RUN-OFF

Best Management Practices

to reduce water pollution with plant protection products from run-off and erosion

TOPPS PROWADIS

DIAGNOSIS

Training Course

Outline

- Introduction and general information
- Significance of PPP entry routes to surface water
- Objectives of training and BMP concept
- Typs of runoff
- Diagnosis in practice
- Diagnosis results
- Link runoff risks with mitigation measures

Introduction and general information

- First TOPPS project 2006 to 2008 (15 countries)
  Focus on point source mitigation (ECPA & Life)
- Second TOPPS project 2009 to 2011 (10 countries - ECPA)
  TOPPS extention to more countries
  Environmentally optimized sprayer
- Third TOPPS project (TOPPS – prowadis, 7 Countries Focus on diffuse sources: spray drift and runoff (ECPA)

Multistakeholder approach, local partners,
Best Management Practices: Development, Transfer, Implementation

TOPPS
PROWADIS

TRAIN
OPERATORS
PROMOTE BEST
PRACTICES &
SUSTANABILITY

www. TOPPS-life.org

Partners Runoff

BE – InAgro

DE – LfL

DK – DAAS

ES – University Cordoba

FR – Arvalis Inst du vegetal

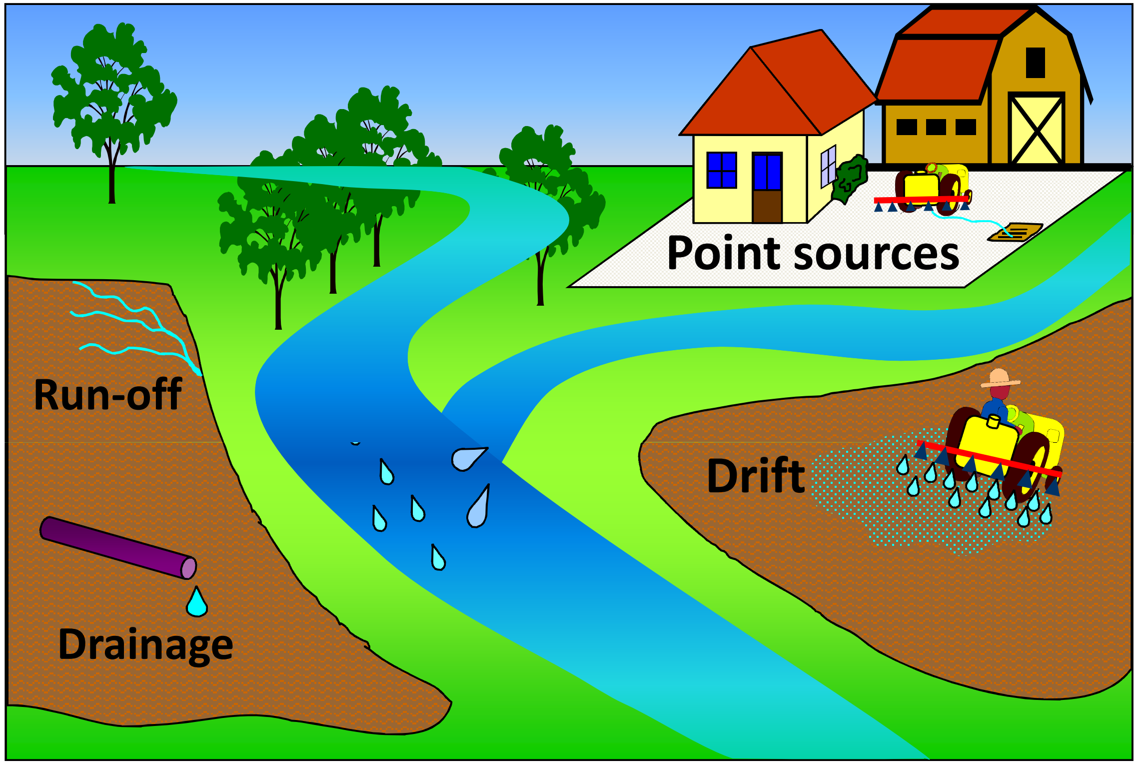
FR - Irstea

IT – University Turin

PL – Nat. Env. Institute

ECPA

Main entry routes of pollutants to surface water from agriculture



Diffuse sources	*Nitrogen*
	Phosphate
Point source	*Pesticides (PPP)*

POINT SOURCES & DIFFUSE SOURCES IMPORTANT

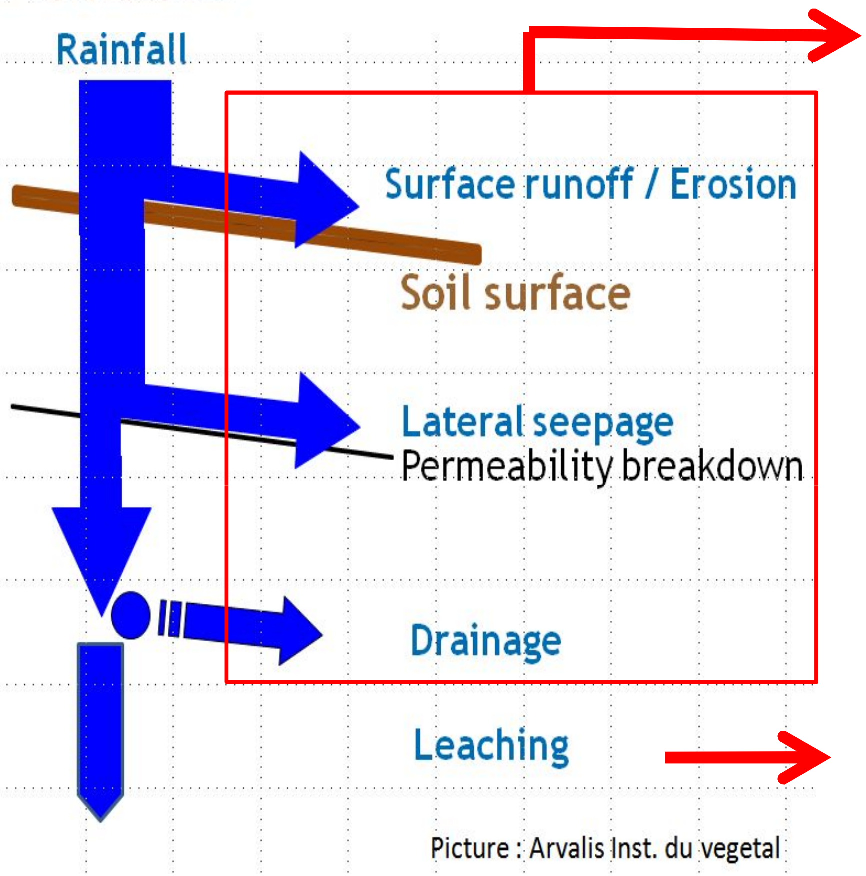
River Basin Management Plans use point sources definition for urban and industry pollution generally not in the agriculture context

Nitrogen - NO_3

- Key plant nutrient – without N no protein / low yield
- Bound in organic matter and mineralized by aerobe microorganisms (temparature, moisture, air)
- Mineral fertilizer + organic fertilizer
- Plants utilize N mainly as Nitrate
- Nitrate is water soluble
- If plants cannot utilze Nitrate risk of water transfer

Challenge:
Predict availability of Nitrogen for plants during the season
Predict uptake of Nitrogen by the crop
Adapt fertilization to the timely plant needs

Nitrogen water transfer



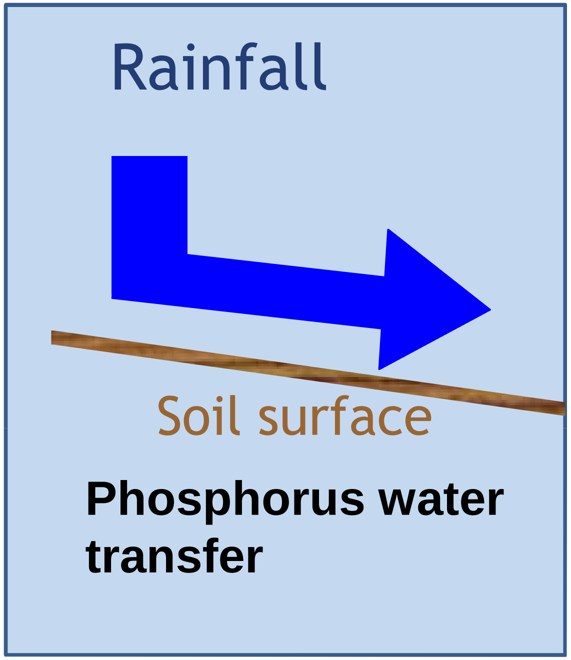
Surface water
- Runoff / Erosion
- Lateral seepage
- Tile drainage (special form of runoff)

N - Ground water (leaching)
transfer during times of groundwater recharge
late autumn to spring
(soils are water saturated) ,
vegetation growth is low or no vegetation present

Nitrogen can be transfered by all water pathways

Key pollutants from Agriculture Phosphorus

- P – is delivered to the topsoil from the soil substrate
(average P content in the earth crust 0,05%)
- P- fertilizers mainly originate from minerals (raw phosphates - sourced from Florida, Russia, China, Marokko) and organic fertilizers (Guano, manure)
- P – is bound in the soil in organic and inorganic forms.



Phosphorus is not water soluble transfer to water is mainly through soil particles: Erosion

Key pollutants from Agriculture

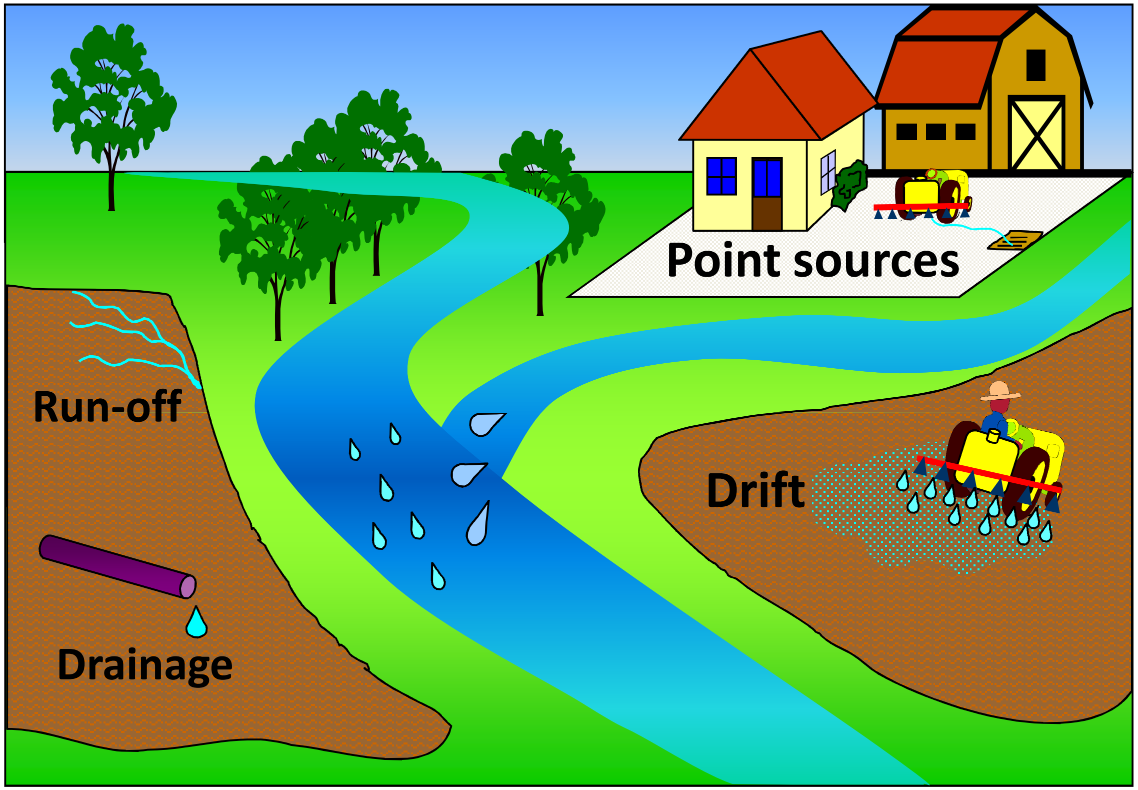
Pesticides (PPP)

- The **WFD** and the **SUD** (Directive on sustainable use of pesticide) gave stronger focus to the use phase of plant protection products (PPP)
- Mitigation of water contamination from Nutrients and PPP are mainly related to the correct use and application and the improvements of technologies and infrastructure.
- **TOPPS - Projects** started 2005 and are realized as multistakeholder projects in EU countries with local experts and partners (ECPA & Life).
- Focus is on the development, dissemination and implementation of Best Management Practices (BMPs) to mitigate contamination of water from pesticides.

BEST MANAGEMENT PRACTICES (BMP)
DEVELOPMENT, TRANSFER, IMPLEMENTATION

Significance of PPP entry routes to surface water

Significance of PPP entry routes to surface water



Diffuse sources	
Runoff about 35 %	Happens mainly in the field
> 50 % Point source	Happens mainly on the farm

Mitigation measures need to address all potential entry routes point sources and diffuse sources

Specific for PPP

- Most important for PPP transfer is the **time between application and the rain / runoff event**.
  Risk is reduced the bigger the time intervall
- The longer **PPP is in contact with soil** the more can be **degraded**.
  - Drainage better than surface runoff
- **Transfer route depends on PPP chemical and physical behavior**
  - water solubility (transfer mainly in the water phase)
  - absorption on soil particles (transfer mainly with soil particles)
- Drainage is a special case of runoff
  (if drainage works generally no surface runoff)

PPP mitigation measures largely mitigate
N and P entries to surface water

Objectives of training and BMP concept

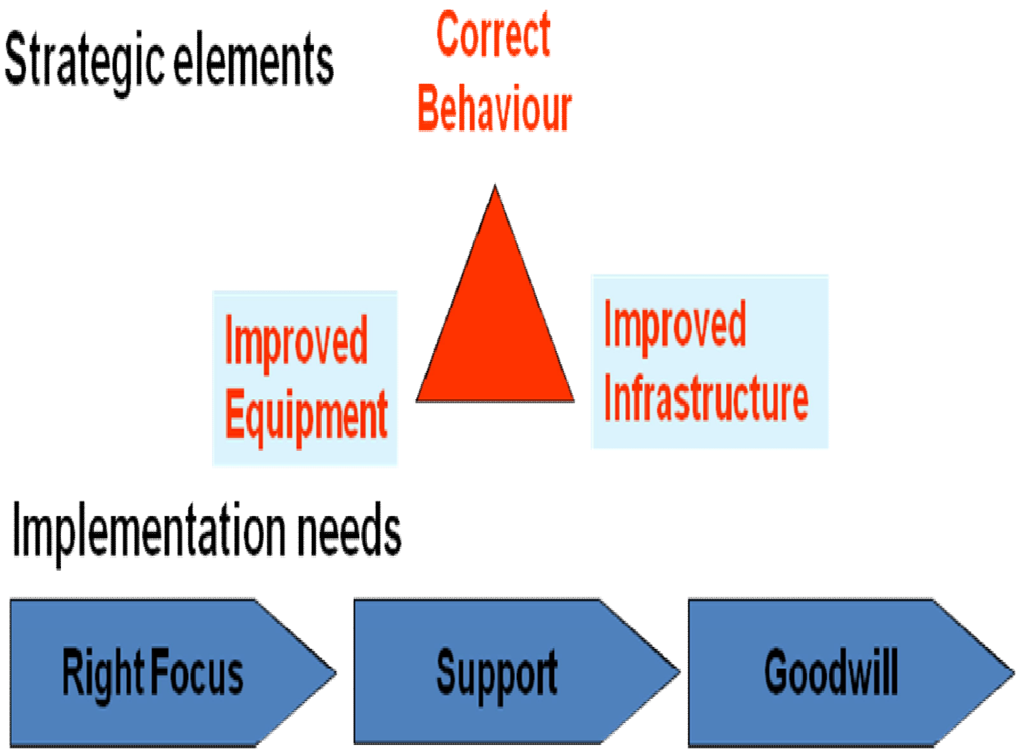
- Present TOPPS BMP - mitigation concept

- **Present and demonstrate the diagnosis methode to determine the transfer risk of PPP in a catchment and in a field**
- **Provide guidance on buffer sizing and location**
- **Link diagnosis with mitigation measures**
- **Enable participants to transfer knowledge to advisers and farmers (Train the Trainer)**

