TOPPS Water Protection

TOPPS PROWADIS

TOPPS ACADEMY

15-18th June 2015

Grugliasco (TO)

DISAFA Università degli studi di Torino

TRAINING COURSE ON PREVENTION OF PPPs CONTAMINATION BY RUNOFF AND EROSION

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DISAFA - University of Torino

RUNOFF team

Who we are

University of Torino

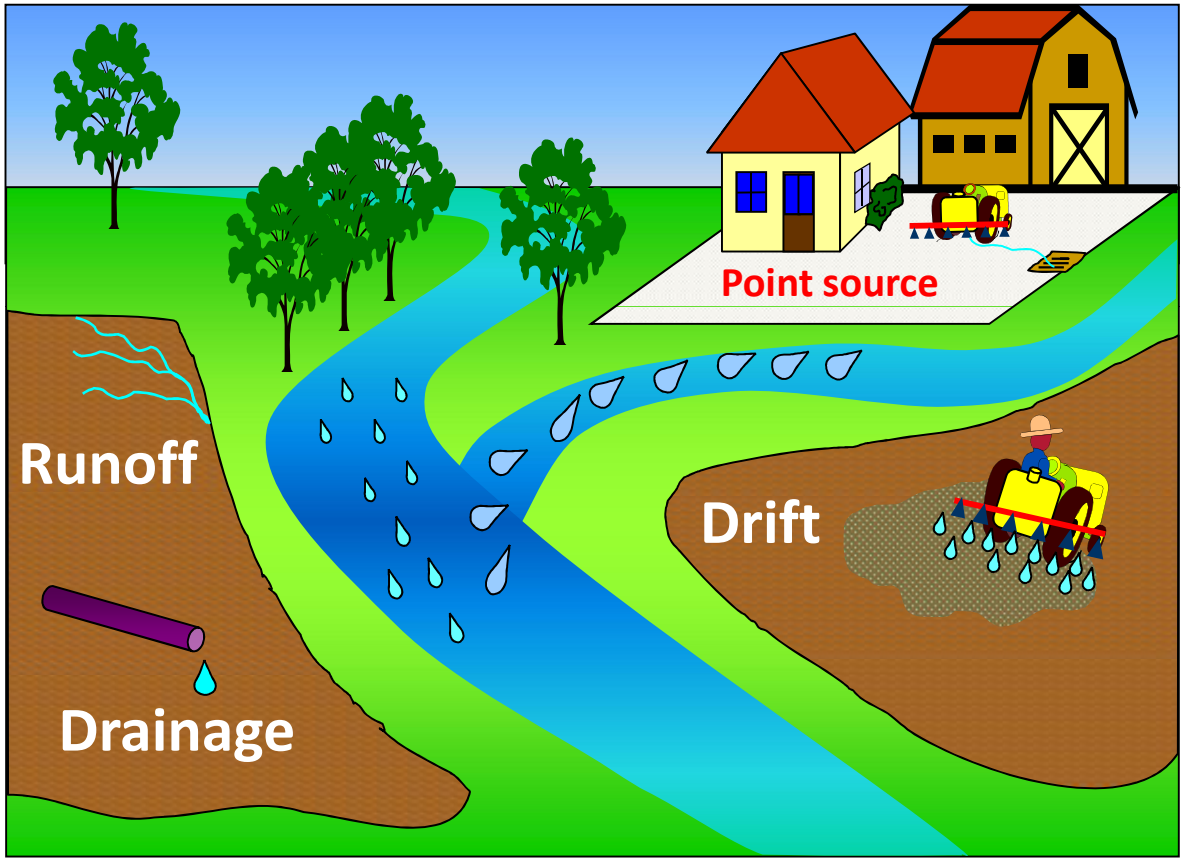
Department of Agriculture, Forestry and Food Sciences

(formerly Faculty of Agriculture)

Sustainable Weed Management research team

- Weed/crop interactions
- Resistance of weeds to herbicides
- Biology and ecology of weeds
- Environmental fate of herbicides

Source of water contamination with pesticide



Diffuse source Runoff about 35 % Drift about 15%	Field
Point source > 50 %	Farm

(da Roettele, 2012)

Directive 2009/128 CE

Article 11 - Specific measures to protect the aquatic environment and drinking water

a) Giving preference to pesticides that are not classified as dangerous for the aquatic environment […]

b) Giving preference to the most efficient application techniques such as the use of low-drift pesticide application equipment […]

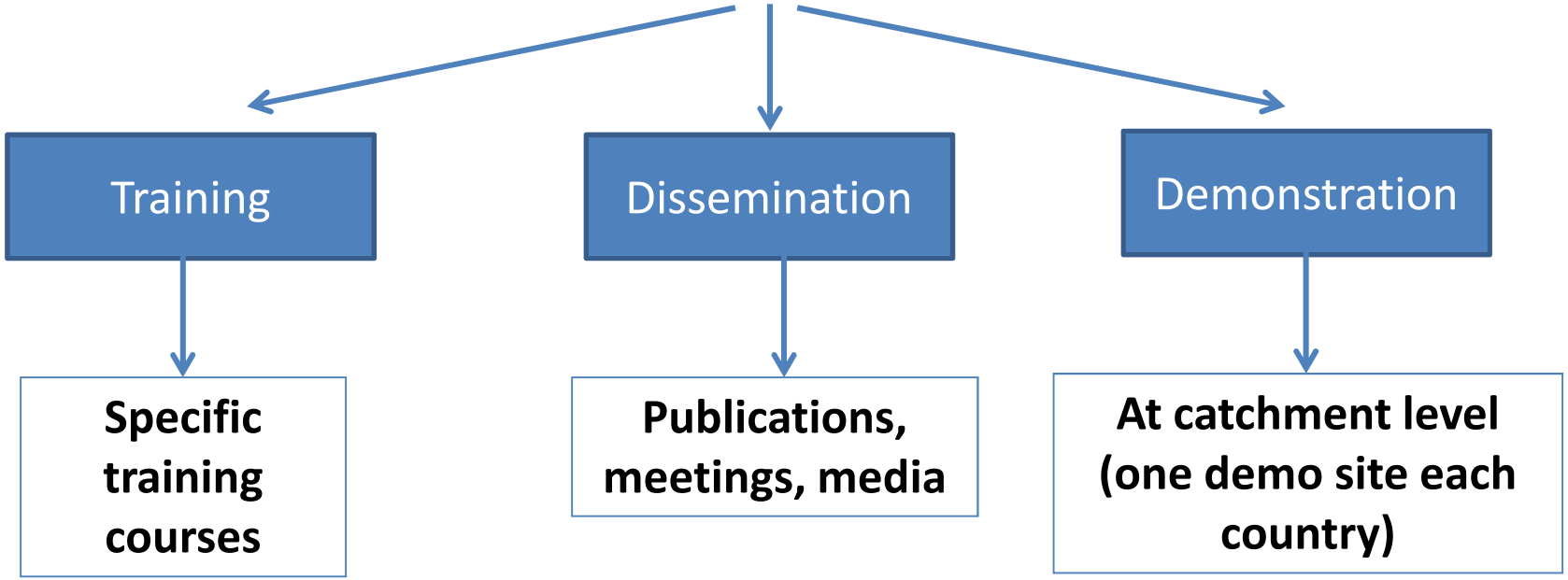
c) use of mitigation measures which minimise the risk of off-site pollution caused by spray drift, drain-flow and run-off. […]

d) reducing as far as possible or eliminating applications on or along roads, railway lines, […] with a high risk of run-off into surface water or sewage systems.

Aims of TOPPS-PROWADIS project 2011-2014

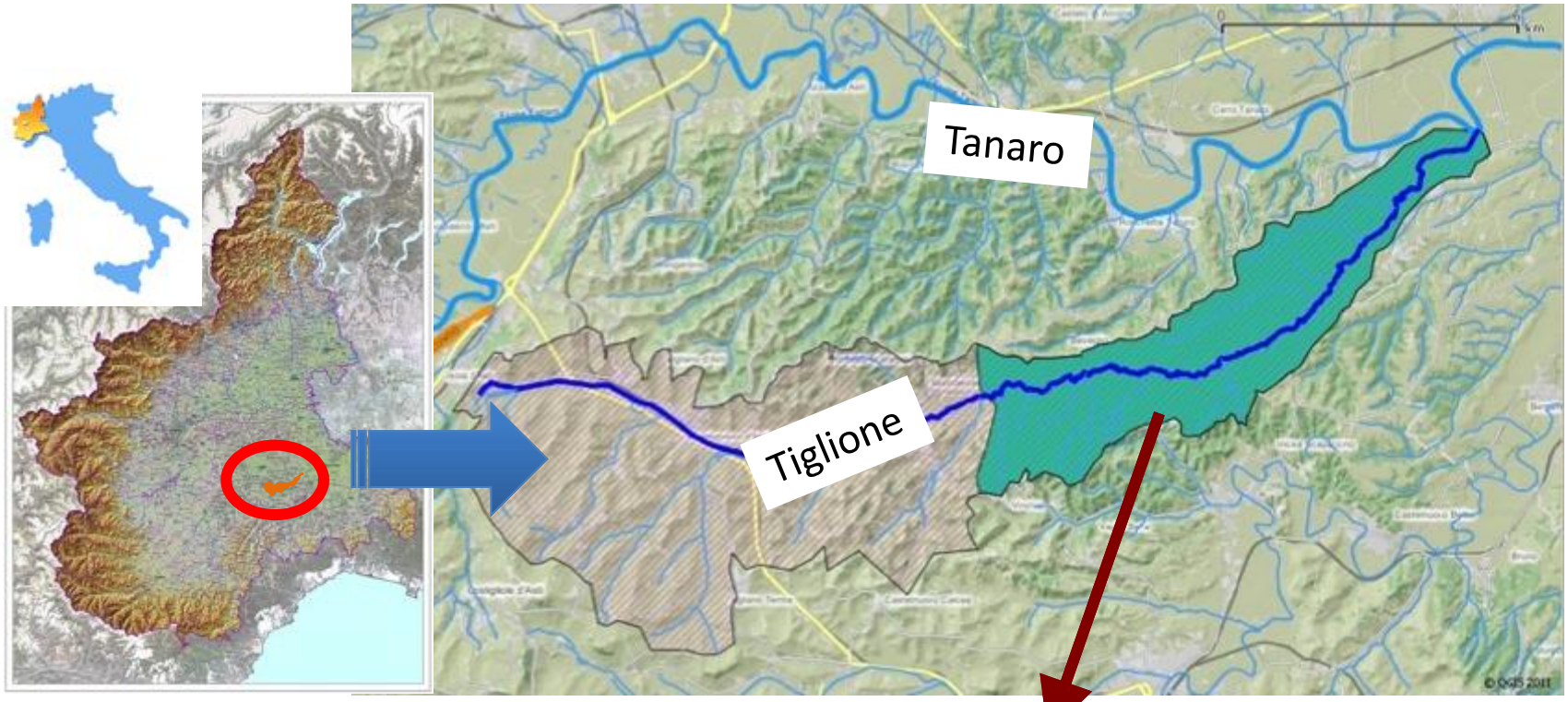
RUNOFF

- **Development of methodology approved at EU level to diagnose the runoff risk**
- **Definition of mitigation measures to limit runoff risk**
- **Dissemination of standard Best Management Practices (BMP)**



