SIXTH FRAMEWORK PROGRAMME

FOOTPRINT

FOOT-CRS (catchment and regional scale) and FOOT-NES (national and EU scale): Concepts, inputs and outputs

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Overview

1. Concepts for surface water
2. Concepts for groundwater
3. Necessary inputs
4. Tool outputs
5. State of development
6. Demonstration

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Remember: Different scales and purposes for FOOT-CRS and FOOT-NES

> FOOT-CRS: Emphasis on

1. Identifying the areas most contributing to the contamination of water resources by pesticides
2. Defining and/or optimising action plans at the scale of the catchment (what-if scenarios)

> FOOT-NES: Emphasis on

1. Identifying the areas most at risk from pesticide contamination
2. Assess the probability of pesticide concentrations exceeding legal or ecotoxicologically-based thresholds

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1. Concepts for surface water

> FOOT-CRS

- real surface water network
- PECsw are calculated at the catchment outlet (i.e. for one point)

> FOOT-NES

- hypothetical edge-of-field water bodies (FOCUS ditch, stream, pond; with FOCUS upstream catchment)
- PECsw and PECsed are calculated for each agro-environmental scenario (NUTS2/climate/STU/crop combination) → afterwards spatial aggregation

> PECsw:

- separately for each input path (surface runoff + erosion + interflow; drainage; drift)
- in FOOT-NES also PECsed, TWACsw, TWACsed

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The FOOTPRINT metamodel database, surface water variables

- model output variables:
  - daily pesticide drainage loss (for some soils, loss via subsurface lateral flow!)
  - associated daily drainflow volume (for some soils, interflow volume)
  - associated month
  - daily pesticide runoff loss
  - associated daily runoff volume
  - associated month (also used for erosion)
  - daily pesticide erosion loss
  - daily eroded sediment yield
- FOOT-CRS: Extracted model output: maximum daily loss for each month (n = 240)
- FOOT-NES: 11 percentiles of the whole time series (return periods between 10 d and 10 years): 90^{th}, 95^{th}, 96.7^{th}, 98.0^{th}, 98.7^{th}, 99.0^{th}, 99.33th, 99.50^{th}, 99.73^{th} (1 year), 99.90^{th}, 99.97^{th}

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Pesticide inputs into sw via surface runoff, erosion and drainage

- FOOT-CRS
  - runoff/erosion: perform routing and explicitly calculate runoff and erosion load reduction by reinfiltration or redeposition, respectively
  - drainage: multiply losses with mitigation factor (from mitigation manager), default value = 1
  - lateral subsurface flow: inputs = losses
- FOOT-NES
  - for each pathway, multiply losses with mitigation factor (from mitigation manager), default value = 1

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Drift input calculation

> use modified drift equation based on FOCUS (2001) and Rautmann et al. (2001).

> FOOT-CRS
- calculate drift input (as % of application rate) from each grid cell (5 * 5 m^2), considering mitigating landscape elements
- calculate drift input grid for each of 8 wind directions and sum up over catchment area, then do (weighted) averaging

> FOOT-NES:
- distance from field to top of bank is user input
- distance from top of bank to water surface is part of water body definition (FOCUS values)
- drift input is multiplied by 1.2 for the stream (like in FOCUS)

Drift in FOOT-CRS

> Independent from the soil type

> Use river network and landscape features

> Computed within a 150m buffer around the rivers

> Principle : distance in 8 main directions, weighted by the presence of mitigating landscape features
- “cost-weight” of mitigating feature is 1 / (1-mitigating efficiency)
- Two seasonal conditions

	Seasonal condition	
	Winter (deciduous trees without foliage)	Summer (deciduous trees with full foliage)
hedges/forest - deciduous	25 %	75 %
hedges/forest - evergreen	75 %	75 %
Other	0 %	0 %

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PECsw (FOOT-CRS)

- very simple equations proposed: dilution and dispersion
- apply Gustafson equation to simulate the effect of „geomorphological dispersion“; Gustafson equation converts a pulse into a breakthrough curve and thus lowers the maximum PEC
- calculate PEC for several percentiles of input → interpolate CDF

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FOOT-CRS PECsw equations

PECsw,drain_X = (Lsw,drain_X + Lsw,interflow_X) / (B(t) + D(t) + Z(t)) * GF

PECsw,runoff/erosion_X = (Lsw,runoff_X + Lsw,erosion_X * ERF + Lsw,interflow_X) / (B(t) + R(t) + Z(t)) * GF

PECsw,drift_X = Lsw,drift_X / Q(t) * AF * GF

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PECsw and PECsed (FOOT-NES)

> hypothetical edge-of-field water bodies

> routines from STEP3 of the STEPS-1-2-3-4 software (M. Klein, IME Schmallenberg, Germany), slightly adapted
- factor 0.2 for erosion contribution removed
- input pathways treated separately as opposed to (drift + drainage) or (drift + runoff/erosion)

> Within FOOTPRINT, the STEP3 calculation is run for 7 consecutive days (168 hours).

> On the first day, the pesticide inputs from the MACRO or PRZM metamodel or from the drift calculations are added (disaggregated to hourly values).

> The following days are run with zero inputs of pesticide and runoff/drainflow.The STEPS-1-2-3-4 algorithms produce both
- initial PECsw and PECsed and
- time weighted average concentrations (TWAC) over 7 days or shorter.

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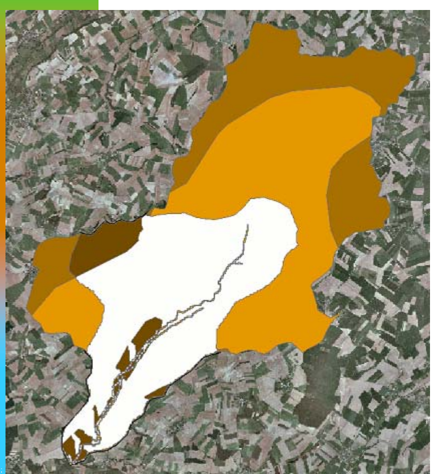
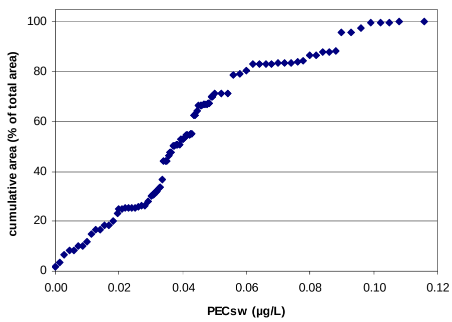
FOOT-NES: Two types of spatial output

Output 1: map



Output 2: CDF



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FOOT-NES: Spatial aggregation of PECsw/sed for map display

> User has 3 different options of PEC display for a polygon:
- area-weighted mean PEC, referring to only the treated area
- area-weighted mean PEC, referring to the total polygon (unique NUTS2/climate/SMU/CLC combination) area
- maximum PEC occurring in the treated area (i.e. the highest PEC of all agro-environmental scenarios occurring in the NUTS/climate/SMU/CLC combination)

> All three options have meaningful interpretations. However, the first option can yield much higher values than the second.

