



# Water Well Rehabilitation Technologies and Well Asset Management

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# Learning Outcomes

- Understanding Basic Well Design
- How Wells Plug/Foul
- Well Rehabilitation Technologies
- The Components of an Effective Well Rehabilitation
- Operation and Maintenance of wells
- Best Practice for Sustainable Well Asset Management





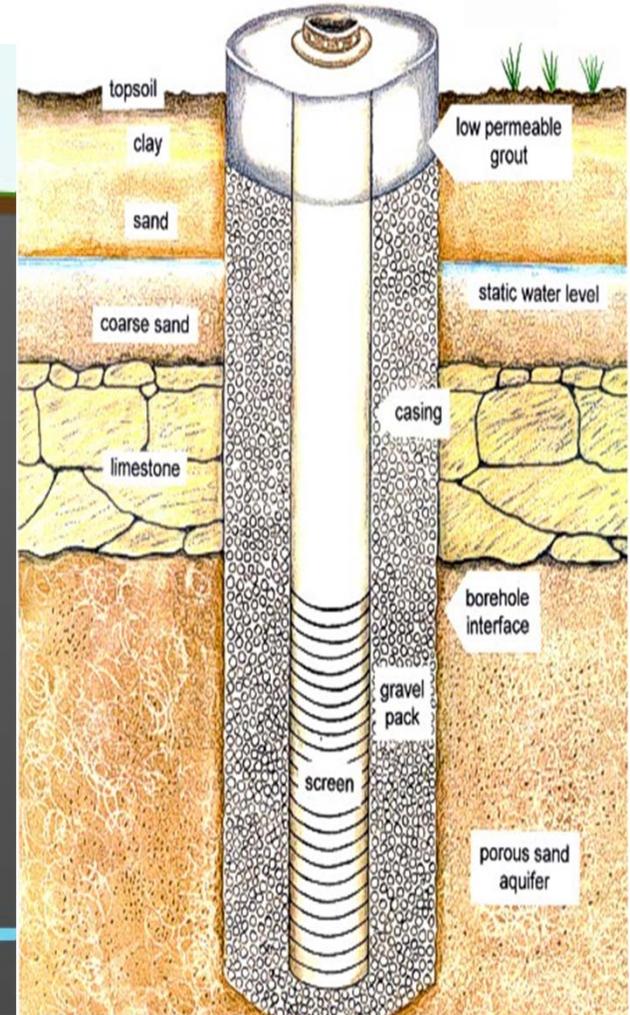
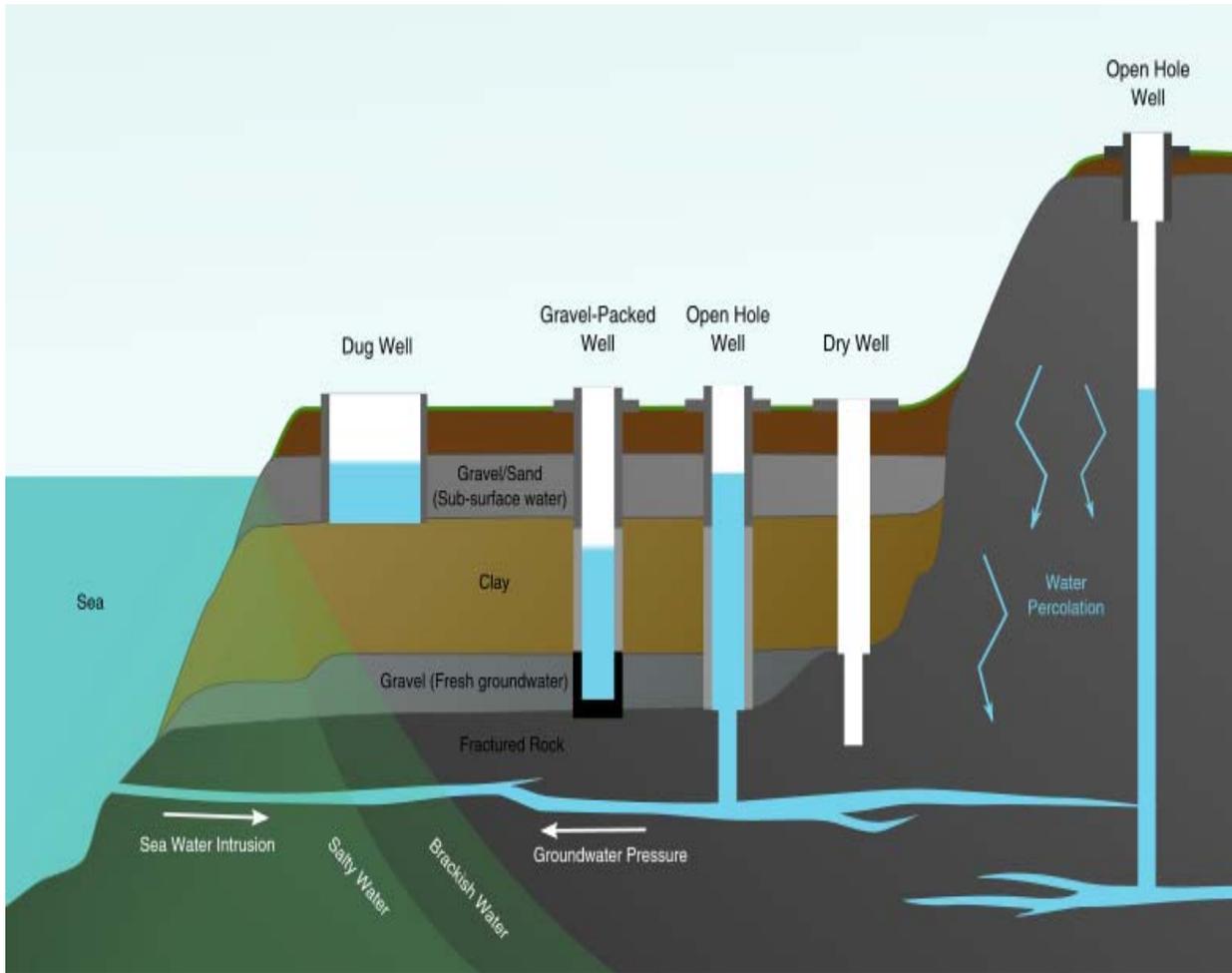
# Overview

1. Basics of Well Design and Formations
2. Symptoms of Well Plugging
  - I. Review of Typical Well Screens
3. Well Rehabilitation
  - I. Technologies and Procedures
  - II. Review of How CO<sub>2</sub> Technology Works
  - III. Effects of Plugging Conditions
4. Traditional Approach: Run to Failure
  - I. Benefits of Maintaining Wells with In Well Maintenance Tools
5. Benefits of an Asset Management Program



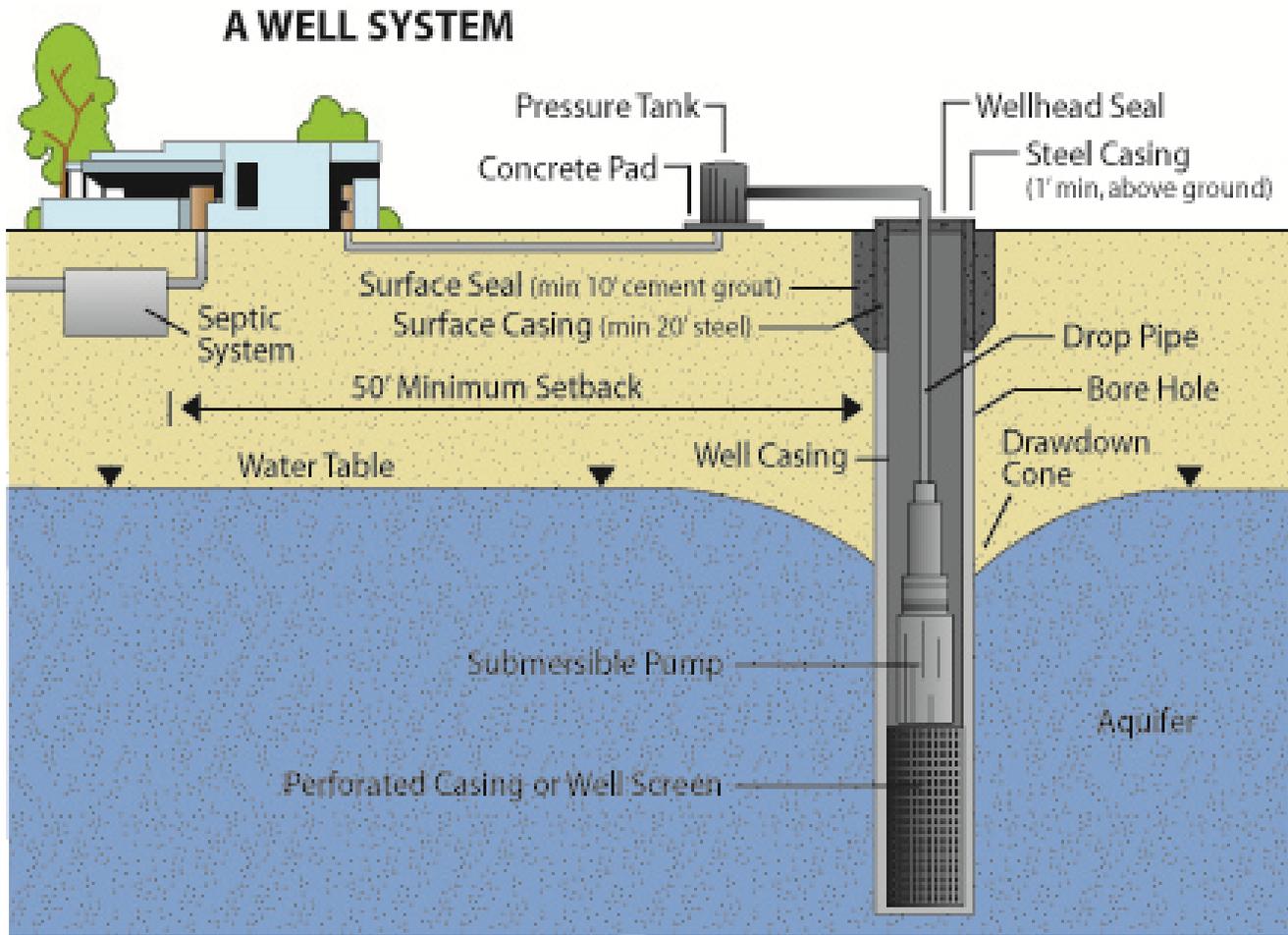


# Water Well Basic Designs





# Standard Well Design



Specific Capacity =  
Gallons per Minute  
per foot of  
Drawdown  
( $SC = \text{GPM} / \text{FT of DD}$ )