Italian demonstration area

Tiglione valley



Tiglione catchment area
about 6900 ha
Tiglione river
total lenght: 25.7 km

Sub-catchment
about 3300 ha
Tiglione river
total lenght in sub-catchment: 18.0 km

Tiglione valley

Tiglione valley

Runoff

Runoff

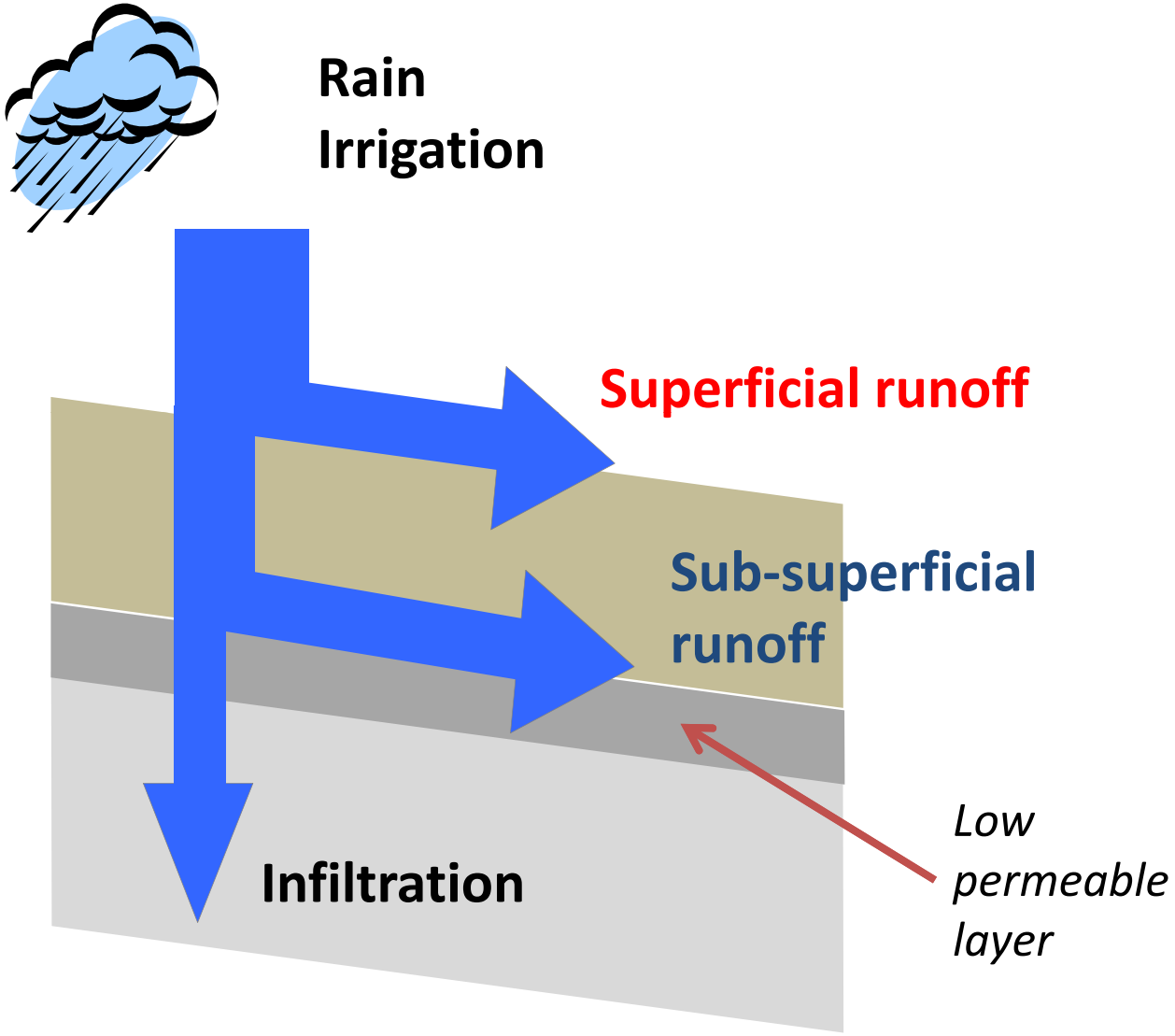
- Runoff is the movement of the water on soil surface and into the subsurface
- Originated from rain and irrigation

Runoff cause transport of:

- substances dissolved in water (**runoff**)
- particle of soil (**erosion**)

Runoff

Superficial and sub-superficial runoff

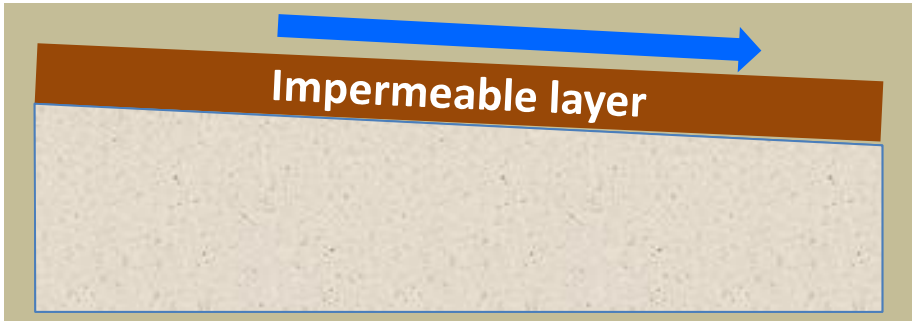


Runoff

Type of superficial runoff

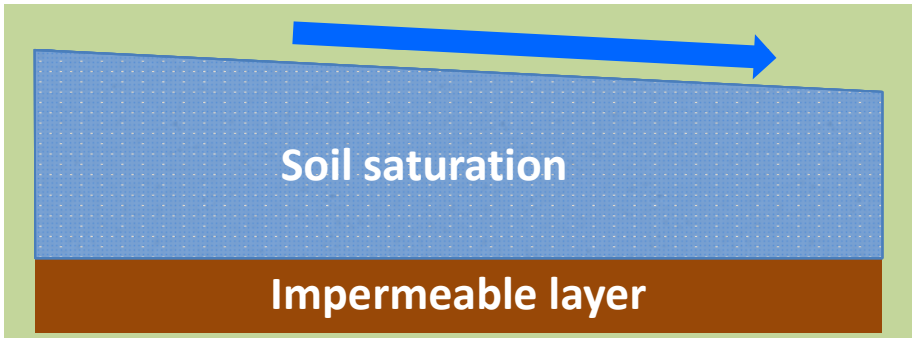
Infiltration restriction

Low permeable layer on surface
(e.g. capping)



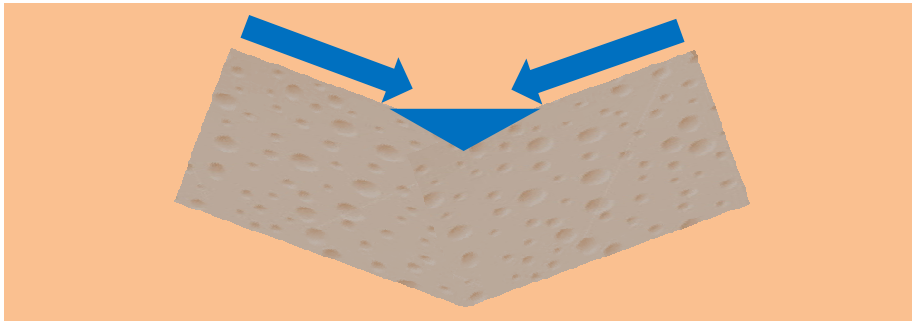
Saturation excess

Low permeable layer in depth (e.g. plough pan/permeability disruption)



Concentrated runoff

Runoff in talweg

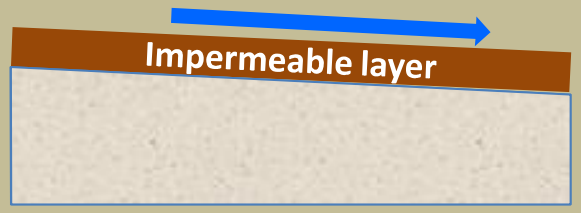


Type of runoff

Runoff due to infiltration restriction

Infiltration restriction:

a) Heavy texture / poor structure
b) Capping, crusting, compaction
c) High and short intensity storms
d) Low vegetative cover
e) All year long



Type of runoff

Runoff due to saturation excess

Saturation excess:

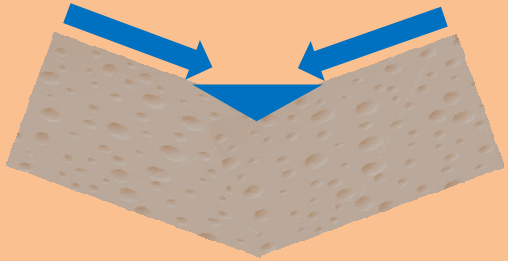
a) Shallow soils
b) Impermeable layers
c) Concave slopes
d) Mainly in winter or early spring

Type of runoff

Runoff due to concentrated flow

- Water collected from the field produce concentrated water flows
- Runoff is often associated with sediment transportation (erosion)
- Depends on slope and soil management

