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Quality Assurance

Guidelines to better Quality
1st Edition - August 2005

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Impress
Information according § 5 TMG:

Drilling Contractors Association (DCA)
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RESPONSABILITY IN PARTNERSHIP

TABLE OF CONTENTS

1 RECOMMENDATIONS

DCA recommends to read and use this paper in combination with the Technical Guidelines 2nd Edition, February 2001.

Issues discussed here are guidelines for quality assurance for design, contracting and execution of pipeline crossing projects carried out by using the horizontal directional drilling method.

2 INTRODUCTION

The Workshop II of the DCA Symposium in Aachen in October 2003 concerned “Contractual- and Insurance Issues”. It was concluded that a Workgroup on “Handling of Soil and Contractual Quality in Horizontal Directional Drilling” would be useful in order to summarize the most important items and to establish check-lists for good practice and high quality.

The Work group has been founded, due to the desire to emphasize the understanding that “Soil” is the major element in an HDD project especially when a Lump Sum contract solution is requested.

The additional guidelines and checklists are made in order to assist and in gaining the proper attention of all parties engaged in an HDD project.

Aachen, August 2005

Drilling Contractors Association (DCA)

3 QUALITY ASSURANCE OF HDD vs. SUBSOIL AND UNDERGROUND RISK

Working with and understanding Soil is a major key to quality assurance. Thus this is a major issue for quality assurance on any drilling project. In most European countries the subsoil and underground risk is a common term in the field of engineering and construction works.

The subsoil and underground risk can be defined as follows:

Quote: *"The subsoil risk is an unavoidable remaining risk which can lead to unpredictable effects and difficulties during the use of the subsoil respectively the use of the present contents of the subsoil, groundwater, contamination etc.*

> *The subsoil risk exists :*
>
> *a) although the person who provides the subsoil / underground conditions, has done everything for the complete investigation and characterization of the subsoil, ground water and underground conditions with respect to the current, updated standards and laws*
>
> *b) and although the contractor had fulfilled the demand of his examination and notice duty".*
>
> (Prof. Dr. jur. Klaus Englert 1995, Prof. Dr.-Ing. Rolf Katzenbach 1995)

The client specifies what he needs and defines the choice of the location of the crossing. Thus the definition reflects the relationship between the person who provides the subsoil / underground conditions and the subsoil and underground risk.

The definition also makes responsible the companies or persons engaged in assisting the client for the technical and geotechnical investigations, drilling design, tender and / or supervision, which are usually named the engineers or consultants.

Difficulties during the use of the subsoil may lead to additional measures and expenses to finalize the scope of work.

4 PROJECT PHASES

Any construction project can be divided in three main phases and a set of procedures and related milestones.
In order to achieve a high quality HDD project all parties involved should be aware of the following procedures.

Phase	Procedure (see flow charts)	Scope / Milestones
Tender phase	Project Engineering Client	Preparation of tender Issue tender with definition of work
Bidding phase	Preliminary Engineering Bidder/ Tenderer prior to submission	Bid submission Contract awarding procedure Award
Construction phase	Project Engineering Contractor after the award Project Execution Contractor	Work preparation Beginning project execution on-site Completion on-site and off-site

5 QUALITY FORMULA

The quality of an HDD project depends on human and technical resources. All parties involved in the project must be aware of these requirements and should be aware that they can take effect in each phase of the project.

The quality can be expressed by the following dependencies.

Quality of the whole project

The ***quality of the whole project*** depends on:

- quality project engineering client
- quality project engineering contractor
- quality construction phase
- qualified project team concerning experiences and capacities
- qualified data exchange and well-adjusted communication

Quality project engineering client

The ***quality of the project engineering client*** depends on:

- quality geotechnical and historical investigation
- quality and feasibility of the design
- reasonableness and feasibility of the scope of work

Quality project engineering contractor

The ***quality of the project engineering contractor*** depends on:

- quality of the geotechnical design
- quality of the procedures
- pressure of time
- qualification of the project team

Quality construction phase

The ***quality of the construction phase*** depends on:

- quality of material and equipment
- qualification of project team

Is there a difference between large drillings and small drillings in HDD?

Elements quoted from the report mentioned under Reference 1

Quote 1

Mini drillings are mainly characterised by the use of small rigs. Because of this, the projects are of a much smaller scale than those in which maxi drillings are used. This difference in scale also entails a totally different kind of risks. The (financial) risk of a maxi drilling is usually much bigger than that of a mini drilling. However, a mini drilling is carried out more often, and that is why this form of drilling deserves special attention.

Quote 2

The risks of drilling with small rigs usually originate from one of the following three factors:

1. low prices
2. low threshold to “the market”
3. location of the project

Quote 3

Conclusion:

With regard to the execution of mini drillings, one can conclude that the execution of drilling projects under the current market conditions (price competition) injures the carefulness and quality of the drillings. Consequently, there is a major risk of an unsuccessful drilling.

In view of the relatively small damage to its own equipment (relatively cheap), the contractor may take this risk. The consequential damages however may be much larger and even unforeseeable.

We therefore have to ask clients, authorities, engineers and other parties understand these differences.

If one wants to pay a minimum one may take considerable risks!

6 FLOW CHARTS

The procedures consist of a number of working steps. The working steps are represented as flow-charts and additional check-lists concerning the extent of the procedures
(see appendix Fig. 1 – Fig. 4).

How to use the flow-charts and the check-lists?

The complexity of an HDD project depends on the technical requirements and geotechnical standards to be taken into account. The technical standard is a function of the number, the length and the diameter of the pipelines or cables to be installed, the type and the material and the requirements for the correct positioning. In general the difficulty of the requirements increase with the length and diameter of the crossing. The geotechnical standard depends on the complexity of the topography and the geology and the requirements for safety, serviceability and durability of nearby buildings and subsurface infrastructure. The requirements are higher with increasing heterogeneity of the layers to be passed, with increasing complexity of the local hydraulic conditions and with increasing proximity of other constructions (existing buildings, pylons, foundations, sheet piles, cables, pipelines, etc.).

In this guideline three categories are distinguished:

1. Category 1 routine HDD project
2. Category 2 standard HDD project
3. Category 3 complex HDD project

DCA recommends the following classification:

Category 1 HDD projects

- Short distance crossings
- Installation of pipes and cables with small diameters.
- Unconsolidated or weak consolidated fine grained soils
- Overall homogeneous and undisturbed underground conditions.
- Lack of nearby buildings and subsurface constructions
- Low sensitivity concerning settlement or deformation

- Cover larger than the allowable minimum cover concerning the most common regulations
- Low sensitivity to mud break outs
- Static mud pressure far below the maximum allowable mud pressure

Category 1 HDD Projects can mainly be based on the evaluation of existing documents and local experiences.

Category 3 HDD projects

- Long distance crossings (drilling length ≥ 500m)
- Installation of large diameter pipes (bore diameter ≥ 500mm)
- Difference in elevation between the entry / exit point (≥ 10m)
- Soil type: gravel or rock
- Soil condition: strongly fractured formations with discontinuities
- Any drilling project where rock and soil layers must be passed consecutively
- HDD projects with complex hydraulic conditions
- Drilling trajectory close to the allowable minimum depth of cover
- Drilling trajectory close to existing structures and foundations with high sensitivity concerning settlement or deformation (in general ≤ 5 m)
- Any project where additional grouting techniques are likely to be executed

Category 3 HDD projects need detailed and specific studies.

