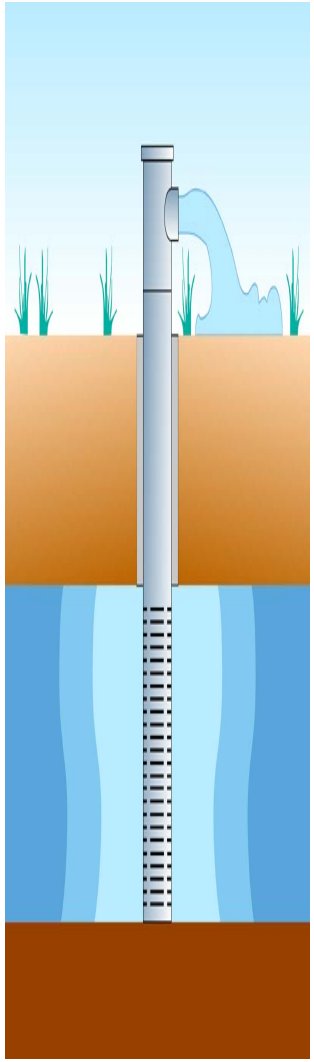
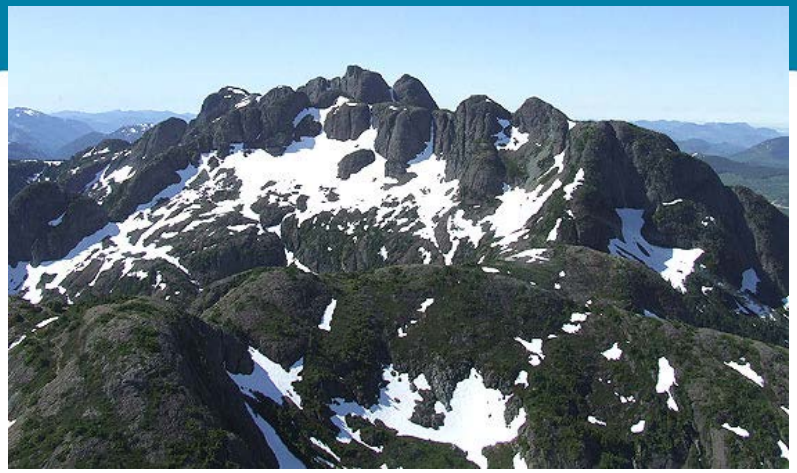
ENGLISHMAN RIVER WATER SERVICE





Aquifer Storage Recovery Program

Parksville, Vancouver Island

British Columbia

February 22, 2012

R. David G. Pyne, P.E.

ASR SYSTEMS

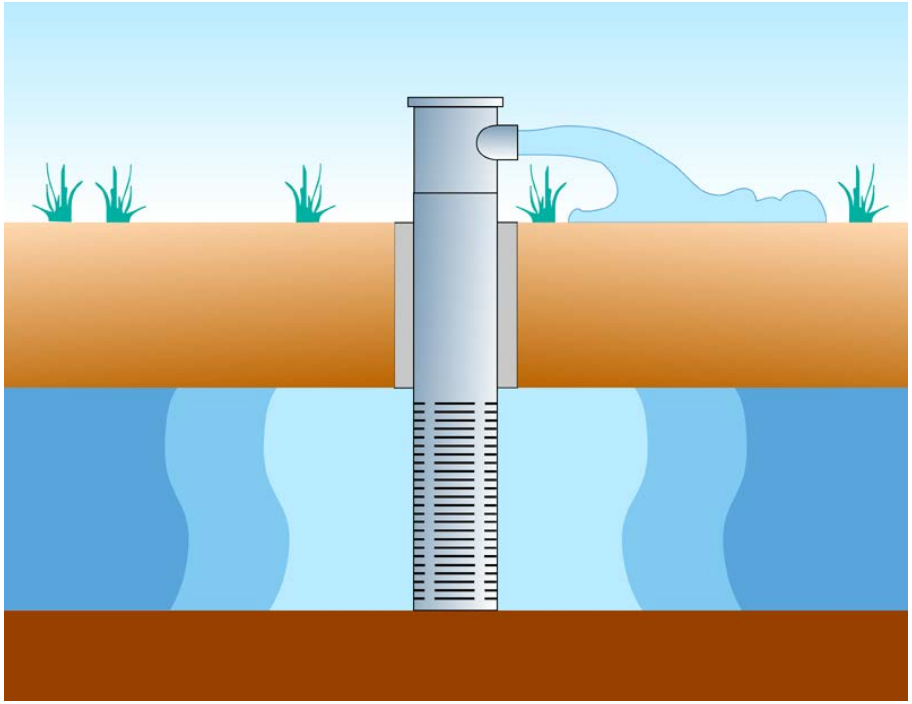
Englishman River – A Beautiful Gem to be Protected

Why Aquifer Storage Recovery (ASR) ?

