Outline of Sediment Disaster Early Warning in Japan

December 2, 2014

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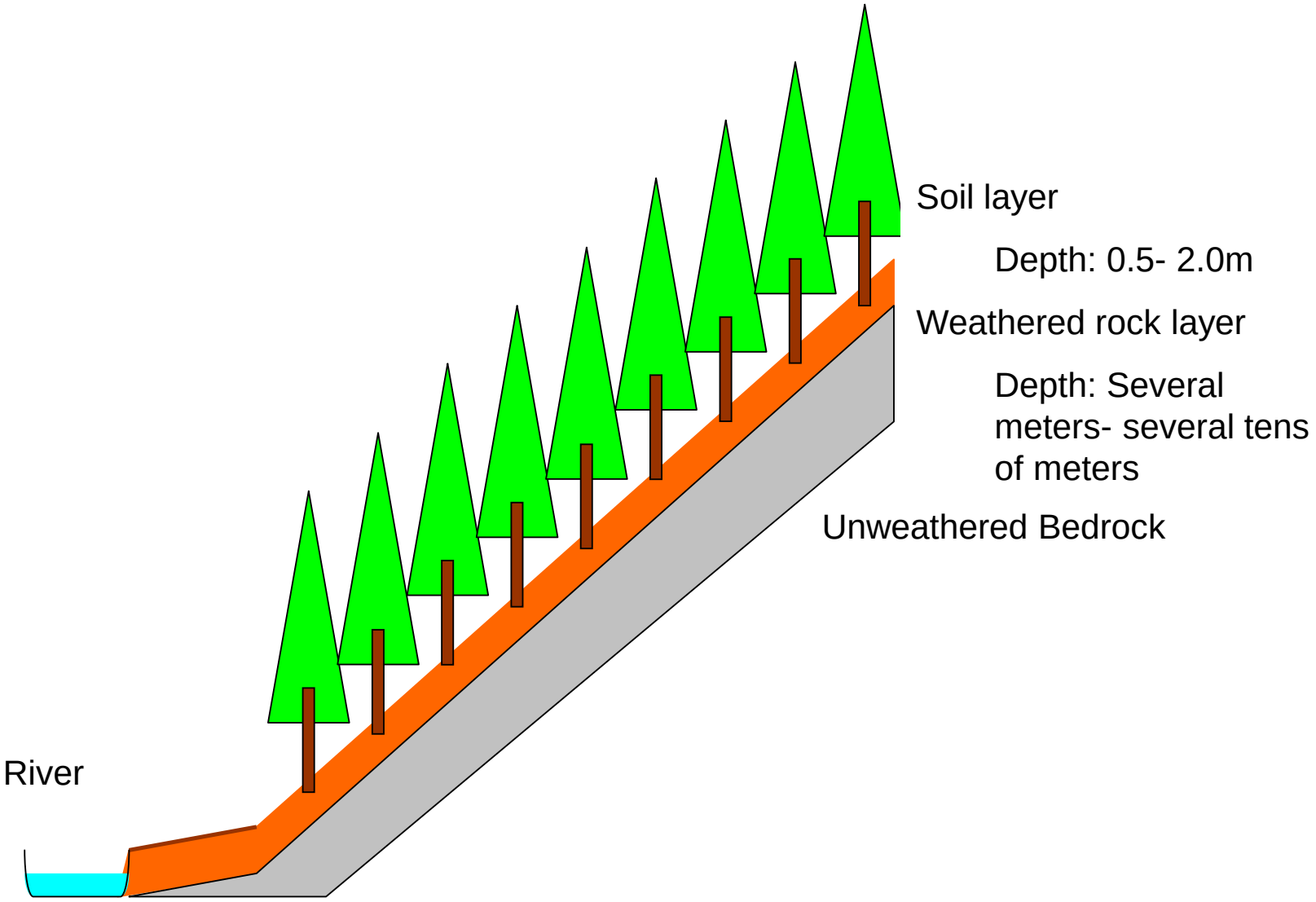
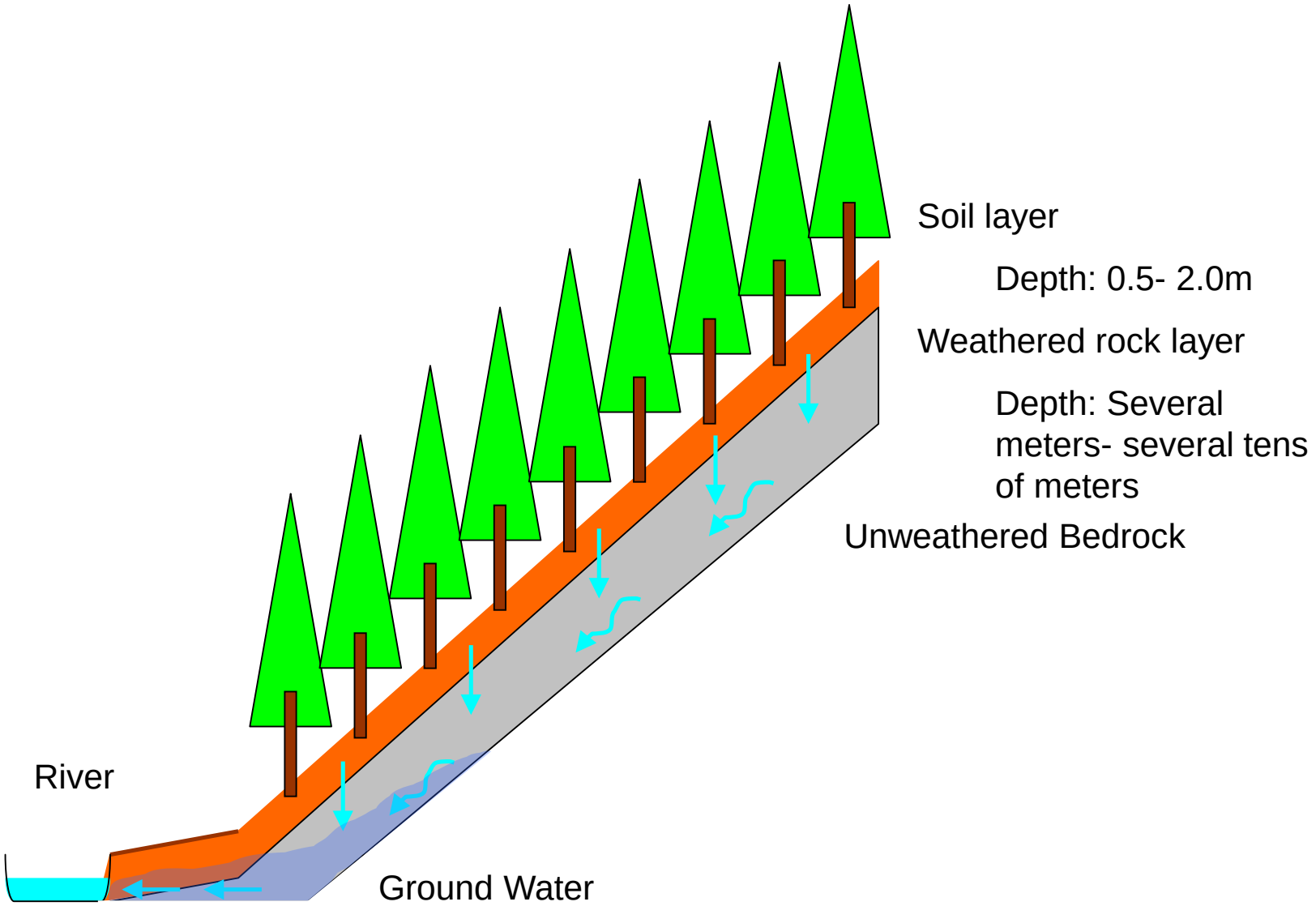
National Institute for Land and Infrastructure Management (NILIM)
Ministry of Land , Infrastructure, Transport and Tourism (MLIT)

Why do landslides occur?



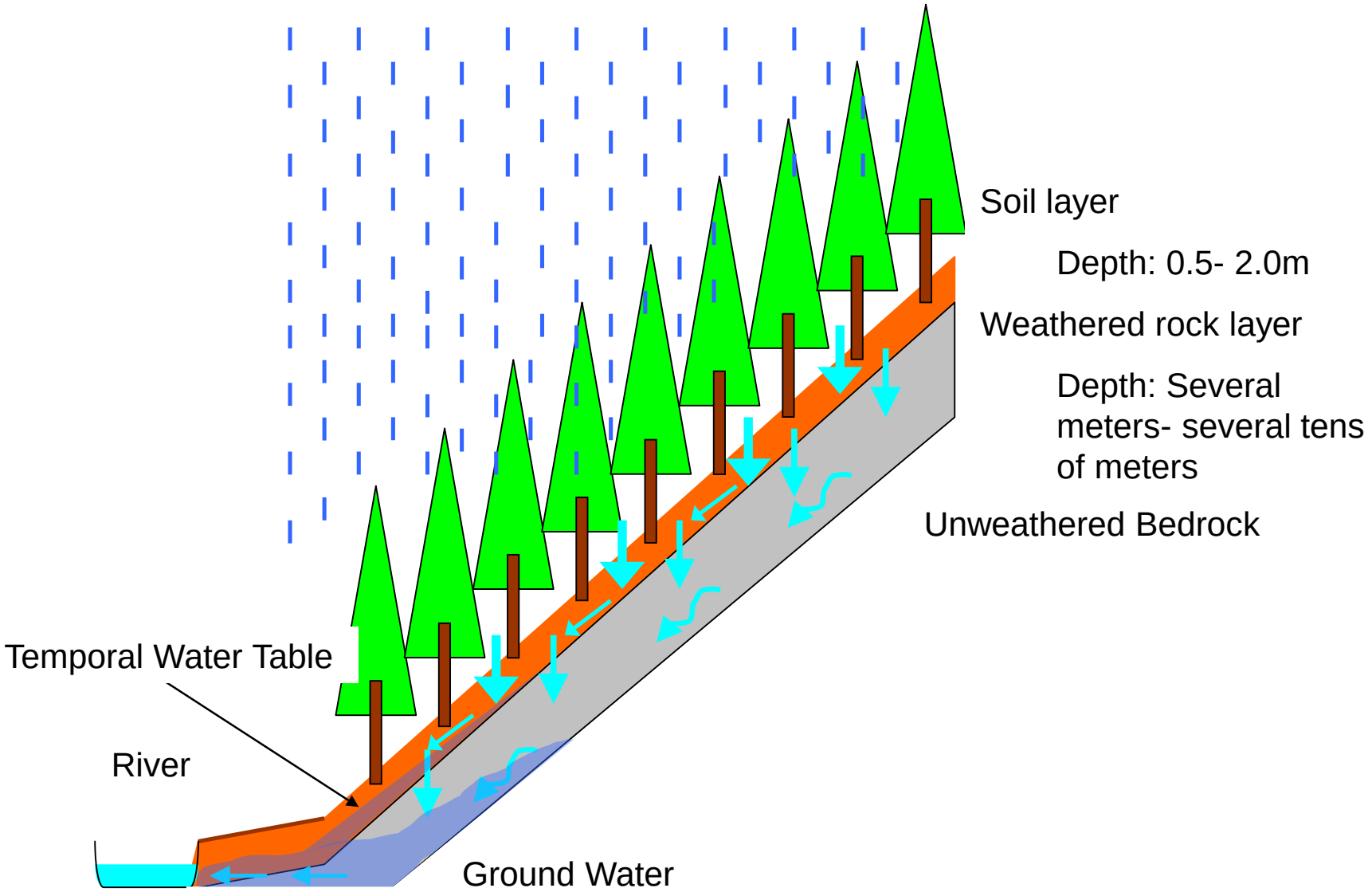
How does water flow in a slope?

Why do landslides occur?



