TOPPS PROWADIS

RUNOFF

Best Management Practices

to reduce water pollution with plant protection products from runoff and erosion

Field manual

TOPPS-Prowadis STEPS

Methodology at catchment and field scale

Catchment diagnosis

Data collection

Landscape, farm description, soil types, geology, hydrology…

1

2

Field diagnosis

Assessment of agricultural practices

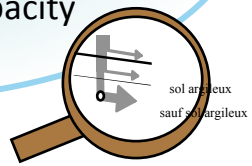
- Tillage, cropping and PPPs use practices
- Spring/summer and winter/ autumn seasons

Field diagnosis

3

Identification of water pathways and type of runoff

Categorization soil permeability and water holding capacity



4

Runoff risk level

Assessment of risks for diffuse and concentrated runoff by using dashboards

Dashboards

5

Selection of mitigation measures (BMPs)

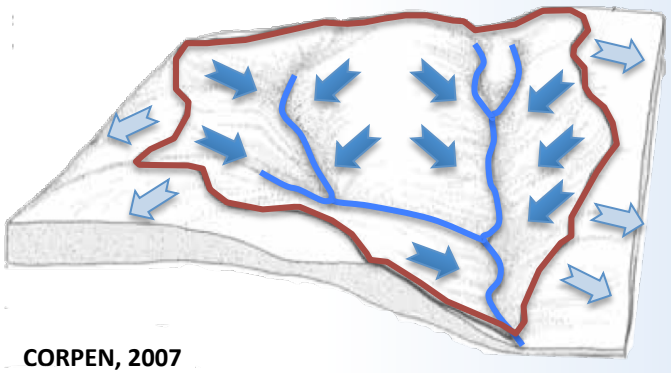
1. Soil management
2. Cropping practices
3. Vegetative buffers
4. Retention structures
5. Adapting PPPs and timing
6. Optimized irrigation

BMPs

Based on: **AQUAPLAINE® concept,** *ARVALIS-Institut du végétal*

Collection of data needed for catchment diagnosis

Diagnosis at catchment level



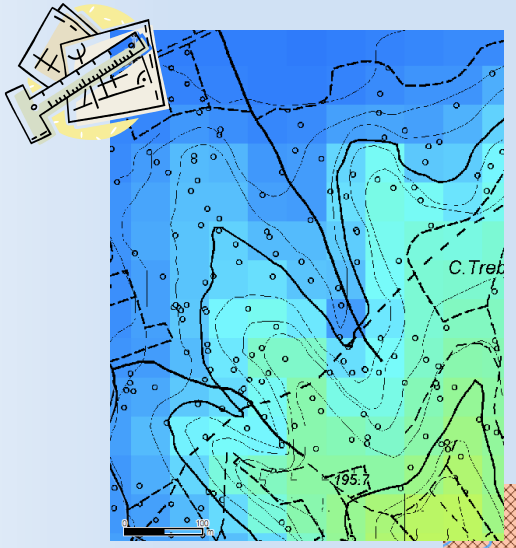
CORPEN, 2007

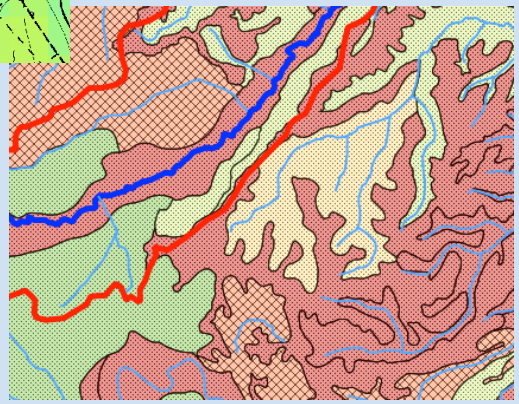
- Runoff is generated at CATCHMENT and FIELD scale.
- Water body pollution is caused if contaminated surface water leaves the field.
- Mitigation measures can be achieved through field practices and vegetative buffers retaining water in the field.

Landscape information

Maps

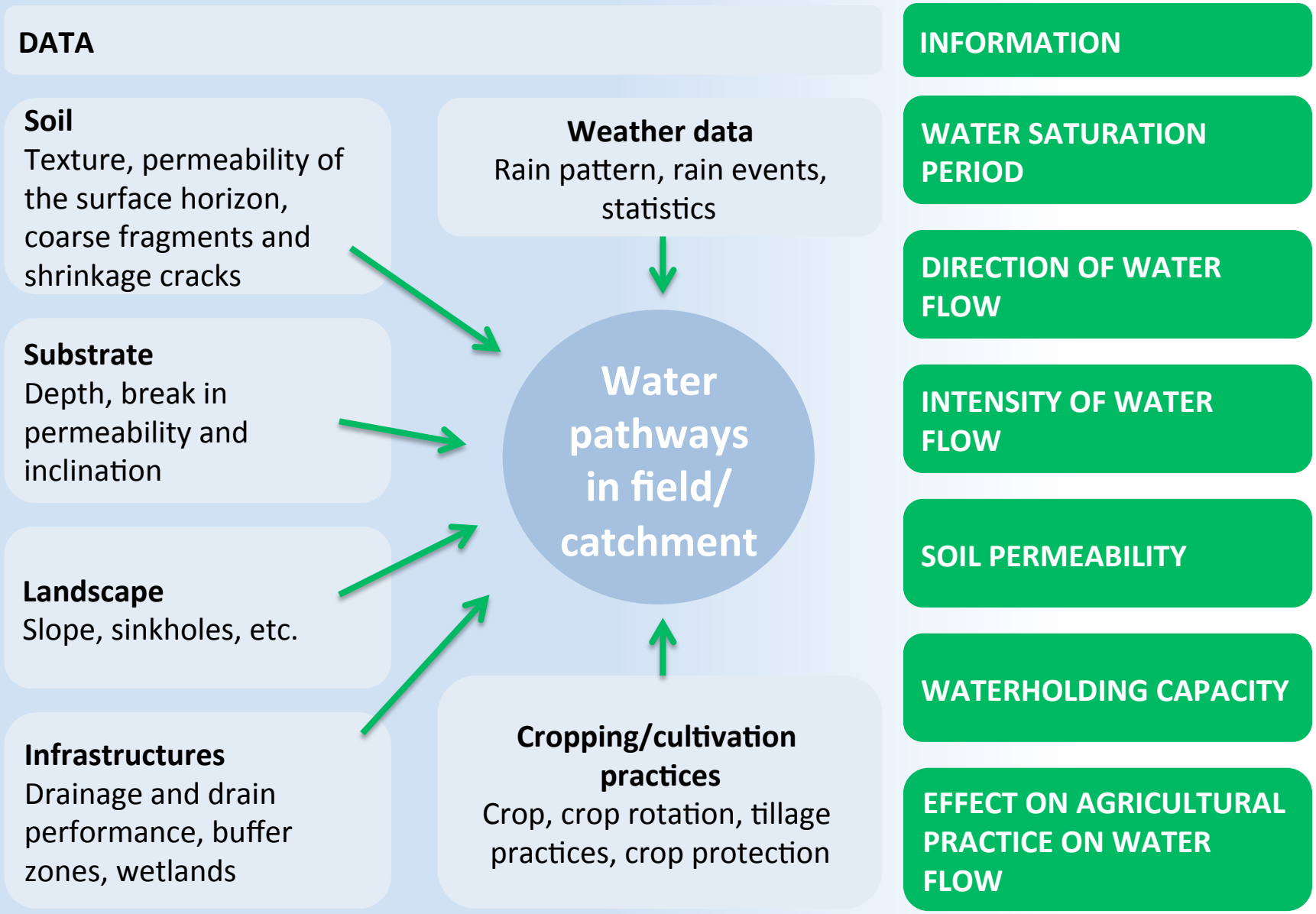
Pedological and geological maps, elevation and slope, soil hydrology and texture, hydrographic network, orthophoto, etc.





