



GUDI-GARP Assessment

Groundwater Under Direct Influence of surface water

Gw @ Risk of containing Pathogens

1. Concepts
2. Guidelines
3. Examples

Presentation to BCGWA, 14 Oct 2017

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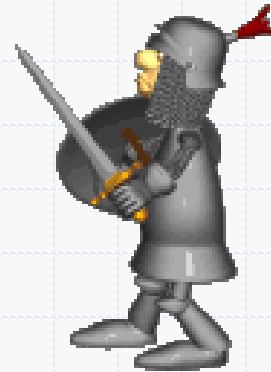
What's the big idea ?

- groundwater needs to be protected from surface contaminants, including surface water

surface
contaminants



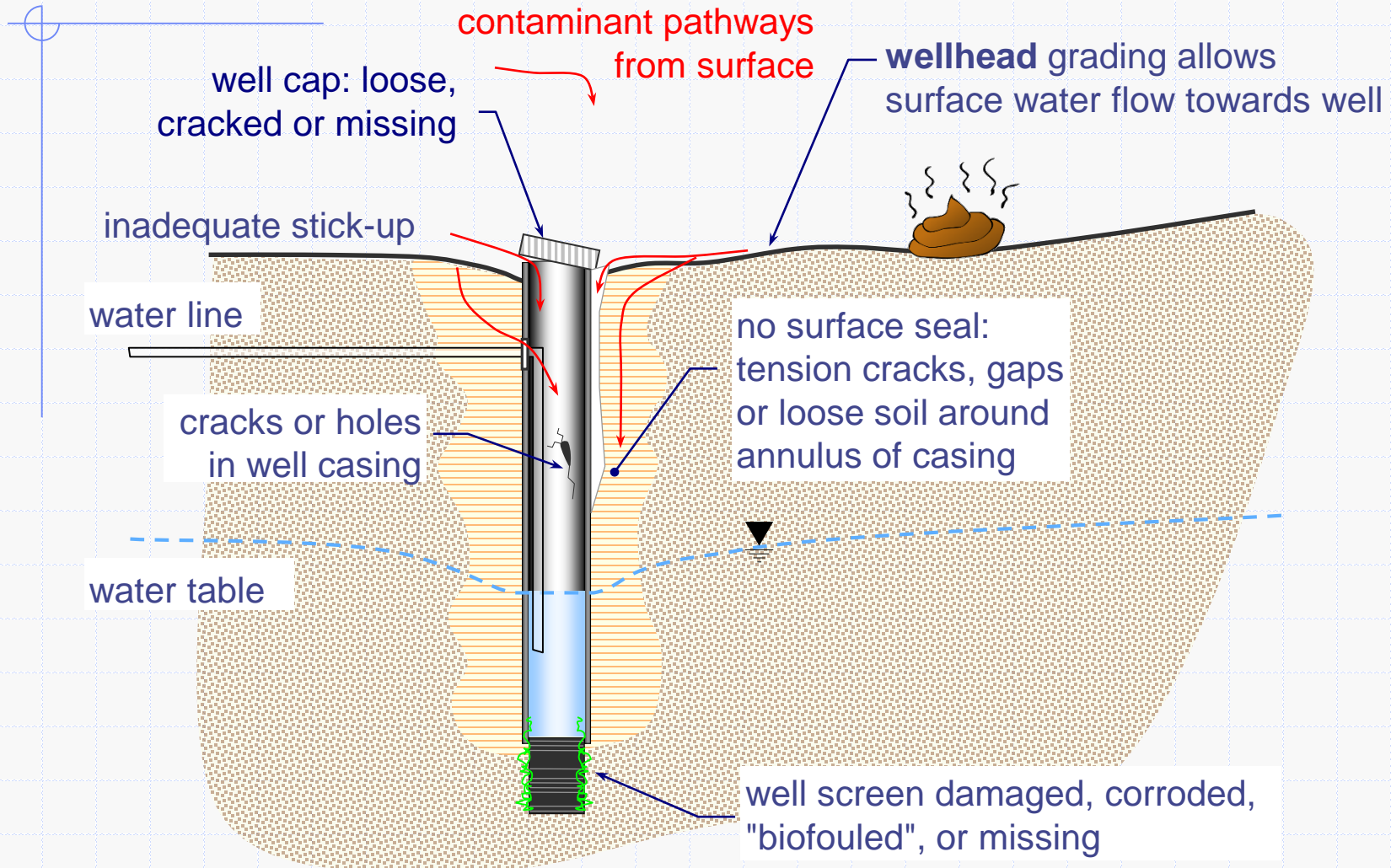
aquitards
land use planning
construction standards
qualified drillers



