POST-FIRE IMPACT ON THE WATER QUALITY OF A RESERVOIR: an integrated watershed-reservoir approach.

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Impacts on the water quality

PRIMARY IMPACTS:

Lost of vegetation canopy, degradation of soil properties, lost of goods.

SECONDARY IMPACTS:

Water quality degradation and contamination, increasing episodes of flood and mudflows.

CONTAMINATED WATER NEWS AFTER 2017 FIRES IN PORTUGAL

SOCIEDADE

Chuvas contaminam águas de Ansião com cinzas dos incêndios

12 DEZ 2017 00:00

Durante esta terça-feira, "poderá haver períodos de falta de água".

12/12/2017: Rains contaminate Ansião waters with ash from fires

https://www.jornaldeleiria.pt/noticia/chuvas-contaminam-aguas-de-ansiao-com-cinzas-dos-incendios-7799

PAÍS

atualizado 12 Dezembro 2017, 08:22

Há água contaminada no concelho de Ansião

https://www.rtp.pt/noticias/pais/ha-agua-contaminada-no-concelho-de-ansiao_a1045797

12/12/2017: There is contaminated water in Ansião municipality

Enxurradas obrigam município de Ansião a interromper captação de água

PORTUGAL / 08 JUL 2017 / 17:45 H.

https://www.dnoticias.pt/pais/enxurradas-obrigam-municipio-de-ansiao-a-interromper-captacao-de-agua-BM1680322#

08/07/2017: Floods forces the municipality of Ansião to interrupt water intake

Objectives

- Combined use of a watershed and a reservoir model in a reference situation

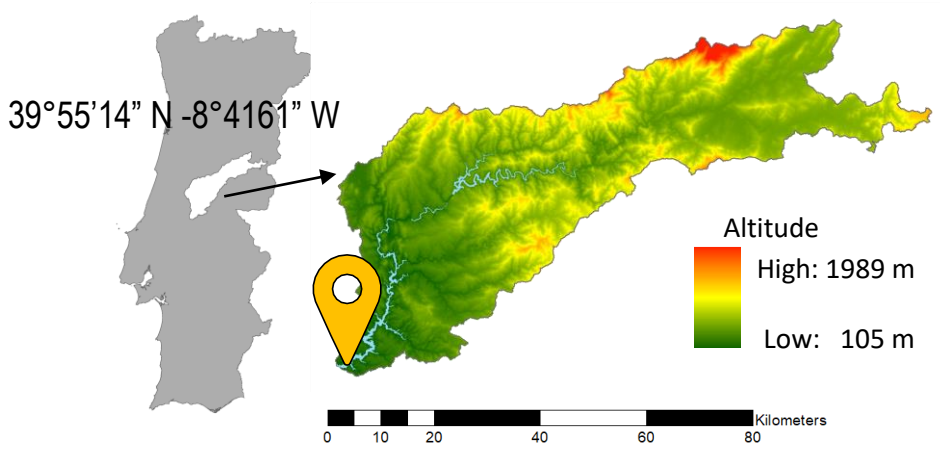
Can the output of the watershed model be used as inputs for the reservoir one?

- Create post-fire scenarios to study the impacts on the hydrological regime and on the water quality of the downstream waterbodies:
  - Effects studied at three different scale: sub-basin, entrance to the reservoir, and dam wall

Is the reservoir able to dissolved the high contamination measured at its entrance?

Study area

- Watershed: River Zêzere



- Bed length of 214 km
- Drainage area of ~ 3490 km²
- Main landuse: shrublands (27%), forests (21%), agriculture (17%)

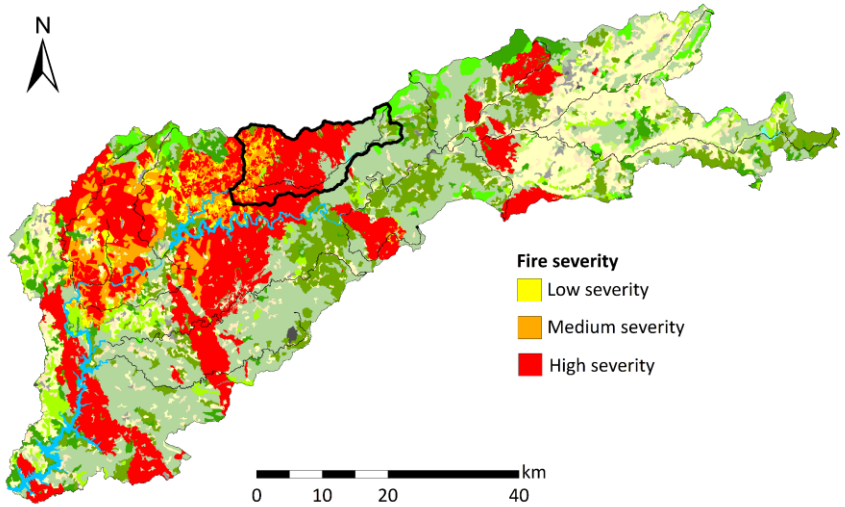
- Reservoir: Castelo de Bode

- Total capacity of 1095.0 hm³
- Useful capacity 902.5 hm³
- Flooded area of 3291 ha
- Used to supply Lisbon area

Study area

2017 fire season

- Several major fires events occurred in the watershed, burning 30% of its area.
- Two major events stood out, the Pedrogão Grande and Góis Fires, which burned more than 47 thousand hectares.



