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On the use of SWAT for the identification of the most cost-effective nitrogen abatement measures for river basins

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Towards river basin management plans

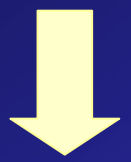
- High environmental concerns
- Limited financial resources

- ‘Good’ water status to be reached by 2015
  - Set by EU Water Framework Directive (WFD)
  - Objectives to be reached at lowest cost
  - Set of actions; pollution abatement measures

- **My research:** Methodology to reach the water quality objectives at lowest cost

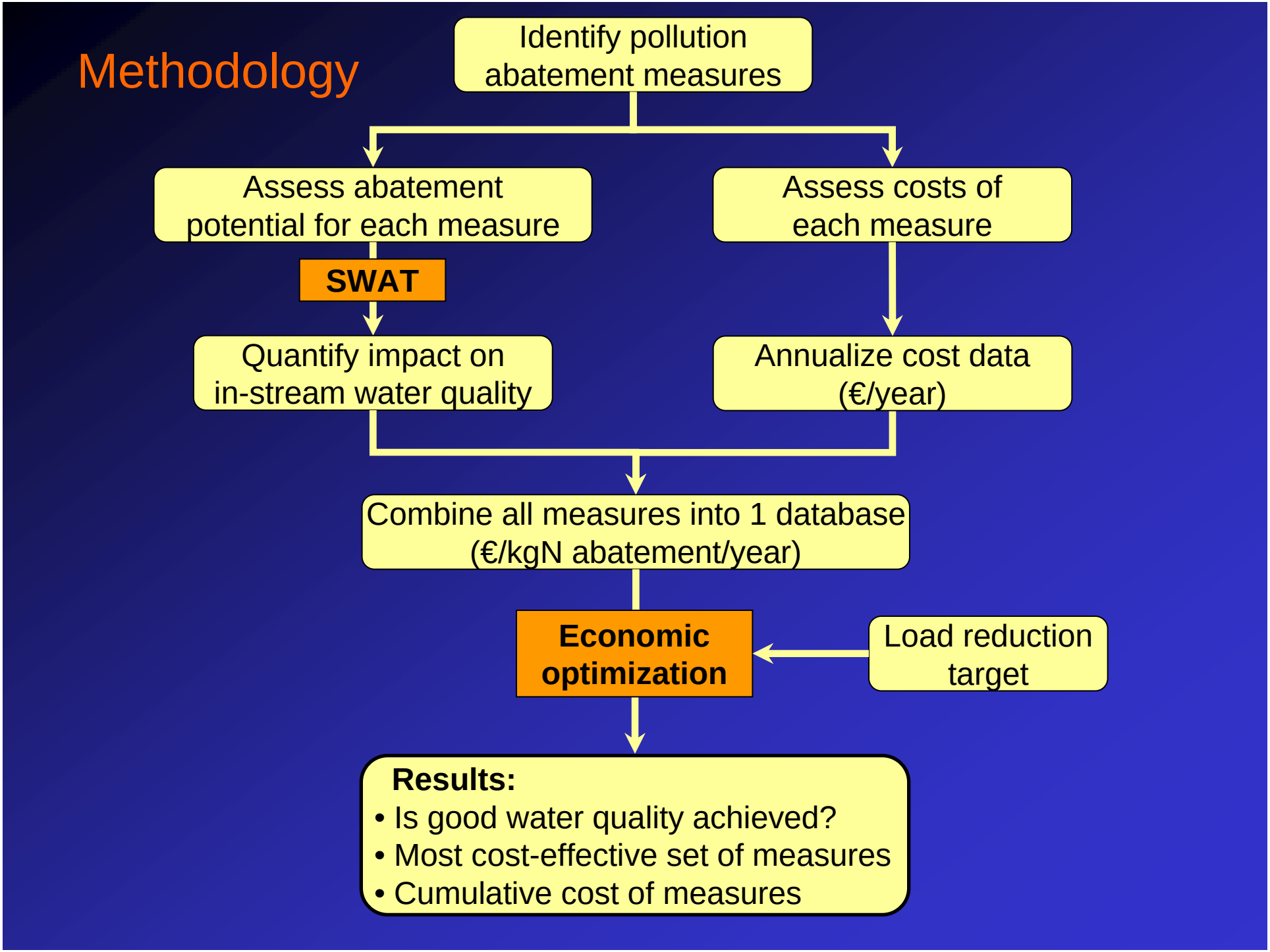
Need for modelling?

