



# Hydraulic connection & stream depletion from well pumping: what contractors should know

By: Mike Wei, P. Eng.

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Qualicum Beach, BC

# Take-aways

- In BC, SW & GW are managed together if sources (stream; aquifer) are likely hydraulically connected.
- Hydraulic connection allows *interception* and *induced infiltration* from well pumping to occur to deplete streamflow.
- Hydraulic connection and stream depletion isn't just restricted to unconsolidated, unconfined aquifers near a stream.
- Stream depletion takes time to fully occur (days to years), depending on  $d$ ,  $T$ ,  $S$  (or  $S_y$ ), nature of geology and streambed sediments.

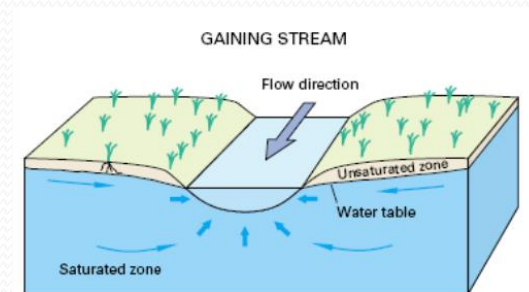
# SW/GW interaction

Gaining Stream: Groundwater discharges maintain or contribute to a net gain in streamflow

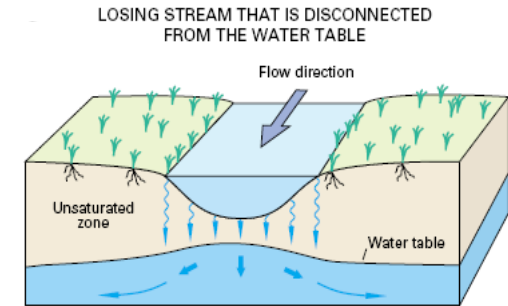
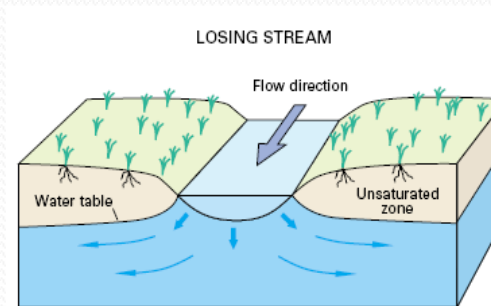
Losing Stream: Seepage through the streambed causes a loss in streamflow (stream can be perched)

Irregular and Dynamic:

- Spatially variable
  - Perched vs not perched\*
  - Streambed deposition & erosion
  - Under-lying geology\*
- Temporally variable
  - Seasonal precipitation patterns\*
  - Bank and floodplain storage
  - Riparian vegetation



Source: Alley et al. (1999)



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\* Available data can help assess this.



# Hydraulic connection

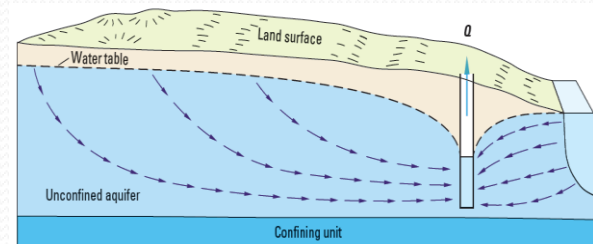
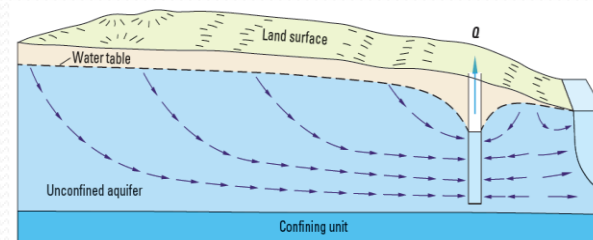
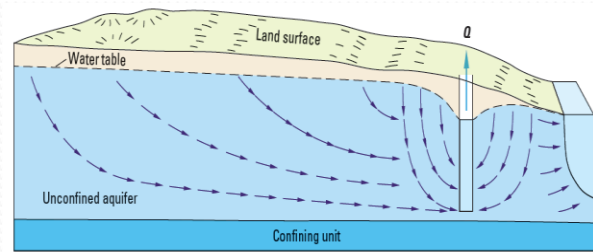
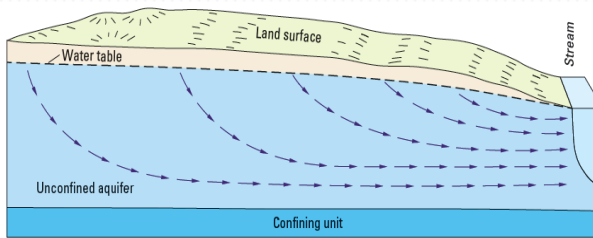
- In BC hydraulic connection must meet the test of “reasonably likely”.
- To manage rights, hydraulic connection should be pinpointed to a specific stream reach.