Category 2 HDD projects

HDD projects which are neither in class 1 nor 3, should be assigned as category 2. Category 2 HDD projects can be based on a minimum of on-site and off-site investigations.

It is recommended, that if any one element fits to a higher category the whole project should be classified in this higher category. The given limit values should not be used as strict mathematical limits. They are more indicative and should be used with common sense.

In individual cases HDD projects of higher standards can be classified to be of the routine type (Category 1), if a comparable drilling has already been carried out successfully at the same site and if the corresponding documents including the geotechnical and geophysical results are available.

The most important criteria are summarized in the table below:

Criteria	Category 1	Category 2	Category 3
HDD project category	routine	standard	complex
		All HDD projects, which fall outside the limits of category 1 and category 3	
Drilling length	Short, ≤ 150 m		long, ≥ 500 m
Drilling diameter	small, ≤ 200 mm		large, ≥ 500 mm
Nearby infrastructure	absent		distance ≤ 5 m
Difference in elevation entry/exit point	negligible		≥ 10 m
Depth of cover	>> allowable minimum		close to the allowable minimum
Static mud pressure	<< the allowable maximum		close to the allowable maximum
Soil type	Fine grained soils e.g.: silt, fine sand		Coarse grained soils or rock e.g.: non-cohesive soils ≥ 40 % gravels / cobbles imbedded hard and soft strata, rock
Soil conditions	Homogenous formations undisturbed formations		Occurrence of discontinuities Strongly fractured formations soil stabilisation necessary e.g.: grouting, techniques
Permeability	$\leq 5 \times 10^{-4}$ m/s		$> 5 \times 10^{-3}$ m/s
Groundwater / soil salinity	Fresh water environment		Marine environment
Nearby infrastructure: Sensitivity concerning mud break outs, settlement or deformation	absent	low	high

Once the category of an HDD project is determined, the flow-sheets in the appendix can be used to get detailed information about the To-do's to achieve quality assurance in the related working steps.

The different working levels in the flow-sheets and check-lists are indicated as:

• = To-do's for category 1-3
■ = Additional to-do's as of category 2
□ = Additional to-do's for category 3

7 CHECK LISTS HDD (to be used by all parties)

The following five check-lists serve as a tool for quality assurance for soil and underground related contractual matters. They have been made by the input of all DCA members, thus reflecting the opinion and the experience of clients, contractors, engineers and consultants. They should be used parallel to the existing DCA guidelines as additional recommendations. The check-lists 1+2 should be used for quality assurance concerning the definition of crossing, the recommended extent of the soil information and the overall output of the geotechnical site investigations. The check-list 3 shows the most important parameters for field and laboratory testing for non cohesive and cohesive soils. The check-list 4 shows the relation between the correct sampling for grain size distribution, the chosen coring diameter and the related detection level of the layer depth and should be used non cohesive soils. The check-list 5 shows the most important parameters for field and laboratory testing for semisolid rocks and rocks.

The geotechnical terms and parameters used in the check-lists 3+5 are defined and described in the European Prestandards ENV 1997-2 und ENV 1997-3 published by the European Committee for Standardization.

Remark:
“It is important to underline that the European Prestandards are still subject to constant change and shall not be referred to as European Standards. They do not replace national standards for equipment and performance of different test methods. Nevertheless they provide generally accepted requirements for the most common field and laboratory tests. The referred definitions are used here to have a common framework and a common language as the national standards may differ and can’t be used vice versa. “

Further information about national and international standards for field and laboratory testing of soil and rock samples can be found at the internet sites mentioned here under:

European Union	European Committee for Standardization (CEN)	www.cenorm.be
Austria	Österreichisches Institut für Normung (ON)	www.on-norm.at
France	Association Française de Normalisation (AFNOR)	www.afnor.fr
Germany	Deutsches Institut für Normung e.V. (DIN)	www2.din.de
Great Britian	British Standards Institution (BSI)	www.bsi-global.com
Netherlands	Nederlands Normalisatie-instituut (NEN)	www.nen.nl
Swiss	Schweizerische Normen-Vereinigung (SNV)	www.snv.ch
United States	American Society for Testing Materials (ASTM)	www.astm.org
International	International Organization for Standardization (ISO)	www.iso.org
International	International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE)	www.issmge.org

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Check-list 1: Definition of crossing

		Category 1	Category 2	Category 3
Scope of project	Pipe technical data	X	X	X
Client	Definition of allowable pipe installation loads and stresses	X	X	X
	Drillability	X	X	X
	Coordinate system		X	X
	Level reference system	X	X	X
Site information	Accessibility	X	X	X
Client / Contractor	Height limitations		X	X
	Weight limitations		X	X
	Nearby buildings and subsurface constructions (pylons, foundations, sheet piles etc.)	X	X	X
	Existing utilities (cables, pipelines, etc.)	X	X	X
	Pipeline stringing area	X	X	X
	Photos, aerial photo		X	X
Drawings	Top view	X	X	X
Client / Contractor	Scaled location plan * * including nearby buildings, plants, pylons, fences, estate boundaries, electricity / water supply sources, special protection areas etc. * including nearby, subsurface constructions (foundations, sheet piles, cables, etc.	X	X	X
	Longitudinal sections		X	X
	Longitudinal sections including soil layers			X
Drilling Profile	Horizontal + vertical profile	X	X	X
Client / Contractor	Entry and exit point	X	X	X
	Hole diameter	X	X	X
	Radii of curvature: vertical, horizontal + combined radii	X	X	X
	Straight & curved sections	X	X	X
	Slant tangential sections		X	X
	Entry- and Exit angles	X	X	X
	Cover to river bed, lake or sea bottom	X	X	X
	Cover to ground surface	X	X	X
	Over bend section		X	X
Drilling parameters /	Pilot drilling operation	X	X	X
Program	Reaming operations	X	X	X
Contractor	Cleaning runs / wiper trip			X
	Pull back operation	X	X	X
	Pump rate	X	X	X
	Circulating volume	X	X	X
	Mud pressure		X	X
	Solids content	X	X	X
	Cutting volume			X
	Drilling / Reaming speed		X	X
	Bore hole and bit hydraulics / bore hole stability		X	X

Check-list 2: Soil information

	Topics	Category 1	Category 2	Category 3
Site investigation	Topography and hydrography	X	X	X
	Historical Investigation	X	X	X
	Water level changes	X	X	X
	Location of river beds, scours, currents	X	X	X
	Climatic data	X	X	X
Geotechnical Investigation	Boreholes		X	X
	Cone-Penetration-Test		X	X
	Soil and rock sampling		X	X
	Groundwater level measurements		X	X
	Pore pressure measurements		X	X
	Abrasivity			
Laboratory Tests	Soil classification		X	X
	Rock classification			X
	Shear and strength parameters		X	X
	Geochemistry		X	X
	Hydraulic parameters		X	X
Geophysical Investigation	Detection of soil / rock layers, discontinuities and obstacles by means of : Geo-electric or; seismic or hydro-acoustic or Geo-radar			X
Geotechnical report	Soil and rock classification	X	X	X
	Drillability	X	X	X
	Geological section and groundwater situation	X	X	X
	Recommendation interaction between ground-pipeline		X	X
	Hydrographical data	X	X	X
Geotechnical Design	Borehole stability, arching, minimum cover		X	X
	Hydraulic calculations, soil balance		X	X
	Calculation of rig anchor			X
	Calculation interaction ground-pipeline			X
	Nearby Infrastructure: Verification of limit states			X

