Reference Ground Conditions for Construction

Are the current Hong Kong GBRs Fit for Purpose?

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October 2013

Content of Presentation

- **Reference Ground Conditions & GBRs within the context of risk management**

- **Continuity of identification/management of ground condition risk**

- **Ownership of GBRs - why is it a design deliverable?**

- **Examples from current HK GBRs**

Objective is not to criticise individual GBRs – seeking to illustrate they are a product of a system which may be flawed

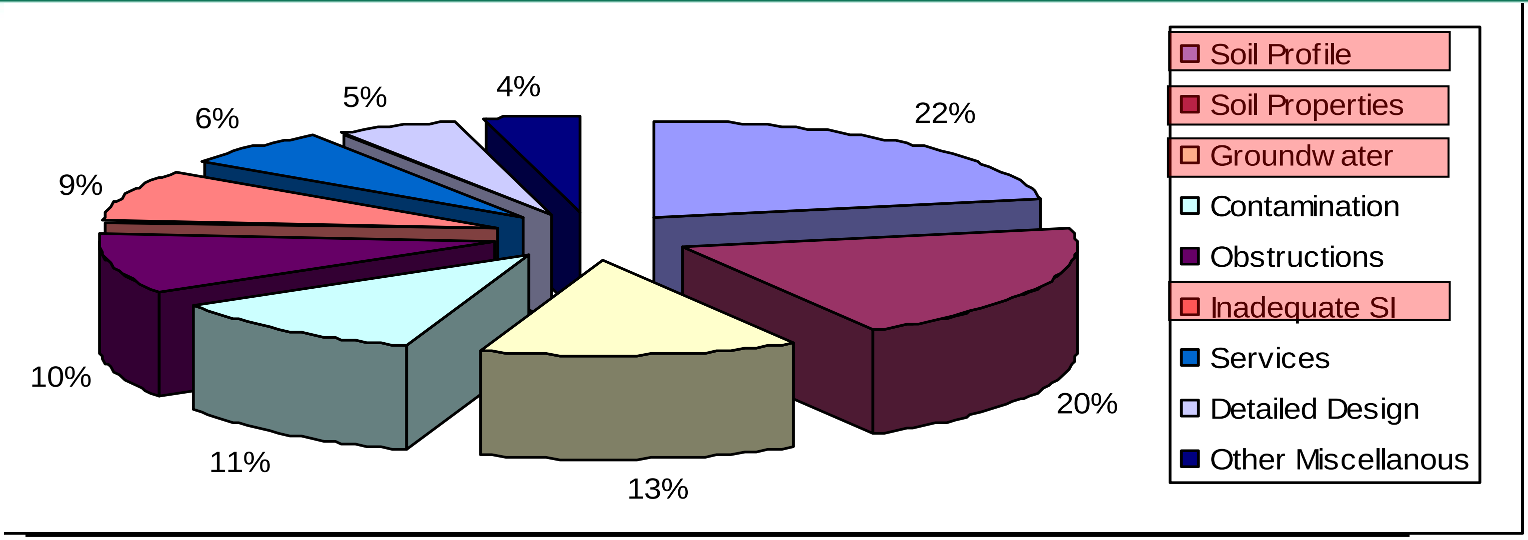
Ground Condition Risk on Infrastructure Projects

- **Infrastructure projects tend to be linearly extensive**
- **Combinations of design/construction elements**
- **Multiple contracts – different designers/contractors**

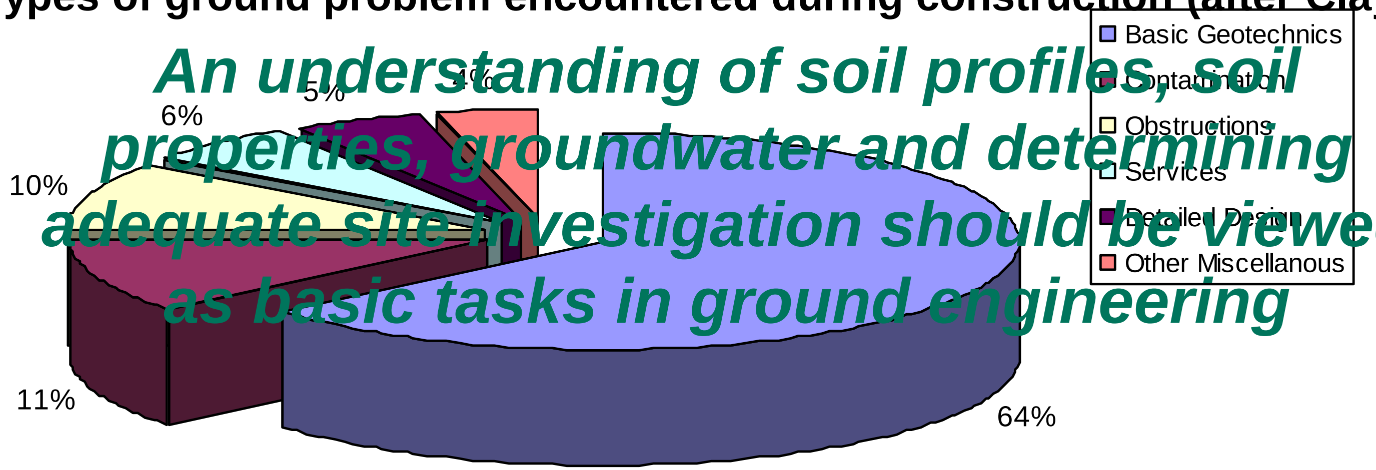
Engineers seek to impose uniformity on elements of design, construction and commercial elements of project

but have to accommodate variability in ground conditions

Are we managing ground condition risk?



