CONNECTING WATER TO LIFE

ECONOMIC EVALUATION OF AQUIFER STORAGE AND RECOVERY SYSTEMS

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When evaluating the feasibility of conducting aquifer storage and recovery (ASR), there is a tendency to focus on the technical aspects such as water compatibility, recharge rates, and facility siting. However, it's equally important to evaluate the economics of conducting ASR. An economic assessment is valuable for choosing between different ASR concepts and for comparing the economics of ASR to other water supply alternatives.

An ASR economic assessment typically comprises a life-cycle cost analysis that considers the capital and operation, maintenance and replacement (OM&R) costs associated with developing and operating an ASR system. The result of the exercise is a present value cost per volume (e.g., PV cost per acre-foot) of recharged, and potentially recovered water, that can be used as a common currency for comparing alternatives.

Described herein is an approach to conducting ASR economic assessments and tips for interpreting and applying the results

Step 1 – Identify and Estimate Cost Components

The first step is to tabulate each of the relevant ASR system cost components and categorize them by capital and OM&R. This tabulation will include attributes such as unit, frequency, and unit cost. An example Cost Data Reference Table structure is illustrated below.

Example Capital Cost Table Structure

COST COMPONENT	UNIT	FREQUENCY	UNIT COST
Land Acquisition	Acre	Once	$
ASR Well Construction	Well site	Once	$
Pre-Treatment Facilities	Facility	Once	$

Example OM&R Cost Table Structure

COST COMPONENT	UNIT	FREQUENCY	UNIT COST
Electrical	kwh	---	$
Source Water Purchase	$/AF	---	$
Routine Well Maintenance	$/well	Annually	$
Well Pump Replacement	$/well	Every 10 years	$

ASR system cost components can include, but are not limited to, the following:

Capital Costs

- Land and/or easement acquisition
- Source water treatment, capacity upgrades, and/or pre-treatment facilities
- Source water conveyance piping to recharge facility
- Recharge facilities
- Groundwater monitoring facilities
- Ancillary facilities, including valves, meters, yard piping, controls, site security
- Electrical power, if not available at the site
- Recovery facilities, if separate from recharge facilities
- Recovered water treatment / disinfection
- Recovered water conveyance piping

OM&R Costs:

- Source water purchase costs, if applicable
- Source water and recovered water treatment facility operating costs
- Pipeline maintenance
- Recharge facility operations and maintenance
- Equipment replacement (pumps, motors, valves, meters)
- Labor, both operations and administrative
- Water sampling and analysis
- Regulatory compliance

