DEPARTEMEN TEKNIK SIPIL
SEKOLAH VOKASI
UNIVERSITAS GADJAH MADA

Analisis Hidrologi dan Drainase

Konsep Hidrologi

13.02.2020

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Website: http://wakhidatik.staff.ugm.ac.id/

Concept

what

- Hydrology : the science of water (occurrence, circulation, distribution of water on earth & earth's atmosphere)
- **Two basic concepts: hydrologic cycle & water balance**

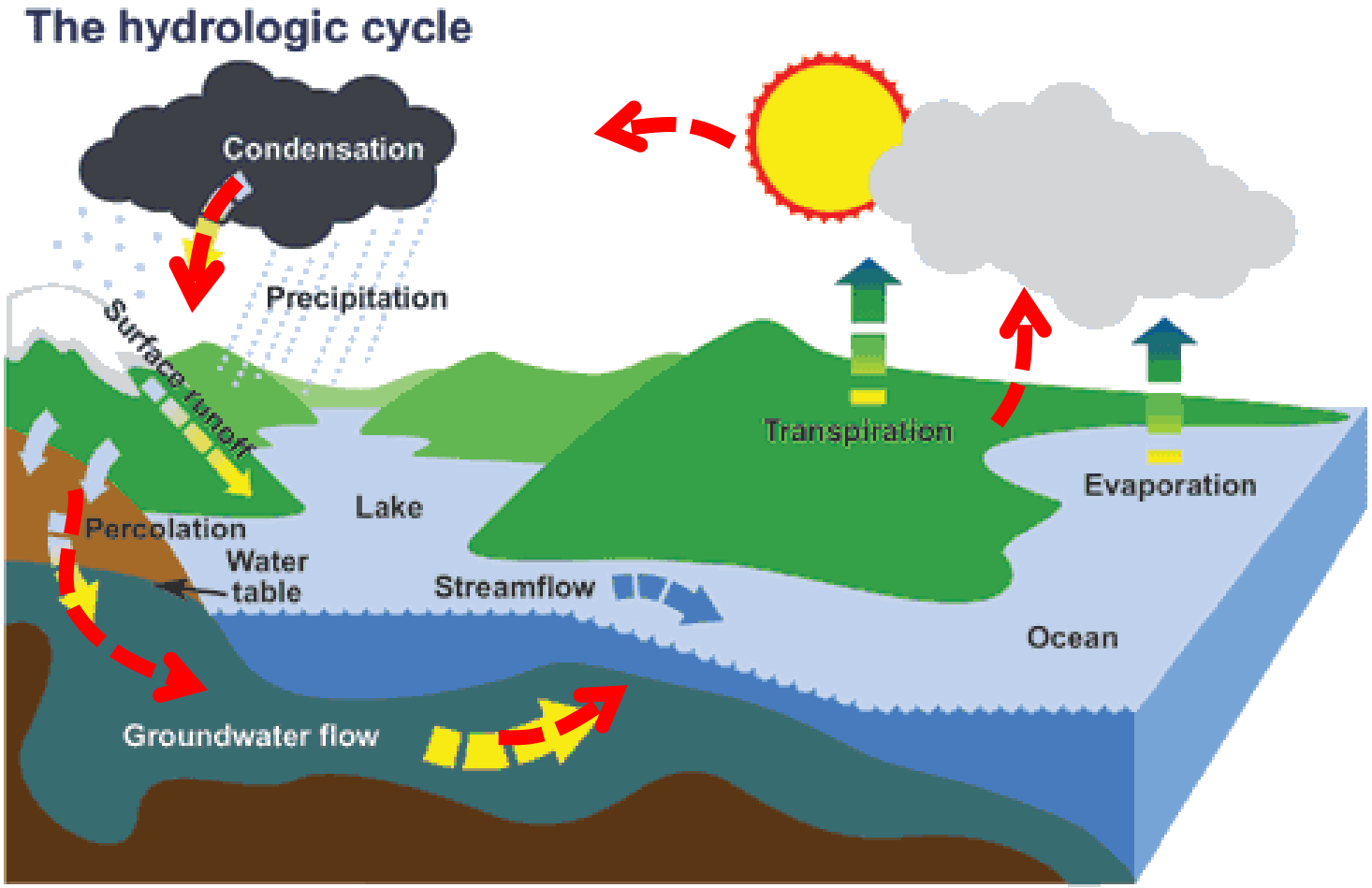
why

- Need to estimate water resources
- **Need to predict flood & drought, and how to combat them**
- etc

where

Irrigation facility, **drainage facility**, flood defense, water supply, waste water facility, power plant / pembangkit listrik tenaga air (PLTA), dll

Hydrologic Cycle: Siklus Hidrologi



https://www.canada.ca/en/environment-climate-change/services/water-overview/basics/hydrologic-cycle.html

Hydrologic cycle (1)

Evaporation

- Liquid to gas
- Driven by sun
- Occurs on raindrops, free water surfaces (seas, lakes), etc
- Evapotranspiration

Evaporation & evapotranspiration (water – water vapor) → **Condensation** (water vapor - liquid) – small droplets – bigger droplets – saturated → **precipitation**

Precipitation

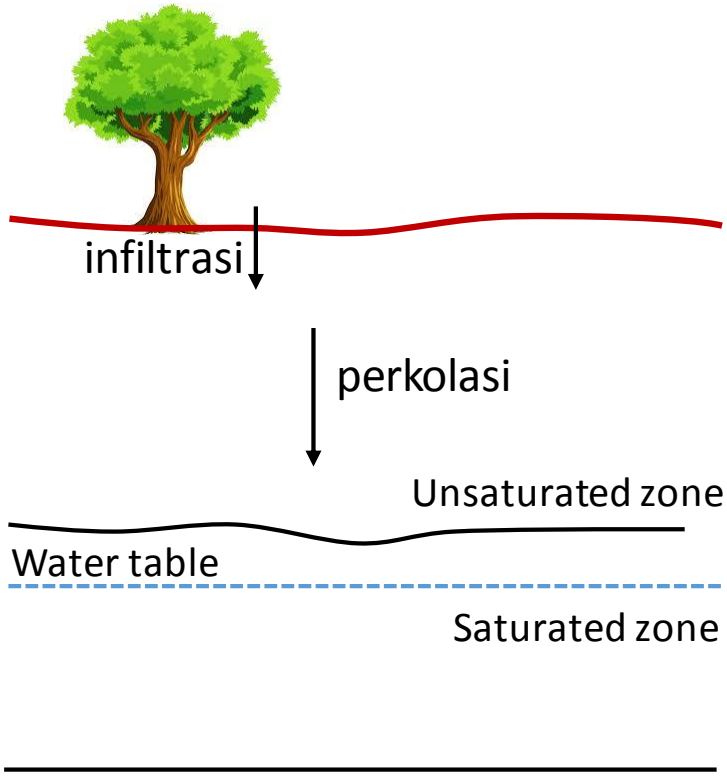
- Rain, snow, hail (small ice particles)
- Become: runoff (surface, subsurface)
- Interception : rainfall will first intercepted by vegetation cover (i.e. leaves)

https://www.nwrfc.noaa.gov/info/water_cycle/hydrology.cgi

Hydrologic cycle (2)

Infiltration

- Water movement **into** soil
- Affect the soil moisture



Percolation

- Movement of water **through** the soil, and it's layers, by gravity and capillary forces
- Recharge the groundwater

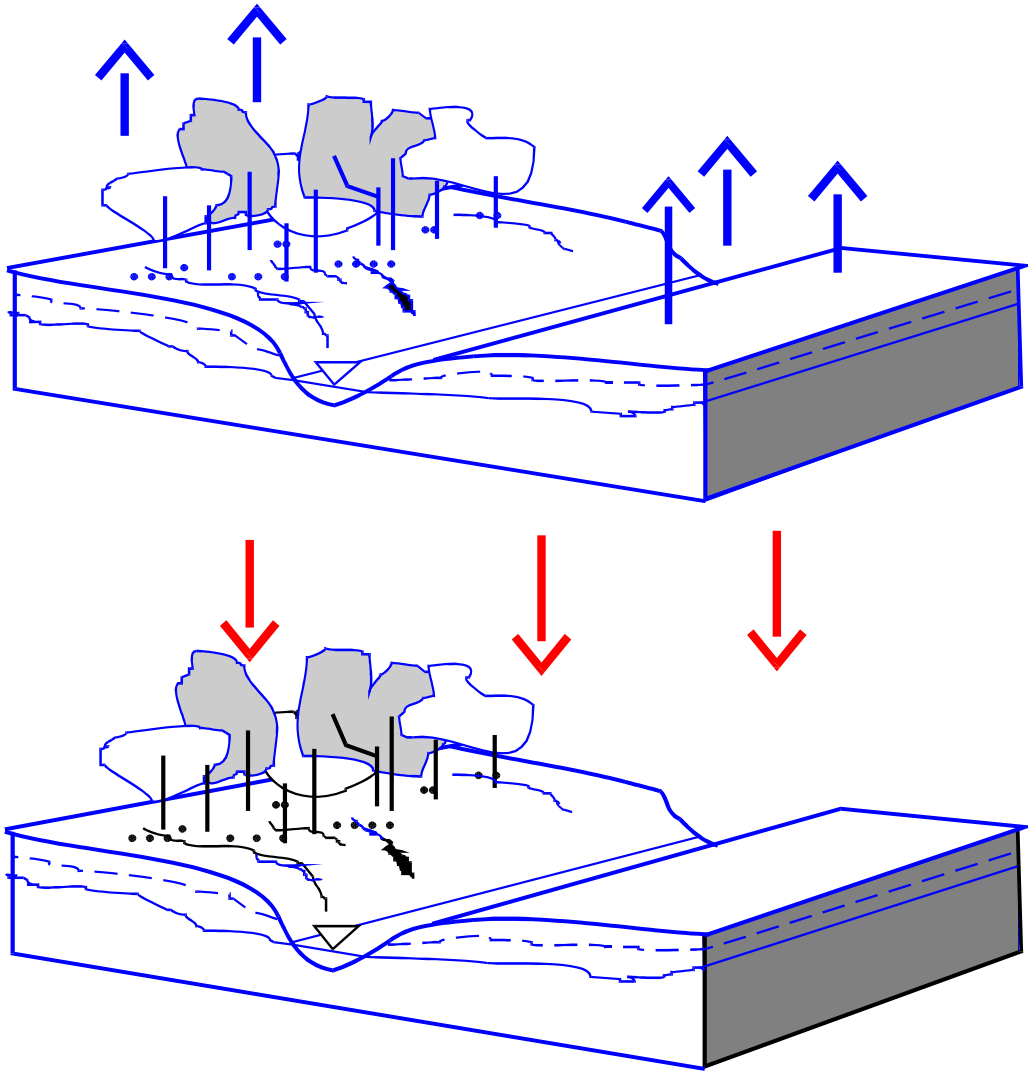
Runoff

- After the water saturated the soil → surface runoff

Streamflow

…. and repeat back to evaporation…

Siklus Limpasan (1)