ground
water
aquifer



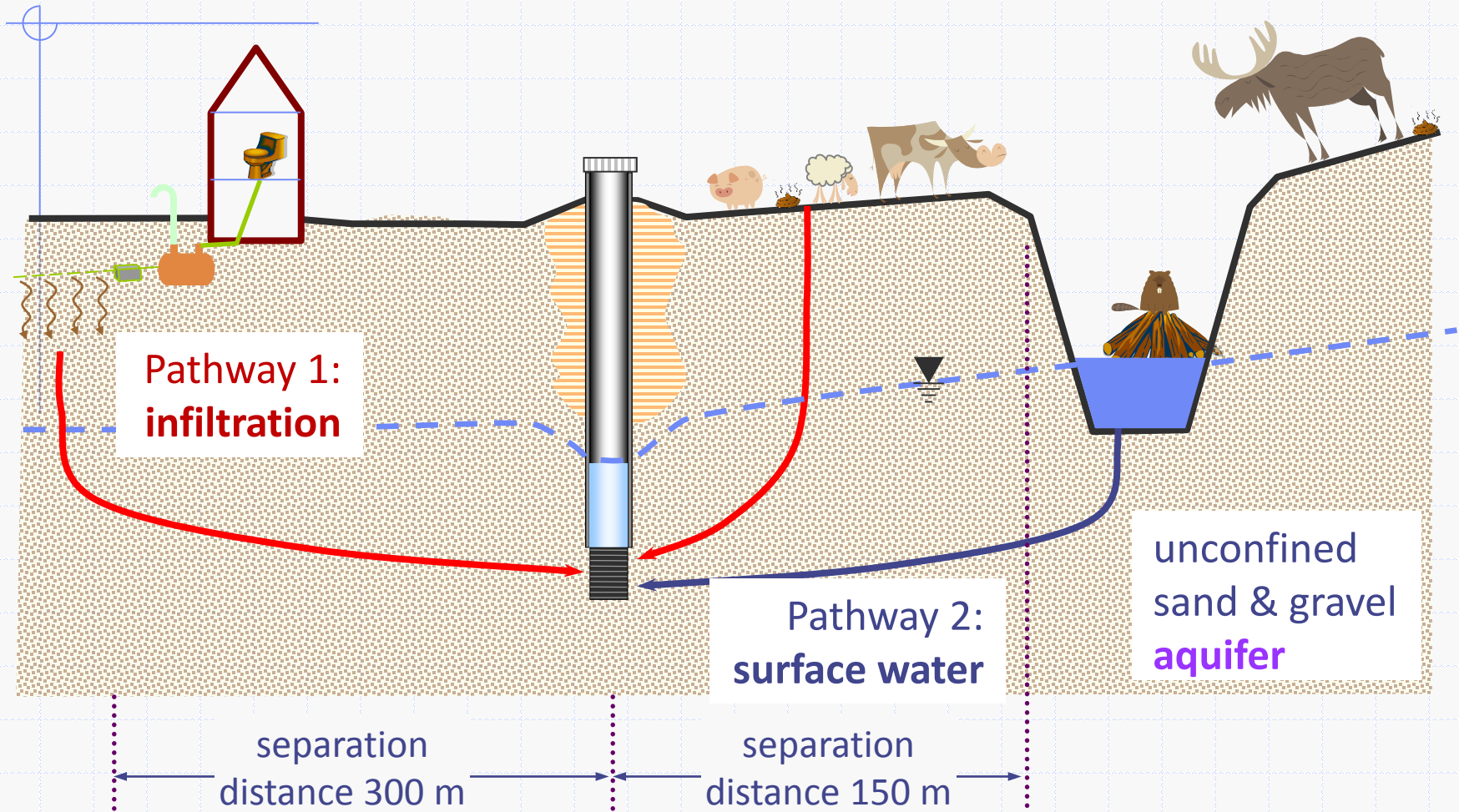
Pathogen Pathways – Well Construction



adapted from: http://pa.water.usgs.gov/reports/wrir_96-4212/report.html



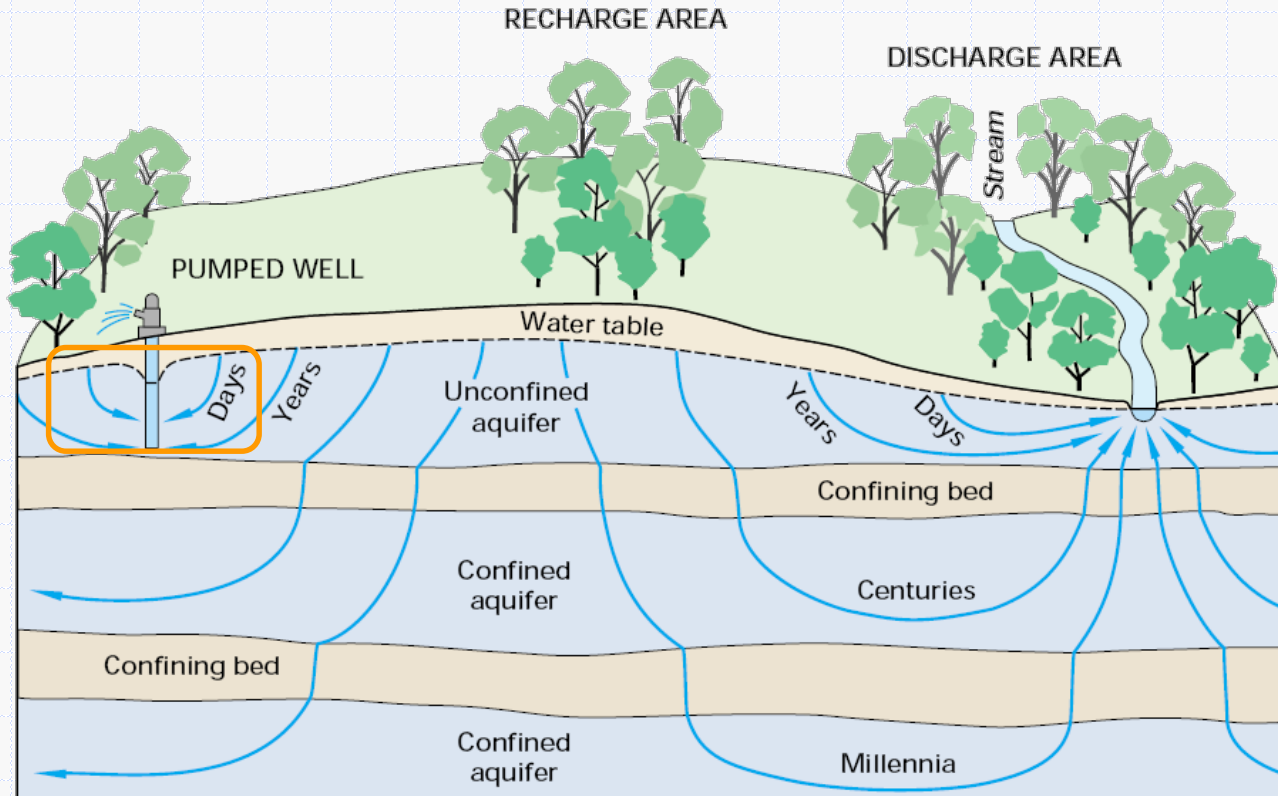
Pathogen Pathways – Location & Aquifer



adapted from: http://pa.water.usgs.gov/reports/wrir_96-4212/report.html



Groundwater age

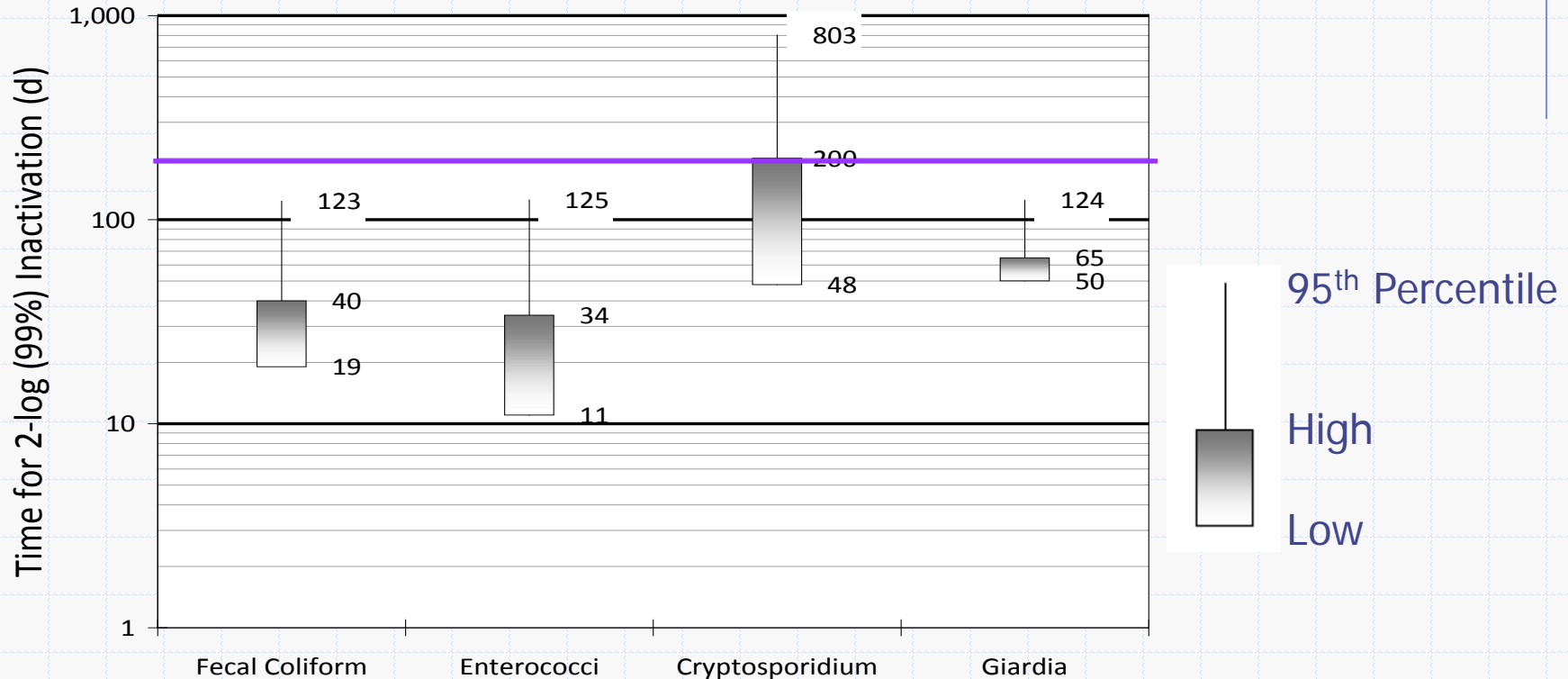


Winter, et al. (1998)



Pathogen Persistence

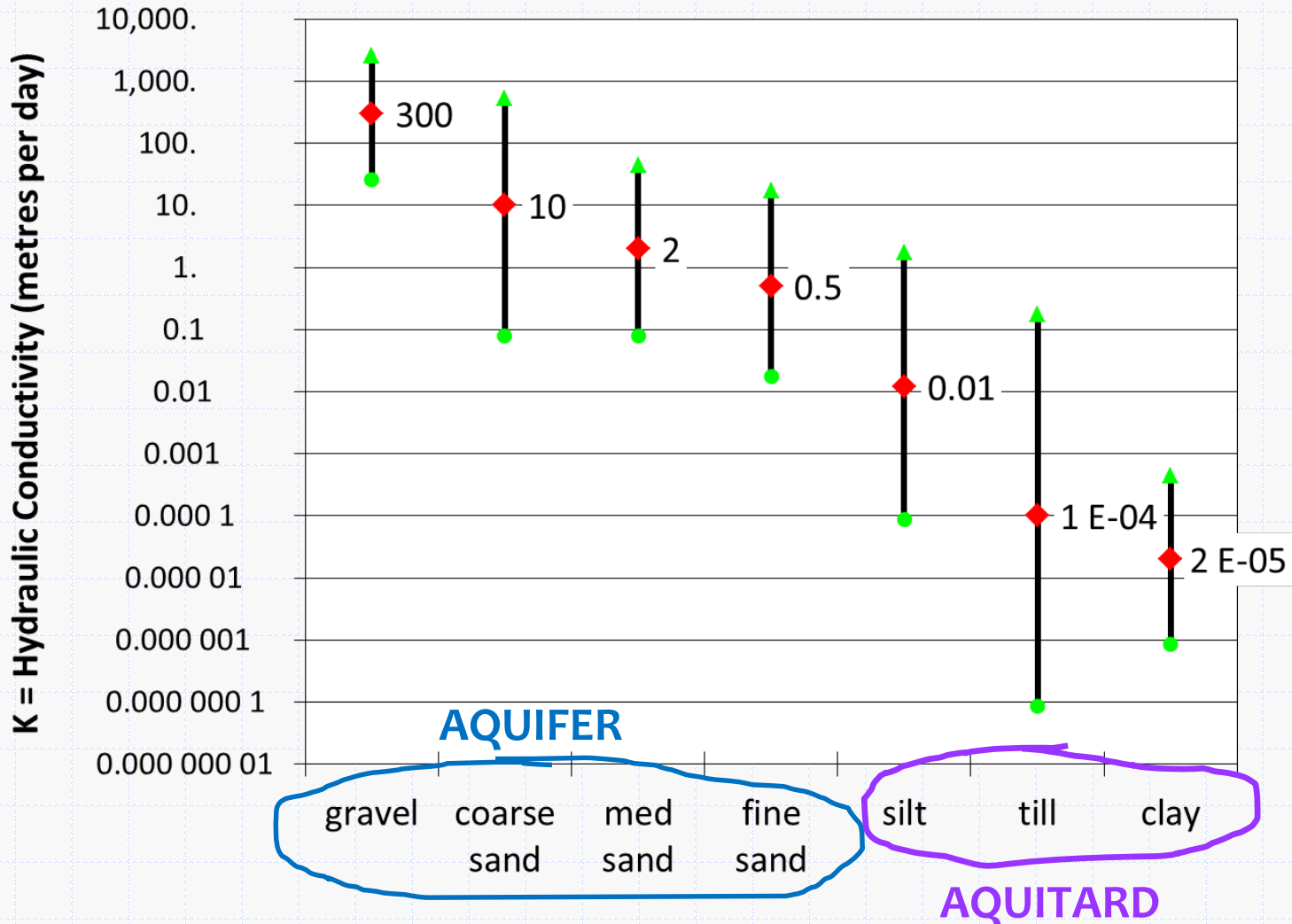
Survival of Contaminant
Microorganisms in Model ASR
Conditions for Florida
David E. John - USF College of
Marine Science



current practice is to use Time of Travel (TOT) from surface as an indicator of susceptibility – values below a threshold trigger additional scrutiny ... BC guidelines use **200 days**



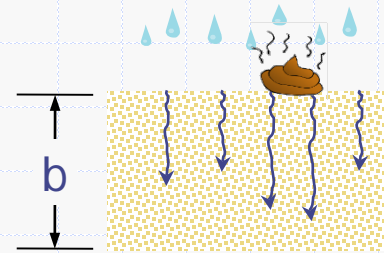
Hydraulic Conductivity (K) – range





Infiltration Time

- Darcy's Law vertical infiltration
 - $v \approx K$
- time of travel (t)
 - $t = b / v$
 - b from lithology in well log
 - K (v) from well log and previous chart
 - $t = b / K$



