Aquifer Storage Recovery (ASR) Technology and System Development Overview

Presented by

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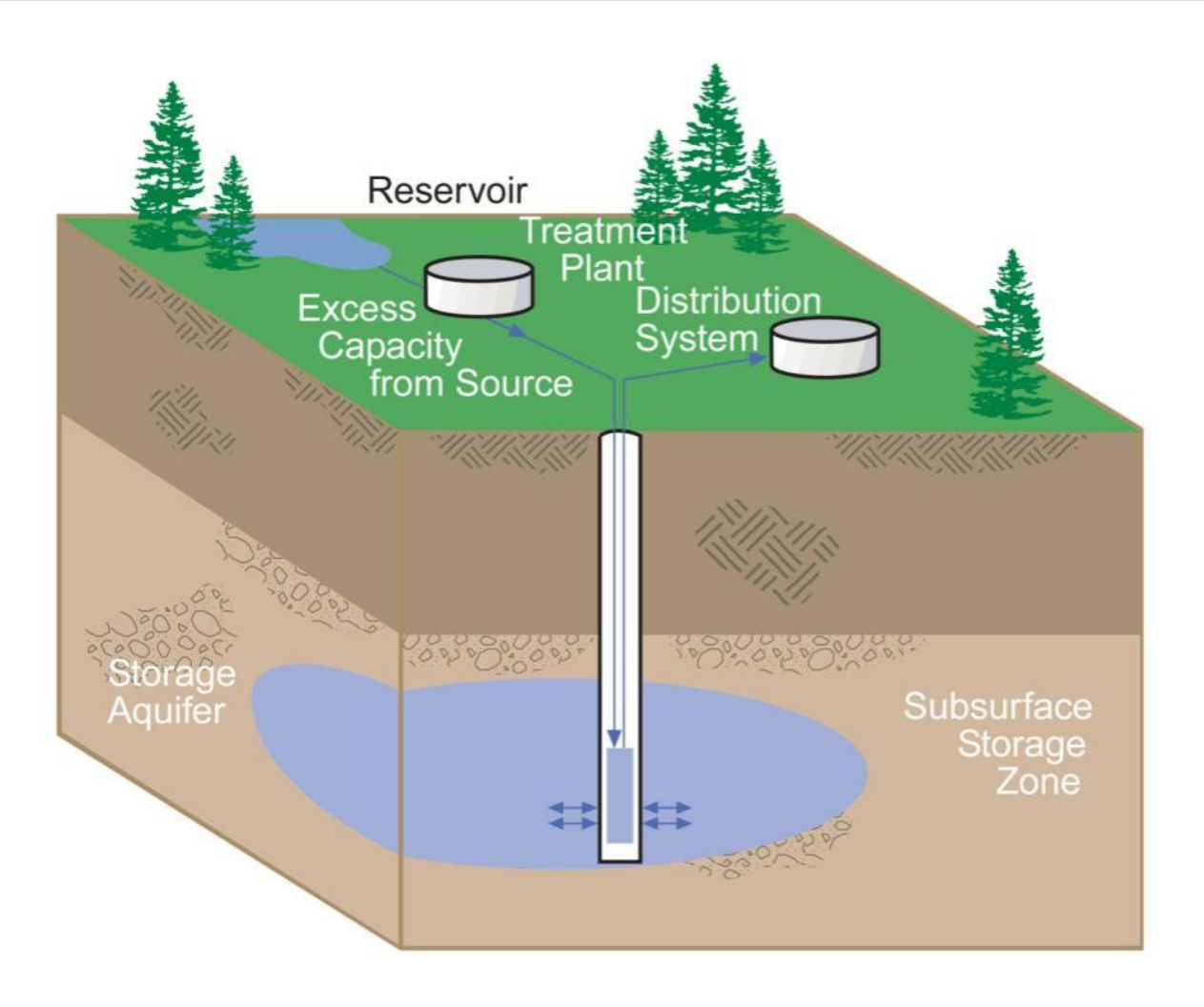
What is ASR?