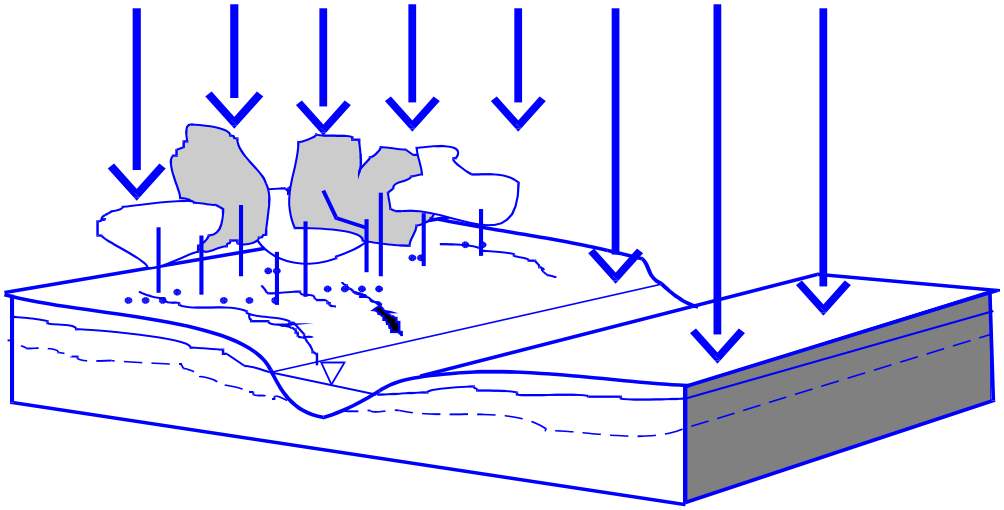


TAHAP I:
Akhir musim kemarau
-Evaporasi dominan
-Belum ada hujan
-Permukaan kering

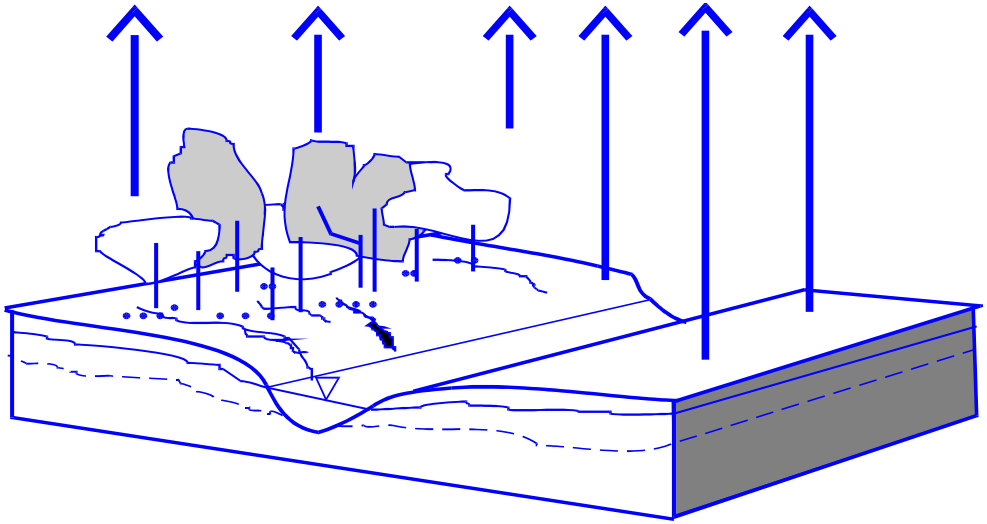
TAHAP II:
Awal musim penghujan
-Mulai ada hujan sedikit
-Belum cukup membentuk surface runoff

Ref: Sri Harto, BR., "Hidrologi: Teori, Masalah, dan Penyelesaian". Naffiri Offset: Yogyakarta. 2000

Siklus Limpasan (2)



TAHAP III:
Puncak musim penghujan
-Soil moisture capacity tercapai
-Surface runoff dominan
-Sering terjadi banjir



TAHAP IV:
Awal musim kemarau
-Pengatusan subsurface flow
-Penguapan intensif
-Soil moisture berkurang

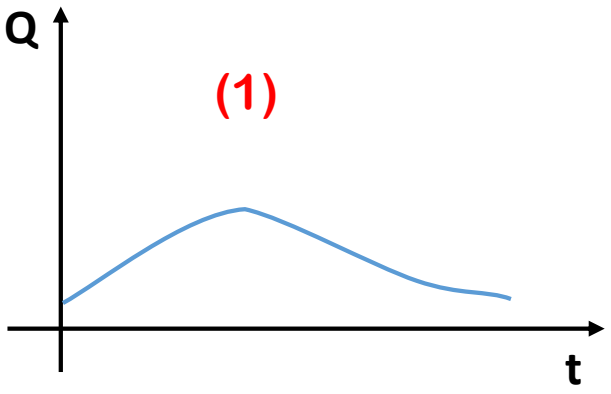
Ref: Sri Harto, BR., "Hidrologi: Teori, Masalah, dan Penyelesaian". Naffiri Offset: Yogyakarta. 2000

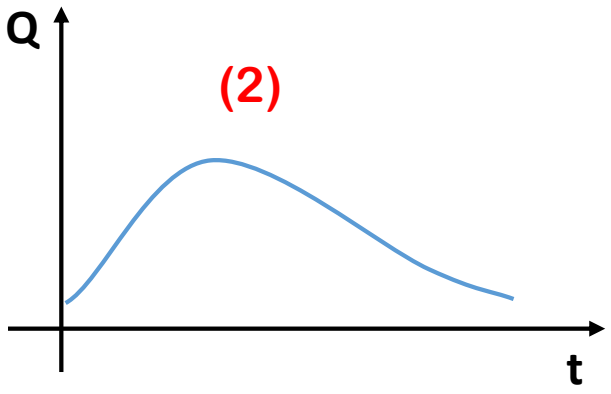
Pola Perubahan Hidrologi (Question)

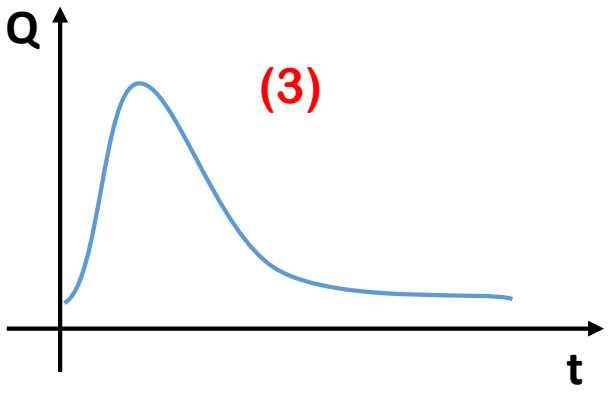
(A)

(B)

(C)





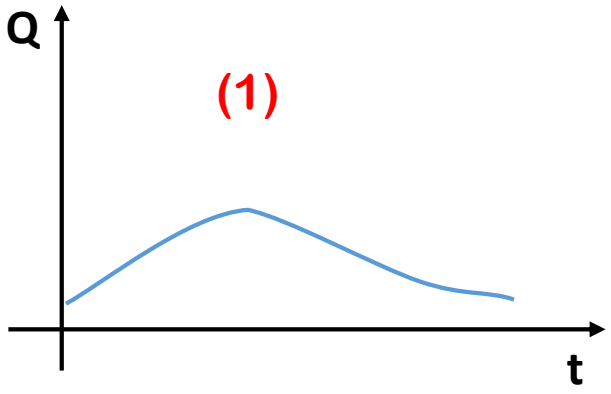


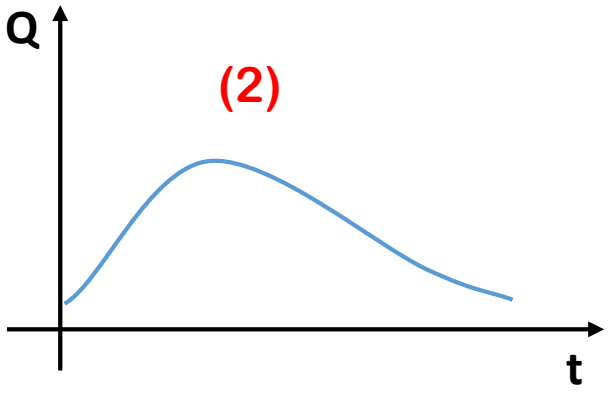
Pola Perubahan Hidrologi (Answer)

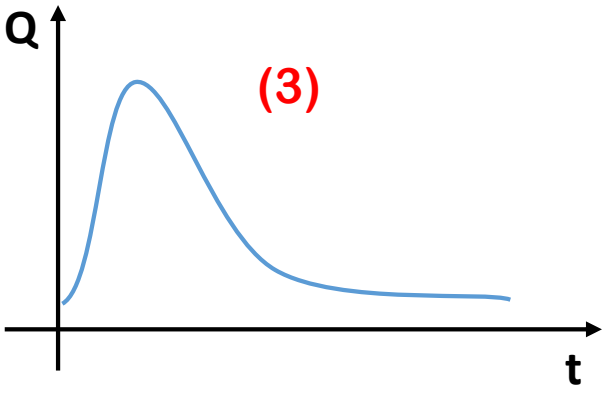
(C)

(A)

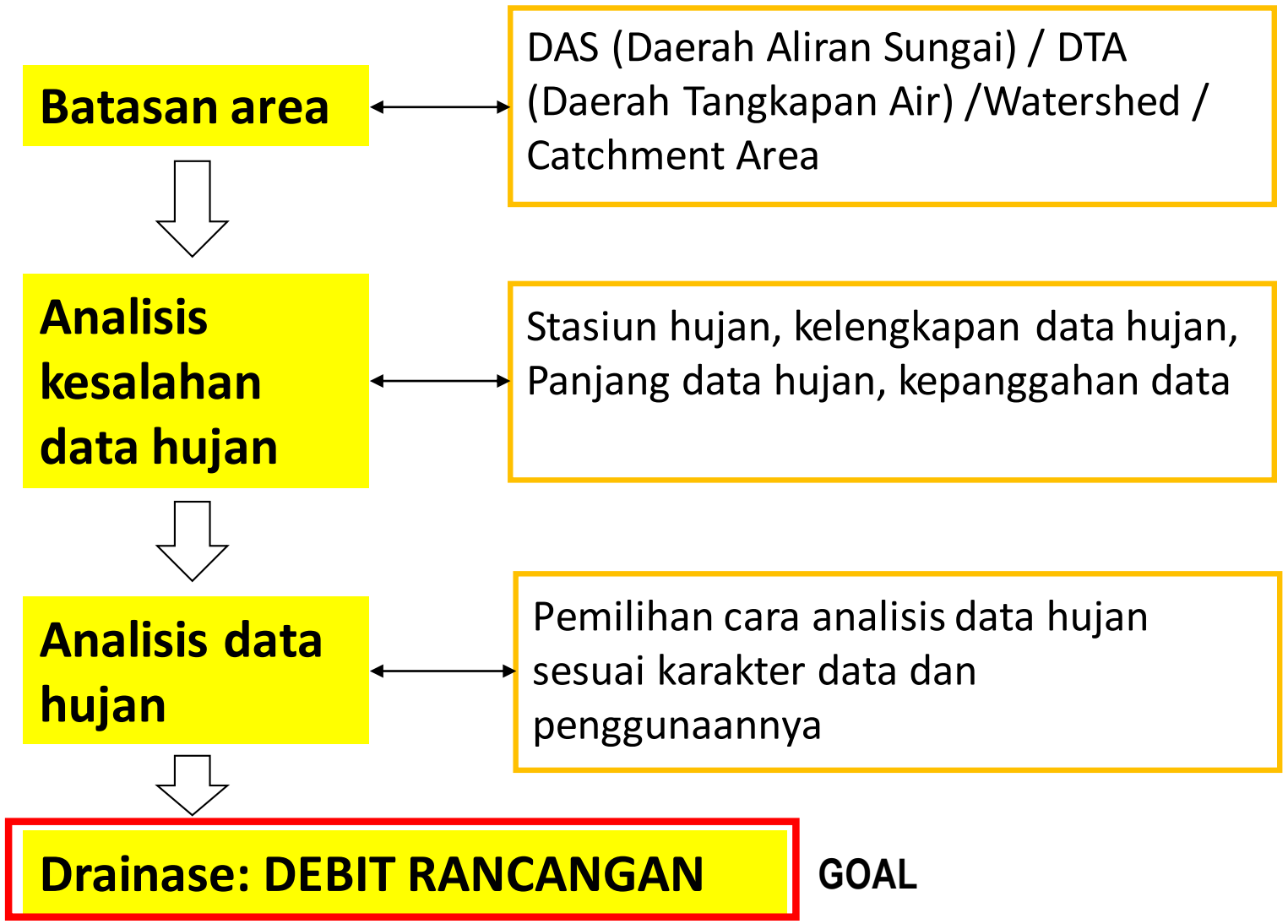
(B)