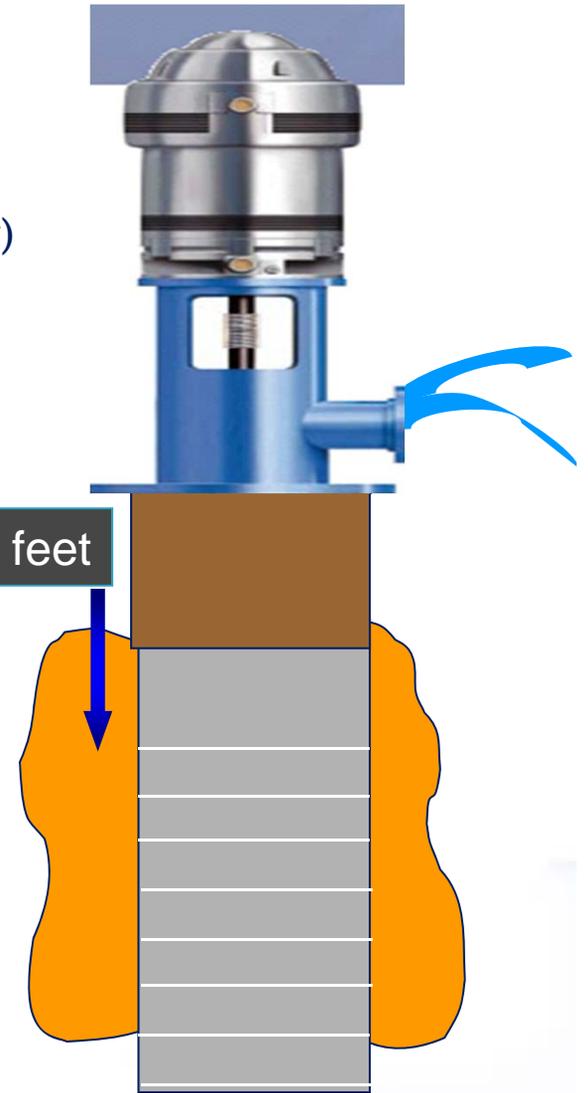


# Water Well Plugging: Common Causes

1. Biofouling–Mineral Encrustation
2. Mechanical–Formation Fines (Silt and Clay)
3. Chemical– Precipitation of Minerals



Maximum 2 feet





# Symptoms of Well Plugging

- A. Reduces Production–Increase Sand Production
- B. Loss of Efficiency–More Expensive Water
- C. Changes in Water Quality–Increased Cost
- D. Corrosion–Metal loss, Premature Failure of Well Casing
- E. Total Loss of Capital Investment



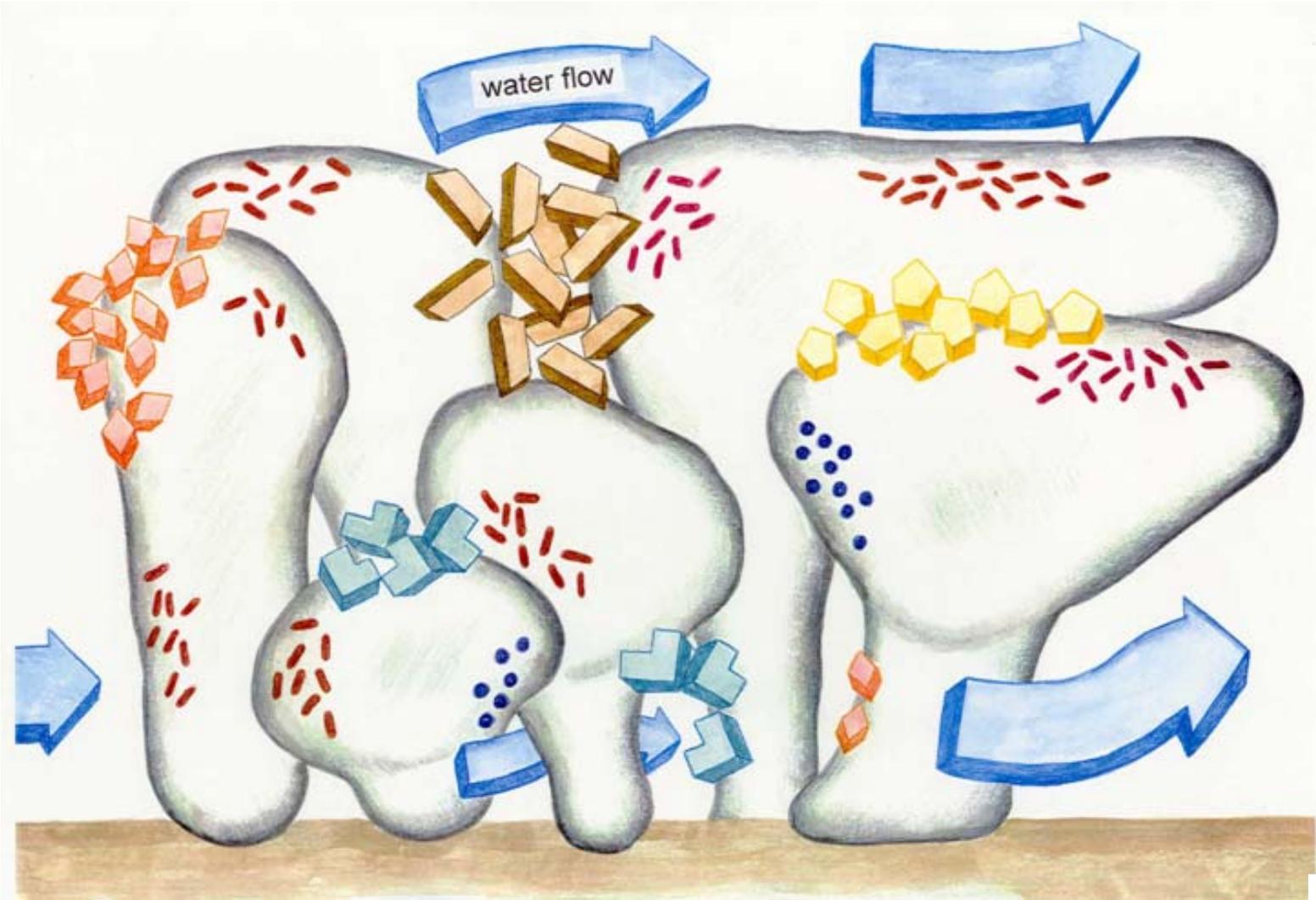


# What is Biofilm?

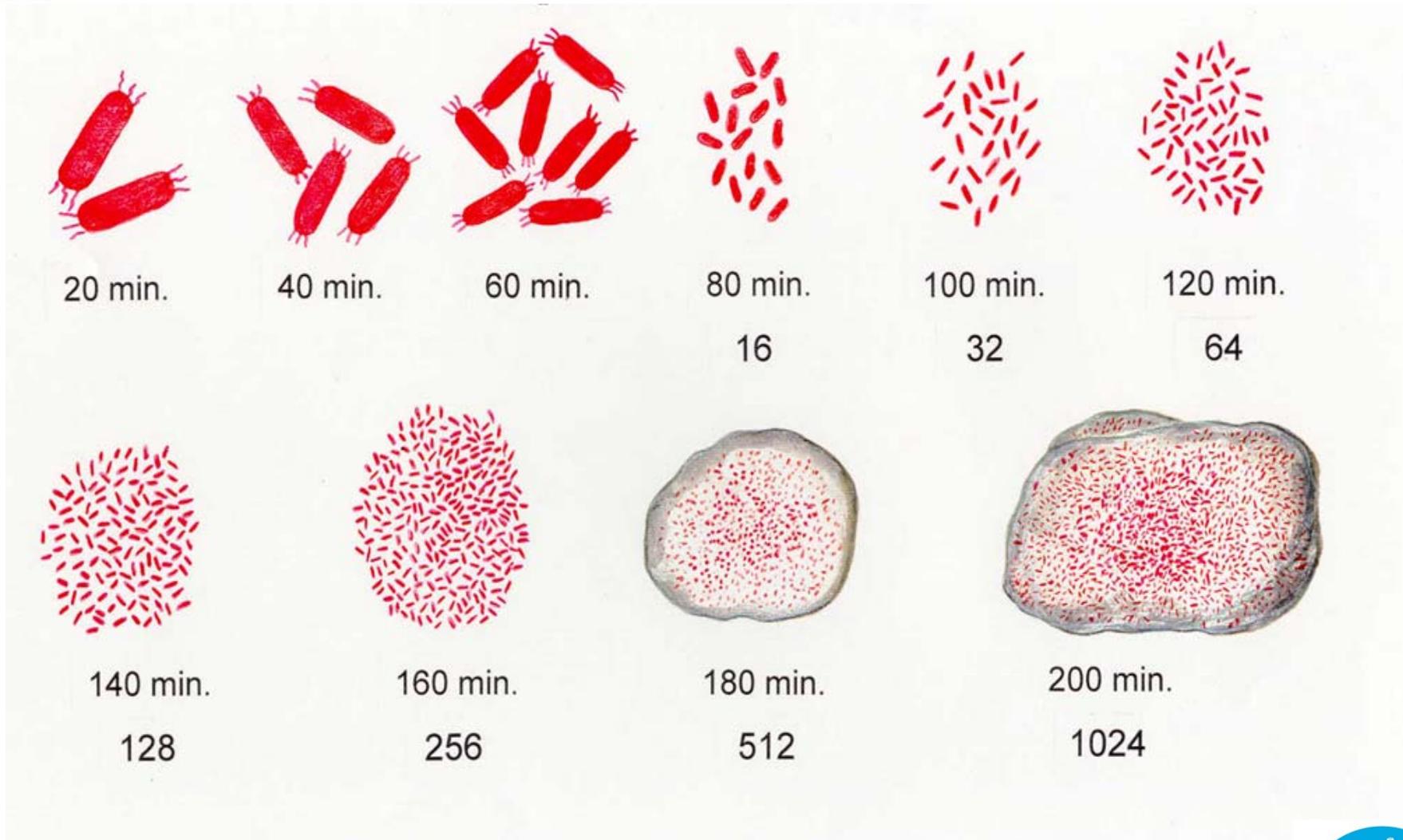
- ▶ The bacterial cells
- ▶ The colonies they form
- ▶ The polysaccharide slime they secrete for protection