- Water placed for storage in an aquifer by well injection
- Water is recovered from the same (or proximate) well as needed



Enhanced Recharge Terminology

- Automatic Speech Recognition (**ASR**)
- Alkali Silica Reaction (**ASR**),
- Answer Seizure Ratio (**ASR**)
- Annual Security Report (**ASR)**
- Articular Surface (hip) Replacement' (**ASR**)
- Acceleration/Slip Regulation (**ASR**)
- Asian Soybean Rust (**ASR**)
- Answer Supervision Ratio (**ASR**),
- Automotive Shredder Residue, (**ASR)**
- Artificial Silicon Retina (**ASR**)
- Americans for Secure Retirement
- Architects for Social Responsibility
- Artificial Surf Reefs (**ASR**)
- The Association for the Sociology of Religion **(ASR)**
- Australian Seabird Rescue (**ASR**) in 1992
- Accredited Seller Representative (**ASR)**

- ASR - Aquifer Storage and Recovery
- AR - Artificial Recharge
- MAR - Managed Aquifer Recharge
- MUS - Managed Underground Storage

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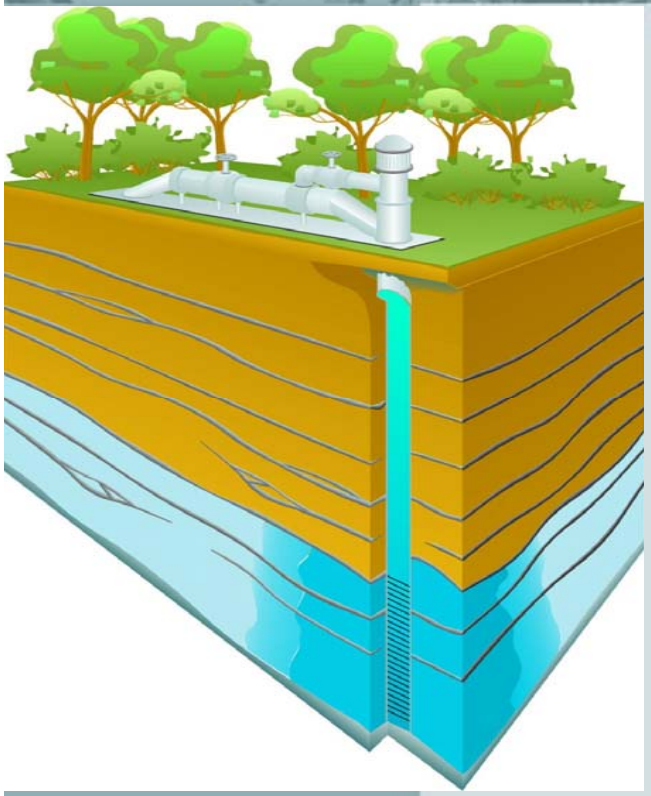
Why? Water Availability and Economics



- Water Availability: Groundwater and Surface Water Supplies are increasingly over-allocated.
  - Minimum instream flows
  - Conjunctive use policies
- ASR Can Redistribute Supply Profile to:
  - Provide Peaking Capacity
  - Optimize WTP Operations
  - Leverage Available Water
  - Emergency Backup Supply
  - Large Project Deferral

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ASR Project Applications/Benefits

- **Resource Management**
  - Low-impact new supply source
  - Restore GW levels
  - Reduce land subsidence
  - Enhance wellfield production
  - Prevent saltwater intrusion
  - Surface water mitigation strategies
- **Water Quality Management**
  - Response to turbidity events
  - Improve water quality (e.g. pH, Iron/manganese, salinity)
- **Economics**
  - Defer Capital Costs
  - Low Cost Supply/Source Alternative
  - WTP Design Optimization
  - Thermal Storage

