DG Environment

Preparatory action on development of prevention activities to halt desertification in Europe

ABOT

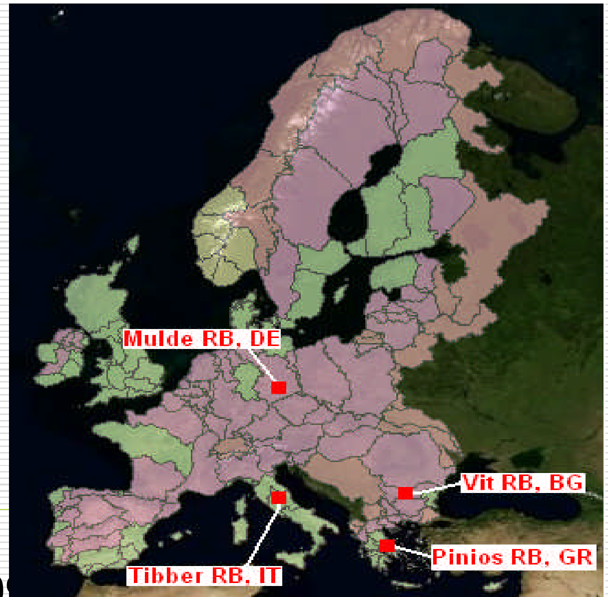
Assessment of water Balances and Optimisation based Target setting across EU River Basins

Coordination meeting of Desertification projects, Brussels, 09/12/2012

Project Objectives

- **Overall aim:** support the EC's effort to identify means and develop prevention activities to halt desertification in Europe, by focusing on complementing EU water resources balances elaborated in the framework of SEEAW and supplementing ongoing projects which tackle water scarcity, droughts and desertification

- **4 Pilot River Basins**: Tiber, Mulde, Pinios, Vit



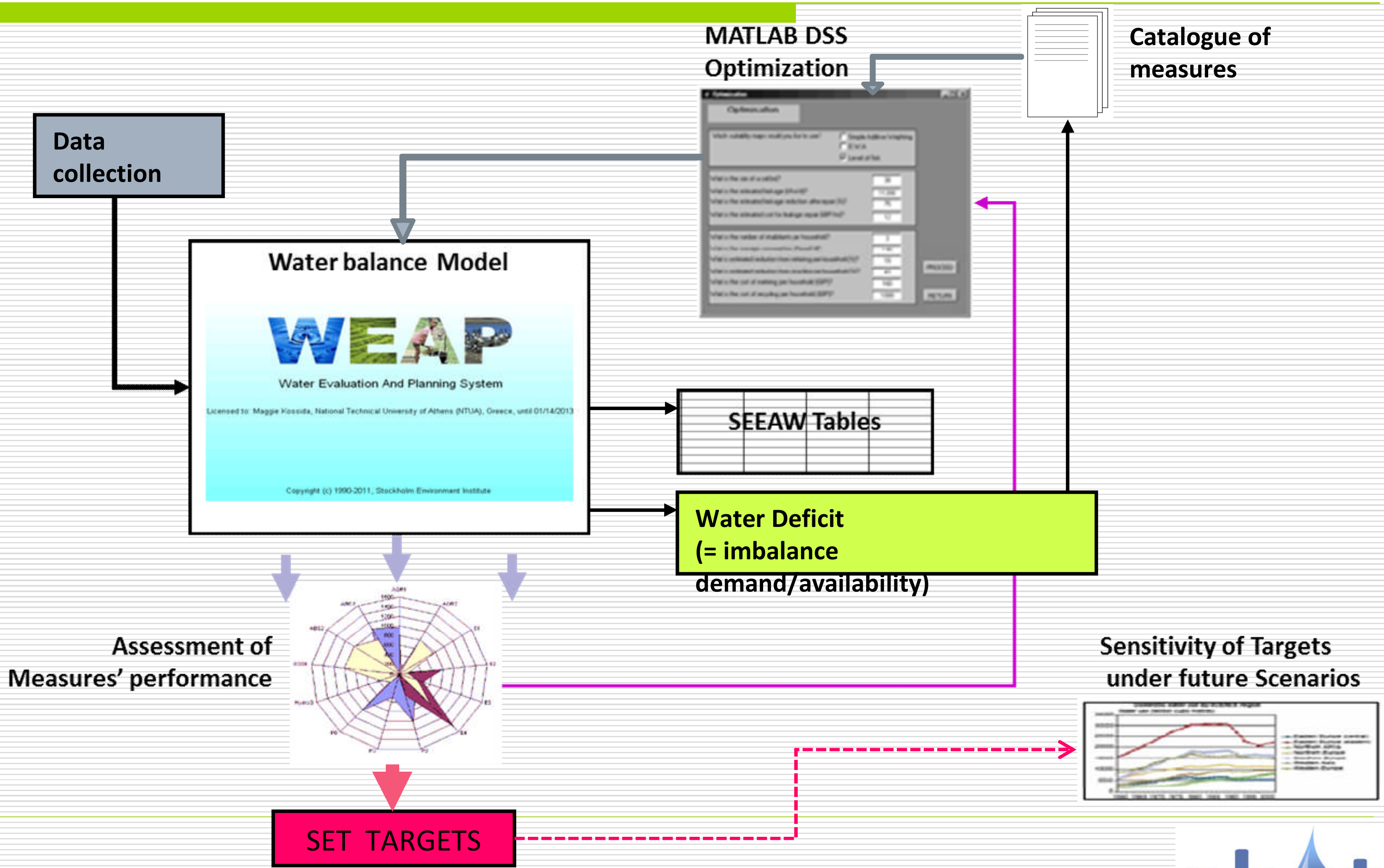
Project Specific Objectives for the pilot RBs

- Collect, process and analyse the necessary **datasets** that are indispensable for the development of the SEEAW and **feed them in the SEEAW-ECRINS**
- **Develop detailed water resources balances** based on the method applied by the SEEAW and using an analytical physical based model to accurately capture the interactions of the different components of the water cycle
- **Identify** management, technological and economic **measures** allowing the setting up of optimal water management involving local stakeholders and water managers.
- **Develop a library of “wish” measures** that can improve the water balance and alleviate the possible deficit between availability and demand (i.e. increase supply, reduce demand), and **test/simulate their impact and effectiveness against specific criteria**, (e.g. water use reduction per economic activity, cost, environmental and socio-economic benefits)

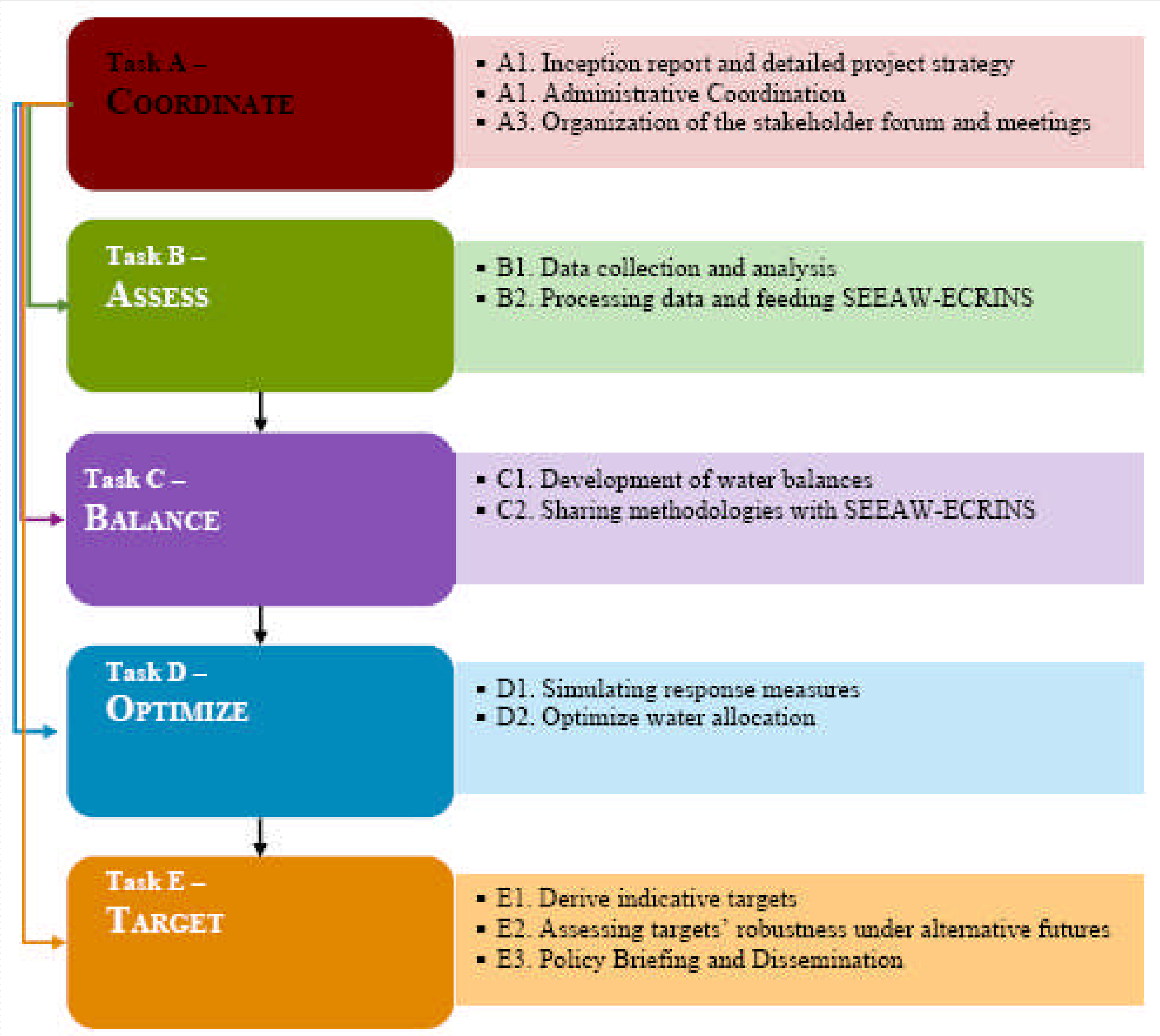
Project Specific Objectives for the pilot RBs

- **Build optimisation algorithms** in order to estimate possibilities for optimization of **water allocation** to meet demand, as well as the **water saving potential** associated to the different measures under specific context
- **Run an optimisation** process under specific criteria and constraints to select the optimum measures against a specific objective function.
- **Derive sector specific targets** regarding water efficiency, water-reuse, ecosystem services, land-use and climate change adaptation which will allow the preservation and/or restoration of the natural water balance. Cross-compare these outputs with the purpose of **proposing targets according to different typology of RBs**.
- **Run a sensitivity analysis for these proposed targets for 3 alternative futures** (climate and socio-economic) in order to evaluate their robustness.
- Share and **disseminate** results and involve local stakeholders in the process.
- Post process the results to provide **input to the Blueprint** and 2012 WS&D Policy Review.

Schematical layout of the project idea



Overview of the tasks/workflow



Task A: management and methodology development task √

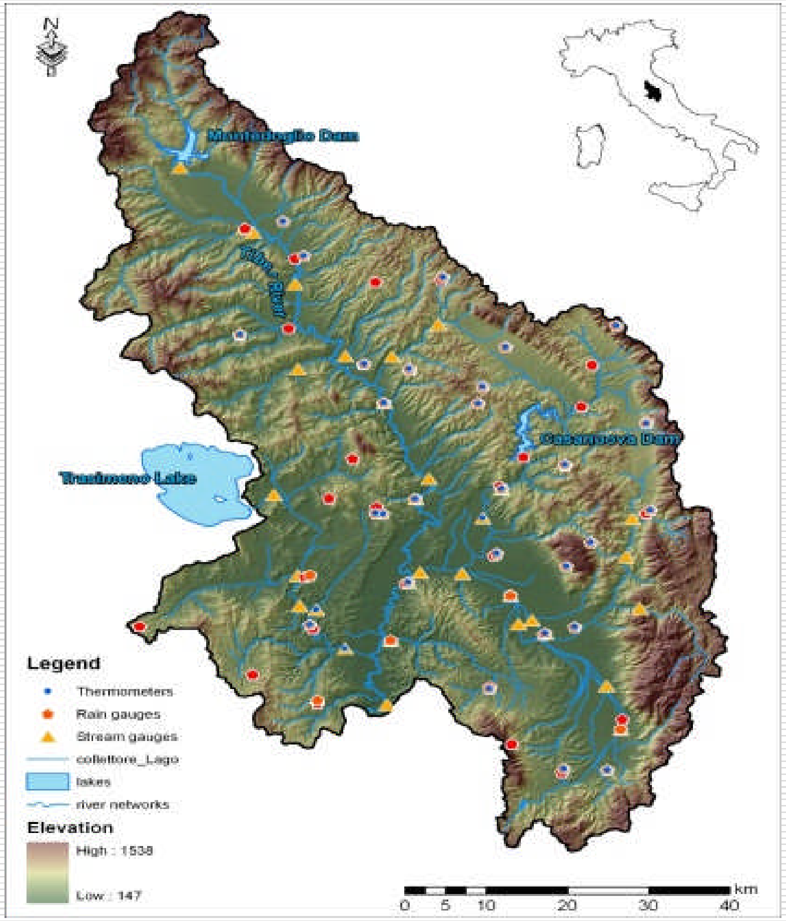
Tasks B: data collection and analysis task √