Check-list 3: Testing of soils

Testing	Parameter	Symbol	Unit	Category 1	Category 2	Category 3
Classification testing	Soil forming minerals, Abrasivity		-		X	X
	Grain size distribution	PSD	-		X	X
	Plasticity / Consistency index	I_p , I_c	% / -		X	X
	Clay activity index / Swelling	I_a	- / %		X	X
	Organic content	-	%		X	X
	Bulk density	γ	kN/m³		X	X
	Particle density	γ	kN/m³		X	X
Strength and compressibility testing	Internal friction	φ	°			X
	Cohesion	c	kN/m²			X
	Undrained Shear strength	c_u	kN/m²			X
	Stiffness	E	kN/m²			X
	Unconfined compressive strength	q_u	kN/m²			X
	Cone resistance, side friction	q_c / f_r	MPa		X	X
	Layer boundaries	-	-			X
Permeability testing	Permeability	k	m/s		X	X
	Pore pressure	u	kPa		X	X
	Hydraulic gradient	i	‰		X	X
Chemical testing	Salinity	-	‰		X	X

Check-list 4: Coring and sampling for grain size distribution

Requirements	Supposed maximum grain size from historical investigations				
Historical investigation needed for decision on coring diameter	Fine gravel	Medium gravel	Coarse gravel		Cobbles
	2 - 6,3 mm	6,3 - 20 mm	20 - 40 mm	40 - 63 mm	63 - 200 mm
	Required quantities / coring geometry for representative samples / detection level of layer depth				
Required minimum sampling mass	≥ 0,4 kg	≥ 2 kg	≥ 15 kg	≥ 70 kg	≥ 120 kg
Required minimum sampling volume	≥ 0,3 dm³	≥ 1,3 dm³	≥ 10 dm³	≥ 45 dm³	≥ 80 dm³
Required diameter for boreholes	≥ 80 mm	≥ 120 mm	≥ 180 mm	≥ 273 mm	≥ 324 mm
Related detection level of gravely soil layers by coring with the minimum borehole diameter	~ 0,05 m	~ 0,1 m	~ 0,5 m	~ 0,75 m	~ 1 m

Check-list 5: Testing of rocks

Testing	Rock parameter	Symbol	Unit	Category 3
Classification testing	Abrasivity		-	X
	Point load test		MN/m²	X
	Uniaxial compressive strength	σ_c	MN/m²	X
	Internal friction	φ	°	X
	Cohesion	c	kN/m²	X
	Brazil test, Uniaxial tensile strength	σ_z	MN/m²	X
	Rock quality designation Index	RQD	-	X
	Bulk density	γ	kN/m³	X
	Water content, Dry density	w, γ	%, kN/m²	X
	Rock pressure		kN/m²	X
	Rock fabric	-	-	X
	Layer boundary	-	-	X
Permeability testing	Permeability	k	m/s	X
	Pore pressure	u	kPa	X
	Hydraulic gradient	i	‰	X
Chemical testing	Salinity	-	‰	X

8 GRAPHICS ON DIFFERENT TYPES OF UNDERGROUND CONDITIONS

In addition to the check-lists a set of graphics is given (see appendix Fig. 5 – Fig. 10).

The examples are shown as a part of a drilling profile and/or a certain range of a geotechnical parameter mentioned in the check-lists. The situation is given in the left column.
In the right column a suitable adaptation of the drilling profile or a set of recommendations are given.

9 REFERENCES

Risk Control – Trenchless Techniques for Underground Infrastructure
Assessment of Drilling Risks
NSTT / Bolegbo-vok, June 2003

Original title: Risicobeheesing sleufloze technieken voor ondergrondse infrastructuur
Inventarisatie van boorrisico's

Horizontal Directional Drilling - DCA Technical Guidelines
2nd Edition - February 2001
Drilling Contractors Association (DCA-Europe)
Charlottenburger Allee 39
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10 APPENDIX

