What is a Water Well

**water well** — an excavation that is drilled, cored, bored, washed, driven, dug, jetted, or otherwise constructed for the purposes of extracting groundwater, monitoring groundwater, using the geothermal properties of the earth, or injecting water into an aquifer or subsurface reservoir.

**definition from the National Ground Water Association's Lexicon of Groundwater and Water Well System Terms**

Construct the Well

- Excavate
- Set casing
- Gravel pack / open hole completion
- Seal the annular space
- Develop the well for production

**An Excavation Means A Hole In The Ground**

- Drill a hole
  1. Create a cutting
  2. Clean the hole
  3. Stabilize the bore
  4. Protect the formation and formation fluids
Excavate

1. Create a cutting
   - What geology are we intersecting
     - Coarse soils
       • Sand, gravel, rock
     - Fine soils
       • Clay and shale
   - What tooling do we use
   - Drilling fluid additives
   - Mud properties

2. Clean the hole
   - Get the cuttings out of the way
     - Cuttings size, annular velocity and fluid hydraulics
     \[
     AV = Po \times \left( \frac{24.52}{D_h^2 - D_p^2} \right)
     \]
   - Remove them from the mud
   - Drilling fluid additives
   - Mud properties

3. Stabilize the hole
   - Geology
   - Drilling fluid additives
   - Mud properties

4. Protect the formation and formation fluids
   - Don’t contaminate the ground water
   - Don’t plug up the production zone
   - Drilling practices
   - Drilling fluid additives
   - Mud properties

Construction

- Set casing
- Filter pack
- Drilling practices
- Mud properties

Seal the Annular Space

- Grout
  - Bentonite
  - Cement
- Effectiveness depends on the drilling phase
Develop

- Develop the well for production
  - Remove any impediments to production
  - Defined development program
  - Drilling practices
  - Drilling fluid additives
  - Mud properties

Introduction To Drilling Fluids

- Drilling Fluids are part of the good drilling practices success formula
- What are Drilling Fluids?
- What do Drilling Fluids do?
- How do they do what they do?
- The understanding of drilling fluids starts with learning the language of drilling fluids – in other words the functions and properties of drilling fluids

What is Drilling Fluid?

- Specialty
- Polymers
- Bentonite
- Water

What does a Drilling Fluid do?

Functions of Drilling Fluids

- Remove cuttings from the bit and transport them to the surface
- Allow the cuttings to be removed at the surface

Functions of a DRILLING FLUID

Functions of a DRILLING FLUID
Functions of a DRILLING FLUID

- Suspend cuttings when not circulating
- Stabilize and support the Wellbore
- Protect the formation and the formation fluids
- Insure reliable geologic information
- Control subsurface pressures
- Cool and Lubricate the bit and drillstring

Friction = Heat

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Functions of a DRILLING FLUID

 Transmit hydraulic energy to the bit

Functions of a DRILLING FLUID

 Maximize Wellbore Value

How does a Drilling Fluid perform its functions?

Properties of Drilling Fluids

Drilling Fluid Properties

- Fluid properties are the language of drilling fluids
- Drilling Fluid Properties tell us if the fluid is working for us or against us
  - They tell us if the fluid is performing its functions
- Allows
  - Building desirable fluid properties initially
  - Maintaining desirable fluid properties during use

How Do We Know If a Drilling Fluid Can...

1. Remove cuttings from the bit and transport them to the surface
2. Allow the cuttings to be removed at the surface
3. Suspend cuttings when not circulating
4. Stabilize and support the Wellbore
5. Protect the formation and the formation fluids
6. Insure reliable geologic information
7. Control subsurface pressures
8. Cool and Lubricate the bit and drillstring
9. Transmit hydraulic energy to the bit
10. Maximize Wellbore Value

Drilling Fluid Properties

- Viscosity
- Rheology
- Density
- Sand Content
- Filtration
- Calcium Hardness
- pH
Viscosity

- Defined as the fluids “Resistance to flow”
- Thickness of the fluid
- Measured with a Marsh Funnel Viscometer
- Measured with a Rheometer
- Why?
  - Relates to hole cleaning, cuttings settling, borehole stability and pumping pressures