Types of ground problem encountered during construction (after Clayton,2001)



An understanding of soil profiles, soil properties, groundwater and determining adequate site investigation should be viewed as basic tasks in ground engineering

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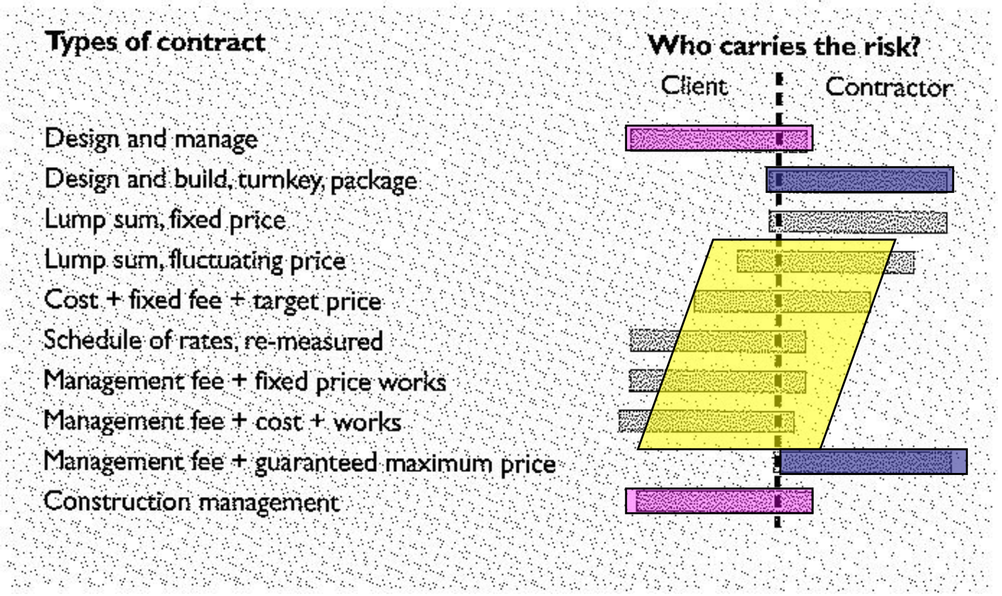
Our recent experience on major infrastructure projects

Number & Nature of Projects	Type/range of problems investigated	Source of Problem
8 Projects involving tunnelling	10 cases of excessive ground movement	4 cases of an unbuildable design
10 projects involving land reclamation	8 cases of ground collapse or the risk of instability	8 examples of a lack of understanding/application of basic soil mechanics
13 projects involving deep excavations	12 cases of significant cost/time overrun	7 examples of site investigation data inconsistent with design assumptions
3 projects involving major cut slopes or retaining walls	5 cases of failure to control ground water	6 examples of failure to validate design assumptions during construction
3 projects involving large embankments on soft ground		10 examples of a lack of continuity of geotechnical input during project
		4 examples of an inappropriate specification for construction
		2 examples of an inadequate FoS for design product

In most cases – problem was adequately understanding and communicating risk

Managing Ground Condition Risk on Infrastructure Projects

- **Take ownership of risk**
- **Transfer Risk**
- **Insure Risk**



The party best placed to manage risk should take ownership

but……

those with the greatest knowledge on risk - least incentive to manage it?

Transfer of disproportionate risk does not guarantee a cost-effective outcome

Evidence is that a shared risk approach can help manage ground condition risk and control project costs