- consider a 15 m thick surficial layer of...
- fine sand: $K \approx 0.5$ m/d
 - $t = 15 / 0.5 = 30$ d
- silt: $K \approx 0.01$ m/d
 - $t = 15 / 0.01 = 1500$ d

RISK
LOW RISK

∴ any **sand or gravel** is at risk of transporting pathogens via the infiltration pathway

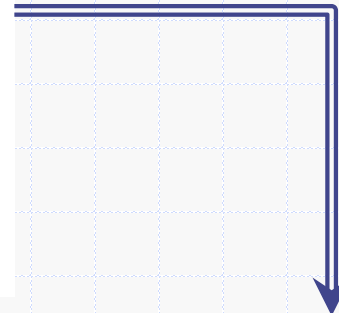


BC GARP guideline ⇒ GW TOs

GUIDANCE DOCUMENT FOR DETERMINING GROUND WATER
AT RISK OF CONTAINING PATHOGENS (GARP)
INCLUDING GROUND WATER UNDER DIRECT INFLUENCE
OF SURFACE WATER (GWUDI)

Version 2
April 2013

Health Protection Branch
Population and Public Health Division
Ministry of Health



*Drinking Water Treatment Objectives (Microbiological)
for Ground Water Supplies in British Columbia*

Draft Version 9

March 2013



GUDI / GARP v2

- Similar to previous 2006-2013 version 1
- Screening completed by well owner (or consultant, driller) if possible, or by Northern Health if not
- Setback from surface water is now **150 m**
- Avoid conflict between *High* and *Low* water levels
- Septic within **300 m** is now a risk factor
 - *unless:*
 - ◆ well is *properly sealed* in a *confined aquifer*
 - extend casing and seal down to confining unit
 - locate wells *upgradient* from contaminant sources



Groundwater Treatment Objectives

- All new wells regulated by Health under the DWPA (see classification flowchart) are screened for *groundwater at risk of containing pathogens*
- If *LOW RISK*, disinfection is *optional*.
- If *AT RISK*, disinfection is *mandatory*.
 - general GARP: 4-3-2-1-0 (like surface water)
 - virus-only GARP: when only risk factor is a human sewage source, 4-1-0
 - no treatment for Crypto, Giardia
 - no requirement for two forms of treatment

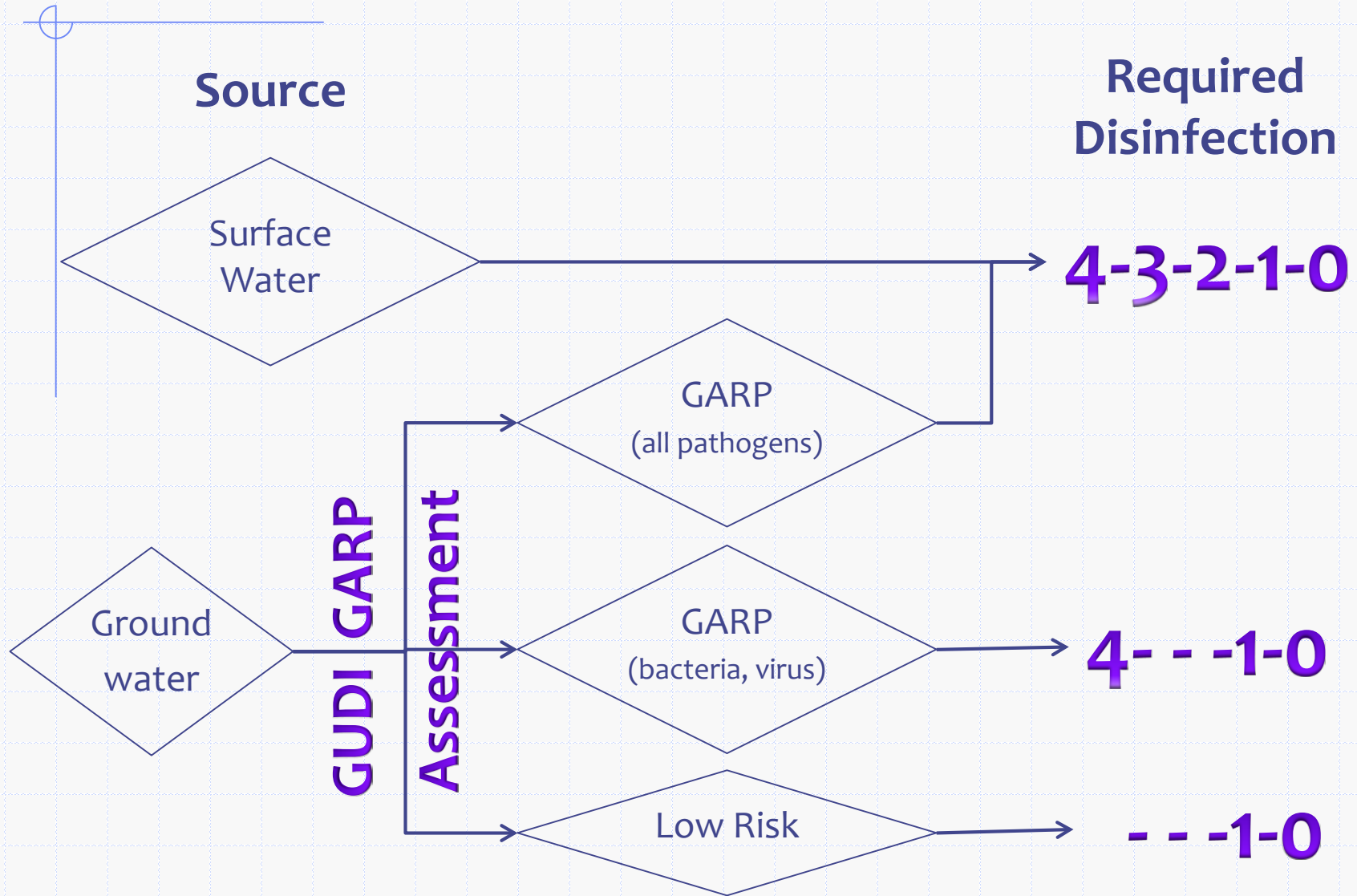


Detailed well construction log is critical

- Well ID plate
- Identify first saturated soil (water table)
- Identify fractures in rock, even if not making water
- Static water level
- GPS coordinates in decimals using WGS84 datum
 - great: 54.83971°N, 127.64272°W 😊
 - good: UTM zone 9U 587,166 m E 6,077,799 m N
 - worse: 54°43'27.3" N, 127°35'49.8"W 😞
 - useless: 54'43 27 172"35.498