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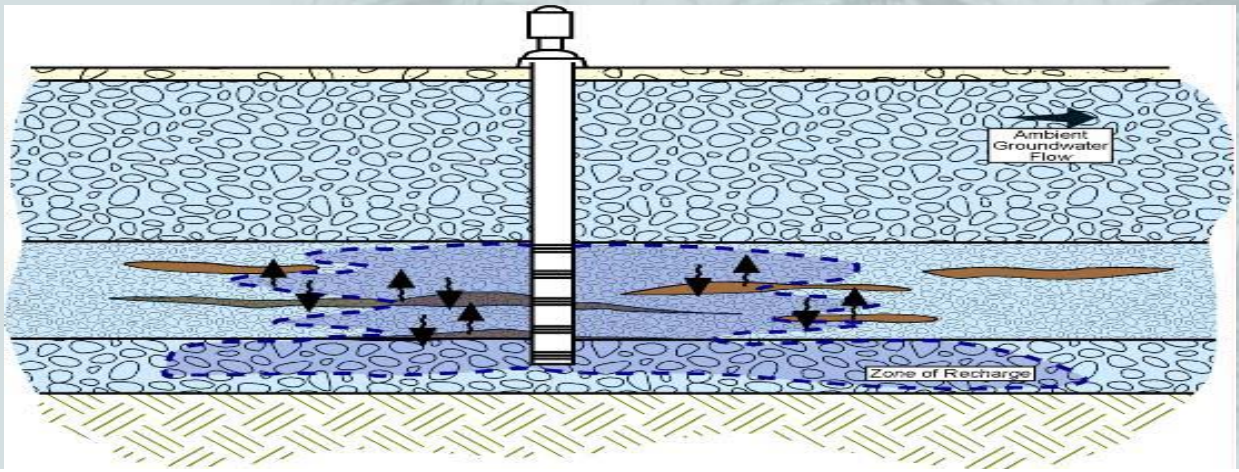
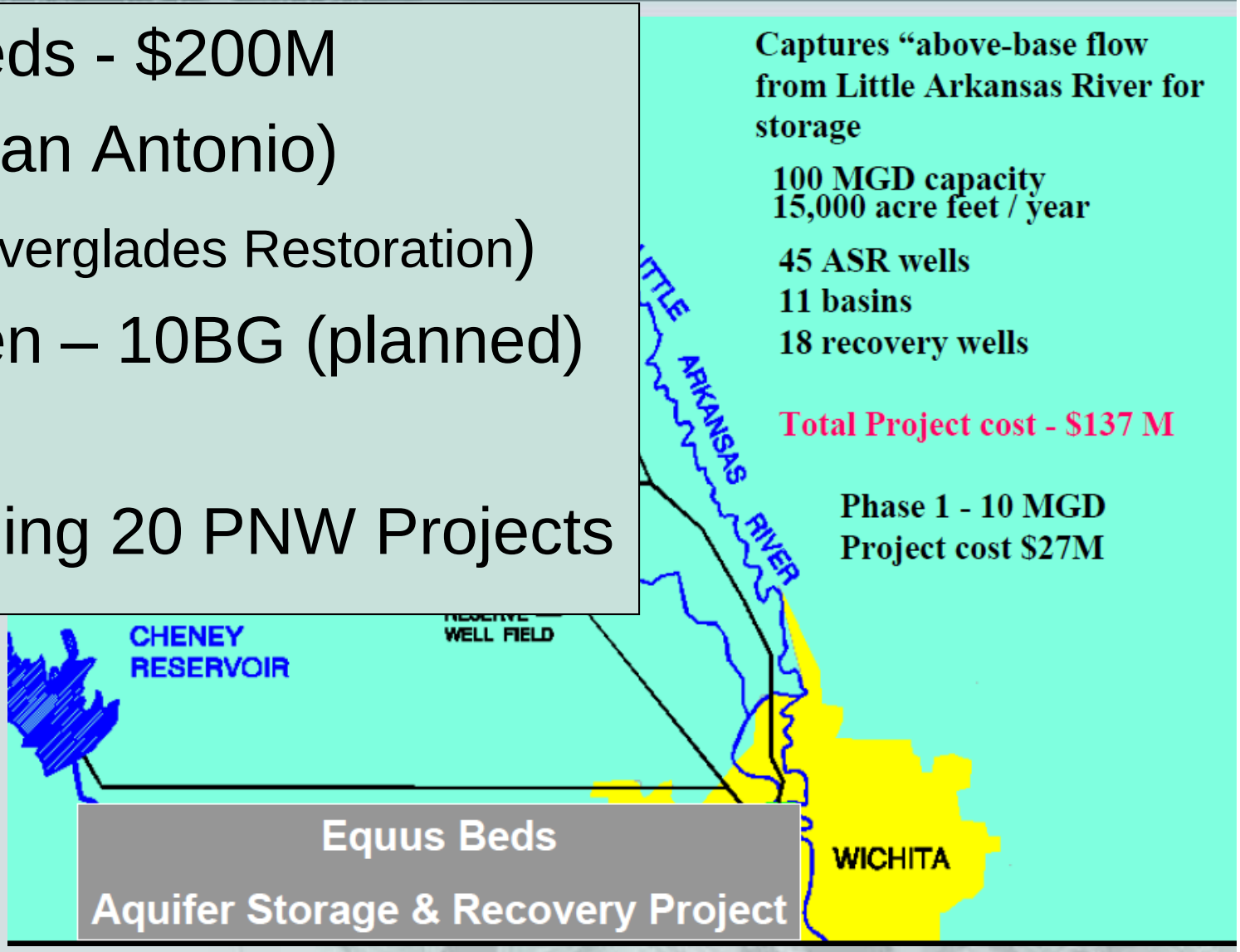
An Ideal ASR Setting

