PRESPA LAKE WATERSHED MANAGEMENT PLAN

Project achievements

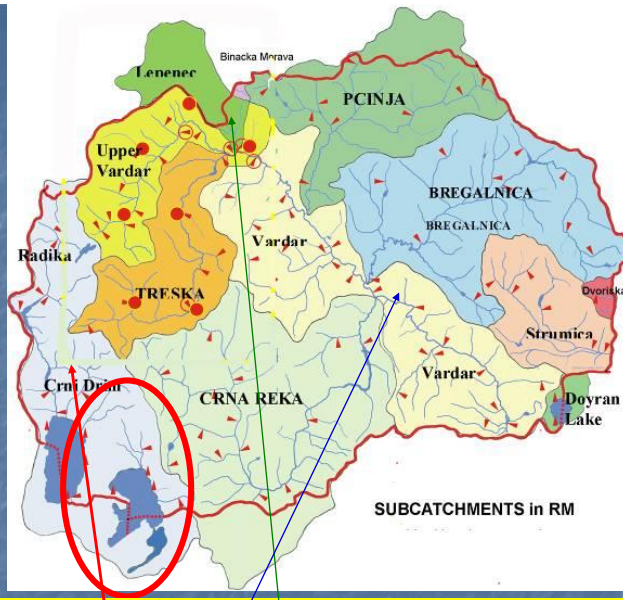
Prof. d-r Ivan Blinkov
(on behalf of the team)

- **Билатерален состанок меѓу Министерството за животна средина и просторно планирање на Република Македонија и Министерството за животна средина и води на Република Бугарија на тема: Управување со водиSeptember**
- **13-12, 2013 , Скопје**

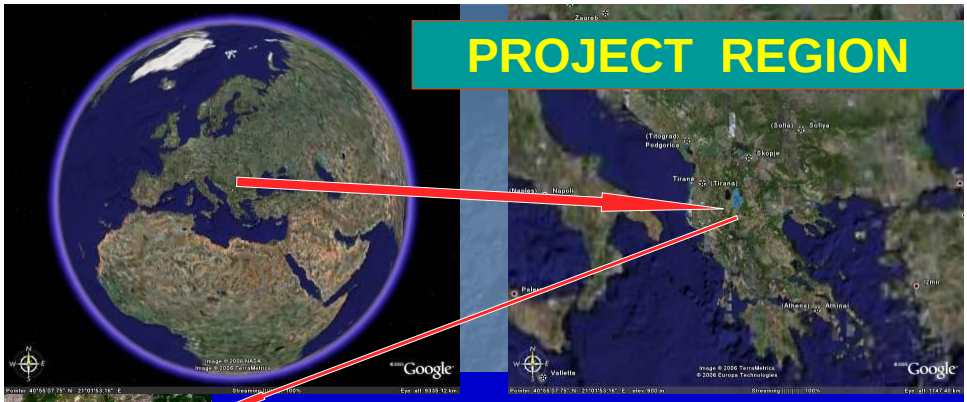
The total water resources
6,37*10^9 m^3 (normal year)
4,80*10^9 m^3 dry year),
out of which 80% are carried in the Vardar basin.

3100 m^3/capita

Uneven spatial and timely distribution over the country, more favorable conditions in the WM but being characterized over all the national territory by a timely distribution which presents long drought spells and high intensity rainfalls which constitute at the same time a threat for crops and which prone erosion phenomena.



-Black Sea basin - (44 km^2 or 0.17 %) ;
- Adriatic Sea basin (3359 km^2 or 13.07 %)
-Aegean Sea basin (22310 km^2 or 86.76%)



- Basin area of 1,600 km^2 shared between the three neighboring countries (MK 62%, AL 17%, GR 21%)
- Approximately 30,000 inhabitants (MK 75%, AL 17%, GR 8%)
- Local economy based on agriculture, tourism, fishing, NTFP's, factories in MK…

has been identified as one of Europe's major trans-boundary "ecological bricks" and biodiversity "hot spot

Prespa Region: Unique Values Of The Ecosystem Under Continuous Stress

- Underlying causes for stress on ecosystem health:
  - Serious decline of the water level of the Prespa Lake
  - Inappropriate scale for land-use and water use planning
  - Ecosystem objectives not sufficiently incorporated into the sectoral legal and regulatory instruments, plans, policies etc.
  - Pollution from pesticides, fertilizers and industrial compounds
  - Waste management practices (agricultural, indust., domestic)
  - Fisheries management practices
  - Forestry management practices
  - Protected areas management
  - Wastewater management
  - Unilateral and piecemeal approach to managing shared resources!!!
- Need for coordinated transboundary action

