
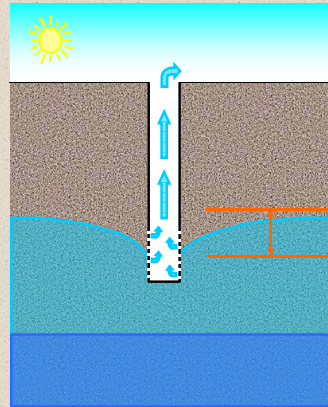


### Water Wells & Drilling

August 5, 2009



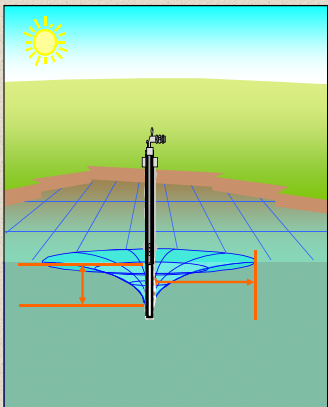
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### Water Wells:

- When pumped:
- **“Drawdown”**
- Cone of Depression
- A function of permeability and pump rate

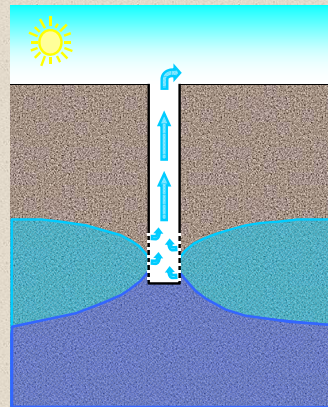
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### Water Wells:

- **“Radius of Influence”**  
= radius of cone of depression
- A function of permeability and pump rate

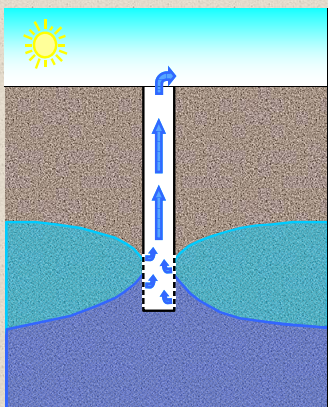
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### Water Wells:

- **“Upconing”**
- or:
- Salt water intrusion
- A function of **lens thickness, well depth**, permeability, and pump rate

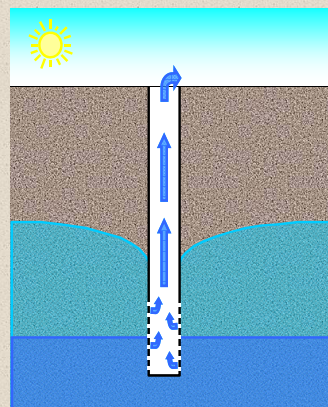
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### Well Depth:

- Too close to transition depth:
- Production rate will always be limited

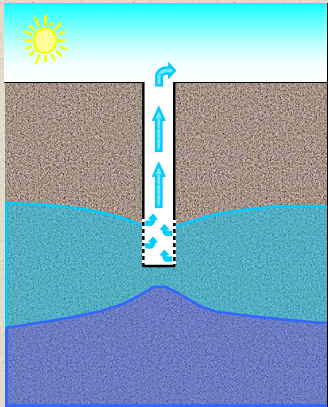
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### Well Depth:

- In transition zone:
- Never had a chance!

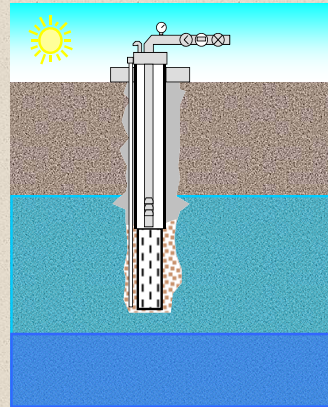
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**Well Depth:**

- Ideal:
  - Shallow penetration “skims” fresh water from surface
- Production can be maximized
  - Still limited by aquifer/recharge characteristics

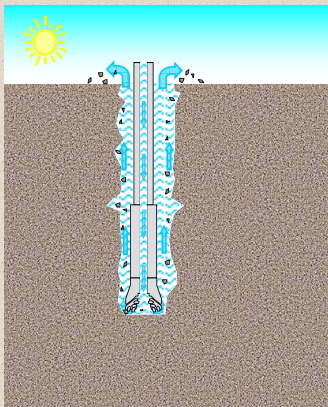
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**Water Well Components**

