# How Grout impacts Water Quality

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Nebraska City May 25, 2011

# Facts about Nebraska

- Population ~ 1.7 million
  - Relies on Ground Water for 1.2 million people

- Economy- Agriculture based
- 3.2 billion in income
- 40% cattle and calves
- 31% corn
- 14.7% soybeans - 4.3% hogs
  - Industry- Manufacturing

- Natural Resources-

Ground Water
- Enough to cover NE 30 feet in depth

Oil

Found in SE& SW parts of NE

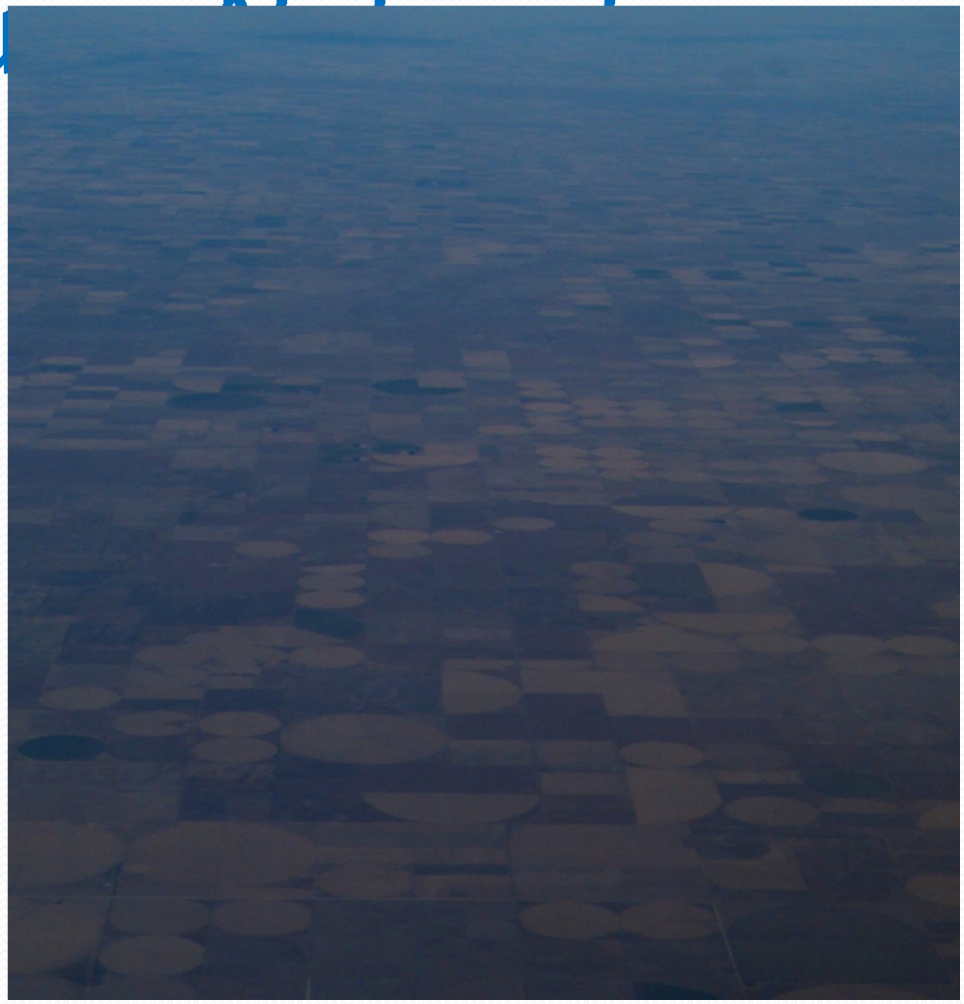
Grain

40% of crop land irrigated

Livestock
- 2 million head of cattle* 2008 USDA

# Ground water u

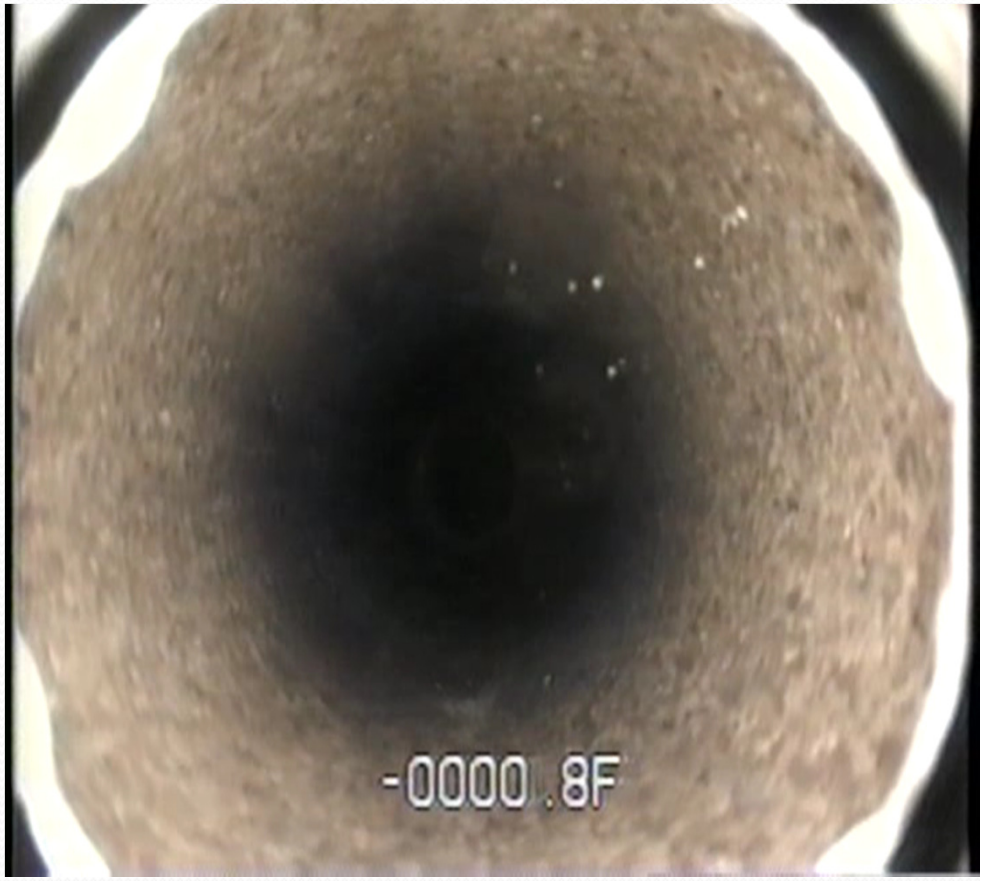