- Flow in the Englishman River is sometimes muddy during the Fall and Winter, and therefore it is more difficult for the water to meet drinking water standards.
- Water quality standards are being raised, requiring improved treatment processes
- To ensure water supply reliability and excellent drinking water quality, Arrowsmith Water Service and the Englishman River Water Service plan to build a new water treatment plant
- Cost of the new facilities can be reduced significantly by effectively integrating ASR technology into the water supply planning project, treating and storing water underground during winter months for recovery during summer months to help meet peak demands

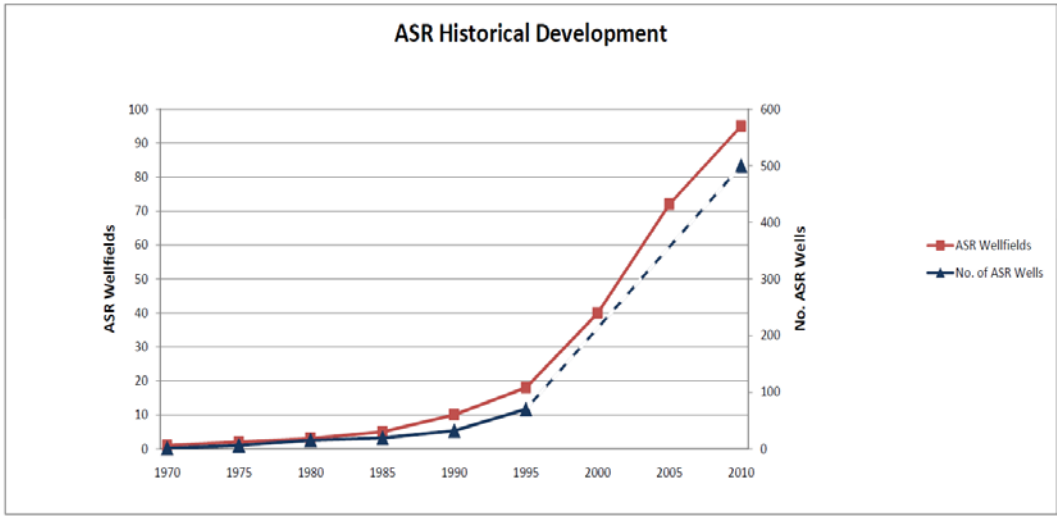
What is ASR?

Definition: Storage of water in a suitable aquifer through a well when the water is available for recharge, and recovery of stored water from the same well when it is needed

