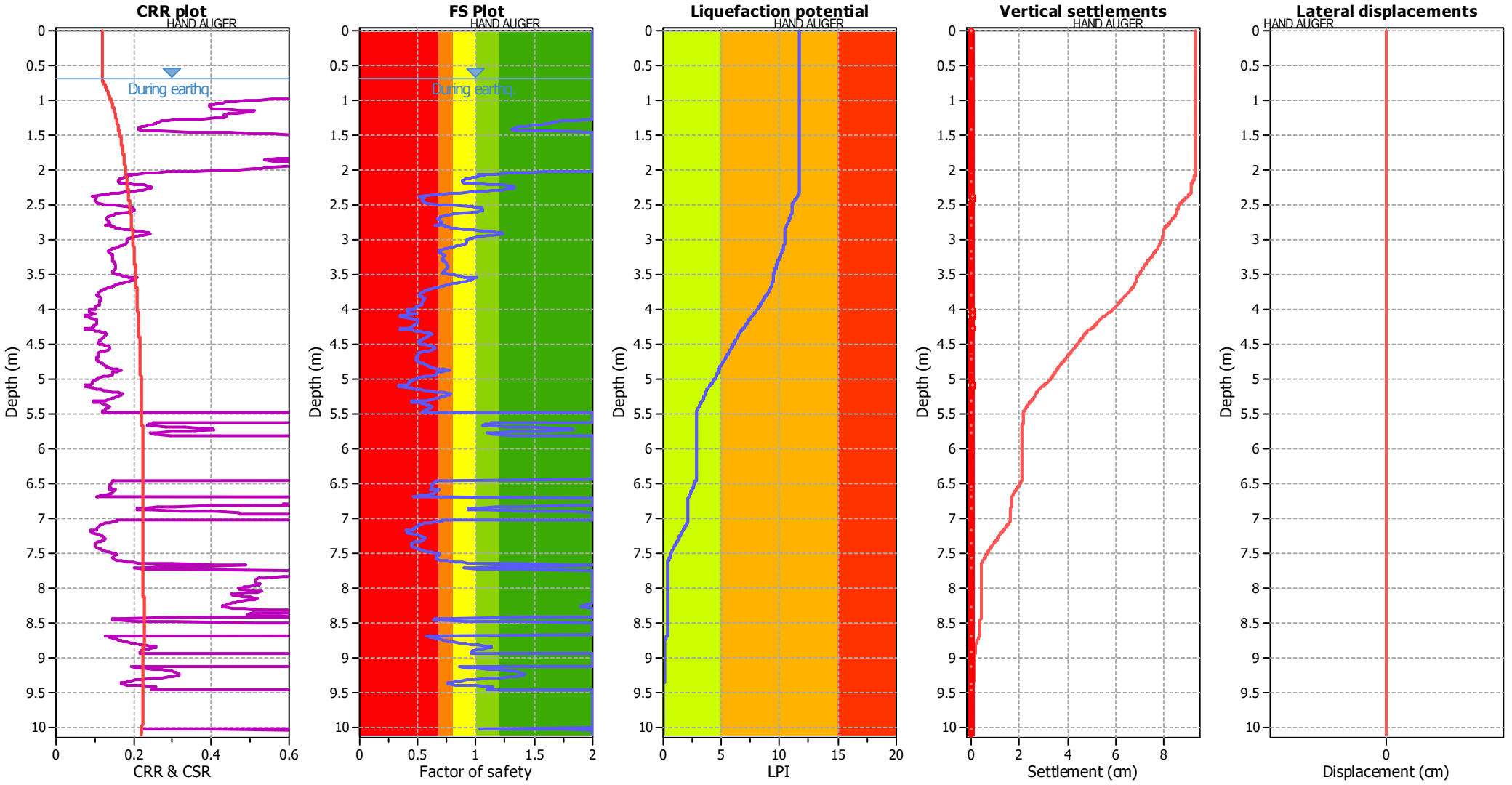






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

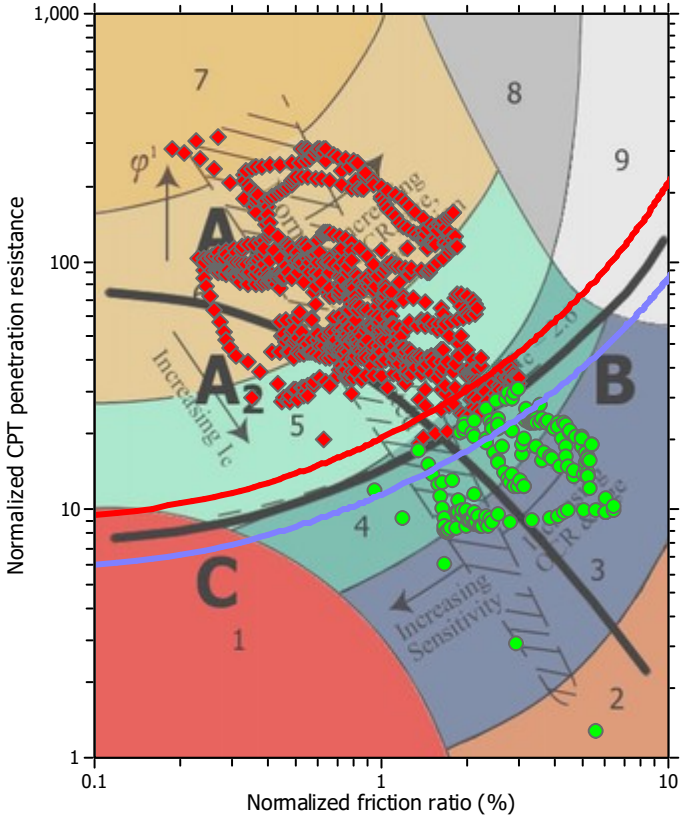
F.S. color scheme

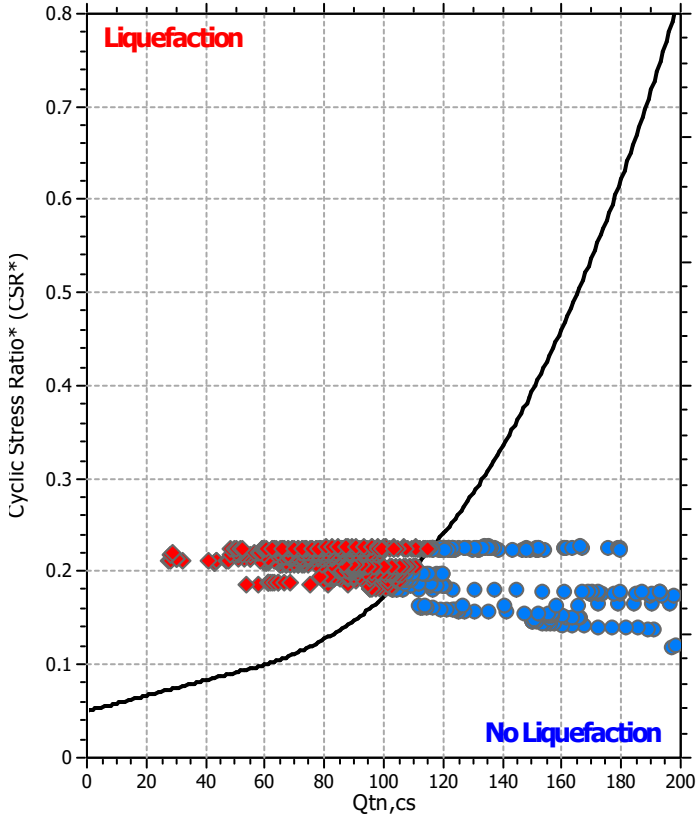
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

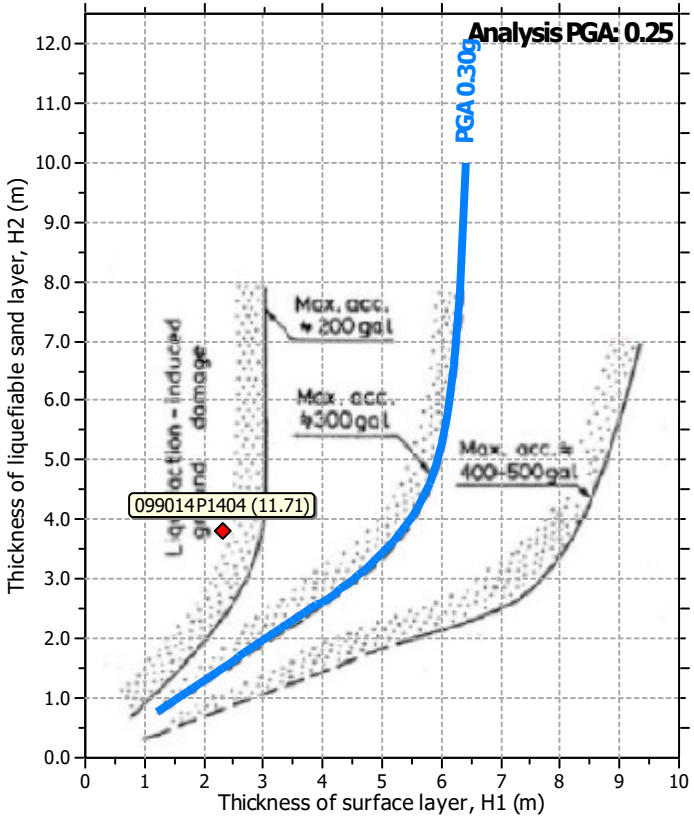
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

REPORT - ZONA RNN_01

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

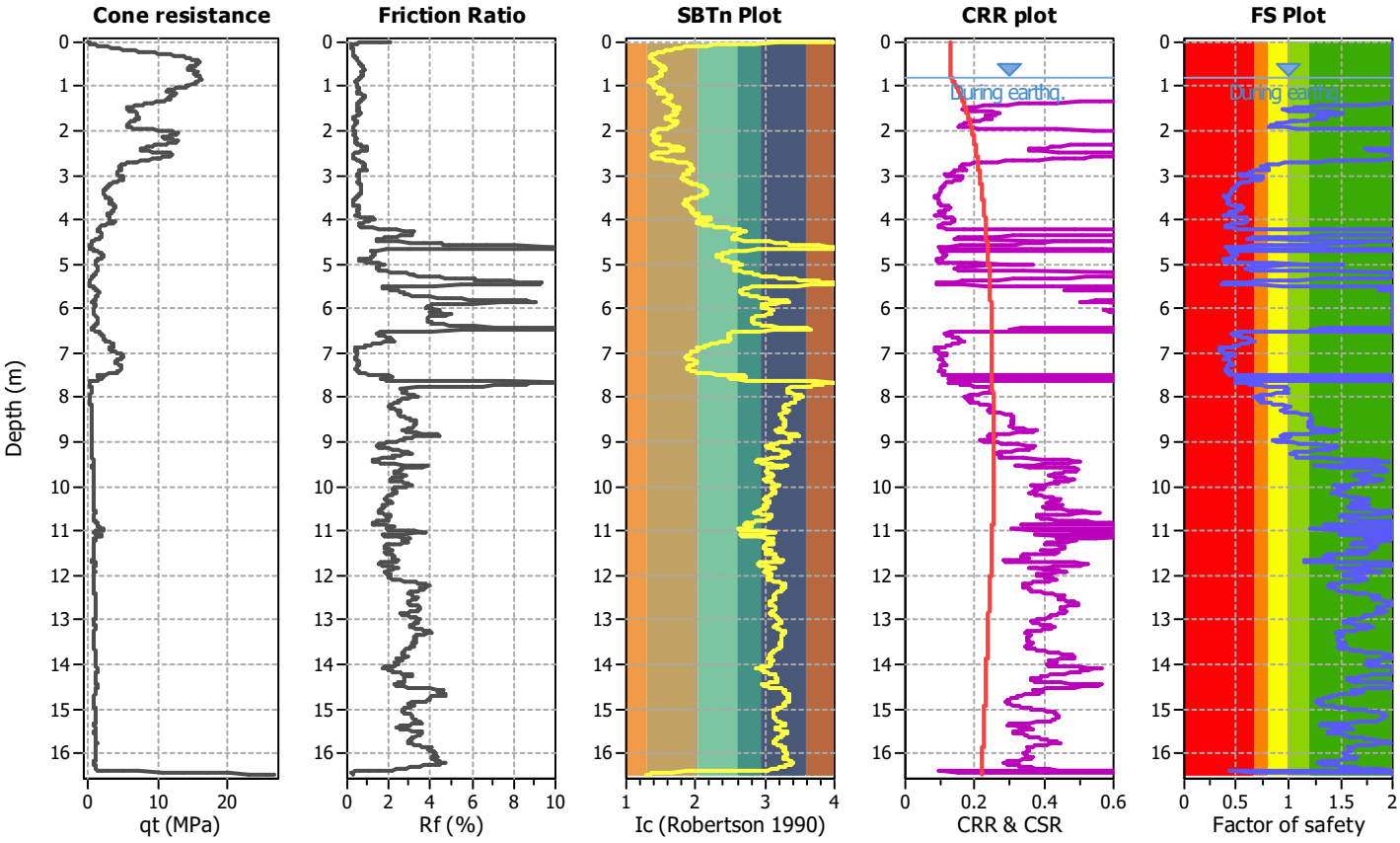
LIQUEFACTION ANALYSIS REPORT

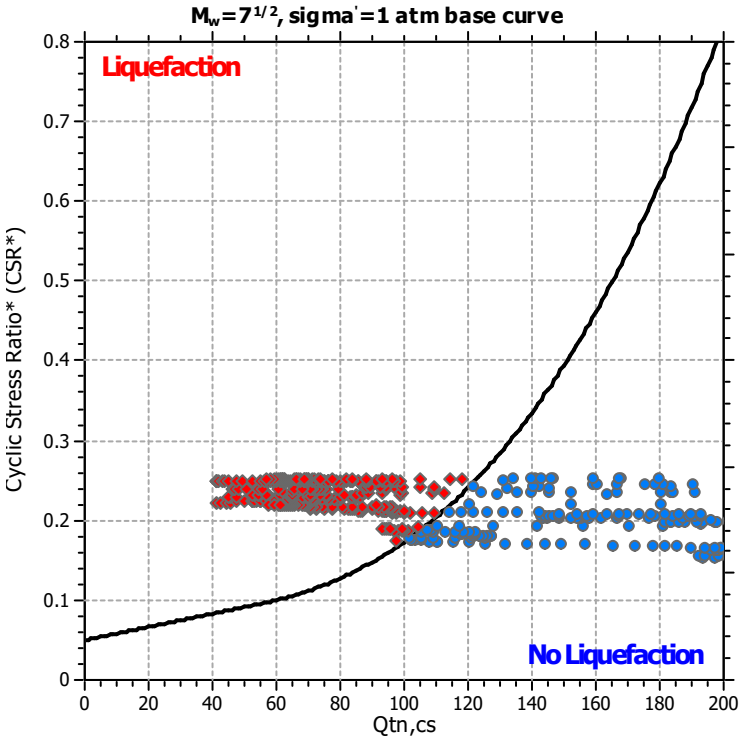
Project title : MS3 Rimini_RNN_01 **Location : Rimini**

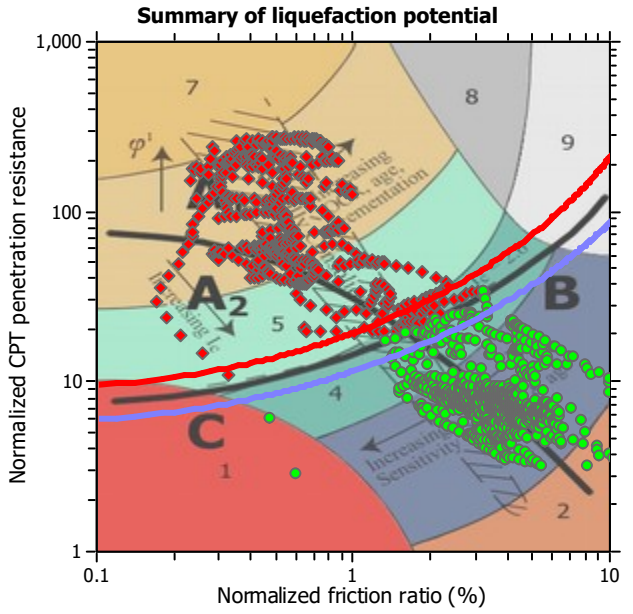
CPT file : CPTe_05

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

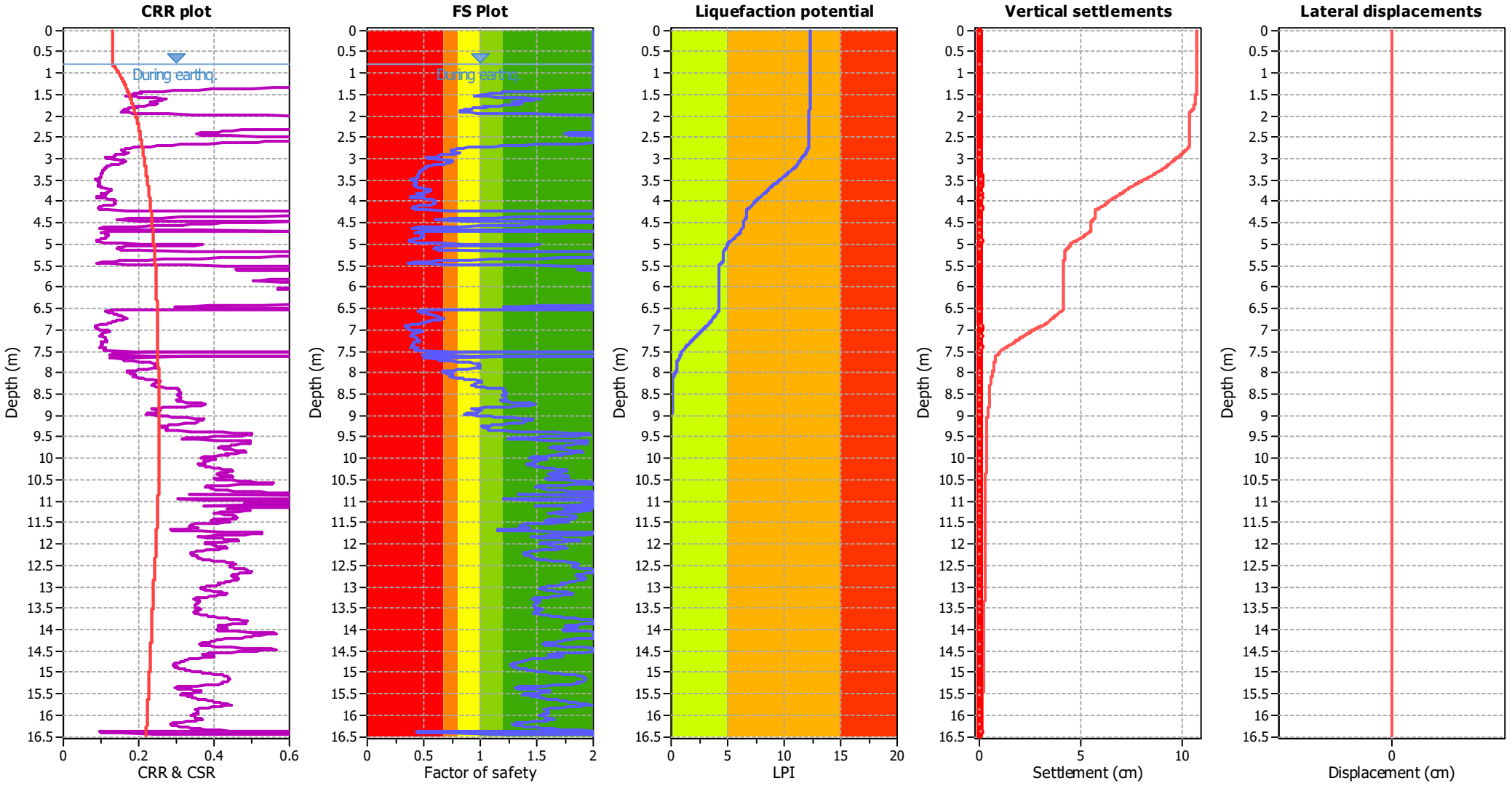






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

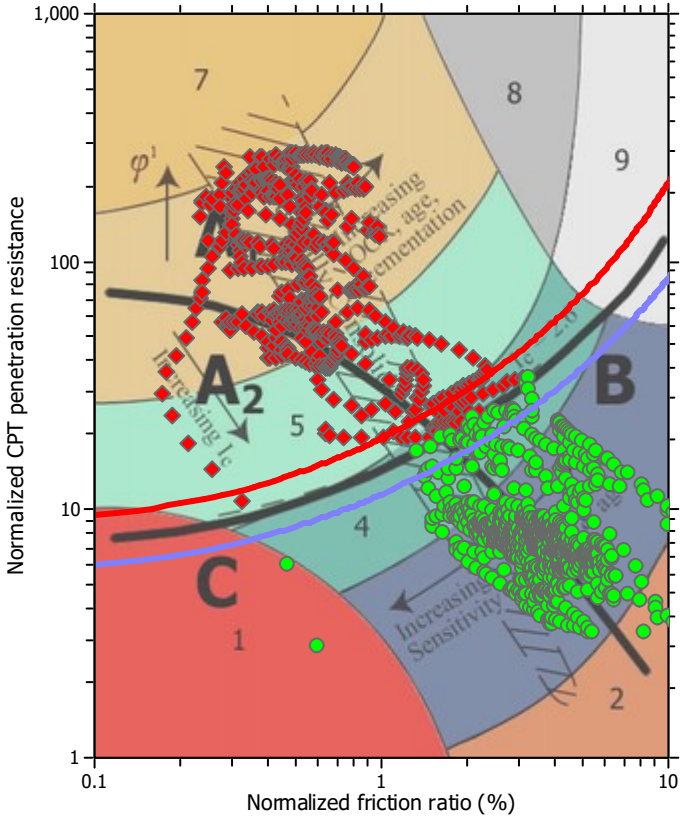
F.S. color scheme

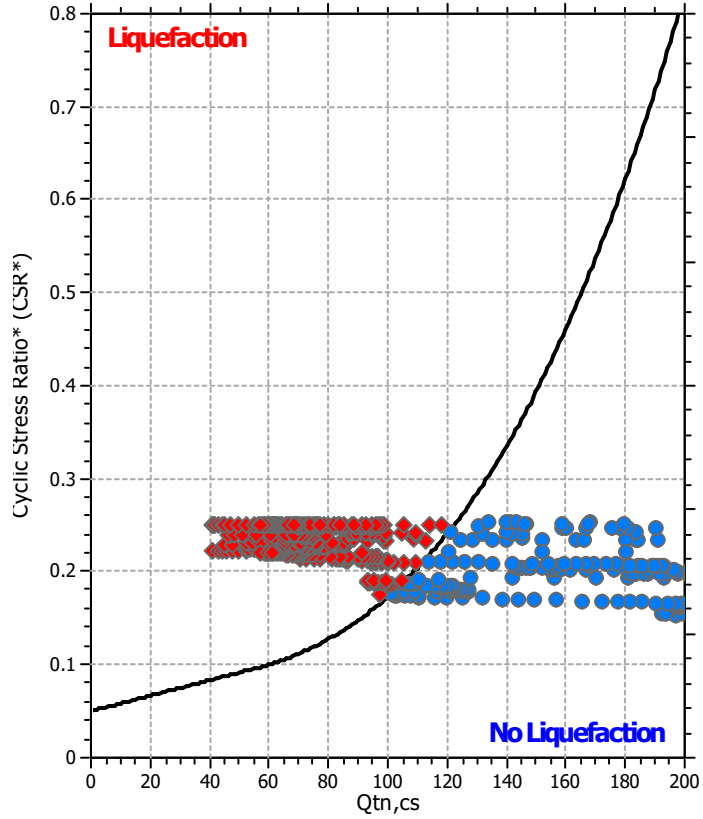
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

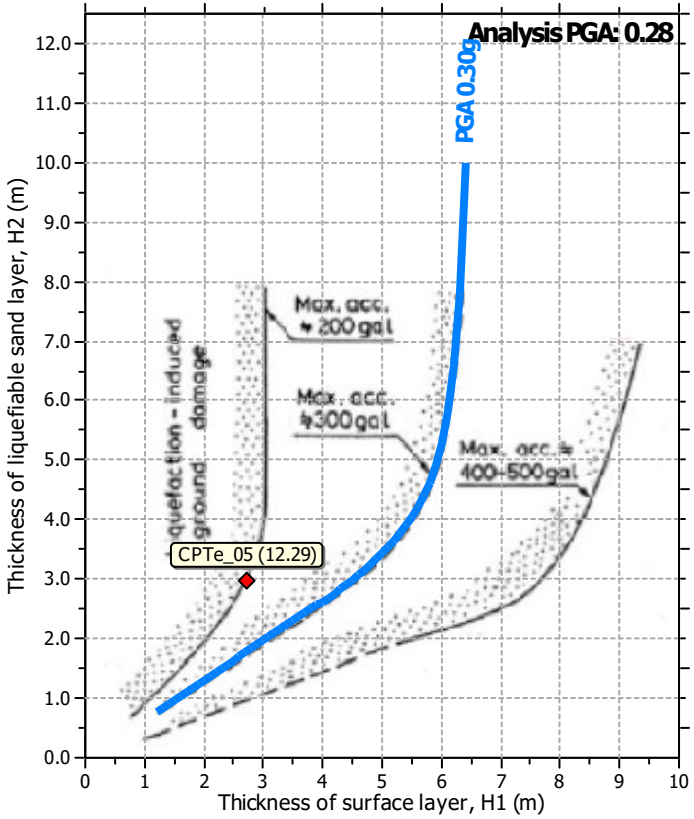
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

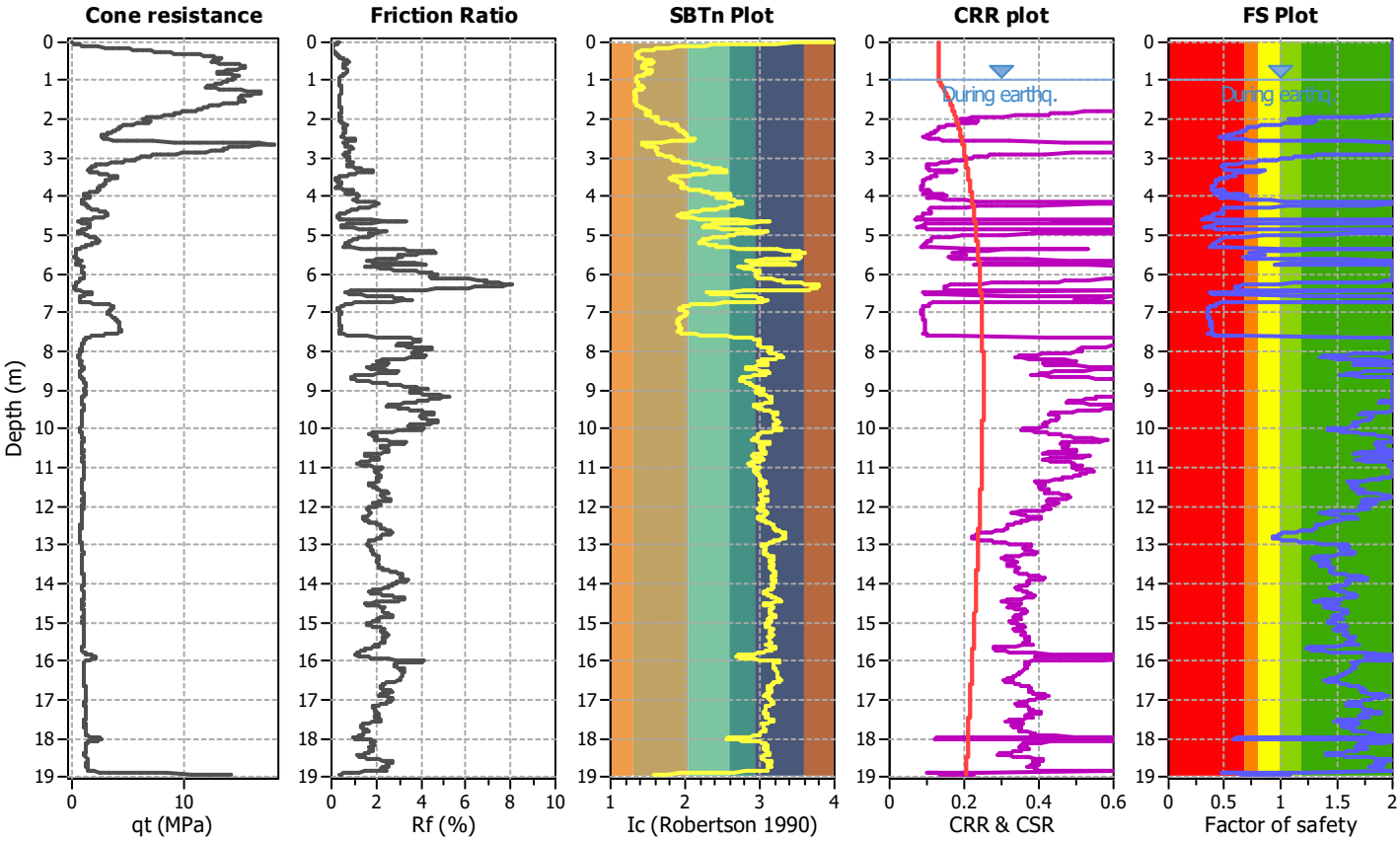
LIQUEFACTION ANALYSIS REPORT

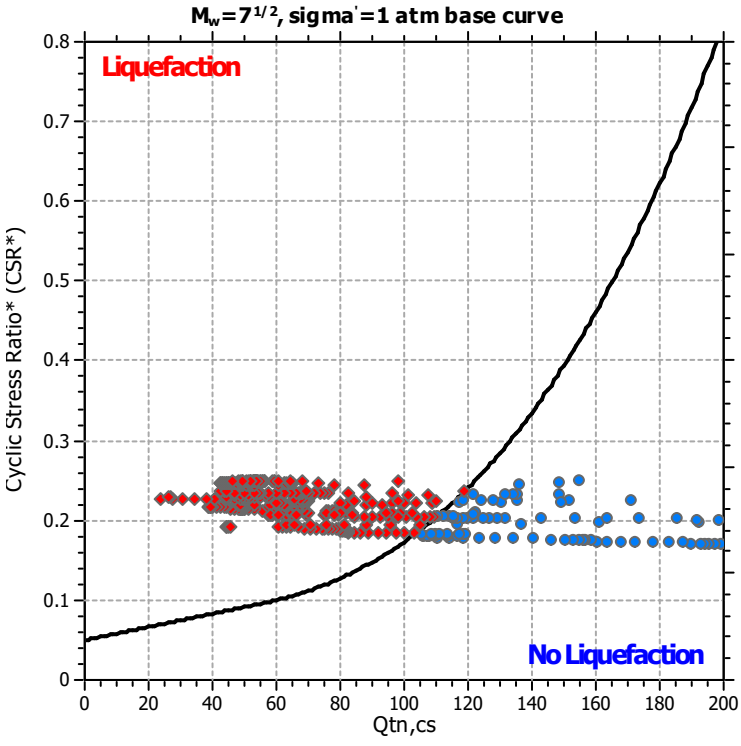
Project title : MS3 Rimini_RNN_01 **Location : Rimini**

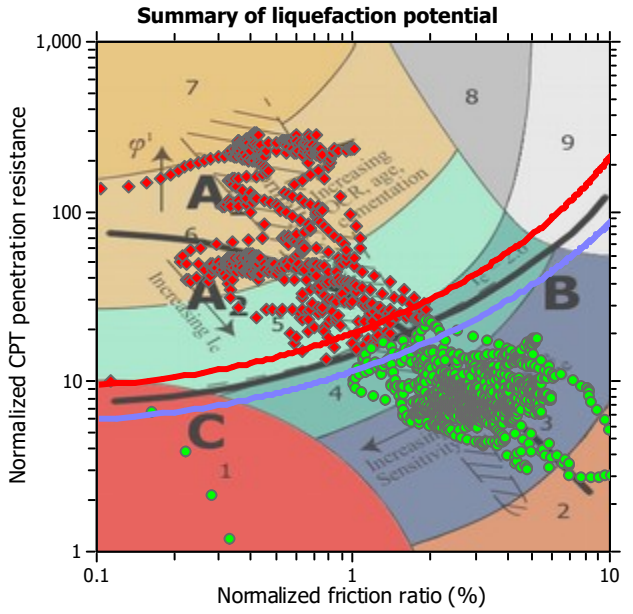
CPT file : CPTe_06

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.20 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

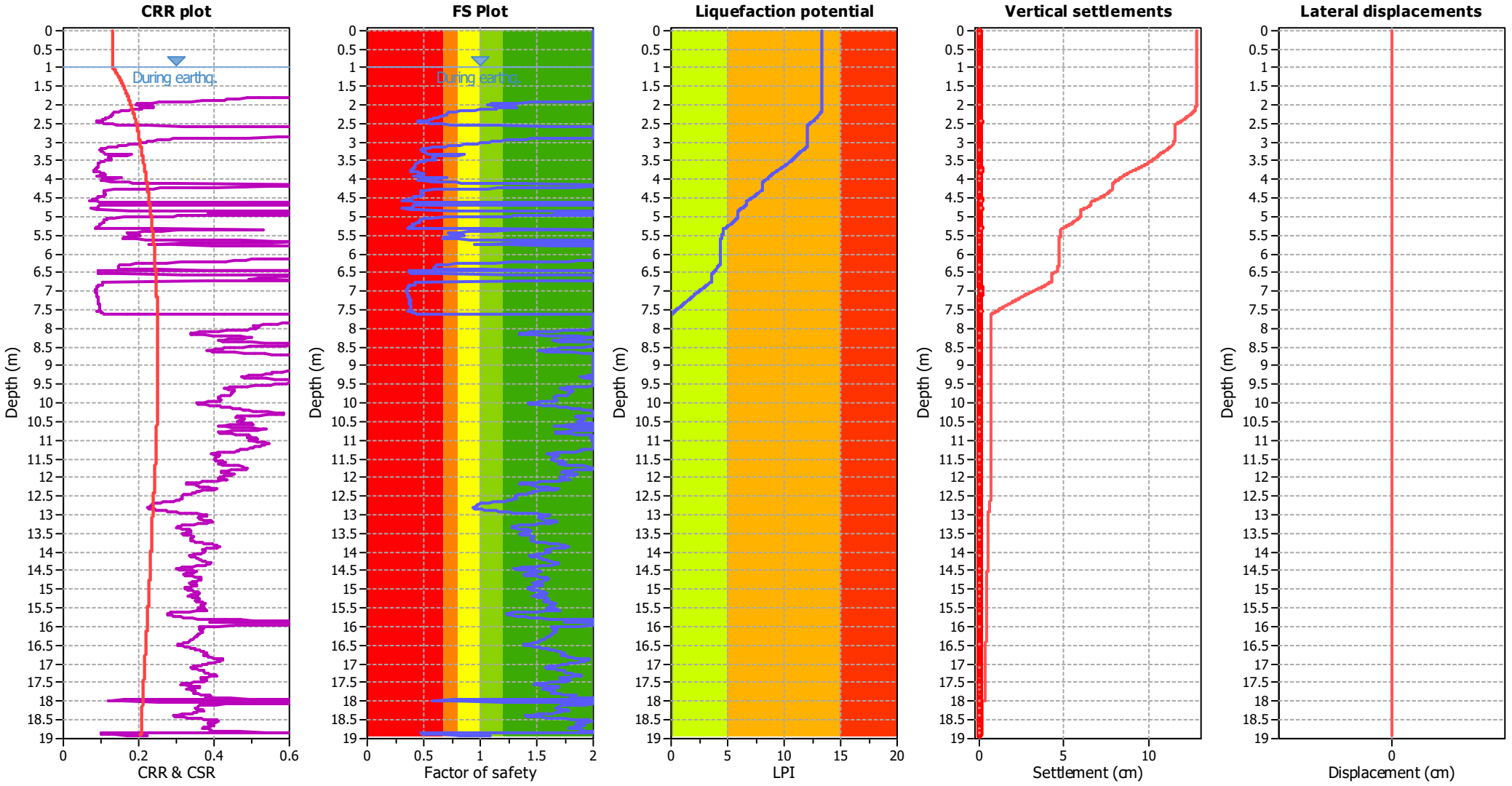






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	N/A

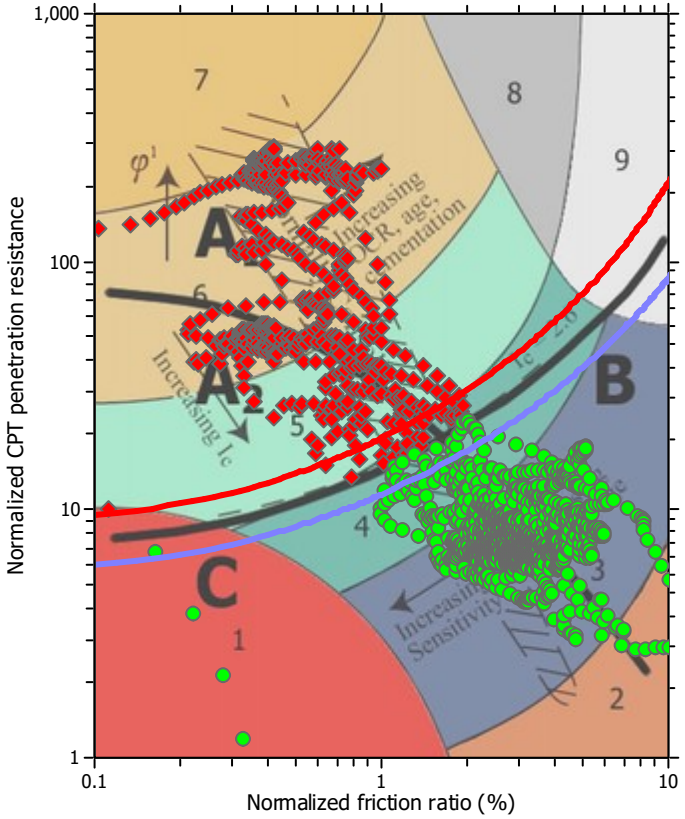
F.S. color scheme

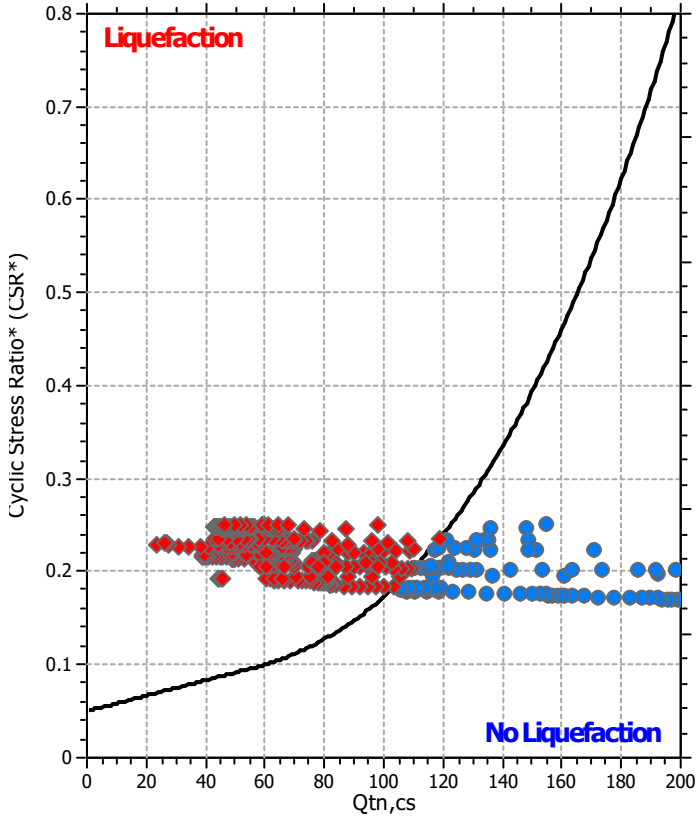
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

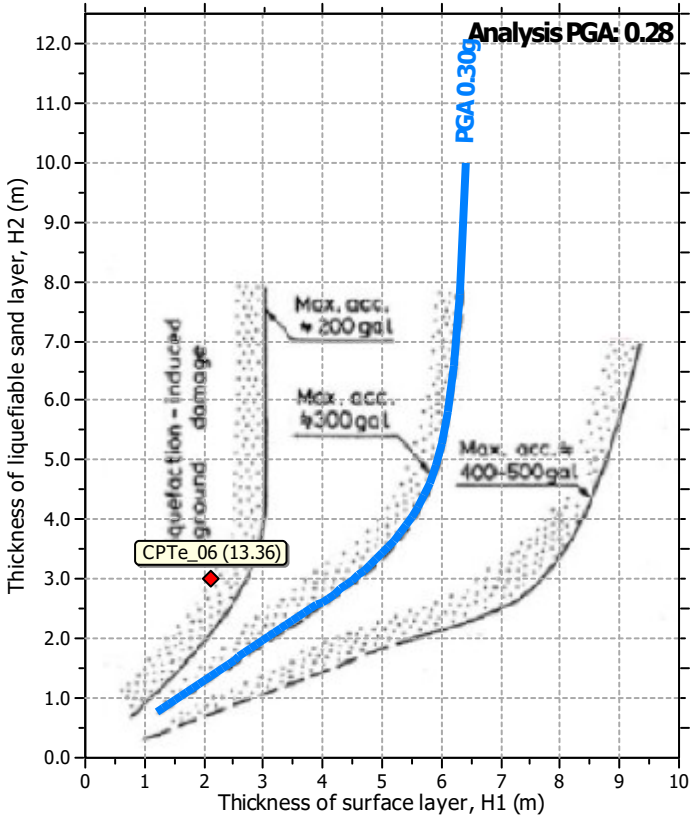
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	N/A

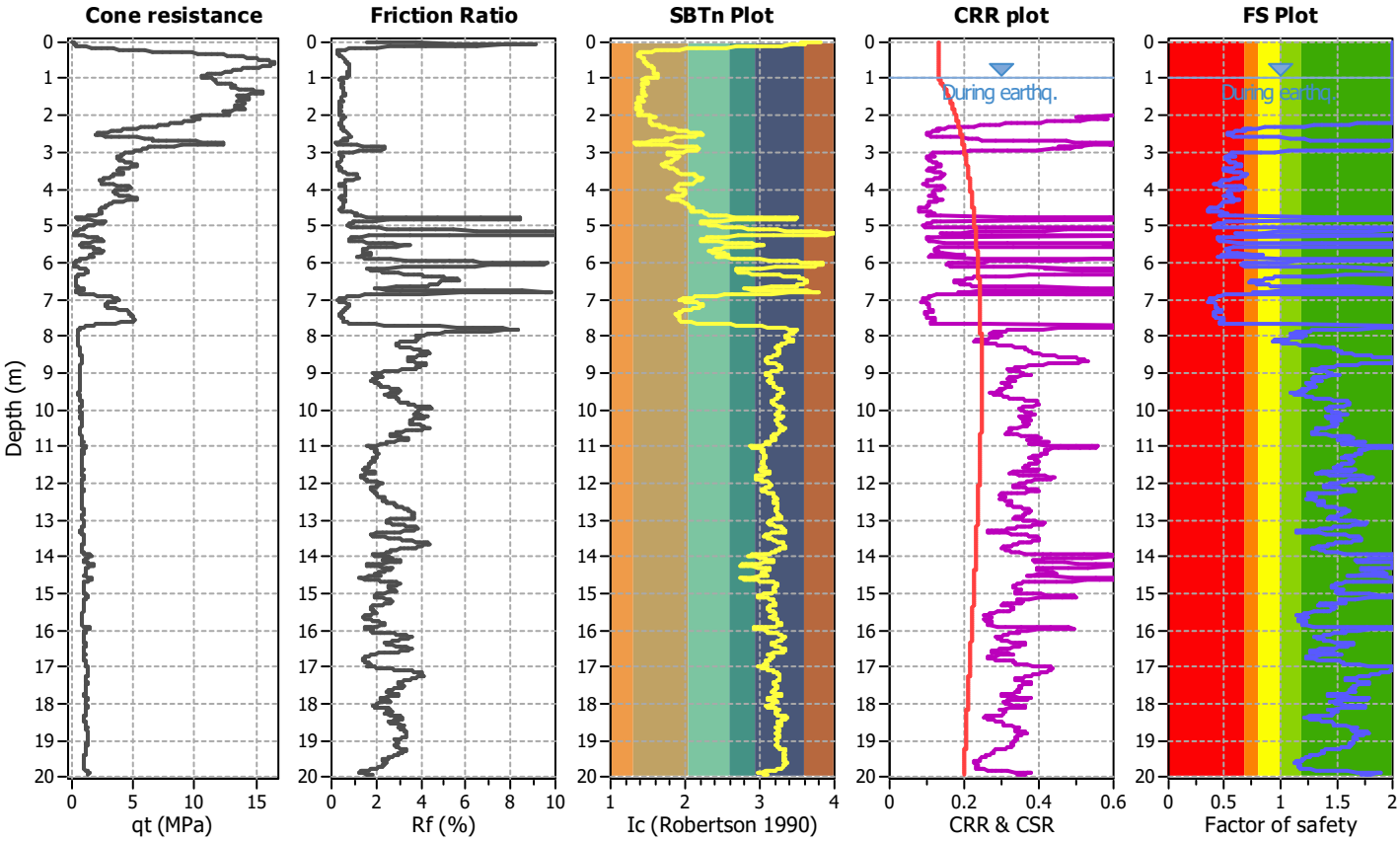
LIQUEFACTION ANALYSIS REPORT

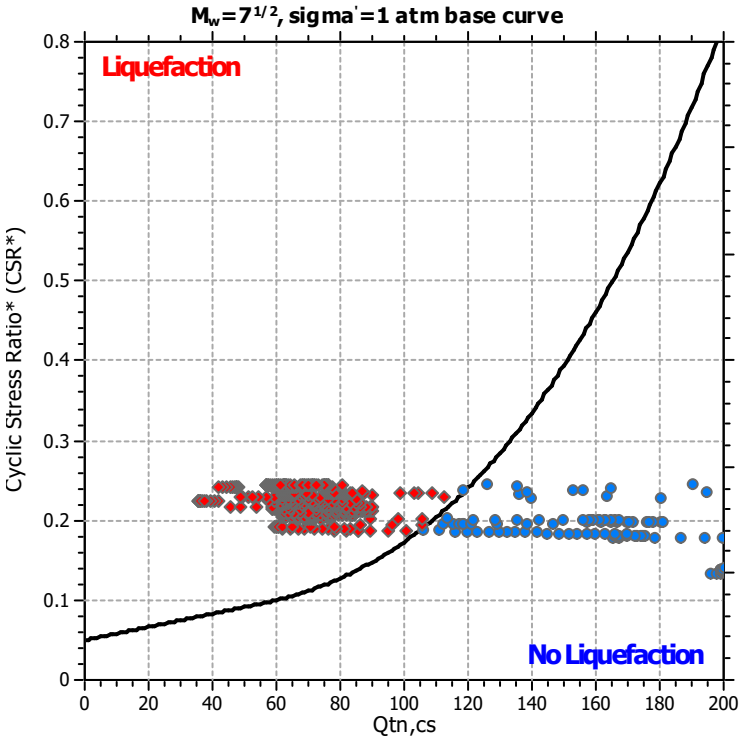
Project title : MS3 Rimini_RNN_01 **Location : Rimini**

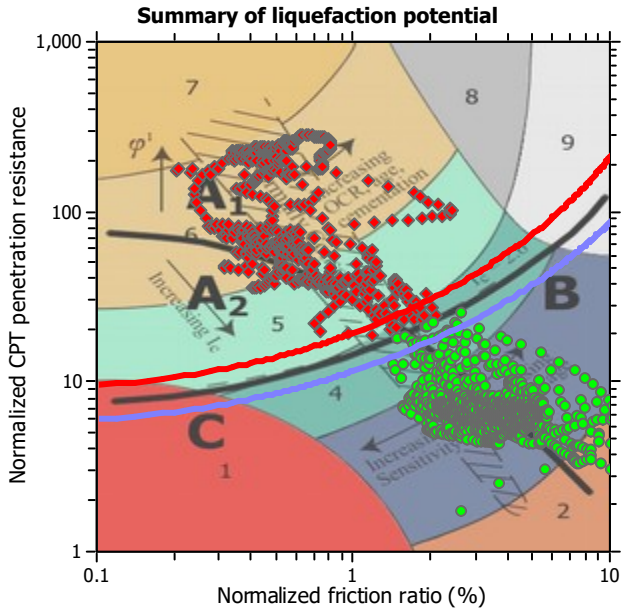
CPT file : CPTe_07

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.30 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

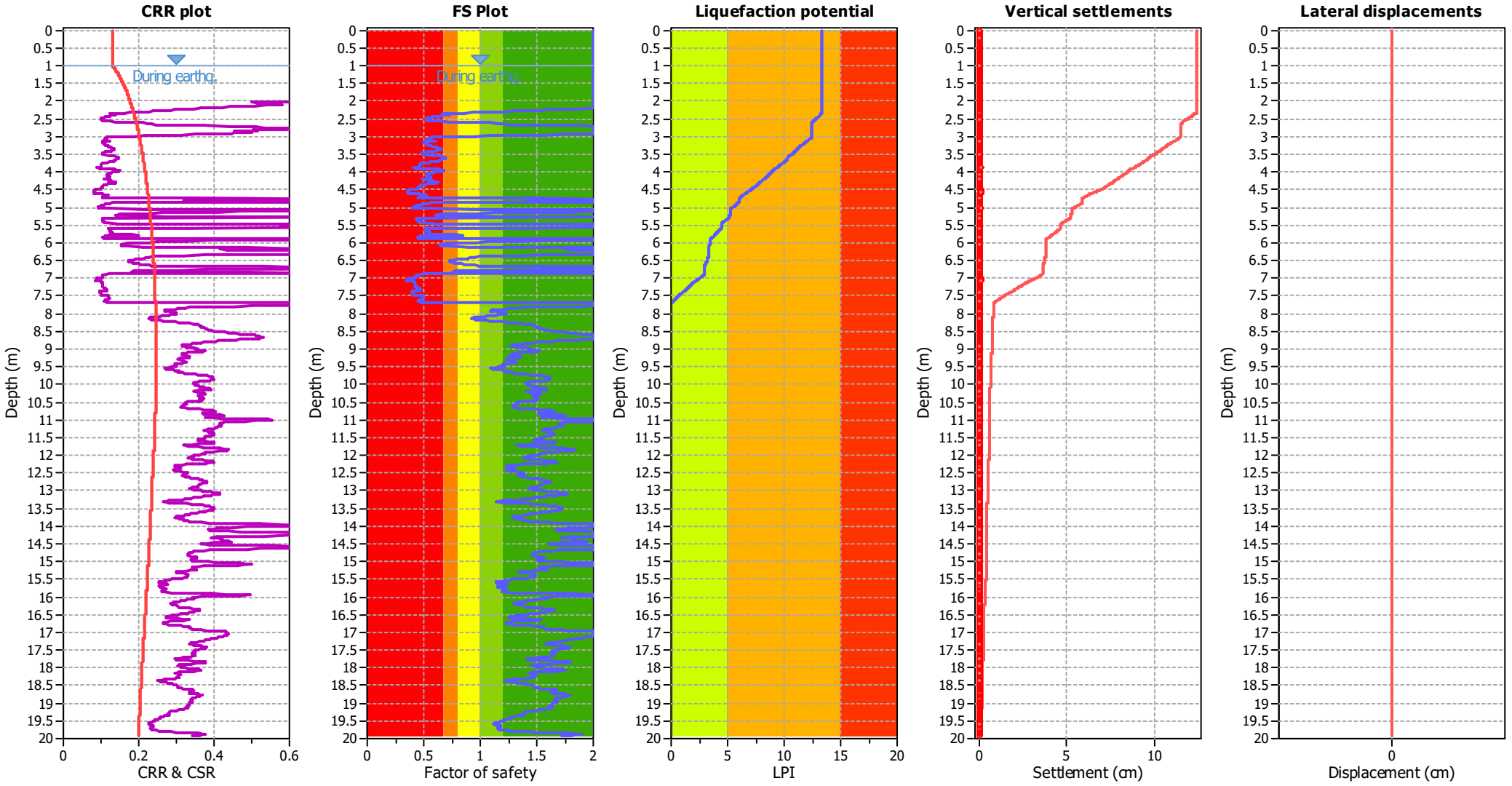






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.30 m	Fill height:	N/A	Limit depth:	N/A

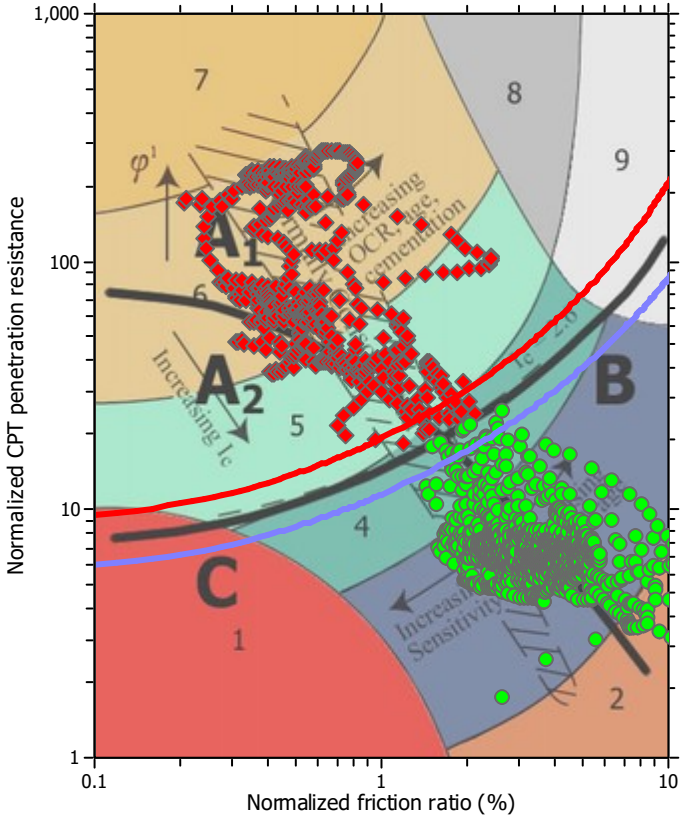
F.S. color scheme

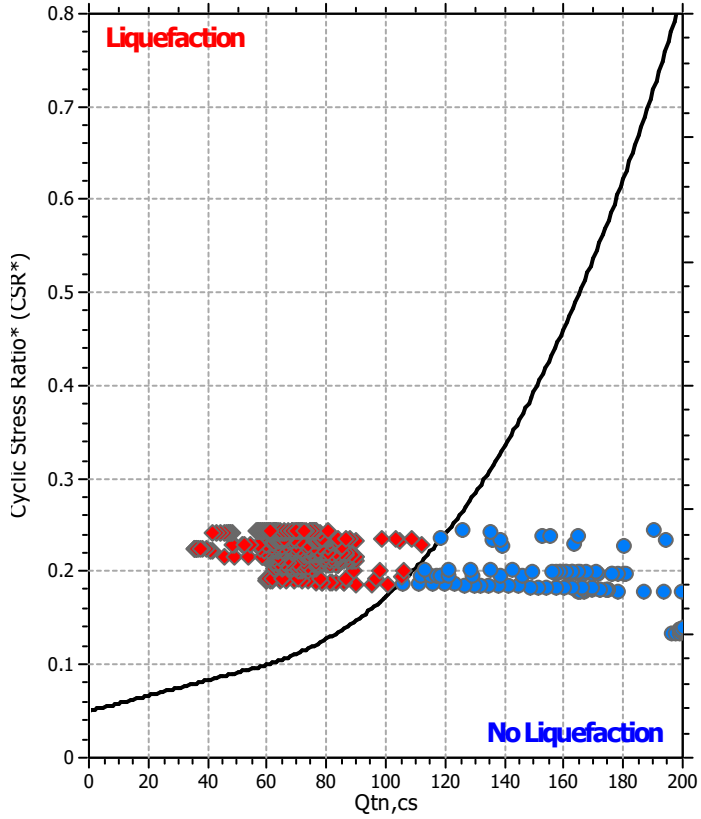
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

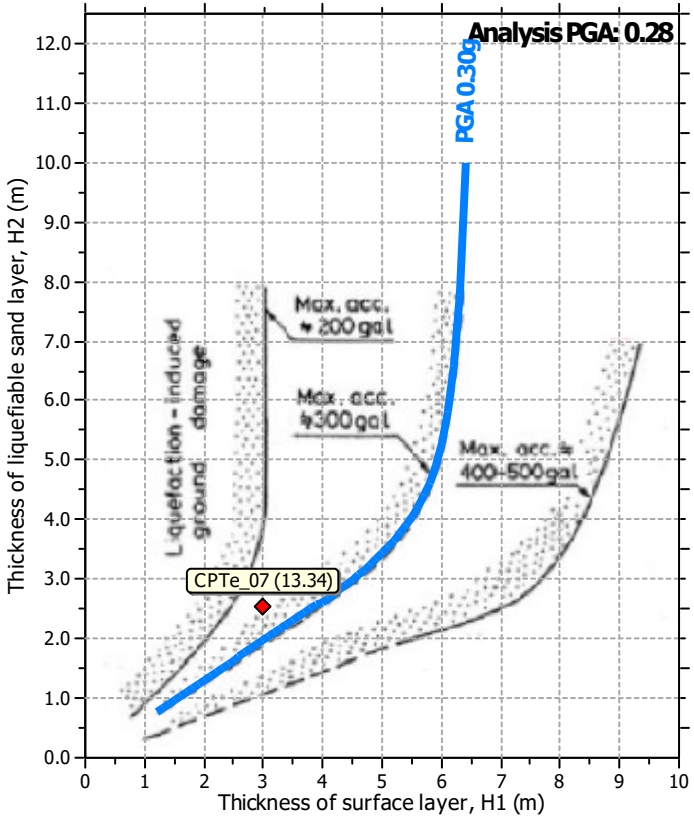
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.30 m	Fill height:	N/A	Limit depth:	N/A

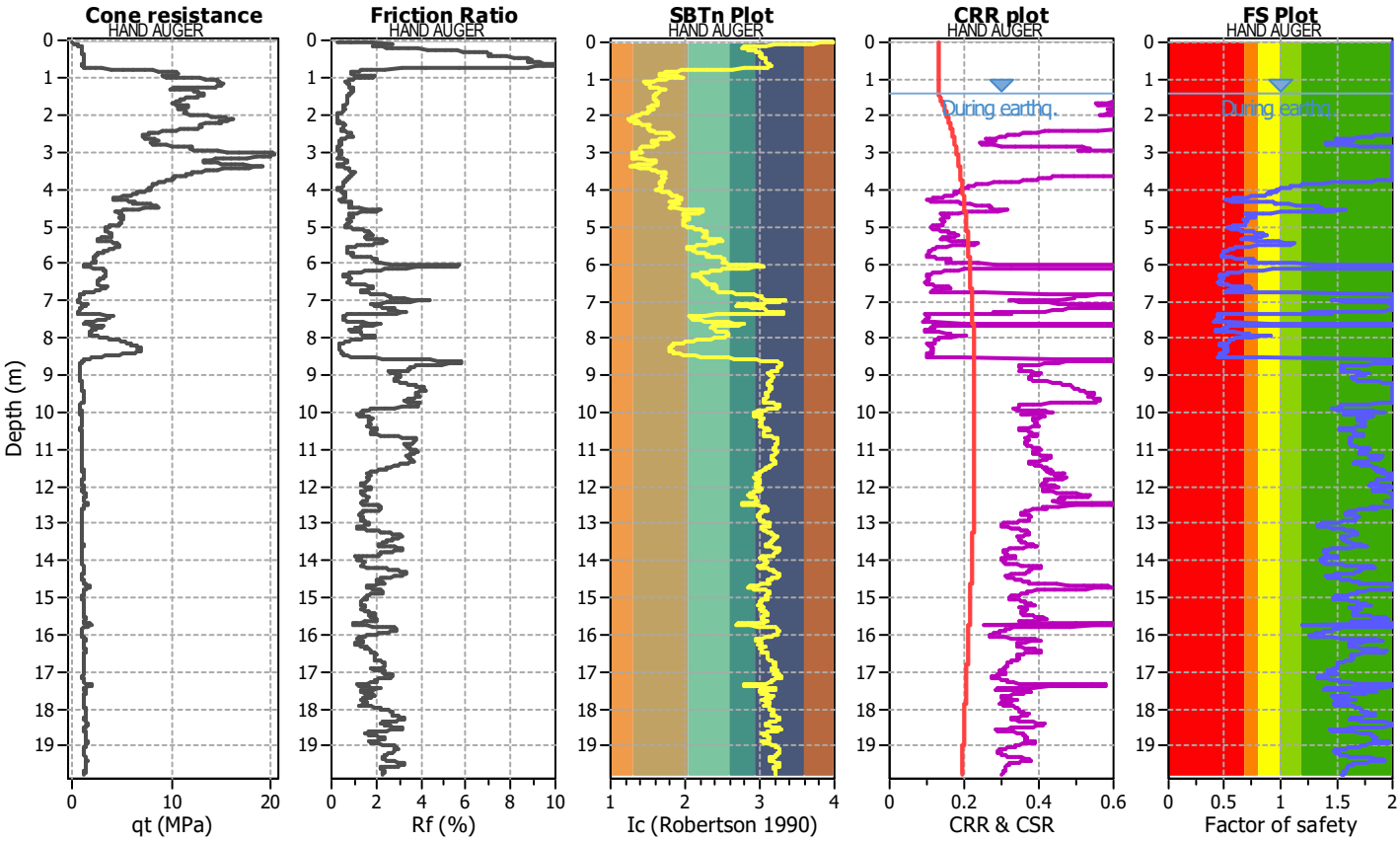
LIQUEFACTION ANALYSIS REPORT

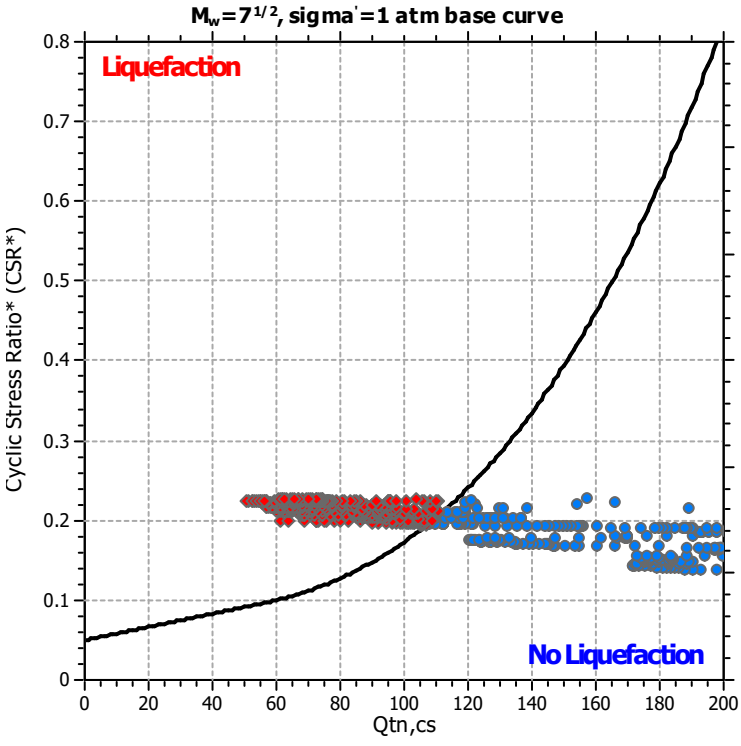
Project title : MS3 Rimini_RNN_01 **Location : Rimini**

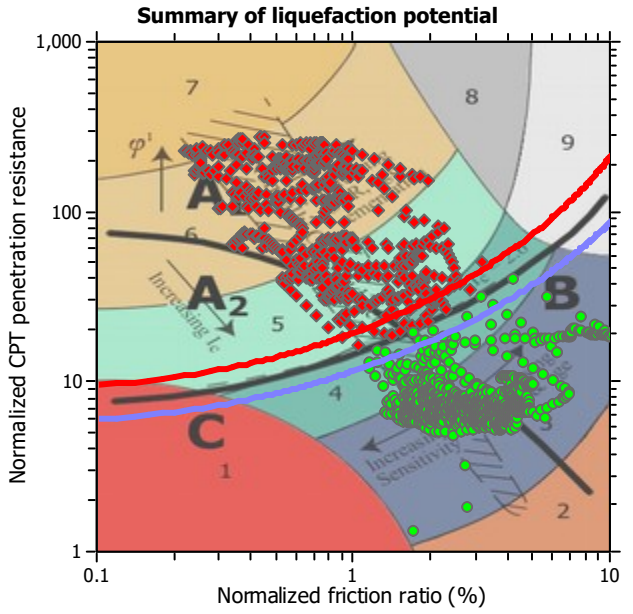
CPT file : 099014P1407

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.80 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.40 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

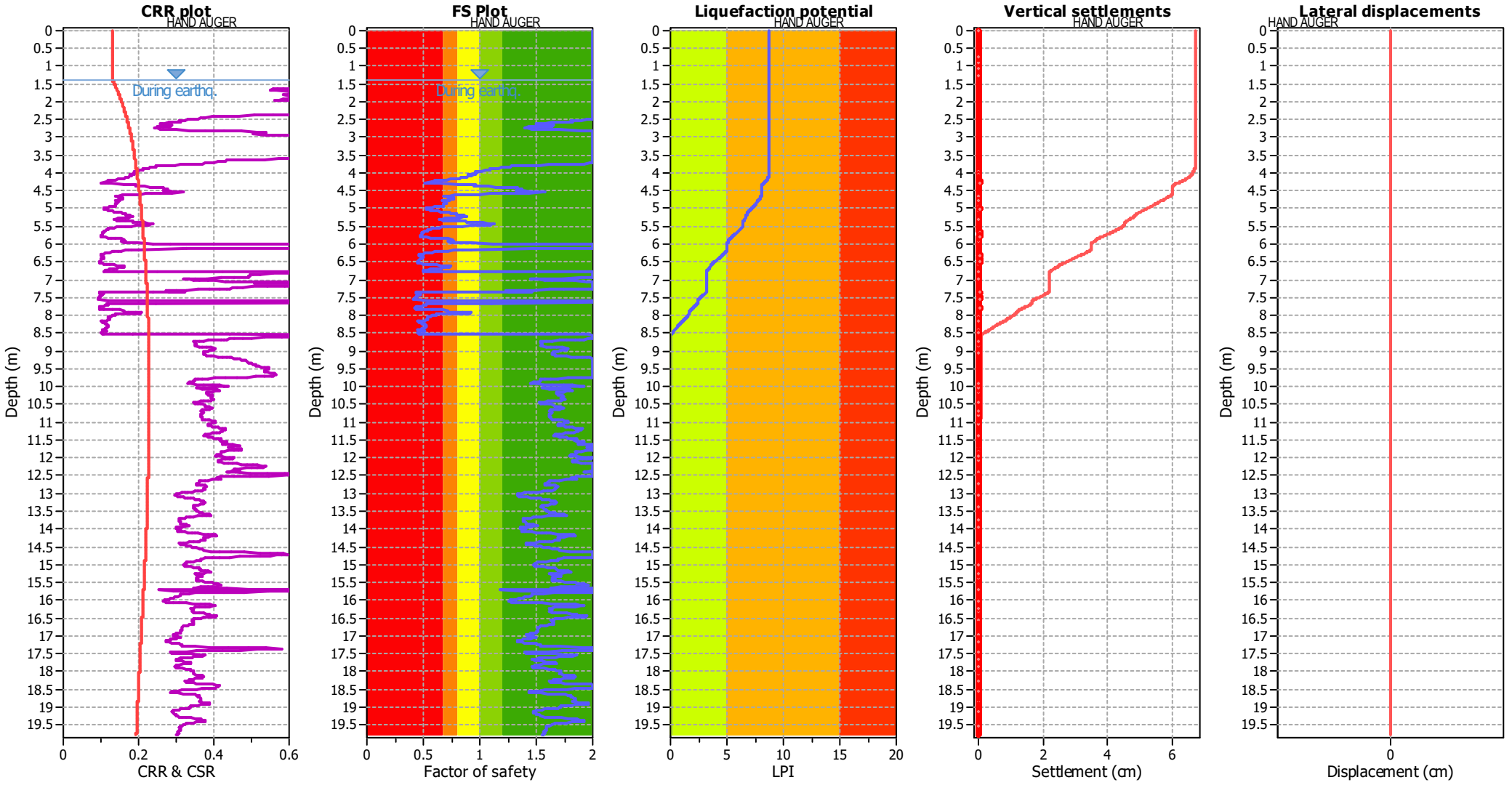






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.40 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

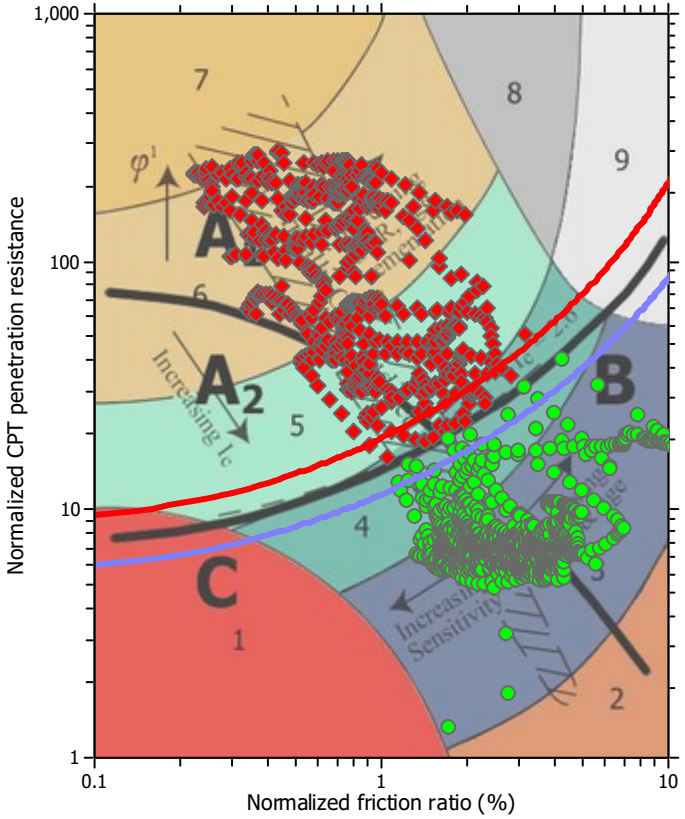
F.S. color scheme

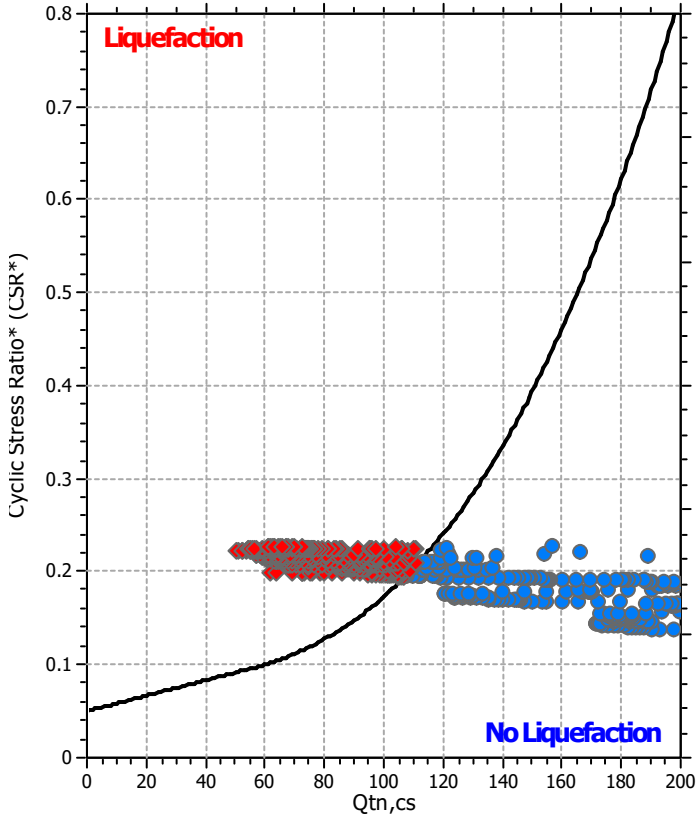
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

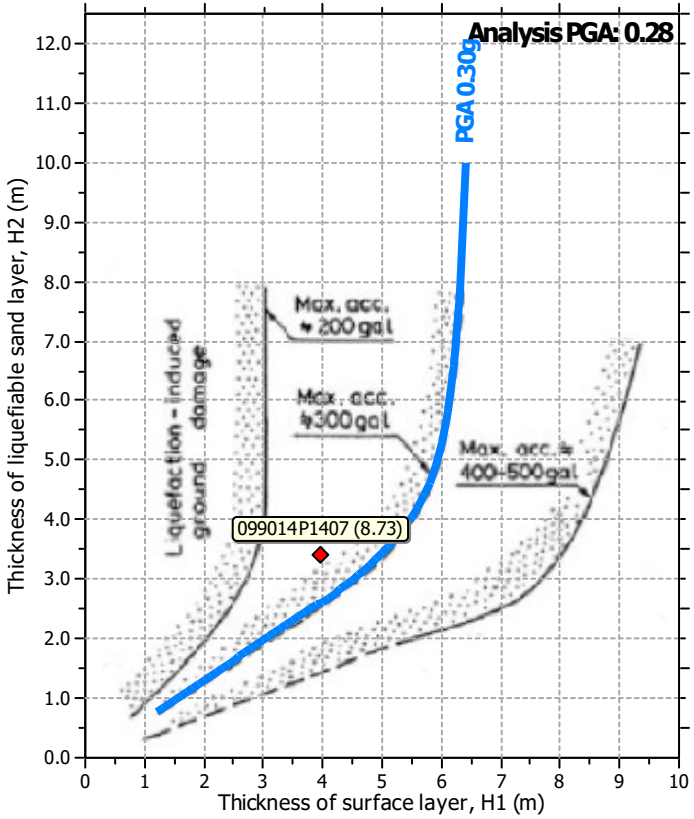
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.40 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

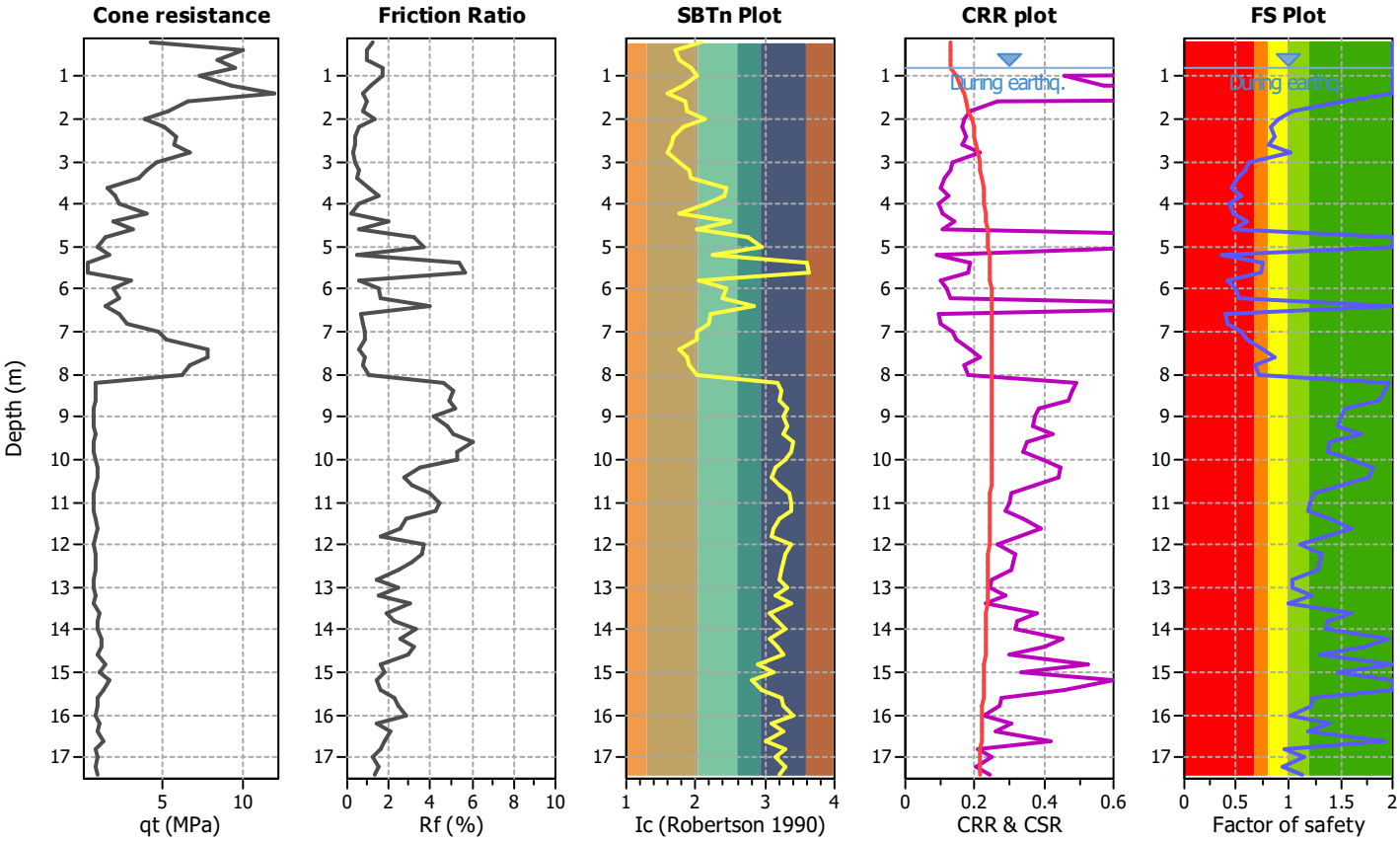
LIQUEFACTION ANALYSIS REPORT

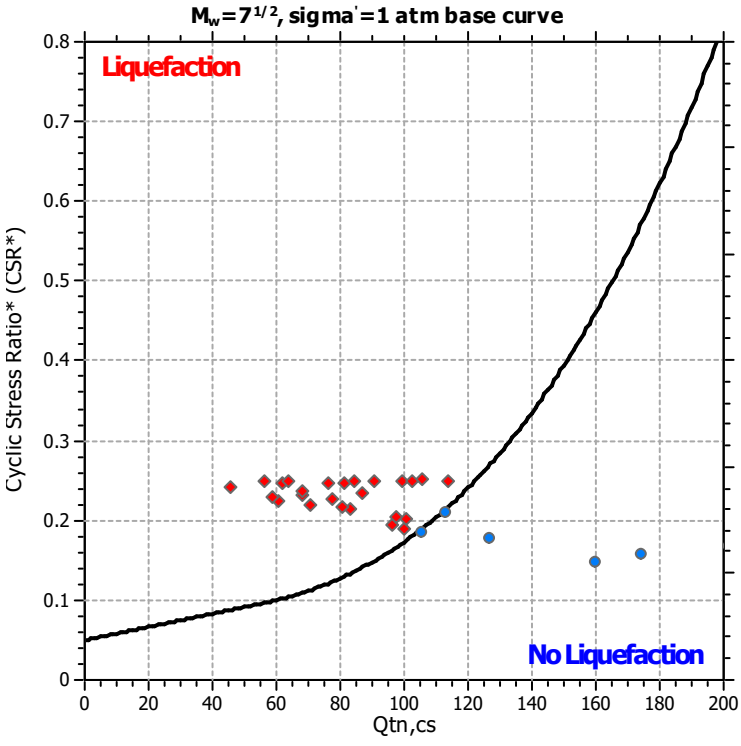
Project title : MS3 Rimini_RNN_01 **Location : Rimini**

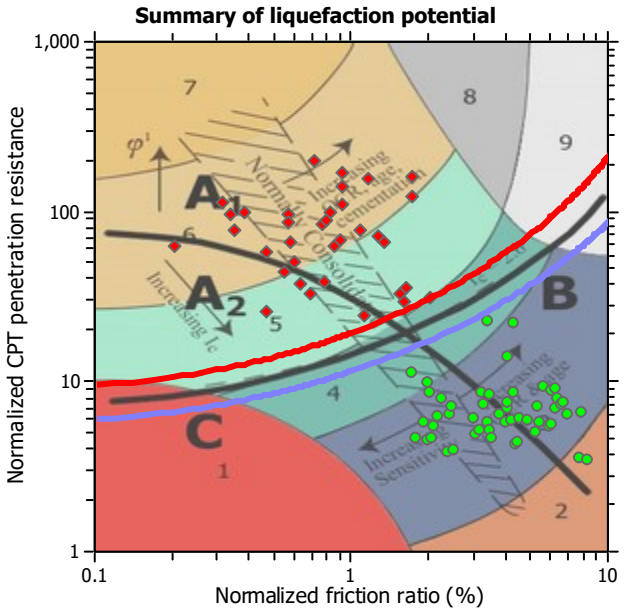
CPT file : 099014P297

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	0.80 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	1	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

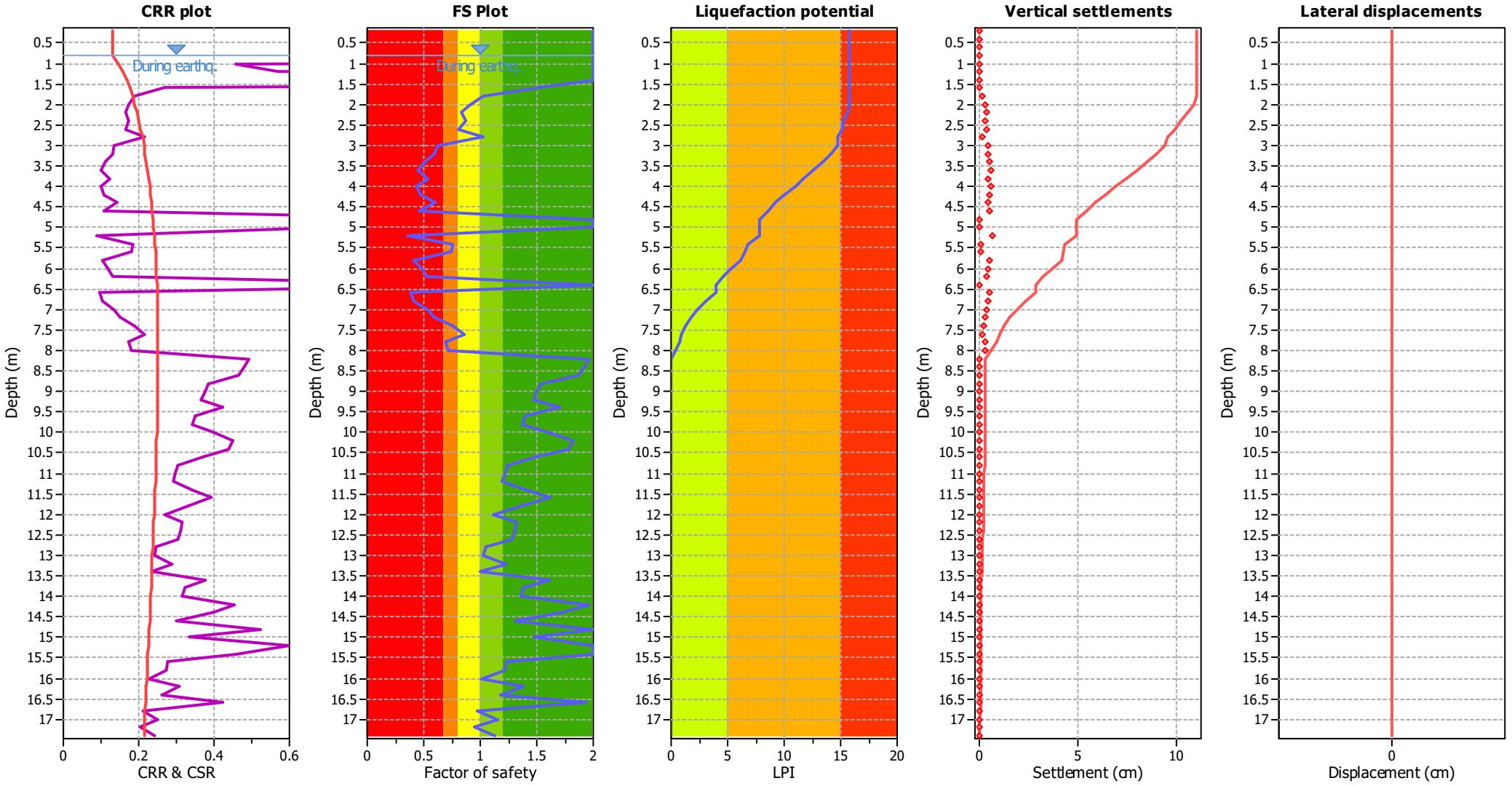






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	1	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.80 m	Fill height:	N/A	Limit depth:	N/A

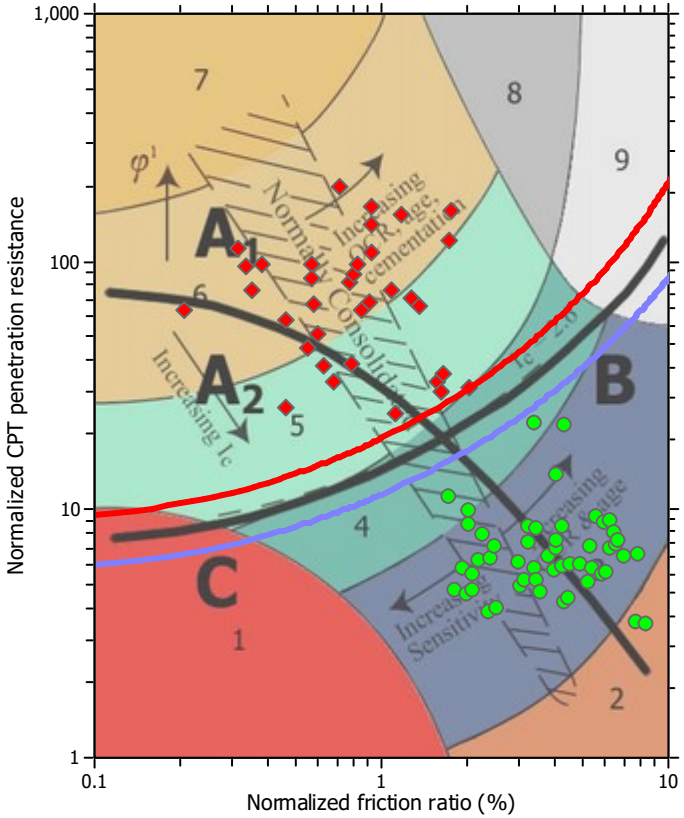
F.S. color scheme

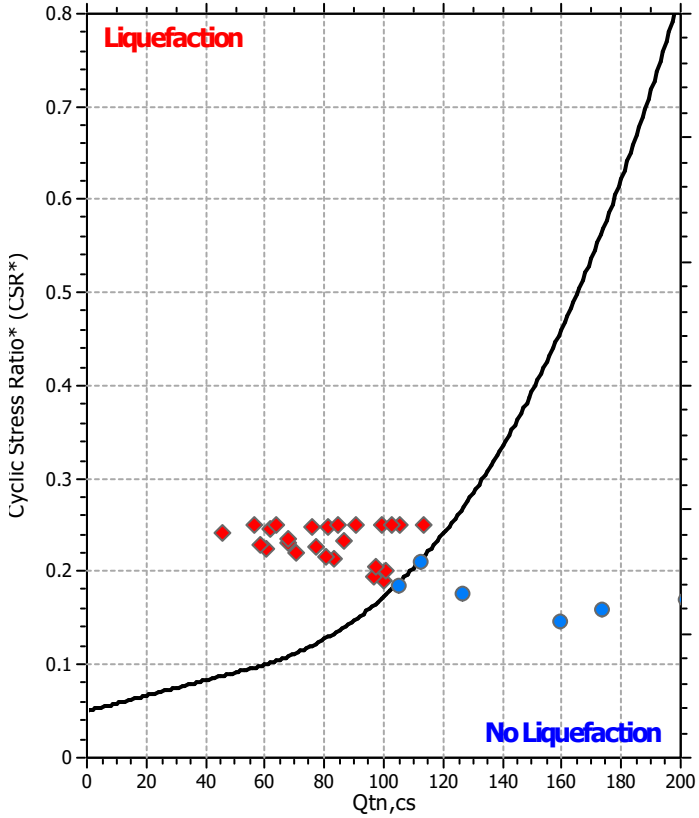
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

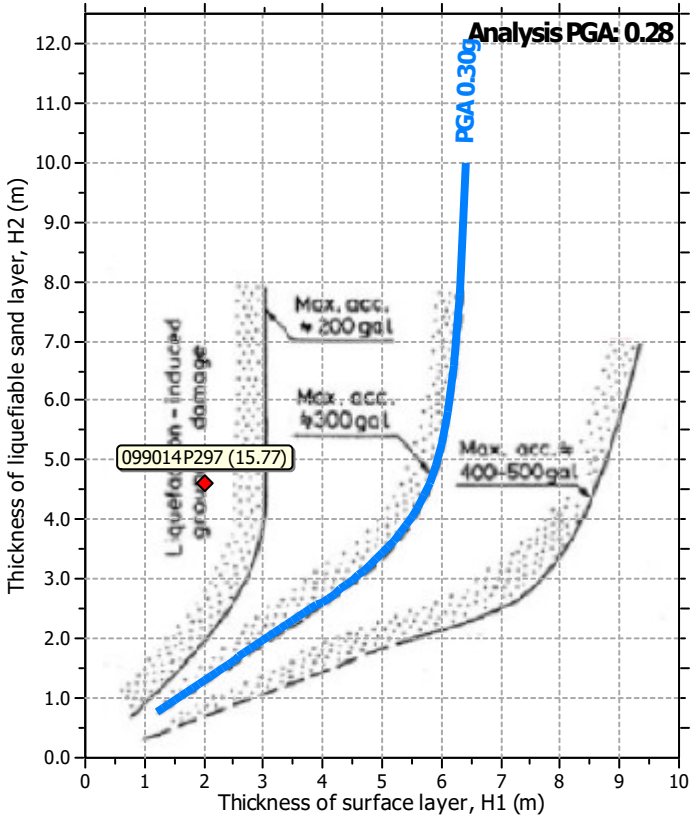
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	1	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.80 m	Fill height:	N/A	Limit depth:	N/A

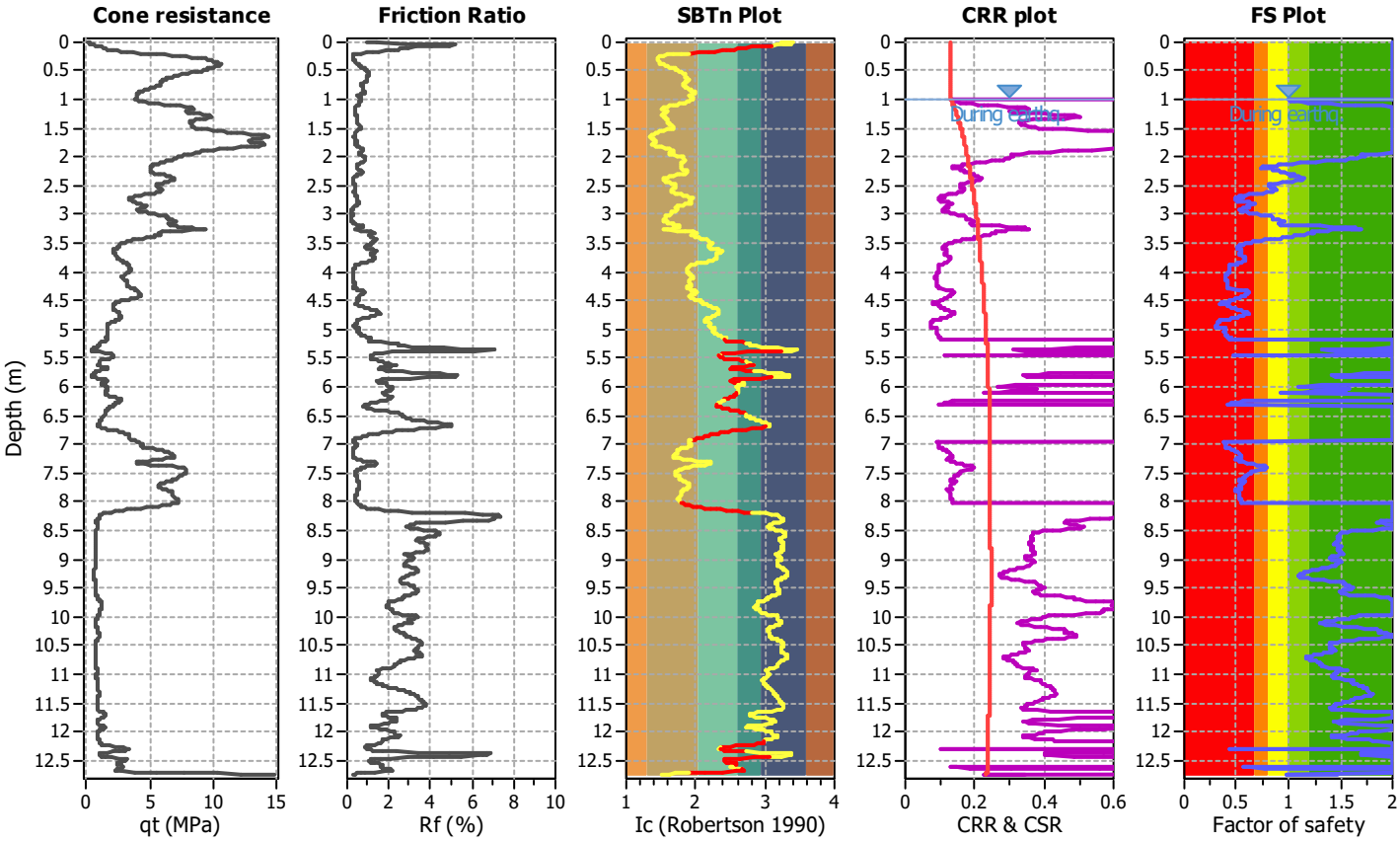
LIQUEFACTION ANALYSIS REPORT

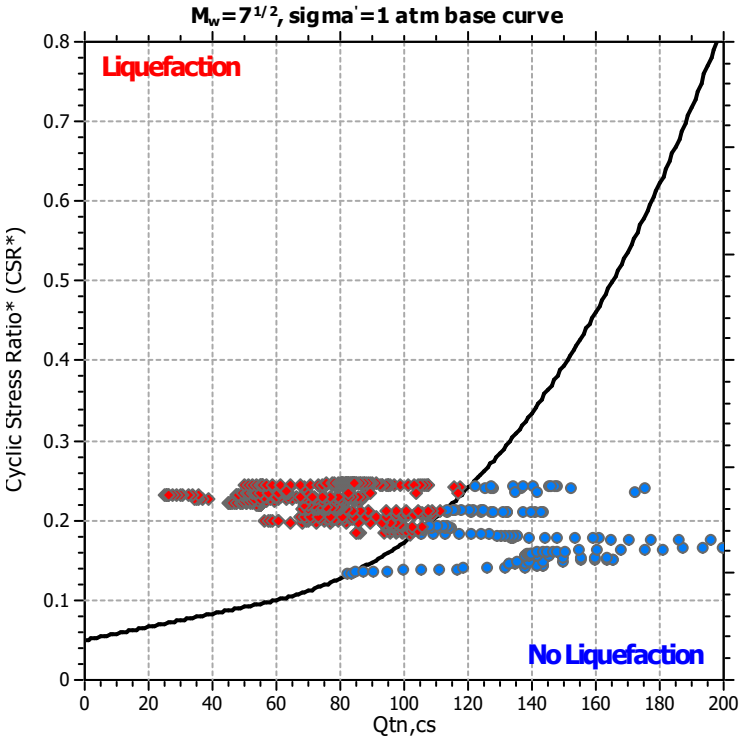
Project title : MS3 Rimini_RNN_01 **Location : Rimini**

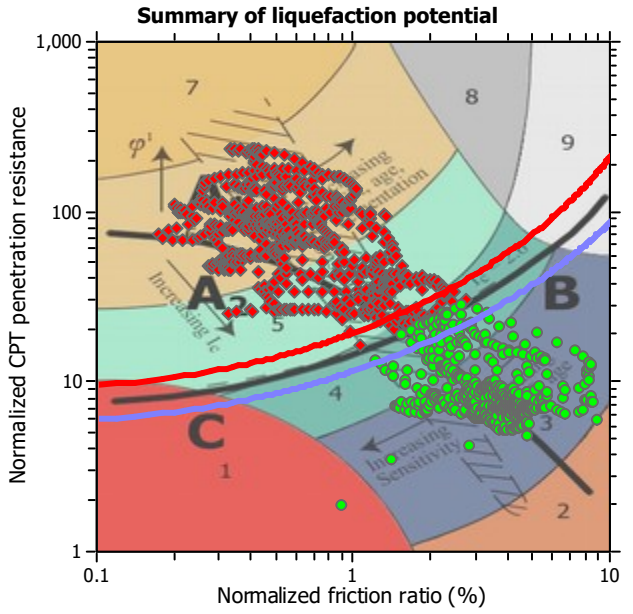
CPT file : CPTe_08

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.30 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

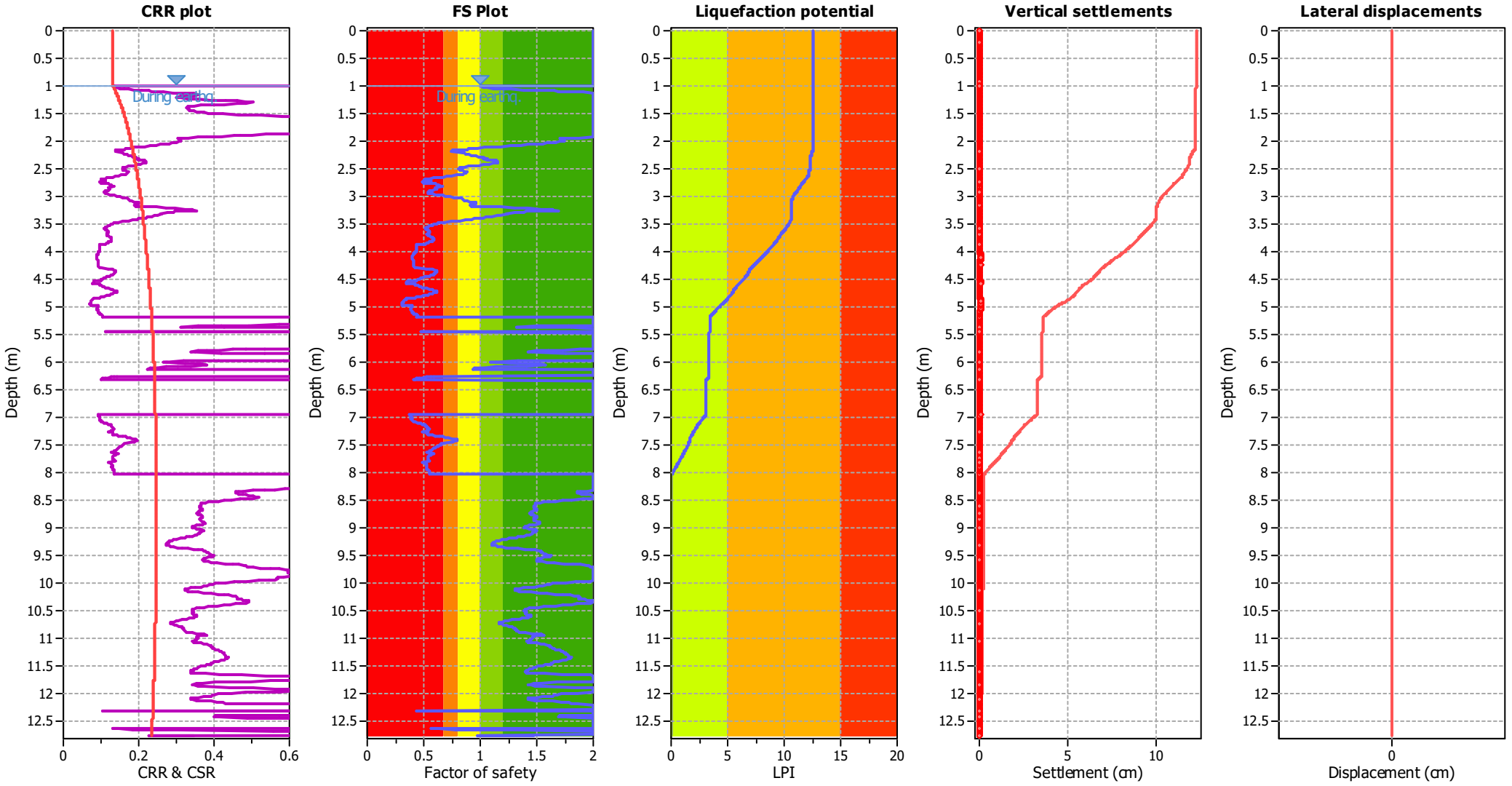






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.30 m	Fill height:	N/A	Limit depth:	20.00 m

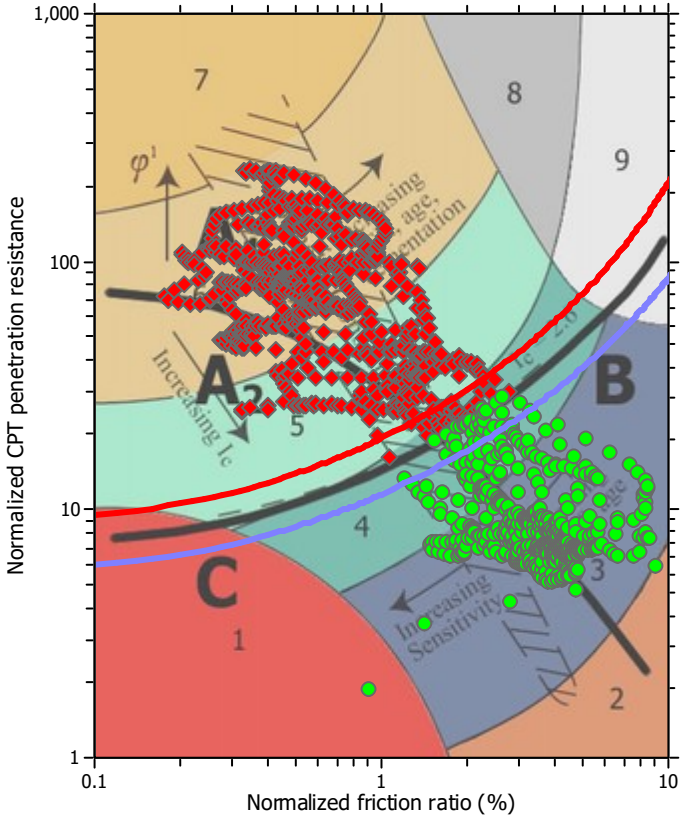
F.S. color scheme

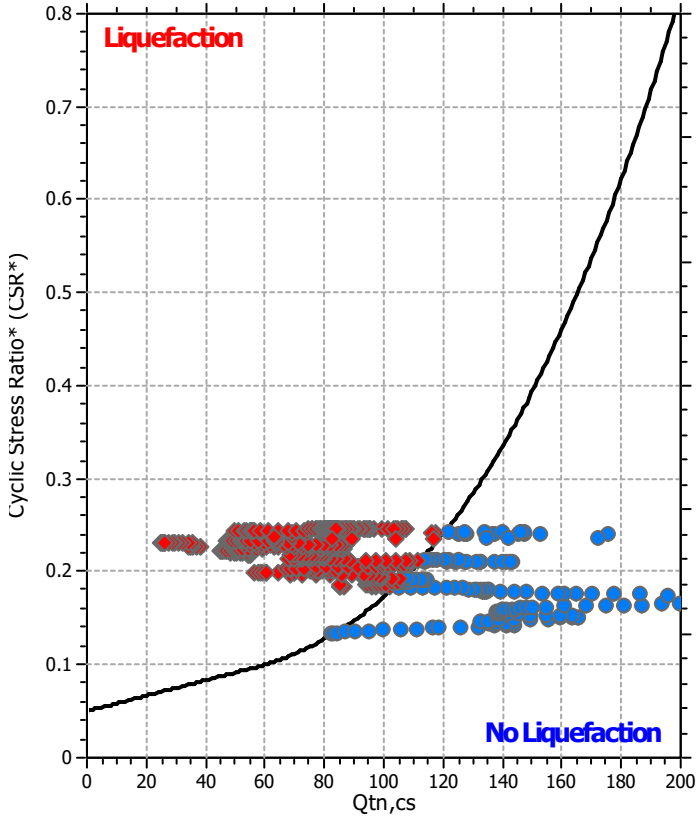
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

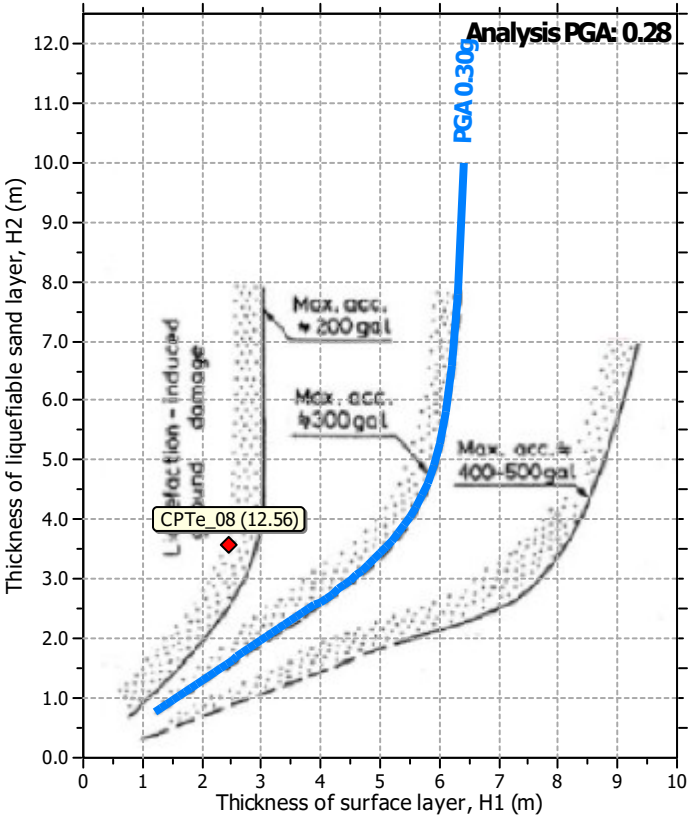
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.30 m	Fill height:	N/A	Limit depth:	20.00 m

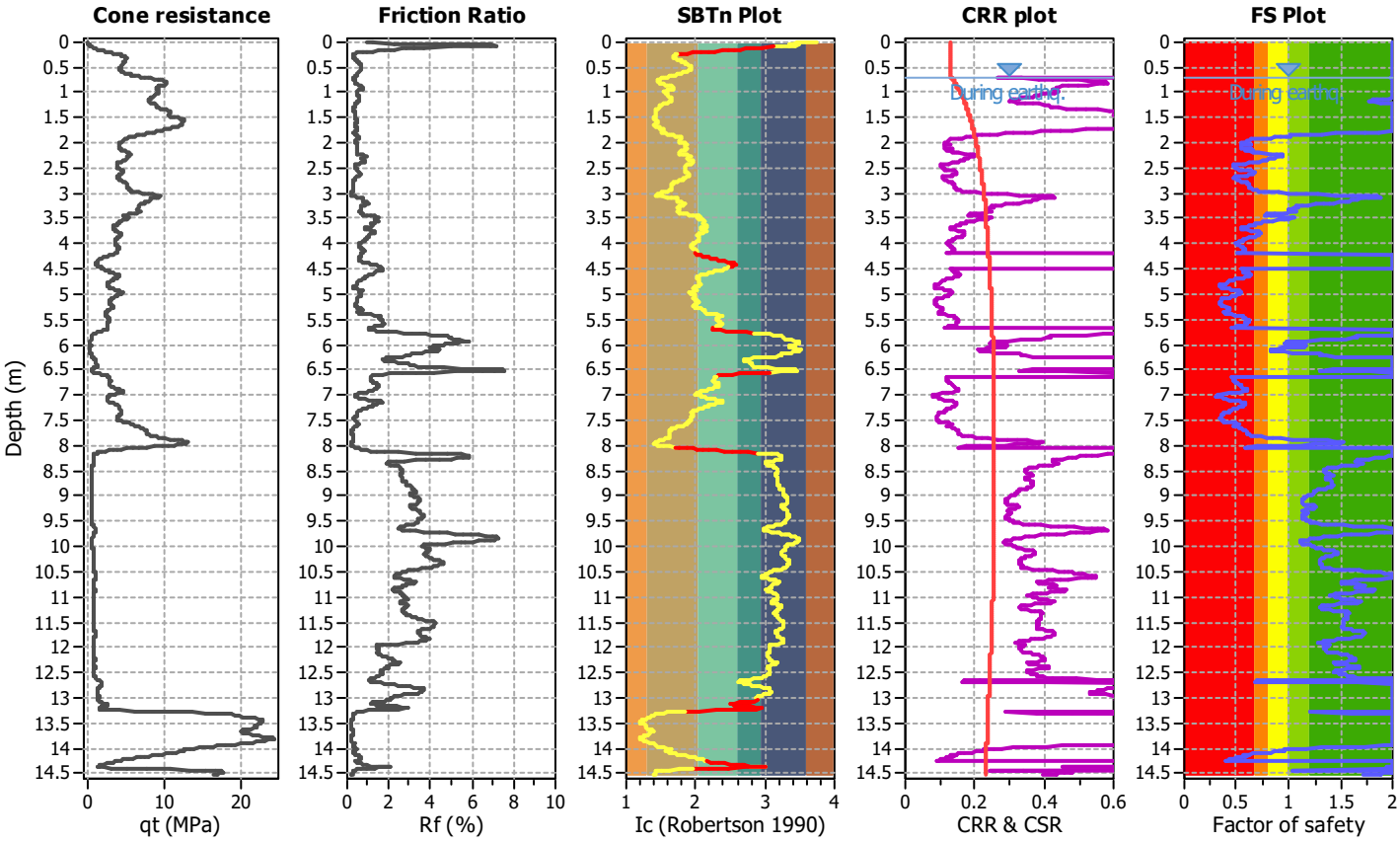
LIQUEFACTION ANALYSIS REPORT

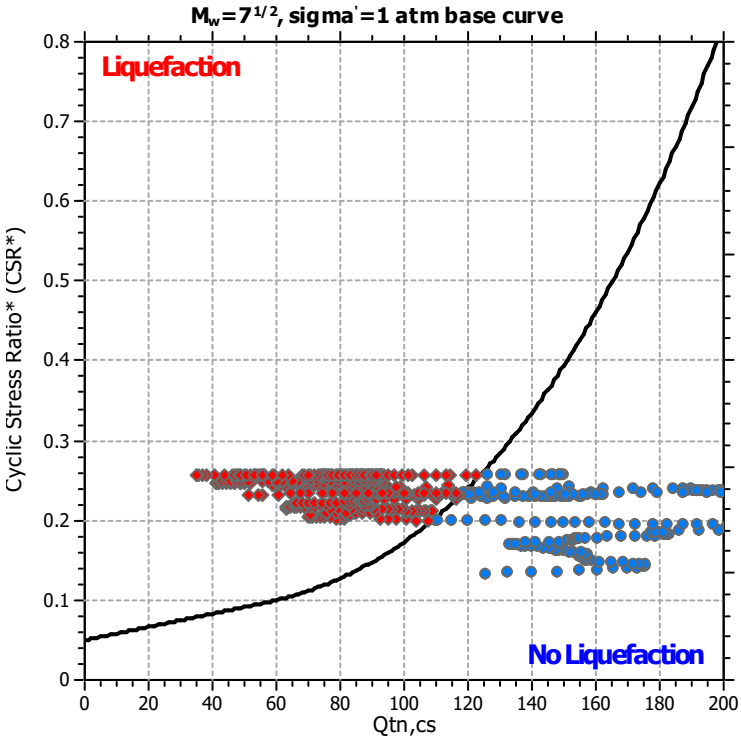
Project title : MS3 Rimini_RNN_01 **Location : Rimini**

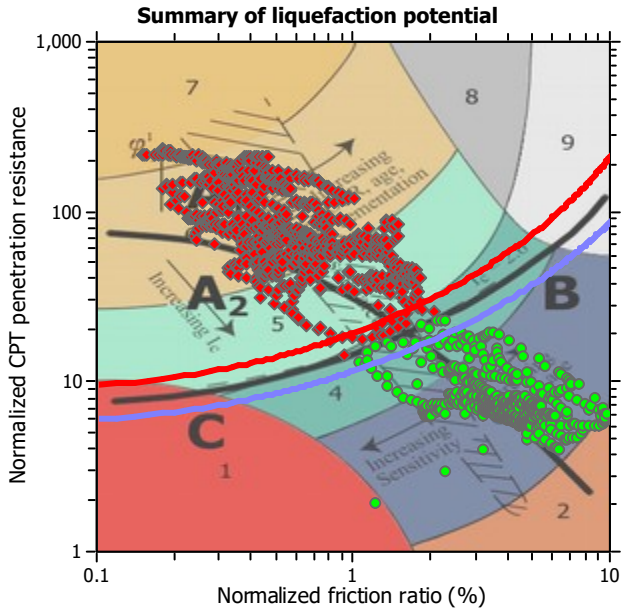
CPT file : CPTe_09

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.70 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

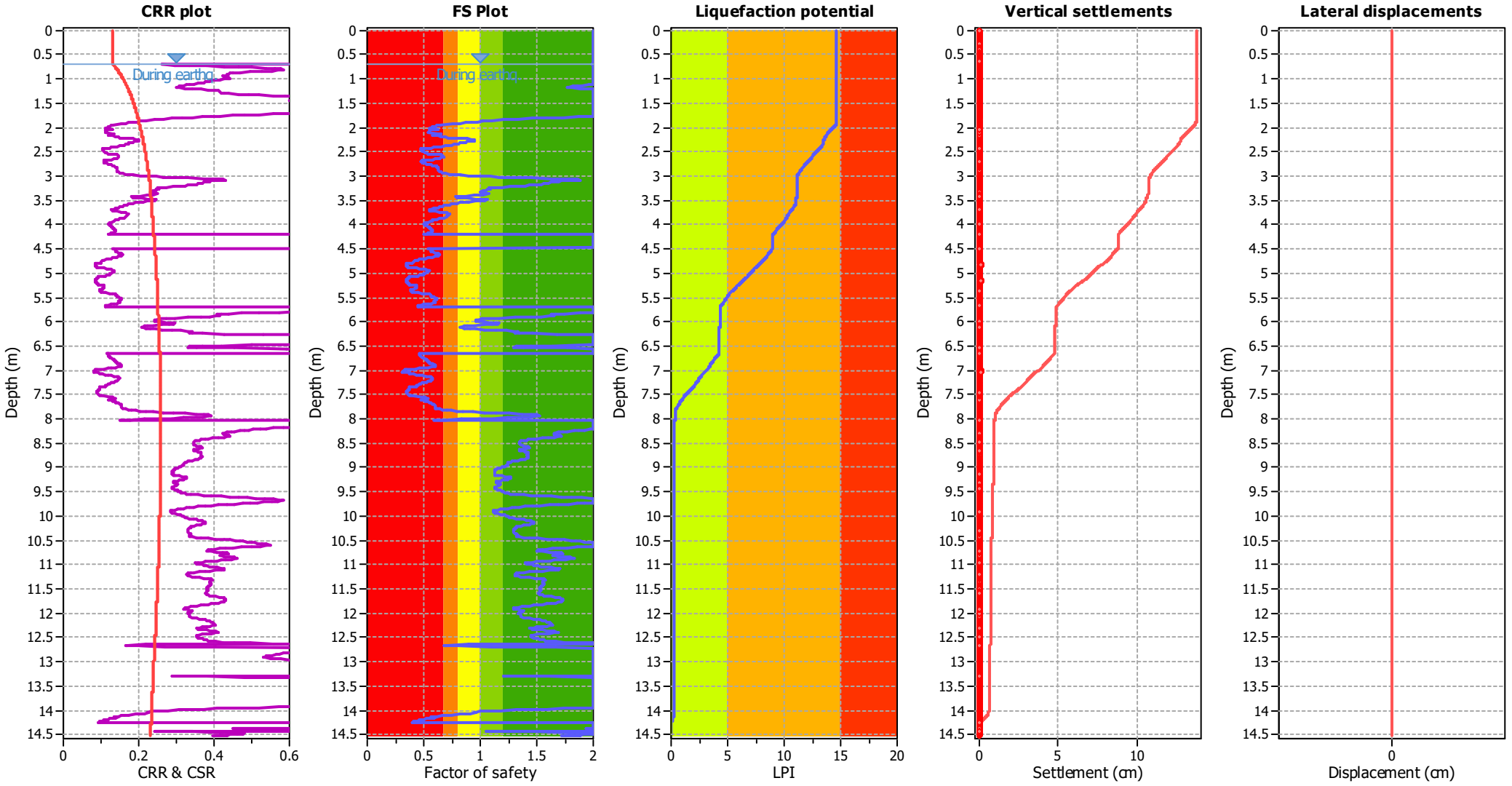






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

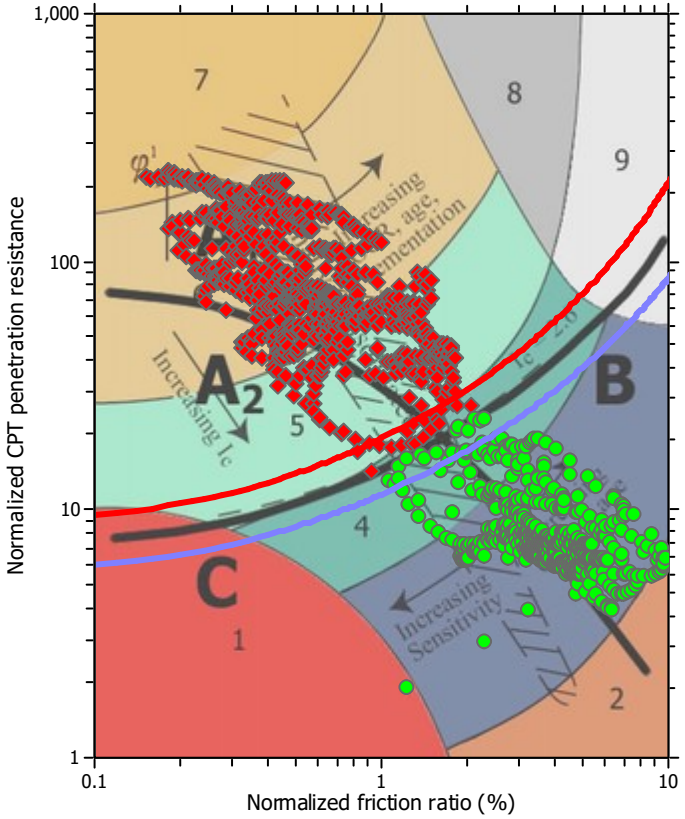
F.S. color scheme

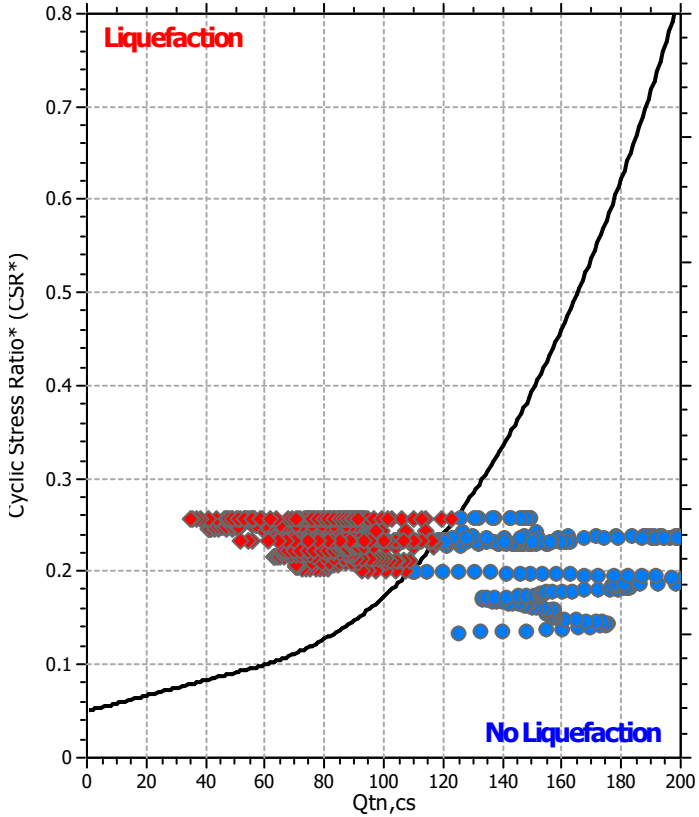
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

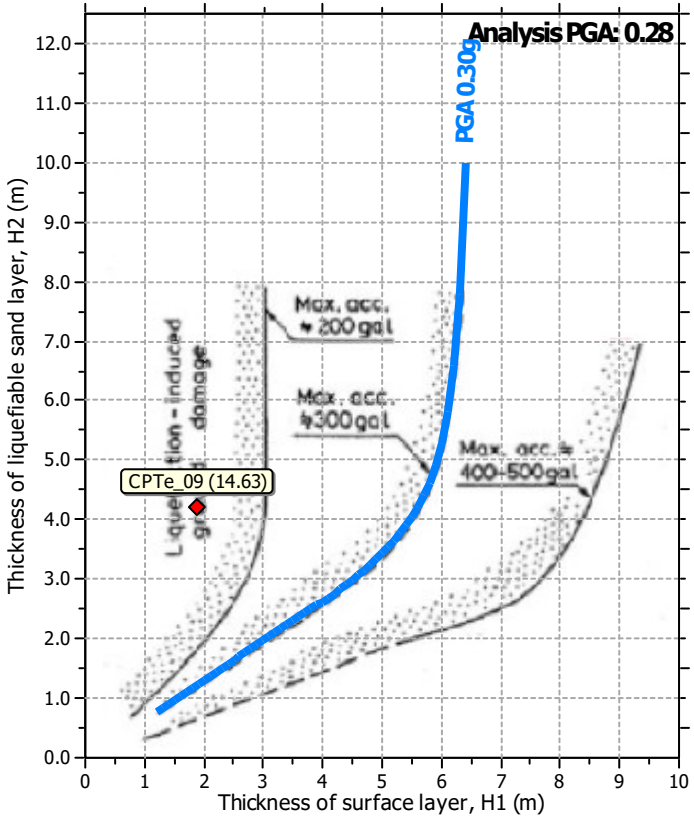
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

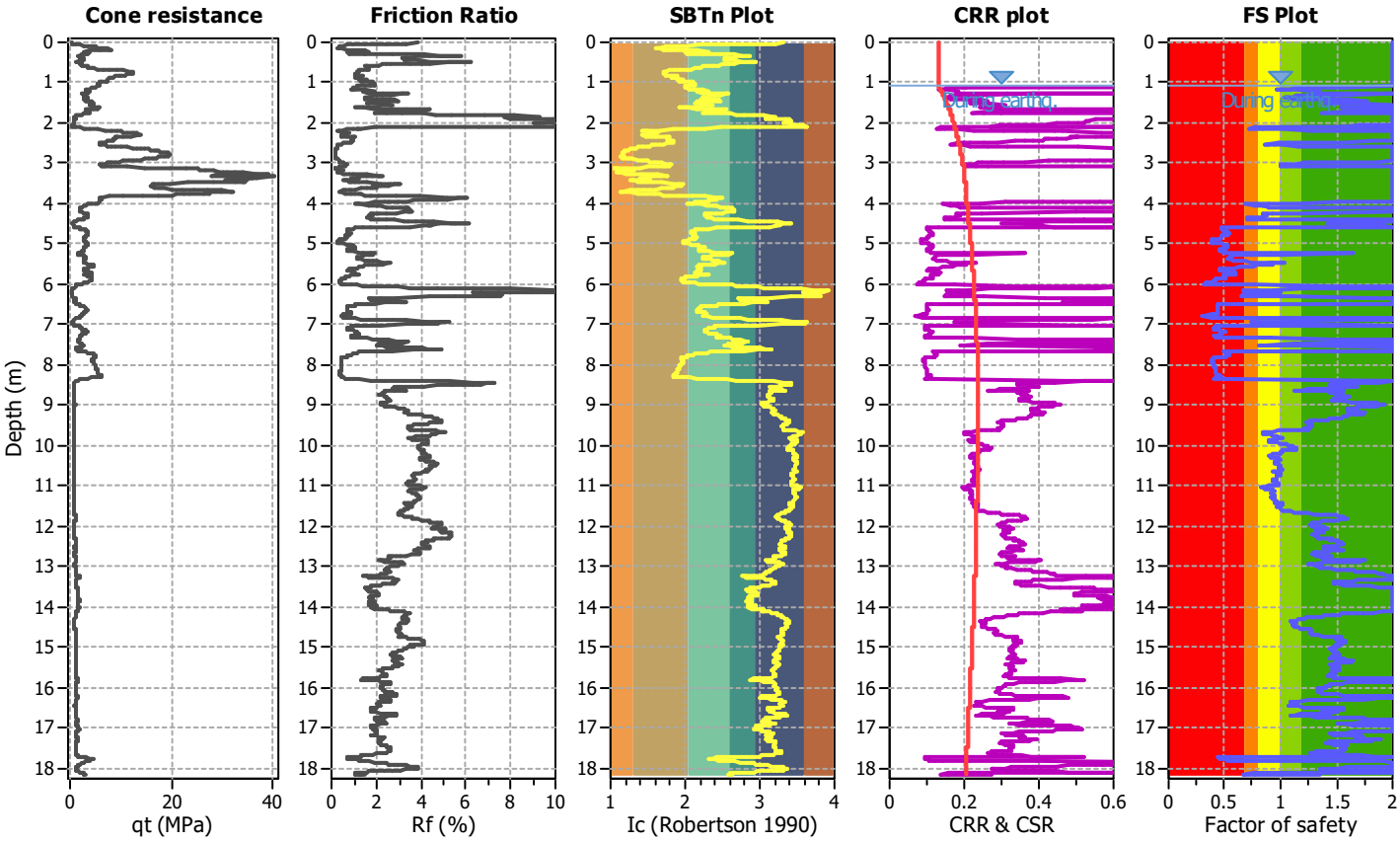
LIQUEFACTION ANALYSIS REPORT

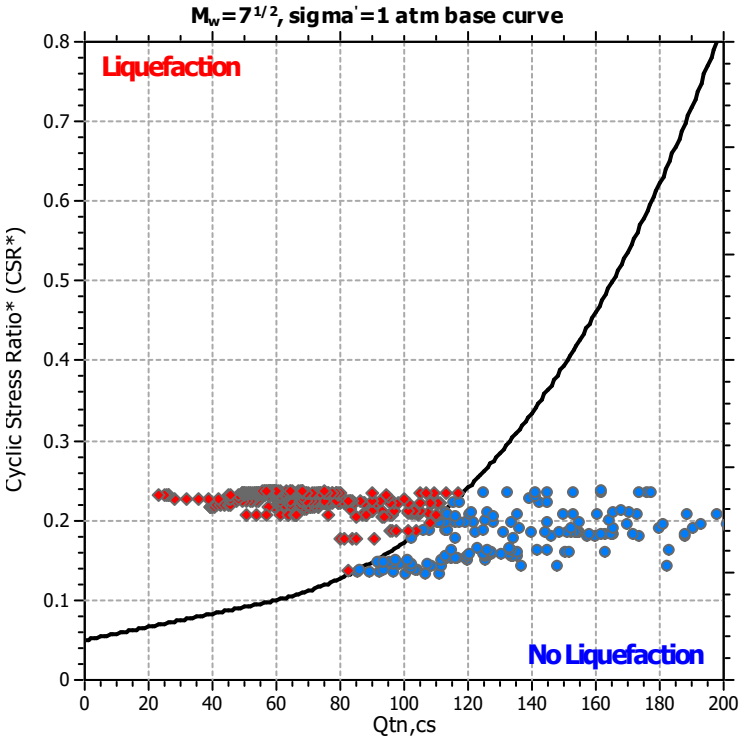
Project title : MS3 Rimini_RNN_01 **Location : Rimini**

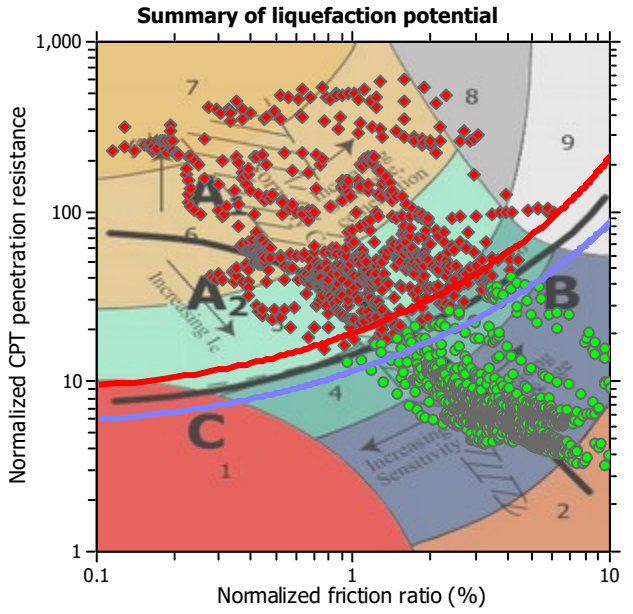
CPT file : 099014P1444

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.50 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.10 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

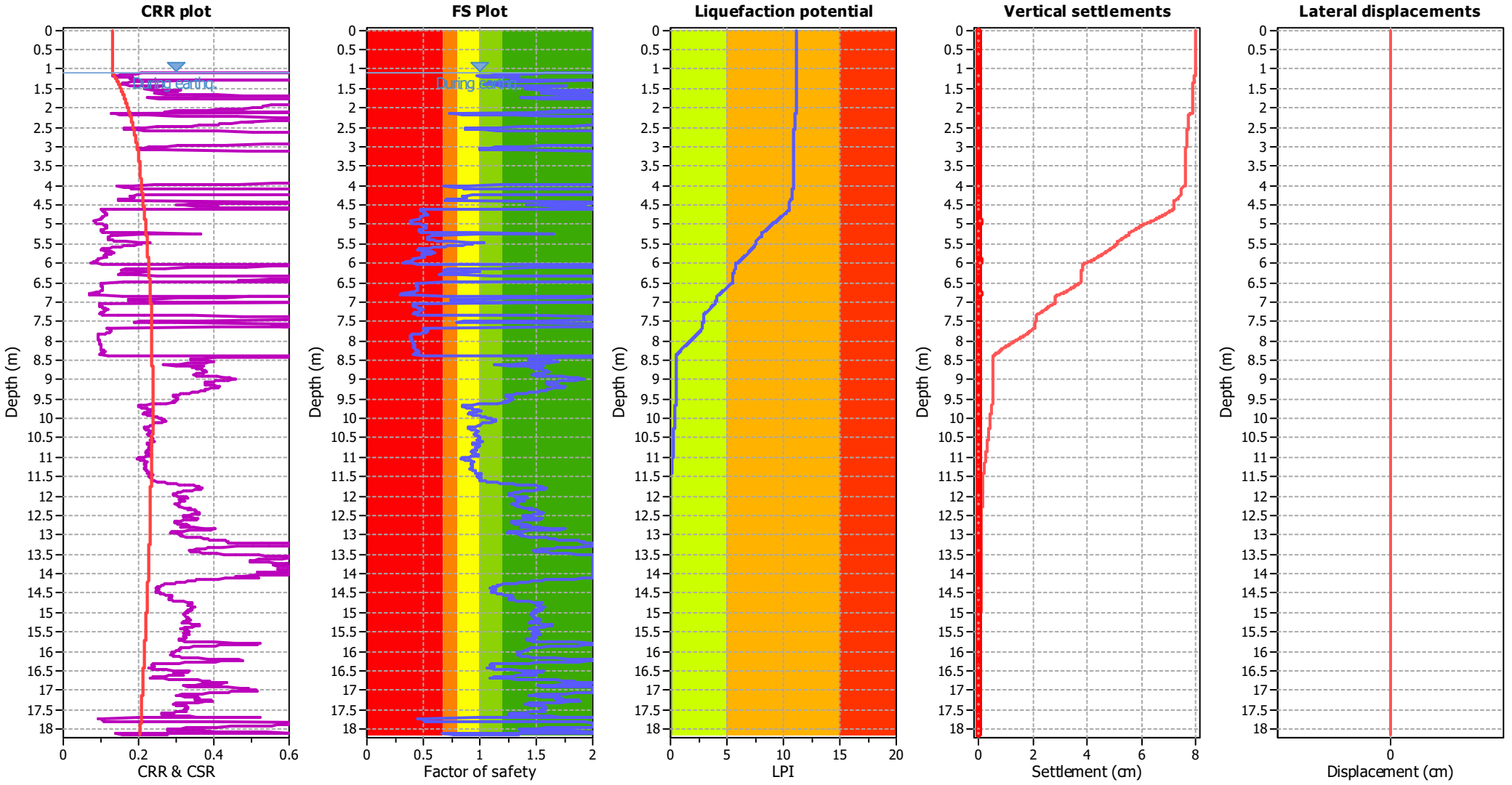






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.10 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

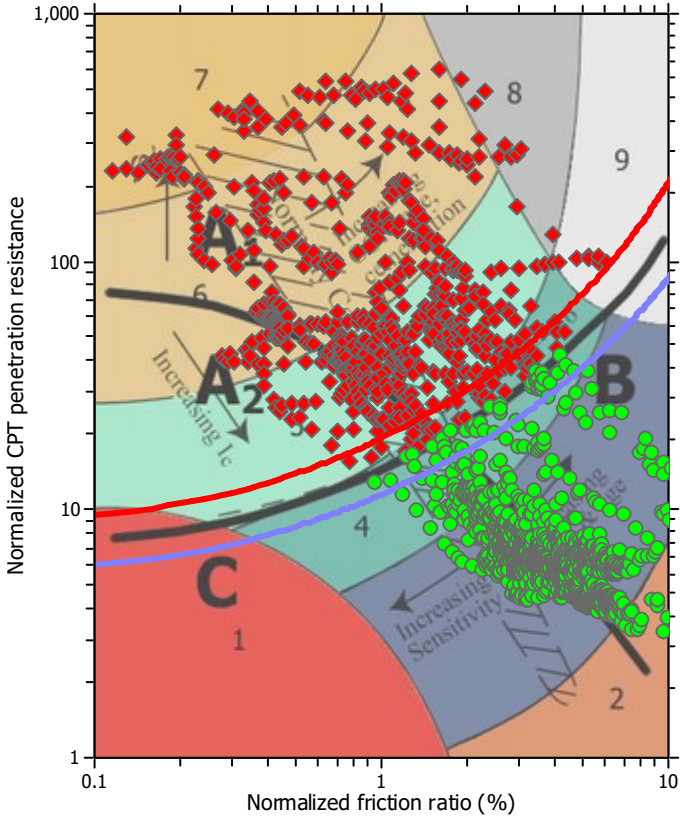
F.S. color scheme

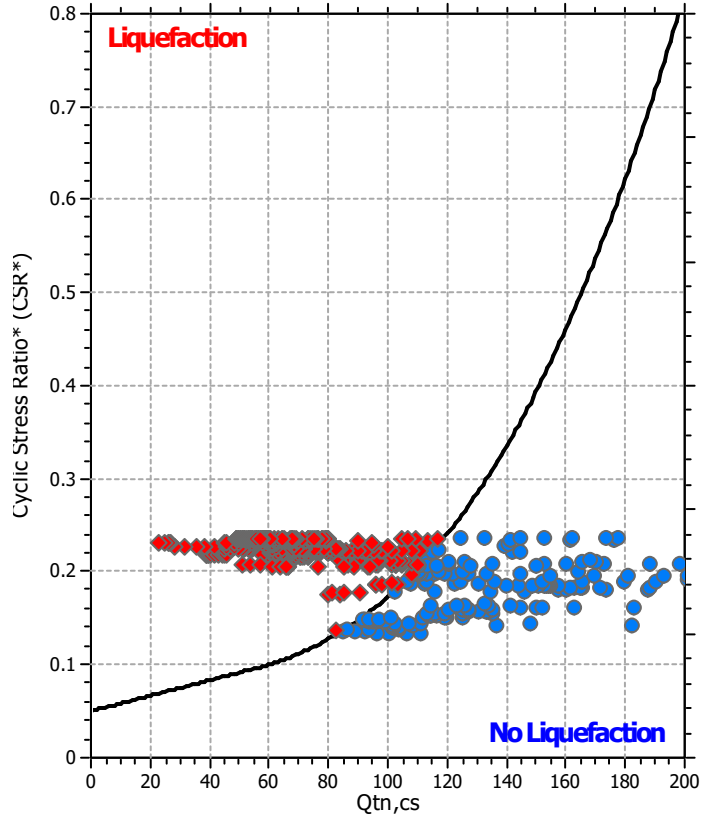
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