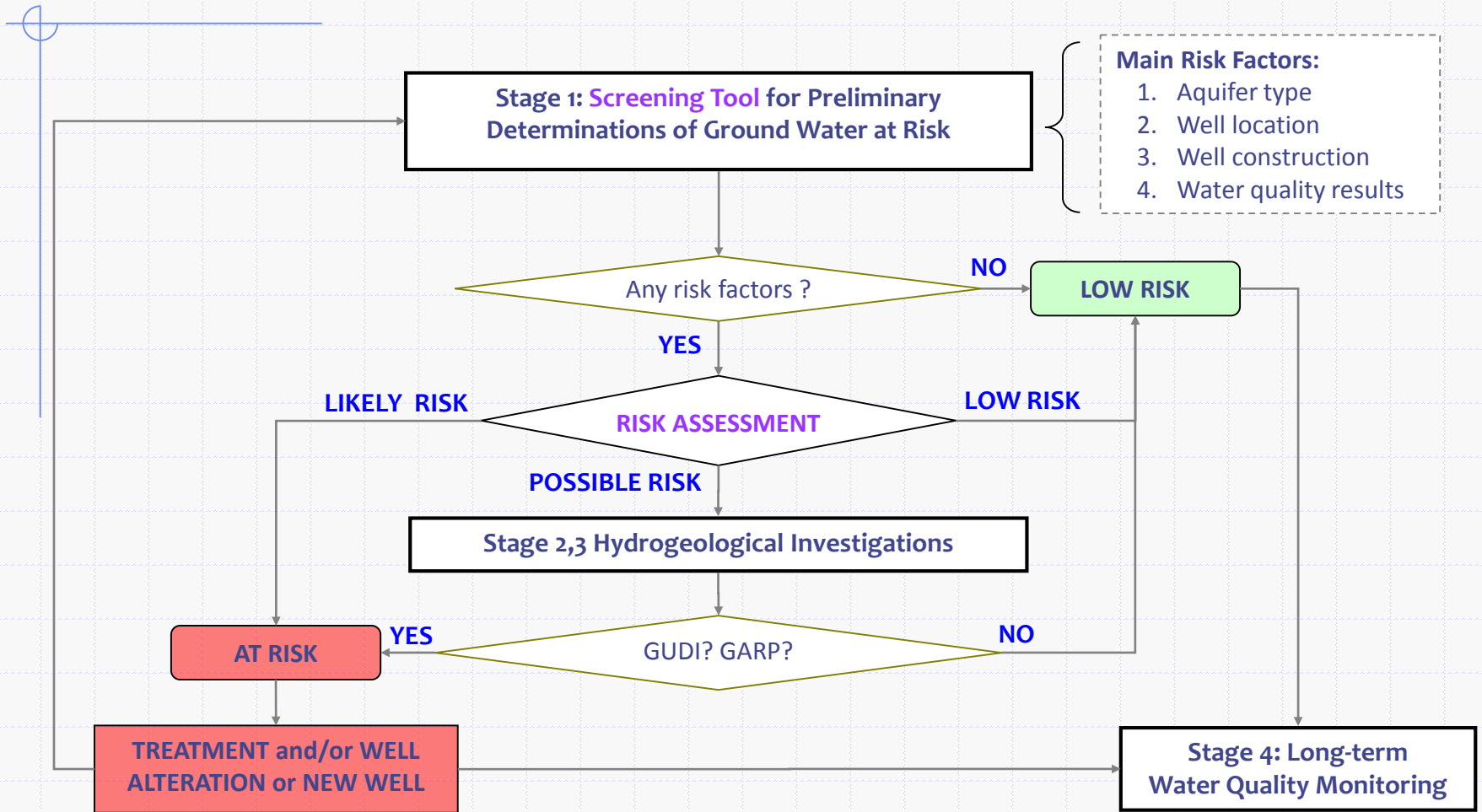


Disinfection Requirements





GUDI/GARP Assessment Flowchart





GUIDELINES



4 categories of risk factors

- AQUIFER TYPE and SETTING
 - Provincial aquifer mapping (iMapBC)
- WELL LOCATION
 - Public Health Act, Health Hazards Regulation
- WELL CONSTRUCTION
 - Ground Water Protection Regulation
- WATER QUALITY RESULTS
 - Drinking Water Protection Regulation
 - Guidelines for Canadian Drinking Water Quality



1. Aquifer Type and Setting

RISK FACTORS and CRITERIA	At Risk	Low Risk	Unk	Comments
Shallow well with intake depth < 15m below ground and in an unconfined aquifer, or any karst well [e.g. sand & gravel or bedrock from intake to surface]	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	PHE can review well log / mapped aquifers. <div style="border: 2px solid purple; border-radius: 15px; height: 150px; width: 100%;"></div>

- Intake depth =
 - Top of screen (cased well)
 - Uppermost saturated fracture (uncased, fractures noted)
 - Bottom of casing (uncased, no fractures noted)



2. Well Location (1 of 2)

RISK FACTORS and CRITERIA	At Risk	Low Risk	Unk	Comments
Well situated inside setback distances of the HHR or from a possible source of contamination <i>incl. septic</i> [contam: 30 m ; dwelling: 6 m ; dump: 120 m ; septic system 300 m]	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Separation from known Contaminant Sources

- *Public Health Act: Health Hazards Regulation*
- *Public Health Act: Sanitary Sewerage Regulation:*
 - Standard Practice Manual
- Level 2: consider upgradient versus downgradient