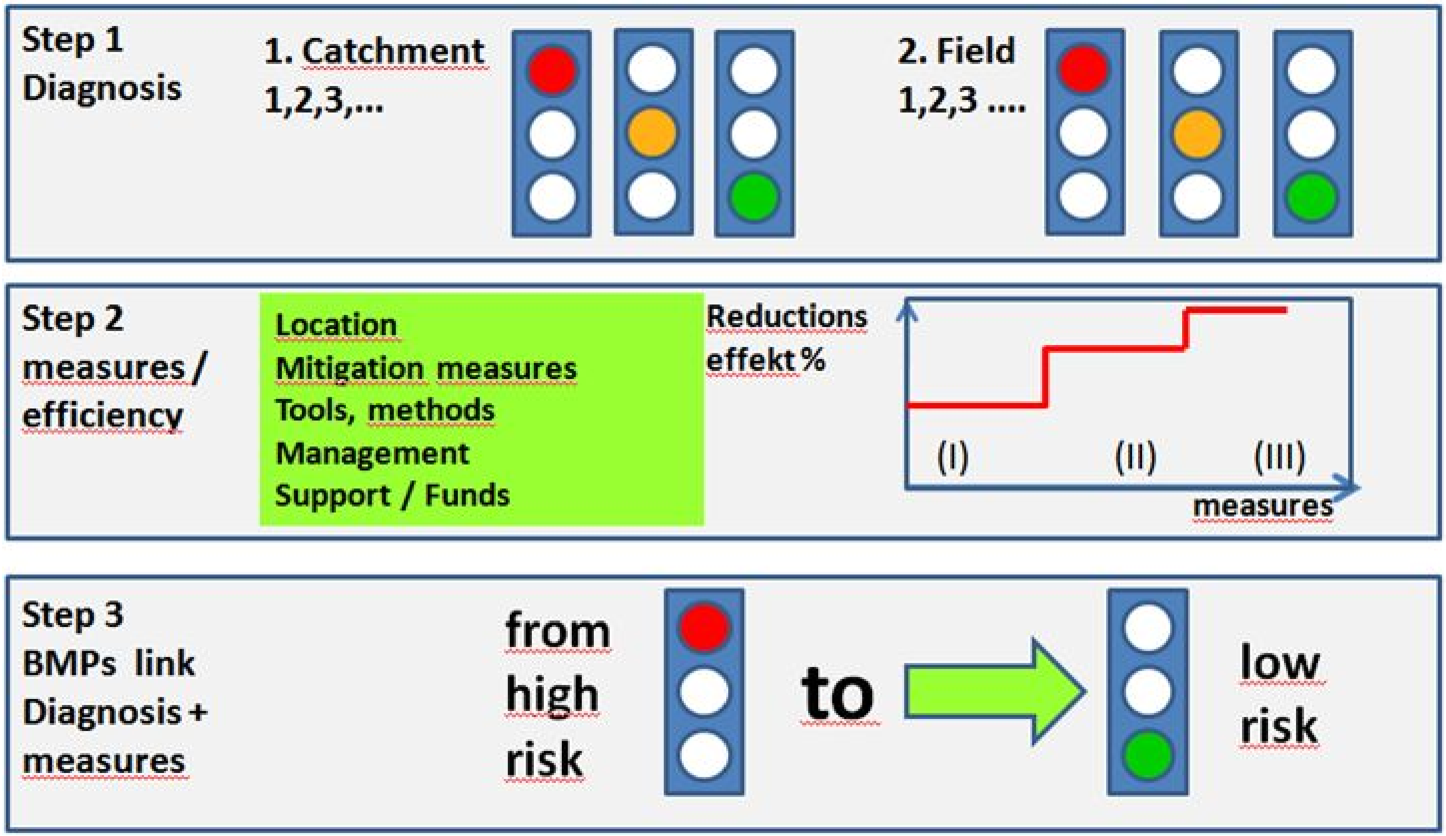
- Enable to give BMP recommendations to mitigate the entry risk of PPP to water

BMP - concept

- BMP were developed from experts in 7 EU – countries BE, DE, DK, ES, FR, IT, PL
- Competences vary from science to farmer advice
- BMP were discussed on National and European level in stakeholder workshops
- BMPs provide critical mass to be further transfered into more EU countries
- First TOPPS project on point sources + TOPPS project on diffuse sources will deliver rather complete recommendations for water protection

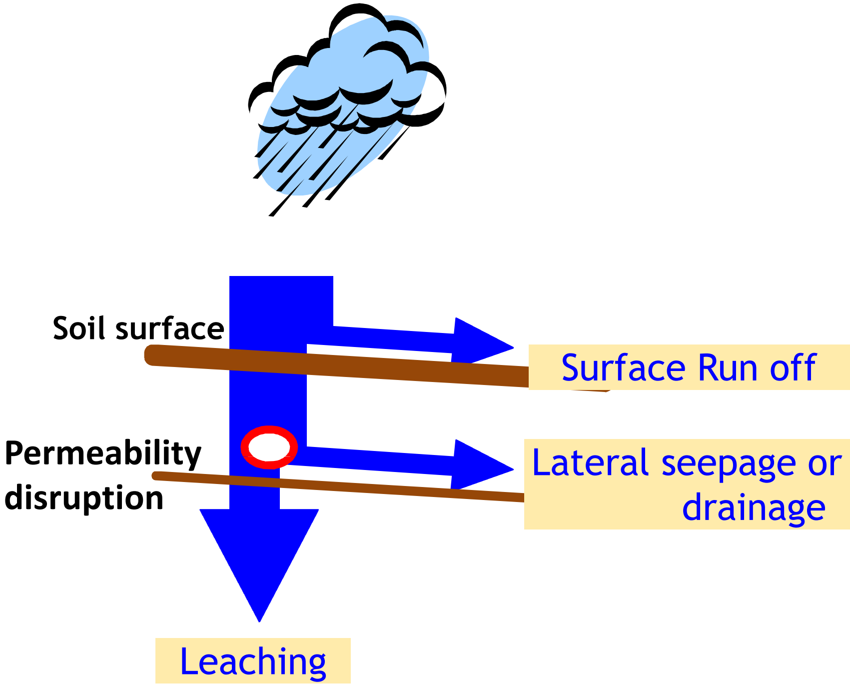


BMP – concept
Stepwise process



BMP = Diagnosis + adapted mitigation measures

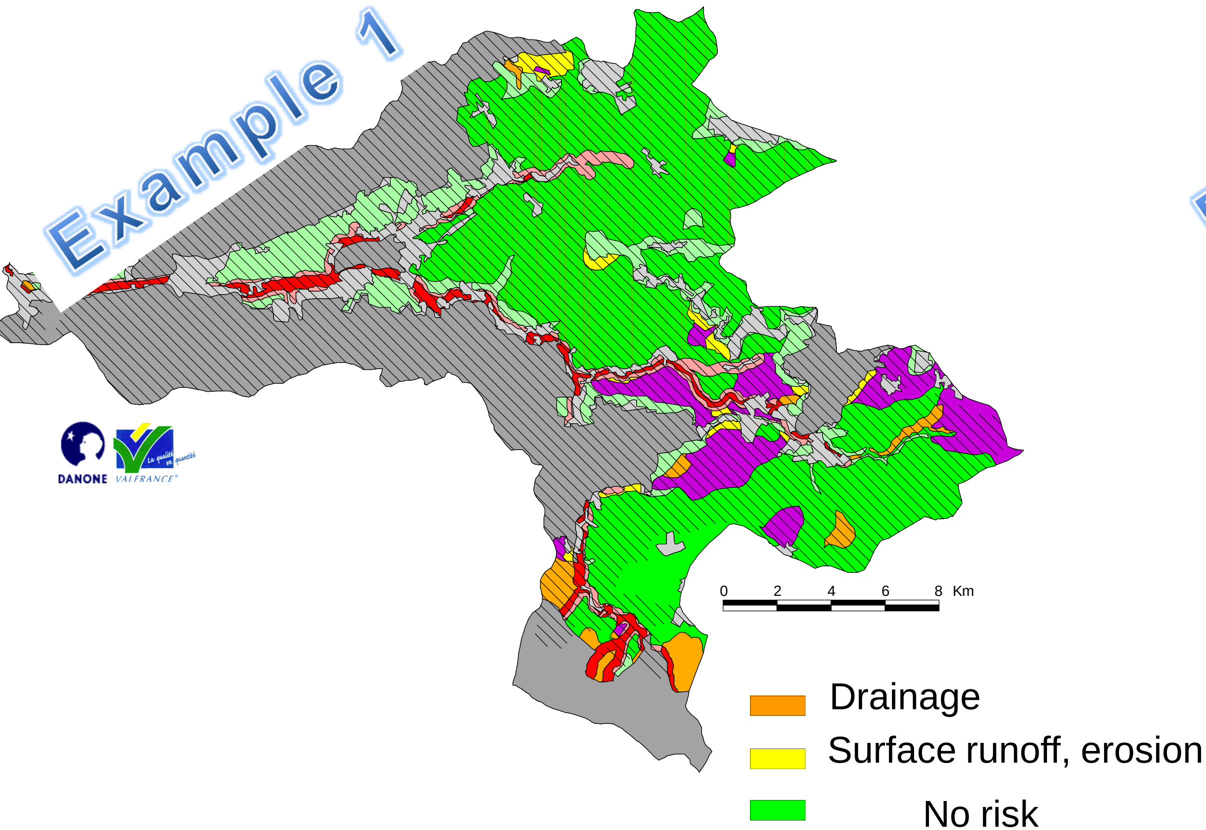
Understand the water pathways



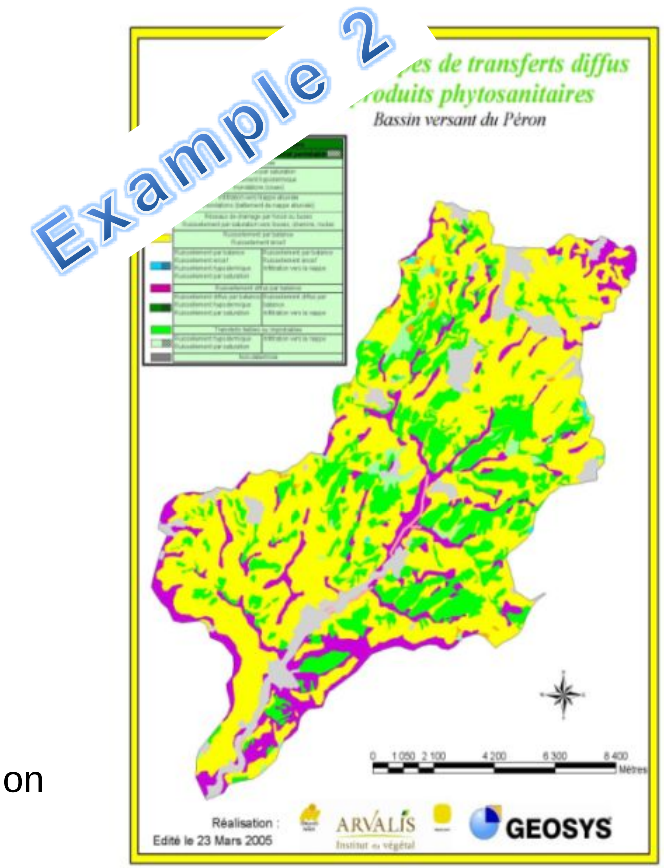
- Surface runoff occurs when water does not infiltrate the top soil
- Lateral seepage (subsoil water flow) water infiltrates top soil layer and does not further infiltrate due to a permeability disruption (e.g. plough pan, bedrock)
- Drainage
  Special kind of runoff: water saturation is avoided by artificial installation
- Leaching
  Water infiltrates the soil and can reach groundwater

Picture: Arvalis Inst du vegetal

Local conditions, local results



Catchment of la Nonette



Catchment of agripéron

Focus only on areas with a runoff risk

Identify water circulation to identify runoff type

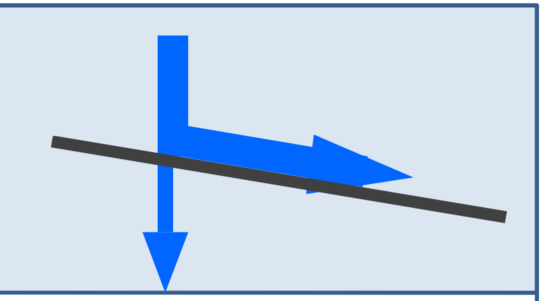
Related to permeability of the surface layer

- **Surface run off by infiltration restriction**
- Capping soil, plough pan
- Impermeable surface layer

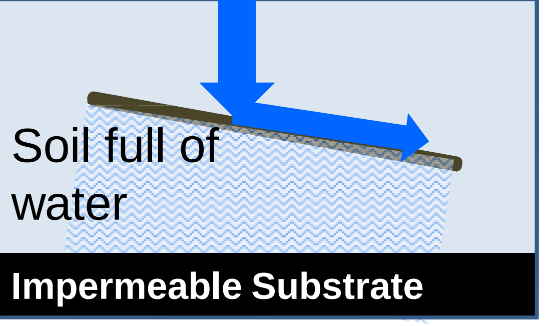
Related to permeability of the subsoil

- **Run off by saturation**
- Leaching
- Lateral seepage
- Drainage

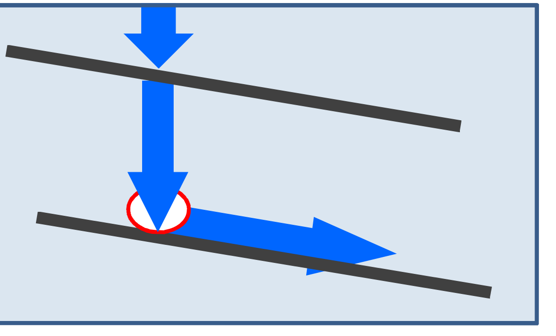
Types of runoff



- # Surface runoff
- a) **Infiltration excess:**
  volume of rain > than soil infiltration
- **b) Saturation excess (mainly winter)**
  water holding capacity is full



- # Subsurface runoff
- **Lateral soil seepage**
  impermable layer / artifical drainage



How runoff looks like
Infiltration restriction or saturation

Source : ARVALIS

Source : J.Maillet-Mezeray- ARVALIS

Source : E.Masson - ARVALIS

Source : JP Gillet- ARVALIS

How runoff looks like: Concentrated runoff

Source : G.Le Hénaff - IRSTEA

Source : G.Le Hénaff - IRSTEA

Source : ARVALIS

JMM - ARVALIS

Sometimes erosion comes along with runoff

Source : J.Maillet-Mezeray- ARVALIS

Source : G.Le Hénaff - IRSTEA

Diagnosis the first step to mitigate runoff

Key factors for runoff

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…. after the plot diagnosis you should have a good understanding of all factors listed

Soil:
Texture, permeability of the surface horizon, coarse fragments and shrinkage cracks

Substrate:
Depth, break in permeability and inclination

Landscape:
Slope, swallets and sinkholes

Adjustments:
Drainage and drain performance
Buffer zones

Meteorological data:
Date sown, crop and crop rotation

+

Type of water flow in the soil

+

Cultivation data
Crop, date sown and crop rotation
Tillage pan

Soil saturation period

Direction in which the water is flowing

Effect of practices on water flow

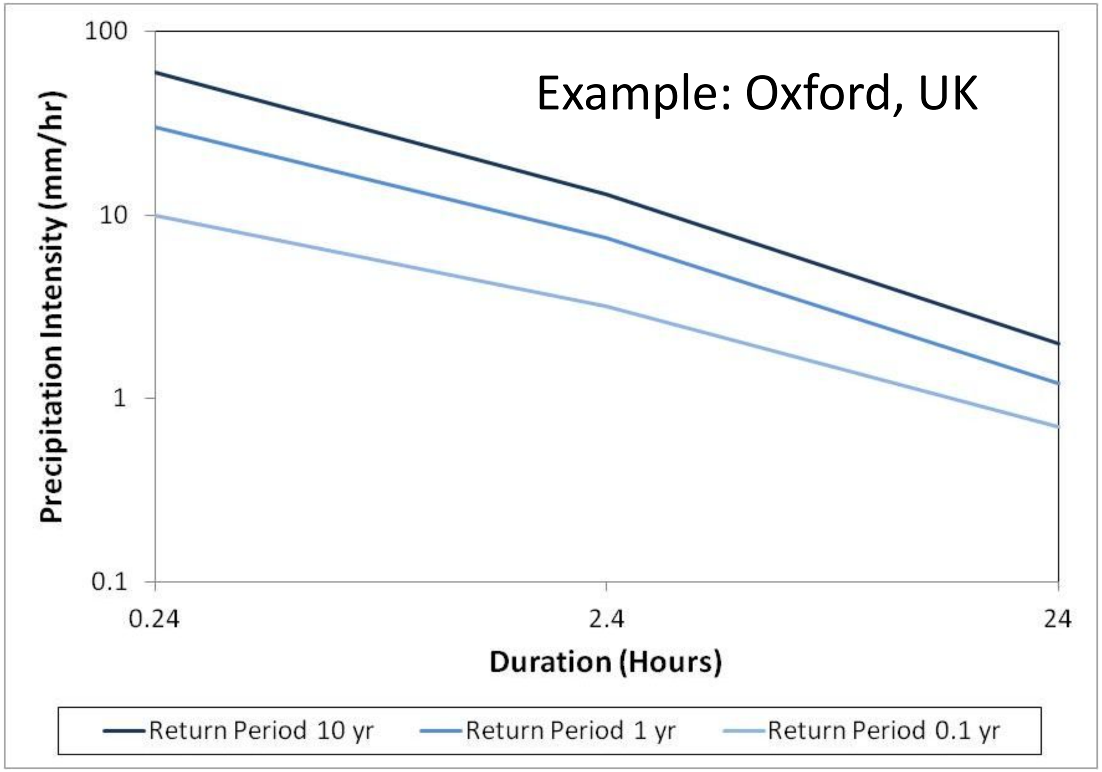
+

Intensity of water flow

Arvalis Inst du vegetal

Key Factors Determining Runoff & Erosion : WEATHER

- Weather patterns – frequency, intensity & duration



REPRESENTATIVE WEATHER PATTERNS SHOULD BE TAKEN AS BENCHMARKS TO DETERMINE NEEDED RISK MITIGATION – EXTREMS ARE DIFFICULT TO MITIGATE

What should be the mitigation target in relation to rain events?

