“Introduction to Drilling Geothermal Boreholes"

Brock Yordy – Global Drilling Trainer & SME

Proud Father, Husband &, 3rd Generation Driller
Water - Geothermal- Construction Drilling SME
Prof Experience – Baroid, Suez, Veolia
Drilling Workforce Development
DoL – IGSHPA – HEET
NYSERDA: Geothermal Drilling SME
HEET: Advisory Board Member
Co-Founder Geothermal Drillers Association
Owner Developed Well Group
Drilling Programs, Consulting, & Training

WARNING

The following presentation features tribal drilling knowledge acquired by drilling professionals or under the supervision of geothermal professionals. Accordingly, Brock Yordy must insist that everyone who engages with this presentation consider the following advice.

Applying Tribal Knowledge to Engineered Specifications

1. Drilling is the imperfect combination of science, physics, and self-taught tribal knowledge compounded over years of success and failure.
2. Drilling is a disruptive process; the key to success lies in your conscious choice of the drilling program that minimizes the impact on the surrounding environment.
3. Drillers, Contractors, Engineers, Scientists, and Clients have entered a powerful partnership to uncover the mysteries of the subsurface.

The Drilling System.
Defining the Subsurface Conditions

Geology	Formation Hydraulics	Depth to Water	Subsurface Challenges

Drilling Capabilities

Rig capabilities

- Horsepower – Depth
- Rotation – Bit Selection
- Pulldown – Force – Angle
- Pullback – Depth – Tool Assembly
- Diameter – Depth – Angle

Drilling Methods

- Mud Pumps
- Air Compressor
- Sonic
- Dual Rotary
- Reverse Circulation

Drilling Contractor Qualifications

Special Tools

Special Methods

Applied Science & Fundamentals

The Drill Crew – Critical System Operation

- Safety First
- Goal for the day
- Quality Installations
- Site & Environment Management
- Goal for project completion
- Preparation & Planning
  - Foreseen Issues
  - Unforeseen Issues

Roles & Responsibilities

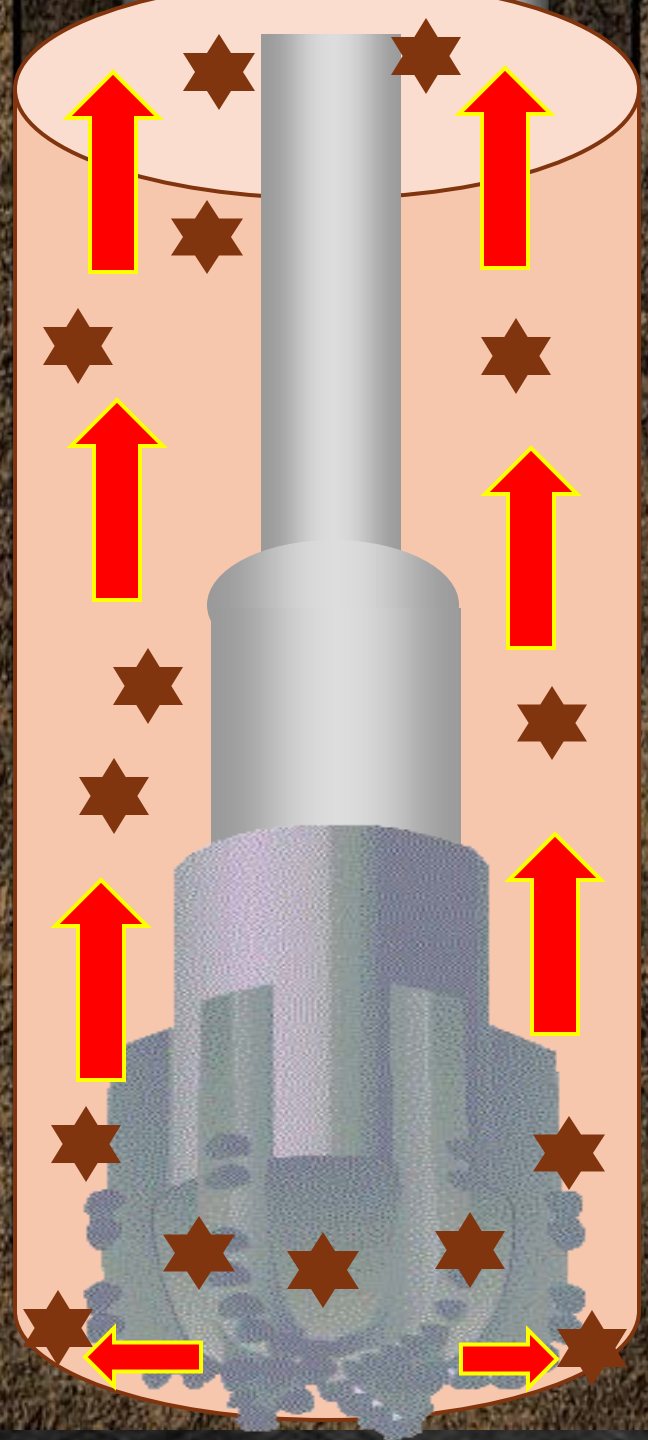
Driller: Rig Operation, Product Installation, Resource Extraction, Project Completion, & Record Keeping.

