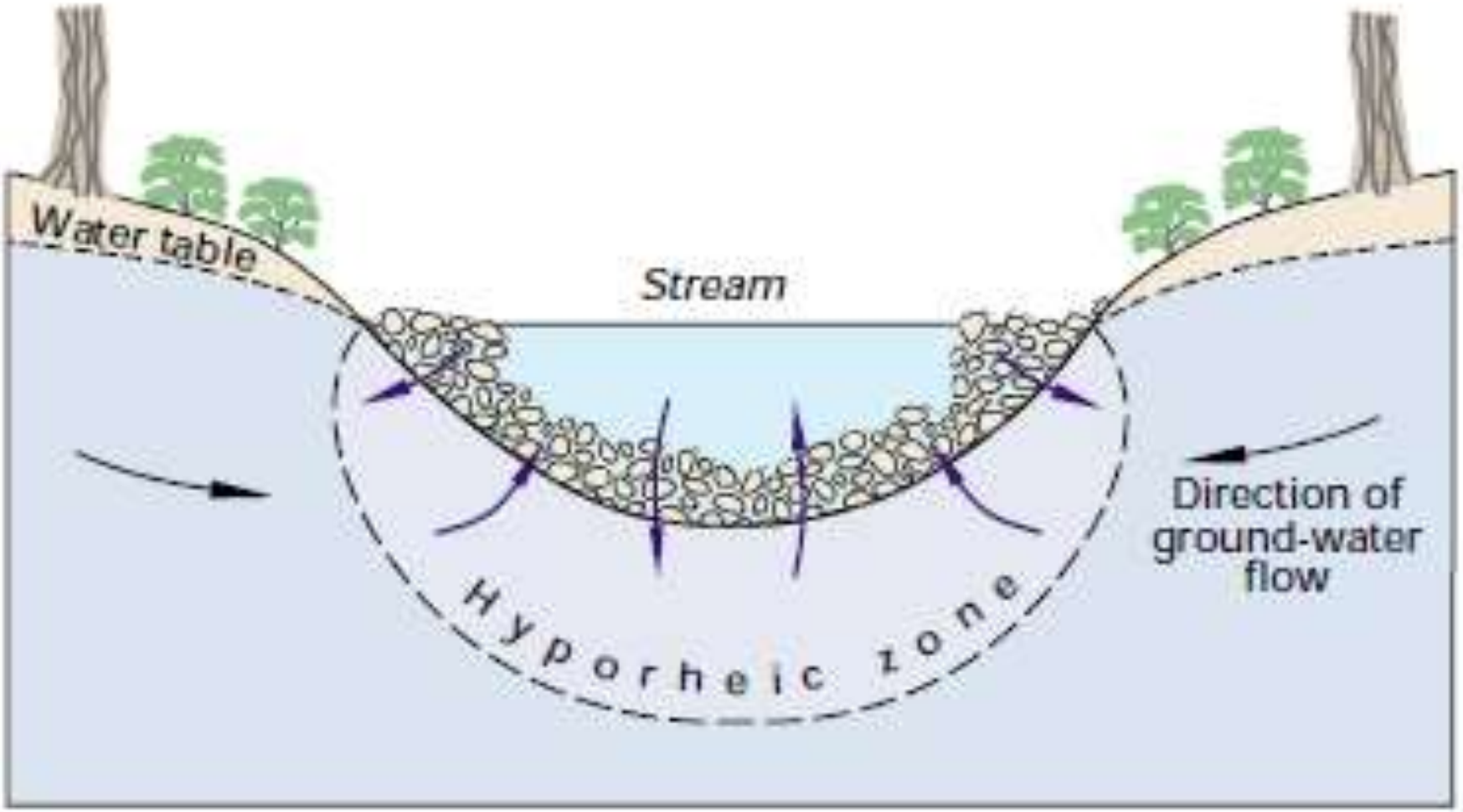
Evaluation of Groundwater Discharging to Surface Water – Adventures in the Hyporheic Zone

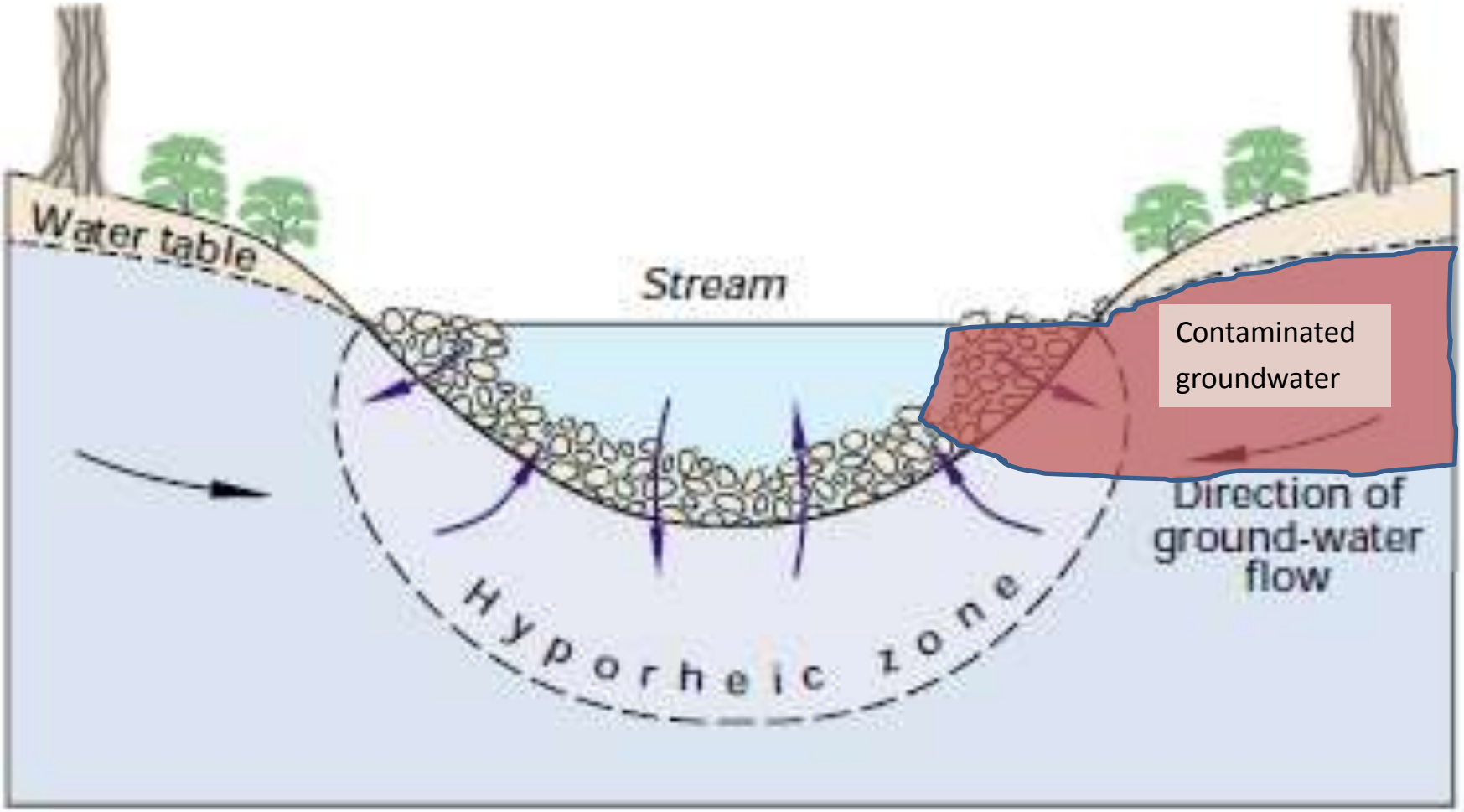
Presented at WEDA Midwest, St. Louis, MO,
by Gene McLinn, Burns & McDonnell, April 18, 2013