What are the mechanisms and tools used to implement this

Reasonable foreseeability approach

Geotechnical Factual and Interpretative Reports

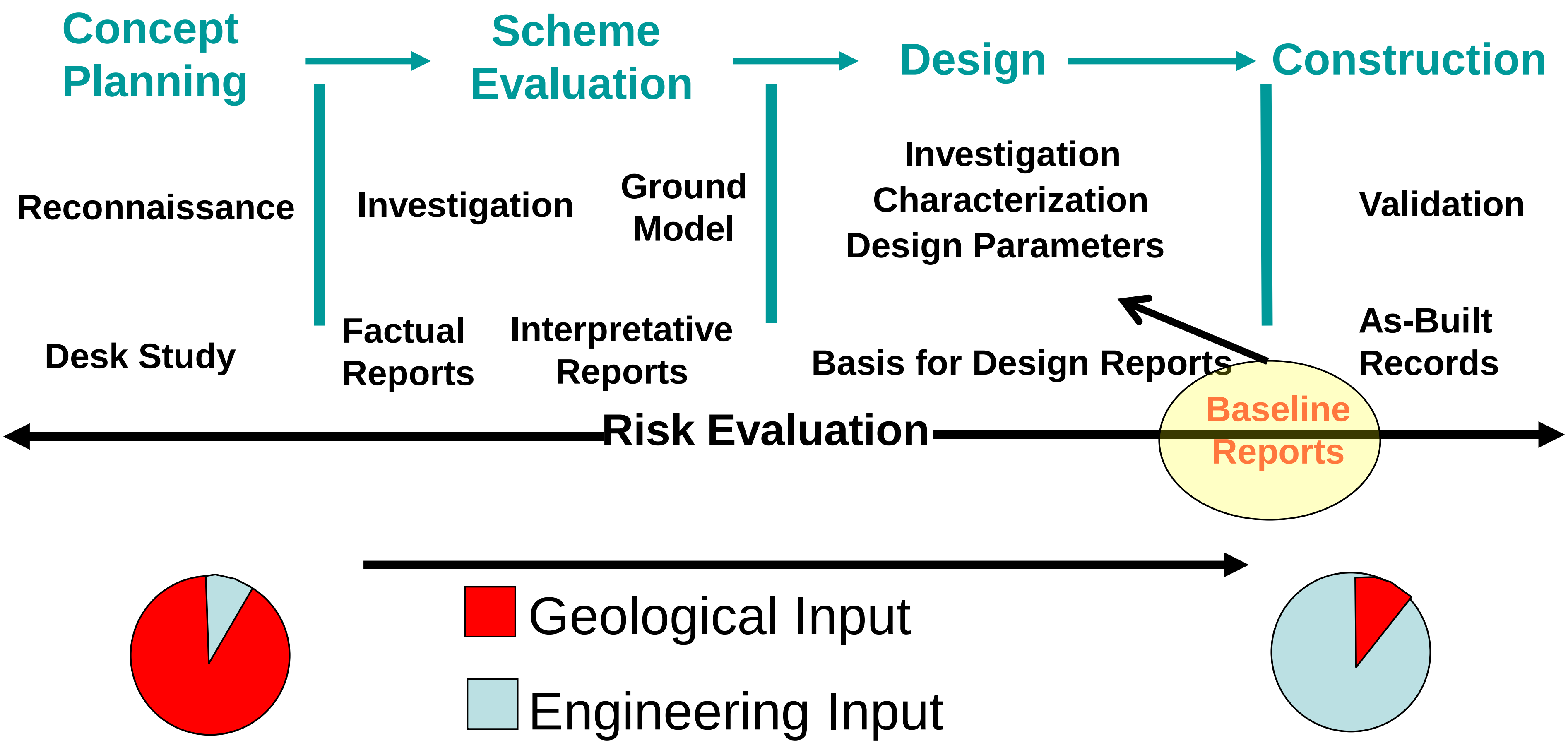
Differing Site Conditions approach

Statement on Reference Ground Conditions (GBR)

Move to objective measurement of ground conditions with respect to contractually agreed benchmark

In order to effectively and responsibly share risk – have to know what it represents - for both parties

Identification of Ground Risk and Reference Conditions with Respect to Project Timelines



Statement on Reference Ground Conditions should be a product of project risk assessment – not an isolated phase deliverable

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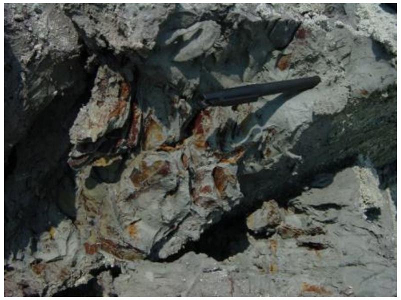
Developing a Risk Profile:
Same Ground Conditions – Different Perspective



The focus of the geologist
Formation/Origins of Soils/Rocks
Alteration
Composition – Fabric – Structure
Ground Model

The focus of the design engineer
Strength
Compressibility
Permeability
Permanent Works

The focus of the construction engineer
Temporary Works
Conditions that will impact productivity & attainment of specifications

Effective risk profile must include consideration of all perspectives

GBR based too heavily on design phase will not reflect full profile of ground condition risk

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GBR compiled as a Design Deliverable – the pitfalls

- Insufficient consideration given to construction process –same GBR for TBM and D&B tunnel (viaducts!)
- “smoothing” of data – design relies on representative values – risk in construction determined by anomalies/outliers
- Some design parameters not suitable as baseline parameters – permeability
- Designers don’t have time to take effective ownership of GBR

Ownership of GBR is a fundamental problem to be addressed

Examples of dealing with ground condition risk through GBRs - Viaducts

- Linear structure but ground condition risk is very location specific – Piers
- Nature of major ground condition risk also very specific – pile foundations
- Two principal risks - at individual pier locations
  - Variation in rockhead level
  - Obstructions above founding level

