Small Pumped Hydroelectric Storage

September 19, 2018
Board of Public Utilities
Informational Meeting

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Pumped Storage Concepts

- Use water for gravitational potential energy storage, pumped from a lower elevation reservoir to a higher elevation.
- Pump water up using excess or off-peak energy
- Flow water down through turbine to generate energy
- Pumping and generation losses makes the plant a net consumer of energy

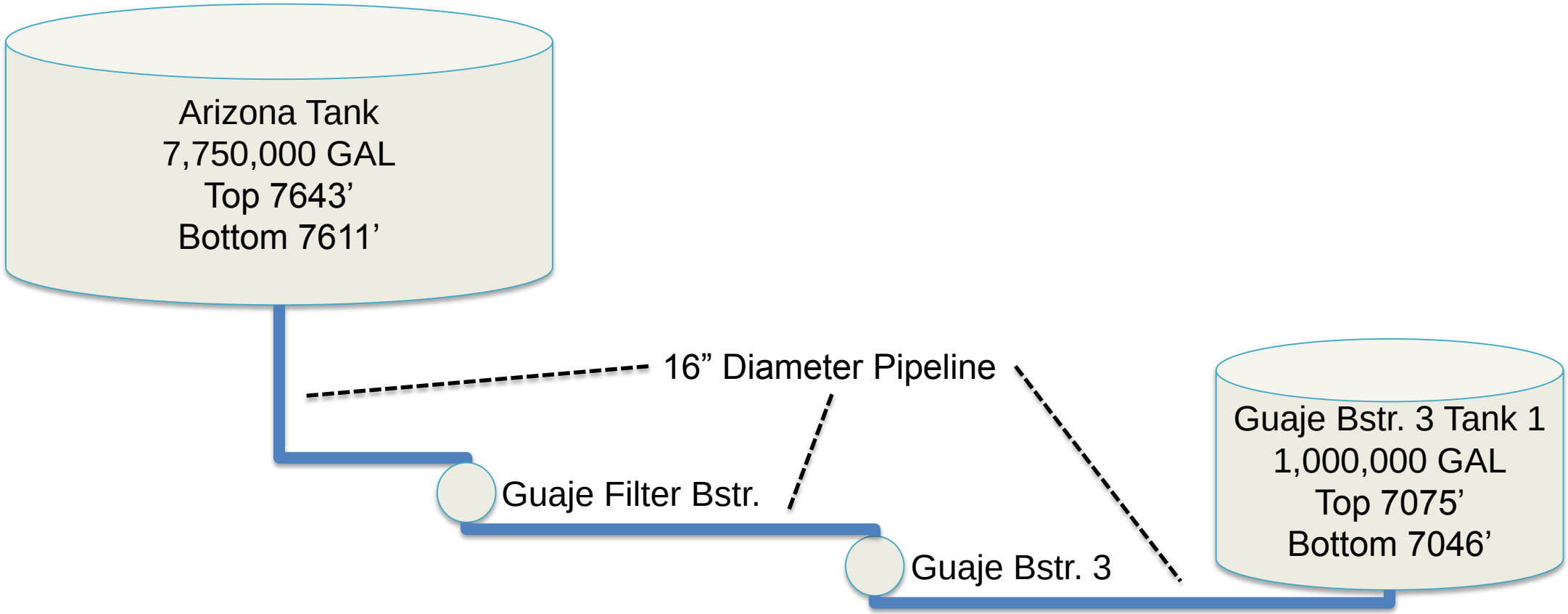
Potential Benefits

- Storing excess local wind and solar energy
- Peak shaving and energy arbitrage
- Load balancing
- Ancillary services – frequency regulation and reserves