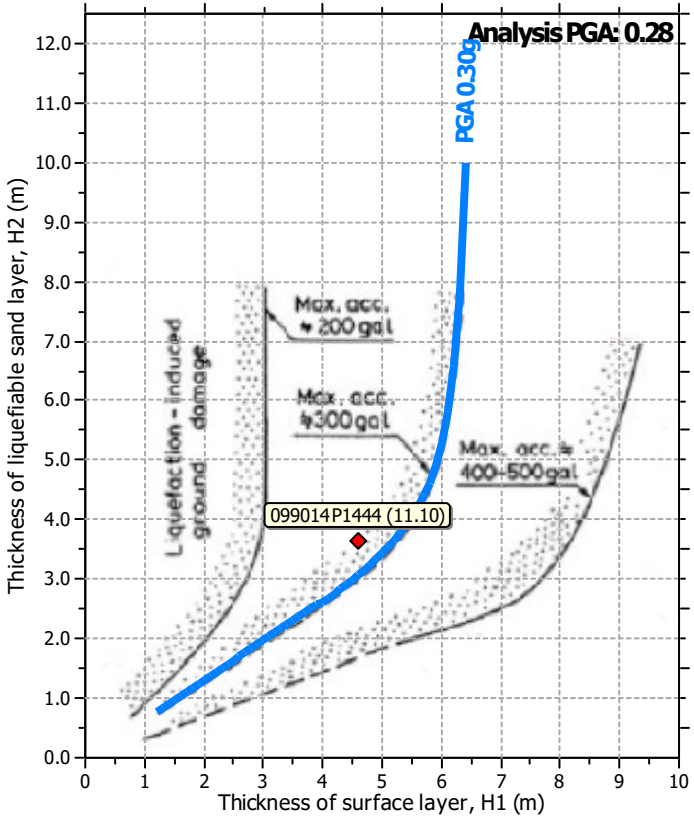
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.10 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

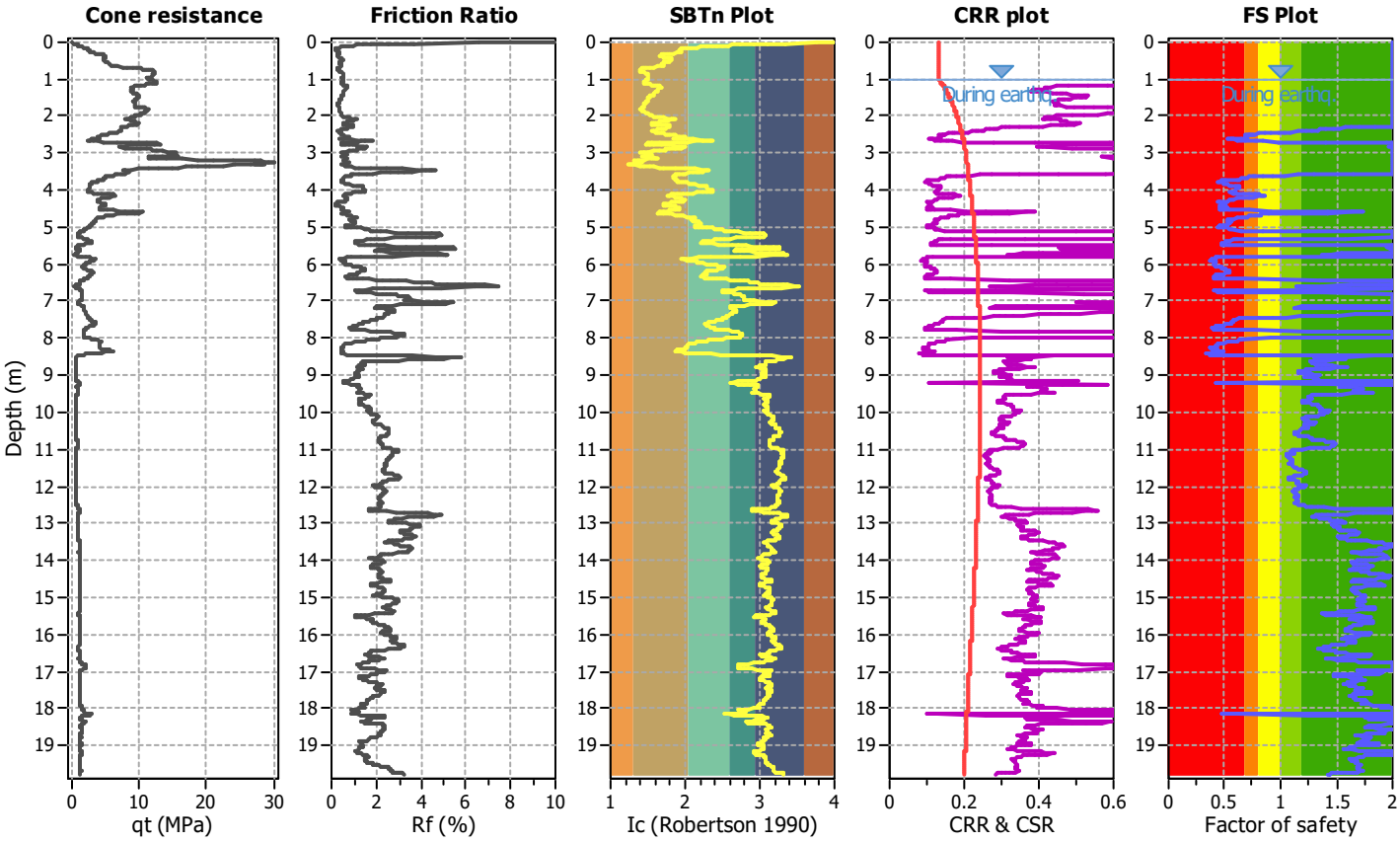
LIQUEFACTION ANALYSIS REPORT

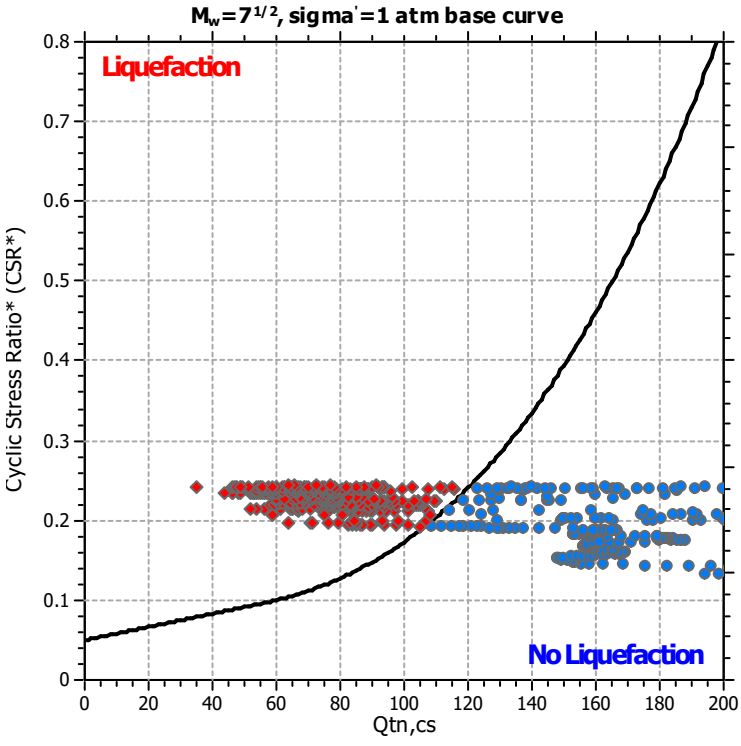
Project title : MS3 Rimini_RNN_01 **Location : Rimini**

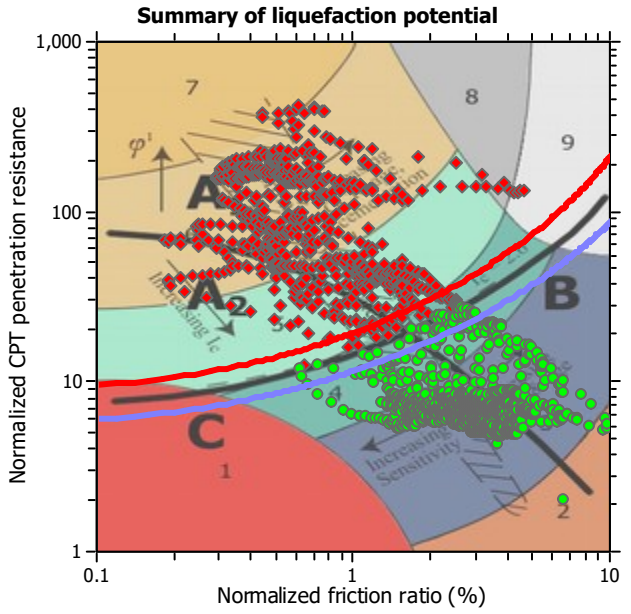
CPT file : 099014P1413

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.50 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.28	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

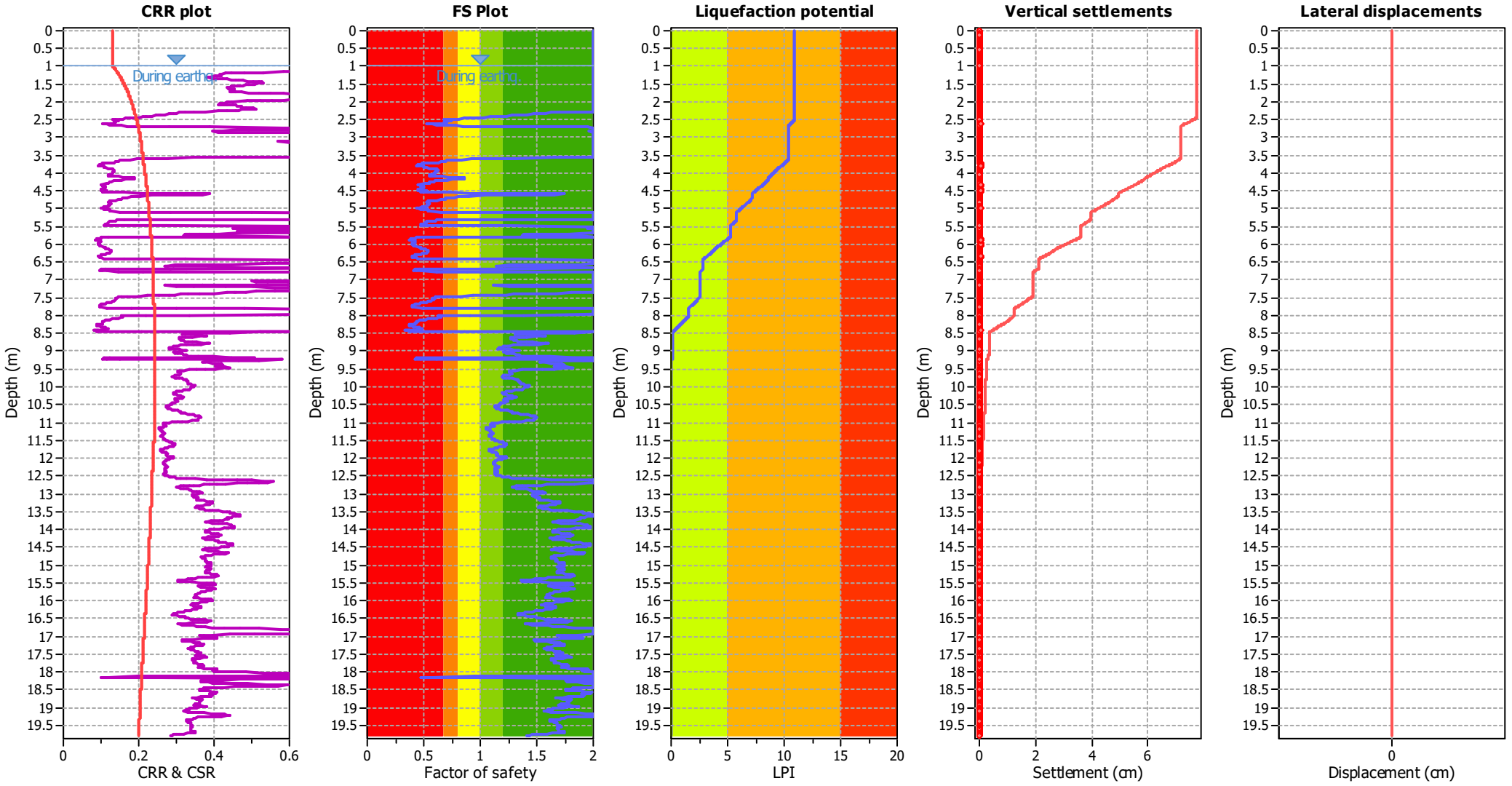






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

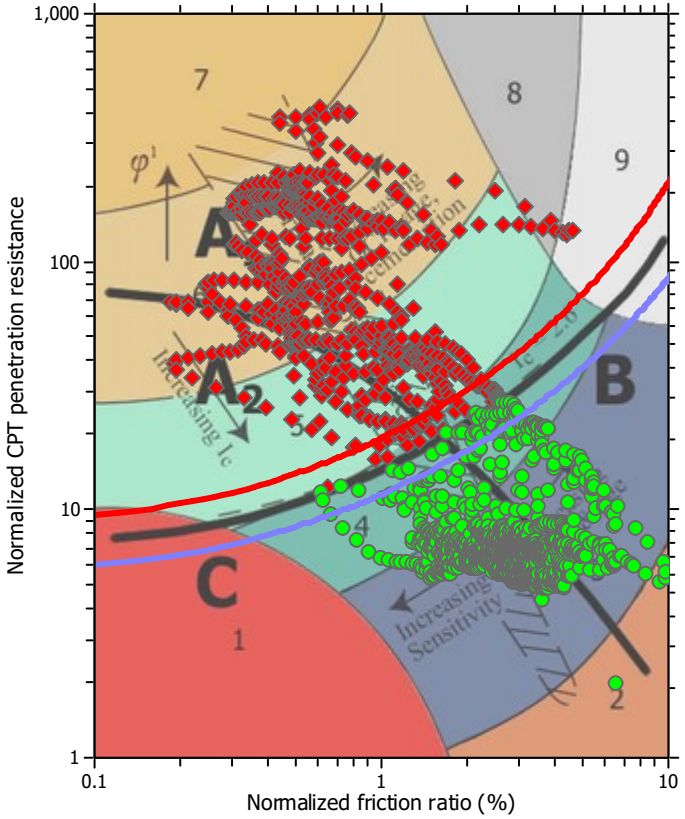
F.S. color scheme

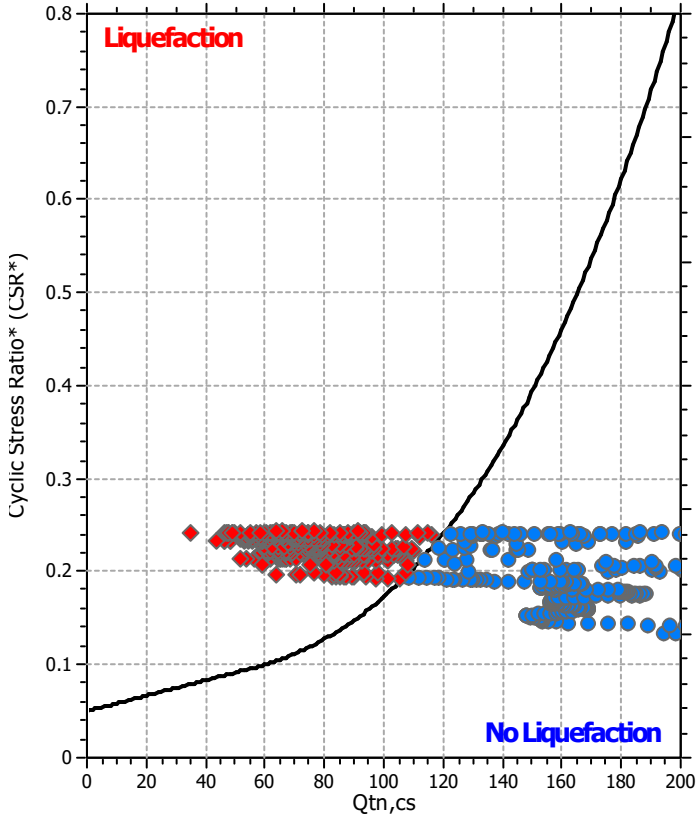
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

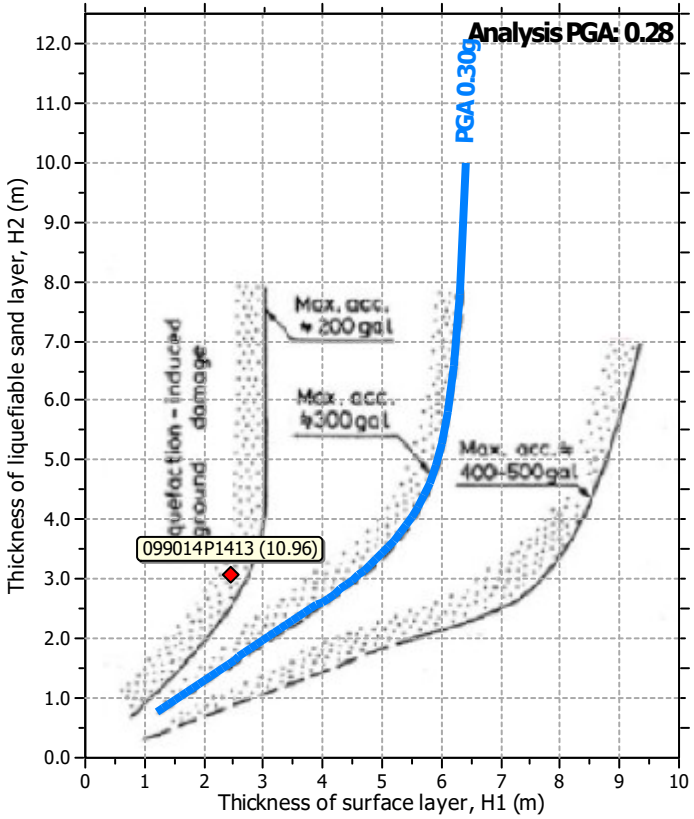
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.28	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	N/A

REPORT - ZONA RNC

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

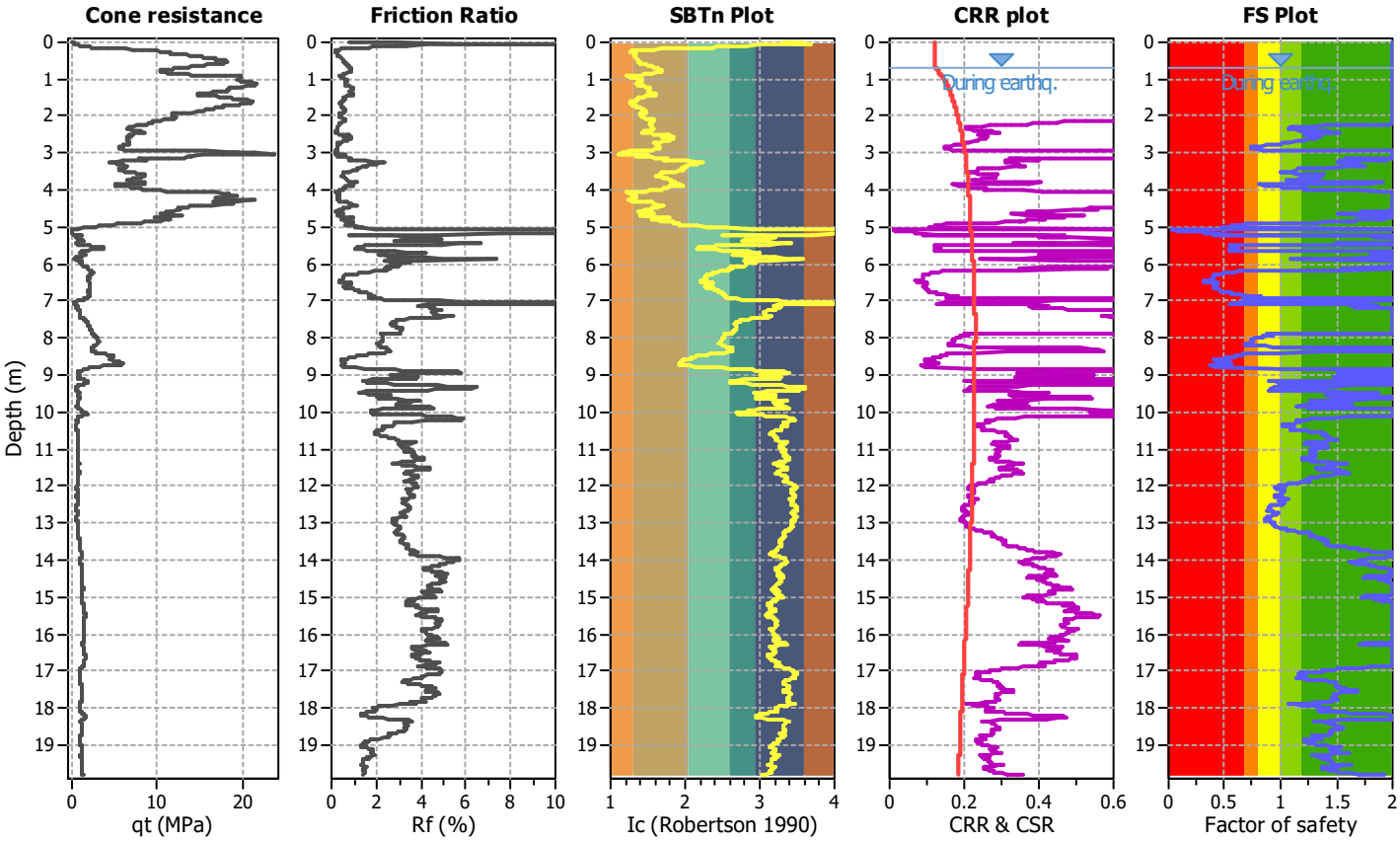
LIQUEFACTION ANALYSIS REPORT

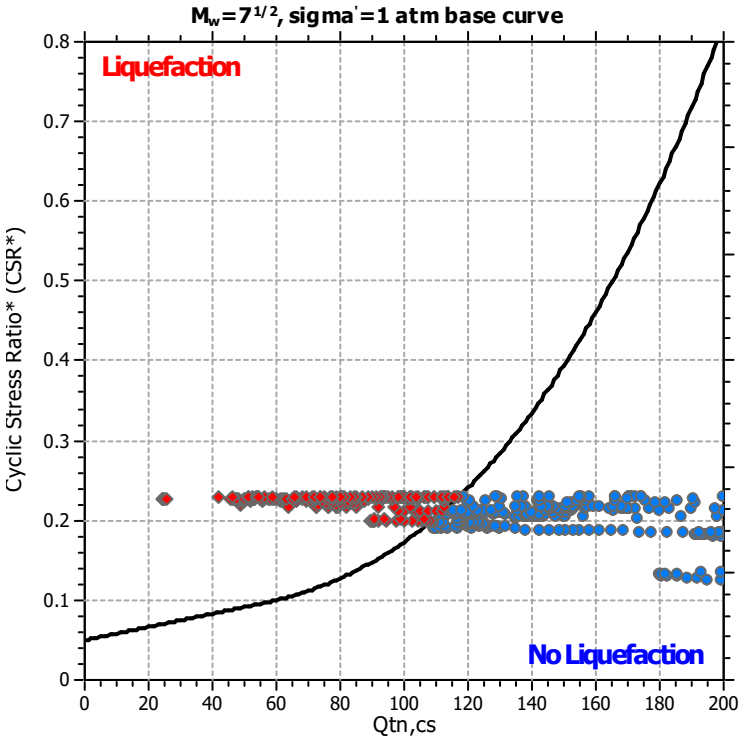
Project title : MS3 Rimini_RNC **Location : Rimini**

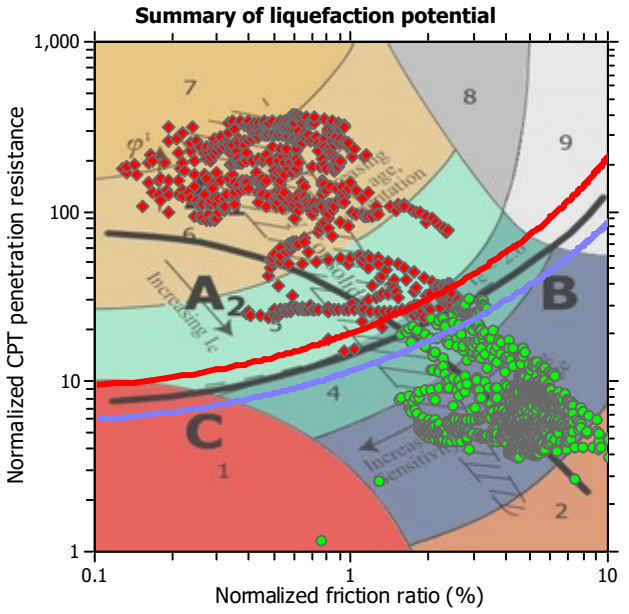
CPT file : CPTe_10

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.20 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.70 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

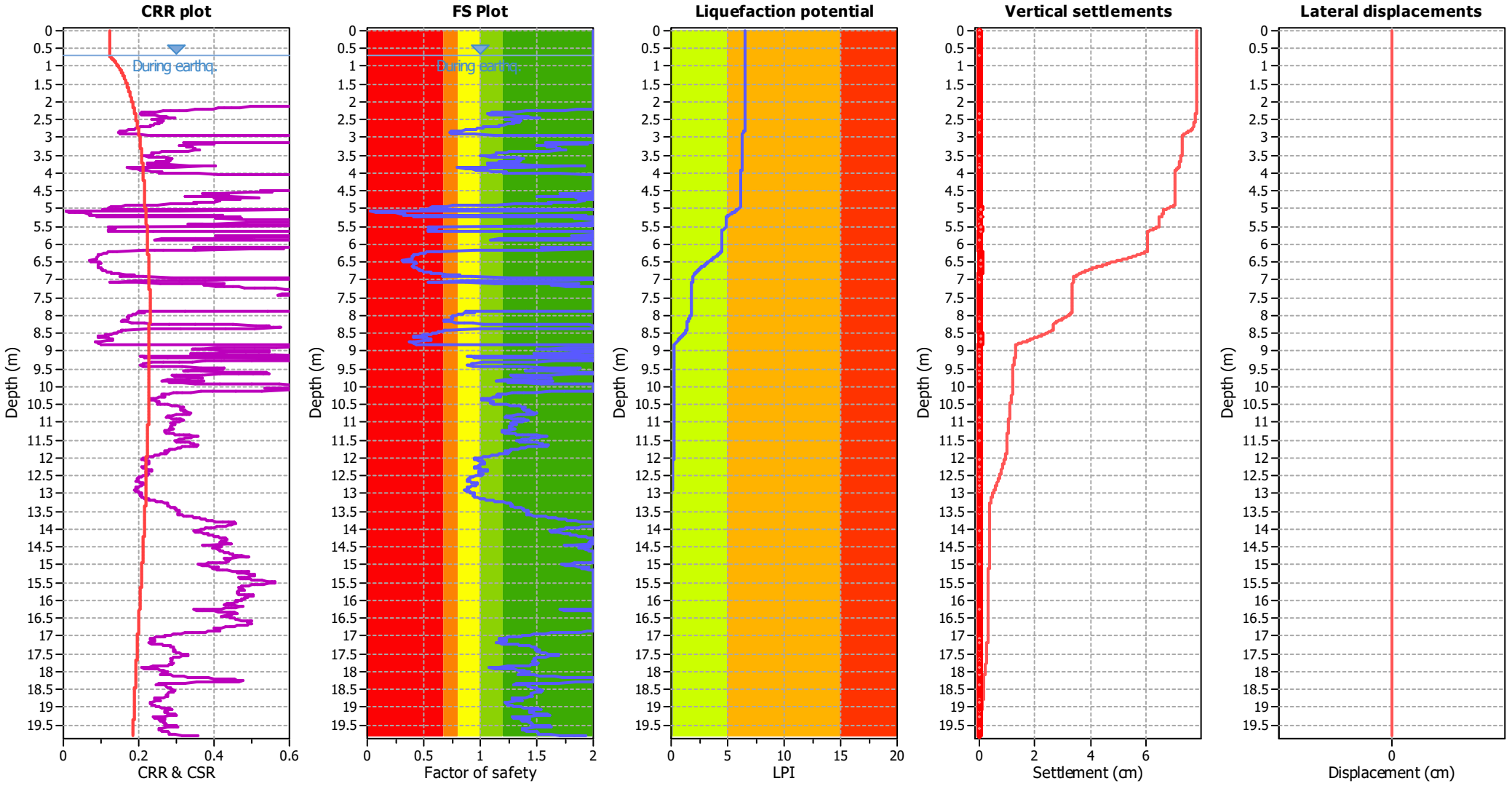






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	20.00 m

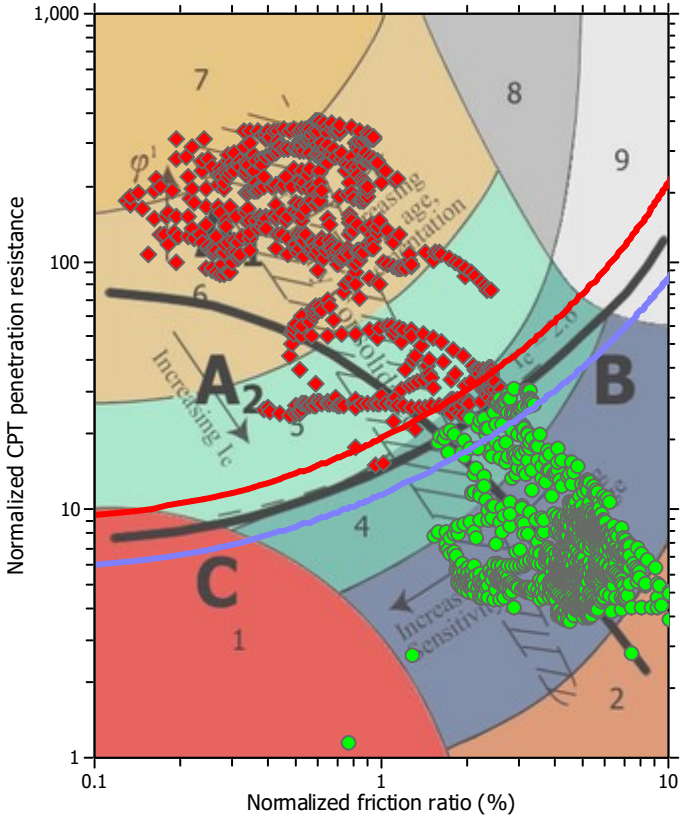
F.S. color scheme

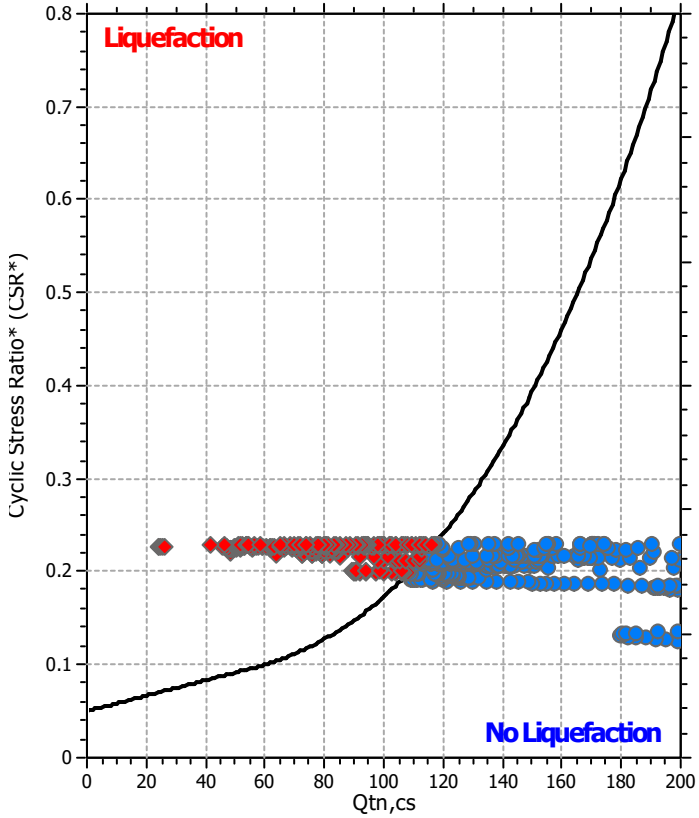
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

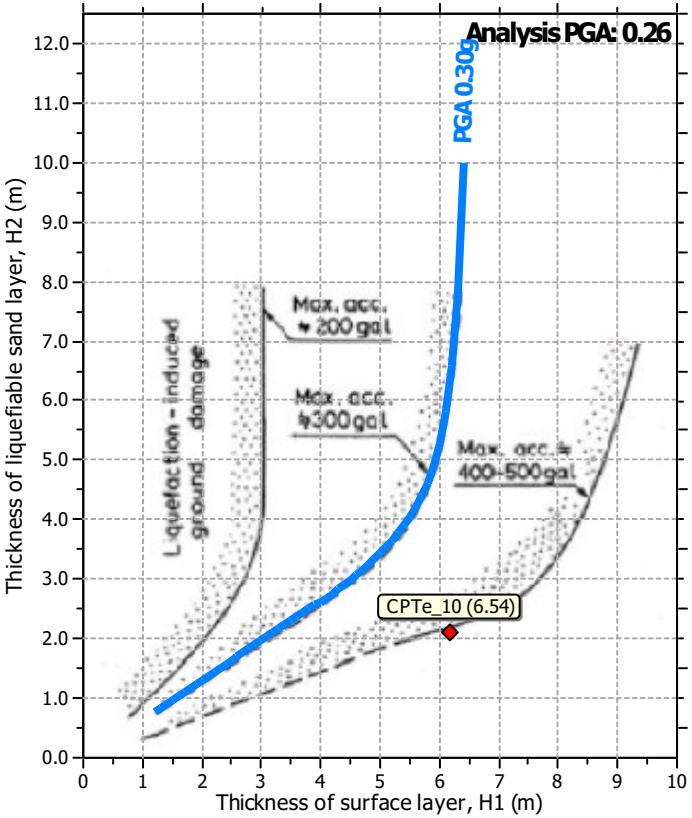
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	20.00 m

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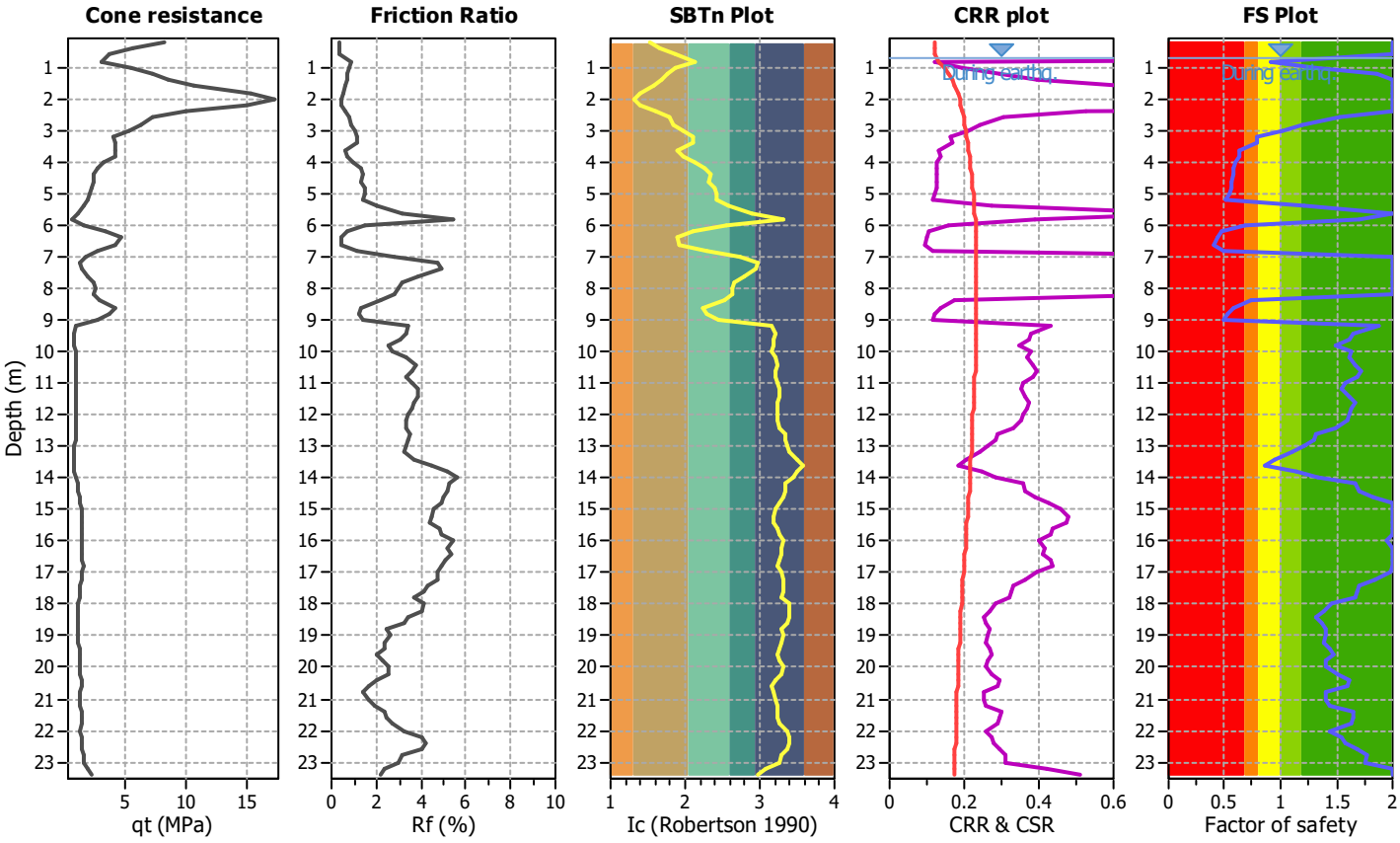
LIQUEFACTION ANALYSIS REPORT

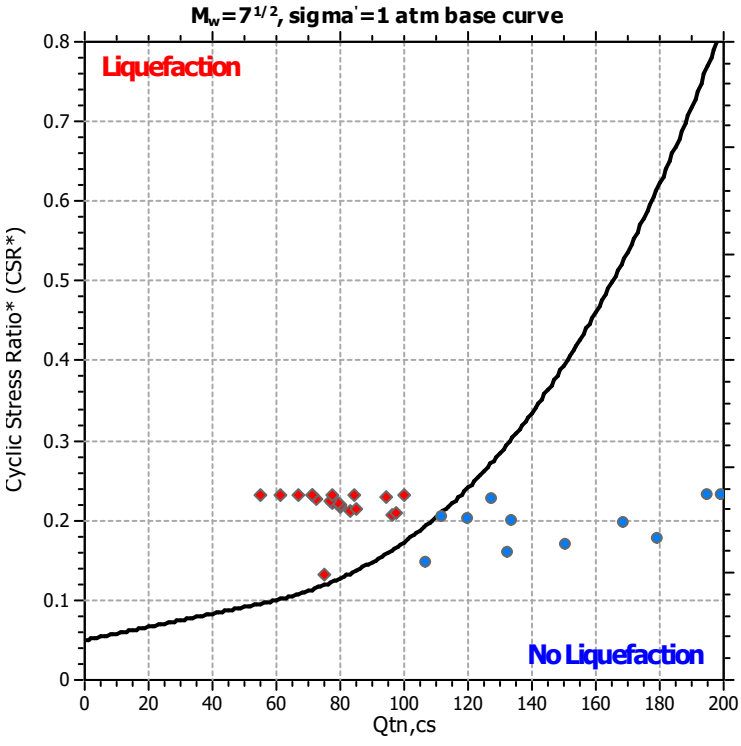
Project title : MS3 Rimini_RNC **Location : Rimini**

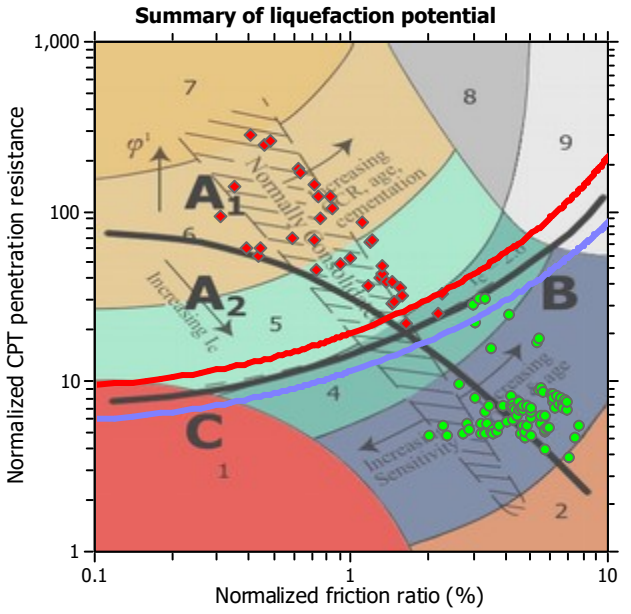
CPT file : 099014P300

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.70 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

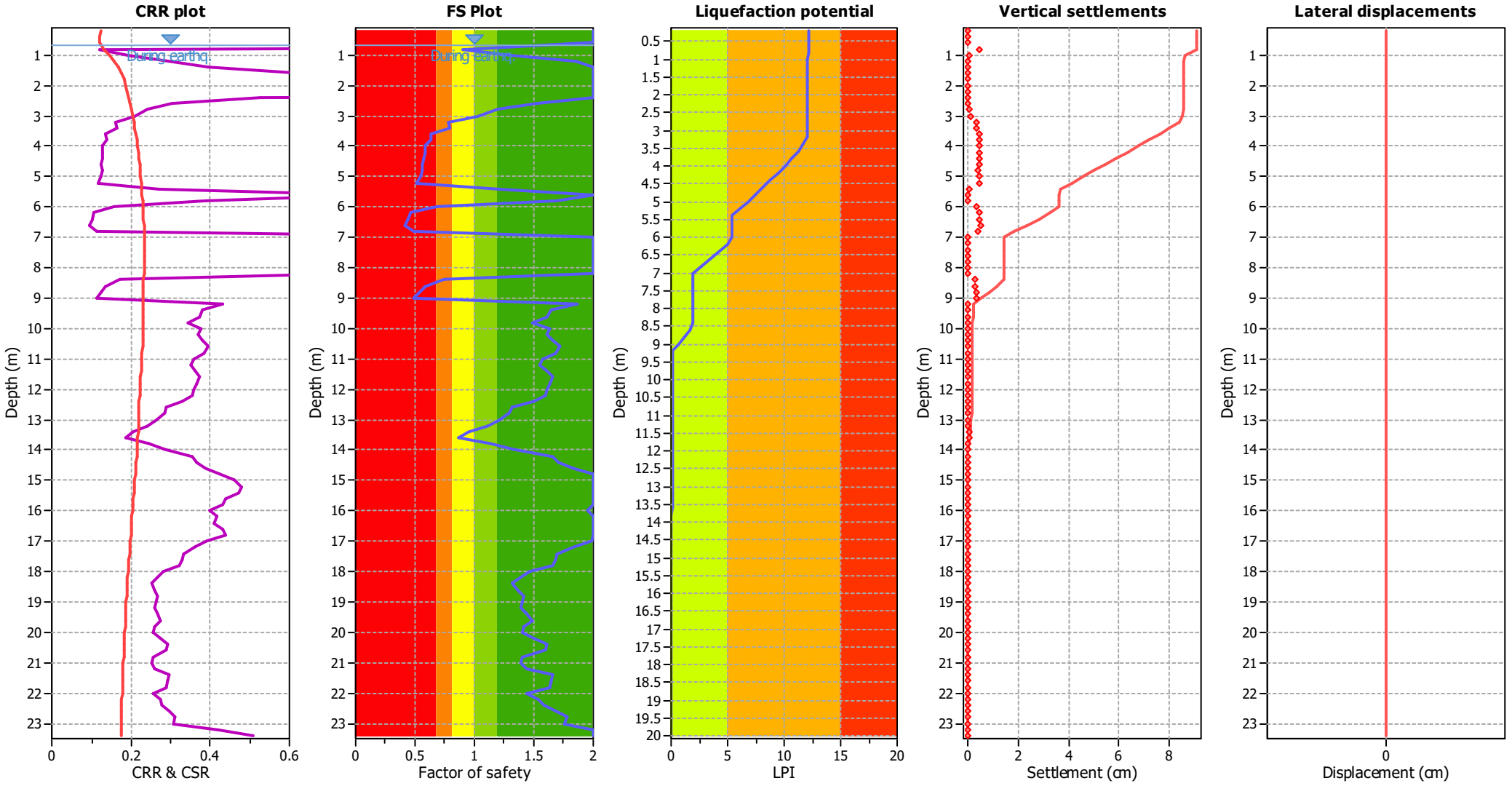






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

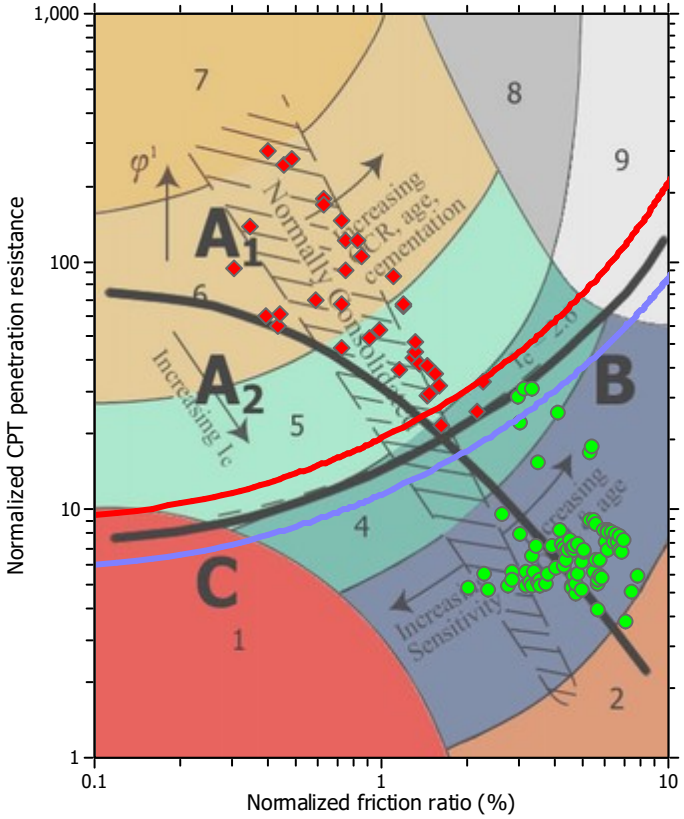
F.S. color scheme

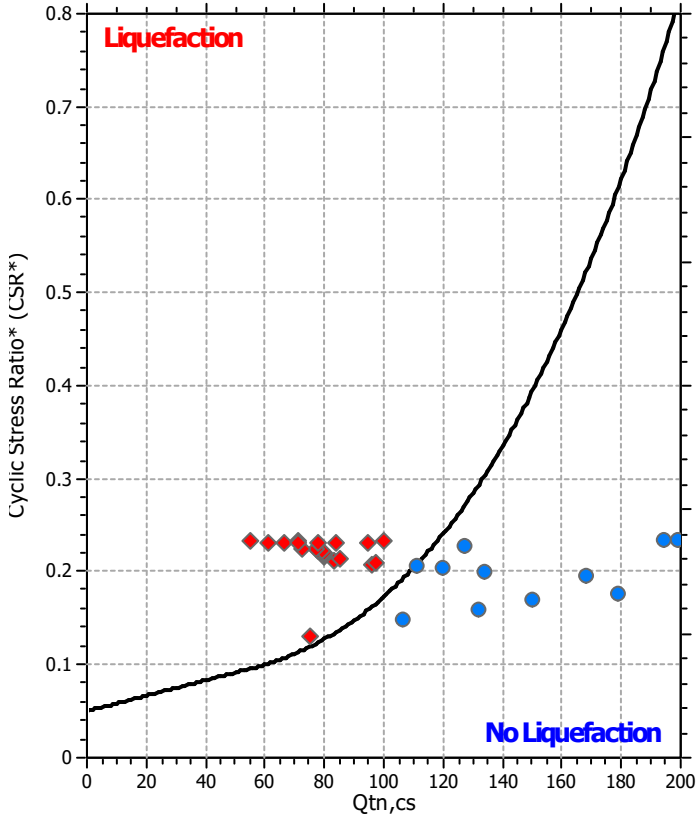
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

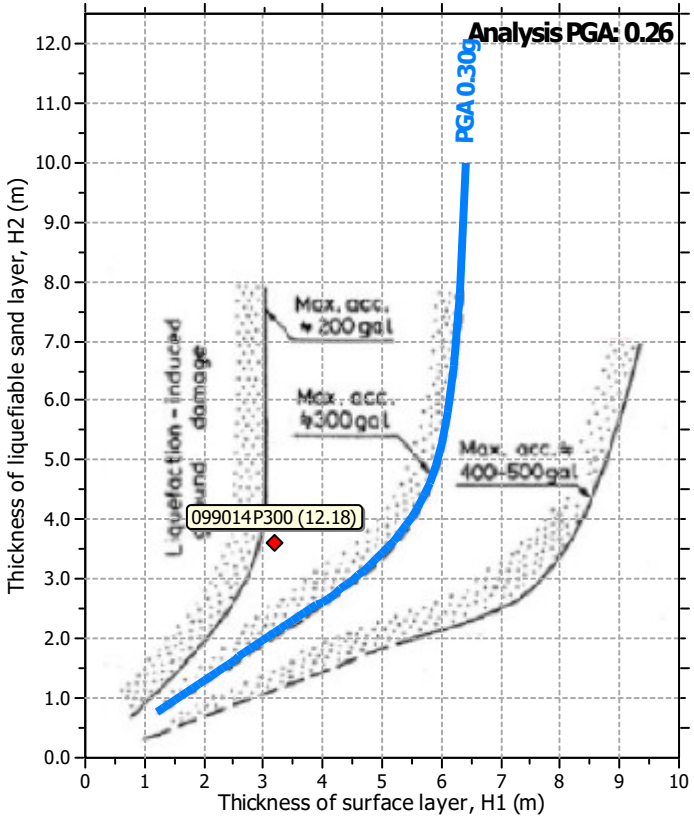
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

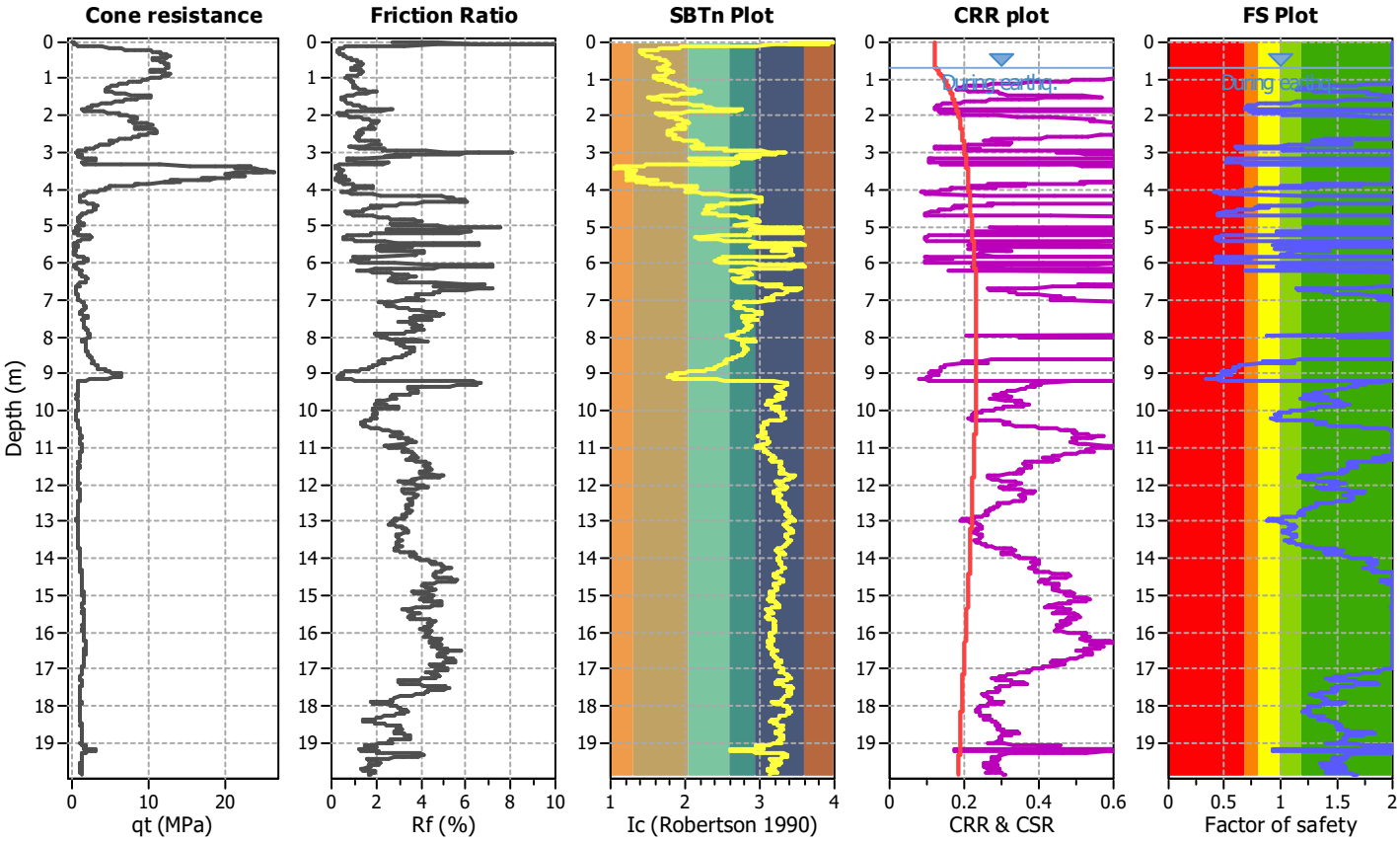
LIQUEFACTION ANALYSIS REPORT

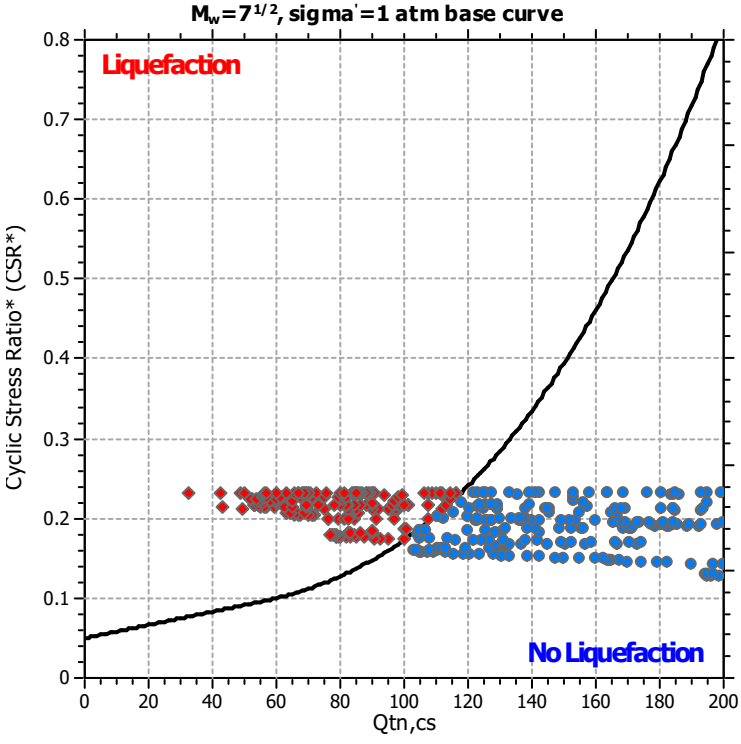
Project title : MS3 Rimini_RNC **Location : Rimini**

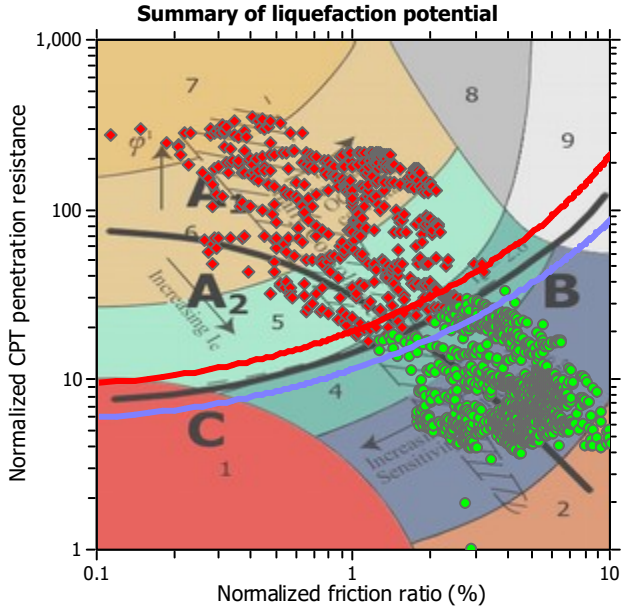
CPT file : CPTe_19

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.40 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.70 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	1	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

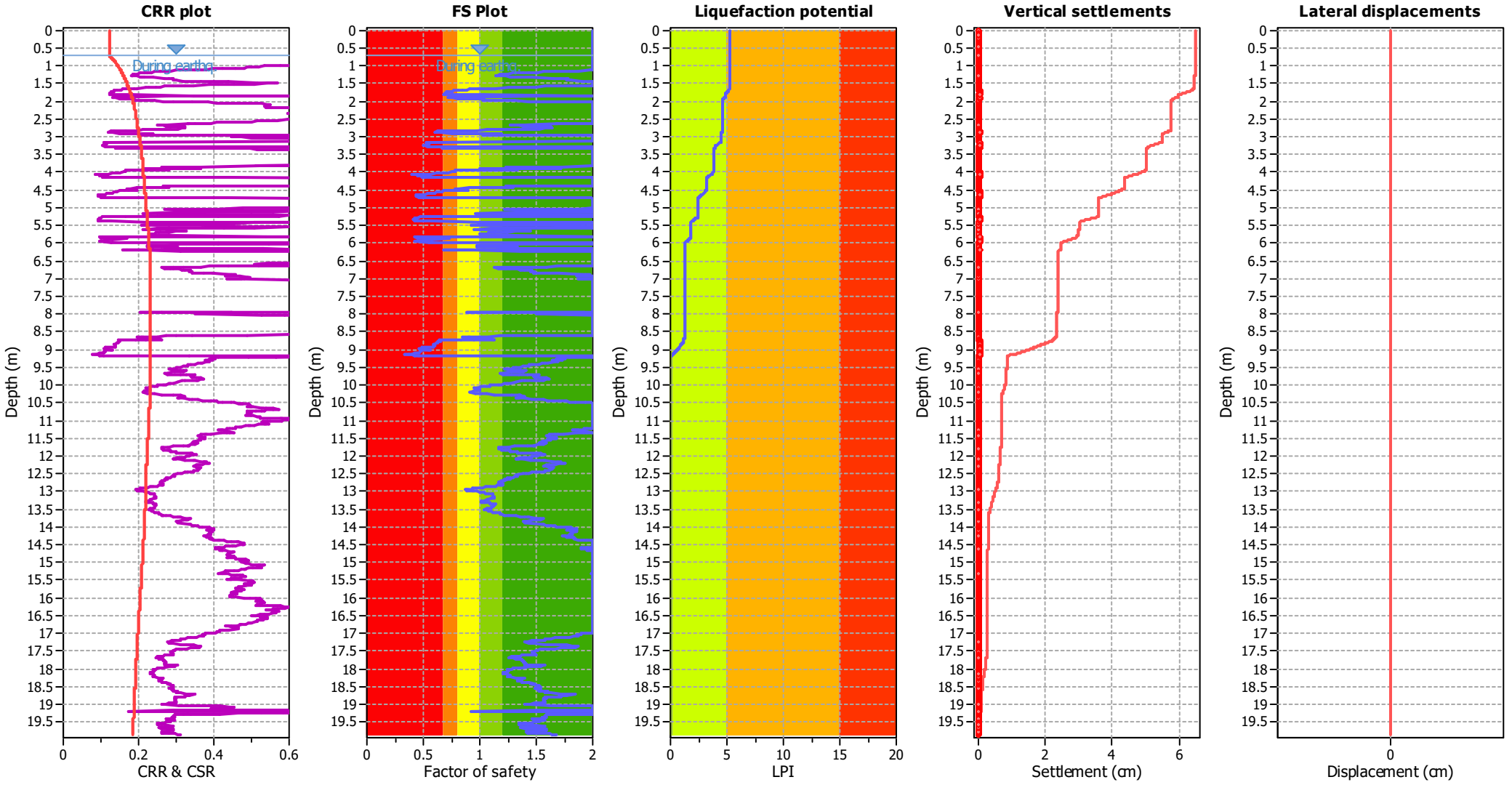






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	1	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.40 m	Fill height:	N/A	Limit depth:	N/A

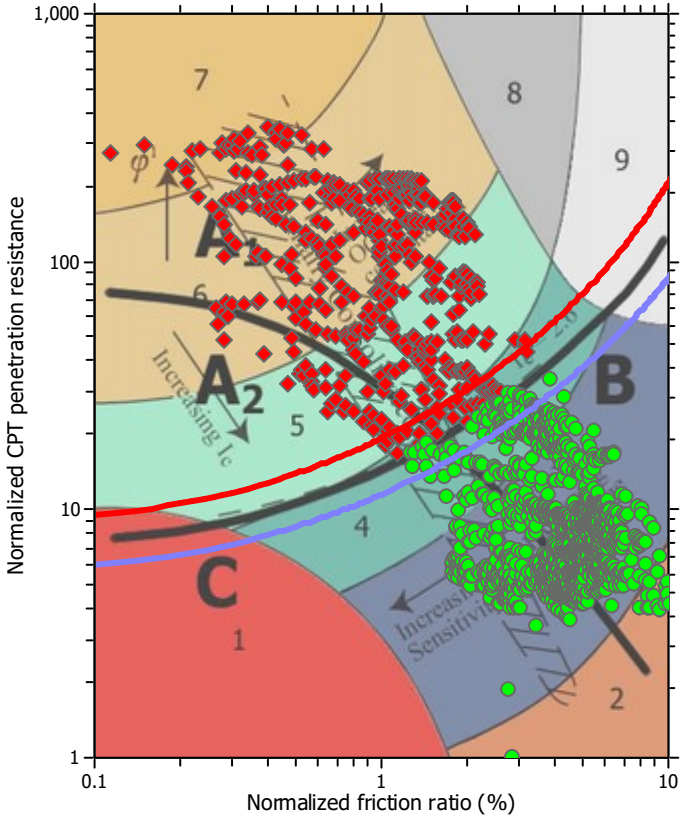
F.S. color scheme

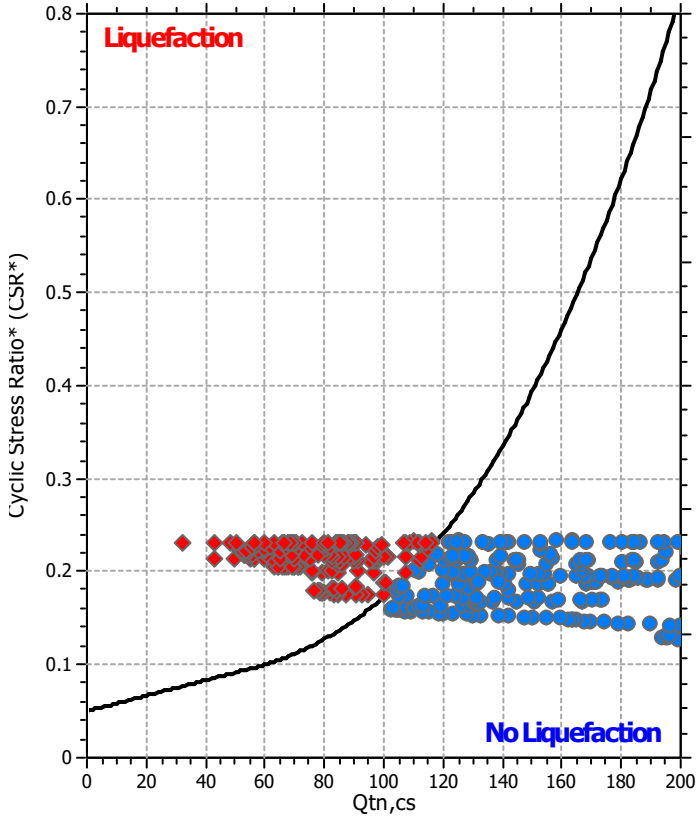
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

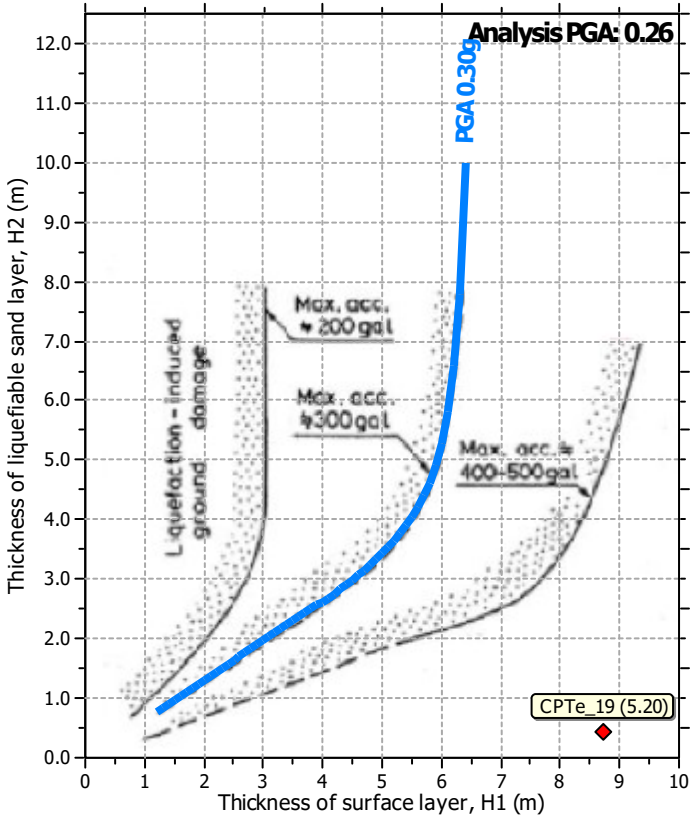
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	1	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.40 m	Fill height:	N/A	Limit depth:	N/A

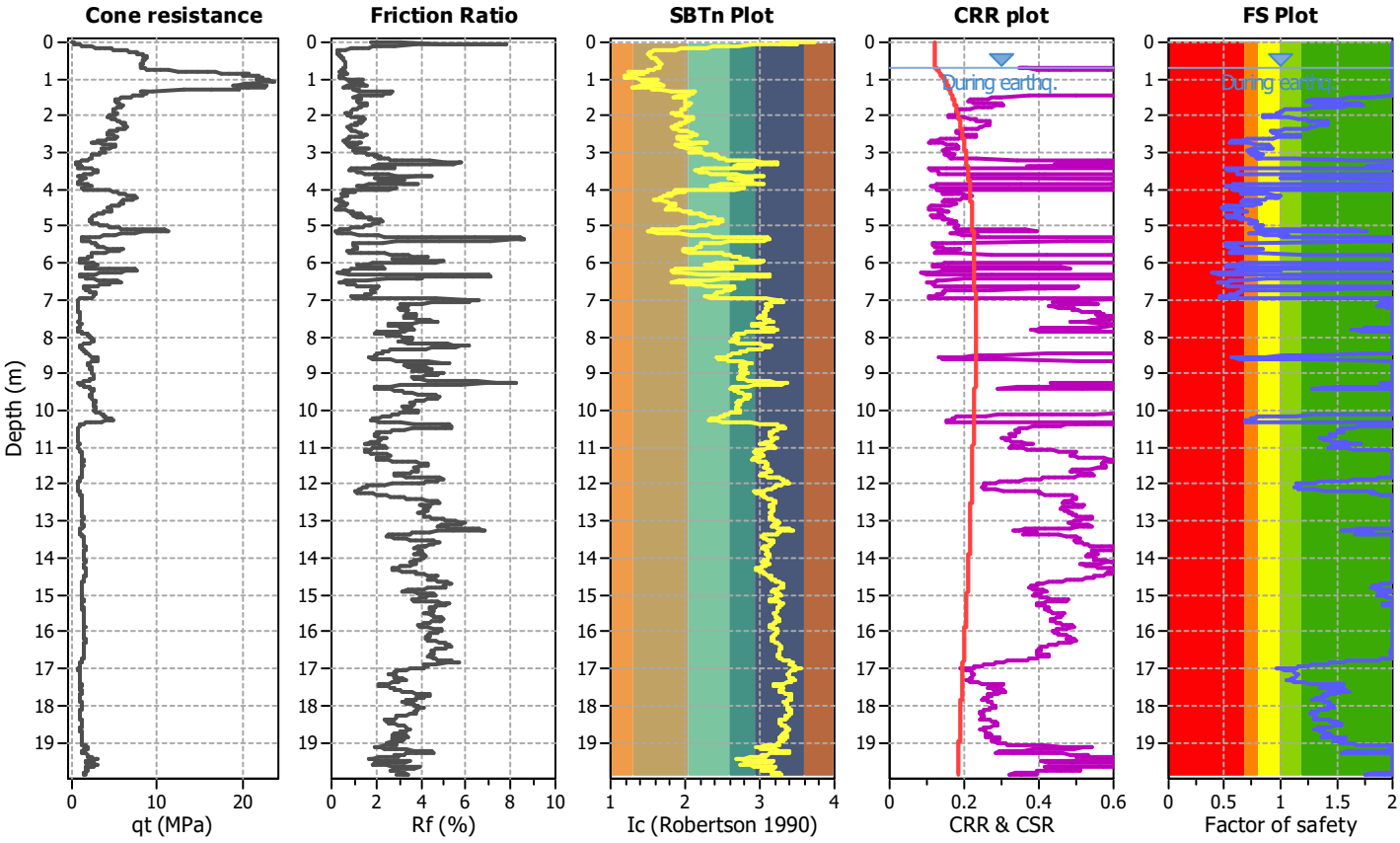
LIQUEFACTION ANALYSIS REPORT

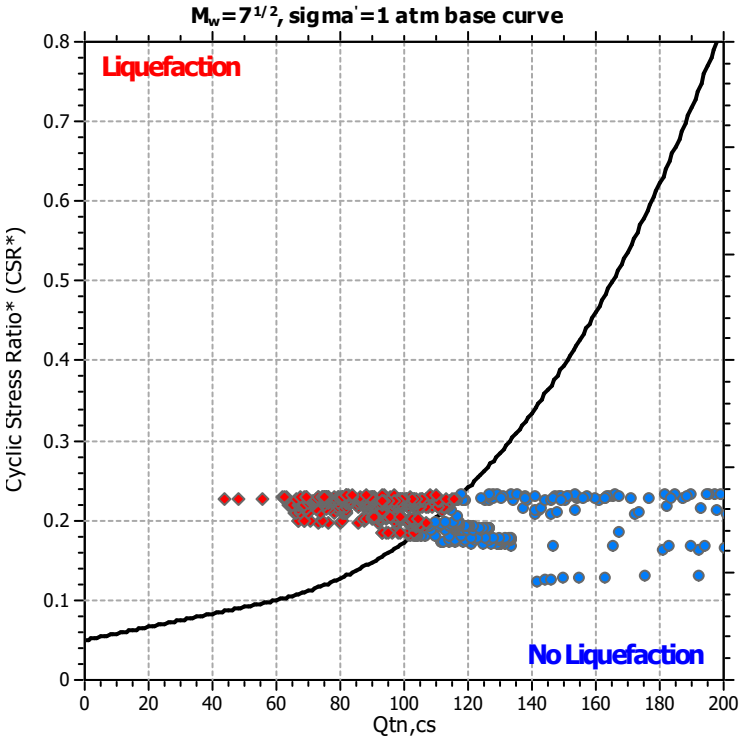
Project title : MS3 Rimini_RNC **Location : Rimini**

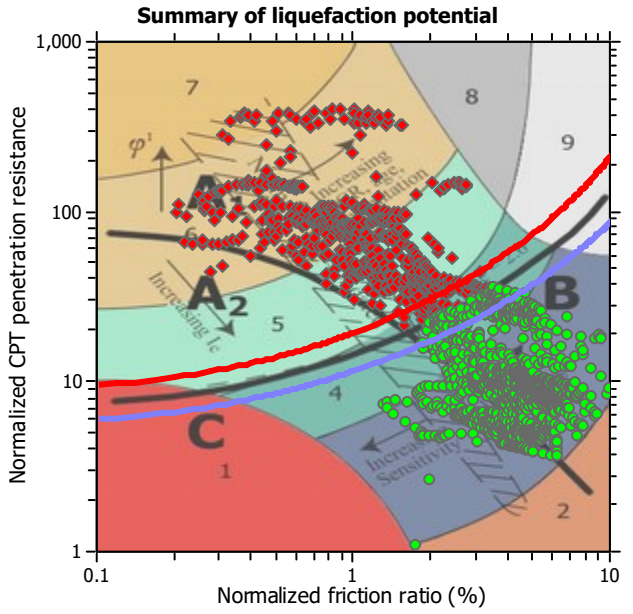
CPT file : CPTe_11

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.10 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.70 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

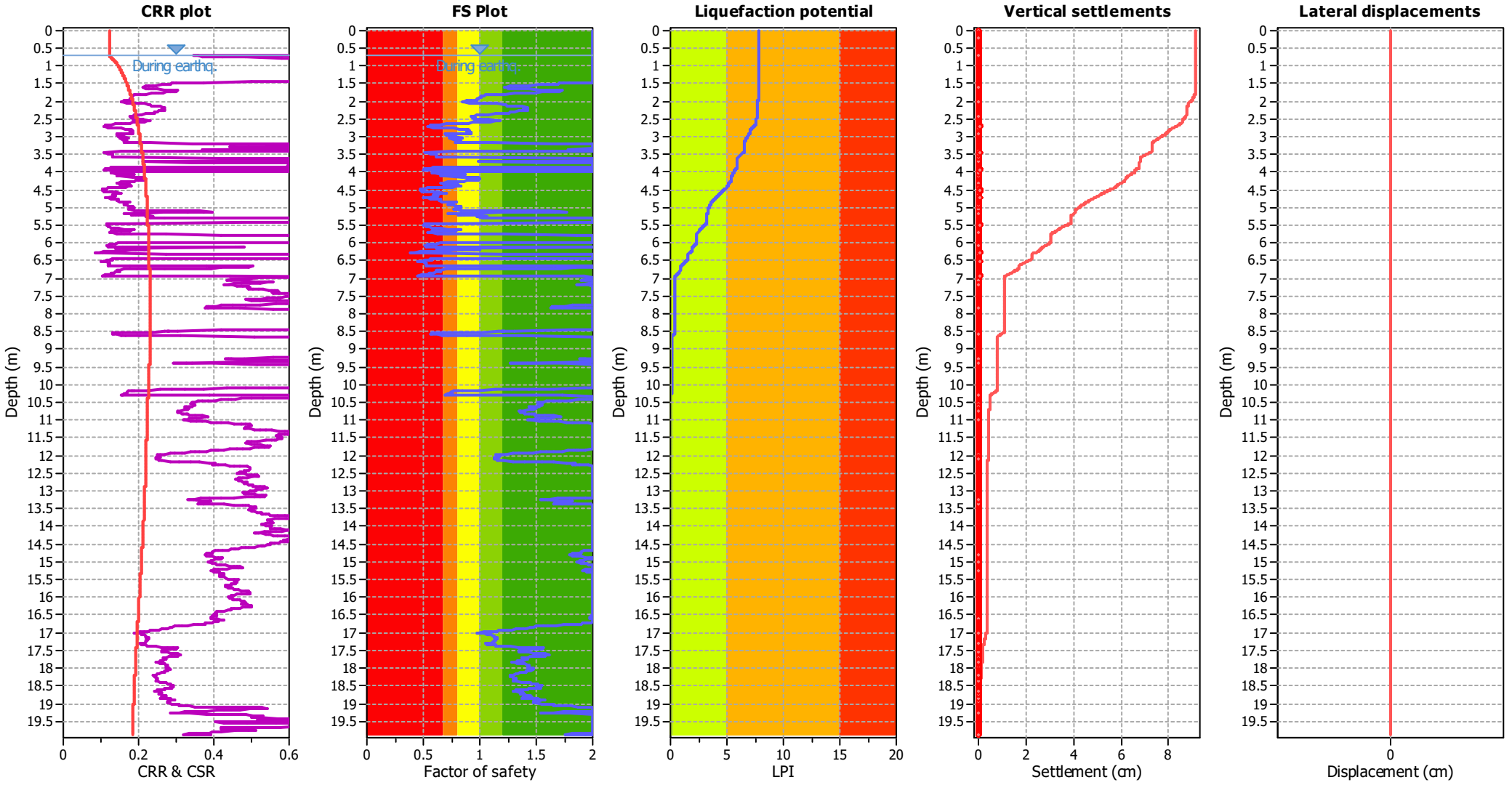






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.10 m	Fill height:	N/A	Limit depth:	N/A

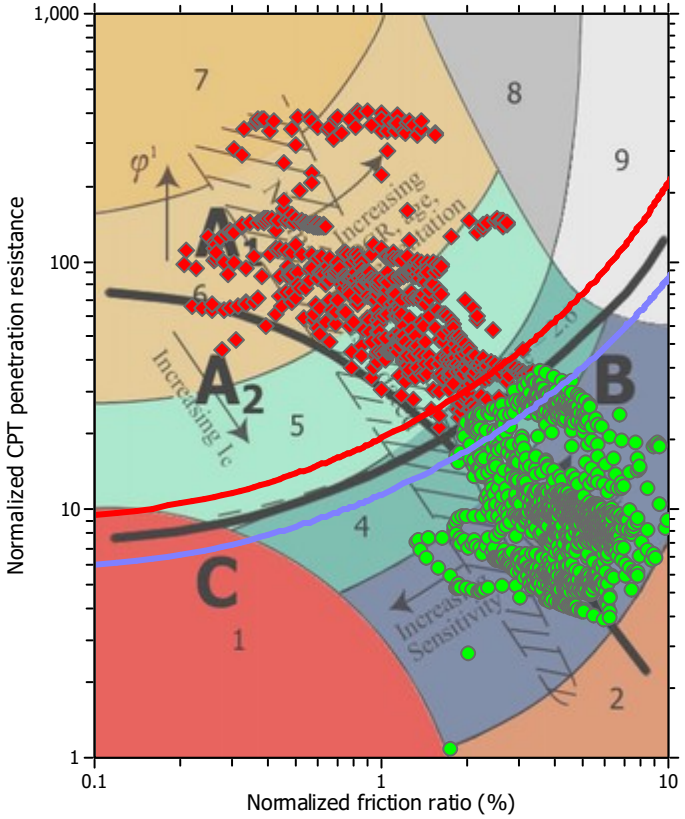
F.S. color scheme

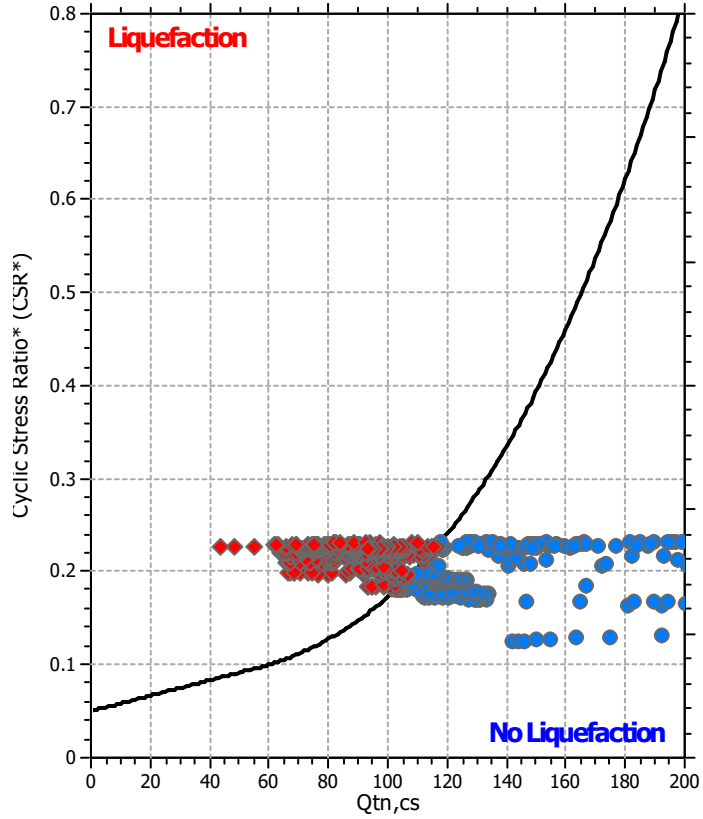
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

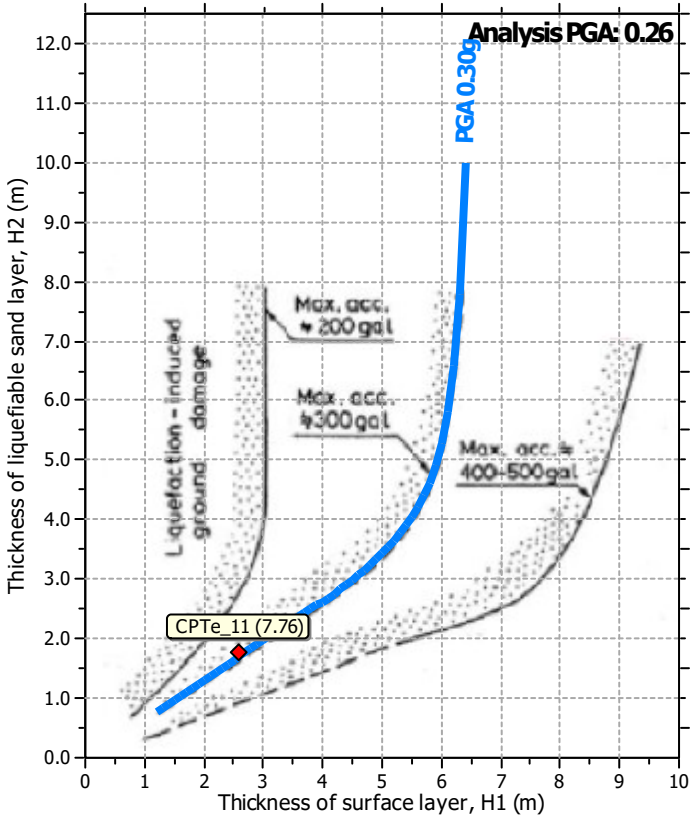
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.10 m	Fill height:	N/A	Limit depth:	N/A

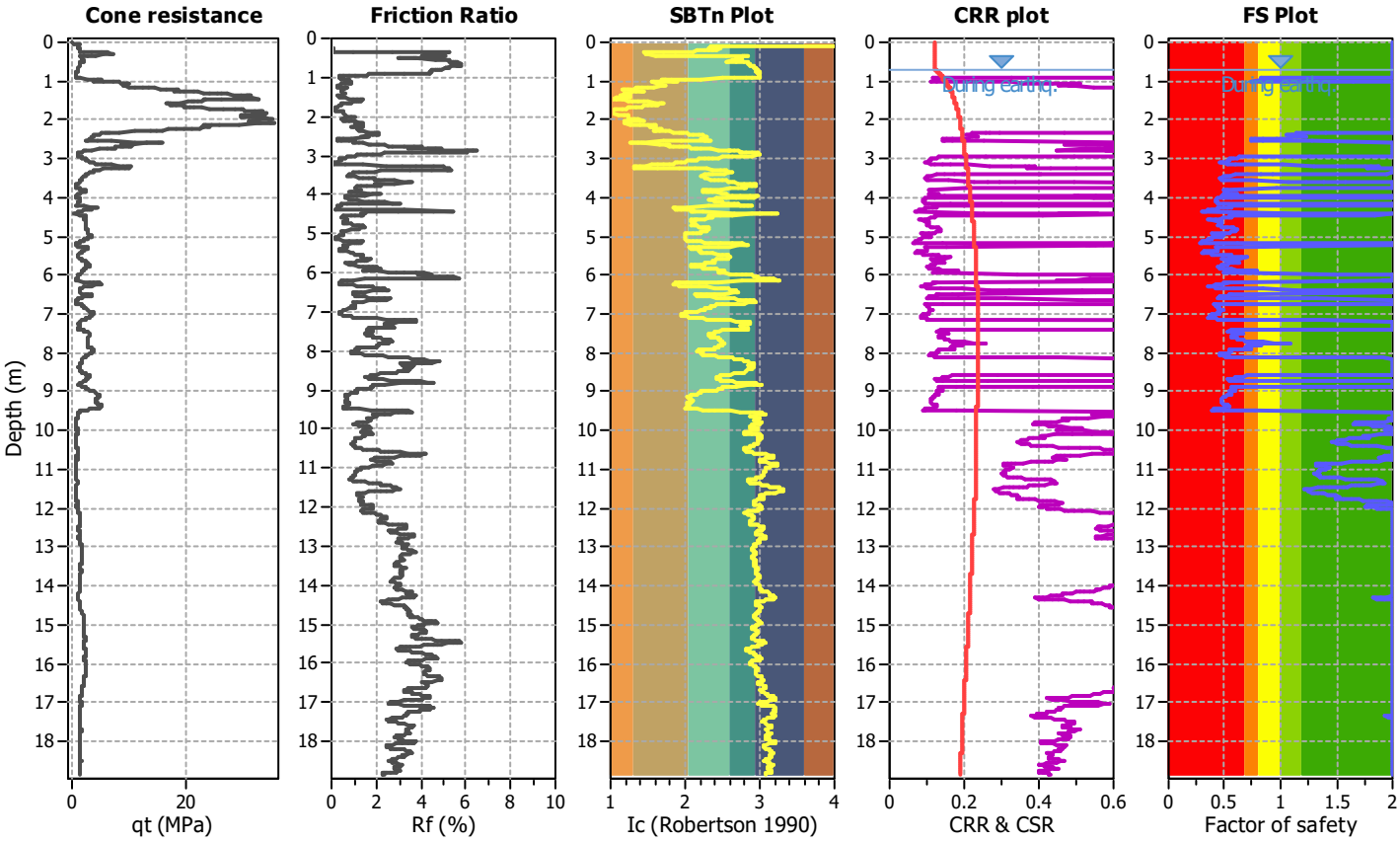
LIQUEFACTION ANALYSIS REPORT

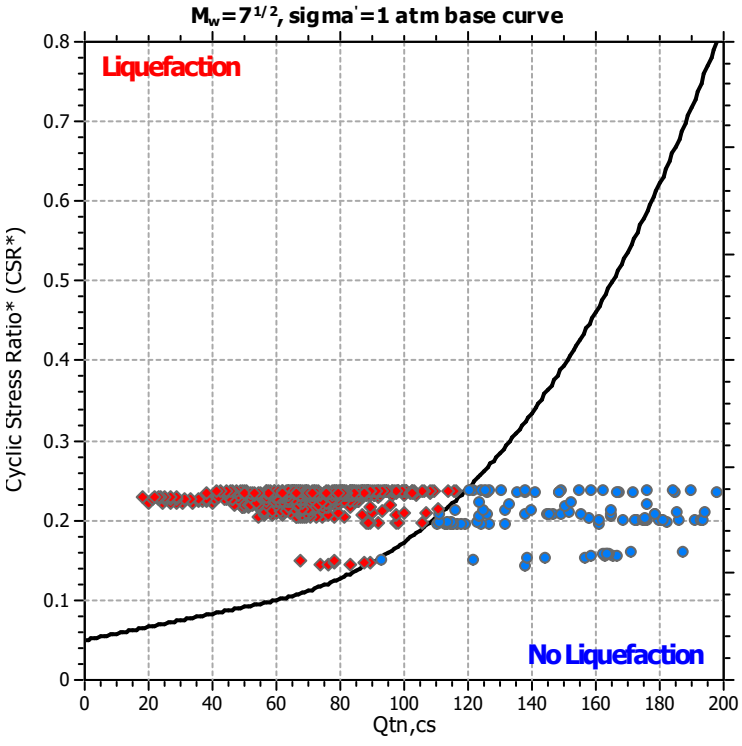
Project title : MS3 Rimini_RNC **Location : Rimini**

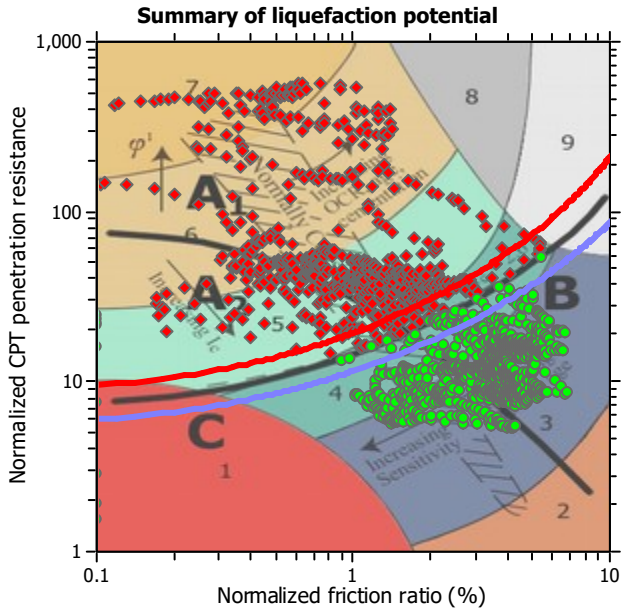
CPT file : 099014P1417

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	0.80 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.70 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

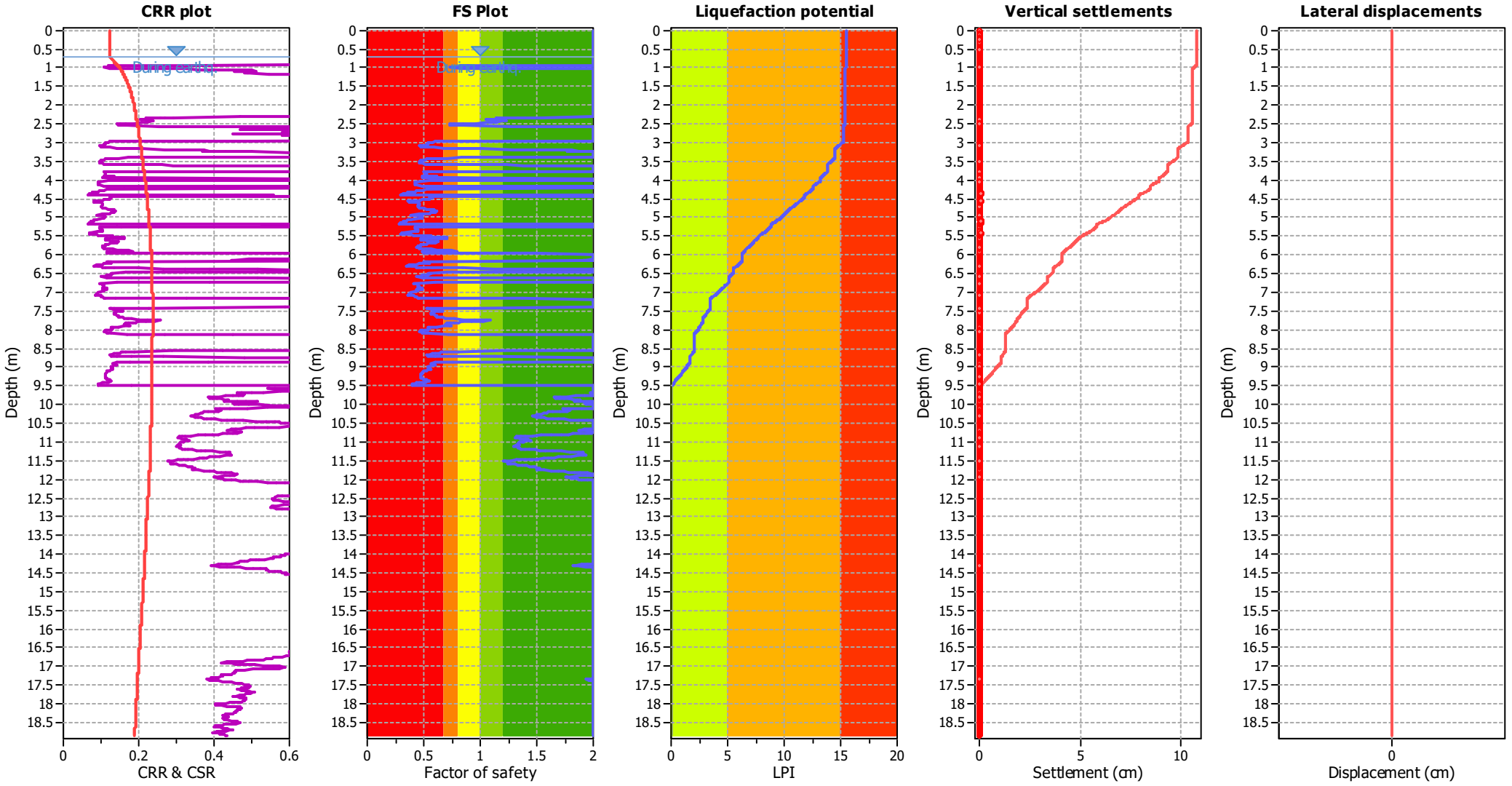






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.80 m	Fill height:	N/A	Limit depth:	N/A

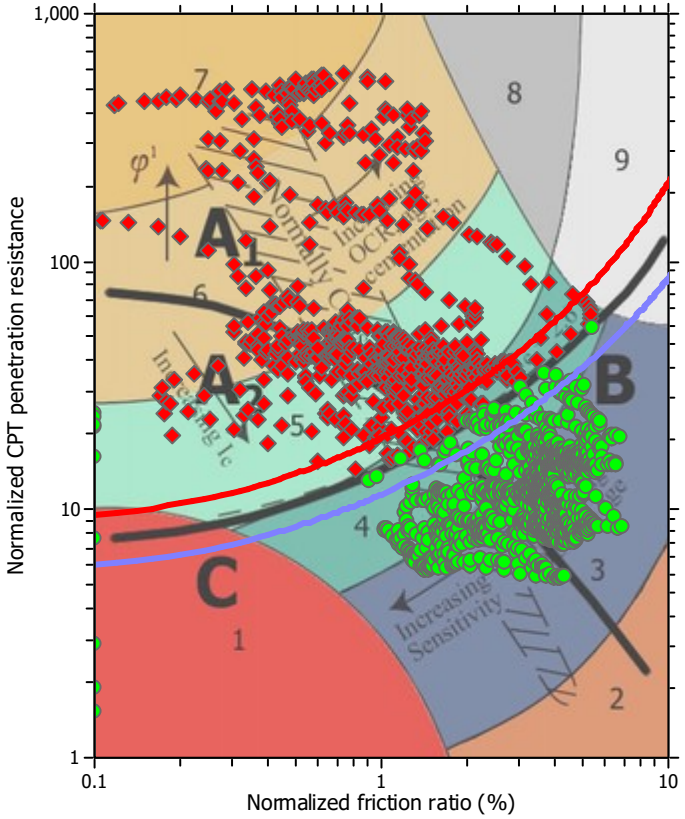
F.S. color scheme

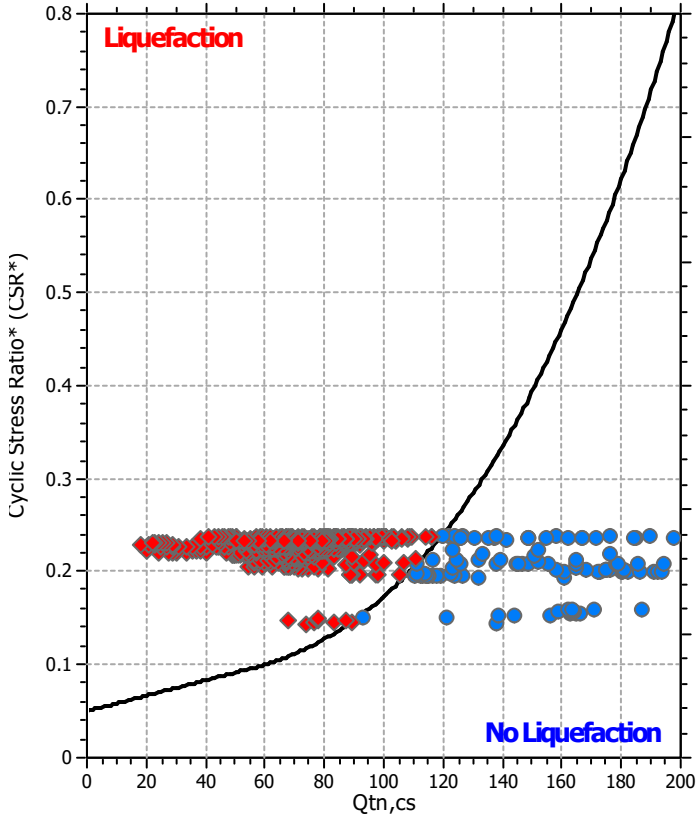
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

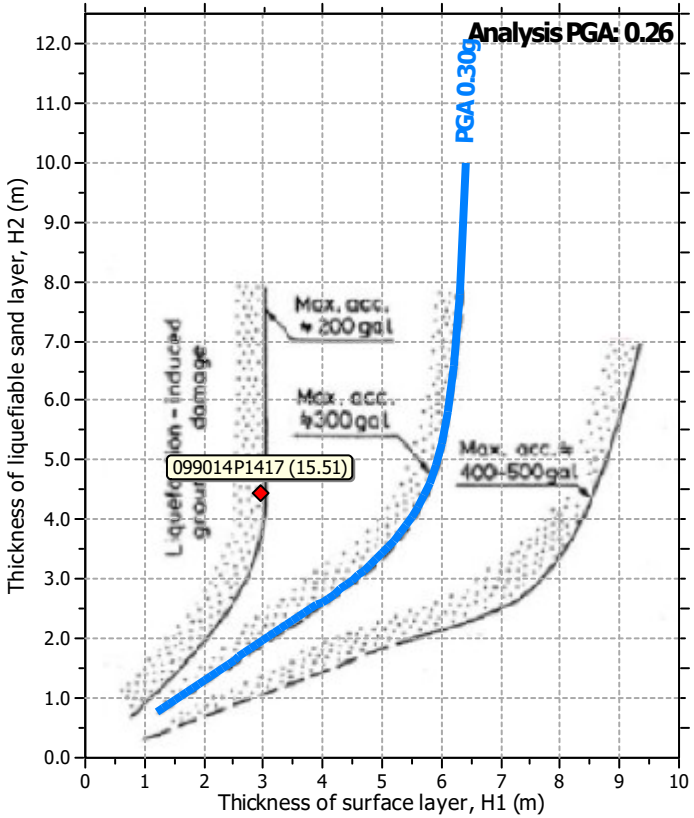
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.80 m	Fill height:	N/A	Limit depth:	N/A

REPORT - ZONA RNS_01

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

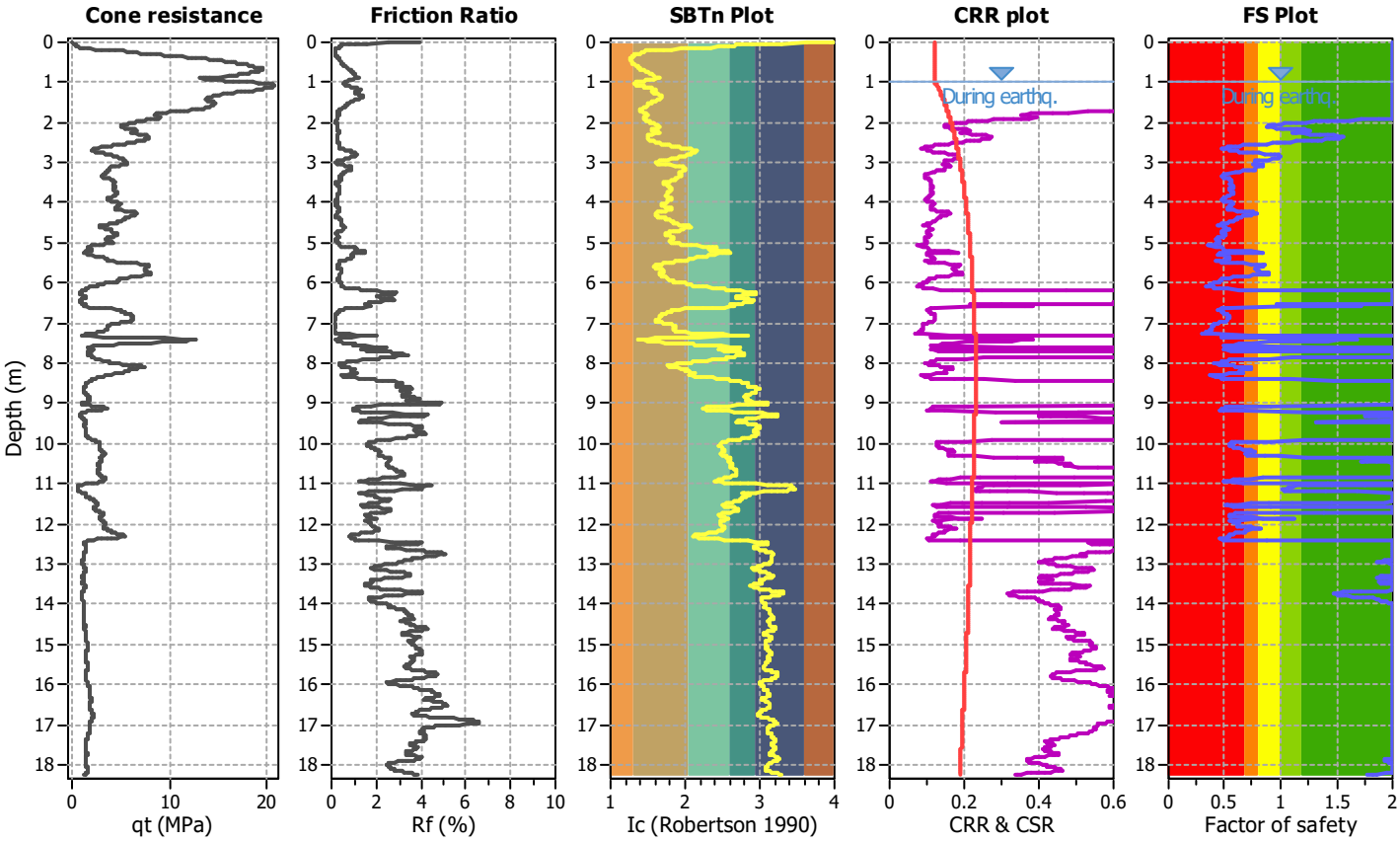
LIQUEFACTION ANALYSIS REPORT

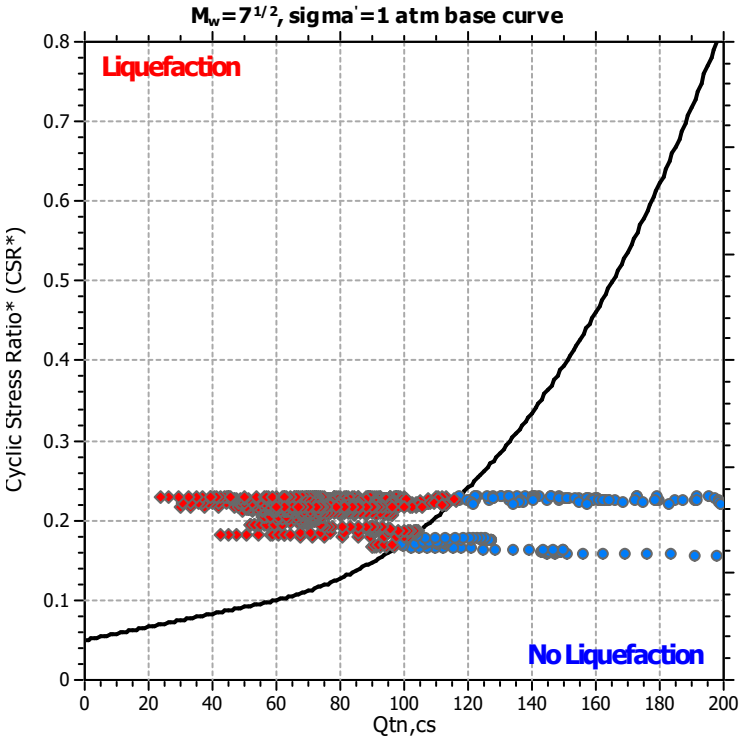
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

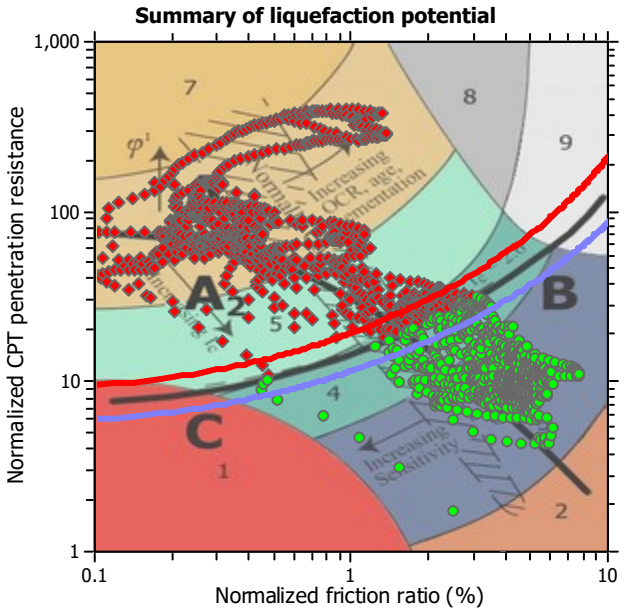
CPT file : 099014P1422

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.30 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

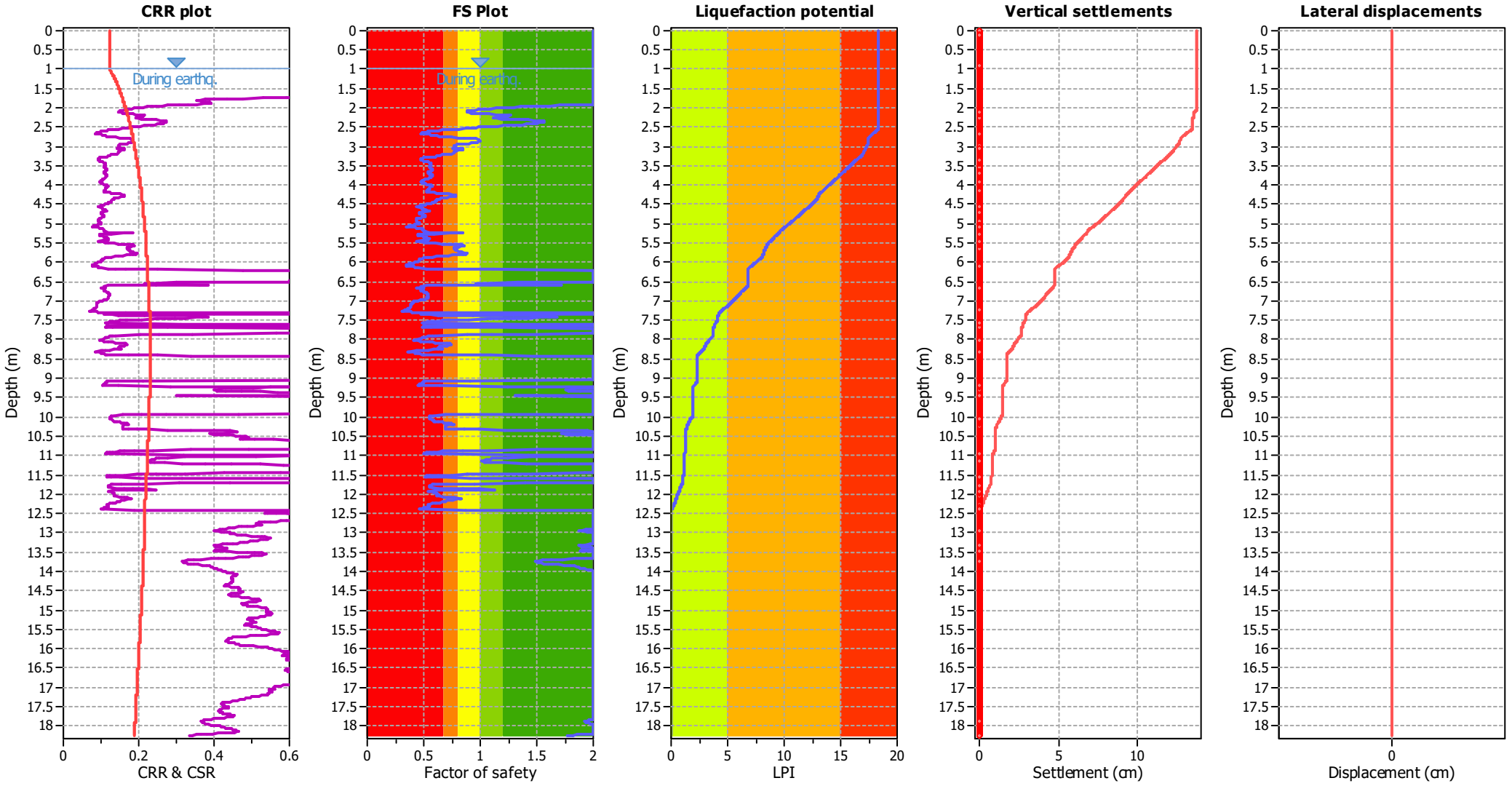






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.30 m	Fill height:	N/A	Limit depth:	N/A

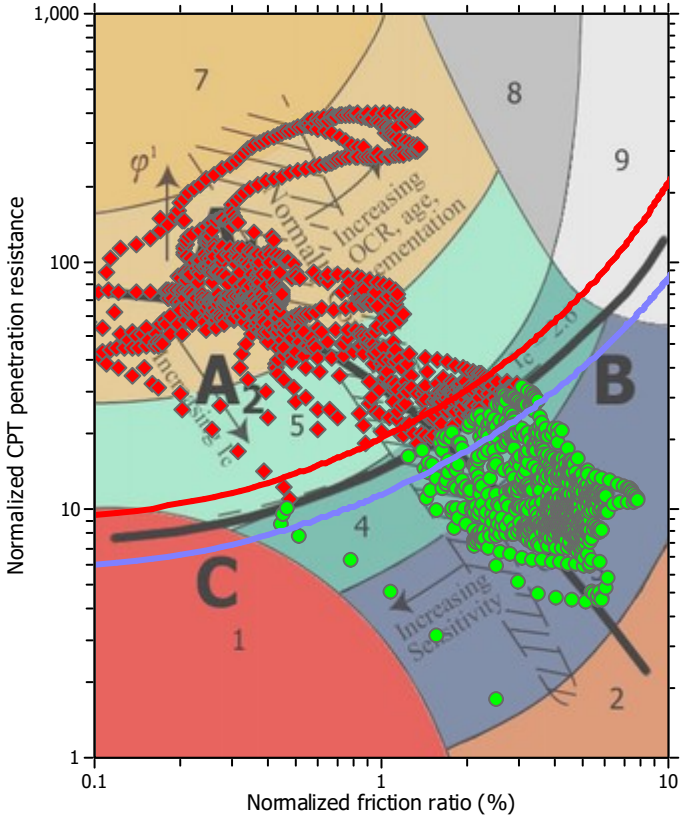
F.S. color scheme

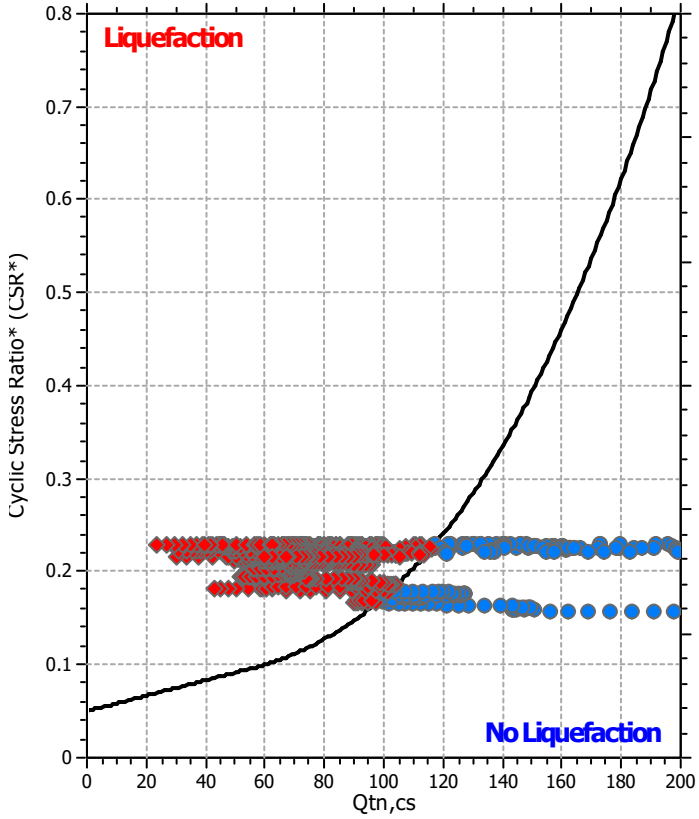
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

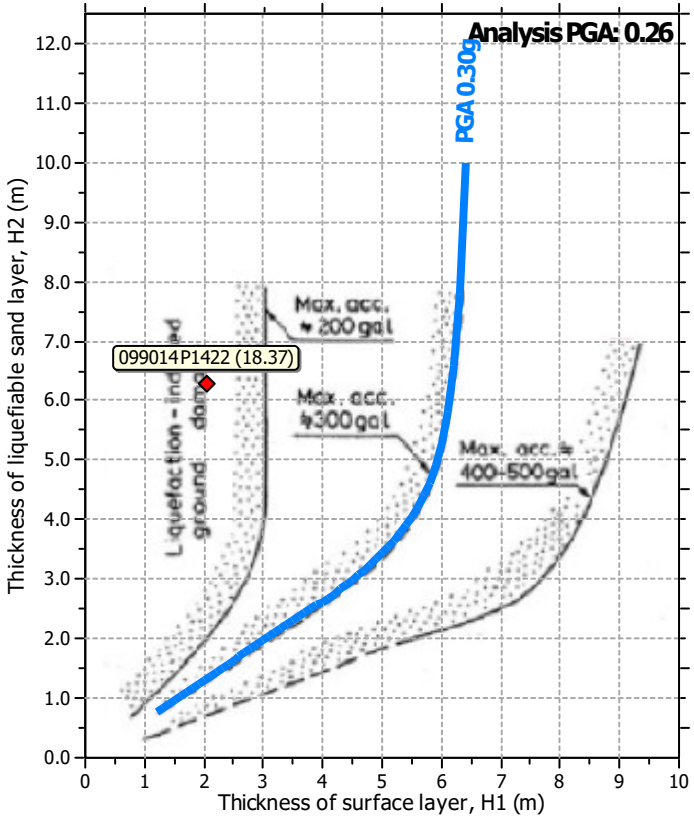
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.30 m	Fill height:	N/A	Limit depth:	N/A

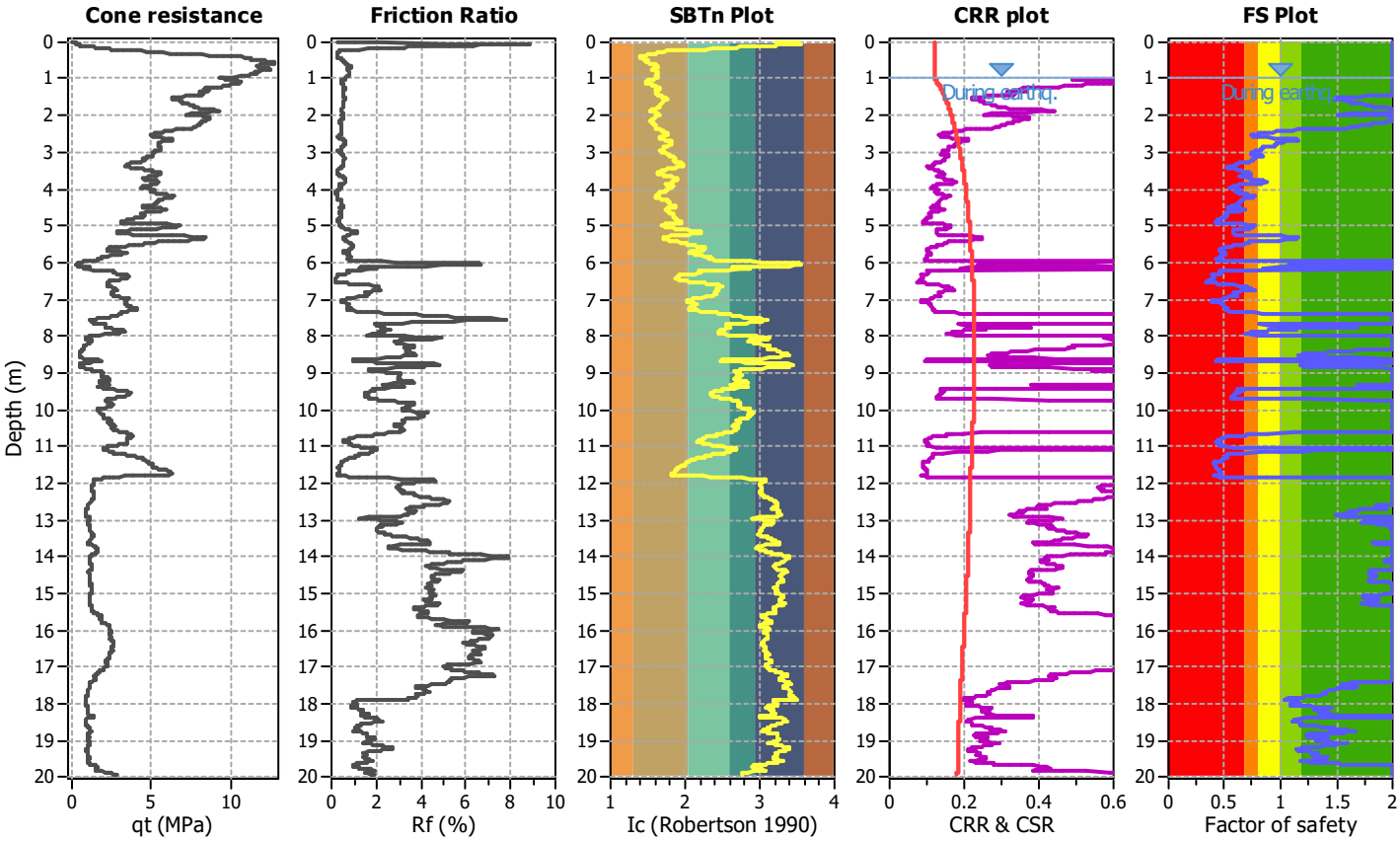
LIQUEFACTION ANALYSIS REPORT

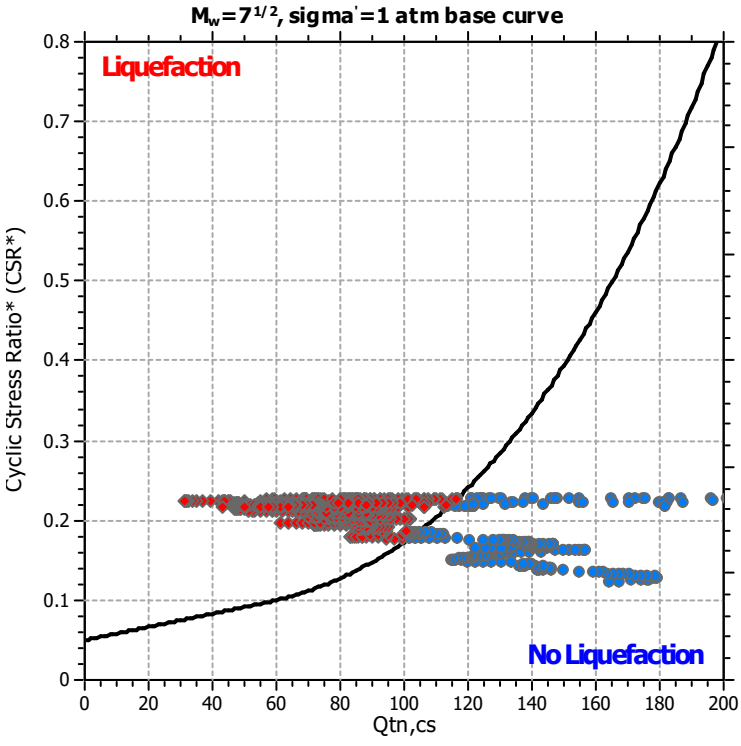
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

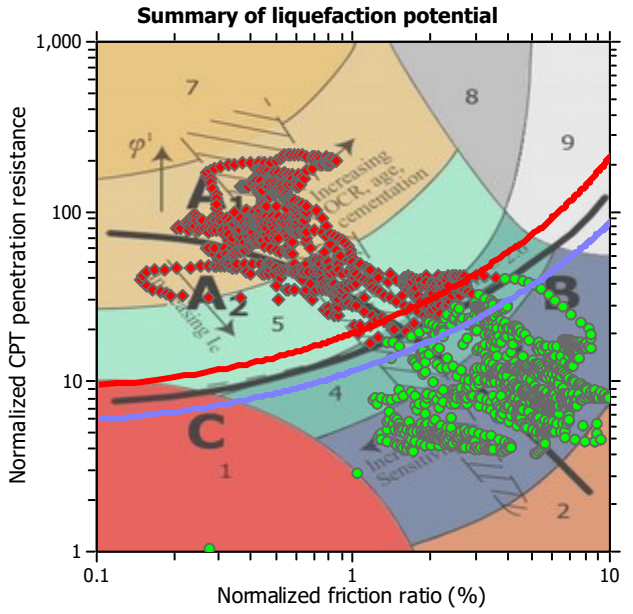
CPT file : CPTe_20

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.10 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

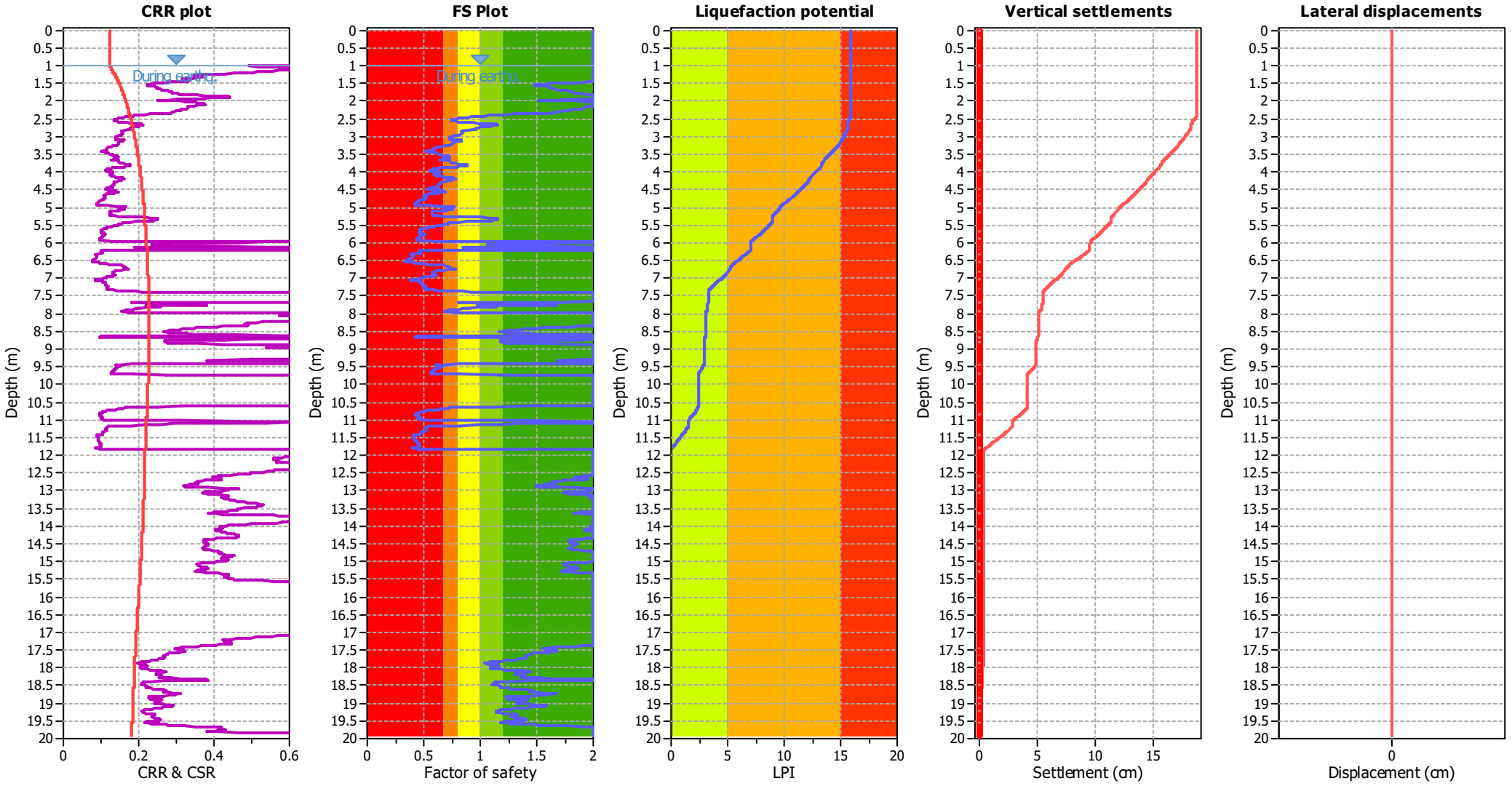






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.10 m	Fill height:	N/A	Limit depth:	20.00 m

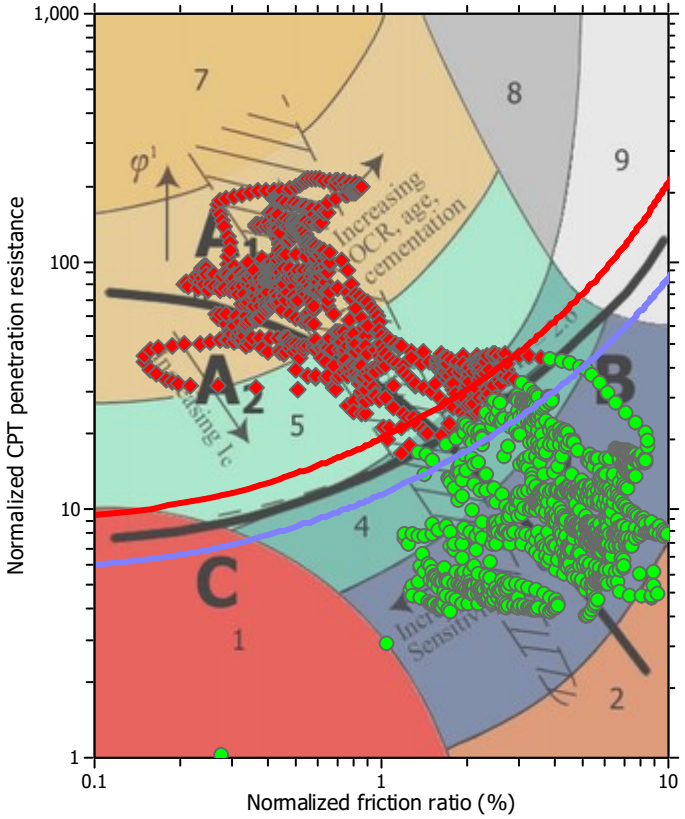
F.S. color scheme

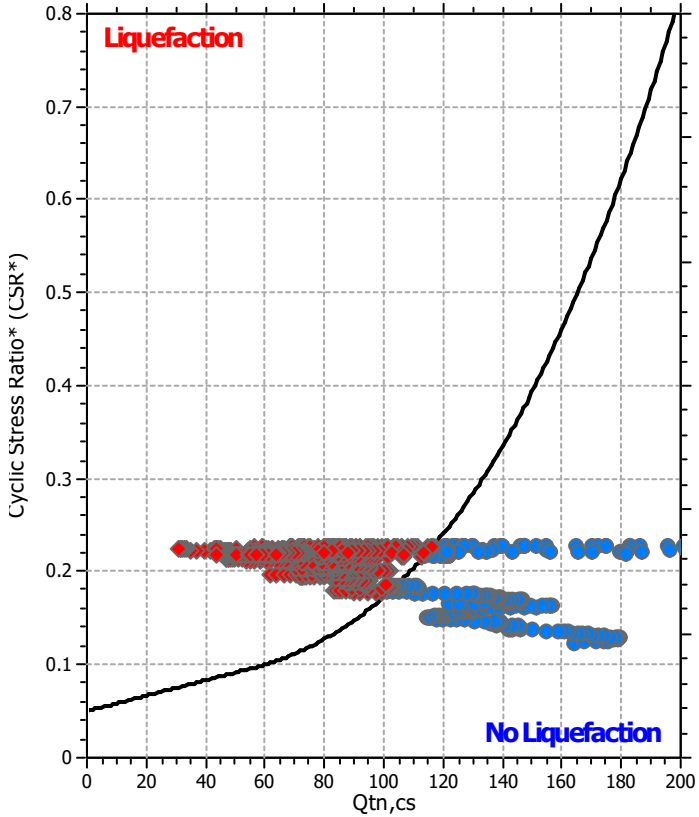
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

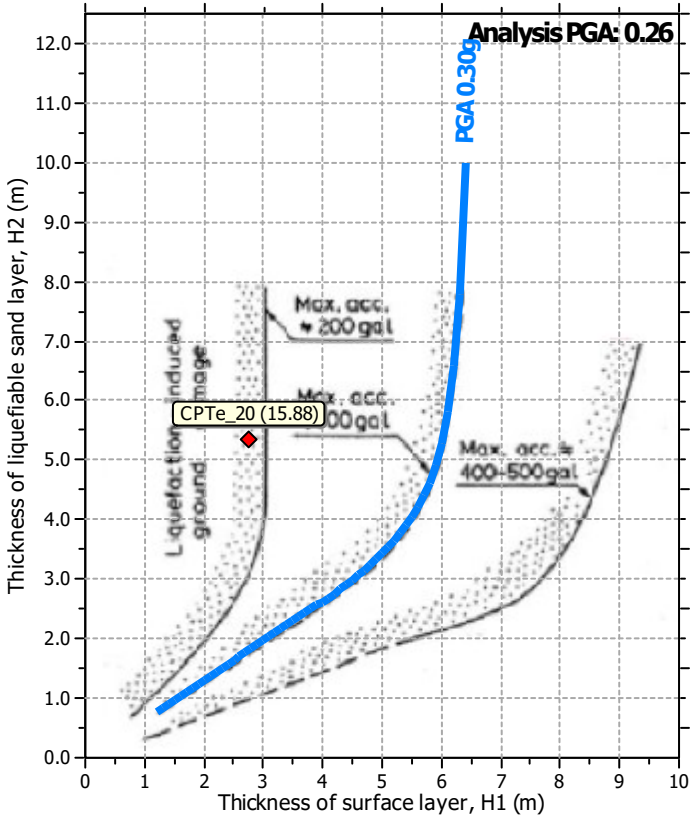
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.10 m	Fill height:	N/A	Limit depth:	20.00 m

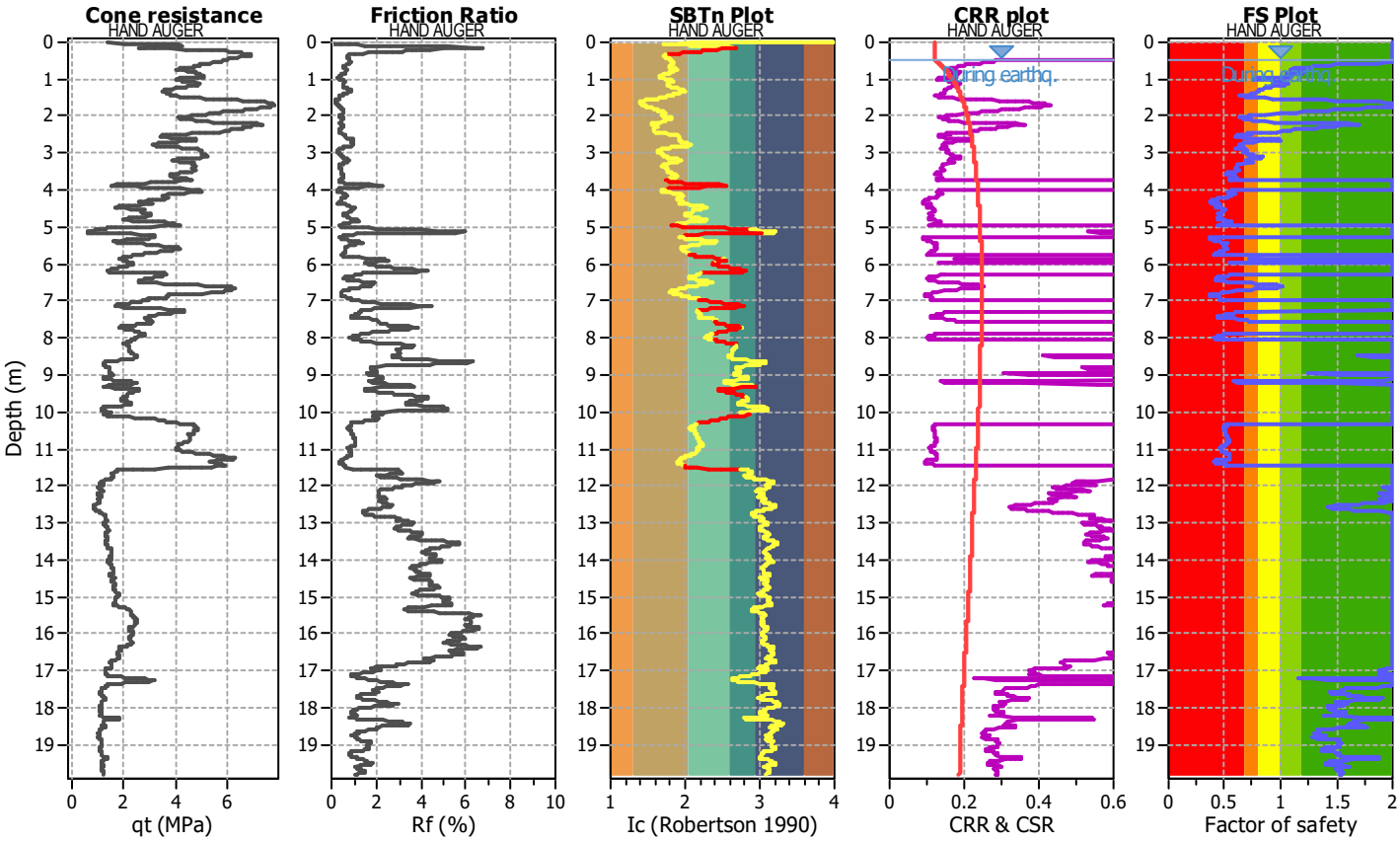
LIQUEFACTION ANALYSIS REPORT

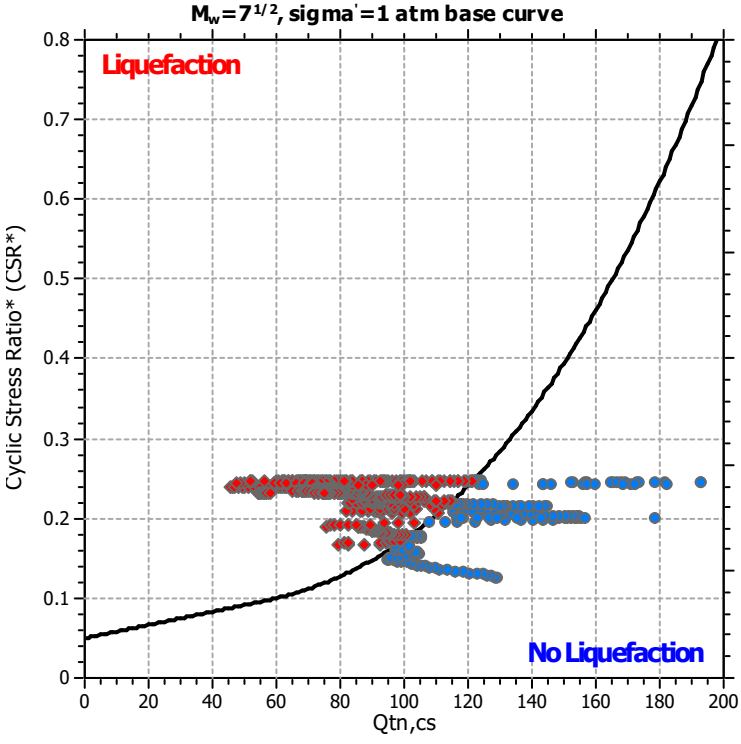
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

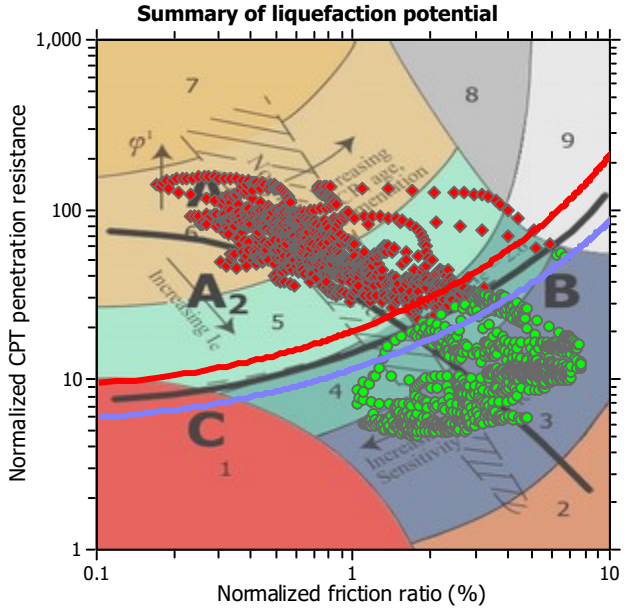
CPT file : 099014P1421

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	0.50 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.50 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