TALWEG



Type of runoff

Concentrated runoff

GULLY EROSION

DEPOSITION

Type of runoff

Concentrated runoff

Type of runoff

Concentrated runoff

GULLY EROSION

Type of runoff

Concentrated runoff

Runoff

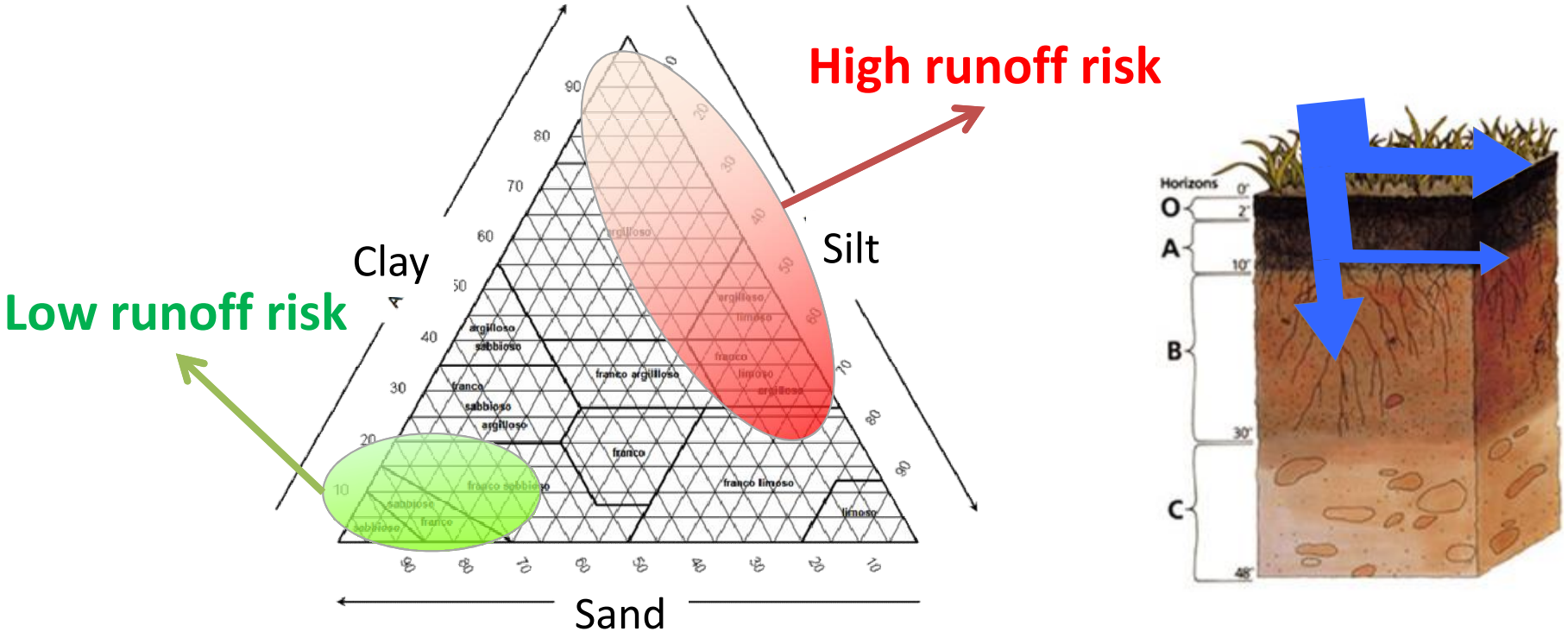
Factors influencing runoff

- Soil characteristics: permeability, texture, capping, water holding capacity, depth
- Topography: slope, field shape
- Soil cover
- Barrier to water movement
- Rain intensity and frequency
- Proximity to surface water

Runoff

Soil

Soil permeability affected by texture, structure of soil, organic matter content, soil covering, stratigraphy of soil



