



LeonardRice
ENGINEERS, INC.

Groundwater Solutions for Indirect Potable Reuse

2014 Rocky Mountain Water Reuse Workshop

August 14, 2014

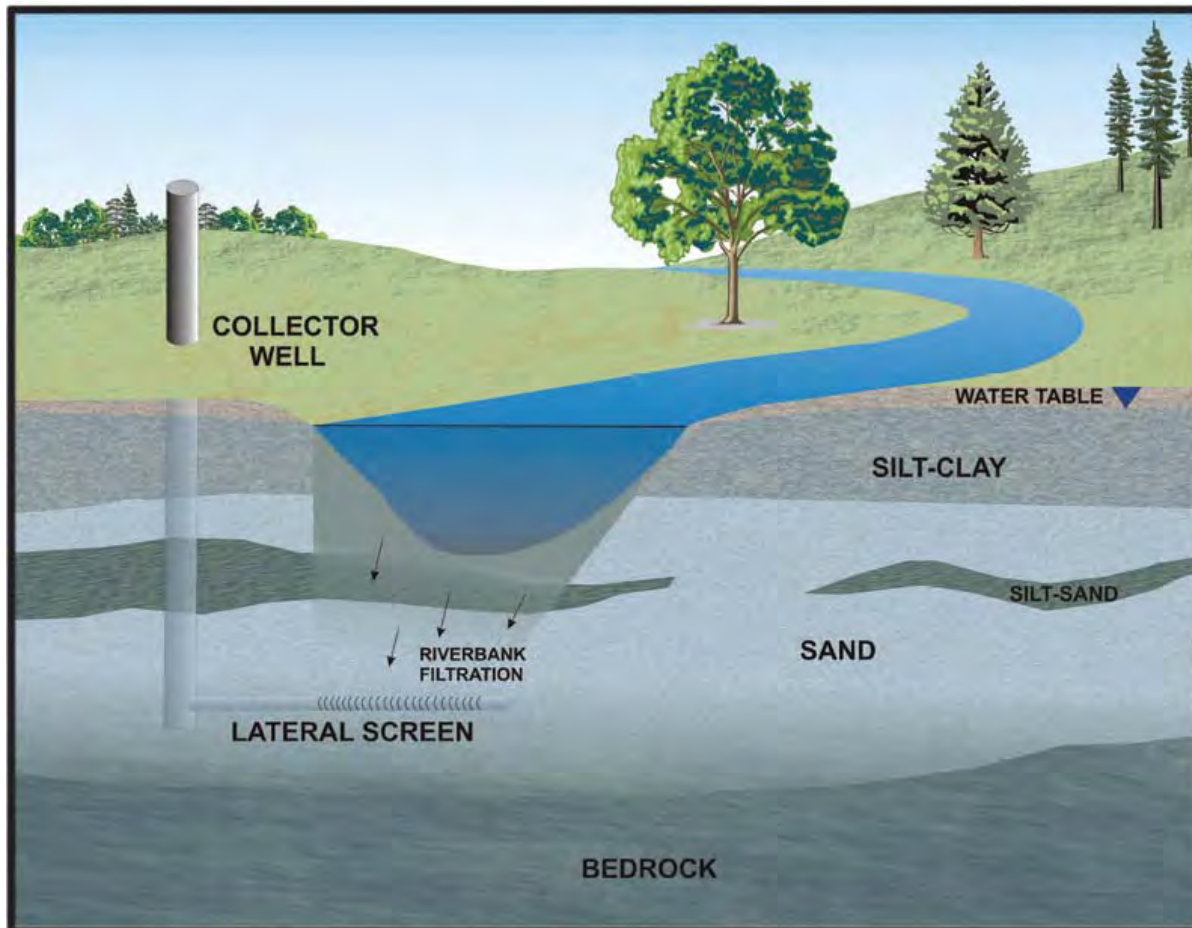
Dave Colvin

Agenda

- Types of water reuse groundwater solutions
- Benefits
- Feasibility project design
- Limitations
- Conclusions

Types of Groundwater Solutions for IPR

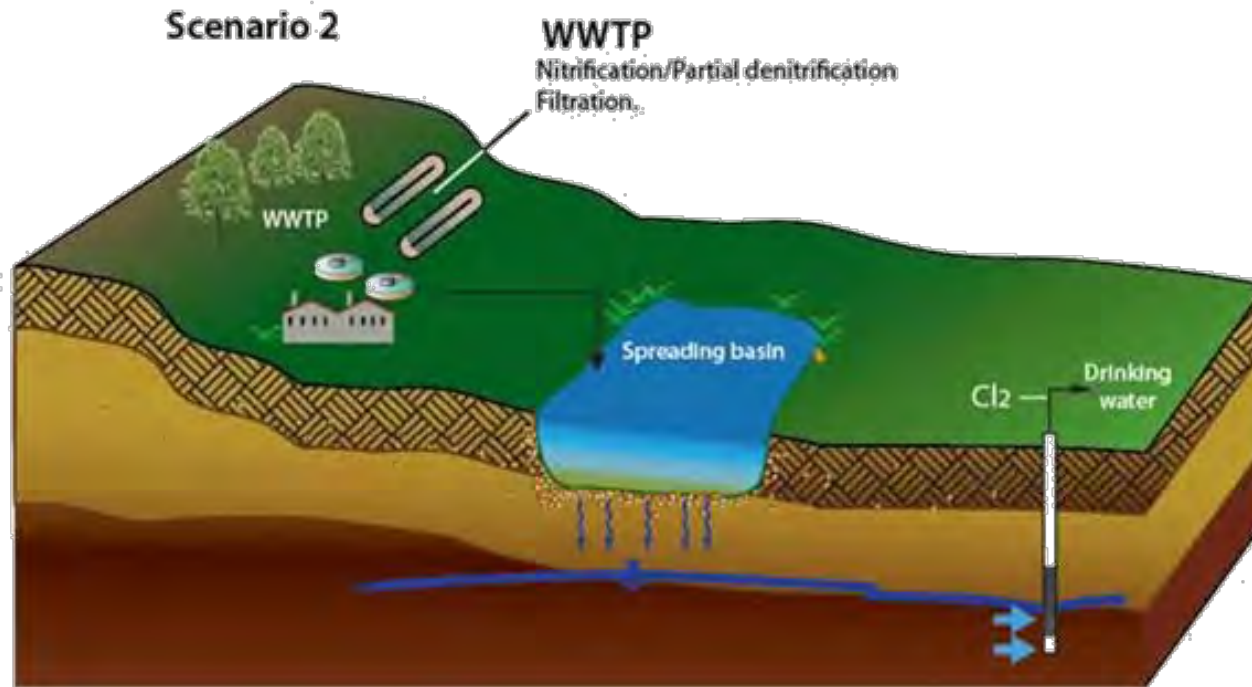
- Riverbank Filtration



Source: Kelly, B.P., and Rydlund, P.H., Jr., 2006, Water-Quality Changes Caused by Riverbank Filtration Between the Missouri River and Three Pumping Wells of the Independence, Missouri, Well Field 2003–05: U.S. Geological Survey Scientific Investigations Report 2006–5174, 48 p.; <http://pubs.usgs.gov/sir/2006/5174/pdf/sir2006-5174.pdf>

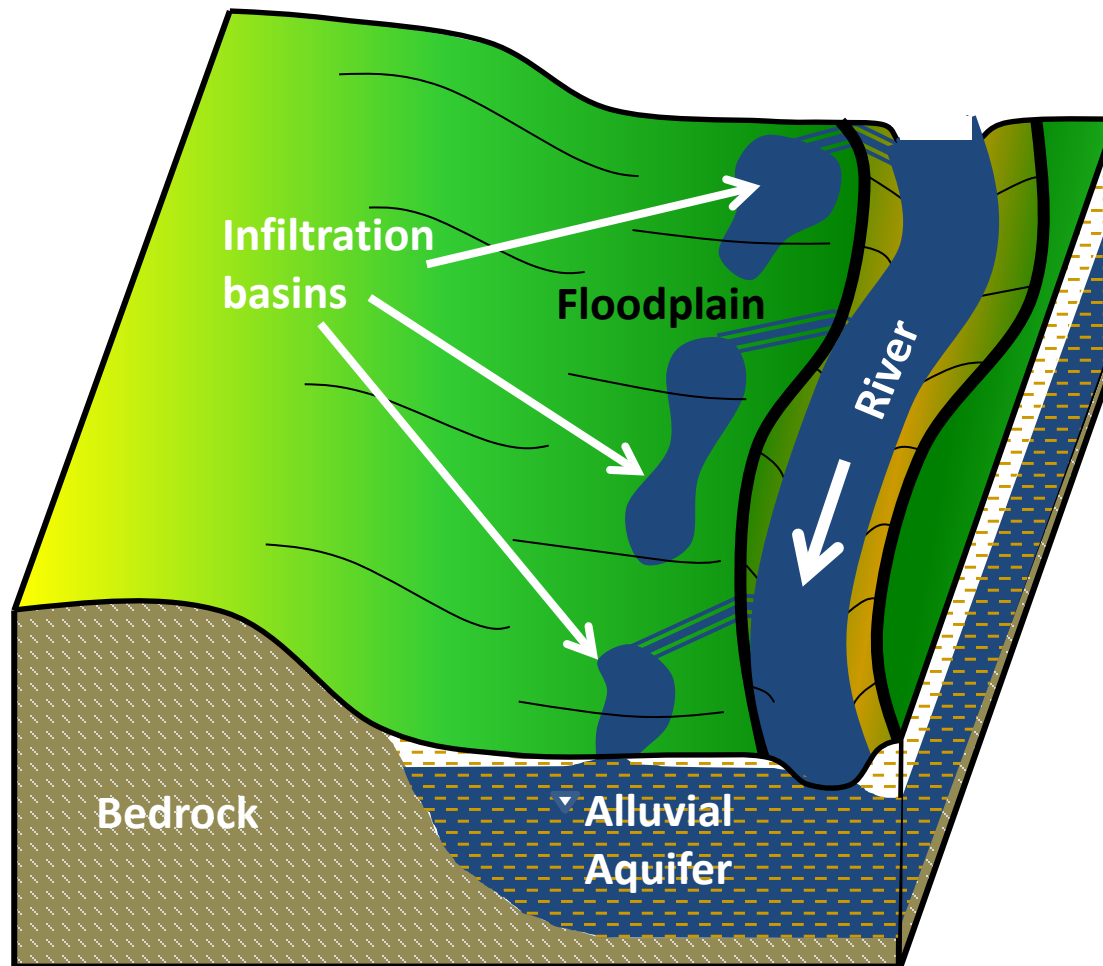
Types of Groundwater Solutions for IPR

- Riverbank Filtration
- Soil aquifer treatment



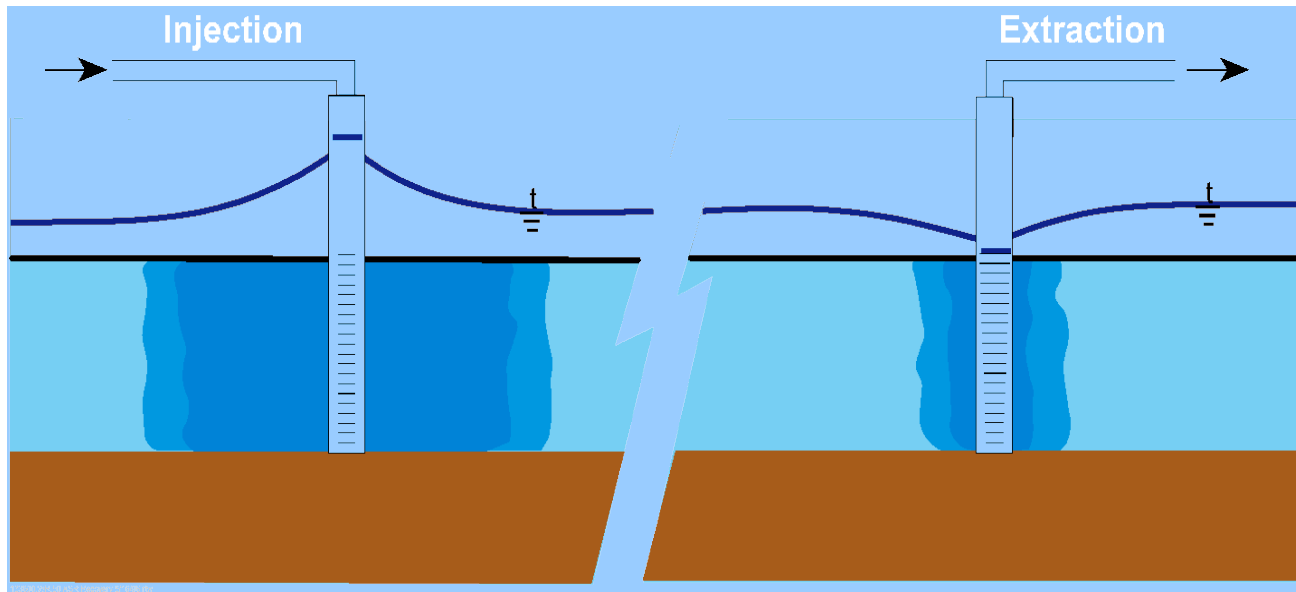
Source: http://www.westcas.org/PDF/Fall_2012_presentations/October_2012-SNYDER.pdf

