Water Cycle and Hydrology

Groundwater processes and chemistry

Water Forum Suriname & GCCA+

Water Training

Integrated Water Resources Management

July, 17th – 18th 2023

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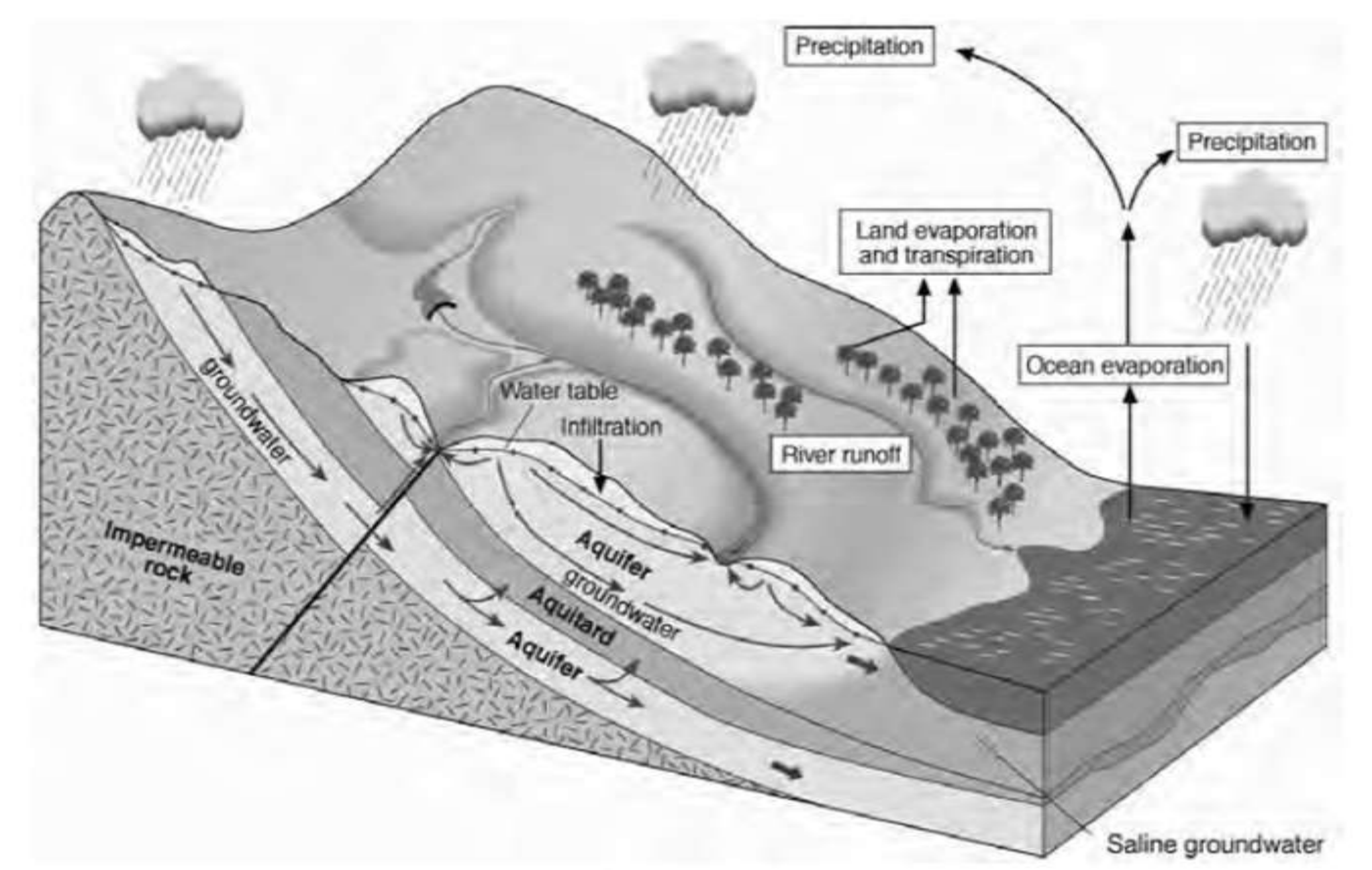
The natural hydrological cycle



Source: WHO 2006

Groundwater in the hydrological cycle

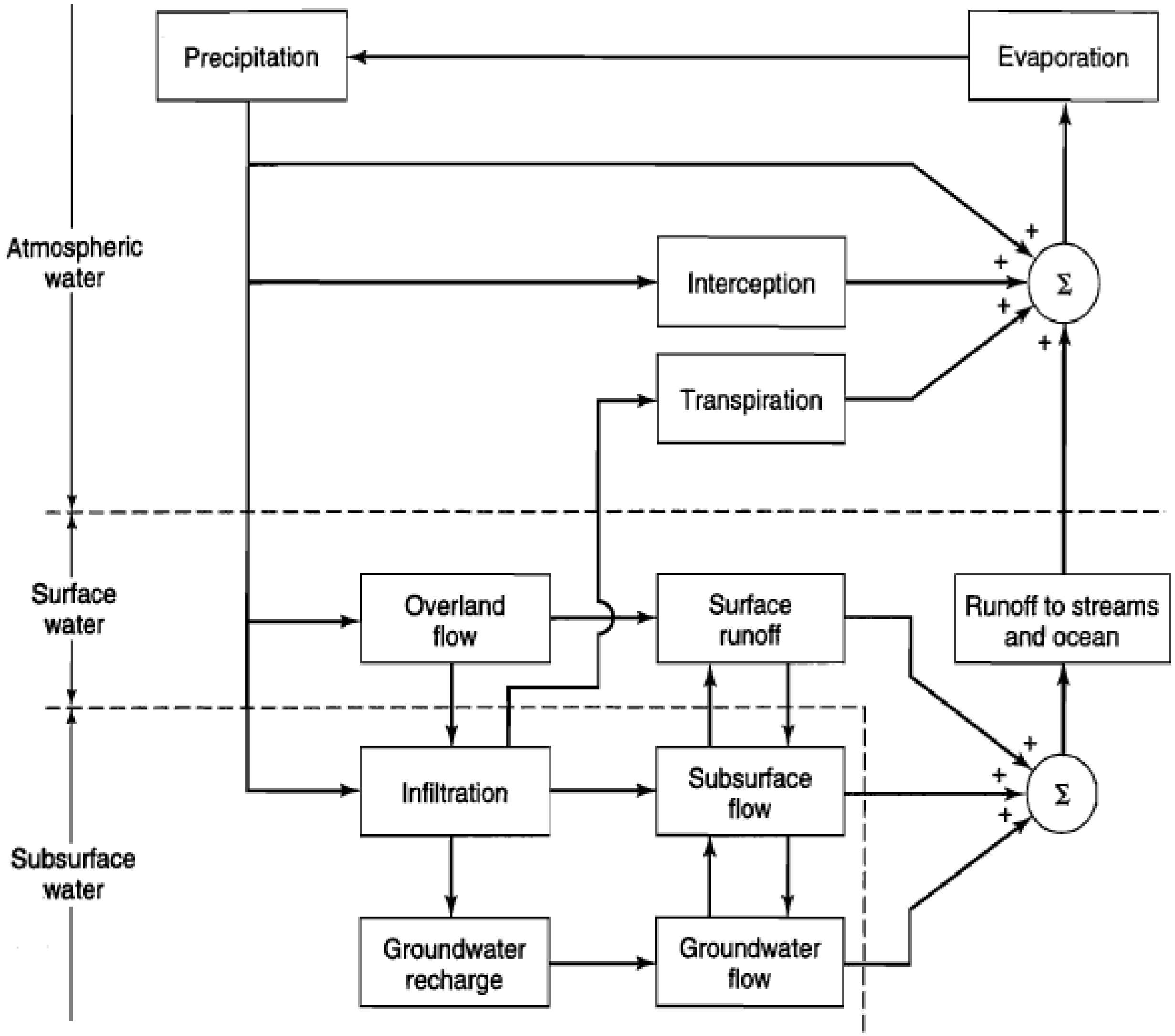


Figure 1.5.2. Block-diagram representation of the global hydrologic system.[22]

Soil moisture and groundwater

Unsaturated zone

- Voids filled with air and moist
- Zones:
  - Soil moisture zone, close to soil surface
  - Intermediate vadose zone
  - Capilair zone

Saturated zone

- Voids filled with water
- Ground water

Pheatic surface/Groundwater surface

- Border between unsaturated and saturated zone

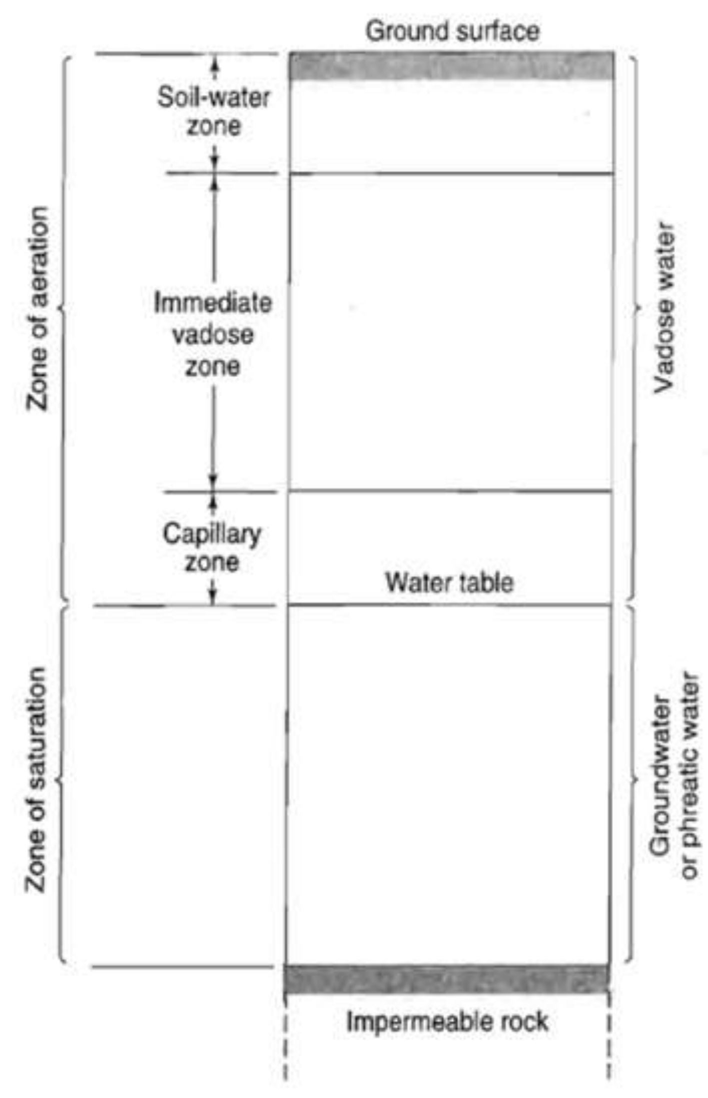


Figure 2.3.1. Divisions of subsurface water.

Aquifers

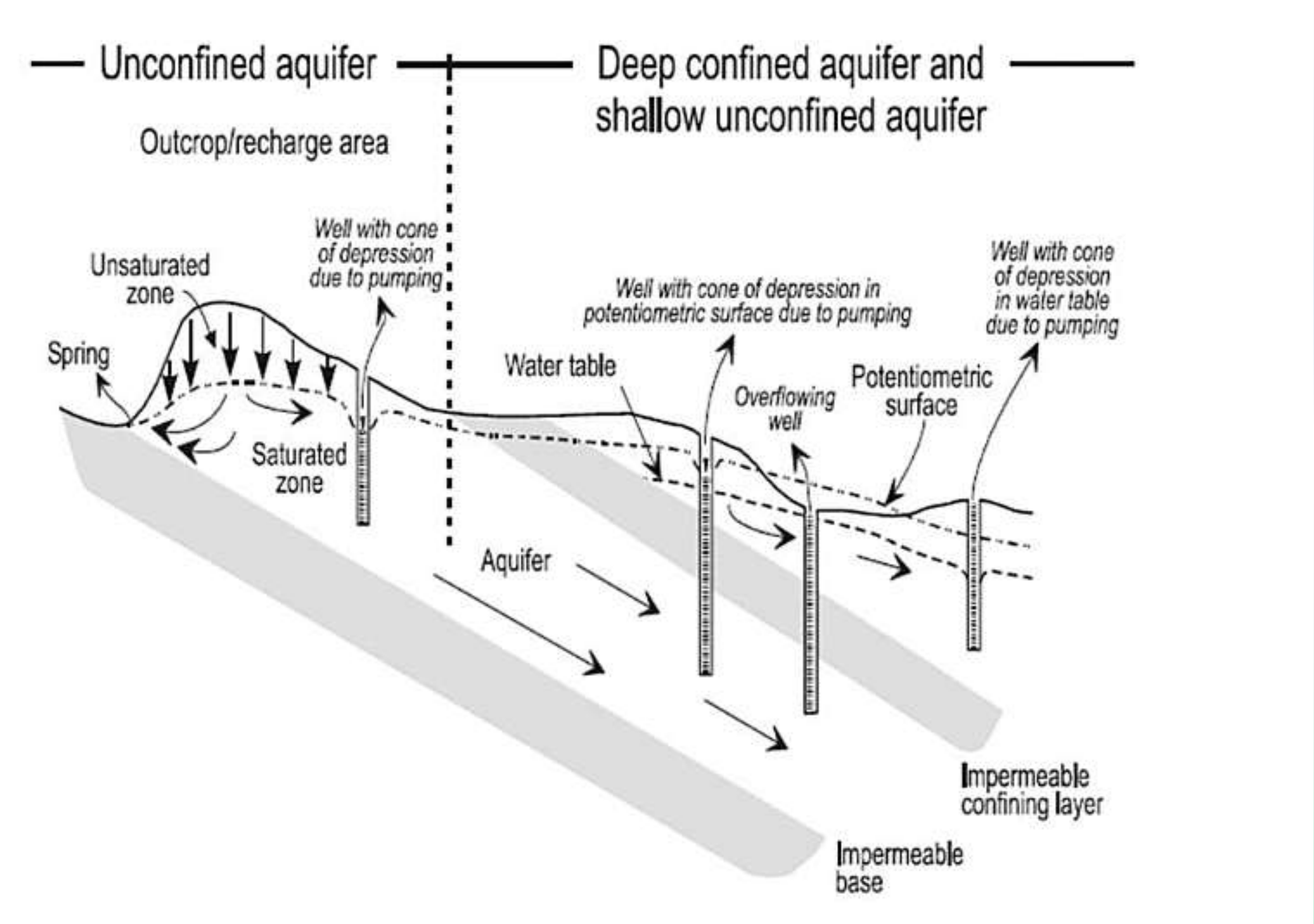
Is a water bearing strata, important for groundwater use

- **Unconfined aquifer: upper layer is in connection with the atmospheric pressure**
  - **Upper part of aquifer permeable**
  - **Upper part In contact with the atmopheric pressure**
  - **Undeep ground water**

- **Confined aquifer: confined by impermeable ground layers**
  - **Top and bottom enclosed by impermeable layers**
  - **Water under pressure due hydrostatic pressure**
  - **Water may well up**
  - **A spring, when the water wells up above the soil surface**
  - **Deep groundwater**