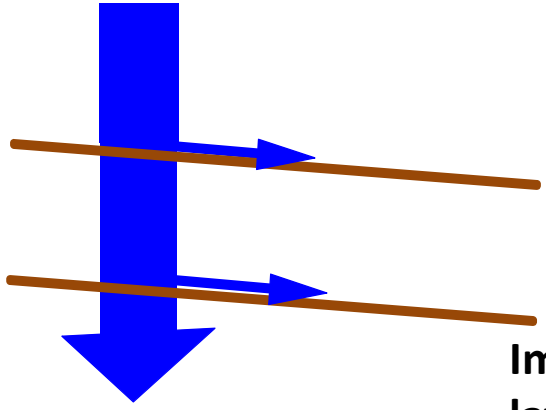
Runoff

Soil permeability

Key-factor of water infiltration in soil

High permeability

No runoff



No obstacle to infiltration

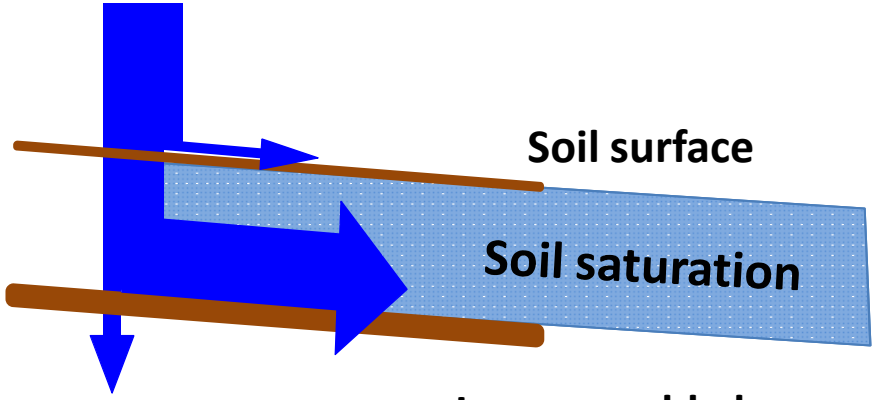
No superficial runoff

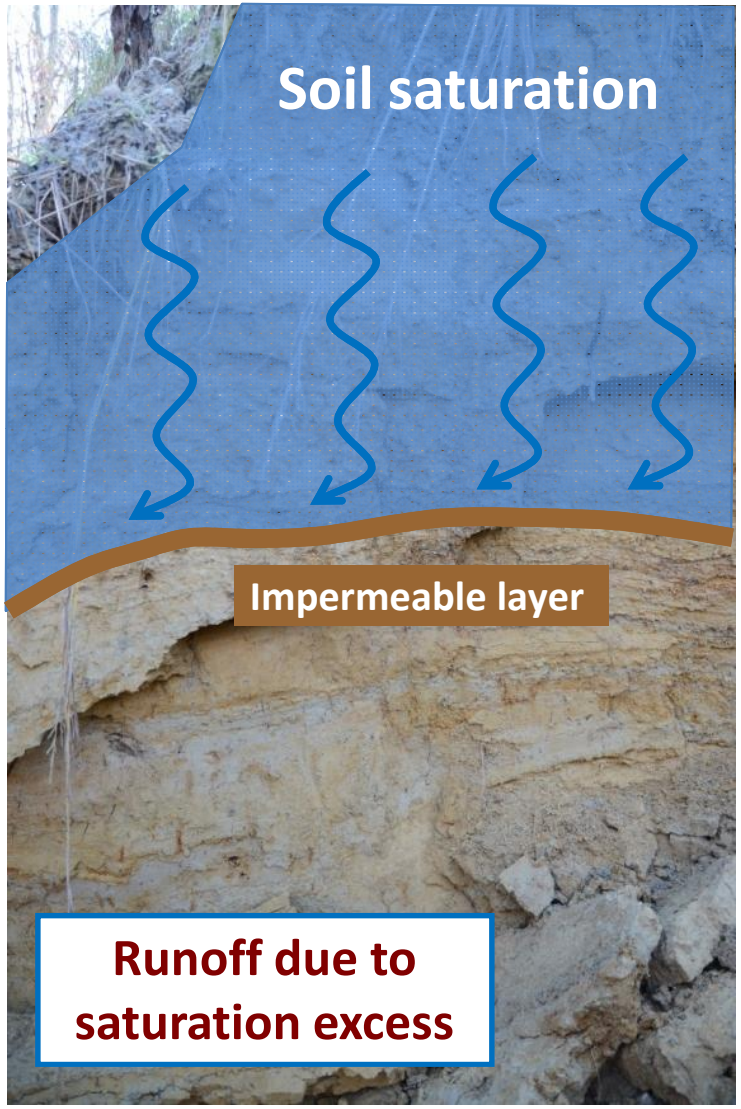
Runoff

Soil permeability

Low permeability in sub-surface

Superficial and sub-superficial runoff





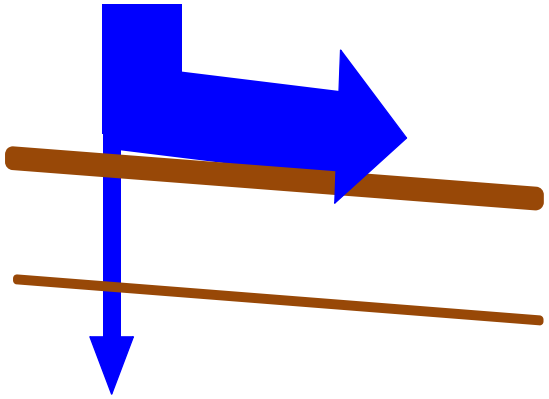
Runoff

Soil permeability

Low permeability in surface

Soil capping

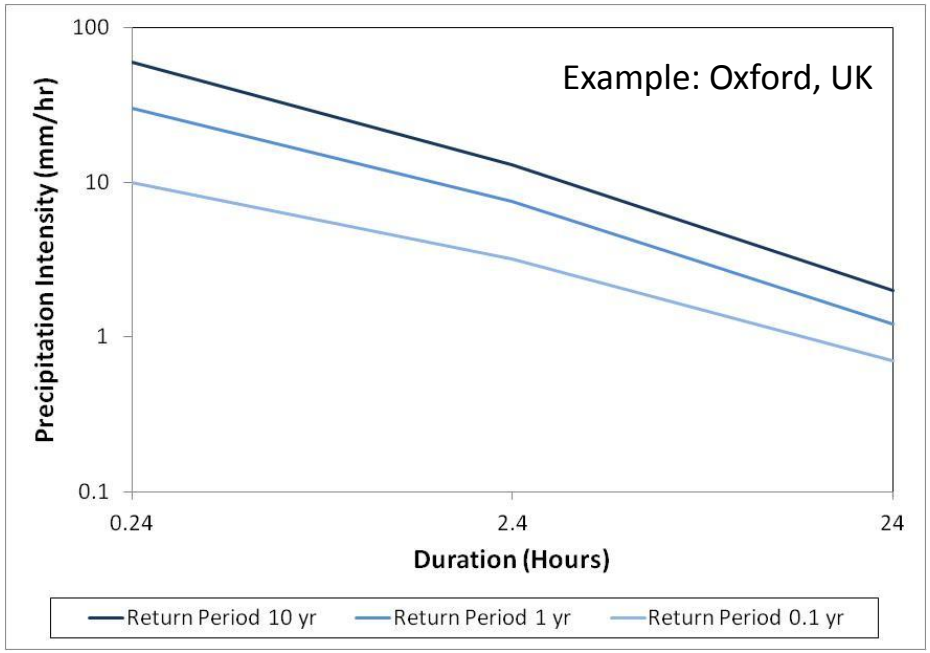
Superficial runoff



Runoff due to infiltration restriction

Weather

Weather patterns: frequency, intensity & duration



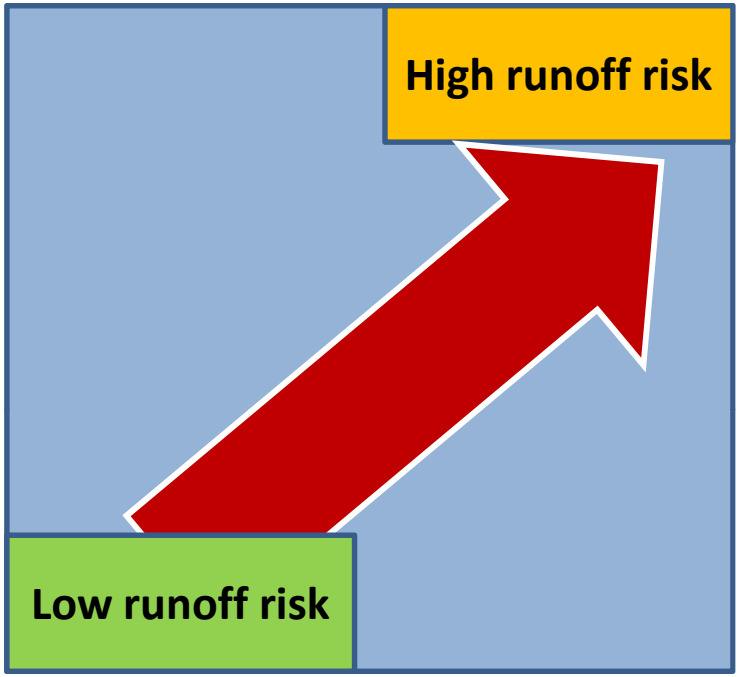
- Representative weather patterns should be taken as benchmarks to determine needed risk mitigation
- Extremes are difficult to mitigate

Runoff

Infiltration restriction

Rain intense (big volume in short time)

Rain less intense (low volume in long time)



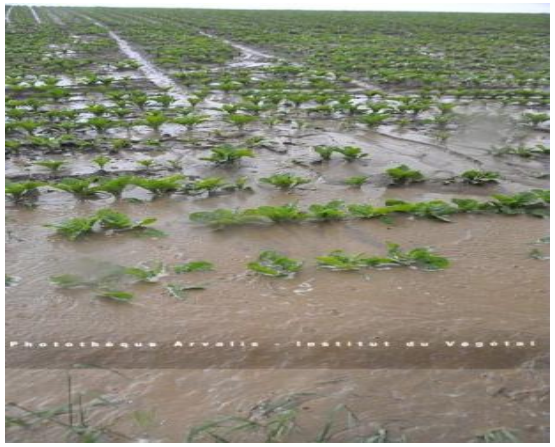
No capping soil; soil surface **permeability high**

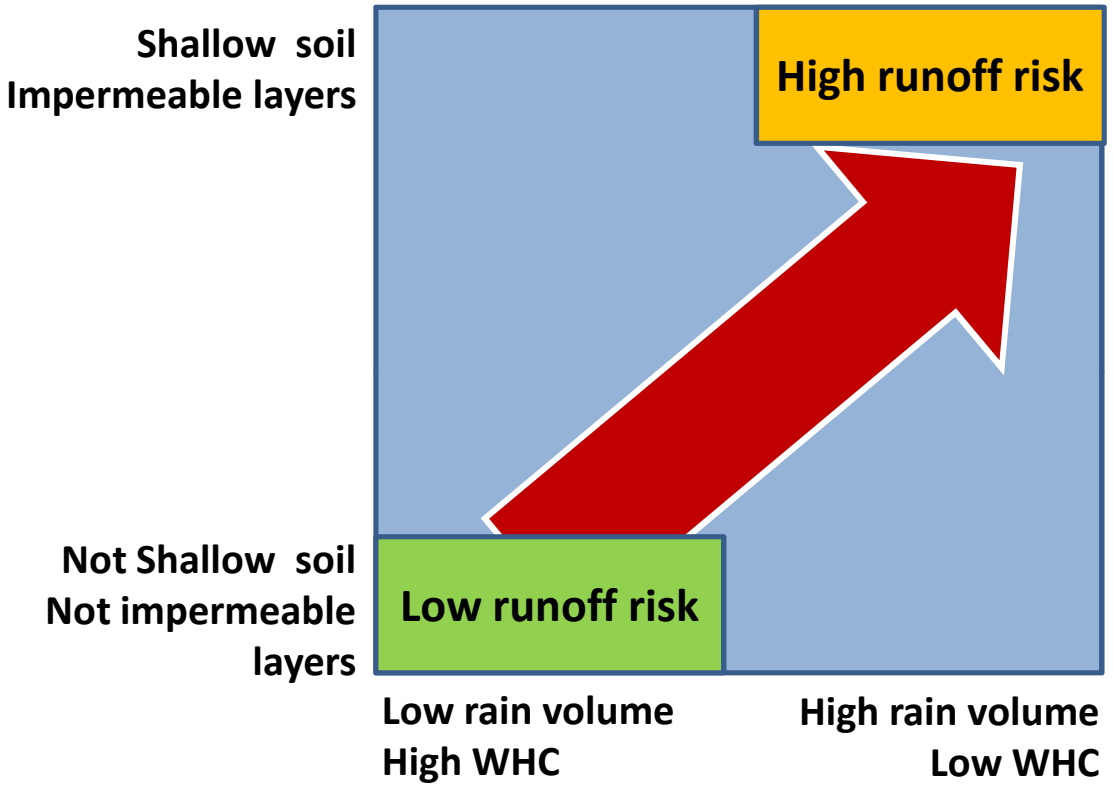
Capping soil; soil surface **permeability low**

More a rain intensity problem (spring summer)

Runoff

Saturation excess



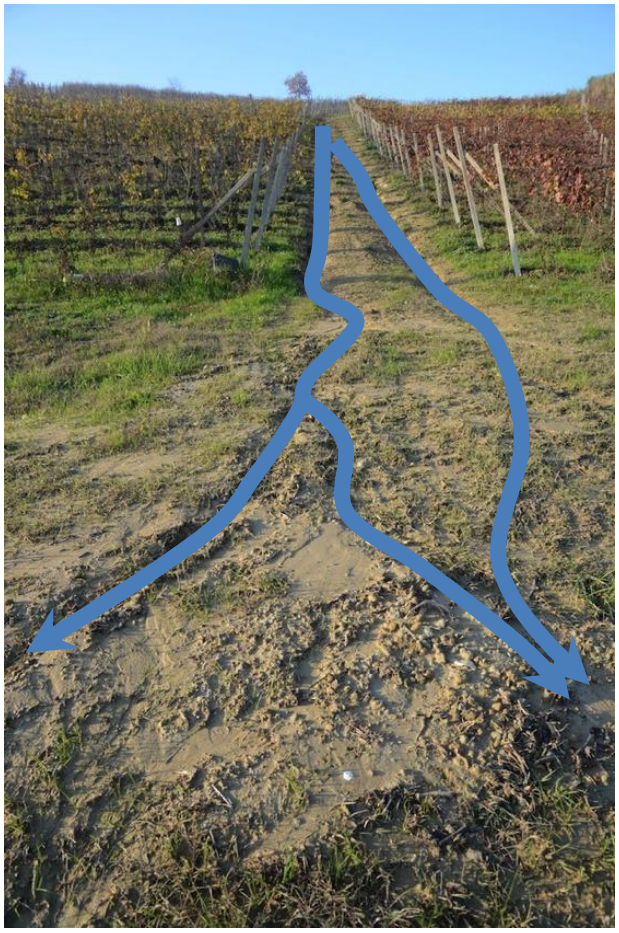


More a rain volume and water storage capacity problem (winter)

Runoff

Slope

Steep fields have a high risk of runoff and erosion than flat fields due to the higher speed of the surface water flows.



Runoff

Length and size of field

- Large fields have a high risk of runoff through concentrated water flows on soil surface
- Major risk with crops/plantations planted along the slope. Prefer planting across the slope (contour tilling)
- Divide large fields vulnerable to runoff by implementing vegetate buffers/barriers

Runoff

Roughness and soil covering

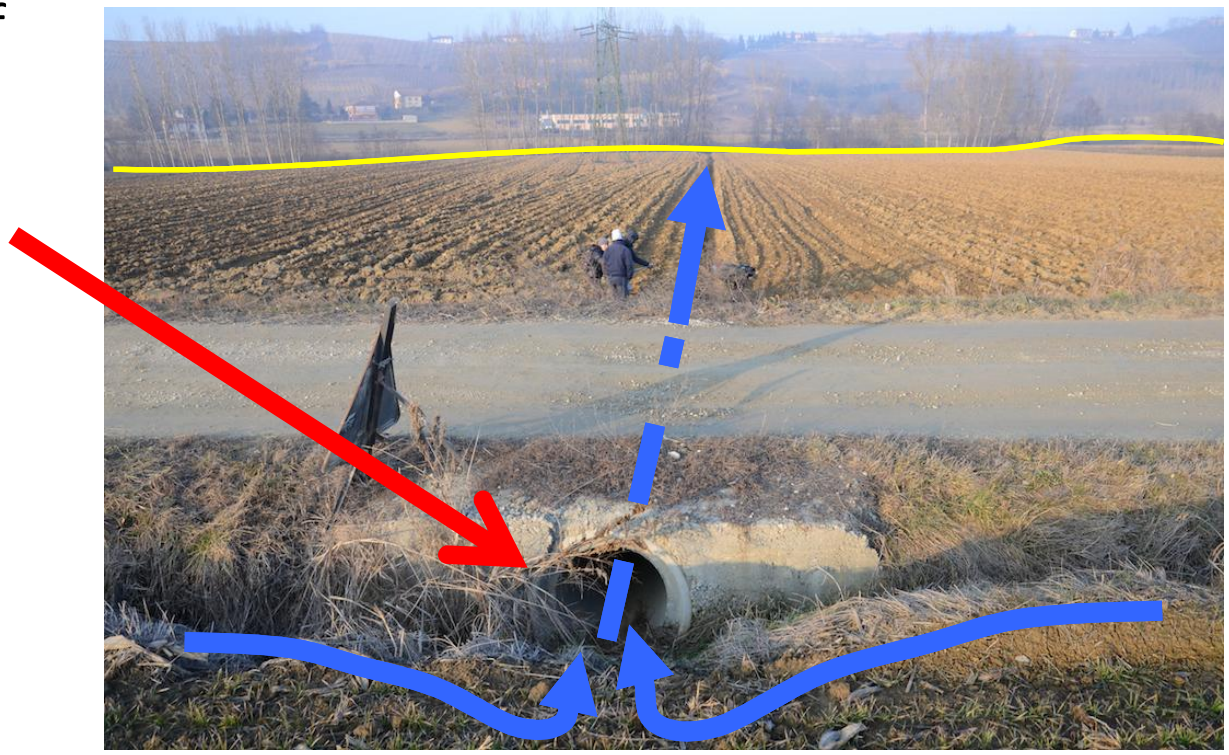
- Roughness and soil covering limit runoff and erosion
- Increase the infiltration of water into the soil and retain water into the field
- Linked to soil management and cropping practices

