Groundwater Wells
Construction, Maintenance and Troubleshooting

Presentation Material Courtesy of:
Alberta Food & Agriculture
Alberta Environment - Working Well Program
Prairie Farm Rehabilitation Administration
Alberta Water Well Drilling Association
Outline

• Well Components

• Understanding the Cause of Well problems

• Preventing/Resolving Well problems

• Diagnosing Well Problems
Well Components/Well Construction
Typical Drilled Well Construction with Screen

Well Screens
Parts of a Drilled Well

WATER TABLE

Borehole
Casing
Annulus (sealed with cement or bentonite)
Pump
Formation Seal
Perforated Liner
Well Screen
Packer
Formal Seal
Perforated Liner

UNCONFINED AQUIFER (gravel)

CONFINED AQUIFER (fractured shale)

Well Cap
Access Tube
Pitless Adaptor
Borehole
Casing
Annulus (sealed with cement or bentonite)

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Formation Seal
Perforated Liner
Well Screen
Packer
Water System
Following well construction it is important to;

- Develop the well to remove fine sediment and drilling fluids
- Correctly perform a yield test to determine the pumping rate and to determine the depth at which the pump should be placed – an ideal pump rate will keep the water level above the screened area of the well
- Obtain the drillers report
Understanding the Cause of Well Problems

- Many possible causes
- Understanding the cause is necessary to prevent or fix the problem
Some causes of well problems/deterioration:

- Bioufouling
- Mineral Incrustation
- Sediment plugging
- Structural Failure (corrosion, poor construction)
- Over-pumping
- Aquifer Depletion
- Well interference
- Contamination

Often occur in combination
• Symptoms
  – Reduction in yield
  – Changes in water quality (i.e. changes in taste, odour, colour, chemistry, microbiology)
  – Sand or silt in water
  – Dissolved gas in water
Biofouling

- Slime forming *bacteria* that accumulate in a well
  - Installing & pumping a well
    - ↑ nutrients & oxygen
  - Cause ↑ bacteria
- Plugs well
- Decrease in water yield
- Corrosion of metal parts
- Impacts Water Quality
Flow brings nutrients and clay particles

CO₂ Escapes

Mineral Deposits

Biofilm

Sils and Clays

Bio-wastes

Static water level

Drawdown Curve
Clean Well Screen Vs Biofouled Well Screen
Biofilm Interferes With Water Flow

Sand Grains → Biofilm

Picture Provided by Environment Canada
• **Symptoms**
  
  – gradual decrease in yield (lower pumping water level)
  – slime buildup on household plumbing fixtures and livestock waterers (check toilet tank)
  – changes in water quality leading to
    • staining of plumbing fixtures and laundry
    • bad taste and odour (rotten egg smell)
    • water discolouration
  – increased corrosion of steel and iron parts of the well.
Biofouling

• What to Do?
  – regular disinfection (shock chlorination)
  – may need to have well cleaned first by a well driller
Mineral Incrustation

- Mineral Incrustation
  - Build up mineral scale in your well and water system
  - Accelerated by overpumping and bacteria
  - Plugs well, decreases water yield, impacts water quality
Mineral Incrustation

• Symptoms
  – Gradual decrease in yield
  – mineral scale on household plumbing fixtures and livestock waterers
  – changes in water quality
Mineral Incrustation

• What to Do?
  – reduce pumping rate
  – chemical analysis of water to determine risk
  – Clean the well and distribution system
Well construction affects biofouling and mineral incrustation.
Sediment Plugging

• Sediment Plugging
  – Sediment plugs well screen and surrounding aquifer
  – Caused by overpumping or poor well design & construction

• Symptoms
  – Sediment in well water and Decrease in yield

• What to Do?
  – Existing wells: reduce pumping rate
  – New wells: use a qualified drilling contractor
Structural Failure

• **Corrosion**
  – Chemical substances ‘eat away’ metal casings, screens, pumps
  – Sediment enters well through holes
  – Accelerated by bacteria & cascading water
  – $\text{CO}_2$, $\text{O}_2$ & $\text{H}_2\text{S}$ make water corrosive

