HDD IN HIGH-COMPLEXITY SUBSOIL

CASE STUDY OF THE RIO GRANDE CROSSING

Speakers: Carlos Chaves; Jan Laenge
Bamberg, 10/Oct/2025

DrillCon
Formerly DrillTec

DCA

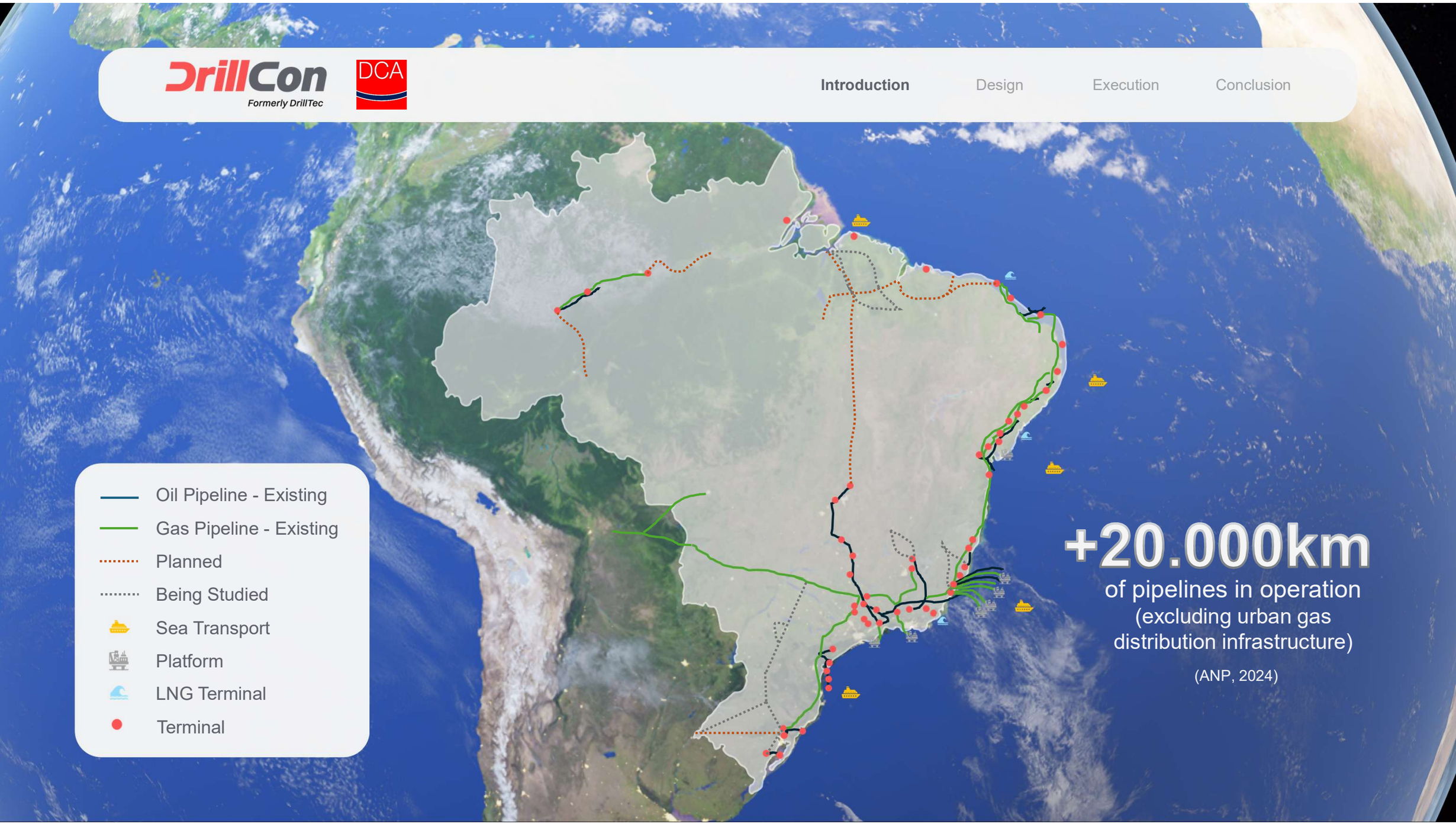
AGENDA

1. Introduction
2. Design
3. Execution
4. Conclusion

DrillCon
Formerly DrillTec

DCA

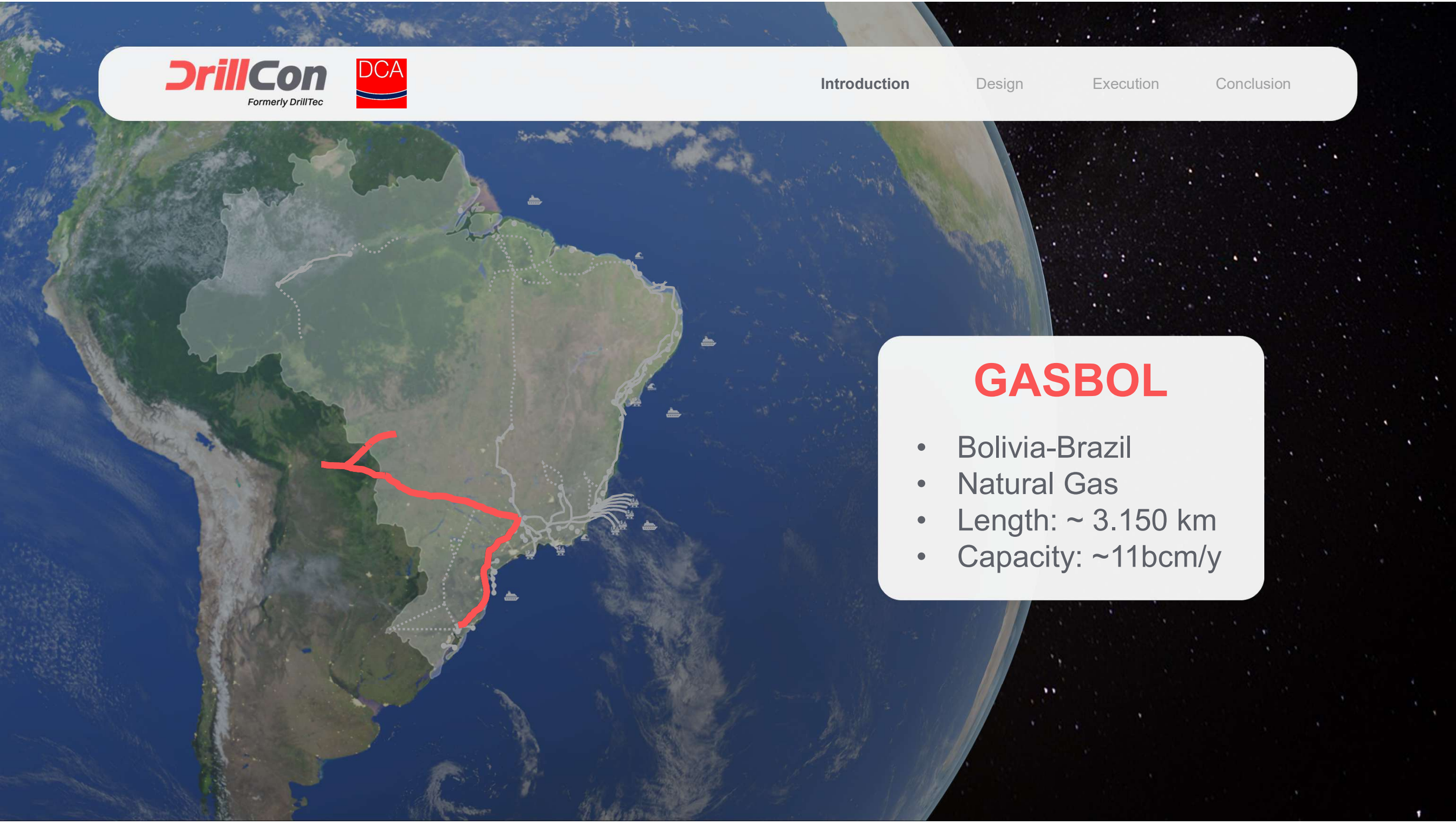
Introduction



+20.000km

of pipelines in operation
(excluding urban gas distribution infrastructure)

(ANP, 2024)

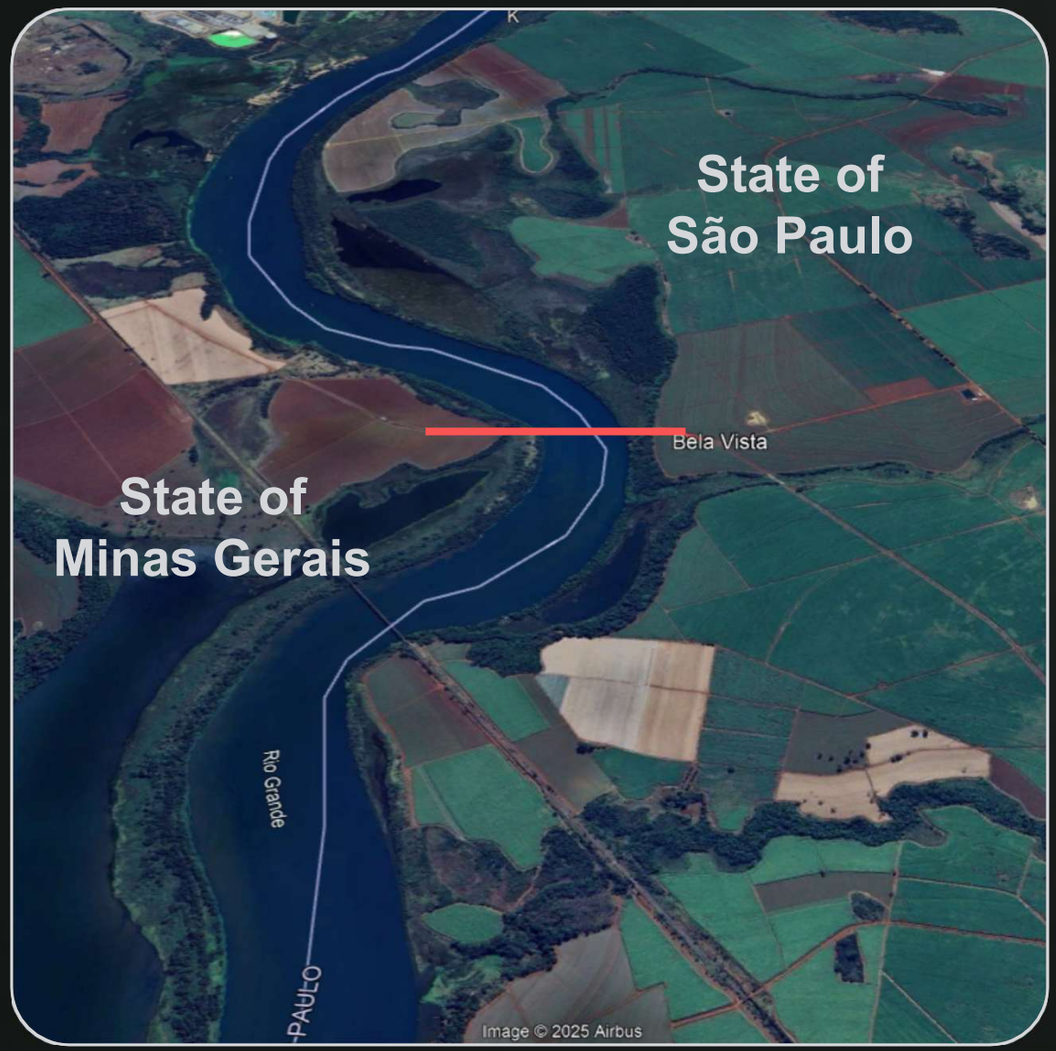


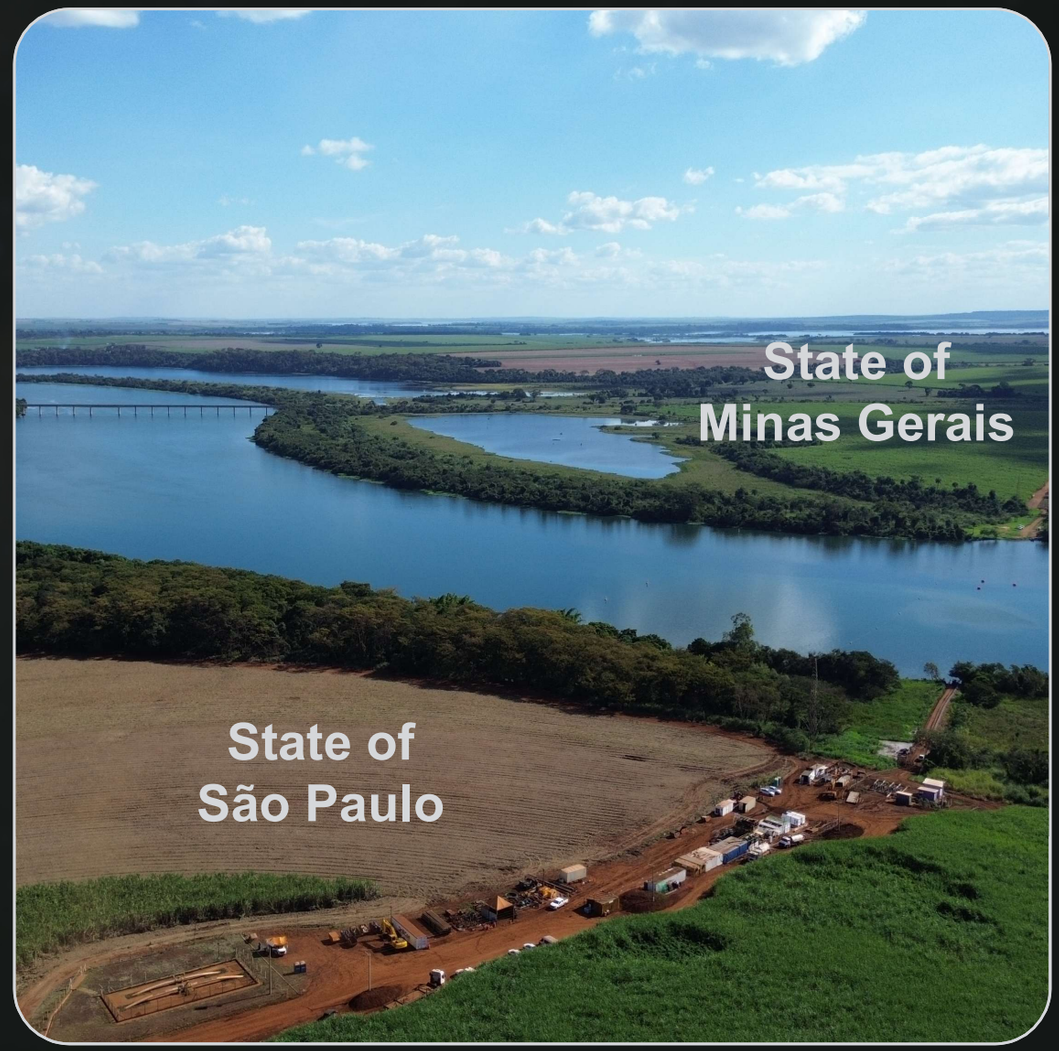
GASBOL

- Bolivia-Brazil
- Natural Gas
- Length: ~ 3.150 km
- Capacity: ~11bcm/y

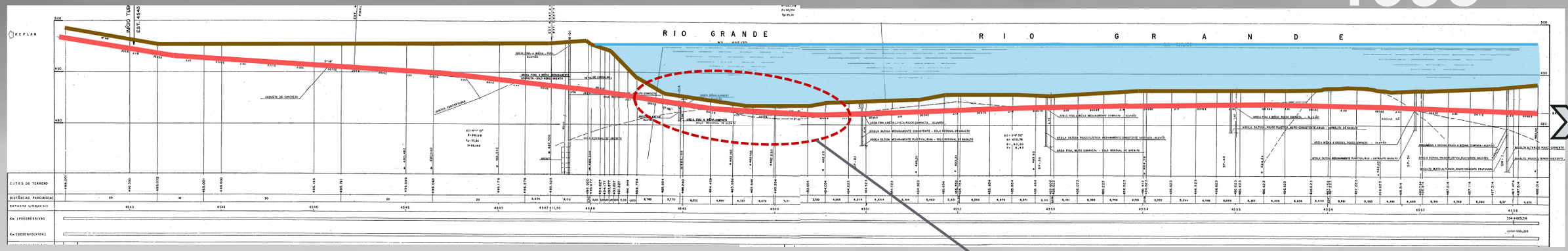
OSBRA

- SP-Brasília (FD)
- Multiproduct (Refined fuels)
- Length: ~ 964 km
- Capacity: ~12mcm/y

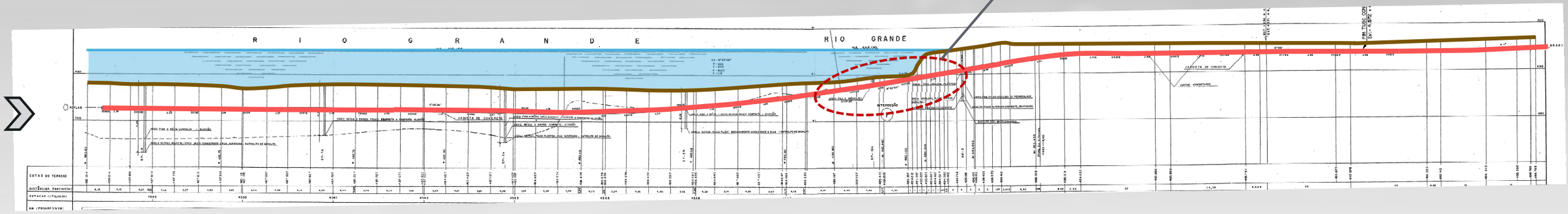

State of
São Paulo
Bela Vista
State of
Minas Gerais
Rio Grande
Image © 2025 Airbus

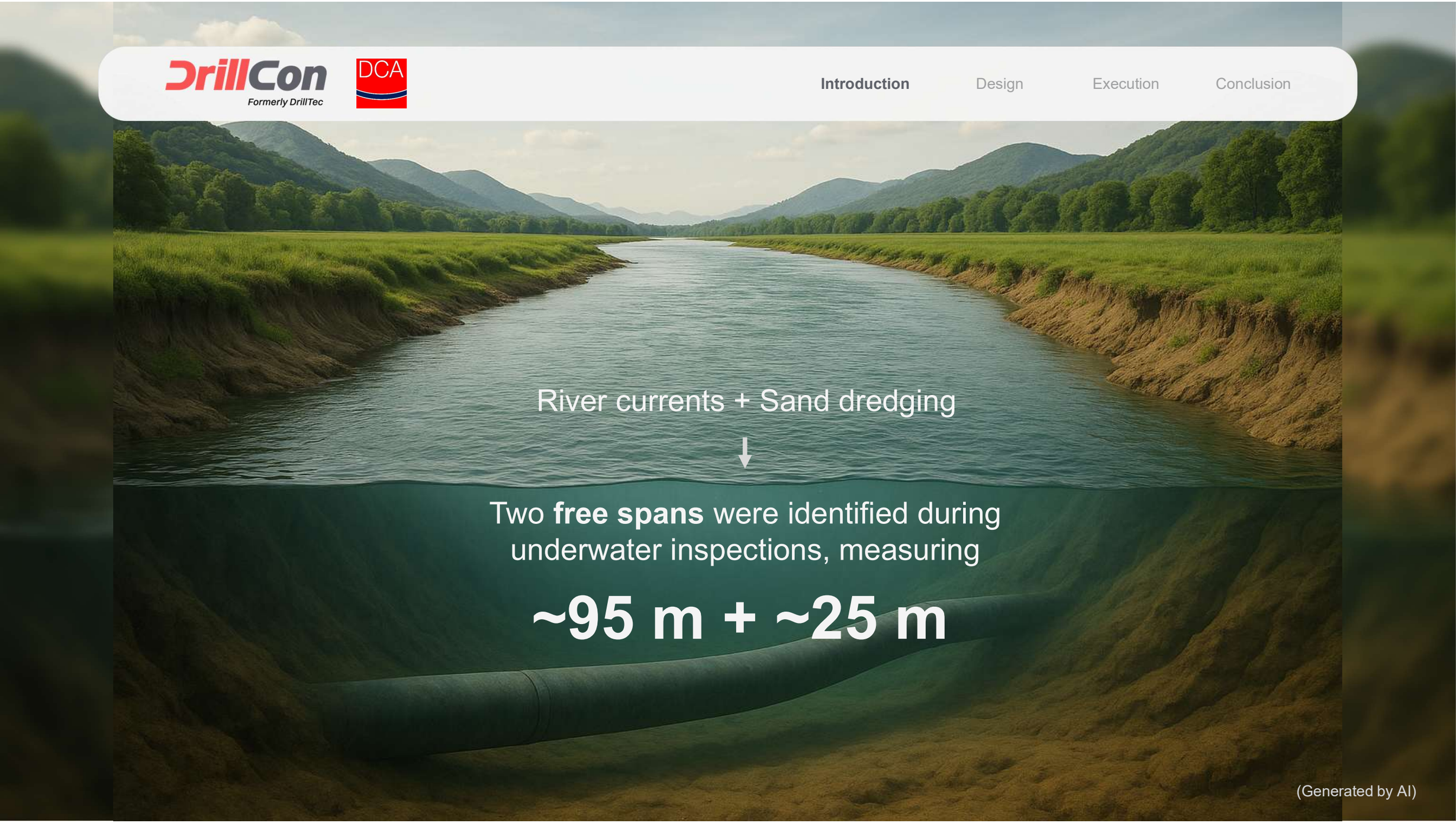

State of
Minas Gerais
State of
São Paulo

1995



Minimum cover of 1.5 meters





River currents + Sand dredging

↓

Two **free spans** were identified during underwater inspections, measuring

~95 m + ~25 m

(Generated by AI)

Two **free spans** were identified during underwater inspections, measuring

~95 m + ~25 m

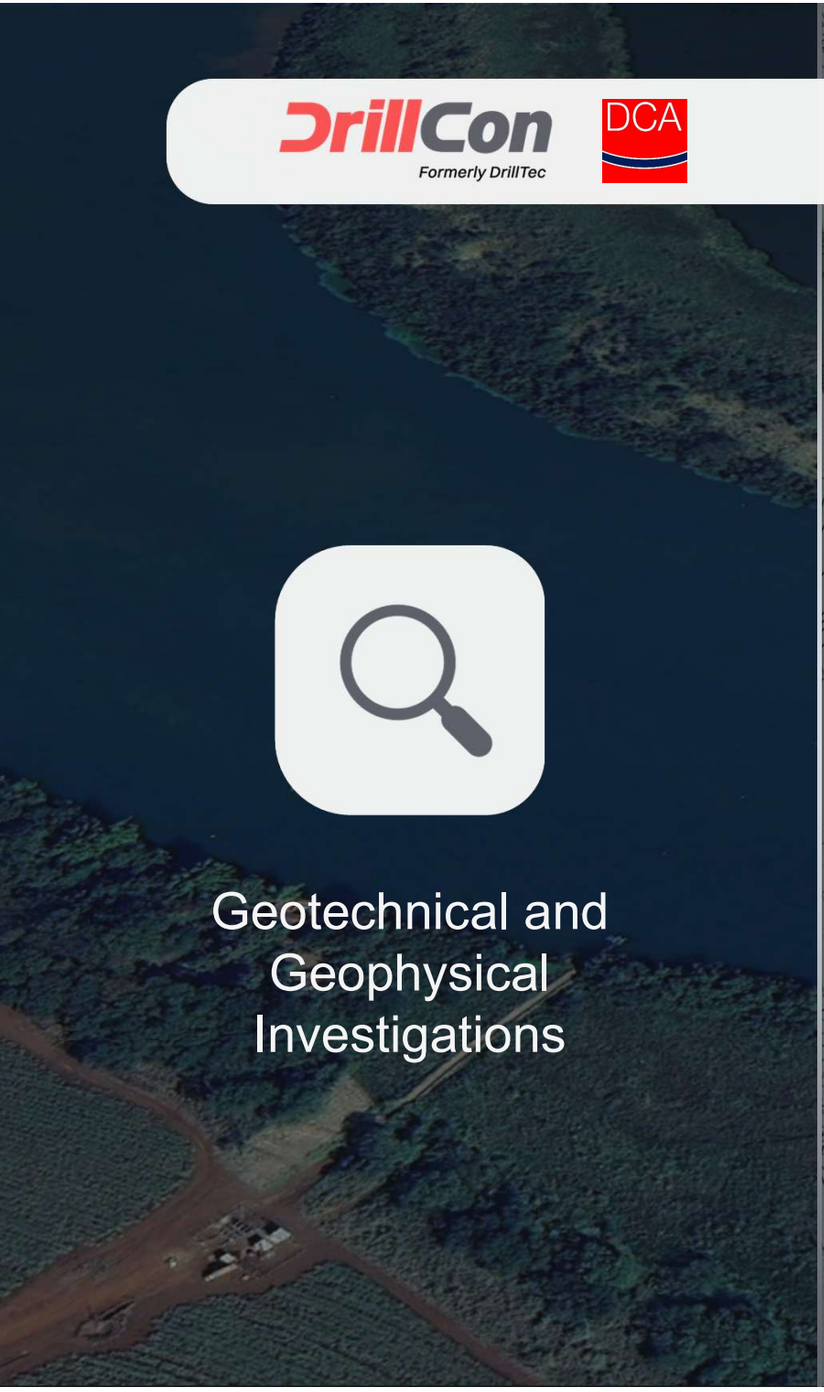
→

- Critical **structural compromise** potential
- High risk of **operational failure**