> Same applies to display of edge-of-field losses and inputs into surface water.

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FOOT-NES: Spatial aggregation for display as CDF

> User has 2 options:

a) the statistical population of the CDF is the total area over which the aggregation is performed (AOI, NUTS2, NUTS0)

b) the statistical population of the CDF is only the treated area fraction in the area over which the aggregation is performed.

> The first option will yield a flatter CDF with an intercept. However, the curvature of the CDF's will be the same.

> For each temporal percentile selected in the pesticide scenario manager, a spatial CDF is produced. Spatial and temporal variability are kept strictly separate.

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2. Concepts for groundwater

> same PECgw calculation approach for FOOT-CRS and FOOT-NES

> PECgw are calculated for the bottom of the profile, not for 1 m depth

> qualitative risk assessment for deeper groundwater (more detailed for FOOT-CRS)

The FOOTPRINT metamodel database, groundwater variables

> same content for FOOT-CRS and FOOT-NES

> average leaching concentration over the 20-year simulation period
- flux concentrations for most soils (FOOTPRINT hydrologic groupings L, M, N, W, X, Y)
- resident concentrations for soils with shallow groundwater (FOOTPRINT hydrologic groupings O, P, Q)
- no output for soils with impermeable substrate (FOOTPRINT hydrologic groupings R, S, T, U, V)

> mean annual percolation (average over the 20-year period)

Spatial aggregation for map display

- There are four different options for PECgw display:
  - a) area-weighted mean PECgw, referring to only the treated area
  - b) area-weighted mean PECgw, referring to the total polygon (unique NUTS2/climate/SMU/CLC combination) area
  - c) flux– and area-weighted mean PECgw, referring to the total polygon area
  - d) maximum PEC occurring in the treated area (i.e. the highest PEC of all agro-environmental scenarios occurring in the polygon)
- While in option c) it is implicitly assumed that groundwater is horizontally well mixed over the polygon area, in the other options it is implicitly assumed that groundwater is not well mixed horizontally.

Spatial aggregation for display as CDF

- Works exactly the same way as for surface water.
- Separate CDF‘s for the different types of leaching concentration.
- Will be shown afterwards in demo.

3. Inputs into the tools

- See following tables.
- Blue: Already delivered with the tools on DVD, but can be replaced by better-resolved user data if he likes.
- Green: Delivered with the tools on DVD and cannot be replaced.
- Red: NOT delivered with the tools on DVD, must be organized by user.
- n.a. not applicable

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List of inputs (1)

Dataset	Geo-graphic	Default	Can be replaced by user	format	Relevant for which tool
FOOTPRINT scenario map	Yes	NUTS2/climate/SMU/CLC polygons (obtained by intersection)	Yes	Polygon (shape)	Both
FOOTPRINT soil map	Yes	European soil database	Yes	Polygon	Both
FOOTPRINT land cover map	Yes	Corine land cover	Yes	Polygon	Both
Administrative boundaries	Yes	Nuts2 map	Yes	Polygon	Both
FOOTPRINT agro-environmental scenario database	Yes	Contains area fractions of STU's and crops / crop groups	Yes	Mdb	Both
FOOTPRINT climatic scenario map	Yes	Result from WP2 (HF, SB)	NO	Polygon	Both
Surface water network	Yes	CCM2	Yes	Polyline	CRS only
DEM	Yes	SRTM	Yes	Grid	CRS only
Catchment boundaries and outlet location	Yes	CCM2	Yes	Polygon	CRS only
area-specific daily discharge	Yes	data from GRDC in Koblenz	Yes	grid or .mdb	Both
area-specific daily baseflow	Yes	derived from discharge and BFI	Yes	grid or .mdb	Both
SUGAR map used for GW vulnerability assessment	Yes	EU-wide SUGAR map is provided as default; FOOT-CRS user can create own SUGAR map	No	Polygon	Both

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List of inputs (2)

Dataset	Geo-graphic	Default	Can be replaced by user	format	Relevant for which tool
other layers for GW vulnerability assessment	Yes	No	n.a.	Polygon	CRS only
Compounds DB	No	Footprint PPDB	No	.mdb	Both
Metamodel DB	No	Footprint MM	No	.mdb	Both
Landscape features	Yes	No	n.a.	Polygon	CRS only
SW water body characteristics	Yes	Default resolution NUTS-2 or country (NUTS0) level; not yet available for FOOT-CRS	yes	part of FOOTPRINT agroenv. scenario database	Both
Pesticide application data: - application rate - application month - fraction of crop area that is treated with the pesticide of concern.	Yes.	No, this is crucial user input.	n.a.	The pesticide application scenario is stored in csv-type files by the pesticide scenario manager	Both
Pesticide properties: - Koc - DT50 soil - DT50 water - DT50 sediment - reference temperature of water/sediment degradation study	no	For most registered compounds, default values for most pesticide properties are available in the PPDB.	n.a.		Both

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4. Outputs of the tools (1)

pathway	FOOT-CRS	FOOT-NES
leaching to groundwater	PECgw: • average leaching concentrations over the whole simulation period of 20 years: flux concentrations for most soils, resident concentrations for soils with shallow groundwater, no output for soils with impermeable substrate • the PECgw are not calculated for 1 m depth, but for the bottom of the profile • PECgw are calculated for each agrov-env. scenario (NUTS2/climate/SMU/CLC/STU combination) and then aggregated for map display and display as CDF	PECgw: • average leaching concentrations over the whole simulation period of 20 years: flux concentrations for most soils, resident concentrations for soils with shallow groundwater, no output for soils with impermeable substrate • the PECgw are not calculated for 1 m depth, but for the bottom of the profile • PECgw are calculated for each agrov-env. scenario (NUTS2/climate/SMU/CLC/STU combination) and then aggregated for map display and display as CDF (NUTS2, NUTS0 or whole area of interest)