Photo: N. Bilodeau

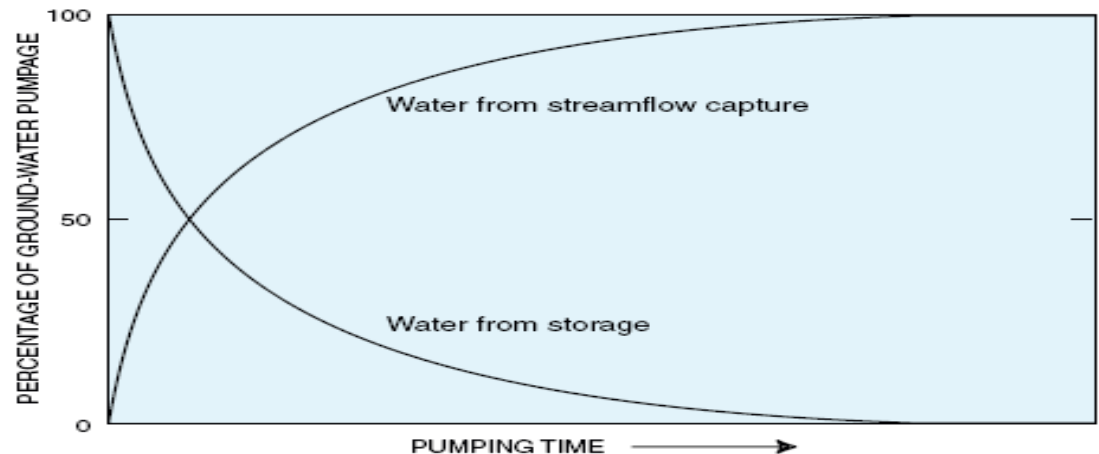
\* *Water Sustainability Act* definition

# Streamflow depletion processes



Source: Barlow and Leake (2012)

- Depletion of streamflow from well pumping caused by the combined effects of:
  - 1) direct infiltration of water from the stream;
  - 2) interception of groundwater which would otherwise eventually discharge to the stream.
- Depending on the local site conditions, one process may be more prevalent than the other.

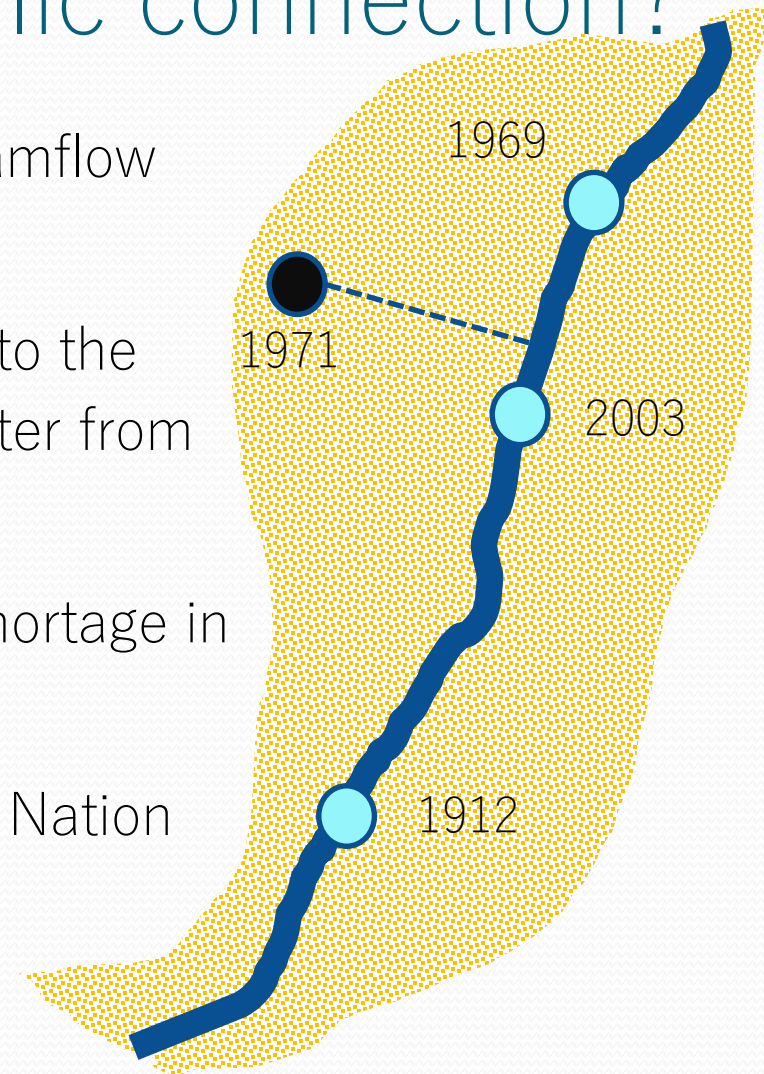


Source: Alley et al. (1999)

