USGS
science for a changing world

Landslide Hazards Program

Laguna Landslide Images

2005 Laguna Beach

LANDSLIDE PREVENTION

USGS
science for a changing world

Landslide Types and Processes

Landslides in the United States occur in all 50 States. The primary regions of landslide occurrence and potential are the coastal and mountainous areas of California, Oregon, and Washington, the States comprising the intermountain west, and the mountainous and hilly regions of the Eastern United States. Alaska and Hawaii also experience all types of landslides.

Landslides in the United States cause approximately $3.5 billion (year 2001 dollars) in damage, and kill between 25 and 50 people annually. Casualties in the United States are primarily caused by rockfalls, rock slides, and debris flows. Worldwide, landslides occur and cause thousands of casualties and billions in monetary losses annually.

The information in this publication provides an introductory primer on understanding basic scientific facts about landslides—the different types of landslides, how they are initiated, and some basic information about how they can begin to be managed as a hazard.

La Conchita, coastal area of southern California. This landslide and earthflow occurred in the spring of 1995. People were evacuated and the houses nearest the slide were completely destroyed. This is a typical type of landslide. *Photo by R.L. Schuster, U.S. Geological Survey.*

TYPES OF LANDSLIDES

The term "landslide" describes a wide variety of processes that result in the downward and outward movement of slope-forming materials including rock, soil, artificial fill, or a combination of these. The materials may move by falling, toppling, sliding, spreading, or flowing. Figure 1 shows a graphic illustration of a landslide, with the commonly accepted terminology describing its features.

The various types of landslides can be differentiated by the kinds of material involved and the mode of movement. A classification system based on these parameters is shown in figure 2. Other classification systems incorporate additional variables, such as the rate of movement and the water, air, or ice content of the landslide material.

Although landslides are primarily associated with mountainous regions, they can also occur in areas of generally low relief. In low-relief areas, landslides occur as cut-and-fill failures (roadway and building excavations), river bluff failures, lateral spreading landslides, collapse of mine-waste piles (especially coal), and a wide variety of slope failures associated with quarries and open-pit mines. The most common types of landslides are described as follows and are illustrated in figure 3.

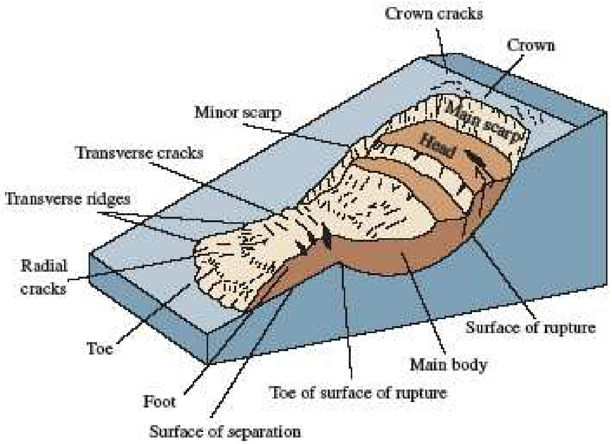


Figure 1. An idealized slump-earth flow showing commonly used nomenclature for labeling the parts of a landslide.

SLIDES: Although many types of mass movements are included in the general term "landslide," the more restrictive use of the term refers only to mass movements, where there is a distinct zone of weakness that separates the slide material from more stable underlying material. The two major types of slides are rotational slides and translational slides.

Rotational slide: This is a slide in which the surface of rupture is curved concavely upward and the slide movement is roughly rotational about an axis that is parallel to the ground surface and transverse across the slide (fig. 3A).

Translational slide: In this type of slide, the landslide mass moves along a roughly planar surface with little rotation or backward tilting (fig. 3B). A *block slide* is a translational slide in which the moving mass consists of a single unit or a few closely related units that move downslope as a relatively coherent mass (fig. 3C).

FALLS: Falls are abrupt movements of masses of geologic materials, such as rocks and boulders, that become detached from steep slopes or cliffs (fig. 3D).

LANDSLIDE PREVENTION

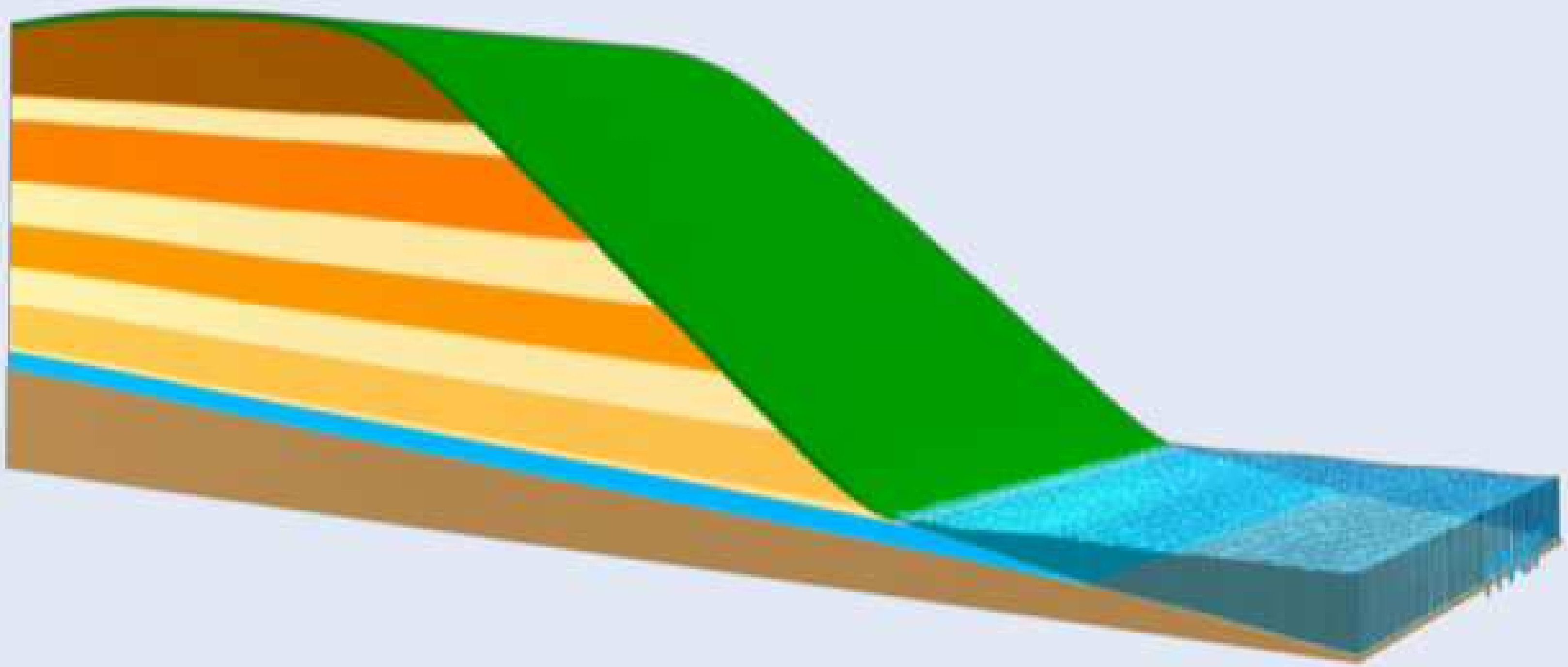
NO-DIG TECHNOLOGY AS A PREVENTION FOR ENVIRONMENTALLY HAZARDOUS LANDSLIDES

Istvan Szemesy
Sycons Ltd., Hungary

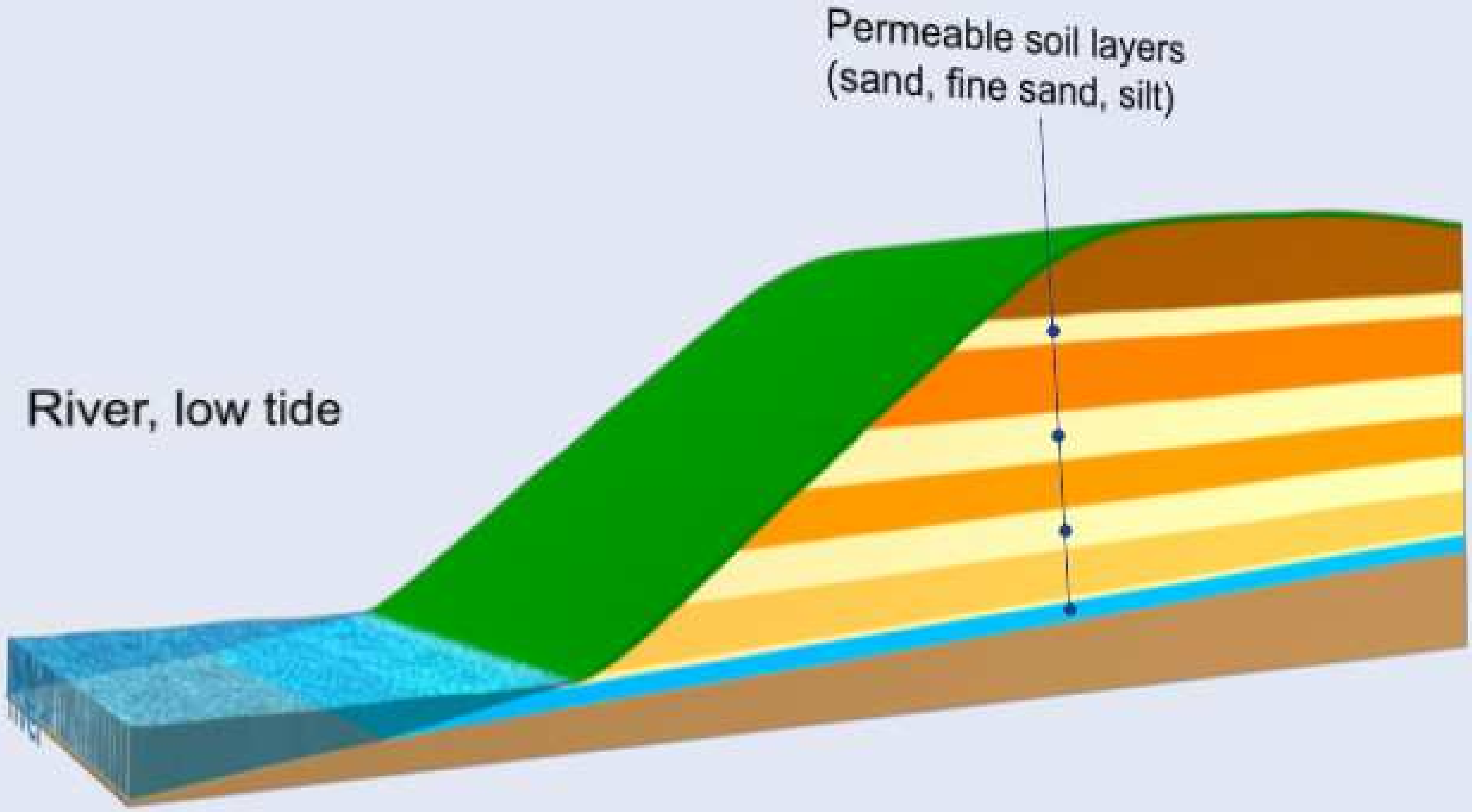
General geotechnical information on the land-slide endangered areas in Hungary. The main reasons of occurrence.