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Outputs of the tools (2)

pathway	FOOT-CRS	FOOT-NES
drift	drift inputs into sw PECsw at the catchment outlet • 9 different drift percentiles available (user can only choose one drift percentile at a time)	1. drift inputs into sw 2. PECsw , PECsed, TWACsw, TWACsed (for 1-7 days) in hypothetical edge-of-field water body • 9 different drift percentiles available (user can only choose one drift percentile at a time)
drainage	edge-of-field drainage losses drainage inputs into sw PECsw at the catchment outlet • using maxima for each calendar month of the 20-year MACRO time series → n = 240 • If enough percentiles of PEC are available, exceedance frequencies of 0.1 µg/L at the catchment outlet can be calculated	edge-of-field drainage losses drainage inputs into sw PECsw, PECsed, TWACsw, TWACsed in hypothetical edge-of-field water body • using different percentiles (user can select one or more of 11 available percentiles) from 20-year MACRO time series (to enable calculating an exceedance frequency) • If enough percentiles of PEC are available, exceedance frequencies of given ecotox endpoints in edge-of-field water bodies can be calculated • losses, inputs, PEC and TWAC are calculated for each agrov-env. scenario (NUTS2/climate/SMU/CLC/STU combination) and then aggregated for map display and display as CDF (NUTS2, NUTS0 or whole area of interest)

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Outputs of the tools (3)

pathway	FOOT-CRS	FOOT-NES
surface runoff and erosion	edge-of-field pesticide runoff losses edge-of-field pesticide erosion losses edge-of-field pesticide losses via subsurface flow pesticide runoff inputs into sw pesticide erosion inputs into sw pesticide inputs into sw via subsurface flow PECsw at the catchment outlet • using maxima for each calendar month of the 20-year MACRO time series → n = 240 • If enough percentiles of PEC are available, exceedance frequencies of 0.1 µg/L at the catchment outlet can be calculated	edge-of-field pesticide runoff losses edge-of-field pesticide erosion losses edge-of-field pesticide losses via subsurface flow pesticide runoff inputs into sw pesticide erosion inputs into sw pesticide inputs into sw via subsurface flow PECsw, PECsed, TWACsw, TWACsed in hypothetical edge-of-field water body • using different percentiles (user can select one or more of 11 available percentiles) from 20-year MACRO time series (to enable calculating an exceedance frequency) • If enough percentiles of PEC are available, exceedance frequencies of given ecotox endpoints in edge-of-field water bodies can be calculated • losses, inputs, PEC and TWAC are calculated for each agrov-env. scenario (NUTS2/climate/SMU/CLC/STU combination) and then aggregated for map display and display as CDF (NUTS2, NUTS0 or whole area of interest)
point sources	to be clarified	nothing

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5. State of development

> There have been some scientific and technical difficulties.

> FOOT-CRS and FOOT-NES development is a few months behind schedule (sorry).

> But beta versions of the most important modules are available now.

> They are not very convenient yet, but they do give an impression how the final tools will look like.