Runoff and erosion is a process which has shaped our landscapes since millions of years, it cannot be avoided but in it can be managed

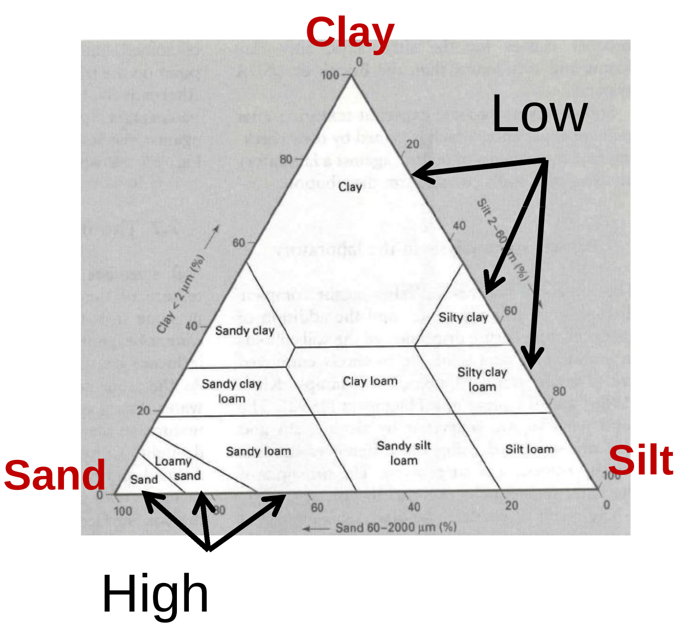
- Define mitigation targets based on representative rain events (focus on storms in spring / summer - intensity and duration
- Define representative situation where water saturation of soil in winter cause runoff
  (focus on rain duration and volume)

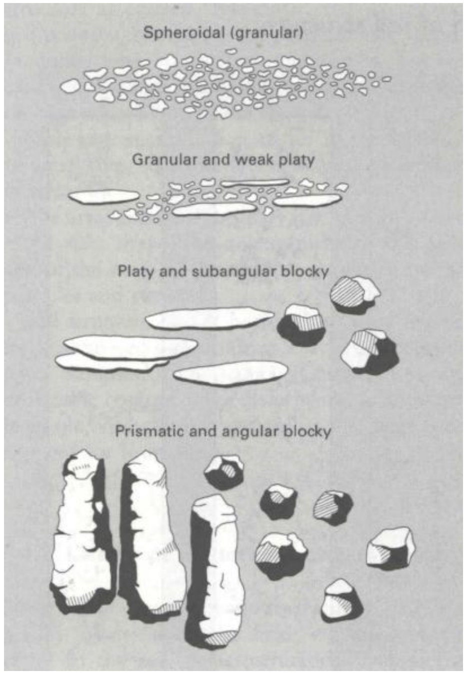
show some local weather data

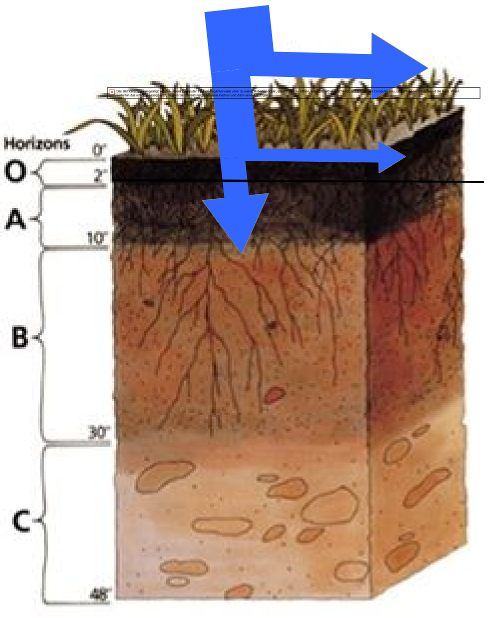
Key Factors Determining Runoff & Erosion: SOIL

Runoff & erosion are *complex*, but largely dependent on:

- Soil permeability – soil texture, structure & layering, soil cover





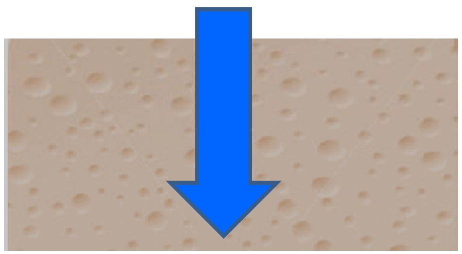


KEY MITIGATION MEASURES FOCUS ON INFLUENCING WATER INFILTRATION

Permeability of **topsoil** and **subsoil** important to diagnose

PERMEABILITY

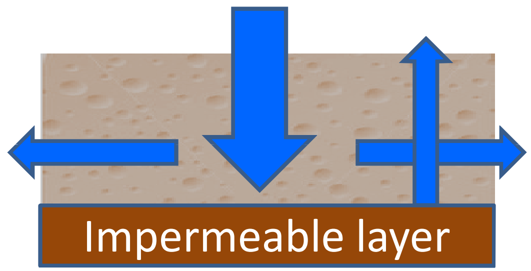
Rain volume infiltrated in soil



- Permeability high
- Infiltration high
- No surface runoff

SUBSOIL PERMEABILITY

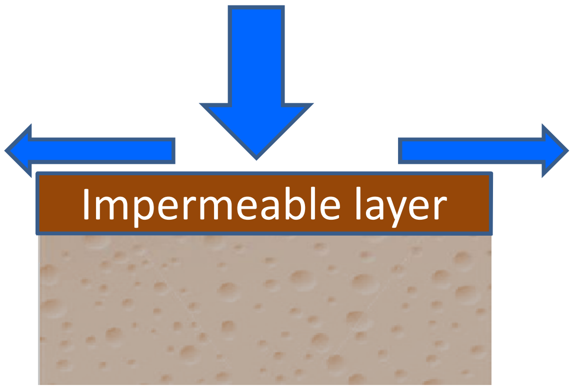
if soil is saturated runoff will occur: bucket is full



- Capacity of storage depend on soil depth
- if soil is saturated runoff occurs (surface / lateral seepage)

TOPSOIL PERMEABILITY

limited infiltration



- Capacity of storage low
- Surface runoff risk high
- Erosion very likely

SOIL PERMEABILITY KEY FACTOR FOR WATER INFILTRATION

Key factors determine runoff risk
Proximity to water

Pictuer: Pipe below road transfers run off water fast via a deep furrow on the other side to the river

- Field producing runoff is far away from water means low risk for water contamination
- Important is not only the distance to a water body but also the speed runoff water can reach it (m / s)
- Look out for short cuts

Picture: Univ Turin

Key Factors Determining Runoff & Erosion: Landscape

- **Topography – affects amount & speed of runoff + erosion**

Slope steepness

Slope shape

Slope roughness & surface cover

Slope length & surface cover

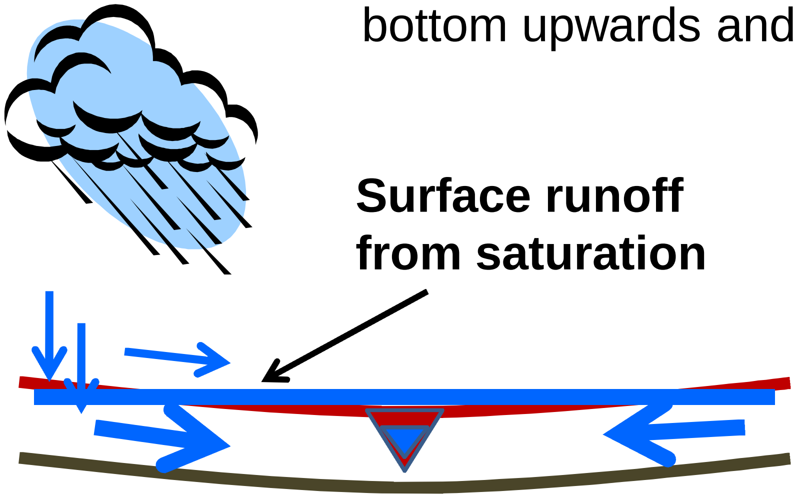
MITIGATION MEASURES FOCUS ON SOIL SURFACE MANAGEMENT

Topographic position

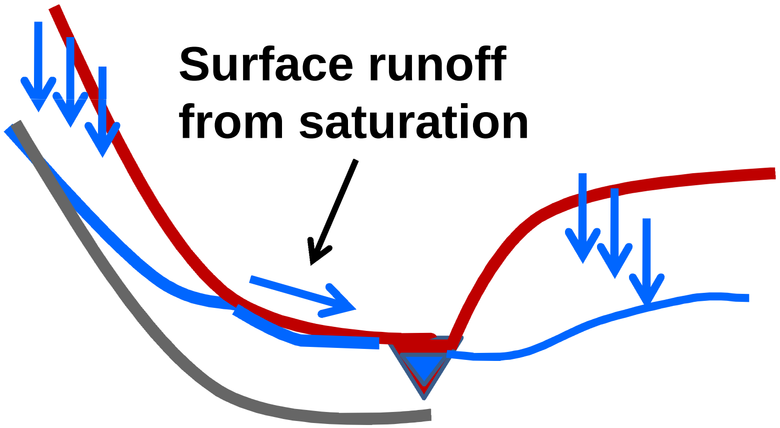
(mainly relevant in water saturation situations).

Rate of infiltration: slope steepness, slope length and surface roughness influence the rate of infiltration of water into the soil

Buckett is full: valley form is an additional factor to consider as the impermeable subsurface layer will fill up the soil from the valley bottom upwards and create surface runoff.



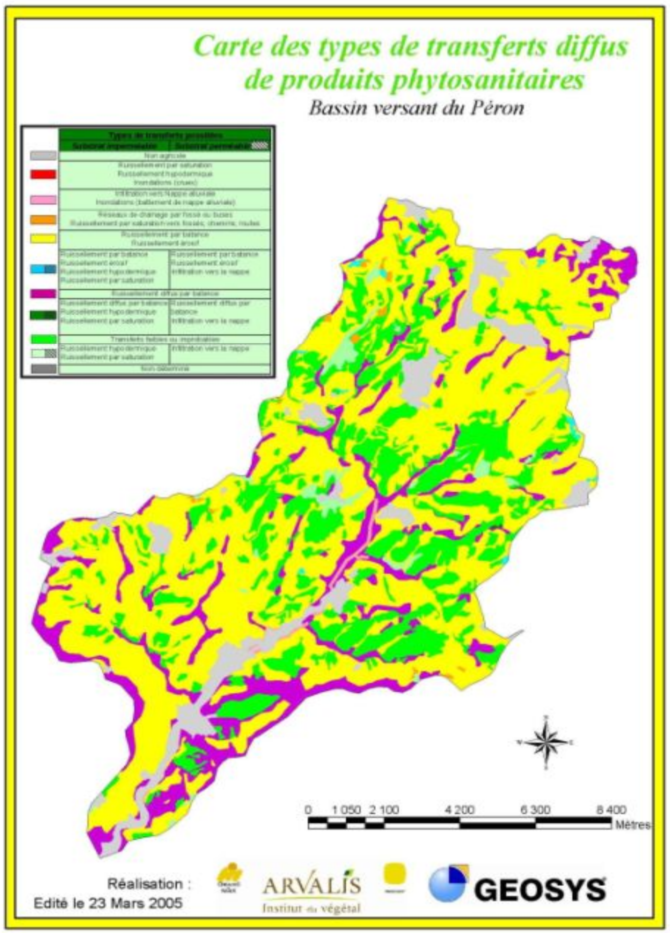
Wide valley
Wet flooded valley



Narrow valley

Water saturated soils have limited infiltration capacity

Understand the landscape in relation to water flow and transfer risk of pollutants



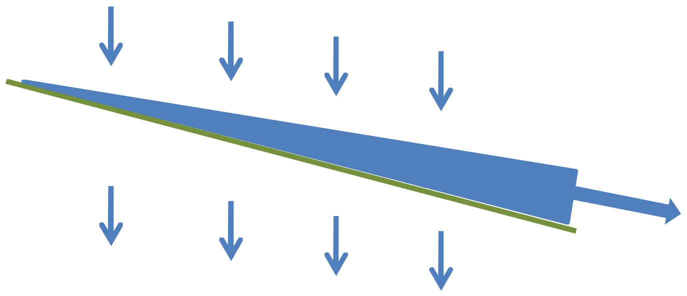
- Only parts of a landscape may have a risk of runoff (focus)
- Mitigation measures may already exist (e.g.Vegetative buffers / wetlands - are they effective?)
- Intensive interaction with farmers help to understand the situation (farmers know their fields)
- Consider seasonal aspects of runoff

Surface runoff, erosion risk areas

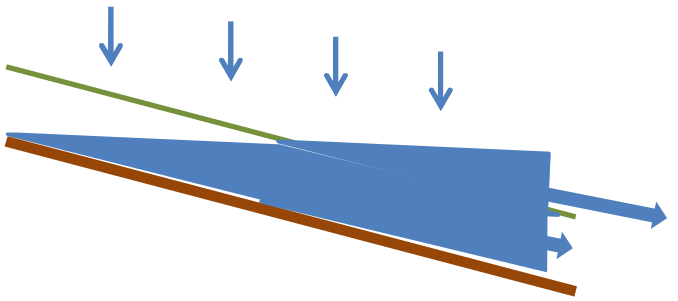
Example: Agriperon 14000 ha France
40% of the area has a runoff risk
Source: Arvalis Inst du vegetal)

Diagnosis considers two runoff situations

- **Runoff by Infiltration Restriction – Surface Permeability Issue**
  - Heavy texture / poor structure
  - Capping, crusting, compaction
  - High and short intensity storms
  - Low but long rain
  - Low vegetative cover
  - All year long!



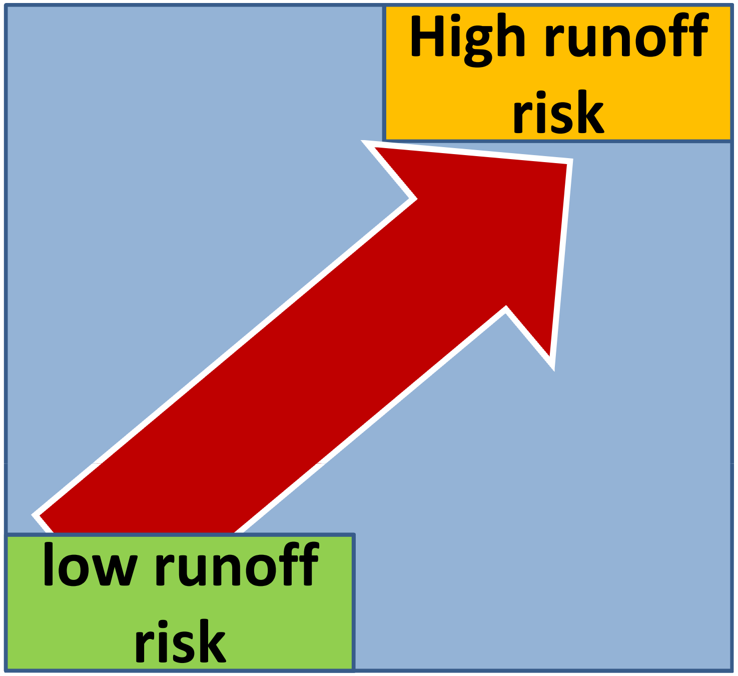
- **Runoff by Saturation Excess – Subsurface Permeability Issue**
  - Shallow soils
  - Impermeable layers
  - Concave slopes
  - Shallow wide valleys
  - Mainly in winter or early spring!



Basic runoff risk -Infiltration restriction

Rain intense
(big volume in short time)

Rain less intense
(low volume in long time)



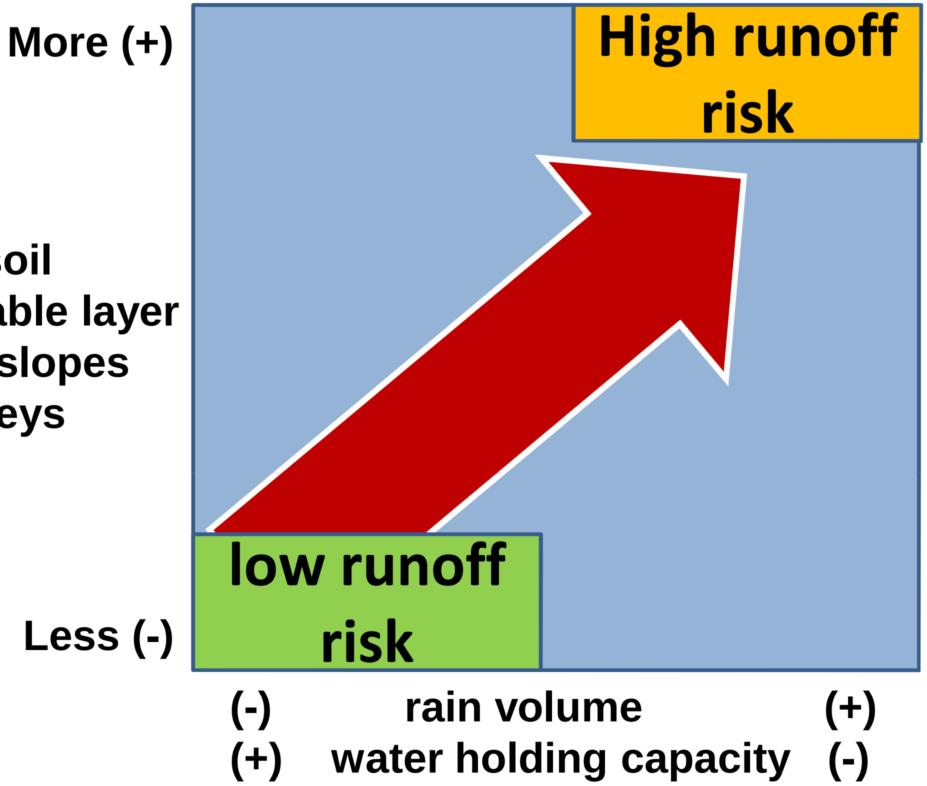
No capping soil; soil surface **permeability high**

Capping soil; soil surface **permeability low**

…. More a rain intensity problem (spring summer)

Basic runoff risk - Saturation excess

- Shallow soil
- impermeable layer
- Concave slopes
- wide valleys



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

Signs for runoff

splash erosion

runoff in wheel tracks; furrow ditch

outwash and deposits

Open furrow in a talweg

Pictures Cemagref

Signs of sedimentation

Pictures: Unito, Arvalis, IRSTEA

Special type of runoff / erosion Concentrated runoff

Picture: R.Poulsen DAAS, DK

- Water accumulates in the field and builds a „water stream“
- Signs of concentrated flow suggest the need for more intense mitigation measures
- Concentrated runoff is in most cases associated with massive transfer of soil (erosion)

Concentrated runoff

Signs of erosion indicate concentrated runoff and always need mitigation measures

Pictures: JMM - ARVALIS

Drainage

Drainage systems transport excess water out of fields in order to increase the productivity of the land or prevent salinization of irrigated soils (semi arid / arid areas)

