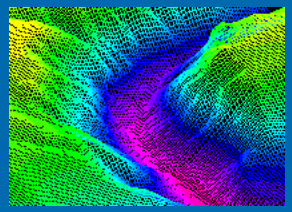
Land use and water resources in the Cuiabá River Basin

Peter Zeilhofer – Departament of Geography (UFMT)

Dr. Gilson A. L. Rosa (Prof.) – Time series analysis
Dra. Eliana B. Lima Rondon (Prof.) – Urban impacts on water quality
Gabriella C. Araújo (MSc. Student) – Landuse and water quality in the Miranda River Basin?



Suzy Mara Klemp (MSc. Student) – Spatial prediction of sprinkler irrigation
Olga Kummer (MSc. Student) – Spatial Decision Support Systems
Leonardo Hallak (MSc. Student) – Land use change and runoff
Bruno de Deus (MSc. Student) – Rainfall interpolation and RS estimation
Naomi Onga (MSc. Student) - Land use change and runoff modeling
Adriano dos Santos (MSc. Student) - Precipitation scenarios for Mato Grosso

Carlos U. R. de Oliveira (MSc.) – WWW-Decision Support Systems
Dr. Gilson A. L. Rosa (Prof.) - Database applications
Pedro Salves Arraes – WWW-Decision Support Systems
Ivairton Santos (Prof.) - GIS-integration of hydrological models

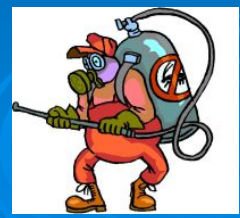
Some related current research

- Impacts of aquacultures in the Cuiabá catchment (Eliana B. N. R. Lima)

- Interference of climatic variations and land use on the water balance in the Teles Pires catchment (P. Zeilhofer)

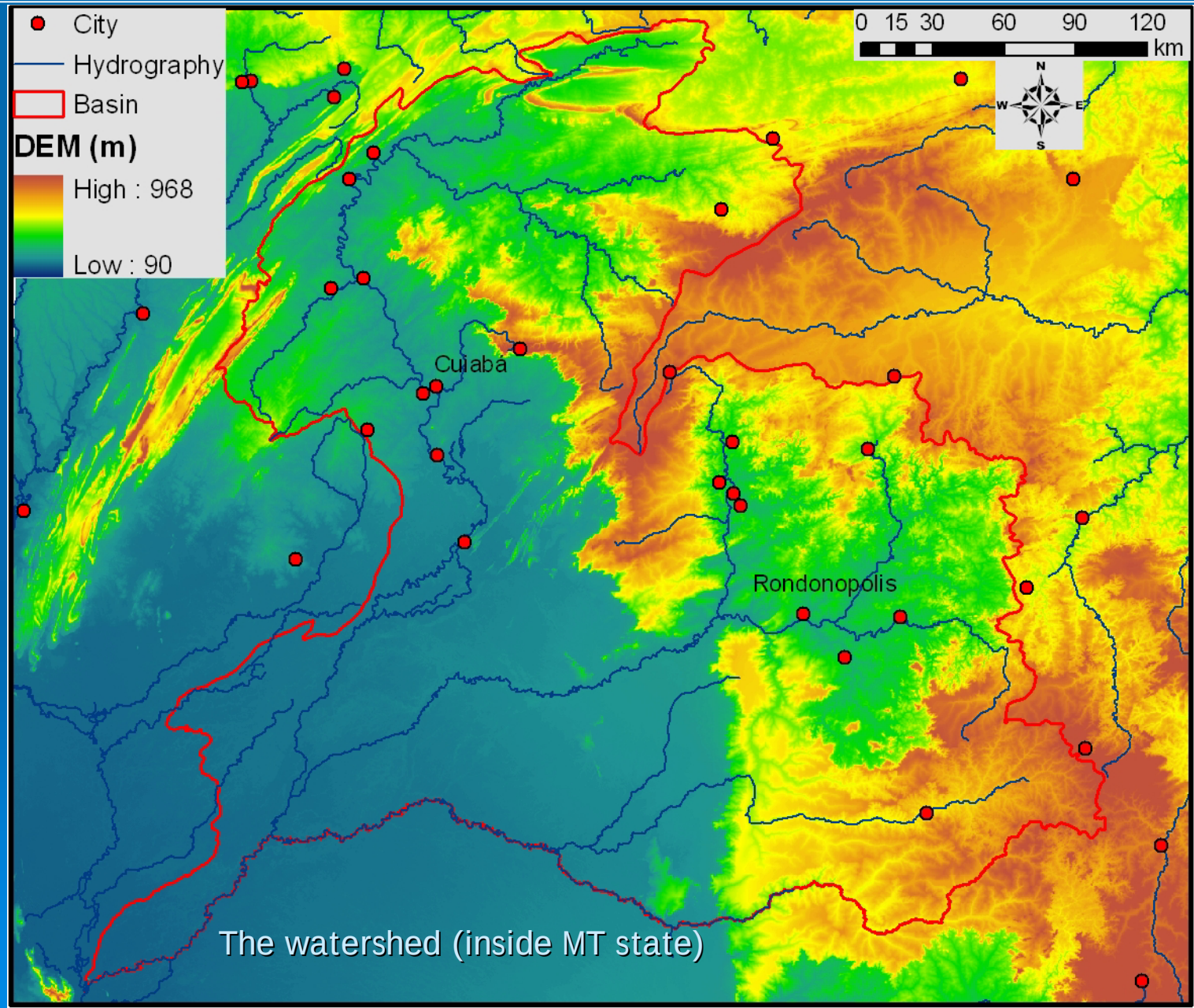
- Development of a Web-based SDSS for water use allocation (P. Zeilhofer)

- Eliana Dores: diverse projects on pesticide contamination of surface and sub-surface waters



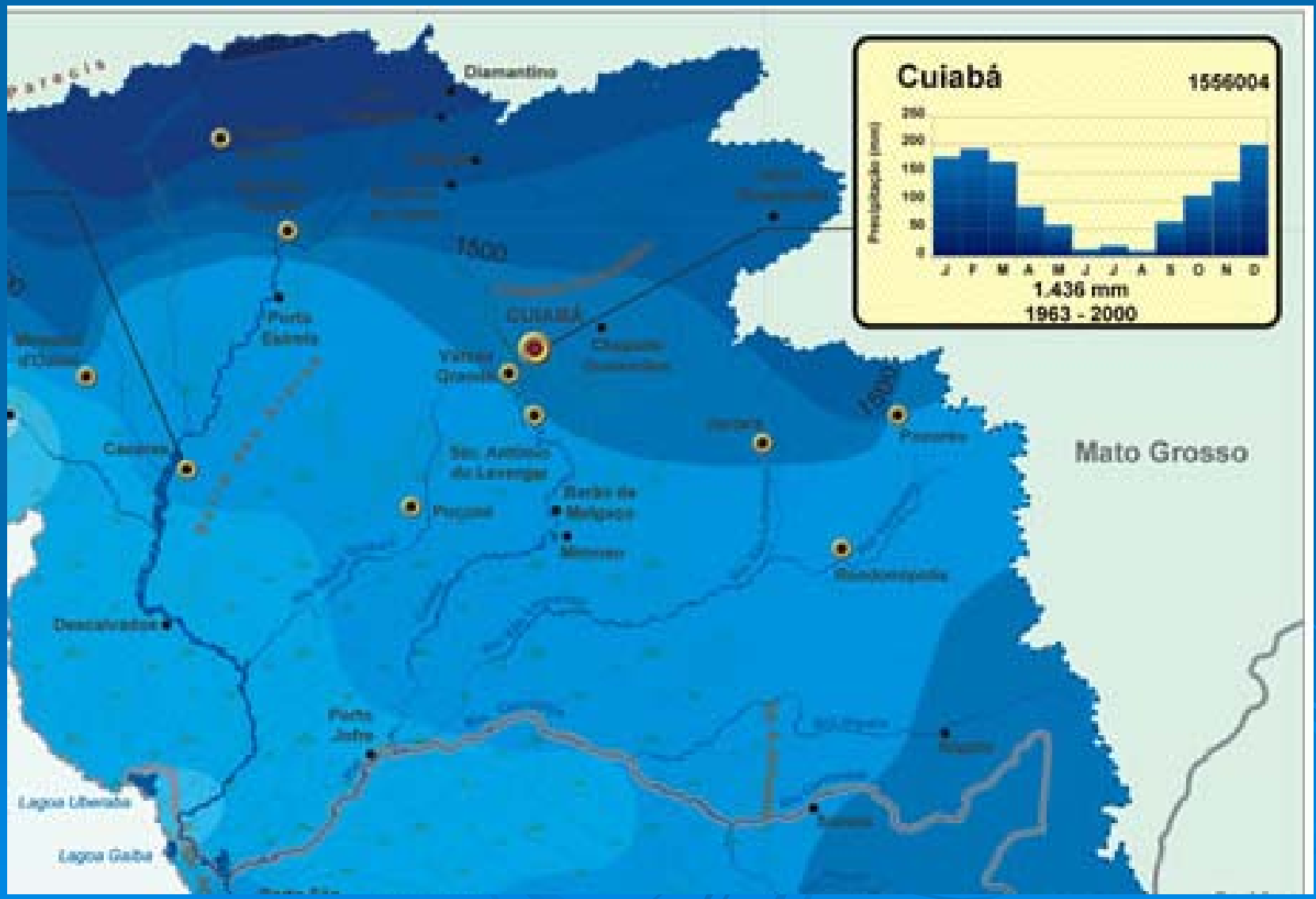
Land use and water resources in the Cuiabá River Basin

