PRODUCTIVE SALTLAND PASTURES

# PRODUCTIVE SALTLAND PASTURES
# Salinity Manual

## Module 4
## Groundwater

GRAMIL CENTRE

Department of Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA

natural resource management program

All photos from SGSL DAFWA team

# GROUNDWATER BASICS

## GROUNDWATER DEFINITION

Groundwater is water stored in the pores of soil or rock in a saturated state to form an aquifer. Water stored in the vadose zone or unsaturated zone is not groundwater.

## TERMS AND DEFINITIONS

Some common terminology used to describe groundwater and aquifers is defined in the table 2 and Figure 1 on Page 4.

| TERM | DEFINITION |
|---|---|
| Aquifer | A subsurface mass of water-saturated rock or regolith that receives, stores and transmits significant quantities of water |
| Aquiclude | Rock or regolith of low permeability that does not transmit groundwater easily |
| Aquitard | Rock or regolith that limits groundwater flow from one aquifer to another |
| Confined aquifer | An aquifer constrained by a confining layer causing groundwater to be under pressure |
| Unconfined aquifer | An aquifer open to the soil surface not restricted by a confining layer and is not under pressure |
| Piezometer | A bore measuring the potentiometric surface of a confined or semi-confined aquifer |
| Well | A bore measuring the watertable of an un-confined aquifer |
| Porosity | The ratio of the volume of spaces which can hold water to the total volume of the rock or sediment. |
| Permeability | Capacity of water to flow through the soil |
| Groundwater gradient | % slope of the watertable surface in a cross-section of the landscape |
| Hydraulic conductivity | The rate of water movement through a known soil measured in m/day ) |
| Vadose zone | Vadose zone means the zone between the ground surface and any aquifer. The points just above the water table where soil pores may contain either air or water. This is also called the zone of aeration. |

# HOW GROUNDWATER FLOWS

Groundwater moves through the soil or rock fractures by gravity and hydraulic pressure. Soil is made up of solids (soil particles) and air spaces (voids). Groundwater is found in the voids. The amount of water which can be held in these voids is dependent on soil properties.

Porosity is the percent of voids in a given volume of soil. An aquifer exists when some or all of the voids are full of water and well connected.

The ease with which water moves through the soil is quantified by hydraulic conductivity (K) (m/day) and is specific for a given soil type. For example, the hydraulic conductivity of the aquifer beneath Fence Road (Dumbleyung) is 0.5 m/day (George 1992) and 0.01 to 1.10 m/day beneath the Wagin townsite.

The volume of soil approximately 1m above the watertable is known as the "capillary fringe" or "phreatic zone". This area is influenced by "wicking" a process whereby water is pulled up due to the surface tension of water.

The zone above the water table and capillary zone is known as the "vadose zone" and is where water is held against and around individual soil particles. Typically, this zone has large fluctuations in soil moisture content due to additions such as rainfall, and withdrawals such as evaporation and uptake by plant roots.