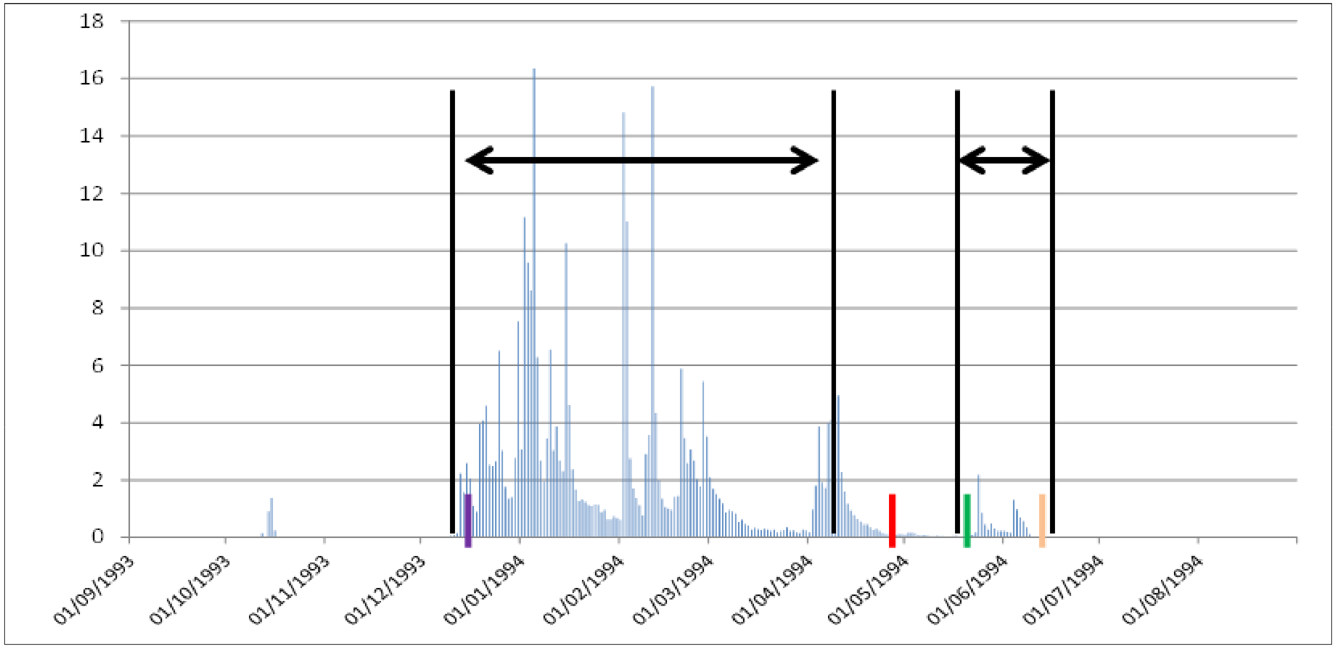
Drainage of excess water

Important to note: water from drainage systems are generally discharged out of the fields. Therefore out of the field mitigation measures are required (retention structures).
Contamination risk of drain water for PPP is lower than for runoff due to slower water movement and degradation in the soil
Other solution would be to play on application period (before drainage period)

- Outflow from drainage during water saturation of soils in late autumn winter and early spring
- Local weather stations provide information on water saturation levels of soils in an area
- Check and if there is water outflow from drainage pipes

Drainflow dependent on soil saturation

Example: Western France (La Jaillière) 1993 / 1994



Drainflow winter
Jan to end March

Drainflow early
summer June

Avoid application of PPP during times of water saturation

Different scales for the diagnosis (variable among EU- countries)

Region : Decision making unit for stakeholders

Catchment: Investigation unit to understand transfer and implement suitable action plan

Fields: Units to understand the movement of excess water:

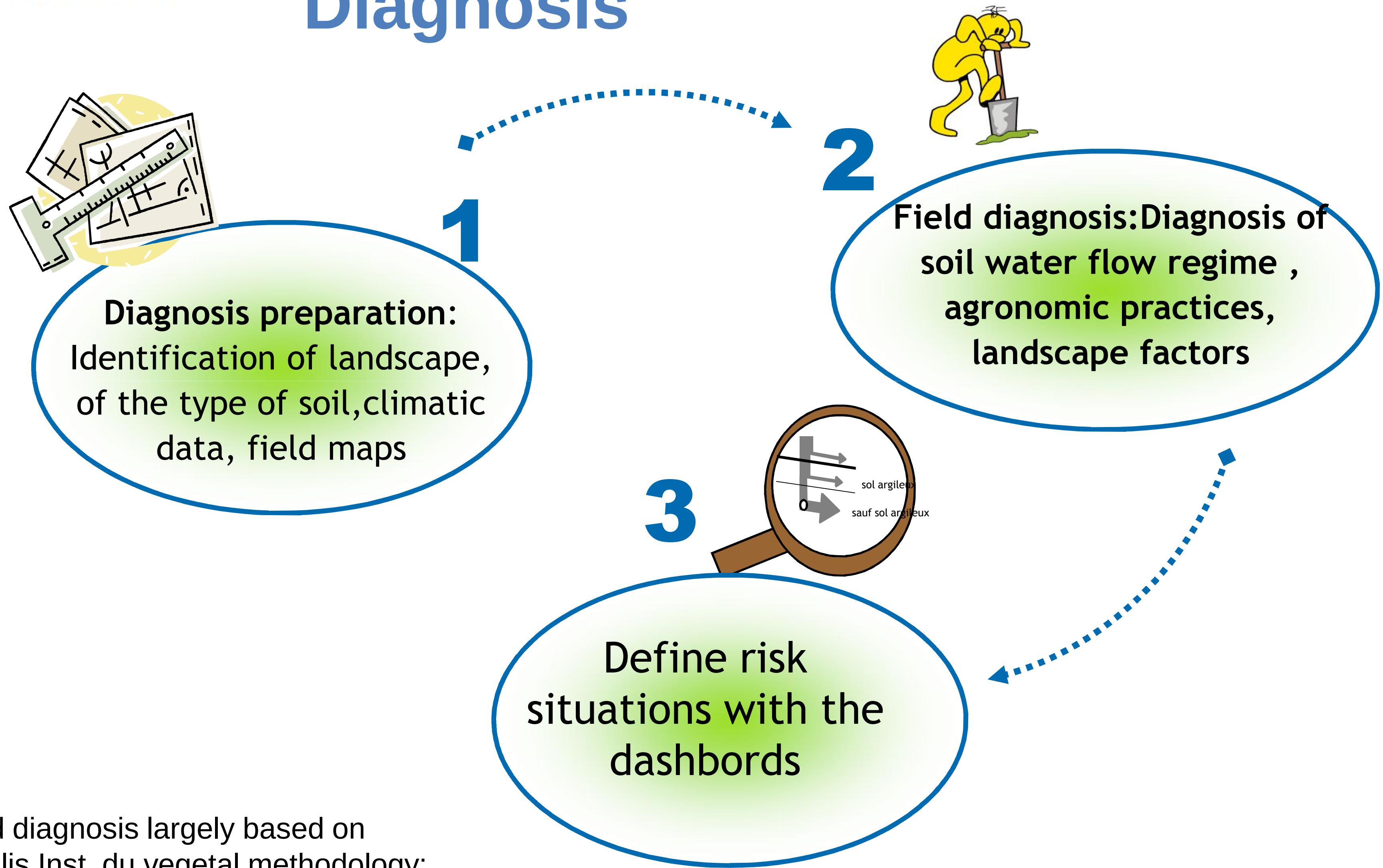
- In different locations in the catchment
- At different period of time

Farm: Decision making unit

Diagnosis in practice

Catchment
Plot
Step by step
What to observe on field

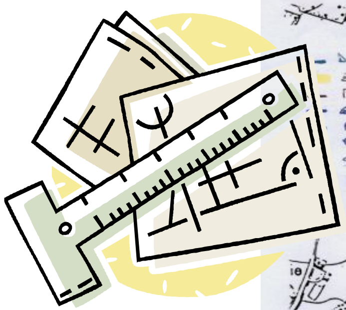
Catchment + field Diagnosis



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

Diagnosis at catchment level

Information on farm practices and landscape

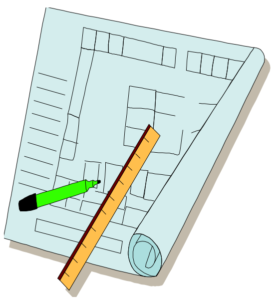


Maps on:

- Pedology,
- Geology,
- Slope
- Hydrology,
- Hydrography,
- Crop rotation.

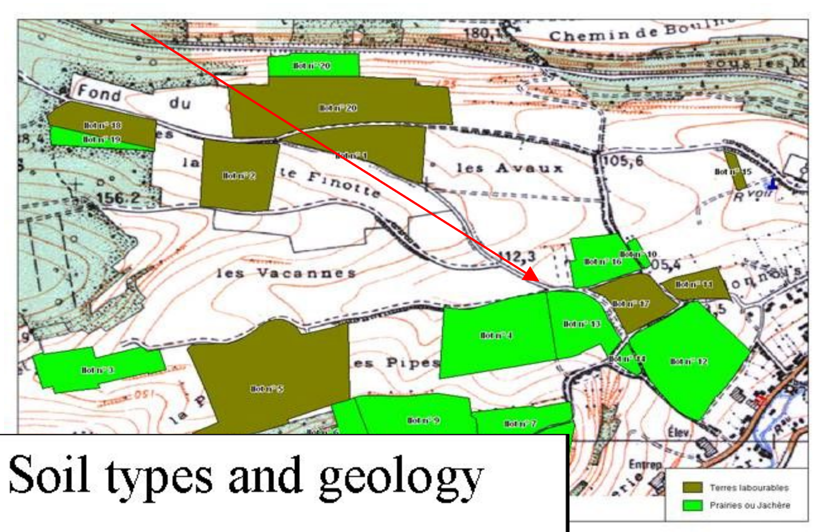
….. Data gathering often possible to prepare in the office

Diagnosis at catchment level



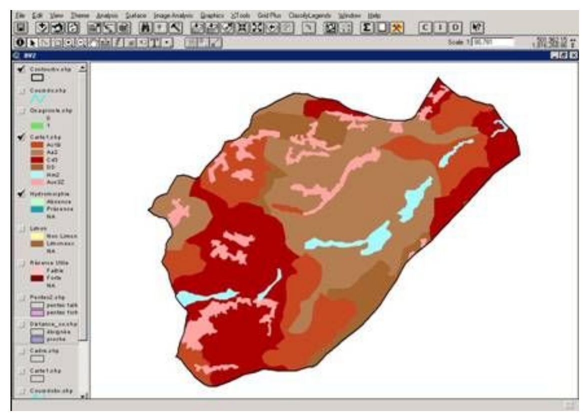
Topograpy maps useful to understand water flow

Fields localization



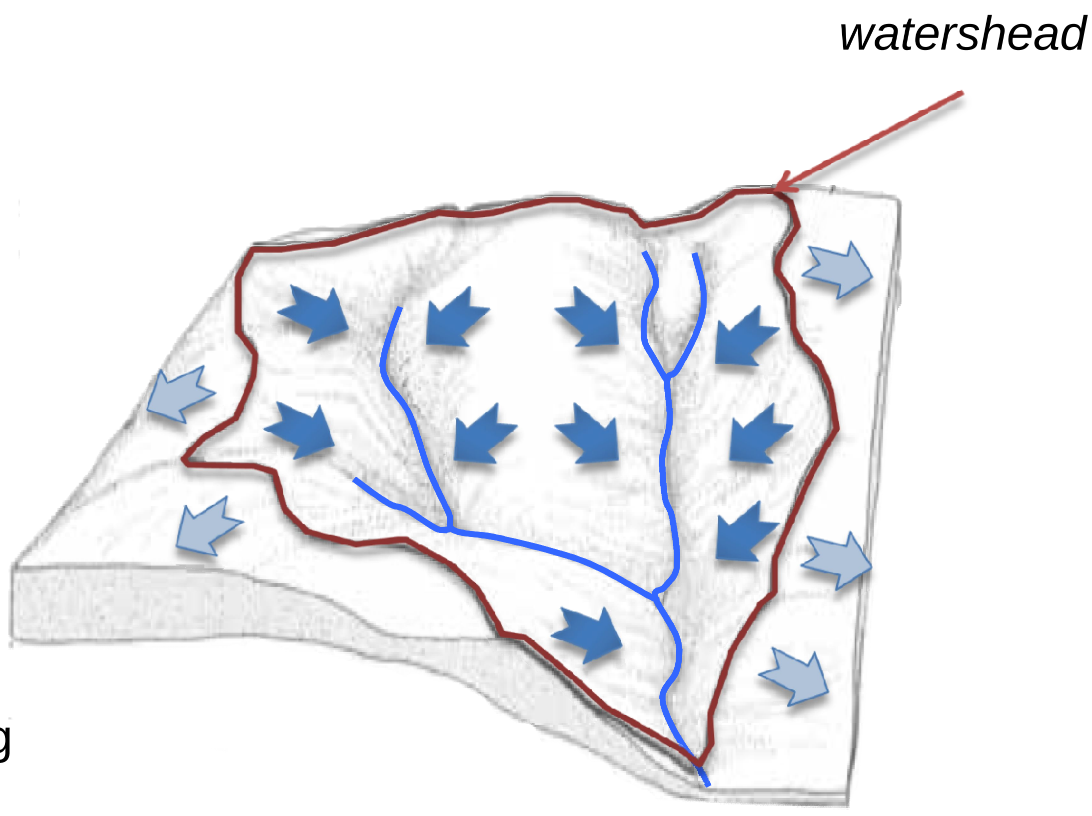
Soil and geological maps are necessary (geological situation determine genesis of soil and permeability) Karstic soils, ……..)

- Soil types and geology



Diagnosis at catchment level

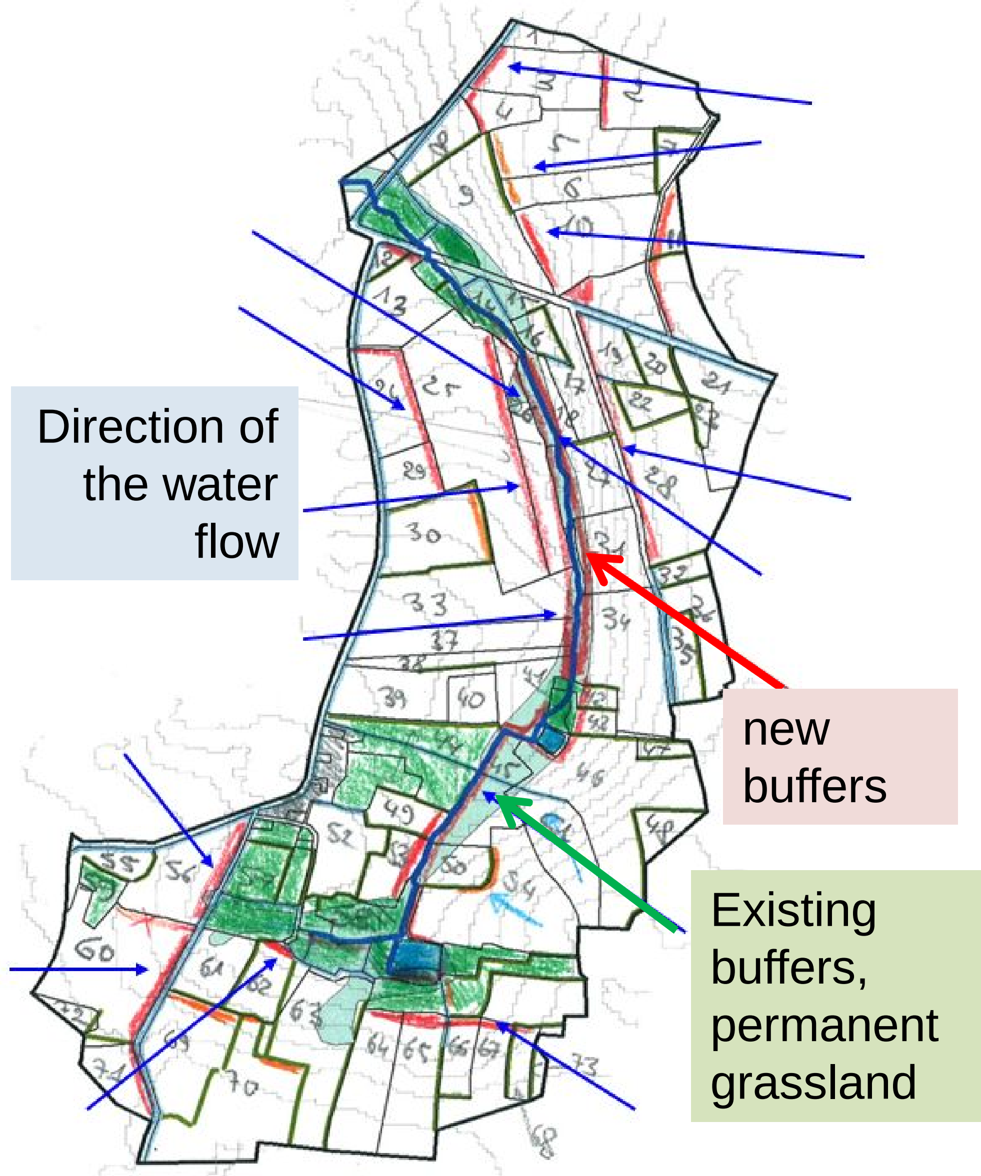
- Runoff produce effects at TERRITORIAL scale.
- Water body contamination may results either from adjacent field or upstream fields.
- Mitigation of runoff and erosion can be achieved by adopting practices affecting the entire catchment.



Diagnosis result at catchment level

Example : Fontaine du Theil ; Bretagne, FR

- Topographic information of landscape
- Hydrologic network (streams/ditches
- Water flow and direction in the landscape
- Field map / sizes / orientation (Agriculture use)



Irstea

Vegetative buffer zones diagnosis

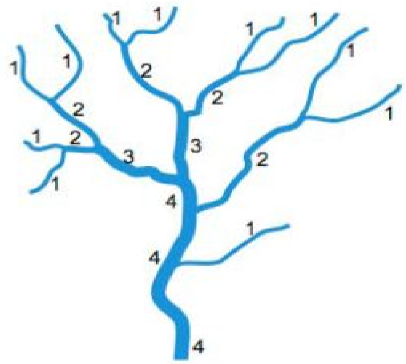
Two step diagnosis approach:

a) From the water body view (Riparian analysis)

Bank, existing buffer, vegetation of buffer, adjacent fields, hydromorphy, hydraulic connection between water course and slope ….

b) From the catchment view (Catchment analysis)

Water flow in catchment, riperian buffers sufficient, infiltration of soil, observation of runoff, field observations …..



