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Wellhead and Source Water Protection for Municipal Supply

Dorothea Hanchar
Groundwater Resources Manager
Water Resources Management Division
Environment and Conservation

Groundwater – Resource at Risk

- Not readily observed
  - (out of sight – out of mind)
- Not easy to measure
  - (complex flow in fractured rocks)
- SLOW! And Fast!

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Sources of Groundwater Contamination

- Point Source
- Non-Point Source

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Point Source Contamination:

- On-site septic systems
- Leaky tanks or pipelines
- containing petroleum products
- Leaks or spills of industrial chemicals at manufacturing facilities
- Underground injection wells (industrial waste)
- Municipal landfills
- Livestock wastes
- Leaky sewer lines
- Mill tailings in mining areas
- Sludge disposal areas at petroleum refineries
- Land spreading of sewage or sewage sludge
- Graveyards
- Road salt storage areas
- Wells for disposal of liquid wastes
- Runoff of salt and other chemicals from roads and highways
- Spills related to highway accidents
- Asphalt production and equipment cleaning sites
- Chemicals used at wood preservation facilities

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Non-point sources

- Fertilizers on agricultural land
- Pesticides on agricultural land and forests
- Contaminants in rain, snow, and dry atmospheric fallout

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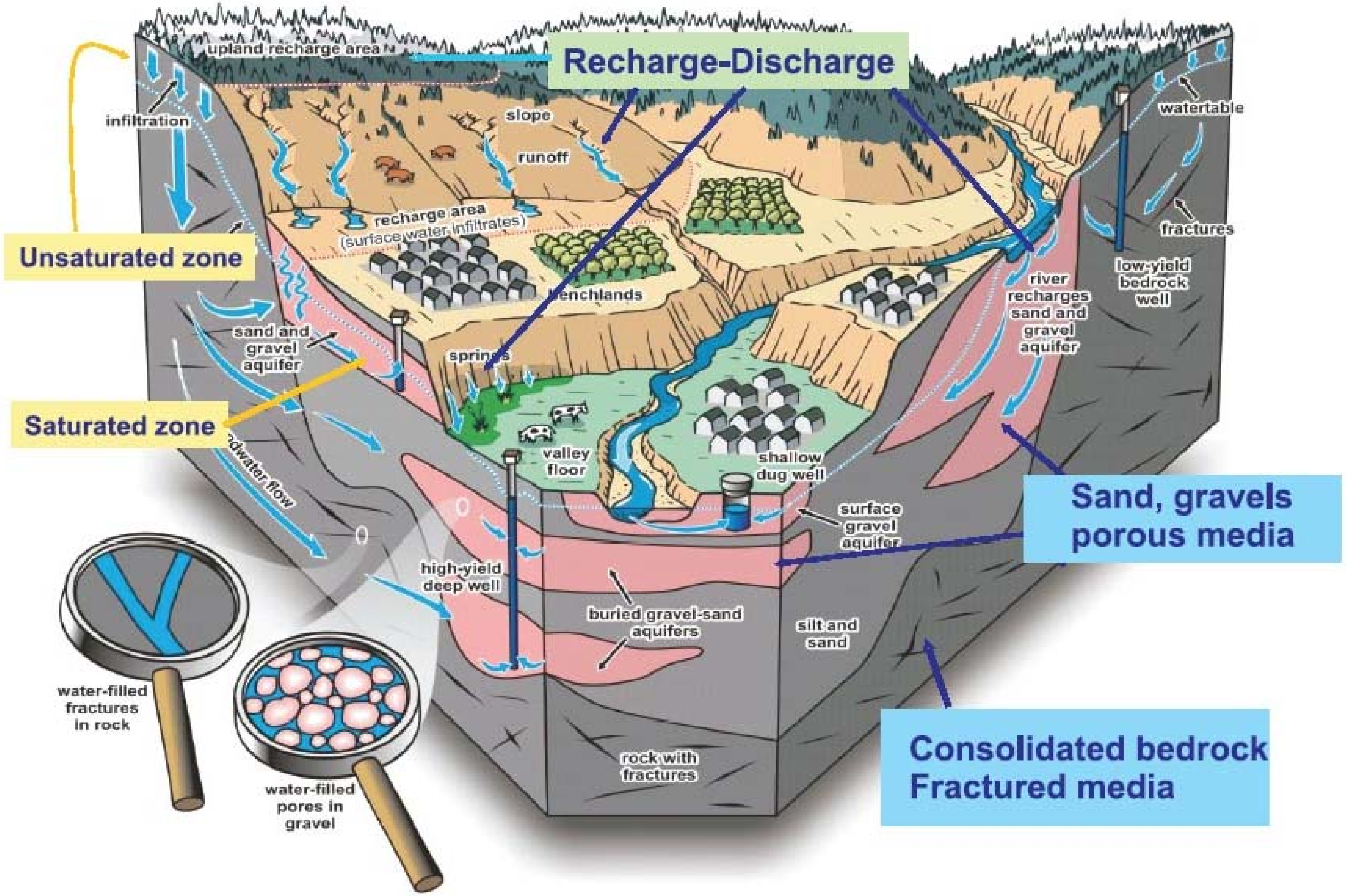

Figure 3. Groundwater flow and geological units forming aquifers.

Source: Groundwater Sustainable Development in Canada, 2008

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- “Capture Zone” refers to the three-dimensional region that contributes the groundwater extracted by one or more wells

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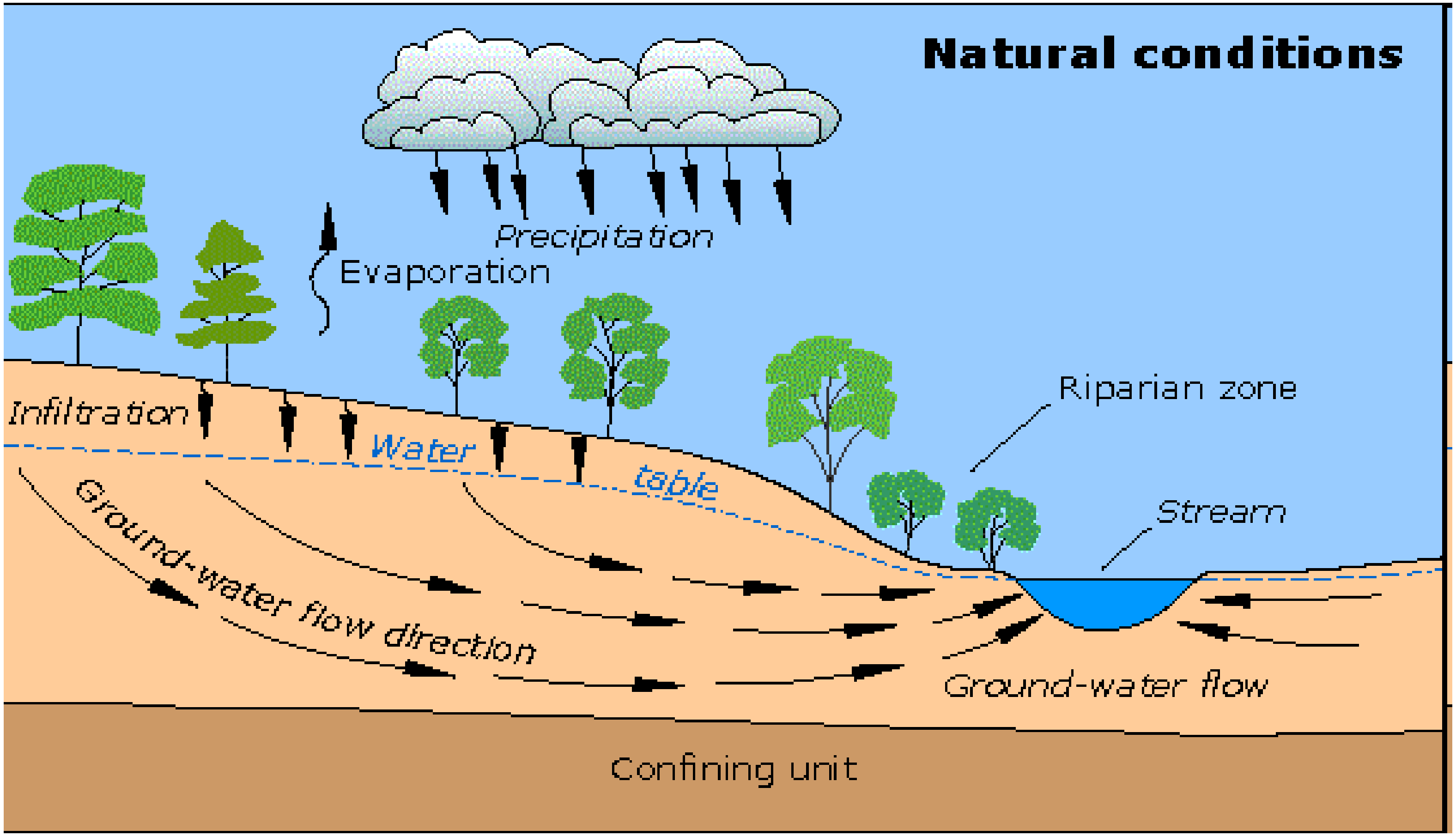

