Hydrological data monitoring, data processing, data analysis and dissemination

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IHE DELFT Institute for Water Education

unesco Centre Under the auspices of UNESCO

Hydrological cycle and Water Resources

What is hydrology?

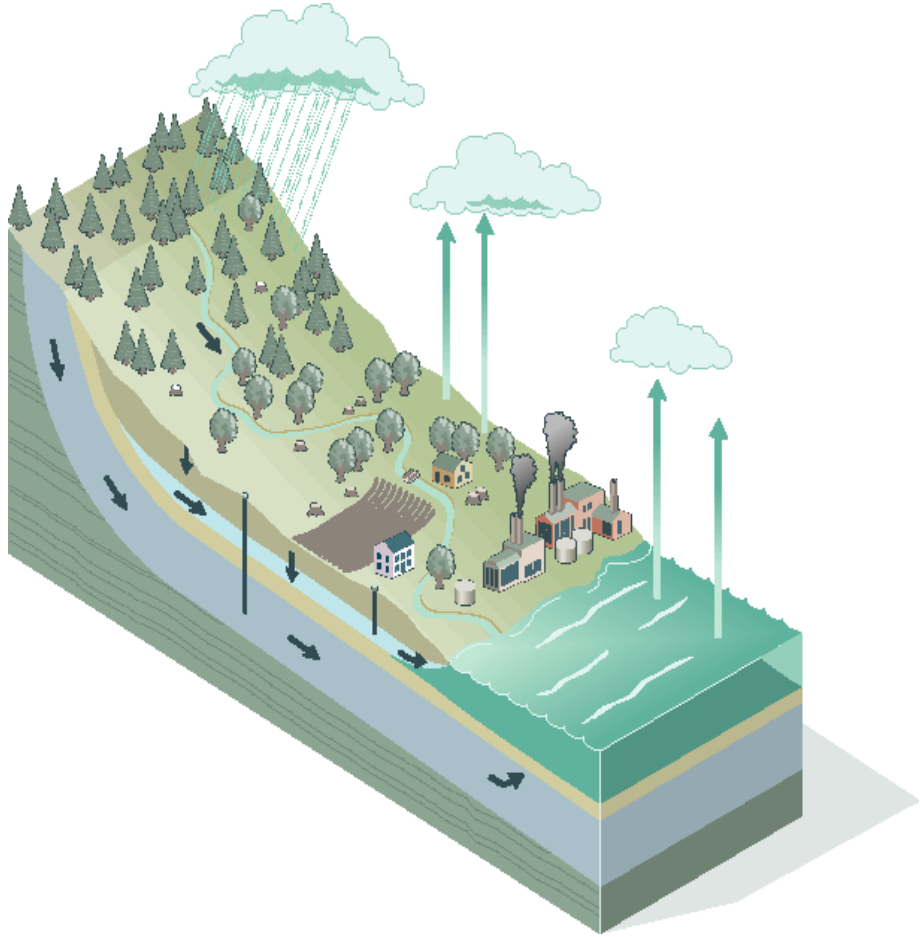
The term hydrology is from Greek: ὕδωρ, hydōr, "water"; and λόγος, logos, "study"

- **UNESCO 1964:**

  "Hydrology is the science which deals with **terrestrial waters**, their **occurrence**, **circulation** and **distribution** on our planet, their **physical and chemical properties** and their **interaction with the physical and biological environment**, including the **effect on them by the activity of man**".

- Hydrology restricted to terrestrial water movement, different from meteorology, oceanography, climatology.

- Hydrology addresses both quantity and quality of water.

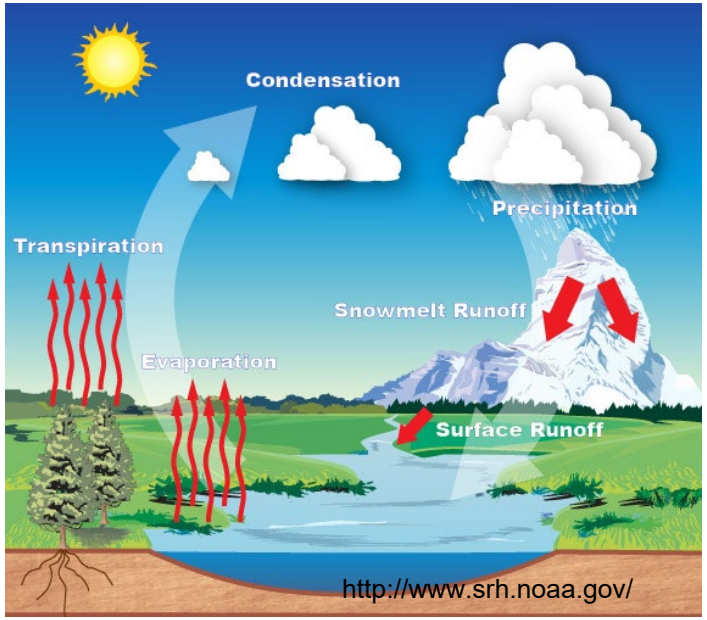


Source: http://www.ldeo.columbia.edu/~martins/hydro.html

Related sciences

Hydrometeorology:
a branch of meteorology and hydrology that studies the transfer of water and energy between the land surface and the lower atmosphere

Hydroclimatology:
a branch of climatology and hydrology that studies how climate influence hydrological cycle



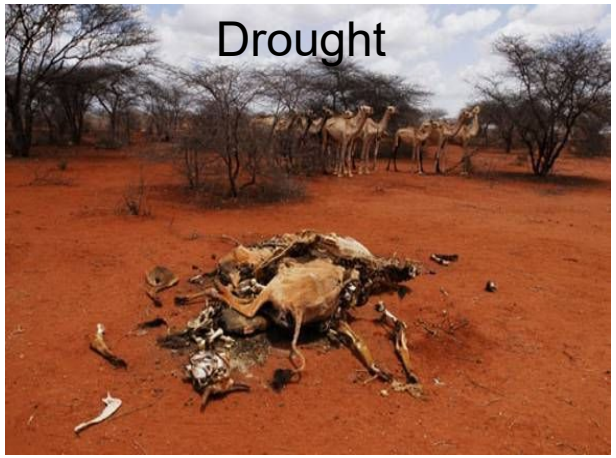
Ecohydrology:
a branch of ecology and hydrology, that study how organisms interacts with hydrological cycle