- There were very intensive rainy periods in 1999-2000 and 2003-2004.
- Large scale landslides occurred on the areas, where clay, silt, loessic and fine sand layers had been settled in a slight slope to a river.
- In stable, positive balanced situation the groundwater outflow capacity of the permeable layers is equal, or higher, than the volume of the streaming groundwater arrives from the background collector areas.
- In cases when the volume of the streaming groundwater increases suddenly (e.g. extreme precipitation), or the outflow capacity of the permeable layers decreases dramatically, there is no more positive balance between the streaming groundwater volume and the outflow capacity.
- Result:……………. LANDSLIDES

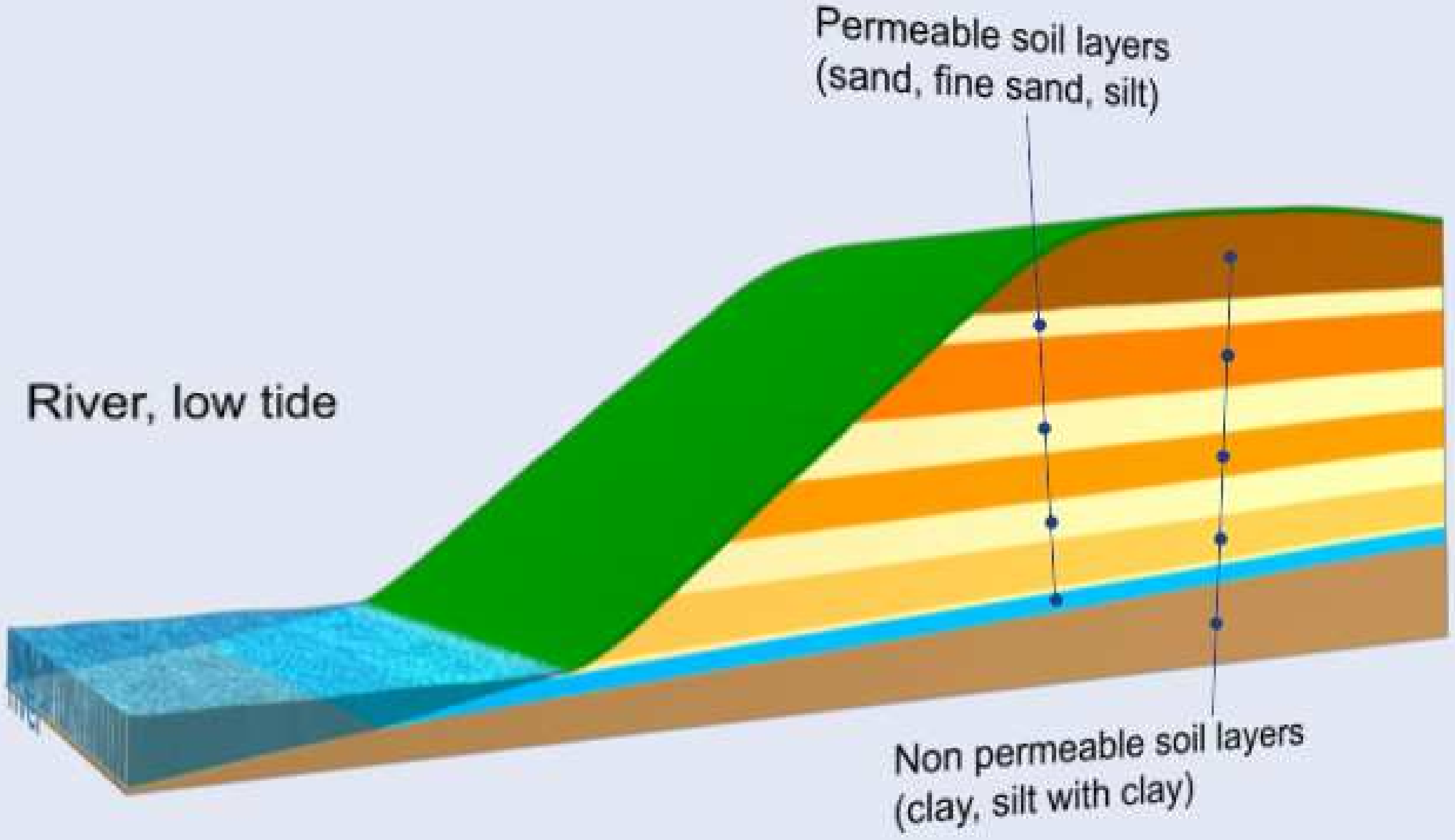
Stable situation



Stable situation