From Barlow and Leake, 2012

# Why determine hydraulic connection?

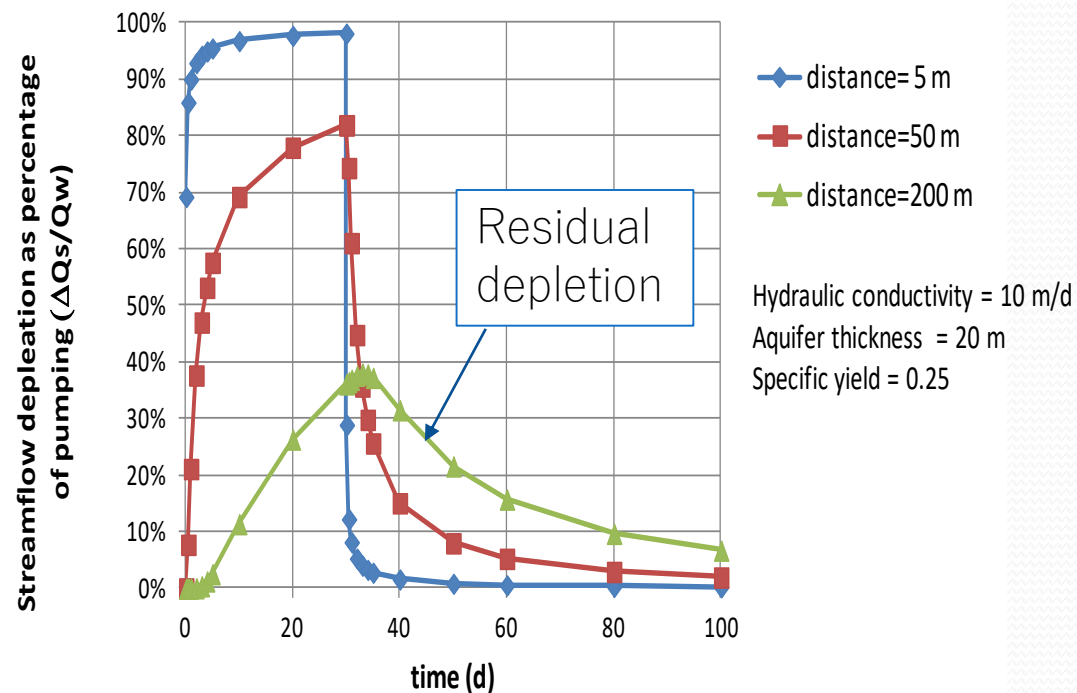
- Assess impact of well pumping on streamflow (EFN) and senior rights on a stream.
- Add the licensed groundwater demand to the stream to inform future allocation of water from the stream.
- Support taking of action during water shortage in a stream.
- Assess impact of well pumping on First Nation traditional water uses.



# Water management perspectives

1. The diversion of groundwater from an aquifer on a connected stream – this is long-term (e.g., years); and

2. The diversion of groundwater from an aquifer connected to a stream when enforcing precedence of rights during times of critical low flow – this is short-term (e.g., weeks-months).