Hydrometry:
measurements of hydrological cycle parameters

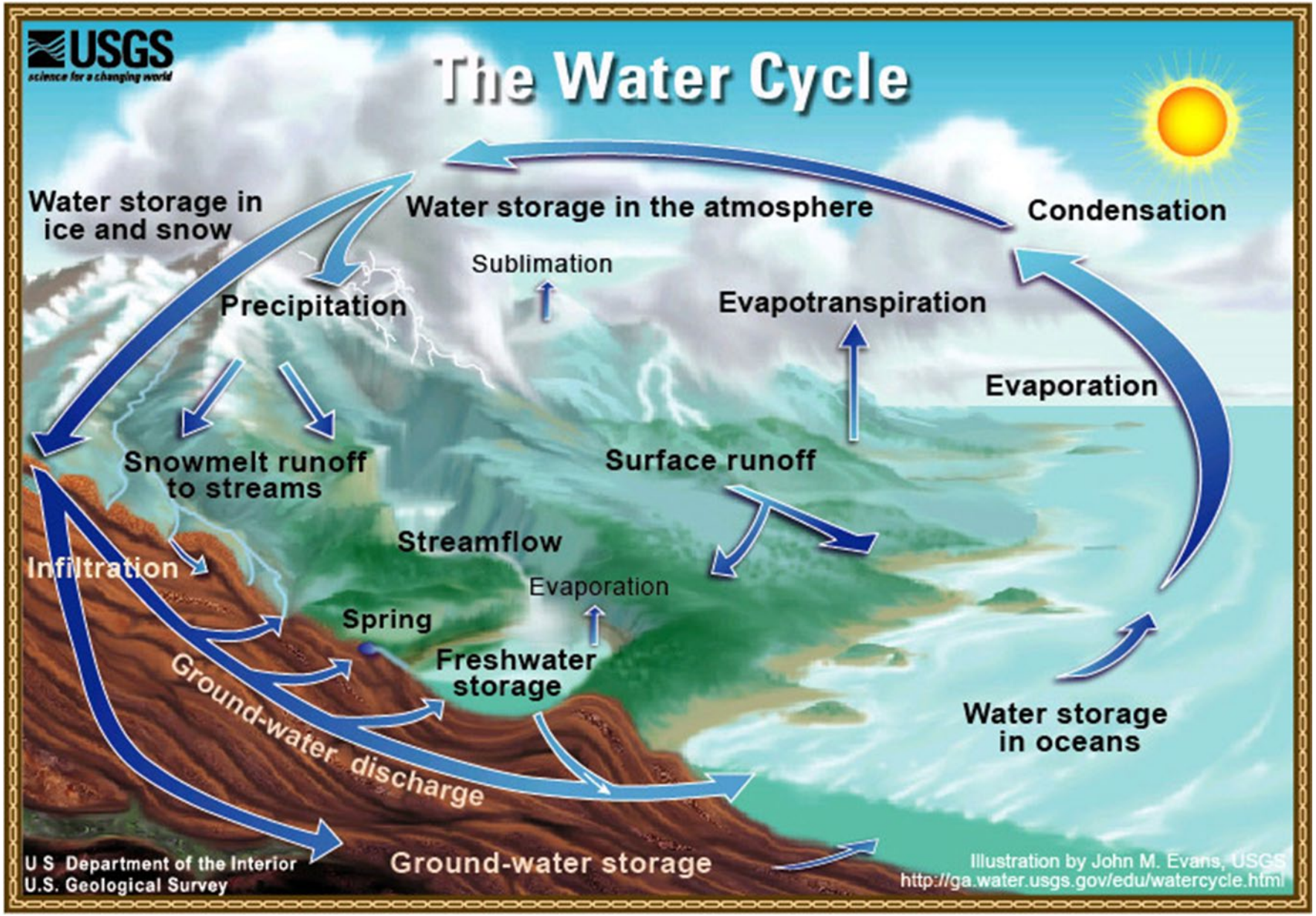
Hydrogeology:
a branch of geology and hydrology that studies groundwater movement

Why do we need hydrology?

