

Finding the ASR

Alternative Energy Nexus Through Micro-Hydro!

Brief Background
ASR Hydropower Generation
Well 14 Pilot Study
Power Estimates
Hydropower Installation Examples
FERC Conduit Exemption
Summary

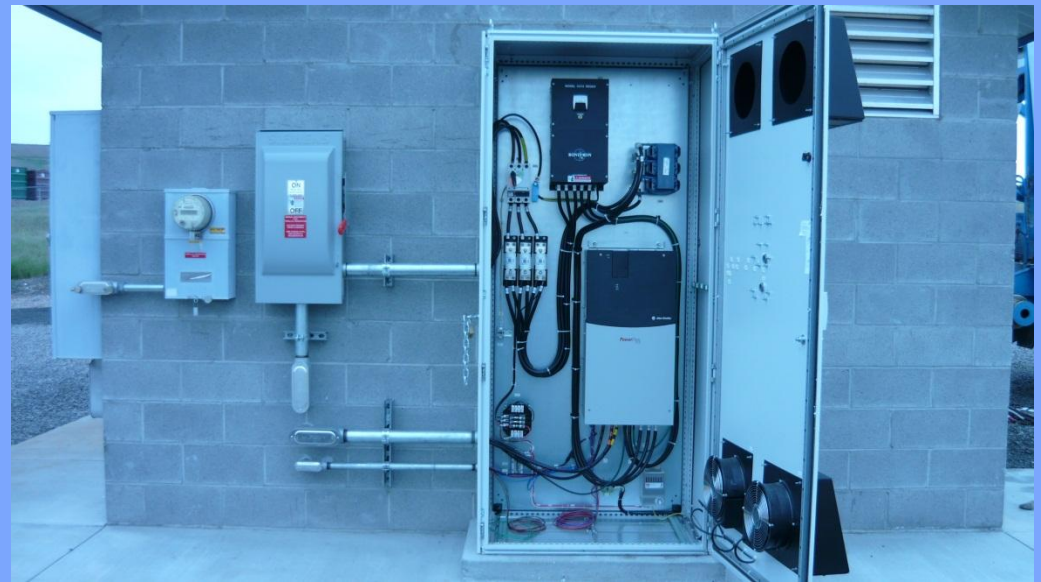


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Brief Background



Well 5 – 50 kW Micro-turbine



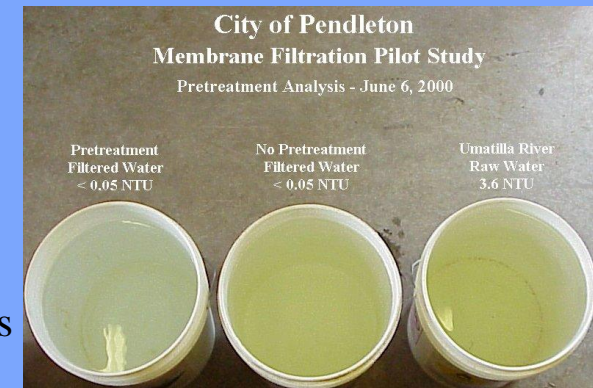
Well 14 – 45 kW Regenerative Drive & 100 HP VFD



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Aquifer Storage & Recovery

- Aquifer Storage & Recovery (ASR) discussions began in mid-1990s
- Surface water influenced “spring” source determination late-1990s
- Slow Sand Pilot Study completed in 1998
- Membrane Pilot Study completed in 2000
- Hydrogeologic Feasibility Study completed in 2002
 - Surface water and native ground water compatibility
 - Drinking water in / drinking water out!
- OWRD ASR Limited License #006 issued May 2003
 - Well 1, Well 5, & Well 14: utilize as ASR wells
 - Well 2, Well 4, & Well 8: future ASR wells
- OWRD ASR Limited License #006 renewal April 2013
 - Well 1, Well 4, Well 5, Well 8, Well 14: utilize as ASR wells
 - Well 2: future ASR wells



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Aquifer Storage & Recovery

- Membrane WTP in production June 2003
- Pendleton ASR Program began in December 2003
- 10 ASR “cycles” have been completed
 - 11th ASR cycle: **860 million gallons stored to date**
- Native groundwater declines
 - 3.4-feet per year prior to ASR to average of 0.8-feet per year
 - Net zero decline when storing over 500 million gallons