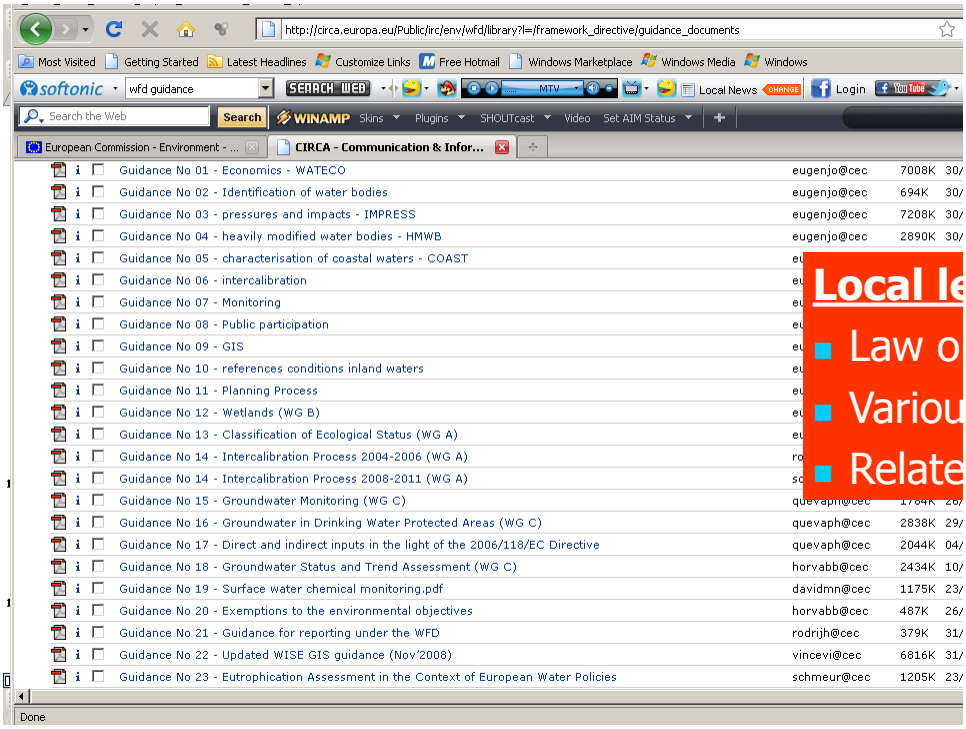
Project facts

- **UNDP Project:** ***DEVELOPMENT of PRESPA LAKE WATERSHED MANAGEMENT PLAN***
- **Reference No.:** ***RFQ 50/2009***
- **Programme:** ***Integrated Ecosystem Management in the Prespa Lakes Basin (No. 00051409)***
- **Project Beneficiary:** ***Ministry of Environment and Physical Planning***
- **Project implemented by:** ***Geotehnicki Inzenering doo, Skopje (GTI)***
- **Project duration:** ***18 months (October 2009 – April 2011)***

TASKS

- ***DEVELOPMENT of PRESPA LAKE WATERSHED MANAGEMENT PLAN***
- **SEA report**
- **Manual for preparation RBMP**

Todor Conevski, grad.civ.eng.	**Team leader**
Prof. d-r Svetislav Krstid, grad. biol.	**Deputy Team leader, water quality**
Prof. d-r Ivan Blinkov, grad.for.eng	**Land use, GIS, harmful impact of water**
M-r.eng. Vladimir Stavric, grad. civ.eng	**WFD principles, WM Planning**
Prof. d-r Ordan Cukaliev, grad. agr.eng	**Irrigation, agriculture**
Jens Longholt, grad.env. eng.	**WM Planning**
M-r Igor Ristovski, grad.env.eng.	**SEA expert**
Zvonko Kočovski, grad. ecc.	**Economist**
M-r Ivan Minčev, grad.for.eng	**GIS / RS**
M-r Ġoko Dinev, grad. arch.	**SEA expert**
Josif Mileski, grad.eng.	**Hydrology**
Mitko Dimov, grad.eng. geol.	**Hydrogeology**
Radmila Bojkovska Spirovska,	**WQ monitoring**
D-r Trajče Talevski	**Fishes**
D-r Marina Talevska	**Macrophyts**
M-r Valentina Slavevska Stamenkovid	**Macrozoobenthos**
Prof. D-r Trajce Stafilov	**Chemical analyses**
D-r Ivanco Kaevski, M-r Sanja Spirovska	**Hydrological modeling Hydrological modeling**
Irina Soreva, grad biol.ecol.	**Field sampling and laboratory**
Martina Blinkova, grad. biol.ecol.	**Field sampling and laboratory**



IDENTIFIED CONSTRAINS

This was the first WMP in the Republic of Macedonia prepared according to the new rules – Water Framework Directive that was incorporated in the current Law on Water (2008).

- **WFD needs are not fully in accordance with the situation in the Republic of Macedonia.**
- **In the WFD guidance documents is noticed that some issues can be adopt to the country need but some issues are perhaps neglected in the legislation**
- **Those topics are: drought, irrigation needs, erosion and torrents.**

Look out! The methodology from this Guidance Document needs to be adapted to regional and national circumstances within the frame of the Directive.

The Guidance Document proposes an overall methodological approach. It describes principles and the processes in the management cycle. Because of the diversity of circumstances within the European Union, the logical approach and answers to questions will vary from one river basin to the other. This proposed methodology will therefore need to be tailored to specific circumstances.