# Formation of Biofilm and Filtration of Minerals

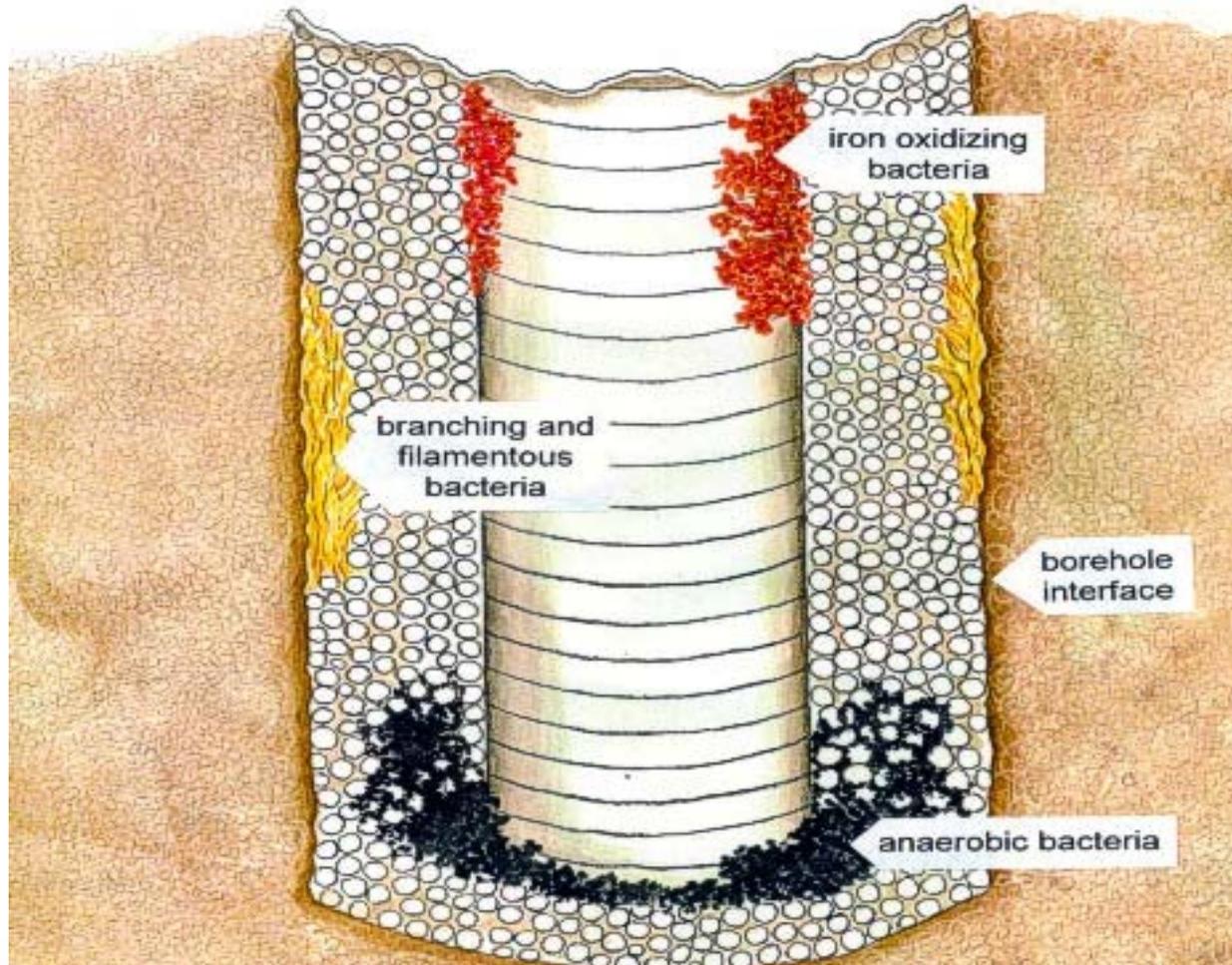


# Exponential Growth Rates





# Bacteria in Water- Wells





# US EPA: TCR Violations 2011

(917 Total Violations)



AL	AR	AZ	CA	CO	CT	DE	FL	GA	IA	ID	IL	IN	KS	KY	LA	MA	MD	ME	MI	MN	MO	MS	MT	NC	ND	NE	NH	NJ	NM	NV	NY	OH	OK	OR	PA	RI	SC	SD	TN	TX	UT	VA	VT	WA	WI	WV	WY
12	56	21	52	7	6	2	28	19	7	15	14	8	11	18	38	82	3	8	21	5	61	32	40	5	1	58	11	26	9	9	14	17	30	16	14	6	2	2	0	88	18	14	6	0	26	3	6