Tasks C and D: modelling tasks
In progress

Task E: policy related and dissemination task

Water Balance Models of 4 Pilot RBs using WEAP

1. Tiber RB, Italy

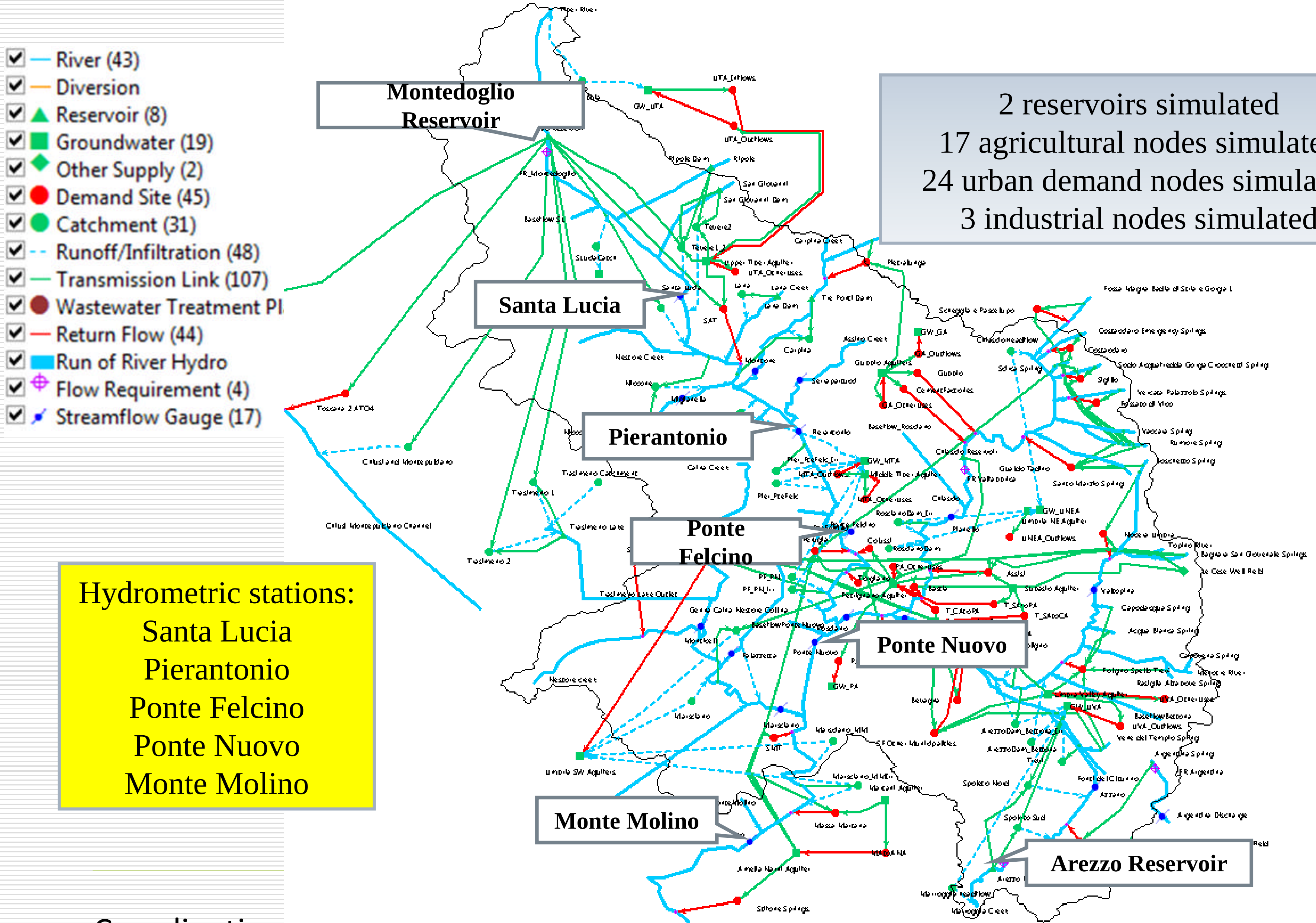


Drought conditions (2002, 2008)

Impact on springs, lakes, groundwater

Drinking, irrigation, tourism water uses

Area studied for calibration\validation
‘Current Accounts’ year: 2008; Project period: 2008-2011



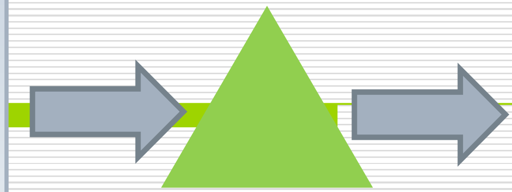
2 reservoirs simulated
17 agricultural nodes simulated
24 urban demand nodes simulated
3 industrial nodes simulated

Hydrometric stations:
Santa Lucia
Pierantonio
Ponte Felcino
Ponte Nuovo
Monte Molino

INPUT

- Total capacity of reservoir
- Volume-elevation curve
- Maximum hydraulic outflow
- Net evaporation (Linacre approach)
- Initial storage volume
- Observed storage volume
- Maximum volume of water in reservoir
- Volume not available for allocation

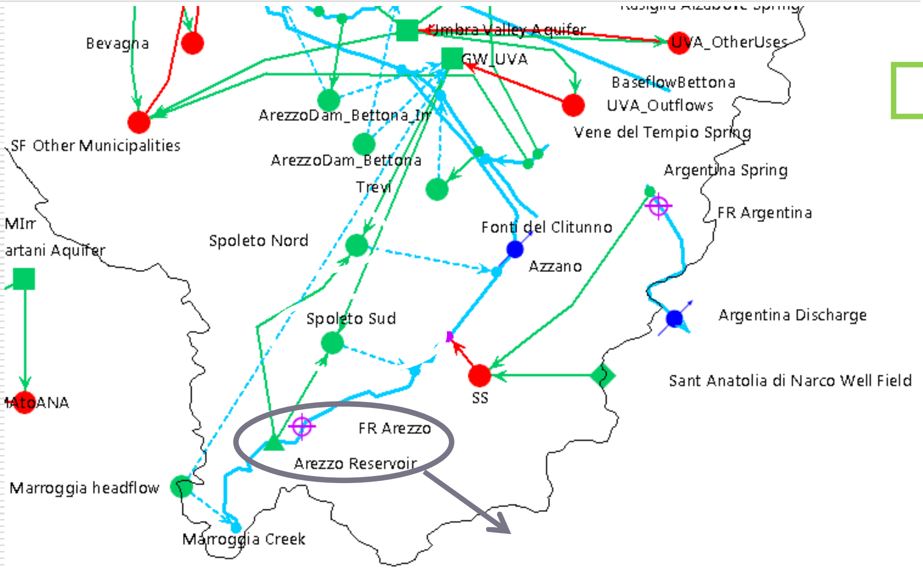
RESERVOIR

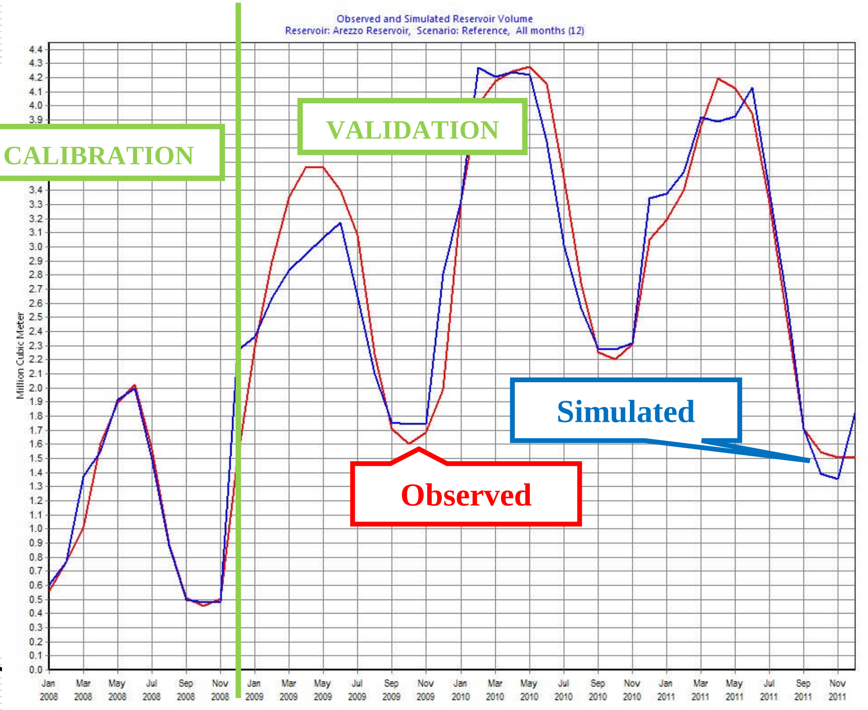


OUTPUT

Reservoir storage volume

‘Arezzo’ reservoir: comparison between observed and simulated storage volumes





Agricultural nodes

17 agricultural nodes simulated as catchments with Rainfall Runoff (FAO) method

INPUT

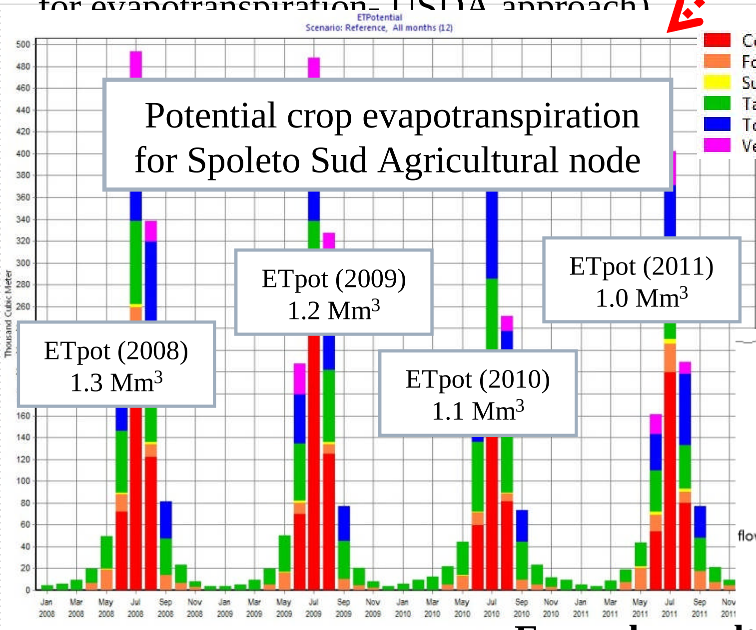
- •P (2008-2009) (precipitation)
- •T (2008-2009) (temperature)
- •Kc (FAO crop coefficient)
- •IrrFrac (irrigation efficiency = 0.75)
- •Crops area (A)

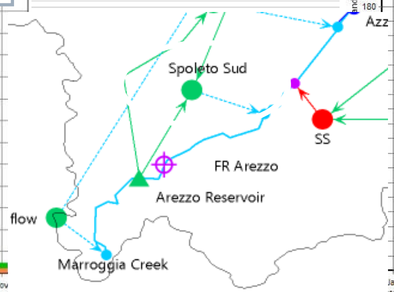
- •ETref (reference crop evapotranspiration - Penman Monteith equation)
- •Peff (% of precipitation that can be used for evapotranspiration- USDA approach)

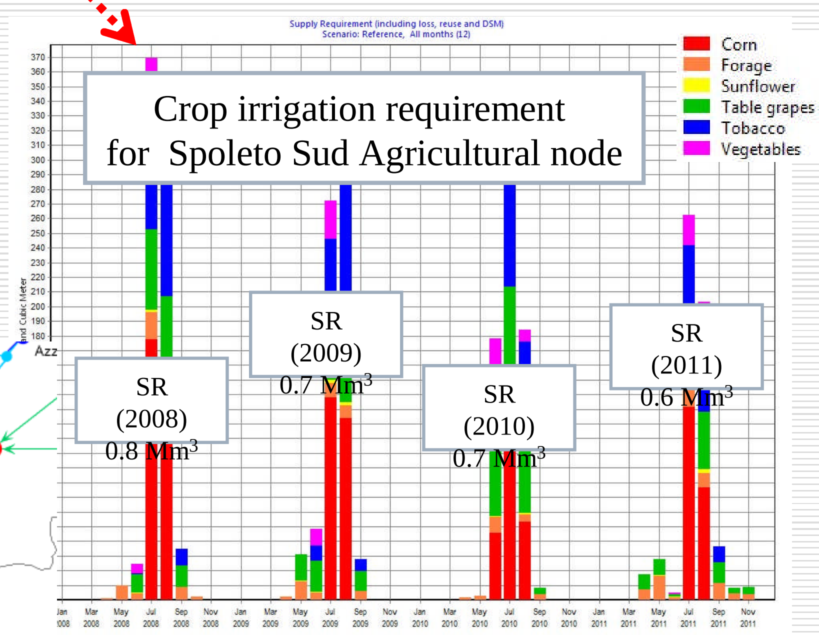
CATCHMENT

OUTPUT

- •Pavailable for ET = P*A*Peff
- •ETpotential (Potential crop Evapotranspiration) = Etref*kc*A
- •PShortfall=Max(0, Etpotential - Pavailable for ET)
- •SupplyRequirement (Crop irrigation requirement)=(1/IrrFrac)*PShortfall