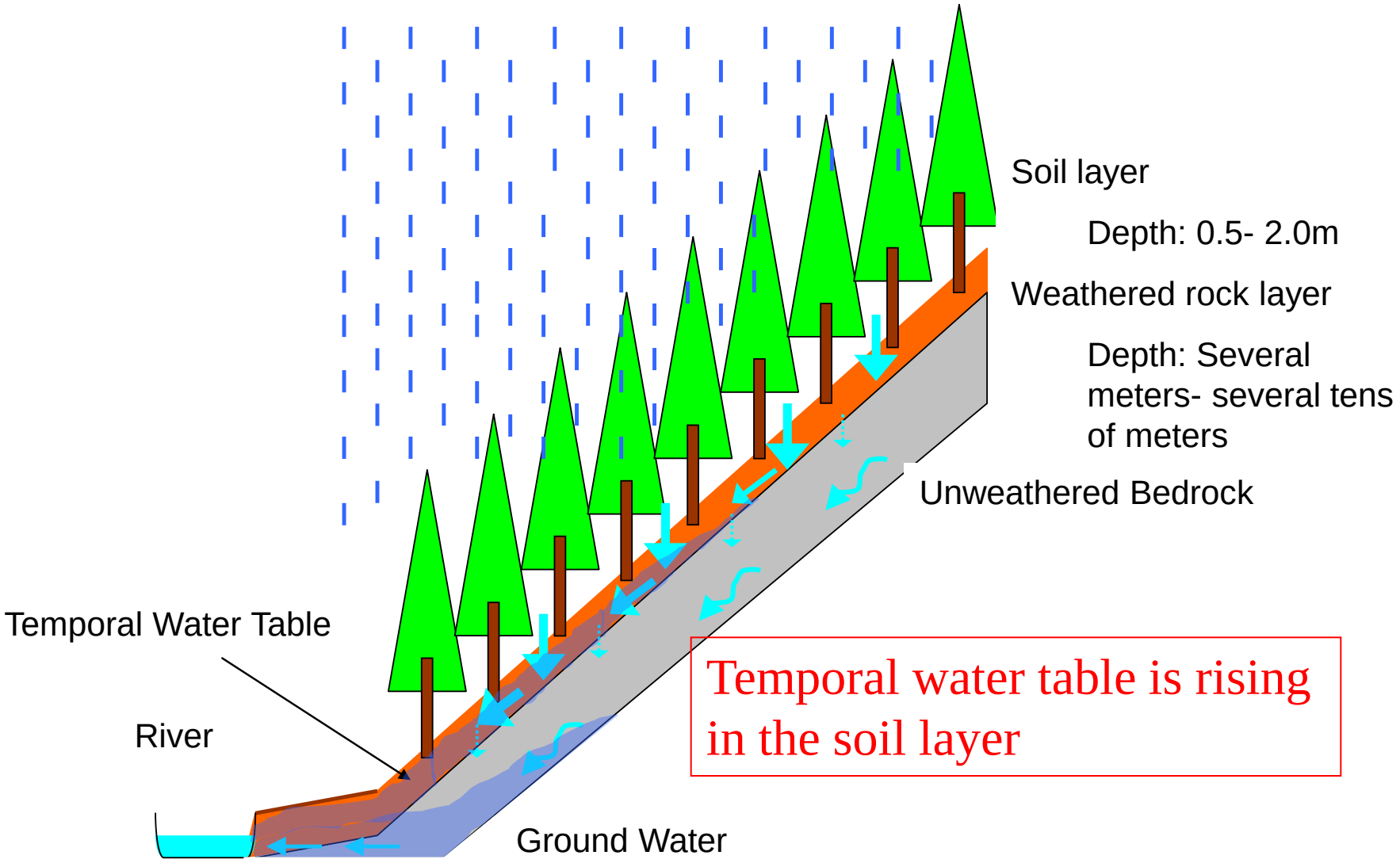
How does water flow when it rains?

Why do landslides occur?



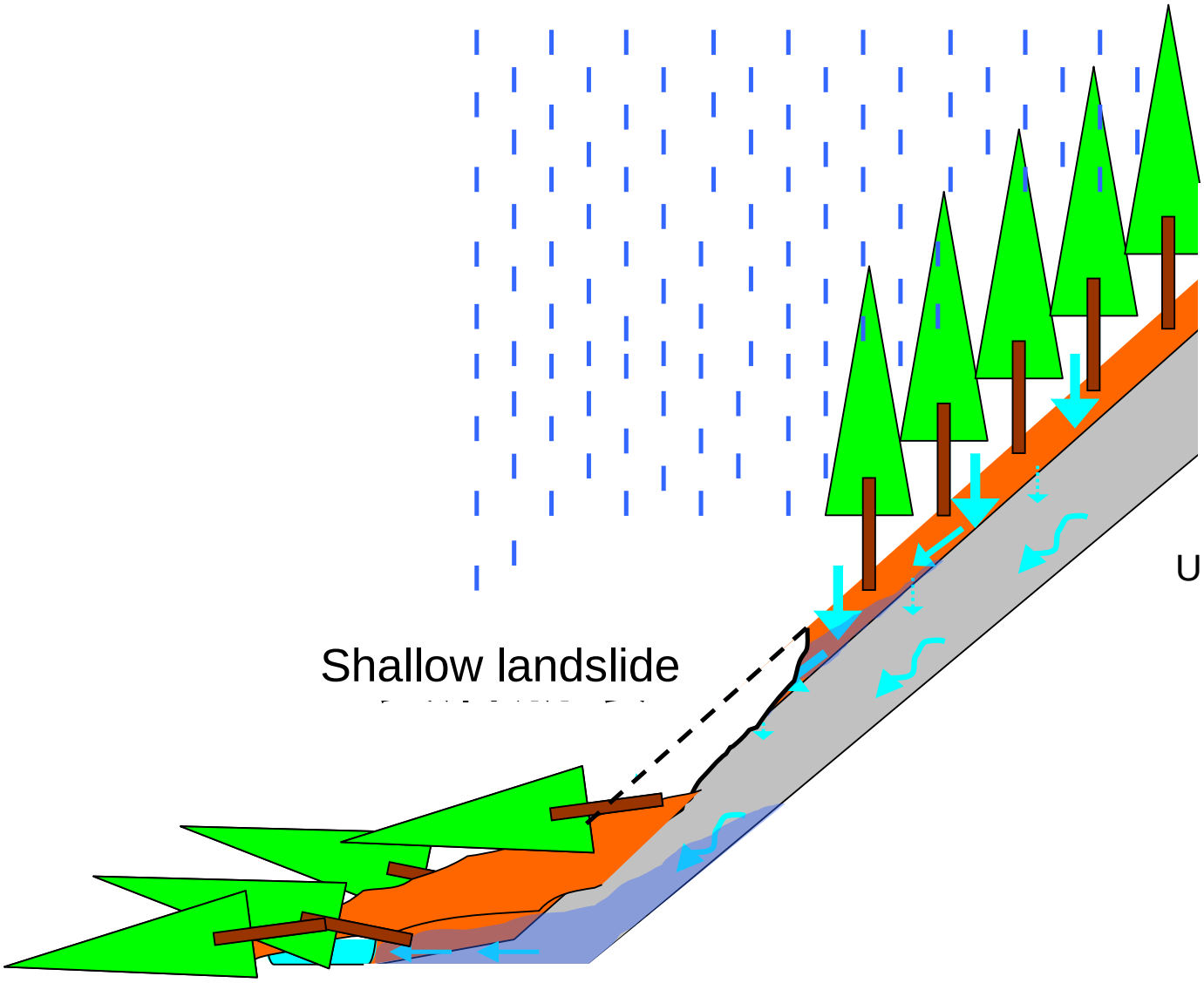
If a weathered rock layer is impermeable…

Why do landslides occur?



How does a landslide occur when the situation is like this?

Why do landslides occur?



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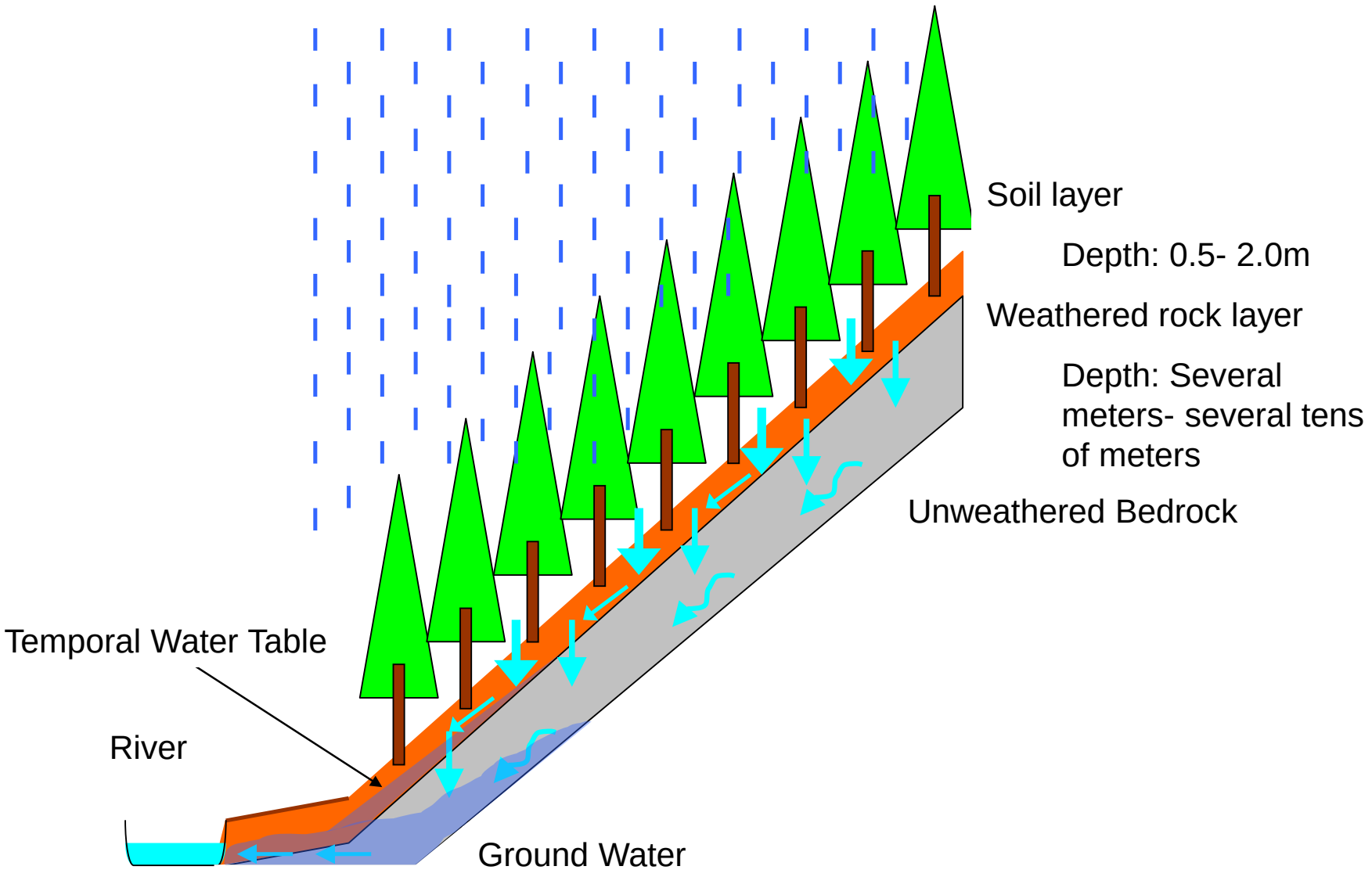
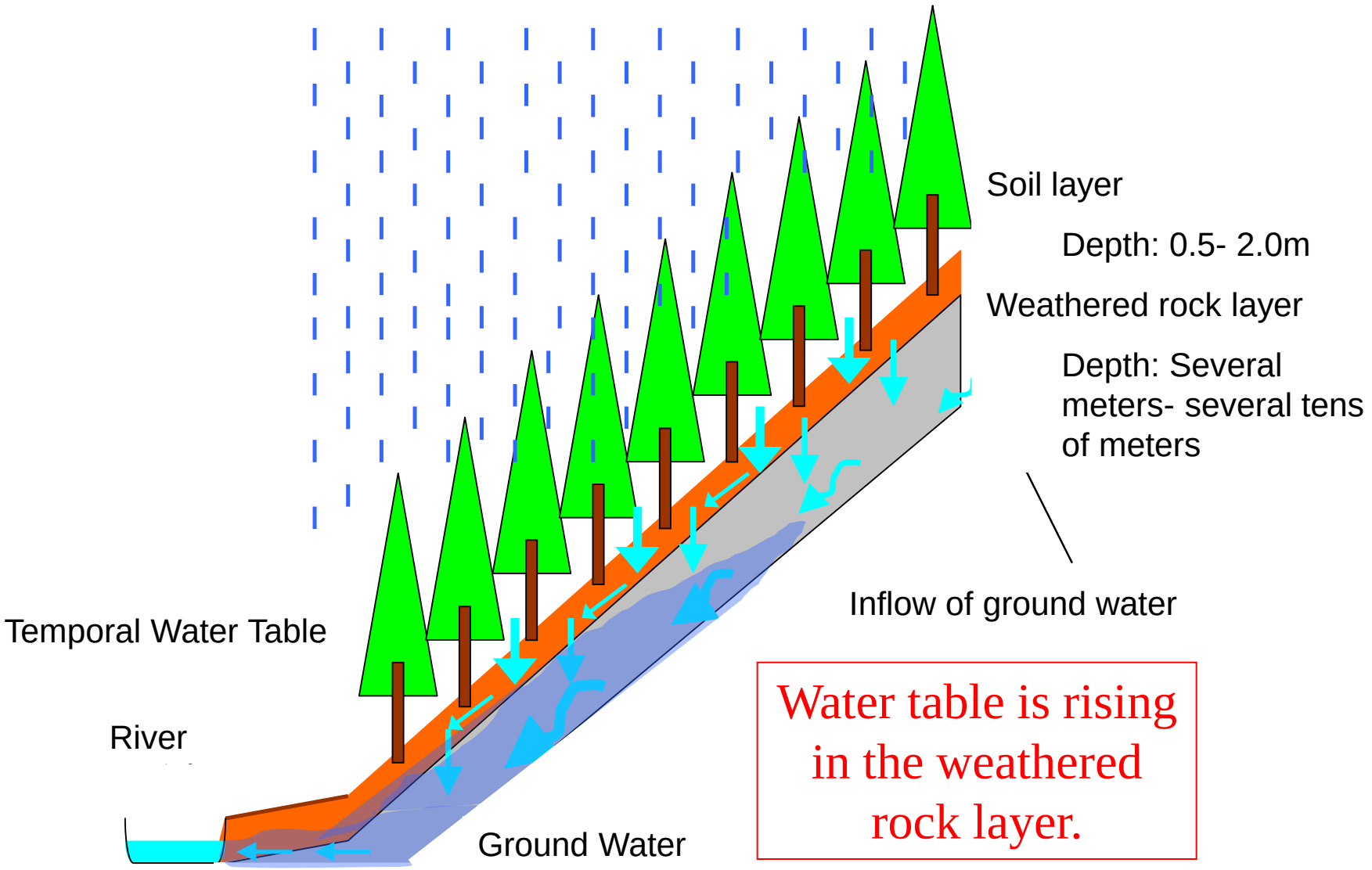