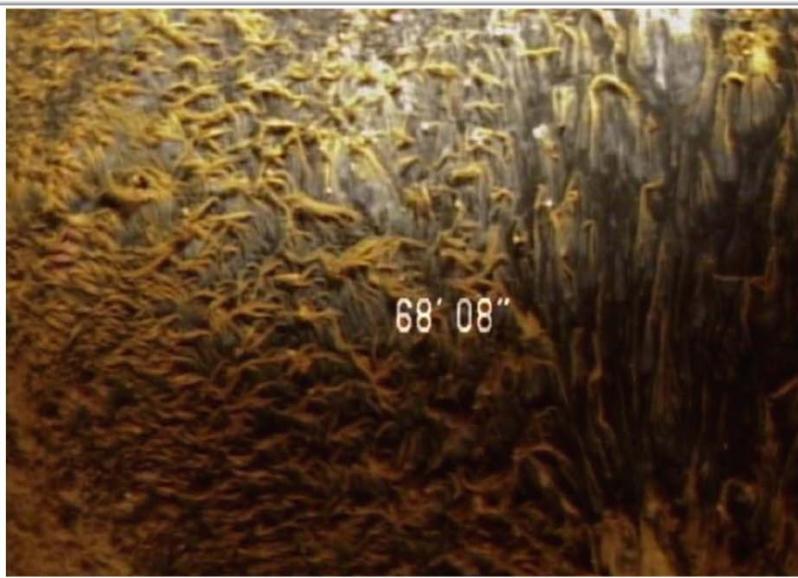




# ORGANICALLY BOUND IRON

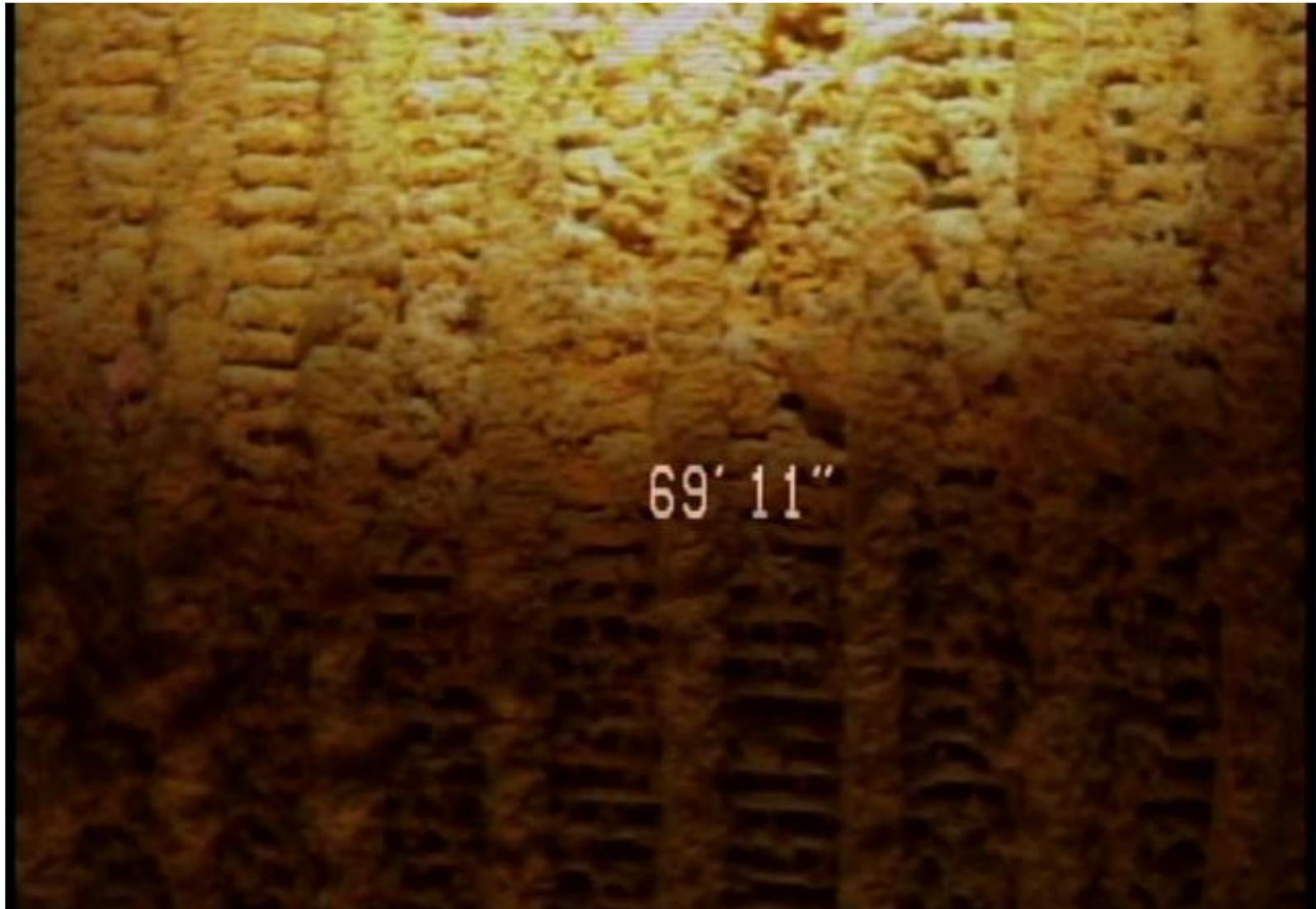


# Open Hole Rock Wells and Screened Wells





# Wire Wrap Well Screen



# Typical Iron Encrustation



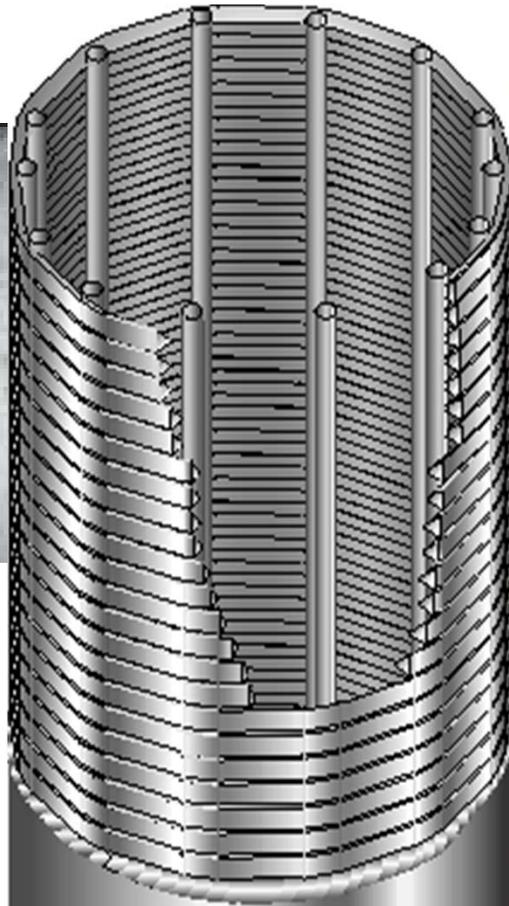


# Common Well Screens

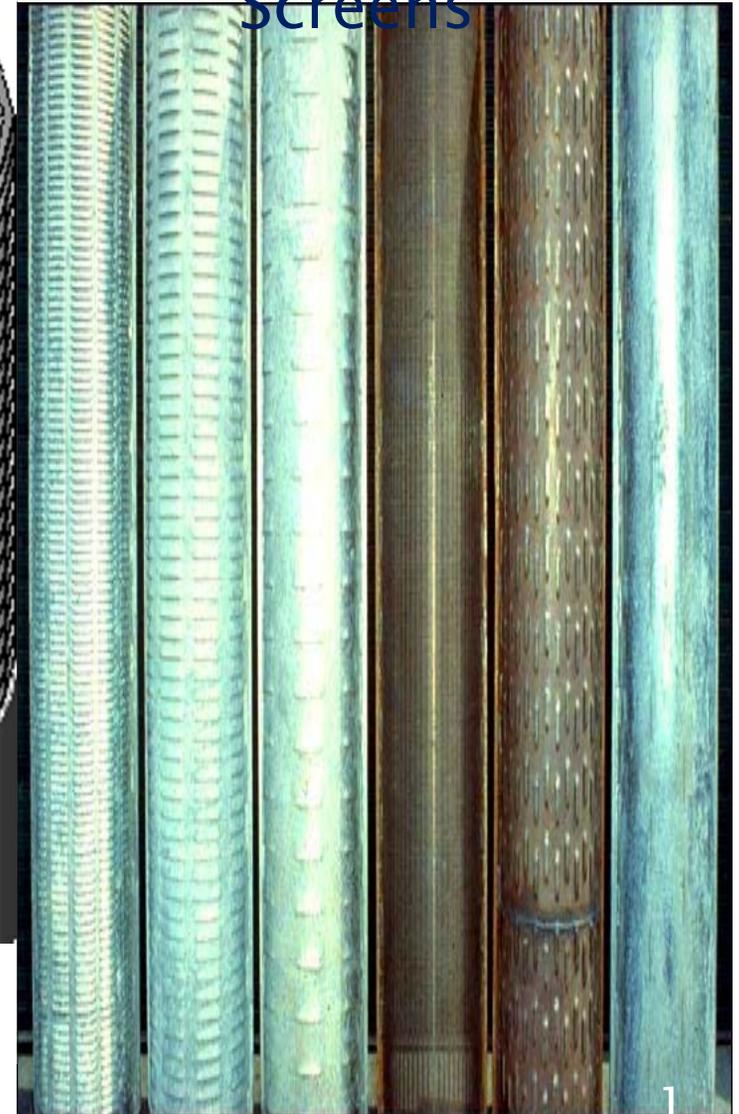
## Other Common Screens



Louvered Screen



Wire Wrap Well Screen





# Overview

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# 9 Steps for Effective Rehabilitation

1. Pre-Rehabilitation Pump Test
2. Remove Pumping Equipment
3. Video Inspection
4. Mechanical Cleaning/Wire Brush
5. Rehabilitation Process Application
6. Re-Development
7. Video Inspection
8. Re-Install Pumping Equipment
  - a. Install Maintenance Tools
9. Post Rehabilitation Pump Test





# Well Rehabilitation Procedures and Approaches

## Rehabilitation Treatments...

- Can Involve Many Different Strategies or a Combination of More than one:
  - Chemical CO<sub>2</sub> (Aqua Freed)
  - Mechanical *Percussive (Airburst)*
  - *Thermal* Explosives (Sonar Jet)
- Must be Custom Tailored, Based on Cause of Problem, Well Construction Details and Type of Formation
- Must Have Penetration to Clean the Surrounding Formation
- Must Have Good Agitation During Redevelopment
- Must Achieve Effective Deposit Disruption and Removal





# Well Asset Management



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## Asset Management

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Most wells eventually lose capacity and experience lower pumping water levels, resulting in increased pumping costs. Implementing a time-based maintenance program can avoid potential problems. Ongoing performance monitoring can signal when it's time for rehabilitation to maintain or restore performance. **BY RAY REECE, BILL PREHODA, AND RANDY MOORE**

# MAINTENANCE WELL ASSET MANAGEMENT INCREASES SERVICE LIFE

*Editor's Note: This is the second of a three-part series of articles based on a series of AWWA webinars on distribution system issues. The first article, which appeared in the September 2013 issue, described what biofilms are, what problems they create, how they relate to coliforms, and how to evaluate them. This article reviews water well rehabilitation technologies and discusses how they can be incorporated into a well asset management program. The final article, which will appear in the November 2013 issue, will cover new leak-detection technologies coming to the United States. For more information, visit [www.awwa.org/webinars](http://www.awwa.org/webinars).*

**W**ATER WELLS, like other distribution system assets, require periodic maintenance and rehabilitation. An effective condition assessment can help you select the proper rehabilitation technology (or technologies) from a wide array of options. It's possible to develop a sustainable well asset management program and, with some rehabilitation technologies, install hardware in the well that allows periodic maintenance without removing the pump. Based on the condition assessment and ongoing monitoring data, a cleaning schedule can be established to maintain performance and water quality.

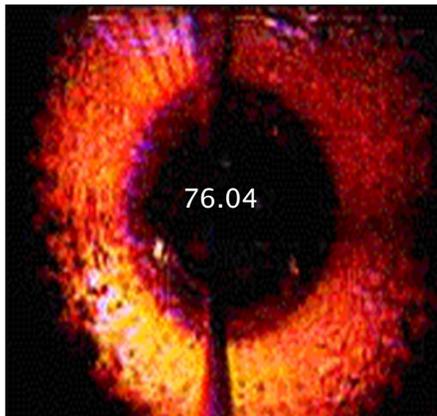
PHOTOGRAPH: BERTHOLD TECHNOLOGIES



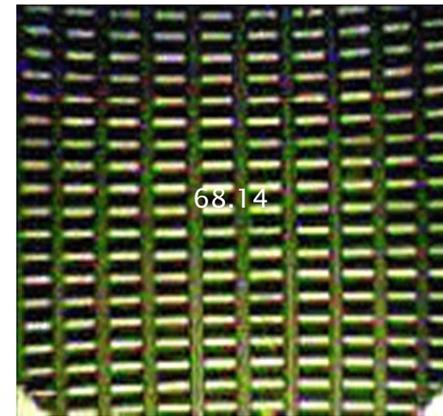
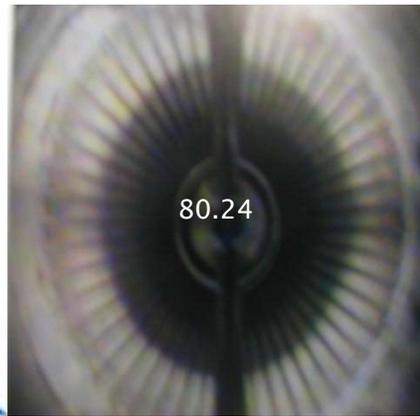
# Aqua Freed CO<sub>2</sub> Technology