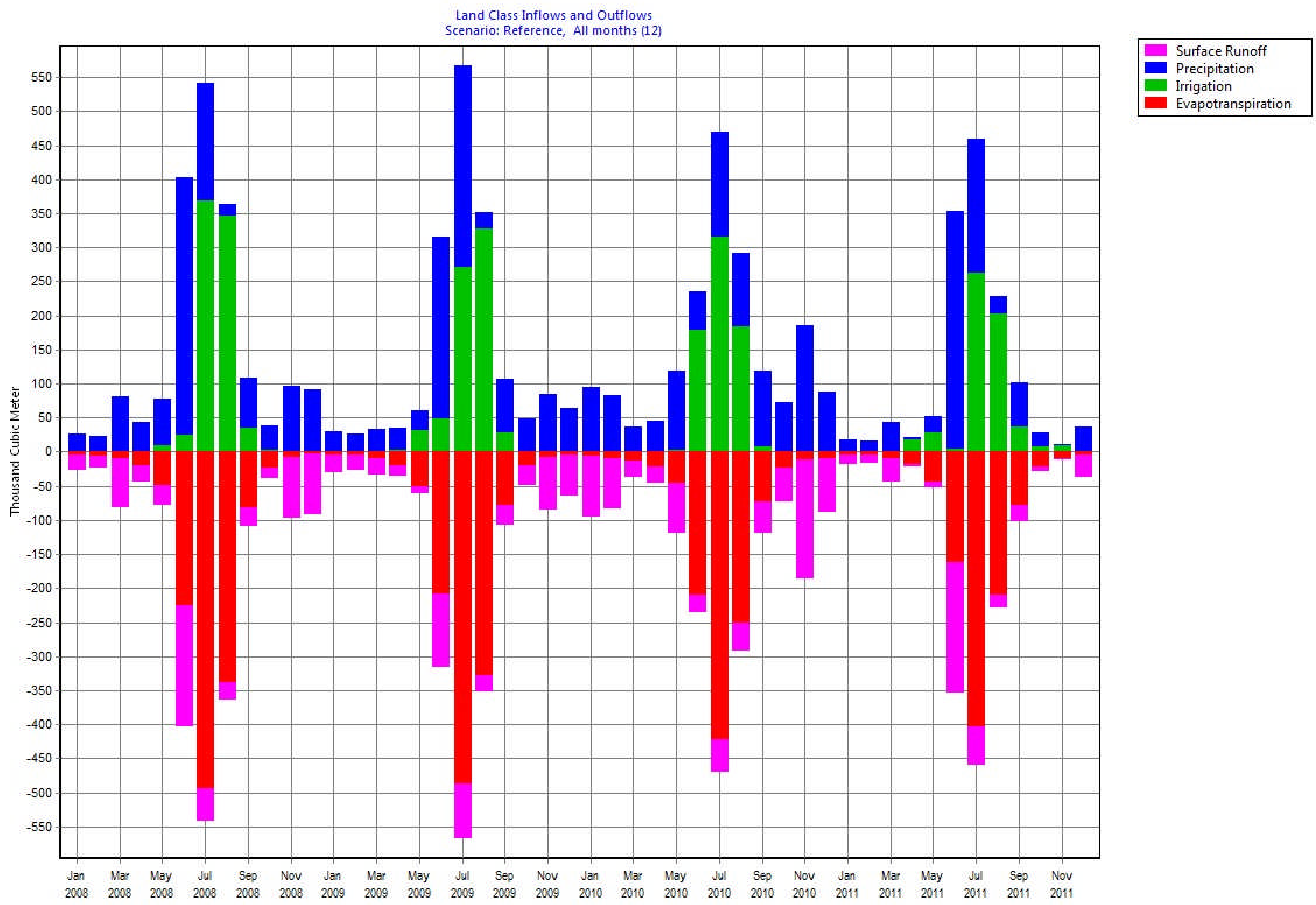






Example results for the 'Spoleto Sud' agricultural node

Agricultural nodes



Example results of water balance for the "Spoleto Sud" agricultural node

Urban nodes

24 urban nodes simulated as demand sites

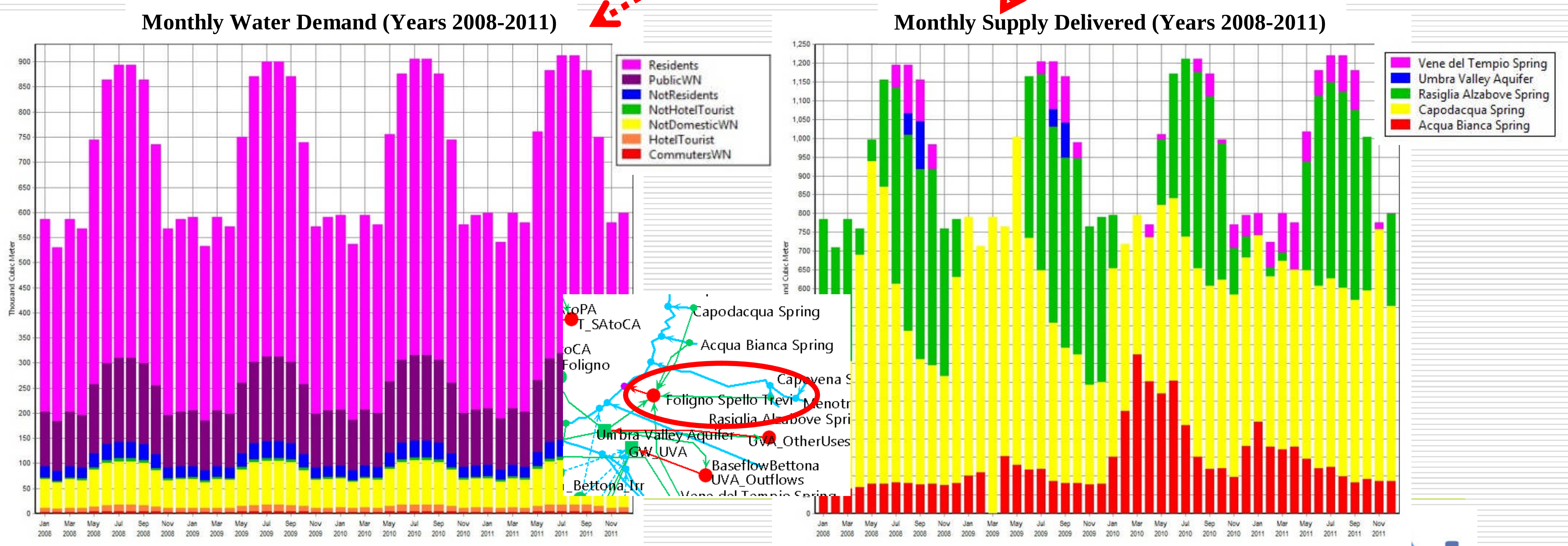
INPUT

- Annual water use rate
- Monthly variation of annual demand
- Loss rate = 24 %
- Consumption (% of inflow consumed) =15%

DEMAND SITE

OUTPUT

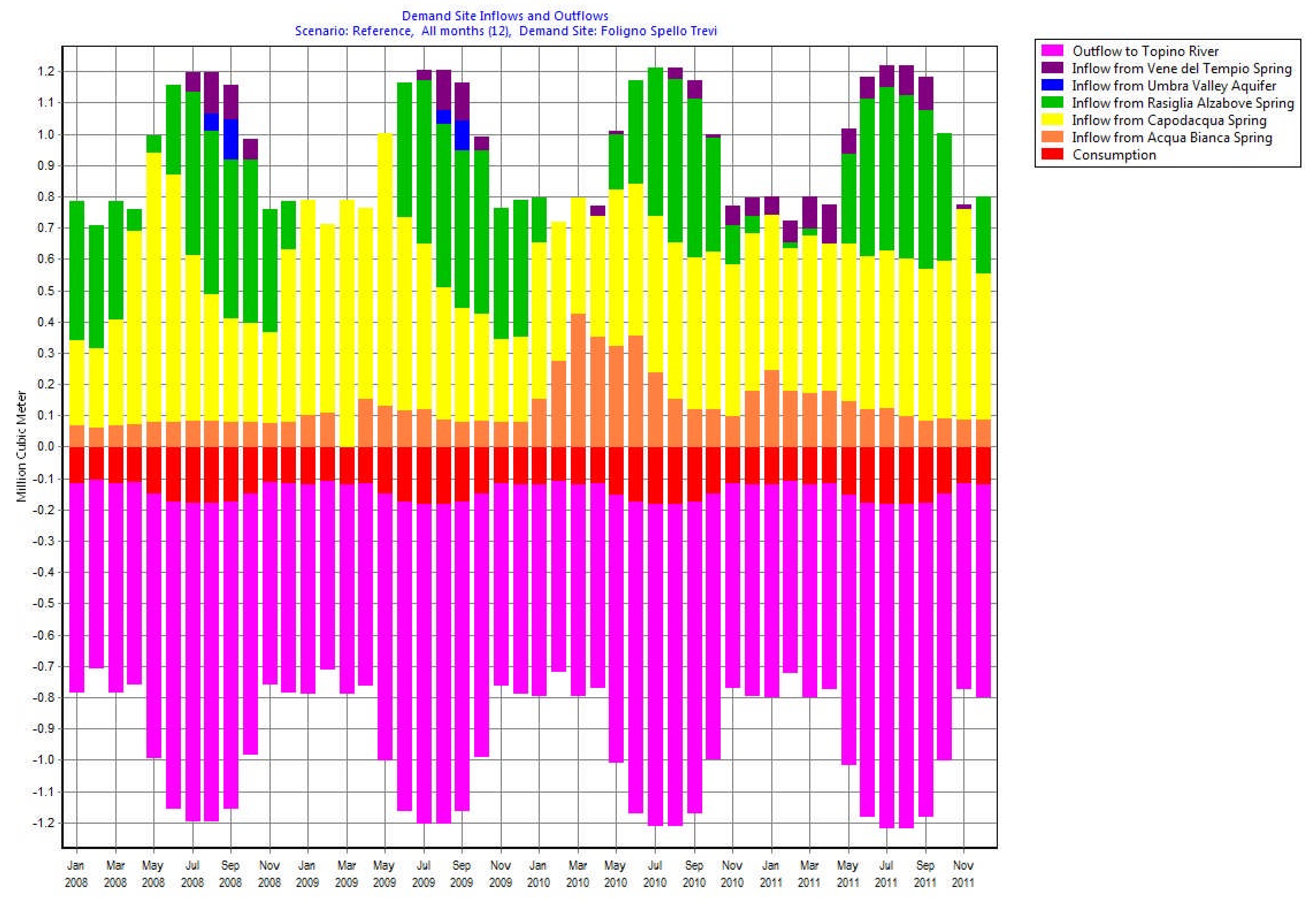
- Water demand
- Supply delivered
- Unmet demand