• **Poor Construction**
  – Damage to pump and screen during installation
  – Poor selection and placement of gravel pack and well seal
  – Improperly sealed annulus
  – Overpumping can cause fragile wells to fail

• **Symptoms**
  – Sudden appearance of sediment in water
  – Change in water quality – high turbidity
Structural Failure

• Corrosion - What to Do?
  – Regular disinfection (shock chlorination)
  – Avoid over-pumping
  – Use plastic casing liners & stainless well screens
  – Drill a new well

• Poor Construction - What to Do?
  – Prevention – ensure well is properly designed & constructed & be prepared to pay for quality
  – Recondition well – if not economical, plug well and re-drill new well
  – Do not over-pump well
Overpumping

• One of the most common causes of well failure

• Occurs when water is withdrawn at a faster rate than the well was designed for

• Problem increases if pump is placed below the top of the well screen and water is drawn-down below the top of the screen or slotted portion of the well
Aquifer Depletion

Indicator
- Loss in production combined with lower non-pumping water level

Cause
- Water withdrawn exceeds recharge
  - “Mining the aquifer”
  - Can be caused by overpumping

Well Interference

Indicator
- Short term fluctuation in water levels

Cause
- Occurs when the cone of depression from two wells overlaps, reducing the water available to both wells
Aquifer Depletion

• Symptoms
  – Lower non-pumping (static) water level
  – Dropping water levels in nearby wells

• What to Do?
  – Regularly check static water levels
  – Reduce pumping rates & water use
  – Drill new well into deeper aquifer
  – Identify nearby wells tapped into same aquifer
Potential Contamination Sources

- Agricultural runoff
- Waste retention pond
- Fertilizer application
- Livestock yards
Is the a well or scratching post??
Example of a problem well

- Surface casing
- Borehole
- Bentonite seal
- Perforated liner

Ken Williamson-AAFRD
Poor Sewage System

- Well
- Cesspool
- Clay
- Water table
- Sand aquifer

Ken Williamson-AAFRD
Groundwater filled dugout

clay

saturated sandstone

shale
An influent-losing stream supplies water to the zone of saturation and is characteristic for arid climates.
Old well contamination

New well

Old well

Casing

Corrosion or bad formation seal

Contaminated aquifer

Open hole

Aquifer

Ken Williamson-AAFRD
Inside well pit

Water in pit

High water line at the casing height

Metal plate cover on well

Ken Williamson-AAFRD
backflow

Vacuum breaker

Frost free hydrant

hose

6” air gap

Sprayer tank

well

Drain hole

Pitless adaptor

Ken Williamson-AAFRD
Install a Good Well

- Features of a Good Well
  - Setbacks
  - Landscaping
  - Pitless adaptor (no pits!)
  - Vermin-proof well cap
  - Watertight borehole seal
  - Single aquifer source
  - Backflow prevention
  - User-friendly

Preventing Well problems
### Setbacks

<table>
<thead>
<tr>
<th>Facility</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watertight septic tank</td>
<td>10 m (33 ft.)</td>
</tr>
<tr>
<td>Weeping tile effluent disposal field or evaporation mound</td>
<td>15 m (50 ft.)</td>
</tr>
<tr>
<td>Sewage surface discharge</td>
<td>50 m (165 ft.)</td>
</tr>
<tr>
<td>Sewage lagoon</td>
<td>100 m (329 ft.)</td>
</tr>
<tr>
<td>Above-ground fuel tanks</td>
<td>50 m (165 ft.)</td>
</tr>
<tr>
<td>Manure storage facility</td>
<td>100 m (329 ft.)</td>
</tr>
<tr>
<td>Manure application area</td>
<td>30 m (100 ft)</td>
</tr>
<tr>
<td>Landfill</td>
<td>500 m (1,641 ft.)</td>
</tr>
<tr>
<td>Leaching cesspool</td>
<td>30 m (100 ft.)</td>
</tr>
</tbody>
</table>

Environmental Farm Plan: [www.albertaefp.com](http://www.albertaefp.com)
Landscaping