- Hole
- Casing
- Intake (screen)
  - Filter Pack
- Sounding tube
- Annular seal
- pump
- Well head


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**The Hole:**

- Rotary Drilling
- Drilling fluid
  - Lifts cuttings
  - Cools/lubes bit
  - Controls hole pressure


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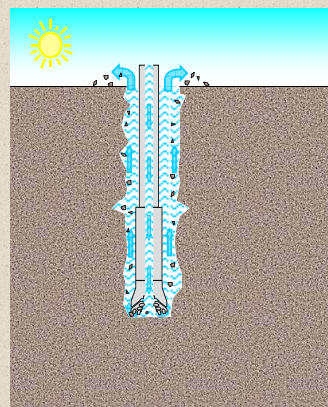
- Rotary Drilling Rig

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• Rotary drilling: bit



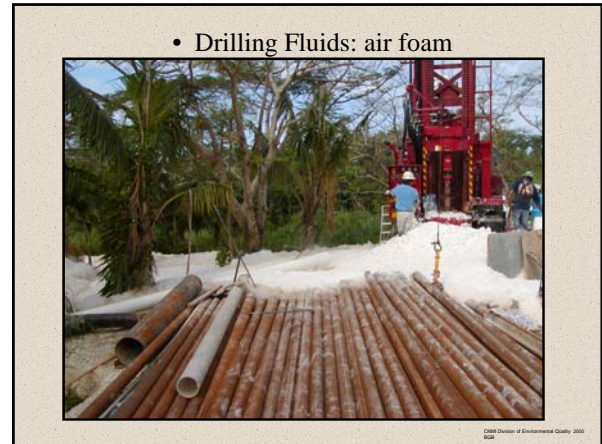
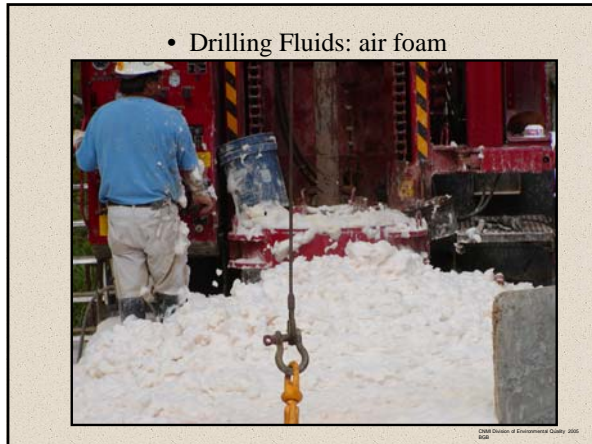
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**Drilling Fluids:**

- Air
  - Dry or Foam
- Advantages:
  - Leaves hole “clean”
    - Easier development
  - Less mess than mud
- Drawbacks:
  - Not good if cavities
  - Drilling in saturated formations more difficult

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**Drilling Fluids:**

- Mud
  - Bentonite – a type of clay
- Advantages:
  - Good in unconsolidated formations
  - Good in saturated holes
- Drawbacks:
  - Hole must be cleaned
    - mudcake
  - Fluid handling messy

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**Drilling Fluids:**

- How mud works:
  - Fluid penetrates formation
- “Mudcake” forms on wall
  - “seals” borehole
    - Pressure
    - Fluid movement
  - Holds in loose formation material

