HYDROGEOLOGY AND DRILLING SUPERVISION TRAINING

Day 1

Hydrogeology and Drilling Supervision Training - Course Syllabus

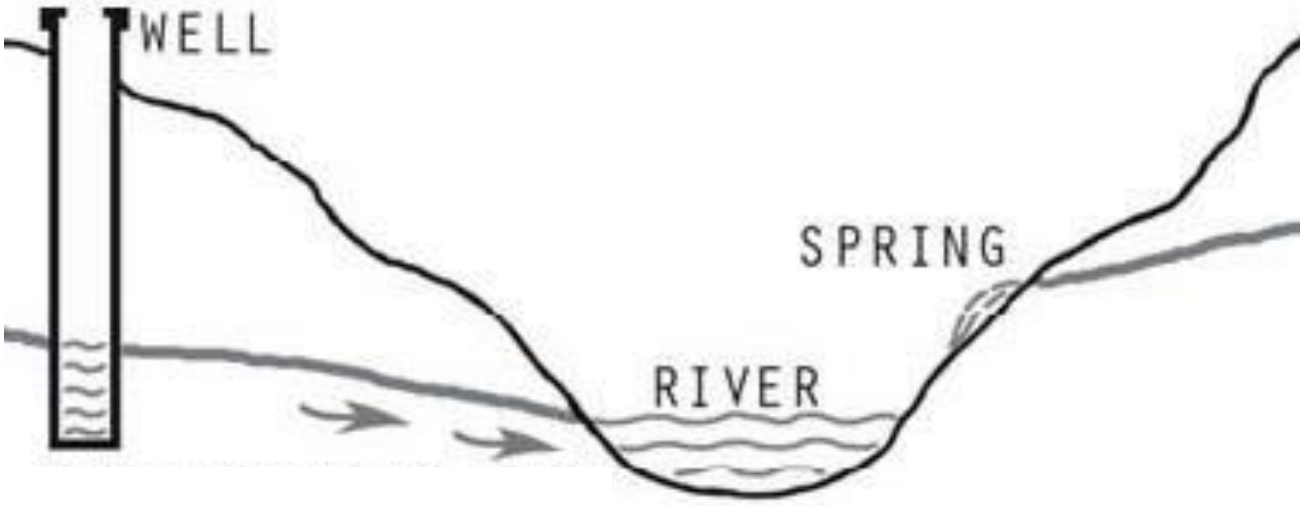
SESSION	DAY 1	DAY 2	DAY 3	DAY 4
1 08.30 09.15	Inauguration and Welcome Introduction Training objectives	Drilling Techniques Drilling Data	Development and Pumping Tests Relevant Contract Detail	Handpump Design and Maintenance Maintenance and Software
2 09.15 10.00	Introduction to Geology Relevance to Hydrogeology Geology of Zambia Identification	Drilling Contracts Drilling Supervision Data Collected	Pump Installation Depth Calculations	Rehabilitation Water Point Mapping
10.00 10.30	**Coffee/Tea Break**			
3 10.30 11.15	Introduction to Hydrogeology The hydrological cycle Permeability and porosity	Geophysical Surveying Types of survey equipment Contract for siting Geophysics BoQ	Construction of Civil Works Contractual Issues Related To Civil Works BoQ	Contract Management Progress meetings Dealing with contractors Papertrail Froms
4 11.15 12.00	Project Area Hydrogeology Hydrochemistry	Geophysical Surveying Borehole Location	Construction of Civil Works Iron filters	Contract Management Liability Invoice Appraisal
12.00 13.00	**Lunch Break**			
5 13.00 13.45	Mathematics as a useful tool Why is it useful Units	Technical Specification Borehole Design Borehole design specification	Introduction to Mapping Types of maps Position	Question and Answer Session This session to be devoted to items selected by participants
6 13.45 14.30	Applications to Hydrogeology Useful calculations and unit conversions	Borehole BoQ Borehole Design Practical	Global Positioning Systems GPS Set up GPS Data Transfer and accuracy	Continuation of Q & A session
14.30 15.00	**Coffee/Tea Break**			
7 15.00 15.45	Practical Session on identification of rocks	Practical session on application of Mathematics to Hydrogeology	Pump installation calculations Pumping test calculations	Evaluation and Final Discussion
8 15.45 16.30	Practical session on useful Mathematics	Practical Session on Borehole Design	Practical Session on GPS Creating Waypoint and tracks Transferring GPS data	Wrap Up

Course Objectives

- Introduction to Geology and Hydrogeology
- Drilling Supervision Techniques
- Borehole Design
- Pumping Test Interpretation and Depth Settings
- Rehabilitation and Water Point Mapping
- Contract Management
- GPS and Mapping

Objectives to Demystify Groundwater

- **Where do rivers come from?**



Groundwater and Geology

- **Hydro - Geology**

•Groundwater is stored and transmitted by rocks

•Groundwater can only be understood with an appreciation of Geology

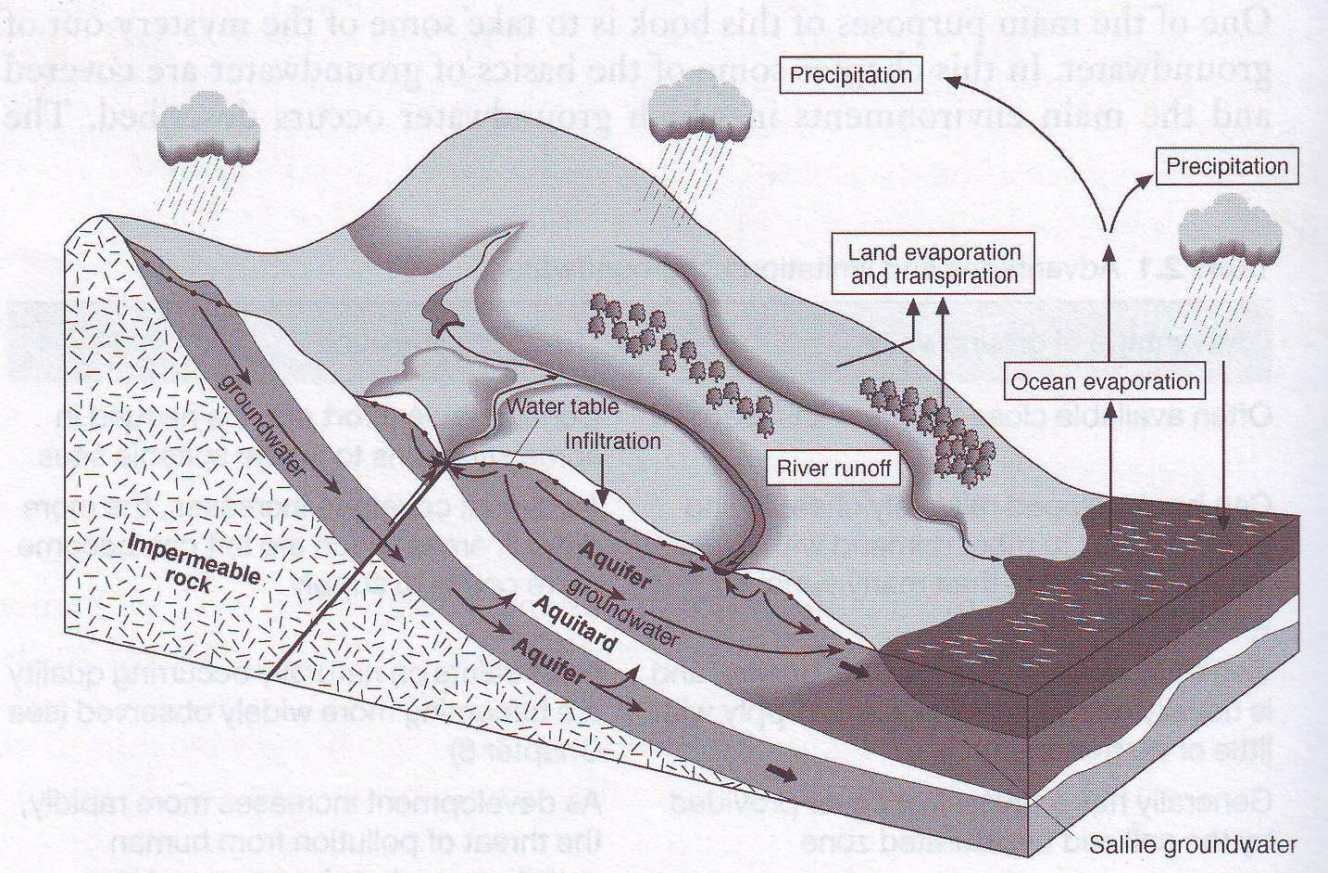
- **97% of Fresh Water**

- **Over 1.5 Billion People**

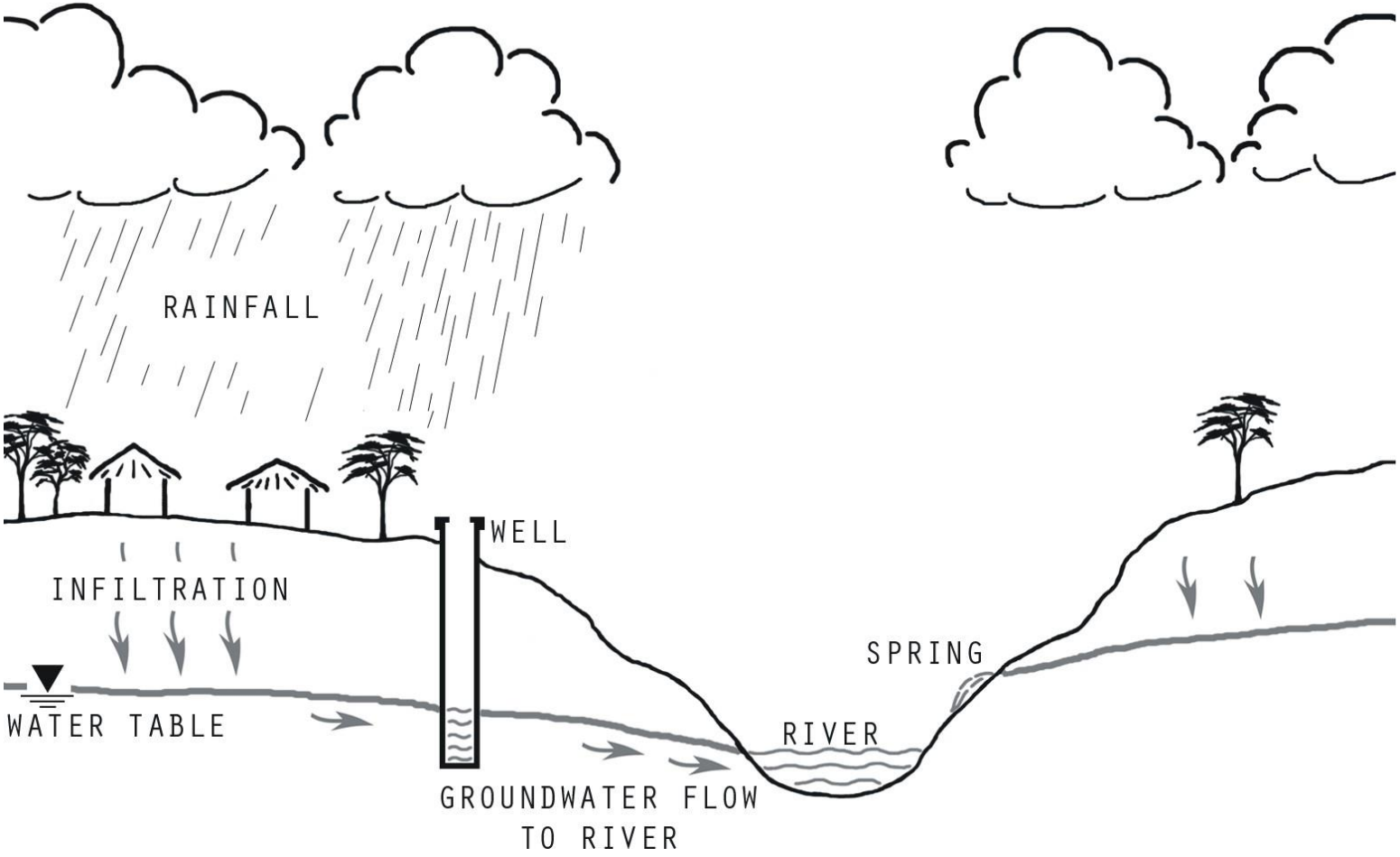
Main Purpose in Understanding Geology in Rural Water Supply Projects

- **Permeability and porosity**
- **Geophysical Method**
- **Drilling Technique**
- **Water Quality**
- **Logistics**