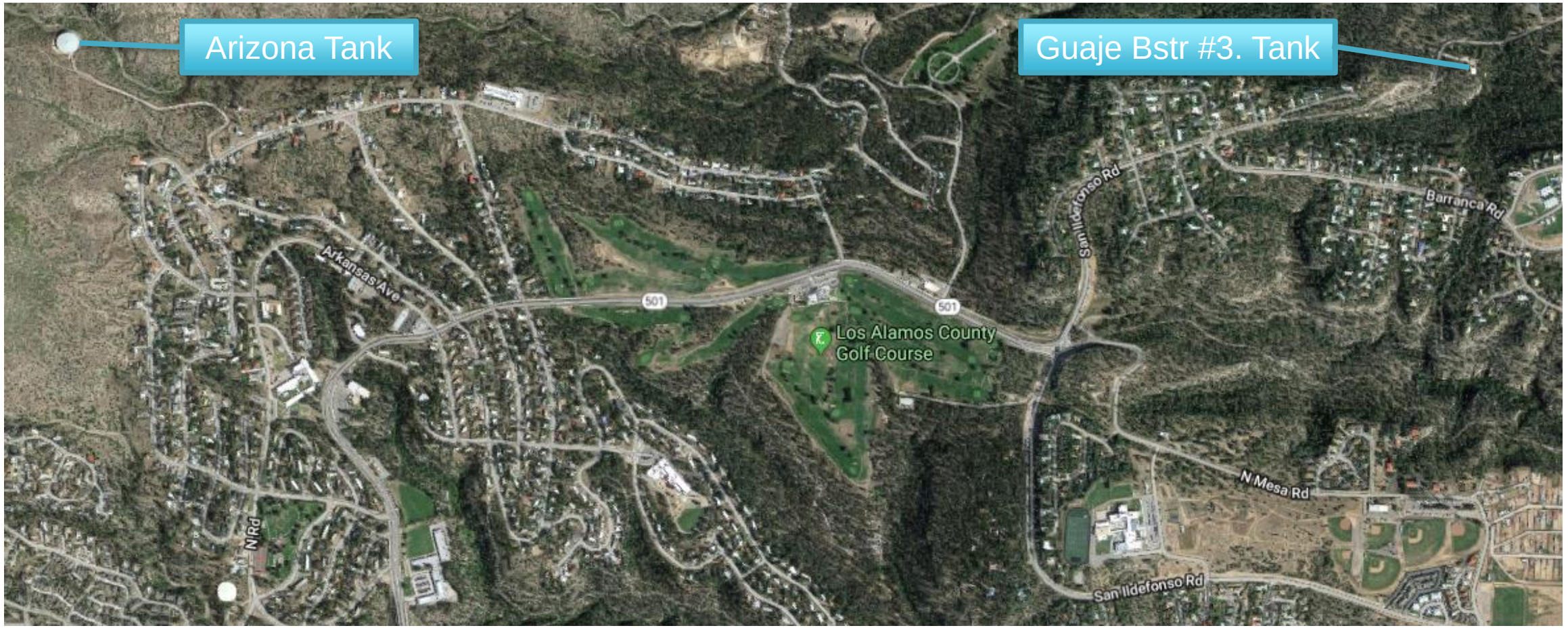
Costs

- Justifying investments in new pumped storage plants remains very challenging with current electricity market economics
- Small pumped storage plants being the most challenging due to capital and O&M cost for little benefit.

