HydroTechnics™ Sensor Installation

- HydroTechnics™ sensors provide information on groundwater flow velocity and direction based on propagation of induced thermal gradients
- Sensors are installed directly into a boring and output data continuously to a datalogger for up to 2 years

HydroTechnics™ Sensor Installation

- A heating element within the probe heats the the groundwater inside the probe to 20-30°C above background
- The temperature distribution at the surface of the probe provides a 3-D interpretation of groundwater advection following computer processing of the data

HydroTechnics™ Sensor Installation

- Data can be collected manually or remotely using a dialup connection
- Datalogger can store up to several months of output.

HydroTechnics™ Sensor Installation

HydroTechnics™ Power Settings

Dover AFB Funnel & Gate				
Probe ID	**R (ohms)**	**V (volts)**	**I (amps)**	**P (Watts)**
A1	38.4	50	1.30	65.1
A2	40.0	50	1.25	62.5
G1	39.6	30	0.76	22.7
G2	40.5	30	0.74	22.2

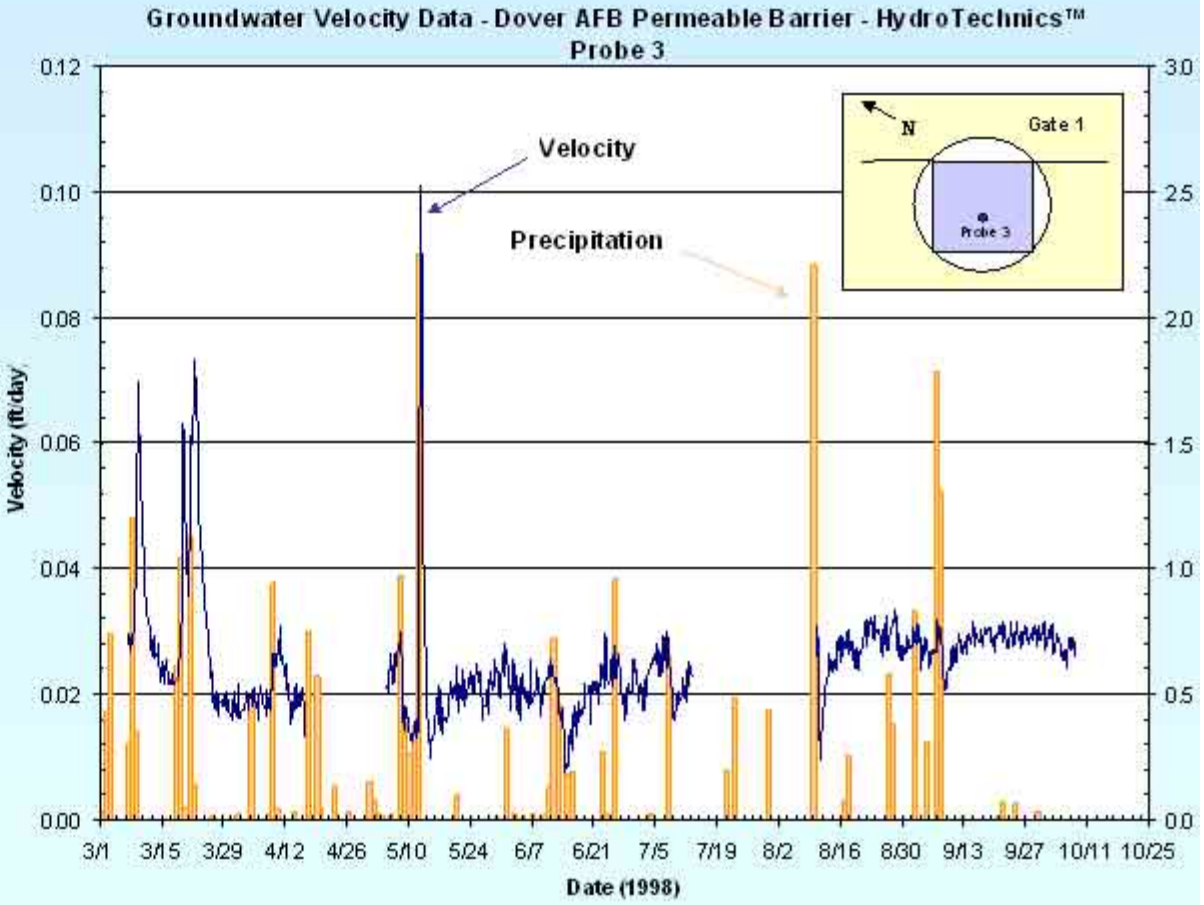
Lowry Campus Funnel & Gate				
Probe ID	**R (ohms)**	**V (volts)**	**I (amps)**	**P (Watts)**
HT0080	43	50	1.16	58.1
HT0081	44	50	1.14	56.8

Calibration and Post-Processing HydroTechnics™ Sensor Data

- Run one 8-hr test where probe response is monitored as temperature ramps up; HT processes and returns calibration files
- Restart power to sensors and datalogger, then begin acquiring signal
- Download datalogger (before loop ends)
- Run PC-based programs to convert temperature data into velocity vectors
- Dump data into spreadsheets for storage and developing graphical representations.