Runoff

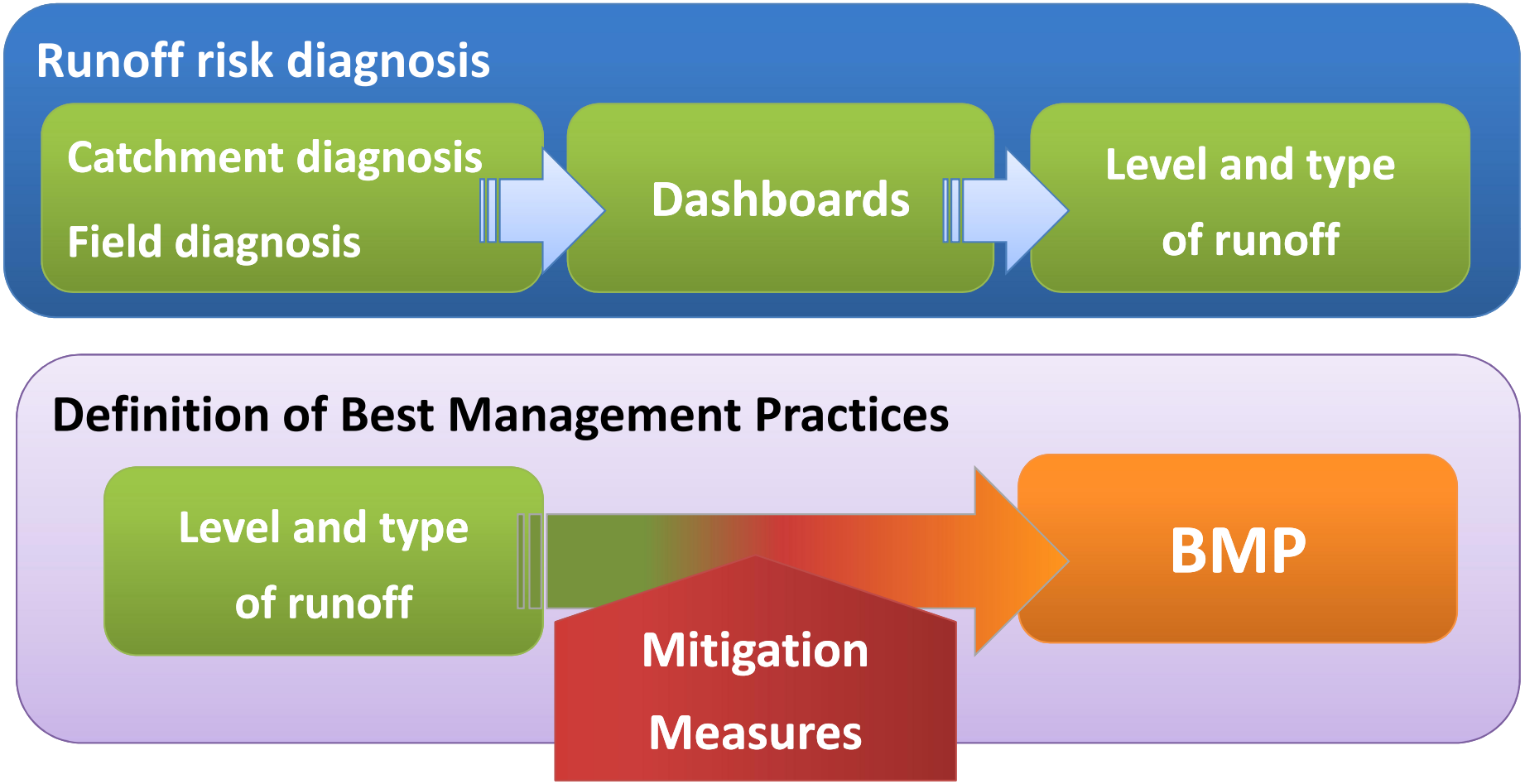
Proximity to surface water

- Low risk of water contamination in fields far from water body.
- Consider speed of the water flow directed to the superficial water body.

- Shortcuts move runoff water from uphill directly to the stream

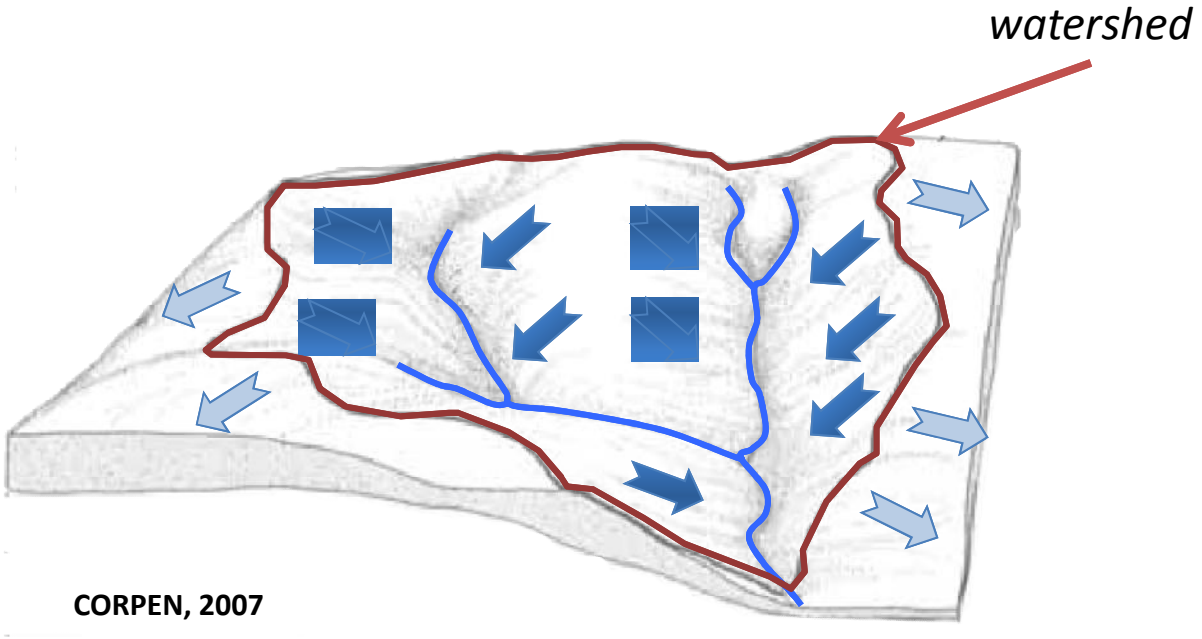


TOPPS-Prowadis approach to determine risk of runoff and BMP



Runoff

Diagnosis at catchment level



CORPEN, 2007

- Runoff is generated and produce effects at CATCHMENT and FIELD scale.
- Water body pollution is caused if contaminated surface water leaves the field.
- Mitigation measures can be achieved through field practices and vegetative buffers retaining water in the field.

Catchment and field diagnosis

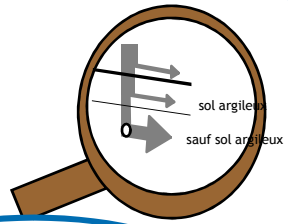
1

Diagnosis preparation: Identification of landscape, of the type of soil,climatic data, field maps

2

Field diagnosis: Diagnosis of soil water flow regime, agronomic practices, landscape factors

3



Define risk situations with the dashboards

Field diagnosis based on
Arvalis Inst. du vegetal methodology:
Aquaplaine

Catchment diagnosis

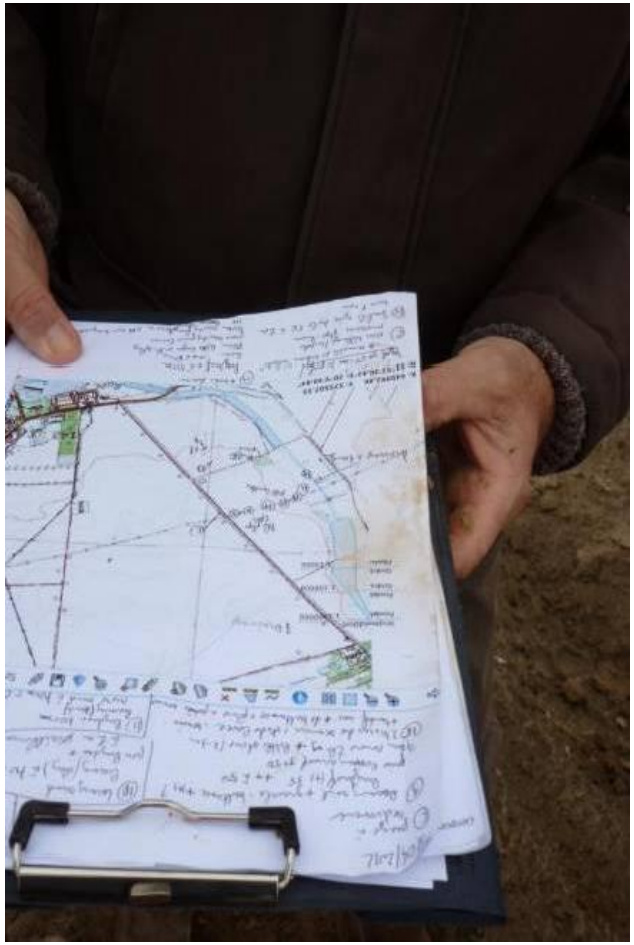
Information on farm practices and landscape

Maps on:

- **Pedology**
- **Geology**
- **Slope**
- **Hydrology**
- **Hydrography**
- **Crop rotation**

….. Data gathering often possible to prepare in the office.