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**Drilling Problems:**

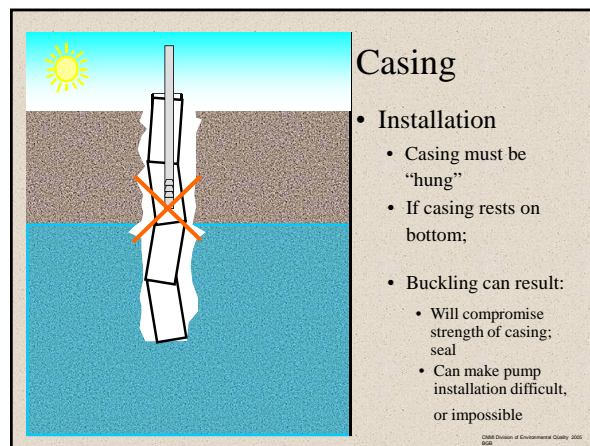
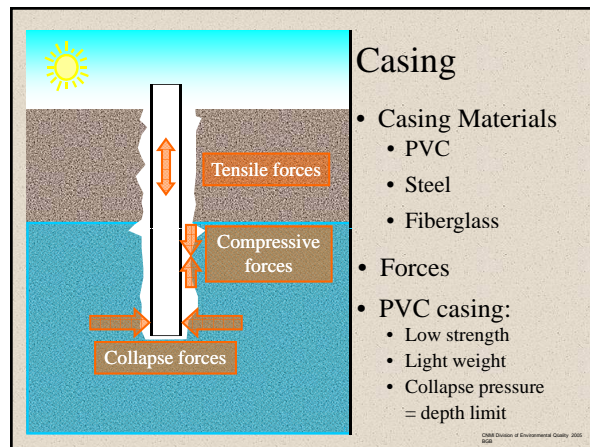
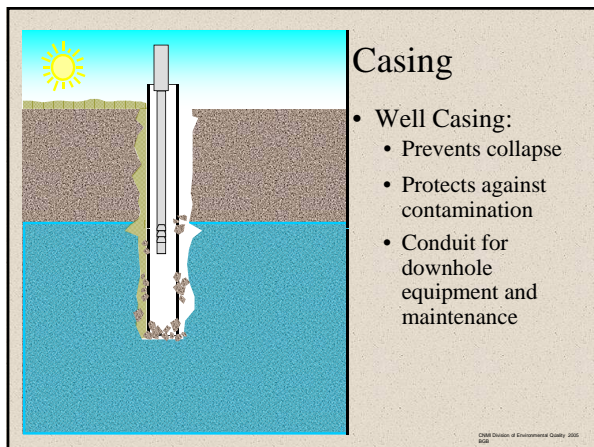
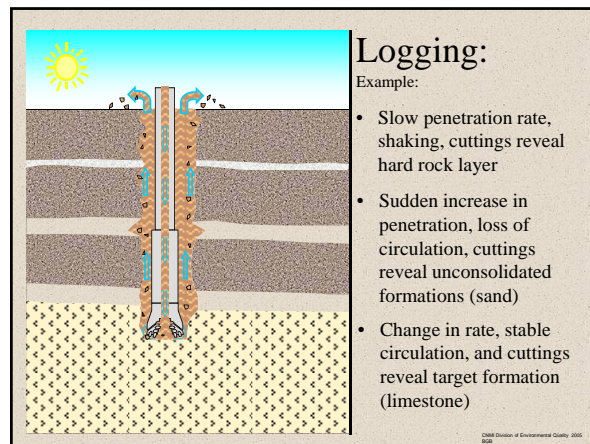
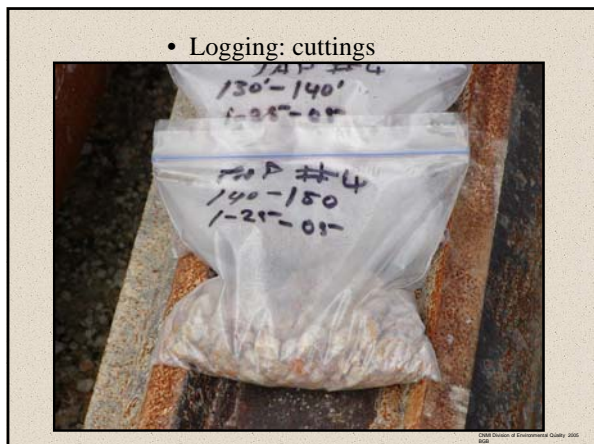
- “Lost circulation”
- Can lead to:
  - Loss of control
  - Collapse of borehole
  - Loss of drill string
  - Loss of hole

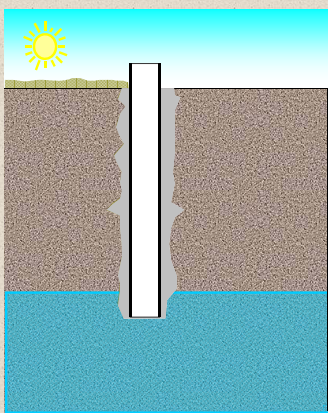
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**Well Logging**

- Logging:
  - a “picture” of downhole geology
- Using:
  - Drilling rate/behavior (hardness, fluid loss, etc.)
  - Cuttings

