Harney Groundwater Investigation

Groundwater Terms & Analyzing Differing Data

Oregon Water Resources Department

Groundwater Terms

- Total Hydraulic Head
- Hydraulic Gradient
- Hydraulic Conductivity
- Groundwater Level Contours
- Hydraulic Connectivity

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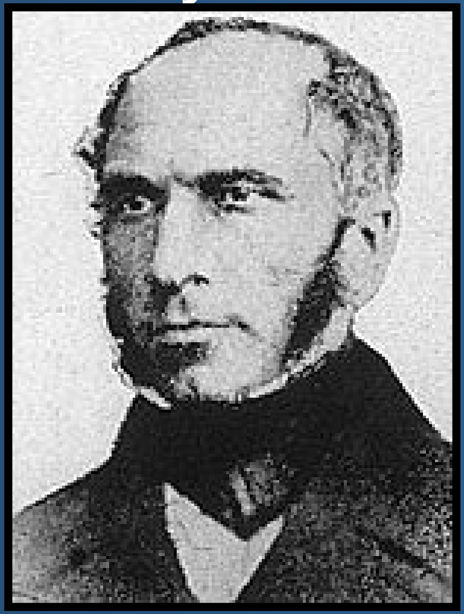
Groundwater Terms

Darcy's Law



Source: Wikipedia

Henry Darcy
1803-1858
French Hydraulic Engineer

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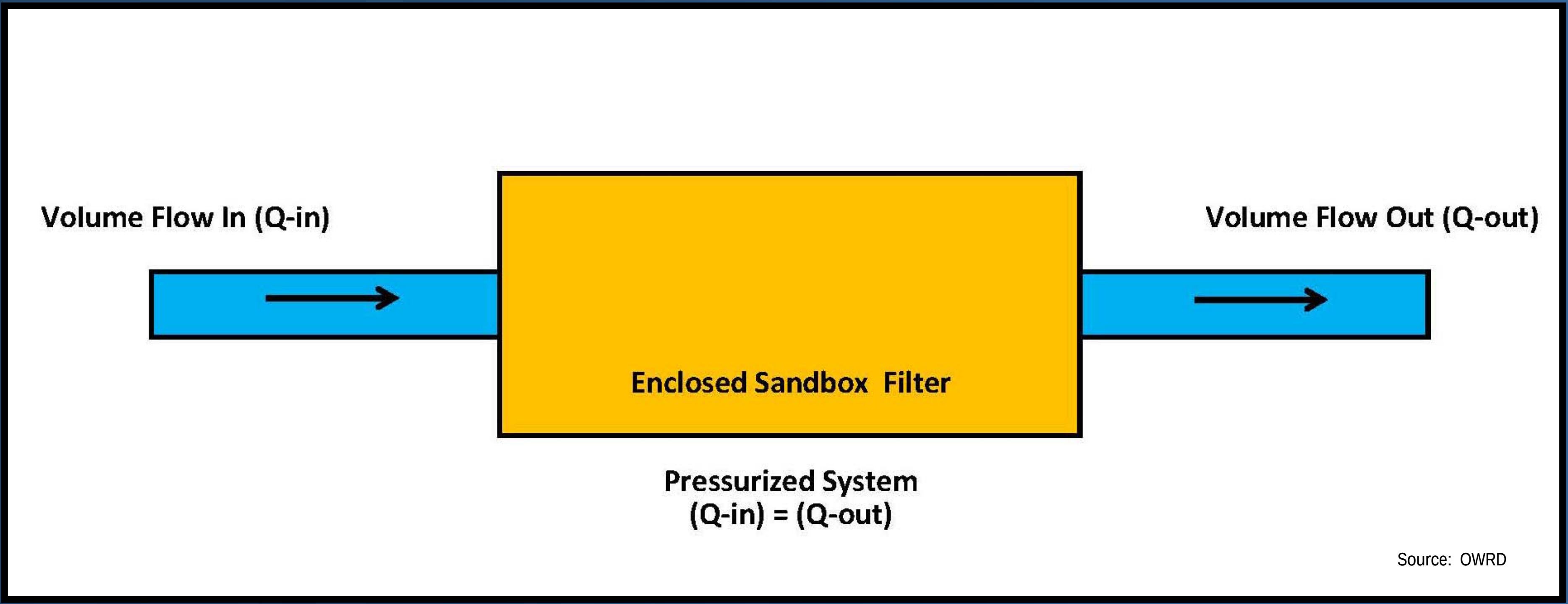
Groundwater Terms

Darcy's Law



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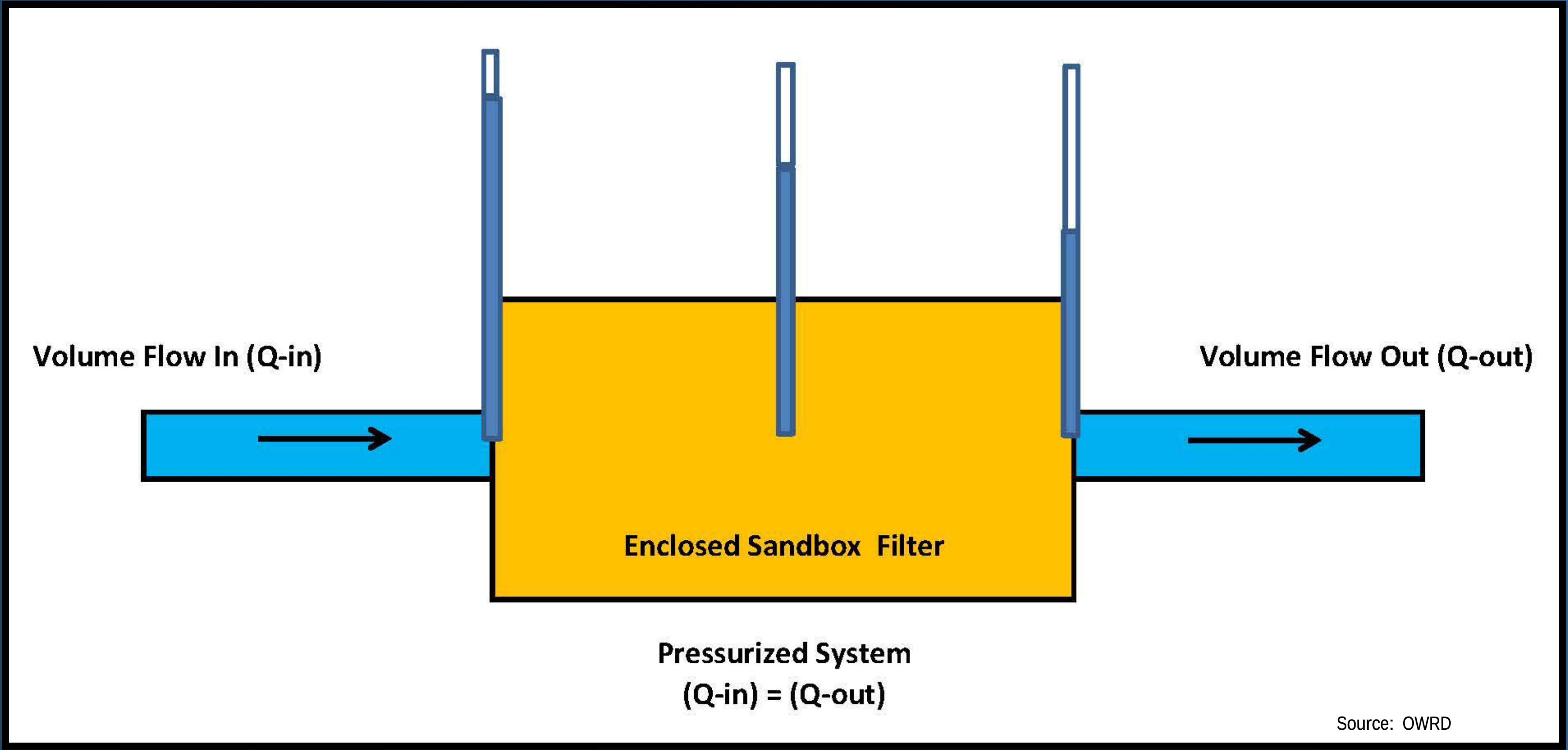
Groundwater Terms