Fig. 1

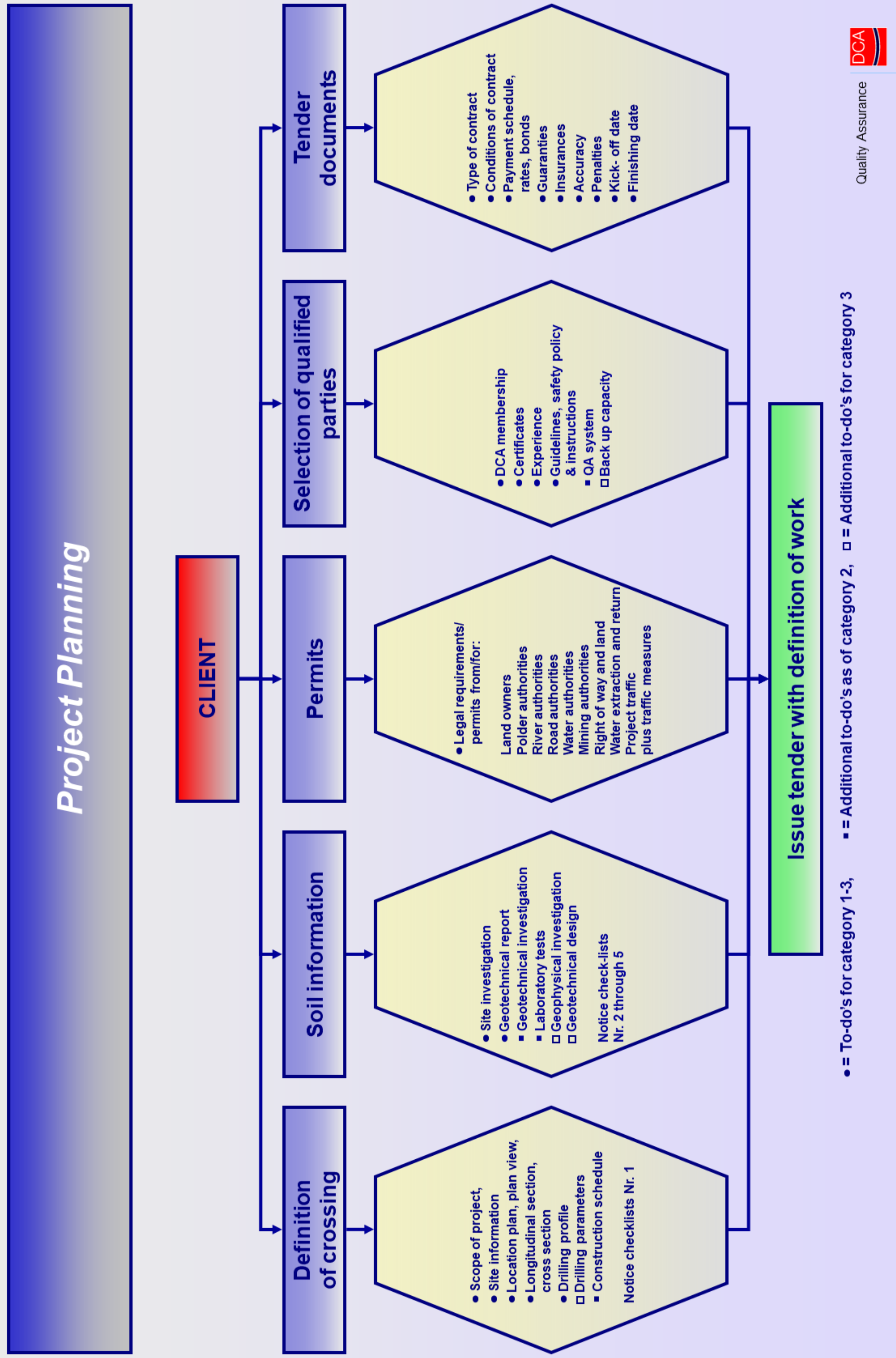
Project Planning
CLIENT
Definition of crossing
Soil information
Permits
Selection of qualified parties
Tender documents
● Scope of project,
● Site information
● Location plan, plan view,
● Longitudinal section, cross section
● Drilling profile
□ Drilling parameters
▪ Construction schedule
Notice checklists Nr. 1
● Site investigation
● Geotechnical report
▪ Geotechnical investigation
▪ Laboratory tests
□ Geophysical investigation
□ Geotechnical design
Notice check-lists Nr. 2 through 5
● Legal requirements/ permits from/for:
Land owners
Polder authorities
River authorities
Road authorities
Water authorities
Mining authorities
Right of way and land
Water extraction and return
Project traffic
plus traffic measures
● DCA membership
● Certificates
● Experience
● Guidelines, safety policy & instructions
▪ QA system
□ Back up capacity
● Type of contract
● Conditions of contract
● Payment schedule, rates, bonds
● Guarantees
● Insurances
● Accuracy
● Penalties
● Kick- off date
● Finishing date
Issue tender with definition of work
● = To-do's for category 1-3, ▪ = Additional to-do's as of category 2, □ = Additional to-do's for category 3
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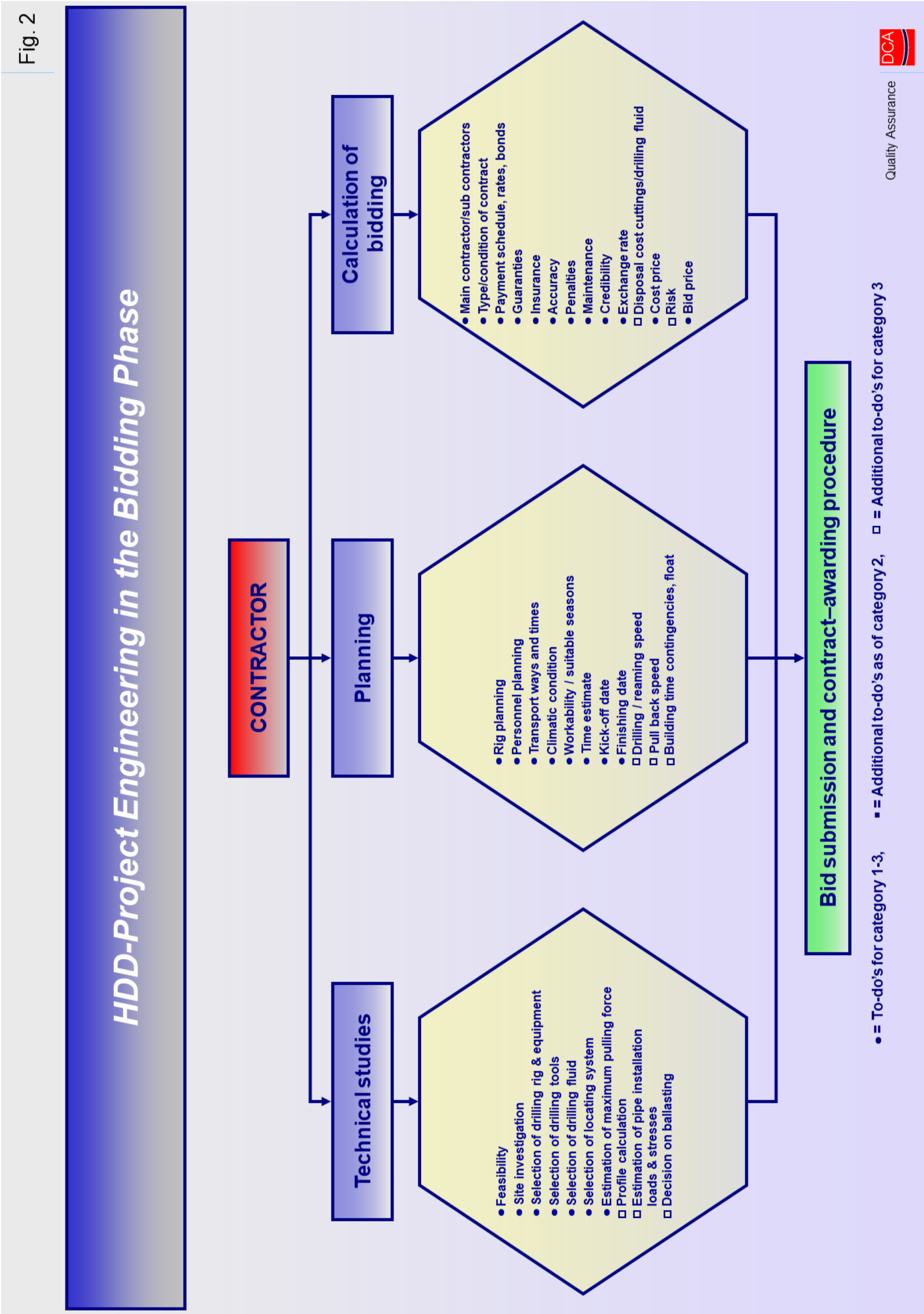
Fig. 2