But how to reach WFD goals and purposes when…

(a) There are no continuous data on water quality parameters

(b) There is no monitoring in the watershed

(c) There is no information on human pressures in the watershed

(d) There are no data on priority substances in the watershed

(e) There is no delineation of water bodies in the watershed

(f) There is no information on past conditions in the watershed

(g) There are no reference conditions established in the watershed

(h) There is no GIS database in the watershed

Advantages

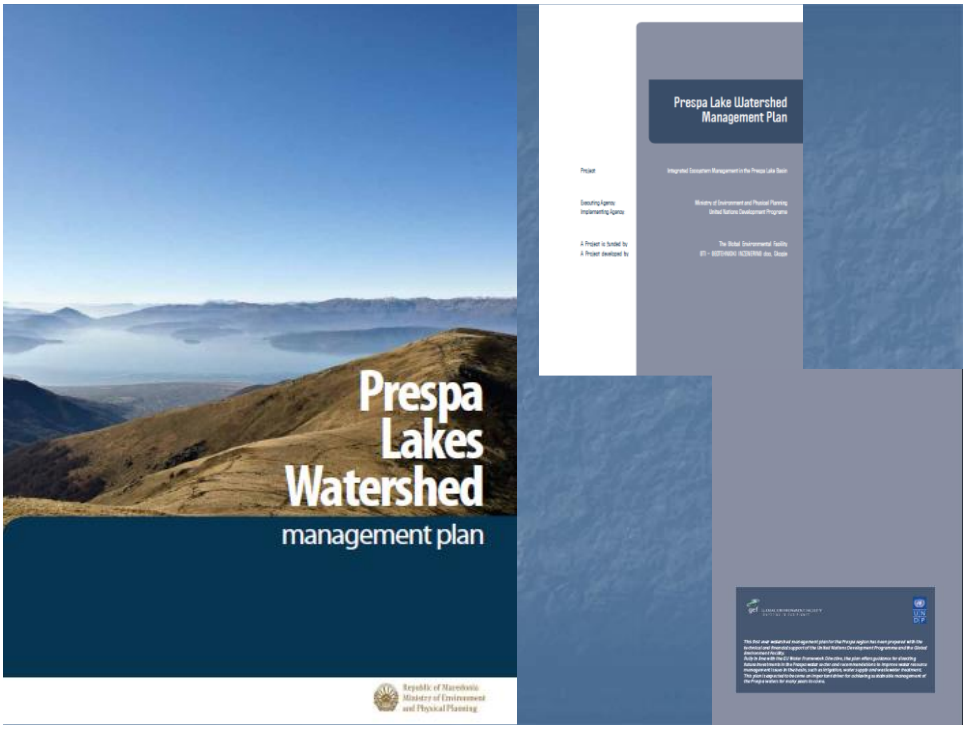
- According to the ToR – 9 experts, we include 23 experts
- Great enthusiasm in the team
- Long term experience of the members of the team in projects in the region

Achievements

- **Watershed Management Plan**,
- *Plan is accompanied with 5 technical reports and 3 annexes,*
- TR - 1 - Data collection and analyses of existing conditions - 53 pgs.
  TR-1 - Annexes - 95 pgs
- TR- 2 - Identification of the major watershed management issues in Prespa Lake Watershed - 267 pgs
  TR-2 Annexes - ID of water bodies - 81 pgs
- TR - 3 - GAP Analyze and Programme of Measures - 75 pgs
- TR- 4 - Public Consultation Process - 45 pgs
- TR-5 Preliminary expert judgment related to protected zones -
  TR-5 – Annex - Maps in scale 1:25000

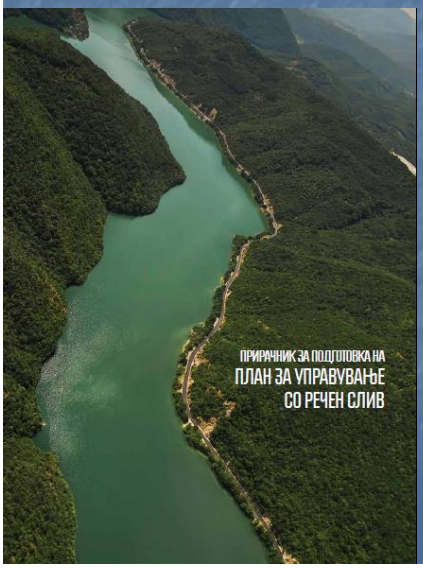
r

- SEA Report,
- Manuel for preparation RBMP (on Macedonian language)
- Complete GIS database.



Manuel for preparation RBMP

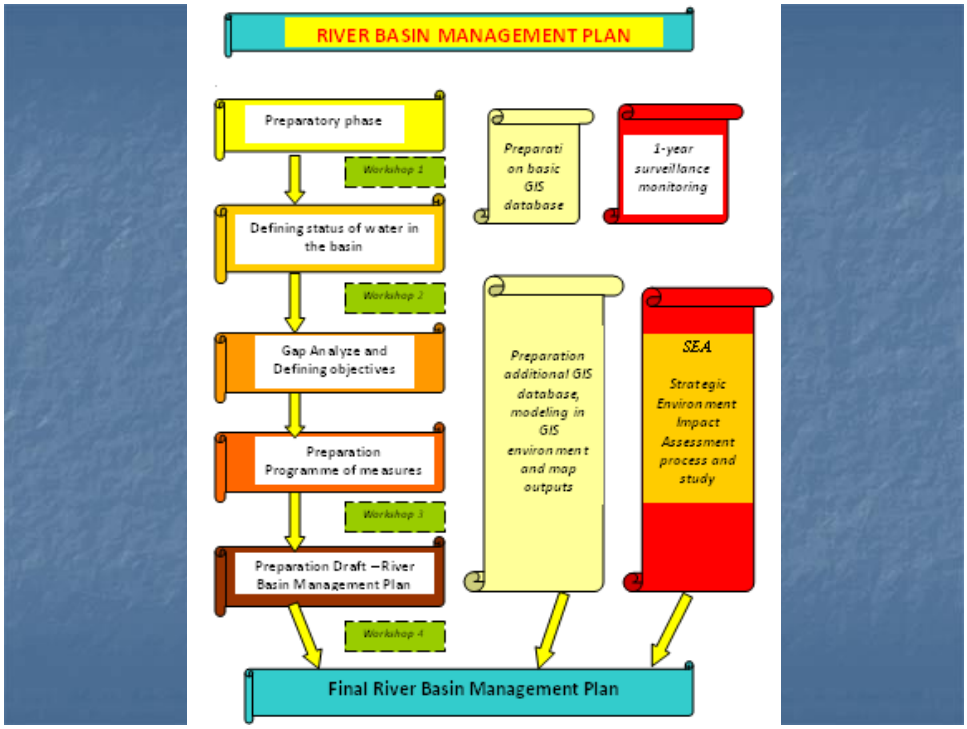
110 pgs



Автор: проф. д-р Иван Блинков

Коавтори: дипл. екон. Звонко Кочовски, Поглавје В. Економски анализи на користењето на вода и 11.1. Економски анализи на алтернативите
проф. д-р Светислав Крстиќ, Анекс 1 – Мониторинг програма