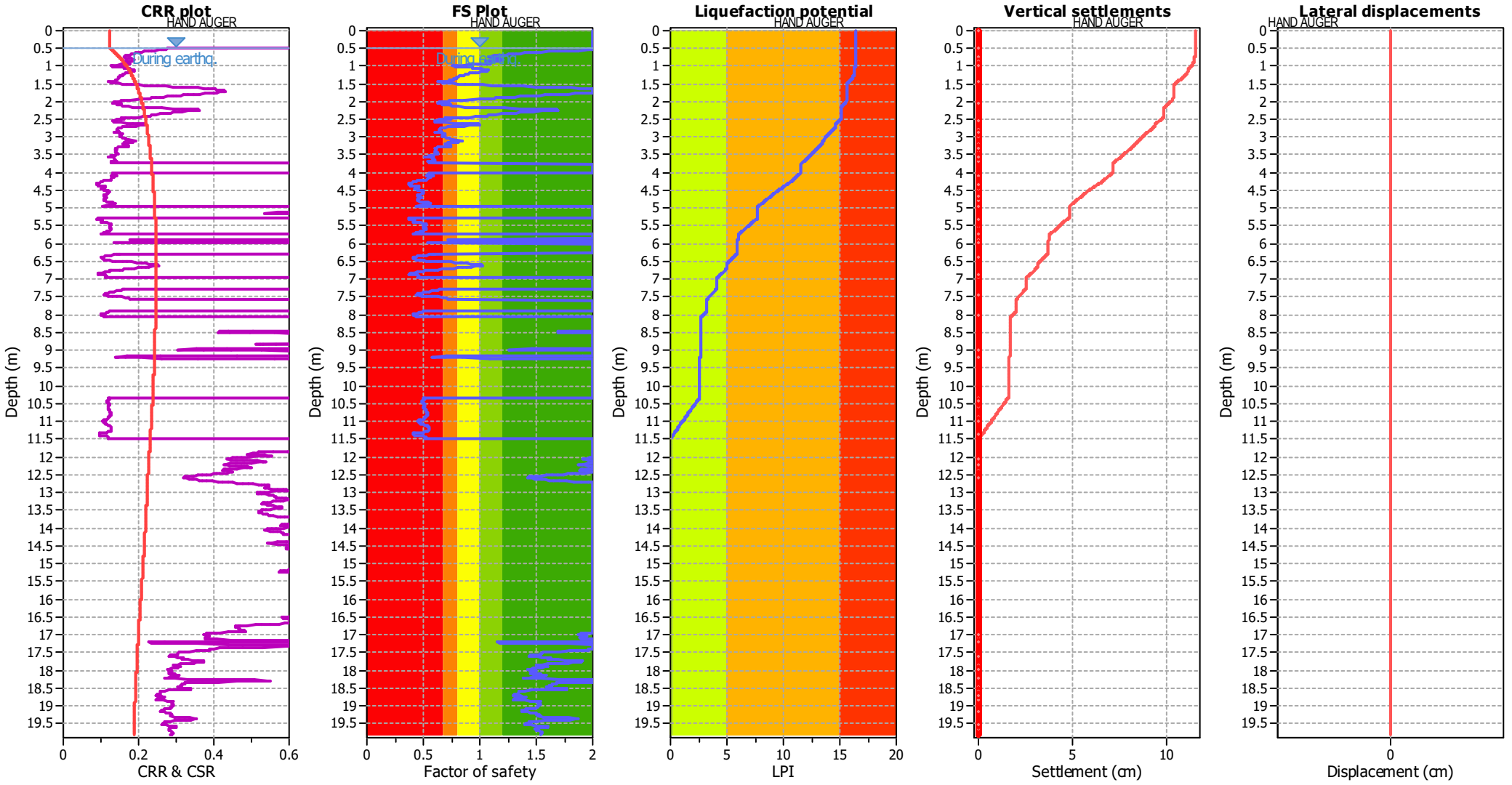






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.50 m	Fill height:	N/A	Limit depth:	N/A

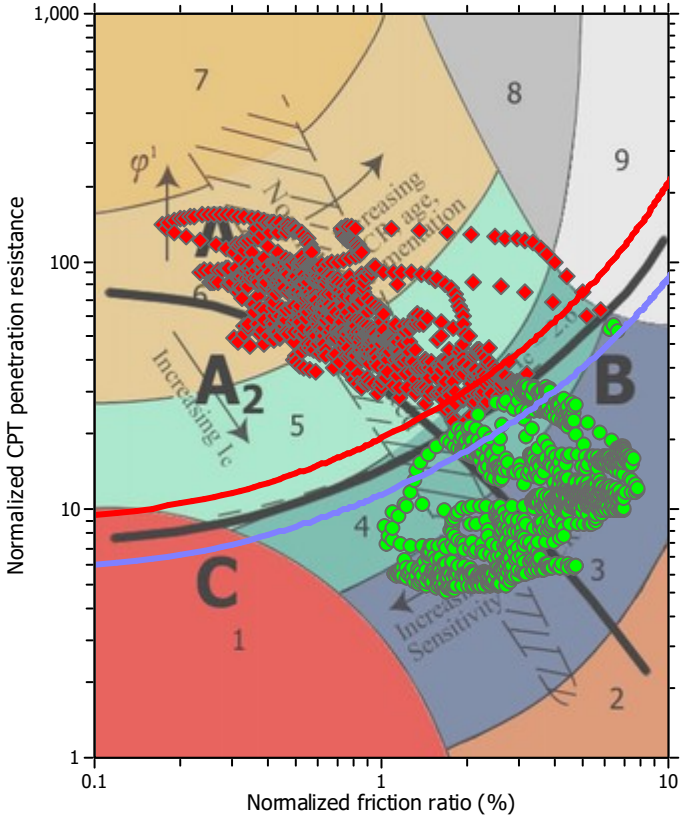
F.S. color scheme

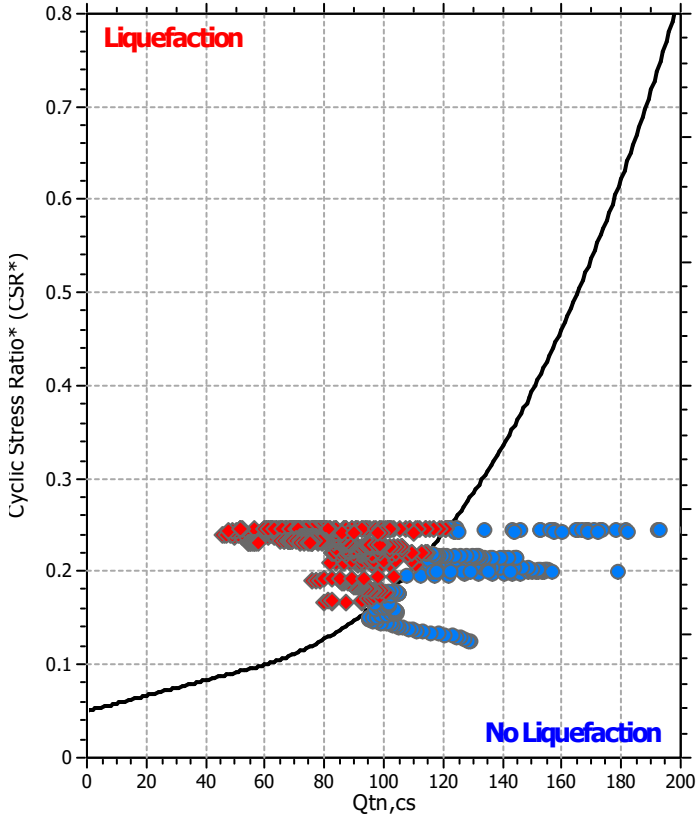
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

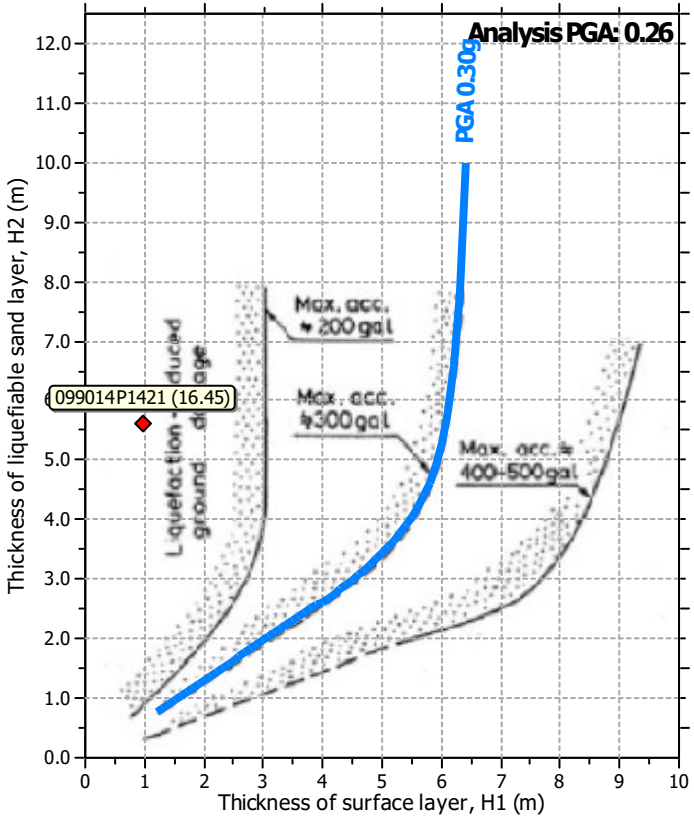
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.50 m	Fill height:	N/A	Limit depth:	N/A

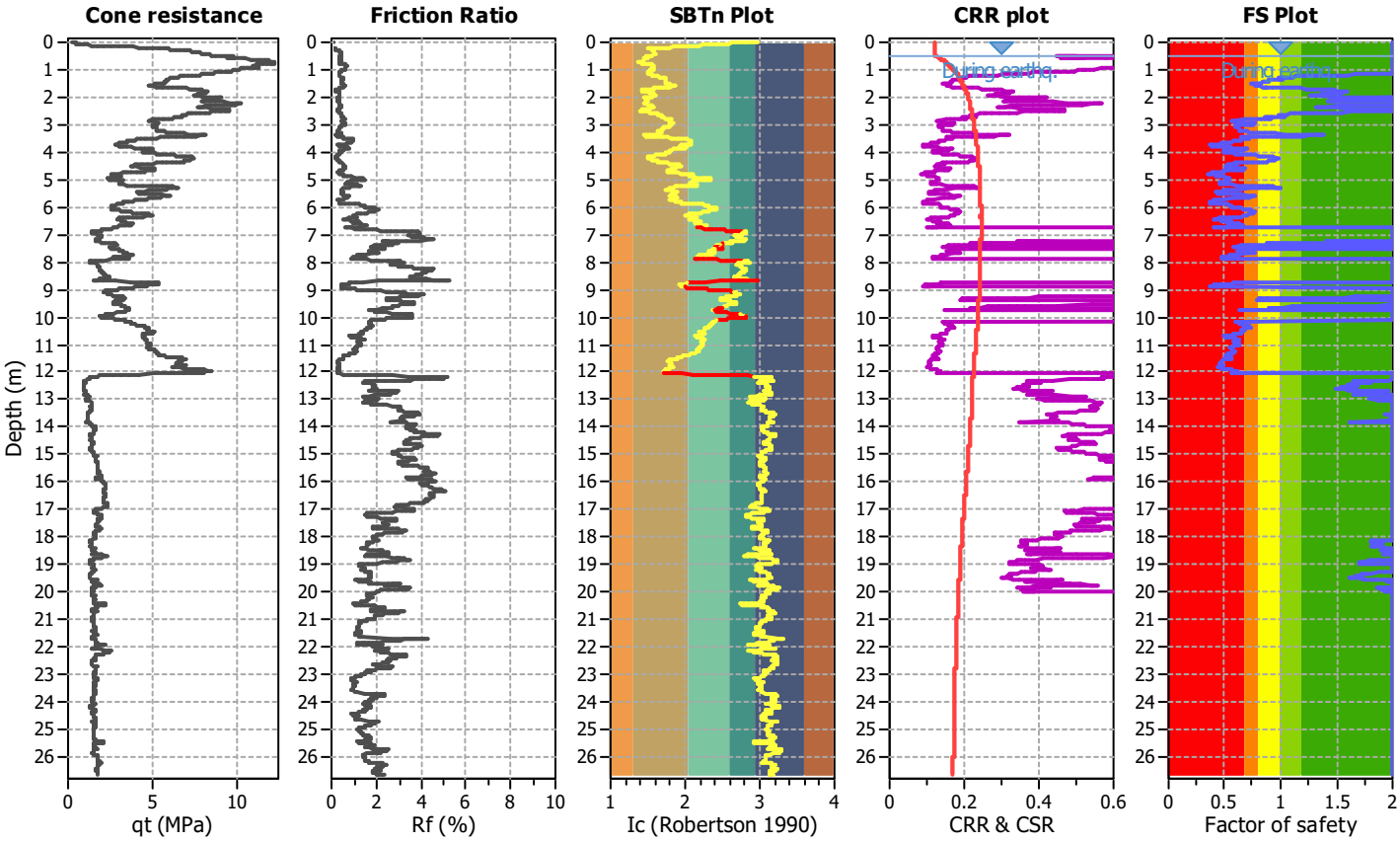
LIQUEFACTION ANALYSIS REPORT

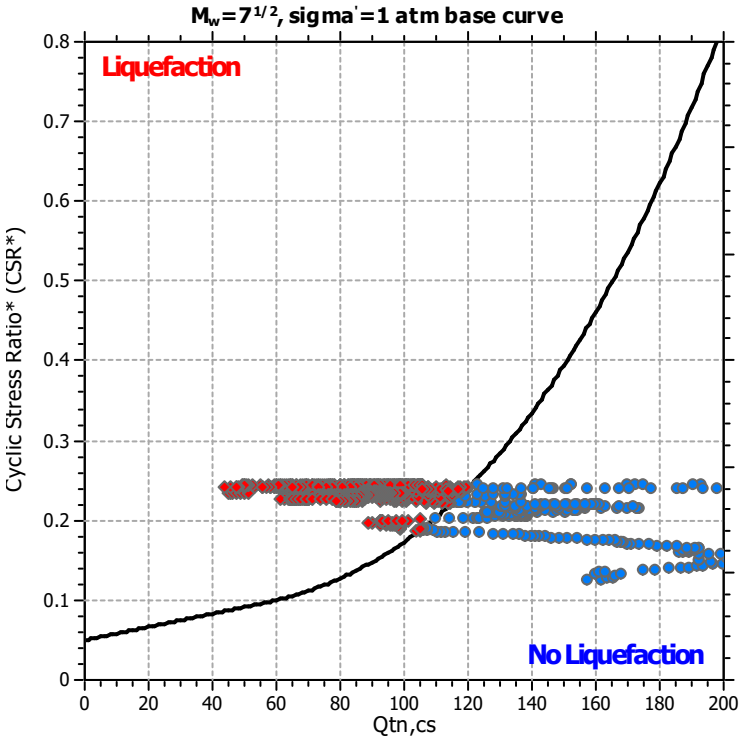
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

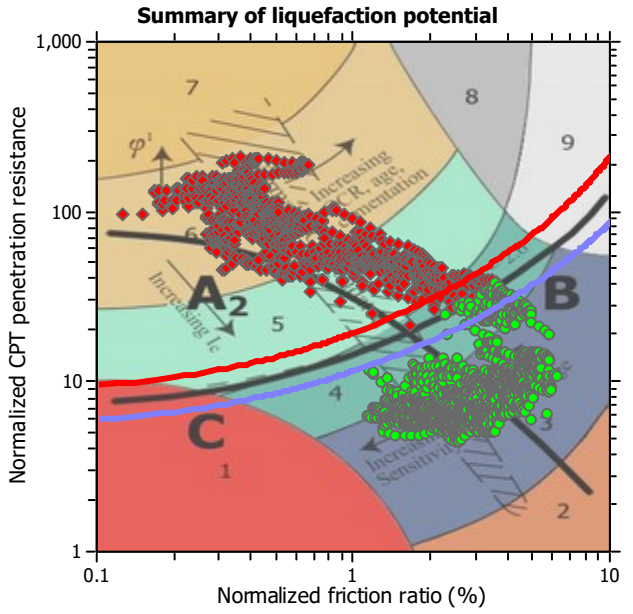
CPT file : 099014P1277

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	0.30 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.50 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

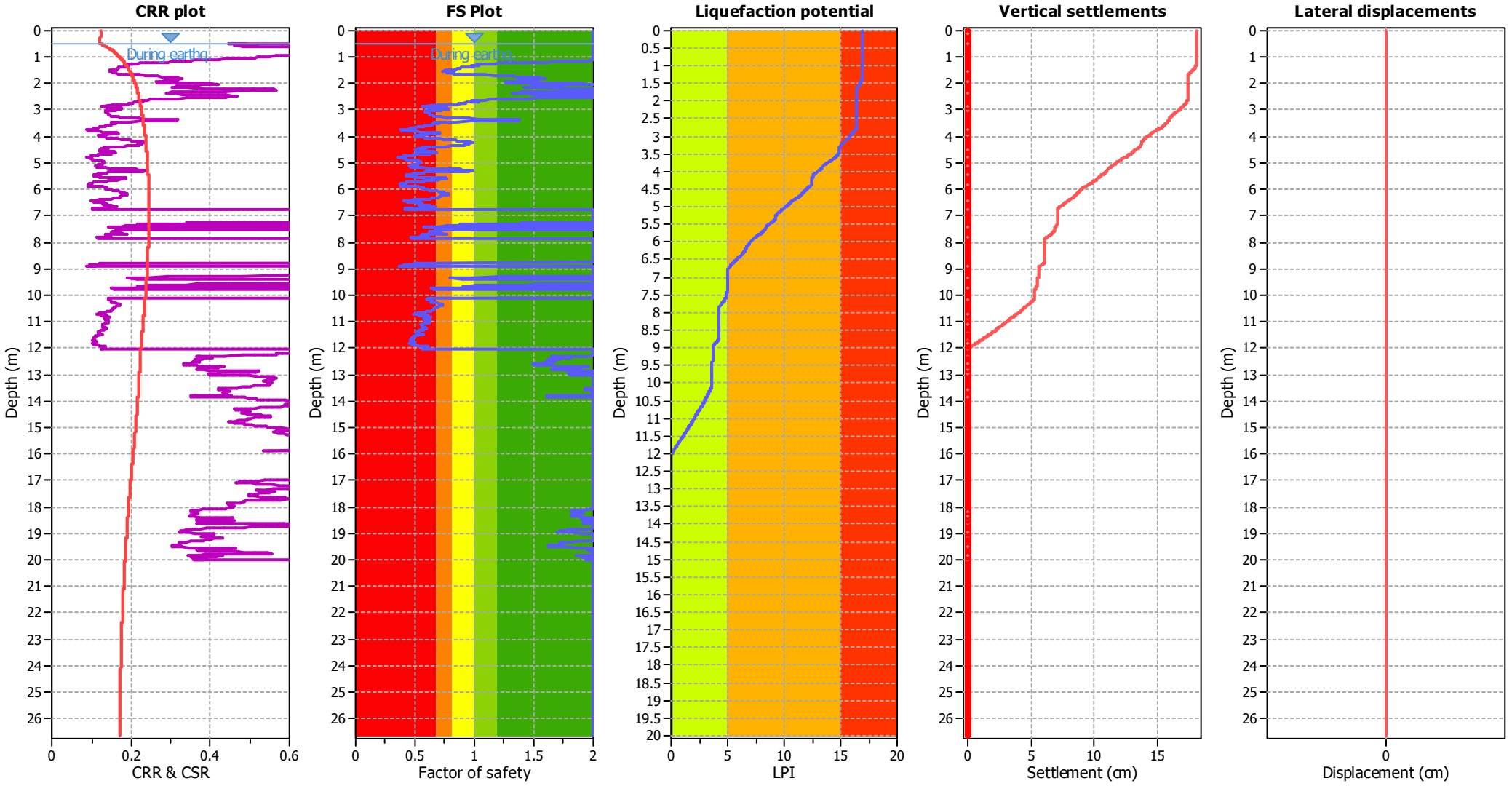






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.30 m	Fill height:	N/A	Limit depth:	20.00 m

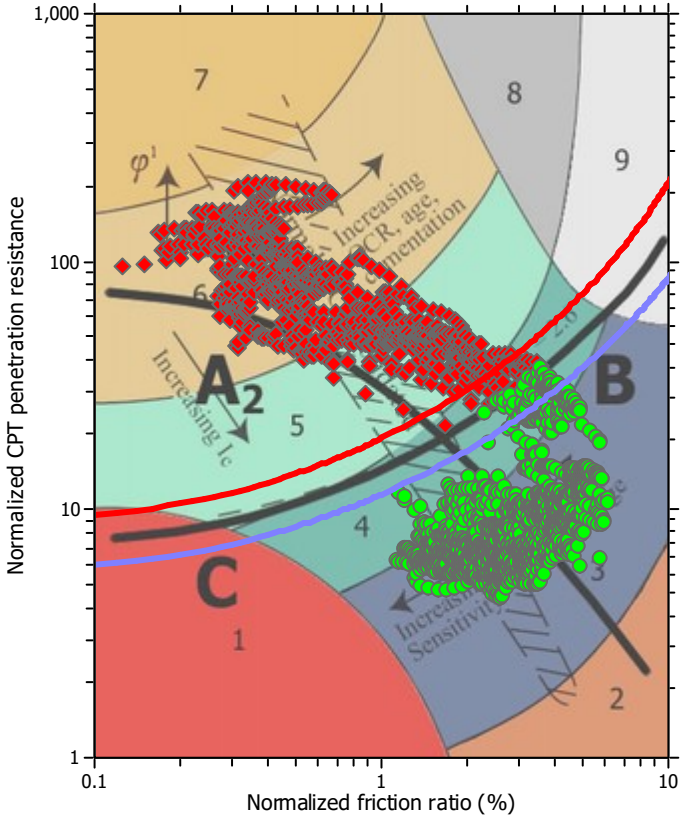
F.S. color scheme

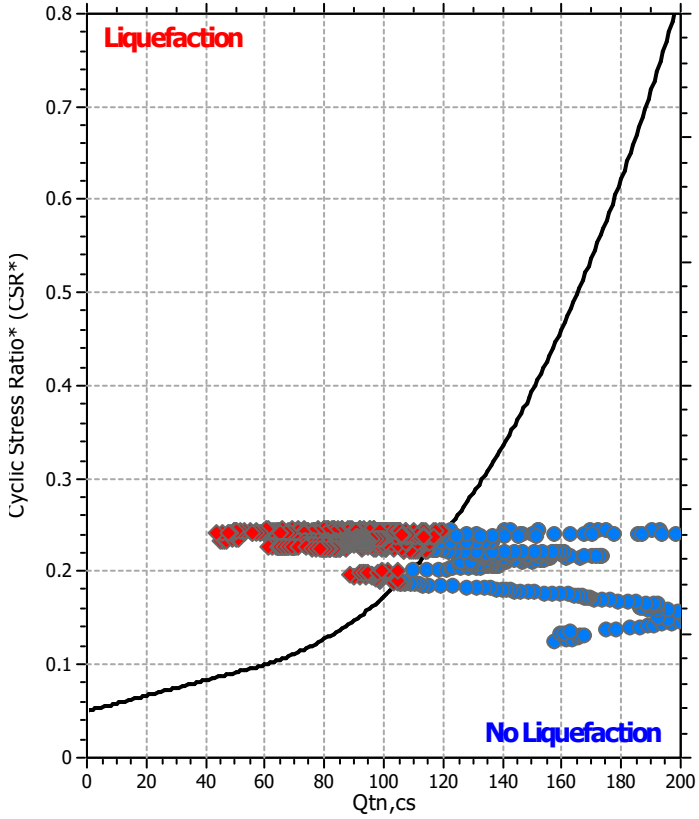
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

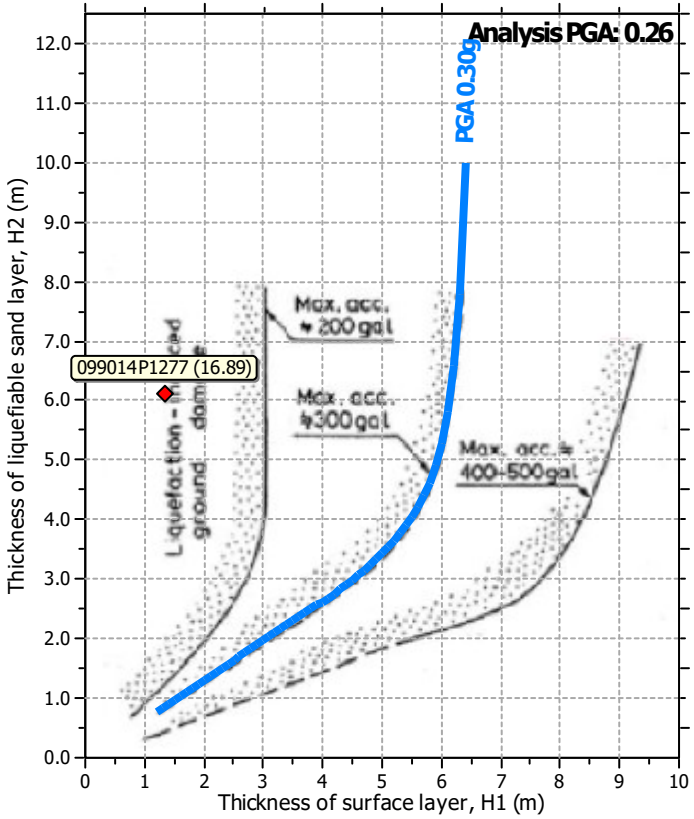
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.30 m	Fill height:	N/A	Limit depth:	20.00 m

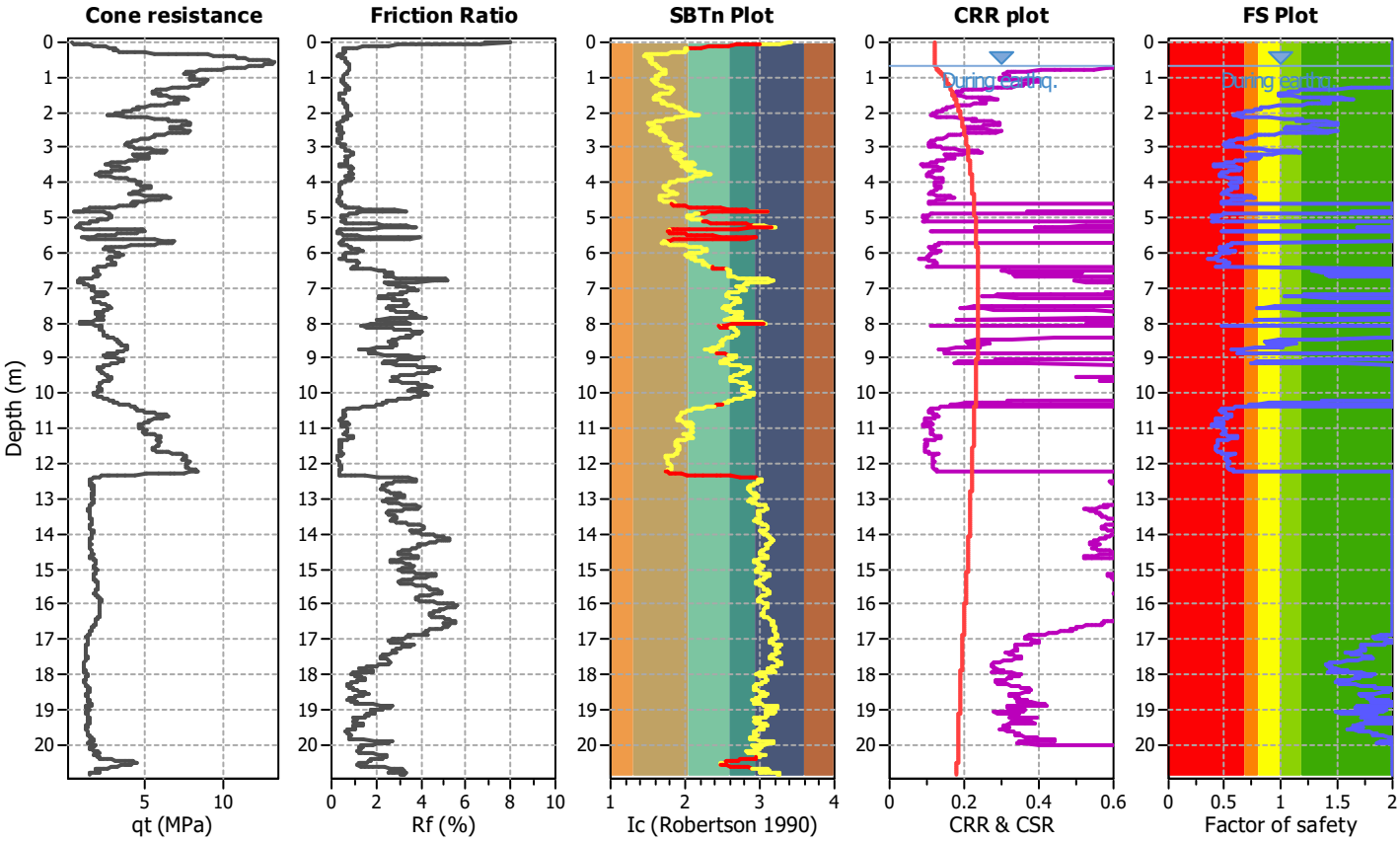
LIQUEFACTION ANALYSIS REPORT

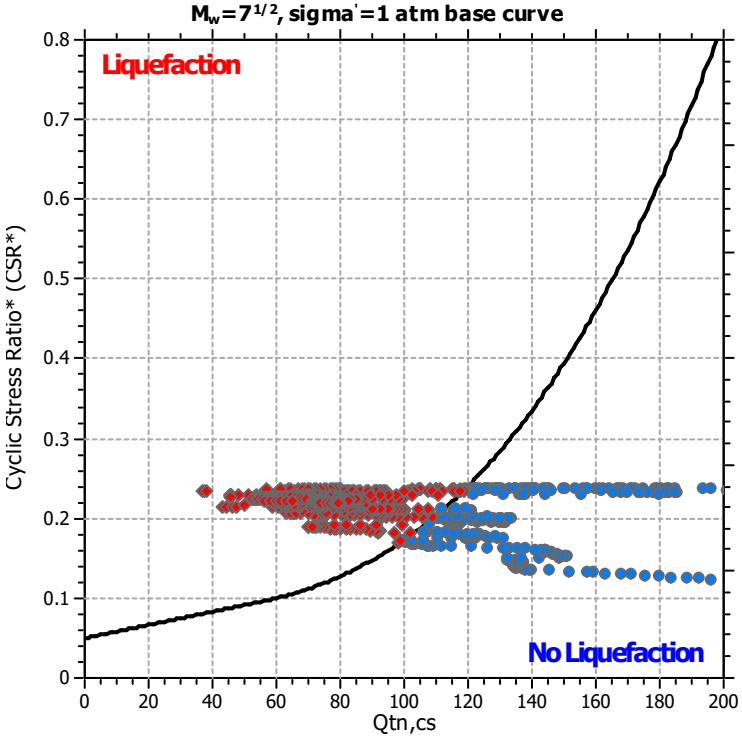
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

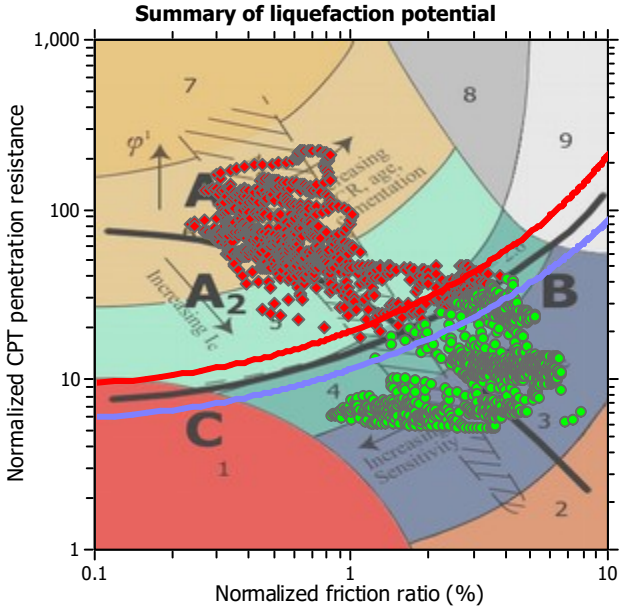
CPT file : 099014P1278

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	0.80 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.70 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

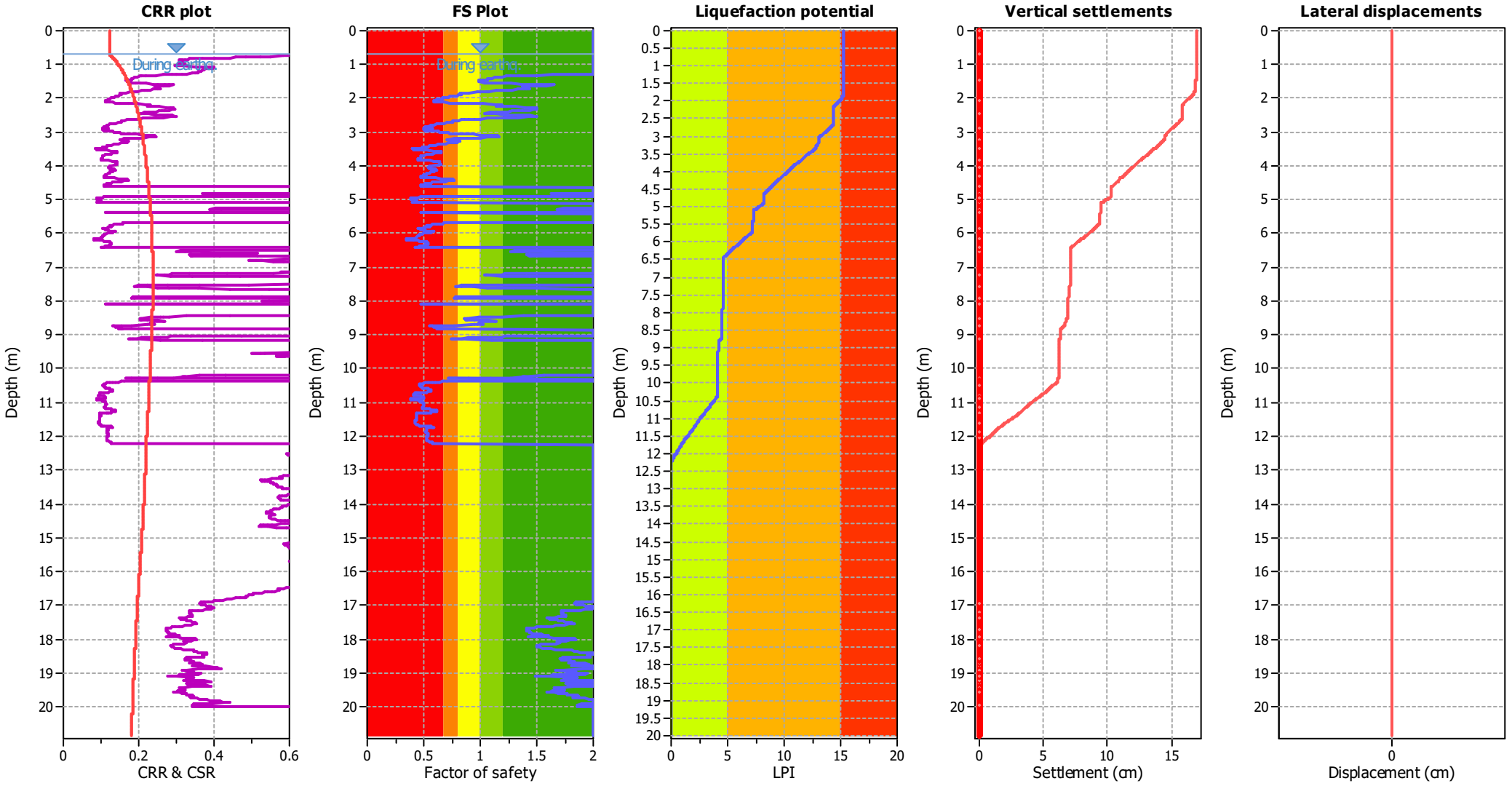






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.80 m	Fill height:	N/A	Limit depth:	20.00 m

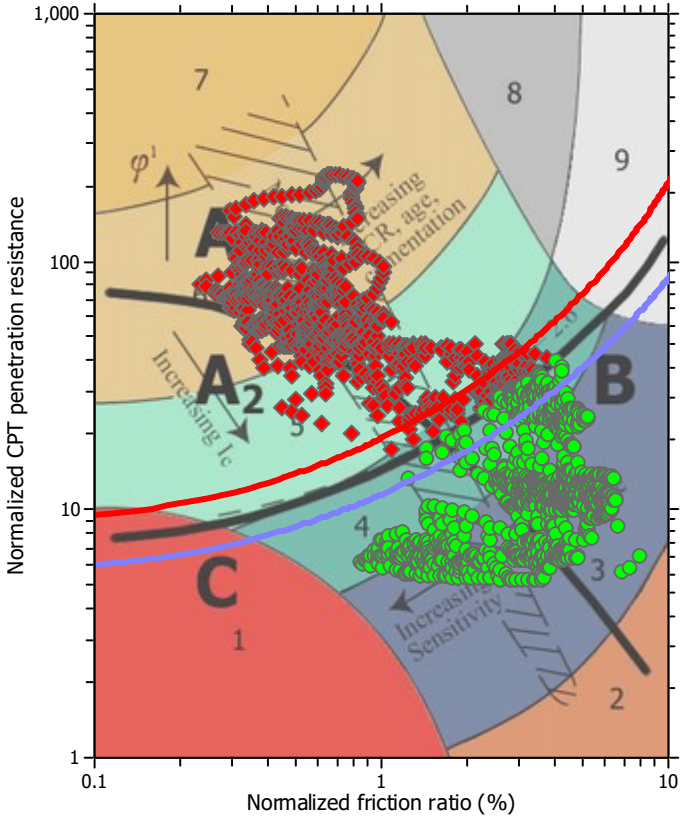
F.S. color scheme

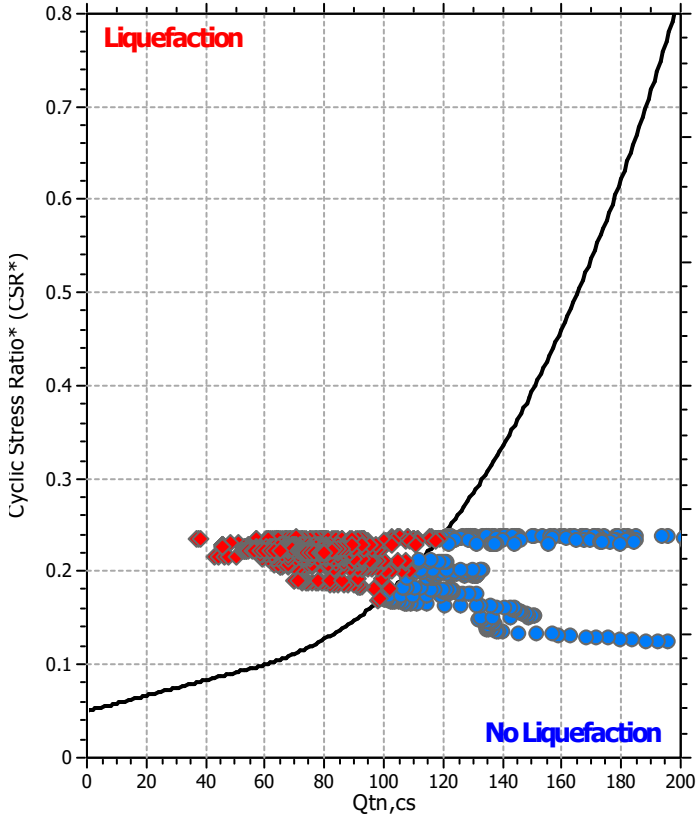
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

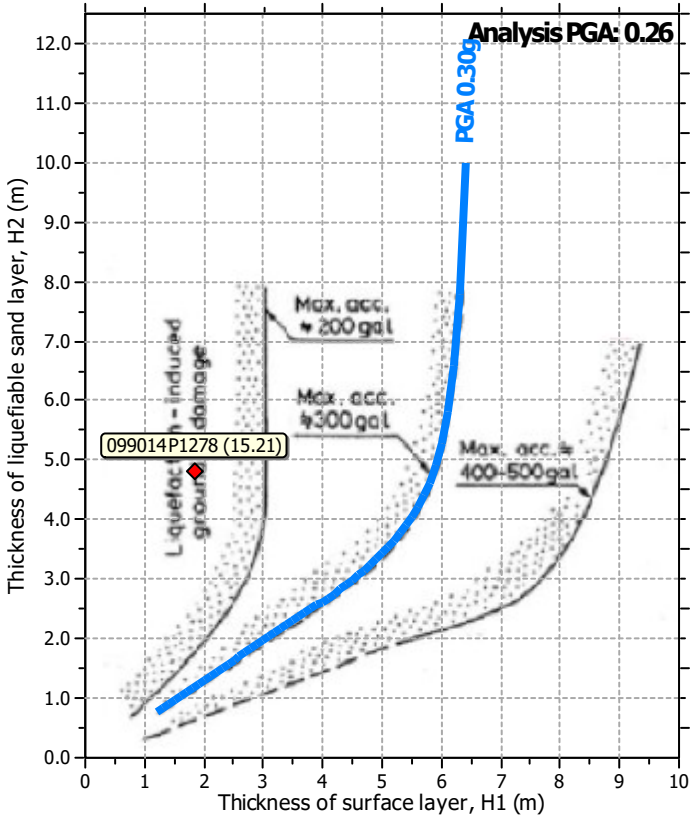
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.80 m	Fill height:	N/A	Limit depth:	20.00 m

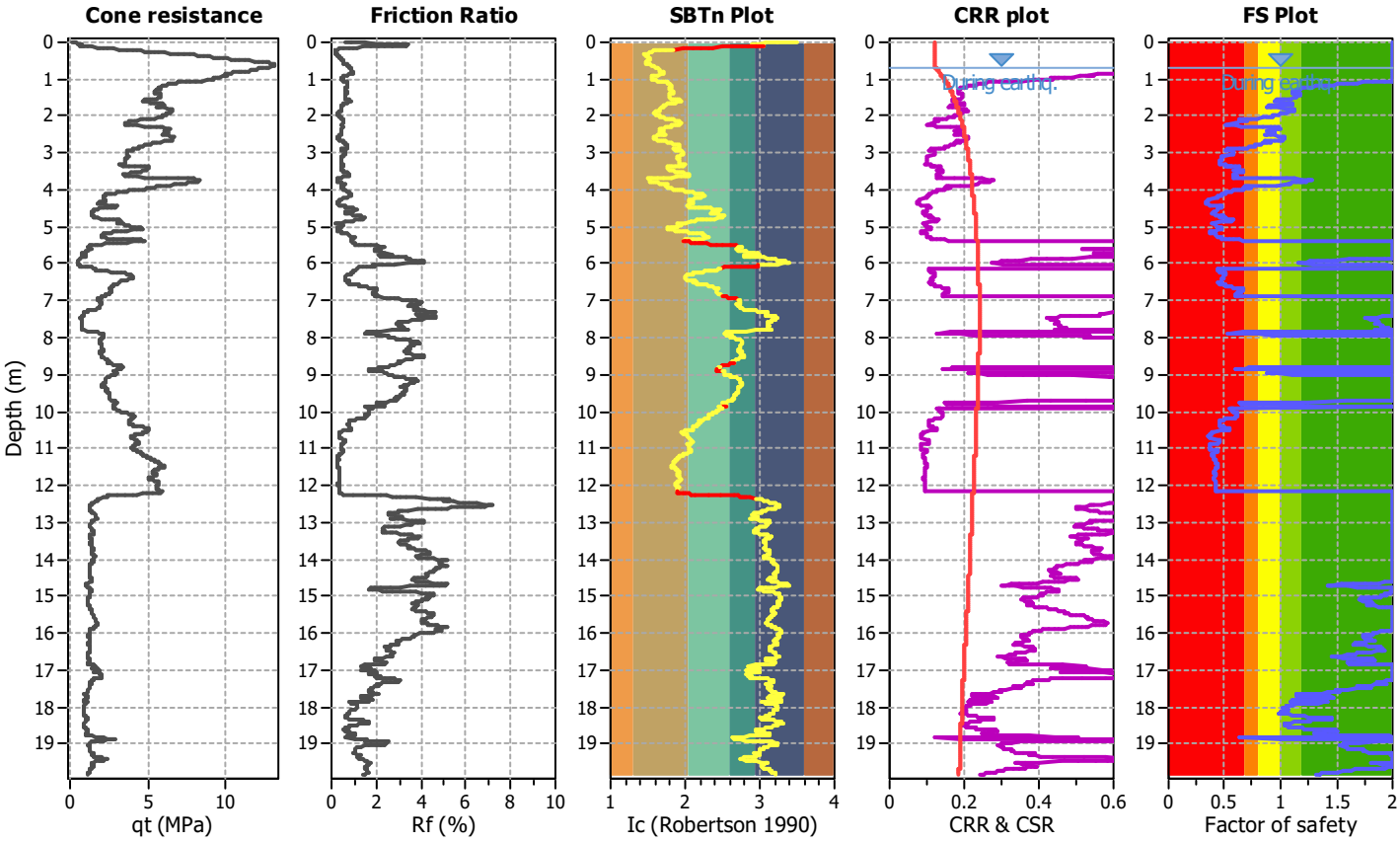
LIQUEFACTION ANALYSIS REPORT

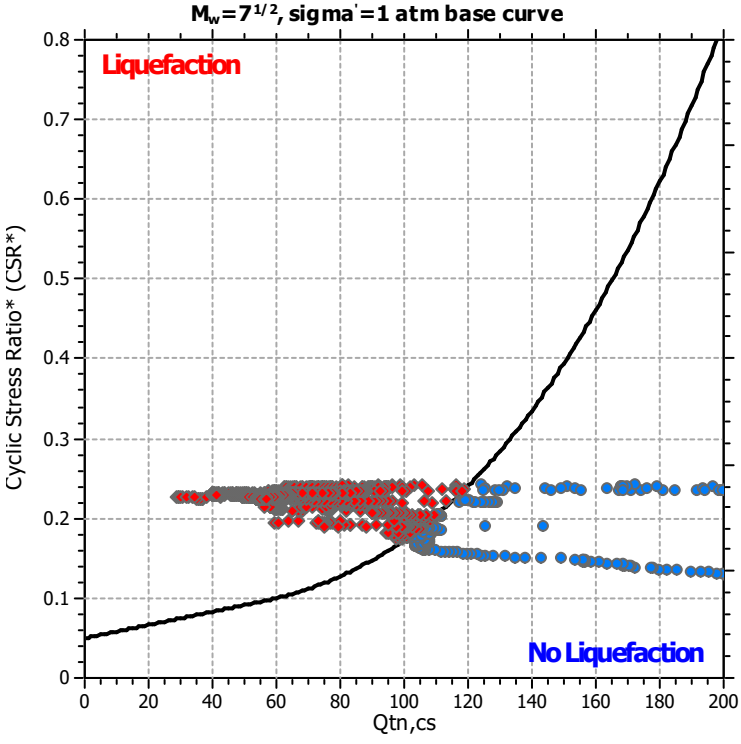
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

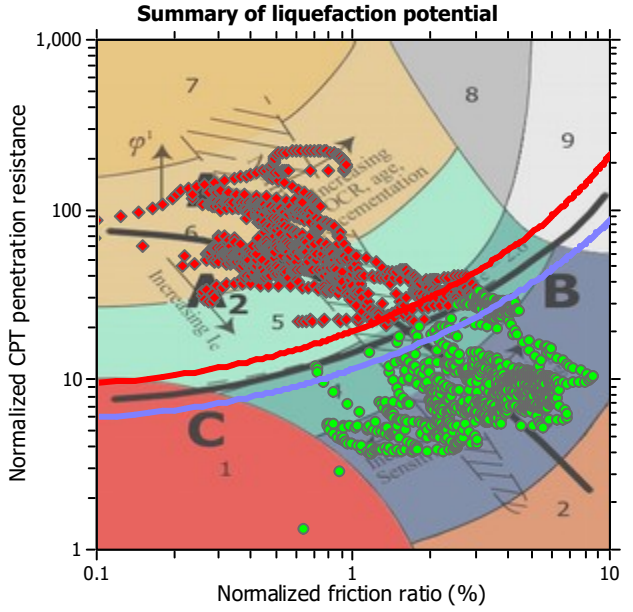
CPT file : CPTe_13

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	0.90 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.70 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

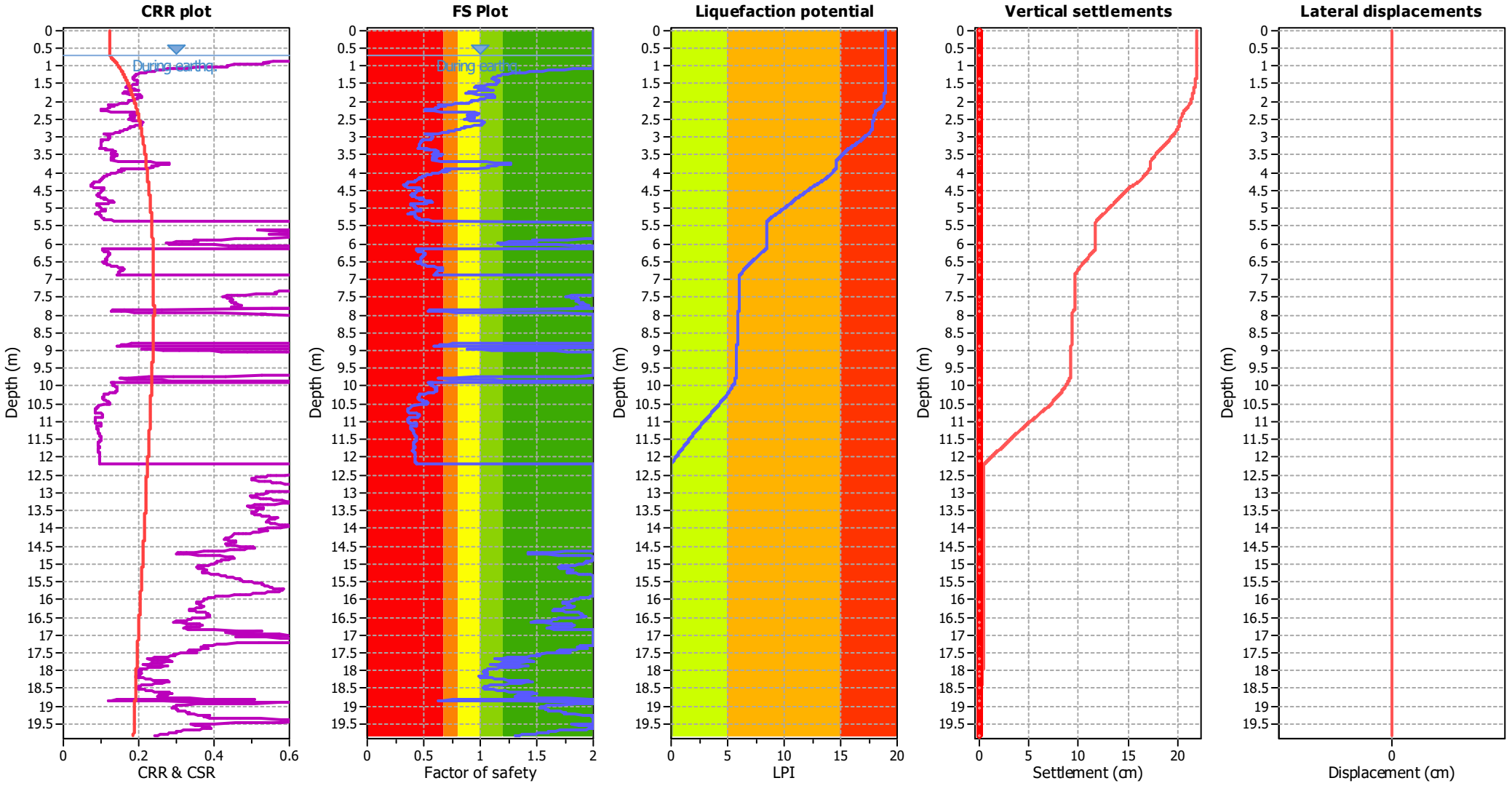






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

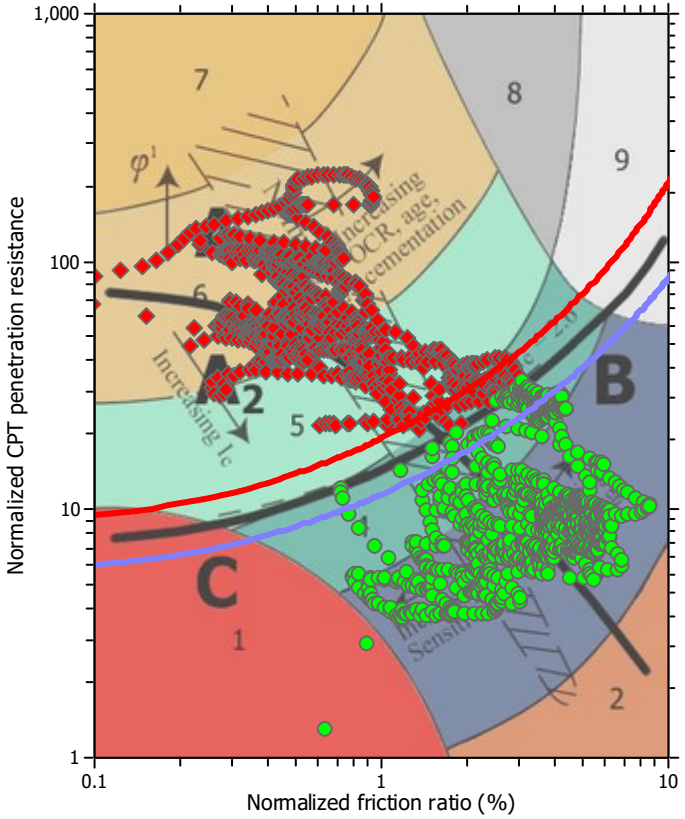
F.S. color scheme

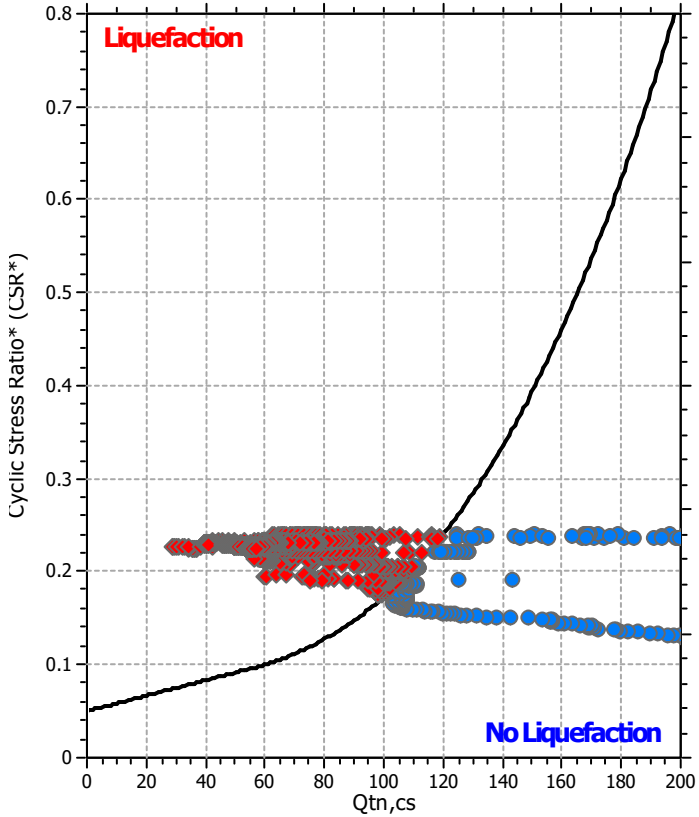
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

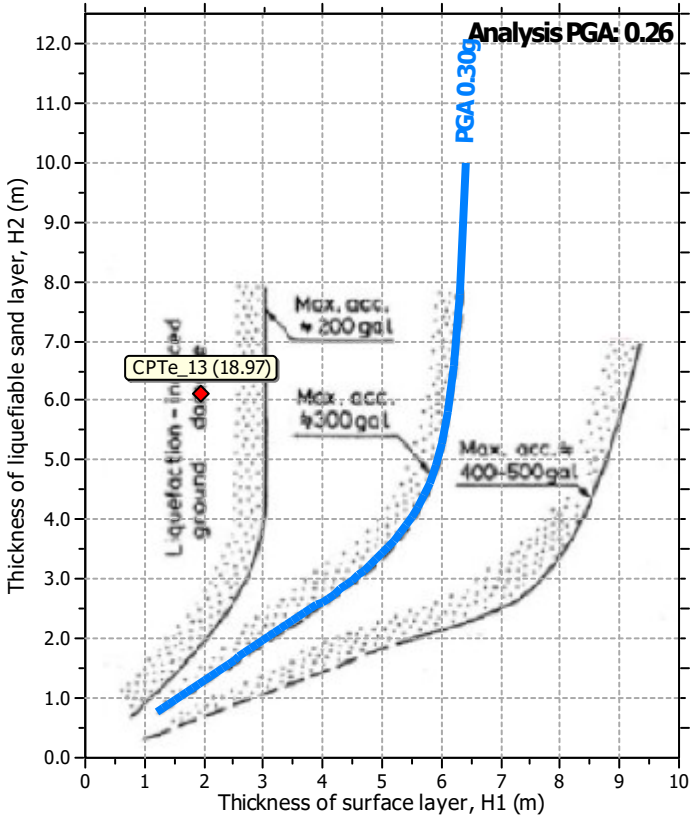
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.90 m	Fill height:	N/A	Limit depth:	N/A

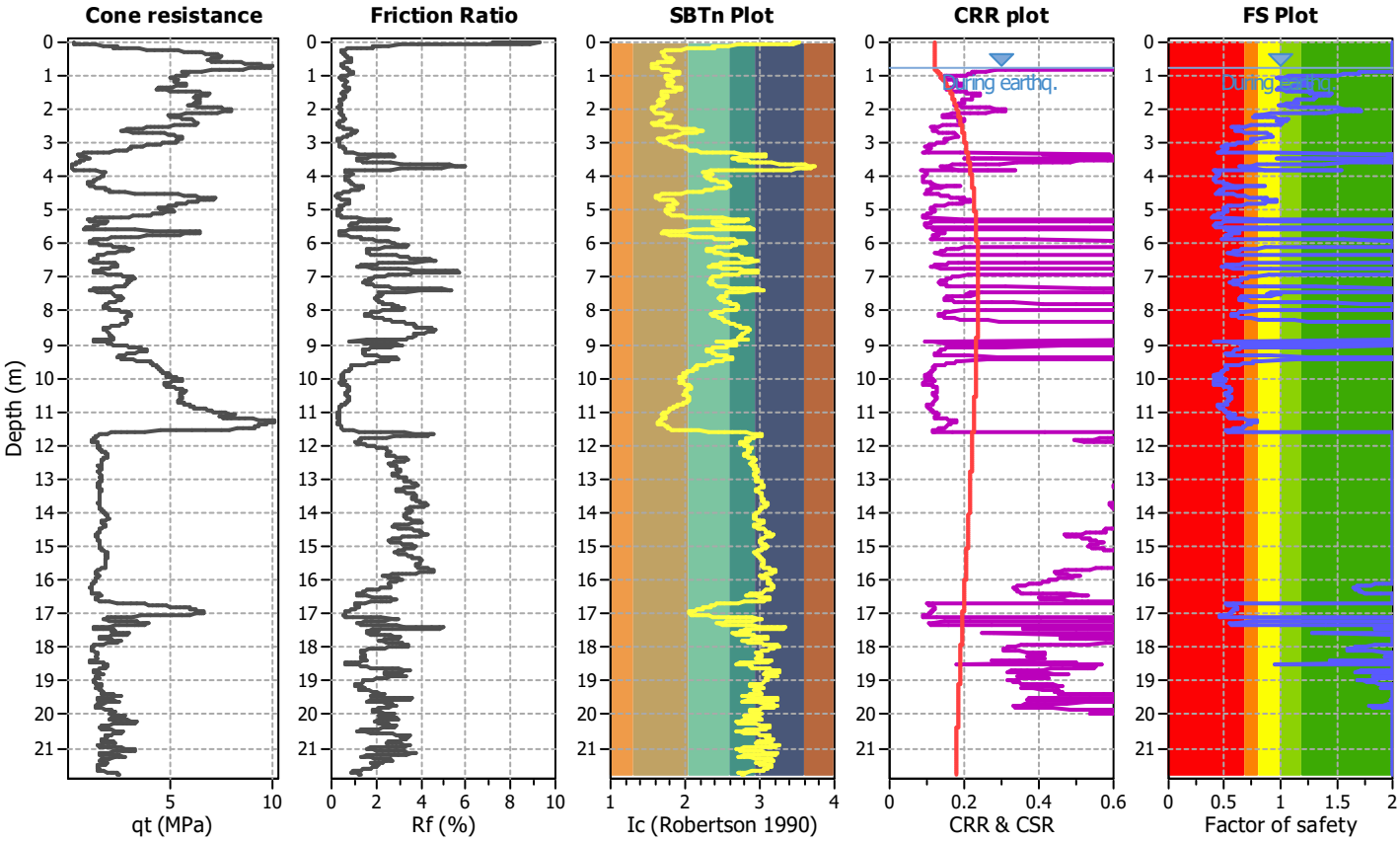
LIQUEFACTION ANALYSIS REPORT

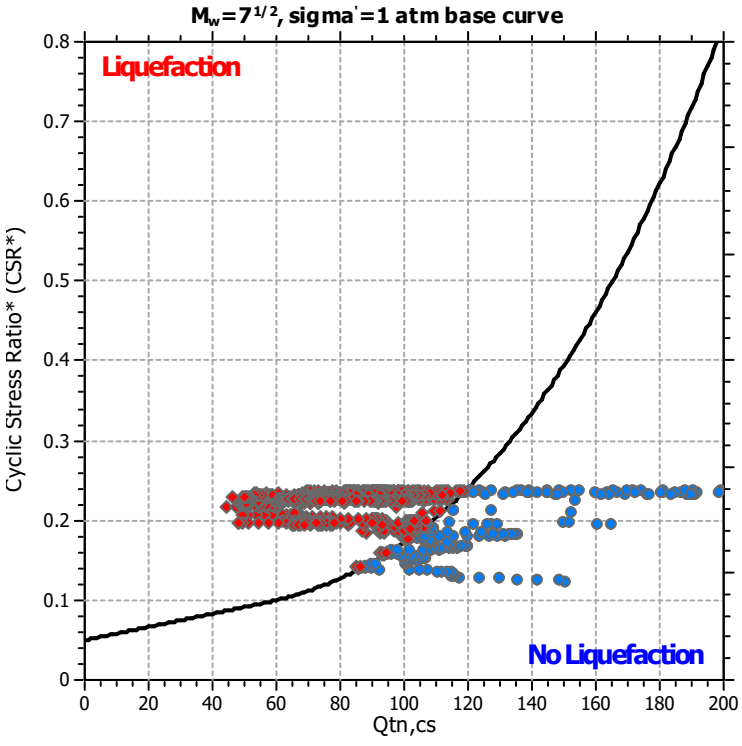
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

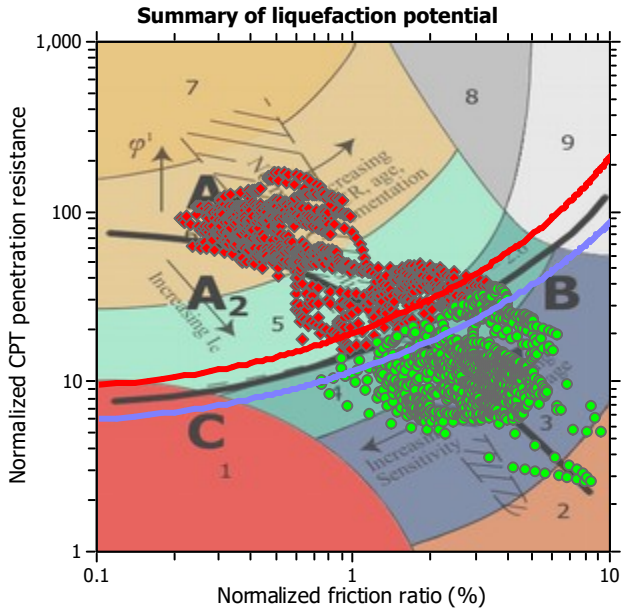
CPT file : 099014P1280

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

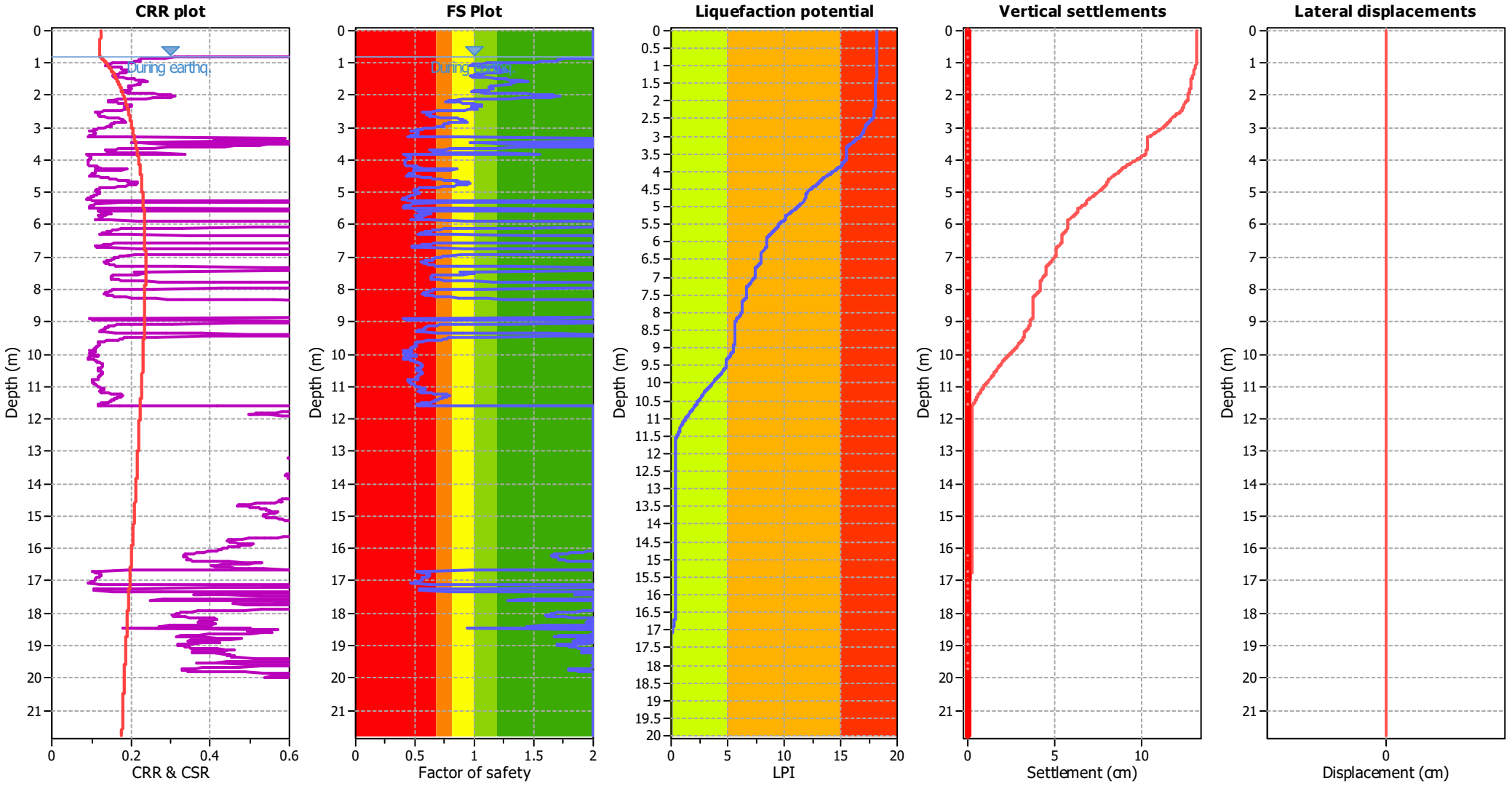






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	20.00 m

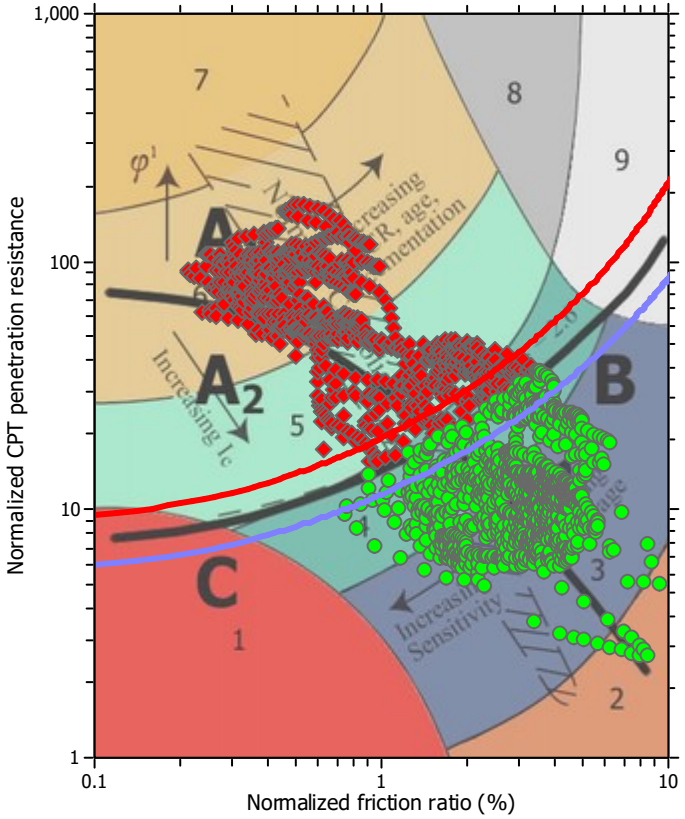
F.S. color scheme

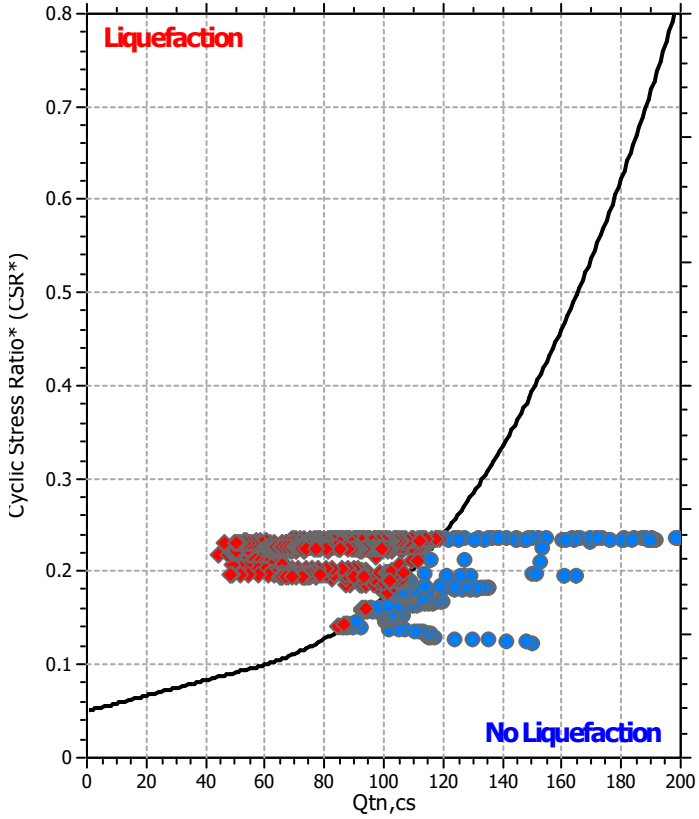
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

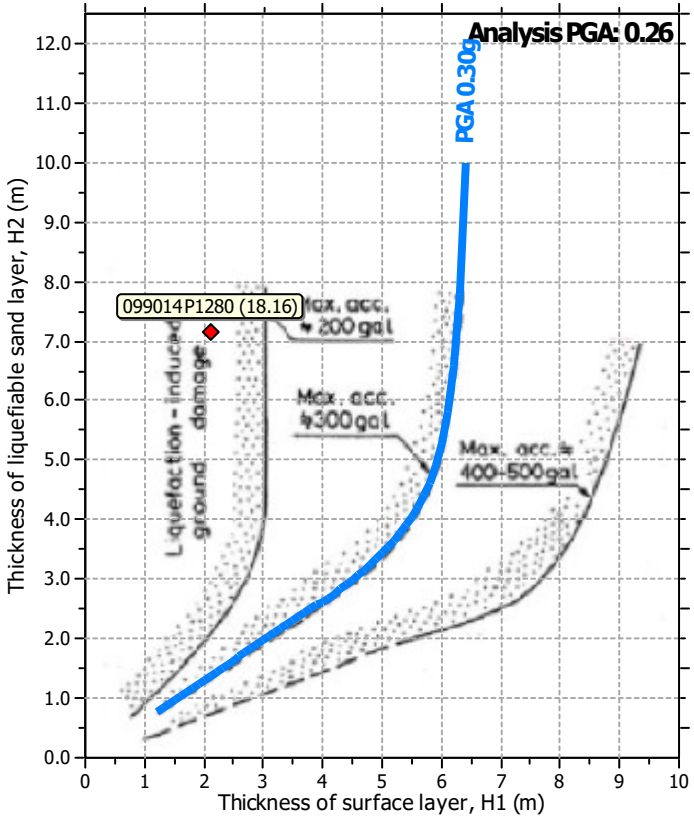
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	20.00 m

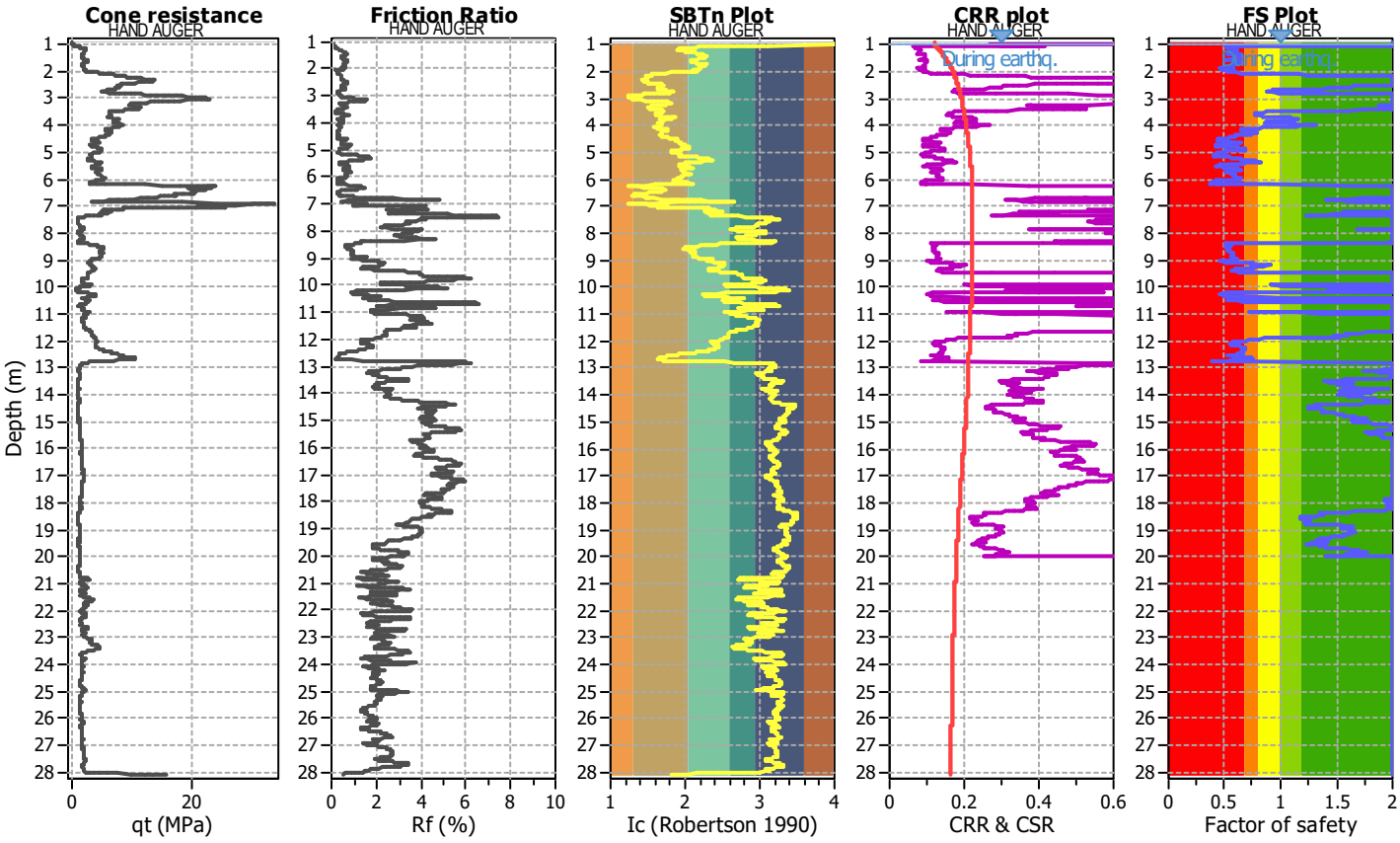
LIQUEFACTION ANALYSIS REPORT

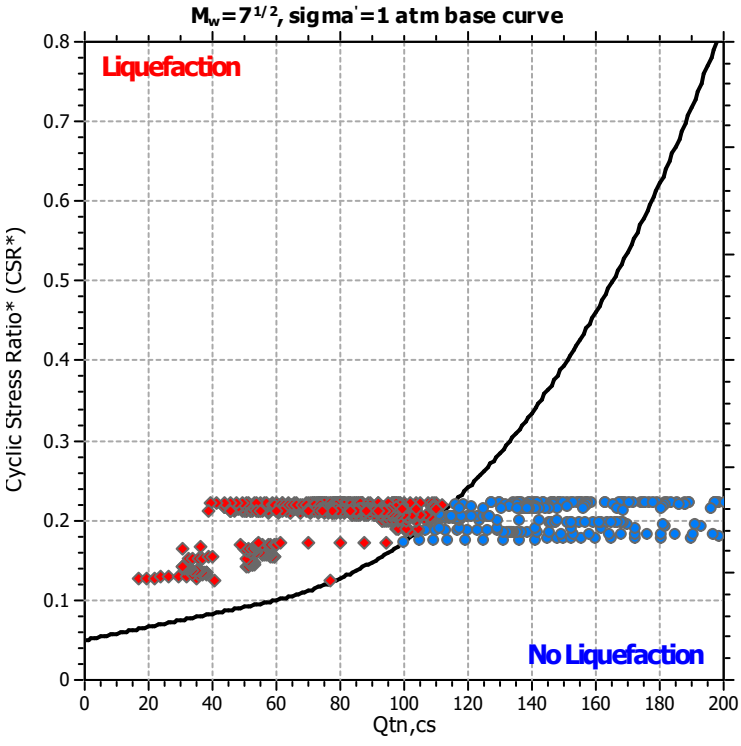
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

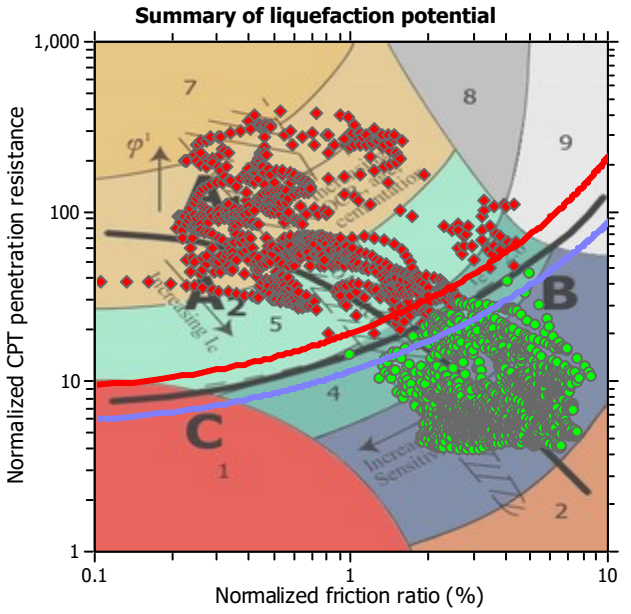
CPT file : SCPTE_1

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.50 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

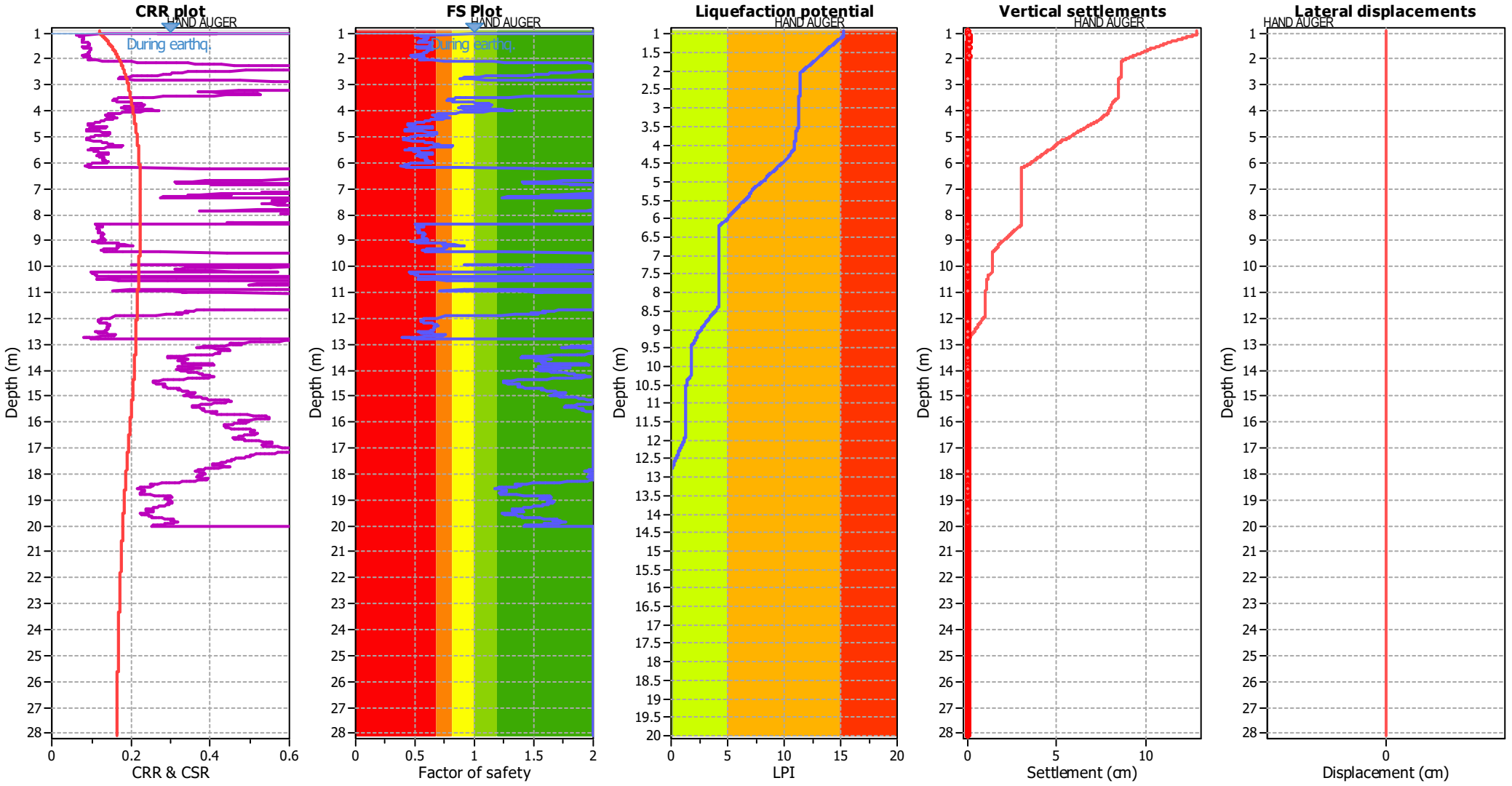






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	20.00 m

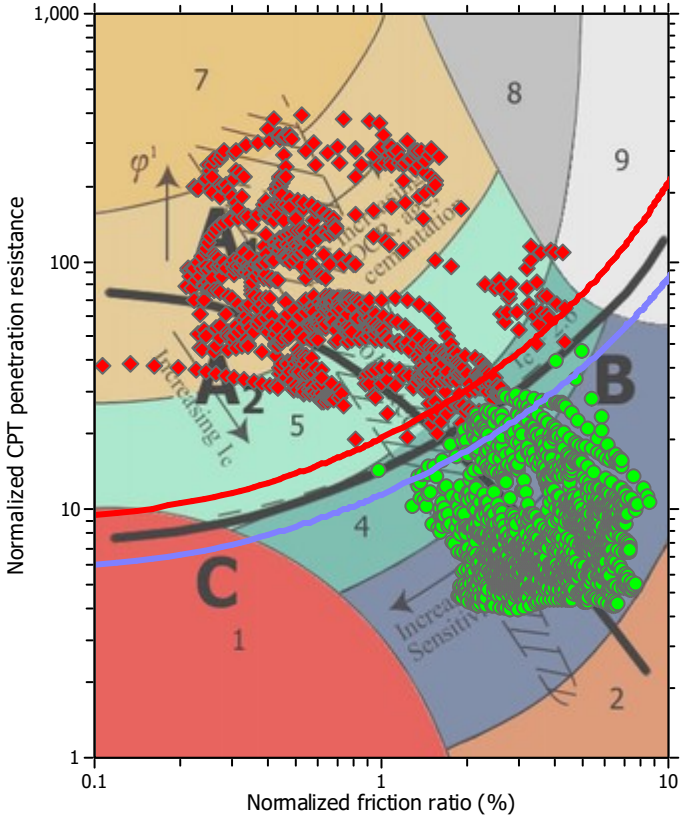
F.S. color scheme

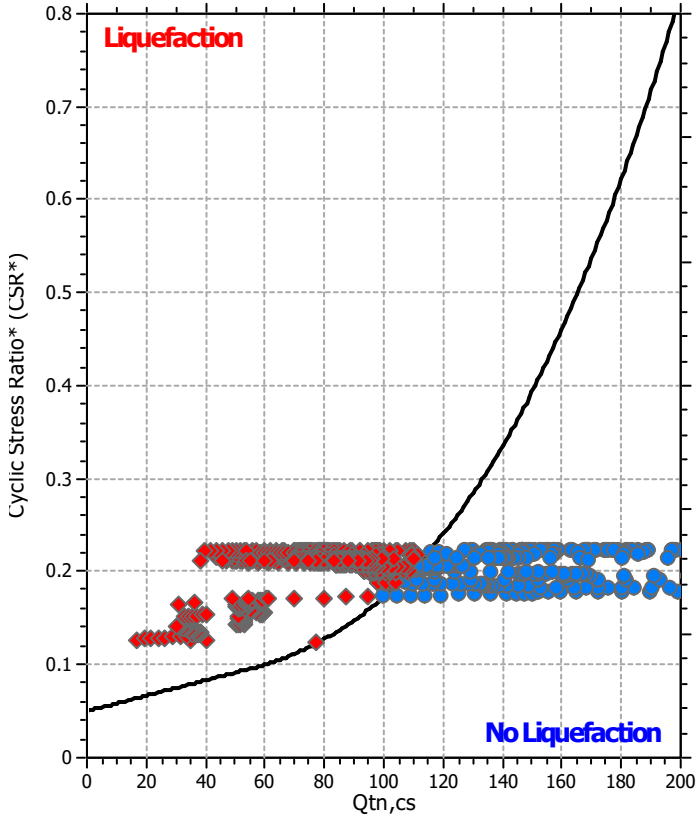
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

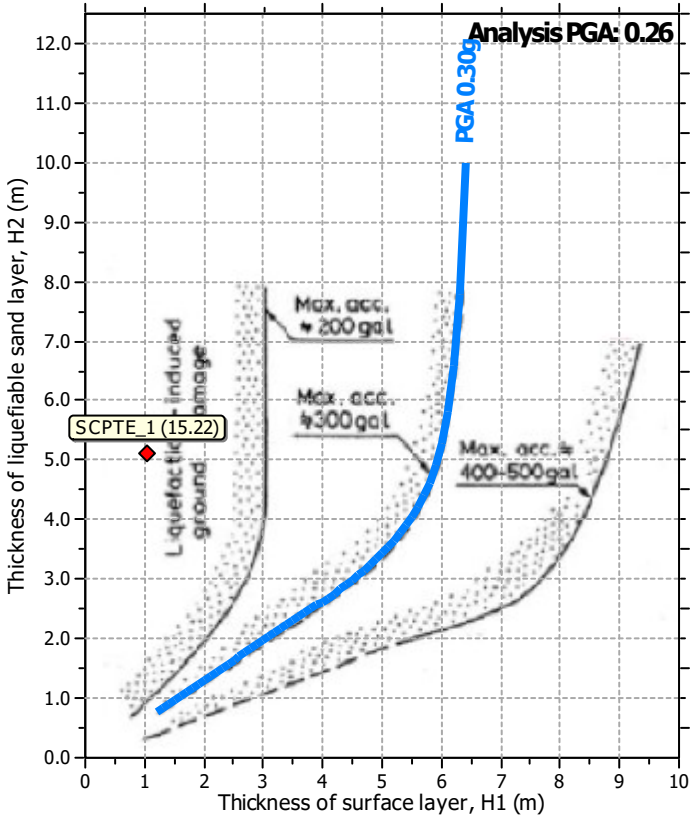
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	20.00 m

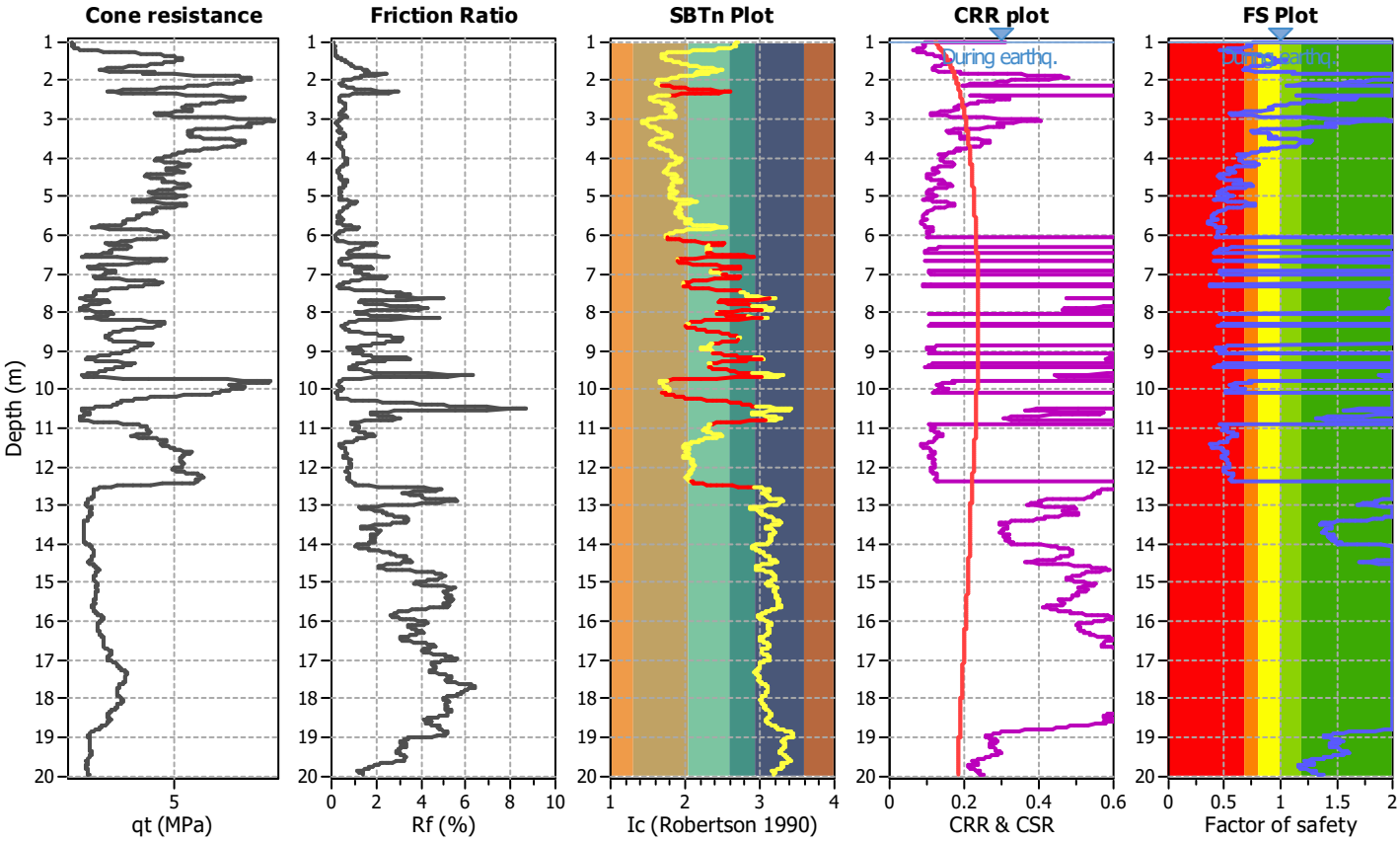
LIQUEFACTION ANALYSIS REPORT

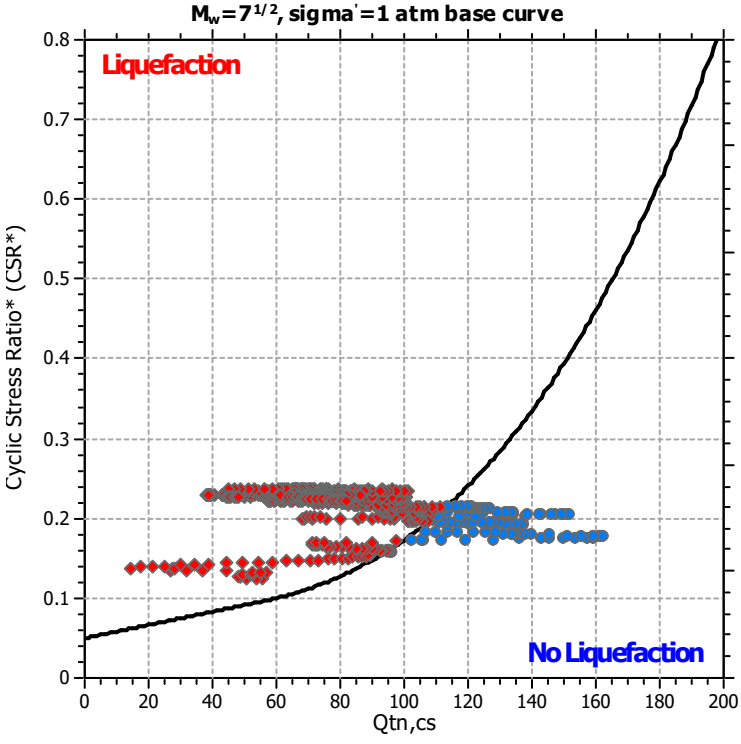
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

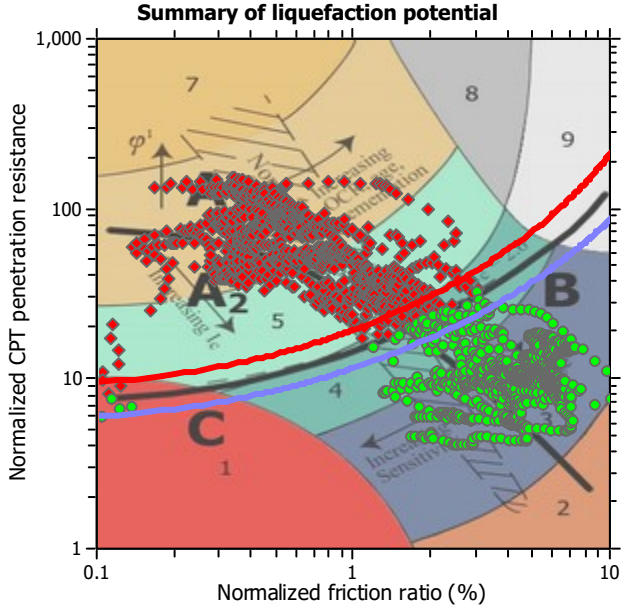
CPT file : CPTE_21

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.50 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

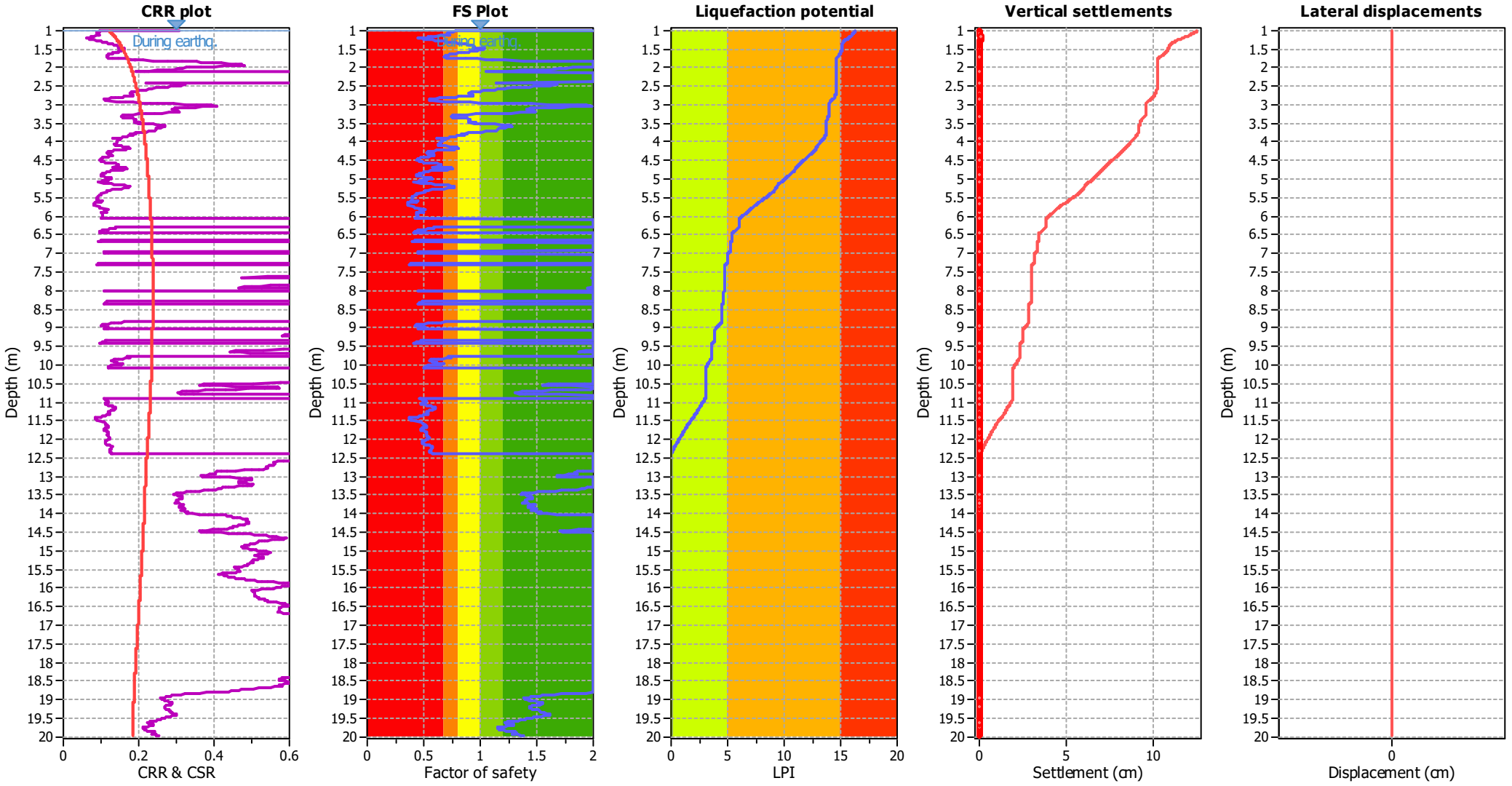






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	20.00 m

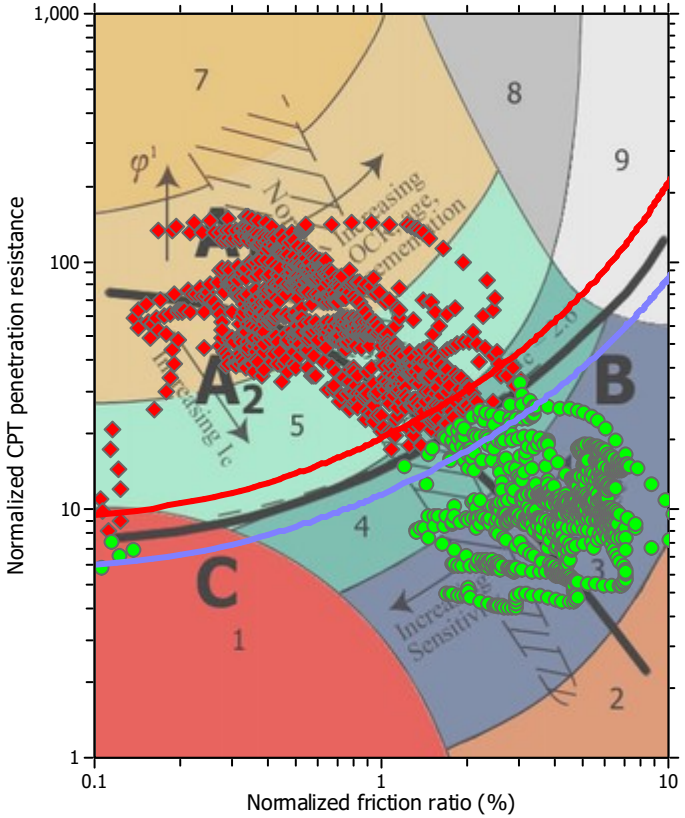
F.S. color scheme

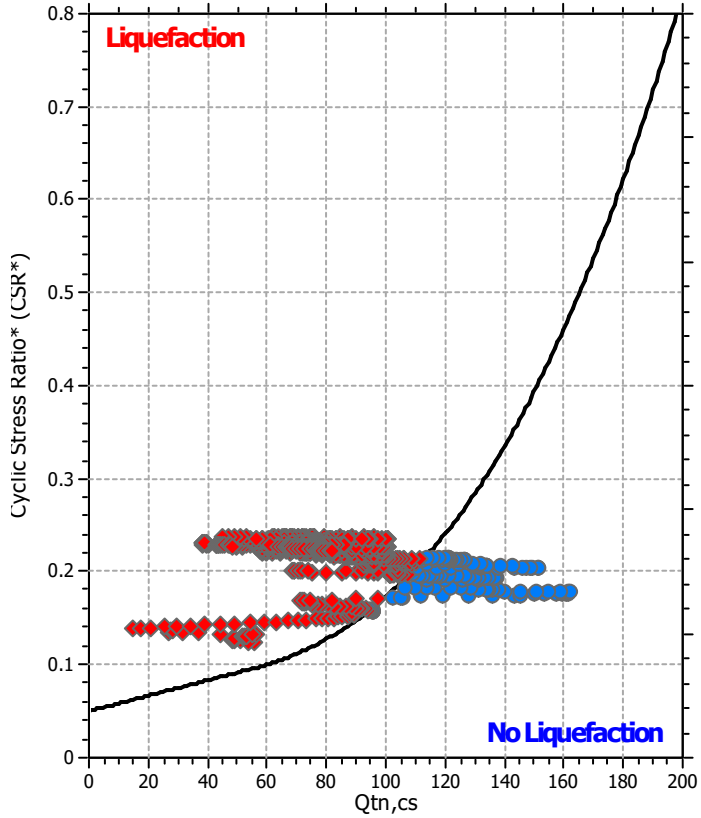
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

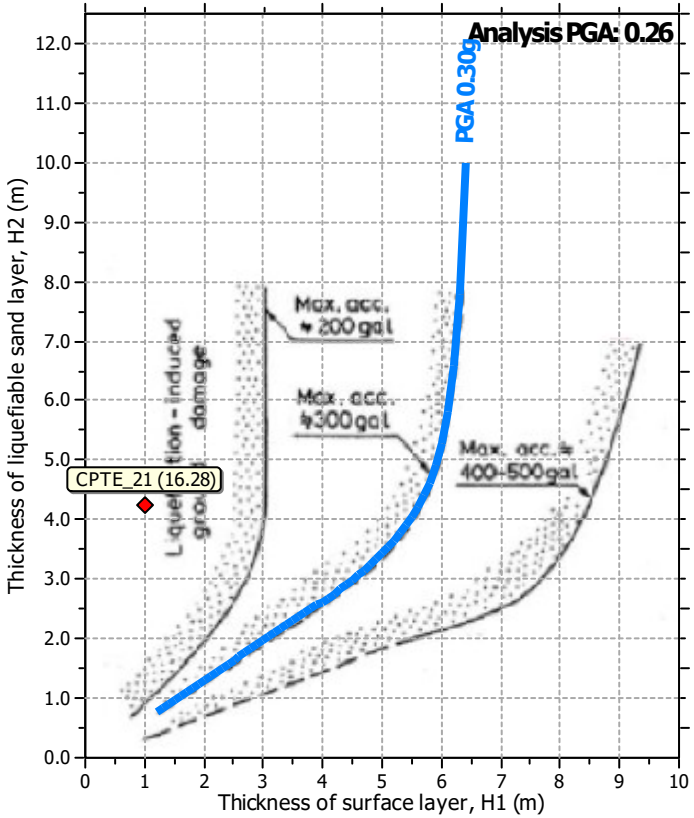
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	20.00 m

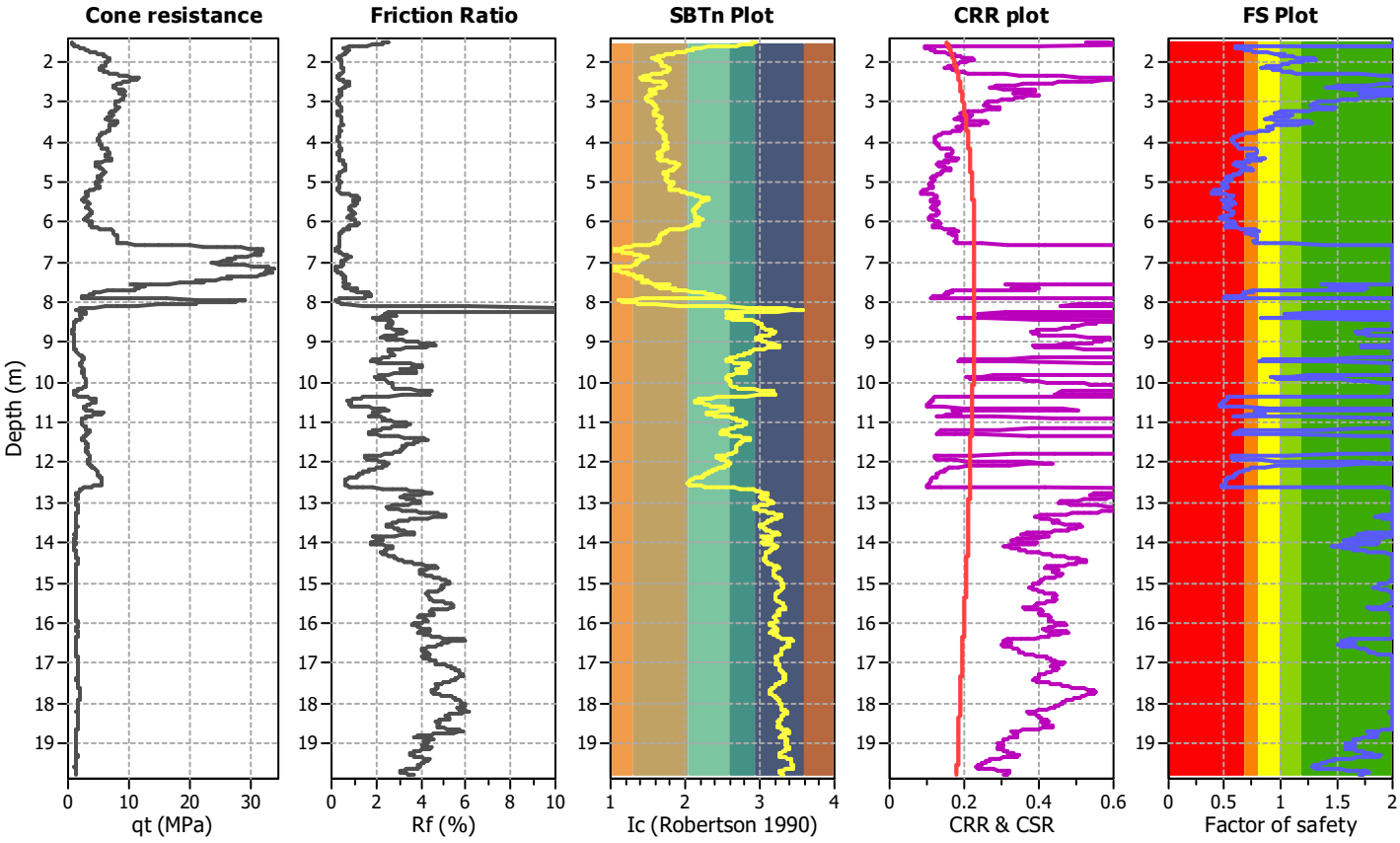
LIQUEFACTION ANALYSIS REPORT

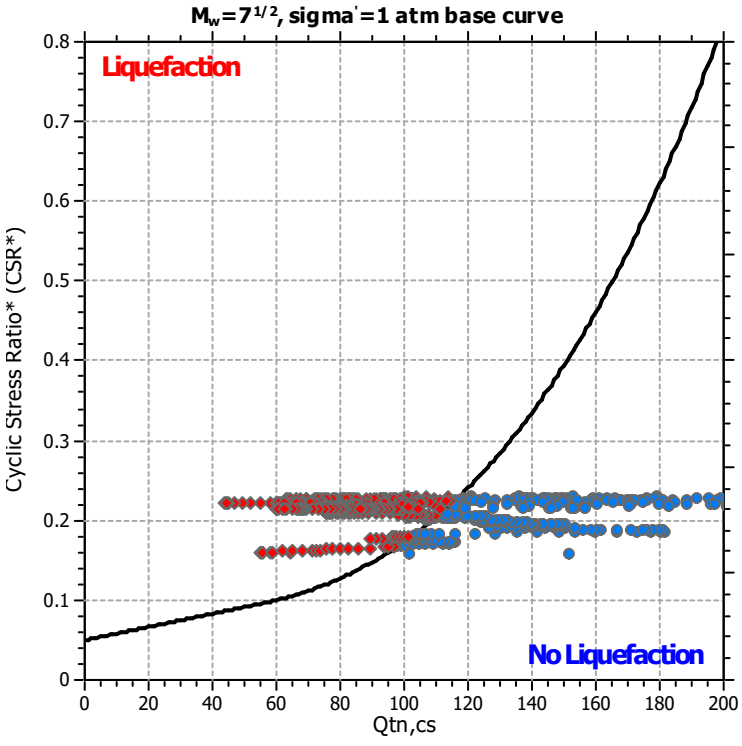
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

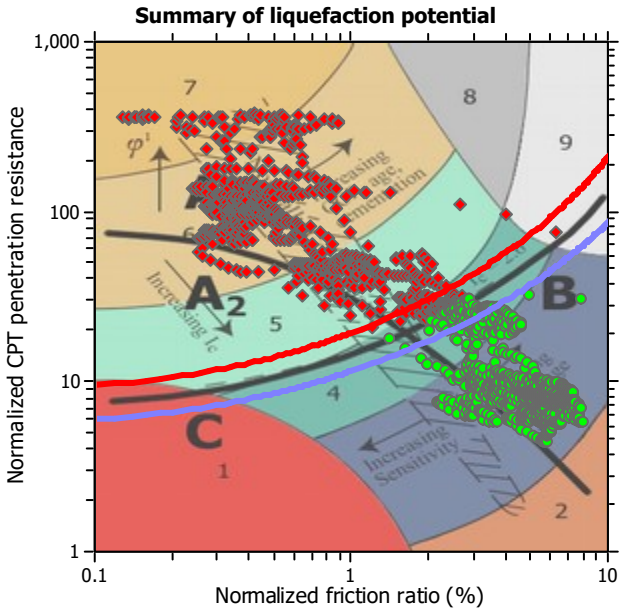
CPT file : CPTE_22

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.50 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

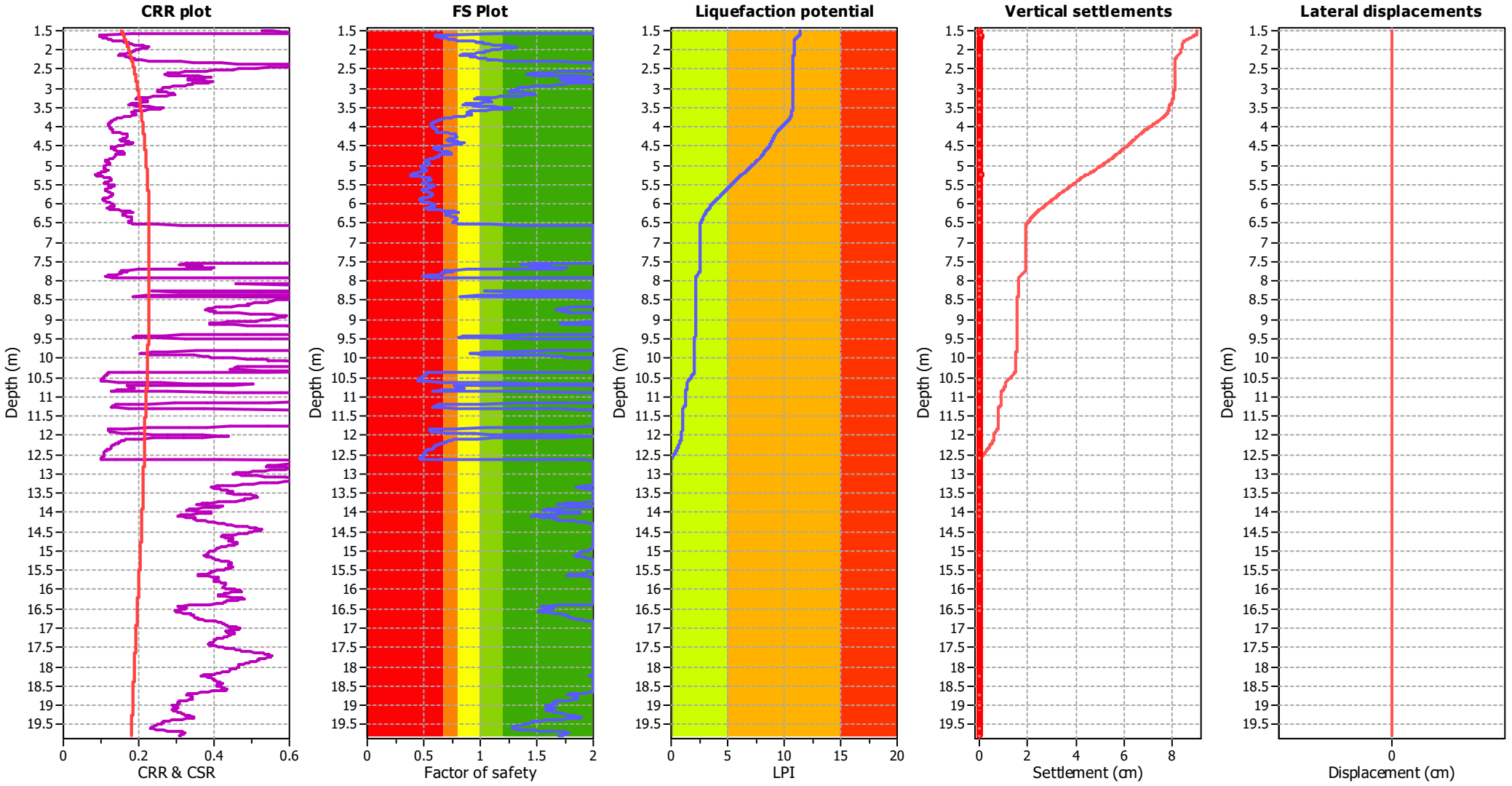






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	20.00 m

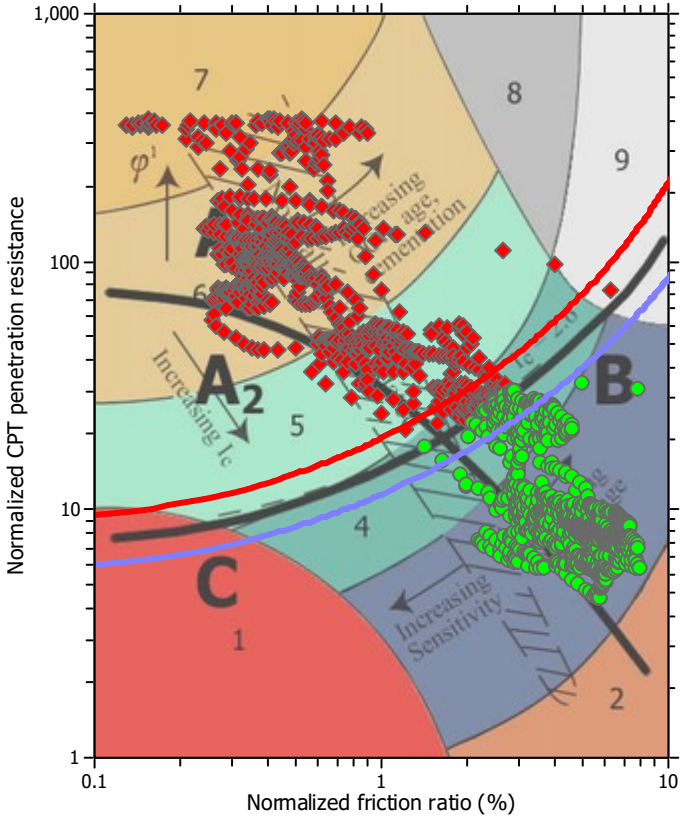
F.S. color scheme

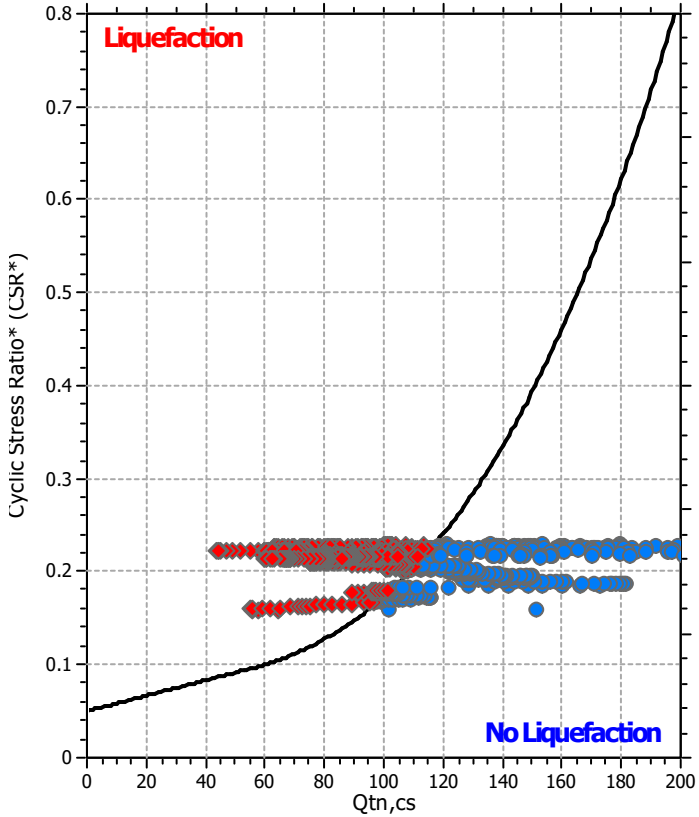
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

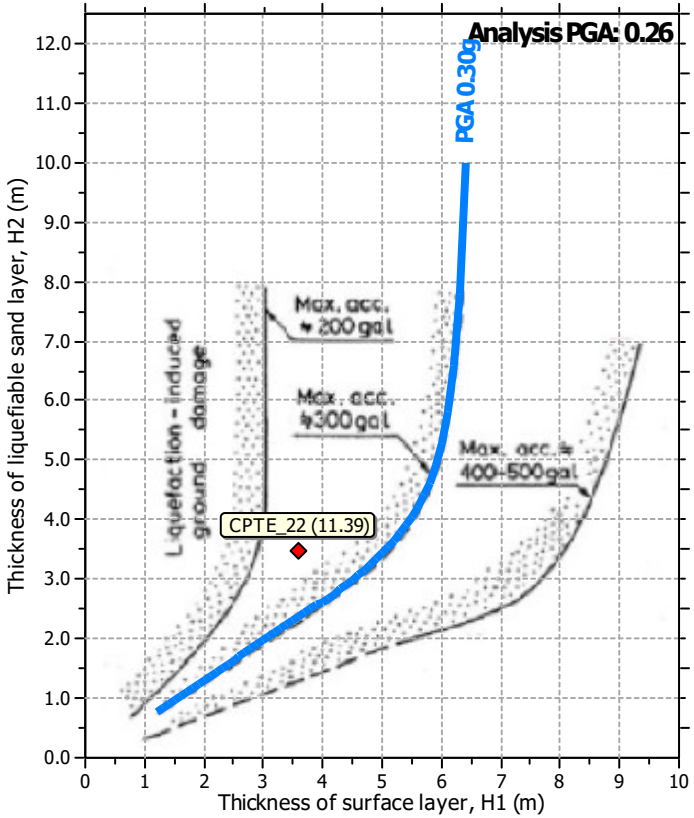
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	20.00 m

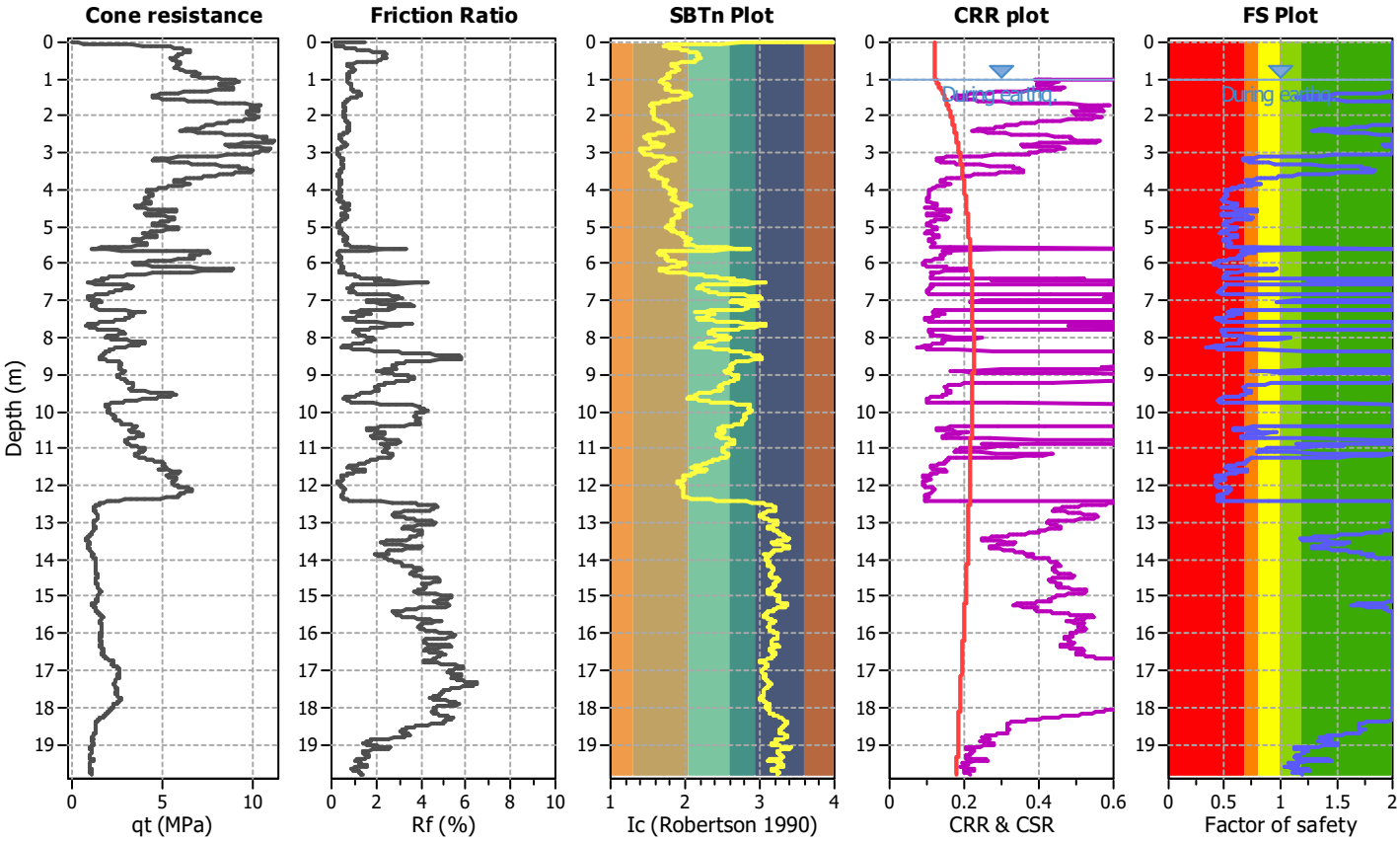
LIQUEFACTION ANALYSIS REPORT

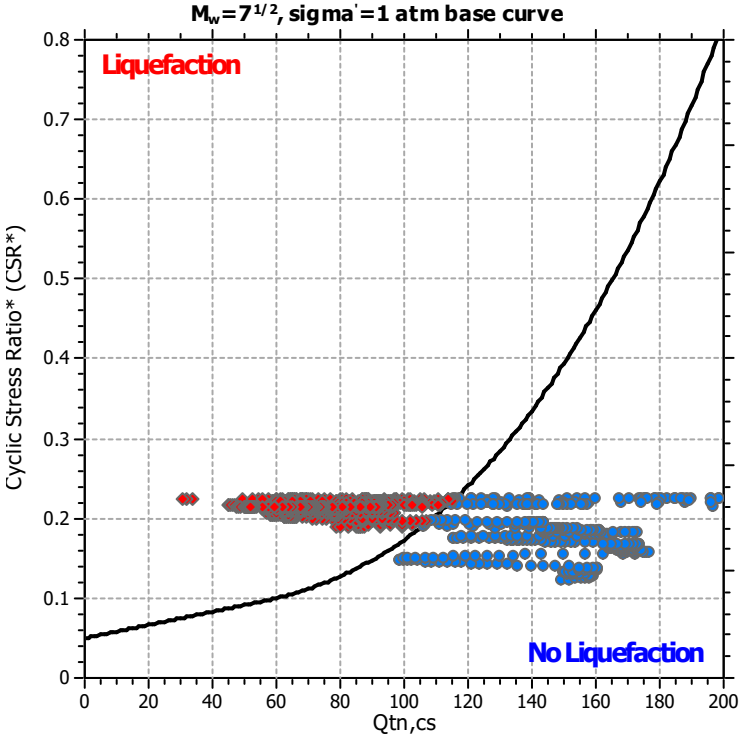
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

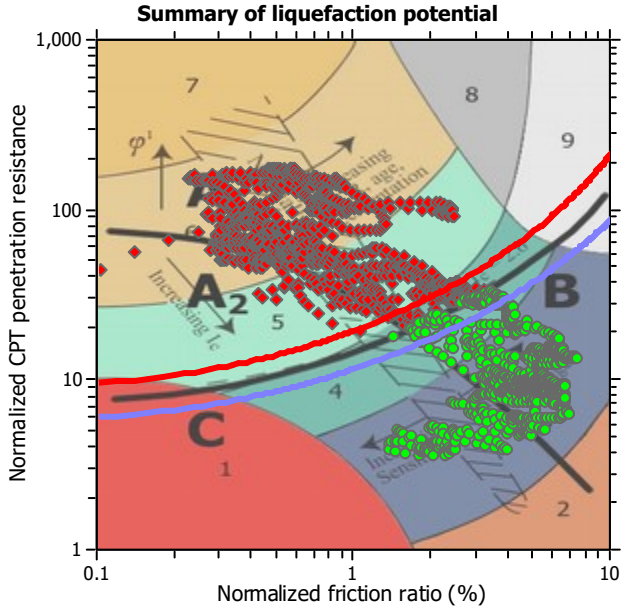
CPT file : CPTE_23

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.50 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

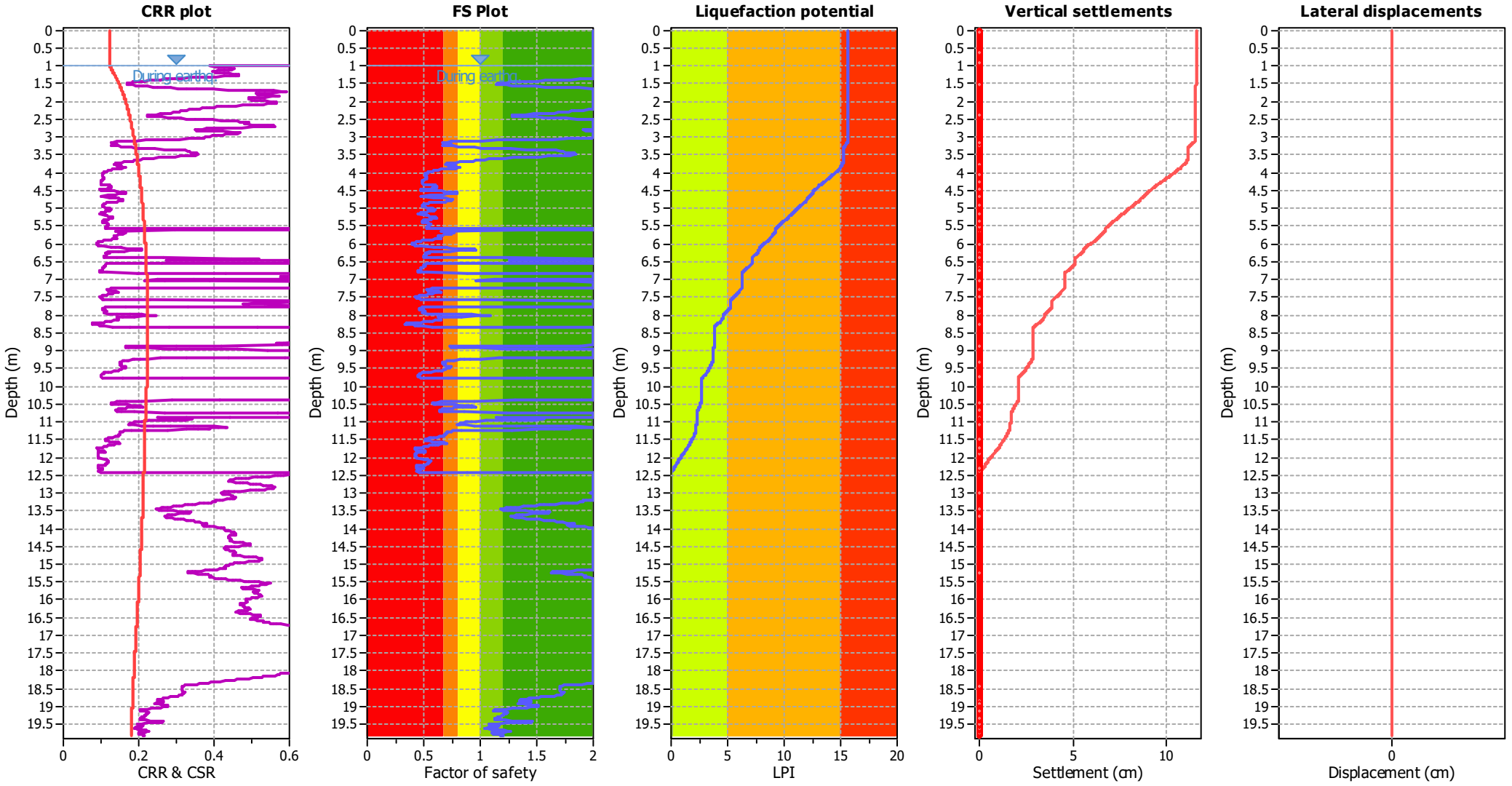






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	20.00 m

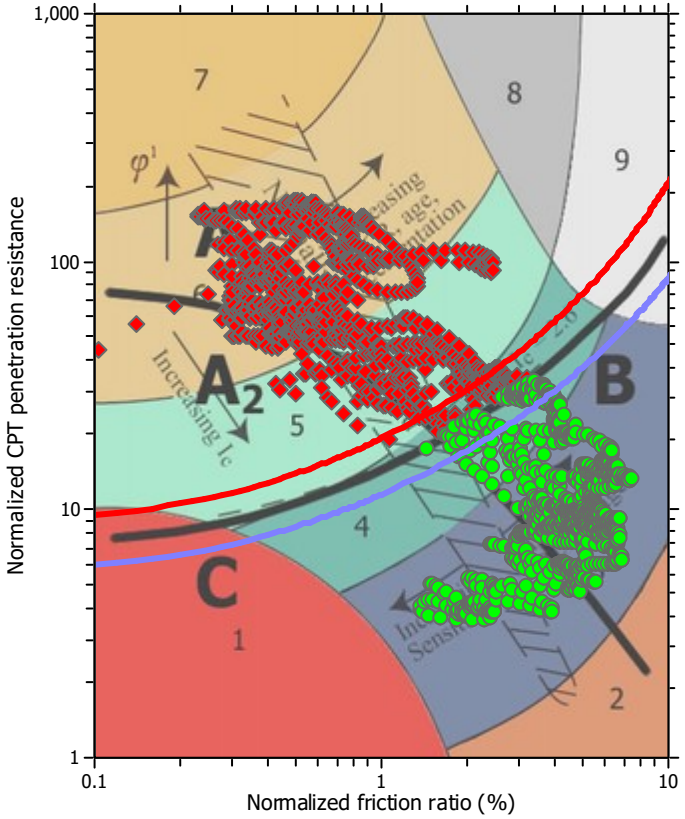
F.S. color scheme

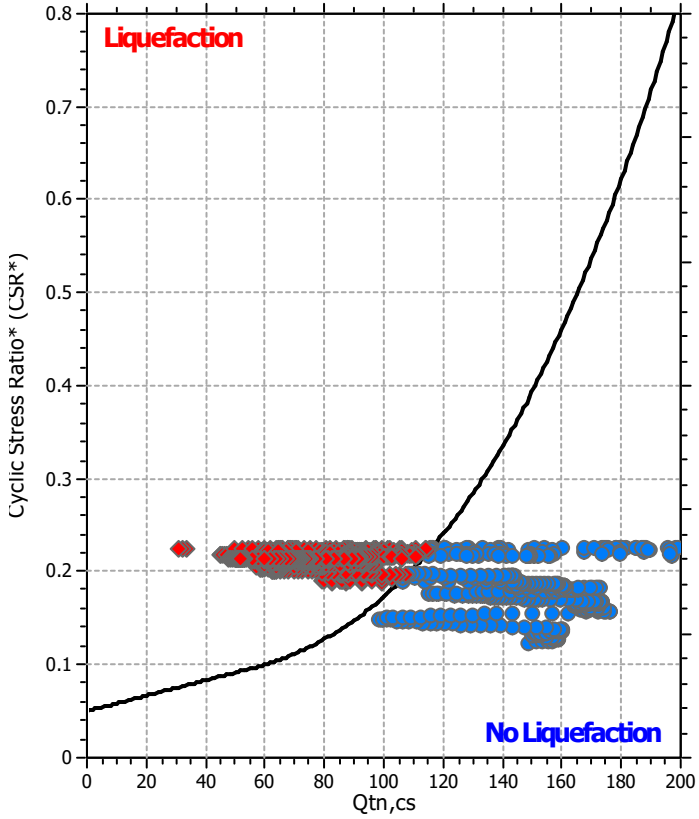
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

