Horizontal Directional Drilling for Water Supply Applications

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History of Horizontal Water Wells

- **Horizontal/Directional Oil Wells in the 1930s – Present**
- **Directional "River Crossings" in the 1970s**
- **Environmental Applications for the Department of Energy in 1988**
- **Utilized for Most Remediation Applications by 2018**
- **Water Well Applications**
  - **"Raney Collector Wells"**
  - **Hillside wells**
  - **Horizontal Directional Installations**

Applications/Advantages of Horizontal Wells

Allows screen placement in areas unreachable for traditional vertical wells

- **Target thin aquifers**
- **Screens can cross fractures/bedding planes**
- **Screen can be placed under surface water bodies**
- **Well heads are not directly above the screen. Can place screens directly under surface locations which are inaccessible to drilling equipment.**

Directional Control/Steering

- The drill string is steered by pushing the drill pipe against an asymmetric bit with a hydraulic jet; “duck bill” or bent sub
- The force against the bit or sub forces the drill pipe in direction of the bit orientation
- When the entire assembly is rotated, the drill string goes straight
- A sensor behind the bit sends the direction/orientation of the bit to the surface

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Directional Control/Steering

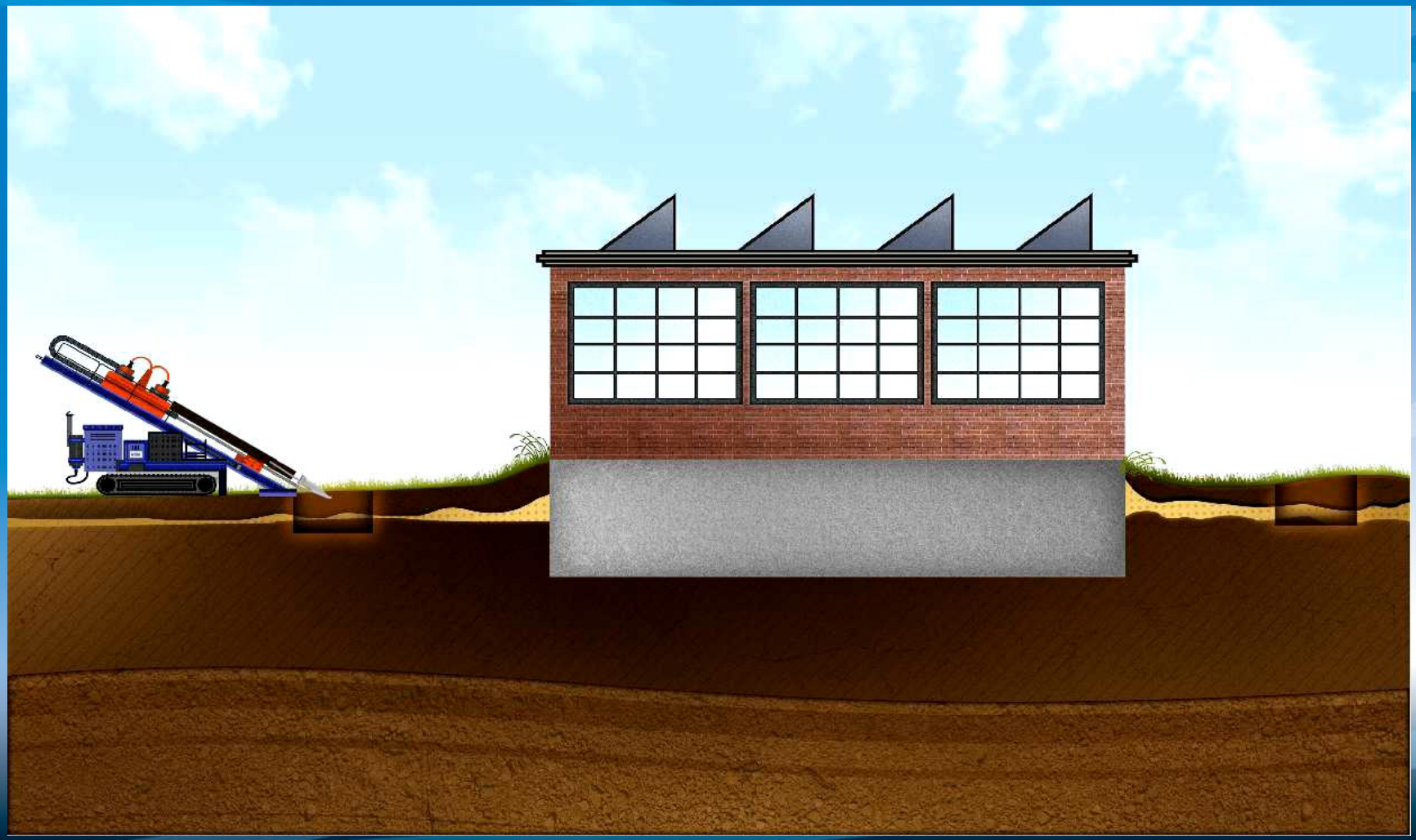
Mud Rotary Drilling Method

- **Maintain hole stability**
- **Remove cuttings**
- **Limit drilling fluid loss to the formation**
- **Cool bit and steering tools**