HDD-Project Engineering in the Bidding Phase
CONTRACTOR
Technical studies
Planning
Calculation of bidding
• Feasibility
• Site investigation
• Selection of drilling rig & equipment
• Selection of drilling tools
• Selection of drilling fluid
• Selection of locating system
• Estimation of maximum pulling force
□ Profile calculation
□ Estimation of pipe installation loads & stresses
□ Decision on ballasting
• Rig planning
• Personnel planning
• Transport ways and times
• Climatic condition
• Workability / suitable seasons
• Time estimate
• Kick-off date
• Finishing date
□ Drilling / reaming speed
□ Pull back speed
□ Building time contingencies, float
• Main contractor/sub contractors
• Type/condition of contract
• Payment schedule, rates, bonds
• Guaranties
• Insurance
• Accuracy
• Penalties
• Maintenance
• Credibility
• Exchange rate
□ Disposal cost cuttings/drilling fluid
• Cost price
□ Risk
• Bid price
Bid submission and contract–awarding procedure
• = To-do's for category 1-3,
▪ = Additional to-do's as of category 2,
□ = Additional to-do's for category 3
Quality Assurance
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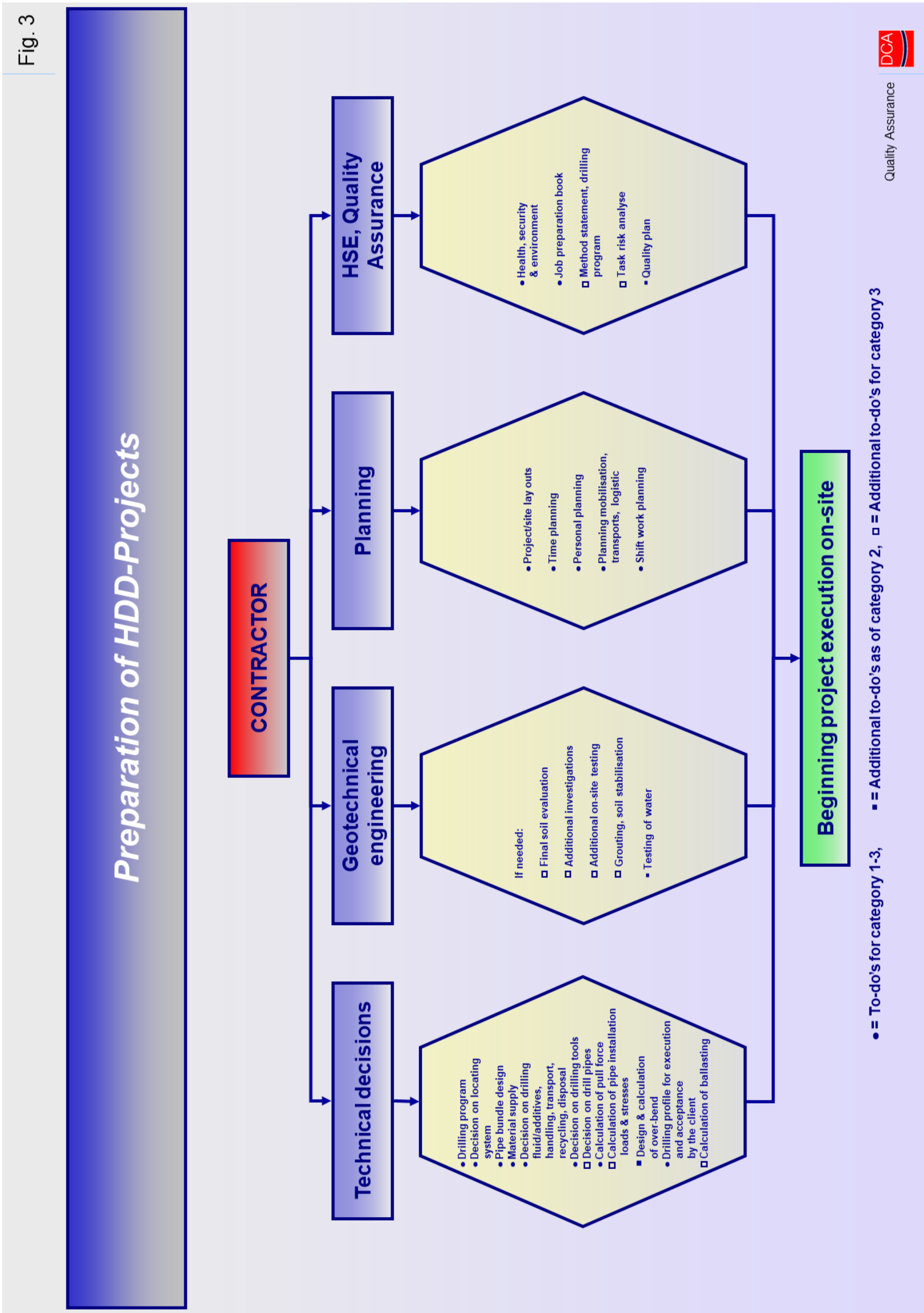
Fig. 3
Preparation of HDD-Projects
CONTRACTOR
Technical decisions
Geotechnical engineering
Planning
HSE, Quality Assurance
• Drilling program
• Decision on locating system
• Pipe bundle design
• Material supply
• Decision on drilling fluid/additives, handling, transport, recycling, disposal
• Decision on drilling tools
□ Decision on drill pipes
• Calculation of pull force
□ Calculation of pipe installation loads & stresses
▪ Design & calculation of over-bend
• Drilling profile for execution and acceptance by the client
□ Calculation of ballasting
If needed:
□ Final soil evaluation
□ Additional investigations
□ Additional on-site testing
□ Grouting, soil stabilisation
▪ Testing of water
• Project/site lay outs
• Time planning
• Personal planning
• Planning mobilisation, transports, logistic
• Shift work planning
• Health, security & environment
• Job preparation book
□ Method statement, drilling program
□ Task risk analyse
▪ Quality plan
Beginning project execution on-site
• = To-do's for category 1-3,
▪ = Additional to-do's as of category 2,
□ = Additional to-do's for category 3
Quality Assurance
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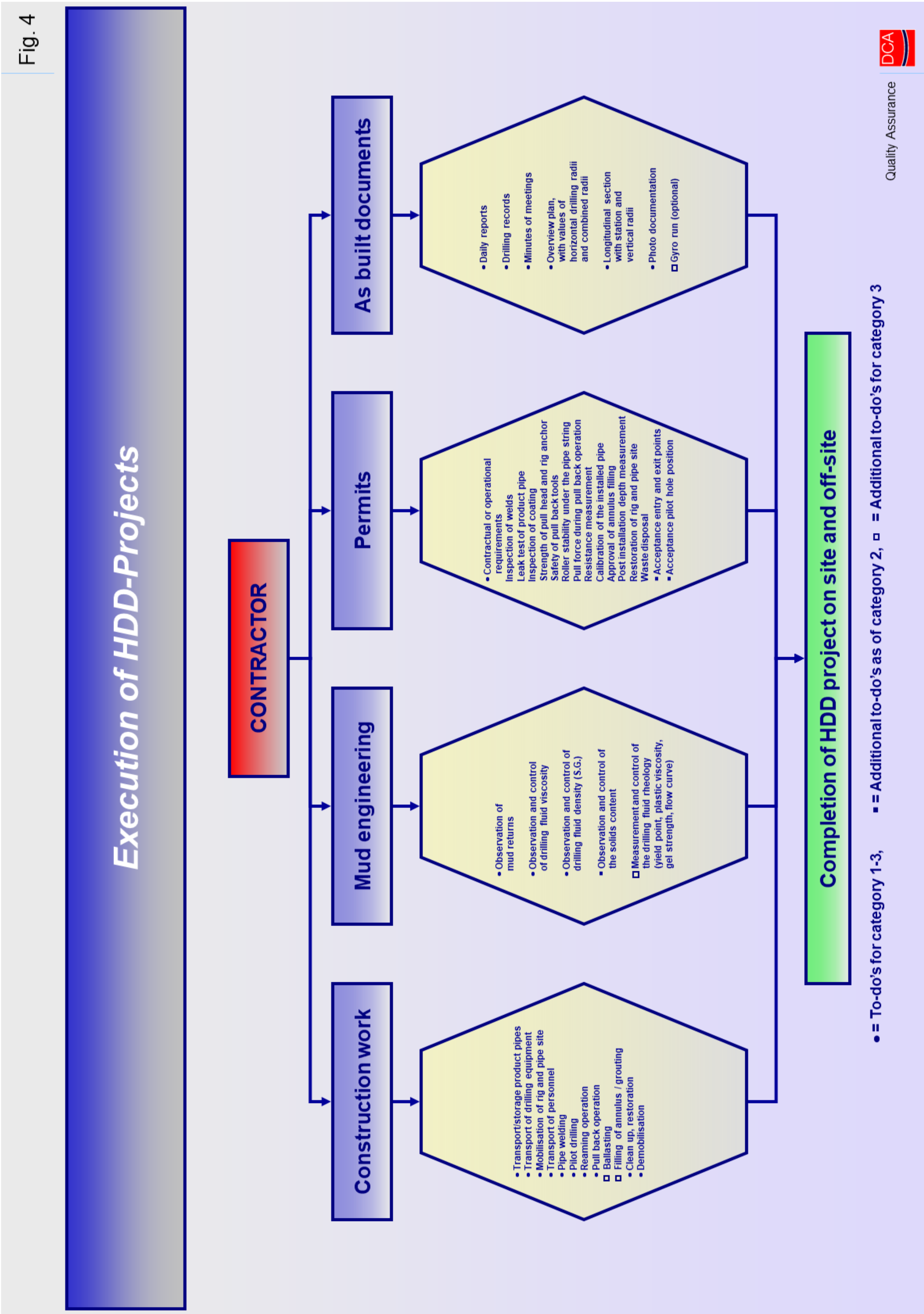
Fig. 4
Execution of HDD-Projects
CONTRACTOR
Construction work
Mud engineering
Permits
As built documents
• Transport/storage product pipes
• Transport of drilling equipment
• Mobilisation of rig and pipe site
• Transport of personnel
• Pipe welding
• Pilot drilling
• Reaming operation
• Pull back operation
▫ Ballasting
▫ Filling of annulus / grouting
• Clean up, restoration
• Demobilisation
• Observation of mud returns
• Observation and control of drilling fluid viscosity
• Observation and control of drilling fluid density (S.G.)
• Observation and control of the solids content
▫ Measurement and control of the drilling fluid rheology (yield point, plastic viscosity, gel strength, flow curve)
• Contractual or operational requirements
Inspection of welds
Leak test of product pipe
Inspection of coating
Strength of pull head and rig anchor
Safety of pull back tools
Roller stability under the pipe string
Pull force during pull back operation
Resistance measurement
Calibration of the installed pipe
Approval of annulus filling
Post installation depth measurement
Restoration of rig and pipe site
Waste disposal
• Acceptance entry and exit points
• Acceptance pilot hole position
• Daily reports
• Drilling records
• Minutes of meetings
• Overview plan, with values of horizontal drilling radii and combined radii
• Longitudinal section with station and vertical radii
• Photo documentation
▫ Gyro run (optional)
Completion of HDD project on site and off-site
• = To-do's for category 1-3, ▪ = Additional to-do's as of category 2, ▫ = Additional to-do's for category 3
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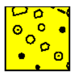
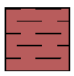
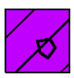
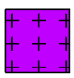
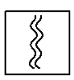
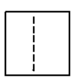
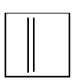
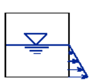
L E G E N D