Integrated approach

WATERSHED MODEL

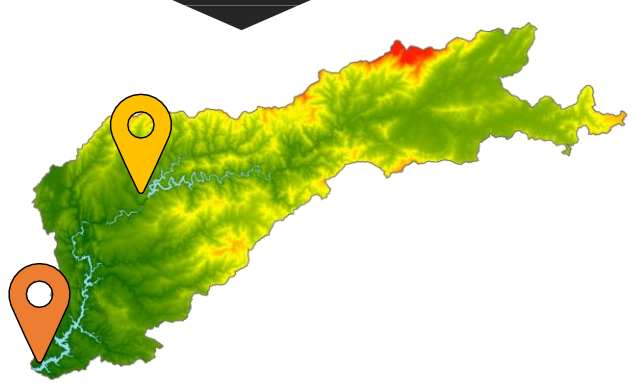
- Soil and Water Assessment Tool (SWAT), continuous in time, semi-distributed, and processes-based model.
- Divide the watershed in hydrological response units (HRUs).
- Description in: *Assessing the adequacy of SWAT model to simulate postfire effects on the watershed hydrological regime and water quality* - https://doi.org/10.1002/ldr.3476

RESERVOIR MODEL

- Two dimensional, longitudinal and vertical, hydrodynamic and water quality model (*Cole and Wells, 2008*).
- Waterbody divided into a variable spaced mesh (Δx,Δz), considering negligible lateral variation.

WATERSHED MODEL

Calibration and validation

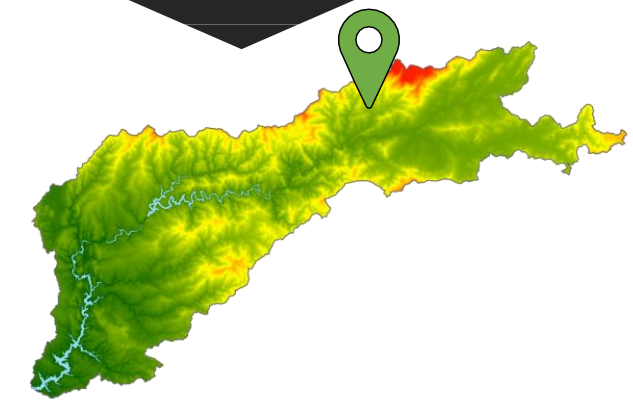


- **Flow**:
  - Calibration period 12 years,
  - Validation period 4 years.

	Station	Time-step	Period	Observed average ($m^3 s^{-1}$)	Predicted average ($m^3 s^{-1}$)	R^2 (-)	NSE (-)	PBIAS (%)
Flow C – calibration V – validation	Cabril	Daily	C	38.06	40.85	0.37	0.36	7.34
			V	44.62	46.76	0.46	0.46	4.77
		Monthly	C	38.33	41.02	0.79	0.77	6.99
			V	44.68	44.68	0.87	0.84	4.77
	Castelo de Bode	Daily	C	57.59	72.92	0.25	-0.67	22.4
			V	74.11	81.98	0.36	0.11	10.7
		Monthly	C	57.93	73.23	0.61	0.42	26.41
			V	74.12	82.18	0.79	0.79	10.87

WATERSHED MODEL

Calibration and validation



- **<u>Water quality</u>**:
  - Overall scarcity of data (100 values in 12 years period).

Water quality	Station	Time-step	Period	Observed average ($m^3 s^{-1}$)	Predicted average ($m^3 s^{-1}$)	R^2 (-)	NSE (-)	PBIAS (%)
Nitrate (NO_3-N)	Ponte Pedrinha	Daily	-	2.53	2.70	0.91	-	-
Phosphate (P_2O_5)		Daily	-	0.116	0.115	0.96	-	-
Tot P (P)		Daily	-	0.137	0.183	0.95	-	-
Cohesive sediments		Daily	-	58.10	89.52	0.49	-	-