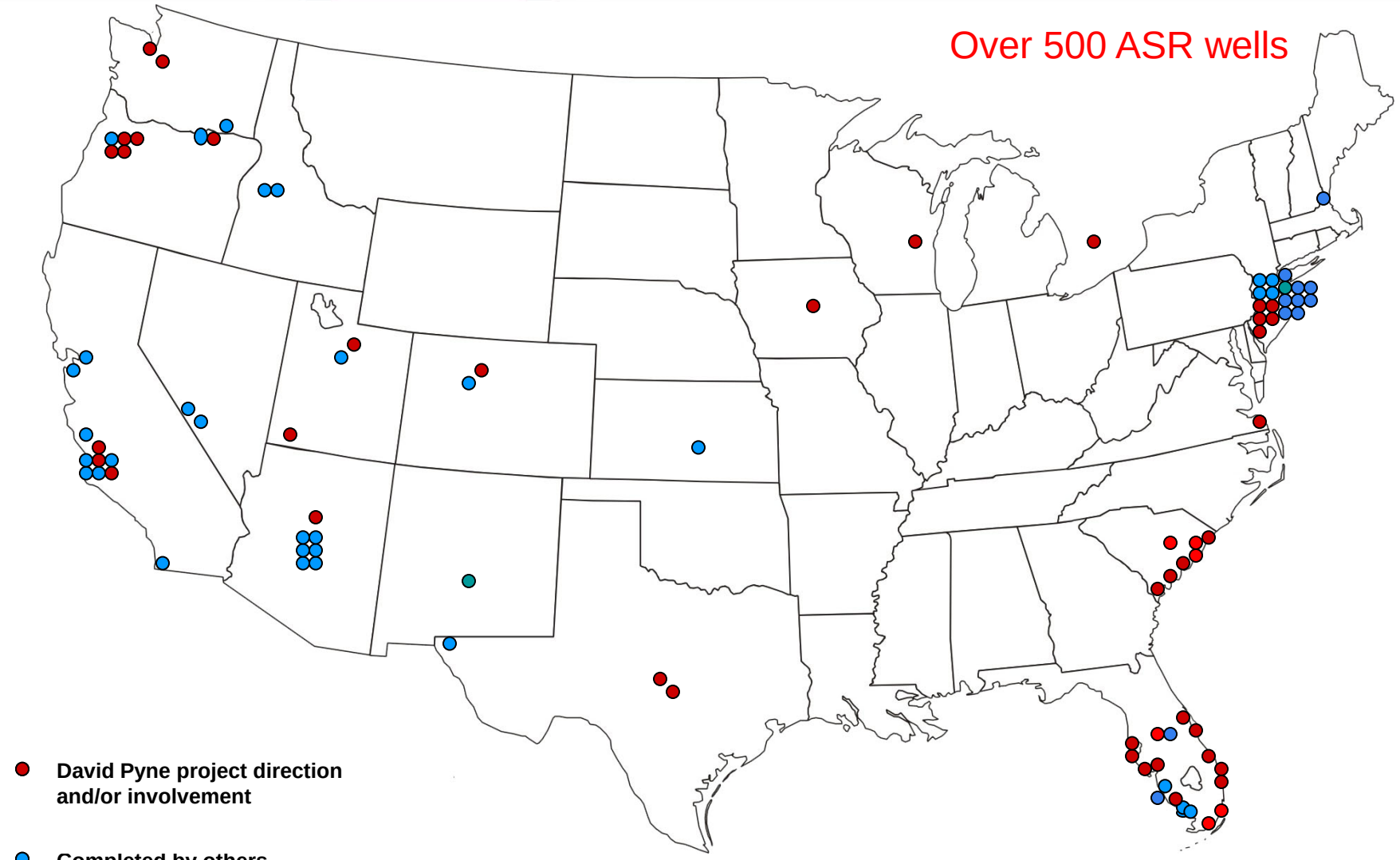


ASR Development has been rapid during the past twenty years

- Rapid growth in ASR implementation during the past 20 years, in US and other countries
- 26 different types of ASR applications
- Many different types of water sources for aquifer recharge
- Storage in many different types of aquifers and lithologic settings

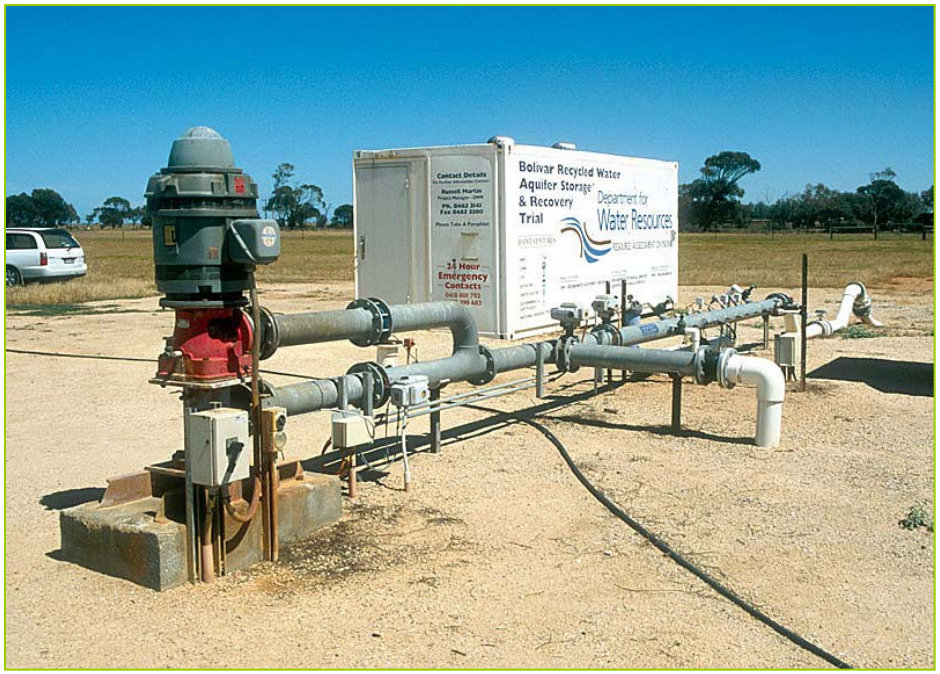


At least 100 Operational ASR Wellfields in the United States - January 2012



Global implementation of ASR since 1985 to achieve water supply sustainability and reliability

- Australia
- India
- Israel
- Canada
- England
- Netherlands
- South Africa
- Namibia
- United Arab Emirates
- And others in development (Kuwait, Taiwan, Indonesia, Qatar, possibly China)



Adelaide, Australia ASR Well

A broad range of water sources and storage zones is utilized for ASR

- Water sources for ASR storage
  - Drinking water
  - Reclaimed water (AZ, TX, FL, NJ, CA)
  - Seasonally-available stormwater
  - Groundwater from overlying, underlying or nearby aquifers
- Storage zones
  - Fresh, brackish and saline aquifers
  - Confined, semi-confined and unconfined aquifers
  - Sand, clayey sand, gravel, sandstone, limestone, dolomite, basalt, conglomerates, glacial deposits
  - Vertical “stacking” of storage zones