Well Materials (Screen & Casing)

- **Two Main Considerations**
  - **Strength**
    - **The materials must have sufficient tensile strength for installation and collapse strength for long term horizontal operation**
  - **Open area**
    - **Water supply wells are designed with high open area for maximum flow rates**

Continuous Well Installation



New Solutions to Old Challenge Colorado

- **Shallow, thin surficial aquifer**
- **Directly connected to perennial stream**
- **Vertical well screens dewatered in summer months or periods of low stream flow**

New Solutions to Old Challenge Colorado

- **Horizontal Vertical Well Couplet**
  - **Vertical well installed and accurately surveyed**
  - **Horizontal well drilled in close proximity to vertical well**
  - **Horizontal screen section hydraulically tied to vertical well screen section – no physical connection**

Horizontal Vertical Couplet – Continuous Installation

New Solutions to Old Challenge Colorado

- **Six wells installed**
  - **All wells drilled as continuous (double ended)**
    - **Average length – 585'**
    - **Screen depth – 40' bgs**
  - **Five wells completed as couplet**
  - **One well completed as "stand alone"**
  - **6" diameter steel screen and casing**
    - **Screen both slotted and specialty designed "armored rod-based wire-wrapped"**

New Solutions to Old Challenge Colorado

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Well development

- **Jetting, airlift pumping**

Well performance

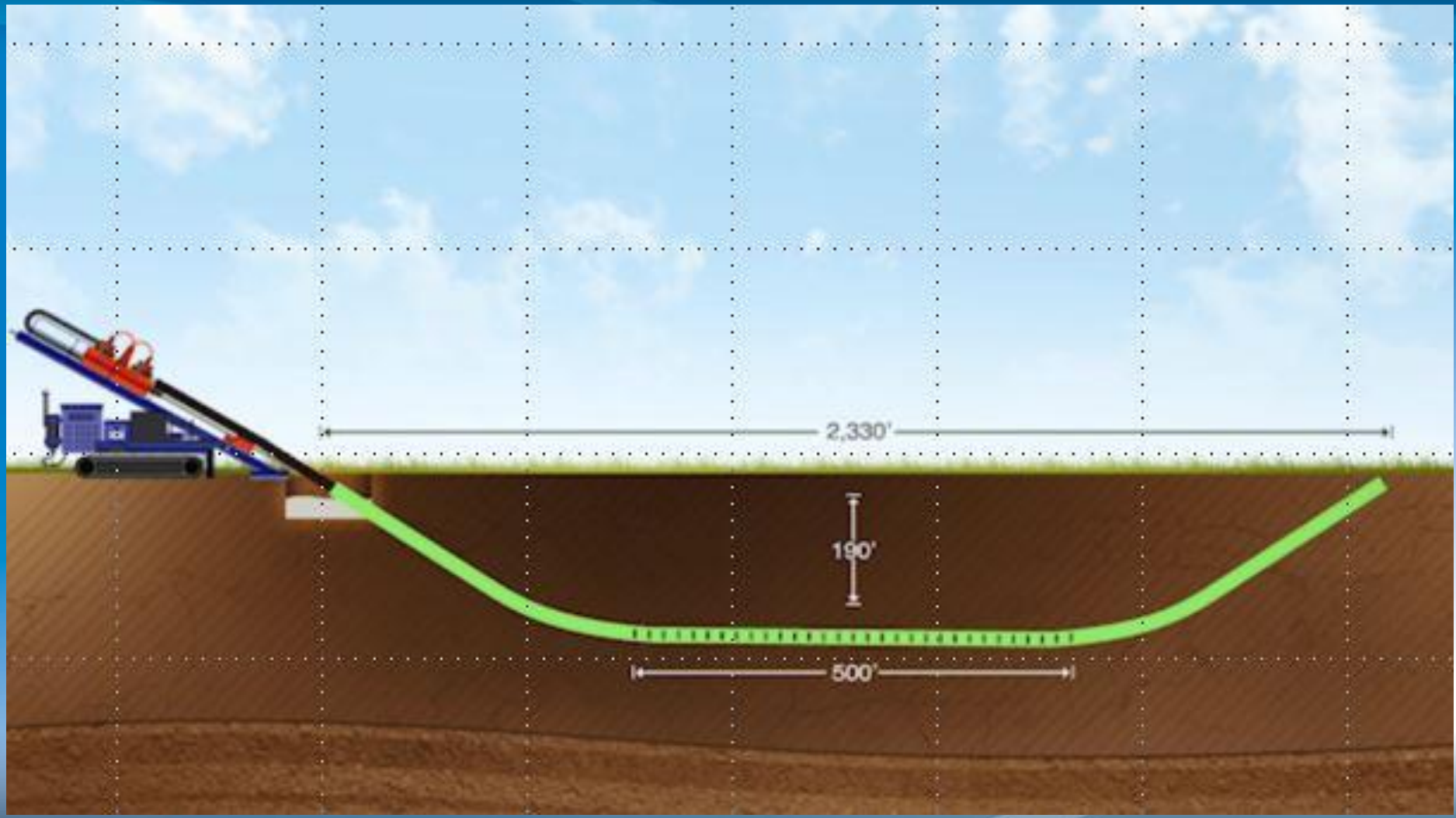
- **Horizontal-vertical well couplets produce more than twice as much water as vertical wells alone**
- **Yield from lateral well is very dependent on proximity to vertical well**
  - **Closer the wells are the greater the flow from lateral to vertical**
  - **Yield is highly dependent on soil's hydraulic conductivity between the two wells**
- **Stand-alone horizontal well with pump out-produces couplets**

