Groundwater Under the Direct Influence of Surface Water (GWUDI)

Steve Wallace, Alberta Environment

Canadian Institute of Public Health Inspectors Annual Education Conference
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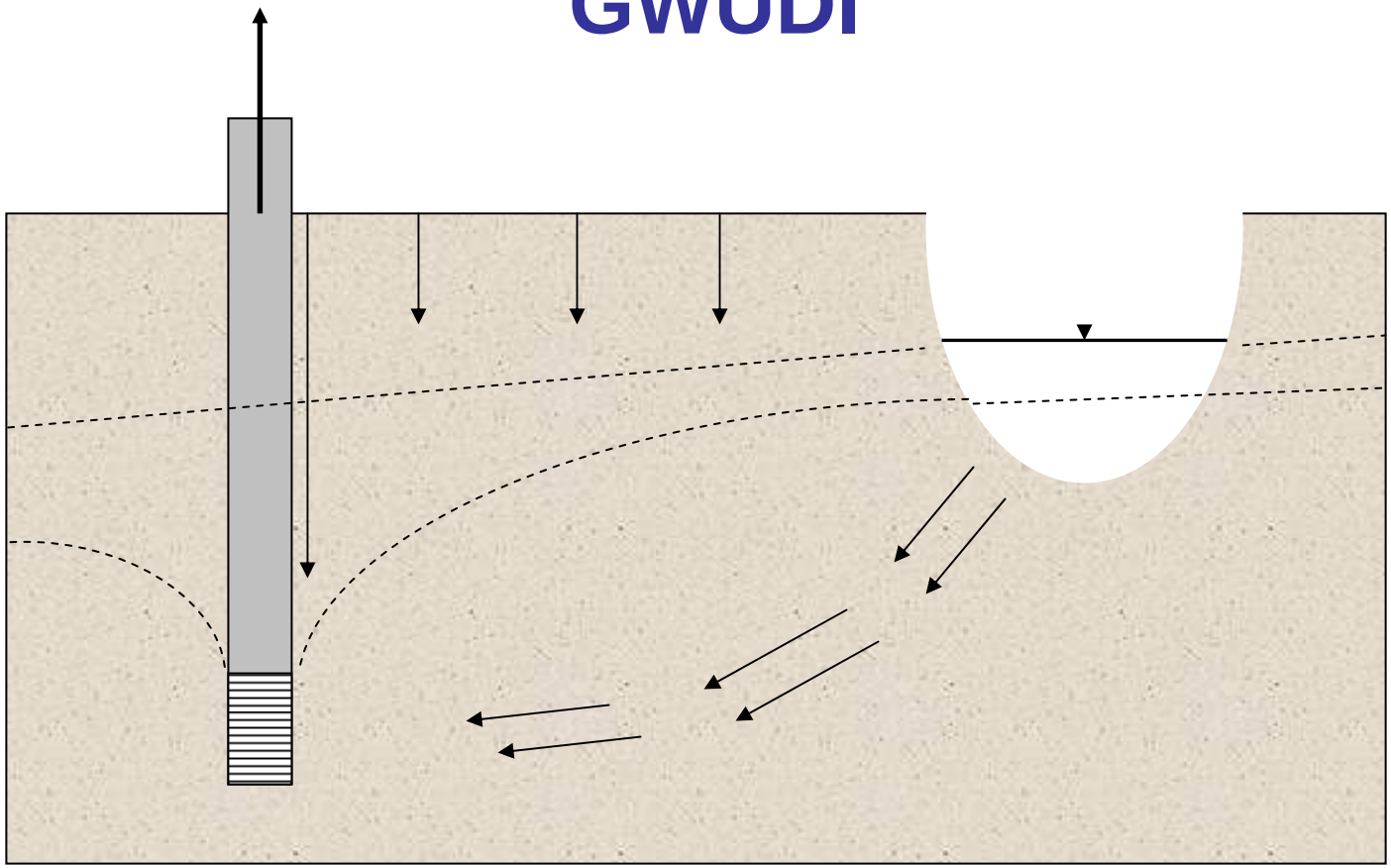
GWUDI

- Groundwater under the direct influence of surface water with respect to potential impacts from pathogenic microorganisms
- Also known as GUDI
- Considers the travel of pathogens from a surface water source to the production interval of a groundwater well
- A non-GWUDI well may have a hydraulic connection with surface water over longer time frames
- Surface water may include surface run-off and/or rapid infiltration from surface (depends on jurisdiction)

GWUDI



GWUDI Guidelines in Alberta

- "high quality groundwater" must not be GWUDI according to *Potable Water Regulation (277/2003)* under the *Environmental Protection and Enhancement Act* (EPEA)
- Municipal waterworks systems must be designed to meet the following S & G according to the *Potable Water Regulation*
- *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems (Alberta Environment, revised Jan 2006)*

  http://environment.alberta.ca/2910.html
- Assessment Guideline for GWUDI in "Appendix E"

GWUDI Guidelines in Alberta

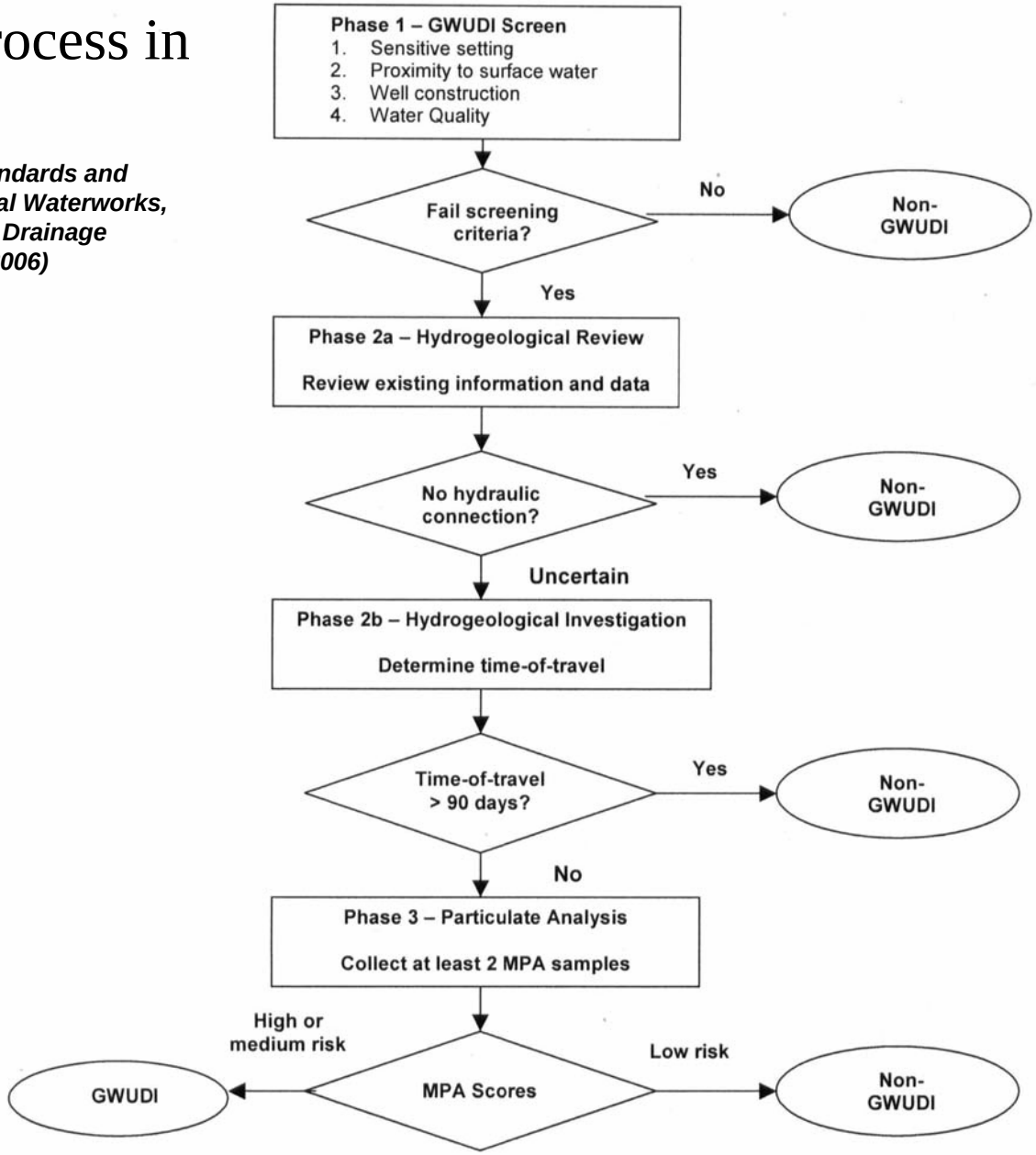
- Any well source declared GWUDI must be treated according to stringent surface water treatment requirements (filtration and disinfection) under an *EPEA* approval.
- In Alberta, this includes operations such as bed & breakfast facilities, private campsites, rental accommodations, daycare facilities, schools and restaurants
- Above facilities starting to be visited by Public Health Inspectors as they are regulated under *Public Health Act*
- If Public Health Inspector suspects any of the above facilities has a GWUDI source, Alberta Environment is contacted