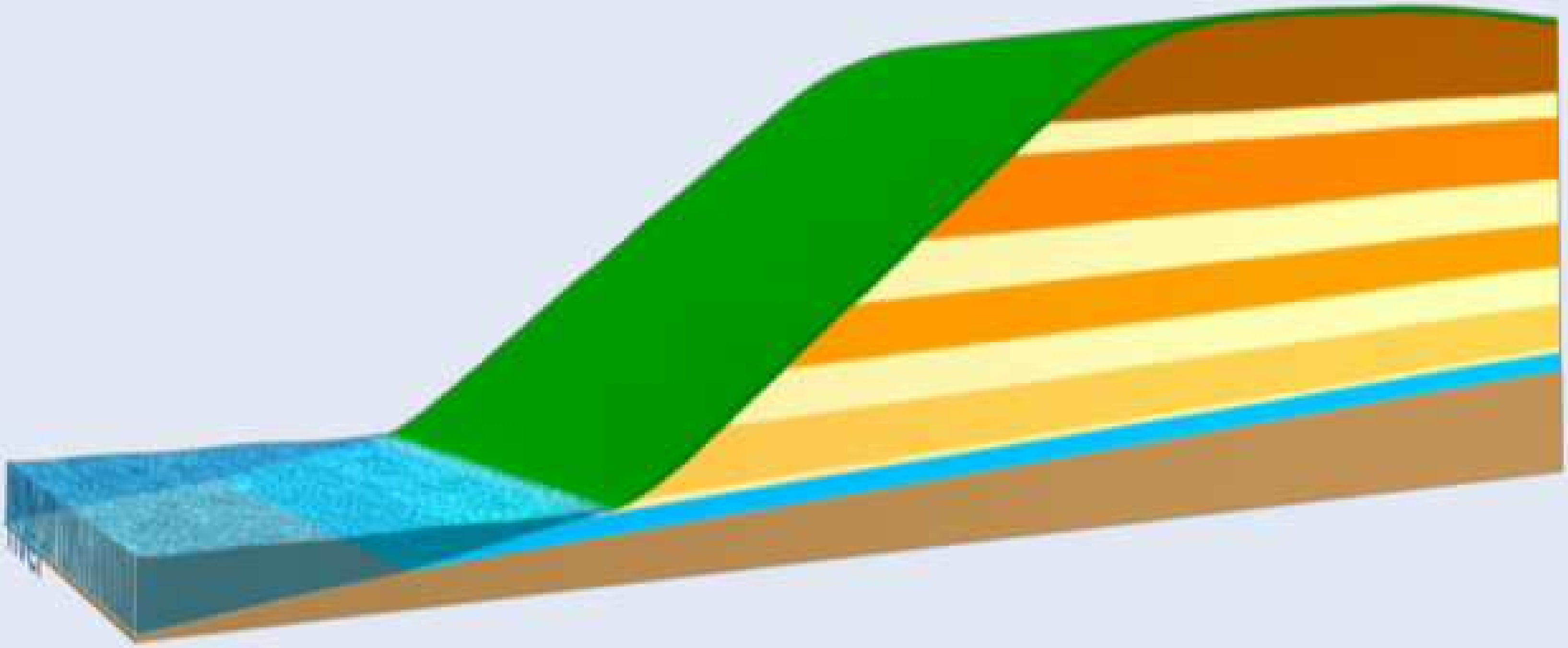


Stable situation



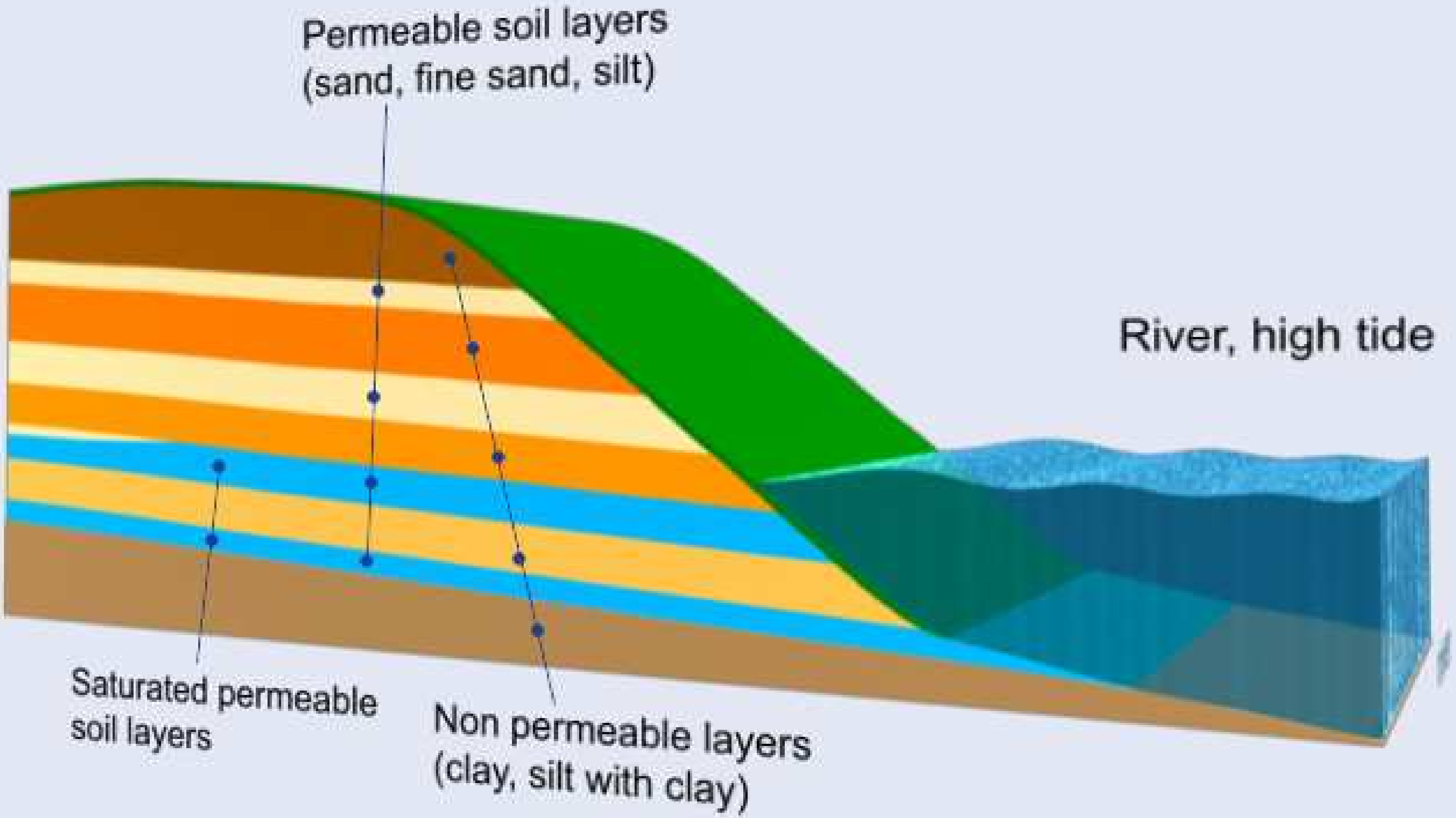
LANDSLIDE PREVENTION

High tide No. 1

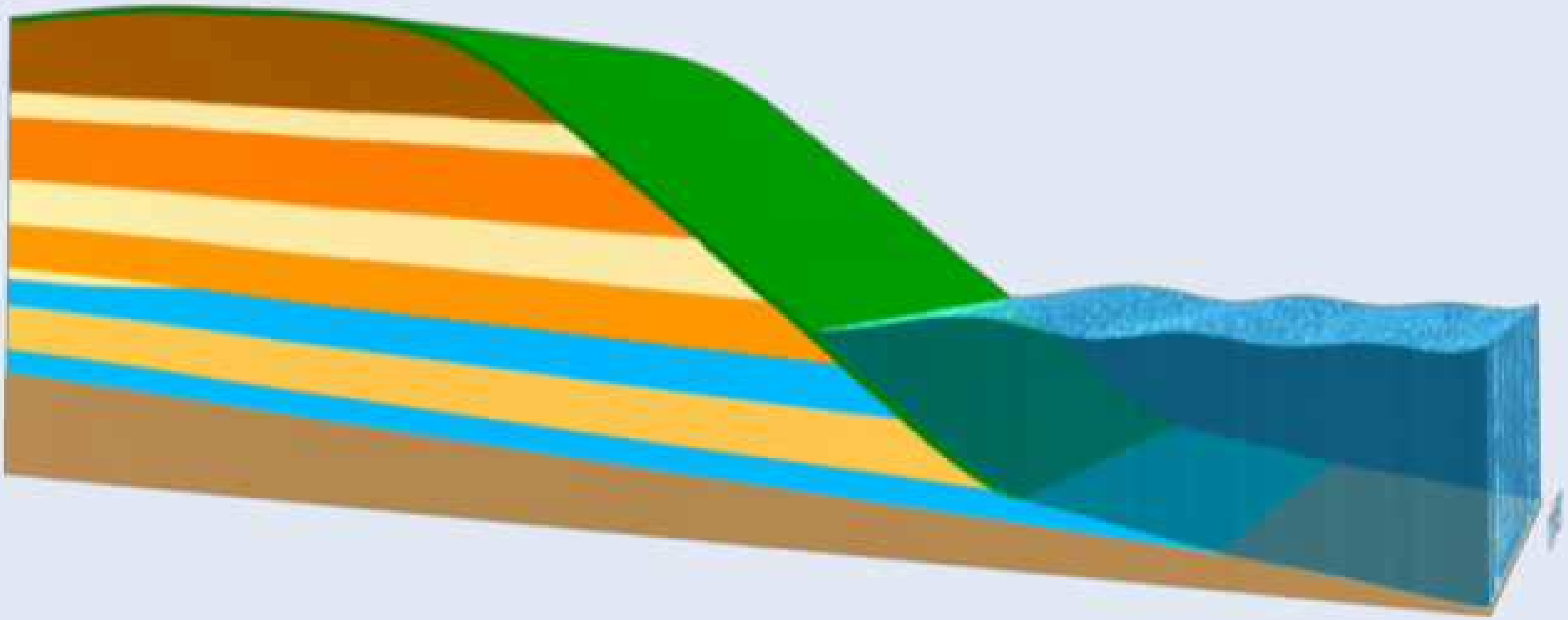


LANDSLIDE PREVENTION

High tide No. 1

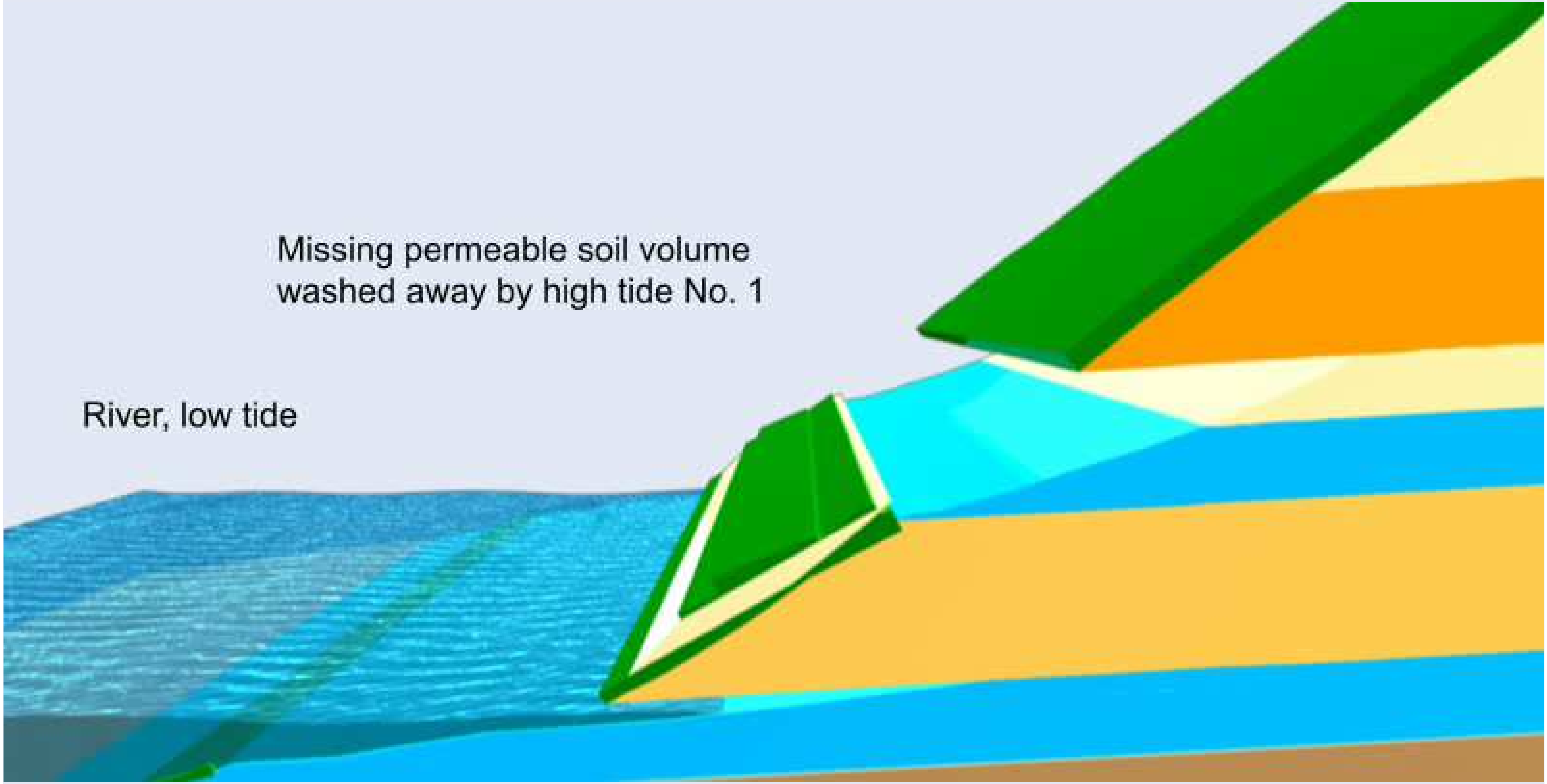


Short time after high tide No. 1

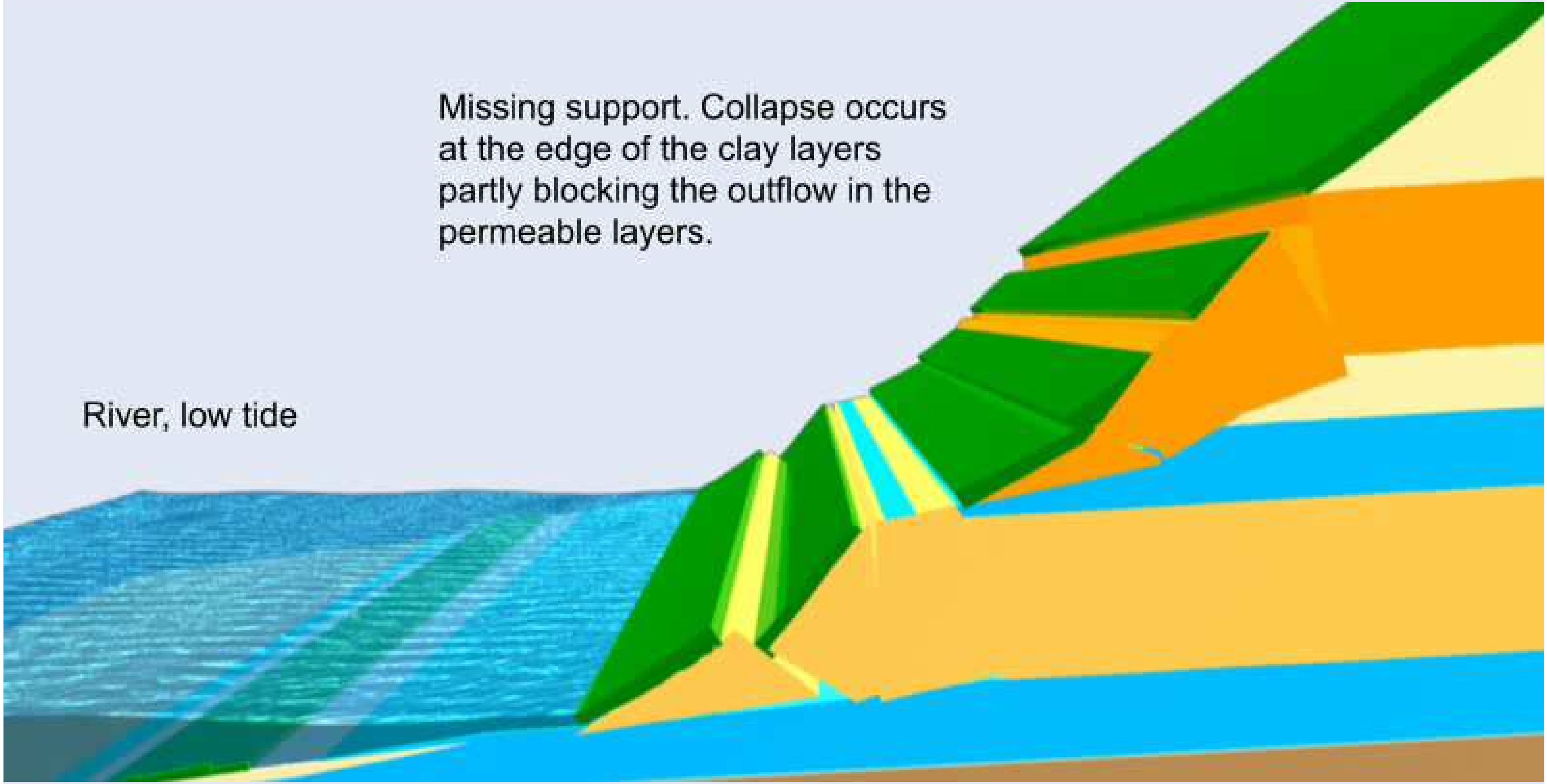


LANDSLIDE PREVENTION

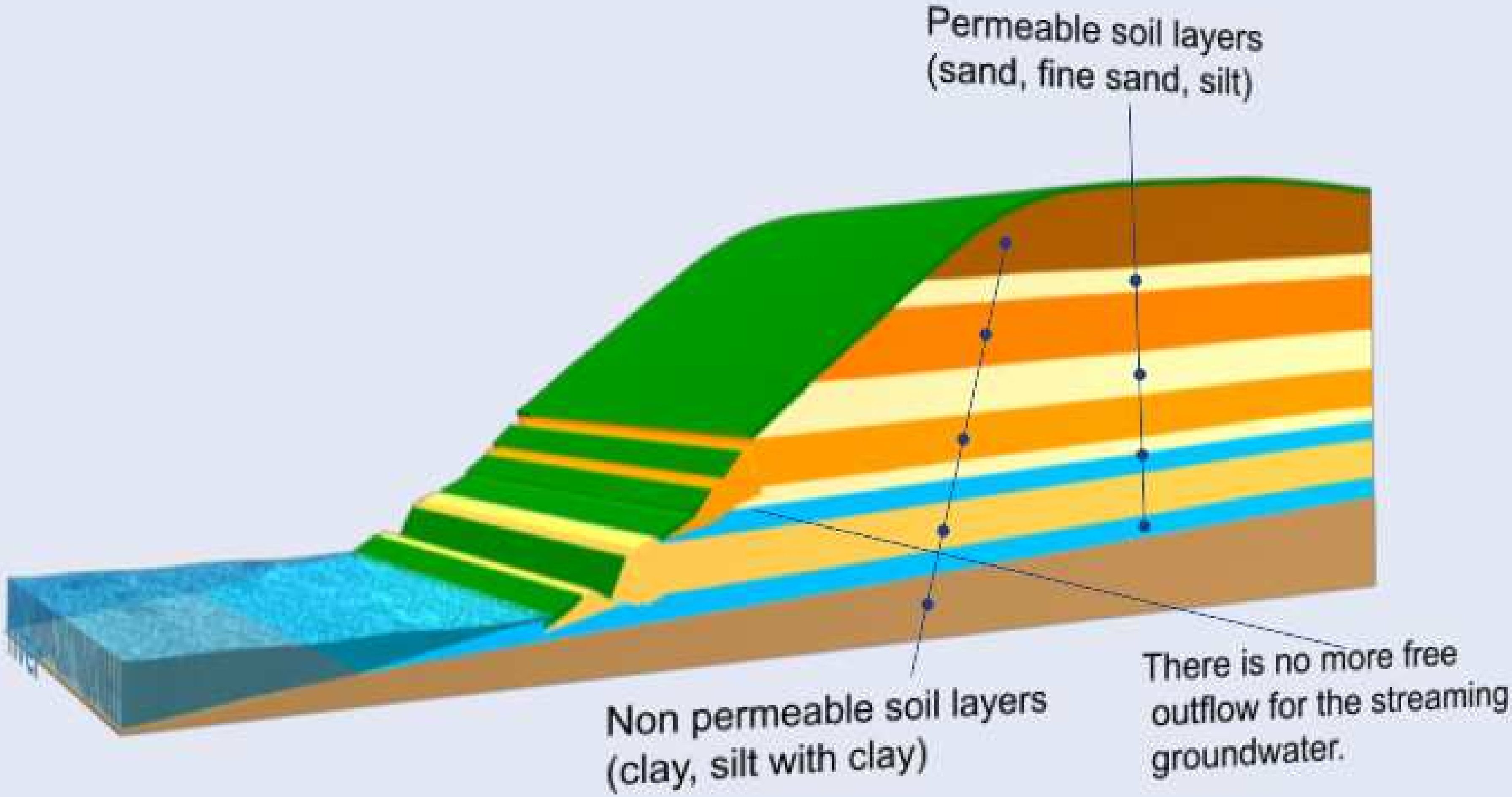
Short time after high tide No. 1



Short time after high tide No. 1

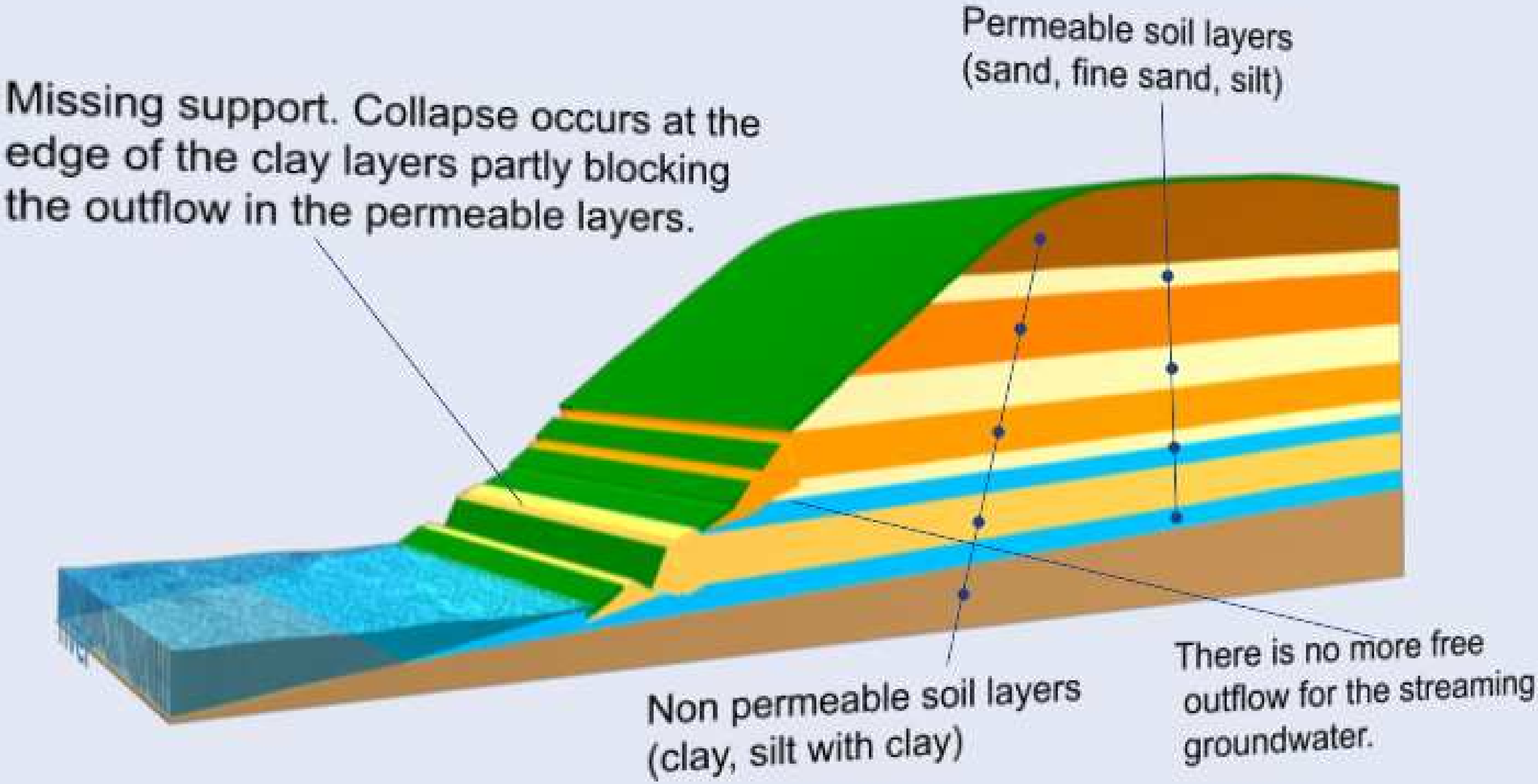


Short time after high tide No. 1

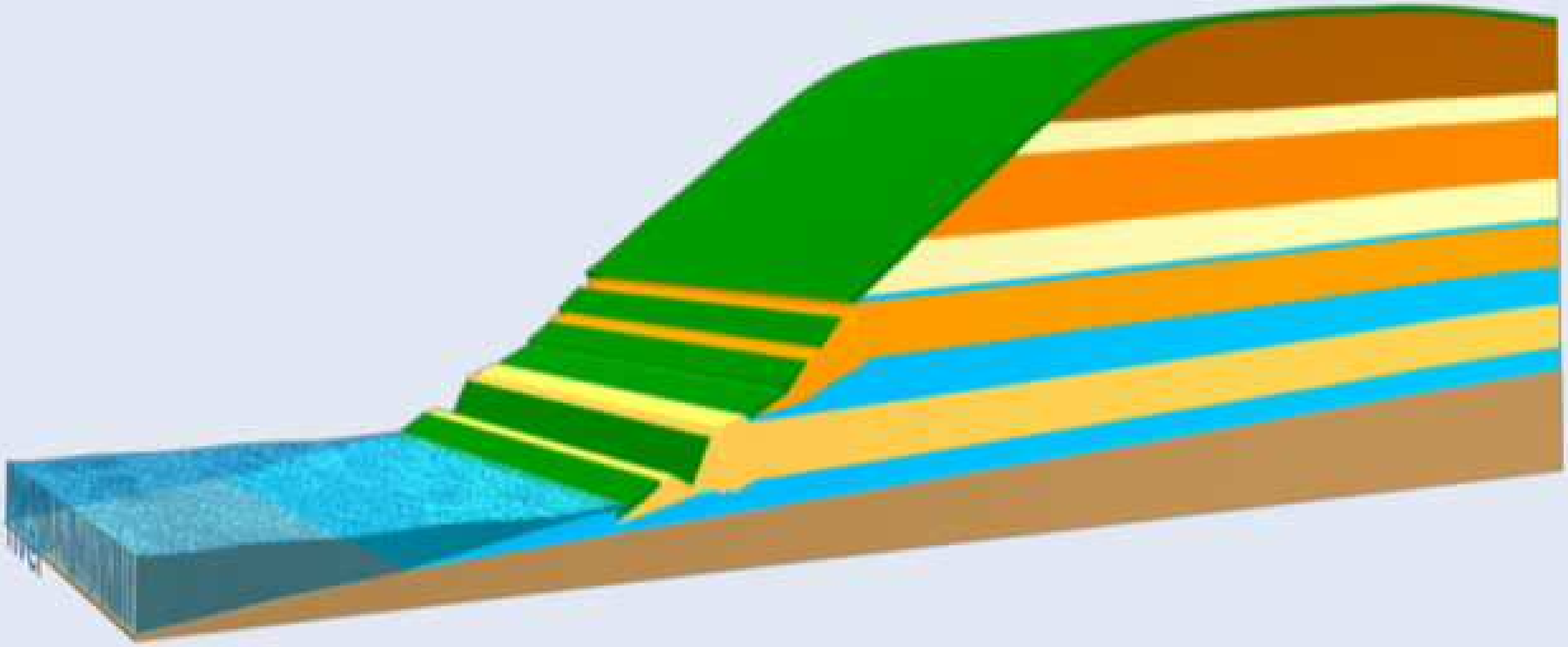


LANDSLIDE PREVENTION

Short time after high tide No. 1

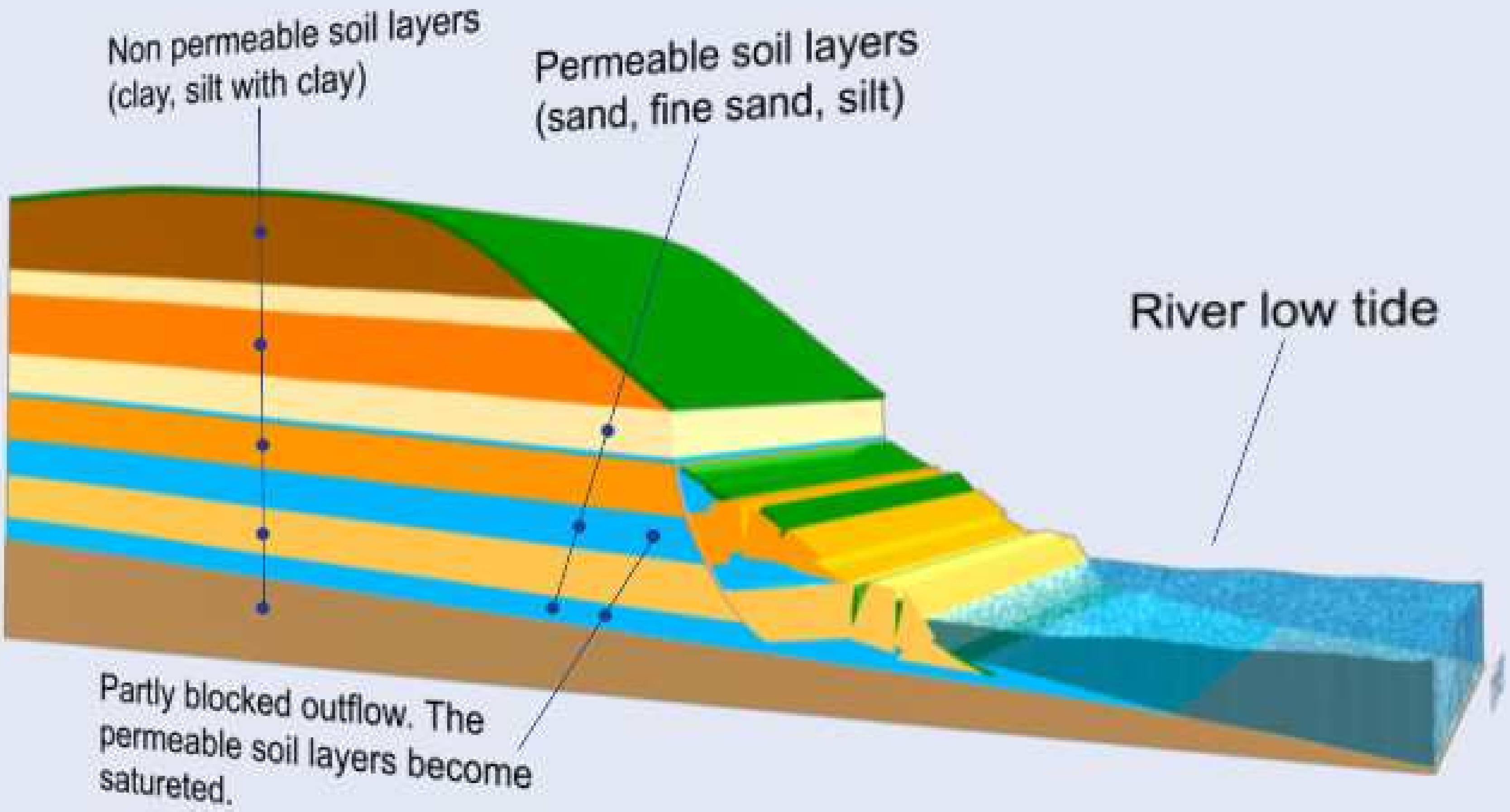


First movements occur after high tide No. 2

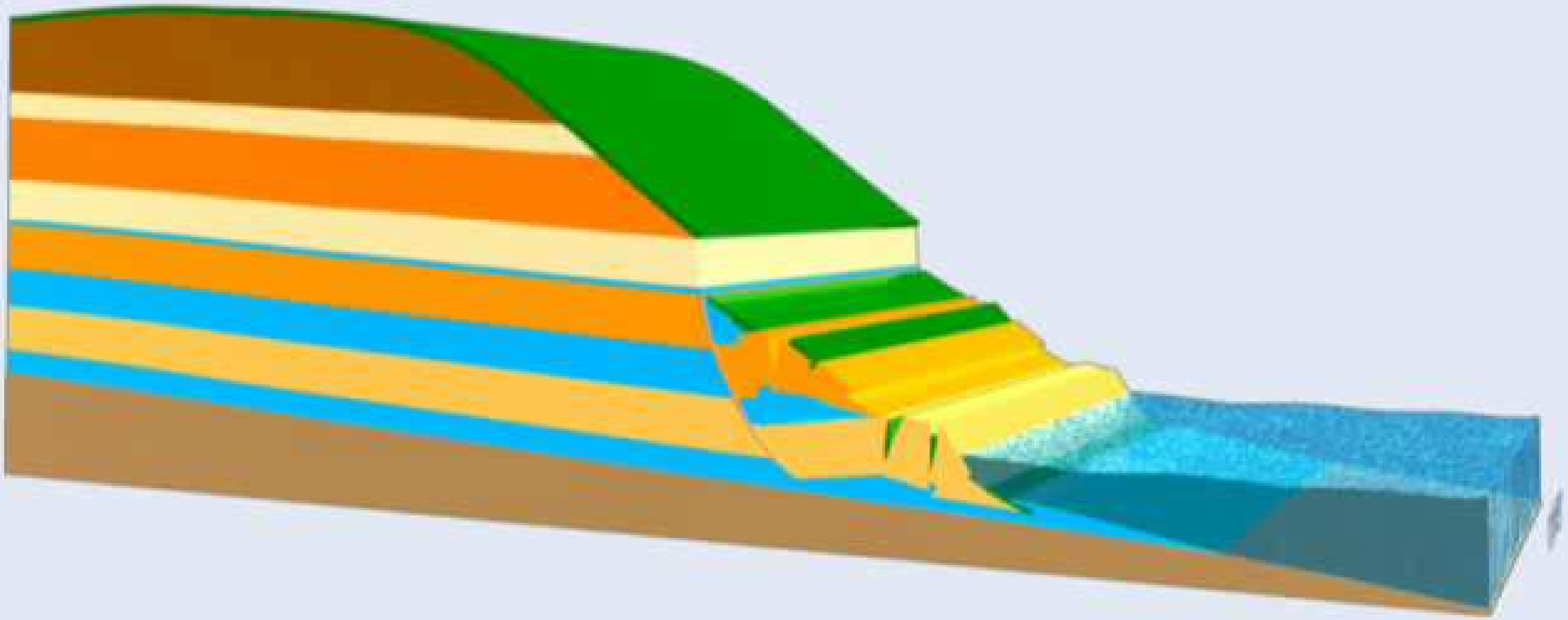


LANDSLIDE PREVENTION