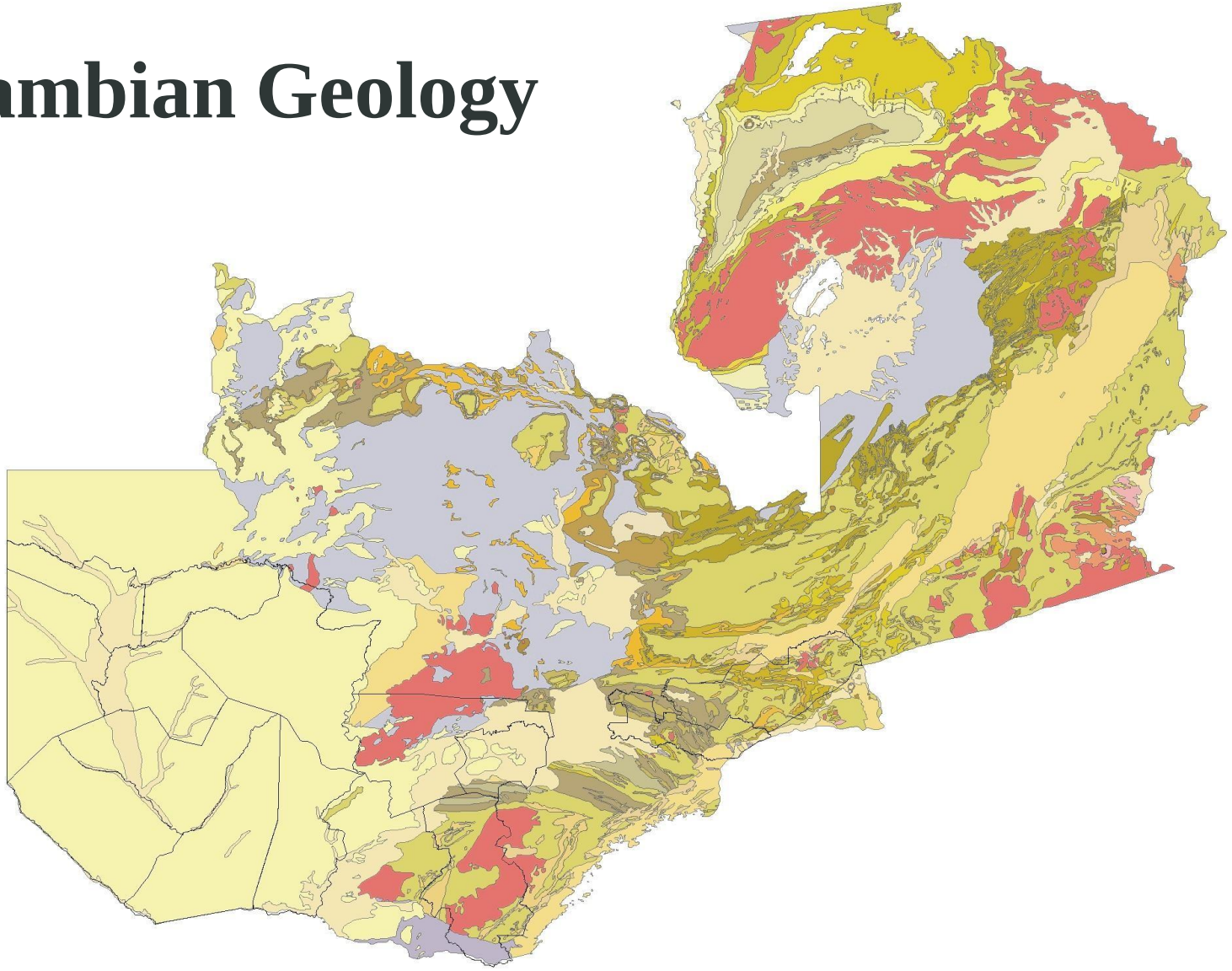
The Hydrological Cycle



The Hydrological Cycle



Zambian Geology



Main Geological Division

- **Igneous**

← **Time**

- Sedimentary

- Metamorphic

All types present in project area

All start as Igneous rocks

Igneous Rocks

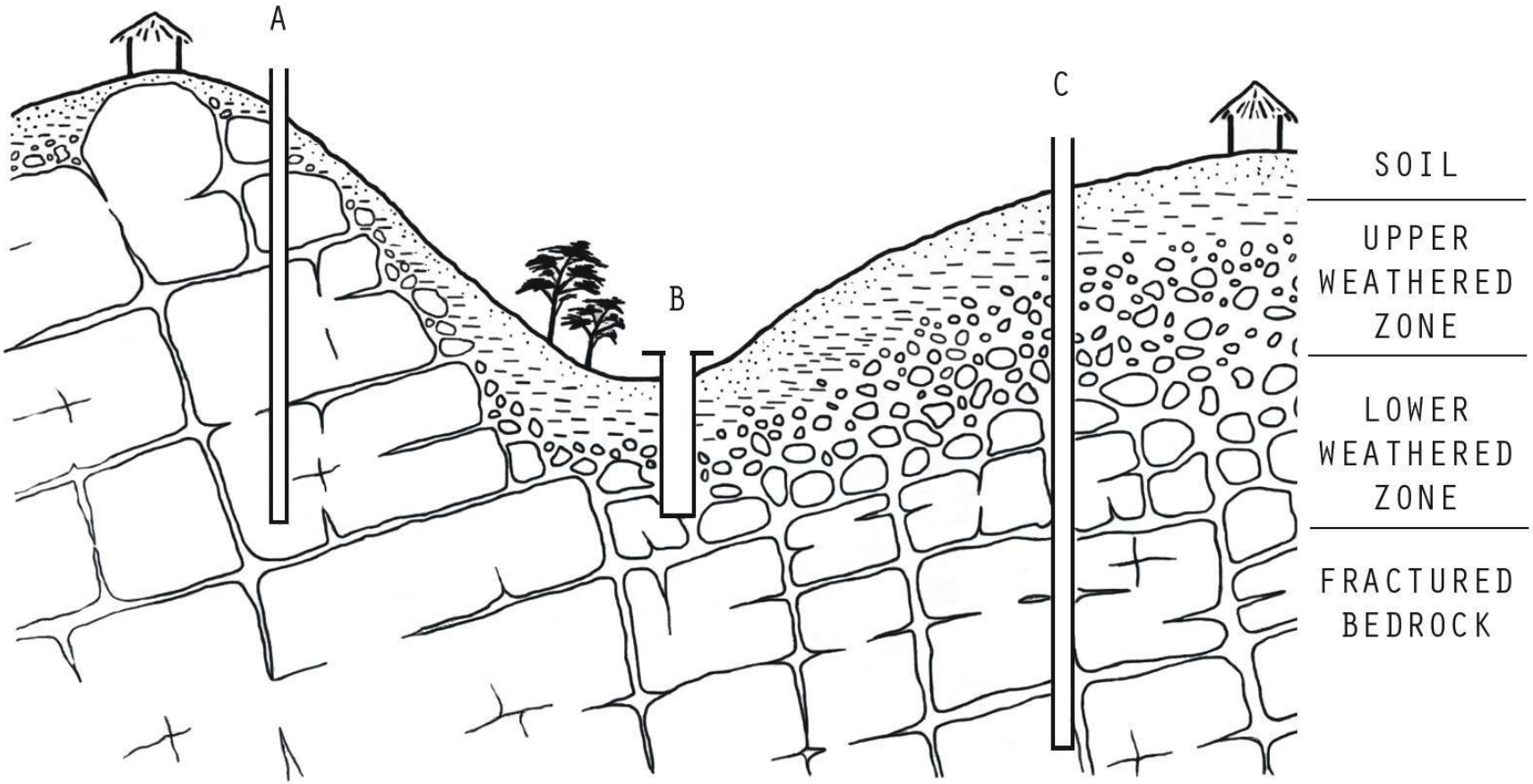
- Intrusive
- Extrusive

Very large subject - maps

Crystalline – no pore space

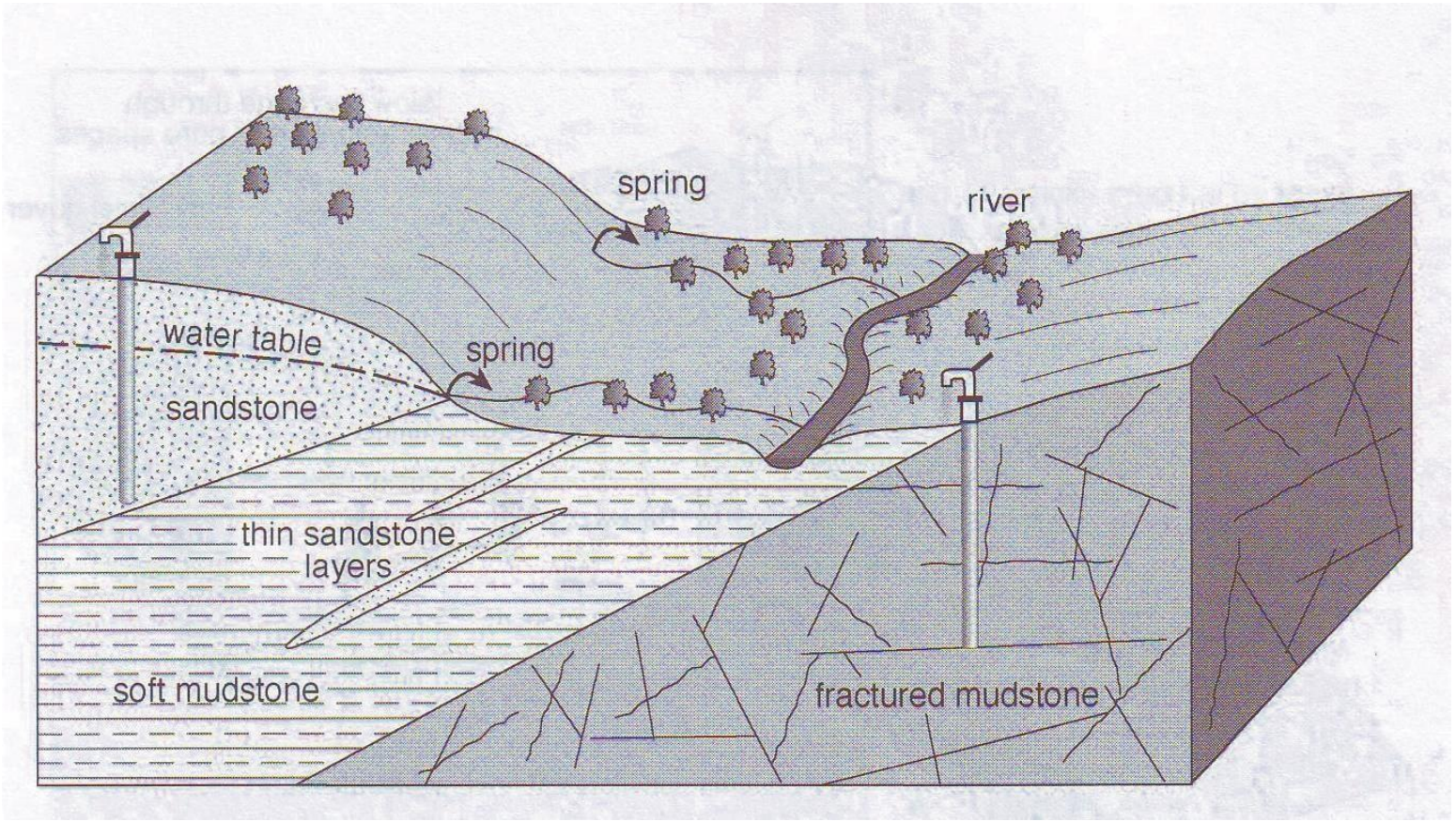
Cover large area

Weathering of Bedrock

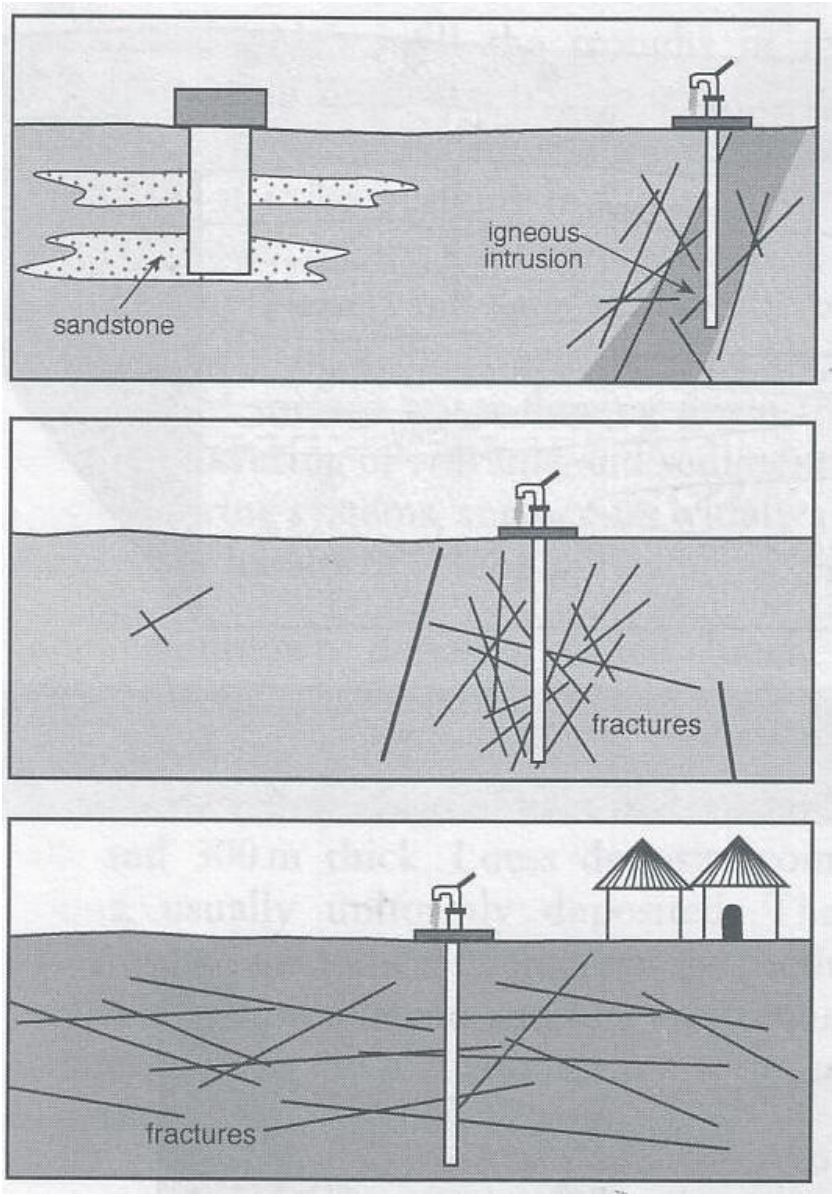


Picture of Weathering Profile

Sedimentary Rocks



Mudstones

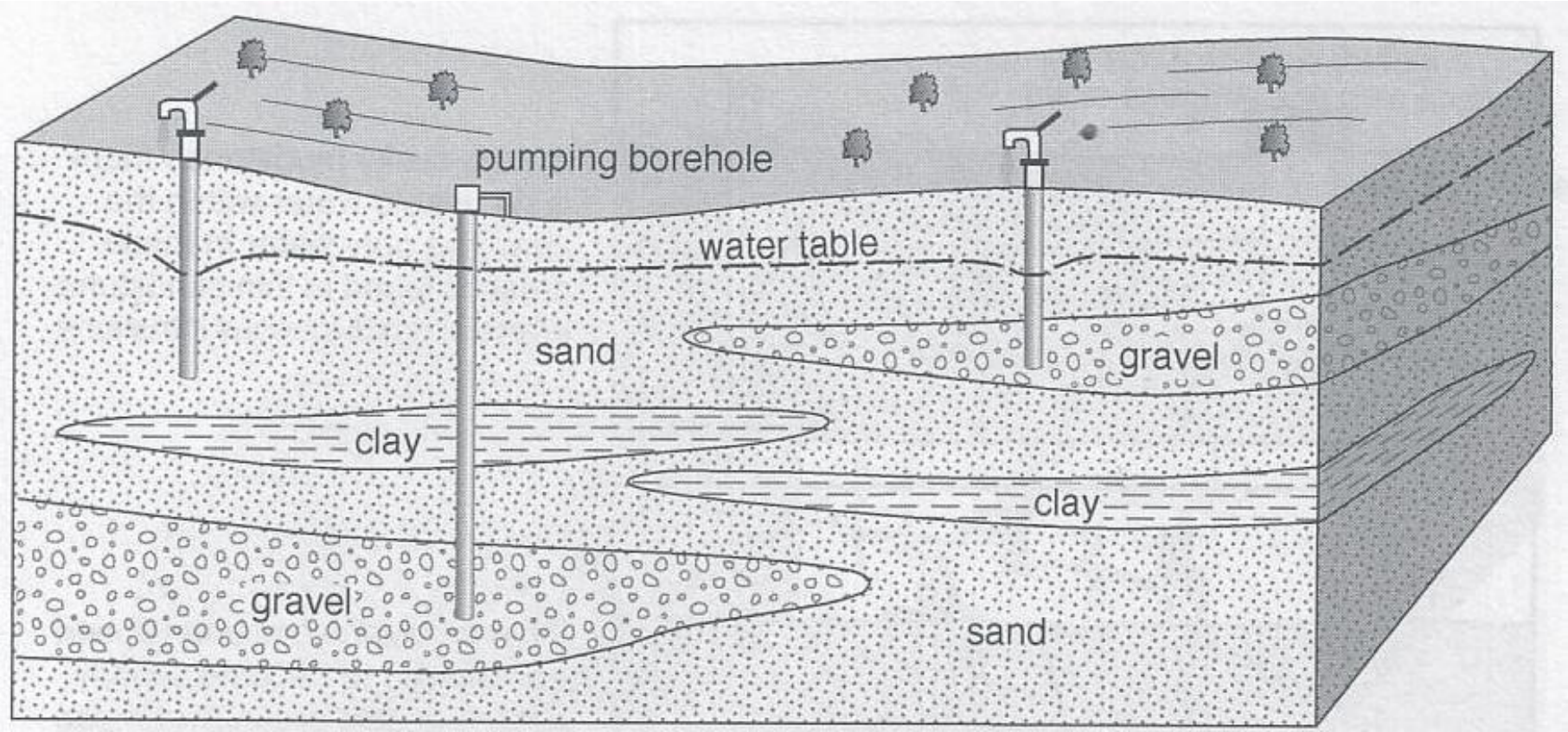


Sand Lenses

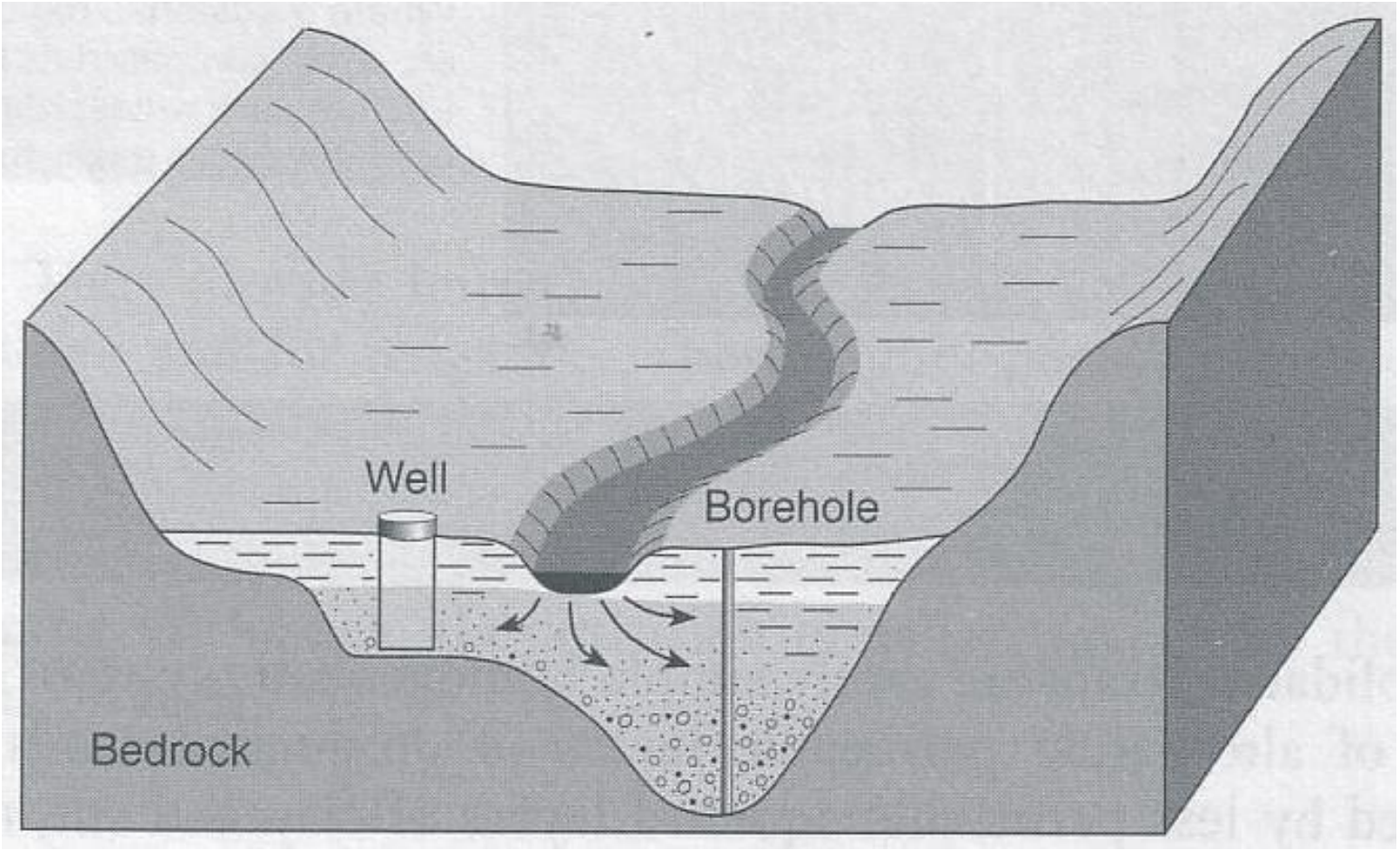
Harder Mudstones

Fractured Shales

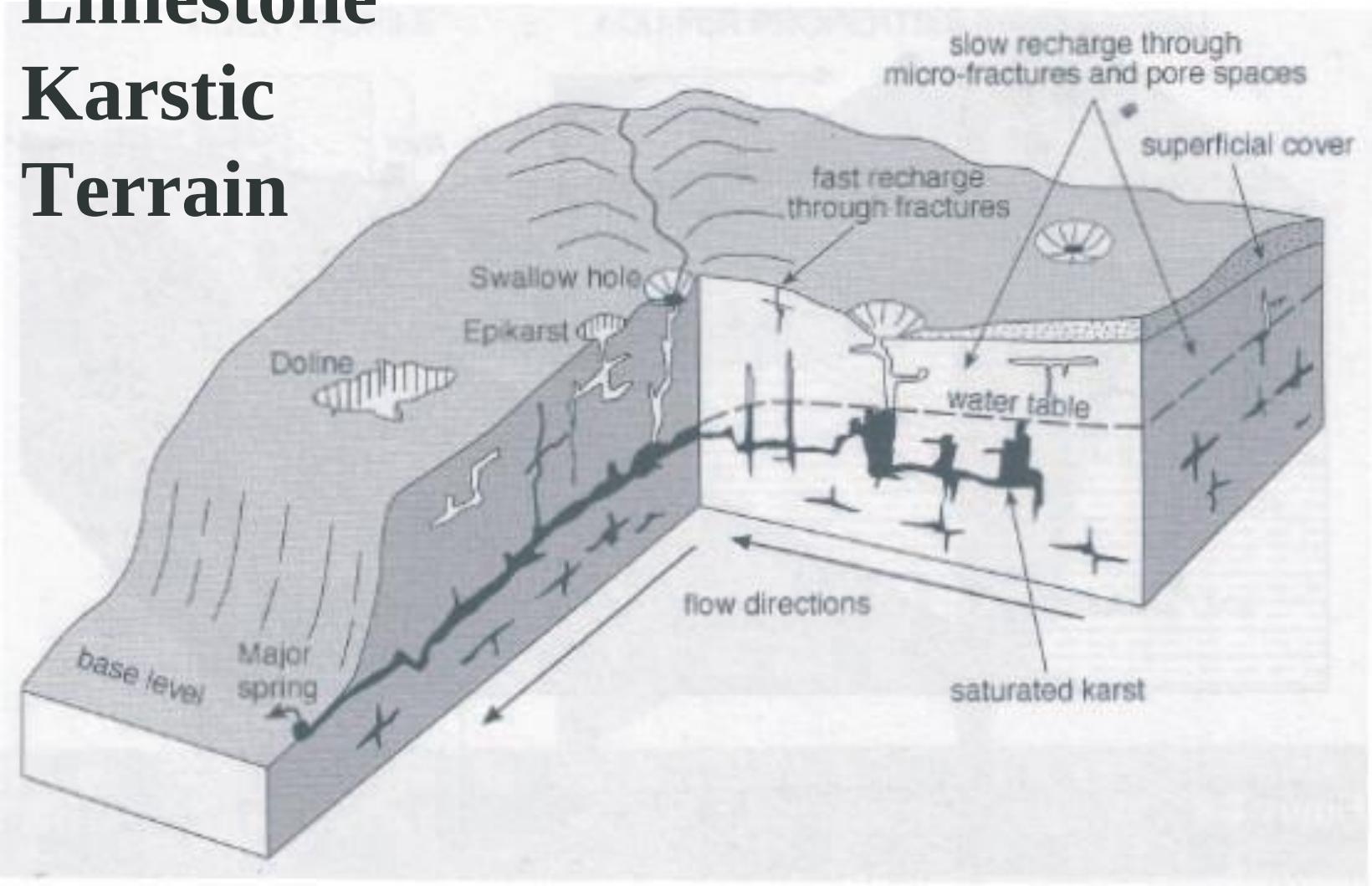
Alluvial Basin



Riverside Alluvium



Limestone Karstic Terrain

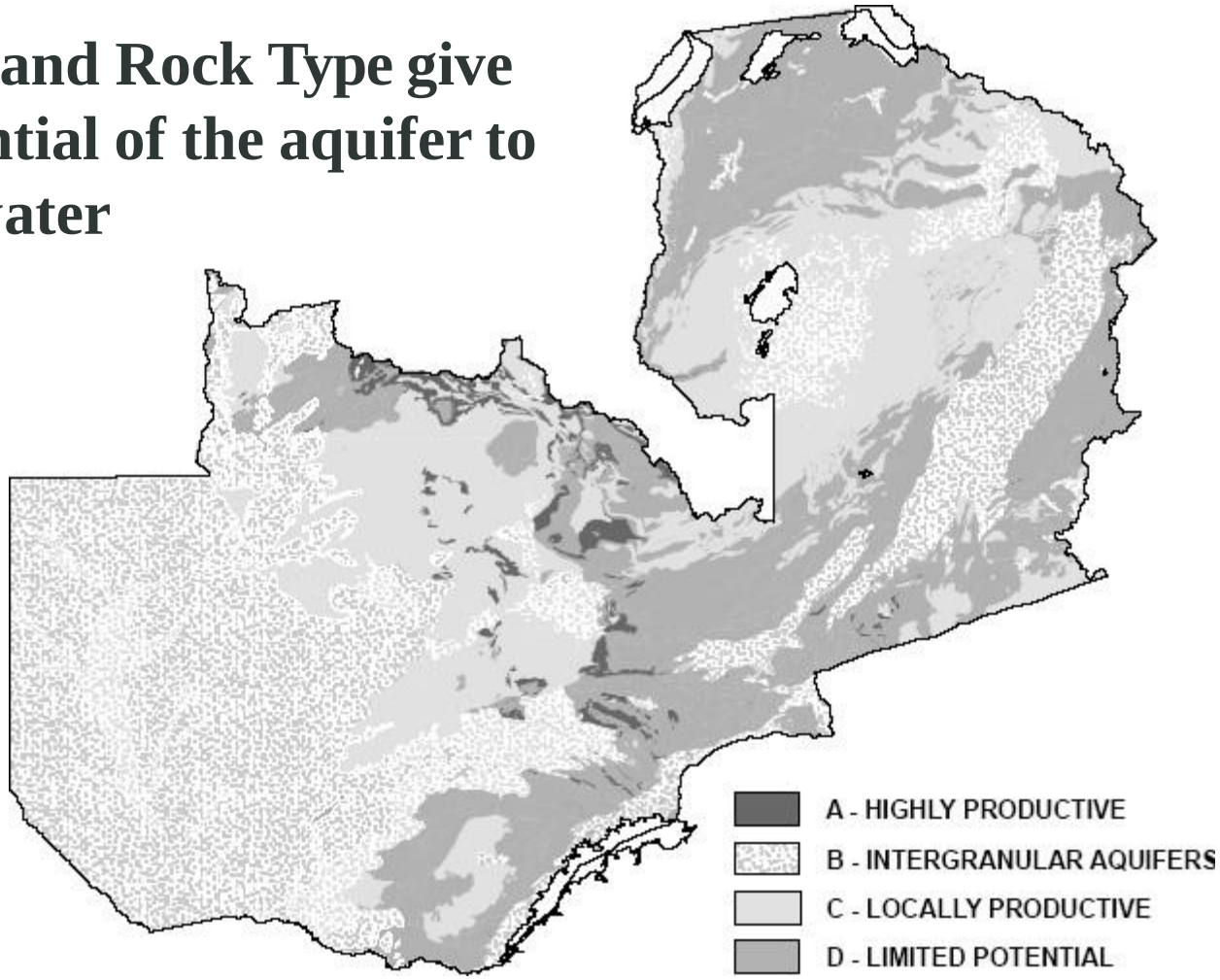


Permeability and Porosity

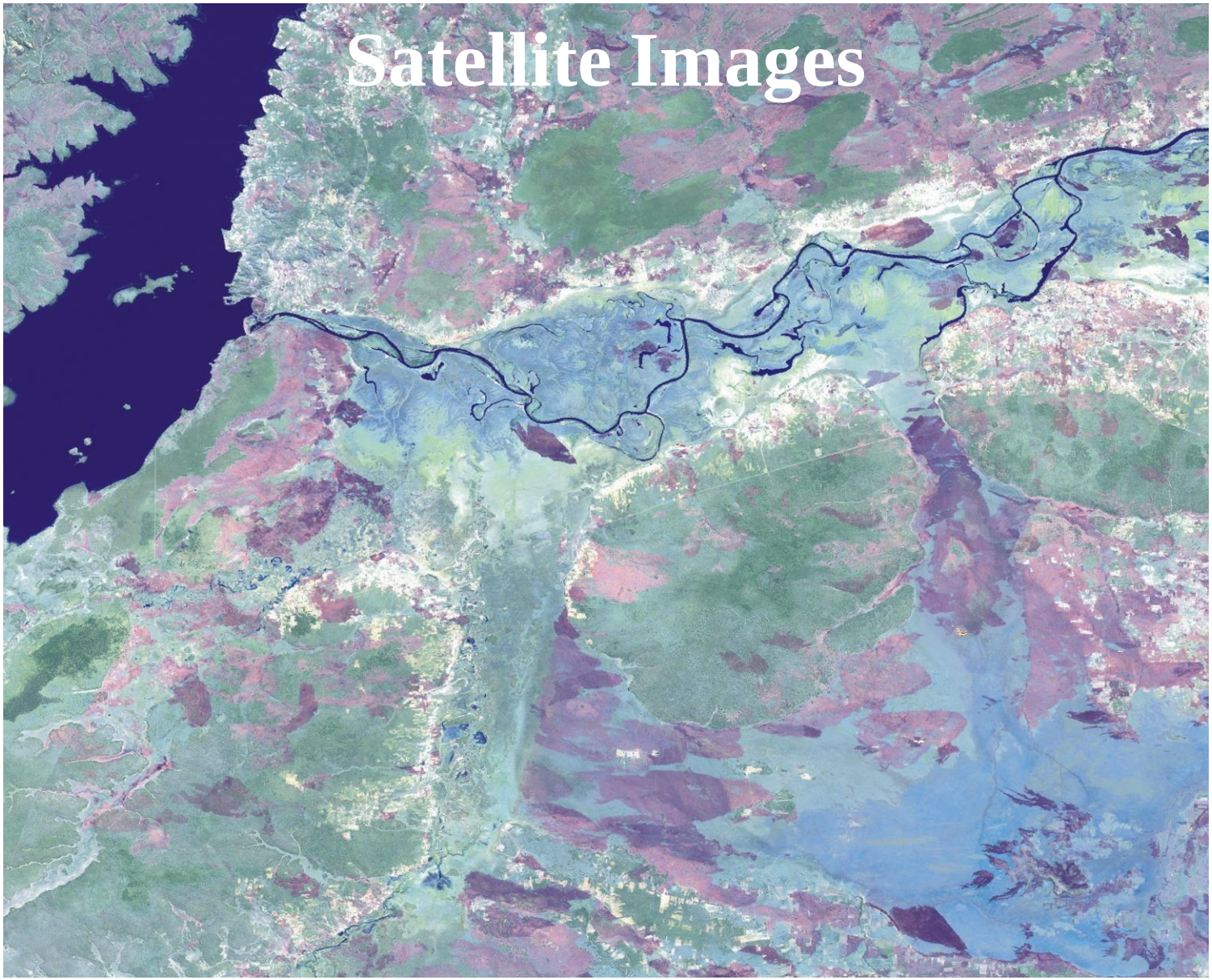
- **Storage**
- **Crystalline Hard Rocks**
- **Sedimentary**
- **Combination - Dual Porosity**
- **Weathering**