- Pollution abatement measures applied randomly
- Worst polluters targeted first
- No evidence that measures will achieve environmental targets
- Complexity ↑ when subbasin area ↑



- SWAT for impact on in-stream water quality
- Economic tool to select cheapest combination of measures
- Coupling SWAT-Economic tool

Methodology



Economic optimization: Cost-Effectiveness

- Cost-minimization as objective function
- When environmental target is fixed
- ‘Benefits’ = pollution load reduction (kgN reduction)
- Few cost & effect data available (at basin scale)

Impact on water quality in SWAT2005

Needed

- Calibration of a water quality model
- Determine immission coefficients α
- Run scenario's of pollution abatement measures

→ Pre- and Postprocessing tools needed for SWAT2005

immission coefficient

$$\alpha = \frac{\text{load that reaches the control section}}{\text{load emitted at the source of the pollution}}$$

Pre- and postprocessing tool for SWAT2005

- Make input files for water quality modelling
  - MGT files for fertilizer application
  - Point source pollution files
- Read-in SWAT2005 output
- Plot graphs for flow and water quality parameters
- Calculate objective functions
  - such as BIAS, R^2, SSQ, NSE
- Calculate average daily load

- **Excel tool**: easy to use, user-friendly interface
- **Matlab tool**: can be automated AND linked to economic tool

Excel tool for SWAT2005

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Run SWAT.EXE

Import New Run

ABOUT

Calvaltool.xls v1.05 - SWAT2005 Postprocessor

Developed by **Mutembei**
Master thesis project - May 2005
IUPWARE - VUB
http://www.iupware.be
Promotor: Prof. PhD. Ir. W. Bauwens

Help

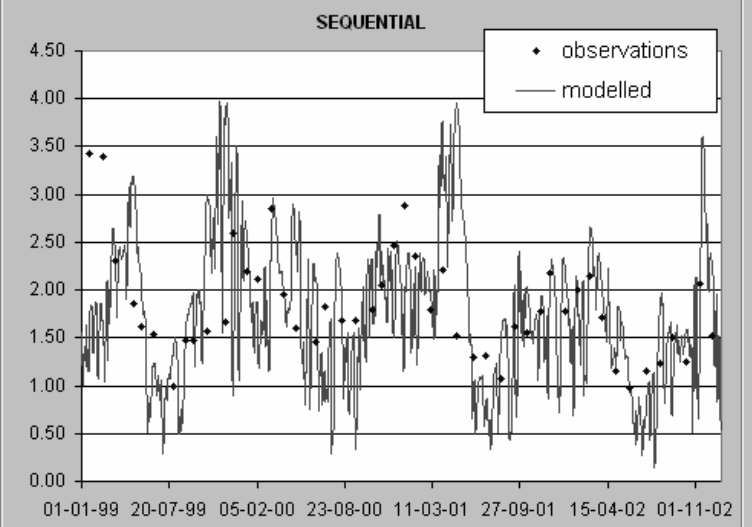
PARAMETERS

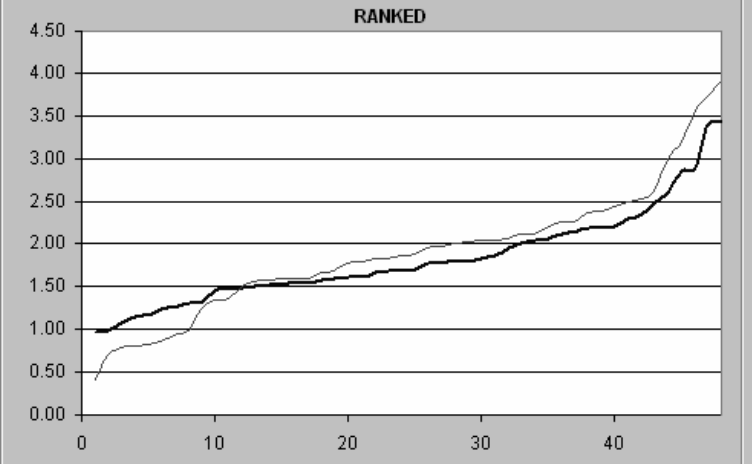
○ FLOW (m³/s)	○ NH3 (mg/L)	○ CHLOROPHYL A (mg/L)
○ SEDIMENT (mg/L)	○ NO2 (mg/L)	○ TEMPERATURE (°C)
○ ORGANIC N (mg/L)	○ MINERAL P (mg/L)	○ KJELDAHL N (mg/L)
○ ORGANIC P (mg/L)	○ CBOD (mg/L)	○ TOTAL N (mg/L)
◉ NO3 (mg/L)	○ DISSOLVED OXYGEN (mg/L)	○ TOTAL P (mg/L)