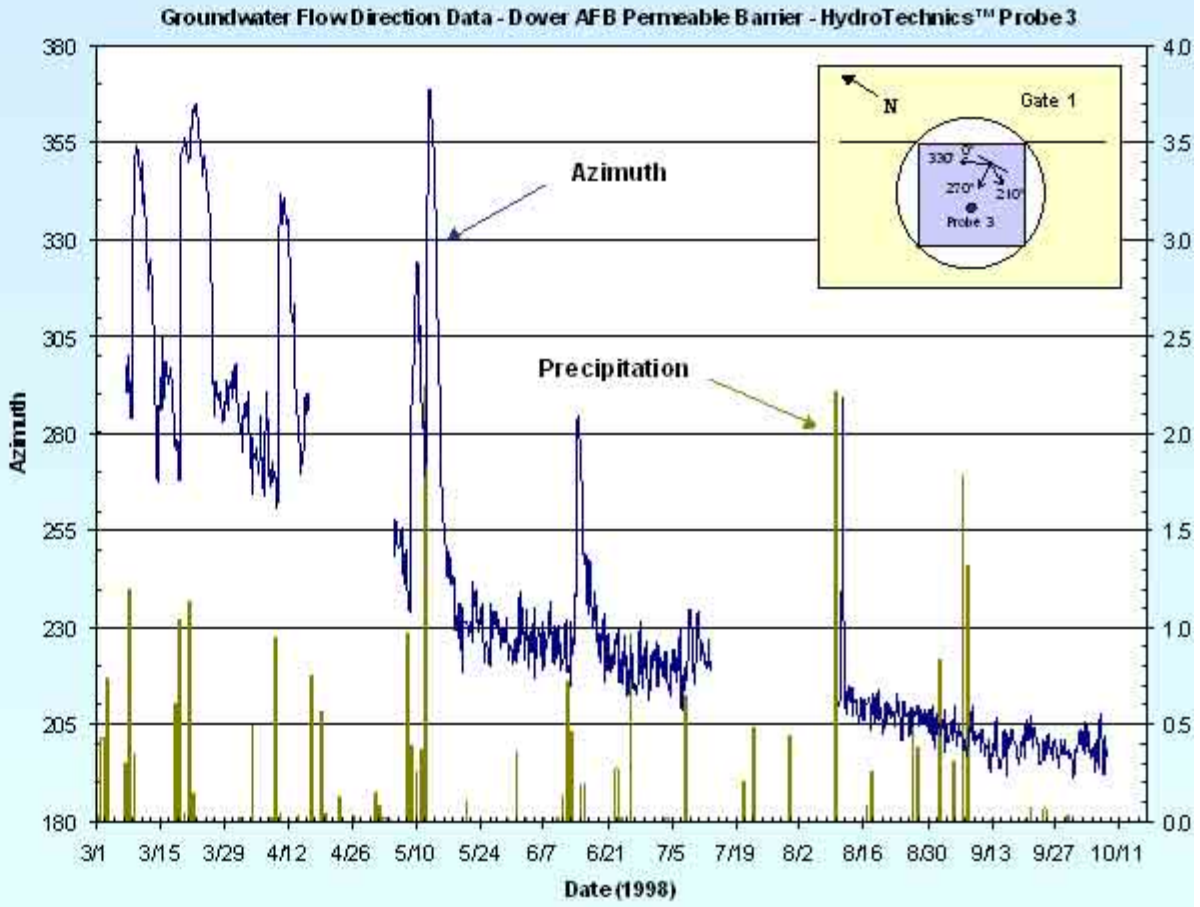
HydroTechnics™ Results – Dover AFB

- After an initial stabilization period, the average velocity was ~0.02-0.03 ft/day
- Sensors in the two Fe gates responded rapidly to precipitation events