First movements occur after high tide No. 2



High tide No. 3



LANDSLIDE PREVENTION

when the volume of the groundwater streaming in the permeable layers exceeds the outflow capacity of these layers?

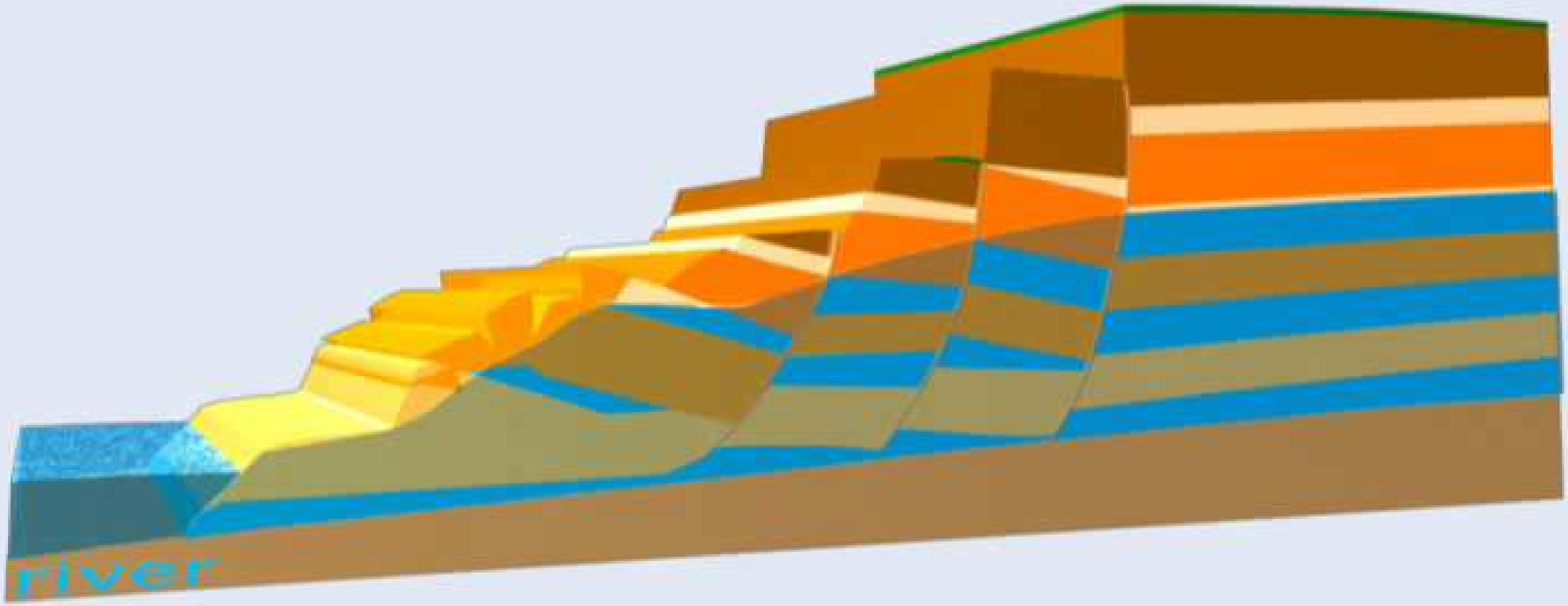
There are two possibilities to recreate the balance:

- Drastic minimization of the streaming groundwater in the permeable layers on the slide endangered areas. (Limit the infiltration on the background water collector areas by leveling, grassing, forest plantation, construction and proper maintenance of the rainwater systems, sewer and freshwater network, no septic tanks allowed!!!!)
- Significant increase in the outflow capacity of the permeable soil layers.
- **The combined application of the above mentioned two possibilities is the real solution !!!!!!!**