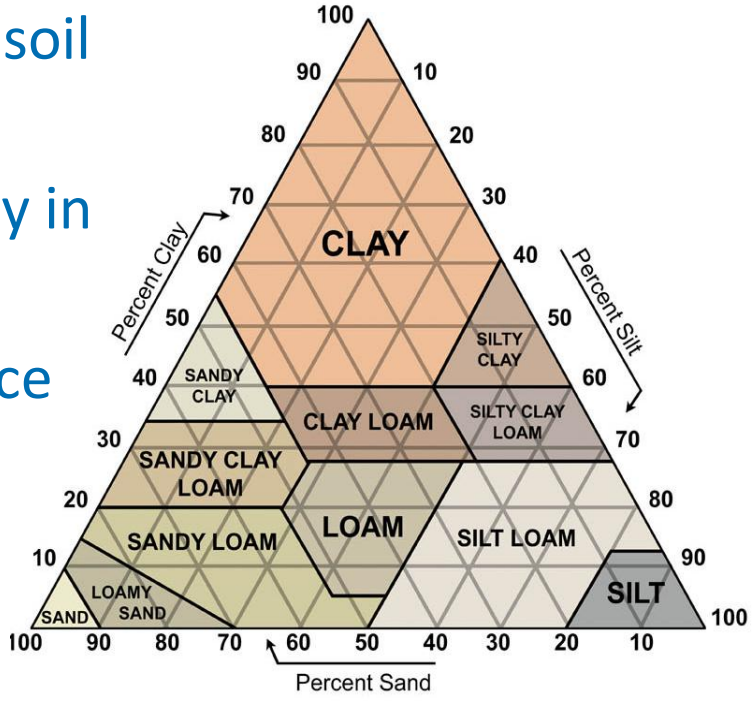
Field diagnosis



Field diagnosis

Identify soil characteristics

- Determine the substrate permeability
- Determine the permeability of the surface horizon
- Determine changes in permeability in soil profile
- Determine the available water capacity in top soil
- Observe evidence of capping or surface run-off / erosion



Field diagnosis

Symptoms for water saturation: Hydromorphic soils

- Hydromorphy is a visible result from water saturation in the soil. This saturation occurs because of a lack of natural drainage (high groundwater), or due to a subsoil layer of low permeability.

Indicators

- Colored areas below top soil are visible (green, grey colors, iron and manganese accumulation / concretions, with red-brown and black colors).
- Low-permeability subsoil (clayey or loamy subsoil, hard rock or rock rubble such as a shale layer, a granitic layer, a non karstic limestone layer) at 80 cm or less below a more permeable topsoil (sand or sandy loam)
- Soil remain wet for at least 2 to 5 days after rain.

Field diagnosis

Symptoms for water saturation: Hydromorphic soils

Field diagnosis

Symptoms for capping soil

- Pour structural stability of soil surface (splash effects from raindrops)
- Soils with large portions of fine sand and silt are typically susceptible to capping

Indicators

- Fine layers of sediments are visible on soil surface layer
- Soil lacks medium and coarse sand particles

Field diagnosis

Crusted soil

Source : J.Maillet-Mezeray- ARVALIS

Field diagnosis

Field diagnosis

Concentrated runoff

Field diagnosis

Concentrated runoff

Concentrated runoff is in most cases associated with massive transfer of soil (erosion)

Field diagnosis

Concentrated runoff

Pictures: JMM - ARVALIS

Signs of erosion indicate concentrated runoff and always needs mitigation measures

Field diagnosis

Determine the effect of practices: soil management & cropping practice

- Soil covering (crop and date sown)
- Soil cultivation (intensity of tillage, surface roughness)
- Crop rotation /Crop distribution (Winter / Spring)

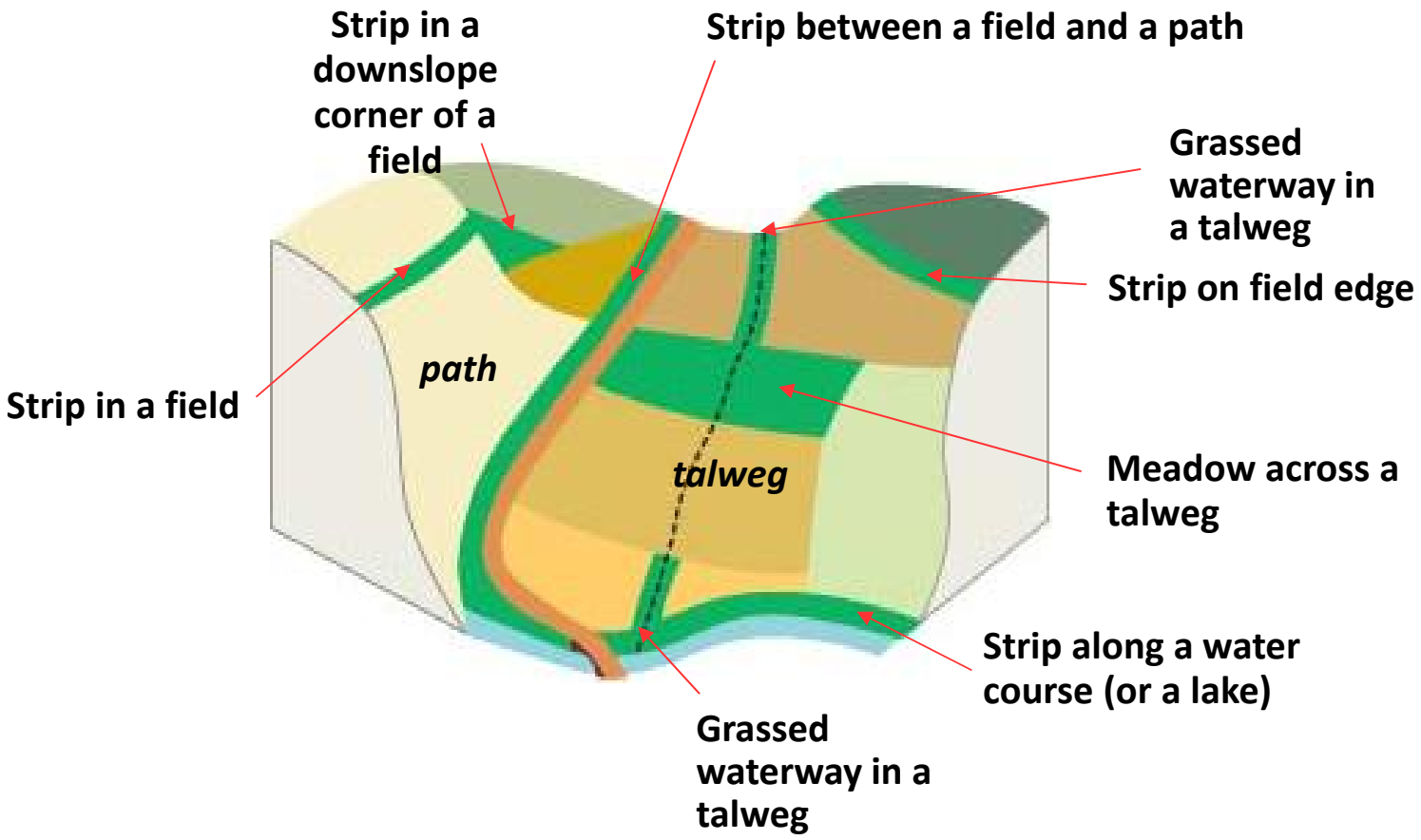
Field diagnosis

Determine relevant landscape elements

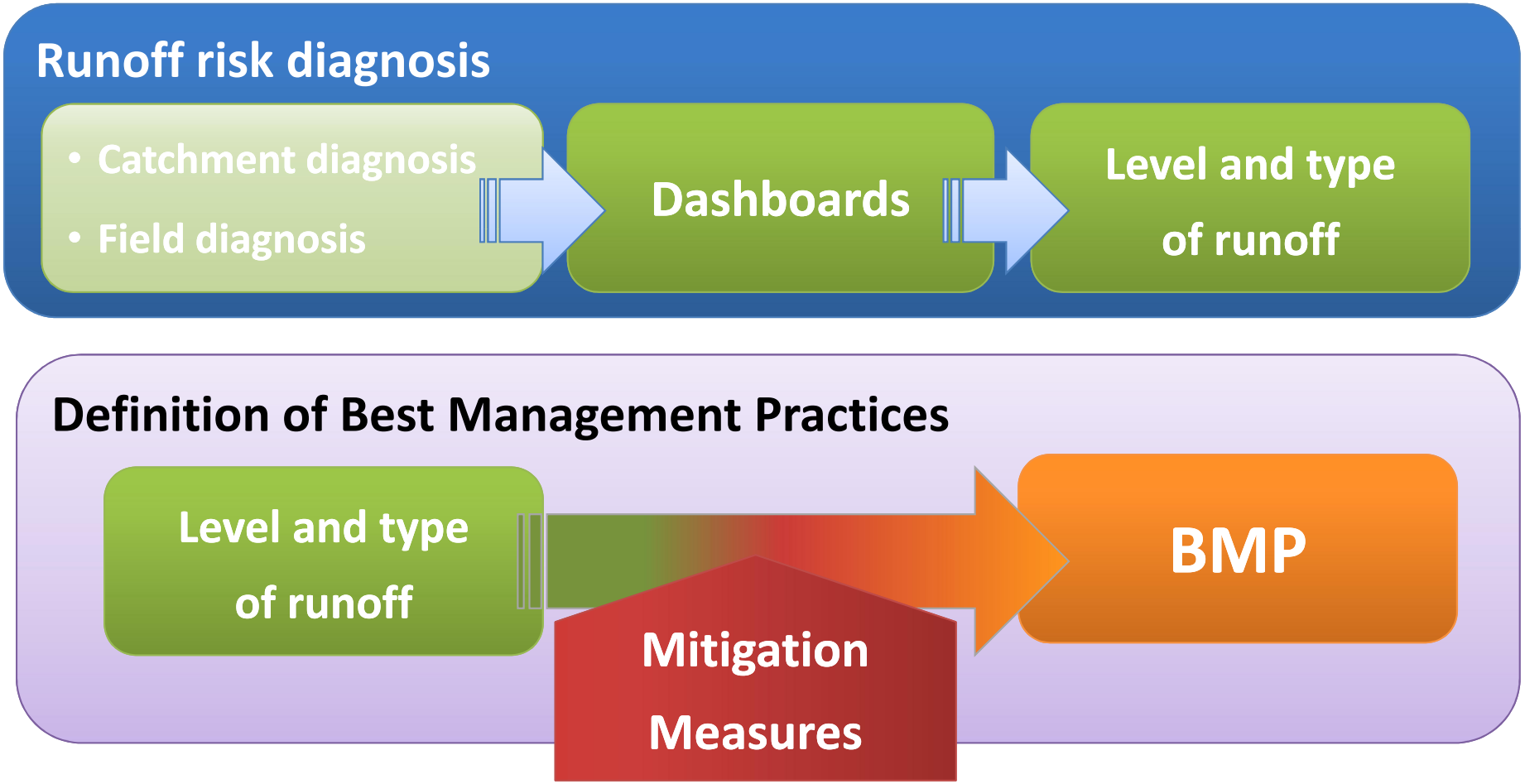
- Type of buffers, if any
- Talweg
- Retention structures
- Shortcuts
- Drainage system
- Slope length and shape