Notional Design



Aerial View



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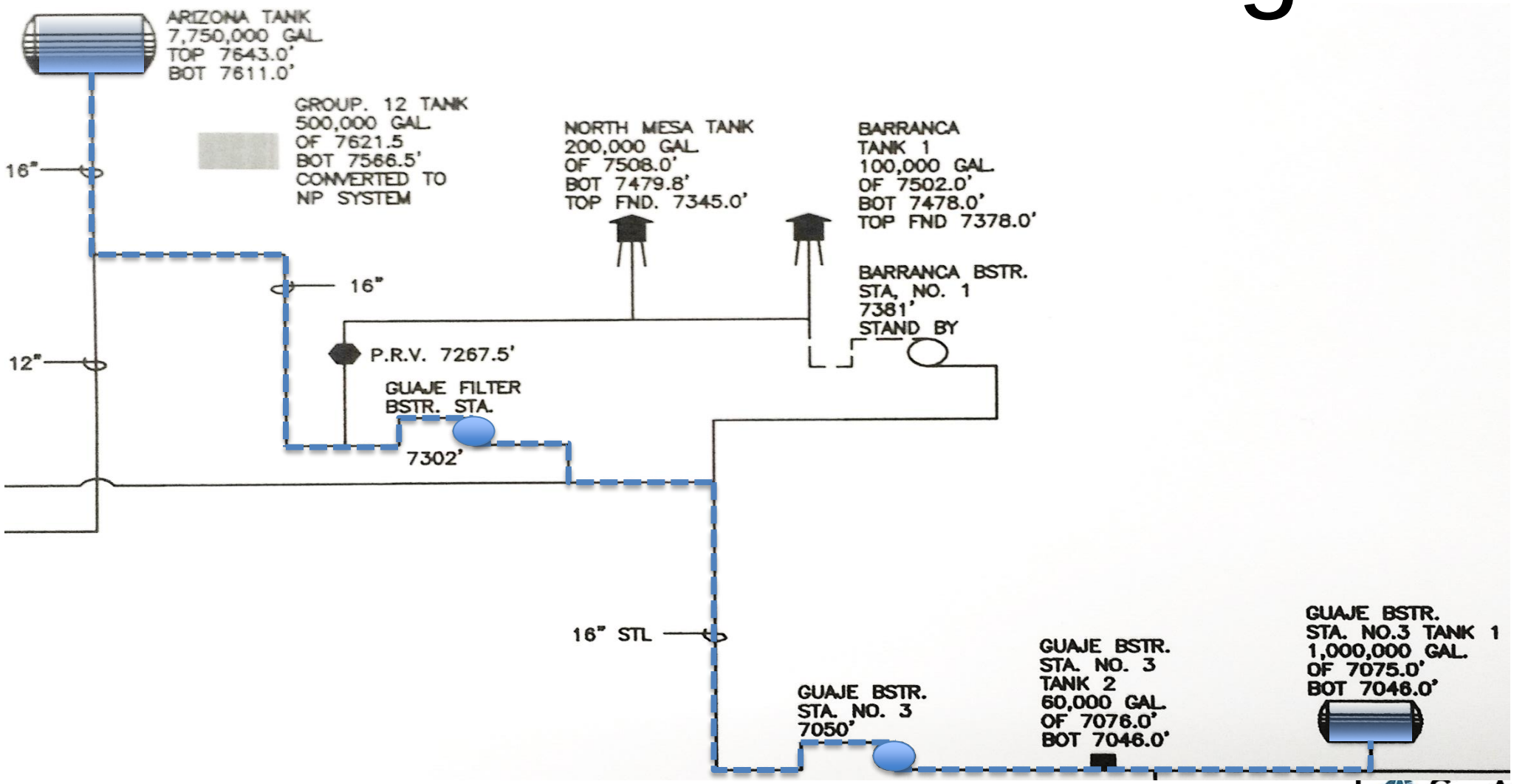
Schematic Drawing