- Broad Based Rehabilitation Technology
- Environmentally Safe (Green Technology)
- Excellent Generation and Penetration of Energy
- Sensitive to Delicate Conditions (Old or PVC Wells)
- Excellent at Removing Bacterial Biofilms and Mineral Deposits

Before Treatment



After Treatment





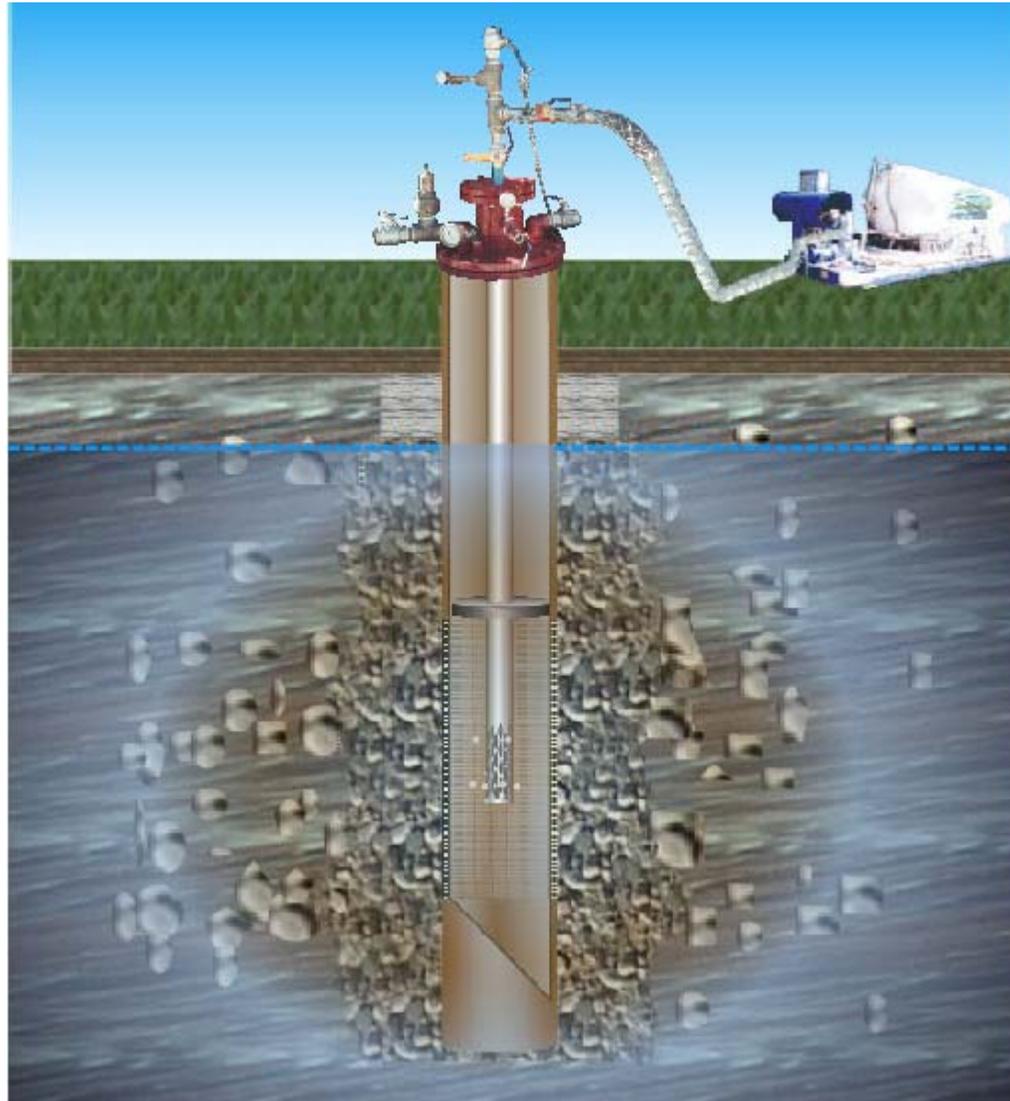
# How CO<sub>2</sub> Process Works:

- **Energy Released During Phase Changes:**
  - Liquid to Gas (570 Times Volume Expansion)
  - Liquid to Solid (Dry Ice)
  - Solid to Gas (Sublimation)
- **Formation of Carbonic Acid (H<sub>2</sub>CO<sub>3</sub>) a Mild Acid (Approx. pH=5) Allowing Some Dissolution of Scale**
- **Pore Water Freezing Allows Scale and Biofilms to be Dispersed**
- **Carbon Dioxide has Surfactant Properties that help Penetration of the Aquifer, Scale & Biofilm**