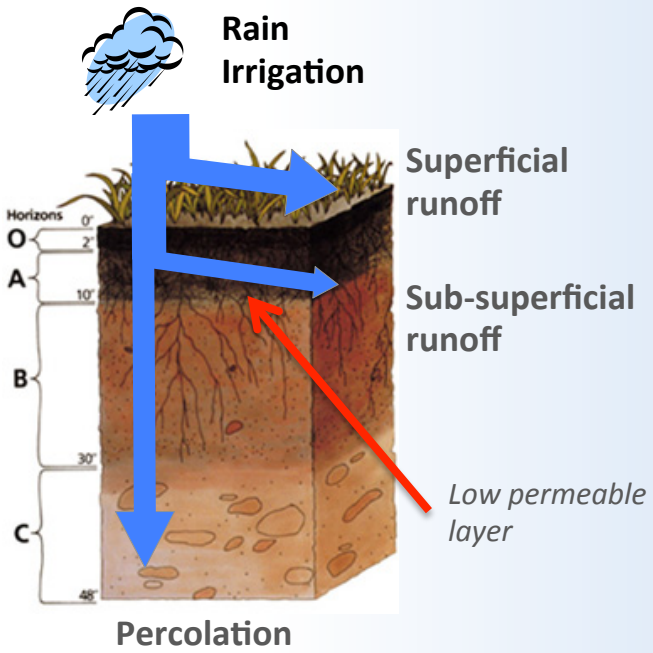
CATCHMENT DIAGNOSIS

Collection of data needed for field diagnosis



Identification of superficial runoff type

Superficial and sub-superficial runoff



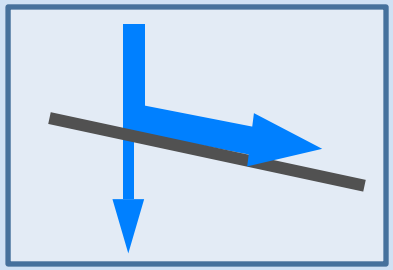
Superficial runoff

Infiltration restriction

Mainly in spring/summer

CAUSE

- Heavy texture/poor structure
- Capping and compaction on surface
- High intensity storms
- Low vegetative cover