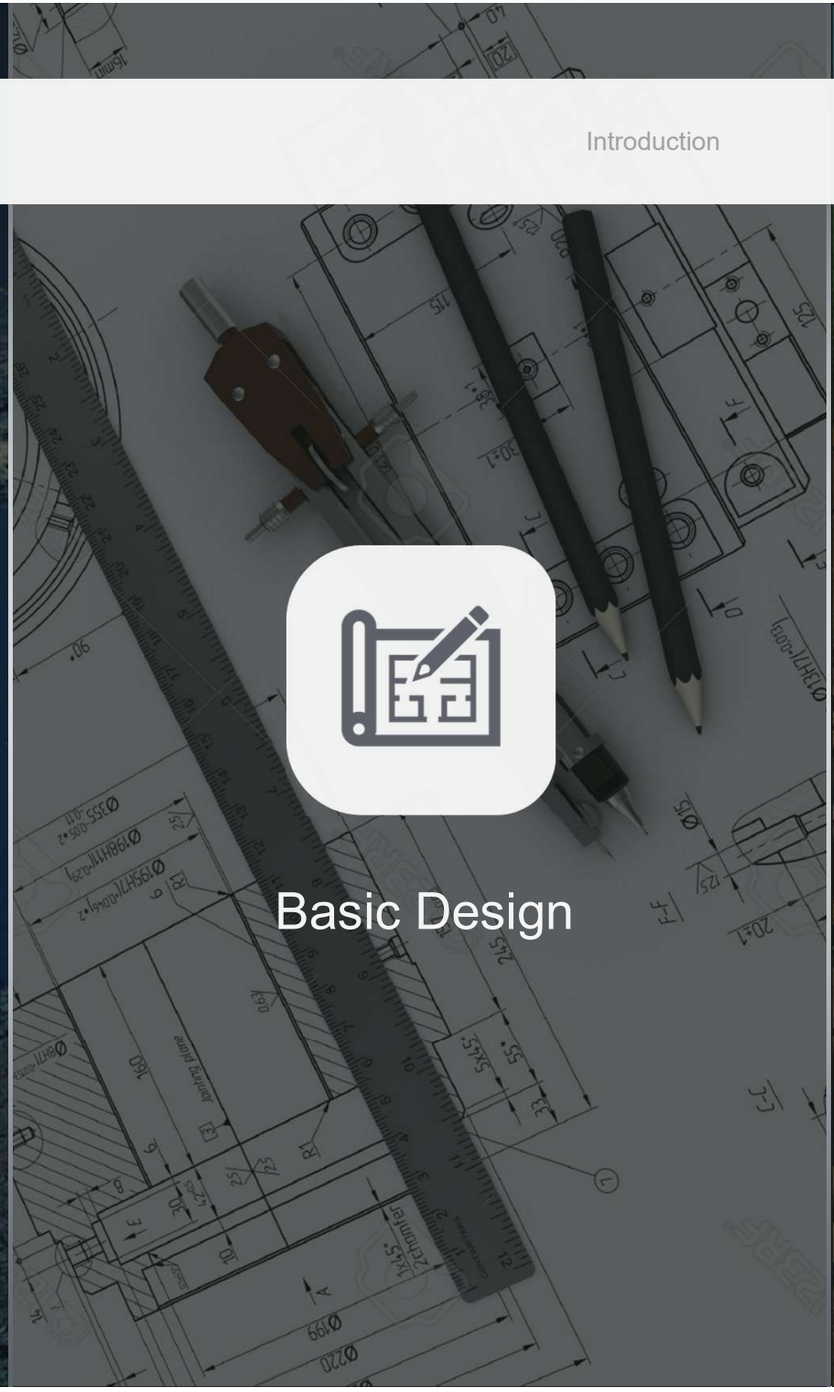
→

- Provisional emergency interventions for **risk mitigation**
- Emergency actions for **definitive intervention**

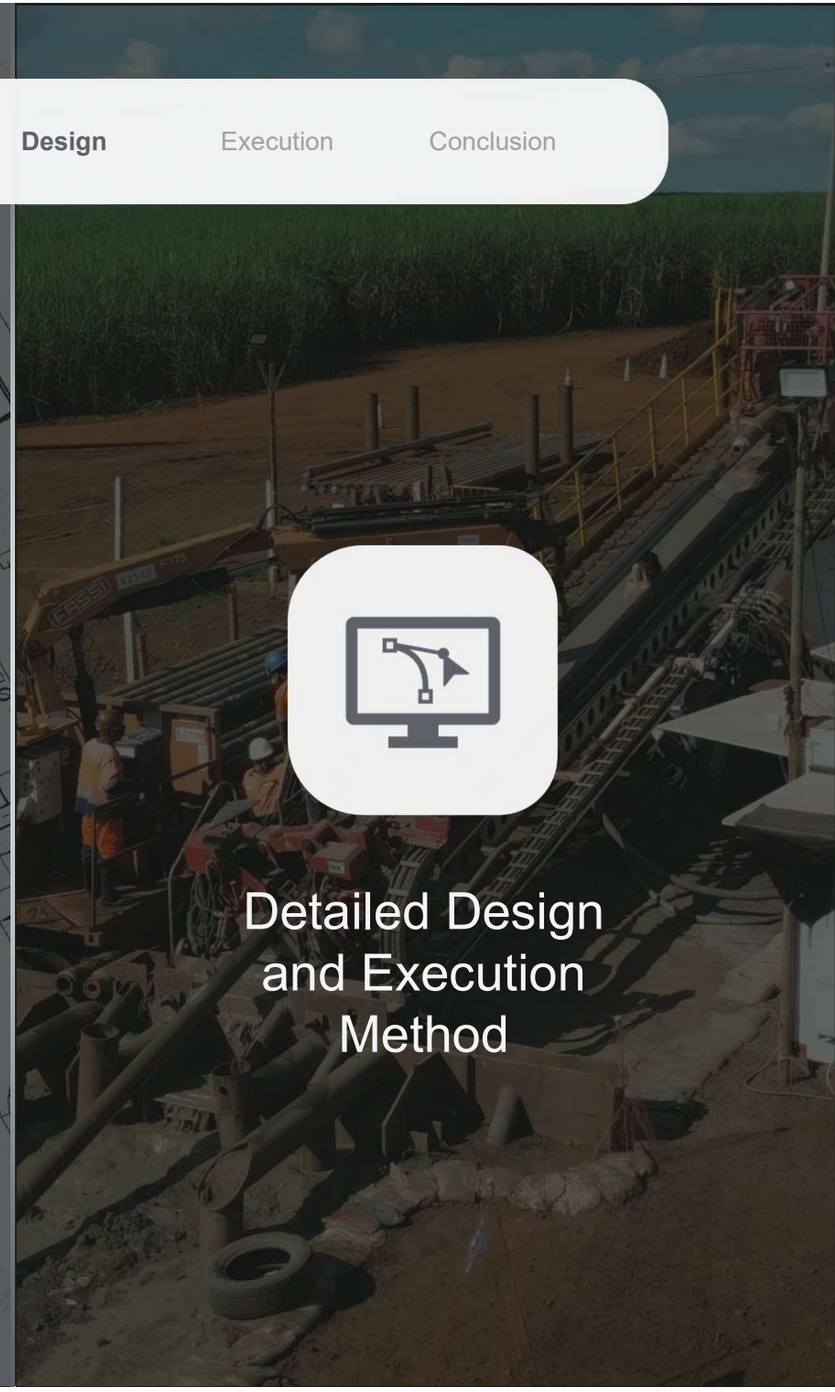
Design



Geotechnical and Geophysical Investigations

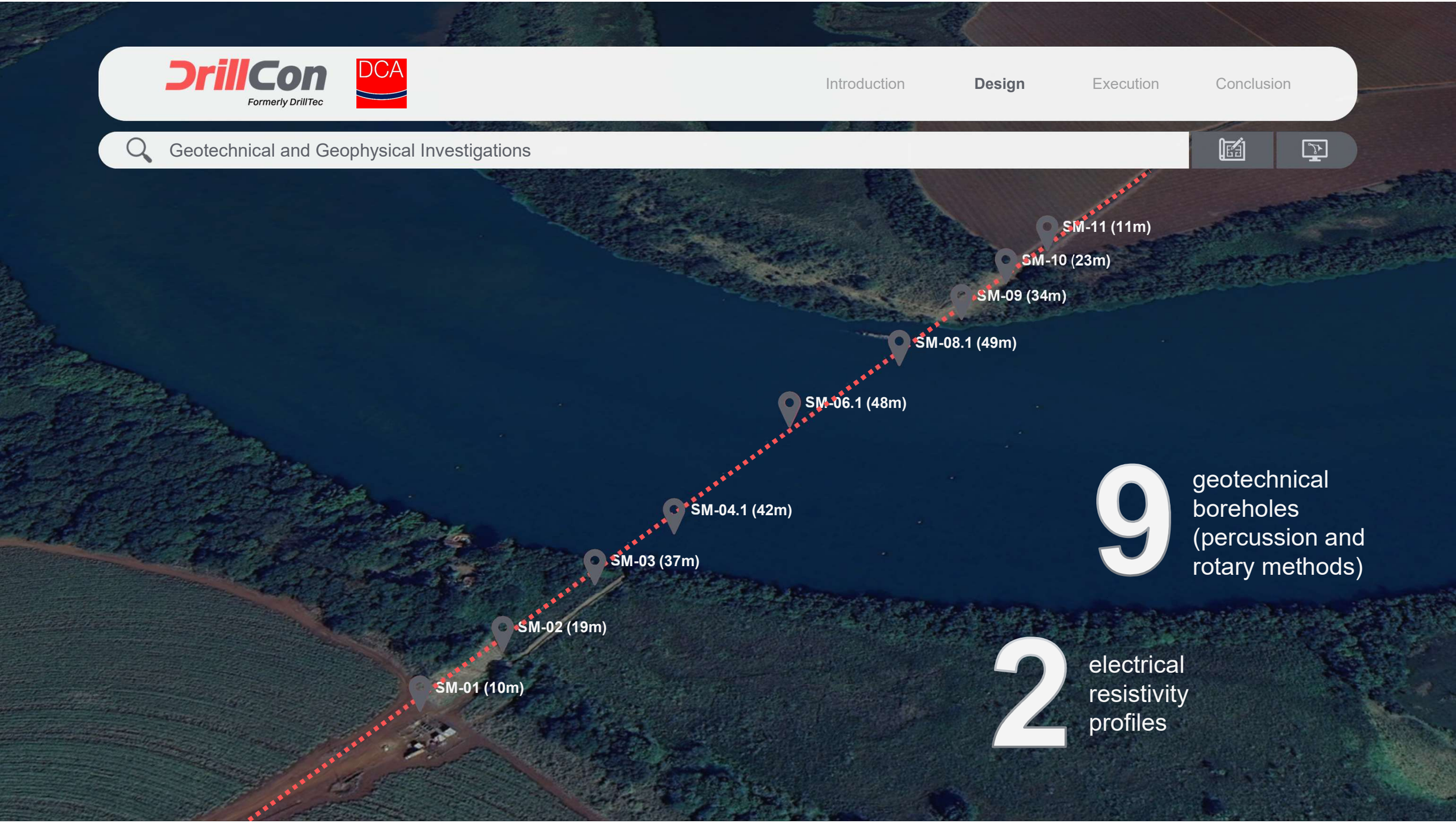


Basic Design



Detailed Design and Execution Method

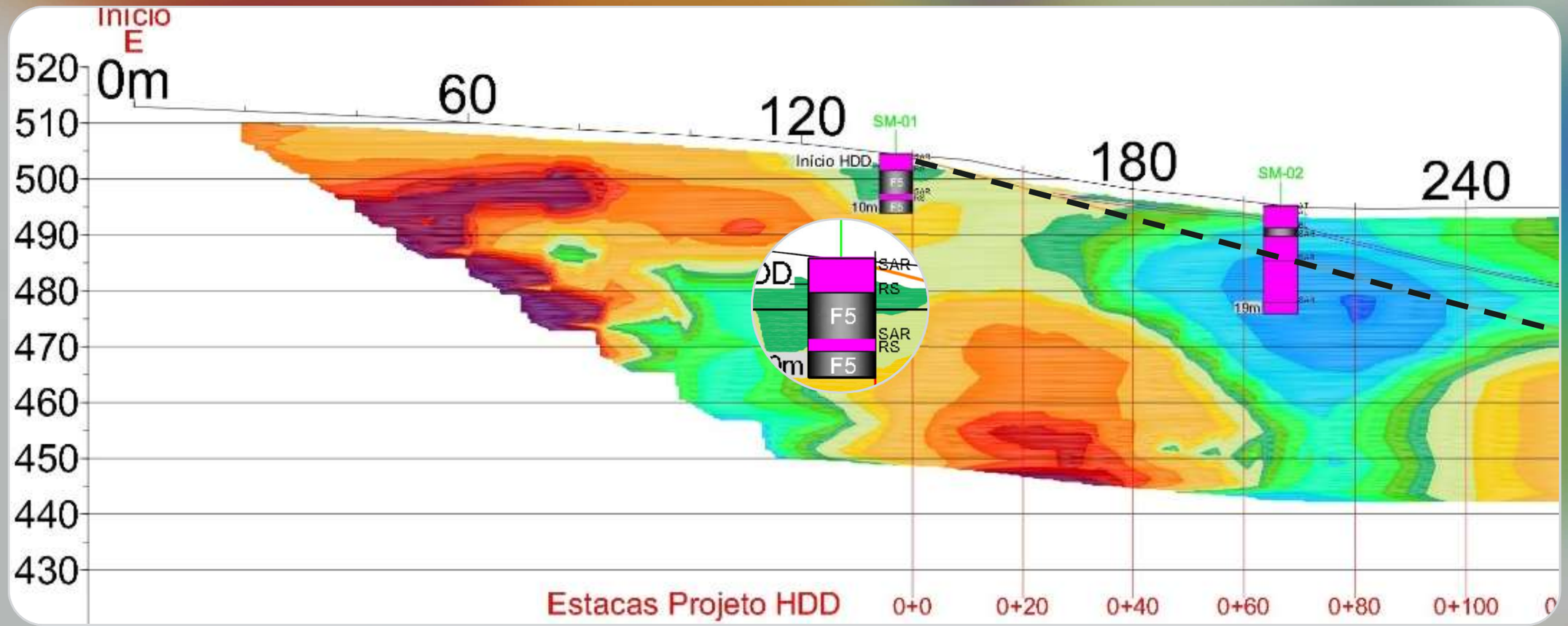
Geotechnical and Geophysical Investigations

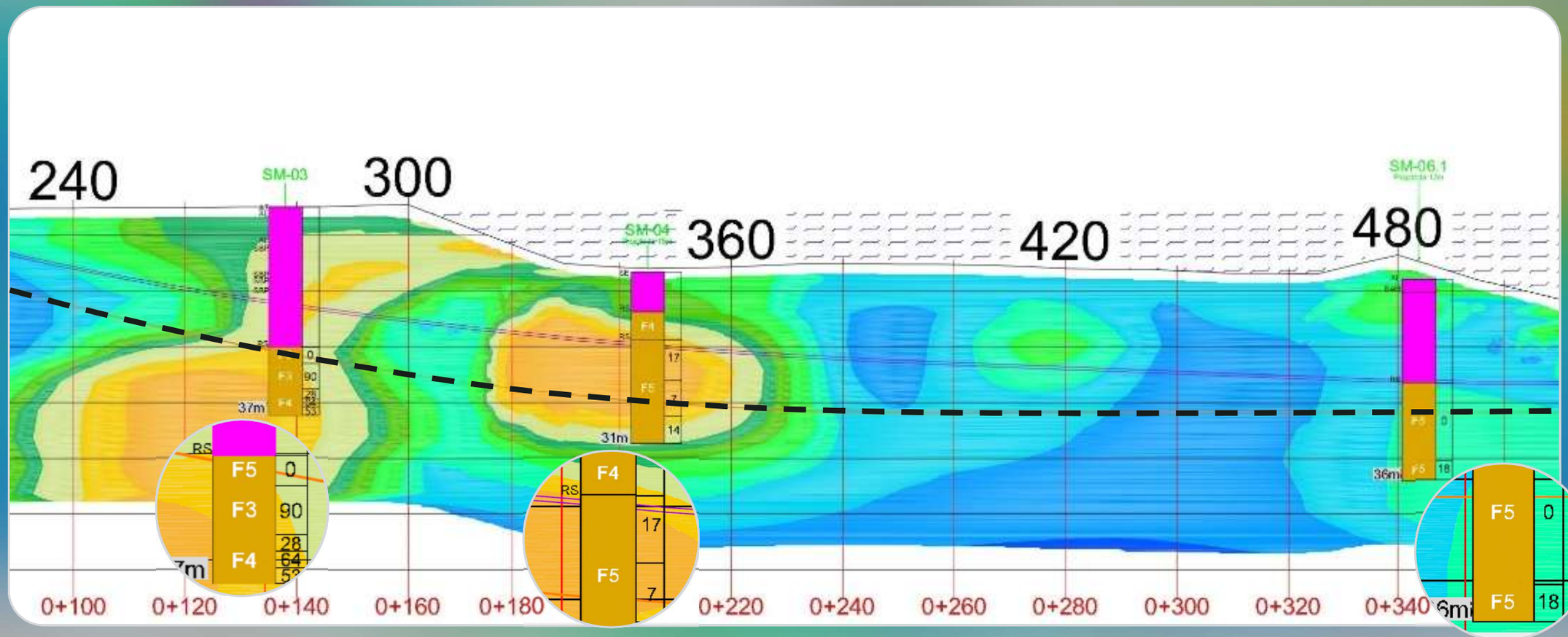


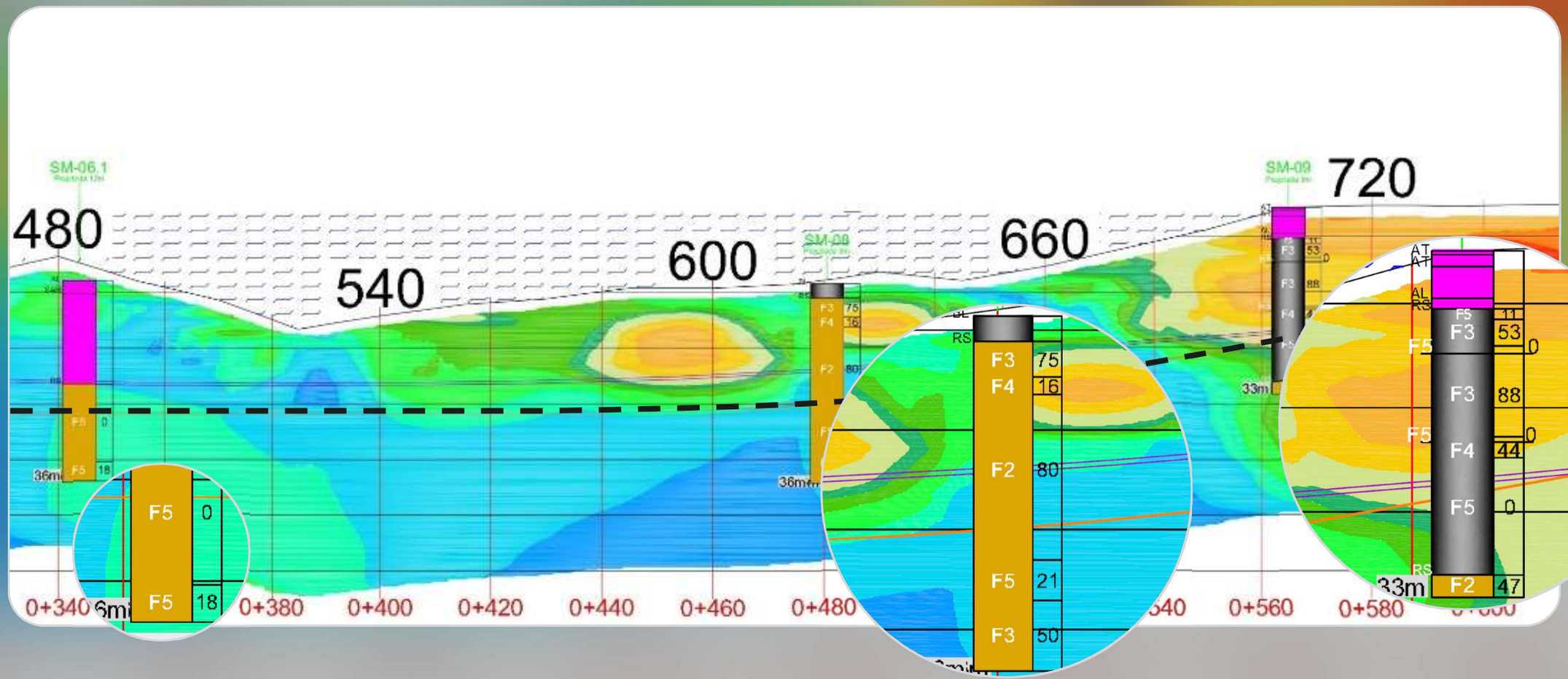
9 geotechnical boreholes (percussion and rotary methods)