Groundwater Discharging to Surface Water



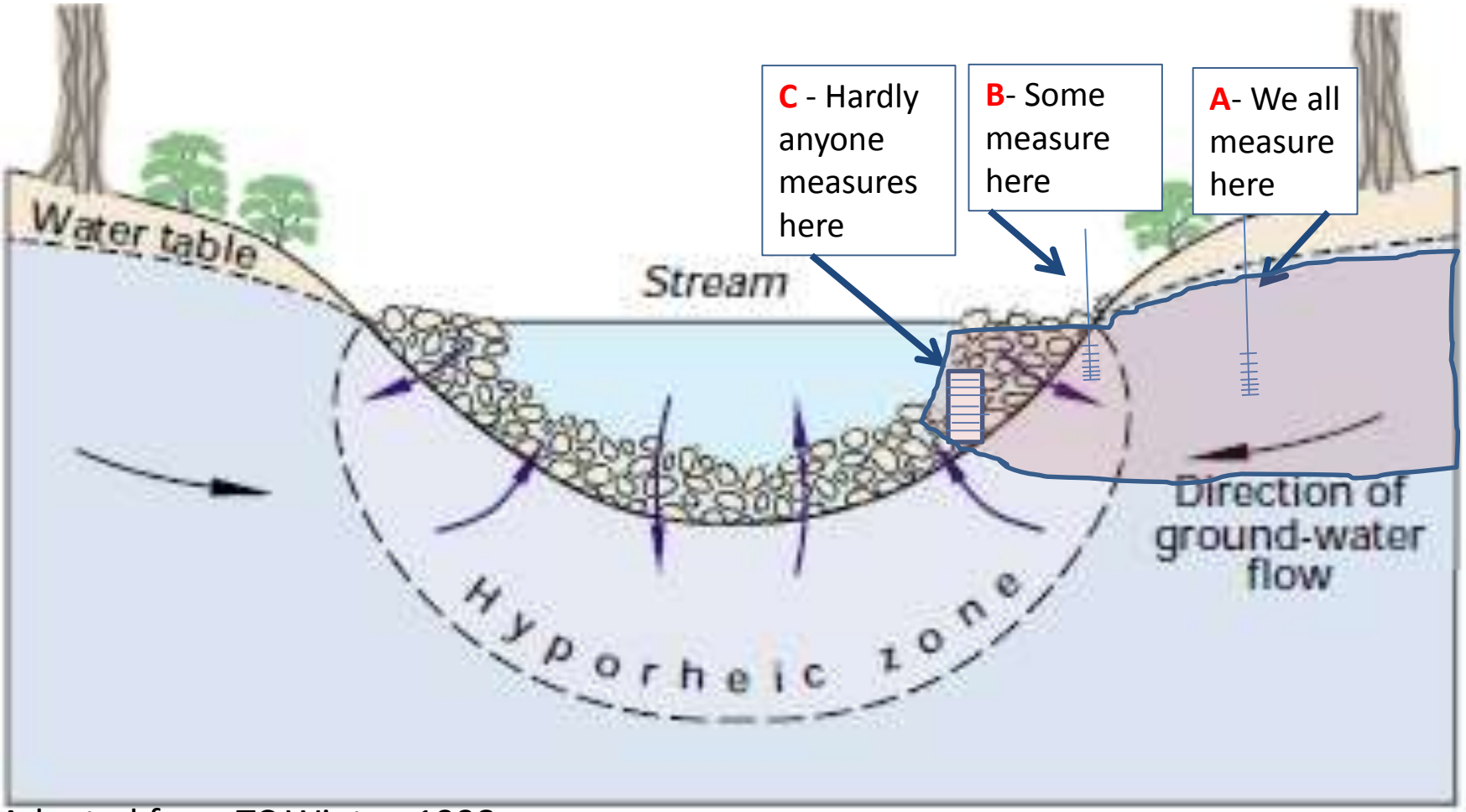
TC Winter, 1998

What If Contaminated Groundwater Is Discharging to Surface Water?



TC Winter, 1998

- Are the contaminant concentrations measured in wells at **A** representative of the groundwater discharging to the river?
- How much of the groundwater contamination needs to be addressed with, say, a sediment treatment cap?