Example results for the "Foligno Spello Trevi" civil node

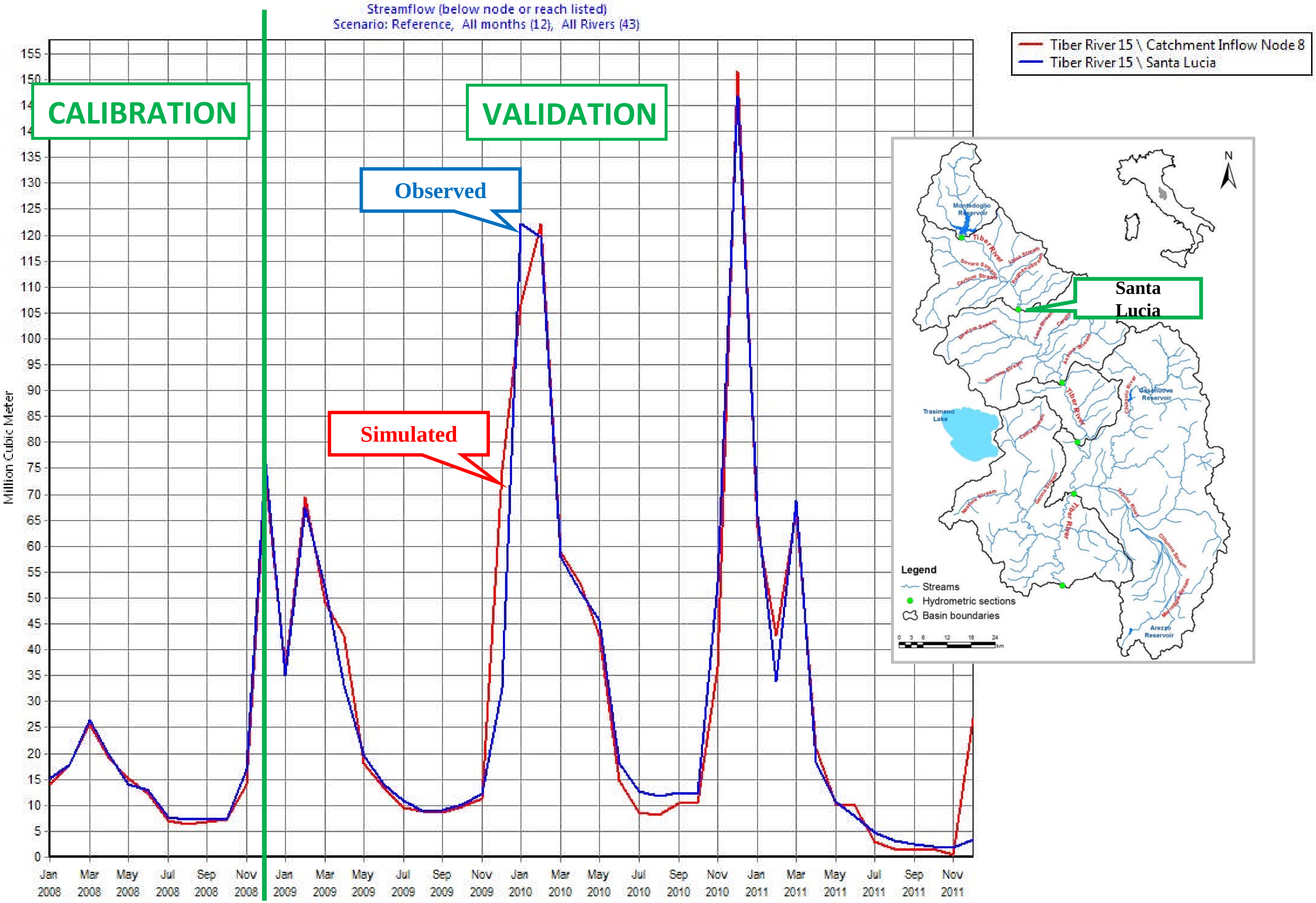
UNMET DEMAND = 0

Urban nodes

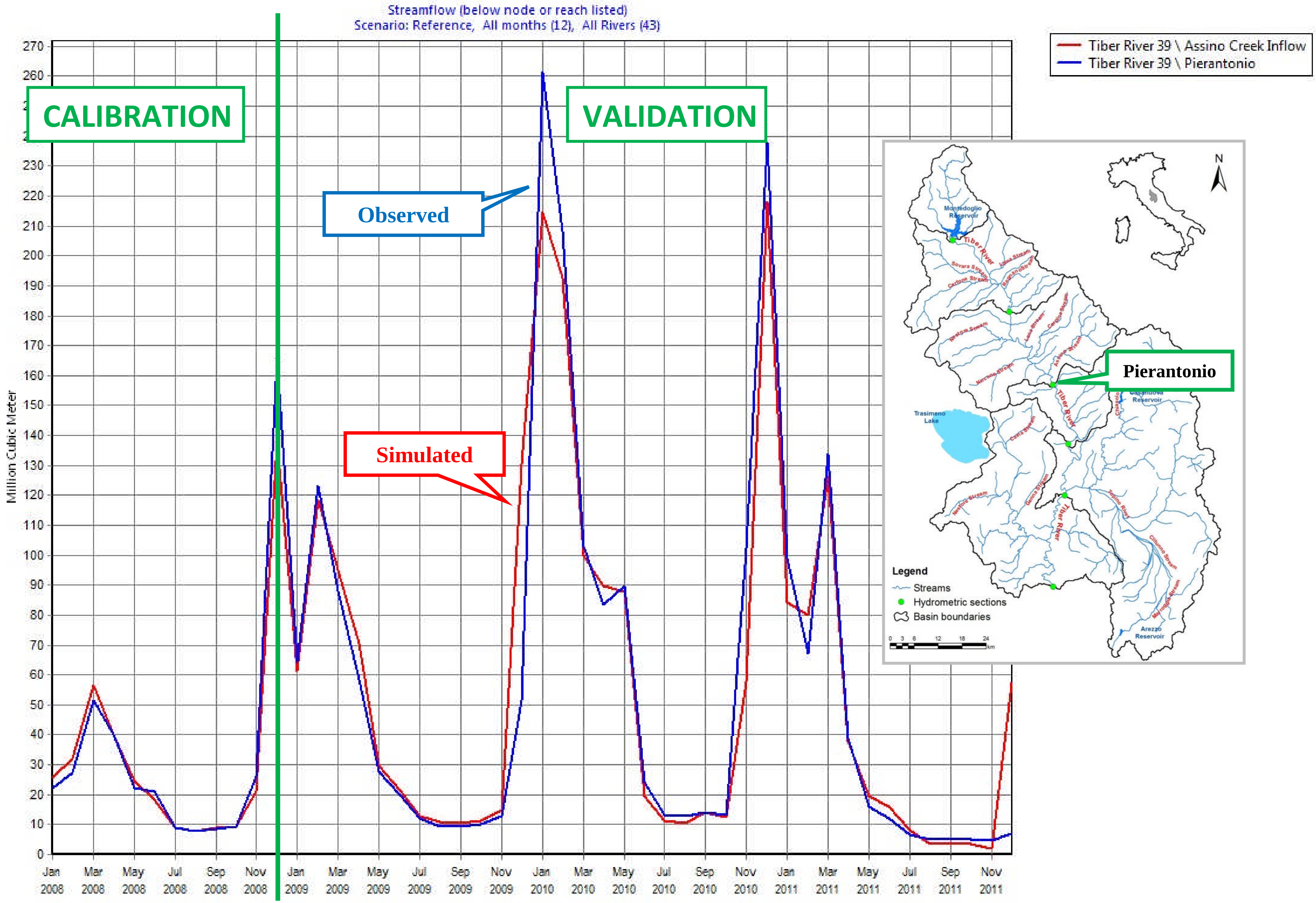


Example results of water balance for the Foligno Spello Trevi civil node

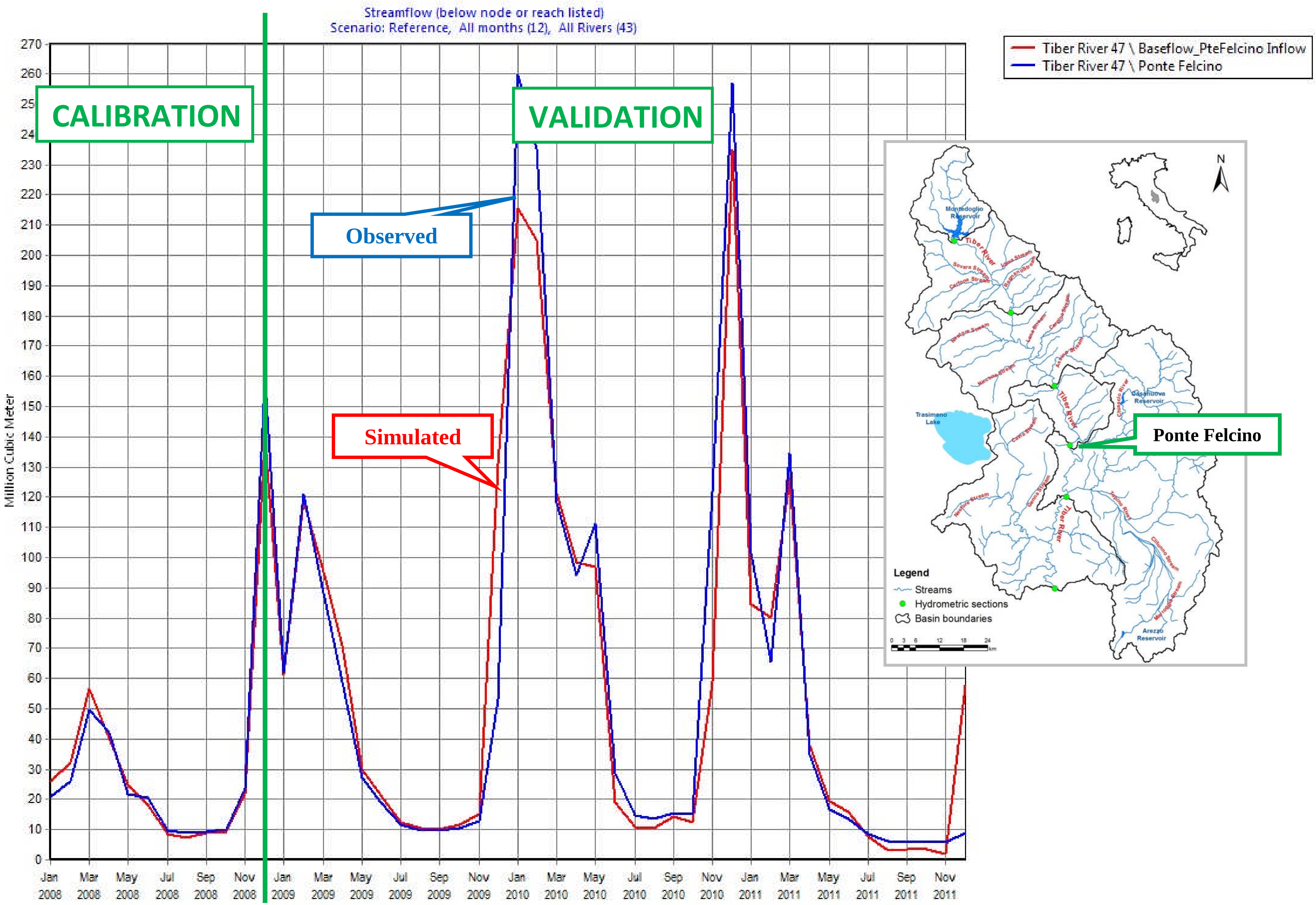
‘Santa Lucia’ hydrometric site: comparison between observed and simulated discharges



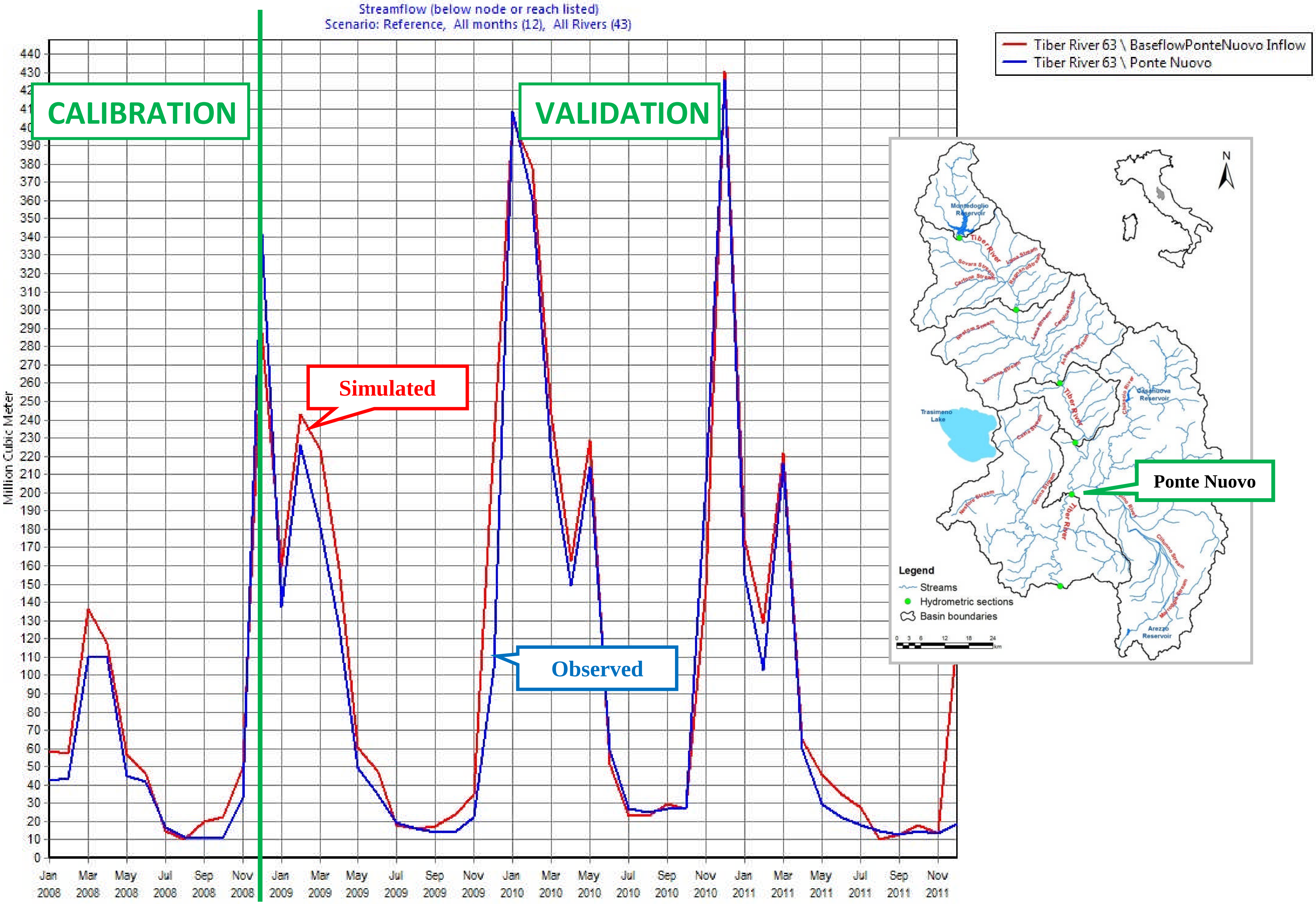
‘Pierantonio’ hydrometric site: comparison between observed and simulated discharges



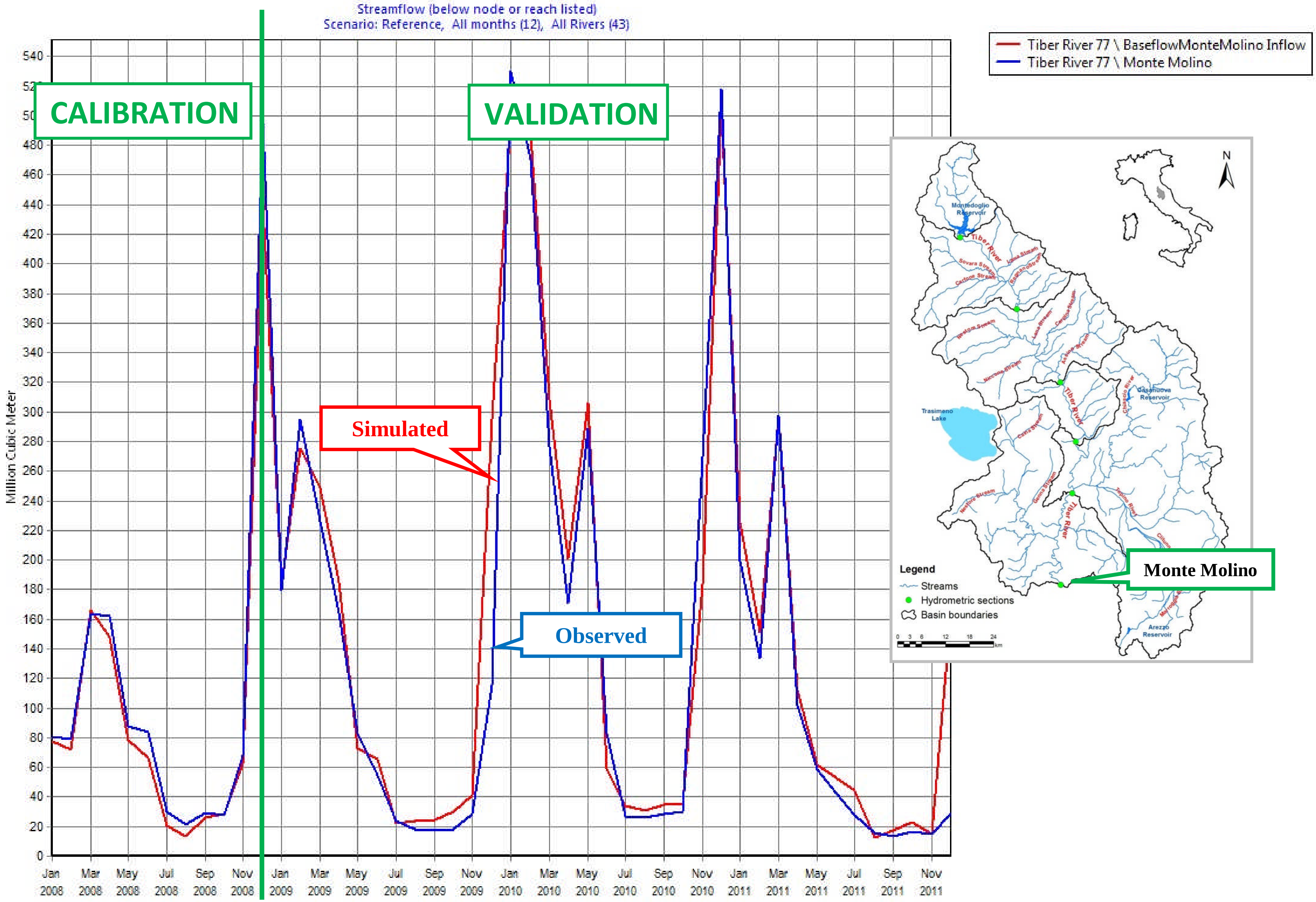
‘Ponte Felcino’ hydrometric site: comparison between observed and simulated discharges



‘Ponte Nuovo’ hydrometric site: comparison between observed and simulated discharges



‘Monte Molino’ hydrometric site: comparison between observed and simulated discharges

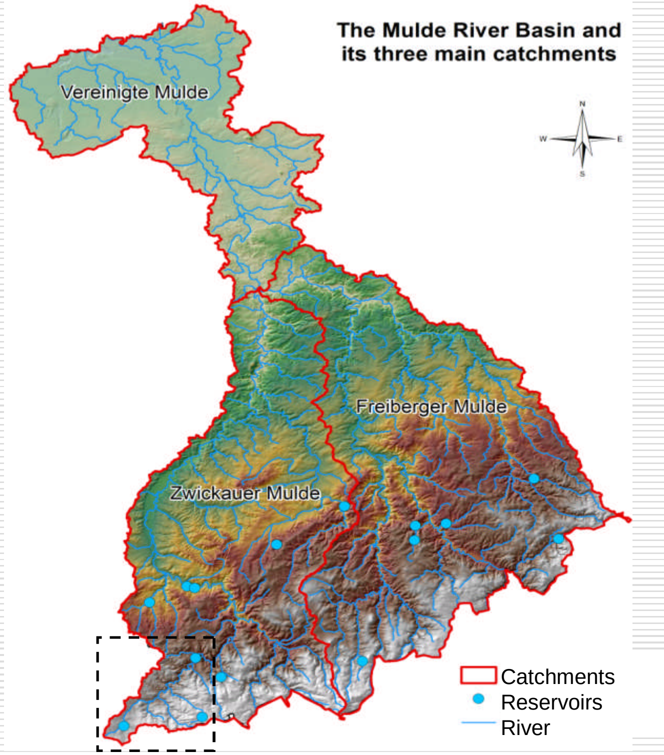


2. Mulde RB, Germany

major tributary of the Elbe

Increasing drought trends

Impacts on agriculture (25% loss of yield), forestry, soil protection, reservoir management



Considered data & components (selection)

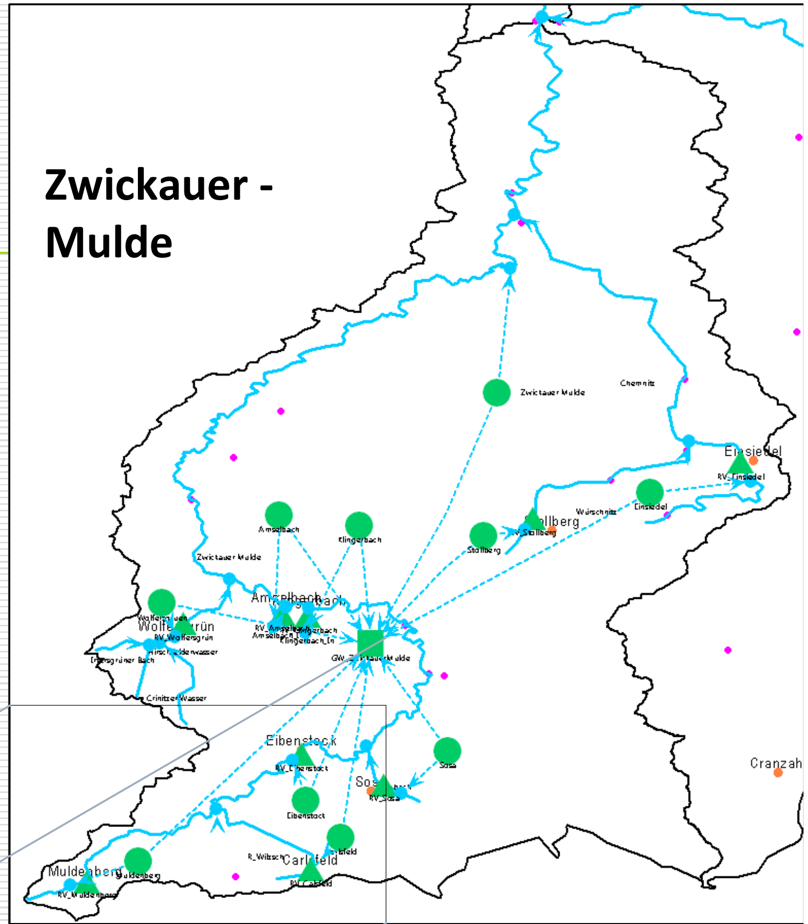
- Daily streamflow data of 36 gauges; climate data of 252 monitoring stations; in-/outflow and capacities of 15 water reservoirs
- Data on abstraction and sewage disposal of the public and non-public sector for the year 2007