- Top of well at about 1 ft above ground
- Surface mounding (slope away from well to prevent surface pooling and contamination)
Well Pits vs. Pitless Adapters

- Runoff
- Leakage
- Seepage

- Install water line below frost level
- Pitless Adapter

- Well Casing
- Pump

- Pressure Tank
…Vermin-proof Well Cap
...Watertight Borehole Seal
…Single Aquifer Source

Bentonite or cement seal

Poor quality aquifer (hard)

Poor quality aquifer (hard)

Good quality aquifer (soft)
…Backflow Prevention

Vacuum breaker
Frost free hydrant
Sprayer tank

6” air gap

hose

Well

Drain hole

Pitless adaptor
...User Friendly
Preventative Maintenance

... systematic approach of scheduled inspections, regular monitoring and preventative treatments to prevent the premature deterioration of a water well supply.

Benefits of Preventative Maintenance

• Inspections and Monitoring
  - alerts owner to changes in well performance and water quality before the problem becomes severe
  - one step in providing a “safe” water supply

• Preventative treatments
  - extend well life/reduce frequency of well rehabilitation or well replacement
  - reduce pumping costs
  - restore lost pumping capacity
1. Inspect Your Well & Property

- **Monthly (Seasonally) Inspection:**
  - Well cap secure, vents unblocked
  - No gap around well casing
  - No ground settling or water ponding around well
  - Setbacks between well and potential contaminants
  - Manure, fertilizers not over-applied
  - Pressure tank & water treatment system operating properly
  - Septic system working properly
2. Test Your Well Water

• Test for coliform bacteria twice a year
• Routine water chemistry test every two years
• Test when water quality changes
Biological Monitoring for Nuisance Bacteria

- **BART™** (Biological Activity Reaction Test) A Patented Test System for detecting the presence and activity levels of selected groups of nuisance bacteria that are often involved in the biofouling of a water well
Beyond Routine Monitoring

Arsenic – MAC 10 µg/L (ppb)
• skin lesions, cancer, nervous system disorders

Selenium – MAC 0.01 mg/L
• nervous and circulatory systems, hair loss

Manganese – AO is < 0.05
• metallic taste, black staining

Other Trace metals

Carbon Dioxide
• spurting at tap or milky water

Organics (hydrocarbons), Radionuclide

Heterotrophic plate Count (HPC) –
• high levels may indicate biofouling
• >500 retest for coliform bacteria
Rural Water Quality Information Tool

- Web-based
  - Input your test results
  - Tells you suitability of your water for different uses:
    - Drinking, livestock, irrigation, etc.

www.agric.gov.ab.ca/app84/loadMain
3. Plug Old Holes

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/wwg414
4. Manage Land Activities

Environmental Farm Plan: www.albertaefp.com
5. Keep Good Records

Well maintenance diary

<table>
<thead>
<tr>
<th>Date Completed</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-08-04</td>
<td>Sample</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date Completed</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-08-04</td>
<td>extended casing above ground, landscaped around</td>
</tr>
</tbody>
</table>

Water quality testing diary

<table>
<thead>
<tr>
<th>Date Tested</th>
<th>Parameters</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006-08-04</td>
<td>minerals / metals / bacteria</td>
<td>normal</td>
</tr>
</tbody>
</table>

www.wellaware.ca
• Reports filled out by drillers after a water well has been drilled
• Location of adjacent/abandoned wells
• Water quality analysis reports
• Water level measurements
• Records of maintenance or repair
6. Disinfect the well

- Yearly, if you have **symptoms** of biofouling
- Following **change** in water clarity, color, odor or taste
- Immediately after installing a **new well**
- After well, pump or any part of plumbing is opened for **repairs** or maintenance
- Following contamination by **flood water**
- When water quality tests show presence of **coliform** bacteria
- Must be done regularly to be effective
- Not effective in poorly maintained wells
Dosage and Types of Chlorine

• Dosage - 200 milligrams per liter (Water Act)

• Liquid - sodium hypochlorite is 5.25% (household bleach) or 12% (industrial bleach) strength