FOOT-CRS

> DEMONSTRATION………

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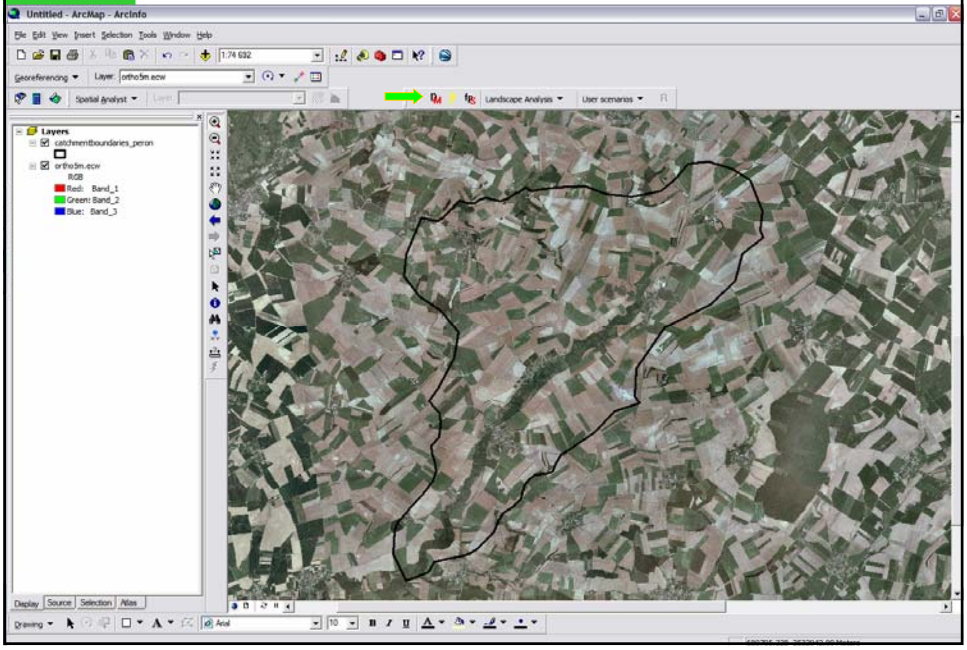
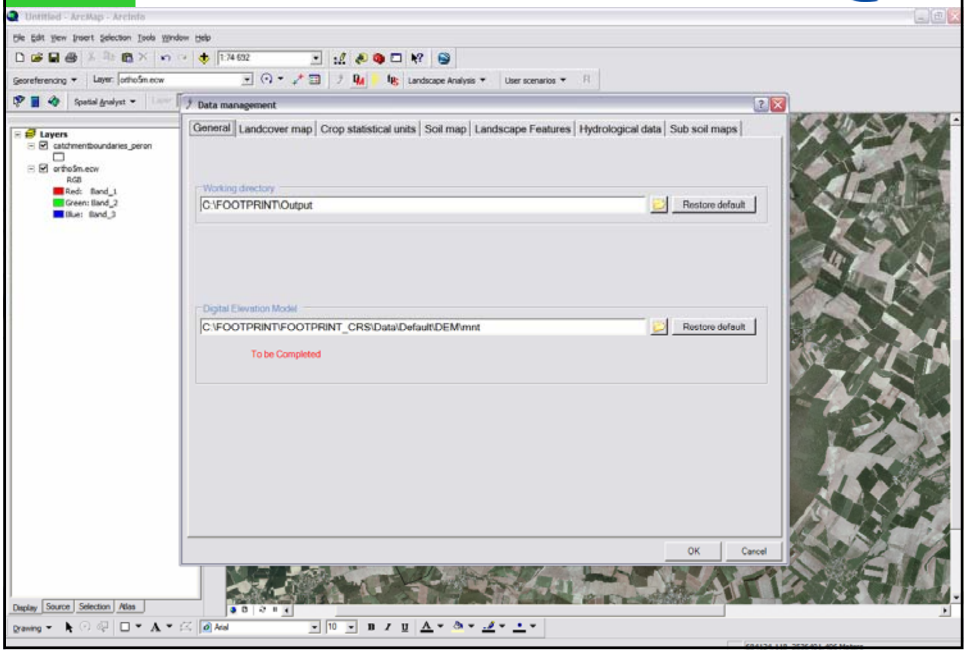
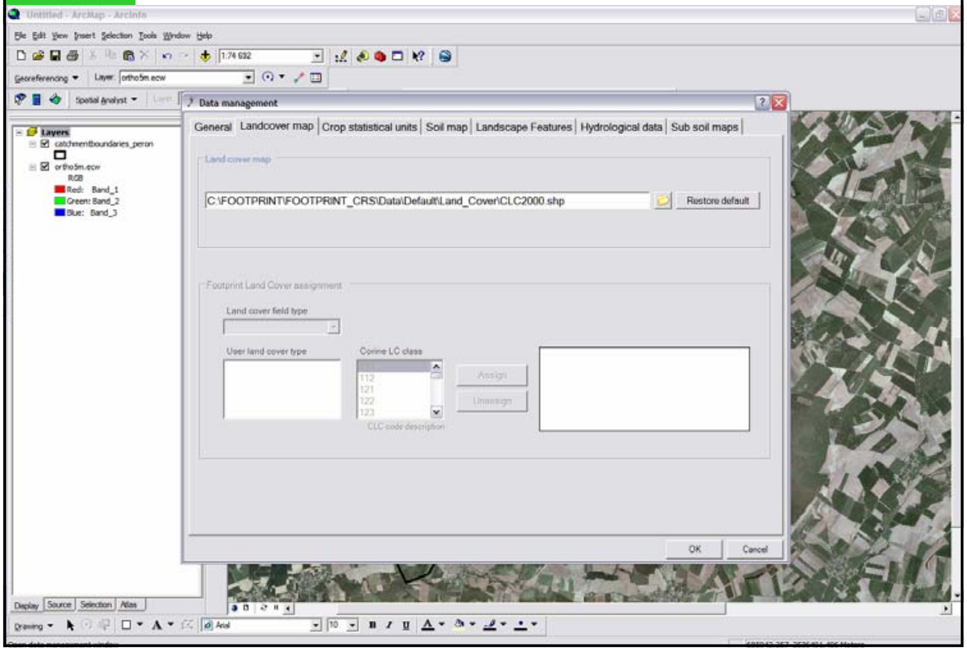
Data management – Open window



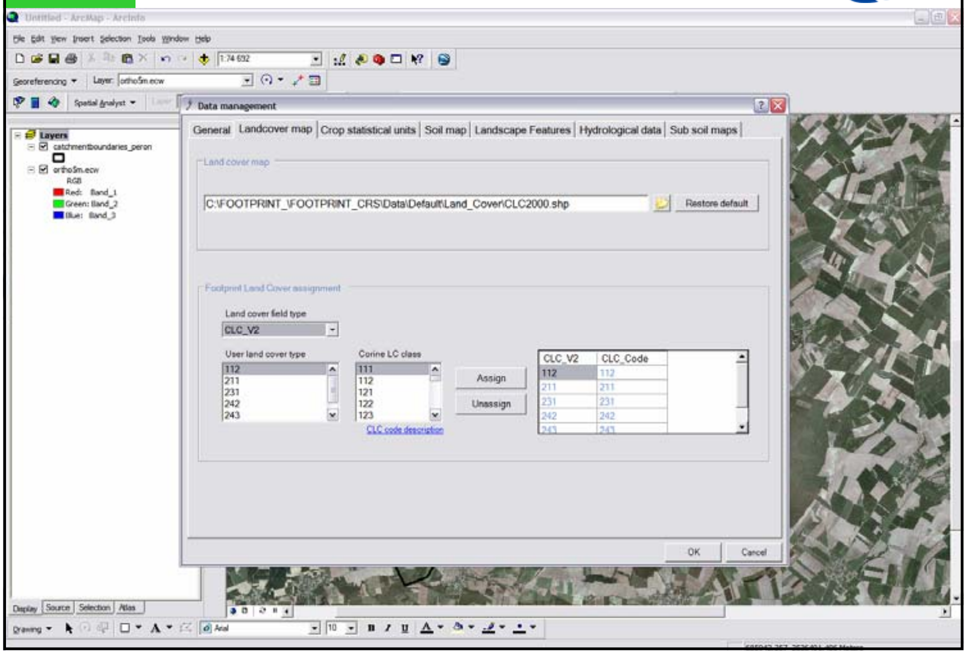
Data management – General settings + DEM – User can change the datasets