2003: WTP Membrane Room



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Aquifer Storage & Recovery

| Water Year | ASR Cycle | Stored Volume (MG) | Water Source Mass Balance | | | |
|------------|-----------|--------------------|---------------------------|----------------|-------------|----------------|
| | | | Surface Water | | Groundwater | |
| | | | Volume (MG) | Percentage (%) | Volume (MG) | Percentage (%) |
| PRIOR | | | | 38 | | 62 |
| 2004 | 1 & 2 | 376 | 1,350 | 87 | 206 | 13 |
| 2005 | 3 | 235 | 914 | 58 | 649 | 42 |
| 2006 | 4 | 493 | 1,304 | 85 | 231 | 15 |
| 2007 | 5 | 390 | 1,117 | 68 | 527 | 32 |
| 2008 | 6 | 474 | 1,393 | 88 | 191 | 12 |
| 2009 | 7 | 405 | 1,222 | 76 | 391 | 24 |
| 2010 | 8 | 519 | 1,274 | 94 | 83 | 6 |
| 2011 | 9 | 534 | 1,282 | 97 | 39 | 3 |
| 2012 | 10 | 545 | 1,292 | 90 | 138 | 10 |
| AVERAGE | | 441 | 1,239 | 82 | 273 | 18 |

Note: MG: million gallons

Note: 100 MG = 1 irrigated circle at 125-acres with 2.3-feet of water applied

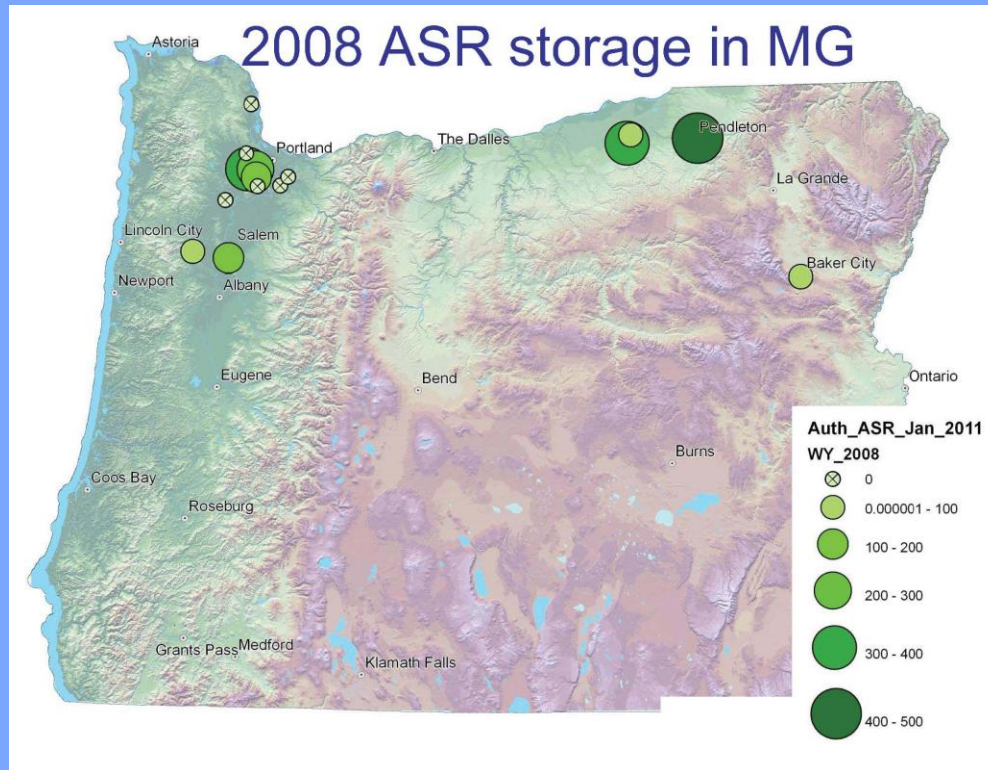
Note: 2005: 3rd lowest Umatilla River winter flows of record

Note: ASR is about 36% of total WTP production (to date)