WATERSHED MODEL

Post-fire scenario

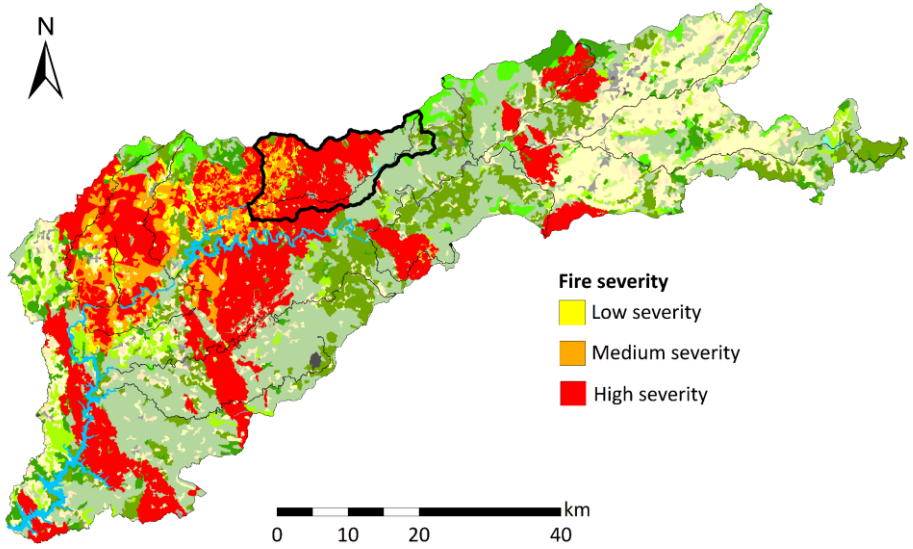


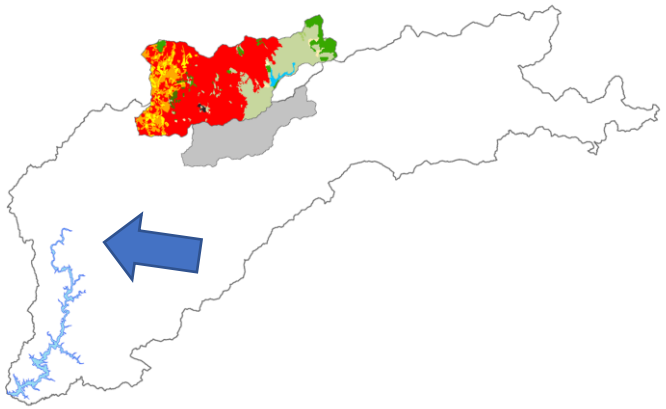
Table – *Assessment of the impacts of forest fires on soil erosion and water quality*

	FIRE SEVERITY		
	Low	Medium	High
Curve number (*Higginson & Jarnecke, 2007*)	+5	+10	+15
C factor (*Fernández et al., 2010*)	0.01	0.05	0.1
K factor (*Fernández et al., 2010*)	0.014	0.015	0.016

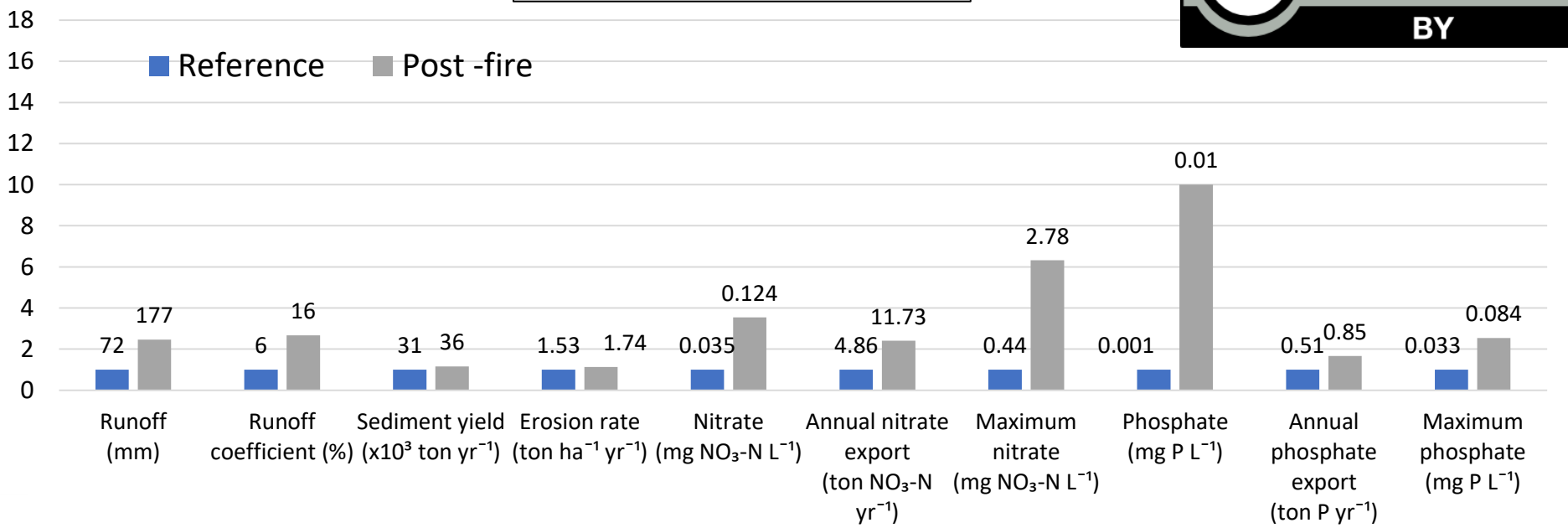
- New land-use and soil type for each level of severity.
- New SWAT simulation with new HRUs