2º Workshop Int. Workshop on Catchment Management in the Rio Cuiaba Basin

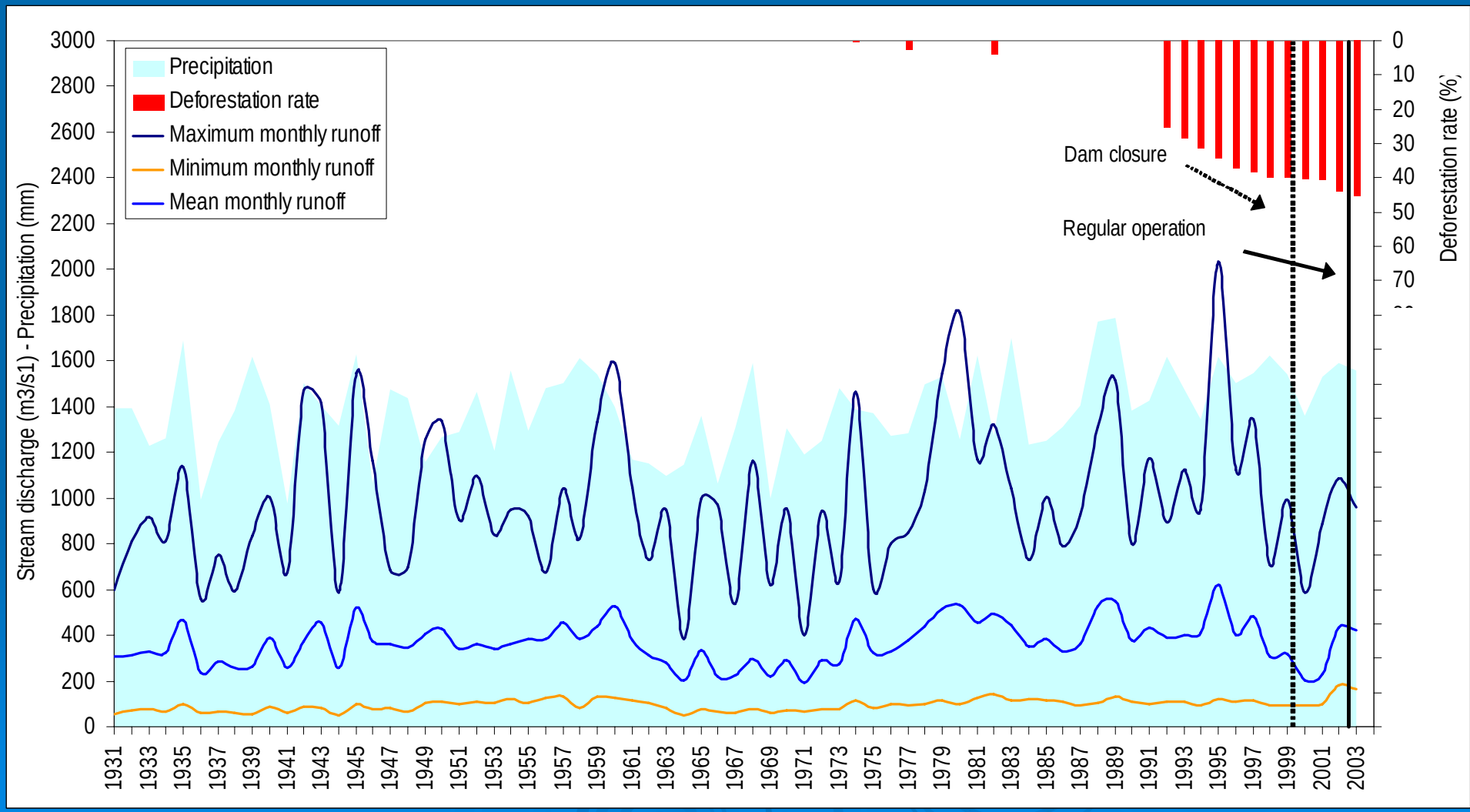


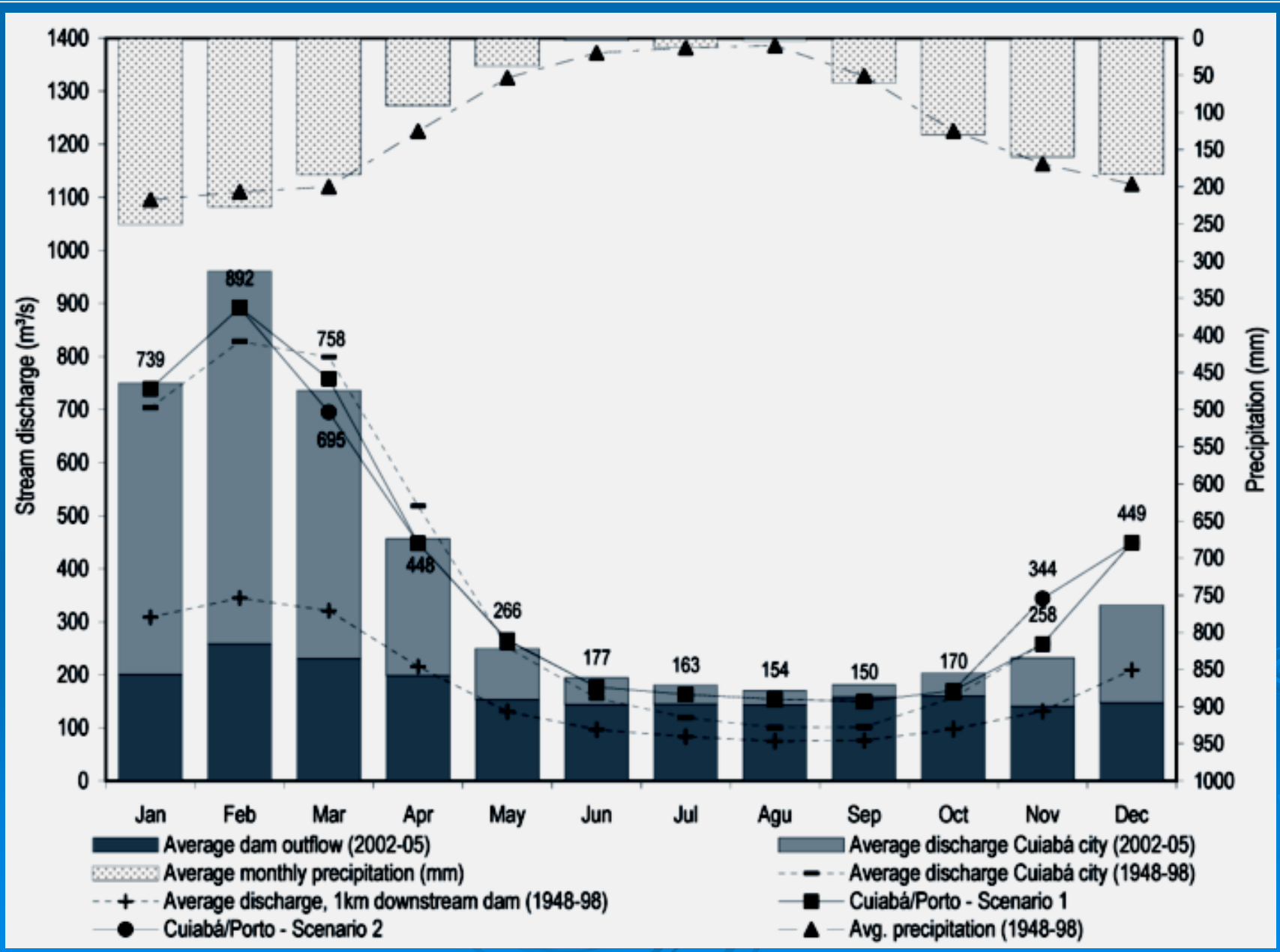
The watershed (inside MT state)

Precipitation



Long-term runoff of the Cuiabá River in Cuiabá




Stream discharge (m³/s)
Precipitation (mm)
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
739
892
758
695
448
266
177
163
154
150
170
258
344
449
Jan
Feb
Mar
Apr
May
Jun
Jul
Agu
Sep
Oct
Nov
Dec
Average dam outflow (2002-05)
Average discharge Cuiabá city (2002-05)
Average monthly precipitation (mm)
Average discharge Cuiabá city (1948-98)
Average discharge, 1km downstream dam (1948-98)
Cuiabá/Porto - Scenario 1
Cuiabá/Porto - Scenario 2
Avg. precipitation (1948-98)