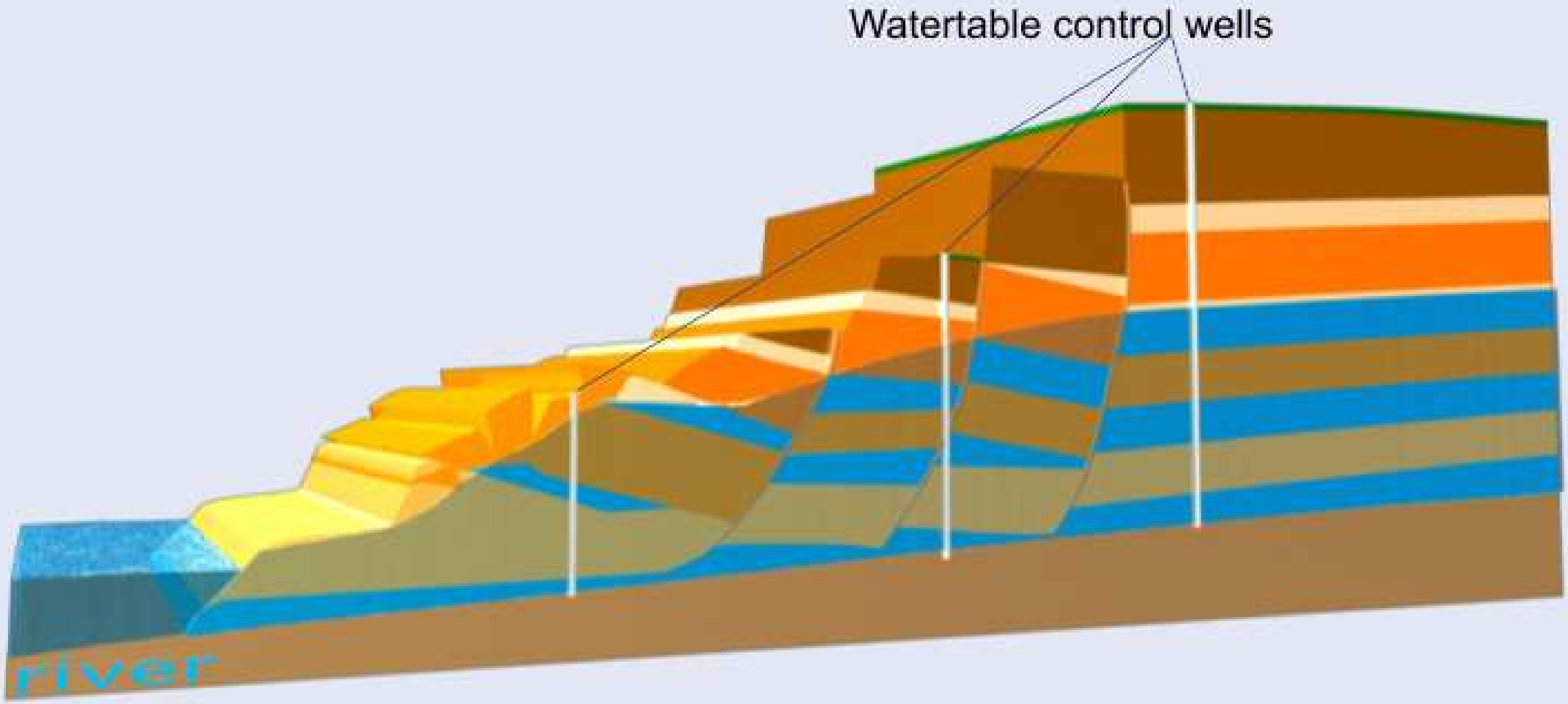
Increase of permeability and outflow capacity of the permeable layers on the land-slide endangered areas

- Very detailed geotechnical and geodesy survey to detect the position, the depth and the thickness of the subsurface layers. Samples for laboratory tests.
- Laboratory tests and evaluation of the test results.
- Drilling a network of groundwater level monitoring wells.
- Mid term monitoring of the groundwater level prior to start with the design works.
- Design of the bored(drilled) subsurface long distance filter collector (drainage) system placed in the permeable layers.
- Construction of the subsurface long distance filter collector(drainage) system with special self cleaning plastic filter pipes by HDD and/or horizontal thrustboring.
- Monitoring the water table decrease.