Hydrology - Second step modelling. After the validation of the soil moisture method the model is lifted on the next scale: <u>Subcatchment scale</u>

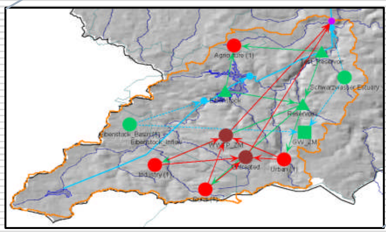
Demand - Due to data synchronisation difficulties, demand is represented on the basis of 15 administrative units

Supply - The main water supply (>60%) comes from 13 reservoirs which complicate the hydrological modelling

Problems - Hydrological Calibration is difficult due to the reservoirs and supply - demand data can hardly be synchronised



Subcatchment "Zwickauer Mulde"



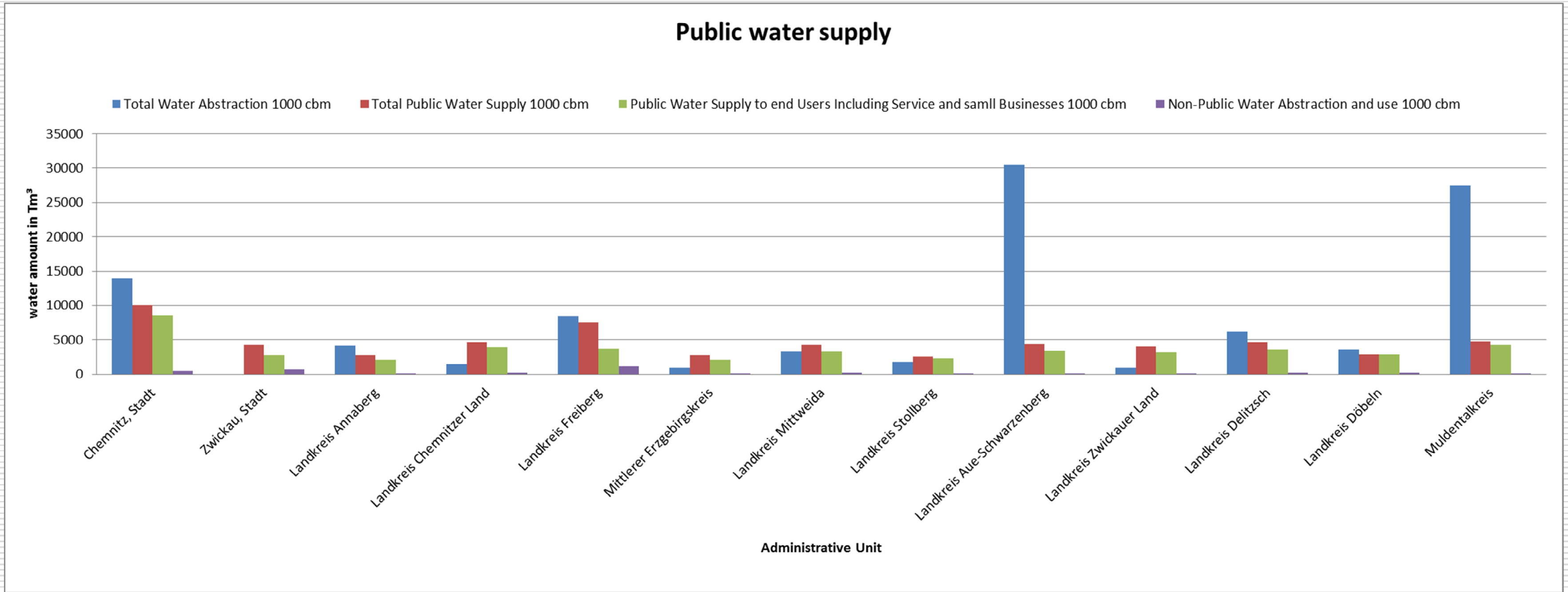
Test-Catchment

- Reservoirs
- Reservoir Catchments

Demand/Supply: The graph below shows high variability between water abstraction and water consumption in the regions. Reasons are:

-Water transfer between regions

-Long distance supply by reservoirs



Solution: Direct link between source (mainly reservoirs) and demand sites

Demand/Supply: Water management in the Mulde catchment have a 120-year tradition. 13 reservoirs cover 2/3 of the water demand, buffer the natural availability and protect against the high flood risks in the plains

The Einsiedel reservoir was a price winning construction build in 1992-1994. Among others it supplies the city of Chemnitz with water

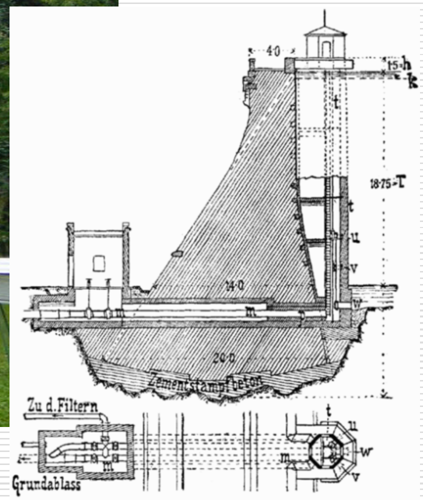
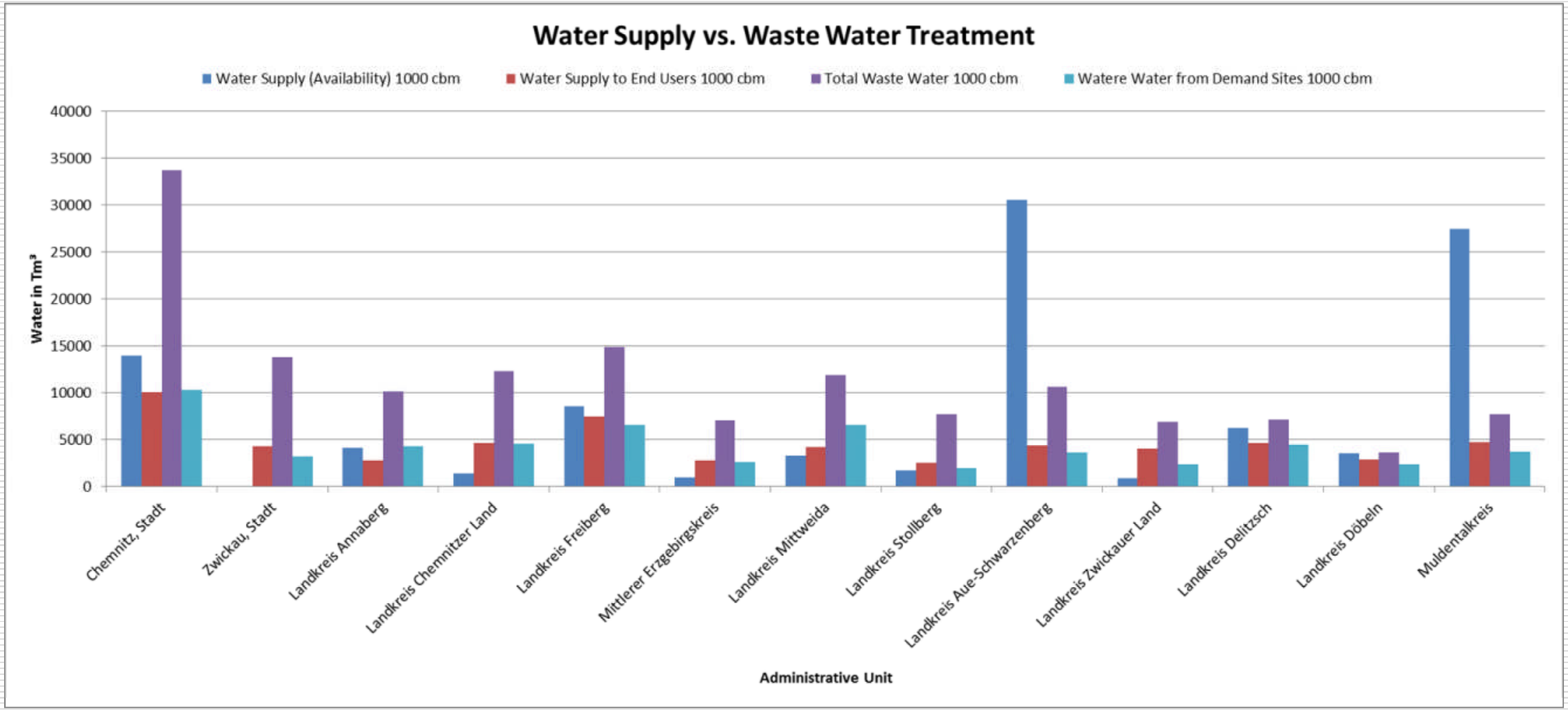


Fig. 17. Chemnitz-Talsperre.

Waste Water and Demand Sites: The Balance between water abstraction, supply and waste water occurrence varies in the regions based on different sources, degree of sealed areas and precipitation inhomogeneity.



General Difficulties

- Water supply, waste water treatment and environmental sources are handled on different scales
- WEAP is demanding very detailed input data and clear links between source and demand site which is difficult to be achieved on the catchment scale
- The modelling of reservoirs within a hydrological modelling scheme creates large uncertainties

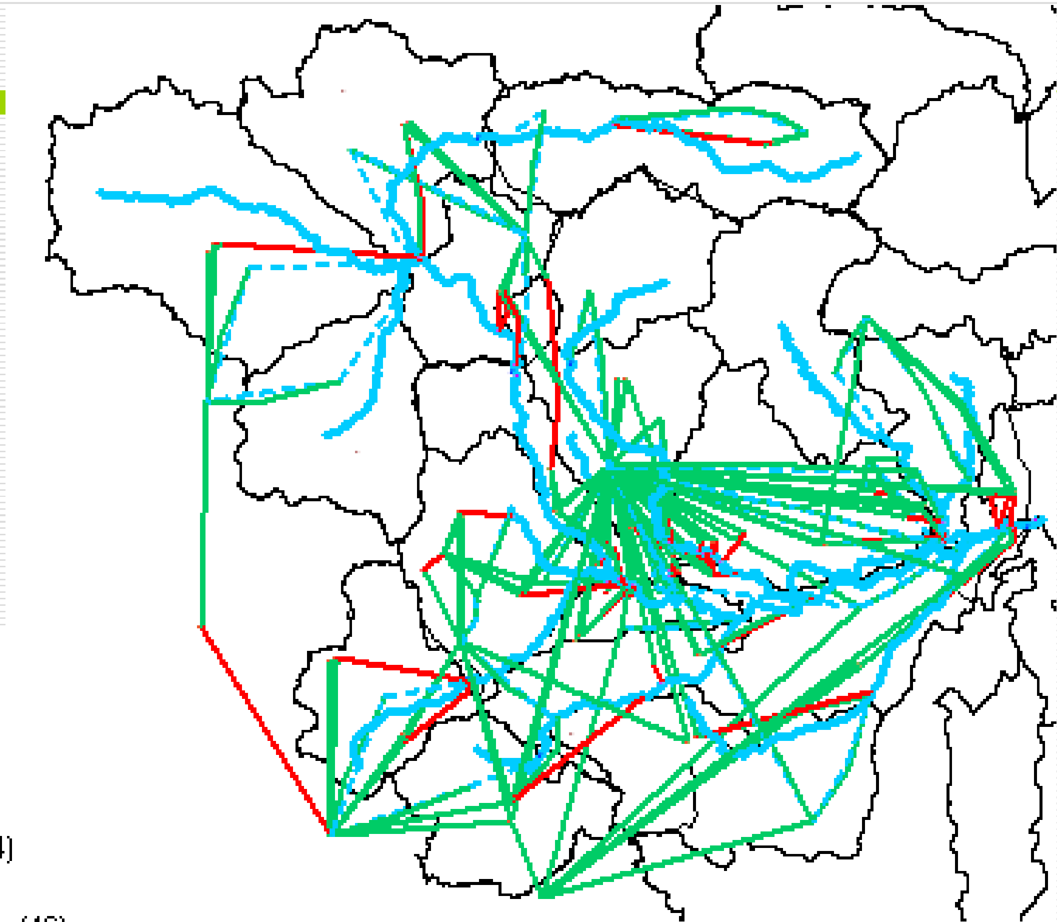
Solution:

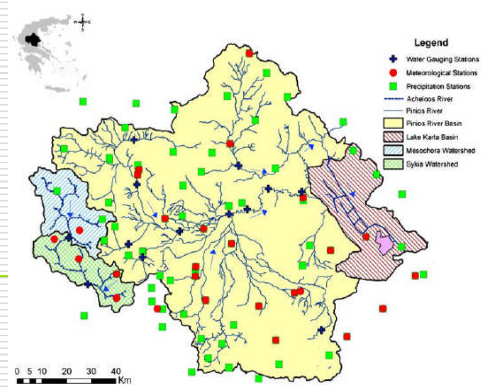
Two modelling scales with 1)A hydrological model with catchments for any reservoir and 2) A demand/supply model on the administrative scale (data driven) with direct links to the main resources

Advantage:

All available data is used and different scales can be applied simultaniously

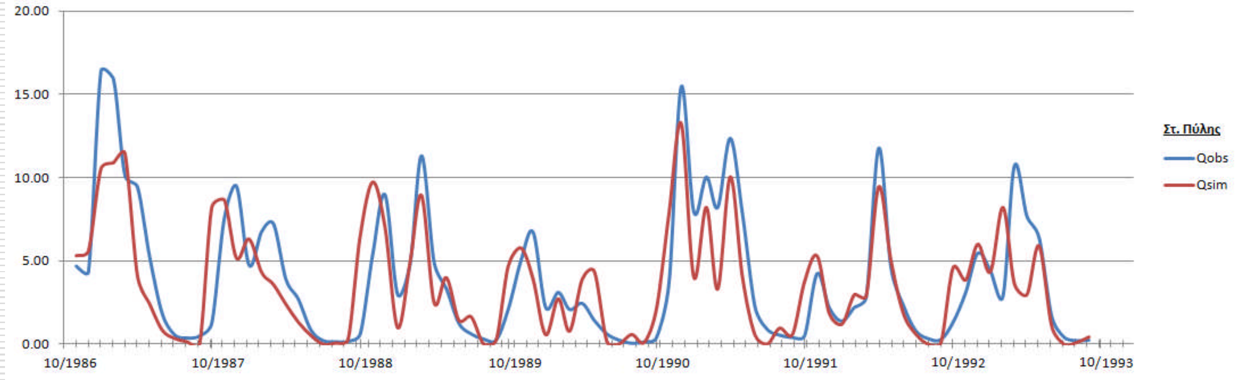
3. Pinios RB, Greece



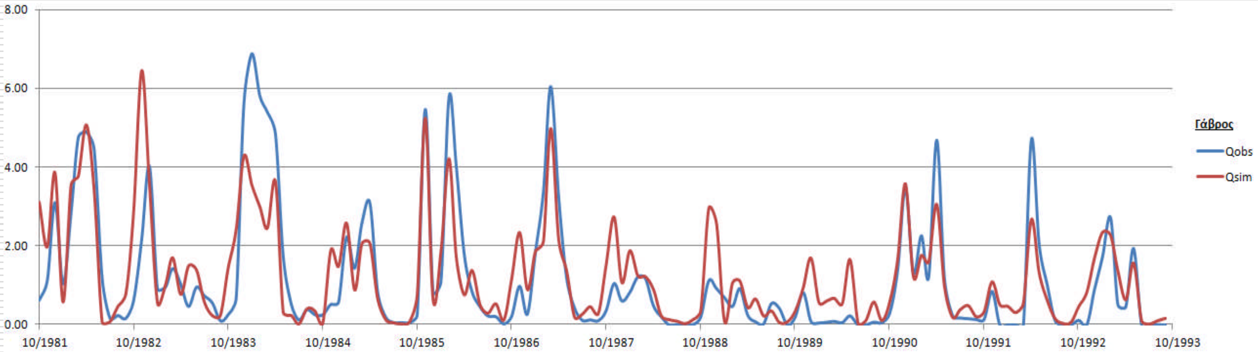


Frequent Drought episodes, desertification is becoming an issue
Main agricultural area of Greece (>275,000 ha irrig.)
Competing uses, July irrigation deficit 114hm3)