WATERSHED MODEL

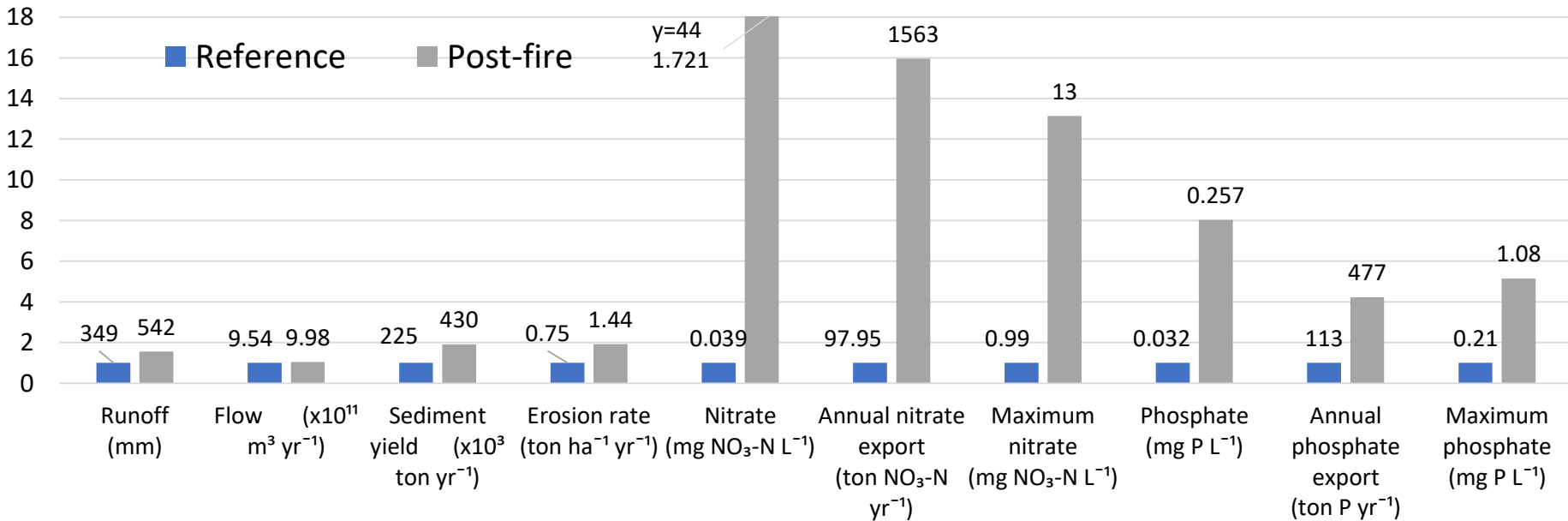
Post-fire scenario



Sub-basin post-fire impacts



Entrance to the reservoir post-fire impacts

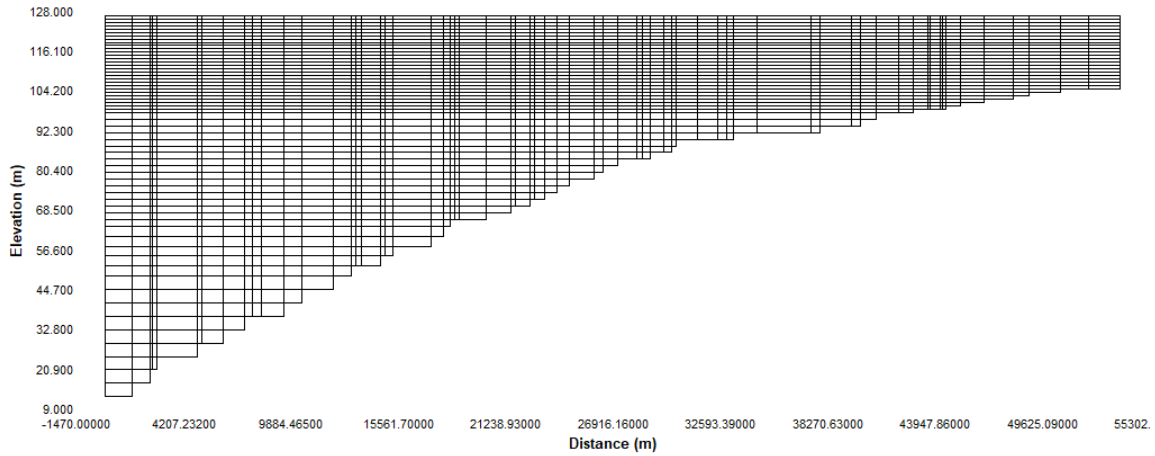


RESERVOIR MODEL

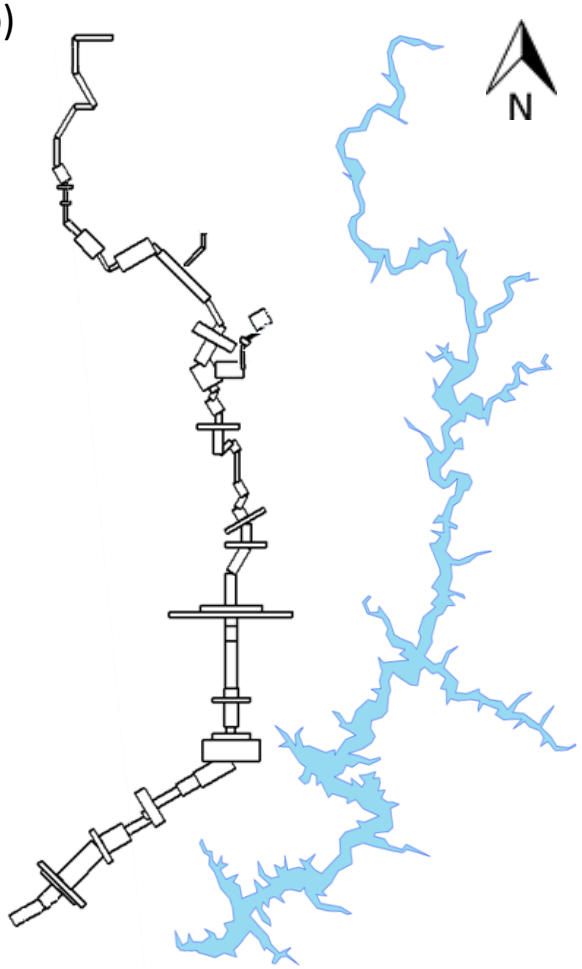
Representation

Figure - Castelo de Bode a) longitudinal profile, b) plan view, c) bathymetry validation.

a)



b)



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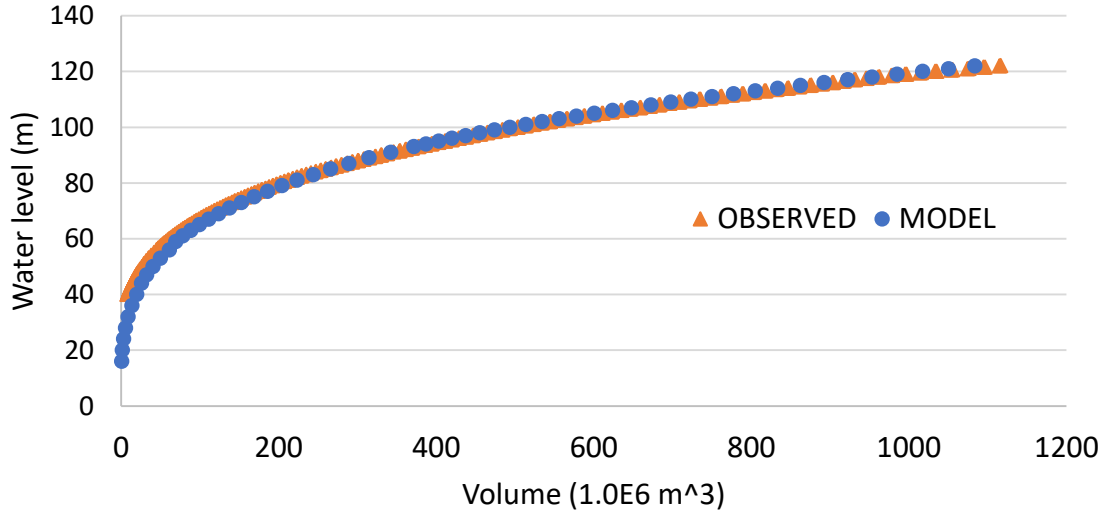