• Too much chlorine is less effective and can damage a well
Effect of pH on Chlorine Effectiveness in Water

<table>
<thead>
<tr>
<th>Water pH</th>
<th>Biocidal Effectiveness</th>
<th>Oxidative Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>100 %</td>
<td>0 %</td>
</tr>
<tr>
<td>8.0</td>
<td>12 %</td>
<td>88 %</td>
</tr>
<tr>
<td>9.0</td>
<td>2 %</td>
<td>98%</td>
</tr>
<tr>
<td>10.0</td>
<td>&lt; 1 %</td>
<td>&gt; 99 %</td>
</tr>
</tbody>
</table>

Note: pH Reduction can dramatically increase the effectiveness of chlorine in high pH waters.
Methods of Shock Chlorination

1. Simple Chlorination
   - Poor results!!

2. Bulk Displacement
   - Much better results!!
Step by step procedures for
‘Shock Chlorination of Small Diameter Wells’
‘Modified Procedure for Large Diameter Wells (24-36 inches)’
provided in the Fact Sheets or Water Wells Manual

Water Wells That Last for Generations.
www.agric.gov.ca/water/wells or (780) 427-2700
Poorly Maintained Wells

- Shock chlorination may not work on **poorly maintained** wells – must be professionally cleaned FIRST and then the pH of the treatment water adjusted with acid.
- Well Rehabilitation - Job for a **professional** well driller – Often extremely dangerous
Diagnostic Procedures

• Discussion with the Well Owner
• Evaluation of existing well records if available (i.e. water quality, drillers report, water level records, well production tests)
• Water quality analysis (i.e. chemical and microbiological)
• Visual inspection of the well site, toilet tank, pump and drop line
• Water level measurements and production tests
Things to consider

• What are the problems (i.e. loss in yield, change in water chemistry, increased microbial activity, taste, odour, discolouration, gas in the water, sand pumping)
• When were the problems first observed?
• Are the problems ongoing or seasonal?
• Has there been any increased demand on the well or changes in the operation?
• Has there been any increase in power usage?
• Consider other wells on the property including stand-by or abandoned wells.
Diagnostic Procedures
Drillers report

• Look for
• Possible Well construction problems
  - Poor or improperly located seal
  - Multi-aquifer completions
  - Pump in screened area
• Higher than recommended pump rates
• Losses in yield
• Age
<table>
<thead>
<tr>
<th>Chemical Test</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkalinity (as CaCO3)</td>
<td>Used together with pH, hardness, calcium and magnesium to determine the possibility of carbonate scale</td>
</tr>
<tr>
<td>pH</td>
<td>Gives an indication of corrosive condition of water</td>
</tr>
<tr>
<td>Chlorides/nitrate</td>
<td>Change in chloride may indicate contamination or mixing of waters. Increased nitrate may also indicate pollution</td>
</tr>
<tr>
<td>TDS (total inorganic and organic content)</td>
<td>Changes in TDS verify changes in specific ions (e.g. the dissolution of iron pyrite leading to an increase in iron and sulfide)</td>
</tr>
<tr>
<td>Iron</td>
<td>Increasing levels of iron indicate that oxidation is occurring (through biofouling or over pumping). Iron deposits are most likely to accumulate in the well and distribution system when oxidation is occurring and iron levels are in excess of 1.0 mg/L</td>
</tr>
<tr>
<td>Sulphate</td>
<td>Change in the concentration of sulphate may indicate the presence of certain bacteria and the possible cause of corrosion, deposits, taste or odor problems. Also high levels of sulphate combined with high levels of calcium can lead to calcium sulfate scaling</td>
</tr>
<tr>
<td>Manganese</td>
<td>Levels above 0.1 mg/L can result in significant accumulation and blockage</td>
</tr>
</tbody>
</table>
Resources

- Alberta Environment
- Alberta Agriculture, Food and Rural Development
- Prairie Farm Rehabilitation Administration
- Local Drilling Companies
- Alberta Water Well Drilling Association
- Local Public Health Inspectors
- Private Laboratories