EVALUATION OF THE OPTIMAL LOCATION OF MONITORING SITES BASED ON HYDROLOGIC MODELS AND GIS TECHNOLOGY

De Girolamo A.M., Lo Porto A., Passarella G., Garnier M.

Water Research Institute - CNR, BARI – ITALY

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INTRODUCTION (1)

- Surface water represents an important source of drinkable supply.
- Protecting such a resource from contamination processes is a task of increasing importance.

INTRODUCTION (2)

- Diffuse pollution from intensive agricultural practices is the main responsible of nutrients and pesticides intake in the hydrologic cycle.

INTRODUCTION (3)

- Pollution of surface water systems caused by agricultural activities is strongly conditioned by soil physical and chemical properties, geomorphology, land use, management practices, and climate.

INTRODUCTION (4)

- The availability of schematic and synthetic tools to assess surface water quality is an urgent demand of the River Authorities everywhere in the world.
- Any managerial tool needs monitored data. (i.e. models require data for calibration and validation).

INTRODUCTION (5)

- Existing monitoring networks in surface water can be extensively used to gather water quality information.

PROBLEM (1)

- Monitoring networks are often designed on the basis of already existing or easy to reach monitoring sites in a watershed; this approach often increases the sampling cost but sometime does not means more extensive and reliable information.

PROBLEM (2)

- The first step to correctly define a monitoring program is the identification of the optimal location of monitoring points among several candidates to keep under control the evolution of the water quality.
- The second step consists in defining the temporal frequency of sampling campaigns.

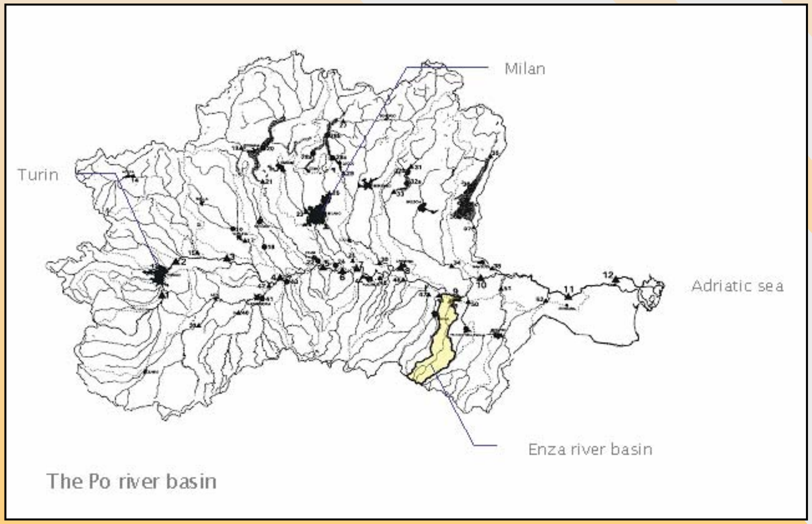
OBJECTIVE

- To propose and test a methodology for locating the optimal position of monitoring points within a watershed.
- The parameters to be monitored, the location of the monitoring points and the sampling temporal frequencies can be determined through the definition of several critical points.

METHODOLOGY

- The methodology consists in using SWAT coupled with GIS technologies to evaluate the optimal location of monitoring sites within a watershed.

STUDY AREA (1)



- River length: 99 km
- Catchment area: 884 km^2
- Annual rainfall: 950 mm
- Annual snow prec.: 60 cm
- Mean flow: 10 m^3/s
- Fertilizer application:
  - 50 kg/ha P
  - 170 kg/ha N
  - 10 t/ha/year of dairy cattle and pig manure

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STUDY AREA (2)