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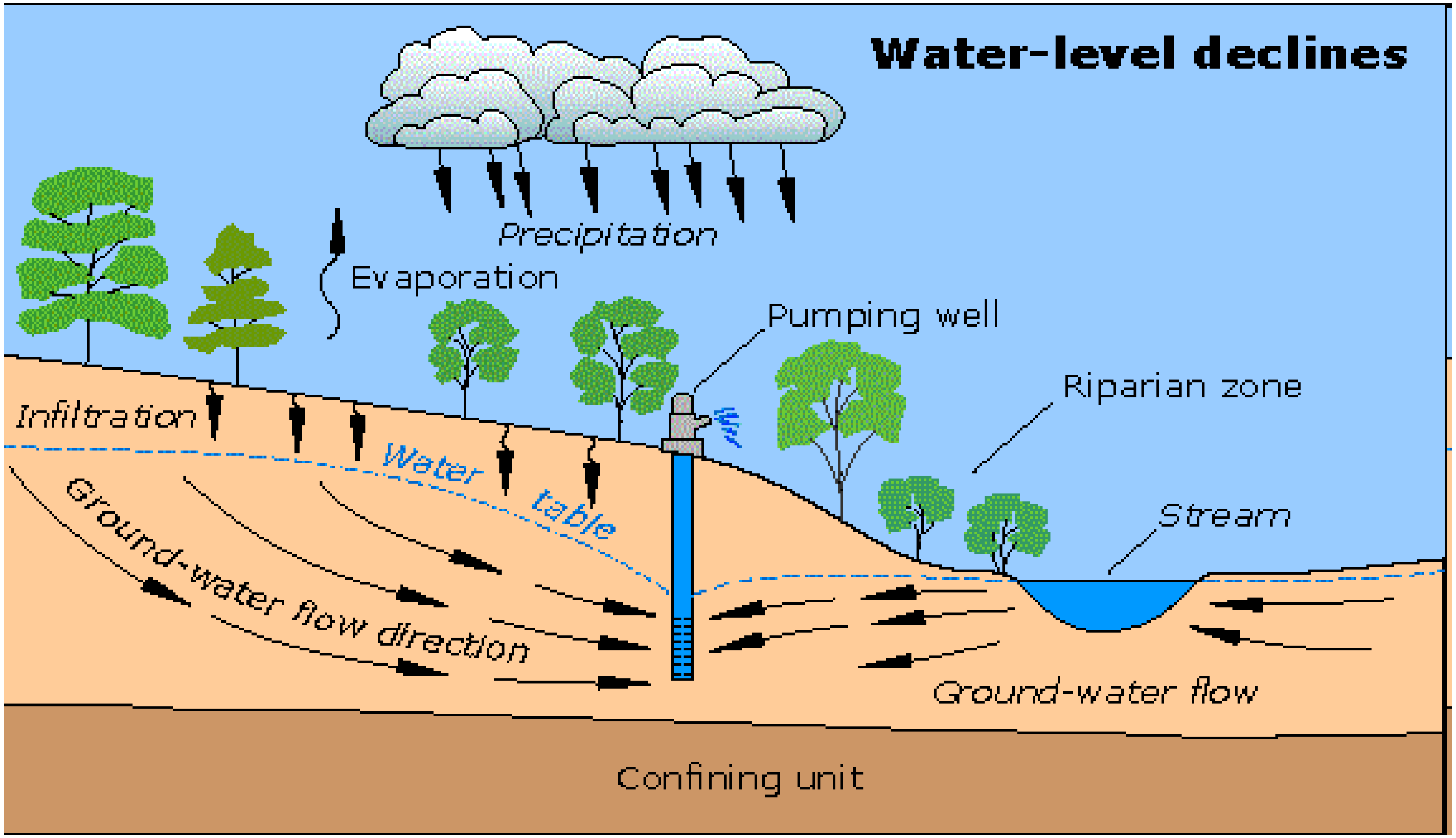