Types of Groundwater Solutions for IPR



- Riverbank Filtration
- Soil aquifer treatment
- Managed Aquifer Recharge

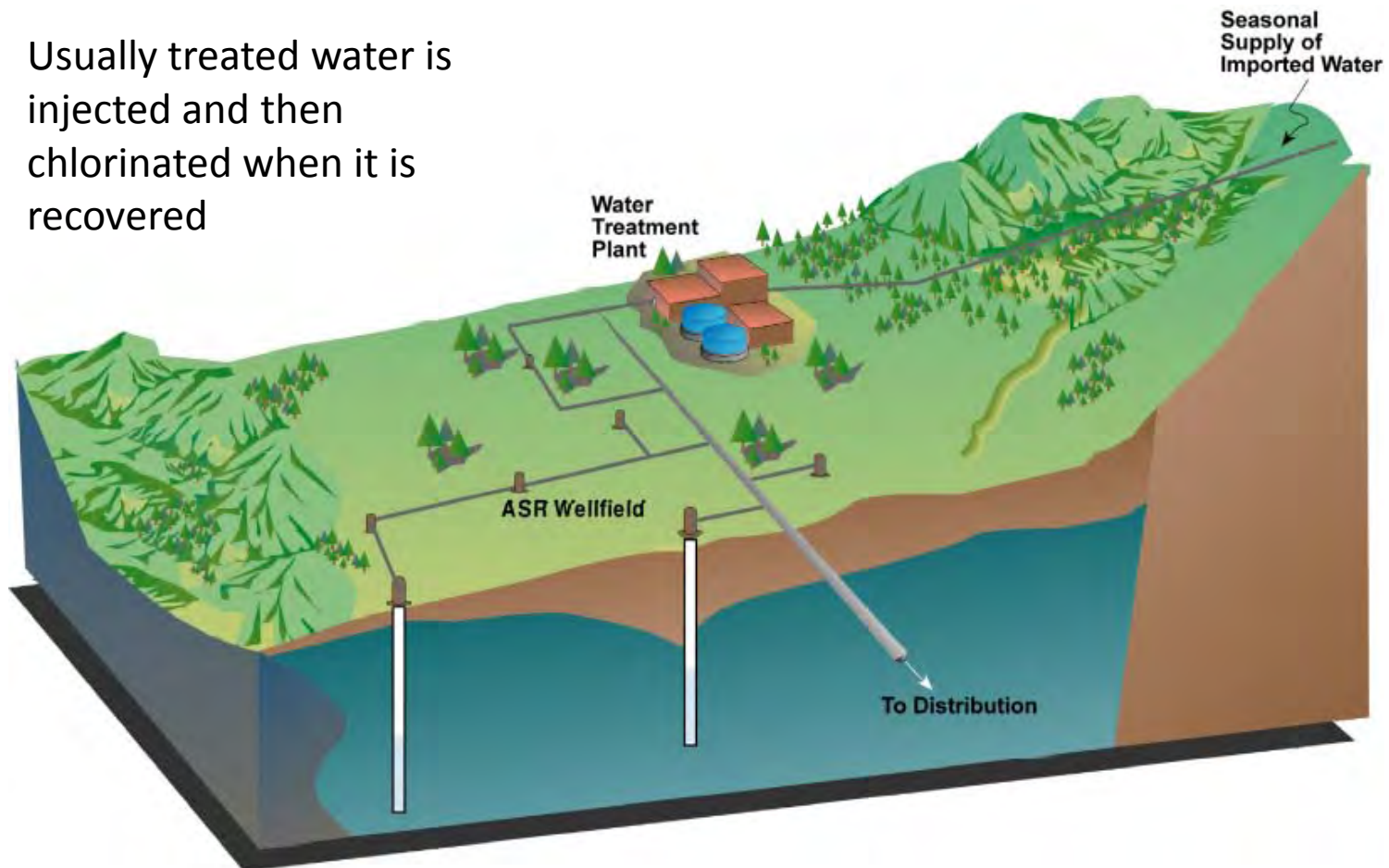
Types of Groundwater Solutions for IPR



- Riverbank Filtration
- Soil aquifer treatment
- Managed Aquifer Recharge
- ASR?

Is ASR IPR?

Usually treated water is injected and then chlorinated when it is recovered



Source: http://www.dep.state.fl.us/geology/geologictopics/asr4/presentations/thursday_15/foreman_agwt4_15_04.pdf

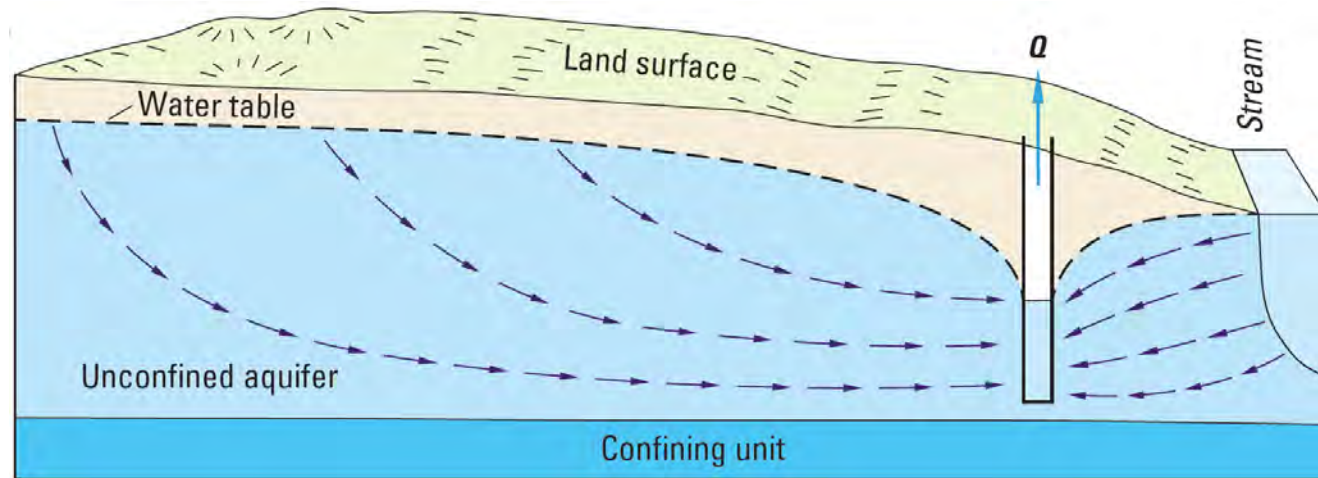
Benefits

Reduced
treatment costs

Attenuates
contaminant
spikes

Bank Storage

Easier to permit
(some aspects)



Source:

Barlow, P.M., and Leake, S.A., 2012, Streamflow depletion by wells—Understanding and managing the effects of groundwater pumping on streamflow: U.S. Geological Survey Circular 1376, 84 p.

(Also available at <http://pubs.usgs.gov/circ/1376/>)

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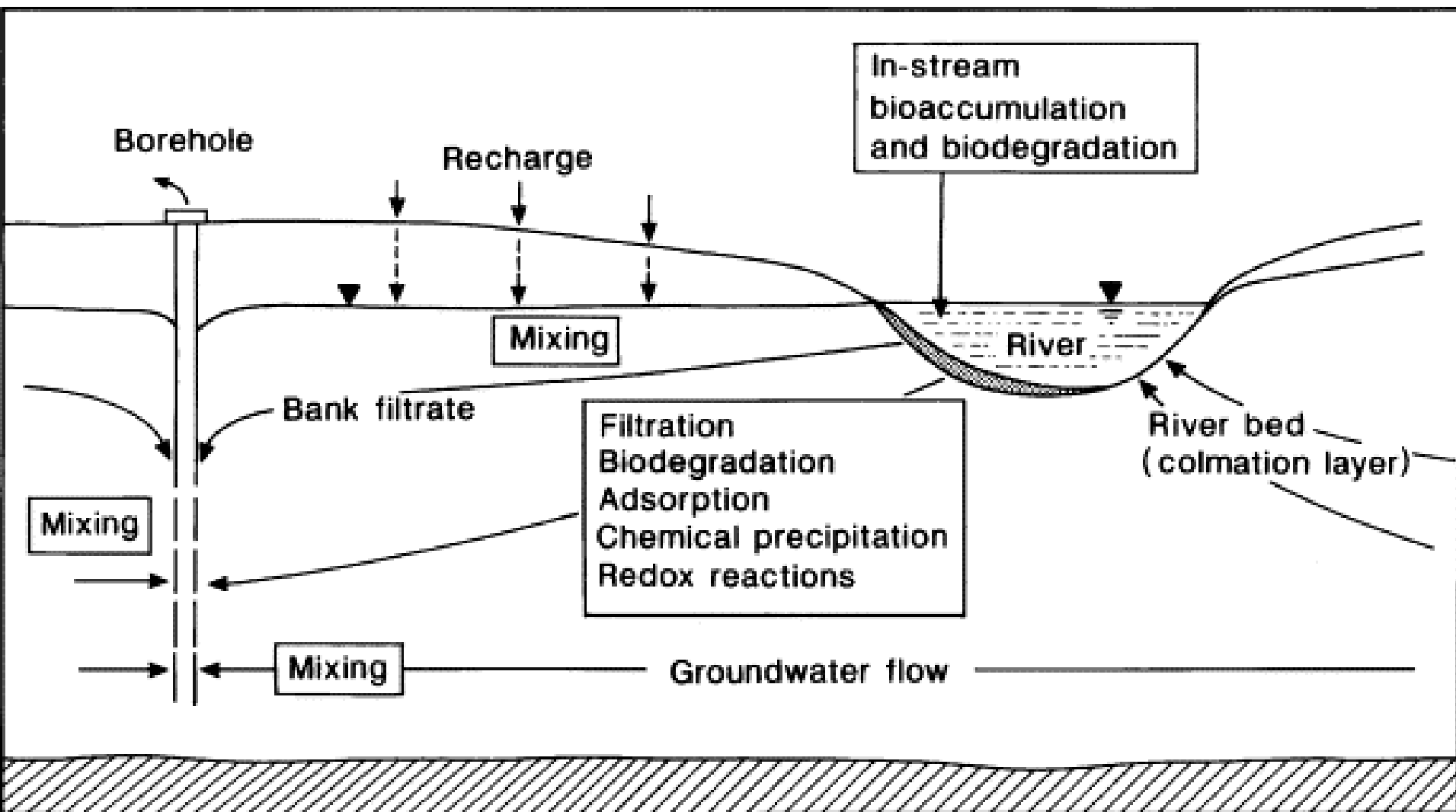
Easier to permit
(some aspects)