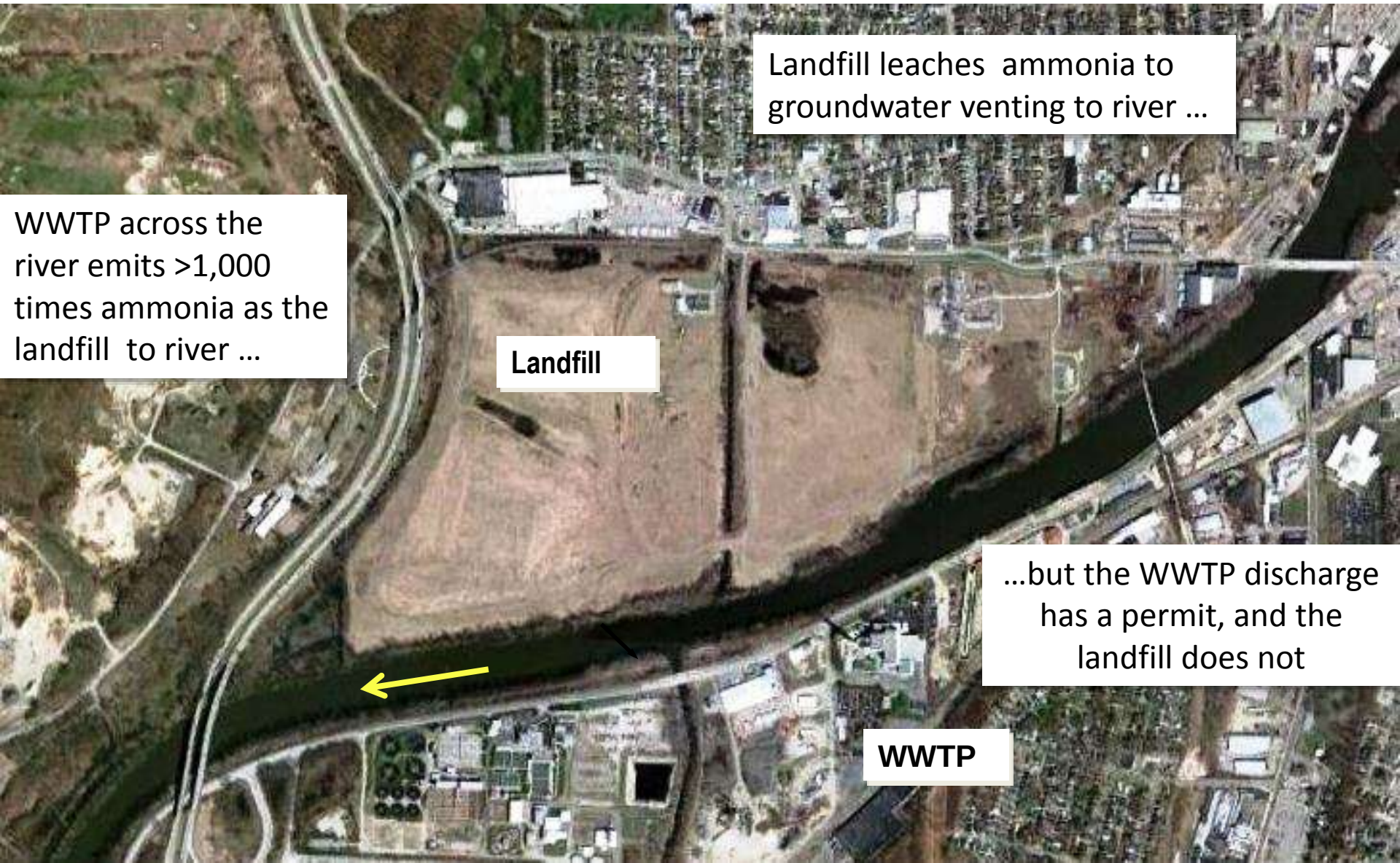
Adapted from TC Winter, 1998

Example 1 –Ammonia Discharge to a Fully Allocated Stream

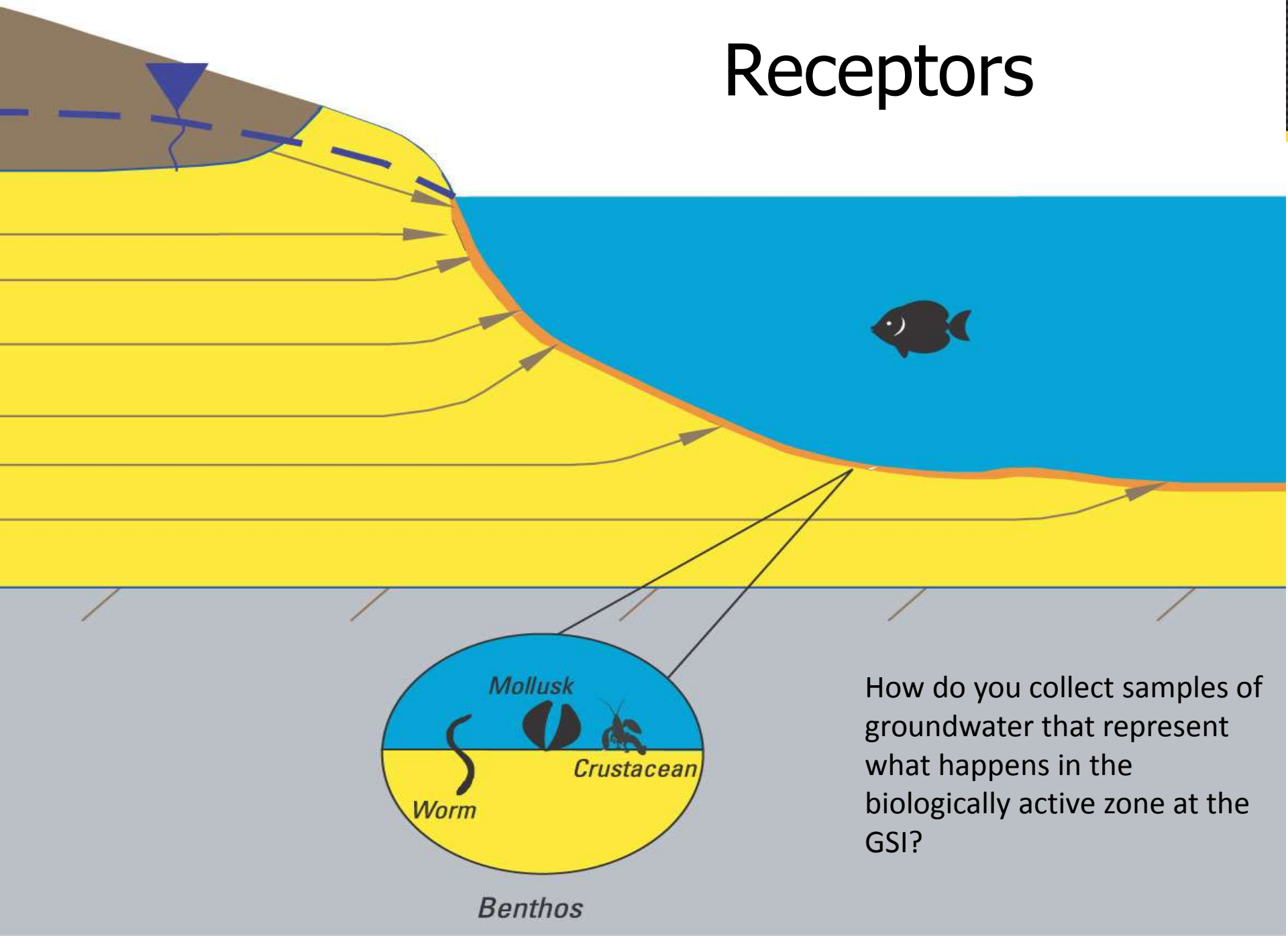
- MSW landfill - 1920s to 1978
- Ammonia produced by decay of organic matter (food waste and sewage sludge), common constituent in landfill plumes
- Extensive monitoring shows that ammonia is the only COPC in groundwater at the site, based on concentrations of ammonia detected in monitoring wells between landfill and river

(Figures adapted from McLinn, 2005)