Phased Approach

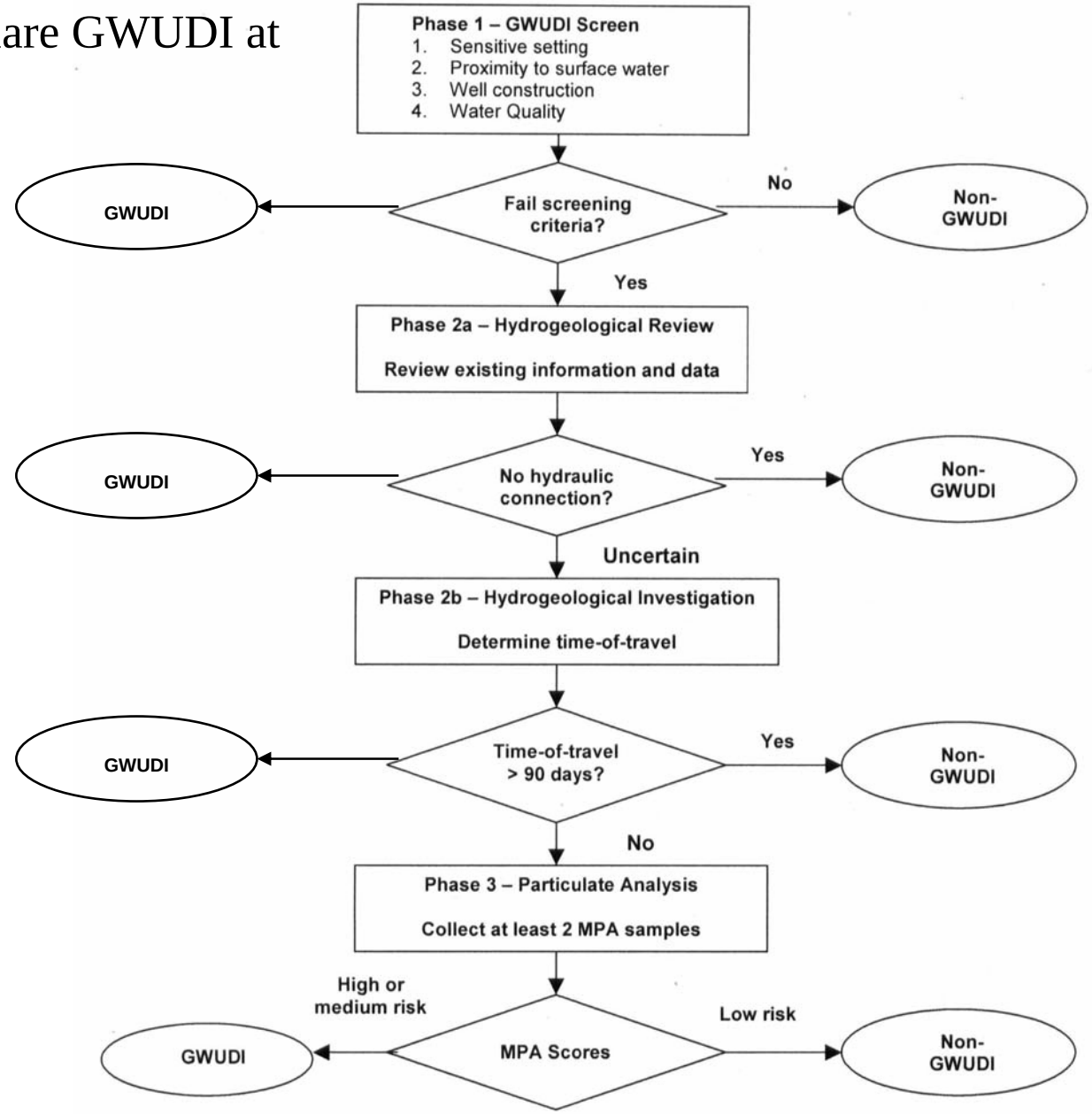
- Phase 1 GWUDI Screen
- Phase 2a Hydrogeological Review
- Phase 2b Hydrogeological Investigation
- Phase 3 Microscopic Particulate Analysis

GWUDI Process in Alberta

(from Appendix E - *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems, revised Jan 2006)*



Can declare GWUDI at any step



Phase 1 GWUDI Screen

1. Sensitive setting
2. Proximity to surface water
3. Well construction
4. Water quality

Phase 1 GWUDI Screen

1. Sensitive Setting – source shall not be:

a. spring, infiltration gallery, shallow collector system, artificial recharge system, bored or dug well

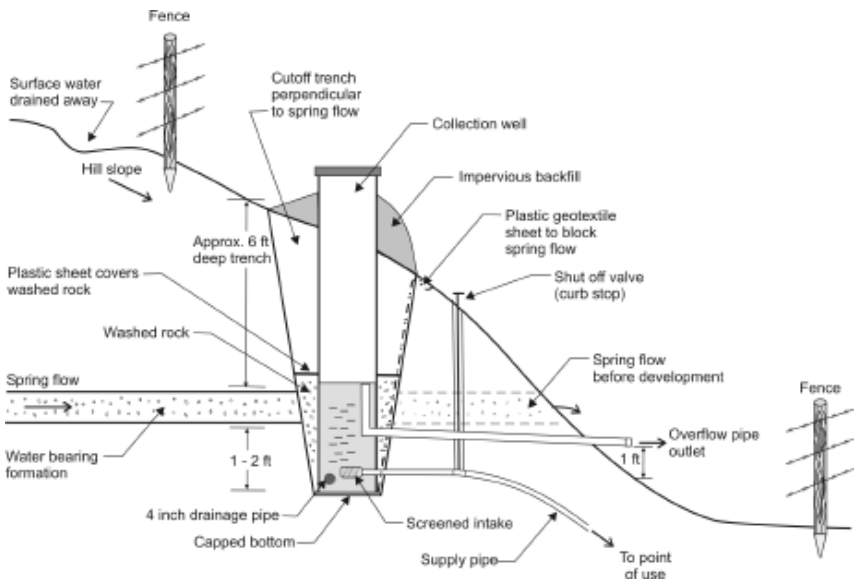
b. well with production zone < 15m below ground level

c. well in an unconfined aquifer

d. well completed in fractured or karst bedrock exposed near surface

Spring Source

Fails screening criteria 1a



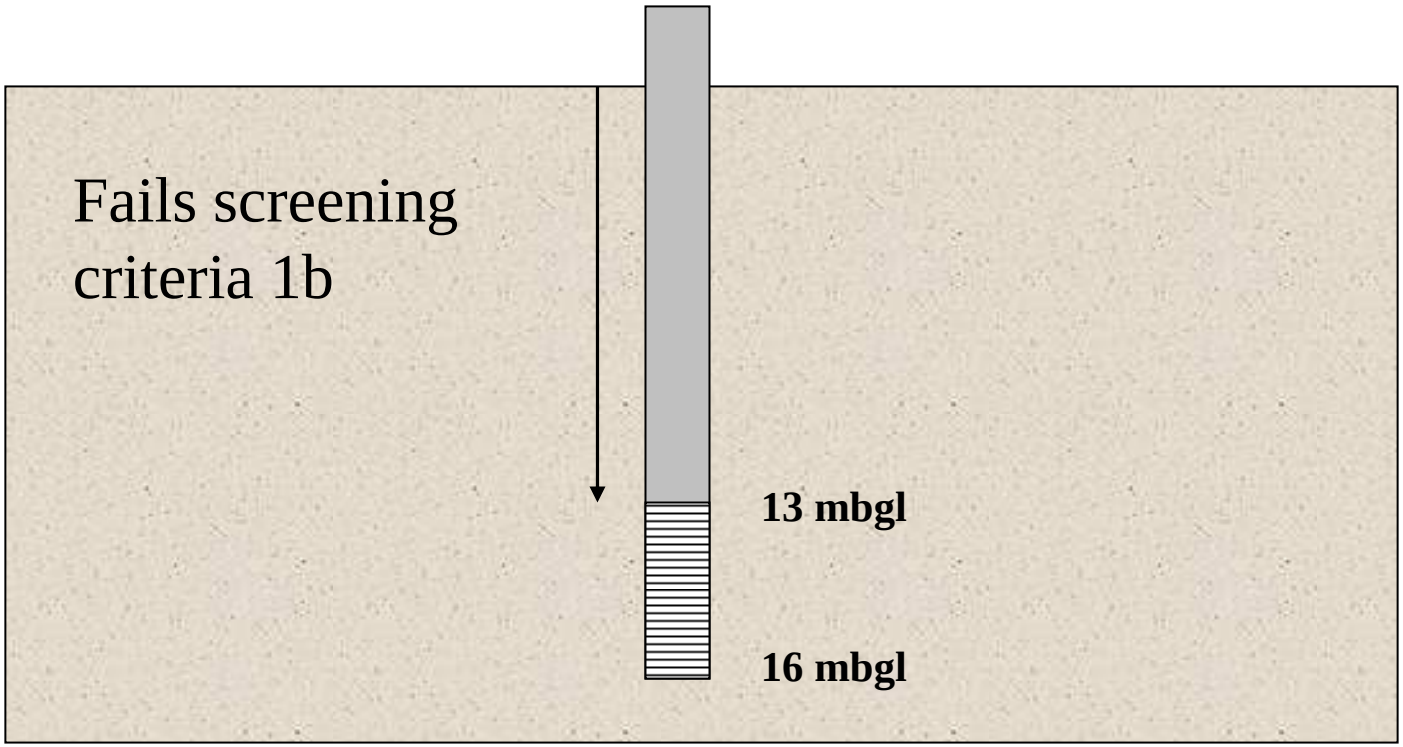
Source: Alberta Agriculture and Rural Development http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex4595

Bored Well

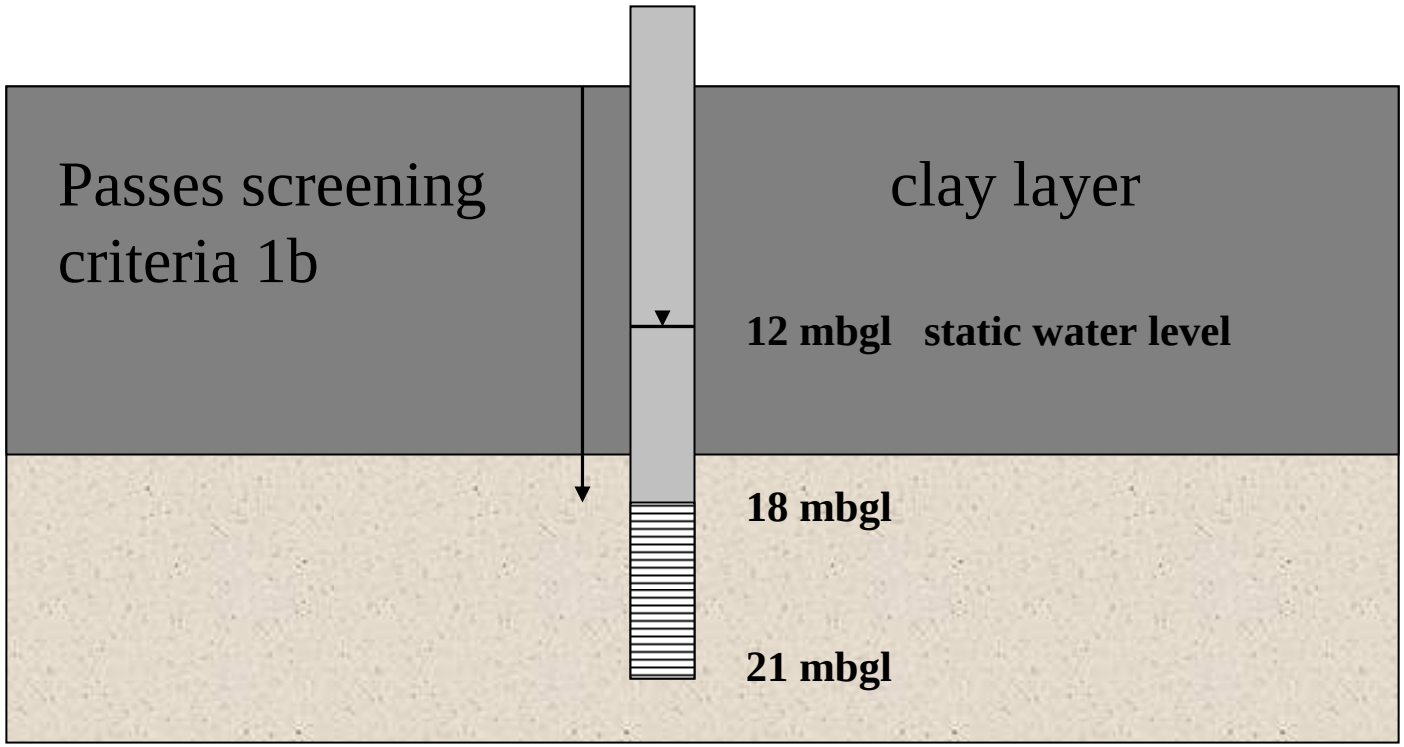
Fails screening criteria 1a

Photos courtesy of:
Alberta Agriculture and Rural Development

Depth to Production Zone



Depth to Production Zone



Where to get well information?