2 electrical resistivity profiles

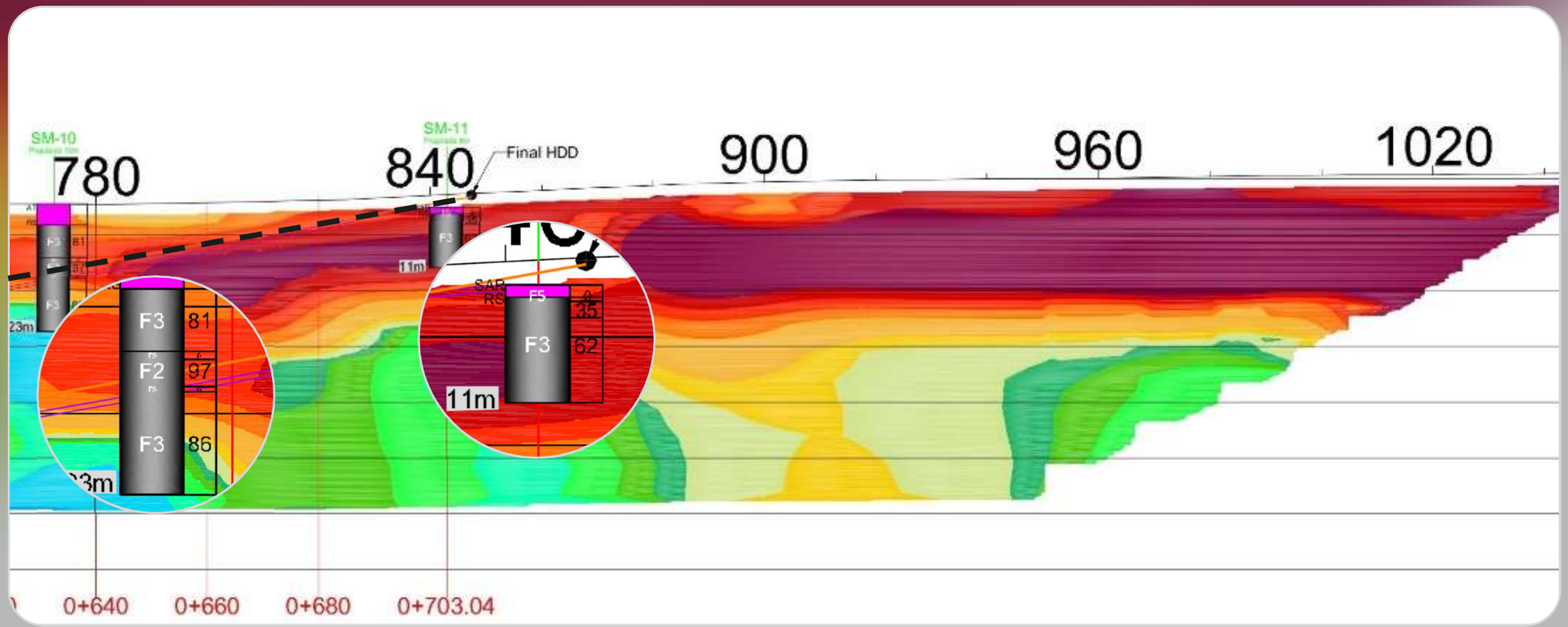
Geotechnical and Geophysical Investigations




240
SM-03
300
SM-04
360
420
480
SM-06.1
37m
31m
36m
RS
F5
F3
F4
0
90
28
64
17
7
18
0+100
0+120
0+140
0+160
0+180
0+220
0+240
0+260
0+280
0+300
0+320
0+340


SM-06.1
480
540
600
660
720
SM-09
0+340
0+380
0+400
0+420
0+440
0+460
0+480
0+560
0+580
F5 0
F5 18
F3 75
F4 16
F2 80
F5 21
F3 50
F3 53
F3 88
F5 0
F4 44
F5 0
F2 47
33m

Geotechnical and Geophysical Investigations



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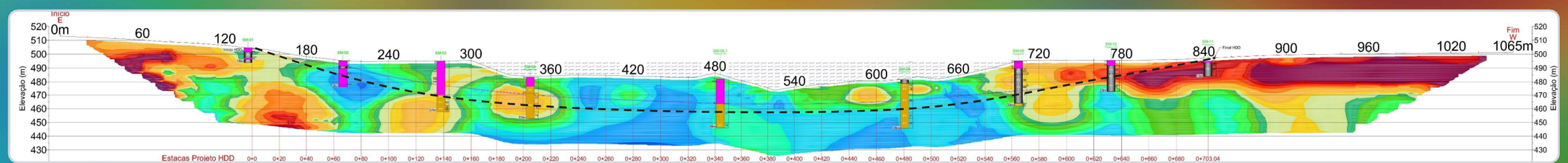


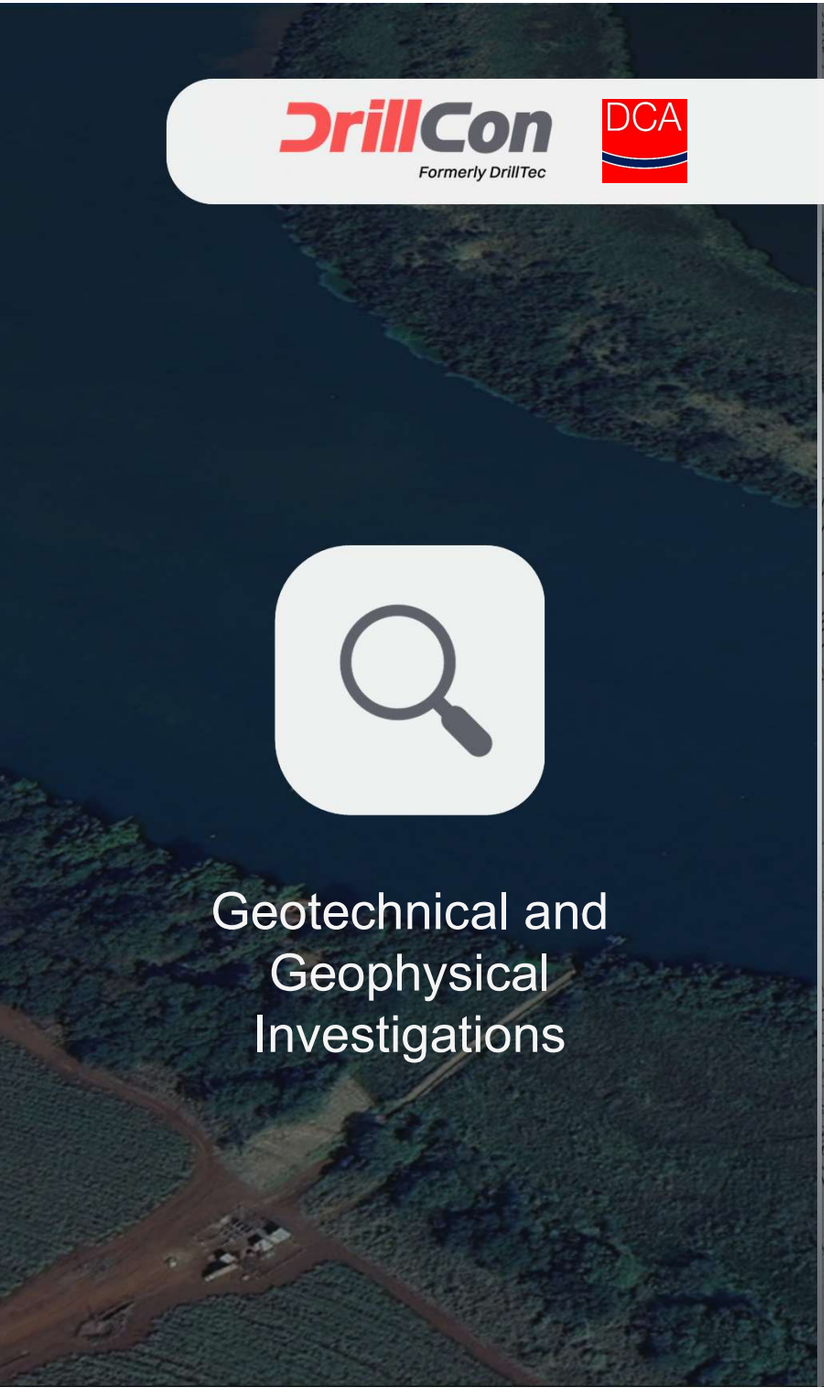
1.24 CAI

247 MPa UCS

≤0.26 CAI

19-27 MPa UCS

CAI – Cerchar Abrasivity Index
UCS – Uniaxial Compressive Strength



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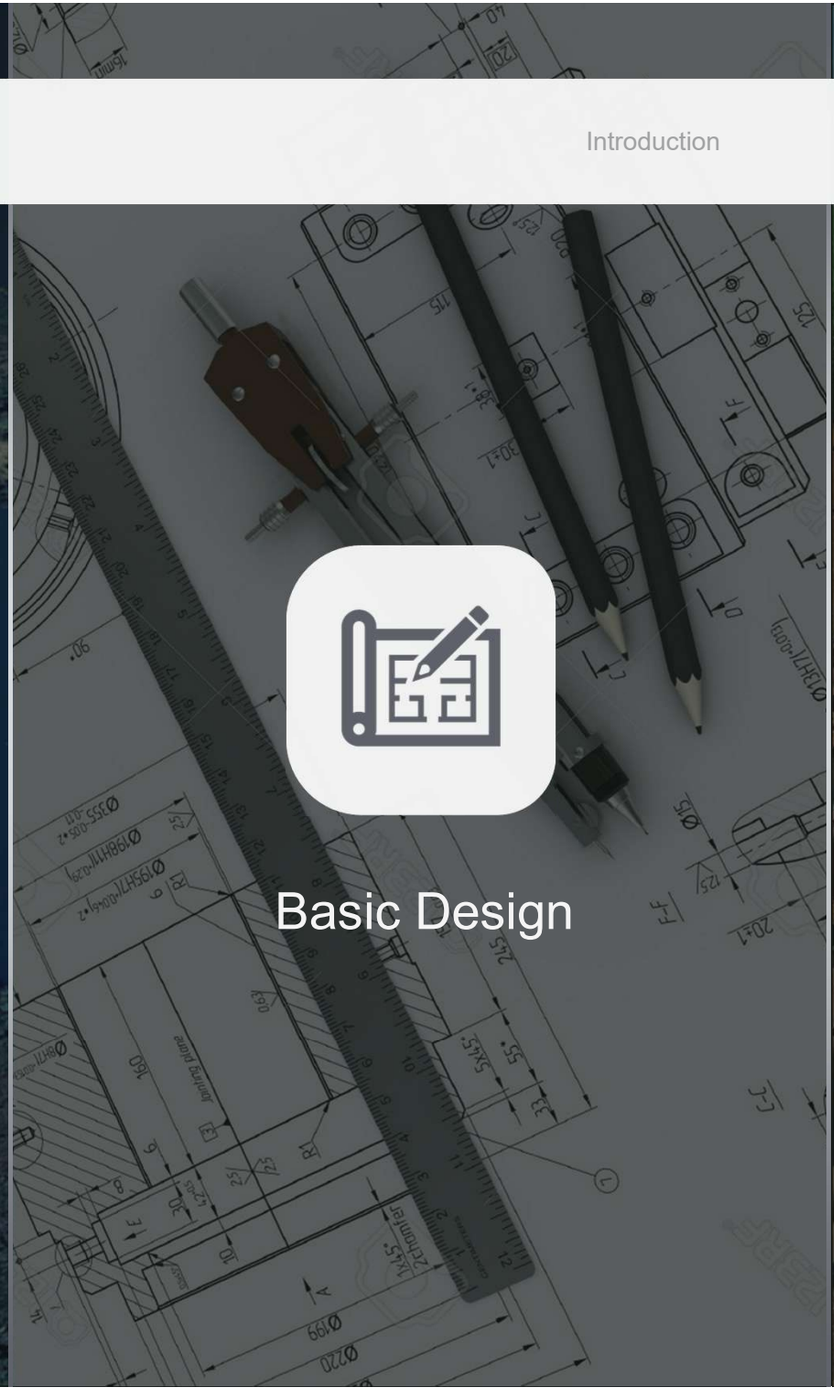
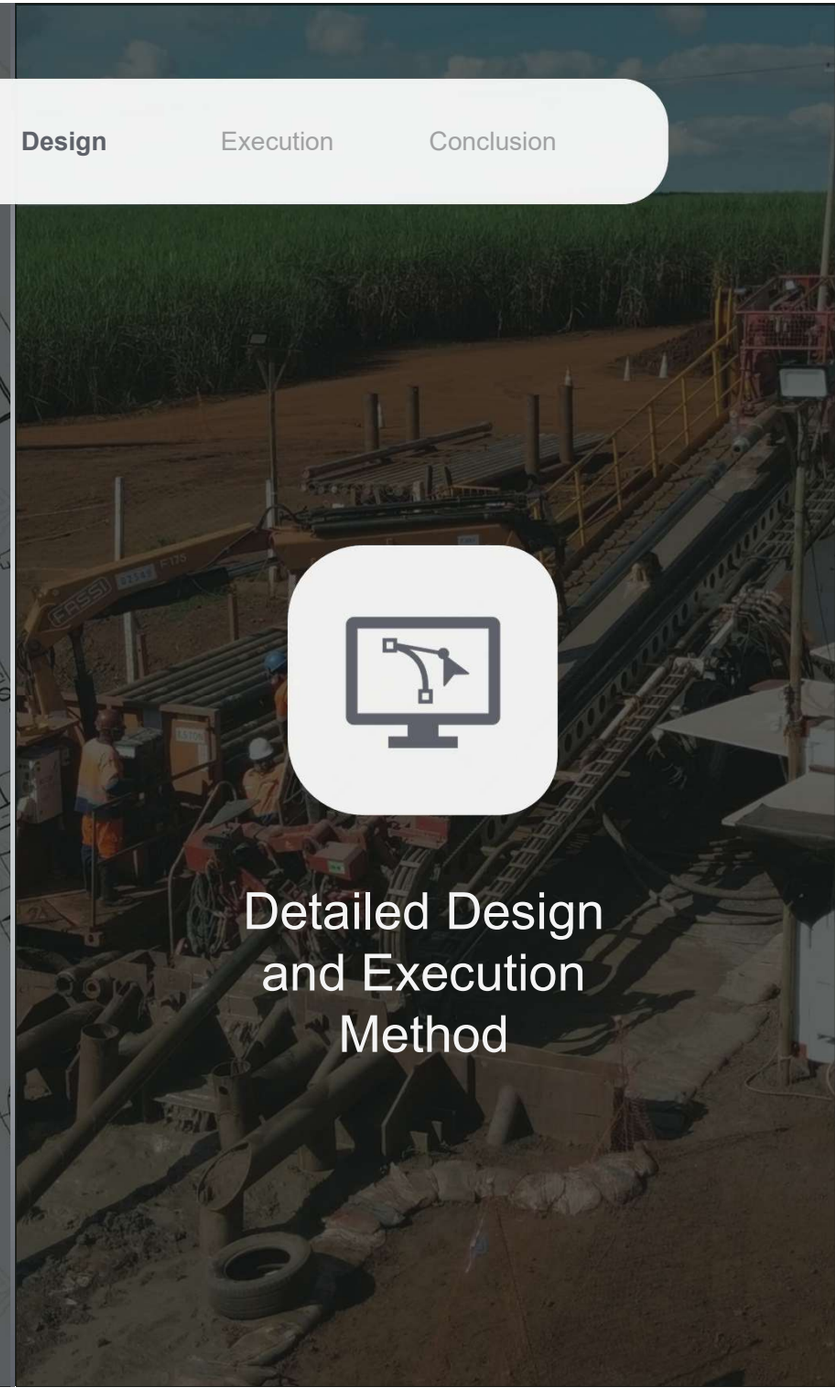


Basic Design



Detailed Design and Execution Method

Basic Design

Descriptive Report

Technical Drawing (Plan and Profile)

Technical Specifications

Geotechnical and Geophysical Campaign

Bathymetric Sections

As-Built Drawings

Material Requisition

Basic Design

Descriptive Report

Technical Specifications

Material Requisition

Manufacturing Standard / Material	API 5L X65
Outside Diameter	20”
Wall Thickness	0.375”
Design Standard	ASME B-31.4 / ABNT NBR 15280
Coating	Three-Layer Polyethylene – 3LPE
Fluid	Gasoline / Diesel / Jet Fuel / Ethanol
Design Temperature	20ºC
Design Pressure	92.8 kgf/cm² (1,320 PSI)
Minimim Curvature Radius	610 m
Entry and Exit Angle	10-16° / ≤10º
Length	830 m

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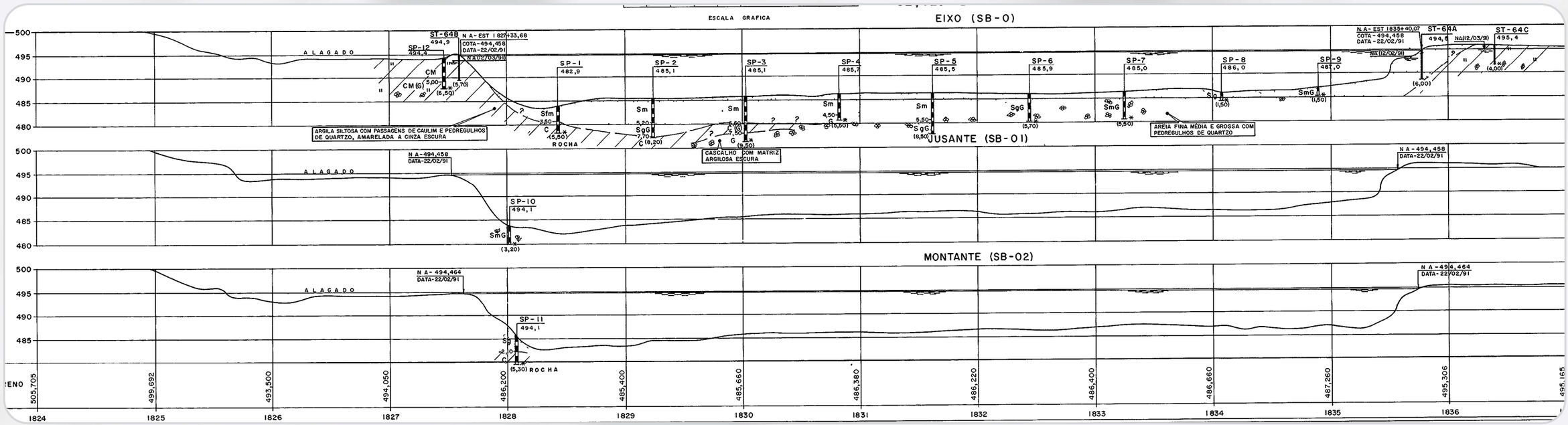
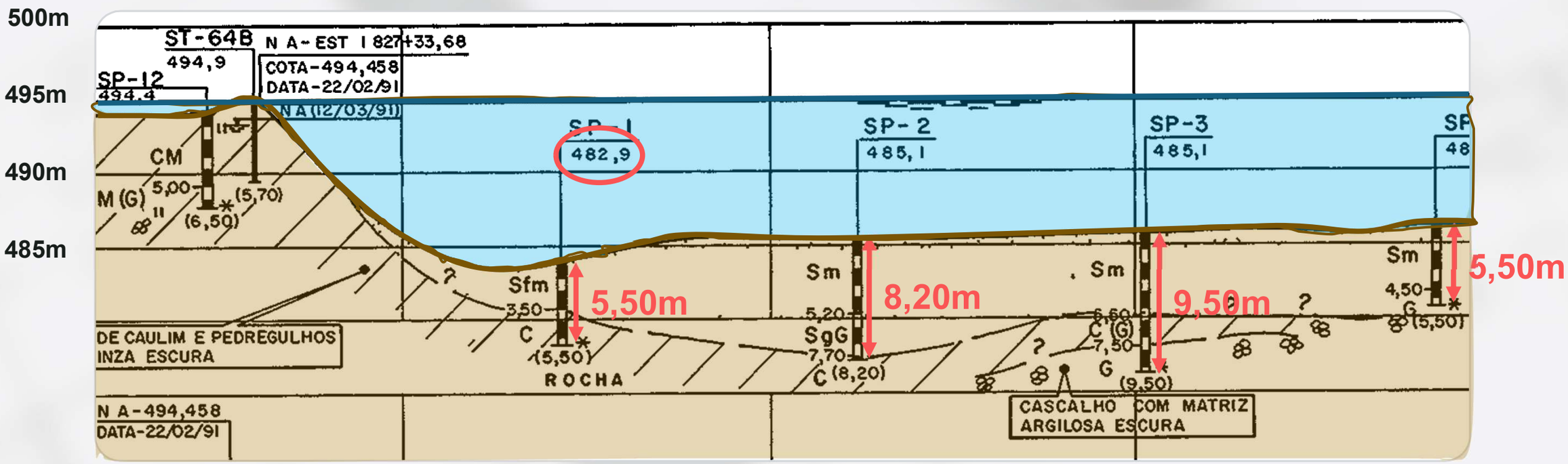
Basic Design

Bathymetric Sections



Bathymetric Sections



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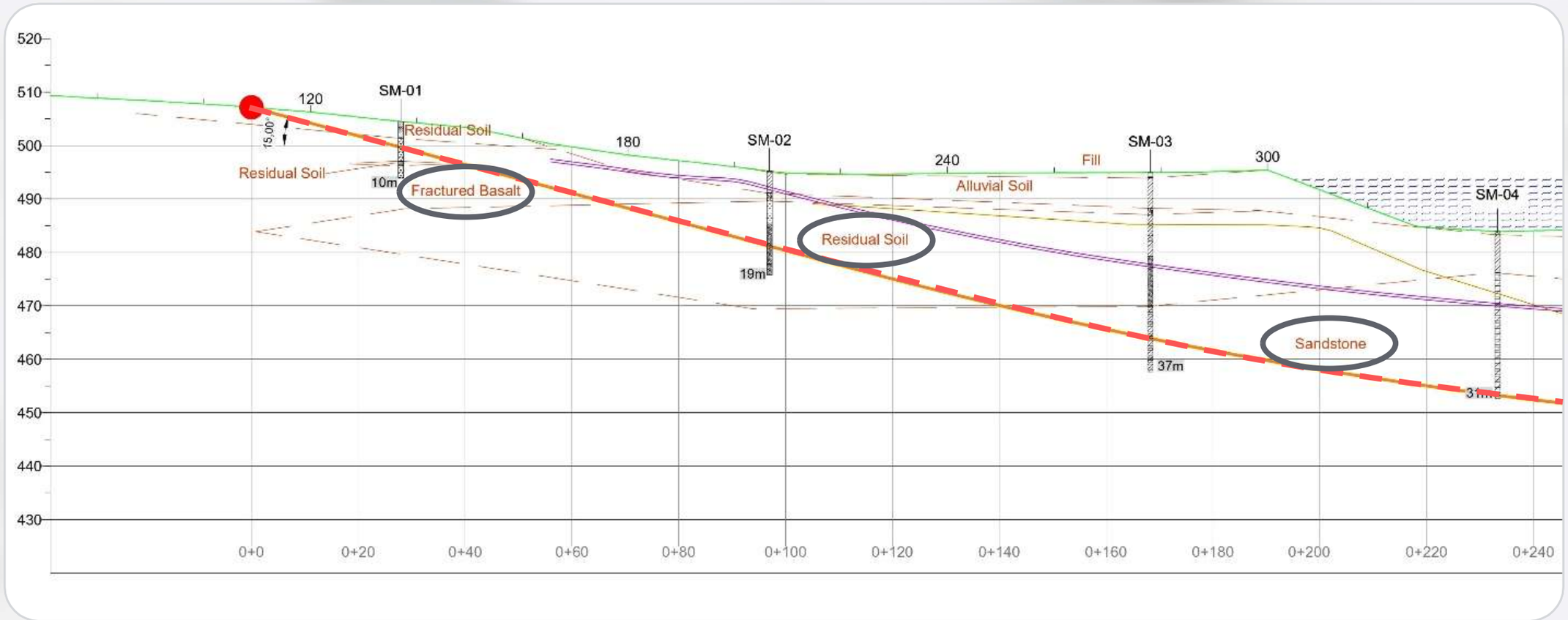