ASR Operating Ranges

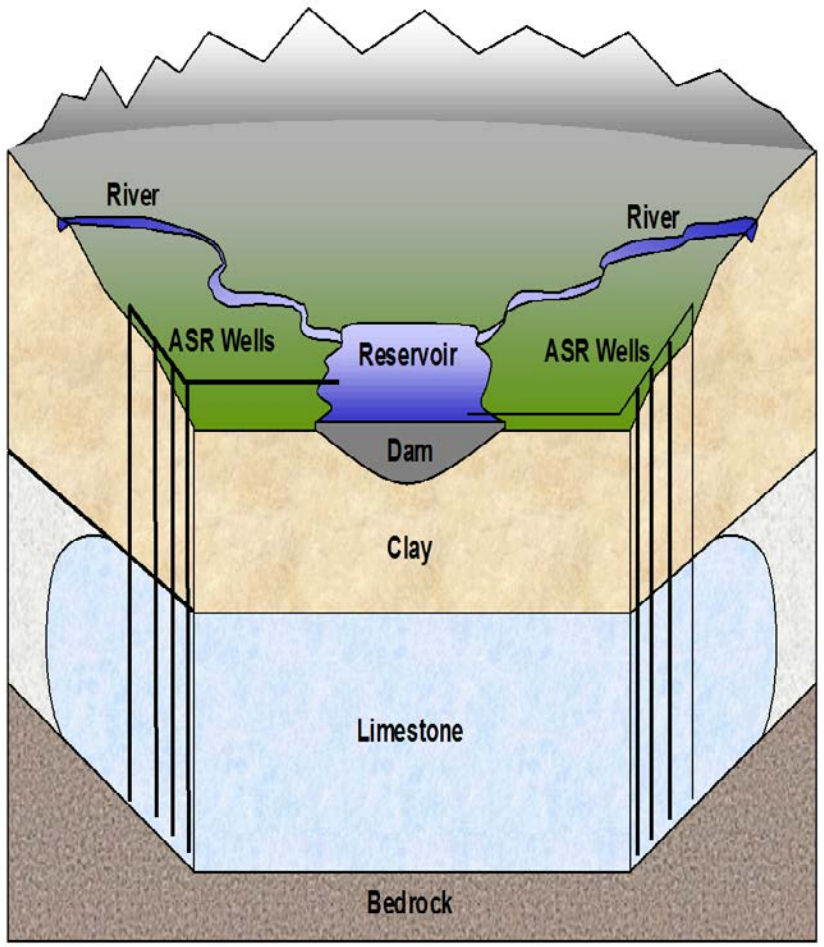
- Well depths
  - 30 to 2700 feet
- Storage interval thickness
  - 20 to 400 feet
- Storage zone Total Dissolved Solids
  - 30 mg/l to 39,000 mg/l
- Storage Volumes
  - 100 AF to 270,000 AF
  - (30 MG to 80 BG)
- Bubble radius less than 1000 ft
- Individual wells up to 8 MGD capacity
- Wellfield capacity up to 157 MGD