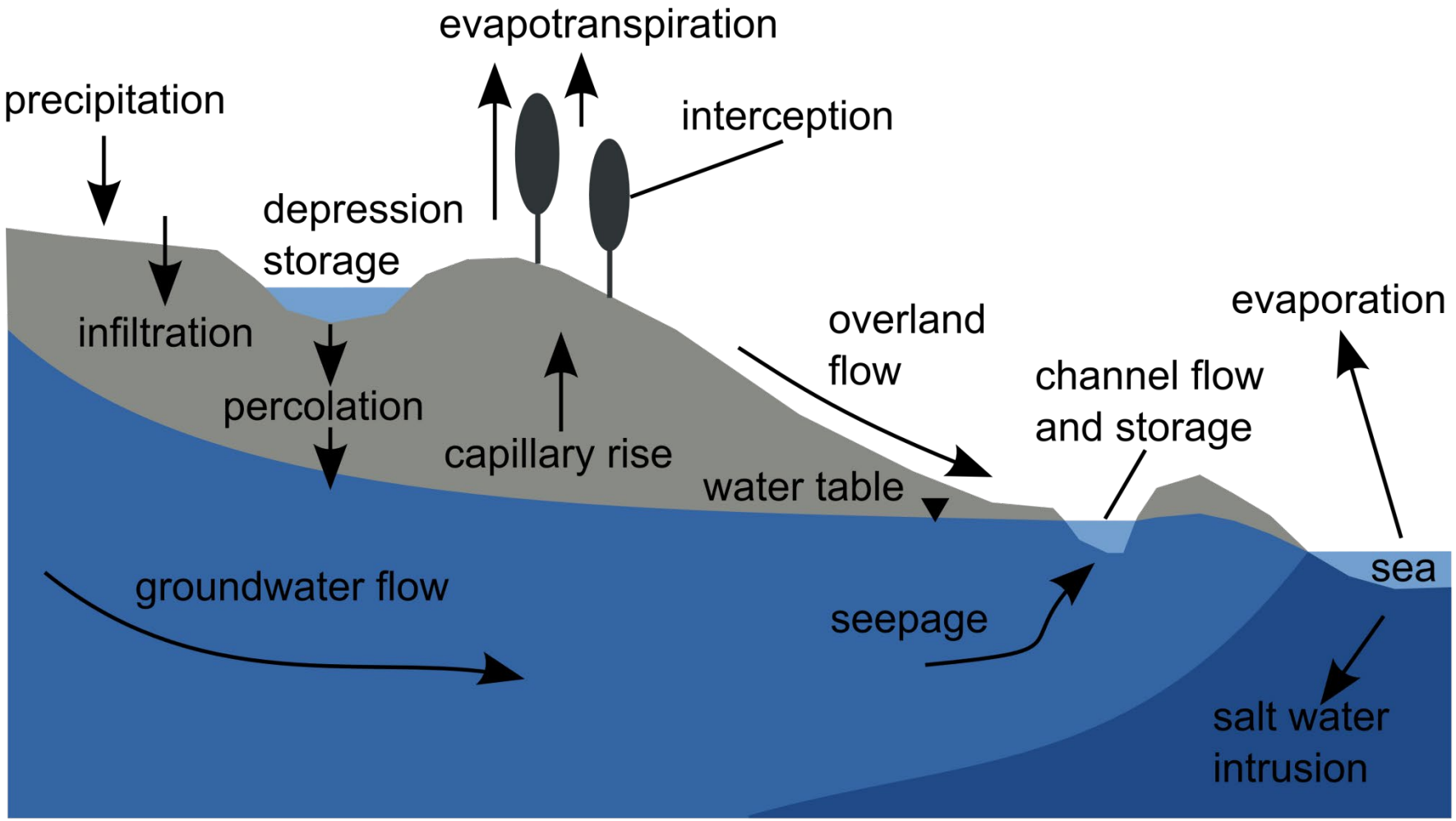
Hydrology input is required when information on water quantity/quality is needed



Elements of the Hydrological Cycle



Elements of the Hydrological Cycle



Descriptive representation of the hydrological cycle

Typical data requirements for WRA and WRD

Streamflow
- Monthly and annual
- Flow duration
- Low-flow frequency
- High-flow frequency

Lake and reservoir levels
- Monthly and annual

Precipitation
- Monthly and annual
- heavy rainfall statistics

Evaporation and temperature
- Monthly and annual

Groundwater levels
- Monthly and annual
- Mean annual min / max

Water quality
- Rivers / lakes / groundwater

Spatial physiographic data
- Topography
- Land cover / land use
- Geomorphology
- Soils
- Geology - hydrogeology

Water use
- Abstractions / diversions
- Irrigation
- Reservoirs
- Waste water outflows

Socio-economics
- Population
- Economic activity

Water Balance

Precipitation = Runoff + Evapotranspiration + storage change per time step

$$P = R + ET + dS/dt$$

Long-term average of dS/dt is often zero!

for long-term the equation reduces to:

$$\overline{P} = \overline{R} + \overline{ET}$$

The importance of storage changes

$$P = R + ET + dS/dt$$

1. Storages at the system earth:
   - Atmosphere
   - Soil water / groundwater
   - Oceans
   - Ice caps, glaciers, snow
   - Rivers, lakes
   - Surface storage (interception)
   - Biosphere

2. Water fluxes between the storages:
   - Precipitation
   - Evaporation
   - Transpiration
   - Discharge
   - Interactions surface - groundwater
   - Snow/ice melt
   - etc.