GBR should be focused on addressing these risks

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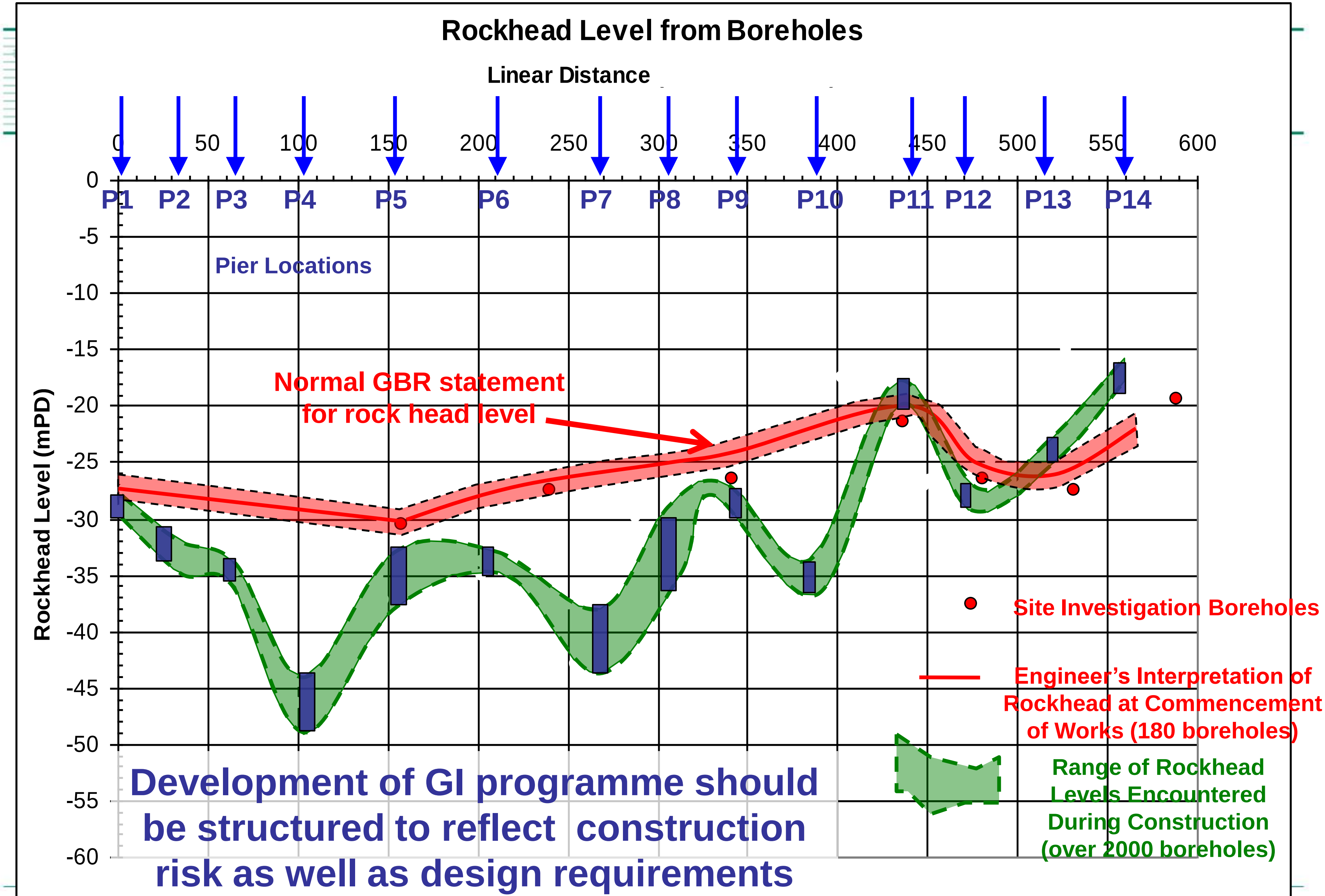

Development of GI programme should be structured to reflect construction risk as well as design requirements

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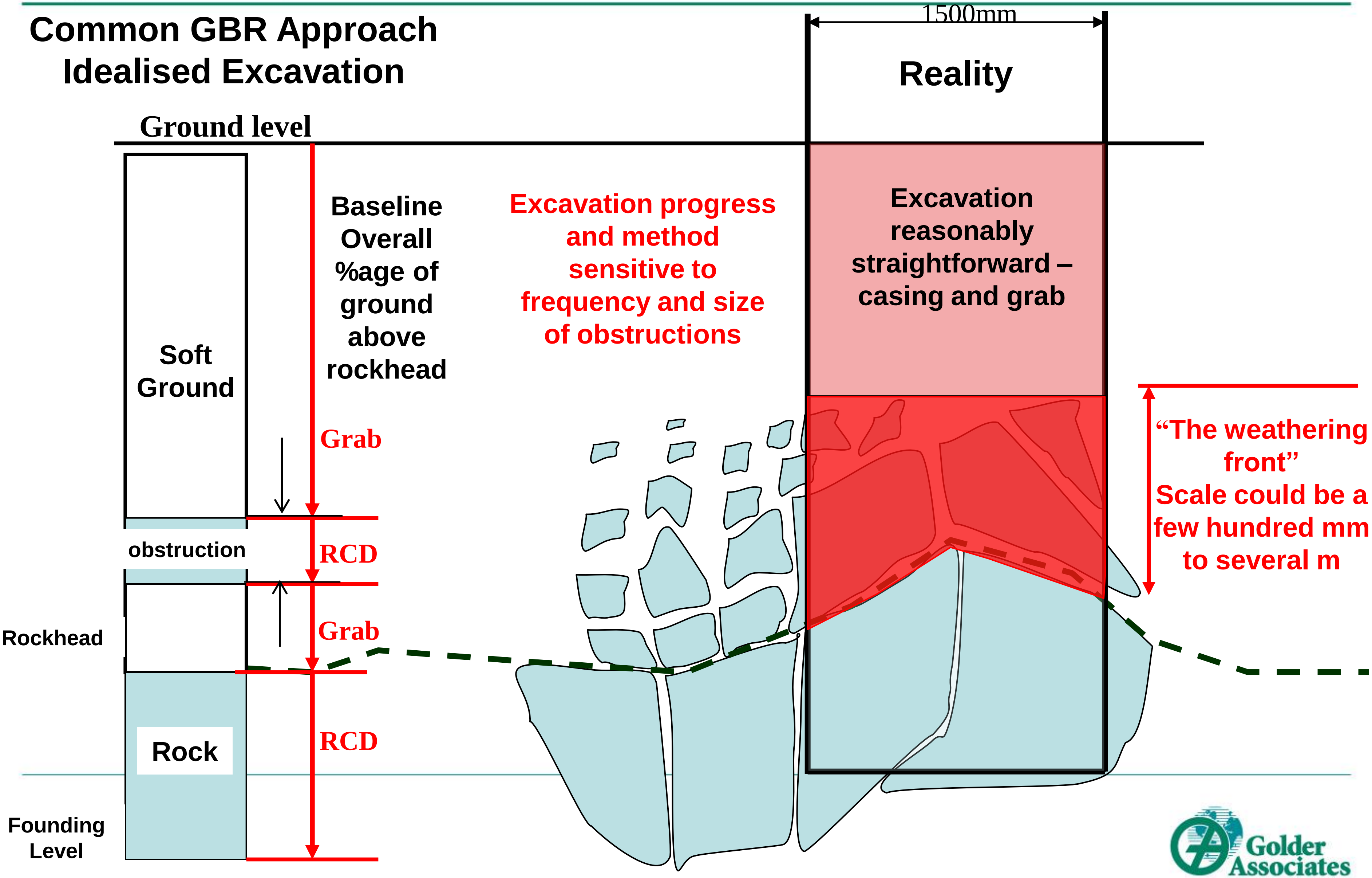
Ground Condition Risk – Obstructions Above Founding level