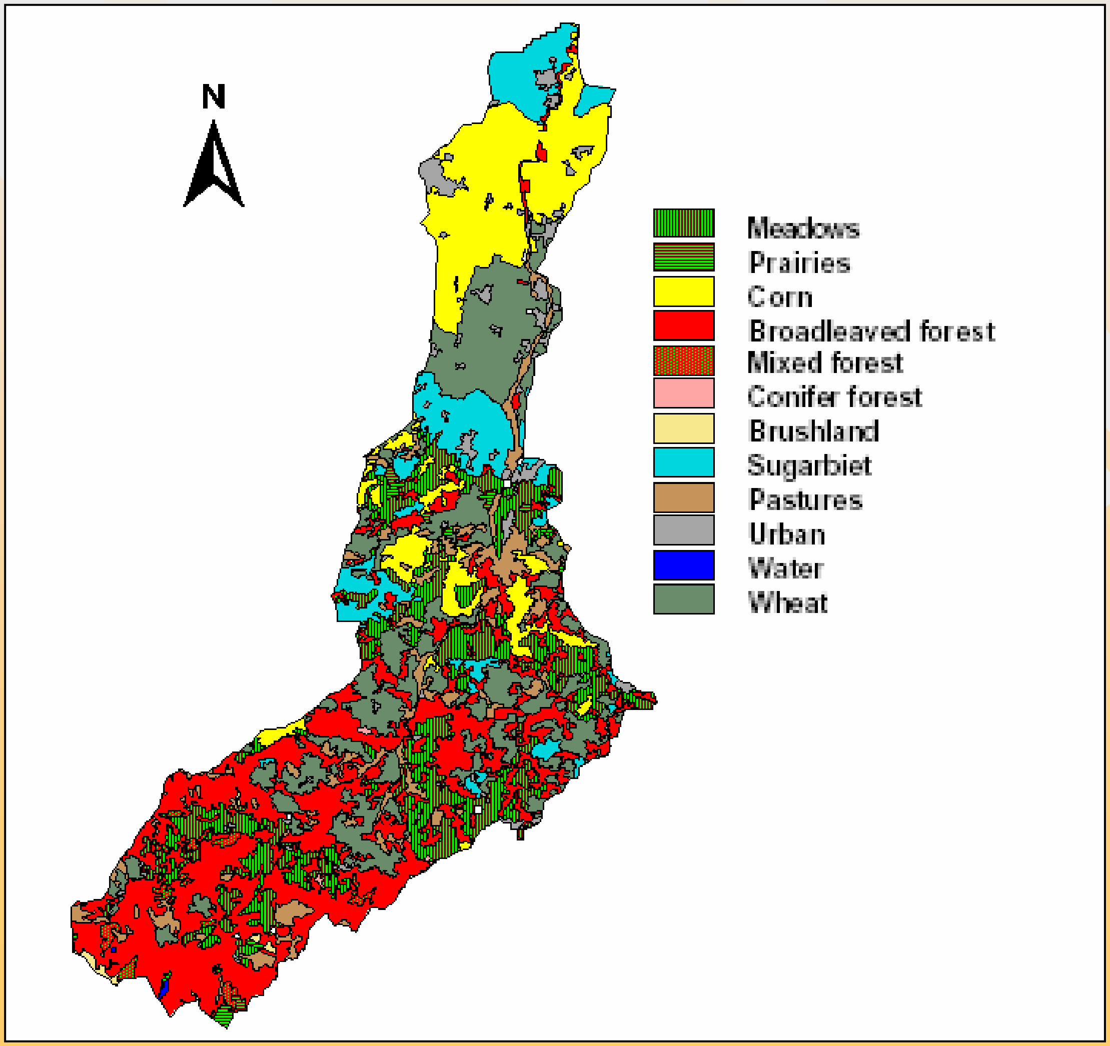
- Enza River is moderately clean.
- Diffuse pollution from agriculture is by far the primary cause of pollution.

Major activities in the catchment	Estimation of % contribution to total load of Nitrogen	Estimation of % contribution to total load of Phosphorus
Agriculture	60	50
Aquaculture	0	0
Domestic sewage	10	5
Industry	30	45
Others	0	0

AVAILABLE DATA

- DEM
- Vector contour lines layer
- General-purpose maps
- Raster topography
- Land-use map
- Soil map
- Temperature and precipitation
- Flow and water quality
- Management input
- Management and crop parameters

LAND-USE MAP


N
Meadows
Prairies
Corn
Broadleaved forest
Mixed forest
Conifer forest
Brushland
Sugarbiet
Pastures
Urban
Water
Wheat