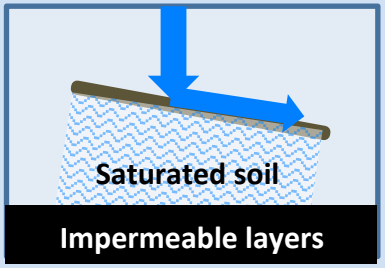


Saturation excess

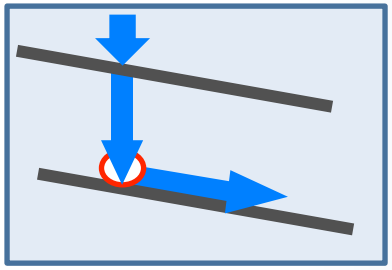
Mainly in autumn/winter

CAUSE

- Superficial soil
- Impermeable layers



Sub-superficial runoff



CAUSE

- Lateral seepage
- Sub-superficial impermeable layer
- Artificial drainage

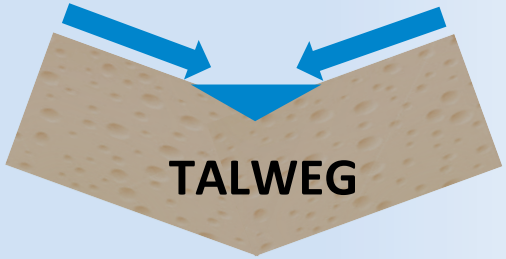
TYPE OF RUNOFF

Identification of superficial runoff type

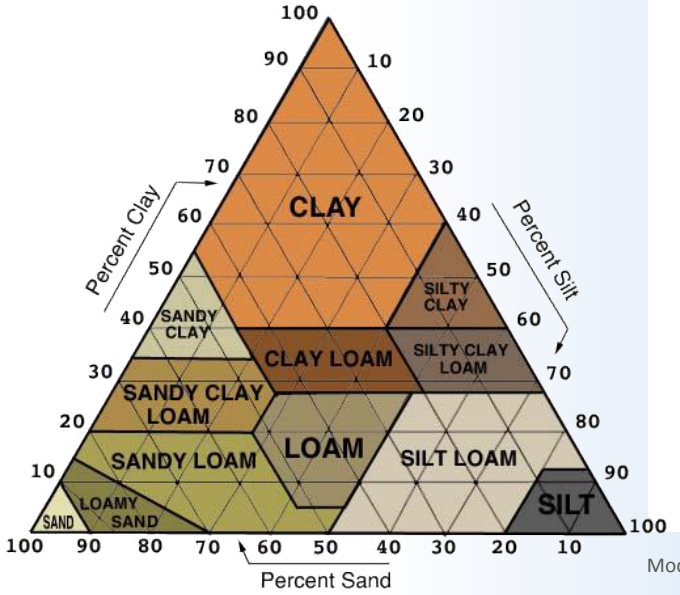
Runoff from infiltration restriction

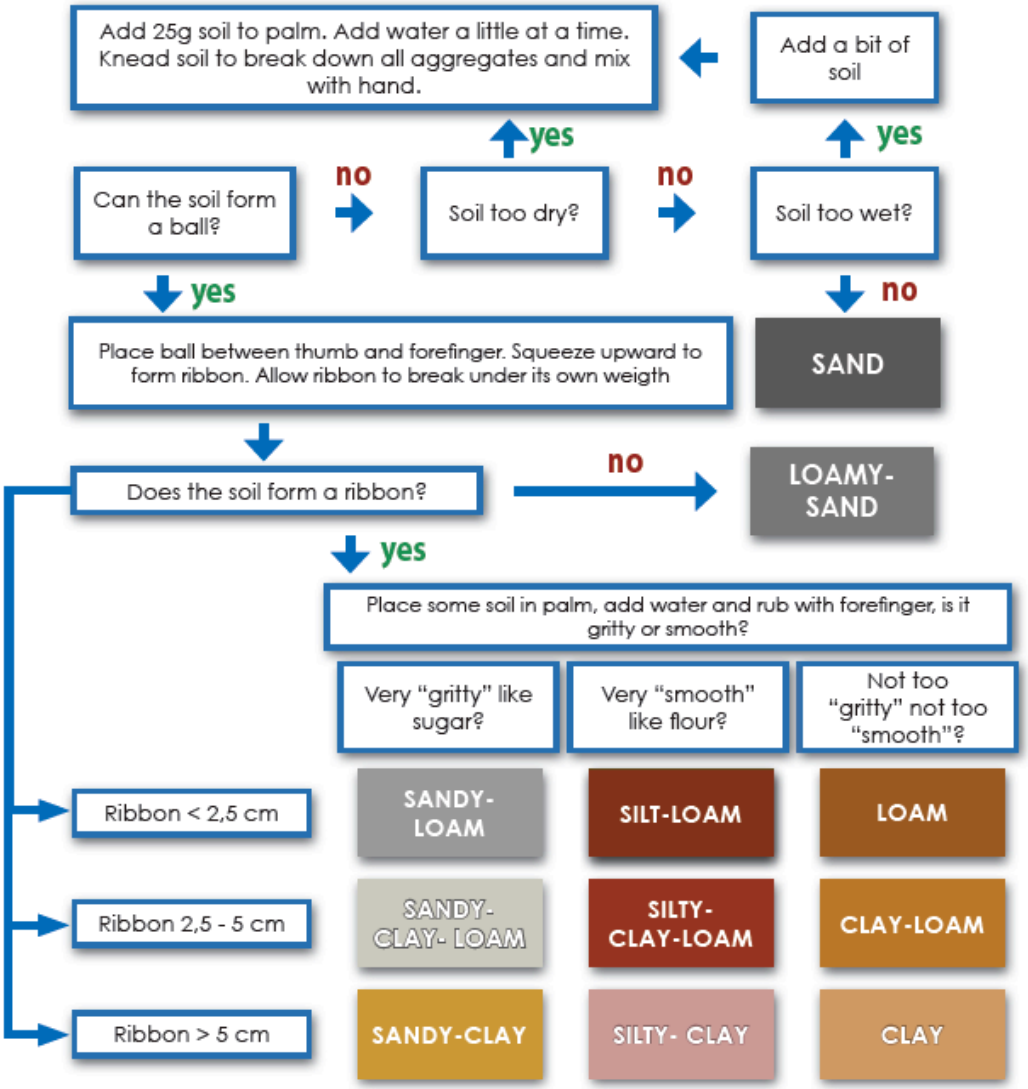
Runoff from saturation excess

Runoff from concentrated flows



Practical method to determine soil texture





Modified from S.J. Thien. 1979. A flow diagram for teaching texture by feel analysis. Journal of Agronomic Education. 8:54-55.

SOIL TEXTURE

Determination of water holding capacity (WHC)

Calculation of WHC

a) Determine texture
b) Determine soil depth

Example:
sandy clay texture, depth 100 cm

1.7mm x 100 cm **= 170 mm WHC**

Determine WHC for the entire horizon up to 100 cm depth or to depth of permeable layer.