Source: USGS

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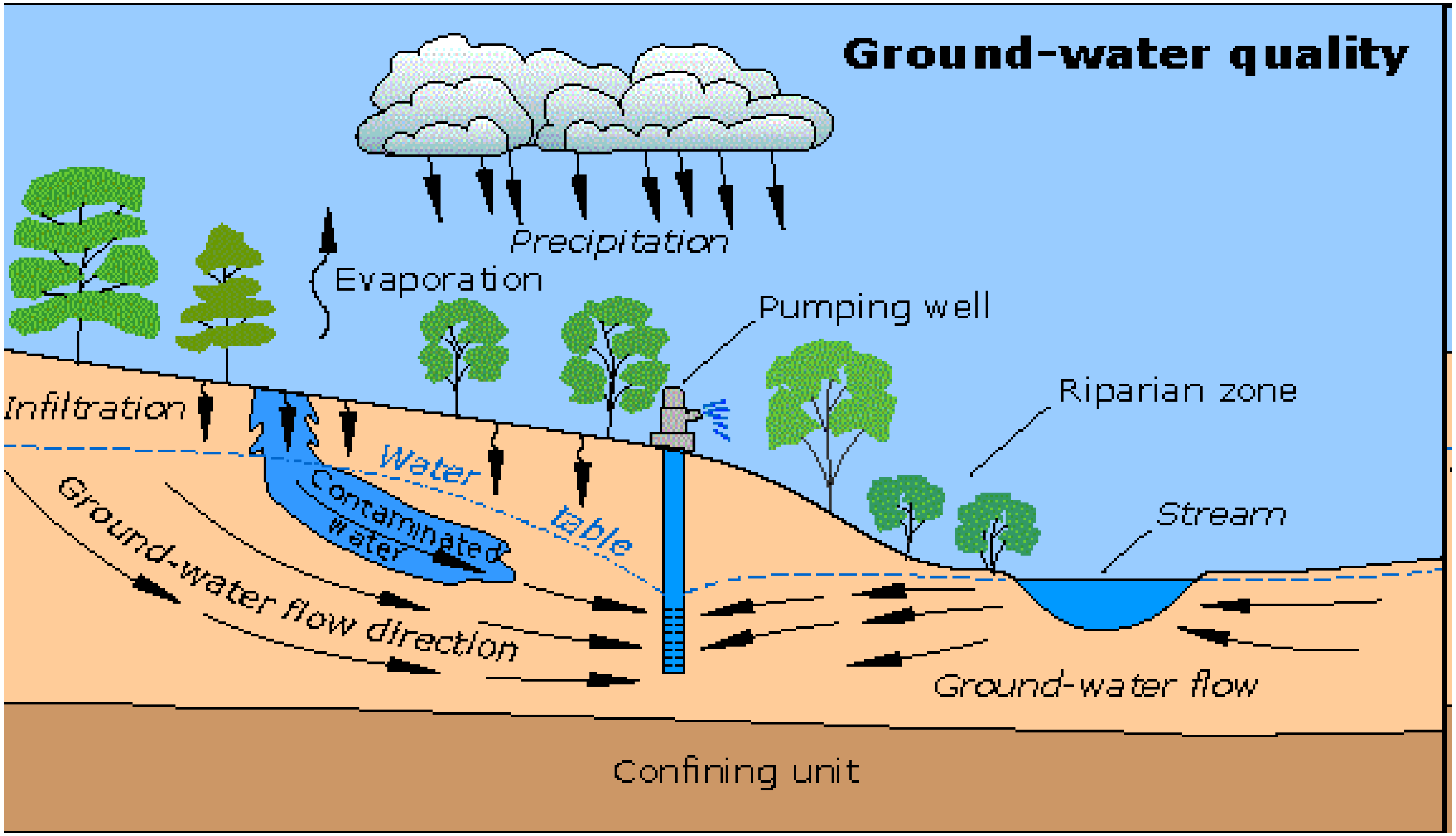
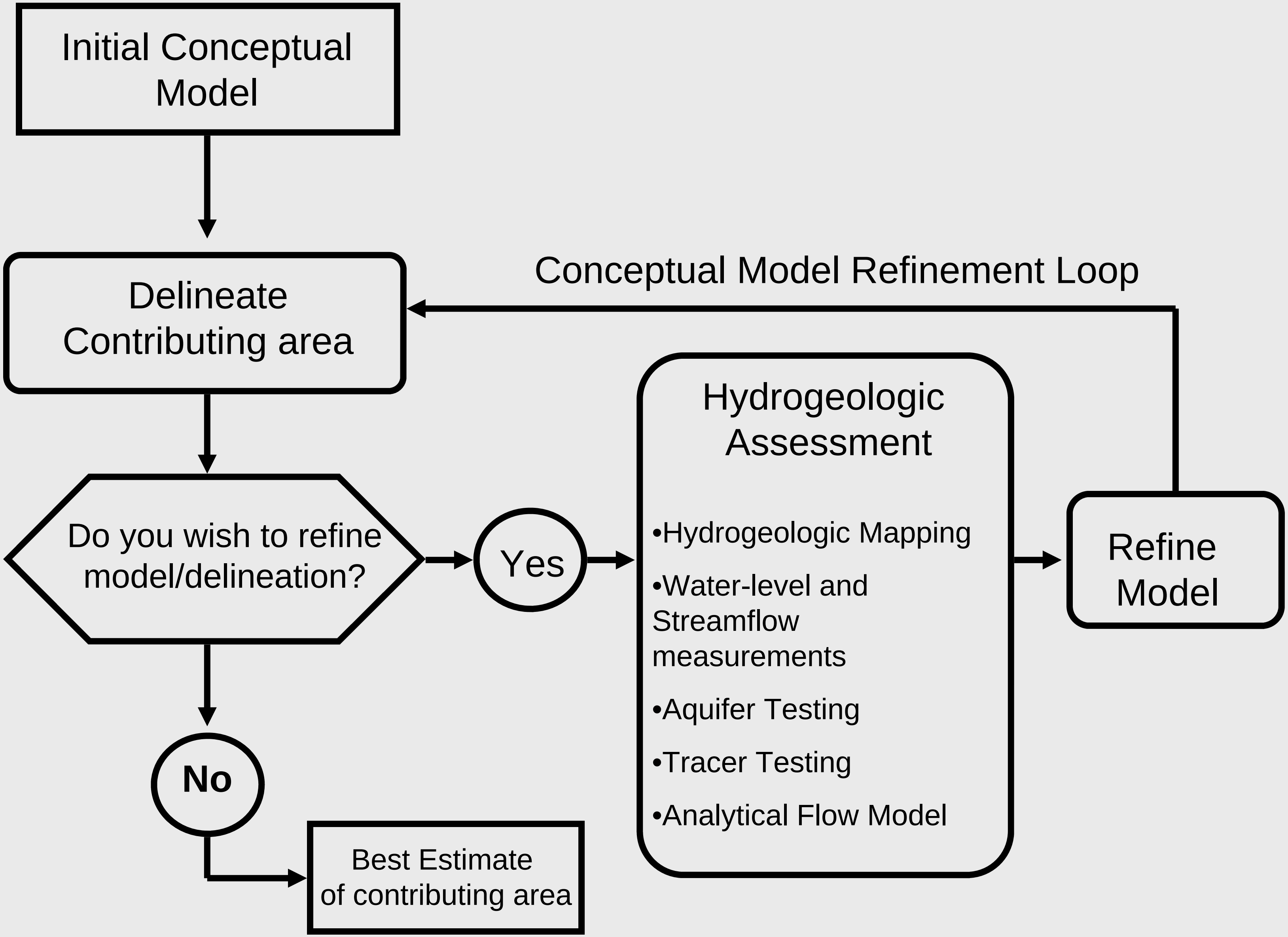


Source: USGS

Overall Strategy for Delineating Contribution Areas in Bedrock Aquifers



Source: USGS WRI 95-4033

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Components of a Hydrogeologic Assessment

- Hydrogeologic Mapping
- Water-level and Streamflow measurements
- Aquifer Testing
- Tracer Testing
- Analytical Flow Model