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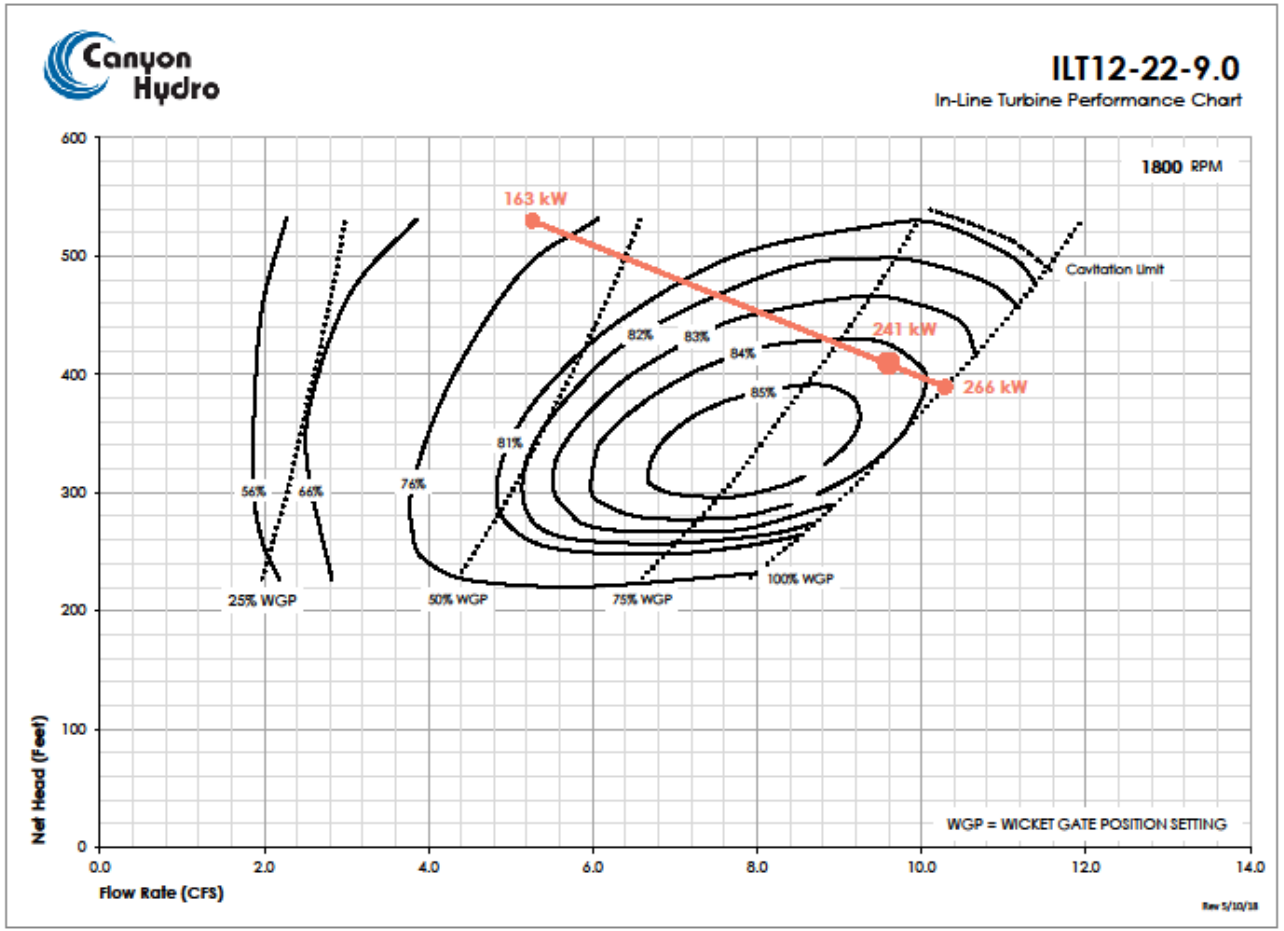
Canyon Hydro Turbine Generator