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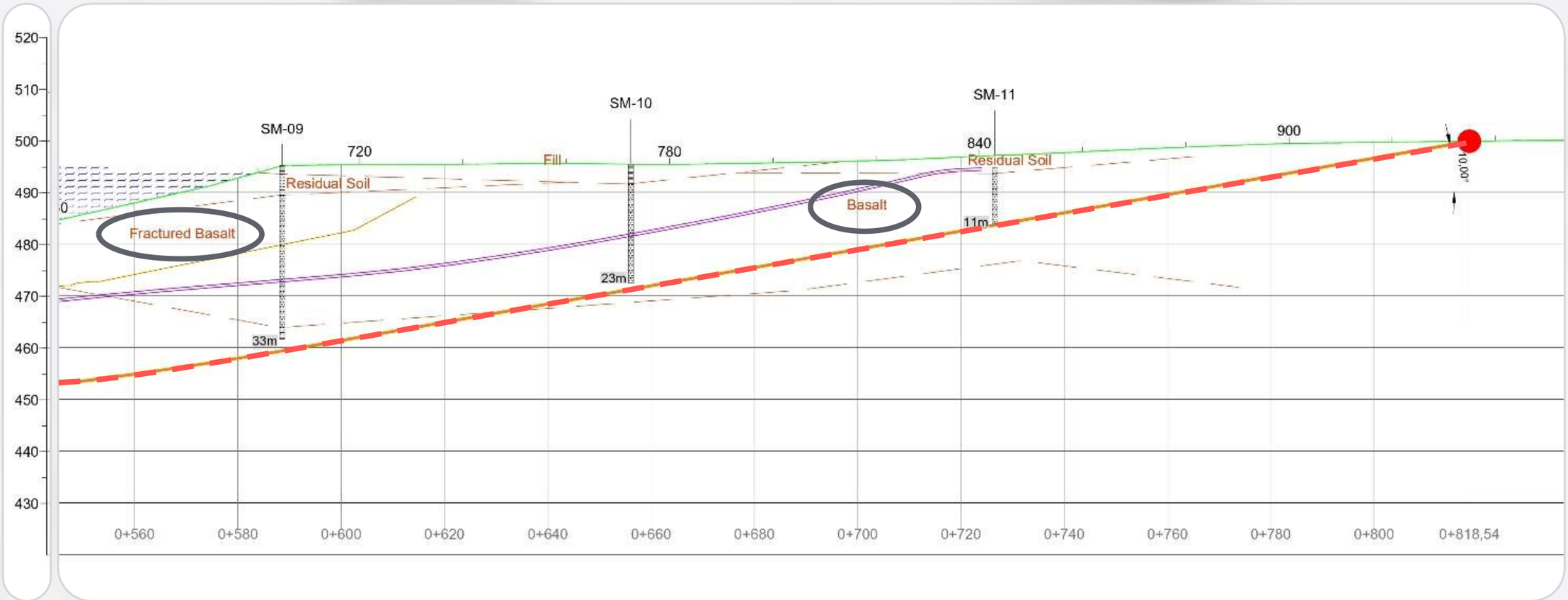

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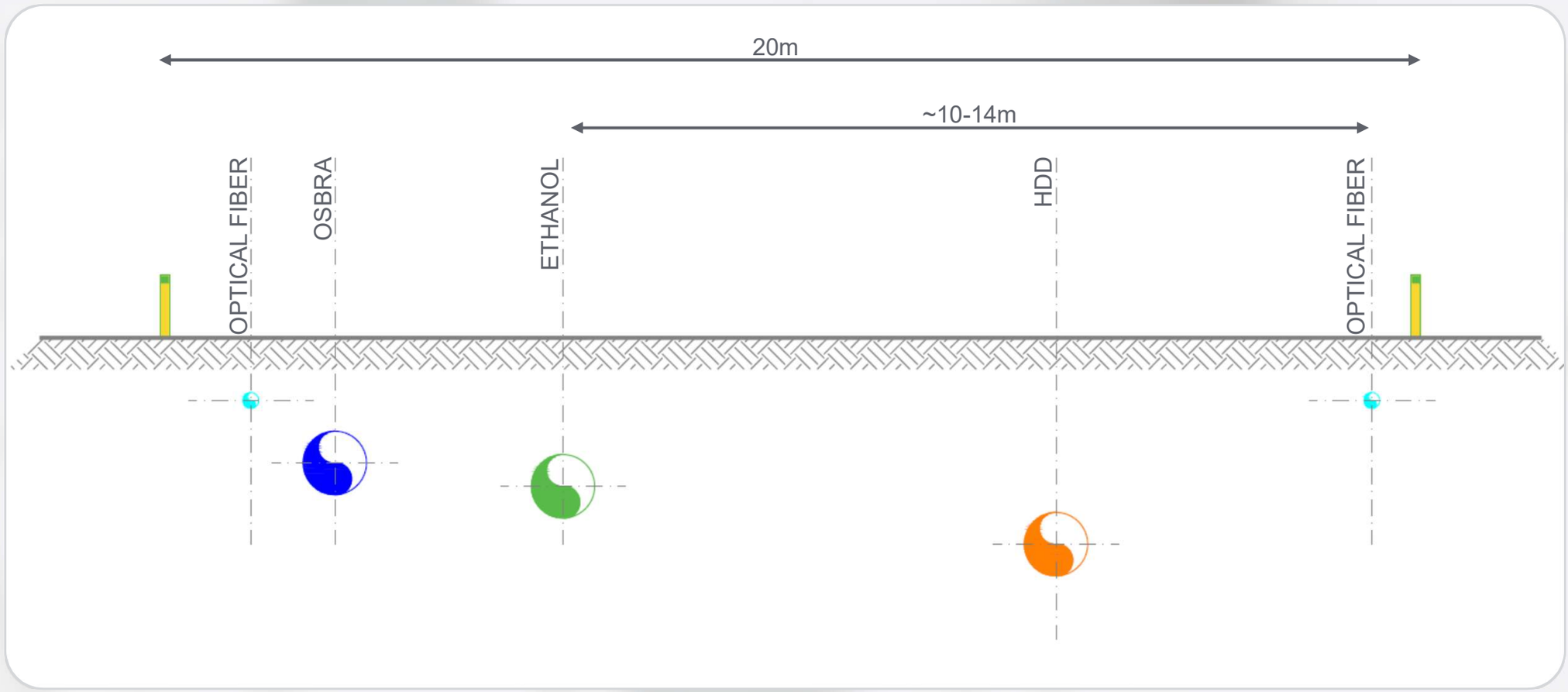

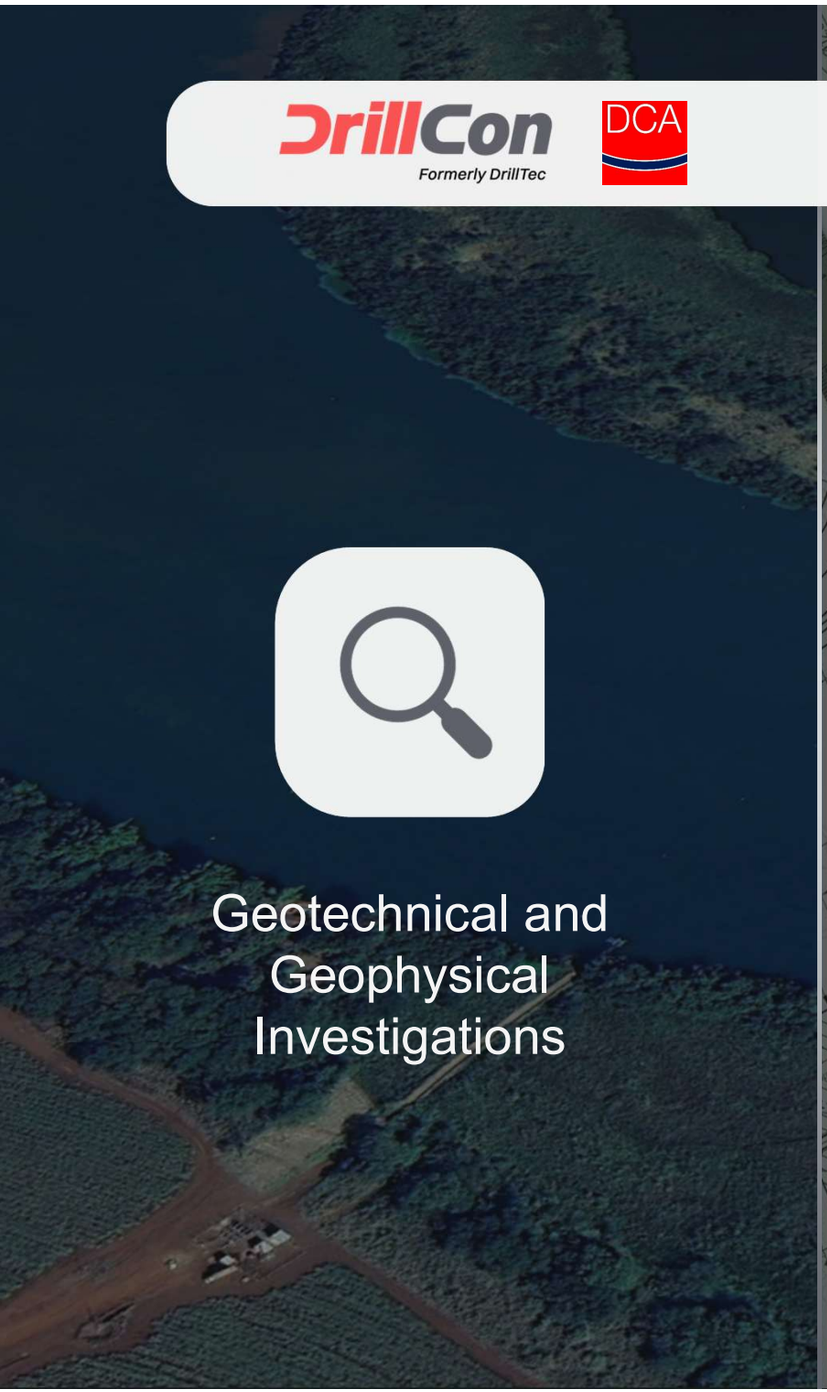

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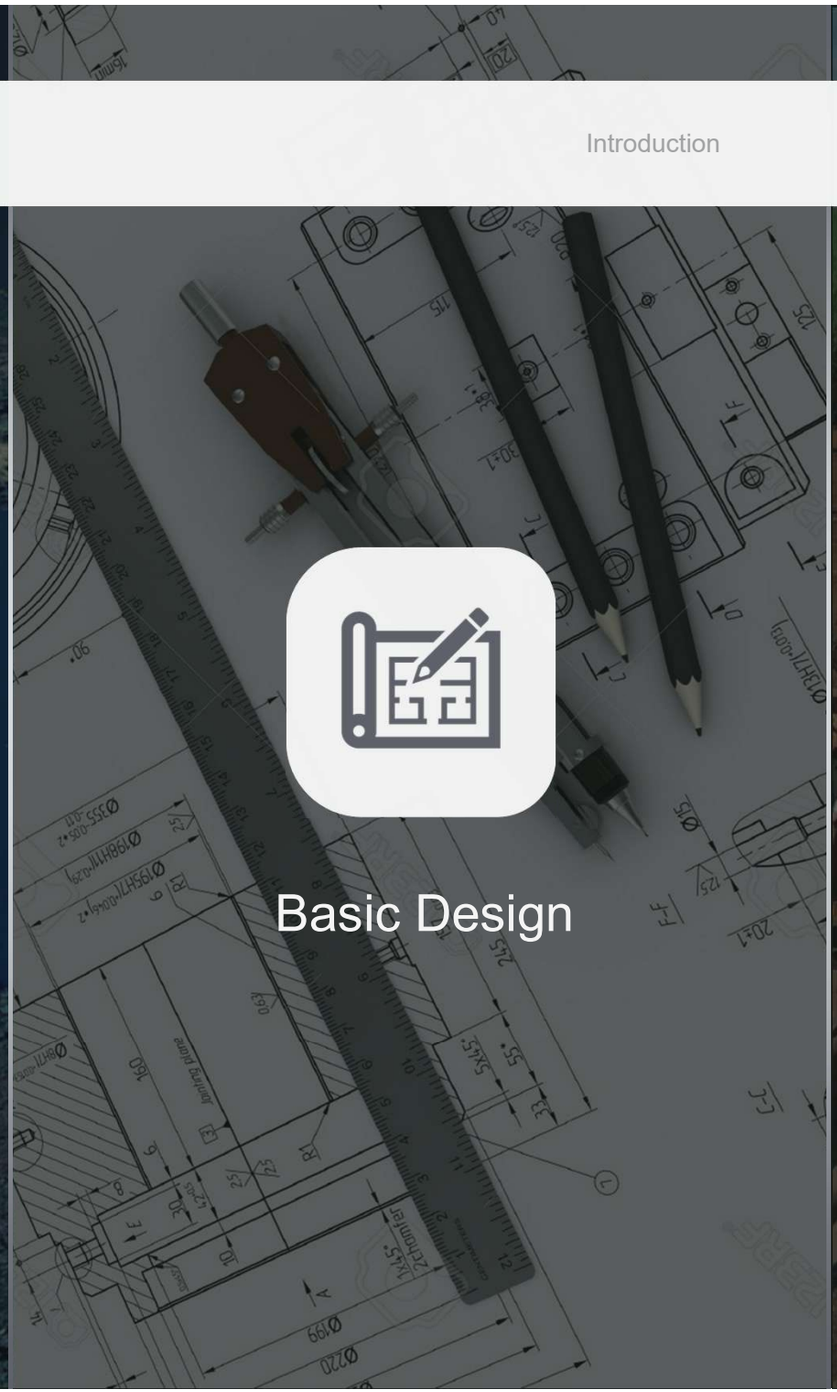

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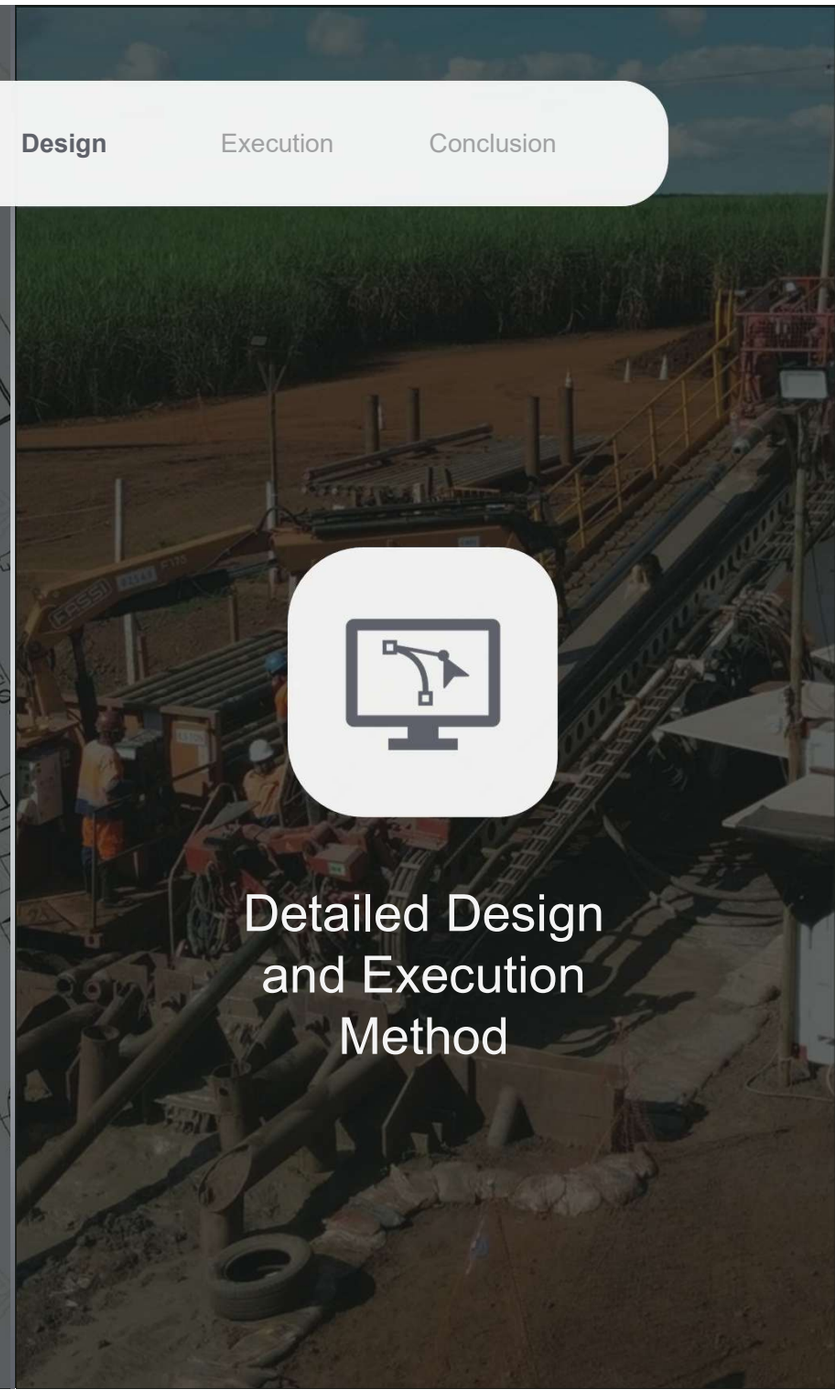

Detailed Design and Execution Method

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Planning

Technical Drawings and Layouts

Execution Procedures

Calculation Reports

Detailed Design and Execution Method

- **Planning**
  - Technical Site Visit
  - Topographic Survey
  - Interference Verification
- **Technical Drawings and Layouts**
  - Plan and Profile
  - Layouts of Construction Sites
  - Product Pipe Positioning and Catenary
- **Execution Procedures**
  - Drilling Procedure
  - Equipment and Tools Specifications
  - Drilling Fluid Program
  - Welding, Inspections and Hydrostatic Testing
- **Calculation Reports**
  - Rig Anchor
  - Mechanical Stresses on the Product Pipe
  - Pulling Head

Detailed Design and Execution Method

Technical Site Visit | Topographic Survey | Interference Verification

Detailed Design and Execution Method

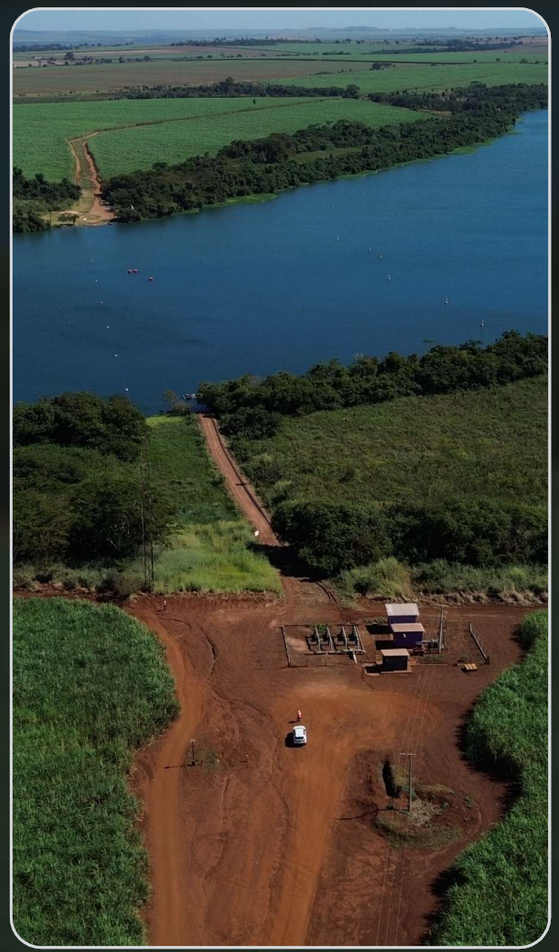
Technical Site Visit

Topographic Survey

Interference Verification

Detailed Design and Execution Method

Technical Site Visit



Topographic Survey

Interference Verification

Mapped

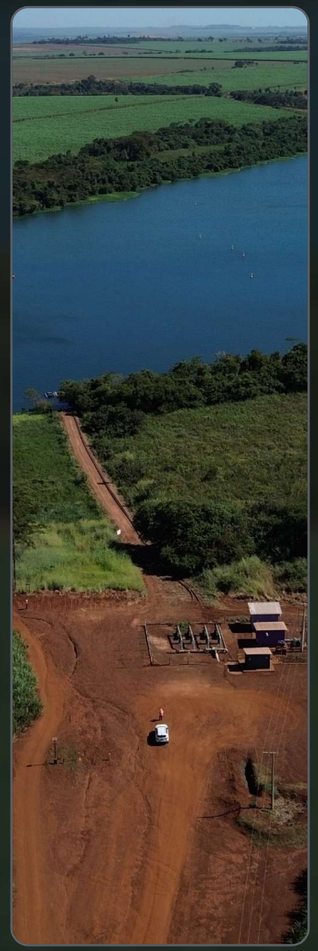
- 2x Optical Fibers
- Ethanol Pipeline
- OSBRA
- Permanent Preservation Area (PPA)

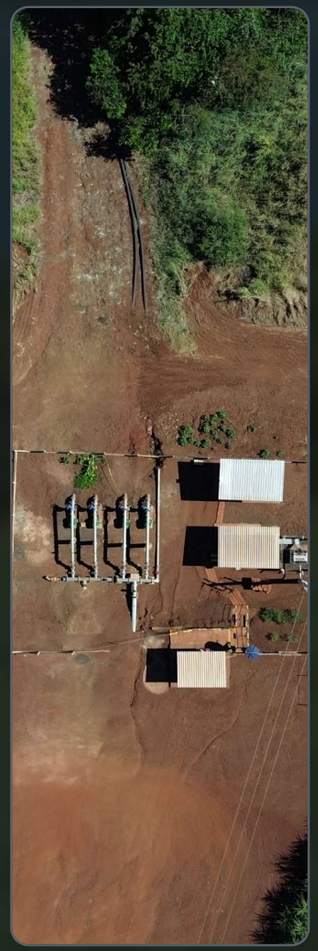
Unmapped

- 2x Water Mains
- Valve Area
- Poles and Electrical Lines
- Sugarcane Cultivation

Detailed Design and Execution Method

Technical Site Visit





Topographic Survey

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- Ethanol Pipeline
- OSBRA
- Permanent Preservation Area (PPA)

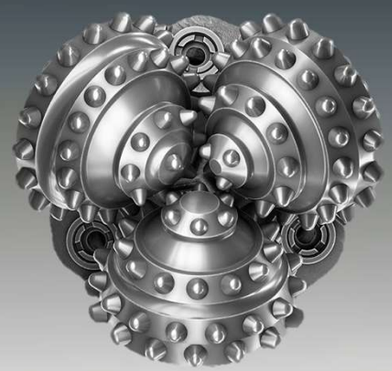
Unmapped

- 2x Water Mains
- Valve Area
- Poles and Electrical Lines
- Sugarcane Cultivation

Interference Verification

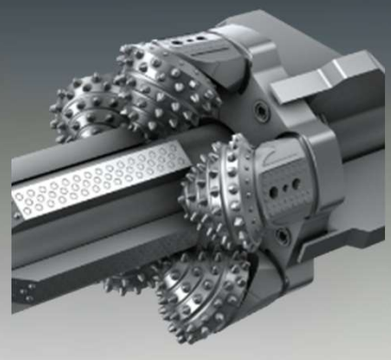
- Technical, Quality, Environmental and Safety Procedures
- Comprehensive Contingency Plan

Drilling Procedure



Ø12 1/4” Pilot Hole

Ø16” Casing Pipe
P2 + PGM
Robust Drilling Fluid Program



Ø26” Reaming

Backreaming method
1.3 to 1.6x Ø20”