If a weathered rock layer is permeable…

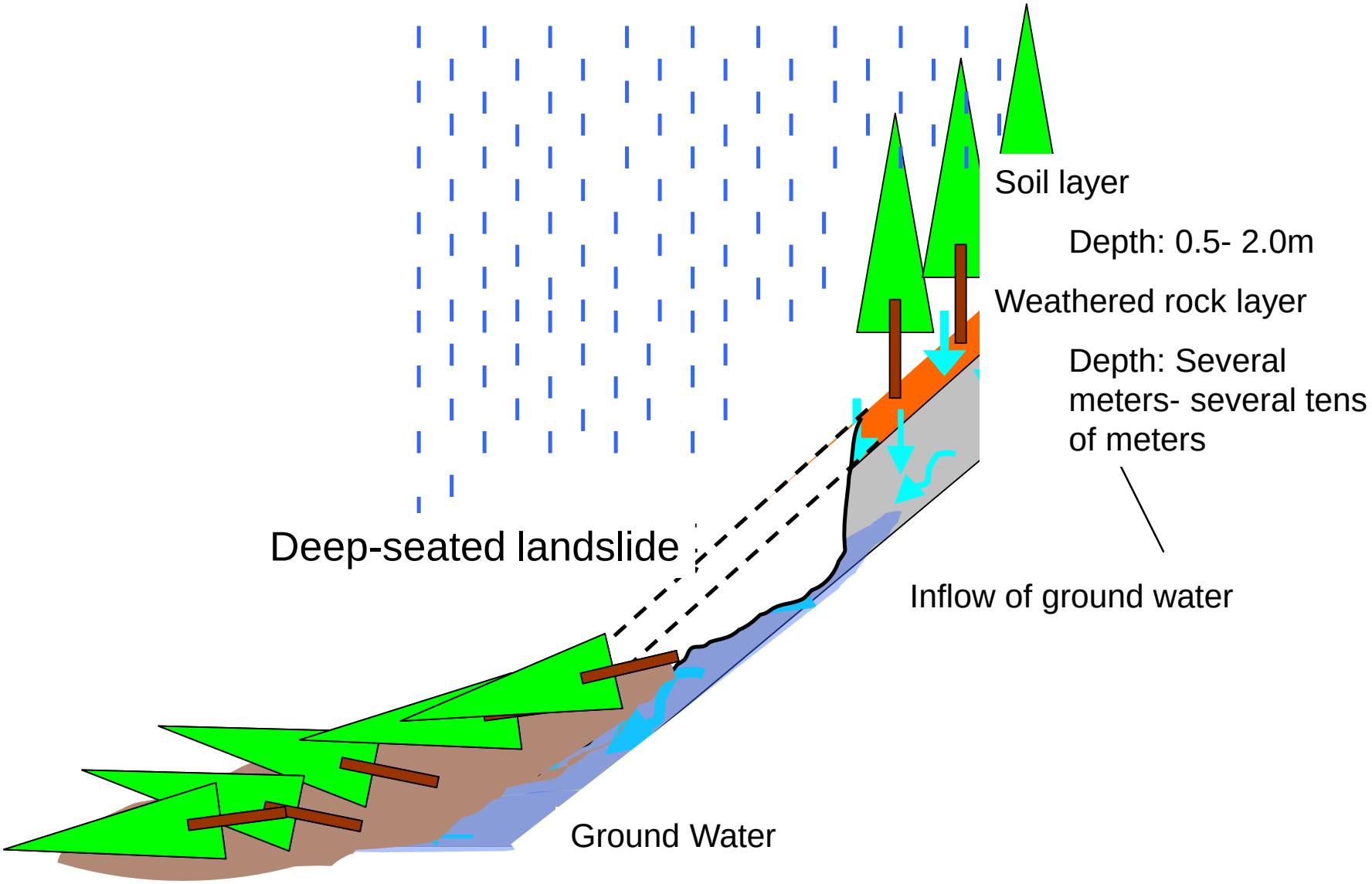
Why do landslides occur?



Water table is rising in the weathered rock layer.

How does a landslide occur when the situation is like this?

Why do landslides occur?



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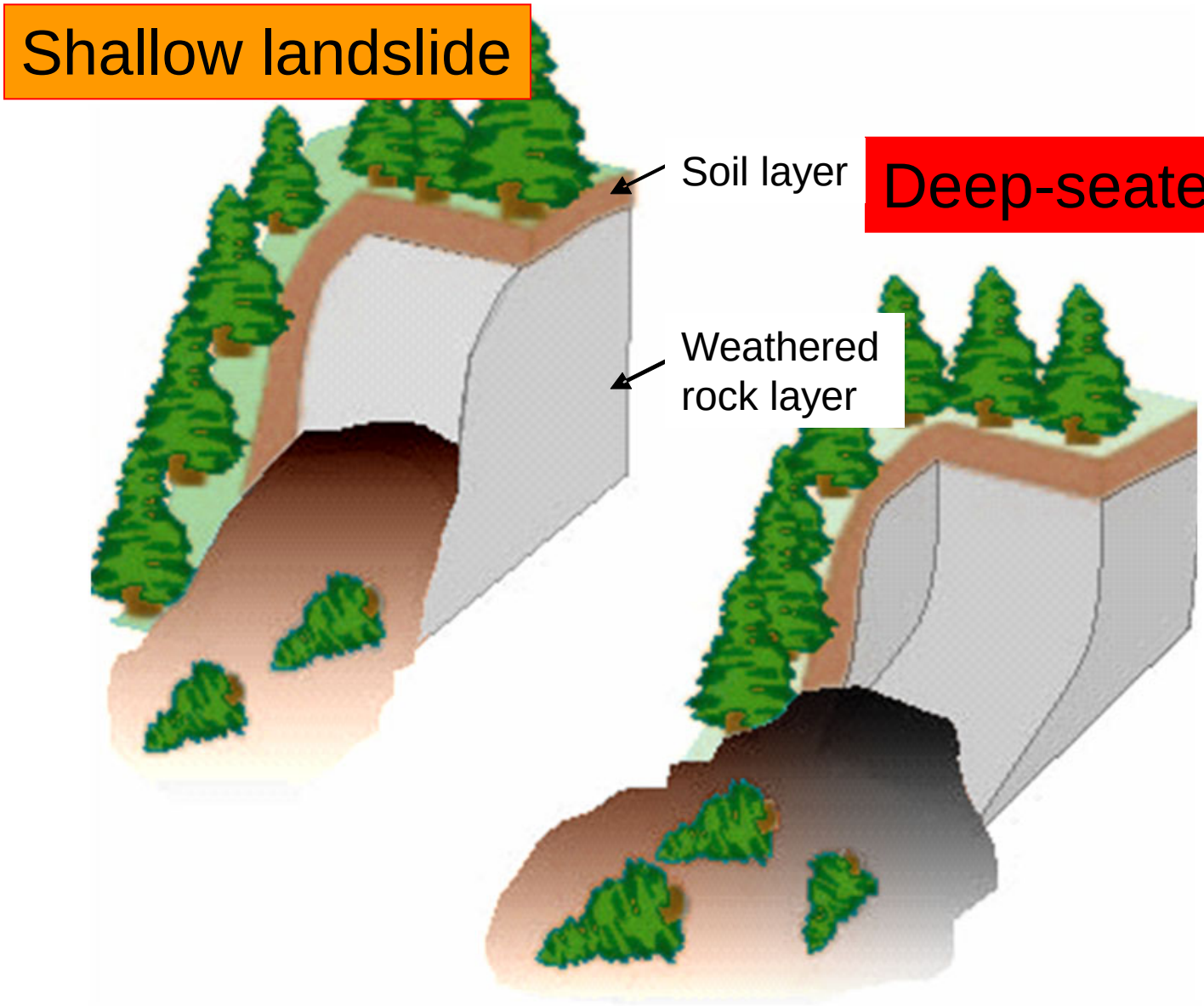
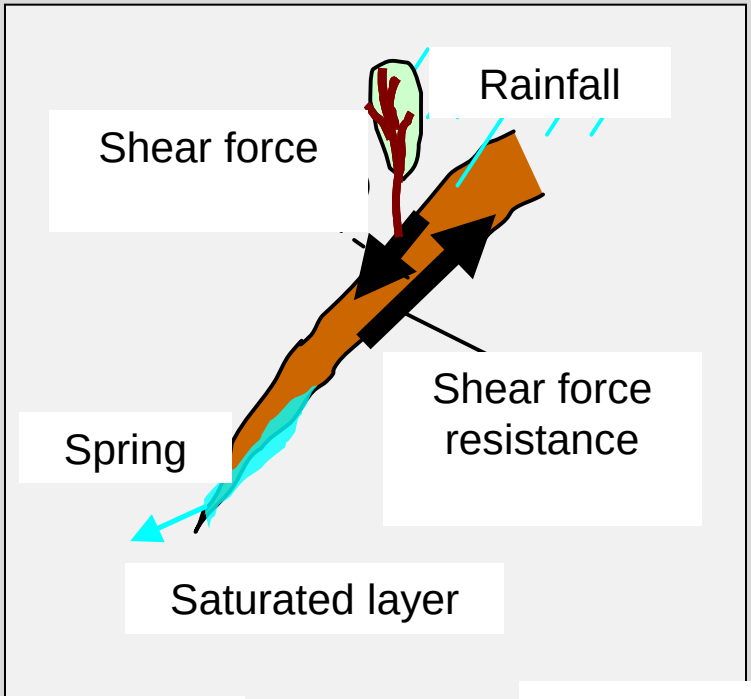
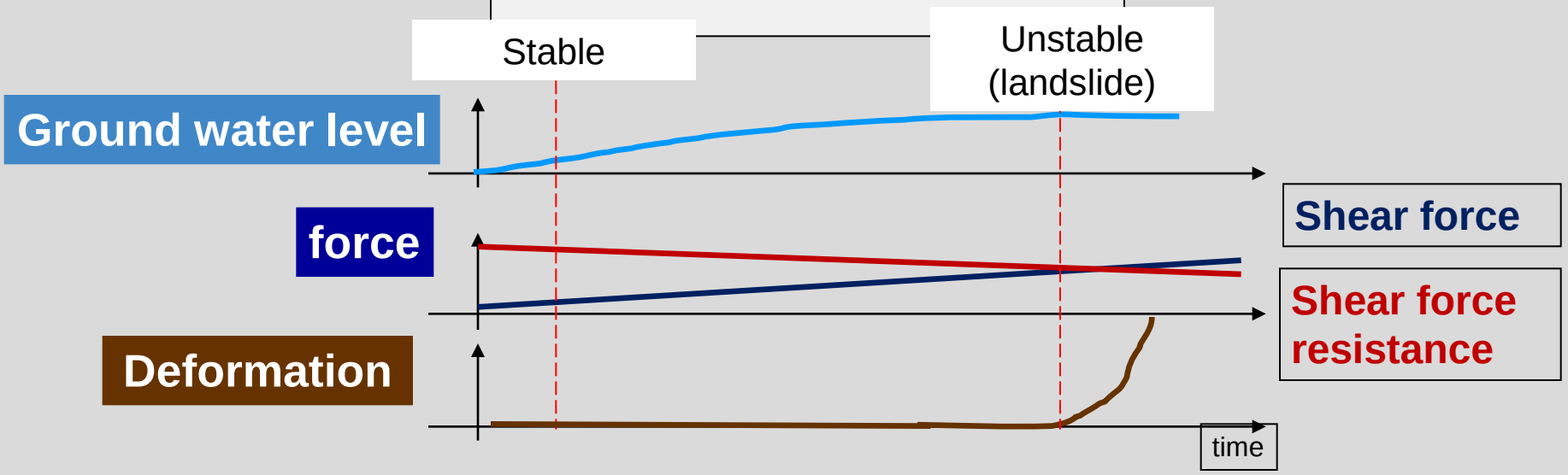


A mechanism of landslide





How to predict landslides?

- When?
- Where?
- How much volume?

How to predict landslides?