Public perception



Source: <http://www.savingwater.co.za/wp-content/uploads/2012/04/Toilet-tap.jpg>

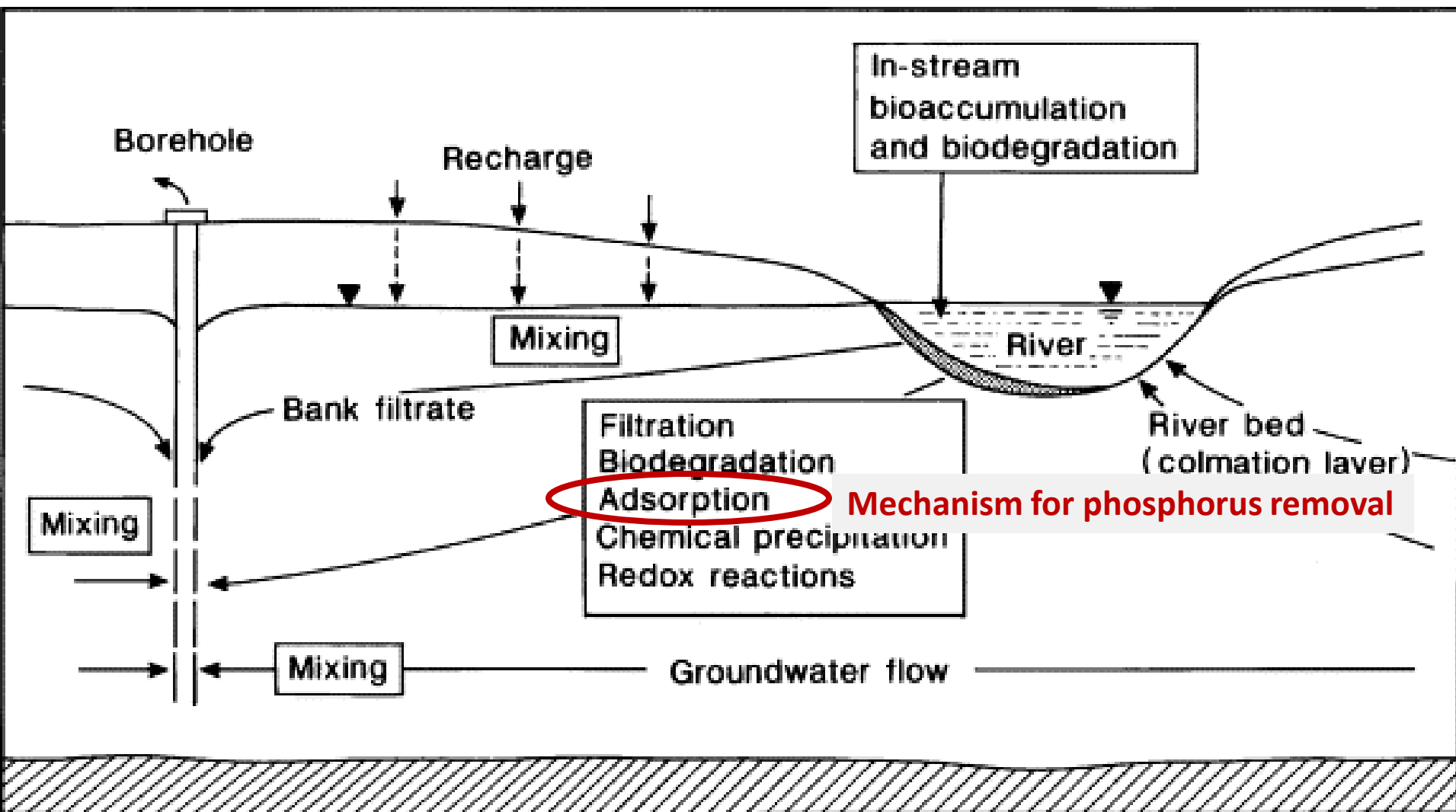
Aquifer Treatment Contaminant Removal



Source:

K.M. Hiscock, T. Grischek, 2002. Attenuation of groundwater pollution by bank filtration. Journal of Hydrology, Volume 266, Issues 3–4, 15 September 2002, Pages 139–144 [http://dx.doi.org/10.1016/S0022-1694\(02\)00158-0](http://dx.doi.org/10.1016/S0022-1694(02)00158-0)

Aquifer Treatment Contaminant Removal



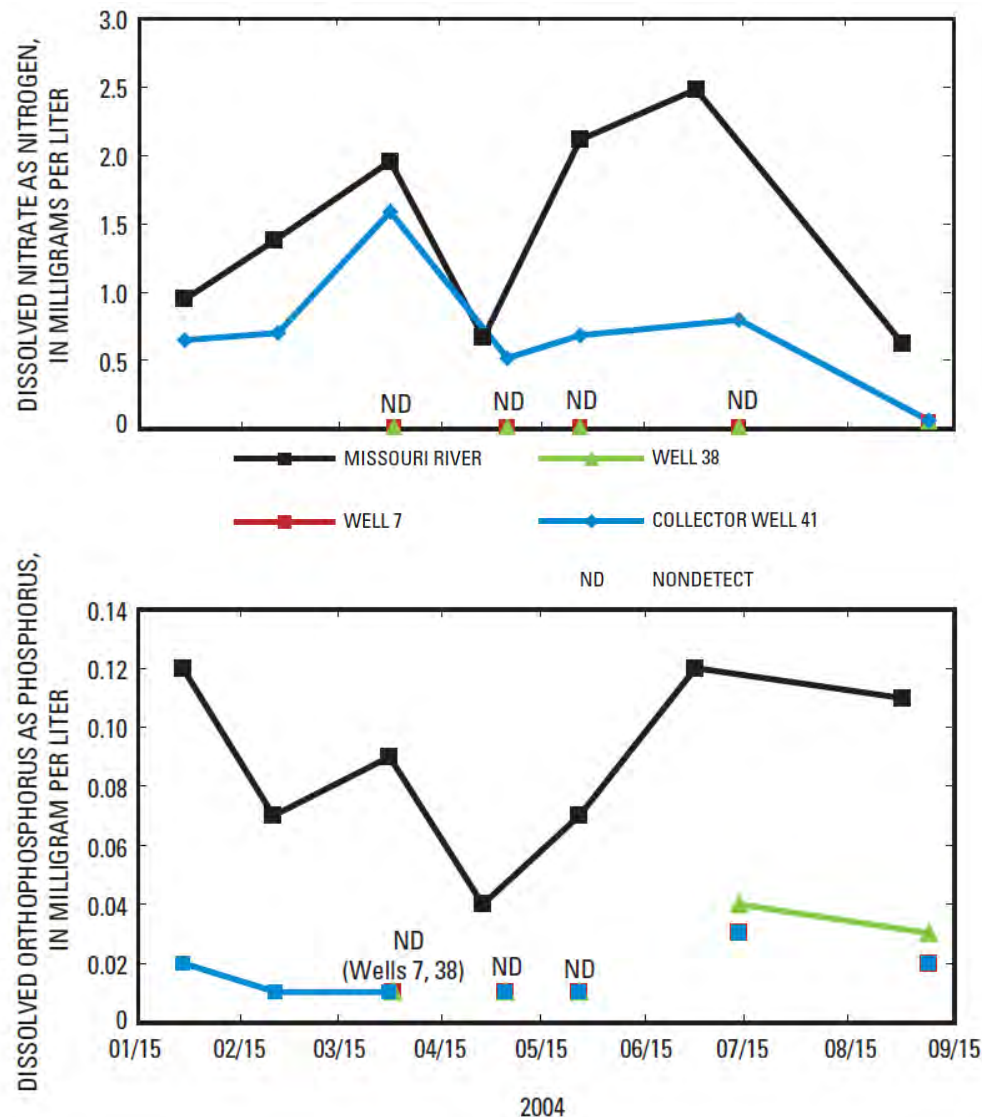
Source:

K.M. Hiscock, T. Grischek, 2002. Attenuation of groundwater pollution by bank filtration. Journal of Hydrology, Volume 266, Issues 3–4, 15 September 2002, Pages 139–144 [http://dx.doi.org/10.1016/S0022-1694\(02\)00158-0](http://dx.doi.org/10.1016/S0022-1694(02)00158-0)

Water Quality Improvements

Target Contaminant Removal

- Nutrients:
 - Nitrogen
 - Phosphorous



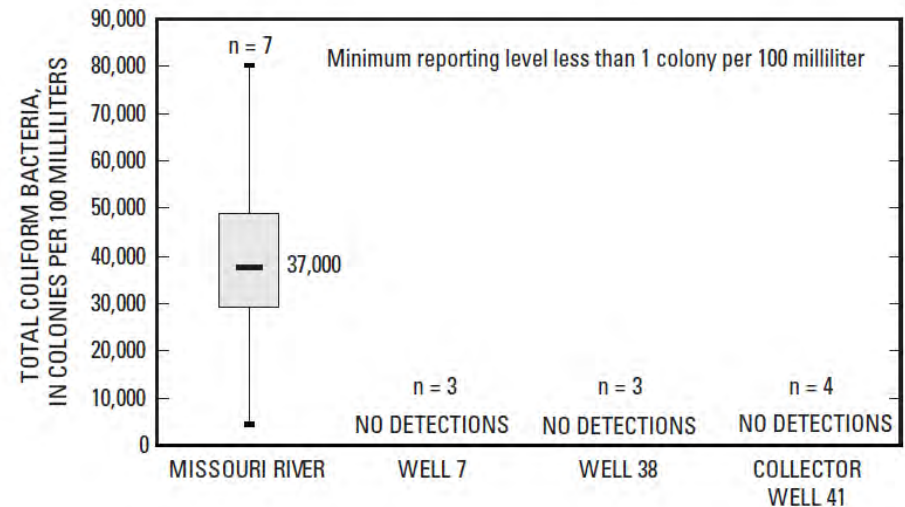
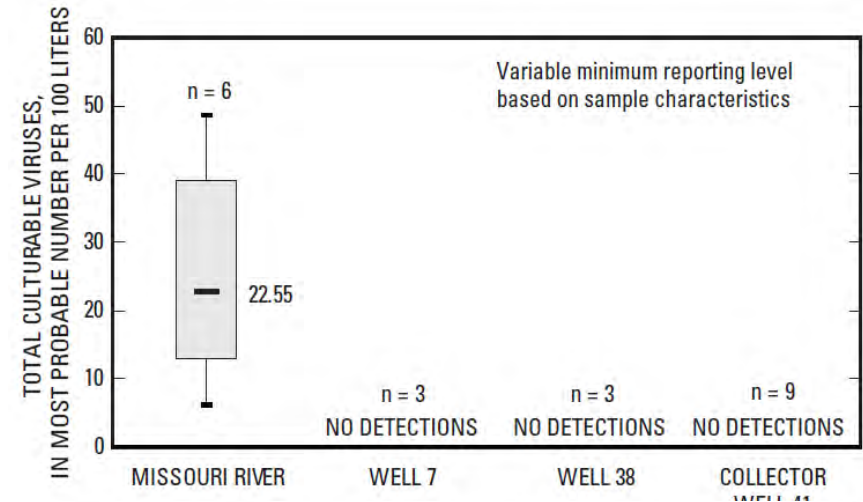
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Water Quality Improvements

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Water Quality Improvements

Target Contaminant Removal

- Nutrients:
 - Nitrogen
 - Phosphorous
- Bacteria/Viruses
- Emerging contaminants
 - Pharmaceuticals and other personal care products
 - Plasticizers
 - Pesticides



Source: <http://growingblue.com/wp-content/uploads/2012/07/PPCPs-in-Water-300x193.jpg>

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- Prevention of invasive species migration



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 - Plasticizers
 - Pesticides
- Prevention of invasive species migration
- TOC
- TSS
- Turbidity
- Taste and Odor

Turbidity (NTU)

Water Samples:



Groundwater Feasibility Evaluation

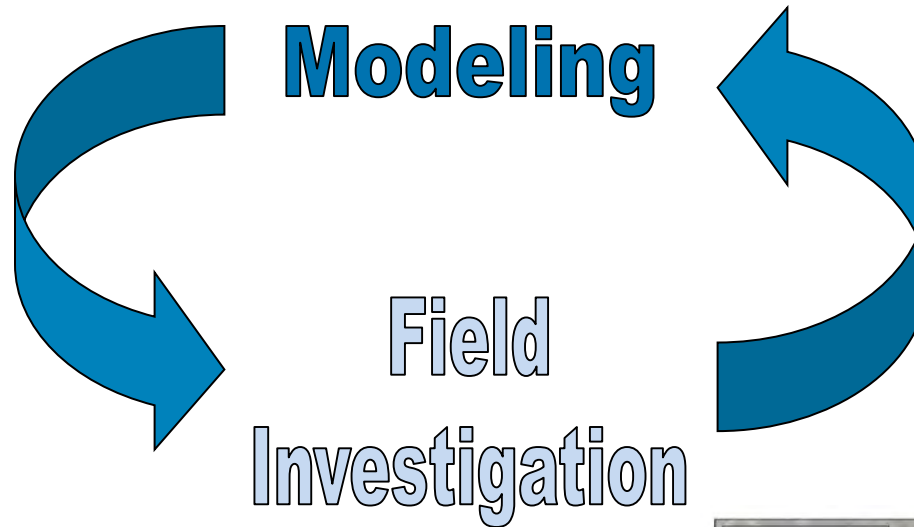
Evaluating the feasibility of Groundwater Solutions for IPR

Water Quantity: Maximize well production

IPR Water Capture: Quantify the amount of IPR water captured by the groundwater system

Water Quality: Maximize water quality improvements

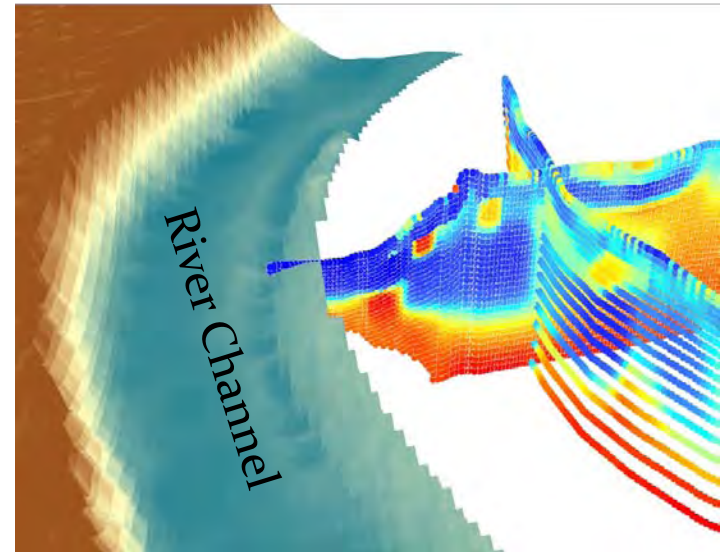
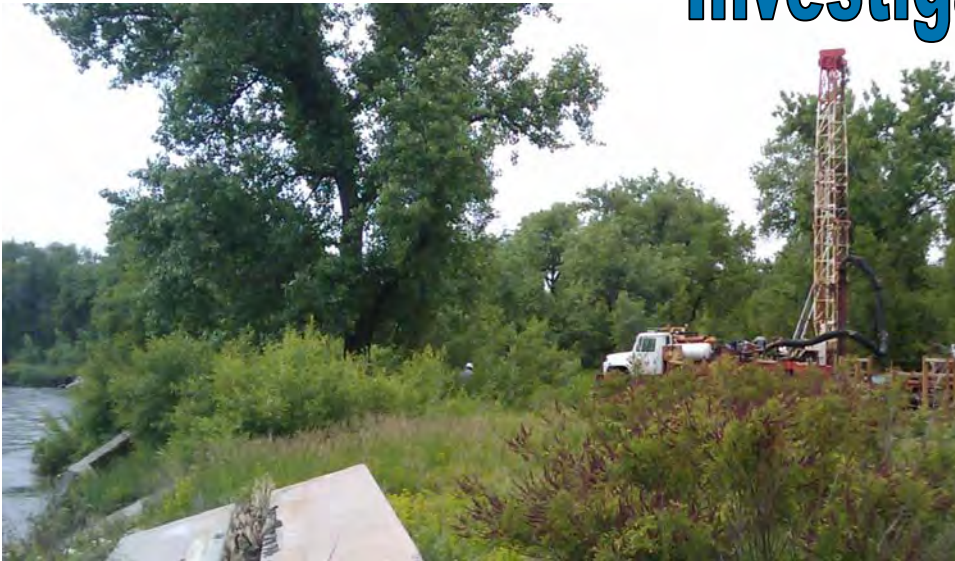
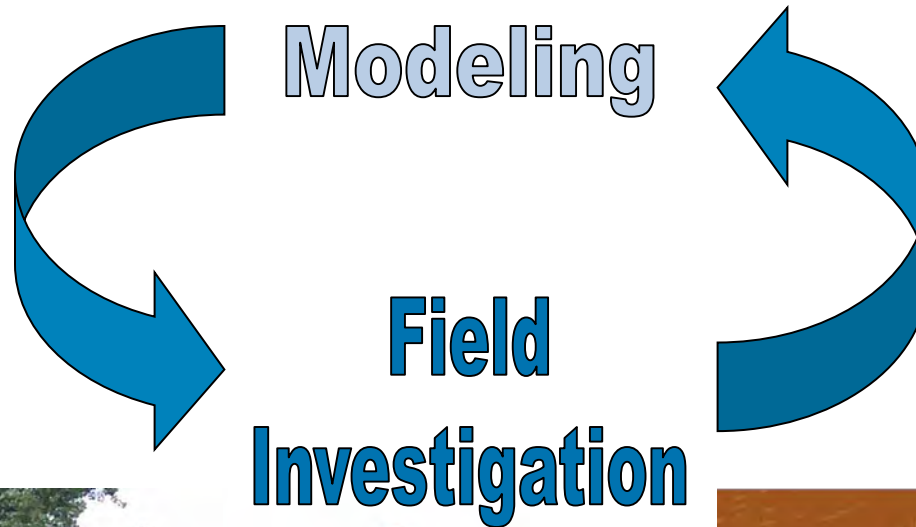
Groundwater Feasibility – Iterative Phasing



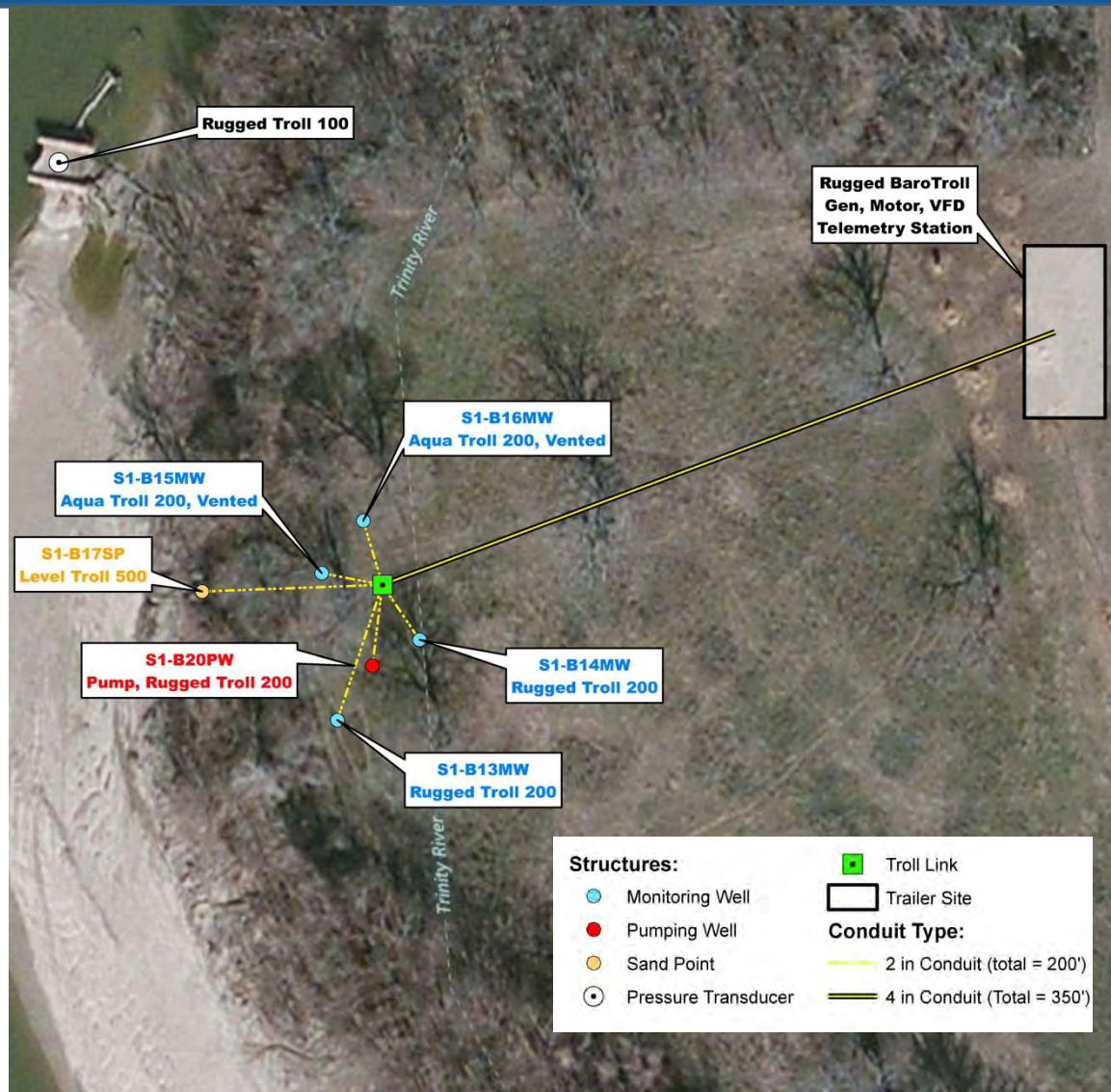
A light blue 3D rectangular block is shown. A black arrow points into the left face of the block, and another black arrow points out of the right face. The equation $Q = K i A$ is printed in black on the front face of the block.