Field diagnosis

Possible presence of buffer structures in the landscape



TOPPS-Prowadis approach to determine risk of runoff and BMP



Definition of risk level

Dashboards to assess runoff risk

- Dashboards helps to make stepwise decisions giving focus to most important factors
- Decision is based on concrete data but also on expertise from adviser / farmer

Risk levels

High risk

Medium risk

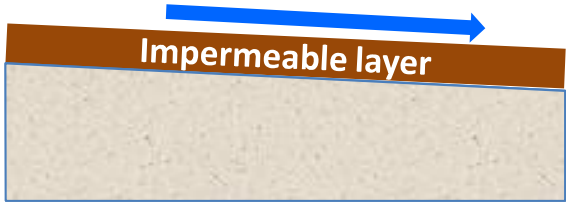
Low risk

Very low risk

Definition of risk level

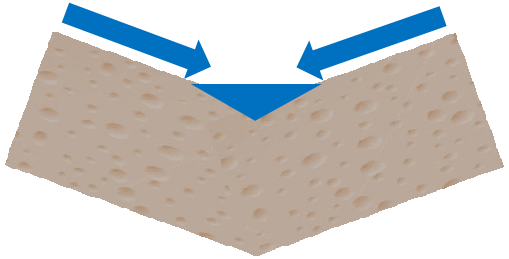
Three dashboards to analyze the 3 types of runoff

- **1. Infiltration restriction**



- **2. Saturation excess**

- **3. Concentrated runoff**



Dashboard 1: Infiltration restriction

Proximity to Surface Water	Permeability of the Topsoil	Steepness of Slope	Risk Class & Scenario
Field Adjacent to Water Body	LOW	STEEP (>5%)	I 7
		MODERATE (2-5%)	I 6
		SHALLOW (<2%)	I 5
	MEDIUM	STEEP (>5%)	I 4
		MODERATE (2-5%)	I 3
		SHALLOW (<2%)	I 2
	HIGH	STEEP (>5%)	I 3
		MODERATE (2-5%)	I 2
		SHALLOW (<2%)	I 1

Proximity to Surface Water	Transfer of run-off to downhill				Risk Class & Scenario
Field Not Adjacent to Water Body	YES	Runoff reaches water body?	YES		T 3
			NO		T 2
	NO				T 1

HIGH RISK

MEDIUM RISK

LOW RISK

VERY LOW RISK

color:
level of risk

I 4

letter:
type of runoff

number:
specific actions

Best Management Practices

Example of scenarios

I1

Maintain good agricultural practices on field to minimize runoff and erosion.

I3

Reduce runoff at source by using all suitable in-field measures. Furthermore, implement buffers (in-field, edge-of field) or suitable measures at landscape level (e.g. talweg buffers, retention structure), especially for fields with spring crops, or when in-field measures are not viable.

I4

Minimize risk for runoff and erosion with all viable in-field measures, edge-of-field buffers, and landscape measures (buffers, retention structures). Combine effective measures to achieve maximum effect.

Dashboard 2: Saturation excess

Proximity to Surface Water	Drainage Status	Topographic Position	Subsoil Permeability		WHC*	Risk Class & Scenario
Field Adjacent to Water Body	Not Artificially Drained	Bottom of slope (con-cave)/Valley bottom (see scenario A)	Plough pan + Permeability disruption		ALL WHCS	S 4
			Plough pan OR Permeability disruption		<120 MM	S 4
					>120 MM	S 3
			No plough pan & Permeability disruption		<120 MM	S 3
					>120 MM	S 2
		Upslope/ Continuous slope	Plough pan + Permeability disruption		ALL WHCS	S 4
			Plough pan OR Permeability disruption		<120 MM	S 3
					>120 MM	S 2
			No plough pan & Permeability disruption		<120 MM	S 2
					>120 MM	S 1
	Artificially Drained	All Positions	Plough pan + Permeability disruption		ALL WHCS	SD 3
			Plough pan OR Permeability disruption		<120 MM	SD 3
					>120 MM	SD 2
			No plough pan & Permeability disruption		<120 MM	SD 2
					>120 MM	SD 1
Field Not Adjacent to Water Body	Not artifically Drained	Transfer of runoff to downhill field?	YES	Runoff reaches wa-ter body?	YES	T 3
					NO	T 2
			NO			T 1

HIGH RISK

MEDIUM RISK

LOW RISK

VERY LOW RISK

* WHC = Waterholding capacity

Best Management Practices

Example of scenarios

S1 / SD1*

Maintain good agricultural practices on field to minimise run-off and erosion.

S2 / SD2*

Reduce run-off at source using suitable in-field measures. If this is not possible, consider implementation of buffer zones (edge-of-field, in-field).

S3 / SD3*

Reduce run-off at source by using all suitable in-field measures. Furthermore, implement buffers (in-field, edge-of-field) or suitable measures at landscape level (e.g. talweg buffers, retention structure), especially for fields with spring crops, or when in-field measures are not viable.

Dashboard 3: Concentrated runoff

			Risk Class & Scenario
Run-off is not generated in the audited field	Run-off coming from uphill area in the catchment		C 1
Run-off is generated in the audited field	Run-off concentrating in wheel tracks		C 2
	Run-off concentrating in corner		C 3
	Run-off concentrating in field access area		C 4
	Run-off moderately concentrated in rills	No hydromorphic soil	C 5
		Hydromorphic soil	C 6
	Run-off moderately concentrated in talweg	No hydromorphic soil	C 7
		Hydromorphic soil	C 8
	Run-off strongly concentrated	Gully not in talweg	C 9
		Gully in talweg: High infiltration soil in buffer	C 10
		Gully in talweg: Low infiltration soil in buffer	C 11

Best Management Practices

Example of scenarios

C1

Prevent concentrated run-off at source uphill in catchment. Make run-off risk audit of the field where run-off is generated. Implement buffers and retention structures to intercept any concentrated run-off downhill.

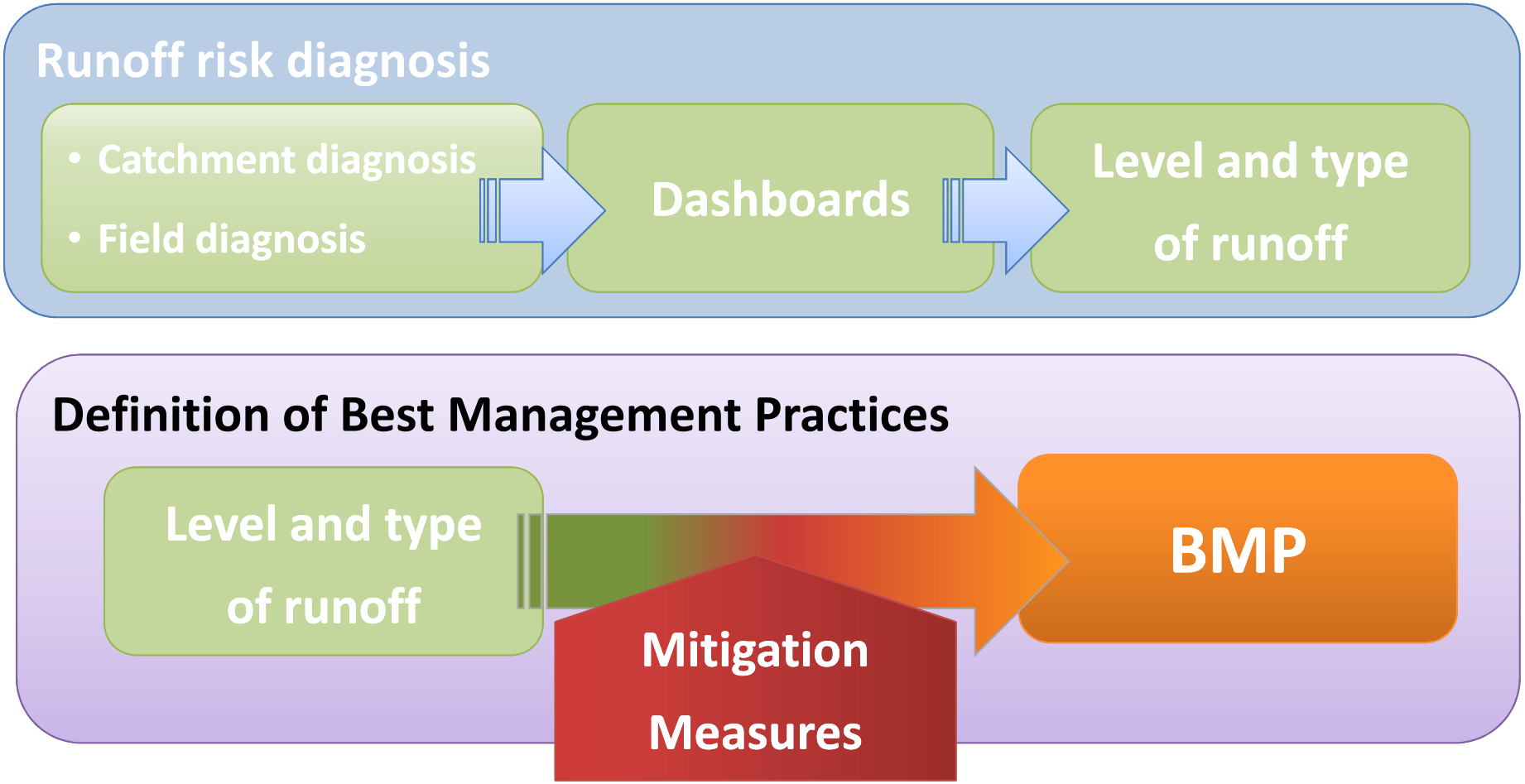
C2

Manage tramlines across slope orientation. Practice double sowing on headlands. Enlarge headlands.

C10

Close gullies, implement or enlarge talweg buffer, implement vegetated ditch or infiltration retention ponds. Reduce length of field by in-field buffers. Audit uphill areas in which implement mitigation measures.