Physical Method

- To predict landslides by physically compute the force balance between shear-force and shear-force resistance at each slope. 。

Empirical Method

- To predict landslides by using rainfall indexes (cumulative rainfall, rain intensity, effective rainfall, etc.) based on the record of landslide occurrences.

Merit and Demerit

Physical method:

- Can predict “when”, “where” and “how much volume” of landslide occur.
- Can apply to where no record of landslide.
- However, it is very complicated and difficult to determine initial condition and parameters like soil constants.

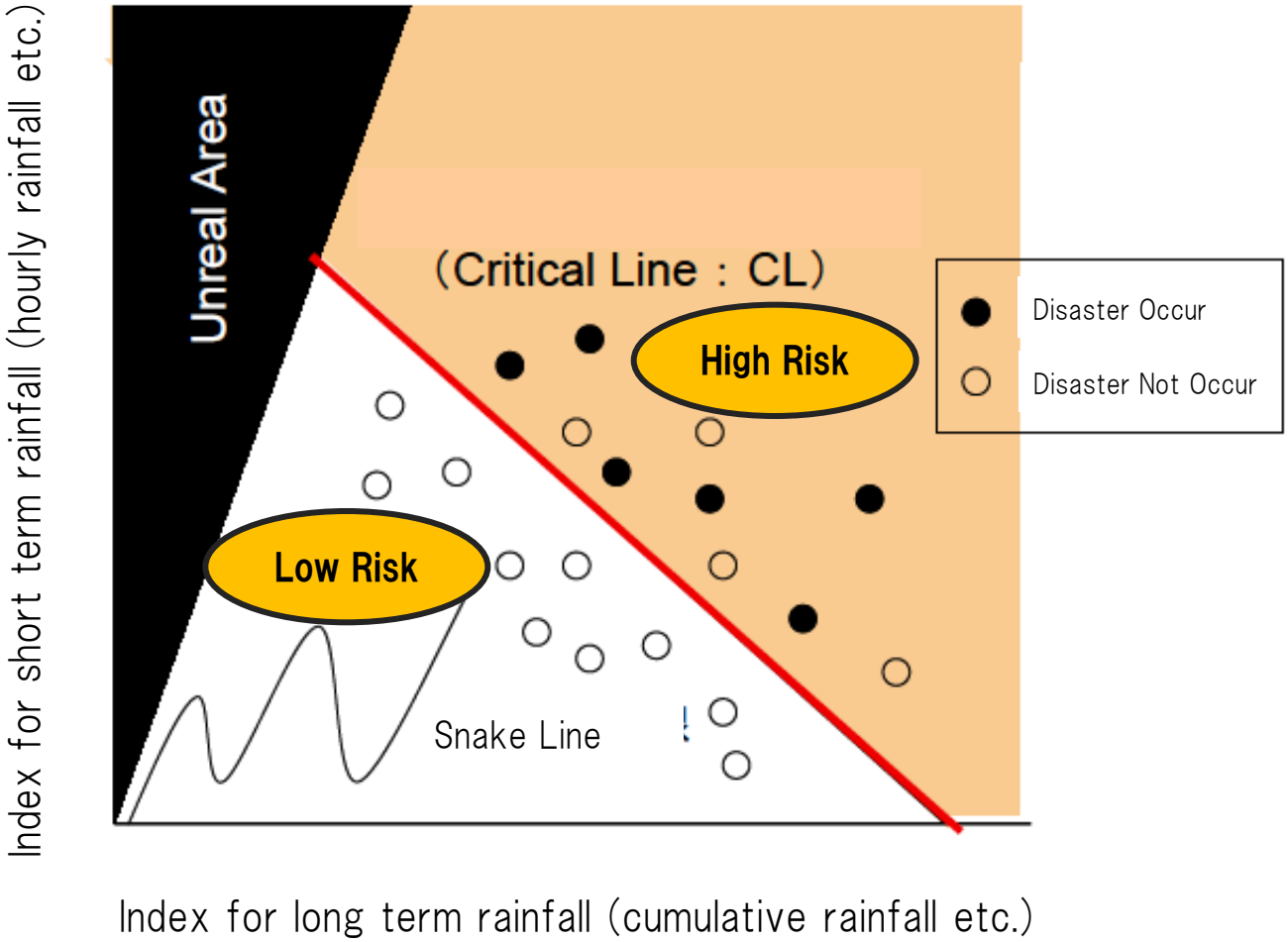
Empirical method:

- Is simple.
- Is not good at predicting “where” and “how much volume” of landslide occur.
- Needs past records of rainfall and landslide occurrences.
- Is in practical use in Japan.

Principle of Japanese Empirical Method

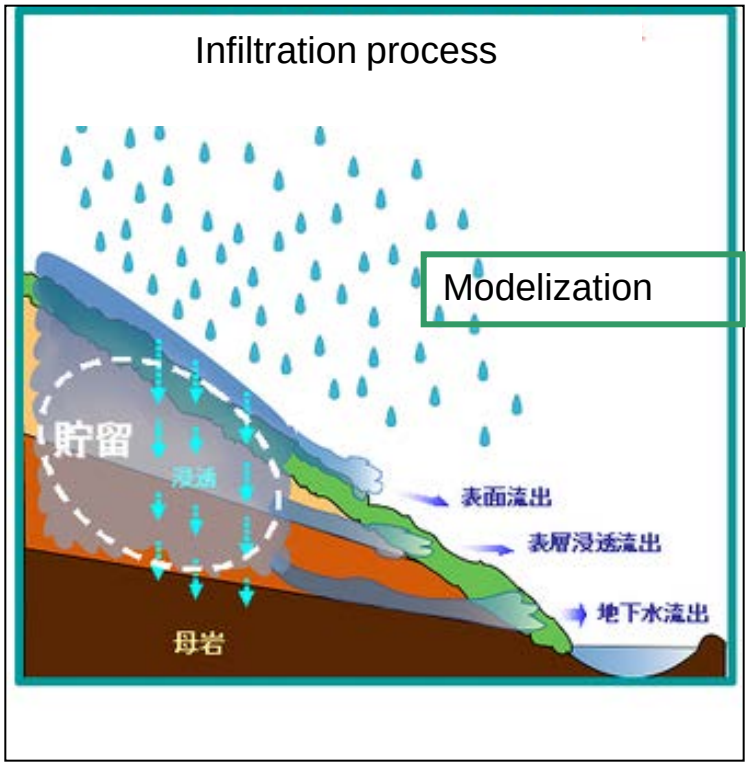
- Prediction of landslide based on the combination between long-term rainfall index and short-term rainfall index.

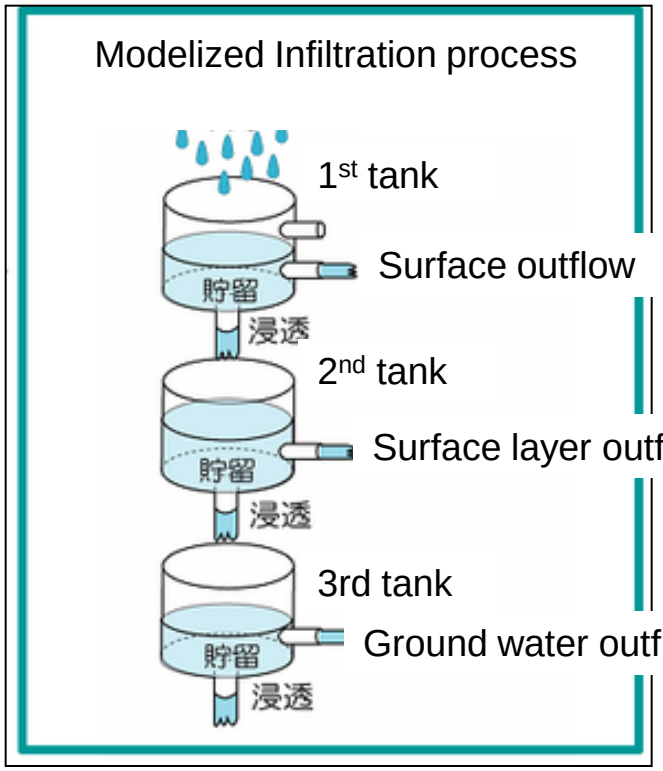
Landslide ⇒ Rainfall Intensity ⇒High, Cumulative Rainfall ⇒Small **or** Rainfall Intensity ⇒Low, Cumulative Rainfall ⇒Large



Long-term Rainfall Index

- Modelization of infiltration process by using tank model

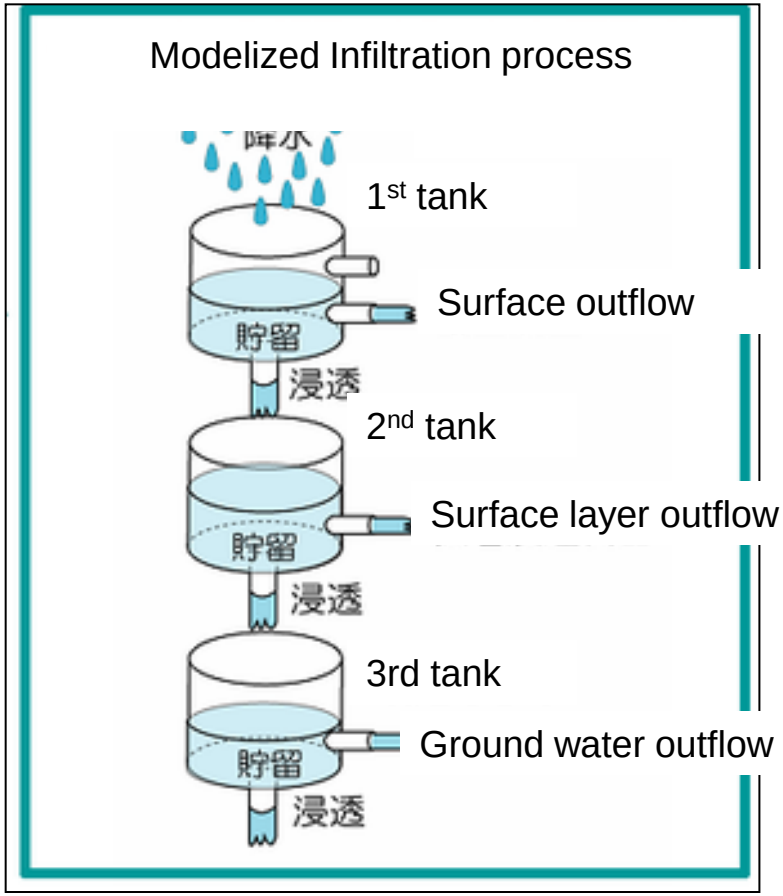


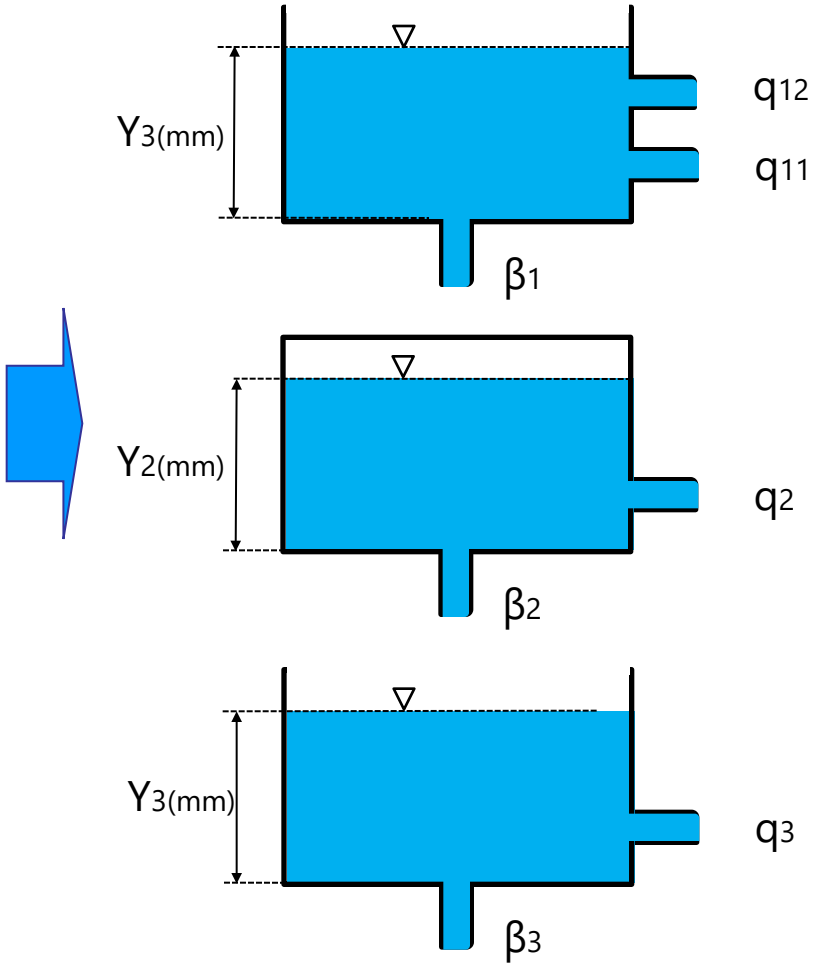


※JMA

Soil Water Index

- Three-tank tank model
- Soil Water Index is calculated as the total value of each tank's water depth.