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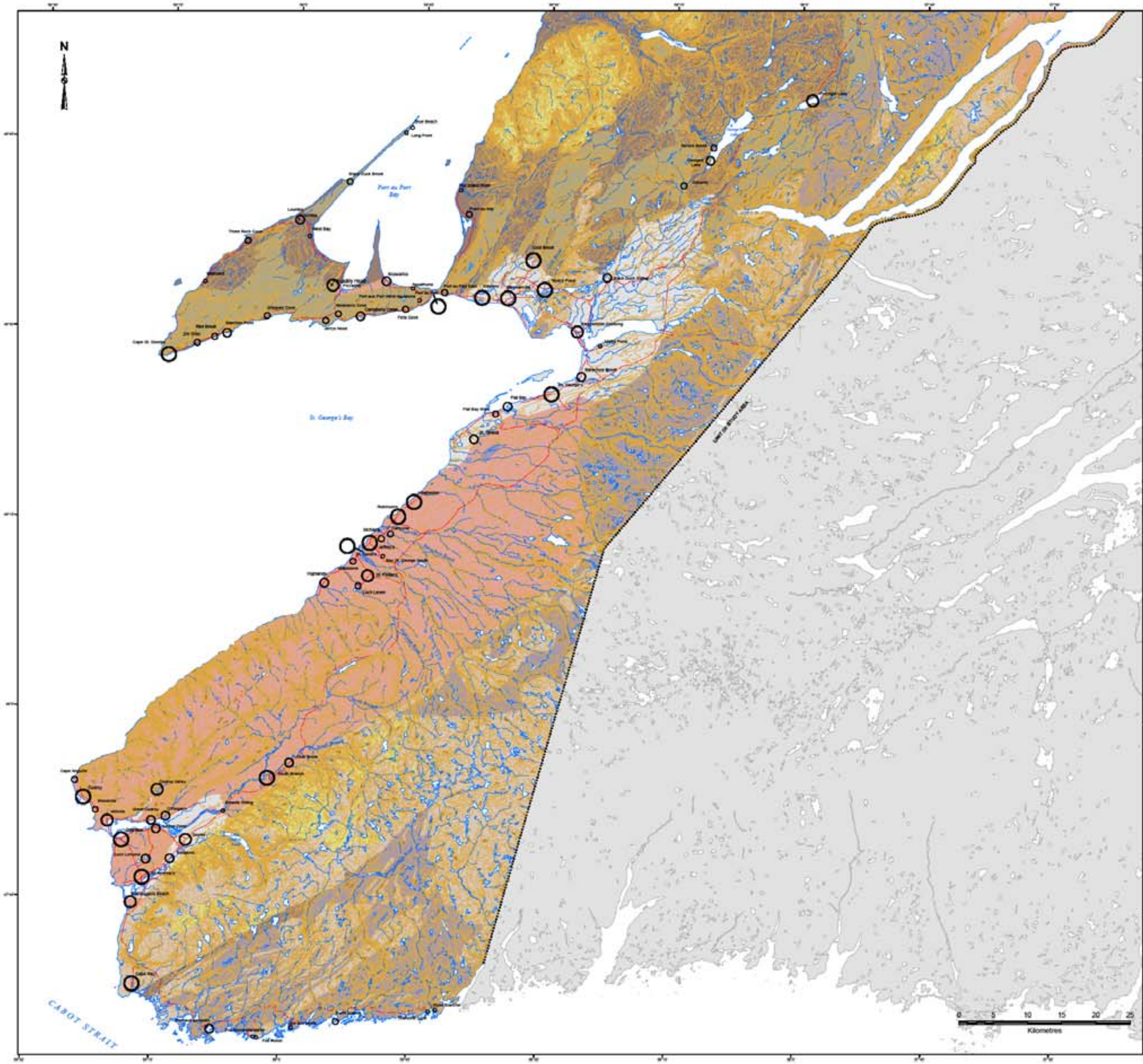

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Map No. 3c

HYDROGEOLOGY

Western Newfoundland

Bedrock Hydrostratigraphic Units

Hydrostratigraphic Unit	Lithology	No. of Wells	Well Yield Characteristics (L/min)			Well Depth Characteristics (m)	
			No. of zero values	Average	Median	Average	Median
Unit 1 **Moderate Yield** Granitic and Gneissic Rocks	granite, granodiorite, gabbro, gneiss	70	9	27.3	8	45.4	37.8
Unit 2 **Moderate Yield** Clastic Sedimentary Rocks	sandstone, shale, phyllite, quartzite, conglomerate, limestone, dolostone	467	58	33.4	10.0	53.75	40
Unit 3 **Moderate Yield** Carbonate Sedimentary Rocks	limestone, breccia, conglomerate, dolomite	557	126	37.0	9.0	41.56	36.15
Unit 4 **Moderate Yield** Carboniferous Sedimentary Rocks	sandstone, conglomerate, siltstone, mudstone	577	71	64.0	27.3	49.8	37.8
Unit 5 **Low Yield** Ophiolite Complexes	ultramafic gabbro, sheeted diabase	45	5	19.7	7	61.5	56
Unit 6 **Low Yield** Metavolcanic and Metasedimentary Rocks	schist, felsic–mafic volcanic flows, tuffs	39		18.4	8.2	56.2	50.3

Surficial deposits - Unconsolidated sediments

Surficial Hydrostratigraphic Units

Unit A – Till Deposits
Well yields range from 0 litres per minute (L/min) to 232 L/min and average 48 L/min. Well depths range from 9 meters (m) to 40 m and average 21 m. The available data indicates that on average, wells drilled within Unit 1 have a moderate potential yield.

Unit B – Sand and Gravel Deposits
Well yields range from 0 L/min to 1,793 L/min and averaged 74 L/min. Well depths range from 5 m to 121 m and averaged 29 m. The available data indicates that wells drilled within Unit B have a high potential yield.

Number of Wells Listed Per Community

- 1 - 3
- 4 - 9
- 10 - 15
- 16 - 20
- > 20

Note: See Appendix II for well descriptions

Elevation in feet above mean sea level. Contour interval approximately 100 feet.

REFERENCE:

Government of Newfoundland and Labrador, Department of Environment, Water Resources Division, Water Resources Management Division, Water Well Data for Newfoundland and Labrador, unpublished, 2005.

Colman-Sadd, S. P., and Crisby-Whittle, L. V. J. (compilers) 2000: Partial bedrock geology dataset for the Island of Newfoundland (NTS 02E, 02F, 02L, 02M, 11O, 11P, 12A, 12B, 12G, 12H, 12I, 12P and parts of 01M, 02D). Newfoundland and Labrador Department of Natural Resources, Geological Survey, Open File NFLD/2616 version 6.0.

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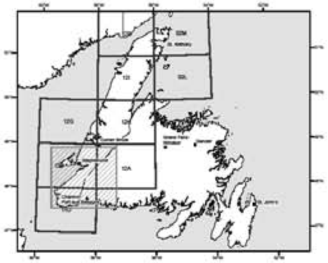

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Lineament Analysis –

- Lineament analysis is based on the identification of aligned topographic features (potential fracture traces) on the land surface using aerial photographs and other remotely sensed imagery.