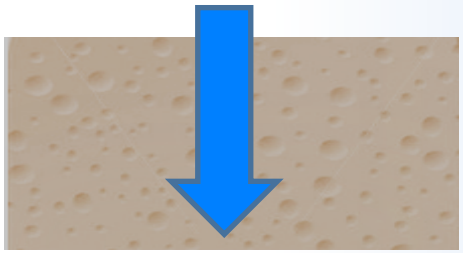
Soil texture	Water Holding Capacity (mm water / cm soil)	
	Average	Range
Sand	0.4	0.1-1.2
Loamy sand (medium sand)	0.8	0.4-1.4
Loamy sand (very fine sand)	1.0	0.6-1.8
Sandy loam	1.3	0.8-1.8
Loam Silt loam Silt	1.7	1.2-2.2
Clay loam Sandy clay loam Silty clay loam	1.8	1.2-2.4
Sandy clay Silty clay Clay	1.7	1.0-2.2

Soils with water holding capacities > 120 mm have no water contamination risk

Soil permeability

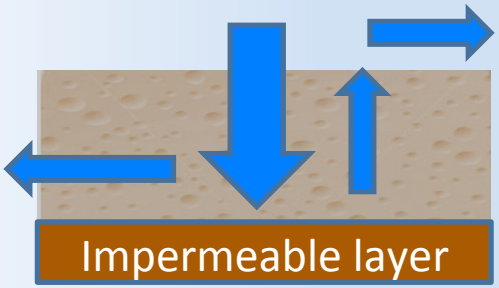
PERMEABILITY: capacity of soil to allow water to pass through it

HIGH PERMEABILITY
Non capping soils, sandy/sandy loam soils, loamy/silt soils, high organic matter content, non swelling clays



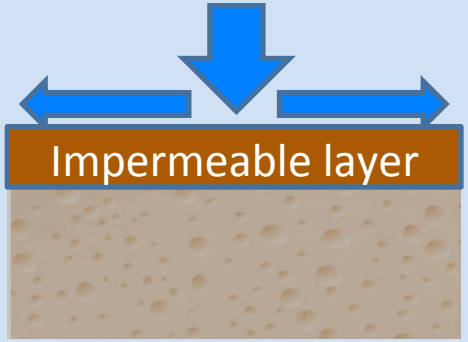
High permeability
=
High infiltration
=
Low risk of superficial runoff

LOW PERMEABILITY IN SUB-SURFACE
Runoff due to soil saturation



Soil saturation, plough pan
=
High risk of superficial and sub-superficial runoff

LOW PERMEABILITY IN SURFACE
Runoff due to reduced infiltration



Low WHC, capping soil, clayey/loamy soils
=
High risk of superficial runoff

Soil permeability: key factor for infiltration of water in the soil

Low permeability in sub-surface: HYDROMORPHIC SOILS

Symptoms

- Presence of water saturation in the soil.

Causes

- Subsoil layer of low permeability.

Indicators

- Colored areas below topsoil 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 remains wet for at least 2 to 5 days after rain.

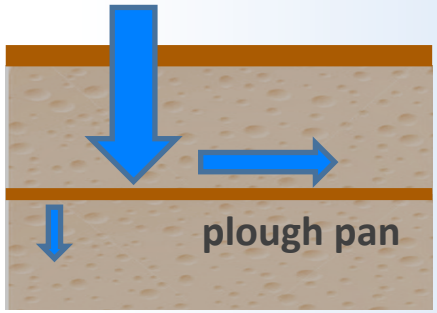
Low permeability in sub-surface: PLOUGH PAN

Symptoms

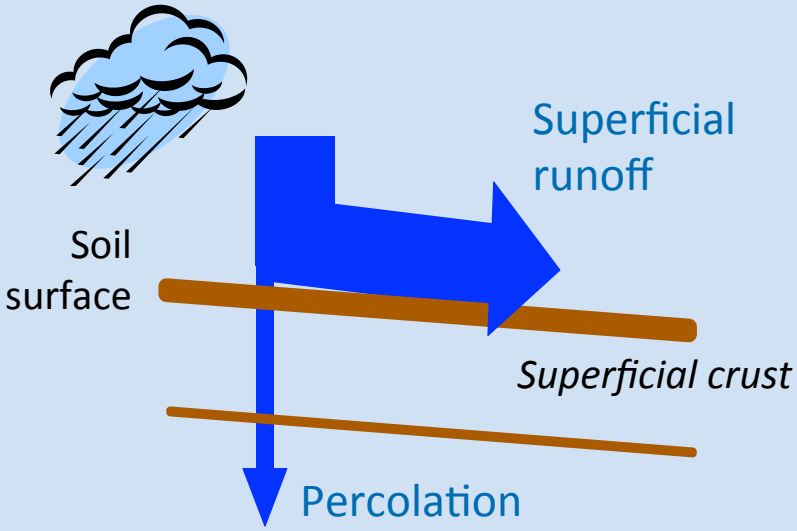
- Presence of water in surface

Causes

- Presence of hard plough pan



Low permeability in surface: CAPPING SOILS



Symptoms

- Superficial runoff

Causes

- Pour structural stability of soil surface (splash effects from raindrops).
- Superficial crust
- 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.

Landscape factors: EXISTING MEASURES

Collection of information about existing mitigation measures (vegetated buffers, retention structures, hedges, woodlands) field length and size, talweg, drainage system, shortcuts.