- A deep confined aquifer with storage capacity;
- An area experiencing rapid growth and limited supply options;
- A utility with seasonal turbidity issues;
- An existing network of groundwater extraction wells and distribution infrastructure that could be converted for ASR;
- Planned significant new capital expenditures (WTP expansion, storage facilities)
- MDD >> ADD



ASR Project Scale

- Equus Beds - $200M
- SAWS (San Antonio)
- CERP (Everglades Restoration)
- Lakehaven – 10BG (planned)
- Umatilla
- Approaching 20 PNW Projects



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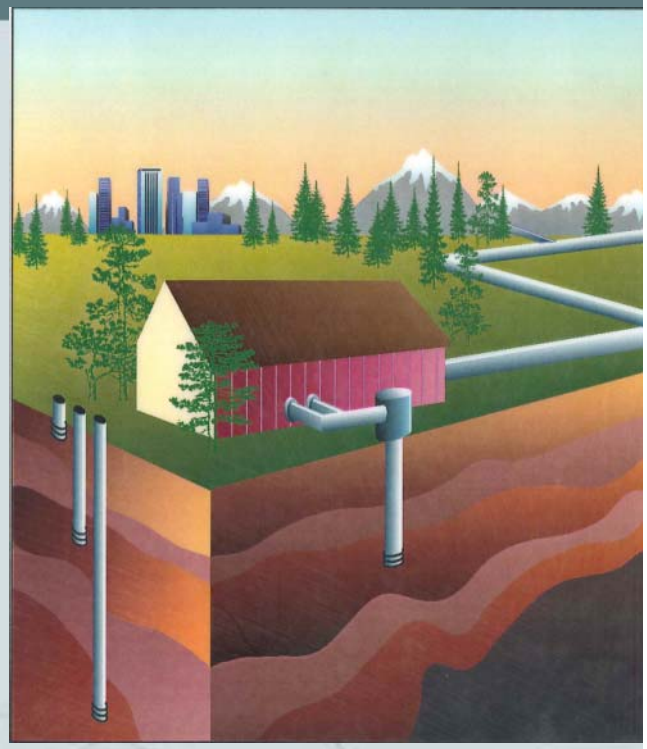
ASR Project Development

There's no one size fit – feasibility is utility-specific

- Source Availability*
- Hydrogeology*
- Water Quality*
- Permitting
- System Integration
- Design
- Well Retrofit/Installation
- ASR Testing
- Operations and O&M



** Typically completed as a fatal flaw analysis.*

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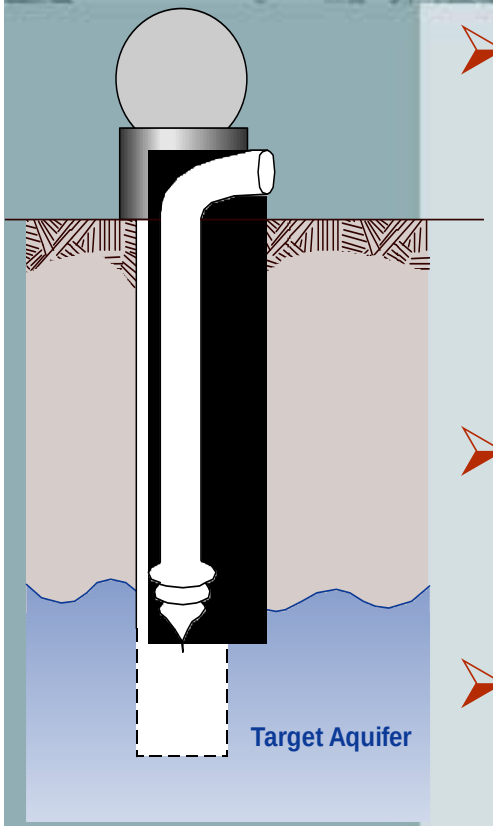
Typical ASR Issues



- Water Rights
  - Existing
  - New
  - Reservoir
  - Secondary
- Source and Distribution of Recharge Water
  - surface water and/or groundwater, timing, availability
- Infrastructure (engineering, financial)
  - water transmission, economic feasibility
- Aquifer Suitability
  - capacity, yield, containment
- Mixing Reactions
  - chemical & biological, well / aquifer clogging
- Water Quality (health & regulatory)

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ASR Experience Needed

- **Hydrogeology**
  - Geology/Stratigraphy
  - Geophysics
  - Well Construction
  - Well and Aquifer Hydraulics
  - Testing and Analysis
  - Hydrogeochemistry
  - Natural Attenuation
  - Hydrologic System Conceptualization
  - Porous Media and Fractured Rock Modeling
  - 3D - Visualization

- **Engineering and Permitting**
  - Water System Modeling
  - Water Treatment
  - Pumping Systems
  - Facility Design
  - Instrumentation
  - Controls
  - Operations
  - Cost and Constructability
  - Water Rights
  - SEPA
  - Water Source Approvals

A Multi-Disciplinary Team is Required….