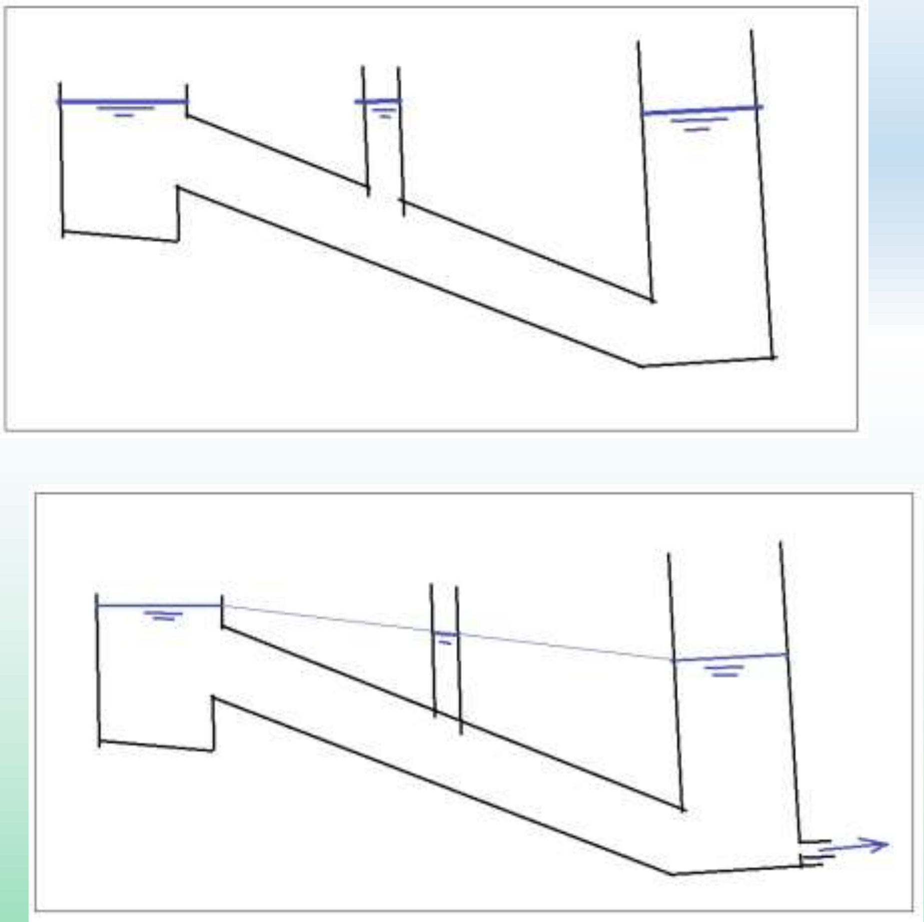
- **Leaky aquifer**
  - **Combination of both**

Confined an unconfined aquifers

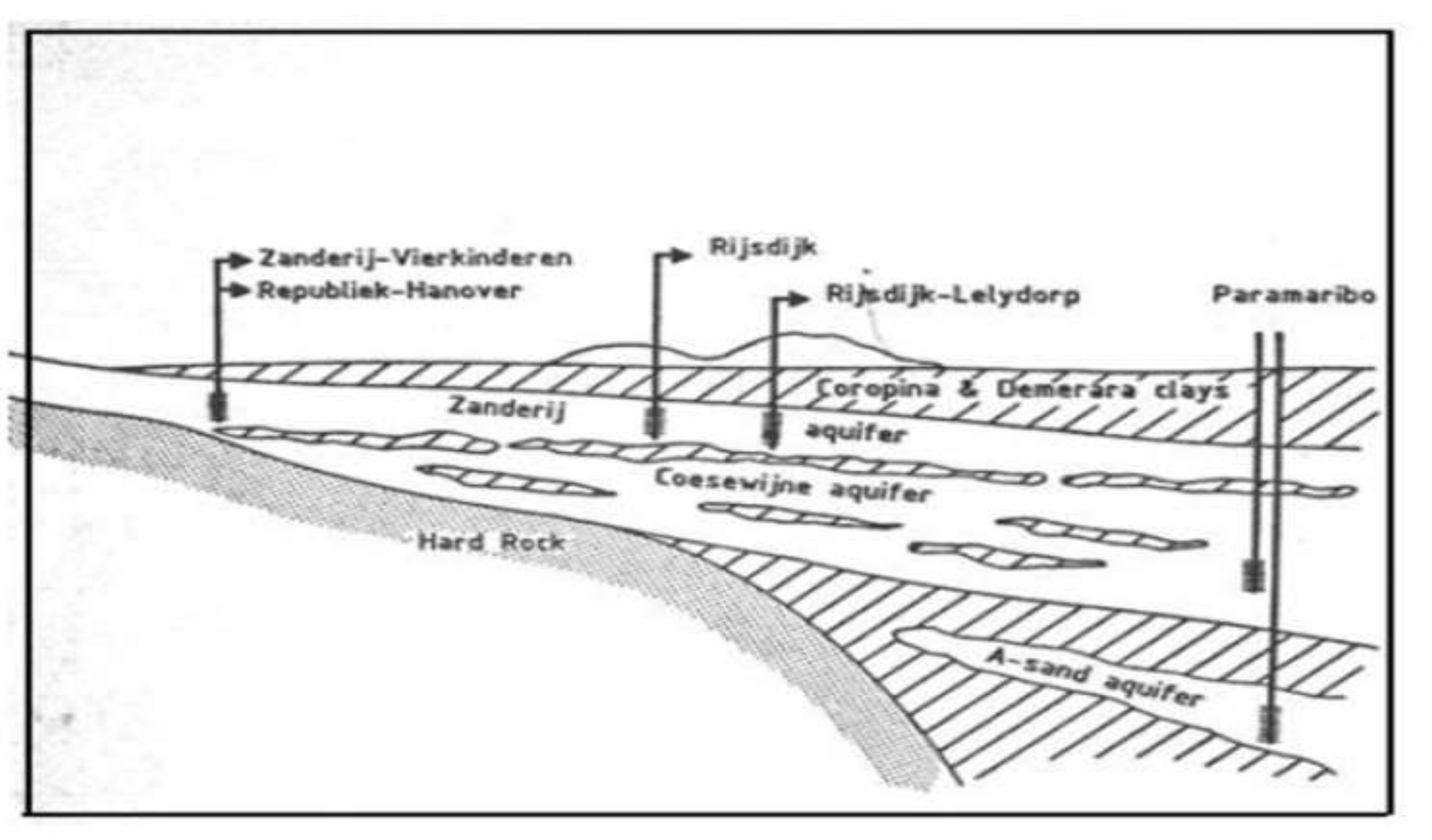


Source: WHO 2006

Flow through pipes



Aquifers in Suriname



Mainly found in the coastal plain.

Build up of

- unconsolidated sediments, consisting of a sequence of clay, sand, sandy clay, clayey sands, gravel with more or less kaolin content, and thin bed organic compounds.

Type of aquifers

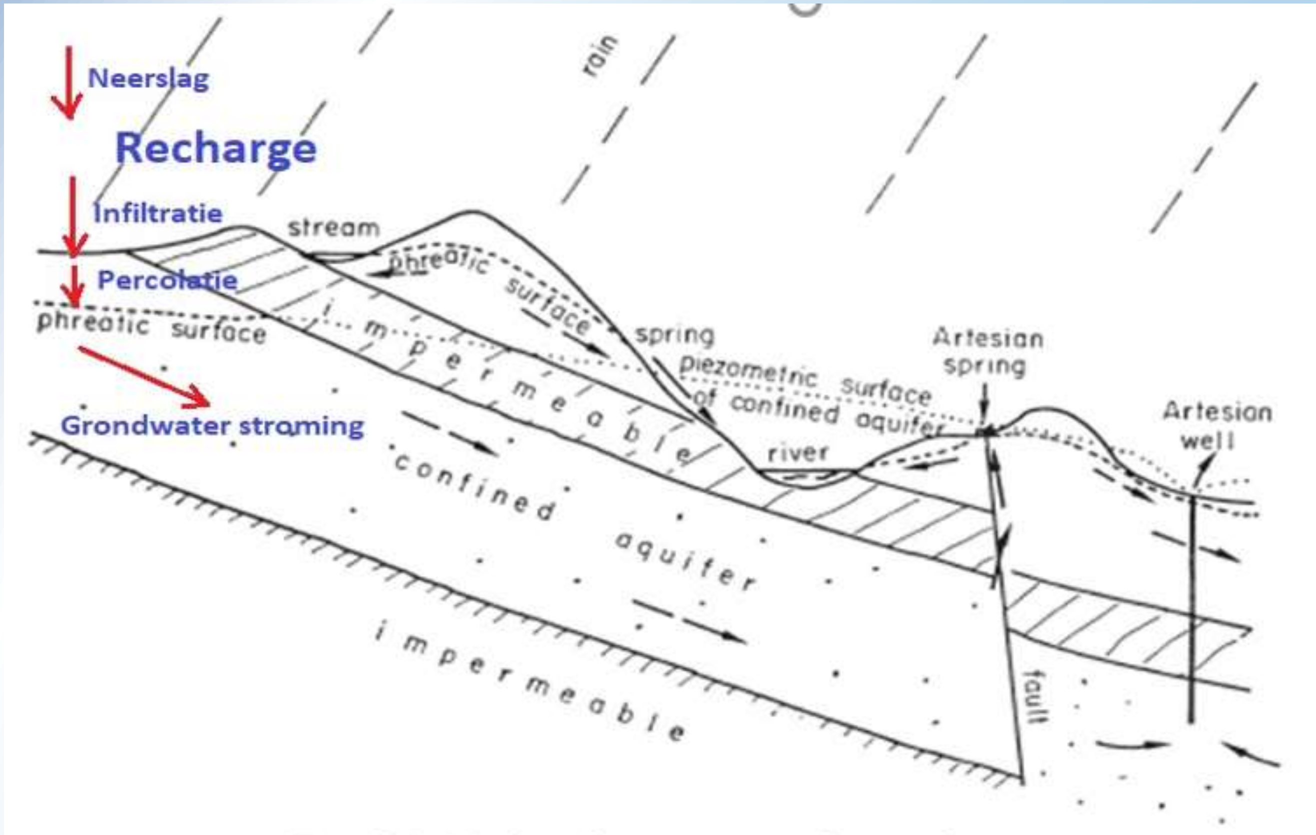
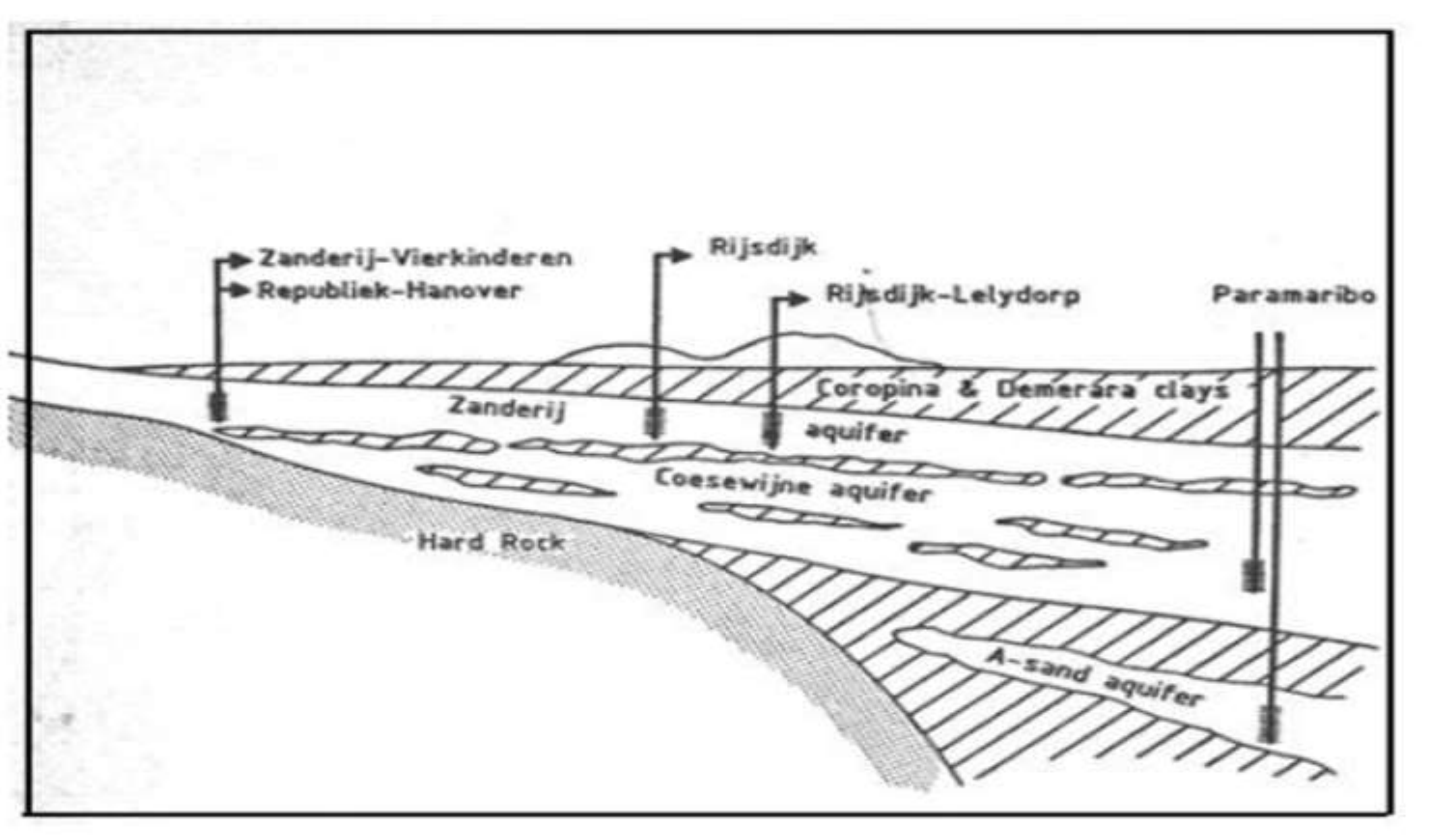


FIG. 5.1 *Modes of occurrence of groundwater*

Groundwater systems

- Shallow groundwater and deep groundwater aquifers
- Unconfined and confined aquifers,
- Recharge, depletion, mining
- Water quality
  - Salinity: Max. 250 mg Cl^-/l for drinking water and max. 300 mg Cl^-/l for freshwater crops

Aquifers in Suriname



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Build up of

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Aquifers in Suriname

- **Aquifers classified based on the geological ages:**
  1. Nickerie,
  2. Onverwacht,
  3. A-sand,
  4. Coesewijne,
  5. Zanderij,
  6. Coropina
  7. Demerara aquifers.
- **Freshwater aquifers**
  - A-sand aquifers (Oligocene age),
  - Coesewijne aquifers (Miocene age)
  - Zanderij aquifers (Plio-Pleistocene age) .

- **Deep ocean floor (Groen)**
  - below the brackish groundwater in front of the coast of Suriname, enormous amount of freshwater stored,
  - sufficient for the water supply in Suriname for about 200,000 years under the current rate.

Aquifers in Suriname

Zanderij aquifer

- Freshwater
- Outcropping aquifer in the savanna area,
  - Annual recharge annual estimated at 480 mm in the savanna West of Zanderij
  - Anual recharge 200 mm in the Old Coastal plain at Rijsdijk.
- Depth 30-50 m
- Thickness 10-20 m
- Area 35,000 km^2
- Withdrawals: 37 % of drinking water supply, about 45,600 m^3/day

A-sand aquifers

- Freshwater
- Terminate Southward against the uprising basement.
- Depths 120-350 below soil surface
- Thickness: 60-80 m
- Withdrawals: 32 % of drinking water supply, about 39,000 m^3/day
- Area 15,000km2

Aquifers in Suriname

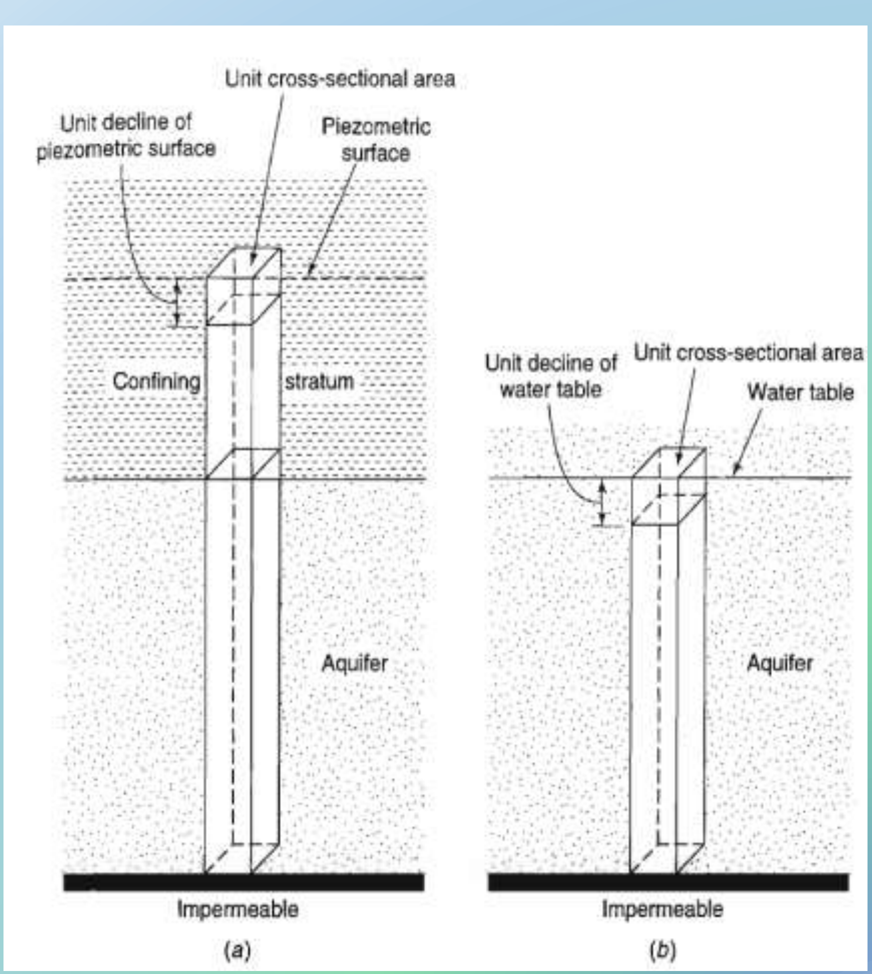
Coesewijne aquifers

- Freshwater
- Upper aquifers in contact with the overlying Zanderij aquifer.
- Overlain by thick clay deposits (Demerara formation) towards the seaward end, sealing themselves from saltwater intrusion
- Depths 230 m
- Thickness 100-120 m
- Withdrawals: 31 % of drinking water supply, about 38,600 m^3/day

Aquifers

Storage coefficient (storativity)

- Volume of water that an aquifer releases from or takes into storage per unit surface area of aquifer per unit change in component of head normal to that surface.
- Coefficient dimensionless quantity involving water volume per volume of aquifer.