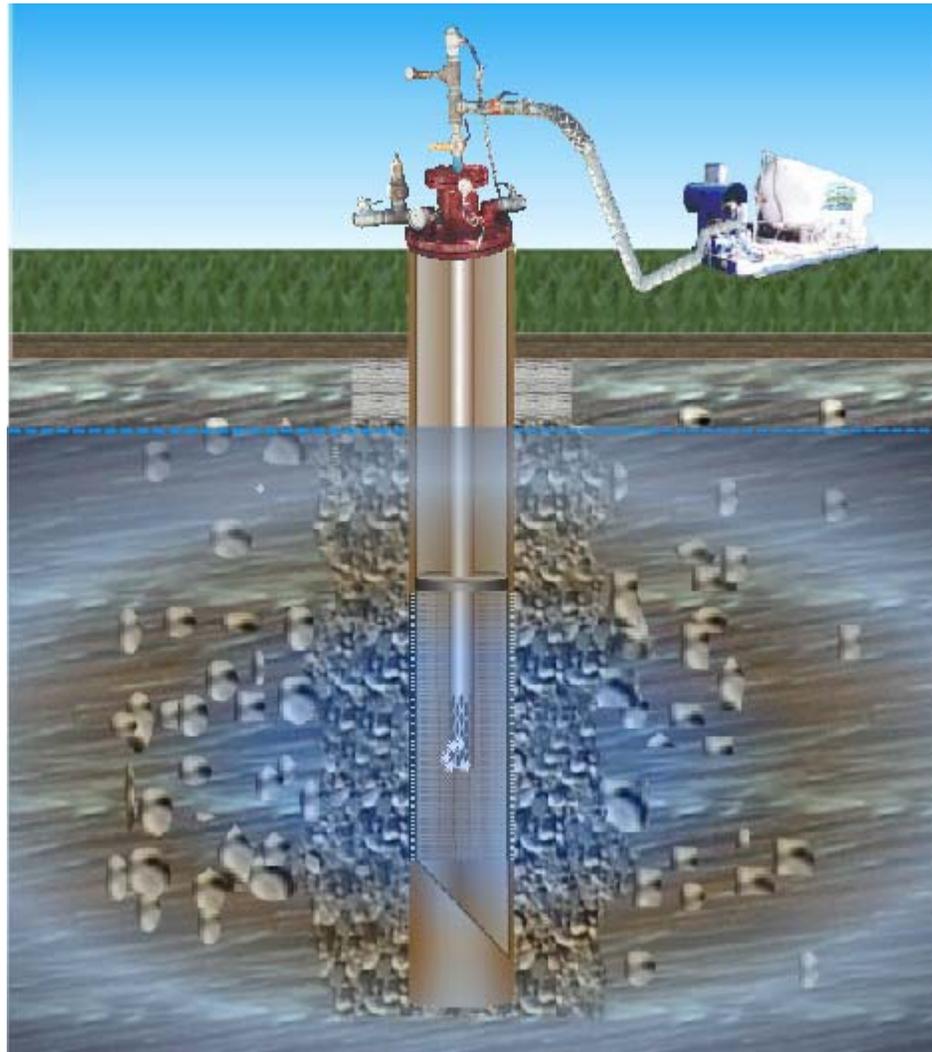


# FIRST STAGE: Seal the Well and Inject CO<sub>2</sub> in the Gaseous State.





# SECOND STAGE: CO<sub>2</sub> Injection in Liquid State at Controlled Pressures

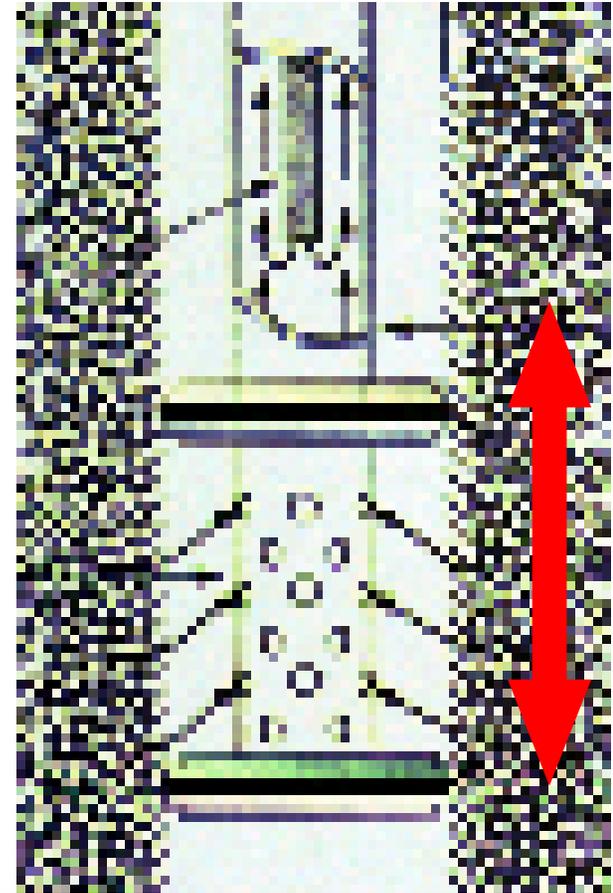




# WELL DEVELOPMENT



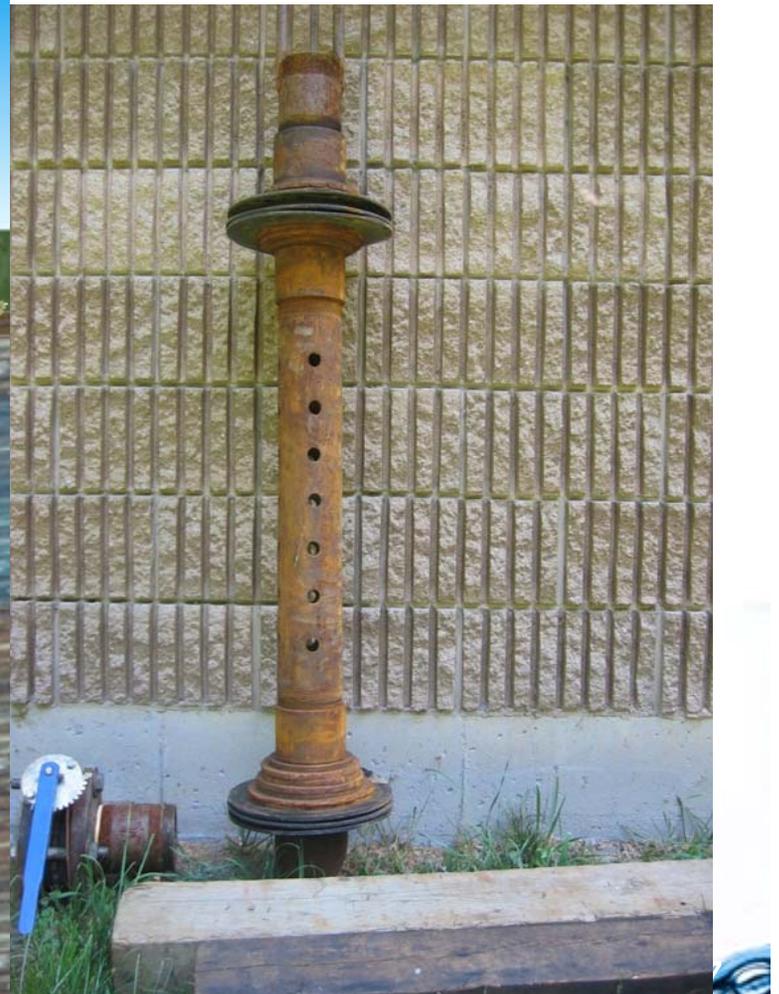
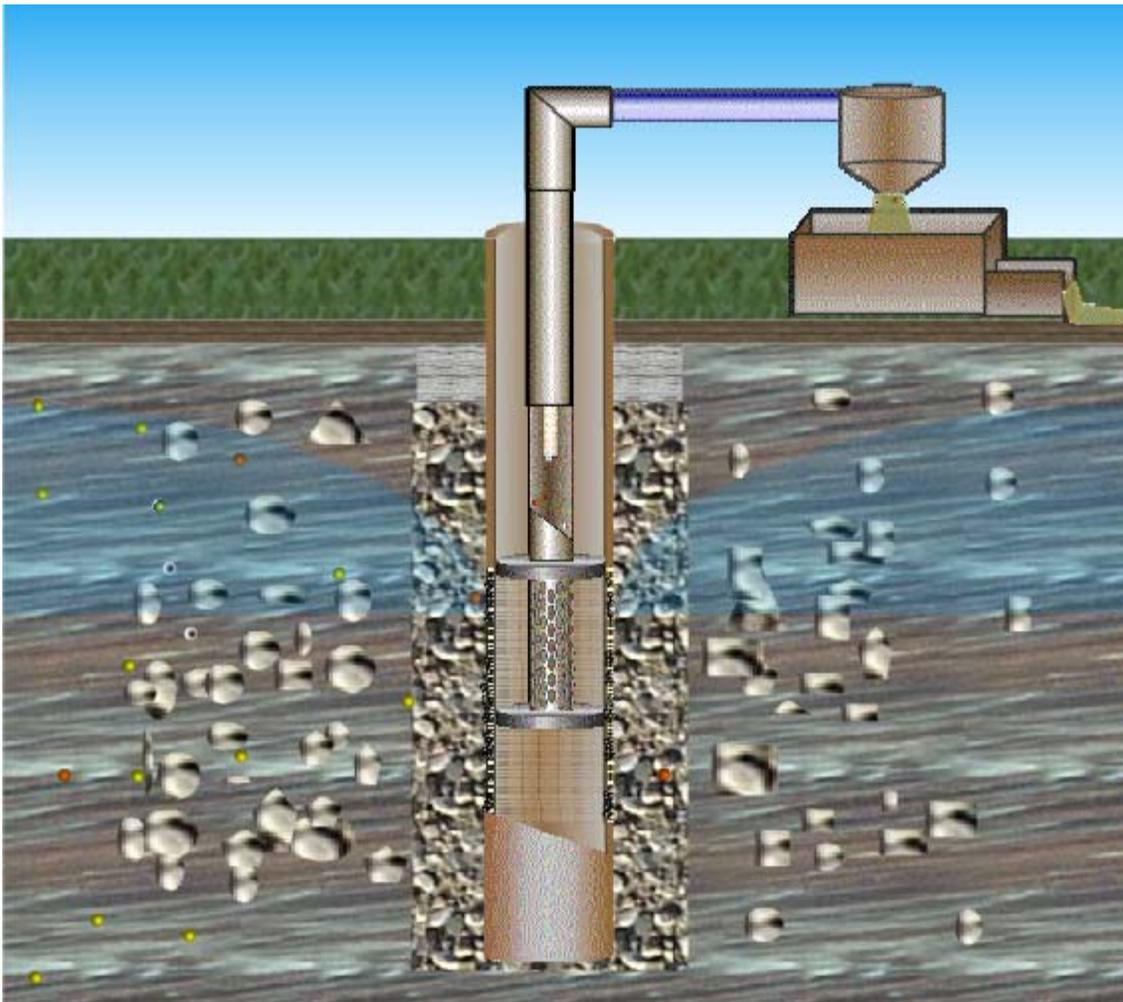
**The Simultaneous Swab-and-Air Lift Method is Often Used For Large Water Production Wells.**



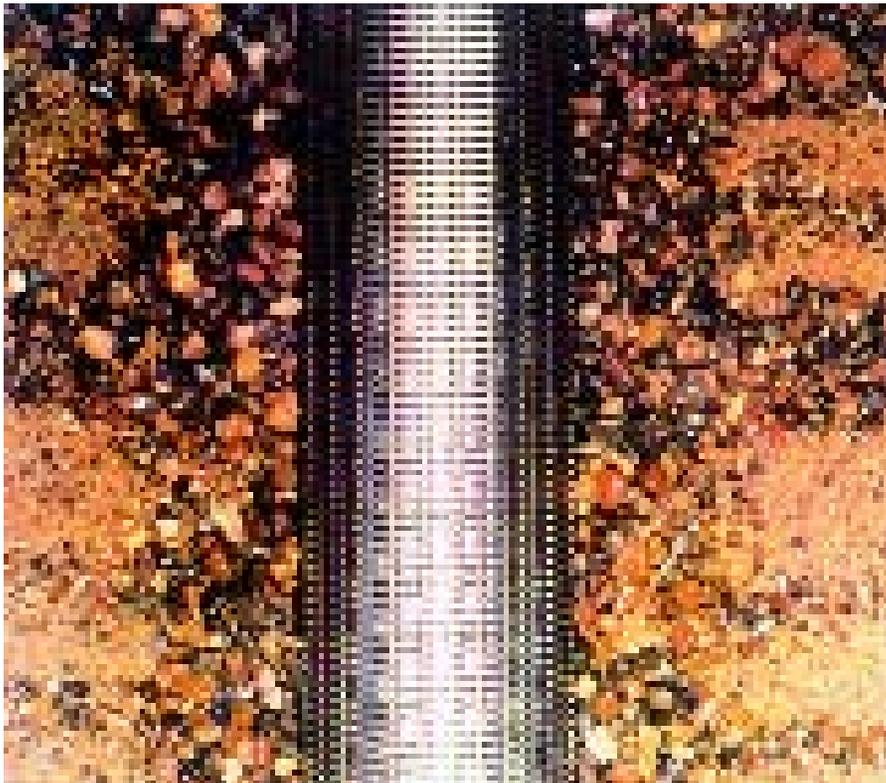


## THIRD STAGE: Re-Development with Double Disk Surge Block and Airlift/Pump.

Most Effective Method of Development – Removing the Detached Material



# WELL DEVELOPMENT



- **A Properly Developed Filter Pack Will be Graded away from the well**
  - ◆ **Finer sediment farther from the well**
  - ◆ **Coarser sediment near the well**





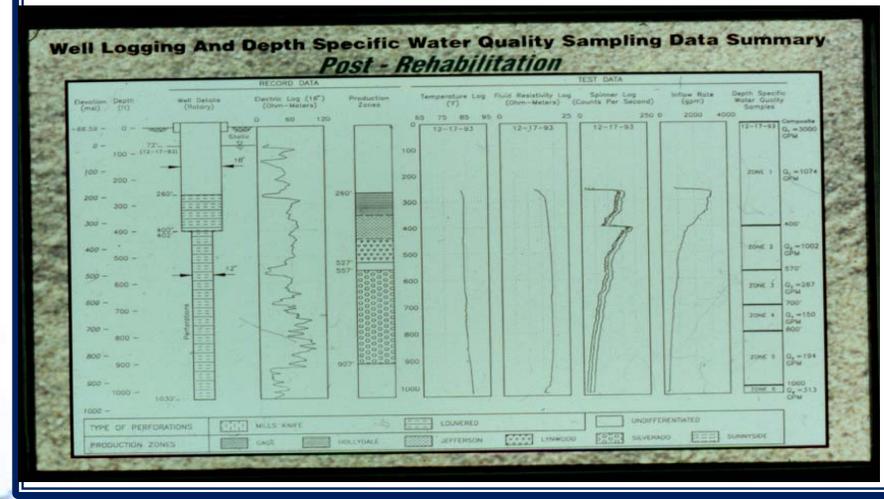
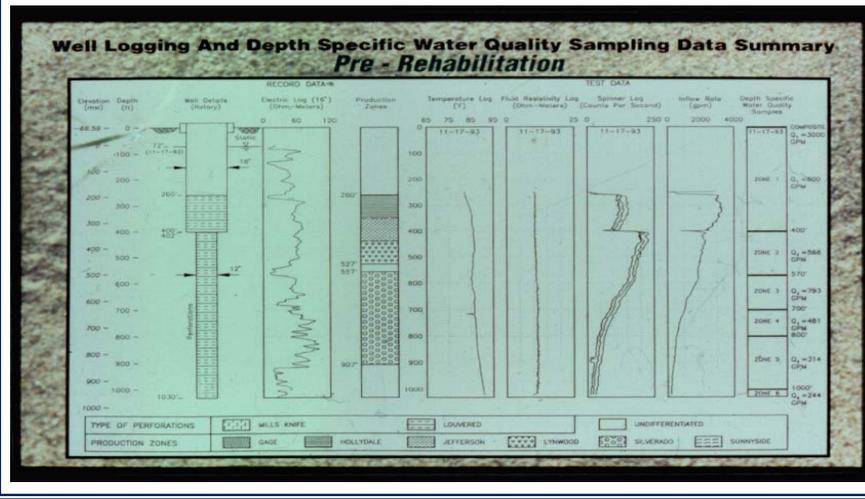
# Actual Plugging Impact Before and After Rehabilitation