- Irrigation- 94%- 7.5 bgd
  - 93,000 registered irrig.
- Domestic- 4%- 380 mgd
  - Private and public
- Livestock- 1%- 108 mgd
- Industry- .1% - 11 mgd
- Ground Water pollution concerns:
  - Chemicals
  - Bacteria- pathogens



# UNL Demonstration

# Nebraska Grout Study- Changes Conventional Thinking

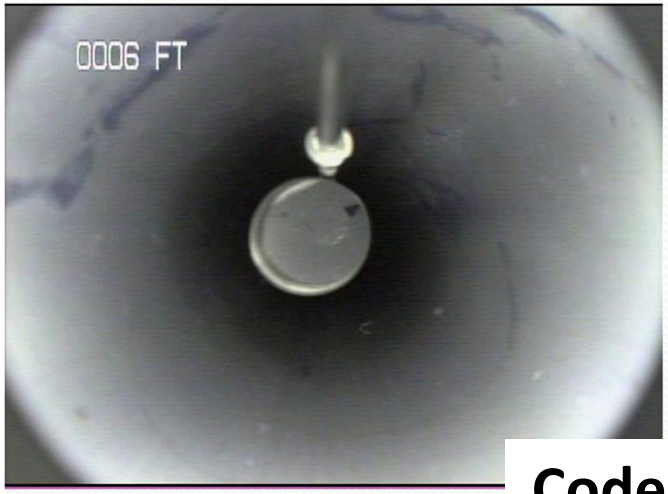
- In-situ Study
  - Visual component
    - Allows full length perspective
    - Studies differing geologic conditions
    - Real world testing
    - Dye testing
    - Limitless time frame for study
    - Non-destructive
    - Effective for all types of grout materials
    - Led to new discoveries beyond study