Konsep Urutan Analisis Hidrologi

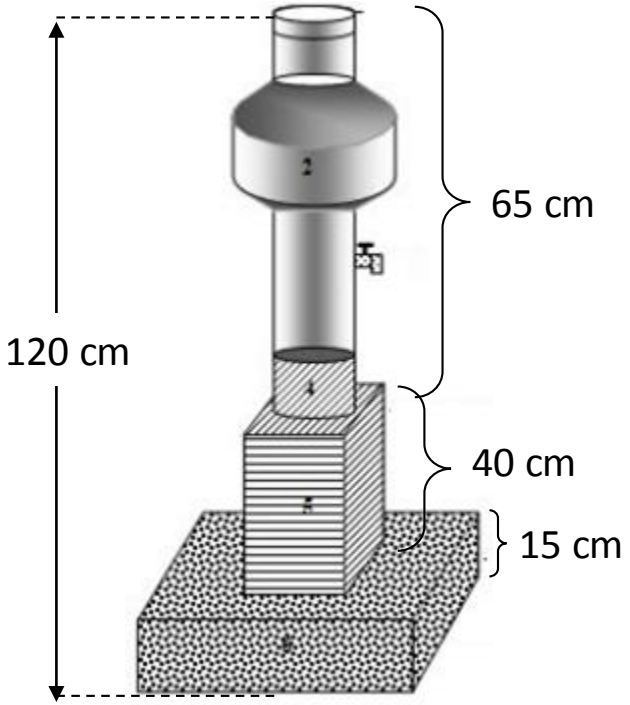


Pengukuran Curah Hujan

Pengertian^2

- Intensitas hujan, i (mm)
  - Tinggi air per satuan waktu (mm/menit, mm/jam, mm/hari)
- Kejadian hujan:
  - Hujan actual
  - Hujan rencana
- Agihan hujan
  - Agihan hujan jam-jaman
  - Agihan hujan harian
  - Agihan hujan bulanan / tengah bulanan
- Hyetograph
- Pencatat/Penakar hujan

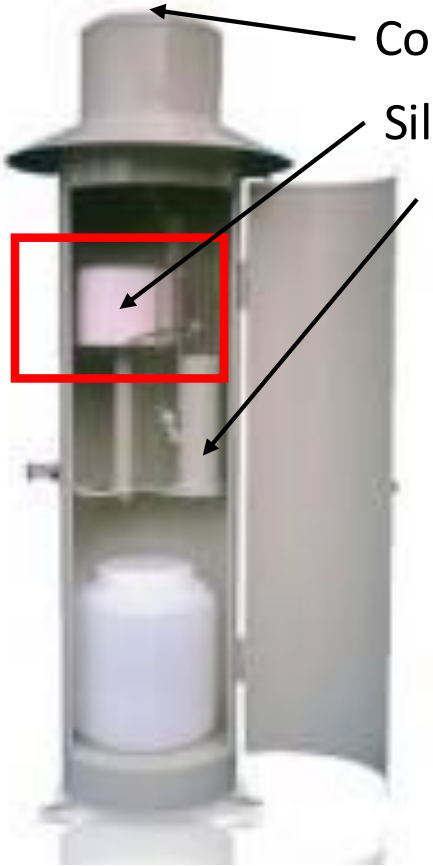
Alat Ukur / Penakar Hujan Manual



- Menghitung volume air selama 24 jam
- Alat dibuka dan diukur secara teratur setiap hari (periodik) pada pukul 07:00,
- Hanya mengukur jumlah hujan, tidak dapat diketahui durasi hujan dan intensitas hujan maksimum pada suatu kejadian hujan

ARR: Automatic Rainfall Recorder (1)

ARR tipe Hellmann



- Silinder terus berputar sesuai waktu
- Air hujan masuk → pelampung bergerak → membuat grafik pada kertas silinder.
- Apabila ketinggian grafik mencapai 10 mm (angka maksimal), air terbuang melalui syphon, grafik turun ke 0 (nol) lagi, pencatatan diteruskan..

http://www.th-friedrichs.de/en/products/rain/rain-gauge/hellmann-rain-gauge/

Contoh hasil pencatatan data hujan

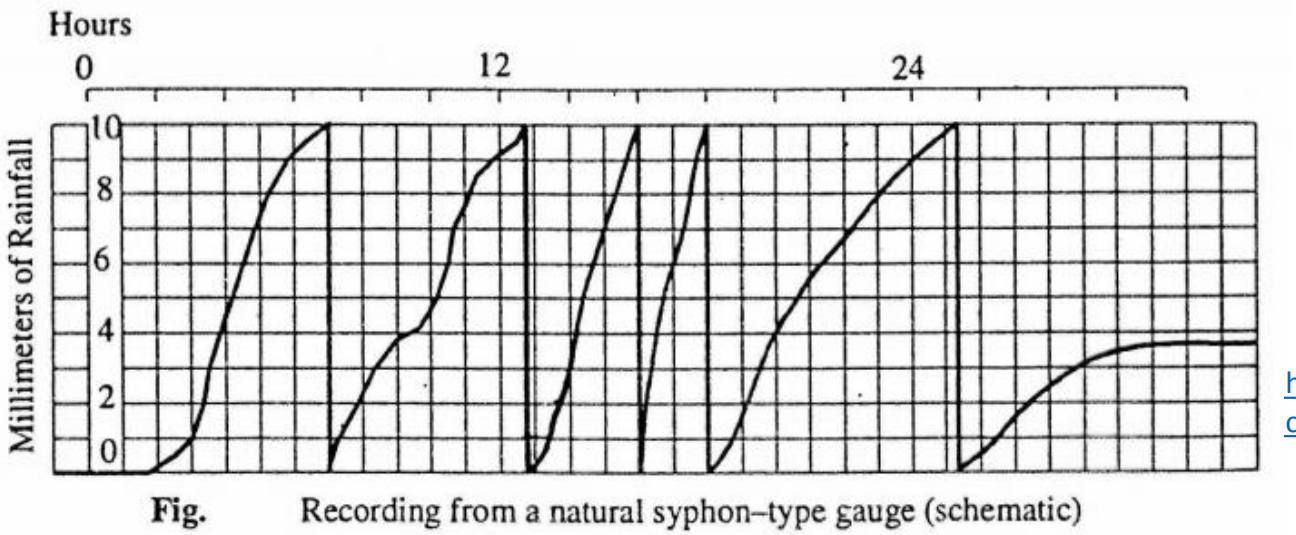
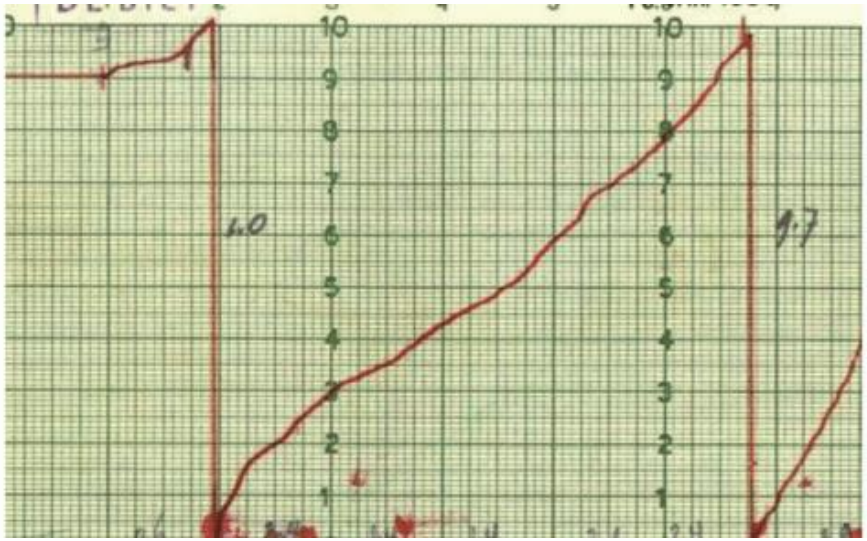


Fig. Recording from a natural syphon–type gauge (schematic)

https://civilclassroom.files.wordpress.com/2014/05/precipitation.pdf

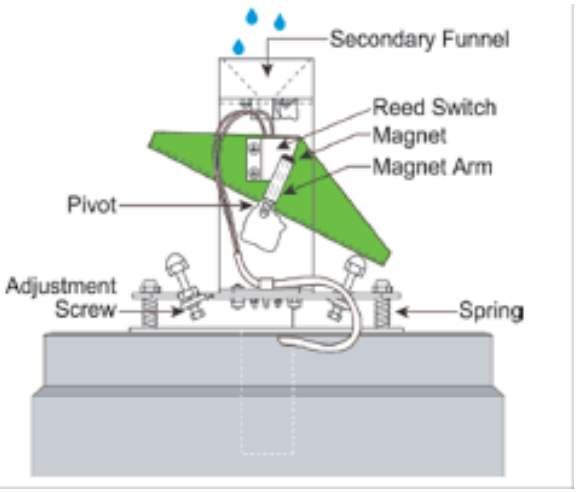


https://www.knmi.nl/kennis-en-datacentrum/achtergrond/recovery-and-disclosure-of-historical-meteorological-observations-hisklim

ARR: Automatic Rainfall Recorder (2)

ARR tipe Tipping Bucket

Video: Missisipi WMO Youtube Channel
https://www.youtube.com/watch?v=ygLJV8upFQ4



- Mencatat setiap jungkit via sensor yang terpicu oleh magnet
- Kapasitas wadah: 0.5 mm each sides

Contoh hasil pencatatan data hujan

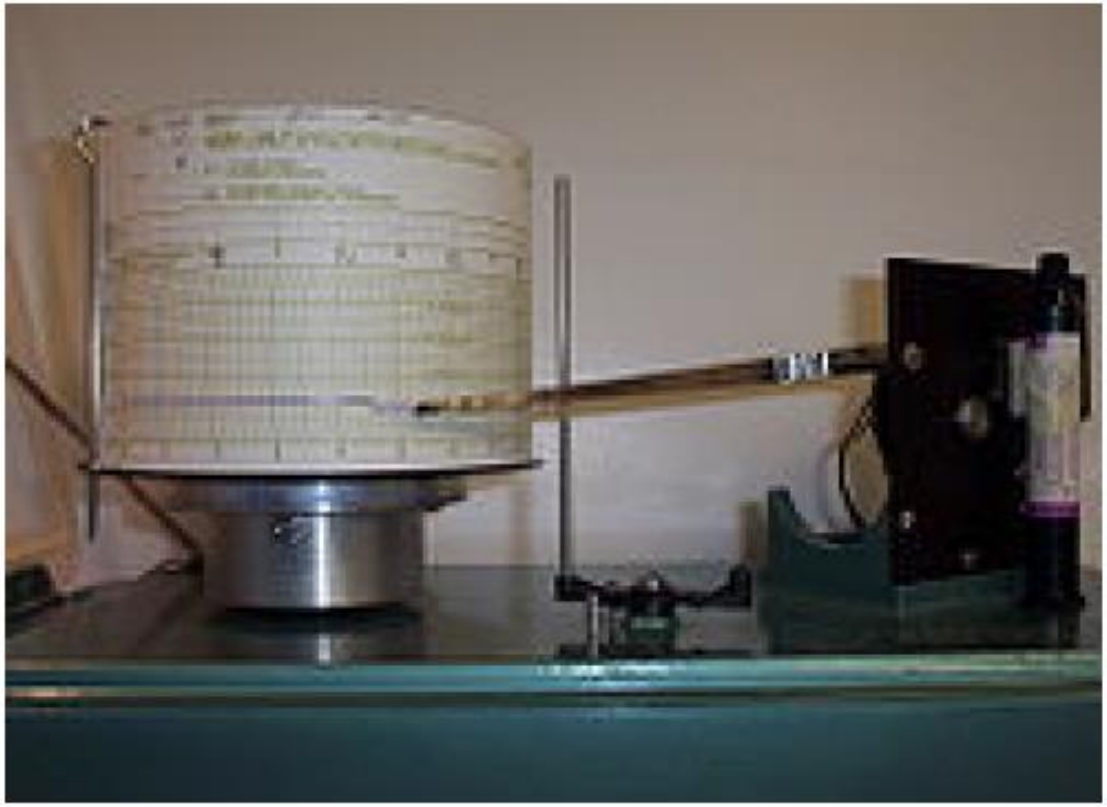


Fig. 1 Tipping bucket rain gauge recorder.