Assistant Driller: Rig Support, Tool Handling, Product Assembly, Product Installation, & Project Wrap-Up.

Field Technician: Solids Control Management, Tooling Layout, Product Layout, Product Assembly, Product Installation, & Clean Up

Borehole Creation

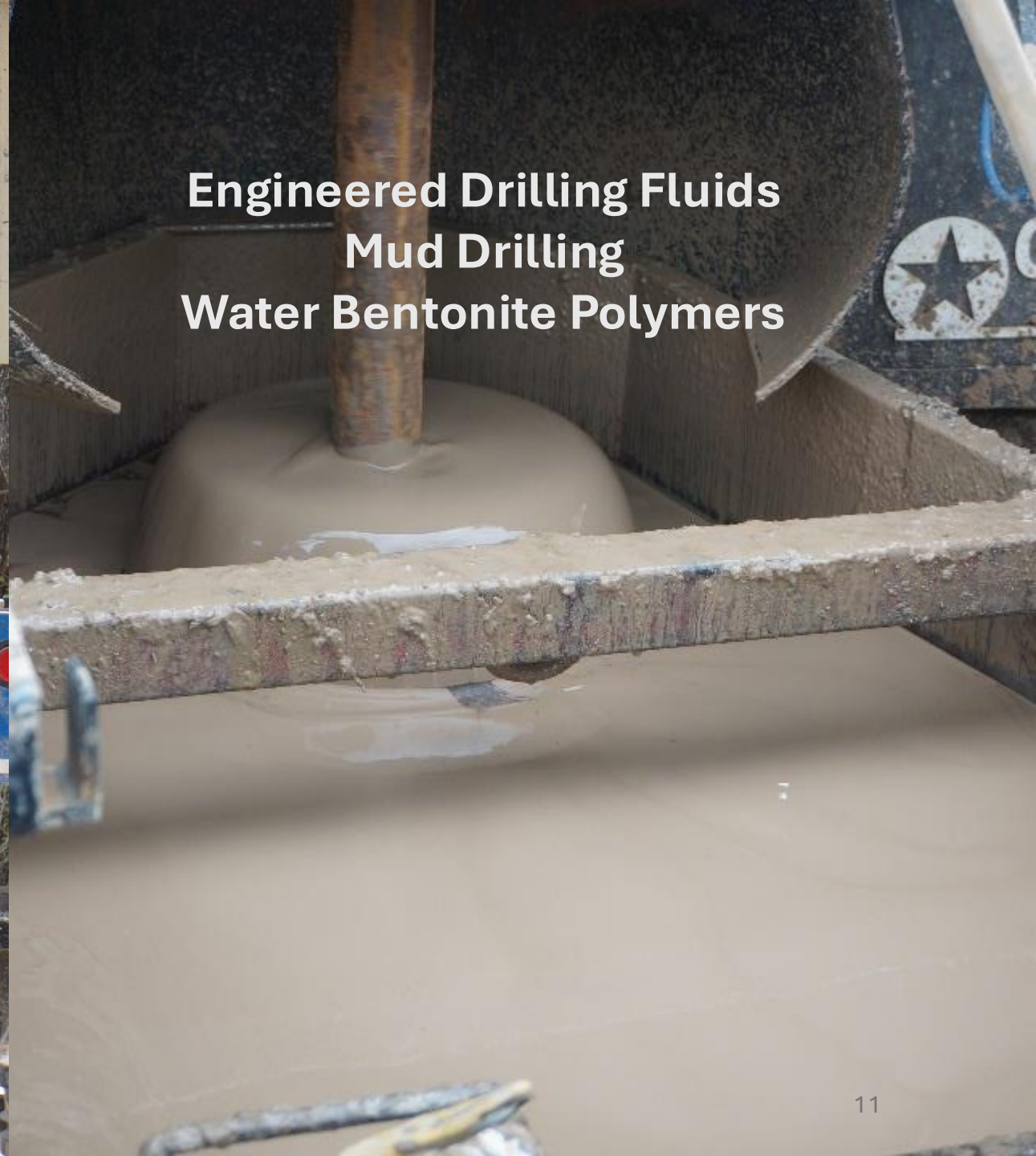
1. Pressure + Cutting Force
    a) Rotation
    b) Percussion
    c) Velocity
    d) Frequency
2. Cuttings Removal
    a) Mechanical
    b) Flushing
        i. Water
        ii. Air
        iii. Drilling Fluids