Focus on water courses of order 1 , max 2

Irstea

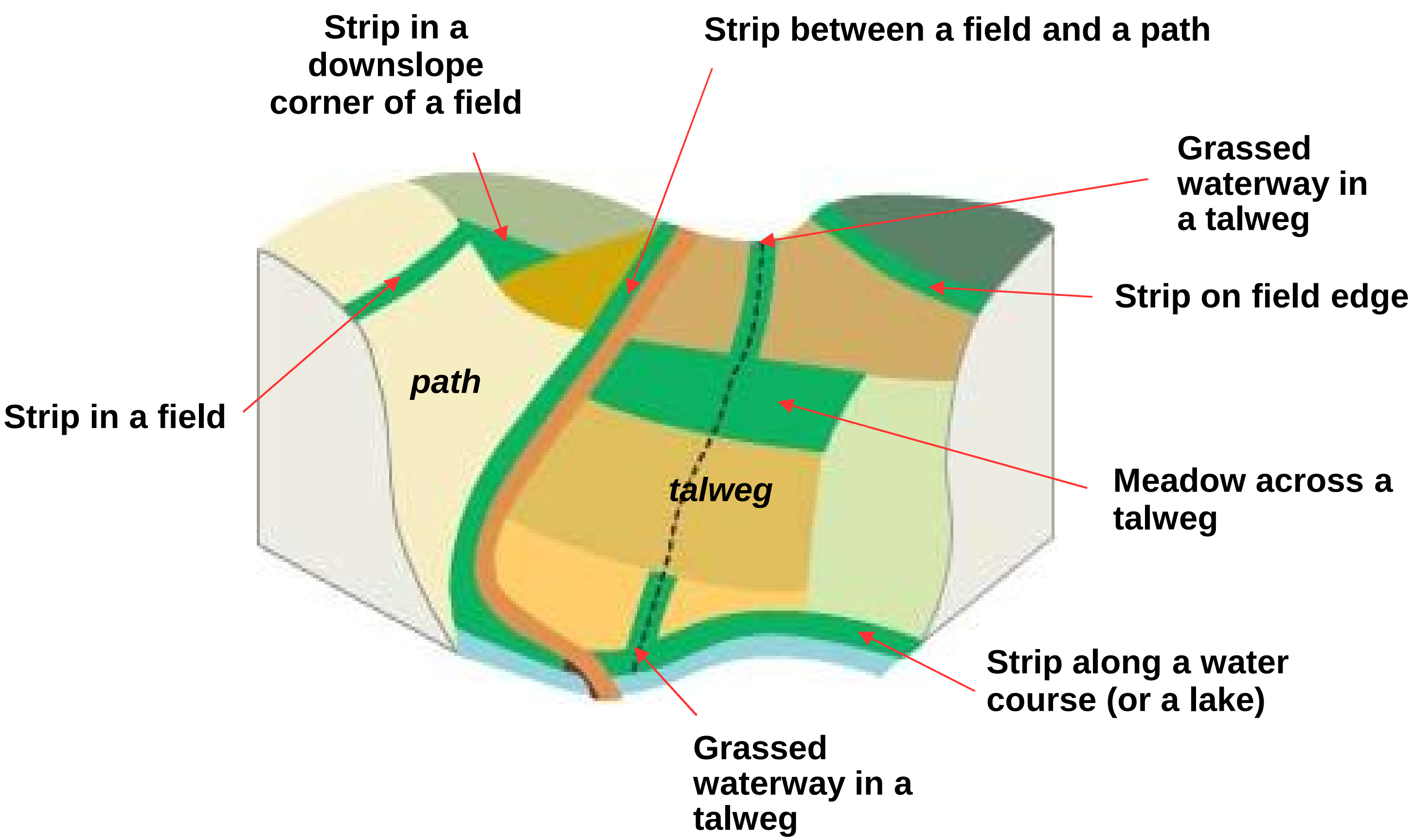
Vegetative Buffers

Vegetative Buffers are efficient mitigation measures if correctly located and dimensioned

- Catchment and field diagnosis need to evaluate the efficiency of buffers present
- For new buffers propose buffer location, type and size where they can be most efficient

Main function of buffer:
Increase water infiltration capacity &
Capture of sediments

Buffer types / location



Buffer efficiency depends on correct composition, location and dimensioning and maintenance

Picture: JJG / Irstea

Vegetative buffer
Situations / buffer types

Runoff from uphill field

Surface runoff in the uphill field of the buffer zone

Diffuse or concentrated runoff
It is quite easy to distinguish diffuse runoff from concentrated runoff. Concentrated runoff accumulates e.g. in talwegs or , furrows.
Picture:Irstea

Picture: JJG / Irstea

Vegetative buffer
Situations / buffer types

Runoff diffuse slightly concentrated

Diffuse or slightly concentrated runoff

Three cases can be distinguished:
- truly diffuse runoff,
- runoff that concentrates in a corner
- elementary drain systems.

Diffuse runoff and temporary hydromorphy

Soil permeable all over the year represents the best efficiency.
temporary hydromorphy negatively influences the buffer’s efficacy. Evaluation needs to analyse coincidence of PPP application timing and hydromorphy
Picture:Irstea

Picture: JJG / Irstea

Vegetative buffer
Situations / buffer types

Drainage special form of runoff

Buried primary drains flowing directly into water course
Mitigation measures out of field wetland, vegetated ditch

Picture: JJG / Irstea

Vegetative buffer
Situations / buffer types

Runoff clearly concentrated

Clearly concentrated runoff
A talweg is susceptible to carry an important amount of water, that a buffer zone is not likely to be able to infiltrate. In most cases, one single buffer zone would not be sufficient to deal with such situation. (Talweg buffer)
Pictures:Cemagref

Picture: JJG / Irstea

Vegetative buffer
Situations / buffer types

Runoff clearly concentrated

Concentration runoff caused by a narrow talweg within or between fields.
The topography that causes runoff to concentrate uphill may extend on the buffer

Concentration produced by the presence of a talweg in large field or in a talweg
Runoff gets deeper than the soil's surface, which prevents dispersion.
A corrective measure is necessary, in addition to dispersion constructions

Picture: JJG / Irstea

Vegetative buffer
Situations / buffer types

Runoff situation determins the buffer zone /measure

Interception by a ditch
From a technical point of view, a ditch with a strong - at least seasonal water load – should be treated like a watercourse.

Interception by a buried drainage collector or a shafted ditch
If there is a possibility to uncover the tube the establishment of a wet buffer zone might be envisaged. In the opposite case, there is no possibility to put into place a buffer zone.

Picture: JJG / Irstea

Buffer models (dry / wet)

Riparian gras / hedge buffer:
diffuse runoff, above and on the buffer zone, with convenient infiltration capacity all year long. Ideal situation for a buffer

Riparian hedge / wood buffer :
The downhill part is often hydromorphic and causes surface runoff by saturation. A buffer zone (grassed or forested) will only be efficacious during the period where there is no hydromorphy.
(saturated soil cannot infiltrate water)

Picture: JJG / Irstea

Buffer models (dry / wet)

Wetlands (natural / artificial) contain an open water body (temporary or permanent, shallow): lagoons, vegetated ditches, pools, ... Its cleaning function is essentially linked to the product's fate in this particular water environment.

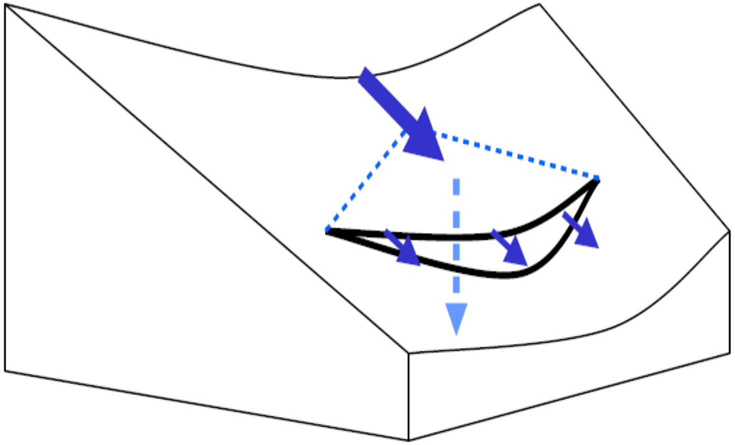
Field corner buffer zone
Fields with „double shape“ are frequent. If infiltration is not disturbed buffer can work well. Many times the field access is via the corner therefore soil compaction by machines !

Picture: JJG / Irstea

Buffer models (dry / wet)

Dispersive structures
Constructions and corrections of streamlets. Concentrated runoff may be dispersed by fascines or mini dams.

Retention basin - infiltration
When the buffer zone's soil is permeable and if the topography does not allow dispersion, one or several retention basins (in a cascade) would be an adapted solution



Picture: JJG / Irstea

Buffer models (dry / wet)

Grassed waterways
Grassed trenches, which can be implanted in a talweg or across cultivated fields are a solution for runoff concentration, regardless of any eventual erosive conditions. In practice, grassed trenches are mostly put in place to fight erosion.

Picture:USDA

Buffer sizing tools applicable directly in the field are not yet available

- Buffer efficiency needs to be monitored and adaptions according to observations are necessary
- Buffer sizing is currently in the field a qualitative approach as quantitative tools are not yet available
- Models (VSF mod) being applied to simulate buffer locations and sizes

Concentrated runoff

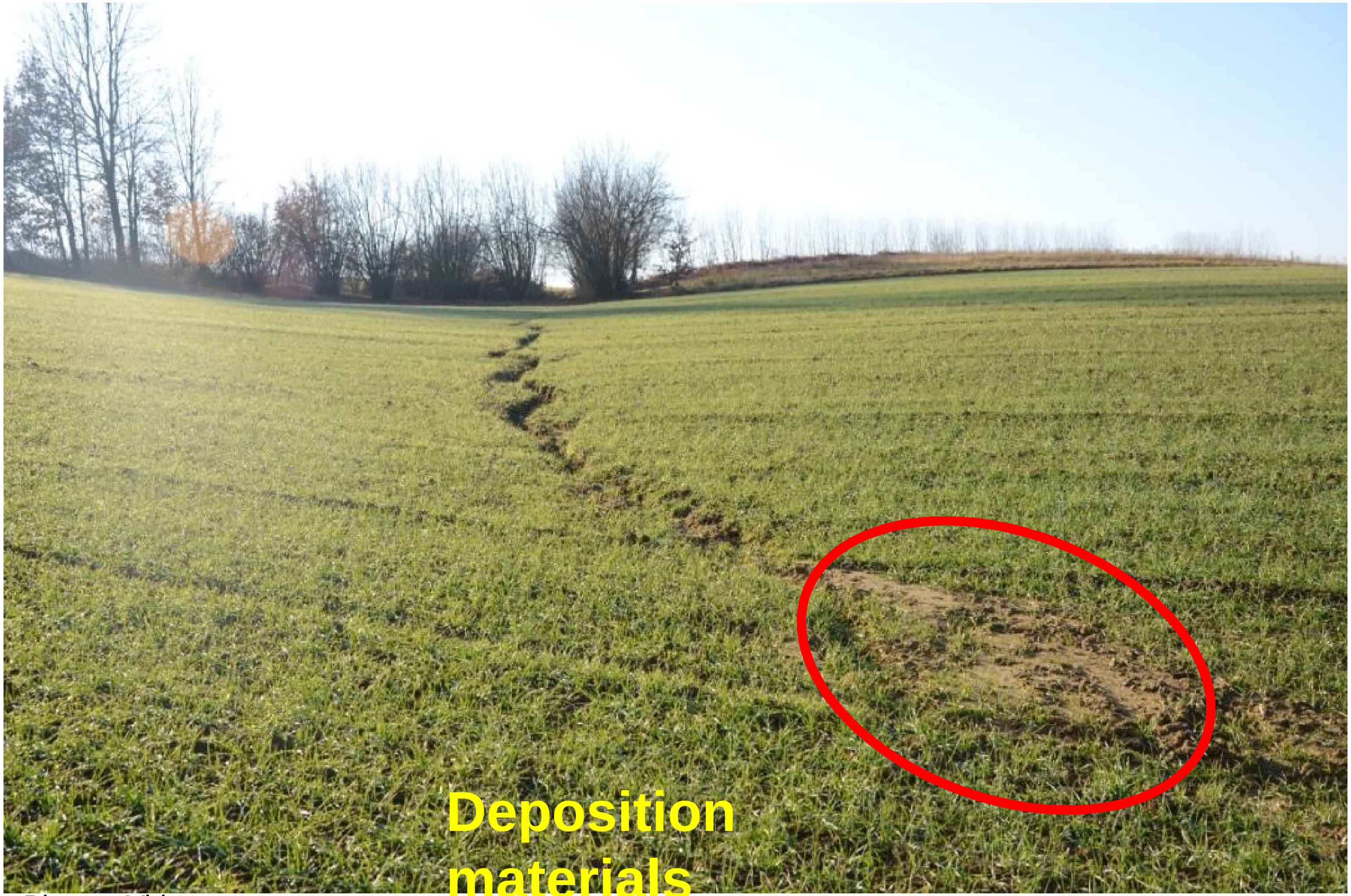
- Water accumulates in the field and builds a water stream
- Signs of concentrated flow suggest the need for more intense mitigation measures
- Concentrated runoff is in most cases associated with massive transfer of soil (erosion)

Concentrated runoff

TALWEG

Picture: Vidotto

Concentrated runoff



Picture: Vidotto

Concentrated runoff

GULLY EROSION

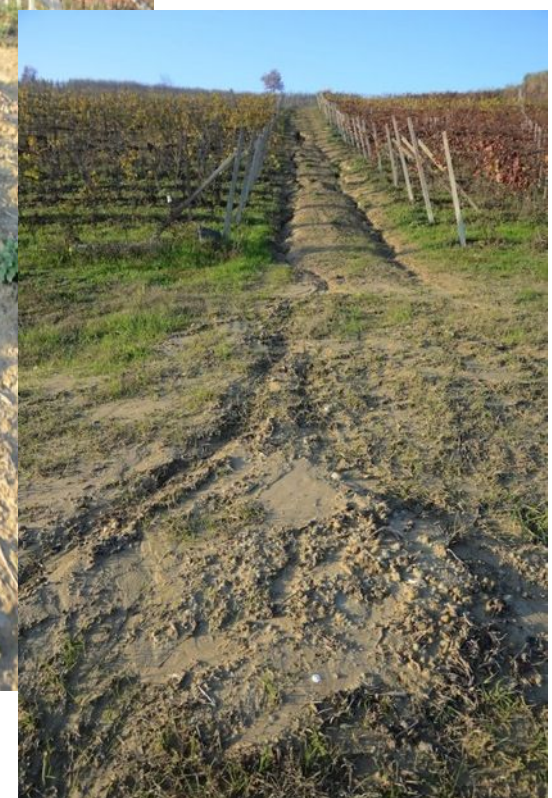
SEDIMENTATION

Picture: Vidotto

Concentrated runoff

Picture: Vidotto

Concentrated runoff in a vineyard



GULLY EROSION

Picture: Vidotto

Diagnosis and mitigation of concentrated Runoff & Erosion

<table>
<tr><td rowspan="11">Runoff generated in the audited field?</td><td>No</td><td colspan="2">Runoff coming from uphill area in the catchment</td><td>C1</td></tr>
<tr><td rowspan="10">Yes</td><td colspan="2">Runoff Concentrating in Wheel tracks</td><td>C2</td></tr>
<tr><td colspan="2">Runoff concentrating in corner</td><td>C3</td></tr>
<tr><td colspan="2">Runoff concentrating in field access area</td><td>C4</td></tr>
<tr><td rowspan="2">Runoff moderately concentrated in rills</td><td>No hydromorphic soil</td><td>C5</td></tr>
<tr><td>Hydromorphic soil</td><td>C6</td></tr>
<tr><td rowspan="2">Runoff moderately concentrated in talweg</td><td>No hydromorphic soil</td><td>C7</td></tr>
<tr><td>Hydromorphic soil</td><td>C8</td></tr>
<tr><td colspan="2">Runoff strongly concentrated - Gully not in talweg</td><td>C9</td></tr>
<tr><td rowspan="2">Runoff strongly concentrated
Gully in talweg</td><td>High infiltration soil in buffers</td><td>C10</td></tr>
<tr><td>Low infiltration soil in buffer</td><td>C11</td></tr>
</table>

Mitigation proposals (1)

C1. Prevent concentrated runoff at source uphill in catchment: Make runoff risk audit of the field where runoff is generated. In addition, buffers and retention structures may be needed to intercept any concentrated runoff downhill (see right-hand side of dashboard).

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.

Mitigation proposals (2)

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.

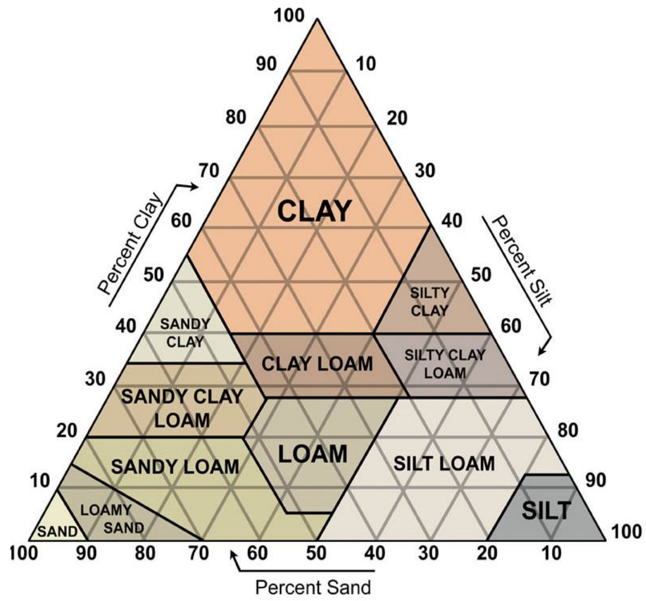
C11. Close gully. If talweg buffer doesn`t exist, implement vegetated talweg buffer and /or Wetland or meadow. If talweg buffer exists, widen talweg buffer and implement with fascines, and/or implement wetland or meadow.