Geology and Hydrogeology of Zambia

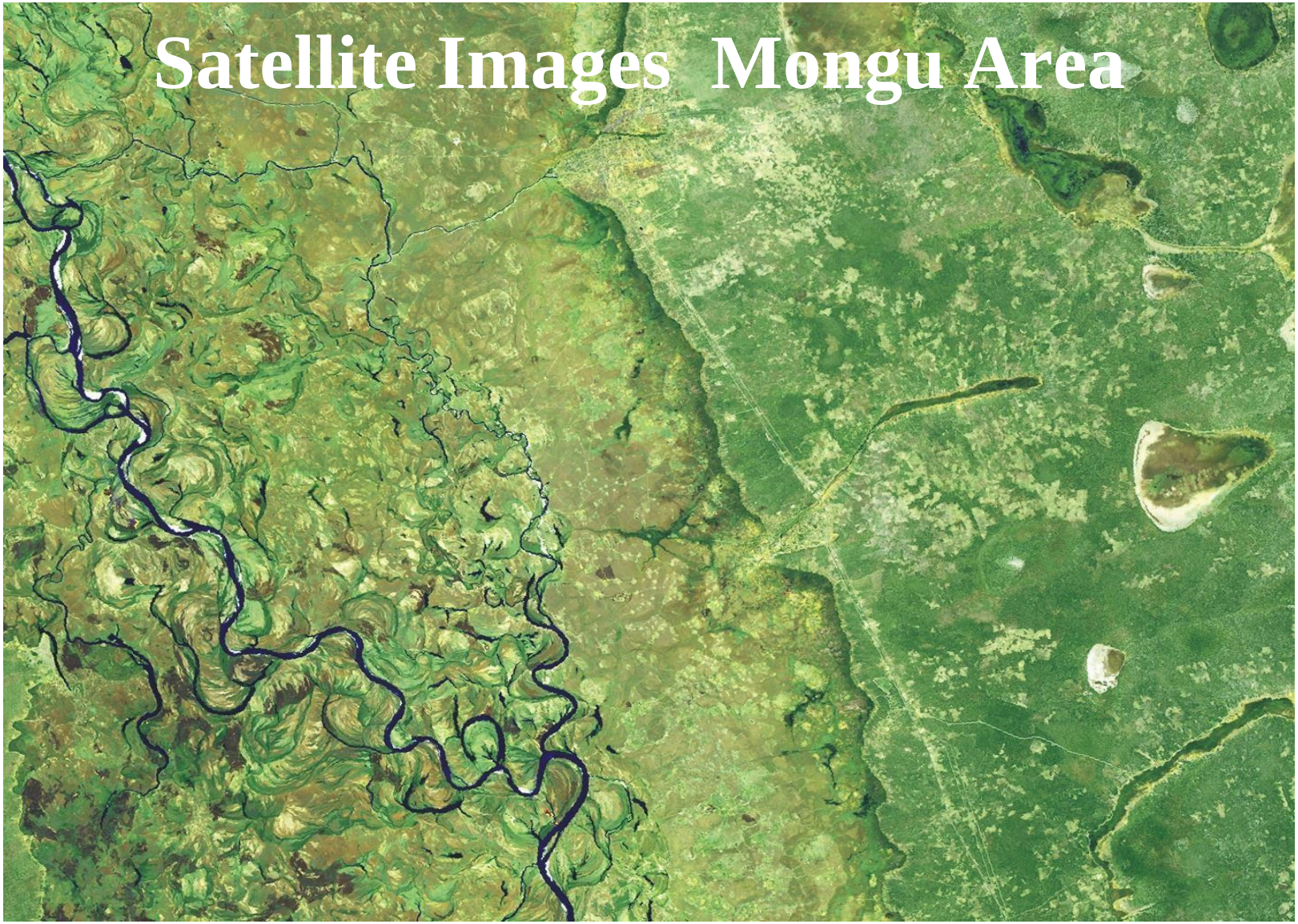
Geology and Rock Type give the potential of the aquifer to supply water