Direct Air Rotary

Conventional Mud Rotary


Engineered Drilling
Fluids
Air Drilling
Siff Foam


Engineered Drilling Fluids
Mud Drilling
Water Bentonite Polymers

Target Up Hole Velocity

MUD Drilling

Water-Based Drilling Fluids

60 to 150 feet per minute

Direct Air Drilling

3,500 to 7,500 feet per minute

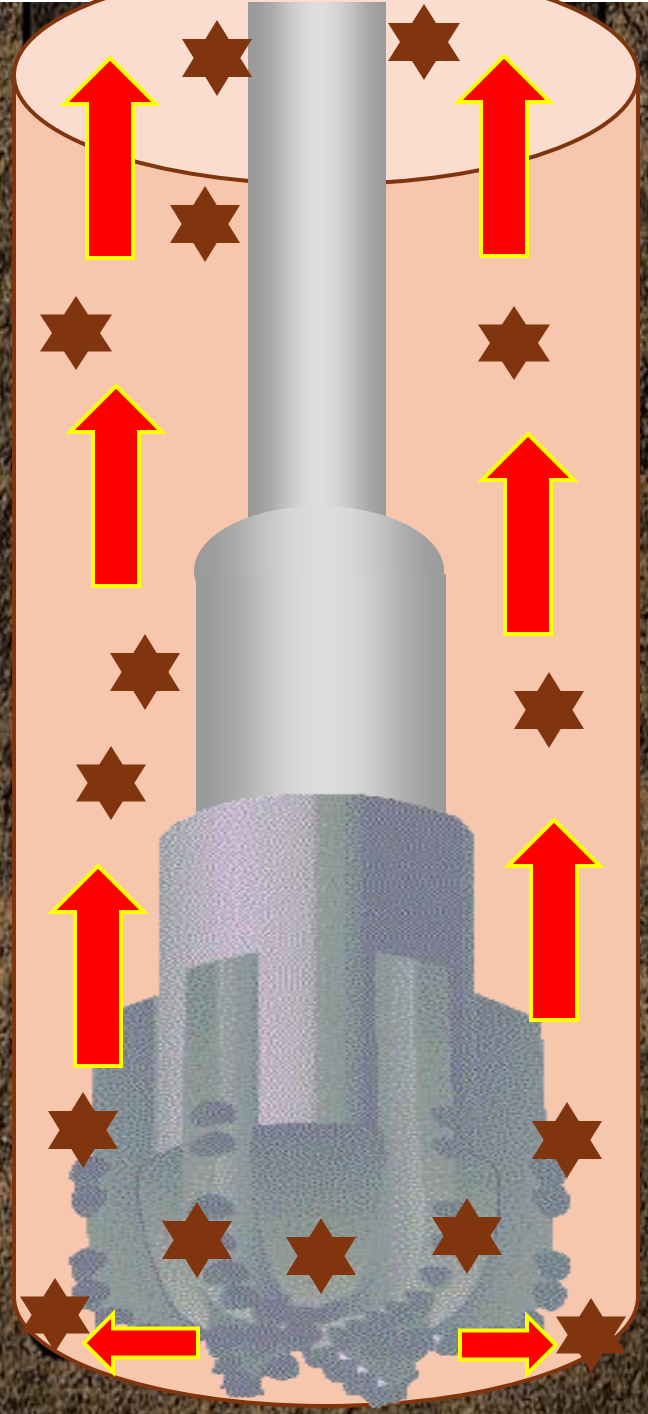
Air Foam Drilling

Water + air + foaming agent = foam

200 feet per minute

Engineered Fluid Solutions

100 feet per minute



Drilling Program Objectives

- **Efficient Rate of Penetration:** Matching Ideal Drilling System with geologic conditions.
- **Minimal Impact**: The Borehole has minimal impact or influence on the surrounding environment, both subsurface and surface.
  - Fragile Subsurface Formations.
  - Water Production: Fresh, Brackish, Salt Water
  - Volatile Gas: CO^2, H^2S, Methane
  - Dust, Noise, Drill Cuttings
- **Data Gathering**: Realtime analysis of subsurface information: changes in geology, subsurface challenges, loss zones.

Discovering the unknown together!

Results of Proper Borehole Creation

- **Open**: Borehole free of drilling cuttings and solids from surface to bottom.
- **Gauge**: The hole diameter maintained within the specified diameter and direction from surface to total depth. Diameter within 2/32nd of the bit diameter.
- **Stable**: Borehole integrity is free from swelling or collapse while tooling is out of the hole.
- **Straight**: Drilled to the desired direction or angle specifications
- **Seamless Product Installation**
  - Loop to Bottom
  - Annular Seal to Top
- **Efficient Resource Extraction**