Rock properties affecting ground water

Porosity of rock or soil

- A measure of contained interstices or voids expressed as ratio of volume of interstices to total volume (can also be expressed in %)

$$\alpha = \frac{V_v}{V} = \frac{V_t - V_s}{V_t}$$

α = porosity

V_v = volume of voids V_s = volume of solids V = total volume

Or

$$\alpha = \frac{\rho_m - \rho_d}{\rho_m} = 1 - \frac{\rho_d}{\rho_m}$$

ρ_m = density of mineral particles (grain density)

ρ_d = bulk density

- Effective porosity: amount of interconnected pore space available for fluid flow , expressed as ratio of interconnected interstices to total volume
- Primary and secondary porosity are associated with orriginal and secondary interstices resp.

Zone of saturation

- Groundwater fills all of the voids.
- (effective) porosity is direct measure of water contained per unit volume.
- A portion of the water can be removed by draining or pumping; molecular and surface tension forces hold the remainder of water in place.

$$S_r = \frac{w_r}{V_t}$$

Specific Retention (S_r)

- Is ratio volume of water it will retain after saturation against the force of gravity to its own soil/rock volume
- W_r = volume occupied by retained water
- V_t = bulk volume of soil or rock

Zone of saturation

Specific Yield (S_y)

- Is ratio volume of water that after saturation can be drained by gravity to its own volume

$$S_y = \frac{w_y}{V_t}$$

W_y = volume of water that can be drained by gravity after saturation

V_t = bulk volume of soil or rock

Groundwater flow

Flow through soil (porous medium)

Darcy law

V = k.S

V = velocity of water through soil (m/s)

k = permeability of soil (m/s)

S = hydraulic gradient (m/m) (of energy line, lijn van energie potentieel))

See figure: S = -Δh/Δ L

Q = V.A → V = Q/A

Q = Discharge

A = Area of soil cross-section of flow

Analogy with electricity

V = I.R

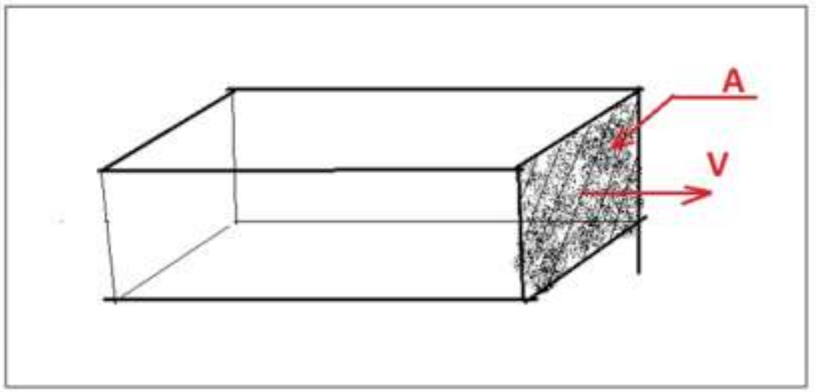
I = V/R

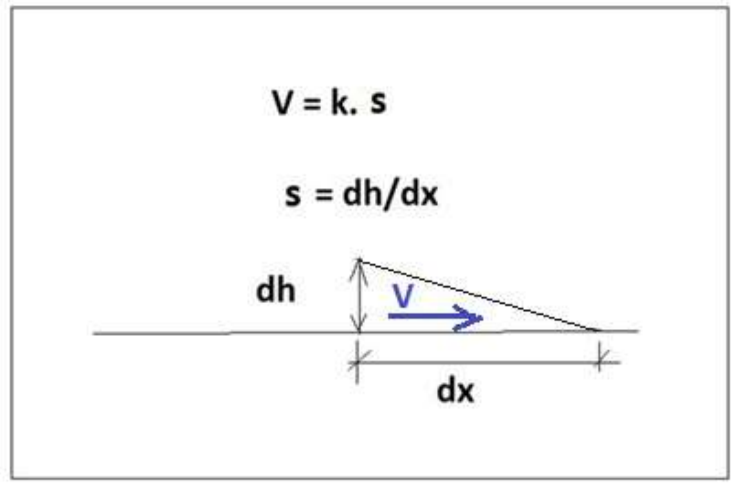
I = Electrical current

V = difference in electrical potential

R = ressistant

I/R = conductiviyty = k





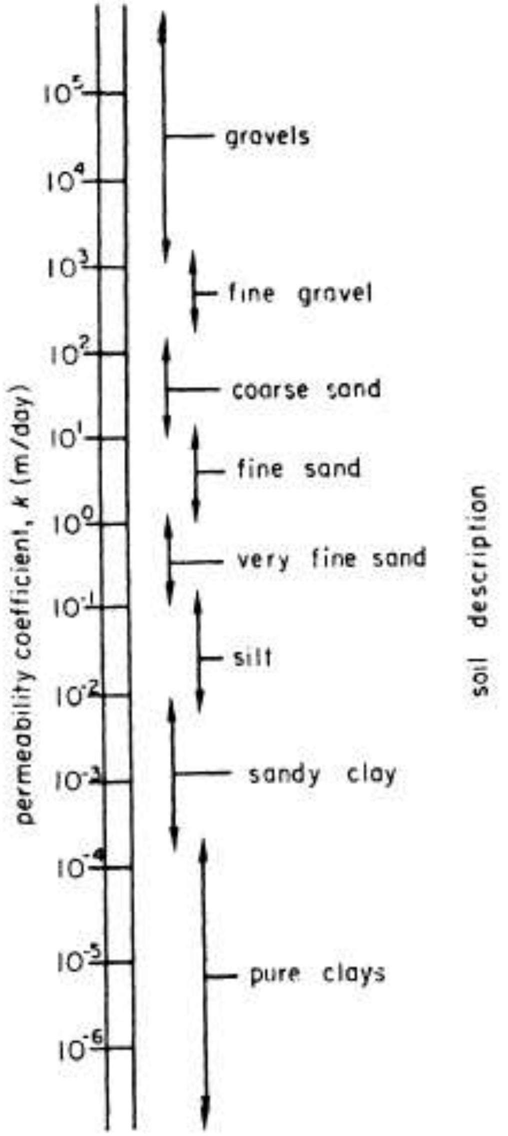


Figure 5.4 *Range of permeability in natural soils*

Flow through an aquifer

Slope is negative in the flow direction

$v = Q/A$

$S = -\Delta h/\Delta l$

$v = k.S \quad \rightarrow v = -k.dh/dl$

S is negative.

$Q = v.A =(-k.dh/dl).A$

S = slope of the energy line

Energy line: line that represents the elevation of energy head (potential energy, in feet or meters) of water flowing in a pipe, conduit, or channel.

Flow through confined aquifer

Confined aquifer

- ***Idealized aquifer***
- ***Unidirectional flow*** in a confined aquifer
- Permeability k
- Groundwater flowing from left to right,
- Energy required to move the water through the pores is continually using up the available head (flow ressistant in the soil)
- Line of potential head as indicated by piezometers introduced into the aquifer, is ***declining.***

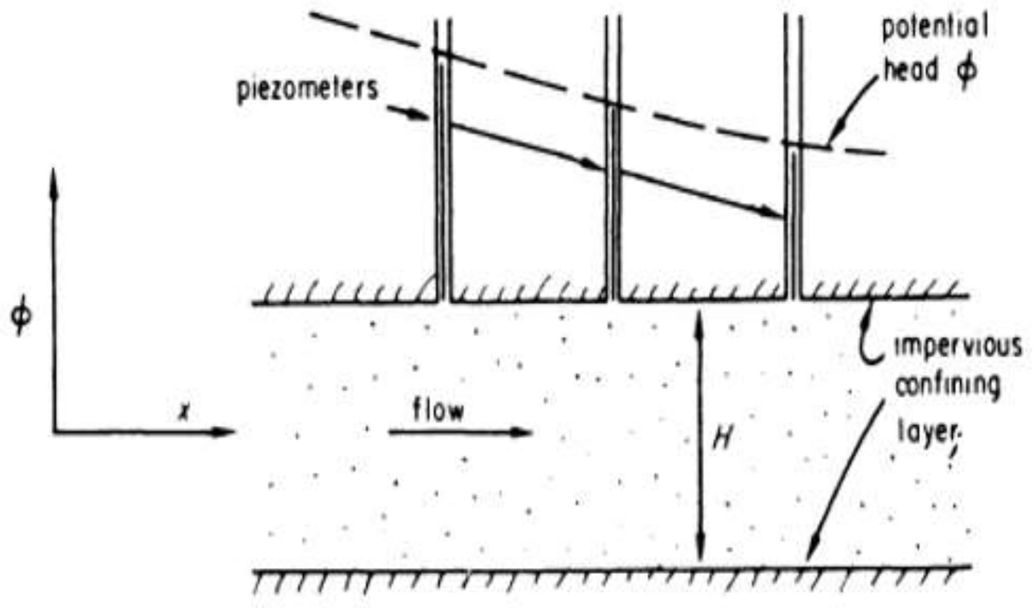


Figure 5.5 *Flow in a confined aquifer*

Steady Confined Flow

Water withdrawn from the aquifer, through a drilled well

r = horizontal coordinate from radially from the centre of the well

S = drawdown measured from undisburbed piezometric surface

Q_o = steady stage discharge

r = distance in flow direction

$S_1 - S_2 = [Q_o/(2\pi kH)].Ln\ (r_2/r_1)$

(Thiems equation)

S1 and S2 = drawdown at resp. point 1 and 2

r1 and r2 = distance to points 1 and 2 resp. rom centre of the well

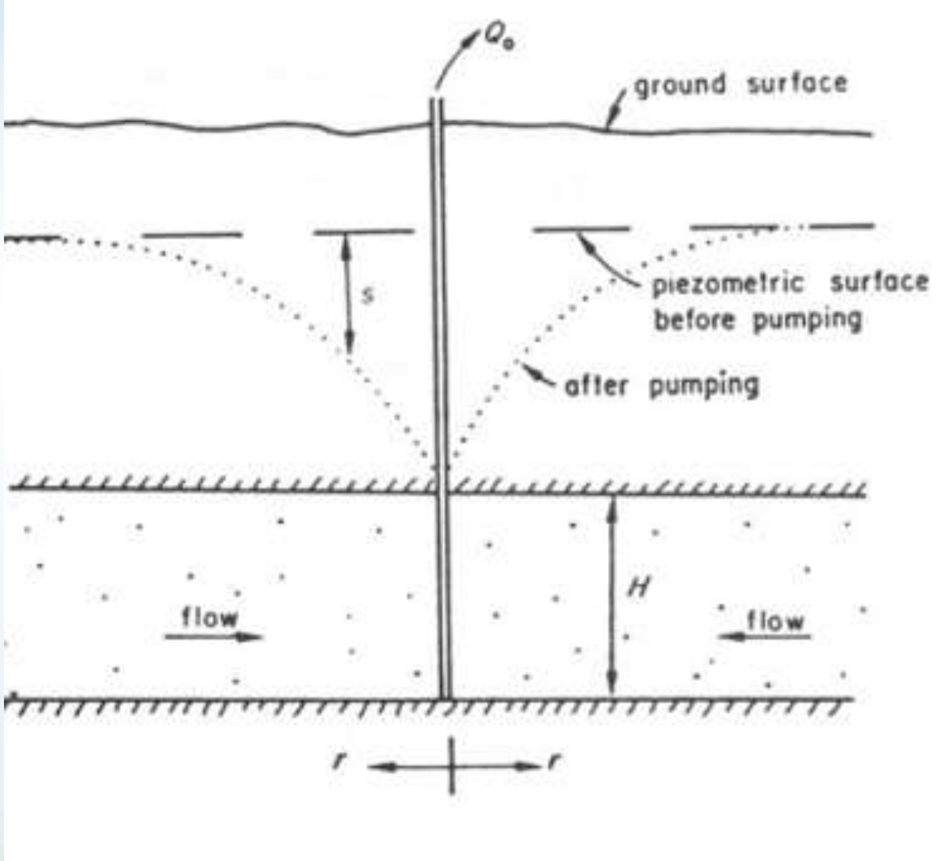


Figure 5.11 *Well pumping from a confined aquifer*

Steady Confined Flow

kH = coeëficient of transmisibility

Indefinitely Integrating results

$$S1-S2= [Qo/(2\pi kH)].Ln (r2/r1)$$

Q_0 and R are boundary conditions

S = drawdown

r = distance from the centre of the well

When r2 = R, S2 = 0

Q_0 = discharge from the well

$$S = [Q_o/(2\pi kH)].Ln (R/r)$$

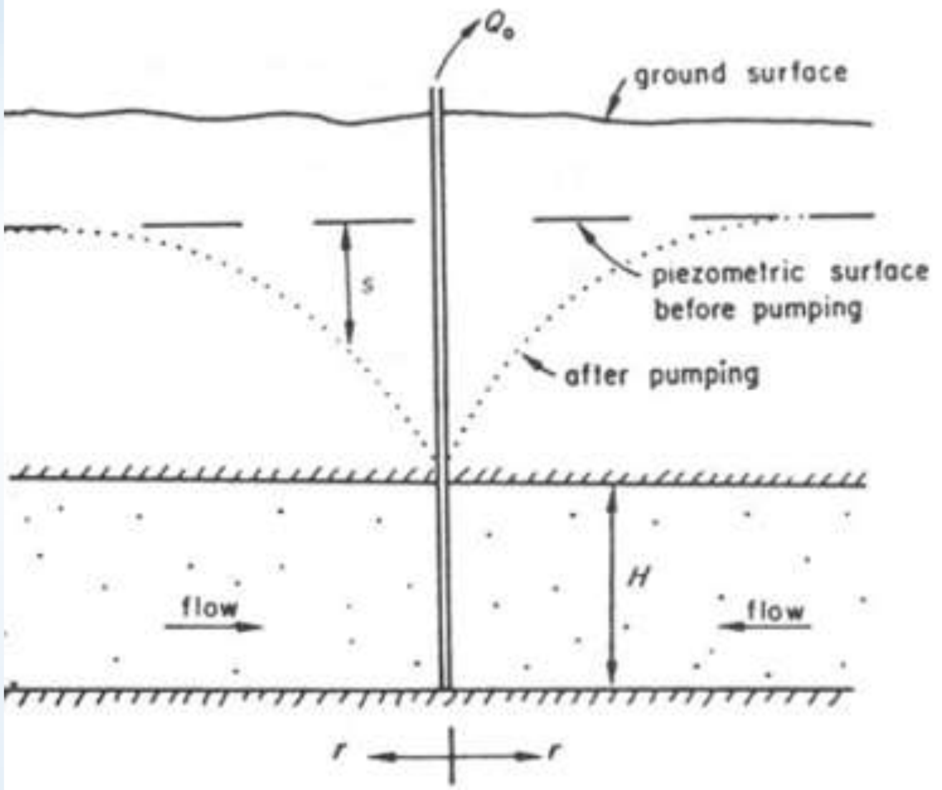


Figure 5.11 *Well pumping from a confined aquifer*

Steady Confined Flow

Example

Fully penetrated well

Outside diameter 0.5 m

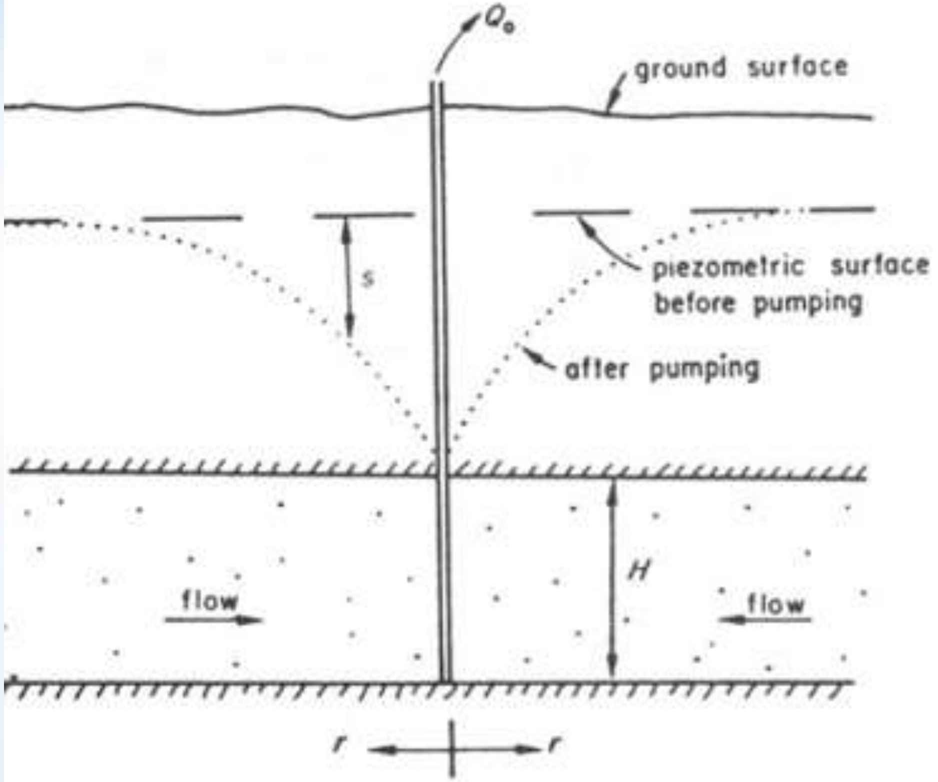
Constant discharge 0.08 m^3/sec from aquifer