OBJECTIVE FUNCTIONS

	SEQUENTIAL		RANKED	
Average of observations	MEANobs	1.825	MEANobs	1.825
Average of simulations	MEANsim	1.901	MEANsim	1.901
BIAS	**BIAS**	-0.076	**BIAS**	-0.076
Correlation coefficient	**R**	**0.166**	**R**	0.984
Sum of Squares	SSQ	36	SSQR	3
Number of observations	Nobs	48	Nobs	48
Variance of observations	VARobs	0.31	VARobs	0.31
Nash-Sutcliffe Efficiency	**NSE**	-1.391	**NSE**	0.805
LN Nash-Sutcliffe Efficiency	**LNSE**	-1.522	**LNSE**	**0.560**
Adapted Nash-Sutcliffe Efficiency	**ANSE**	-1.280	**ANSE**	0.817

GRAPHS





Export All Graphs

AVERAGE DAILY LOADS (kg/day)

SEDIM	ORGN	ORGP	NO3	NH3	NO2	MINP	CBOD	KjN	TOT N	TOT P
9.26E+03	3.35E+02	9.60E+01	8.17E+02	2.02E+02	1.84E+01	5.71E+01	1.06E+03	5.37E+02	1.37E+03	1.53E+02

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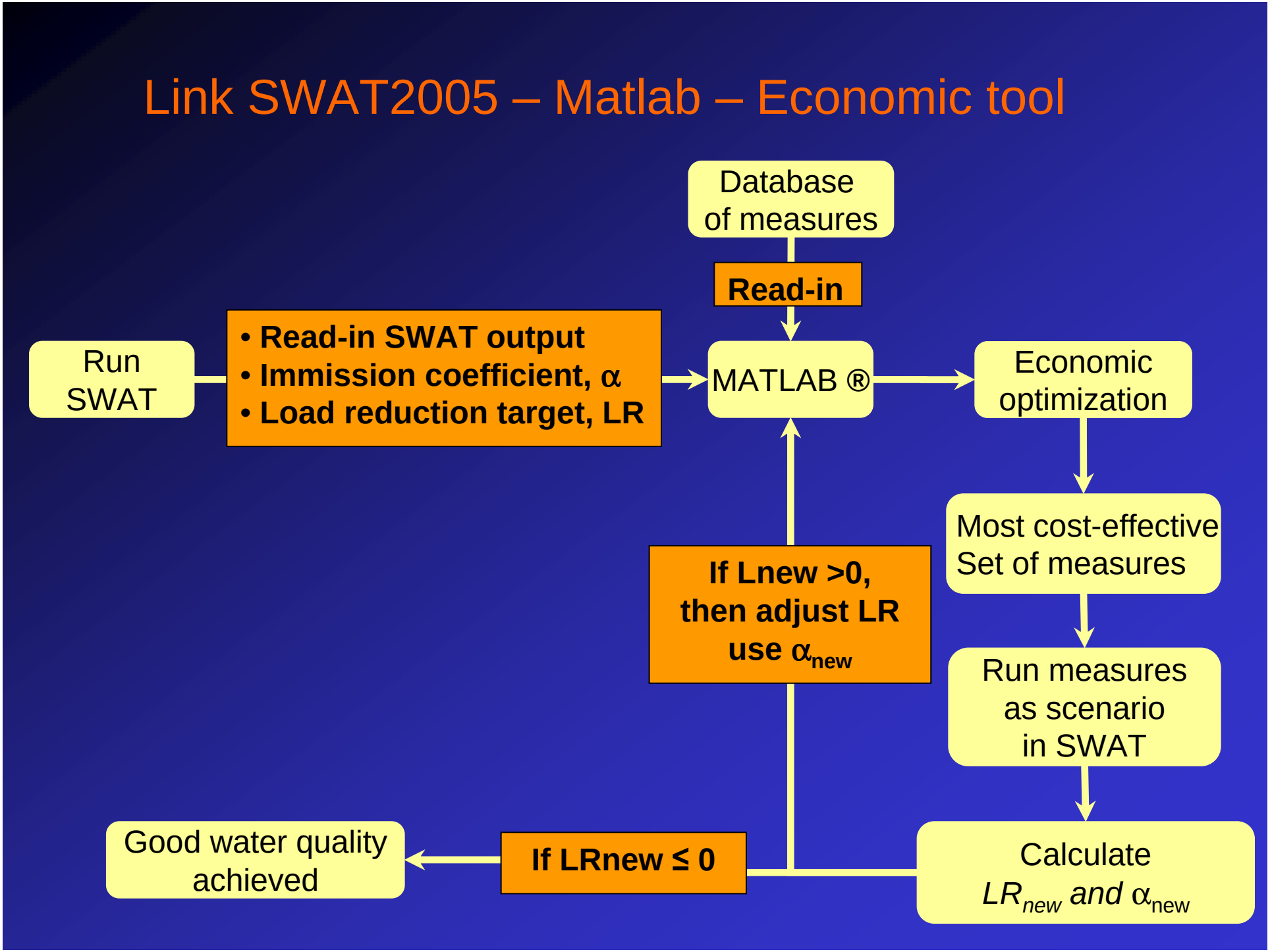
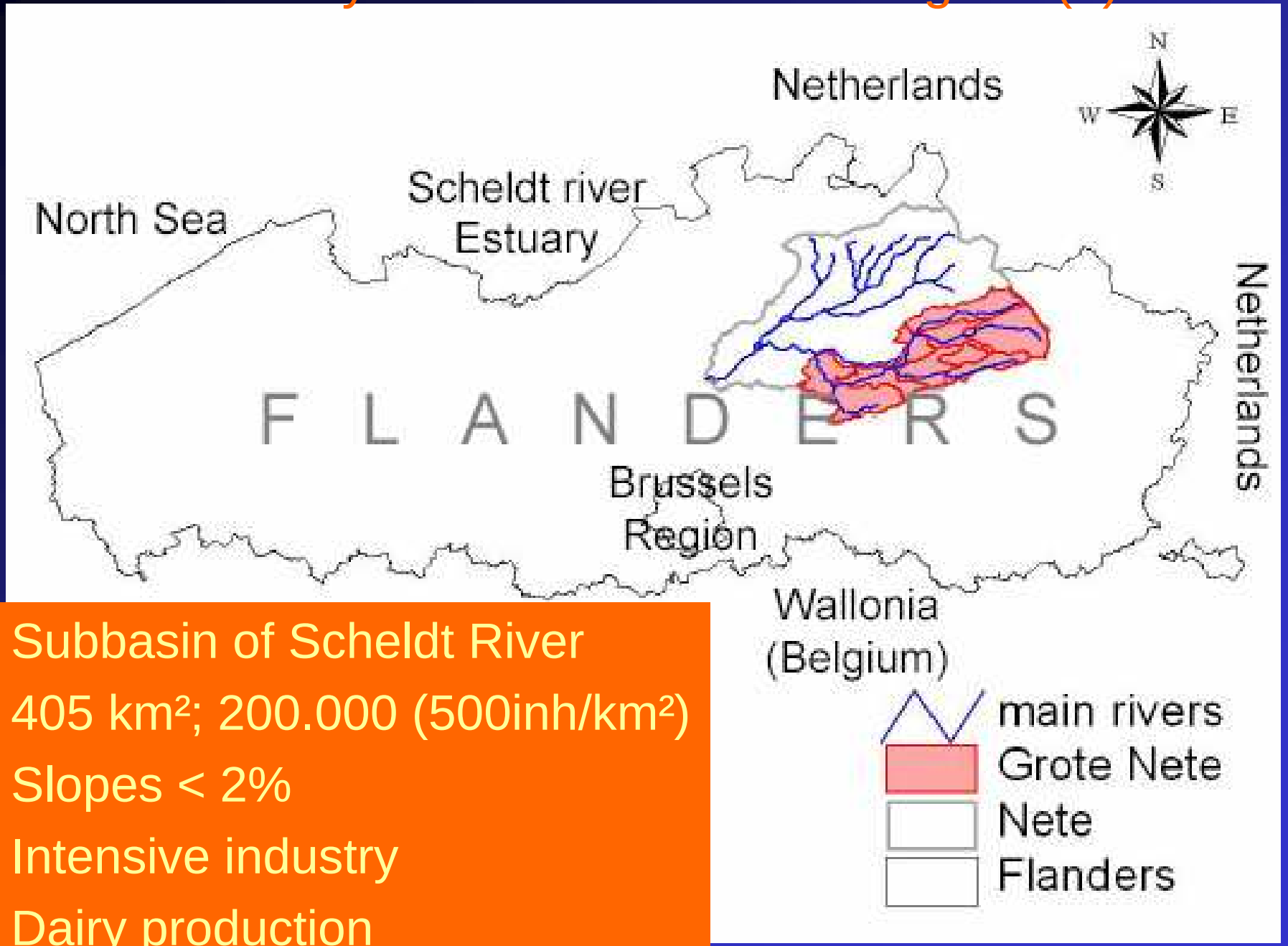
MAIN | observations | model | calval | sequential | ranked | residues | trend | SETUP