Drilling Cuttings
Drill Solids
Spoils
Results of Borehole Creation

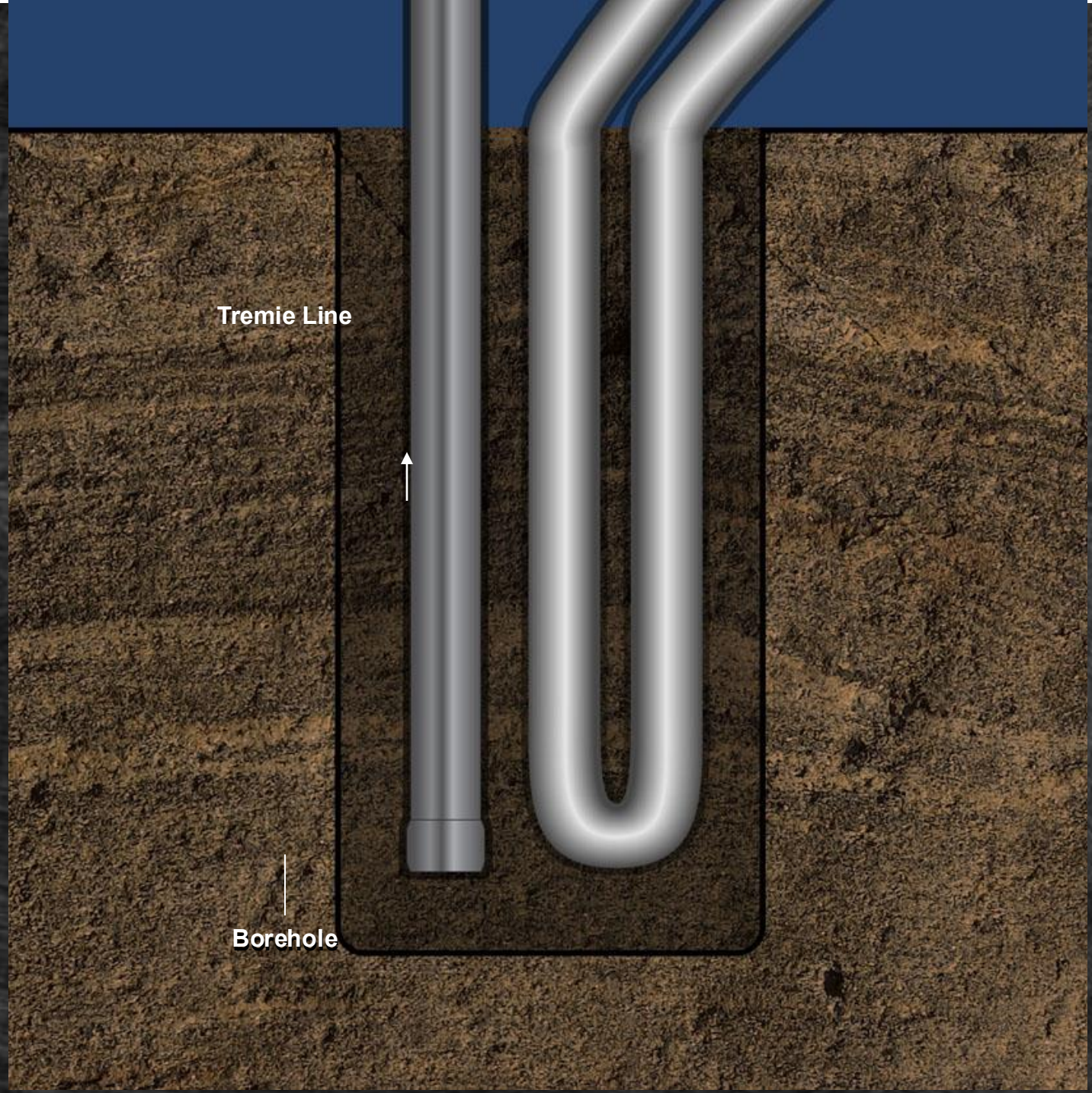
6” x 400’ = 2.9 CY

6” x 850’ = 6.17 CY