New Solutions to Old Challenge Texas

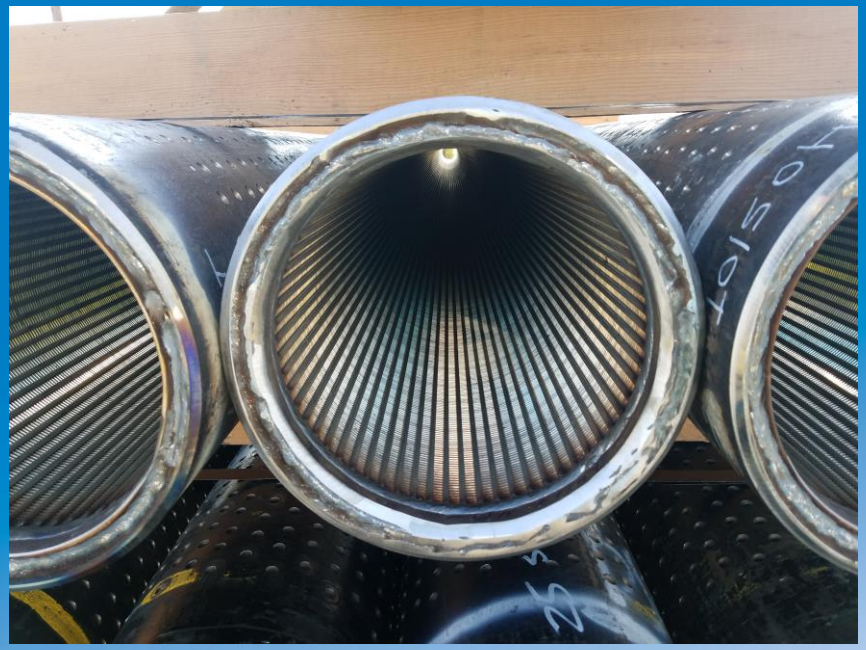
- **Deep surficial aquifer**
  - **Top of aquitard about 200' bgs**
- **Ground water elevations dropping over time**
- **Vertical well screens are becoming dewatered**
- **Vertical wells pumping about 50 gpm**