## Total Flow 3000 gpm Before Rehabilitation

Zone 1:	600 gpm
Zone 2:	568 gpm
Zone 3:	793 gpm
Zone 4:	481 gpm
Zone 5:	314 gpm
Zone 6:	244 gpm

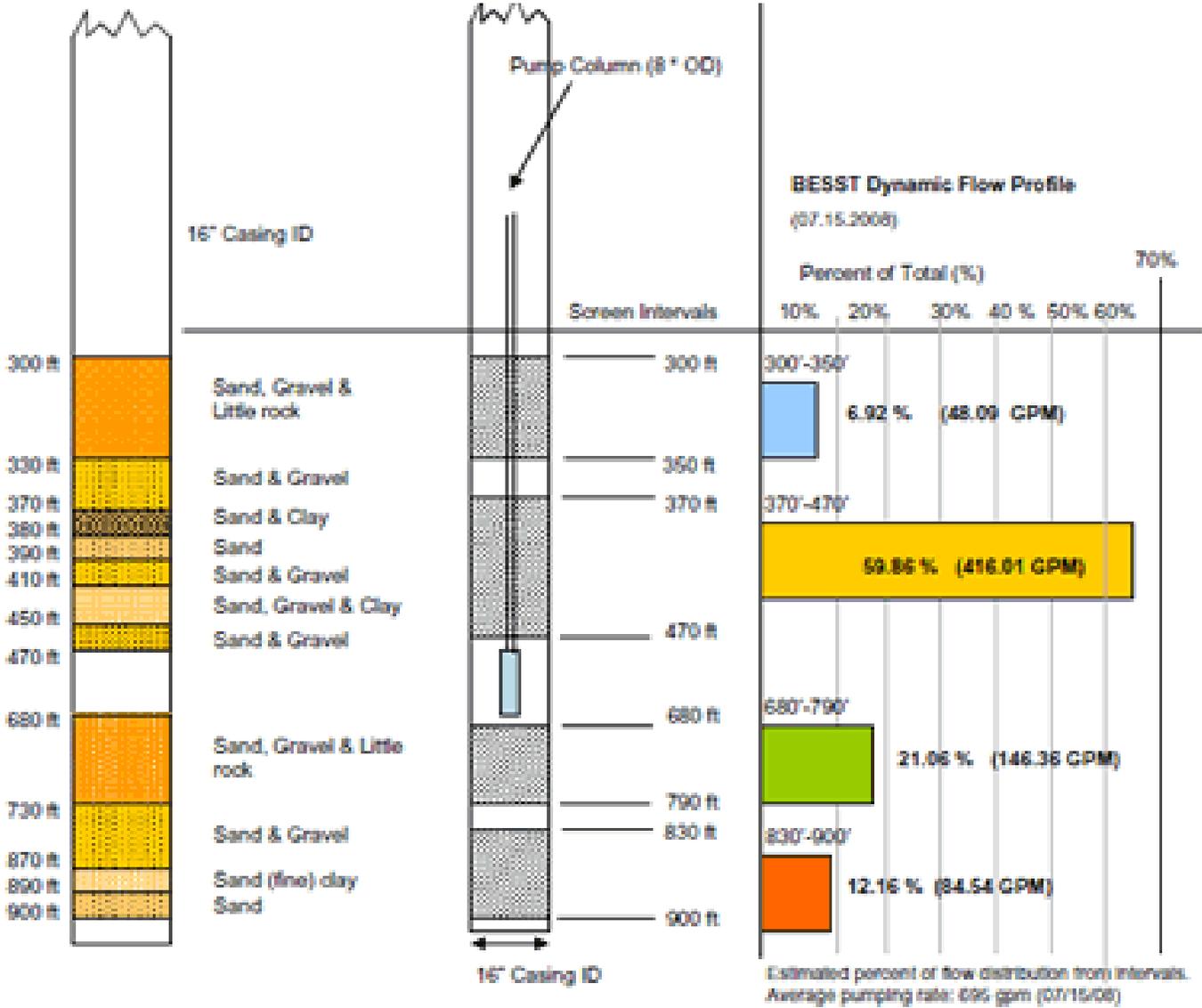
## Total Flow 3000 gpm After Rehabilitation

Zone 1:	1,074 (+79%)
Zone 2:	1,002 (+76%)
Zone 3:	267 (-64%)
Zone 4:	150 (-69%)
Zone 5:	194 (-38%)
Zone 6:	313 (+28%)





# Flow Log Showing Pump Setting and Geological Profile







# Desoto, Kansas





# Overview

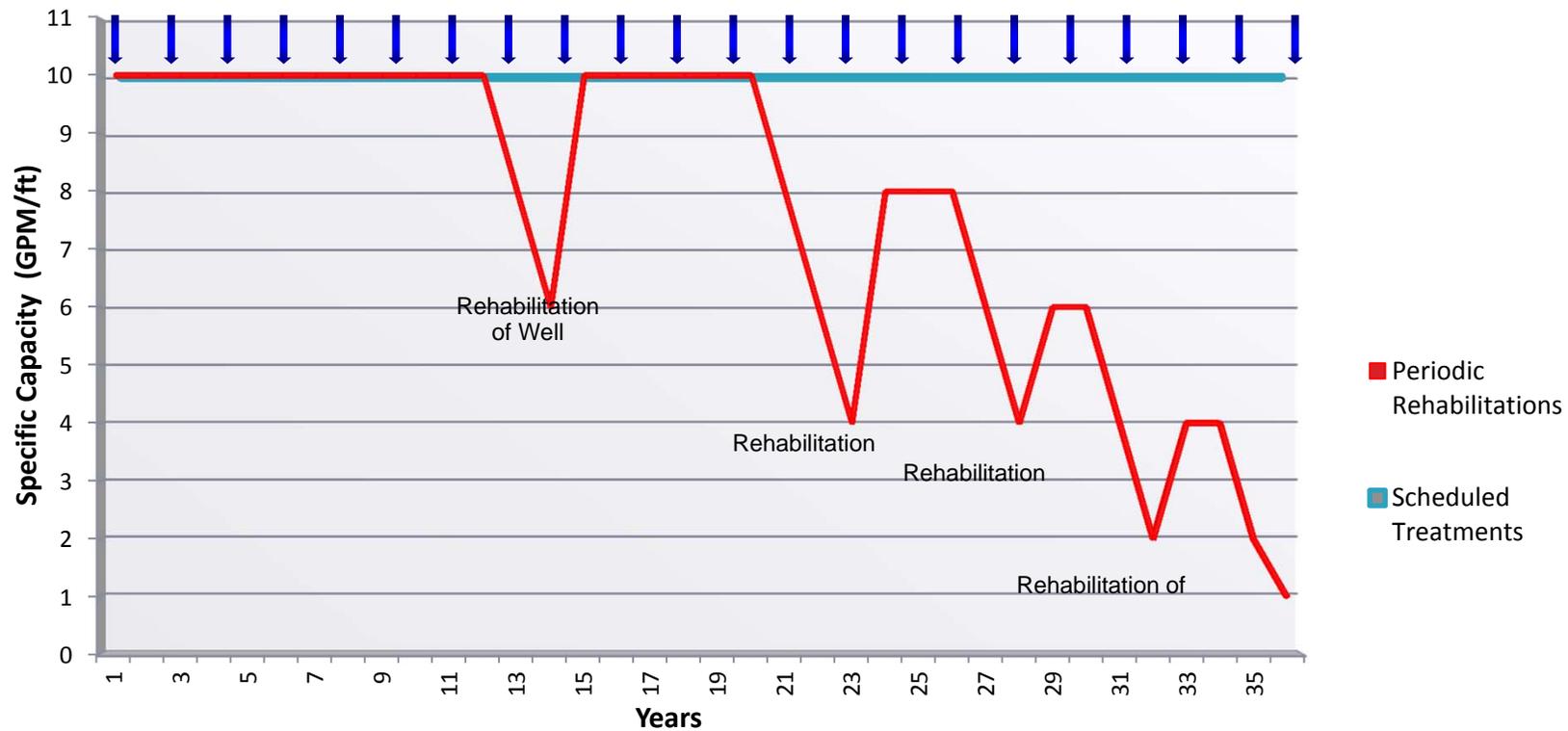
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# Historical Standard Operation