# Bentonite Slurry

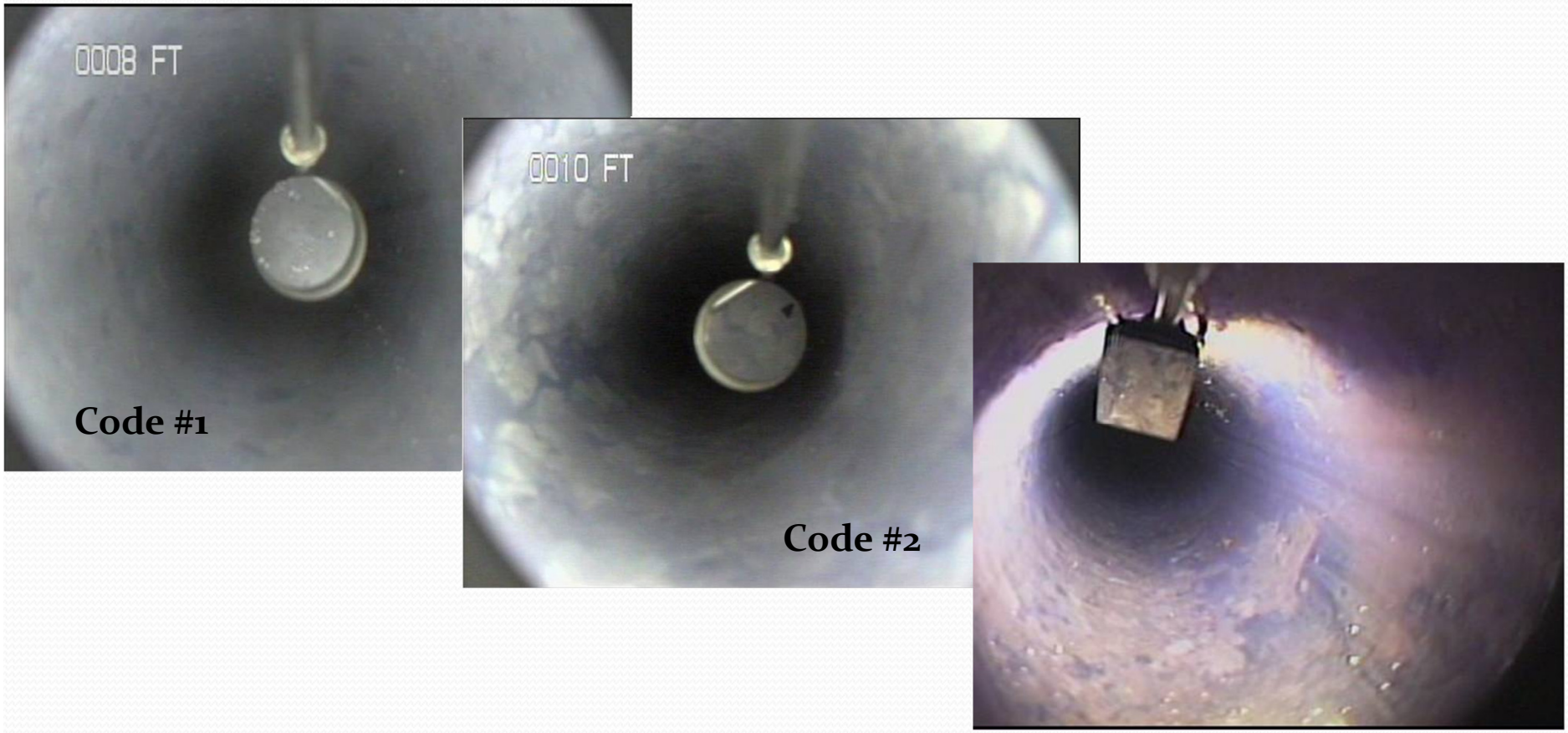

Code #1 – Good


Code #3 – Cracks and Voids




**Code #2 – Cracks**

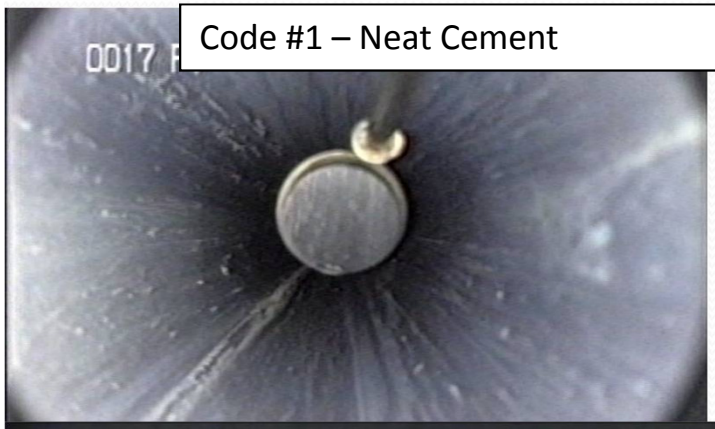
# Bentonite Chip



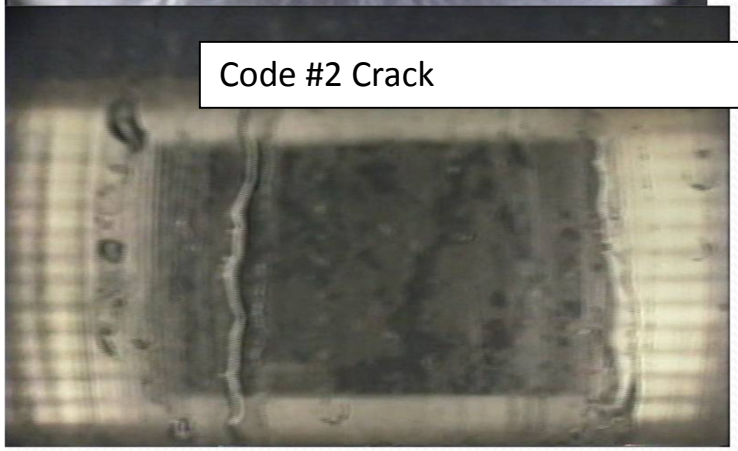
# Closed Loop Slurries-Code #3


# Cement-Based

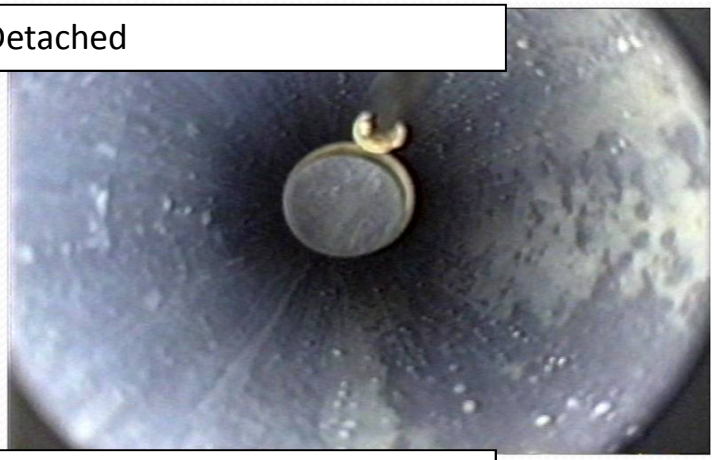
Code #1 – Neat Cement



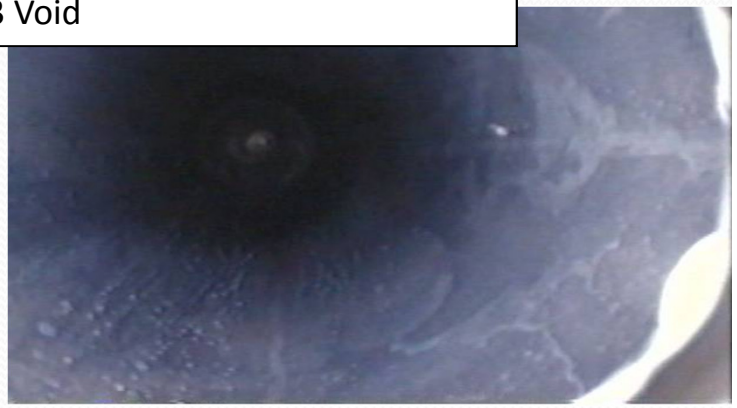
Code #2 Crack



Code #3 Detached



Code #3 Void



# Dye Test SOP

- Fluorescent Dye (green)
- Validates the condition of the grout

# Neat Cement Penetrates Bentonite Chips

# Grout Compositions

- Bentonite Slurries; 16% to 30% Solids- little difference in performance, inadequate in vadose zone, will not rehydrate…
- Geothermal Grouts- bentonite without additives are inadequate
- Bentonite Chip- Consistent material performs best when hydrated/ will rehydrate
- Cement-Based Grouts- Provide structural stability, vulnerable to cracking and micro annulus