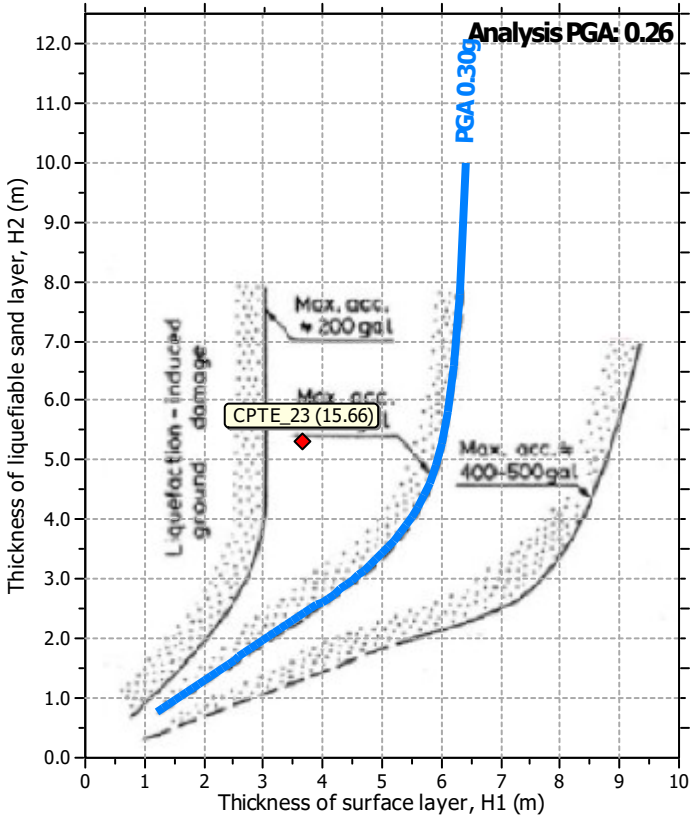
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	20.00 m

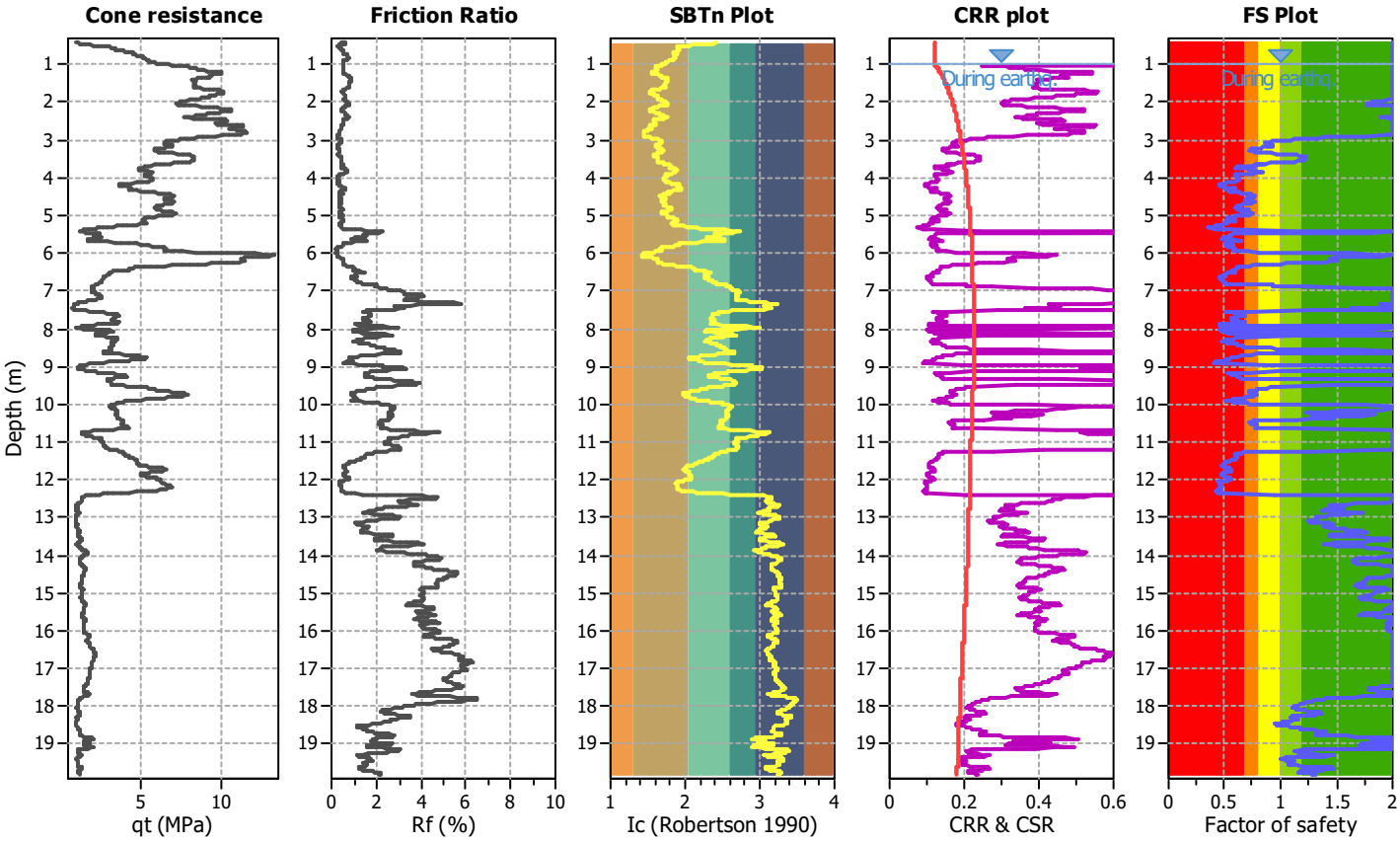
LIQUEFACTION ANALYSIS REPORT

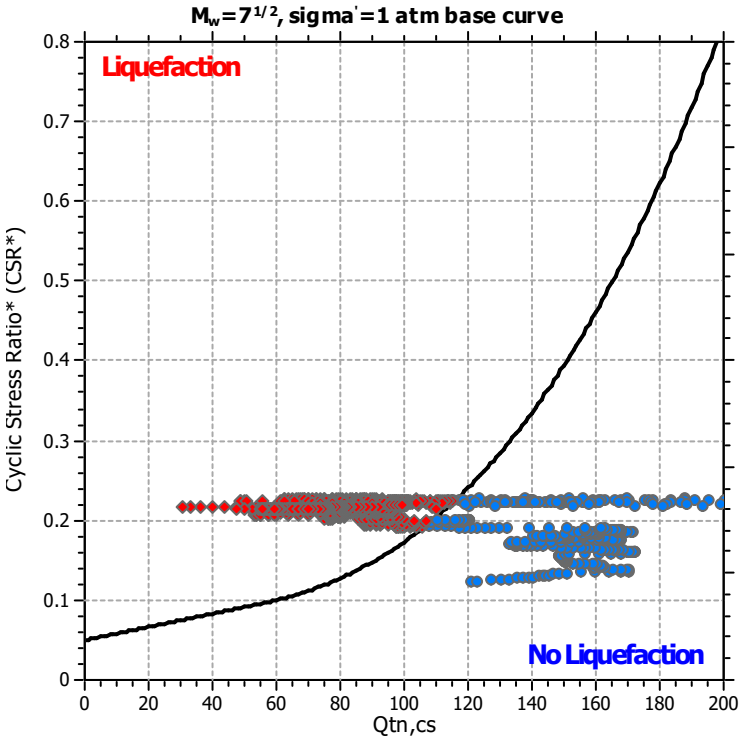
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

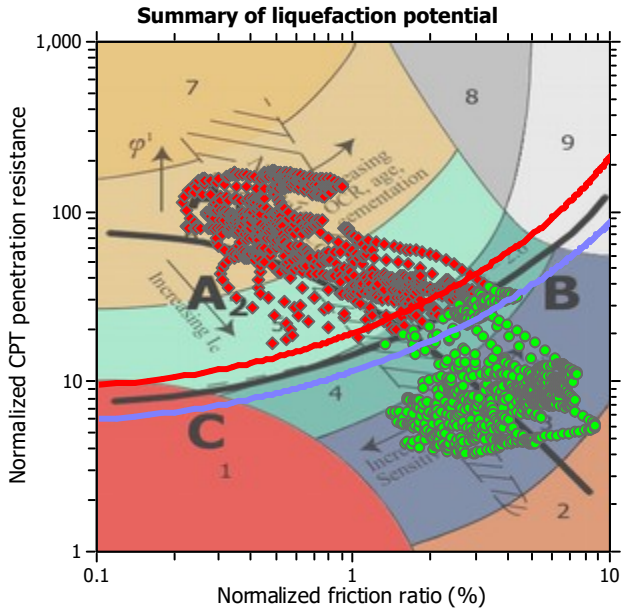
CPT file : CPTE_24

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

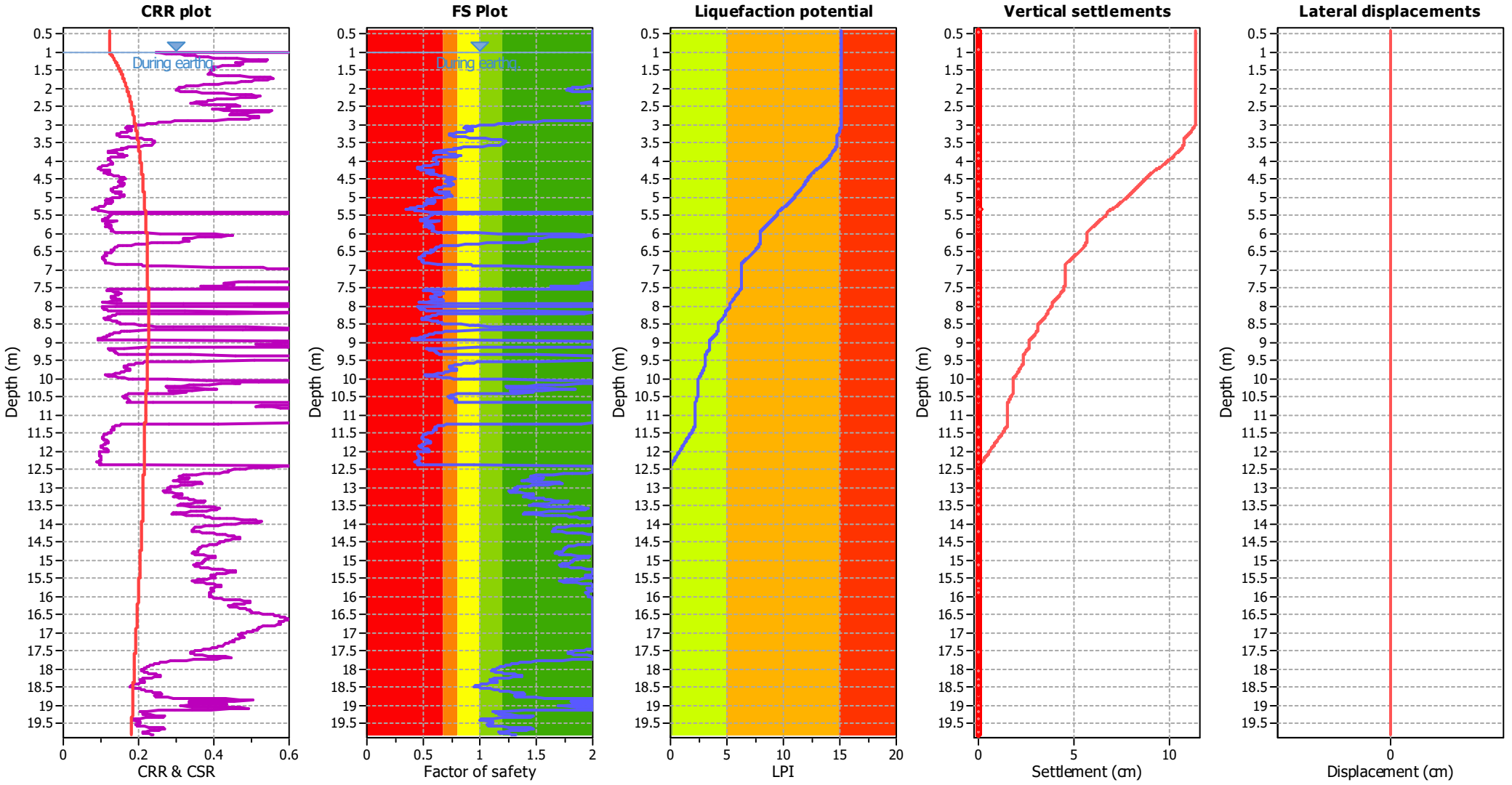






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

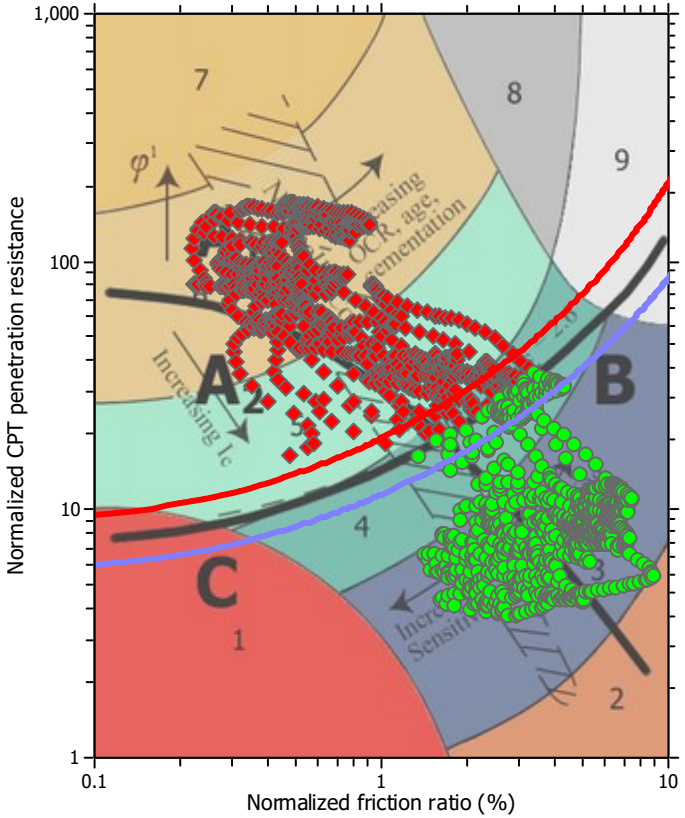
F.S. color scheme

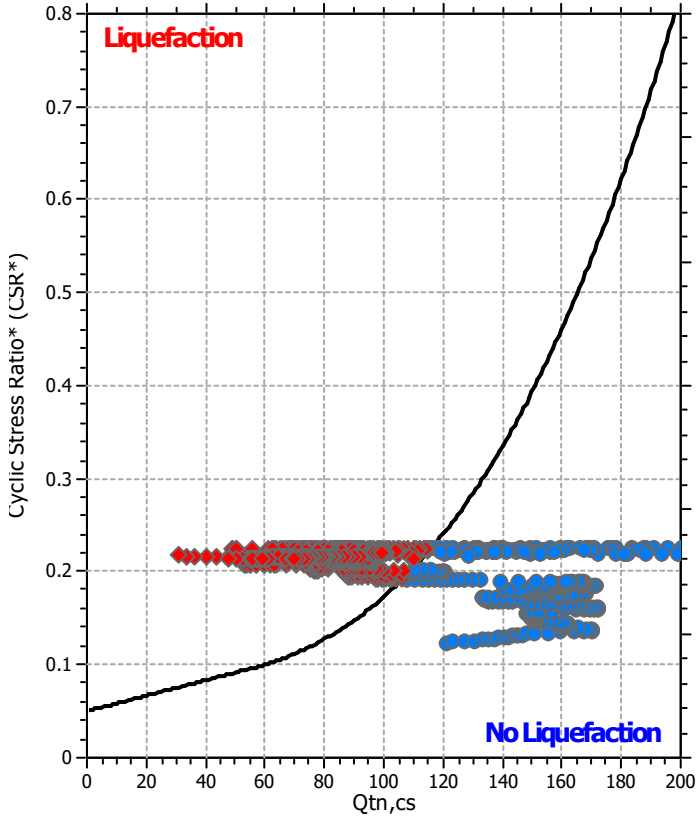
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

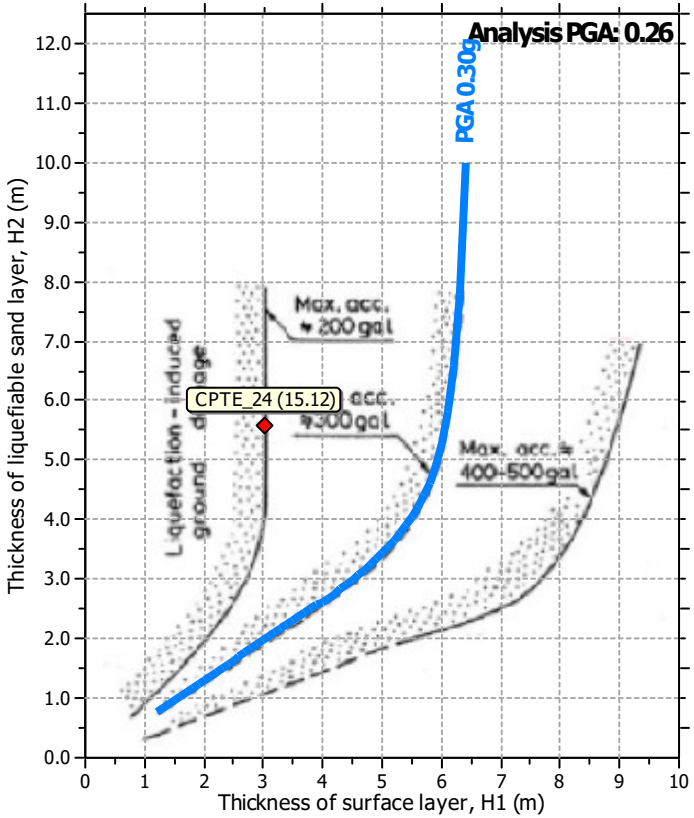
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

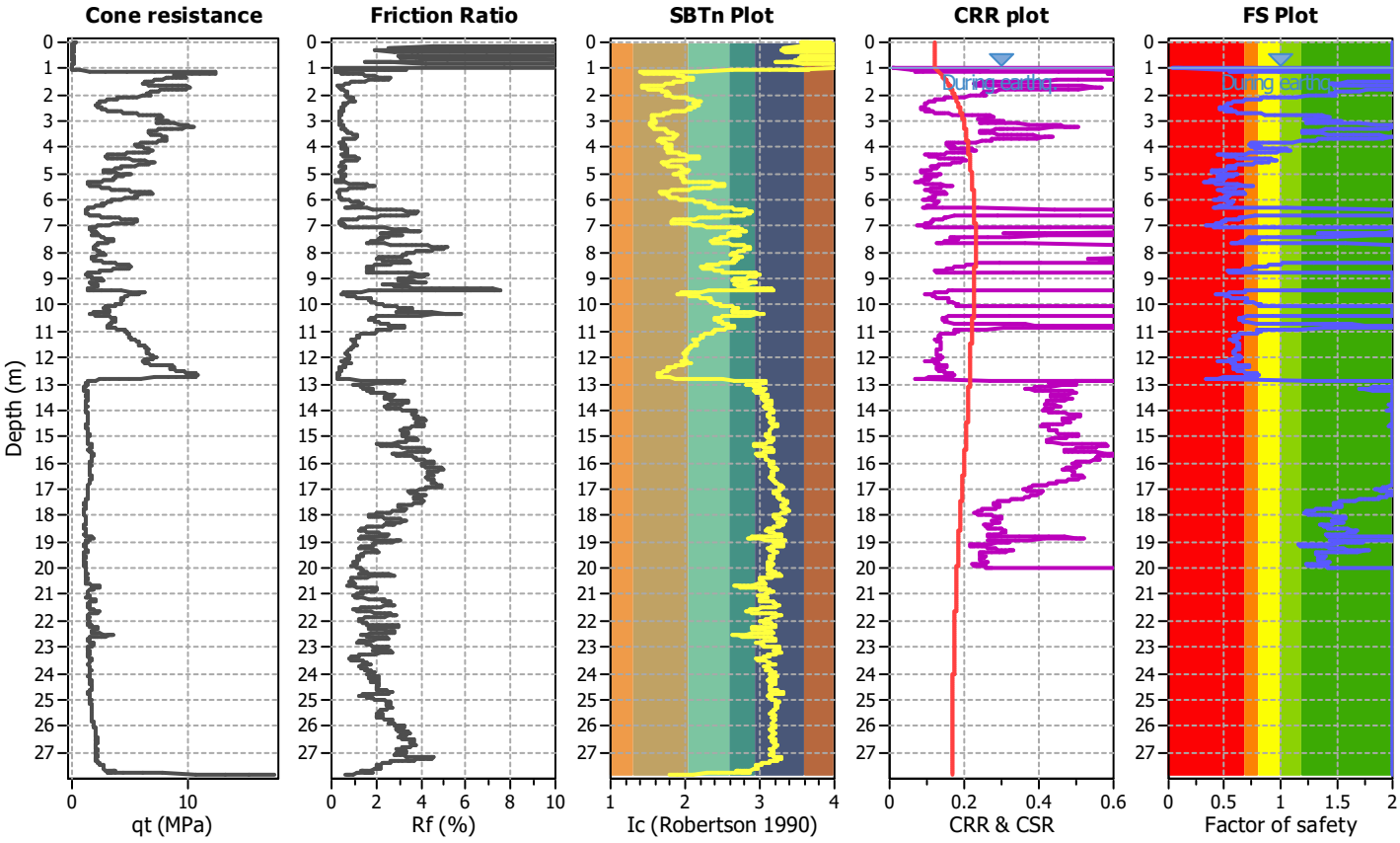
LIQUEFACTION ANALYSIS REPORT

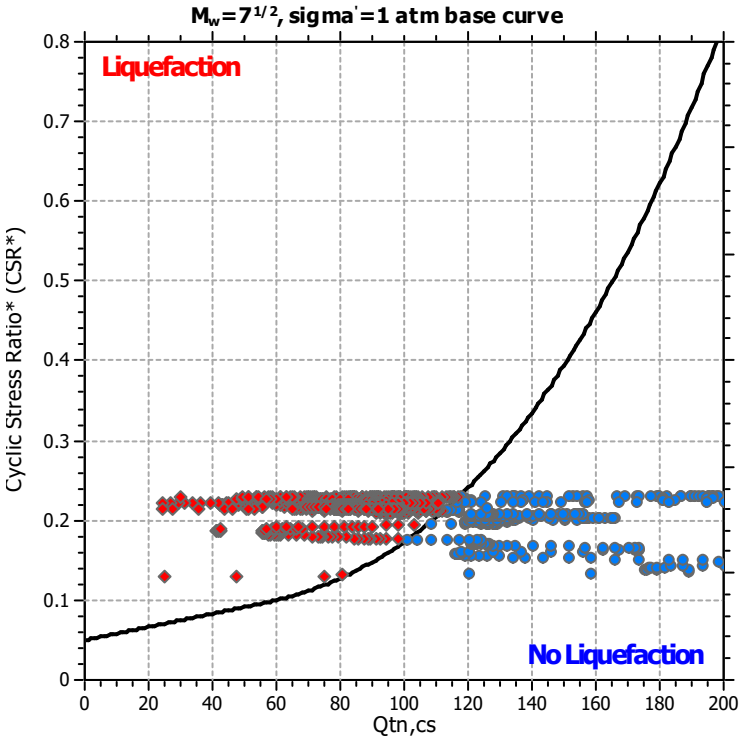
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

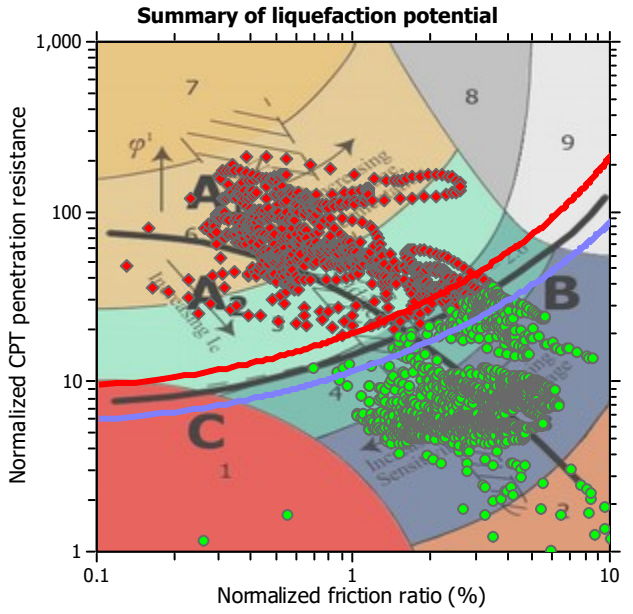
CPT file : 099014P1336

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.50 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

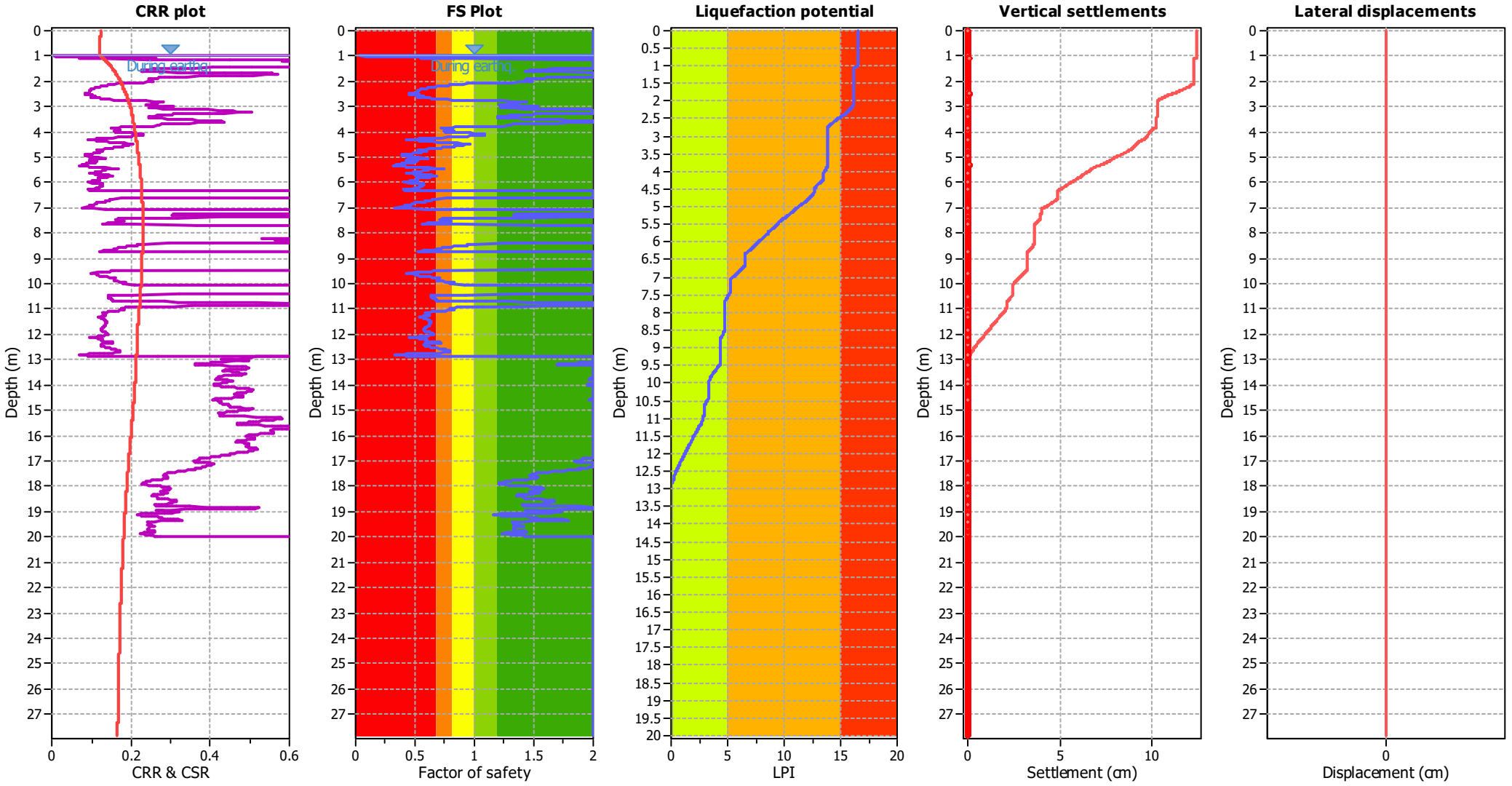






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	20.00 m

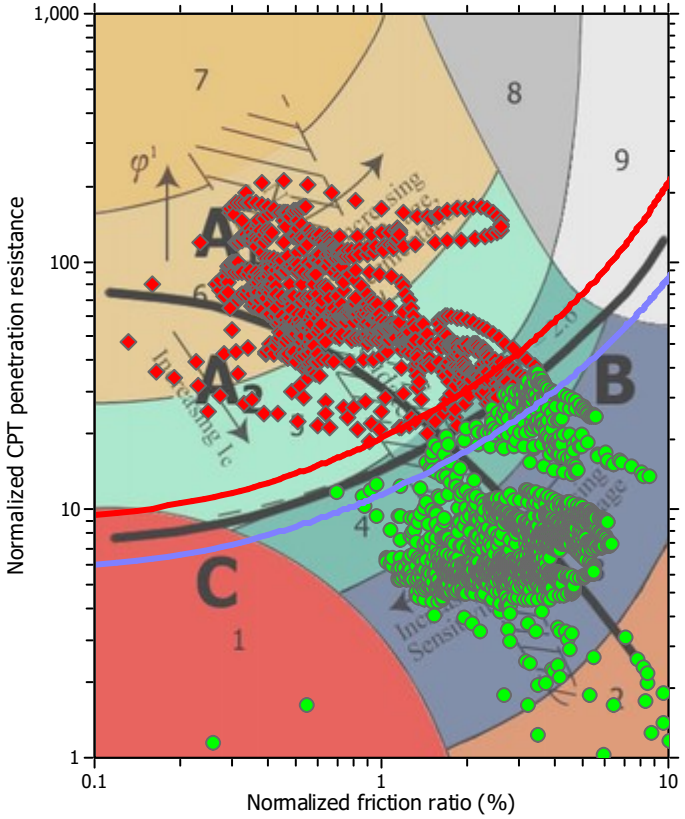
F.S. color scheme

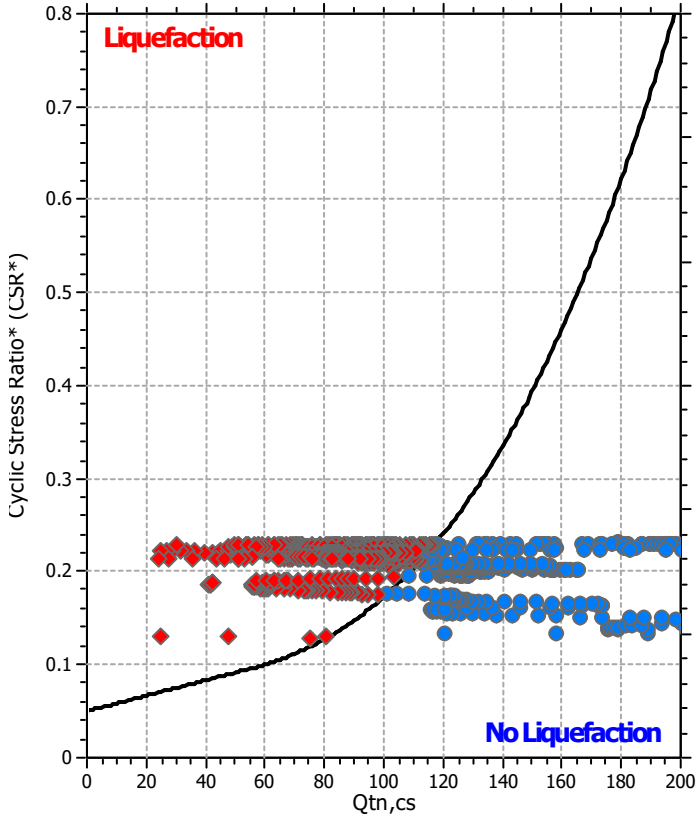
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

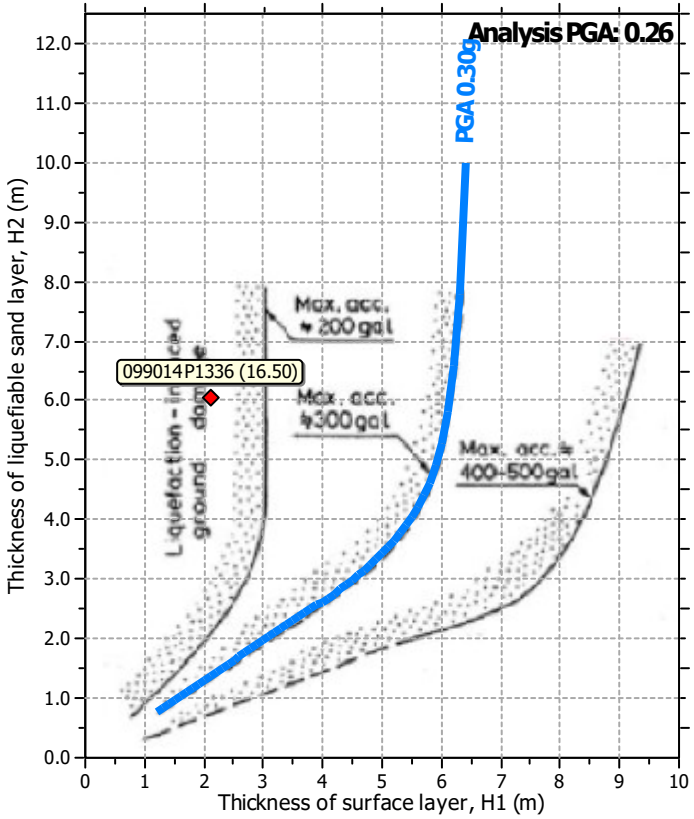
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	20.00 m

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

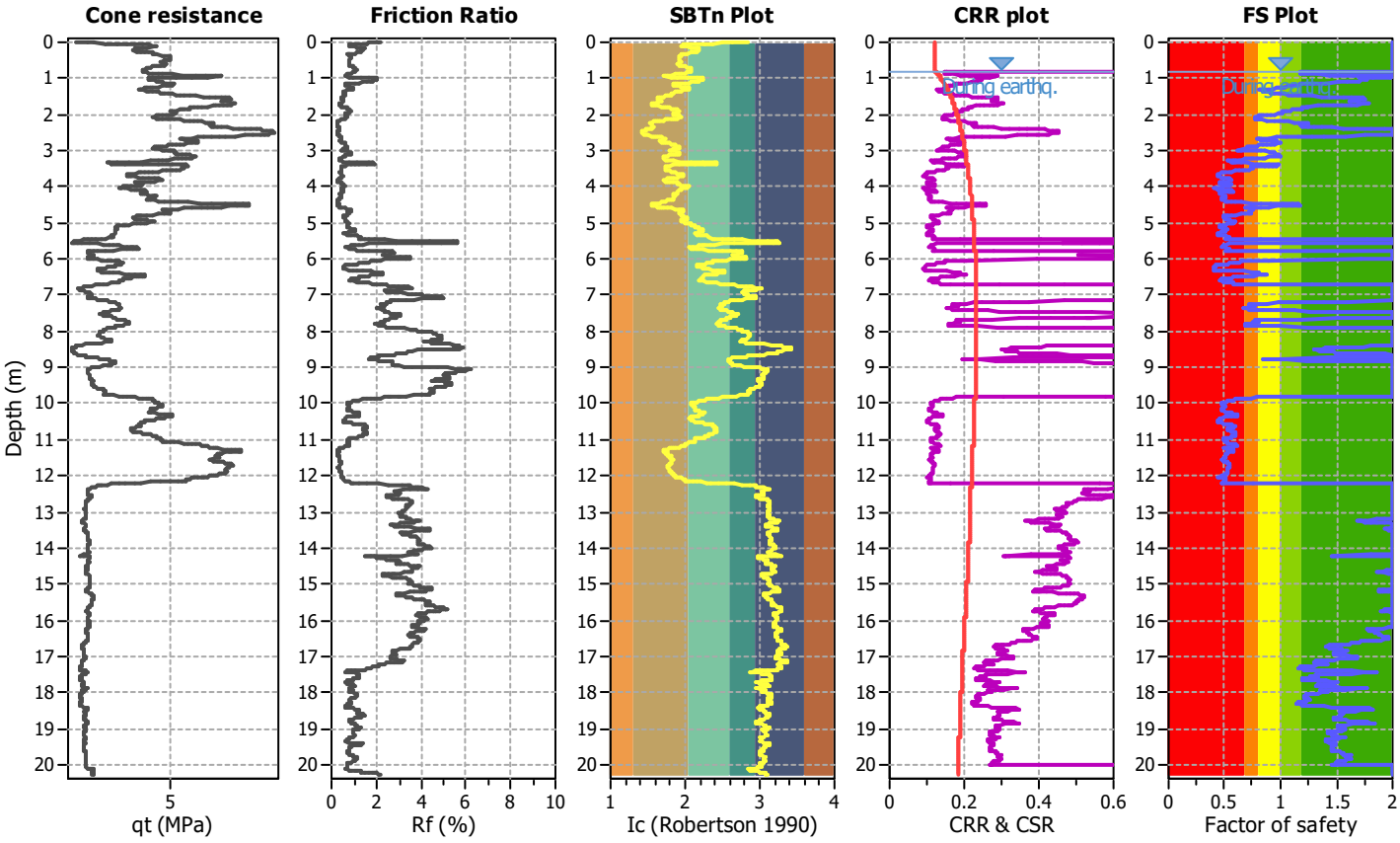
LIQUEFACTION ANALYSIS REPORT

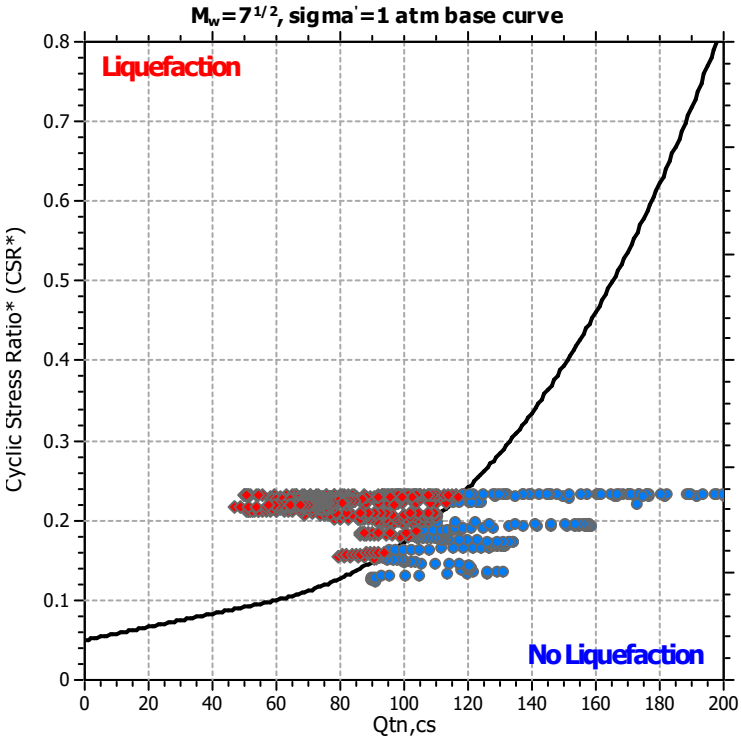
Project title : MS3_PA_Rimini_RNS_01 **Location : Rimini**

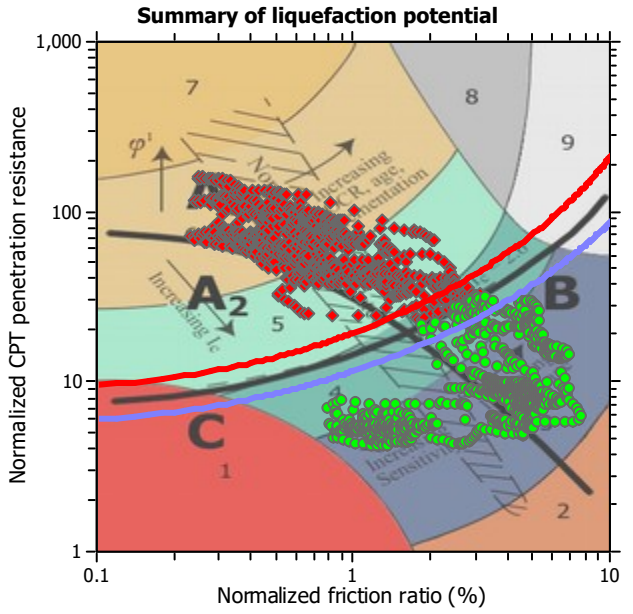
CPT file : 099014P1279

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.26	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

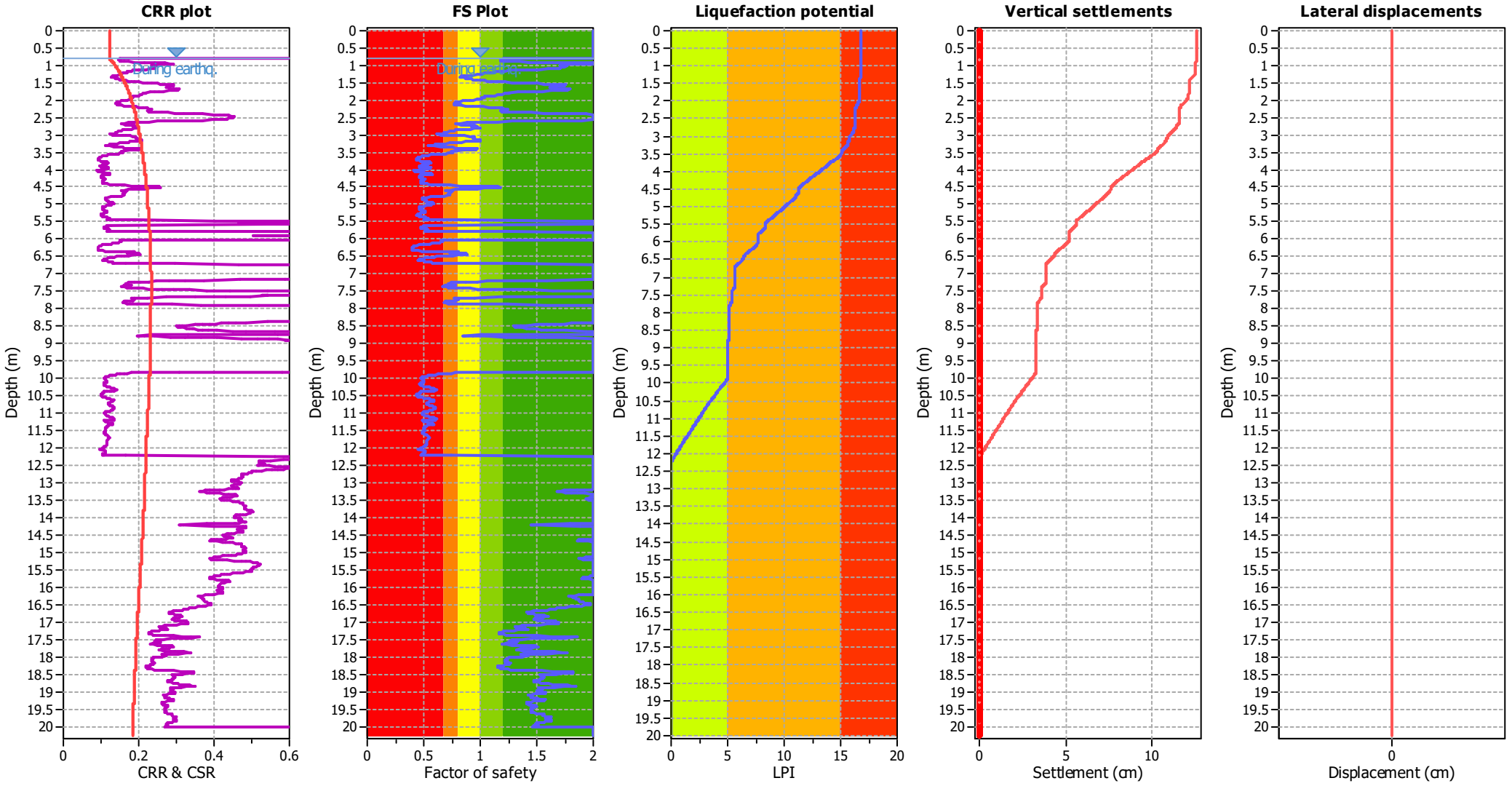






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	20.00 m

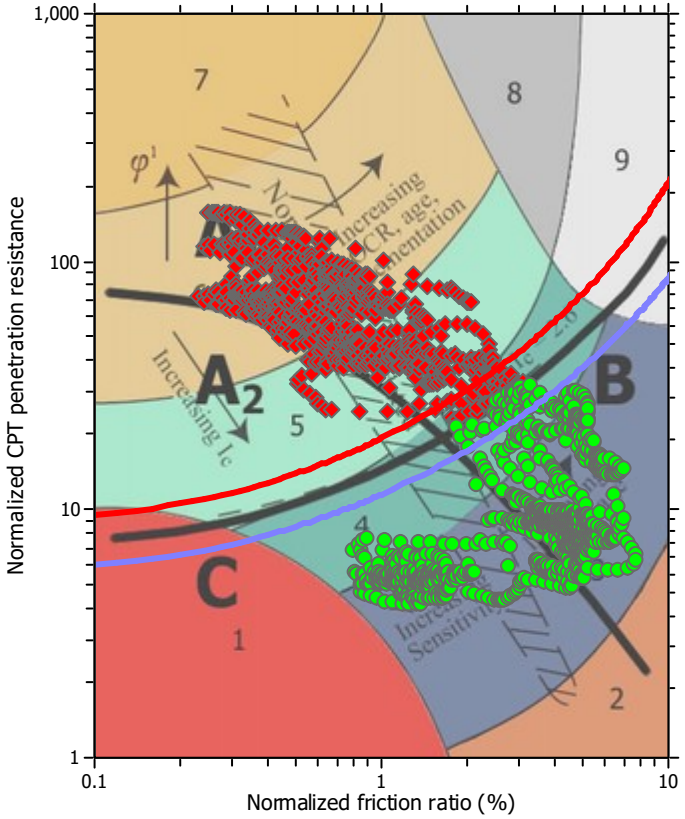
F.S. color scheme

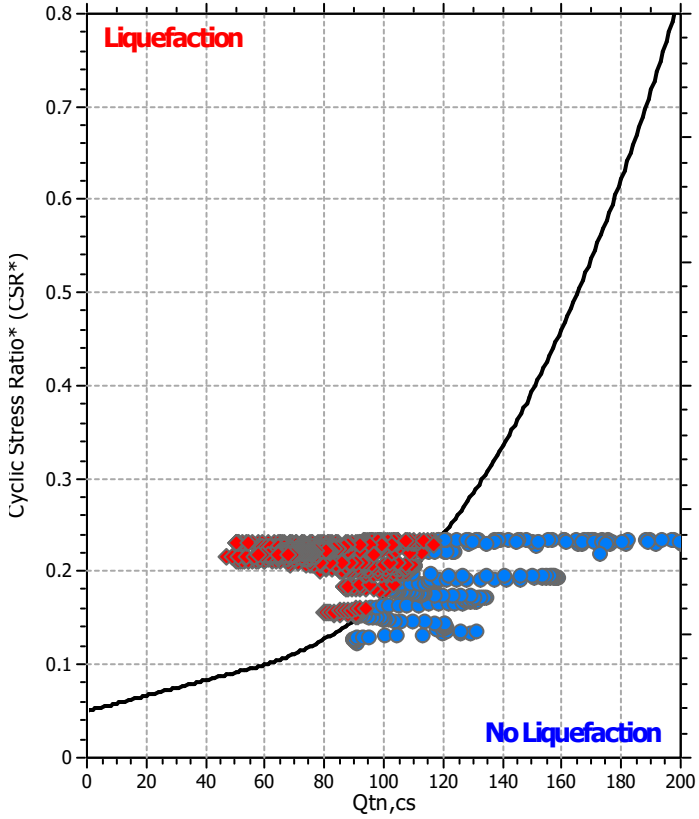
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

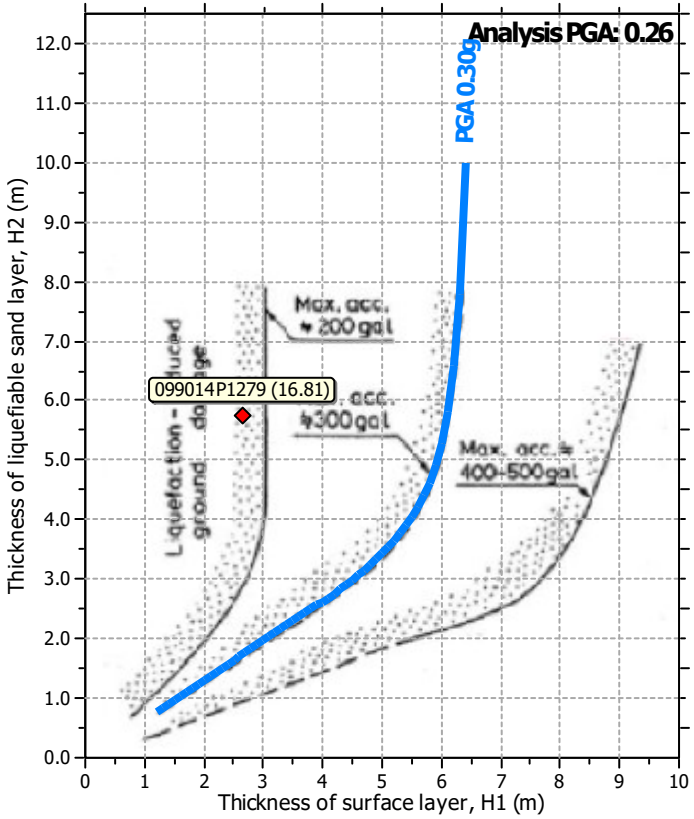
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.26	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	20.00 m

REPORT - ZONA RNS_02

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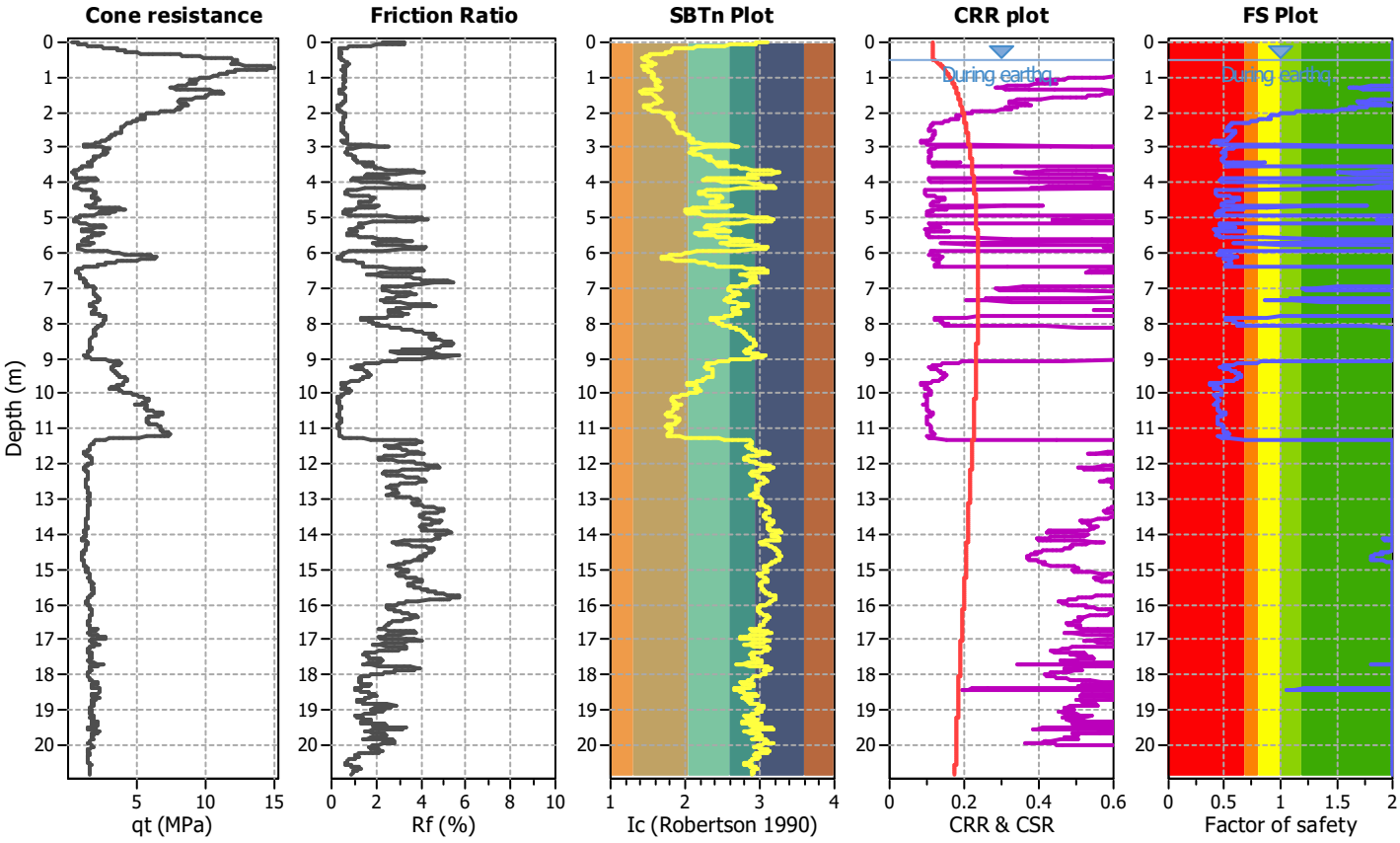
LIQUEFACTION ANALYSIS REPORT

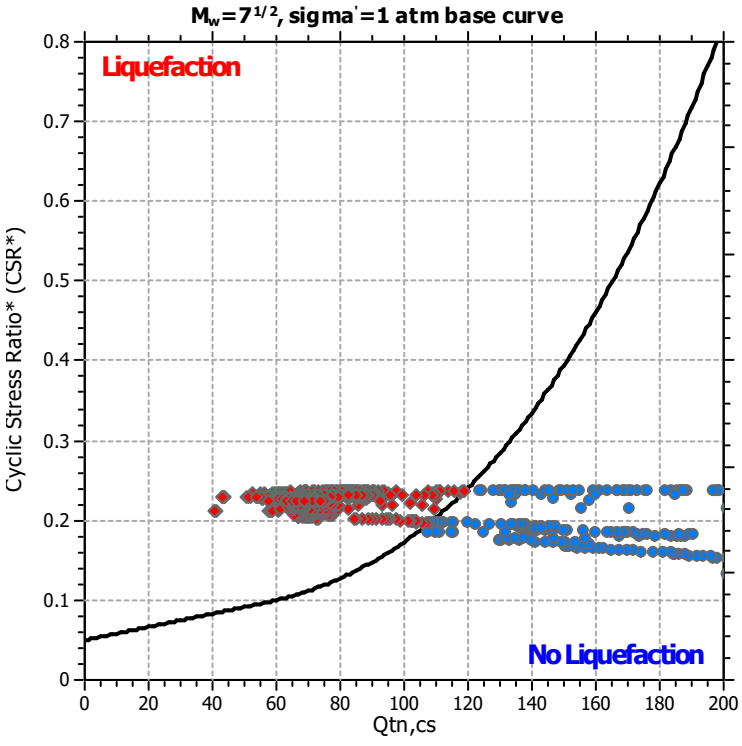
Project title : MS3_PA_Rimini_RNS_02 **Location : Rimini**

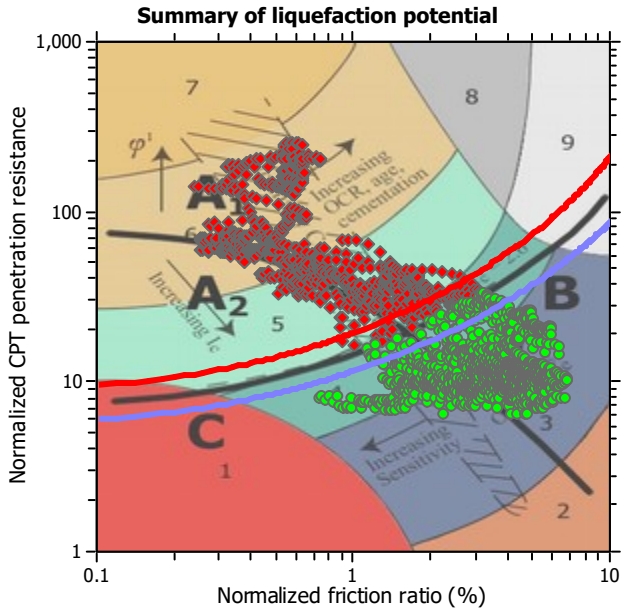
CPT file : 099014P1282

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.50 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

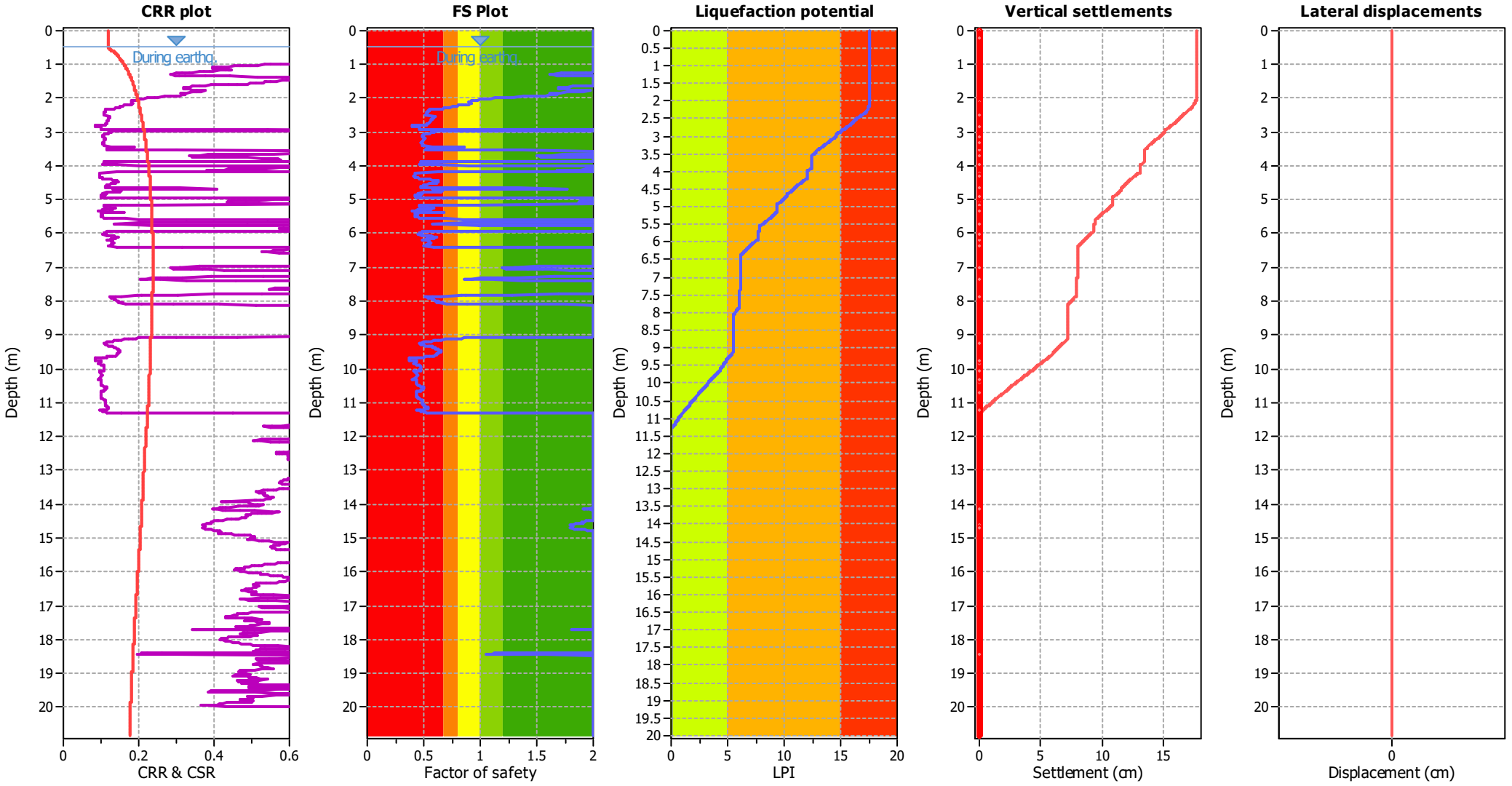






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	20.00 m

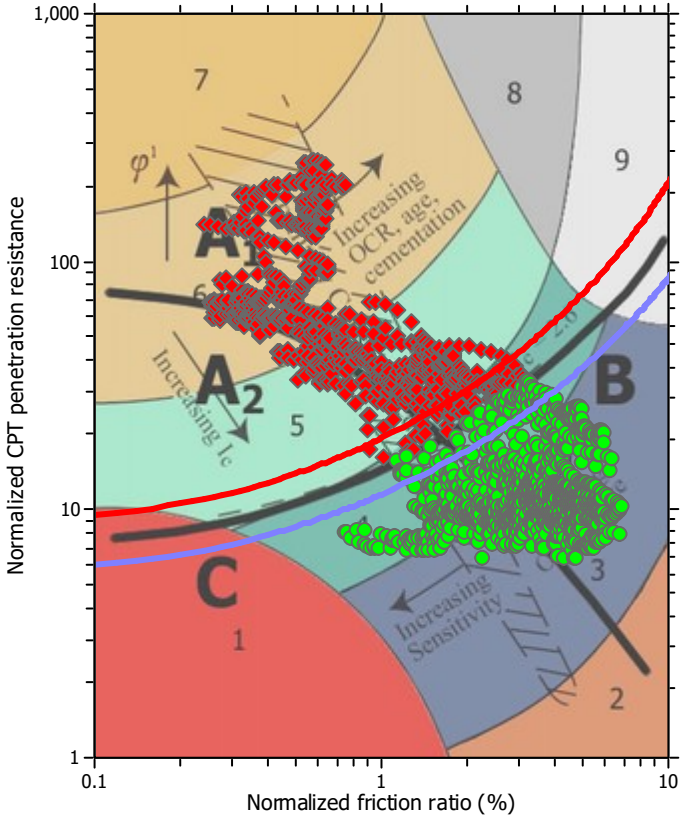
F.S. color scheme

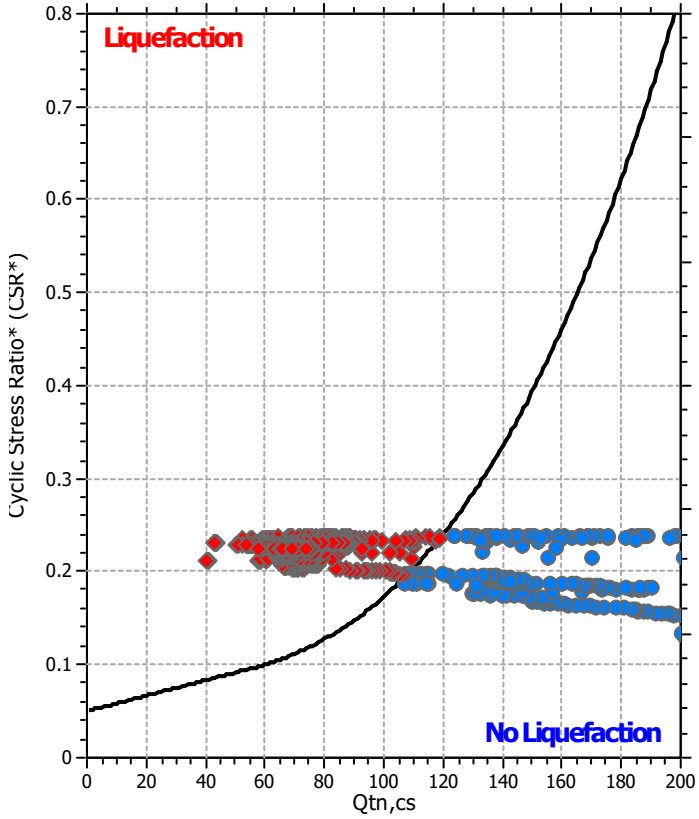
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

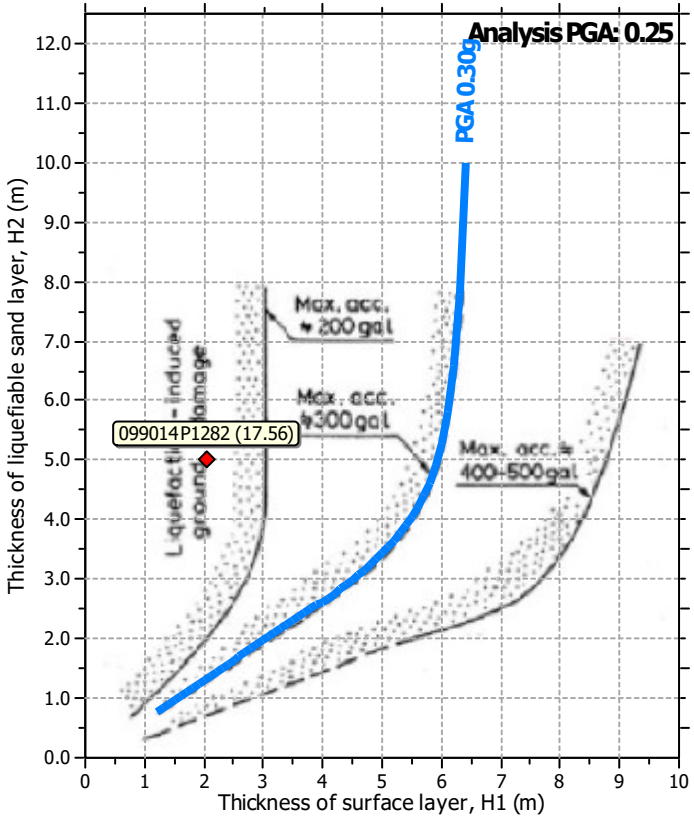
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.50 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	20.00 m

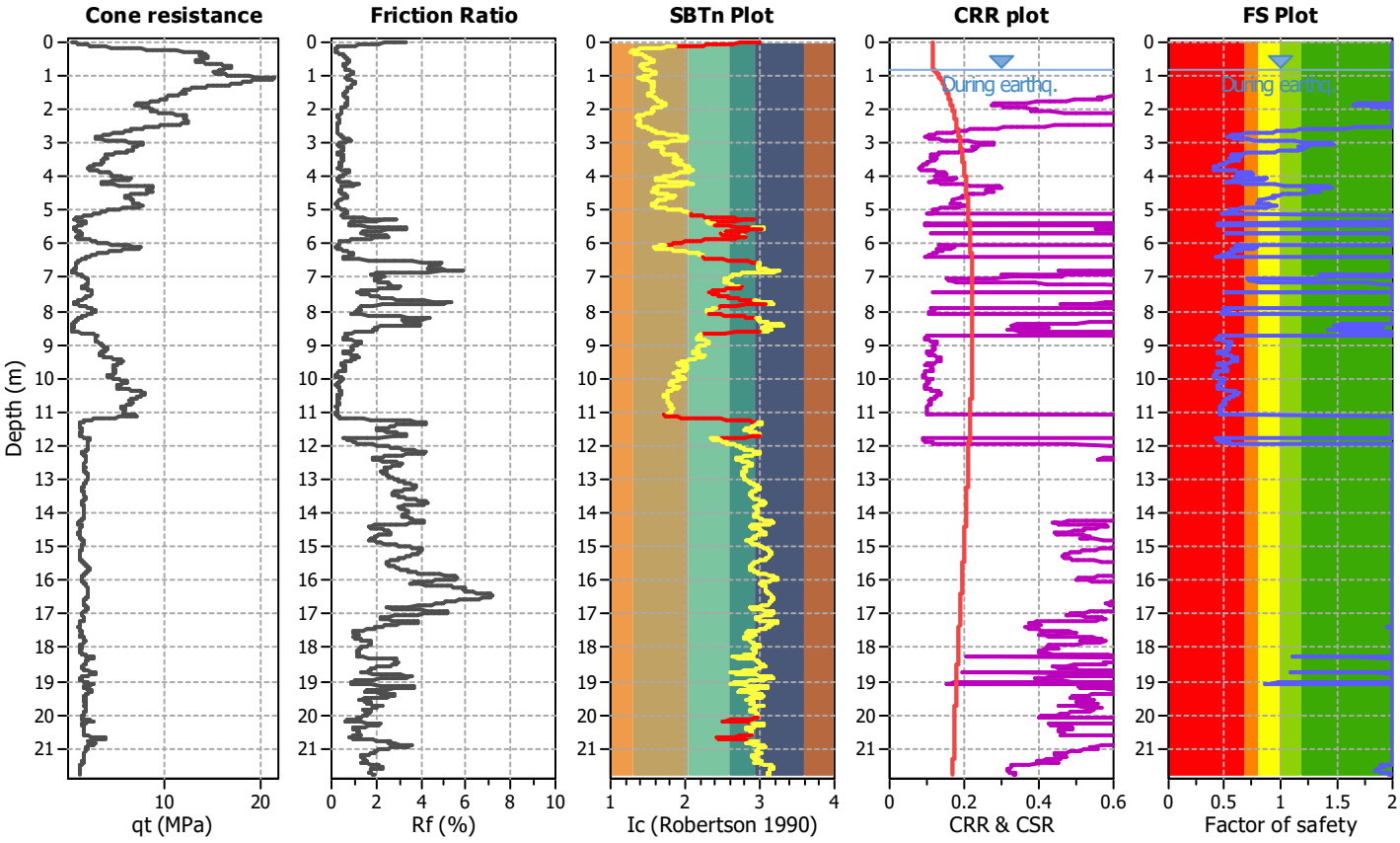
LIQUEFACTION ANALYSIS REPORT

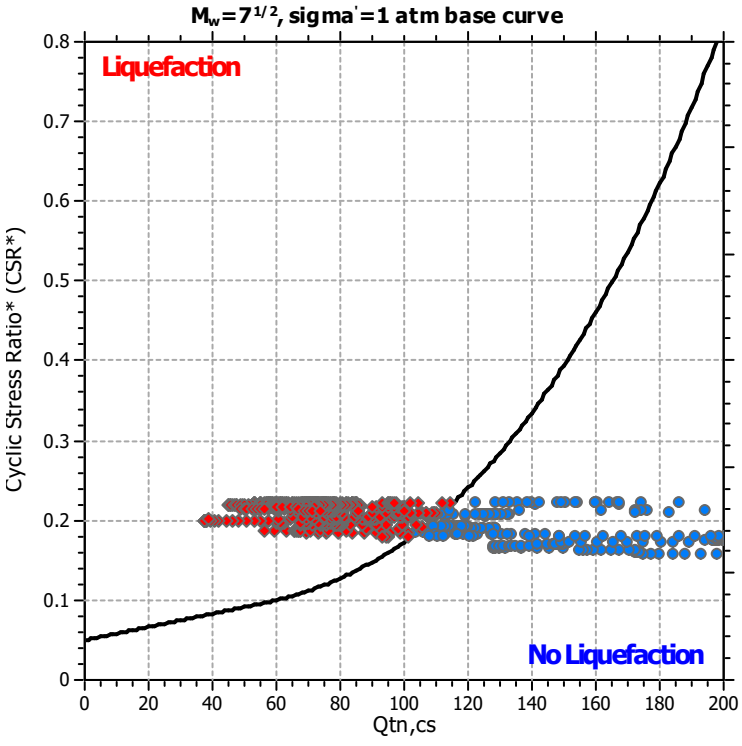
Project title : MS3_PA_Rimini_RNS_02 **Location : Rimini**

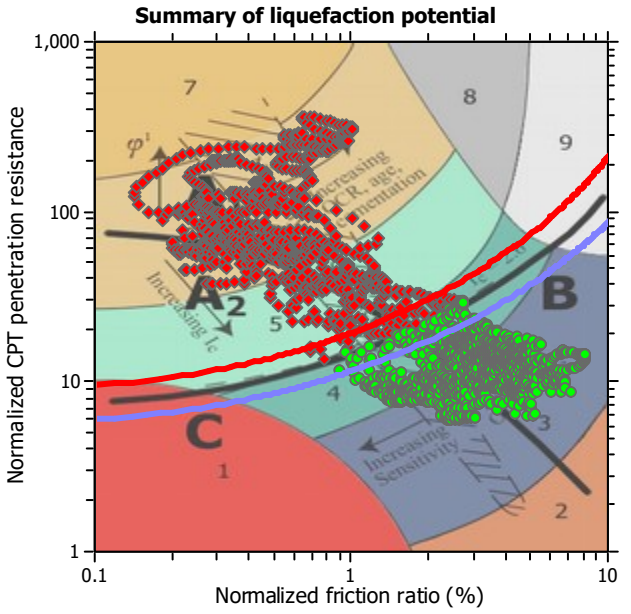
CPT file : 099014P1283

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	0.80 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

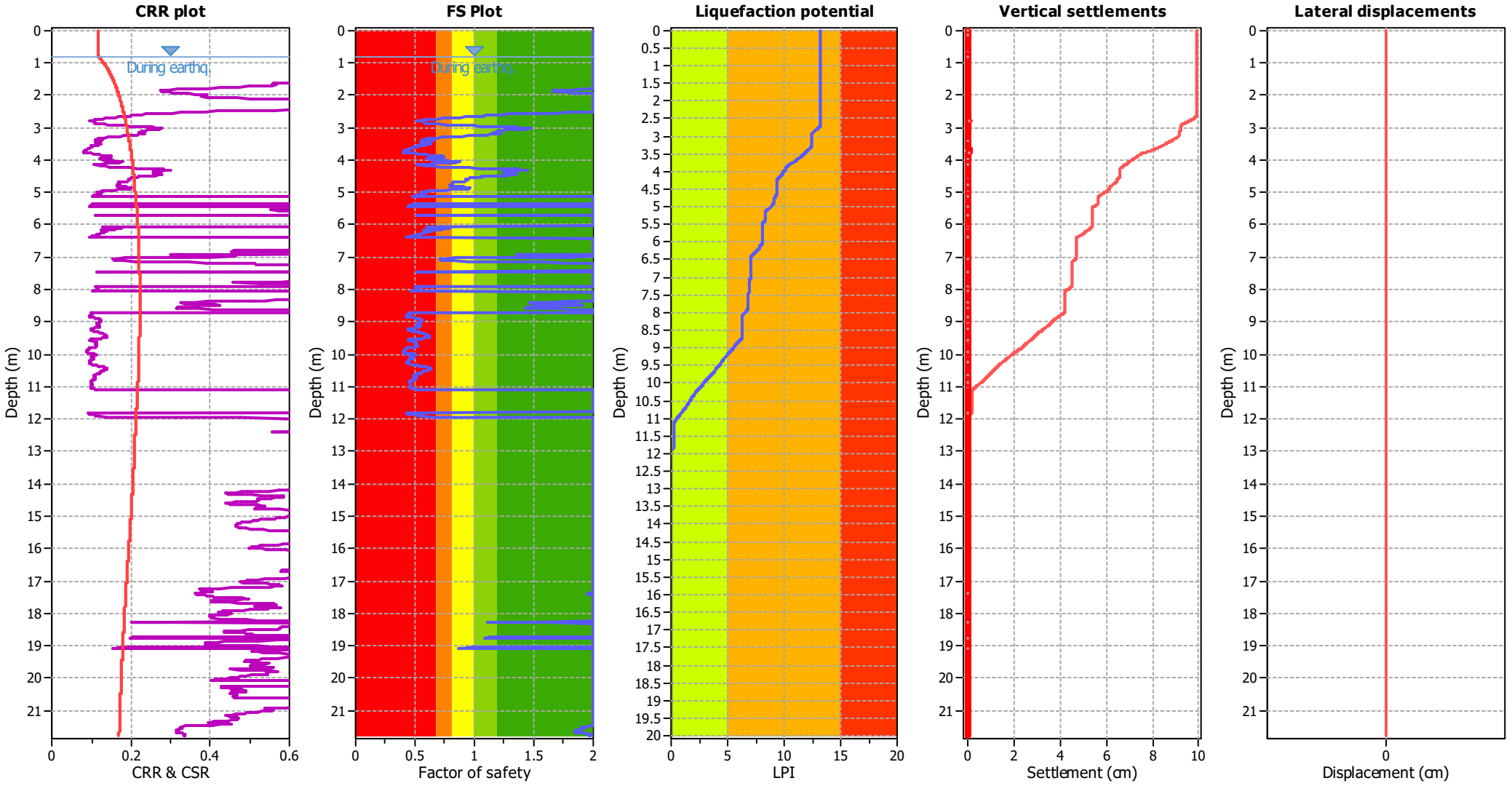






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.80 m	Fill height:	N/A	Limit depth:	N/A

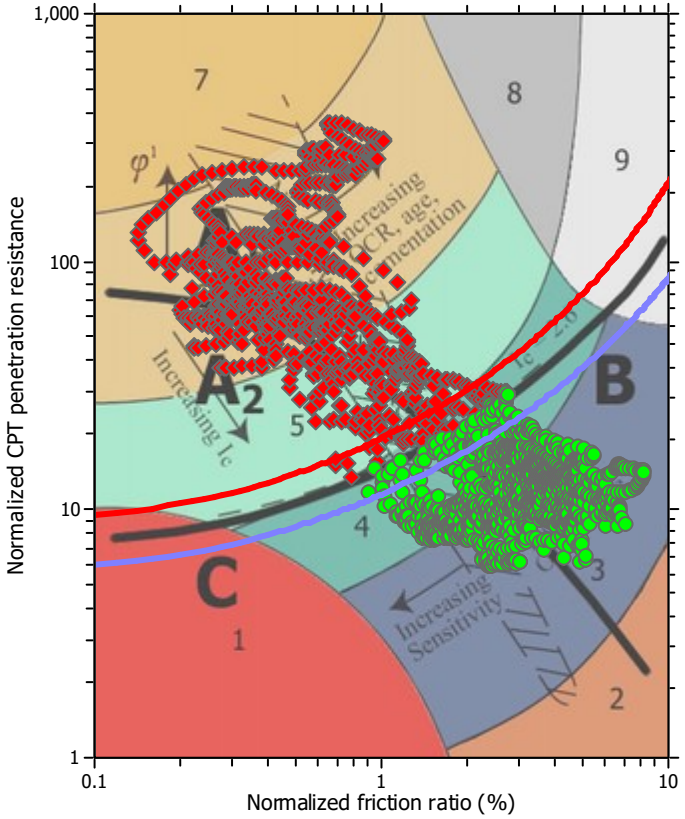
F.S. color scheme

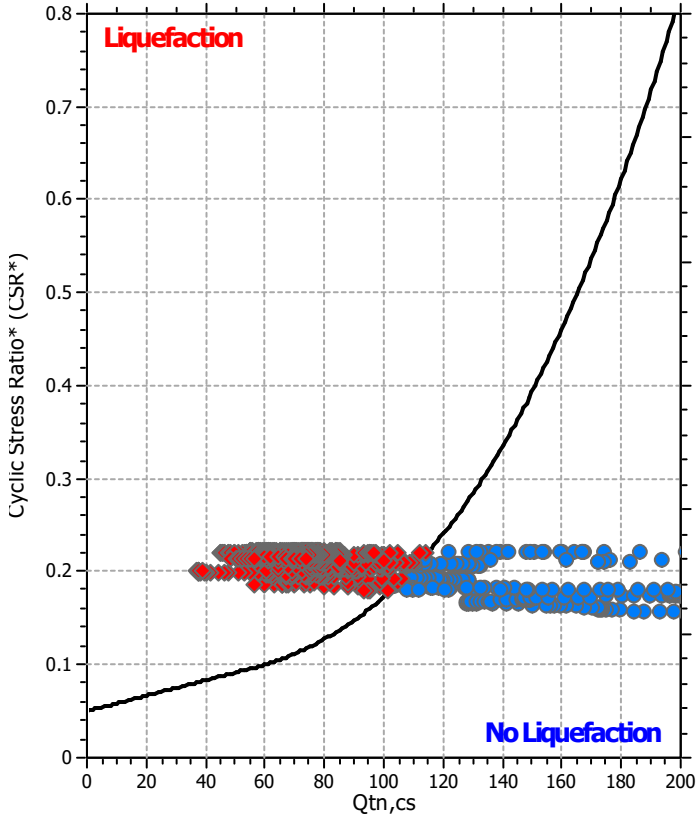
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

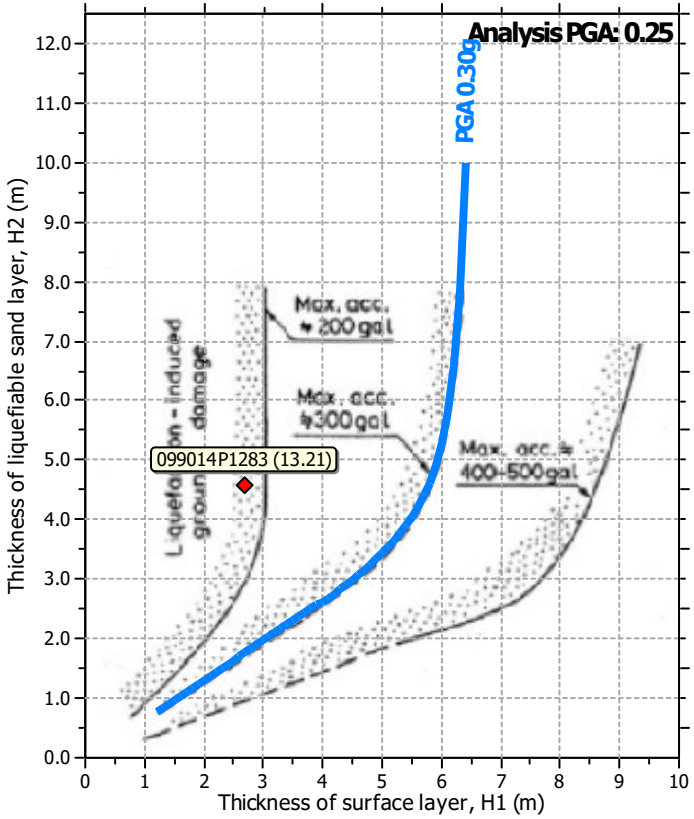
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	0.80 m	Fill height:	N/A	Limit depth:	N/A

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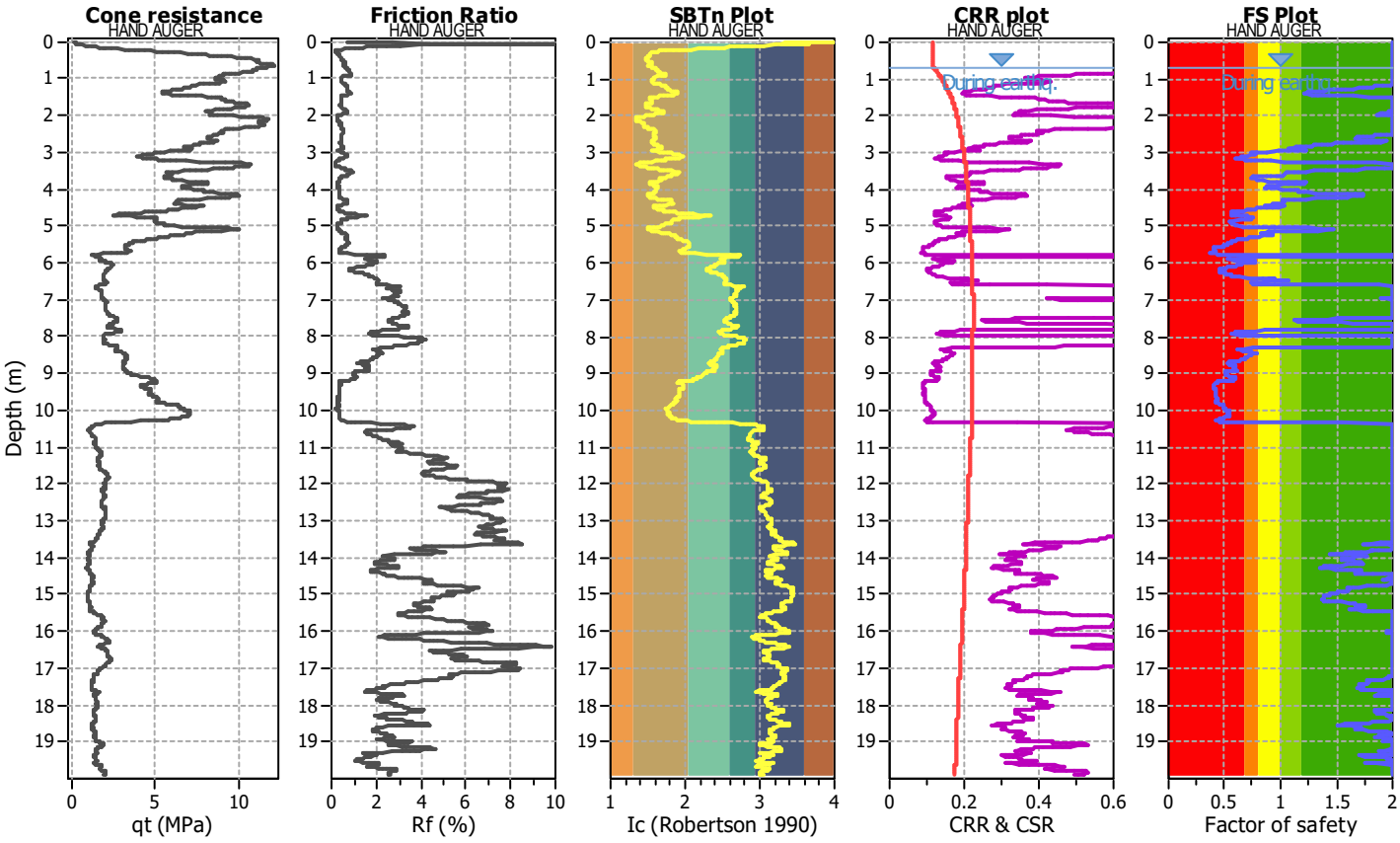
LIQUEFACTION ANALYSIS REPORT

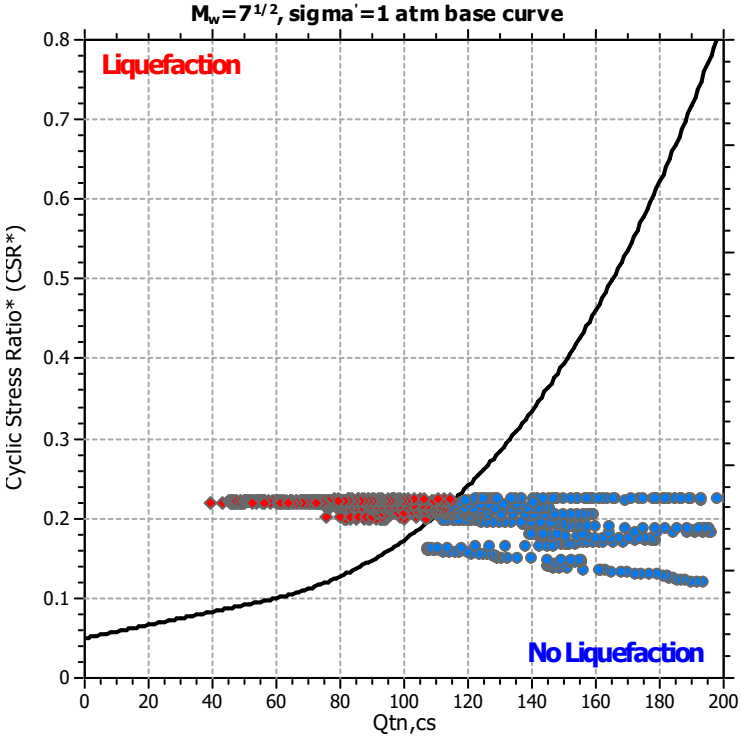
Project title : MS3_PA_Rimini_RNS_02 **Location : Rimini**

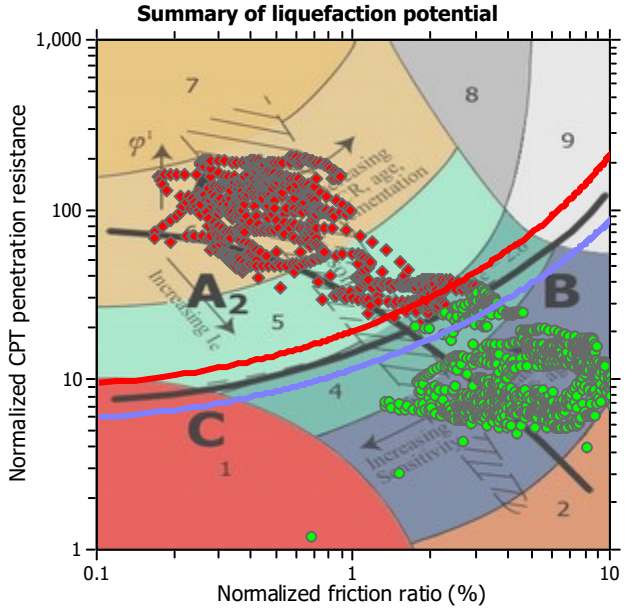
CPT file : CPTe_14

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	0.80 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.70 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

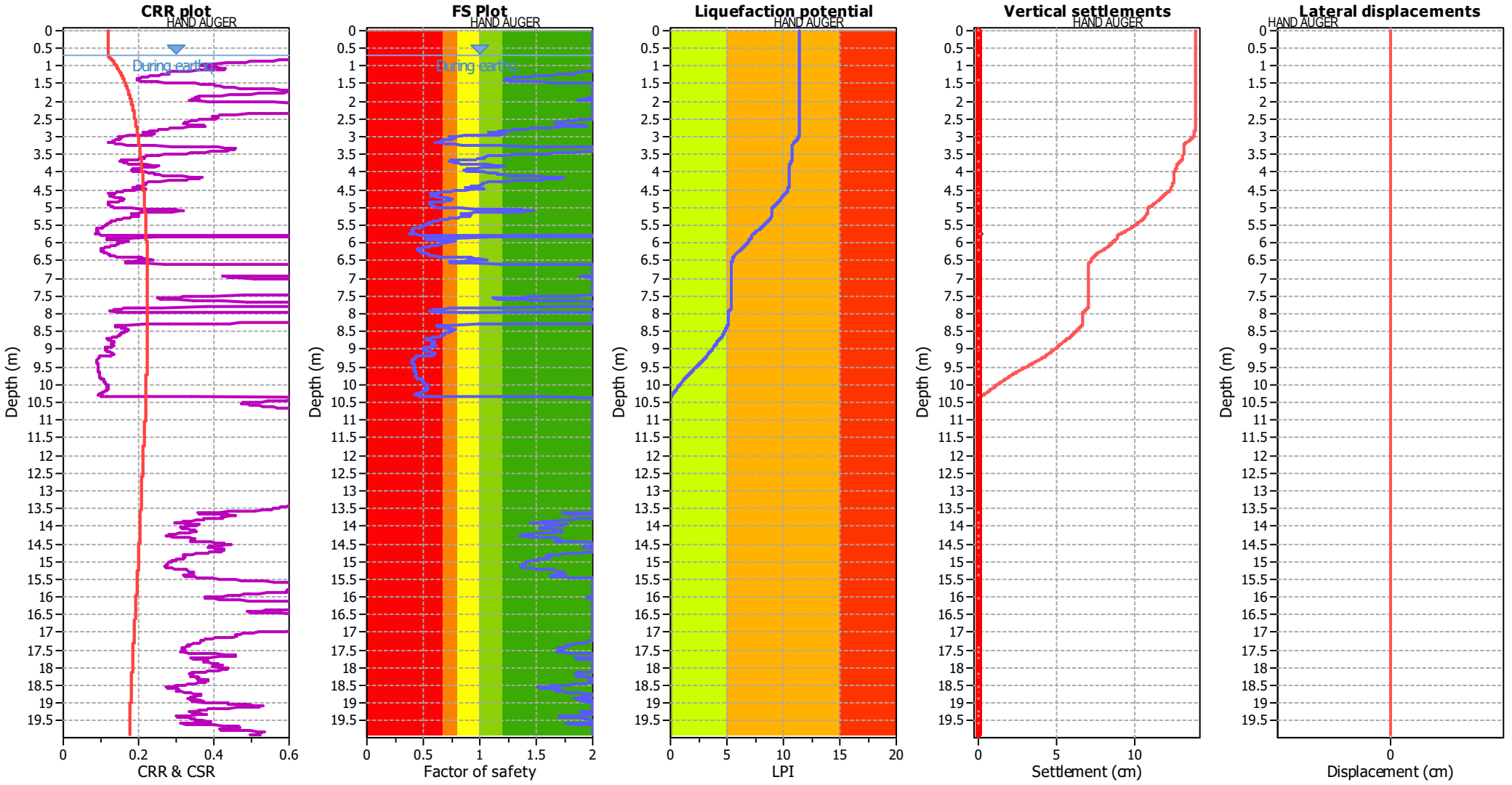






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.80 m	Fill height:	N/A	Limit depth:	20.00 m

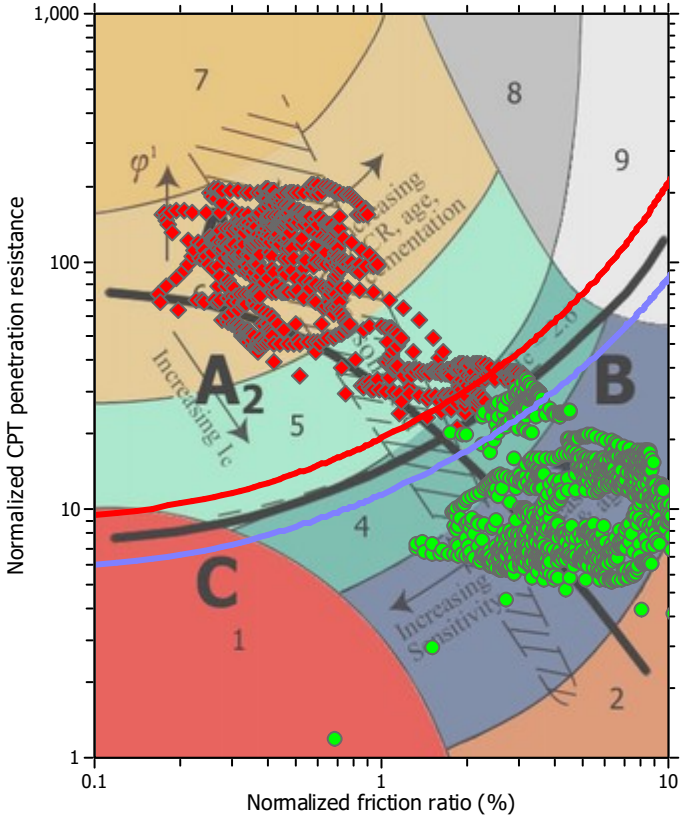
F.S. color scheme

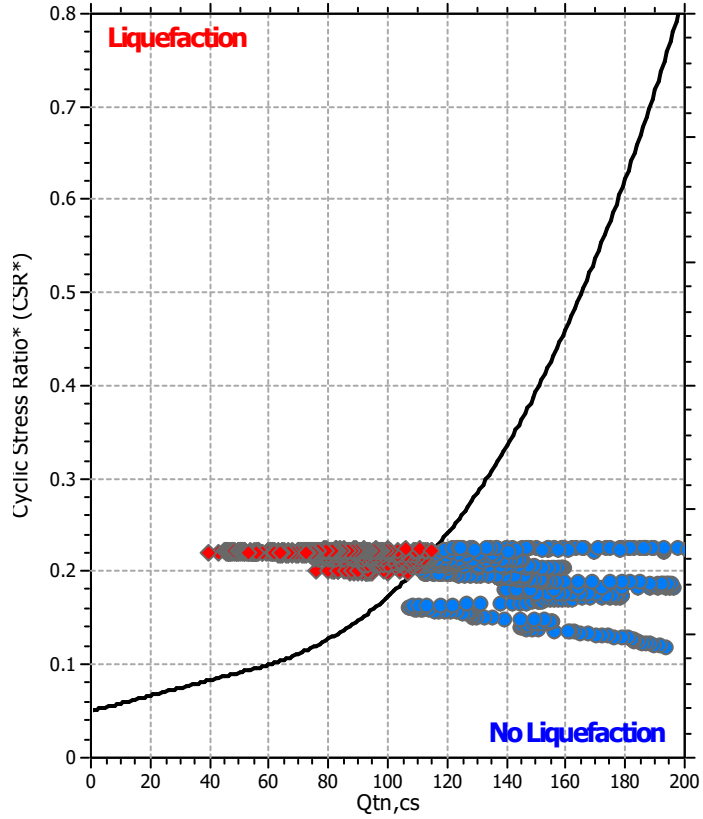
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

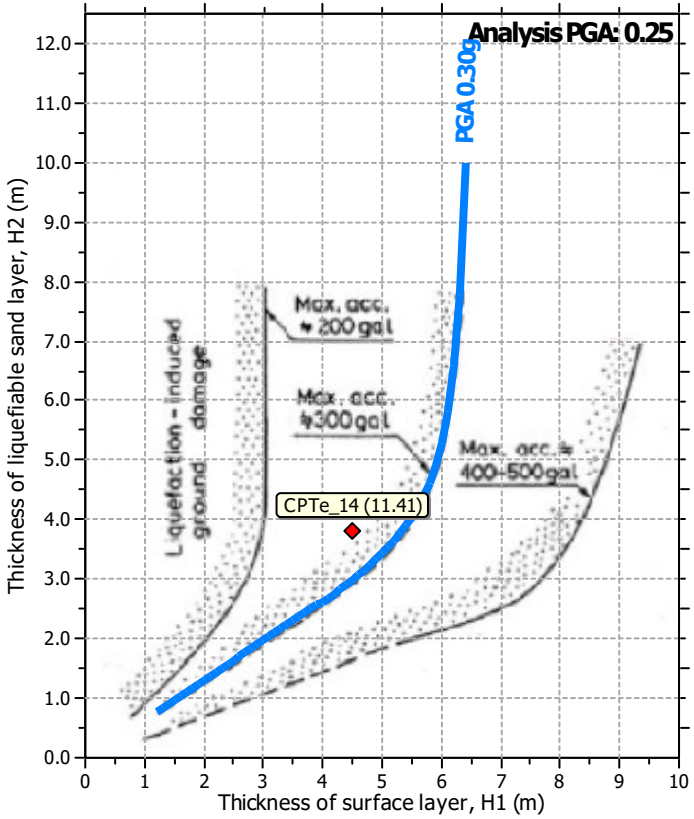
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	0.80 m	Fill height:	N/A	Limit depth:	20.00 m

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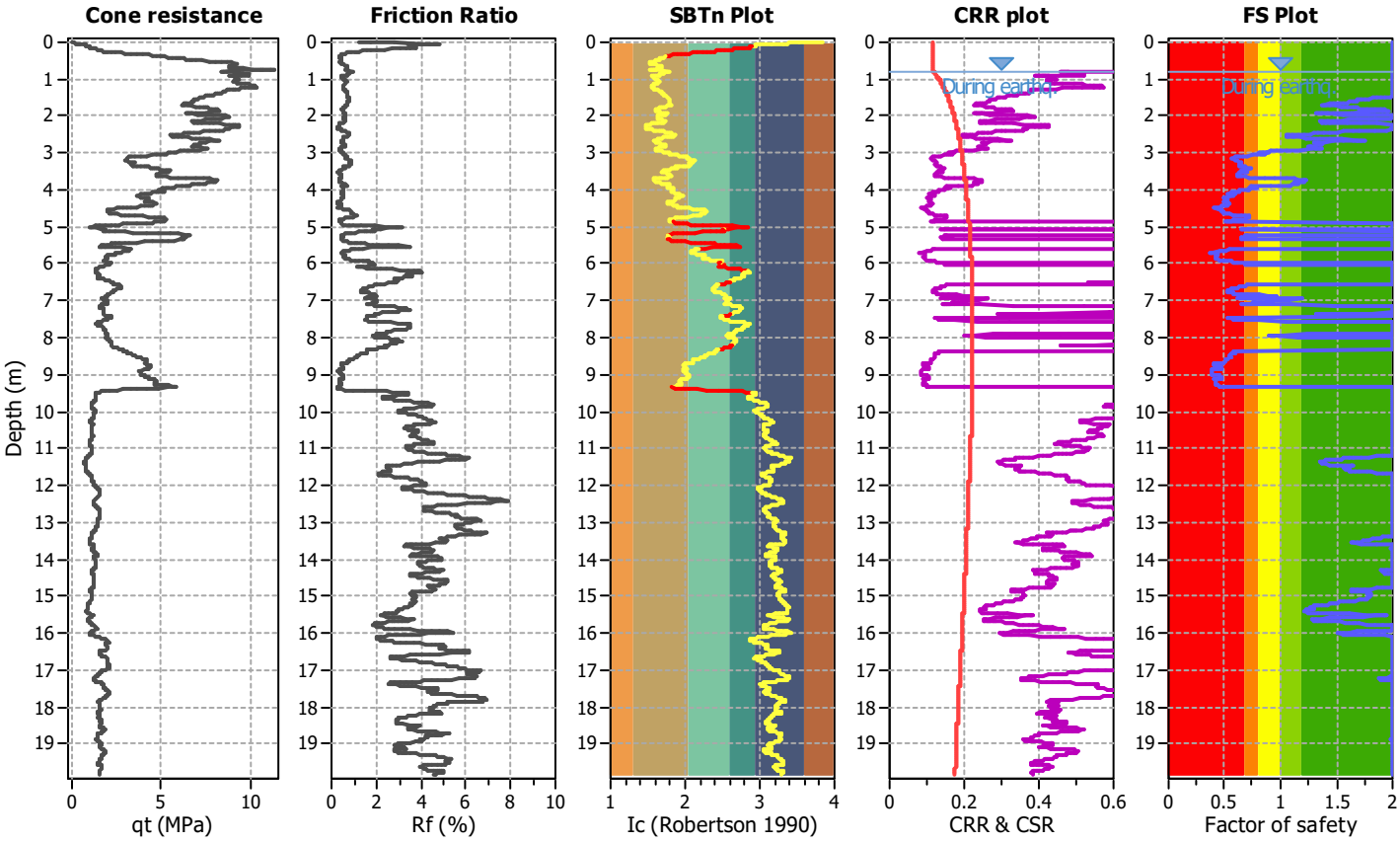
LIQUEFACTION ANALYSIS REPORT

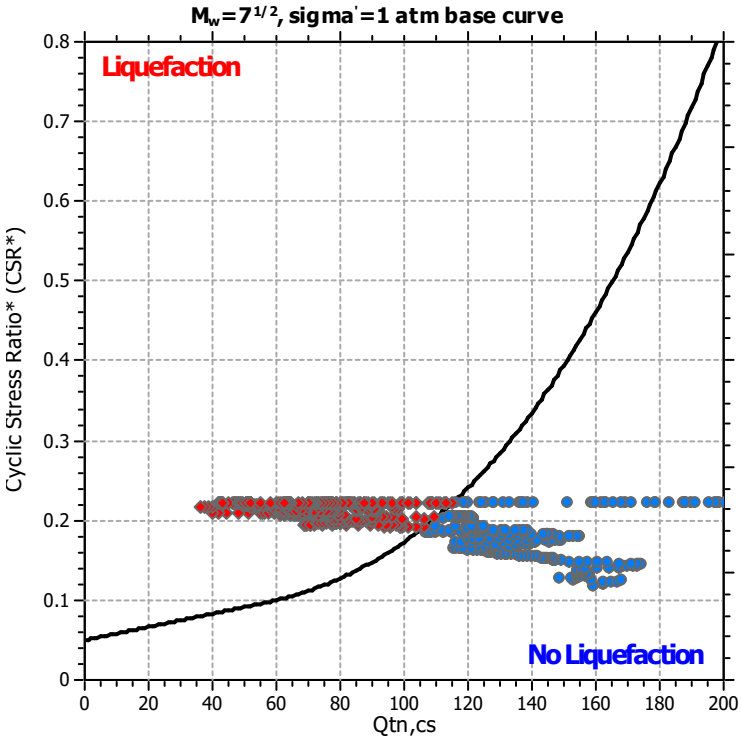
Project title : MS3_PA_Rimini_RNS_02 **Location : Rimini**

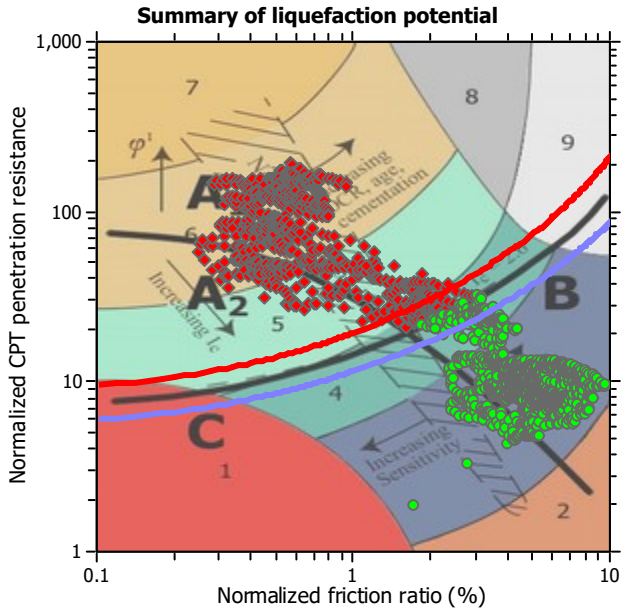
CPT file : CPTe_15

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.20 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

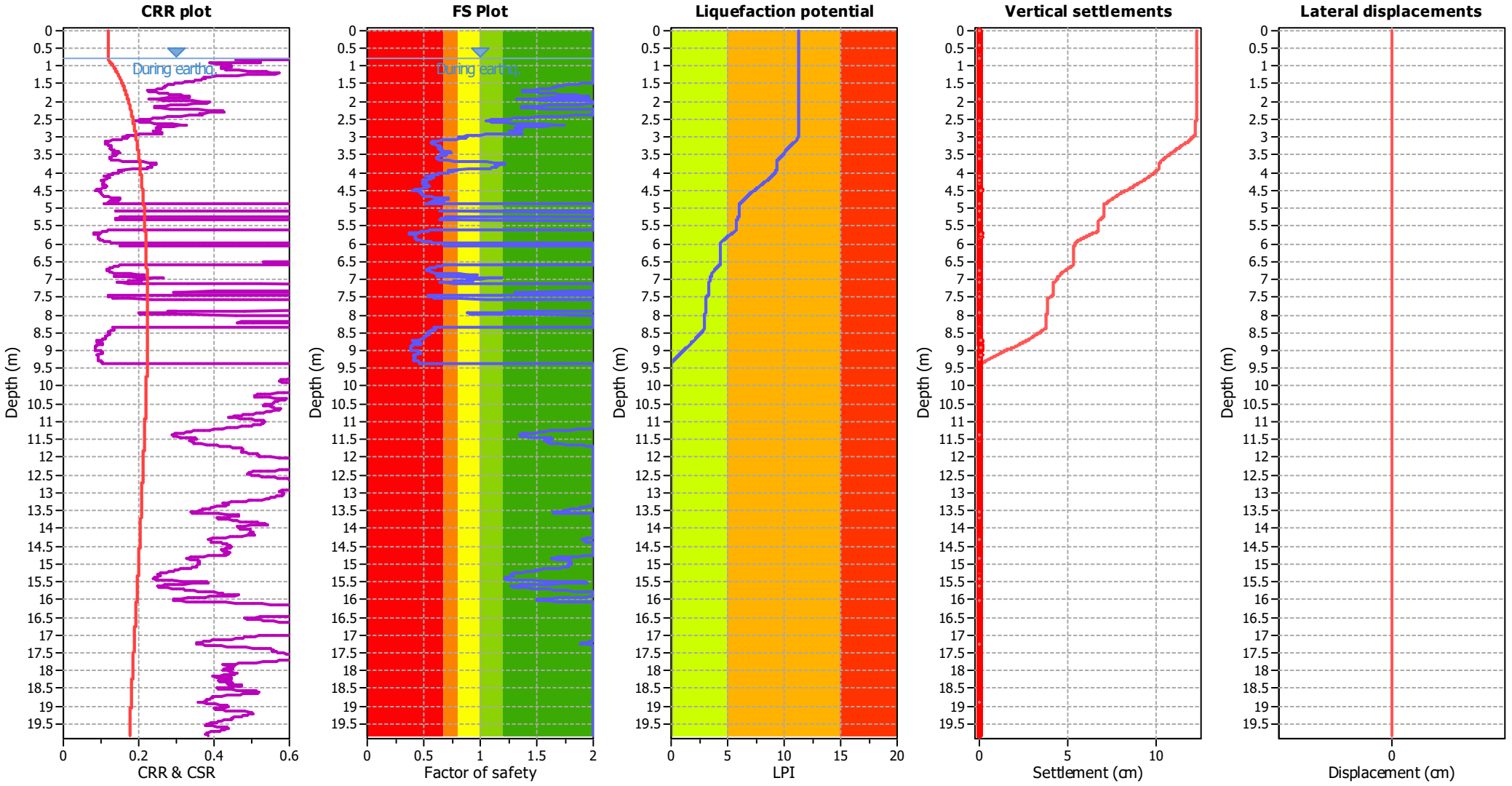






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	20.00 m

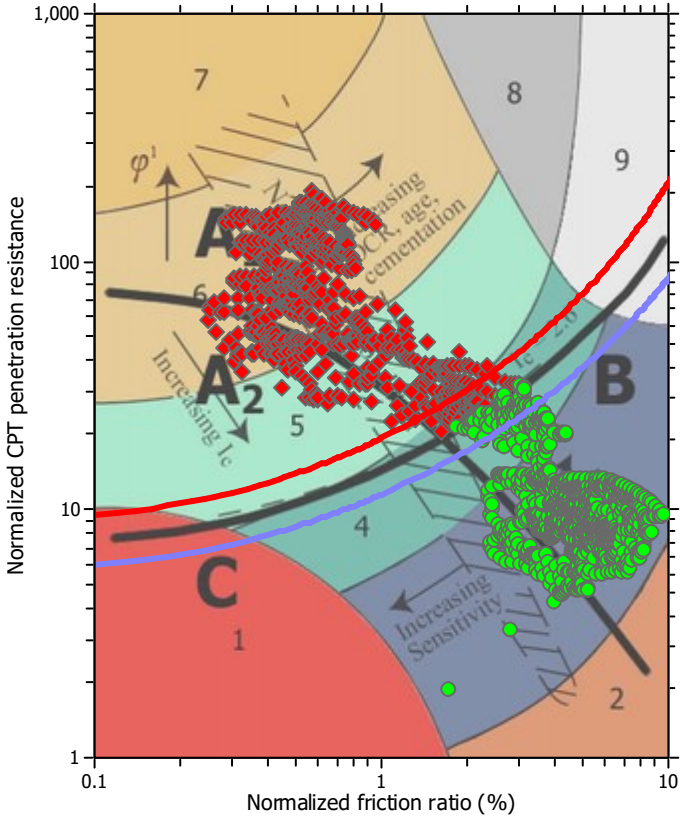
F.S. color scheme

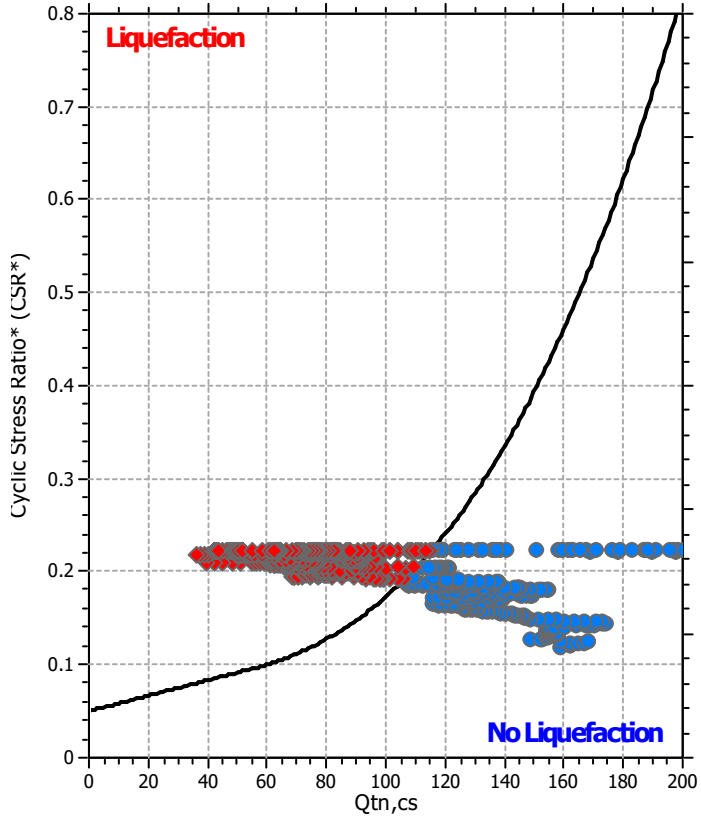
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

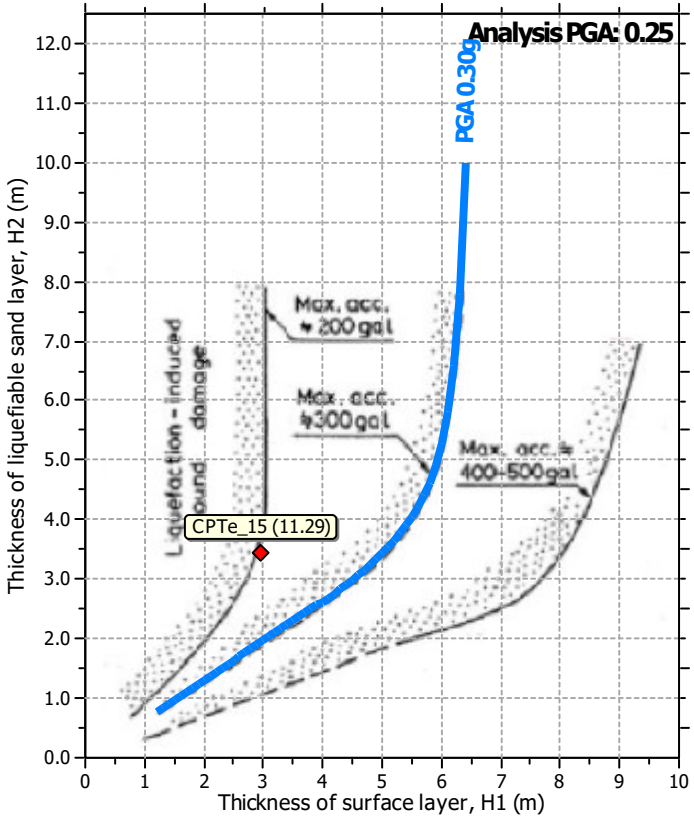
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	20.00 m

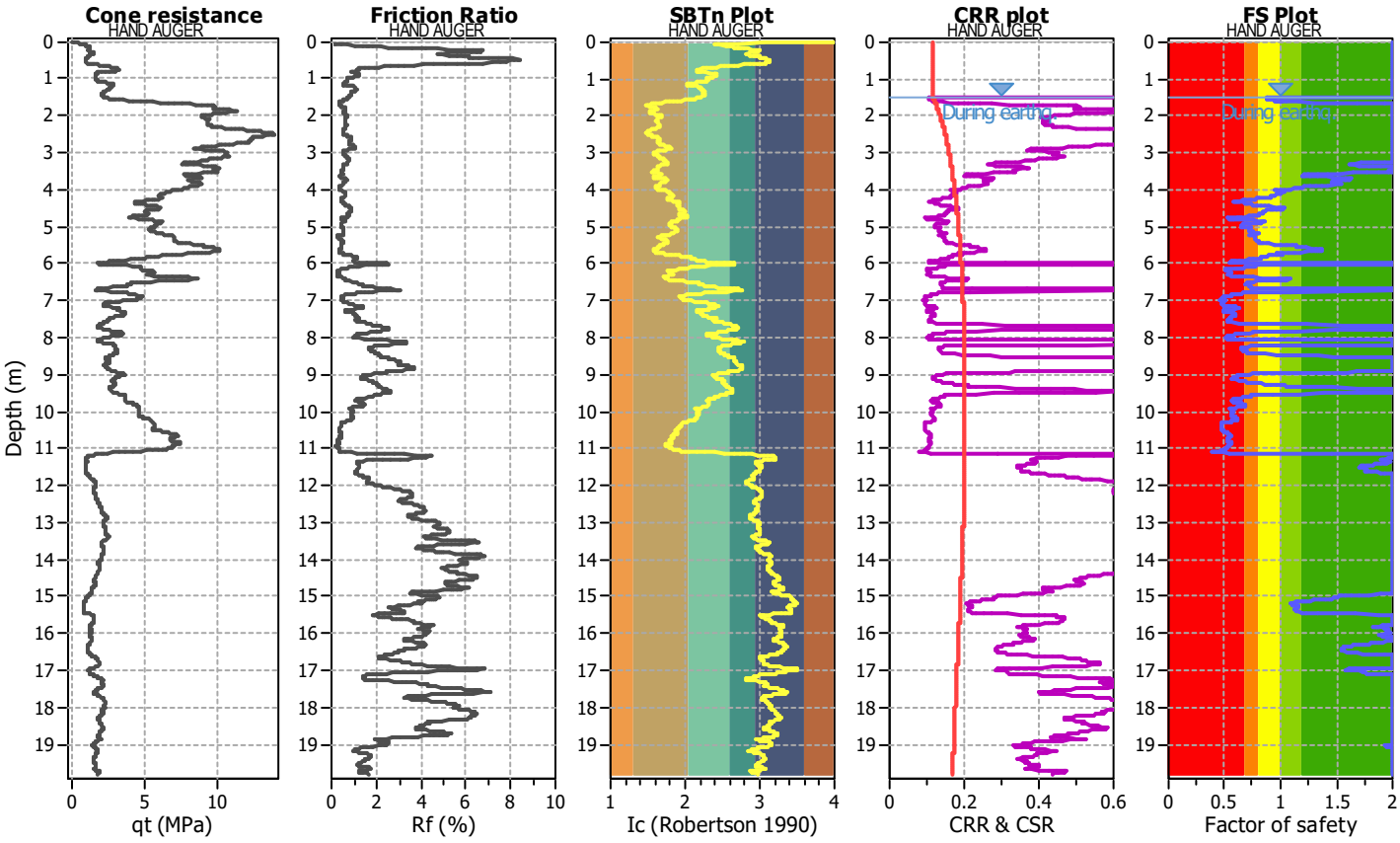
LIQUEFACTION ANALYSIS REPORT

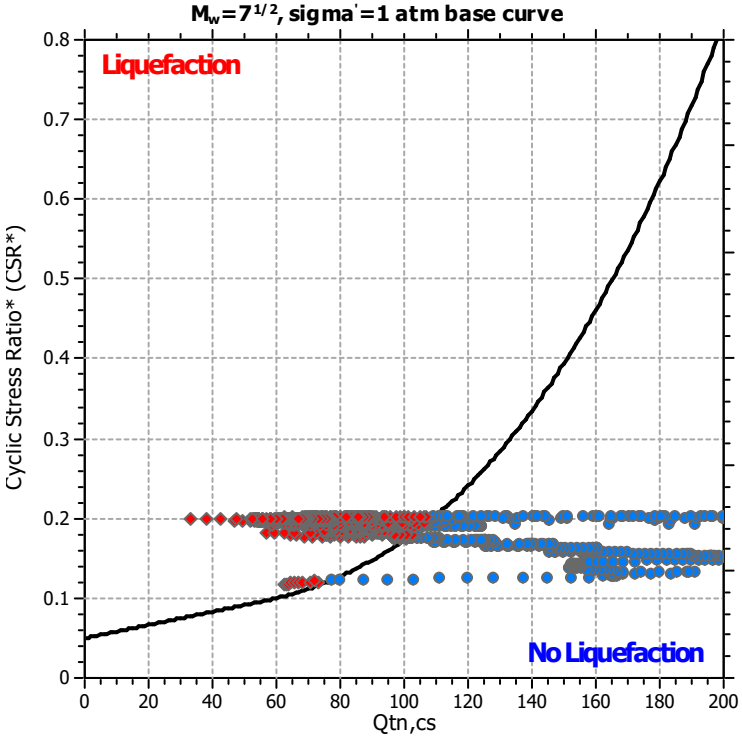
Project title : MS3_PA_Rimini_RNS_02 **Location : Rimini**

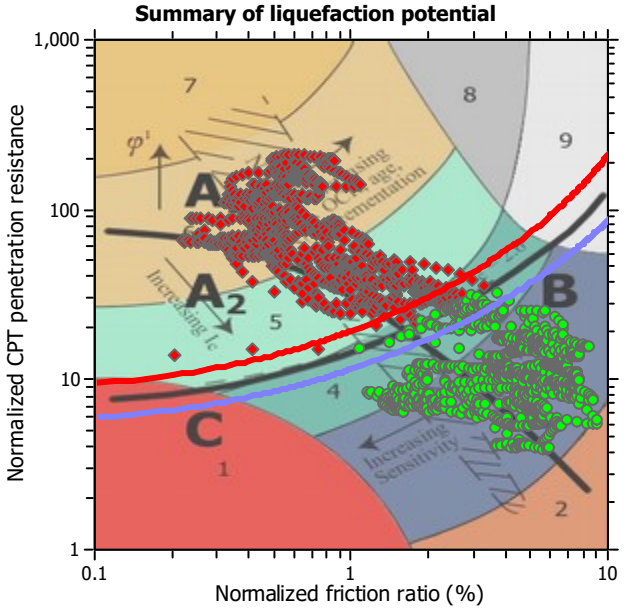
CPT file : CPTU_2_PMarv

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.50 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

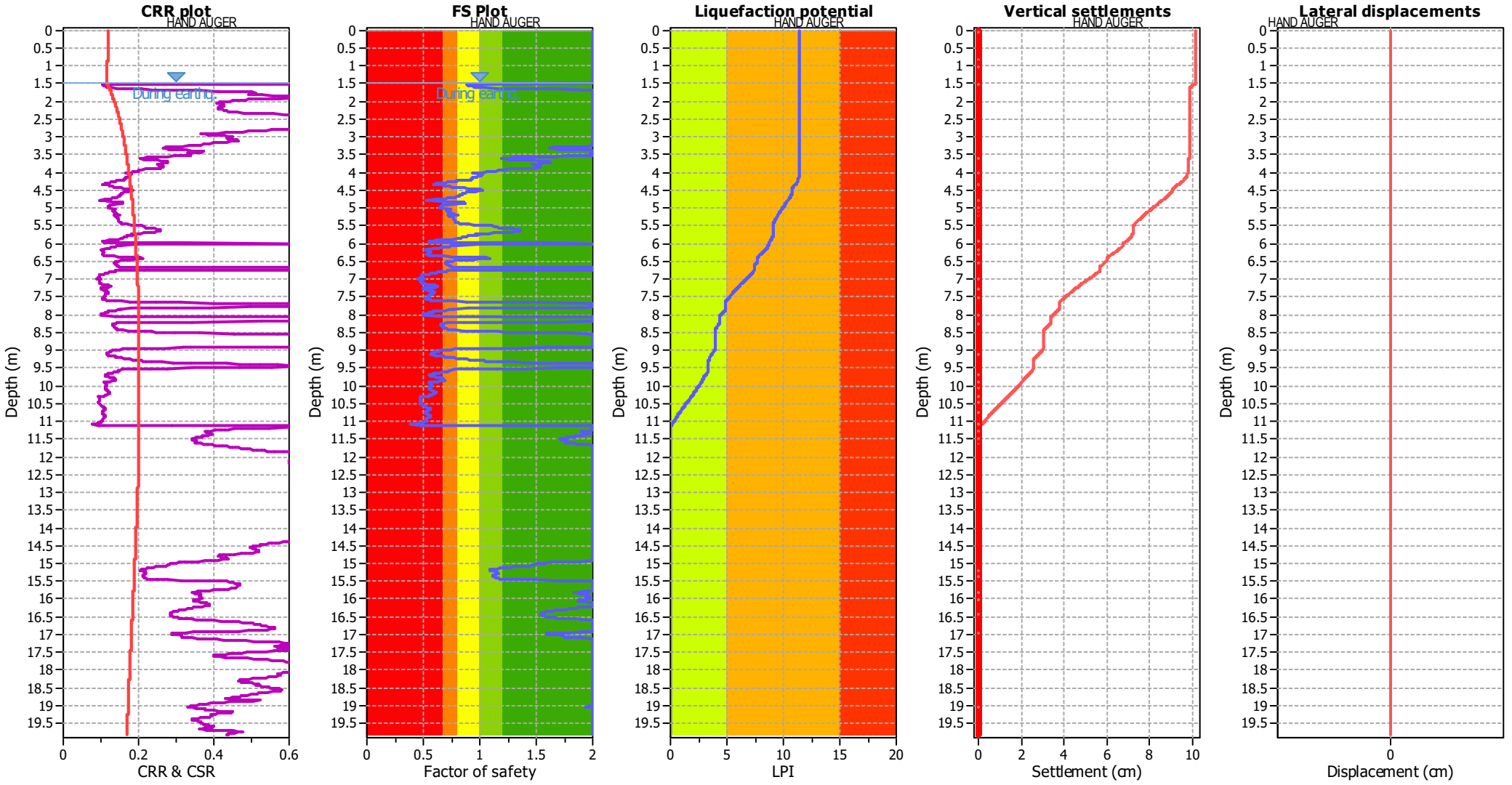






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

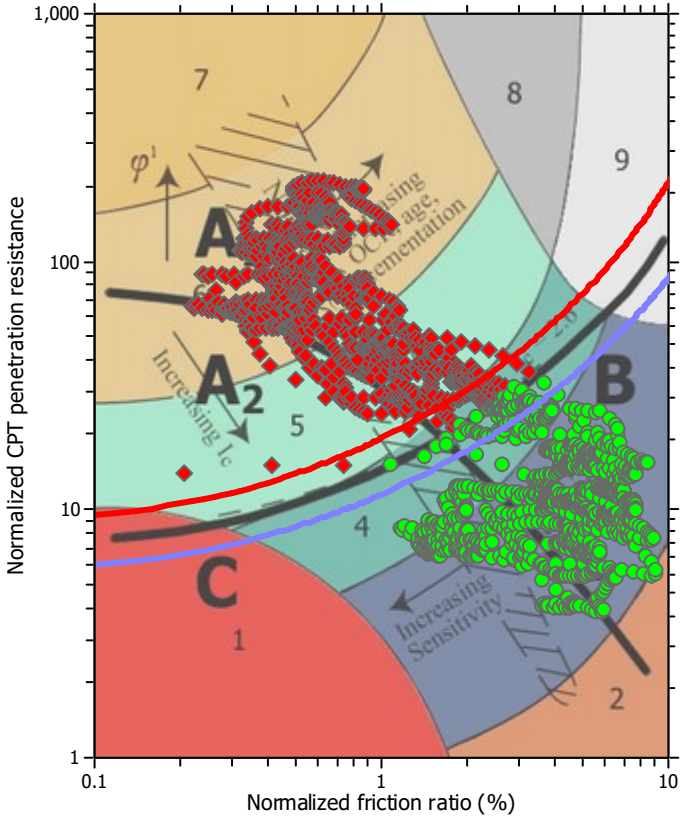
F.S. color scheme

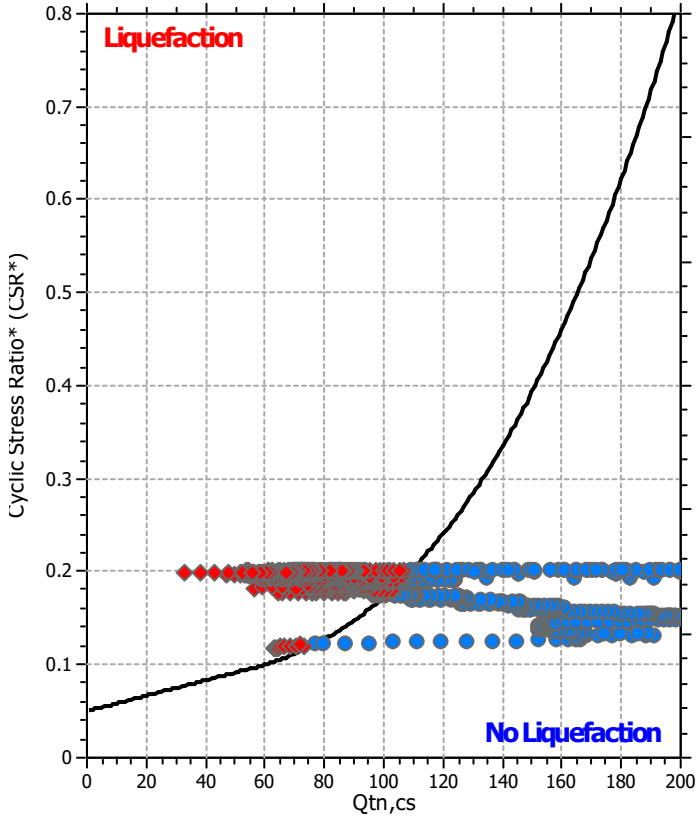
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

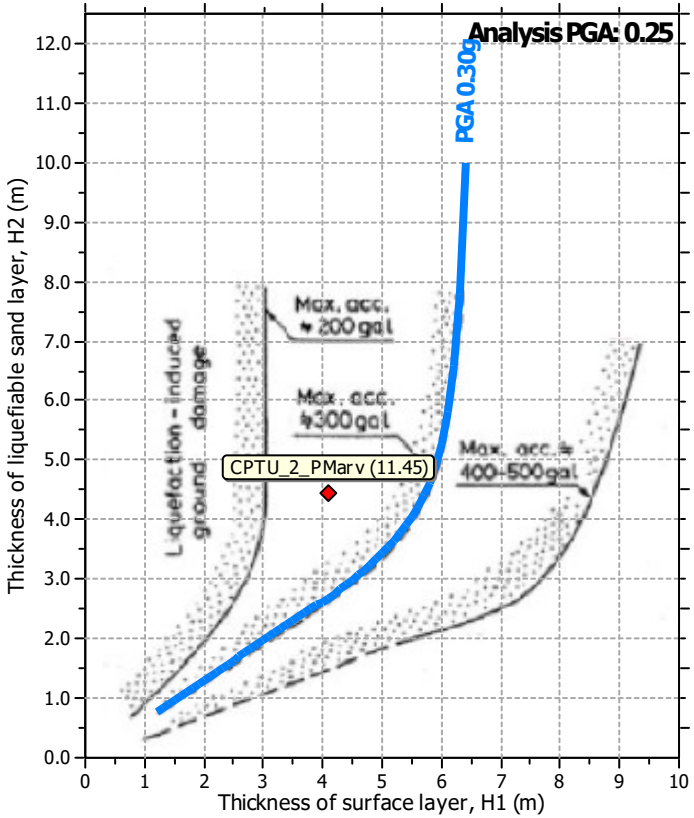
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

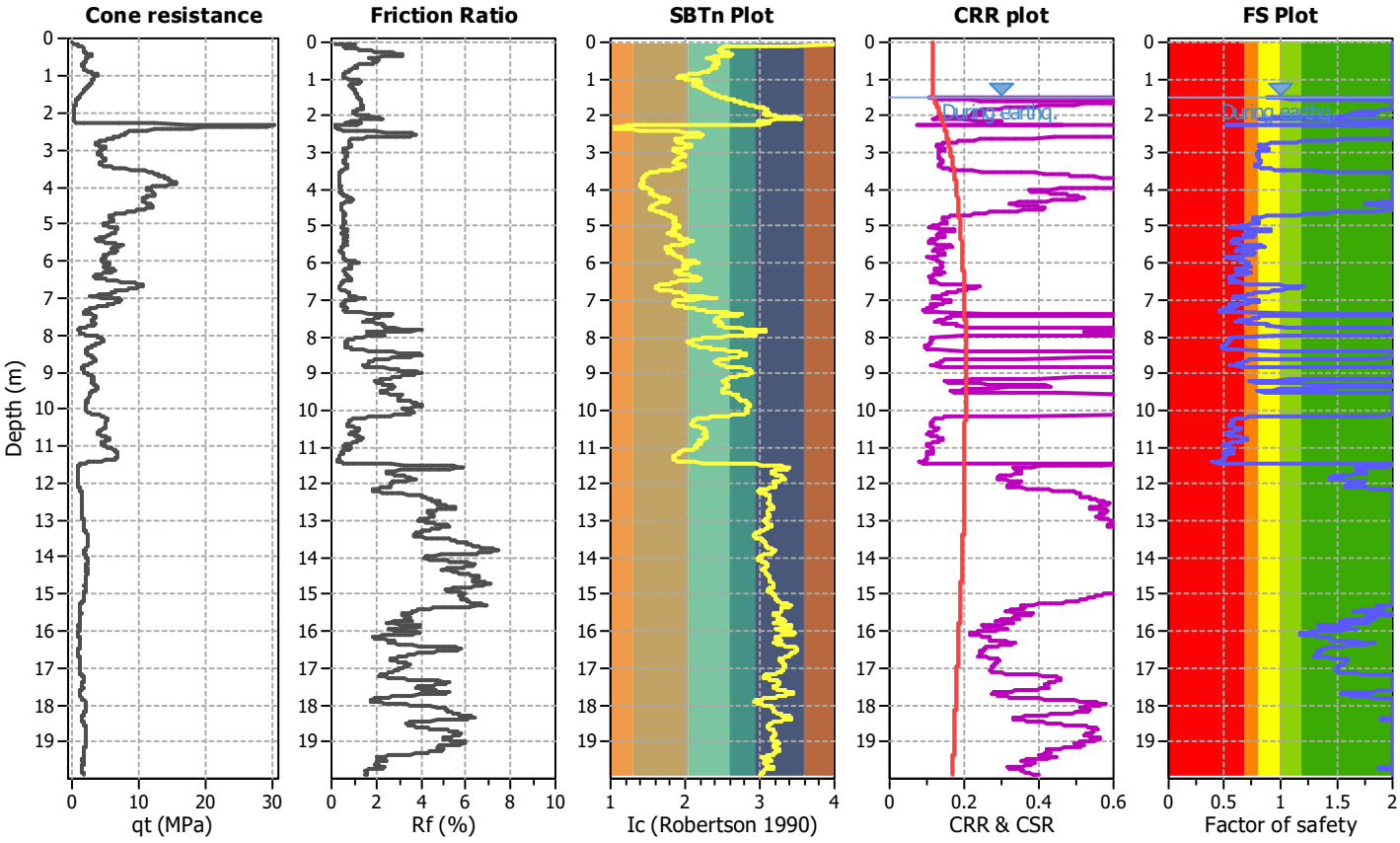
LIQUEFACTION ANALYSIS REPORT

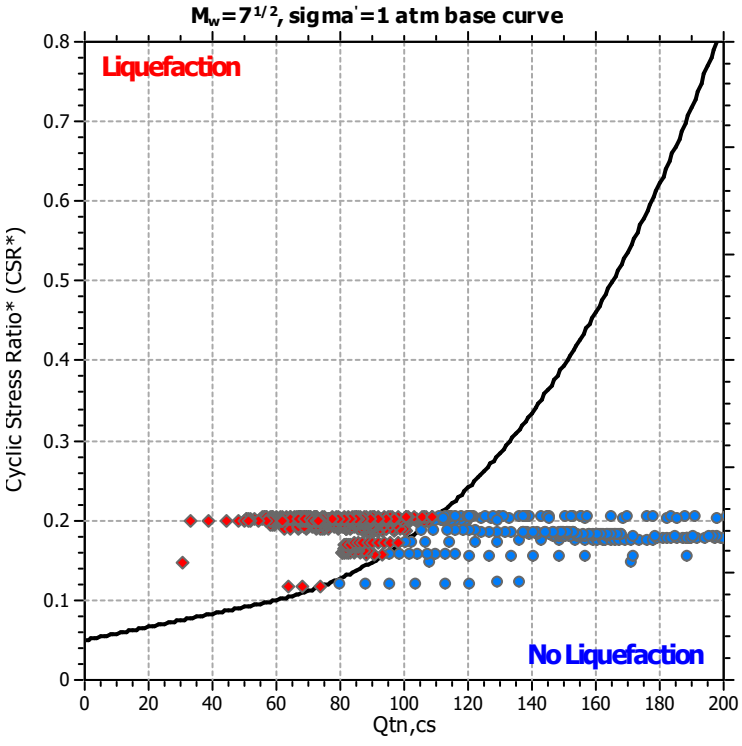
Project title : MS3_PA_Rimini_RNS_02 **Location : Rimini**

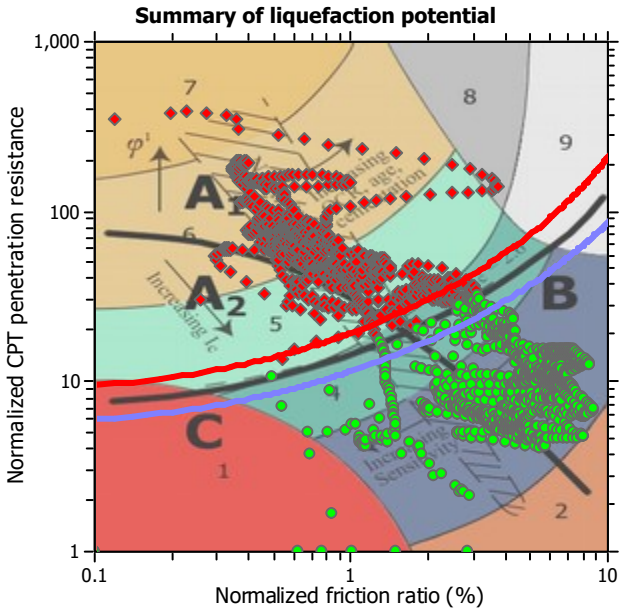
CPT file : CPTU_3_MArv

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	2.50 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.50 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.25	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