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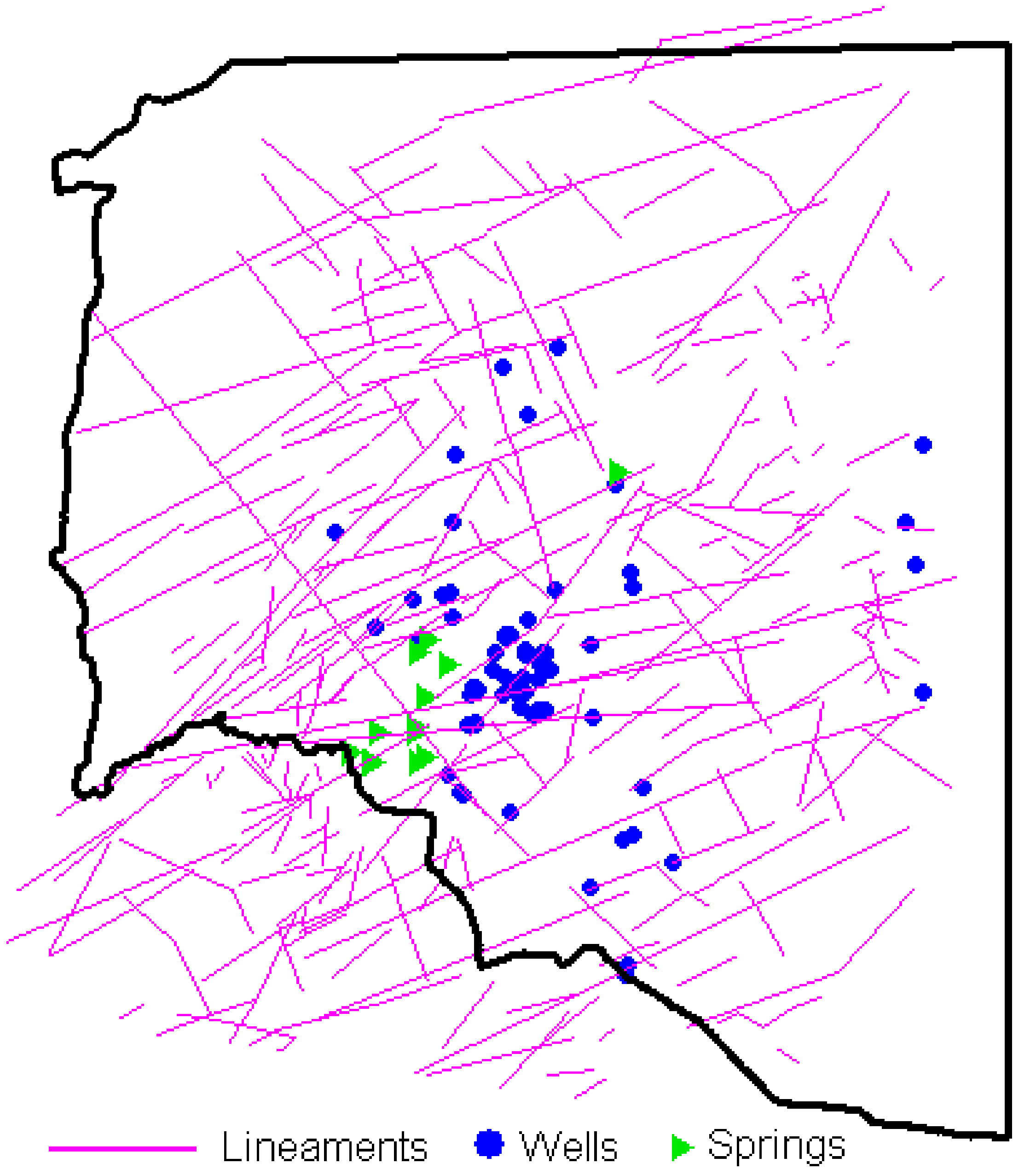

Source:http://www.fao.org/

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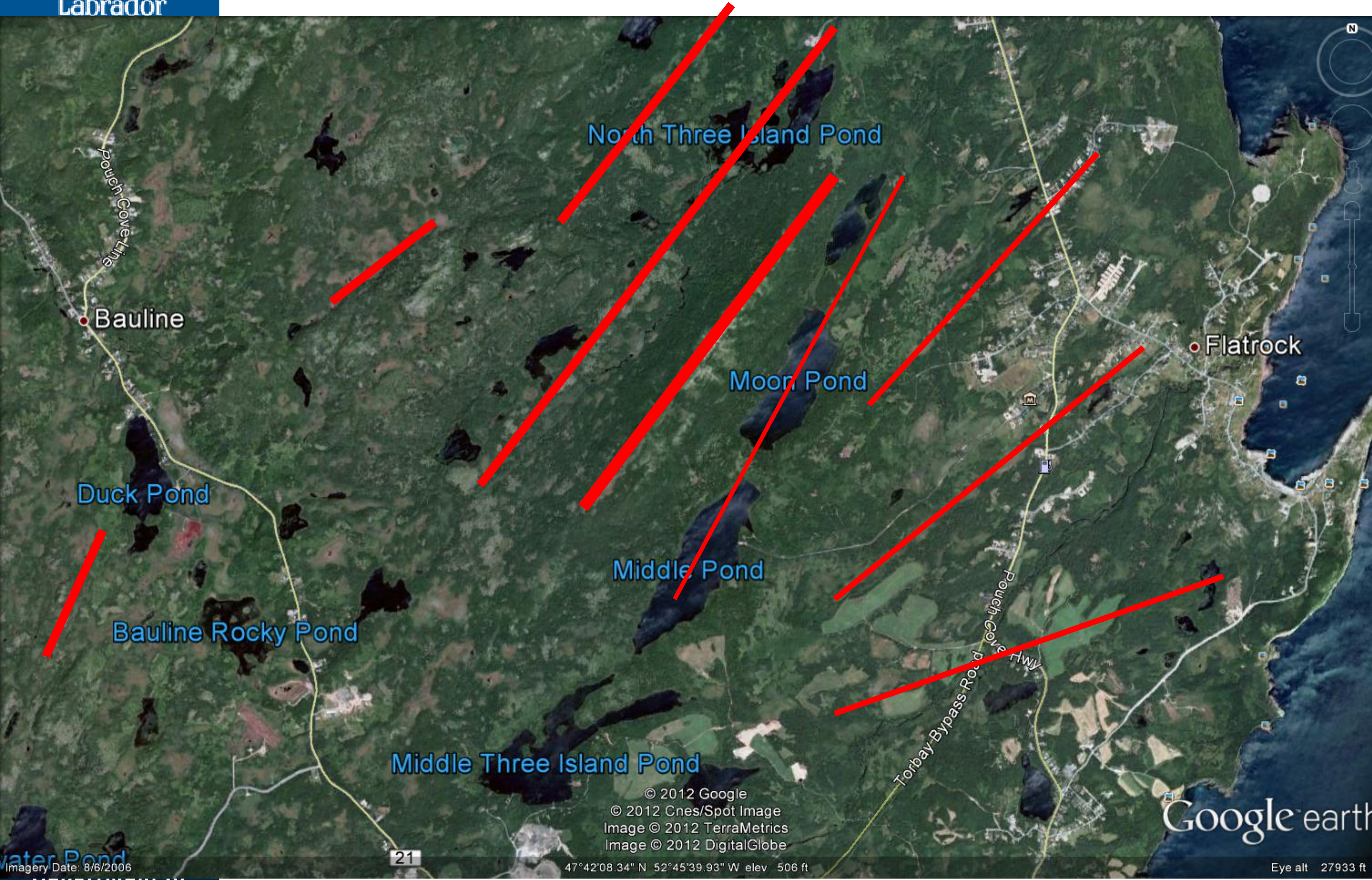

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Water Level and Stream flow Measurements

- Needed to define local groundwater flow direction
- Ideally, can show preferential flow direction near well(s)