Recharge Basin

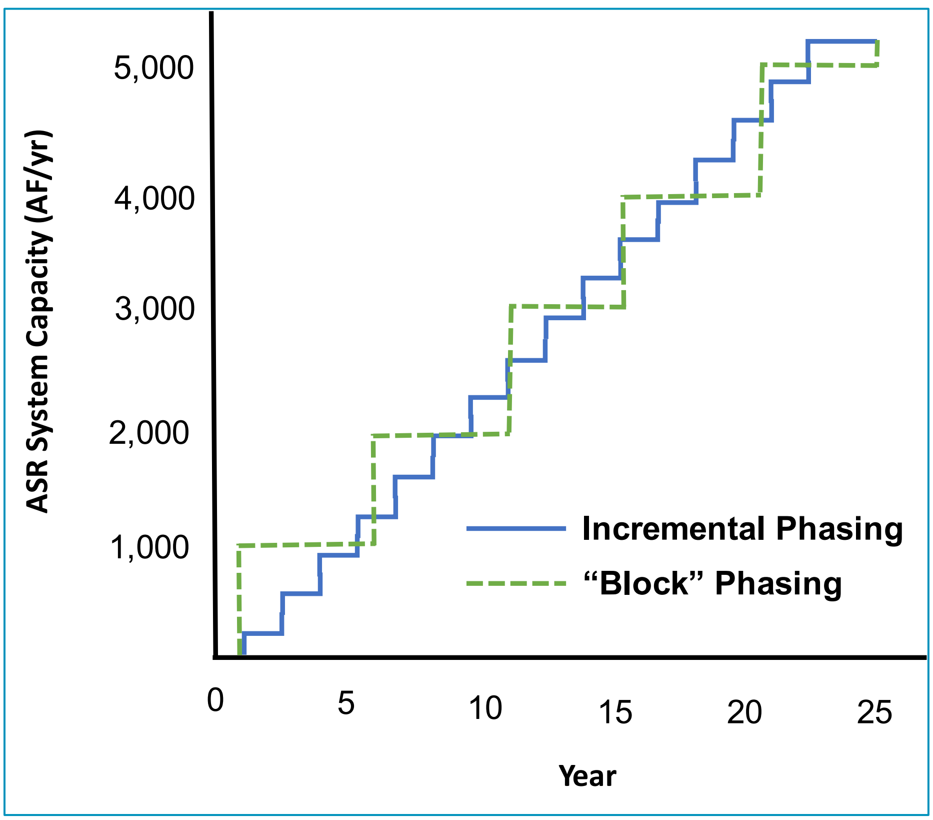
Step 2 – Set Up Life-Cycle Cost Model

Once each of the cost components is identified and estimated, a life-cycle cost model is developed. Excel™ is typically adequate for life-cycle cost modeling, and enhanced functionality can be incorporated with Macro scripts.

Assumptions: In addition to the cost components discussed above, certain assumptions must be made, including:

- **Life-cycle:** period of time the system is expected to be operated
  - Typically, 30 to 50 years
- **Discount rate:** rate (%) that future cash flows are discounted to present value
  - Typically, 3 to 5% depending upon an organization's cost of capital
- **Capital cost escalation rate:** rate of increase in the cost of materials, equipment, and construction
  - 3 to 4% annually, depending upon economic conditions
- **OM&R cost escalation rate:** rate of increase in the cost of labor, services, and consumables
  - 2 to 3% annually, depending upon labor market and economic conditions
  - Use a separate rate for significant components that escalate at a faster rate

Phasing: The life-cycle cost model should consider project phasing since ASR systems are commonly developed in phases. Phasing can occur incrementally, such as adding one ASR well per year, or in larger blocks. The economics of different phasing approaches can be evaluated as part of scenario analysis.



Fixed and Variable Costs: Some ASR system costs are fixed (fixed costs), meaning they occur whether or not the system is operated, and others vary based on system operations (variable costs). Fixed costs, including insurance, in-house labor, electrical service base charges, and regulatory compliance occur each year and often scale with system capacity. Variable costs, such as chemicals, power, and source water acquisition costs, vary annually based on the throughput of the system.

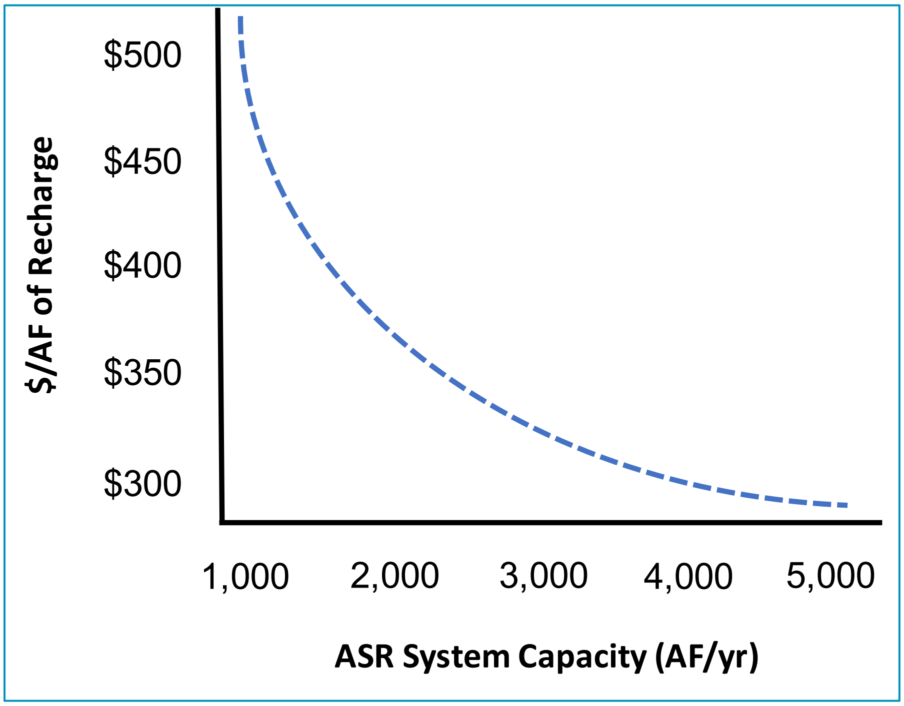
Each row of the model represents a year in the life-cycle of the project and includes the capital and OM&R costs (cash flows) that occur in that year. These costs are escalated based on the assumed capital and OM&R escalation rates, summed, and discounted back to present value based on the selected discount rate and year they occur. Each of the annual present value costs are then summed to arrive at the life-cycle cost of the ASR system. This cumulative present value is divided by the total volume of water recharged over the life-cycle of the project to yield the present value cost per volume of recharged water ($/acre-foot or $/MGD).