Transmisibility= 25×10^{-3} m^2/s

(Transmisibility = k.H)

Aquifer in contact with lake 2 km away

Estimate drawdown at wellface



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Steady Confined Flow

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Constant discharge 0.08 m^3/sec from aquifer

Transmisibility= 25×10^{-3} m^2/s

(Transmisibility = k.H)

Aquifer in contact with lake 2 km away

Estimate drawdown at wellface

$S = [Q_o/(2\pi.k.H)].Ln(R_0/r)$

Distance to lake is 2 km

R_0 may be taken as 2L (at R_0 s=0)

(2x2000 = 4000m)

$S = [0.08/(2\ \pi.\ 25\times10^{-3}).Ln(4000/0.25)$

$= (0.08\times9.68\times10^3)/157.08 = 4.9$ m.

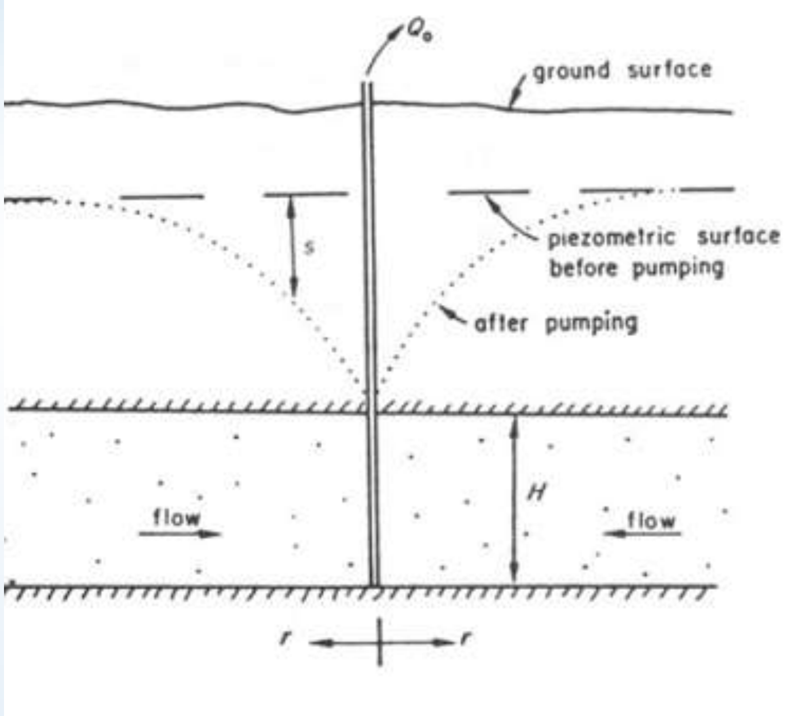


Figure 5.11 *Well pumping from a confined aquifer*

Steady confined flow

Example

Well drilled **in centre of circular island**, **1 mile diameter**, in a large lake.

Well completely penetrates a sandstone aquifer, **50 ft thick.**

Permeability **50 ft/day**

Drawdown max **10 ft** at well, **1ft diameter**.

Steady discharge ?

Boundary condition:

S = 0 when r = 2640 ft

(1 mile = 5280 ft)

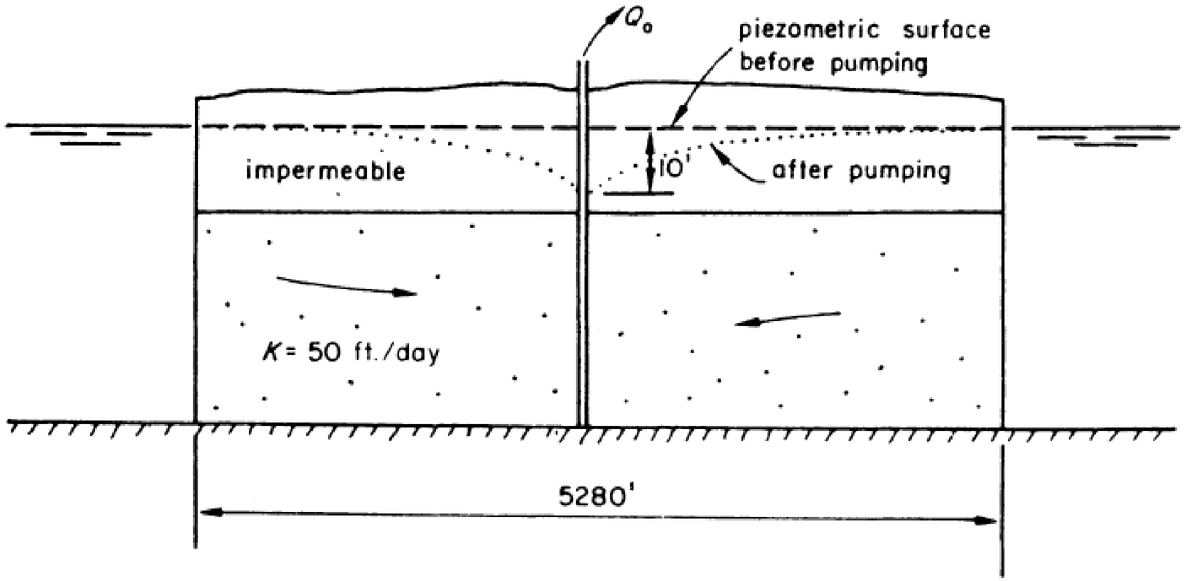


Figure 5.14 *Pumping from a central well in a circular island and confined aquifer*

Steady confined flow

$S = -[Q_o/(2\pi.k.H)].\text{Ln } r + C$

If $s = 0$ when $r = R$

$\boldsymbol{S = [Q_o/(2\pi kH)].\text{Ln } (R/r)}$

$10 = [Q_o /(2\pi x50x50)].\text{Ln}(2640/0.5)$

Therefore

$Q_o= 10x(2\pi x50x50)/\ln5280 = 50000\ \pi/8.572 = 18340 \text{ft}^3/\text{day}$

$= 0.212 \text{ft}^3/\text{sec}$

1 mile = 5280ft

Flow in an aquifer with phreatic surface (unconfined aquifer)

Aquifer with a phreatic surface, resting on an impermeable base.

Darcy's Law

Vs = -k.dØ/dl

L = distance measured in flow direction

s is flow direction

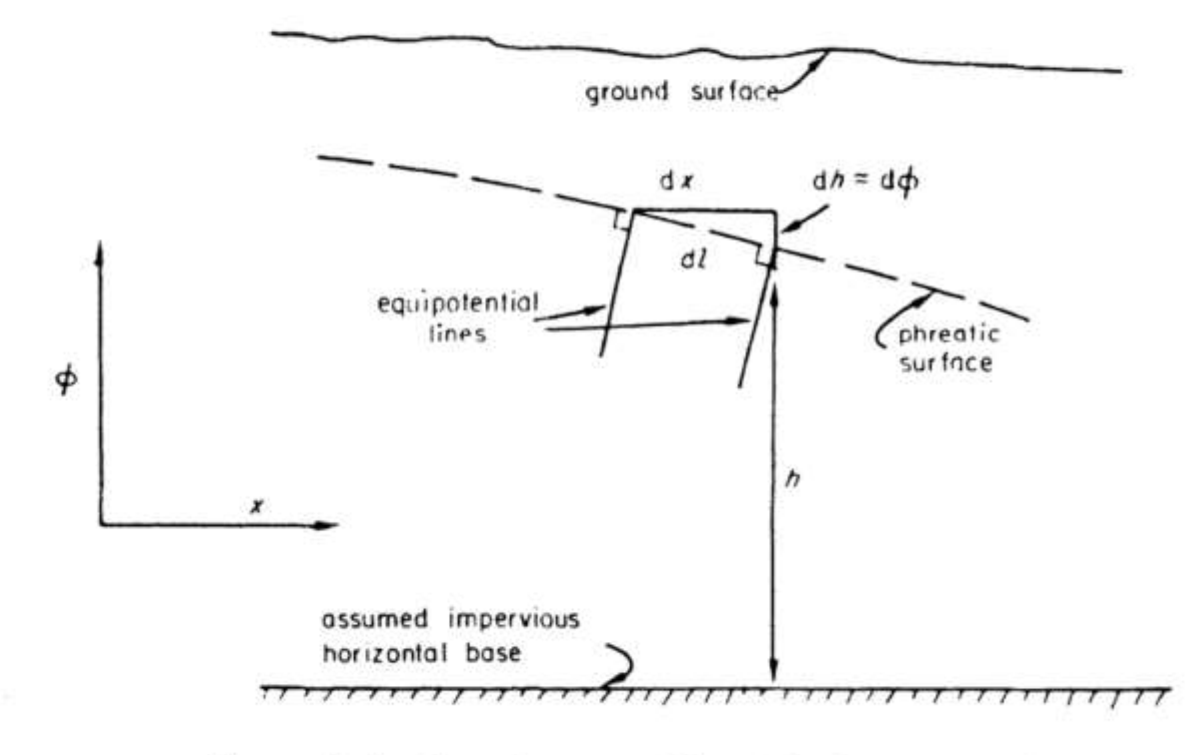


Figure 5.6 *Flow in an aquifer with phreatic surface*

Flow in an aquifer with phreatic surface

Assumptions Depuit

- dØ/dl = dØ/dx

  (dØ is small)

- All flow lines in aquifer horizontal and equipotential lines nearly vertical(exept near abstraction points)