Landfill and Wastewater Treatment Plant

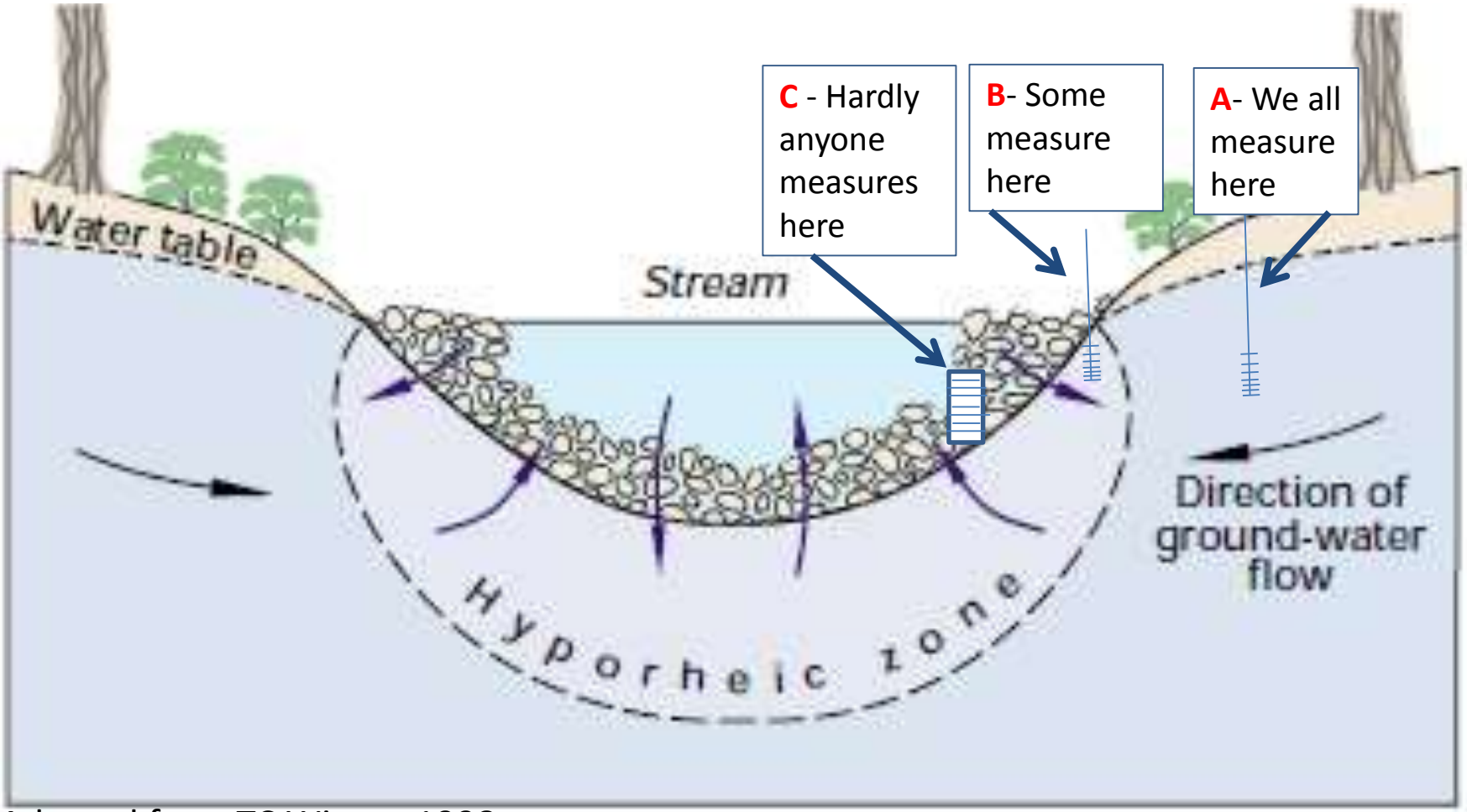


Receptors



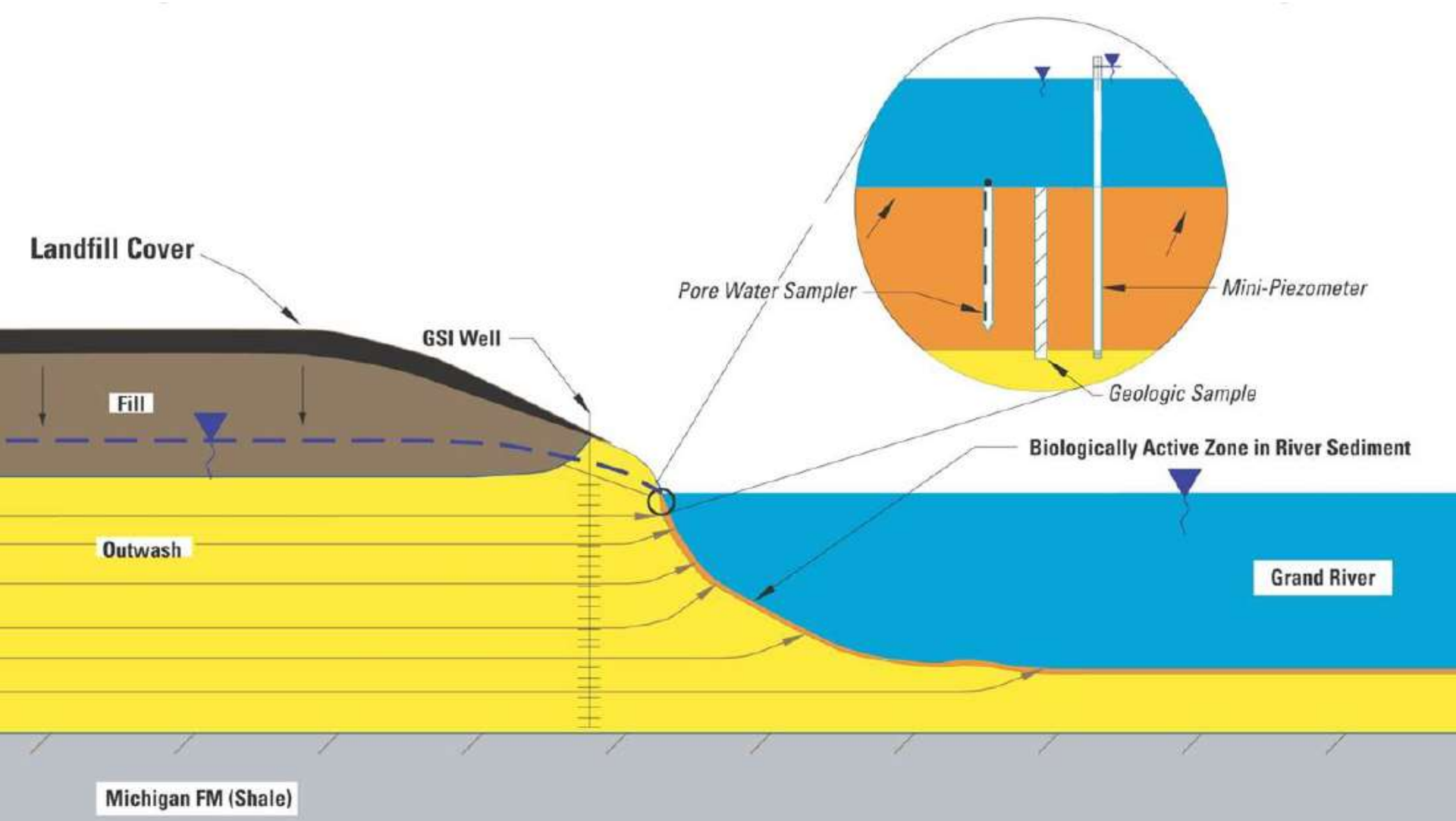
How do you collect samples of groundwater that represent what happens in the biologically active zone at the GSI?

- Are the ammonia concentrations measured in wells at **A** representative of the groundwater discharging to the river?
- How much of the ammonia in groundwater from the landfill actually reaches the river?