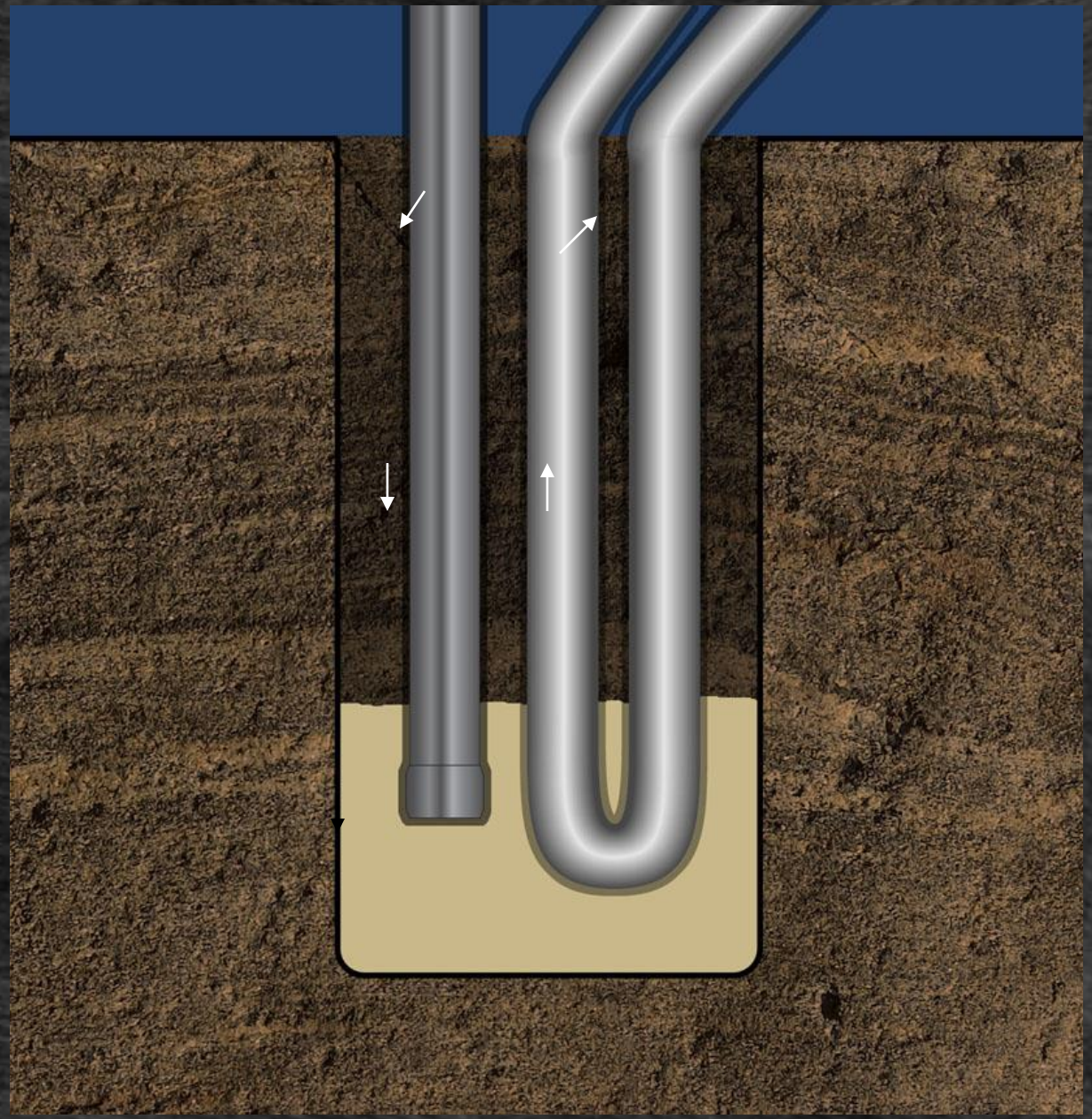
Dump truck = 10 CY

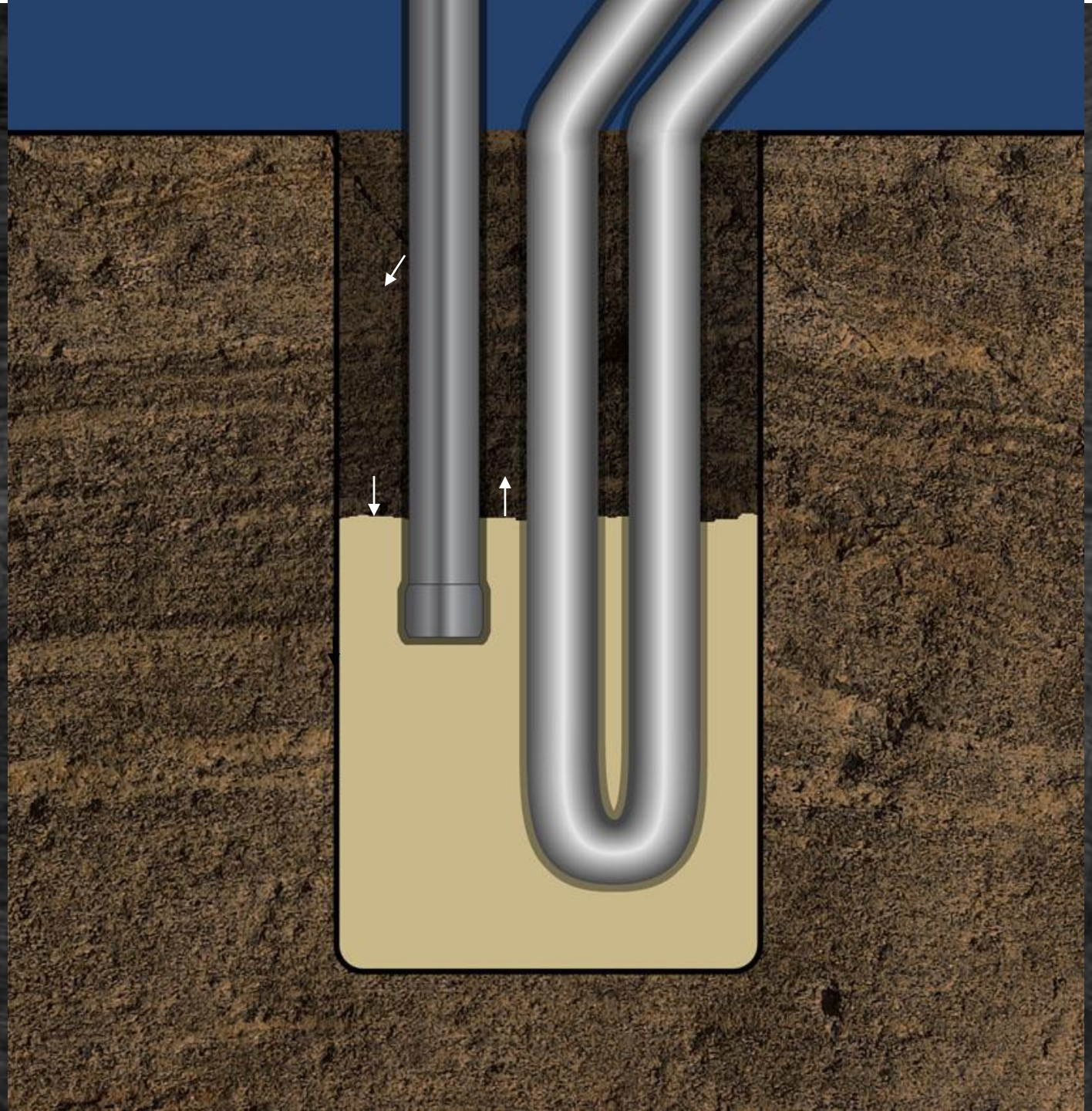
Loop Specifications
1.25 - 1.5 HDPE U-Bends or Alternative Engineered Designs