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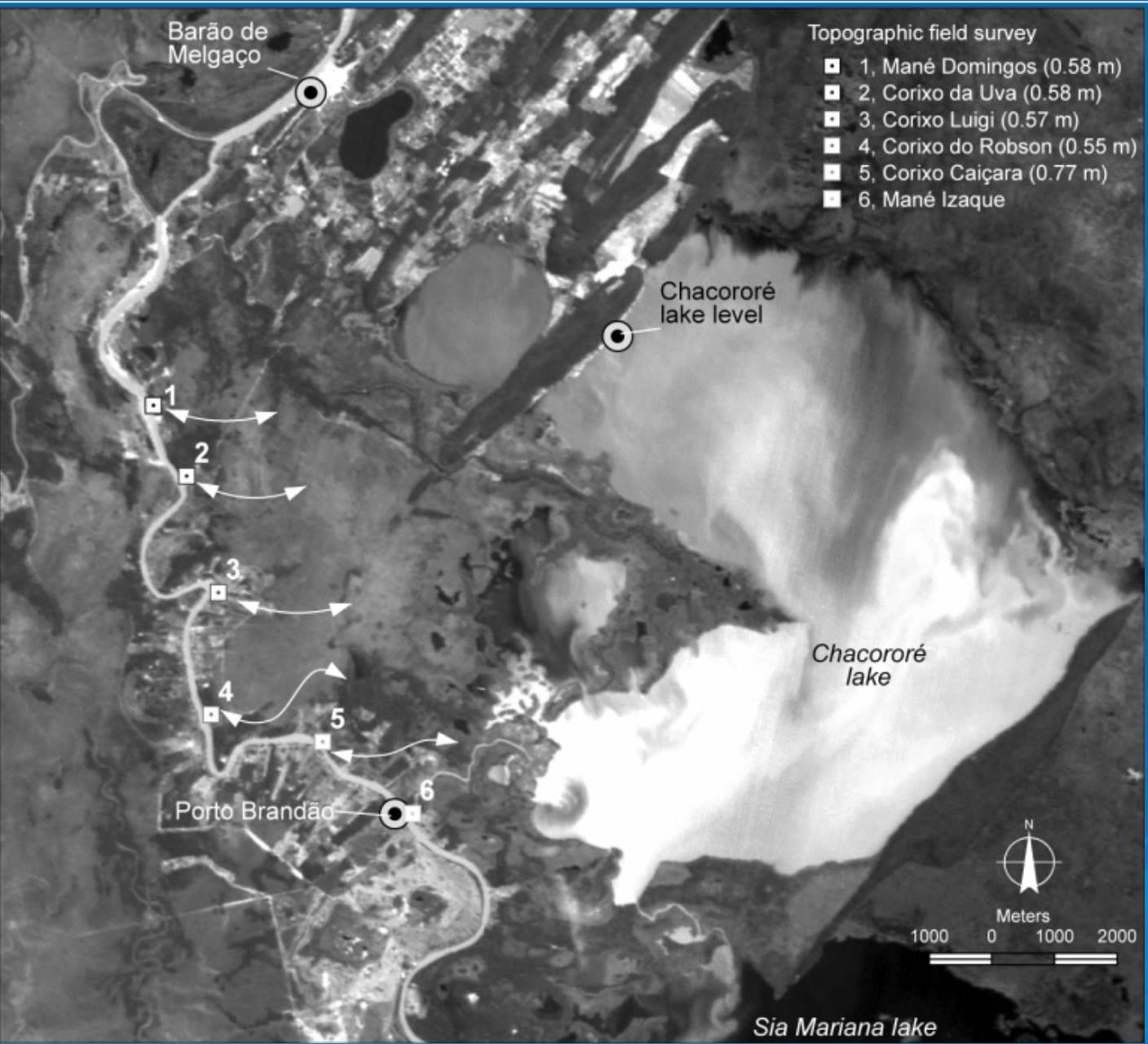
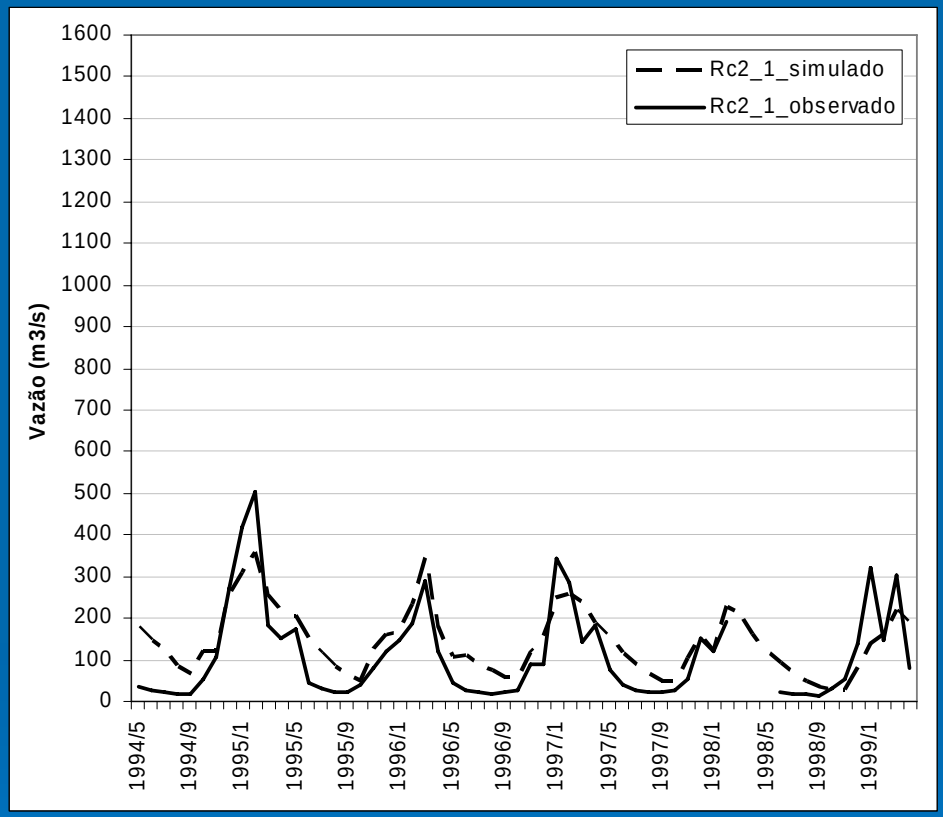
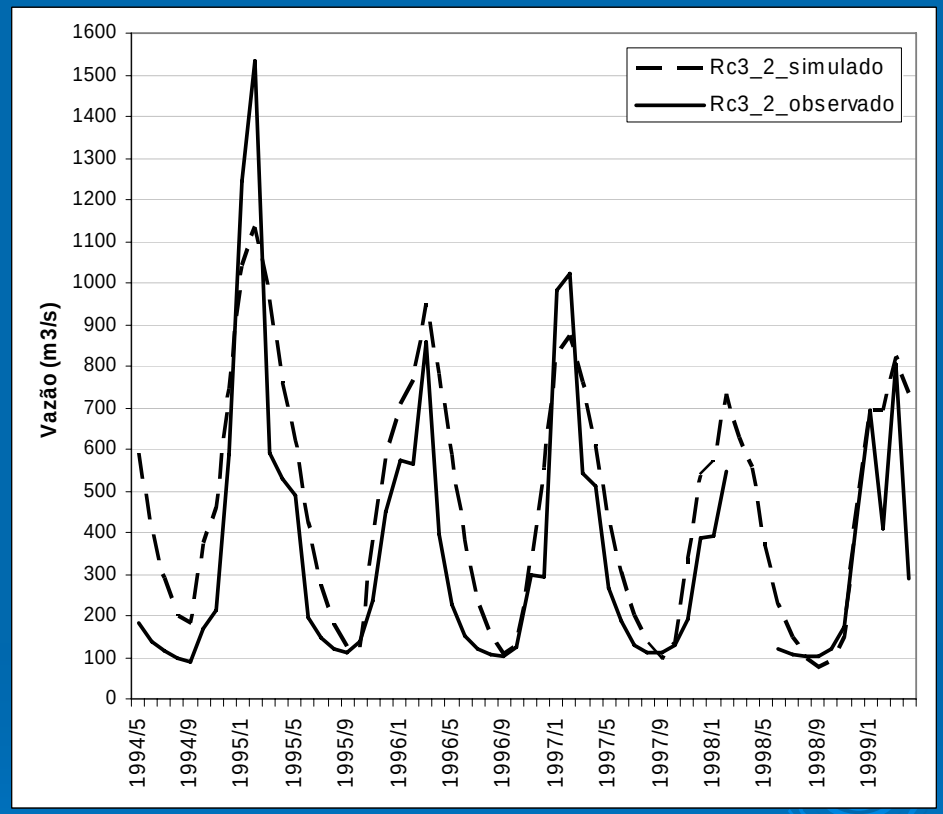


Gauging station	Cuiabá river, upstream the M. Izaque tie channel		Mané Izaque tie channel			Chacororé lake
Campaign	Level (m)	Runoff (m^3/s)	Level (m)	Runoff (m^3/s)	Flow direction	Level (m)
09/03/01	3.02	363.68	3.02	66.67	→	2.47
17/04/01	2.66	178.50	2.66	23.06	←	2.81
18/05/01	1.60	114.94	1.60	7.09	←	1.99
12/06/01	1.40	114.60	1.40	3.48	←	1.83
10/07/01	1.27	90.20	1.27	2.21	←	1.67
15/08/01	1.23	100.81	1.23	2.01	←	1.43
22/09/01	1.38	113.13	1.38	(*)	←	1.29
16/10/01	2.11	232.46	2.11	(**)	→	1.25
15/11/01	1.49	121.54	1.49	(*)	→	1.70
04/12/01	3.12	405.40	3.15	73.89	→	2.19
23/01/02	4.41	653.09	4.41	107.46	→	4.09
28/02/02	4.38	678.65	4.38	143.97	→	3.89
02/04/02	4.16	584.49	4.16	121.74	→	3.58
18/05/02	2.56	201.98	2.56	(*)	→	2.55
06/07/02	1.83	143.96	1.83	1.35	←	2.29