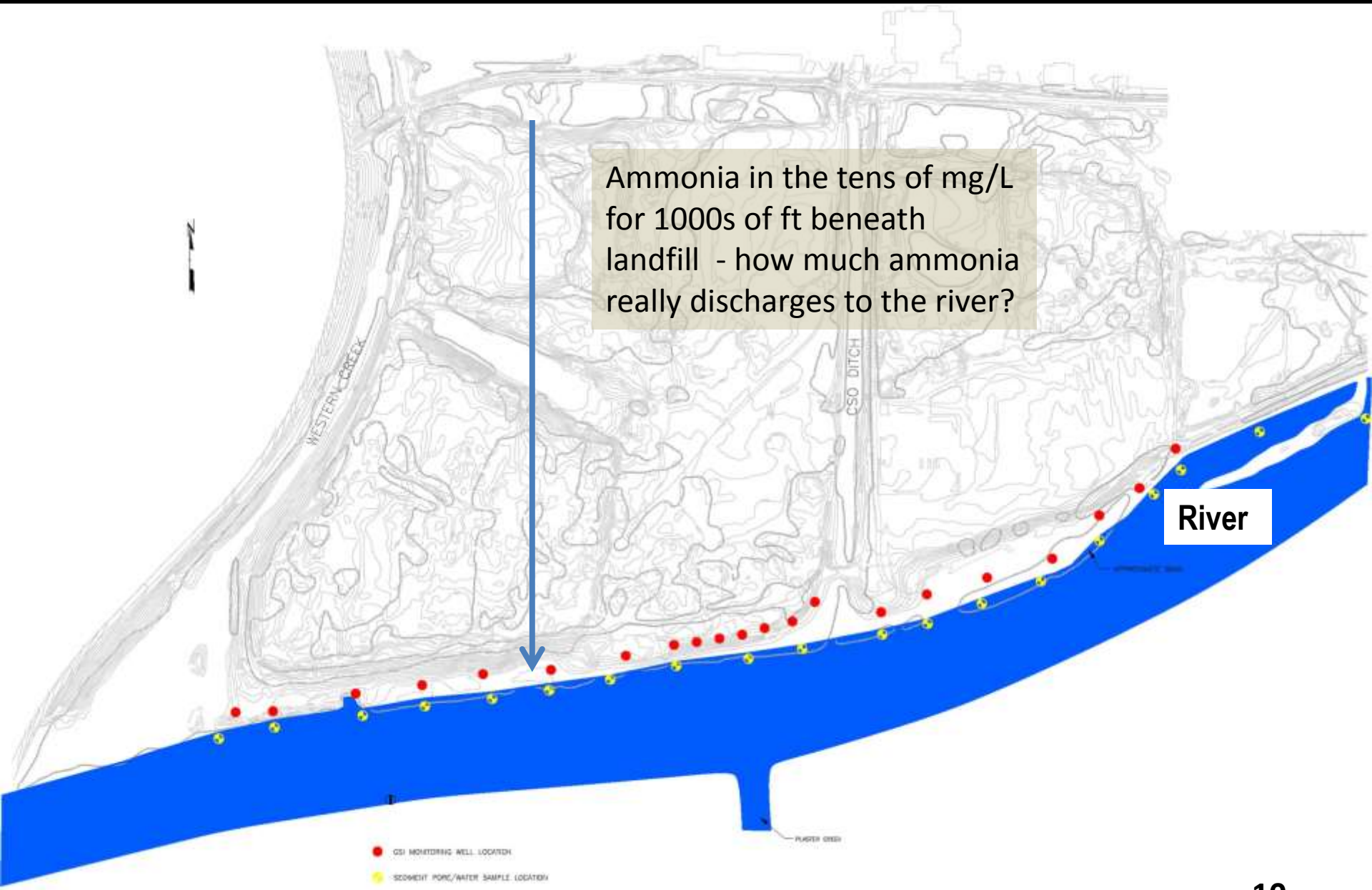


Adapted from TC Winter, 1998

Site-Specific Array to Assess Ammonia Fate in the River

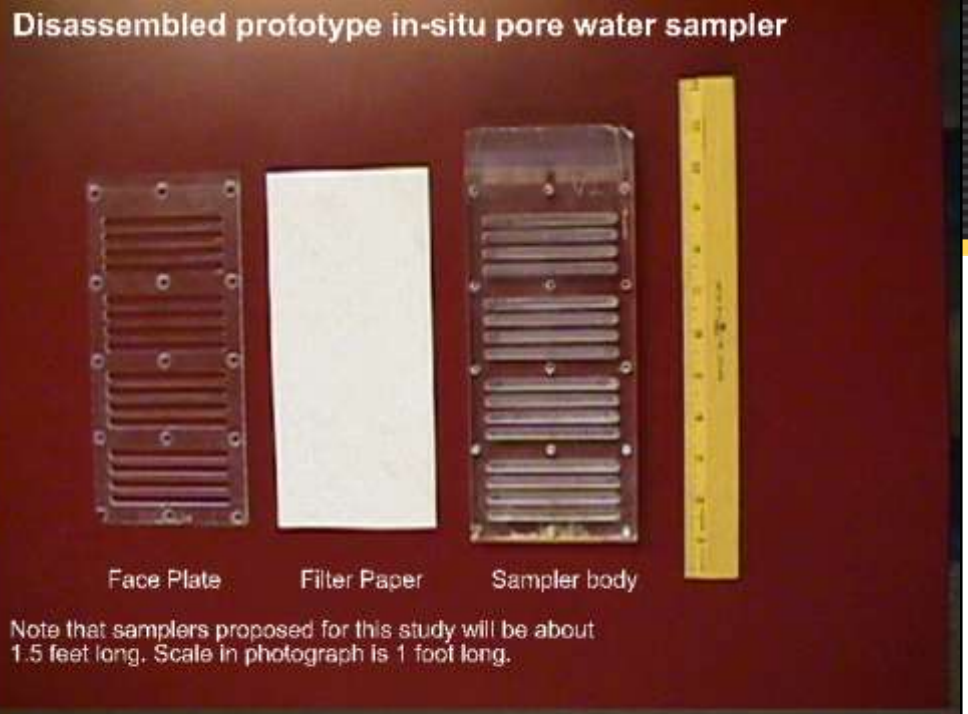


Monitoring Well and Mini-Piezometer/Diffusion Sampler Array

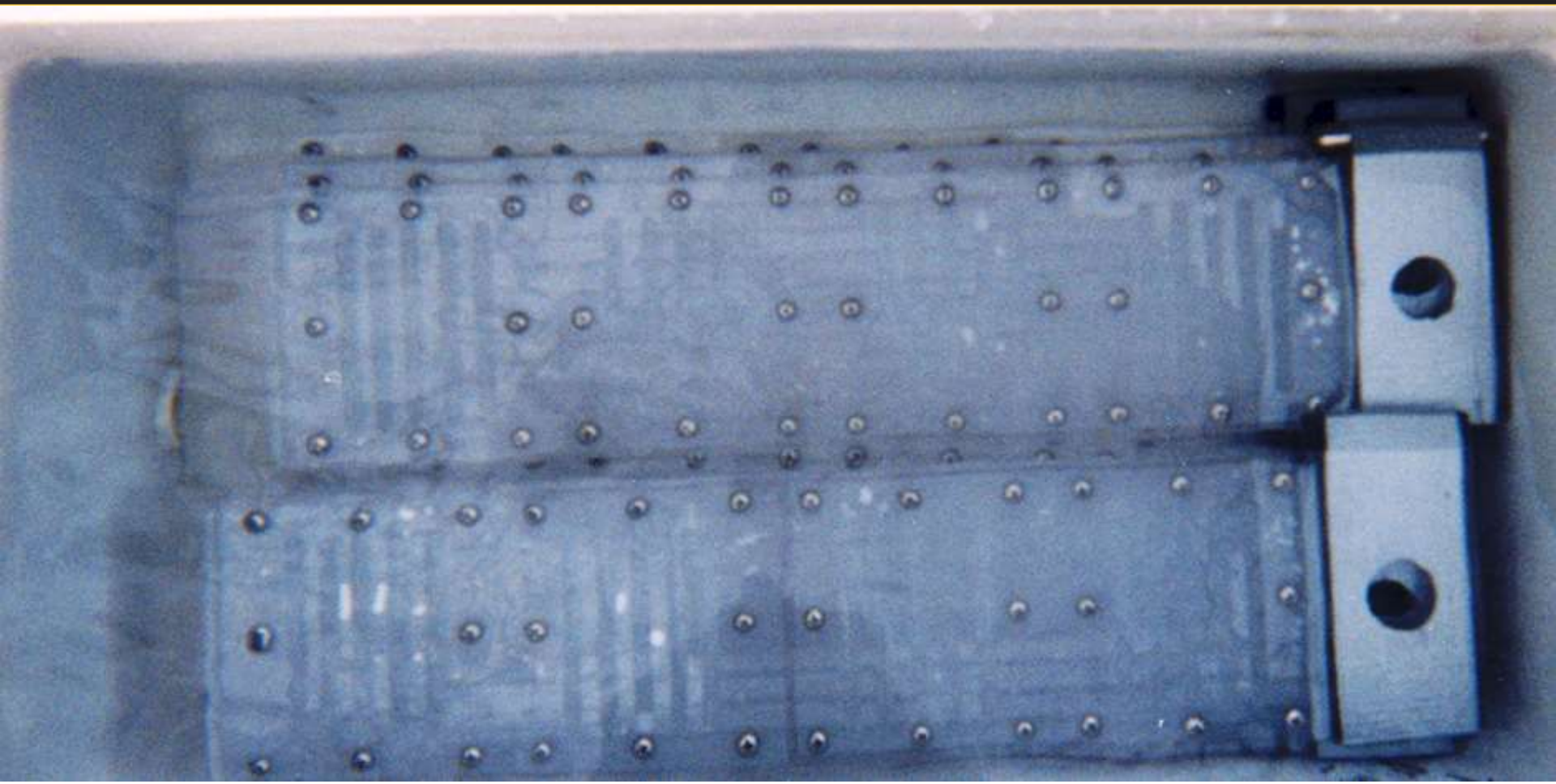


Diffusion Sampler/ Peeper Construction

- Custom-manufactured
- Plastic (soft) sampler with nylon filter
