Rehabilitation of Groundwater Recovery Wells

“Improved Treatment Technology”
Recovery Well Rehabilitation Outline

- Perspective
- Well Rehabilitation Basics
- New Technology
- Case Histories
- Application - Special Case - Problem / Solution
- Questions
Recovery Well Rehabilitation Perspective

- Water Treatment Background
  - Prevention of Corrosion
  - Prevention of Mineral Deposits
  - Microbiological Control

- Wichita – Air Capital of the World
  - Pumping a lot of Groundwater
Recovery Well Rehabilitation Goals

Reduce Costs and Speed Closure

- Increase Flowrate and Specific Capacity
- Increase Time between Rehabbing events
- Reduce Equipment Corrosion
- Not Harmful to Environment
- Minimize Overall Costs of Rehabbing Well
Well Rehabilitation Problems

- Physical (Silts, Clay, Sand)
- Mineral (Carbonates, Sulfate, Sulfides, Oxides)
- Biological – Many forms
Well System Deposits

"One size does not fit all"
Biological Fouling

Biofilm to Biomass to Biofouling

- Polysaccharide layers
  - adheres to surface
  - protects the organism
  - provides nutrient capture
  - 30 – 100 times the weight of the organism

- Polysaccharide layer increase under stress
  - Flow
  - Chlorine
Biological and Iron Fouling

- Iron Reducing Bacteria
- Sulfate Reducing Bacteria - Corrosive to Iron
- Localized MIC (Microbiologically Influenced Corrosion)
Incrustation

- Biomass
- Mineral Deposits – Often Calcite
- Iron Fouling
Traditional Well Rehabbing

- Mechanical – Many methods
- Chlorine
- Acid - A few common acids
  - Most common – HCl
Traditional Well Rehabbing- Acid

- Some methods can be corrosive
- Some methods may require long treatment times
- Some methods limited penetration of biomass
Traditional Well Rehabbing - Chlorine

- Does not penetrate thick biomass
- Stimulates polysaccharide production
- Can form additional chlorinated organics
Evaluating Probable Well Foulants

- **Water Analysis**
  - LSI – Calculation
  - Iron / Manganese content

- **Bacterial Analysis**
  - Heterotrophic
  - Sulfate Reducing Bacteria
  - Iron Related Bacteria
  - ATP (Adenosine Triphosphate) Analysis

- **Deposit Analysis**
Well Rehabilitation Survey

- Date well was originally drilled
- Type of formations - describe
- Hole size
- Casing size
- Type of casing material
- Type of screen
- Screen length
- Location
- Well depth
- What is pump depth
- Diameter of column pipe
- Does well have a check valve below surface
- Does the pump have tail pipe
- How much
- How is pump powered
- If combustion engine, does it have clutch
- Does well head have a inspection hole (access to casing)
- What size is access hole
- Can the pipe be disconnected from the throat of the pump easily
- Are you willing to get the draw down taken on your well prior to and after treatment
- Are you willing to have the volume tested before and after
- Volume of well when first put on pump
- Volume now
- Standing fluid depth (feet of fluid in casing)
- Pumping fluid level (feet of fluid in hole after continuous pumping for at least one hour)

Water Treatment Technology for Groundwater Rehabilitators
### Well Specific Capacity History and Report

<table>
<thead>
<tr>
<th>Well ID</th>
<th>Pump Test</th>
<th>Pumping Rate (GPM)</th>
<th>Static Water Level (Ft)</th>
<th>Pumping Water Level (Ft)</th>
<th>Drawdown (Ft)</th>
<th>Specific Capacity (GPM/Ft)</th>
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Chlorine Dioxide in Recovery Well Rehabilitation
Introduction
Chlorine Dioxide History:

- Discovered in 1811
- Primary drinking water disinfectant in over 500 US cities
- Food additive status
- Because of dioxin and chlorination by-product concerns ClO$_2$ is now the primary paper bleaching chemical
Chlorine Dioxide

- **Industrial Application**
  - disinfectant
  - legionella control
  - odor control
- **Paper Making**
  - bleaching
  - paper machine - food contact paper
- **Oil Field**
  - downhole stimulation
  - waterflood and water disposal bacteriological control
**What is ClO$_2$?**

- ClO$_2$ is a mild oxidizer but it is also a powerful disinfectant.