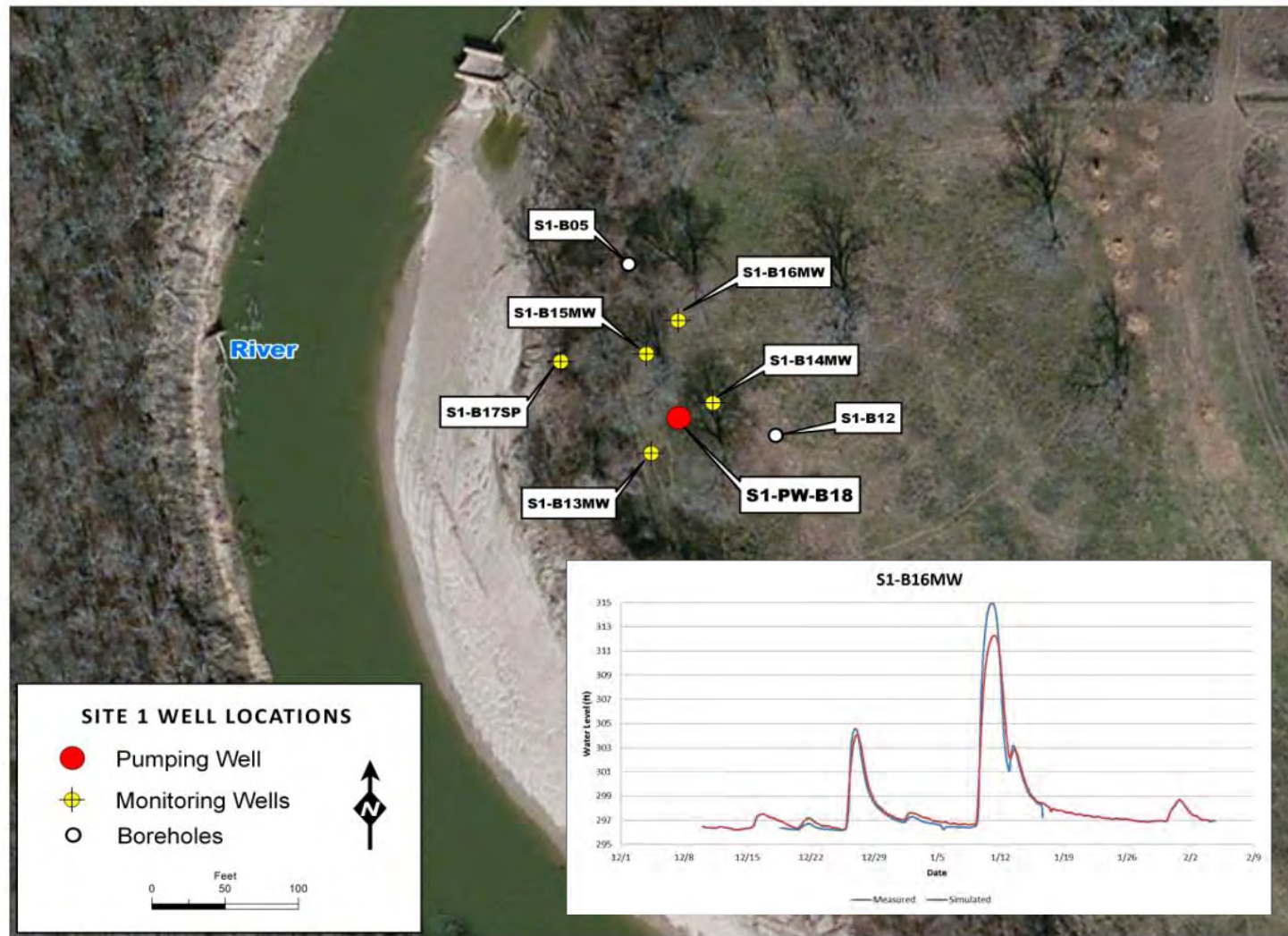
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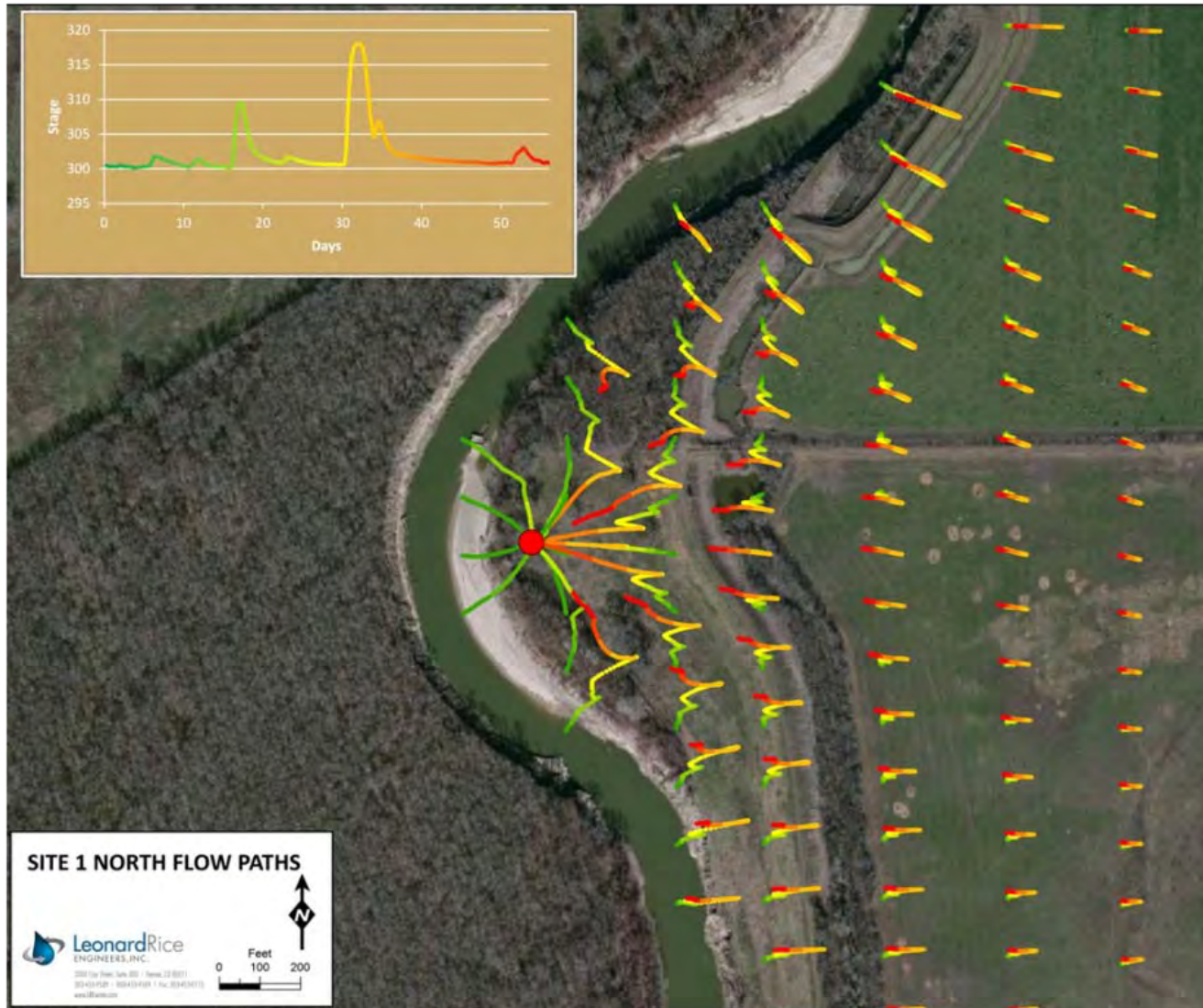
Groundwater for IPR Pilot Testing



Groundwater for IPR Pilot Testing



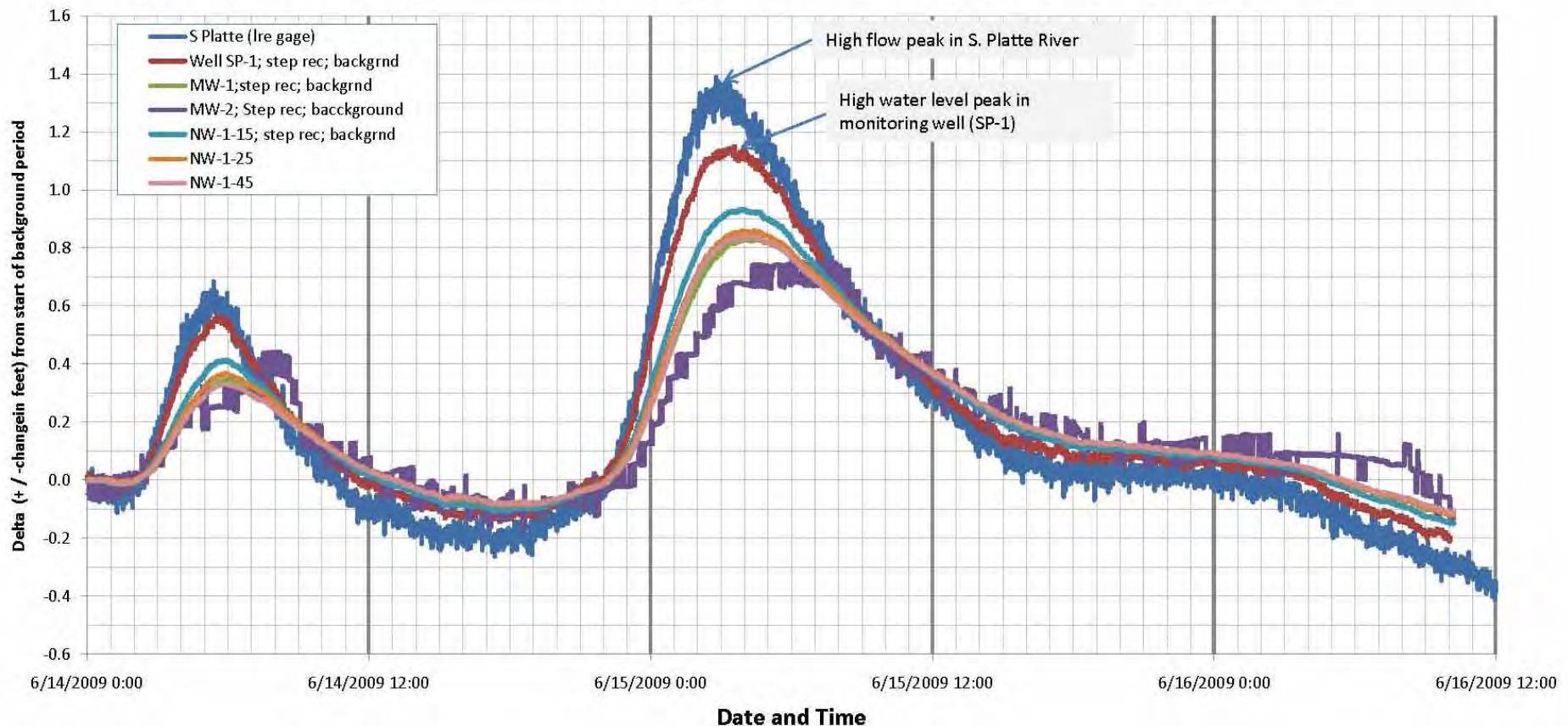
Groundwater for IPR Pilot Testing



Groundwater – Pertinent Data Types

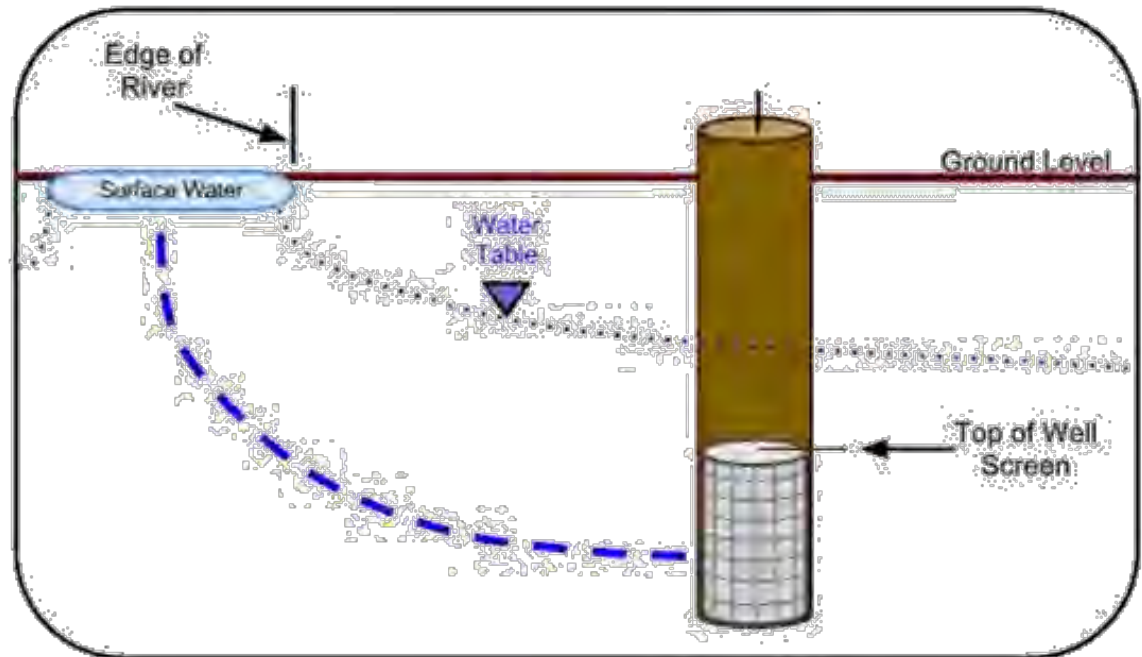
- River Stage/ Aquifer Response

Figure A-1. Change in River Level and Monitoring Wells (background data)