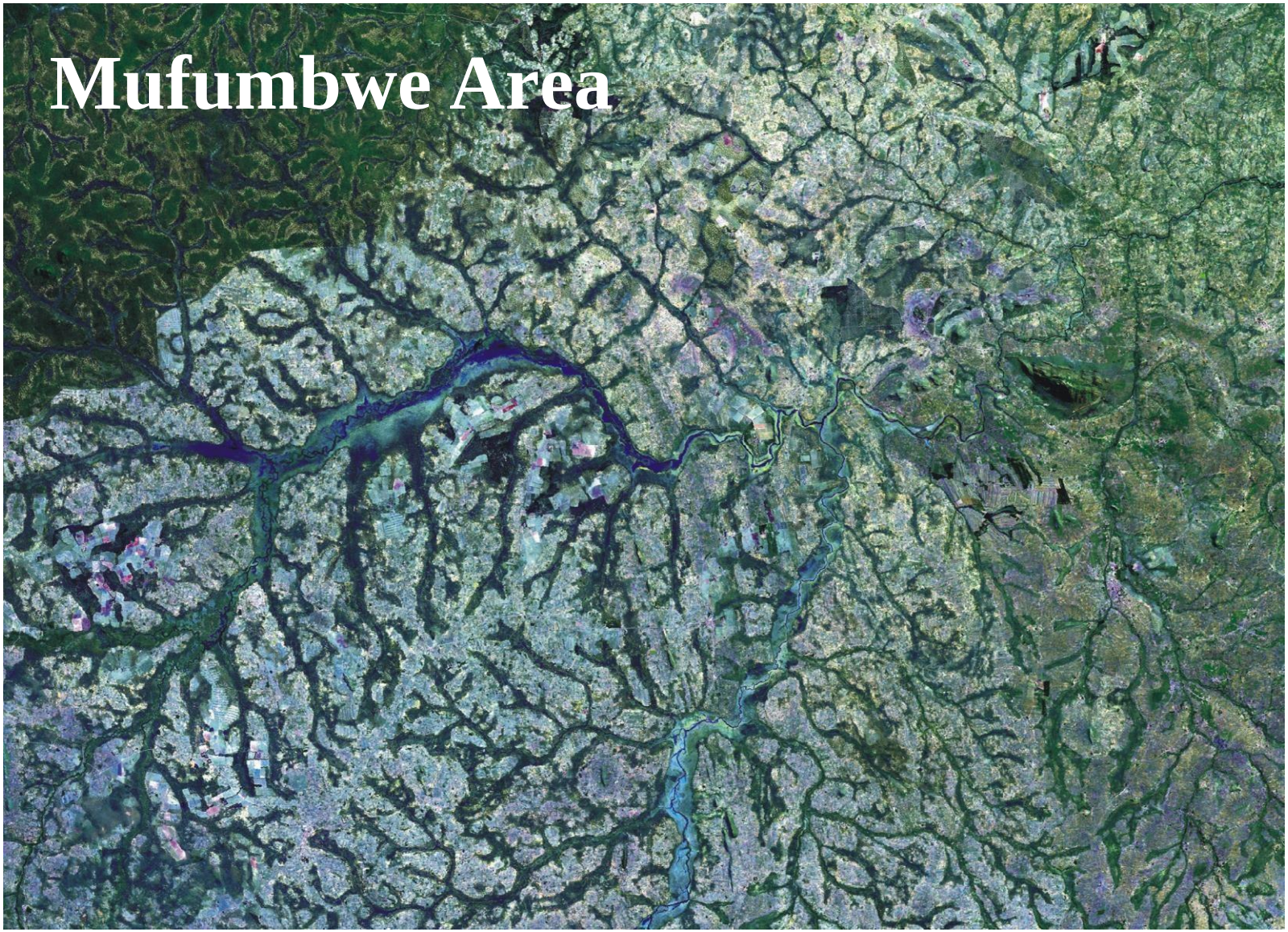
Satellite Images



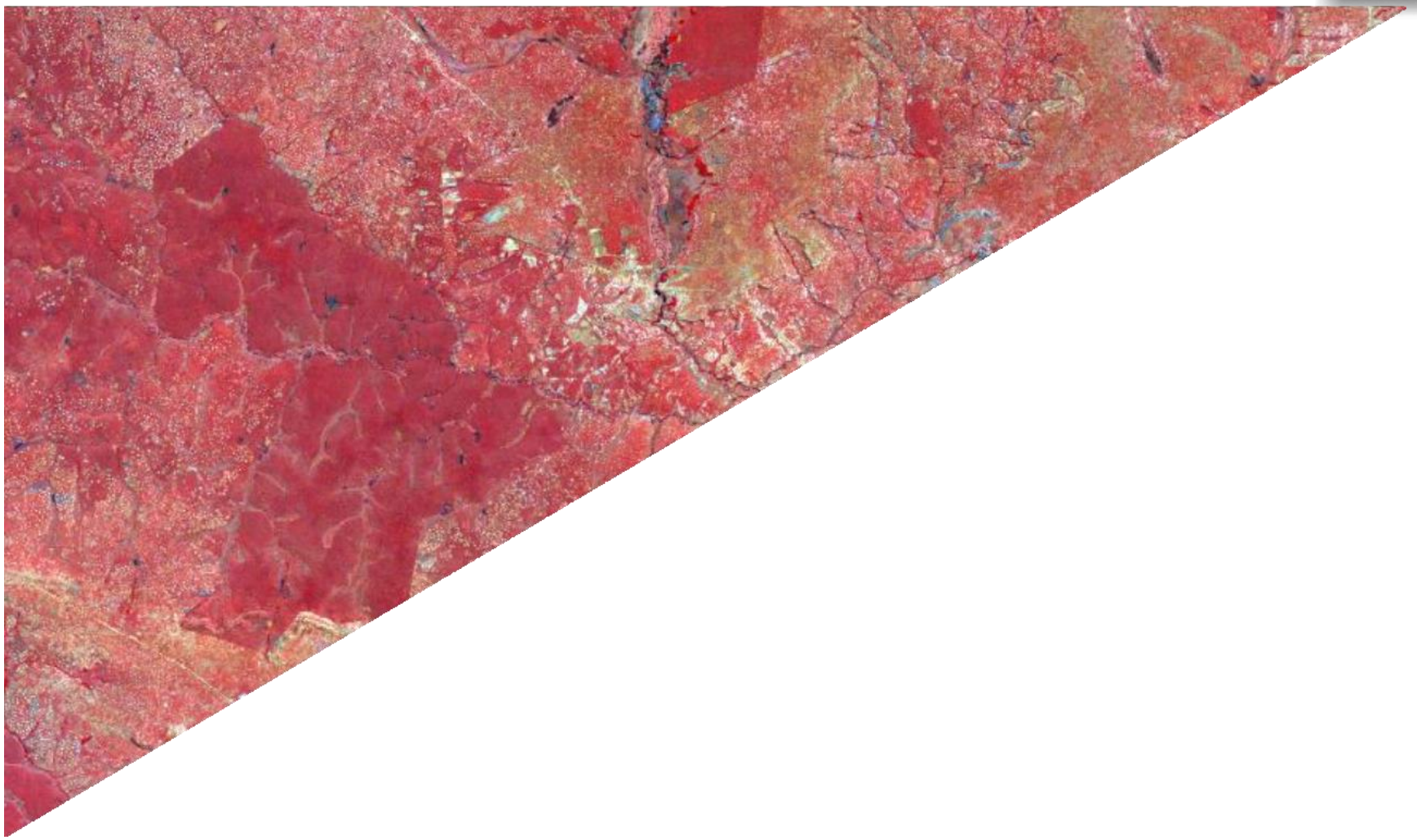
Satellite Images Mongu Area



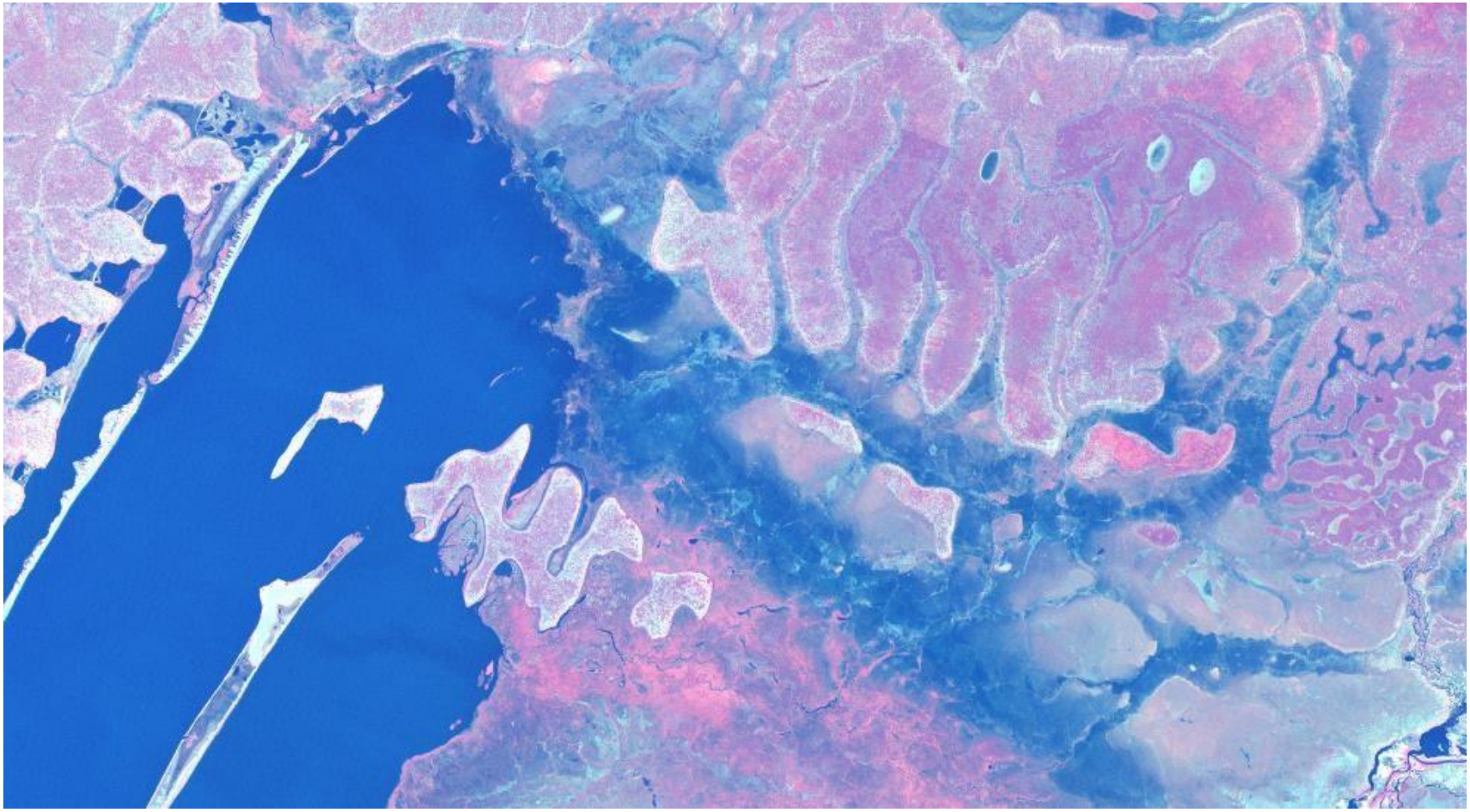
Mufumbwe Area

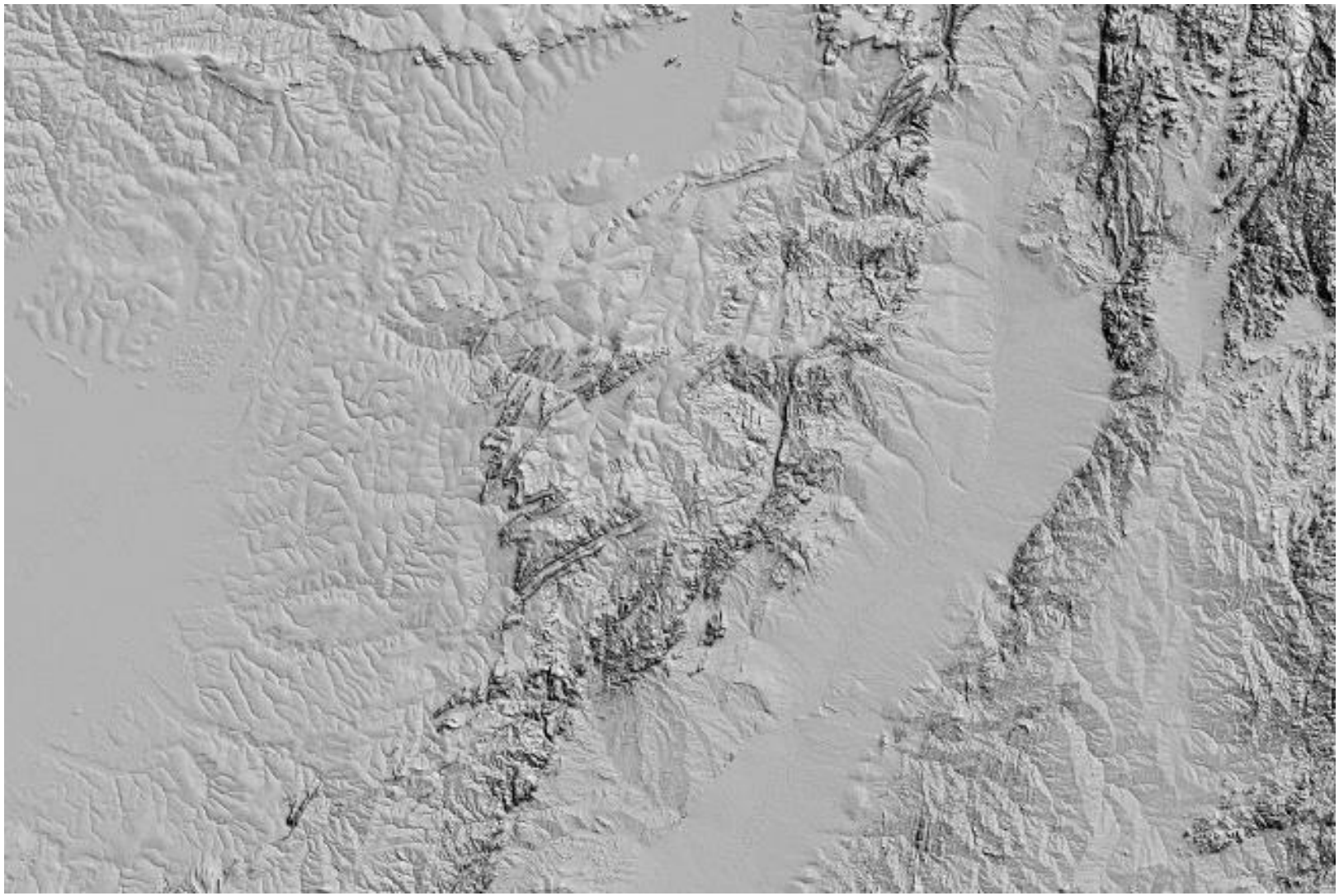


Landsat Images

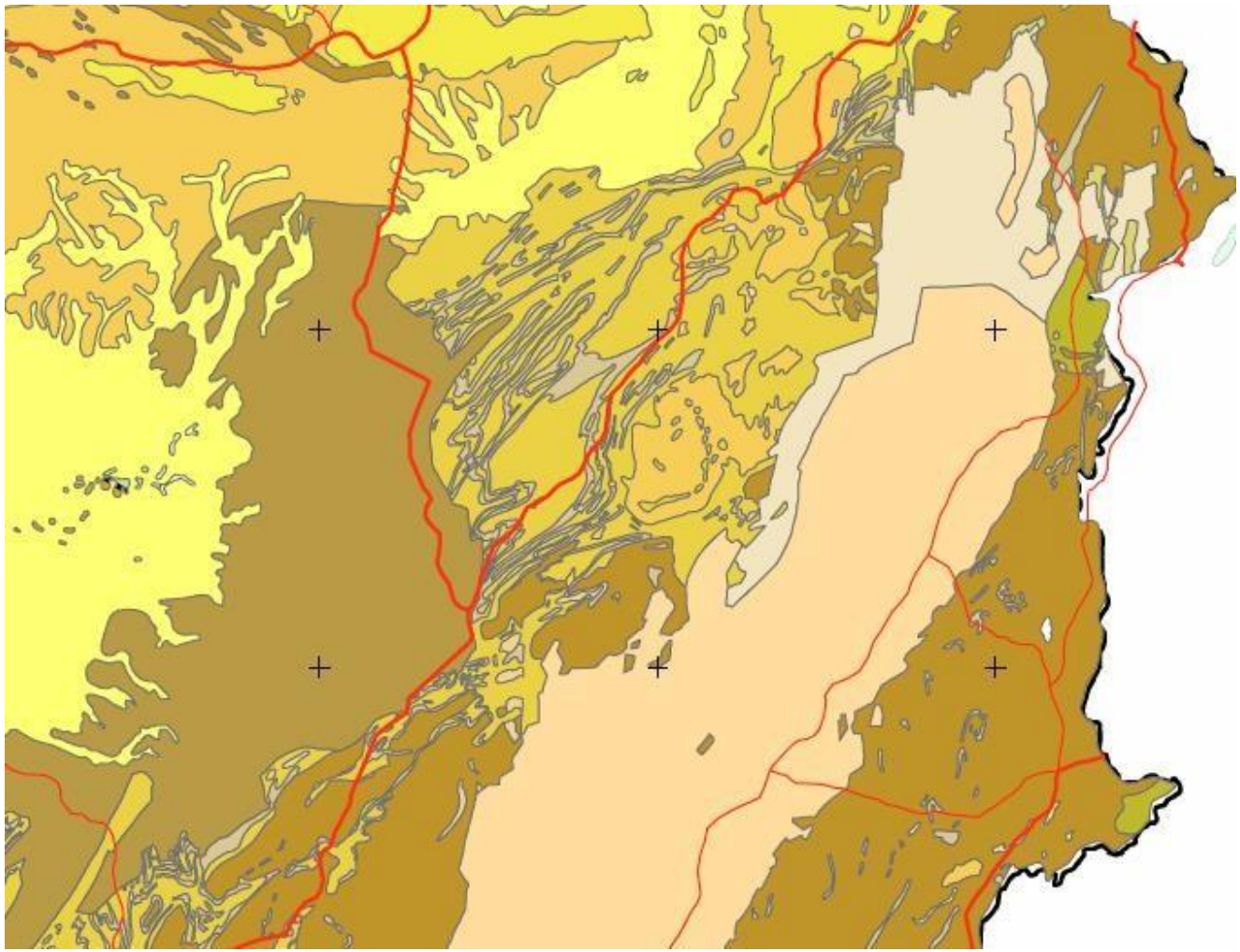


Landsat Images

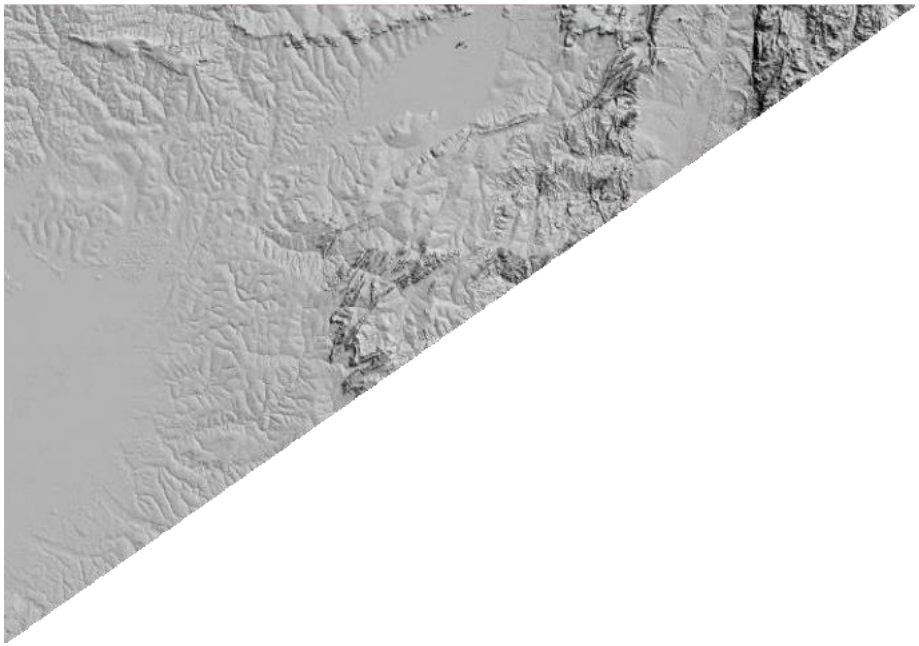


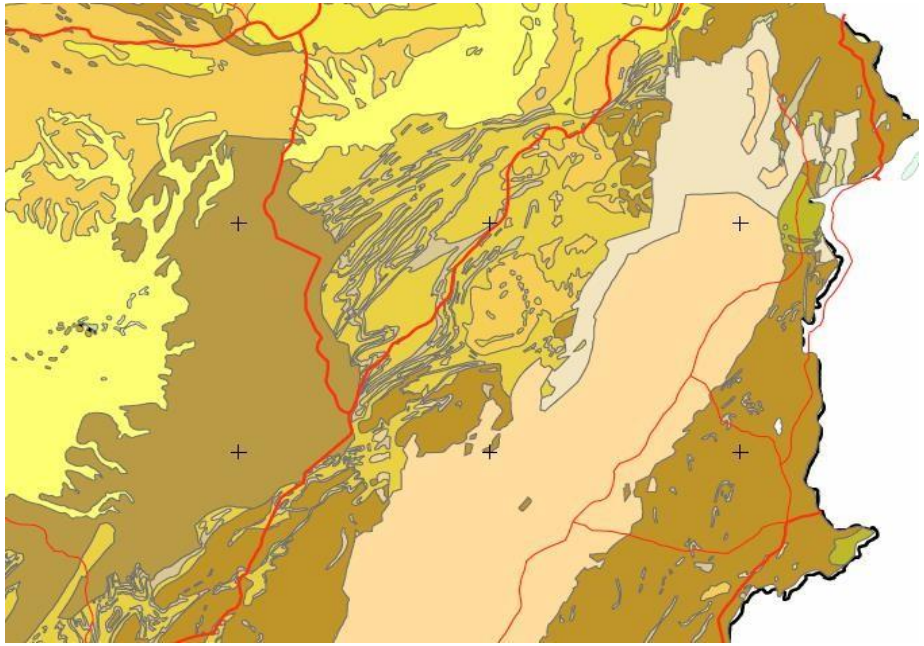


SRTM Area Geology

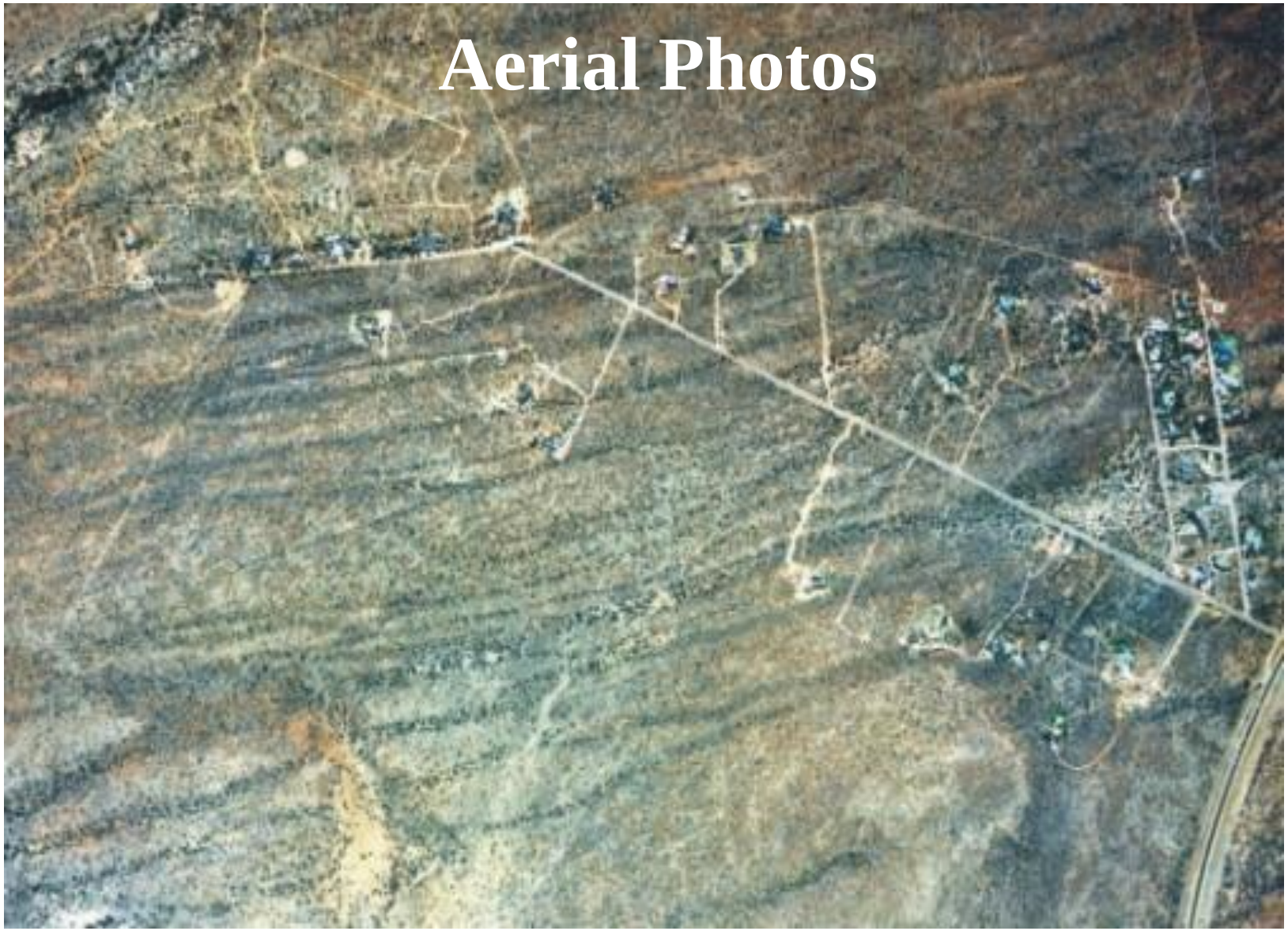


SRTM and Geology





Aerial Photos



Geology linked to Landsurface

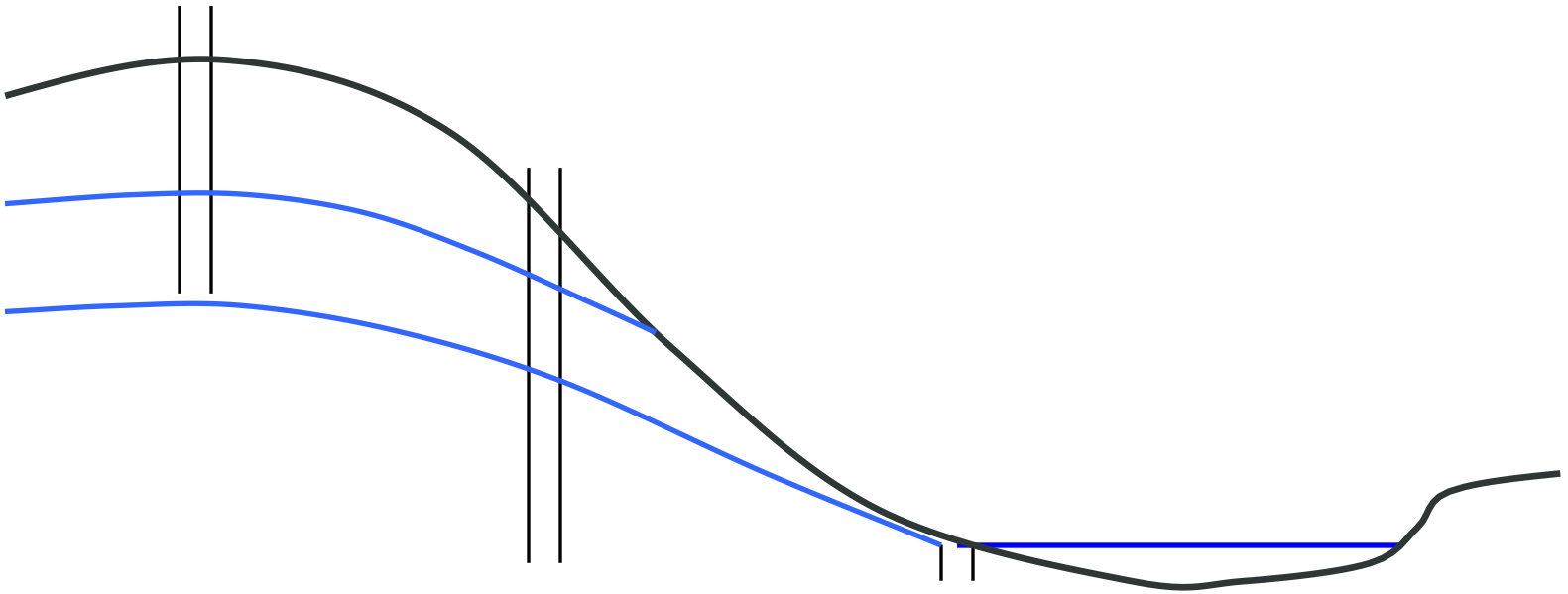
What is seen around as the landsurface

Results of Geology and Climate

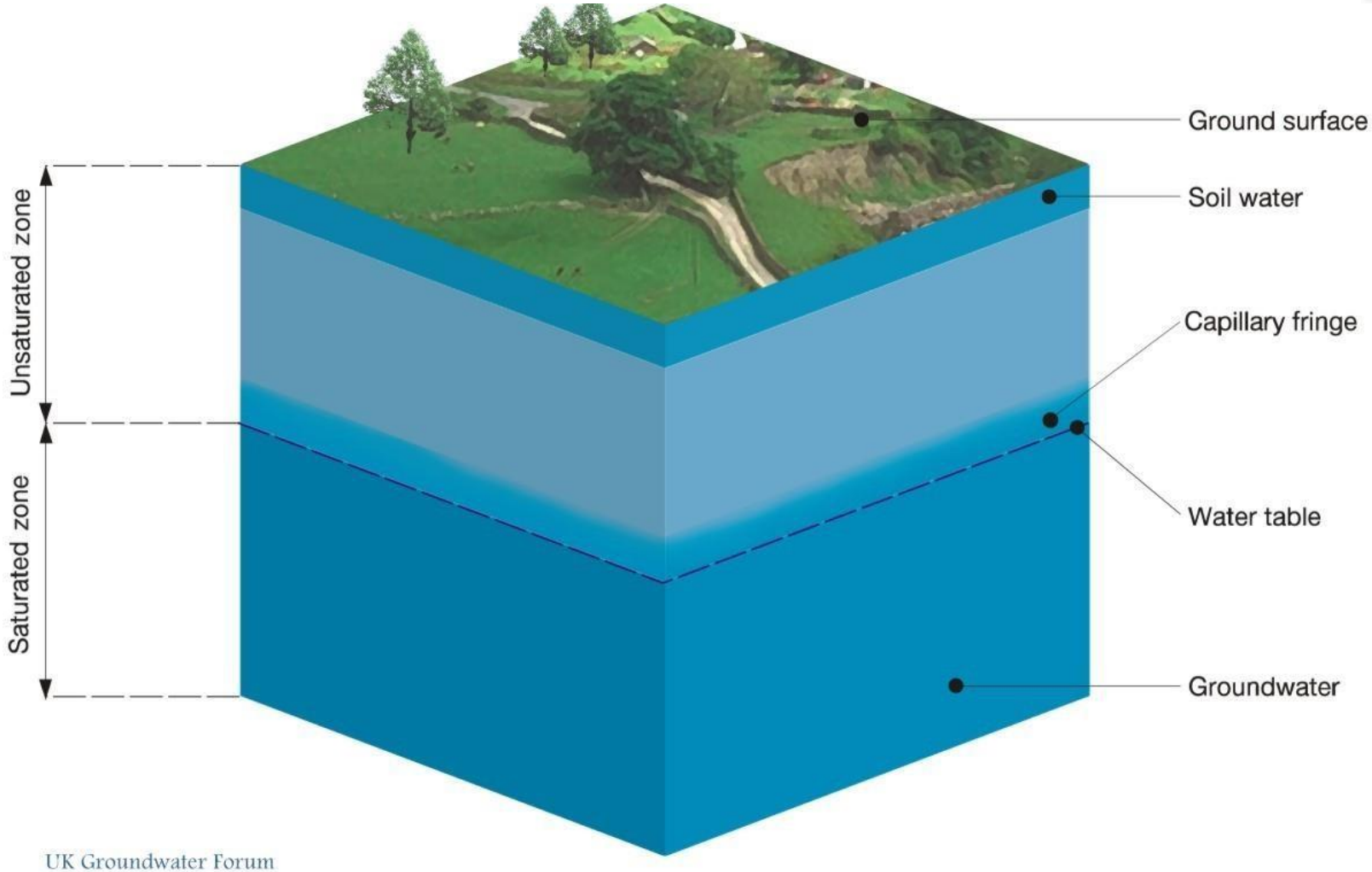
Why Use Groundwater

- Areas where there is no surface water nearby
- Quality is good
- Responds slowly to changes in weather patterns
- Drought
- Safer than collecting from Rivers