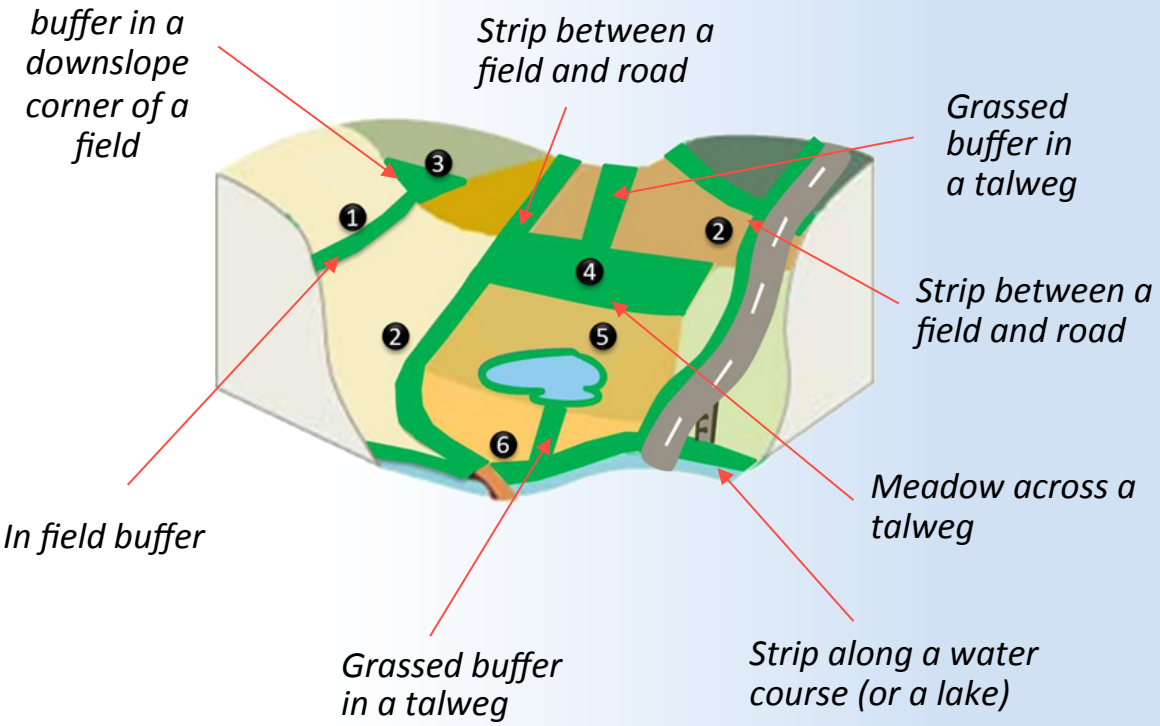
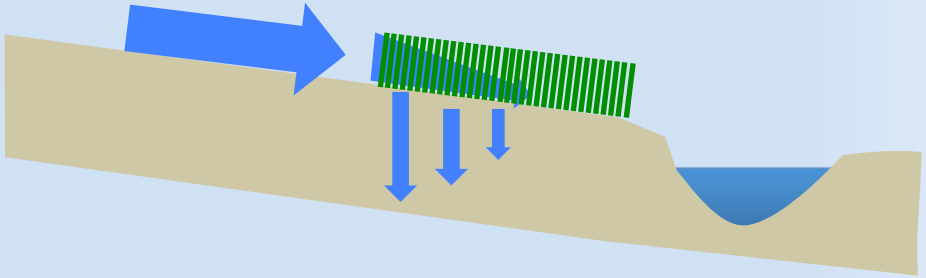


Image: Corpen / Artwet

Retention structures: wetlands

Landscape factors: VEGETATIVE BUFFERS

Slow down runoff, capture sediments, increase water infiltration capacity, stabilize river banks and increase biodiversity



- Placed perpendicularly to runoff flow
- Covered with uniform vegetation (grass, bushes, hedges or trees)
- Regularly mowed and maintained
- Integrated by other mitigation measures

Landscape factors: AGRONOMIC PRACTICES

Crop	Cultivation	Crop rotation	Tillage	Maintenance
Winter Spring	Row crop Broadcast Crop	Cover crop No cover crop Following crop	Ploughing Minimum tillage No tillage	Passes on field Tramlines Rough seedbed Fine seedbed






LANDSCAPE FACTORS

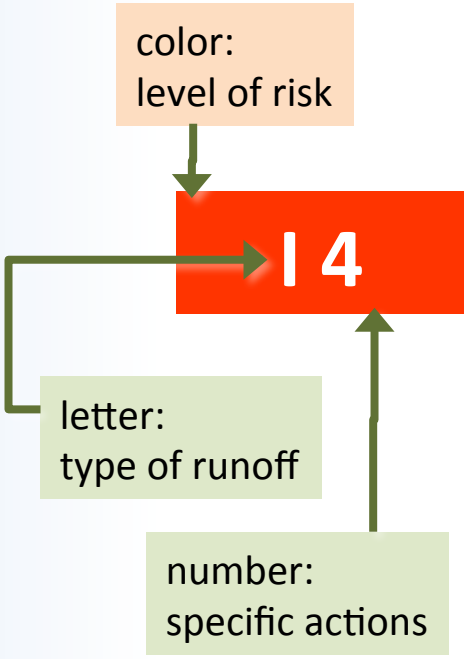
DASHBOARD 1

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
Field Not Adjacent to Water Body	Transfer of run-off to downhill: YES	Runoff reaches water body? YES	T 3
		Runoff reaches water body? NO	T 2
	Transfer of run-off to downhill: NO		T 1

Take decisions from left to right

Risk class & Scenario
T = Runoff for transfer
I = Runoff for infiltration restriction



HIGH RISK
MEDIUM RISK
LOW RISK
VERY LOW RISK

Best Management Practices: infiltration restriction

I1	Maintain good agricultural practices in field to minimize runoff and erosion. Prepare rough seedbed, use cover crops increase coverage with organic materials and manage field access areas.
I2	Manage tramlines, plant robust cover crop and manage field access areas. Reduce runoff at source using in-field measures. If this is not applicable, implement buffer zones (edge-of-field, in-field).
I3	Use in field bunds, reduce tillage intensity, enlarge headlands, adopt double sowing in more risky areas, use edge of field buffers, reduce length of field by in field buffer and use edge of field bunds. Implement talweg buffers and retention structure, especially for fields with spring crops, or when in-field measures not viable.
I4	Reduce soil tillage, apply contour tilling, apply strip cropping, establish talweg buffer, establish hedges and woodland buffers, build fascines, establish vegetated ditch and establish artificial wetlands and ponds. Combine effective measures to achieve maximum mitigation.

T1	Maintain good agricultural practices in field to minimize runoff and erosion. Prepare rough seedbed, use cover crops increase coverage with organic materials and manage field access areas.
T2	Prepare rough seedbed, use cover crops, increase soil coverage with organic materials and manage field access areas. In case of large amount of runoff: stop at source to avoid fast infiltration in downhill plot (ground water protection). If runoff transfer to downhill plot is not sufficient to mitigate risk of runoff, see measure T3.
T3	Reduce soil tillage, apply contour tilling, do strip cropping, establish talweg buffer, establish hedges and woodland buffers, build fascines, establish vegetated ditch and establish artificial wetlands and ponds. In case of large amount of runoff: stop at source to avoid fast infiltration in downhill plot (ground water protection).