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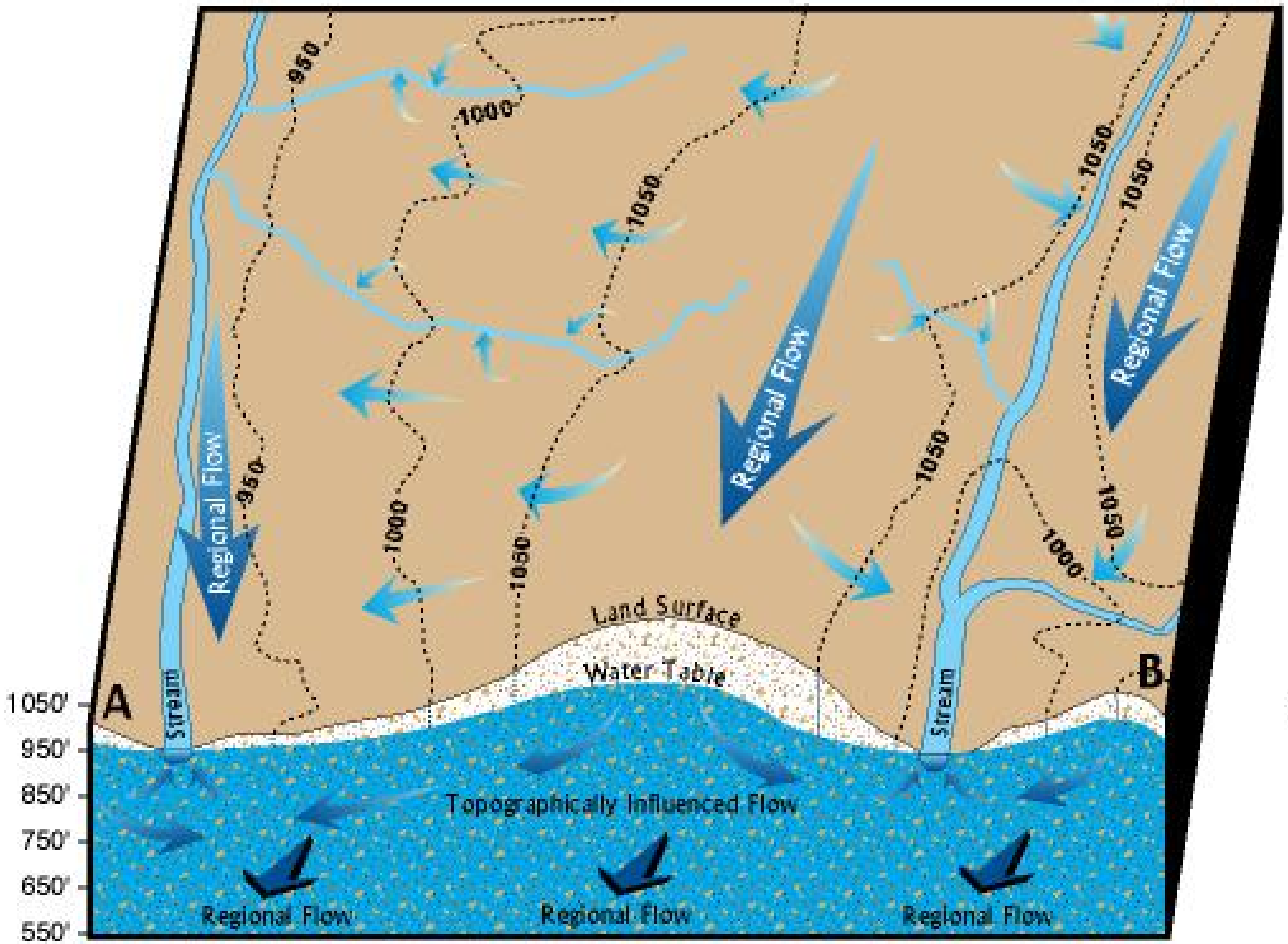
Topographically Influenced and Regional Ground Water Flow



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Ground Water Flow Direction Arrows over Potentiometric Surface Map Contours

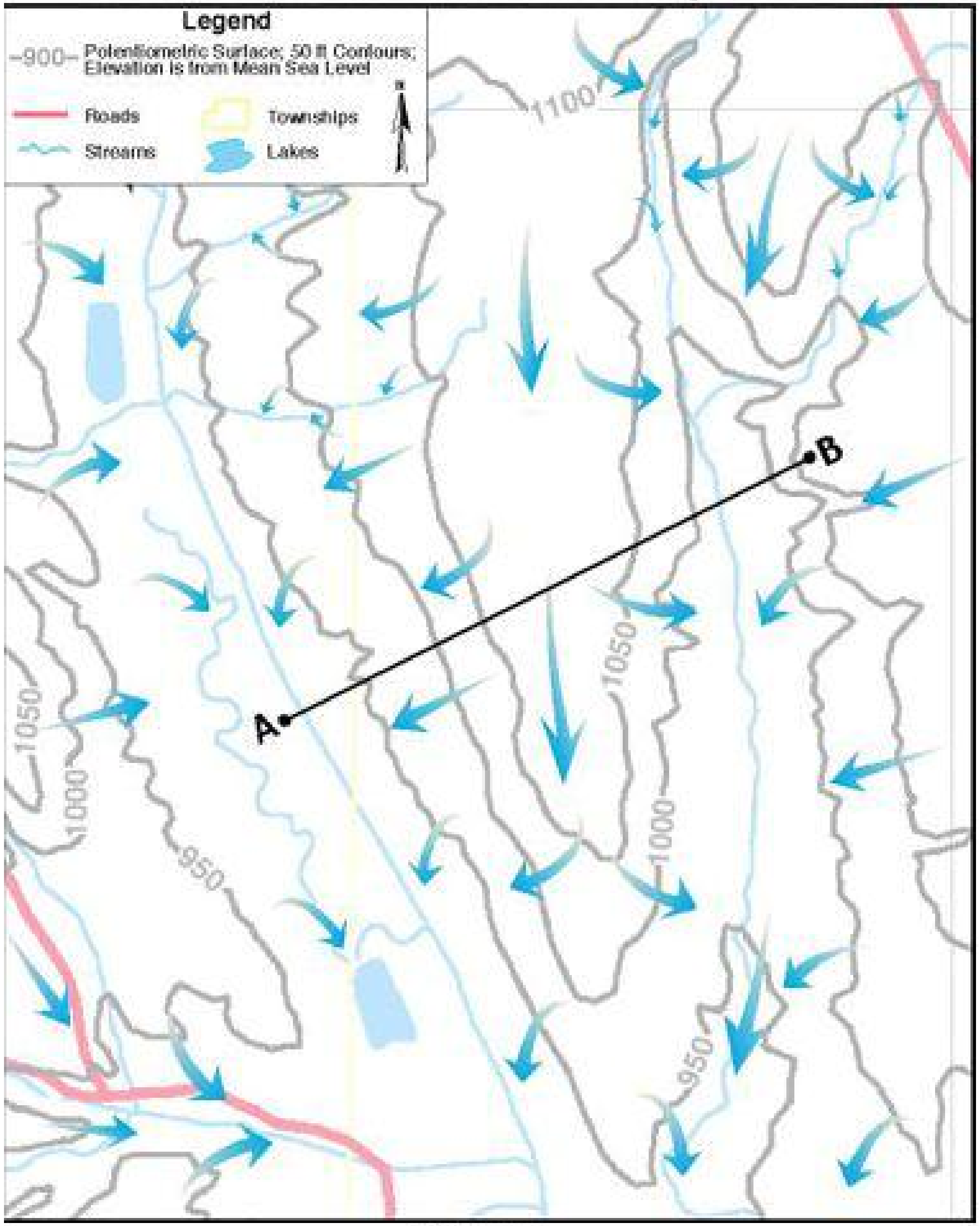

Figure 2.