Darcy's Law



Groundwater Terms

- Darcy's Law: Darcy's Equation

$$Q = K A \frac{(h1 - h2)}{L}$$

Where:

Q = volumetric flow rate (cubic feet / sec)
K = hydraulic conductivity of the material (feet / sec)
A = cross-sectional area (thickness (ft.) x width (ft.))
h1 & h2 = total hydraulic head at location 1 & 2 (feet)
L = distance from location 1 to location 2

Groundwater Terms

- Darcy's Law: Darcy's Equation

$$Q = K A \frac{(h1 - h2)}{L}$$

Similar to equation for electrical circuits (Ohm's Law):

$$V = I R$$

Rewritten: $I = \frac{1}{R} V$

Groundwater Terms

- Darcy's Law: Total Hydraulic Head

Total height of water in well above a datum

Three Components

- Elevation head (height due to elevation)
- Pressure head (height due to pressure)
- Velocity head (often disregard, low GW velocity)

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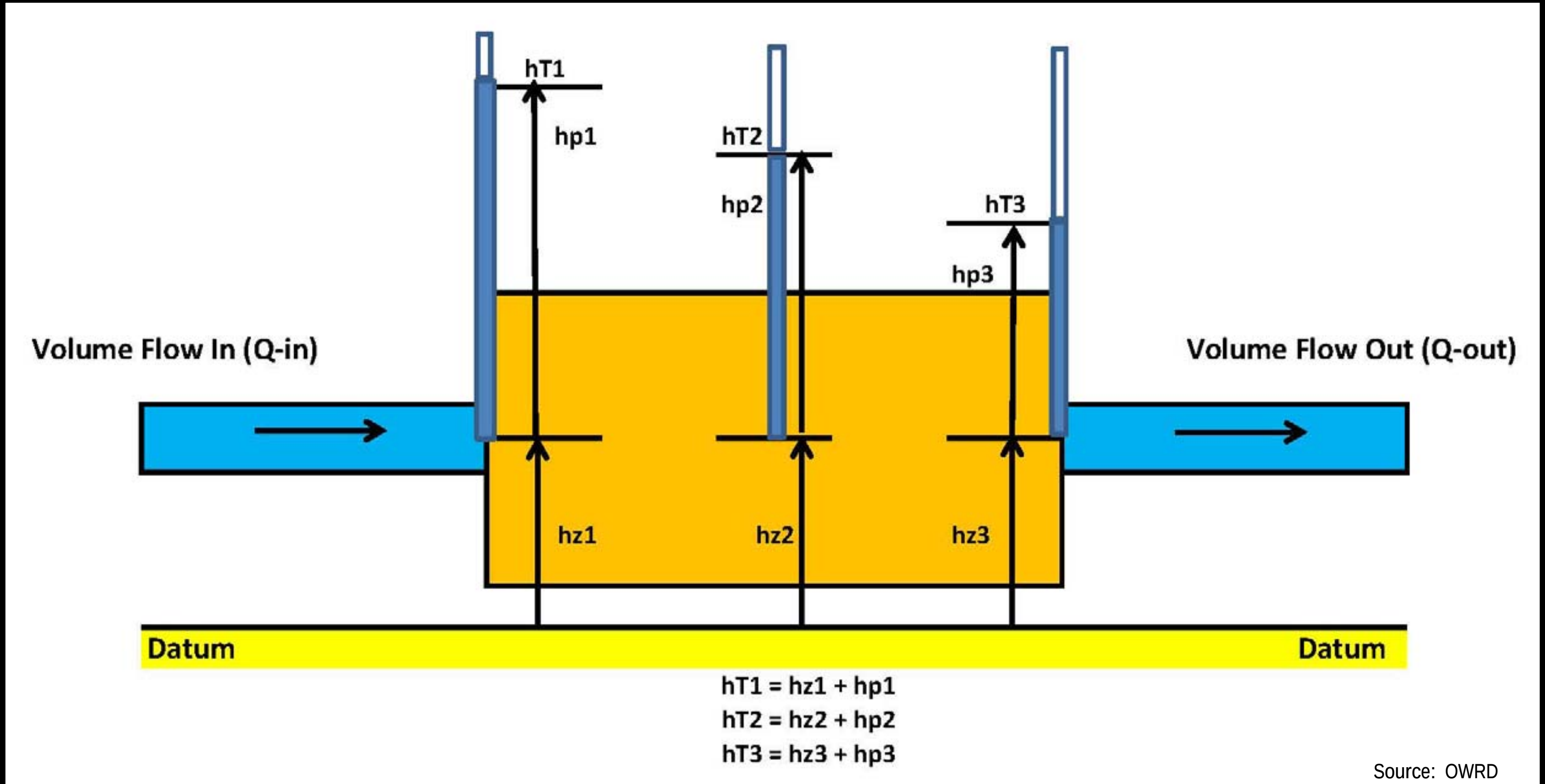
Groundwater Terms