Внатрешна контрола: проф. д-р Орданч Чукалиќ
проф. д-р Светислав Крстиќ
м-р инж. Владимир Стаиќ



EXISTING HYDROMETEOROLOGICAL STATIONS IN PRESPA REGION - MACEDONIAN PART

Meteorological data series – KFW – up to 2004

Hydrological data series - KWF – up to 2004

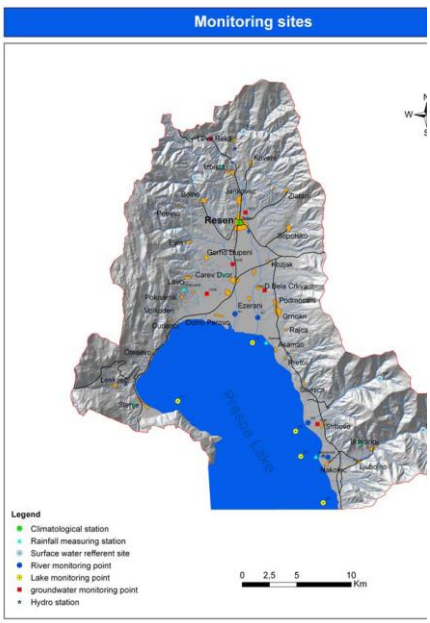
Added data up to 2009

Carried some measuring aimed for WQ aspects

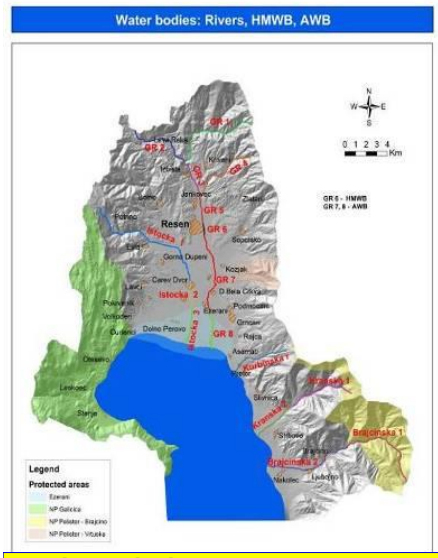
Data for water objects

Collected other relevant data (new abstractions..

Modeling



Delineation of Surface water bodies



Rivers (13) **Lake Wb (1)**

Heavily modified water bodies (1) **Artificial water bodies (2)**

Surface WB typology

- Different for rivers or lakes
- Rivers: typology system A or system B
- All surface WB inn Prespa region belong to eco-region 6 (Hellenic-Western Balkan region), S (small sized basins), M- (mountain basins > 800 masl) , S – (dominant silicate geological structure)
- Surface water bodies are classified as
- Rivers – type 1
- Heavily modified water bodies – type 1h
- Artificial water bodies – type 1a
- Lake – type - 1L

Typology – system A

Name	Eco-region	Altitude	Size	Geology		Type
SURFACE Water Bodies - RIVERS						
Istočka Reka 1	6	M	S	S	*	1
Istočka Reka 2	6	M	S	S		1
Istočka Reka 3	6	M	S	S		1
Golema Reka 1	6	M	S	S		1
Golema Reka 2	6	M	S	S	*	1
Golema Reka 3	6	M	S	S		1
Golema Reka 4	6	M	S	S		1
Golema Reka 5	6	M	S	S		1
Kurbinska Reka 1	6	M	S	S		1
Kranska Reka 1	6	M	S	S		1
Kranska Reka 2	6	M	S	S		1
Brajčinska Reka 1	6	M	S	S		1
Brajčinska Reka 2	6	M	S	S		1
SURFACE WATER BODIES – HEAVILY MODIFIED WB						
Golema Reka 6	6	M	S	S		1h
SURFACE WATER BODIES – ARTIFICIAL WB						
Golema Reka 7	6	M	M	S		1a
Golema Reka 8	6	M	M	S		1a

Name		*Lake Prespa*
Eco-region	Hellenic Western Balkan	6
Altitude	844,3 – 853,4	M
Size	259,4 [>100 km^2]	L
Geology	Silicate / Carbonate	S/C
Depth	55 m [>15 m]	
Type		**1L**

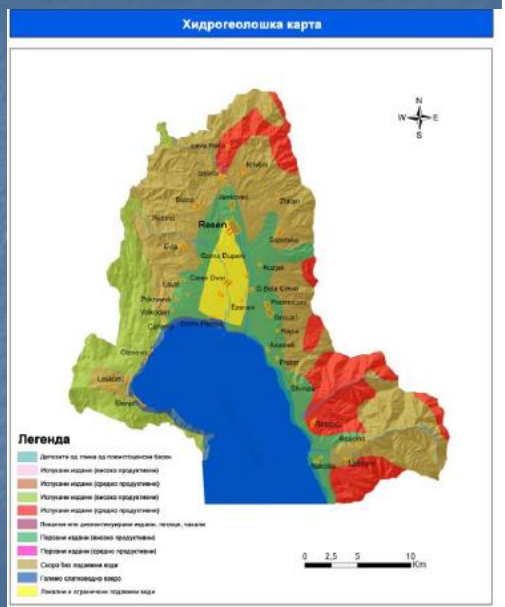
Delineation of Ground water bodies

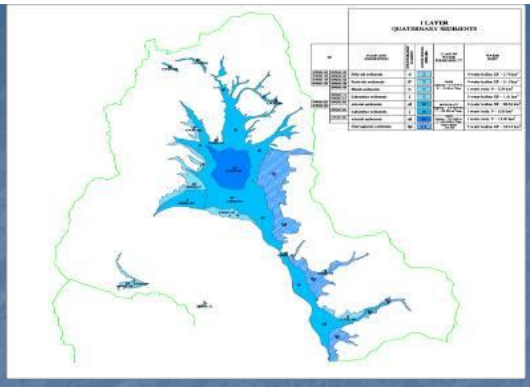
GWB should be delineated in 3 dimension.