Fig. 5

figure/ symbol	description/ designation
	Sand
	Gravel
	Silt
	Clay
	Peat
	Boulder Clay
	Rock
	borehole, drilling tool / drilling direction, if critical / casing / sleevepipe
	pasty-liquid, $I_c < 0{,}5$
	semi plastic, rigid, $0{,}75 < I_c < 1{,}00$
	solid, $I_c > 1{,}25$
	groundwater level, static pore pressure
aquifer	permeable layer
aquitard	layer of very low permeability

Cl – clay
Si – silt
Sa – sand
Gr – gravel
Co – cobble

Fig. 6

A1 – Non-cohesive soils (sandy and gravelly soils)

Underground situation | Recommendation suitable adaptation

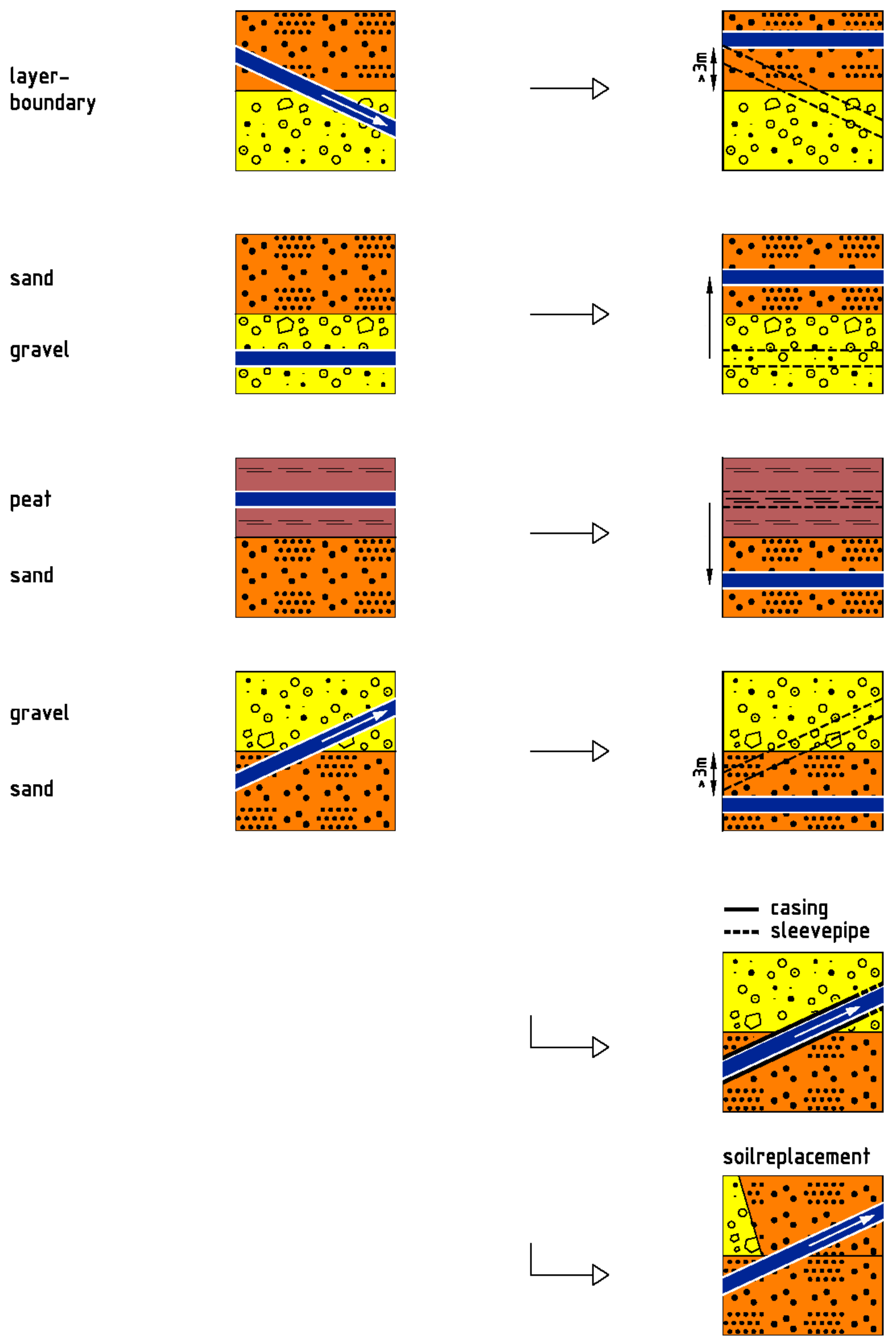
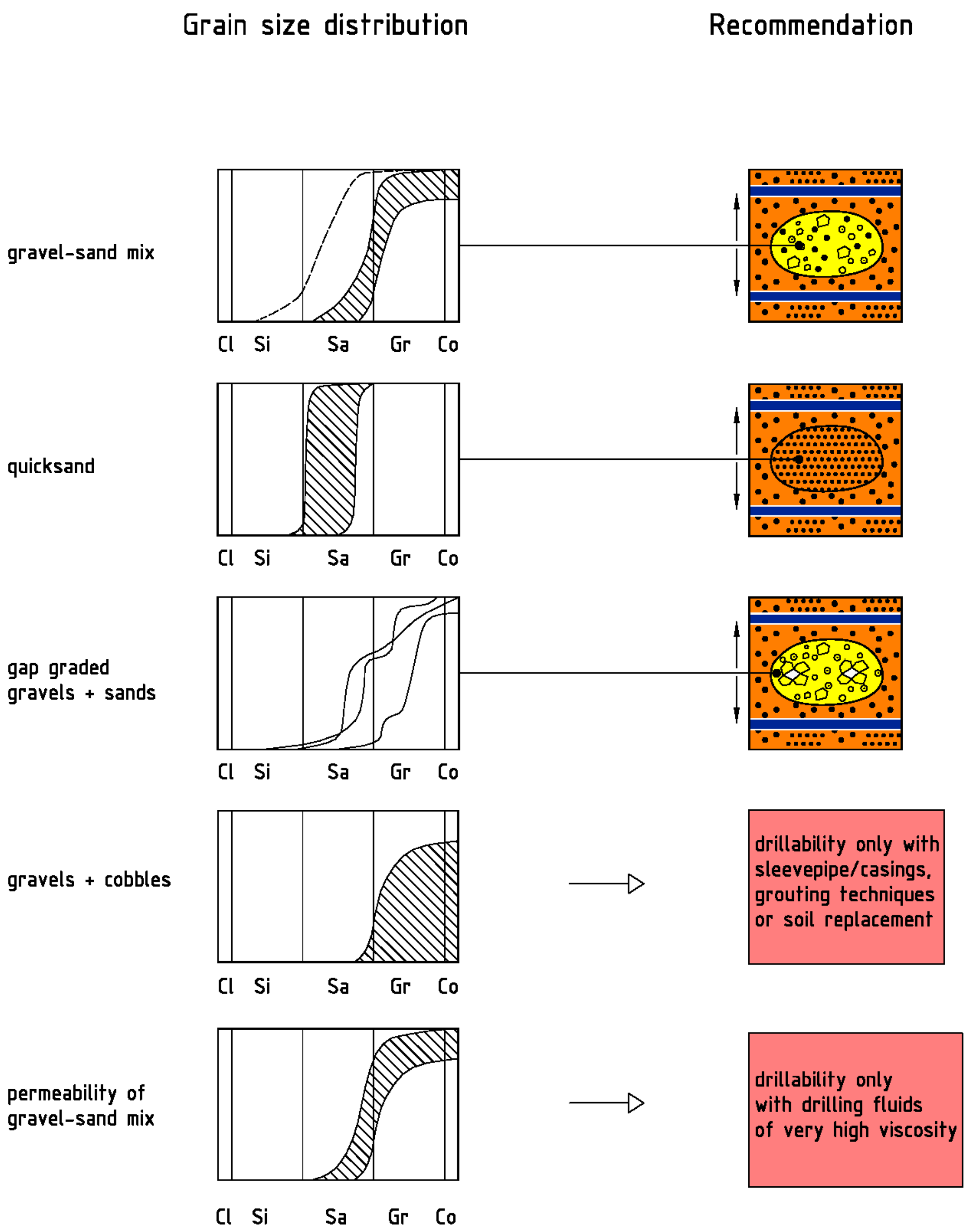