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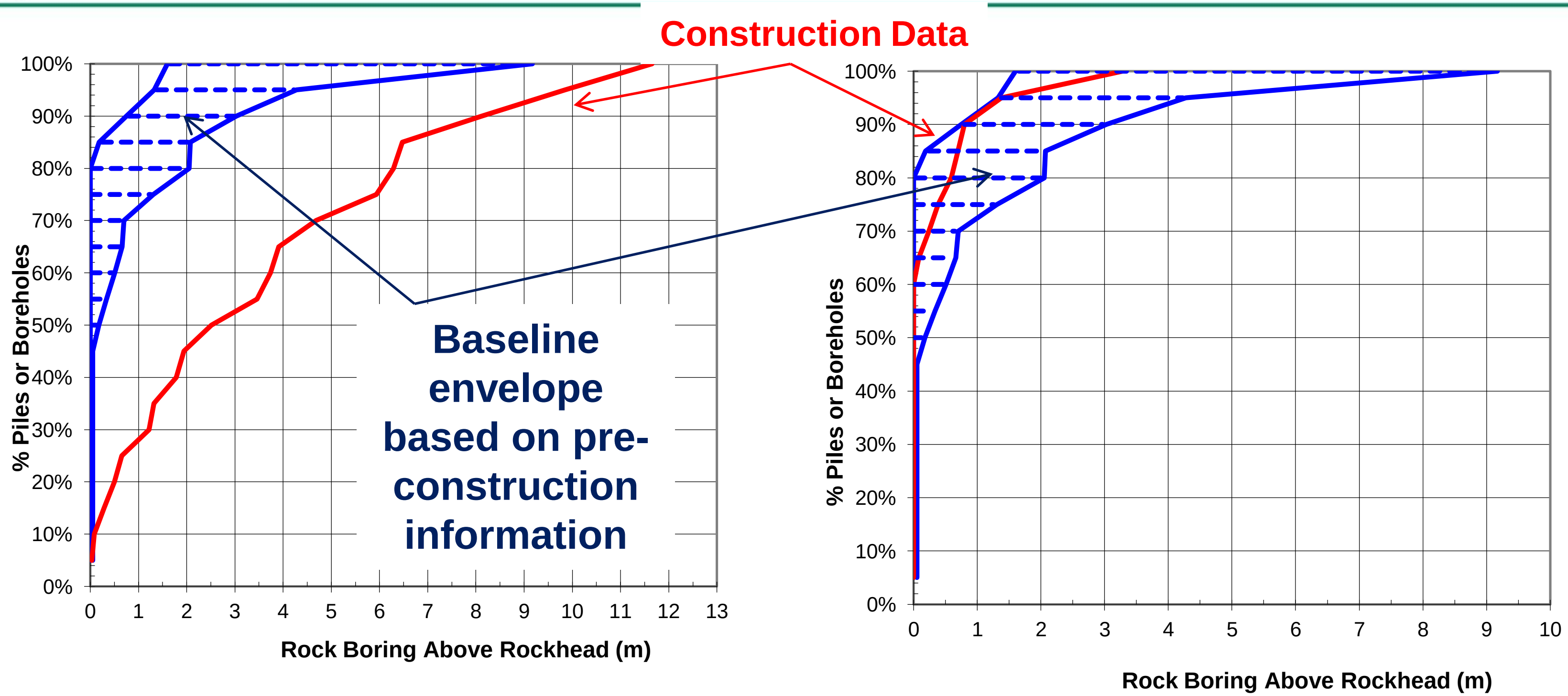
Baseline for rock above rockhead
Alternative approach