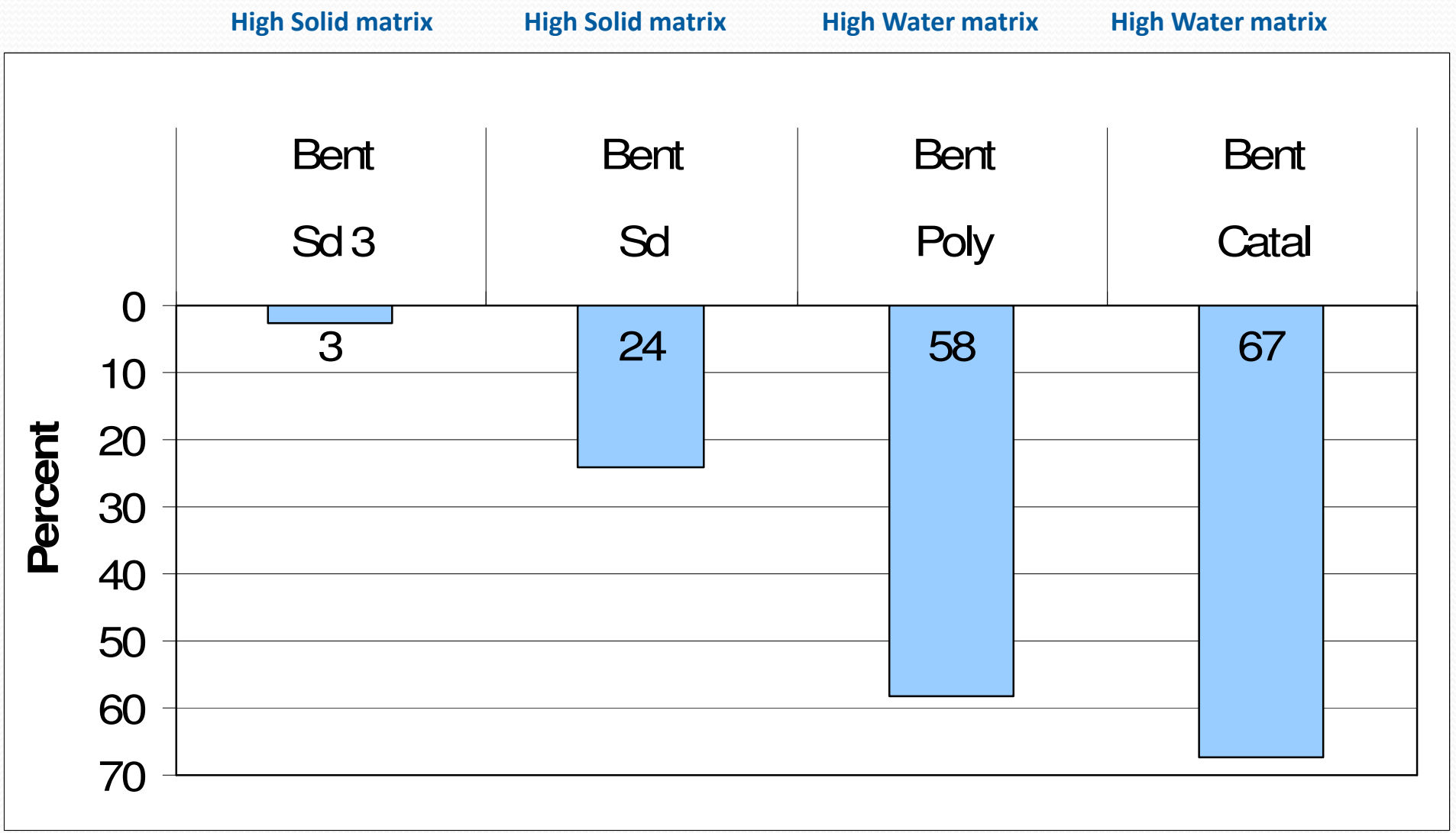
# Vadose Zone Study 2008-2009

# Grout Comparisons- High Water vs High Solids

- 19 recipes where looked at:
- 8- High Water content- low solids
- 11- High solids content- low water

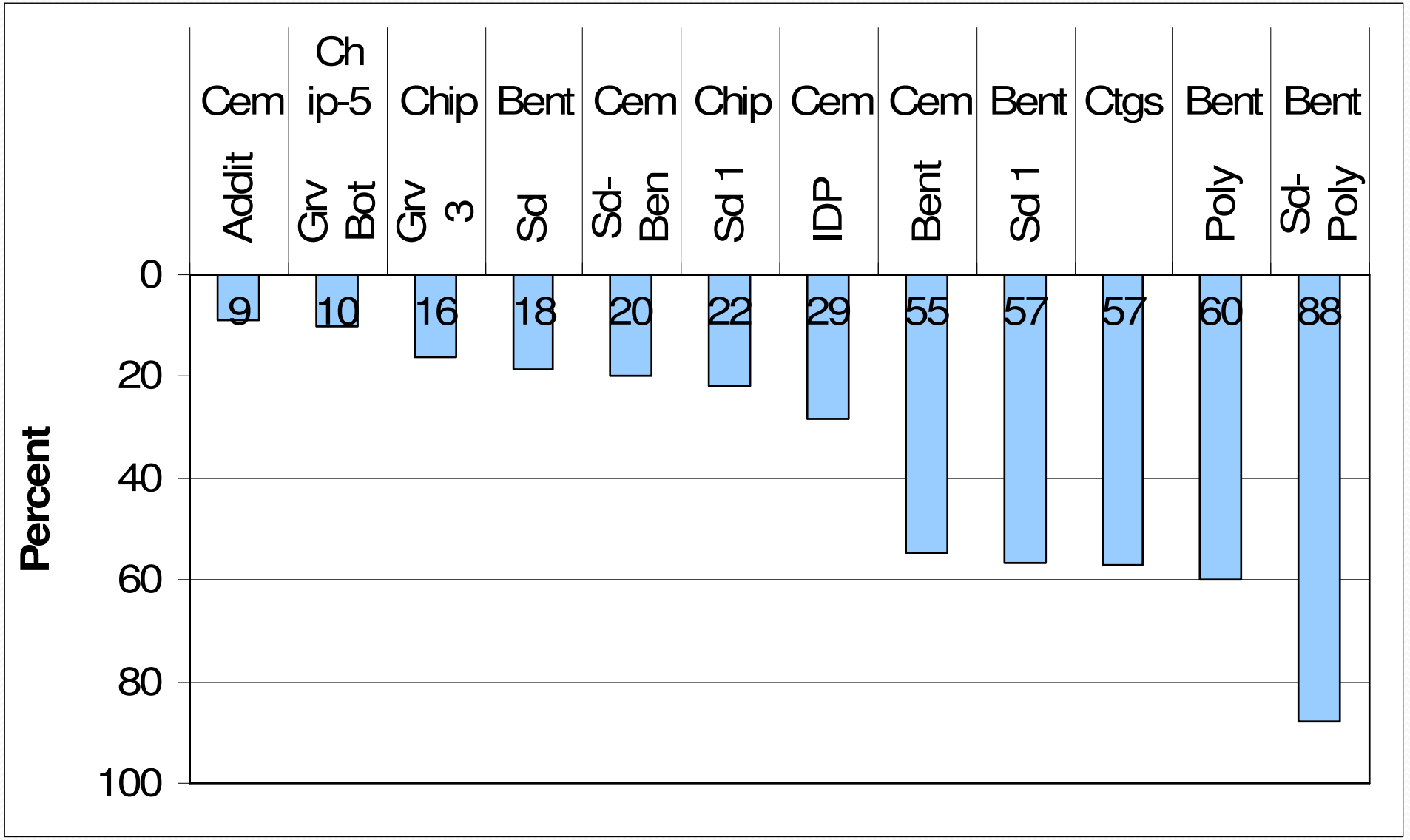
Combinations of Bentonite and Cements matrix