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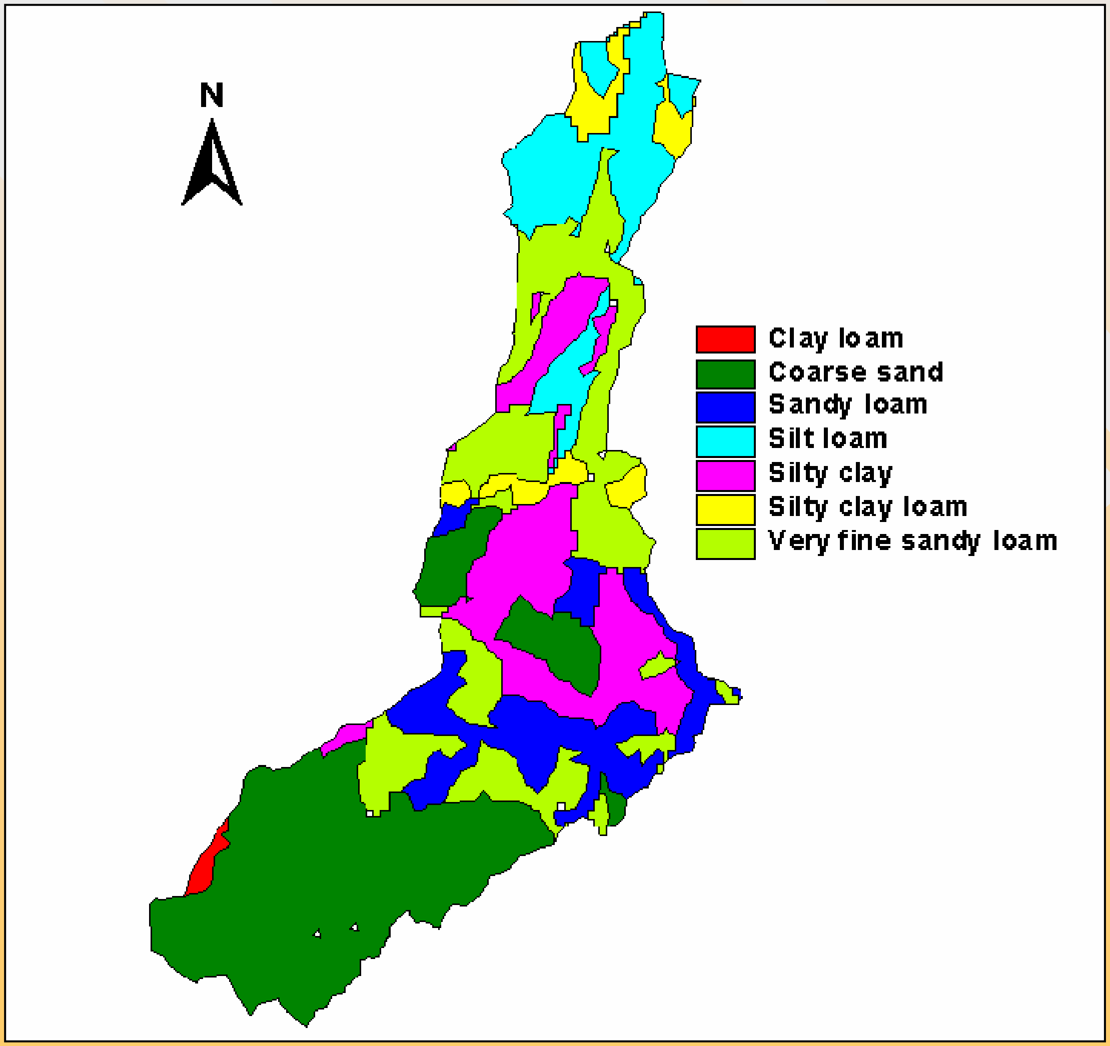
SOIL MAP



RESULTS AND DISCUSSION (1)

- Only one HRU per sub-basin was considered, assigning the most common landuse/soil type combination to the whole subbasin.
- According to this scheme, 44 sub-basins (HRU) where defined within the catchment.

RESULTS AND DISCUSSION (2)

PROBLEM

- The automatic GIS tracing of the Enza river network produced reliable results only in the upstream course of the river where its steepness is relatively high but it failed in the flat part of the basin where the mean land gradient is less than 1%.

RESULTS AND DISCUSSION (3)

SOLUTION

- The SWAT-GIS interface greatly improved the correspondence between the real and the modelled stream when a digitalized stream shapefile was “burned-on” the DEM.

RESULTS AND DISCUSSION (4)

SWAT produced:

1. predicted values of water balance, erosion, nutrient and pesticide fate, crop grow in every sub-basin/HRU;
2. discharge and water quality parameter values at each sub-basin outlet and at several *key nodes*.