  dØ/dx = dh/dx

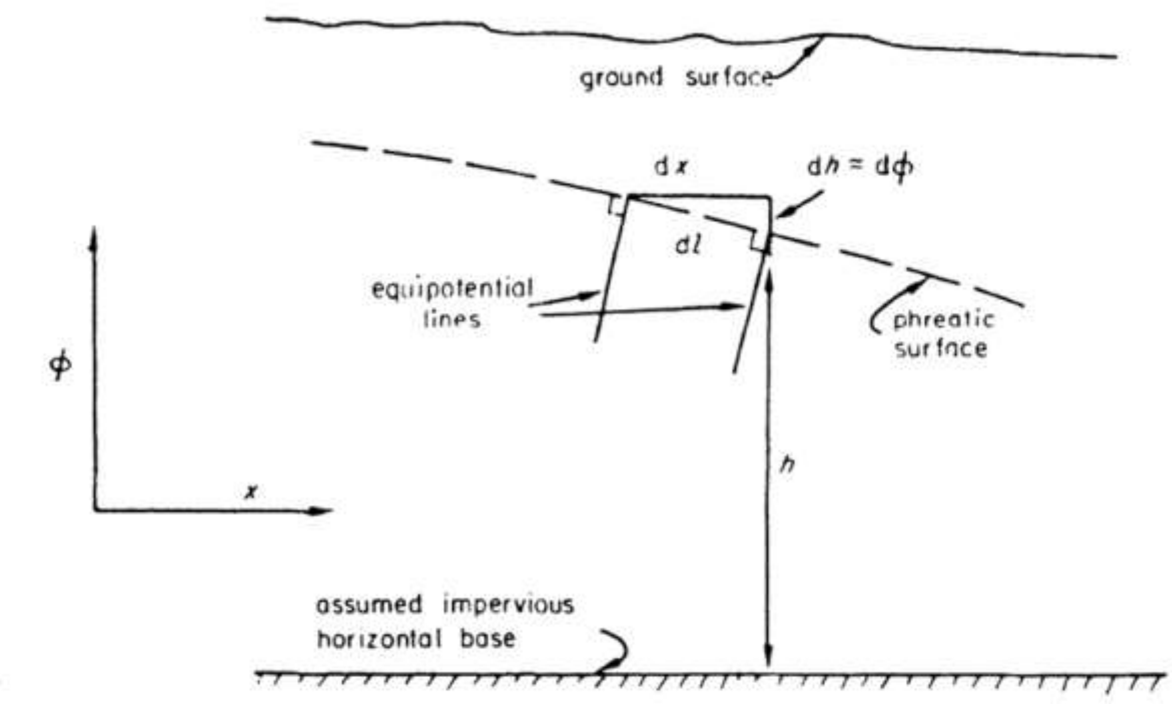


Figure 5.6 *Flow in an aquifer with phreatic surface*

Steady unconfined flow

Integrating

$h^2 =(Q_o / \pi.k).\ln r + C$

If $h = H$ at $r = R$

Then

$H^2 – h^2 = [Q_o/(\pi r)].\text{Ln}(R/r)$

R satifying the boundary conditions

r_0 = redius of the well

$$H^2 – h_0^2 = [Q_o/(\pi k)].\text{Ln}(R/r_0)$$

Remark: H and h are water depth

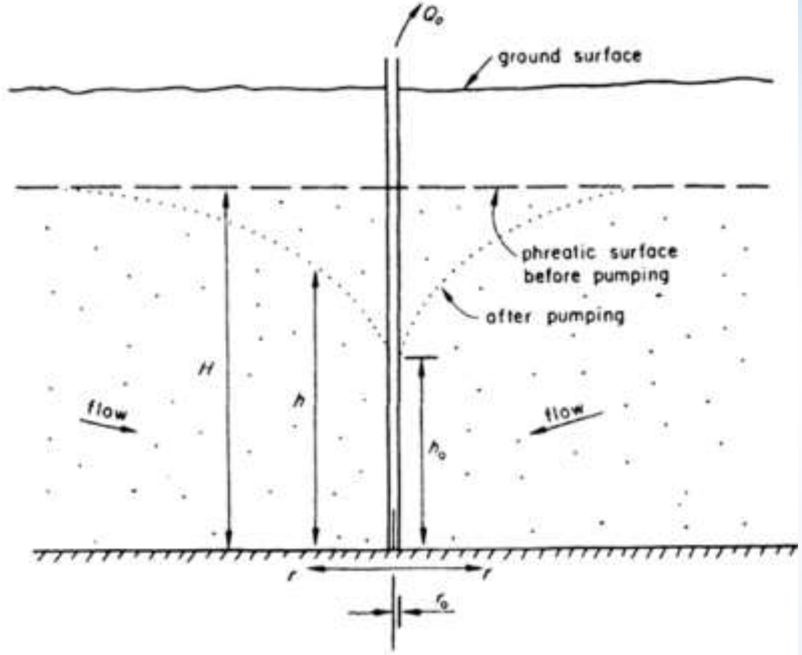


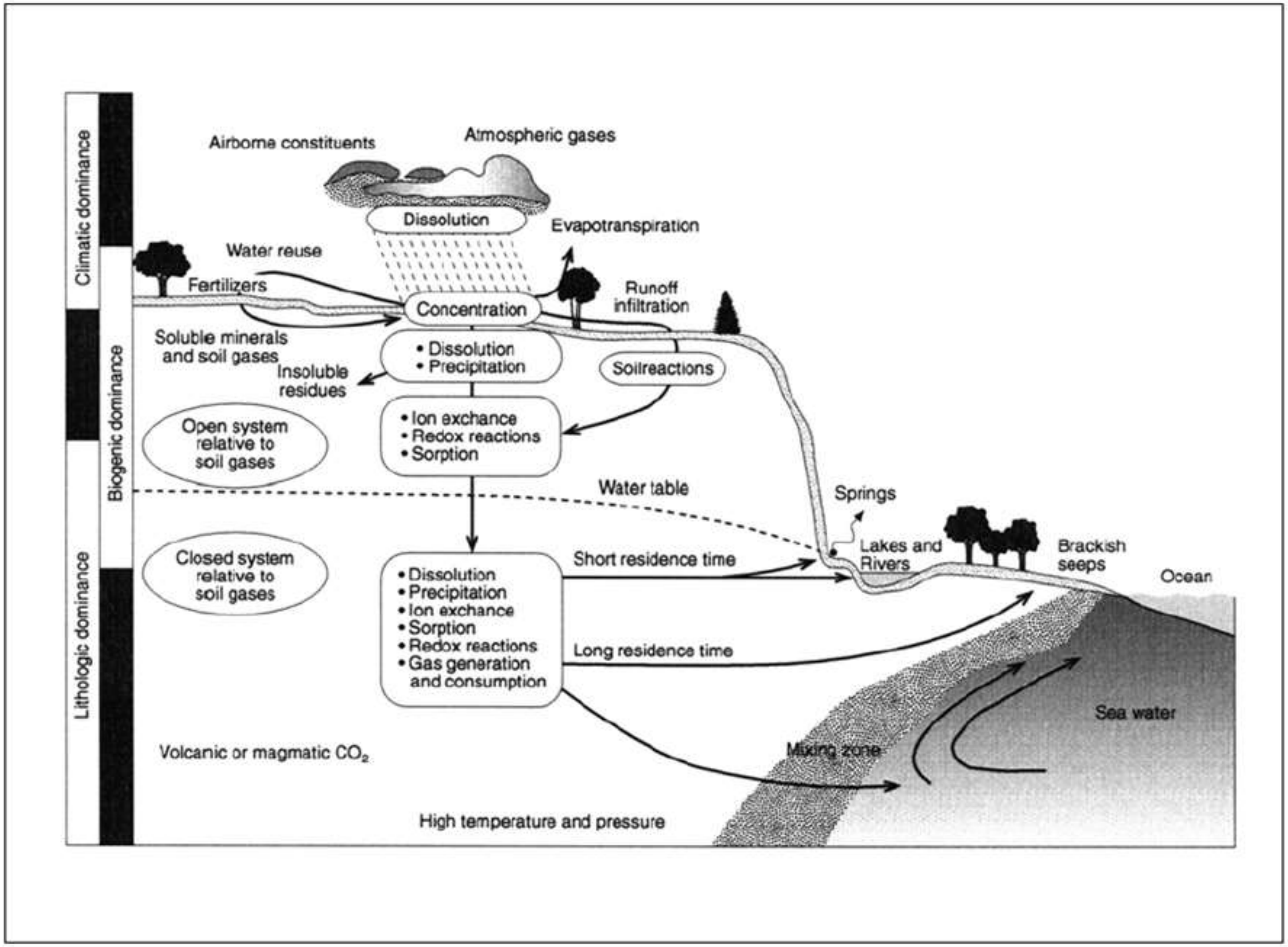
Figure 5.13 *Well pumping from an unconfined aquifer*

Groundwater quality

Disolving properties of water

- Water consists of two atoms of hydrogen and one of oxygen, which give it a chemical formula of H_2O.
- Water frequently is referred to as the universal solvent because it has the ability to dissolve at least small amounts of almost all substances that it contacts.
- The composition and concentration of substances dissolved in unpolluted ground water depends on:
    1. the chemical composition of precipitation,
    2. the biologic and chemical reactions occurring on the land surface and in the soil zone,
    3. the mineral composition of the aquifers and confining beds through which the water moves.
- The quality of ground water depends both on the substances dissolved in the water and on certain properties and characteristics that these substances impart to the water.

Figure 2.1 Factors controlling groundwater composition



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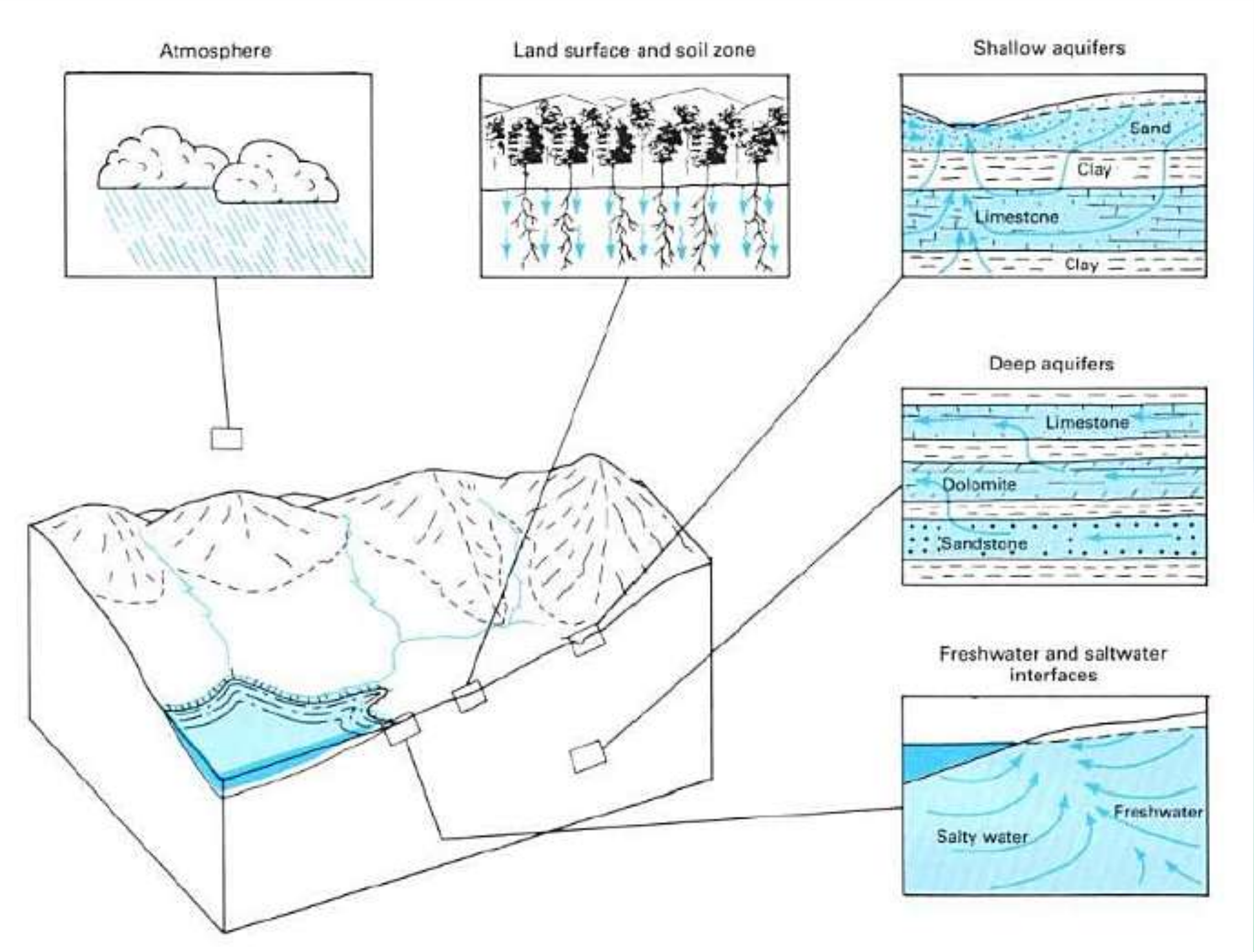
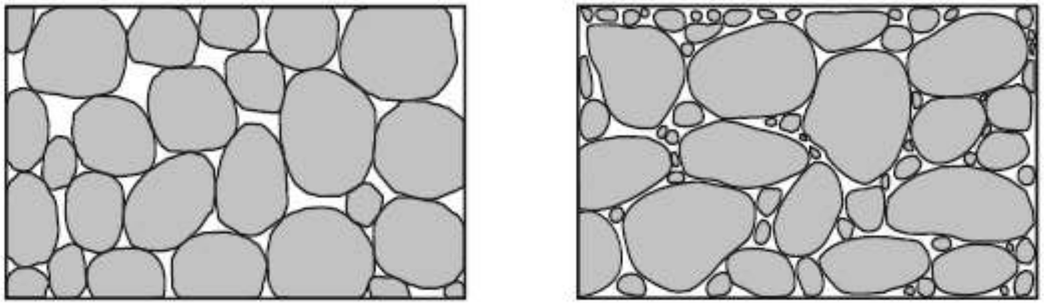
Chemical of Ground water



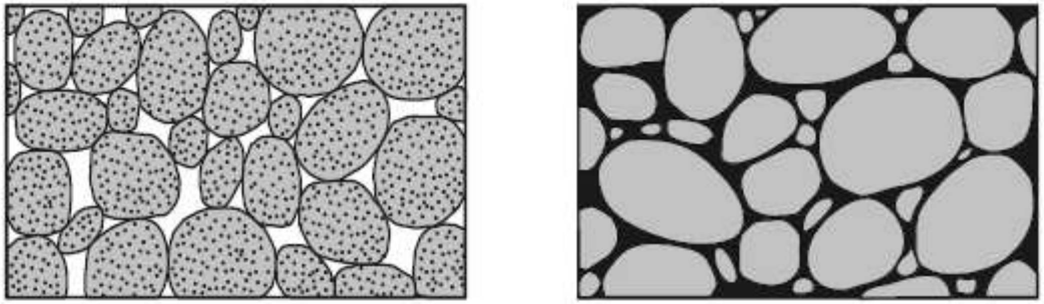
THE CHEMICAL CHARACTERISTICS OF GROUND WATER ARE DETERMINED BY THE CHEMICAL AND BIOLOGICAL REACTIONS IN THE ZONES THROUGH WHICH THE WATER MOVES

Source: USGS



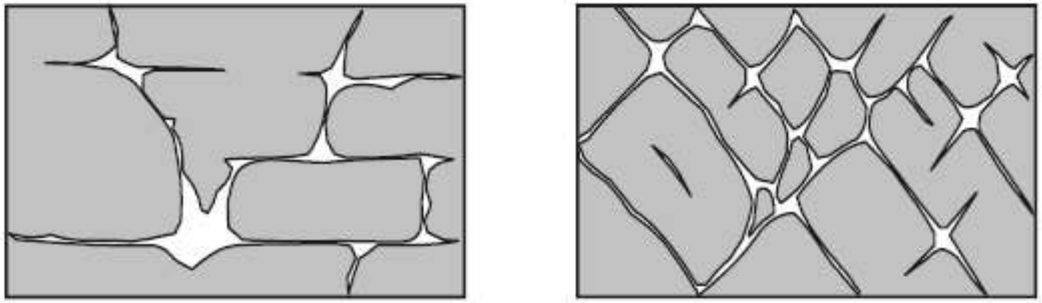
(A) Well-sorted, unconsolidated sedimentary deposit having high porosity

(B) Poorly sorted sedimentary deposit having low porosity



(C) Well-sorted sedimentary deposit consisting of pebbles that are themselves porous, so the deposit as a whole has high porosity

(D) Sedimentary deposit whose porosity has been diminished by the deposition of mineral matter between the grains

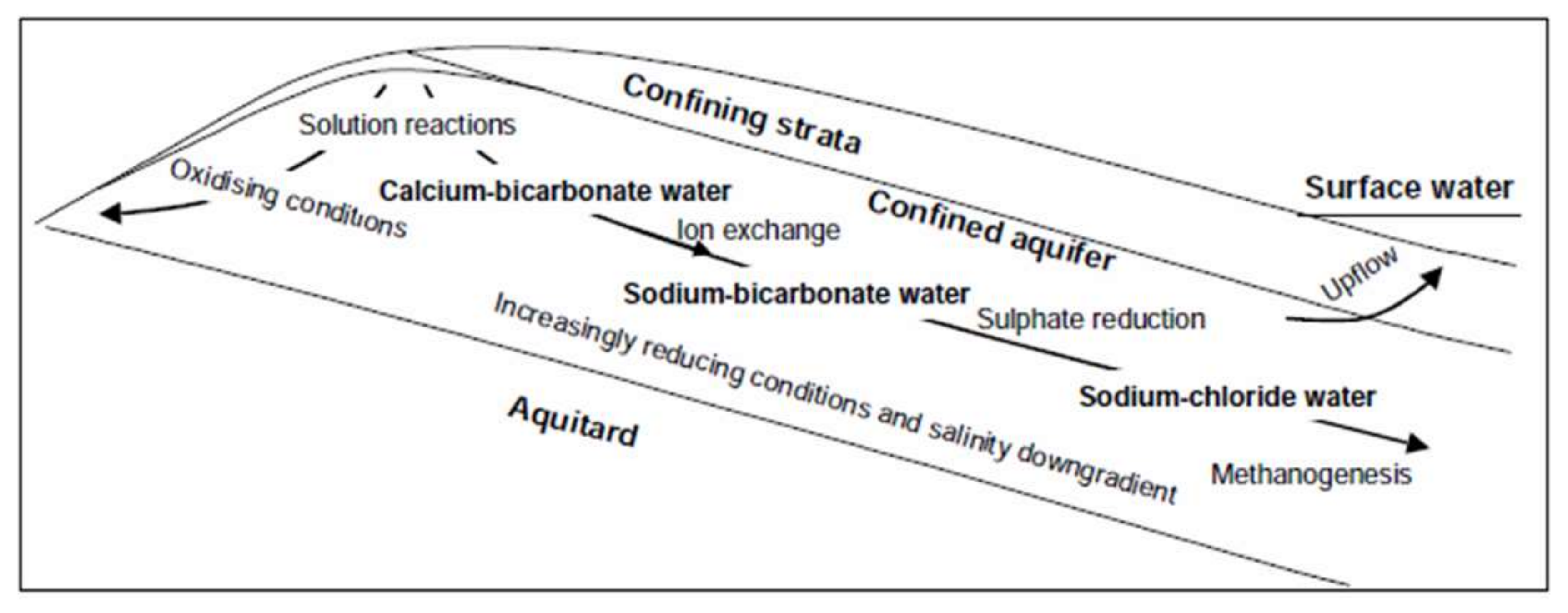


(E) Rock with porosity increased by solution

(F) Rock with porosity increased by fracturing

Figure 2.4. Rock texture and porosity of typical aquifer materials (based on Todd, 1980)