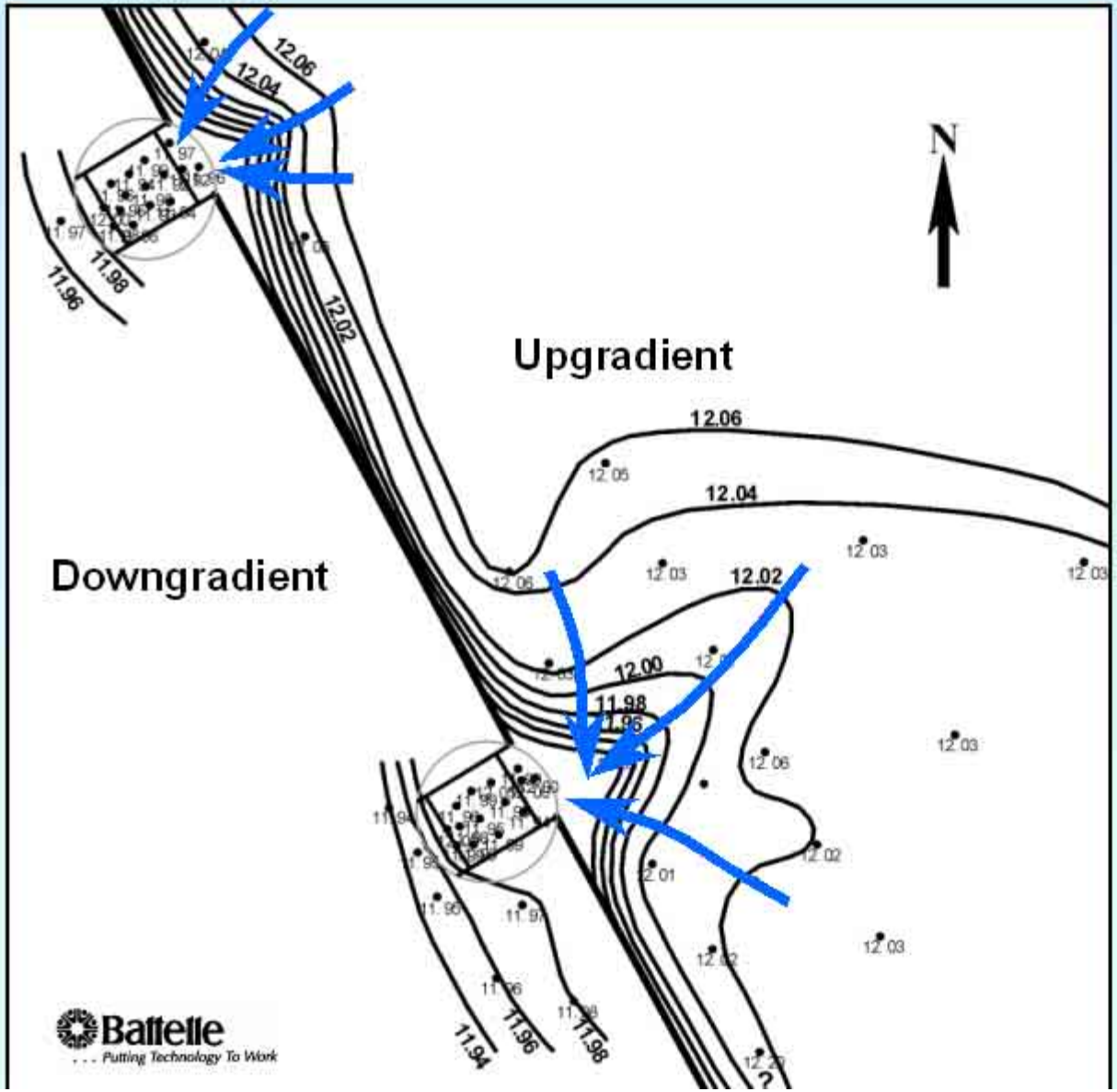


HydroTechnics™ Results – Dover AFB

- After stabilization, the flow direction was directly through the gate
- Precipitation events briefly affected flow direction, and sometimes led to momentary reversals