DASHBOARD 2

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

Risk class & Scenario
T = Runoff for transfer
S = Runoff for saturation excess
SD = Runoff for saturation excess + artificial drainage

Take decisions from left to right

HIGH RISK
MEDIUM RISK
LOW RISK
VERY LOW RISK

WHC = Water holding capacity of soil

Best Management Practices: saturation excess

S1/SD1	Maintain good agricultural practices in field to minimize runoff and erosion. Prepare rough seedbed, use cover crops, increase soil coverage with organic materials, manage field access areas.
S2/SD2	If this is not possible, consider implementation of buffer zones (edge-of-field, in-field). Manage tramlines, plant robust cover crop and manage field access areas. Reduce runoff at source using in-field measures, or establish edge-of-field and in-field buffer zones.
S3/SD3	Use in field bunds, reduce tillage intensity, enlarge headlands, adopt double sowing in more risky areas, use edge of field buffers, reduce length of field by in field buffer and use edge of field bunds. Implement talweg buffers and retention structure when in-field measures are not viable.
S4	Reduce soil tillage, apply contour tilling, do strip cropping, establish talweg buffer, establish hedges and woodland buffers, build fascines, establish vegetated ditch and establish artificial wetlands and ponds. Combine effective measures to achieve maximum mitigation.
T1	Maintain good agricultural practices in field to minimize runoff and erosion. Prepare rough seedbed, use cover crops, increase soil coverage with organic materials, manage field access areas.
T2	Prepare rough seedbed, use cover crops, increase soil coverage with organic materials and manage field access areas. In case of large amount of runoff: stop at source to avoid fast infiltration in downhill plot (ground water protection). If runoff transfer to downhill plot is not sufficient to mitigate risk of runoff, see measure T3.
T3	Reduce soil tillage, apply contour tilling, do strip cropping, establish talweg buffer, establish hedges and woodland buffers, build fascines, establish vegetated ditch and establish artificial wetlands and ponds. In case of large amount of runoff: stop at source to avoid fast infiltration in downhill plot (ground water protection).

DASHBOARD 3

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

Risk class & Scenario
Runoff risk is always HIGH with signs of concentrated runoff. Always needs application of mitigation measures.
C = Concentrated runoff

Take decisions from left to right

HIGH RISK
MEDIUM RISK
LOW RISK
VERY LOW RISK

Best Management Practices: concentrated runoff

C1	Prevent concentrated runoff at source uphill in catchment. In addition, buffers and retention structures may be needed to intercept any concentrated runoff downhill
C2	Manage tramlines. Practice double sowing in headlines. Enlarge headlands.
C3	If soil is not hydromorphic: Implement buffer zones in corner of field. If soil is hydromorphic: Implement edge-of-field bunds; Construct retention ponds.
C4	Manage field access area.
C5	If buffer doesn't exist, implement edge-of-field buffer zones. If edge-of-field buffer exists, widen buffer, and/or implement fascines, hedges /hedgerows or retention structure. If possible, divide field with in-field buffer upslope.
C6	If buffer doesn't exist, Implement wide edge-of-field buffer zones (wet meadow). If edge-of-field buffer exists, widen buffer zone further (wet meadow) and/or implement wetland. If possible, divide field with in-field buffer upslope.
C7	If vegetated talweg buffer doesn't exist, do double sowing or establish vegetated talweg buffer (at the bottom), vegetated ditch or slow infiltration retention pond. If vegetated talweg buffer already exists, widen talweg buffer upslope, establish vegetated ditch or retention pond. If possible reduce slope length (strip cropping, in-field buffer) upslope where concentration of runoff starts.
C8	If no vegetated talweg buffer exists, implement vegetated talweg buffer or vegetated wetland downslope in talweg. If vegetated talweg buffer exists, widen talweg buffer (wet meadow) and/or construct artificial wetland as retention structure.
C9	Close gully. If edge-of-field buffer doesn't exist, implement buffer AND Implement fascines or retention structure. If edge-of-field buffer exists, implement fascines or retention structure.
C10	Close gully. If no buffer exists, implement vegetated talweg buffer. If talweg buffer exists, widen talweg buffer upslope and implement vegetated ditch or retention pond for slow infiltration.
C11	Close gully. If talweg buffer doesn`t exist, implement vegetated talweg buffer and /or Wetland or meadow. If talweg buffer exists, widen talweg buffer and implement with fascines, and/or implement wetland or meadow.

MITIGATION MEASURES TOOLBOX

Mitigation measure toolbox

Position I: in field
O: out of field

Priority I (In) ⇨ O (Out) ⇨ I + O (In + Out)

Risk level

GENERAL Always implemented	VERY LOW RISK	LOW RISK	MEDIUM RISK	HIGH RISK

Soil management

- Reduce tillage intensity (I)
- Prepare rough seedbed (I)
- Manage surface soil compaction (I)
- Manage subsoil compaction (I)
- Manage tramlines (I)
- Establish in-field bunds (I)
- Do contour tilling/disking (I + O)

Cropping practices

- Use Crop rotation (I + O)
- Do strip cropping (I + O)
- Use annual cover crops (I)
- Double sowing (I)
- Use perennial cover crops (I)
- Enlarge headlands (I)

Vegetative buffers

- Use in-field buffers (I)
- Use edge-of-field buffers (I + O)
- Use riparian buffers (O)
- Establish talweg buffers (I + O)
- Establish hedges (O)
- Establish/maintain woodlands (O)
- Manage field access areas (I + O)

Retention structures

- Establish vegetated ditches (O)
- Establish artificial wetlands/ponds (O)
- Use edge-of-field bunds (O)
- Build fascines (I + O)

Adapted use of pesticides

- Adapt application timing (I)
- Optimize seasonal timing (I)
- Adapt product/rate selection (I + O)