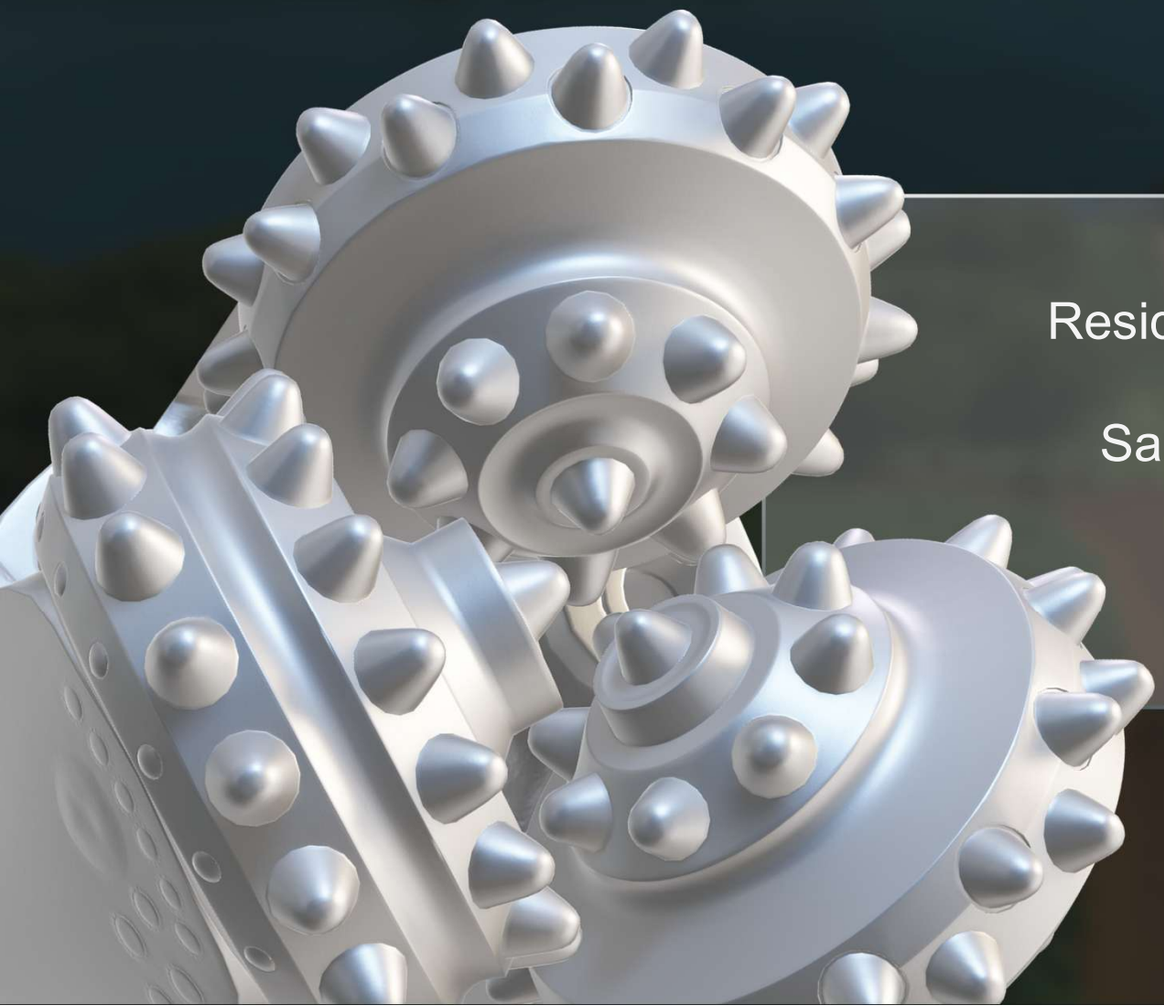
Cleaning and Conditioning

Preparation for Pullback

Pullback

Installation of the Ø20” Product Pipe

Equipment and Tools Specifications



Drill Bits Program

Residual Soil Sandstone	2x **Ø12 ¼” MT** **IADC 327**
Basalt	1x **Ø12 ¼”TCI** **IADC 637**

Equipment and Tools Specifications

Drill Bits Program

2x
Ø12 ¼" MT
IADC 327

1x
Ø12 ¼"TCI
IADC 637

Reamers Program

2x
Ø26" MT

1x
Ø26"TCI
IADC 637

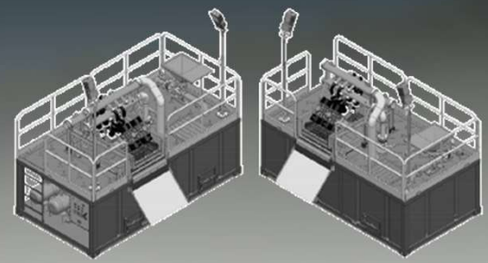
Drill Pipes

Ø5 ½" x 9.5m
28.05 lb/ft
Grade S135
Premium Class
API-RP-7G-2

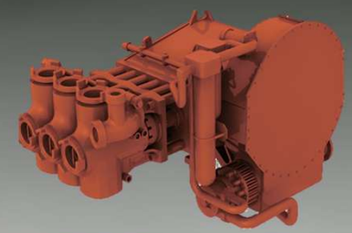
Equipment and Tools Specifications

Drilling Rig
Push/Pull: 306 tf
Torque: 90 kN.m

Power Pack
470 kW
20 ft Container



Recycling System
Scalper + Desander + Desilter
Additional Unit to Pipe Side (No Return Line)

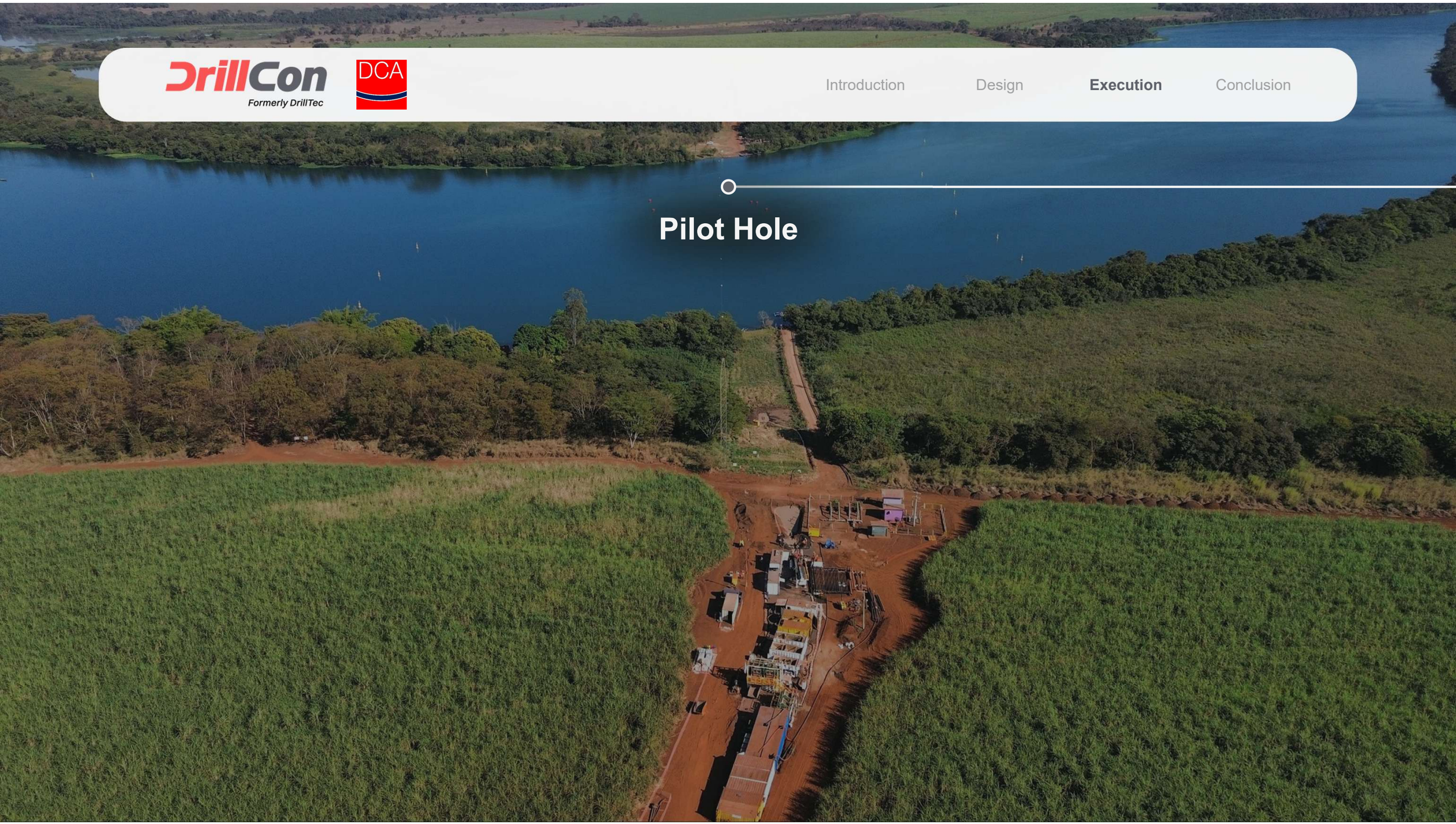


2x Triplex Pumps
660 GPM @ 10 bar
700 GPM @ 10 bar

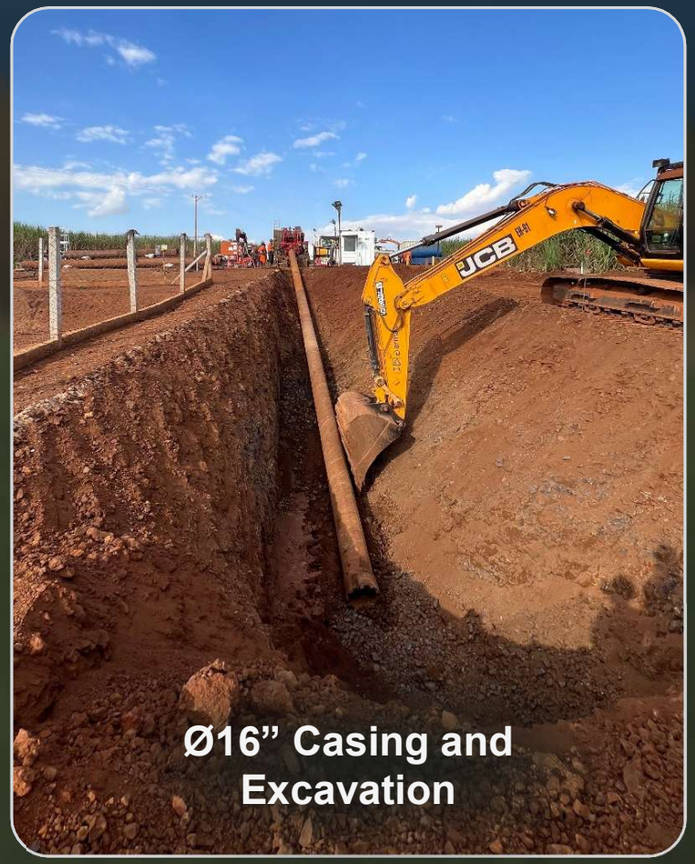
+ Mixers, Tanks, Skips, Generators, Transfer Pumps, ...

Execution

Pilot Hole



Pilot Hole



Ø16” Casing and Excavation

Pilot Hole

Plan		Execution	
15	days	15	days
5.2	Avg. ROP (m/h)	7.5	Avg. ROP (m/h)
830	Length - MD (m)	830	Length - MD (m)
610	Min. Radius/3 Jt. (m)	612	Min. Radius/3 Jt.(m)

Pilot Hole

Execution

15 days

7.5 Avg. ROP (m/h)

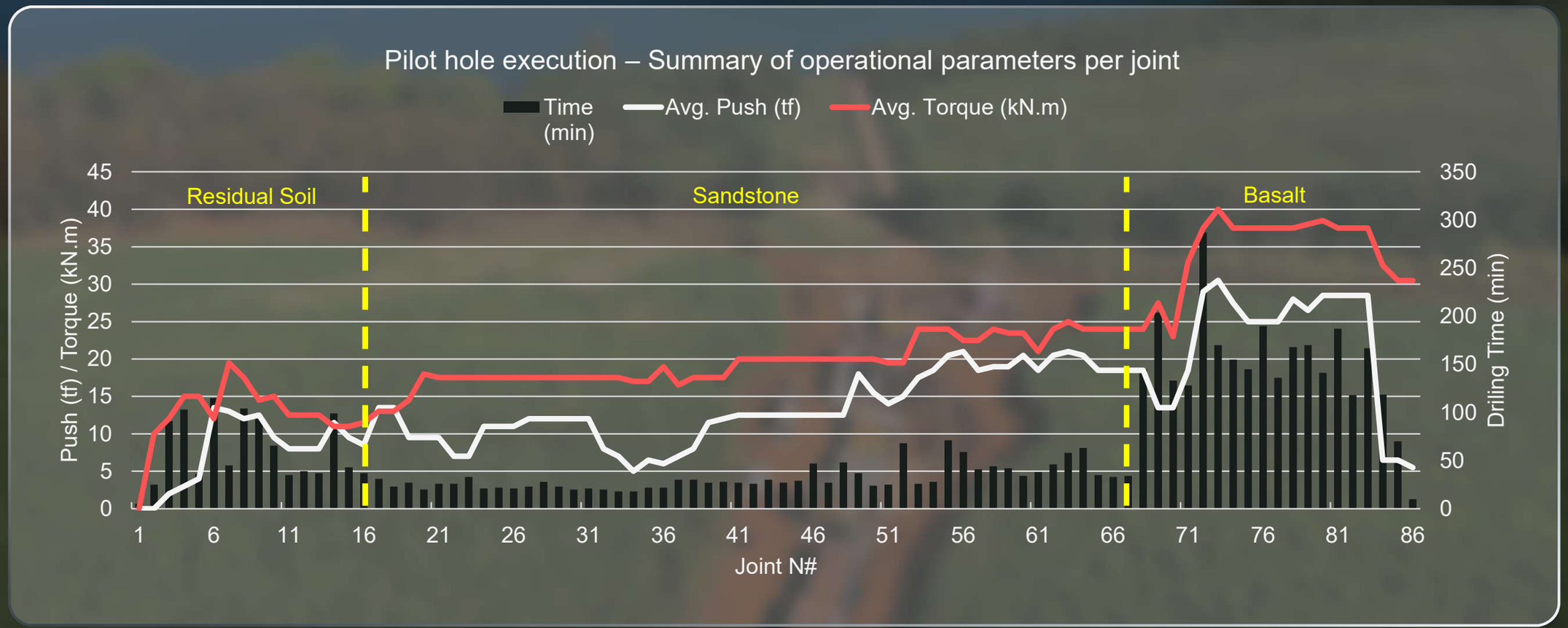
830 Length - MD (m)

612 Min. Radius/3 Jt.(m)

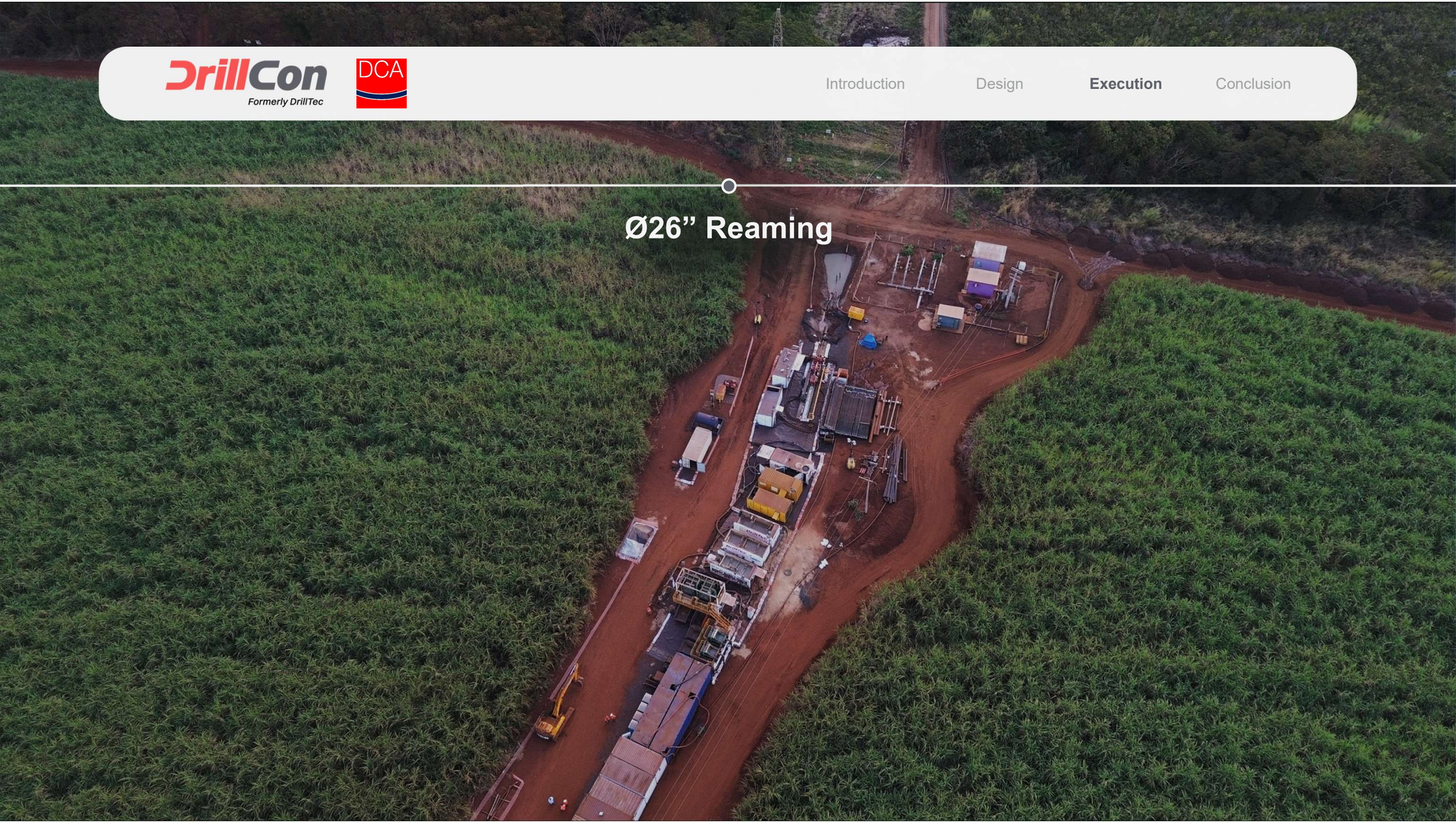
12 productive days

3 downtime days

Pilot Hole


Pilot hole execution – Summary of operational parameters per joint
Time (min)
Avg. Push (tf)
Avg. Torque (kN.m)
Residual Soil
Sandstone
Basalt
Push (tf) / Torque (kN.m)
Driling Time (min)
Joint N#
0
5
10
15
20
25
30
35
40
45
0
50
100
150
200
250
300
350
1
6
11
16
21
26
31
36
41
46
51
56
61
66
71
76
81
86

Ø26” Reaming

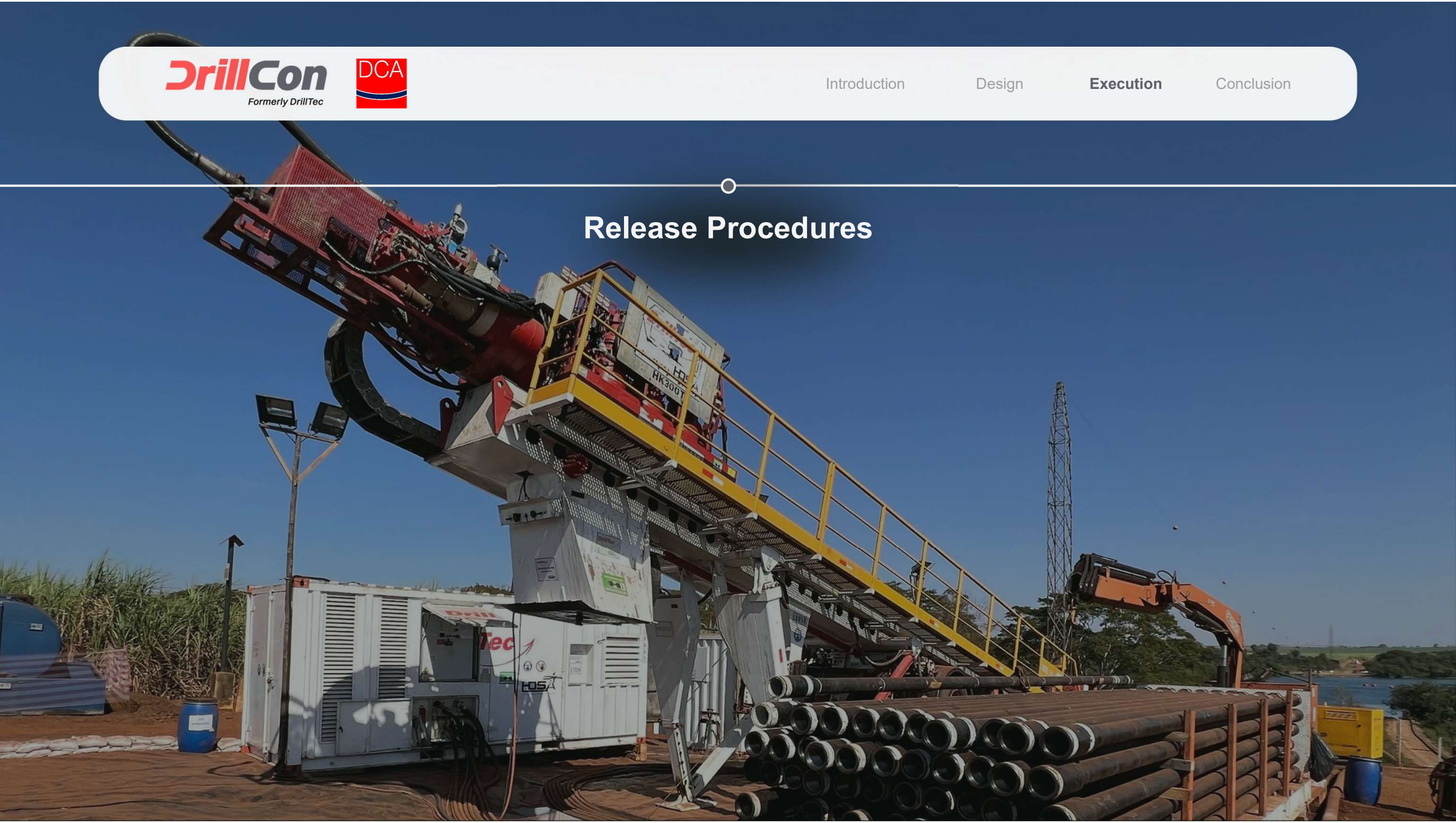


Ø26” Reaming

Ø26” Reaming

- Fire in sugarcane plantation (Rig Side)
- Activities temporarily halted
- Activities resumed the following day
- **Drill string and Ø26” reamer stuck**