NGFlow: Validation



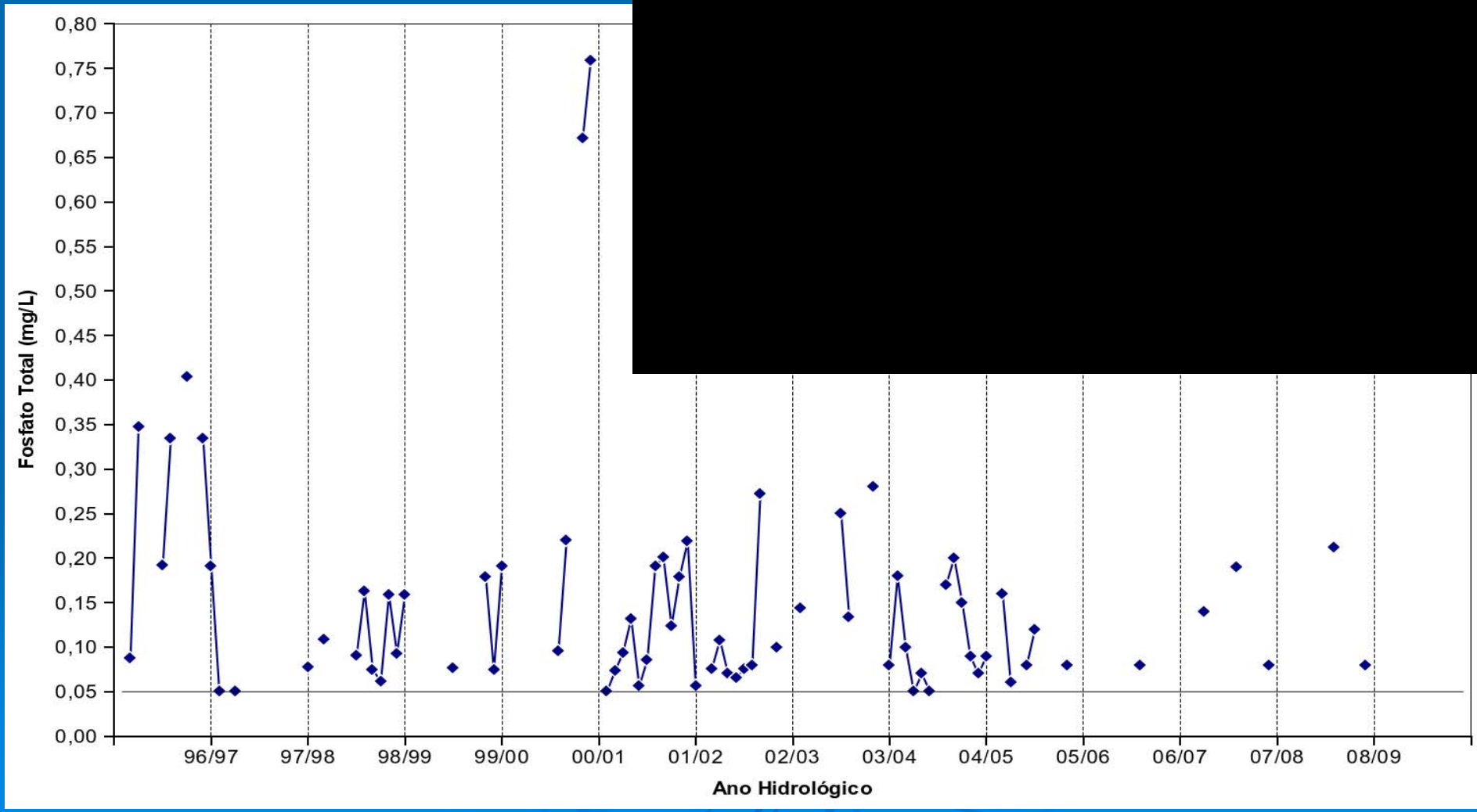


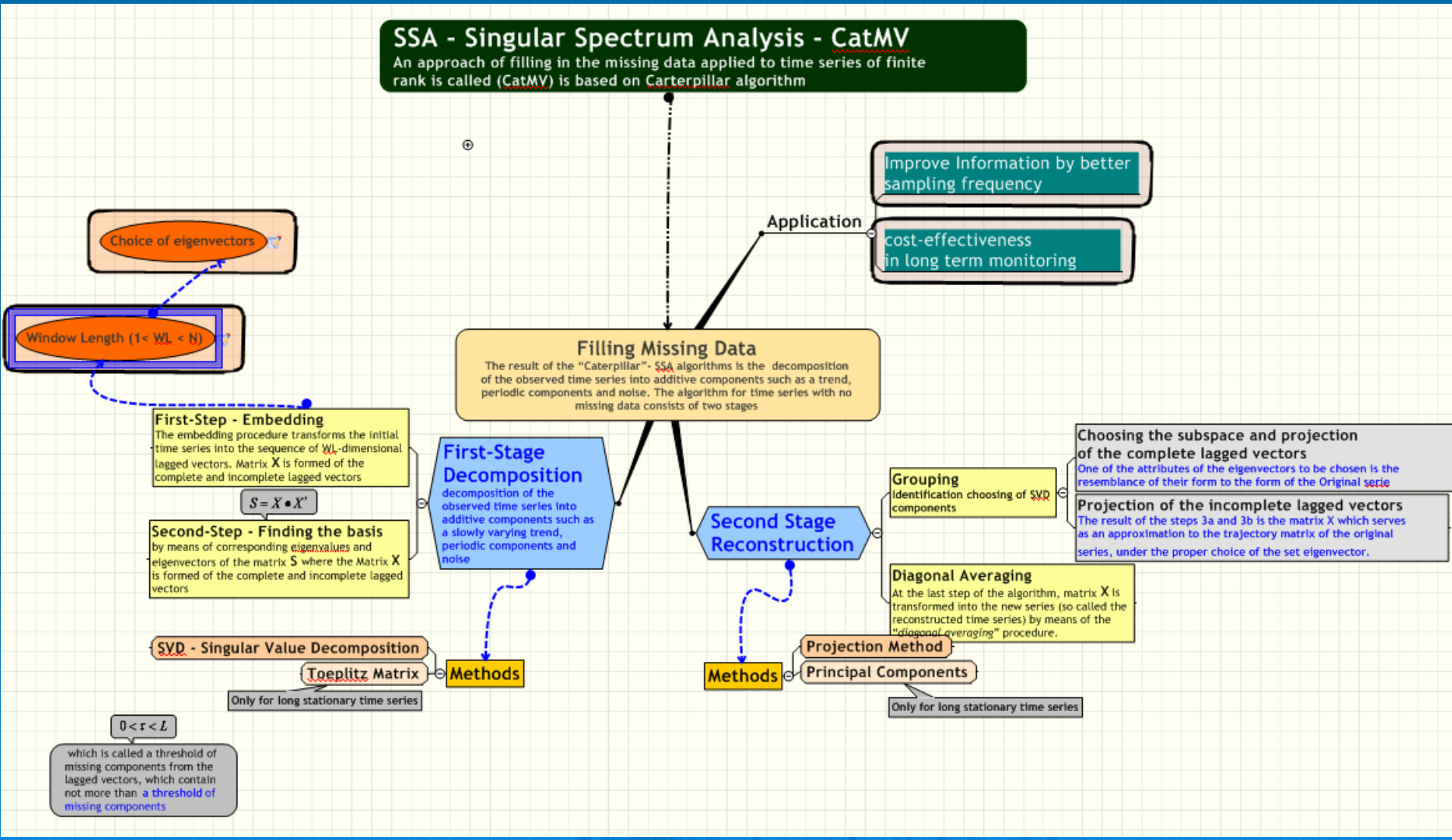
Station	Code (ANA)	Description	*RMSE*	*COE**
Rc2_1	66160000	Cuiabá river, 80 m downstream the confluence with the Quebó river	0,089	0,433
Rc3_2	66250001	Cuiabá river, city of Rosário Oeste	0,067	0,792

**COE*: Coeficiente of Nash & Sutcliffe

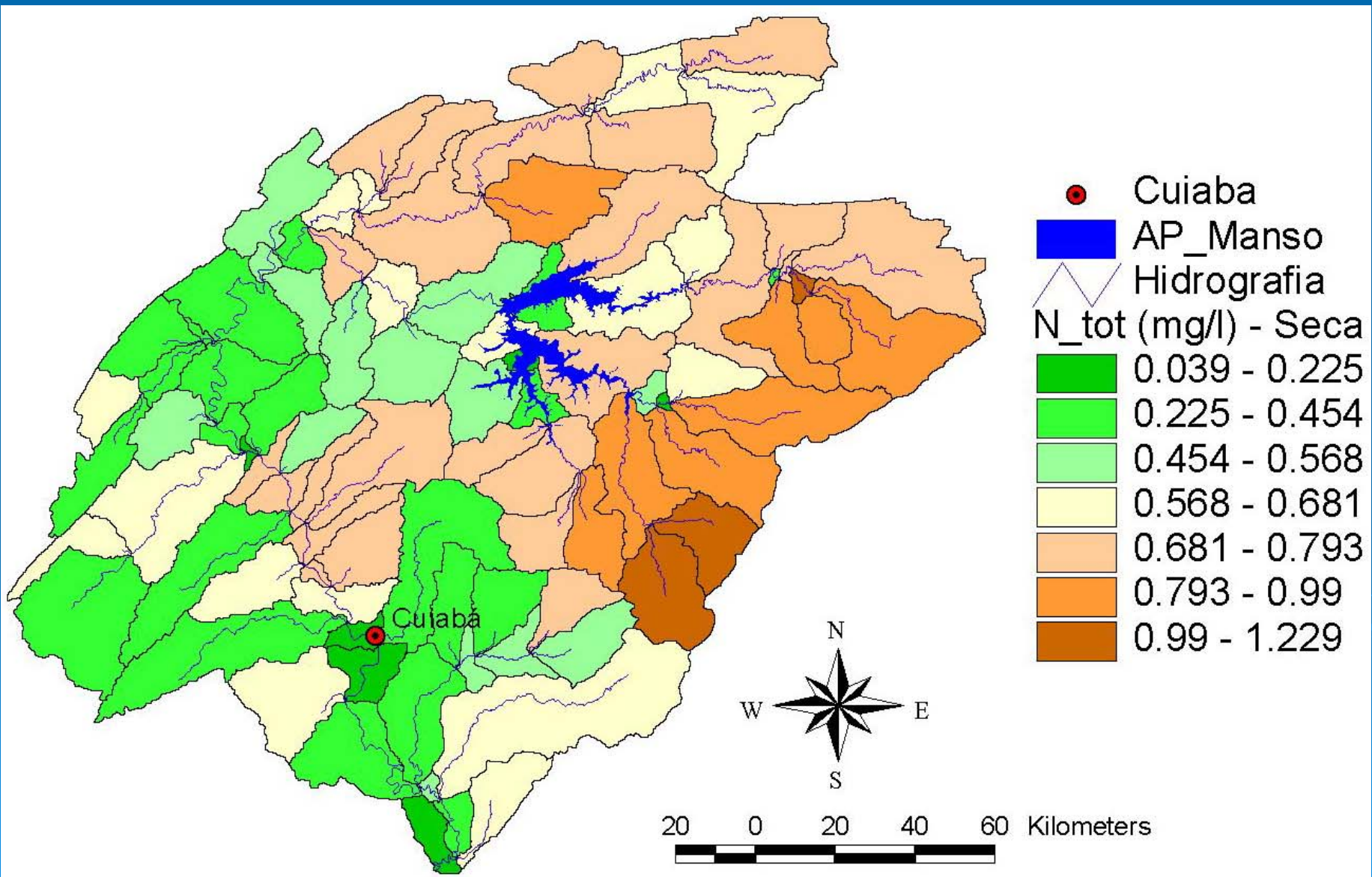
Water quality monitoring network in the watershed and landuse in the basin.... See in the GIS