Water Balance Units

Precipitation = Runoff + Evapotranspiration + storage change per time step

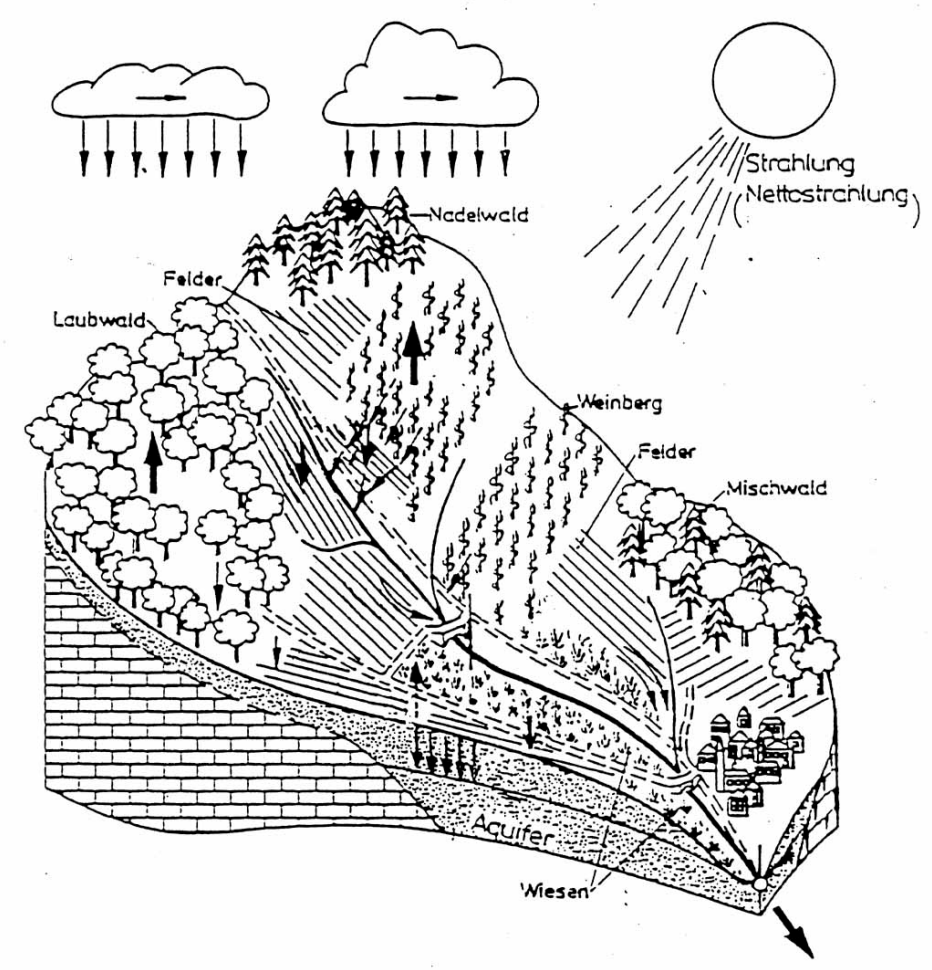
$$P = R + ET + \Delta S$$

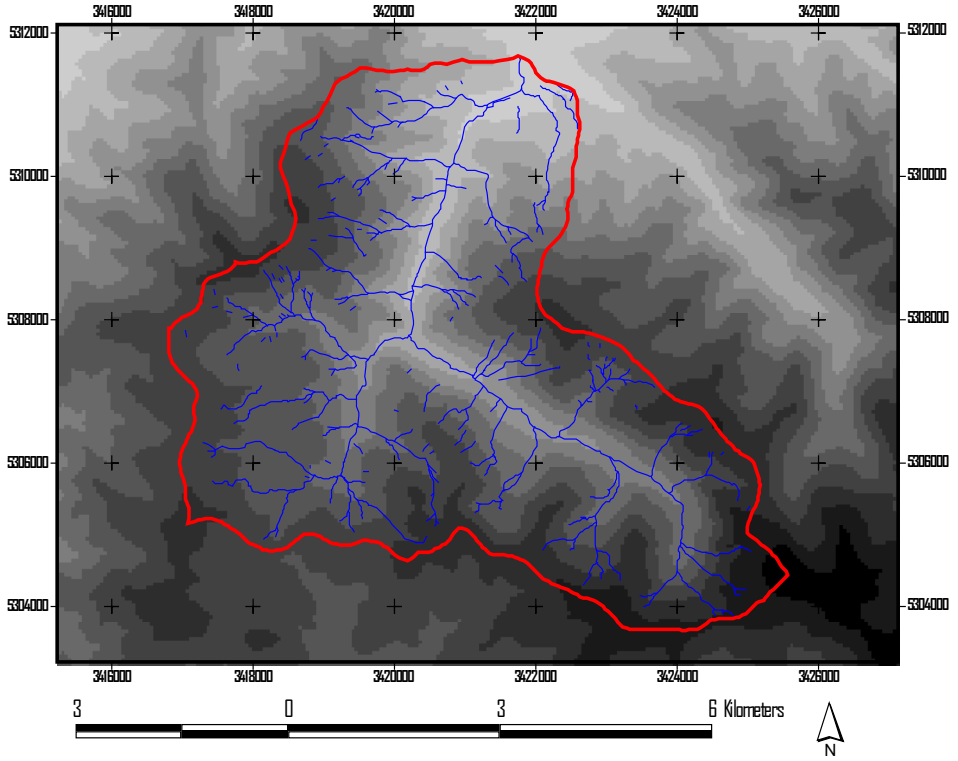
Most commonly expressed in mm water depth
over a specified period of time

Precipitation is already measured in mm
River flow is usually measured in m^3/s

$$R = \frac{Q \cdot \Delta t}{A}$$

What is a Hydrological Catchment?



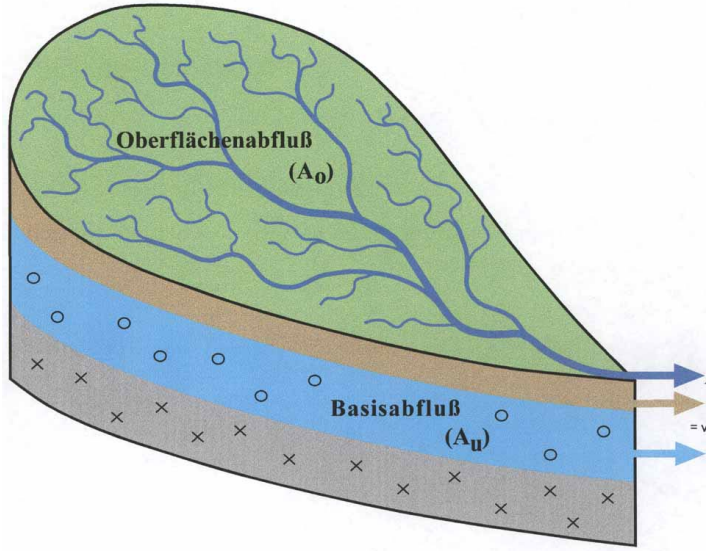


Topographic Control of the Watershed

(Maimai Catchment, New Zealand;
picture from prof. Jeff McDonnell, Corvallis, USA)