New Solutions to Old Challenge Texas

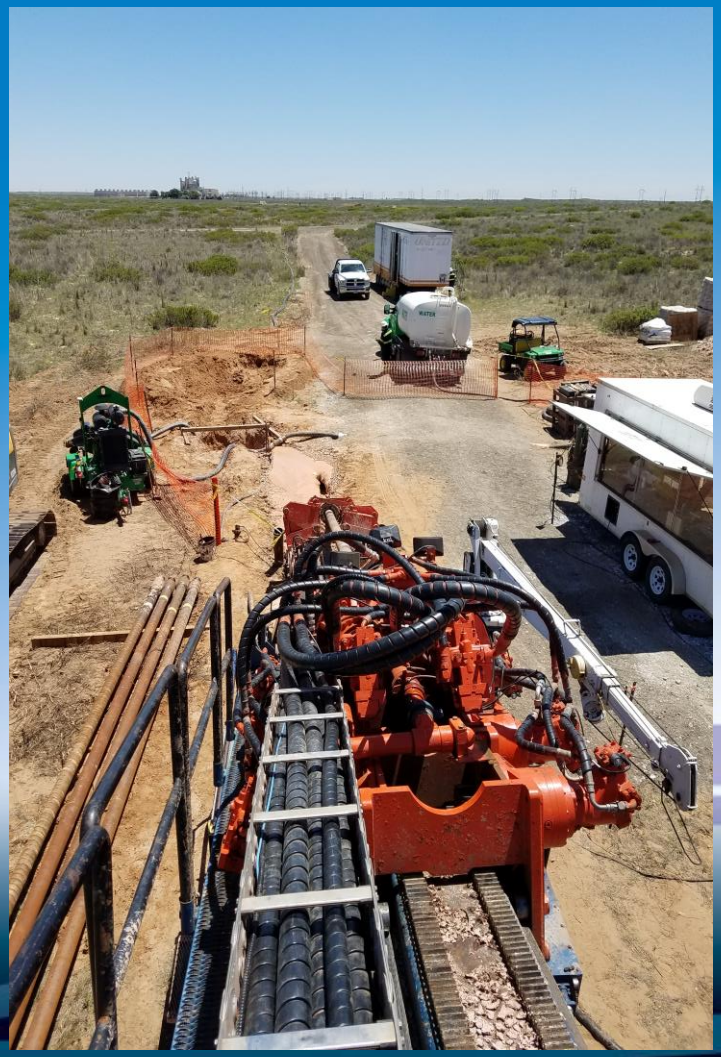
- **The plan, based on surface resistivity and test hole drilling**
  - **Continuous well – double ended**
  - **2,000'+ long**
  - **Screen depth ~ 190' bgs**
  - **12" steel screen and casing**
  - **Screen length 500'**
    - **Specially designed pipe-based, wire-wrapped**


2,330'
190'
500'

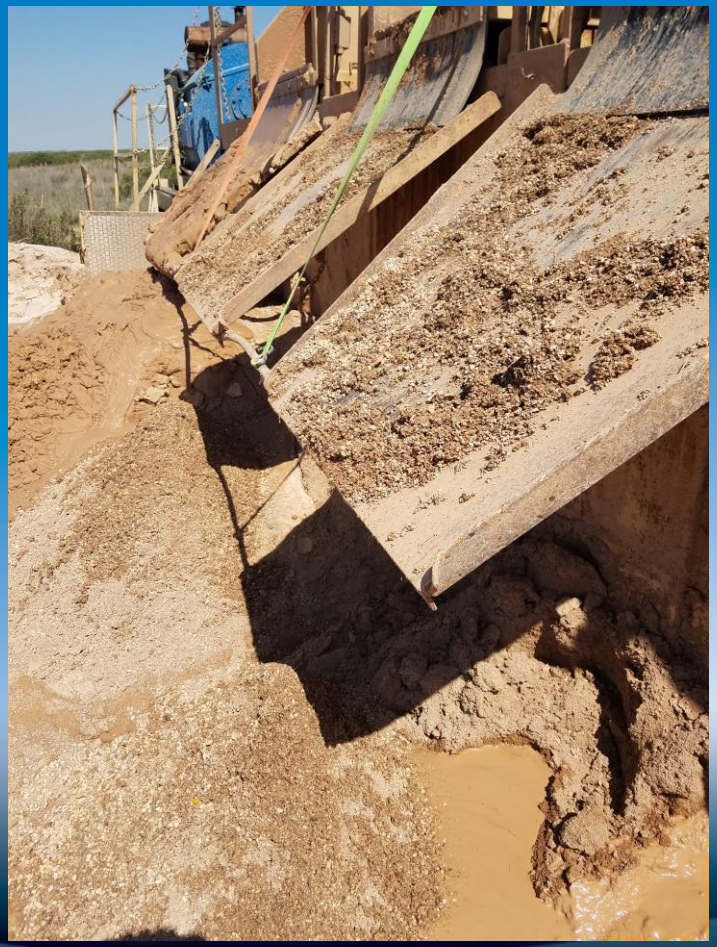
New Solutions to Old Challenge Texas



Installation



Screen Section Formation



Well Materials

Exit Location 2,330’ From Entry

Start Back-Reaming

Start of Well Installation

Success

Initial Development

Final Test Pumping

Well Head

Results

- Pump step test
  - Max flow of 910 gpm (560 gpm from east side pump and 350 gpm from west side pump)
- Continuous pump test
  - 48 hrs at 650 gpm (east side pump only)
- Current online production ~650 gpm (continuous). 13' of available head above west end of well screen at this pump rate

Summary

- Horizontal Directional Drilling (HDD) methods are a viable method to install water supply wells
- Horizontal vertical couplets may have limited flow rates
  - Production is directly related to the proximity of horizontal laterals to vertical well.
- Well material considerations are important for horizontal wells
  - Maximize open are AND maintain strength for installation
- Horizontal wells require a unique development approach
- Advantages of horizontal water wells
  - Target thin aquifers
  - Surface directly above aquifer is inaccessible for drilling equipment
  - Access water under surface water (streams, lakes, etc.)

Thank You!

- **Questions???**

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