Delineation was done according to the SHARIN water permeability classes.

GWB in Prespa are located in 3 different layers

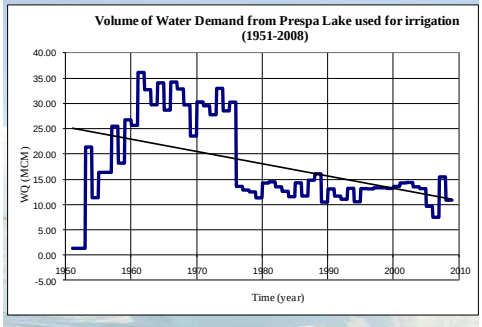
There are 6 delineated GWB:
3 in Quaternary sediments ,
1 in Pliocene sediments
2 in Triassic carbonate rocks





NO.	GWB	SURFACE (km^2)	STRATIGRAPHIC ELEMENT	GEOLOGIC LAYER	TYPE OF AQUIFER	CLASS OF WATER PERMEABILITY
1	GWB01201	68.08	Q [al + pr + j]	Youngest Quaternary sediments	porous	poor & moderate
2	GWB01202	15.45	Q [al]		porous	moderate
3	GWB01301	13.20	Q [al]		porous	high
4	GWB02201	118.03	Pl_3	Upper Pliocene sediments	porous	moderate
5	GWB03201	11.80	$T_2^{1,2}$	Middle and Upper Triassic carbonate rocks	karstic	moderate
6	GWB03301	96.73	$T_2^{1,2}$		karstic	high

Water use and pressures



#	Settlement	Connection to WS and WW systems	Percentage of coverage by the central WW system	Untreated wastewater discharge (m3/day)	Effective Pollution Load (kg BOD/day)	Effective Pollution Load (kg TSS/day)	Effective Pollution Load (kg P/day)	Effective Pollution Load (kg N/day)	Type of Impact to Golema Reka
1	Resen	WS + WW	70%	356.9	131.2	183.7	5.8	7.7	Direct
2	Krusje	WS	0%	10.4	4.3	6.0	0.2	0.2	Indirect
3	Leva Reka	WS	0%	5.9	2.4	3.4	0.1	0.1	Indirect
4	Izbiste	WS	0%	17.2	7.0	9.9	0.3	0.4	Indirect
5	Krveni	WS	0%	2.6	1.1	1.5	0.0	0.1	Indirect
6	Jankovec	WS + WW	60%	84.2	28.1	39.3	1.2	1.6	Direct
7	G. Bela Crkva	WS	0%	18.2	7.5	10.5	0.3	0.4	Direct
8	D. Bela Crkva	WS	0%	23.1	9.5	13.3	0.4	0.6	Direct
9	Ezerani	WS	15%	16.8	8.1	11.4	0.4	0.5	Direct
10	Podmocani		0%	29.8	12.2	17.1	0.5	0.7	Indirect
11	Grocari		0%	40.7	16.7	23.4	0.7	1.0	Indirect
12	Sopotsko		0%	21.6	8.9	12.4	0.4	0.5	Indirect
13	Zlatari	WS	0%	11.5	4.7	6.6	0.2	0.3	Indirect
14	Kozjak	WS	0%	11.4	4.7	6.6	0.2	0.3	Indirect
	Total		55%	650	246	345	11	14	

Map of water objects

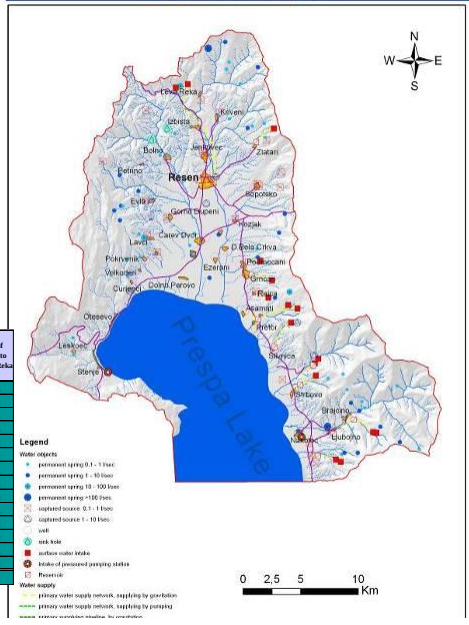


Table 4.3-8. Characteristics of main water objects – Sheet: Lerin 1

Map - Lerin 1	Cadastral number	Type of water object and location	capacity [m³/day]	Volume of object [m³]	depth of groundwater [m]	Possibility for pollution	Possibility for drinking
1	2	3	4	5	6	7	8
1		wells .Asamati(11)					
2	469	water supply. Asamati & Kurbinovo					
2./2	469	reservoir Asamati. Pretor				no	yes
3	470	captured source .Rajca	86,4		0	no	yes
4	3455/2	spring	25,92		0	no	yes
5	3454	spring	302,4		0	no	yes

- City of Resen and few villages connected to common water supply system
- The second WSS is local (Kurbinovo-Asamati-Pretor) 500 inhabitants.
- Other settlements – independent local systems

- Daily Water needs
- - for industry 700 m³/ден
- - For citizens 110 l/capita

- Experience from the latest dry period – lack of 30 l/s

Irrigation

- **WUC - 2500 ha** (300ha system, 2200 wells and rivers)
- Irrigation techniques: drip irrigation (70%), furrows (30%)