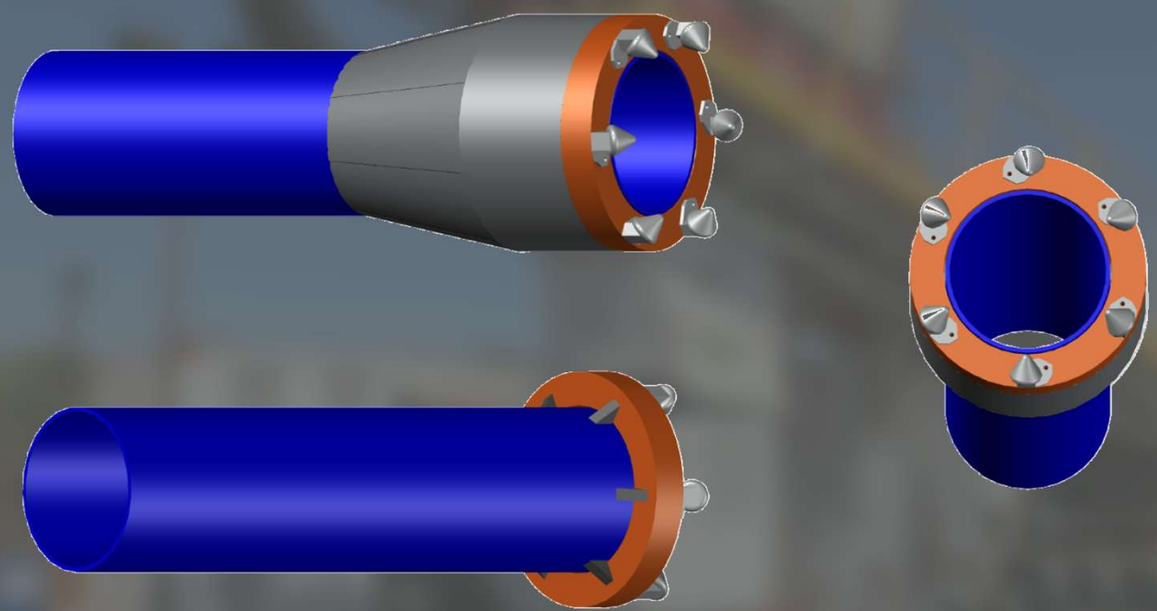
Release Procedures

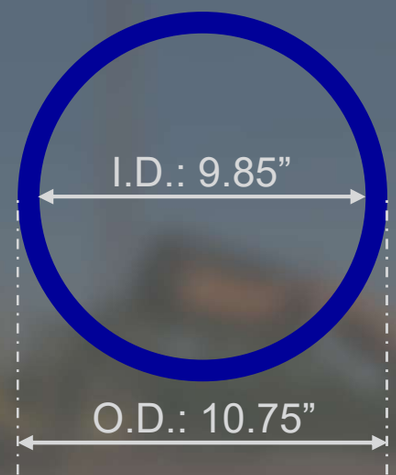


Release Procedures

1

Washover

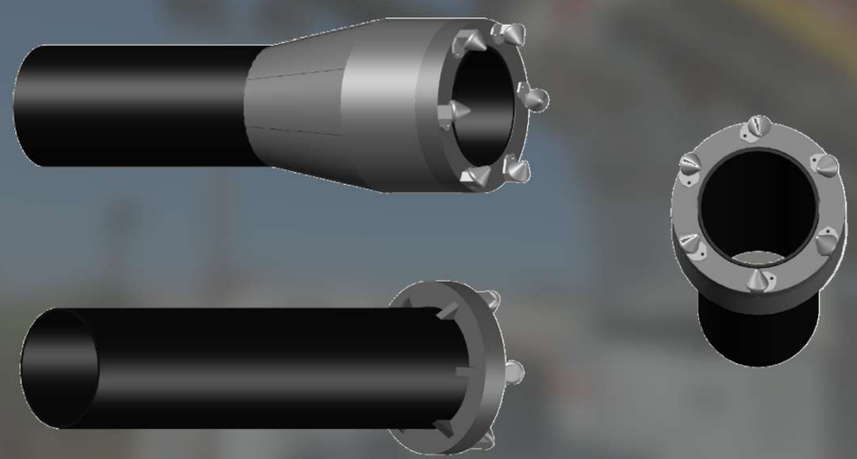




Release Procedures

1

Washover



2

Multiply the acting loads

Second drilling rig

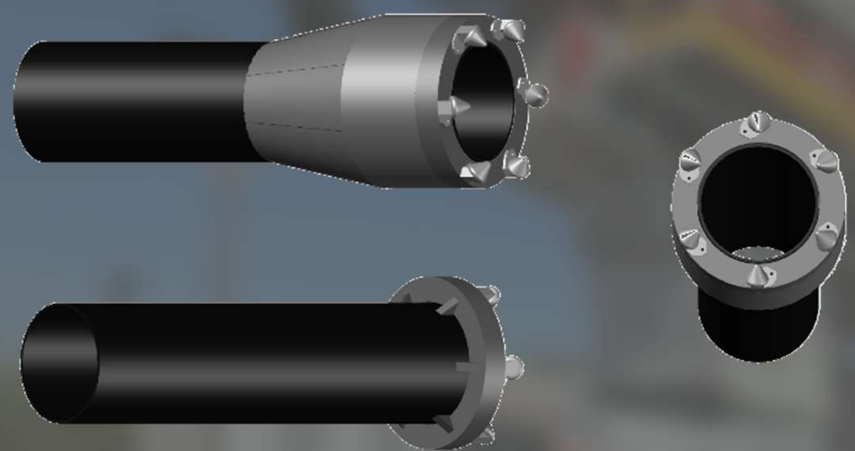
+

Pneumatic hammer

Release Procedures

1

Washover



2

Multiply the acting loads

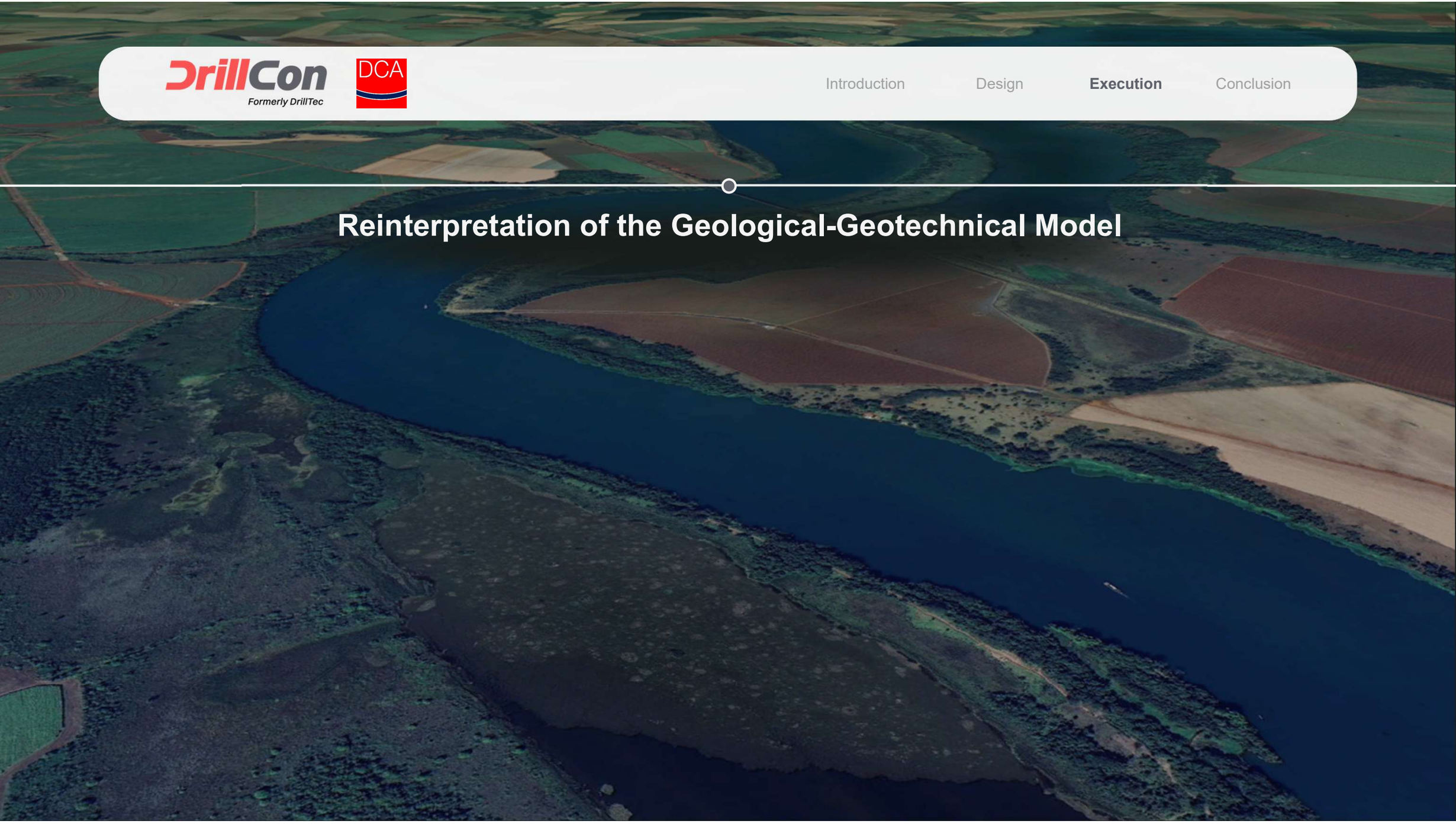
Second drilling rig

+

Pneumatic hammer

Immediate release was not achieved

Reinterpretation of the Geological-Geotechnical Model



Reinterpretation of the Geological-Geotechnical Model

Broaden geological-geotechnical knowledge base

- Data from investigation campaign
- Drilling parameters
- Critical events
- Specialized technical-scientific references

Reinterpretation of the Geological-Geotechnical Model

- Geological maps
- Regional and local stratigraphic framework
- Contextualizing the geological units
- Structural and lithological relationships

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Avoid limitations and interpretive bias

Reinterpretation of the Geological-Geotechnical Model

Formations

Uberaba

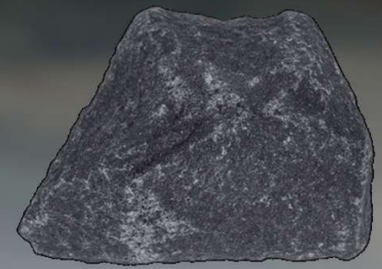
Sandstones, mudstones, siltstones, claystones and conglomerates.
Clay-silt layer as basal section.

Botucatu

Sandstones, discontinuities and irregular thickness.

Piramboia

Sandstones, clayey sandstones and conglomeratic sandstones.
Clay-rich basal section.



Serra Geral

Predominantly basalt, commonly with secondary minerals, including quartz, calcite, zeolites, fluorite and clays.

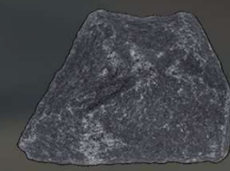
Reinterpretation of the Geological-Geotechnical Model

Formations

Uberaba

Botucatu

Piramboia



Serra Geral

Main Materials

Basalts of Serra Geral Fm., in which alteration produces residual soils and neoformed smectite, with swelling behavior.

Sandstones of Botucatu Fm., usually weak, in which clayey cement or pelitic intercalations reduce strength and increase susceptibility to weathering.

Clayey materials, occurring as residual or sedimentary layers, characterized by rapid degradation and swelling potential.

Reinterpretation of the Geological-Geotechnical Model

Formations


Uberaba


Botucatu


Piramboia


Serra Geral

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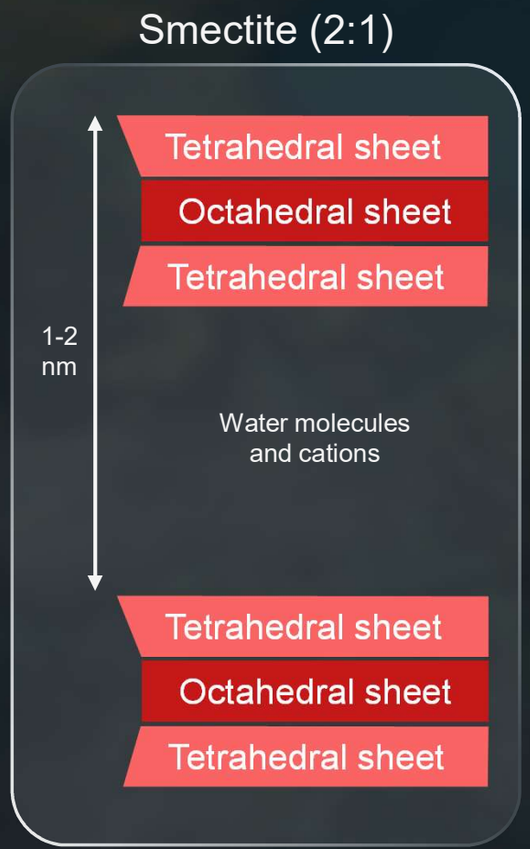
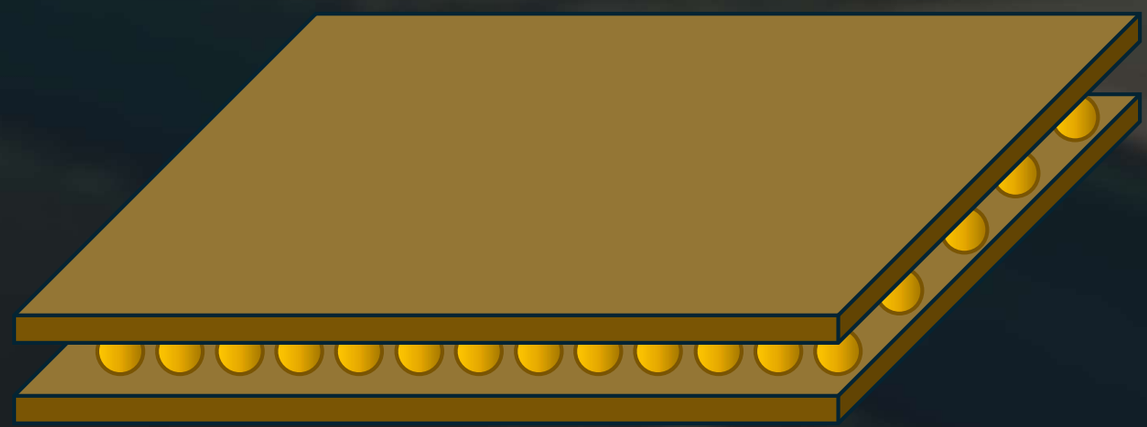
Swelling clay minerals

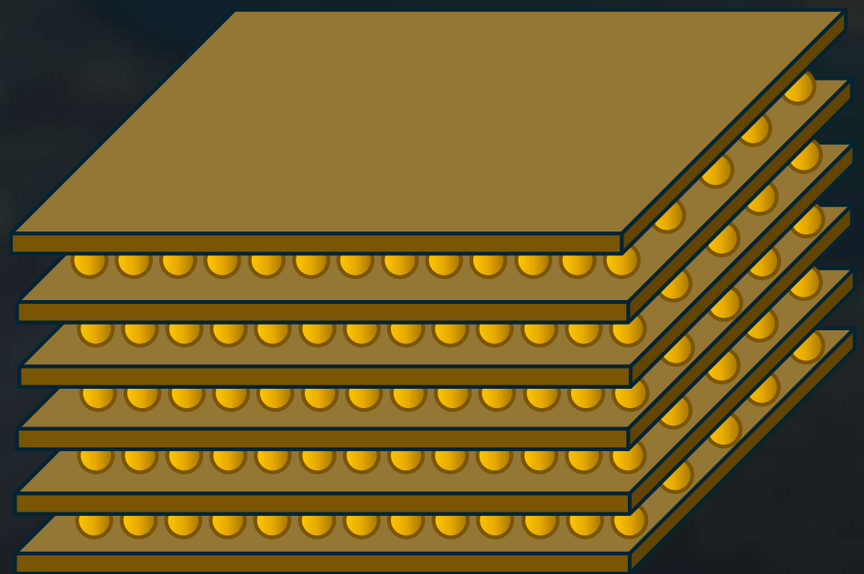
Reinterpretation of the Geological-Geotechnical Model





Dry clay

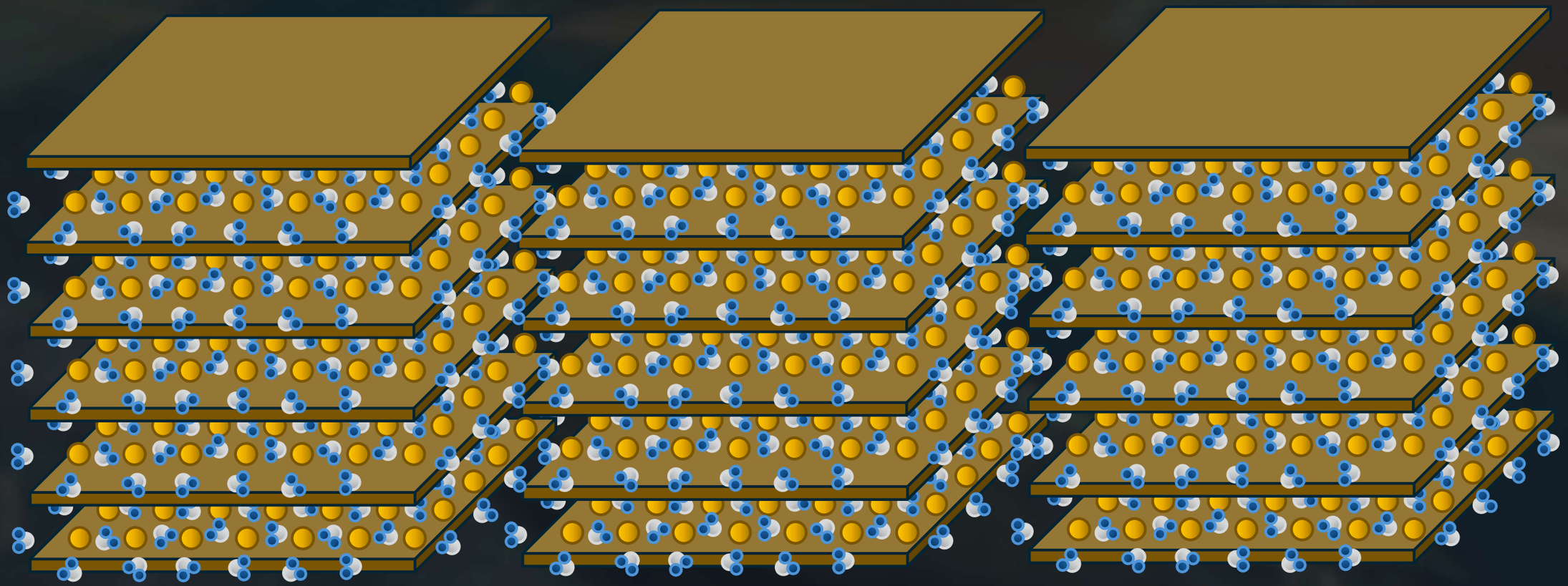
Reinterpretation of the Geological-Geotechnical Model



Dry clay

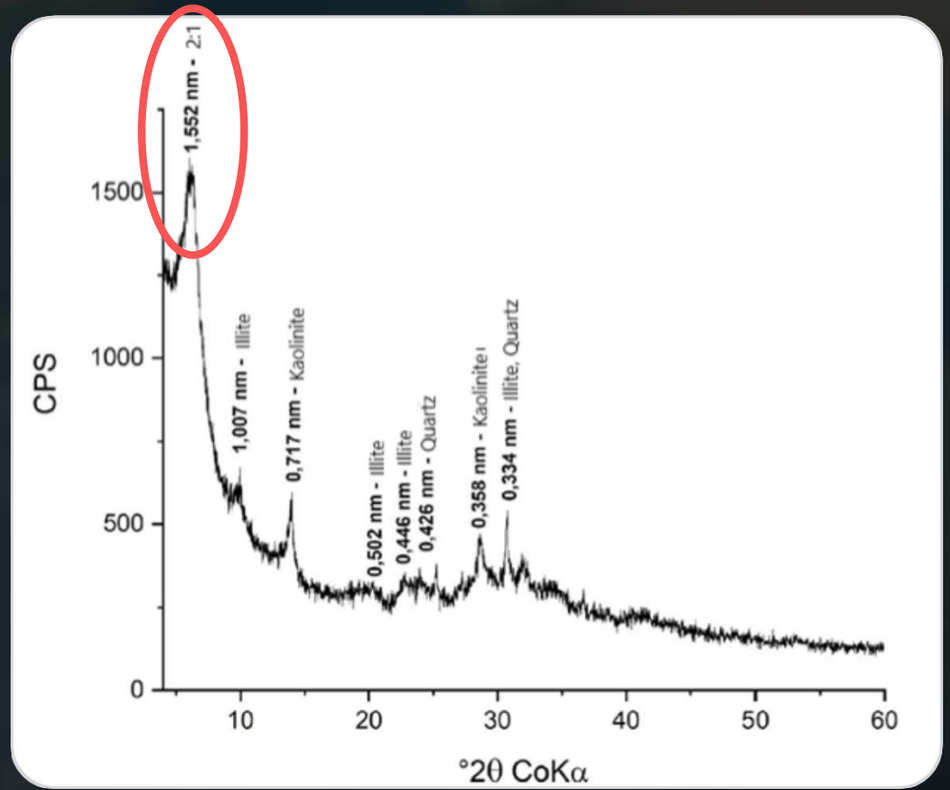
Water

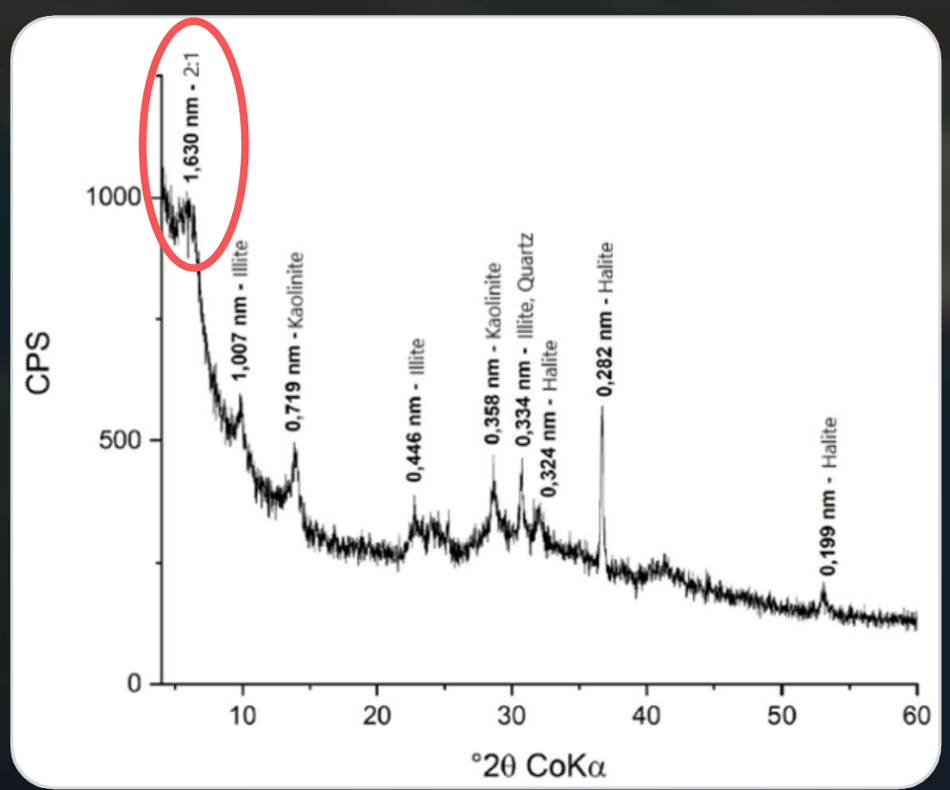
Reinterpretation of the Geological-Geotechnical Model