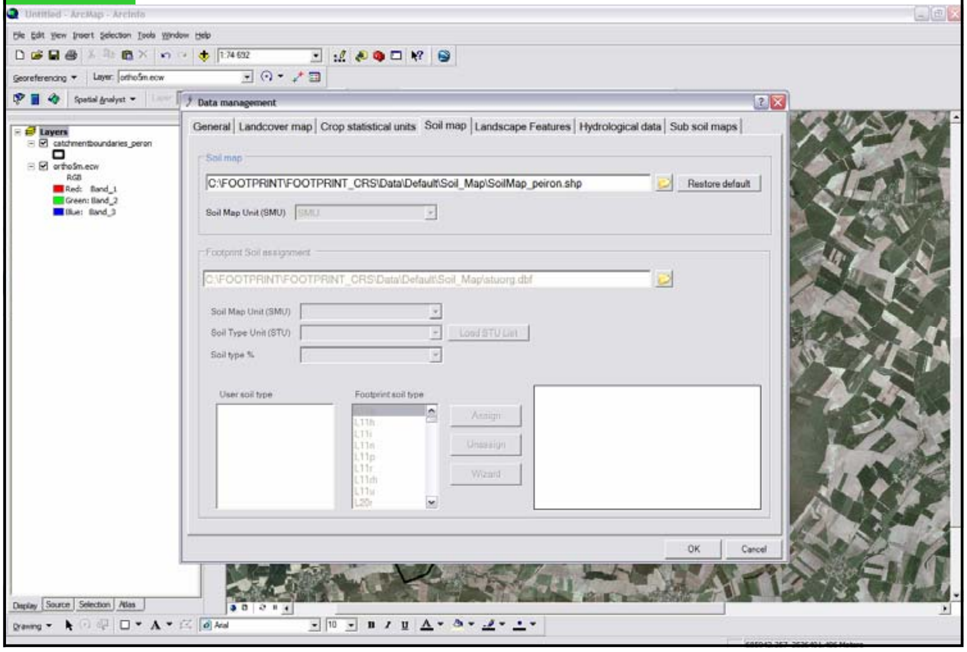
Data management – Land cover – Default data: CLC2000



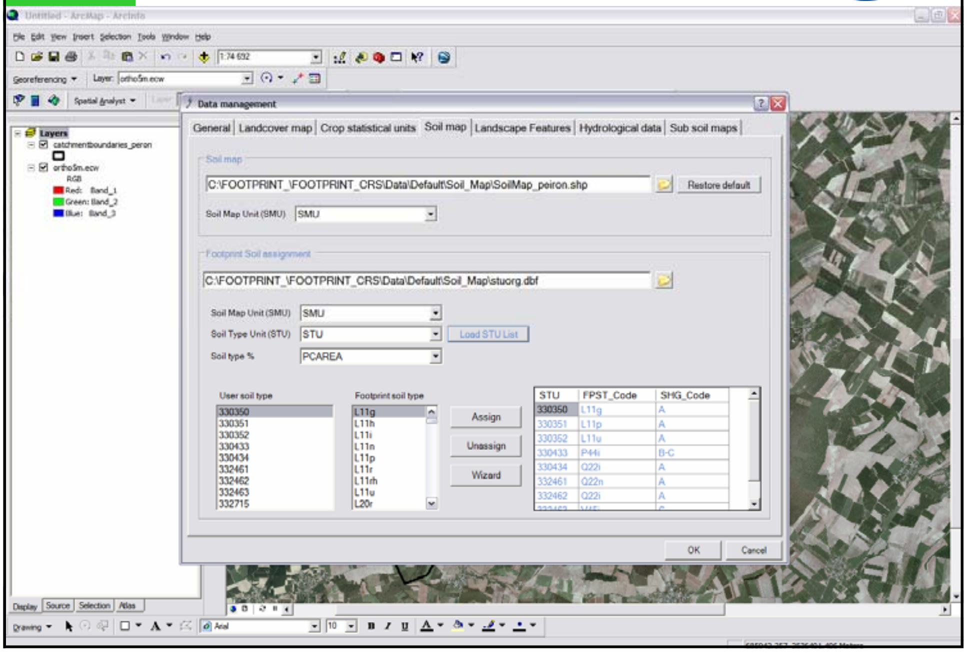
Data management – Land Cover: User can use own data + CLC classes assignment



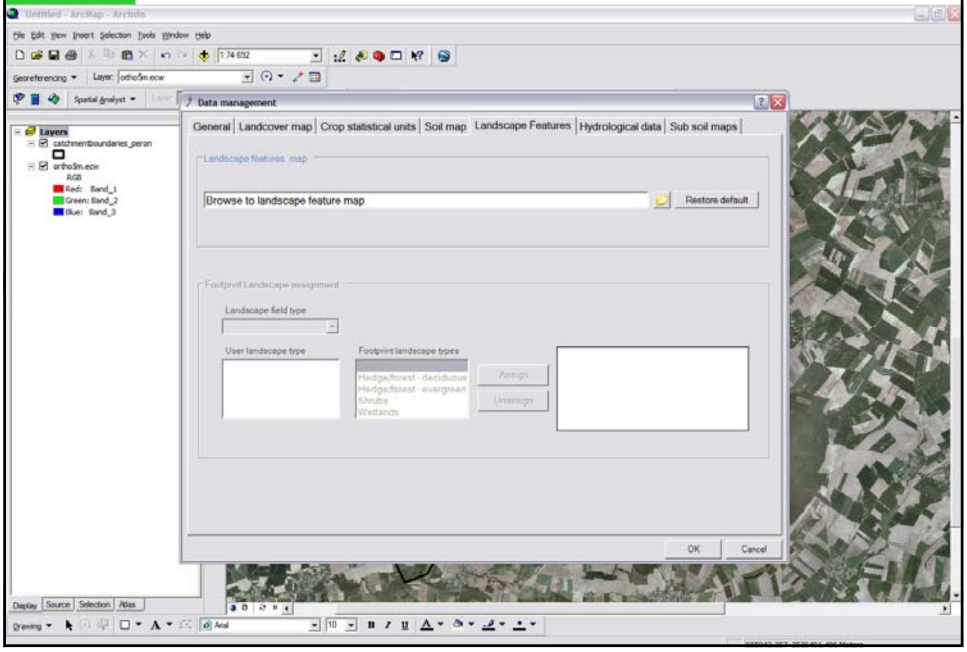
Data management – Soil map: Default data = SGDBE