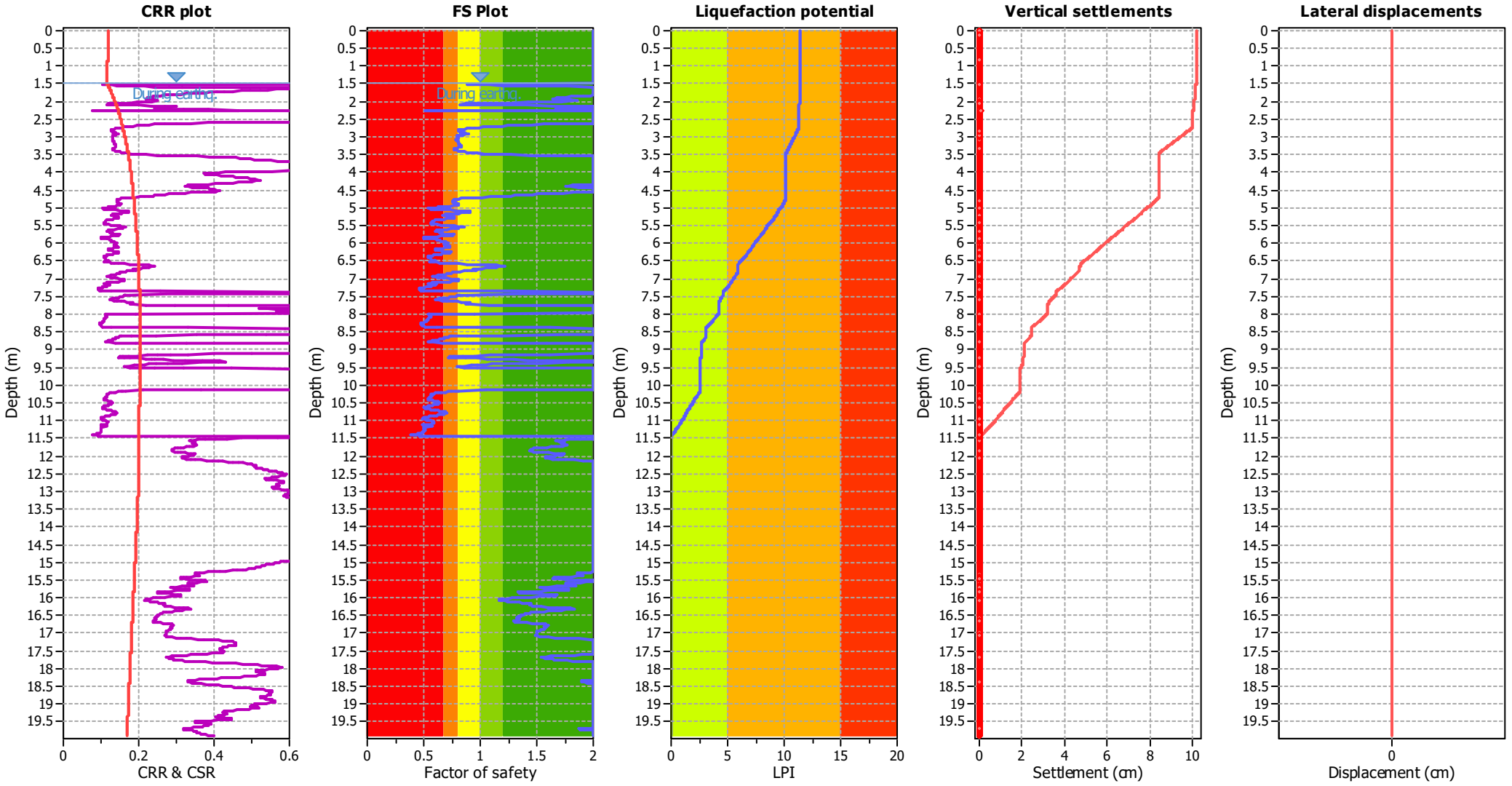






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	20.00 m

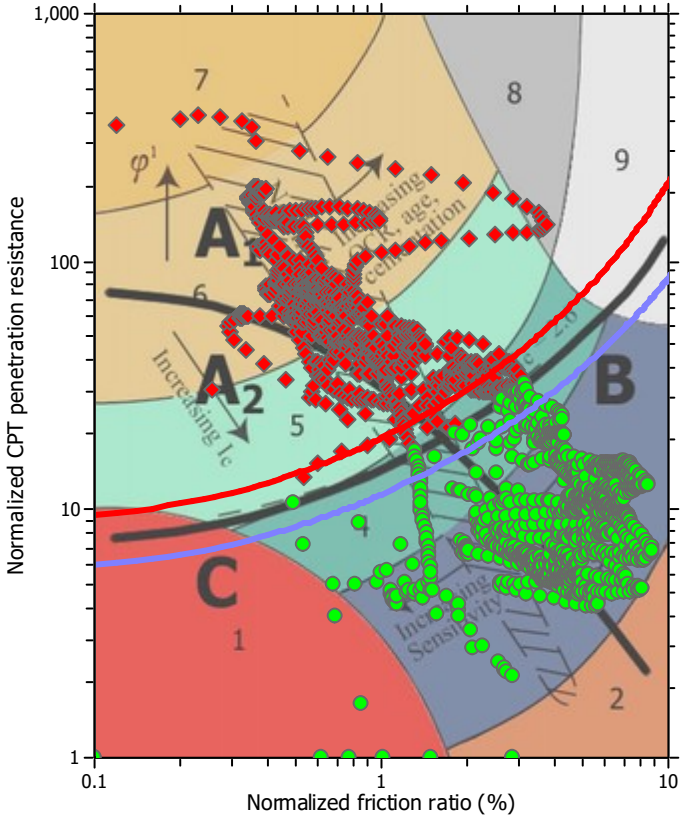
F.S. color scheme

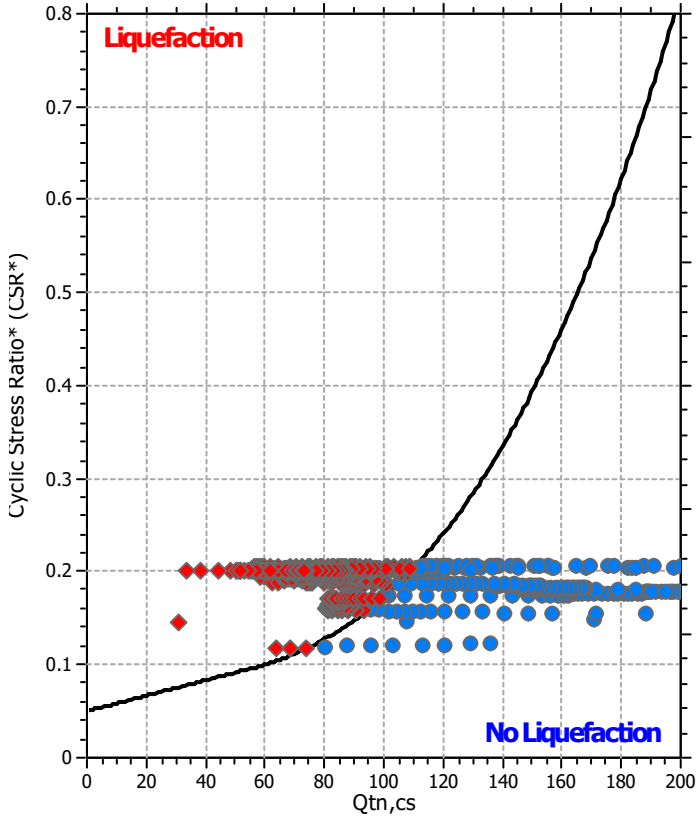
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

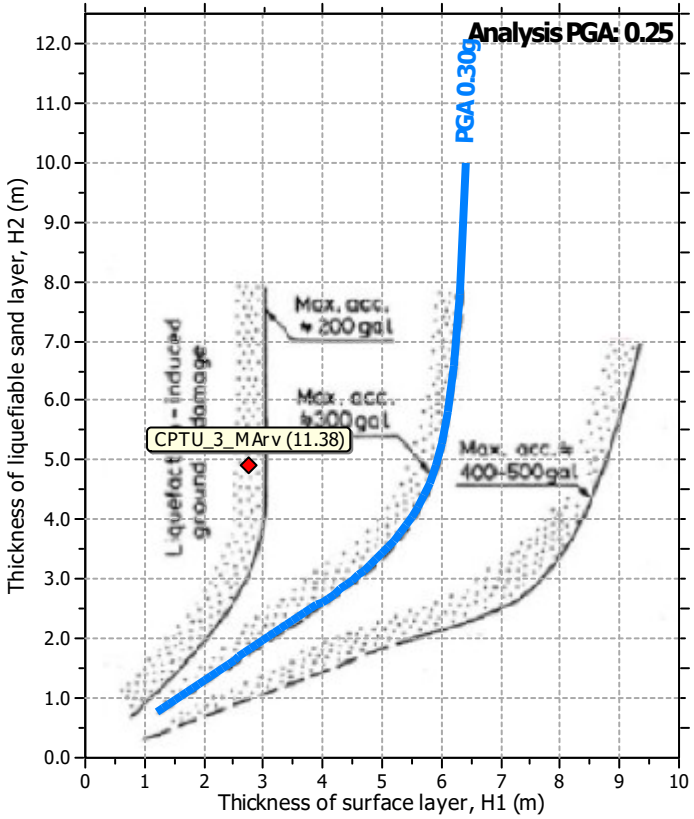
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.50 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.25	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.50 m	Fill height:	N/A	Limit depth:	20.00 m

REPORT - ZONA RNS_03

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

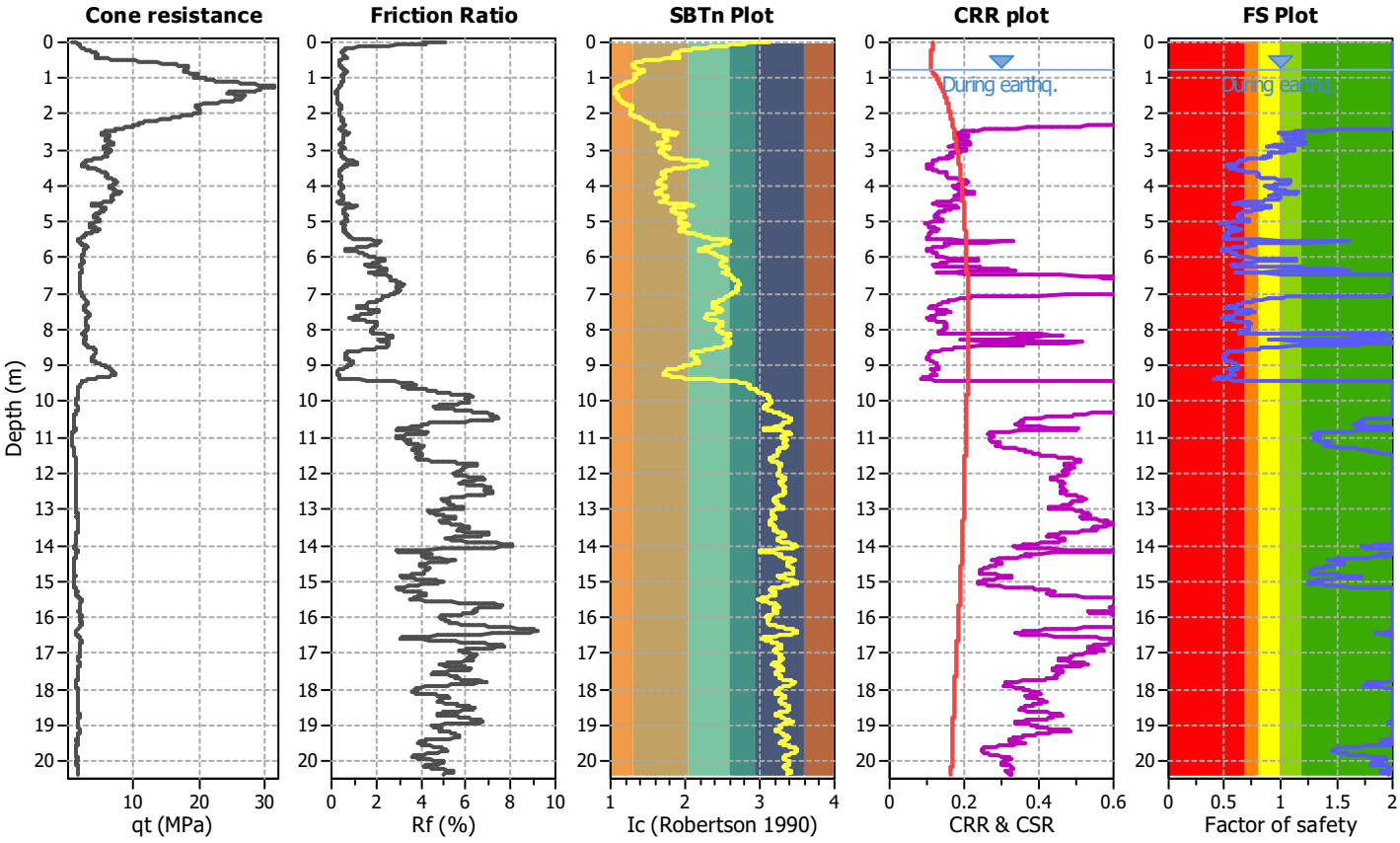
LIQUEFACTION ANALYSIS REPORT

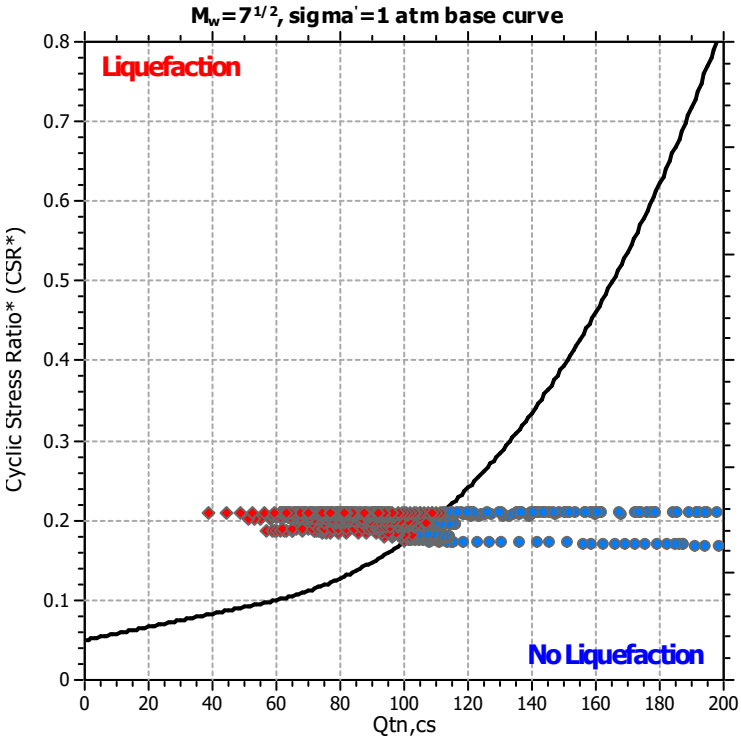
Project title : MS3_PA_Rimini_RNS_03 **Location : Rimini**

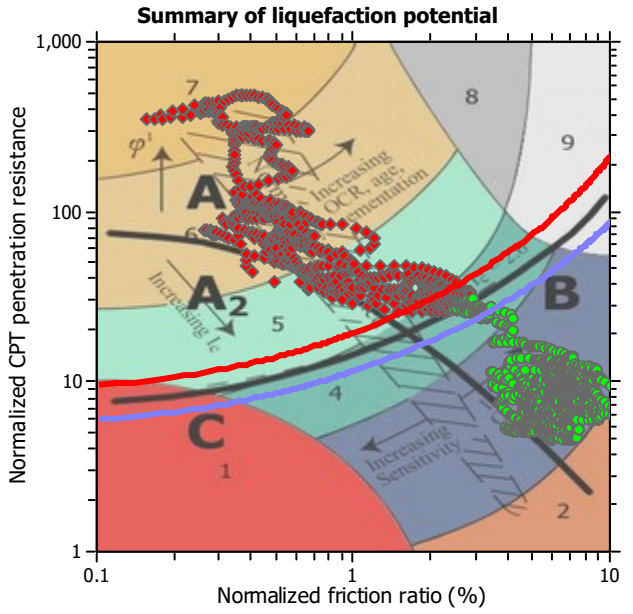
CPT file : 099014P1288

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.24	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

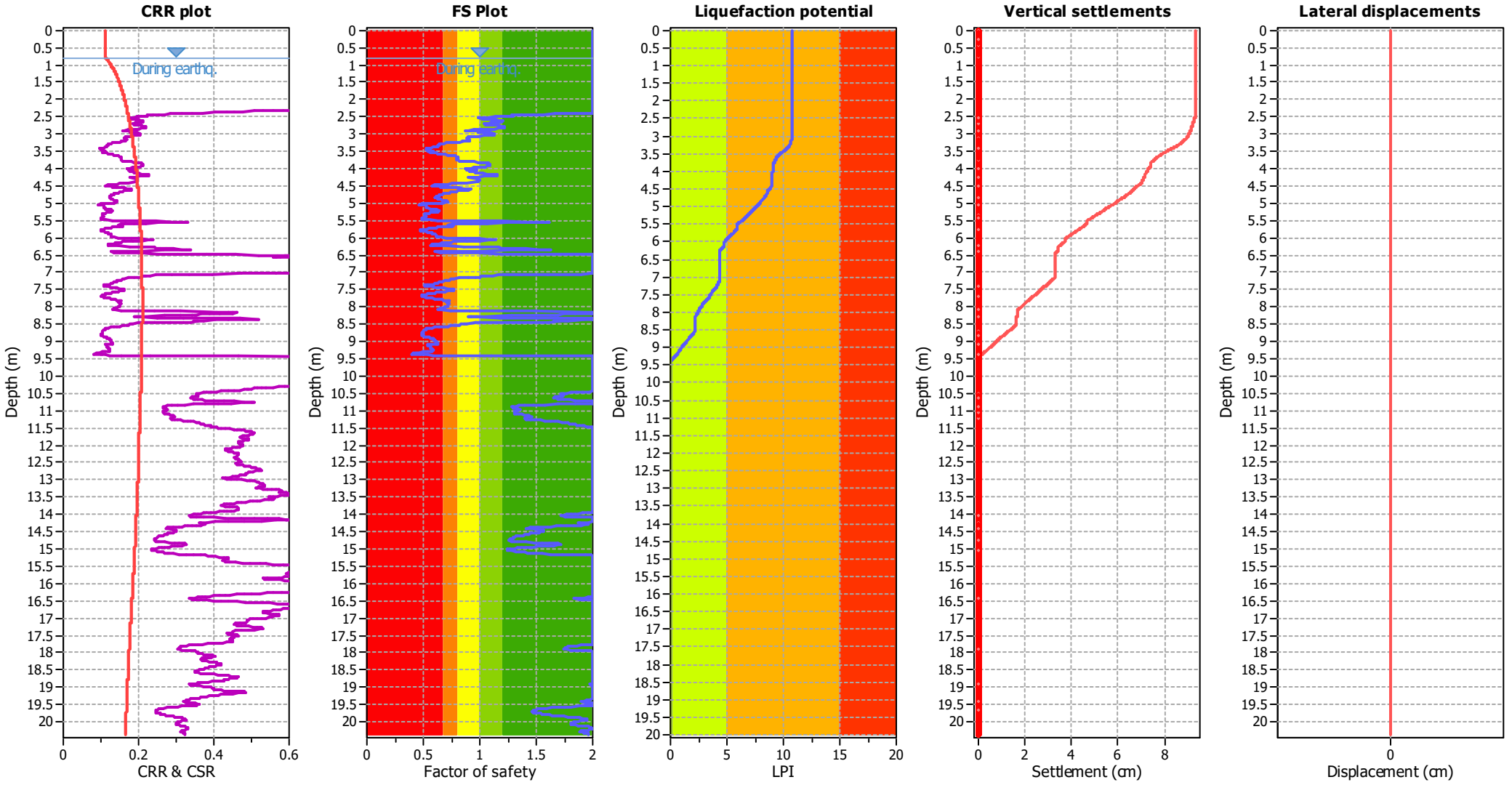






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

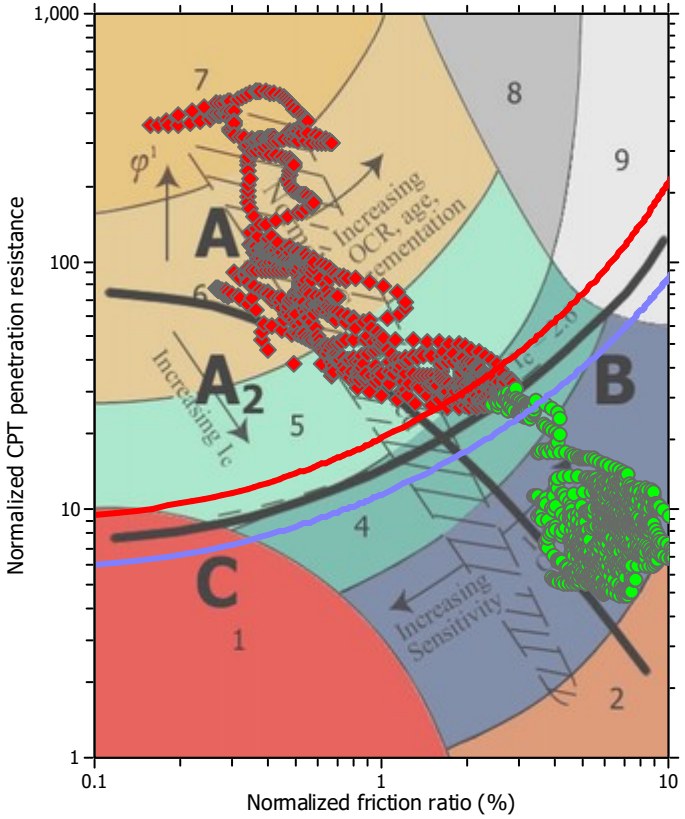
F.S. color scheme

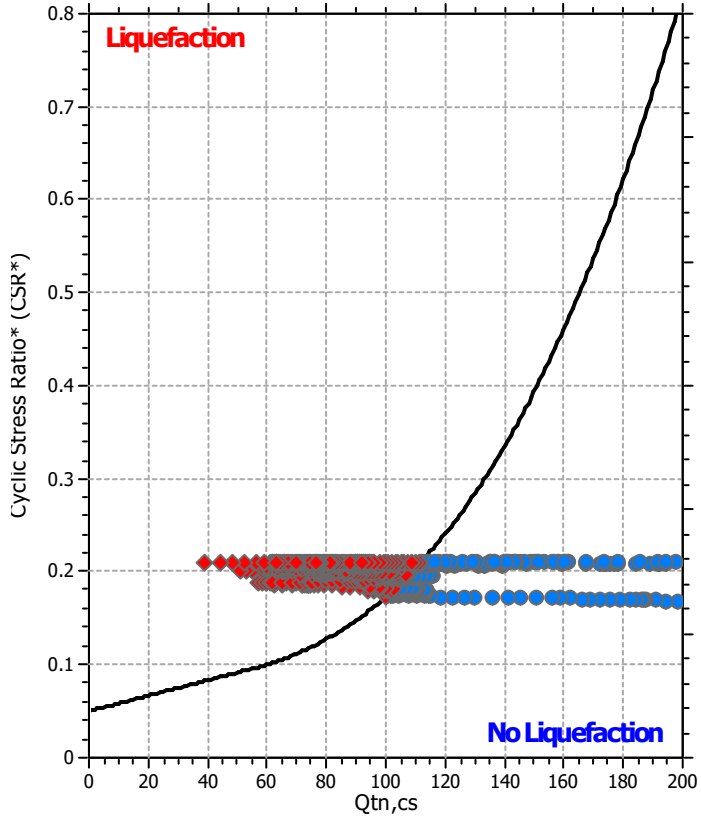
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

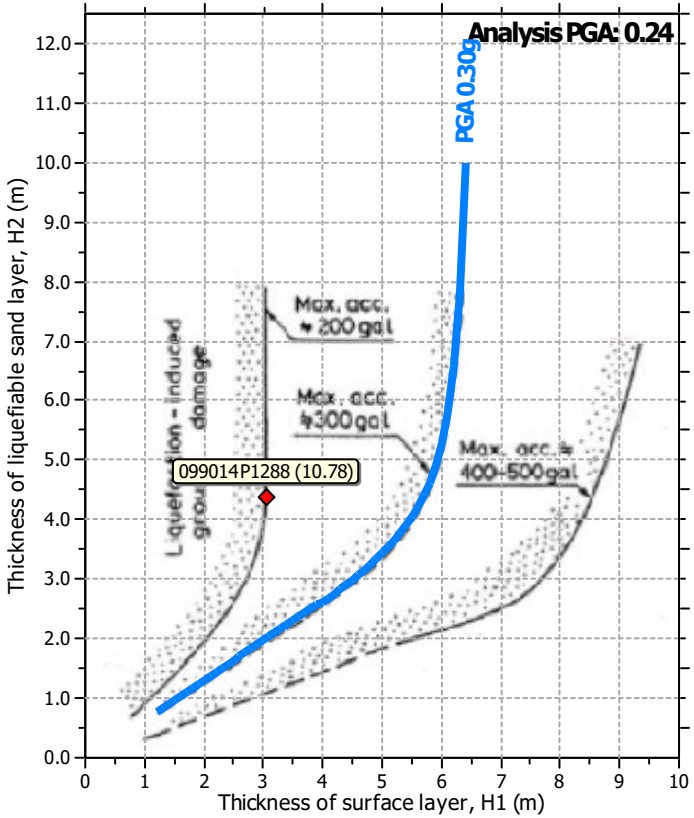
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

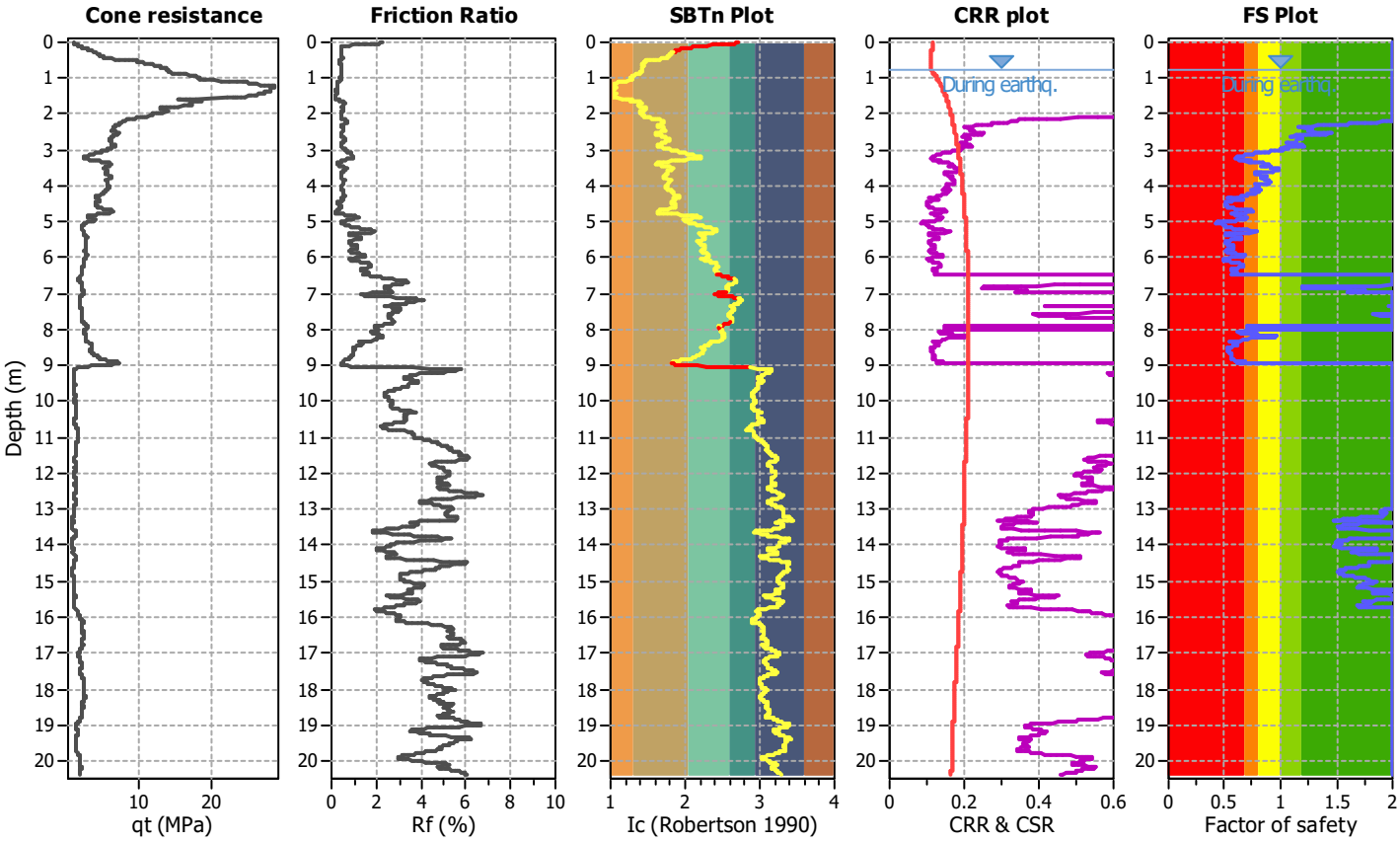
LIQUEFACTION ANALYSIS REPORT

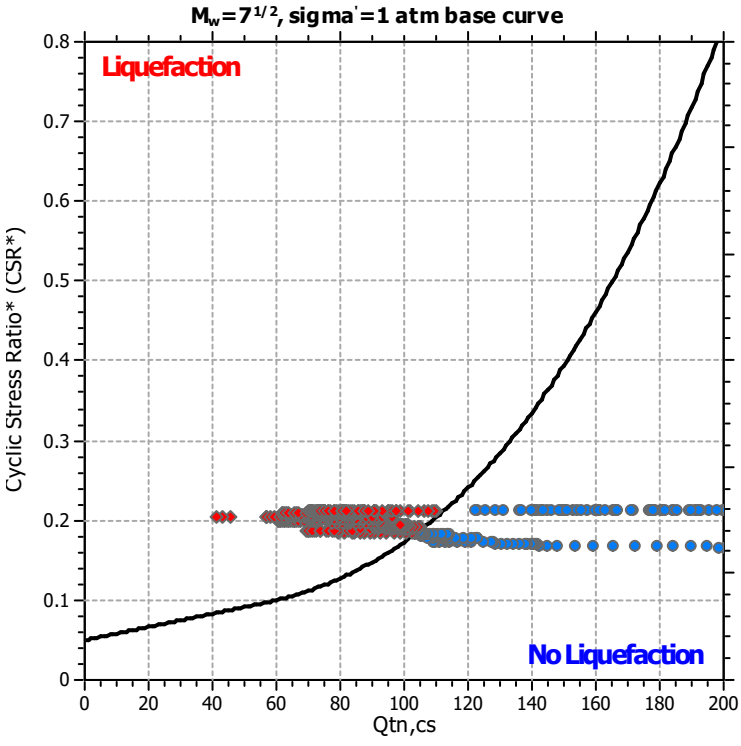
Project title : MS3_PA_Rimini_RNS_03 **Location : Rimini**

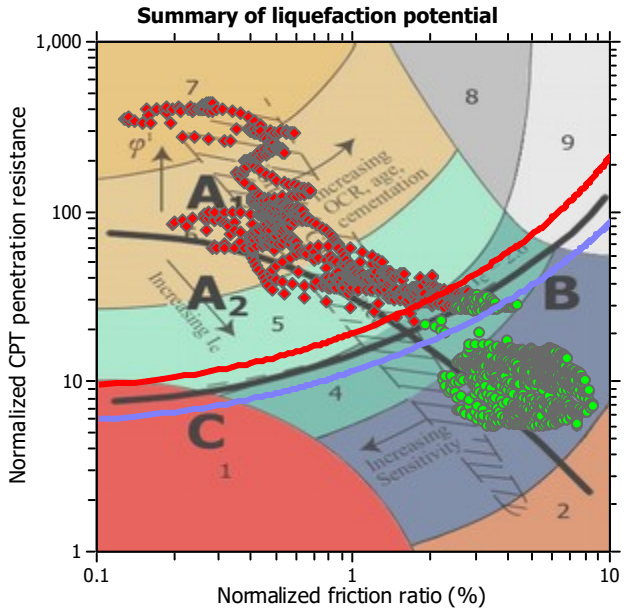
CPT file : 099014P1290

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.24	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

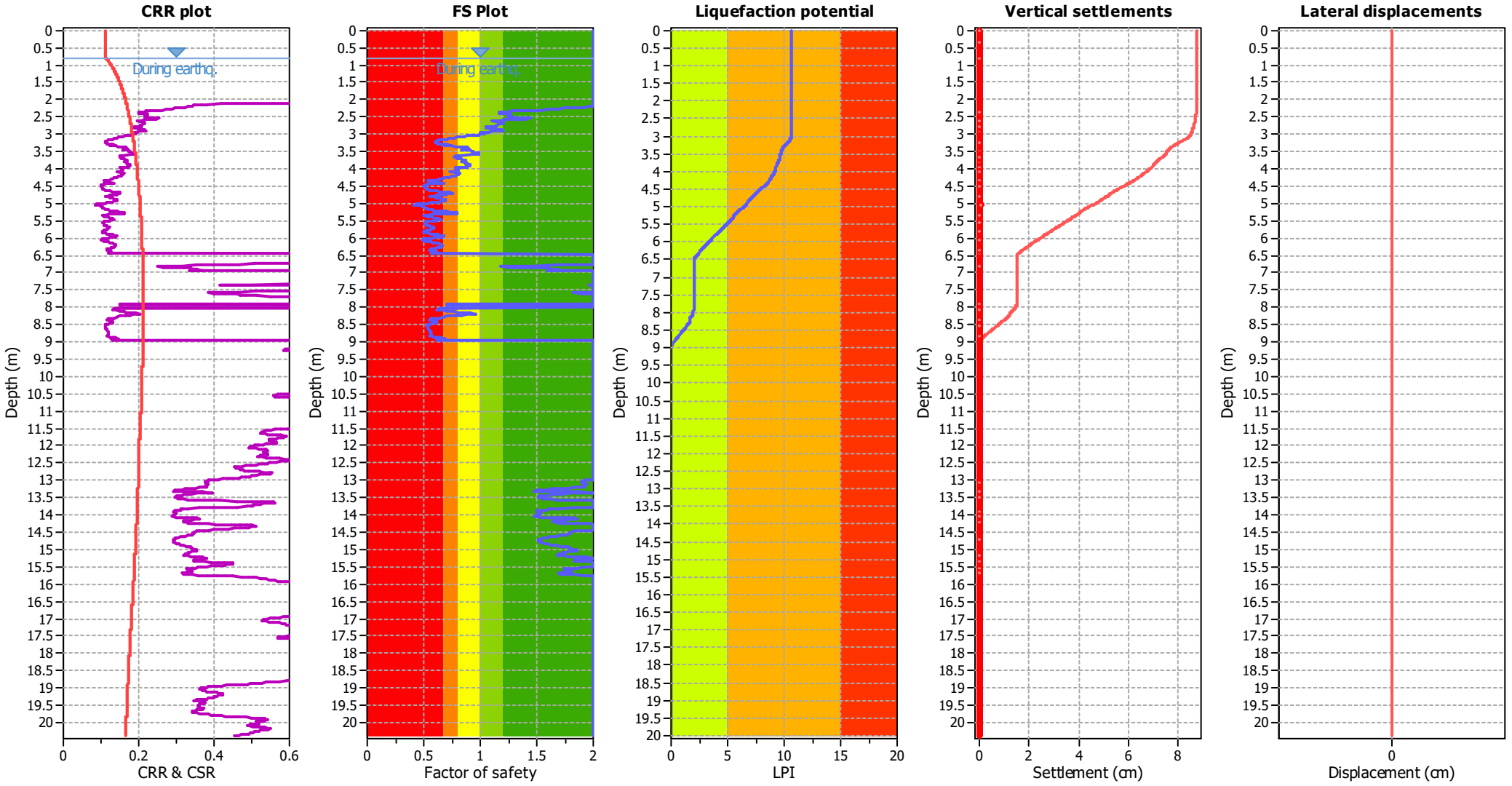






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

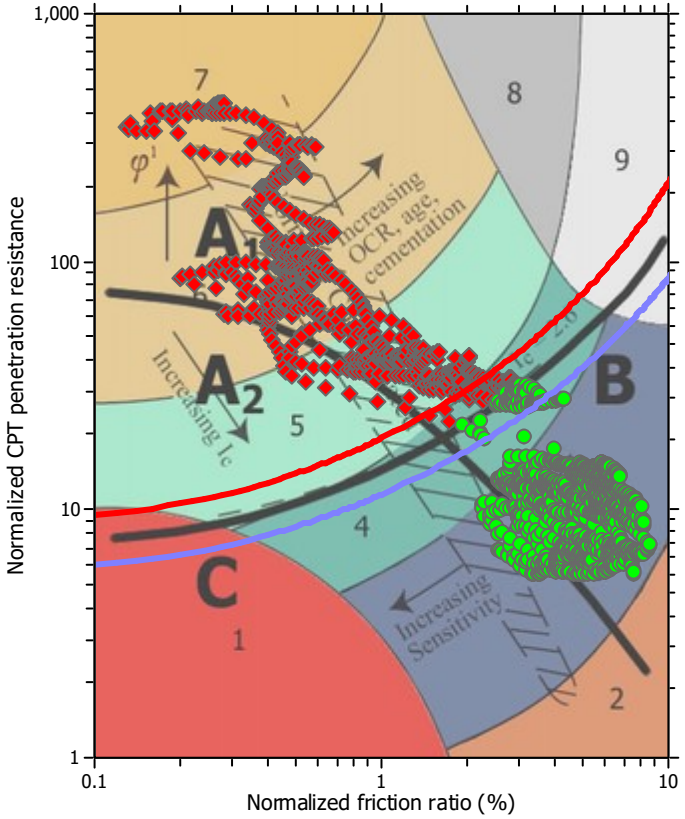
F.S. color scheme

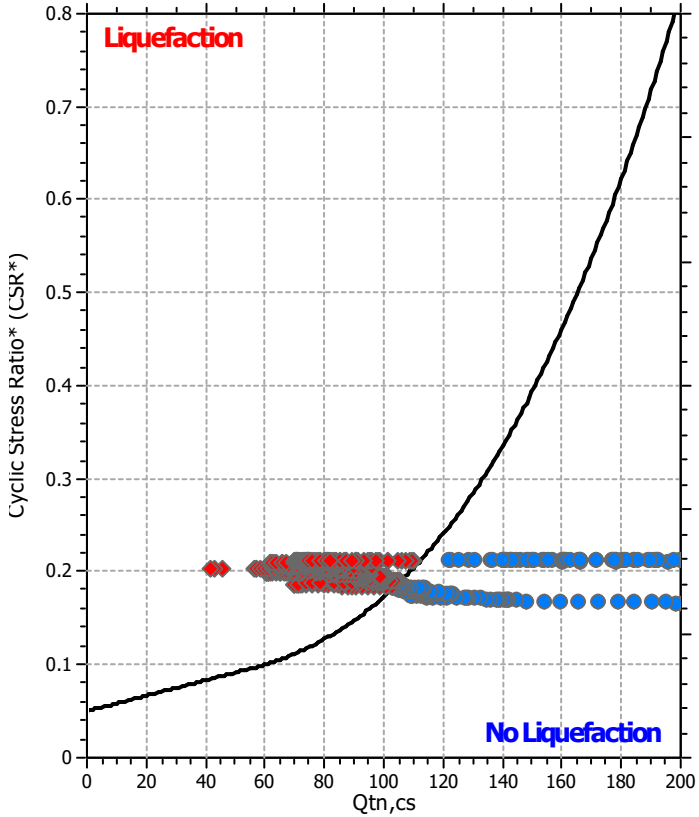
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

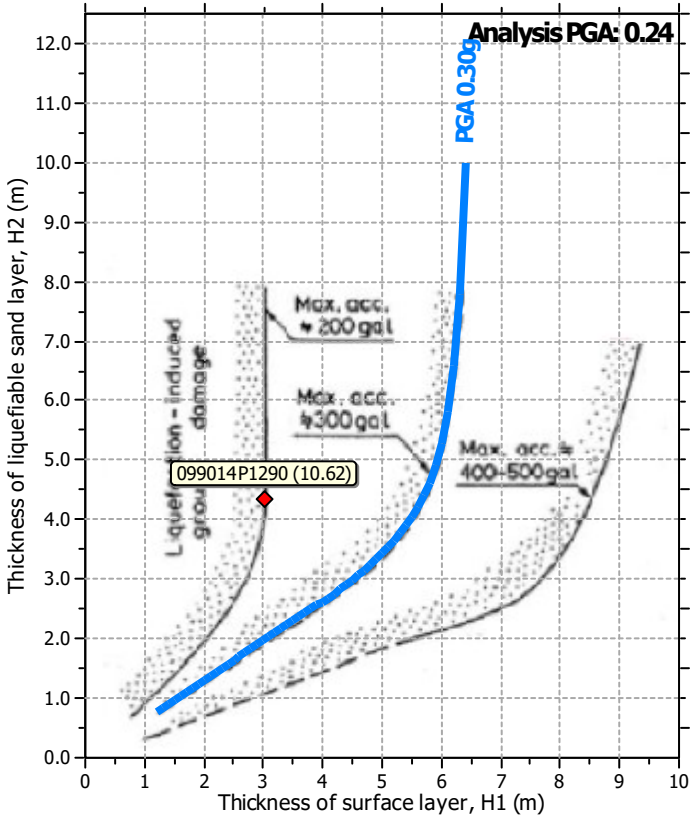
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

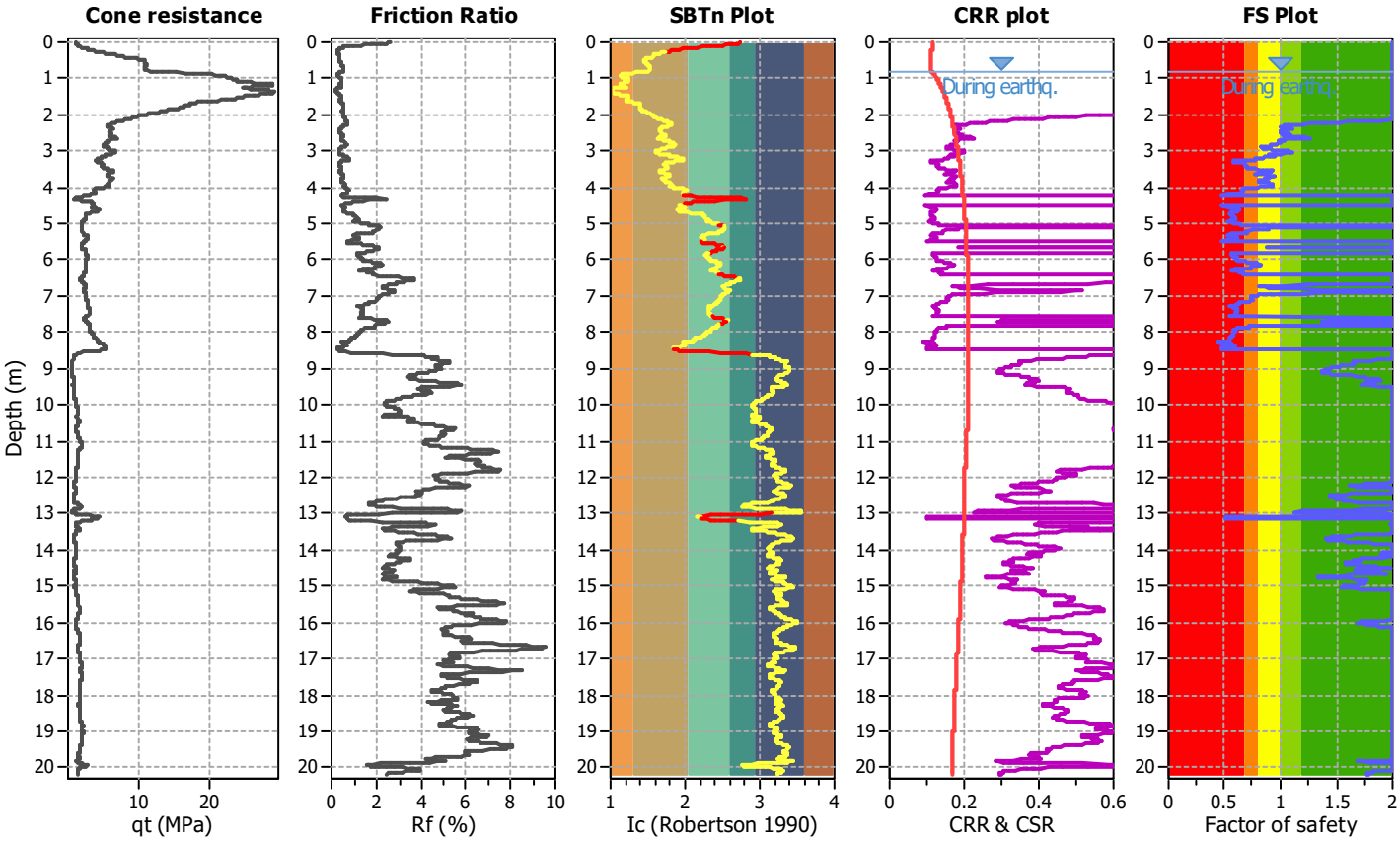
LIQUEFACTION ANALYSIS REPORT

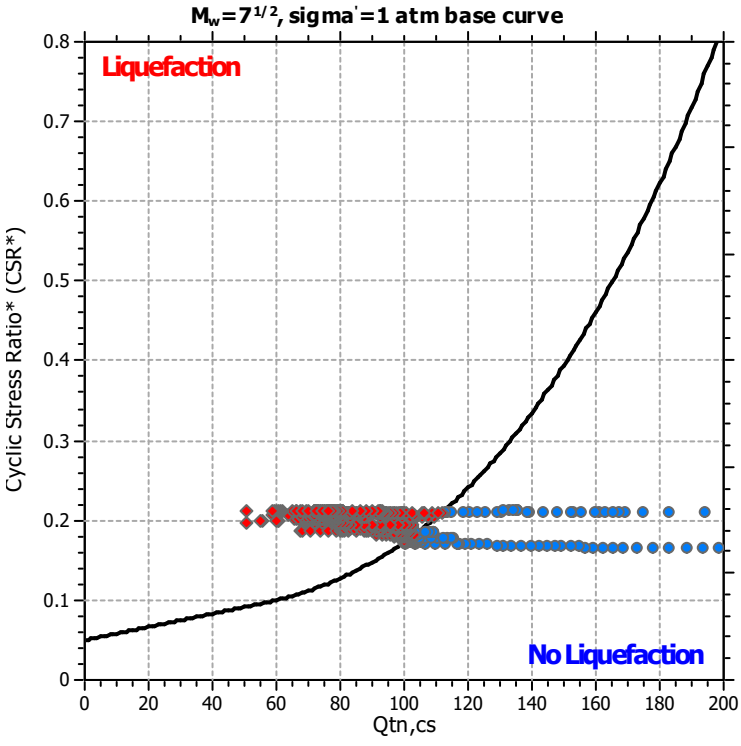
Project title : MS3_PA_Rimini_RNS_03 **Location : Rimini**

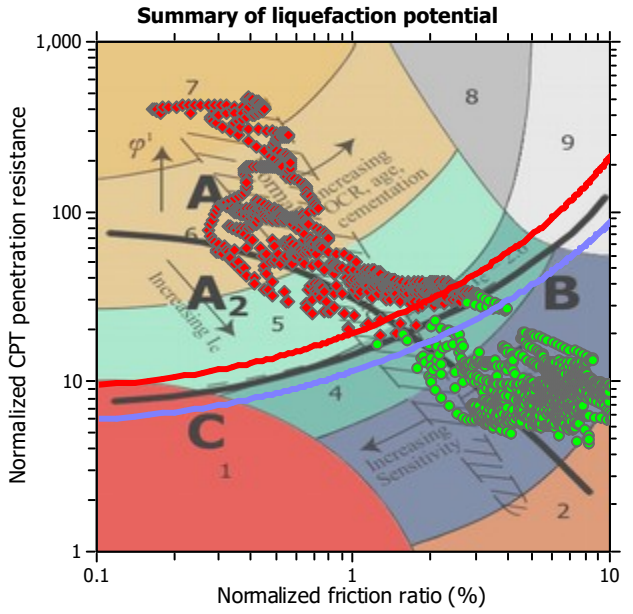
CPT file : 099014P1292

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.24	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

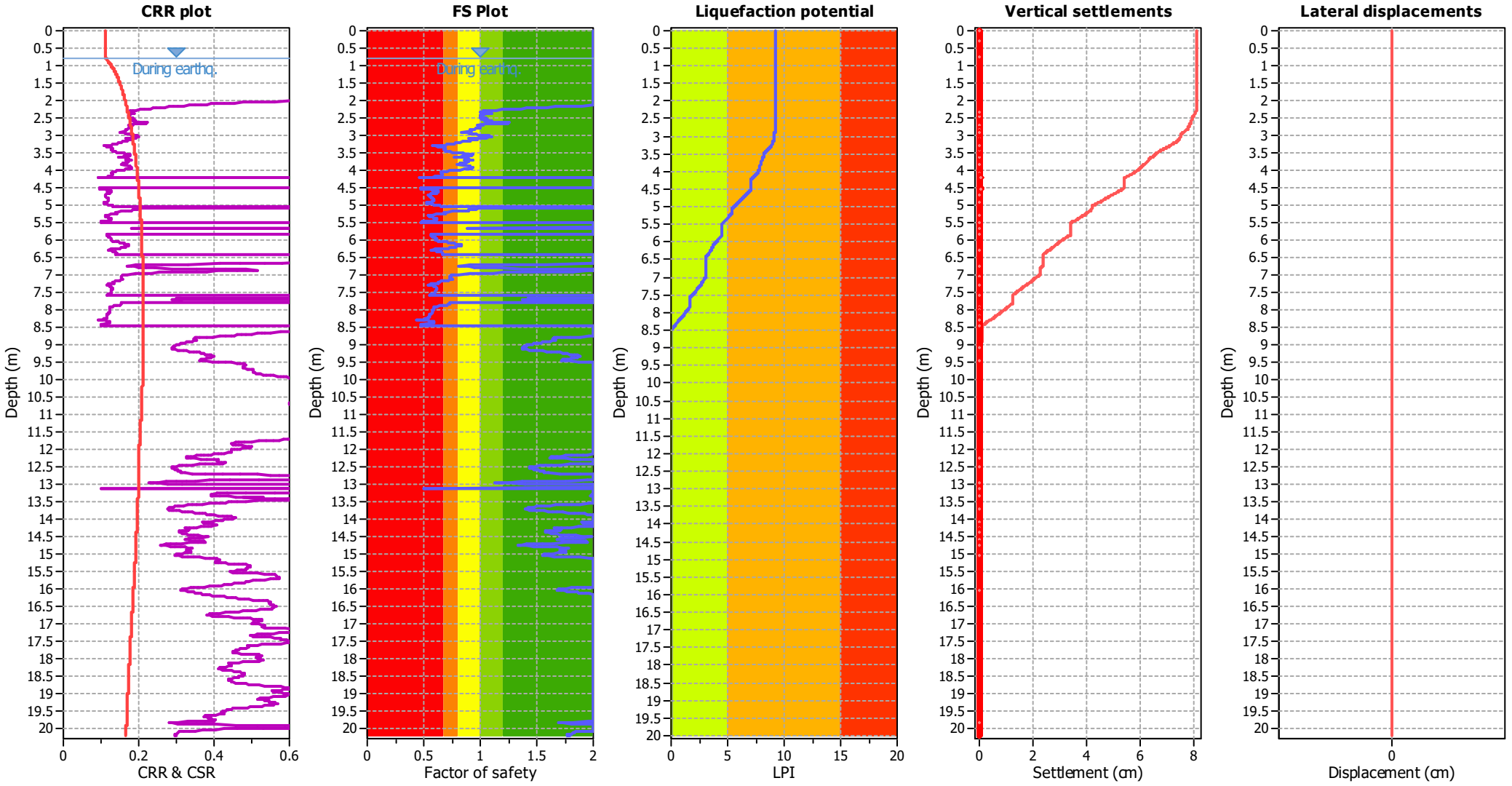






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

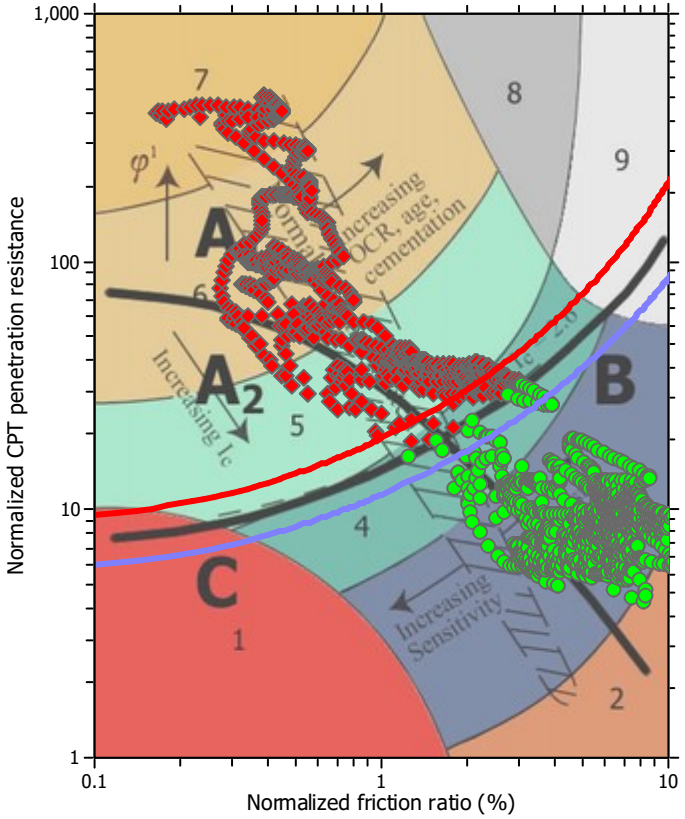
F.S. color scheme

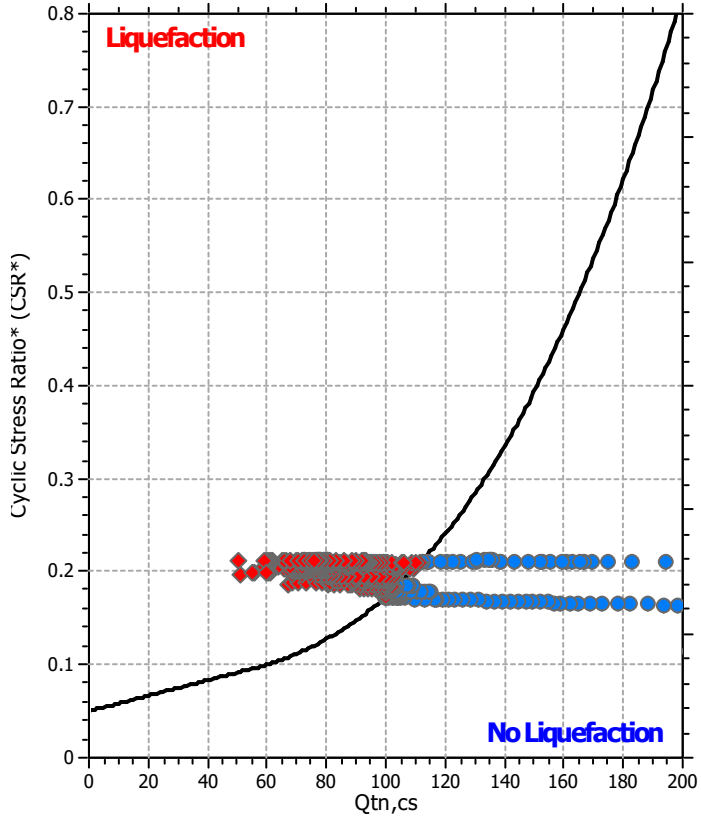
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

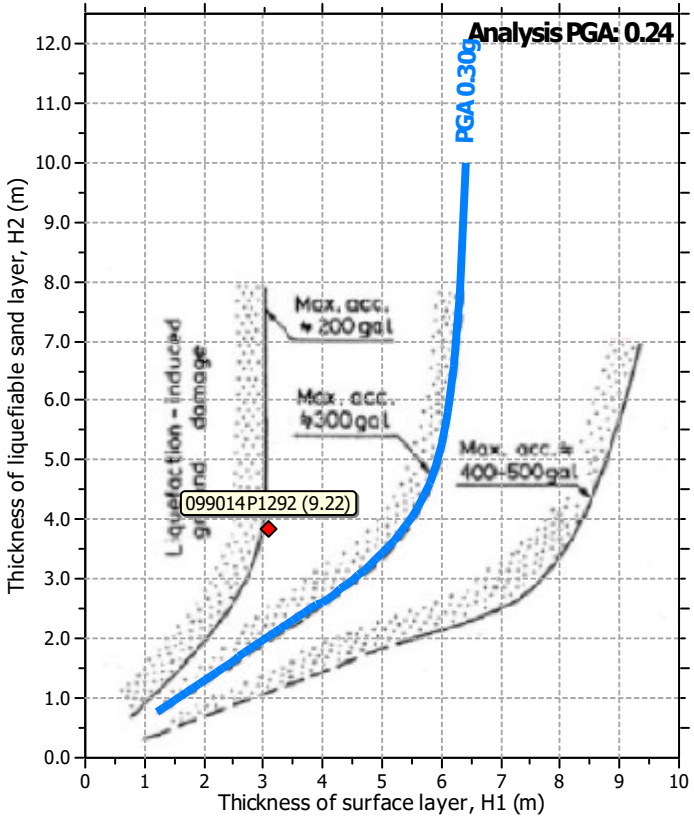
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

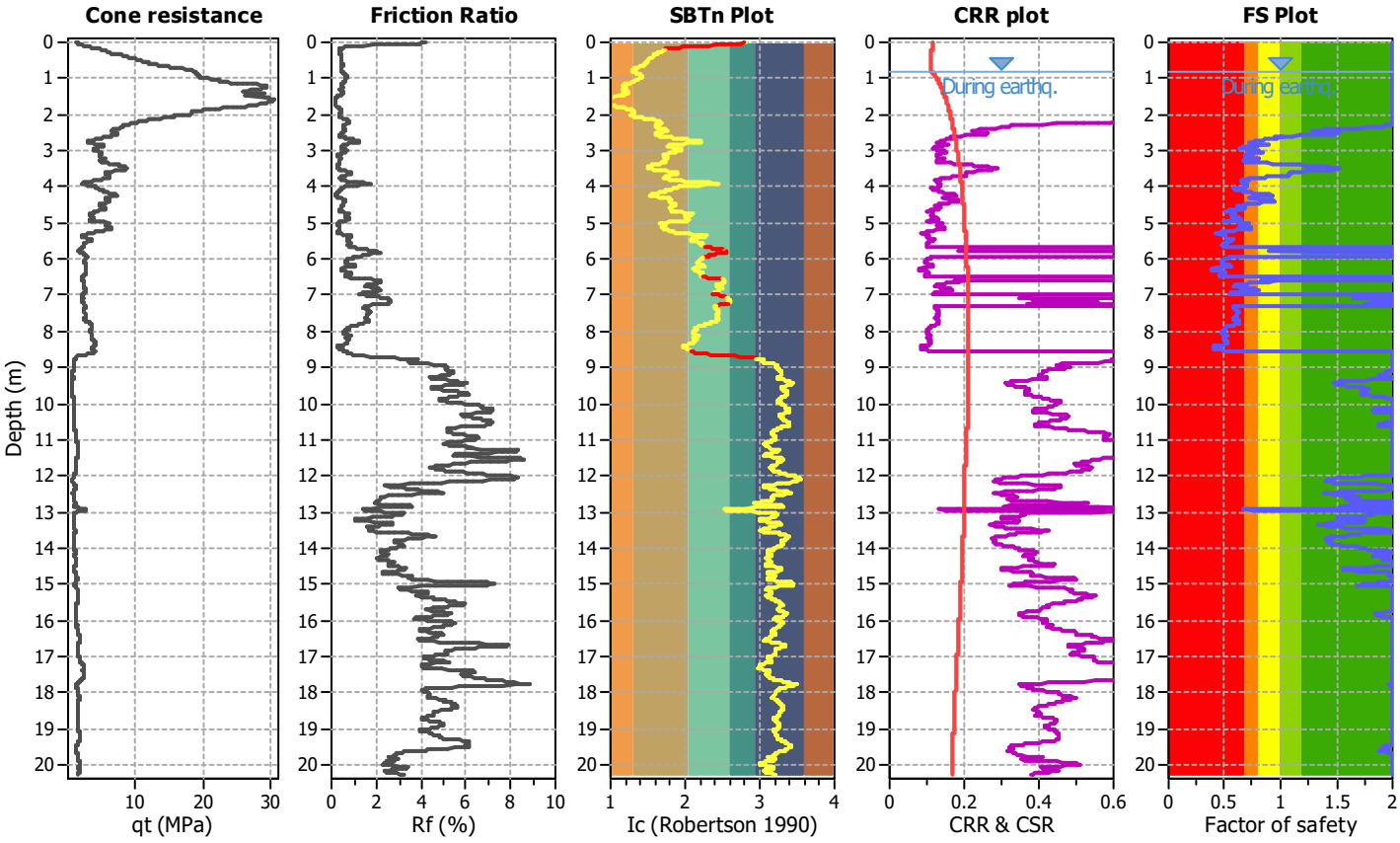
LIQUEFACTION ANALYSIS REPORT

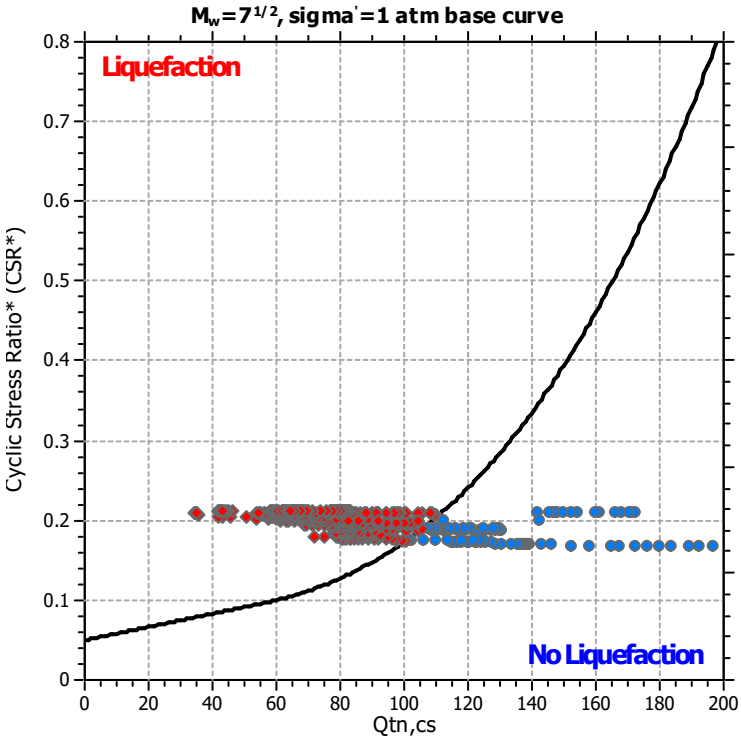
Project title : MS3_PA_Rimini_RNS_03 **Location : Rimini**

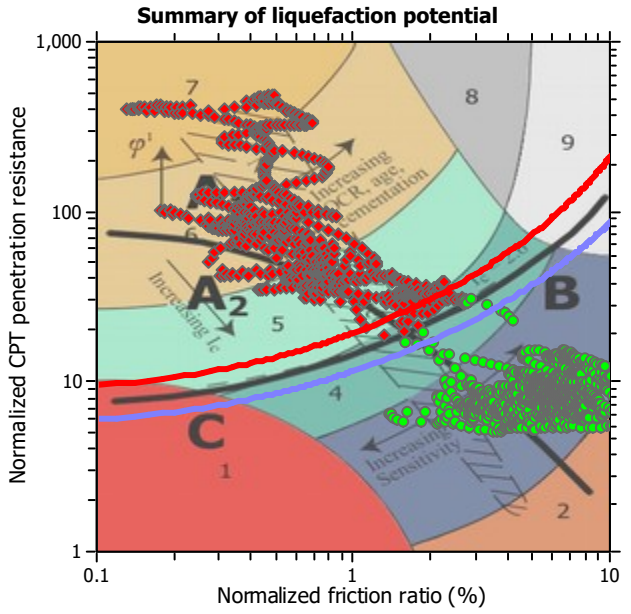
CPT file : 099014P1293

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.24	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

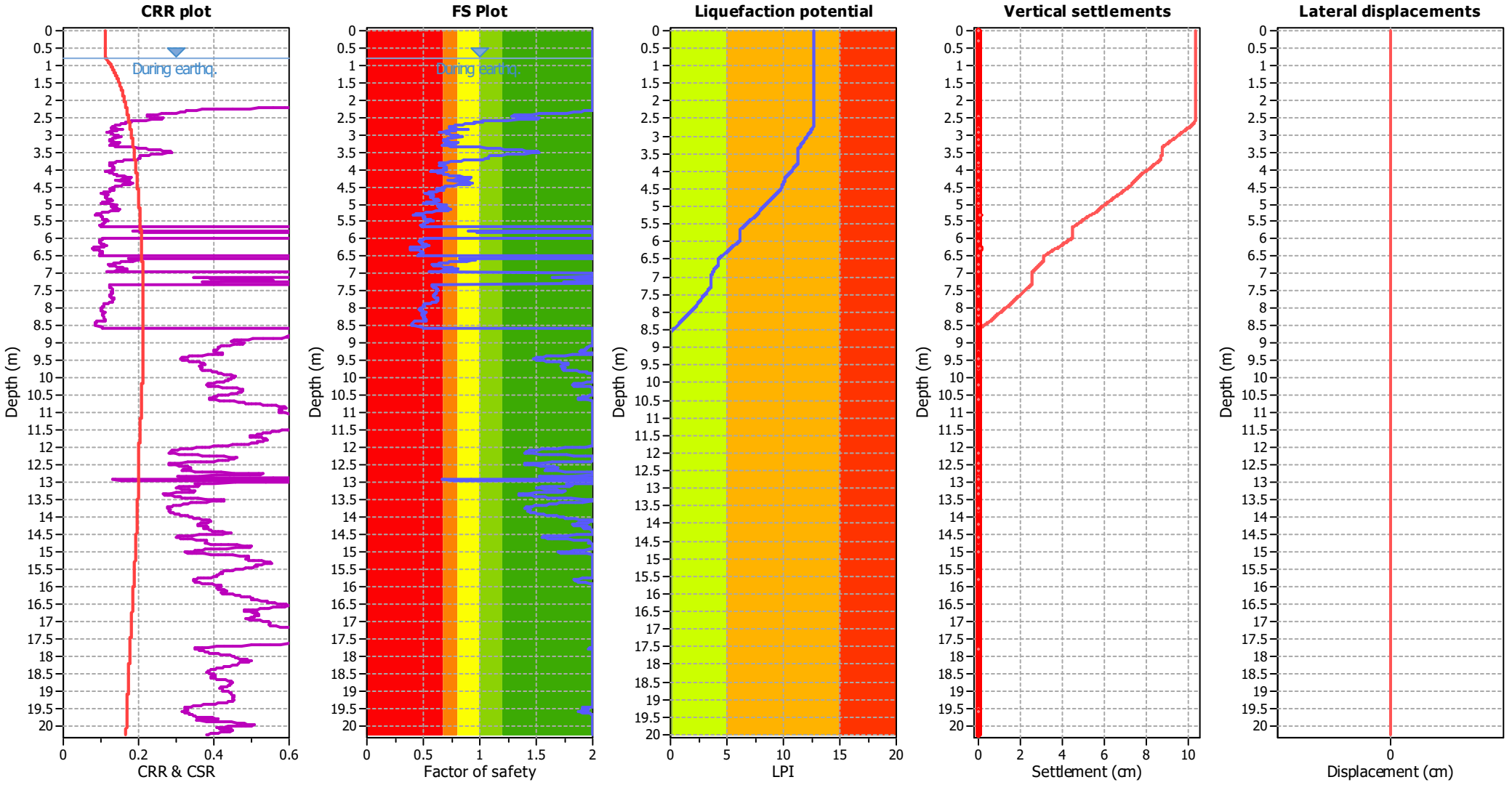






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

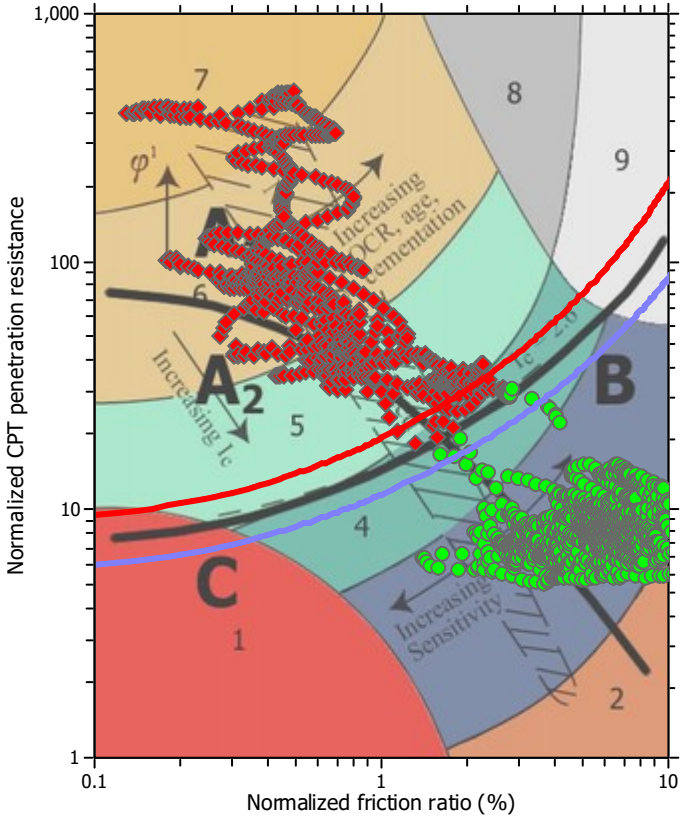
F.S. color scheme

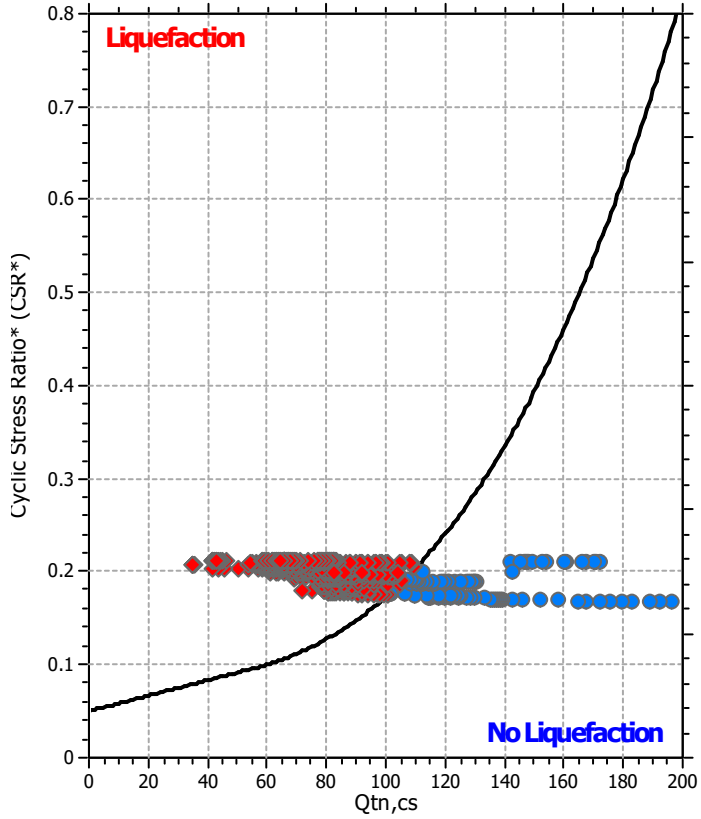
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

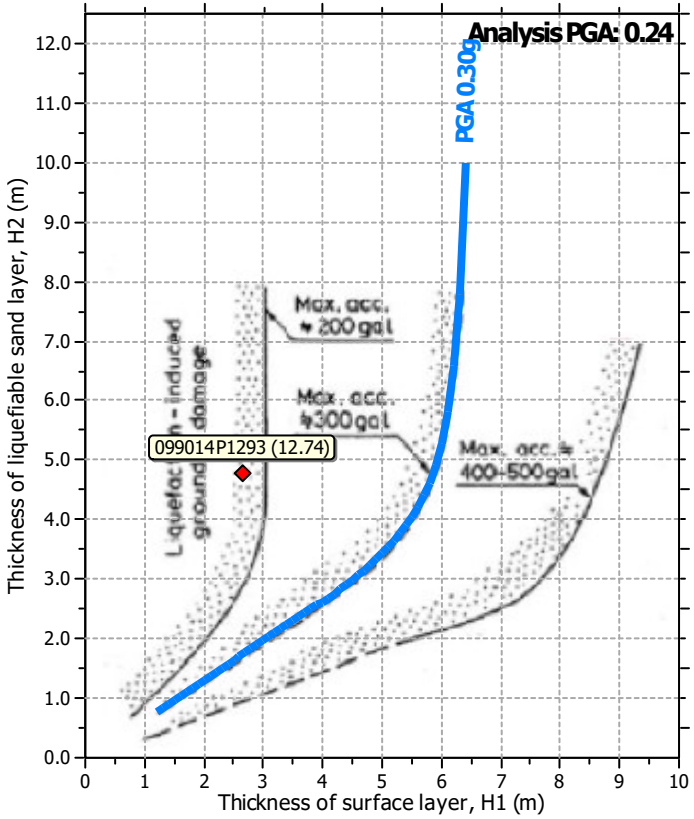
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

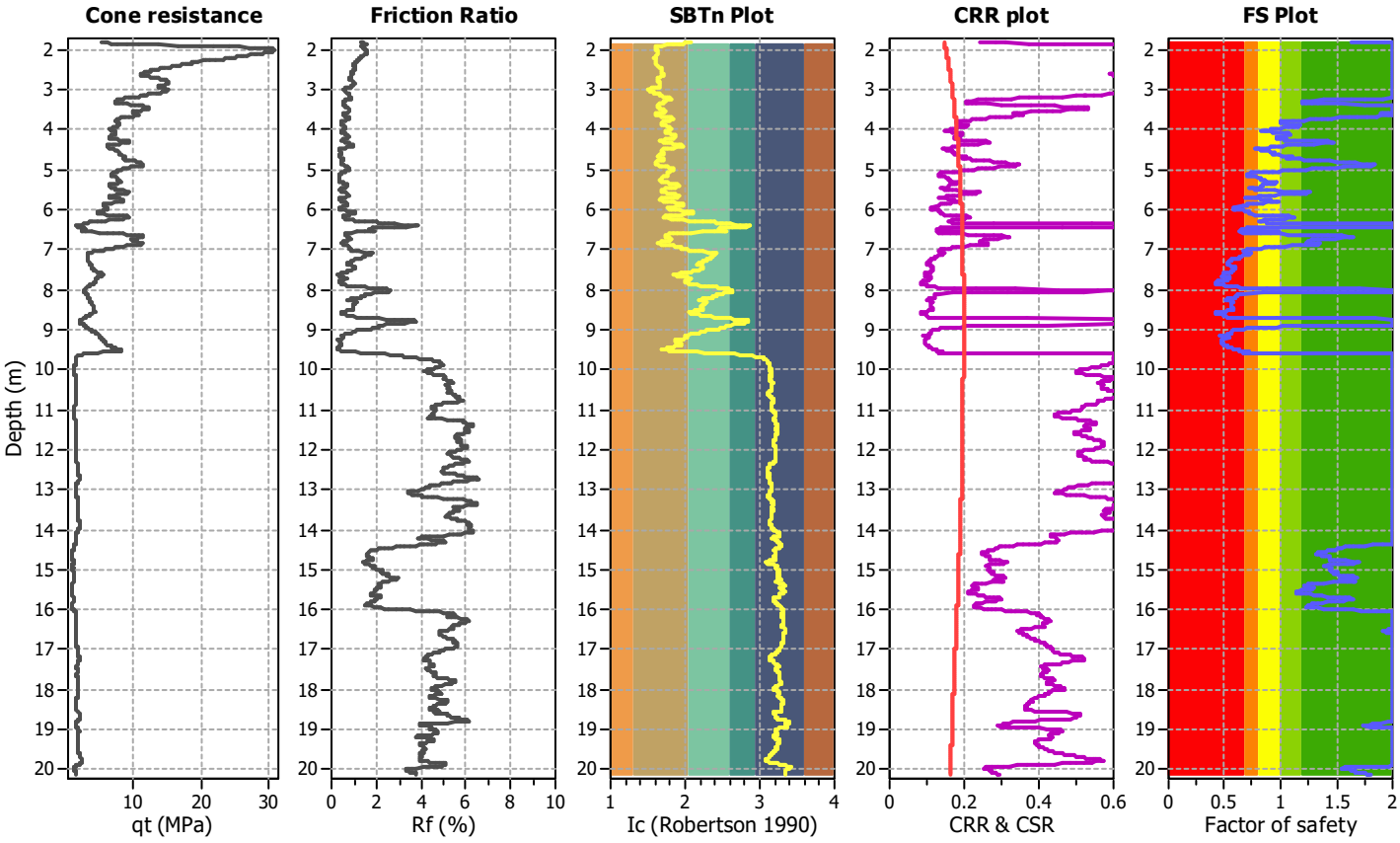
LIQUEFACTION ANALYSIS REPORT

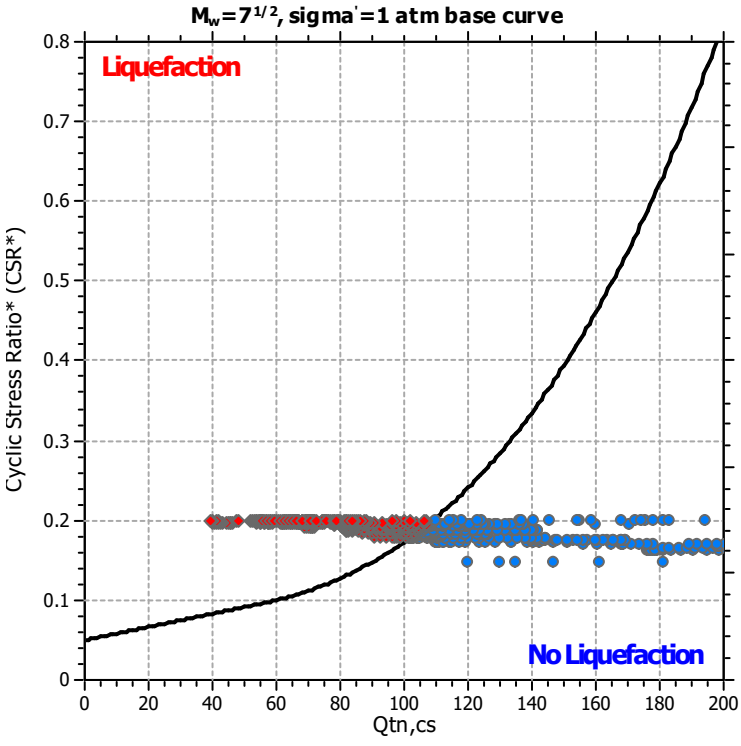
Project title : MS3_PA_Rimini_RNS_03 **Location : Rimini**

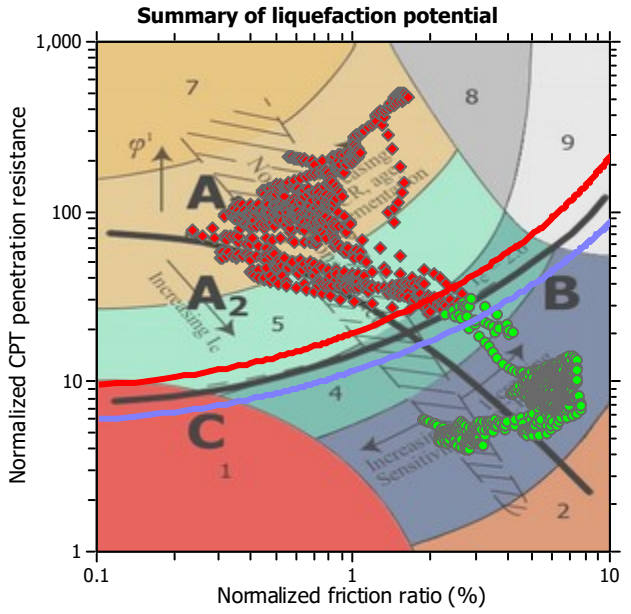
CPT file : 099014P1295

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.24	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

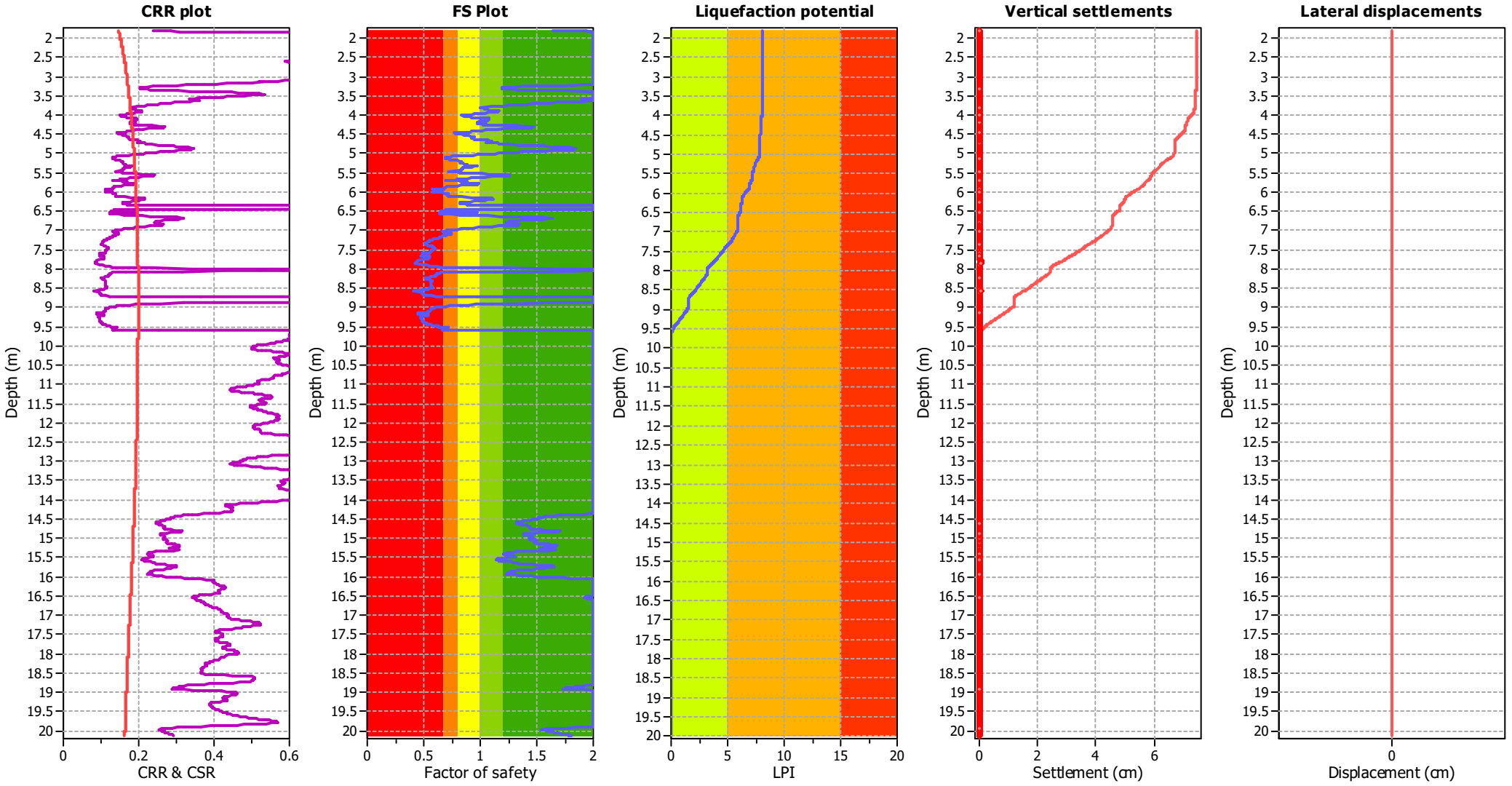






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

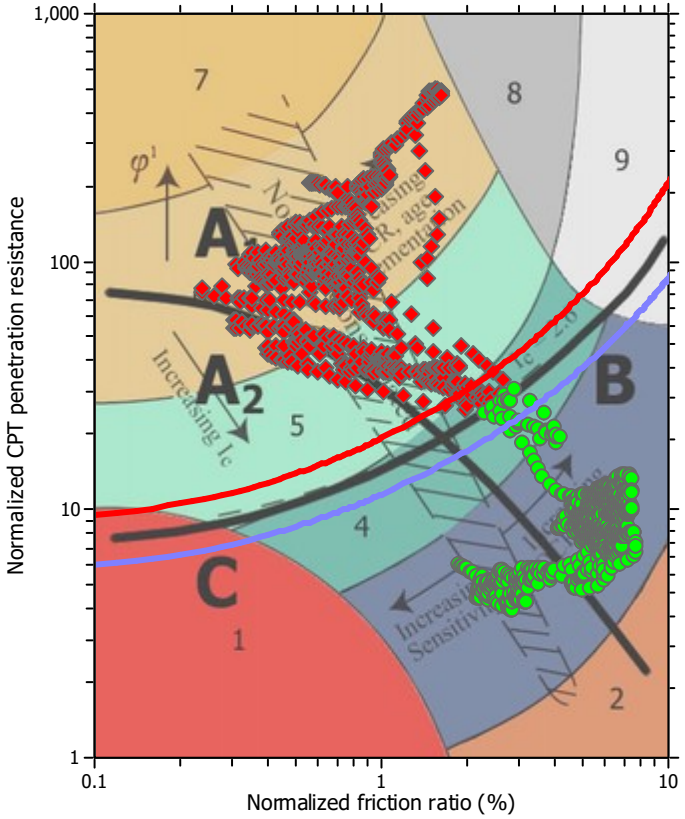
F.S. color scheme

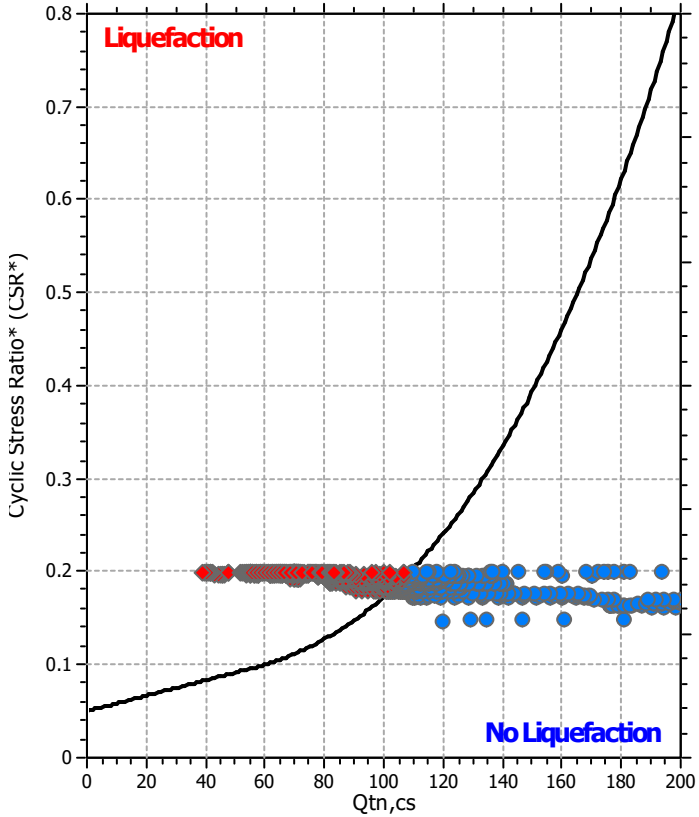
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

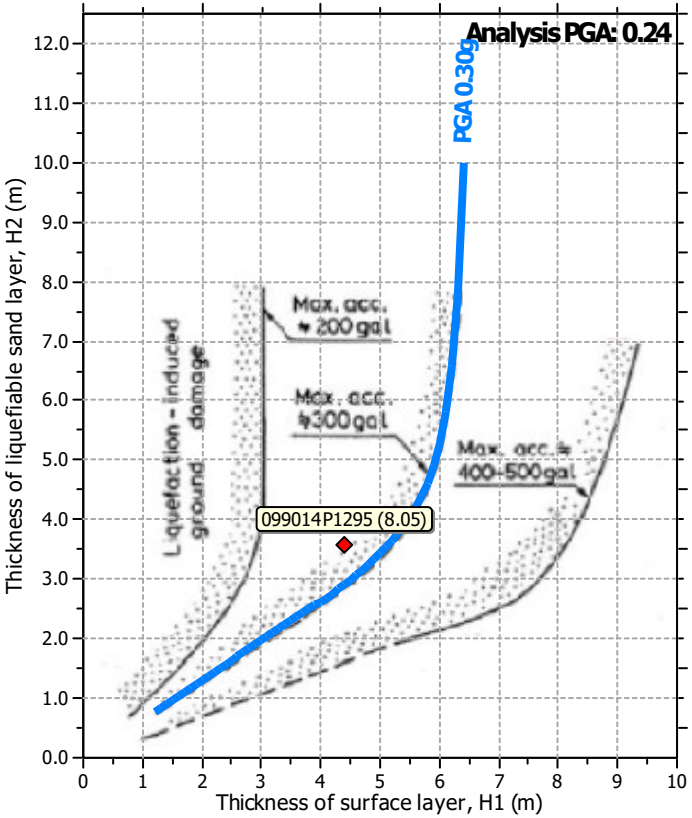
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

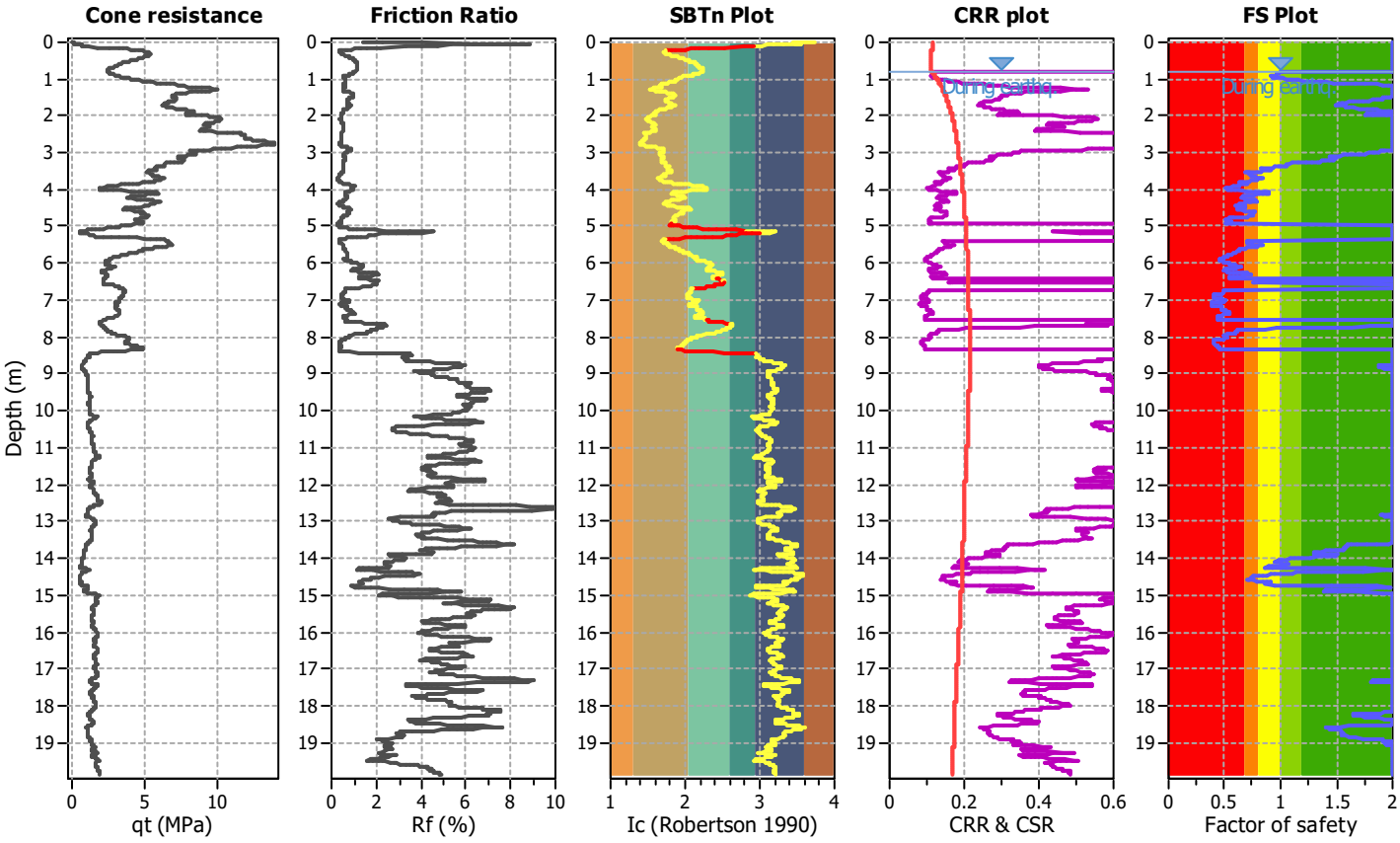
LIQUEFACTION ANALYSIS REPORT

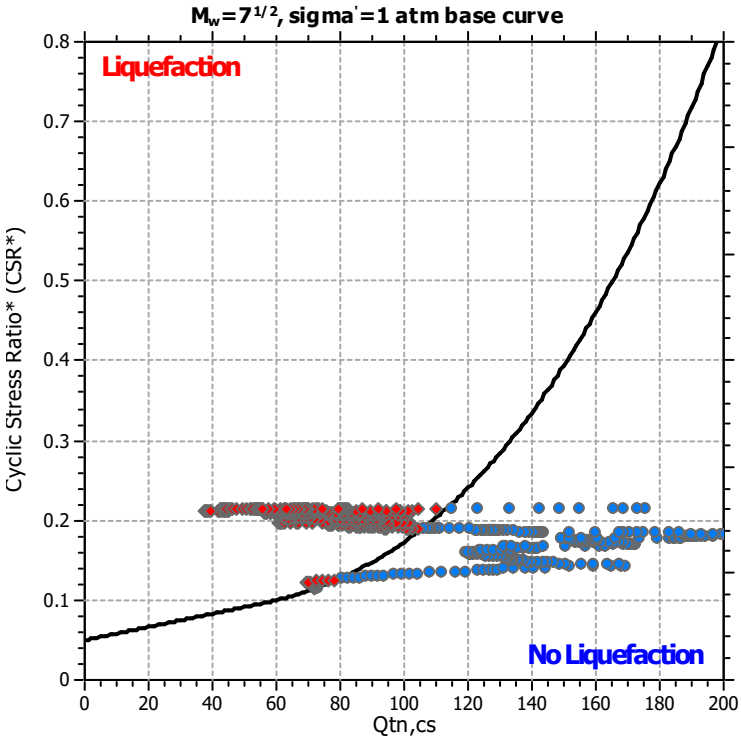
Project title : MS3_PA_Rimini_RNS_03 **Location : Rimini**

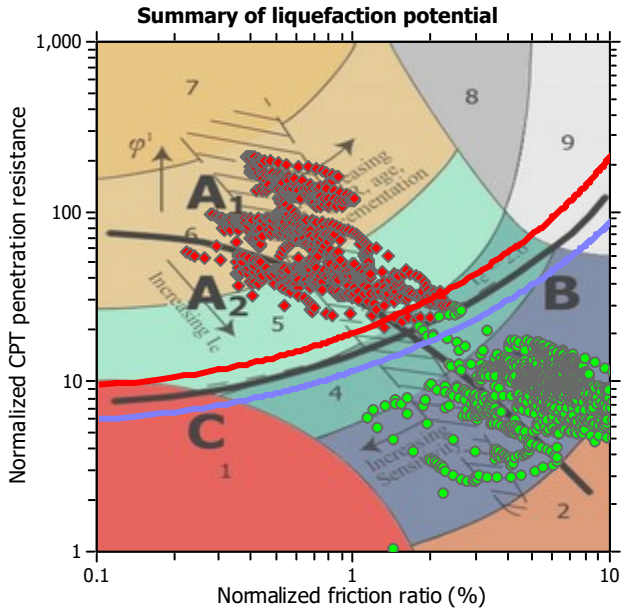
CPT file : CPTe_16

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.30 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.24	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

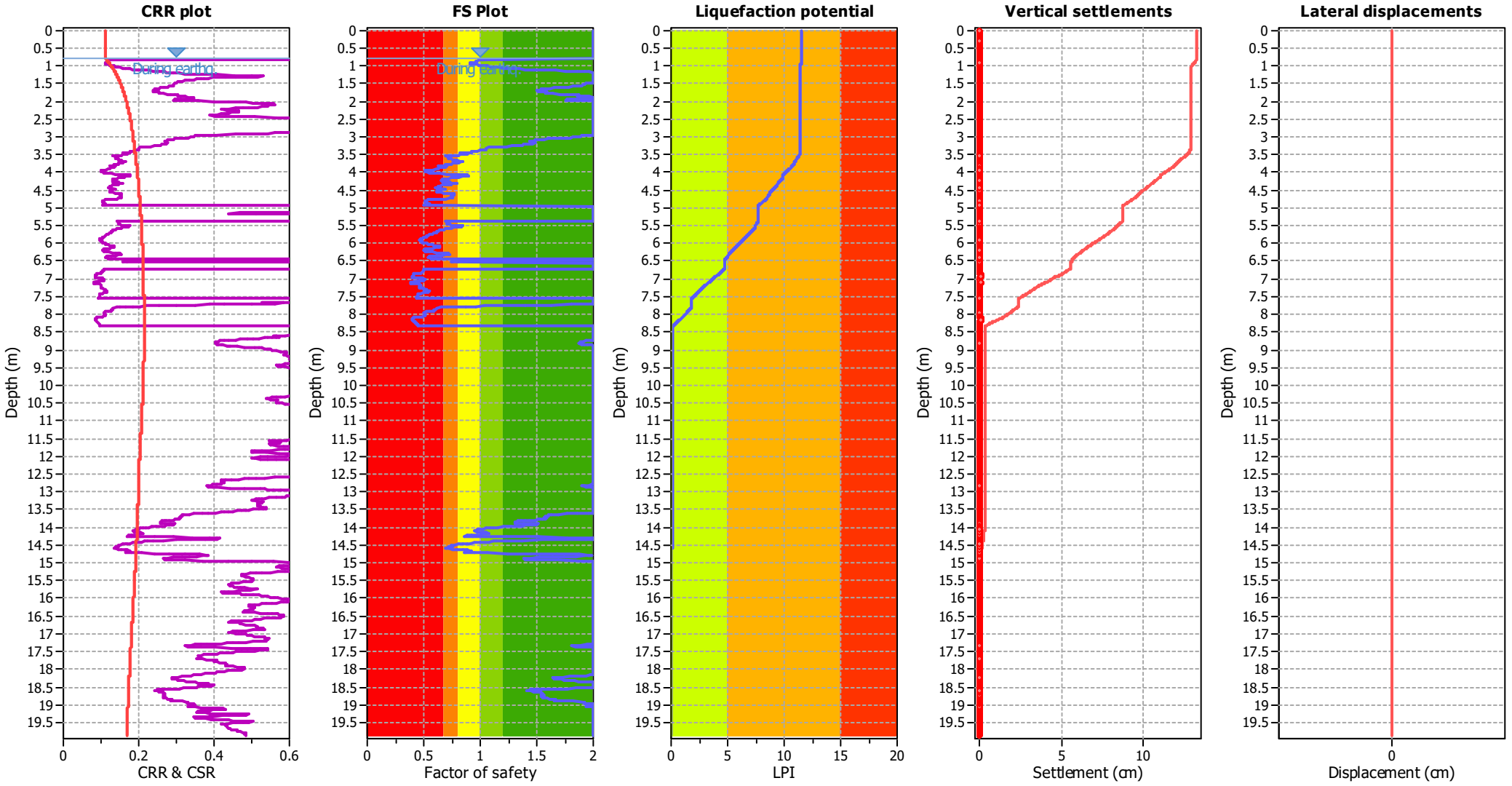






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.30 m	Fill height:	N/A	Limit depth:	20.00 m

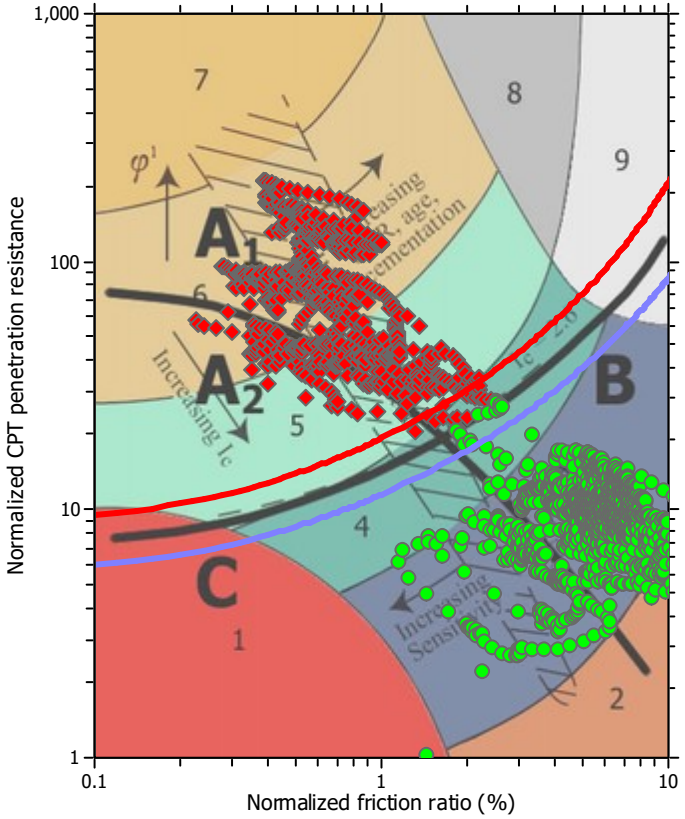
F.S. color scheme

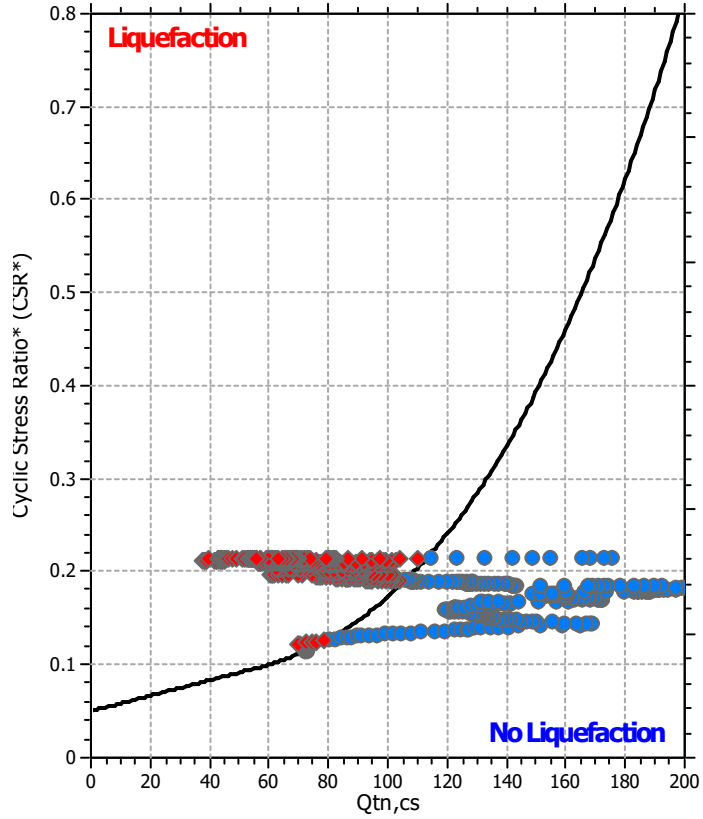
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

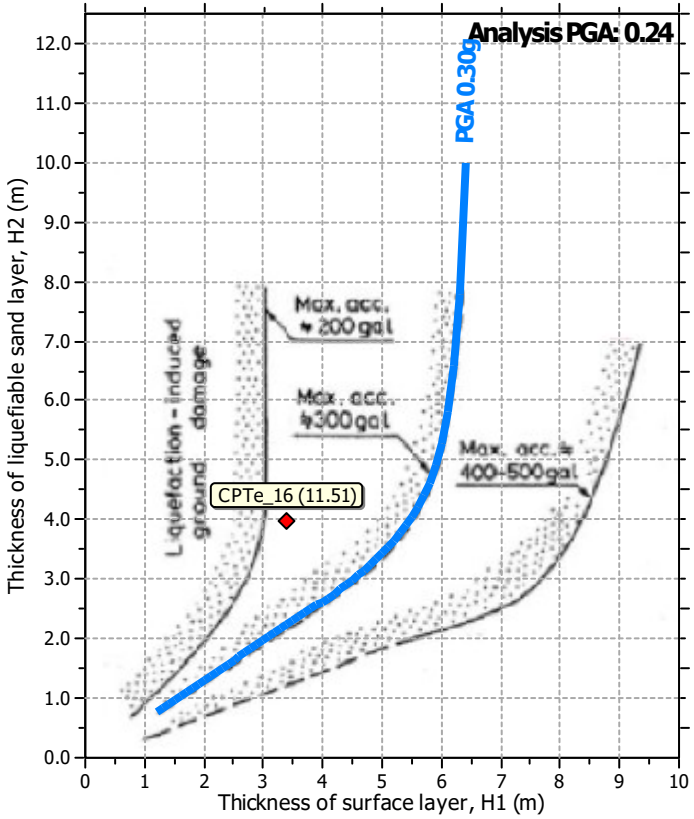
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.30 m	Fill height:	N/A	Limit depth:	20.00 m

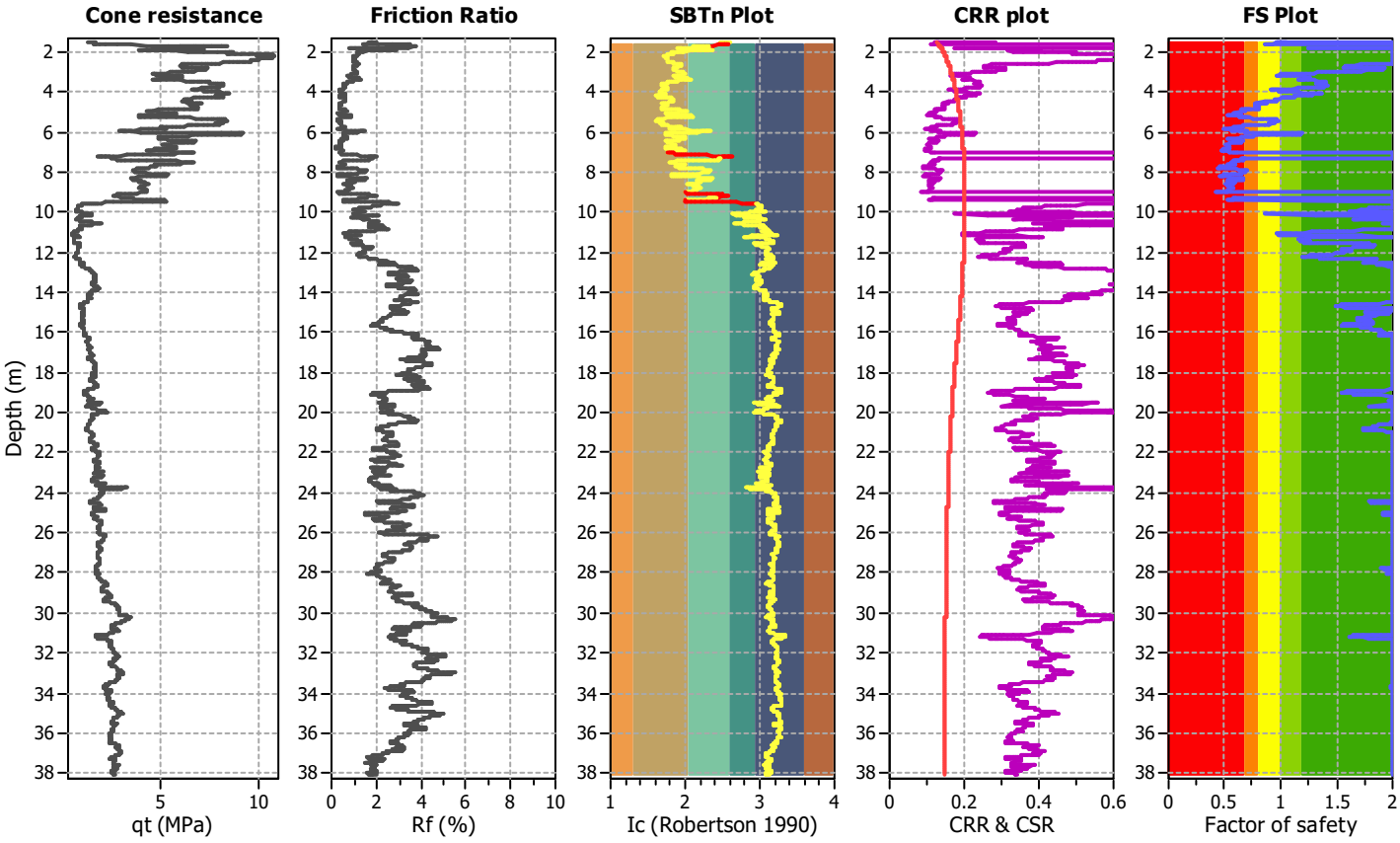
LIQUEFACTION ANALYSIS REPORT

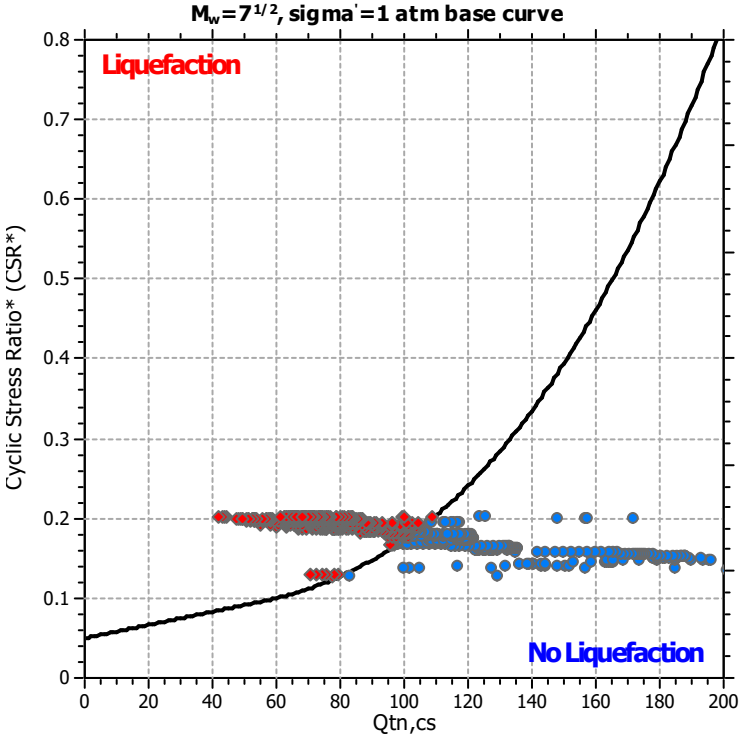
Project title : MS3_PA_Rimini_RNS_03 **Location : Rimini**

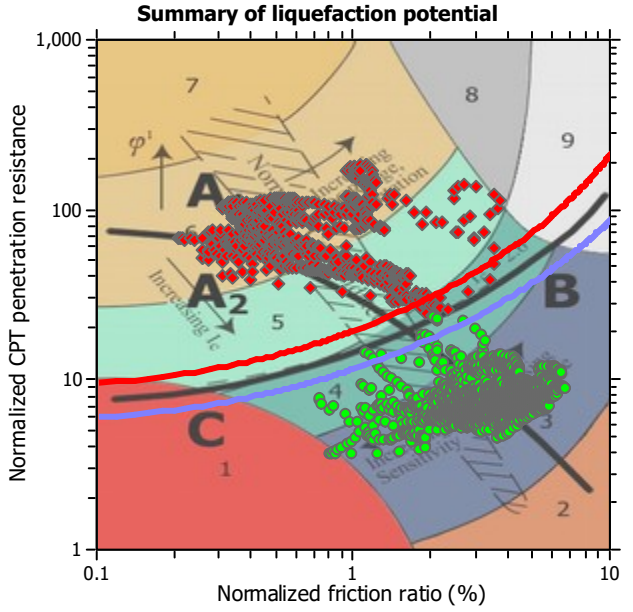
CPT file : 099014P1297

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.20 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.24	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

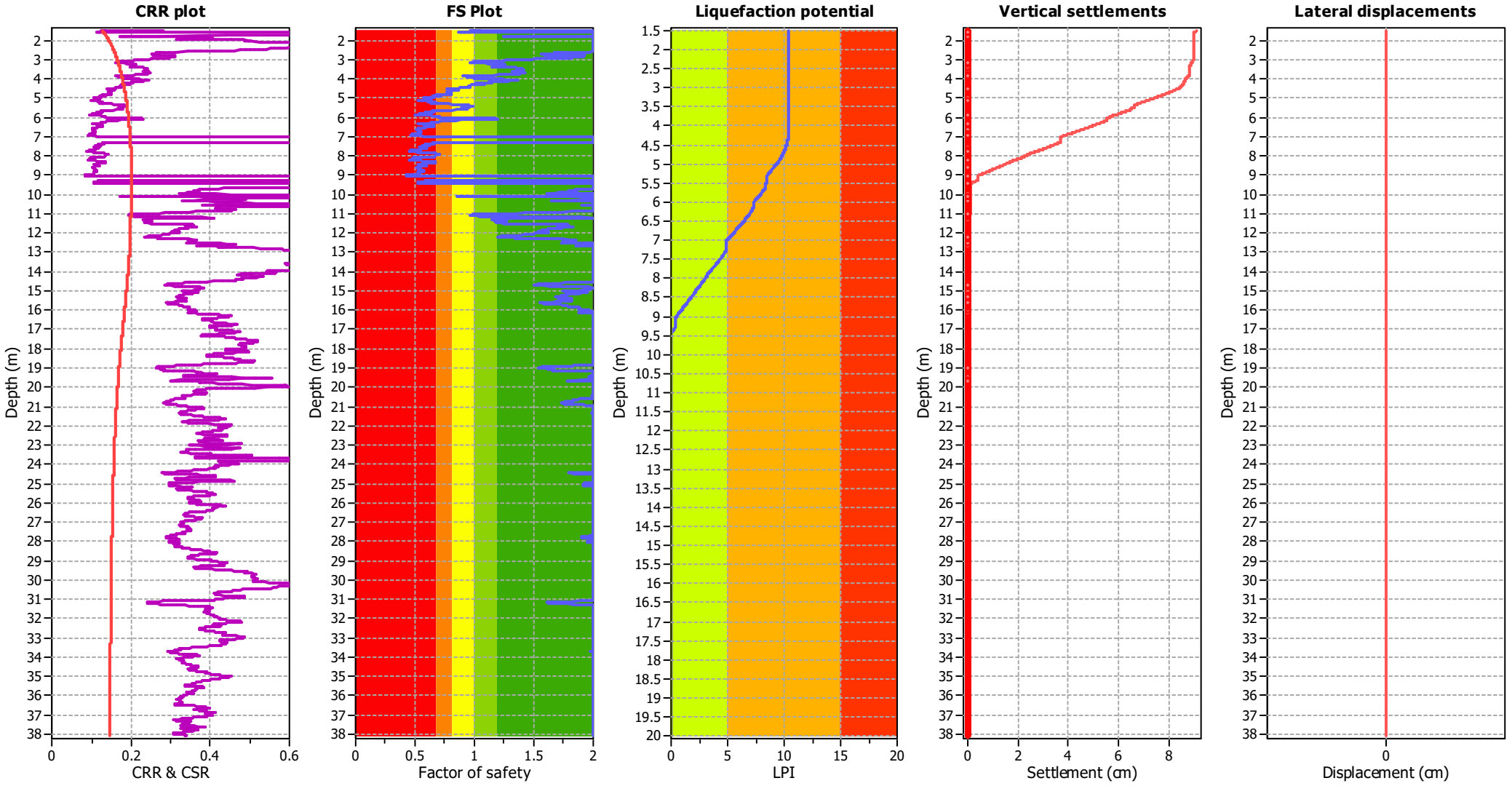






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.20 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

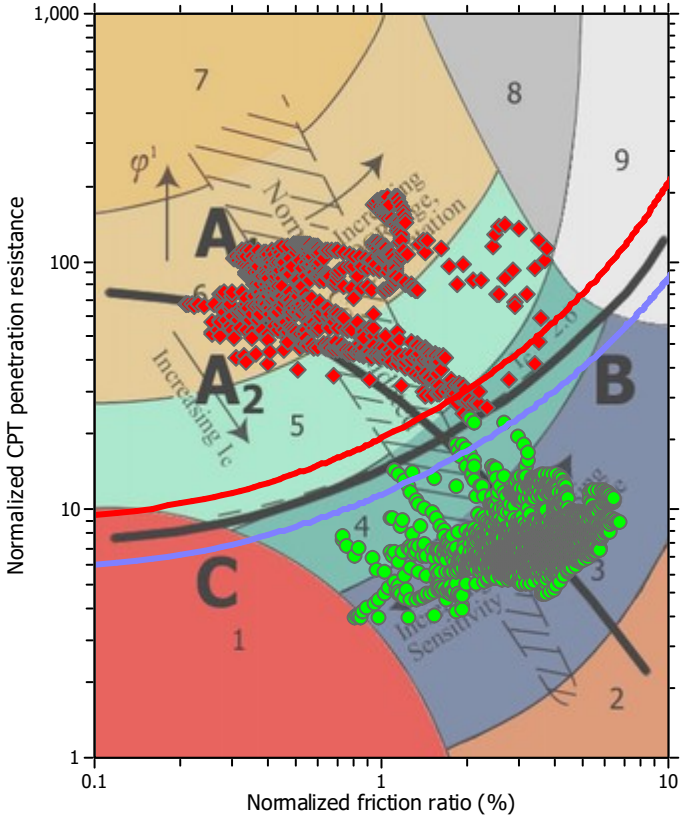
F.S. color scheme

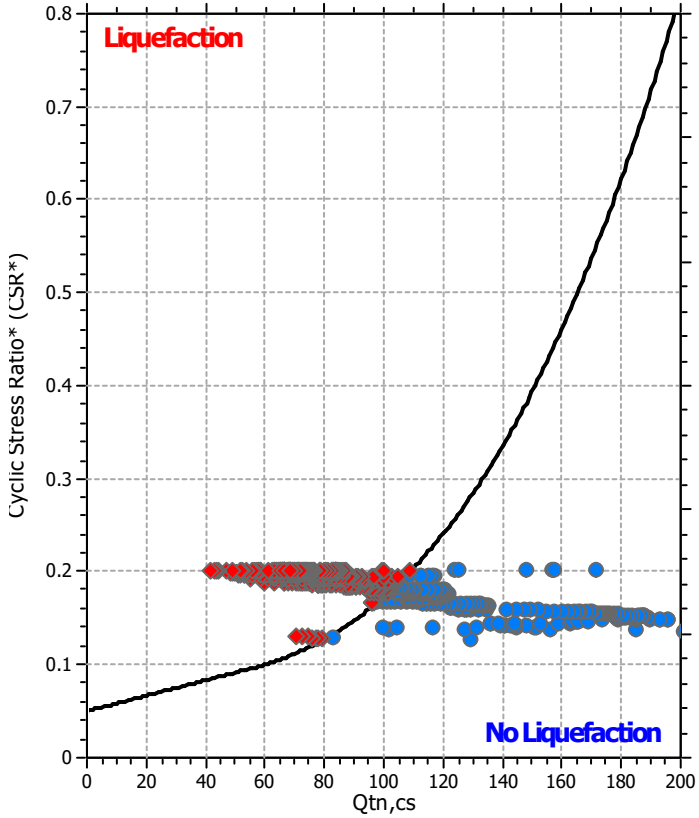
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

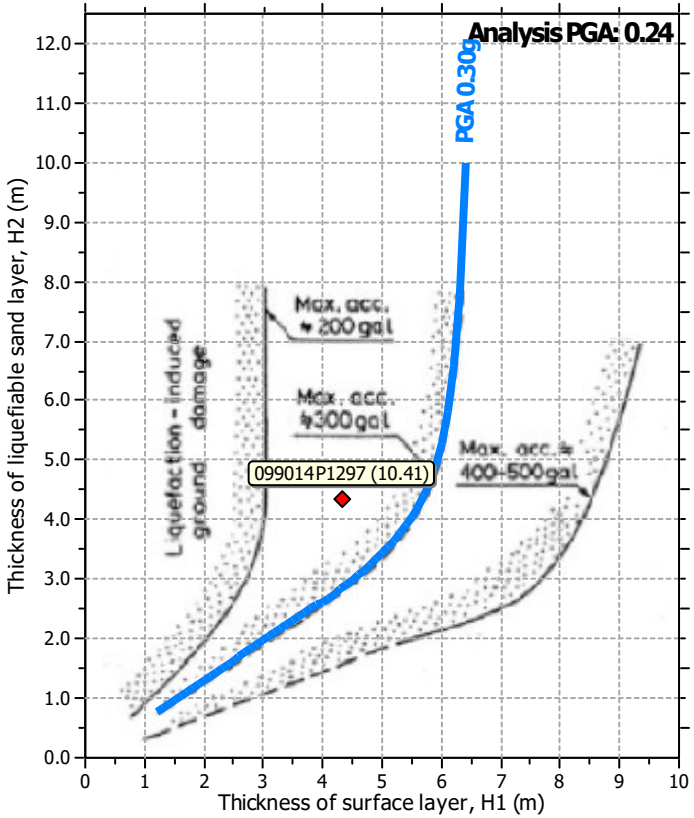
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.20 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	N/A

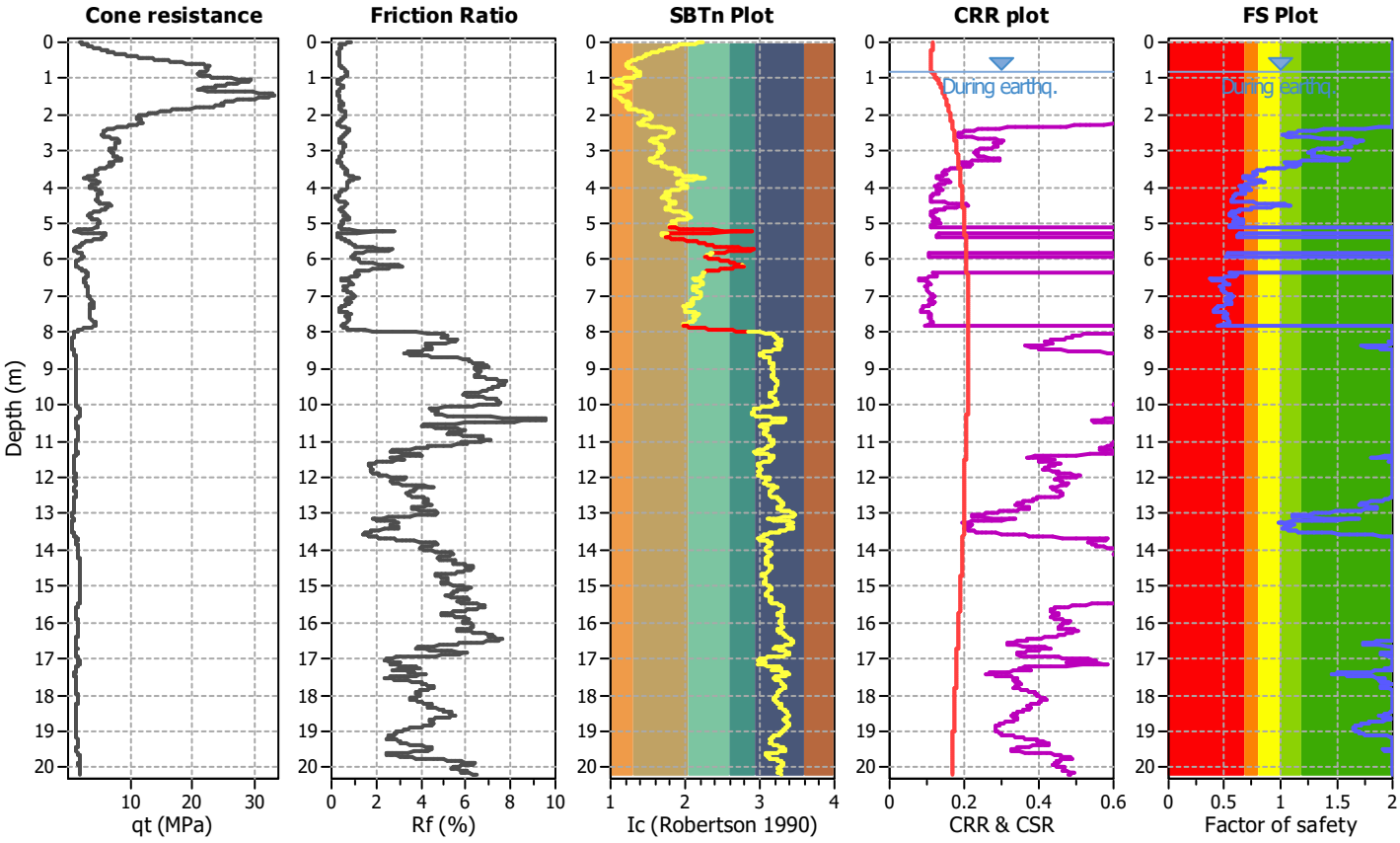
LIQUEFACTION ANALYSIS REPORT

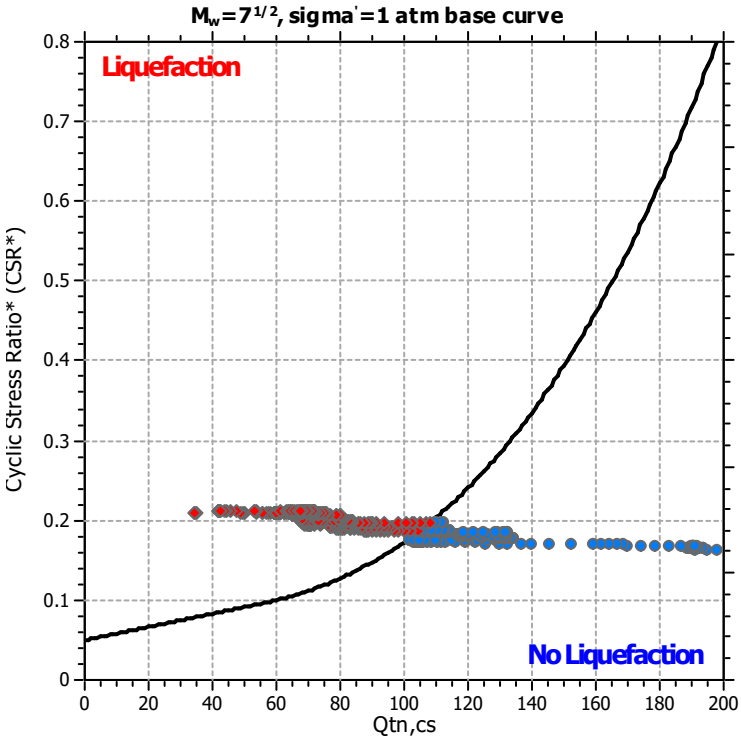
Project title : MS3_PA_Rimini_RNS_03 **Location : Rimini**

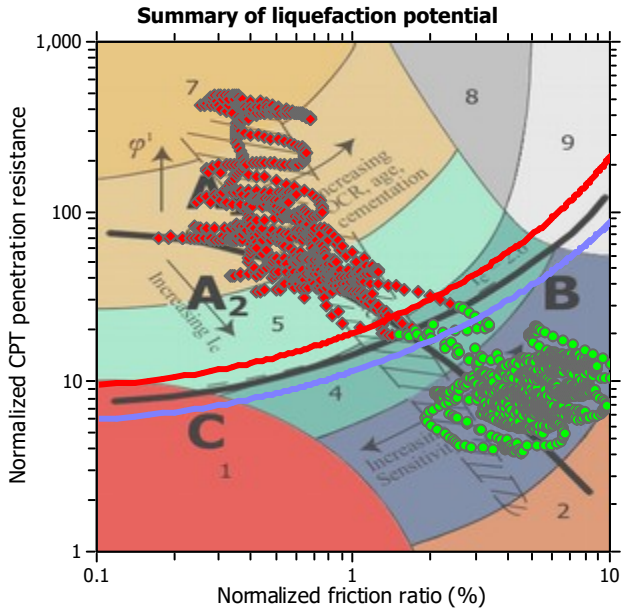
CPT file : 099014P1301

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.24	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

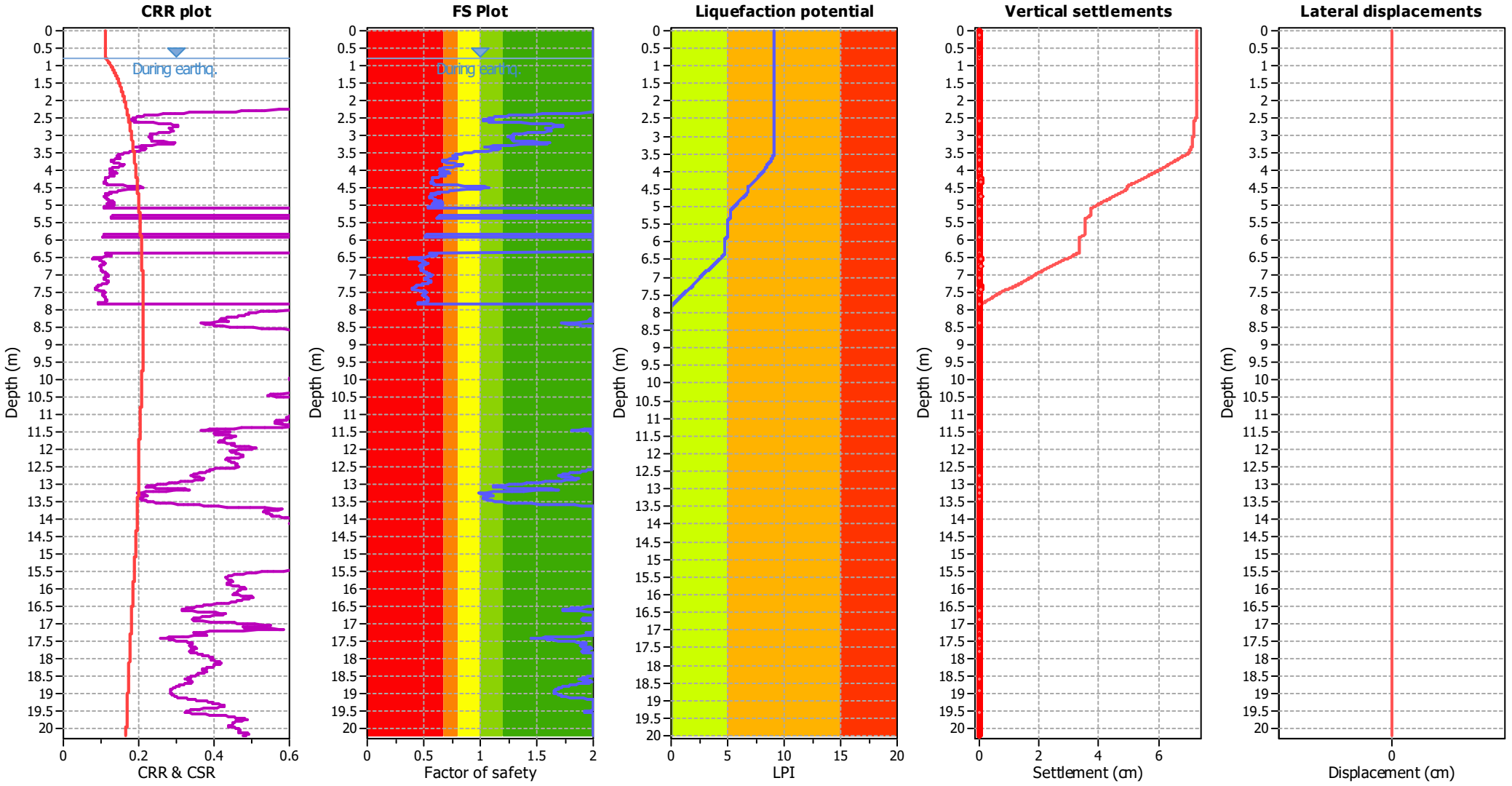






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

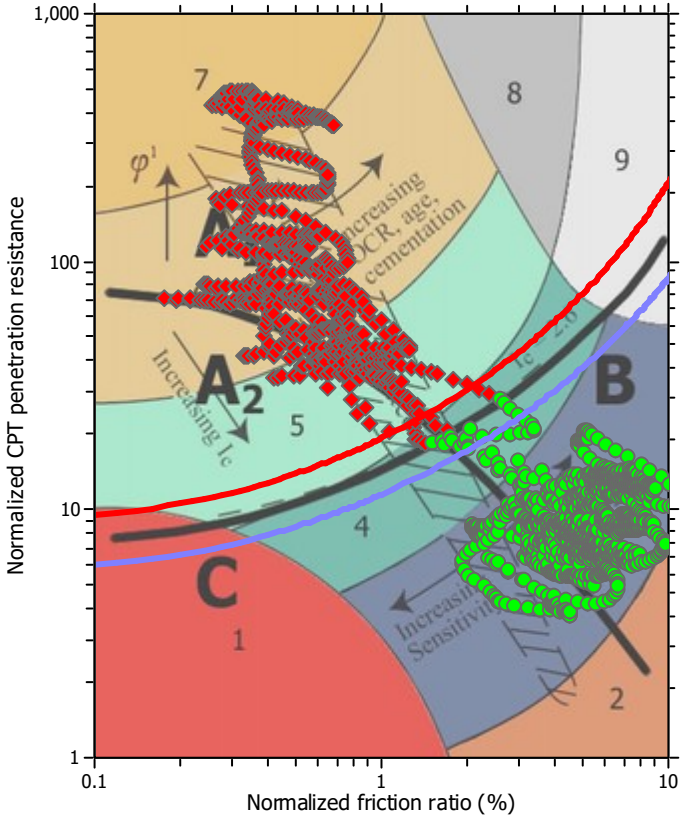
F.S. color scheme

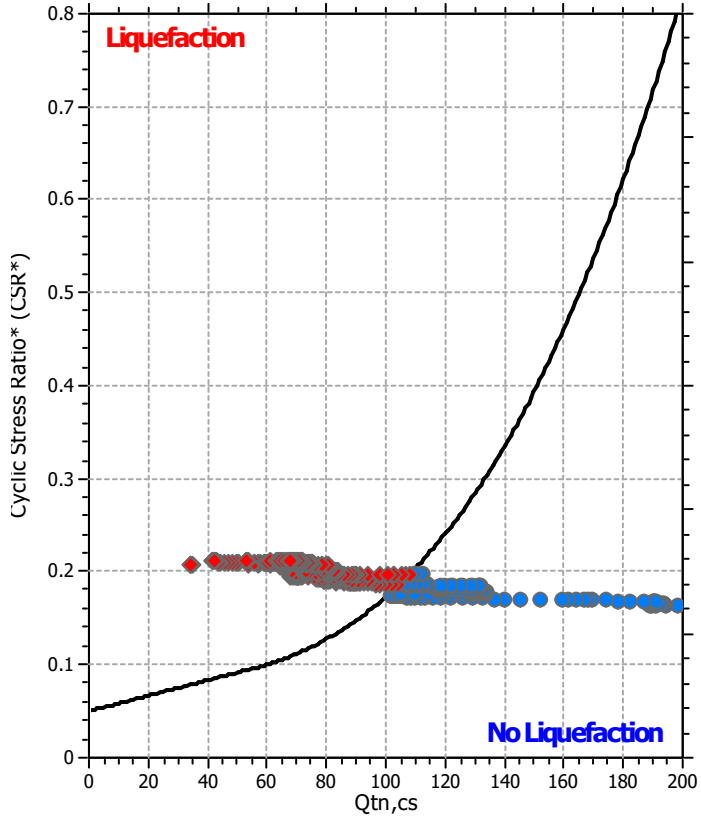
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