Darcy's Law: Total Head



Source: OWRD

Groundwater Terms

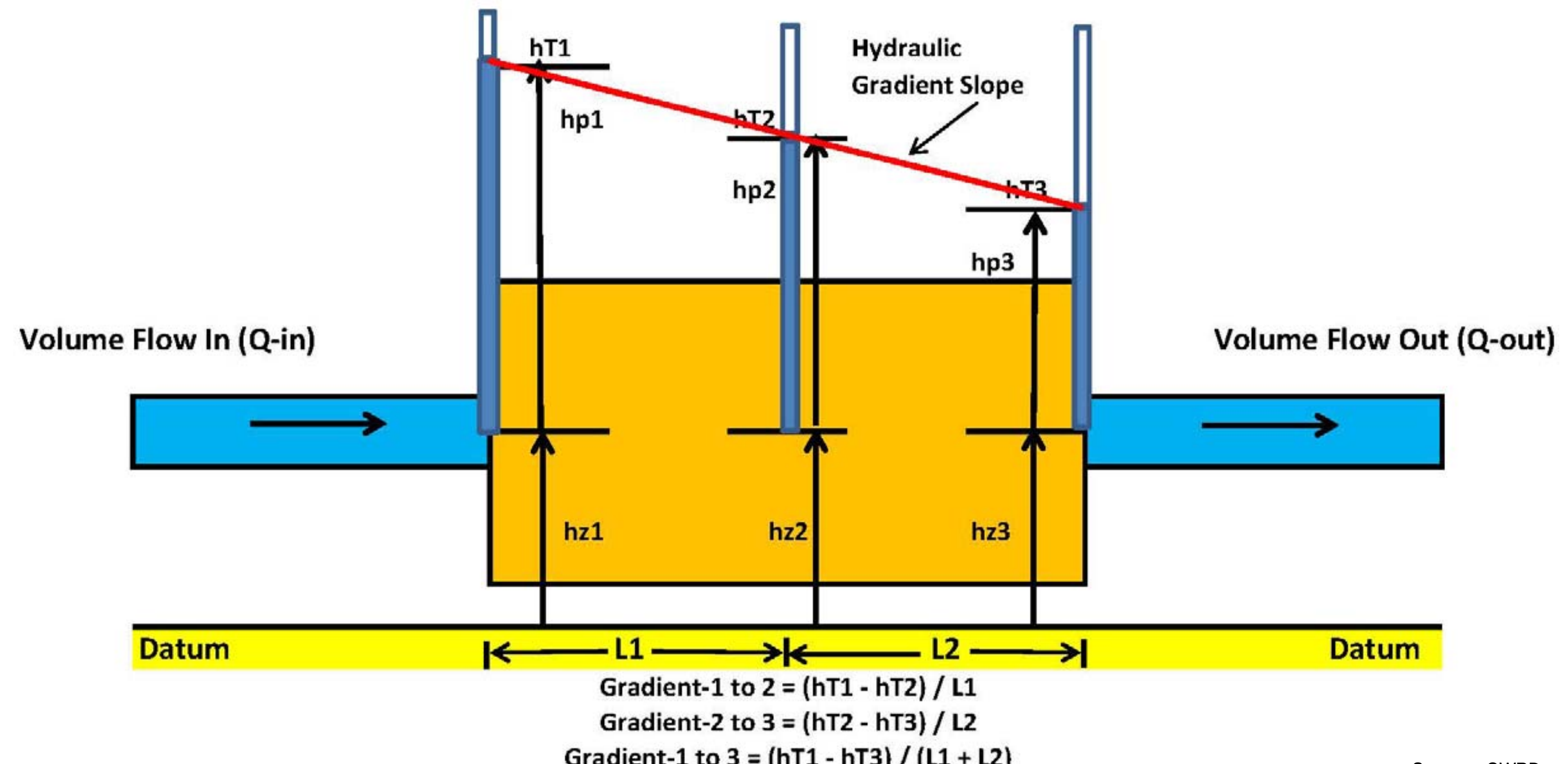
- Darcy's Law: Hydraulic Gradient

Change in total head per unit distance measured in the direction of steepest change

$$\frac{(hT1 - hT2)}{(\text{distance from } hT1 \text{ to } hT2)}$$

Groundwater Terms

Darcy's Law: Hydraulic Gradient



Source: OWRD

Groundwater Terms

Darcy's Law: Hydraulic Gradient

Let: hT1 = 10.0 feet, ht2 = 7.5 feet, hT3 = 5.0 feet
L1 = 50 feet, L2 = 50 feet, L1 + L2 = 100 feet

Then:

Gradient 1 to 2 = (10.0 ft – 7.5 ft) / 50 ft
= 2.5 ft / 50 ft = 0.05

Gradient 2 to 3 = (7.5 ft – 5.0 ft) / 50 ft
= 2.5 ft / 50 ft = 0.05

Gradient 1 to 3 = (10.0 ft – 5.0 ft) / 50 ft
= 5.0 ft / 100 ft = 0.05

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Groundwater Terms

- Darcy's Law: Hydraulic Conductivity (K)

  The capacity of a material to transmit water

  It is:

  - The volume of water at a given viscosity
  - That will move within a unit of time (T)
  - Under a unit hydraulic gradient
  - Through a unit area (A) measured at a right-angle (90 degrees) to the direction of flow

  It is expressed as: length / time (such as ft / day)

Groundwater Terms

- Darcy's Law: Hydraulic Conductivity (K)

  The capacity of a material to transmit water

  If the hydraulic conductivity is low (K is small):
  - The material has less capacity to transmit water
  - A larger hydraulic gradient is needed to move the same volume of water

  If the hydraulic conductivity is high (K is large):
  - The material has more capacity to transmit water
  - A smaller hydraulic gradient is needed to move the same volume of water

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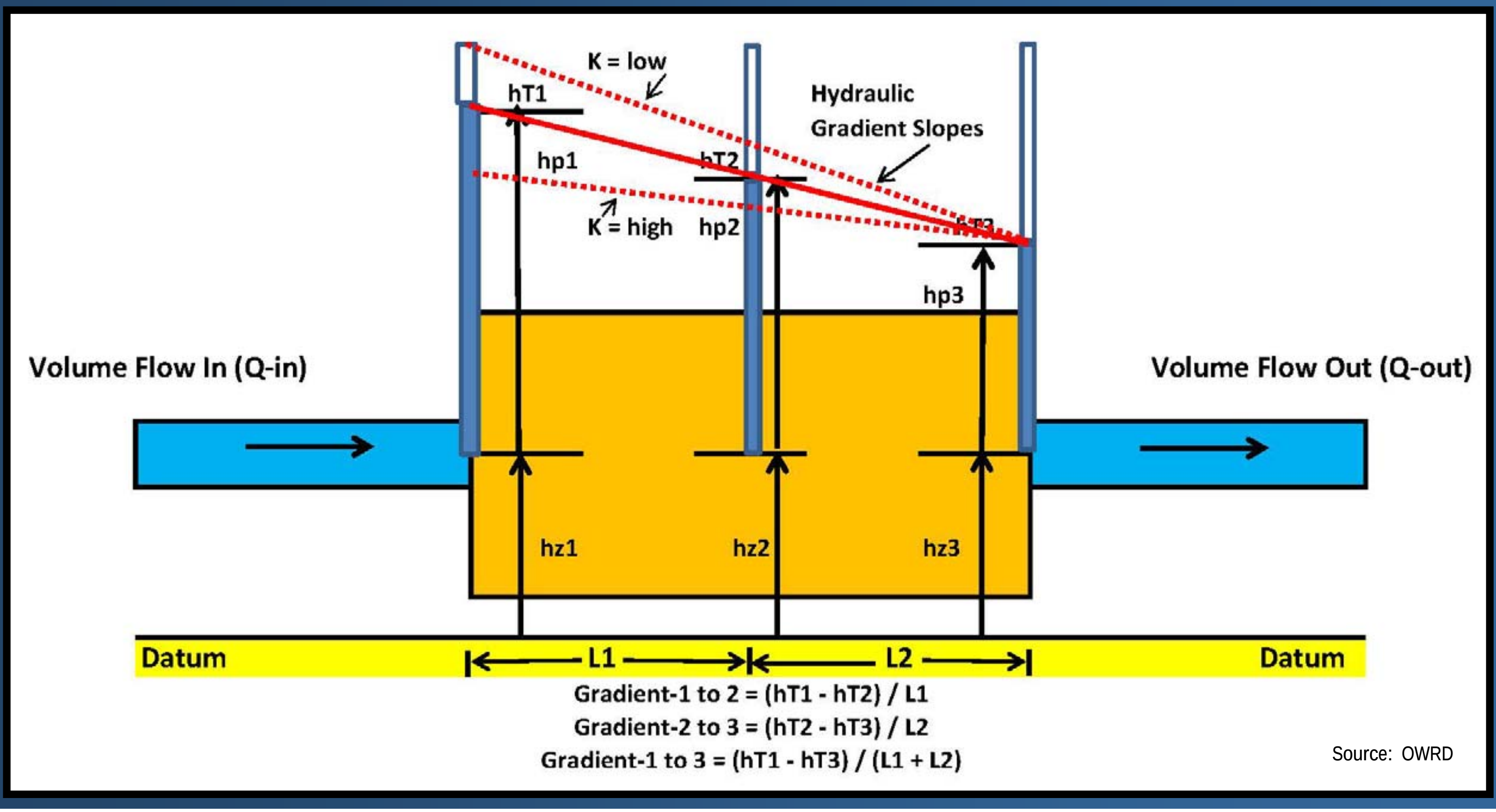
Groundwater Terms