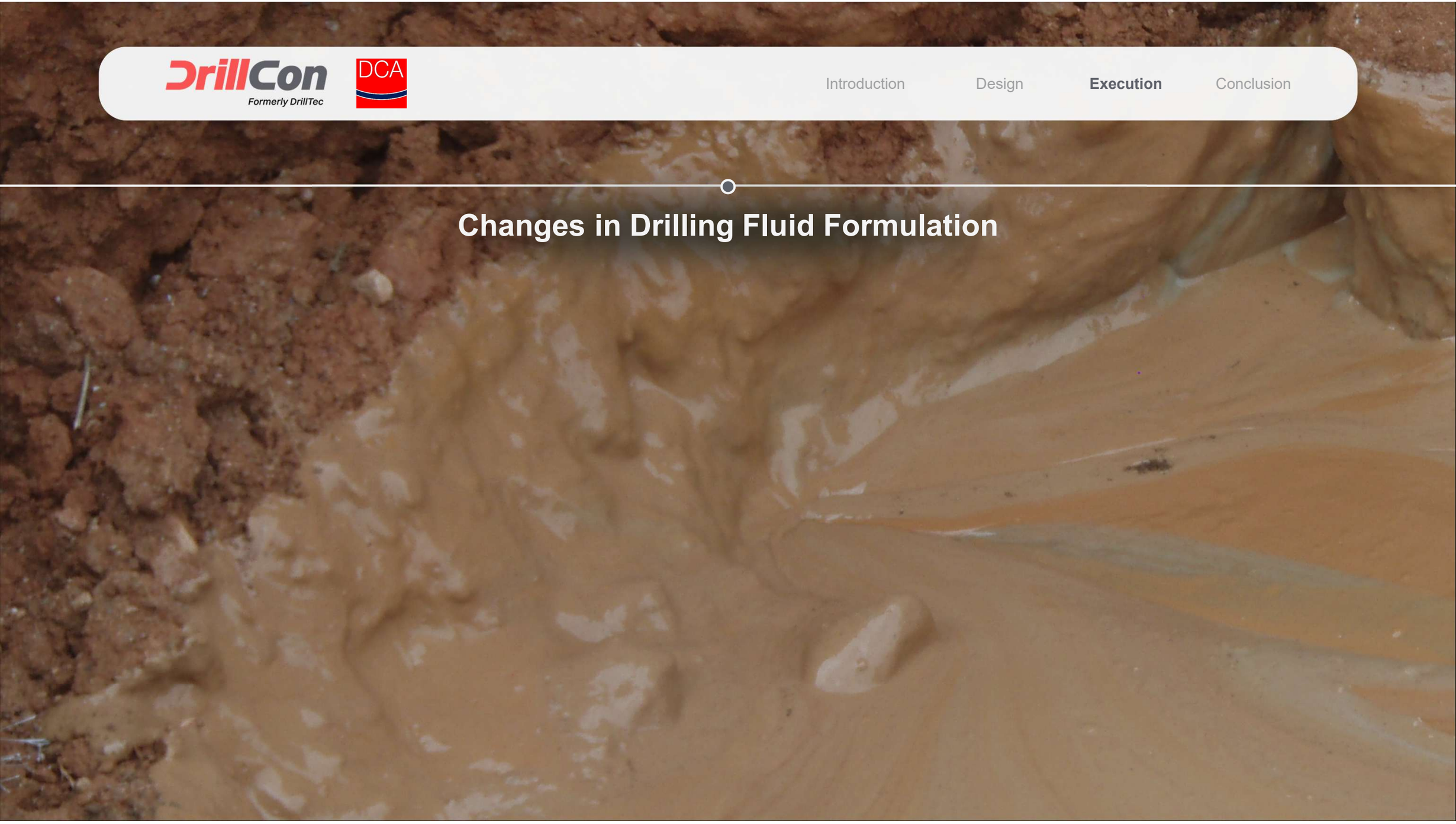
Reinterpretation of the Geological-Geotechnical Model

X-ray diffraction (XRD)





Changes in Drilling Fluid Formulation



Changes in Drilling Fluid Formulation

- Mineralogical diagnosis
- Bentonitic fluid intensified hydration and swelling
- Polymeric fluid with clay-inhibiting additives
- 2 days of continuous circulation from both sides
- Incorporation of clayey material
- Internal stresses were attenuated

Changes in Drilling Fluid Formulation

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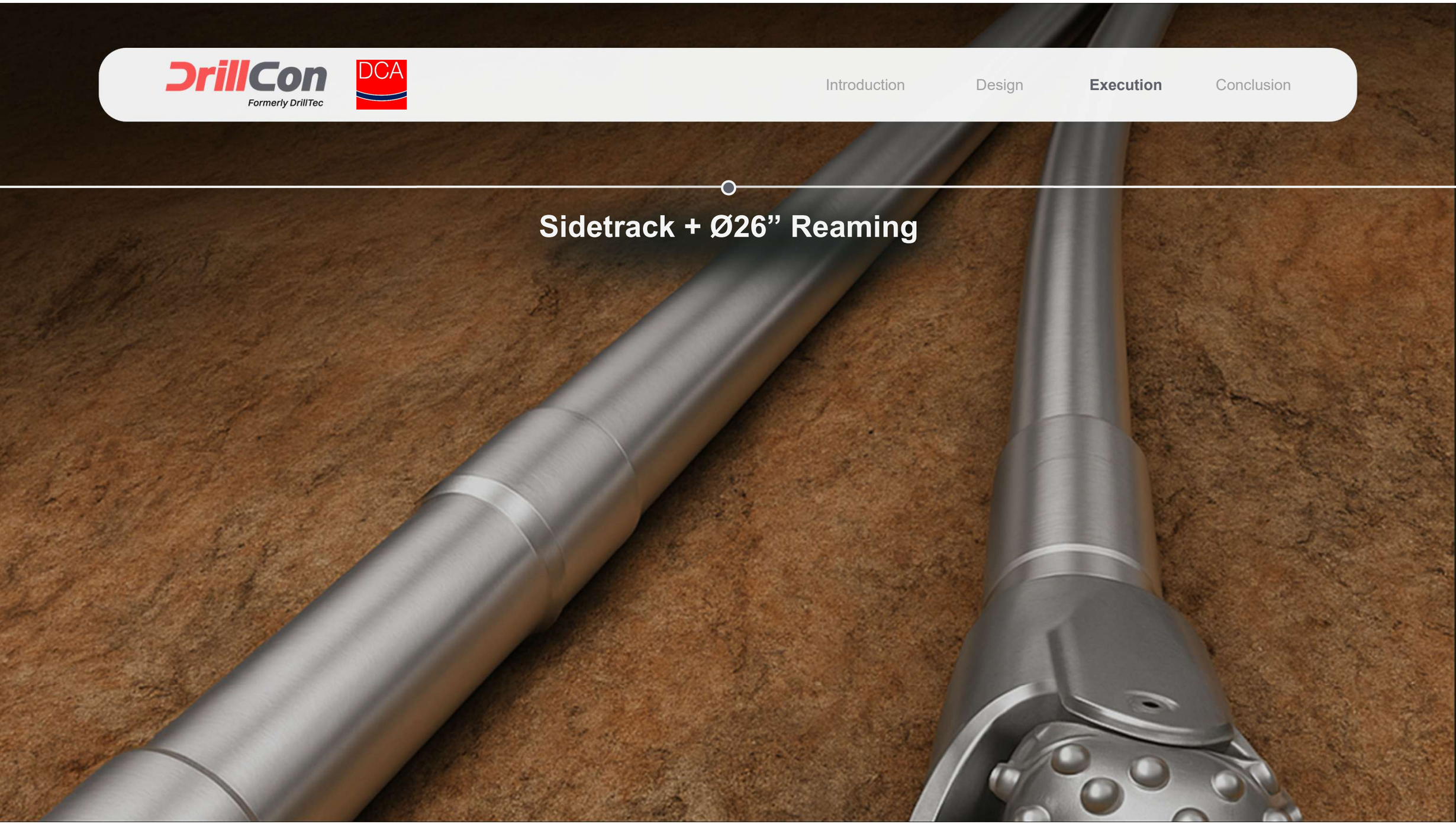
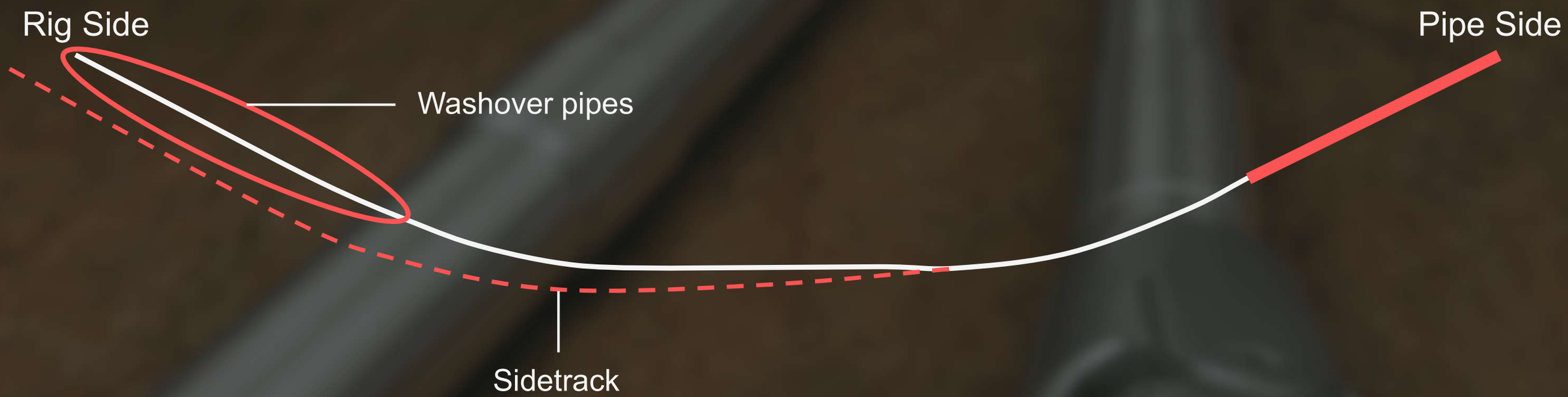
Release of the drill string and Ø26”

Sidetrack + Ø26” Reaming



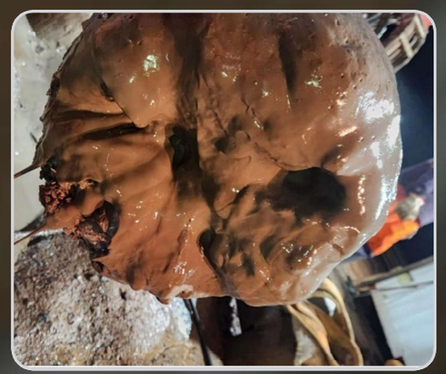
Sidetrack + Ø26” Reaming

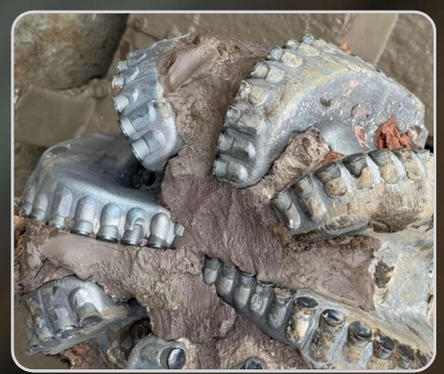


Sidetrack + Ø26” Reaming

Ø12 ¼” PDC bit

- Duration: 9 days
- Section Length: ~ 509 meters
- Total Length (MD): ~854 meters
- Avg. ROP: 5,70 m/h





Sidetrack + Ø26” Reaming

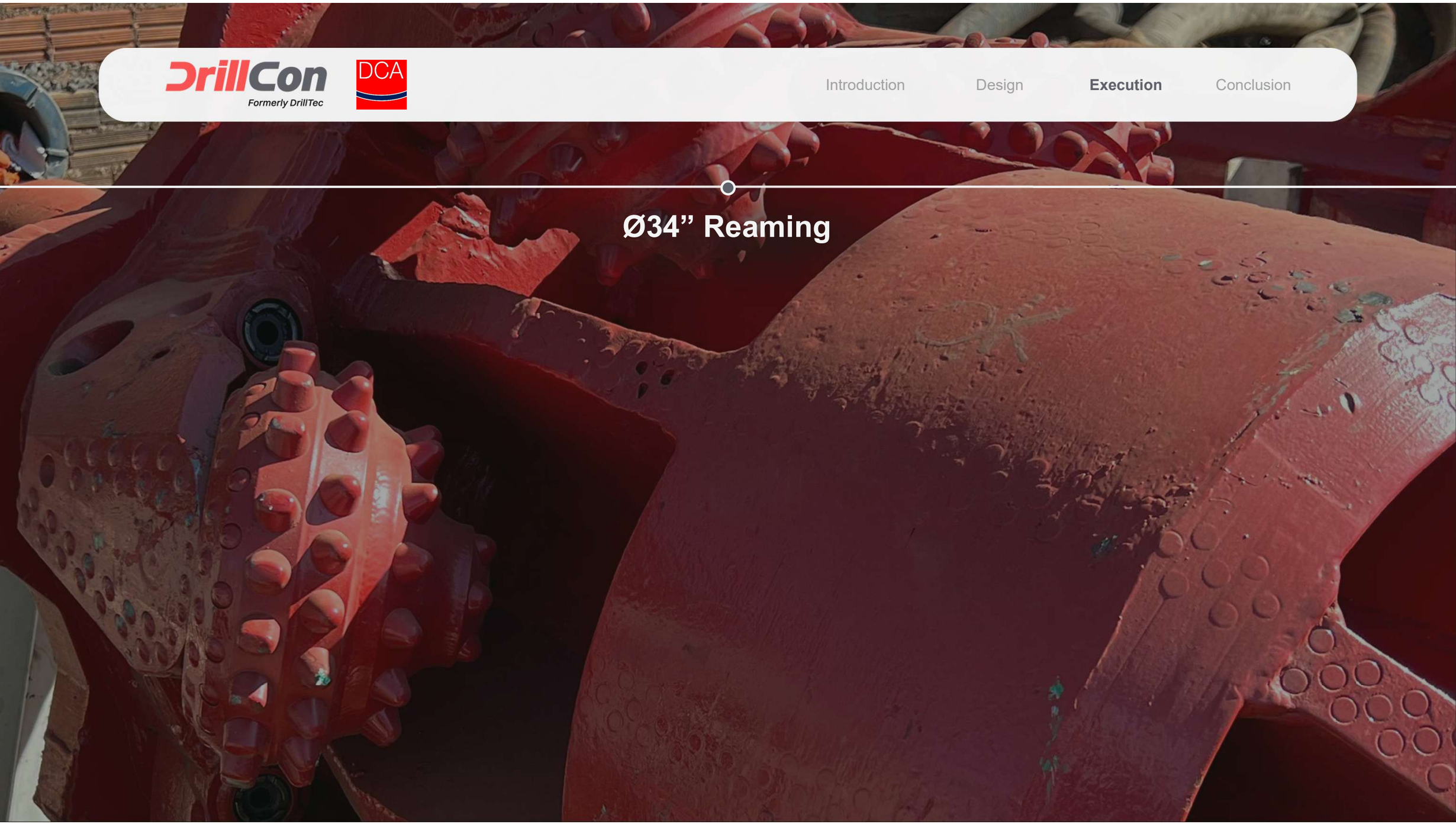
Sidetrack ✓

Ø26” Reaming ✓

Cleaning ✓

Pullback?

Ø34” Reaming



Ø34” Reaming

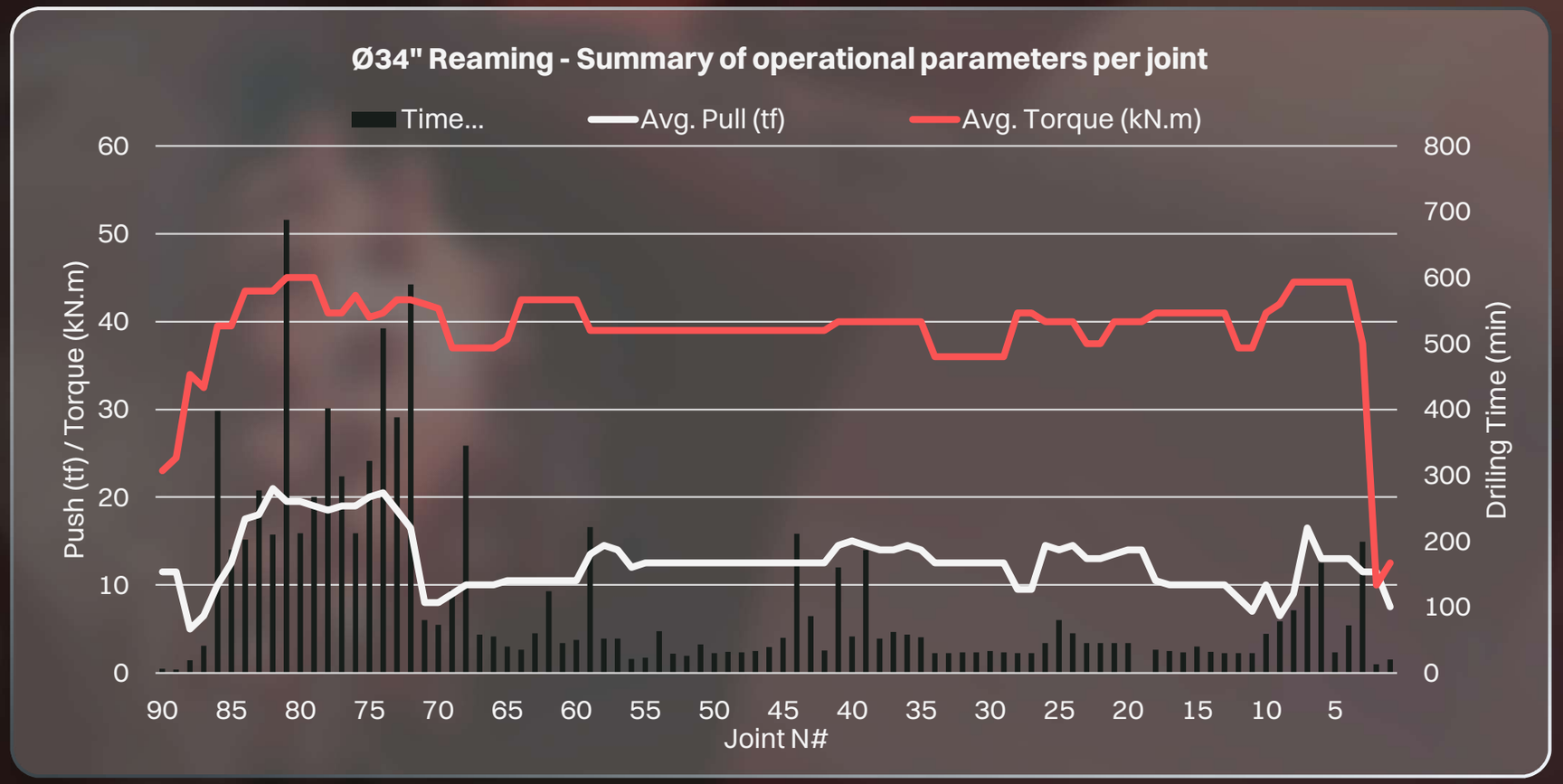
Ø20”

1.3x
Ø26”

1.6x
Ø32”

1.7x
Ø34”

Ø34” Reaming



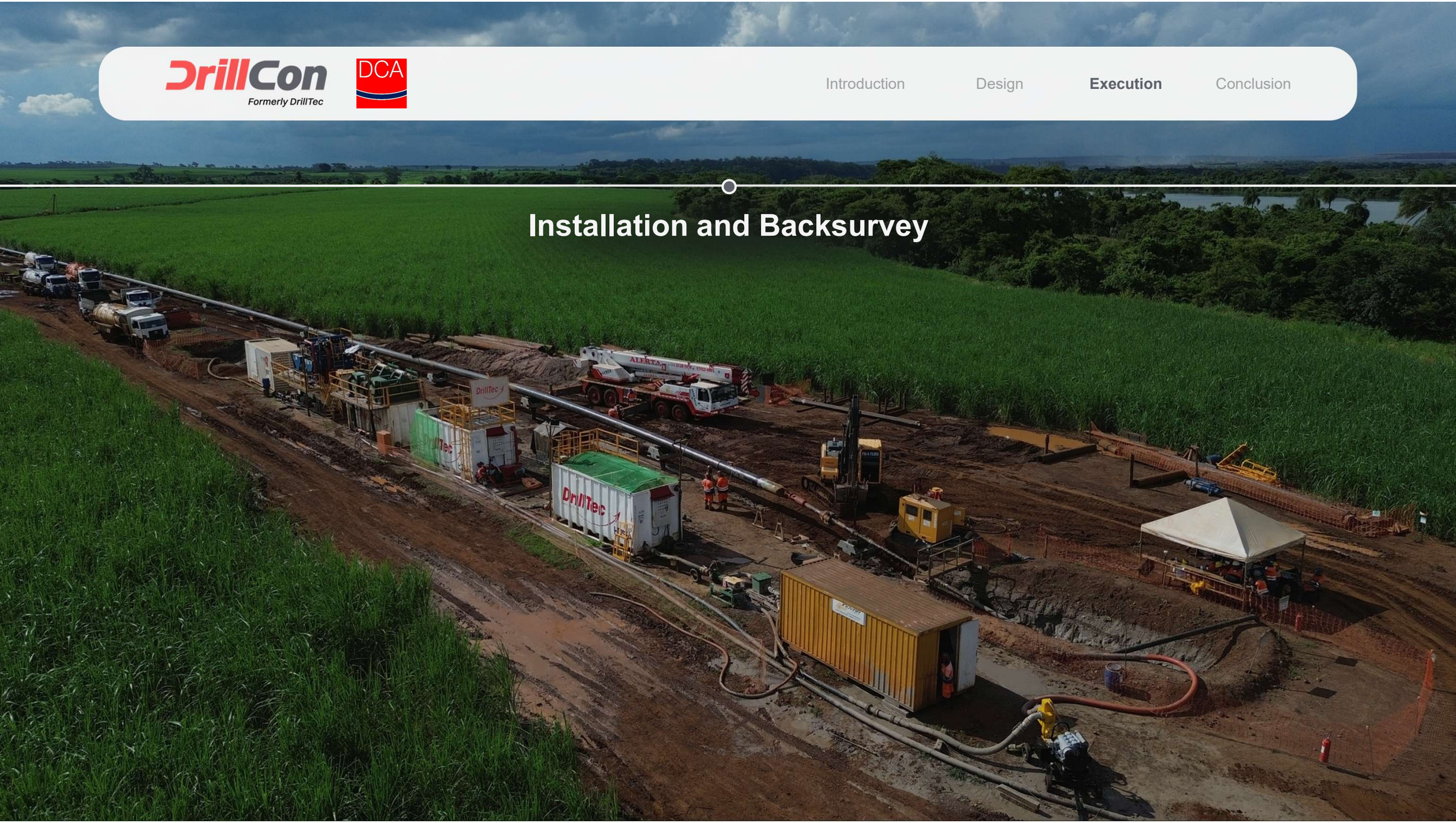
12 days

4.8-5.3 m/h

35-45 kN.m

10-15 tf

Installation and Backsurvey

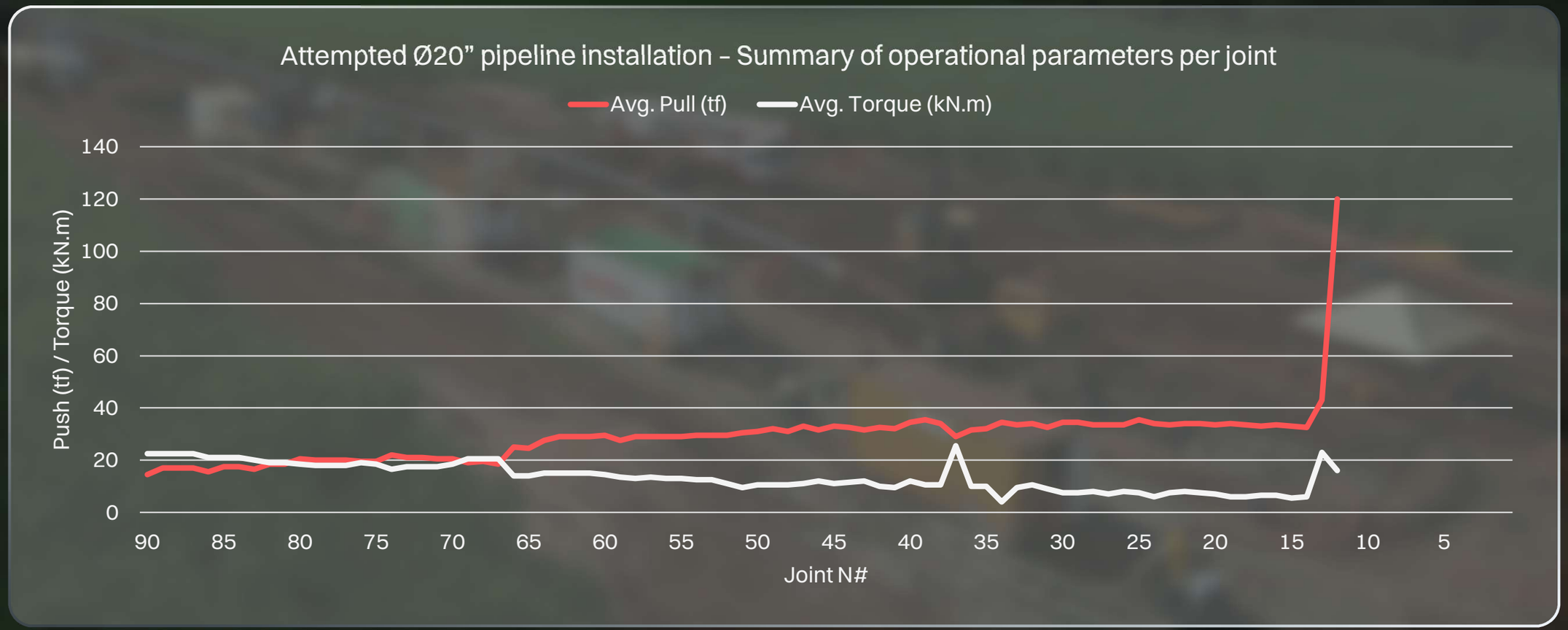


Installation and Backsurvey

Sidetrack ✓ Ø26” Reaming ✓ Cleaning ✓ Ø34” Reaming ✓ Cleaning ✓

Pullback?