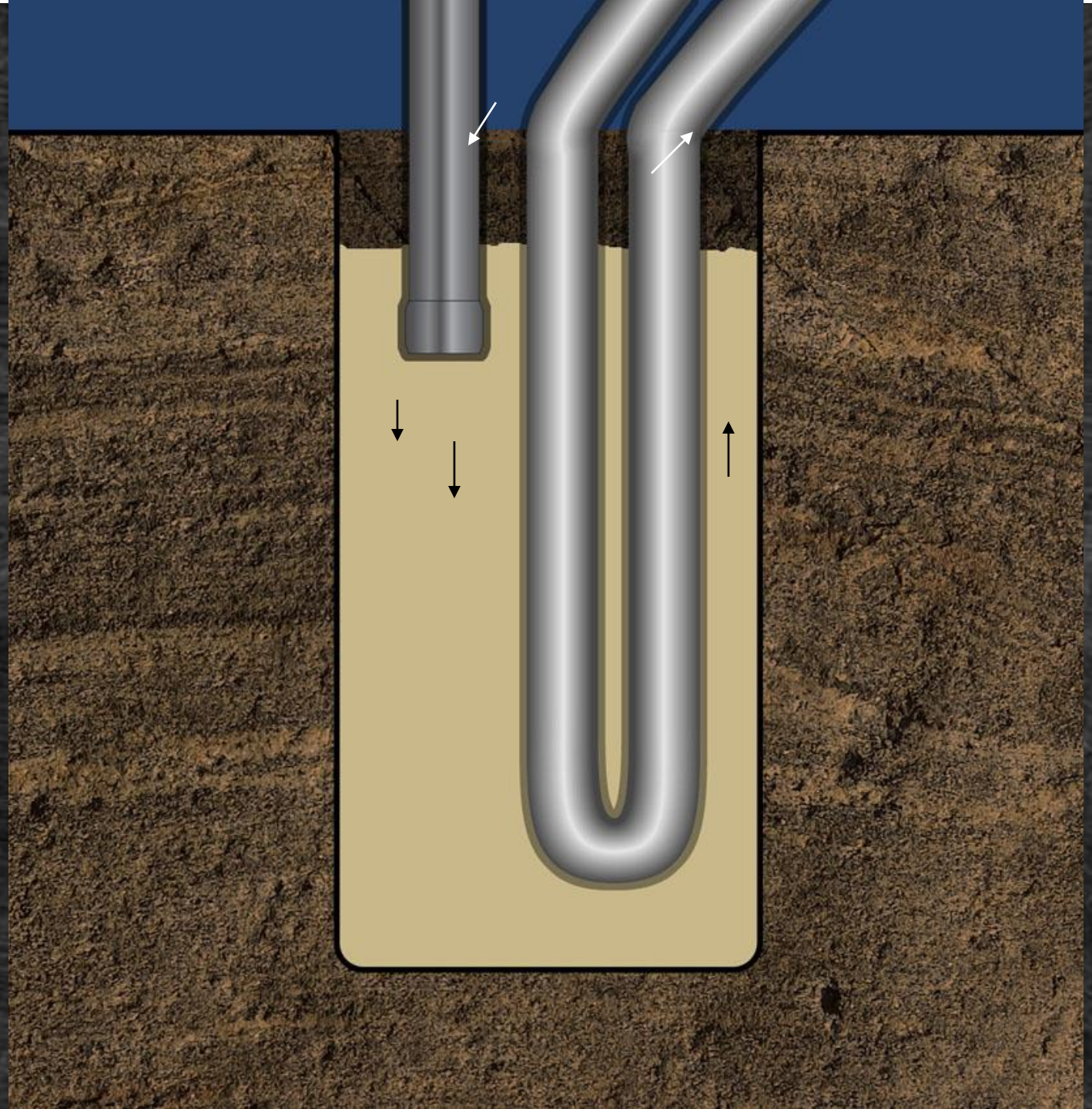
The Grouting Process


Tremie Line
Borehole


500/200
V-140X
Grout Pump Auto
Grout Pump Manual
DANGER
Geo-Loop Inc. Aurelia, Iowa
712-434-2125
TGLite
GeoPro-Tech