## HYDROLOGICAL CYCLE

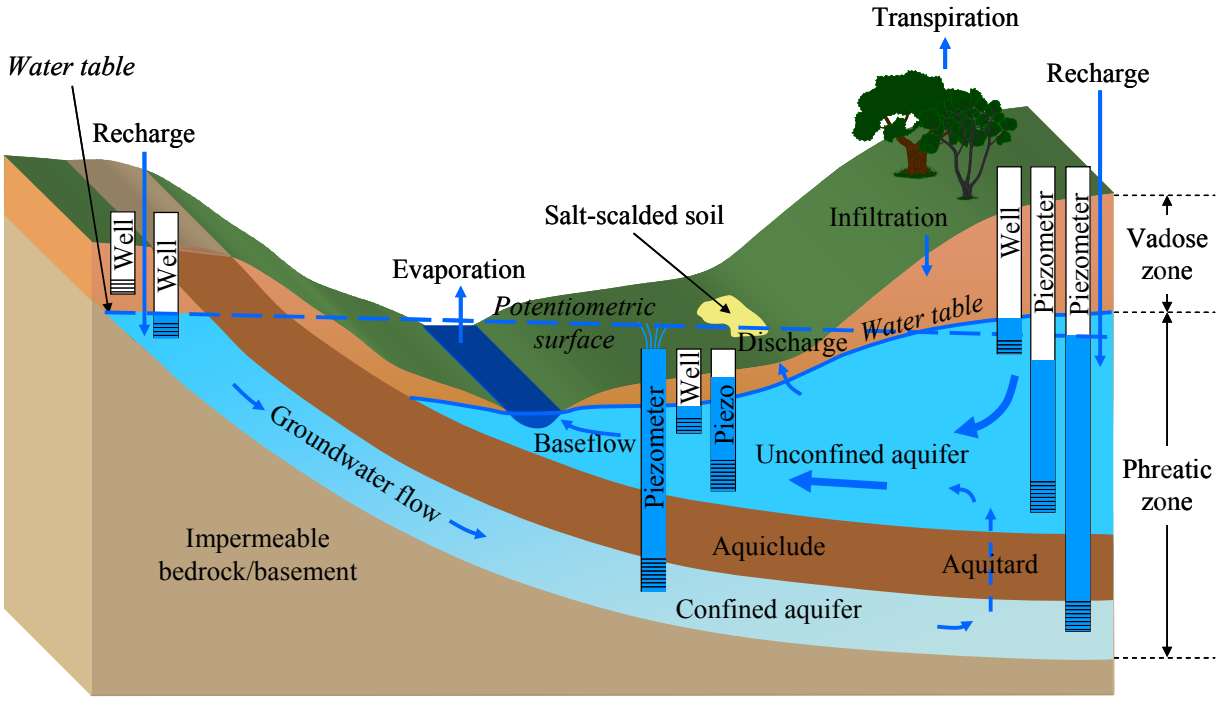


Figure 1: Basic diagram showing components of the hydrological cycle and groundwater terminology. (M. Smith)

## AQUIFER TYPES

Unconfined aquifers have a direct connection with rainfall and respond relatively quickly to changes in storage of soil moisture. In wet years groundwater levels in unconfined aquifers will rise quickly. Generally bores drilled and cased in these aquifers are called “wells” (such as in the cross sectional landscape diagram above). Often farmers will dig pits into sandy unconfined aquifers to water stock in wetter times.

Semi-confined aquifers is where groundwater is confined due to a layer of tight clays or rock but are not fully confined because groundwater can escape or leak through the layer either in fractures or where the soil is more permeable. Bores drilled and cased into these aquifers are known as piezometers and measure water level plus groundwater pressure, this is the general case in the SW of WA.

Confined aquifers are where groundwater is separated by a confining layer above and below. Bores drilled and cased into these aquifers are known a piezometers and measure water level plus groundwater pressure.

Farmer and salinity officers measuring the groundwater levels below the surface and taking a water sample from a piezometer

# AQUIFER HYDROLOGICAL CHARACTERISTICS

## POROSITY

Some rocks contain void spaces and others remain more solid. When solid rocks are near the surface the physical and chemical weathering processes create voids, fractures and openings between rocks. In sediments, porosity consists of the voids between solid fragments. The void spaces will depend on the particles (Table 2):

- **Fracturing** – how crack align
- **Packing** – how the grains of particles are assembled?
- **Shape and size** – are they spheres or angular?
- **Sorting** – are they all the same size or some larger and some smaller?

Table1 Adapted from Fetter (2001:75).

| POROSITY RANGES FOR SEDIMENTS | |
|---|---|
| **Well-sorted sand or gravel** | 25-50% |
| **Sand and gravel mixed** | 25-50% |
| **Silt** | 35-50% |
| **Clay** | 33-60% |

A good example of a clay soil of extremely low porosity.