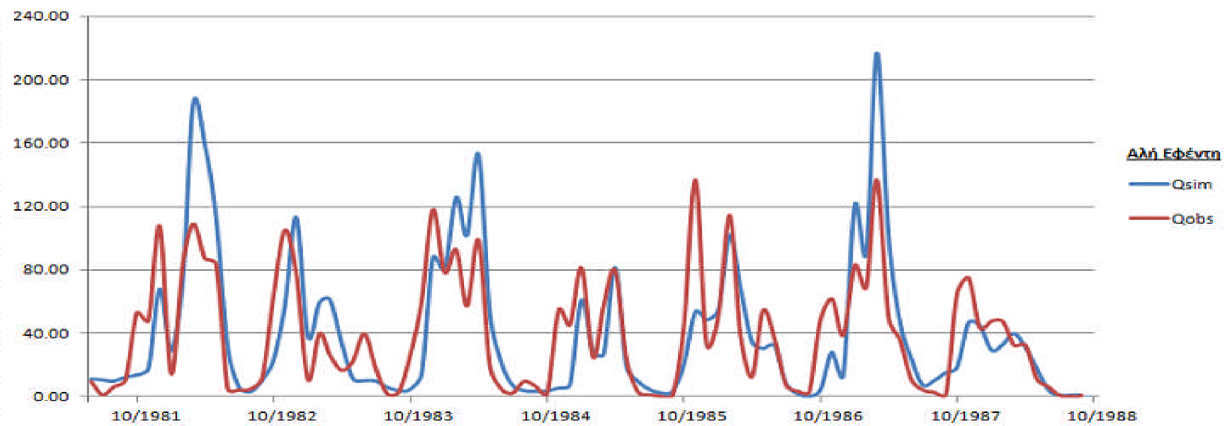
Calibration



Pyli hydrometric station



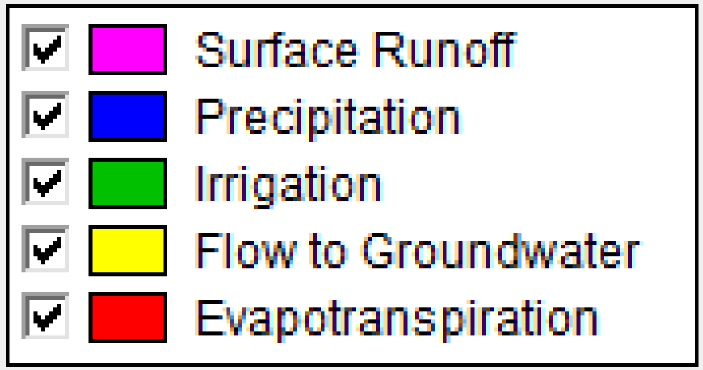
Gavros hydrometric station

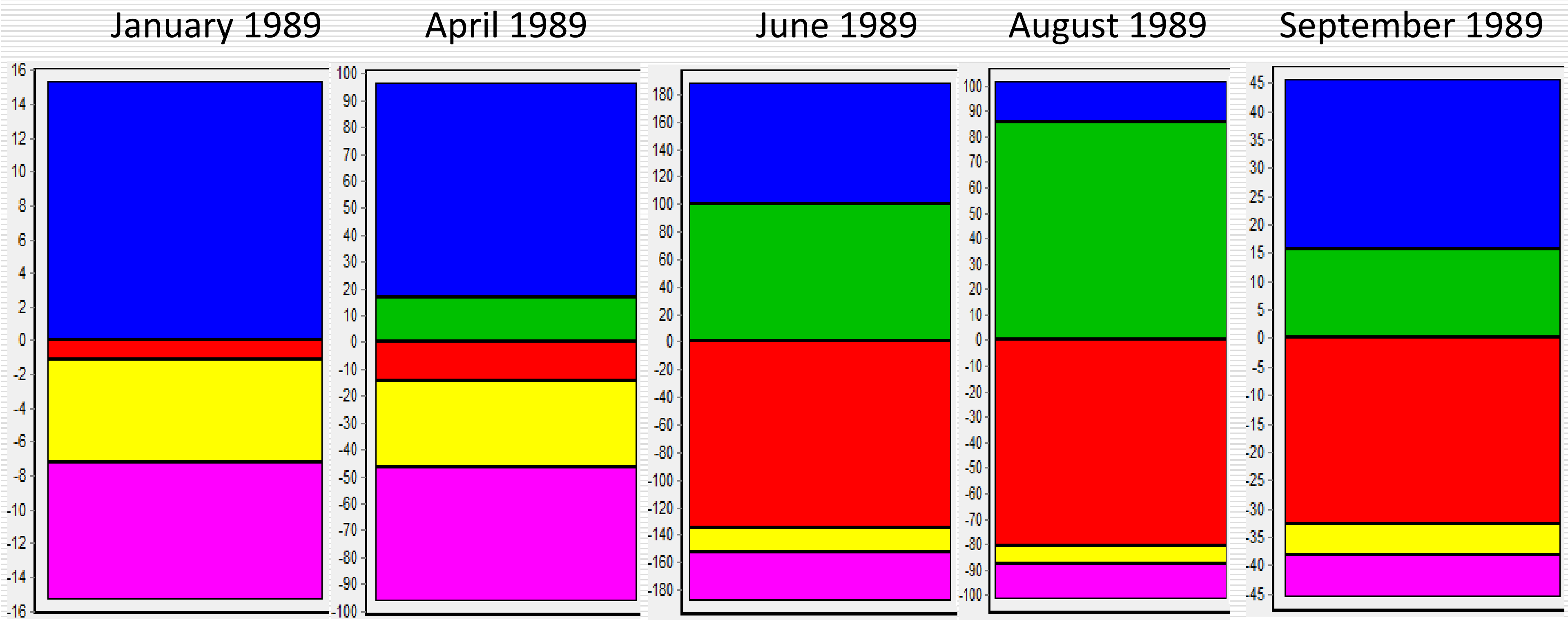


Ali Efenti (outlet) hydrometric station

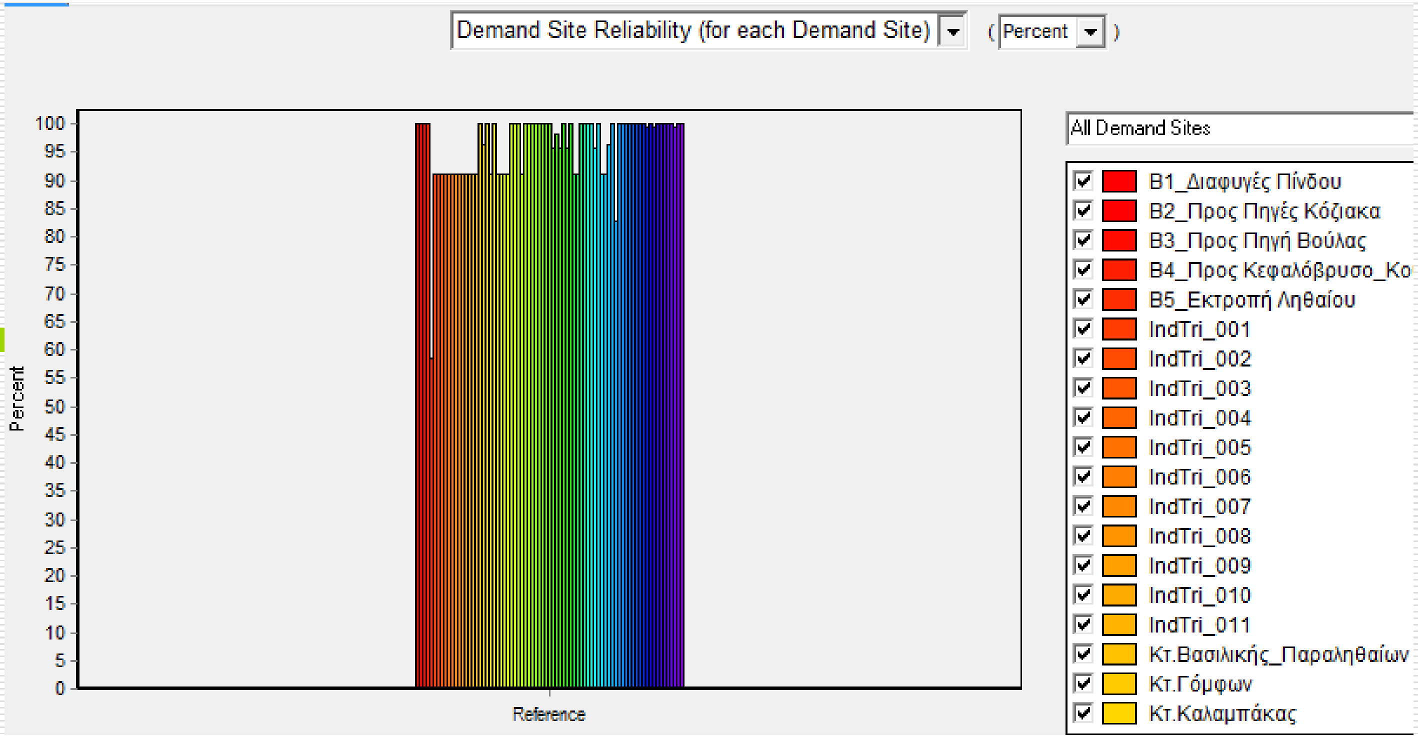
abot

Water accounts stocks for the dry year 1989

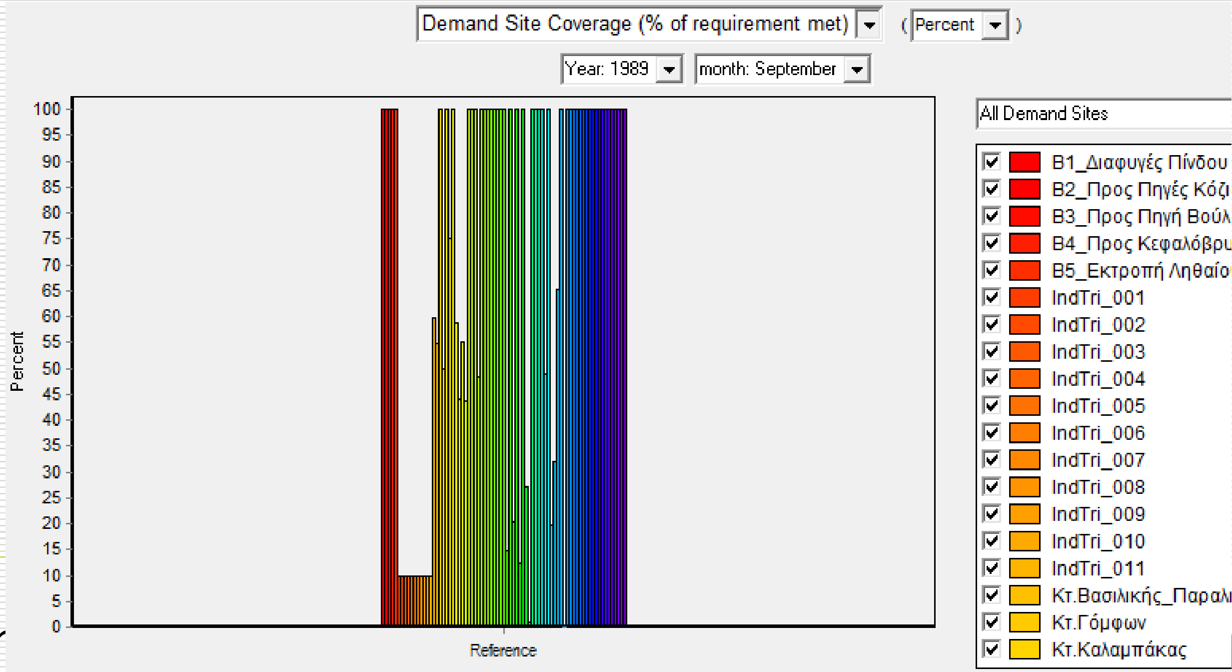




Demand site Reliability



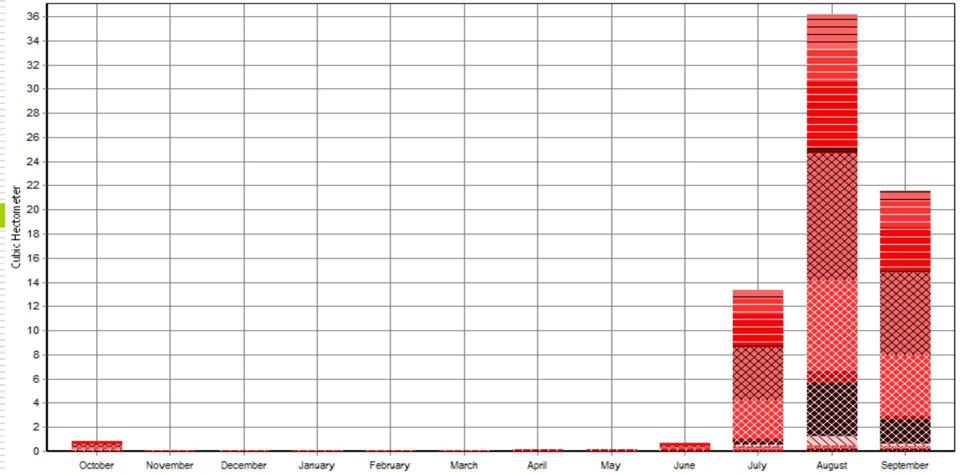
Demand site Coverage (September 1989 dry year)