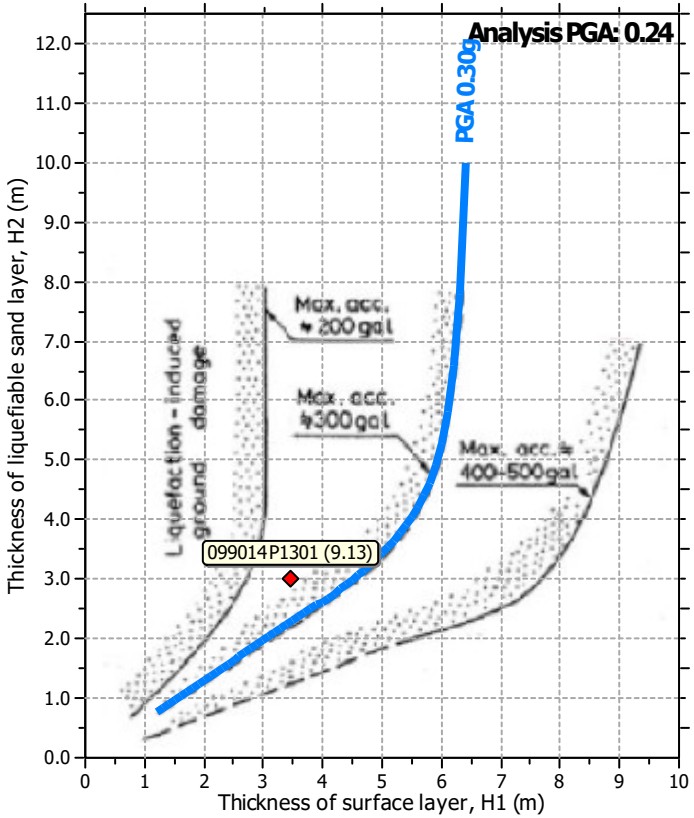
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.24	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

REPORT - ZONA RNS_04

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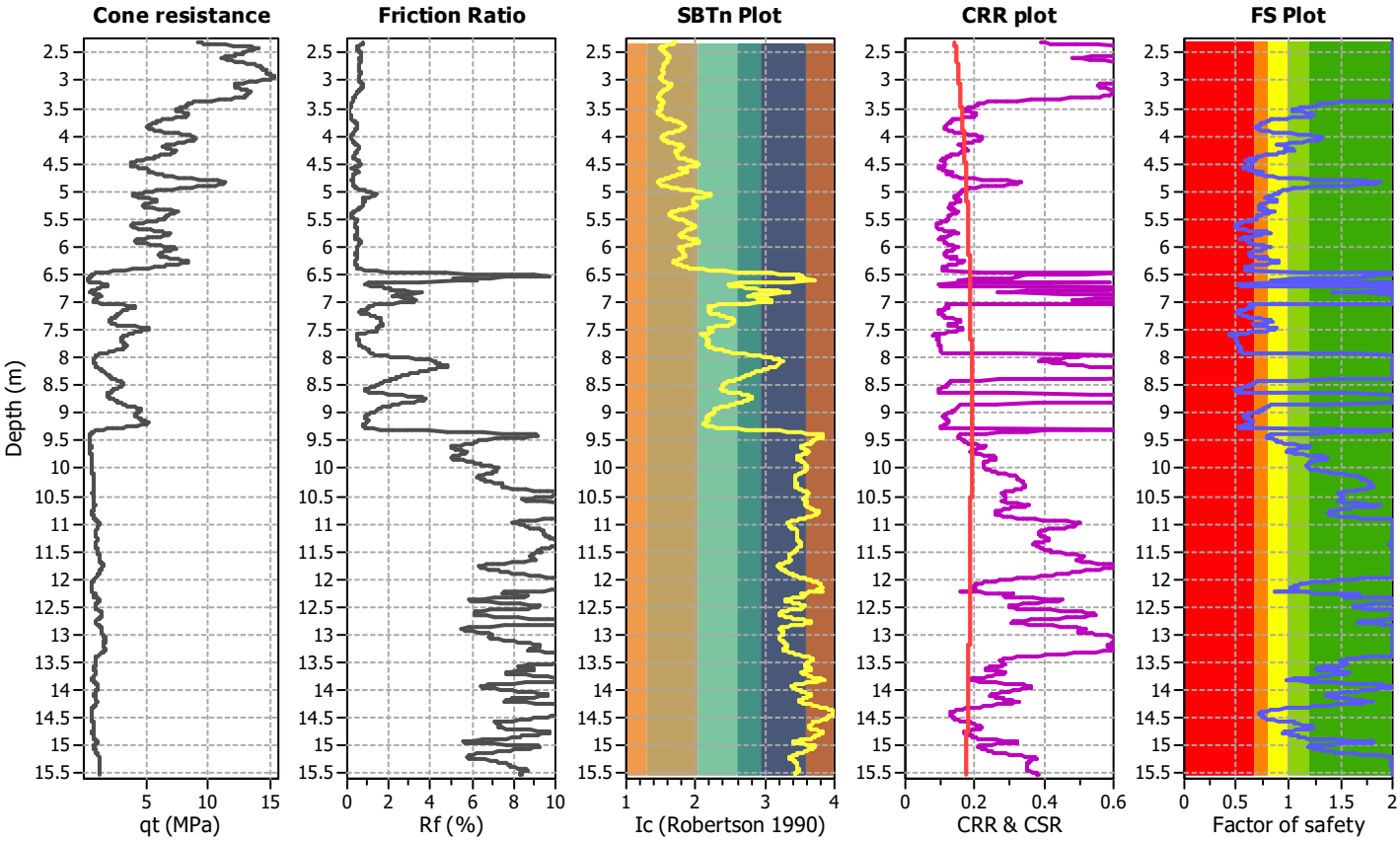
LIQUEFACTION ANALYSIS REPORT

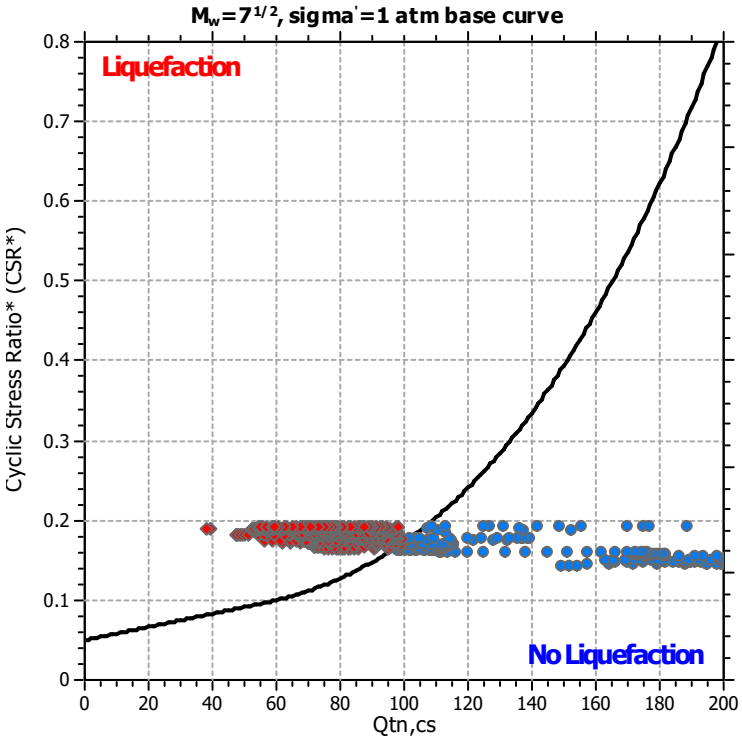
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

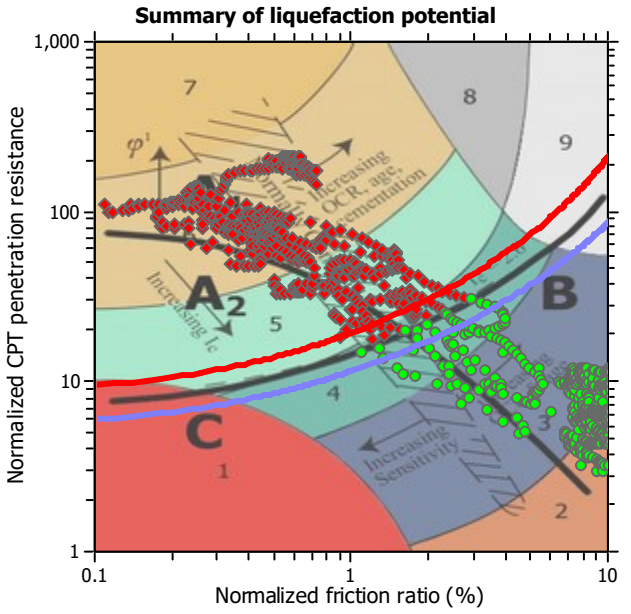
CPT file : 099014P1225

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	2.16 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.20 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

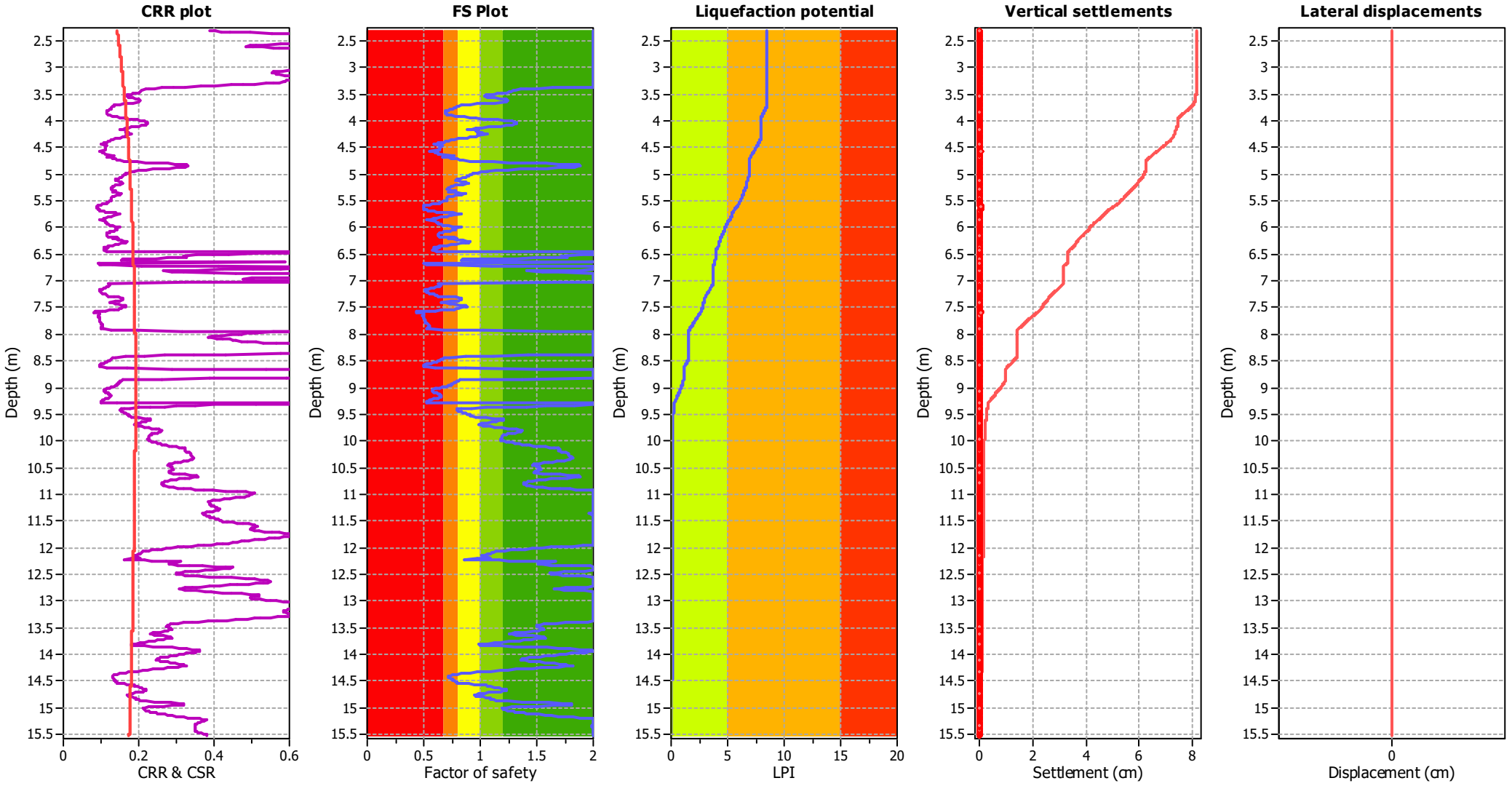






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.20 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.16 m	Fill height:	N/A	Limit depth:	N/A

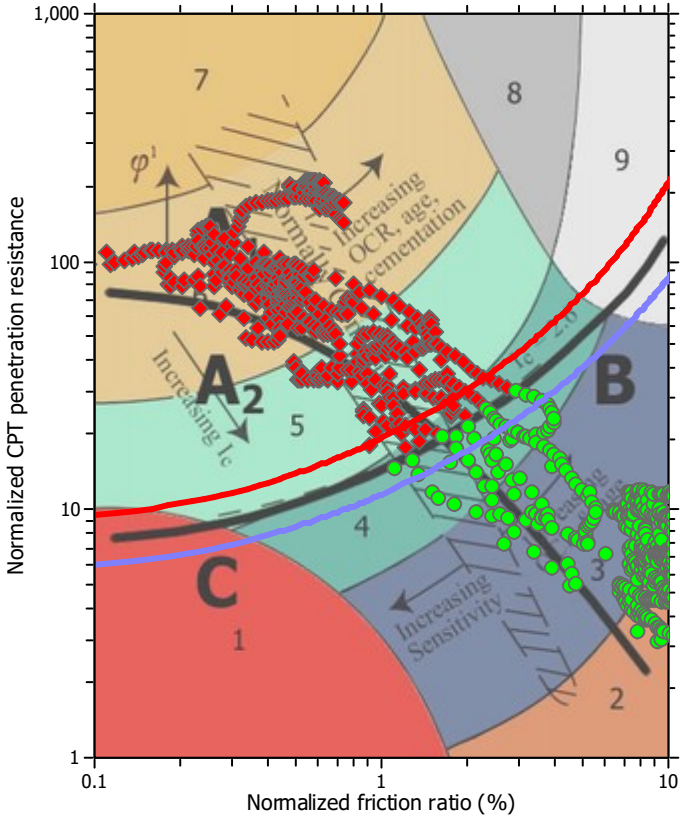
F.S. color scheme

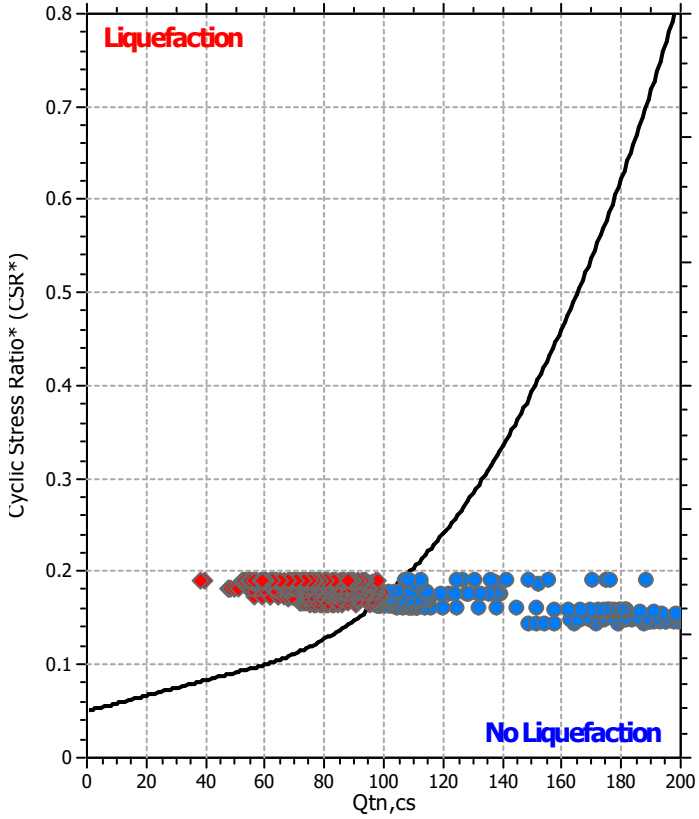
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

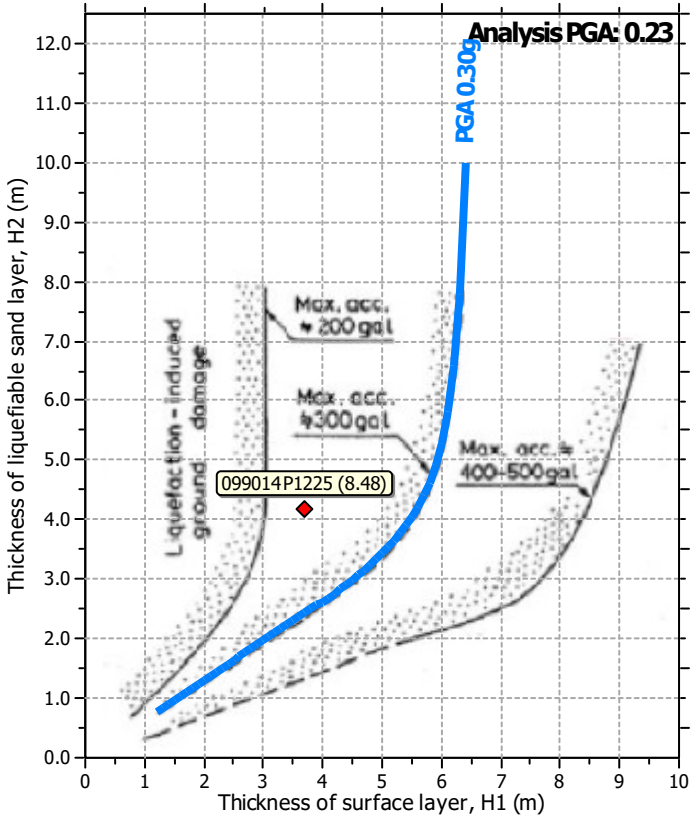
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.20 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	2.16 m	Fill height:	N/A	Limit depth:	N/A

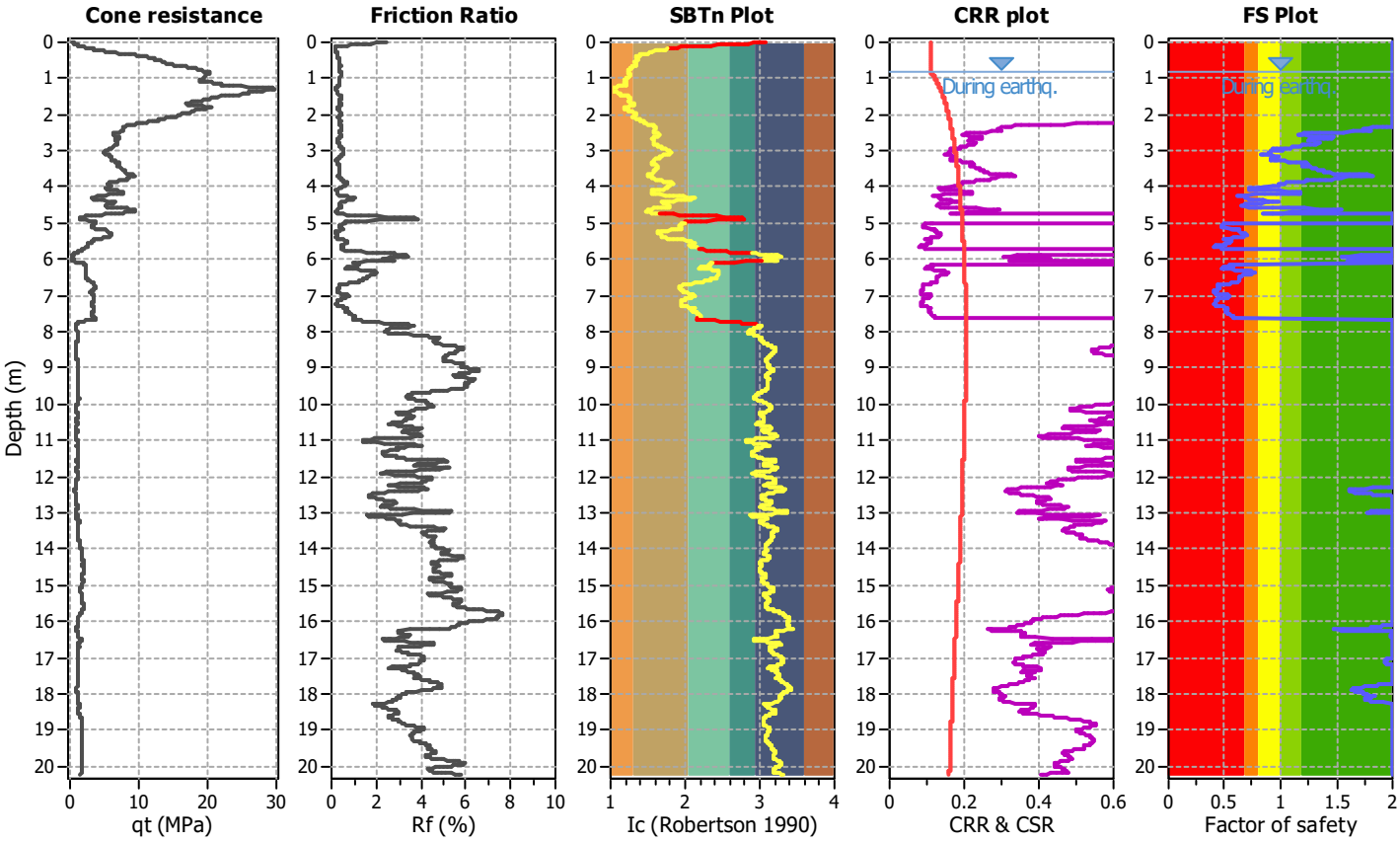
LIQUEFACTION ANALYSIS REPORT

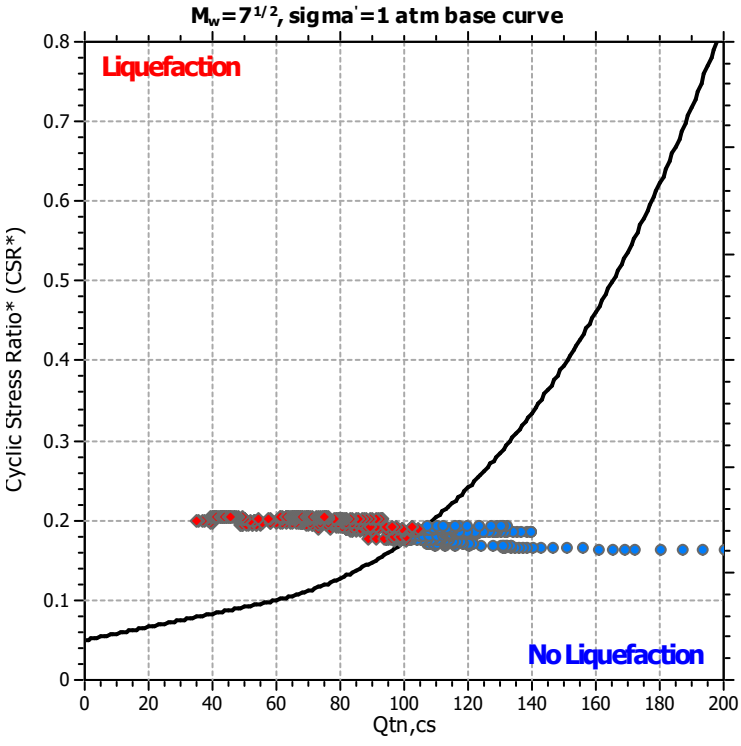
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

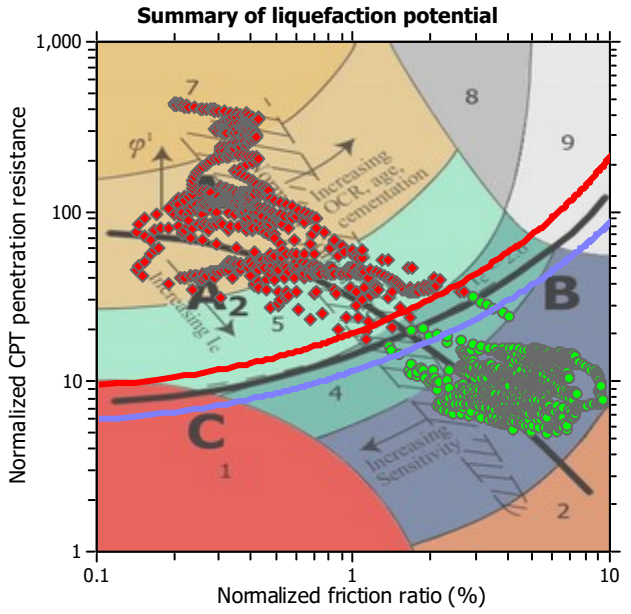
CPT file : 099014P1302

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

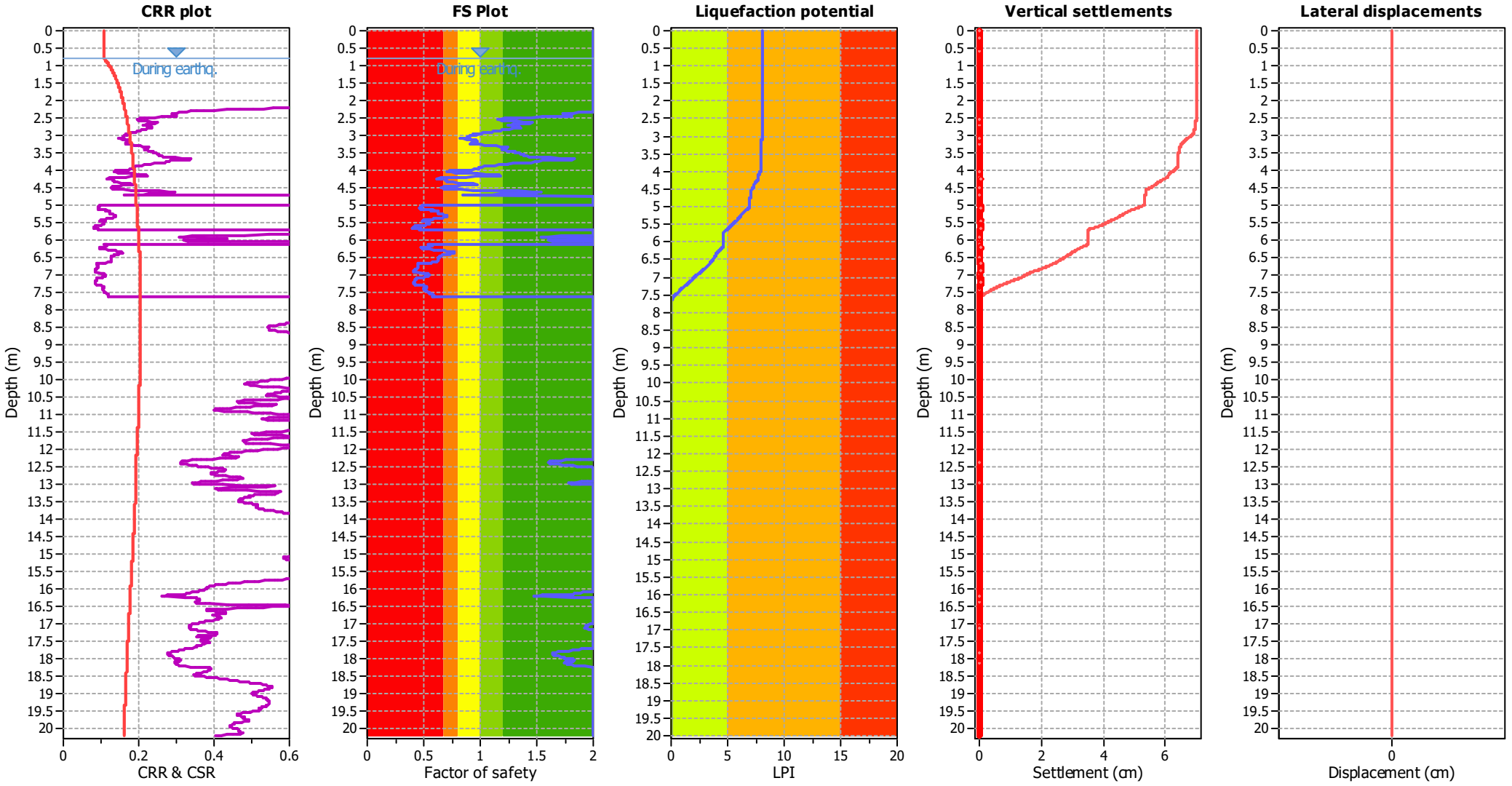






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

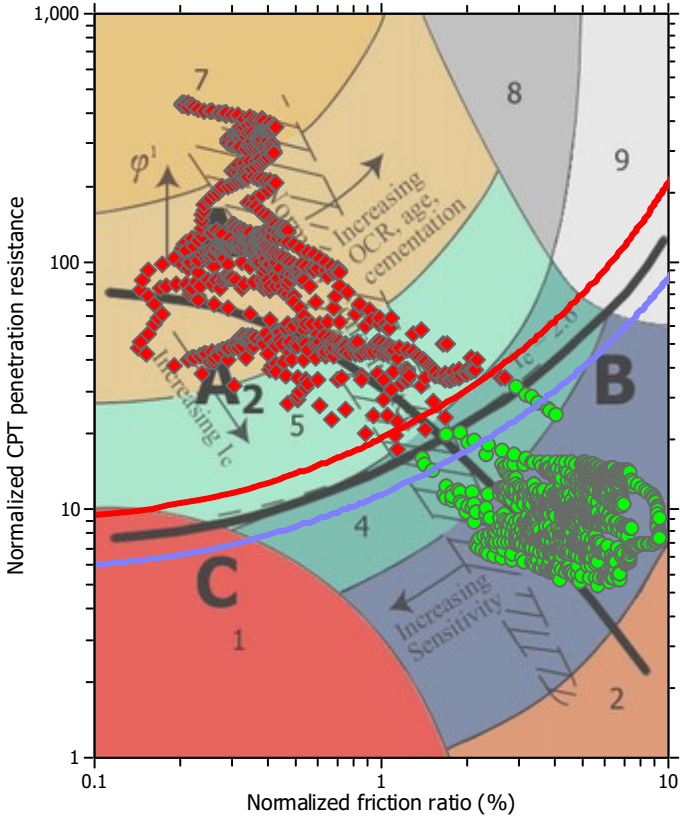
F.S. color scheme

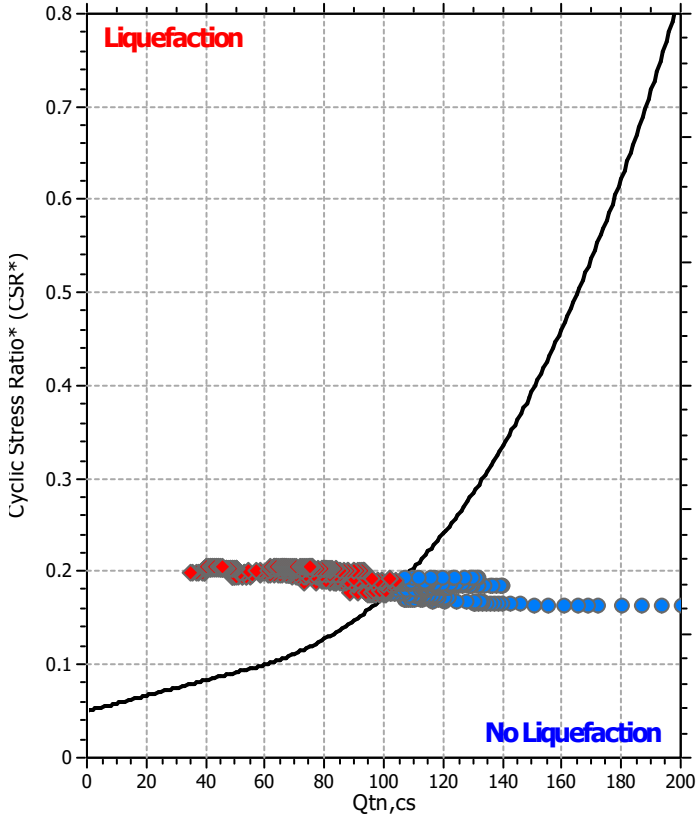
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

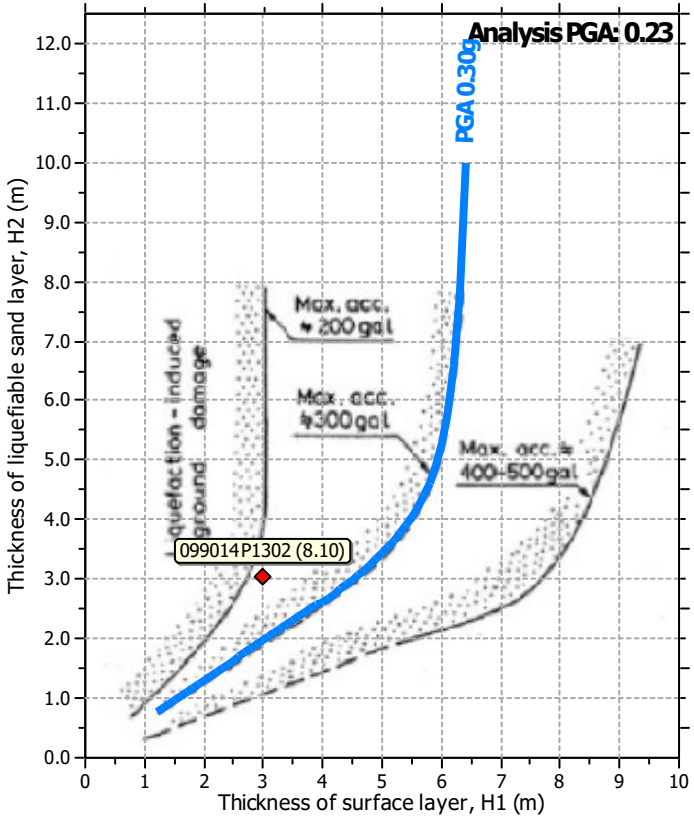
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

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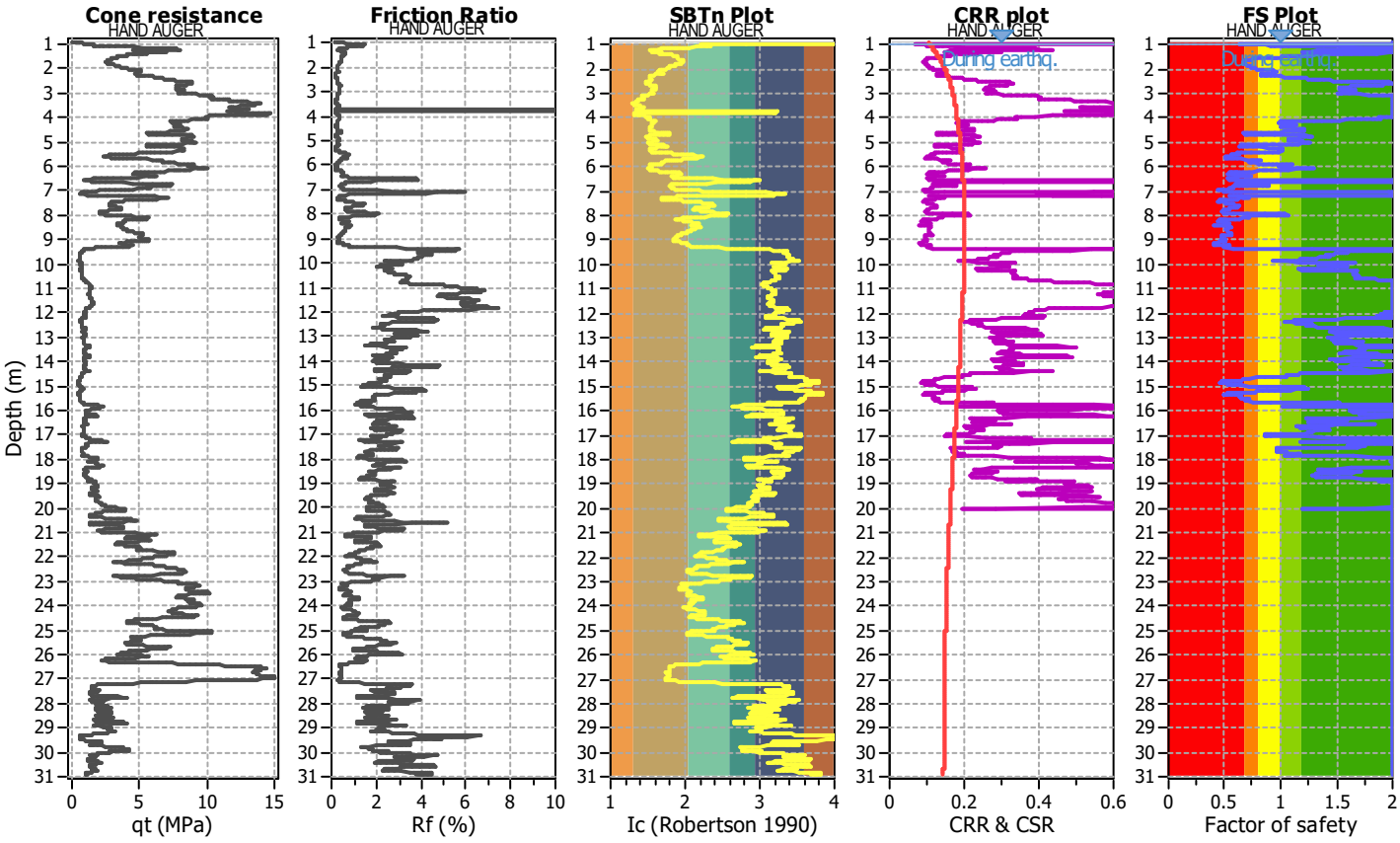
LIQUEFACTION ANALYSIS REPORT

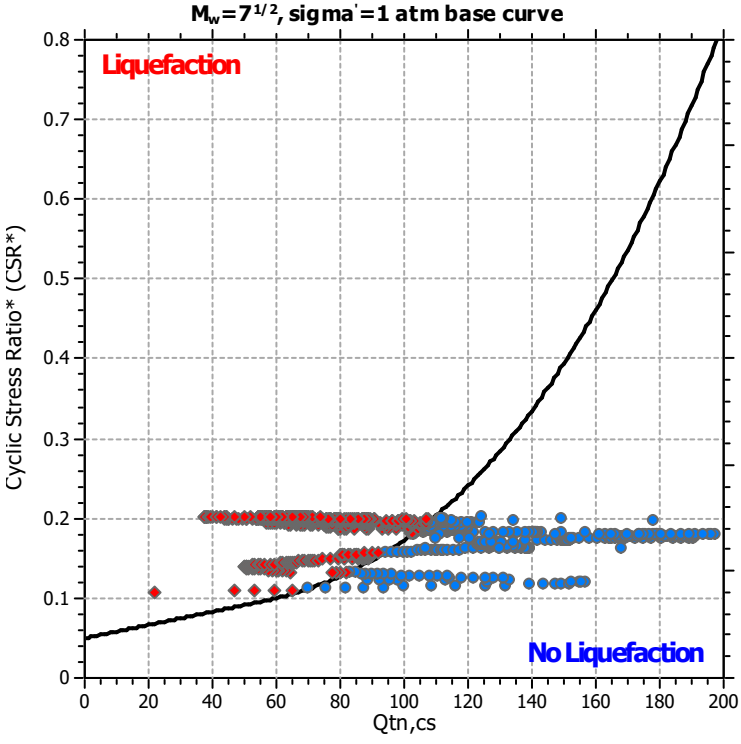
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

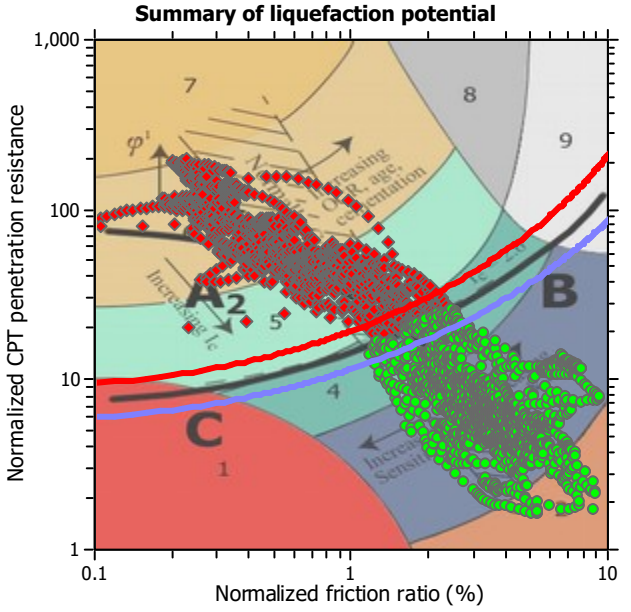
CPT file : 099014P1226

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.50 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

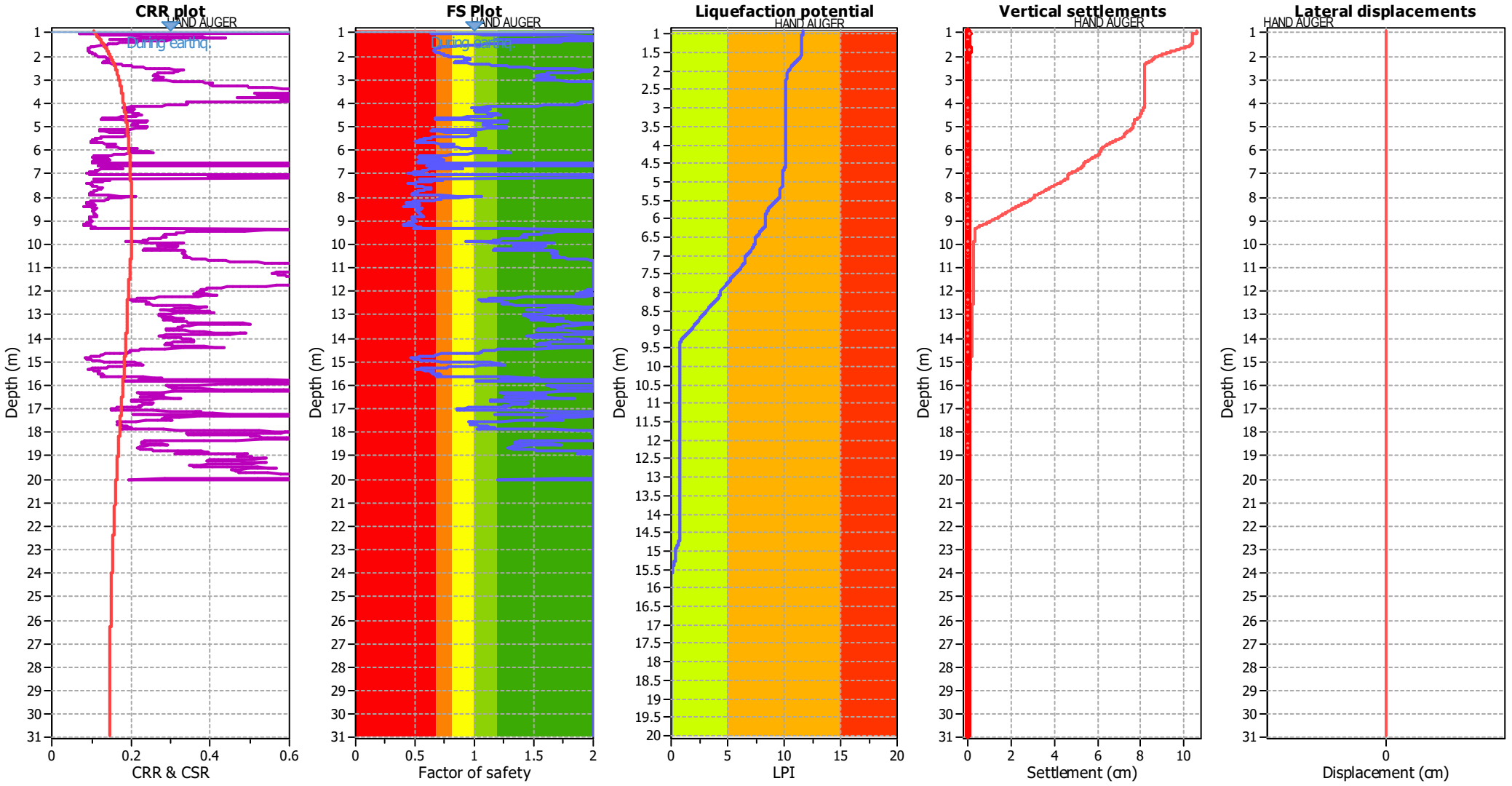






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	20.00 m

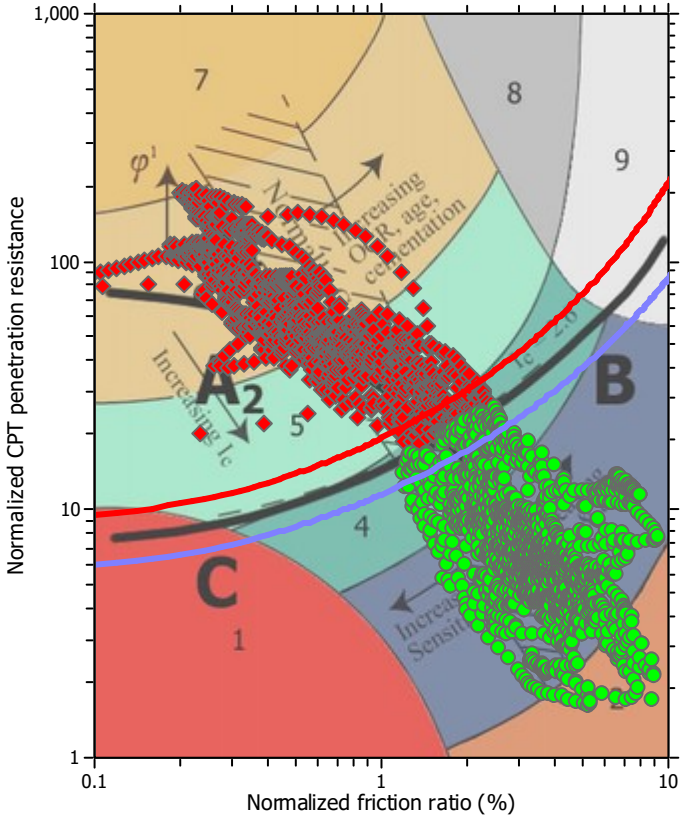
F.S. color scheme

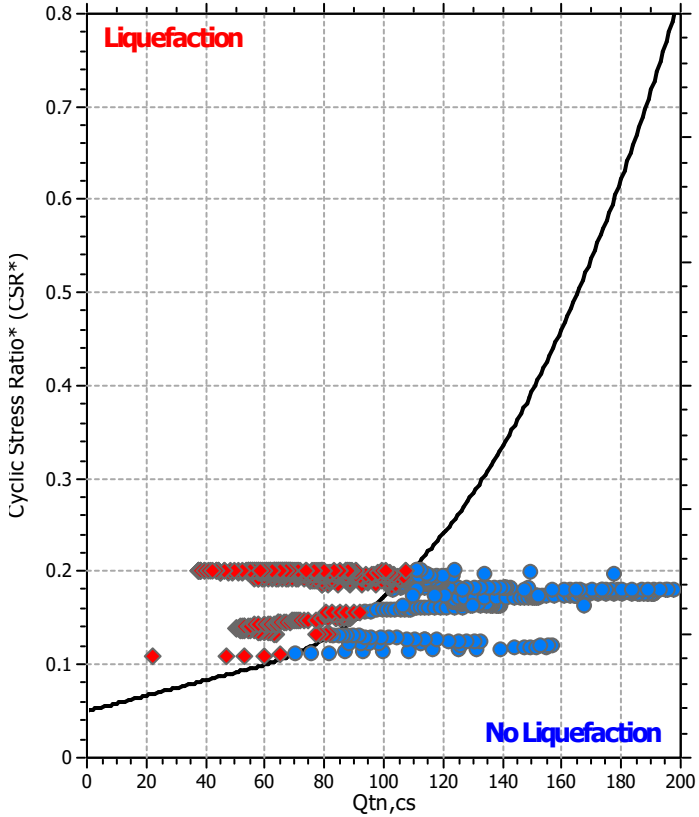
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

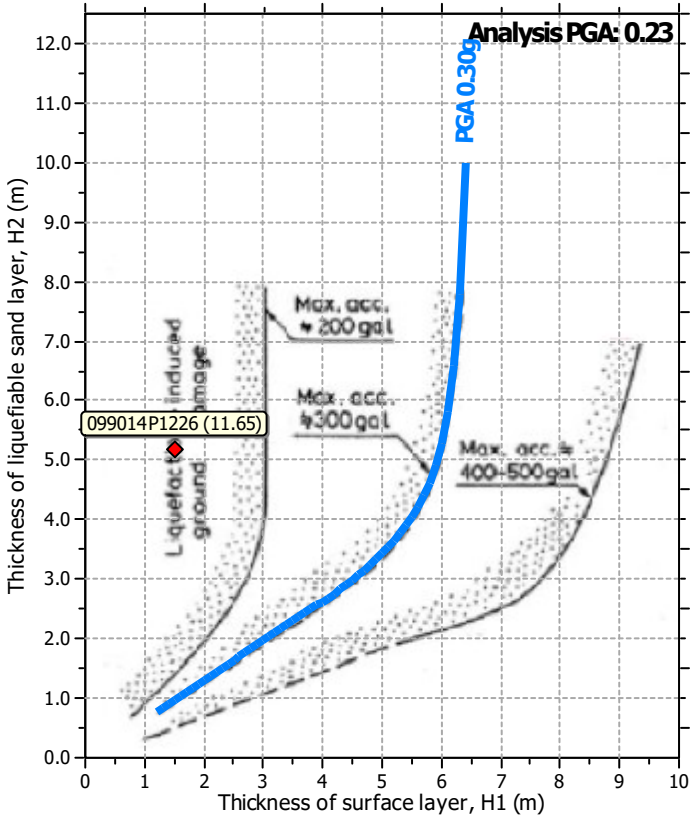
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.50 m	Fill height:	N/A	Limit depth:	20.00 m

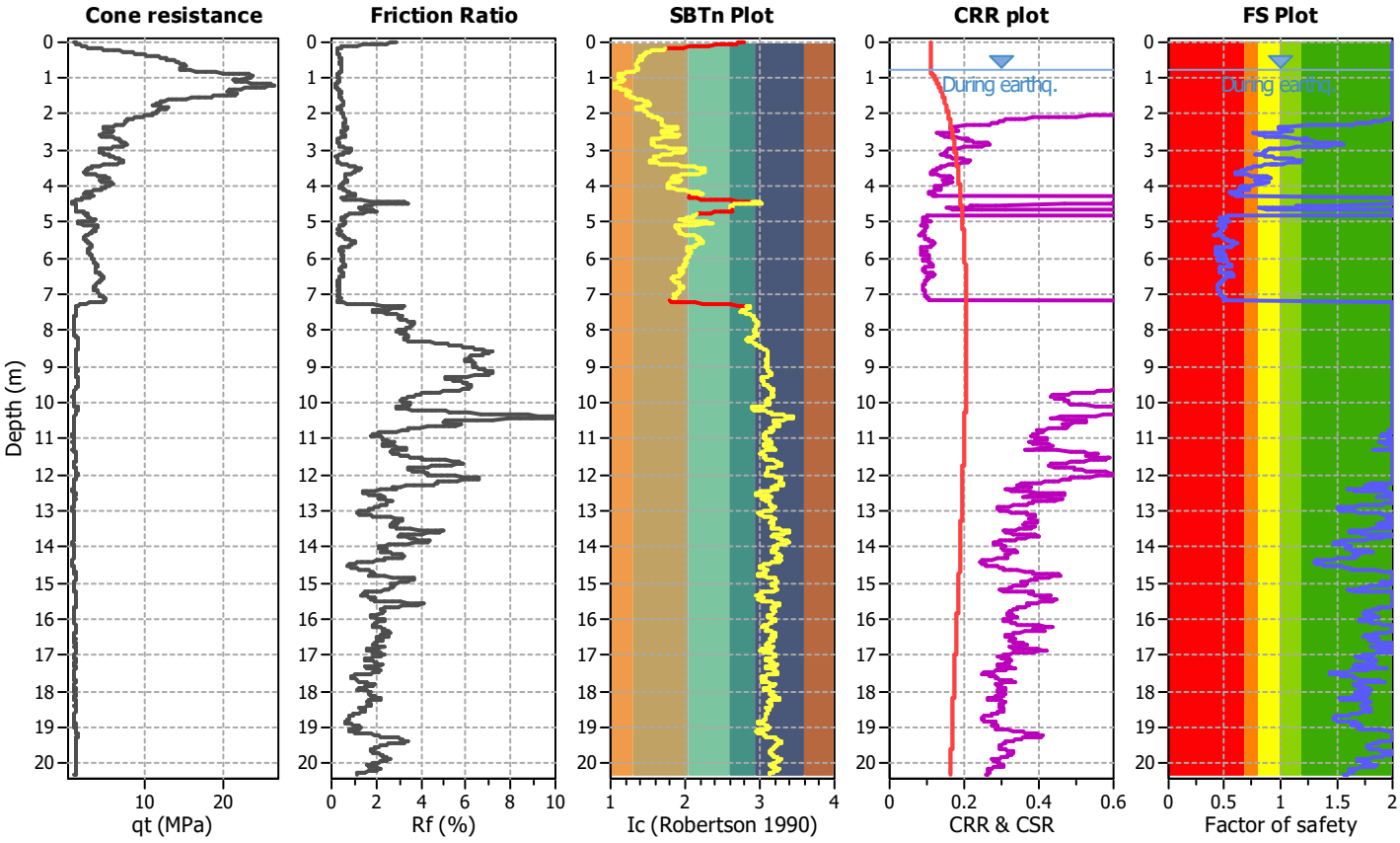
LIQUEFACTION ANALYSIS REPORT

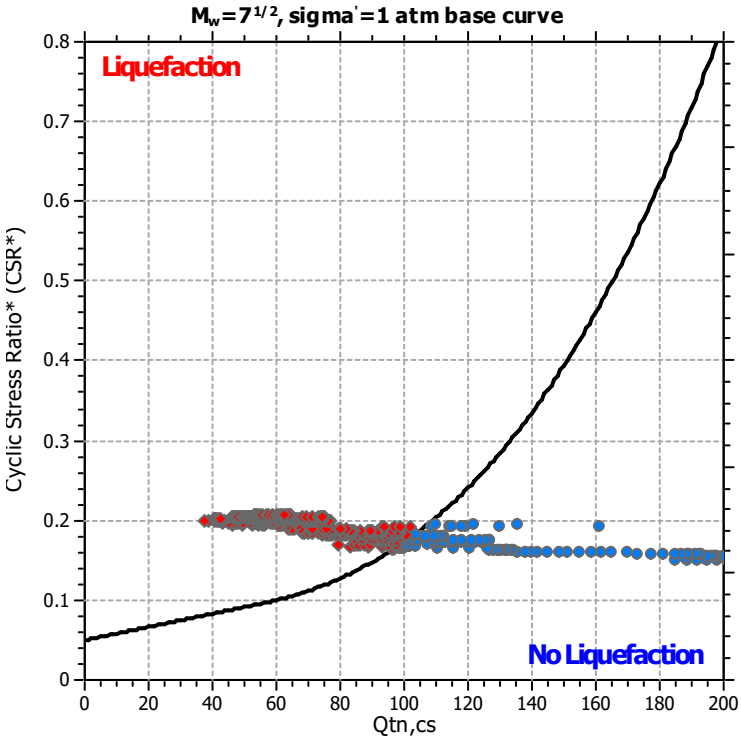
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

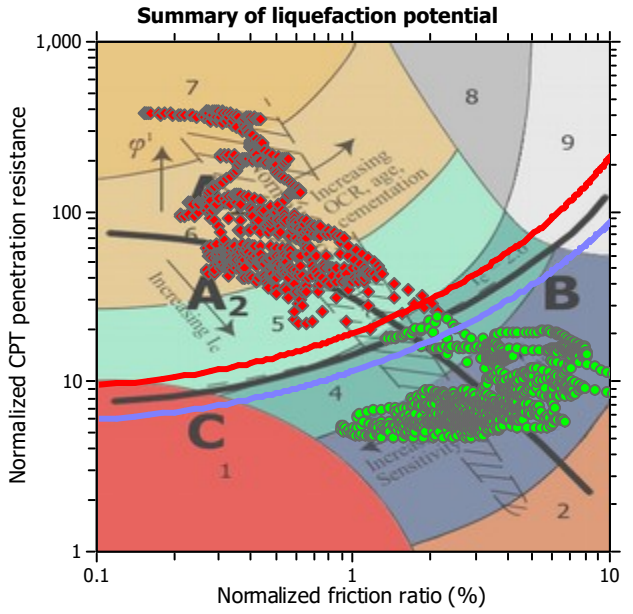
CPT file : 099014P1303

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

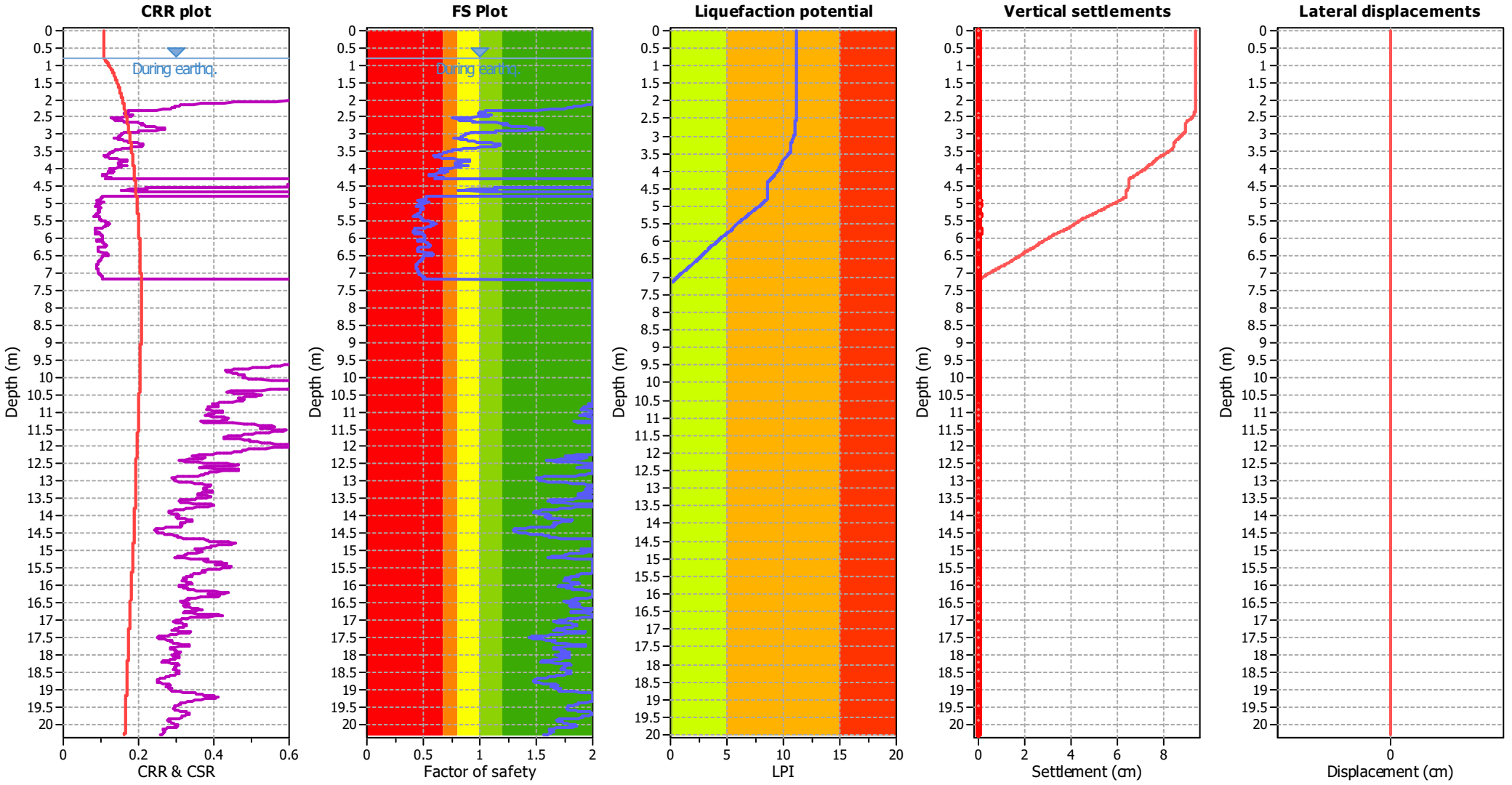






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

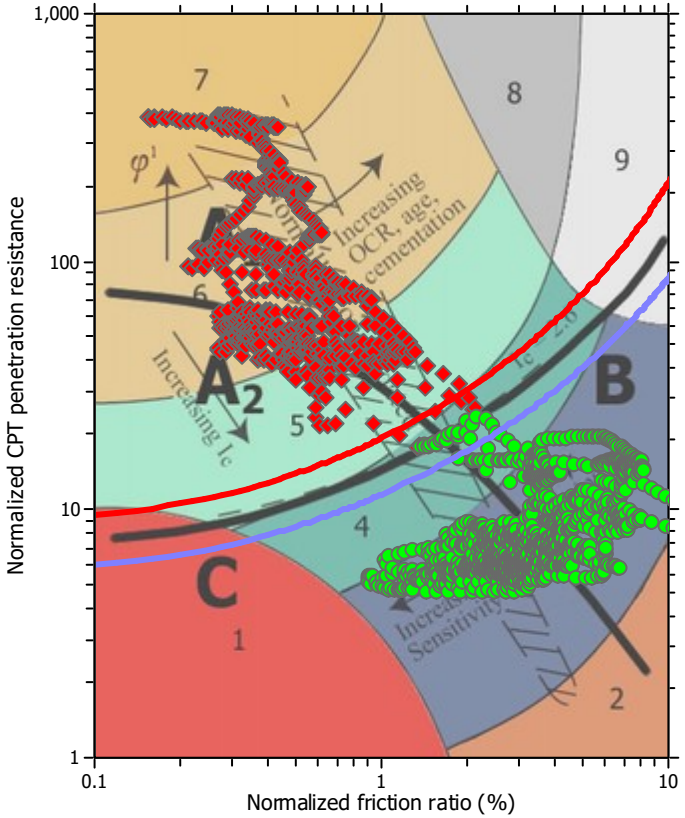
F.S. color scheme

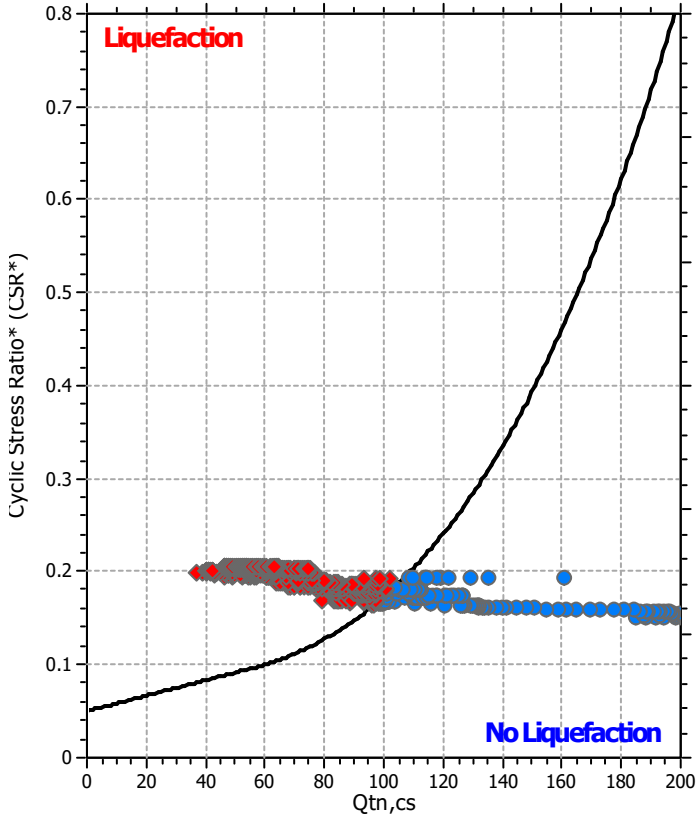
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

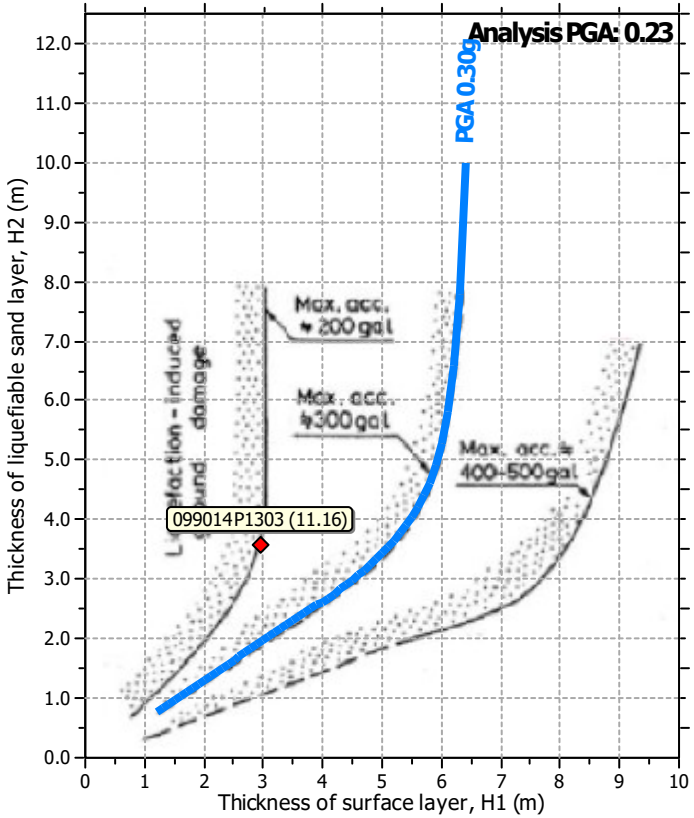
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

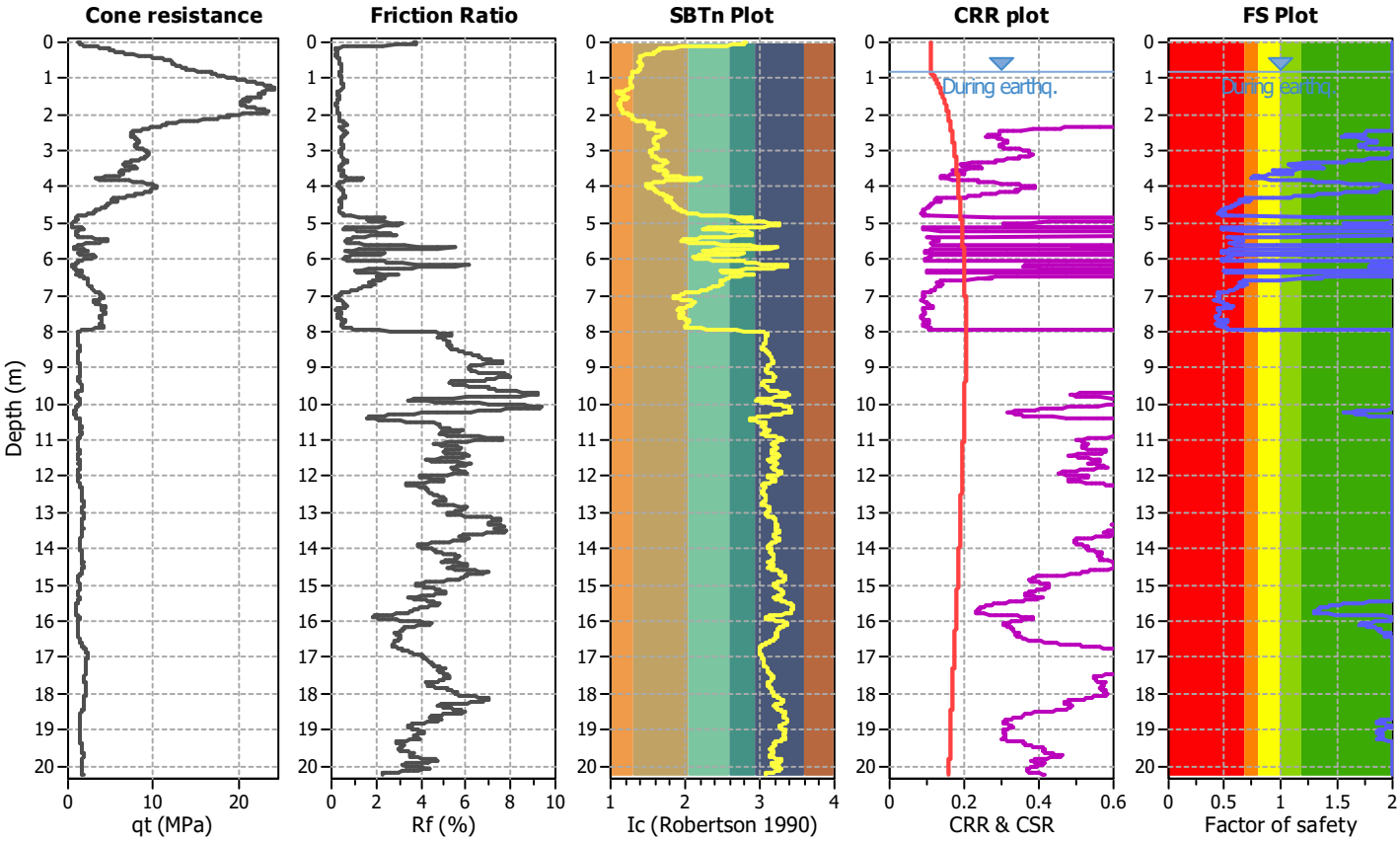
LIQUEFACTION ANALYSIS REPORT

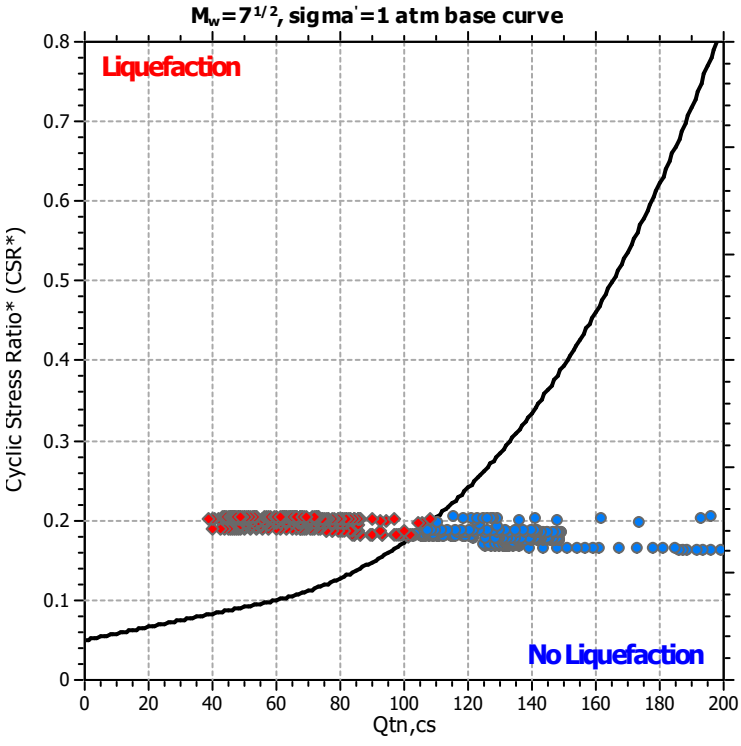
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

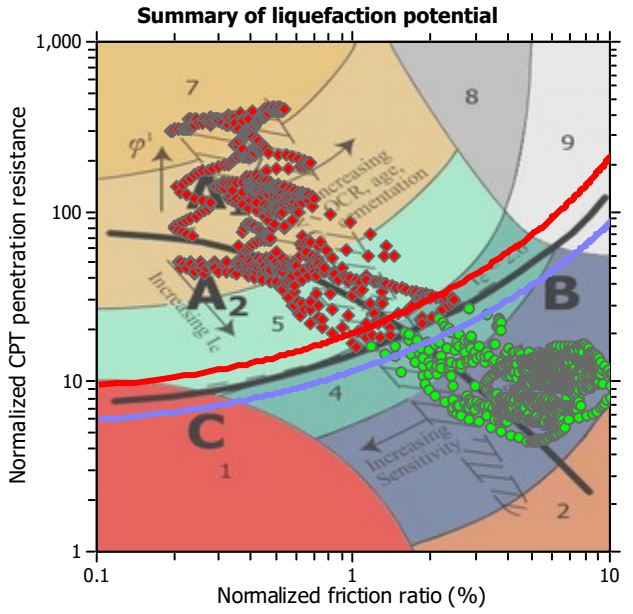
CPT file : 099014P1306

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

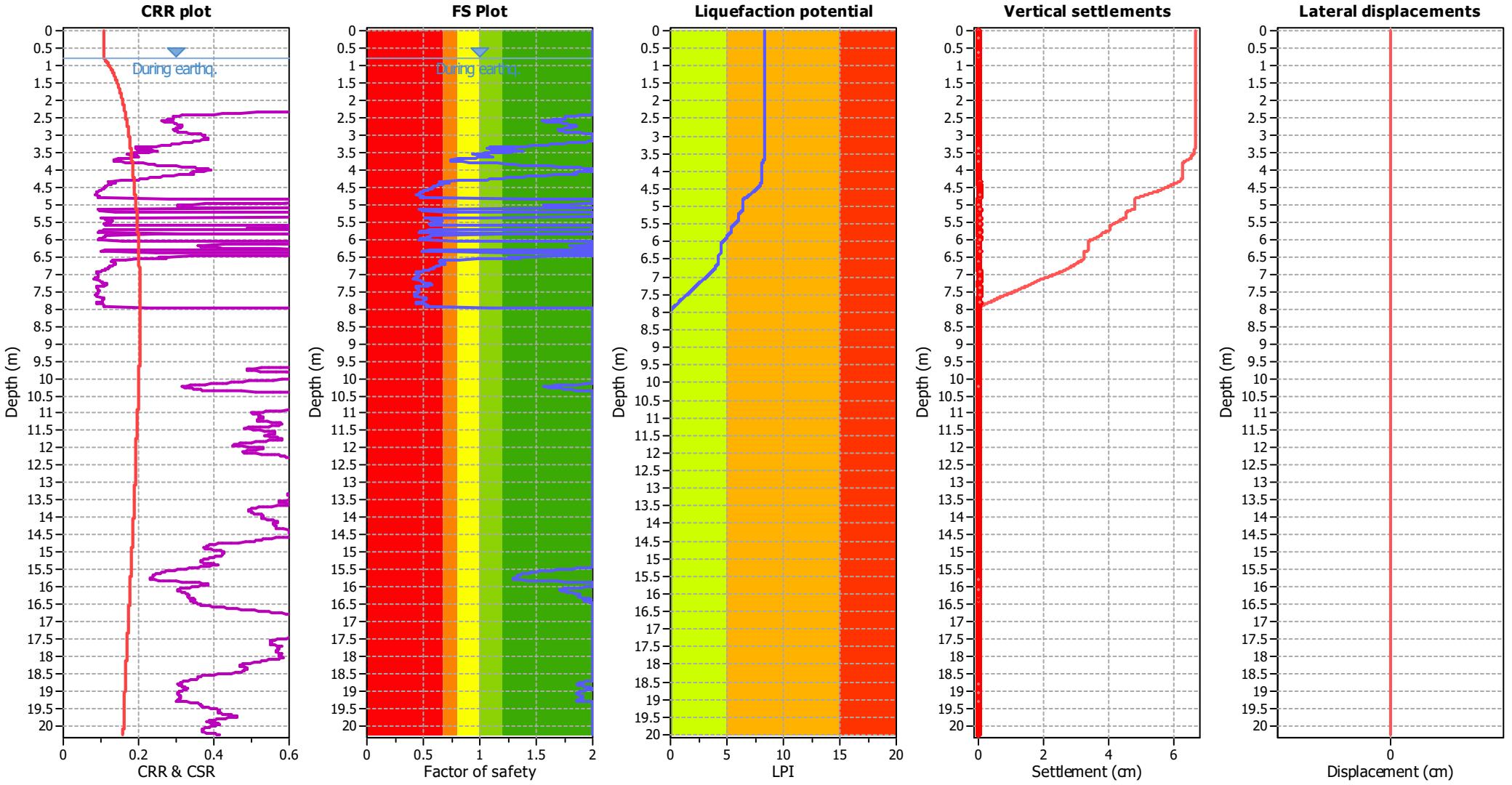






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

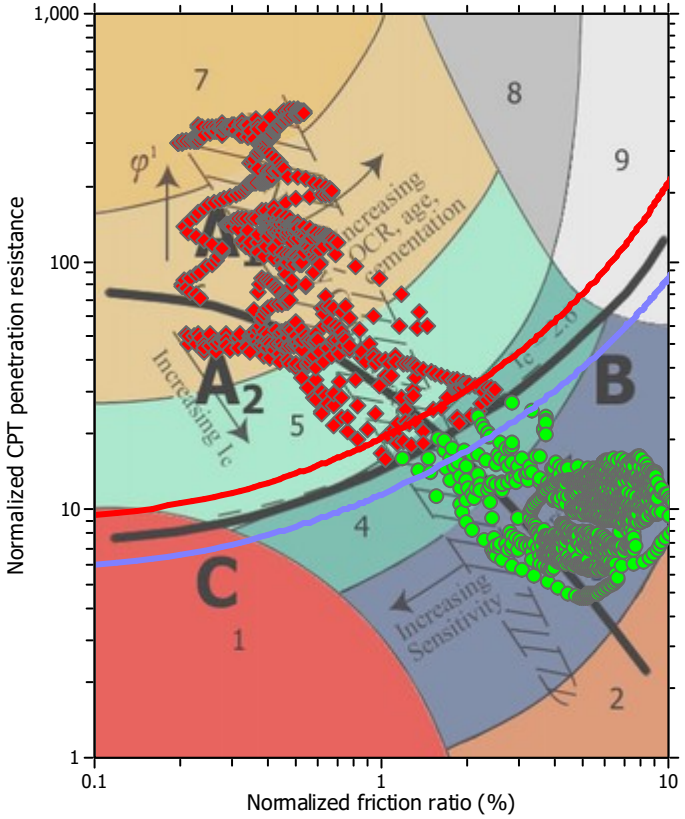
F.S. color scheme

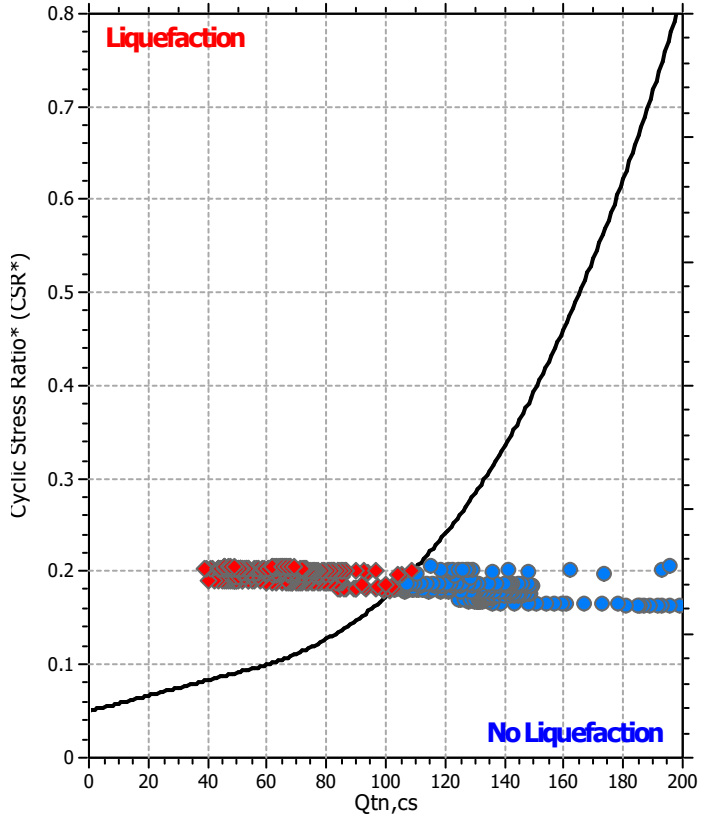
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

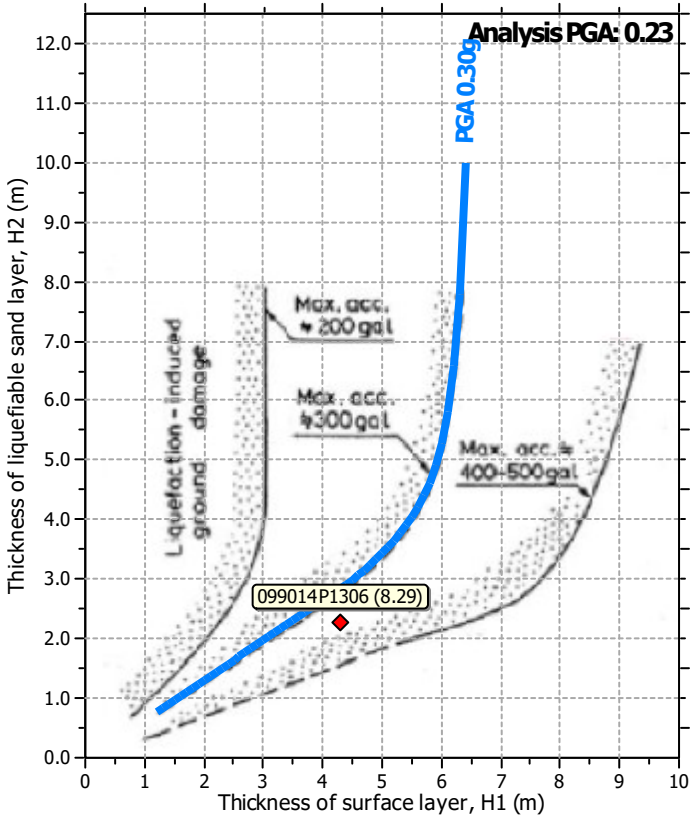
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

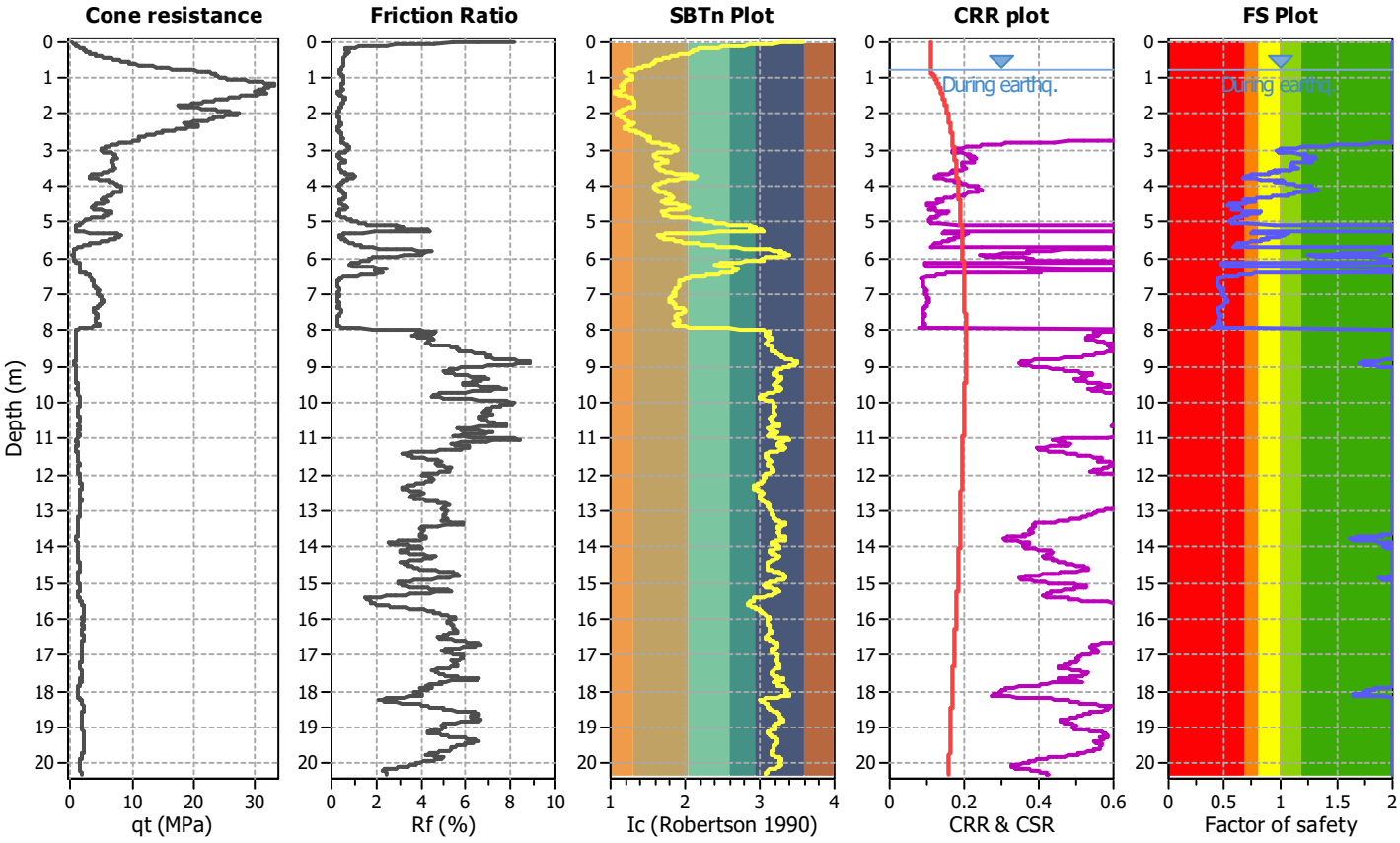
LIQUEFACTION ANALYSIS REPORT

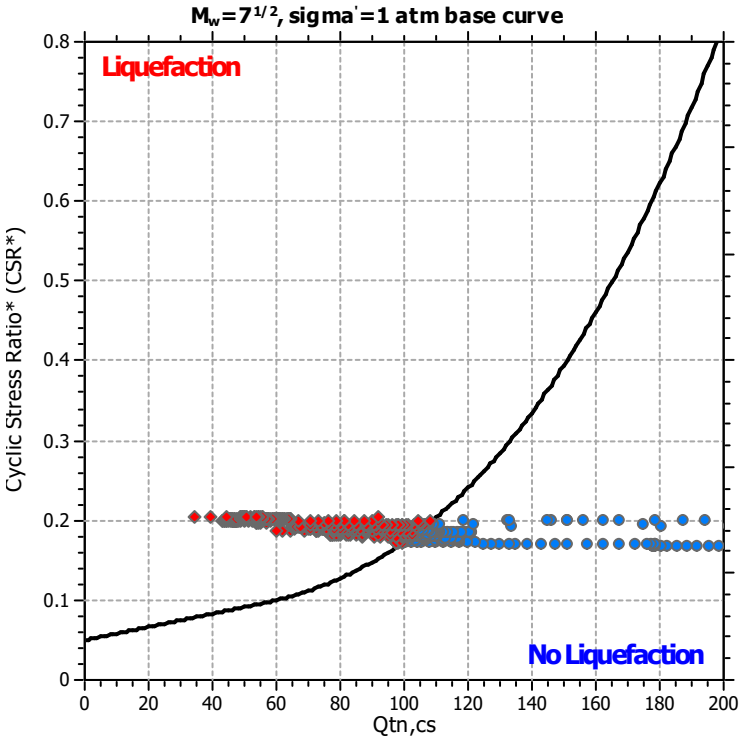
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

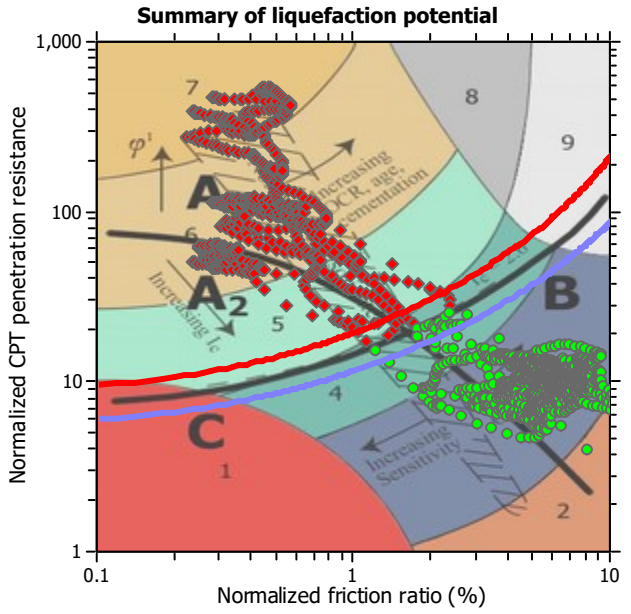
CPT file : 099014P1307

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

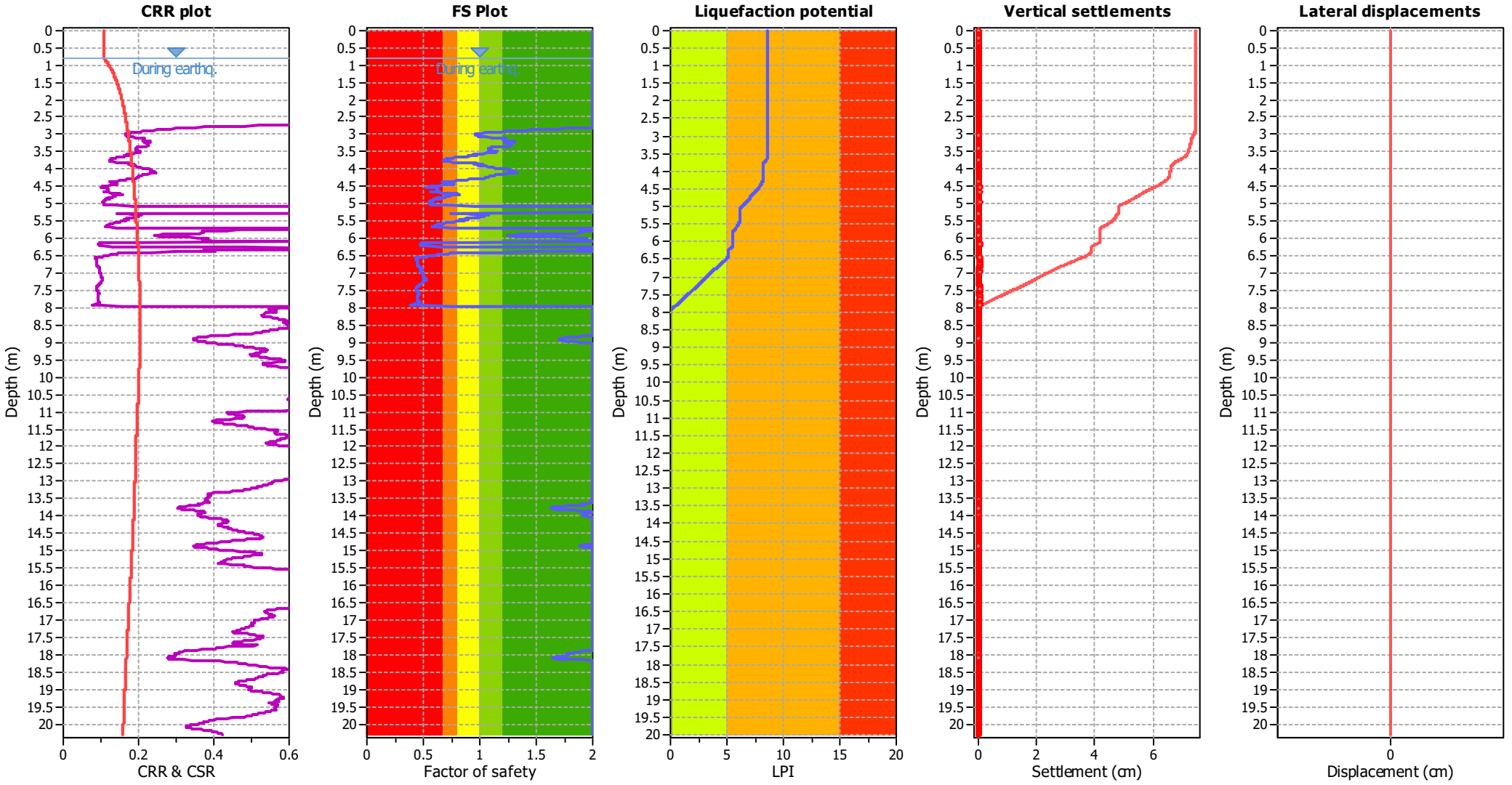






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

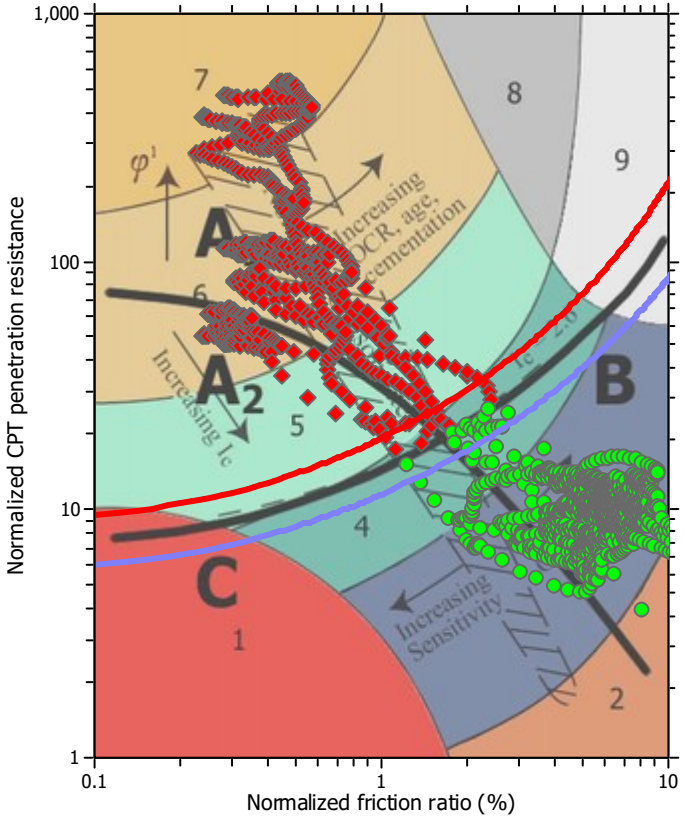
F.S. color scheme

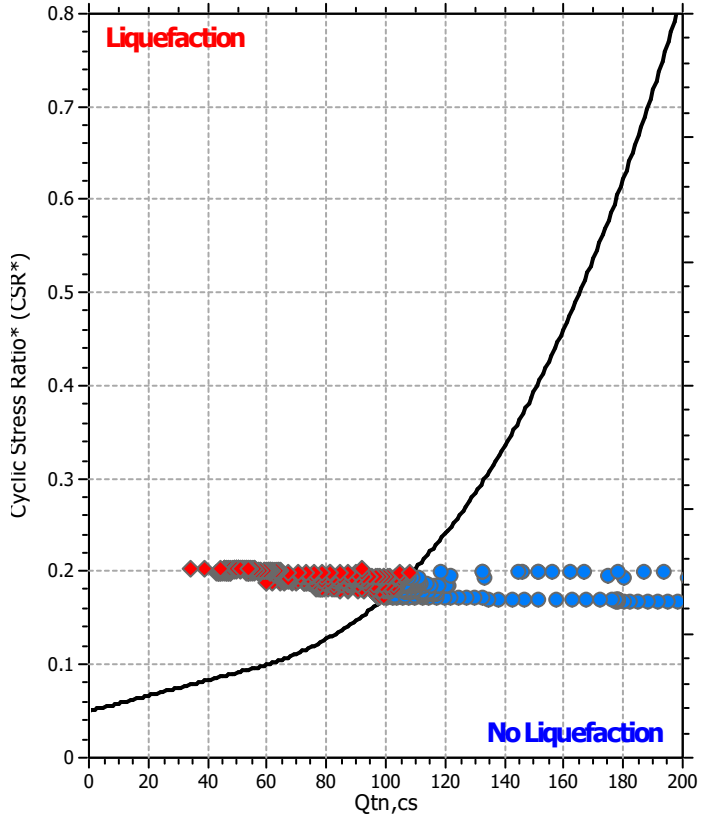
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

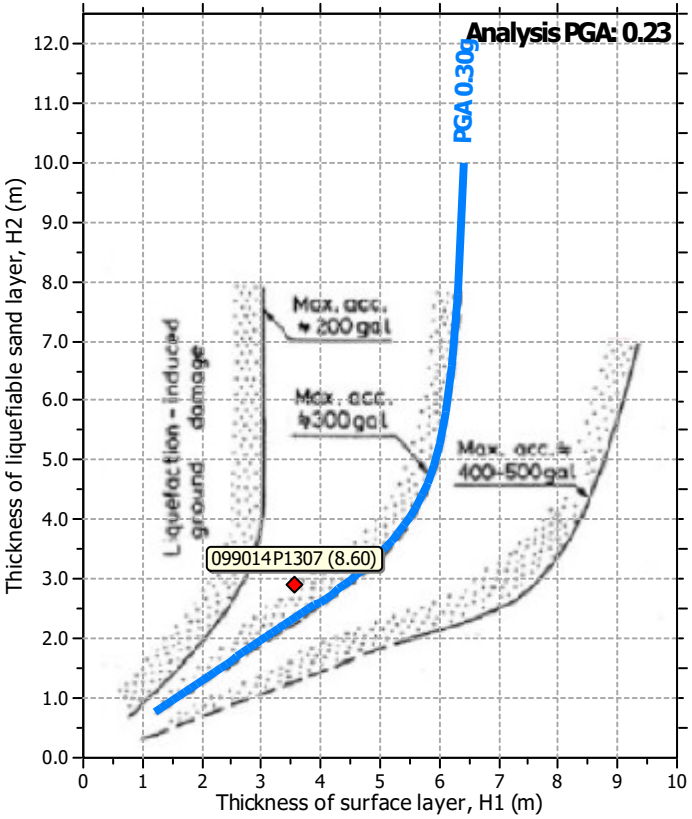
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

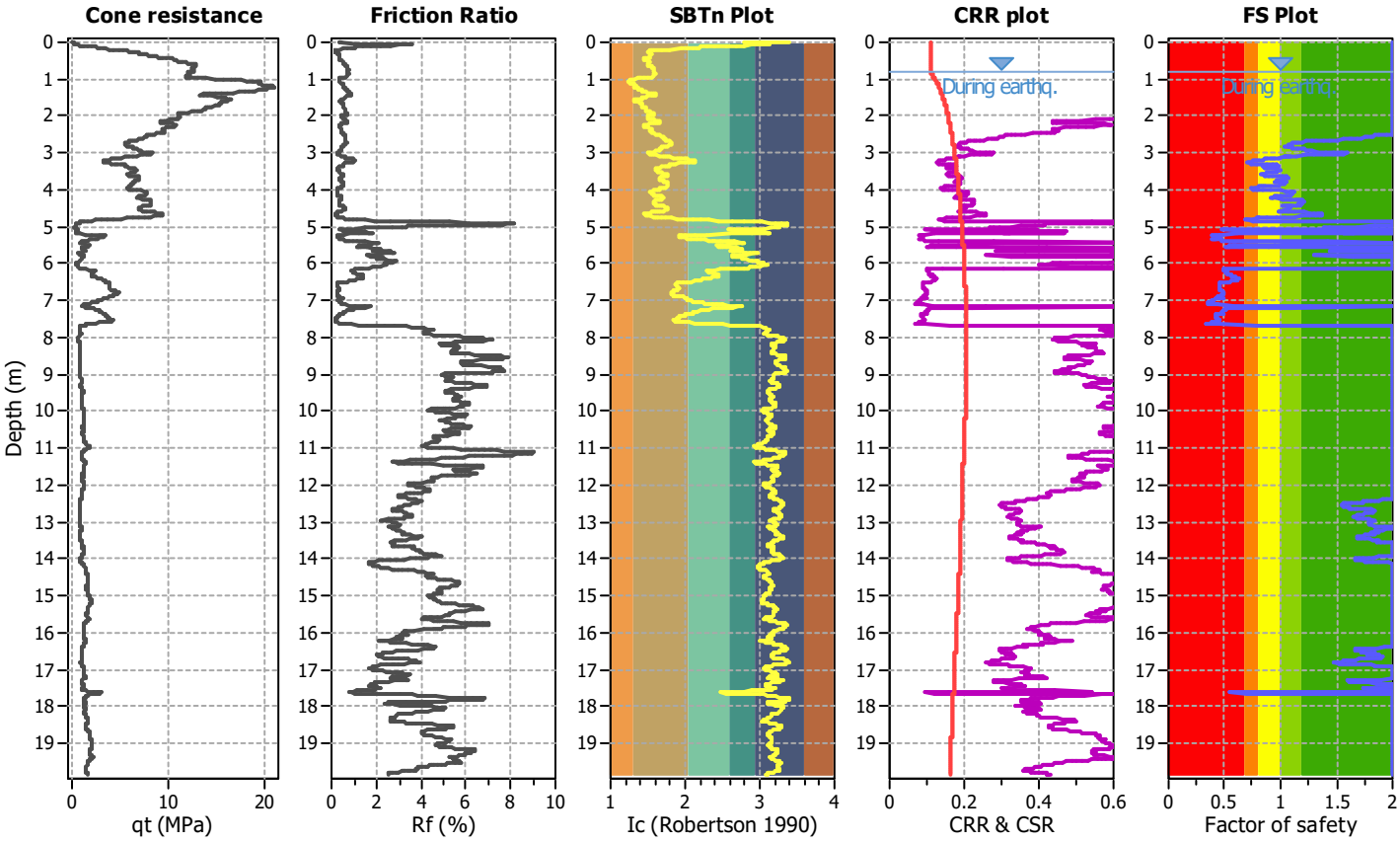
LIQUEFACTION ANALYSIS REPORT

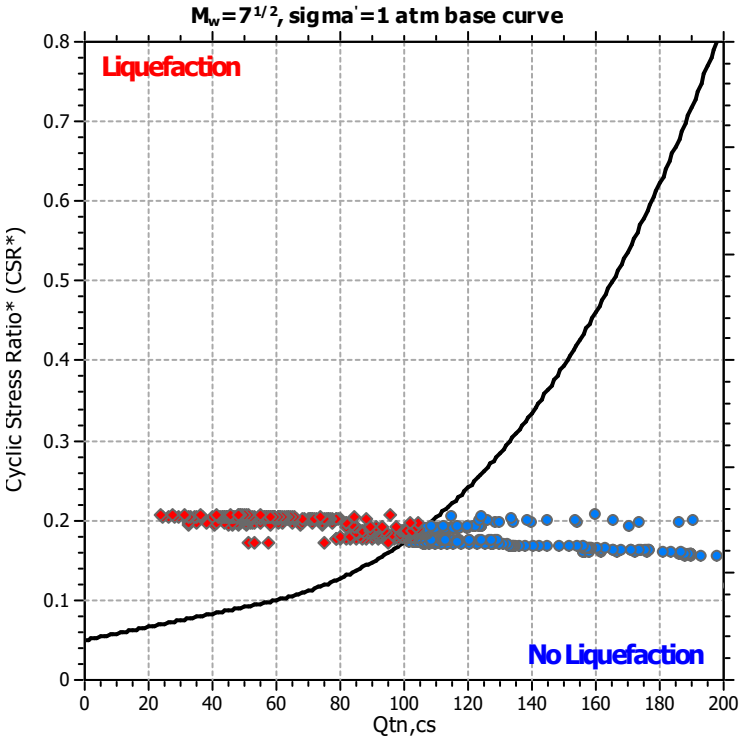
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

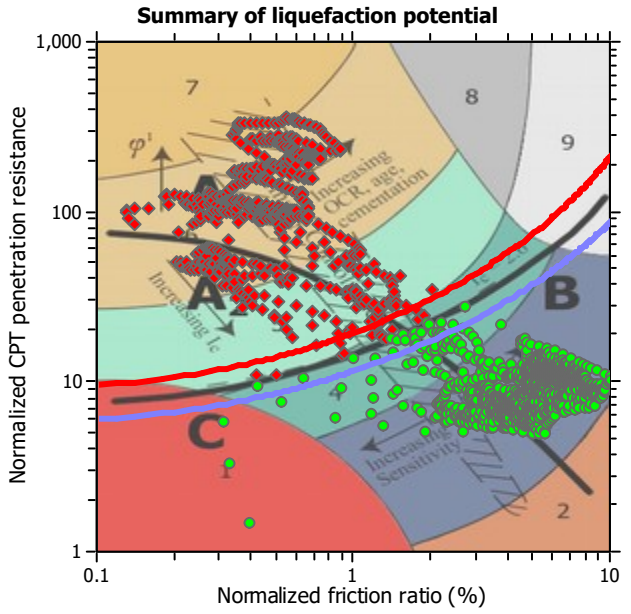
CPT file : CPTe_17

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.20 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

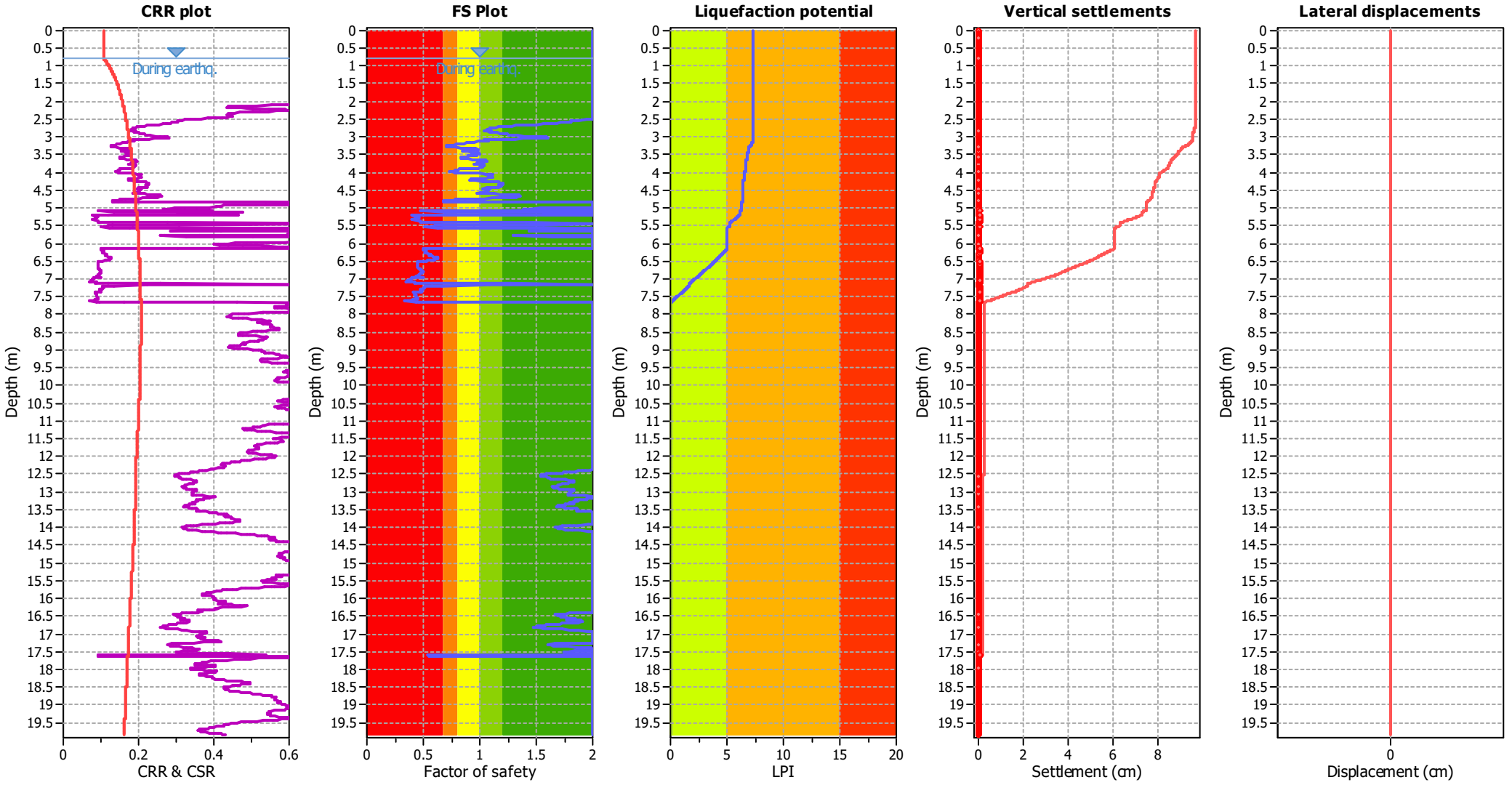






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	20.00 m

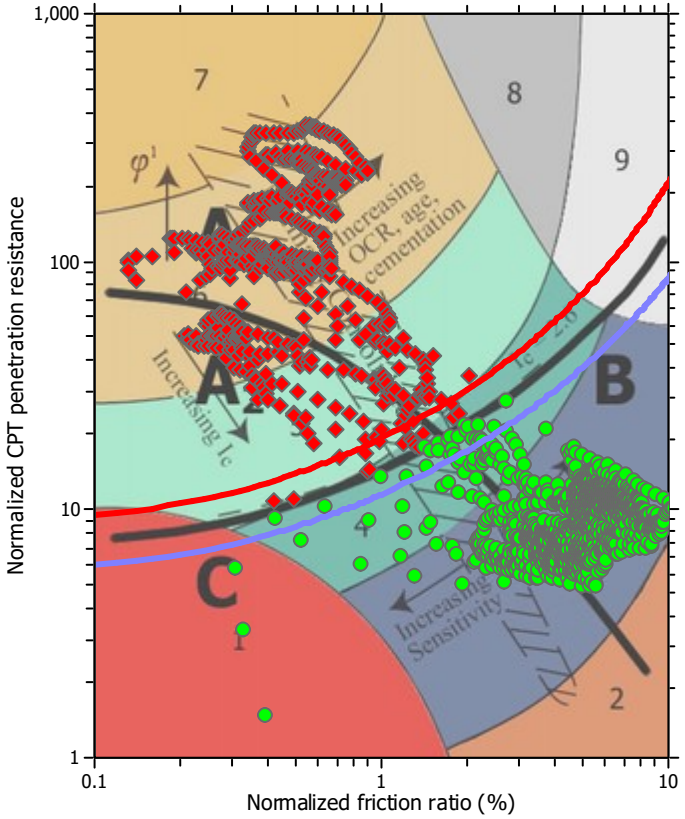
F.S. color scheme

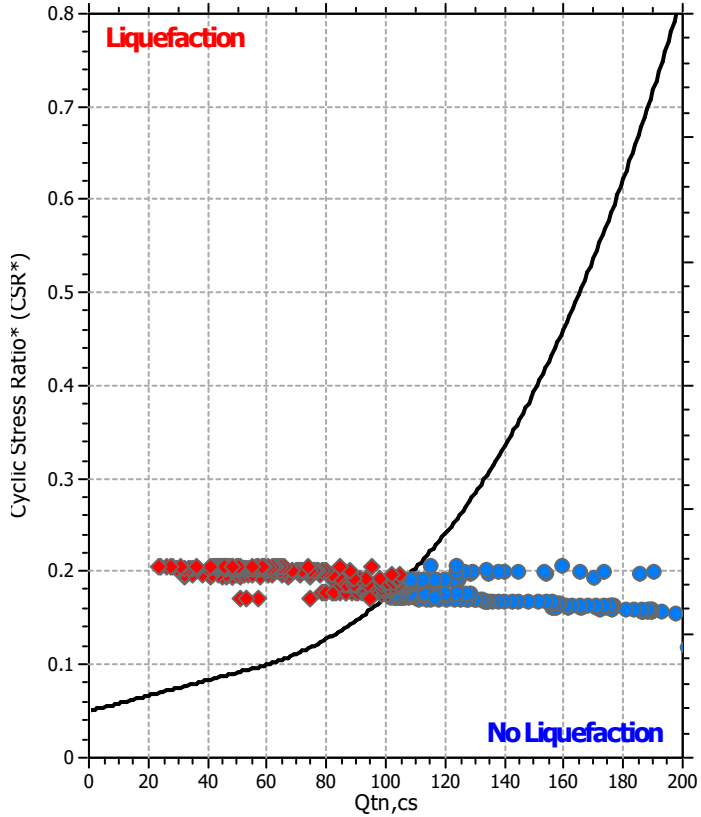
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

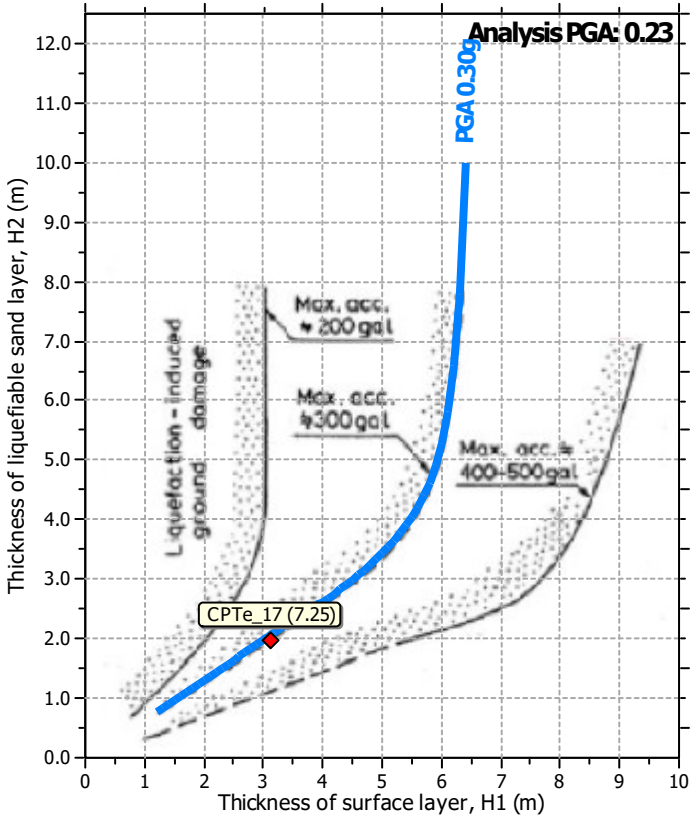
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	20.00 m

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

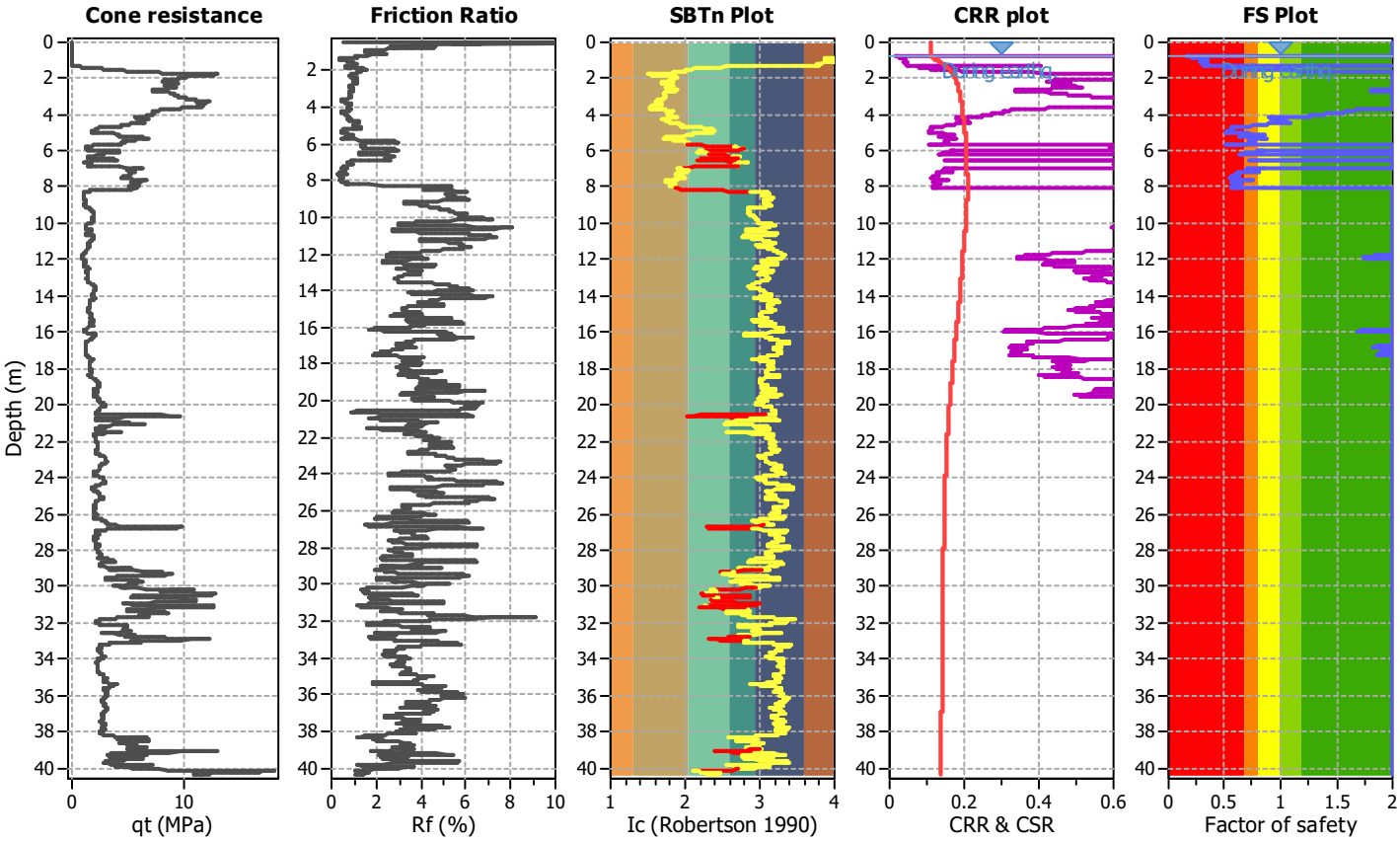
LIQUEFACTION ANALYSIS REPORT

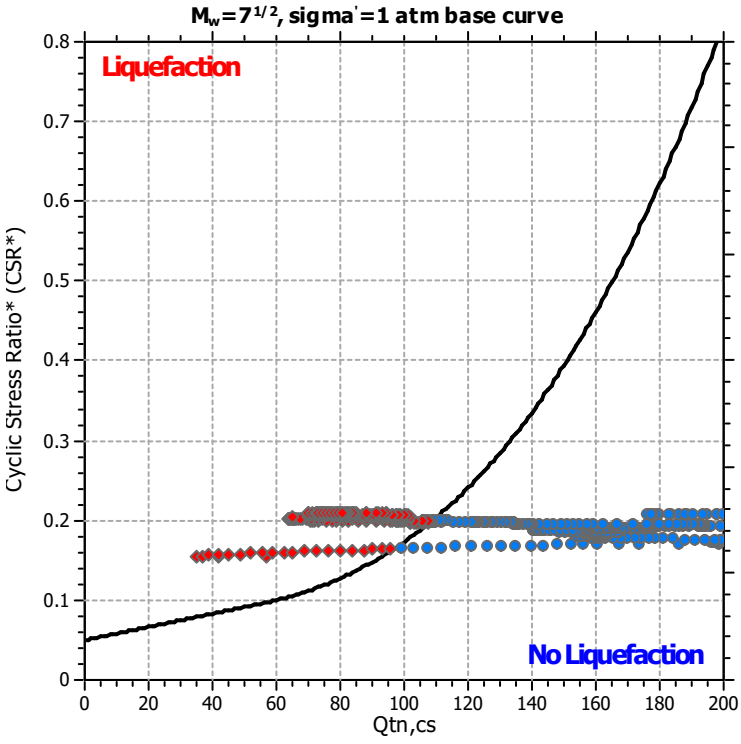
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

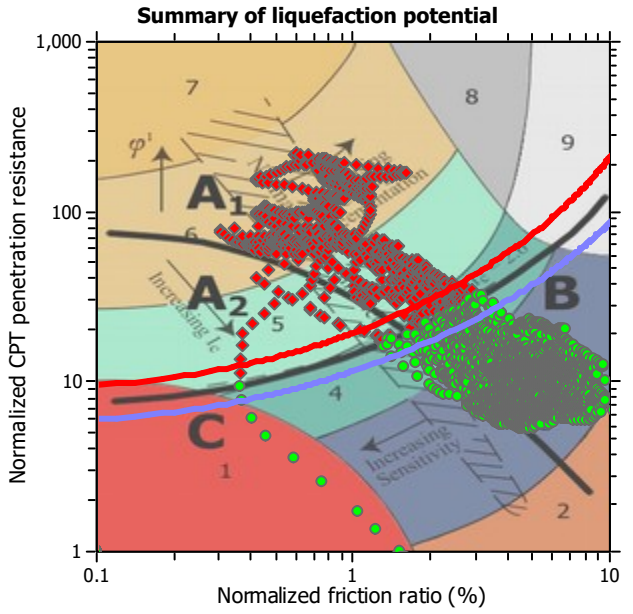
CPT file : 099014P1311

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

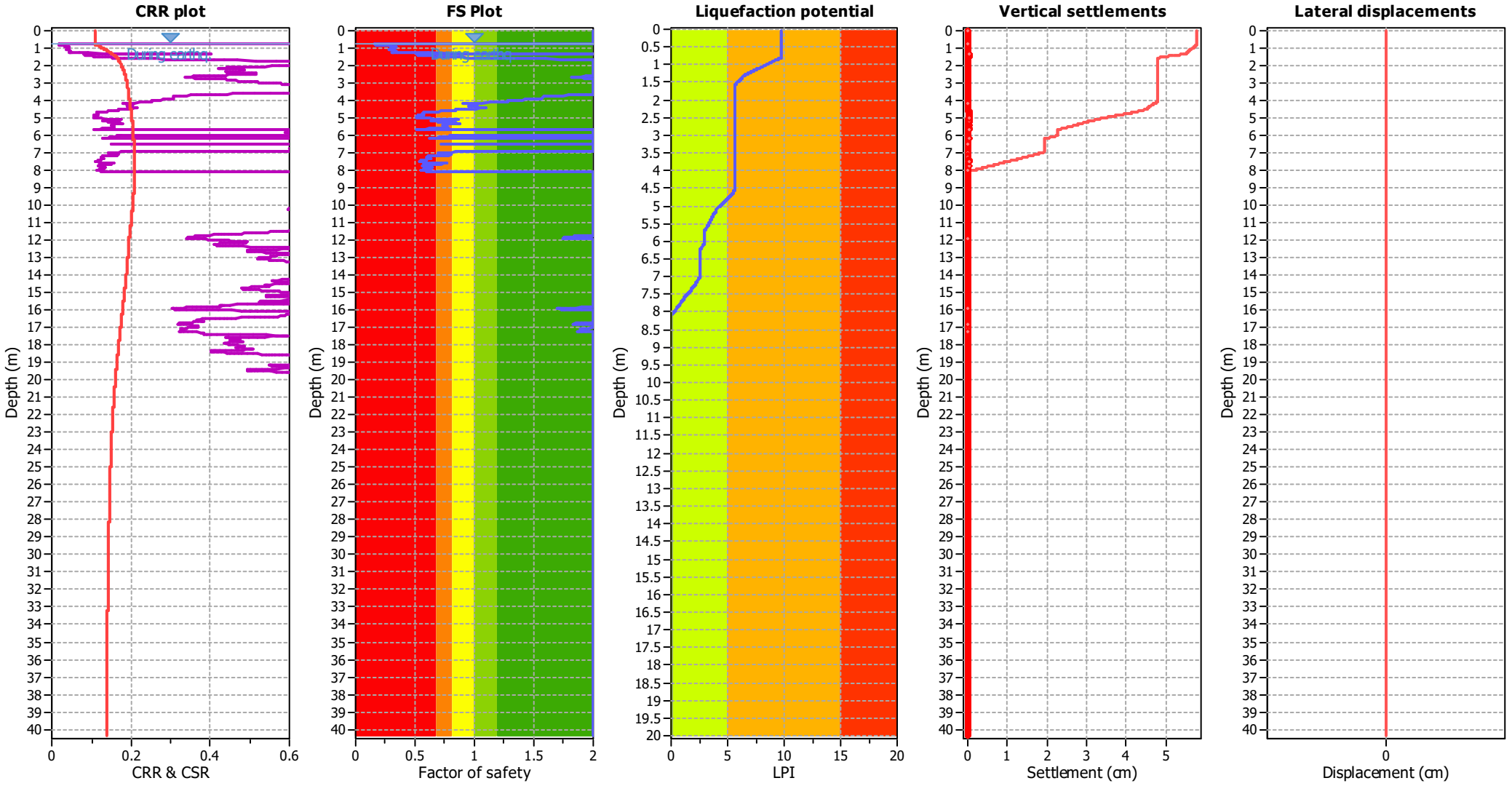






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	20.00 m

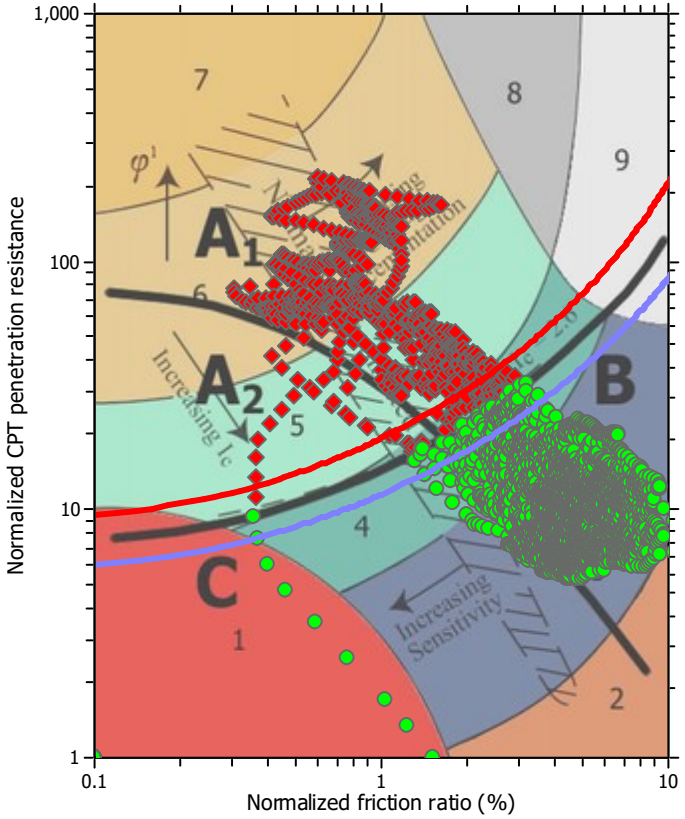
F.S. color scheme

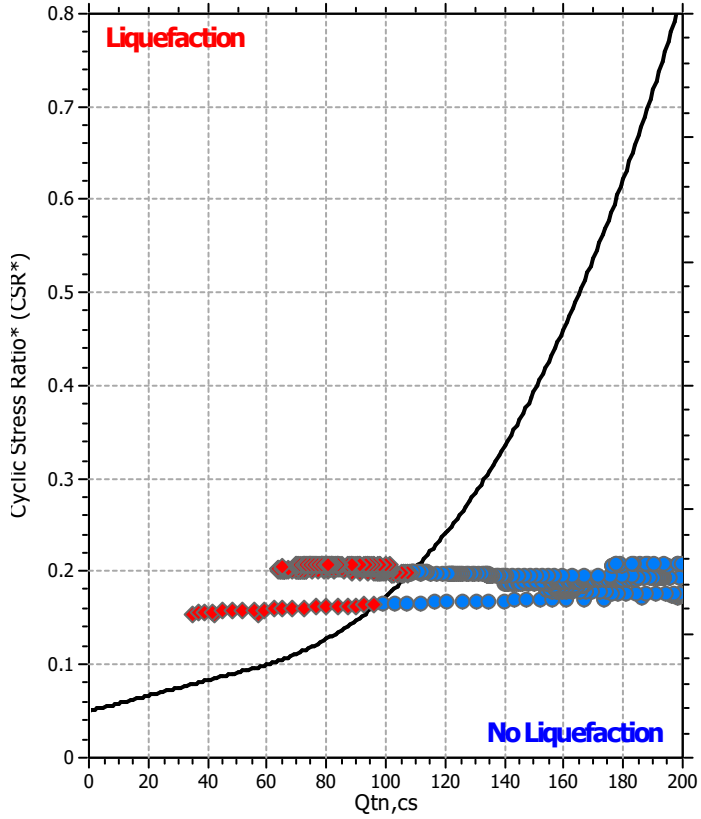
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

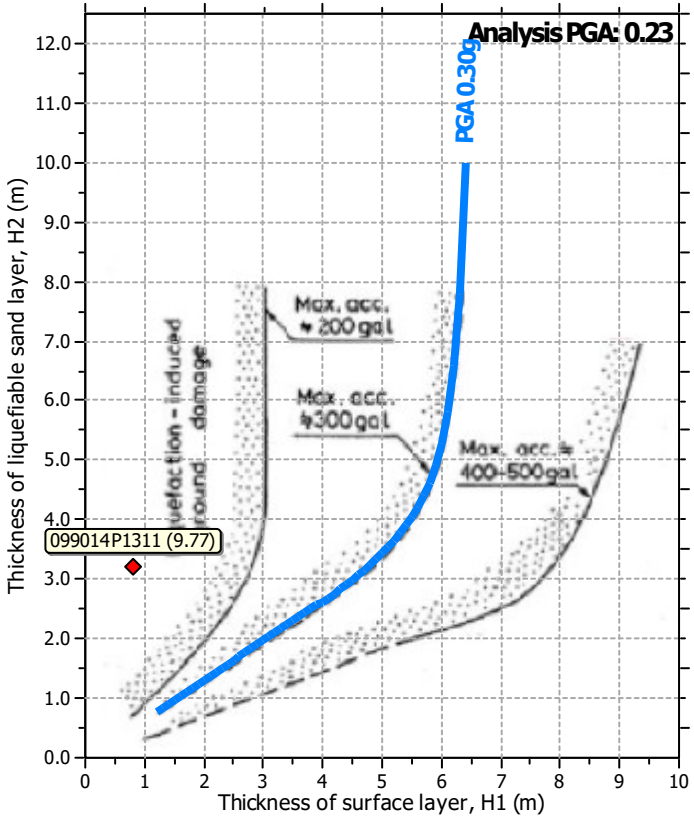
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	20.00 m

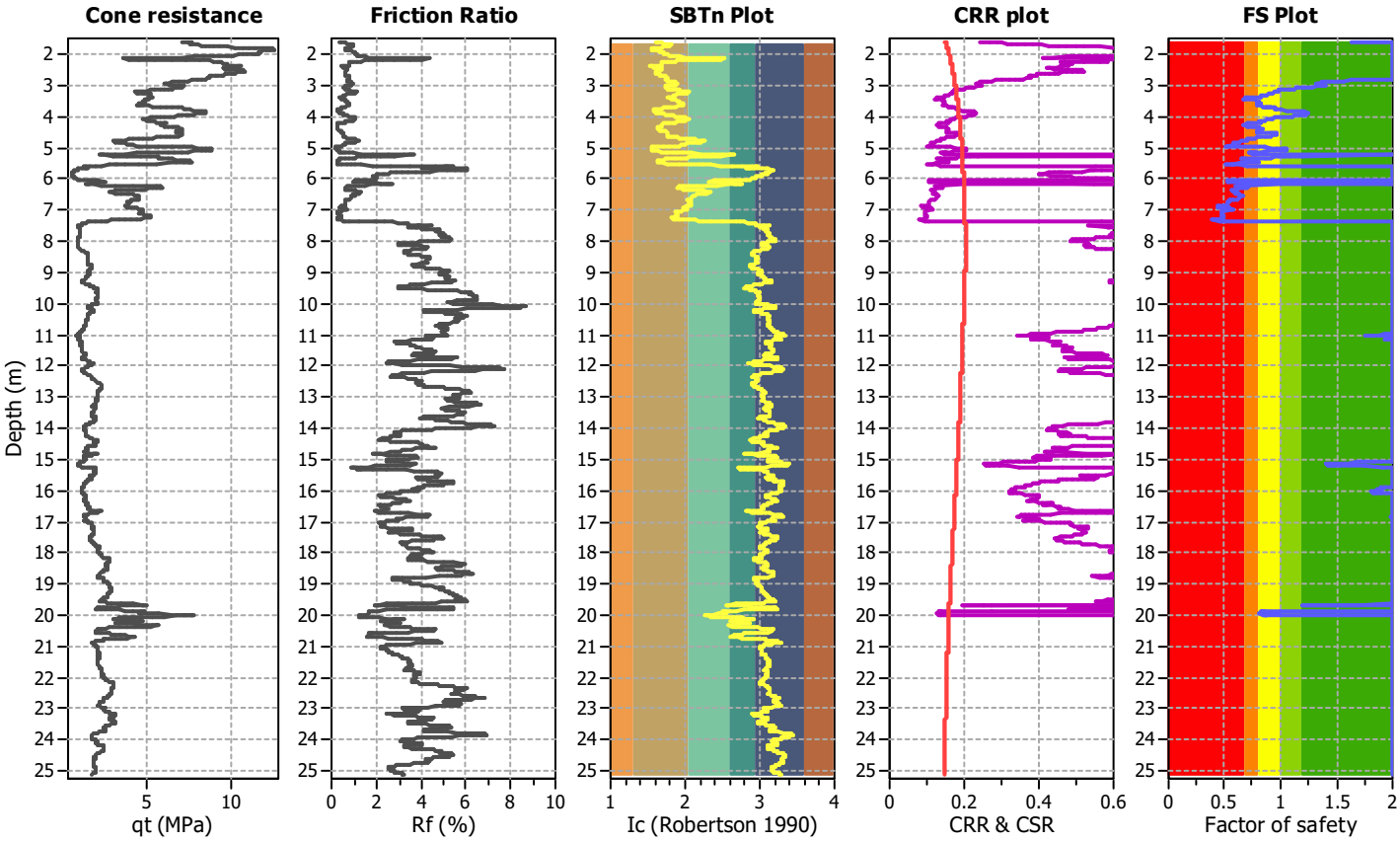
LIQUEFACTION ANALYSIS REPORT

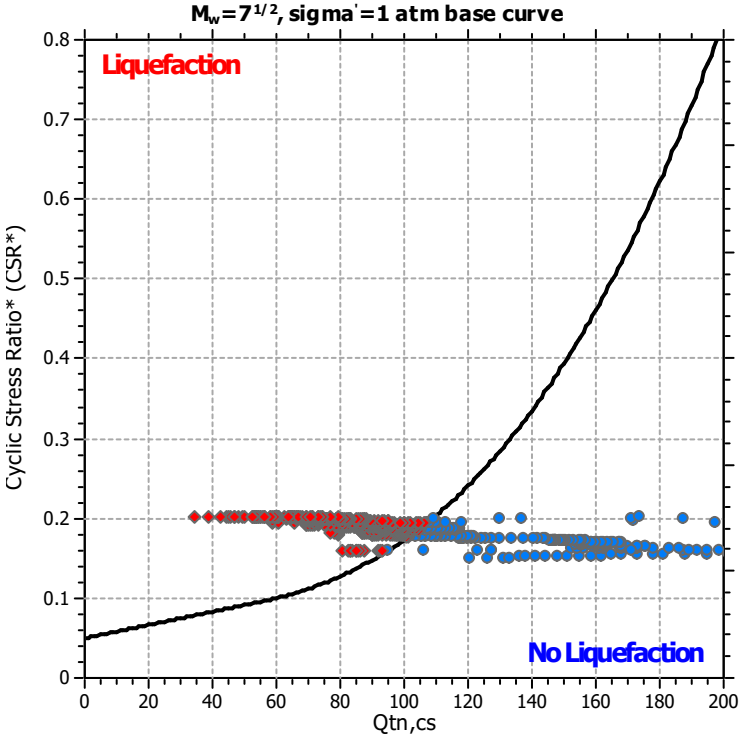
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