Darcy's Law: Hydraulic Conductivity (K)



Source: OWRD

Groundwater Terms

- Darcy's Law: Hydraulic Gradient

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$$\frac{(hT1 - hT2)}{(\text{distance from } hT1 \text{ to } hT2)}$$

Groundwater Terms

- Darcy's Law: Hydraulic Gradient

Hydraulic Head Contour Line
Equipotential Line

A line on a map or a cross-section
along which the total heads are the same

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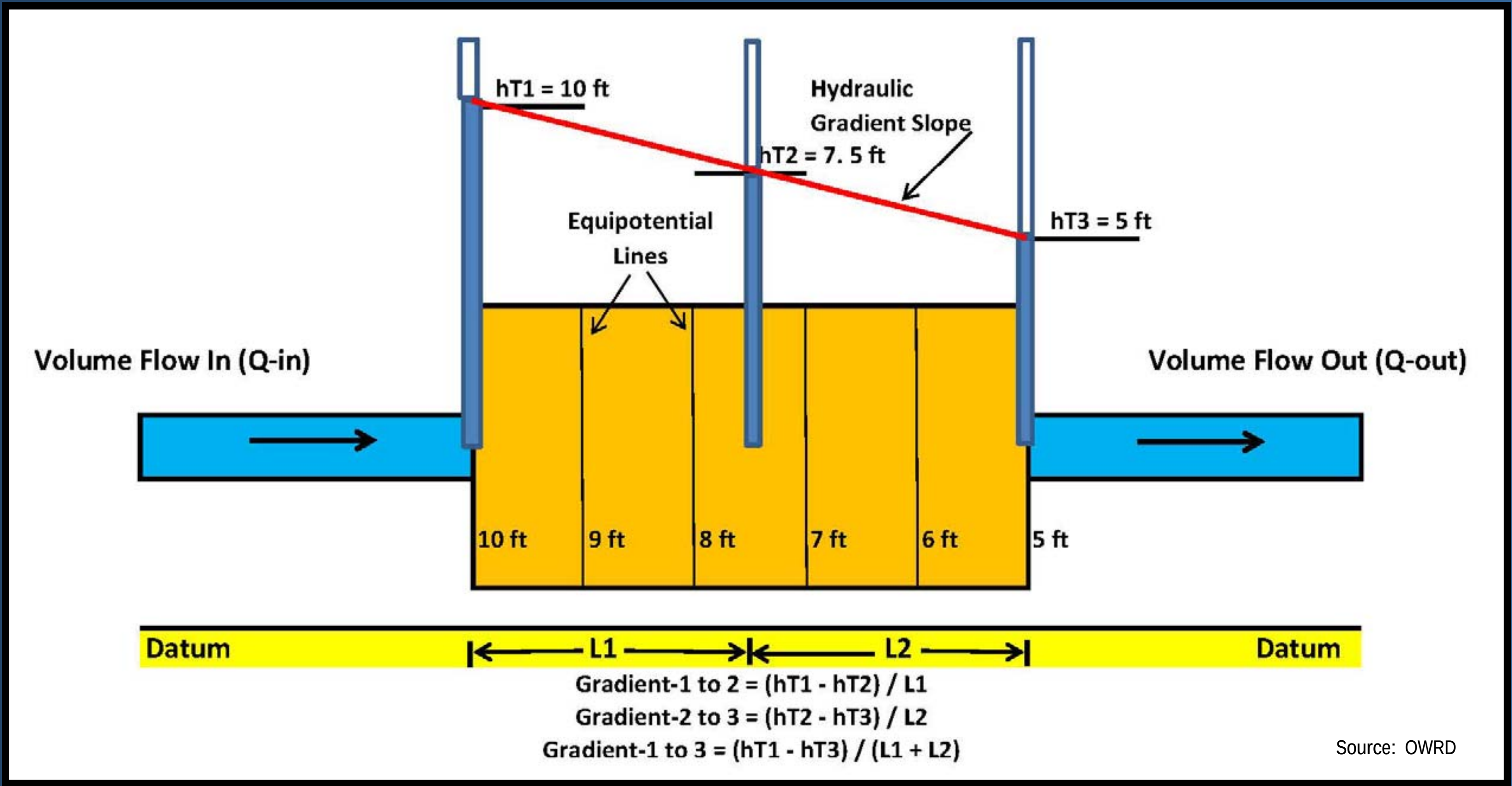
Groundwater Terms

- Darcy's Law: Hydraulic Gradient (original gradient)



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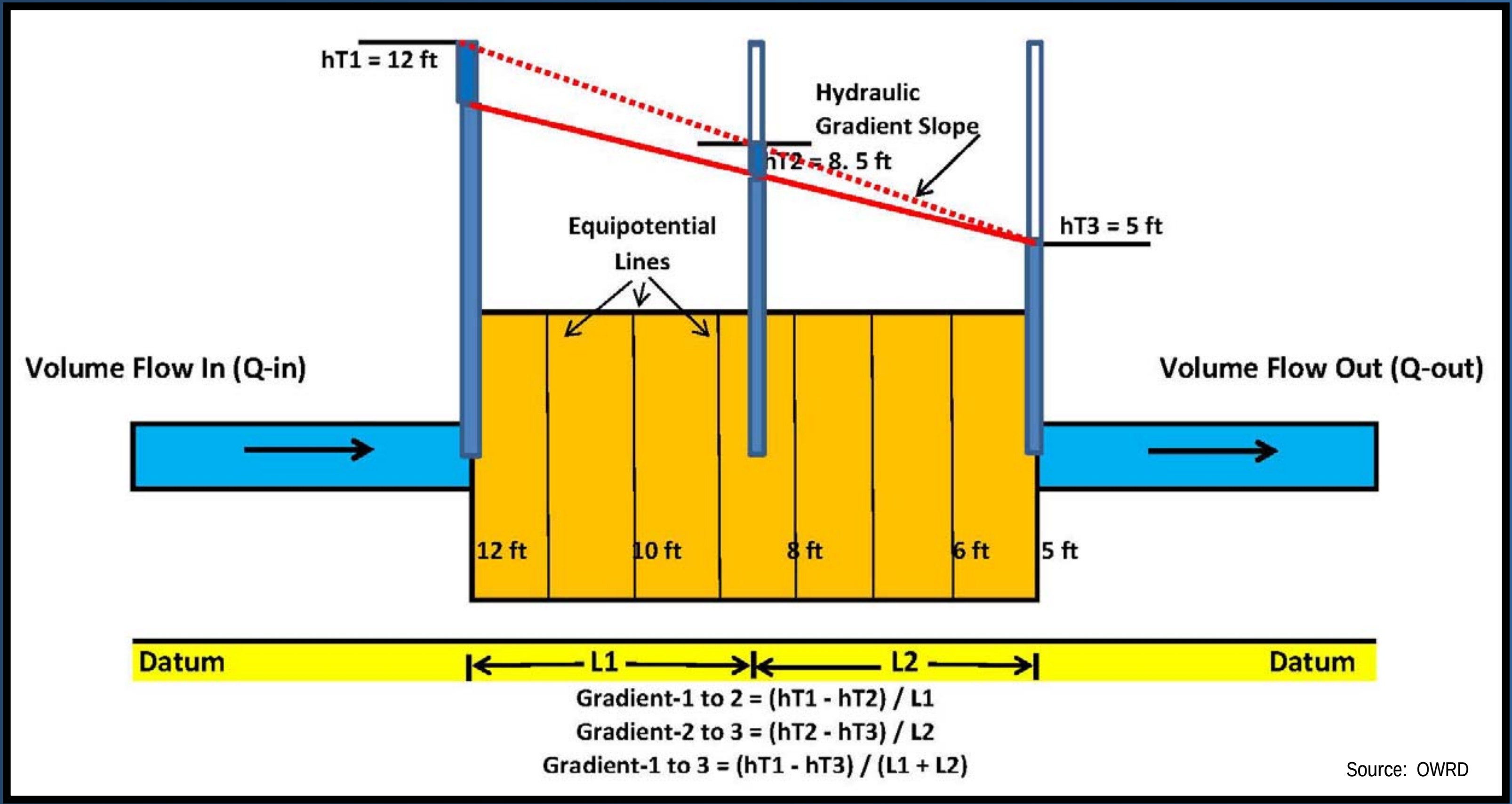
Groundwater Terms