Link SWAT2005 – Matlab – Economic tool

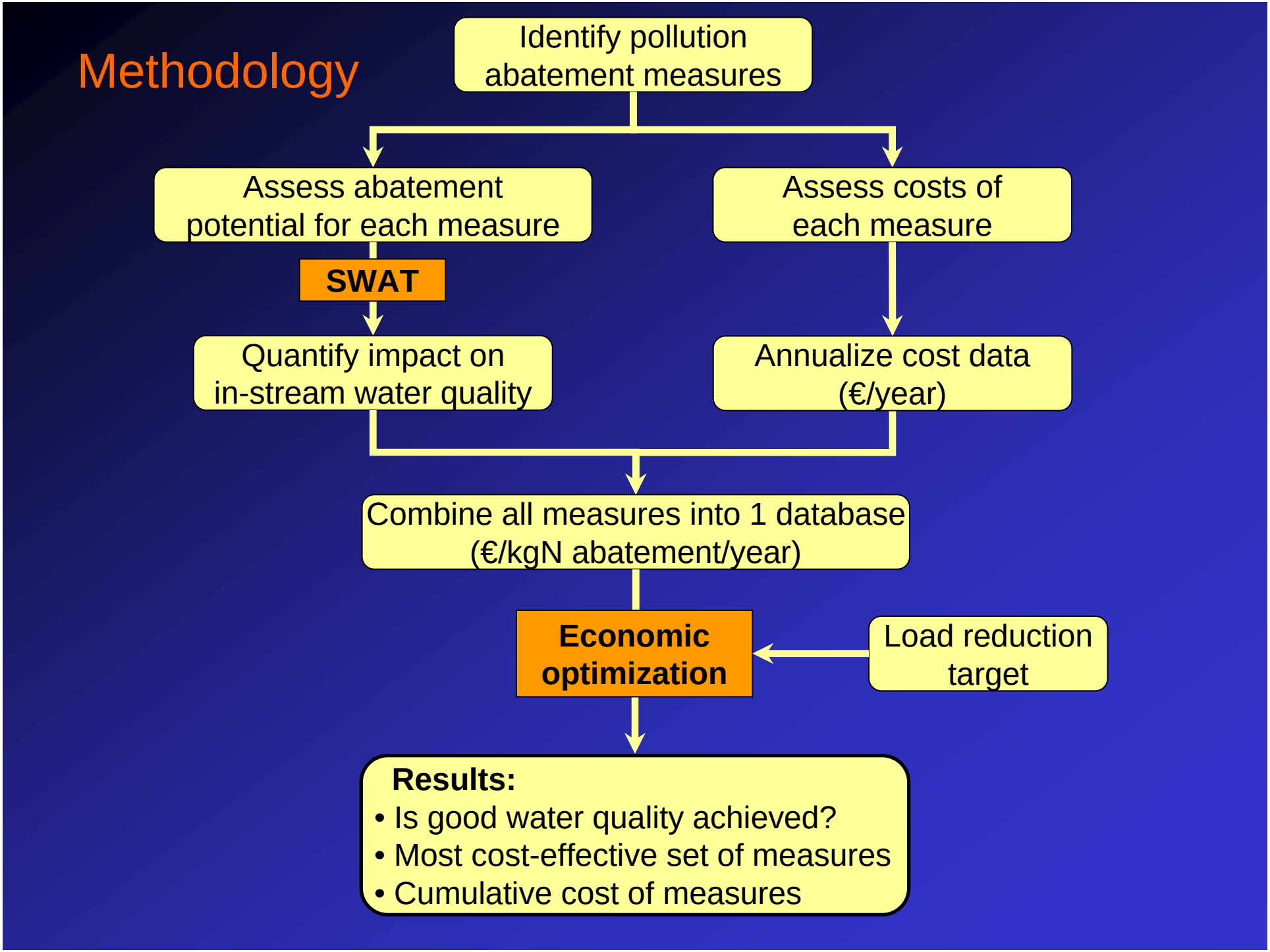


Case study: Nete river basin in Belgium (1)