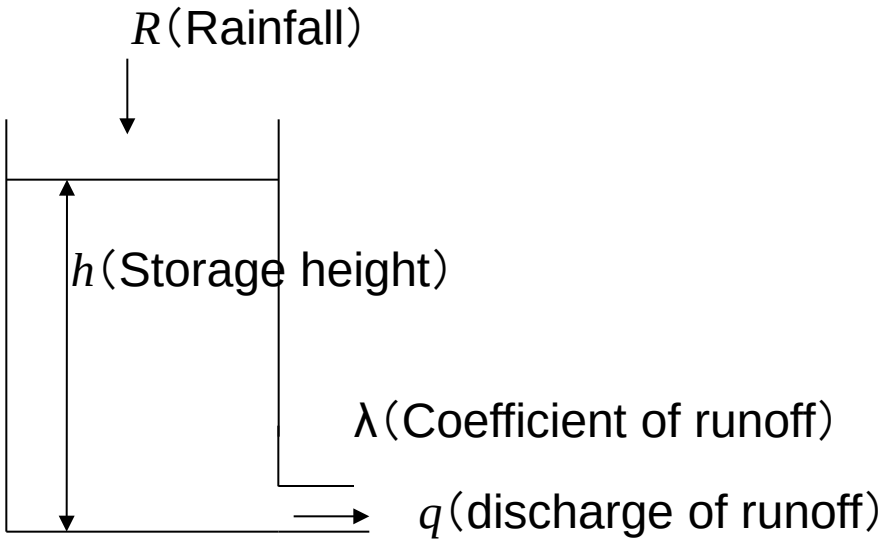
Soil Water Index: $Y=Y_1+Y_2+Y_3$

Effective Rainfall

- Effective rainfall is one of the long-term rainfall index.
- It is considered decrease of past rainfall effectiveness due to ground water runoff.
- Effective rainfall is said to be a specific case of tank model (one-tank tank model) with one outlet at the bottom.

$$Rw = \Sigma \alpha_i \times R_i$$

Rw : Effective Rainfall
R_i: hourly rainfall i hour ahead of time
α_i : deduction coefficient
α_i: =0.5^(i/T), T: Half-life period

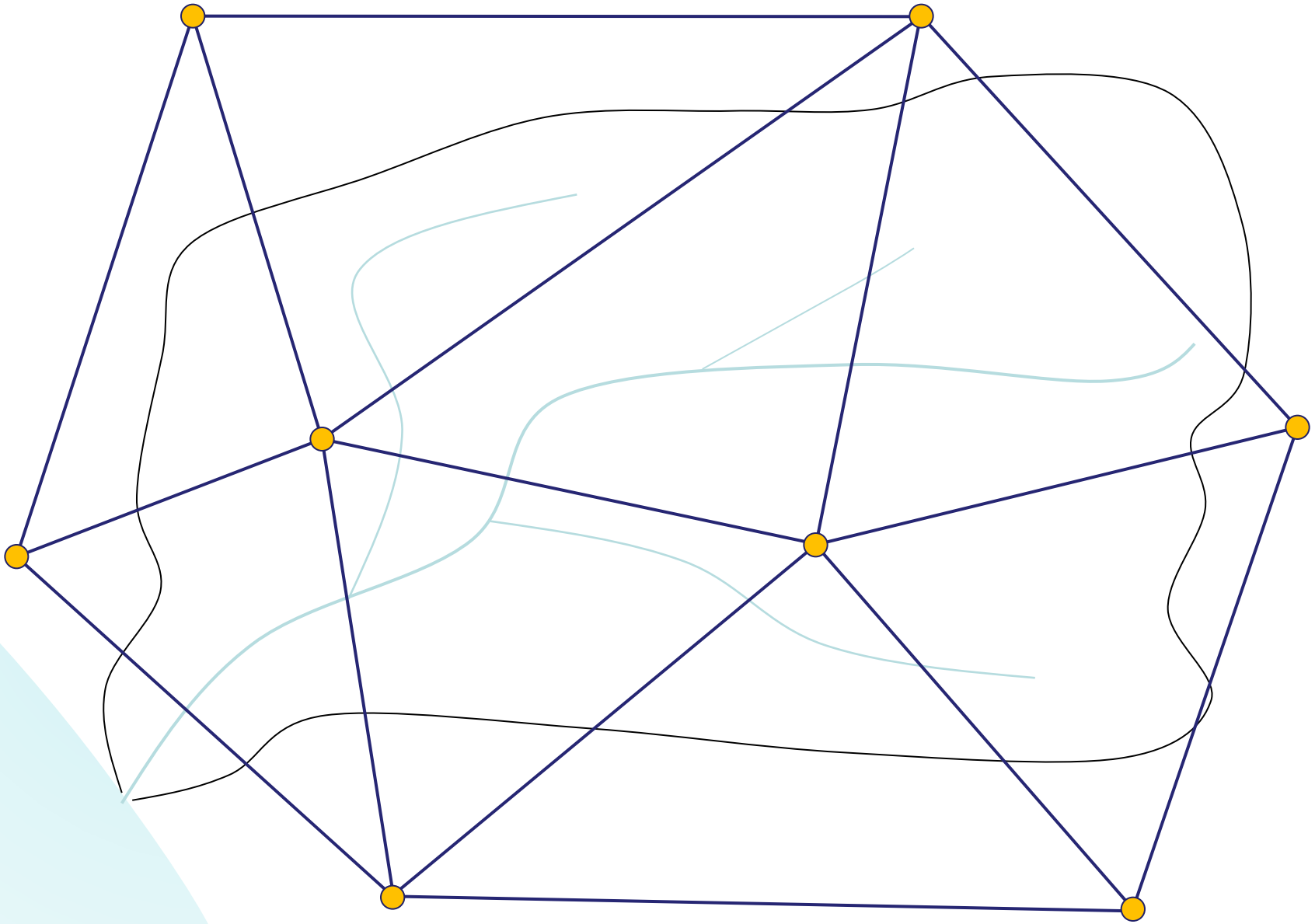


Determine Critical Line for Sediment Disaster Alert

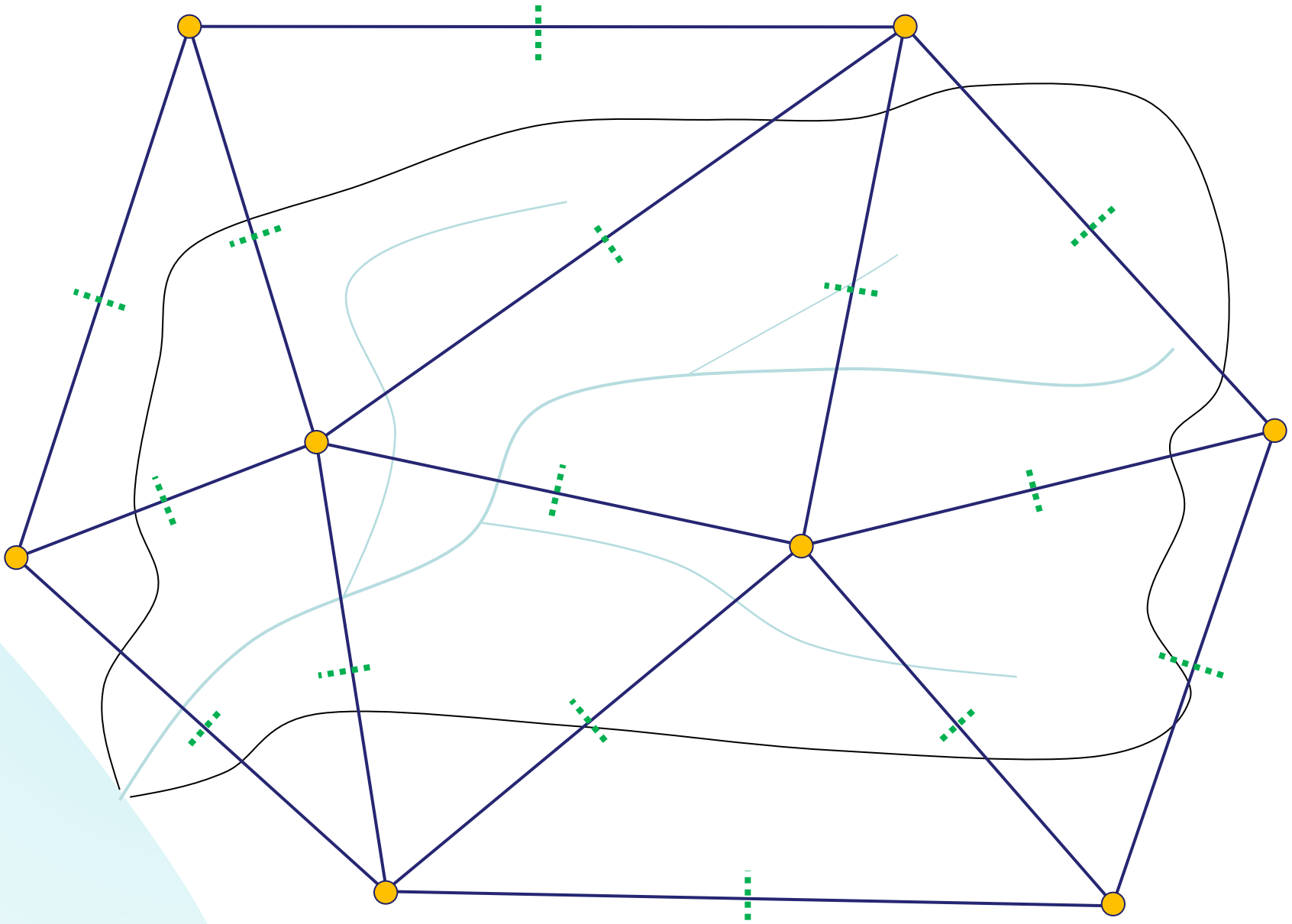
- Plot rain-gauge stations on a map.
- Determine the cover area of each rain-gauge station.
- Collect rainfall data as many as possible (today, provided later).
- Collect landslide records (today, provided later).
- Calculate long (short)-term rainfall index (today, effective rainfall (half-life period of 72 hours and 1.5 hours) is used)
- Plot values of short-term rainfall index corresponding to values of long-term rainfall index which were recorded at the time of landslides occurred.
- Draw a critical line considering the values of rainfall indexes.

Plot rain-gauge stations on a map

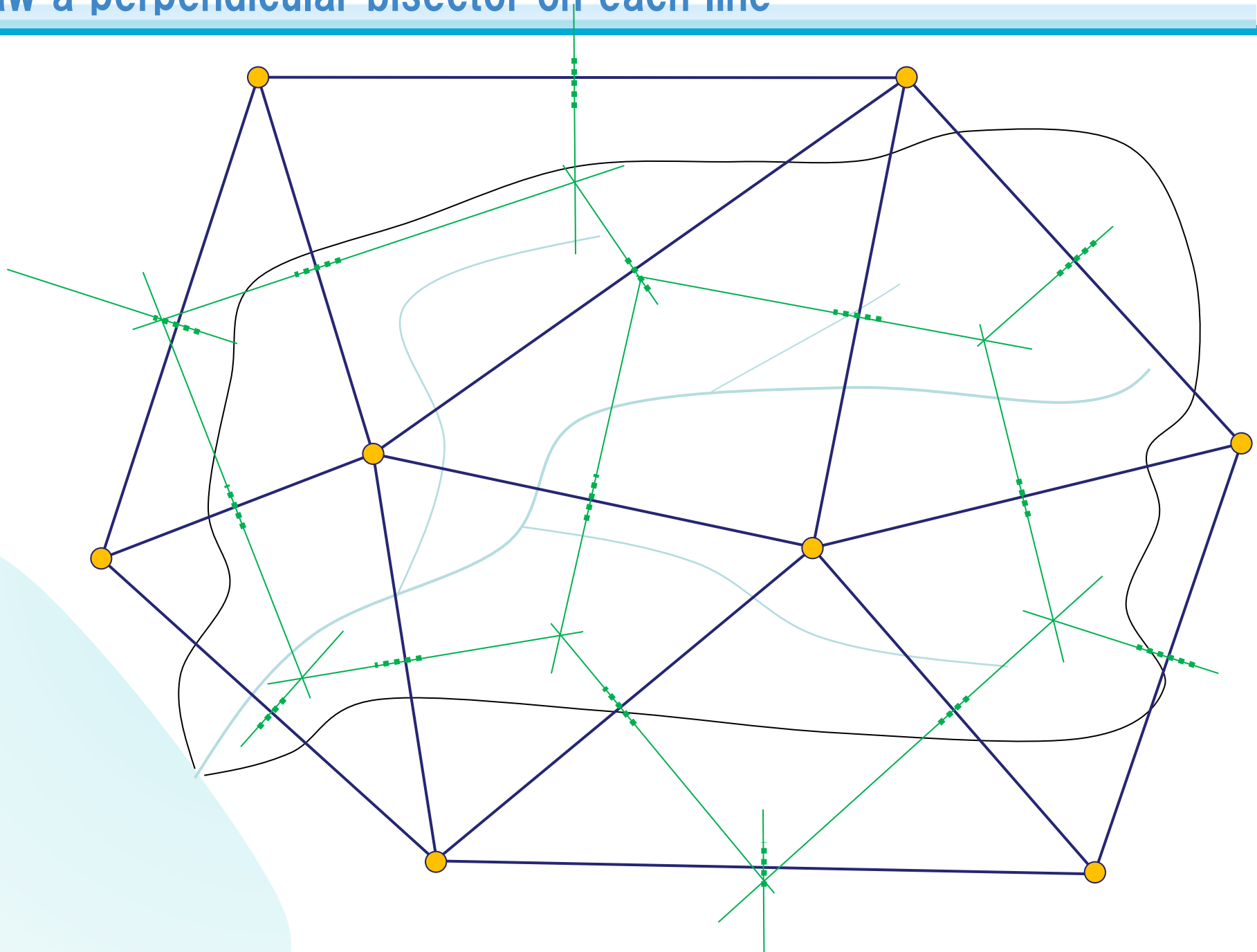
Draw lines between neighboring rain-gauge stations each other