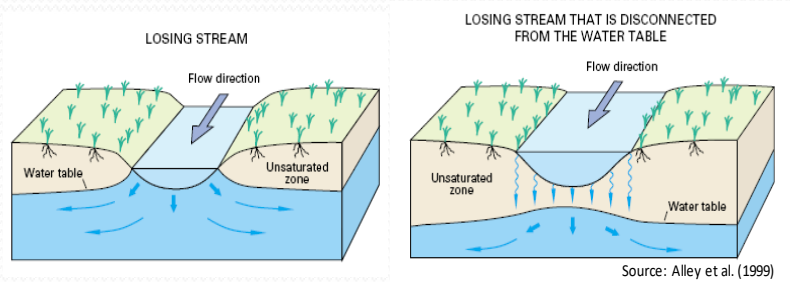




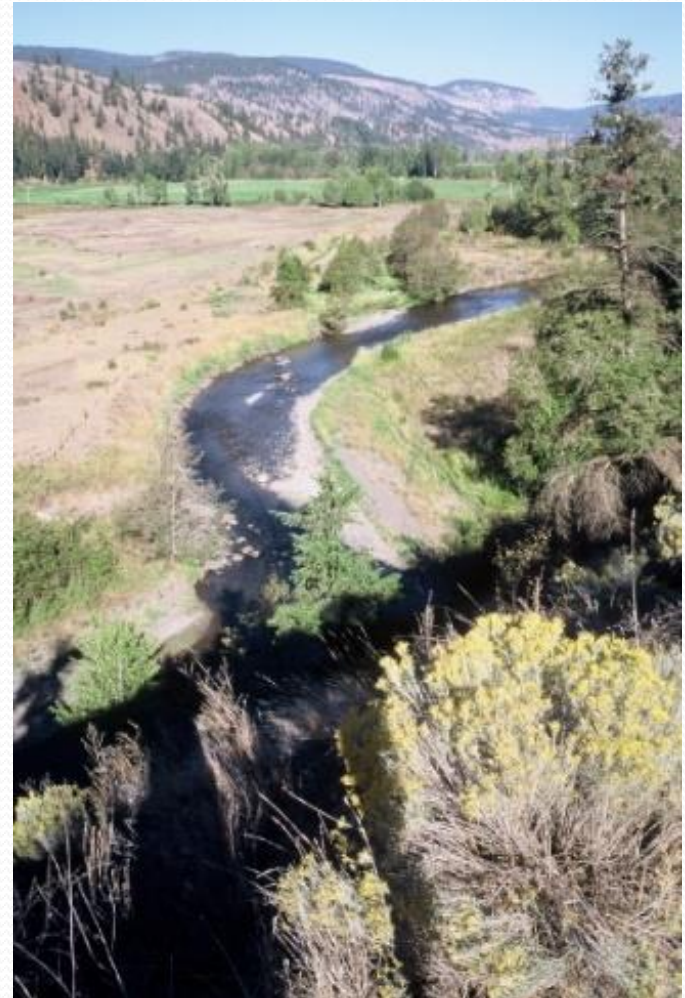
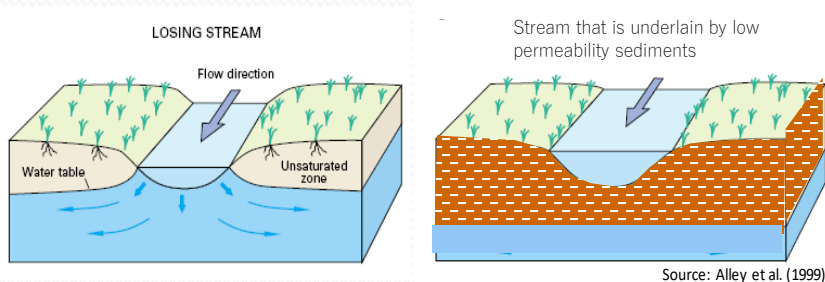
# Determining connection—an approach

Two major factors control hydraulic connection\*:

- Is stream “perched” above the water table or not?