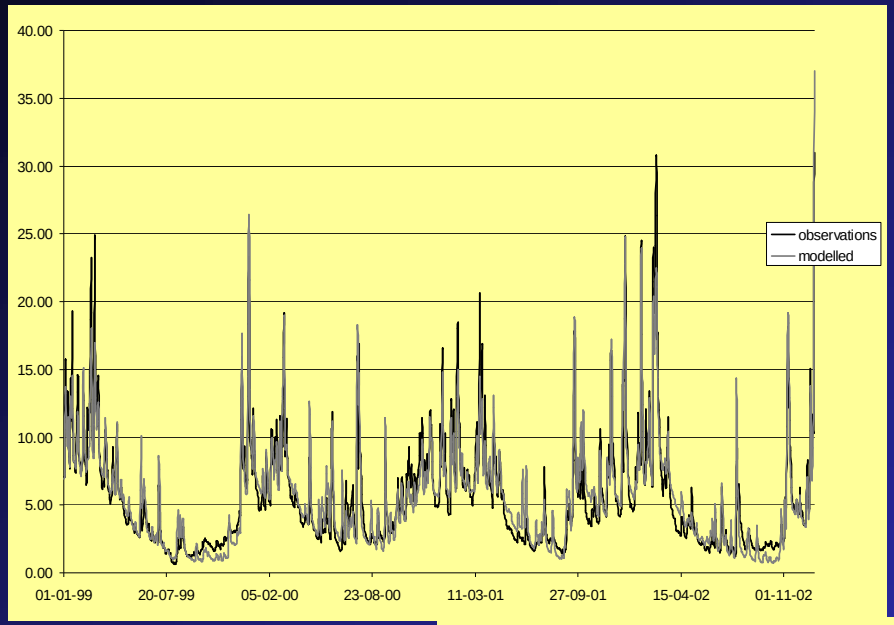
- Subbasin of Scheldt River
- 405 km²; 200.000 (500inh/km²)
- Slopes < 2%
- Intensive industry
- Dairy production

Methodology

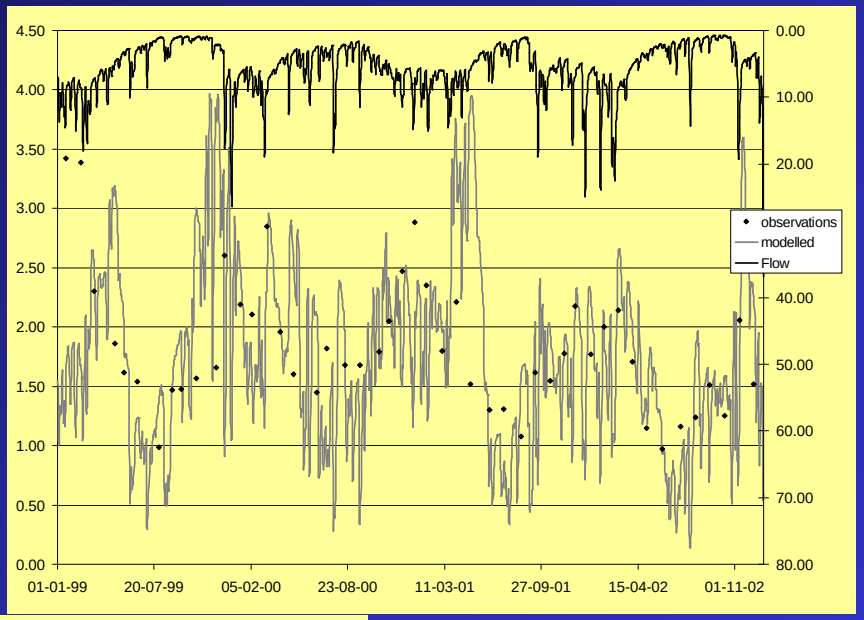


Case Study: SWAT results (2)

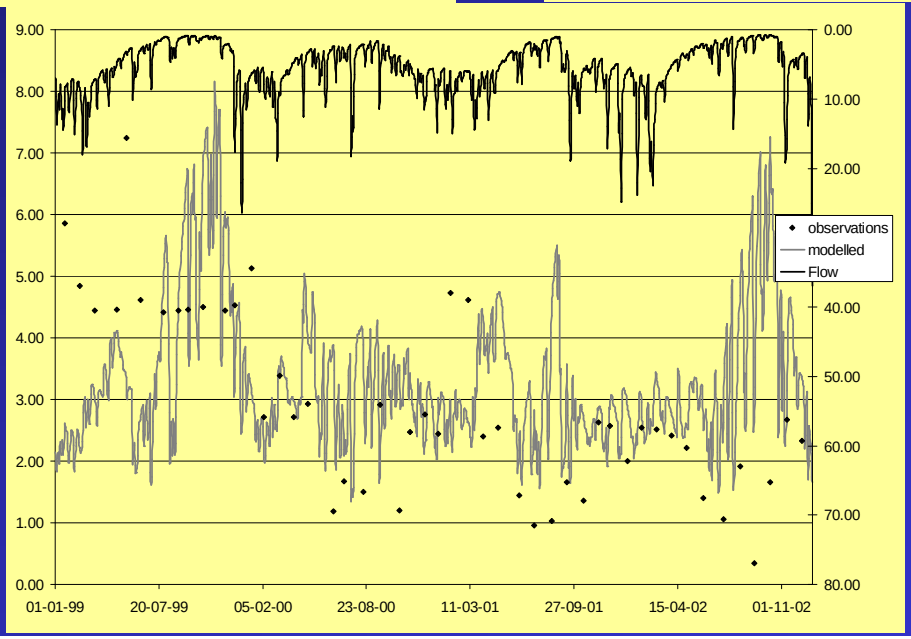
FLOW: NSE 0.87



NO3



Nt



Case Study: Results from CEA (4)
1) CE ratios

CE = Cost / Effectiveness
(in x € /kgN abatement)