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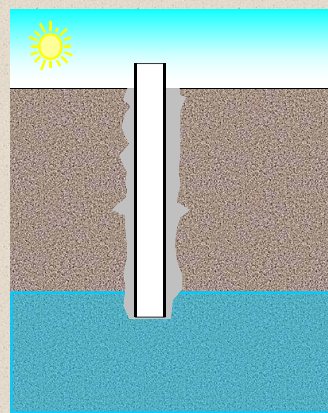




### Annular Seal

- “Grouting”
  - Prevents contamination
  - Supports & protects casing

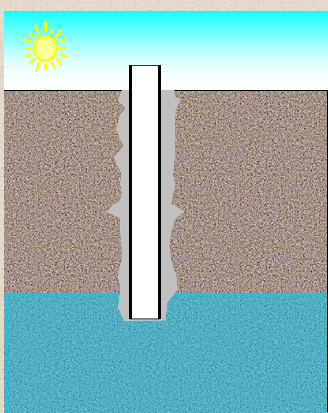
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R02



### Grouting

- Grouting material:
  - Cement slurries:
    - Neat cement
    - Additives:
      - Sand
      - bentonite
  - A proper mix is very important:
    - Heat
    - Shrinkage
    - Density/pressure

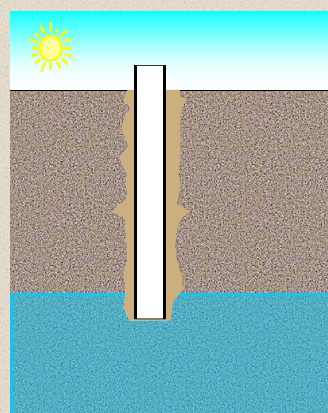
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R02



### Grouting

- Installation concerns with PVC casing:
  - PVC becomes softer with heat
    - Grout should be less than 2” thick
  - Formation collapse can cause PVC pipe to break
    - Center PVC casing before filling and grouting to prevent voids

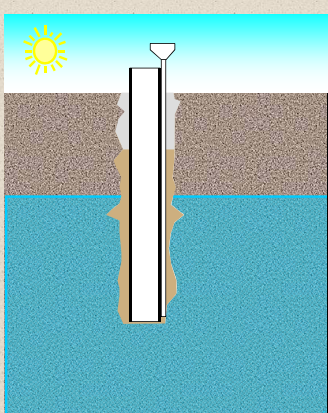
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R02



### Grouting

- Grouting material:
  - Bentonite:
    - A type of clay
    - Swells when wet (very fast)
    - Forms good seal
    - Lower cost than neat cement
    - Pellets or Powder
  - Placement is critical:
    - Swells immediately after wetting

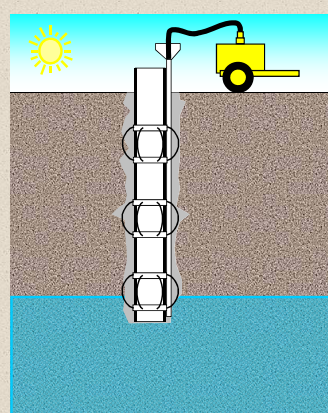
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R02



### Grouting

- Bentonite
  - Must be placed in “slurry” form:
  - Mix ratio & method very critical:
    - Too much water - shrinkage
    - Correct ratio requires addition of ploymer
  - Must be hand mixed by paddle
  - Cannot use near surface – too dry
    - Cement always required

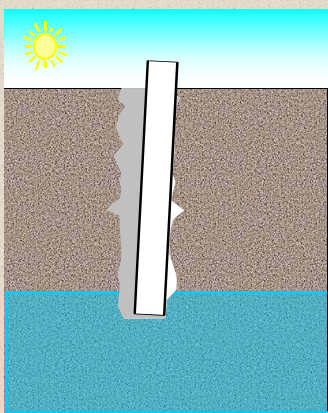
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R02



### Grouting

- Ideal grouting job:
  - Hole 4-6 inches larger than casing
  - Well-mixed slurry
  - Casing centralized
  - Grouting from bottom up, using “tremie” pipe
    - Pump is best

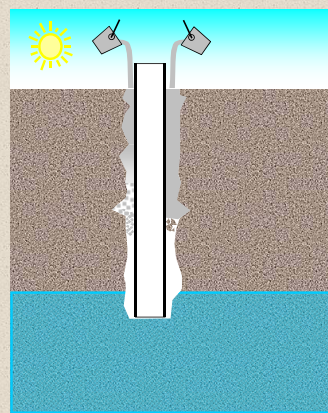
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R02