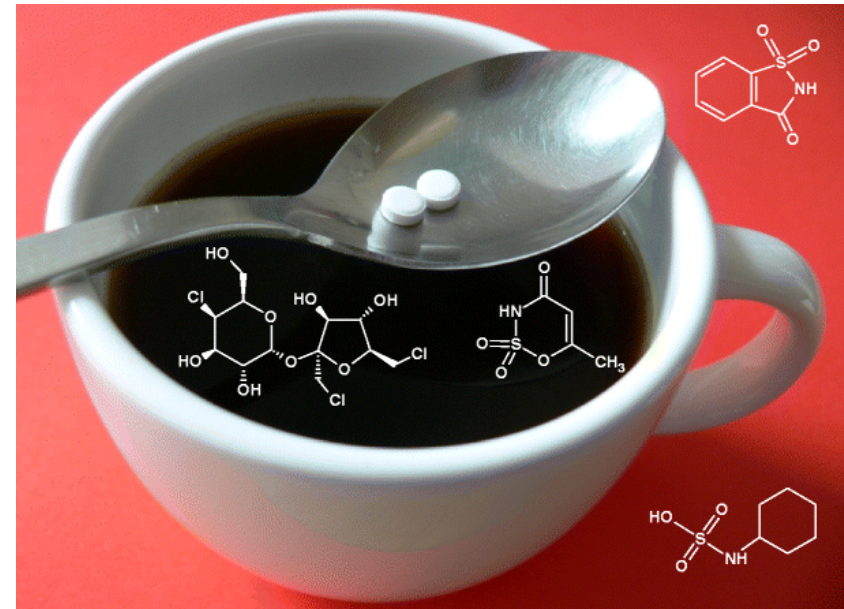
Groundwater – Pertinent Data Types

- River Stage/ Aquifer Response
- Demonstrate capture of river water
 - Glover analytical methods
 - MODFLOW numerical model

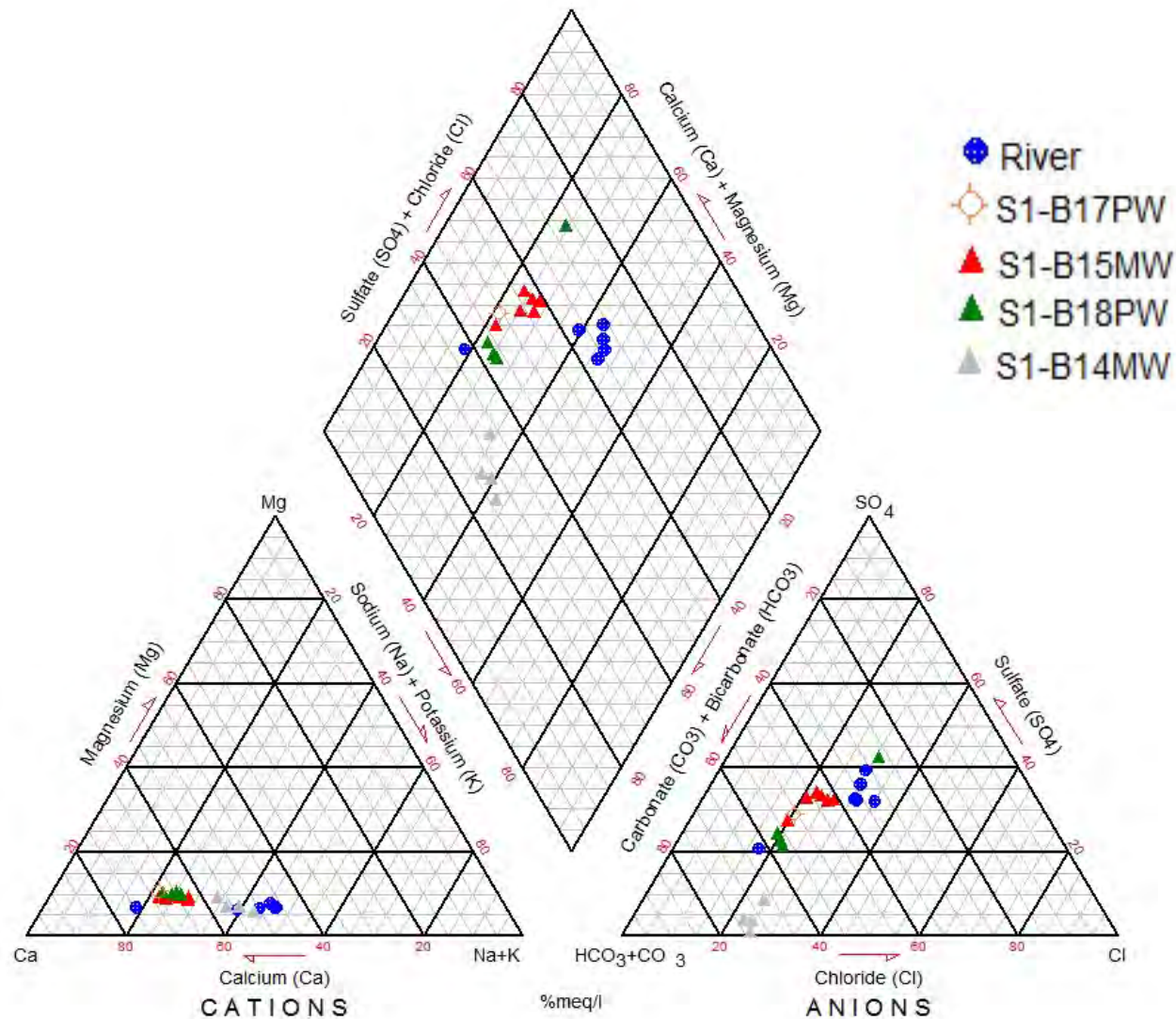


Groundwater – Pertinent Data Types

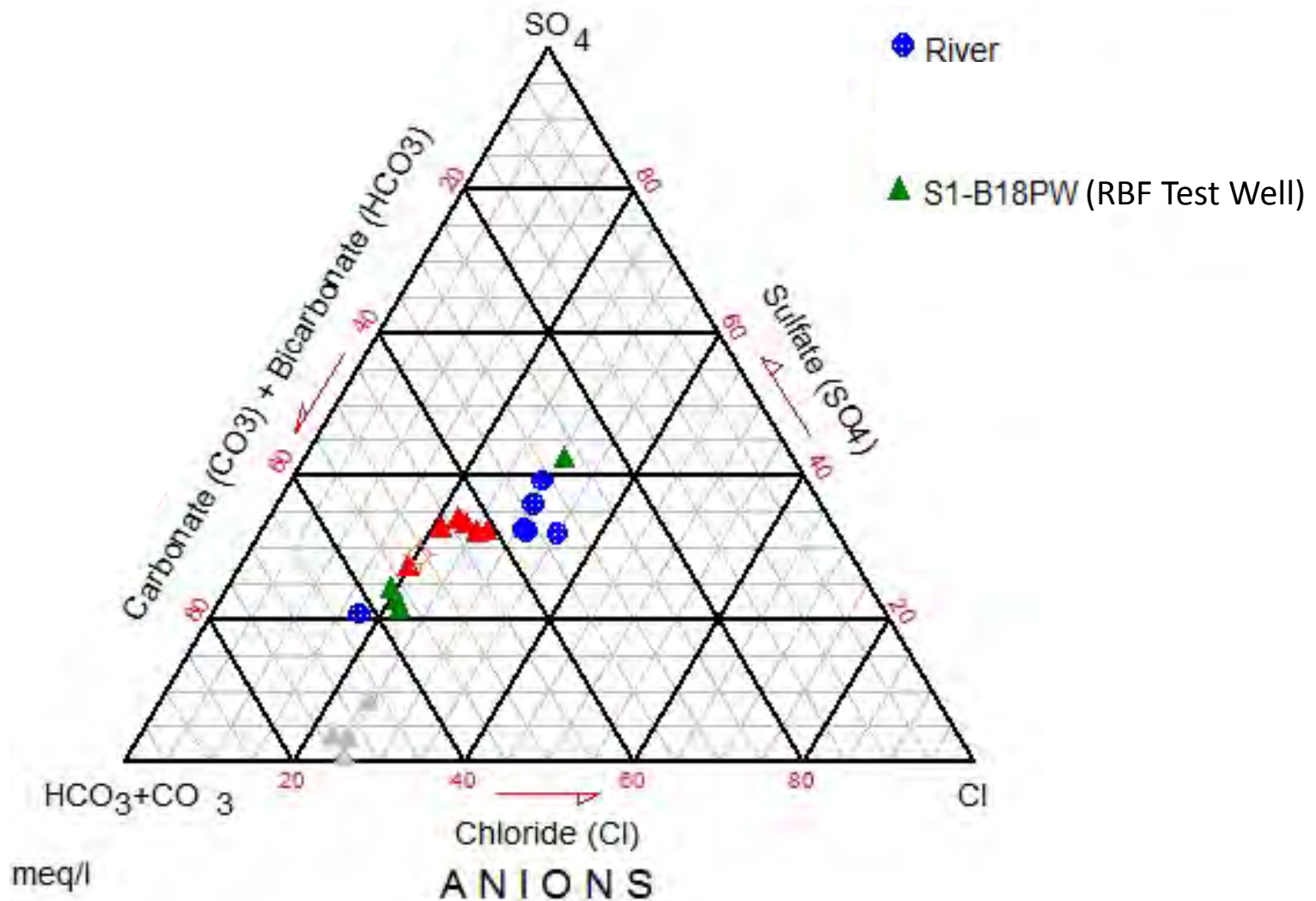
- River Stage/ Aquifer Response
 - Maximize
- Demonstrate capture of river water
 - Glover analytical methods
 - MODFLOW numerical model
- Environmental tracers