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Aquifer Storage & Recovery



OWRD: 2008 Map of Municipal ASR Storage



Aquifer Storage & Recovery

- Sustainable Water Supply -

- Membrane Replacement
 - 10-year Guaranteed Replacement Cost
 - March 2011 deadline to exercise
 - Less than 45% of market cost
 - 13% more capacity than existing membranes
- Membrane Retirement Program: Future WWTP Membrane Bioreactor
 - 50% Installed: December 2011
 - Old membranes left in place at WTP until transfer ready at WWTP
 - 50% new membranes remained crated
 - 50% Installed: September 2012
 - Transferred old membranes to WWTP
- WTP Production
 - 6 MGD to 9.8 MGD
 - ASR supply: 3.5 MGD to 7.3 MGD
 - 450 MG annual increase



**GE Water / ZENON: 500C
Membranes**



Aquifer Storage & Recovery

- Sustainable Water Supply -

| Water Year | ASR Cycle | Stored Volume (MG) | Water Source Mass Balance | | | |
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| 2012 | 10 | 545 | 1,292 | 90 | 138 | 10 |
| AVERAGE | | 441 | 1,239 | 82 | 273 | 18 |
| FUTURE | Increase | 891 Plus 450 | 1,511 | 100 | -177 | -10 |

Note: MG: million gallons

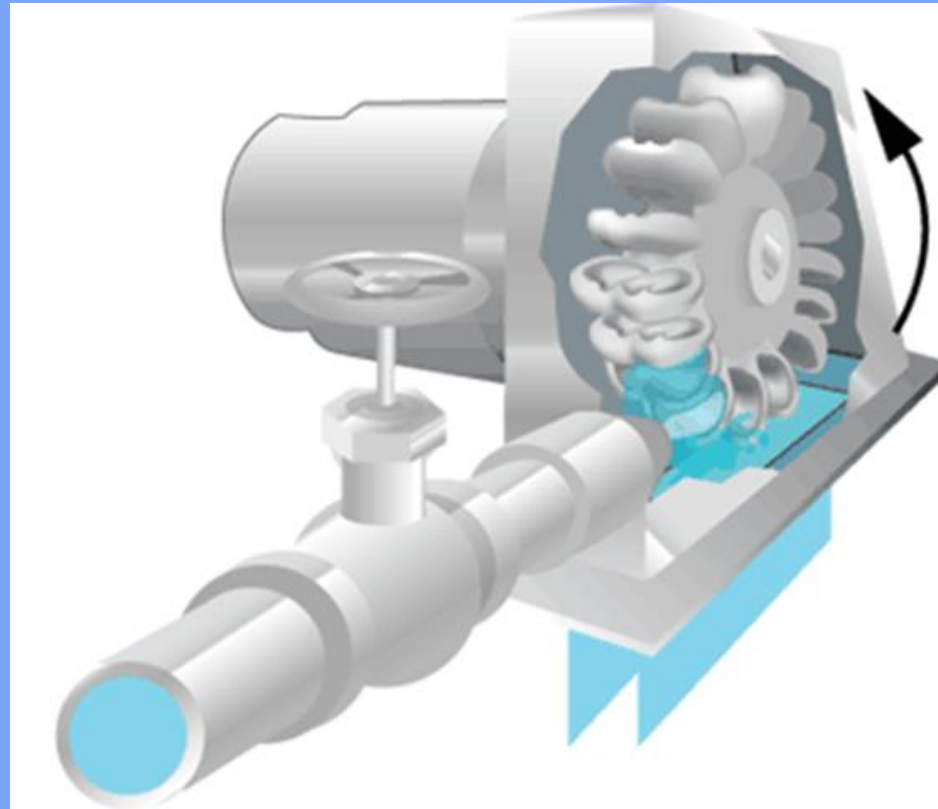
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ASR Hydropower Generation



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Well 14 Pilot Study

- Regenerative Drive Technology -

- **Motor**
 - Existing 100 HP motor
- **Pump bowls**
 - Existing pump bowls
 - 500 gpm recharge and production rate
 - No pump curve data for backwards operation
- **Regenerative drive**
 - Converts excess DC power from motor to 3 phase AC power
- **Variable frequency drive (VFD)**
 - Controls speed of motor to act as a “brake” for controlling reverse flow through bowls
- **Micro-turbine application**
 - TDH available: 208-feet
 - Water to wire efficiency: 70 percent
 - Estimated power: 10 kW



