Well Rehabilitation Methods

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A Well Is a Subsurface Engineering Structure

- Design Elements:
  - Applicable Standards – AWWA; NJDEP
  - Depth & Diameter
  - Screen slot size openings & filter pack design
  - Pump sizing and controls
- Technical Specifications for Installation
- Installation Supervision
- Start-up Testing:
  - Yield; Water Quality; Efficiency (Specific Capacity)
- Routine Maintenance
- Routine Operational Data Collection

Well Diagram
Well Screen and Filter Pack

The Three Steps for Production Well Rehabilitation

1. Diagnose
2. Select a Cure/Process
3. Implement

What Triggers the Need to Redevelop a Well:
1. Well Yield Decline (Q)
2. Increase in Drawdown (s)
3. Decrease of Specific Capacity (Q/s - the 25% rule)

Calculating Specific Capacity

Specific Capacity = Q divided by s
Units = gpm/ft of Drawdown
Tracking Q and Q/s

<table>
<thead>
<tr>
<th>Well</th>
<th>Driller's Quals</th>
<th>Codes and Standards</th>
<th>Products (acids; chlorine, etc.)</th>
<th>Pre-Development Specific Capacity Testing (Q/s)</th>
<th>Pump Removal and Video Logging</th>
<th>Well Redevelopment Procedures</th>
<th>Q/s testing Program during Development</th>
<th>Site Conditions and Storage</th>
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Developing a Technical Specification and BOQ

- Driller's Quals
- Codes and Standards
- Products (acids; chlorine, etc.)
- Pre-Development Specific Capacity Testing (Q/s)
- Pump Removal and Video Logging
- Well Redevelopment Procedures
- Q/s testing Program during Development
- Site Conditions and Storage

Cures - Well Rehabilitation Methods

- Chemical Treatment
- Mechanical Agitation (Surging)
- Hydraulic Jetting
- Combination of Chemical Treatment and Surging/Jetting
- Air-Surging
- Air Burst
- Bedrock Wells - Hydrofracing
Chemical Treatment

- Acids – Incrustation (Hardness) due to precipitation of CaCO3 on a well screen.
- Chlorine – Microbial biomass (slimes);
- Acids - iron/manganese oxides.
- Polyphosphates – well screen blockage by silts and clays.

Incrustation of Well Screen
**Biomass on Well Screen.**

**Iron Oxide Deposits on Pump Bowls**

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**Chemical Placement**

- Quantities to use.
- Often multiple applications are required
- Method of placement in a well:
  - Tremie pipe
  - Air surge or mechanical surging to move the chemicals out into the formation
  - Density concerns
- Residence times before beginning mechanical surging or jetting.

- Safety Precautions – workers and public
- Disposal Considerations
Air Surging & Air-Bursting

Air Surging
- Overview of set-up.
- Application and how it works.
- Benefits.

Air Burst
- A good initial tool for well screens that are heavily incrusted.
- Localized effect.
- Can be used to move rehabilitation chemicals out into the formation.

Airburst Gun
Nitrogen Gas

Equipment

- Cable Tool Rig
- Advantages
- How it operates

Single Surge Block in Well
Double Surge Block

Figure 13.3: When a double-flanged upheaval is used, fill the joints with all available space between the flanges. Use caution the bolts are not tight enough or tighten the work. During pumping, the work is raised and lowered over short distances.

Jetting Tool

Figure 13.7: Two weeks before we designed for a breakdown of injection. This block only shows the steps taken to erect, for the removal of mud from the screens of the twin muffler to the point of the second muffler filter is to it, located in the background of the filter. A filter net in acting, advanced and solid casing that had been created to the surface casing.
Jetting Tool in well

Cautions
• Screen erosion
• Type of well screen material
• Need to pump materials out of the well while jetting

Jetting & Chemical Treatment and Agitation

Hydrofracing

• For Bedrock Wells

• Technique overview:
  • Determine fracture zone areas – geophysical logs.
  • Utilize straddle packers – isolate single zone at a time.
  • Quantify pre- and post- hydrofracing Q/s to quantify improvement in Q/s.
Hydrofracing – Double Packers

Key Operational Data for Production Wells:

- Use as “Indicators” of the need for well rehabilitation
- Water levels
  - Static water levels (swl)
  - Pumping or dynamic water levels (pwl)
- Water level drawdown - s (swl – pwl)
- Historical water level conditions
- Well Pumping Rates (Q)
- Specific Capacity Trends (Q/s)
Quantifying the Well Re-Development Process