Reservoir representation:

- 77 longitudinal sections
- Segment length [106-2890 m]
- Segment width [50-5250 m]
- Layer thickness:
  - 1 m for the first 30 m;
  - 2 m for the next 34 m;
  - 3 m for deepest layers.

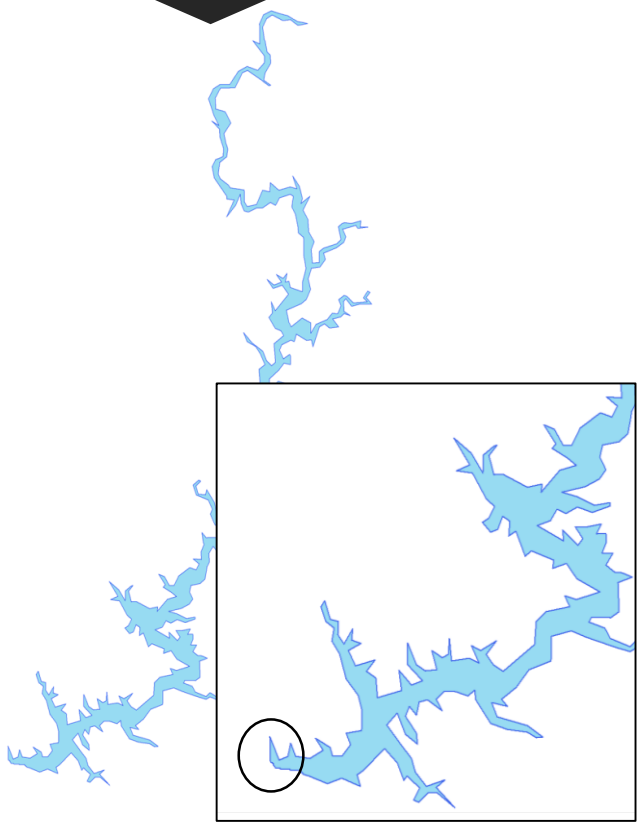
RESERVOIR MODEL

Implementation

Watershed model

Direct data:
flow, phosphate, ammonia, nitrate, nitrite, dissolved oxygen, and TSS;
Indirect data:
algae and organic matter.