Detailed geotechnical and geodesy survey, watertable monitoring prior the design works

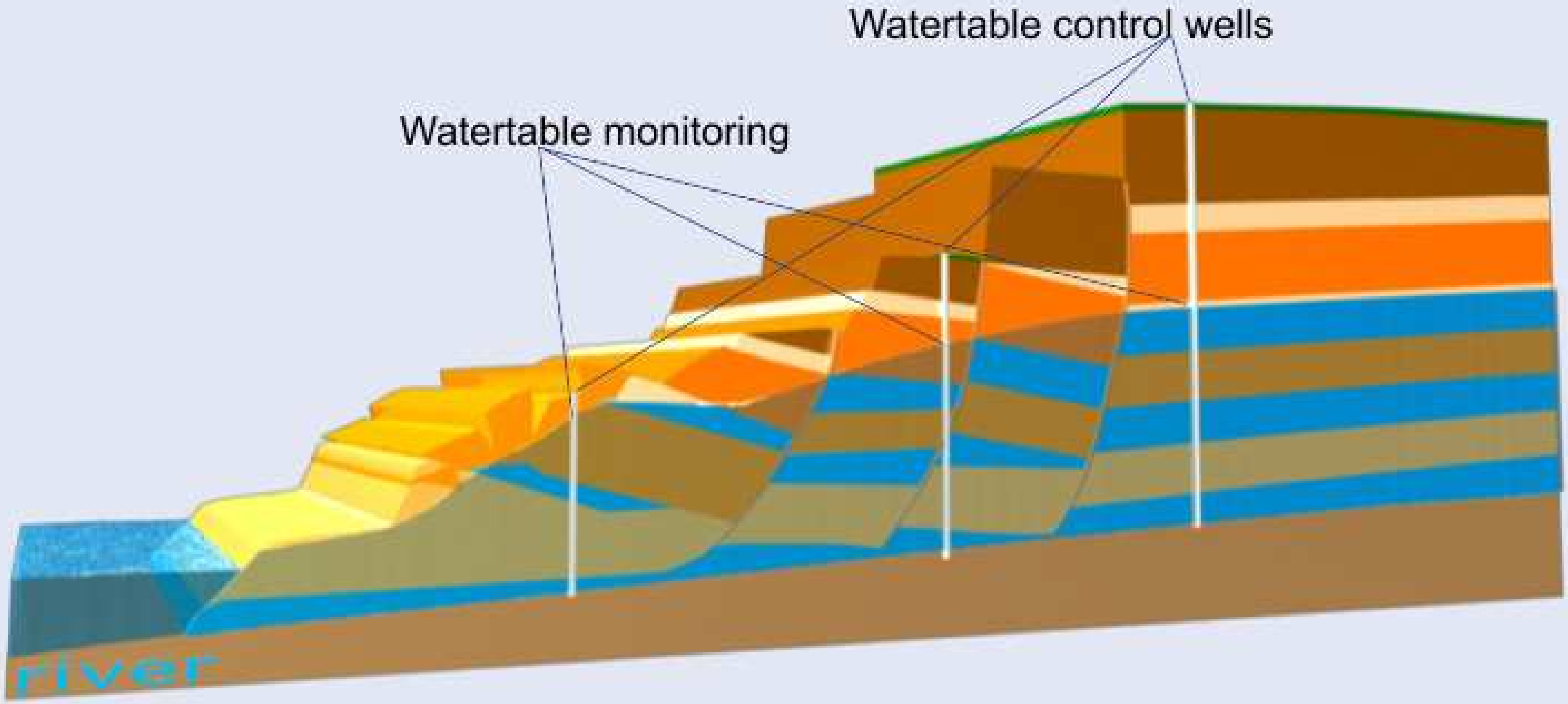


Detailed geotechnical and geodesy survey, watertable monitoring prior the design works



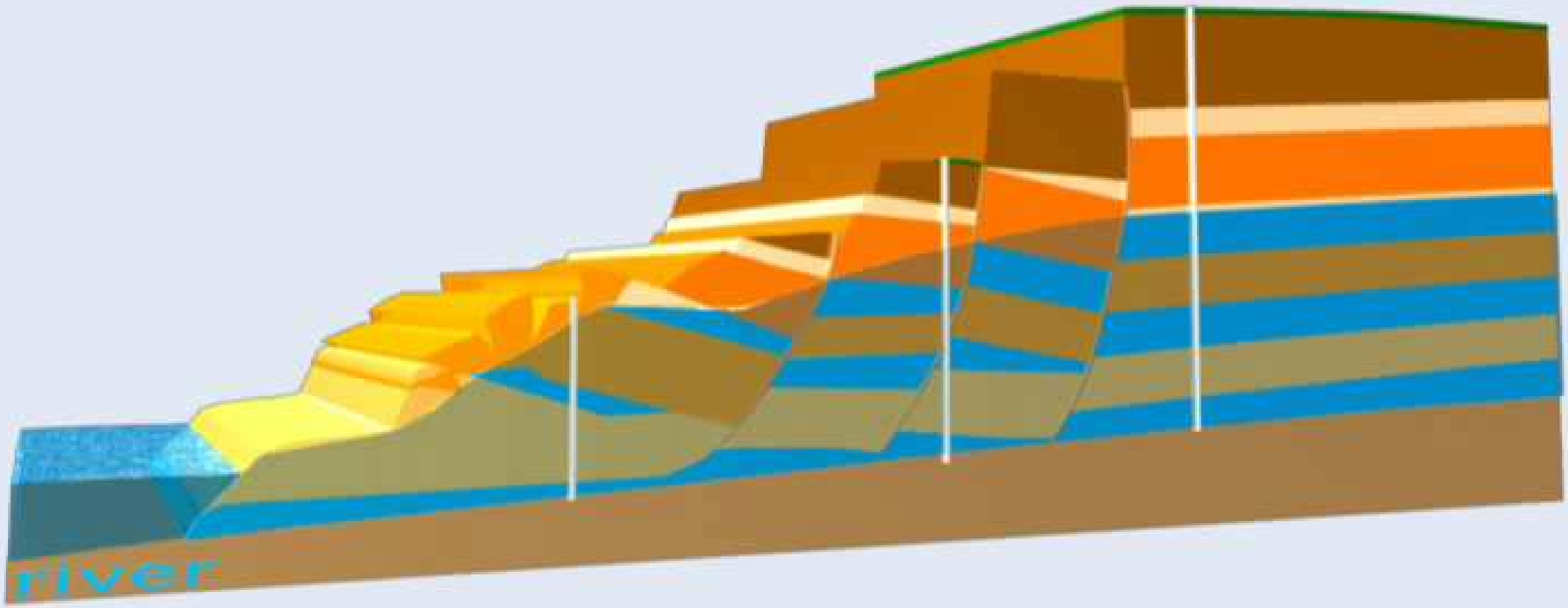
LANDSLIDE PREVENTION

Detailed geotechnical and geodesy survey, watertable monitoring prior the design works