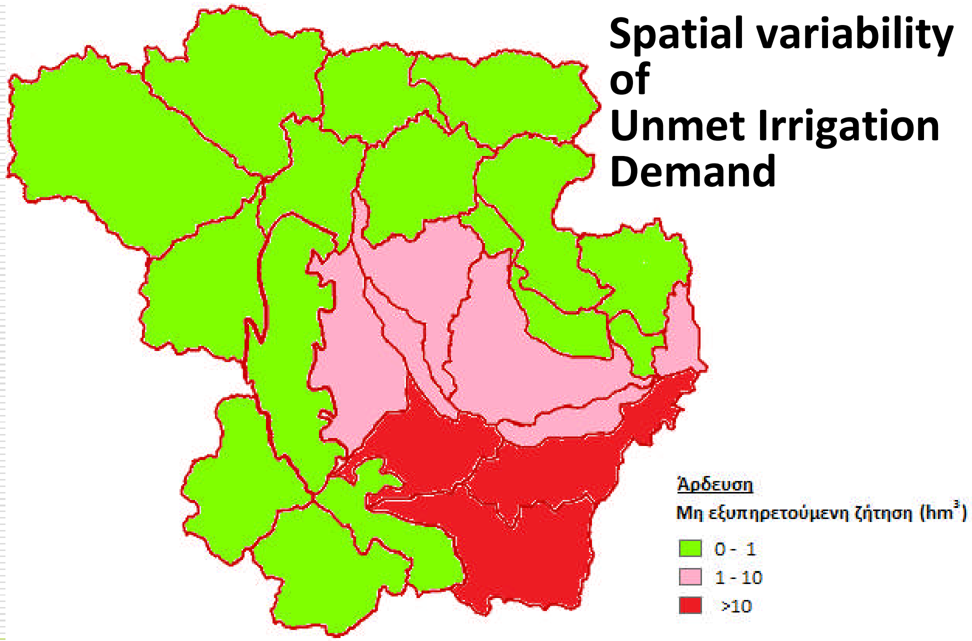
Overall Results for the period 1995-2010

Water Demand (hm^3)		Water Supply (hm^3)	
Domestic	19.63	Domestic	19.58
Irrigation	477.76	Irrigation	406.31
Livestock	6.40	Livestock	4.61
Industry	1.18	Industry	1.00
Total	504.98	Total	431.49
Unmet Demand (hm^3)		Demand Coverage (%)	
Domestic	0.05	Domestic	99.72
Irrigation	71.45	Irrigation	85.04
Livestock	1.79	Livestock	72.01
Industry	0.19	Industry	84.19
Total	73.49	Total	85.45
Long-term Reliability (%)		77.56	

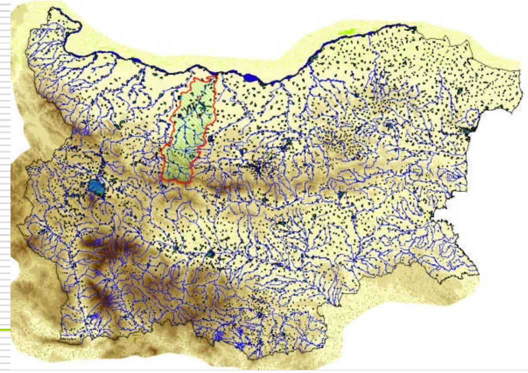
Temporal variability of Unmet Demand

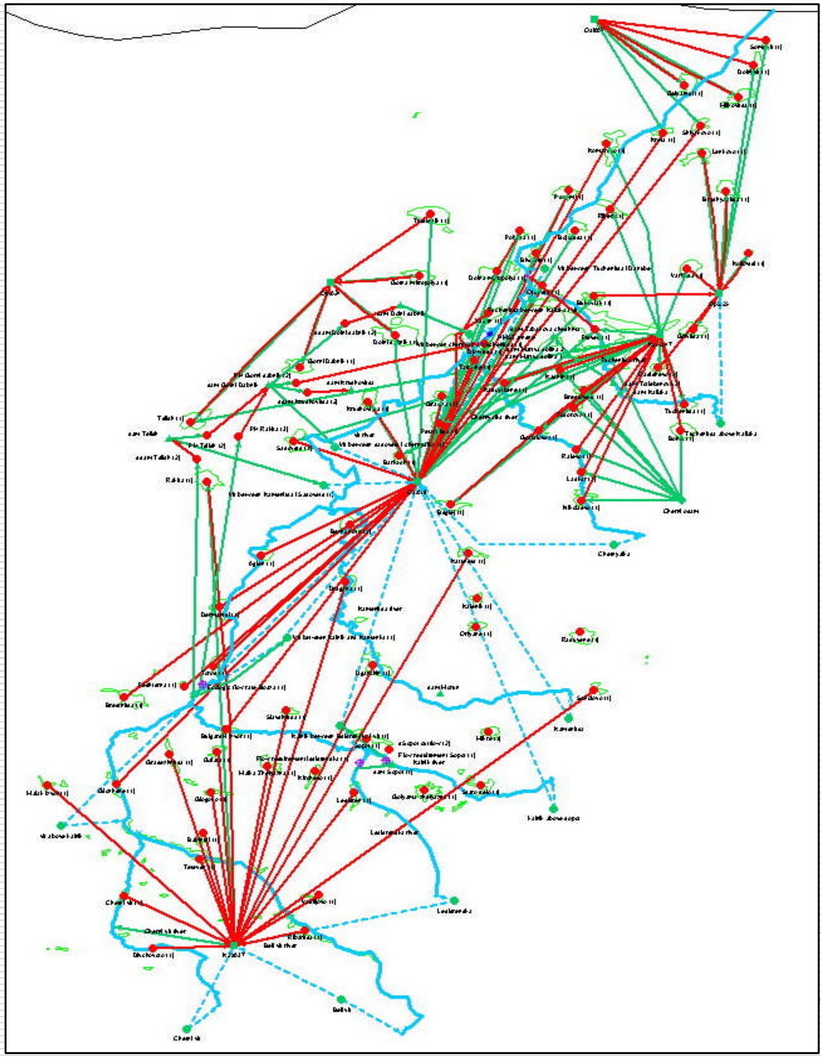


Spatial variability of Unmet Irrigation Demand



4. Vit RB, Bulgaria



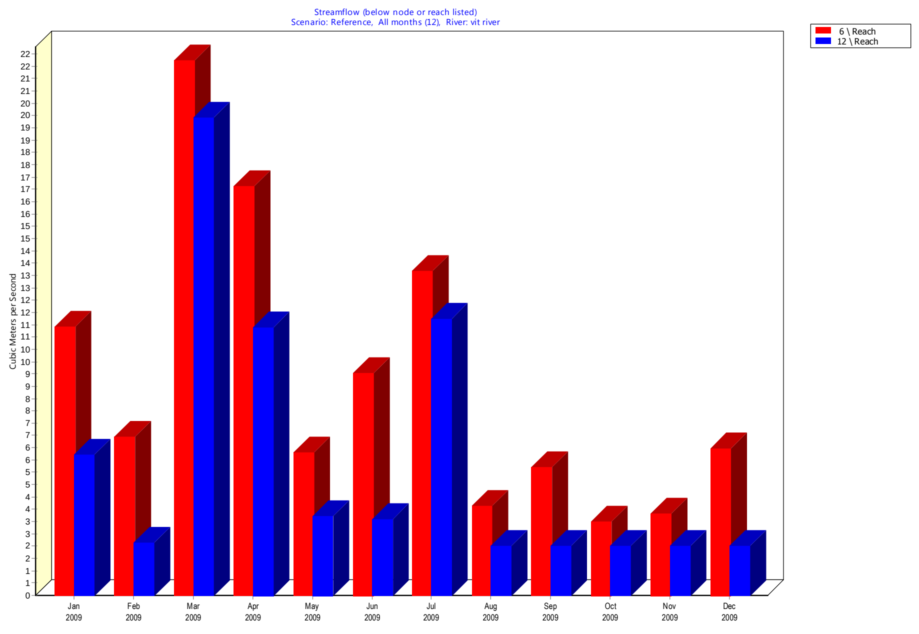


Tributary of Danube
Variability between high and low flows, droughts are usual
main pressures: logging, agriculture, recreational activities, industry, and the settlements within the river valley

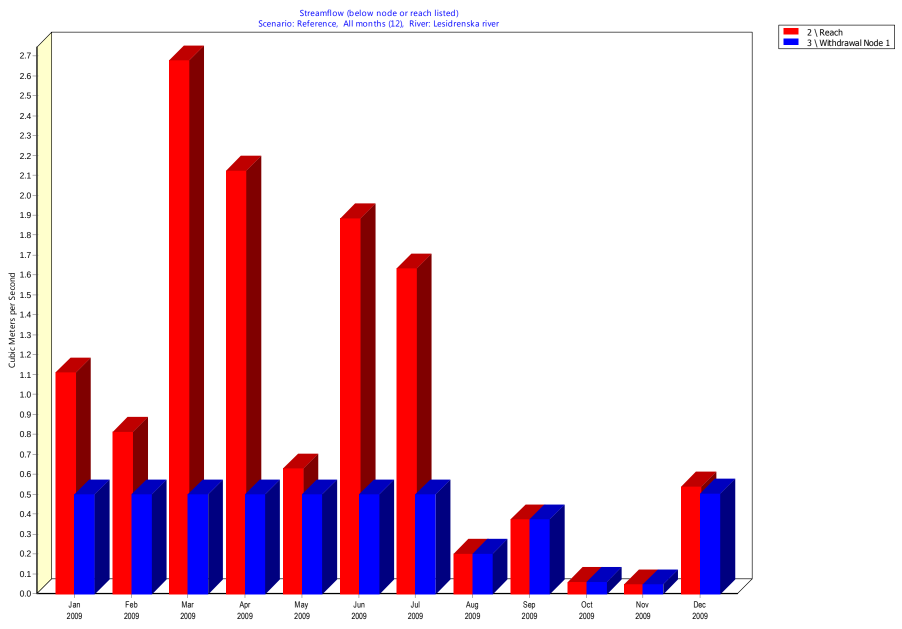
The interconnections as they appear in WEAP model

WEAP modeling of the Rivers withdrawal nodes

Vit river



Lesidrenska river

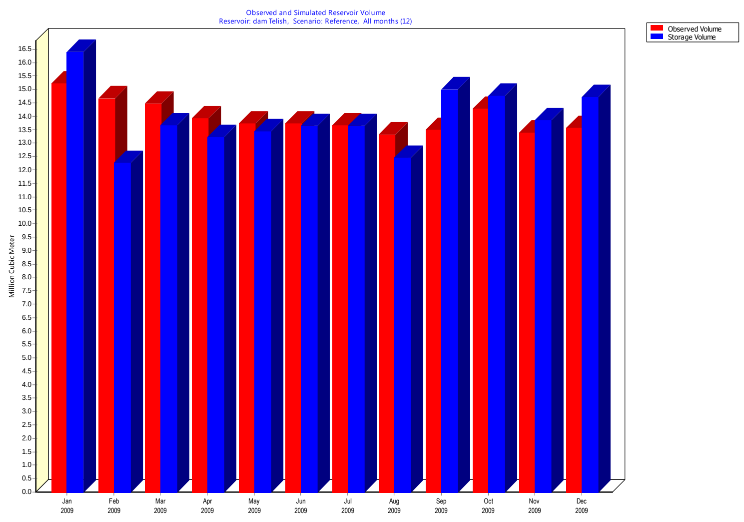


Red- before point of abstraction

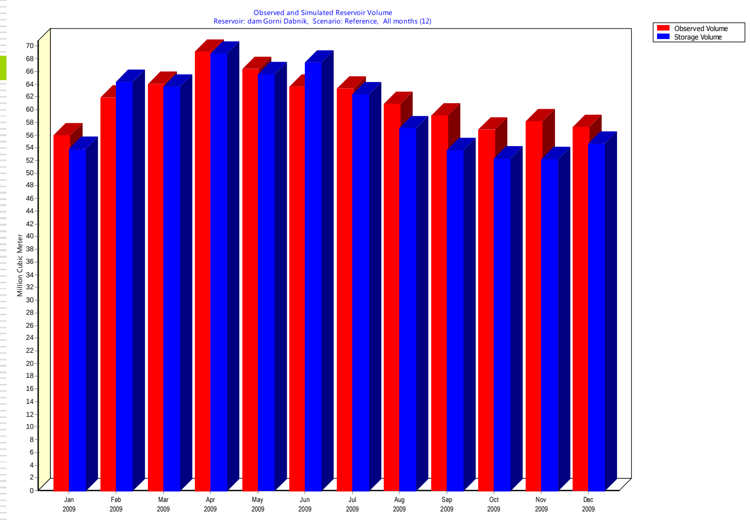
Blue- after point of abstraction

WEAP modeling of the three biggest reservoir 2009

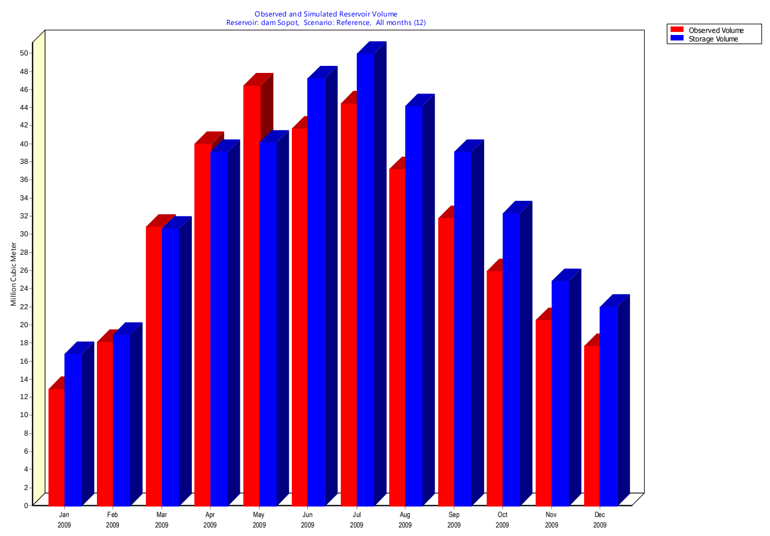
Dam Telish



Dam Gorni dabnik



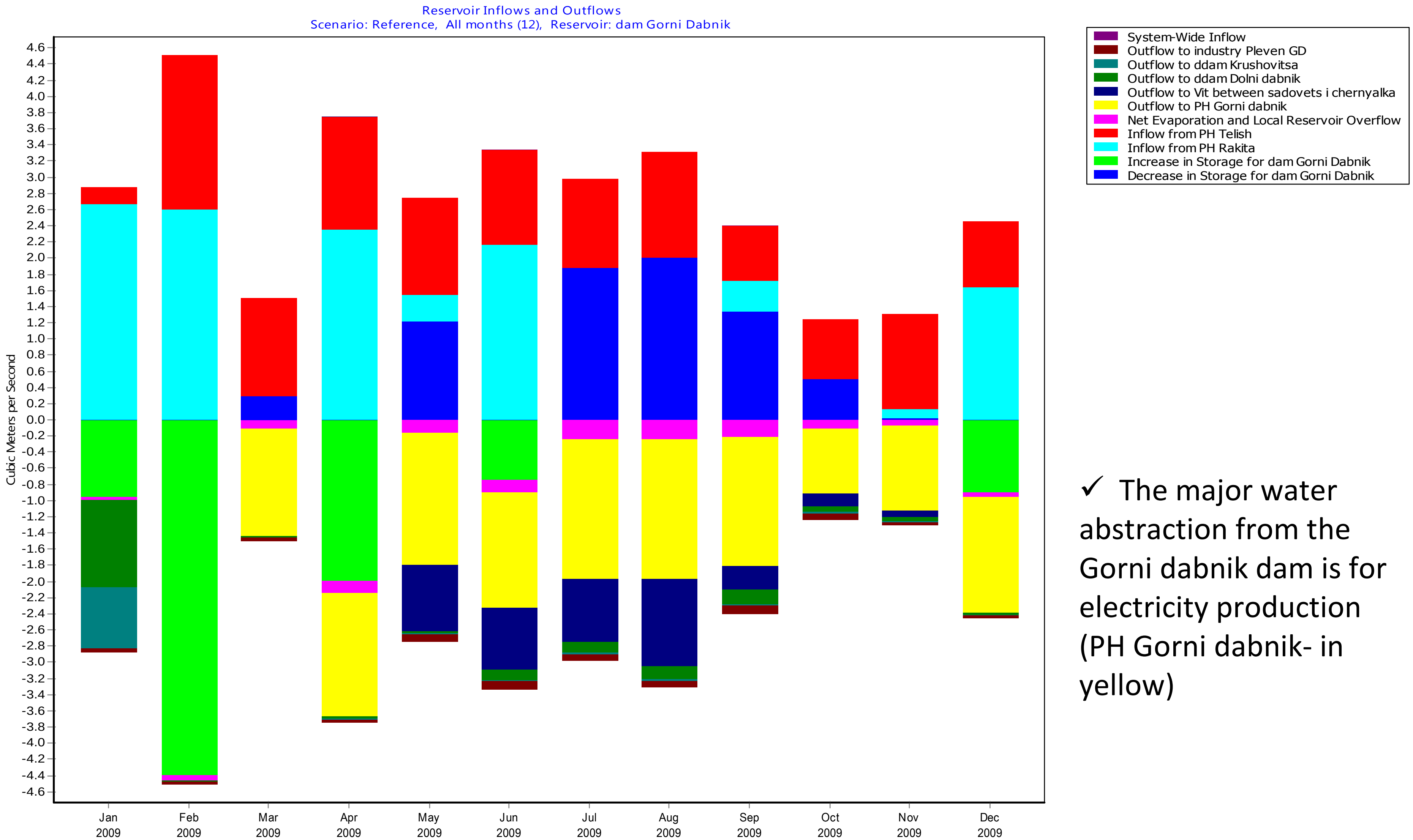
Dam Sopot



Red- observed data

Blue- simulated data

WEAP modeling results: The water balance of the biggest reservoir (Gorni dabnik)