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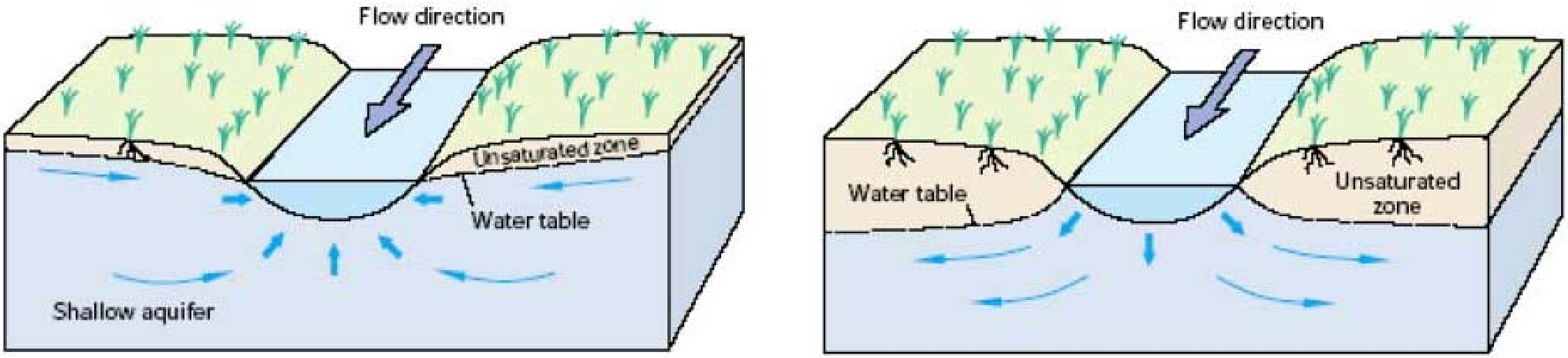
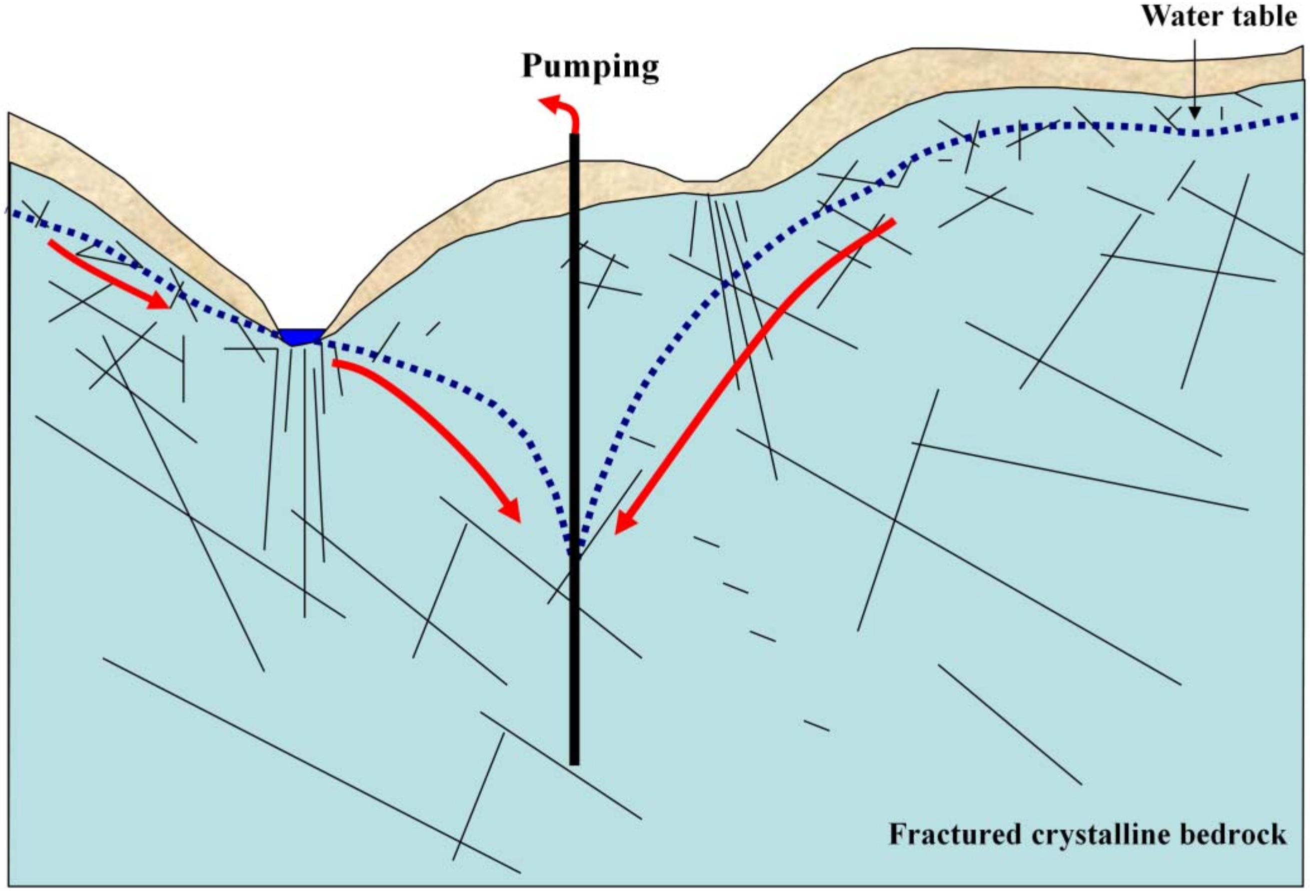


Figure B-2: Gaining (Left) and Losing (Right) Streams and Associated Groundwater Flow Direction

How can groundwater pumping affect streams?



Not to Scale

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Aquifer Test Analysis

- an aquifer test (pumping test, slug test, constant-head test) is a controlled field experiment used to estimate hydraulic properties of an aquifer system such as transmissivity, hydraulic conductivity and storativity (storage coefficient).