ASR well in the Phoenix metropolitan area

Step 3 – Scenario and Sensitivity Analysis

Once set up and populated, the model can be used to evaluate the economics of different ASR system development and operations scenarios; and to assess the sensitivity of the model to various inputs and assumptions. Some examples include the following:

- **Evaluate the relative costs of different types of recharge facilities, such as basins, vadose zone wells, and ASR wells.** Some alternatives might have higher capital costs but lower OM&R costs, and some are more suited for incremental development than others.
- **Compare different system development and sizing alternatives, such as adding capacity incrementally versus in larger blocks; and varying system buildout capacity.** There are typically economies of scale to be gained when infrastructure is developed in larger blocks; however, underutilized capacity can result in a higher cost per volume of recharged water.



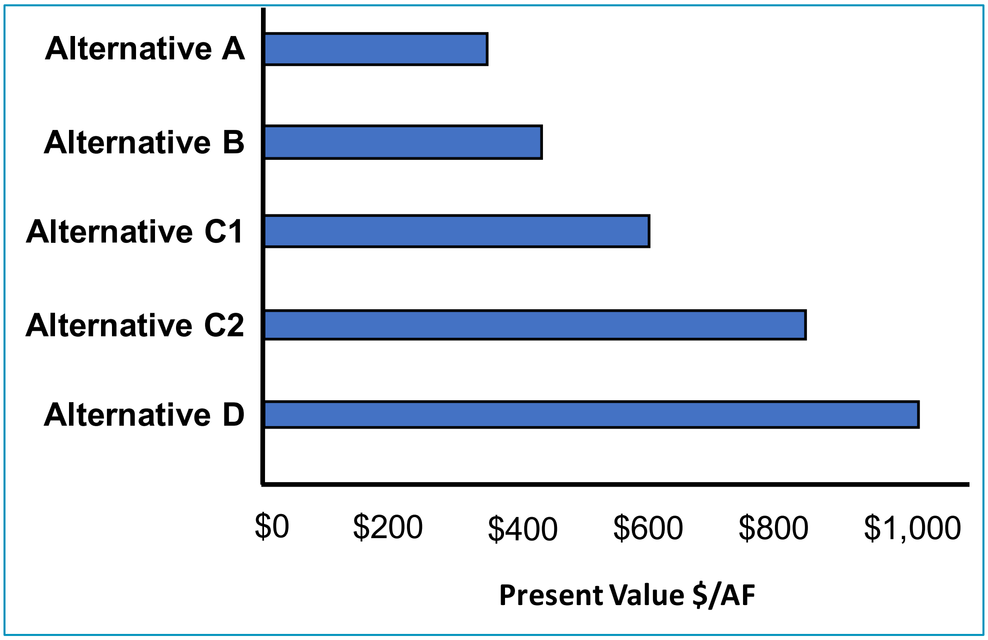
- **Vary assumptions such as discount rate, cost escalation rates, recharge rates, and recharge source water availability to evaluate the sensitivity of modeling results.** Sensitivity analysis is useful for identifying the cost components and assumptions that 'move the needle', or strongly influence the economics of conducting ASR.

Step 4 – Interpret and Apply Model Results

The last step is interpreting and applying the economic modeling results. All else being equal, the alternative (or scenario) that yields the lowest PV cost per volume of recharged water is the most favorable. However, there are other factors that should be considered, including technical feasibility, permitting feasibility, and ease of operations. For example, recharge basins may yield the lowest PV cost, but there could be constraints such as land availability or the presence of shallow, impermeable layers at the proposed recharge site. As such, economics is only one factor to consider when choosing between ASR system alternatives.

Some common applications of ASR economic model results include the following:

- **Select the best alternative:** The best alternative is typically the one that is most economical (i.e., lowest PV cost per volume of recharged water), but is also technically feasible, able to be permitted, and integrates well with the organization's existing assets and operational strategy.
- **Compare to other water supply alternatives:** When conducting long-range water resource planning, water utilities evaluate the pros, cons, benefits, and risks of a variety of water supply development alternatives. These alternatives might range from a new surface water reservoir, to wastewater reclamation, to ASR. ***Economic modeling is highly valuable for comparing diverse alternatives using a common currency.***



- **Optimize ASR system development and operations:** An economic model is a valuable tool to optimize ASR system development and operations. For example, the most economical ASR systems are operated on a continuous basis and their capacity is balanced with recharge source water availability. Modeling results can inform the timing and amount of ASR system capacity development, and yield insights on how to most economically operate the system.