- Water well drilling report
- Landowner, driller or government records
- In Alberta – Groundwater Information Centre (GIC)

  http://environment.alberta.ca/1295.html
- In British Columbia

  http://www.env.gov.bc.ca/wsd/data_searches/wells/index.html

Water Well Drilling Report

Alberta Environment

The data contained in this report is supplied by the Driller. The province disclaims responsibility for its accuracy.

Well I.D.:	0040055
Map Verified:	Map
Date Report Received:	2002/01/29
Measurements:	Imperial

1. Contractor & Well Owner Information

Company Name: LOSNESS DRILLING (1975) LTD.		Drilling Company Approval No.: 38405
Mailing Address: BOX 145	City or Town: LOUGHEED AB CA	Postal Code: T0B 2V0
WellOwner's Name: B.L.W. STOCK FARMS LTD	Well Location Identifier:	
P.O. Box Number:	Mailing Address: RR1, HARDISTY	Postal Code: T0B 1B0
City:	Province:	Country:

2. Well Location

1/4 or LSD	Sec	Twp	Rge	Westof M
15	20	040	10	4

Location in Quarter
400 FT from N Boundary
700 FT from W Boundary
Lot Block Plan
Well Elev: How Obtain:

3. Drilling Information

Type of Work: New Well
Reclaimed Well
Date Reclaimed(yyyy/mm/dd): Materials Used:
Method of Drilling: Rotary
Flowing Well: No Rate: Gallons
Gas Present: No Oil Present: No

Proposed well use: Domestic & Stock
Anticipated Water Requirements/day 1000 Gallons

4. Formation Log

Depth from ground level (feet)	Lithology Description
12	Brown Clay
16	Gray Clay
107	Brown Sand
108	Hard Rocks
117	Brown Clay & Sand
150	Gray Sand
156	Blue Shale

5. Well Completion

Date Started(yyyy/mm/dd): 2001/12/27	Date Completed (yyyy/mm/dd): 2002/01/02
Well Depth: 156 FT	Borehole Diameter: 0 Inches
Casing Type: Plastic	Liner Type:
Size OD: 5 Inches	Size OD: 0 Inches
Wall Thickness: 0.375 Inches	Wall Thickness: 0 Inches
Bottom at: 140 FT	Top: 0 FT Bottom: 0 FT

Perforations / Perforations Size:
from: 0 FT to: 0 FT — 0 Inches x 0 Inches
from: 0 FT to: 0 FT — 0 Inches x 0 Inches
from: 0 FT to: 0 FT — 0 Inches x 0 Inches
Perforated by:
Seal: Bentonite Chips/Tablets from: 0 FT to: 140 FT
Seal: from: 0 FT to: 0 FT
Seal: from: 0 FT to: 0 FT
Screen Type: Stainless Steel — Screen ID: 4 Inches
from: 140 FT to: 150 FT — Slot Size: 0.015 Inches
Screen Type: — Screen ID: 0 Inches
from: 0 FT to: 0 FT — Slot Size: 0 Inches
Screen Installation Method: Attached To Casing
Fittings
Top: Coupler Bottom: Plug
Pack: Artificial
Grain Size: 10-20 Amount: 22 Bags
Geophysical Log Taken:
Retained on Files:
Additional Test and/or Pump Data
Chemistries taken By Driller: No
Held: 0 Documents Held: 1
Pitless Adapter Type:
Drop Pipe Type:
Length: FT Diameter: Inches
Comments:
DRILLER REPORTS DISTANCE FROM TOP OF CASING TO GROUND LEVEL: 1.5'. WELL CHLORINATED. WATER HAULED FORM LOSNESS SHOP 2500 GALS.

6. Well Yield

Test Date (yyyy/mm/dd): 2002/01/02	Start Time: 11:00 AM
Test Method: Pump	
Non pumping static level:	10 FT
Rate of water removal:	9 Gallons/Min
Depth of pump intake:	100 FT

end of pumping:
Distance from top of casing to ground level: Inches

Depth To water level (feet)	Elapsed Time Drawdown Minutes:Sec	Recovery
10	0:00	27.86
19.14	1:00	18.87
21.29	2:00	16.18
22.7	3:00	14.75
23.52	4:00	13.9
24.03	5:00	13.34
24.4	6:00	12.97
24.69	7:00	12.64
24.9	8:00	12.4
25.08	9:00	12.12
25.19	10:00	11.82
25.38	12:00	11.57
25.6	14:00	11.28
25.73	16:00	11.05
25.97	20:00	10.58
26.15	25:00	10.24
26.4	30:00	10.07
26.52	35:00	10
26.68	40:00	11
26.89	50:00	10
27.12	60:00	10
27.3	75:00	10
27.53	90:00	10
27.71	105:0010	
27.86	120:0010	

Total Drawdown: 17 FT
If water removal was less than 2 hr duration, reason why:

Recommended pumping rate: 9 Gallons/Min
Recommended pump intake: 100 FT
Type Pump Installed
Pump Type:
Pump Model:
H.P.:
Any further pumptest information?

7. Contractor Certification

Driller's Name: UNKNOWN DRILLER
Certification No.: 3449AD
This well was constructed in accordance with the Water Well regulation of the Alberta Environmental Protection & Enhancement Act. All information in this report is true.
Signature Yr Mo Day

6. Well Yield

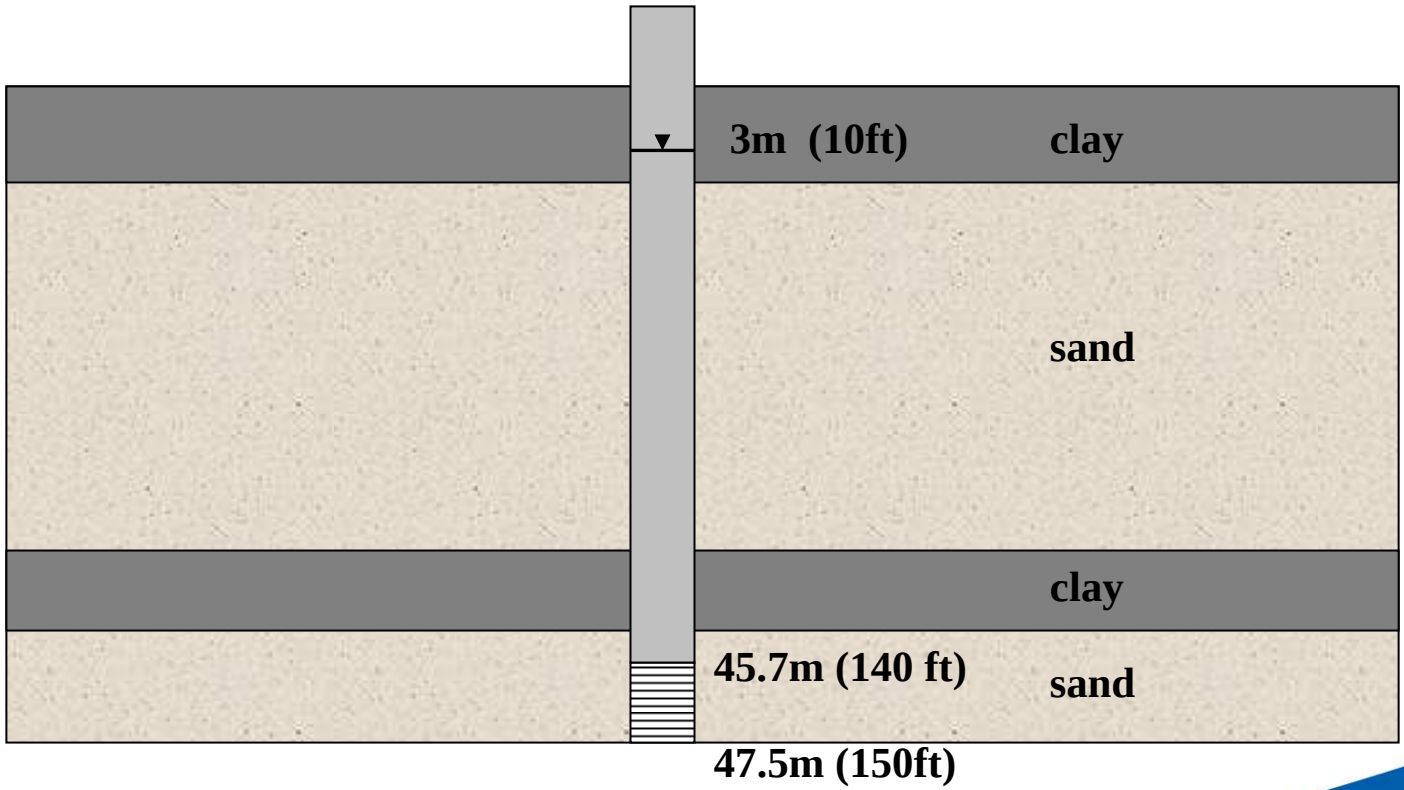
Test Date (yyyy/mm/dd): 2002/01/02	Start Time: 11:00 AM
Test Method: Pump	
Non pumping static level:	10 FT
Rate of water removal:	9 Gallons/Min
Depth of pump intake:	100 FT