## Operate to Failure Compared to Proactive Maintenance of Wells



**What Happens  
When We Wait  
Too Long to  
Rehab?**

**Extensive and  
Hardened  
Mineralization!**

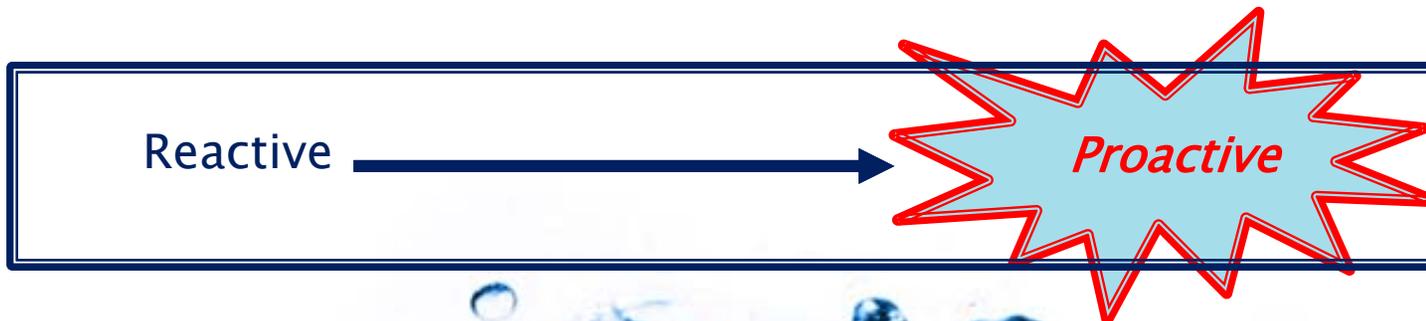


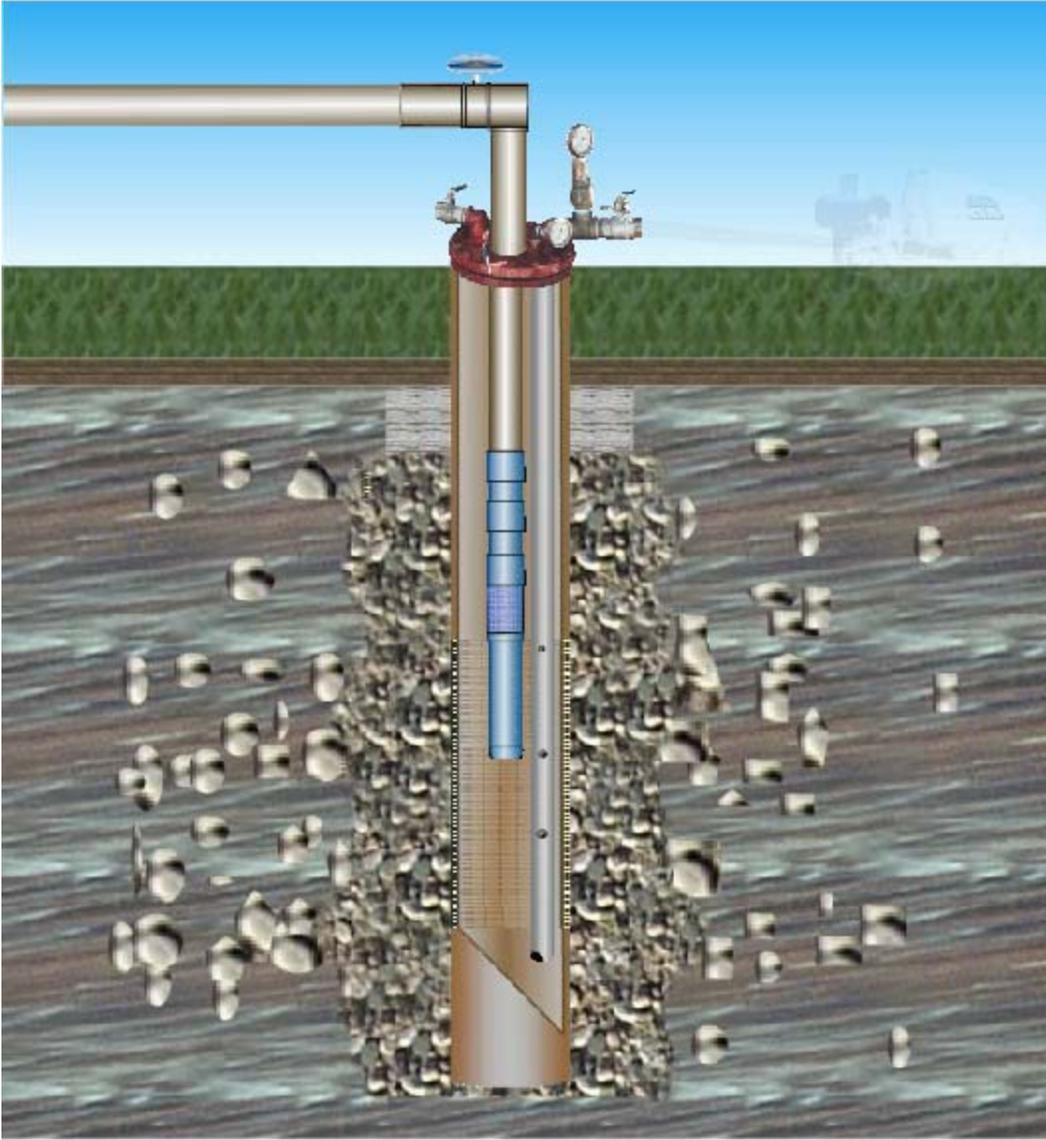


# Aqua Gard CO<sub>2</sub> Maintenance Technology

## Water Well Asset Management Program

1. Well Asset Management Equipment is Permanently Installed
  - a. In well Preventative Maintenance Device is Used for Scheduled Service
2. Very Cost Effective
  - a. Allows Wells to be Effectively Maintained WITHOUT Removing the Pump
  - b. Reduced Down Time During Maintenance Service (usually 24 to 48 Hours)
3. Equipment Allows Effective Energy to be Delivered Well for Cleaning
  - a. Scheduled Service Compared to Reactive Rehabilitation
4. Fixed Budget Pricing and Potential Spread of Initial Cost





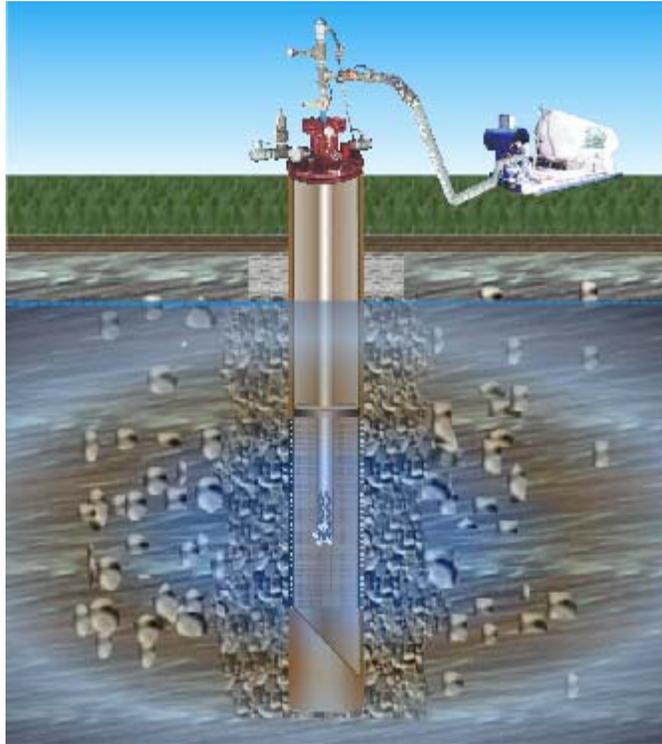


**Well Equipped with AquaGard™ Asset Management**

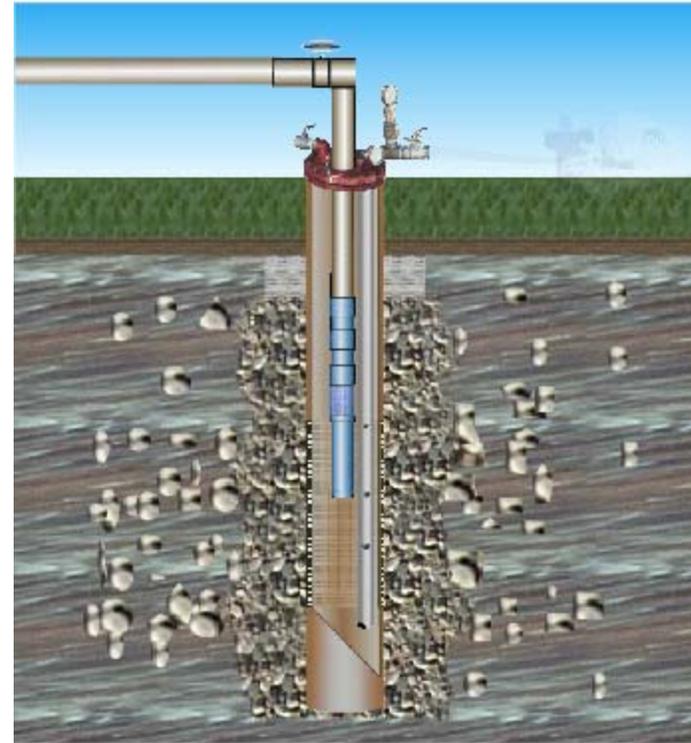




# Rehabilitation and Maintenance Comparisons



Rehabilitation Treatment



Maintenance Treatment





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# Well Asset Management

## Benefits of Well Asset Management

1. Extend Asset Life Cycle (Potentially Indefinitely)
2. Improve and/or Maintain Well Performance
3. Reduced or Maintain Operational Cost (Specific Capacity and Well Efficiency)
4. Maintain Consistent Water Quality
5. More Predictable Maintenance Cost (Flat and Fixed Annual Fee)
6. Improved Annual Knowledge of Well and System Condition
7. Potential Single Source Responsibility
8. Time Based Proactive Maintenance and Management of Wells

**Best Sustainable Practice to Maintain Water Well Production, Quality & Equipment**





# Questions?

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