Fig. 7

A2 – Non-cohesive soils (sandy and gravelly soils)



B - Cohesive soils (clay and silty soils)

Fig. 8

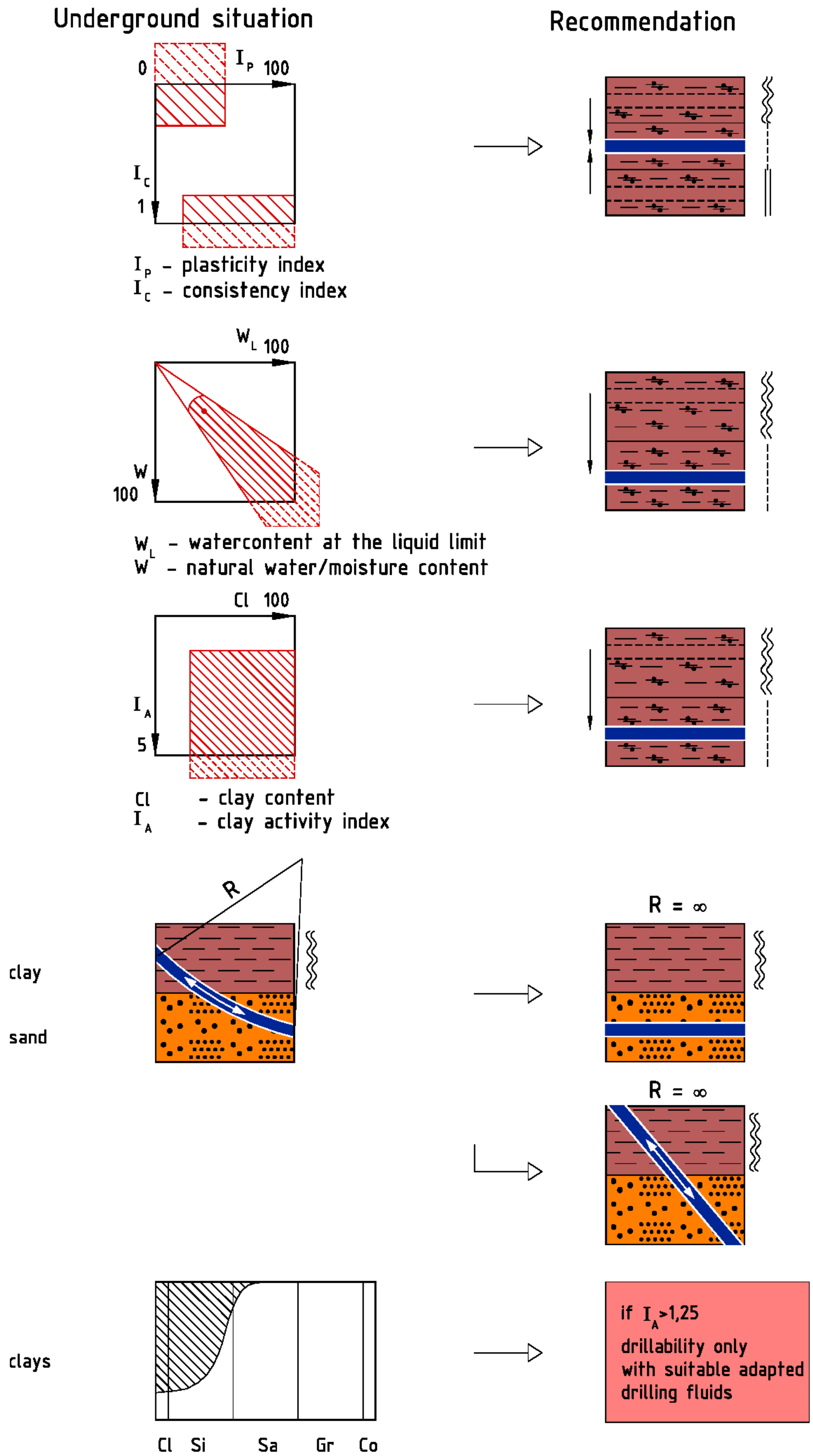


Fig. 9

C – Groundwater situation + permeability