5. Well Completion

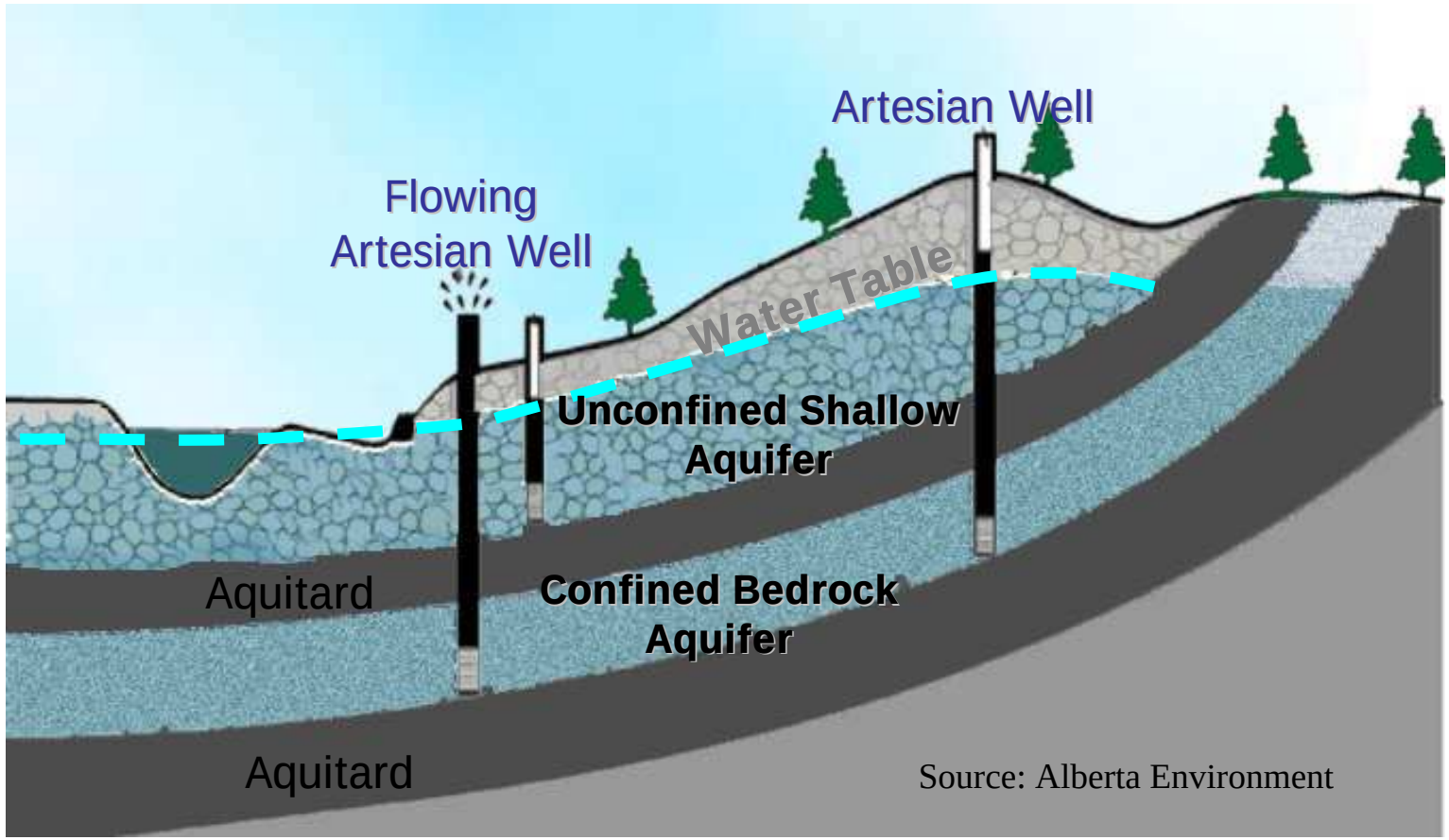
Date Started(yyyy/mm/dd): 2001/12/27	Date Completed (yyyy/mm/dd): 2002/01/02
Well Depth: 156 FT	Borehole Diameter: 0 Inches
Casing Type: Plastic	Liner Type:
Size OD: 5 Inches	Size OD: 0 Inches
Wall Thickness: 0.375 Inches	Wall Thickness: 0 Inches
Bottom at: 140 FT	Top: 0 FT Bottom: 0 FT

Perforations / Perforations Size:
from: 0 FT to: 0 FT — 0 Inches x 0 Inches
from: 0 FT to: 0 FT — 0 Inches x 0 Inches
from: 0 FT to: 0 FT — 0 Inches x 0 Inches
Perforated by:
Seal: Bentonite Chips/Tablets from: 0 FT to: 140 FT
Seal: from: 0 FT to: 0 FT
Seal: from: 0 FT to: 0 FT
Screen Type: Stainless Steel — Screen ID: 4 Inches
from: 140 FT to: 150 FT — Slot Size: 0.015 Inches

Diagram for drilling report on previous slide:

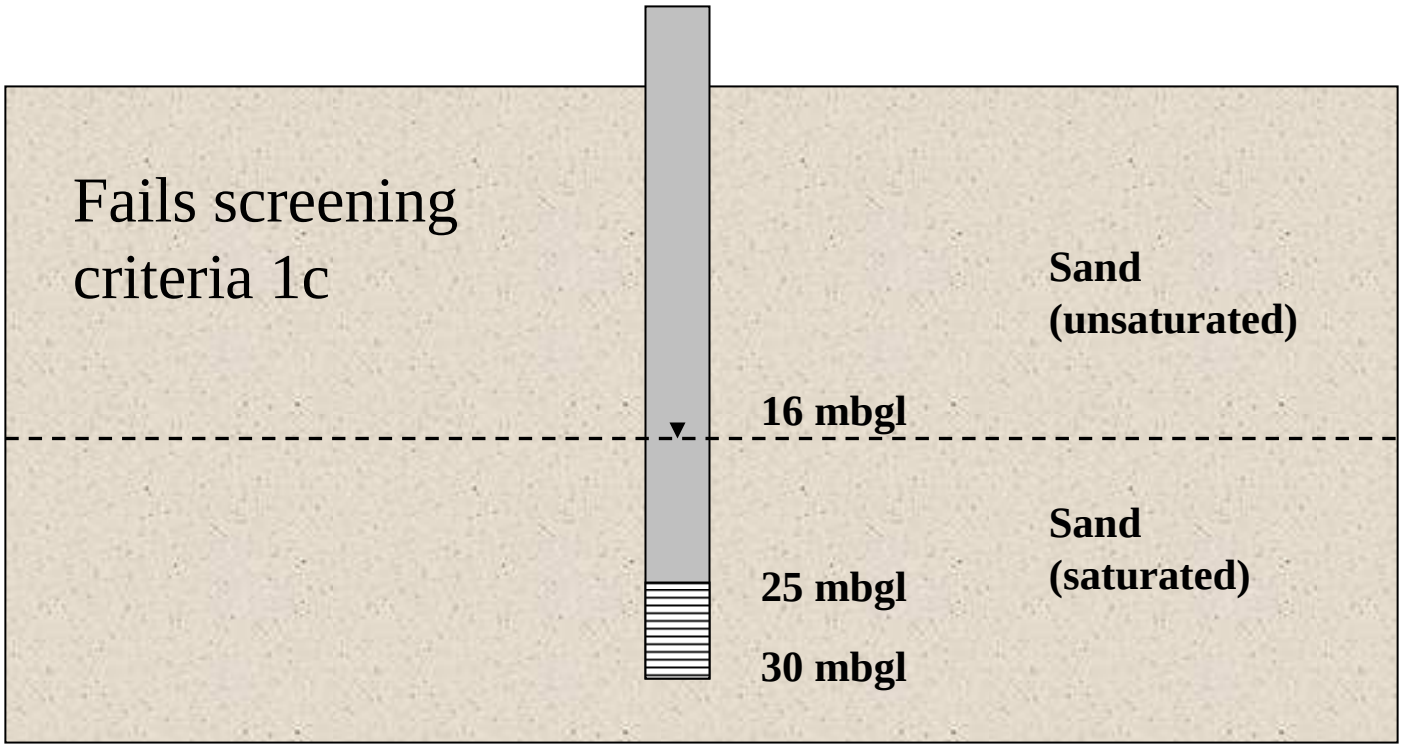


Unconfined Aquifer



Unconfined aquifers tend to be sand and/or gravel deposits, often in valleys (floodplain) but not always (glacial deposits like moraines and eskers). Bedrock can be unconfined where exposed near or at surface.

Unconfined Aquifer



Water Well Drilling Report

Alberta Environment

The data contained in this report is supplied by the Driller. The province disclaims responsibility for its accuracy.

Well I.D.:	0404404
Map Verified:	Map
Date Report Received:	1981/05/13
Measurements:	Imperial

1. Contractor & Well Owner Information

Company Name: GOODISON WATER WELL DRILLING		Drilling Company Approval No.:
Mailing Address:	City or Town:	Postal Code:
WellOwner's Name: KANANASKIS GOLF COURSE #2	Well Location Identifier:	
P.O. Box Number:	Mailing Address: KANANASKIS PARK	Postal Code:
City:	Province:	Country:

2. Well Location

1/4 or LSD	Sec	Twp	Rge	Westof M
02	35	022	09	5

Location in Quarter
0 FT from Boundary
0 FT from Boundary

Lot Block Plan

Well Elev: 4825 FT
How Obtain: Survey-Tra

3. Drilling Information

Type of Work: New Well
Reclaimed Well
Date Reclaimed: Materials Used:
Method of Drilling: Cable Tool
Flowing Well: No Rate: Gallons
Gas Present: No Oil Present: No

Proposed well use: Municipal
Anticipated Water Requirements/day 0 Gallons

4. Formation Log

Depth from ground level (feet)	Lithology Description
66	Sand & Gravel

Unconfined aquifer

5. Well Completion

Date Started(yyyy/mm/dd): 1981/03/01	Date Completed(yyyy/mm/dd): 1981/03/01
Well Depth: 66 FT	Borehole Diameter: 0 Inches
Casing Type: Steel	Liner Type:
Size OD: 10.75 Inches	Size OD: 0 Inches
Wall Thickness: 0 Inches	Wall Thickness: 0 Inches
Bottom at: 54 FT	Top: 0 FT Bottom: 0 FT
Perforations from: 0 FT to: 0 FT from: 0 FT to: 0 FT from: 0 FT to: 0 FT	Perforations Size: 0 Inches x 0 Inches 0 Inches x 0 Inches 0 Inches x 0 Inches
Perforated by:	
Seal: Driven from: 0 FT Seal: from: 0 FT Seal: from: 0 FT	 to: 0 FT to: 0 FT to: 0 FT
Screen Type: Stainless Steel from: 54 FT to: 64 FT	Screen ID: 0 Inches Slot Size: 0.01 Inches
Screen Type: from: 0 FT to: 0 FT	Screen ID: 0 Inches Slot Size: 0 Inches
Screen Installation Method:	
Fittings Top: Packer	 Bottom: Bail
Pack: Grain Size:	 Amount: 0