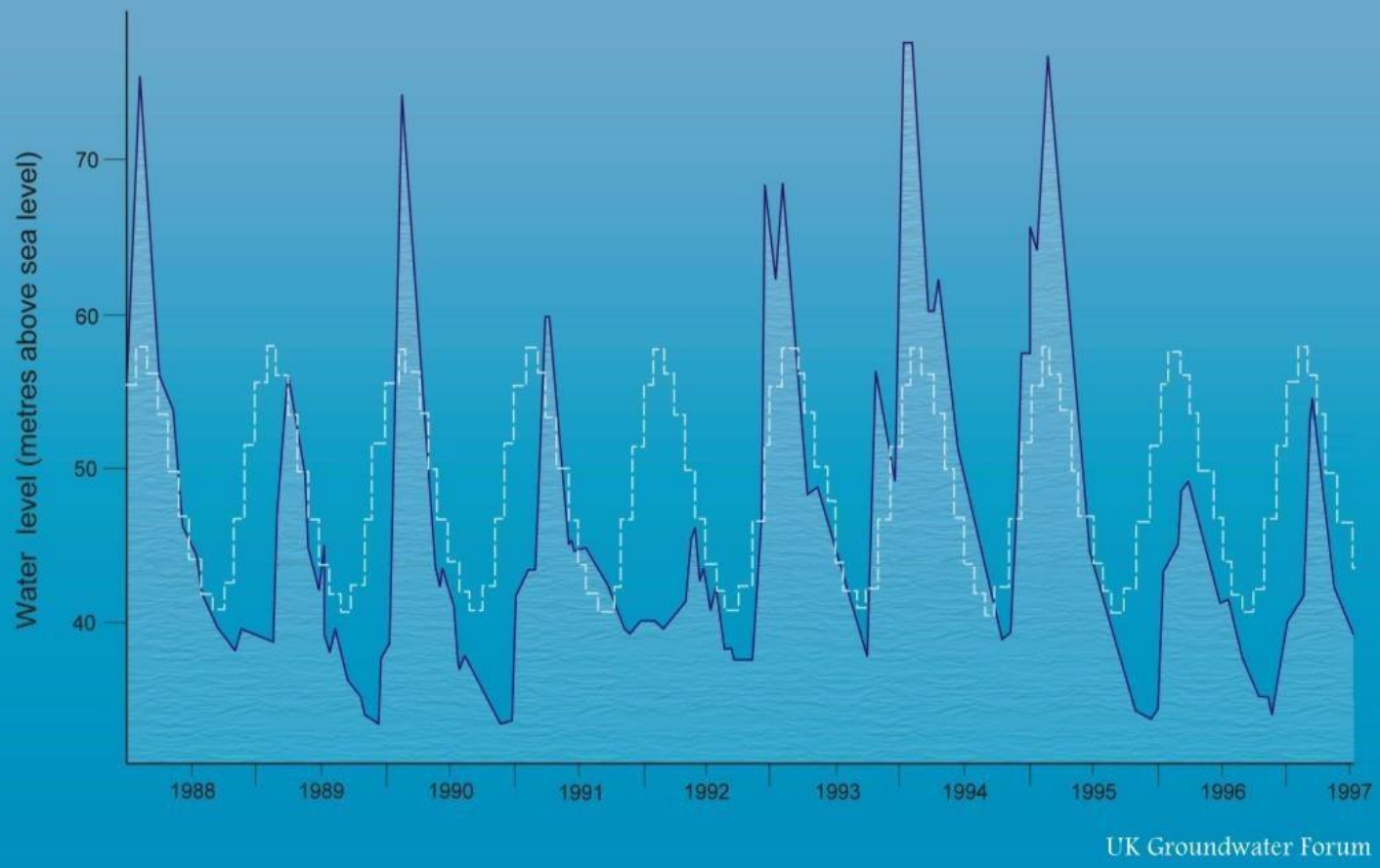
The Water Table Profile



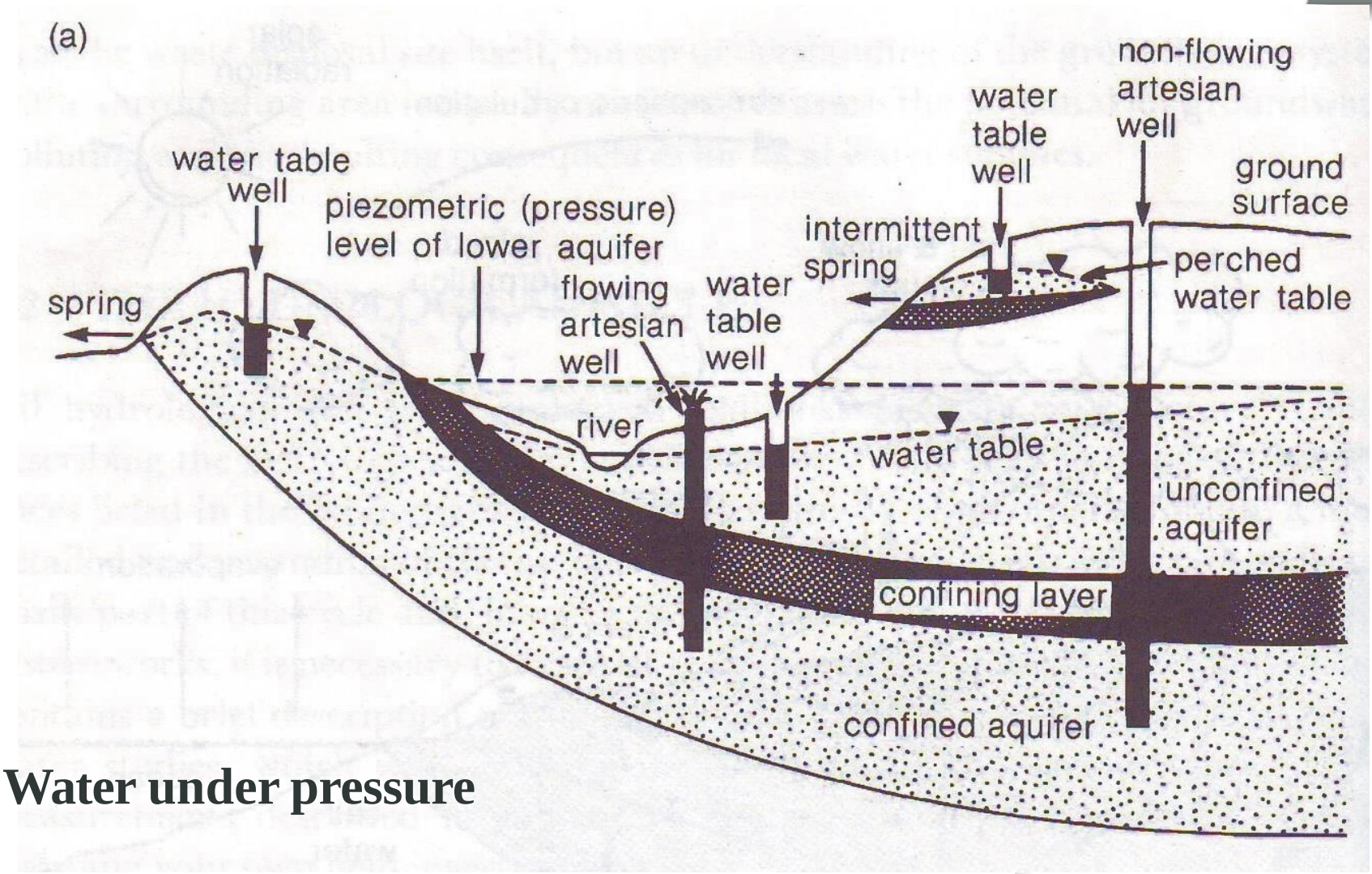
The Water Table



The Hydrograph



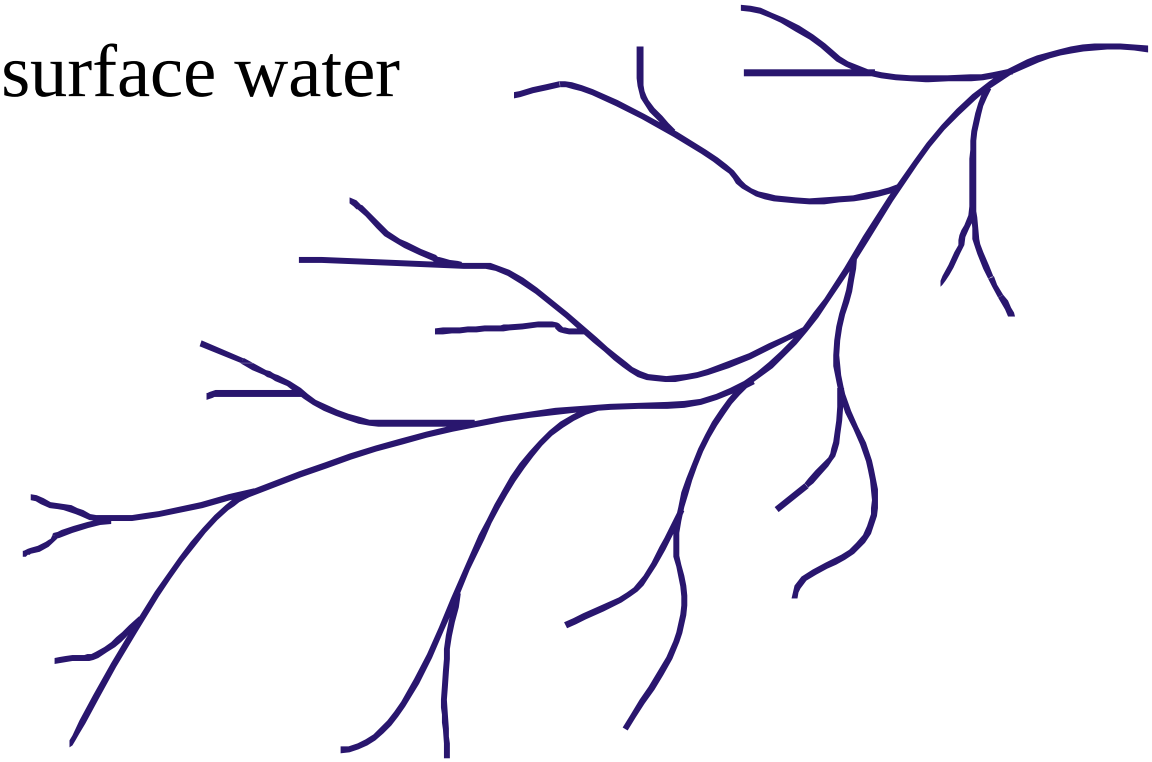
Types of Water Table



Water under pressure

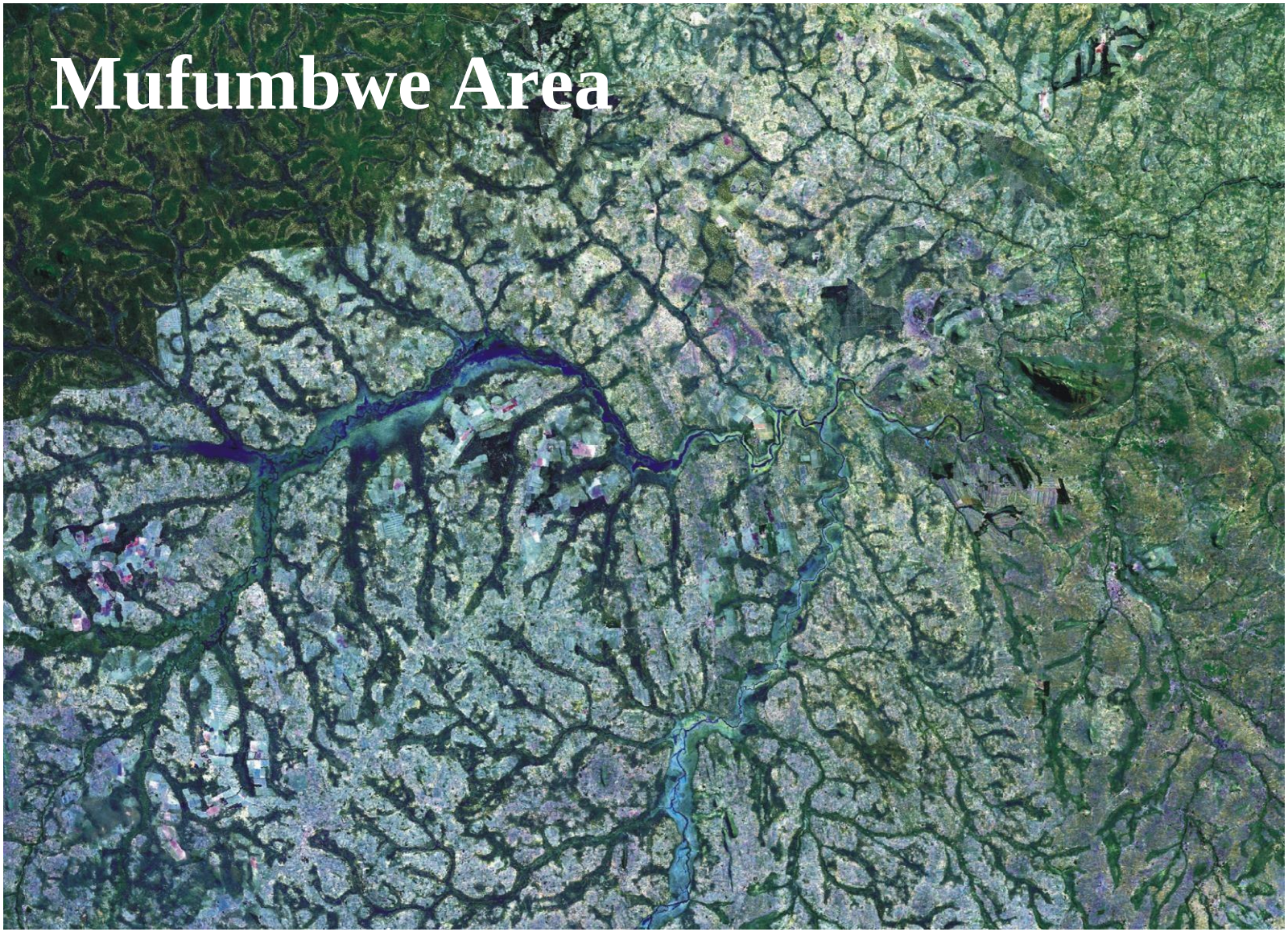
River Basin

- Density of drainage network
- Groundwater surface water link

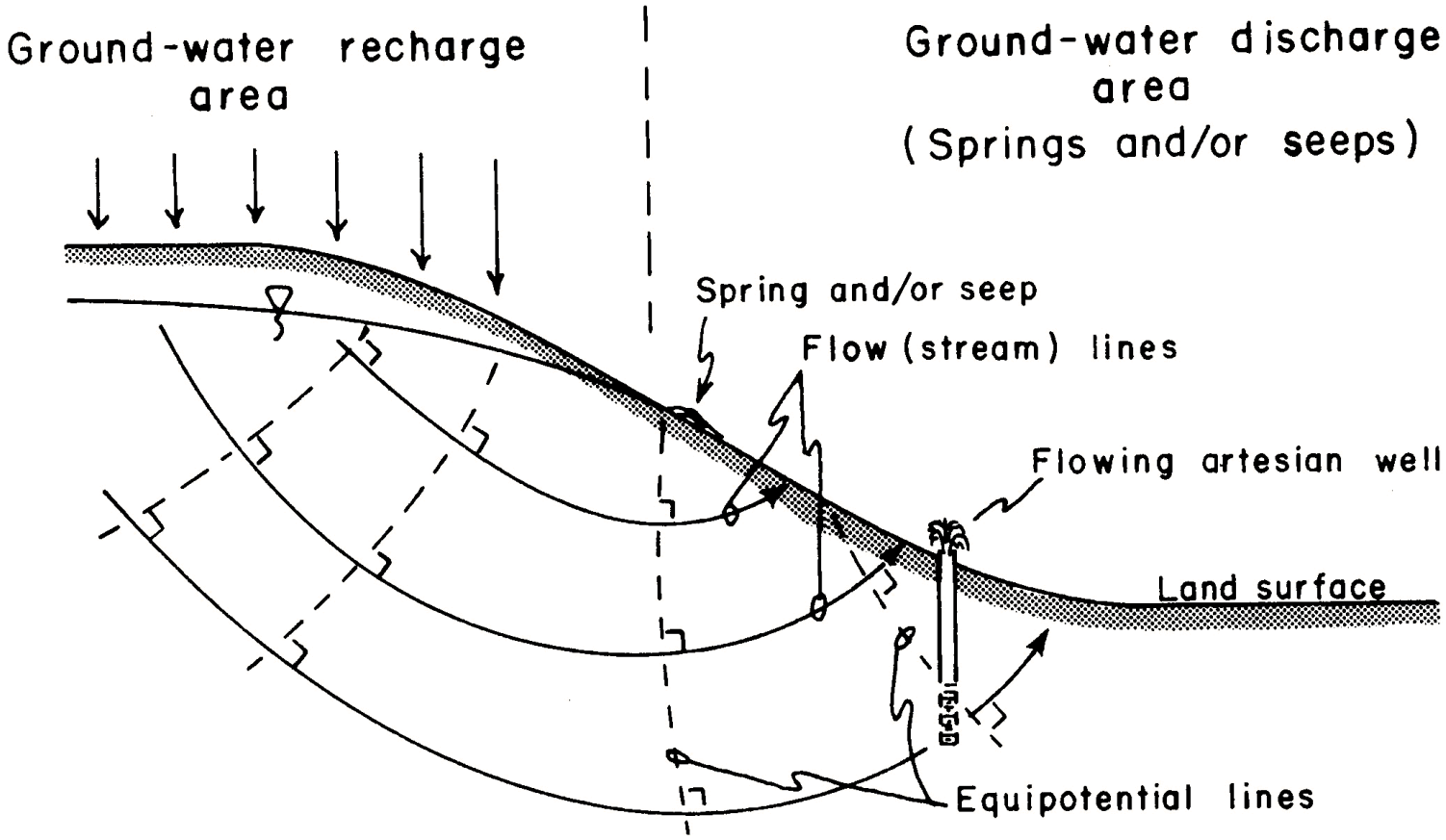


Mongu Area

Mufumbwe Area



GW Basin System



Using Groundwater

- Groundwater comes to the surface to form:

  Springs

  Streams

  Marshes

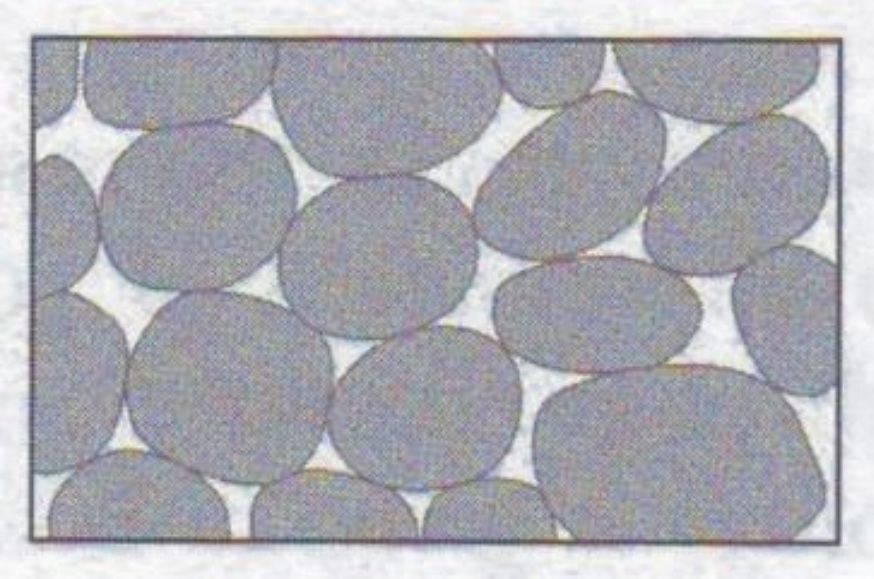
- Water table meeting the surface

- Wells ancient method of abstraction

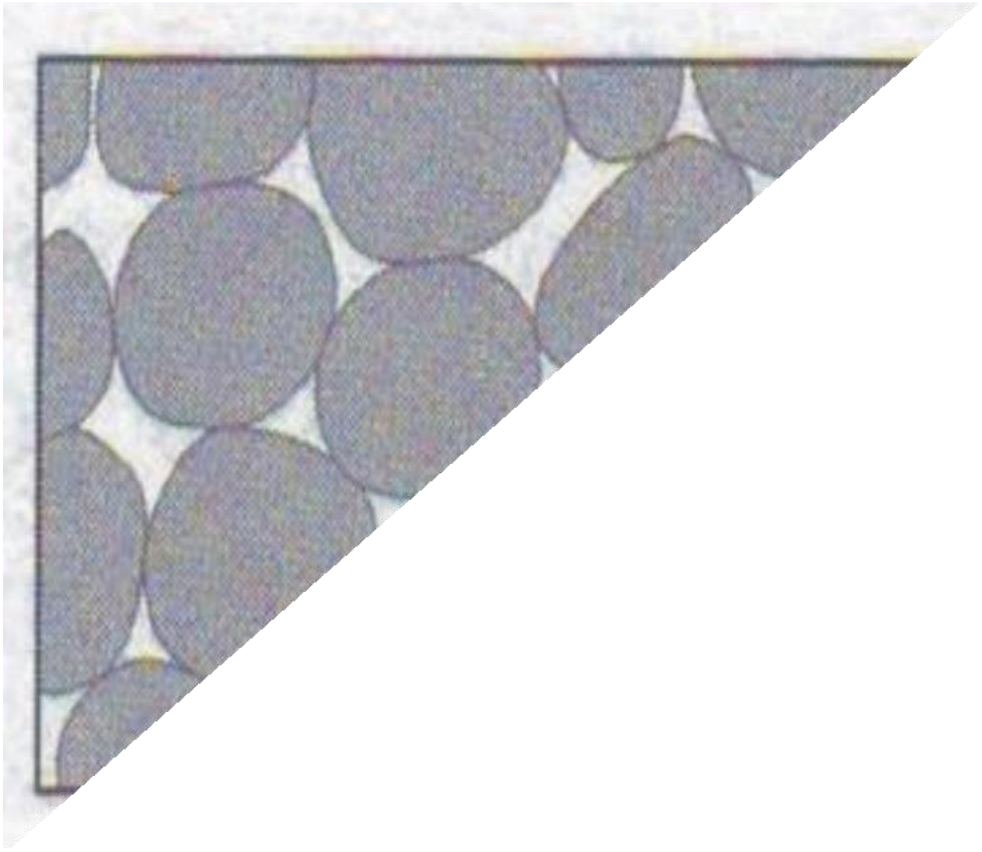
Aquifers

Groundwater is not present in all rocks

Aquifers store and transmit Groundwater



Porosity



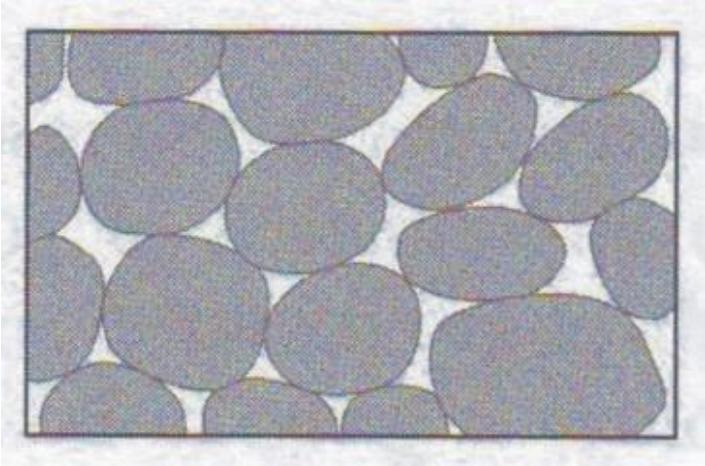
Proportion of space

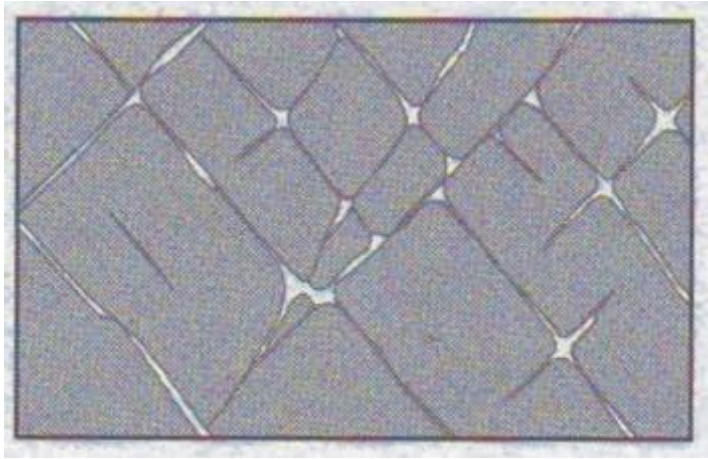
Compared to

Proportion of Volume

Main Properties of Aquifers

- Small spaces
- Large area of small spaces



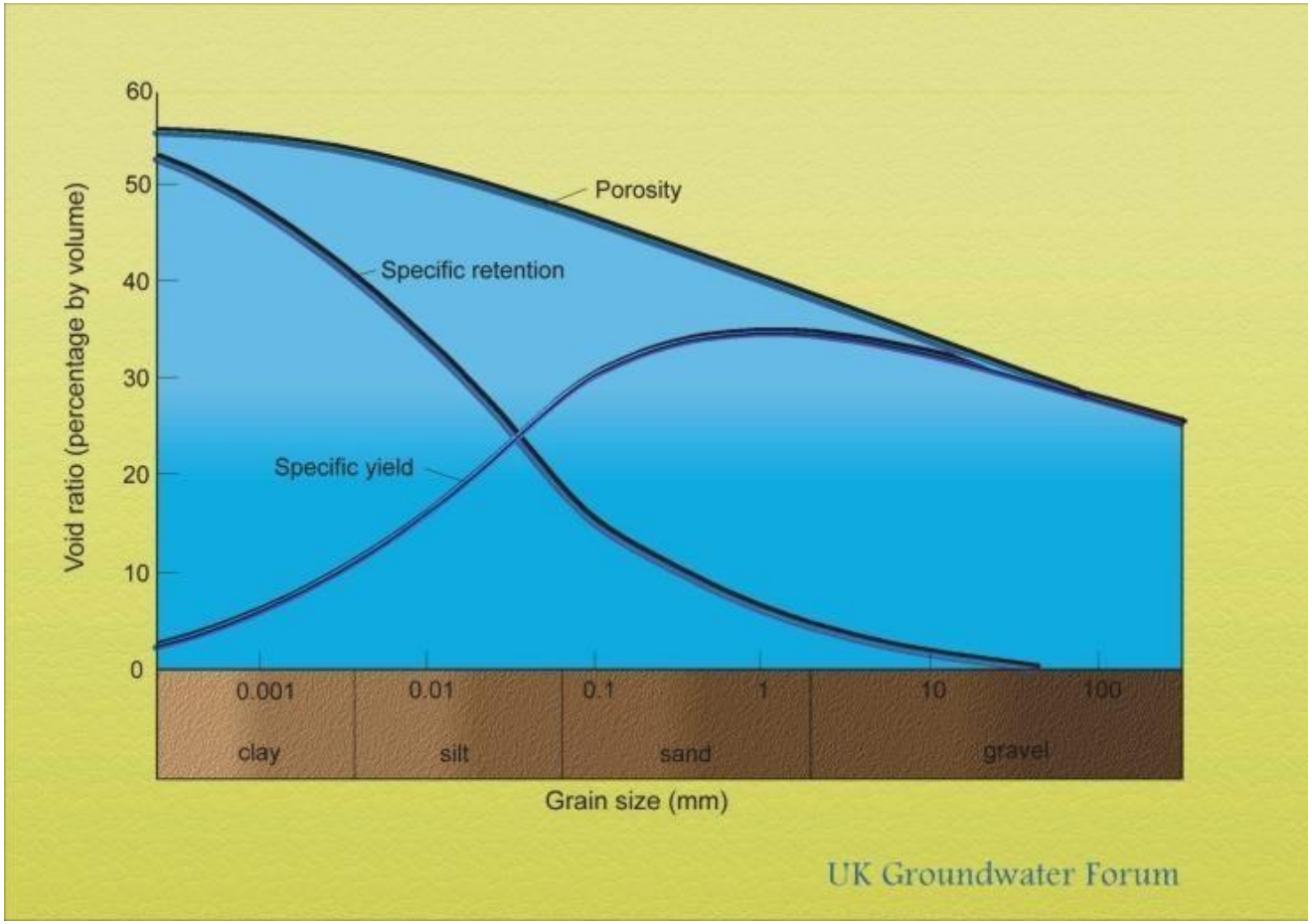


Permeability

- Porosity not enough for groundwater development
- Clays are highly porous
- Volume of water that drain naturally
- Specific Yield

•For groundwater development Specific Yield more important than porosity

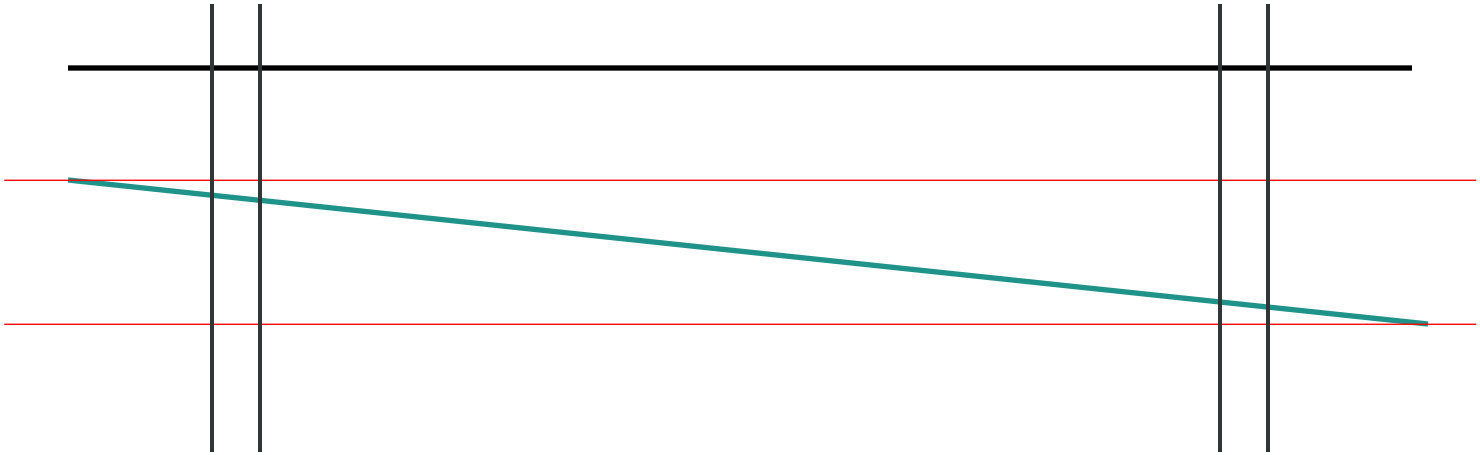
Porosity Vs Specific Yield



Movement of Water

Slope of the water table

Hydraulic gradient

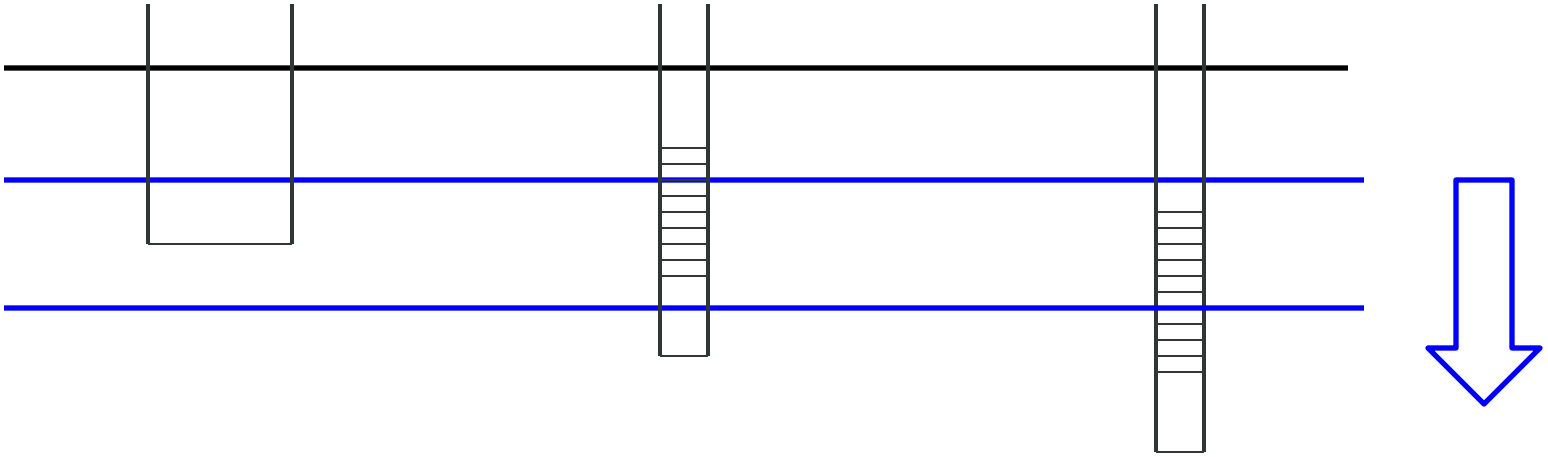


Why Wells and Boreholes Dry Out

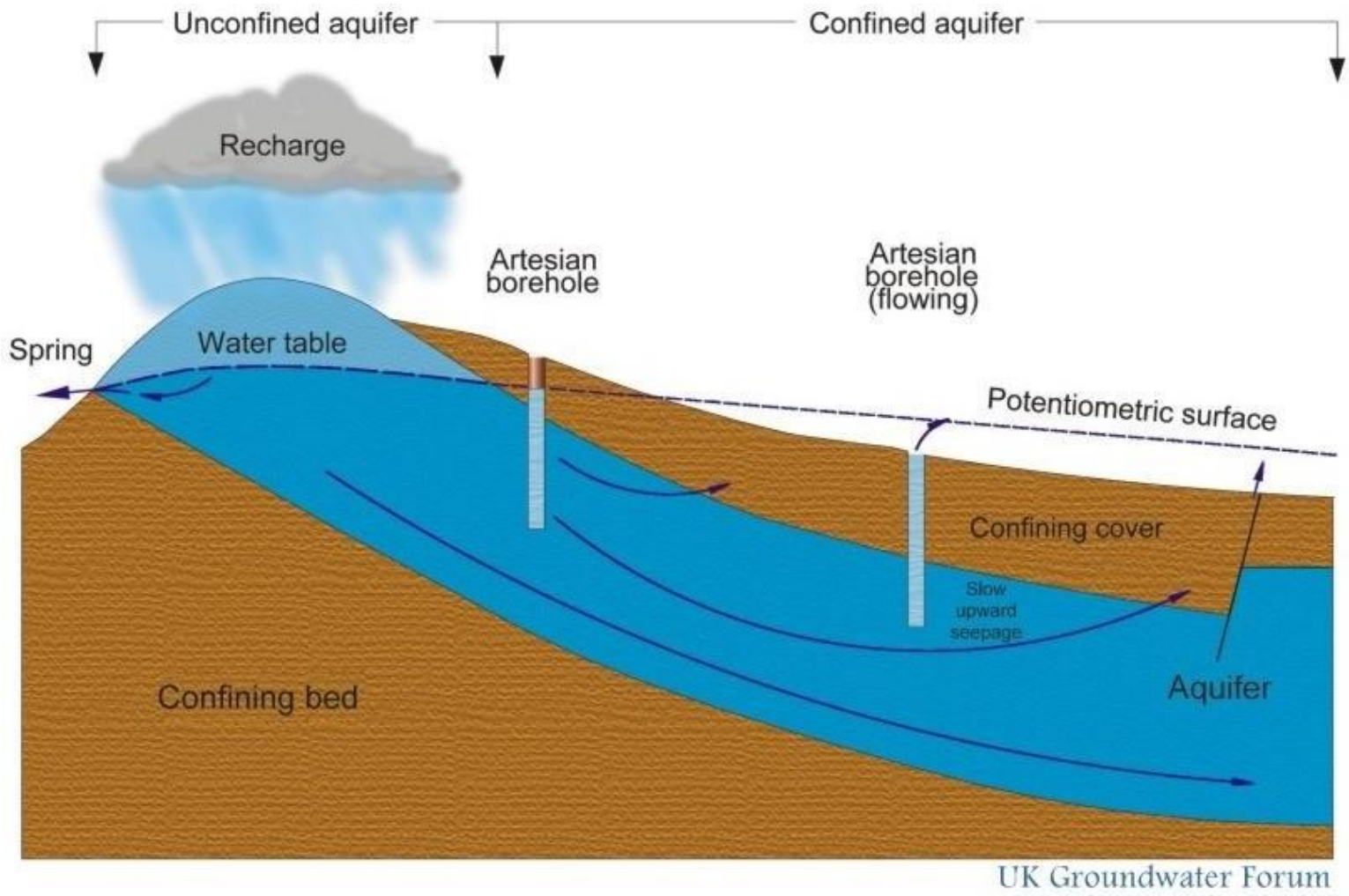
The water table fluctuates according to annual rainfall - some years much lower

Can drop below base of water points

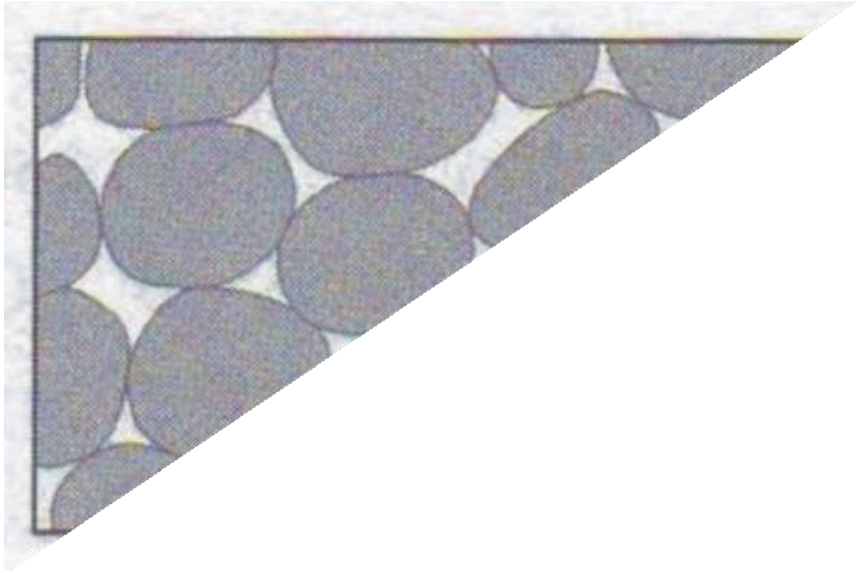
Drilling after rains – beware!!

