FLOWING ARTESIAN WELLS

EXPERIENCES WITH CONTROL AND CLOSURE IN BRITISH COLUMBIA

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OUTLINE

- What’s All the Fuss About? ... no worries right?
- Know your regulations ... and the potential consequences?
- Artesian Conditions: Theory vs. Practice
- What Are the Objectives of Control and Closure?
- Grouting with Cement
- Direct Closure or De-Pressurization First?
- Control and Closure of Existing Flowing Wells
- Diversion ... short and long-term
- Conclusions

PRESENTERS

Richard Cronin
Qualified Well Driller (B.C. Canada)

- Well drilling contractor in Ontario and British Columbia (35 Years).
- Flowing well control and grouting service in British Columbia, Alberta and Manitoba (20 Years).
- Colorado School of Mines grouting training (2005).
- Currently working as a superintendent with BC Groundwater Consulting Services on a variety of groundwater control projects.
- Experience with control and closure of open boreholes, cased wells, springs, flowing excavations (and other unmentionable things).

Thierry Carriou
Professional Engineer (B.C. Canada)

- Training in Geology, Hydrogeology and Mining Engineering in British Columbia and Montana Tech.
- Experience as a consultant, crew foreman, engineer and superintendent (25 years).
- Director of BC Groundwater Consulting Services Ltd. (15 Years).
- Work experience has focused exclusively on groundwater supply, well design / drilling, dewatering, depressurization, infiltration, injection, flowing well control, grouting and groundwater studies.

ACKNOWLEDGEMENTS

Successful artesian well control and closure requires a team approach. We thank all contractors and clients who have provided opportunity, collaboration and learning...

BACKGROUND
WHAT’S ALL THE FUSS ABOUT?
No Worries Right?

• Safety first!
• Protect your employees and yourself.
• There is always a risk of subsidence occurring when drilling water wells.
• The potential for subsidence increases when artesian conditions are encountered.
• Artesian wells that experience breakout around the wellhead are at particularly high risk of subsidence.
• Artesian conditions at shallow depth (less than 50 feet) should be considered a hazardous condition.
• Don’t kid yourself…the risk is real!

WHAT’S ALL THE FUSS ABOUT?
No Worries Right?

• Consider ourselves fortunate if drilling in a known artesian area.
• In these areas the general public, clients and regulators generally understand there is a cost to properly drilling, control and complete.
• Areas with unknown artesian conditions or “rogue” high-pressures are the worst-case scenario for the contractor, consultant and owner.

• Do your homework.
• Don’t cut corners.
• Uncontrolled flow can lead to bankruptcy.

A properly constructed well will be an asset and not a liability.

NO ONE OWNS THIS PROPERTY?

KNOW THE REGULATIONS IN YOUR AREA

• New “Water Sustainability Act” and “Ground Water Protection Regulation” enacted in February 2016
• Defines artesian control as follows:
  1. The artesian flow is clear of sediment.
  2. The artesian flow is entirely conveyed through the production casing to the wellhead.
  3. The artesian flow may be mechanically stopped for an indefinite period of time in a manner which prevents leakage on to the surface of the ground.
  4. The artesian flow does not pose a threat to property, public safety or the environment.

KNOW THE REGULATIONS IN YOUR AREA
AND THE POTENTIAL CONSEQUENCES!

• The new act and regulation define violations as an offence with the following consequences:
  ➢ Flow not ongoing…fine less than $200,000 and / or imprisonment less than 6 months.
  ➢ Flow ongoing…fine less than $200,000 per day and / or imprisonment less than 6 months.
  ➢ Potential statutory (regulation) and civil implications are severe whether in the USA or Canada.
ARTESIAN CONDITIONS … IN THEORY

ARTESIAN PRESSURE

ARTESIAN CONDITIONS … IN PRACTICE

ARTESIAN CONDITIONS … IN PRACTICE

ARTESIAN CONDITIONS (DHHP)

- Understanding the basics is important.
- This is the first step to maintaining control (“overbalance”) during drilling and achieving a successful closure.
- General approach is to achieve a column weight exceeding DHHP whether using mud (drilling) or cement (closure).
- It is very difficult to confirm that overbalance is maintained if pressures are unknown or occur at shallow depth.
- Artesian conditions at shallow depths may require “mechanical” control (casing and flanged connections) rather than reliance on column weight.

WHAT ARE THE OBJECTIVES?

- Focus of our work is on situations considered to be “out-of-control”:
  1. Bypass of discharge and sediment around the wellhead.
  2. Discharge with sediment produced from the casings and / or bore.
  3. Shallow wells / bores and excavations with pressures and flows too high or risky to attempt direct grouting.
- Important to identify, understand, assess and report what the specific objectives are. Is there more than one? Very likely!

APPROACH, OBJECTIVES AND EXAMPLES OF CONTROL AND CLOSURE
**APPROACH**

- Every situation is unique.
- Expect the unexpected.
- Seek external assistance and advice (contractor, professional and legal).
- Team up with a qualified experienced hydrogeologist or engineer with a proven track record … and insurance.
- Consider specialty contractor services.

  - If engaging a professional, ensure they accept the role of preparing instructions in consultation with the driller.
  - Also, assign them the role of ensuring that all work is carried out in accordance with the regulations in your area.

**EXAMPLES**

0034.7 ft

![Looking down with the camera into the confining layer](image)

**FLOWING CASED WELL**

50 USgpm

**EXAMPLES**

Looking down with the camera into the confining layer.