6. Well Yield

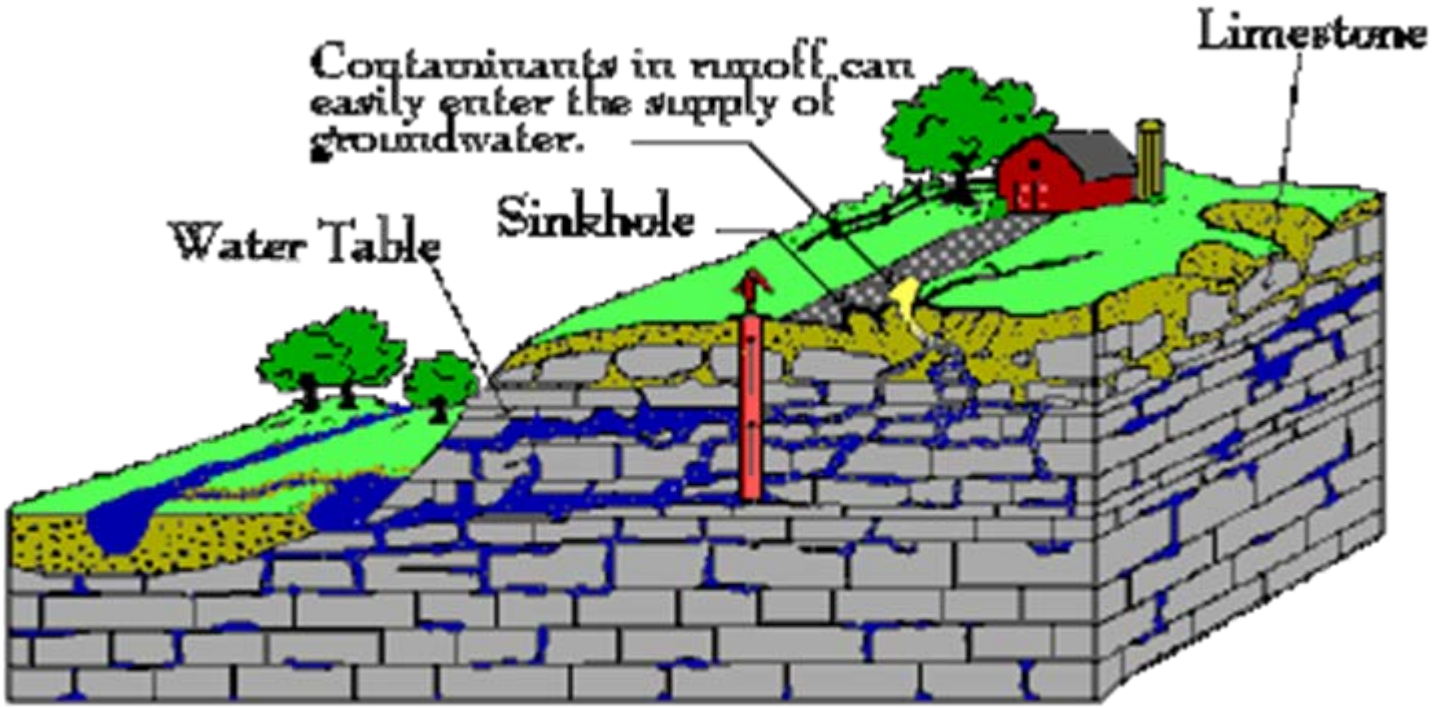
Test Date(yyyy/mm/dd): 1981/03/01
Start Time: 11:00 AM
Test Method: Pump
Non pumping static level: 24.9 FT
Rate of water removal: 400 Gallons/Min
Depth of pump intake: 0 FT
Water level at end of pumping: 33 FT
Distance from top of casing to ground level: Inches

Depth To water level (feet)
Elapsed Time
Drawdown Minutes:Sec Recovery
Total Drawdown: 8 FT

If water removal was less than 2 hr duration, reason why:

Recommended pumping rate: 0 Gallons/Min
Recommended pump intake: 0 FT
Type Pump Installed
Pump Type:
Pump Model:
H.P.:
Any further pumptest information?

Karst Bedrock

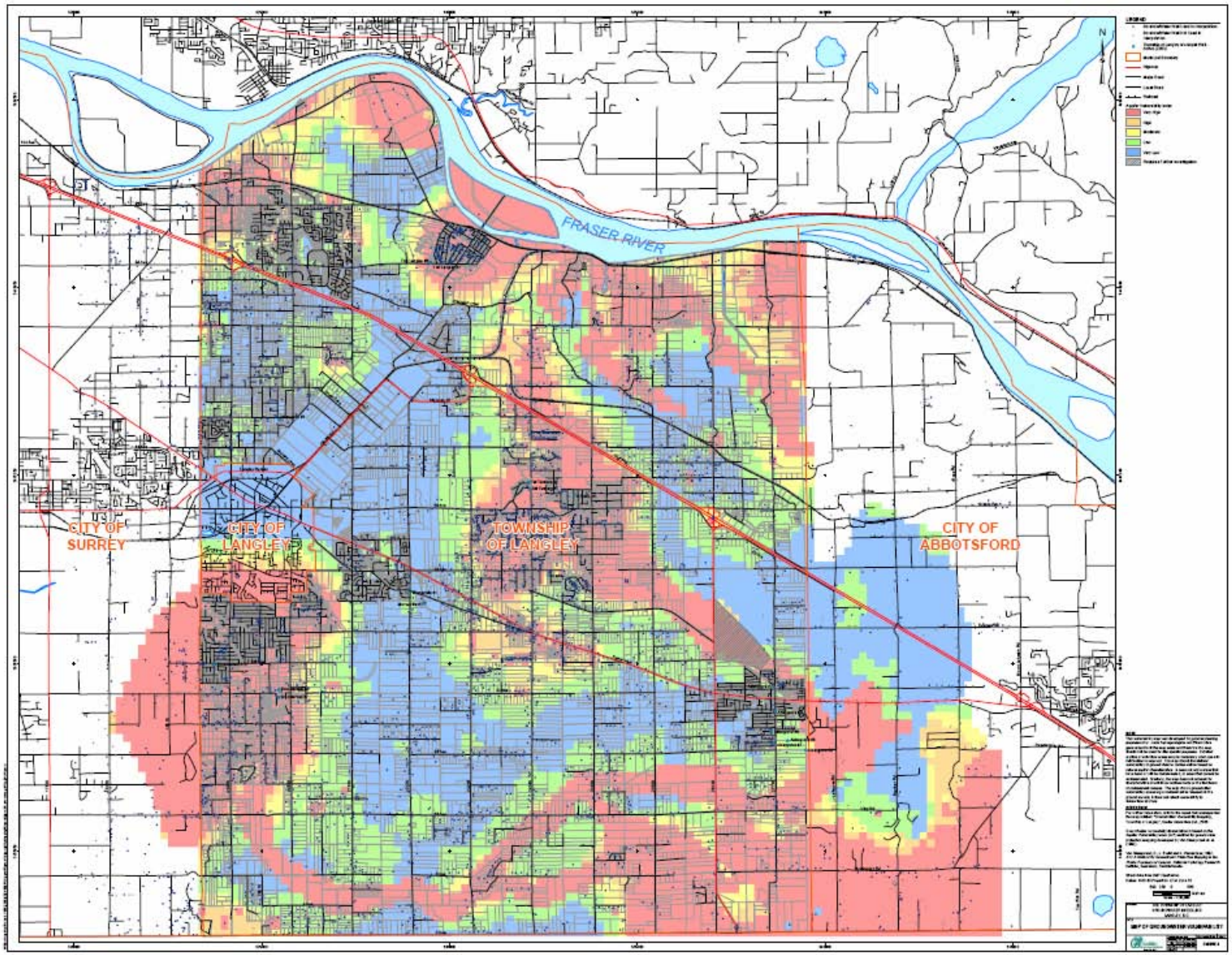


Source: Hallberg et al, 1984

Groundwater Vulnerability Mapping

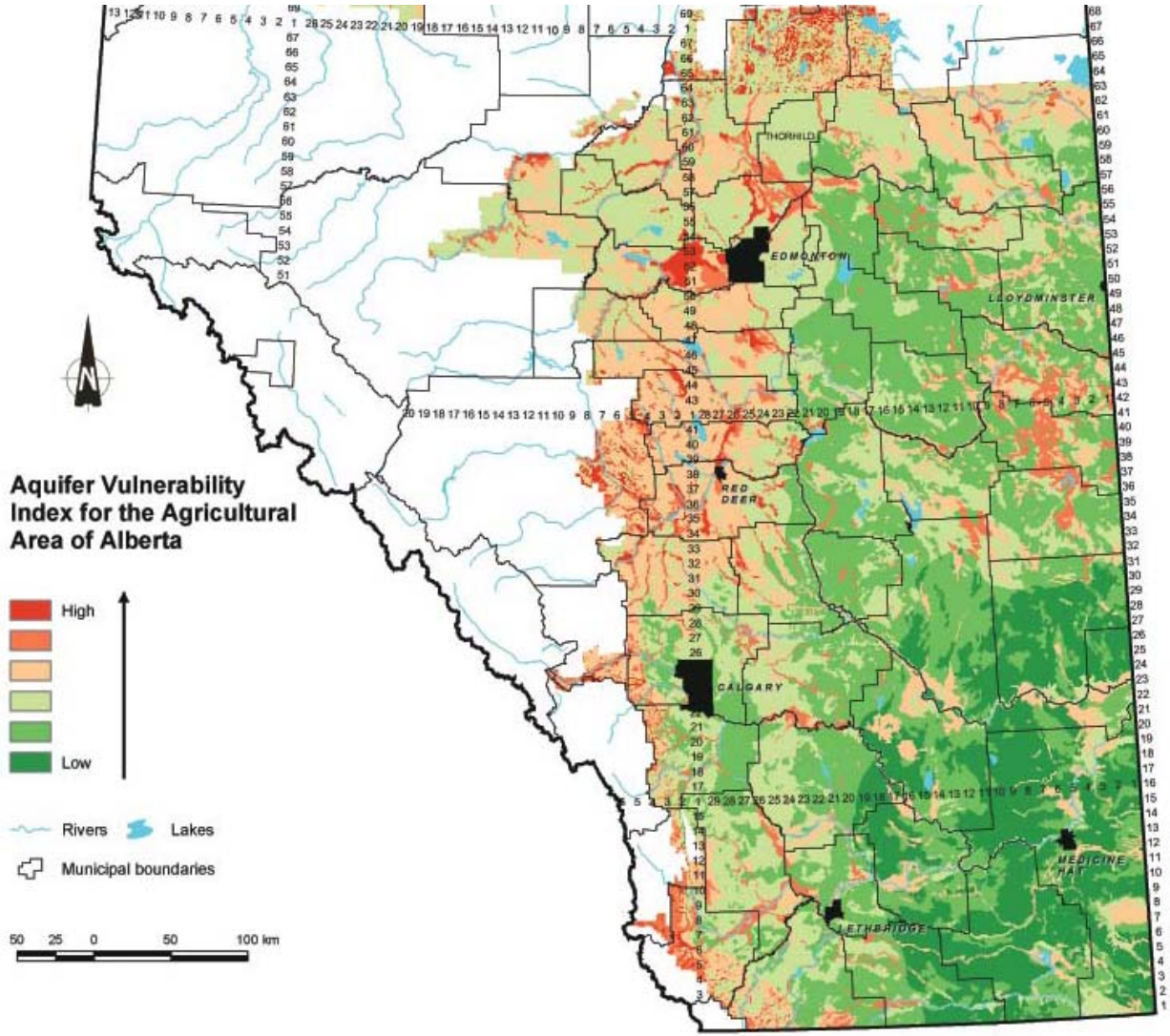
- Can be used to help identify sensitive hydrogeological settings where GWUDI may exist
- Usually based on topography, soil and hydrogeological properties
- High vulnerability areas may not necessarily indicate GWUDI
- Must consider scale of mapping, local well logs may provide better information

Groundwater Vulnerability Mapping – Township of Langley, B.C.