The data problem

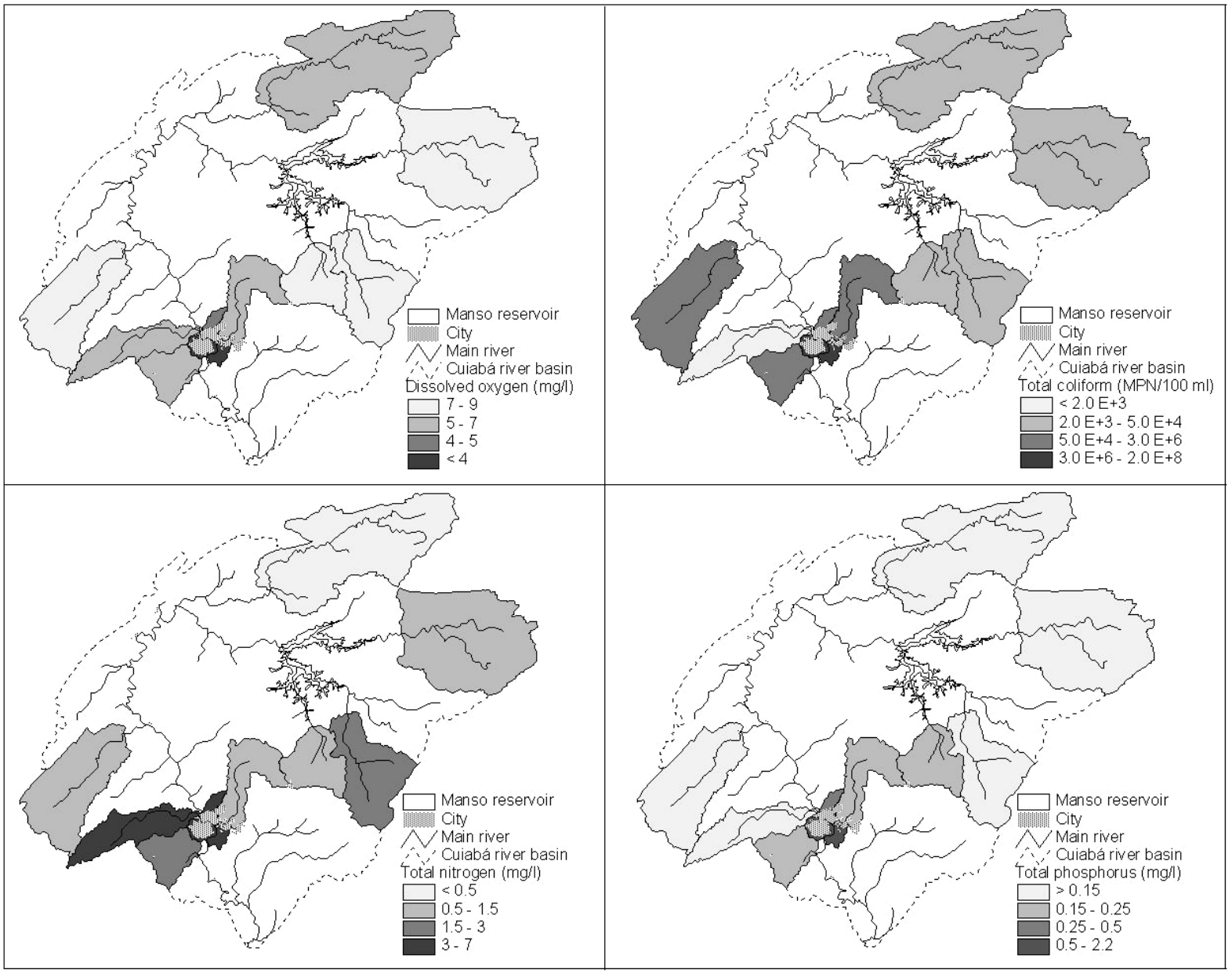



SSA - Singular Spectrum Analysis - CatMV
An approach of filling in the missing data applied to time series of finite rank is called (CatMV) is based on Carterpillar algorithm
Application
Improve Information by better sampling frequency
cost-effectiveness in long term monitoring
Choice of eigenvectors
Window Length (1< WL < N)
Filling Missing Data
The result of the "Caterpillar"- SSA algorithms is the decomposition of the observed time series into additive components such as a trend, periodic components and noise. The algorithm for time series with no missing data consists of two stages
First-Step - Embedding
The embedding procedure transforms the initial time series into the sequence of WL-dimensional lagged vectors. Matrix X is formed of the complete and incomplete lagged vectors
$S = X \bullet X'$
Second-Step - Finding the basis
by means of corresponding eigenvalues and eigenvectors of the matrix S where the Matrix X is formed of the complete and incomplete lagged vectors
First-Stage Decomposition
decomposition of the observed time series into additive components such as a slowly varying trend, periodic components and noise
Second Stage Reconstruction
Grouping
Identification choosing of SVD components
Choosing the subspace and projection of the complete lagged vectors
One of the attributes of the eigenvectors to be chosen is the resemblance of their form to the form of the Original serie
Projection of the incomplete lagged vectors
The result of the steps 3a and 3b is the matrix X which serves as an approximation to the trajectory matrix of the original series, under the proper choice of the set eigenvector.
Diagonal Averaging
At the last step of the algorithm, matrix X is transformed into the new series (so called the reconstructed time series) by means of the "diagonal averaging" procedure.
SVD - Singular Value Decomposition
Toeplitz Matrix
Only for long stationary time series
Methods
Projection Method
Principal Components
Only for long stationary time series
Methods
$0 < r < L$
which is called a threshold of missing components from the lagged vectors, which contain not more than a threshold of missing components

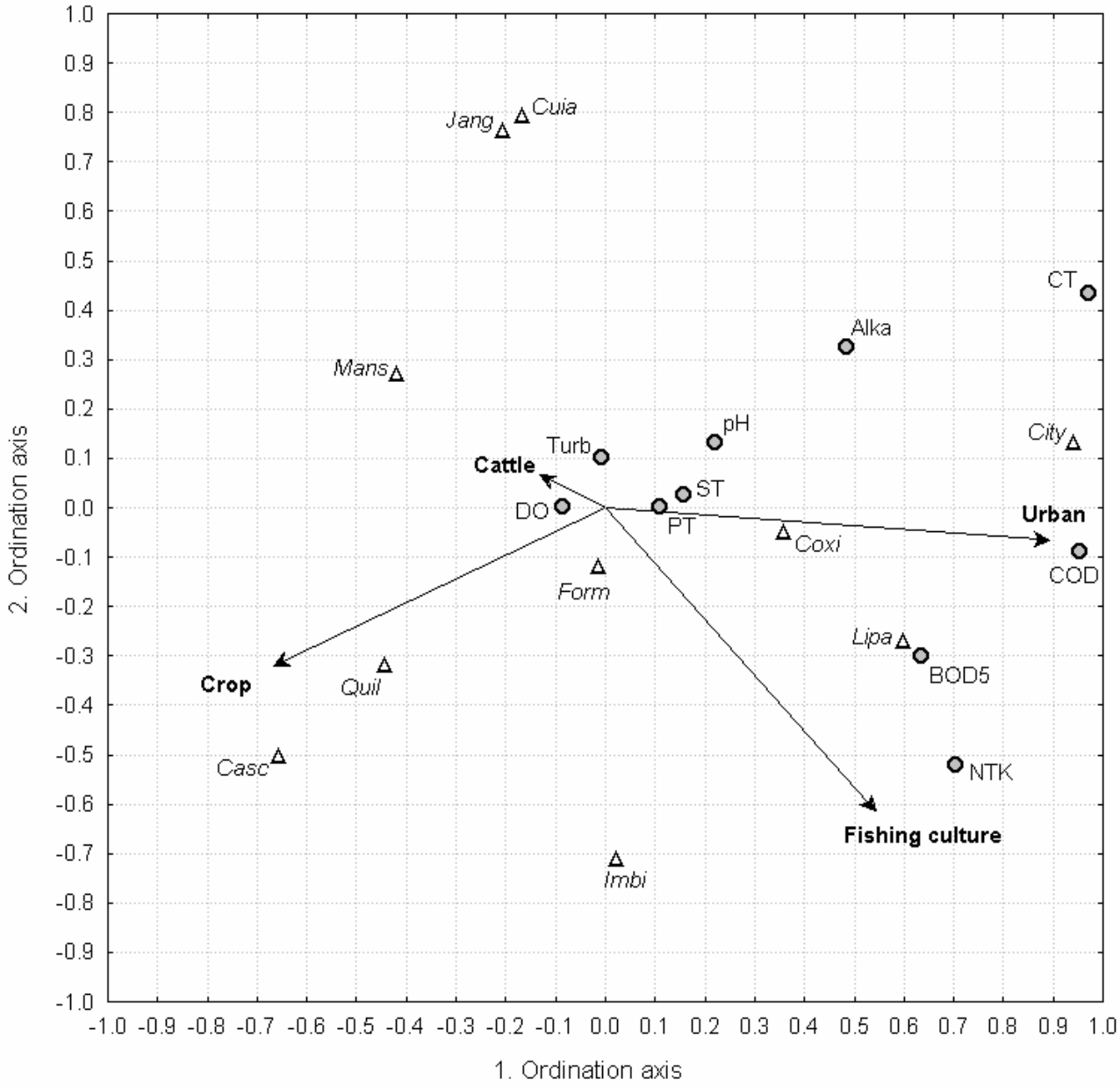
A very simplistic simulation of Total Nitrogen EMC (Pload)