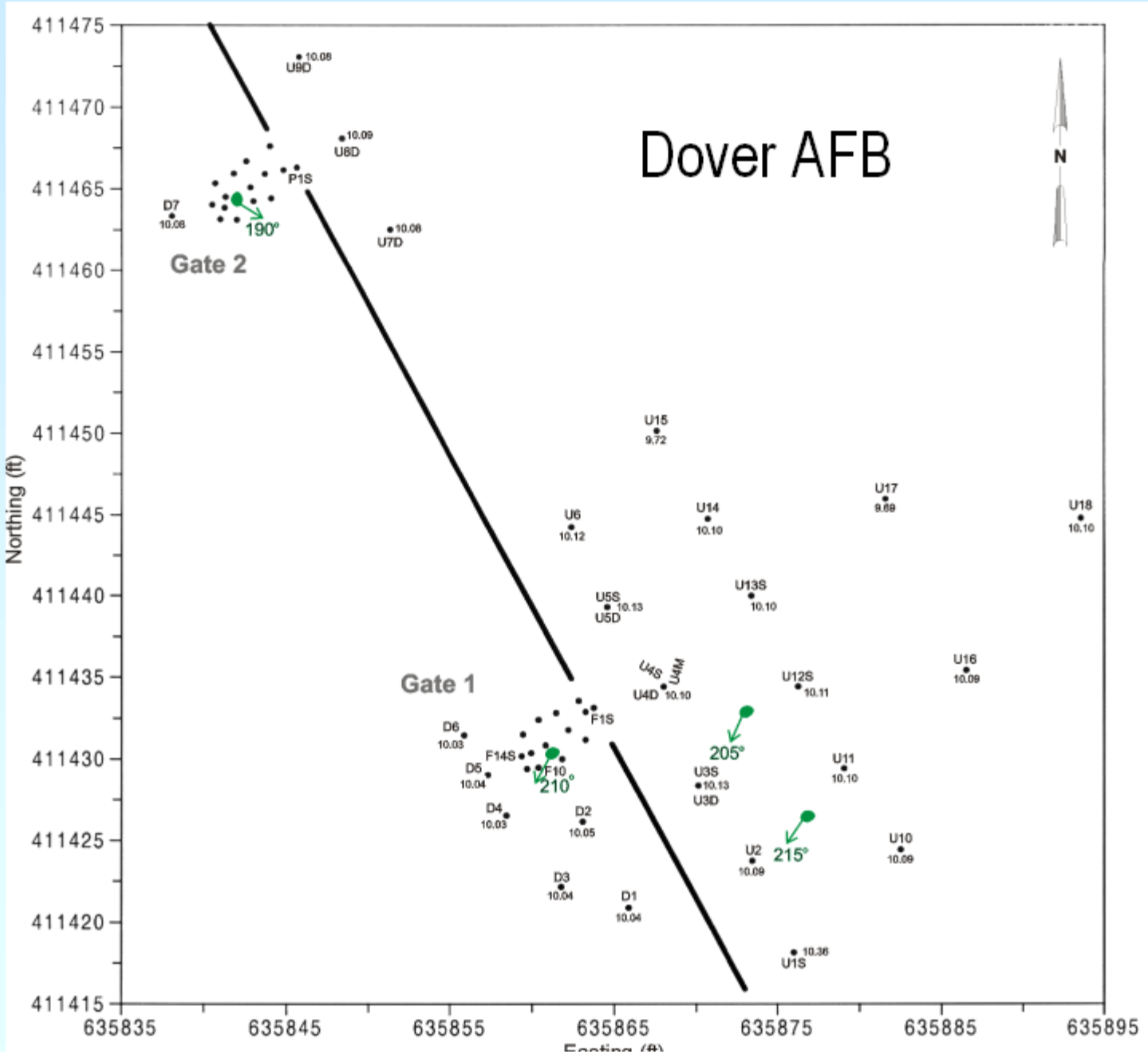
Water Level Measurements – Dover AFB



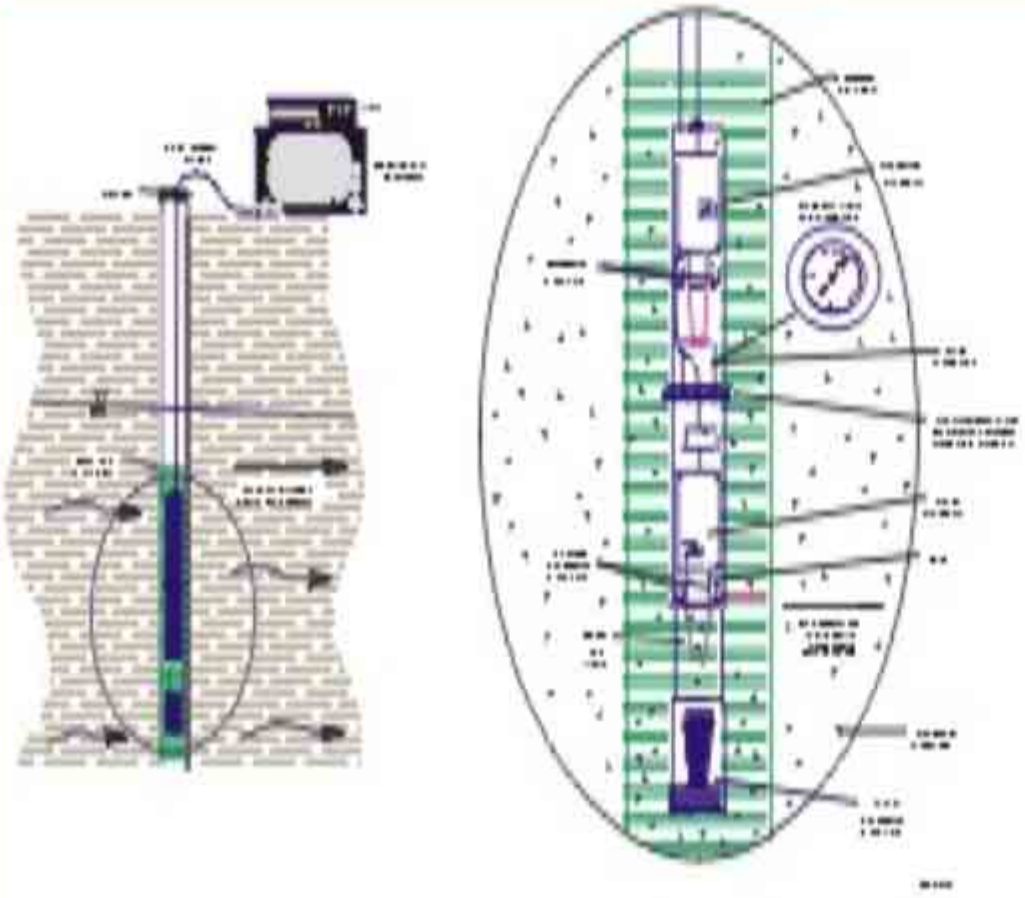
Water level maps provide evidence for asymmetric flow through both gates