**LOOKING DOWN WITH THE CAMERA INTO THE CONFINING LAYER**

Many tools are adaptable to assist oil/water management.

**EXAMPLES**

EXAMPLE OF INPUT FROM A PROFESSIONAL

LAYOUT, ACCESS AND RESTRICTIONS

![View looking outwards from the overlap casing](image)

**VIEW LOOKING OUTWARDS FROM THE OVERLAP CASING**

Water and sediment moving up and out of the well ~ 250 USgpm.

**EXAMPLES**

Enroled "piped" material accumulating at the base of the bore covering a deeper damaged zone.

**EXAMPLES**

Asphalt Washed Out

Groundwater Column

Sonar Suggests 3 - 4 ft

**EXAMPLES**

Aquifer Washed Out

Depth Beyond Casing

Sonar Suggests 3 - 4 ft

**EXAMPLE OF INPUT FROM A PROFESSIONAL**

CONDITIONS PRIOR TO CLOSURE ATTEMPT

![Condition of the bore after washing out](image)

**EXAMPLE OF INPUT FROM A PROFESSIONAL**

Formal Step-by-Step Instructions

![Instructional diagram](image)

**EXAMPLE OF INPUT FROM A PROFESSIONAL**

Formal Step-by-Step Instructions
GROUTING WITH CEMENT  
COMMON PITFALLS AND RECOMMENDATIONS

- In our experience, contractors and professionals alike often overlook the following:
  - Dilution of the cement column from flowing conditions leading to reduced DHHP control.
  - Additional grout volume required due to voids and washouts (caused by drilling and free-flowing conditions).
  - Impaired bonding of cement to casings and borehole walls due to active flow and sediment piping from the well.
  - Grout with visual return to surface. Measure the overflow density.
  - Grouting “blind” is not recommended.
  - Caution when pressure grouting.

GROUTING WITH CEMENT  
COMMON PITFALLS AND RECOMMENDATIONS

- Plan your work. Have all equipment ready, in working order and materials on-site prior to starting. Panic leads to hasty and poor decisions.
- Do not use redi-mix concrete. It will segregate and can bridge.
- Bentonite (on its own) is not a reliable method of pressure control. It is prone to piping and channeling under pressure. Often not enough swelling to stop the flow if breakthrough occurs.
- Consider use of redi-mix trucks to deliver neat cement.
- Additives can be added on-site via the hopper.
- The need for volume increases with uncertainty.
- You may only get one chance to kill the well.

DIRECT CLOSURE

- Introducing cement grout directly into the well under a flowing condition (many techniques).
- Generally a reliable approach for cased wells with an intact wellhead.
- In our opinion, particularly suited to deep wells under low pressure (say 5 psig).
- Cement introduced at depth via a tremmie pipe assists with building an intact cement column to surface.
- Dilution and channeling are major concerns. Cementing to refusal may not be possible or desired.
- Exercise caution if wellhead not previously cemented or discharge currently bypassing around the well.

DEPRESSURIZATION

- Drilling a production well nearby the flowing well prior to attempting closure.
- In our experience, a very reliable first step prior to attempting cement grouting of wells under moderate to high pressure.
- Particularly important when the problem well is experiencing bypass around the wellhead or the wellhead is not reliable or intact.
- In our opinion, this is a necessity prior to attempting cement grouting under piping (sediment-producing) conditions.
- Can complicate cement grouting of the problem well (depends on geology and formation damage).
- Provides opportunities not possible with conventional (direct) cementing:
  - Can conduct testing to determine if piping is extensive (pumping or dye injection).
  - Can stop bypass around the wellhead and sediment production prior to cementing (reduces potential for channeling).
  - Can provide opportunity for direct closure in a depressurized condition (safety).
  - Can directly observe cement breakthrough during grouting process.
  - Can maintain a depressurized condition after cementing and gradually increase artesian pressures (monitoring).
  - Can conduct post-cementing tests.
CONTROL AND CLOSURE OF EXISTING WELLS

- Existing flowing wells are often in a free-discharge condition.
- Opening or closing the valve (or flange) on an existing artesian well has resulted in loss of control many times. Beware of being the last one to touch it. Have the landowner open and close it.
- Exercise caution when conducting inspections. Undetected piping and subsidence can pose a hazard around the well to a considerable distance.
- Our advice is as follows:
  - Conduct all investigations with professional and legal support.
  - Consider drilling a depressurization well, conducting a pumping test and attempt control by pumping prior to directly investigating it.

DIVERSION (SHORT AND LONG-TERM)

- Some “out-of-control” wells or artesian conditions are hazardous.
- Control of such wells can be very difficult even when depressurization is used.
- The cost of attempting depressurization in productive aquifers can be extremely high.
- Depressurization activities in populated areas and near public infrastructure or homes present additional challenges and risks.
- In some cases long-term diversion may be required prior to addressing the problem.
- In our opinion, diversion is never a permanent solution even if accepted by regulation. Who is responsible when it goes out of control the next time?

CONCLUSIONS

- Artesian conditions are a regular natural occurrence. Consider each situation unique.
- Employ best practices and reliable advice.
- Drill that surface casing a little bit deeper and use a larger annular space if it makes sense.
- Don’t cut any corners. The cost of dealing with a problematic or out-of-control artesian well will eclipse any potential cost savings.
- Be careful of blindly following other people’s advice…they will likely not be around if the plan doesn’t pan out.
- Have confidence in your approach and remain steadfast. Rely on your intuition.