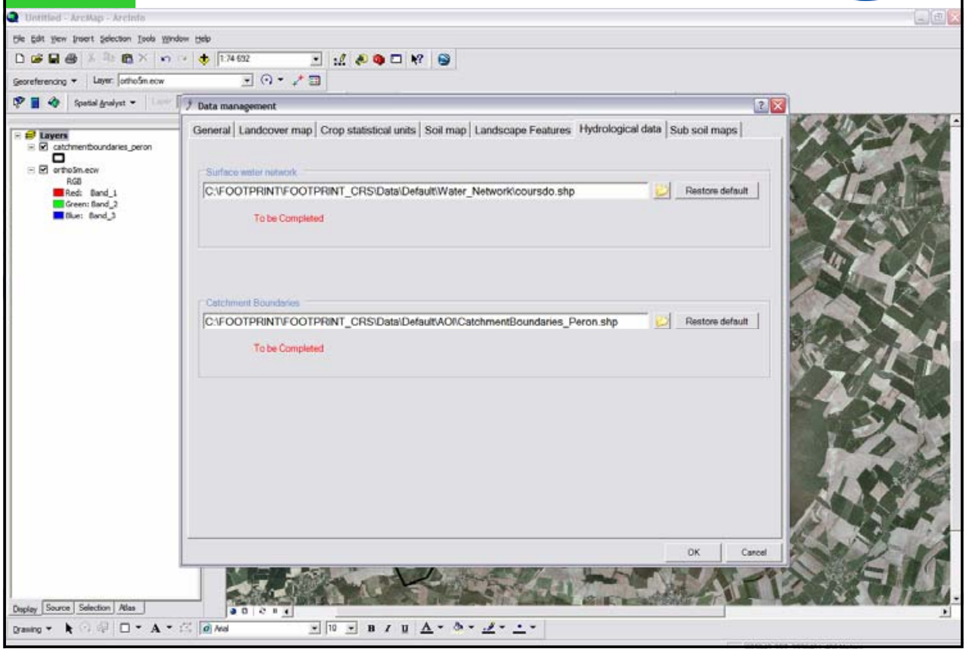
Data management – Soil map: User can use his/her own data



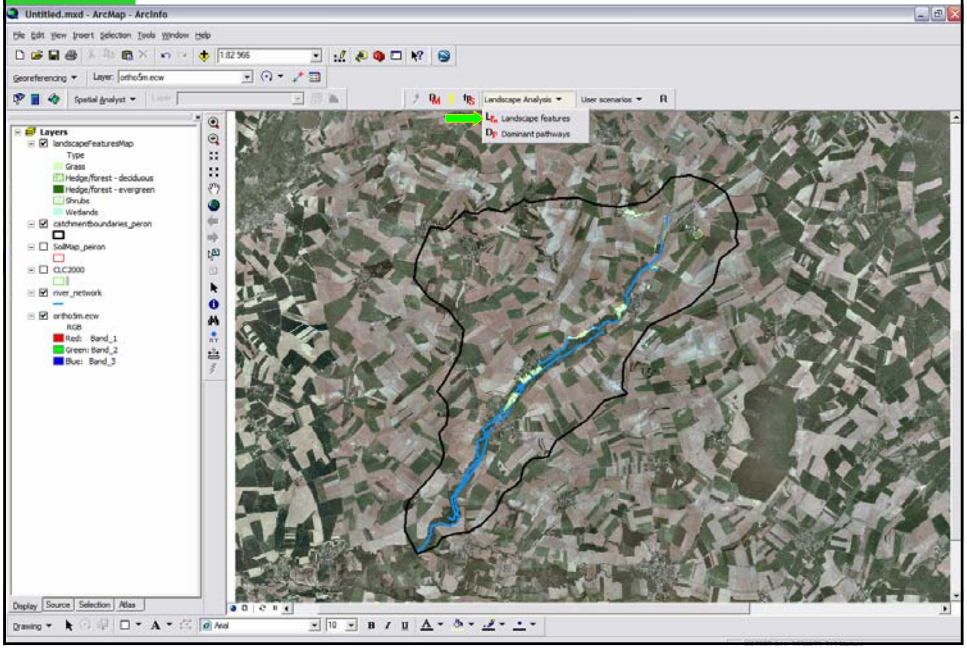
Data management – Landscape features: User can use his/her own data or create it in the Landscape features module



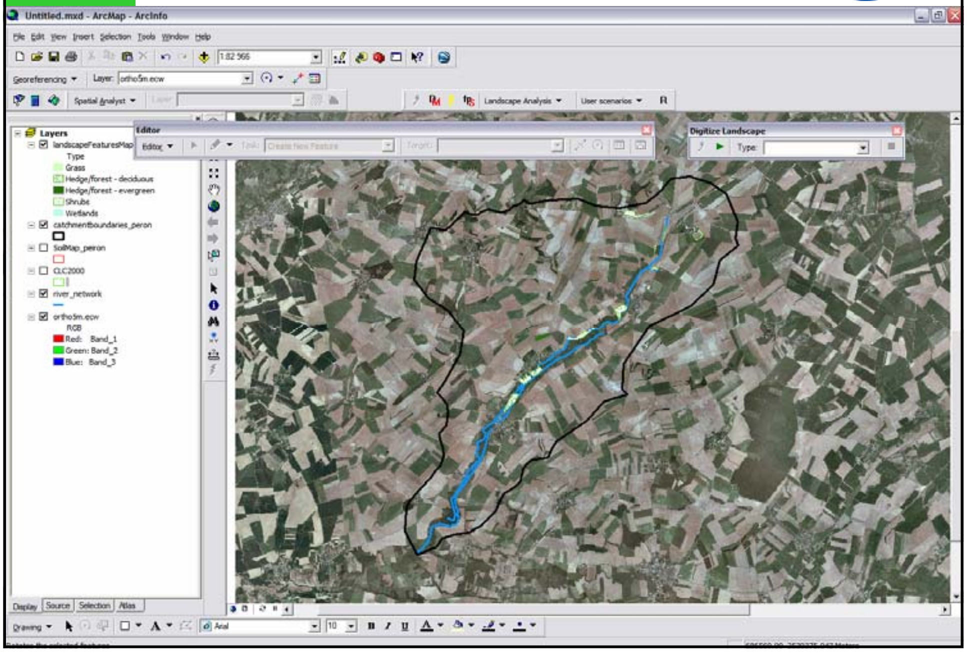
Data management – Hydrological data - Default - User can use own data