Calleguas MWD, California

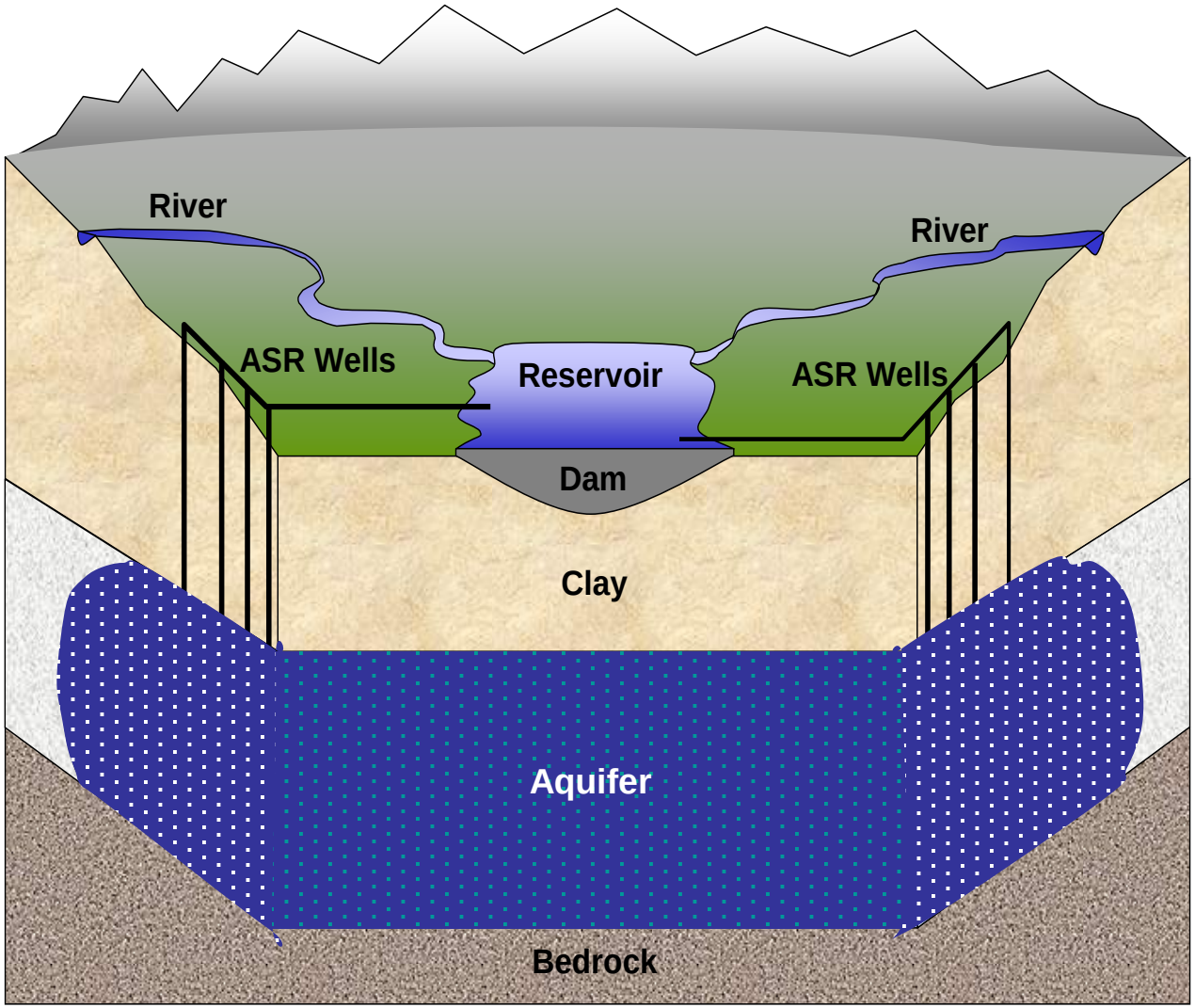
ASR Well

A combination of ASR wells and surface reservoirs is very beneficial for providing water storage

- Surface reservoirs capture water quickly, but…
  - are expensive
  - often have evapotranspiration and seepage losses
  - garner environmental opposition
- Where feasible, ASR wells can store much larger volumes of water
  - occupy little land
  - can be built in increments
  - have few or no losses, but can only recharge and recover water slowly



Aquifer storage of treated drinking water supplements the raw water storage in the surface reservoir.



ASR has many applications to meet local needs

- **Seasonal storage**
- Peak, diurnal and emergency water needs
- Water banking, or long term storage
- Restore groundwater levels
- Reduce subsidence
- **Maintain distribution system flows and pressures**
- Improve water quality
- Prevent seawater intrusion
- Protect endangered species
- Agricultural water supply
- **Temperature control**
- Hydraulic control of contaminant plumes
- **Defer expansion of water facilities**
- ….about 10 other applications to date

Kiawah Island, South Carolina, ASR-2

Identifying and prioritizing these applications is a logical first step in ASR planning

Seasonal Storage

- Store water in wet months for recovery during dry months
- Store best quality water for recovery when needed
- Storage duration days to months
- Store in confined, semi-confined, unconfined aquifers
- Store in fresh, brackish, saline aquifers