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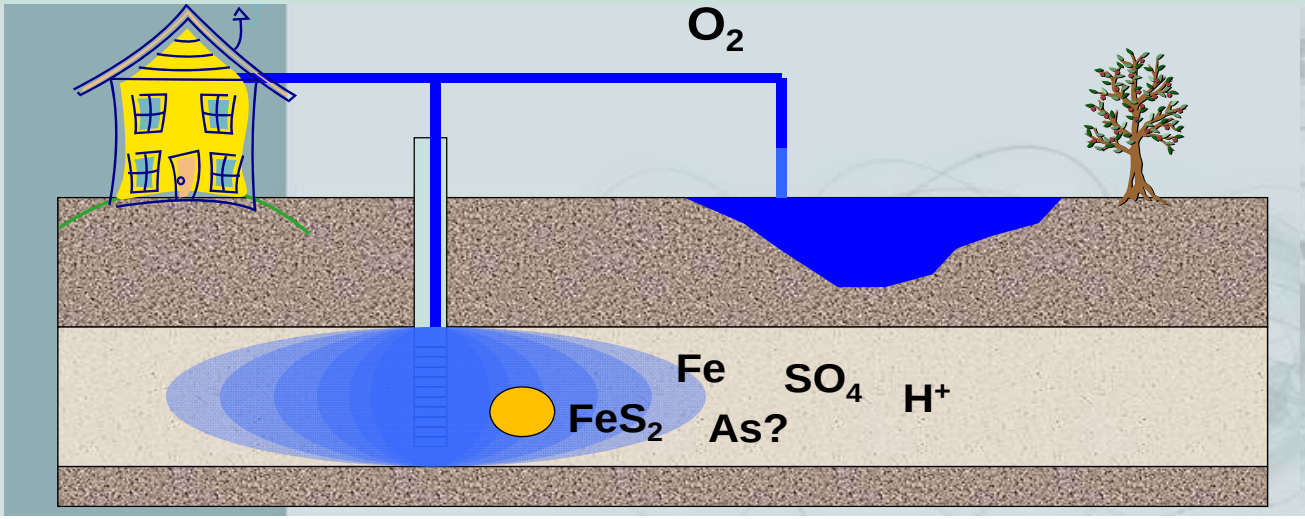
Hydrogeologic Issues

- Storage Capacity, Rates, Volumes
- Hydraulic Continuity
- Maintaining Well Performance
- Response Projections
- Recovered Water Quality



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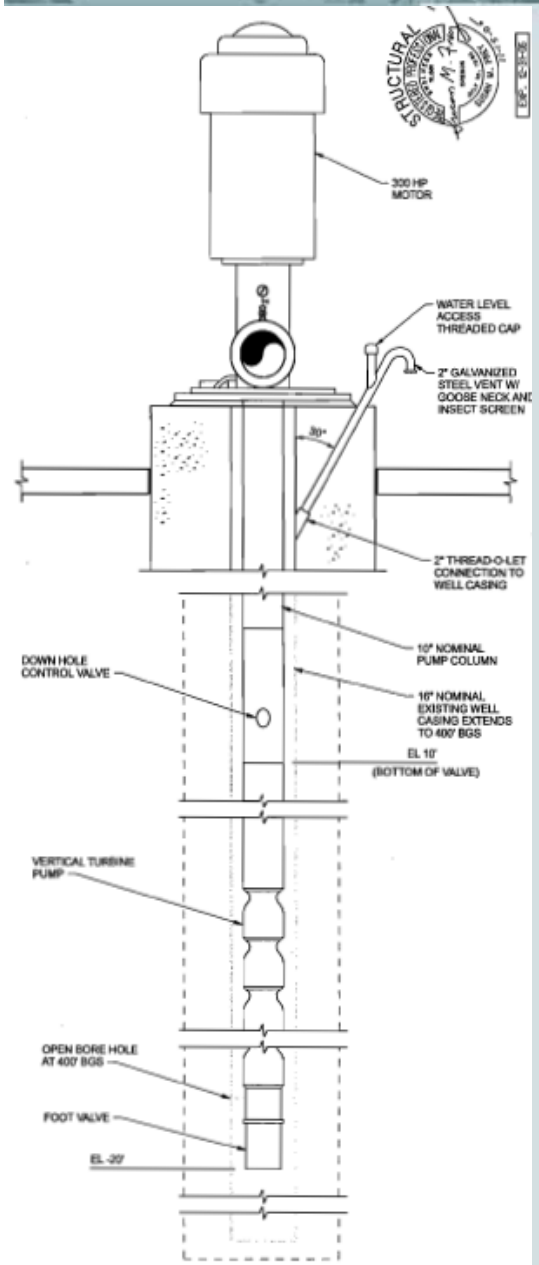
ASR Engineering