- Darcy's Law: Hydraulic Gradient (larger gradient)



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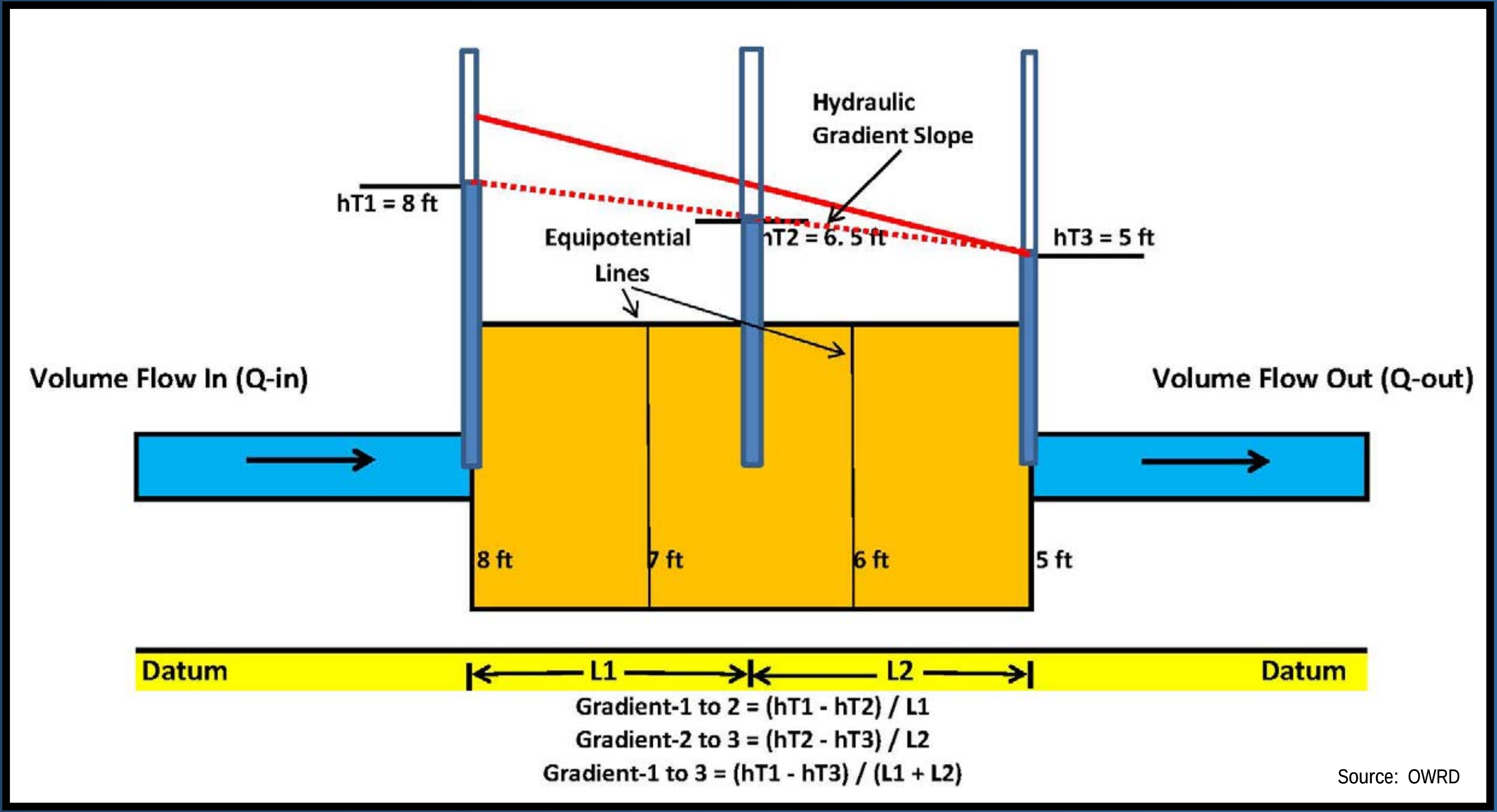
Groundwater Terms

- Darcy's Law: Hydraulic Gradient (smaller gradient)



Groundwater Terms

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Groundwater Terms

- Darcy's Law: Darcy's Equation

$$Q = K A \frac{(h1 - h2)}{L}$$

Similar to equation for electrical circuits (Ohm's Law):

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Rewritten: $$I = \frac{1}{R} V$$

Groundwater Terms

- Darcy's Law: Hydraulic Gradient (2-dimensions) (Total Head or Equipotential Map)

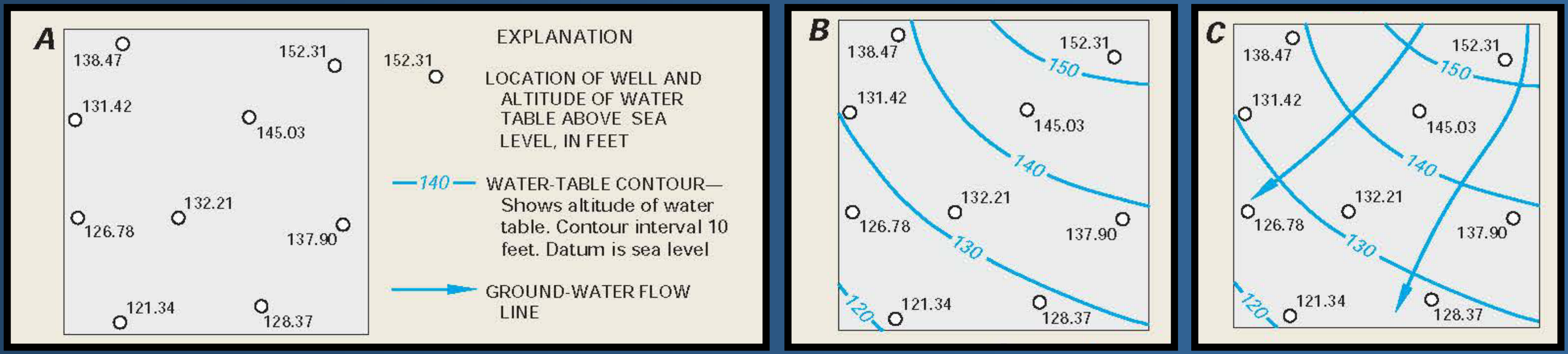


Figure A–2. Using known altitudes of the water table at individual wells (A), contour maps of the water-table surface can be drawn (B), and directions of ground-water flow along the water table can be determined (C) because flow usually is approximately perpendicular to the contours.