Marsh Funnel Viscosity

- Field measurement of the thickness of a fluid
- Reported in seconds per quart or seconds per liter

Rheology

- Rheology is the study of how matter deforms and flows.
  - It is primarily concerned with the relationship of shear stress and shear rate and the impact these have on flow characteristics inside tubulars and annular spaces.
- Shear rate – pump volume, and shear stress – pump pressure, really describe Viscosity – resistance to flowing when a force is applied
- Rheology is the science of viscosity
- Measured with a Rheometer
- Tells us what actually creates the viscosity we see

Rheological Properties

- Plastic Viscosity, PV
  - Determined by size, shape, and number of solids in the mud
  - Measured in centipoise
- Yield Point, YP
  - Measures the forces between the particles in the mud
  - Relates to the carrying capacity of the fluid in motion
  - Measured in lb/100 ft²

Rheological Properties PV and YP

- Why?
  - Tells us what actually creates the viscosity we see
  - Yield point defines carrying ability when fluid is in motion
  - Provides data for hydraulics and pressure loss equations
Rheological Properties

**Gel Strengths**
- Measures the strength of the gelled structure of a drilling fluid while at rest
- Measured at 10 seconds and 10 minutes
- Reported in lb/100 ft²

**Why?**
- Gel strengths define suspension ability when fluid is static
- Indicates relative force required to initiate fluid flow

Density

**Mass per unit volume**
- Weight of the fluid
- Measured with a mud balance

**Why?**
- Used to calculate total solids content of the mud
- Used to calculate hydrostatic head
- Used to determine the efficiency of solids control equipment

Density

**Mud Balance**

Reads in Pounds Per Gallon (lb/gal), Specific Gravity, Pounds per Cubic Foot, and PSI per 1000 Feet of Depth
- Pounds per gallon (lb/gal) or Specific Gravity (SG) are the standard measurements for drilling applications

Sand Content

**Measures the sand sized particle content of the drilling fluid**
- Sand is a size and not a mineral for testing purposes
- Sand size is defined as anything retained on a 200 mesh screen (greater than 74 microns)

**Measured with a Sand Content Test Kit**

**Reported as % by volume**

**Why?**
- Indicates the abrasive constituent of the drilling fluid
- High sand content slows penetration rate
- High sand content contaminates samples

Filtration Properties

**Filtrate Volume and Filter Cake Thickness**
Filtration

- Measured with API Filter Press
- Filtrate reported in milliliters/30 minutes
- Filter Cake reported in 32nds of an inch or millimeters

Why?
- Wallcake building
- Borehole stability
- Filtrate is the water phase of the drilling fluid available to react with the formation and drilled solids
- Protect the formation and formation fluids
- Sample integrity
- Minimize stuck pipe

Total Hardness / Calcium Hardness

- Measures the concentration of cations contributing to total hardness
- Measured with calcium indicator strips or titrations
- Reported in milligrams per liter calcium (mg/l)
- Check the hardness of the make up water and mud filtrate

Why?
- Retards hydration of bentonite and polymers
- Indicates contaminants picked up while drilling

pH

- Indicates the Acidity or Alkalinity of a Fluid
- A pH of 7 is neutral
- Acidic environments range from 0 to less than 7
- Alkaline environments range from greater than 7 to 14
- Check the pH of the make up water and mud filtrate
- Measured with pH strips, papers or meters

Why?
- Slightly alkaline is optimal for hydration of bentonite and polymers

Hardness

Total Hardness Test Strips

Wide-Range pH Strips (0 To 14)
Properties of Drilling Fluids

- Density
- Viscosity
- Rheological Properties
- Filtration Properties
- Sand Content
- pH & Calcium

Water As Your Drilling Fluid?

- Water by itself does NOT perform any of the drilling fluid functions well
- Water may CAUSE drilling problems

Are You Expecting This?

Water by itself does NOT perform any of the drilling fluid functions well
Water may CAUSE drilling problems