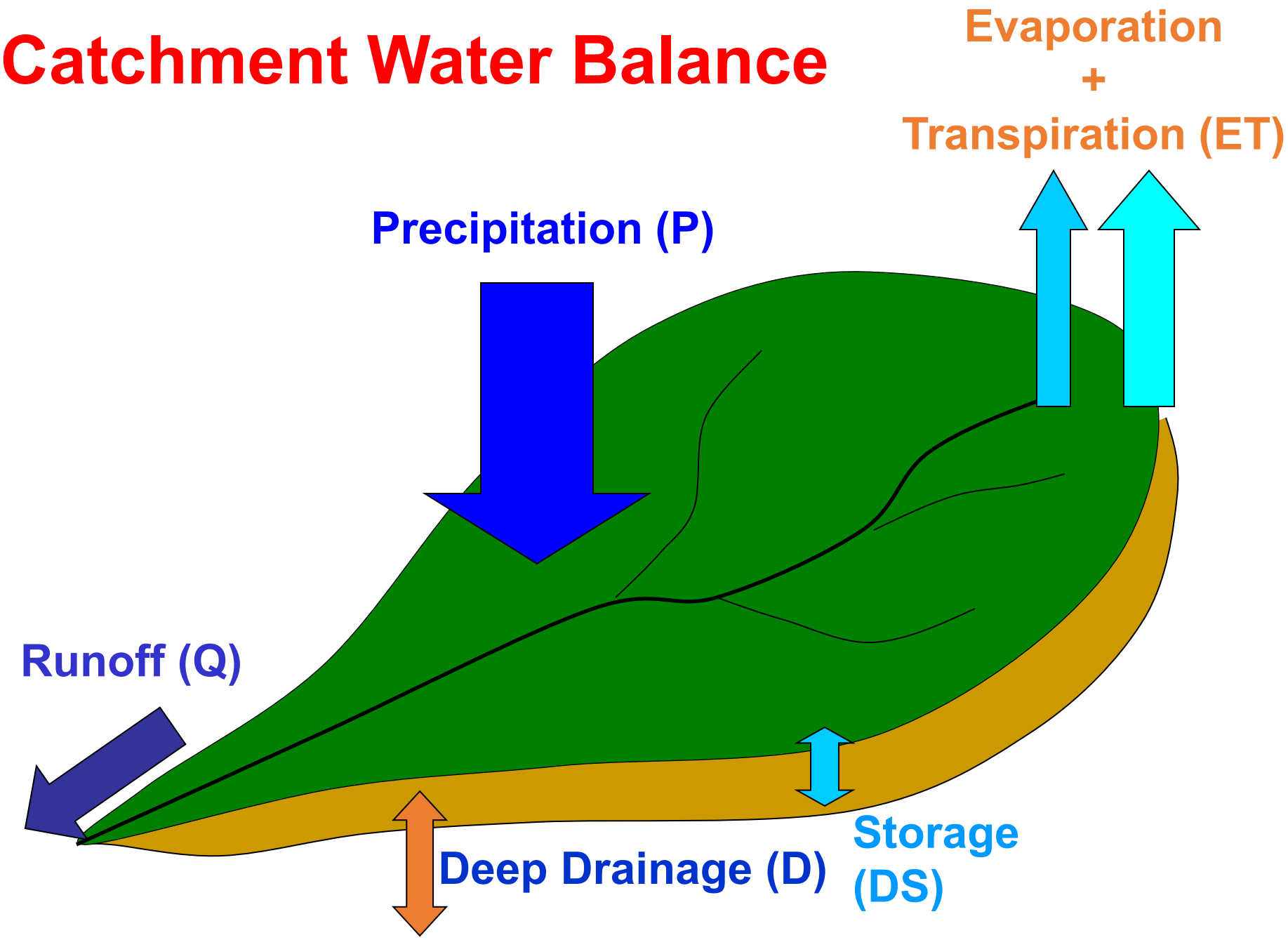
Catchment Approach

Precipitation
Energy



Runoff
ET

Catchment Water Balance



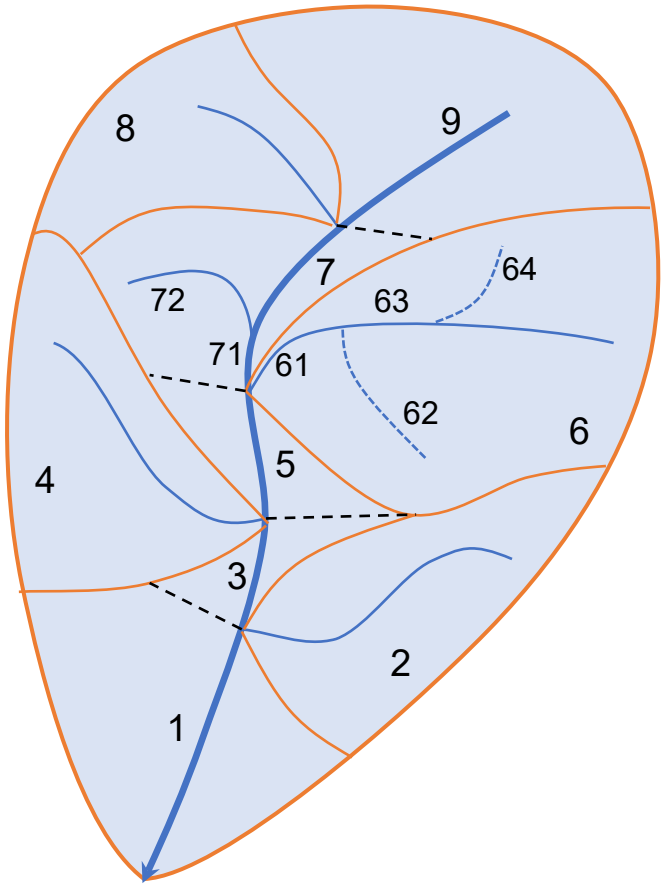
Hydrological units

Hydrological unit delineation and coding
Delineation of the hydrological units follows the widely adopted **Pfafstetter coding system** (Verdin and Verdin, 1999).

This is a **recursive hierarchical subdivision** of larger basins into smaller ones until the desired level of detail is reached.

As an **advantage**, the coding system includes the **topology between the units in a unique way** such that the **downstream linkage** between units can be readily obtained from the codes without consulting maps.