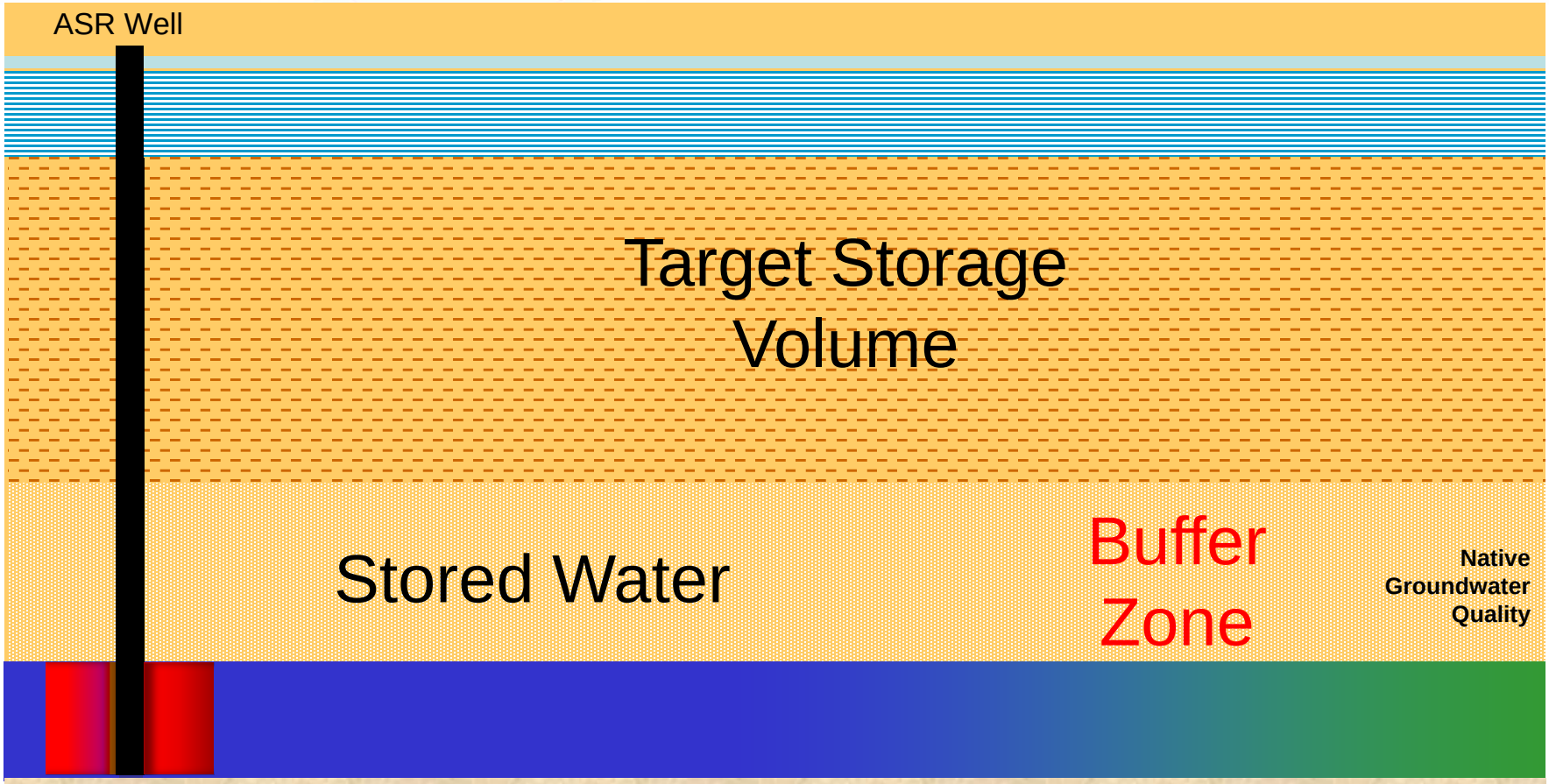
West Palm Beach, Florida
ASR Well – 8 MGD Capacity
Largest ASR Well in the World

Defer expansion of water facilities

- Operate treatment facilities to meet slightly more than average demands, providing for maintenance periods and times of inadequate supply
- Meet maximum day demands from ASR wells; peak hour demands from elevated and ground storage tanks
- Reduce capital costs by typically more than 50%

Highlands Ranch, CO
One of 26 ASR wells underground in vaults

Formation and Maintenance of a Target Storage Volume usually achieves recovered water quality goals



TSV is the sum of the stored water volume and the buffer zone volume. It is expressed in MG/MGD of recovery capacity, or in “days”

Several factors have contributed to ASR global implementation

- Economics
  - Typically less than half the capital cost of alternative water supply sources
  - Phased implementation
  - Marginal cost pricing
- Proven Success
  - About 100 wellfields in 22 states with over 500 operating, fully permitted ASR wells
- Environmental and Water Quality Benefits
  - Maintain minimum flows
  - Small storage footprint compared to surface reservoirs
- Adaptability to Different Situations
  - Fresh, brackish or saline storage aquifers
  - Drinking water, reclaimed water, stormwater or groundwater storage
  - Over 26 different applications

Mt Pleasant, SC – Well ASR-2

ASR Technical/Scientific Issues

- Target Storage Volume (TSV)
- Arsenic
- Microcontaminants
- Iron and Manganese
- Radon
- Hydrogen Sulfide
- Disinfection Byproducts
- Recovery Efficiency
- Well Clogging and Rehabilitation
- Design Issues
- Operating Issues

Marathon, Florida – First ASR well to successfully store drinking water in a seawater aquifer

ASR Economics

- 2010 national average unit cost for ASR is about $1.14 per gallon per day of recovery capacity, within a range of about $0.50 to $2.00.
- ASR solutions to meet local and regional water demands will typically be less than 50% of the cost of alternative supplies