- ✓ The major water abstraction from the Gorni dabnik dam is for electricity production (PH Gorni dabnik- in yellow)

SEEAW Standard Tables

Detailed physical water supply and use table: Monte Molino hydrometric station (year 2008)

Milions cubic metres

		Industries (by ISIC categories)								Households	Rest of the world	Total
		1-3	1-3 *	5-33 41-43	35	36	37	38-39 45-99	Total			
From the environment	1. Total abstraction (=1.a+1.b=1.i+1.ii)	**29.8**	**36.9**	**0.01**		**104.5**			**171.2**			**171.2**
	1.a. Abstraction for own use	**29.8**	**36.9**	**0.01**		**0**			**66.7**			**66.7**
	Hydroelectric power generation											0
	Irrigation water	29.8	36.9						66.7			66.7
	Mine water											0
	Urban runoff											0
	Cooling water											0
	Other			0.01								0
	1.b. Abstraction for distribution	**0**	**0**	**0**		**104.5**			**104.5**			**104.5**
	1.i. From water resources:	**29.8**	**36.9**	**0.01**		**104.5**			**171.2**			**171.2**
	1.i.1 Surface water	12.4	24.1	0		13.9			50.4			50.4
	1.i.2 Groundwater	2.2	0	0.01		90.7			92.9			92.9
	1.i.3 Soil water	15.2	12.8						28			28
	1.ii. From other sources	**0**	**0**	**0**		**0**			**0**			**0**
	1.ii.1 Collection of precipitation											0
	1.ii.2 Abstraction from the sea											0
Within the economy	2. Use of water received from other economic units	**0**	**0**	**0**		**0**			**0**			**0**
	of which:											
	2.a. Reused water								0			0
3. Total use of water (= 1 + 2)		**29.8**	**36.9**	**0.01**		**104.5**			**171.2**			**171.2**

Legend

(* = calibrated values)

ISIC 1-3 *Agriculture, Forestry and Fishing*
ISIC 5-33, 41-43 *Mining and quarrying, Manufacturing and Construction*
ISIC 35 *Electricity, gas, steam and air conditioning supply*
ISIC 36 *Water collection, treatment and supply*
ISIC 37 *Sewerage*
ISIC 38,39, 45-99 *Service industries*

Total abstraction + 171.2 Mm^3
Use of water received from other economic units = 0.0 Mm^3
Total use of water **171.2** Mm^3

Detailed physical water supply and use table: Monte Molino hydrometric station (year 2008)

Milions cubic metres

		Industries (by ISIC categories)								Households	Rest of the world	Total
		1-3	1-3 *	5-33 41-43	35	36	37	38-39 45-99	Total			
Within the economy	**4. Supply of water to other economic units**	**0**	**0**	**0**		**0**			**0**			**0**
	of which											
	4.a. Reused water											0
	4.b. Wastewater to sewerage											0
	4.c. Desalinated water											0
To the environment	5. Total Returns (=5.a+5.b)	**11.8**	**9.5**	**0.01**		**88.8**			**110.1**			**110.1**
	Hydroelectric power generation								0			0
	Irrigation water	11.8	9.5						21.3			21.3
	Mine water								0			0
	Urban runoff								0			0
	Cooling water								0			0
	Losses in distribution because of leakages								0			0
	Treated wastewater								0			0
	Other			0.01		88.8			88.9			88.9
	5.a. To water resources (=5.a.1.+5.a.2.+5.a.3.)	**11.8**	**9.5**	**0.01**		**88.8**			**110.1**			**110.1**
	5.a.1. Surface water	11.8	1	0.01		87.8			100.7			100.7
	5.a.2. Groundwater	0	8.5	0		1			9.5			9.5
	5.a.3. Soil Water	0	0	0					0			0
	5.b. To other sources (e.g. sea water)	**0**	**0**	**0**		**0**			**0**			**0**
6. Total supply of water (=4+5)		**11.8**	**9.5**	**0.01**		**88.8**			**110.1**			**110.1**
7. Consumption (=3-6)		**18**	**27.4**	**0**		**15.7**			**61.1**			**61.1**
of which:												
7.a. Losses in distribution not because of leakages												

(* = calibrated values)

Legend

ISIC 1-3 *Agriculture, Forestry and Fishing*
ISIC 5-33, 41-43 *Mining and quarrying, Manufacturing and Construction*
ISIC 35 *Electricity, gas, steam and air conditioning supply*
ISIC 36 *Water collection, treatment and supply*
ISIC 37 *Sewerage*
ISIC 38,39, 45-99 *Service industries*

Supply of water to other economic units + 0.0 Mm^3
Total Returns = 110.1 Mm^3
Total supply of water **110.1** Mm^3

Total use of water (171.2 Mm^3) - Total supply of water (110.1 Mm^3) = Consumption (61.1 Mm^3)

Asset accounts: Monte Molino hydrometric station (year 2008)

	EA. 131 Surface water						
	EA. 1311 Artificial Reservoirs	EA. 1312 Lakes	EA. 1313 Rivers*	EA. 1314 Snow, Ice, Glaciers	EA. 132 Groundwater	EA. 133 Soil water	Total
1. **Opening Stocks**	**55.21**		**4.7**		**2501.5**		**2561.4**
Increases in stocks							
2. Returns			**34.4**		**9.5**		**43.9**
3. Precipitation			**12.1**				**12.1**
4. Inflows	**197.4**		**3914.7**		**2988.4**		**7100.5**
4.a. From upstream territories	197.4		3170.4		2539.9		5907.7
4.b. From other resources in the territory			744.3		448.5		1192.8
Decreases in stocks							
5. Abstraction	**22.3**		**28.1**		**92.9**		**143.3**
6. Evaporation\Actual evapotranspiration	**4.2**		**9.3**				**13.5**
7. Outflows	**101.17**		**3922**		**1091.6**		**5114.8**
7.a. To downstream territories			3922				3922
7.b. To the sea							
7.c. To other resources in the territory	101.2				1091.6		1192.8
8. Other changes in volume							
9. **Closing stocks**	**125**		**6.6**		**4314.8**		**4446.4**

(* = computed for Tiber River and for the tributaries where abstractions are present)

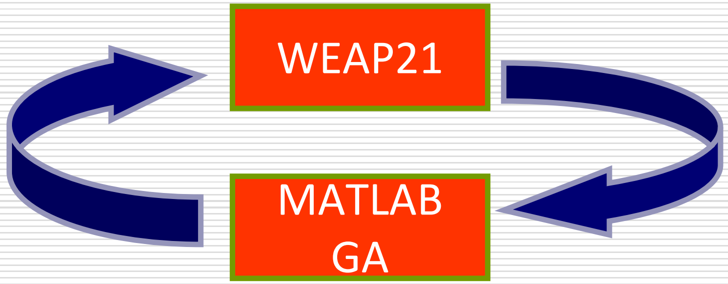
	EA. 131 Surface water						
	EA. 1311 Artificial Reservoirs	EA. 1312 Lakes	EA. 1313 Rivers	EA. 1314 Snow, Ice, Glaciers	EA. 132 Groundwater	EA. 133 Soil water	Outflow to other resources in the territory
EA. 1311 Artificial Reservoirs			101.2				**101.2**
EA. 1312 Lakes							
EA. 1313 Rivers							
EA. 1314 Snow, Ice, Glaciers							
EA. 132 Groundwater			643.1		448.5		**1091.6**
EA. 133 Soil water							
Inflows from other resources in the territory			**744.3**		**448.5**		**1192.8**

Catalogue of Measures

Sector	Water Saving Measures	Water Saving	Unit Cost
Irrigation	Replacement of old pressurized pipes	10%-15%	
	Cleaning and lining open canals	6.2%-30% [4]	
	Replacement of open canals with covered underground pipes	20%-30%	600 €/στρ [2,4]
	Change of agricultural practices		
	Switch to drip irrigation	15% / 30%	60 €/στρ [2]/ 150 €/στρ [2]
	Precision agriculture	20-35% [4]	3 €/στρ [4]
	Treated Wasterwater reuse	variable [4]	0.048-0.467 €/m^3 [4]
	Increase water pricing by 50%	24% [6]	

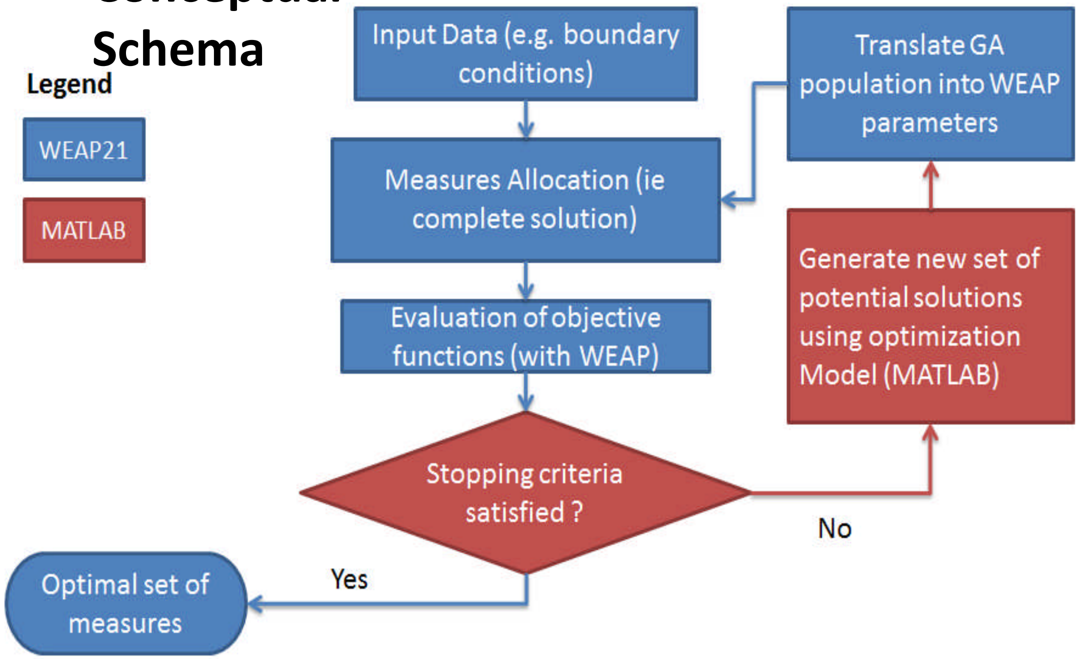
Sector	Water Saving Measures	Water Saving	Unit Cost
Domestic	Frequent monitor and leakage repair in the water supply network	5-7% [1]	
	Replacement of old water supply pipes	20% [2]	
	Promotion of water saving devices in households and offices	29-41% [1]	
	Low flow taps	15% [1]	
	Motion sensor taps	70% [1]	
	Dual toilet flashes	32-55% [1]	150 €/item [1]
	Shower heads	33-44% [1]	20 €/item [1]
	Washing machines	25-33% [1]	600-1000 €/item [1]
	Dishwashers	30-40% [1]	
	Promotion of water saving devices in tourist establishments	10-52% [1]	
	Increase water pricing by 11,9%	8,3% [3] / 7,1% [5]	
Industry	Change of processing type	20-40% [7]	
	Improve the efficiency of heating and cooling systems	variable [7]	
	Water recycling and recurculation	50-90% [7]	
	Rainwater hasrvesting	-	
	Promotion of water saving devices	29-41% [1]	
	Increase water pricing by 10% 10%	2% [8]	

Measures & Optimization

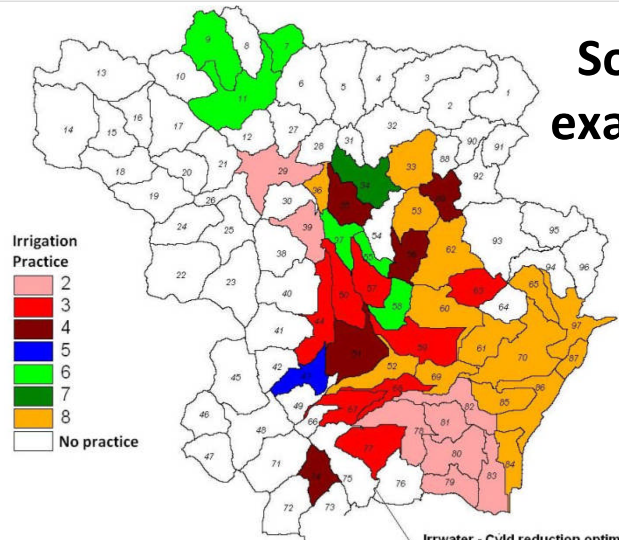


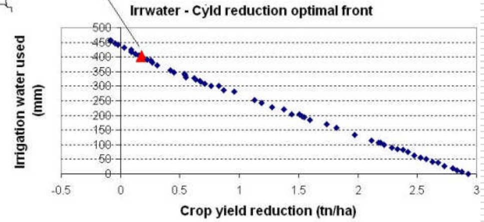
- Coding of BMPs and measures in WEAP and scripting
- Coupling WEAP21 and Matlab GA
- The algorithm will allocate BMPs and technological interventions throughout the catchment, maximizing the cost-benefit function

Conceptual Schema



Solution examples





Multi-objective optimization to identify optimum measures allocation schemes across the catchment

Task E: TARGET

Activity E1: Derive indicative targets

Activity E2: Assessing targets' robustness under alternative future

Activity E3: Policy Briefing and Dissemination future

Thank you!