TOPPS-Prowadis approach to determine risk of runoff and BMP



Mitigation measure toolbox

29 measures (6 categories)

Soil management	• Reduce tillage intensity • Manage tramlines • Prepare rough seedbed • Establish in-field bunds	• Manage surface soil compaction • Manage subsoil compaction • Do contour tilling/disking
Cropping practices	• Use Crop rotation • Do strip cropping • Enlarge headlands	• Use annual cover crops • Use perennial cover crops • Double sowing
Vegetative buffers	• Use in-field buffers • Establish talweg buffers • Use riparian buffers • Use edge-of-field buffers	• Manage field access areas • Establish hedges • Establish/maintain woodlands
Retention structures	• Use edge-of-field bunds • Establish veget. ditches	• Establish artificial wetlands/ponds • Build fascines
Adapted use of pesticides	• Adapt application timing • Optimize seasonal timing	• Adapt product and rate selection
Optimized irrigation	• Adapt irrigation technique	• Optimize irrigation timing and rate

Mitigation measures

SOIL MANAGEMENT

1. Reduce tillage intensity

Direct and indirect action to limit runoff

- Increase crop residues on the surface
- Reduce machinery transit and avoid plough pan

2. Prepare rough seedbed

Preserve soil clods (do not roll over after drilling)

- Slow down speed of runoff water
- Increase the infiltration of water into the soil

Julie Maillet - Mezeray

Mitigation measures

SOIL MANAGEMENT

3. Avoid surface soil compaction (capping, soil crusts)

Soils with silt >30% are typically susceptible

Direct and early actions

- Avoid subsurface compaction
- Avoid ploughing when soil is too moist
- break crusts mechanically (ripping)

4. Avoid subsoil compaction

Limit sub-surface runoff

- Avoid ploughing/harvesting when soil is too moist
- Break compaction mechanically (ripping)
- Growing plants with taproots
- Use low-pressure tires or twin tires

Mitigation measures

SOIL MANAGEMENT

5. Manage/orient tramlines

Crop-free areas where tractor drives

- Orient tramlines across the slope
- Alternate orientation after each cropping season
- Use low-pressure tyres or twin tyres

6. Create bunds in the field (contour bunding)

Retain water in the field and slow down the water flow

- Establish inter-ridge bunds
- Establish bunds across the field slope/follow contour lines

Mitigation measures

SOIL MANAGEMENT

In field bunds: “Diker” (Grimme)

http://www.youtube.com/watch?v=fg8xQqRco5A

Mitigation measures

In field bunds: “Diker” (Grimme)

Mitigation measures

In field bunds: “interbuttes”

Olier C., Ven Eecke P. (2012).
Le cloisonnement des interbuttes

Mitigation measures

In field bunds

- quantité d'eau ruisselée à Baisy-Thy le 25/08/09
- précipitation: 15 mm (dont 8,5mm en < 1h)

Non cloisonné

Cloisonné

Olier C., Ven Eecke P. (2012). Le cloisonnement des interbuttes

Mitigation measures

SOIL MANAGEMENT

7. Implement contour tilling

Slow down water flows and increase water infiltration in soil

Mitigation measures

CROPPING PRACTICES

8. Optimize crop rotation

Influence organic matter, soil structure and soil water retention

- Alternate between winter and spring crops
- Alternate between crops providing a dense soil cover

9. Implement strip cropping in field (across the slope)

- Plant different crops in strips along the contour lines
- Alternate broadcast and row crops

Mitigation measures

CROPPING PRACTICES

10. Establish plant annual cover crops

Cover crop to avoid bare soil

- Allow fast and dense establishment of vegetation
- Leave vegetal residues on the field to protect the soil

11. Apply double sowing

Slow down water flows

- Implement in strip across the slope or in a talweg in addition to the first sowing

Mitigation measures

CROPPING PRACTICES

12. Establish perennial cover crops in plantations

Slow down water flow, increase infiltration of water and soil porosity, trap sediment in runoff

- Establish grasses or mixture of suitable cover crop
- Maintain cover crop by mowing to control the height (10 to 15 cm)

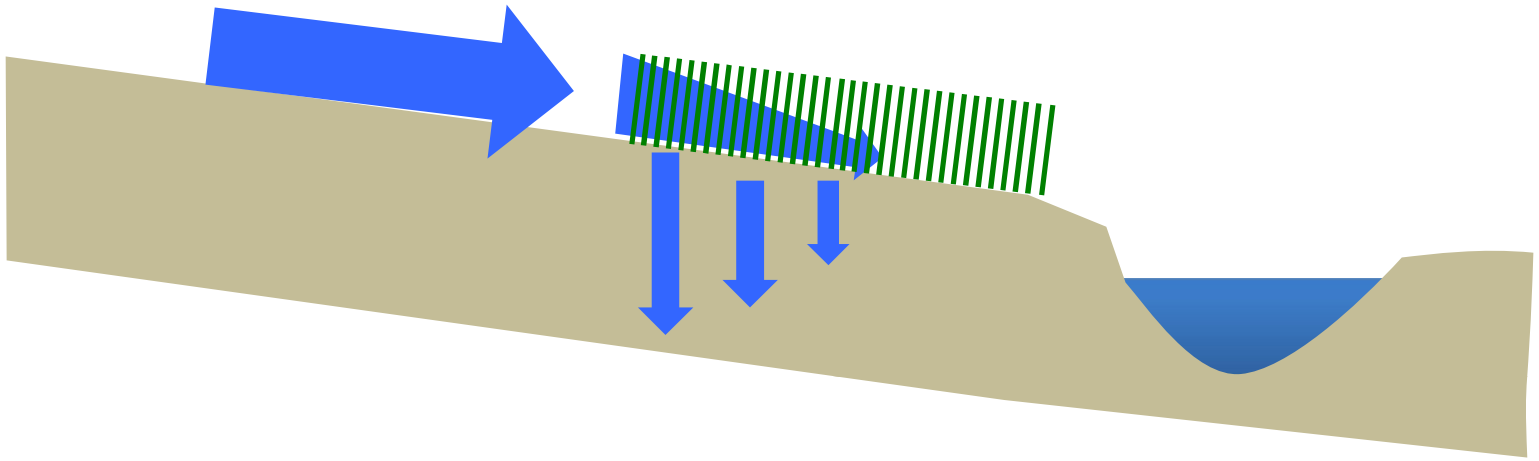
13. Enlarge headlands

Increase mitigation effects

- Apply double sowing of the headland to increase the mitigation effect

Mitigation measures

VEGETATIVE BUFFERS



- Vegetative buffer perpendicular to the runoff water flows
- Intercept runoff from cultivated plots upslope:
  - Slow down surface runoff water
  - Provide infiltration areas for surface runoff water
- Best results if implemented together with Soil management and cropping practices measures

Mitigation measures

VEGETATIVE BUFFERS

14. Establish and maintain in-field buffer

Limit water flows and shortcuts at source

- Follow the contour lines and be part of natural vegetation (non-invasive)
- Provide a dense vegetation cover with stiff leaves to resist the water flow

15. Establish and maintain edge-of-field buffer

Stop runoff water before it enters into a downhill field

- Locate buffers at the downslope end of field to protect next field or road
- Provide a dense vegetation cover

Mitigation measures

VEGETATIVE BUFFERS

16. Establish and maintain riparian buffer

Reduce runoff, stabilizing river banks, increase biodiversity, increase infiltration

- Selects adapt species to the intended protection goals: annual, perennial, or mixed vegetation (grass, bushes, hedges or trees)

Mitigation measures

VEGETATIVE BUFFERS

17. Establish and maintain talweg buffer

Limit concentrated water flow and erosion in a catchment

- Establish plant grass cover along the talweg (in high risk situations, plant hedges in addition to the grass)

Mitigation measures

VEGETATIVE BUFFERS

18. Establish and maintain hedges

19. Maintain woodlands

Limit runoff and drift, increase water infiltration, promote biodiversity

- Implement plant hedges along contour lines or narrow grassed zone along superficial water
- Select robust bush/tree species with deep roots and adapted to environment

20. Manage field access areas

Limit concentrated water flows

- Reduce soil compaction by using a layer of coarse gravel on the top and sow robust grasses species.

21. Establish or maintain vegetative ditches

Retain runoff water and sediment, promote infiltration and evaporation

- Size ditches according to expected runoff (rainfall pattern)
- Remove sediment periodically
- Establish vegetation cover by seeding local species (non-invasive) and manage it regularly

Mitigation measures

RETENTION STRUCTURES

22. Establish or maintain retention ponds/ artificial wetlands

Protect downstream areas by retaining runoff water and transported sediments and allow evaporation and infiltration of water

- Arrange and size
- Detain water in wetland buffer correctly
- Removal sediments regularly

Mitigation measures

RETENTION STRUCTURES

23. Establish or maintain edge-of-field bunding

Keep runoff and erosion in the field

- Dig the soil up and pile it up as bund/dam with a breadth of 30-50cm

24. Implement dispersive constructions

Disperse concentrated surface runoff and retain eroded sediment (permeable to water)

- Establishe fascines, mini-dams of stones and wooden logs across the slope

Mitigation measures

CORRECT PPPs USE

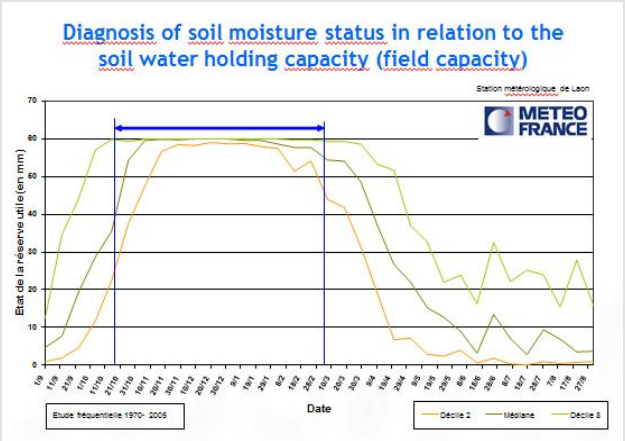
25. Optimize PPPs application timing

26. Optimize seasonal PPPs application timing

27. Select appropriate crop protection products

Reduce surface water contamination

- Do not apply PPPs if rainfall is forecasted within 2 days
- Do not apply PPPs on saturated soil or during groundwater recharge
- Select PPPs according to the time window for application and crop protection problem
- Reduce application rates and use application techniques to reduce PPPs treated area
- Reduce number of applications and amount of PPPs to the necessary minimum



Mitigation measures

IRRIGATION

28. Select irrigation technology

29. Optimize irrigation timing and rate

Prevent runoff risk

- Use less water-consuming and better manageable irrigation technology (sprinkler, drip irrigation)
- Monitor and estimate the correct amount of water needed by the crop