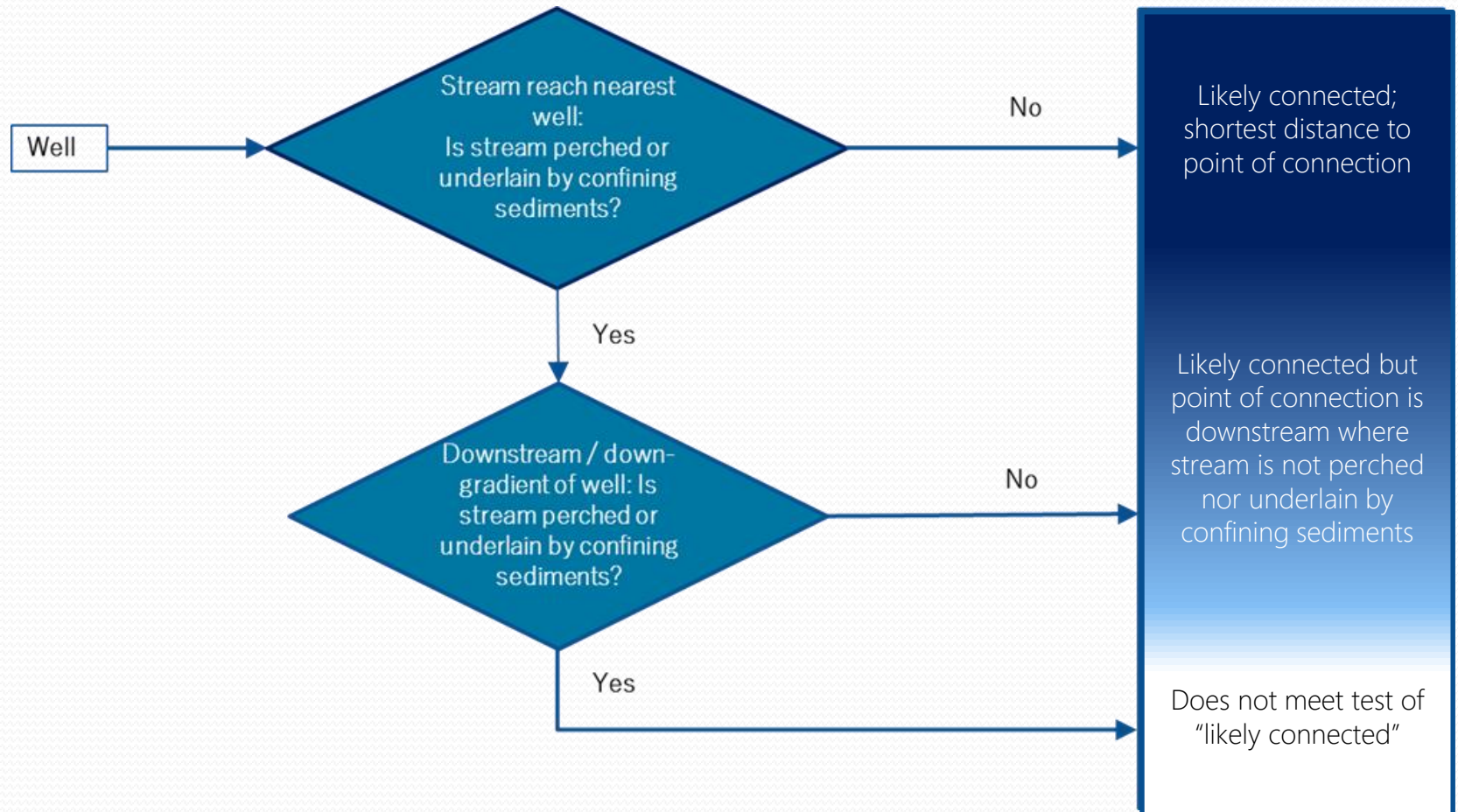


- Is stream directly underlain by low permeability sediments or not?