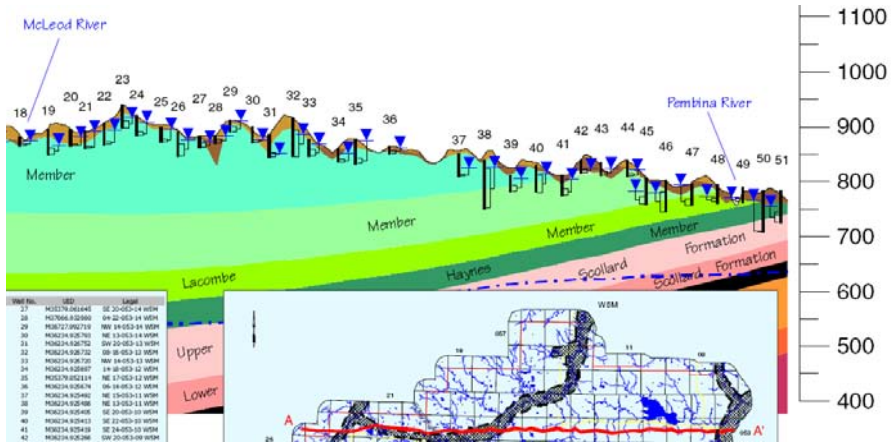
Source: Township of Langley http://www.tol.bc.ca/files/web_files/engineering/environment/key_topics/groundwater/vulnerability.pdf

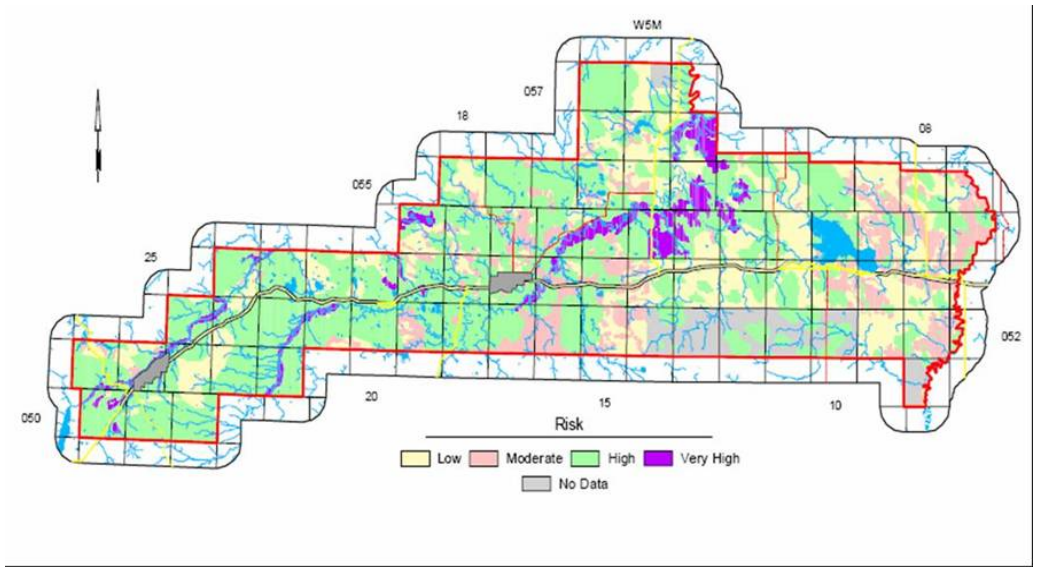
Groundwater Vulnerability Mapping – Alberta



Source: Alberta Agriculture and Rural Development http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex10331

PRFA Regional Groundwater Assessment Reports (Alberta)





Location: Alberta Geological Survey http://www.ags.gov.ab.ca/publications/pubs.aspx?series=spe

Phase 1 GWUDI Screen

2. Proximity to Surface Water

- source shall not be located within 100m of any permanent, intermittent or seasonal water body including:

  ponds, sloughs, lakes, rivers, streams, dugouts, lagoons, reservoirs, irrigation canals or ditches, gravel pits, mining pits or any other open water features

- Consider wetlands and low lying areas, depressions
- Watch campsites !

Photos courtesy of Working Well program

http://environment.alberta.ca/3081.html

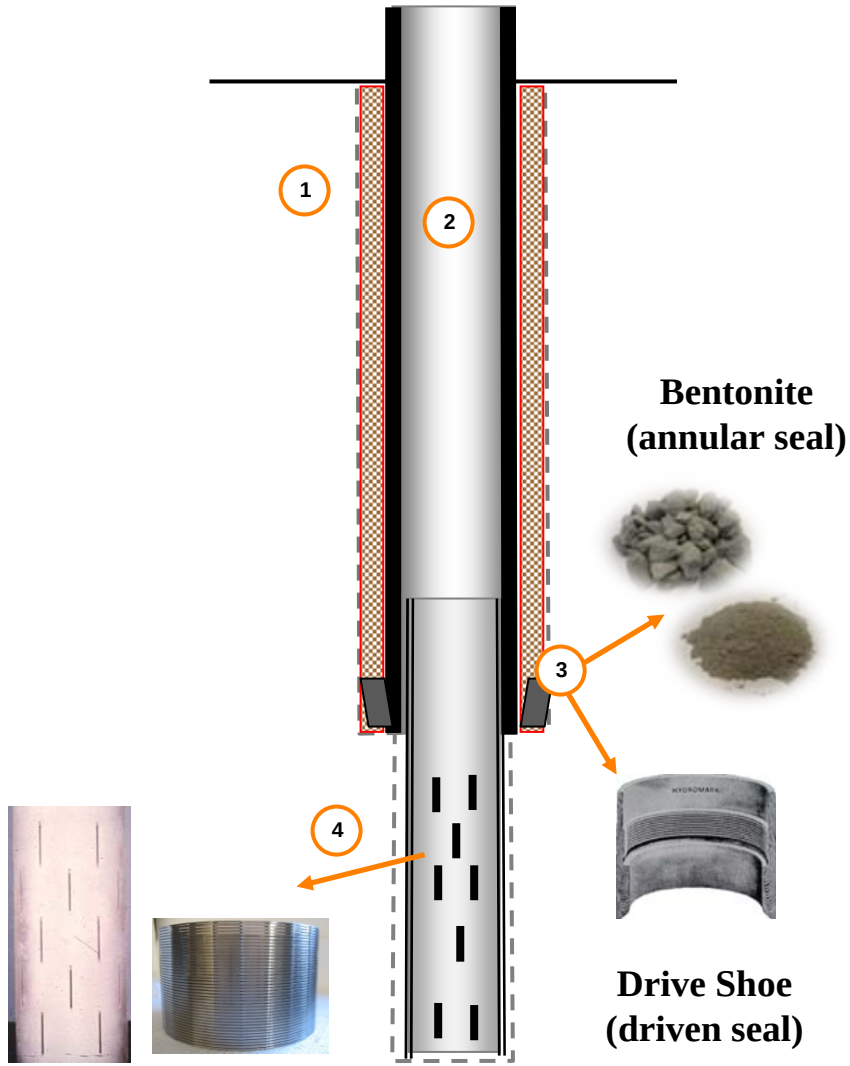
Phase 1 GWUDI Screen

3. Well Construction

- shall meet Alberta Water (Ministerial) Regulation (205/98)
- surface seal that prevents surface water from migrating down annulus (eg. bentonite, cement)
- only water from producing interval enters well
- well head shall be well-graded and drained
- no signs of poor construction or deterioration

Key Components of a Water Well

1. Borehole
   - Conduit to aquifer
2. Casing/Cribbing
   - Keeps borehole open
   - Houses pumping equipment
3. Annular Seal
   - Prevents contamination from surface
   - Prevents mixing of aquifers
   - Sealing method is dependent on type of well construction (bentonite, drive shoe)
4. Well Intake
   - Allows groundwater into the well
   - Slotted liner/casing or screen



Source: Working Well program

http://environment.alberta.ca/3081.html

Water Well Drilling Report

Alberta Environment

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Well I.D.:	0040055
Map Verified:	Map
Date Report Received:	2002/01/29
Measurements:	Imperial

1. Contractor & Well Owner Information

Company Name: LOSNESS DRILLING (1975) LTD.		Drilling Company Approval No.: 38405
Mailing Address: BOX 145	City or Town: LOUGHEED AB CA	Postal Code: T0B 2V0
WellOwner's Name: B.L.W. STOCK FARMS LTD	Well Location Identifier:	
P.O. Box Number:	Mailing Address: RR1, HARDISTY	Postal Code: T0B 1B0
City:	Province:	Country:

2. Well Location

1/4 or LSD	Sec	Twp	Rge	Westof M
15	20	040	10	4

Location in Quarter
400 FT from N Boundary
700 FT from W Boundary
Lot Block Plan

Well Elev: FT
How Obtain: Not Obtain

3. Drilling Information

Type of Work: New Well
Reclaimed Well
Date Reclaimed(yyyy/mm/dd):
Materials Used:
Method of Drilling: Rotary
Flowing Well: No
Gas Present: No
Rate: Gallons
Oil Present: No

Proposed well use: Domestic & Stock
Anticipated Water Requirements/day 1000 Gallons

4. Formation Log

Depth from ground level (feet)	Lithology Description
12	Brown Clay
16	Gray Clay
107	Brown Sand
108	Hard Rocks
117	Brown Clay & Sand
150	Gray Sand
156	Blue Shale

5. Well Completion

Date Started(yyyy/mm/dd):	Date Completed (yyyy/mm/dd):
2001/12/27	2002/01/02
Well Depth: 156 FT	Borehole Diameter: 0 Inches
Casing Type: Plastic	Liner Type:
Size OD: 5 Inches	Size OD: 0 Inches
Wall Thickness: 0.375 Inches	Wall Thickness: 0 Inches
Bottom at: 140 FT	Top: 0 FT Bottom: 0 FT

Perforations: Perforations Size:
from: 0 FT to: 0 FT — 0 Inches x 0 Inches
from: 0 FT to: 0 FT — 0 Inches x 0 Inches
from: 0 FT to: 0 FT — 0 Inches x 0 Inches
Perforated by:
Seal: Bentonite Chips/Tablets
from: 0 FT to: 140 FT
Seal:
from: 0 FT to: 0 FT
Seal:
from: 0 FT to: 0 FT
Screen Type: Stainless Steel — Screen ID: 4 Inches
from: 140 FT to: 150 FT — Slot Size: 0.015 Inches
Screen Type: — Screen ID: 0 Inches
from: 0 FT to: 0 FT — Slot Size: 0 Inches
Screen Installation Method: Attached To Casing
Fittings
Top: Coupler — Bottom: Plug
Pack: Artificial
Grain Size: 10-20 — Amount: 22 Bags
Geophysical Log Taken:
Retained on Files:
Additional Test and/or Pump Data
Chemistries taken By Driller: No
Held: 0 — Documents Held: 1
Pitless Adapter Type:
Drop Pipe Type:
Length: FT — Diameter: Inches

Comments:
DRILLER REPORTS DISTANCE FROM TOP OF CASING TO GROUND LEVEL: 1.5'. WELL CHLORINATED. WATER HAULED FORM LOSNESS SHOP 2500 GALS.