Sumber: Trang, Bui Thi Thu, et al. "Analysis of Storm Pattern for Design Urban Drainage System in the Monsoon Areas of Vietnam." *Journal of Environmental Science and Engineering A* (2018): 49.

https://www.researchgate.net/publication/327121168_Serial_Number_68

Contoh rekap data hujan

DATA HUJAN D.I.YOGYAKARTA TAHUN : 2017

Stasiun : **Bronggang**
Bulan : Januari
Tahun : 2017
No.Kad. :

Kecamatan : Cangkringan
Kabupaten : Sleman
Propinsi : D.I.Yogyakarta.

Pada Dasar : K. Opak
No. Stasiun :
Lokasi Stasiun : S. 07. 67800 / E. 110.45042

Tinggi Dari Muka Laut :
Tahun Pendirian : 2003
Dibangun Oleh : DPUP.DIY

Tanggal	H.B	H.O	JAM																						
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	5	6.7	0.9	0.1	0.8	1.8	1.6	0.1	0.2	0.2	0	0.9	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0
3	3.5	2.7	0	0	0	0	0	0	0.6	1.6	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	18.5	18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.6	5.6	2.9	0.3	0.1	0	0	0	0	0
5	7.5	8.1	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	2.4	2.8	2.1	0.4	0.1	0.1	0.1	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	11.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.7	2.5	5.2	1.4	0.7	0.7	0.1
8	12.5	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.7	18.7	1.6	0	0	0	0	0	0	0
9	15	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0.1	0	0	0	0	0	0	0	0	0
10	1.5	11.5	0	0	0	0	0	0	0	0	0	0	4.3	6.3	0.9	0	0	0	0	0	0	0	0	0	0	0
11	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	3.3	0.2	0	0	0	0	0	0
12	3.5	8.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	5.4	2	0.2	0.2	0	0	0
13	19.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.2	0	0	0	0	0	0
14	23	21.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0.8	0.8	1.2	1.7	2.1	12.8	1.5
15	0	4	0.5	0.2	0.2	0.2	0.4	0.1	0	0	0	0	0	0	0.3	0	0	0	0	0	0.3	1.8	0	0	0	0
16	0.5	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2
17	9	8.1	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	1.7	4.1	1	0.1	0.1	0	0	0.4	0.5
18	23.5	22.9	0.3	0.1	0.3	0.1	0	0	0	0	0	0	0	0	0	2.9	6.5	0	0	6.6	2.8	2.6	0.2	0.2	0.3	0
19	23	0.1	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	21.6	0	0	0	0	0	0	0	0	0	3.1	3.6	5.4	3	1.8	1.8	1.8	0.8	0.2	0.1	0	0	0	0	0
21	0	0.6	0	0.4	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	13	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.2	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	36	28.6	0	0	0	0	0	0	0	0	0	0.1	0.4	0	20.4	5.8	0.9	1	0	0	0	0	0	0	0	0
25	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	6	11.1	1.2	2.8	1	0	0	0	0	0	0	0	0	0	0	0.1	5.9	0.1	0	0	0	0	0	0	0	0
27	28	28.5	0	0	0	0	0	0	0	0	0	0	0	0	1.7	8.3	12.3	1	1.9	0.3	0.1	0.3	1.1	1.5	0	0
28	8.3	8.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	7	0.8	0	0	0	0	0
29	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.2	0.8	1.3	0.5	0.1	0	0	0	0	0
30	9.5	9.6	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	1.9	6.6	0.9	0.1	0	0	0	0
31	53	40.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.4	8.2	0.2	5.4	2.8	5.7	1.4	0.1	0.1	0.1
Jumlah	339.3	306																								
Rata-2	10.95	9.87																								
Maximum	53	40.4																								
Minimum	0.5	0.1																								
H.H	24	27																								

Keterangan :
H.H : Jumlah Hari Hujan
H.O : Hujan Otomatik
H.B : Hujan Biasa

_ : Tidak Ada Data
* : Data Diragukan
Hujan dalam mm (milimeter)

Syarat Pemasangan Alat Penakar Hujan

General rule

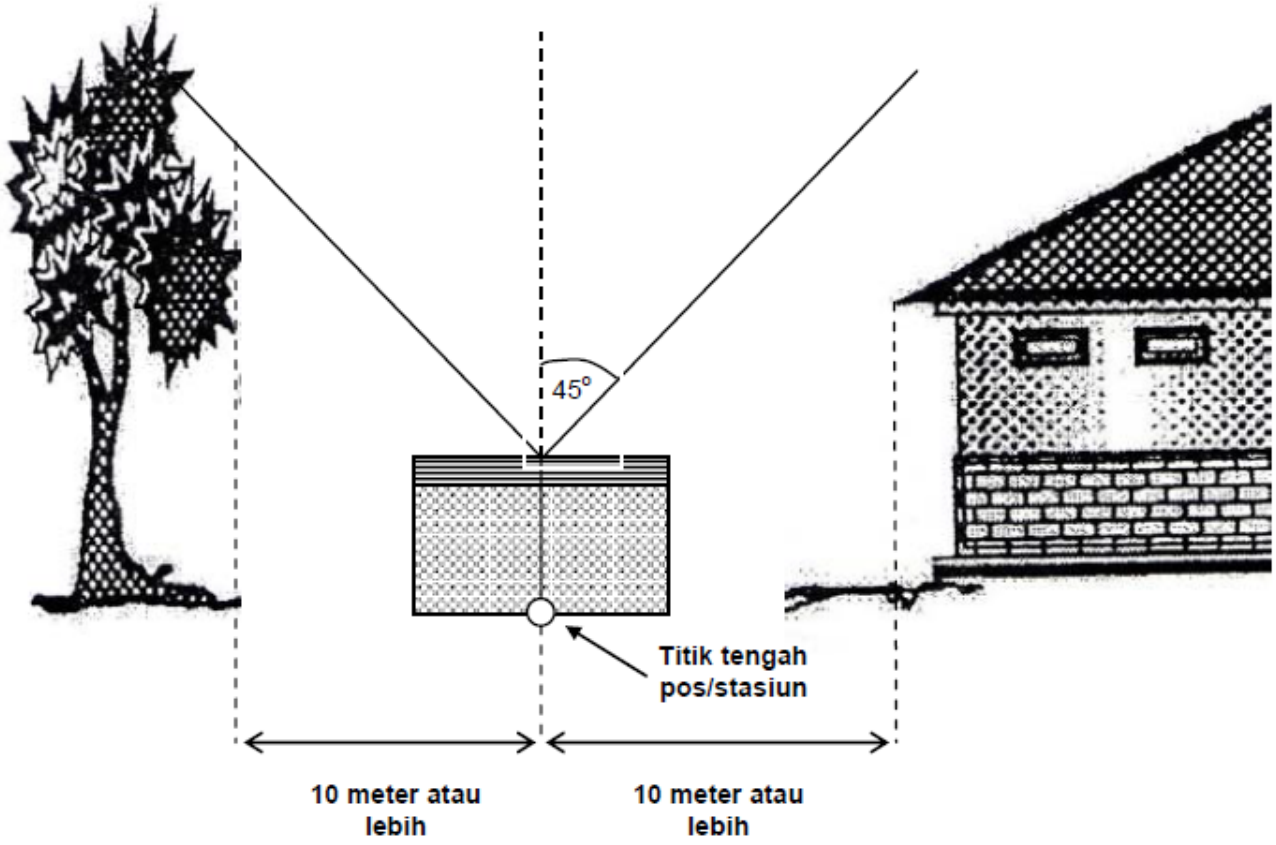
- Tidak dipasang di tempat yang terlalu terbuka (over exposed), seperti di puncak gedung, puncak bukit, etc
- Tidak dipasang di tempat yang terlalu tertutup (under exposed), seperti di antara dua gedung tinggi
- Mudah memperoleh tenaga pengamat

Syarat Pemasangan Alat Ukur (1)

KemenPU

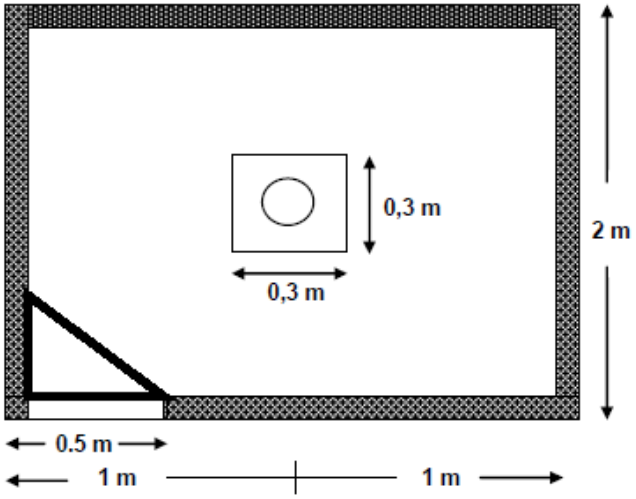
Sumber: Prosedur dan Instruksi Kerja Survei Penempatan dan Pembangunan Pos Hidrologi, KemenPU

A. Cara pemasangan pos hujan dan stasiun klimatologi



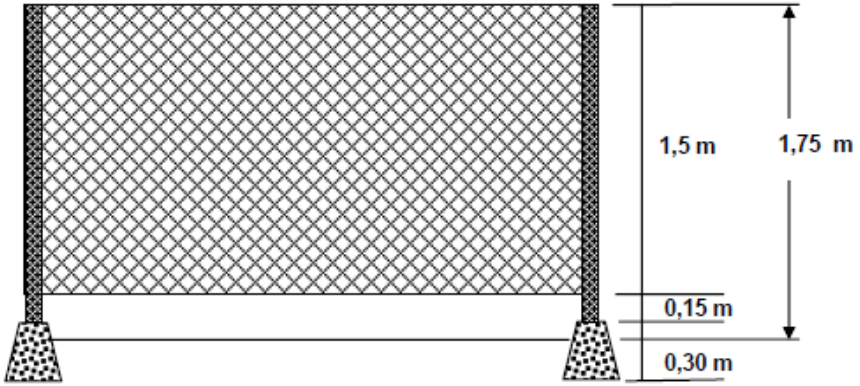
Syarat Pemasangan Alat Ukur (2)

B. Pemasangan pos hujan biasa/manual



Keterangan :

1. Tinggi pagar pos 1,75 meter.
2. Pagar terbuat dari besi dan kawat harmonika.
3. Pintu pos diberi gembok.
4. Corong penampung air hujan dengan luas penampang 100 cm^2.
5. Leher penakar hujan (diameter 13 cm), terbuat dari seng/paralon.
6. Alat dilengkapi tabung penampung air hujan 3 liter terbuat dari seng/paralon dan kran pembuang air.
7. Buat dan pasang papan keterangan pos.



Logo	Nama Instansi Pengelola

Nama Pos : ..... No. Reg. .....

Desa : .....
Kec./Kab : .....
Propinsi : .....
Geografis : .....LU/LS.....BT
Elevasi : .....dpal.
Dibangun :oleh .....; ....- ...- ...