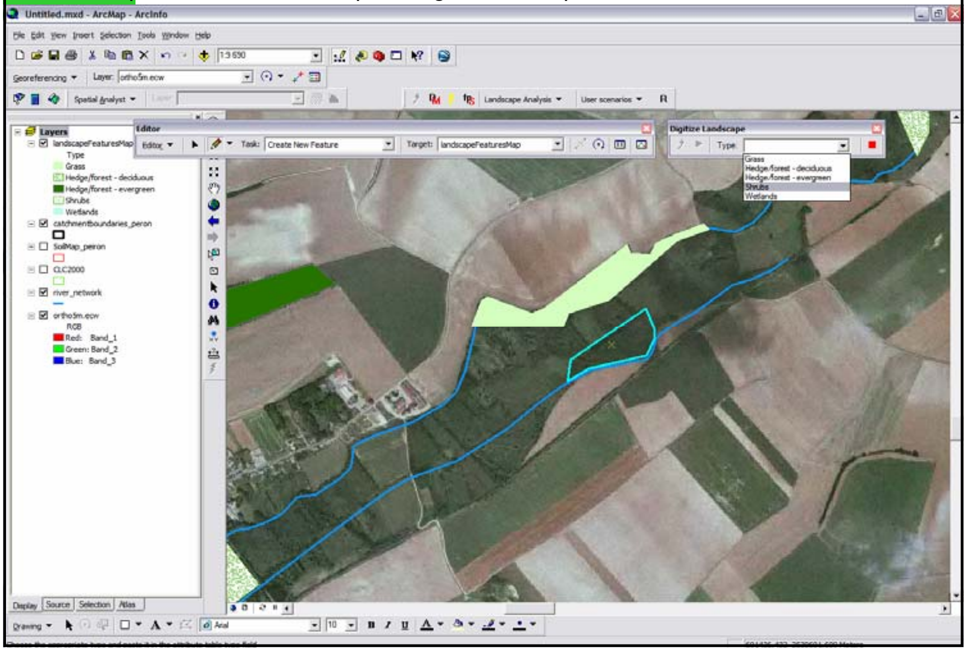
Landscape features – Launch tool



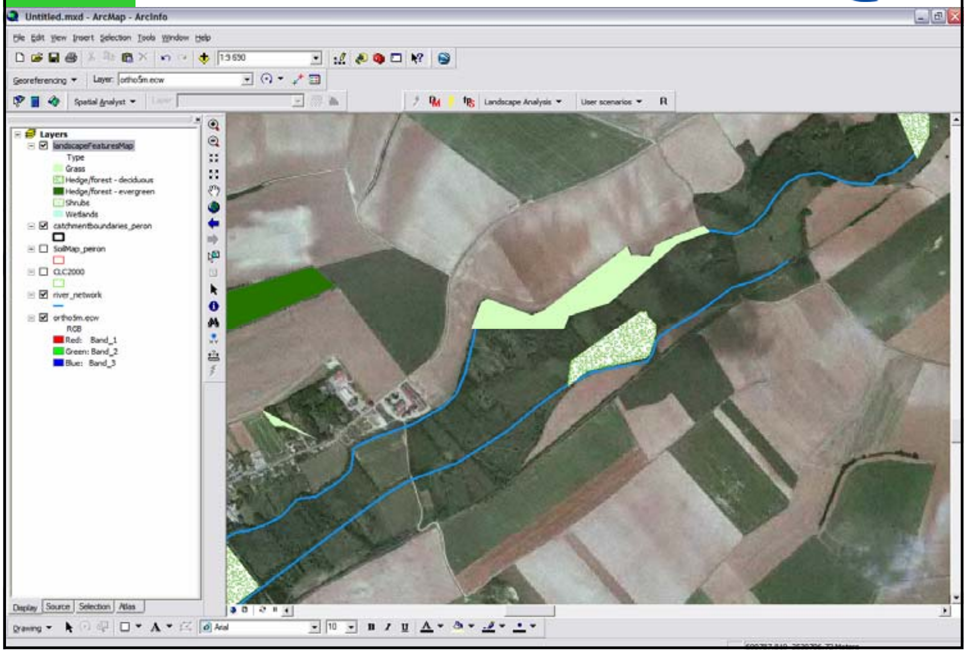
Landscape features – Click on green triangle to create the layer and start editing



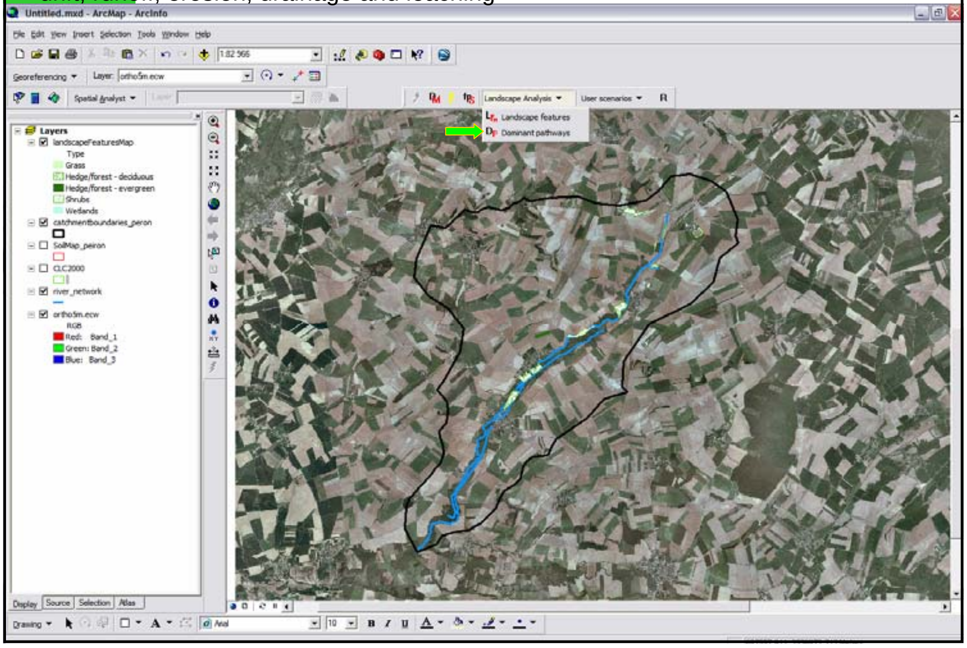
Landscape features – Digitize feature boundaries and assign a FOOTPRINT landscape feature class - Stop editing with red square