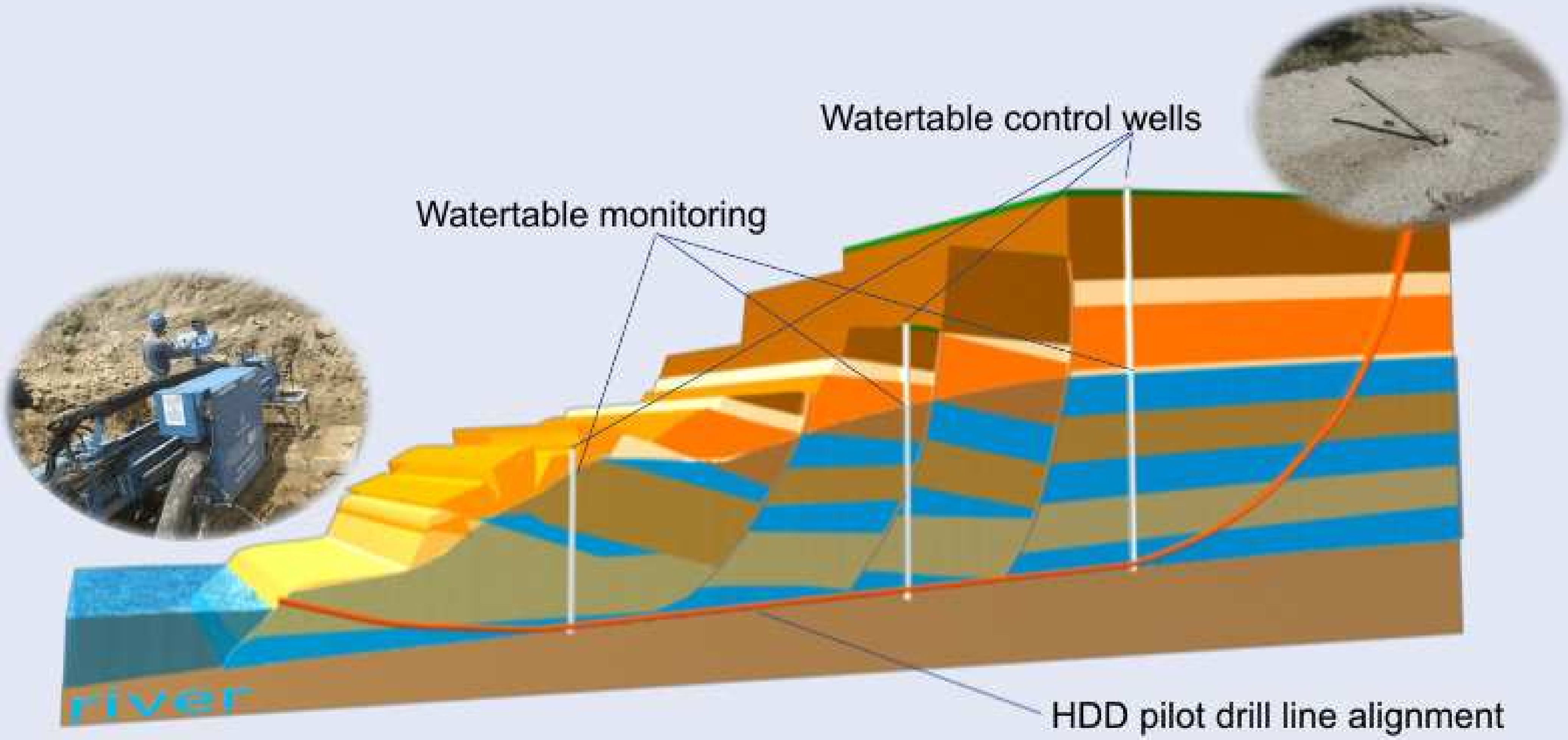


LANDSLIDE PREVENTION

HDD pilot line drill through the possible lowest permeable layers

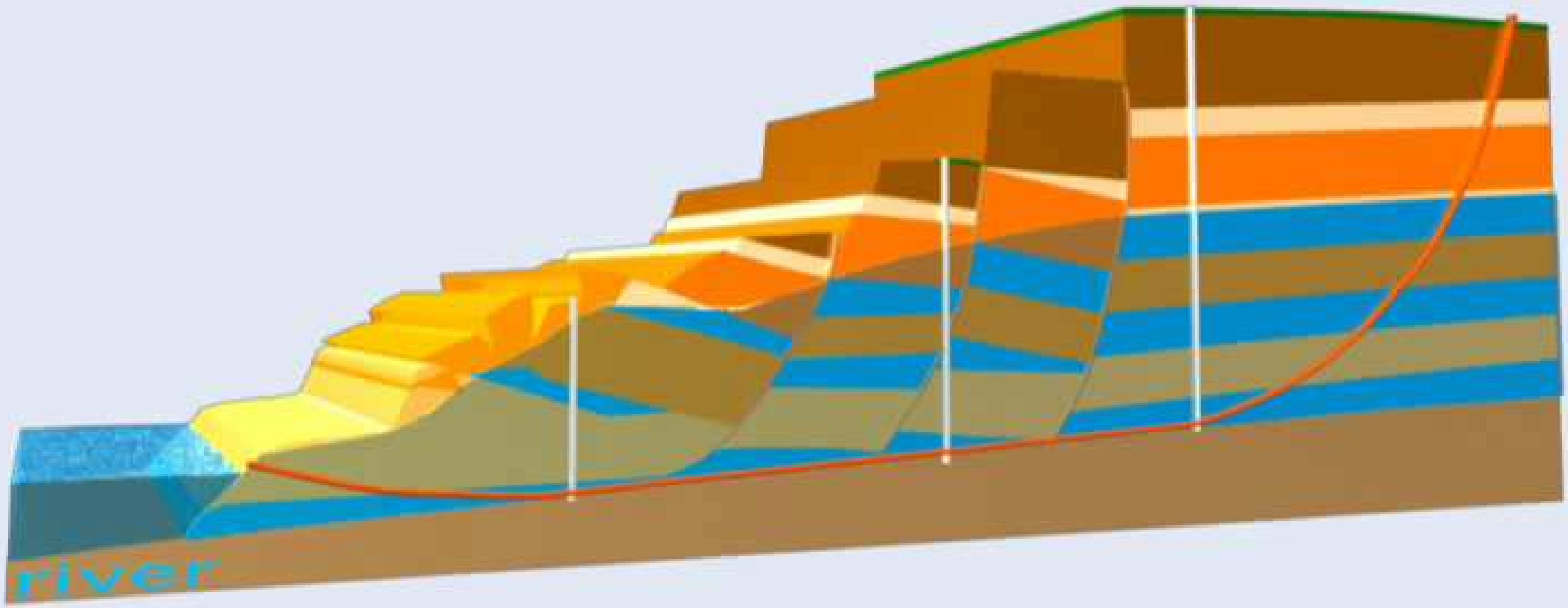


HDD pilot line drill through the possible lowest permeable layers

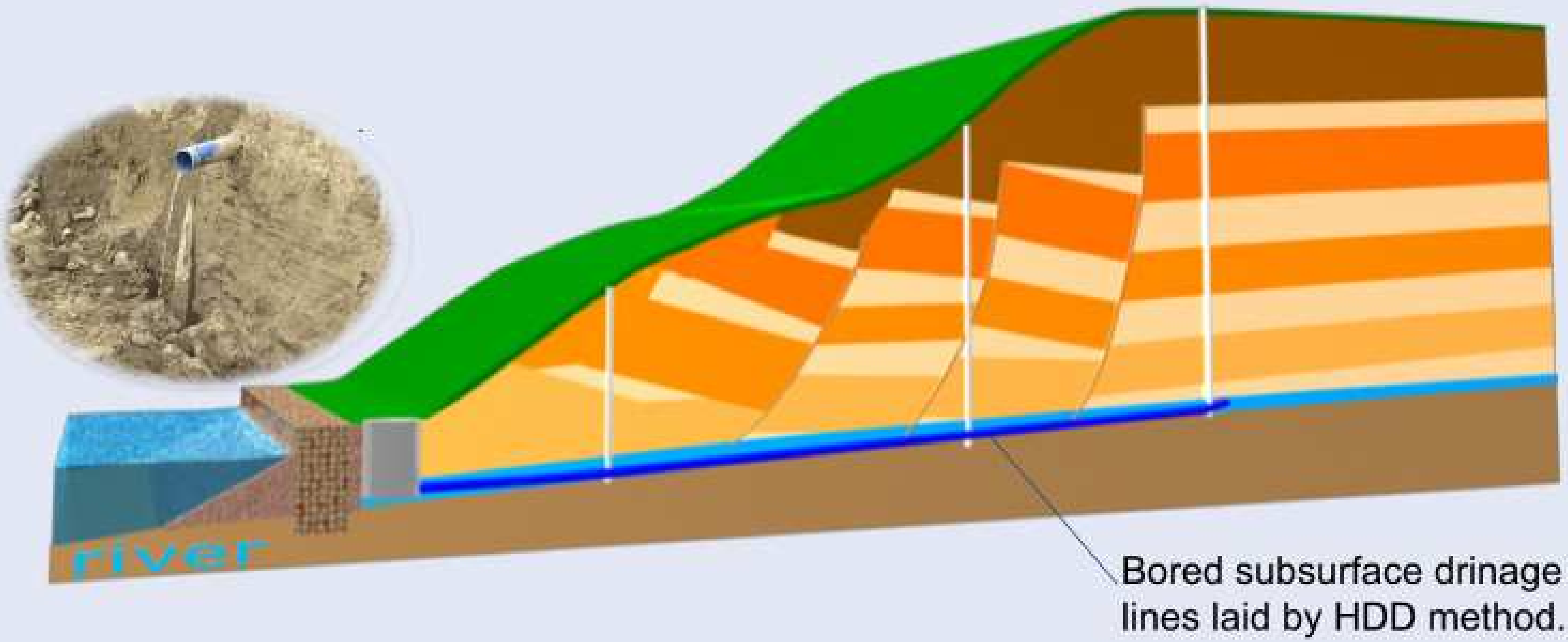


LANDSLIDE PREVENTION

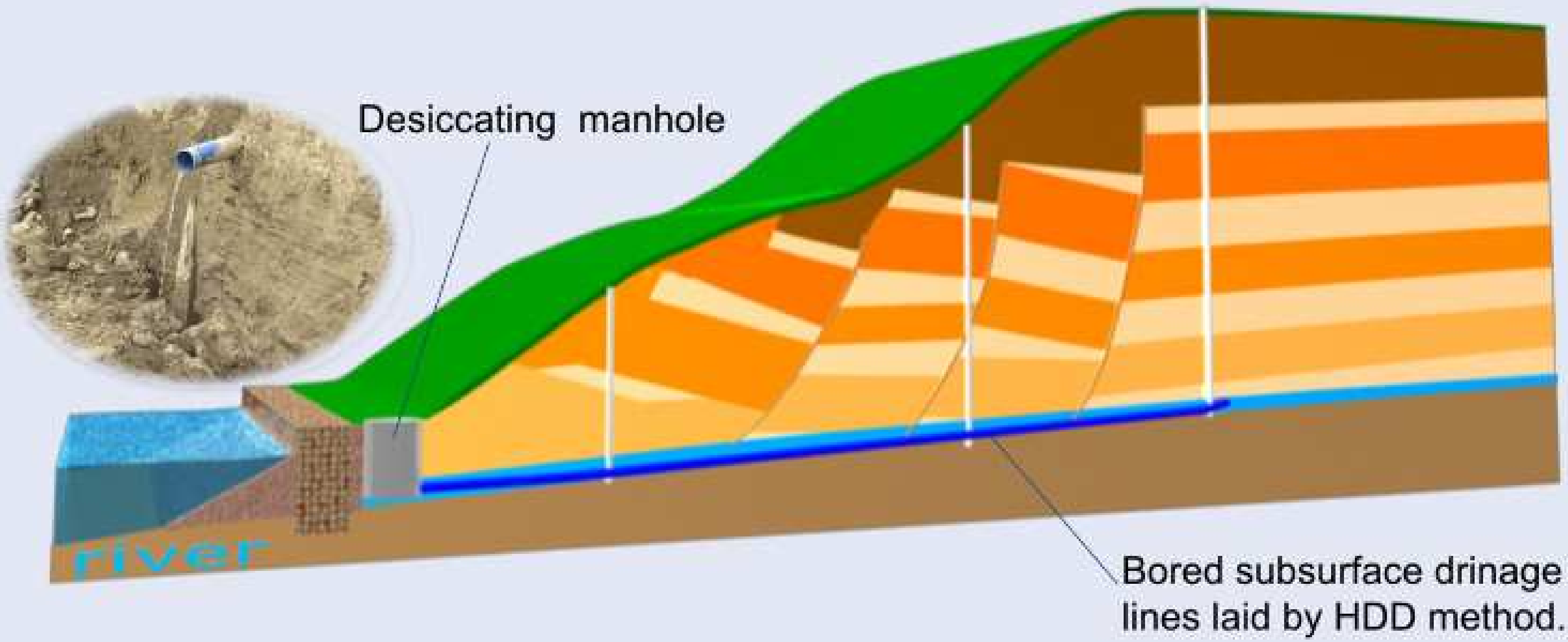
Finished prevention works: special subsurface drainage system with surface leveling and riverside protection structure



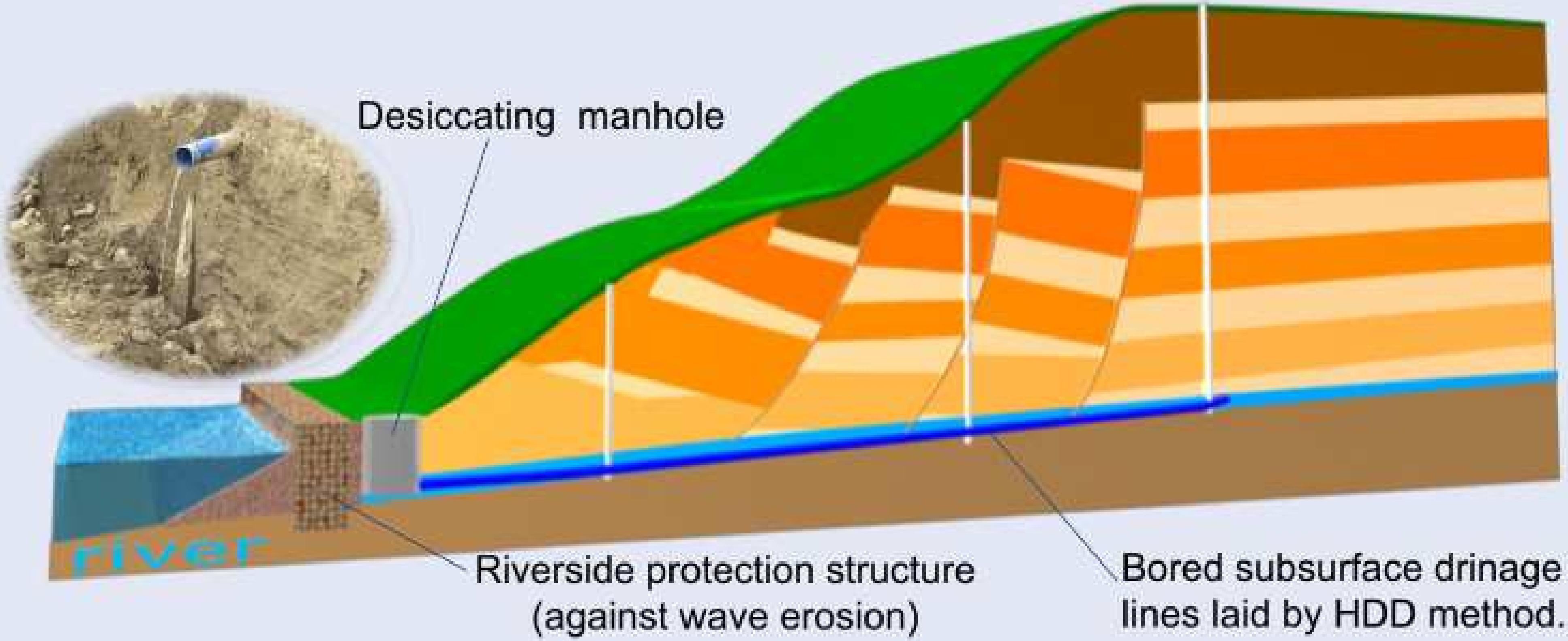
Finished prevention works: special subsurface drainage system with surface leveling and riverside protection structure



