B. Pneumatic Slug Test Procedures

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Why Do You Want to Know K?

- Contaminant Migration Pathways
- Risk Based Corrective Actions
- Monitored Natural Attenuation
- Design Remediation Systems
- Injection of Fluids

K = Important Physical Parameter
Conventional “Mechanical” Slug Test

- **Slug-in Test**: Falling Head Test
- **Slug-out Test**: Rising Head Test

**Flow out**

**Flow in**

**SWL**
A Pneumatic Slug Test

Valve Closed

Valve Open

Valve Open

Air In

Air Out

Transducer

Water Level Falls

Water Level Rises

Flow in

Flow out

Rising Head Test

Equilibrium
Pneumatic Slug Test

Well Diameter Limits?

SP16 (5/8” ID)
1ft screen

Keep release valve ID ≥ Well ID to prevent noise & interference
DP Field Methods to Access Groundwater

Temporary Installations

• Single Tube, Exposed Screen
• Single Tube, Protected Screen
• Dual Tube Profiling

Long Term Installations

• DP Monitoring Wells
Development Required !!!

Without appropriate development slug test results may be biased low ... As much as 10 times !!!

Use check valve & 12V actuator to develop samplers and DP wells

(After Butler et al. 2002)
Pneumatic Slug Test System: GW1600

Kit weighs ~ 30 lbs
Components of the Pneumatic Slug Test System

A) Pneumatic Manifold
B) Adapters for Rods & Casing
C) O-rings – use on each rod joint *
Components ...

A) A to D Converter (logger) [1, 2, 10 & 38 Hz]
B) Transducer 10 psi with 100ft cable
C) Power & Data Cables
Components …

Pressure required for slug test is less than 2 psi. in the well.
Recent Improvements to System

Hand pressure/vac pump and interchangeable pressure/vac gauges allows for both rising and falling head tests
Pressure and Vacuum Gauges

Graduated in inches and centimeters of water pressure.

Record this information for $H_0$ data.

Not psi!
Field Set Up for Pneumatic Slug Testing

- Install Sampler
- Set Screen & Develop
- Attach Pneumatic Manifold
- Insert Transducer
- Initiate Software
- Conduct Slug Test

Screen Must be Saturated for pneumatic testing

Solar heating of cable
Dual-tube Method for K-Profiling

Screen can be removed and re-installed at multiple depths to allow for vertical profiling of hydraulic conductivity

Pre-core for low-K / fine grained materials
Adapters for PVC Wells

2-inch and 4-inch adapters shown, others available
Questions?

Comet Reflection
Kansas Farm Pond
What does the slug test data look like?

- Over Damped Data
- Under Damped Data

Quality Control?

- Field QC
- Post Acquisition QC
Overdamped Test Response ...

Air Pressurization

Rising Head Tests

$H_o = 10.5''$

$H_o = 10.0''$

$H_o = 11.0''$

$H_o = \text{initial change in water level (head)}$

Sample Rate = 2Hz
Screen Point 16
1-foot Screen Int.
Depth = 91 ft
Rising Head? Falling Head? Vacuum Peaks?
Underdamped Test Response ...

Raw Data Plot
PW07D file g

Air Pressurization

Head (ft of water)

Time (seconds)

Why not model this?

DP installed PP well
Nominal ½” PVC
9-ft screen interval
Depth 65ft
Water level 25ft

Slug Test
$H_0 = 6.0”$

Slug Test
$H_0 = 5.6”$
Rising Head or Falling Head Tests?
Slug Test Field QC : Visual Check

Three slug tests with ~same Ho (e.g. 2ft)
- Compare peak height
- Curve symmetry
- Recovery time same
Two additional slug tests with larger & smaller $H_0$

- Are peak heights proportional
- Curve symmetry
- Recovery time same
- Post Acquisition QC

Field QC (cont.)

Is Calculated K independent of $H_0$?
 Slug Test Field QC : Review Data On-site

Baseline offset before & after test: hysteresis

SP16 Installed in weathered sandstone

Ho = 20"

Ho = 30"

Noise spike?
Slug Test Field QC: Review Data On-site

Noise? Inflection point? Change in slope?
Fast early time recovery, higher slope

Slower late time recovery, lower slope

Software Model Fit?
Slug Test Field QC (cont.)

“Double Straight Line Effect”
- More development?
- Bad well construction?
- Correct model?
Field QC: What is wrong with this test?

Este caso se corresponde a la problemática que teníamos al principio. Las líneas base no coinciden entre ellos. Esto lo interpretamos como un mal desarrollo del sondeo/pozo. Para evitar esto aumentamos el tiempo y volumen de bombeo de agua para el correcto desarrollo del sondeo.
PW07D Pneumatic Slug Test
Different Initial Head Values

Initial Head: 10"
Initial Head: 18"
Initial Head: 5.0"
PW07D Pneumatic Slug Test
Normalized Different Initial Head Values

Confirms that the results are independent of magnitude of initial head change and data valid.
Curve Matching of Field Data
High-K Slug Test Analysis

SP07D, 1ft Screen, 60ft deep
Pneumatic Slug Test
18 inches of water displaced

$K = 94.3 \text{ ft/day} \quad (3.33 \times 10^{-2} \text{ cm/sec})$
Why Use Direct Push Methods to Conduct Slug Tests?

Location ... Location ... Location
Depth / Profiles
Screen Interval
Cost, NO Permanent Wells
Efficient ... While sampling!
How Does K Change Vertically and Laterally Here?
Questions?

Cache La Poudre River
Northern Colorado