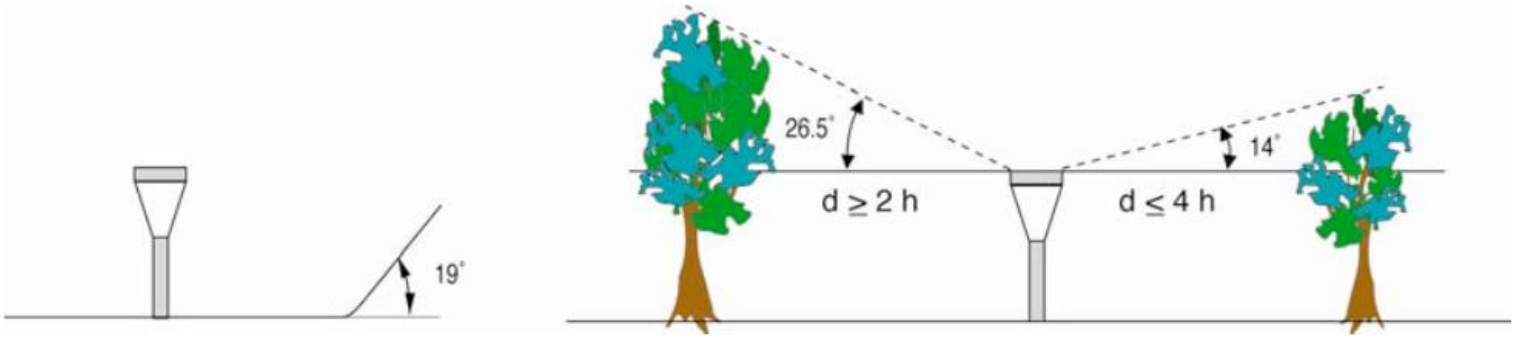
DILARANG MENGGANGGU/MERUSAK BANGUNAN MILIK NEGARA

Standar Pemasangan Alat Ukur WMO (1)

WMO

Class 1

- Flat, horizontal land, surrounded by an open area, slope less than 1/3 (19°). Raingauge surrounded by obstacles of uniform height, seen under an elevation angle between 14° to 26° (obstacles at a distance between 2 to 4 times their height);

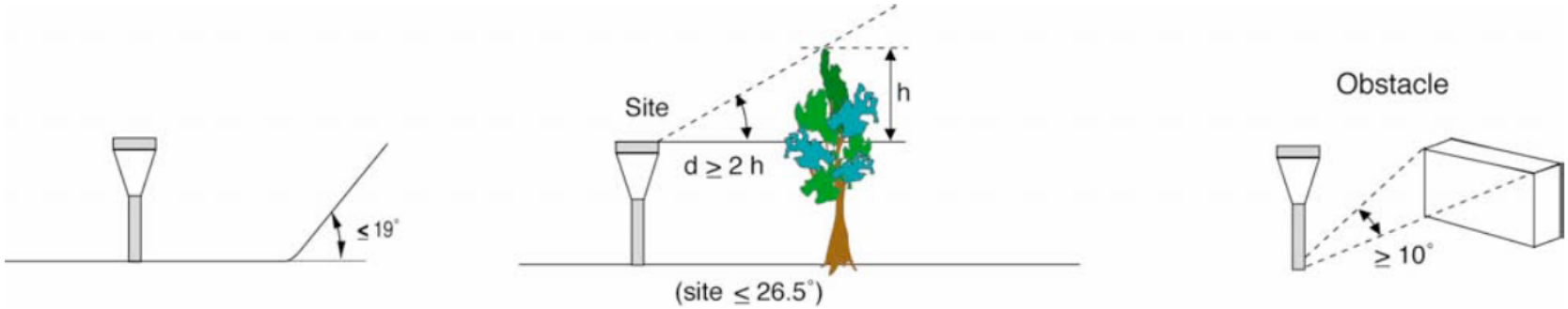


https://library.wmo.int/doc_num.php?explnum_id=4939

Standar Pemasangan Alat Ukur WMO (2)

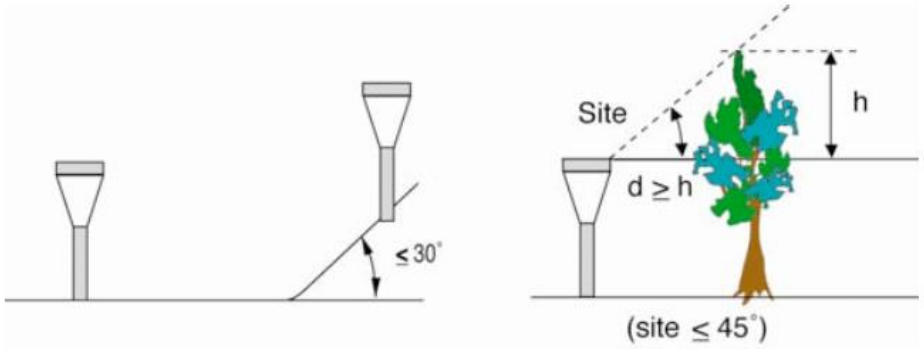
Class 2 (additional estimated uncertainty added by siting up to 5%)

- Flat, horizontal land, surrounded by an open area, slope less than 1/3 (19°);
- Possible obstacles must be situated at a distance at least twice the height of the obstacle (with respect to the catchment's height of the raingauge).



Class 3 (additional estimated uncertainty added by siting up to 15%)

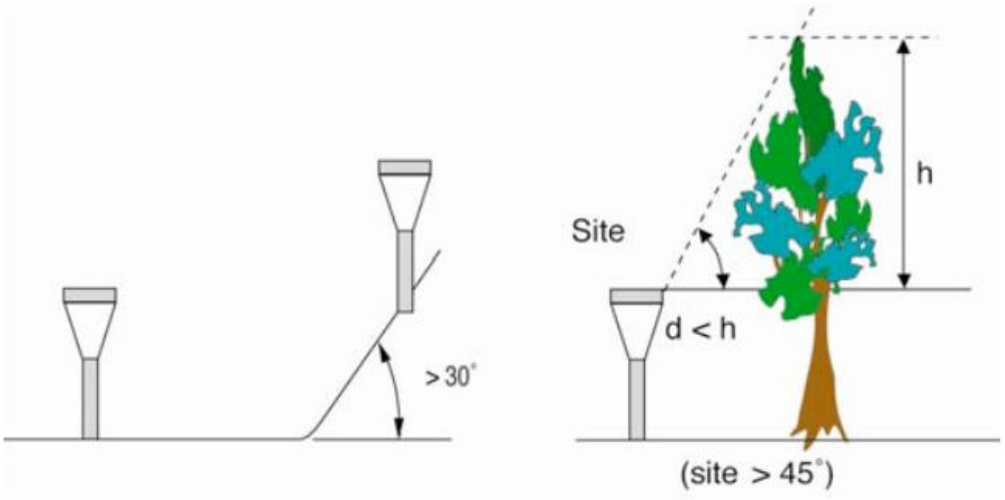
- Land is surrounded by an open area, slope less than 1/2 (≤ 30°);
- Possible obstacles must be situated at a distance greater than the height of the obstacle.



Standar Pemasangan Alat Ukur WMO (3)

Class 4 (additional estimated uncertainty added by siting up to 25%)

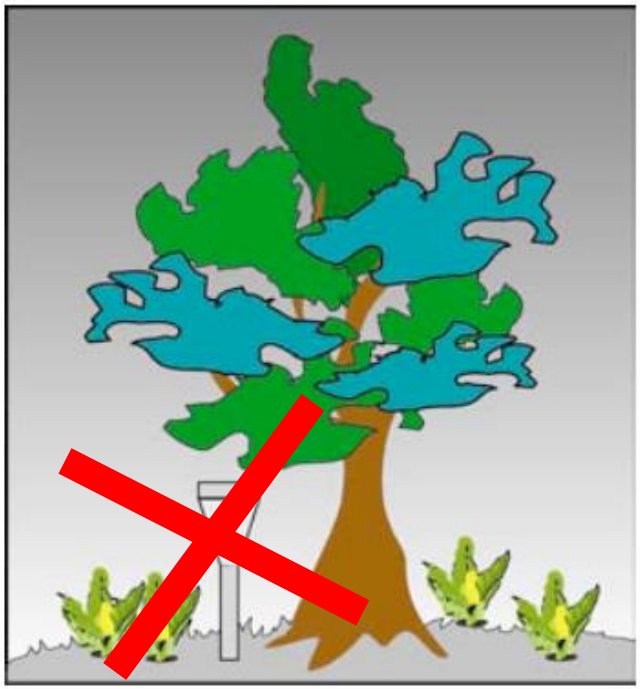
- Steeply sloping land (>30°);
- Possible obstacles must be situated at a distance greater than one half (1/2) the height of the obstacle.



Standar Pemasangan Alat Ukur WMO (4)

Class 5 (additional estimated uncertainty added by siting up to 100%)

- Obstacles situated closer than one half (1/2) their height (tree, roof, wall, etc.).



Thought…

Apabila di sekitar kampus **Dept. Teknik Sipil**, atau di sekitar **Sekolah Vokasi** akan **ditempatkan satu alat pengukur curah hujan**, di mana saja **potensi lokasi** alat?

Di mana saja bisa memperoleh data hujan?

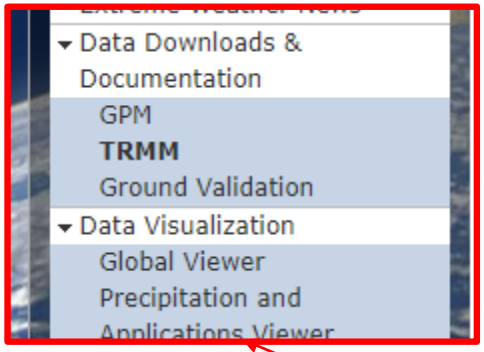
- BBWS (Balai Besar Wilayah Sungai) terkait
- PSDA (Dinas Pengelolaan Sumber Daya Air) terkait
- BMKG (Badan Meteorologi, Klimatologi, dan Geofisika)
- Lain2
  - Area kampus
  - Area industri
  - Area tambang
- Satellite
  - TRMM
  - GPM
  - …