- Wellhead Design
- Recharge Control
- Integration with Distribution System
- Backflushing and Discharge to Waste

ASR Engineering: Design Considerations



Wellhead Design:

- ✓ Recharge Loop
- ✓ Variable recharge rates?
- ✓ Variable discharge rates?
- ✓ Bi-directional metering
- ✓ Air-vent
- ✓ Access tubing (2)
- ✓ Sealed pedestal
- ✓ Discharge to waste
- ✓ Line-flushing
- ✓ Chlorination and De-chlorination
- ✓ Bypass filter monitoring

ASR Engineering: Recharge Control

Entrained air causes air-binding and O_2 Saturation

- Recharge must occur under pressure (i.e. full-pipe)
- Sometimes accomplished through designed bowl/impeller assemblies
- For a significant drop and/or limited system pressure, a down-hole flow control valve may be required.
  - Can be used to vary recharge rate according to daily demand fluctuations
  - Needed to maintain well performance

Slide 14

jti3 Tabed in the last bullet to emphasize that the DHFCV can be used to vary recharge rates if installed. (to contrast with the modified line-shaft pump, which can't be used to fine-tune recharge rates).

May also want to include in the second-to-last bullet that a DHFCV must be used if a submersible pump is the method of extraction (correct?).
jiverson, 5/7/2010