### Grouting

- Typical problems:
  - Casing not centralized
  - Grouting material fails to flow around entire annulus: "Channeling"
    - Does not seal

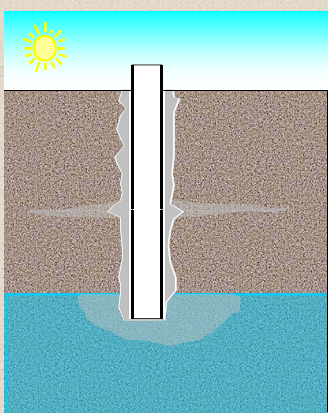
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### Grouting

- Typical problems:
  - Tremie pipe not used:
    - Grout dumped by "gravity" from surface
  - Bridging
  - Grout mixture "segregates"; larger particles separate from cement

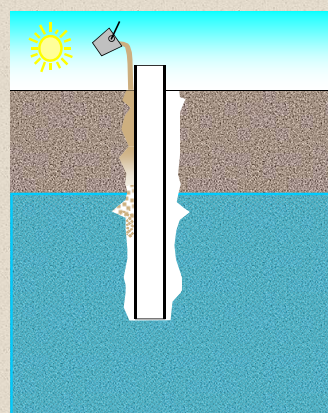
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### Grouting

- Typical problems:
  - Cement slurries:
    - Poor mix (too much water)
      - Shrinkage
      - Loss to formation

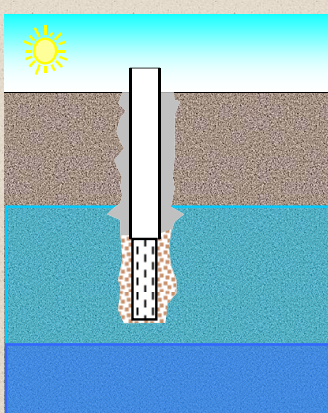
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### Grouting

- Typical problems:
  - Bentonite:
    - Bentonite pellets dumped from surface:
      - Pellets quickly swell & bridge; incomplete seal
      - Under best conditions (frozen), pellets can be dropped 40 feet before hydration begins

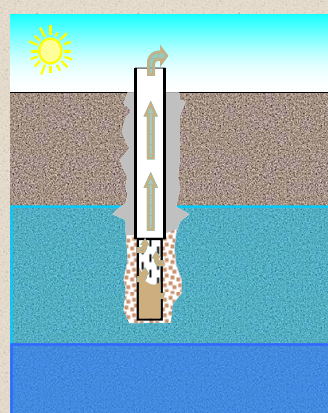
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### Well Intakes

- Open Hole
  - Hard rock
- Well screen
  - Naturally developed
  - Filter Pack

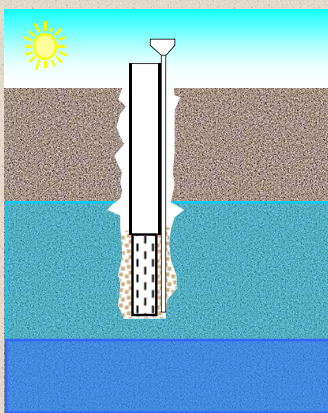
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### Well Intakes

- Well screens:
  - Requires careful design of:
    - Slot size
    - Filter pack material
  - Bad design can lead to sedimentation; poor water quality; and plugging;

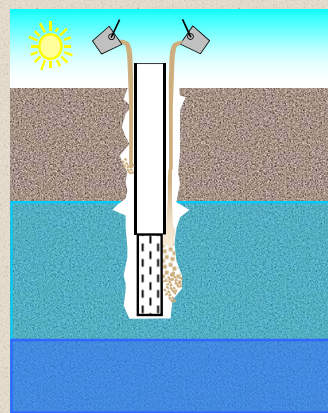
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### Well Intakes

- Filter pack material:
  - Granular, "pea gravel"
  - Size based on formation materials
- Filter pack installation:
  - Place from bottom up; not from surface
    - Tremie pipe