Pier A **Pier B**

Allows a more objective measurement of ground conditions for baseline comparison

Difficulties implementing Baseline Values Example – SPT Values

Soil Type	SPT N Values (No. of Blows/300mm)	
	Maximum Value	Minimum Value
Fill	100	3
Marine Deposit	30	1
Alluvium	65	5
Colluvium	65	5
Completely/Highly Decomposed Monzonite / Syenite	>200	5
Completely/Highly Decomposed Tuff	>200	5
Completely/Highly Decomposed Granite	>200	5

Baseline covers all credible values

Risk Transfer not Risk Sharing

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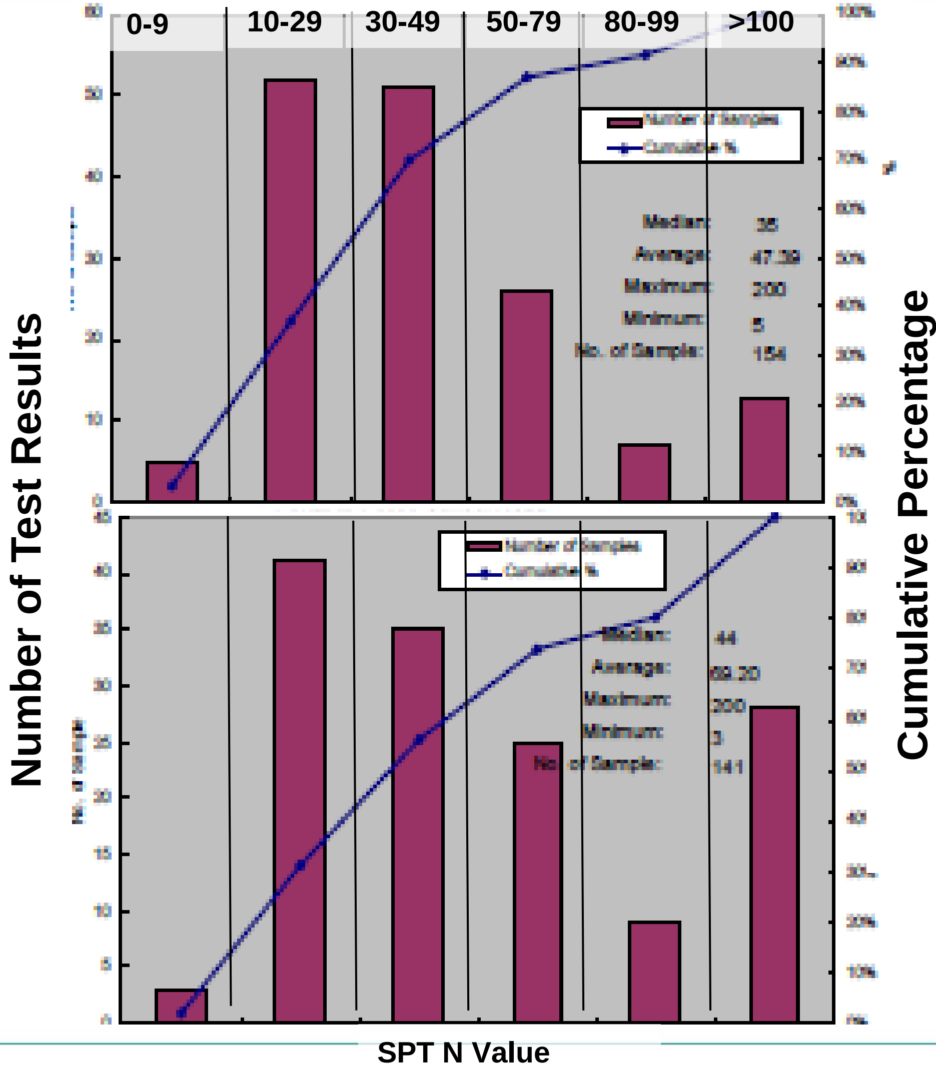
Raw SPT data using simple statistical approach



Rock Type A
70% N < 50
10% N >100

Rock Type B
50% N < 50
20% N >100

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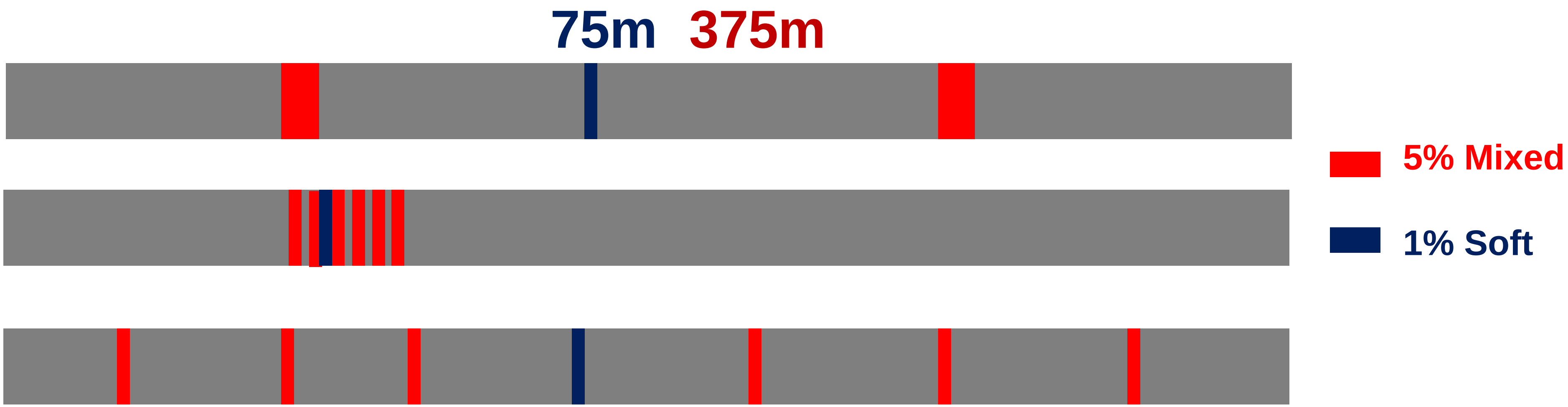
Example of Baselines for Tunnel Geology