- Installed by hand
- Monitor discrete intervals (5 cm long)



Diffusion Sampler Construction



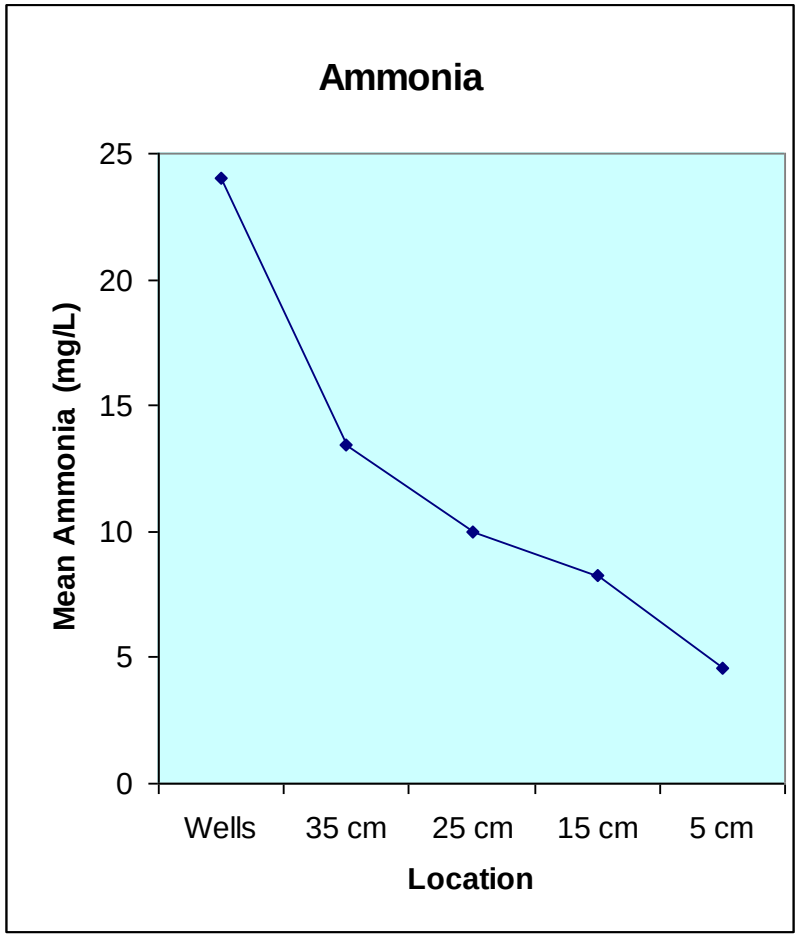
- Filled with degassed, distilled water
- Collect time-averaged samples (leave in place 2 weeks)
- Four sample depth intervals
- Magnet

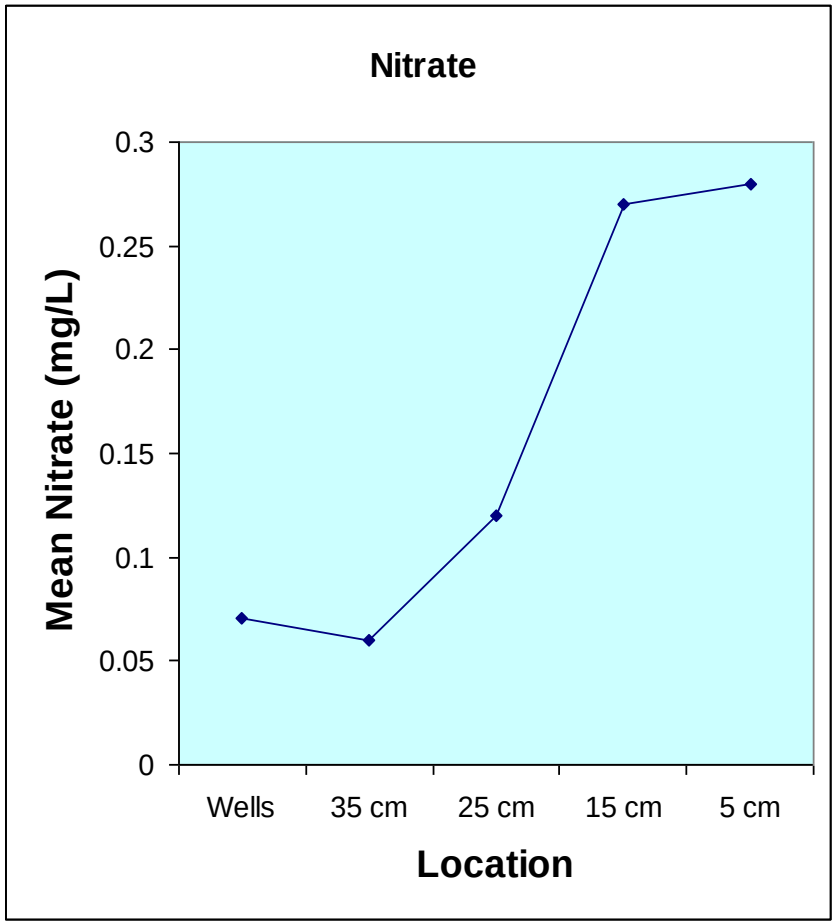
Diffusion Sampler and Mini-piezometer Installation