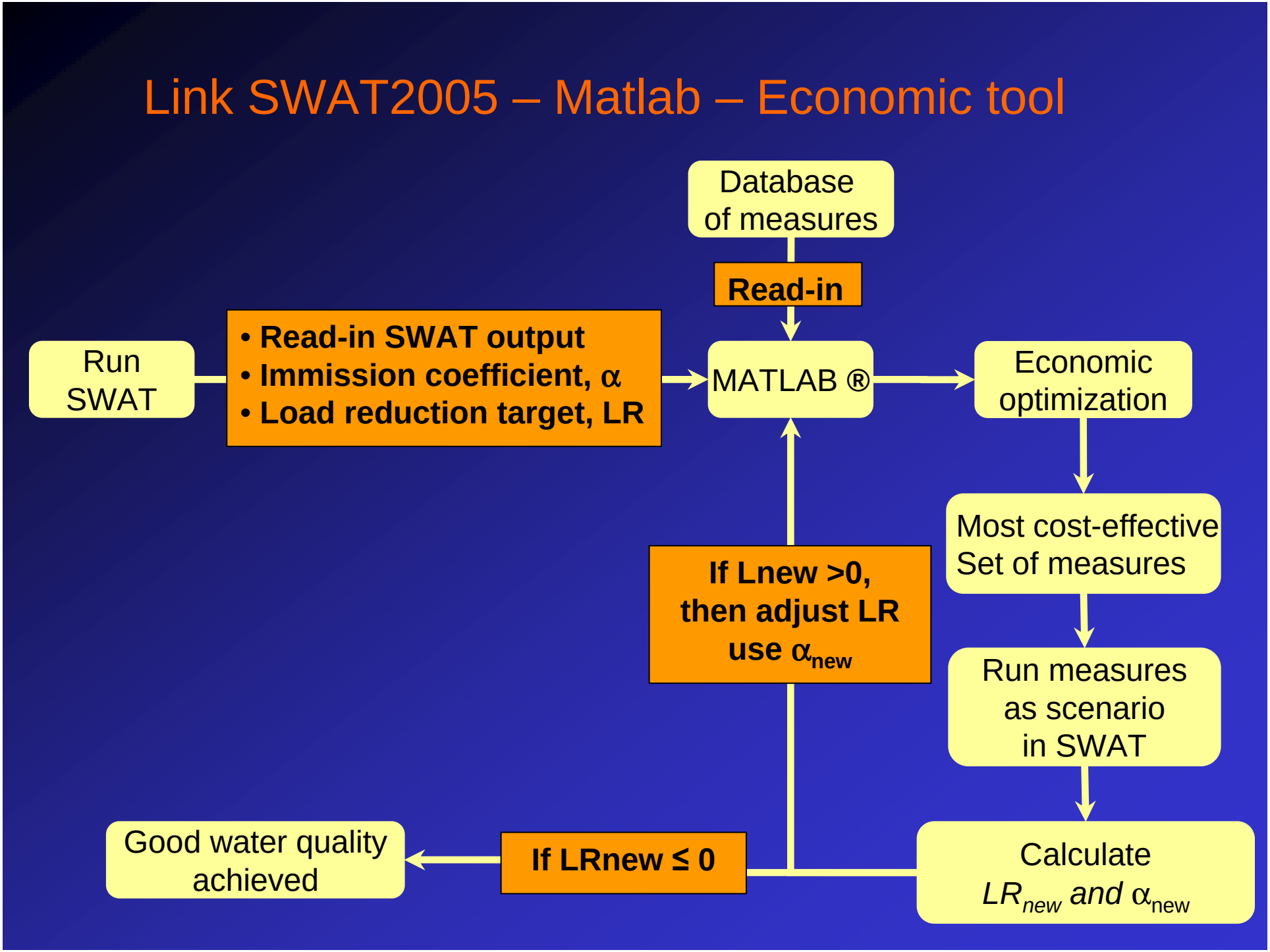
measure	CE ratio (€/kgN abatement)	Rank
Connect to WWTP*	52.8	3
reduce pigs	11.8	2
manure processing	9.6	1