Spatial patterns of water quality in the sub-watersheds of the Cuiabá river



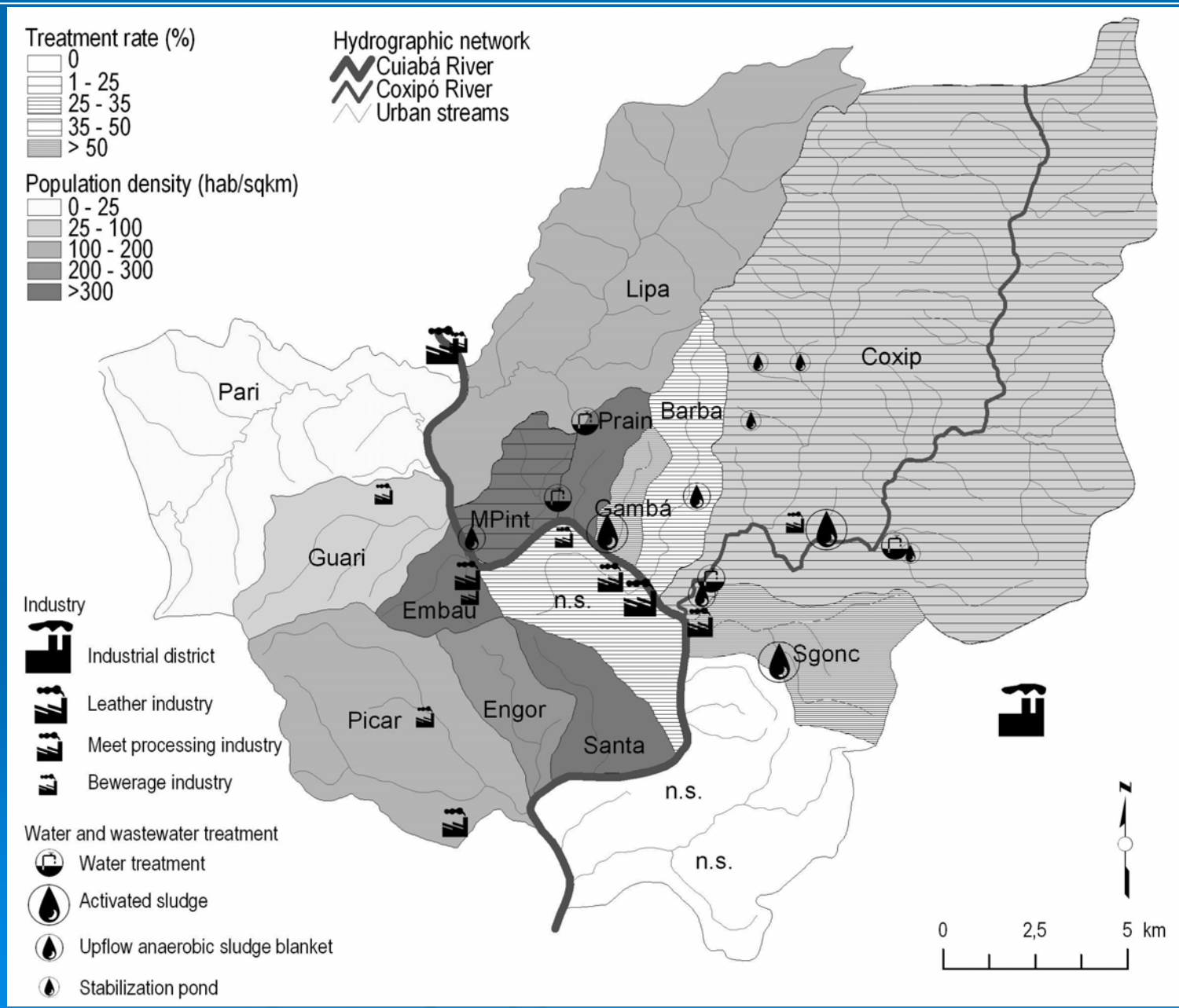
Exploratory analysis of land use – water quality relationships



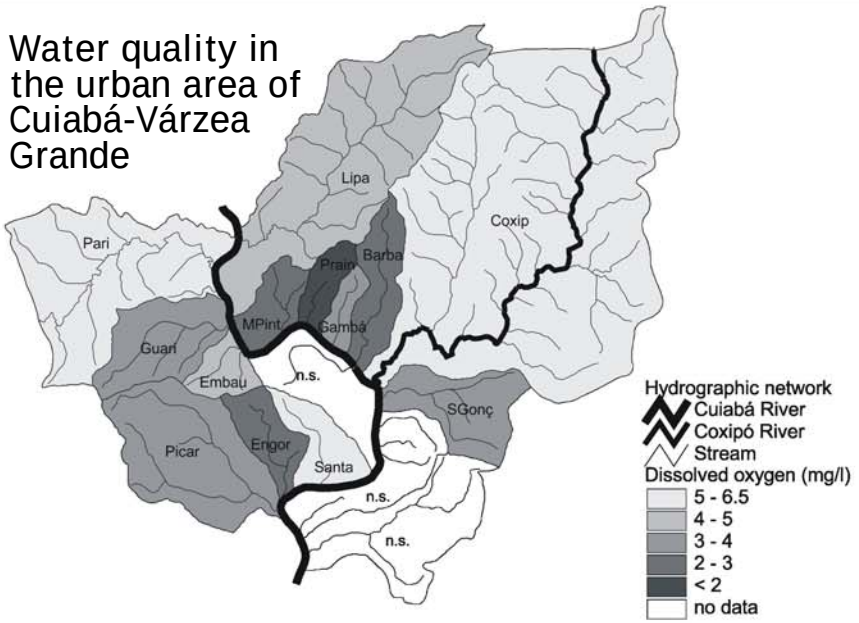
Parameter*	Sampling station C3.1 (n=37)	C3.2 (n=48)	C4 (n=33)	C5 (n=137)	C6 (n=68)	C7 (n=53)	C8 (n=64)	C9 (n=97)	C11 (n=93)	C12 (n=109)	C14 (n=29)
Bio. Oxy. Dem. (BOD5)	**1.50 ±0.56**	**1.79 ±1.17**	**1.21 ±0.79**	**1.43 ±1.00**	**1.17 ±0.66**	**1.35 ±0.79**	**1.26 ±0.63**	**1.24 ±0.66**	**1.38 ±0.89**	**1.75 ±1.18**	**1.17 ±0.48**
Chem. Oxy. Dem. (COD)	**8.79 ±4.15**	**11.31 ±6.87**	**10.48 ±4.07**	**9.54 ±4.81**	**9.56 ±5.53**	**8.81 ±5.90**	**9.16 ±5.42**	**9.87 ±6.42**	**9.46 ±5.49**	**11.50 ±6.38**	**11.93 ±5.25**
Coliform: fecal (CF)	**610 ±858**	**938 ±2543**	**130 ±125**	**3306 ±12547**	**1590 ±2763**	**5157 ±13421**	**6844 ±13460**	**23952 ±38463**	**19491 ±26609**	**22756 ±36830**	**162 ±119**
Coliform: total (CT)	**11158 ±30333**	**25578 ±65468**	**15138 ±49839**	**7398 ±24126**	**4954 ±14282**	**8907 ±22842**	**11738 ±16947**	**36570 ±53470**	**37582 ±41324**	**38687 ±46757**	**18365 ±59673**
Conductivity	**93.19 ±57.75**	**80.54 ±37.60**	**80.21 ±22.08**	**78.29 ±29.10**	**76.56 ±24.14**	**79.18 ±26.84**	**79.91 ±27.78**	**79.57 ±26.18**	**77.63 ±25.46**	**85.27 ±34.17**	**72.97 ±13.12**
Dissolved Oxygen (DO)	**7.26 ±0.83**	**6.92 ±0.86**	**7.08 ±0.93**	**7.27 ±0.81**	**6.99 ±0.67**	**6.86 ±0.69**	**6.83 ±0.74**	**6.89 ±0.68**	**6.68 ±0.68**	**6.51 ±0.82**	**6.64 ±1.03**
Nitrogen: total Kjedahl (NTK)	**0.38 ±0.31**	**0.43 ±0.37**	**0.32 ±0.15**	**0.36 ±0.27**	**0.35 ±0.32**	**0.40 ±0.39**	**0.39 ±0.24**	**0.40 ±0.28**	**0.38 ±0.36**	**0.47 ±0.30**	**0.37 ±0.14**
pH[2]	**7.06 ±1.67**	**7.53 ±0.82**	**7.55 ±0.94**	**7.66 ±0.45**	**7.64 ±0.39**	**7.63 ±0.42**	**7.62 ±0.39**	**7.62 ±0.40**	**7.51 ±0.38**	**7.47 ±0.39**	**7.20 ±1.03**
Phosphorous: total [2] (PT)	**0.12 ±0.08**	**0.12 ±0.17**	**0.13 ±0.08**	**0.08 ±0.07**	**0.08 ±0.07**	**0.07 ±0.06**	**0.07 ±0.05**	**0.10 ±0.09**	**0.11 ±0.09**	**0.13 ±0.13**	**0.15 ±0.11**
Solids: total[2] (ST)	**131.67 ±108.3**	**120.81 ±75.33**	**130.52 ±159.3**	**131.84 ±64.35**	**144.70 ±69.92**	**143.90 ±65.50**	**133.69 ±70.77**	**145.21 ±77.56**	**146.38 ±72.43**	**132.45 ±67.23**	**108.91 ±39.18**
Turbidity[2] (Turb)	**32.01 ±36.89**	**29.16 ±45.39**	**20.77 ±23.32**	**30.22 ±31.92**	**35.42 ±39.90**	**34.62 ±44.20**	**33.03 ±37.59**	**32.32 ±34.63**	**32.01 ±34.21**	**34.75 ±33.06**	**18.54 ±11.85**