- Installation of diffusion sampler in riverbed during period of baseflow (gaining reach)
- No recharge events over monitoring period; flow direction confirmed with hydraulic head measurements (mini-piezometer in foreground)
- Had to pound samplers into sand and gravel river bottom - blank first, then sampler (some attrition)
- Riverbed sample for geologic characterization

Measuring Water Levels in River and Below Riverbed

Results - Changes in Nitrogen Species





- Ammonia is consistently in the 10s of mg/L for the first 2,000 ft of the flow path, but decreases by a factor of five along the last foot (30 cm) of the flow path; nitrate follows an inverse trend (scale change)

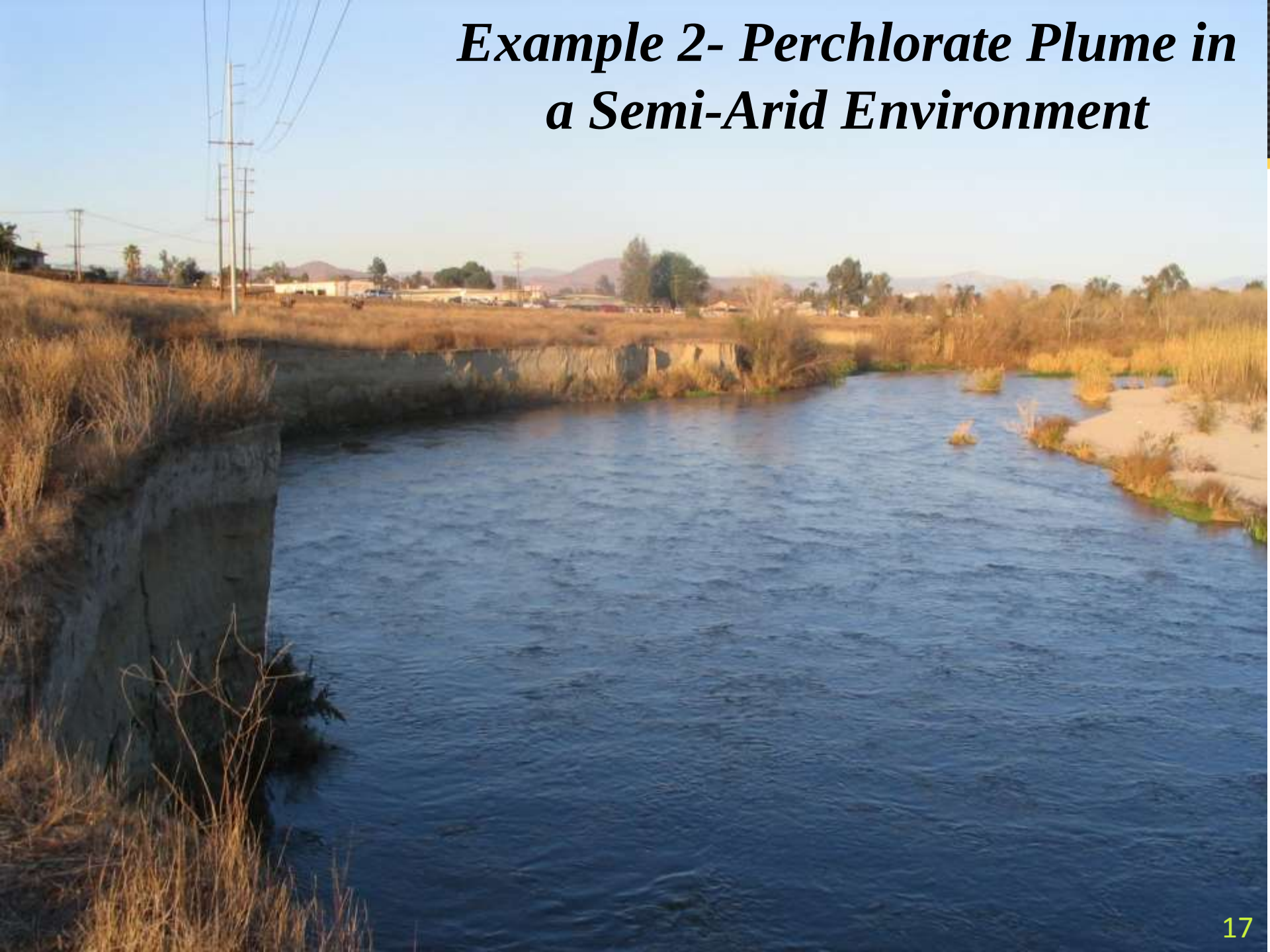
Mechanism for Ammonia Loss

- Ammonia is transformed to (unmeasured) nitrogen gas or nitrous oxide in shallow sediment enriched in oxygen - bioturbation and chemical gradients drive diffusion of oxygen from river into shallow sediment

OR

- Ammonia transport is retarded relative to nitrate transport – nitrate is whisked away faster than it is generated, because transport rate is at disequilibrium with rate of transformation