100 HP Motor, Valves, Piping, Etc.



45 kW Regen Unit



100 HP VFD



Well 14 Pilot Study

- Regenerative Drive Technology -

- Turbine formula:
 - $\text{kW} = [\text{Q (cfs)} \times \text{TDH (ft)} \times \text{N (efficiency)}] / [11.82 \text{ (conversion / constant)}]$
 - N = water to wire efficiency
- Well 14 Pilot Test:
 - Coordinated w/ Pacific Power requirements
 - 9 months: initiate conversation to testing verification
 - Net-metering agreement
 - In-house resources: installed 74 kW regenerative drive, 100 HP VFD, and utility required relay
 - Conducted full-scale pilot test in April 2011



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Well 14 Pilot Study Results

- Regenerative Drive Technology -

- Performed Pacific Power utility required relay test:
 - Maximum total dynamic head condition:
 - Distribution system pressure: 122 psi
 - 28.2 kW @ 535 gpm w/ 472 feet of total head
 - Over and under voltage, over and under current, loss of utility power, etc.
- Calculated water to wire efficiency:
 - $\text{kW} = [Q \text{ (cfs)} \times \text{TDH (ft)} \times N \text{ (efficiency)}] / [11.82 \text{ (conversion / constant)}]$
 - $N = 59.3\%$
- 24/7 Operation:
 - 150 days: 101,572 kWh @ \$0.06/kWh = \$6,108
 - 180 days: 122,163 kWh @ \$0.06/kWh = \$7,330
- Installed cost: \$30,000
- Payback: between 4 to 5 years without incentives



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Power Estimates

Assumptions:

- Hydropower formula: $kW = [Q \text{ (cfs)} \times TDH \text{ (feet)} \times N \text{ (efficiency)}] / [11.82 \text{ (water density, gravity, conversion factors)}]$
 $HP = [Q \text{ (cfs)} \times TDH \text{ (feet)} \times N \text{ (efficiency)}] / [8.82 \text{ (water density, gravity, conversion factors)}]$
- Regenerative drive:
 - 2011 Well #14 Pilot Study: Efficiency determined to be 59.3%
- Microturbine:
 - 20 psi maintained at wellhead (except Well 5)
 - Efficiency determined to be 69.4% based on Cornell microturbine