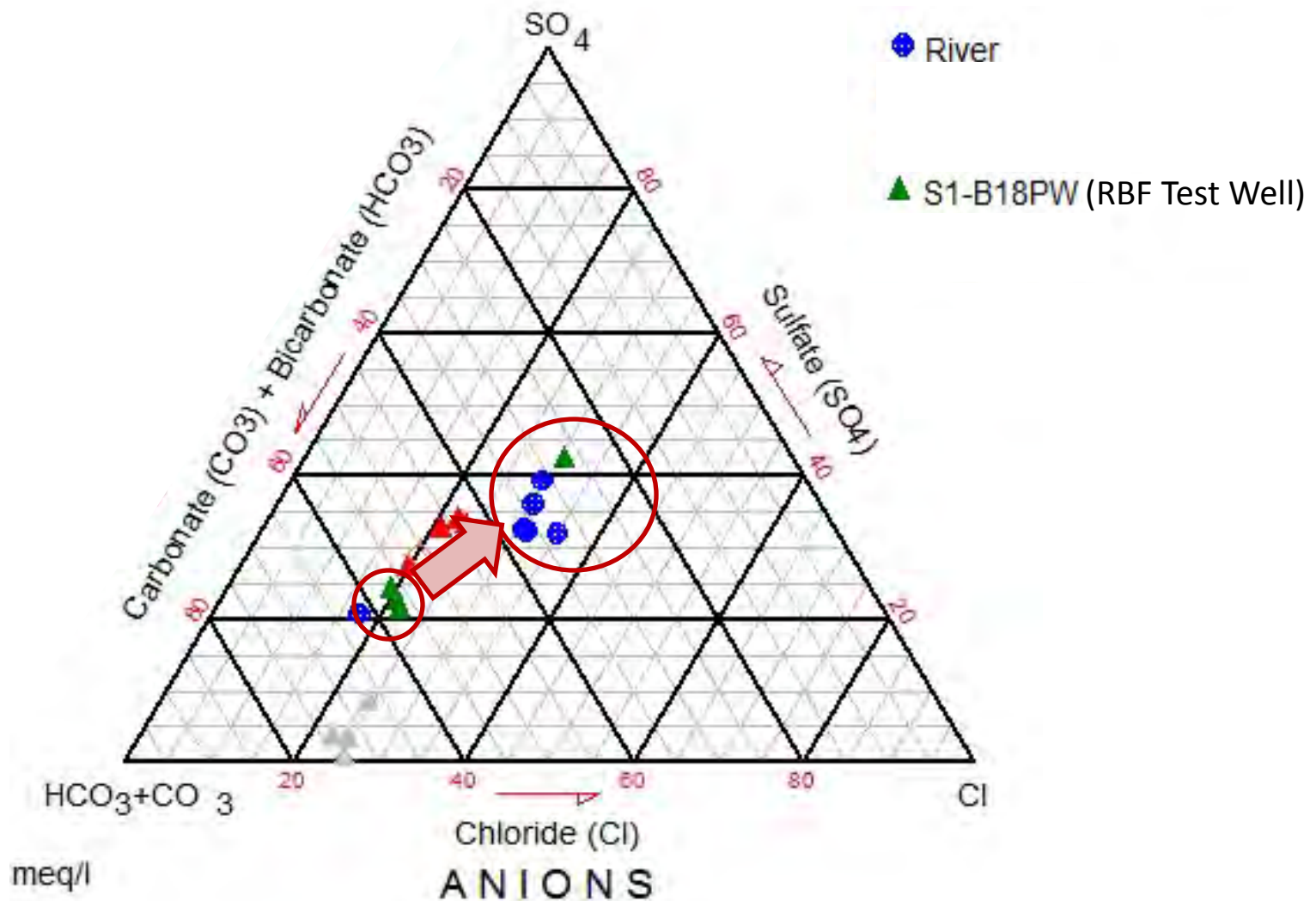
River Water Capture – Piper Diagram



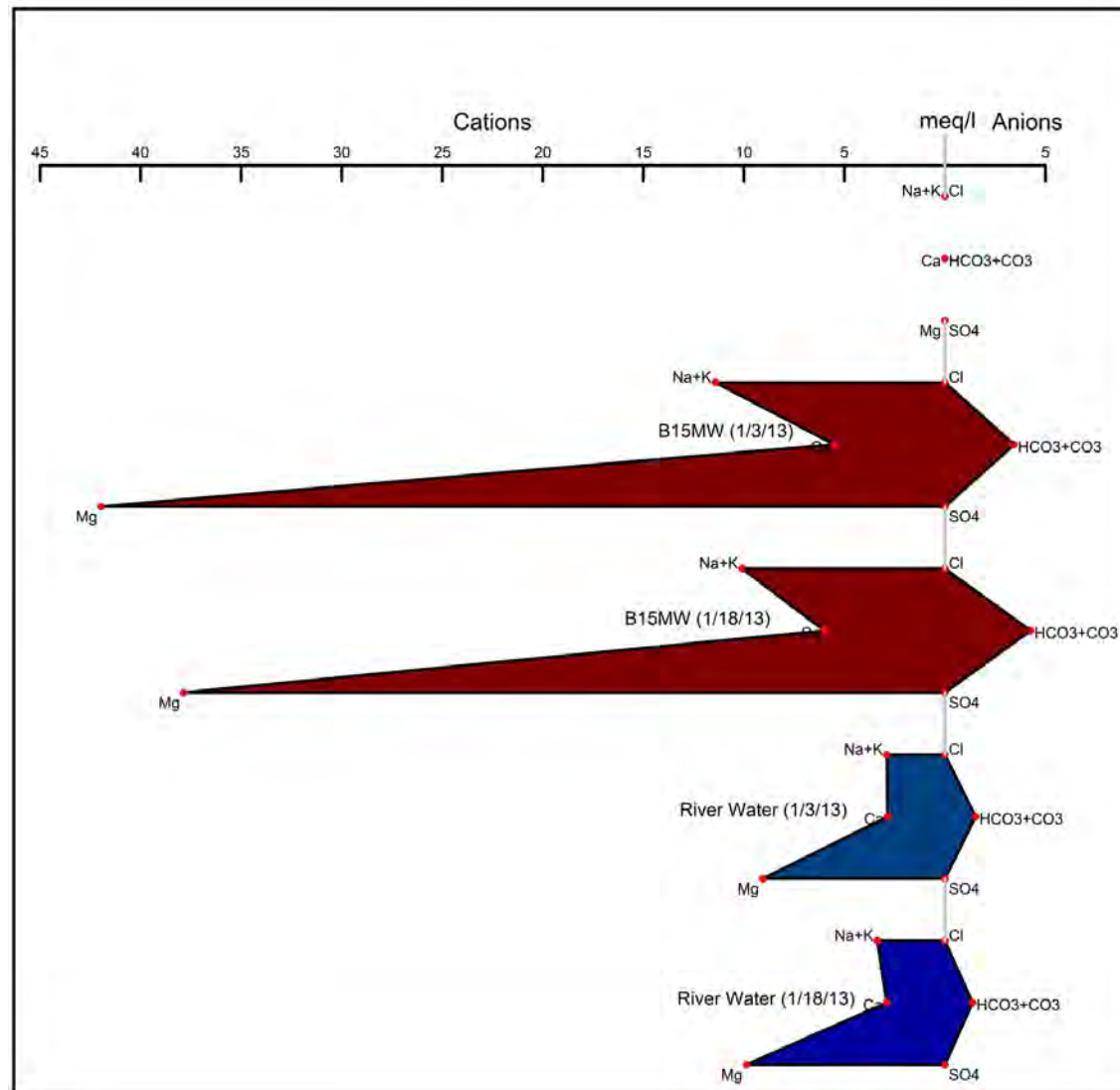
River Water Capture – Piper Diagram



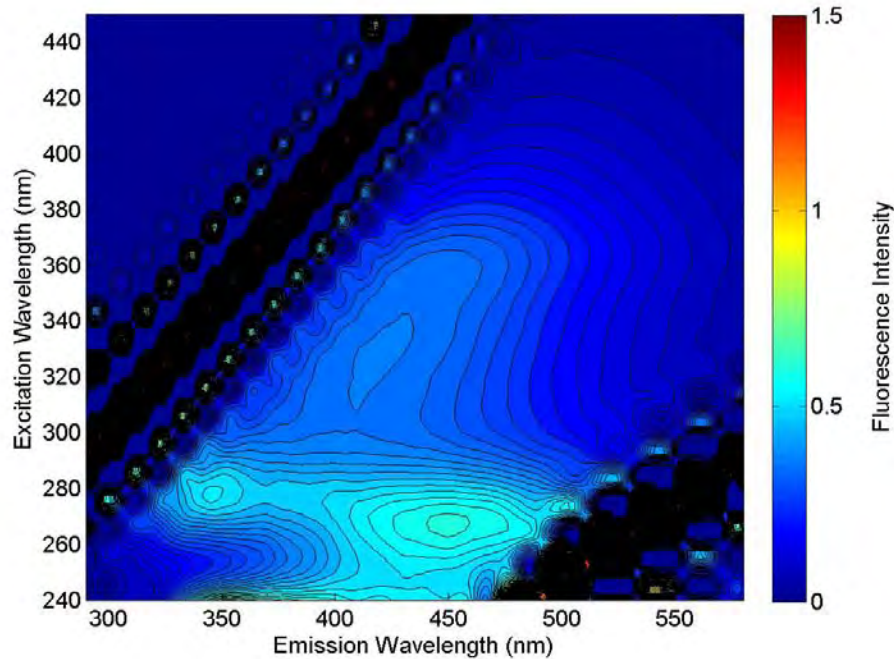
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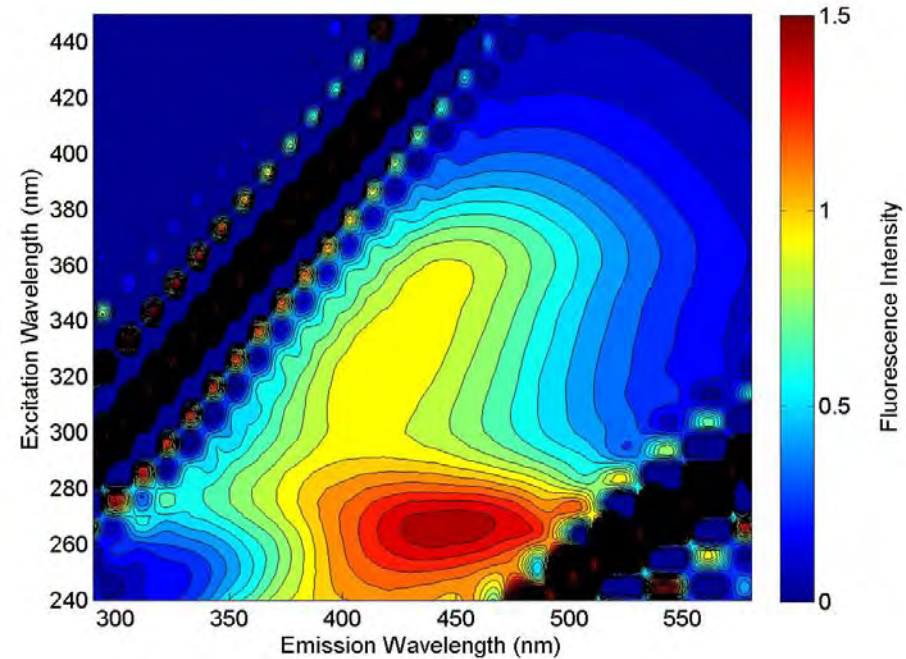
River Water Capture – Stiff Diagram