* Cost of WWTP itself ~ 9 Euro/kg N

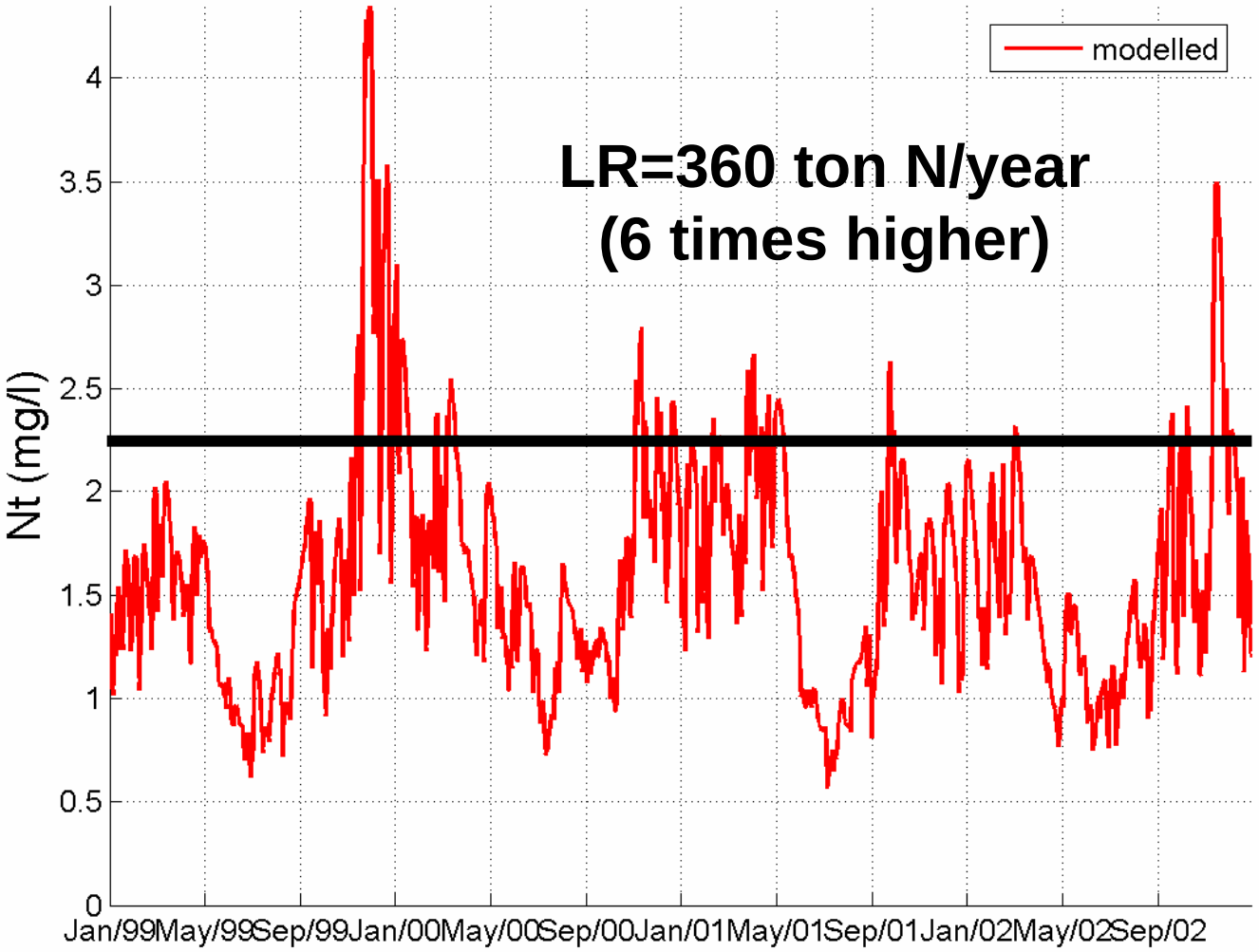
Case Study: Results from CEA (5)
2) Location and selection of abatement actions

Subbasin	Best measures
1	2 manure processing
2	3 manure processing
3	2 manure processing
4	2 manure processing
Total cost	**720 000 Euro/year**

Link SWAT2005 – Matlab – Economic tool



Case Study: Results from CEA (6)
Good water quality reached: NO



Conclusion

- Economic tool for SWAT2005 developed
- Pre- and postprocessing tools developed for SWAT2005 in Excel and in Matlab
- For water quality modelling

- Better load reduction target needed
- Optimization technique needed
- For each subbasin: load reduction target and immission coefficient
- Cost and effectiveness values uncertain