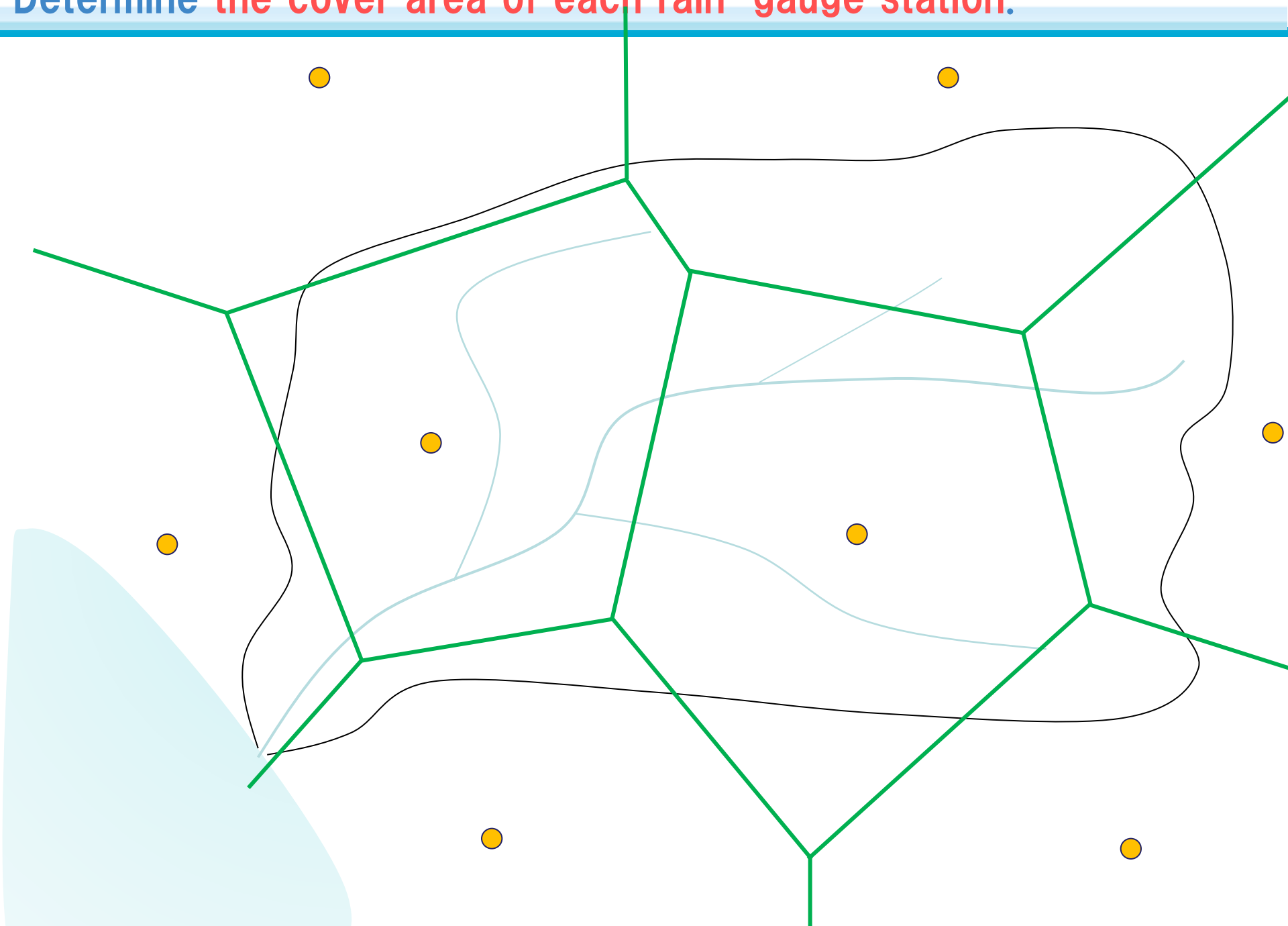
Put a mark at the middle point of each line



Draw a perpendicular bisector on each line



Determine the cover area of each rain-gauge station.



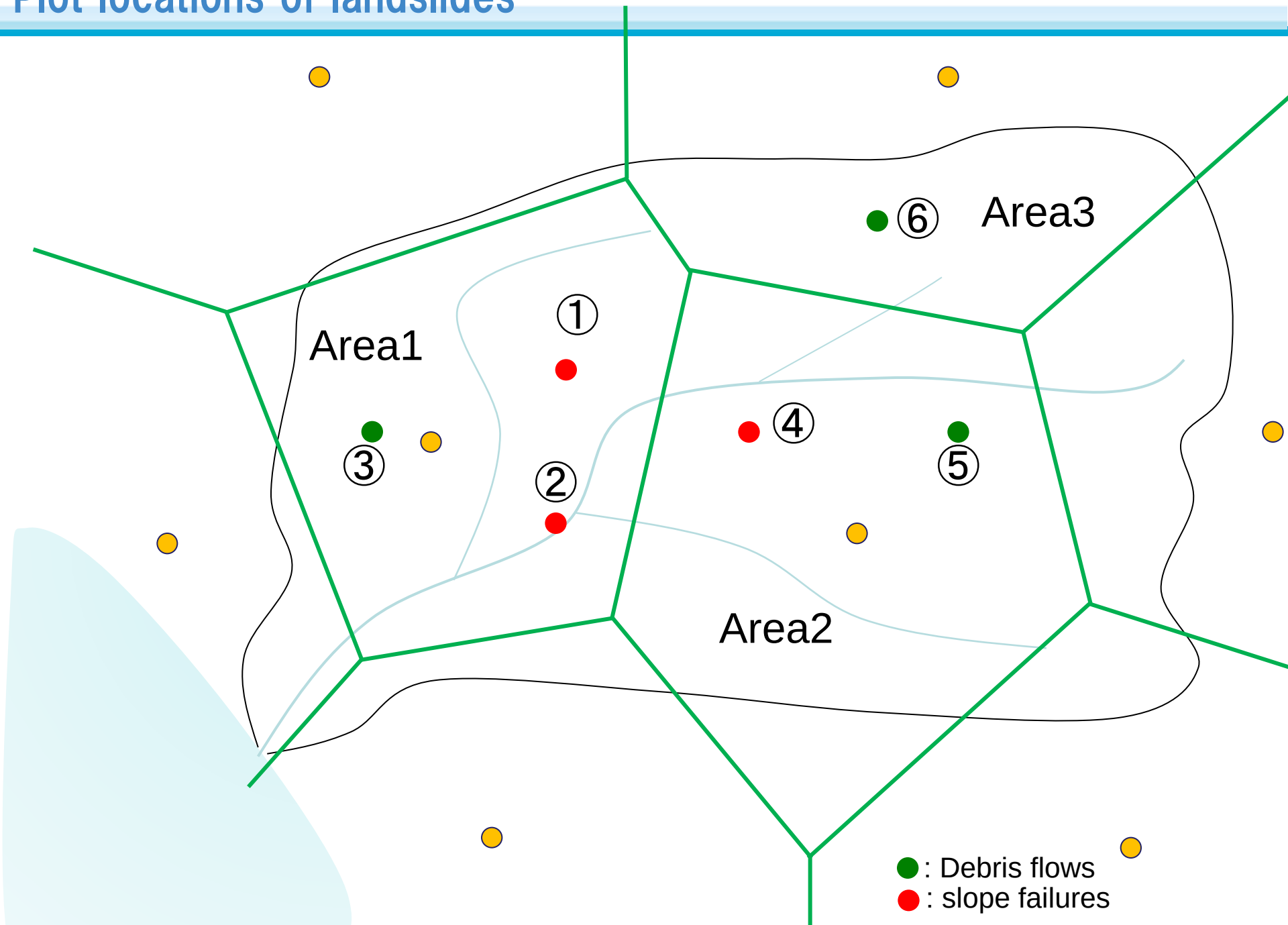
Collect rainfall data as many as possible (today, provided later).

Date	Time	Hourly Rainfall
Dec. 2. 2005	00:00	0.0mm
Dec. 2. 2005	01:00	2.5mm
Dec. 2. 2005	02:00	5.0mm
Dec. 2. 2005	03:00	10.0mm
Dec. 2. 2005	04:00	15.0mm
….		

Collect landslide records (today, provided later).

Number	Date	Time	Area#	Location
①	Jun. 2. 2005	Around 05:00	1	125-2, xx city
②	July. 8. 2006	10:00	1	225-1, yy town
③	April. 30. 2007	Around 03:00	2	357, zz City