6. Well Yield

Test Date (yyyy/mm/dd):	Start Time:
2002/01/02	11:00 AM

Test Method: Pump
Non pumping static level: 10 FT
Rate of water removal: 9 Gallons/Min
Depth of pump intake: 100 FT
Water level at end of pumping: 27 FT
Distance from top of casing to ground level: Inches

Depth To water level (feet)	Elapsed Time Drawdown Minutes:	Sec Recovery
10	0:00	27.86
19.14	1:00	18.87
21.29	2:00	16.18
22.7	3:00	14.75
23.52	4:00	13.9
24.03	5:00	13.34
24.4	6:00	12.97
24.69	7:00	12.64
24.9	8:00	12.4
25.08	9:00	12.12
25.19	10:00	11.82
25.38	12:00	11.57
25.6	14:00	11.28
25.73	16:00	11.05
25.97	20:00	10.58
26.15	25:00	10.24
26.4	30:00	10.07
26.52	35:00	10
26.68	40:00	11
26.89	50:00	10
27.12	60:00	10
27.3	75:00	10
27.53	90:00	10
27.71	105:0010	
27.86	120:0010	

Total Drawdown: 17 FT
If water removal was less than 2 hr duration, reason why:

Recommended pumping rate: 9 Gallons/Min
Recommended pump intake: 100 FT

Type Pump Installed
Pump Type:
Pump Model:
H.P.:
Any further pumptest information?

7. Contractor Certification

Driller's Name: UNKNOWN DRILLER
Certification No.: 3449AD
This well was constructed in accordance with the Water Well regulation of the Alberta Environmental Protection & Enhancement Act. All information in this report is true.
Signature Yr Mo Day

5. Well Completion

Date Started(yyyy/mm/dd):	Date Completed (yyyy/mm/dd):
2001/12/27	2002/01/02
Well Depth: 156 FT	Borehole Diameter: 0 Inches
Casing Type: Plastic	Liner Type:
Size OD: 5 Inches	Size OD: 0 Inches
Wall Thickness: 0.375 Inches	Wall Thickness: 0 Inches
Bottom at: 140 FT	Top: 0 FT Bottom: 0 FT

Perforations: Perforations Size:
from: 0 FT to: 0 FT — 0 Inches x 0 Inches
from: 0 FT to: 0 FT — 0 Inches x 0 Inches
from: 0 FT to: 0 FT — 0 Inches x 0 Inches
Perforated by:
Seal: Bentonite Chips/Tablets
from: 0 FT to: 140 FT
Seal:
from: 0 FT to: 0 FT
Seal:
from: 0 FT to: 0 FT
Screen Type: Stainless Steel — Screen ID: 4 Inches
from: 140 FT to: 150 FT — Slot Size: 0.015 Inches

Photos courtesy of Working Well program

http://environment.alberta.ca/3081.html

Photos courtesy of Working Well program

http://environment.alberta.ca/3081.html

Phase 1 GWUDI Screen

4. Water Quality

- raw or treated water shall not exhibit evidence of contamination of surface water
- no significant occurrence of insects, insect parts, total coliforms (on a regular basis), E.Coli, algae, Giardia, Cryptosporidium or viruses
- no significant and relative rapid shifts in turbidity, temperature, conductivity or pH closely correlating to climatological or surface water conditions

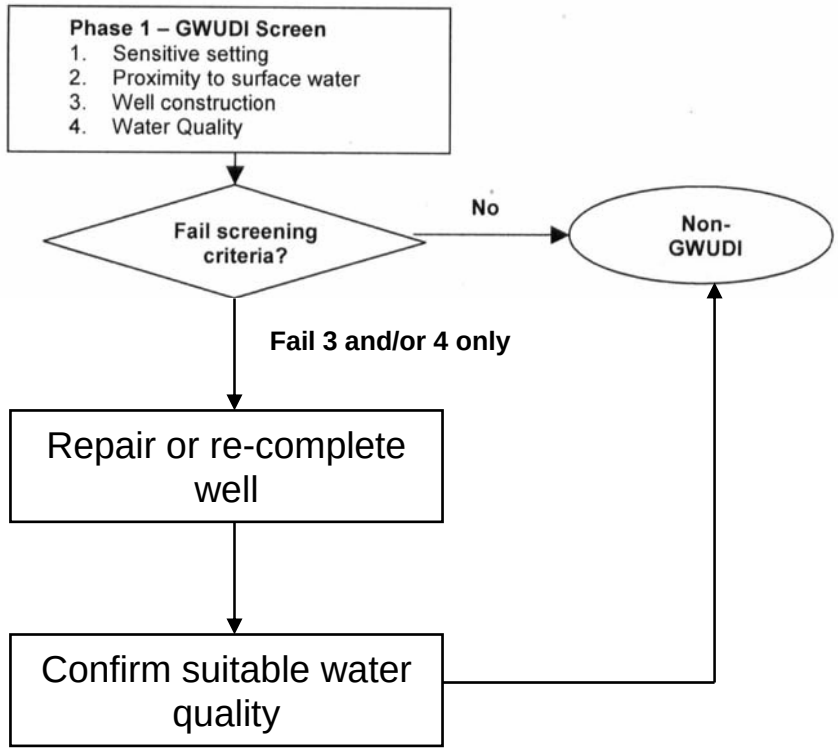
Water Quality

- A source well with no historical water quality problems does not mean a well is not potentially GWUDI
- Well may not be sampled frequently
- Treated water may be sampled instead of raw water
- Basing a GWUDI assessment on water quality alone is not in line with the multi-barrier approach used in most jurisdictions

Phase 1 GWUDI Screen

1. Sensitive Setting
2. Proximity to surface water
3. Well construction
4. Water Quality

If 1 and 2 are met but not 3 and 4, systems owners may modify well construction to ensure 3 and 4 are met instead of proceeding to Phase 2



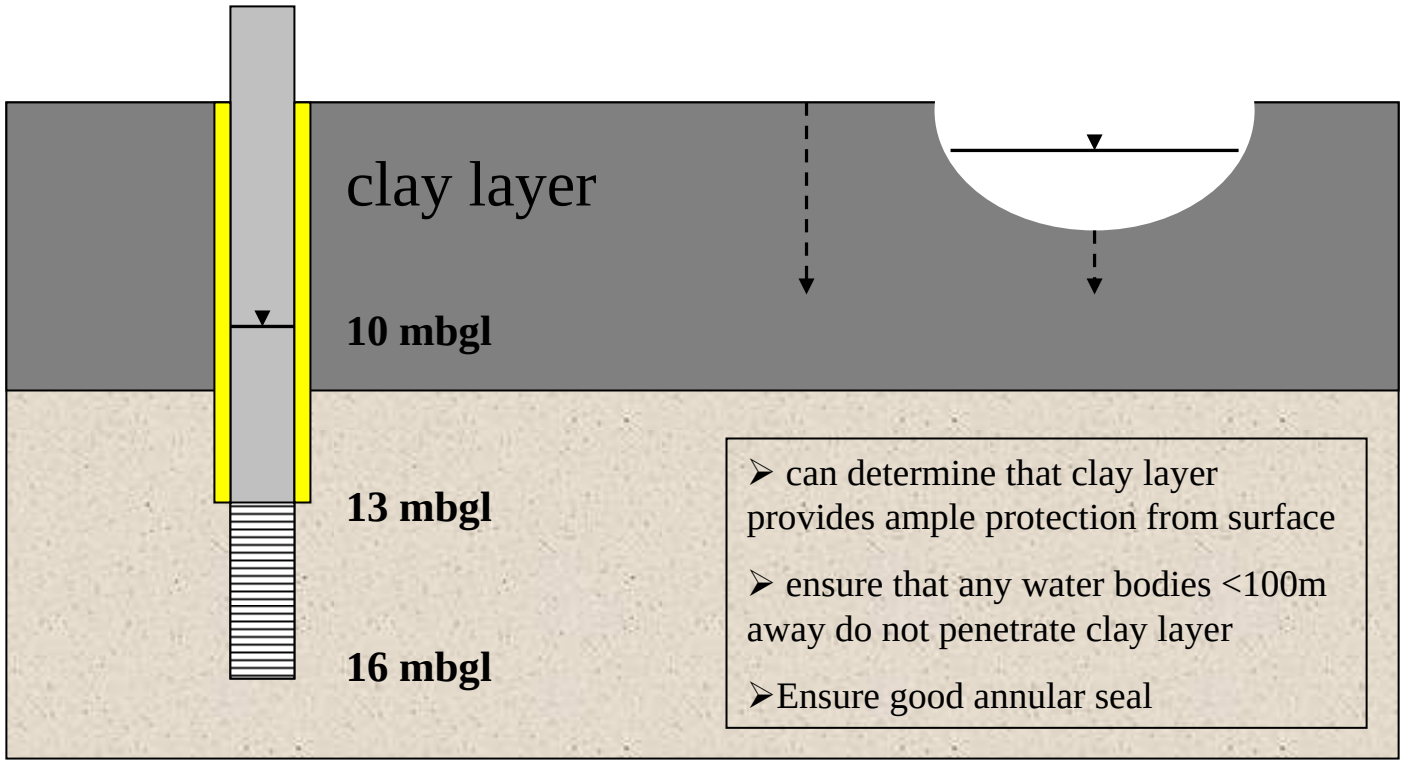
Note: May be easier or not much more expensive to drill a new well