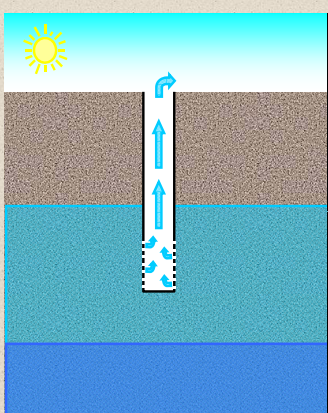
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### Well Intakes

- Filter pack installation:
  - problems similar to grouting:
    - pouring from surface is likely to cause
      - bridging
      - segregation
  - All can be avoided by use of tremie

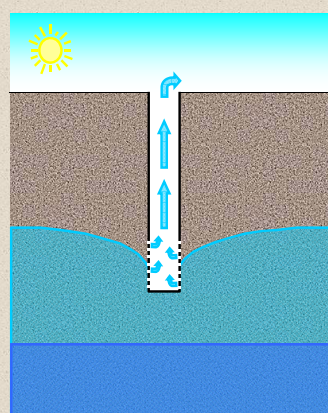
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### Pump testing

- Well is pumped at :
  - Permitted rate (based on need)
  - or
  - Variable rate (CUC wells)
- Well is pumped for:
  - 36 hours

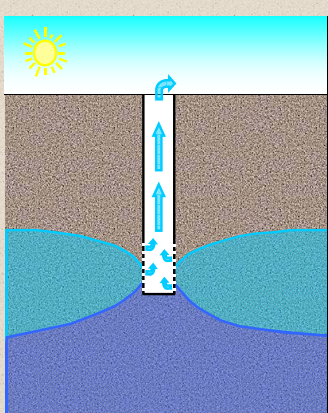
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### Pump testing

- Monitoring:
  - Drawdown

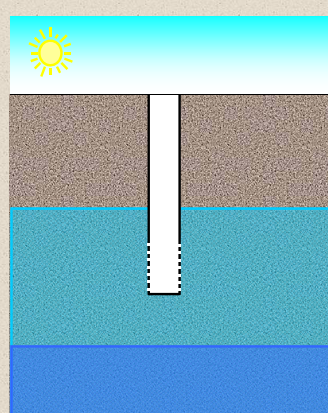
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### Pump testing:

- Monitoring:
  - Drawdown
  - Water quality

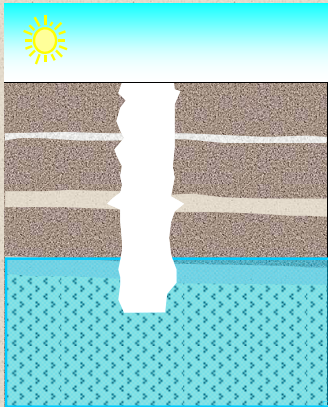
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### Pump testing

- Monitoring:
  - After pumping:
    - Aquifer recovery (level)

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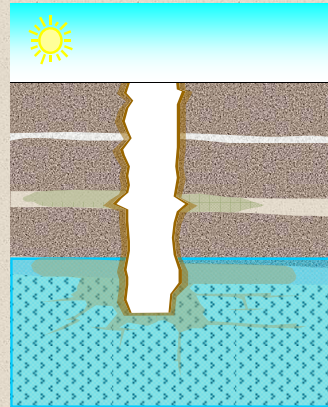


**Well Development**

After drilling, there is a need to:

- “Clean up” the mess and damage caused by drilling
- Maximize water production
- This process is called “Development”

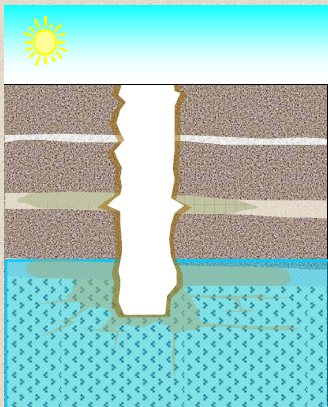
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**Well Development:**

- Drilling damage:
  - Compaction, smearing of borehole
  - Drilling fluid invasion
  - Mudcake

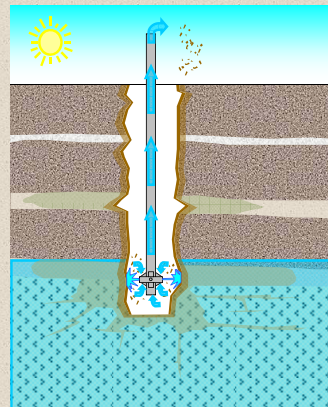
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**Well Development:**