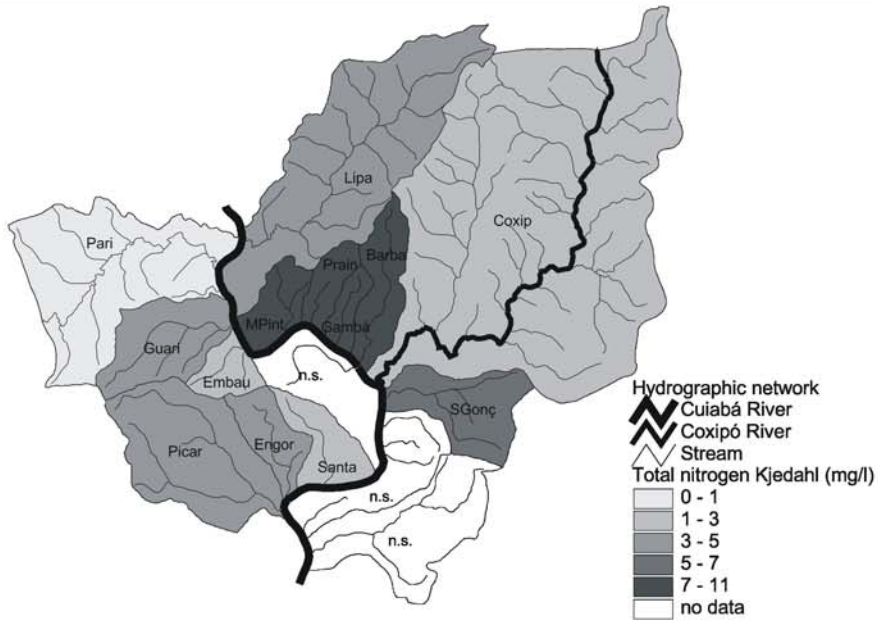
Land use and water resources in the Cuiabá River Basin

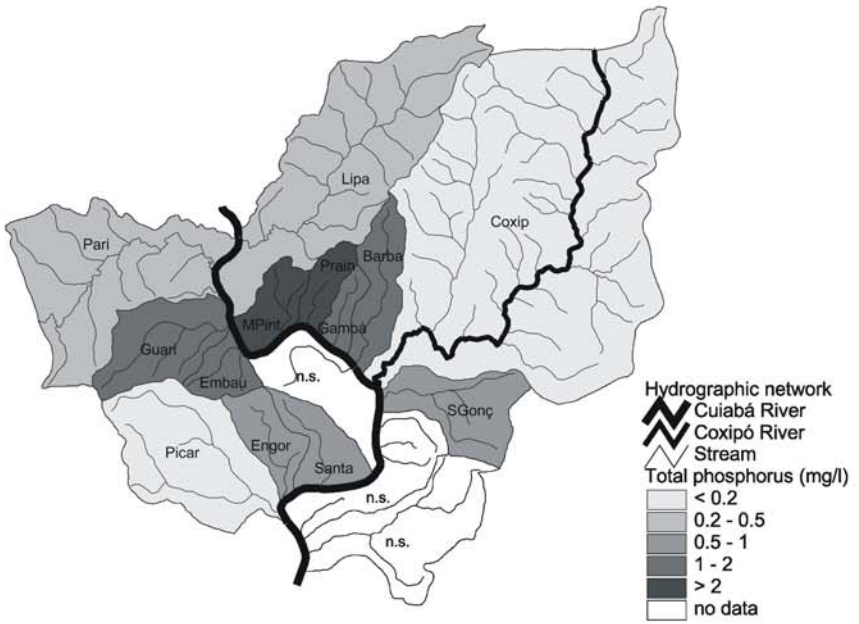
Population densities, infrastructure and industry in the urban area of Cuiabá-Várzea Grande

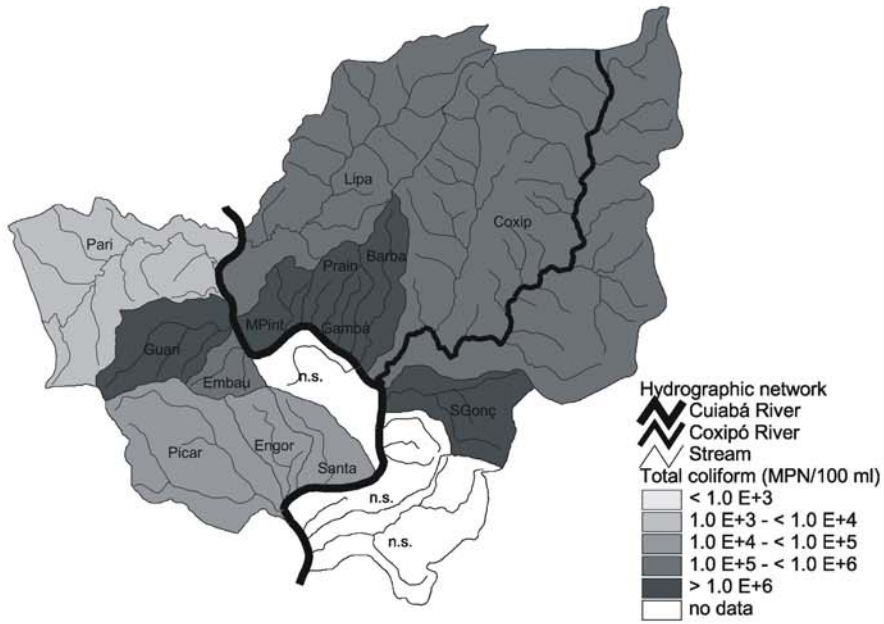


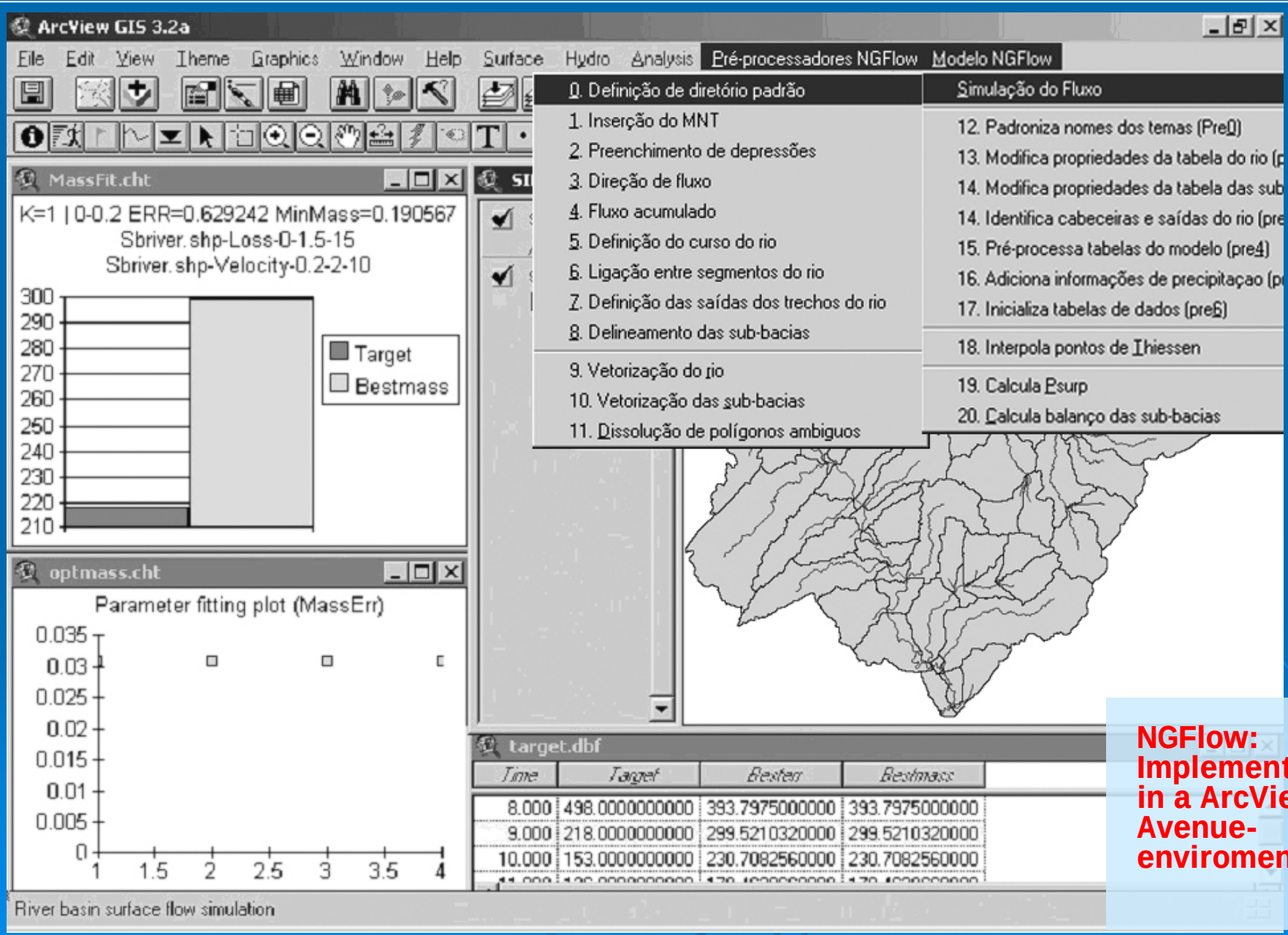
Water quality in the urban area of Cuiabá-Várzea Grande