Installation and Backsurvey



Installation and Backsurvey

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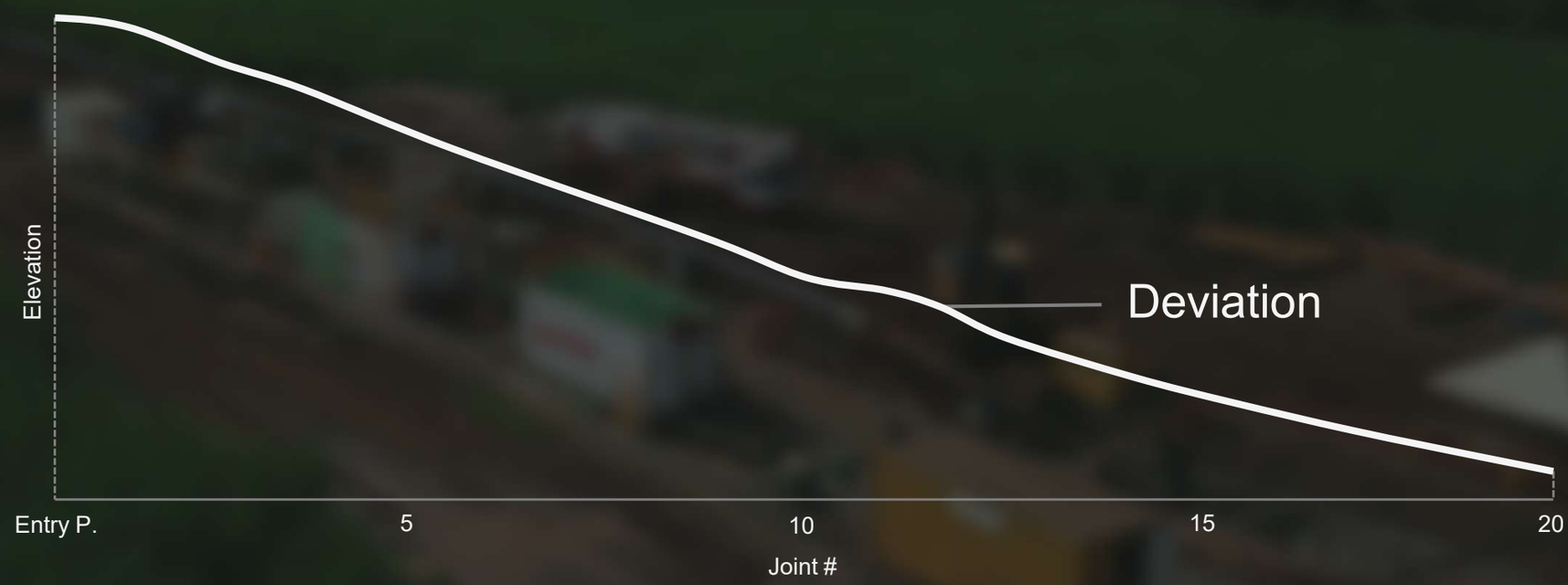
Installation and Backsurvey

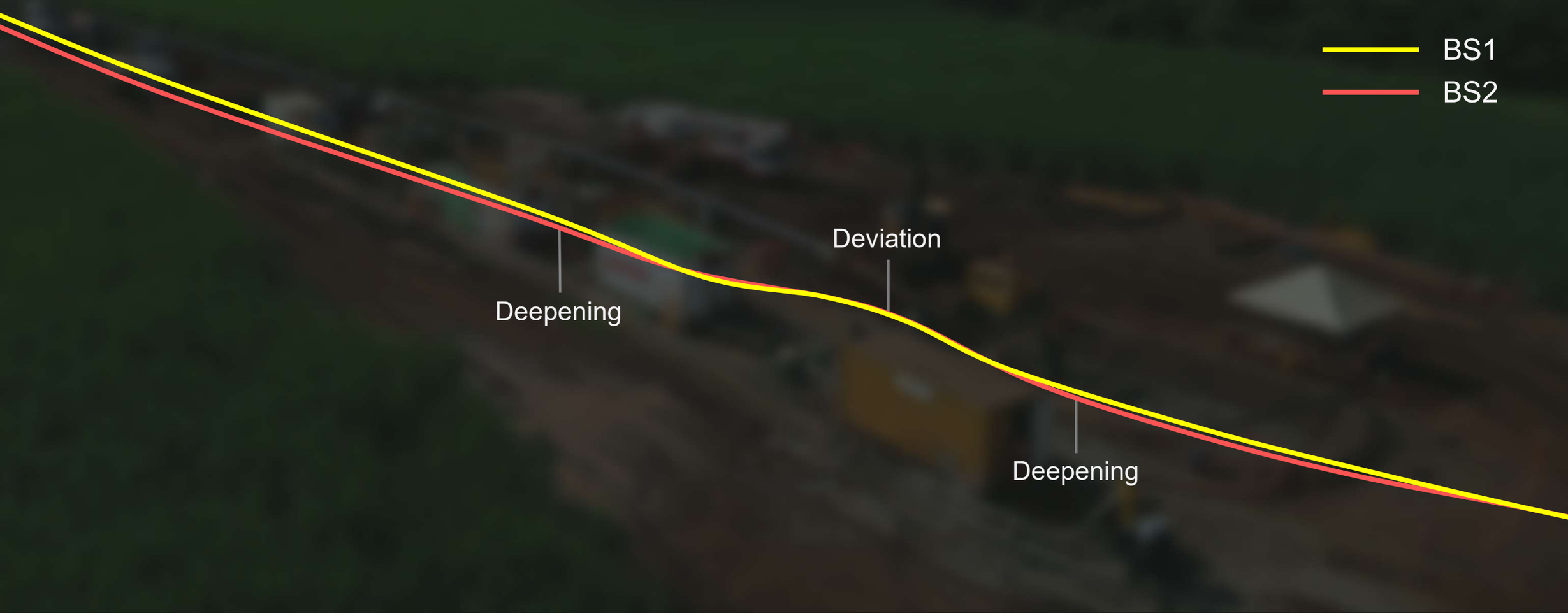


- Backsurvey ✓
- Cleaning ✓
- Dummy Run ✓

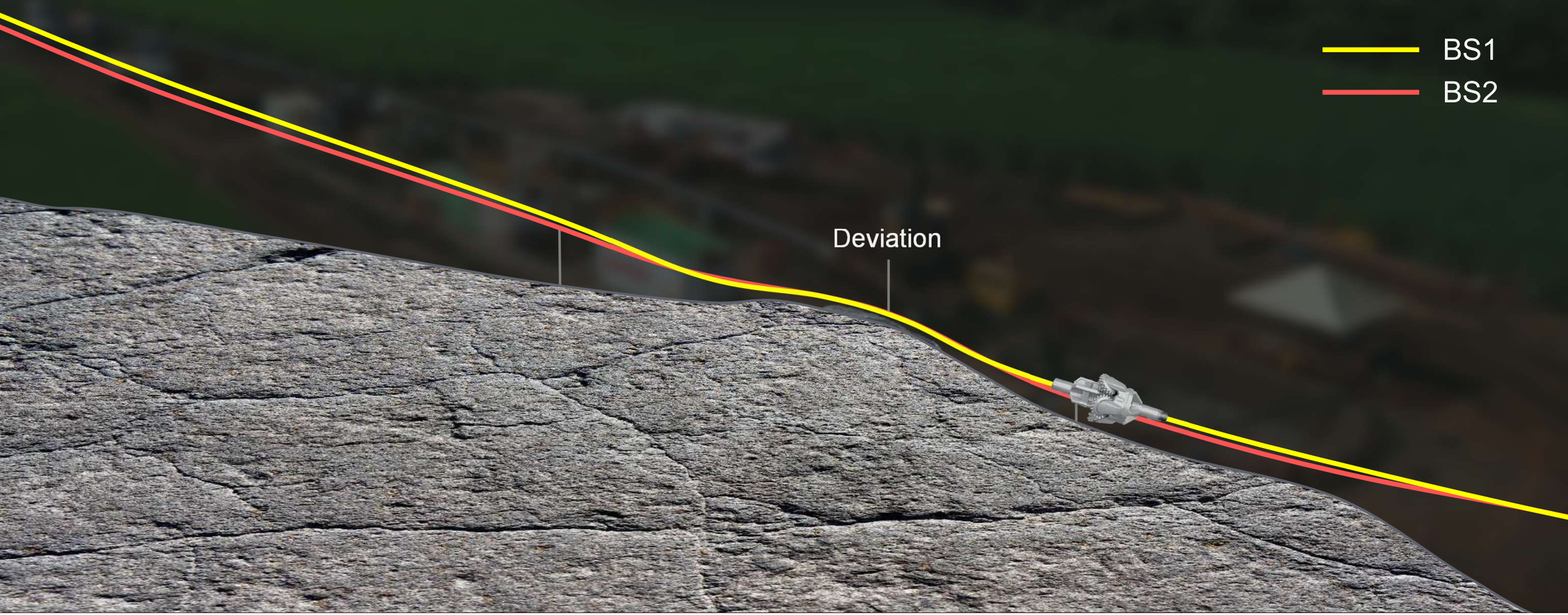
Installation and Backsurvey

Installation and Backsurvey

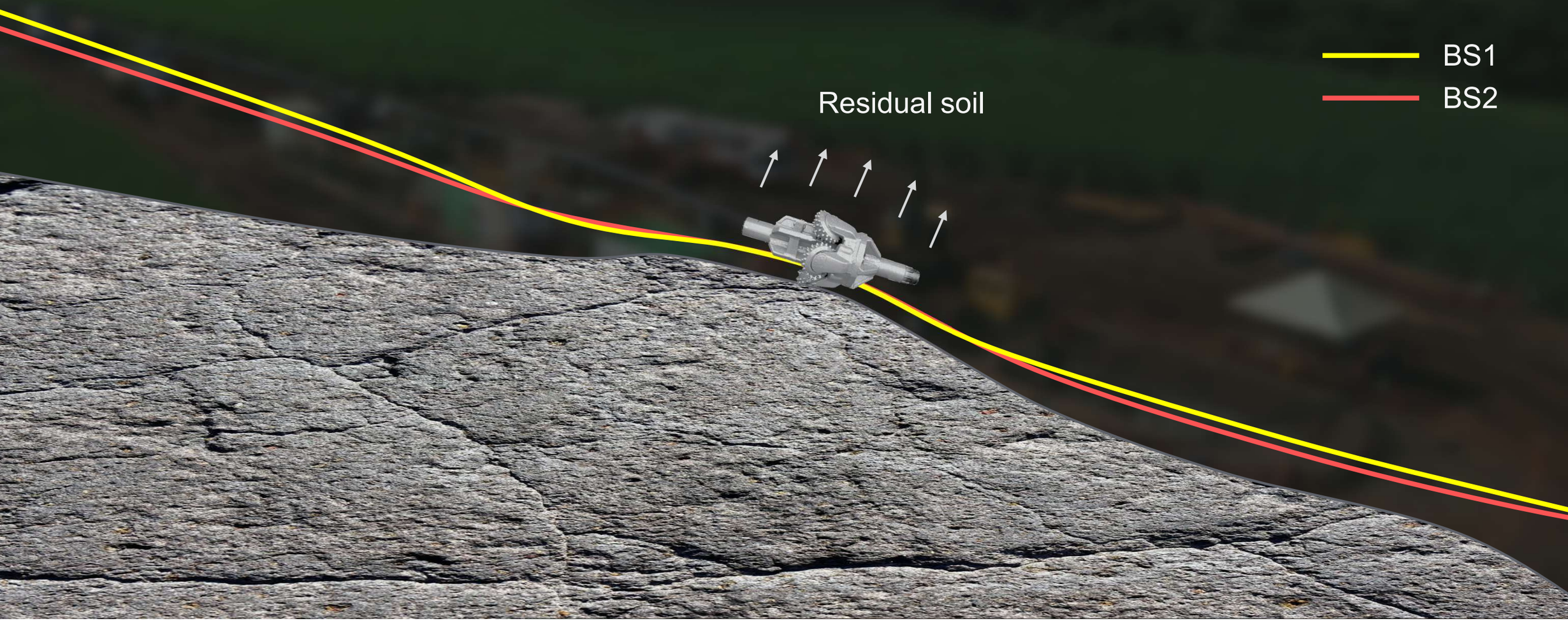
Installation and Backsurvey



Installation and Backsurvey



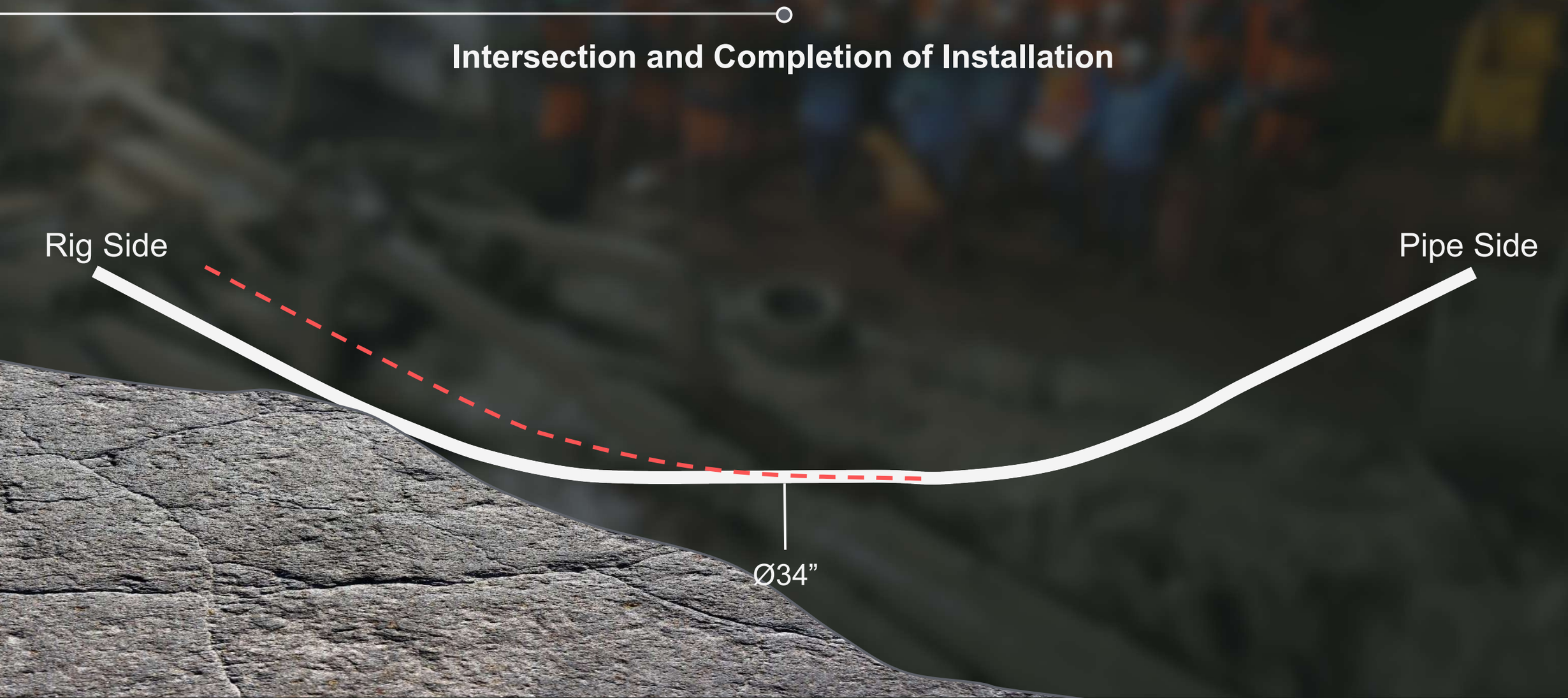
Installation and Backsurvey



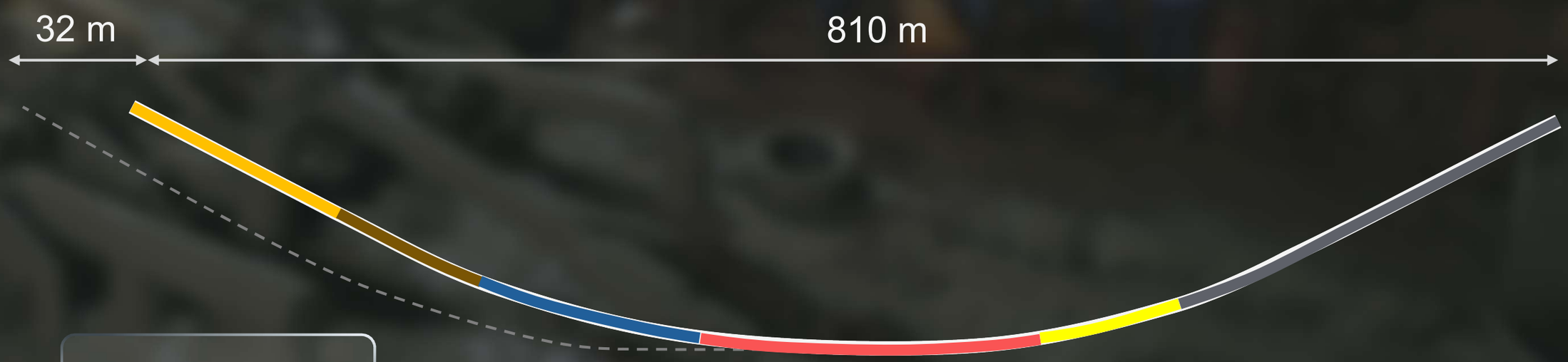
Intersection and Completion of Installation

Intersection and Completion of Installation

Intersection and Completion of Installation



Intersection and Completion of Installation

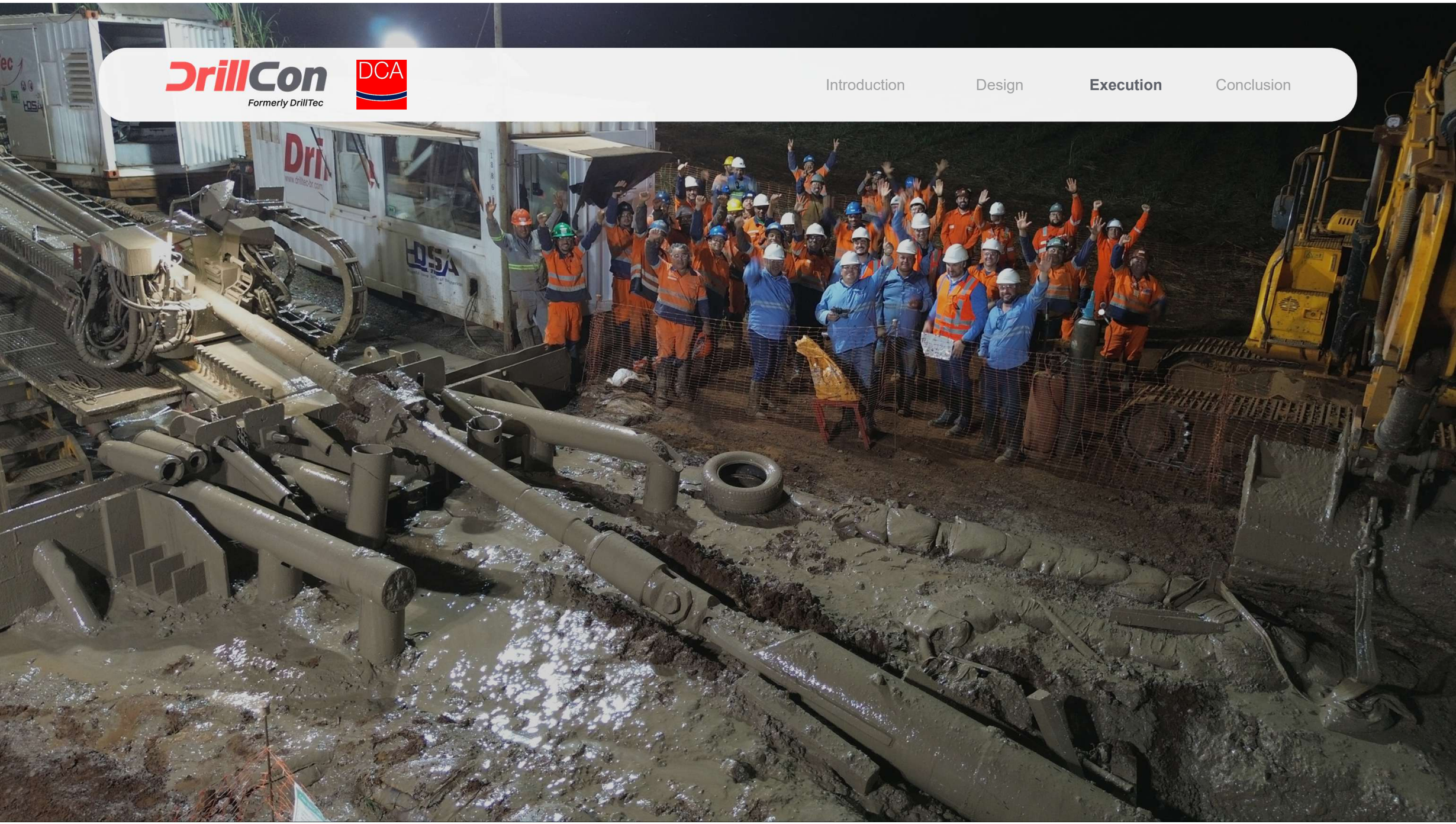


- Abrupt variations
- More pronounced

Intersection and Completion of Installation

Geometric pig → No wall loses or ovalizations beyond normative criteria

Current injection → Coating integrity guaranteed


Dri
HDSA

Conclusion

Entry pit large excavation to remove gravel

Continuous monitoring of drilling parameters

Washover

Additional equipment to combine releasing loads

Complete reanalysis of the geotechnical model

Additional laboratory tests

Polymeric fluid with clay-inhibiting additives

Sidetrack

Backsurvey

Dummy run

Intersection

Quality inspections

Subsurface of high geotechnical complexity

Unforeseen events even with comprehensive and detailed design

Limitations of geotechnical and geophysical investigations

Decisive engineering solutions to reestablish project feasibility

Operational structure for risk mitigation

“Knowledge is power.

“Knowledge is power. Knowledge shared is power multiplied.”

Robert Noyce