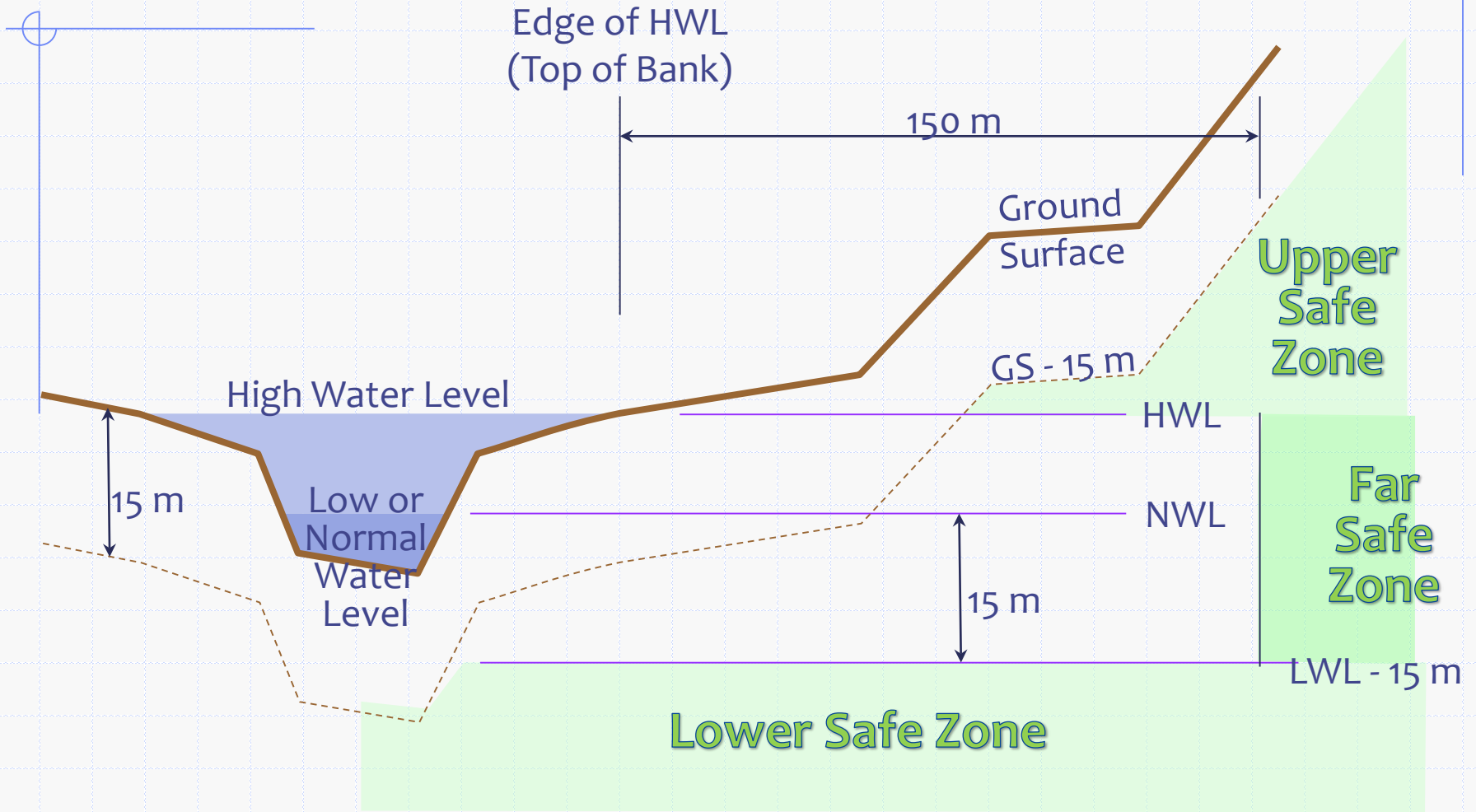


2. Well Location (2 of 2) ... GUDI

RISK FACTORS and CRITERIA	At Risk	Low Risk	Unk	Comments
Well located within 150m of <ul style="list-style-type: none">high water mark ornatural boundary of surface water feature [e.g. top of bank], and with intake < 15m below either: <ul style="list-style-type: none">Ground surface (i.e. "shallow" well) orLow or normal water level (NWL)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Separation from Surface Water Bodies GUDI Refer to next slide . 15m guideline may be <i>increased</i> (sand) or <i>decreased</i> (clay) depending on the surrounding soil type.



GUDI Risk Factors





3. Well Construction (1 to 2 of 4)

RISK FACTORS and CRITERIA	At Risk	Low Risk	Unk	Comments
... does not meet GWPR (s7) re <i>surface sealing</i> . [5 m sealant underground along casing, no visible gaps at surface]	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Disregard if SW cannot reach the wellhead.
... does not meet GWPR (s10) re <i>well cap/cover</i> . [secure cap/cover, prevent entry by people or animals, stop artesian flow]	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	"Secure" → not removable by hand



3. Well Construction (3 to 4 of 4)

RISK FACTORS and CRITERIA	At Risk	Low Risk	Unk	Comments
... does not meet GWPR (s11) re <i>floodproofing</i> . [prevent contam entering, well pit/house must drain or have sump pump, grading to prevent ponding of water at wellhead]	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
... does not meet GWPR (s11) re <i>wellhead protection</i> . [protect from physical damage, stickup 0.3 m above ground/floor, no plastic casing at ground]	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	



4. Water Quality to (1 to 2 of 3)

RISK FACTORS and CRITERIA	At Risk	Low Risk	Unk	Comments
Well shows recurring unsatisfactory bacti results. [any <u>confirmed</u> <i>E.coli</i> or e.g. ≥ 3 total coliforms in last 24 samples]	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	[usually requires >24 samples] <input type="text"/>
Water system has seasonal turbidity problems associated with the well. [e.g. ≥ 5 NTU *]	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="text"/>

- Because new wells never have 24 bacti samples, initial GARP categorisation will be **provisional**
- Aim for 1 NTU ... well development
- Run well to waste until turbidity gone



Risk Assessment

- Risk Assessment:
- Did any risk factor suggest that the system is **At Risk** (as opposed to Low Risk or Unknown)?
 - If Yes then consider disinfection or remediation (see remediation options below), or
 - proceed to Stage 2/3 Hydrogeological Investigation.
- If **Unknown** because information is unavailable for any factor(s) or criteria of the assessment, then **consider** moving to Stage 2/3 Hydrogeological Investigation.
- If **No**, move to Stage 4 Long-term Water Quality Monitoring.



Remediation Options

- Disinfection to meet Health Authority **surface water treatment objectives** requirements (43210)
- Disinfection to meet Health Authority "**virus only**" groundwater treatment objectives
- Well alteration / correct deficiencies in well construction
- Eliminate source(s) of contamination
- Stage 2 Preliminary Hydrogeological Investigation
 - Specific concerns _____
- Stage 4 Long-term Water Quality Monitoring
- Other _____



Comments and DWO Sign-off

- Assessment Comments:

- Completed by:

DATE:

- Health Authority Review Comments:

- Reviewed by (Drinking Water Officer)