- **Irrigation system Prespa (more then 60 years old)**
- **3 sub-systems - needed rehabilitation / reconstruction**
- **In operation 15 June – 15 September**
- **Designed capacity** 1,8 m³/s or 15.552.000 m³/annualy
- Year 2000 – 88,98% of total water demand used for irrigation (83,2% from lake, 10,9 % groundwater, rivers - 4,98%, springs 1,71%)

- CCA **8000-1000 wells on private land**
- **Beside wells, there are intakes fro irrigation - illegal**
- Generally significant water loss

Drip irrigation system:
2 sprinklers 6-8 l/h
Apple stand - 1000 trees/ha - 12000-16000 l/h
Duration 4-7 days - **1152 – 2688 m³/ha**

WATER RESOURCES and WATER USE

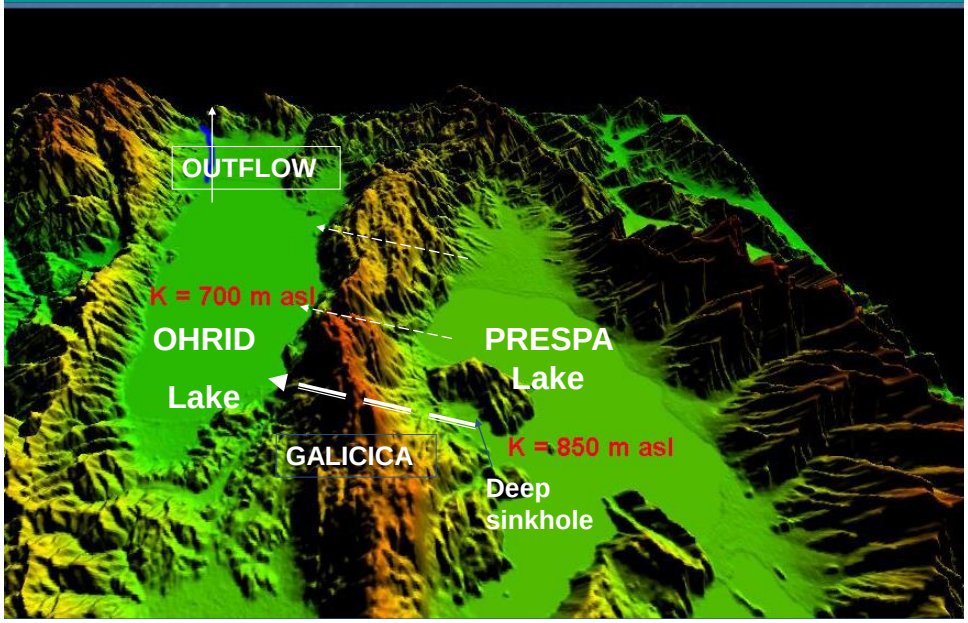
- Total water resources - 250×10^6 m^3/ann.
- Lack of water in the east part of the basin. Following the strategy for development of tourism, increase of lack of water
- Lake level fluctuation dominantly depend on natural factors.
- **"Illegal" water use**
  – wells (impact on groundwater and the lake ecosystem too)
  - intakes on streams – cause dry stream beds and impact ecological status

Water Balance Equation:

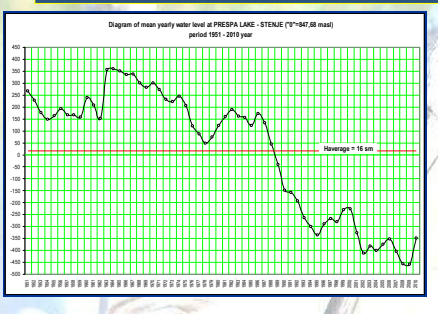
$$Wak(i,j) = Wak(i,j-1) + Winf(i,j) - W_{EF}\,evap\,(i,j) - Wdem(i,j) - Wkars(i,j) \quad [MCM]$$

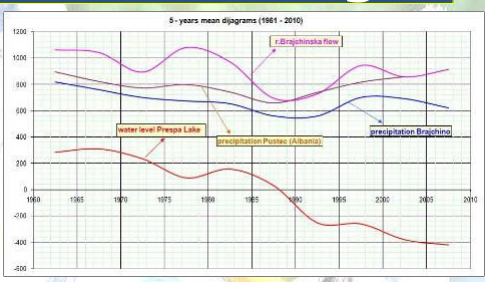
- ***i*** **= index of year**
- ***j*** **= index of month in the year *i***
- **Wak(*i,j*) = lake volume in the year *i*, and month *j***
- **Wak(*i,j-1*) = lake volume in the year *i*, and month *(j-1)***
- **Winf(*i,j*) = runoff volume from the contributing catchment areas**
- **W_{EF} evap (*i,j*) =volume of net evaporation (achieved by subtracting the lake's surface evaporation from total rainfalls into the Lake)**
- **Wdem(*i,j*) = volume of extractions from the Prespa Lake (water demand for water supply and irrigation)**
- **Wkars(*i,j*) = outflow volume from the Prespa Lake into the Ohrid Lake**