Optimized irrigation

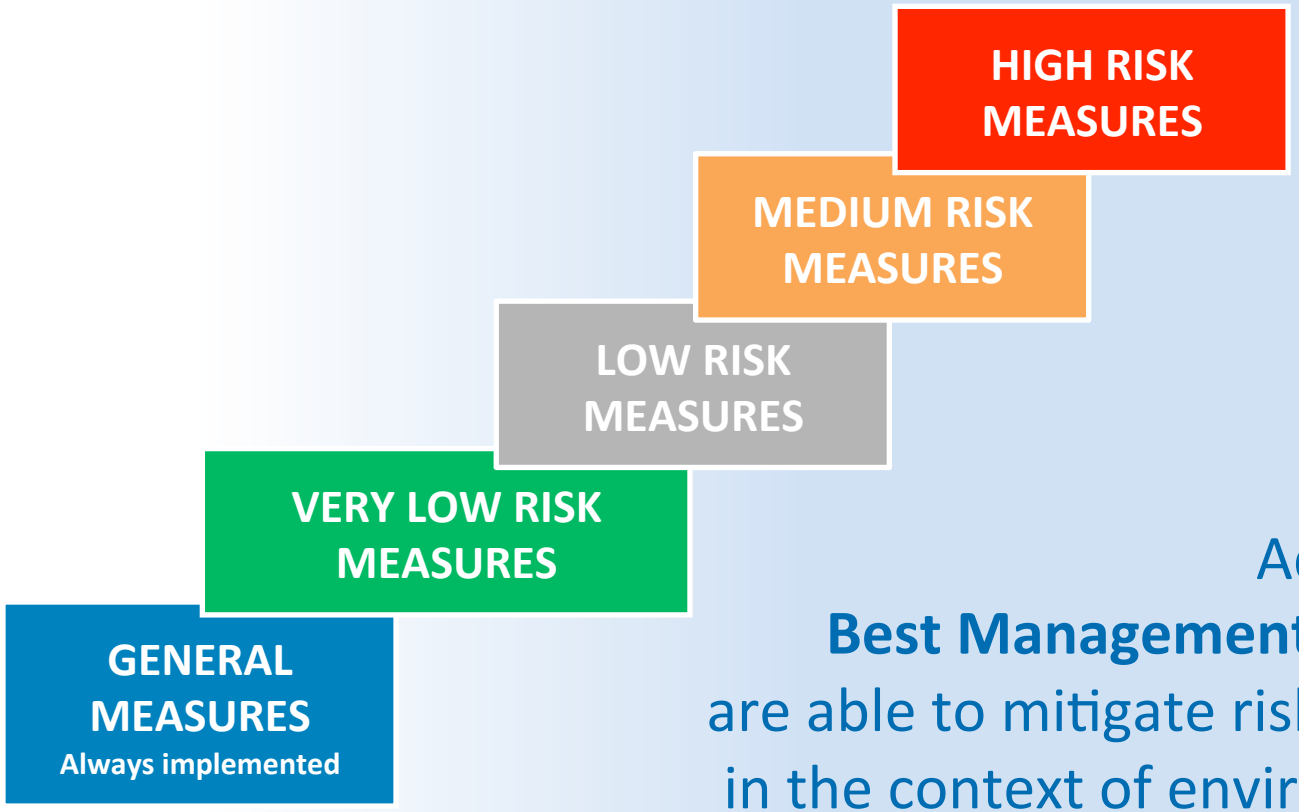
- Adapt technique (I)
- Optimize timing and rate (I)

Mitigation measures

Diagnosis
Assessment of runoff risk

Mitigation measures

Best Management Practices



Adoption of **Best Management Practices** are able to mitigate risk of runoff in the context of environmental, economic and social needs

Check list to use dashboards

CHECK LIST

1	Proximity of field to the water body	Adjacent ☐	Not adjacent ☐	
2	Soil texture From soil map or estimation in field	Texture class _____		
3	Soil water holding capacity Estimable in field from soil texture by using table for WHC	<120mm ☐	>120mm ☐	
4	Slope of the land Using DTM or estimation in field	Low <2% ☐	Medium 2-5% ☐	High >5% ☐
5	Permeability of the topsoil Estimable in field from soil texture and presence of capping	Low ☐	Medium ☐	High ☐
6	Discrete subsurface restriction Presence of plough pan or other infiltration restrictions	None ☐	Pan or other ☐	Pan + other ☐
7	Landscape situation	Valley Floor / Concave Slope ☐	Upslope Concave / Straight Slope ☐	Tile Drained ☐
8	Transfer of runoff to downhill fields or water body	Downhill transfer unlikely ☐	Transfer likely but not to surface ☐	Transfer likely to surface water ☐
9	Signs of any concentrated runoff in the field If No, ignore points from 10 to 14	Yes ☐	No ☐	
10	Presence of concentrated runoff in	Wheel tracks ☐	Field corner ☐	Field access area ☐
11	Presence of moderately concentrated runoff in	Rill ☐	Talweg ☐	
12	Presence of strongly concentrated runoff in	Gully not in talweg ☐	Gully in talweg ☐	
13	Hydromorphic characteristic of soil Verify presence of green/grey colours, iron/manganese concretions with redbrown and black colours, or low-permeability layer in the soil profile by using an auger.	Yes ☐	No ☐	
14	Soil infiltration capacity in buffer	High ☐	Low ☐	

Factors needed to apply dashboards

- Signs of runoff/erosion and them origin
- Runoff water pathways
- Direction of sowing/planting
- Soil texture estimation
- Proximity to the vulnerable water body
- Type of runoff

Runoff due to
INFILTRATION RESTRICTION

- Soil permeability (capping soil)