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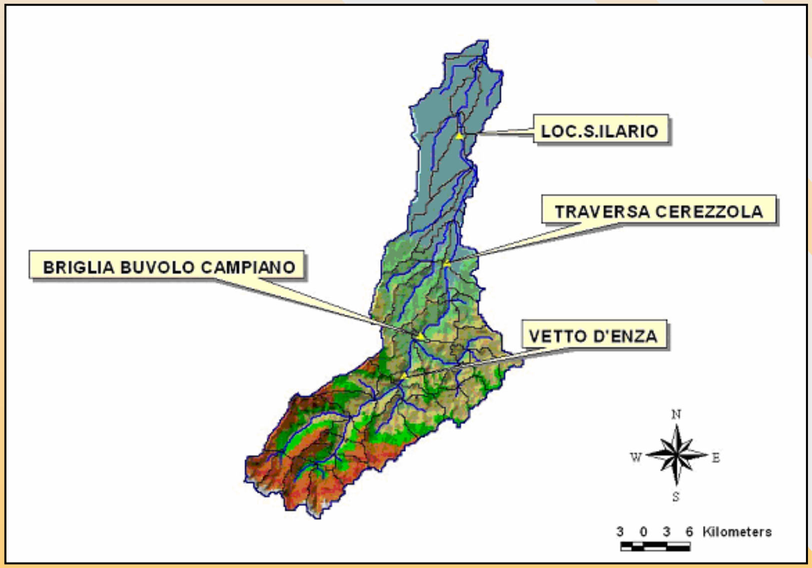
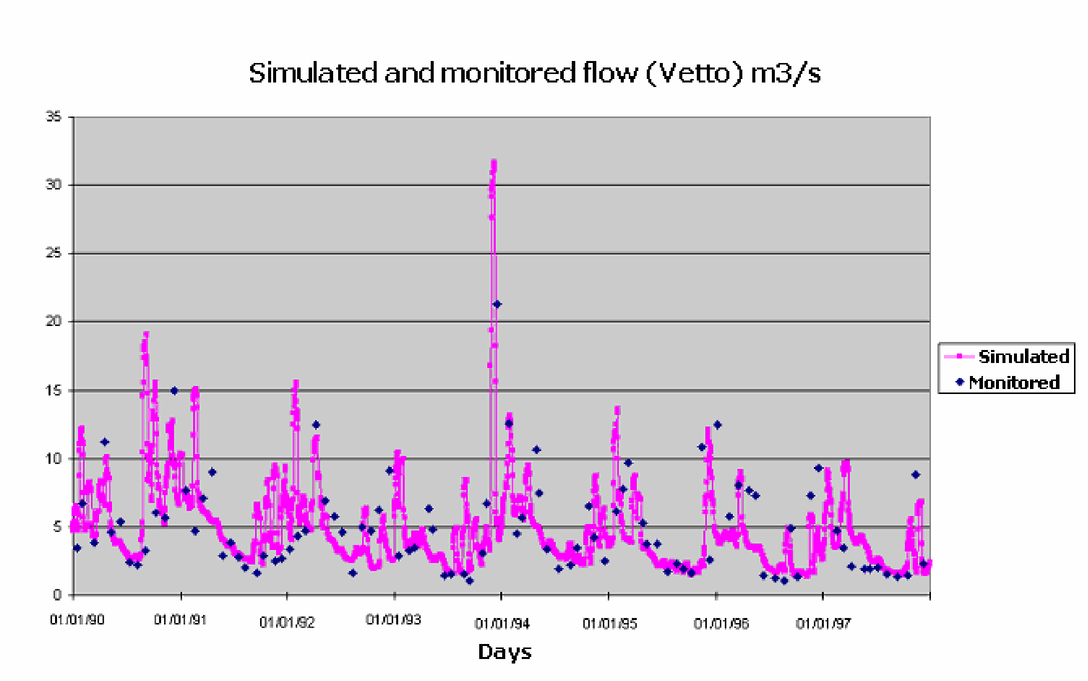
RESULTS AND DISCUSSION (5)



- In order to calibrate and validate the model results, key nodes were associated to four river cross sections where water quality and discharge were monitored.

RESULTS AND DISCUSSION (6)



- It was performed comparing simulated and monitored flow data, firstly at the most upstream monitoring station (Vetto) and then at the following stations along the stream.

RESULTS AND DISCUSSION (7)

- At basin scale the model output revealed the contribution of each considered land use type to every component of the water balance.