Reservoir model



Validation and calibration

- Superficial layer close to the dam wall
- 11 years period of simulation with three years of warm-up:

  Water level:

  - Calibration (1989-1996), validation (1996-2000)

  Water quality parameters:

  - Observed data (17-87) (*SNIRH*) – **scarcity of data**
  - Calibration (1989-2000)

RESERVOIR MODEL

Calibration and validation

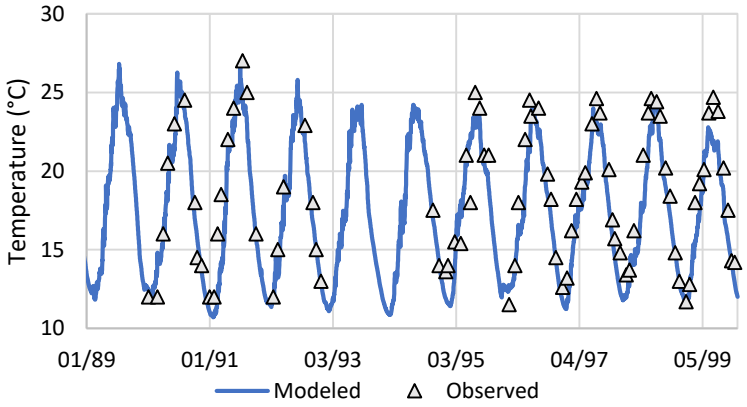
Water level

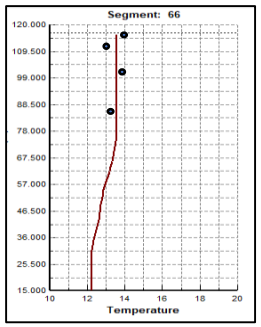
		Calibration	Validation
Average	Observed	111.79	117.28
	Modeled	111.75	117.47
R		0.99	0.99
NSE		0.99	0.98
PBIAS*		0.0003	0.0017

* Absolute values

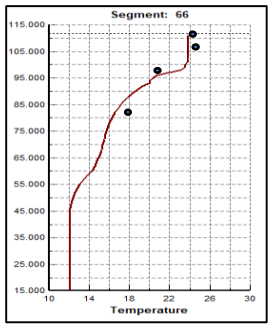
Temperature

N		87
Average	Observed	18.31
	Modeled	17.15
Standard deviation	Observed	4.36
	Modeled	3.98
Median	Observed	18.00
	Modeled	16.85
R		0.926
PBIAS*		6.30
Percentile 75%	Observed	22.68
	Modeled	21.27