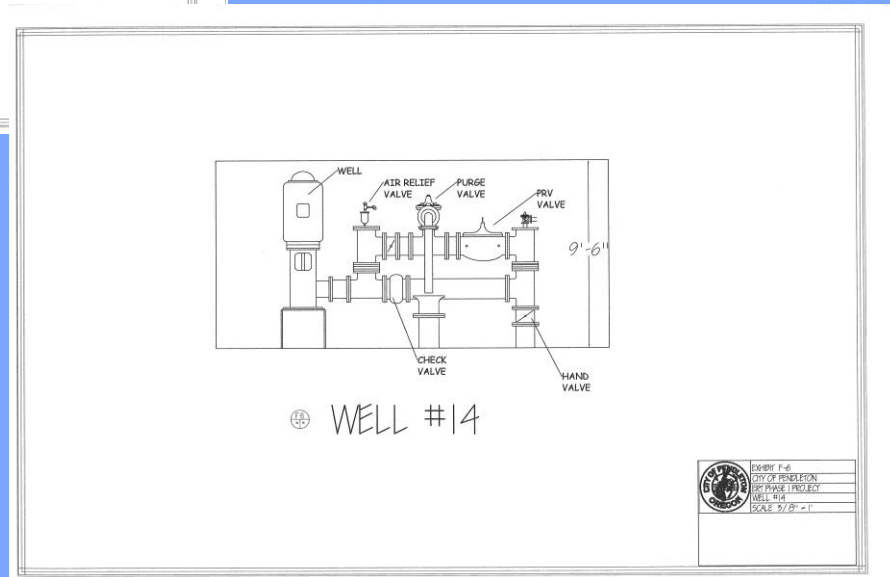
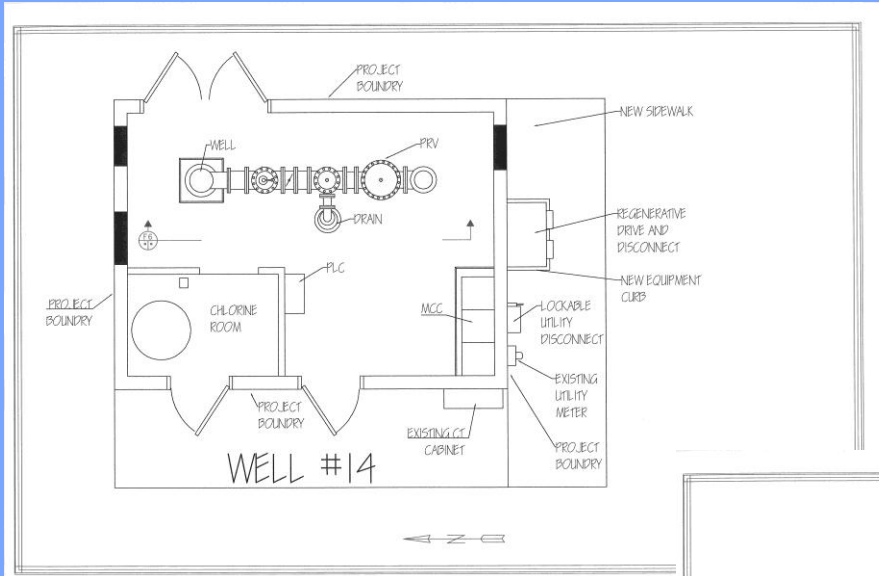
| | Recharge Mode | | | Power Production Estimates | | | | | | | | Installed Costs | 150 Day Payback Period (Years) | 180 Day Payback Period (Years) | |
|--------------------------------|---------------|-------------|-------------|----------------------------|--------------|--------------|--------------|------------------|---------------------|------------------|---------------------|-------------------|--------------------------------|--------------------------------|--|
| | Q (gpm) | Q (MGD) | Q (cfs) | TDH (ft) | kW | HP | 24 Hours kWh | 150 Days kWh | 150 Days \$0.06/kWh | 180 Days kWh | 180 Days \$0.06/kWh | | | | |
| Well 1: | | | | | | | | | | | | | | | |
| - Regen Drive: | 1,225 | 1.8 | 2.7 | 492 | 67.5 | 90.5 | 1,620 | 242,976 | \$ 14,579 | 291,571 | \$ 17,494 | \$ 82,426 | 5.7 | 4.7 | |
| - Microturbine: | 920 | 1.3 | 2.1 | 189 | 22.8 | 30.5 | 547 | 82,038 | \$ 4,922 | 98,446 | \$ 5,907 | | | | |
| Well 4*: | | | | | | | | | | | | | | | |
| - Regen Drive: | 1,100 | 1.6 | 2.5 | 488 | 60.1 | 80.6 | 1,443 | 216,408 | \$ 12,985 | 259,690 | \$ 15,581 | \$ 114,542 | 8.8 | 7.4 | |
| - Microturbine: | 495 | 0.7 | 1.1 | 224 | 14.5 | 19.5 | 349 | 52,314 | \$ 3,139 | 62,777 | \$ 3,767 | | | | |
| Well 5* (split system): | | | | | | | | | | | | | | | |
| - Regen Drive: | 1,650 | 2.4 | 3.7 | 165 | 30.5 | 40.9 | 732 | 109,756 | \$ 6,585 | 131,708 | \$ 7,902 | \$ 59,390 | 9.0 | 7.5 | |
| - Microturbine: | 1,500 | 2.2 | 3.3 | 235 | 46.2 | 61.9 | 1,109 | 166,313 | \$ 9,979 | 199,575 | \$ 11,975 | \$ 61,131 | 6.1 | 5.1 | |
| Well 8: | | | | | | | | | | | | | | | |
| - Regen Drive: | 1,000 | 1.4 | 2.2 | 497 | 55.7 | 74.6 | 1,336 | 200,363 | \$ 12,022 | 240,436 | \$ 14,426 | \$ 85,253 | 7.1 | 5.9 | |
| - Microturbine: | 750 | 1.1 | 1.7 | 240 | 23.6 | 31.6 | 566 | 84,926 | \$ 5,096 | 101,911 | \$ 6,115 | | | | |
| Well 14: | | | | | | | | | | | | | | | |
| - Regen Drive: | 535 | 0.8 | 1.2 | 460 | 27.6 | 36.9 | 661 | 99,214 | \$ 5,953 | 119,057 | \$ 7,143 | \$ 30,844 | 5.2 | 4.3 | |
| - Microturbine: | 400 | 0.6 | 0.9 | 208 | 10.9 | 14.6 | 262 | 39,236 | \$ 2,354 | 47,083 | \$ 2,825 | | | | |
| FY12 TOTAL: | 5,510 | 7.9 | 12.3 | | 287.5 | 385.4 | 6,900 | 1,035,031 | \$ 62,102 | 1,242,037 | \$ 74,522 | \$ 433,586 | 7.0 | 5.8 | |
| Well 2: | | | | | | | | | | | | | | | |
| - Regen Drive: | 2,225 | 3.2 | 5.0 | 476 | 118.6 | 159.0 | 2,846 | 426,971 | \$ 25,618 | 512,366 | \$ 30,742 | \$ 120,000 | 4.7 | 3.9 | |
| - Microturbine: | 1,670 | 2.4 | 3.7 | 221 | 48.4 | 64.8 | 1,161 | 174,131 | \$ 10,448 | 208,957 | \$ 12,537 | | | | |
| POWER (Full Build-Out): | 7,735 | 11.1 | 17.3 | | 406.1 | 544.4 | 9,747 | 1,462,002 | \$ 87,720 | 1,754,402 | \$ 105,264 | \$ 553,586 | 6.3 | 5.3 | |