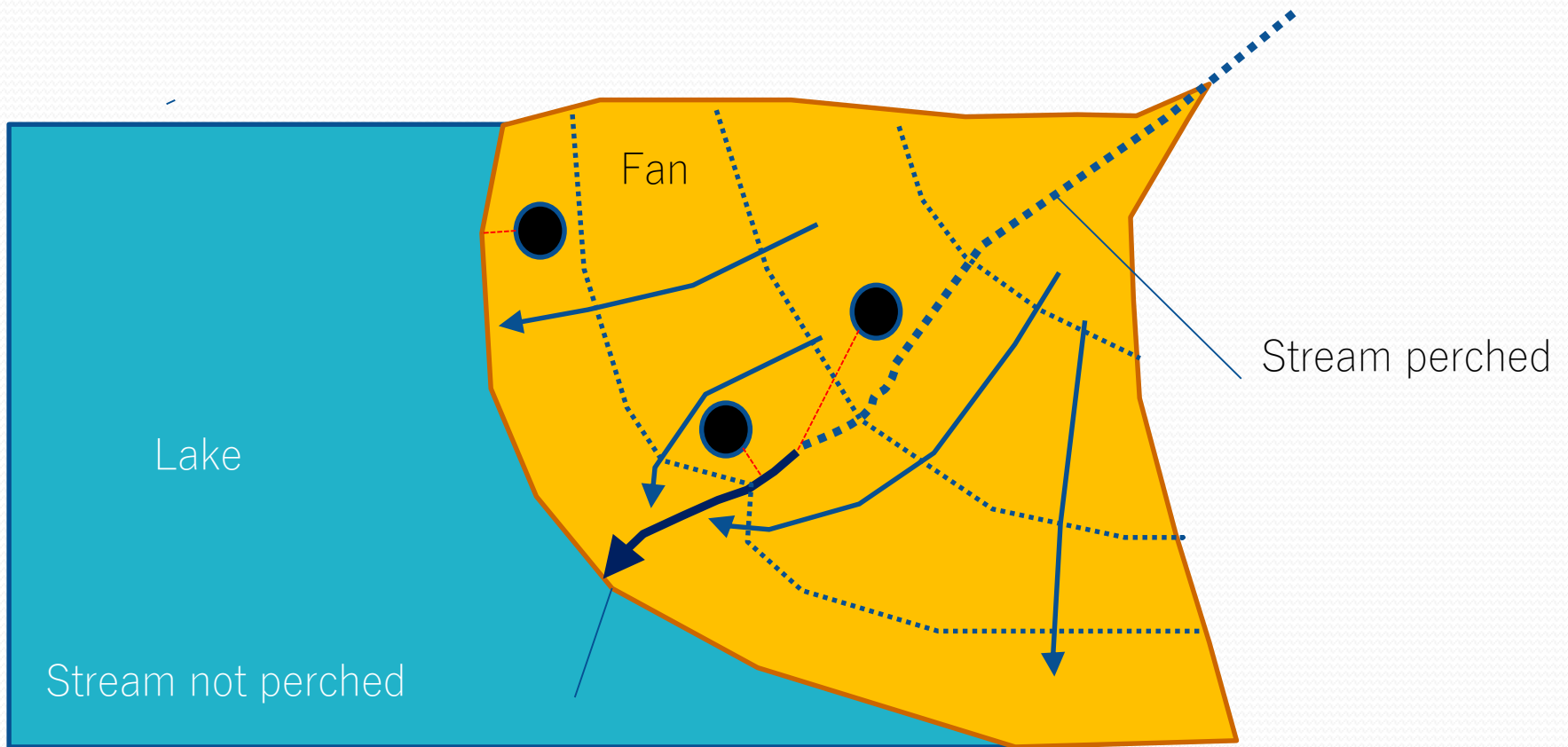




# An approach to determining likelihood of connection



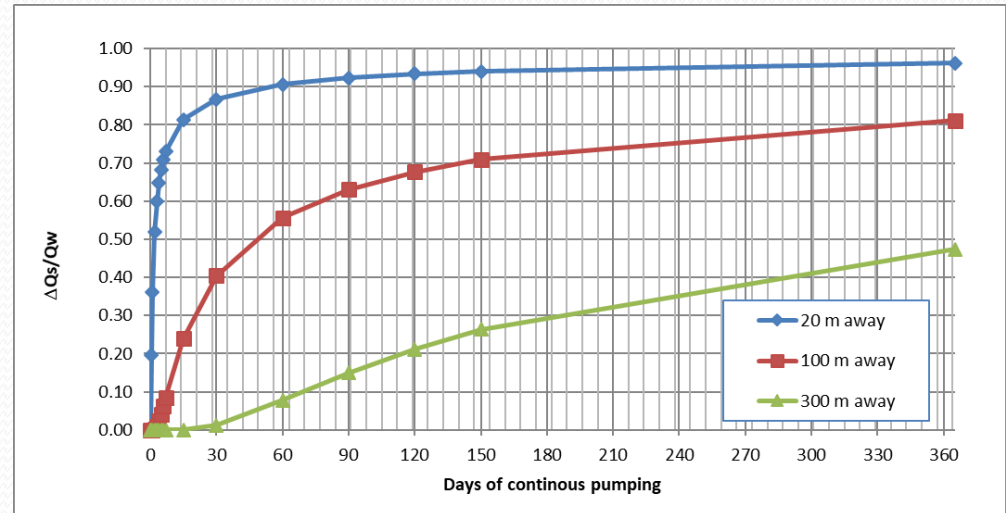
# Point of hydraulic connection



# Stream depletion factor (SDF)

- SDF reflects the “time” significant depletion occurs in response to pumping.

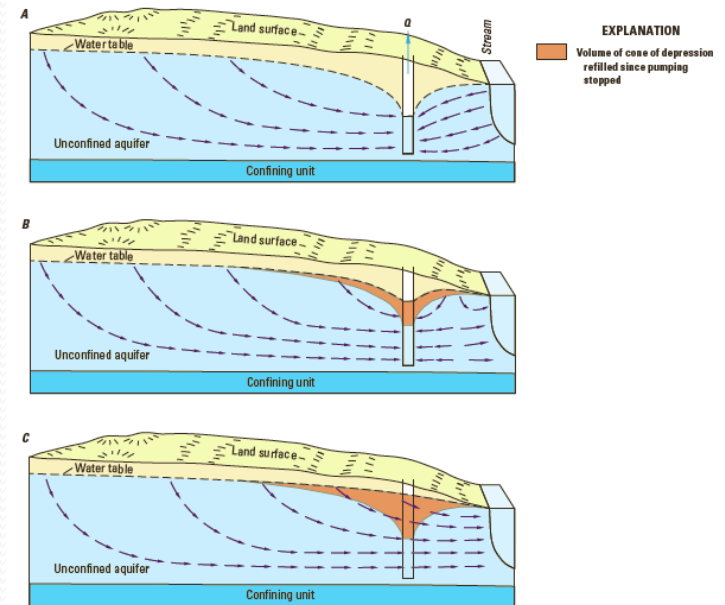
$$SDF = \frac{d^2 S}{T}$$



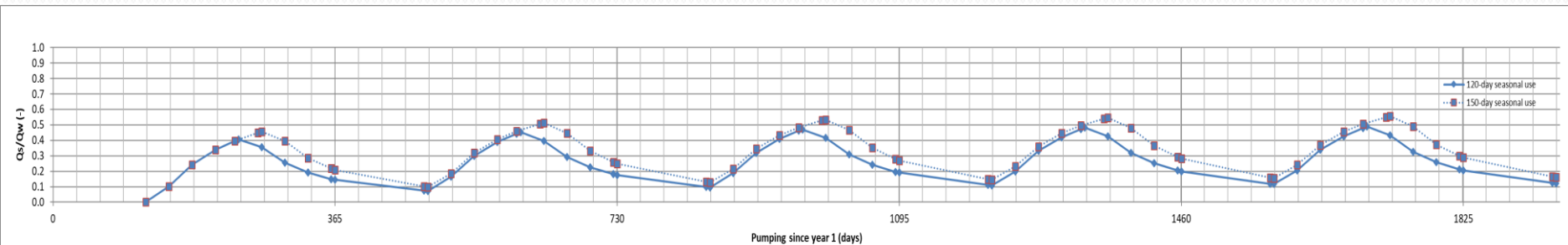
- d=distance from well to stream
- S=aquifer storativity
- T=aquifer transmissivity
- SDF is not the same as groundwater travel time (travel time is generally slower).