Winter – 11/12/1990



Summer – 28/8/1990

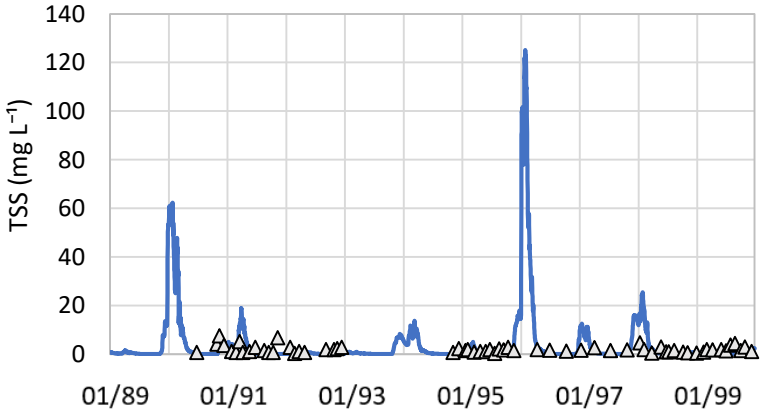
RESERVOIR MODEL

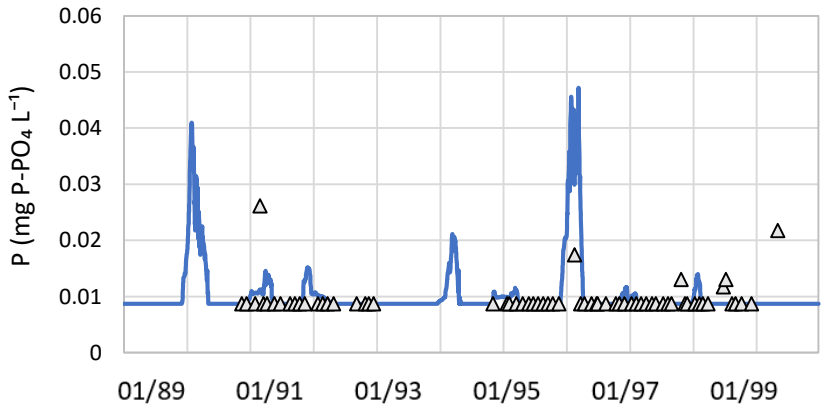
Calibration and validation

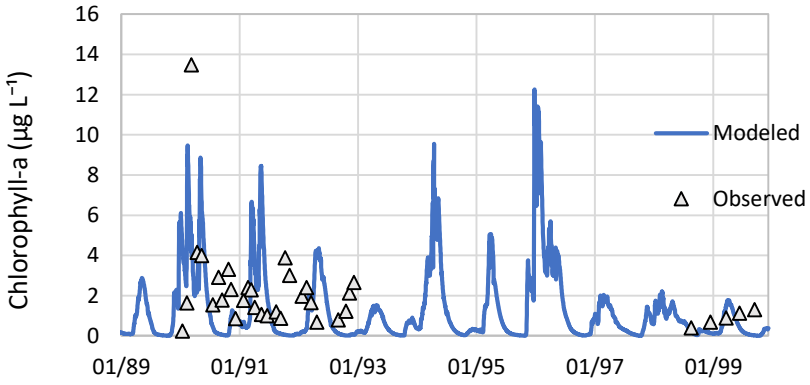
Water quality parameters

	N	Average		Standard deviation		Median		r	PBIAS *	Percentile 75%	
		Mod.	Obs.	Mod.	Obs.	Mod.	Obs.			Mod.	Obs.
TSS (mg L^{-1})	62	1.98	1.73	1.44	3.77	1.65	0.25	0.19	13.09	2.48	1.23
Chlorophyll-a (µg L^{-1})	34	2.14	1.59	2.22	2.25	1.64	0.44	0.22	-25.46	2.46	2.09
DO (mg L^{-1})	17	7.52	8.17	1.32	1.10	7.50	7.96	0.17	-8.70	8.30	9.19
Phosphate (mgP L^{-1})	63	0.009	0.009	0.003	0.004	0.008	0.008	0.28	-3.48	0.008	0.009
Nitrate/nitrate (mgN L^{-1})	70	0.49	0.39	0.29	0.13	0.43	0.38	0.26	20.28	0.59	0.47