Plot diagnosis

Plot diagnosis : key info needed

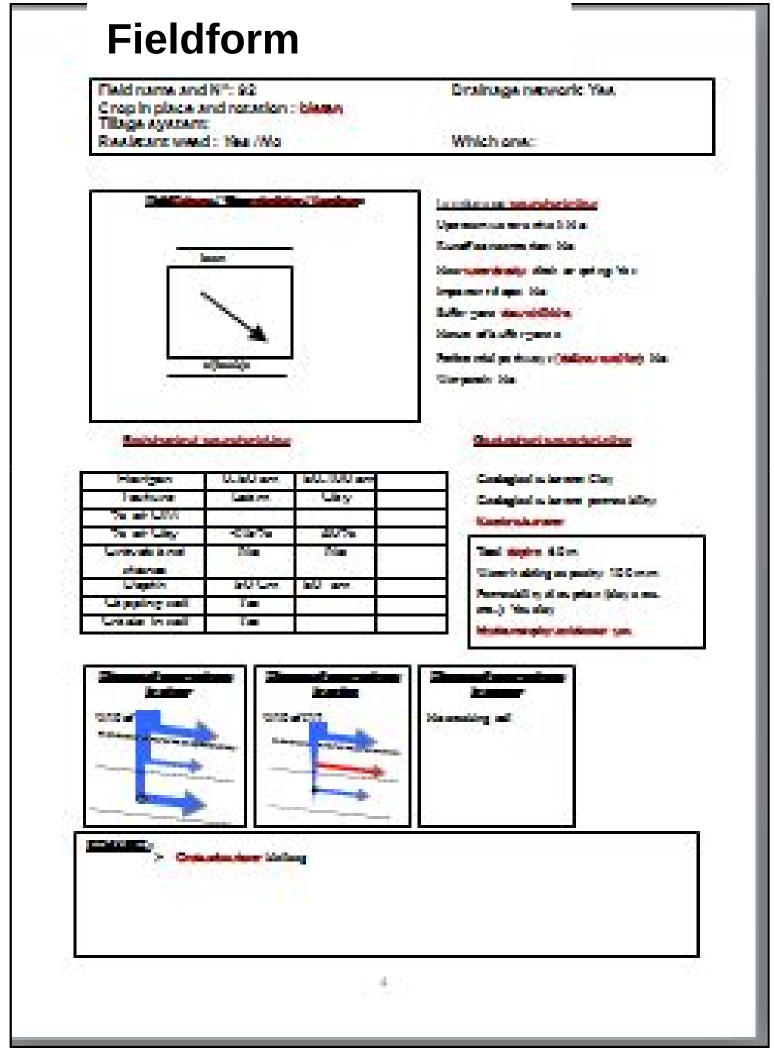
Identify soil characteristics (field methods)

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



Plot diagnosis

Picture: EP-InAgro



Fieldform

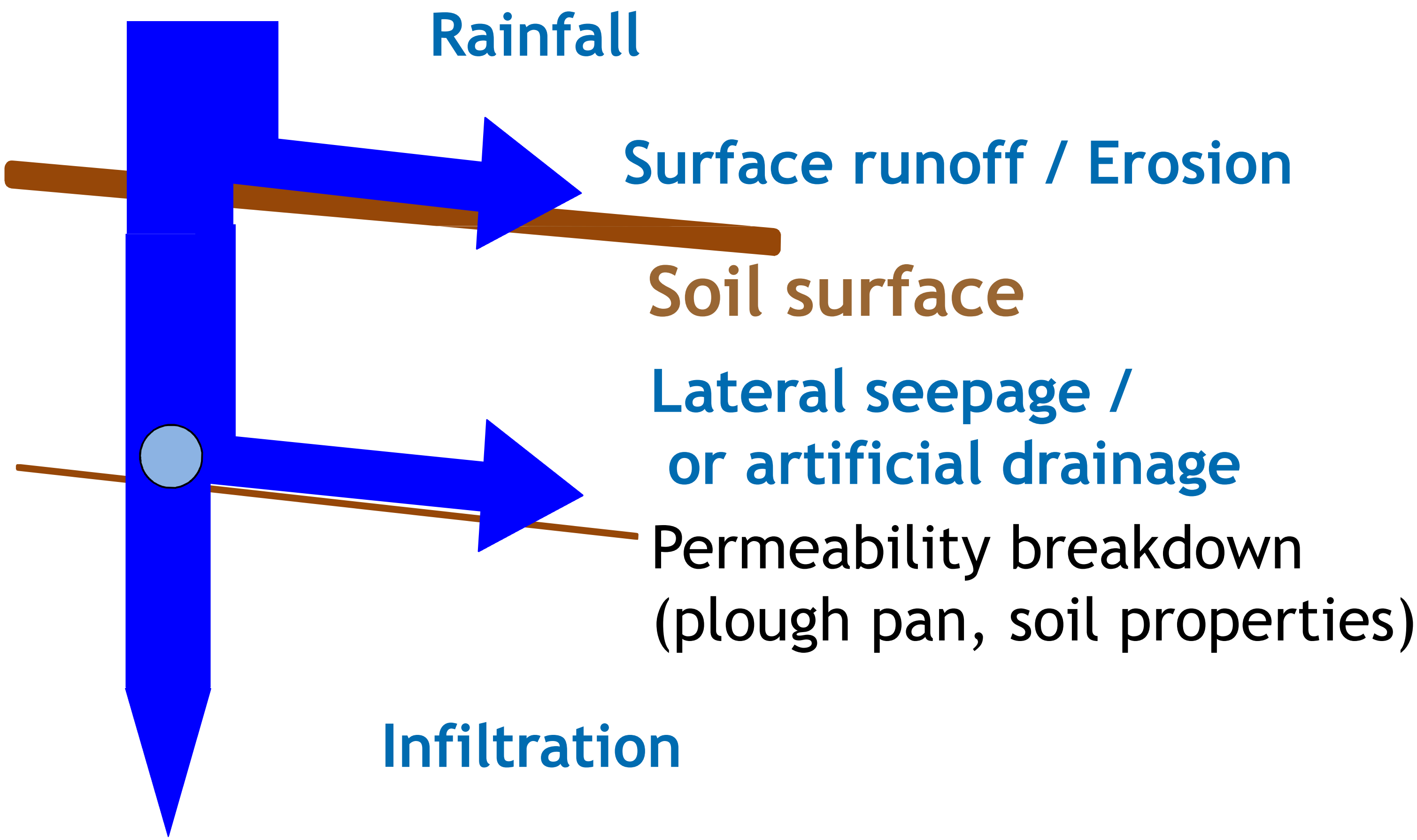
Field name and N°: 92 Drainage network: Yes
Crop in place and rotation :
Tillage system:
Resistant weed : Yes /No Which one:

Crusted soil

Source : J.Maillet-Mezeray- ARVALIS

Plot diagnosis

Identify the types of water flow in the soil and intensity (Runoff types)



Plot diagnosis

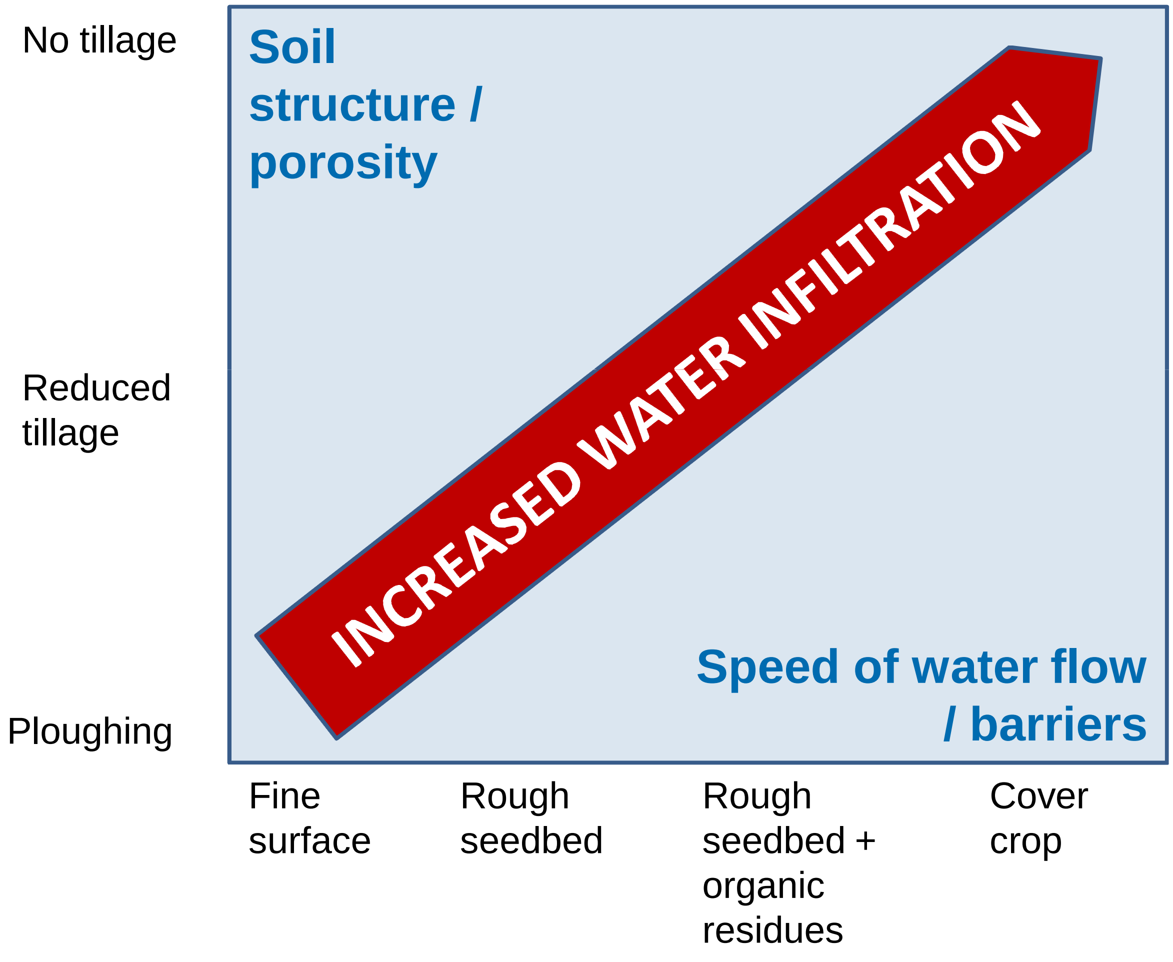
Determine the effect of practices: soil management & cropping practice

Soil covering
(crop and date sown)

Soil cultivation
(intensity of tillage, surface roughness)

Crop rotation /
Crop distribution
(Winter / Spring)

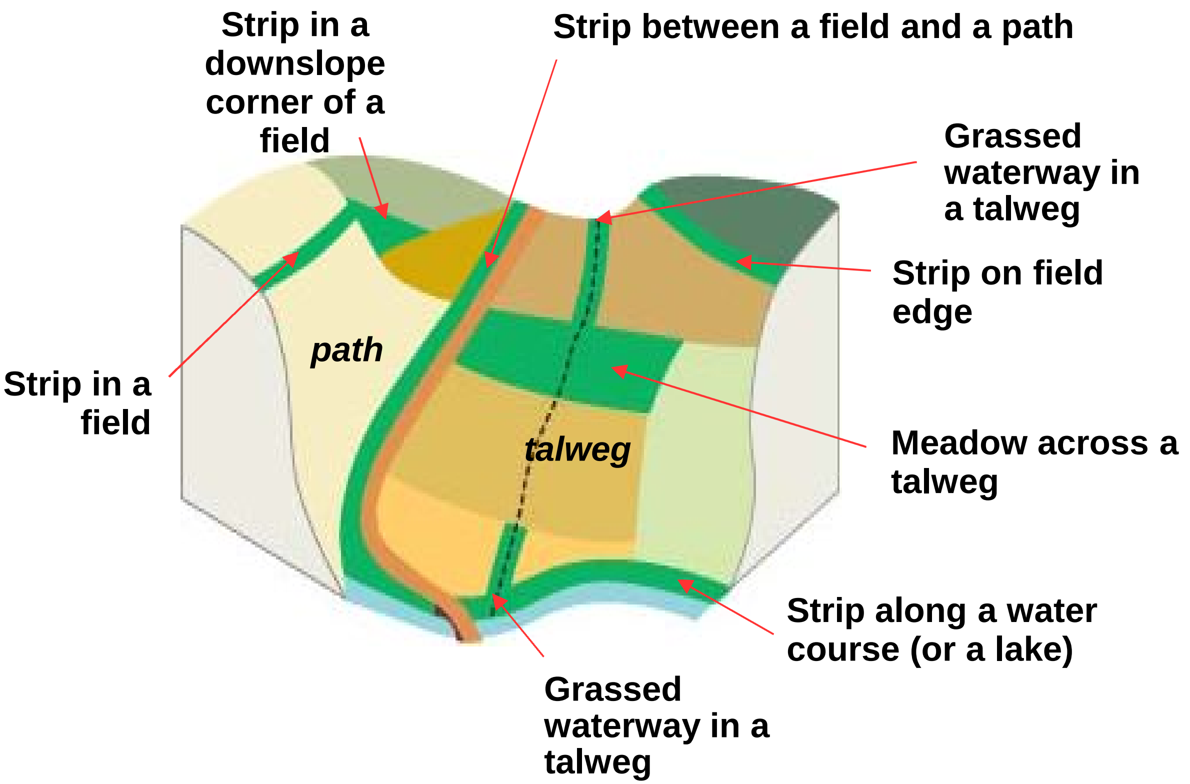
Cropping practices and soil management interact to increase water infiltration



Plot diagnosis

Determine the landscape factors

- Slope length
- Slope shape
- Talweg
- Natural buffers
- Field sizes



Plot diagnosis

Determine the effect of the landscape and adjustments

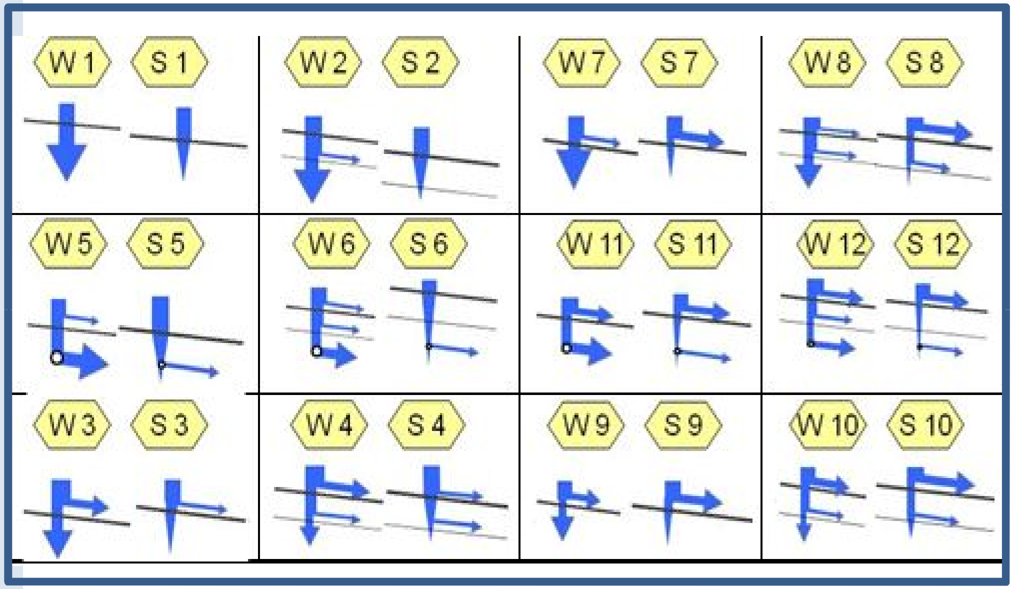
- Type of buffers
- Buffer efficiency ?
- Retention structures
- Drainage systems

Plot diagnosis

Determine water pathways seasonality

- Intense rain, **short**
  Low infiltration:
  spring or summer

- Low intensity rain, **long**
  Saturation of water holding capacity:
  autumn, winter, early spring



w = winter; s = spring

Seasonality of runoff

Low soil cover AUTUMN

Low soil cover SPRING

Important soil cover SPRING

Evaluate the runoff risk in the field

Visible signs / indicators

- Signs of water saturation (hydromorphy)
- Permeability of top and subsoil
- Water holding capacity
- Steepness of slope / slope length
- Proximity to water body
- Agronomic practices
- …. and assume a representative weather pattern

Determine the runoff risk Dashboard help tool

- 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
- Runoff risk analysis combines implicit + tacit knowledge

Two main dashboards need to be considered for each risk analysis

1. Runoff risk estimate for infiltration restriction (D1)
2. Runoff risk estimated for saturation excess (D2)

Diagnosis of Runoff & Erosion for Infiltration excess (D1)

Step 1 – Proximity of Field to Water Body	*Step 2 - Slope of the Land*	*Step 3 – Permeability of the Topsoil*		
		High	Medium	Low
Adjacent	Steep (>5%)	Medium – I3	High – I4	High - I7
Adjacent	Medium (2-5%)	Low – I2	Medium – I3	High – I6
Adjacent	Shallow (<2%)	Very Low – I1	Low – I2	Medium – I5

Step 1 – Proximity of Field to Water Body				
Not Adjacent	***Step 4 – Transfer of runoff to downhill field ?***	Runoff reaches waterbody	YES	High – T3
Not Adjacent	***Step 4 – Transfer of runoff to downhill field ?***	Runoff reaches waterbody	NO	Very Low – T2
Not Adjacent	***Step 4 – Transfer of runoff to downhill field ?***	NO		Very Low – T1

Permeability Classes & BMP for Productivity & Protection by Runoff & Erosion Scenario

Advice tabs	General BMP Measures	BMP for Very Low (T1, T2, I1)	BMP for Low (I2)	BMP for Medium (I3, I5)	BMP for High (T3, I4, I6, I7)

Source: AquaplaineR, TOPPS partners, Syngenta advice framework

Permeability assessment / Definitions

TOPSOIL PERMEABILITY	DIAGNOSTIC Criteria
LOW	• capping soil Or • clayey & loamy soils (>30% clay , < 30% sand) Or • Swelling clay – (> 25% clay)
MEDIUM	• Non capping soil and • Other soil structures
HIGH	•Non capping soil and • Sandy & sandy loam soil < 20% clay, > 65% sand or •Loamy & silt soils (sand + silt > 65%) good aggregate structures & high organic matter > 3% or •Non-swelling clays (< 25% clay)

Risk Scenarios Infiltration restriction (1)

Risk Scenarios	Mitigation targets
Transfer (T1) Very low risk	Maintain good agricultural practices in field to minimize runoff and erosion
Transfer (T2) Very low risk	T1 & 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 acceptable, treat plot as if adjacent to water.
Infiltration (I1) Very low risk	Stop runoff at source using in-field measures and/or edge-of-field buffers OR ensure water infiltration in downhill plot / area by suitable measures (buffers, retention structures) In case of large amount of runoff: stop at source to avoid fast infiltration in downhill plot (ground water protection).
Infiltration (I2) Low risk	Reduce runoff at source using suitable in-field measures. If this is not possible, consider implementation of buffer zones (edge-of-field, in-field).