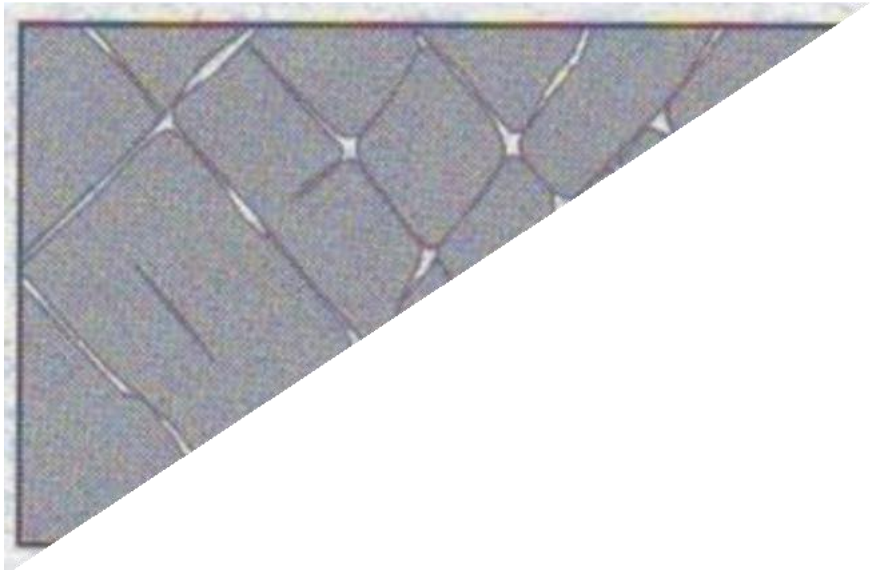


Confined Aquifer and Artesian

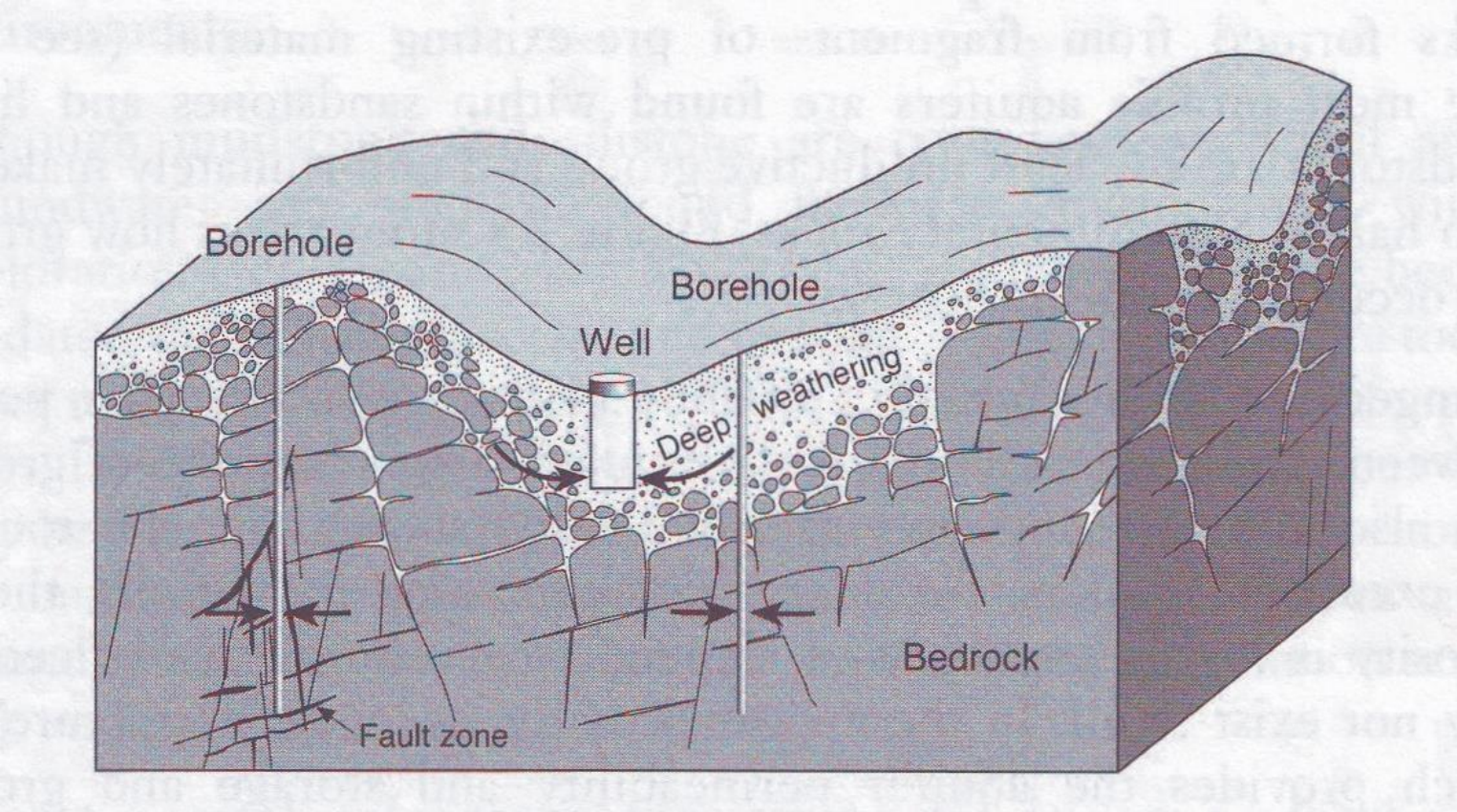


Intergranular and Fractured Aquifers

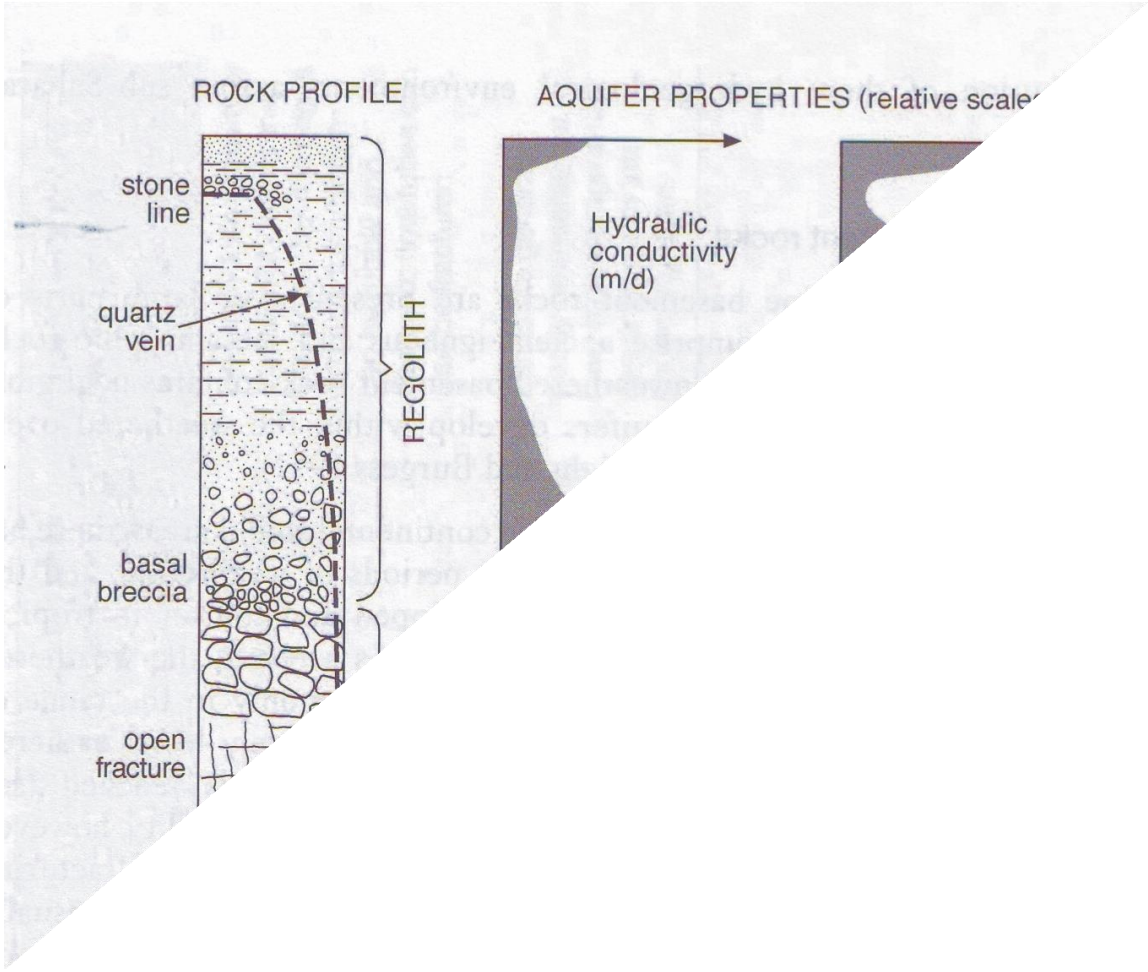




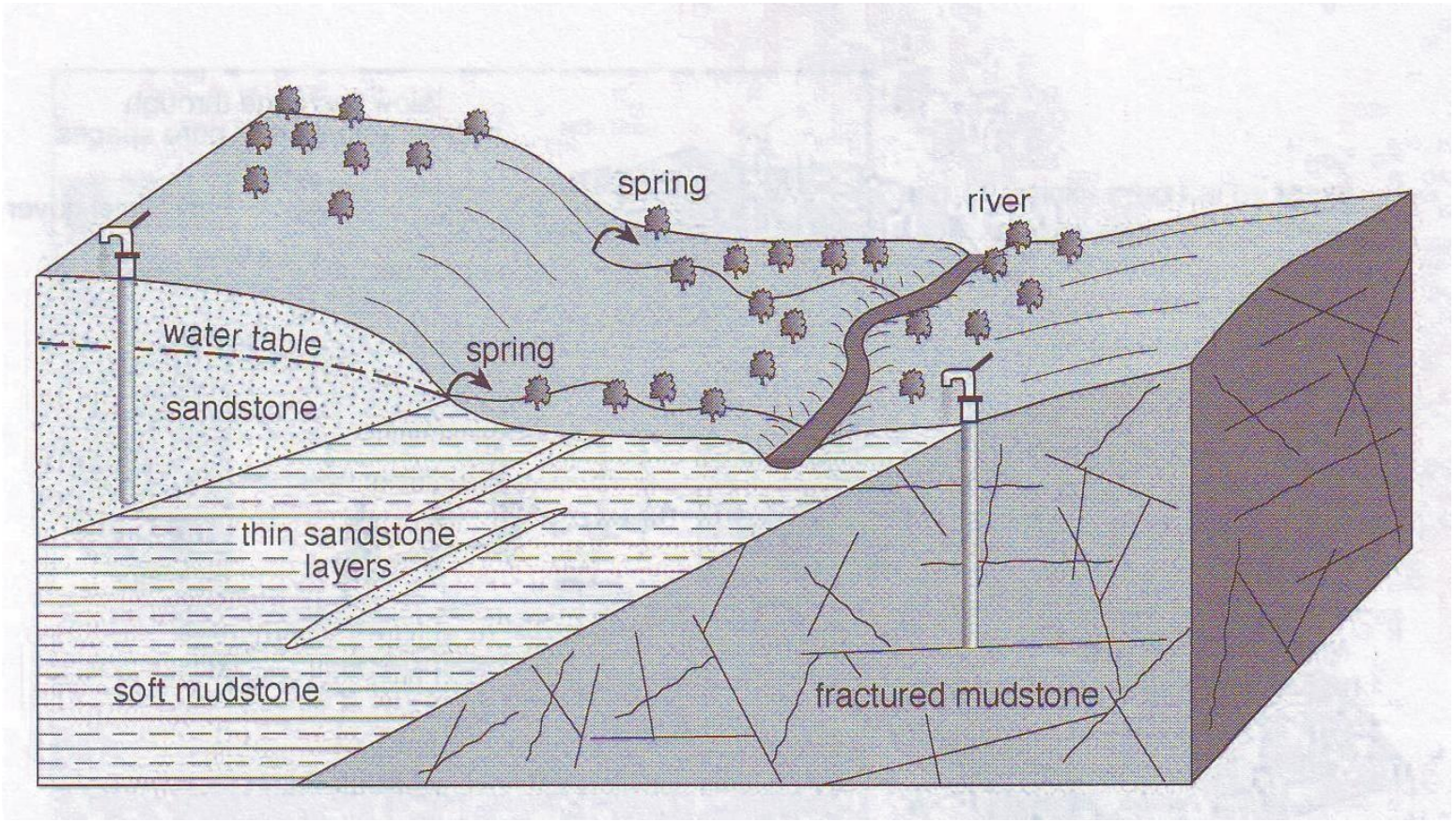
Weathering of Bedrock



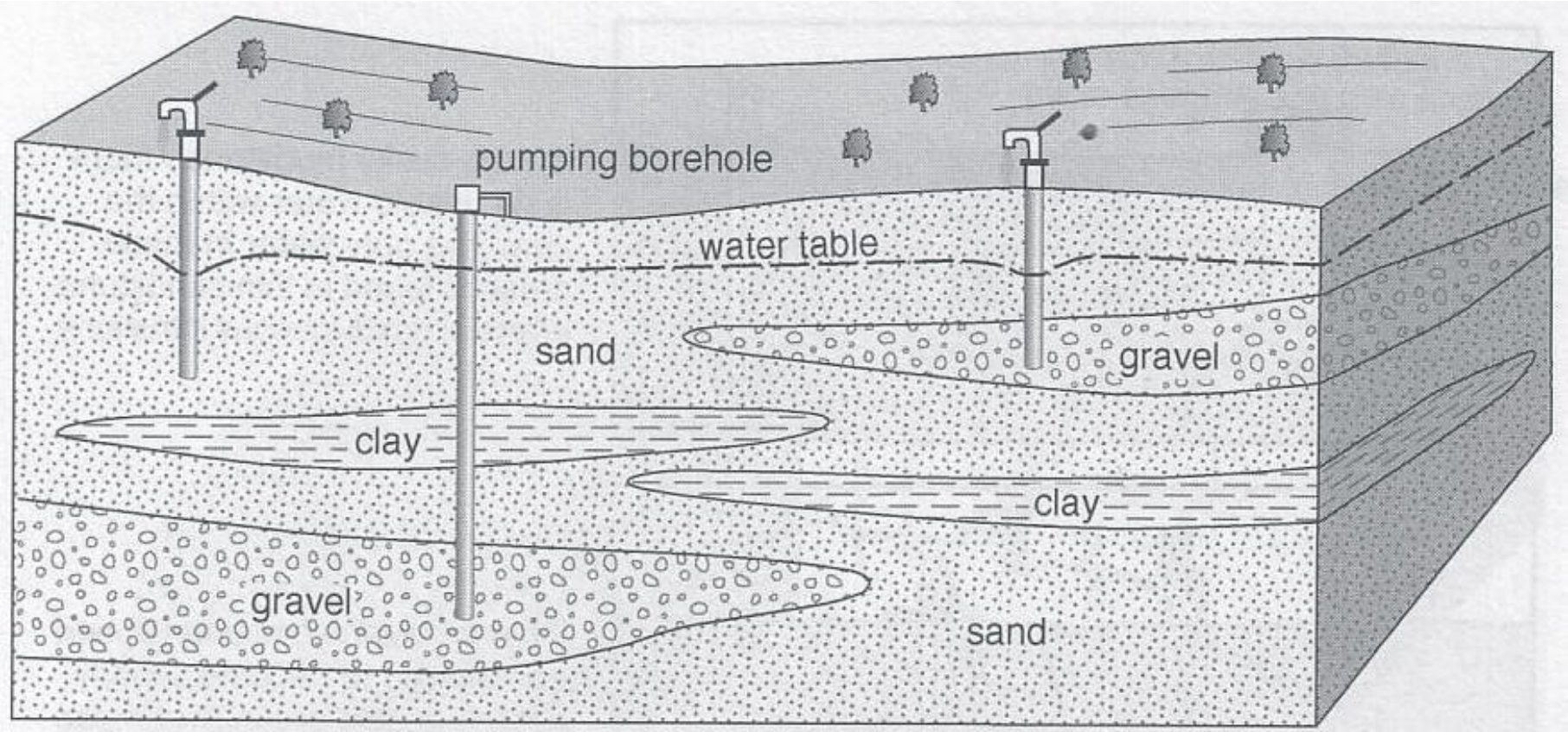
Weathering Profile



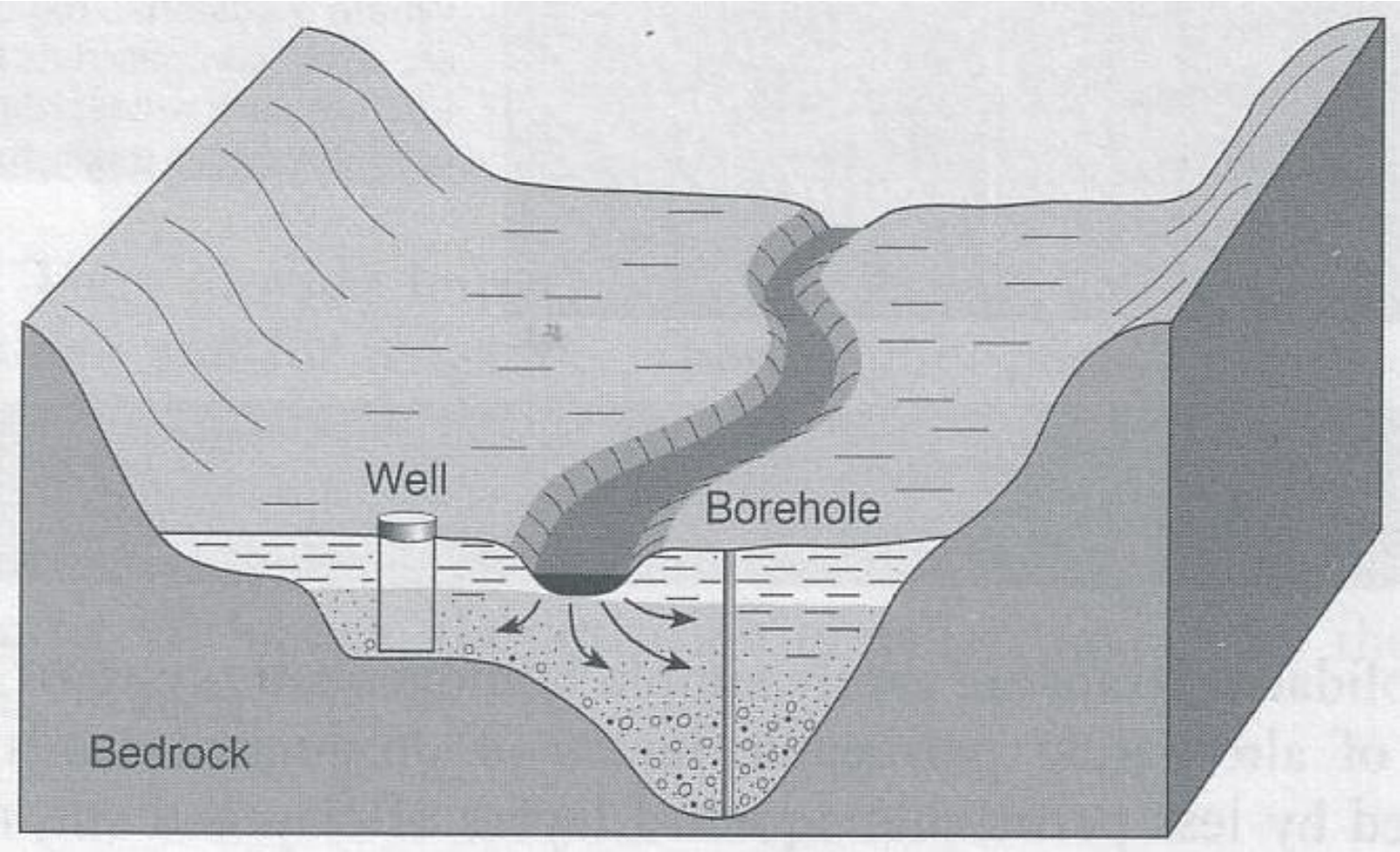
Sedimentary Rocks



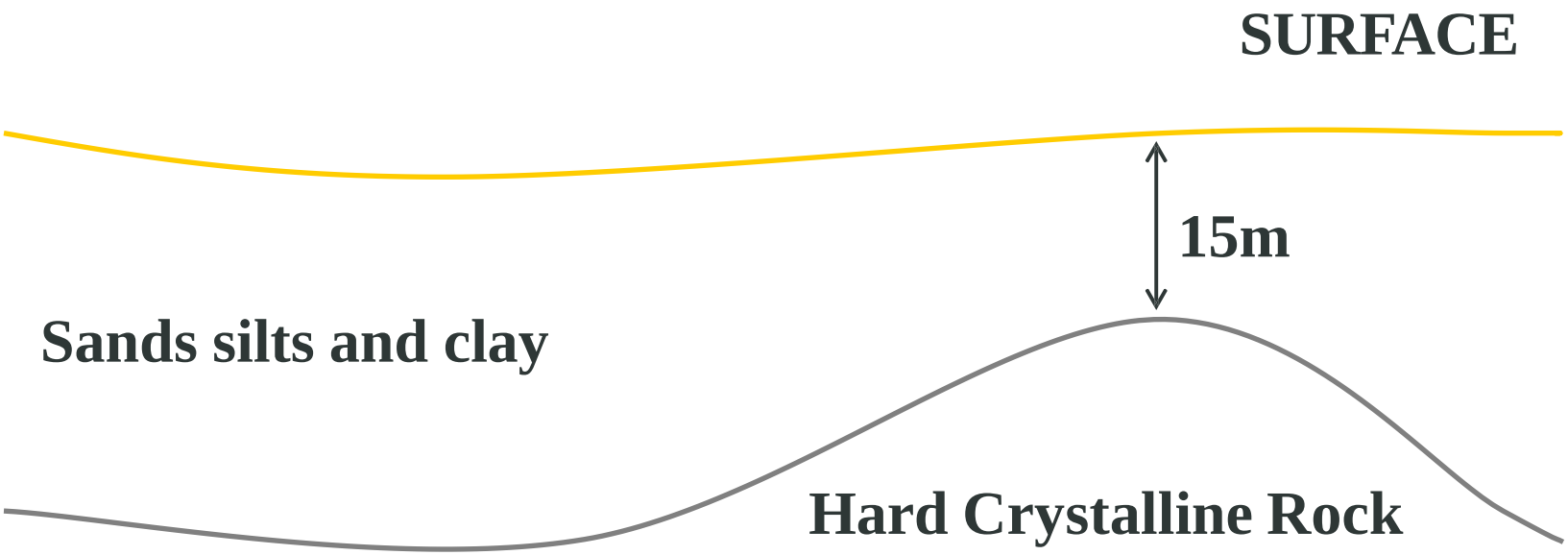
Alluvial Basin



Riverside Alluvium



Sub Kalahari Topography



SUBSURFACE TOPOGRAPHY

Hydrochemistry

Millenium Development Goals

- Quantity
- Cost
- Quality

Quality

Often this parameters importance is underestimated

Groundwater Contamination

Quality

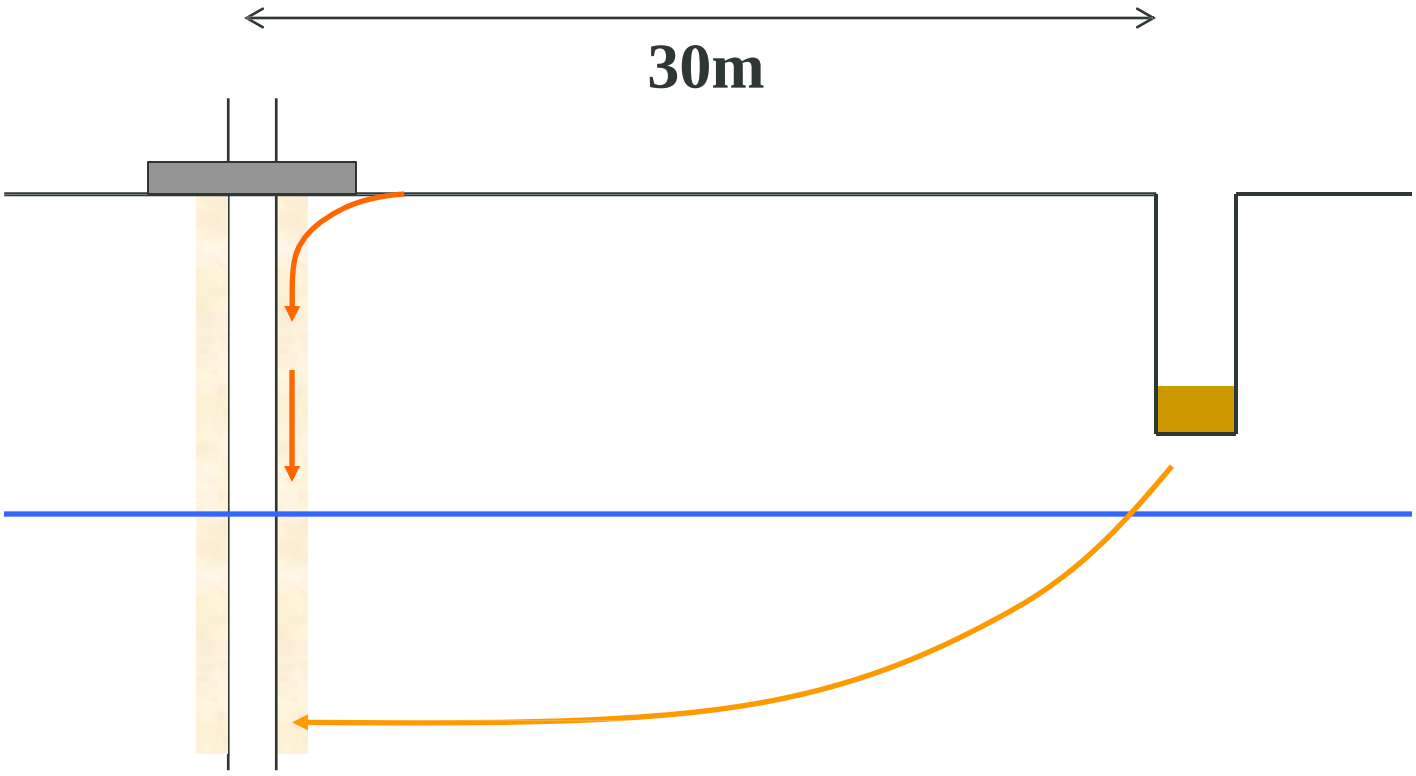
Health and acceptability are based on:

- Chemical
- Microbiological
- Turbidity

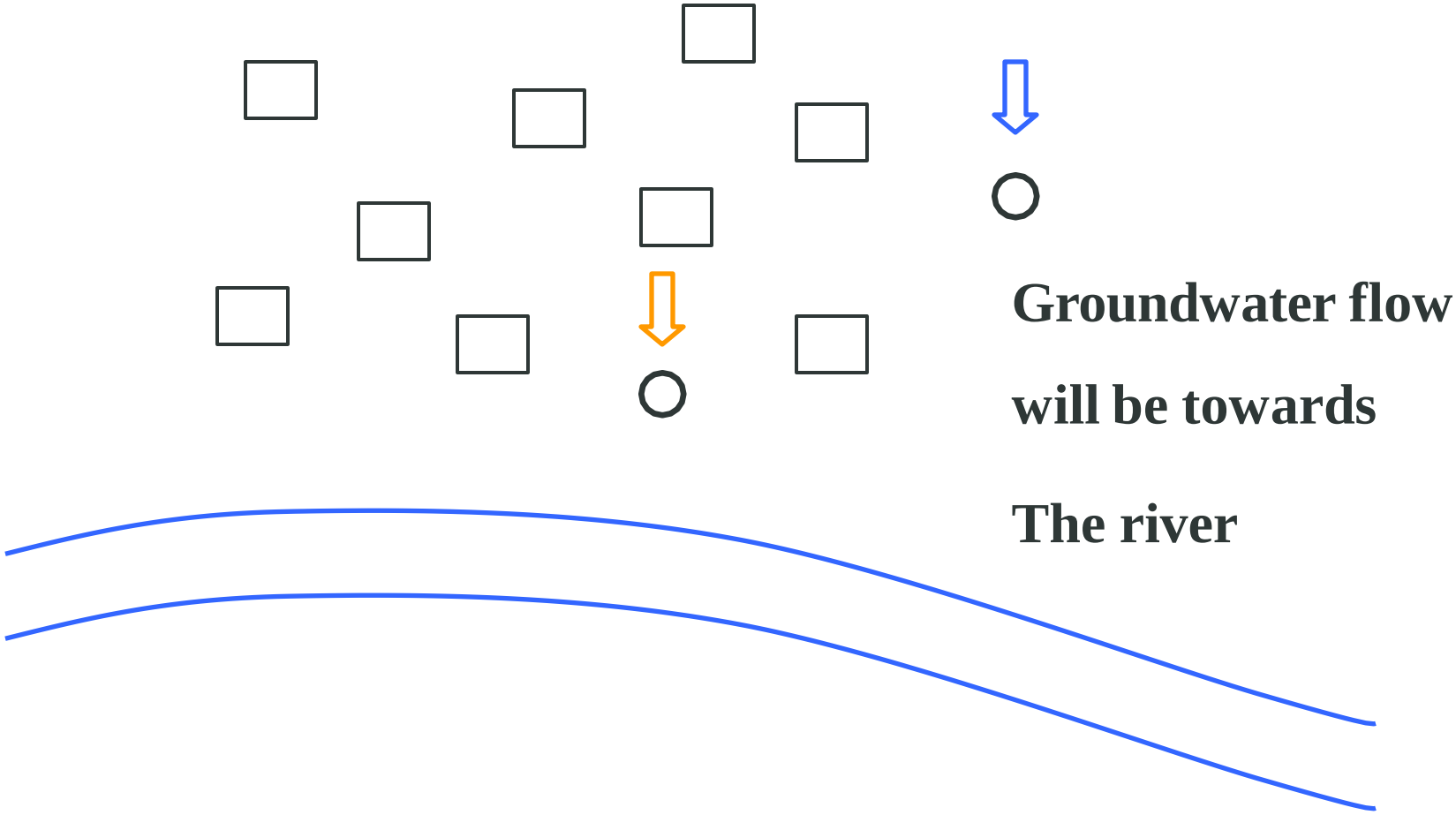
Microbiological

- Sanitation in the Community
- Characteristics of GW System
- Construction of Water Point