Source: USGS

Groundwater Terms

- Darcy's Law: Hydraulic Gradient (2-dimensions) (vertical & horizontal cross-section)

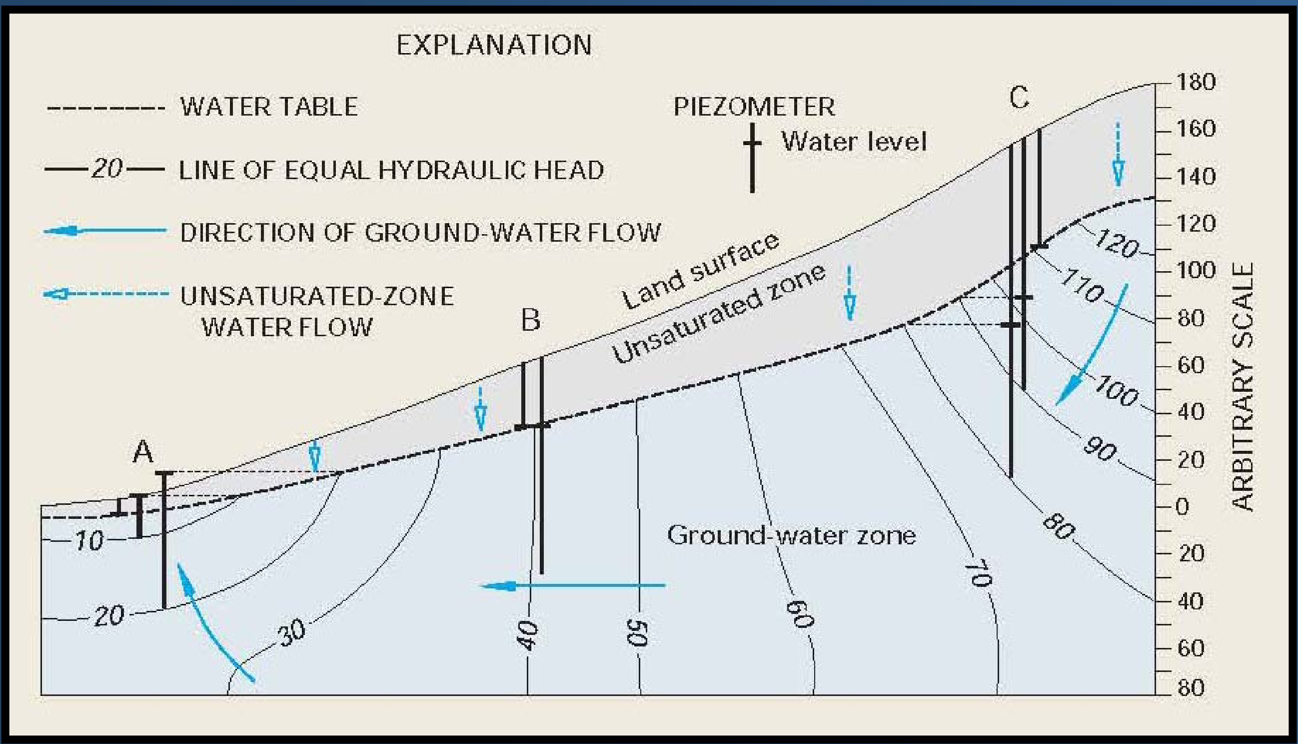
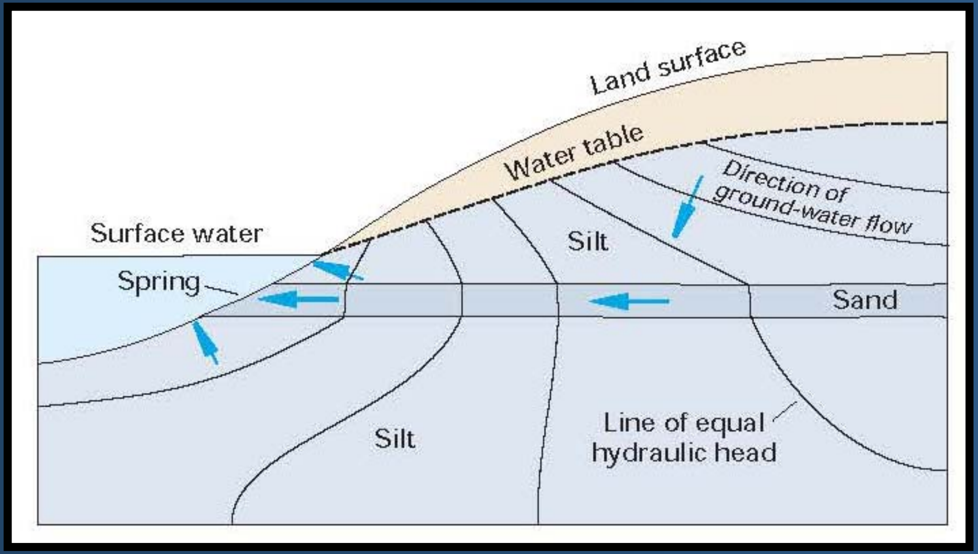


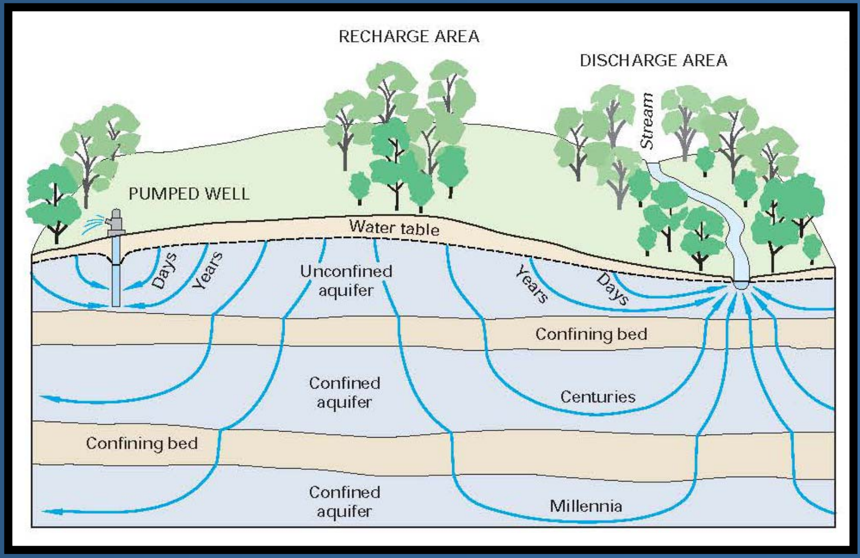
Figure A–3. If the distribution of hydraulic head in vertical section is known from nested piezometer data, zones of downward, lateral, and upward components of ground-water flow can be determined.