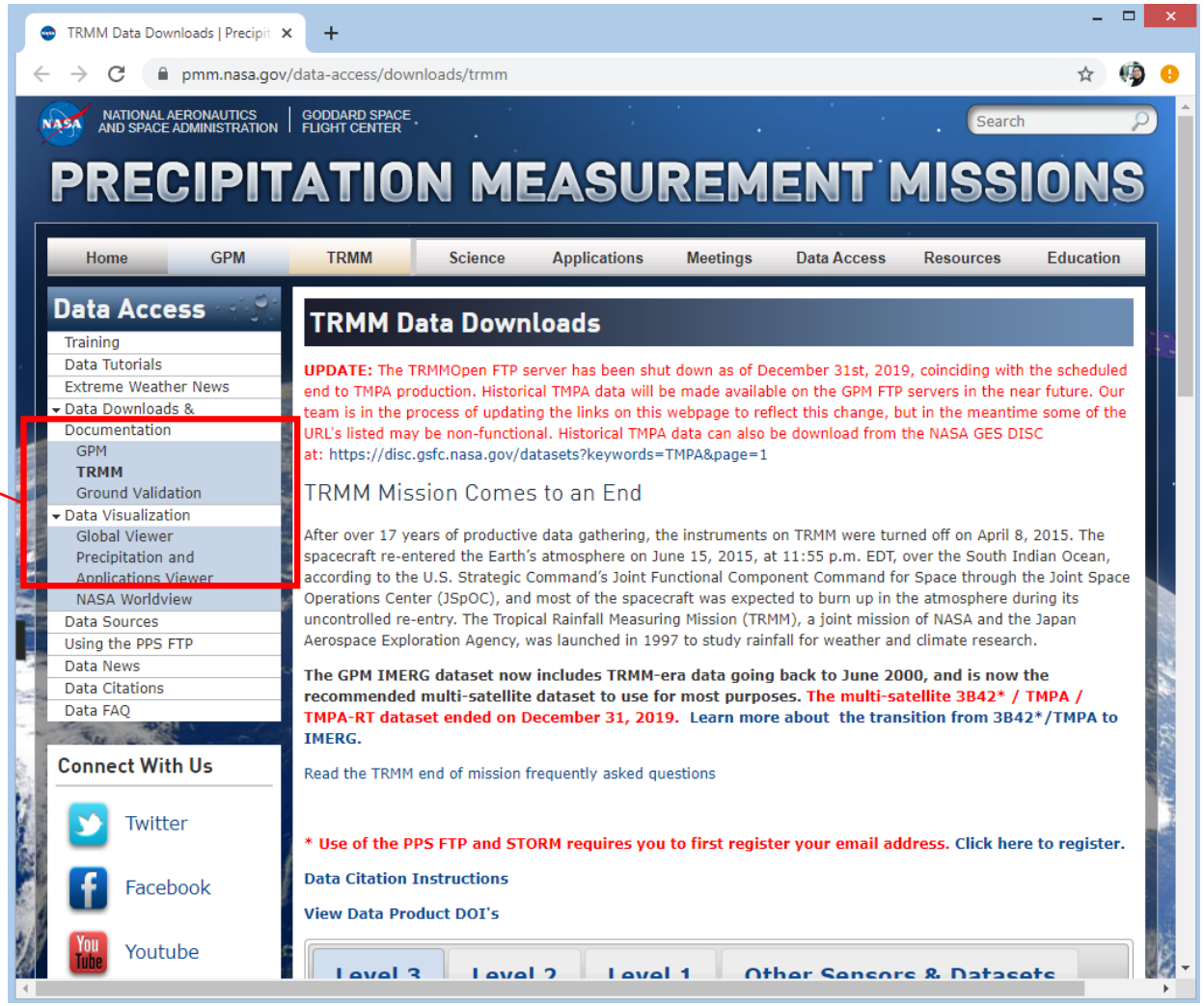
Downloadable Rainfall Data: BMKG

http://dataonline.bmkg.go.id/home

Downloadable Rainfall Data: NASA

https://pmm.nasa.gov/data-access/downloads/trmm





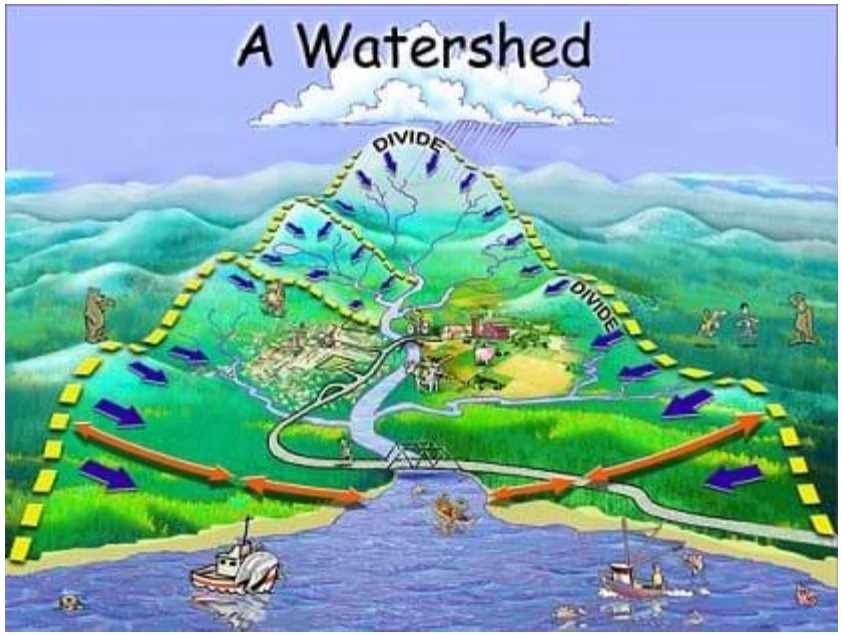
Note: always look for ground measurement as the main data instead of satellite data

Watershed / Catchment Area

Pengertian[2]

- Daerah aliran sungai / watershed / drainage basin / catchment area / river basin
- Daerah tangkapan air / catchment area

https://www.akronohio.gov/cms/Water/Watershed/index.html

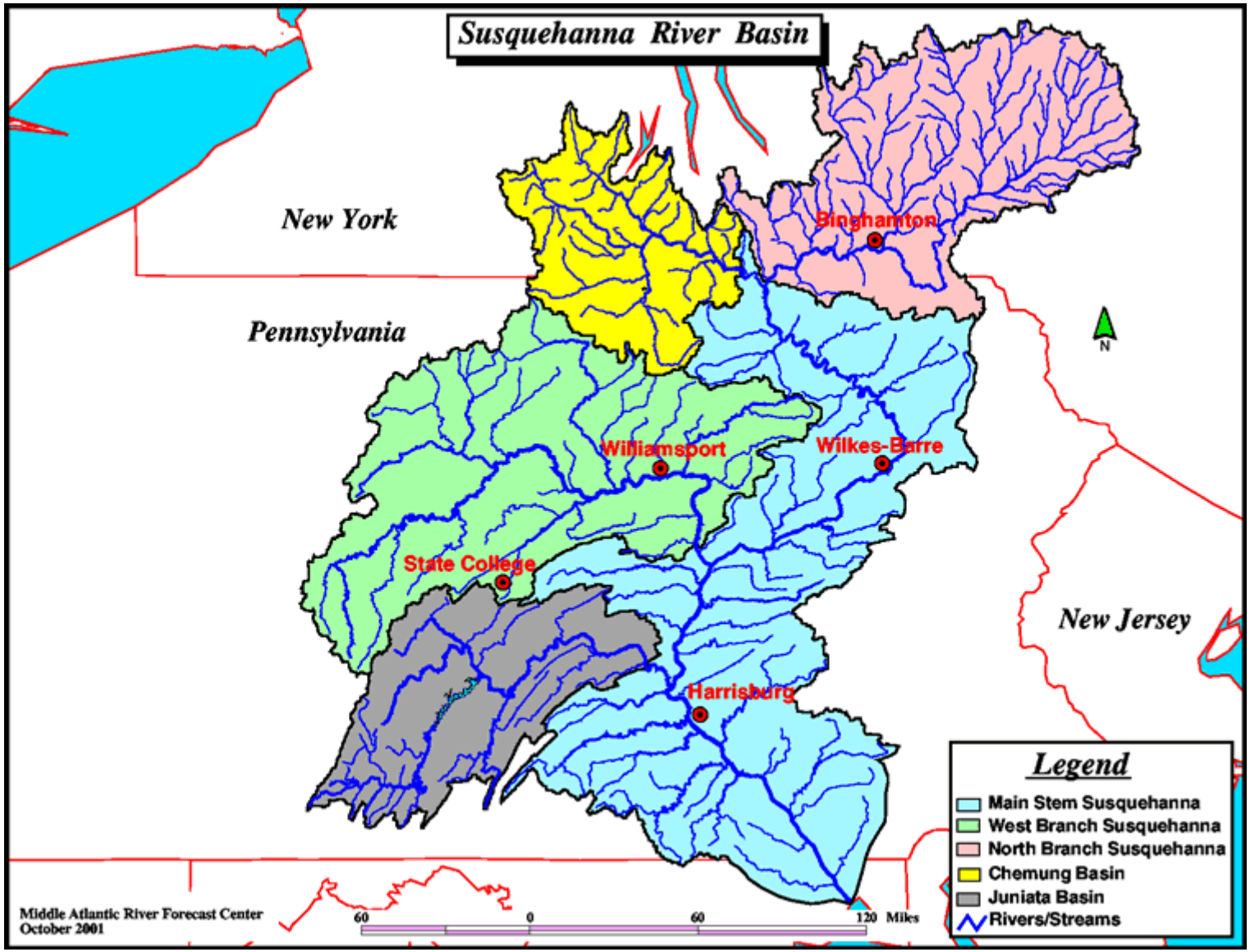


https://www.teachengineering.org/lessons/view/cub_watershed_lesson01

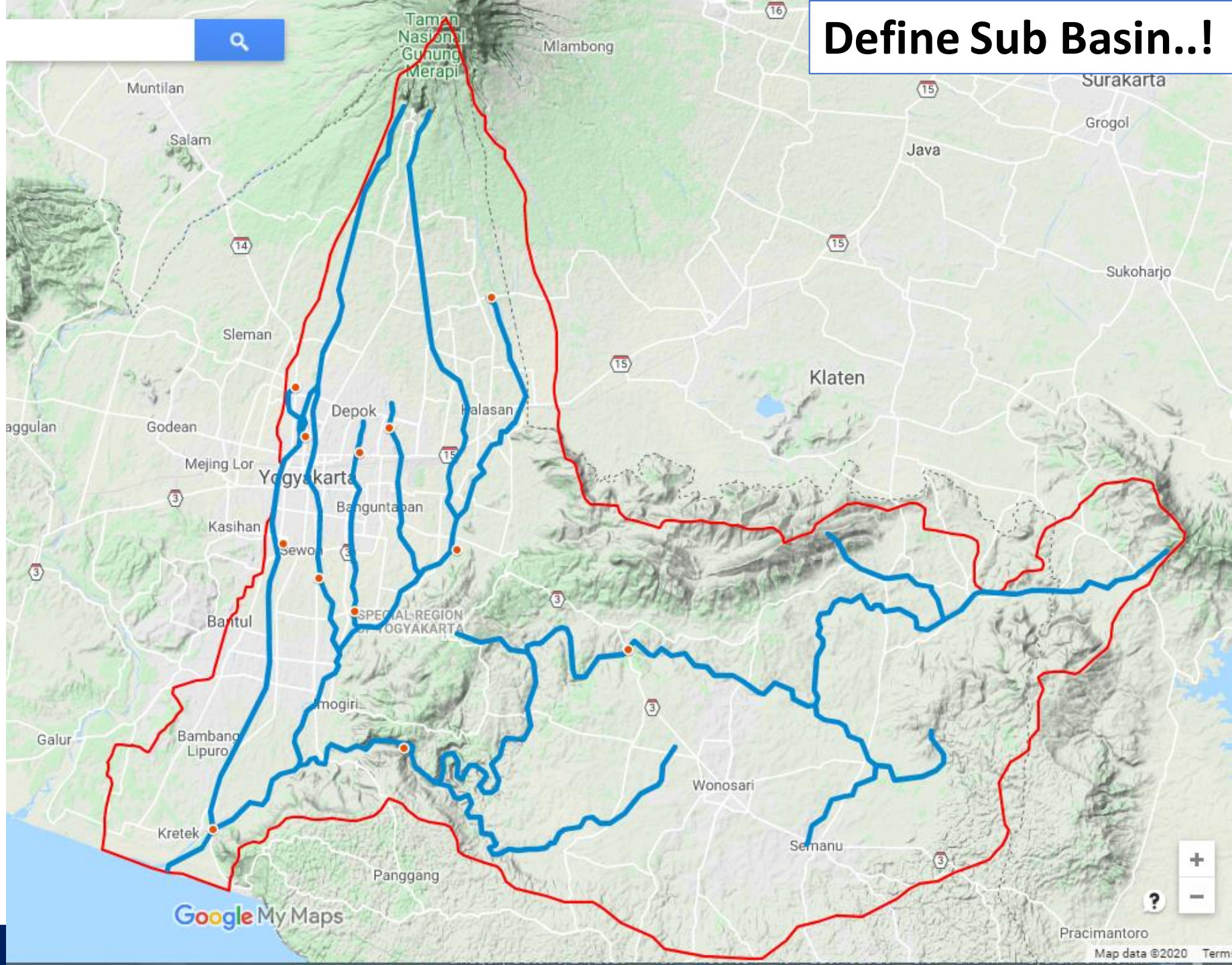
Pengertian DAS

https://opentextbc.ca/geology/chapter/13-2-drainage-basins/

Pengertian DAS & Sub DAS



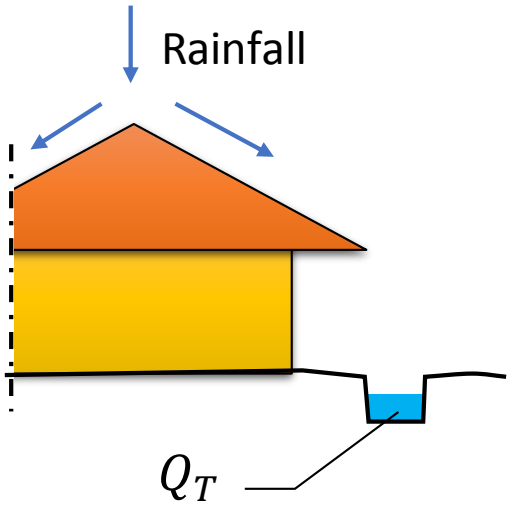
Contoh DAS (Sungai menuju pantai selatan Jawa)