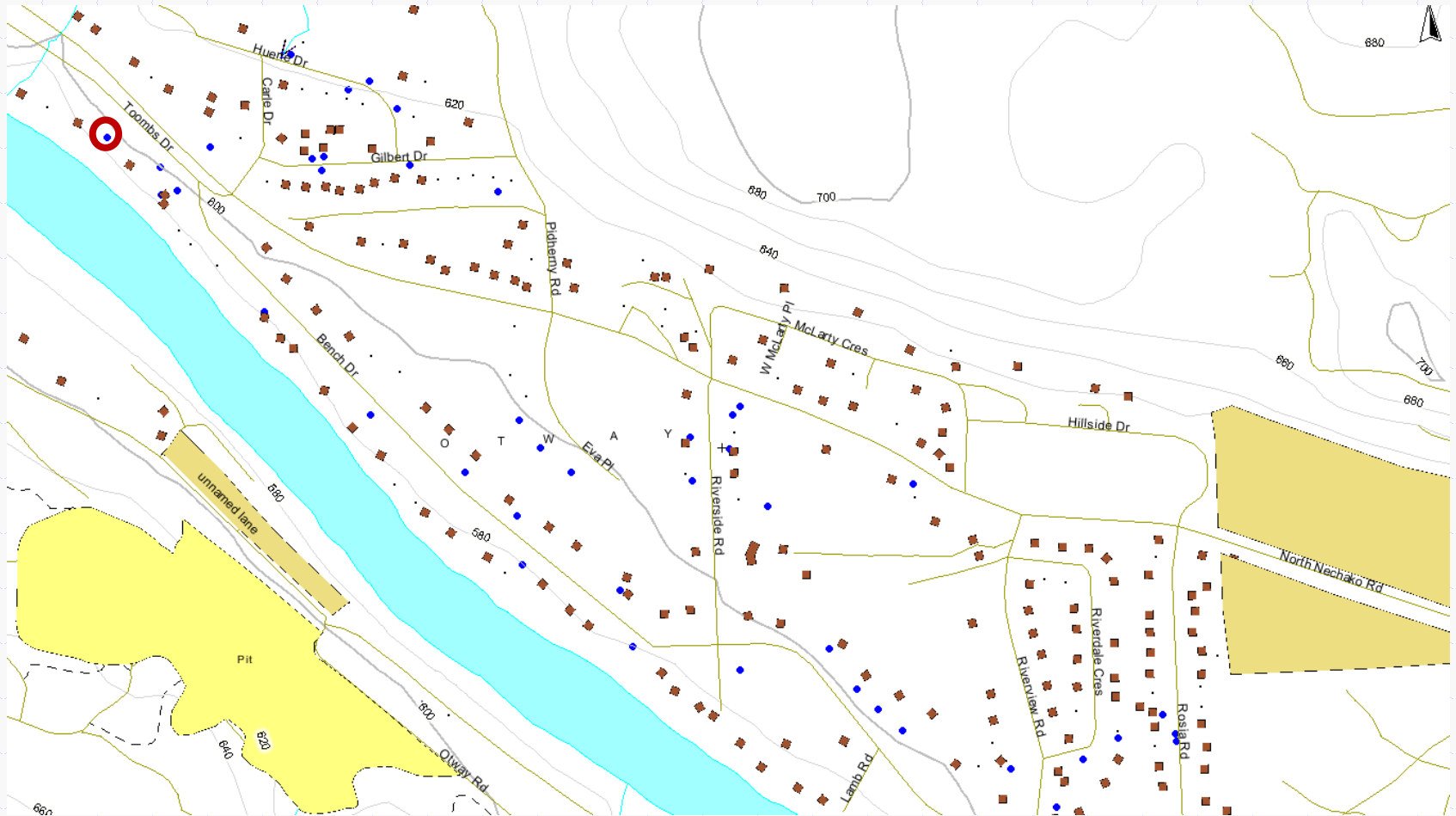
DATE:



EXAMPLES



North Nechako Road, Prince George





Information from Well Log

<https://a100.gov.bc.ca/pub/wells>

- Well Tag Number: **1076**
- Well Diameter: 6 inches
- Well Yield: 15 gallons per minute (gpm)
- Construction Date: 1950
- Static Level: **81** feet
- LITHOLOGY INFORMATION:
 - From 0 to 8 ft GRAVEL
 - From 8 to 11 ft SAND
 - From 11 to 52 ft SAND AND GRAVEL
 - From 52 to 61 ft SAND
 - From 61 to 74 ft **TILL**
 - From 74 to 90 ft GRAVEL AND WATER



Well Lithology

Risk from on-site sewage:

infiltration time (b/K) ↓

S&G: (K=2) → 10 days

Till: (K=0.01) → 400 days

Gravel: (K=300) → 0.2 days

Q: $10d + 400d + 0.2d = ?$

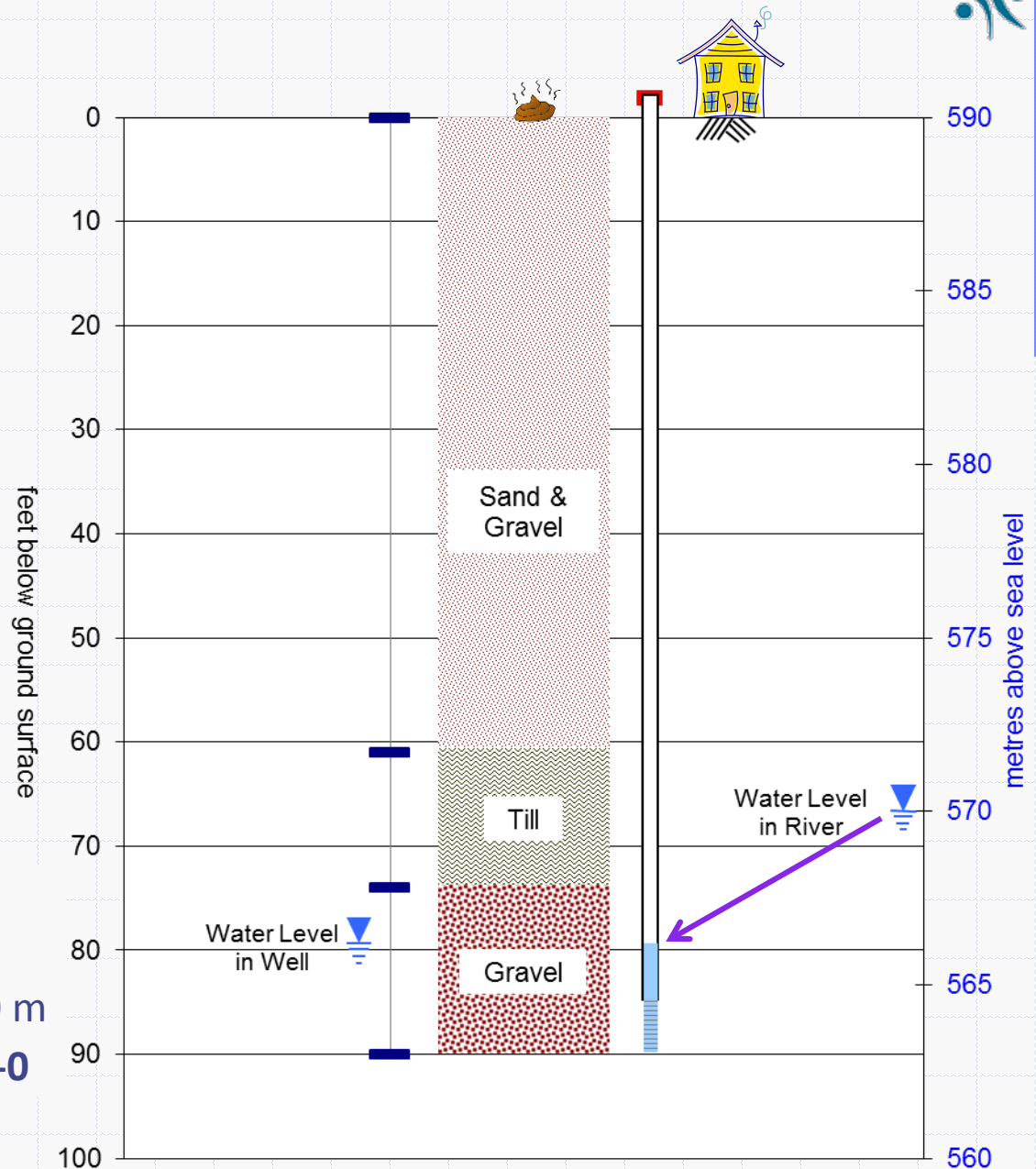
A: 400d !!!