Manatee County, FL

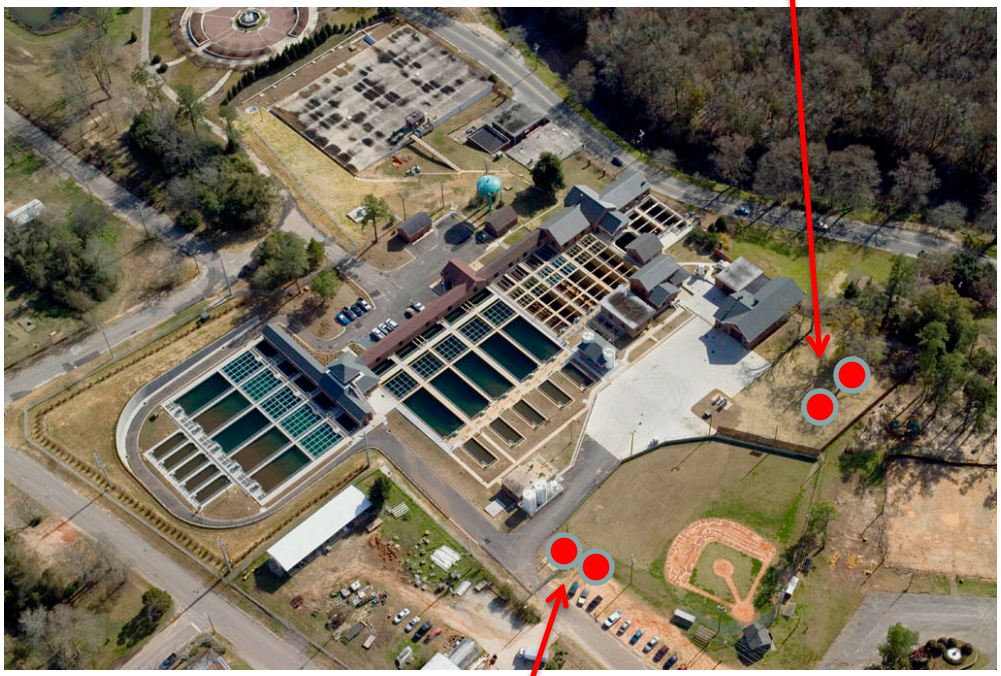
Florida's First ASR Well, 1983

ACEC Grand Award, 1984

The Future …

- Biotechnology/geochemistry advances to achieve subsurface treatment and other water quality objectives
- Larger ASR programs to meet regional and national needs
- ASR wells for storage, treatment and conveyance
- Strategic Water Reserves and Water Banking
- Marginal cost pricing and water storage leasing
- Application of improved well development methods
- Thermal energy storage
- Reclaimed water storage
- Bank filtration/ASR combination technologies
- Desalination/ASR combination technologies (DASR)
- Horizontal Directional Drilled (HDD) ASR wells
- Vertical stacking of storage zones