* Absolute values



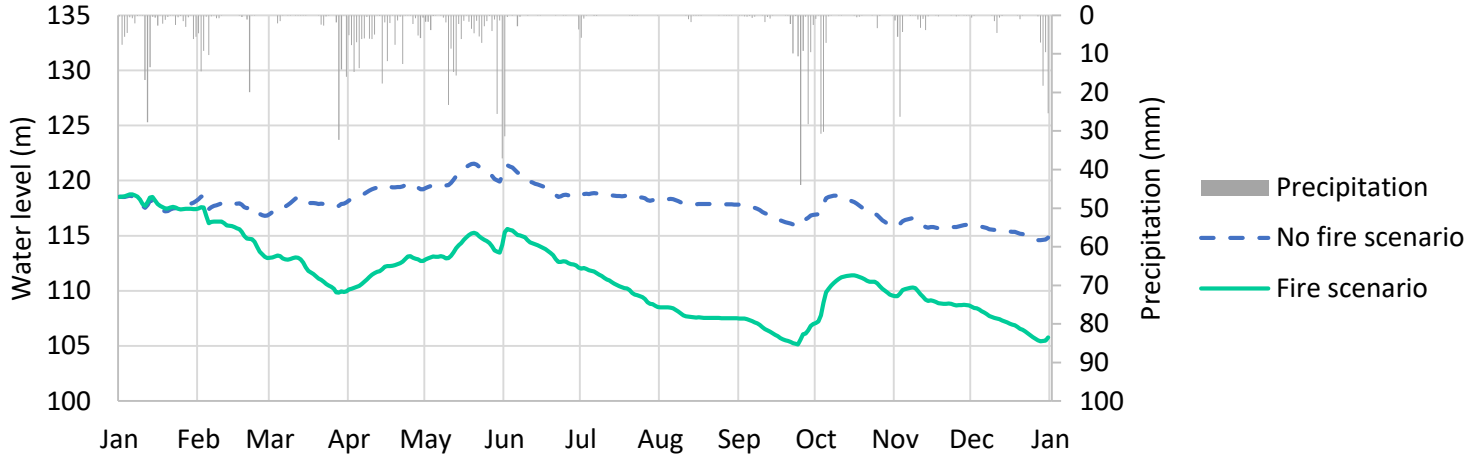




RESERVOIR MODEL

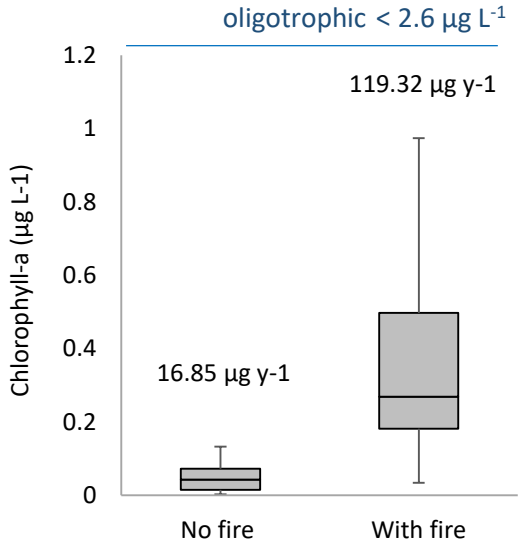
Post-fire scenario

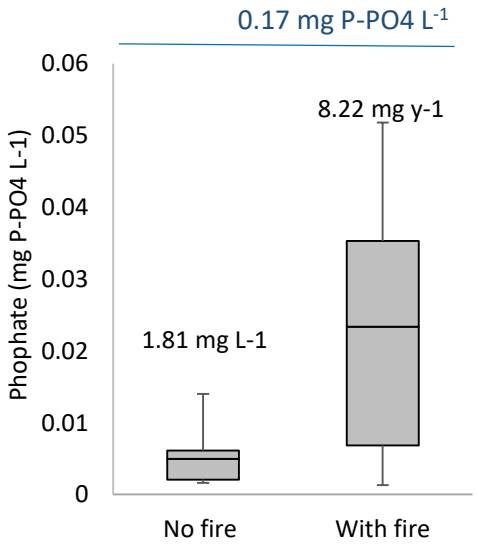
Water level

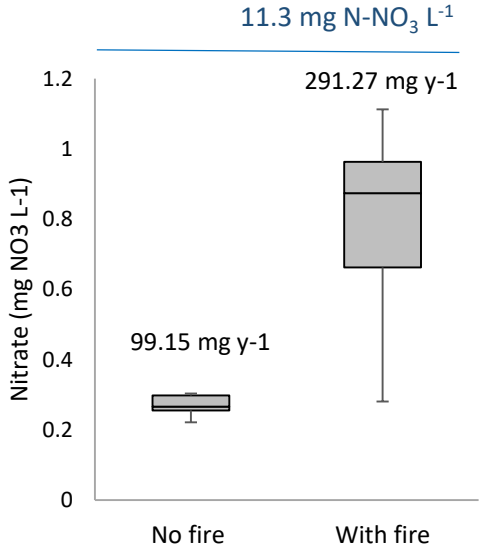


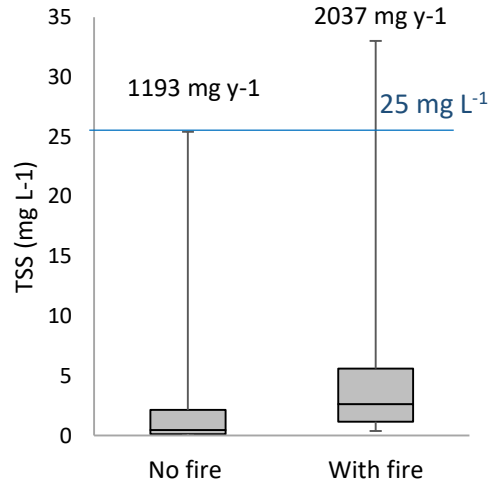
Water quality parameters

Water quality threshold for human consumption (Decreto-Lei n.o 236/98, 1998)

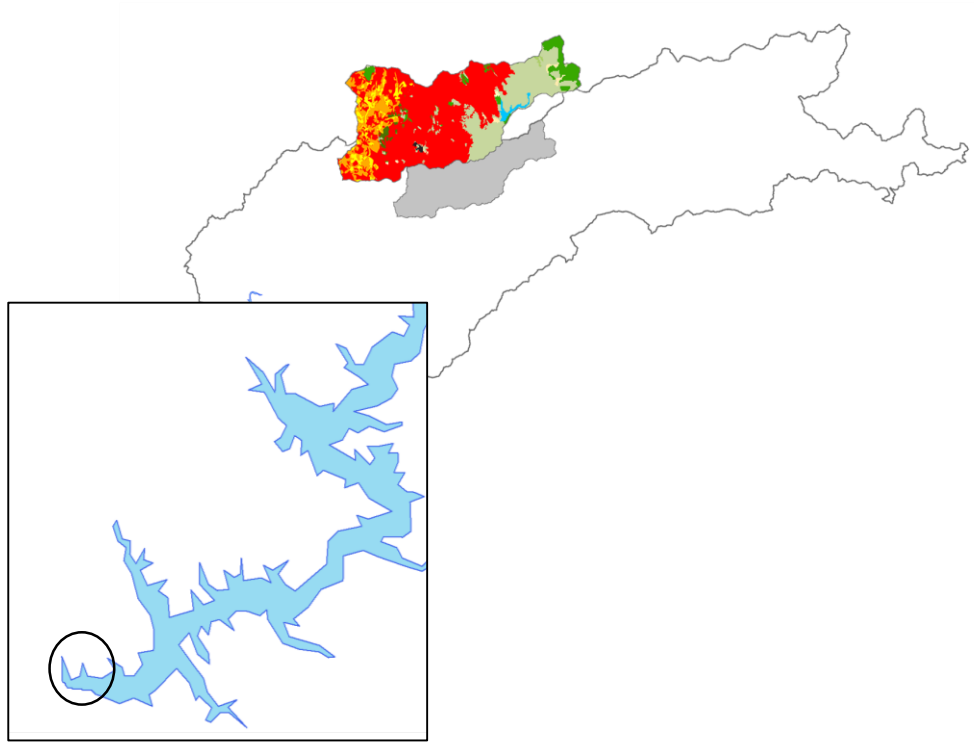








Conclusions



- Satisfactory coupled use of SWAT and CE-QUAL-W2 models
- High water deterioration at the entrance of the reservoir
- Castelo de Bode reservoir able to dilute the high concentration of nutrients
- 2017 fires do not affect the water quality at the dam wall if we consider water used for human consumption

Difficulties:

- Lack of observed data
- Model instability

Future work:

- Benefit of observed data
- Climate change scenarios

Acknowledgments

EGU General Assembly 2020

Thank you for the attention.

FCT
Fundação para a Ciência e a Tecnologia
MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

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