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Hydropower Installations

- Well 14 Layout -



| | |
|--|------------------------------|
| | EXHIBIT F-6 |
| | CITY OF PENDLETON |
| | 5th PHASE PROJECT |
| | ISSUE #14 SCALE 3/8" = 1' |

Hydropower Installations

- Well 14 Equipment -

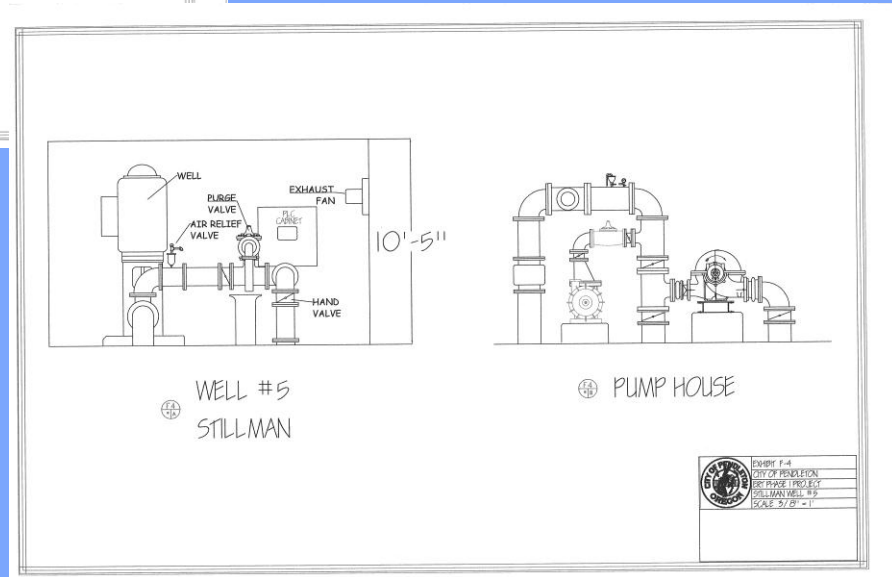
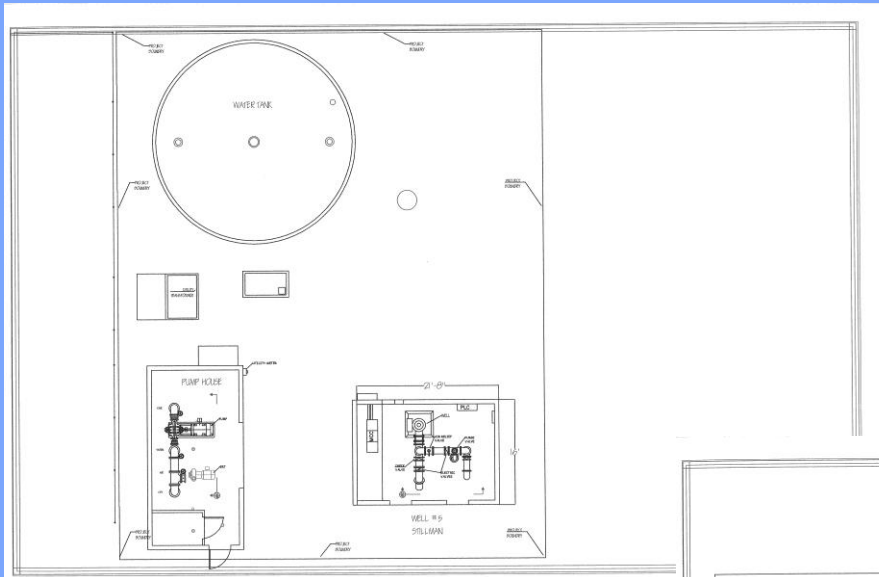
- Existing 100 HP motor with 500 gpm production rate
- 45 kW Regenerative Drive
 - 22 kW utility delivered output
- 100 HP VFD
 - Matched motor rating – first installation