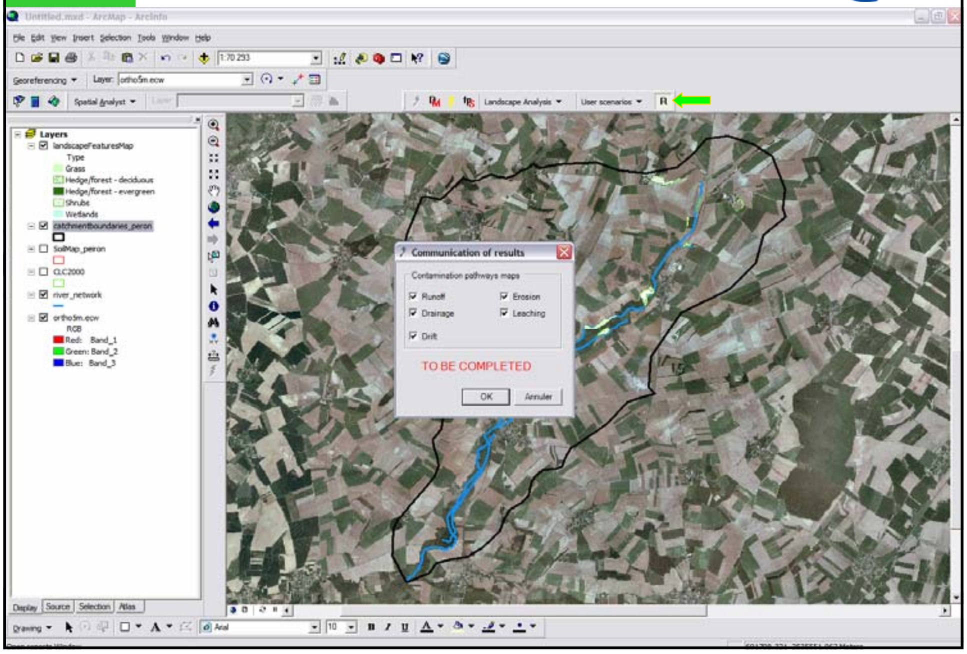
Landscape features



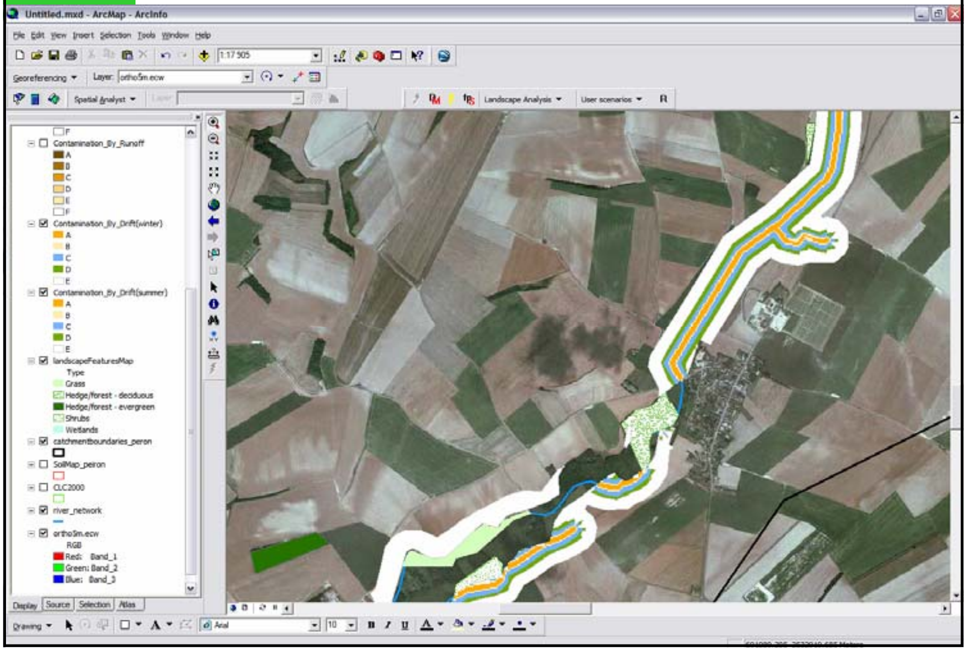
Dominant pathways – Launch – Creates maps of relative importance for the pathways drift, runoff, erosion, drainage and leaching



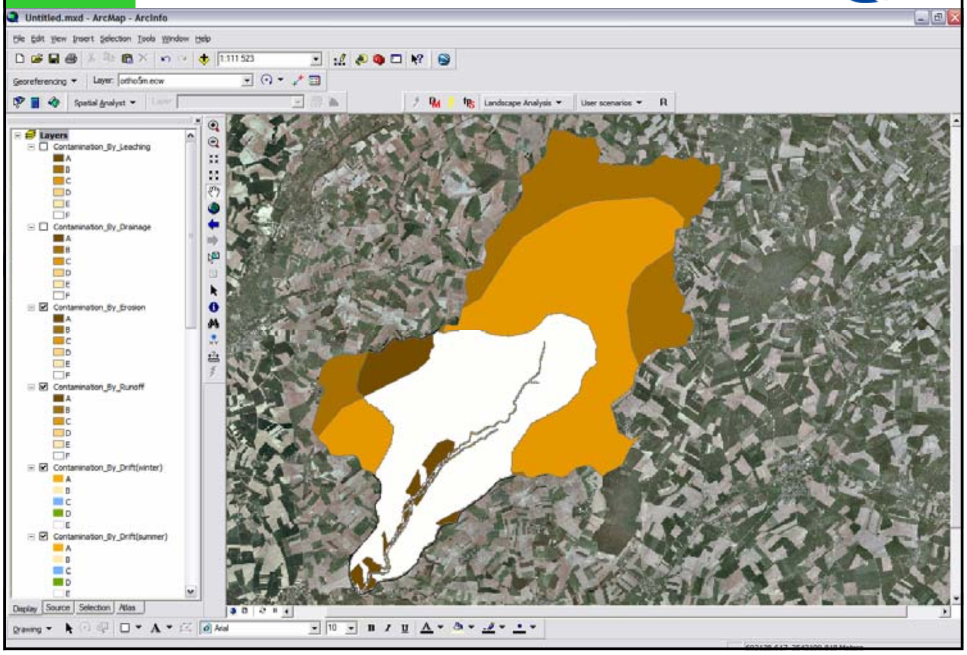
Display maps – Select the resulting maps for display



Display drift maps – 6 classes – one map per seasonal conditions



Display soil dependant pathways maps – 6 classes – one map per pathway



FOOT-NES

> DEMONSTRATION………

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