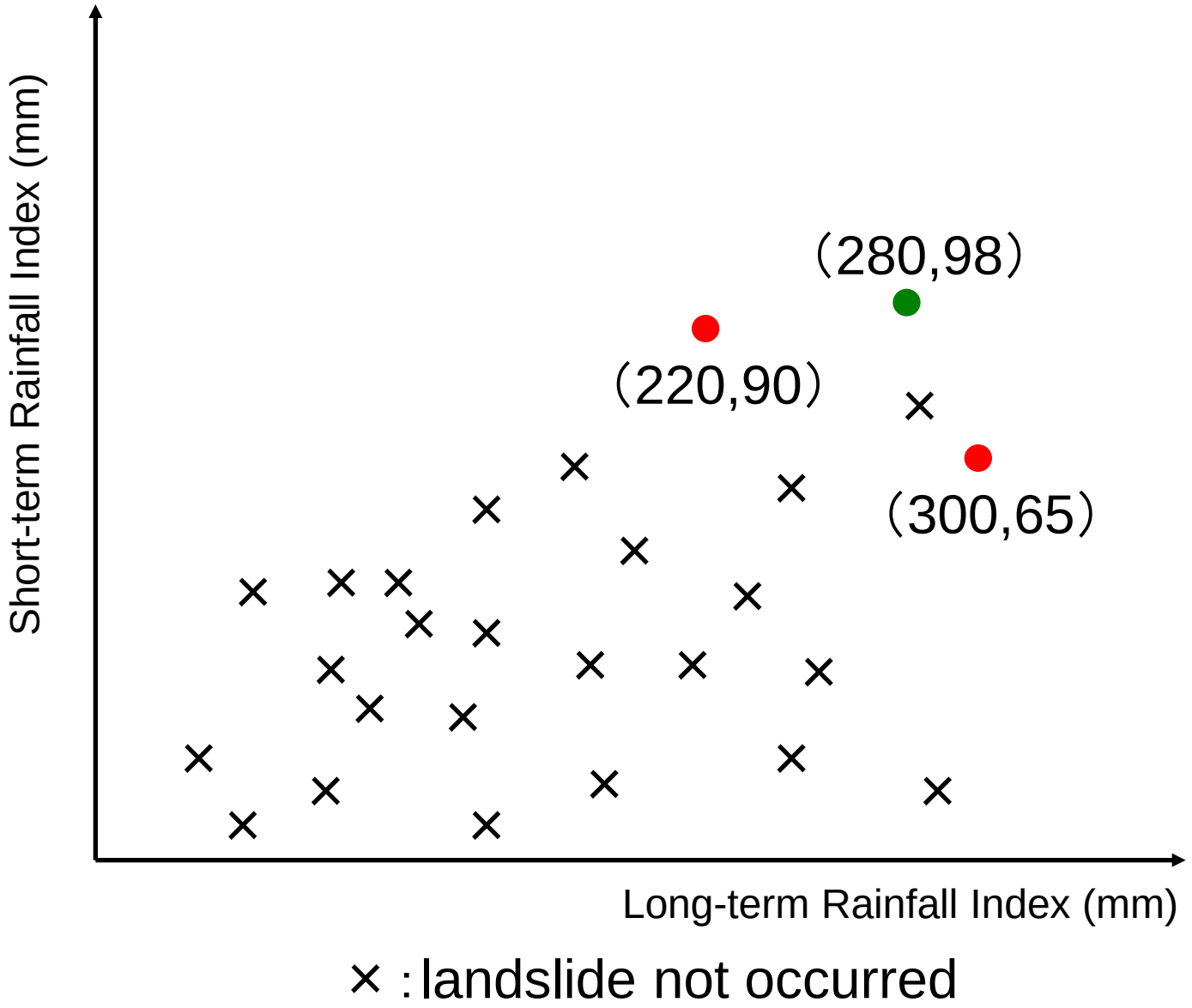
Plot locations of landslides



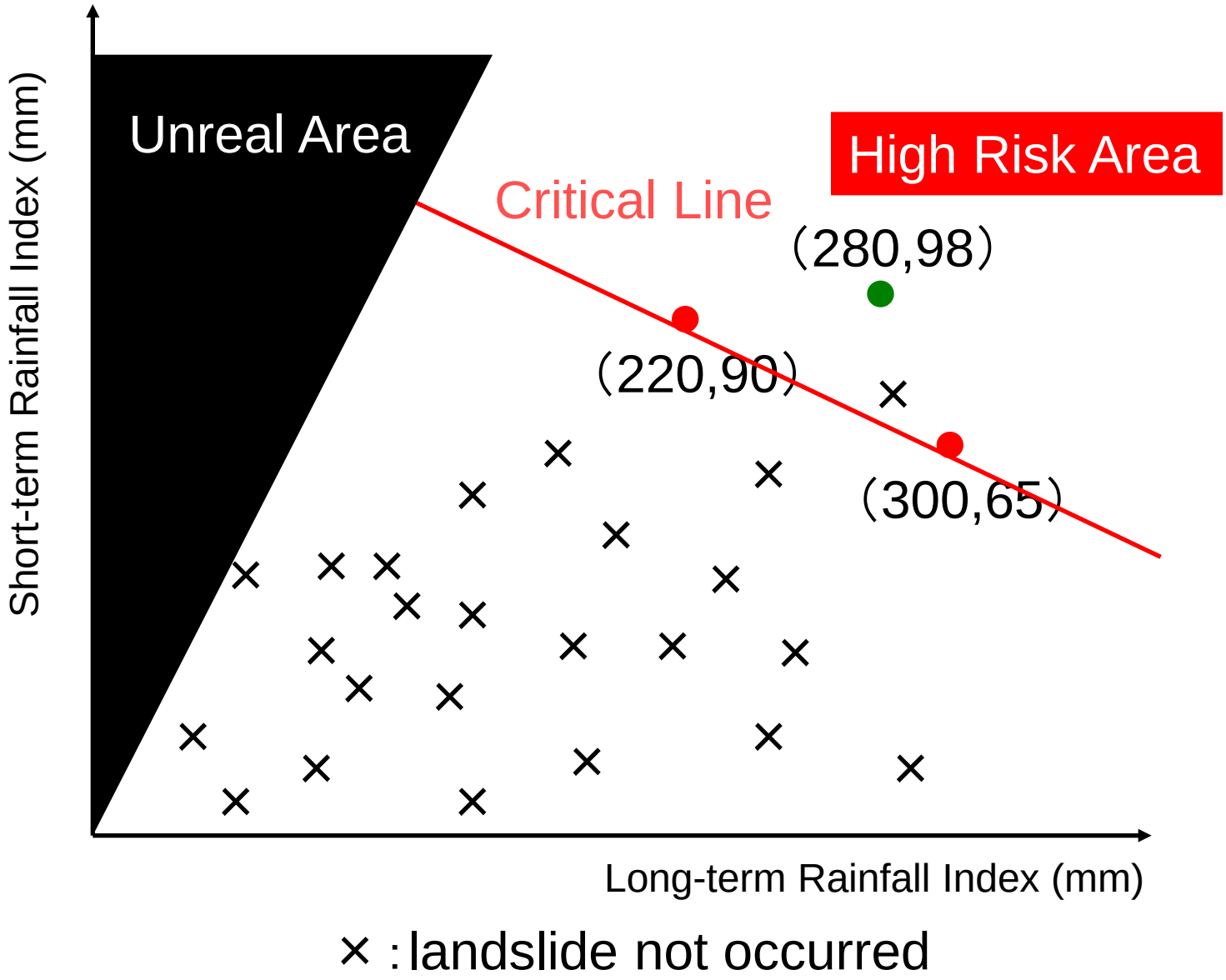
Calculate long (short) -term rainfall index (es)

Number	Hourly Rainfall	Long-term Rainfall Index	Short-term Rainfall Index
①	80mm	220mm	90mm
②	50mm	300mm	65mm
③	90mm	280mm	98mm

Plot values of short-term rainfall index

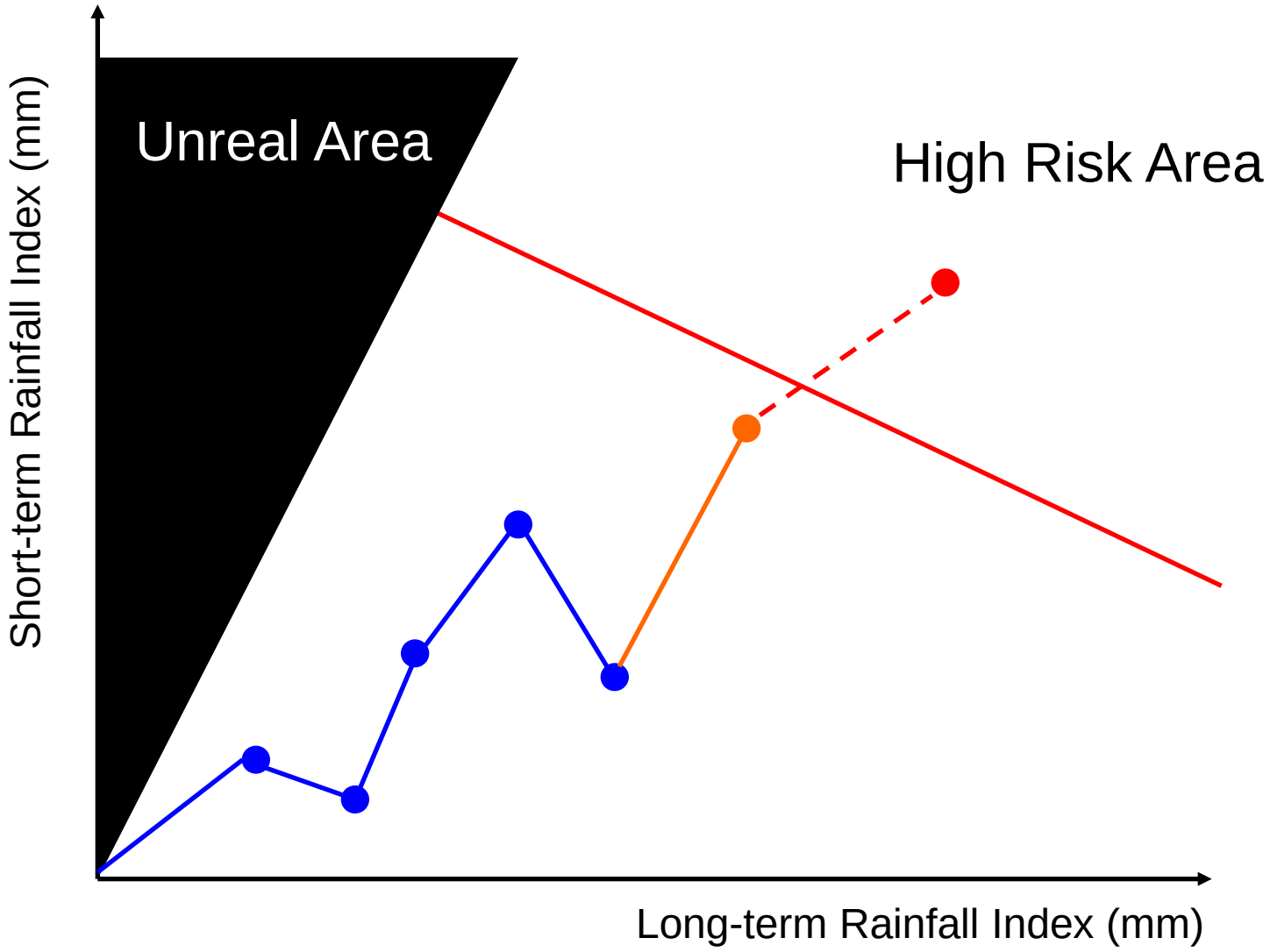


Draw a critical line



× : landslide not occurred

Predict landslides



× : landslide not occurred

Allocation of roles about Sediment Disaster Alert in Japan

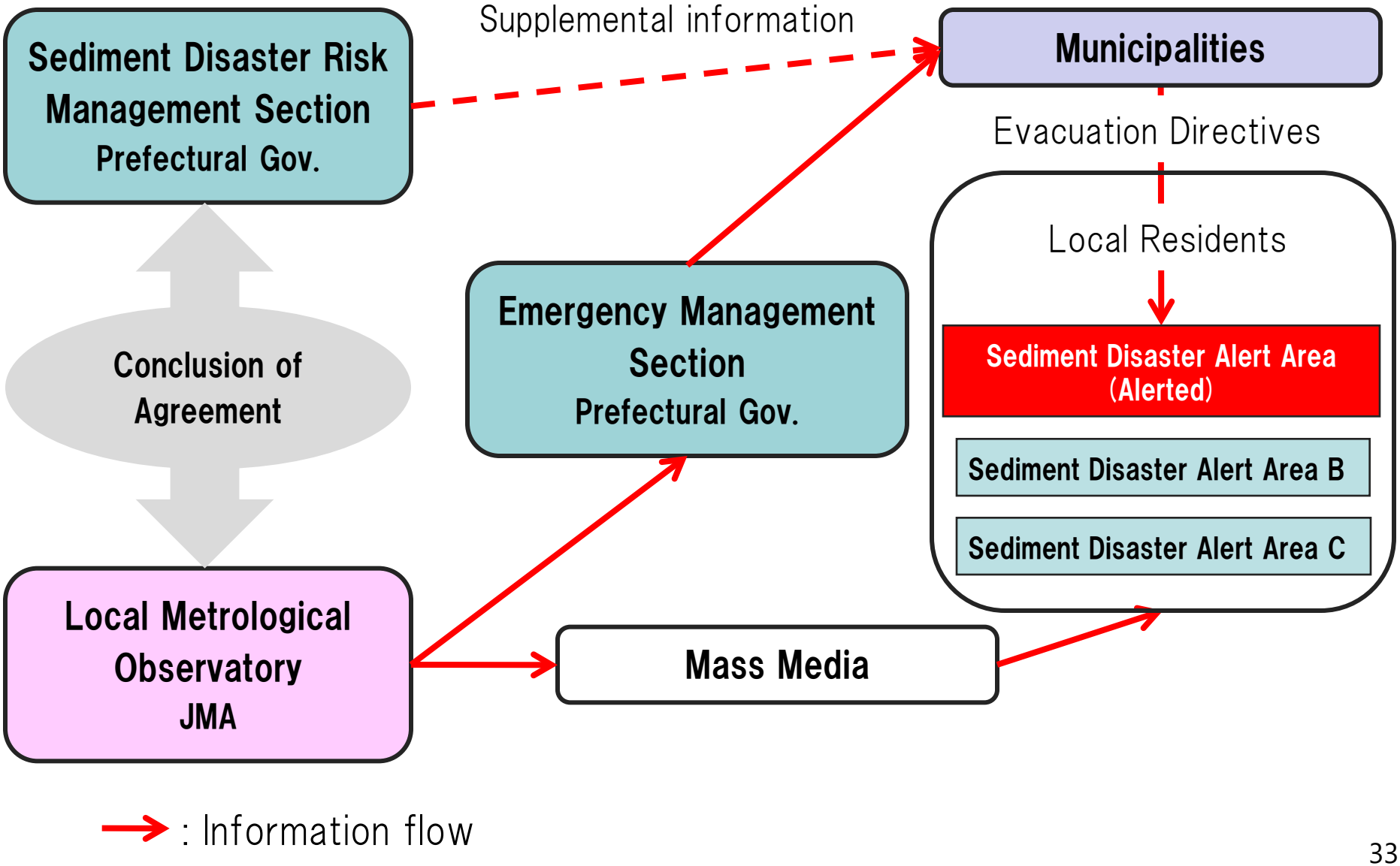
High-risk situation of Sediment Disasters is predicted by using two indicators, Soil Water Index and Hourly Rainfall Intensity.

Local Meteorological Observatory and Prefectural Government jointly issues Sediment Disaster Alerts(SDAs).

Each municipality issues evacuation advisory, when SDA is issued.

※ Cabinet Office asks for municipalities to evacuate their relevant citizens when SDA is issued.