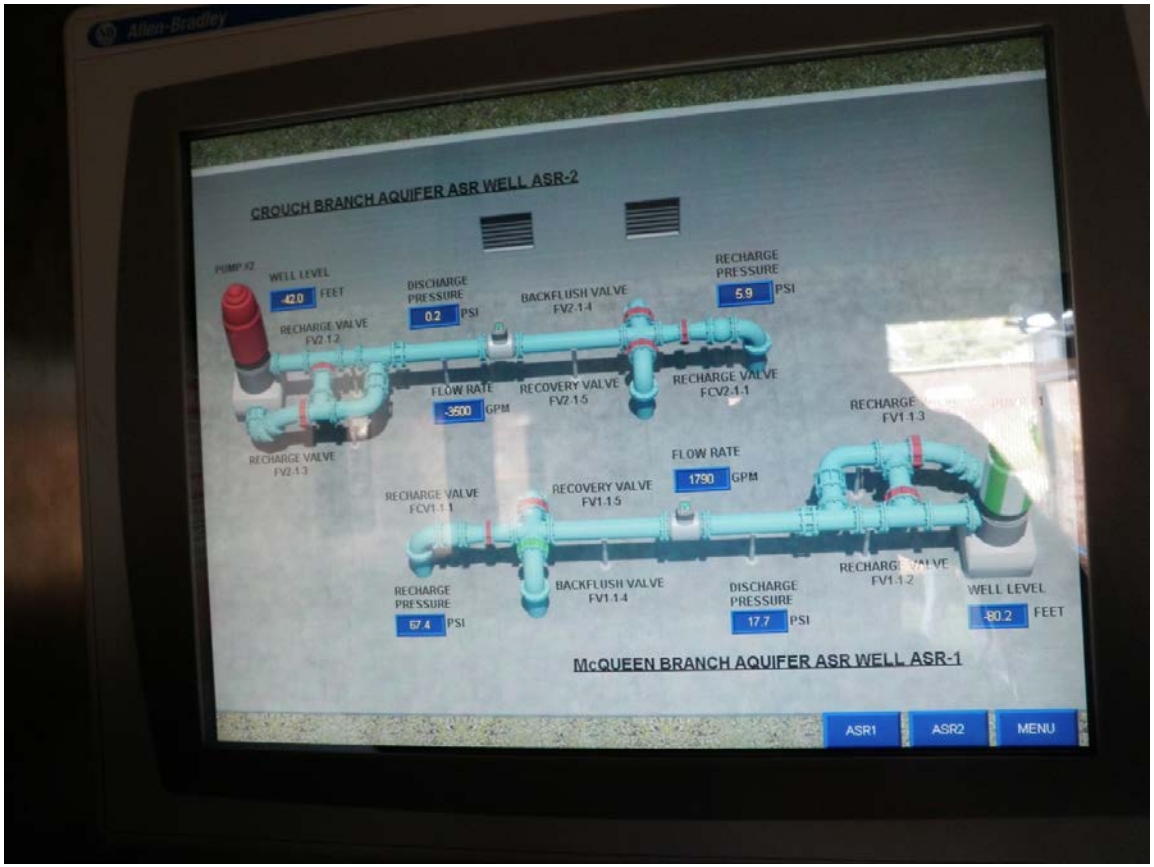
Orangeburg ASR



- 30 MGD Surface Water Treatment Plant
- Water Source – North Fork Edisto River
- Average Day Demand about 10 MGD
- Maximum Day Demand about 15 MGD
- ASR Recovery Capacity 6.5 MGD
- Currently approaching end of Cycle 3, with recovery to the water distribution system

Orangeburg ASR Wellhouse

Orangeburg SC SCADA Screen



Two ASR wells,

In two different aquifers,

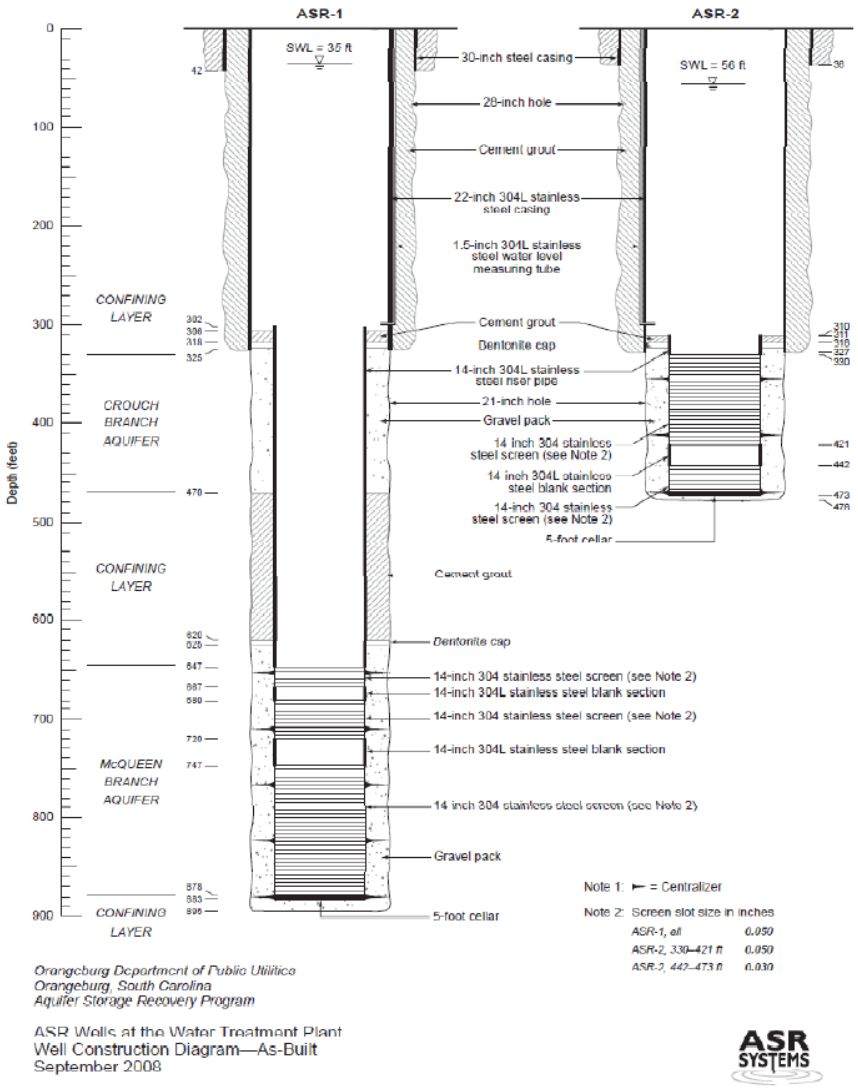
40 feet apart,

In a single wellhouse

Yielding 6.5 MGD

Orangeburg Well ASR-2

Orangeburg ASR Well Construction



- 22-inch SS304 inner casings to about 330 feet
- 14-inch SS304 screens
  - ASR-1 647 to 878 ft
  - ASR-2 330 to 473 ft
- Two 6-inch PVC storage zone monitor wells with similar SS304 screens and settings, equipped with Insitu transducers
  - water level
  - conductivity
  - temperature
  - dissolved oxygen
  - redox potential
  - pH

ASR Book, Second Edition