Risk Scenarios Infiltration restriction (2)

Risk Scenarios	Mitigation targets
Infiltration (I3) Medium risk	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 not viable.
Infiltration (I5) Mediunm risk	Reduce runoff at source by using all suitable in-field measures. 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 not viable.
Transfer (T3)	Stop runoff at source using in-field measures and/or edge-of-field buffers OR ensure water infiltration in downhill plot by suitable measures (buffers, retention structures). In case of large amount of runoff: stop at source to avoid fast infiltration in downhill plot (ground water protection).
Infiltration (I4, I6, I7)	Minimize risk for run off and erosion with all viable in-field measures, edge-of-field buffers, and landscape measures (buffers, retention structures). Combine effective measures to achieve maximum mitigation

Symptoms for capping soil

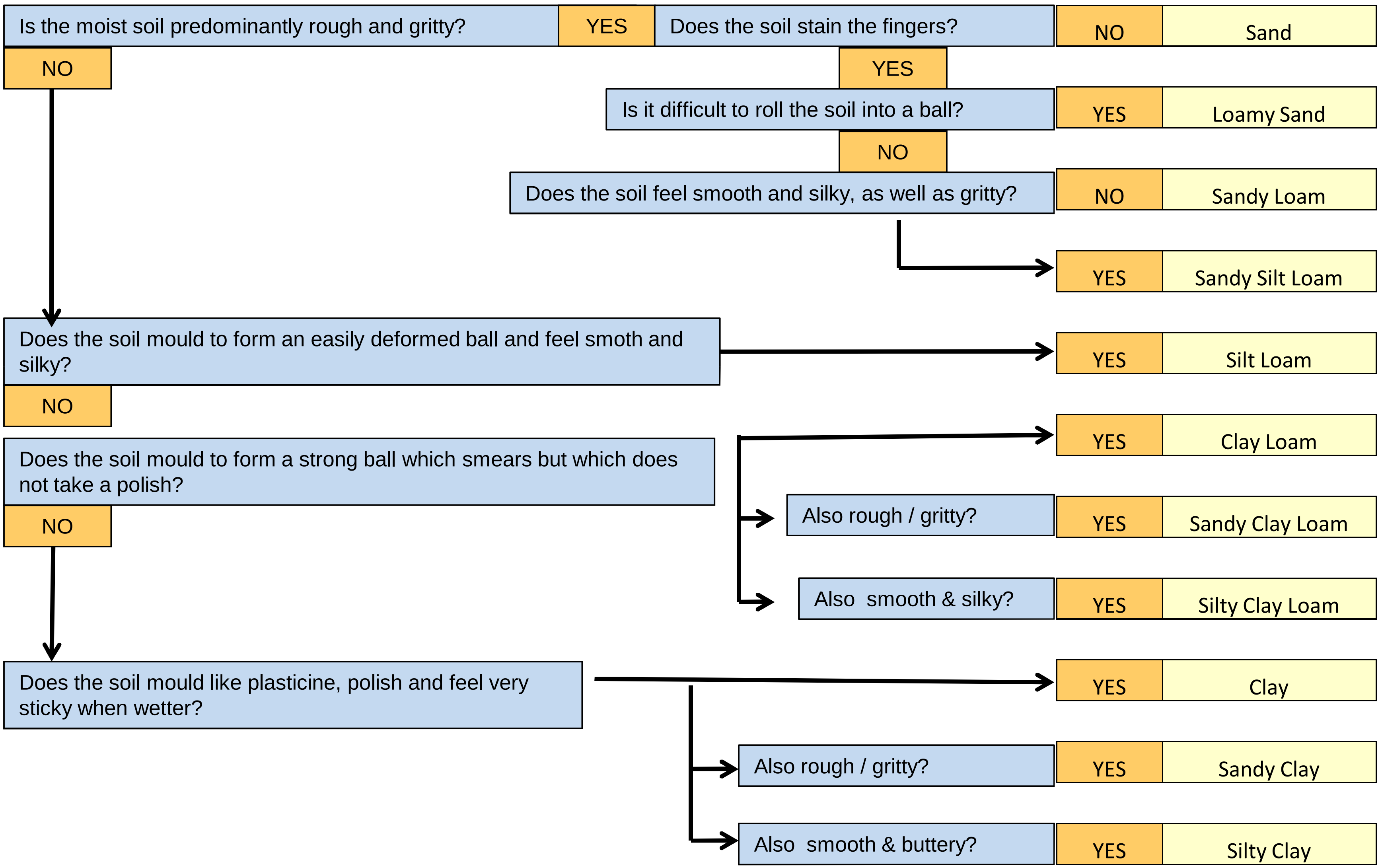
<u>Soil susceptible to capping</u>:

- weak structural stability of soil surface (splash effects from raindrops)
- Soil builds crust at surface, which hinders infiltration of rain water
- Soils with large portions of fine sand and silt are typically susceptible to capping.

<u>Indicators:</u>

- fine layers of sediments are visible on soil surface layer
- Soil lacks medium and coarse sand particles
- Capping soils should not be confused with cracking soils, which also form a crust during summer but keep a high infiltration potential due to desiccation cracks (> 35% clay)

Fieldmethode to determine soil texture



Diagnosis of Runoff & Erosion Saturation Excess (D2)

Step 1 – Proximity of Field to Water Body		WHC *	*Step 2 – Landscape Situation*	*Step 3 – Discrete Subsurface Restriction*: None	Pan or Other	Pan + Other
	Adjacent & WHC	<120 mm	Bottom slope / Concave Slope	Medium – S3	High – S4	High – S4
			Upslope Concave / Straight	Low – S2	Medium – S3	High – S4
			All positions /Tile Drained	Low – SD2	Medium –	Medium – SD3
		>120 mm	Valley Floor / Concave Slope	Low – S2	Medium – S3	High – S4
			Upslope Concave / Straight	Very Low – S1	Low – S2	High – S4
			All positions / Tile Drained	Very Low – SD1	Low – SD2	Medium – SD3

Not Adjacent	**Step 4 – Transfer of runoff to downhill field ?**	YES	Runoff reaches waterbody	YES	High – T3
				NO	Very Low – T2
		NO			Very Low – T1

Restriction Classes & BMP for Productivity & Protection by Runoff & Erosion Scenario

Advice tabs	**General BMP Measures**	**BMP for Very Low** (T1, T2, SD1, S1)	**BMP for Low** (SD2, S1)	**BMP for Medium** (SD3, S3)	**BMP for High** (T3, S4)

Source: AquaplaineR, TOPPS partners, Syngenta advice framework

Risk Scenarios Saturation excess (1)

Risk Scenarios	Mitigation targets
Transfer (T1) Very low risk	Maintain good agricultural practices in field to minimize runoff and erosion
Transfer (T2) Very low risk	T1 & 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 acceptable, treat plot as if adjacent to water.
Saturation drainage (SD1) Very low risk	S1 & Risk of transfer via drainage water: Avoid application of susceptible pesticides during drainflow season (late autumn to early spring) and on cracked soils (spring/summer). If possible, retain drainage water in artificial wetlands/ponds.
Saturation (S1) Very low risk	Maintain good agricultural practices on field to minimize runoff and erosion.

Risk Scenarios Infiltration restriction (2)

Risk Scenarios	Mitigation targets
Saturation (S2 & SD2 -drainage) low risk	Reduce runoff at source using suitable in-field measures. If this is not possible, consider implementation of buffer zones (edge-of-field, in-field). See **D** for drainage risk and G for groundwater risk
Saturation (S3 & SD3 – drainage Medium risk	Reduce runoff at source by using all suitable in-field measures. Furthermore, implement buffers with willow (salix) hedges or suitable measures at landscape level (e.g. talweg buffers, retention structure), when in-field measures not viable. See **D** for drainage risk and G for goundwater risk
Transfer (T3) High risk	Stop runoff at source using in-field measures and/or edge-of-field buffers OR ensure water infiltration in downhill plot by suitable measures (wetland; ponds), retention structures). In case of large amount of runoff: stop at source to avoid fast infiltration in downhill plot (ground water protection).
Saturation (S4)	Minimize risk for run off and erosion with all viable in-field measures, edge-of-field buffers (buffers with willow (salix) hedges), and landscape measures (buffers, wet meadow, retention structures, wetlands). Combine effective measures to achieve maximum effect. If valley bottom or floodplain, see **G** for leaching risk to groundwater

D = Risk of transfer via drainage water: Avoid application of susceptible pesticides during drainflow season (late autumn to early spring) and on cracked soils (spring/summer). If possible, retain drainage water in artificial wetlands/ponds.

G = Risk of transfer to groundwater in alluvial floodplain. Follow product-specific advice to minimize inputs to vulnerable areas (shallow groundwater, sandy soils with low organic carbon)

Symptoms of low permeablitity

Soil with a permeable topsoil over a subsoil of lower permeability.

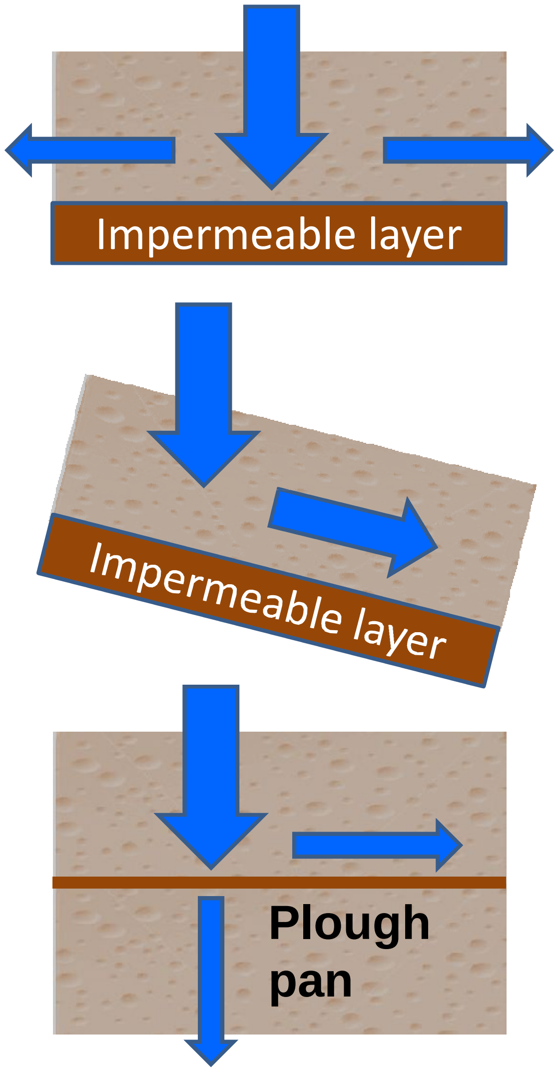
•This leads to water logging in the soil profile as the water percolation into deeper soil layers is hampered by the subsoil horizon of lower permeability.

•Run-off occurs in the upper soil layers as subsurface runoff (also termed interflow or lateral seepage).

•The low-permeability subsoil horizon is located near the soil surface in the unsaturated zone (typically in <100 cm soil depth), otherwise this would be an indicator for a soil with shallow groundwater.

Plough Pan

• Compaction of topsoil beneath ploughing zone - evidence of transient water saturation in soil (concretions, mottles). Plough pans often occur if ploughing is executed at to much soil moisture.



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.

<u>Indicators:</u>

•Coloured areas below top soil are visible (green, grey colours, iron and manganese accumulation / concretions, with redbrown and black colours.

•Low-permeability subsoil (clayey or loamy subsoil, hard rock or rock rubble such as a shaley layer, a granitic layer, a non karstic limestone layer)

•Soil remain wet for at least 2 to 5 days after rain

Symptoms for water saturation: Hydromorphic soils

Field capacity – measure for soil water holding capacity

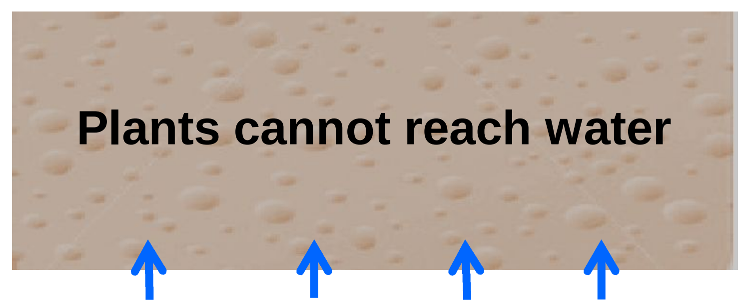
<u>Field capacity</u> / water holding capacity

• Amount of water that is retained in the soil against the force of gravity (mm water - typically calculated for the main rooting zone: e.g. 40 to 120 cm)

• Water content in soil can exceed field capacity during periods of infiltration and drops below field capacity due to evapotranspiration.

• Water content in agricultural soils vary between the field capacity and the wilting point (plant roots cannot extract water below this moisture content).

Situation mainly in winter



Situation mainly in dry spring / summer

Determine water holding capacity

Key criteria: Soil depth and texture

(Example for orientation)

Texture		Density	Water holding capacity (mm of water per soil cm)
S	Sand	1,35	0,70
SL	Sandy loam	1,40	1,00
SC	Sandy clay	1,50	1,35
LlS	Light loamy sand	1,50	1,20
LS	loamy sand	1,45	1,45
LmS	Middle Loamy sand	1,45	1,60
LSC	Loam sandy clay	1,50	1,65
LCS	Loamy clay sand	1,45	1,75
Ll	light loam	1,45	1,30
Lm	Middle Loam	1,35	1,75
LC	Loamy clay	1,40	1,95
CS	Clay sand	1,55	1,70
C	Clay sand	1,45	1,75
CL	clay loam	1,40	1,80

Source: Service de Cartographie des Sols de l'Aisne

Example:
a) Determine texture - SC
b) Determine soil depth – 100 cm

Waterholding capacity estimate:
1,35 mm per cm of soil (SC) multiplied by cm soil depth (100 cm)

Water holding capacity 135 mm

Soils with water holding capacities > 120 mm have very low water contamination risk

Field forms document the diagnosis (1)

Arvalis: Aquaplaine

Field name and N°:	**Drainage network:**
Crop in place and rotation:	
Tillage system: Resistant weed : *Yes / No*	**Which one:**

Field map (draw) / Water circulation / Landscape

Landscape characteristics

Upstream water arrival: yes / no

Runoff concentration: yes /no

Proximity to waterbody, ditch or spring: yes/no

Important slope: < 2%, 5%, >10%

Buffer zone downhill: yes /no

Nature of buffer zones: grassy/ hedge /woodland

Preferential pathways (doline, swallet): Yes / no

Wet patch: yes/no

Field forms document the diagnosis (2)

Arvalis: Aquaplaine

Pedological characteristics

Location or horizon 1

Texture :

% of clay:

Gravels and stones:

Depth:

Capping soil:

Cracks in soil

Location or horizon 2

Texture :

% of clay:

Gravels and stones:

Depth:

Capping soil:

Geological characteristics

Geological substrate:

Geological substrate permeability:

Karstic substrate:

Total depth:

Water holding capacity: <120mm/>120mm

Permeability disruption (clay area, etc..):

Hydromorphy evidence:

Diagram of water pathway in winter

Diagram of water pathway in spring

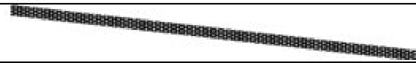
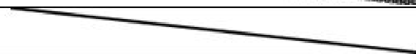
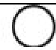
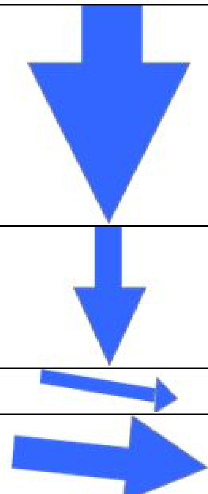
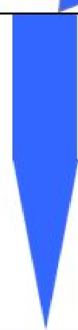
Diagram of water pathway in summer

REMARKS :

Field forms document the diagnosis (3)

Arvalis: Aquaplaine

Legend :

	Soil
	Geological substrate or permeability breakdown
	Drain
	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

TOPPS PROWADIS Diagnosis results

- Mapping of water circulation in a catchment
- Mapping of risk areas in a catchment
- Identification of runoff risks for individual fields
- Common basis to discuss mitigation measures
- Basis to implement mitigation measures to optimize land use and support
- Basis to readdress issues and monitor progress of implementation