Information Flow on Sediment Disaster Alert



Example of Sediment Disaster Alert

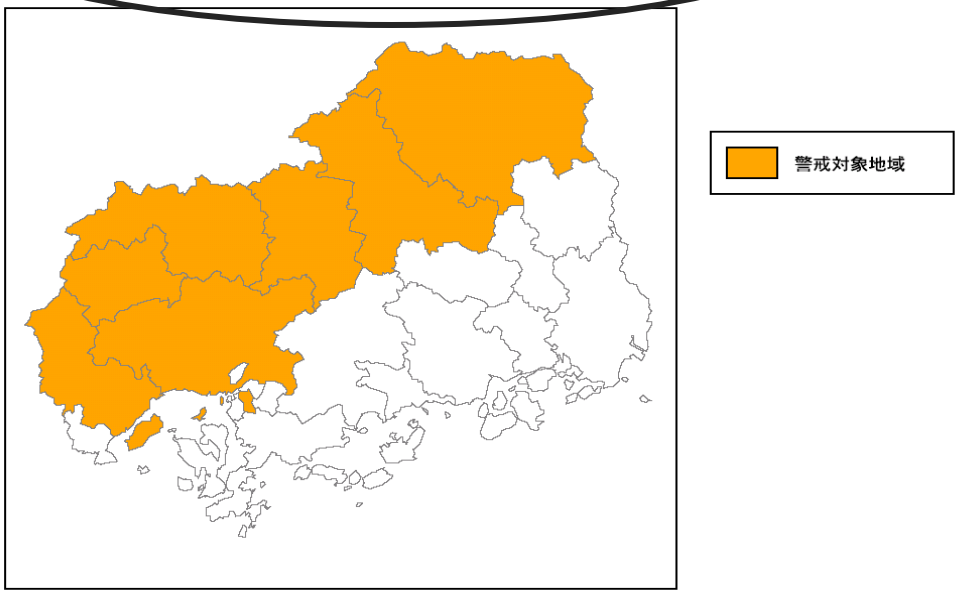
広島県土砂災害警戒情報　第3号

平成18年9月16日　22時10分
広島県　広島地方気象台　共同発表

【警戒対象地域】
広島市　廿日市市　三次市　庄原市＊　安芸高田市　安芸太田町　北広島町

＊印は、新たに警戒対象となった市町村を示します。

【警戒文】
《対象地域拡大》
降り続く大雨のため、土砂災害の危険度の非常に高い状態が続いており、今後２時間以内に、庄原市にも広がる見込みです。土砂災害危険箇所及びその周辺では厳重に警戒してください。警戒対象市町村での今後３時間以内の最大１時間雨量は、多いところで５０ミリです。



問い合わせ先
082-221-3764（広島県　砂防室）
082-223-3951（広島地方気象台観測予報課）

Sediment Disaster Alert No. 3 for xx Prefecture

Alerted Municipalities
A city, B City, C Town..

Body text of alert
Due to heavy rain, high risk situation is continuing. Within 2 hours, A city, B city, C town are at risk.

What is the Basic Scheme?

Weather Warning/Advisory/Alert, including SDA	• Issued by **Japan Meteorological Agency** (JMA) based on **Meteorological Service Act**
Sediment Disaster Risk Management	• Implemented by **Ministry of Land, Infrastructure, Transport and Tourism (MLIT)**, **Prefectural Governments** based on **Sediment Disaster Prevention Act etc**.
Evacuation Directive/Advisory	• Issued by **Municipalities** based on **Disaster Countermeasures Basic Act**.

Japan Meteorological Agency (JMA)

1952
- Started Weather Warning/Advisory.

1954
- Introduced Numerical Criteria on Heavy Rain Warning/Advisory.

2000
- Introduced Numerical Criteria using **Soil Water Index** on Heavy Rain Warning/Advisory.

Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

1984

- Developed prediction methods for debris flows by using two indexes method and released an operation guideline (A Method, B Method).

1990

- Improved the method of 1984 (YANO's Method).

1993

- Improved the method to be able to predict both of debris flows and steep slope failures.

Cooperative Efforts between MLIT and JMA

2005

- Established the system to issue SDAs between a pilot prefecture* and the local meteorological observatory (*Kagoshima prefecture).

2008

- Established the system between every prefectural government and the local meteorological observatory.

2014

- Diet promulgated an amendment bill of the Sediment Disaster Prevention Act to oblige governors to securely transmit SDAs to municipalities.

What is the Motivation for the Cooperation?

Frequent Occurrence of Sediment Disasters, loss of human life, delayed structural measures installation.

Increased expectation for the improvement of non structural measures.

Municipalities are obliged to establish early warning system at every Sediment Disaster Alert Area by Sediment Disaster Prevention Act enacted 2001.

As a corollary of this, municipalities need more accurate alerts for sediment disasters to evacuate their citizens.

What is the First Action?

MLIT as **the leading organization for sediment disasters prevention** and **JMA** as **the leading organization for meteorology** started discussion on the new accurate alert method.

MLIT and **JMA** started discussion to **share rainfall data** obtained from each organization's observation system.

What is the Coordination Process?

2001

- Jointly installed an **Ad-Hoc Liaison Committee** led by director level.

2002

- Jointly installed an **Advisory Board for Sediment Disaster Alert**.

2002

- Jointly select **pilot prefectures and local meteorological observatories**.

What is the Key to Success?

At the very beginning, started from what can be jointly done.

Chose And/Or Method (based on the each organization's existing method.)

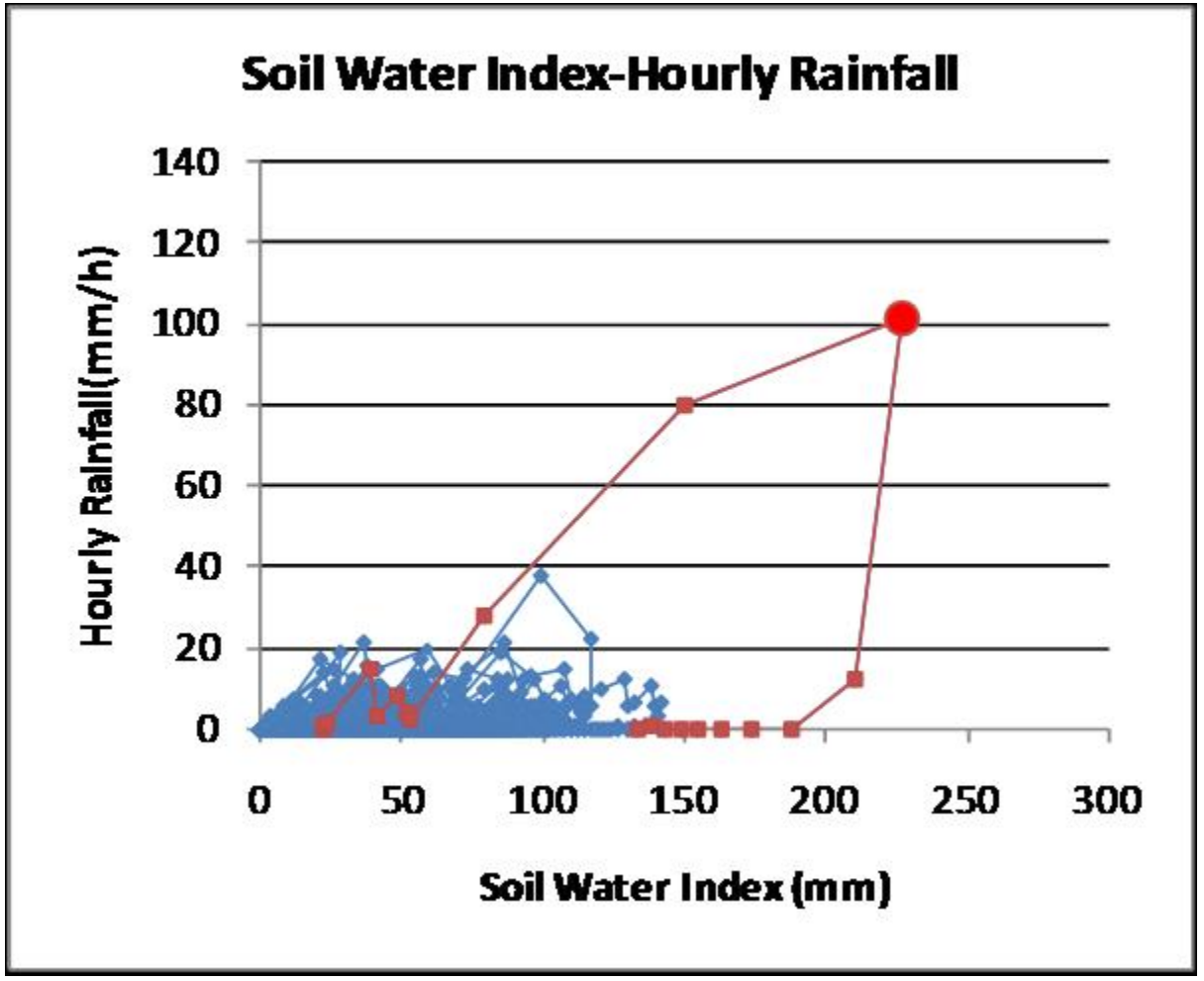
Advanced the Study on the new method in parallel with the pilot.

Established the new method in a manner of adopting some effective techniques from each organization's method.

Technical Coordination

Development of New Method and Guideline	• Jointly studied and issued the guideline by NILIM and JMA.
Detailed Local Criteria	• Studied by Advisory Board in each prefecture and determined based on the situation of the area.

What is the Current Method?



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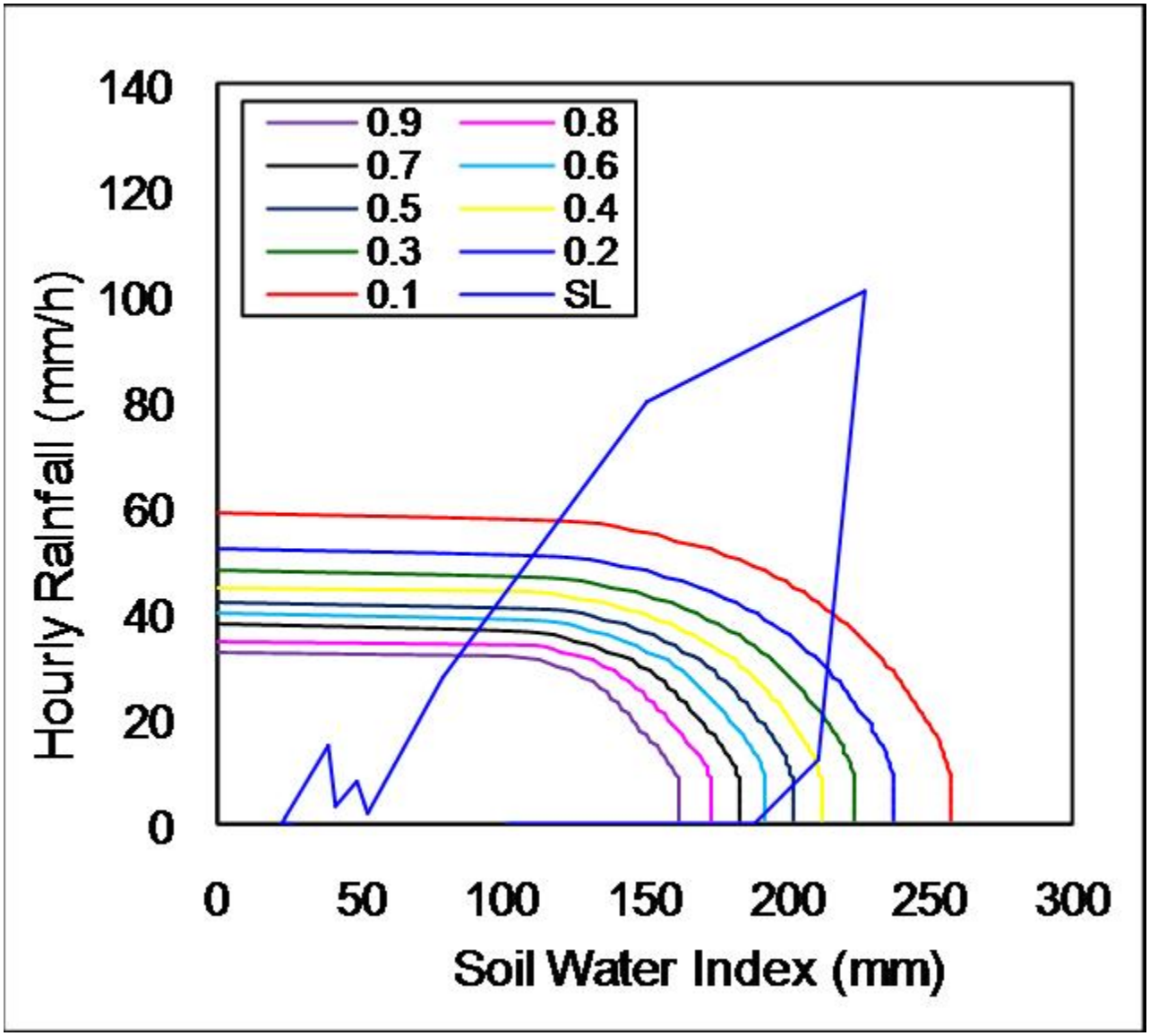

Improvement

Prefectures	• Examine their criteria around every five years.
JMA	• Improves its rainfall observation system and making its rainfall prediction more accurate.
NILIM(MLIT)	• Studies some parameter tuning techniques to respond to the change of the slope situations by earthquakes and volcanic eruptions.