Hydrological units



At confluence of two or more streams:

- main branch has largest catchment area
- other streams are tributaries

1,3,5,7 interbasins along main branch
2,4,6,8 four largest-area tributary basins
9 main branch upstream interbasin

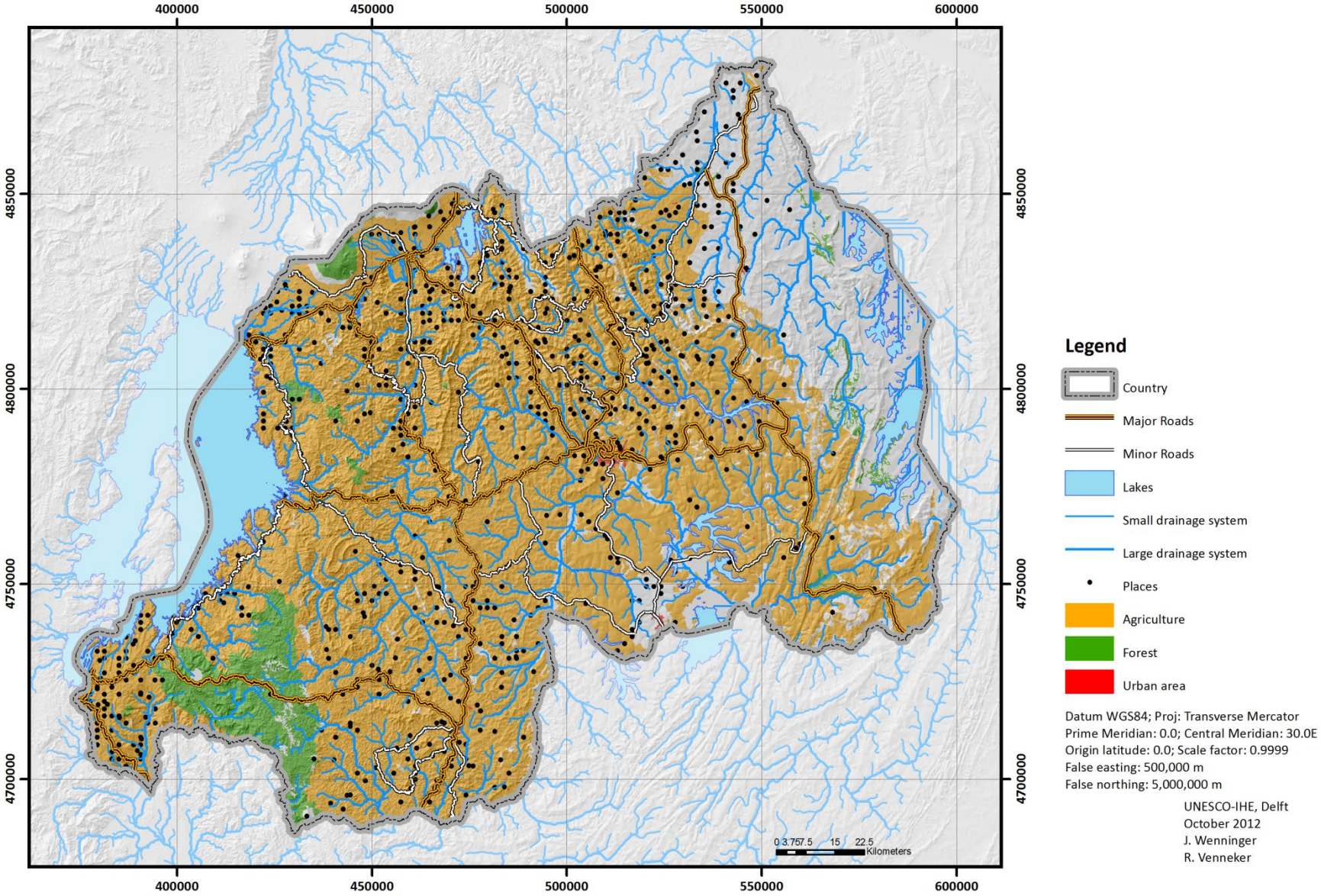
Recursion for basin 6:

61 interbasin along tributary 6
62 tributary sub-basin to 6
63 interbasin along tributary 6
64 tributary sub-basin to 6
Etc.

Recursion for interbasin 7:

71 interbasin along main branch 7
72 tributary basin to main branch 7
Etc.