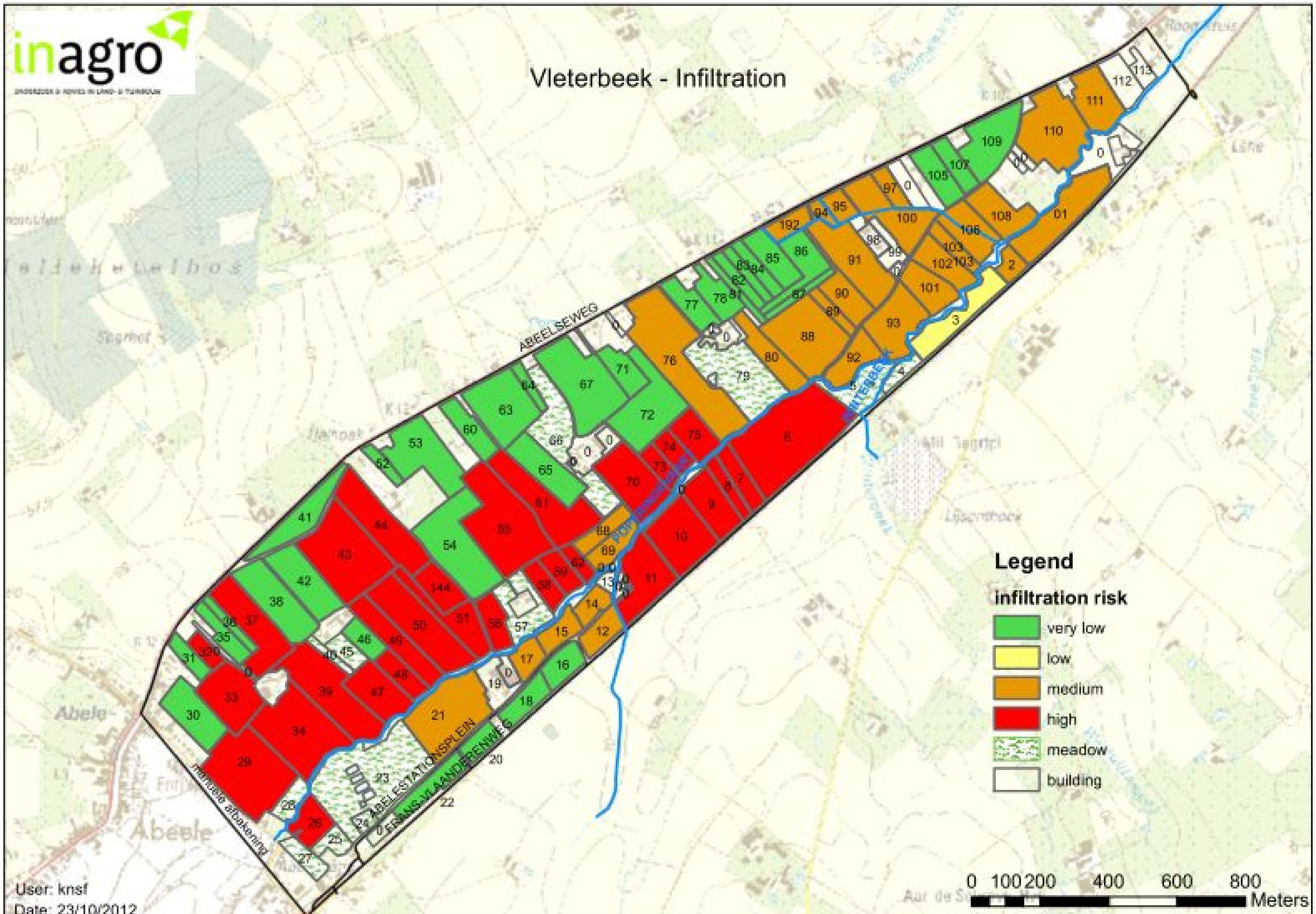
Example : Vleterbeek pilot catchment BE





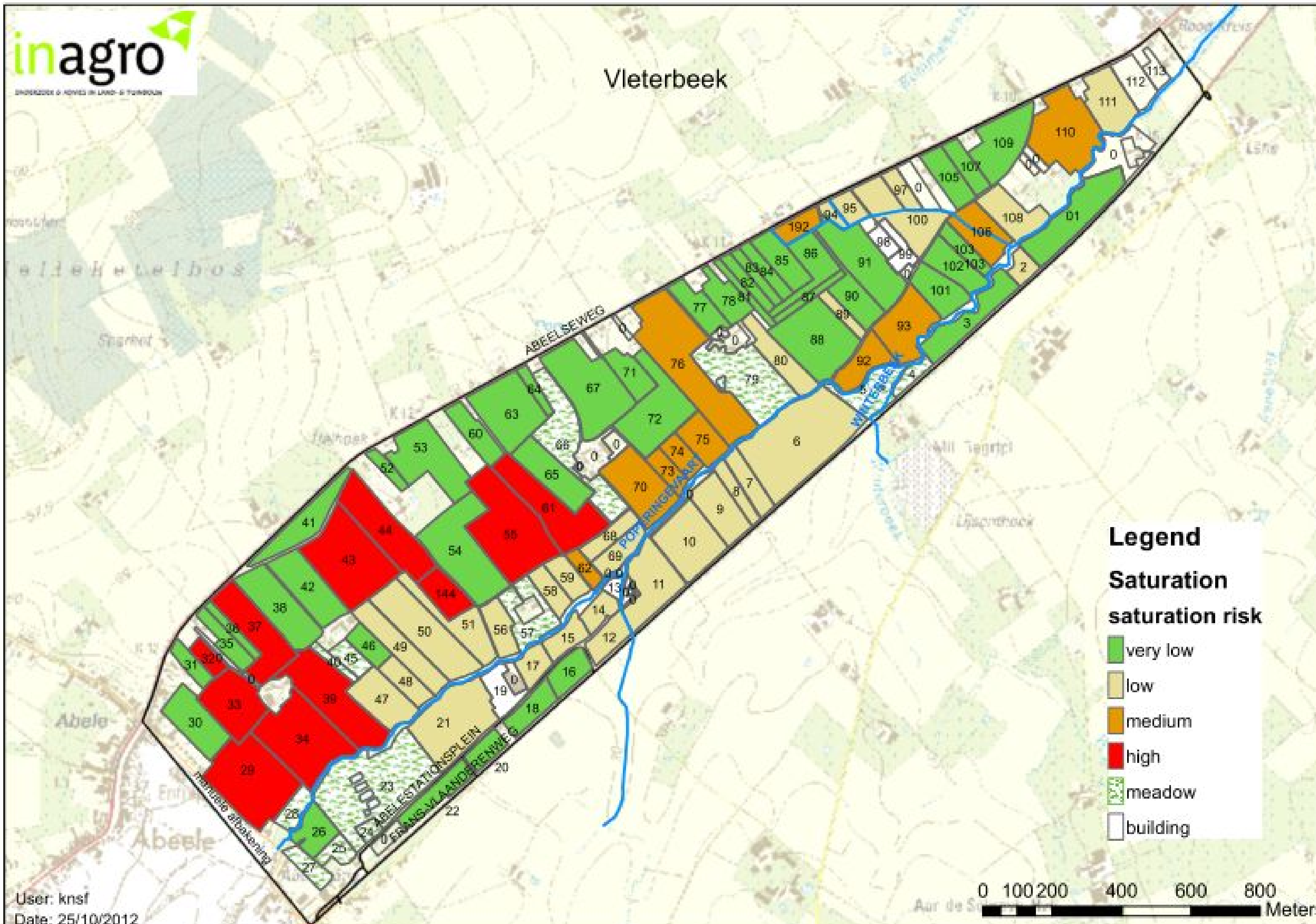
Results Vleterbeek catchment

1. Runoff risk levels due to infiltration restriction



Results Vleterbeek catchment

2. Runoff risk levels due to saturation excess



Vleterbeek catchment

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ONDERZOEK & ADVIES IN LAND- & TUINBOUW

Additional mitigation measures which will be implemented

Vleterbeek catchment BE

Fascines and bunding techniques can be very effective without influencing to much the production systems and areas.

Link risk analysis with mitigation measures

Principles :

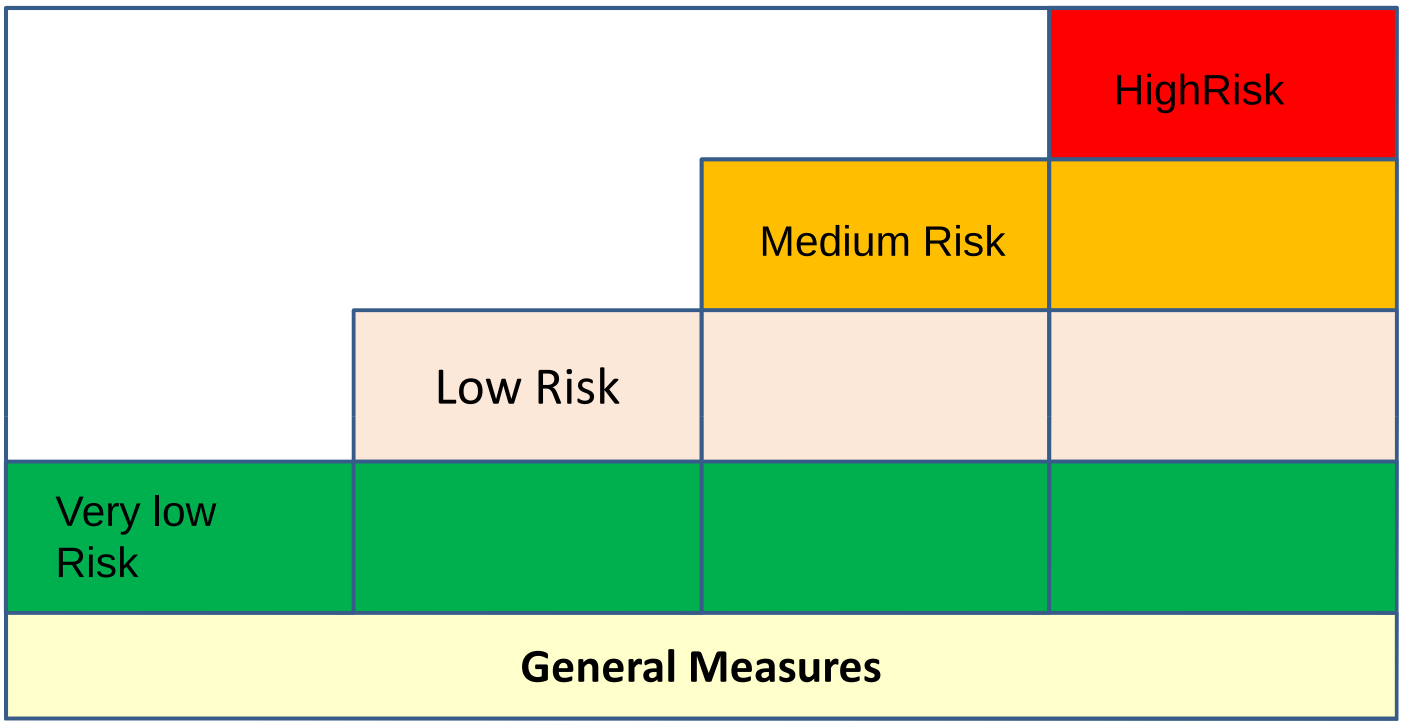
- Runoff water should be kept in the field as much as possible
- If water from uphill enters the field, uphill field should be diagnosed and measures taken there
- If runoff water cannot be maintained in the field, measures should be taken to keep water in the catchment

TOPPS PROWADIS

Mitigation measure toolbox

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 • Increase organic matter
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 & fertilizer	• Adapt application timing • Optimize seasonal timing	• Adapt product and rate selection
Optimized irrigation	• Adapt irrigation technique	• Optimize irrigation timing and rate

Select appropriate set of measures adopted to local situation



Site specific recommendations on Best Management Practices need competent local advicers

General mitigation measures

Measures categories	General measures
Soil Management	Manage surface compaction Manage subsurface compaction Increase organic matter content
Cropping practice	Use crop rotation (spring / winter crops)
Vegetative buffers	
Retention structures	
Adapted use of PPP	
Optimized irrigation	Use modern technologies, adapt timing and rate of irrigation

General mitigation measures should be considered in all situations (Example)

Mitigation measures adapted to very low risk of runoff (Example)

Measures categories		Very low risk mitigation measures
Soil Management	GENERAL MEASURES	Prepare rough seedbed
Cropping practice		Use cover crops Increase soil coverage with organic materials
Vegetative buffers		Manage field access areas Use riperian buffer
Retention structures		
Adapted use of PPP		
Optimized irrigation		

General measures +
very low risk mitigation measures should be applied

Mitigation measures adapted to low risk of runoff (Example)

Measures categories	GENERAL MEASURES	Very Low Risk	low risk mitigation measures
Soil Management			Manage tramlines apply contour tilling
Cropping practice			plant robust cover crop
Vegetative buffers			
Retention structures			
Adapted use of PPP			Adapt application timing
Optimized irrigation			

General measures + very low risk +
low risk mitigation measures should be applied

TOPPS PROWADIS

Mitigation measures adapted to medium risk of runoff (Example)

Measures categories	GENERAL MEASURES	Very Low Risk	Low Risk	Medium risk measures
Soil Management				Use in field bunds Reduce tillage intensity
Cropping practice				Enlarge headlands Double sowing in more risky areas
Vegetative buffers				Use edge of field buffers Reduce length of field by in field buffer
Retention structures				Use edge of field bunds
Adapted use of PPP				Adapt product and rate selection
Optimized irrigation				

General measures + very low risk + low risk + medium mitigation measures should be applied

Mitigation measures adapted to high risk of runoff (Example)

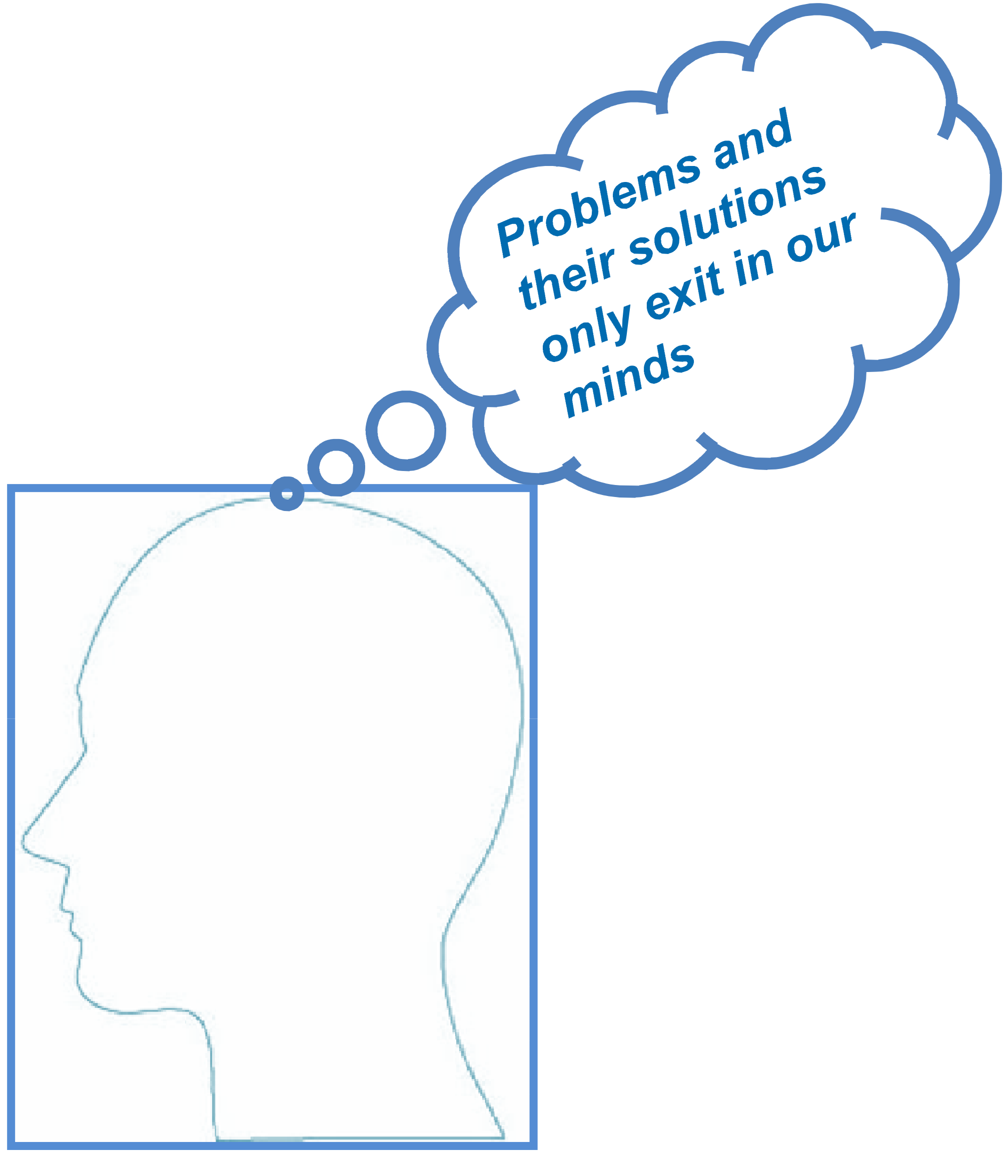
Measures categories	GENERAL MEASURES	Very Low Risk	Low Risk	Medium Risk	High risk measures
Soil Management					Reduce tillage (No tillage),
Cropping practice					Do strip cropping,
Vegetative buffers					Establish talweg buffer Establish hedges / woodland buffers
Retention structures					Build fascines, Establish vegetated ditch Establish artificial wetlands / ponds
Adapted use of PPP					
Optimized irrigation					

General measures + very low risk + low risk + medium + high risk mitigation measures should be applied

TOPPS PROWADIS

Transfers of PPP into water from runoff and erosion cannot be completely avoided

but we can largely reduce it by adapted mitigation measures



Better water protection starts in our minds