Groundwater Flow Direction Line

HydroTechnics™ Measurements



Velocity Measurements with a Colloidal Borescope



Schematic of the Colloidal Borescope in-situ.

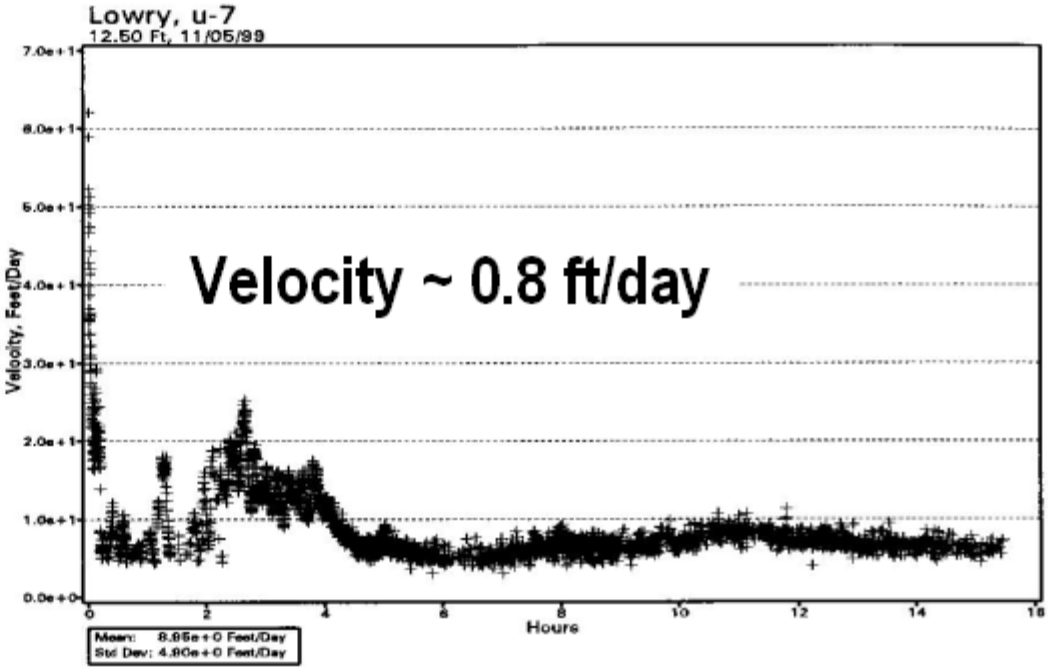
Photo of the borescope.