River Water Capture – Fluorescence Fingerprint Analyses

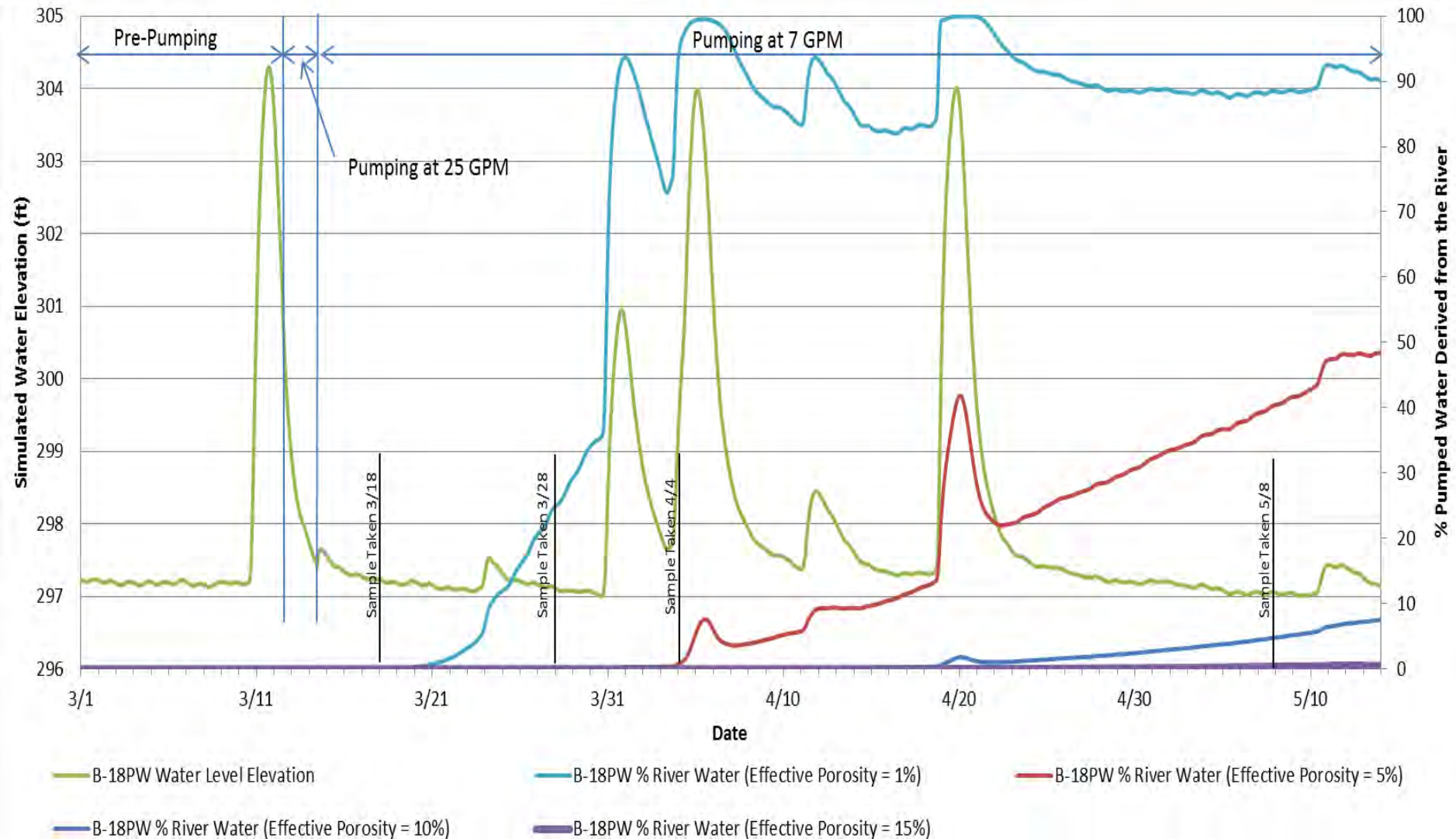


- Groundwater with lower percentage of river water



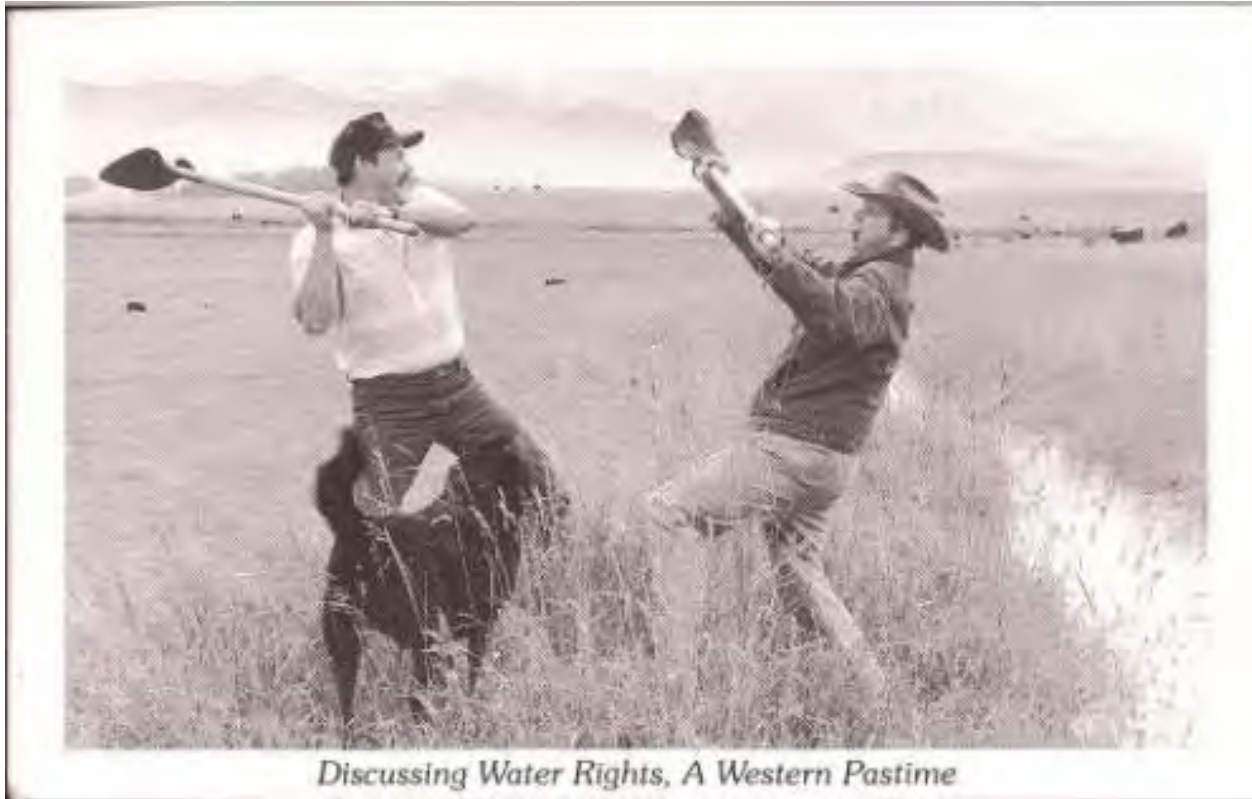
- Groundwater with higher percentage of river water

Corroborating Model and Water Quality Results



Groundwater Limitations

- Water Rights



Source: http://www.onearth.org/files/onearth/water_rights.jpg

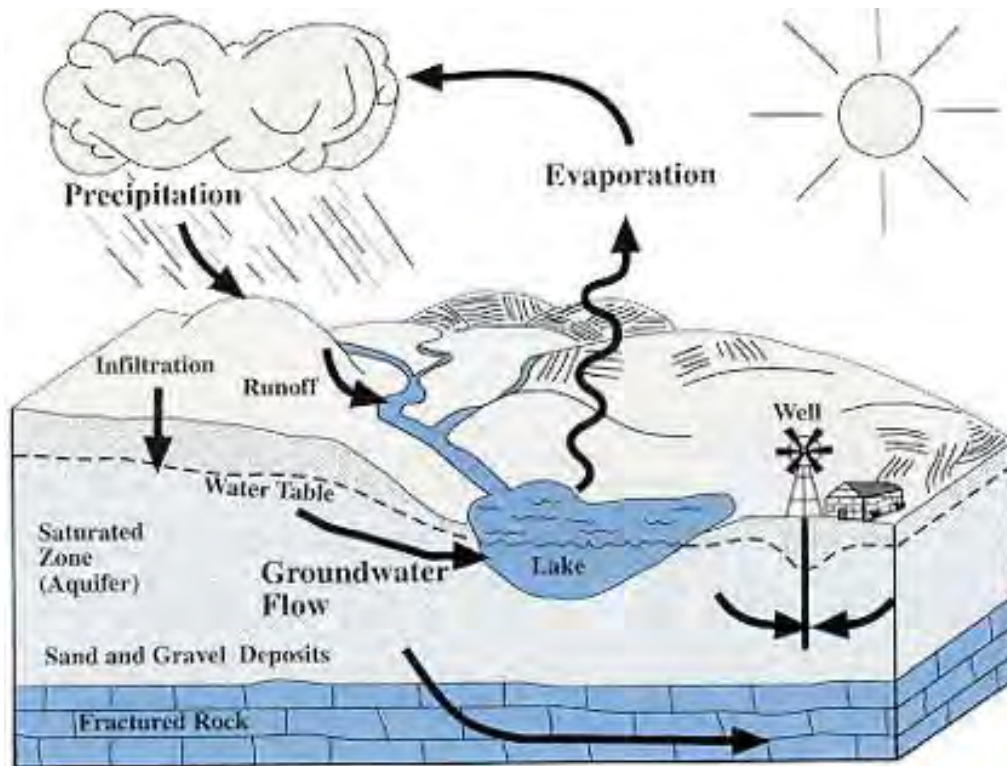
Groundwater Limitations



- Water Rights
- Regulatory concerns

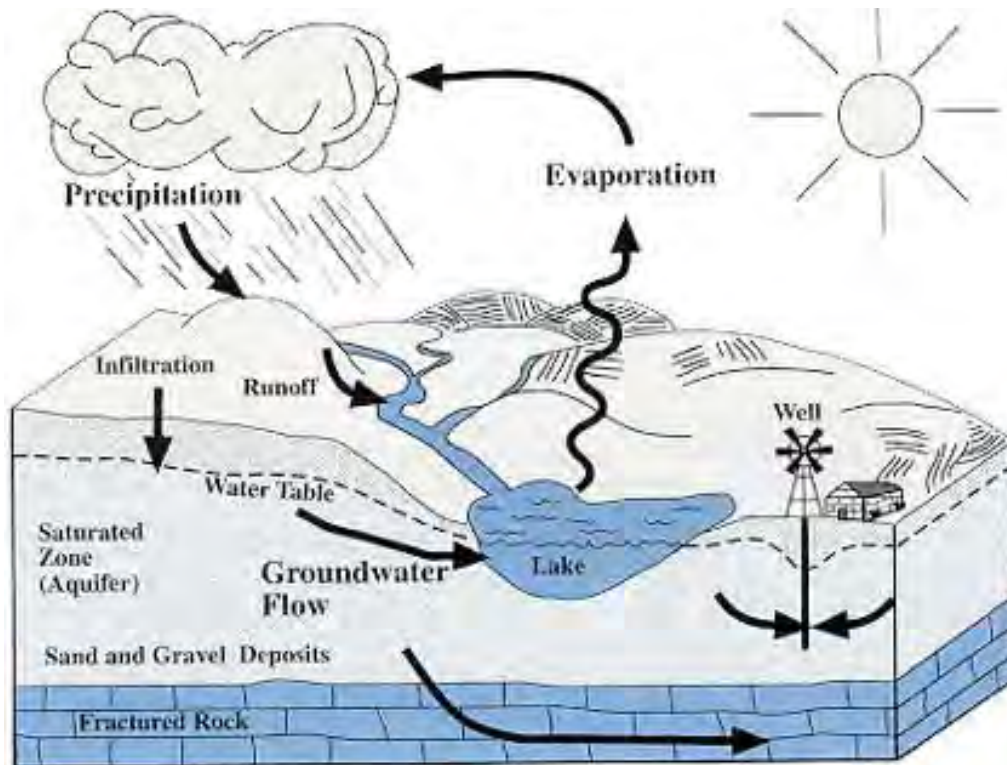
Groundwater Limitations

- Water Rights
- Regulatory concerns
- Rate of groundwater movement

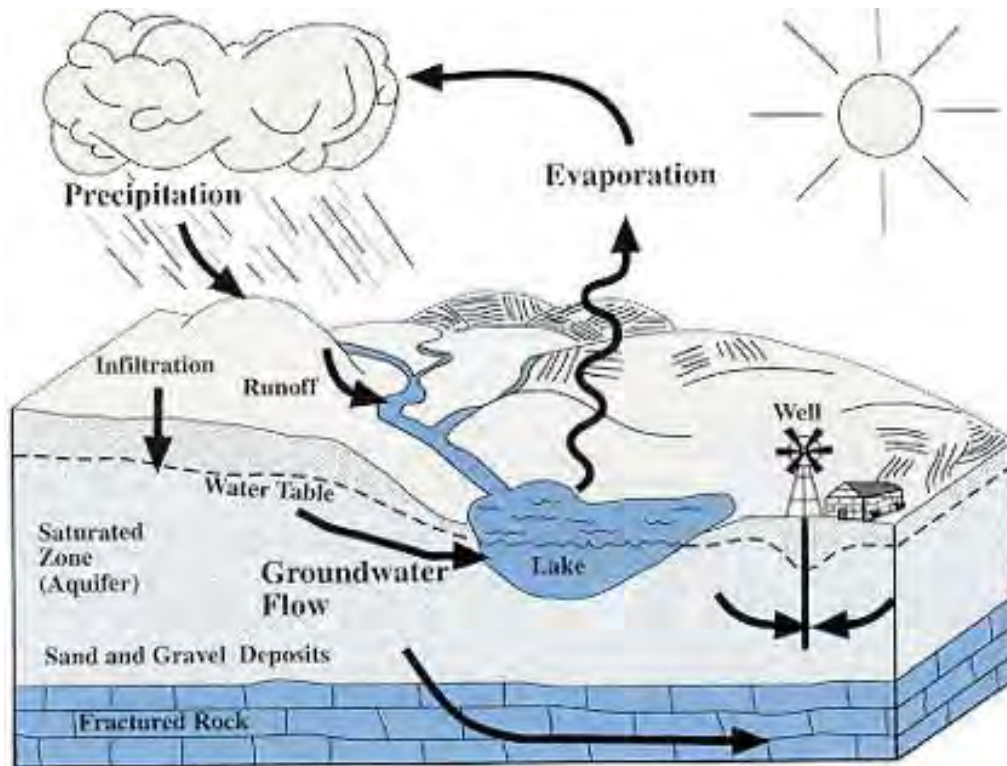


Groundwater Limitations

- Water Rights
- Regulatory concerns
- Rate of groundwater movement
- Amount of control



Groundwater Limitations



- Water Rights
- Regulatory concerns
- Rate of groundwater movement
- Amount of control
- Uncertainty and lack of understanding

Groundwater Solutions for IPR

Conclusions

- Benefits include:
 - Water quality benefits (nutrients, bacteria, viruses, emerging contaminants, and more)
 - Public perception improvements
 - Reduced overall system costs
- Feasibility project design can increase likelihood of success and be the start of permanent infrastructure
- Early awareness of limitations can also help with project success

Questions?

Thank You!