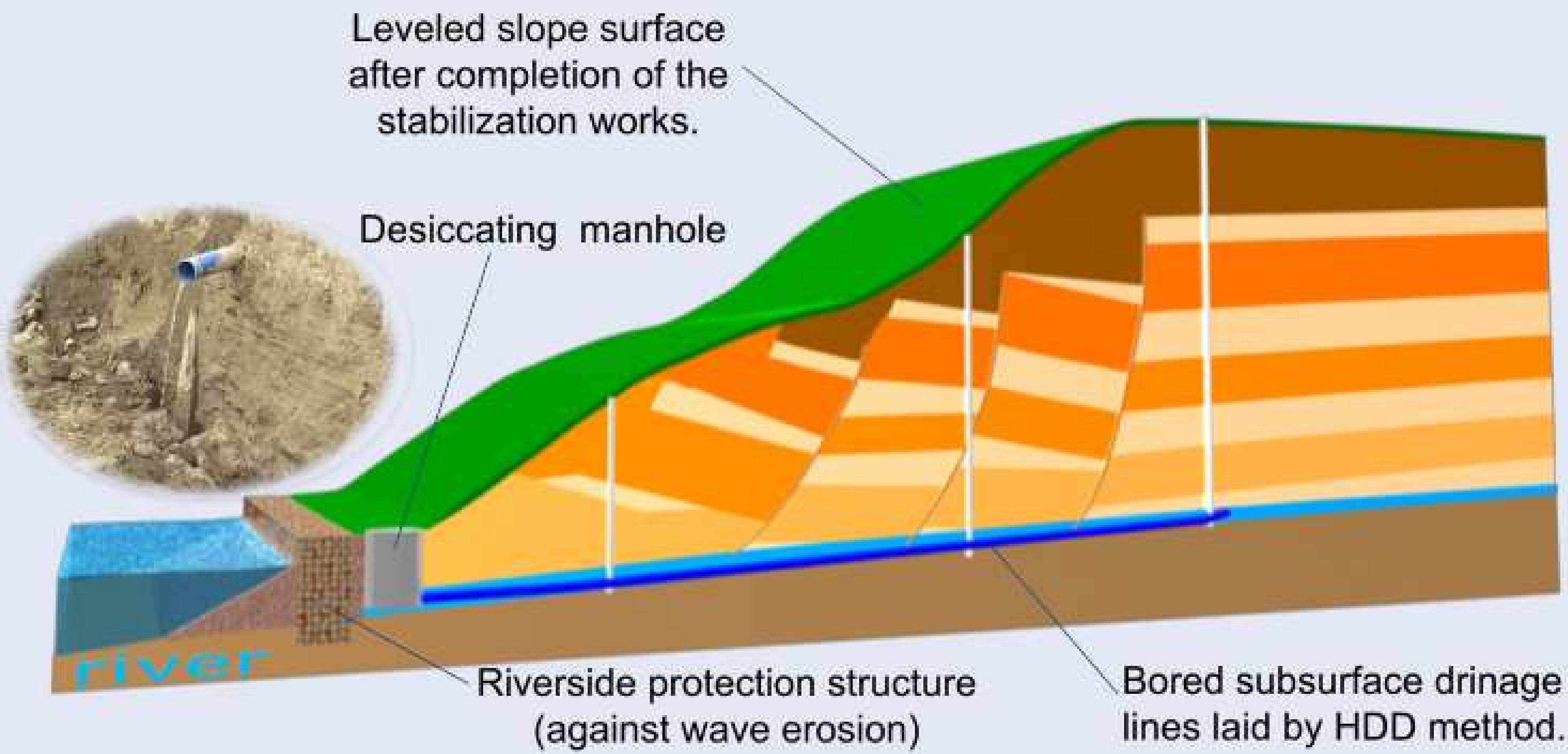
Finished prevention works: special subsurface drainage system with surface leveling and riverside protection structure



Finished prevention works: special subsurface drainage system with surface leveling and riverside protection structure



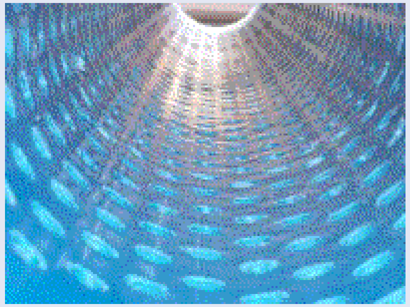
Finished prevention works: special subsurface drainage system with surface leveling and riverside protection structure



LANDSLIDE PREVENTION

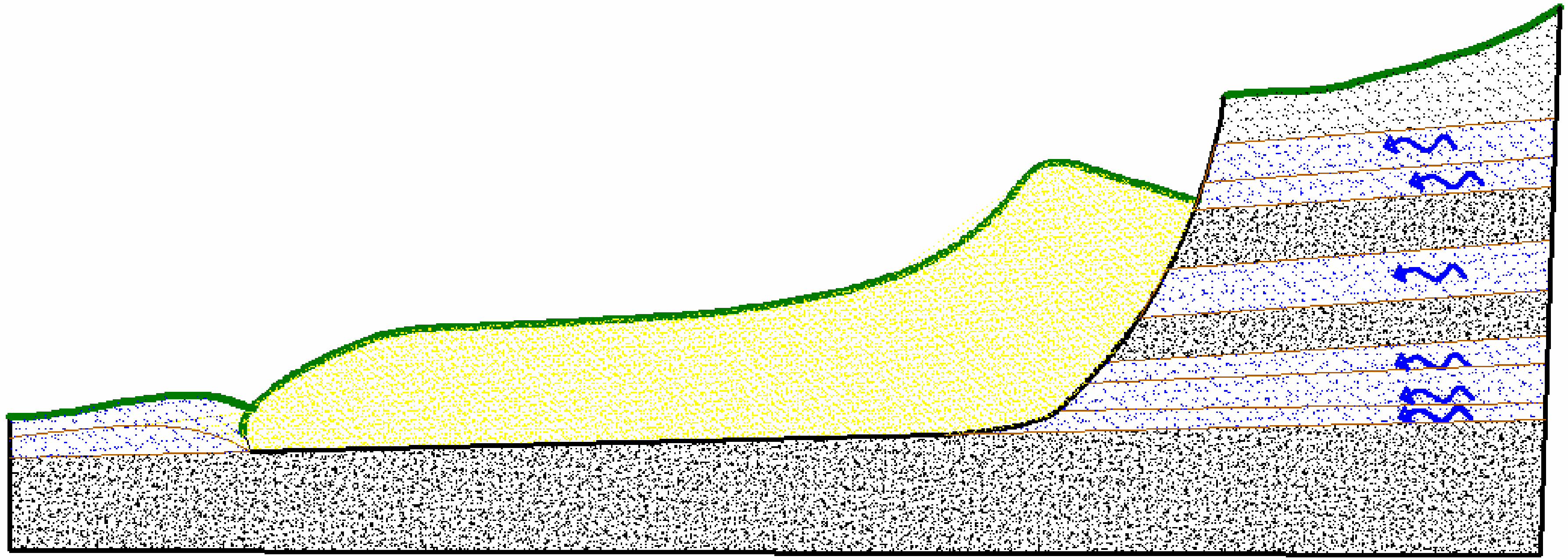
construction of a subsurface drainage system acting as a successful prevention in case of water triggered landslides

- **1** Detection of the permeable layers.
- **2** Test the permeability of the soil in these layers
- **3** Mid time monitoring the watertable on the whole landslide endangered area.
- **4** Selection of the proper, self cleaning filter pipe.
- **5** Design of the subsurface drainage system.
- **6** Laying the subsurface drainage system (by HDD or horizontal thrust-boring)
- **7** Construction of additional protection structures (soil anchors, soil nailing, rc. piles etc.).
- **8** Construction and maintenance the effective surface and subsurface rainwater collector system and sewer network.
- **9** Surface leveling.

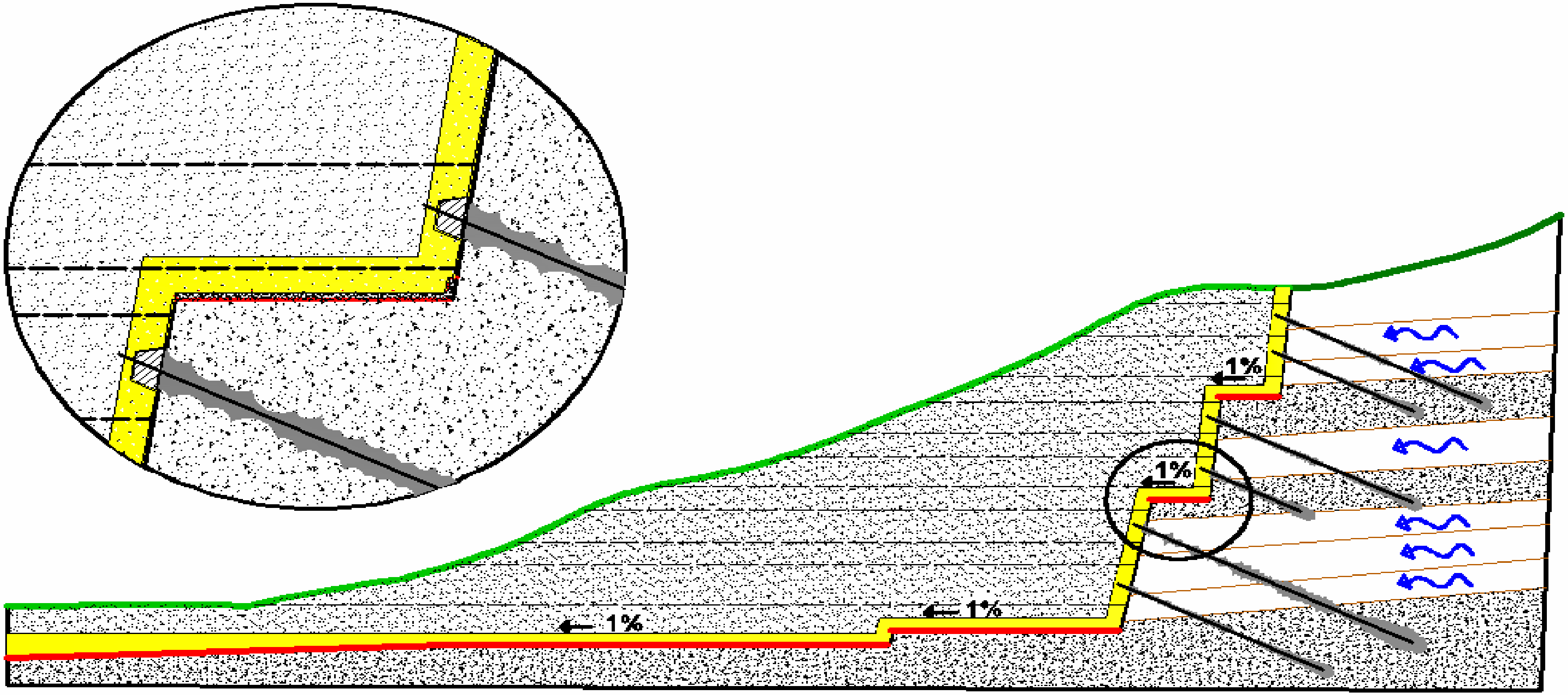


The special self cleaning filter pipe

Slope collapsion ceaused by heavy precipitation triggered landslide



Rehabilittation of the collapsed slope



LANDSLIDE PREVENTION

abilittation of the collapsed slope

Thanks for your kind attention

Questions, remarks?

For additional information please contact me directly:

Istvan Szemesy

Address: **Sycons Ltd**. Harsalja u. 19,H-1029 Budapest / **Hungary**

Phone/Fax : +36 1 3974846, Mobile: +36 20 9787 831

Homepage: **www.sycons.hu**, E-mail: istvan.szemesy@sycons.hu