Flow for Prespa Lake to Ohrid Lake through the karst mountain Galicica

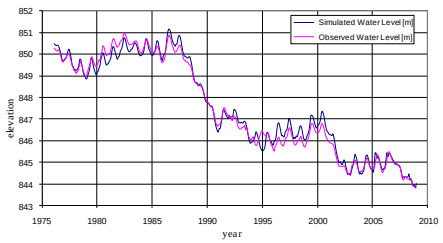


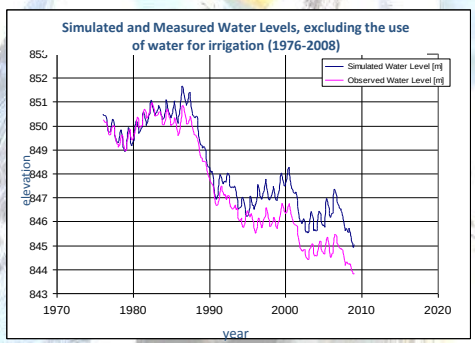
Water balance modeling

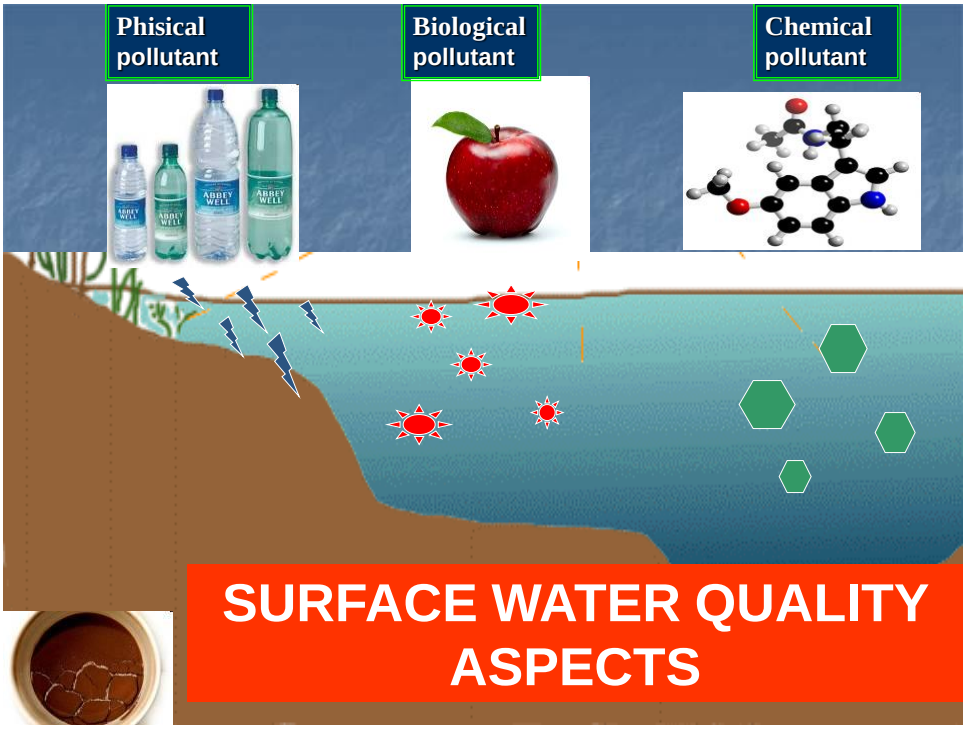




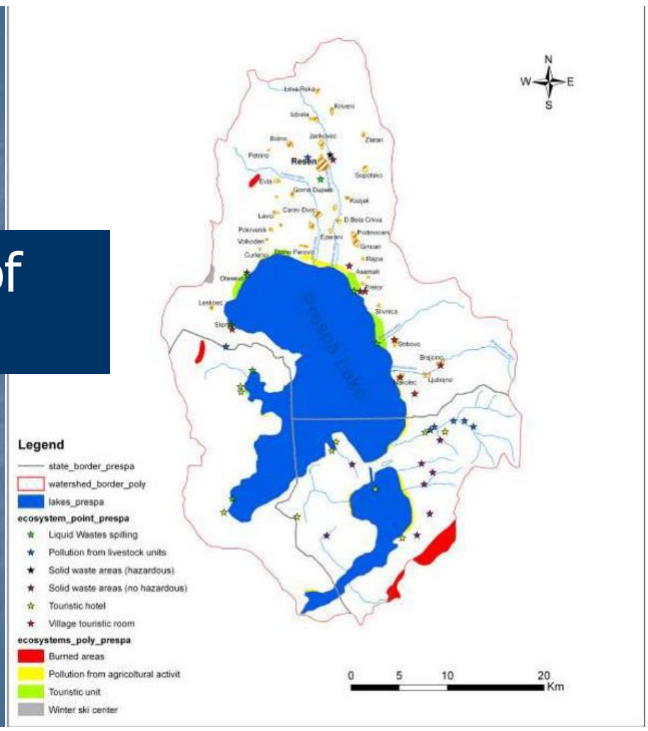
Measured and Simulated Prespa Lake Water Levels (19762008)