The natural hydrological cycle



Source: WHO 2006

The natural hydrological cycle

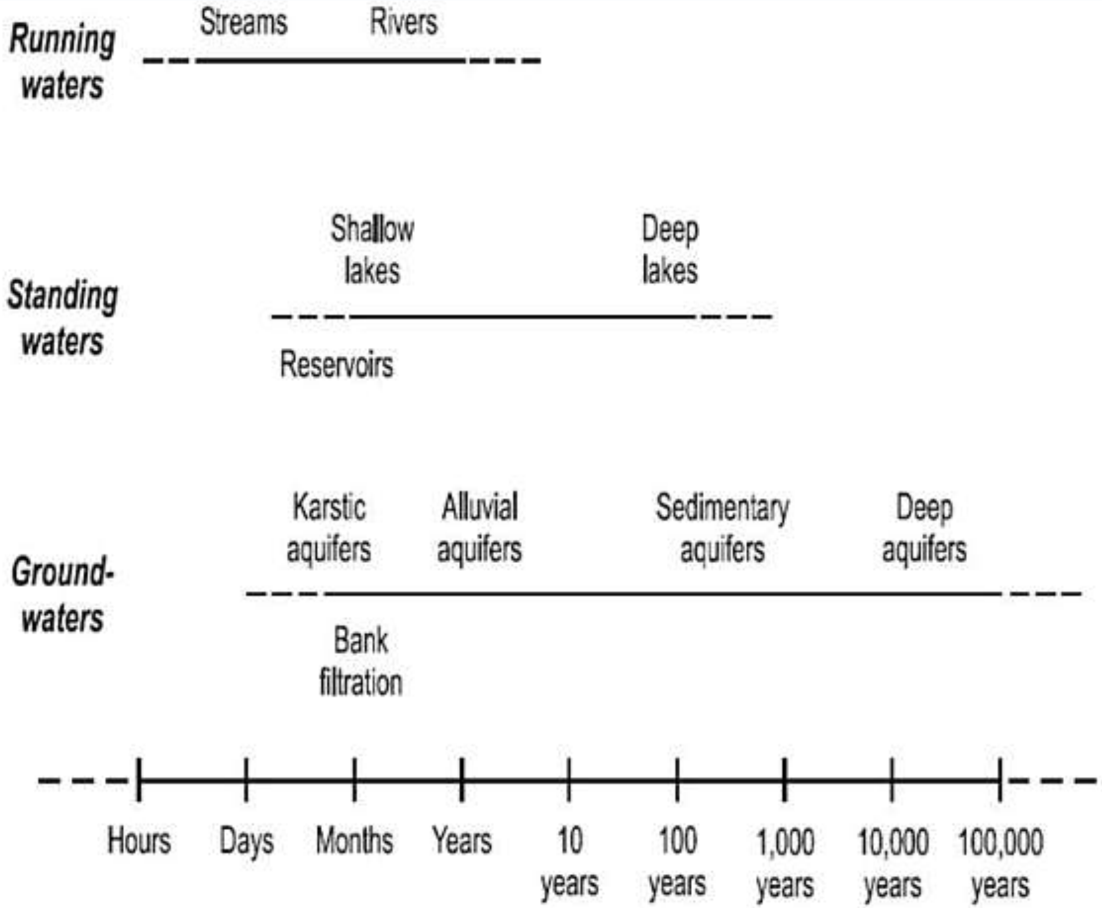


Figure 2.3. Water residence time in inland freshwater bodies (modified from Meybeck *et al.*, 1989)

Source: WHO 2006

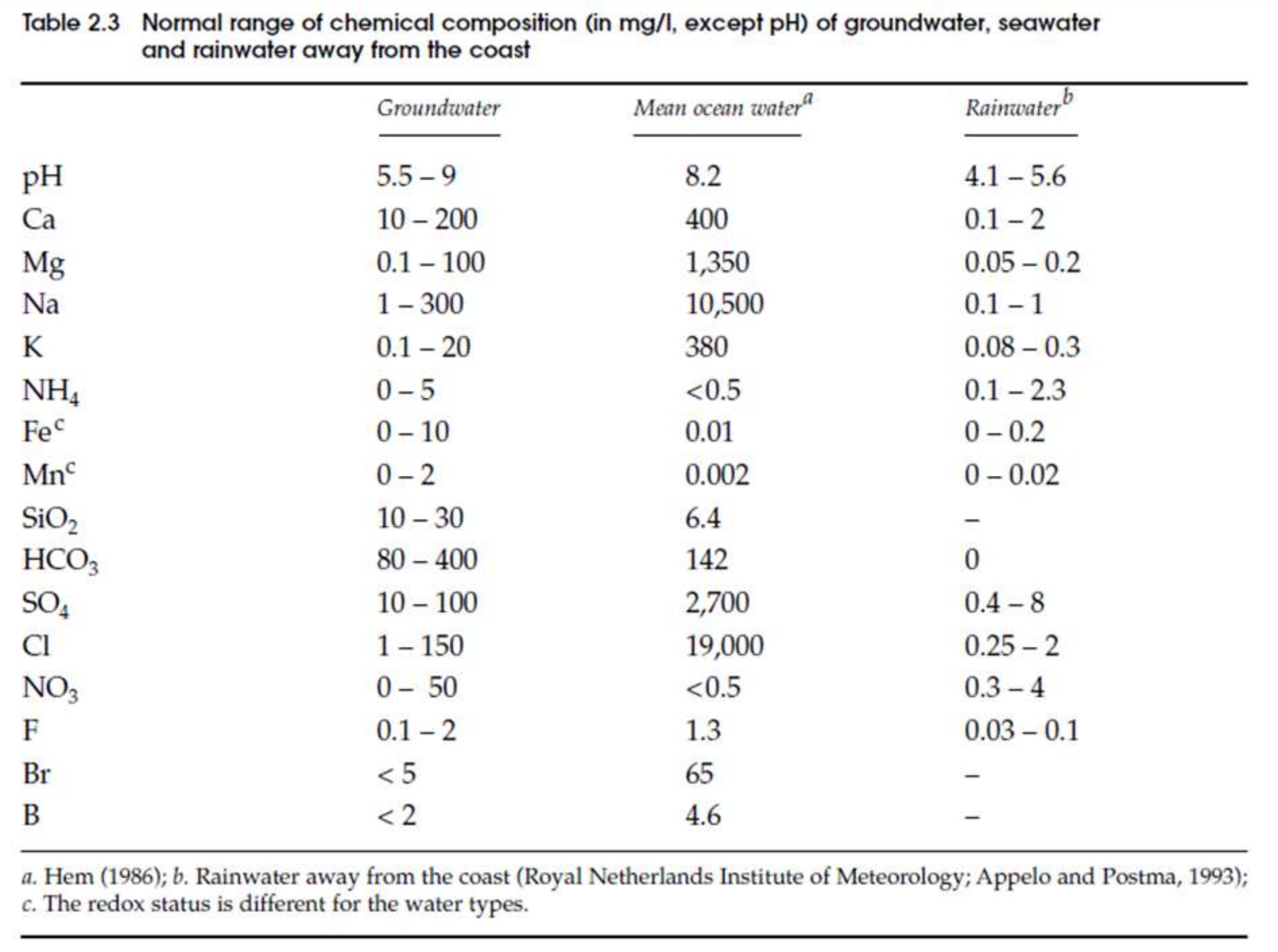


Table 2.3 Normal range of chemical composition (in mg/l, except pH) of groundwater, seawater and rainwater away from the coast

	Groundwater	*Mean ocean water*[a]	*Rainwater*[b]
pH	5.5 – 9	8.2	4.1 – 5.6
Ca	10 – 200	400	0.1 – 2
Mg	0.1 – 100	1,350	0.05 – 0.2
Na	1 – 300	10,500	0.1 – 1
K	0.1 – 20	380	0.08 – 0.3
NH_4	0 – 5	<0.5	0.1 – 2.3
Fe[c]	0 – 10	0.01	0 – 0.2
Mn[c]	0 – 2	0.002	0 – 0.02
SiO_2	10 – 30	6.4	–
HCO_3	80 – 400	142	0
SO_4	10 – 100	2,700	0.4 – 8
Cl	1 – 150	19,000	0.25 – 2
NO_3	0 – 50	<0.5	0.3 – 4
F	0.1 – 2	1.3	0.03 – 0.1
Br	< 5	65	–
B	< 2	4.6	–

a. Hem (1986); *b.* Rainwater away from the coast (Royal Netherlands Institute of Meteorology; Appelo and Postma, 1993); *c.* The redox status is different for the water types.

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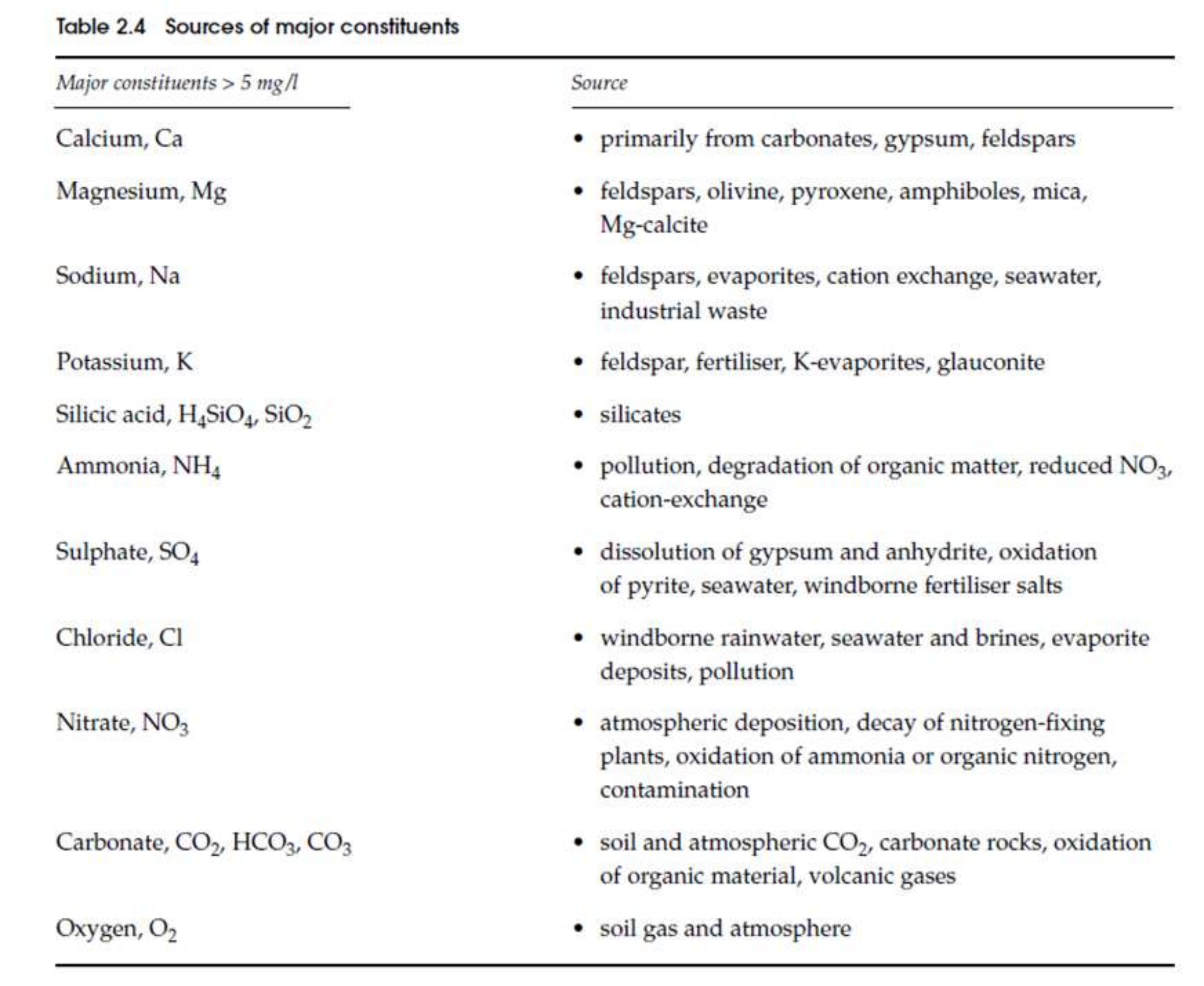

Table 2.4 Sources of major constituents

Major constituents > 5 mg/l	*Source*
Calcium, Ca	- primarily from carbonates, gypsum, feldspars
Magnesium, Mg	- feldspars, olivine, pyroxene, amphiboles, mica, Mg-calcite
Sodium, Na	- feldspars, evaporites, cation exchange, seawater, industrial waste
Potassium, K	- feldspar, fertiliser, K-evaporites, glauconite
Silicic acid, H_4SiO_4, SiO_2	- silicates
Ammonia, NH_4	- pollution, degradation of organic matter, reduced NO_3, cation-exchange
Sulphate, SO_4	- dissolution of gypsum and anhydrite, oxidation of pyrite, seawater, windborne fertiliser salts
Chloride, Cl	- windborne rainwater, seawater and brines, evaporite deposits, pollution
Nitrate, NO_3	- atmospheric deposition, decay of nitrogen-fixing plants, oxidation of ammonia or organic nitrogen, contamination
Carbonate, CO_2, HCO_3, CO_3	- soil and atmospheric CO_2, carbonate rocks, oxidation of organic material, volcanic gases
Oxygen, O_2	- soil gas and atmosphere

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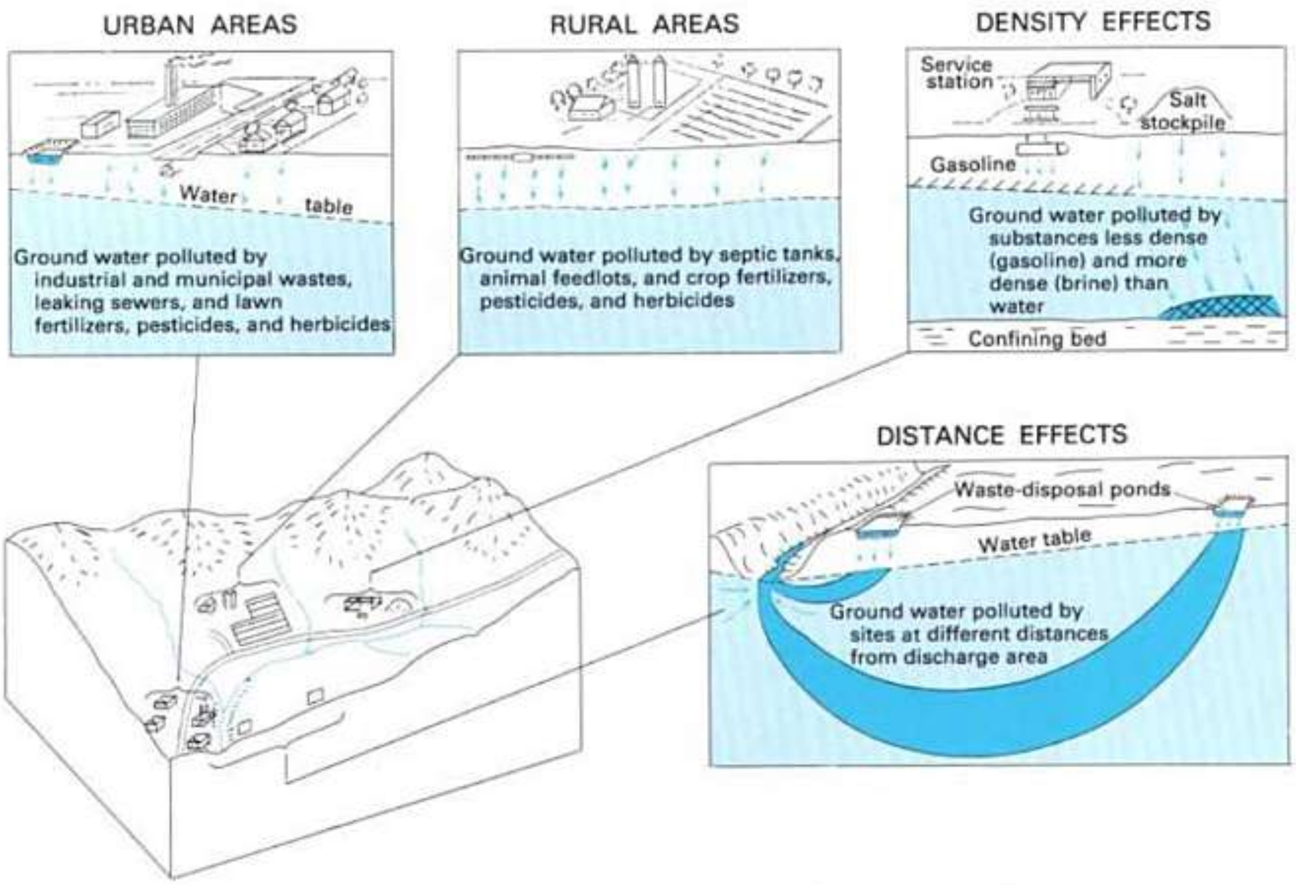
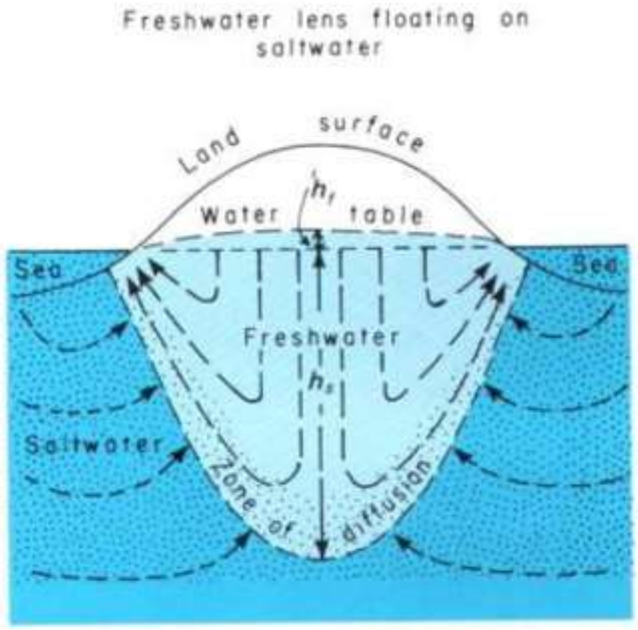
Polution of Ground water