1.1 OVERVIEW


400000
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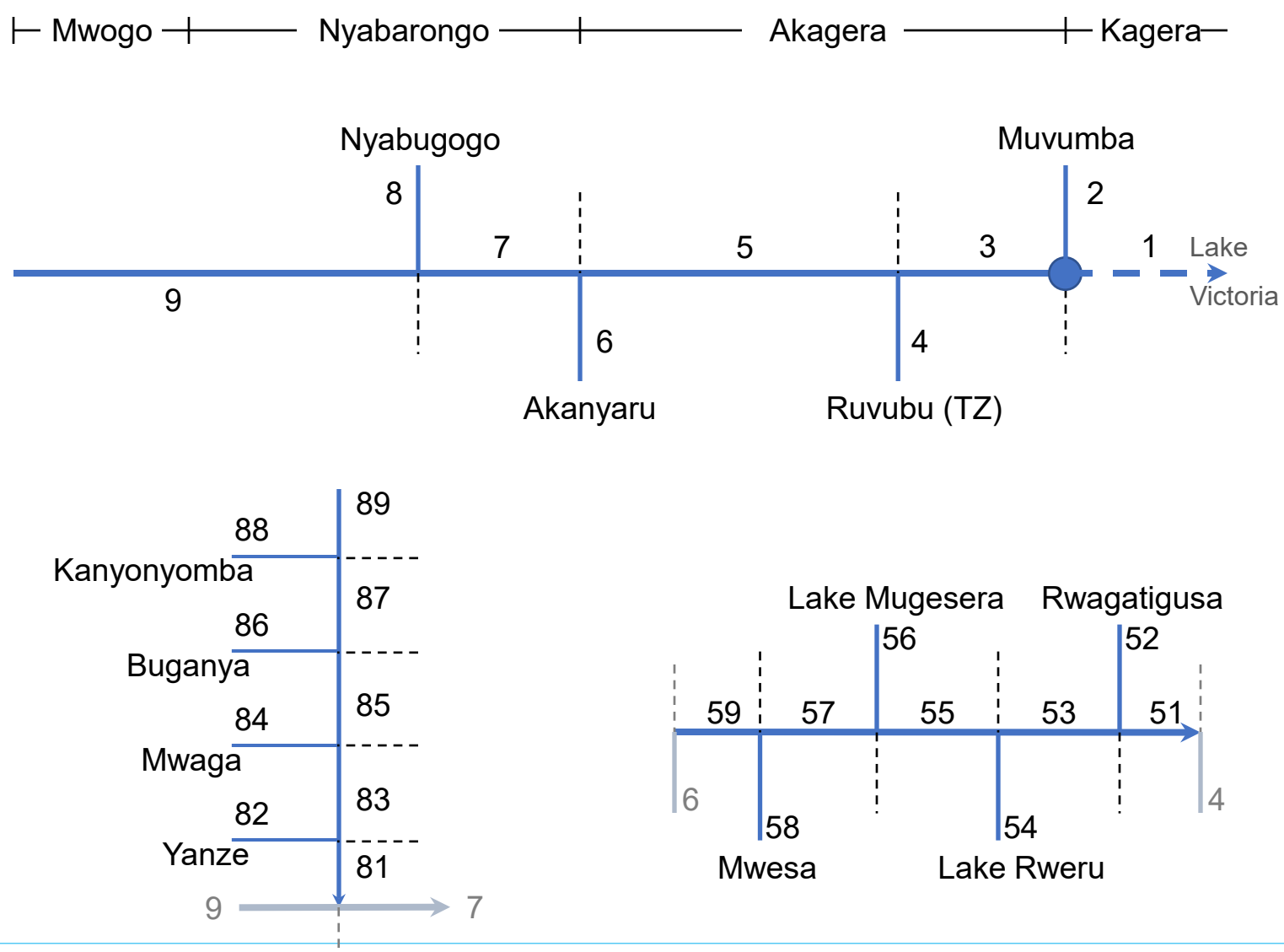
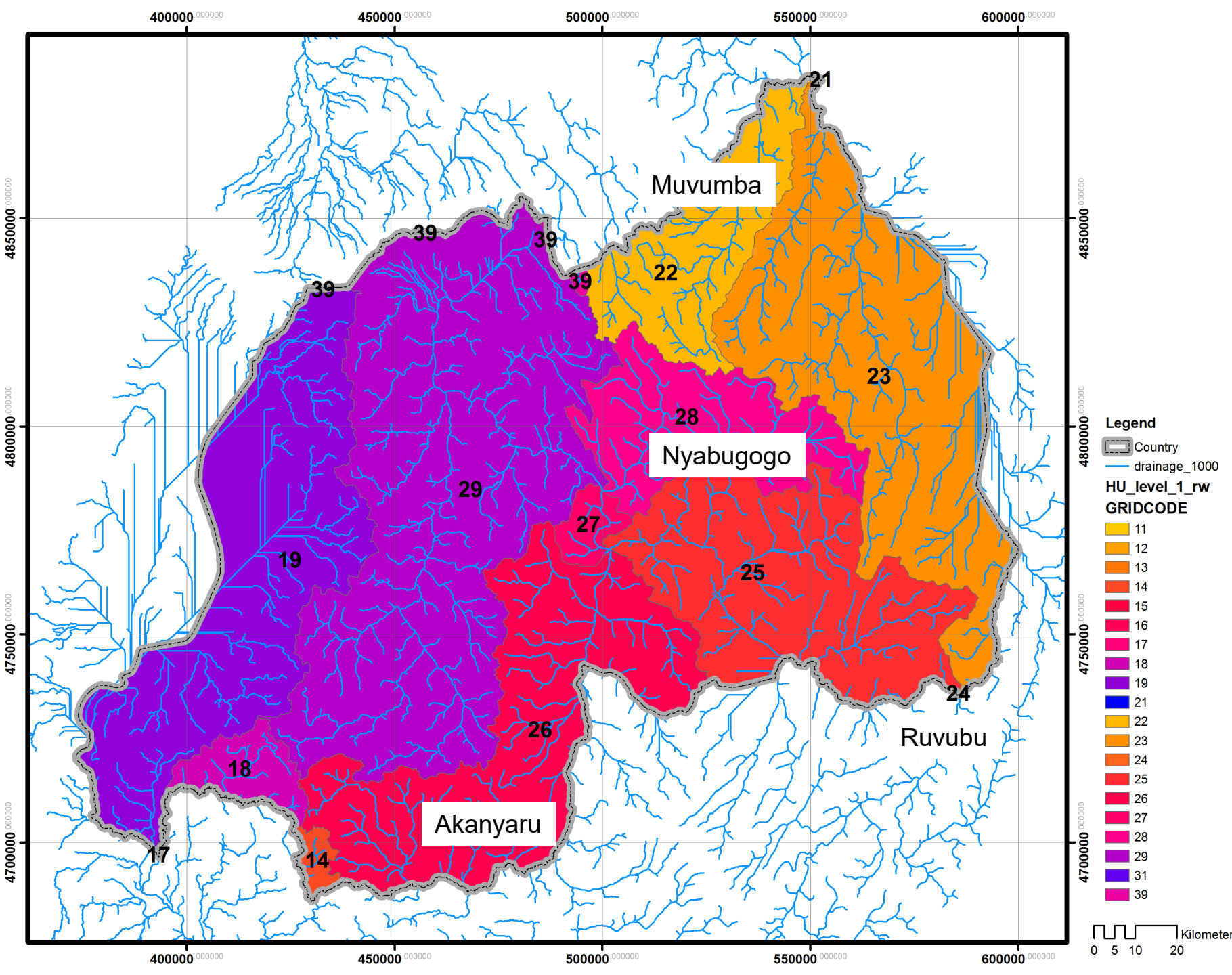
500000
550000
600000
4850000
4800000
4750000
4700000
0 3.757.5 15 22.5
Kilometers
Legend
Country
Major Roads
Minor Roads
Lakes
Small drainage system
Large drainage system
Places
Agriculture
Forest
Urban area
Datum WGS84; Proj: Transverse Mercator
Prime Meridian: 0.0; Central Meridian: 30.0E
Origin latitude: 0.0; Scale factor: 0.9999
False easting: 500,000 m
False northing: 5,000,000 m
UNESCO-IHE, Delft
October 2012
J. Wenninger
R. Venneker