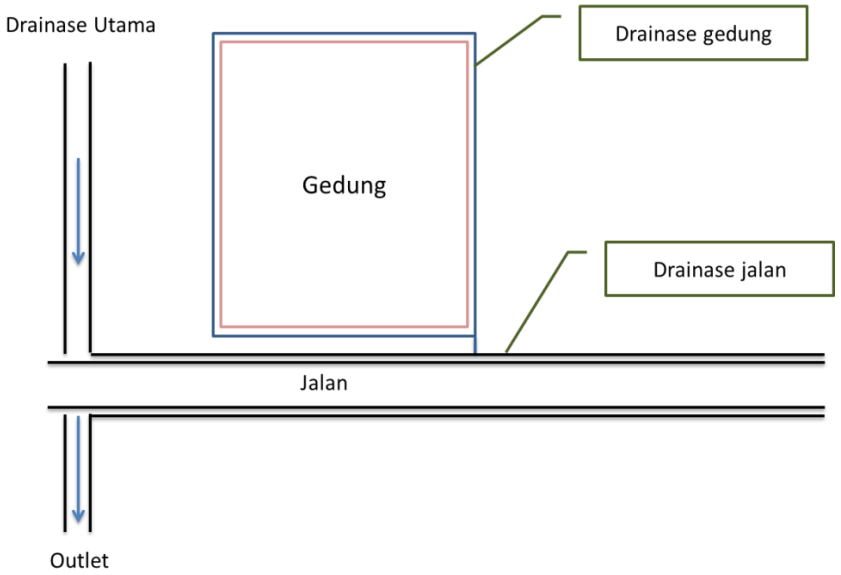

Define Sub Basin..!
Taman Nasional Gunung Merapi
Mlambong
Muntilan
Salam
Surakarta
Grogol
Java
Sukoharjo
Sleman
Klaten
Depok
Godean
Mejing Lor
Yogyakarta
Banguntapan
Kasihan
Bantul
SPECIAL REGION OF YOGYAKARTA
Imogiri
Galur
Bambang Lipuro
Wonosari
Kretek
Semanu
Panggang
Pracimantoro
Google My Maps
Map data ©2020

Catchment Area for Urban Drainage

Daerah Tangkapan Air (Untuk Drainase Urban)

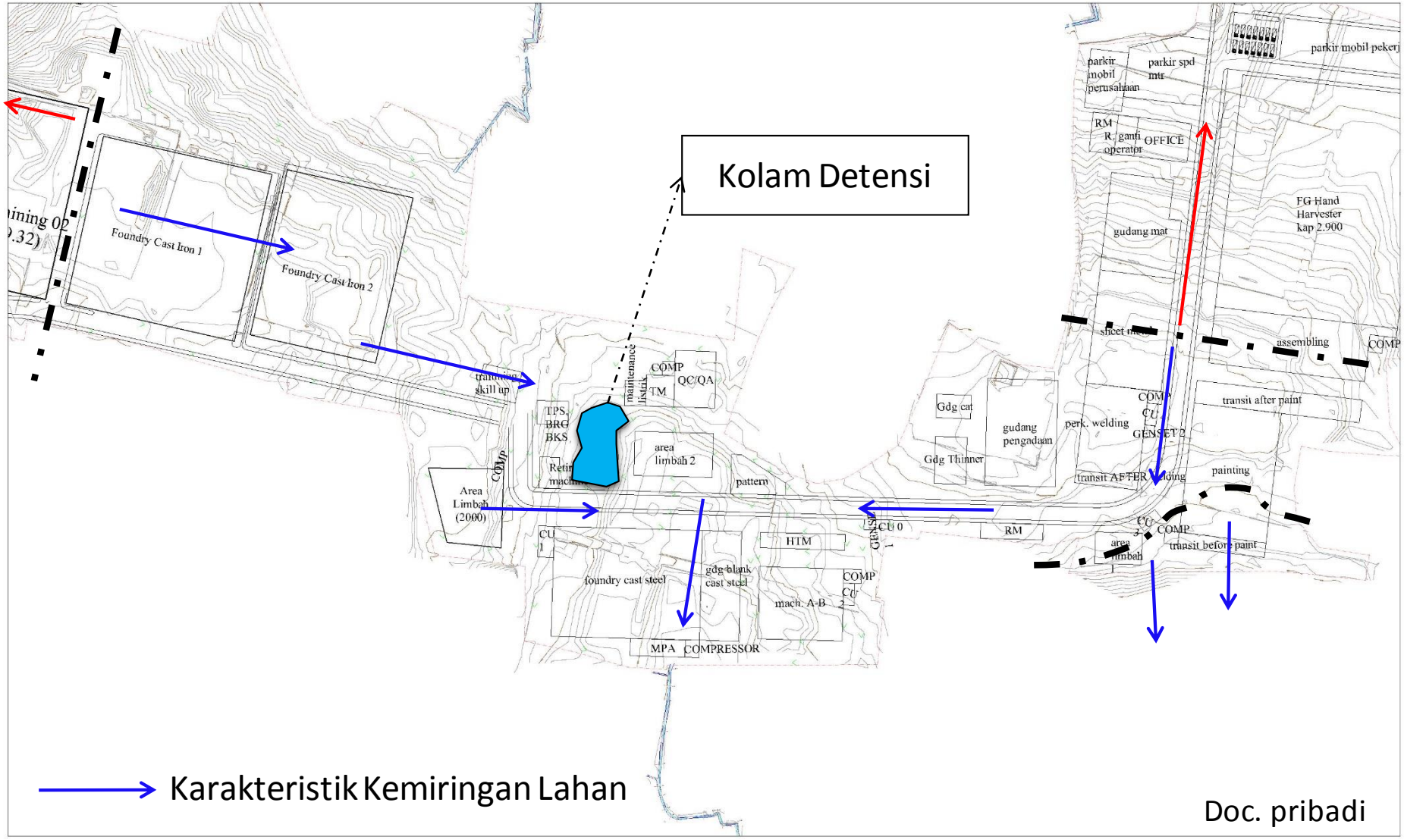
Konsep tata saluran sederhana untuk drainase sebuah kawasan





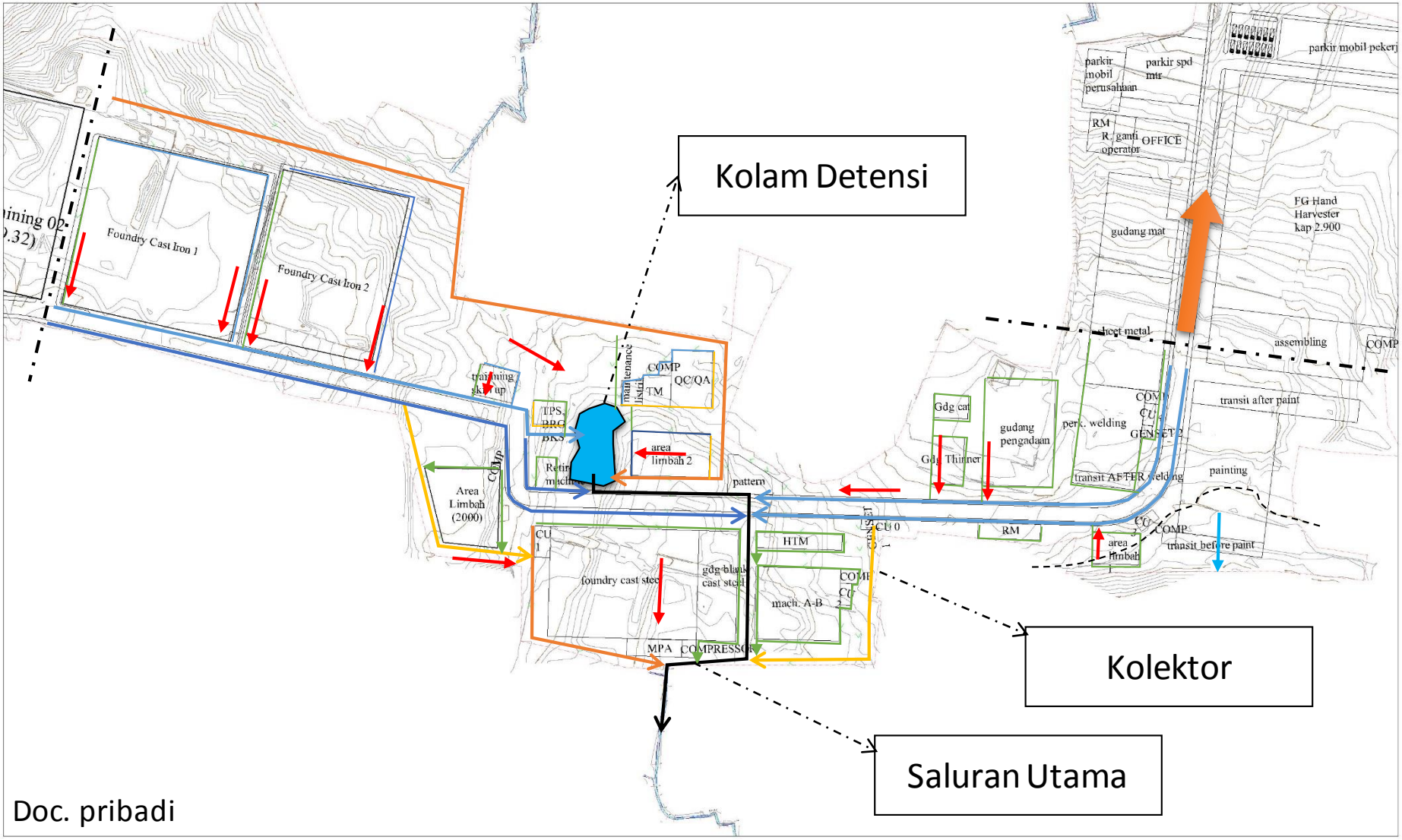
*untuk konsep dan aplikasi drainase berwawasan lingkungan, akan disampaikan pada pertemuan 6 – 9.