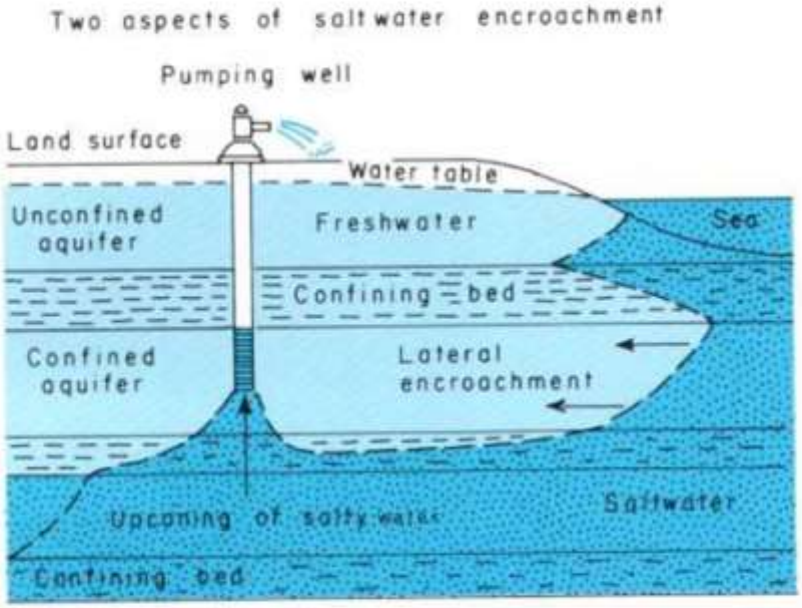
GROUND-WATER POLLUTION OCCURS IN BOTH URBAN AND RURAL AREAS AND IS AFFECTED BY DIFFERENCES IN CHEMICAL COMPOSITION, BIOLOGICAL AND CHEMICAL REACTIONS, DENSITY, AND DISTANCE FROM DISCHARGE AREAS

Source: USGS

Saline encroachment of Ground water



(1)



(2)

Source: USGS

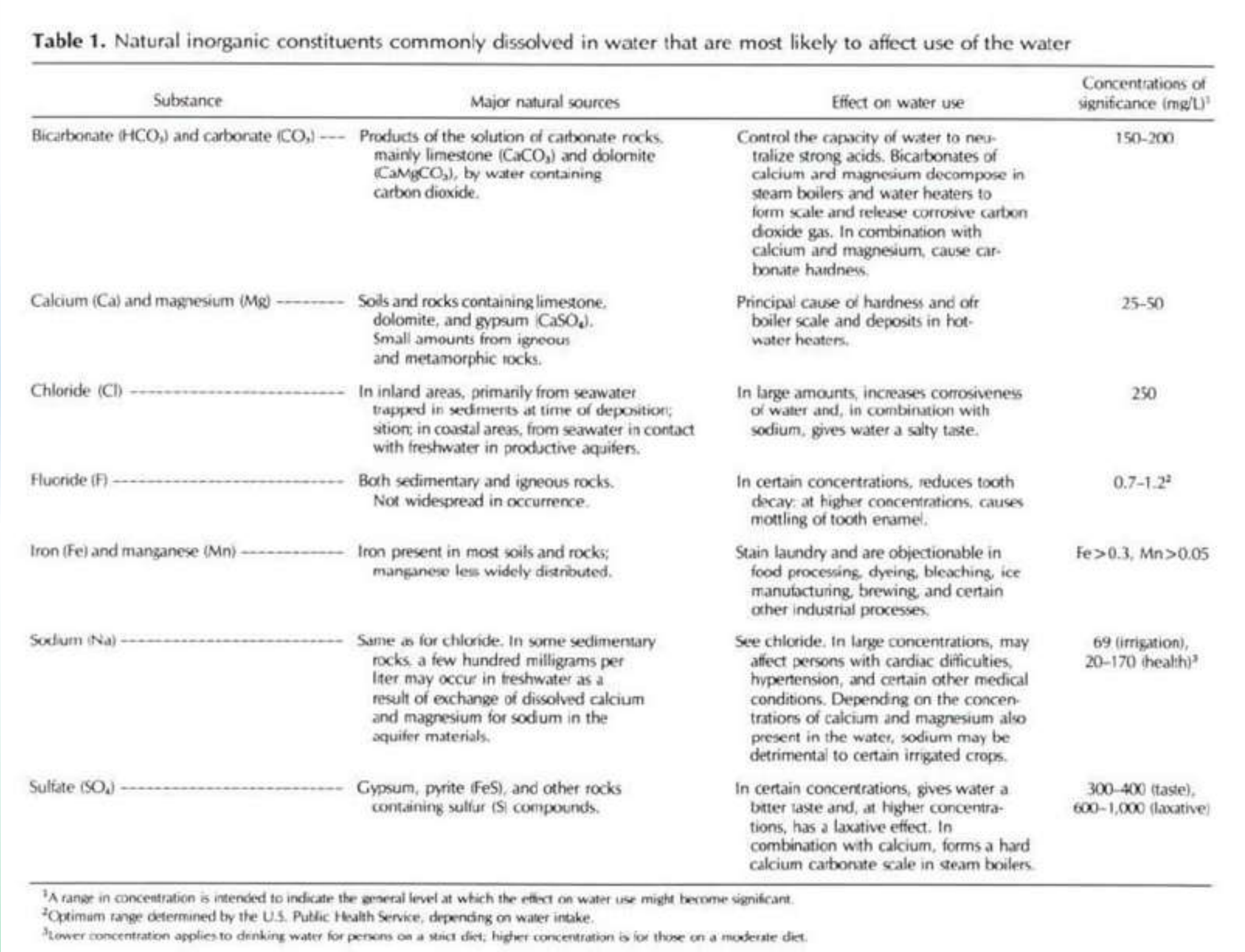


Table 1. Natural inorganic constituents commonly dissolved in water that are most likely to affect use of the water

Substance	Major natural sources	Effect on water use	Concentrations of significance (mg/L)[1]
Bicarbonate (HCO_3) and carbonate (CO_3)	Products of the solution of carbonate rocks, mainly limestone ($CaCO_3$) and dolomite ($CaMgCO_3$), by water containing carbon dioxide.	Control the capacity of water to neutralize strong acids. Bicarbonates of calcium and magnesium decompose in steam boilers and water heaters to form scale and release corrosive carbon dioxide gas. In combination with calcium and magnesium, cause carbonate hardness.	150-200
Calcium (Ca) and magnesium (Mg)	Soils and rocks containing limestone, dolomite, and gypsum ($CaSO_4$). Small amounts from igneous and metamorphic rocks.	Principal cause of hardness and of boiler scale and deposits in hot-water heaters.	25-50
Chloride (Cl)	In inland areas, primarily from seawater trapped in sediments at time of deposition; sition; in coastal areas, from seawater in contact with freshwater in productive aquifers.	In large amounts, increases corrosiveness of water and, in combination with sodium, gives water a salty taste.	250
Fluoride (F)	Both sedimentary and igneous rocks. Not widespread in occurrence.	In certain concentrations, reduces tooth decay; at higher concentrations, causes mottling of tooth enamel.	0.7–1.2[2]
Iron (Fe) and manganese (Mn)	Iron present in most soils and rocks; manganese less widely distributed.	Stain laundry and are objectionable in food processing, dyeing, bleaching, ice manufacturing, brewing, and certain other industrial processes.	Fe > 0.3, Mn > 0.05
Sodium (Na)	Same as for chloride. In some sedimentary rocks, a few hundred milligrams per liter may occur in freshwater as a result of exchange of dissolved calcium and magnesium for sodium in the aquifer materials.	See chloride. In large concentrations, may affect persons with cardiac difficulties, hypertension, and certain other medical conditions. Depending on the concentrations of calcium and magnesium also present in the water, sodium may be detrimental to certain irrigated crops.	69 (irrigation), 20–170 (health)[3]
Sulfate (SO_4)	Gypsum, pyrite (FeS), and other rocks containing sulfur (S) compounds.	In certain concentrations, gives water a bitter taste and, at higher concentrations, has a laxative effect. In combination with calcium, forms a hard calcium carbonate scale in steam boilers.	300–400 (taste), 600–1,000 (laxative)

[1] A range in concentration is intended to indicate the general level at which the effect on water use might become significant.

[2] Optimum range determined by the U.S. Public Health Service, depending on water intake.

[3] Lower concentration applies to drinking water for persons on a strict diet; higher concentration is for those on a moderate diet.

Source: USGS

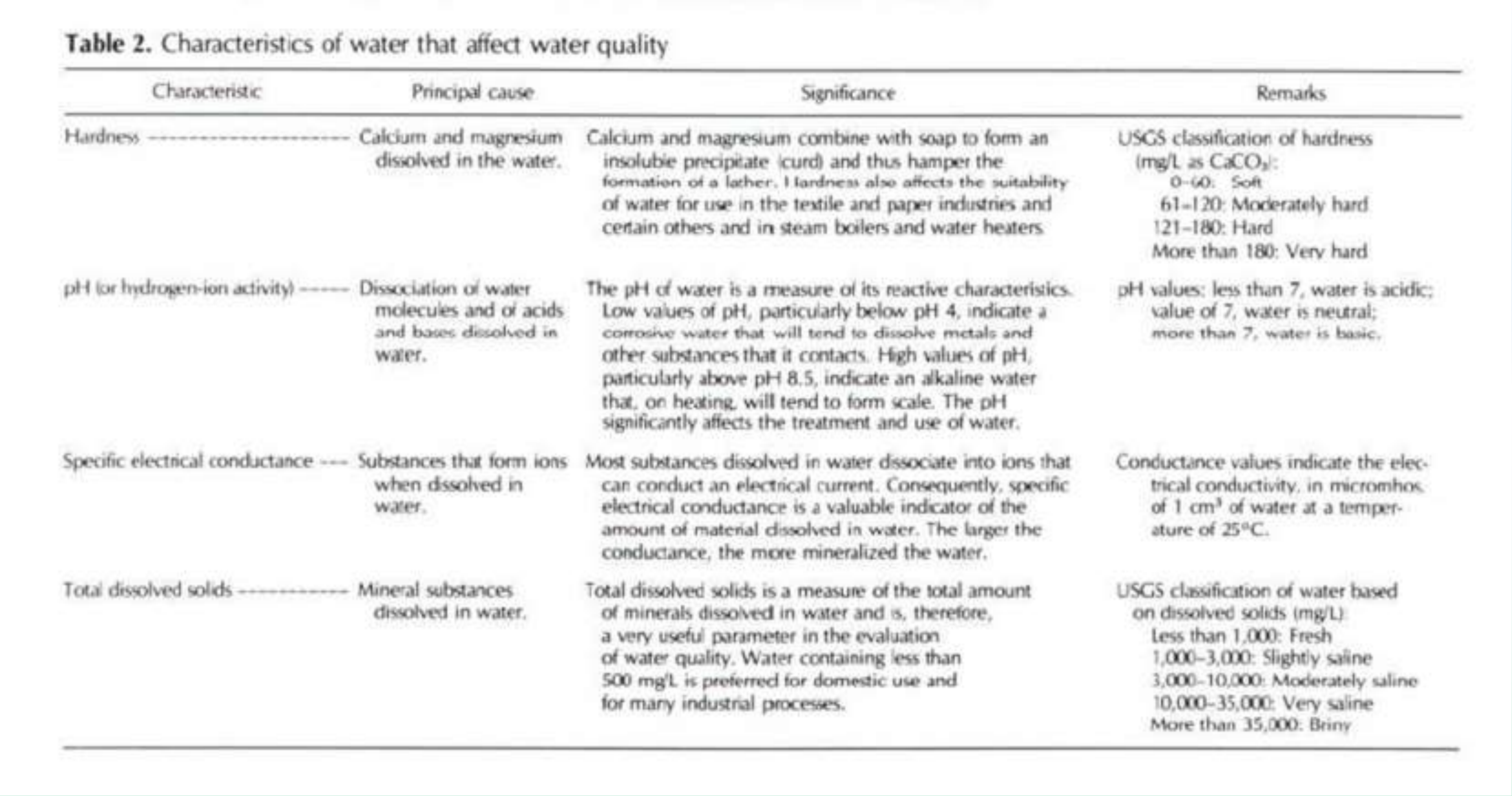


Table 2. Characteristics of water that affect water quality

Characteristic	Principal cause	Significance	Remarks
Hardness	Calcium and magnesium dissolved in the water.	Calcium and magnesium combine with soap to form an insoluble precipitate (curd) and thus hamper the formation of a lather. Hardness also affects the suitability of water for use in the textile and paper industries and certain others and in steam boilers and water heaters.	USGS classification of hardness (mg/L as $CaCO_3$): 0–60: Soft 61–120: Moderately hard 121–180: Hard More than 180: Very hard
pH (or hydrogen-ion activity)	Dissociation of water molecules and of acids and bases dissolved in water.	The pH of water is a measure of its reactive characteristics. Low values of pH, particularly below pH 4, indicate a corrosive water that will tend to dissolve metals and other substances that it contacts. High values of pH, particularly above pH 8.5, indicate an alkaline water that, on heating, will tend to form scale. The pH significantly affects the treatment and use of water.	pH values: less than 7, water is acidic; value of 7, water is neutral; more than 7, water is basic.
Specific electrical conductance	Substances that form ions when dissolved in water.	Most substances dissolved in water dissociate into ions that can conduct an electrical current. Consequently, specific electrical conductance is a valuable indicator of the amount of material dissolved in water. The larger the conductance, the more mineralized the water.	Conductance values indicate the electrical conductivity, in micromhos, of 1 cm^3 of water at a temperature of 25°C.
Total dissolved solids	Mineral substances dissolved in water.	Total dissolved solids is a measure of the total amount of minerals dissolved in water and is, therefore, a very useful parameter in the evaluation of water quality. Water containing less than 500 mg/L is preferred for domestic use and for many industrial processes.	USGS classification of water based on dissolved solids (mg/L): Less than 1,000: Fresh 1,000–3,000: Slightly saline 3,000–10,000: Moderately saline 10,000–35,000: Very saline More than 35,000: Briny