Phase 2a Hydrogeological Review

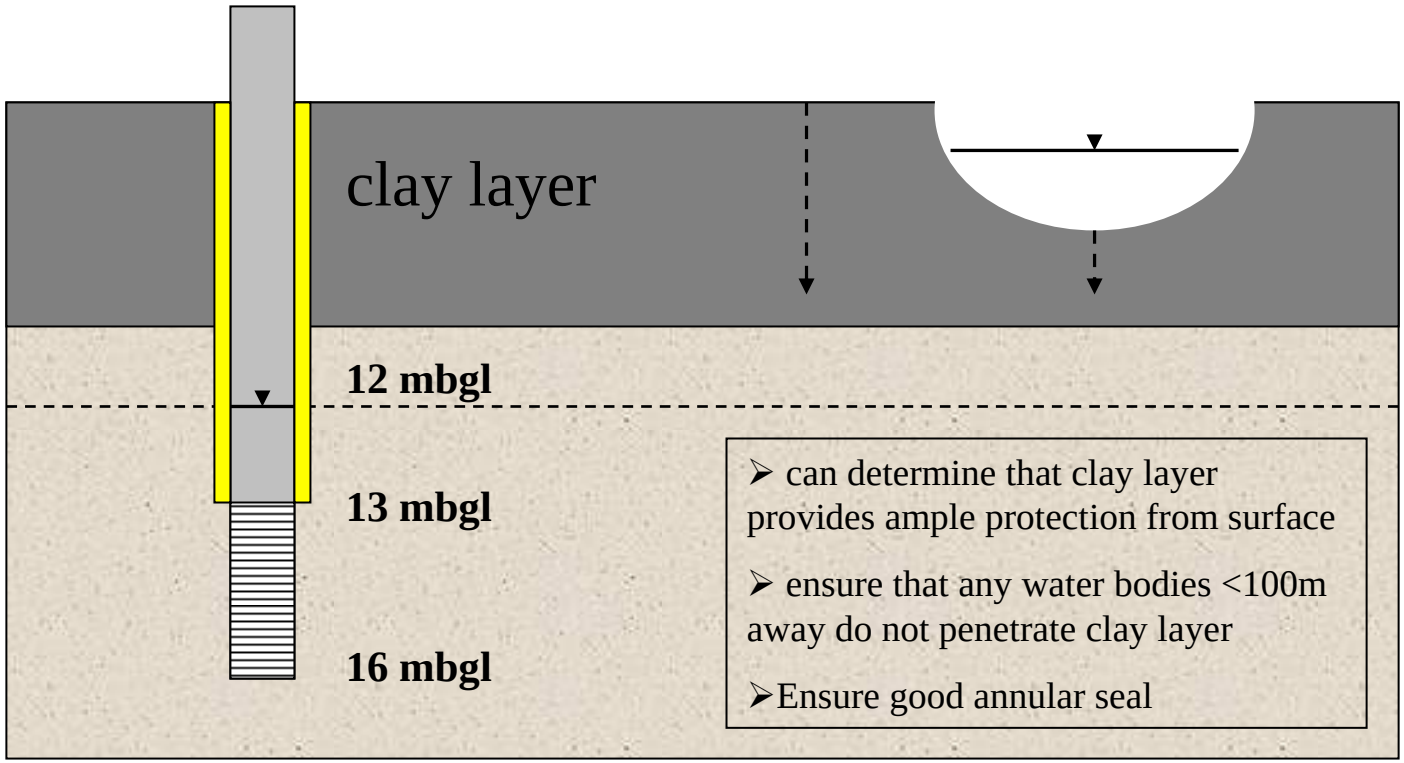
- Desk top evaluation using existing information
- Incorporates other factors that may discount a source as GWUDI that failed the screening criteria
- Best left to a professional hydrogeologist to undertake
- Information to consider/gather includes presence of impermeable layers, depth of surface water bodies, cross-sections, pumping test results, permeability testing of confining units, historical flooding data, historical groundwater quality and level data

Alberta

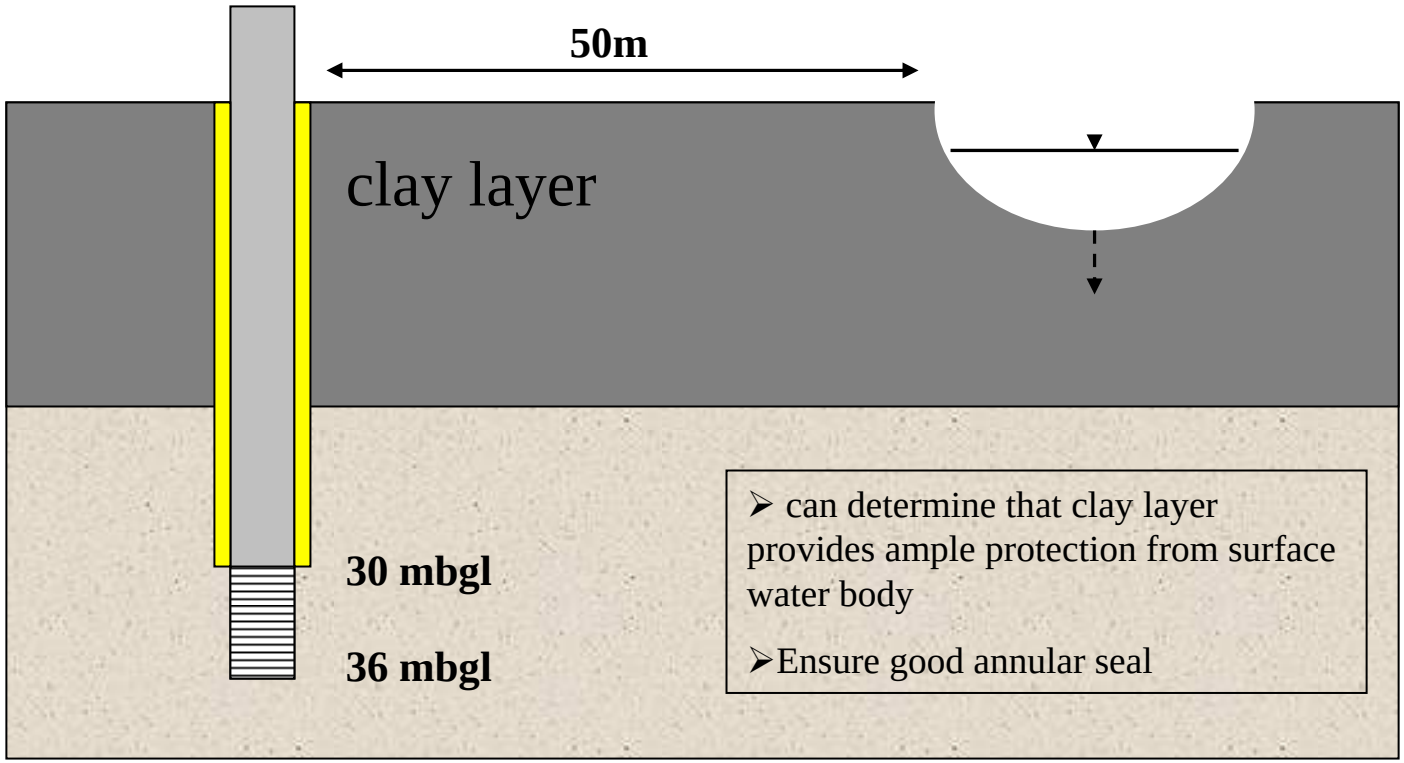
Example 1. Production zone < 15m



Example 2. Unconfined aquifer

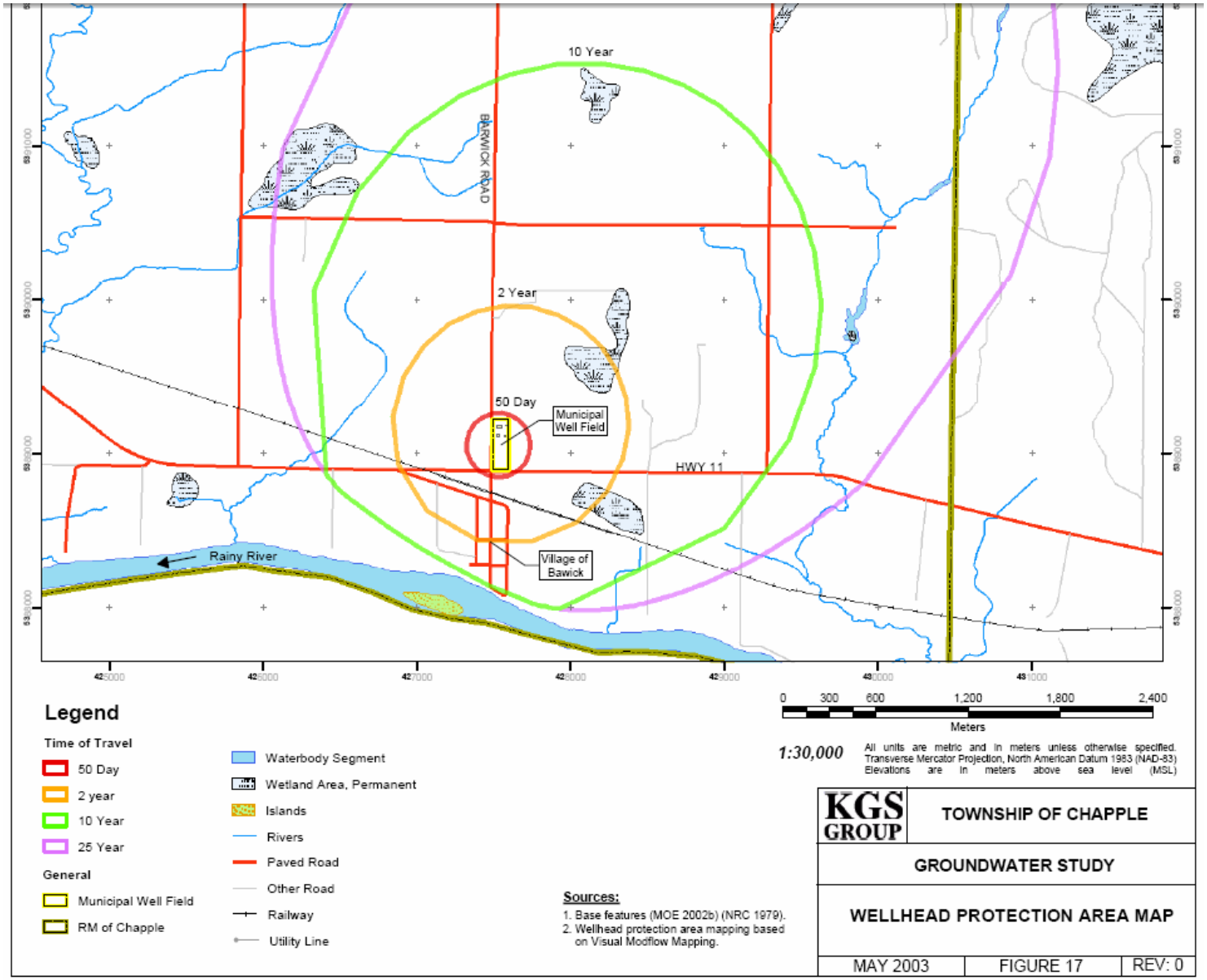


Example 3. <100 from surface water body



Phase 2b Hydrogeological Investigation

- Key is to determine whether time-of-travel (TOT) between surface water body and production zone < 90 days
- Most microbial pathogens do not survive in subsurface > 90 days
- Can use water quality hydrograph analysis, computer modelling (eg. MODFLOW), tracer tests (eg. isotopes)
- Computer modeling may involve determining well head protection areas (WHPAs)
  - Used for land management, not just GWUDI assessment
  - No WHPAs in Alberta



Source: Ontario MOE http://www.ene.gov.on.ca/envision/water/groundwater/chapple/figure17.pdf

Phase 3 Microscopic Particulate Analysis

- Used to determine if there are significant surface water particulates reaching a well source
- Samples must be collected during periods when greatest possibility for surface water to impact a source well (eg. spring melt)
- Sampling time can only be determined after the TOT has been determined under Phase 2 (ie. can't skip phase 2 !)
- Scoring based on USEPA methodology (1992). Medium and high scores are declared GWUDI

Take Home Messages

- Use screening criteria to help identify potential GWUDI situations (note: criteria may vary province to province)
- Contact AENV (or appropriate jurisdiction) when a GWUDI source is suspected
- Have an operator obtain a professional assessment, especially when uncertainty exists
- Don’t rely on historical water quality results alone to discount a well source as potential GWUDI