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Hydropower Installations

- Well 5 Layout -



Hydropower Installations

- Well 5 Equipment -

- Well: 400 HP motor with 2,000 gpm production rate
- 37 kW Regenerative Drive
 - 26 kW utility delivered output: estimate
- 50 HP VFD (undersized for motor – lesson learned)
- Transfer Switch



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Hydropower Installations

- Well 5 Equipment -

- **Booster Pump: 250 HP motor to match well pump**
 - Level control: 80,000 gallon de-aeration tank
- **50 kW Micro-turbine**
 - 42 kW utility delivered output



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Electrical Utility Service

- Pacific Power:
 - Relay testing completed October 2, 2012
 - Net-metering approved for all sites:
 - Well 1, Well 4, Well 5, Well 8, & Well 14



**Utility Required Relay
- SEL-751A**



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FERC Conduit Exemption

- Began process in May 2008
 - Commerce law: “navigable surface water and surface water rights”
 - Morphed with regenerative drive technology
- Two applications:
 - Energy Recovery Technology: Phase I: Existing ASR Wells:
 - Well 1, Well 5, Well 14
 - Energy Recovery Technology: Phase II: Additional ASR Wells:
 - Well 2, Well 4, Well 8
 - Public Meeting: February 2012
 - Phase I and Phase II applications submitted to FERC in May 2012
 - Public Comment Period
 - FERC approval for Phase I and Phase II issued Fall 2012



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Summary

- Regenerative drive versus micro-turbine consideration
 - Total dynamic head
 - Equipment cost: regenerative technology less expensive
 - Equipment layout: regenerative technology footprint typically smaller
 - Payback: regenerative technology quicker payback
- Additional utility power considerations:
 - Produce power all billing period: no demand charge
 - Make more power than used during billing period: No extraneous charges
 - Public purpose (ETO)
 - Dam closures
 - City franchise
 - No direct payment: credit against consumption only



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Summary

- Total investment in micro-hydro equipment: \$380,000
- Power produced to date: \$20,000
 - Estimate \$25,000 by end of recharge season
 - Still have Well 5 regenerative drive to bring on-line at additional cost
- Payback: average of 10- to 15-years
- QUESTIONS (if time allows)
- City staff acknowledgements and contact information:
 - Bob Patterson, Public Works Director, 541.966.0241
 - Tim Smith, Control Systems Manager, 541.966.4518
 - Karen King, Regulatory Specialist, 541.966.0249
 - Jutta Haliewicz, Senior Secretary, 541.966.0240
 - Email: [“first name”.”last name”@ci.pendleton.or.us](mailto:first name.last name@ci.pendleton.or.us)



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