Source: USGS

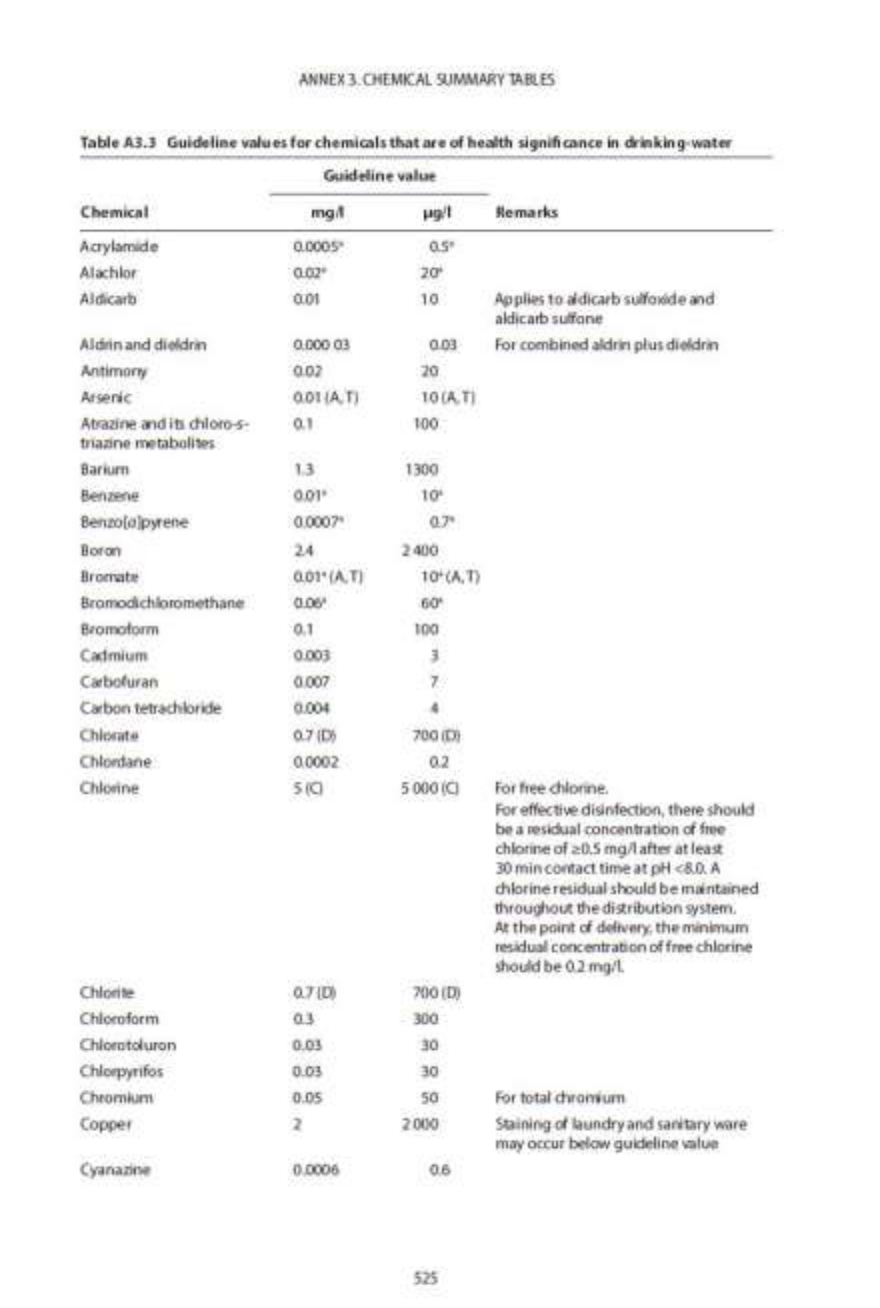


Table A3.3 Guideline values for chemicals that are of health significance in drinking-water

Chemical	Guideline value mg/l	Guideline value µg/l	Remarks
Acrylamide	0.0005[a]	0.5[a]	
Alachlor	0.02[a]	20[a]	
Aldicarb	0.01	10	Applies to aldicarb sulfoxide and aldicarb sulfone
Aldrin and dieldrin	0.000 03	0.03	For combined aldrin plus dieldrin
Antimony	0.02	20	
Arsenic	0.01 (A, T)	10 (A, T)	
Atrazine and its chloro-s-triazine metabolites	0.1	100	
Barium	1.3	1300	
Benzene	0.01[a]	10[a]	
Benzo[*a*]pyrene	0.0007[a]	0.7[a]	
Boron	2.4	2 400	
Bromate	0.01[a] (A, T)	10[a] (A, T)	
Bromodichloromethane	0.06[a]	60[a]	
Bromoform	0.1	100	
Cadmium	0.003	3	
Carbofuran	0.007	7	
Carbon tetrachloride	0.004	4	
Chlorate	0.7 (D)	700 (D)	
Chlordane	0.0002	0.2	
Chlorine	5 (C)	5 000 (C)	For free chlorine. For effective disinfection, there should be a residual concentration of free chlorine of ≥0.5 mg/l after at least 30 min contact time at pH <8.0. A chlorine residual should be maintained throughout the distribution system. At the point of delivery, the minimum residual concentration of free chlorine should be 0.2 mg/l.
Chlorite	0.7 (D)	700 (D)	
Chloroform	0.3	300	
Chlorotoluron	0.03	30	
Chlorpyrifos	0.03	30	
Chromium	0.05	50	For total chromium
Copper	2	2 000	Staining of laundry and sanitary ware may occur below guideline value
Cyanazine	0.0006	0.6	

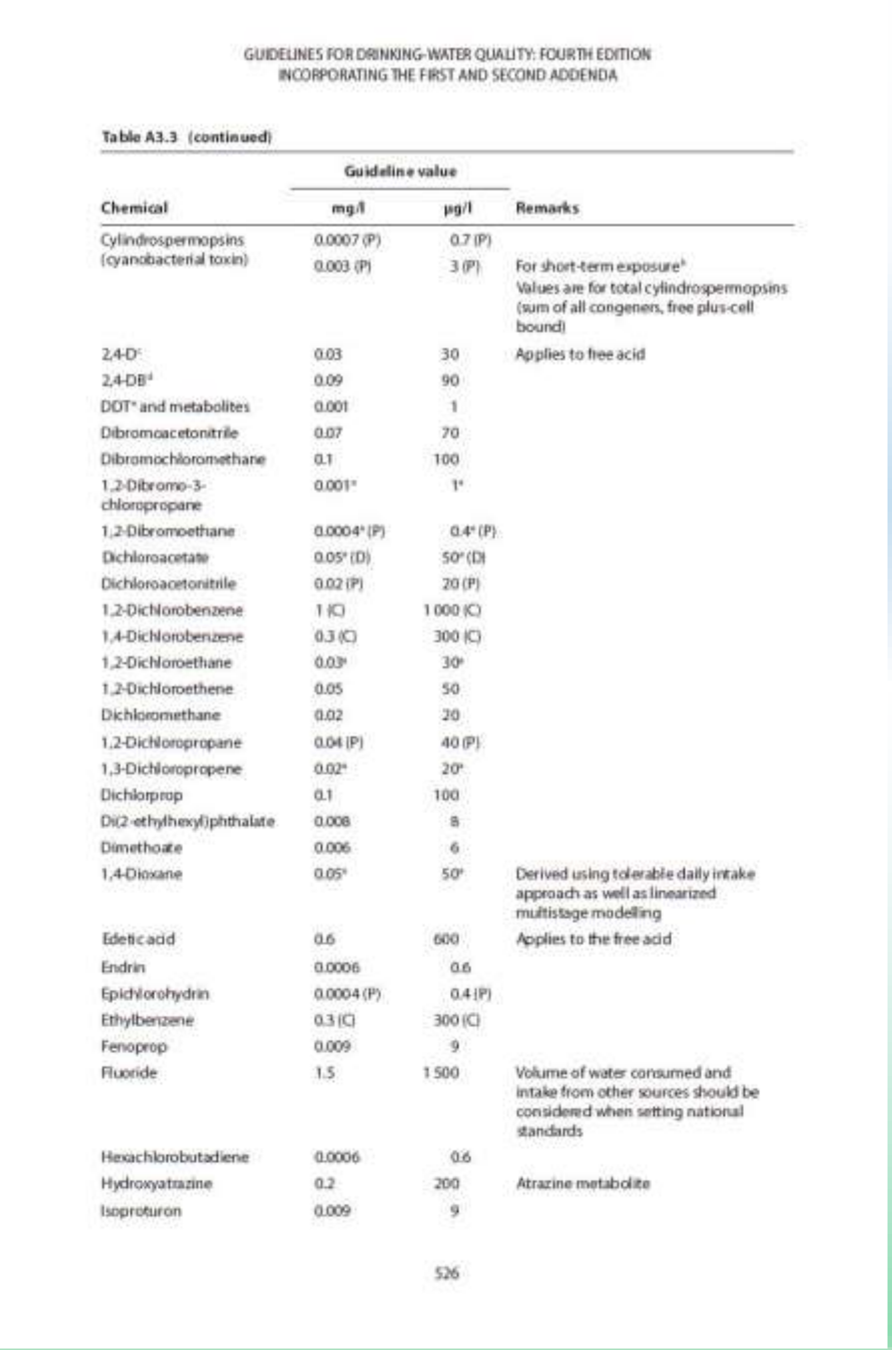


Table A3.3 (continued)

Chemical	Guideline value mg/l	Guideline value µg/l	Remarks
Cylindrospermopsins (cyanobacterial toxin)	0.0007 (P)	0.7 (P)	
	0.003 (P)	3 (P)	For short-term exposure[b] Values are for total cylindrospermopsins (sum of all congeners, free plus-cell bound)
2,4-D[c]	0.03	30	Applies to free acid
2,4-DB[d]	0.09	90	
DDT[e] and metabolites	0.001	1	
Dibromoacetonitrile	0.07	70	
Dibromochloromethane	0.1	100	
1,2-Dibromo-3-chloropropane	0.001[a]	1[a]	
1,2-Dibromoethane	0.0004[a] (P)	0.4[a] (P)	
Dichloroacetate	0.05[a] (D)	50[a] (D)	
Dichloroacetonitrile	0.02 (P)	20 (P)	
1,2-Dichlorobenzene	1 (C)	1 000 (C)	
1,4-Dichlorobenzene	0.3 (C)	300 (C)	
1,2-Dichloroethane	0.03[a]	30[a]	
1,2-Dichloroethene	0.05	50	
Dichloromethane	0.02	20	
1,2-Dichloropropane	0.04 (P)	40 (P)	
1,3-Dichloropropene	0.02[a]	20[a]	
Dichlorprop	0.1	100	
Di(2-ethylhexyl)phthalate	0.008	8	
Dimethoate	0.006	6	
1,4-Dioxane	0.05[a]	50[a]	Derived using tolerable daily intake approach as well as linearized multistage modelling
Edetic acid	0.6	600	Applies to the free acid
Endrin	0.0006	0.6	
Epichlorohydrin	0.0004 (P)	0.4 (P)	
Ethylbenzene	0.3 (C)	300 (C)	
Fenoprop	0.009	9	
Fluoride	1.5	1 500	Volume of water consumed and intake from other sources should be considered when setting national standards
Hexachlorobutadiene	0.0006	0.6	
Hydroxyatrazine	0.2	200	Atrazine metabolite
Isoproturon	0.009	9	

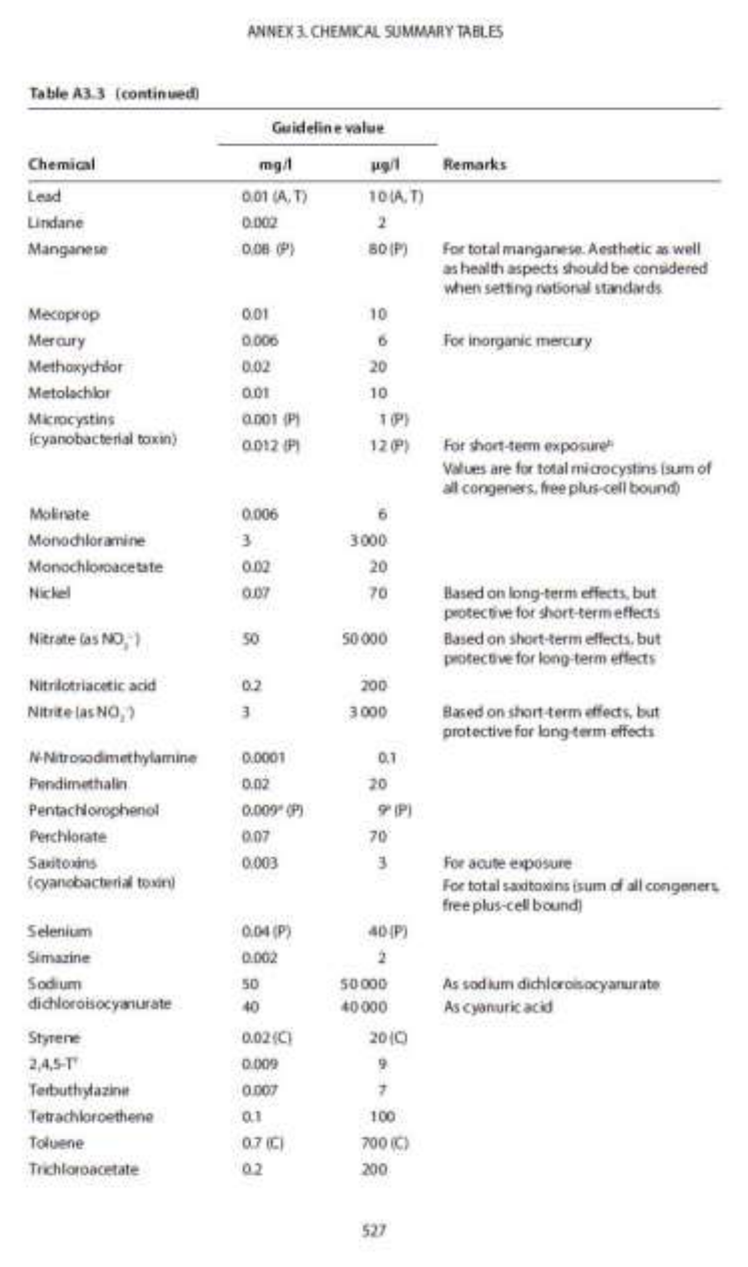


Table A3.3 (continued)

	Guideline value		
Chemical	**mg/l**	**µg/l**	**Remarks**
Lead	0.01 (A, T)	10 (A, T)	
Lindane	0.002	2	
Manganese	0.08 (P)	80 (P)	For total manganese. Aesthetic as well as health aspects should be considered when setting national standards
Mecoprop	0.01	10	
Mercury	0.006	6	For inorganic mercury
Methoxychlor	0.02	20	
Metolachlor	0.01	10	
Microcystins (cyanobacterial toxin)	0.001 (P) 0.012 (P)	1 (P) 12 (P)	 For short-term exposure[b] Values are for total microcystins (sum of all congeners, free plus-cell bound)
Molinate	0.006	6	
Monochloramine	3	3 000	
Monochloroacetate	0.02	20	
Nickel	0.07	70	Based on long-term effects, but protective for short-term effects
Nitrate (as NO_3^-)	50	50 000	Based on short-term effects, but protective for long-term effects
Nitrilotriacetic acid	0.2	200	
Nitrite (as NO_2^-)	3	3 000	Based on short-term effects, but protective for long-term effects
N-Nitrosodimethylamine	0.0001	0.1	
Pendimethalin	0.02	20	
Pentachlorophenol	0.009[a] (P)	9[a] (P)	
Perchlorate	0.07	70	
Saxitoxins (cyanobacterial toxin)	0.003	3	For acute exposure For total saxitoxins (sum of all congeners, free plus-cell bound)
Selenium	0.04 (P)	40 (P)	
Simazine	0.002	2	
Sodium dichloroisocyanurate	50 40	50 000 40 000	As sodium dichloroisocyanurate As cyanuric acid
Styrene	0.02 (C)	20 (C)	
2,4,5-T[f]	0.009	9	
Terbuthylazine	0.007	7	
Tetrachloroethene	0.1	100	
Toluene	0.7 (C)	700 (C)	
Trichloroacetate	0.2	200	

Table A3.3 (continued)

	Guideline value		
Chemical	**mg/l**	**µg/l**	**Remarks**
Trichloroethene	0.008	8	
2,4,6-Trichlorophenol	0.2[a] (C)	200[a] (C)	
Trifluralin	0.02	20	
Trihalomethanes			The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1
Uranium	0.03 (P)	30 (P)	Only chemical, not radiological, aspects of uranium addressed
Vinyl chloride	0.0003[a]	0.3[a]	
Xylenes	0.5 (C)	500 (C)	

A, provisional guideline value because calculated guideline value is below the achievable quantification level; C, concentrations of the substance at or below the health-based guideline value may affect the appearance, taste or odour of the water, leading to consumer complaints; D, provisional guideline value because effective disinfection may result in the guideline value being exceeded; P, provisional guideline value because of uncertainties in the health database; T, provisional guideline value because calculated guideline value is below the level that can be achieved through practical treatment methods, source protection, etc.

[a] For substances that are considered to be carcinogenic, the guideline value is the concentration in drinking-water associated with an upper-bound excess lifetime cancer risk of 10^{-5} (one additional case of cancer per 100 000 of the population ingesting drinking-water containing the substance at the guideline value for 70 years). Concentrations associated with upper-bound estimated excess lifetime cancer risks of 10^{-4} and 10^{-6} can be calculated by multiplying and dividing, respectively, the guideline value by 10.

[b] See the respective chemical fact sheet in chapter 12 for considerations for bottle-fed infants.

[c] 2,4-Dichlorophenoxyacetic acid.

[d] 2,4-Dichlorophenoxybutyric acid.

[e] Dichlorodiphenyltrichlorethane.

[f] 2,4,5-Trichlorophenoxyacetic acid.

END
Thank You