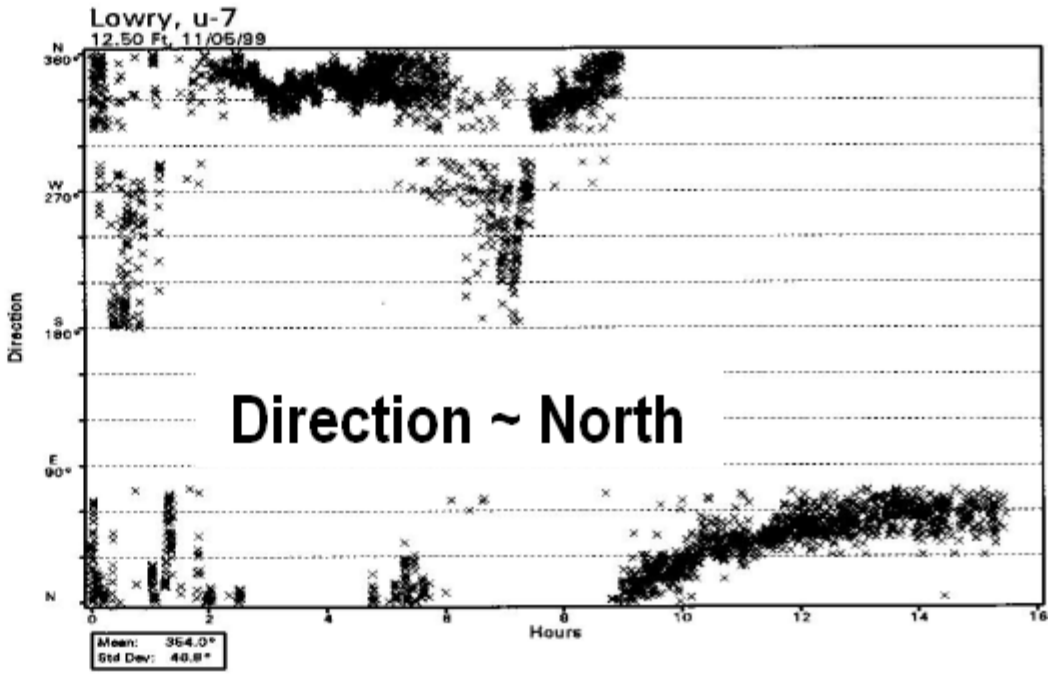
Use of Colloidal Borescope at Lowry AFB

- Portable instrument
- Needs 2-inch-diameter completed wells
- Tracks movement of colloids in the well bore
- One instrument can be used in several wells
- Works only when flow is stable