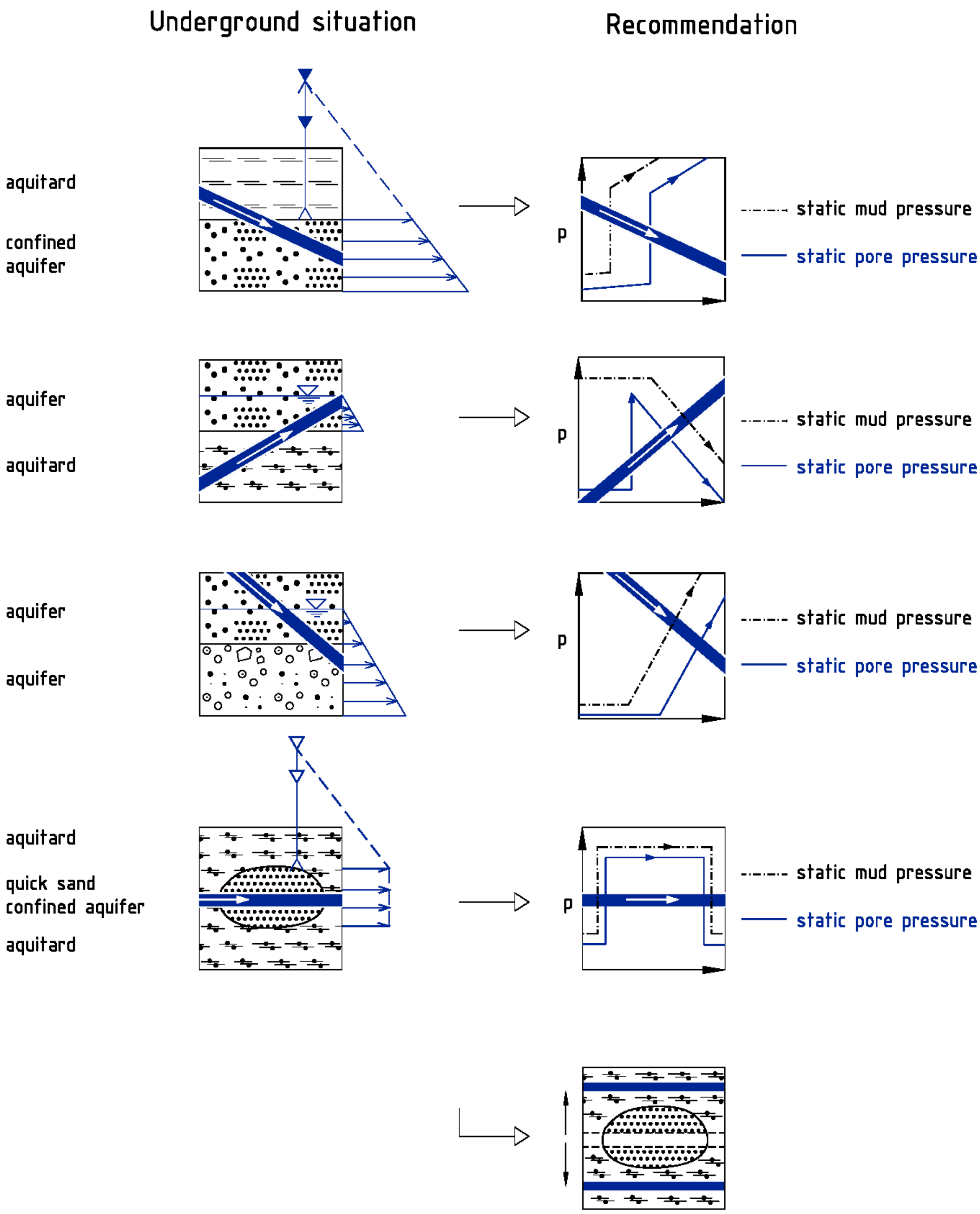
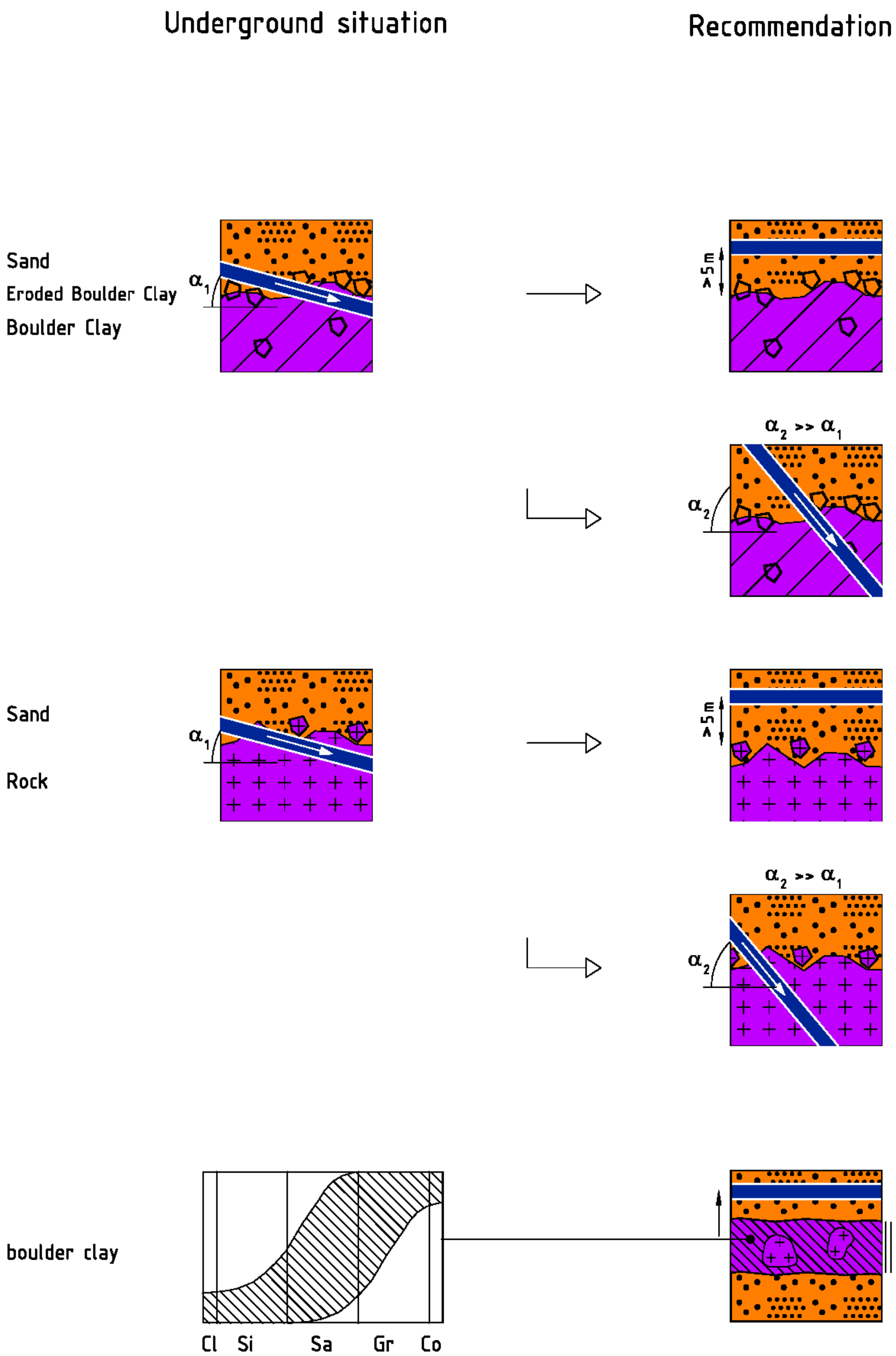


Fig. 10

D - Semisolid rocks and rocks



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