Source: USGS

Groundwater Terms

- Darcy's Law: Hydraulic Gradient (2-dimensions) (vertical & horizontal cross-section)





Source: USGS

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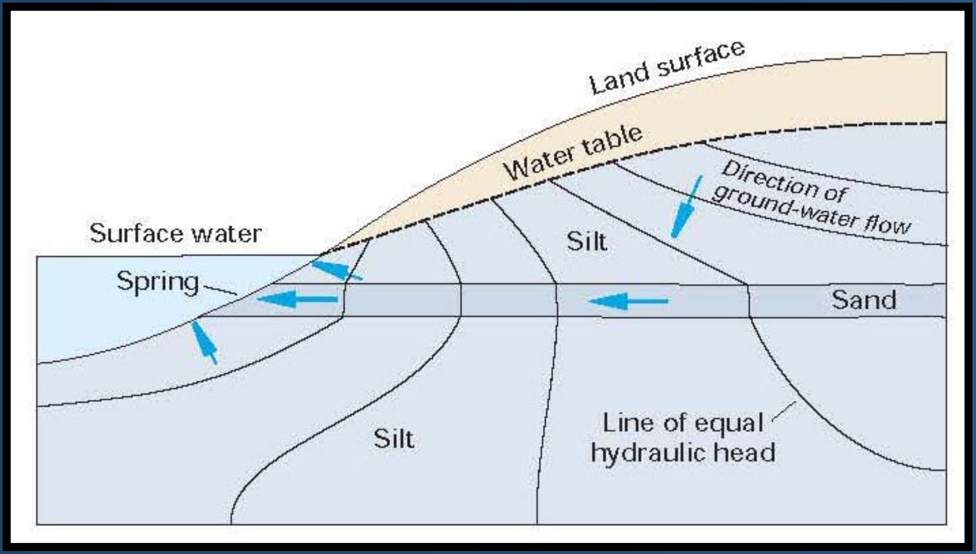
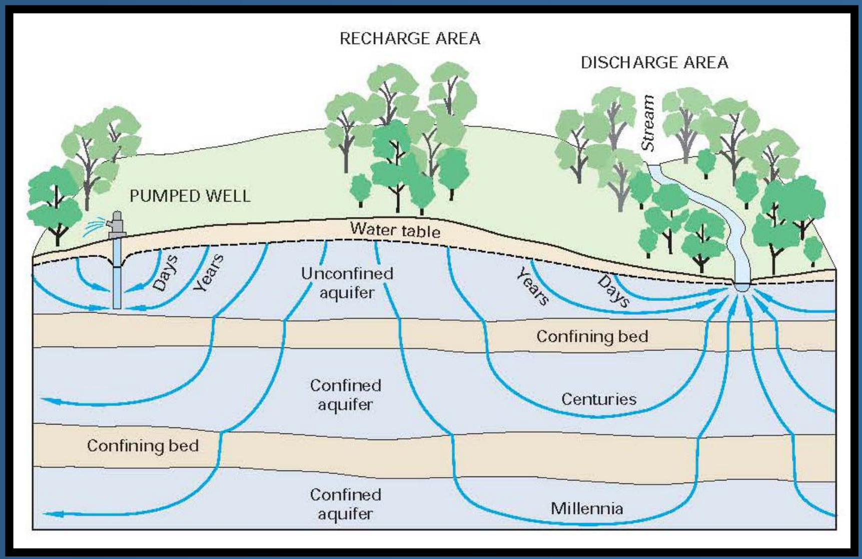
Groundwater Terms

Hydraulic Connectivity





Source: USGS

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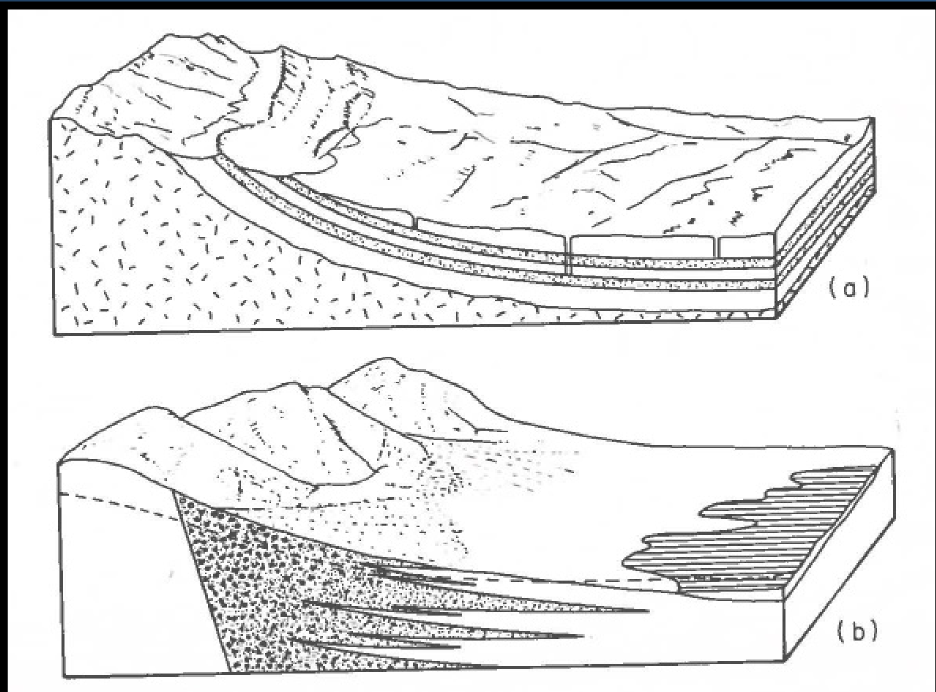
Groundwater Terms

Hydraulic Connectivity



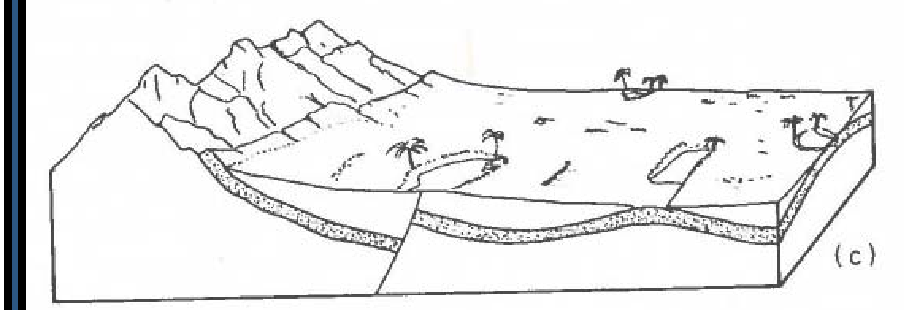


Figure 4.1 Influence of stratigraphy and structure on regional aquifer occurrence. (a) Gently dipping sandstone aquifers with outcrop area along mountain front; (b) interfingering sand and gravel aquifers extending from uplands in intermountain region; (c) faulted and folded aquifer in desert region. Surface water bodies reflect structural features (after Hamblin, 1976).

Source: Freeze & Cherry

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Questions & Thank You

Photo by Chad Sobotka

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Analyzing Differing-Unique Data

OWRD-USGS Methodology for Analyzing Data

All available data will be
Gathered and analyzed

Data identified as differing and / or unique
Will be explained-interpreted or
Identified as a subject for future study & explanation