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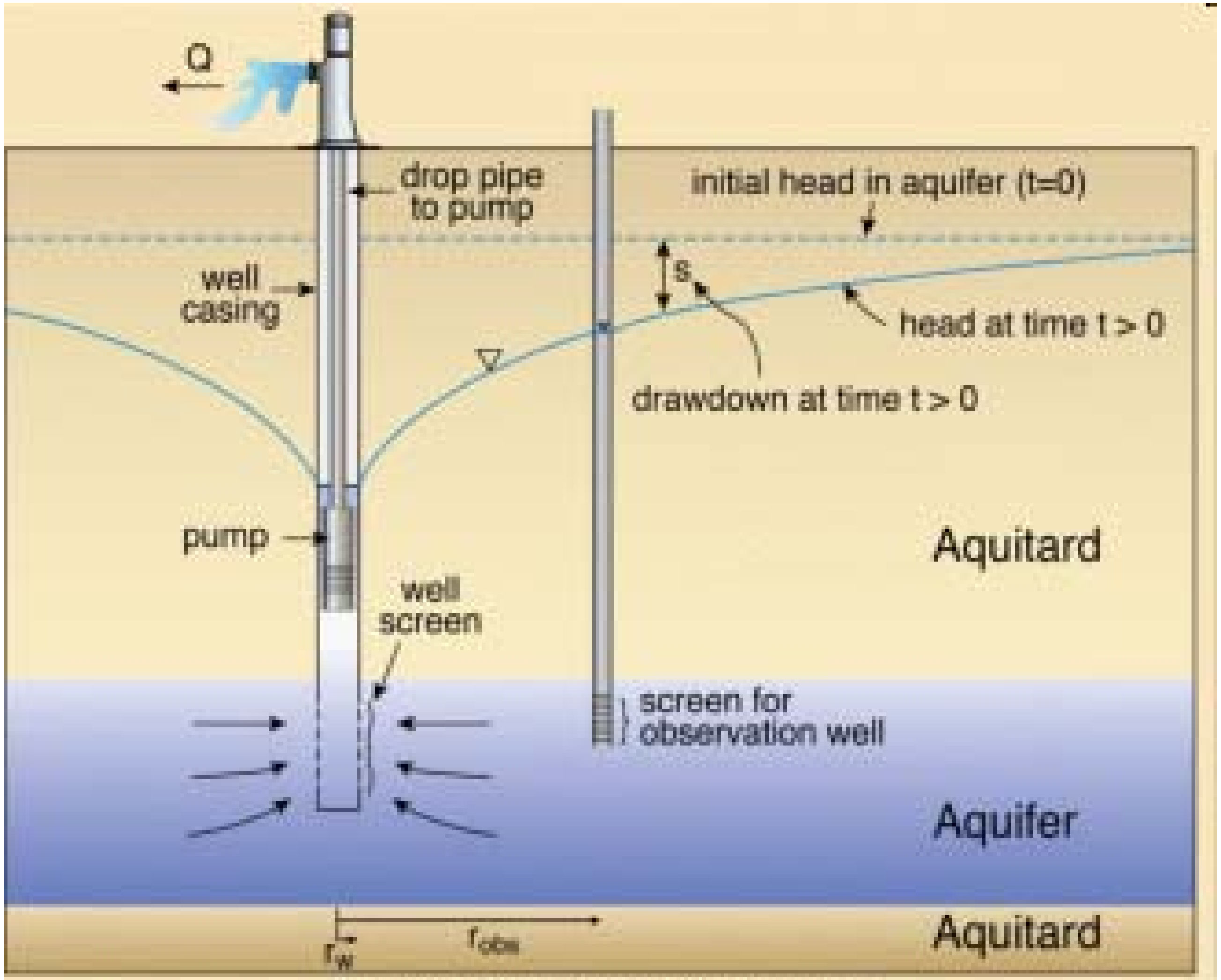

Pumping Test in a Confined Aquifer

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Tracer Tests

- Tracer tests are used to "trace" the path of flowing water.
- The most common tracers used in groundwater studies are:
  - fluorescent dyes such as fluorescein and rhodamine-WT
  - halides such as chloride, bromide and iodide

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Analytical Groundwater Flow Model

- Groundwater models describe the groundwater flow and transport processes using mathematical equations:
  - the direction of flow,
  - geometry of the aquifer,
  - the heterogeneity or anisotropy of sediments or bedrock that form the aquifer
- an approximation and not an exact duplication of field conditions

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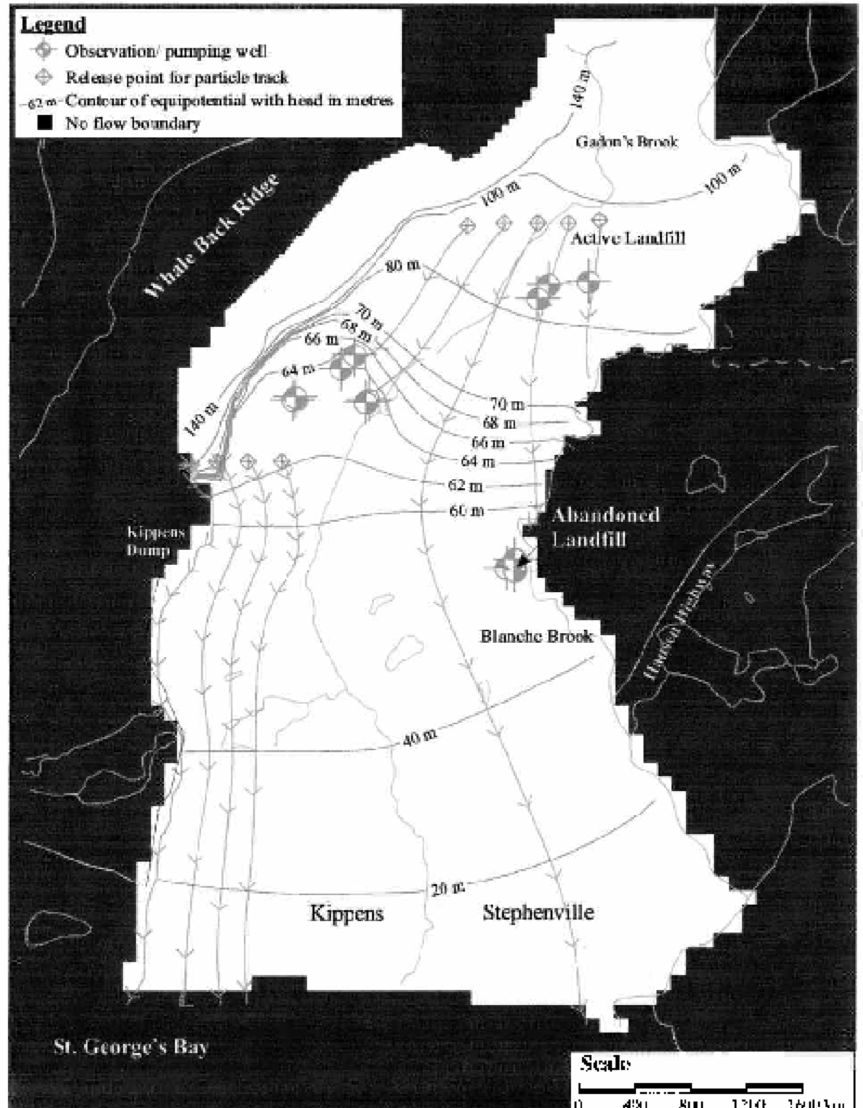

Figure 7-5. Equipotential contours and selected particle tracks for the sandstone aquifer: pumping wells at maximum recommended pumping rates.

Why do we need wellhead protection?

- Safeguard drinking water supplies
- Manage groundwater resources – quality and quantity
- Integrate with land-use planning
- Preventative
- Enforcement

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Designation process

- Application from Town or LSD
- In-house, designate proposed area
- Process through Interdepartmental Land Use Committee
- Notice of Wellhead Protection – with details
- Guidance provided to community

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Large town/Small town

- Larger towns-
  - Studies to evaluate aquifer system
  - Define area based on hydrogeology and recharge areas
  - May designate up to three zones
- Smaller towns-
  - No studies (costly), little data available
  - Pump test data?
  - Area of protection around well, based on population, other criteria

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Benefits

- Permit required from WRMD for development activity in protected area
- Town can oversee development in vicinity of well(s) to ensure protection of resource

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Thank you!

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