Length of Tunnel Section (m)	Baseline Ground Conditions Proportion of Total Length (%)		
	Soft Ground	Mixed Ground	Rock
7,500	1	5	94



Overall %ages of ground classification can be encountered with a range of distributions – all with different risk profiles for construction

Should Baselines of this type for long tunnels state maximum isolated length of minority (most adverse) conditions?

“Mixed Ground” for Tunnelling

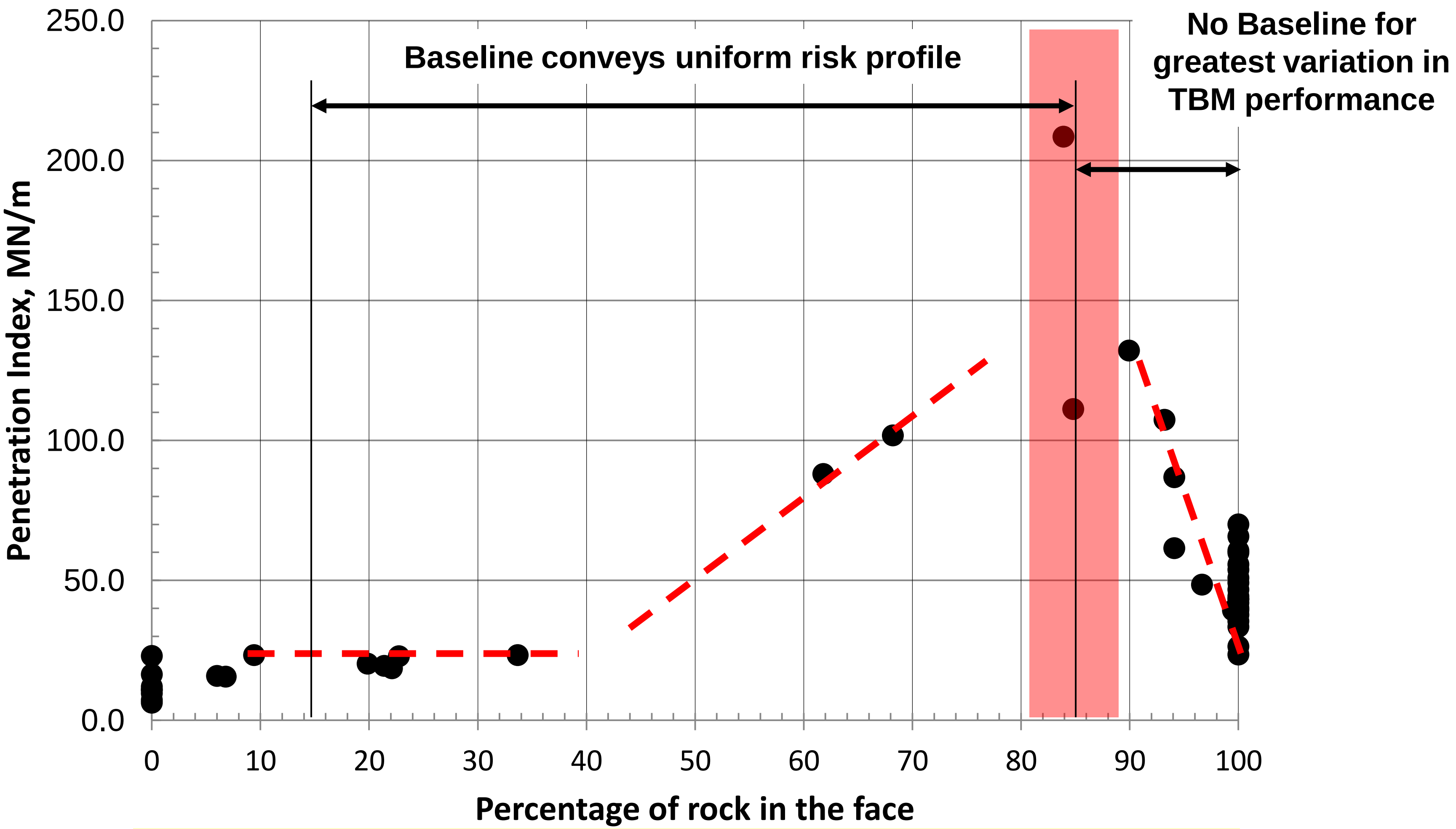
Mixed Ground	Mixed Ground shall mean a combination of Soil and Rock containing between 15% to 85% Rock

Commonly adopted baseline classification currently in use for TBM tunnel projects in HK

but….

- **How can it be measured in a TBM environment?**
- **Is the range commensurate with the ground condition risk?**
- **What risk is it attempting to communicate?**

Measurements of TBM Penetration v Mixed Ground Composition



If the risk is TBM advancement rate
Should we not be basing it on something we can measure accurately?