Runoff due to
SATURATION EXCESS

- Plough pan or low permeable layers
- Low water holding capacity

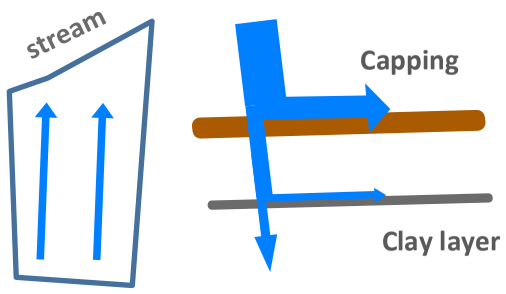
Source: Arvalis - Institute du végétal

TOPPS PROWADIS

Farm form

Field name and N°: Vinchio-Vaglio **Drainage network:** No
Crop in place and rotation: Maize, rotation with wheat
Tillage system: Minimum tillage
Resistant weed : *Yes / No* No **Which one:**

Field map (draw) / Water ciculation / Landscape



Landscape characteristics

Upstream water arrival: yes / no **Yes**
Runoff concentration: yes /no **Yes**
Proximity to waterbody, ditch or spring: yes/no **Yes**
Important slope: < 2%, 5%, >10% **2%**
Buffer zone downhill: yes /no **No**
Nature of buffer zones: grassy/ hedge /woodland **No**
Preferential pathways (doline, swallet): Yes / no **No**
Wet patch: yes/no **No**

Pedological caracteristics

Location or horizon 1

Texture : **Loam**
% of clay: **20-25%**
Gravels and stones: **Absent**
Depth: **0-30cm**
Capping soil: **Yes**
Cracks in soil **Yes**

Location or horizon 2

Texture : **Sandy-loam**
% of clay: **10-20%**
Gravels and stones: **No**
Depth: **30-60cm**
Capping soil:

Geological caracteristics

Geological substrate: **Alluvium - Asti sand**
Geological substrate permeability: **Medium**
Karstic substrate: **No**

Total depth: **100cm; WHC=170mm**
Water holding capacity: <120mm/>120mm
Permeability disruption (clay area, etc..): **Yes**
Hydromorphy evidence: **Yes**

Diagram of water pathway in winter

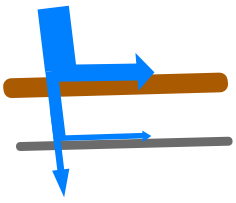


Diagram of water pathway in spring

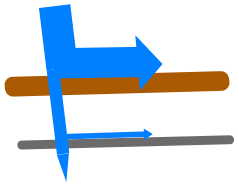


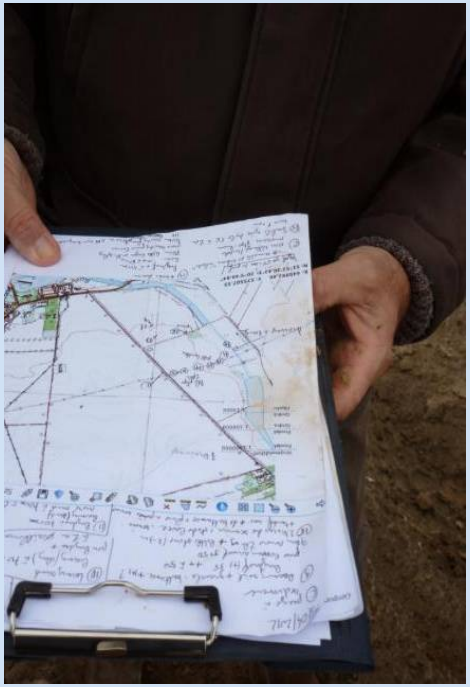
Diagram of water pathway in summer

REMARKS : Soil close to the stream. 1m natural buffer between end of field and stream. Concentrated runoff in the field. Clay layer at 60cm depth, sub-superficial runoff probably occurs. Capping soil on surface (silt>30%). Water logging at the downhill of the field.

Version: 20120727
Methodology coming from aquaplaine, ARVALIS – Institut du végétal

FIELD FORM

Field form



Legend

	Soil surface
	Geological substrate or permeability breakdown
	Drainage system
	The thickness of the arrows symbolizes the proportion of water flow in the relative direction
	This symbol means that water infiltrates and fills up the water holding capacity of the soil. There is no transfer.

Example of application of mitigation measures

Establish grassed and woody buffers in riparian areas

No-buffer

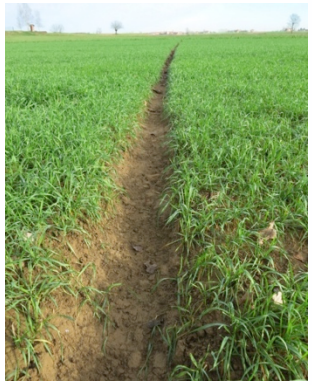
Riparian buffer

Reduce tillage intensity and soil crust

Soil crust

Break capping layer

Dispersive construction: vegetated ditches



Not-vegetated

Vegetated

Perennial cover crops in field access areas

Gully erosion

Vegetated buffer

TOPPS-prowadis is a multi-stakeholder project which started 2011, executed by local partners and experts. TOPPS stands for Train Operators to Promote Best Management Practices & Sustainability.

TOPPS is funded by the European Crop Protection Association (ECPA) and aims to reduce losses of Plant Protection Products to water.

For further information visit

www.TOPPS-life.org

Aldo Ferrero, Francesco Vidotto, Fernando De Palo
Department of Agricultural, Forest and Food Sciences
DISAFA - Università degli Studi di Torino
Largo Paolo Braccini, 2 - 10095 Grugliasco (TO)
Tel: +39 011 670 8780; Fax +39 011 6708789
aldo.ferrero@unito.it

Agrofarma - Federchimica
Associazione nazionale imprese agrofarmaci
Via Giovanni da Procida, 11 - 20149 Milano (MI)
Tel. +39 02 3456 5334; Fax +39 02 3456 5456
agrofarma@federchimica.it

E.C.P.A. - European Crop Protection Association
6 Avenue E. Van Nieuwenhuyse
B-1160 Brussels, Belgium.
Tel. +32 2 663 15 50; Fax +32 2 663 15 60
ecpa@ecpa.eu