Contoh kasus



Doc. pribadi

Contoh kasus



Doc. pribadi

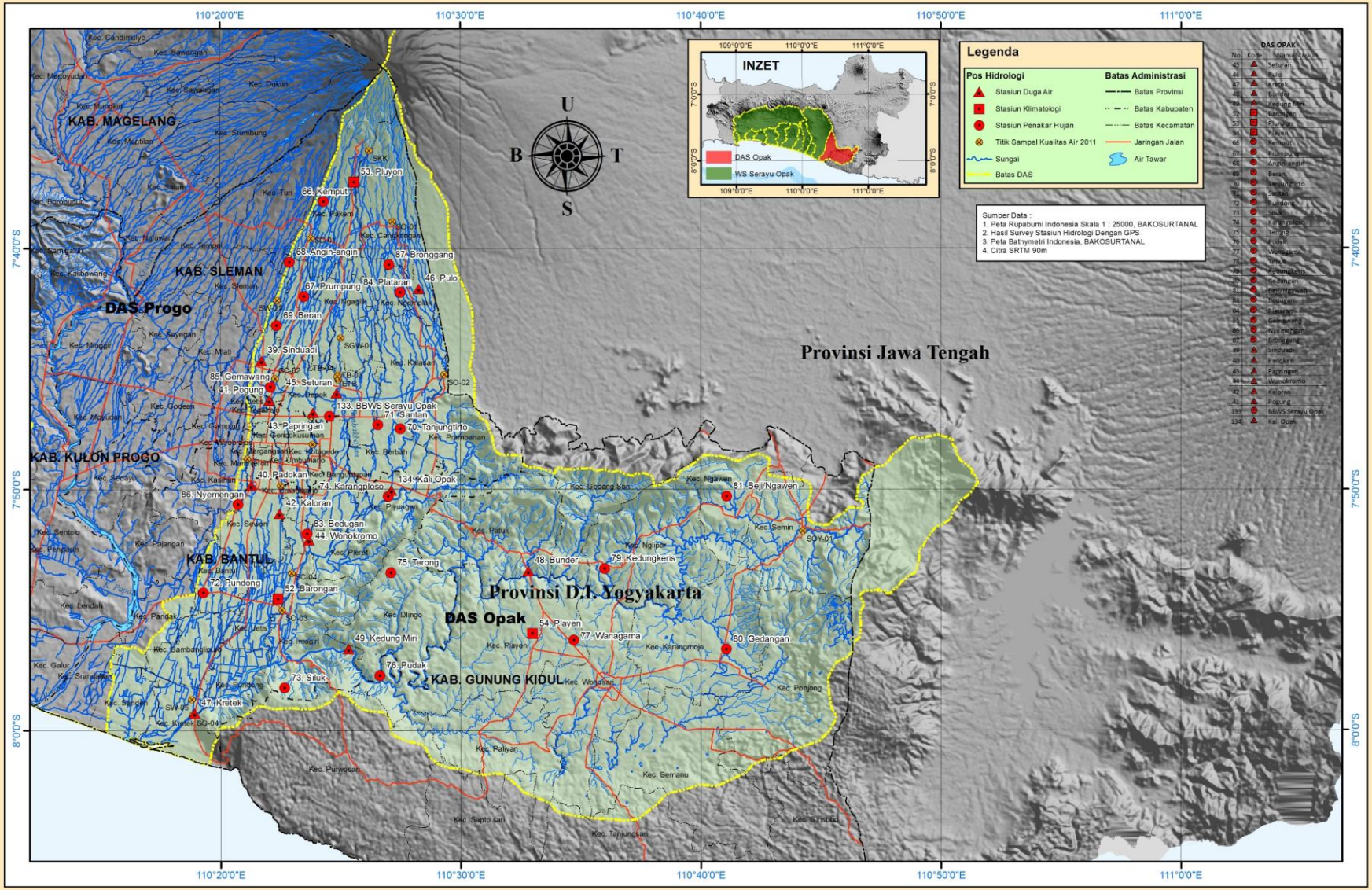
Thought…..

1. Bisakah Saudara menghitung luas catchment area di saluran drainase di sekitar kampus?
2. Coba identifikasi saluran drainase di sekitar Dept. Teknik Sipil, beserta luas beban daerah tangkapan air (*catchment area*) nya..

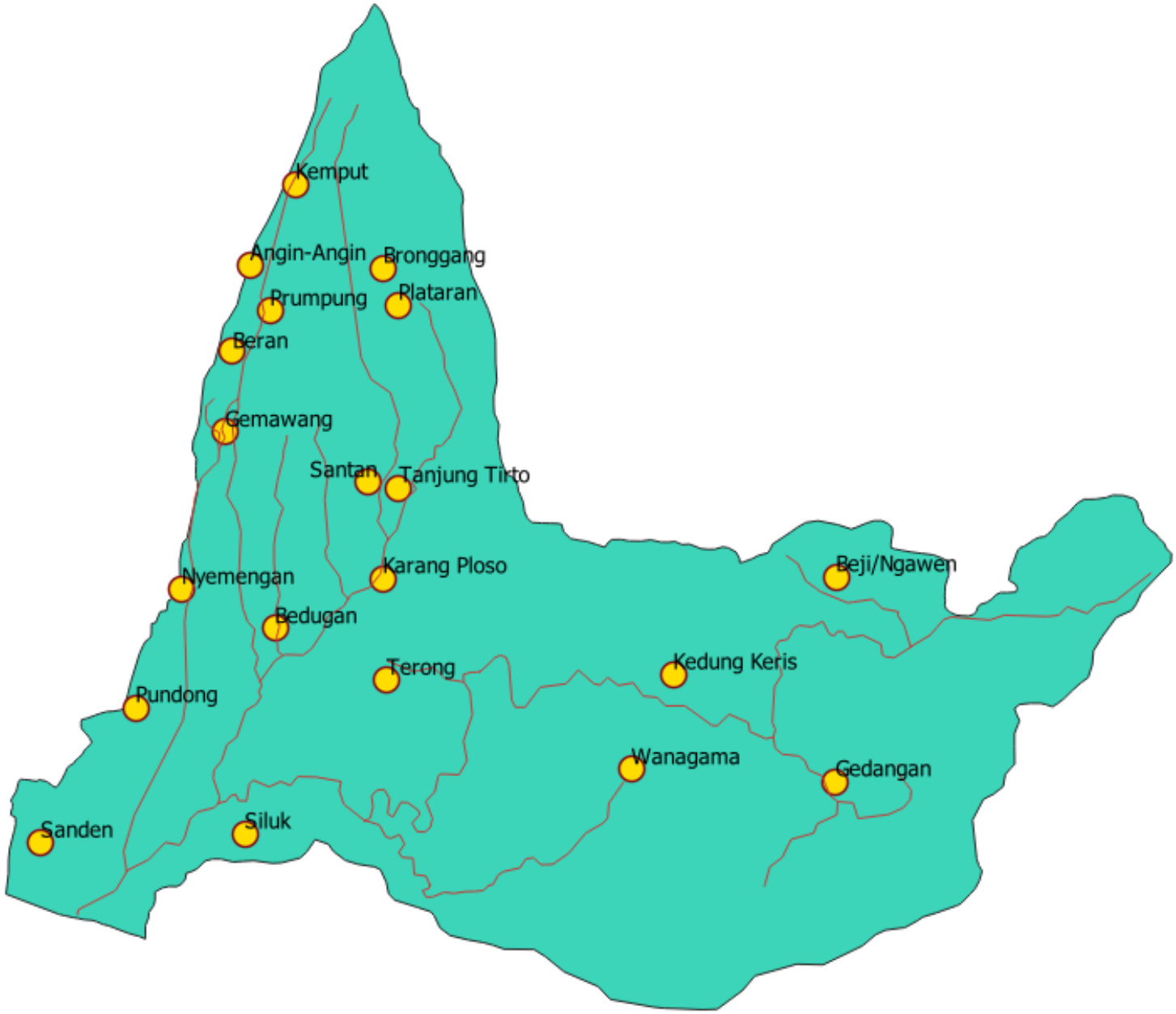
Bisa jadi akan menjadi salah satu tugas di MatKul ini… ☺

Sebaran Stasiun Penakar Hujan

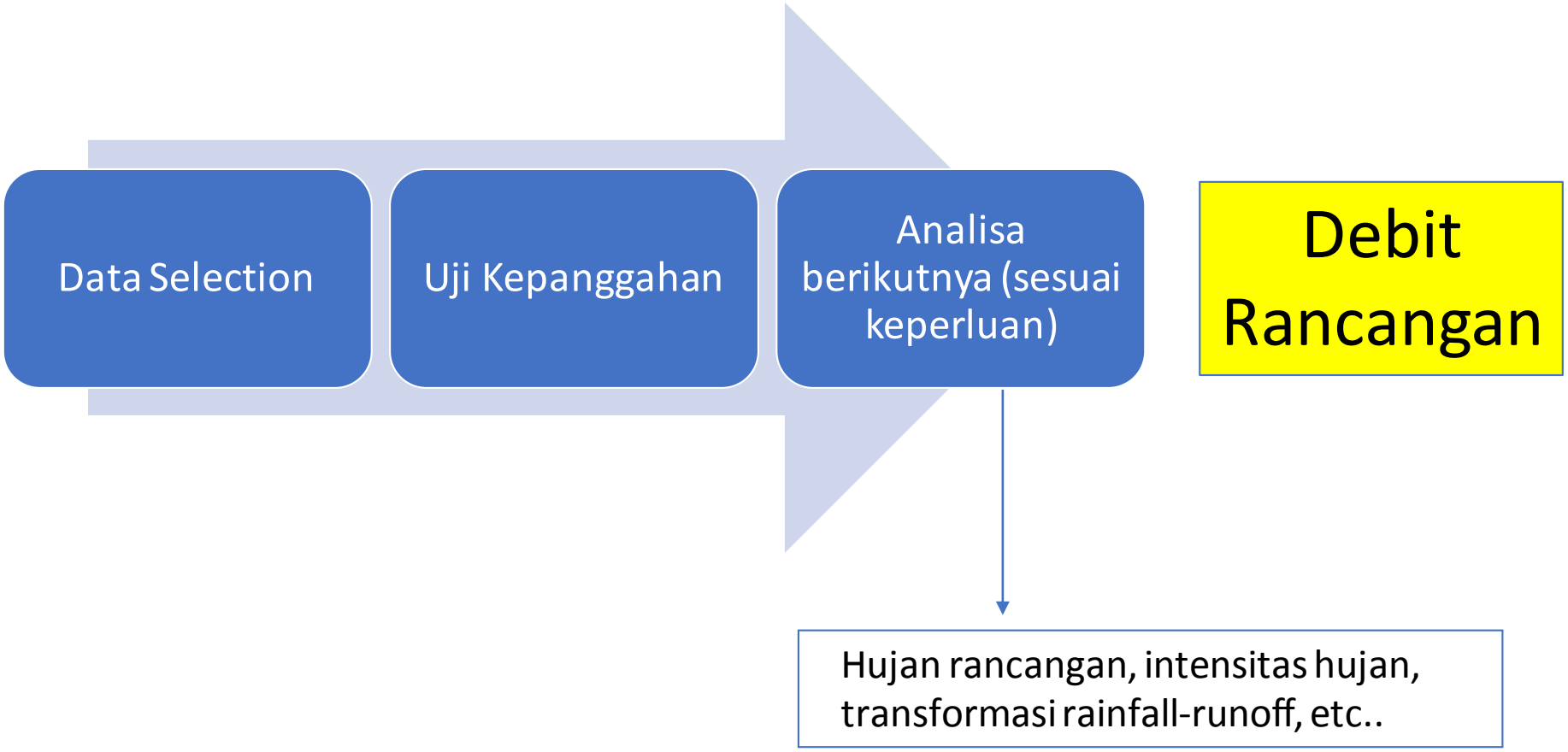
PETA LOKASI STASIUN HIDROLOGI - DAS OPAK



Contoh


Kemput
Angin-Angin
Bronggang
Prumpung
Plataran
Beran
Gemawang
Santan
Tanjung Tirto
Karang Ploso
Nyemengan
Beji/Ngawen
Bedugan
Terong
Kedung Keris
Pundong
Wanagama
Gedangan
Siluk
Sanden

Overview Analisa Data Hujan



(Details will be discussed next week)

What’s next

Materi pertemuan berikutnya

- Cara uji kepanggahan data hujan & Latihan
- Cara menghitung hujan rerata & latihan
- …

See you next week!