- Pre-Development Well Testing – Specific Capacity Pumping Test.
  - Short duration – 0.5 to 1 hour
  - Can use step drawdown pumping test

- Evaluate and Select Redevelopment Method
  - Chemicals
  - Mechanical/Jetting

Process

- Real time Quantification of well re-development progress:
  - Short term (15-minute) specific capacity tests daily

- Post re-development well testing

- Evaluation of effectiveness:
  - Original Q/s = 64 gpm/ft
  - Pre-Development Q/s = 51 gpm/ft.
  - Post development Q/s = 59 gpm/ft.
  - Specific Capacity Gain = 8 gpm/ft.

<table>
<thead>
<tr>
<th>Date</th>
<th>Redevelopment Activity</th>
<th>Incremental Increase to Specific Capacity (gpm/ft)</th>
<th>Total Increase to Specific Capacity (gpm/ft)</th>
</tr>
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<tbody>
<tr>
<td>5/20/20</td>
<td>Secondary Test</td>
<td>0.5</td>
<td>0.5</td>
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<tr>
<td>8/20/20</td>
<td>Acidizing (Pre-Cleaning)</td>
<td>1.5</td>
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<tr>
<td>9/20/20</td>
<td>First Difluoro-Acid Application and Mechanical Jetting</td>
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<tr>
<td>10/20/20</td>
<td>First Chlorine Application (500 ppm) and Mechanical Jetting</td>
<td>6.2</td>
<td>6.2</td>
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<td>11/20/20</td>
<td>Post Acid Jetting and Two Pass Jetting</td>
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<td>12/20/20</td>
<td>Second Difluoro-Acid Application and Mechanical Jetting</td>
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<td>3</td>
</tr>
<tr>
<td>1/20/20</td>
<td>Second Chlorine Application and Mechanical Jetting</td>
<td>3</td>
<td>3</td>
</tr>
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</table>

*Redevelopment work was done between 05/20/20 and 06/20/20*
Key

• Routine collection and analysis of key operational data.

• Timely maintenance.
Case Studies – Economic Analyses

1. Municipal Wells - Cost of Re-development and Value Added versus a New Production Well.

2. NJ Well Field – Energy savings with pump replacement.

3. NJ Well – Cost-Benefit analysis for a re-developed well
1. Redevelopment versus New Well Costs

<table>
<thead>
<tr>
<th>Well</th>
<th>Increase in specific capacity (Q/s)</th>
<th>Flow Gained: Gallons per minute</th>
<th>Re-Development Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV-2</td>
<td>18.3</td>
<td>275</td>
<td>$45,000</td>
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<tr>
<td>CV-3</td>
<td>35.4</td>
<td>380</td>
<td>$55,000</td>
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</table>

**New 600 gpm Production Well**

- Well and Equipment: $400,000 - $500,000
- Consulting: $75,000

2. NJ Well Power Savings

- Pre-Development
  - 40 hp pump
  - Q = 200 gpm

- Post-Development
  - 30 hp pump installed
  - Q = 525 gpm

NJ Well Power Savings (Cont.)

- Pre-development Pumping Costs:
  - $136/Million Gallons
  - $14,350/yr.
  - 105 MGY

- Post-development Pumping Costs:
  - $39/Million gallons
  - $10,760/yr.
  - 276 MGY
3. NJ-Cost Benefit Analysis

- Specific Capacity Gain of 8 gallons per minute per foot of drawdown.
- Re-development Program Cost:
  - Drilling contractor: $40,000
  - Consultant: $15,000
  - Total: $55,000
- Program Benefit:
  - Net Water Gain: 325 GPM
  - Income Gain: Net Water Gain x Net Revenue (Retail Cost – Production Cost).
  - 0.46 mgd x ($4,000/mg - $1,500/mg) = $1,150/day or $420,000/yr.

Questions

- Utility’s Experience in Well Rehabilitation
- Tracking Specific Capacity (Q/s)
- Downhole Camera applications
- Thoughts on 5 – year program for well diagnostic programs:
  - Q/s Testing
  - TV
  - Water Quality Diagnostic Testing
- Well failures case studies
- Well yield decline case studies

Questions

- Well failures case studies
- Well yield decline case studies
- What has worked in the past?
- Cost input?
Discussion

• Thank You