Land use		Contribution
Deciduous forest (FRSD)	→	*Highly responsible for*: water yield *Poor contribution for*: evaporation, surface runoff, sediment load
Corn (CORN), sugar beet (SGBT)	→	*Highly responsible for*: percolation, evaporation, surface runoff, sediment load *Poor contribution for*: water yield
Winter wheat (WWHT), Alfalfa (ALFA)	→	Intermediate behaviour

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RESULTS AND DISCUSSION (8)

- At HRU scale the model output highlighted which land use/soil combinations are responsible for the greatest dump of pollutants to the stream.

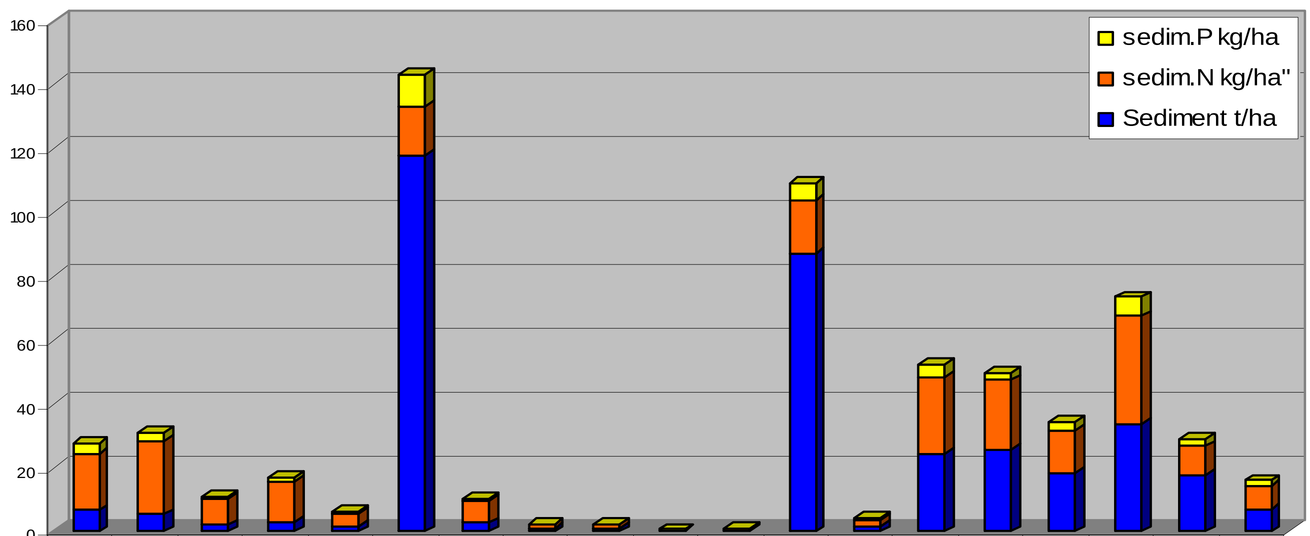
Sediment
- CORN/silty clay
- SGBT/coars sand

Sediment bound P
- CORN/silty clay
- SGBT/coars sand
- WWHT/sandy clay

Soluble P
- CORN/silty clay

Leached nitrogen
- CORN/silty loam
- CORN/f. sandy loam
- ALFA/sandy loam
- CORN/silty clay

RESULTS AND DISCUSSION (9)