Talk to TBM manufacturers?

Other common features of current GBRs in HK

- **Excavation of Rock – always characterized by UCS values**

  Is degree of fracturing and/or tensile strength not more significant?

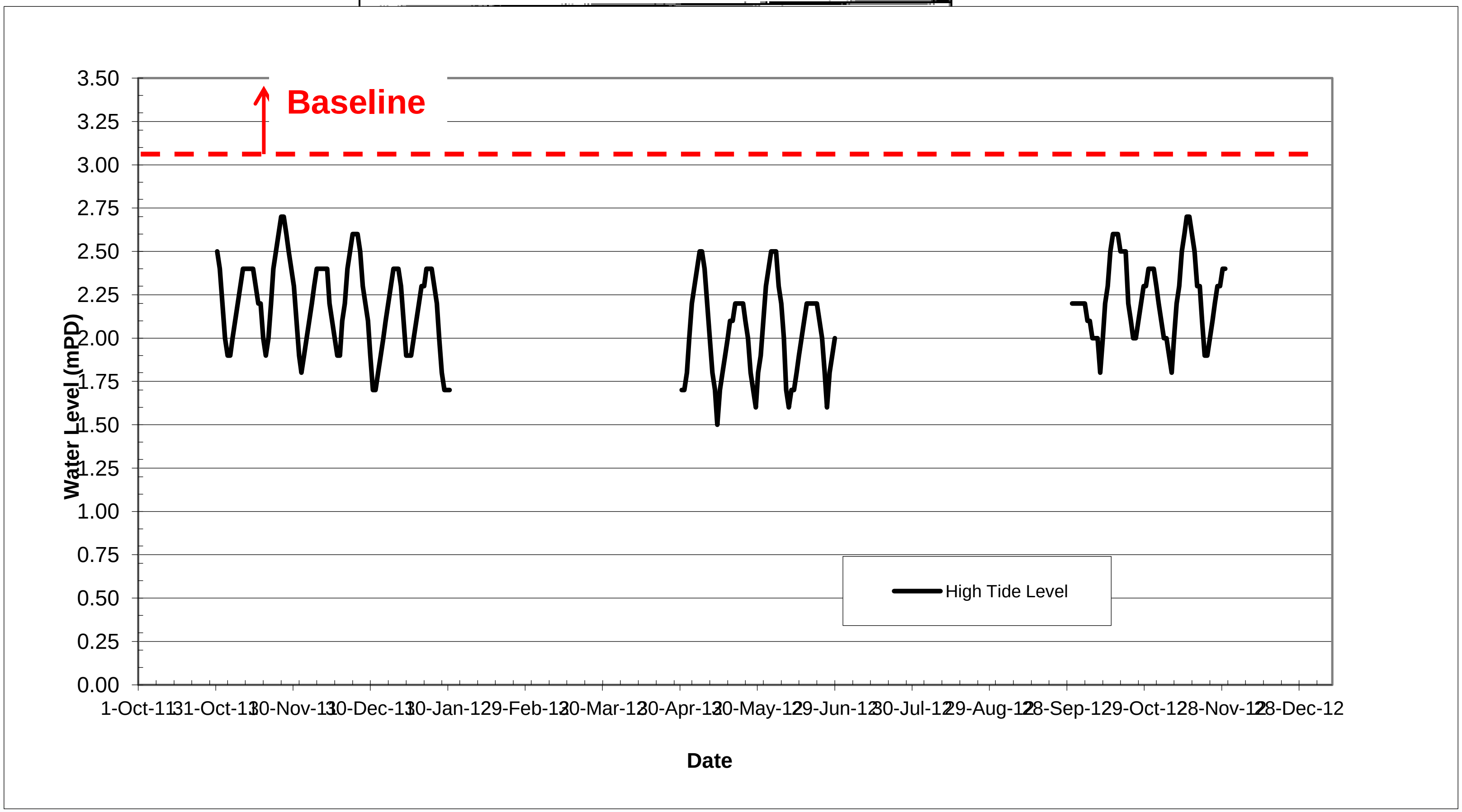
- **Strength parameters for soils – always effective stress**

  Temporary works in fine grained soils governed by undrained behaviour

- **Groundwater levels – often unrealistic**

Example of Groundwater Baseline Statement

Baseline Groundwater Level
3.2m below ground but not lower than 3.1mPD



GBRs in Hong Kong - Summary of Views

- **Reference ground conditions should be a reflection of risk assessment throughout the development of the project – requires continuity from concept planning to construction**
- **Current GBRs in HK are weighted towards design perspective – would benefit from constructability perspective**
- **Too many "global" baselines – insufficient focus on specific conditions & risks**
- **Sometimes the baseline may better expressed using end user requirements**
- **Increased use of statistics in setting baselines – the data is there to be used**
- **Ownership of the GBR – should it be independent of the design delivery process?**

Should it be a Project Management deliverable?

Concluding Remarks

Question Raised: Are the current Hong Kong GBRs Fit for Purpose?

Answer: ????? – Too early to judge

Current Scorecard

	Non GBR Projects	GBR Projects
No of Contracts	approx. 25	approx. 22
No of Ground Condition "Issues"	5	9
No progressed to Mediation/Arbitration	2	??

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Thank you