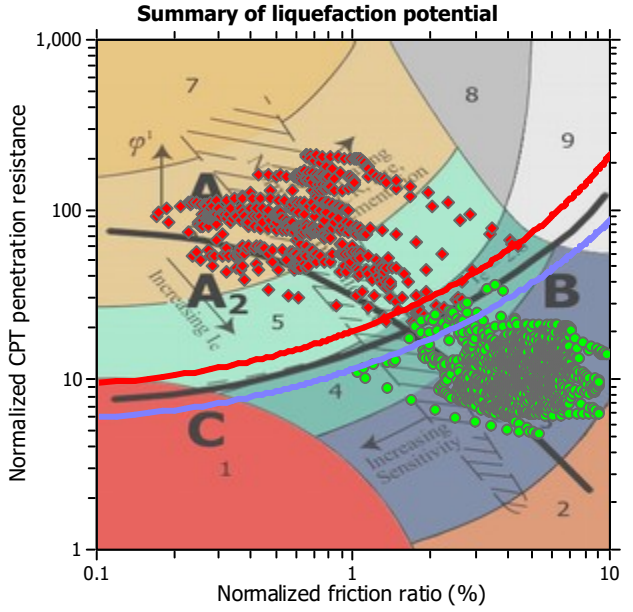
CPT file : 099014P1328

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

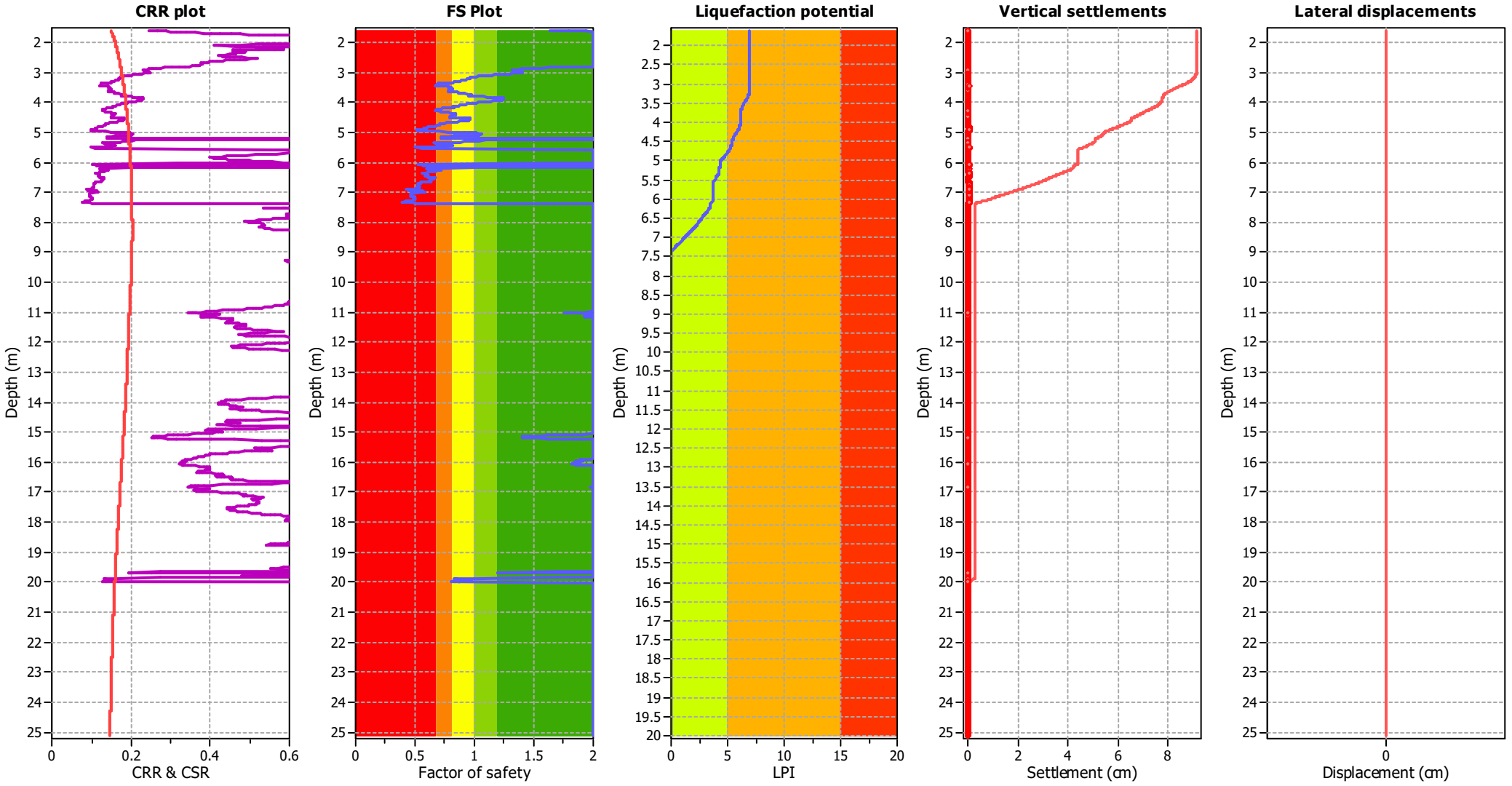






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

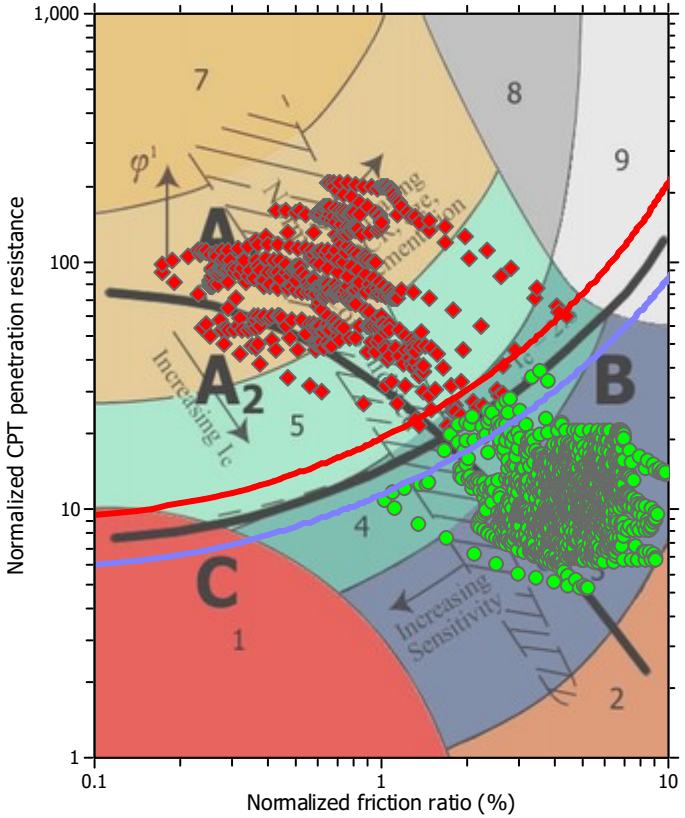
F.S. color scheme

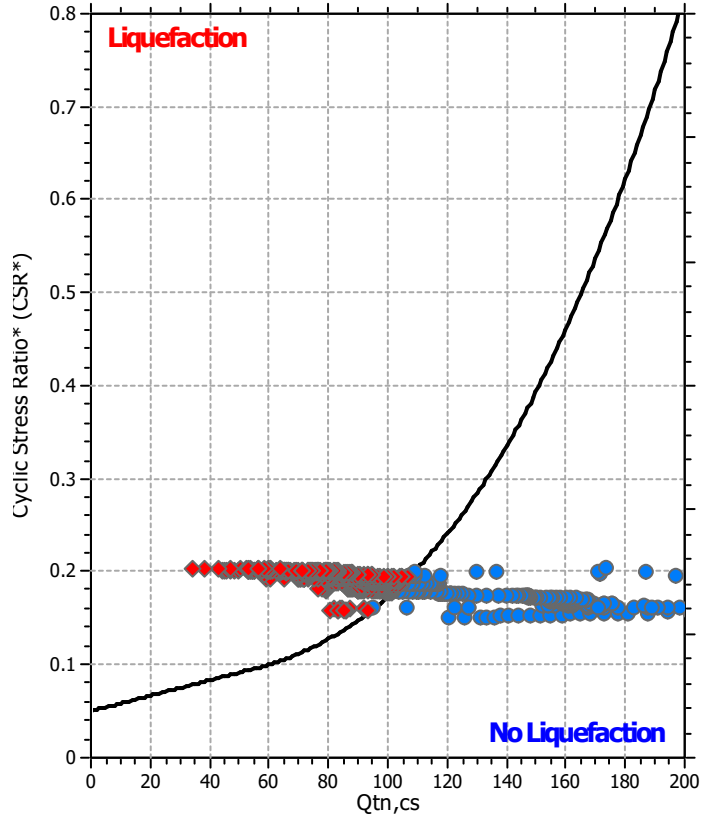
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

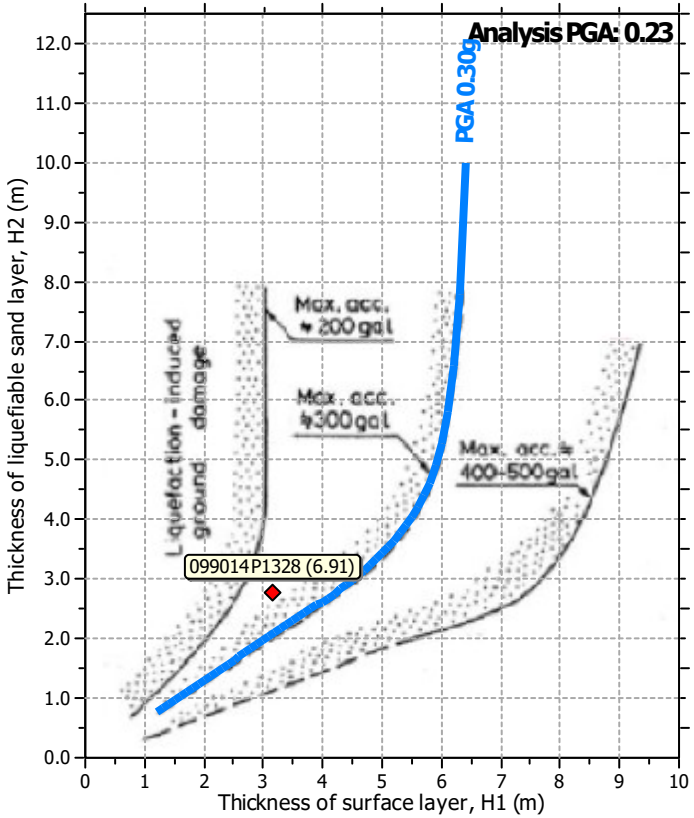
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

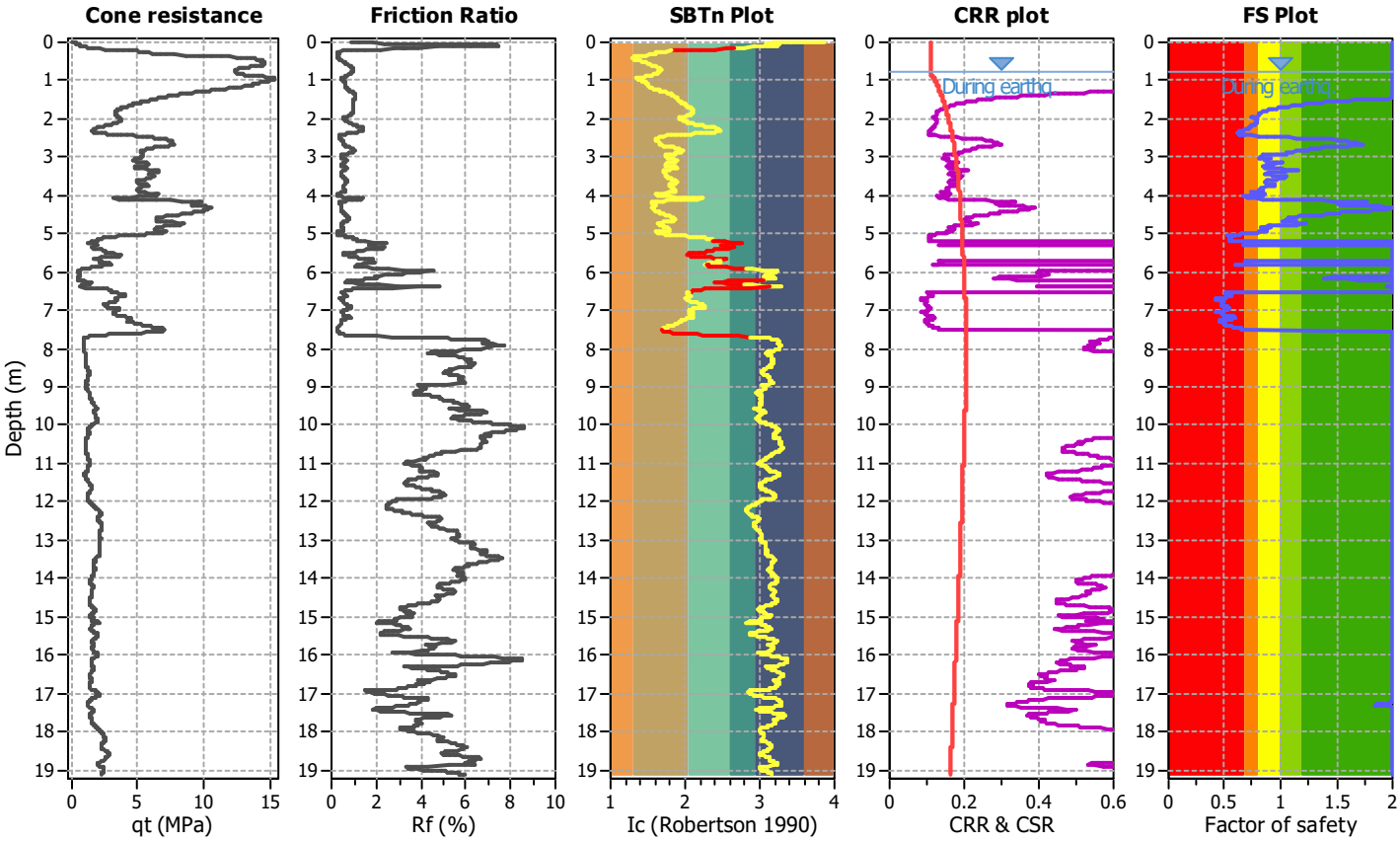
LIQUEFACTION ANALYSIS REPORT

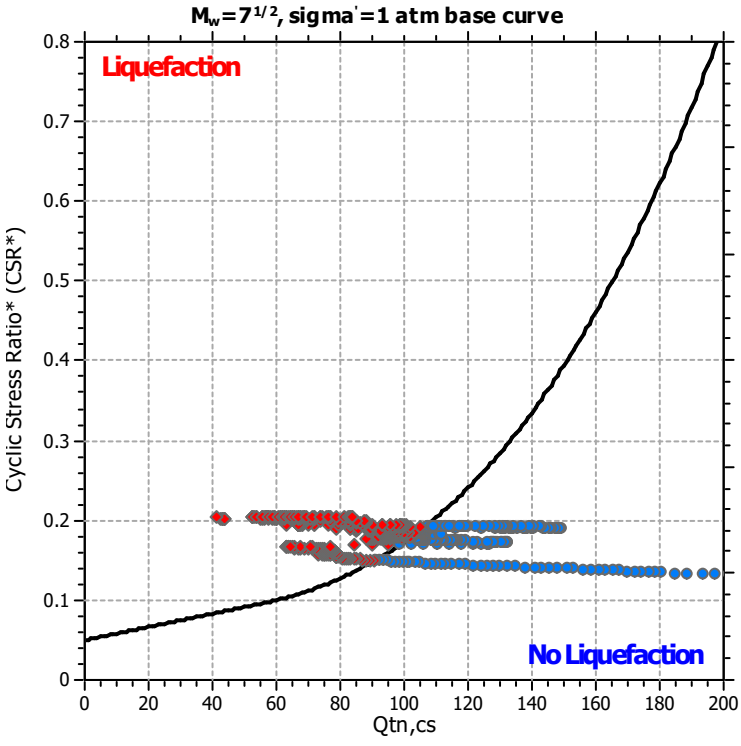
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

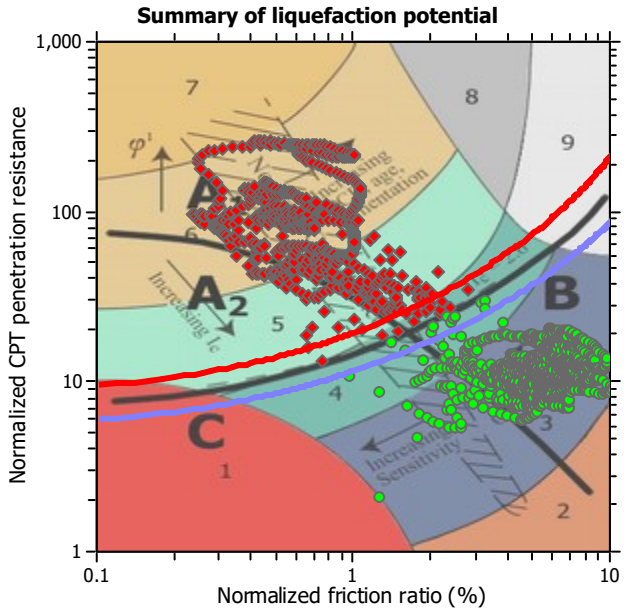
CPT file : CPTe_18

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.20 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

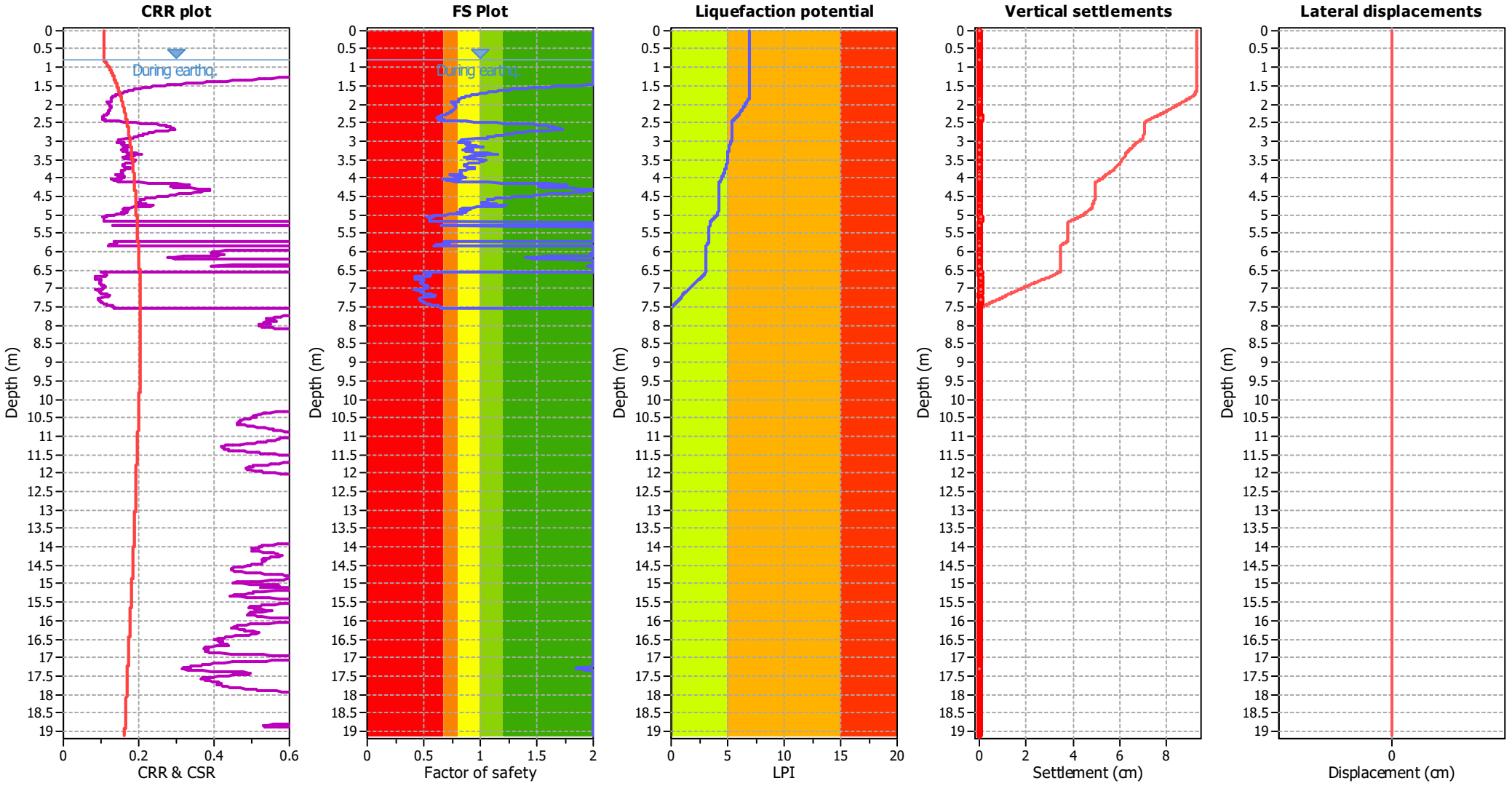






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	20.00 m

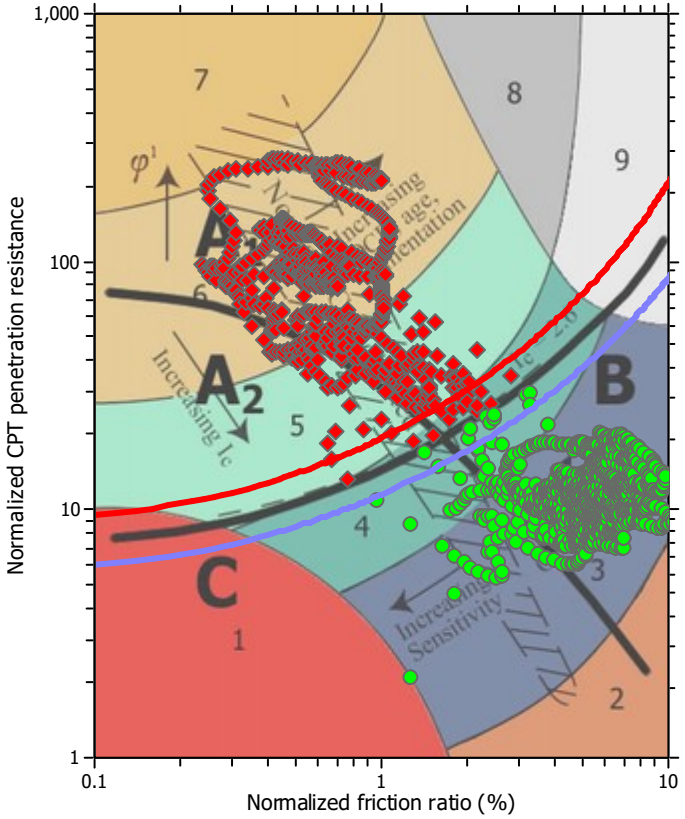
F.S. color scheme

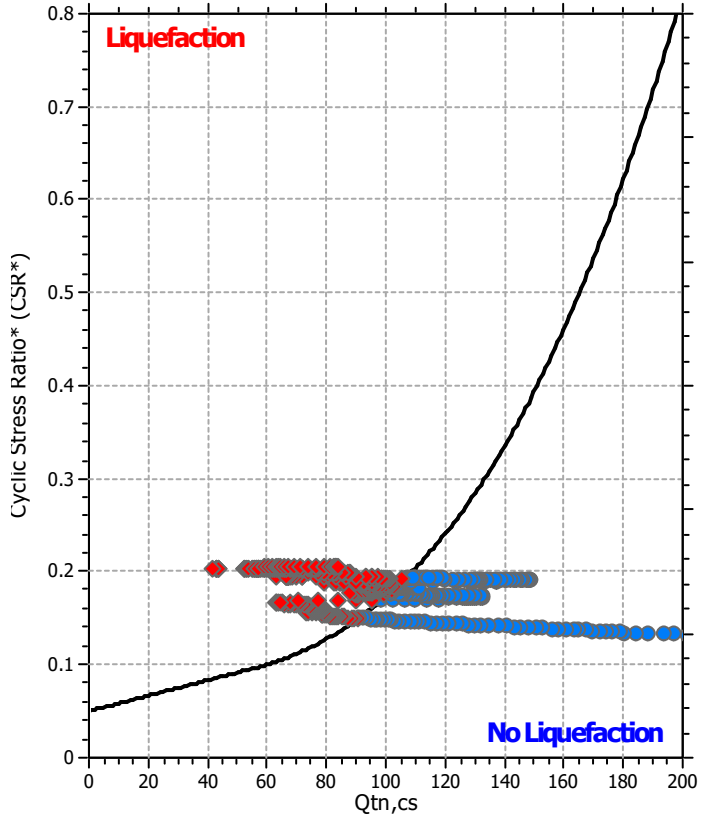
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

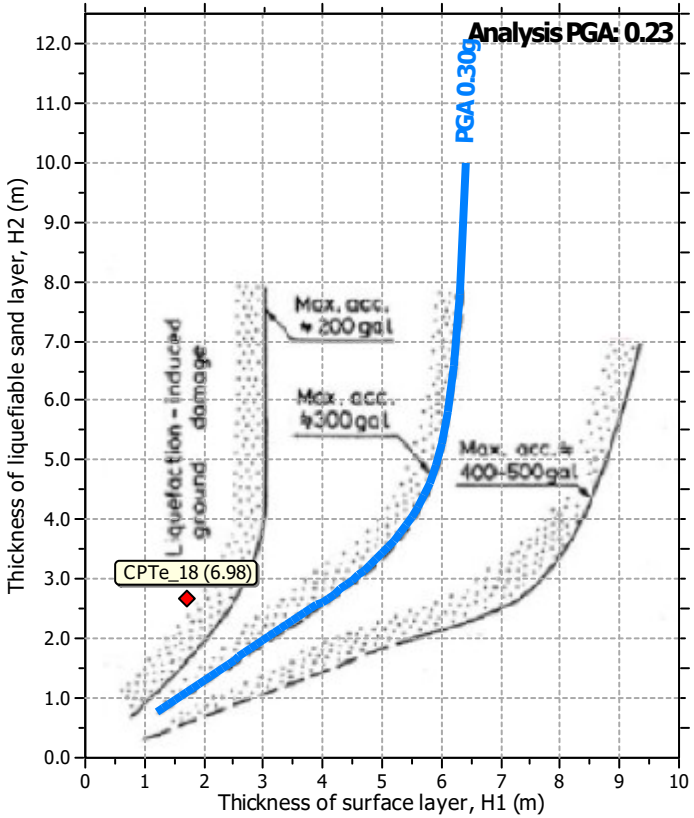
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	1.20 m	Fill height:	N/A	Limit depth:	20.00 m

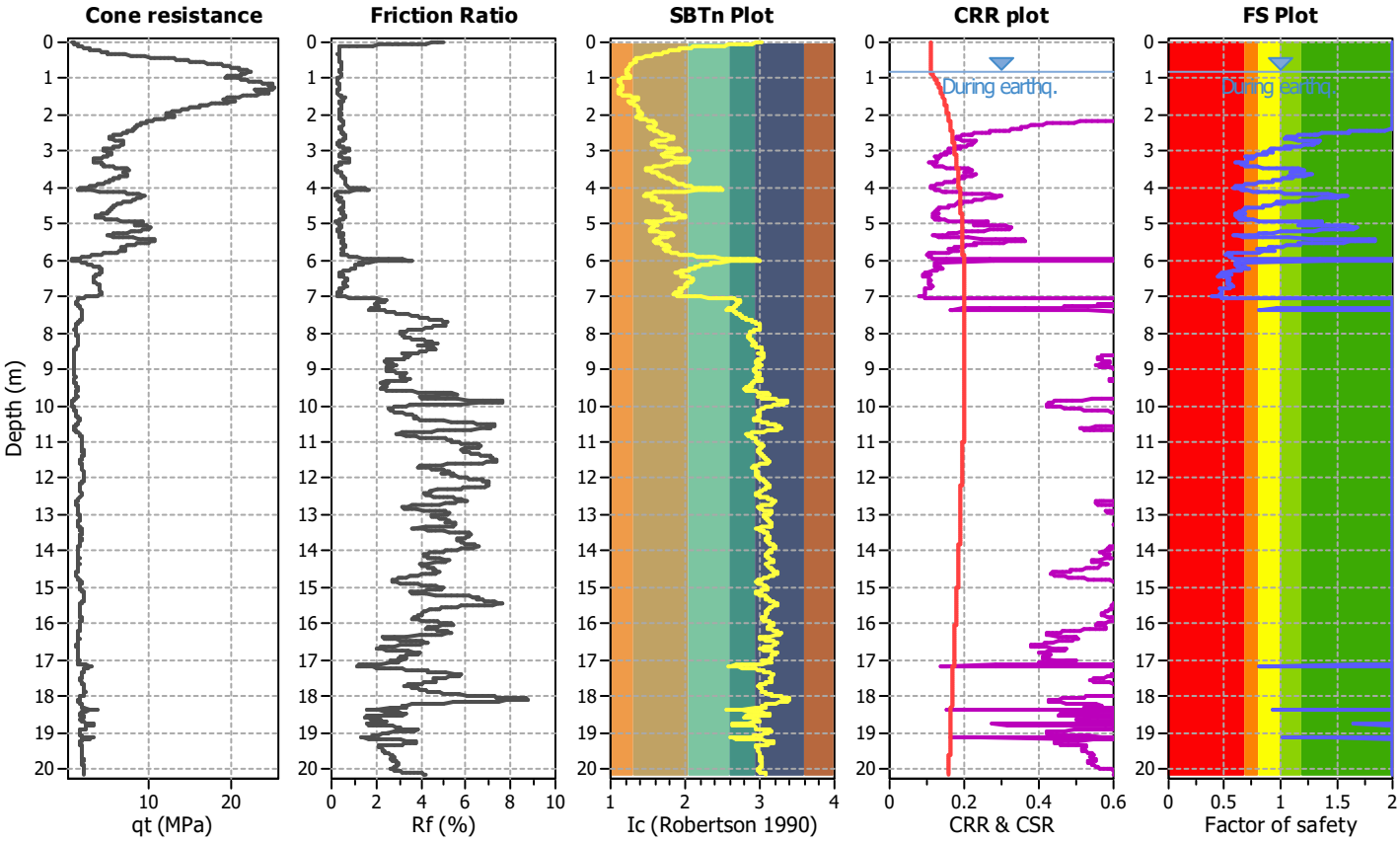
LIQUEFACTION ANALYSIS REPORT

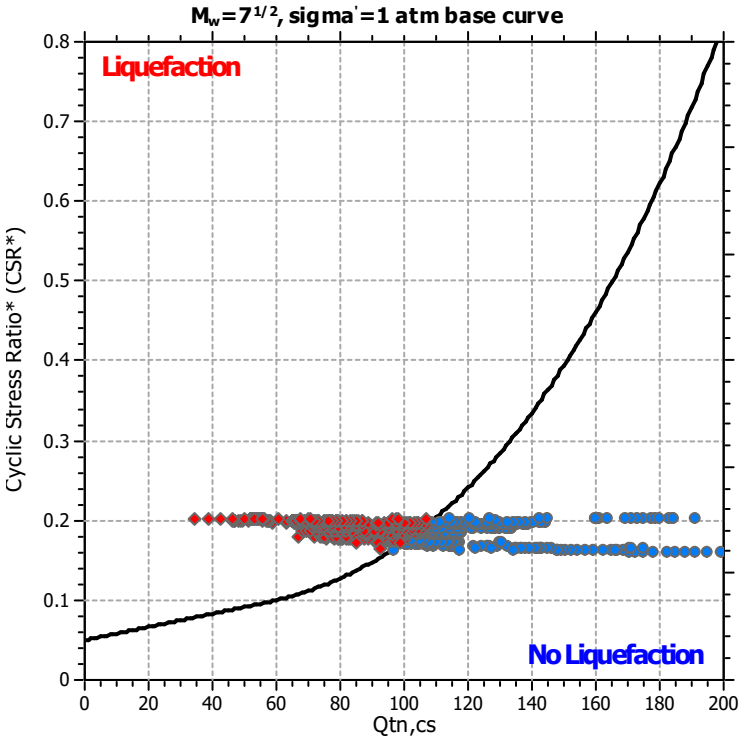
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

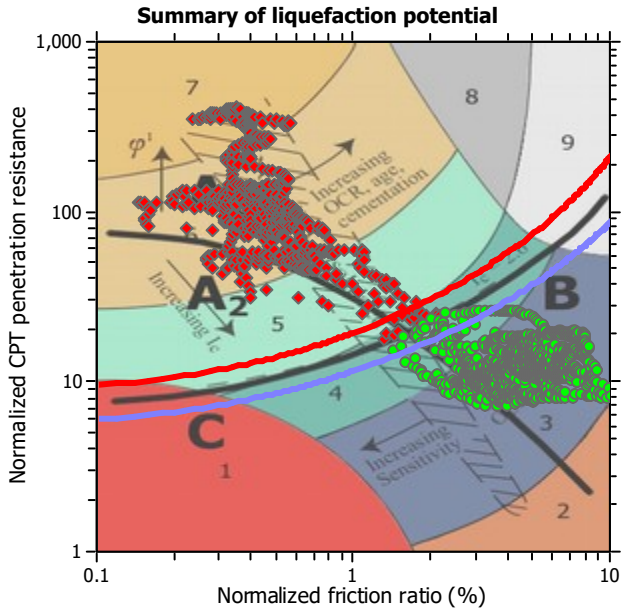
CPT file : 099014P1314

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

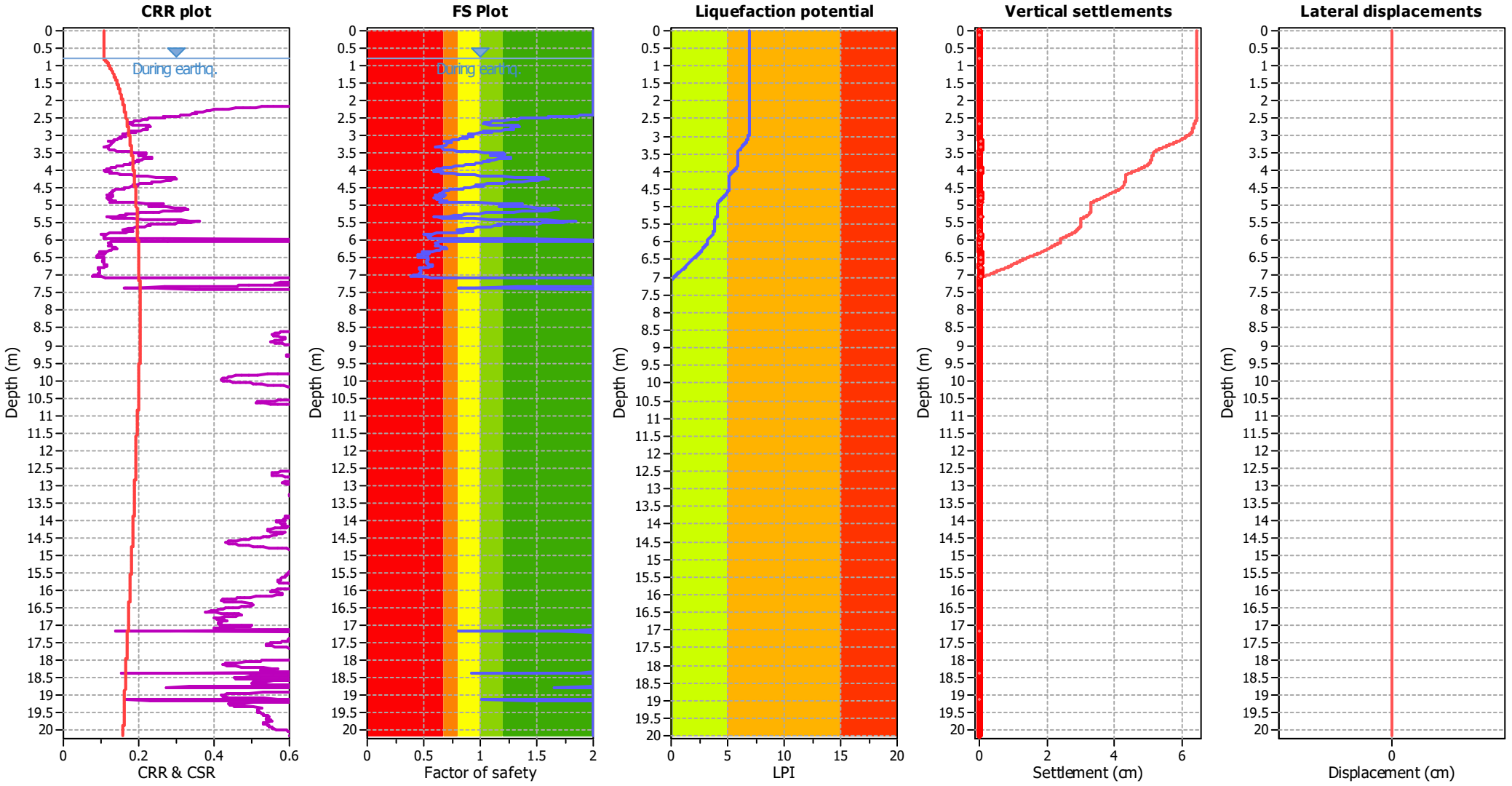






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

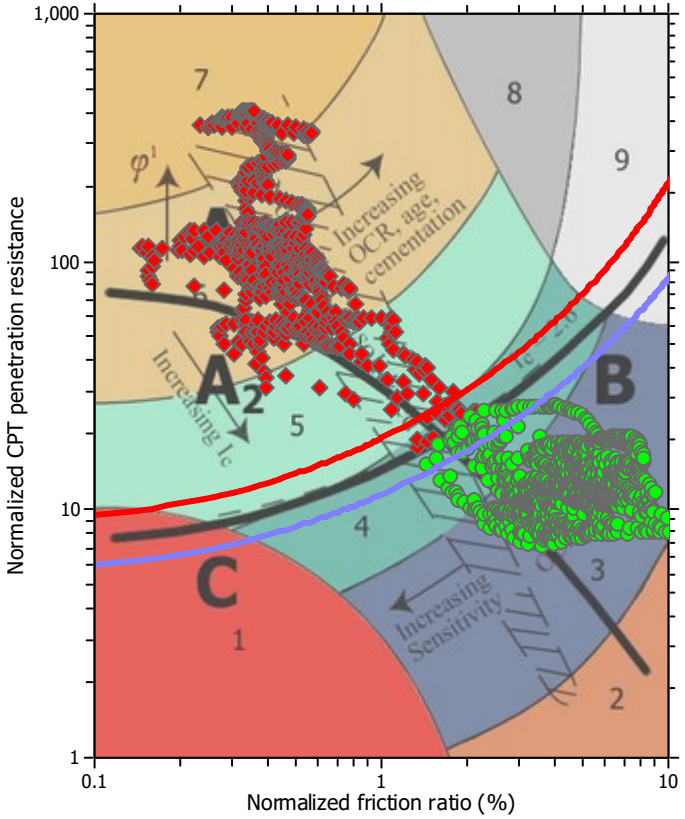
F.S. color scheme

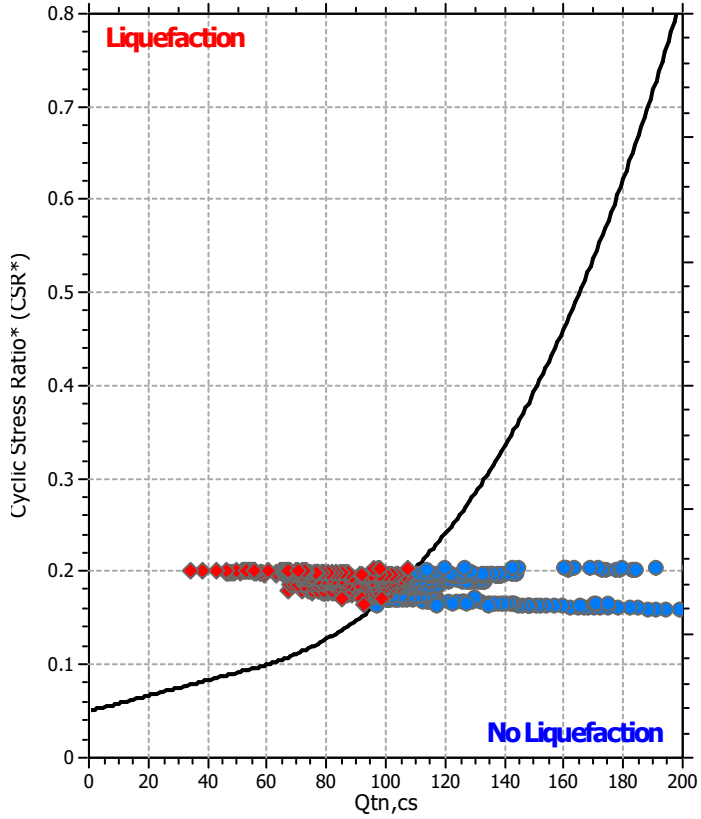
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

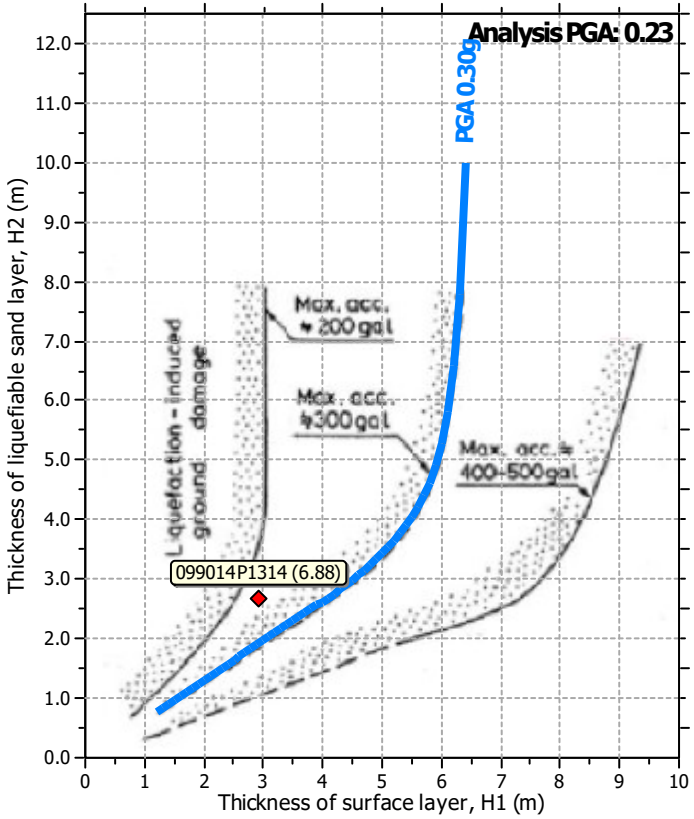
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

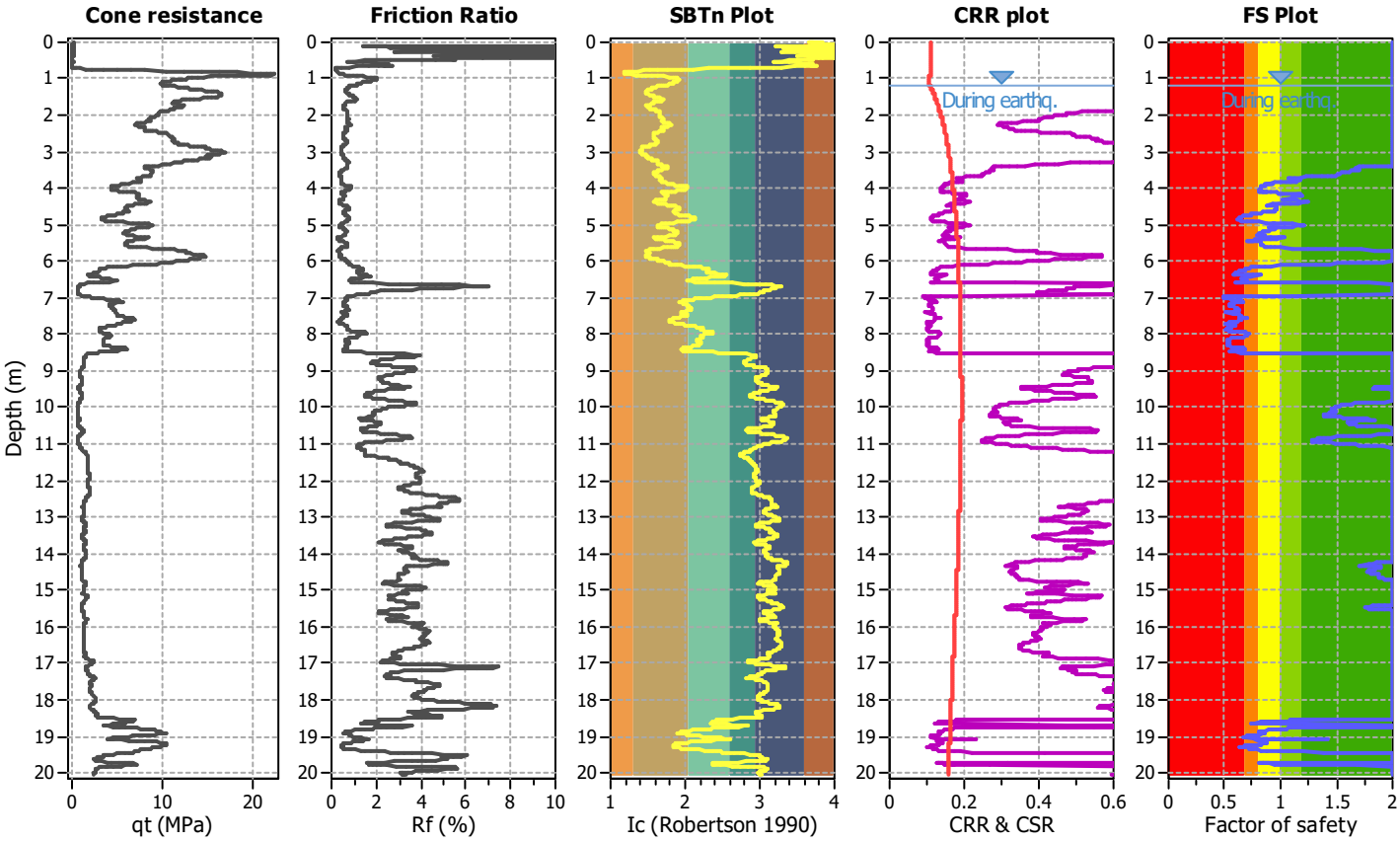
LIQUEFACTION ANALYSIS REPORT

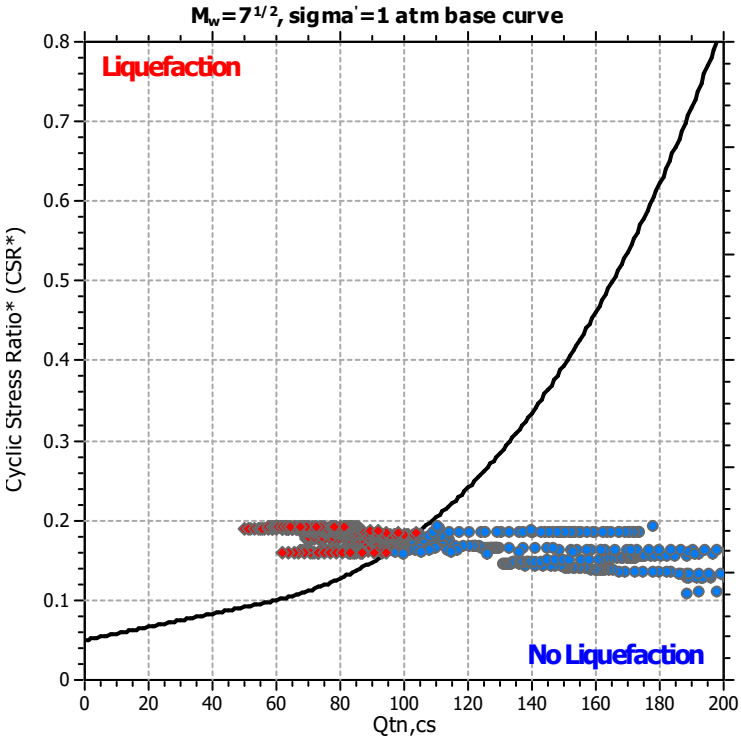
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

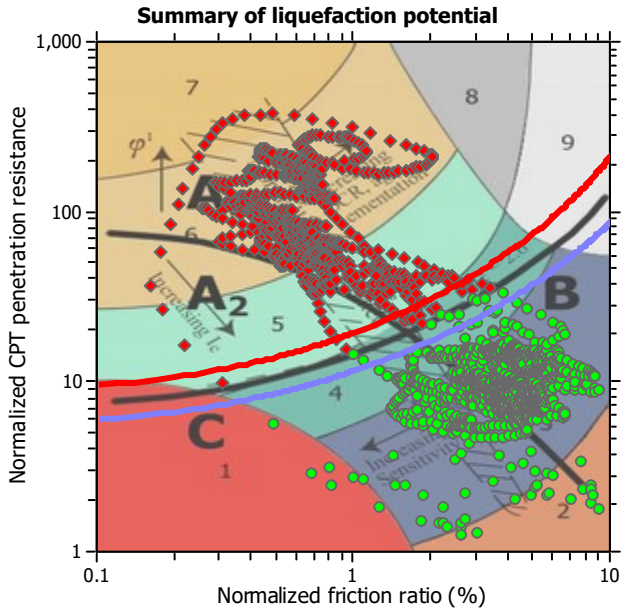
CPT file : 099014P1330

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.95 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.20 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

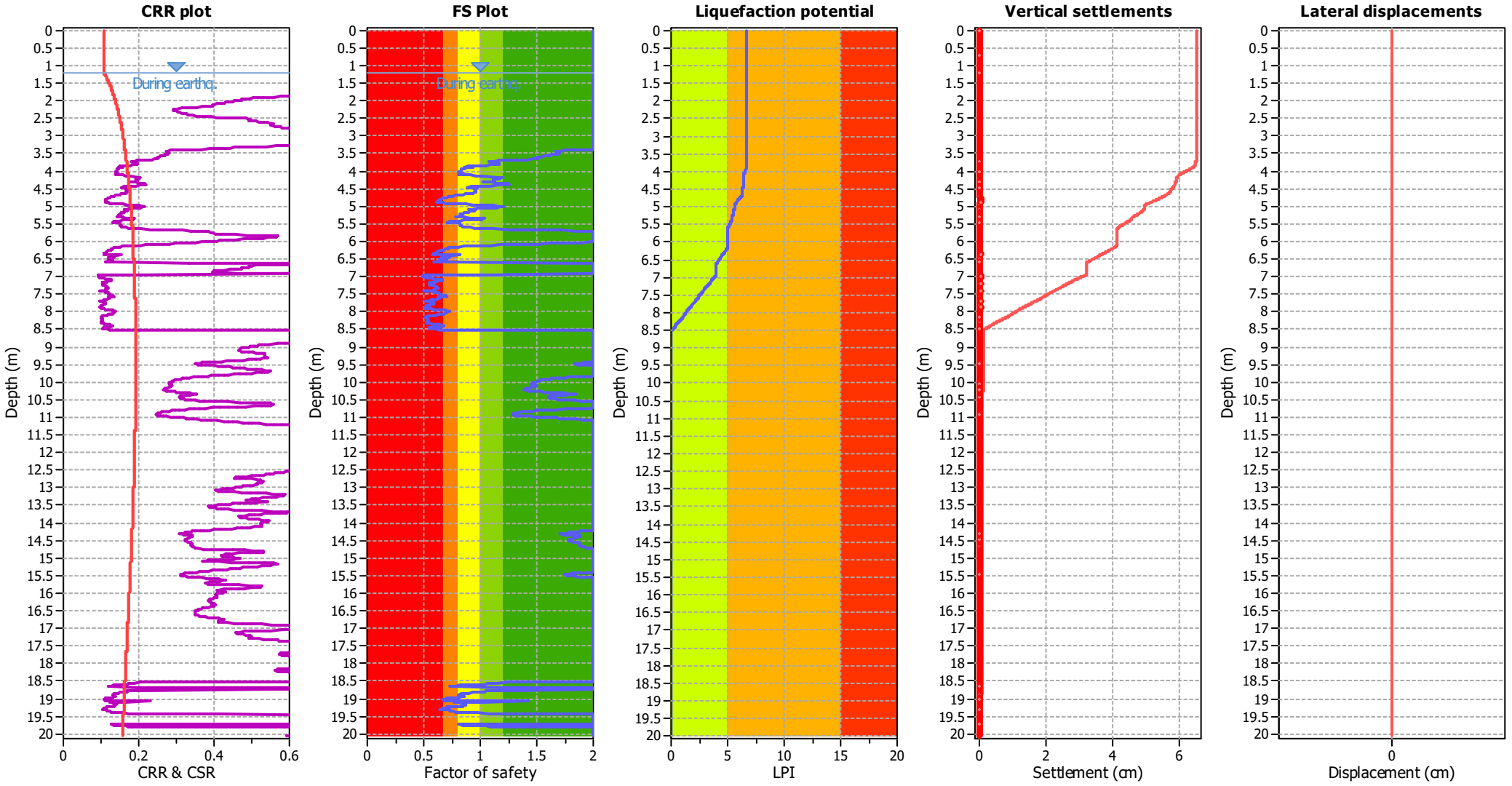






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.20 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.95 m	Fill height:	N/A	Limit depth:	N/A

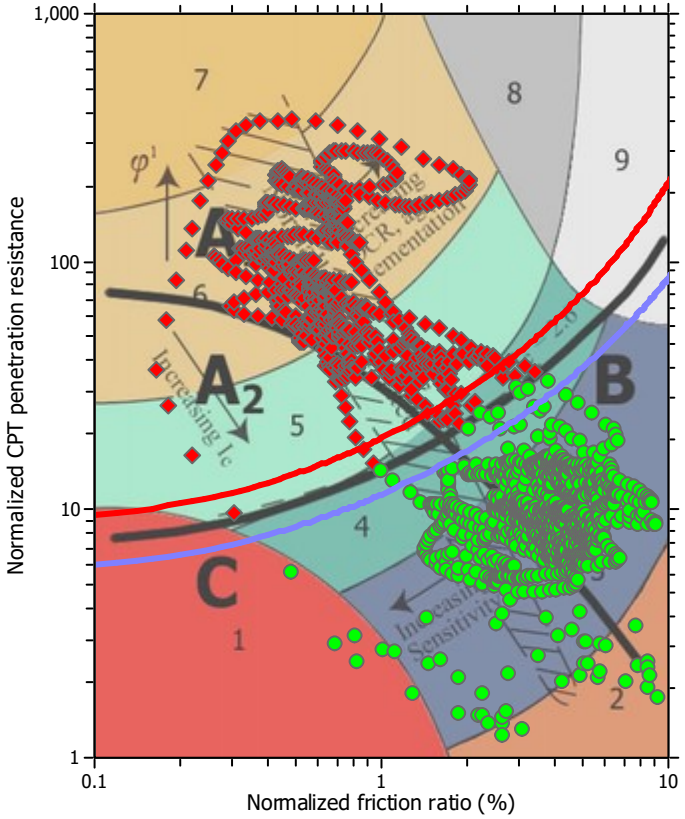
F.S. color scheme

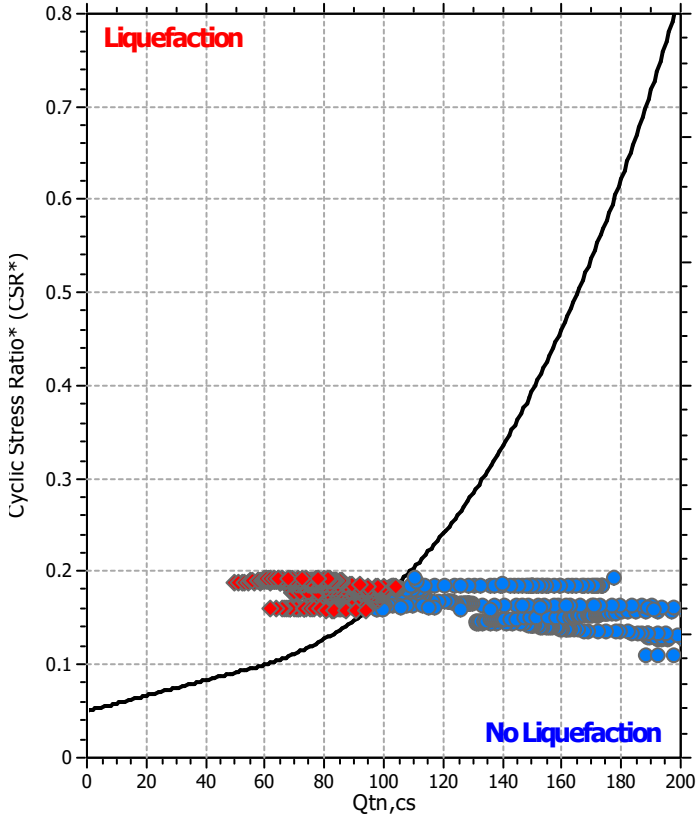
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

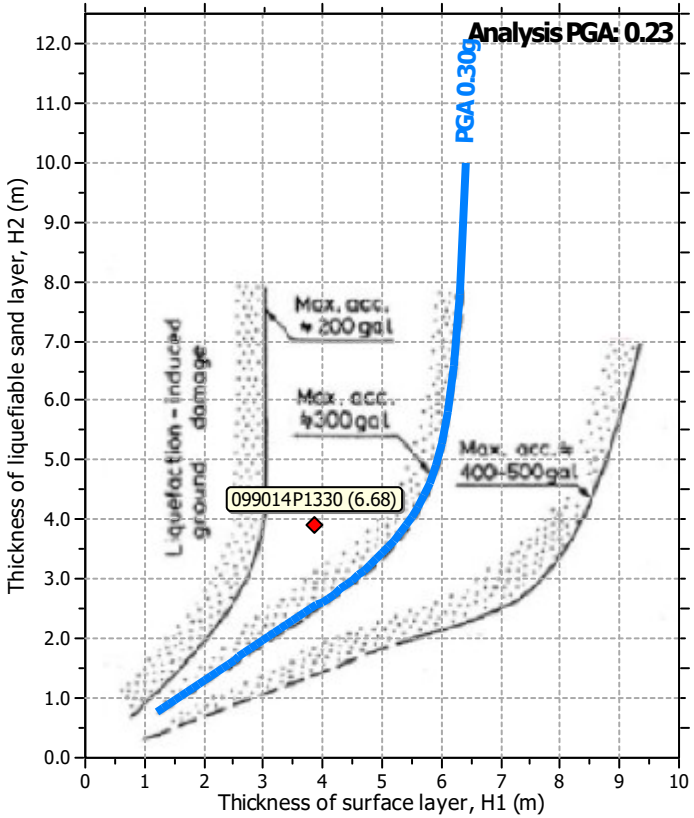
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.20 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.95 m	Fill height:	N/A	Limit depth:	N/A

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

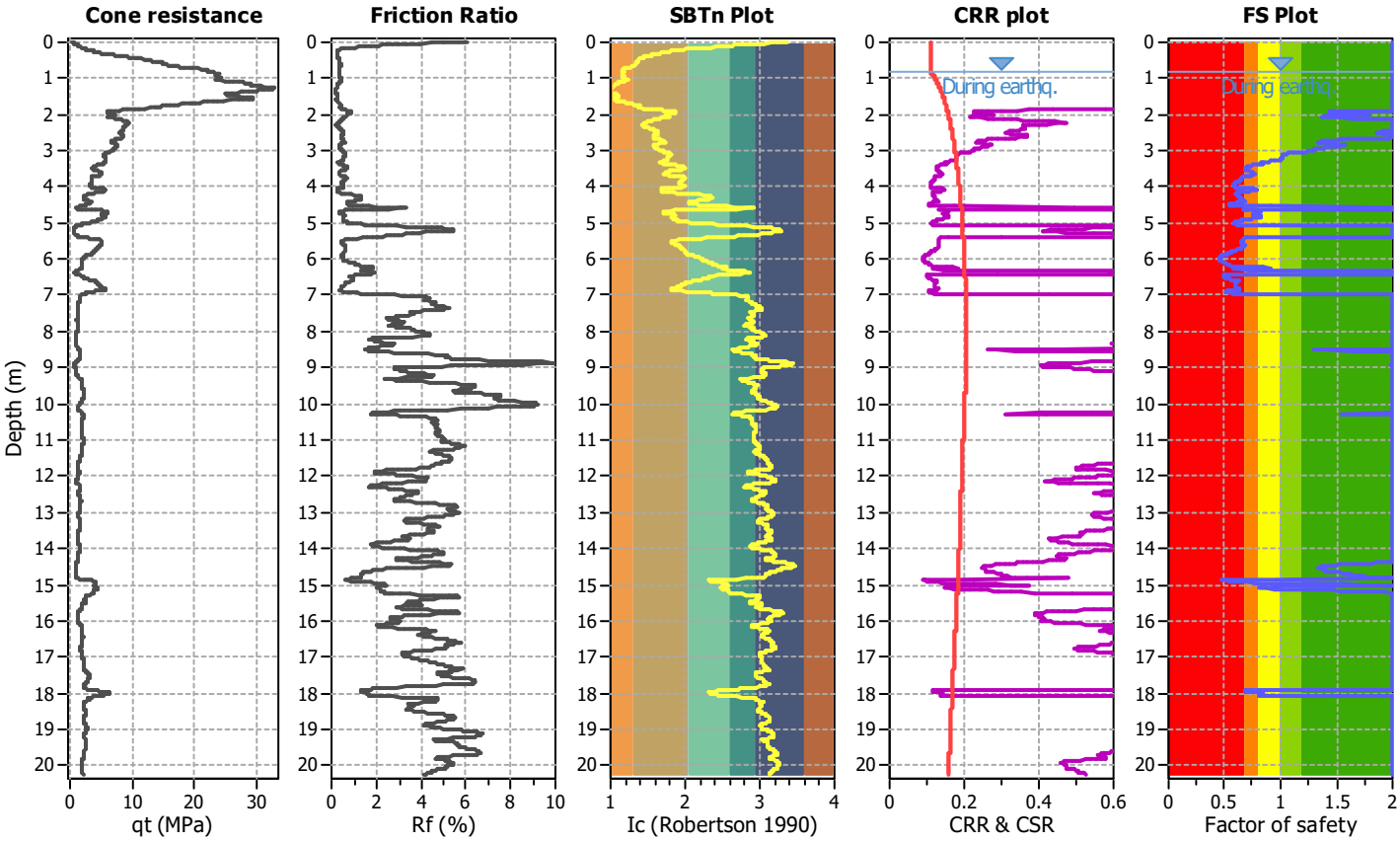
LIQUEFACTION ANALYSIS REPORT

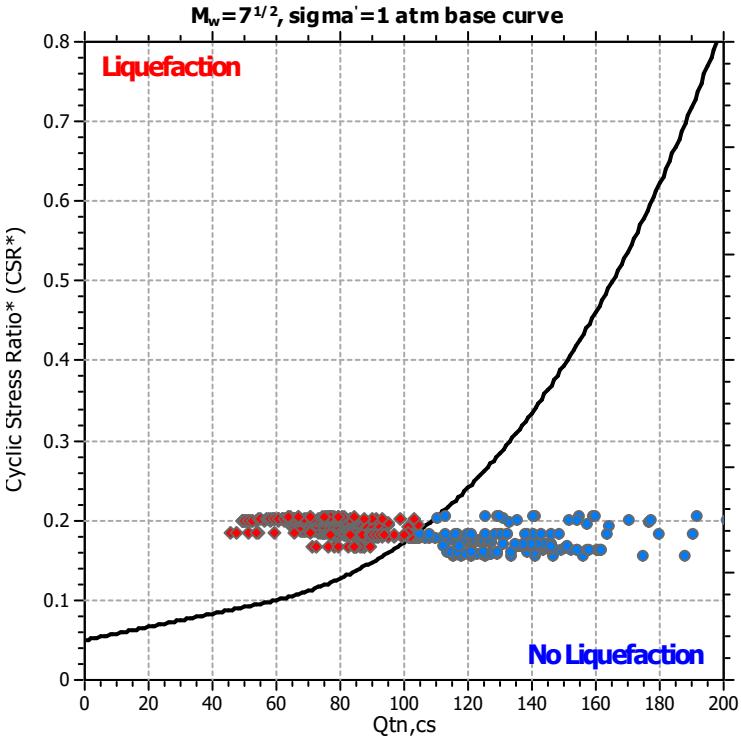
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

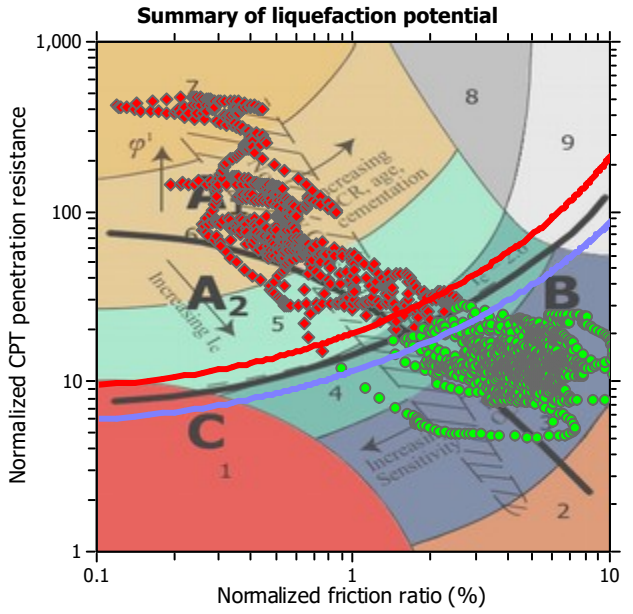
CPT file : 099014P1317

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

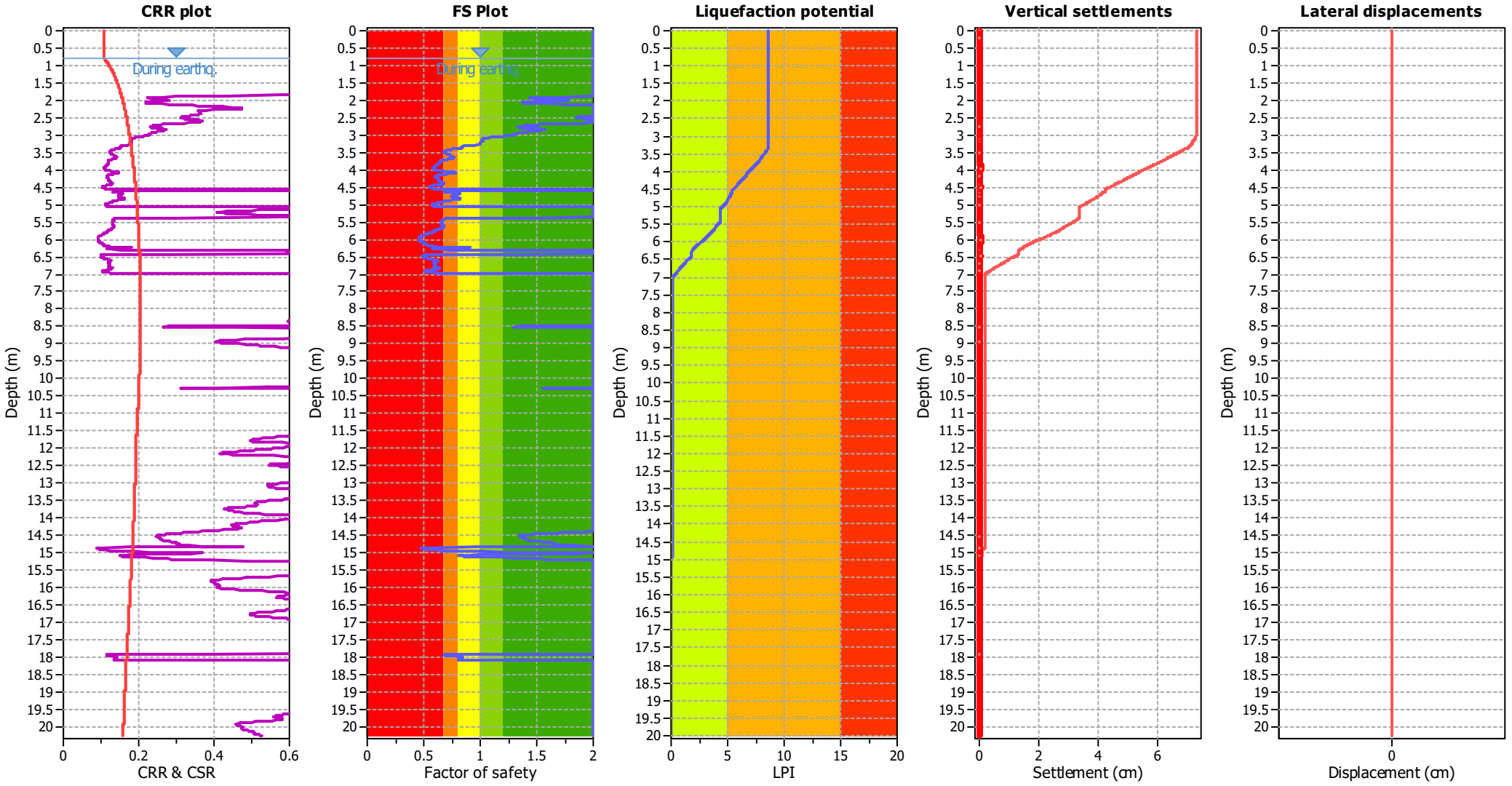






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

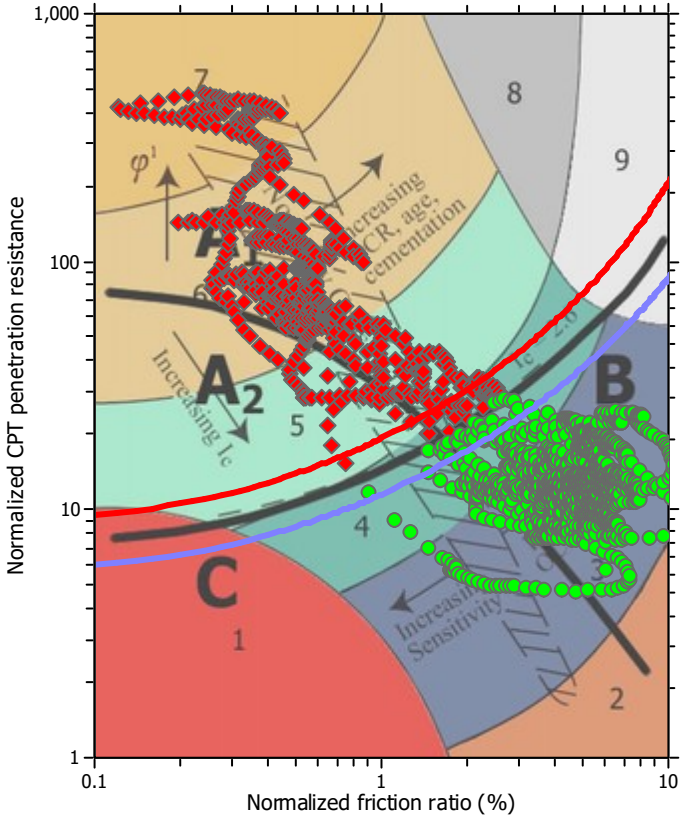
F.S. color scheme

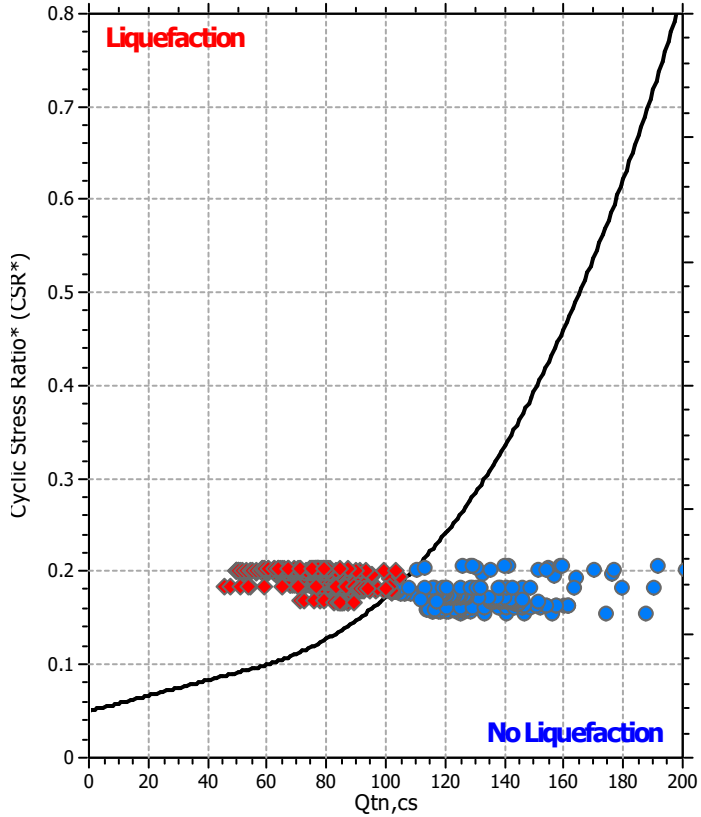
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

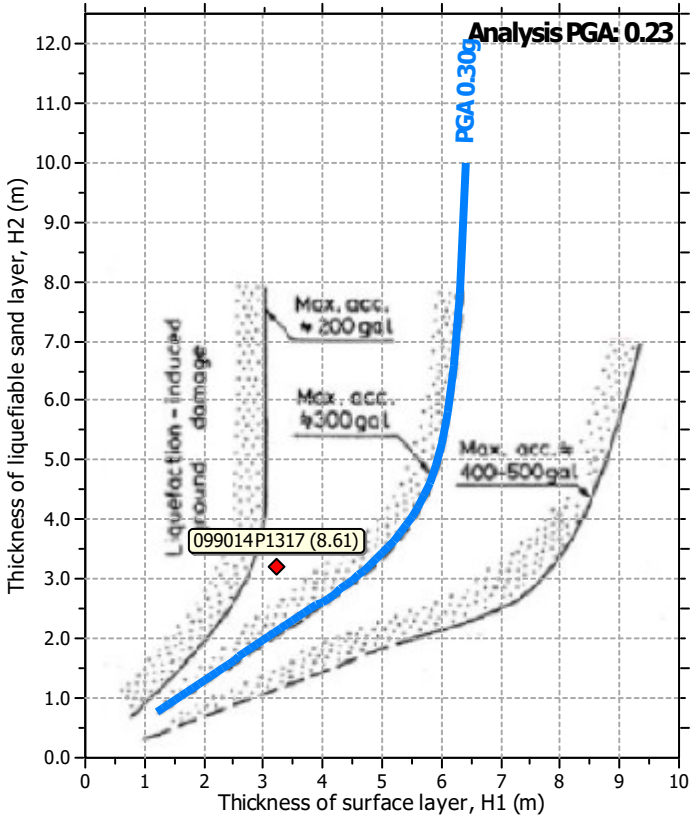
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

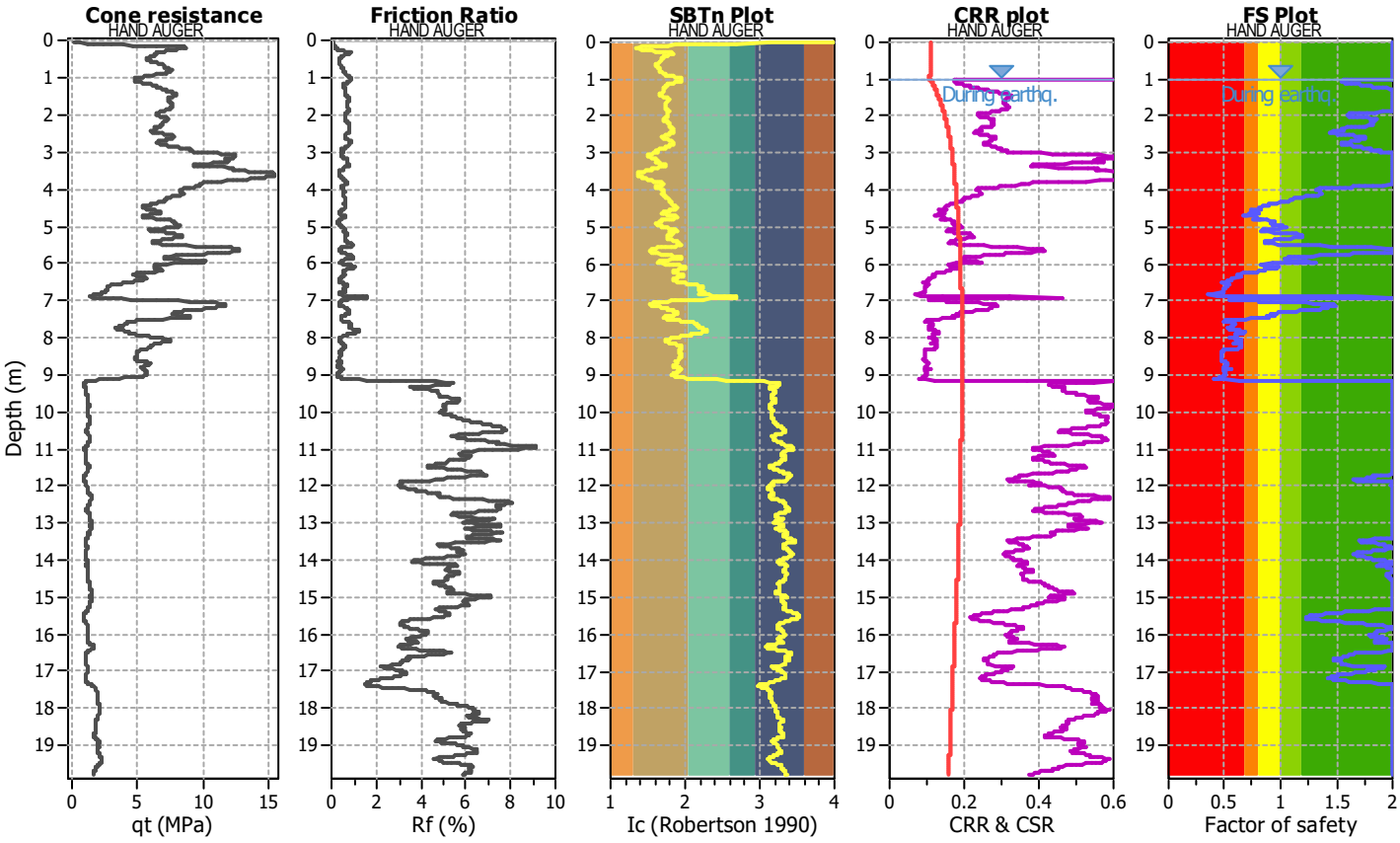
LIQUEFACTION ANALYSIS REPORT

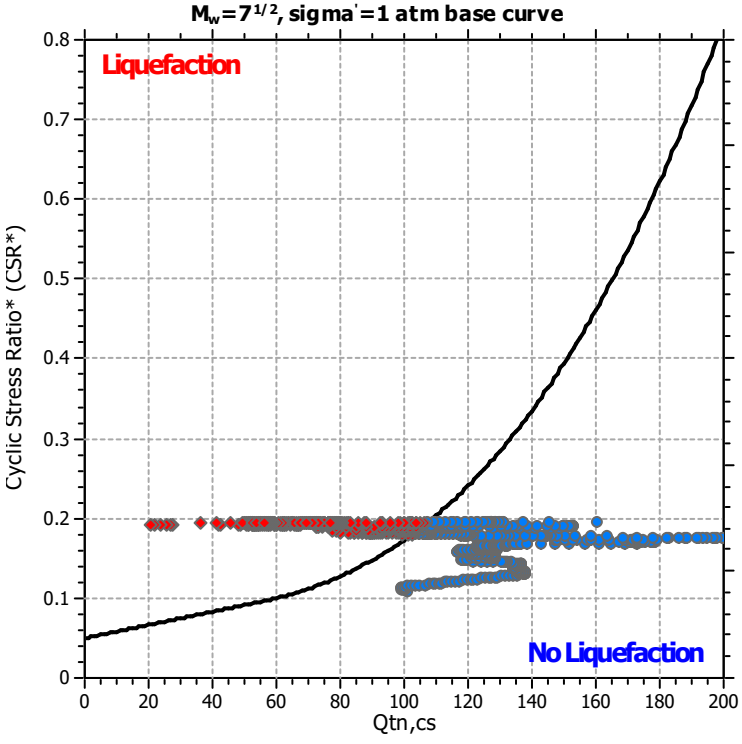
Project title : MS3_PA_Rimini_RNS_04 **Location : Rimini**

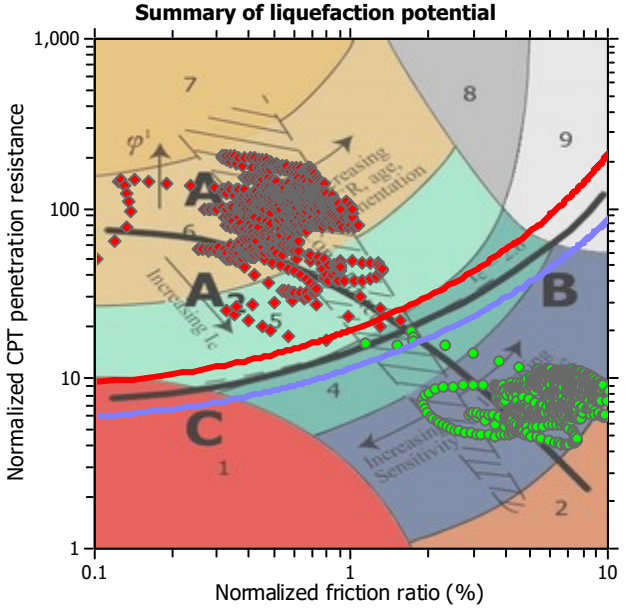
CPT file : CPTE_25

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	2.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	20.00 m
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.23	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

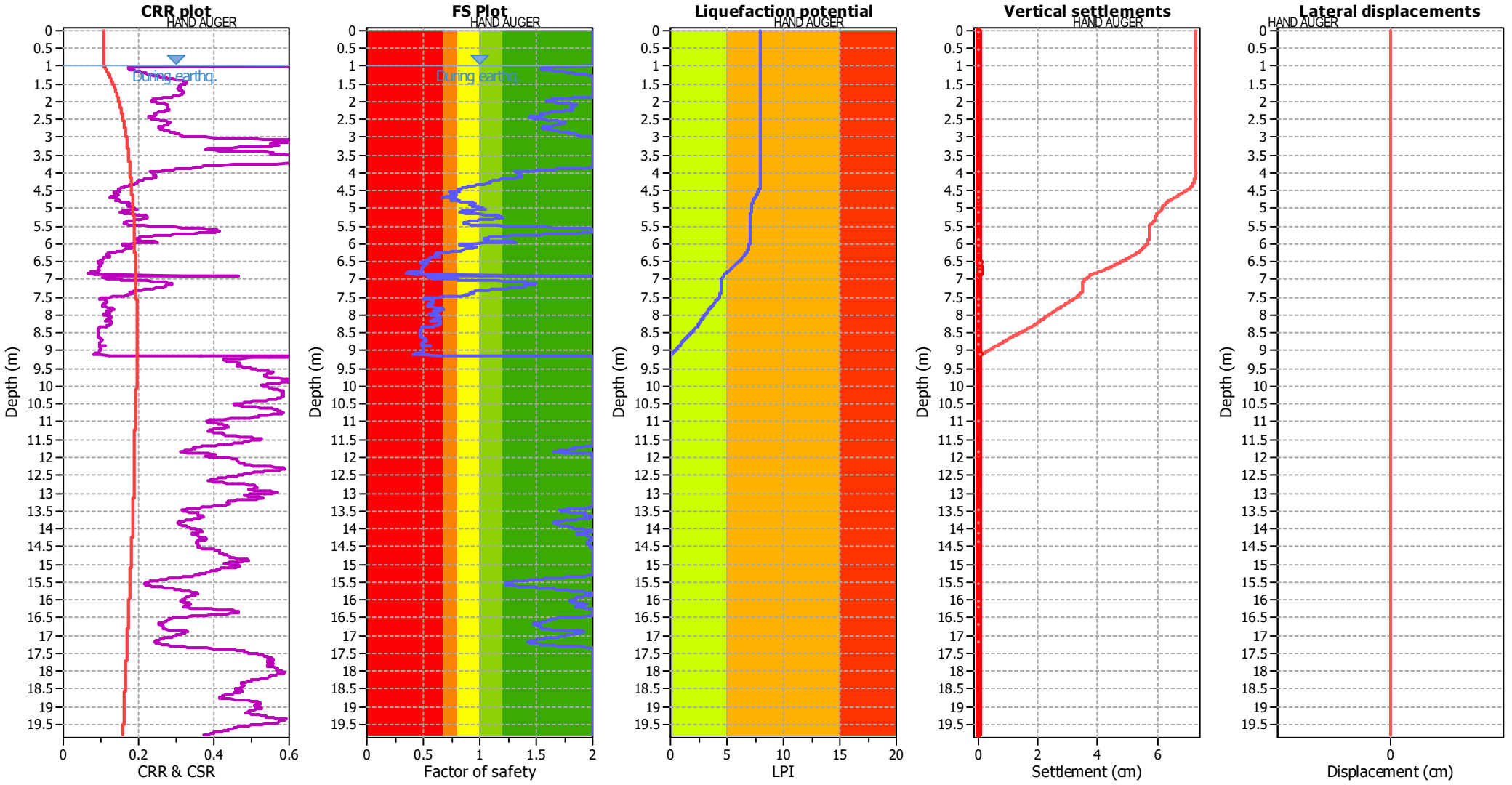






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

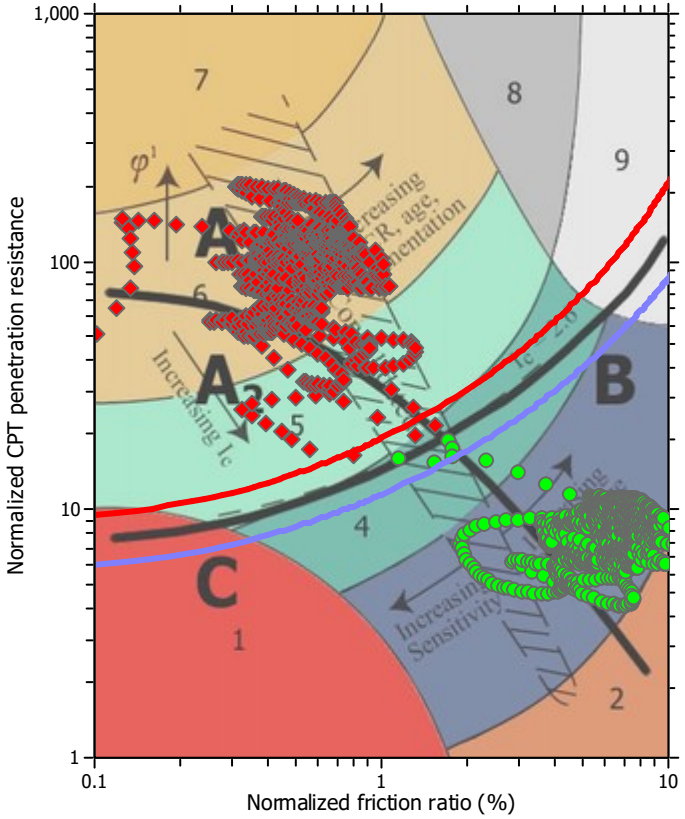
F.S. color scheme

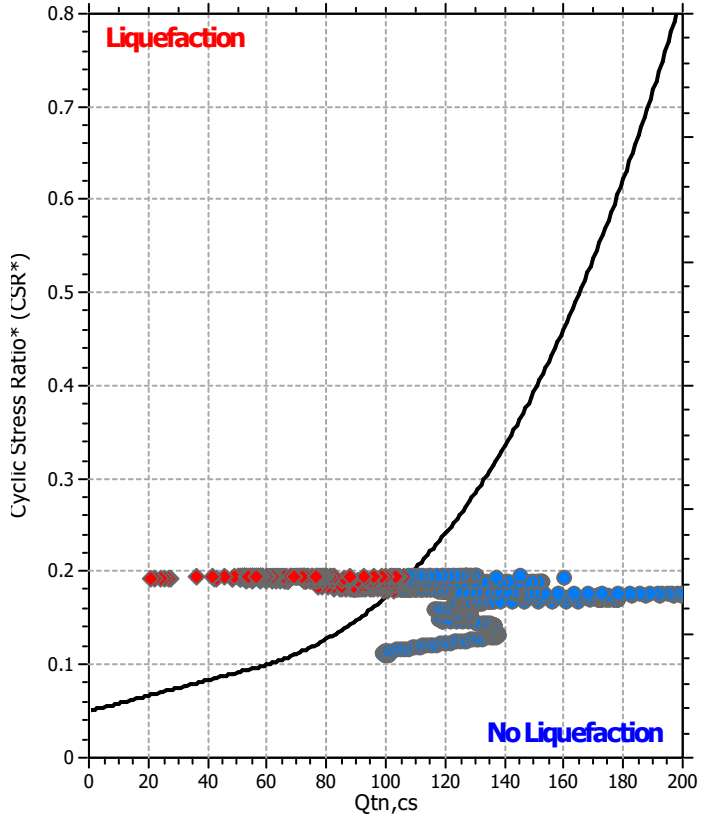
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

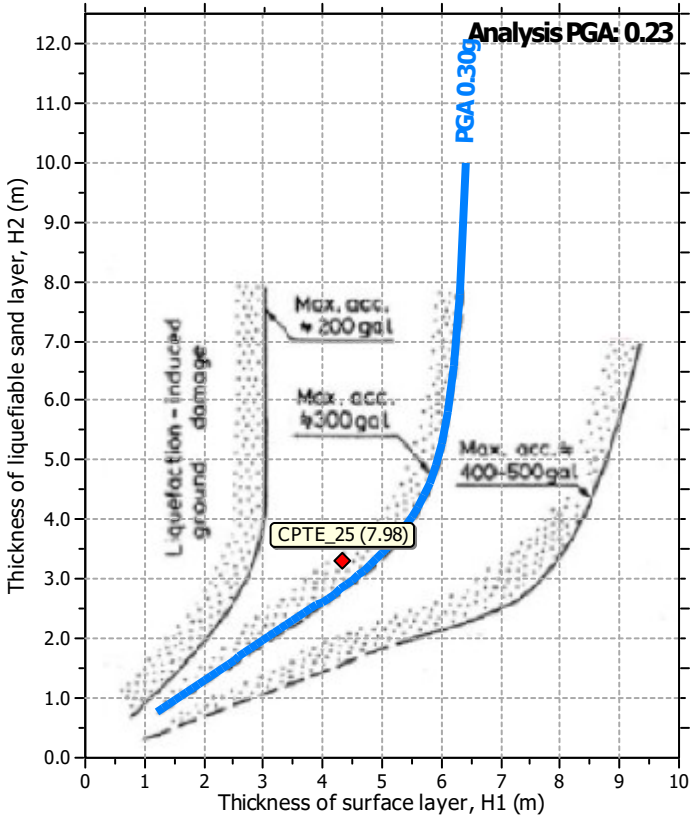
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.23	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	2.00 m	Fill height:	N/A	Limit depth:	20.00 m

REPORT - ZONA RNS_05

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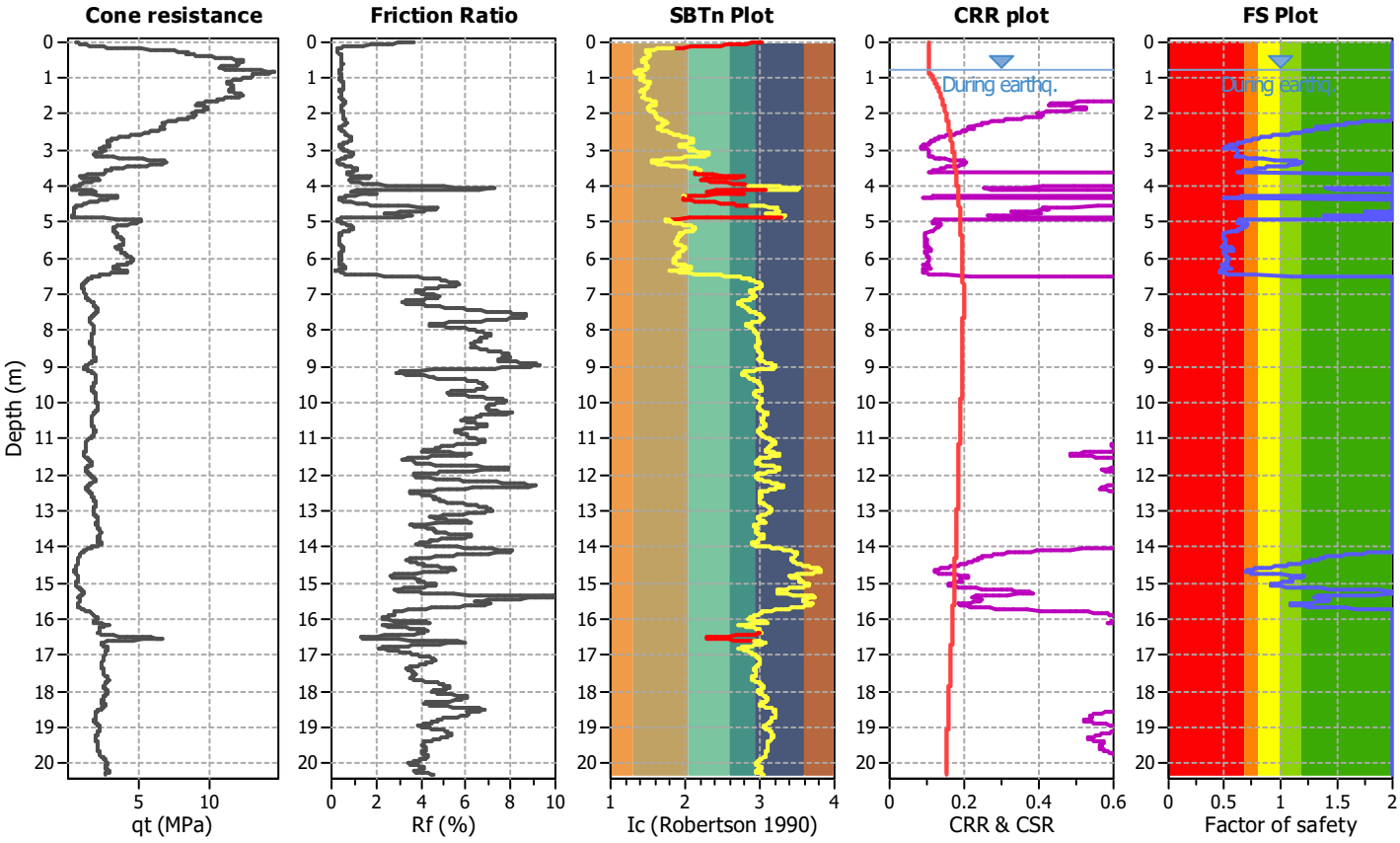
LIQUEFACTION ANALYSIS REPORT

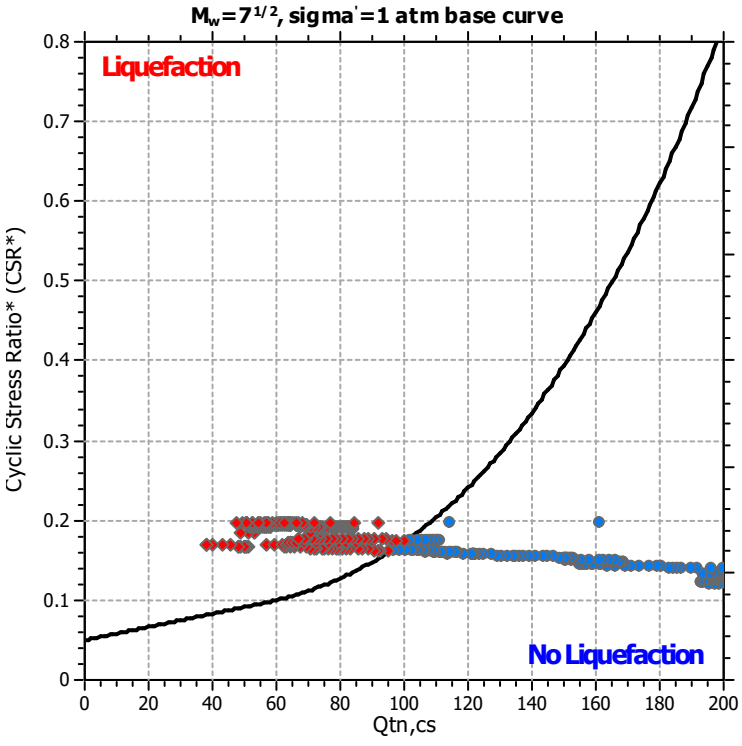
Project title : MS3_PA_Rimini_RNS_05 **Location : Rimini**

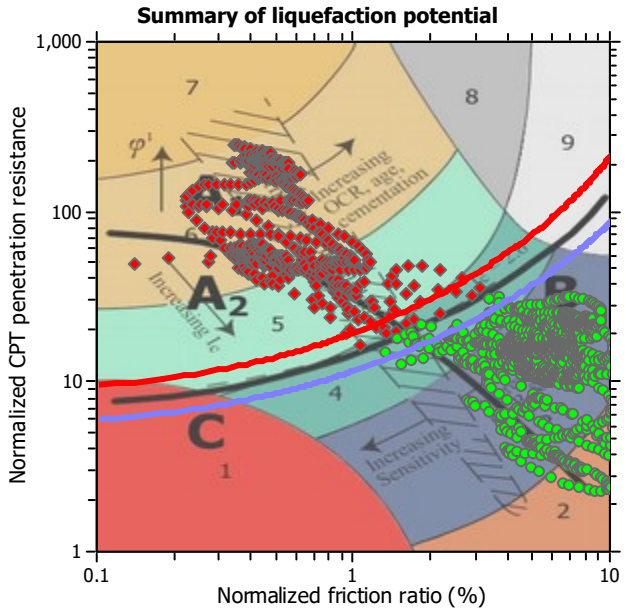
CPT file : 099014P1319

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.22	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

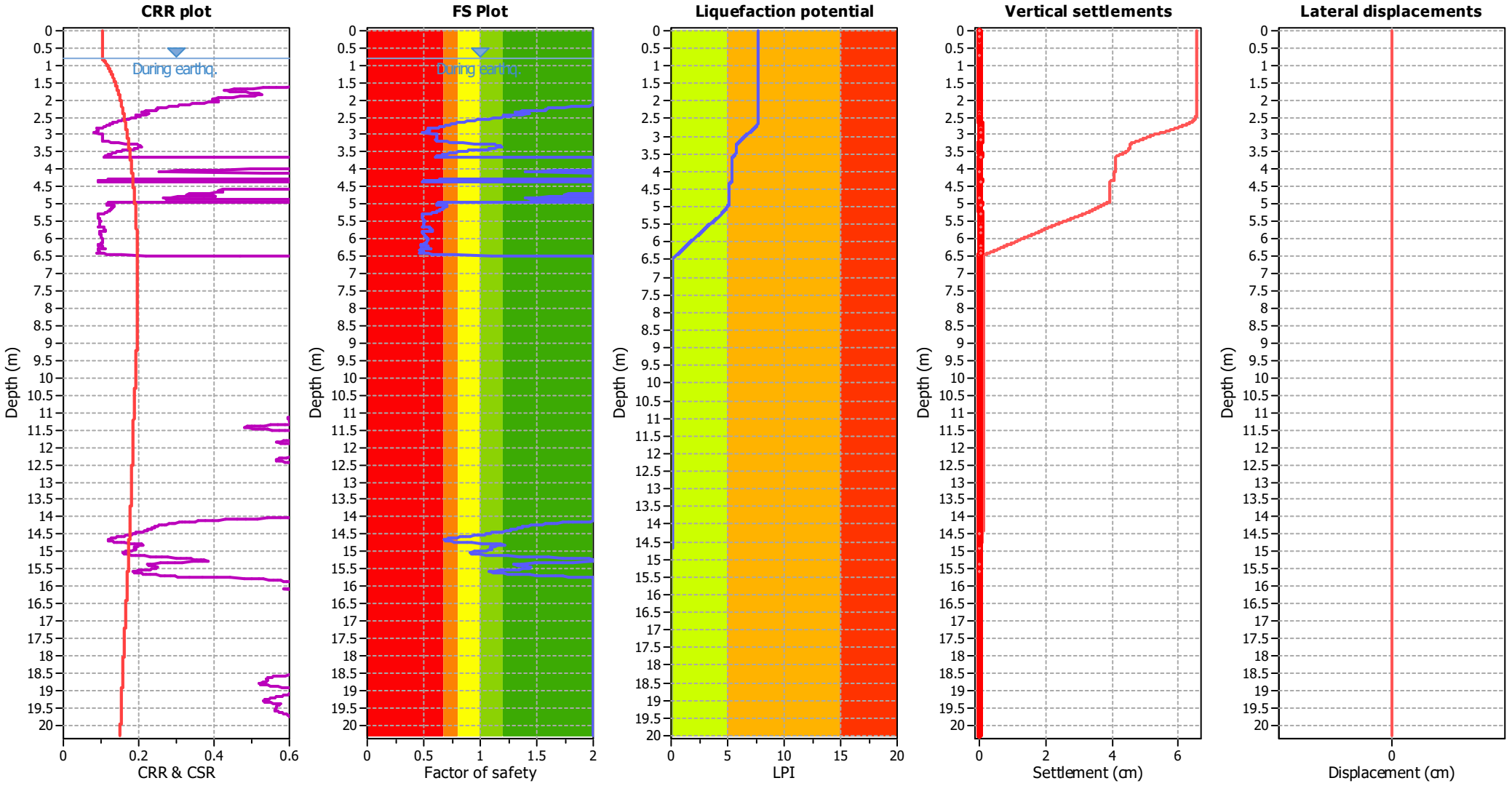






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

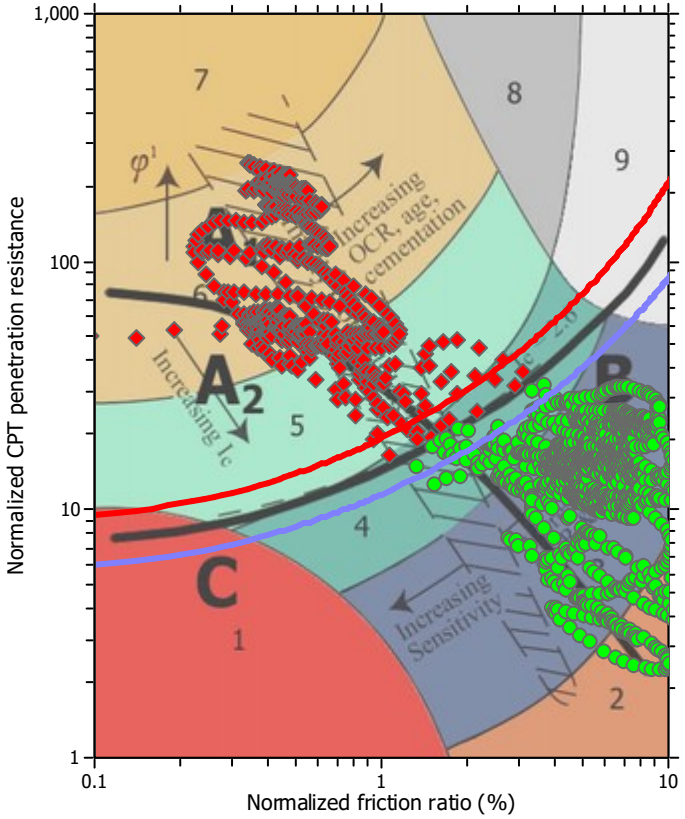
F.S. color scheme

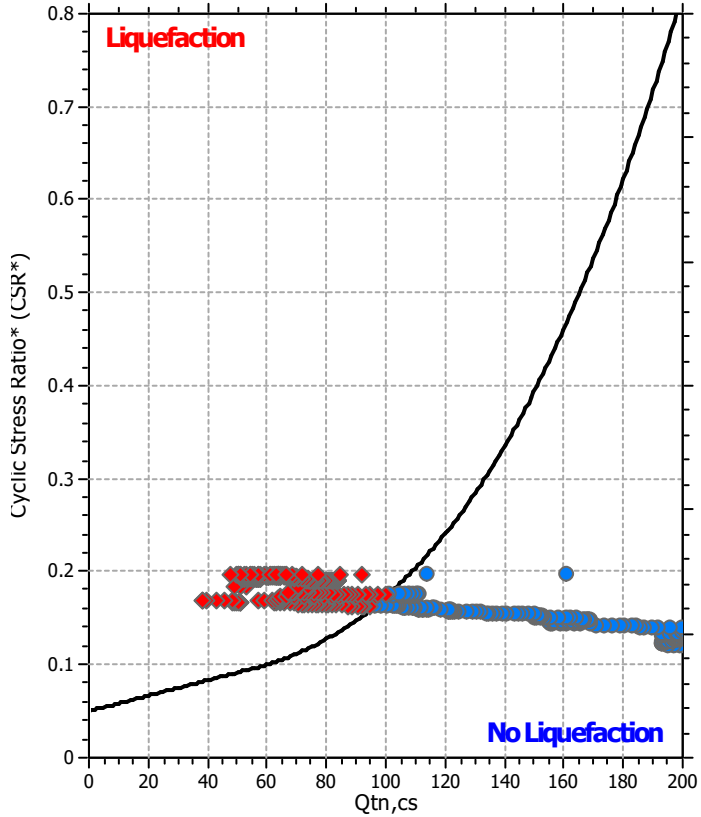
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

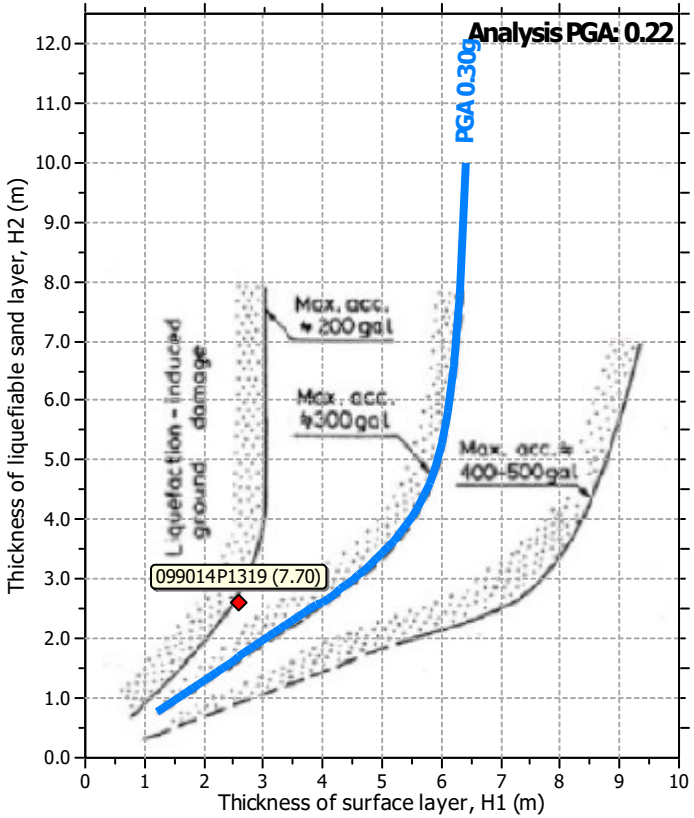
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

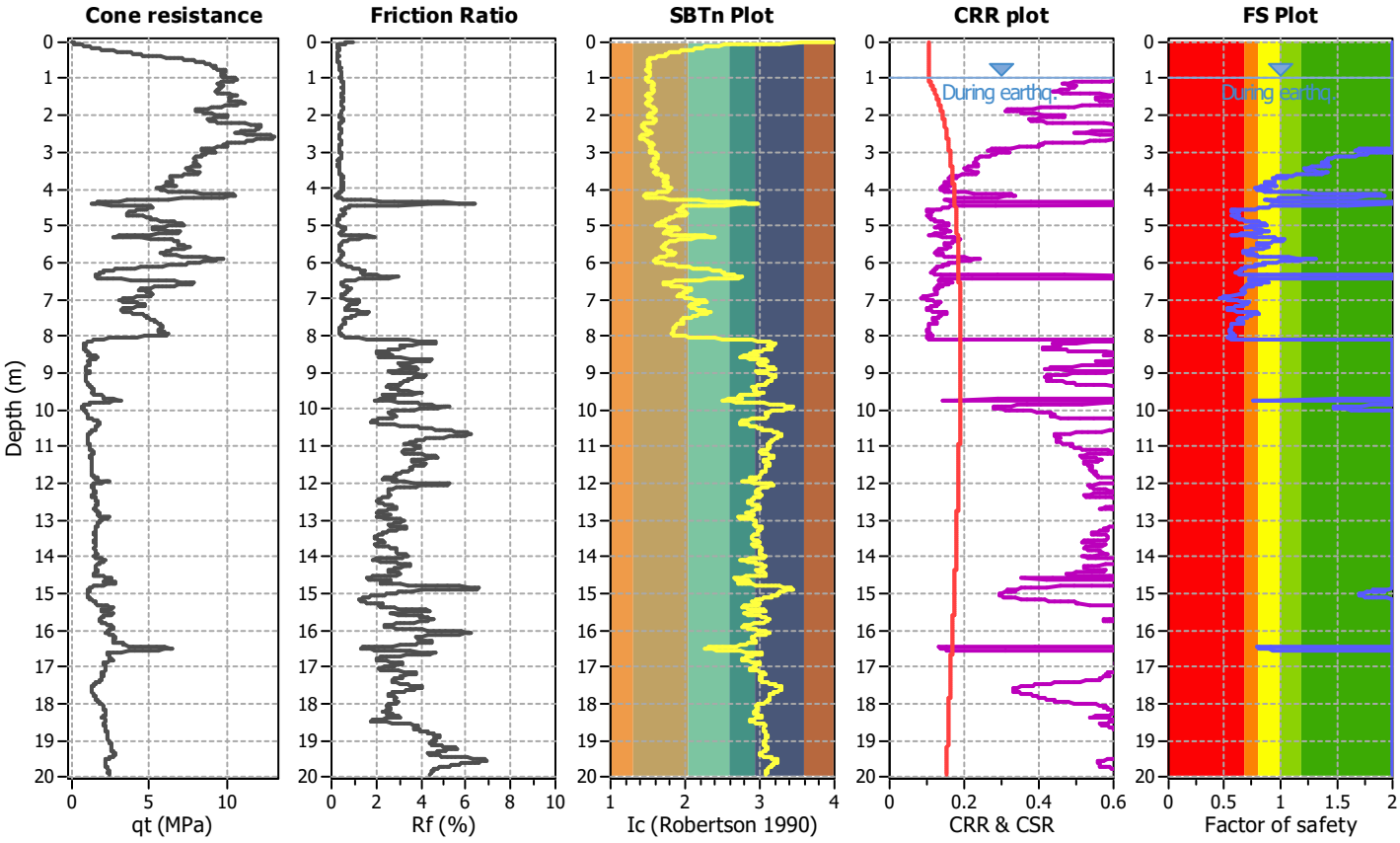
LIQUEFACTION ANALYSIS REPORT

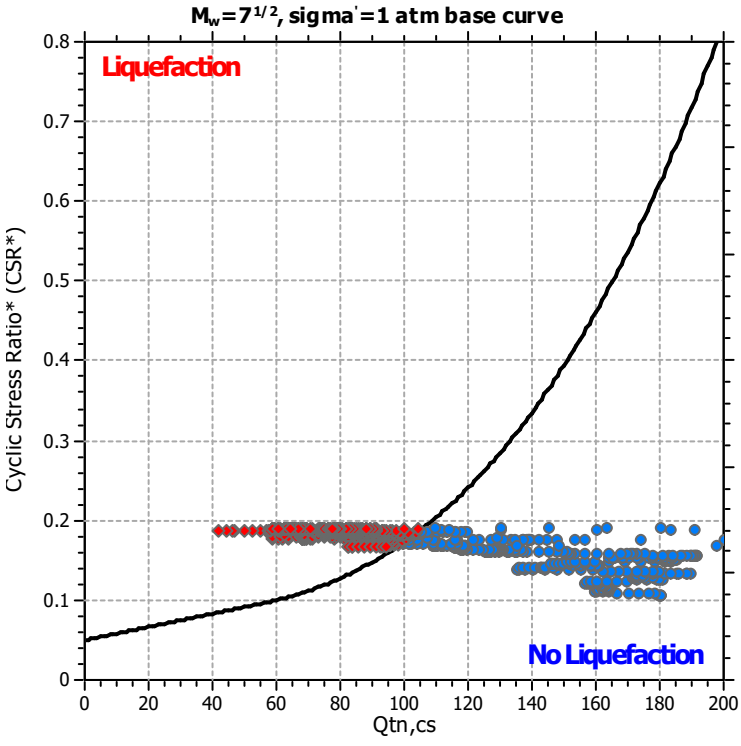
Project title : MS3_PA_Rimini_RNS_05 **Location : Rimini**

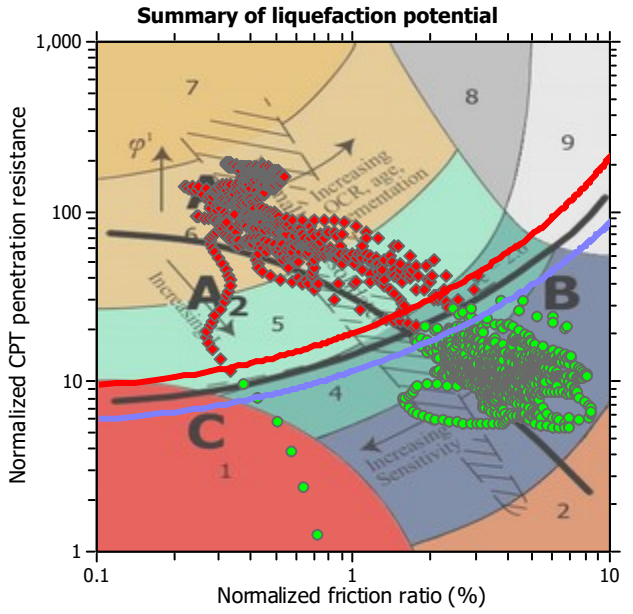
CPT file : 099014P1118

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.80 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	1.00 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.22	Unit weight calculation:	Based on SBT	K_o applied:	Yes		

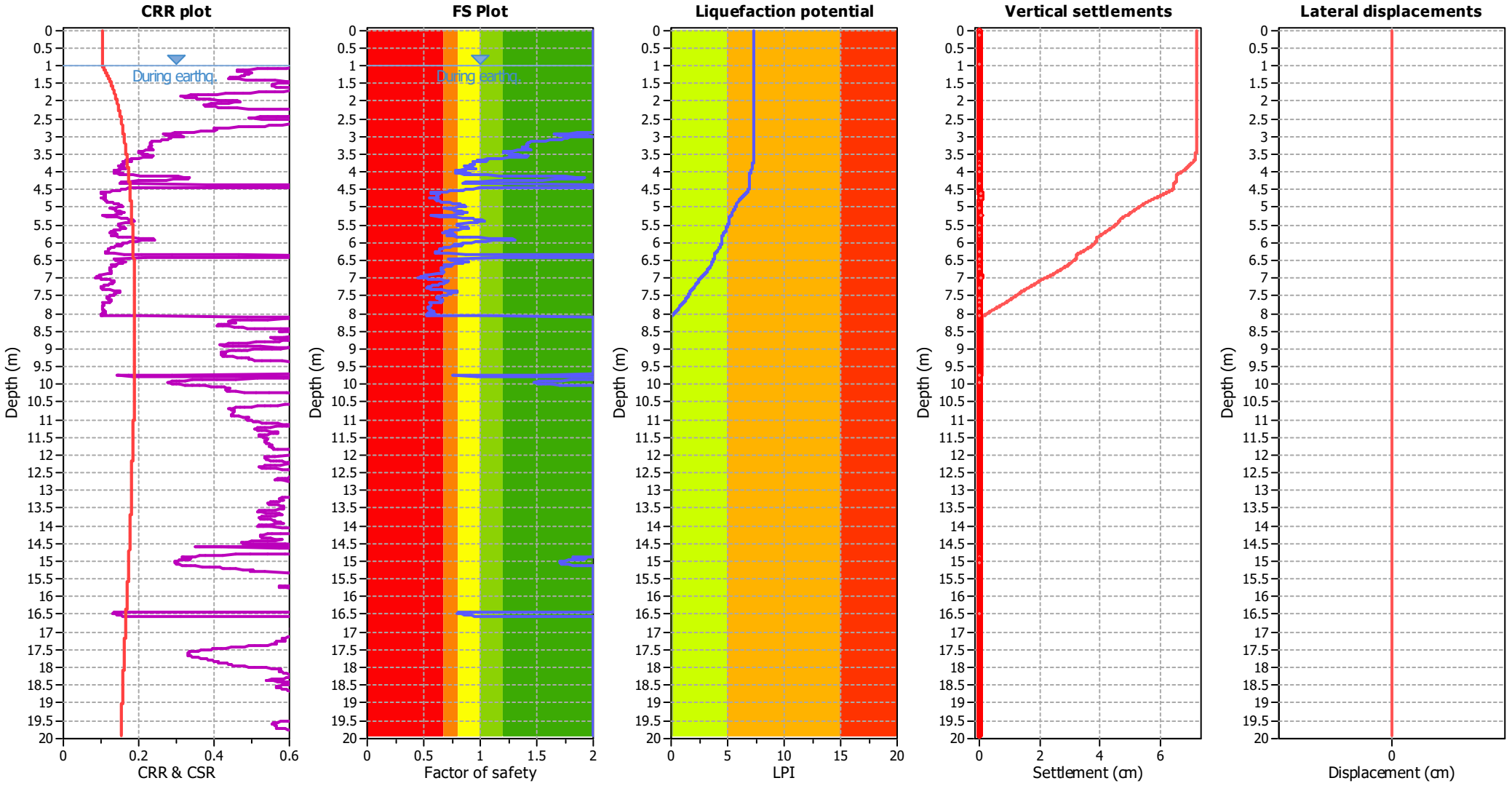






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

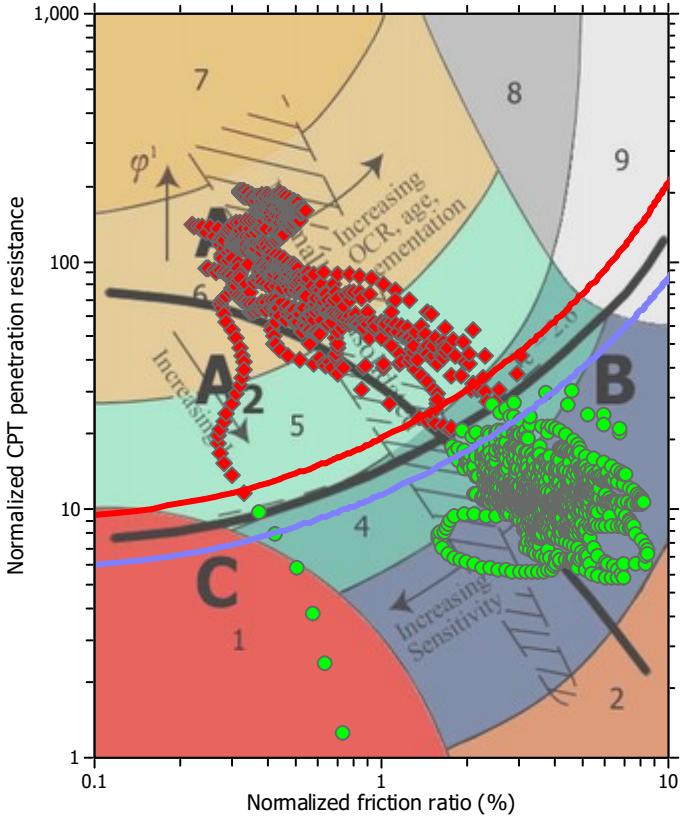
F.S. color scheme

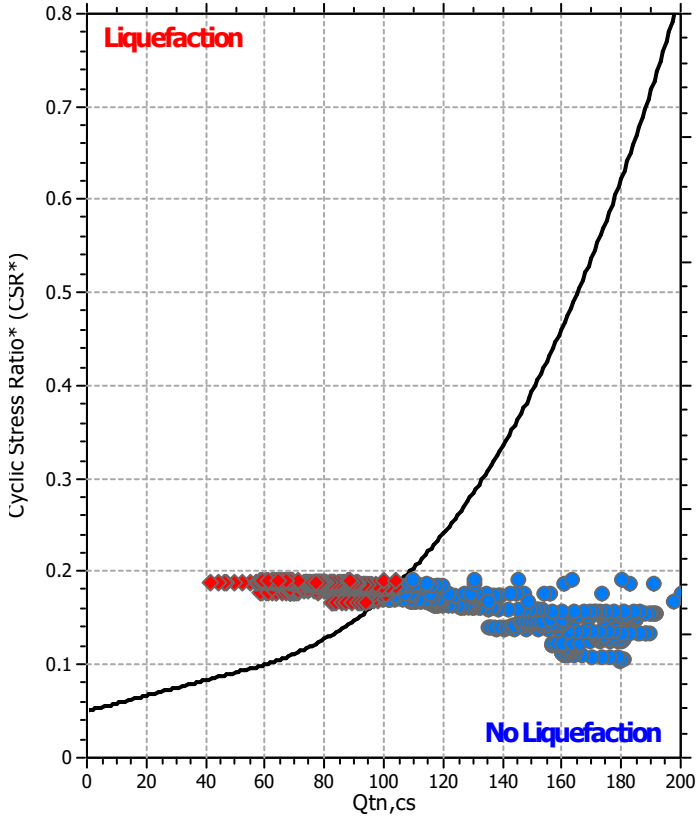
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

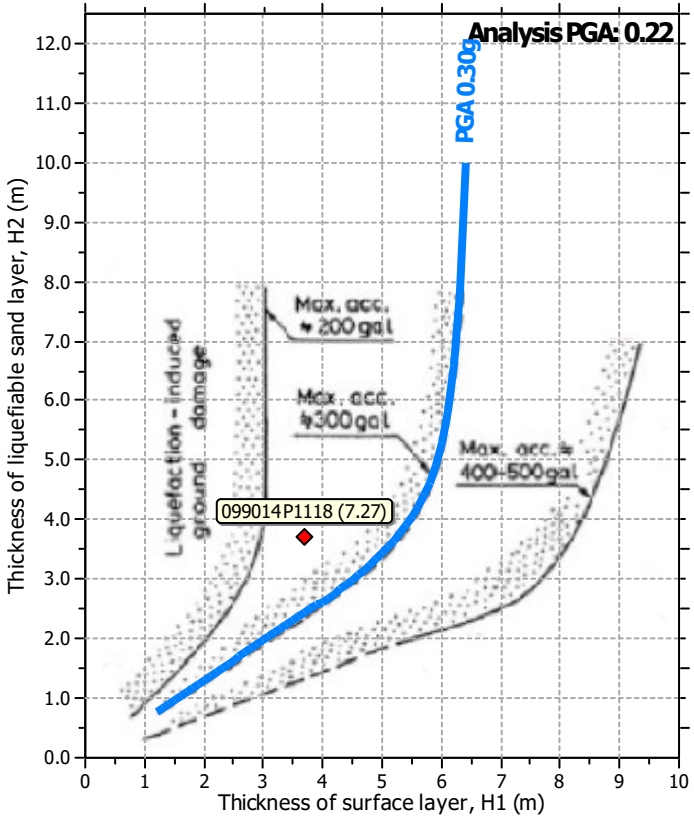
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	1.00 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.80 m	Fill height:	N/A	Limit depth:	N/A

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

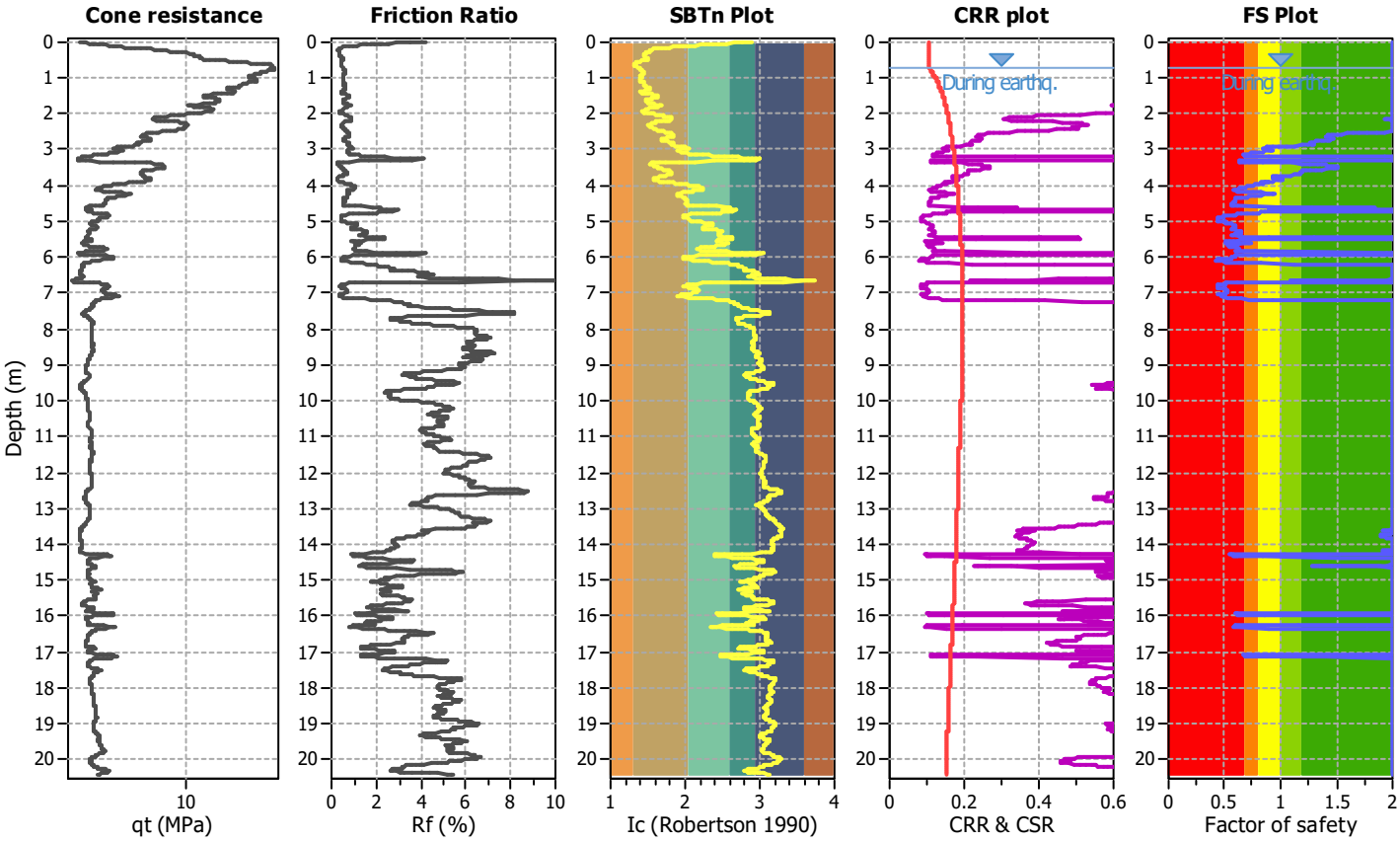
LIQUEFACTION ANALYSIS REPORT

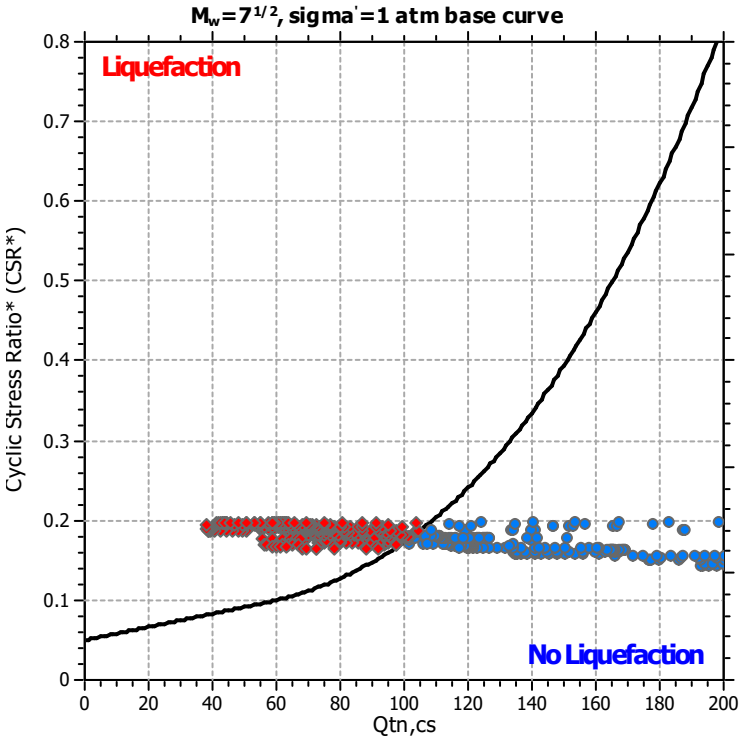
Project title : MS3_PA_Rimini_RNS_05 **Location : Rimini**

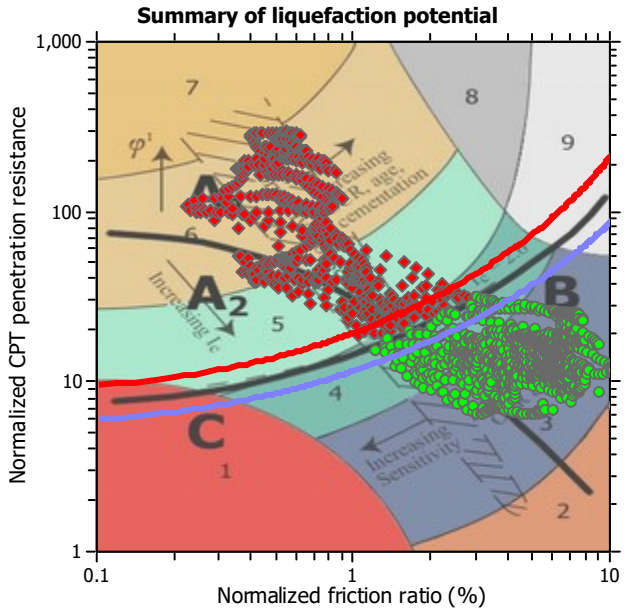
CPT file : 099014P1320

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.70 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.22	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

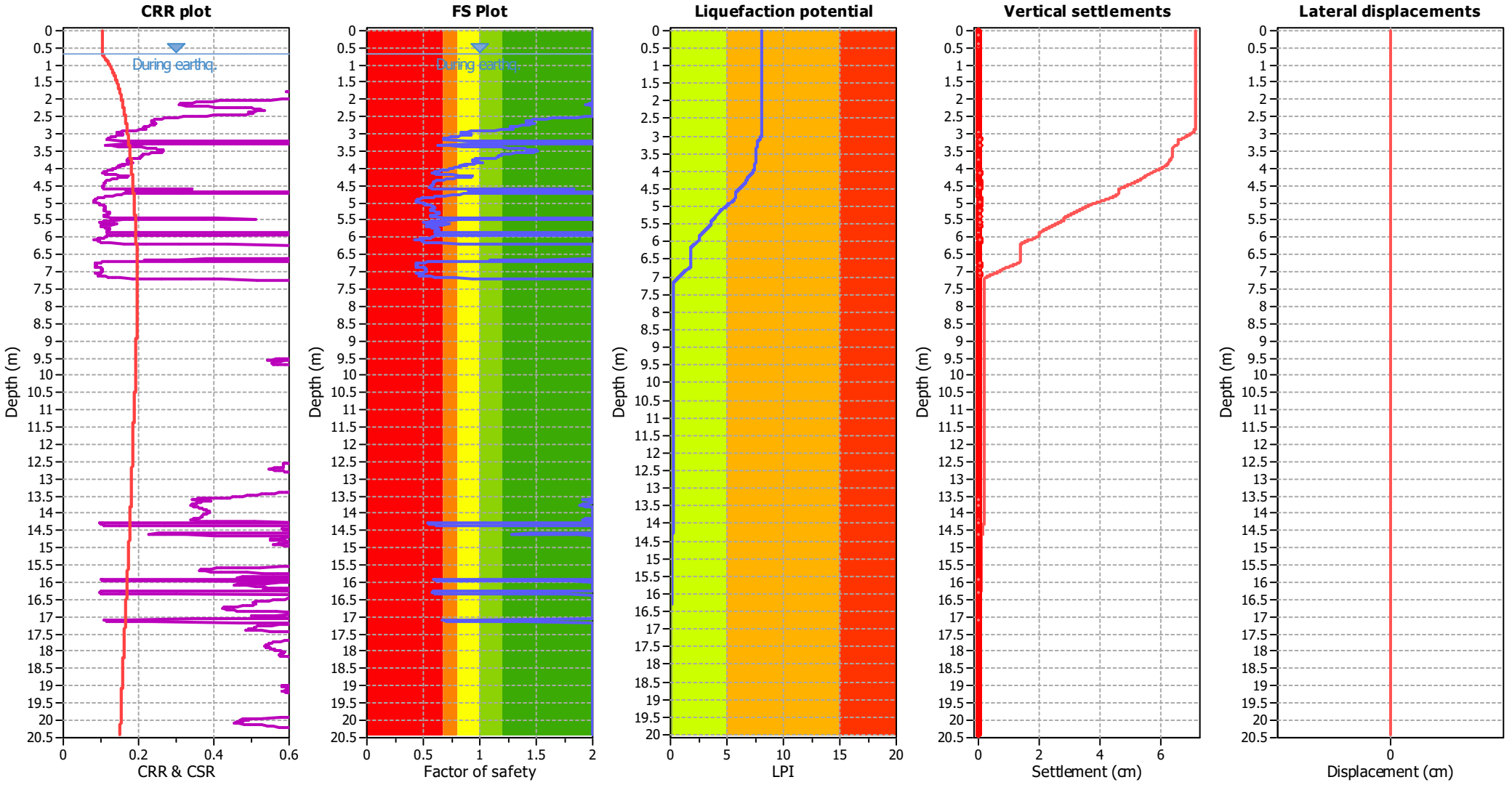






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

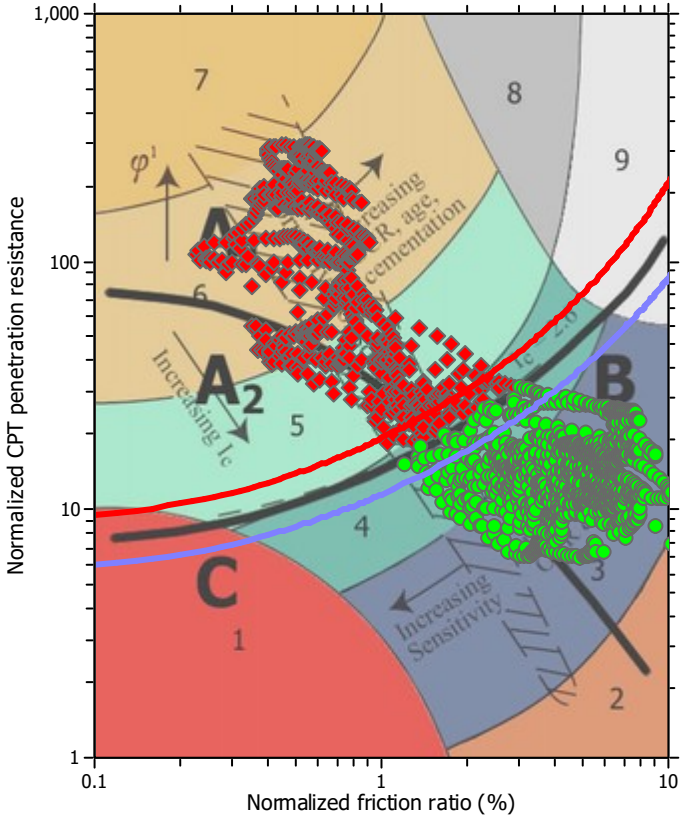
F.S. color scheme

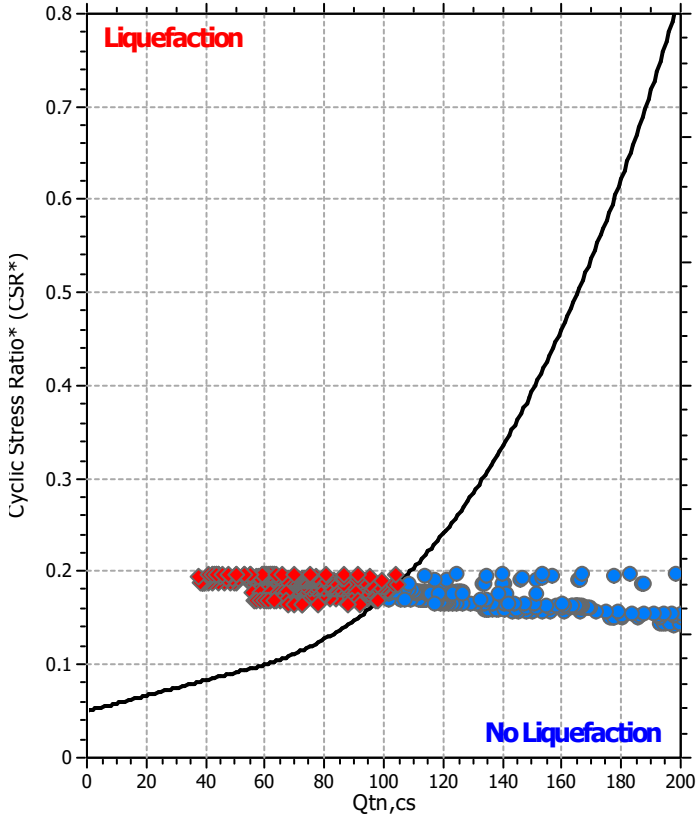
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