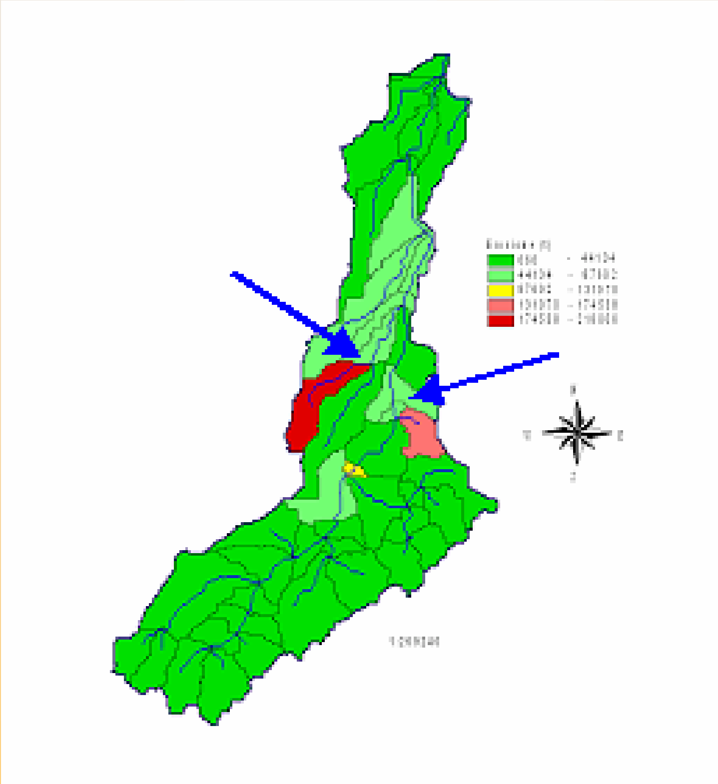
	ALFA coarse sand	ALFA sandy loam	ALFA silty clay	ALFA v.f.sandy	CORN silt loam	CORN silty clay	CORN v.f.san	FRSD coarse sand	FRSD sandy loam	FRSD silty clay	FRSD v.f.sandy	SGBT coarse sand	SGBT silt loam	SGBT v.f.sandy	SWRN v.f.san	WWHT coars	WWHT sandy	WWHT silty clay	WWHT v.f.san
sedim.P kg/ha	3,2	2,8	1,0	1,6	0,5	9,6	0,9	0,1	0,2	0,0	0,1	5,5	0,5	4,3	2,5	2,7	6,1	2,3	1,6
sedim.N kg/ha"	17,7	22,9	8,1	12,6	4,0	15,8	7,0	1,0	1,4	0,3	0,7	16,2	2,3	23,6	21,4	13,4	33,7	8,7	7,2
Sediment t/ha	6,7	5,3	2,0	2,8	1,9	117,5	2,6	1,0	0,8	0,3	0,4	87,2	1,5	24,6	25,9	18,2	33,6	17,9	7,2

Sediment and sediment bound nutrients per HRU

RESULTS AND DISCUSSION (10)

- The location of such HRUs was known thanks to GIS database, consequently those which are mainly responsible for the pollution in the area were easily located.
- This leaded to the reaches selection were monitoring devices should be placed or manual sampling activities should be carried out.

RESULTS AND DISCUSSION (11)

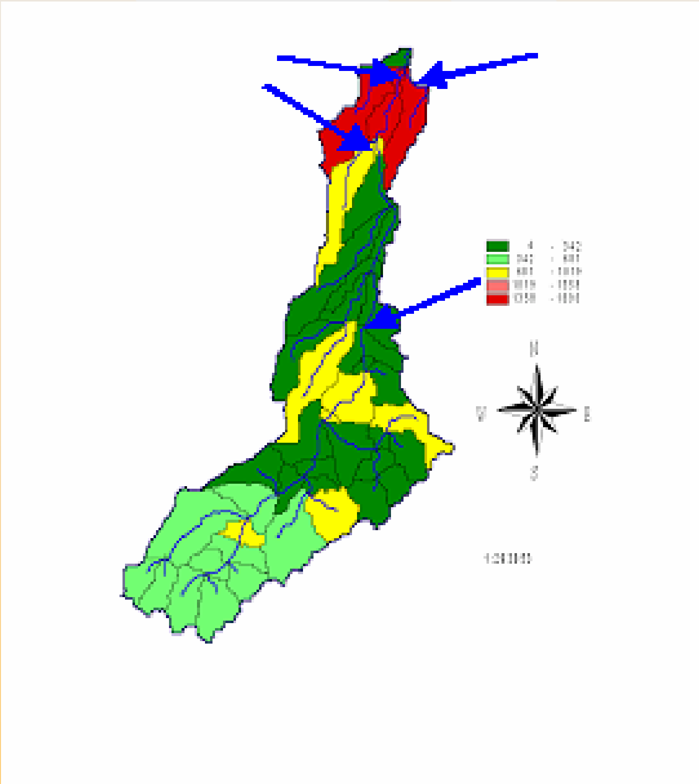


Sediment load map

- Several sites were selected as possible monitoring places because representative of sub-basin contribution, in terms of pollutants load.

Arrows indicate outlet where monitoring stations should be placed

RESULTS AND DISCUSSION (12)



Nitrogen load in leachate

Arrows indicate outlet where monitoring stations should be placed

- Also monitoring station should be placed in a critical position that included between very loaded areas and more clean ones.

CONCLUSIONS

- Integrated use of GIS and hydrological models (SWAT) is suitable to evaluate the response of a natural system to the agricultural land use.
- This tool could strongly support Water Management Authorities in operating actions to reduce pollution.

CONCLUSIONS (2)

- The methodology described operates a good screening for the right location of the monitoring sites, giving a valuable aid in terms of costs and effectiveness.