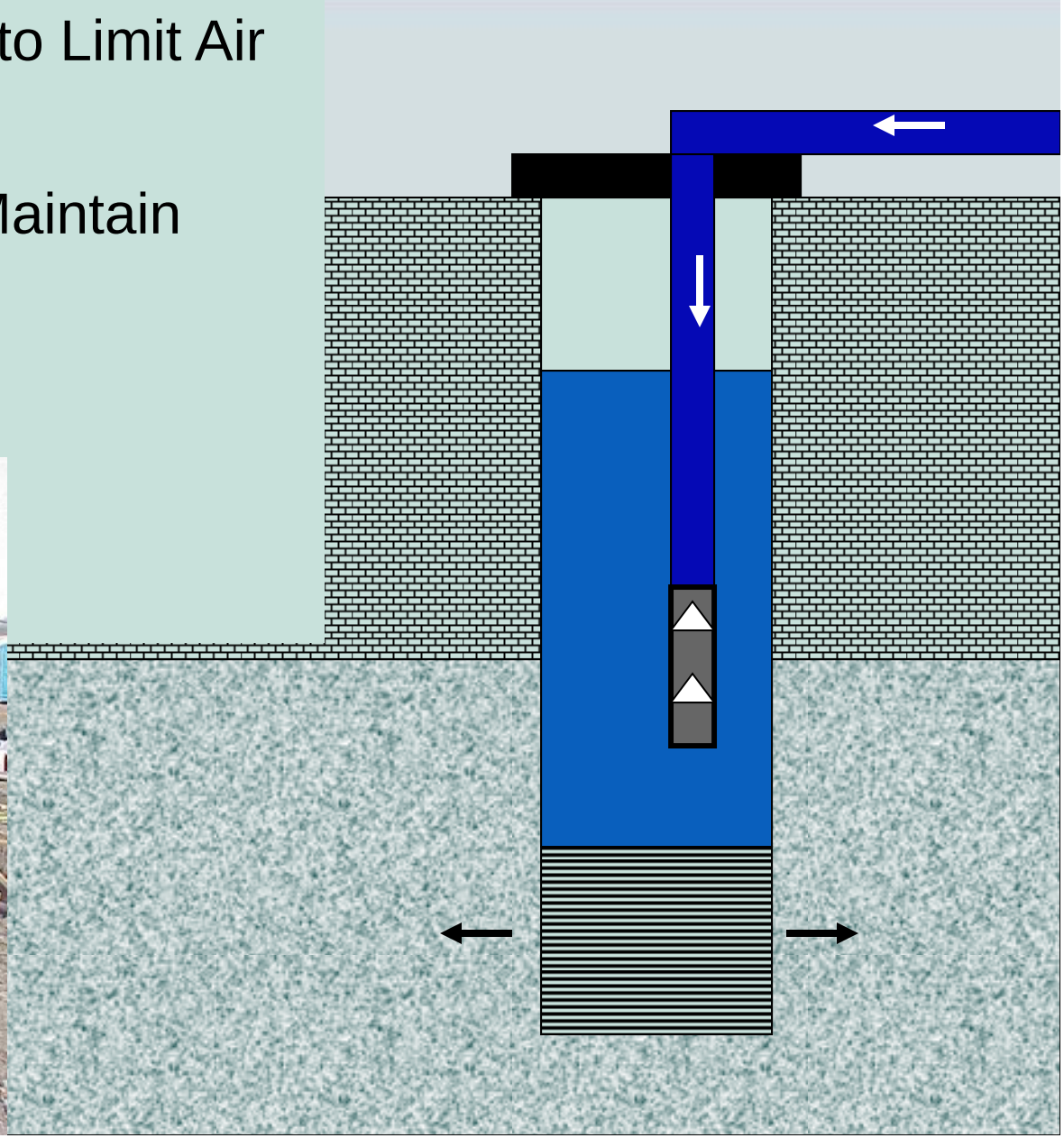
Recharge Control Options

- Recharge Piping Separate from Pumping System
- Design Turbine Pump to Provide Back-Pressure
- Down-Hole Flow Control Valves

Recharge Only Wells

- Requires Flow Control to Limit Air Entrainment
- Requires Pumping to Maintain Well Performance

$$V_{exit} >> V_{entrance}$$



Regulatory Framework

Any project will have these elements:

- Hydrogeologic Feasibility Study
- Water Availability and Rights
- Water Quality Evaluation
- Land Use
- Sampling and Analysis Plan
- UIC Registration
- Design
- Testing
- Monitoring/Reporting

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Regulatory Framework

- Oregon and Washington have ASR Regulations
- Idaho beginning process, current water quality regulations used as guidance
- Primary Difference: Oregon Waiver
  - Some Constituents
  - Tied to Drinking Water Quality
  - Allows Alternative Concentration Limits

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Washington Regulatory Issues

- Source Water Quality:

  Water to be stored in an aquifer for an ASR project must meet water quality standards for ground waters of the state of Washington (Chapter 173-200 WAC). Beneficial use must be preserved (drinking water presumptive standard)

- Anti-Degradation Policy: *WAC 173-200-030*

  Requires evaluation of any human activities that "lower" background water quality, and requires an AKART analysis.

All Known, Available, and Reasonable Methods of Prevention, Control, and Treatment

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AKART

Antidegradation policy

"… beneficial uses shall be maintained and protected and degradation … that would interfere with or become injurious to beneficial uses shall not be allowed."

WAC 173-200-030

- Goal: Protection of Beneficial
  - Ground water quality
  - Drinking water supply
  - Public Interest
- Process: Evaluate Feasibility of Compliance
  - Identify pollutants of concern
  - Evaluate treatment options and cost
  - Recognize potential risks and risk reduction
  - Evaluate Alternatives
  - Select Compliance Strategy

Compliance Strategies

- Un-Treat and Re-Treat Treated Drinking Water
- Public Interest Waiver. WAC 173- 157-200(2) states that Ecology "shall give strong consideration to the overriding public interest in its evaluation of compliance with ground water quality protection standards."
- Point of Compliance Monitoring

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Count Molecules or Gallons?

What About the "R" in ASR?

Betsy Woodhouse – Southwest Hydrology, University of Arizona

Southern Nevada Water Authority ASR well

Getting water into the ground is fairly straightforward: water drains down from a basin or goes down a well. But then what happens to it? Will the water really be there when it's needed? Does it matter if the ex[illegible]t same water is [illegible] actually stored? [illegible]s of the [illegible]ory framework.