## HYDRAULIC CONDUCTIVITY

The rate of water movement in saturated conditions (aquifers) can be calculated using Darcy's Law, 1855-1856. Darcy's law is a proportional relationship between the instantaneous discharge rate through a porous medium, the viscosity of the fluid and the pressure (gradient) drop over a given distance and is represented as hydraulic conductivity (Ksat) (m/day).

| TEXTURE | HYDRAULIC CONDUCTIVITY (m/day) |
|---|---|
| Clay soils | 0.01-0.2 |
| Deep clay beds | $10^{-8}$ - $10^{-2}$ |
| Loam soils (surface) | 0.1-1 |
| Fine sand | 1-5 |
| Medium sand | 5-20 |
| Coarse sand | 20-100 |
| Gravel | 100-1000 |
| Sand and gravel mixtures | 5-100 |

Table showing the range of hydraulic conductivity (Ksat) values for different soils, from Soil Guide.

## SPECIFIC YIELD

Specific Yield is the volume of water that can be added or drains from a saturated rock by gravity compared to the rocks total volume. Water molecules cling to the particles by surface tension. When gravity exerts its downward pull, some of that water will drip from the particle. The water left will form a thinner layer around the particle, but its surface tension force will be stronger. When the surface tension equals the stress of gravity, no more water will "drip" from it. The amount of water that has "dripped" from the particle is it's specific yield. Usually 2-10% for unconfined aquifers and 0.01 – 0.1% for confined layers.



More information:

Visit the DPIRD salinity webpages

Clarke et al., February 200. Dryland salinity in south-western Australia: Its origins, remedies, and future research directions, Australian Journal of Soil Research 40(1):93-113

George R., 1992. Hydraulic properties of groundwater systems in the saprolite and sediments of the wheatbelt, Western Australia, Journal of Hydrology, 130 (1992) 250-278

# REFERENCES

Crossley, E., 2001, Groundwater Study of the Wagin Townsite, Resource Management Technical Report 223, Department of Agriculture, Western Australia.

George R., 1992. Hydraulic properties of groundwater systems in the saprolite and sediments of the wheatbelt, Western Australia, Journal of Hydrology, 130 (1992) 250-278

https://www.academia.edu/23279433/Hydraulic_properties_of_groundwater_systems_in_the_saprolite_and_sediments_of_the_wheatbelt_Western_Australia

Fetter, C., 2001. Applied Hydrogeology, Fourth edition. Prentice-Hall, Inc. New Jersey. Global Groundwater, 2003, 2003 test Pumping Report Fence Road Dumbleyung, Global Groundwater, Western Australia.

Soil Guide. A handbook for understanding and managing agricultural soils. Bulletin 4343. Agriculture Western Australia. 1998.

https://researchlibrary.agric.wa.gov.au/bulletins/2/

# QUESTIONS

1. **What is ' hydraulic conductivity"?**
    - ❑ A type of instrument used to measure groundwater
    - ❑ Water moving through a conductive medium
    - ❑ The rate at which water moves through the soil in m/day

2. **What makes groundwater move within the soil?**
    - ❑ Gravity and hydraulic pressure
    - ❑ Soil particles
    - ❑ A lot of salt

3. **Why is piezometer not measuring the actual depth to the water table?**
    - ❑ Because it is affected by the pressure of the aquifer
    - ❑ Because the bore is installed to bedrock
    - ❑ Because they are usually located in the low part of the landscape

4. **If you saturated the soil and dried it, what area would be the driest?**
    - ❑ Phreatic zone
    - ❑ Aquifer
    - ❑ Vadose zone

5. **Does soil texture affect the rate of water moving through it?**
    - ❑ No, all soil types have air spaces to carry water
    - ❑ Yes, clay is tighter than sand
    - ❑ It doesn't matter; water travels through any soil type

# NOTES

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