In Line Turbine Performance Chart



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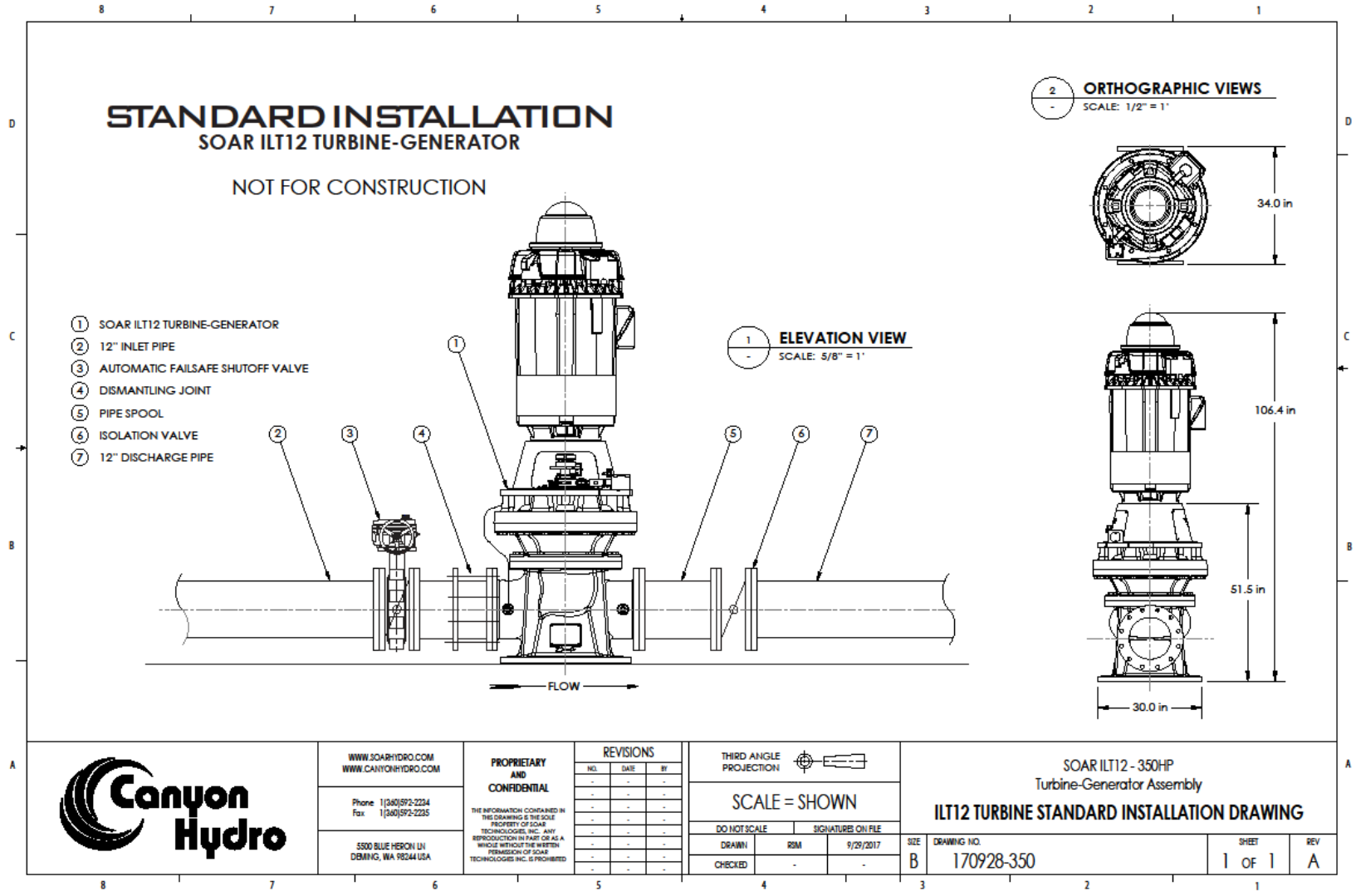
Canyon Hydro Turbine Generator



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Analysis of Benefits

- Storing excess local wind and solar energy
  - Currently no excess renewable energy
- Peak shaving and energy arbitrage
  - Small cost difference in peak and off-peak energy
  - Low efficiency, ~30%, from long, small-diameter pipeline
- Load balancing

- Ancillary services – frequency regulation and reserves
  - Power generation too low to serve this purpose

Does it make sense?

Pumping energy required to move 1 million gallons of water (3640 kWh)

LAC Incremental Cost of Power	$0.0224 kWh
LAC 2017 Average Purchase Power Cost	$0.0334 kWh

Pumping the water up the hill to terminal storage (Arizona Tank)

Valued at LAC Incremental Cost of Power	$81.53 / Day	$2,446/month

Running the Water back down through Generator (Guaje Booster Tank #3)

Power Generated	Valued at Average Purchase Power Cost	$33.40/Day	$1,002/month
ATRR Savings (241 kW delta)			$680/month
Monthly (Cost) / Savings	(Capital and O&M not included)		($764)/month

Capital estimated at $500,000

O&M ?

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Energy Budget

$$E_{generator} = E_{max} - Loss_{head} - Loss_{turbine} - Loss_{generator}$$

$$E_{max} = mGh = 1791\ kWH$$

$$Loss_{head} = \frac{570 - 410}{570} \times E_{max} = 503\ kWH$$

$$Loss_{turbine} = (1 - 0.84) \times (E_{max} - Loss_{head}) = 206\ kWH$$

$$Loss_{generator} = (0.065) \times (E_{max} - Loss_{head} - Loss_{turbine}) = 70\ kWH$$

$$E_{generator} = 1791 - 503 - 206 - 70 = 1012\ kWH$$

Questions