<table>
<thead>
<tr>
<th>Oxidant Species</th>
<th>Formula</th>
<th>Oxidation Potential $E^\circ$ (V)</th>
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<tr>
<td>Hydroxyl free radical</td>
<td>OH-</td>
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<td>Ozone</td>
<td>O$_3$</td>
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<td>Hydrogen peroxide</td>
<td>H$_2$O$_2$</td>
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<td>Permanganate ion</td>
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<td>Hypochlorous acid</td>
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<tr>
<td>Hypochlorite ion</td>
<td>OCl$^-$</td>
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</table>
Why Chlorine Dioxide as cleaner and Disinfectant

- It is a dissolved gas
- It penetrates the layers of biomass
- It penetrates the cell wall
Why Use CLO2 Instead of Conventional Acid plus Biocide Treatment?

- CLO2 destroys and removes sulfides
- CLO2 destroys and removes biomass
- CLO2 penetrates hydrocarbons
- CLO2 is more effective than chlorine
- CLO2 is environmentally friendly and has NO long term animal, plant, or human toxicity
- CLO2 has low corrosion rates
What’s New?

- Simple way to generate chlorine dioxide where it’s needed
- A procedure to clean the biomass, disinfect the well
- A procedure to solublize iron
- Favorable Economics
Chlorine Dioxide Generation

Approved by EPA for Potable Well Rehab
IronSolv V

- Biodegradable Solution
- Citric Acid
- Iron solublizing treatment
Case History 1 - Conditions

- Recovery Well Flowrate Decline 25%
- Biofouling of well previously reported
- Well had sulfide odor
- Iron in recovered water about 1 ppm
Procedures for Rehabbing with CLO2 - Case History 1

- Add about 300 ppm of CLO2 in well bore
- Wait two hours
- Surge Well (with pump or external pump)
- Wait 6-12 hours
- Add Ironsolv V - Iron solublizing treatment
- Wait one hour
- Surge Well
- Wait 3-6 hours
- Pump out well to low level of iron
Case History 1
Case History 1– Results

- Restored well to maximum flowrate typical specific capacity
- Flowrates were maintained for nearly a year
- Removed biomass – Several Gallons - see next slide
- Removed iron up to 367 ppm during surging and solution removal
Case History 1

Slurried Biomass – During Surging and at Disposal
Case History 2

- Wells at Industrial site – Nitrate Plume
- Had experienced severe iron fouling and loss of production causing wells to be abandoned.
- Moderately high iron content in groundwater (5-8 ppm)
- LSI indicated potential for calcite formation
- Specific capacity – Well rehabbing required every 6 months.
Case History 2 - Procedures

- Used Sodium Chlorite/ Sulfamic Acid to generate ClO2 \textit{insitu}. Approx. 300 ppm in well casing.
- Surged and left overnight
- Added Ironsolv V to give about 5% solution in well casing.
- Surged multiple times
Case History 2

Static Surging Method
Case History 2

6B Well Iron Levels

PPM Iron

0 50 100 150 200 250 300 350

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Samples

Disposal

Ironsolv V

ClO₂ & Sulfamic Acid
Case History 2

- Removed over 300 ppm up to 13 well volumes and up to 50 ppm at 20 well volumes
- Treatment effective over 6 well diameters and 20 well volumes
- Specific capacities stable for last 8 months
Special Case Application

In Situ Air Stripping, Sparging, Vapor Extraction, Oxygenation methods, Biostimulation
Insitu Remediation Methods

- Create mineral deposits
- Biological deposits
- Incrustations
Insitu Remediation Methods

- Groundwater Chemistry Often Decreased Effectiveness of the Insitu Methods
  - Decreased Radius of Influence
  - Poor Hydraulic Response through treatment zone
  - Damage to Pumps and Recirc equipment
Insitu Remediation Methods

- Solutions
  - Increase frequency of well Rehabilitation
  - Chemical Treatment injection upgradient of In situ treatment
    - Antiscalants – selected for conditions
    - NSF certified, Agency approved
Goals of rehabbing are to reduce costs and speed site closure.

Well foulants are complex.

Clorine Dioxide and Ironsolv V combination has proven effective as an alternative procedure for certain Recovery wells.

Technology extends to In Situ Remediation Methods.
Well Rehabilitation - An improved Process

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