Real-Time Acquisition of Colloidal Borescope Data

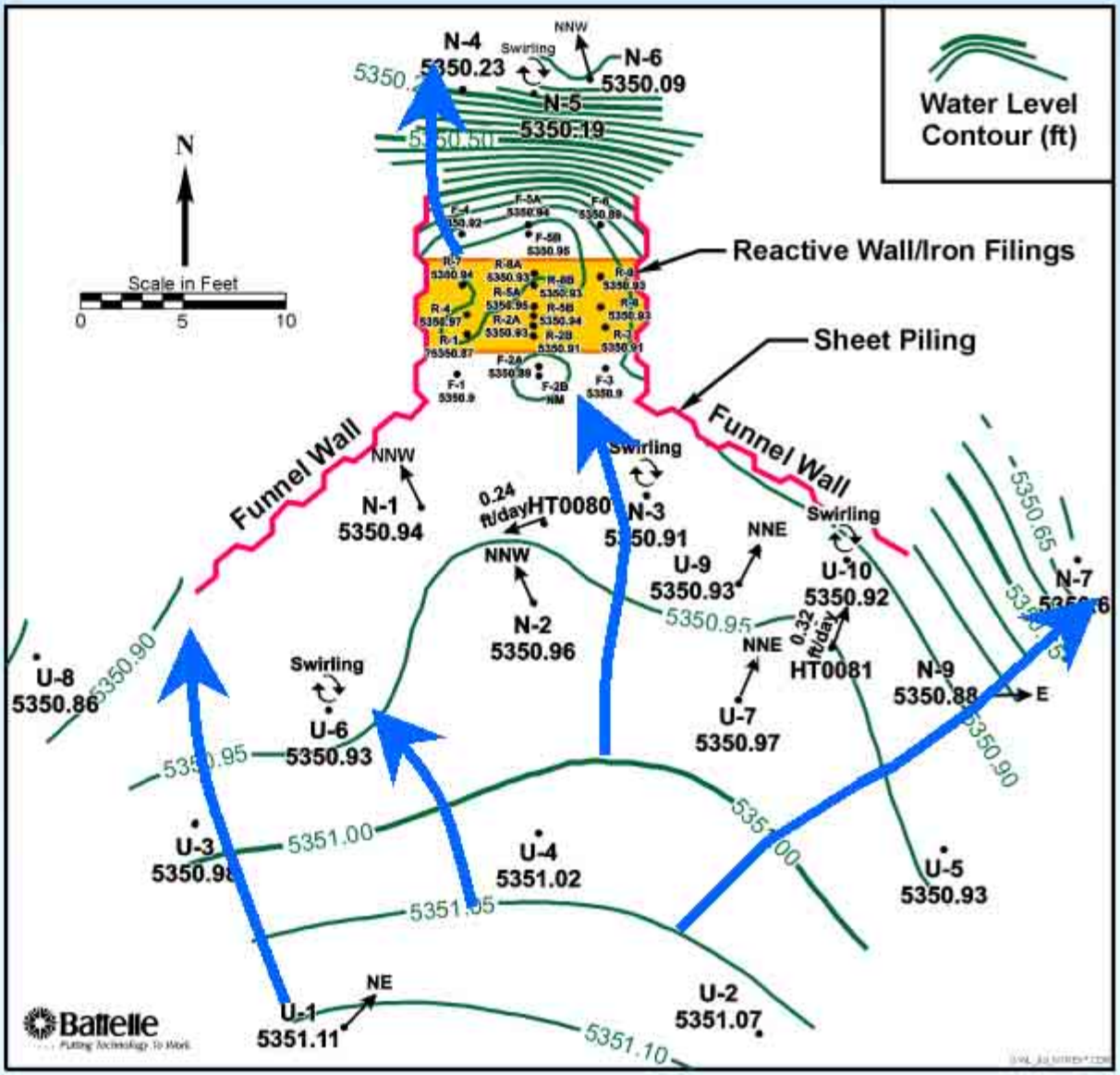
Colloidal Borescope Data – Lowry AFB





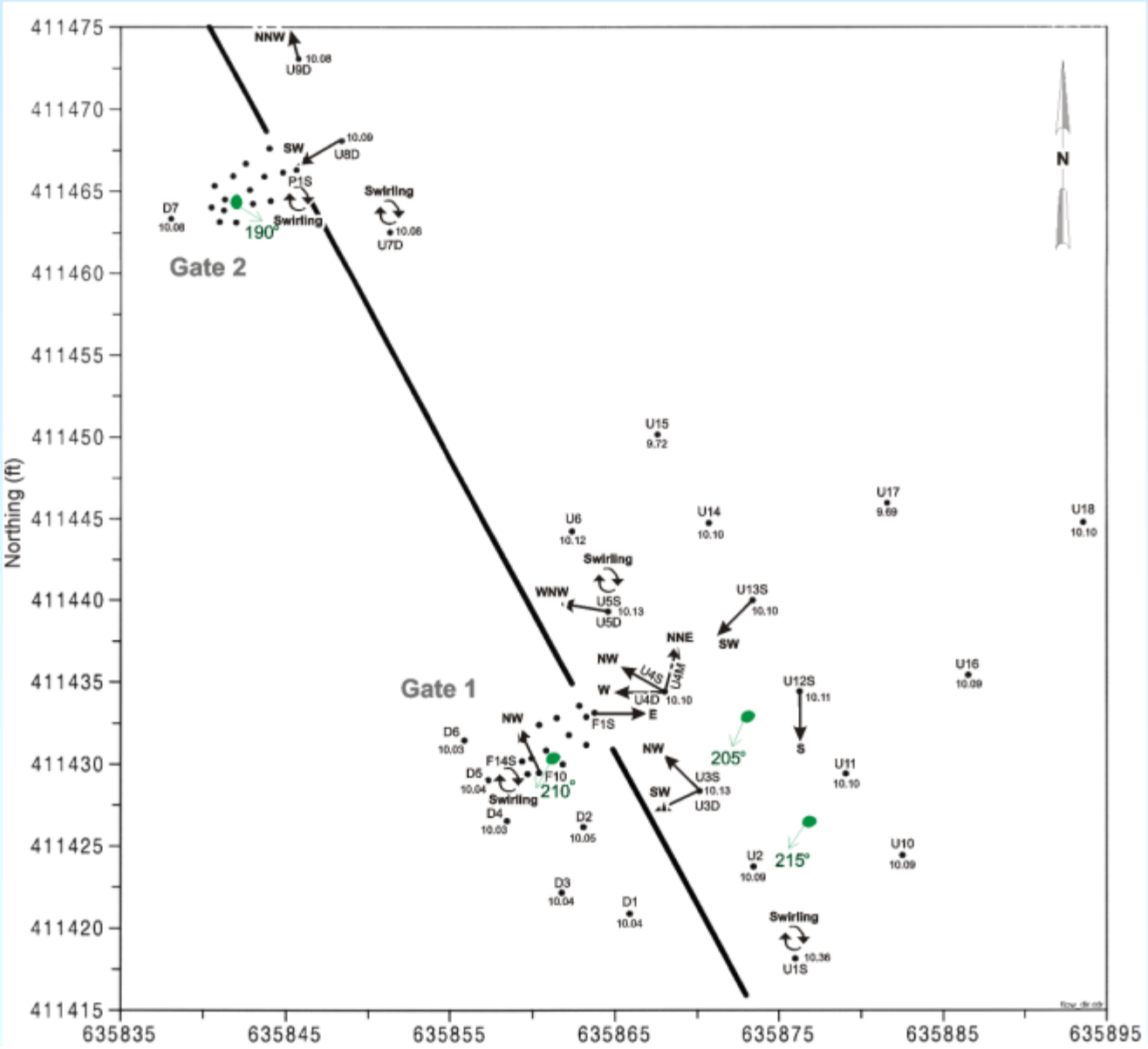
Comparison of Results – Lowry AFB

Asymmetric Capture Zone Caused by Stream Flowing on East Side



Groundwater Flow Direction Line

Comparison of HydroTechnics™ and Borescope Results – Dover AFB



Evaluation of HydroTechnics™ Sensor Performance

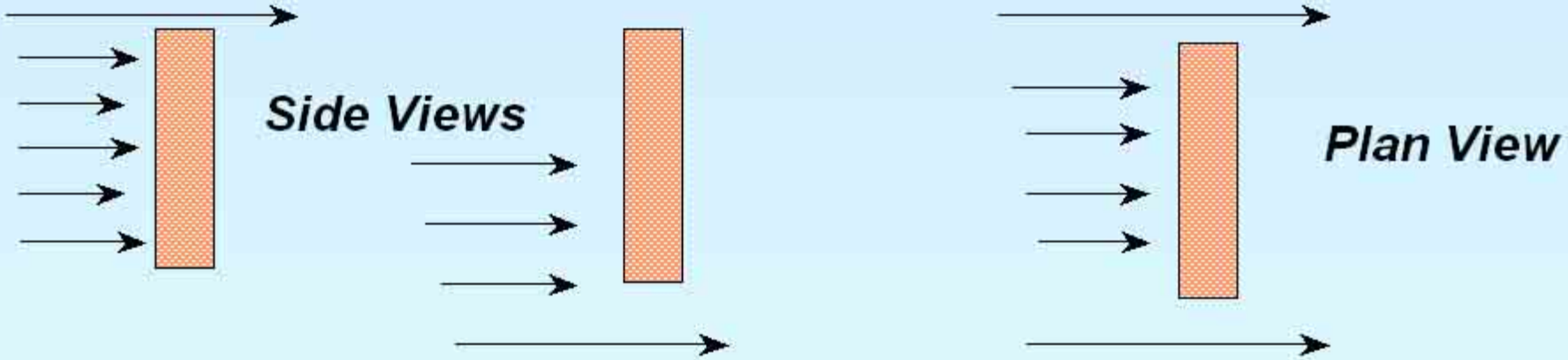
- Continuous data recording over many months
- Able to record effects of rainfall events, seasonal and annual groundwater fluctuations
- HydroTechnics™ sensor measures very localized flow
- Provides velocity and direction for a single point in space, but also get temporal data
- Performance inside ZVI barrier not fully explored; e.g., did not try to optimize power input to sensor

Evaluation of Colloidal Borescope Sensor Performance

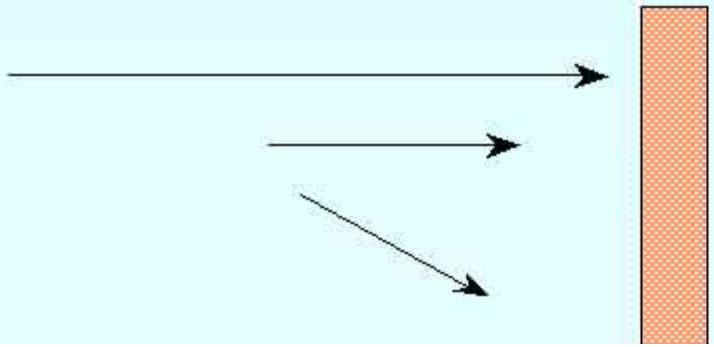
- Colloidal borescope measures particle movement along preferential flow paths
- Results biased toward high conductivity zones
- Works only when flow is stable
- Data collected over period of one day (so it's better not to use probe during atypical conditions)
- Are borescope measurements representative of overall flow conditions? Results are uncertain.

Potential Flow Problems at PRB Sites

- The plume could pass over, under, or around the PRB



- Flux may be non-uniform, thereby creating variable velocity conditions and shifting hydraulic gradient directions



Residence time is a function of particle velocity

Implications for Designing a PRB

- There is a tradeoff between safety factors (plume breakthrough/bypass) and future risk of having to make changes to the PRB to improve hydraulic performance
- Water-level measurements remain the best indicator of bulk groundwater flow
- Selective use of HydroTechnics™ sensors (measures very localized flow) and colloidal borescope (measures preferential flow) may be useful at some highly heterogeneous sites