# Misconceptions about streamflow depletion

- × Depletion stops when pumping ceases:
  - Drawdown cone still exists for a time after pumping ceases; and
  - Depletion continues until aquifer storage is re-filled.



From Barlow and Leake, 2012

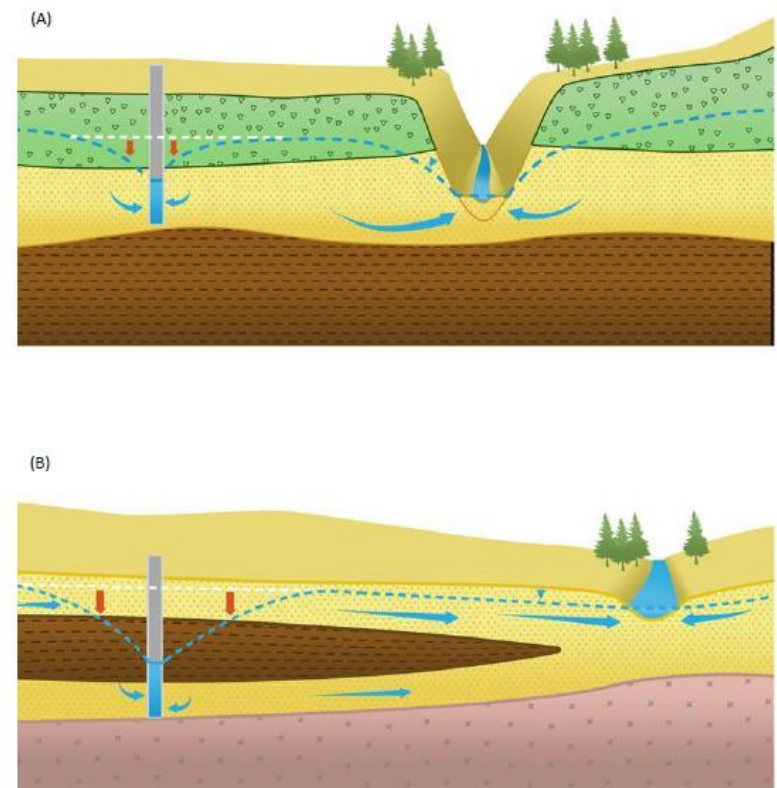




# Misconceptions about streamflow depletion

× Depletion does not occur if well pumping occurs in a confined aquifer:

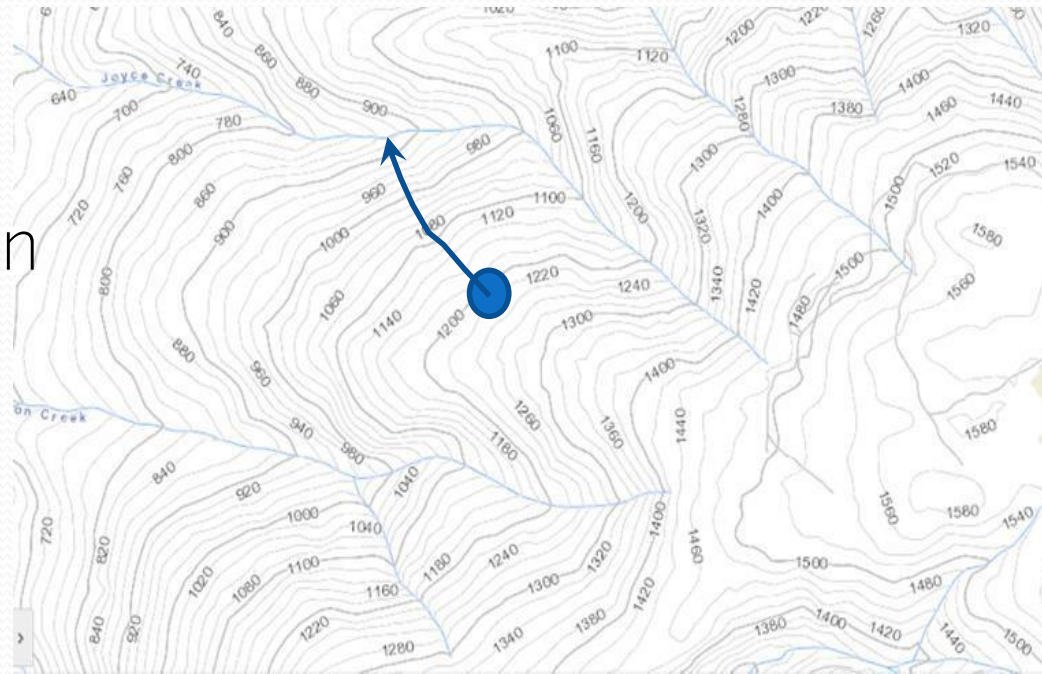
- The stream may have incised through the confining layer;
- The confining layer may pinch out; or
- The confining layer may be semi-permeable, allowing leakage between the stream and the aquifer.