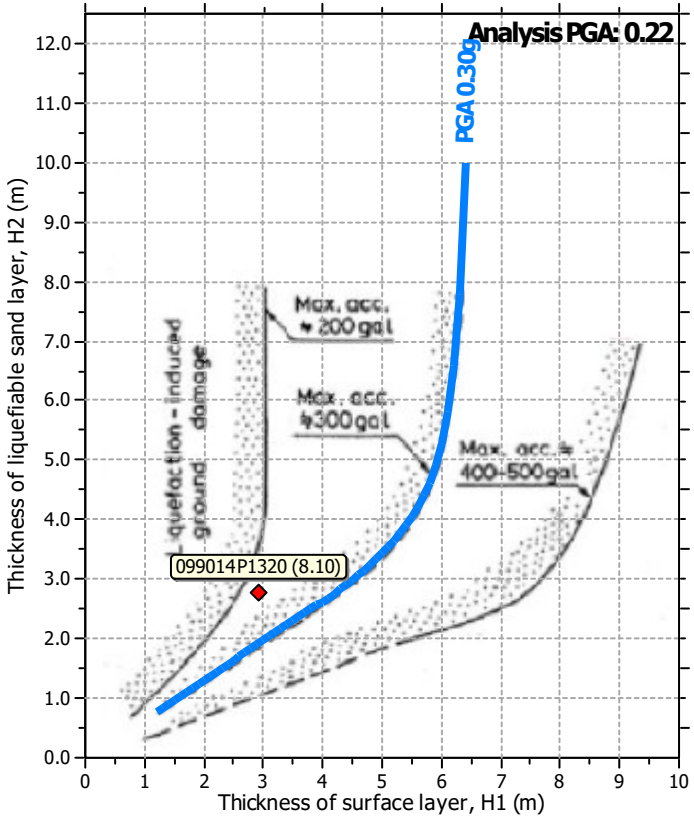
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.70 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

GEOLOGIA E AMBIENTE
Dott. Geol. Alessandro Merli

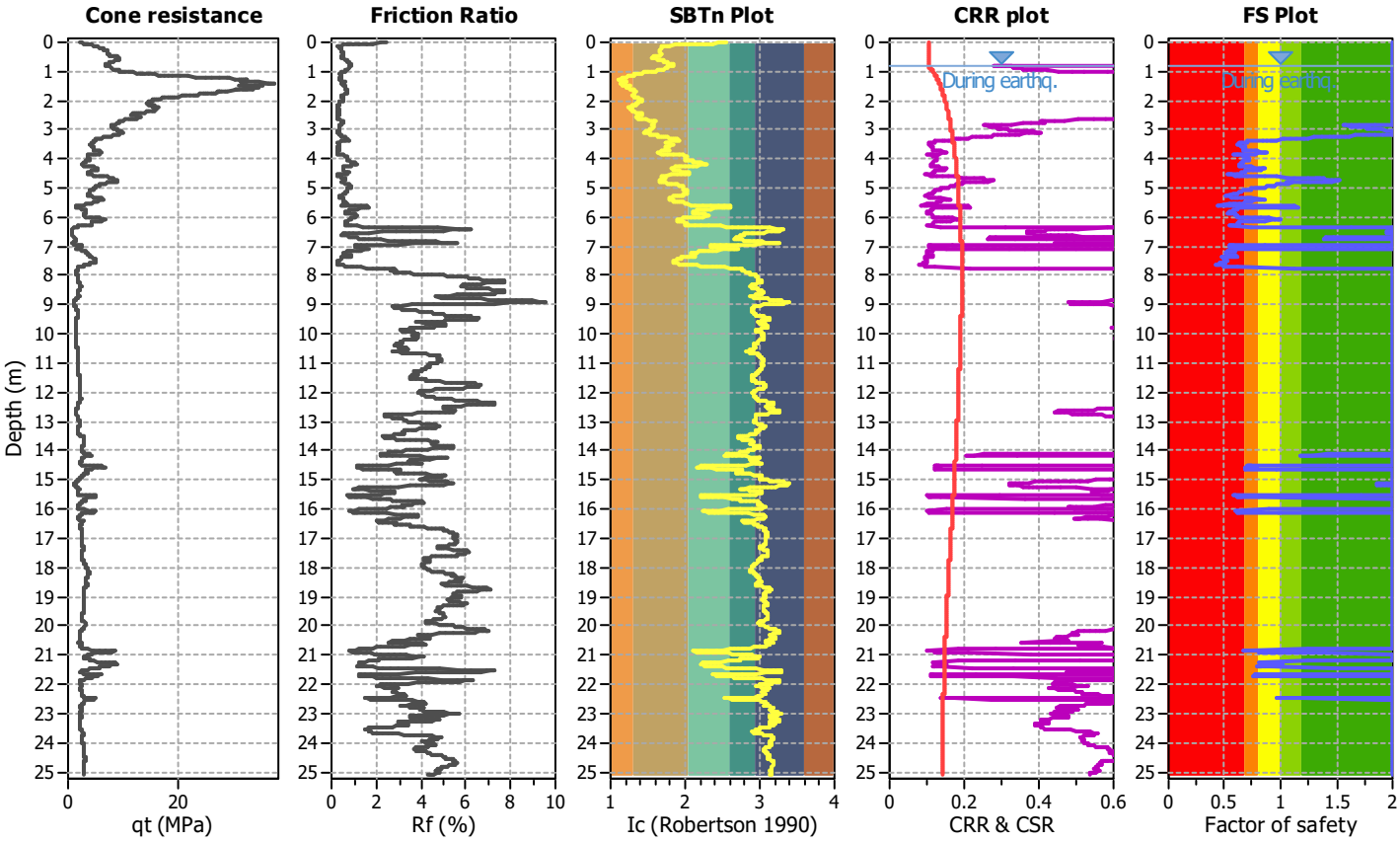
LIQUEFACTION ANALYSIS REPORT

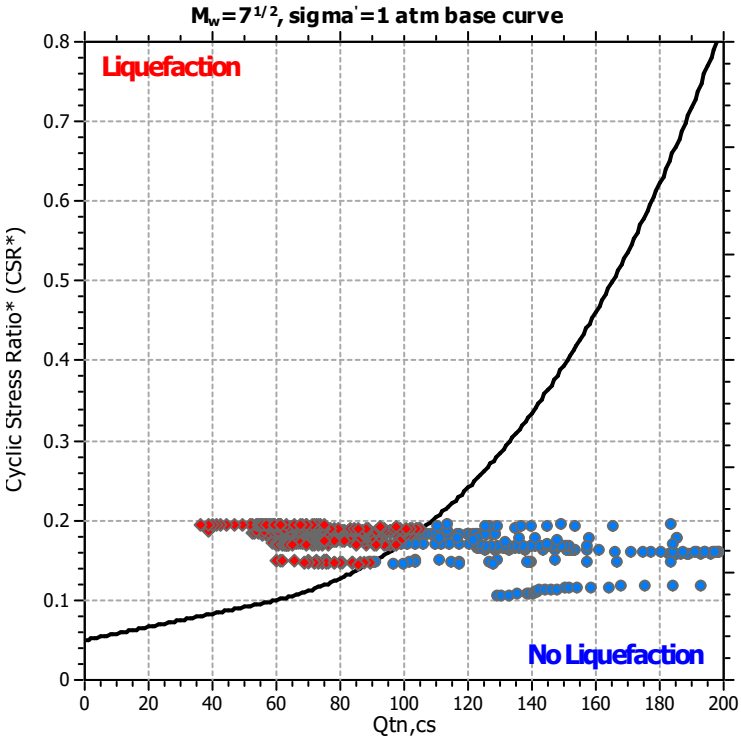
Project title : MS3_PA_Rimini_RNS_05 **Location : Rimini**

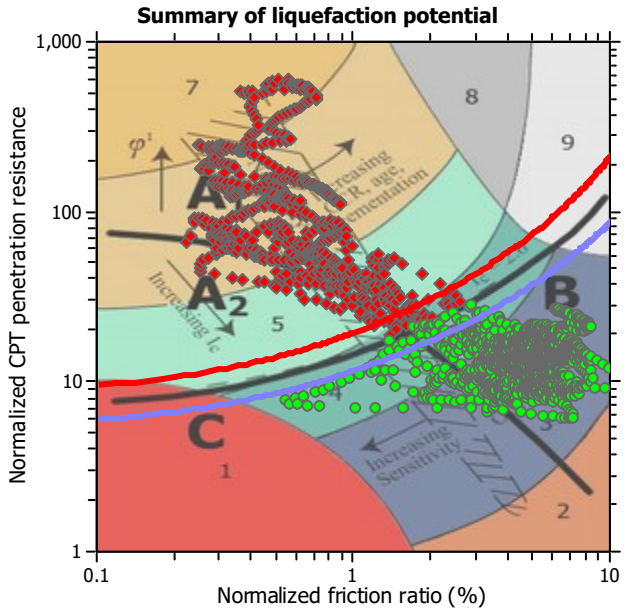
CPT file : 099014P1324

Input parameters and analysis data

Analysis method:	Robertson (2009)	G.W.T. (in-situ):	1.00 m	Use fill:	No	Clay like behavior applied:	All soils
Fines correction method:	Robertson (2009)	G.W.T. (earthq.):	0.80 m	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	5	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	6.16	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.22	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

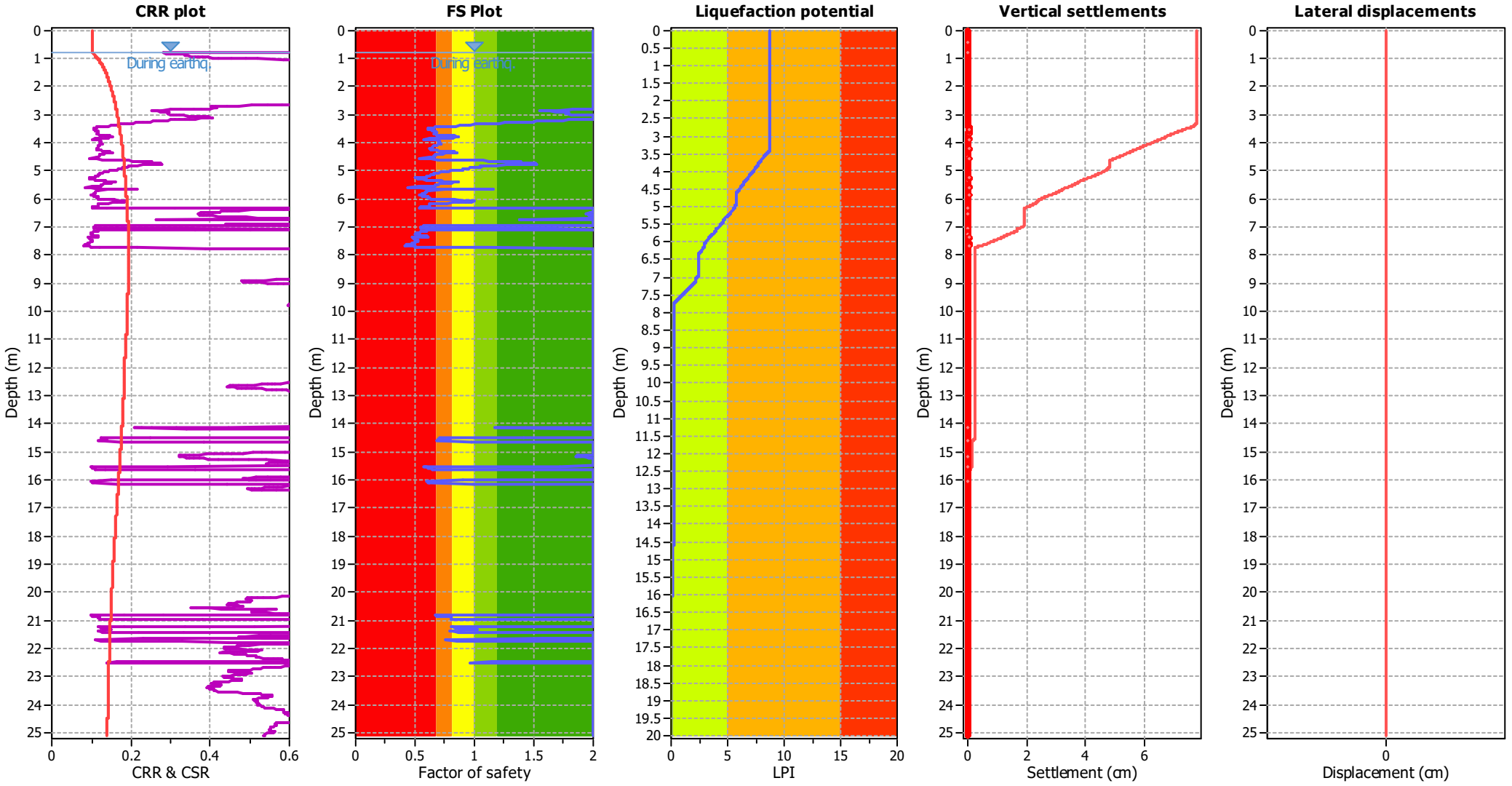






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

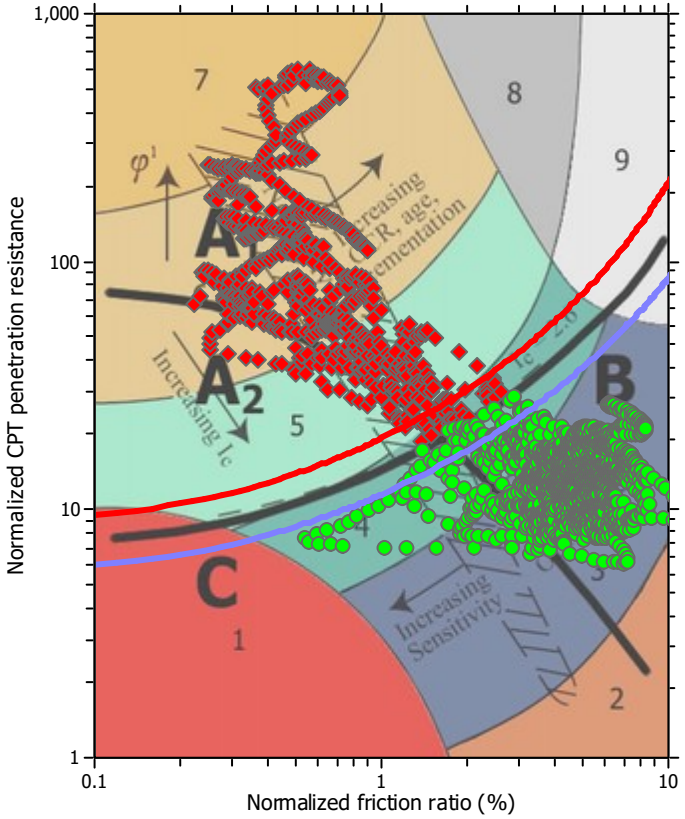
F.S. color scheme

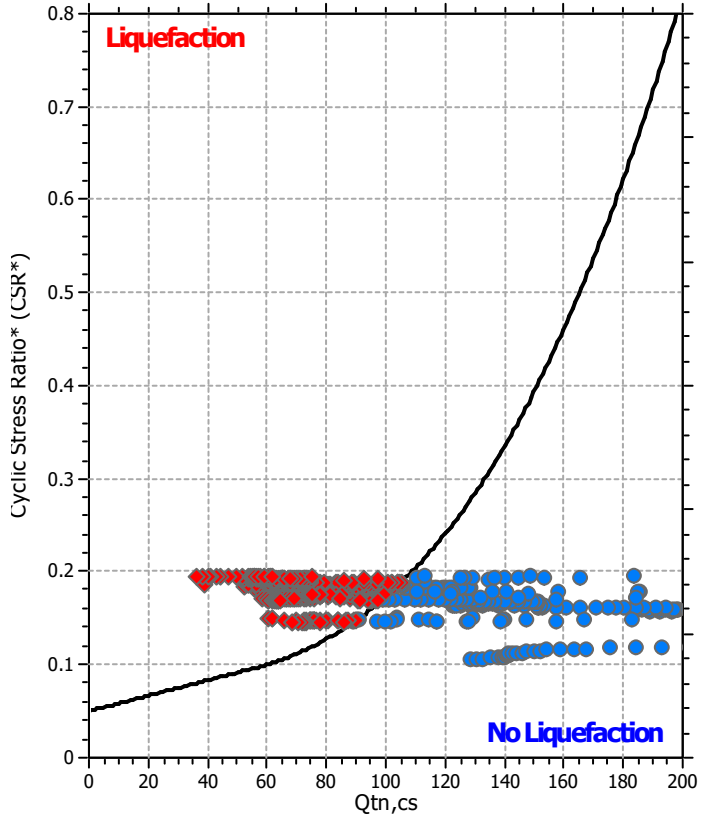
- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

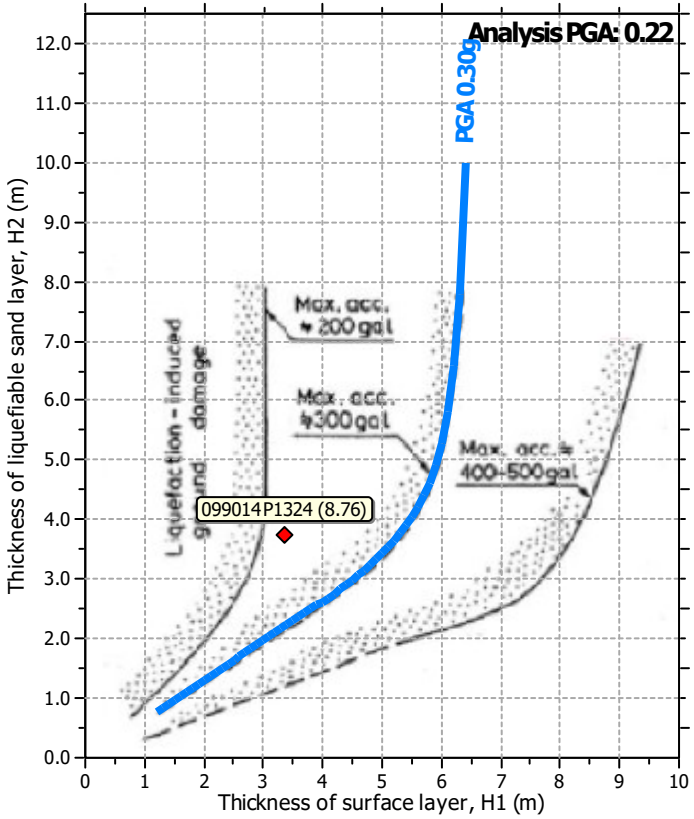
LPI color scheme

- Very high risk
- High risk
- Low risk

Liquefaction analysis summary plots







Input parameters and analysis data

Analysis method:	Robertson (2009)	Depth to water table (erthq.):	0.80 m	Fill weight:	N/A
Fines correction method:	Robertson (2009)	Average results interval:	5	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	6.16	Unit weight calculation:	Based on SBT	Clay like behavior applied:	All soils
Peak ground acceleration:	0.22	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	1.00 m	Fill height:	N/A	Limit depth:	N/A

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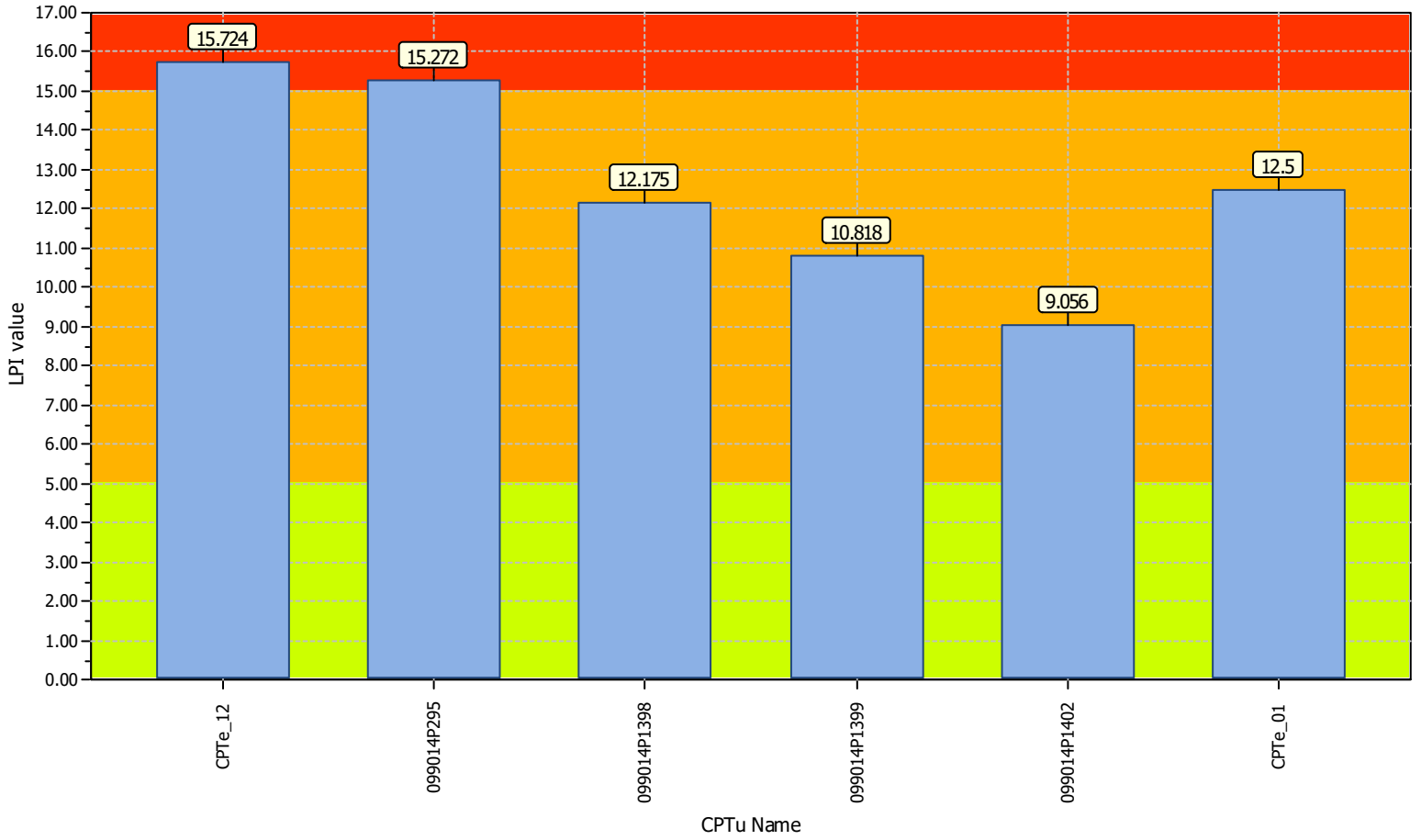
TABELLE PARAMETRICHE DI SINTESI
VERIFICHE DI LIQUEFAZIONE

TABELLE - ZONA RNN_04

Project title : MS3 Rimini_RNN_04

Location : Rimini

Overall Liquefaction Potential Index report



Basic statistics

Total CPT number: 6

0% low risk

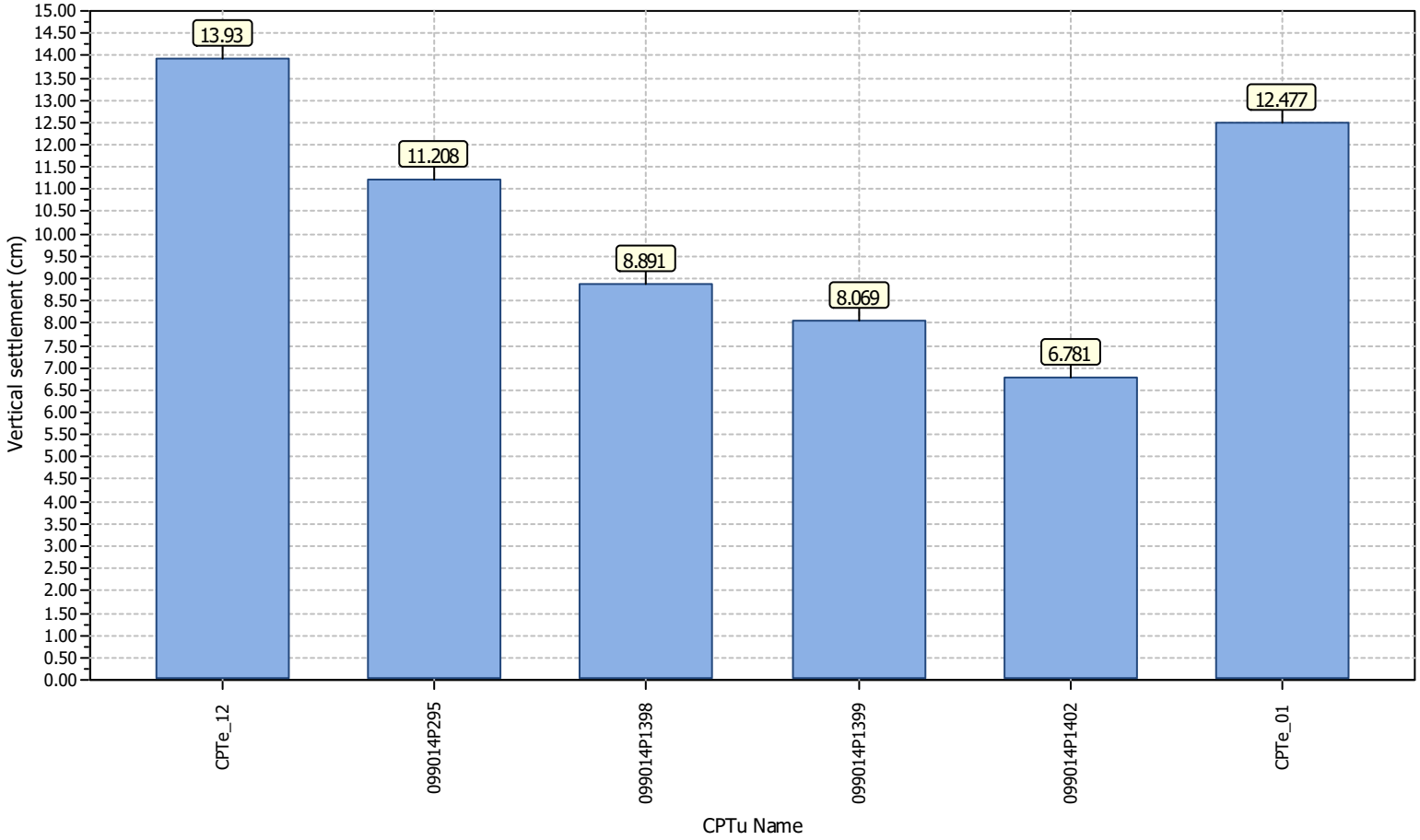
67% high risk

33% very high risk

Project title : MS3 Rimini_RNN_04

Location : Rimini

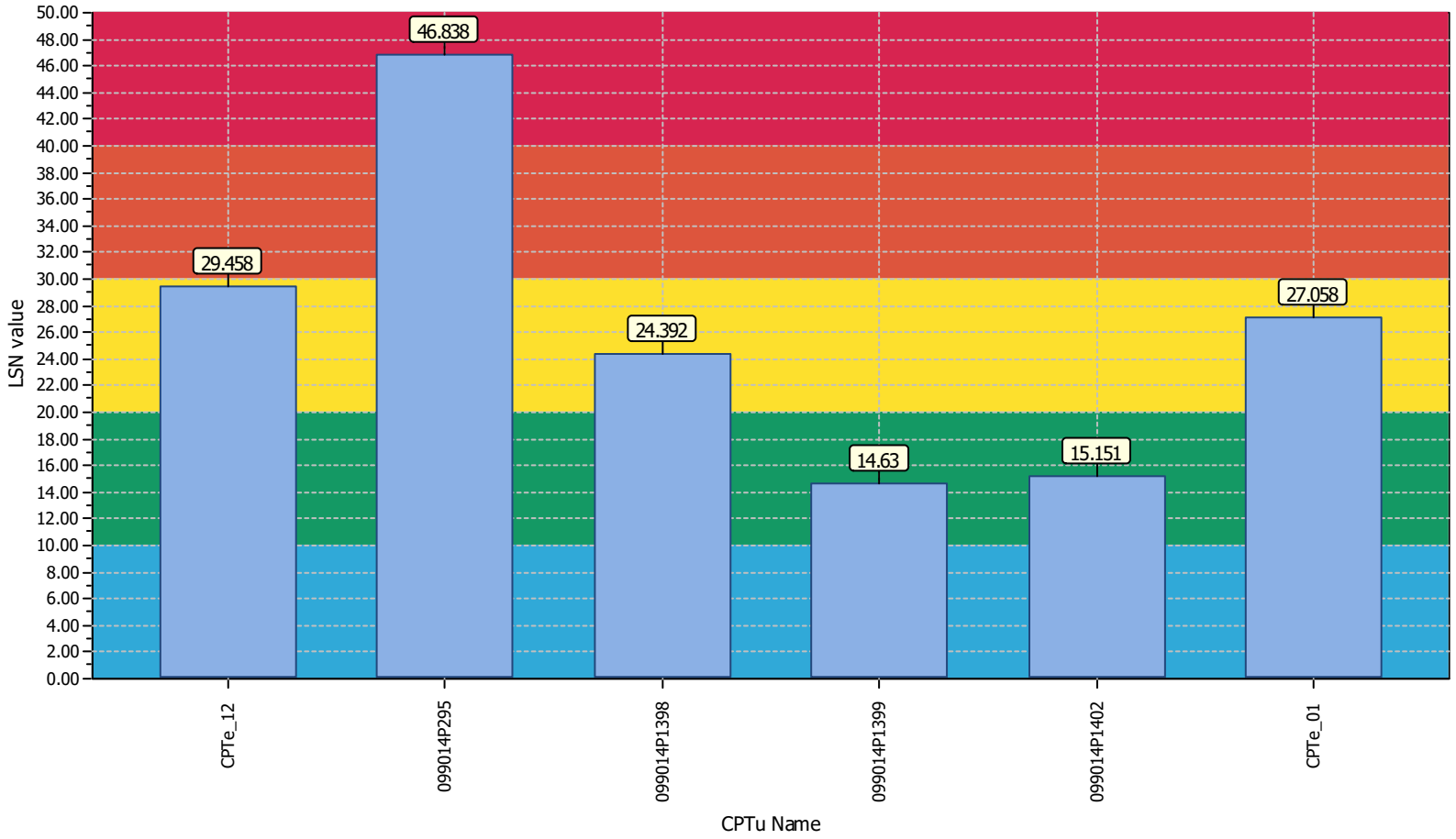
Overall vertical settlements report



Project title : MS3 Rimini_RNN_04

Location : Rimini

Overall Liquefaction Severity Number report



LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

Basic statistics

Total CPT number: 6

0% little liquefaction

33% minor liquefaction

50% moderate liquefaction

0% moderate to major liquefaction

17% major liquefaction

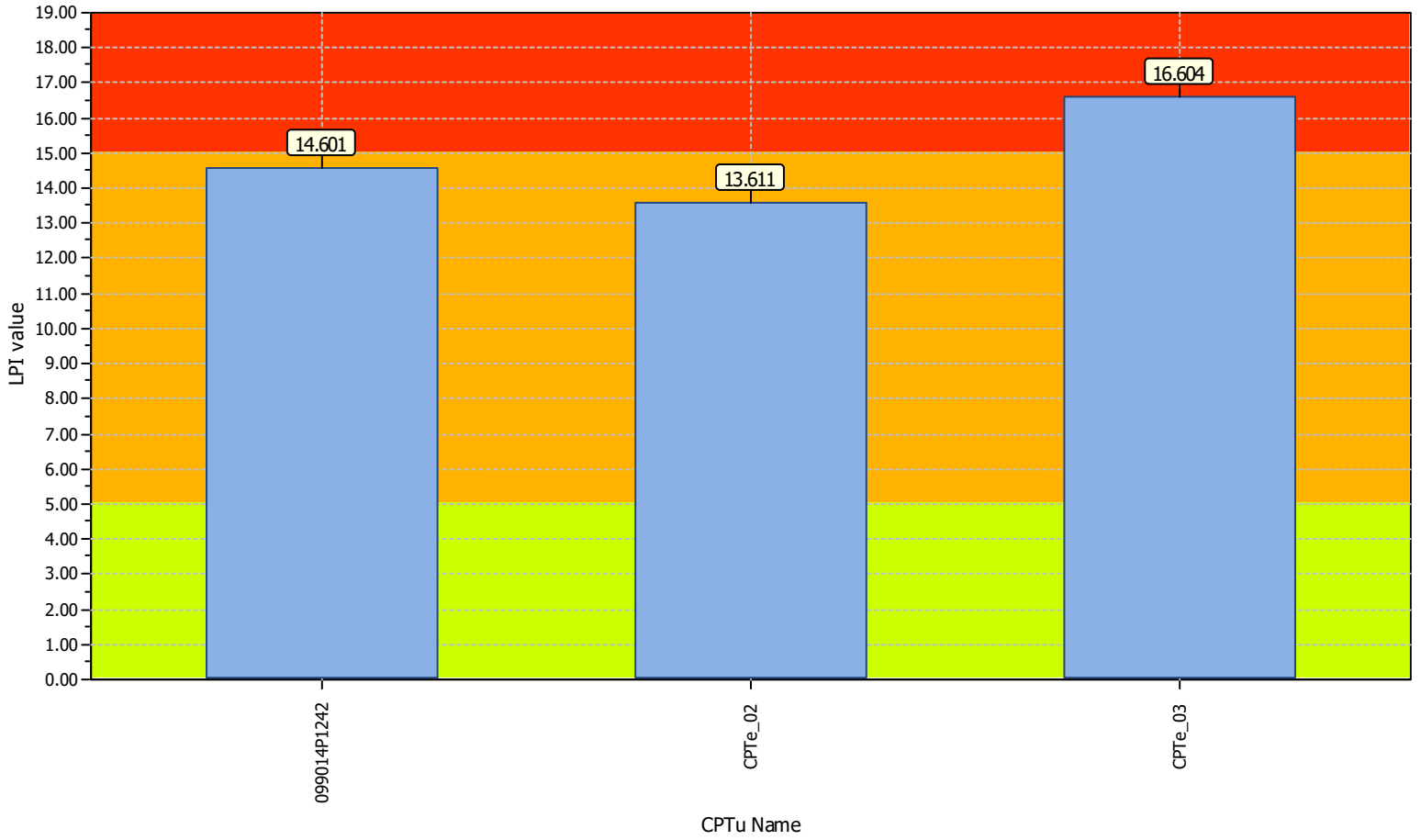
0% severe liquefaction

TABELLE - ZONA RNN_03

Project title : MS3 Rimini_RNN_03

Location : Rimini

Overall Liquefaction Potential Index report



LPI color scheme

- Very high risk
- High risk
- Low risk

Basic statistics

Total CPT number: 3

0% low risk

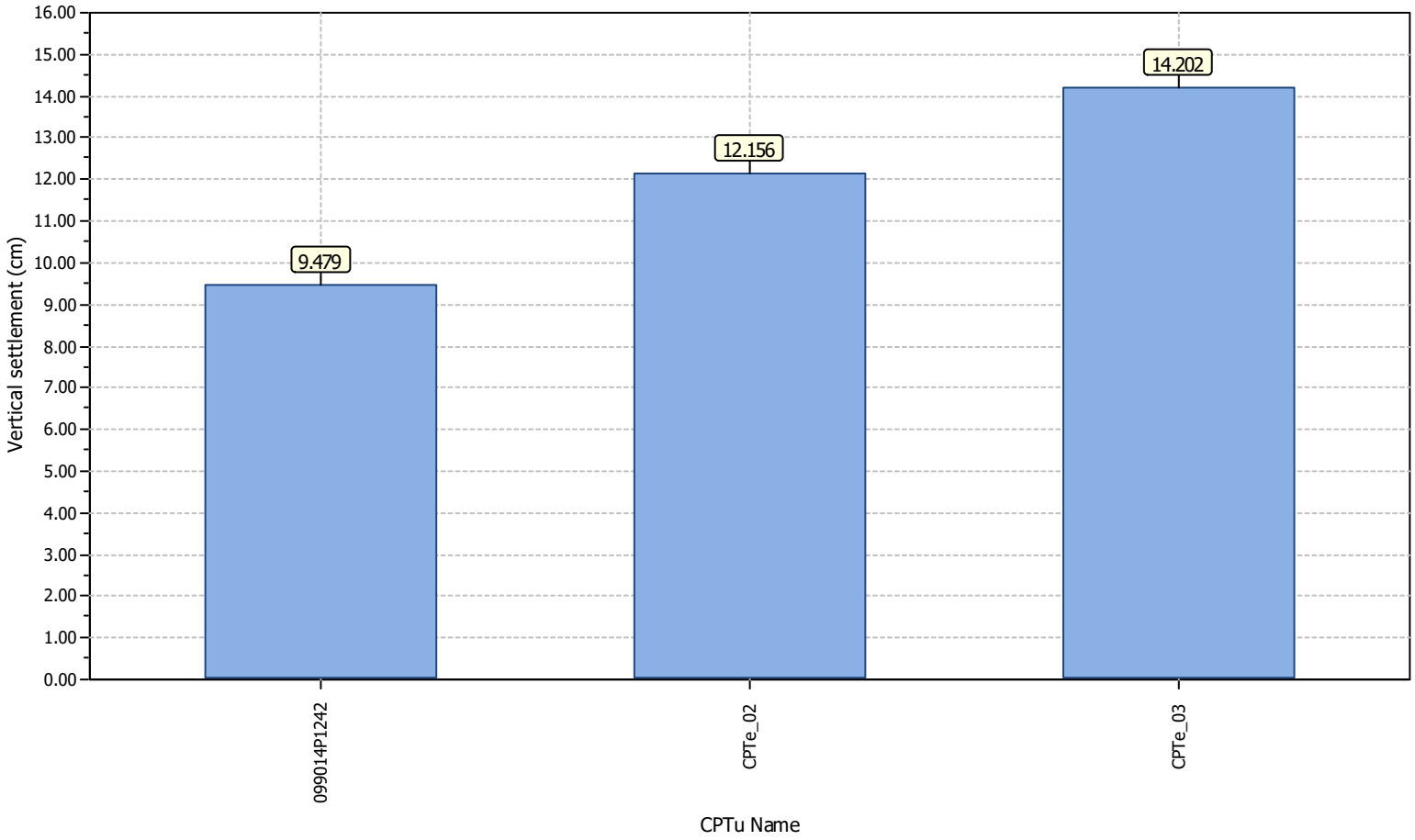
67% high risk

33% very high risk

Project title : MS3 Rimini_RNN_03

Location : Rimini

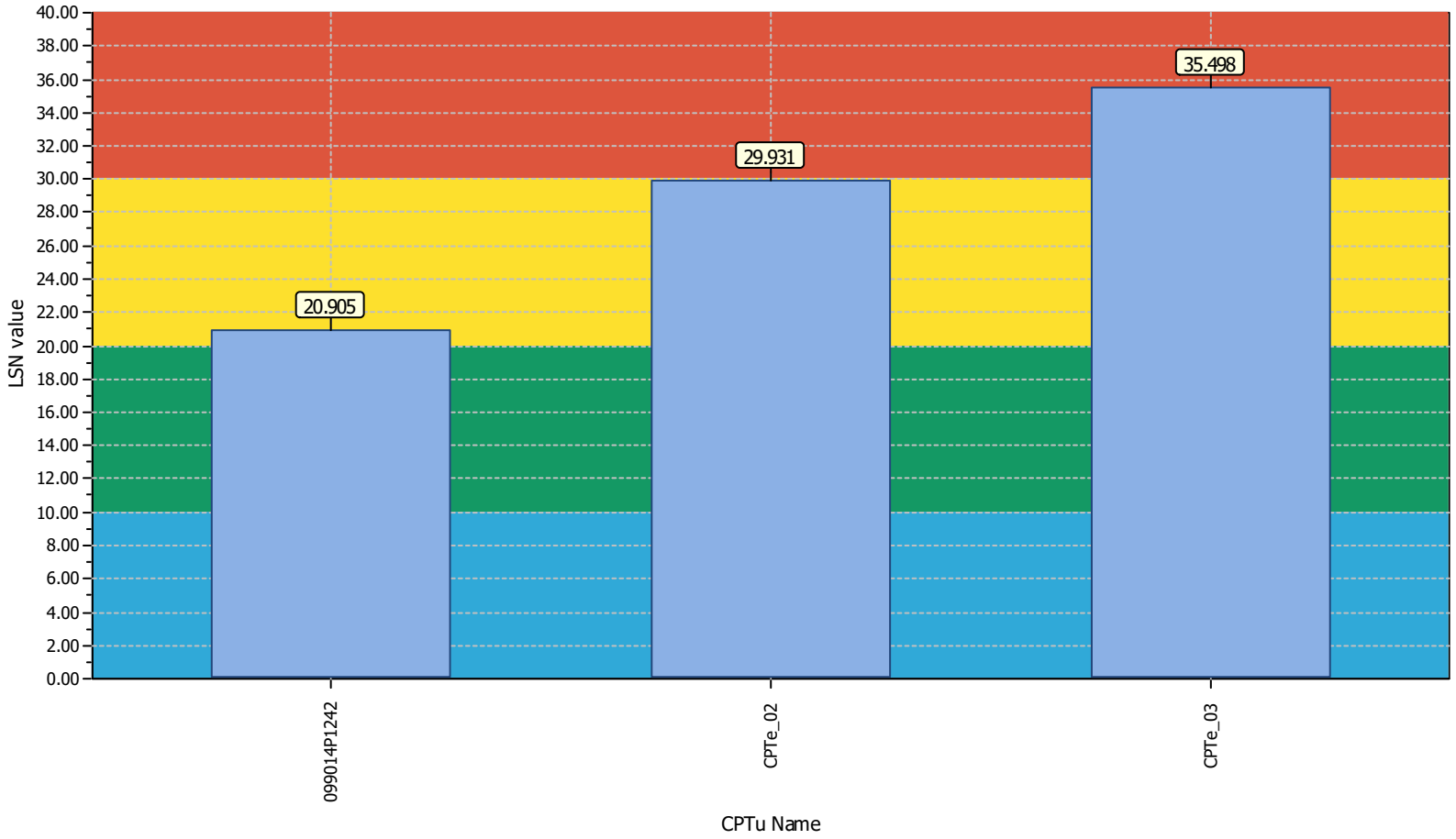
Overall vertical settlements report



Project title : MS3 Rimini_RNN_03

Location : Rimini

Overall Liquefaction Severity Number report



LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

Basic statistics

Total CPT number: 3

0% little liquefaction

0% minor liquefaction

67% moderate liquefaction

33% moderate to major liquefaction

0% major liquefaction

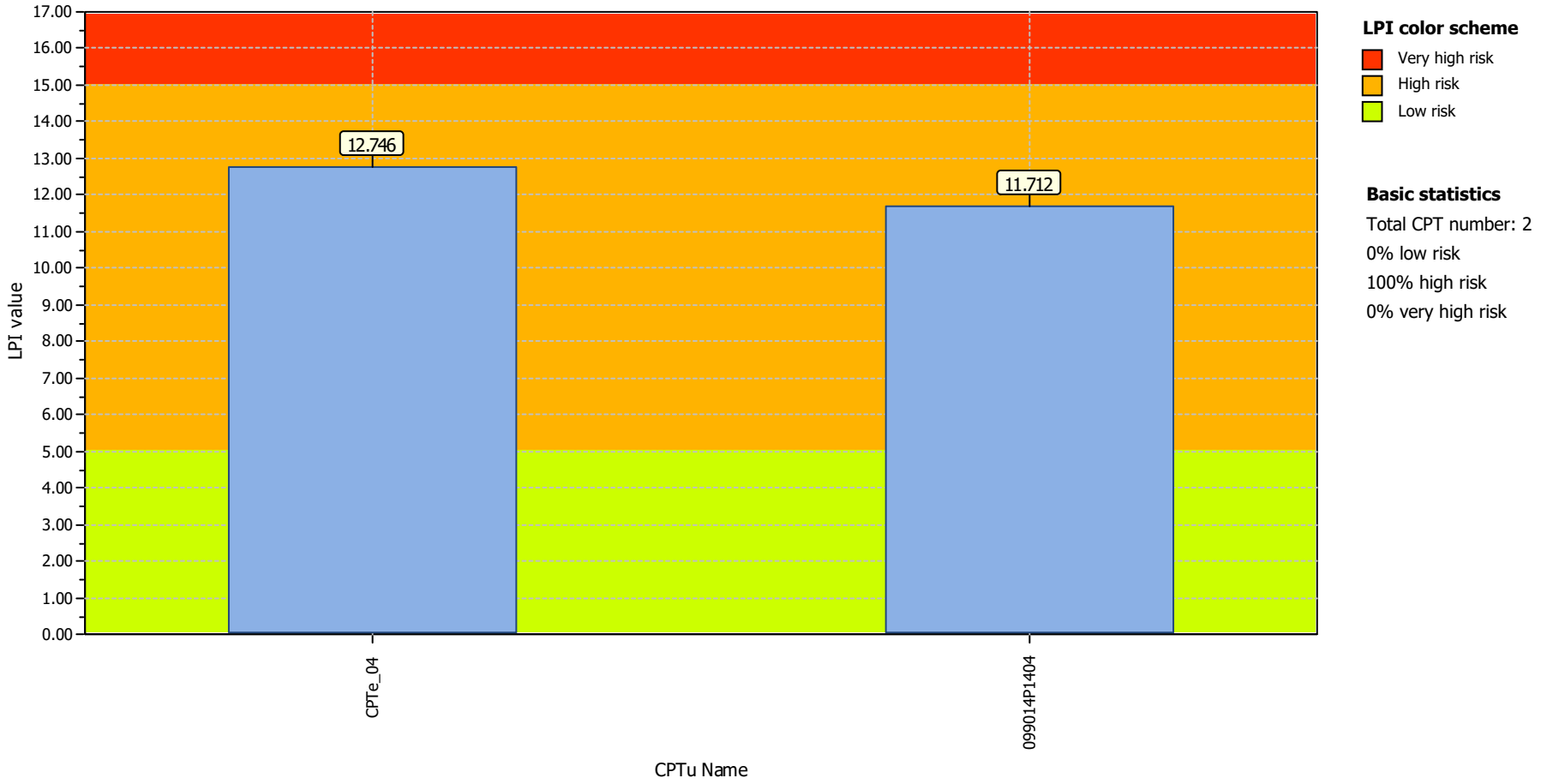
0% severe liquefaction

TABELLE - ZONA RNN_02

Project title : MS3 Rimini_RNN_02

Location : Rimini

Overall Liquefaction Potential Index report



LPI color scheme

- Very high risk
- High risk
- Low risk

Basic statistics

Total CPT number: 2

0% low risk

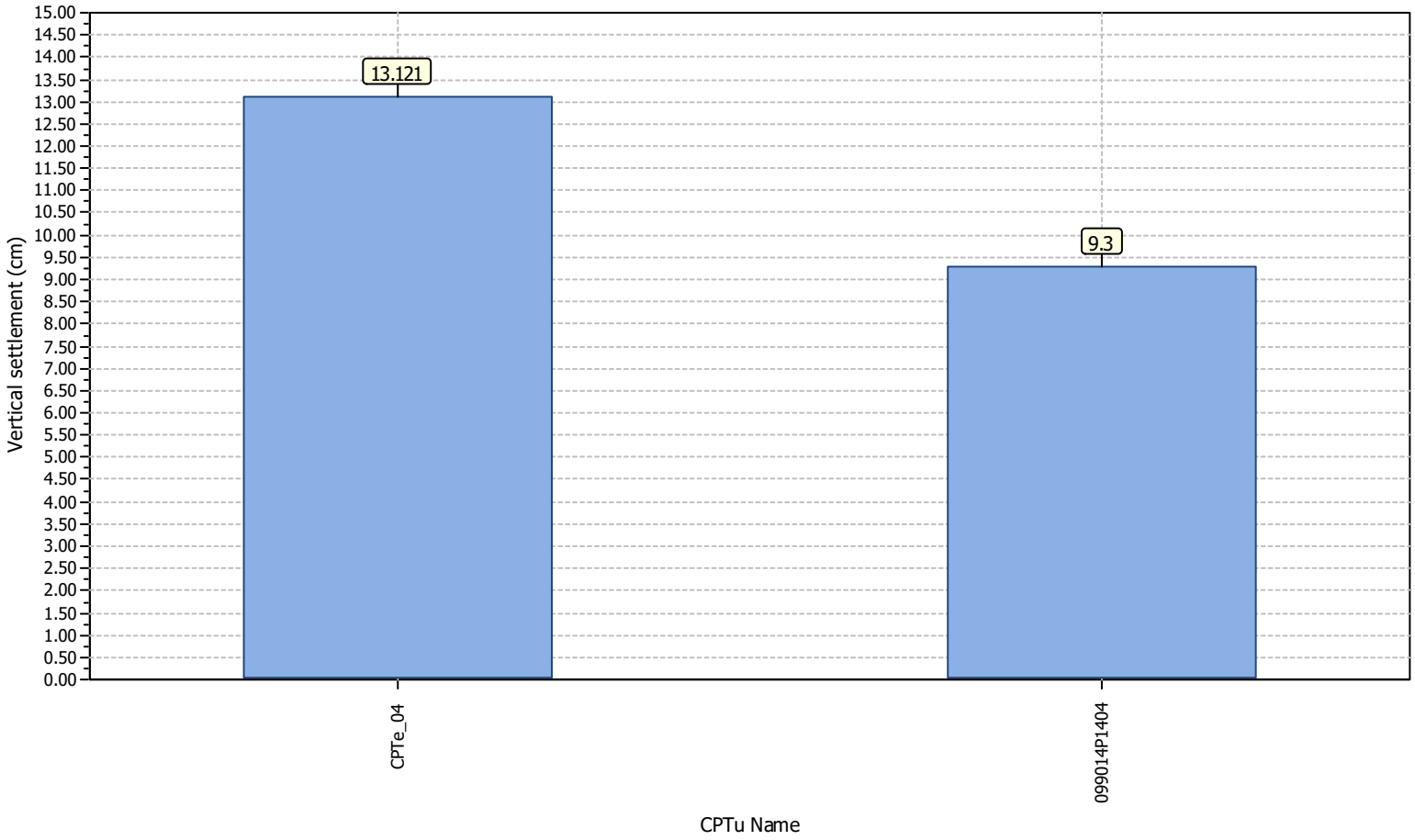
100% high risk

0% very high risk

Project title : MS3 Rimini_RNN_02

Location : Rimini

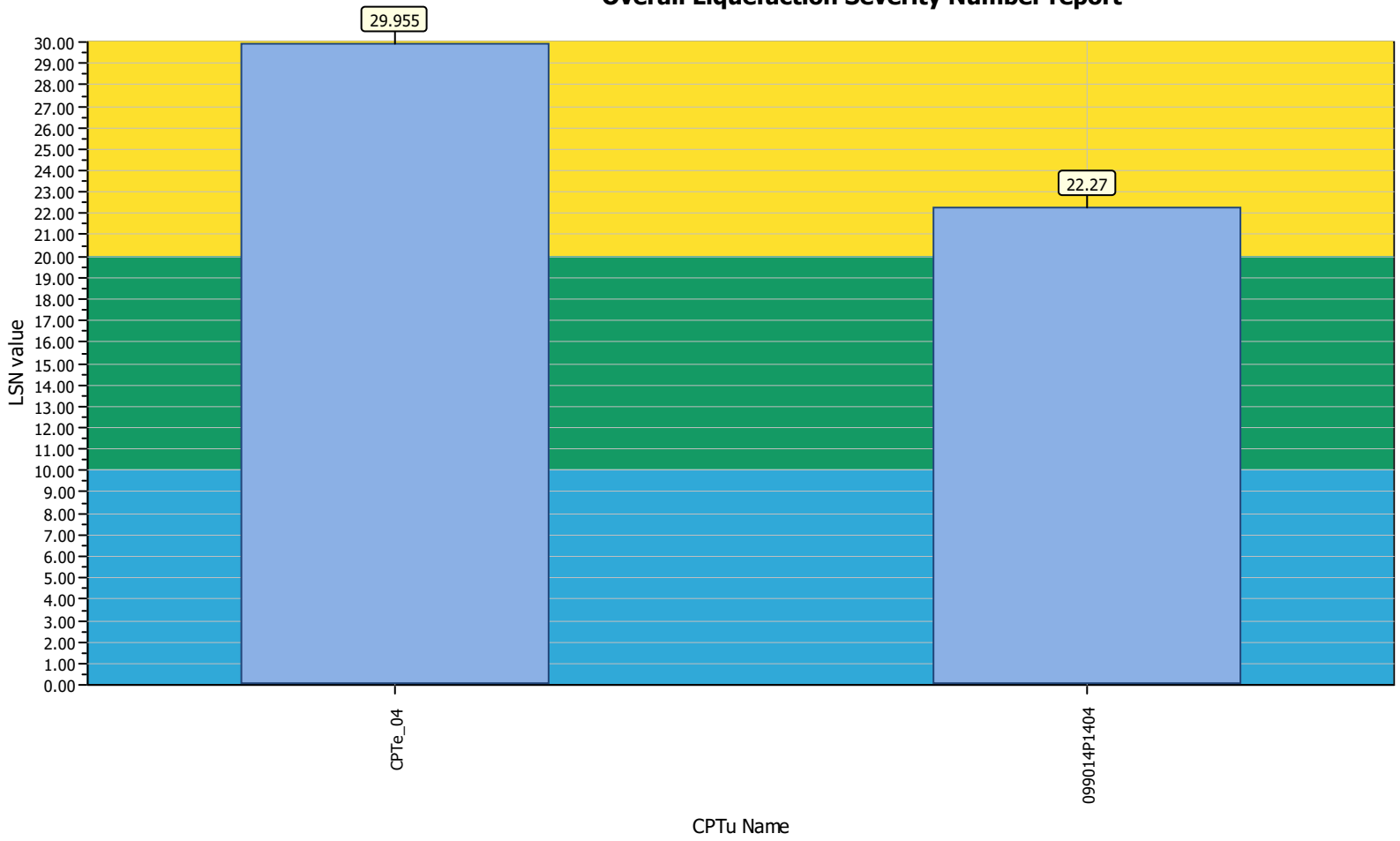
Overall vertical settlements report



Project title : MS3 Rimini_RNN_02

Location : Rimini

Overall Liquefaction Severity Number report



LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

Basic statistics

Total CPT number: 2

0% little liquefaction

0% minor liquefaction

100% moderate liquefaction

0% moderate to major liquefaction

0% major liquefaction

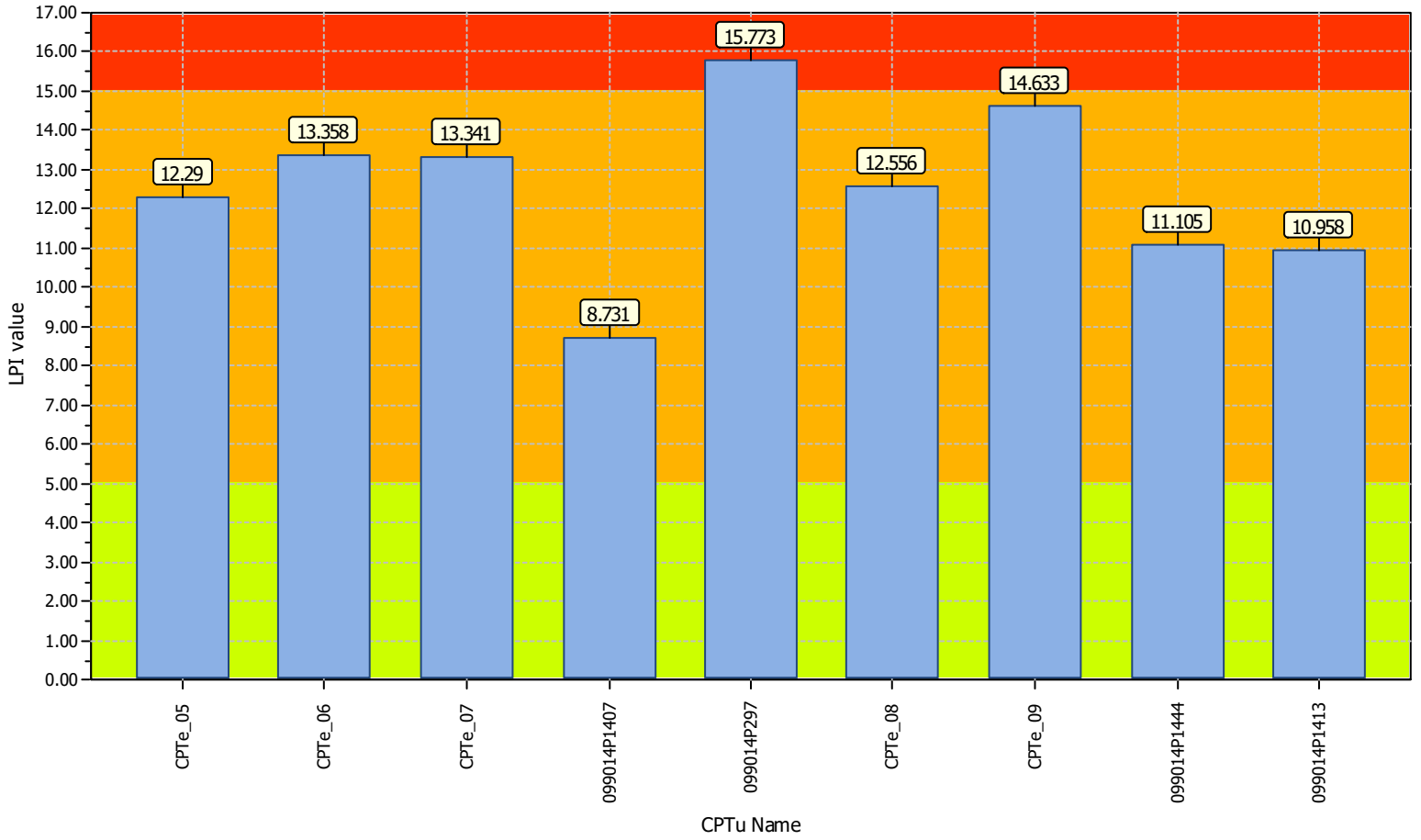
0% severe liquefaction

TABELLE - ZONA RNN_01

Project title : MS3 Rimini_RNN_01

Location : Rimini

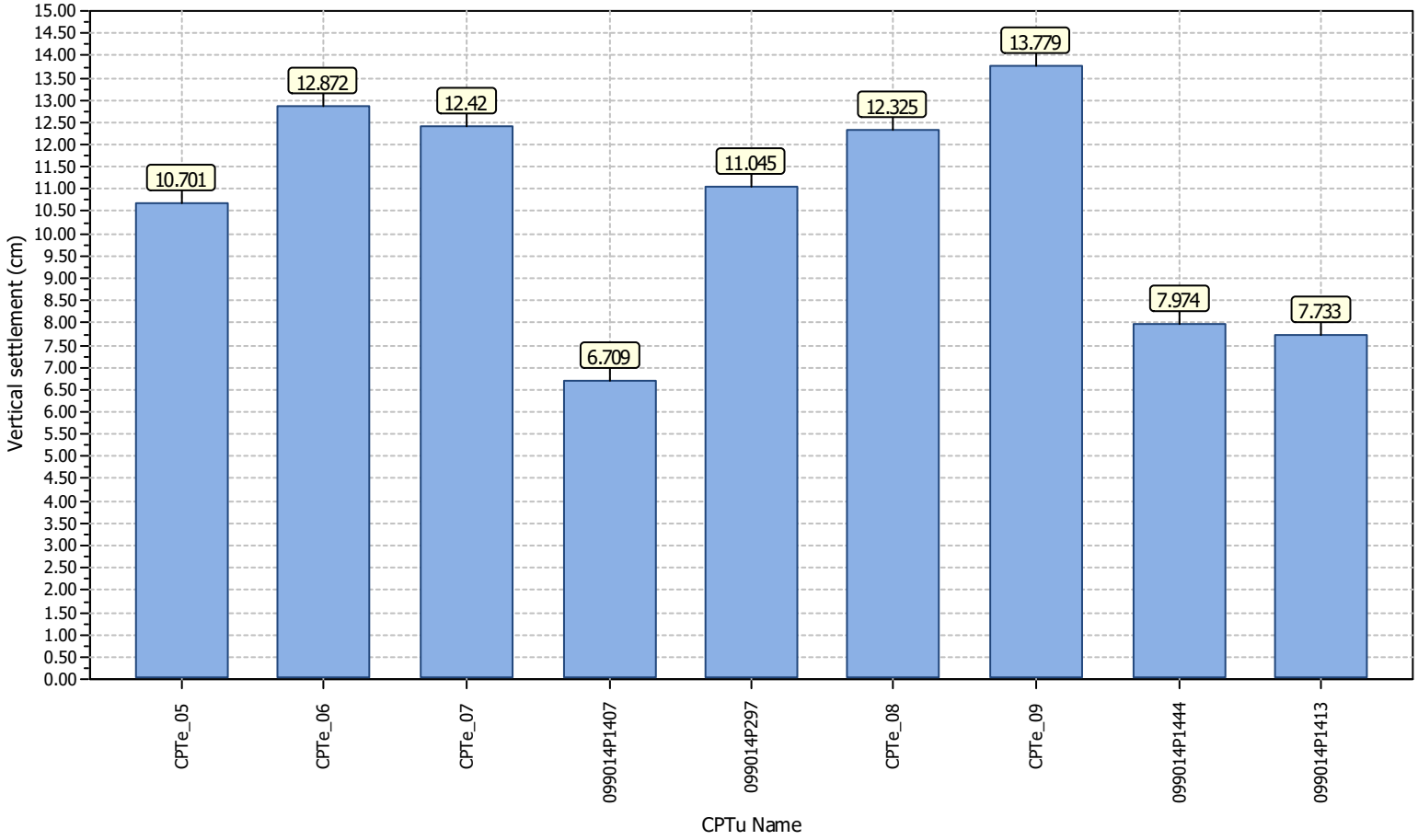
Overall Liquefaction Potential Index report



Project title : MS3 Rimini_RNN_01

Location : Rimini

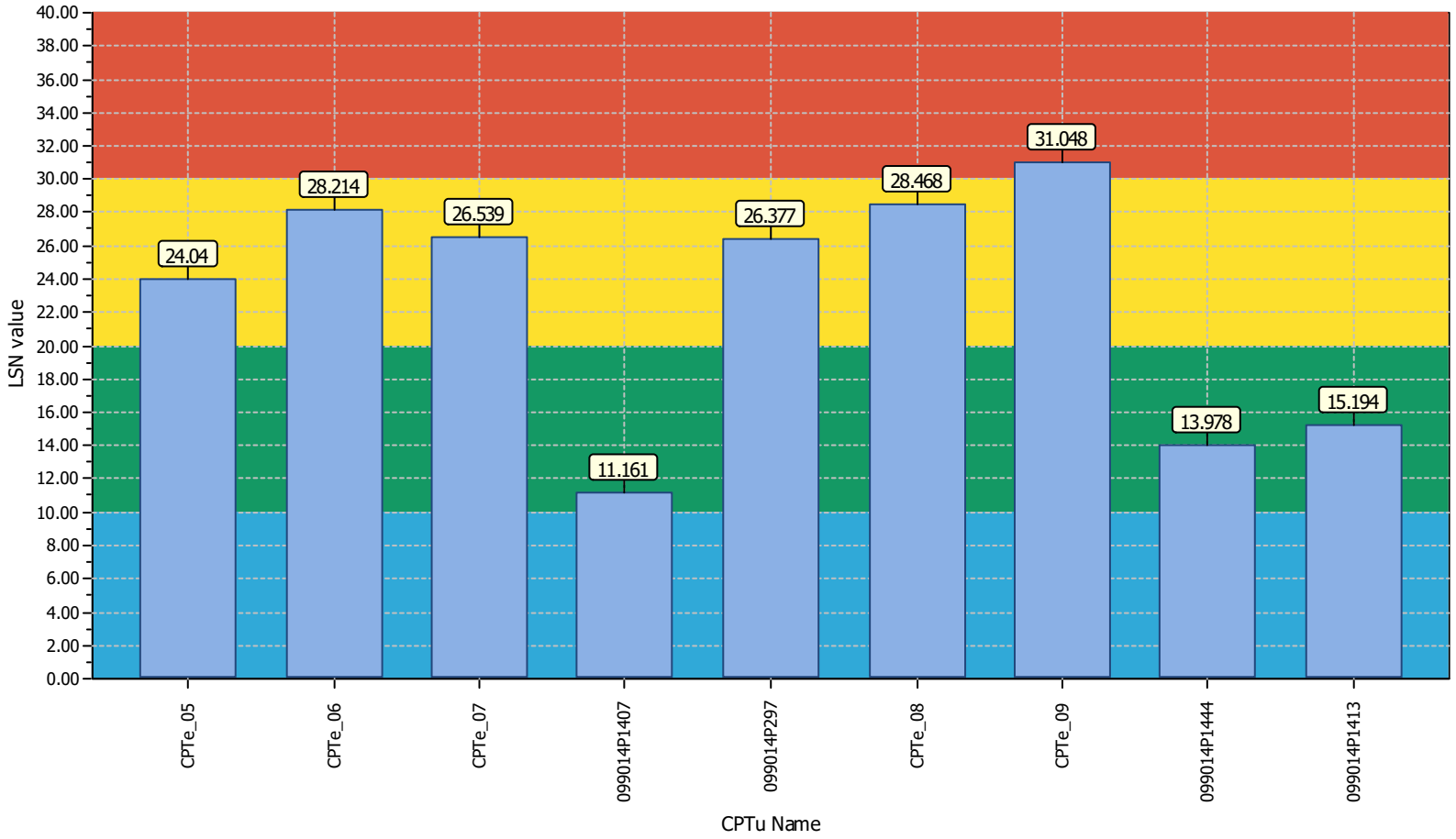
Overall vertical settlements report



Project title : MS3 Rimini_RNN_01

Location : Rimini

Overall Liquefaction Severity Number report



LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

Basic statistics

Total CPT number: 9

0% little liquefaction

33% minor liquefaction

56% moderate liquefaction

11% moderate to major liquefaction

0% major liquefaction

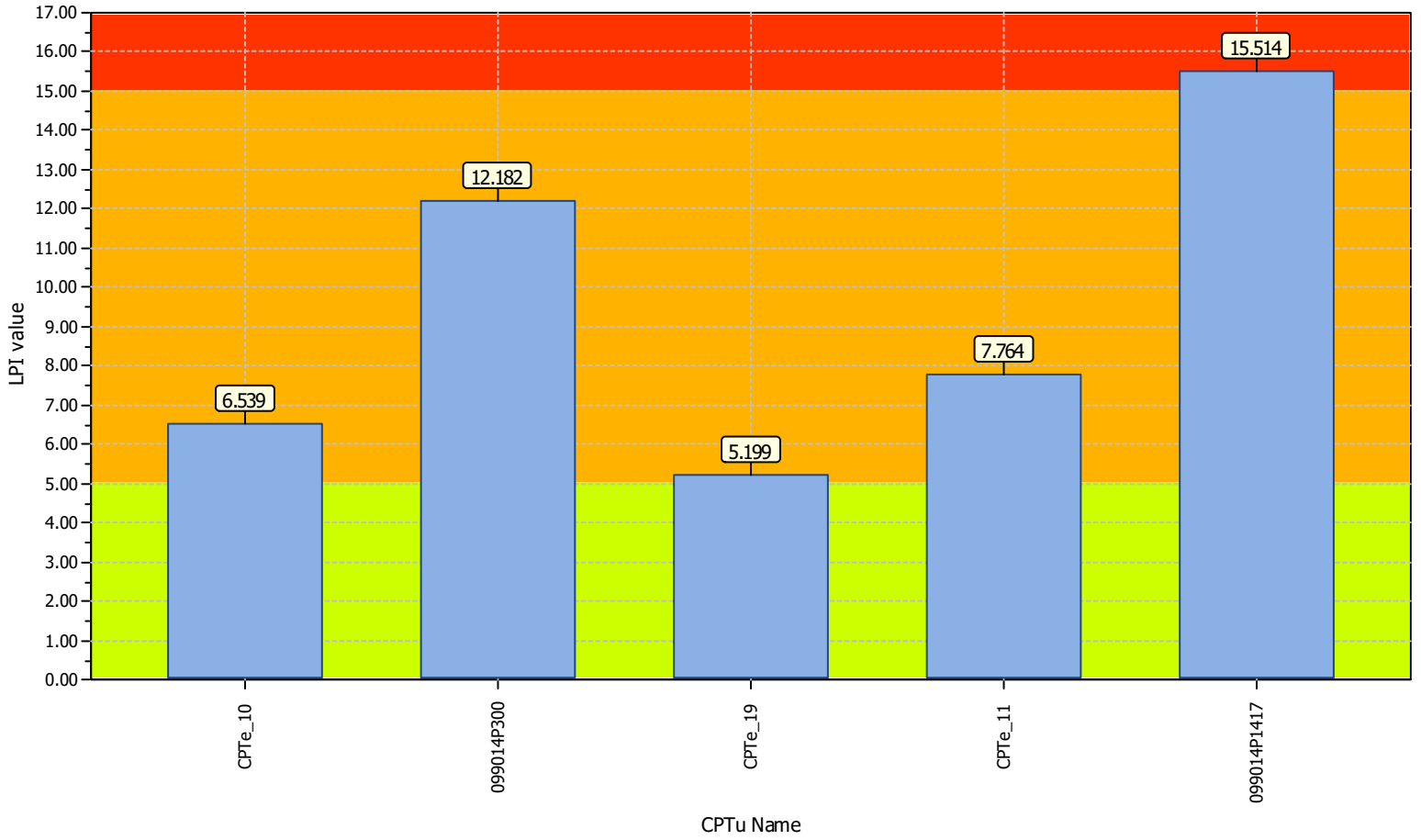
0% severe liquefaction

TABELLE - ZONA RNC

Project title : MS3 Rimini_RNC

Location : Rimini

Overall Liquefaction Potential Index report



LPI color scheme

- Very high risk
- High risk
- Low risk

Basic statistics

Total CPT number: 5

0% low risk

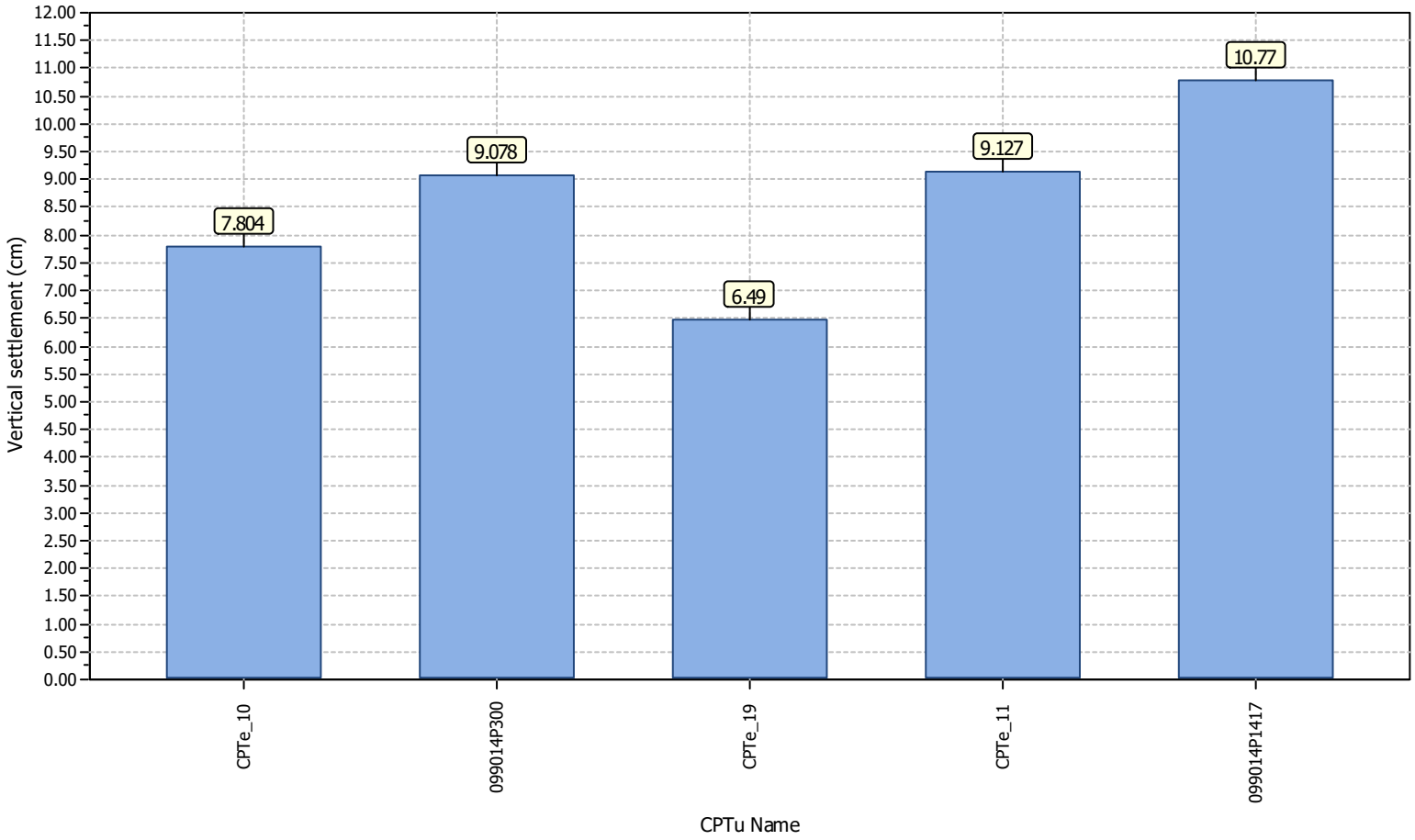
80% high risk

20% very high risk

Project title : MS3 Rimini_RNC

Location : Rimini

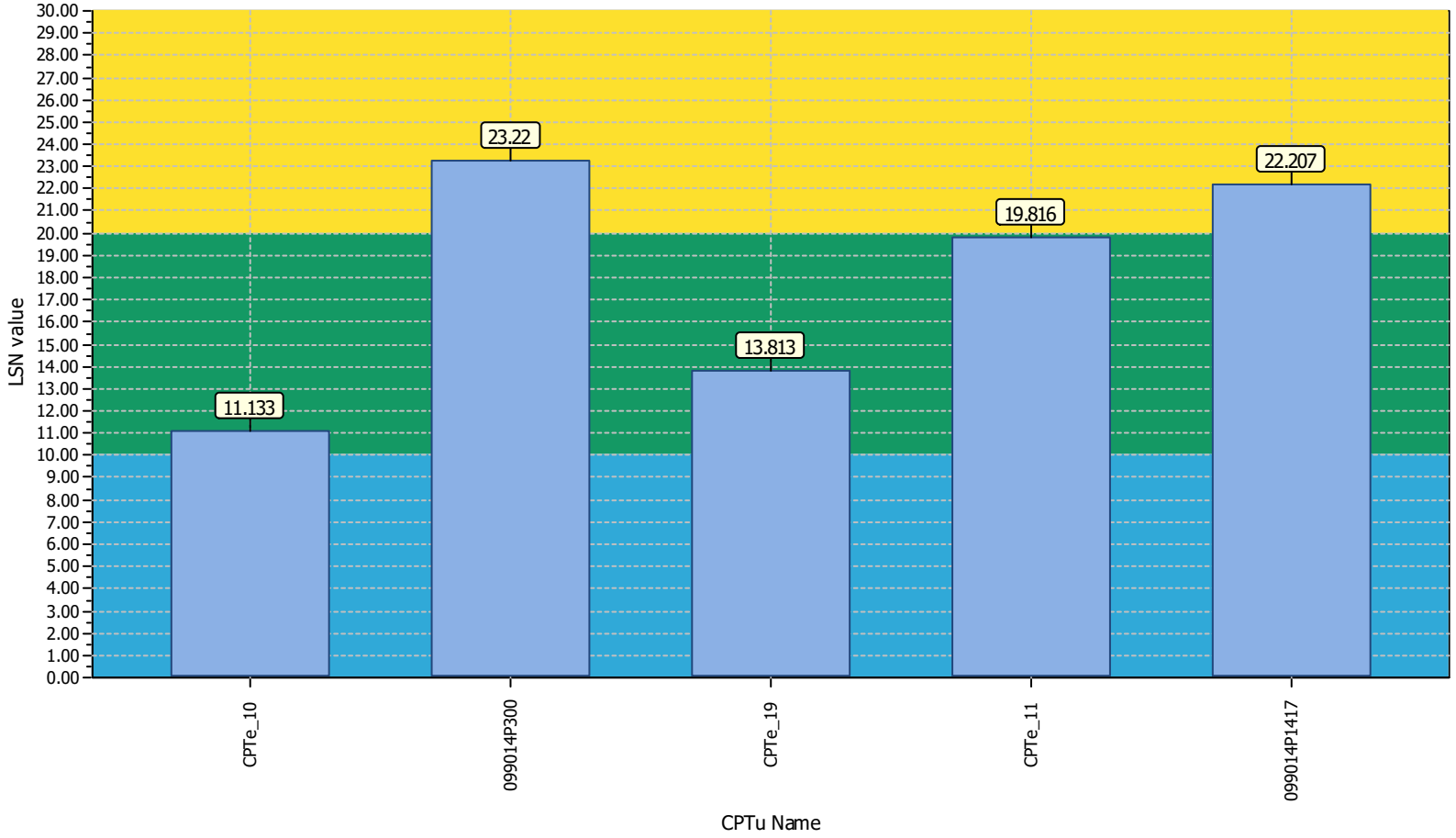
Overall vertical settlements report



Project title : MS3 Rimini_RNC

Location : Rimini

Overall Liquefaction Severity Number report



LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

Basic statistics

Total CPT number: 5

0% little liquefaction

60% minor liquefaction

40% moderate liquefaction

0% moderate to major liquefaction

0% major liquefaction

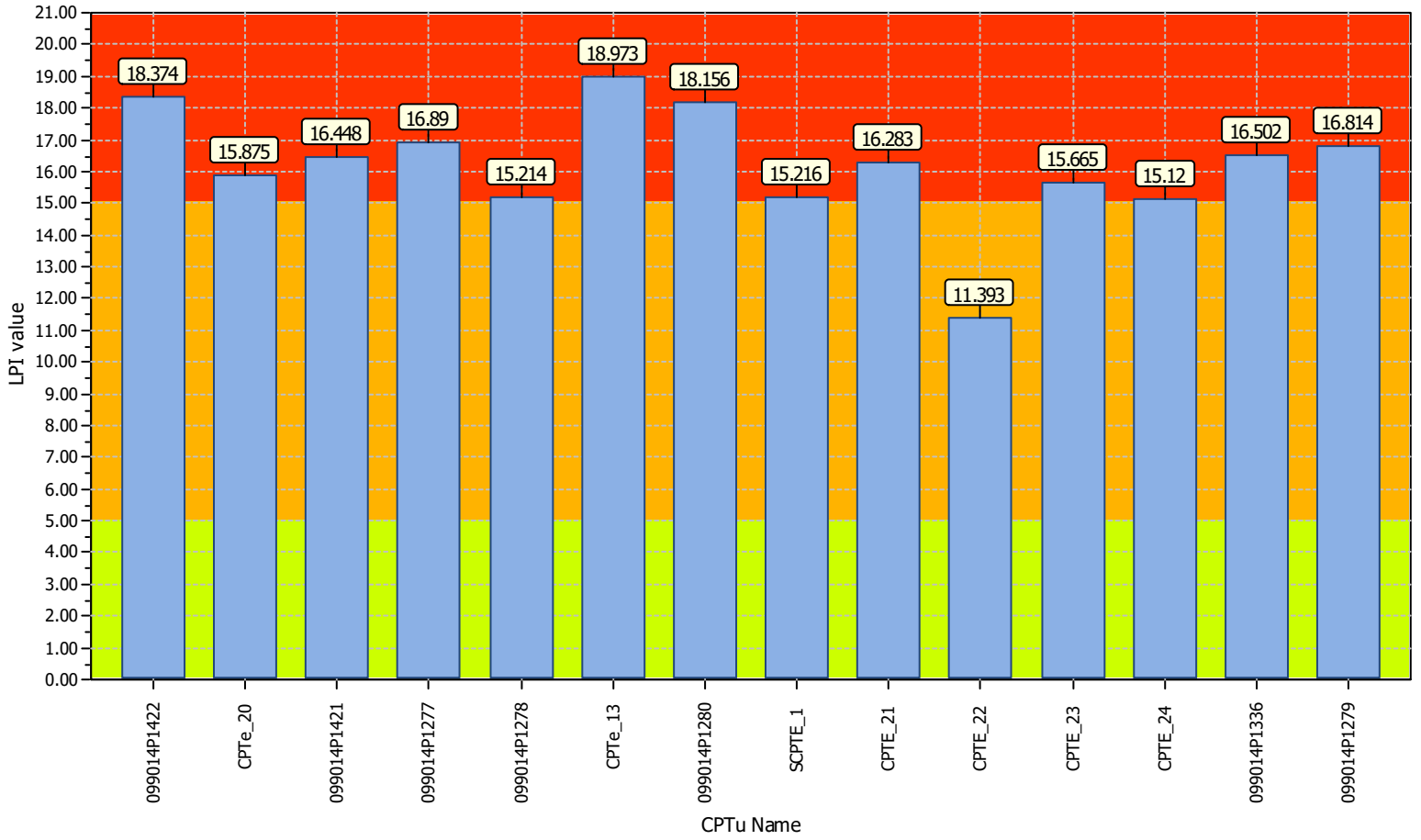
0% severe liquefaction

TABELLE - ZONA RNS_01

Project title : MS3_PA_Rimini_RNS_01

Location : Rimini

Overall Liquefaction Potential Index report



LPI color scheme

- Very high risk
- High risk
- Low risk

Basic statistics

Total CPT number: 14

0% low risk

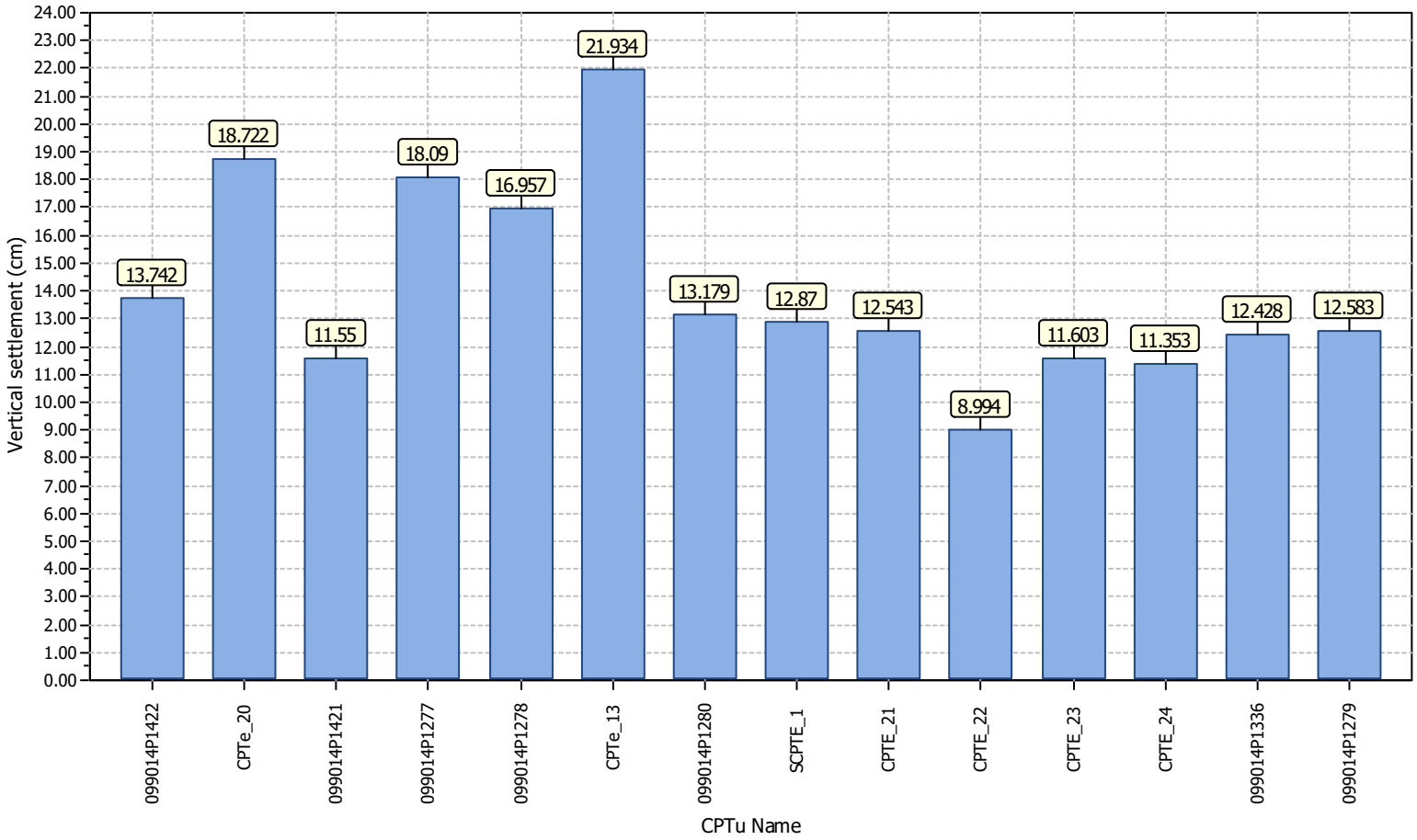
7% high risk

93% very high risk

Project title : MS3_PA_Rimini_RNS_01

Location : Rimini

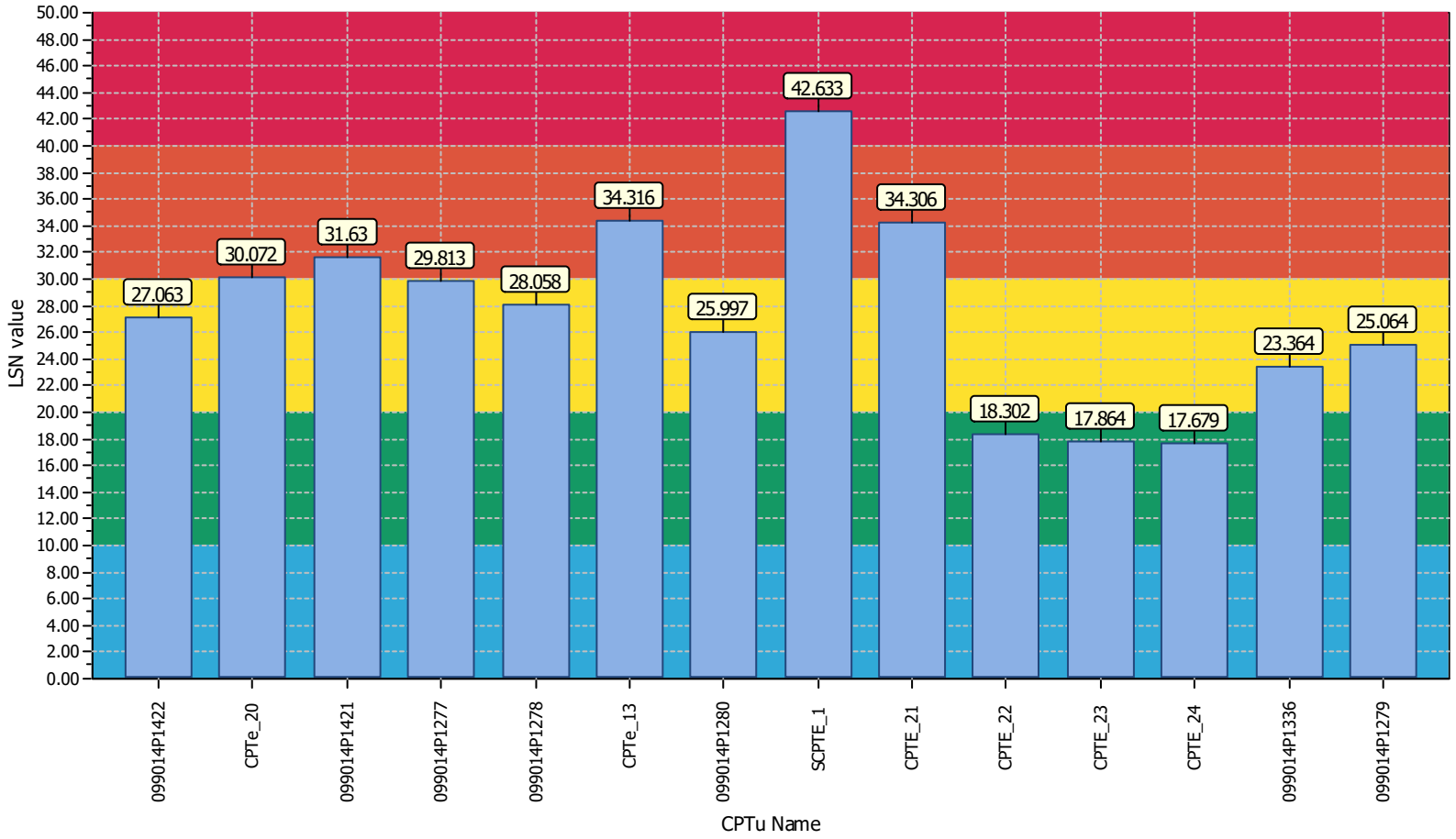
Overall vertical settlements report



Project title : MS3_PA_Rimini_RNS_01

Location : Rimini

Overall Liquefaction Severity Number report



LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

Basic statistics

Total CPT number: 14

0% little liquefaction

21% minor liquefaction

43% moderate liquefaction

29% moderate to major liquefaction

7% major liquefaction

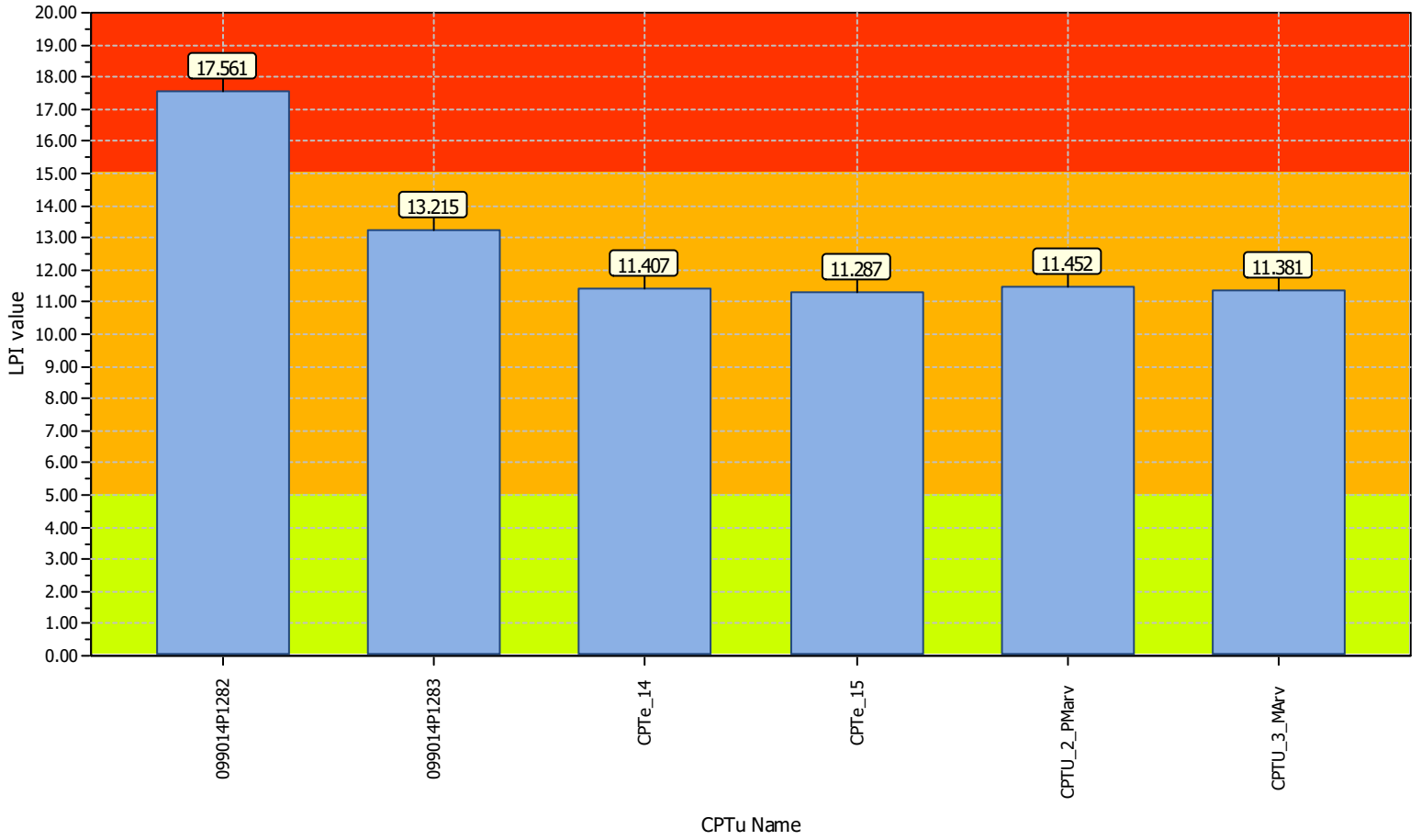
0% severe liquefaction

TABELLE - ZONA RNS_02

Project title : MS3_PA_Rimini_RNS_02

Location : Rimini

Overall Liquefaction Potential Index report



LPI color scheme

- Very high risk
- High risk
- Low risk

Basic statistics

Total CPT number: 6

0% low risk

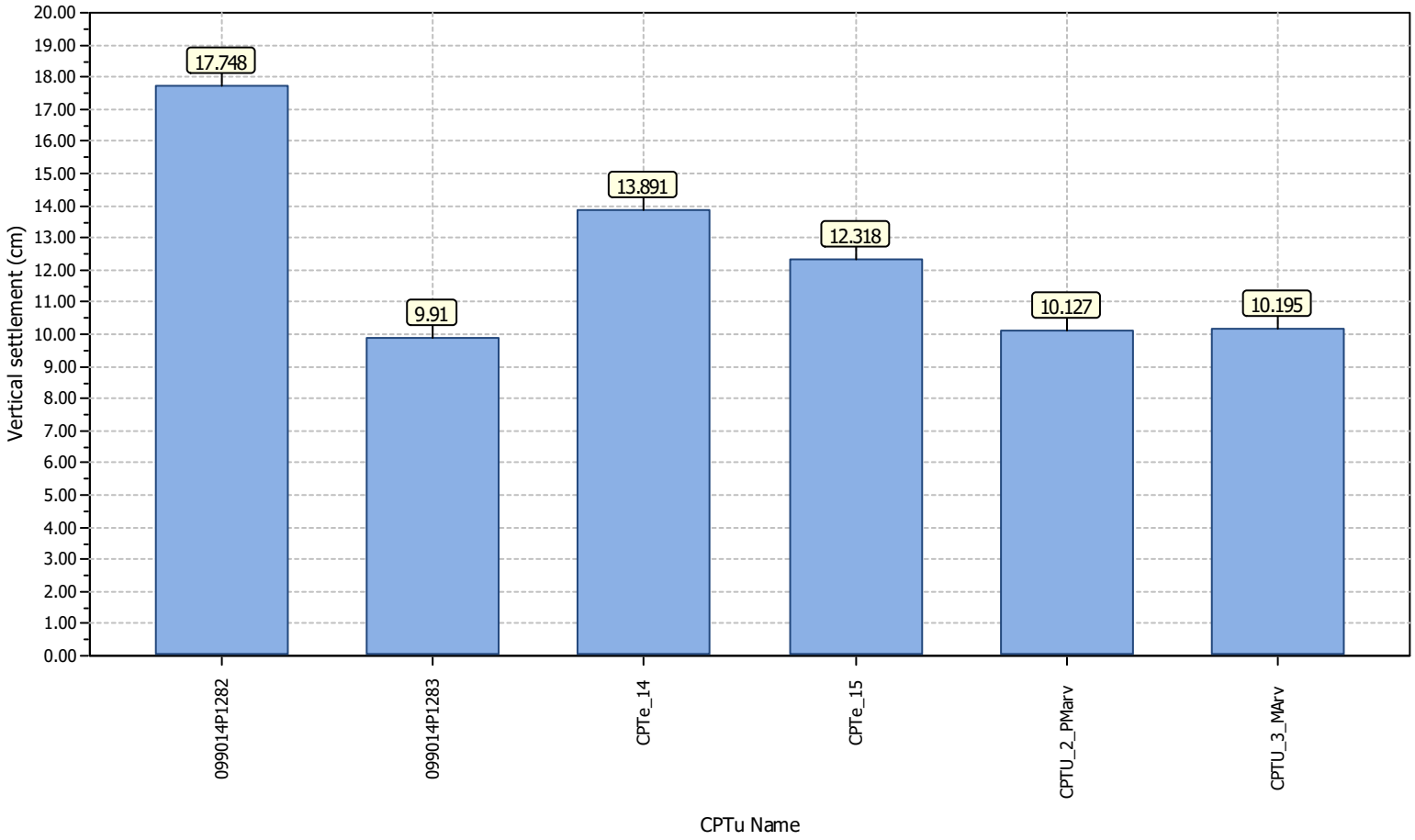
83% high risk

17% very high risk

Project title : MS3_PA_Rimini_RNS_02

Location : Rimini

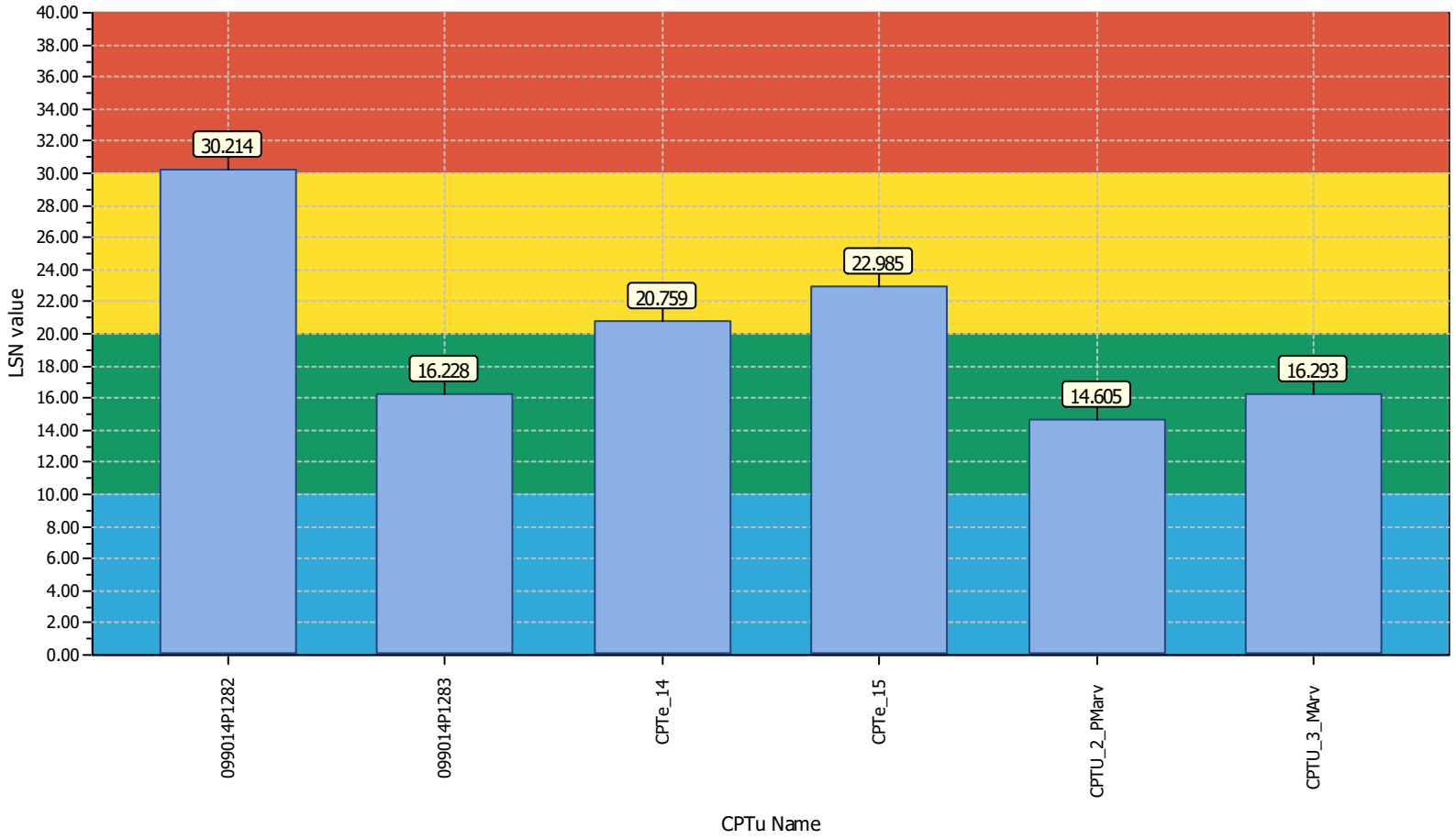
Overall vertical settlements report



Project title : MS3_PA_Rimini_RNS_02

Location : Rimini

Overall Liquefaction Severity Number report



LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

Basic statistics

Total CPT number: 6

0% little liquefaction

50% minor liquefaction

33% moderate liquefaction

17% moderate to major liquefaction

0% major liquefaction

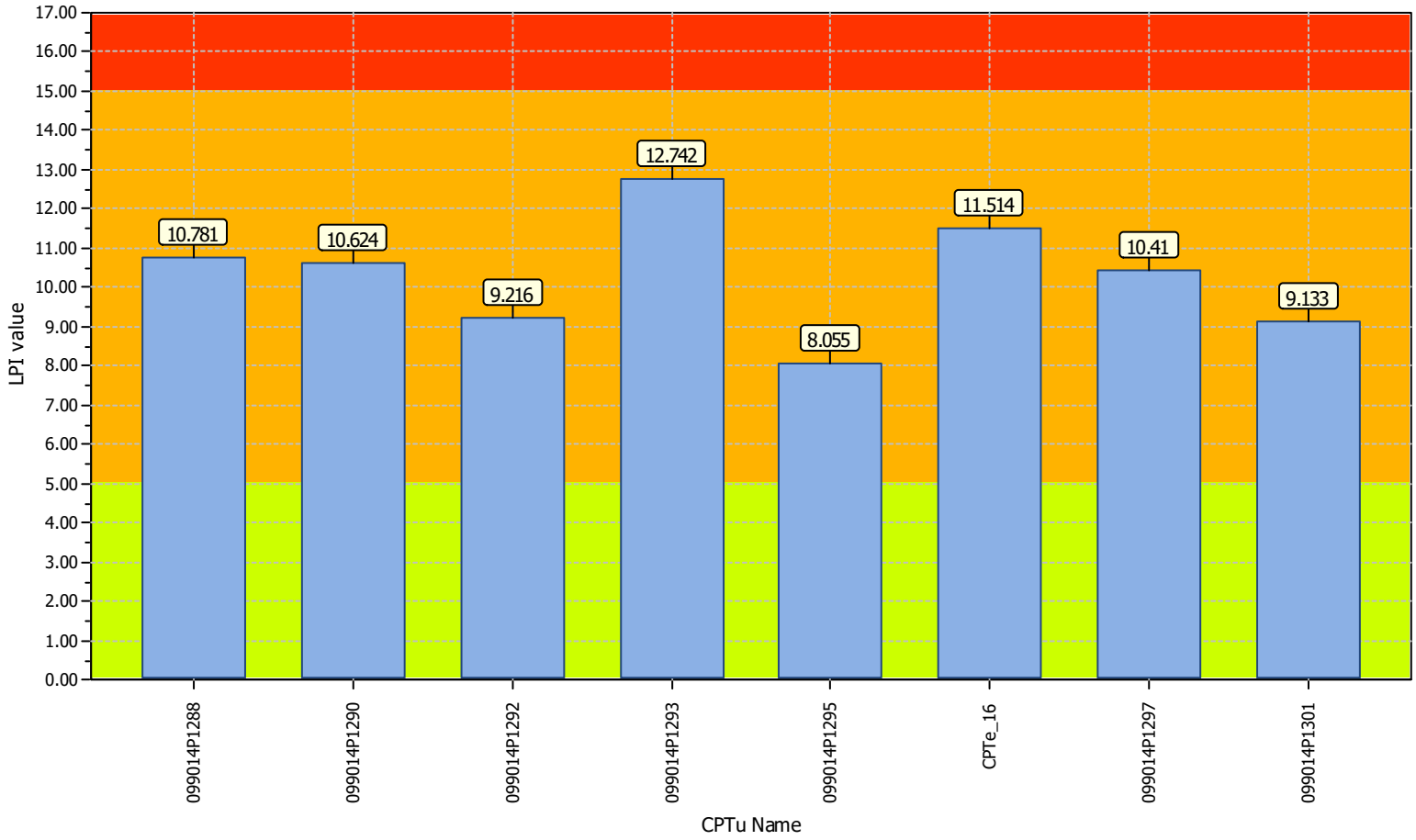
0% severe liquefaction

TABELLE - ZONA RNS_03

Project title : MS3_PA_Rimini_RNS_03

Location : Rimini

Overall Liquefaction Potential Index report



LPI color scheme

- Very high risk
- High risk
- Low risk

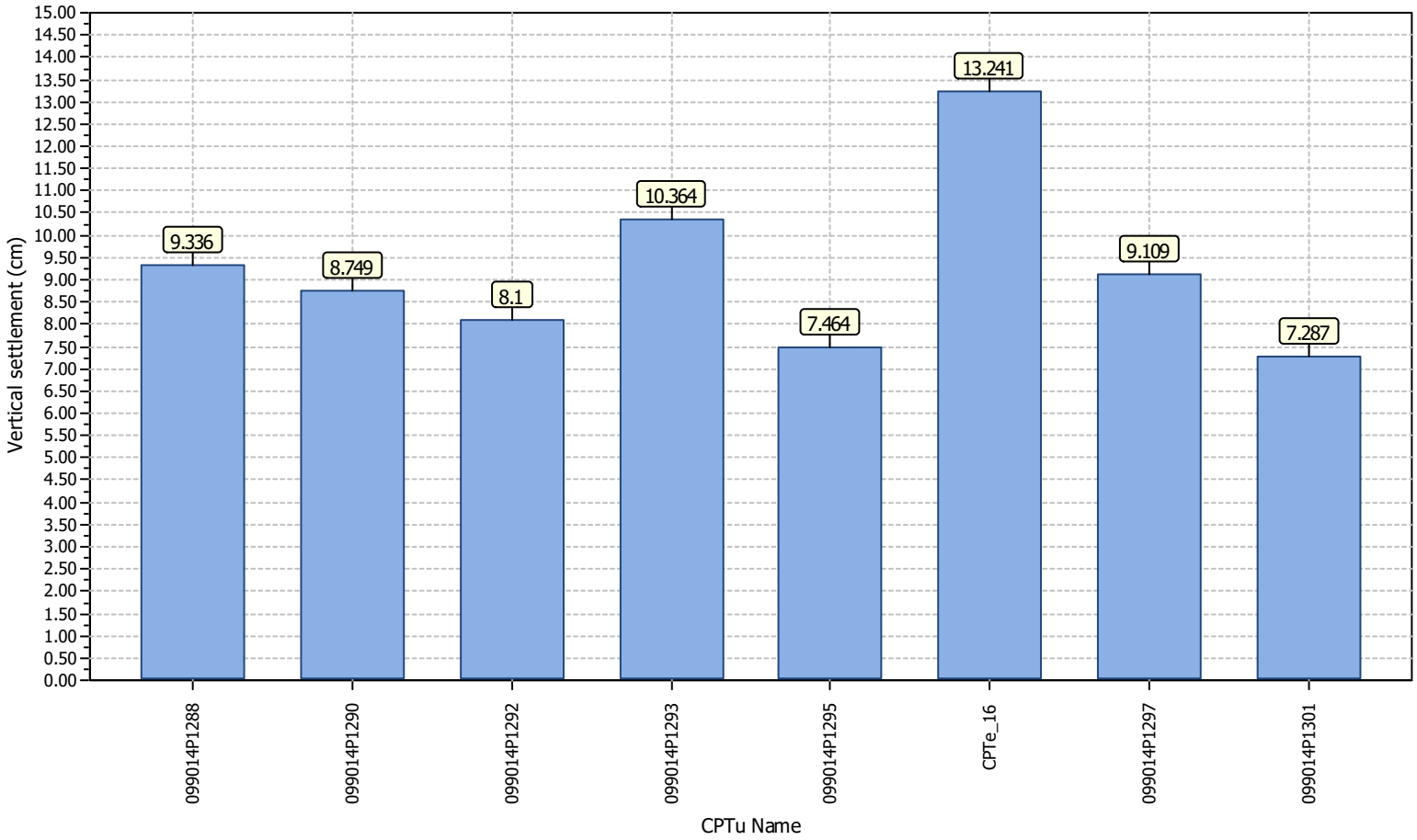
Basic statistics

Total CPT number: 8
0% low risk
100% high risk
0% very high risk

Project title : MS3_PA_Rimini_RNS_03

Location : Rimini

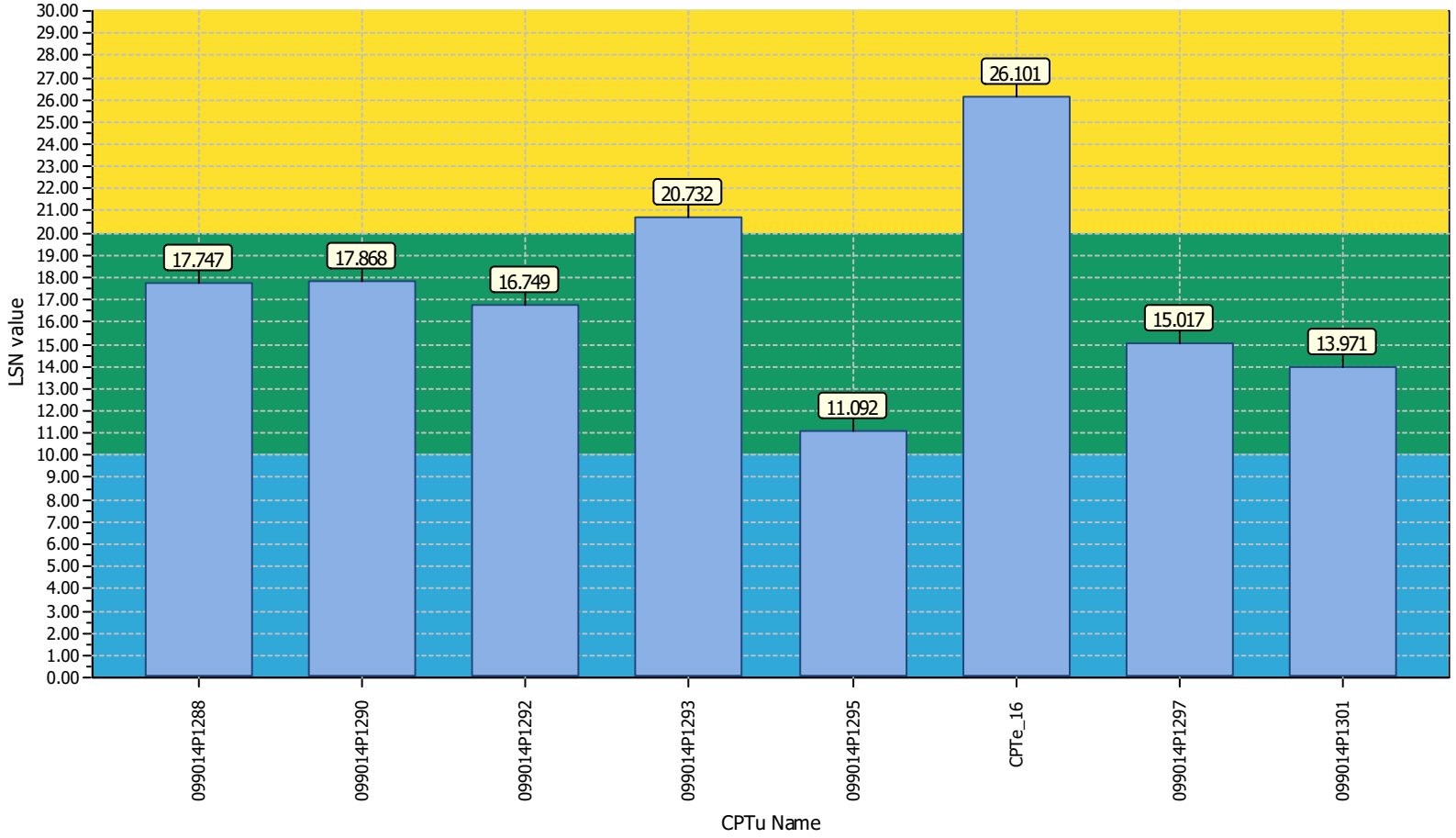
Overall vertical settlements report



Project title : MS3_PA_Rimini_RNS_03

Location : Rimini

Overall Liquefaction Severity Number report



LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

Basic statistics

Total CPT number: 8

0% little liquefaction

75% minor liquefaction

25% moderate liquefaction

0% moderate to major liquefaction

0% major liquefaction

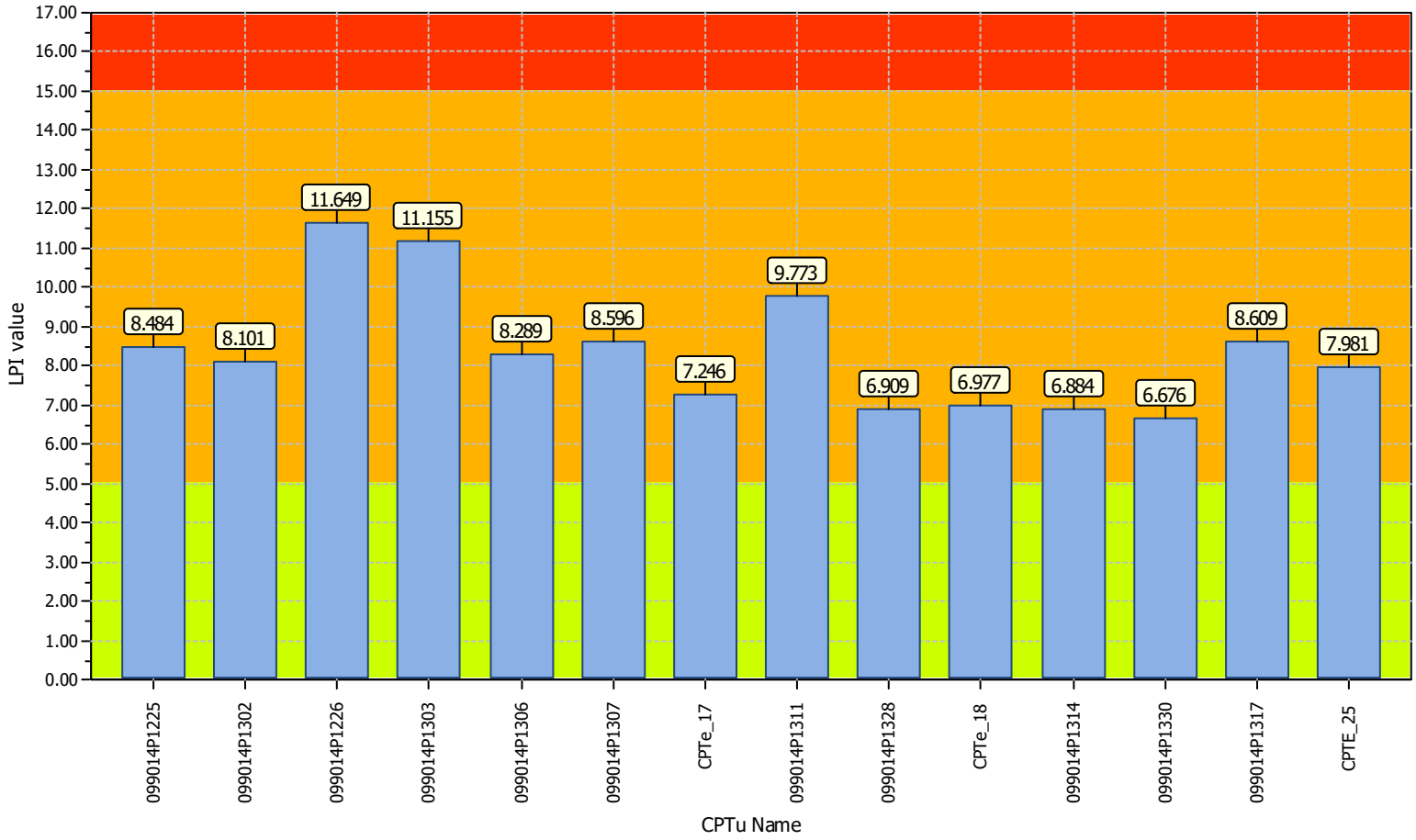
0% severe liquefaction

TABELLE - ZONA RNS_04

Project title : MS3_PA_Rimini_RNS_04

Location : Rimini

Overall Liquefaction Potential Index report



LPI color scheme

- Very high risk
- High risk
- Low risk

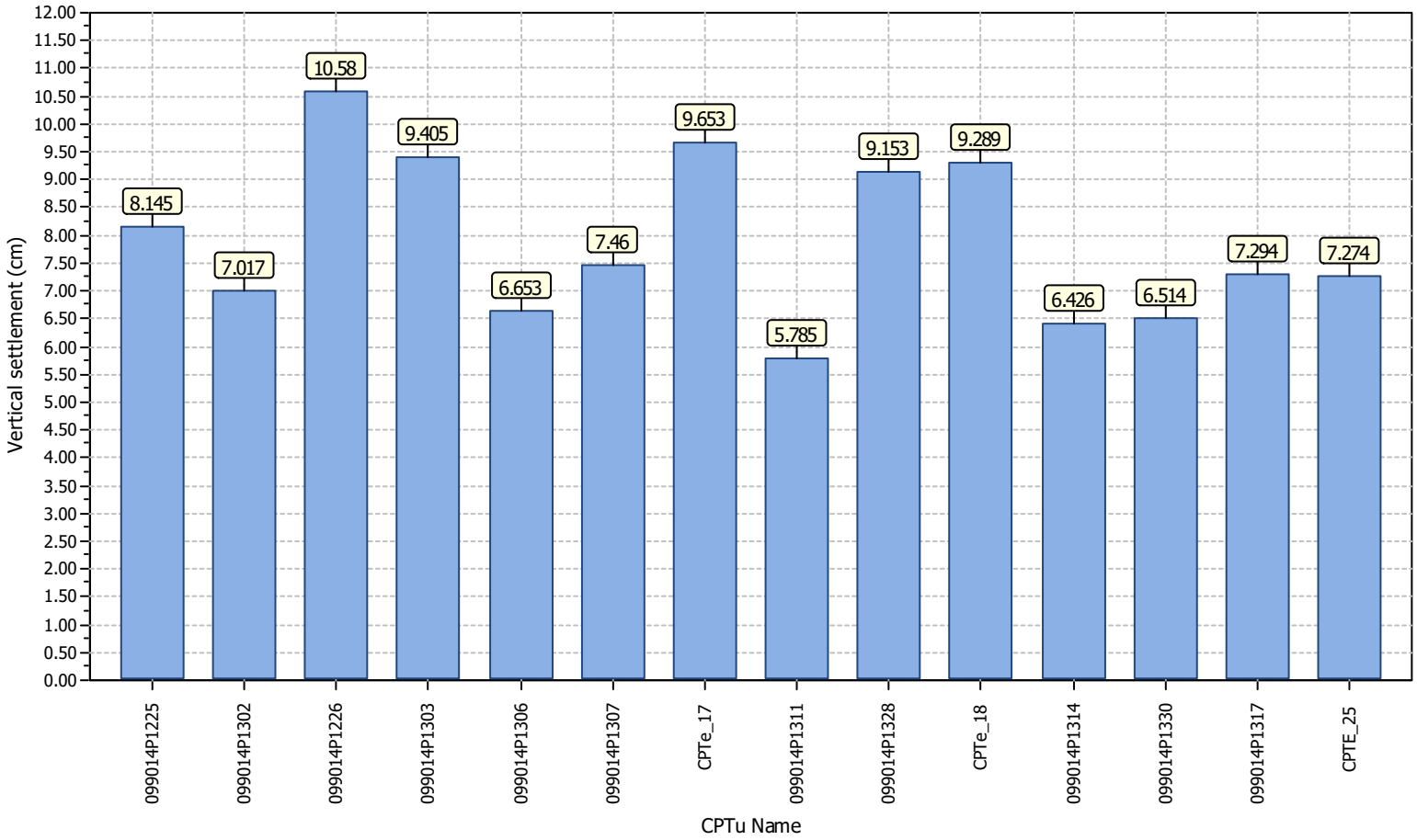
Basic statistics

Total CPT number: 14
0% low risk
100% high risk
0% very high risk

Project title : MS3_PA_Rimini_RNS_04

Location : Rimini

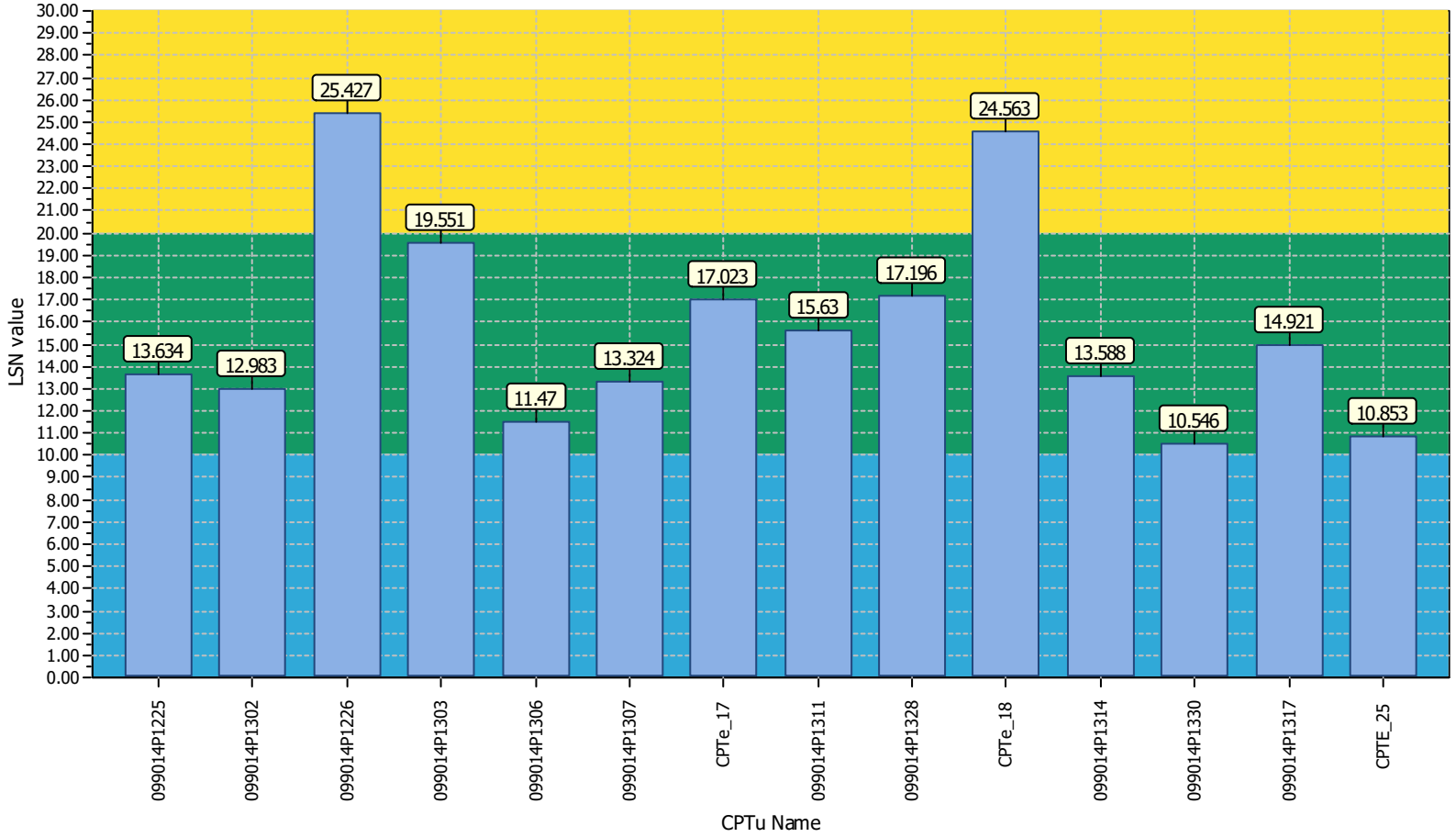
Overall vertical settlements report



Project title : MS3_PA_Rimini_RNS_04

Location : Rimini

Overall Liquefaction Severity Number report



LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

Basic statistics

Total CPT number: 14

0% little liquefaction

86% minor liquefaction

14% moderate liquefaction

0% moderate to major liquefaction

0% major liquefaction

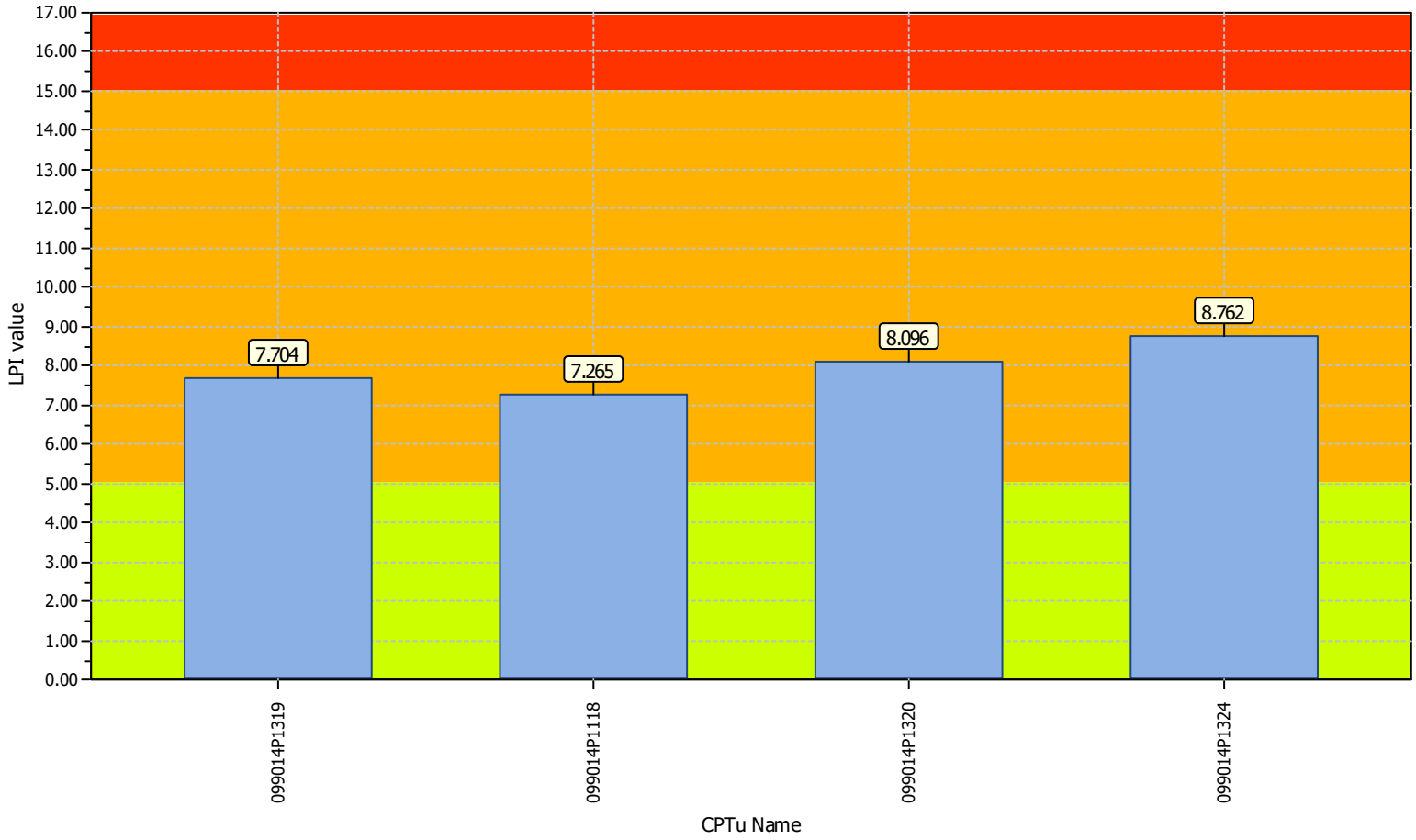
0% severe liquefaction

TABELLE - ZONA RNS_05

Project title : MS3_PA_Rimini_RNS_05

Location : Rimini

Overall Liquefaction Potential Index report



LPI color scheme

- Very high risk
- High risk
- Low risk

Basic statistics

Total CPT number: 4

0% low risk

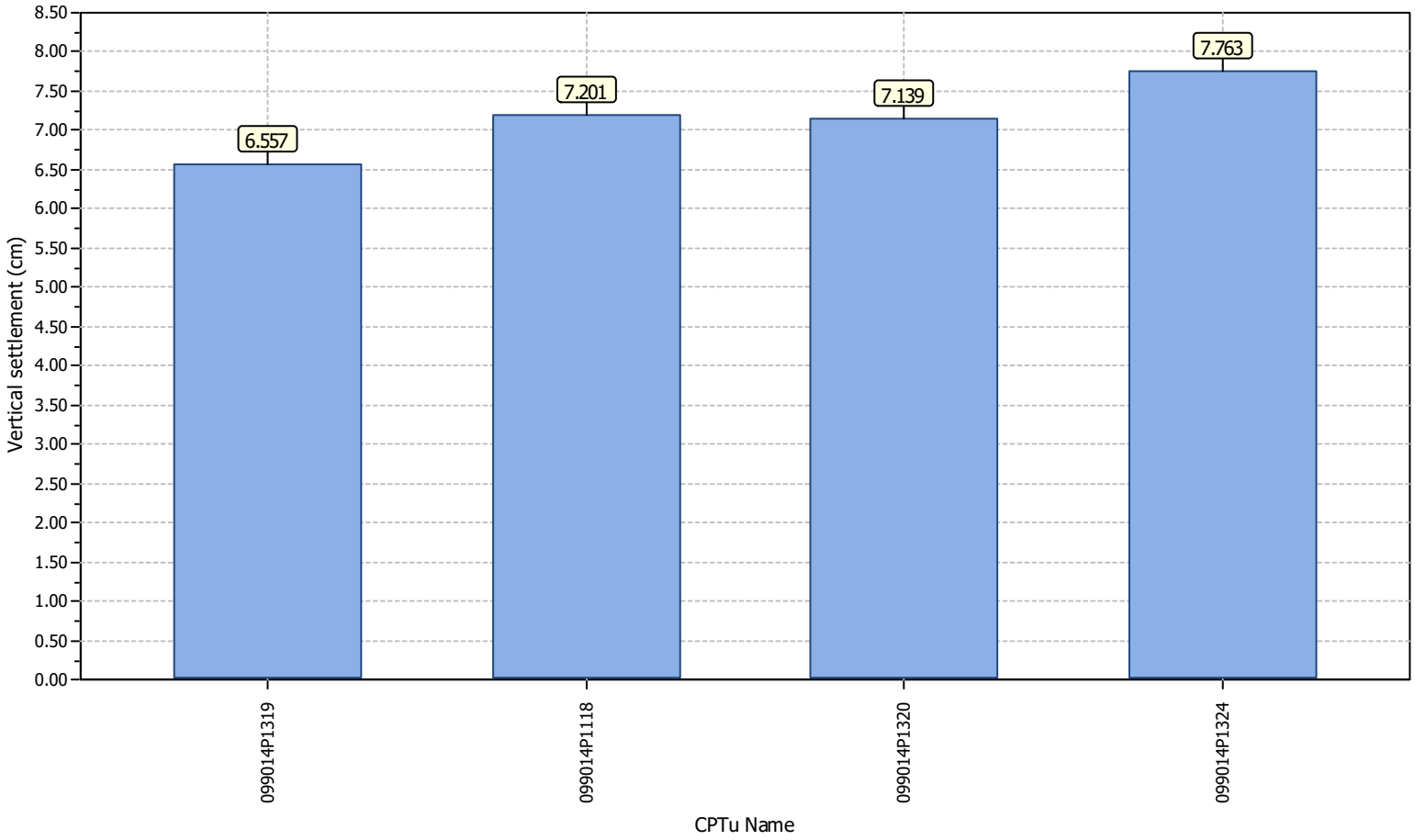
100% high risk

0% very high risk

Project title : MS3_PA_Rimini_RNS_05

Location : Rimini

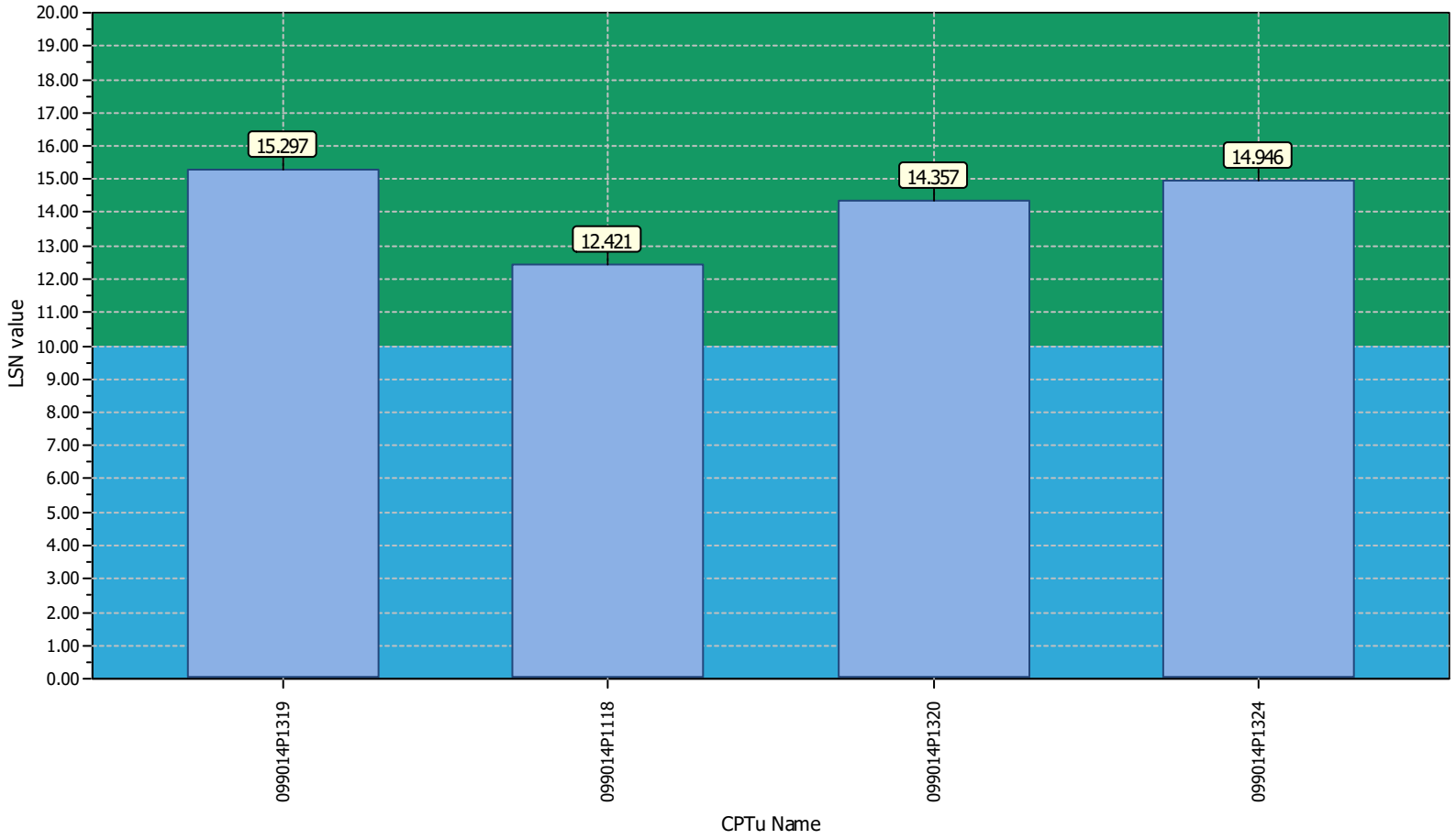
Overall vertical settlements report



Project title : MS3_PA_Rimini_RNS_05

Location : Rimini

Overall Liquefaction Severity Number report



LSN color scheme

- Severe damage
- Major expression of liquefaction
- Moderate to severe exp. of liquefaction
- Moderate expression of liquefaction
- Minor expression of liquefaction
- Little to no expression of liquefaction

Basic statistics

Total CPT number: 4

0% little liquefaction

100% minor liquefaction

0% moderate liquefaction

0% moderate to major liquefaction

0% major liquefaction

0% severe liquefaction