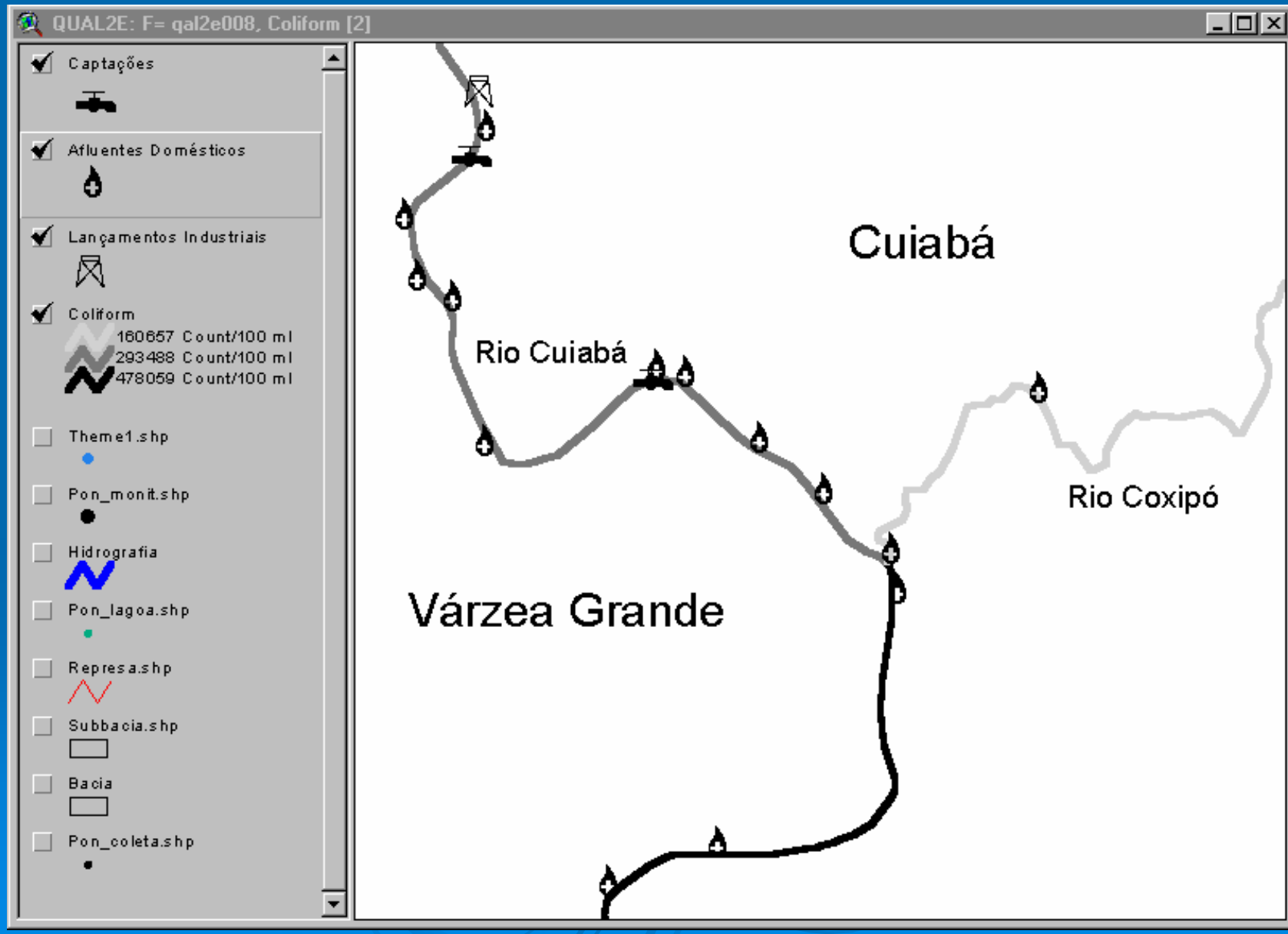


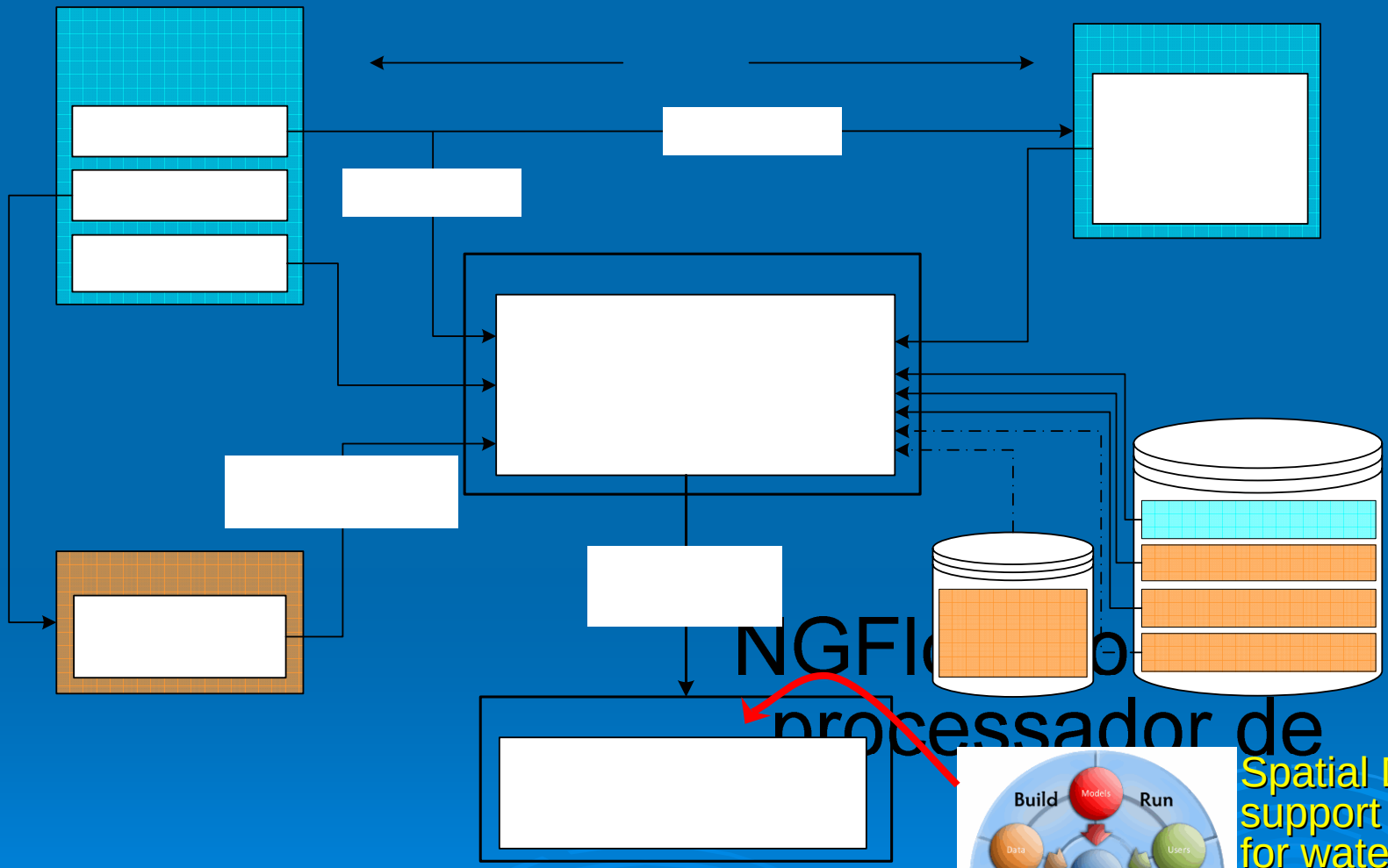




NGFlow: Implementation in a ArcView-Avenue-enviroment

Integration of QUAL2E in the GIS environment of the SIBAC system





Spatial Decision support system for water resource allocation (Outorga)


Thank you very much for your attention!