order of magnitude only

ok (400d > 200d)

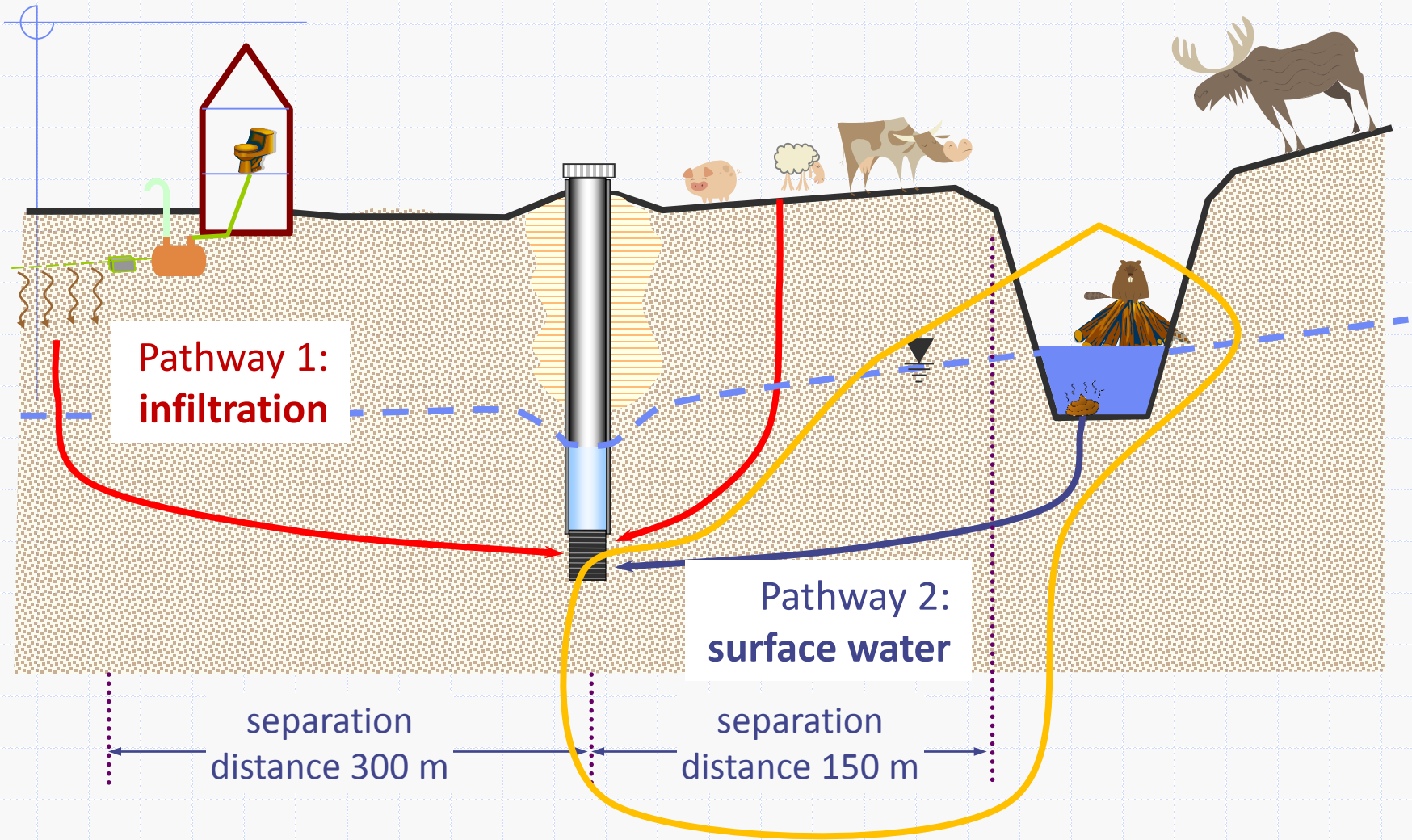
but hydraulic gradient from river to well and within 150 m

→ GUDI → GARP → **4-3-2-1-0**



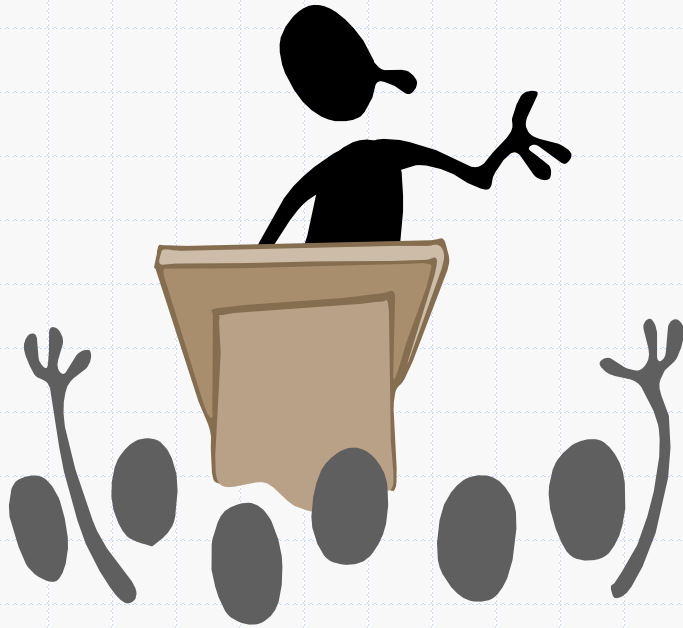


Pathogen Pathways – Location & Aquifer





Questions?



- For any questions or comments please call or email ...
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