# HSA - All Mixes – Match Grout to Environment Dry Borehole Use Dry Mix?



# Rotary – All Mixes

High solids matrix – High Water Matrix



Micro- Annulus  Neat Cement-PVC

# Unconventional Thinking – New Results

- "The borehole cannot be sealed"-Dave Hansen Design Water Technologies.
- Because :

  the surrounding unsaturated zone isn't sealed…

  The unsaturated zone acts as filtration for ground water re-charge…

  Protection of groundwater depends upon ;

  the protection of the filtration system…

  reconstruction of conditions in the borehole that mirror the surrounding soils in the unsaturated zone

# What is Needed?

1. Better understanding of the unsaturated zone physical properties
   - More attention to unsaturated zone geology while drilling the borehole
   - More accurate detail of the borehole recorded on well logs
     - Logging every change no matter where it occurs
     - Know the descriptive language for identifying formations
   - Matching the grout composition to the on-site conditions
     - Unconsolidated vs. Consolidated unsaturated zones

# What is the best method?...Best Material?

- "There is no magic bullet"
  - Grout must  maintain a less permeable seal than the surrounding vadose zone material…
  - No short cuts…
  - Good grout begins with good samples…good samples depend on drilling fluids program…

# In Summary- new truths

- Bentonite perform best kept wet…
- Sand Added to Bentonite Slurries Improves Performance…
- Bentonite slurries will not rehydrate once damaged- Bentonite chips will.
- Chips large bore hole size for deep placement…
- Cement grouts crack above and below water levels, and won't bond to PVC pipe…
- Cement provide stability to the casing in the bore hole…
- Neat Cement intrudes through bentonite chips…
- Bore hole size does not enhance or detract grout performance.

# Revisions of Well Construction- Nebraska

## PUBLIC WATER SUPPLY

- PWS wells are required to grout with chip bentonite above screened openings in addition to grouting any confining layers in the borehole…
- Wells must have seals for surface protection (cement or bentonite chips)

## PRIVATE WATER SUPPLY-proposed

Surface seal plus bentonite aquifer seal

Only high solids grouts for closed loop heat pumps

Minimal screening and full length grouting in areas of water quality concerns

Steel segment extending through the frost zone with cement seal

No grout slurries without high solids additives above saturated zone

Verification by weight of all grout slurries

Uniform minimum grouting standard for all wells-potable

# Why we do what we do…

"Three times I left the planet and found no where else to go… please take care of the spaceship we call planet earth"
-Wally Shirra-NASA astronaut