When fresh water is stored in saline or brackish aquifers, common in the Southeast, mixing of the waters is undesirable: the goal is to recover essentially the same water that was recharged. When fresh water is stored in fresh-water aquifers, as is typical in the Southwest, recovering the same water is less critical. The goal of such projects

in wells demonstrate that the volume of water stored in an aquifer is increasing. The Vidler Water Company has been recharging about 30,000 acre-feet per year of Central Arizona Project water

> *Sometimes recovery of an equivalent mass matters more than getting the same molecules back.*

in its spreading basin facility in western Arizona since 2000; nearly a 200-foot rise in water levels has been observed. The Southern Nevada Water Authority stores

Permeability tests, tracer experiments (primarily using chloride), and flow and transport models have been used to study the behavior of recharged water in an aquifer. In general, recharged water usually stays in a somewhat coherent mass in the subsurface for a period of time after some initial mixing at the entry zone. How much and how quickly the recharged water mixes with native groundwater depends on parameters such as regional groundwater flow velocity and the dispersivity, transmissivity, and heterogeneities of the aquifer.

If water is stored only briefly or the aquifer is not highly transmissive, the recharged water mass will likely maintain

Southwest Hydrology May/June 2008

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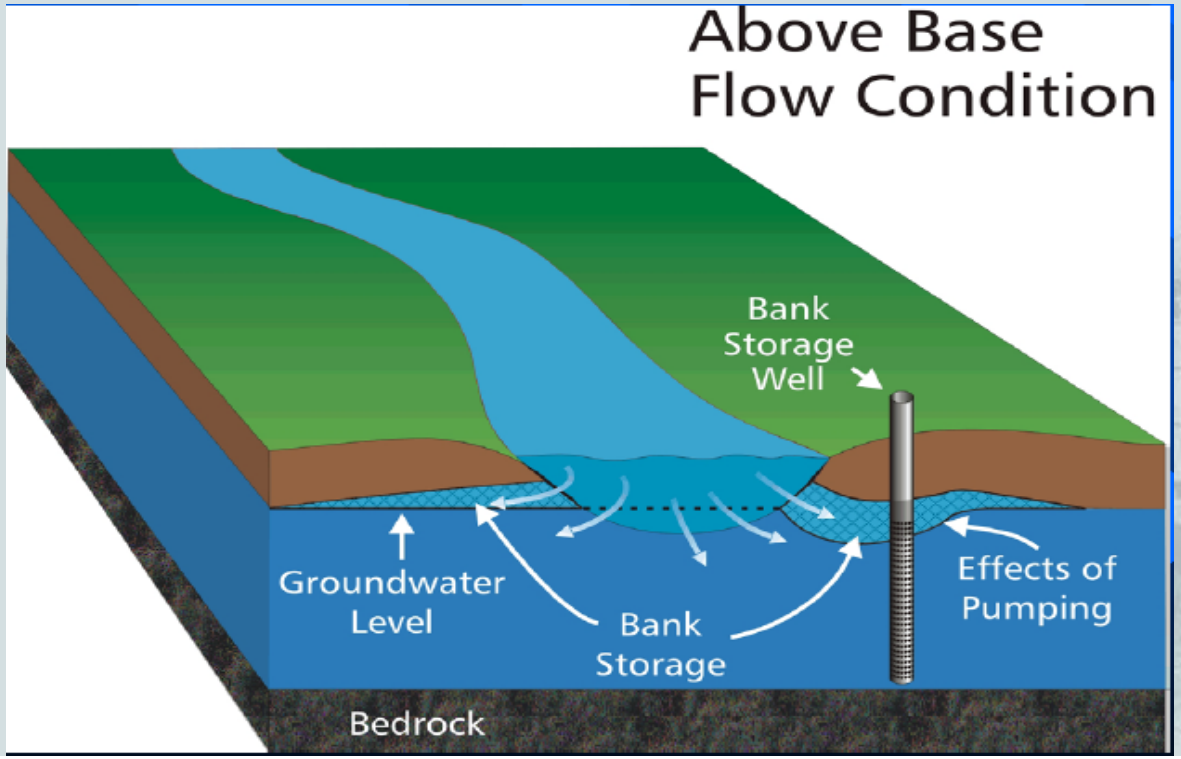
What's Next

RBF Now EPA Approved Method to Meet LT2 SDWA Filtration Standards

- ASR Combined with River Bank Filtration
  - RBF is an accepted approach to surface water treatment
  - Lower treatment costs



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What's Next

- Thermal Storage
- Store Ambient Energy:
  - Winter Cold
  - Summer Heat
- Manufacturing/Power Applications
- NPDES Permitting
- Habitat Mitigation

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What's Next

- Reclaimed Water?
  - Direct
  - AR to ASR

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Questions

Thank you!

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WATER
WATER
WATER