Grouting Geothermal Boreholes

- To replace the Native Material with a media that meets or exceeds the sealing qualities of the native formation.
- To ensure continuous contact between the loop and borehole annulus.
- To completely seal the annular space
  - **Prevent Commingling of Aquifers**
  - **Prevents Surface Contamination**
- To comply with Federal, State, and Local Well Construction Codes
- To meet engineered specifications
  - Thermal conductivity
  - Borefield Integrity

Life Cycle of a Borefield

BOREHOLE DESIGN

SUBSURFACE CONDITIONS

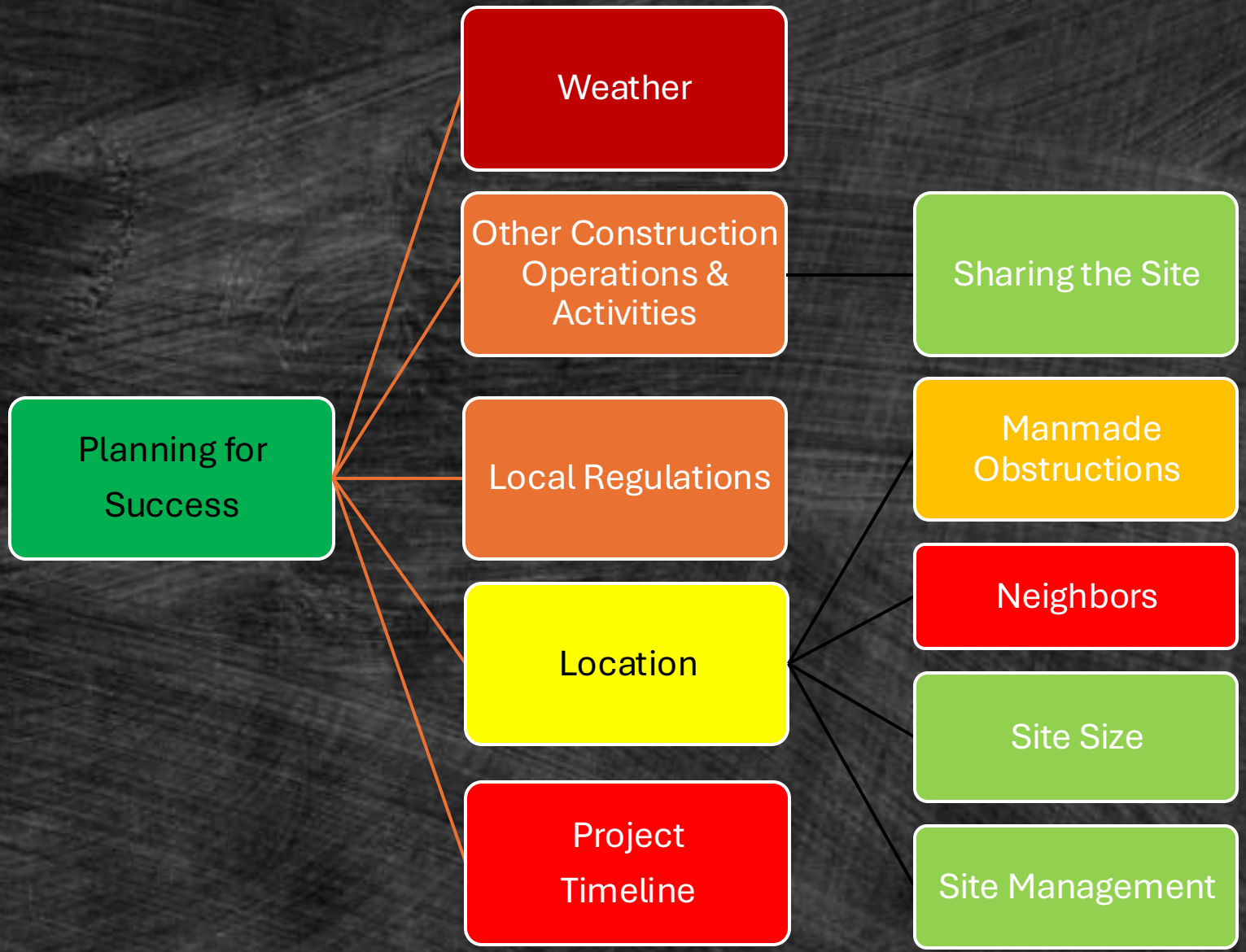
METHOD OF DRILLING

INCORPORATION OF DRILL SOLIDS

METHOD OF SOLIDS CONTROL & SITE MANAGEMENT

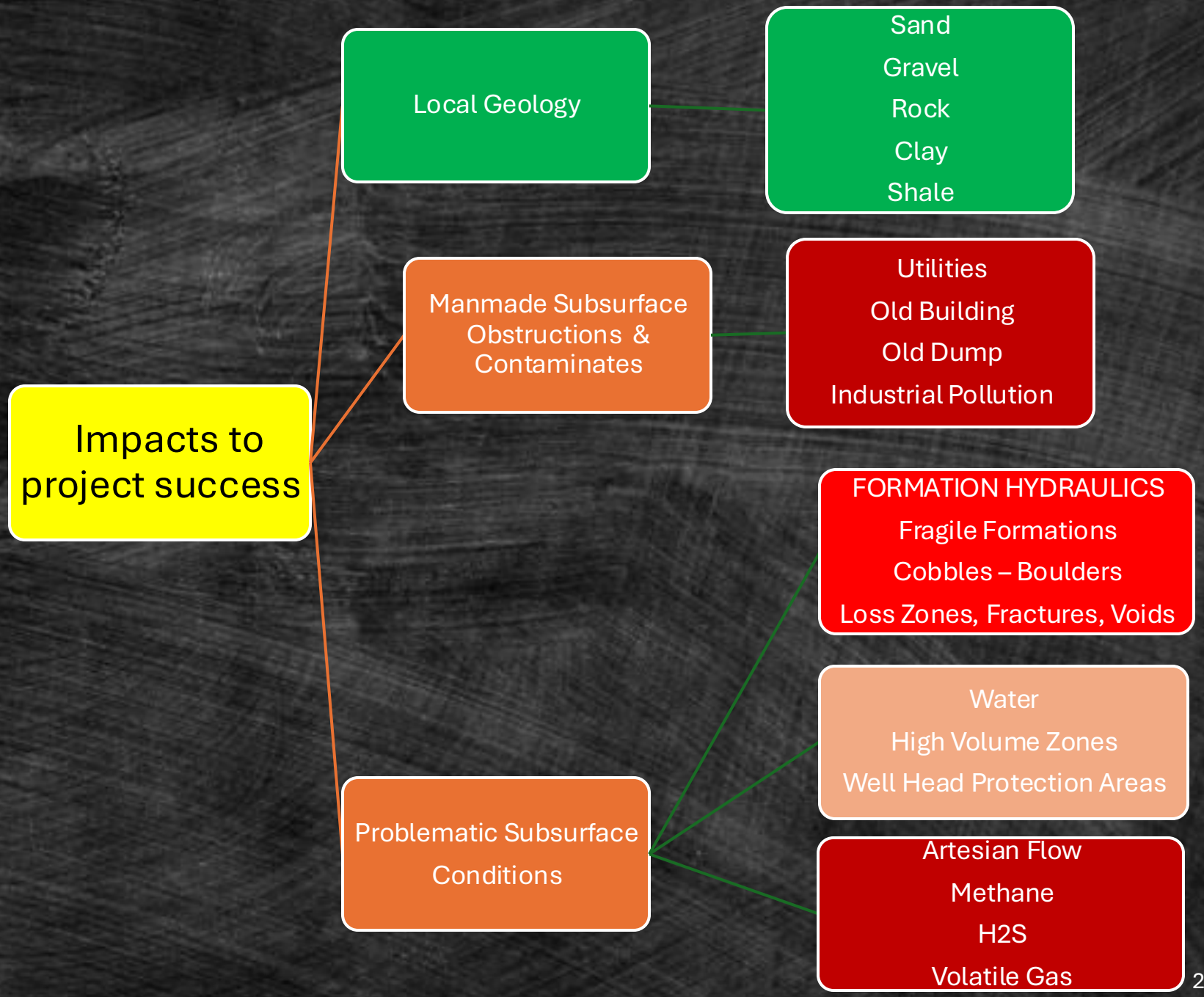
DISPOSAL & SITE RESTORATION

Drilling Project Management



The Reality of Success

Drilling Program Management



Contractor Qualifications

- Equipment
  - Availability
  - Tooling
  - Drilling Method
- Compatibility Location
  - Geology
  - Site Footprint
  - Environmental Demands
  - Site Management
- Project Timeline
- Borehole Design
  - Diameter
  - Loop Type
  - Grout
- Project Restoration, Clean up and Disposal
- Workforce
  - License Qualifications, State Drilling License, IGSHPA
  - Safety Certifications
  - Insurance Standards
  - Quality Installations

Surgical Execution

Lessons Learned

Regardless of the geographic location or geologic conditions, a competent drilling company will approach a project with the following objective:

To safely complete the project with the best drilling methods, equipment, and tooling available while minimizing risk to the company and client.

Every project has the opportunity for a more optimized drilling method, equipment, or tools to increase productivity. Often, equipment availability and cost supersede maximizing drilling efficacy.

Lessons Learned in the Past 22 Years

- Trust in the Qualified Contractors
- Specified Drilling Method & Driller Recommendation
- Test Holes & Representative Samples
- Test Holes vs Test Wells
  - What we can learn from the municipal water well approach.
- Bore Fields & Bore Hole Specifications
  - Early 2000s to Today
- Equipment Capabilities & Limitations
- Loop & Grout Installation shallow to deep.

Thanks

- Brock Yordy
- Co-Founder The Geothermal Drillers Association
- Geothermal Drilling SME, Educator, Trainer, and Journalist

THE DRILLER Newscast

GDA GEOTHERMAL DRILLERS ASSOCIATION

MIT OpenCourseWare
https://ocw.mit.edu/

RES.ENV 007 Geothermal Energy Networks (GENs): Transforming our Thermal Energy System

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