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Questions & Thank You

Photo by Chad Sobotka

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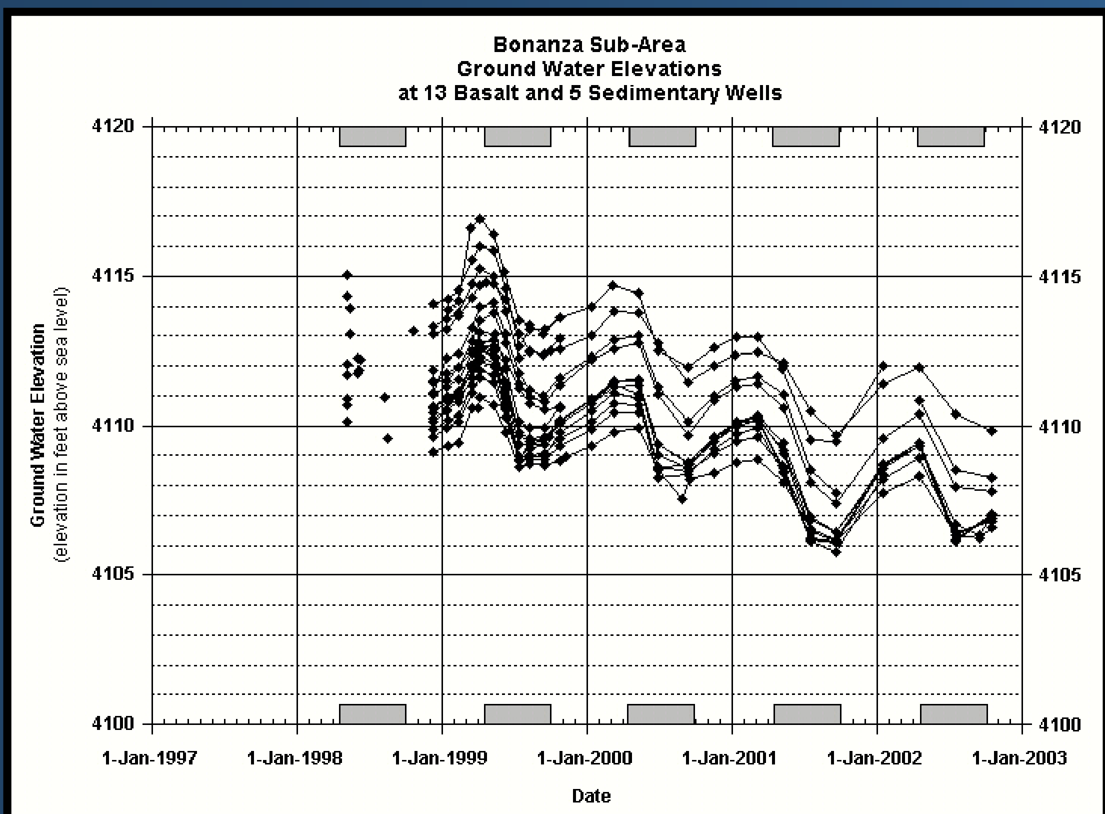
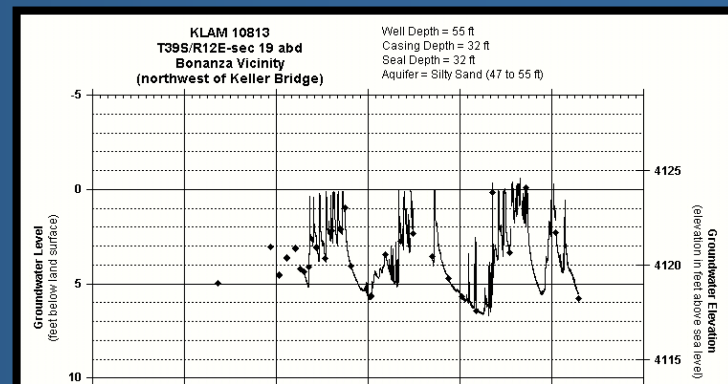
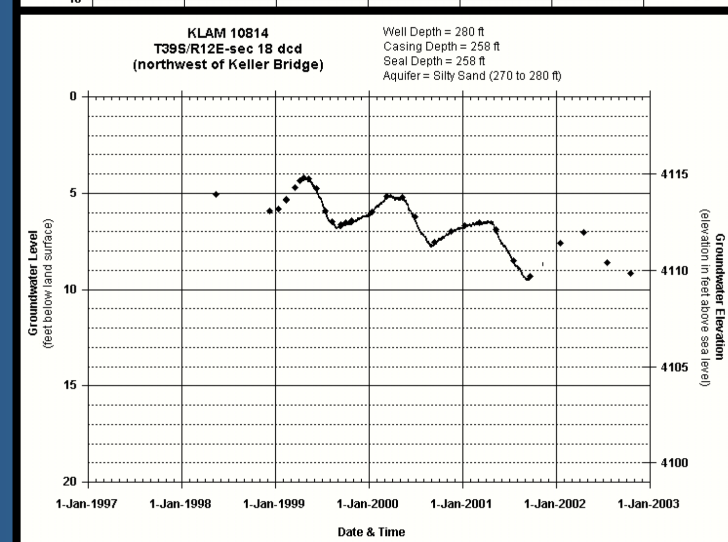
Analyzing Differing-Unique Data







Source: OWRD

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Analyzing Differing-Unique Data

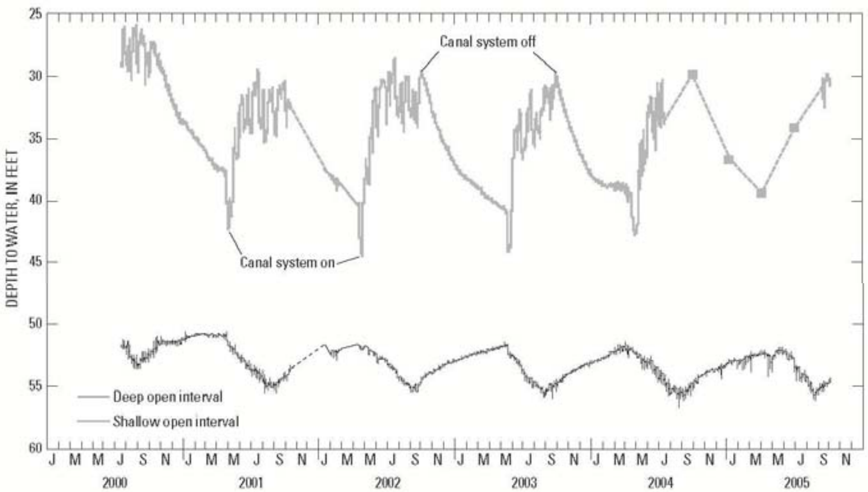

Figure 28. Water-level fluctuations in shallow and deep water-bearing zones in double-completion well 39S/12E-35ABB near Lorella, Oregon.

Source: USGS

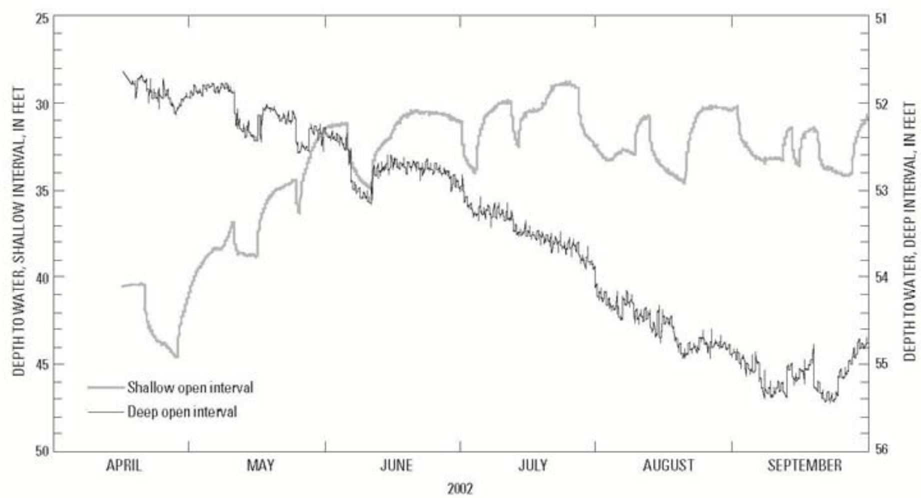

Figure 29. Water-level fluctuations in shallow and deep water-bearing zones in double-completion well 39S/12E-35ABB near Lorella, Oregon, with time scale expanded to show effects of nearby ground-water pumping.

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Questions & Thank You

Photo by Chad Sobotka