Reducing the Risk



Risk in Kalahari Sediments



Groundwater flow will be towards The river

Field Measurements

Parameters

•pH, EC, Fe and N – carried out after drilling and at the end of pumping test

- After sterilisation using chlorine

- Testing of water for Microbiological contamination

Field Testing Kit

Samples for Analysis

Sampling Protocols

- Designates containers
- Labelling
- Acid
- Cool Box

Analysis Results

Laboratory Result Format

- Elements
- Elements and Compounds
- WHO Standards
- Zambian Standards

Main Problem Elements

Laboratory Results

	WHO	Zambian
• Fluoride (mg/l)	1.5	1.5
• Iron (mg/l)	0.3	1.0
• Arsenic (mg/l)	0.010	0.050
• Cadmium (mg/l)	0.003	0.010
• Lead (mg/l)	0.01	0.05

Salinity

- Source of salinity
- How we measure it - conductivity
- How we reduce the problem

Field Testing Readings

- UNITS

1.Make sure you know what units the readings are in

2.If unsure about reading conversion report the unit

- Ask about calibration

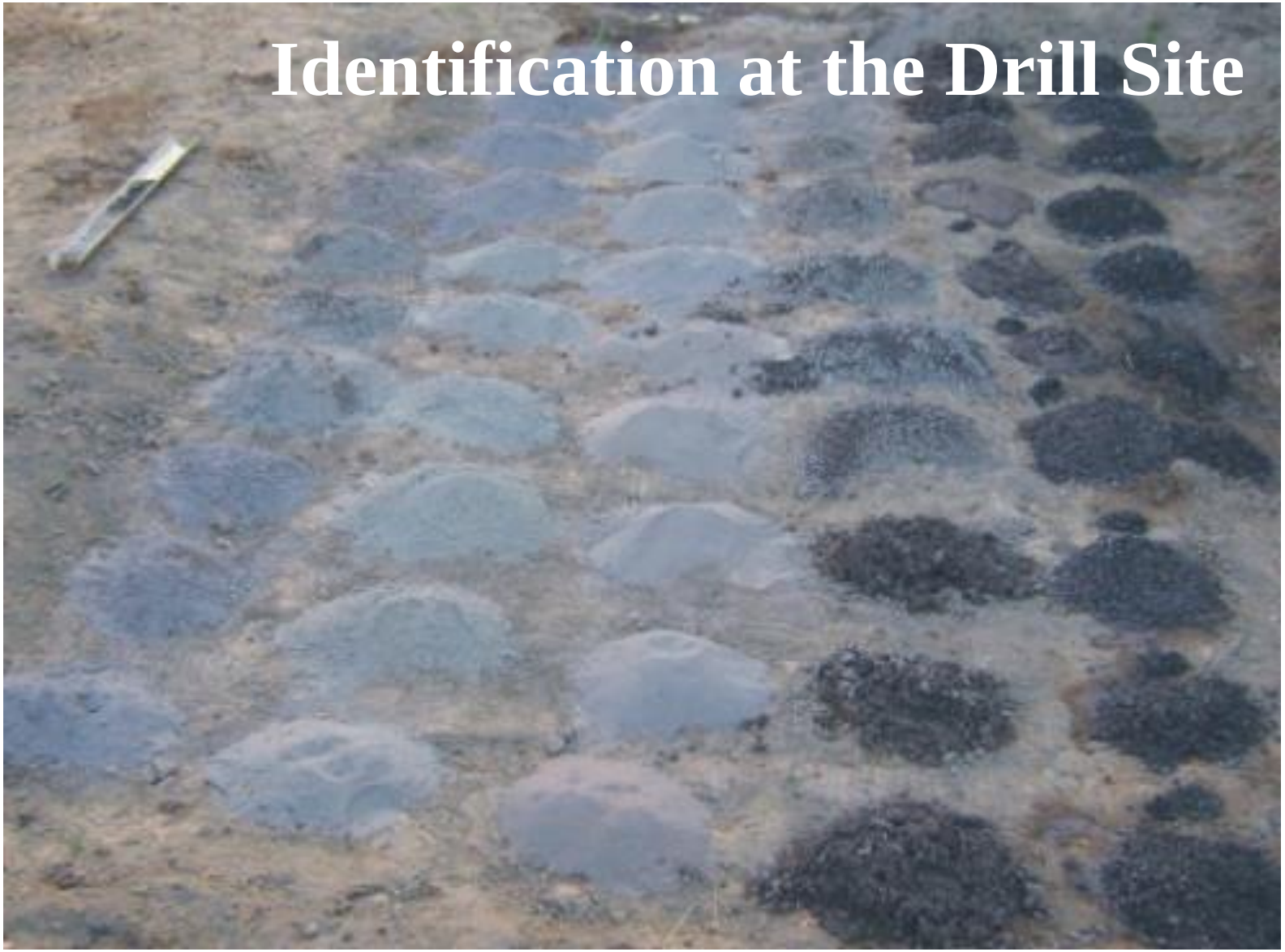
Health and Safety

- Safety Helmets
- Steel toe capped boots
- Gloves
- First Aid Kits
- No access to unauthorised people
- Welding

Identification of Rocks

- **Consolidation**
- **Colour**
- **Grain Size - Roundness**
- **Sorting**
- **Porosity**
- **Weathering - Structures**

Identification at the Drill Site



Lithological Log

NATIONAL RURAL WATER SUPPLY AND SANITATION PROGRAMME
COMPONENT I - RURAL WATER SUPPLY
BOREHOLE CONSTRUCTION REPORT

District:

Borehole Code:

Community:

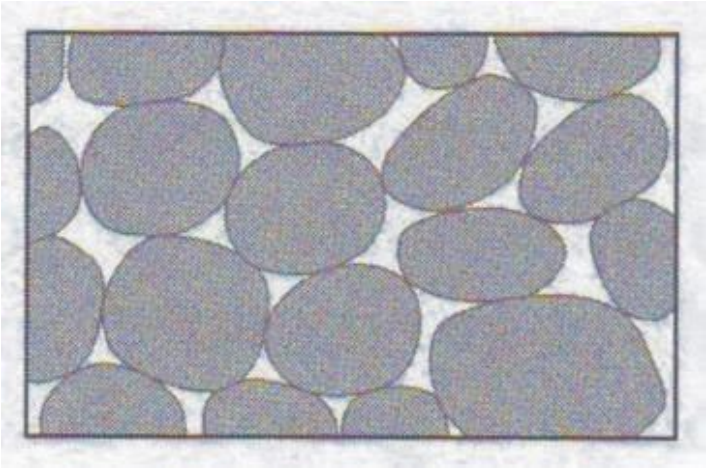
Date started: Driller:

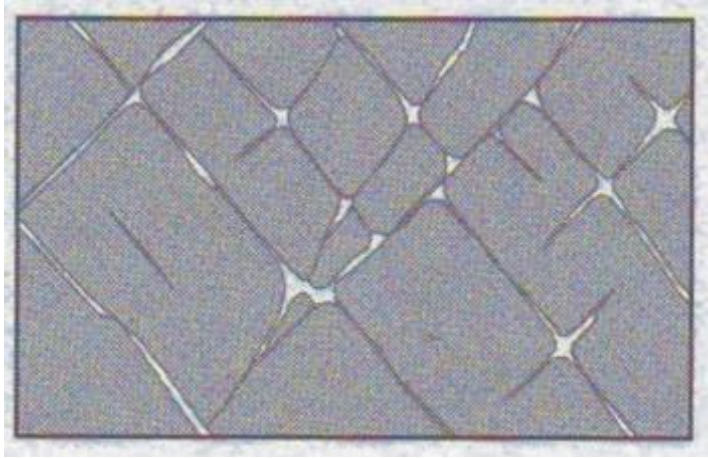
Date finished: Km from last site:

Date	Drilling (Hours)	From (m)	To (m)	Other work	Remark: Geological log (Summary)
					1st water: mbgl
					2nd water: mbgl
					Main water: mbgl
					SWL: mbgl

Geology and Groundwater

- **Don’t Panic**





- **Only key aspect important**

Geology Practical

- **Describe what you see**

- **Use Hydrogeological description of your District**

- **Only key aspect important**

Mathematics

Why is mathematics important ?

Foundation of Hydrogeology due to

The nature of groundwater

Why Is Mathematics Important

- **Flow Rates**
- **Water Levels**
- **Borehole Design**
- **Development**
- **Pumping Tests**
- **Distance/Length**
- **Volume of gravel pack**

Units

Foundation of all work involving numerical data

- **Length mm, cm, m, km, inches**
- **Time second, min, hour, day**
- **Volume Litres, m^3**
- **Weight mg, g, kg, ton**

Combinations of Units

- **Time per unit length**
- **Volume per unit time**
- **Volume per unit length**
- **Volume per unit**
- **Weight per unit volume**

Decimal Point

11111.11

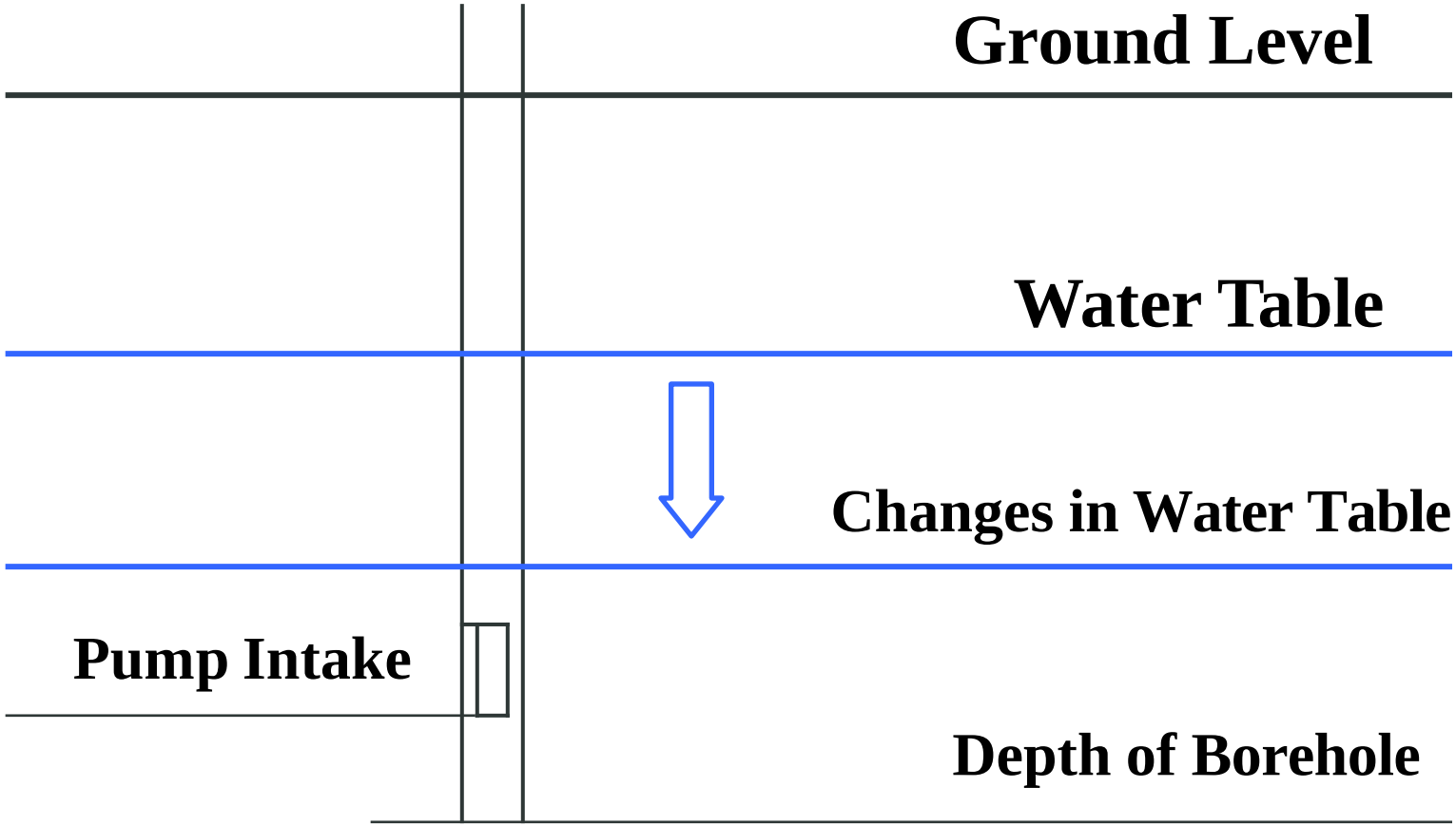
% Percentages

Mental Arithmetic

Flow Rates

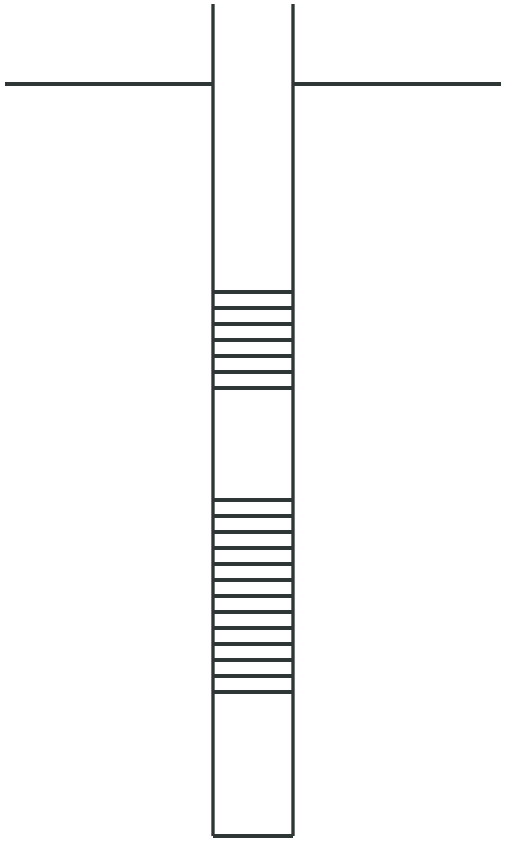
- **Volume**
- **Time**
- **Volume per unit time**
- **l/s - m^3/h**

Water Level


Ground Level
Water Table
Changes in Water Table
Pump Intake
Depth of Borehole

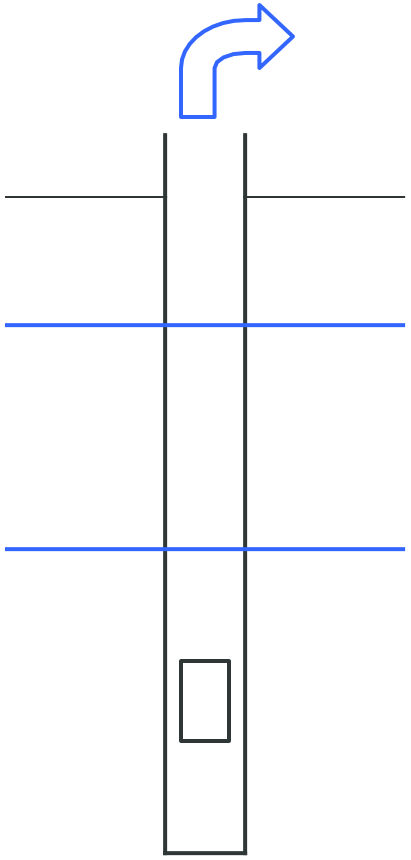
Borehole Design

- **Depth of Flow Horizons**
- **Casing**
- **Screen**
- **Installation**
- **Confusion**



Pumping Tests

- **SWL Static Water Level**
- **Depth of Borehole**
- **Pump Intake Depth**
- **DWL Dynamic Water Level**



Development

- **Development Time**

- **Screen Depth**

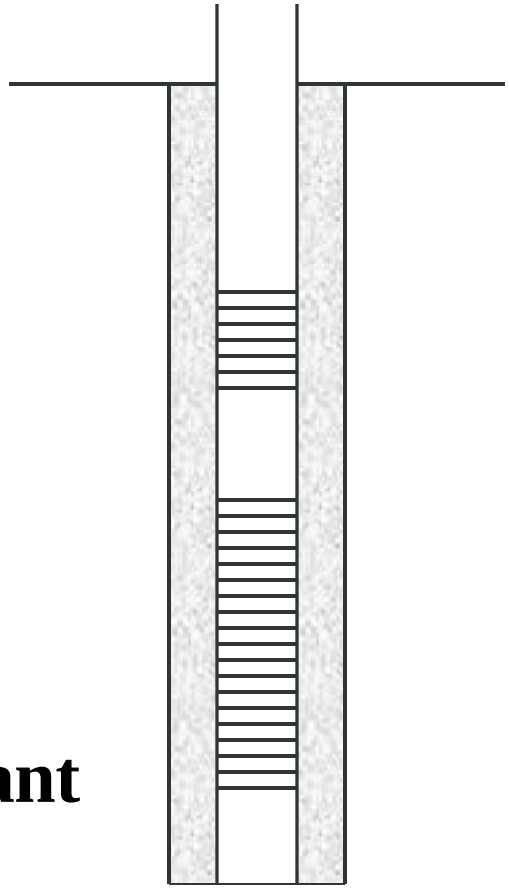
Distance and Length

- **Drilling Meterage**
- **Drilling Diameter**
- **Distances: GPS, Mobilisation**

Volume of Gravel Pack

- **Annular Space**
- **Volume of Gravel**
- **Buckets**

•Ensuring pack is where you want it

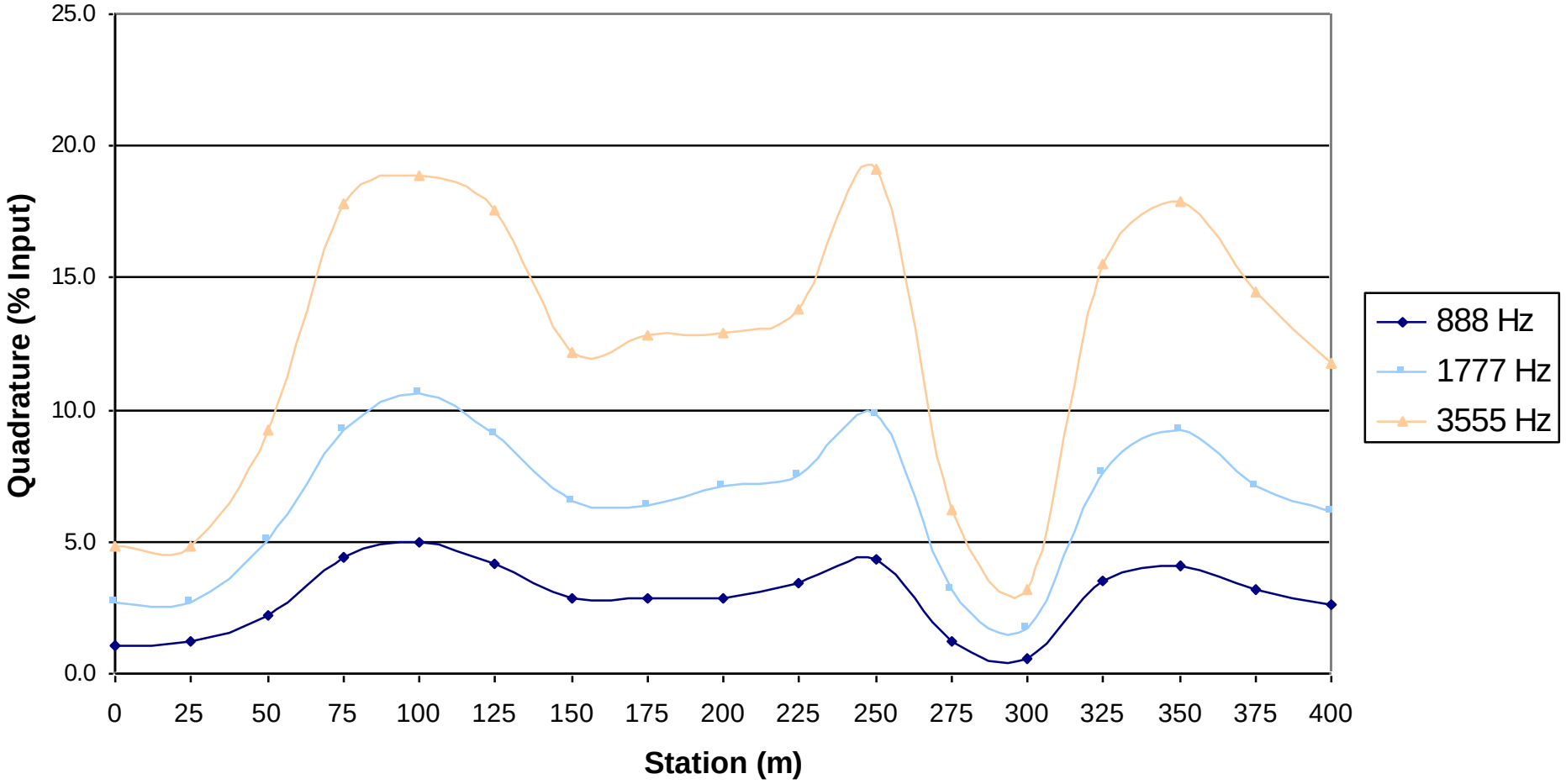


Use of Graphs

- **Geophysical Data**

- **Penetration Rates**

Geophysical Data



Calculations

Examples