- Mudcake removal:
  - Chemicals (polyphosphates)

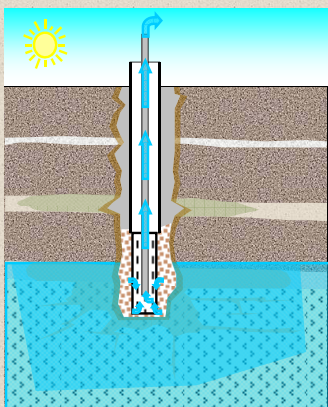
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**Well Development:**

- Mudcake removal:
  - Chemicals (polyphosphates)
  - Jetting/surging

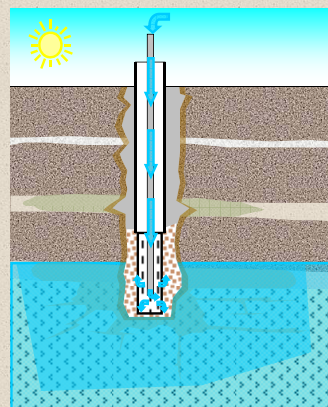
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**Well Development:**

- Pumping/surging
  - Objective: to clean formation of drilling fluids, clay particles, and fine materials
- Methods:
  - overpumping

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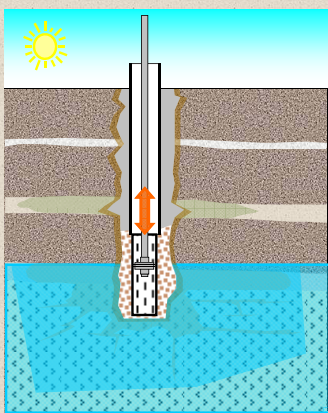


**Well Development:**

- Pumping/surging
  - Objective: to clean formation of drilling fluids, clay particles, and fine materials
- Methods:
  - overpumping
  - backflow

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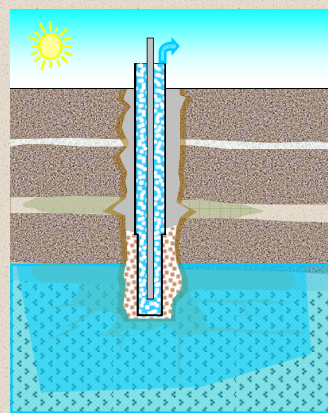




**Well Development:**

- Pumping/surging
  - Objective: to clean formation of drilling fluids, clay particles, and fine materials
- Methods:
  - overpumping
  - backflow
  - Mechanical surging

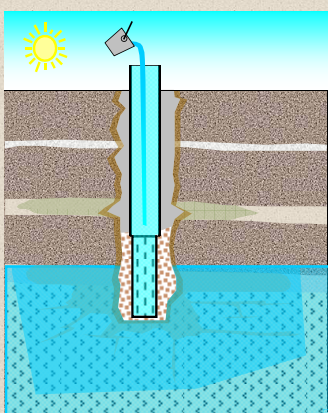
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**Well Development:**

- Pumping/surging
  - Objective: to clean formation of drilling fluids, clay particles, and fine materials
- Methods:
  - overpumping
  - backflow
  - Mechanical surging
  - Air development

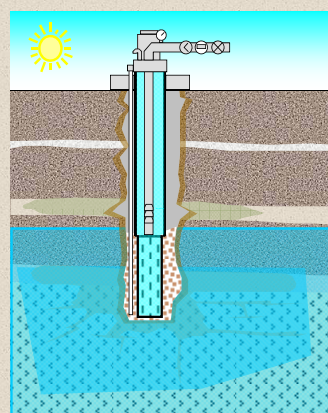
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**Well Development:**

- Disinfection

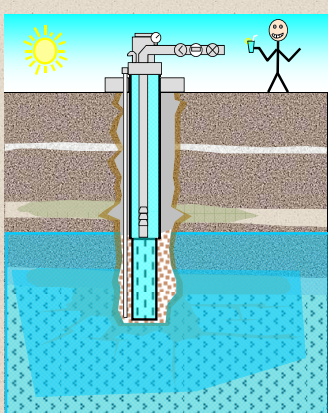
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**Well Completion**

- Pump installation
- Sounding tube
- Well head

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**Well Complete!**

- Enjoy!

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