From Province of BC, 2016

# Misconceptions about streamflow depletion

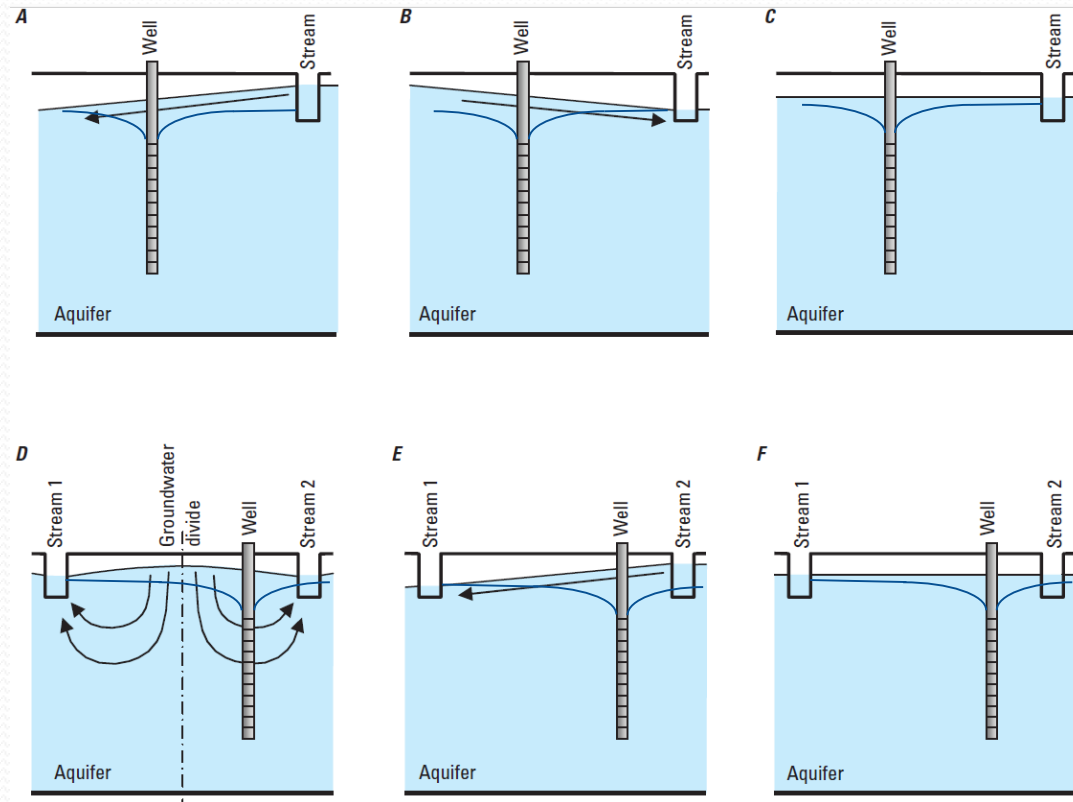
- Unstratified bedrock in mountainous terrain can be hydraulically connected to headwater streams (water in stream not limiting and stream is not perched).



From: Province of BC, 2016

# Misconceptions about streamflow depletion

- ✗ Depletion depends on rate & direction of groundwater flow\*
- ✗ Capture does not occur if a groundwater divide exists between the pumping well and the stream



\* Unless hydraulic connection does not exist at the site.

From Barlow and Leake, 2012

# Concluding thoughts

- Determining hydraulic connection can be challenging, especially on a site basis.
- Geology and water levels are key determining factors – drillers well record is valuable information for this.
- Implicit in task is to determine the PoHC.
- Try simple, systematic approach (e.g., slide 9).





# References

Barlow, P. M. and S.A. Leake, 2012. *Streamflow depletion by wells-Understanding and managing the effects of groundwater pumping on streamflow*. U.S. Geological Survey Circular 1376, 84 pp.

Province of BC, 2016. *Determining the Likelihood of Hydraulic Connection – Guidance for the Purpose of Apportioning Demand from Diversion of Groundwater on Streams*. Version 1.0. Water Science Series, WSS2016-01. Province of BC, Victoria, BC. 21 pp.

## Thank you! Questions?