Example 2- Perchlorate Plume in a Semi-Arid Environment



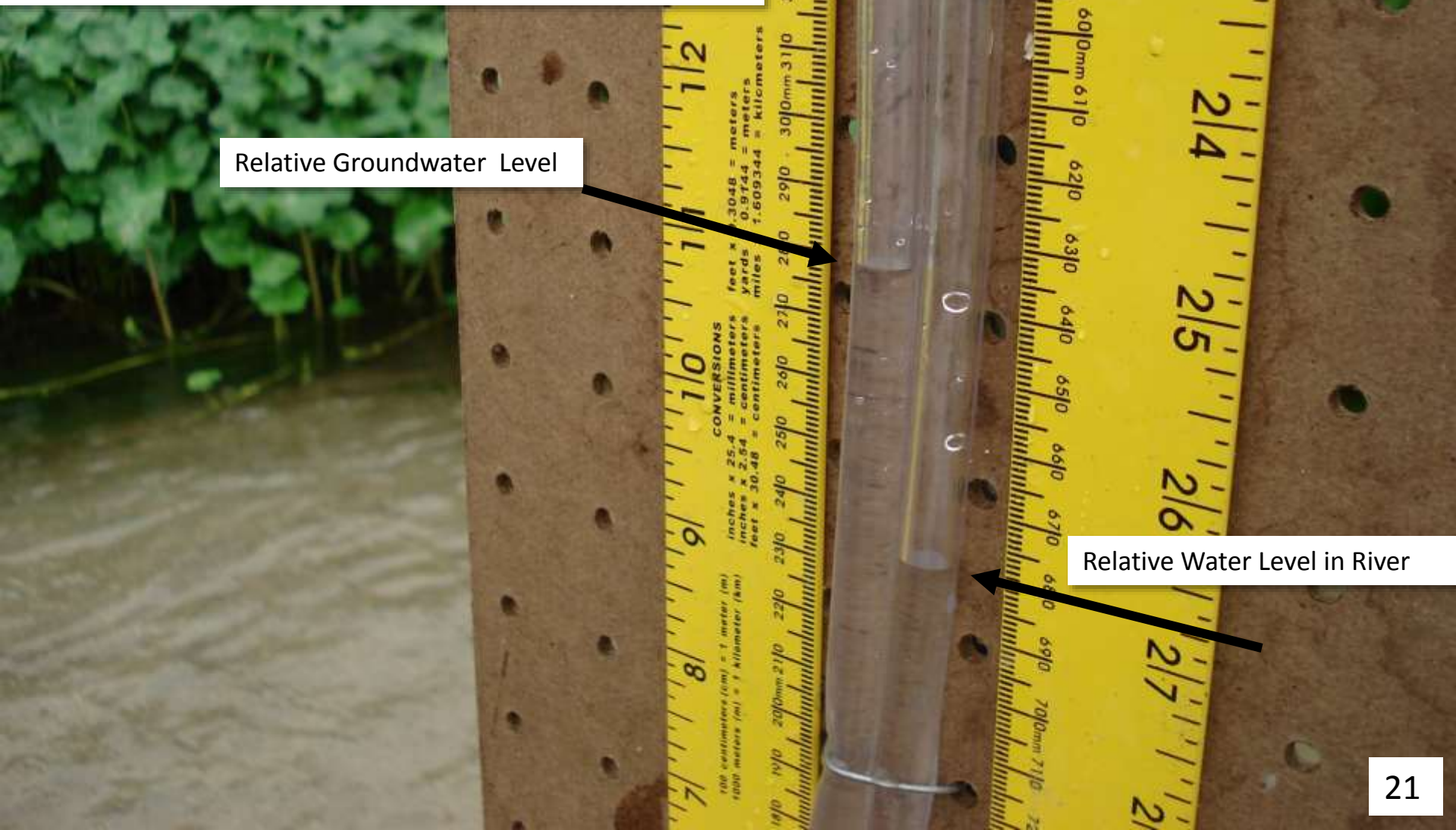
Perchlorate Plume Greater than Five Miles Long – How Much Discharges to the River?

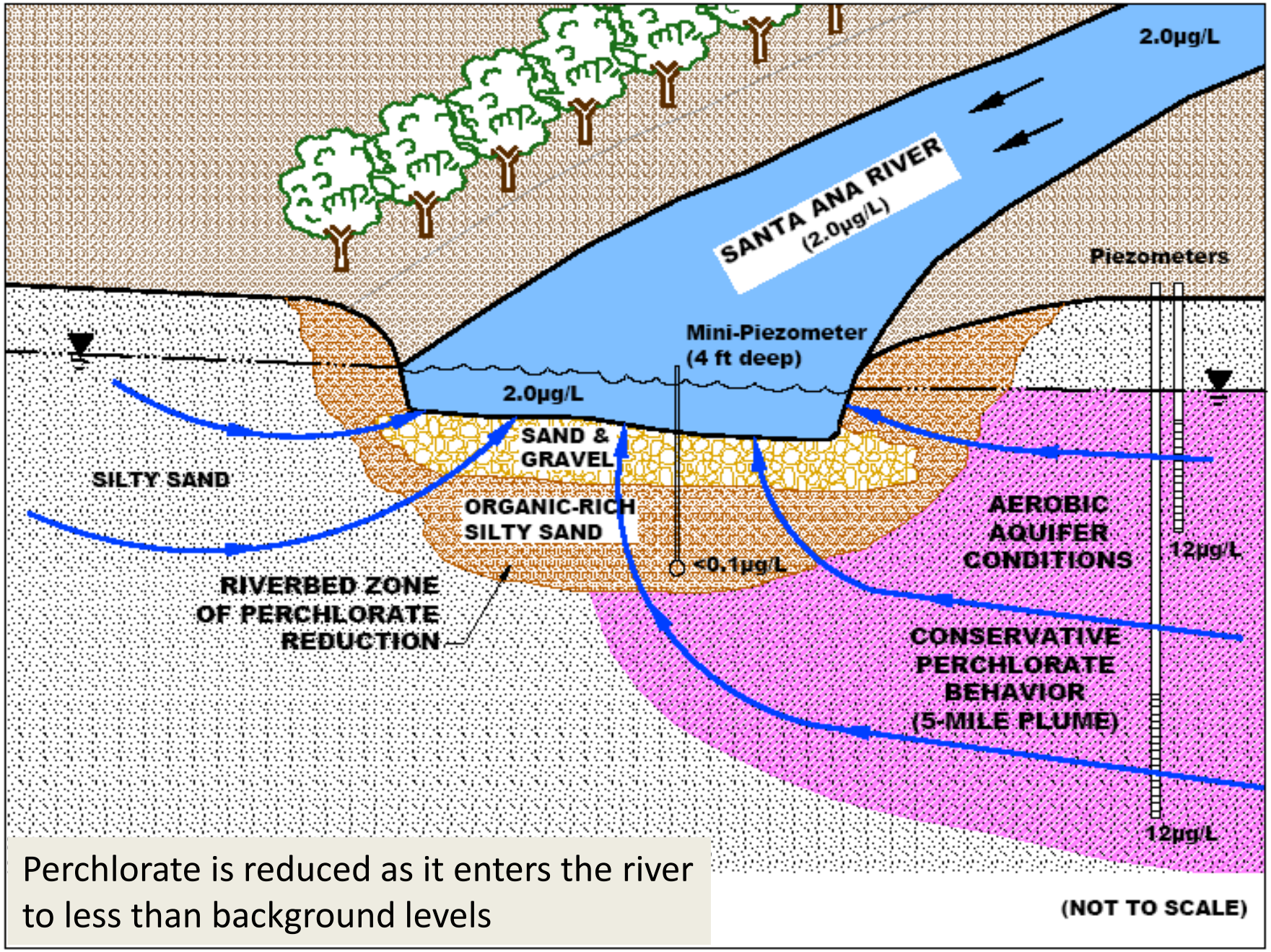
(Adapted from Kenoyer and others, 2009)


Potentiomanometer
Each month, installed 7 mini-piezometers in sediments beneath the Santa Ana River, along 2-mile stretch
Measured hydraulic gradient - up vs. down – beneath river
Mini-Piezometer


Coarse sand typical over most riverbed
Organic-rich silty sand, chemically reducing riverbed sediments, in zone of groundwater discharge

- Where downward gradients, groundwater closely resembles river chemistry
- Where upward gradient, groundwater differs from river
    1. Negative ORP (chemically reducing)
    2. Non-detectable nitrate
    3. Non-detectable perchlorate





Perchlorate is reduced as it enters the river to less than background levels

section.dwg

Conclusions

- In both cases, the use of samples from monitoring wells overestimated the concentration of contaminants in groundwater discharging to the river
- Monitoring programs for assessment of venting groundwater should allow for collection of samples that are representative of water that is actually discharging to the river