HU coding for Nile basin / Kagera main branch

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Akanyaru
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Legend
Country
drainage_1000
HU_level_1_rw
GRIDCODE
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Kilometers
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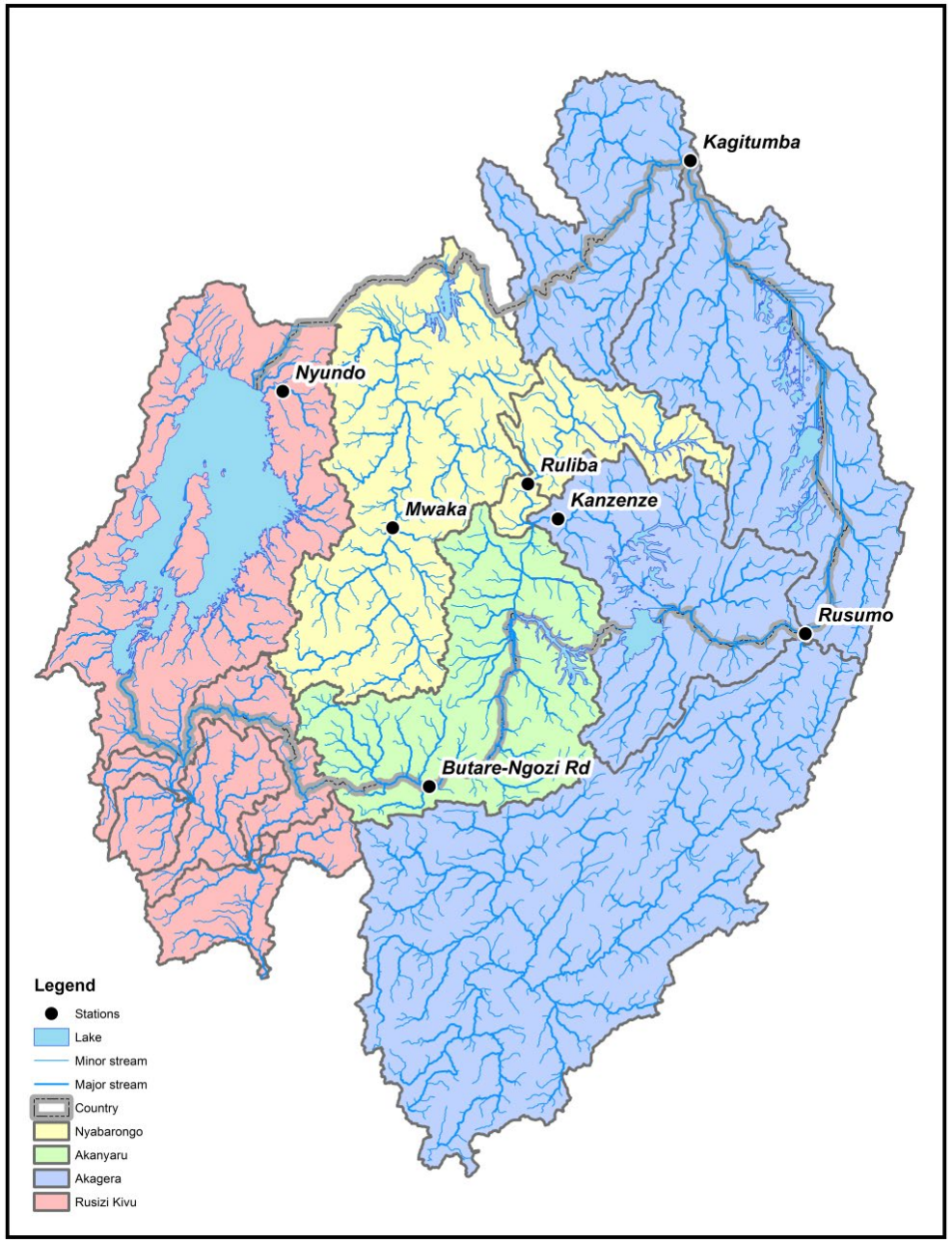
Summary of the major regional drainage areas partly located in Rwanda

River basin	Branch	Total area (km^2)	Area RW (km^2)	Remarks
1 Congo	Rusizi-Lake Kivu	8,721	4,326	at the Bugarama tri-point
	Kaburantwa	505	125	up to Rusizi confluence
	Rusizi sub-basin	12,648	4,451	up to Lake Tanganyika
2 Nile (L. Victoria)	Akagera	27,121	8,916	
	Nyabarongo	8,550	8,485	incl. Mwogo reach
	Akanyaru	5,334	3,411	at the Kagitumba tri-point
	Total	41,005	20,813	
3 Nile (L. Edward)	Rutshuru	4,087	49	up to Lake Edward


Kagitumba
Nyundo
Ruliba
Kanzenze
Mwaka
Rusumo
Butare-Ngozi Rd
Legend
Stations
Lake
Minor stream
Major stream
Country
Nyabarongo
Akanyaru
Akagera
Rusizi Kivu