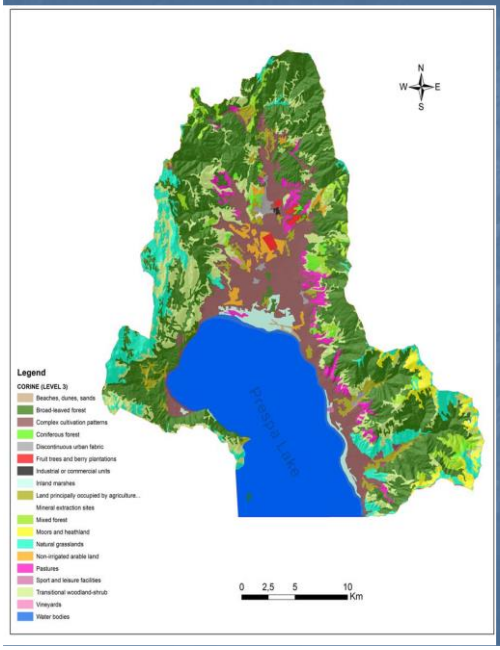


Sources of pollution



Indicator:	SwissLion (Agroplod) doo (5.11.2008) 3rd point (biscuits-napolitana)	SwissLion (Agroplod) doo (5.11.2008) 2nd point (resana cakes)	SwissLion (Agroplod) doo (5.11.2008) 1st point (coffee & peanuts)	Algreta AD Resen (14.10.2009) Recipient Golema River	CD Frut, Carev Dvor (28.11.2008) Recipient Bolsnica river	MDK (II class waters)*	Total:
Fe (mg/L)	/	/	/	>1	0,25	0,3	1,25
Mn (mg/L)	/	/	/	0,315	0,3	0,05	0,615
Al (mg/L)	/	/	/	0,009	/	1-1,5	0,009
Cd (mg/L)	/	/	/	/	0,0005	0,0001	0,0005
Cl_2 (mg/L)	14,9	17,7	82,2	/	0,0025	0,002	114,8
Cr total (mg/L)	/	/	/	/	0,038	0,05	0,038
Cu (mg/L)	/	/	/	/	0,012	0,01	0,012
Ni (mg/L)	/	/	/	/	0,035	0,05	0,035
Zn (mg/L)	/	/	/	/	0,075	0,1	0,075
Turbidity (NTU)	20	10	20	393	/	0,5-1	443
Total *N* (mg/L)	/	/	/	/	/	0,2 -0,32	
TDS *(mg/L) in: surface waters, ground waters*	385	290	580	/	146	500	1.401
Total *P* (mg/L)	/	/	/	/	/	10 – 25	
Eutrophication Indicators – *Most probable number of thermo-tolerant coli form bacteria No/100 ml*	240.000	240.000	240.000	/	/	5 – 50	240.000

Land Cover / Use



Apple stands

Table 29: Land cover/use distribution

CORINE - Class	ha	%
Beaches, dunes, sands	85,82	0,1
Broad-leaved forest	24828,78	32,6
Complex cultivation patterns	9653,27	12,7
Coniferous forest	619,19	0,8
Discontinuous urban fabric	361,34	0,5
Fruit trees and berry plantations	251,44	0,3
Industrial or commercial units	23,09	0,0
Inland marshes	1114,03	1,5
Land principally occupied by agriculture, with significant areas of natural vegetation	2027,16	2,7
Mineral extraction sites	22,88	0,0
Mixed forest	1716,77	2,3
Moors and heathland	1371,80	1,8
Natural grasslands	5033,95	6,6
Non-irrigated arable land	910,61	1,2
Pastures	1693,68	2,2
Sport and leisure facilities	23,83	0,0
Transitional woodland-shrub	8102,53	10,6
Vineyards	35,81	0,0
Water bodies	18258,29	24,0

Water body or Sub-catchment	Apple area	Input of N	Input of P2O5	Input of K2O [kg]	*Total input of fertilizers*	Input of fungicides	Input of herbicides	Input of insecticides and acaricides	*Total input of pesticides*
	[ha]	[kg]	[kg]	[kg]	*[kg]*	[kg]	[kg]	[kg]	*[kg]*
Istočka Reka 1	309,5	73970,1	38377,8	83874	*196221,9*	3095	257,2	1808,8	*5161*
Istočka Reka 2	402,5	96197,7	49910,1	109077,7	*255185,5*	4025	334,5	2352,3	*6711,8*
Istočka Reka 3	45,1	10773,3	5589,5	12215,7	*28578,5*	450,8	37,5	263,4	*751,7*
Golema Reka 1	22	5267,3	2732,8	5972,5	*13972,6*	220,4	18,3	128,8	*367,5*
Golema Reka 2	14,1	3360,1	1743,3	3810	*8913,4*	140,6	11,7	82,2	*234,4*
Golema Reka 3	135,1	32288,9	16752,4	36612,1	*85653,4*	1351	112,3	789,5	*2252,8*
Golema Reka 4	45,6	10909,9	5660,4	12370,7	*28941*	456,5	37,9	266,8	*761,2*
Golema Reka 5	260,4	62244	32294	70577,9	*165115,9*	2604,4	216,5	1522	*4342,8*
Golema Reka 6	116,8	27911	14481	31648,1	*74040,1*	1167,8	97,1	682,5	*1947,4*
Golema Reka 7	935,6	223597,1	116008,5	253534,8	*593140,4*	9355,5	777,6	5467,5	*15600,6*
Golema Reka 8	49,9	11936,9	6193,2	13535,1	*31665,2*	499,5	41,5	291,9	*832,9*
Kurbinska Reka	16,8	4007,1	2079	4543,6	*10629,7*	167,7	13,9	98	*279,6*
Kranska Reka 1	4	952,8	494,3	1080,3	*2527,4*	39,9	3,3	23,3	*66,5*
Kranska Reka 2	110,5	26412,8	13703,7	29949,3	*70065,8*	1105,1	91,9	645,9	*1842,9*
Brajčinska Reka 1	0	0	0	0	*0*	0	0	0	*0*
Brajčinska Reka 2	83,2	19883,5	10316,1	22545,8	*52745,4*	831,9	69,1	486,2	*1387,3*
Galičica with Prespa Lake	757,6	181067,9	93943,2	205311,3	*480322,4*	7576,1	629,7	4427,6	*12633,3*
Istočka Reka- Golema Reka	9,3	2233,2	1158,7	2532,3	*5924,2*	93,4	7,8	54,6	*155,8*
Golema - Kurbinska	194,5	46488,5	24119,5	52712,9	*123320,9*	1945,1	161,7	1136,8	*3243,6*
Kurbinska - Kranska	166,7	39837,9	20669	45171,9	*105678,8*	1666,9	138,5	974,1	*2779,5*
Kranska - Brajčinska	72,5	17330,5	8991,6	19651	*45973,1*	725,1	60,3	423,8	*1209,2*
Brajčinska – Markova noga	98,2	23479,5	12181,8	26623,2	*62284,5*	982,4	81,7	574,1	*1638,2*
Total	3850	920150	477400	1043350	2440900	38500	3200	22500	64200

ESTIMATION OF DIFFUSE SOURCE POLLUTION

Floods

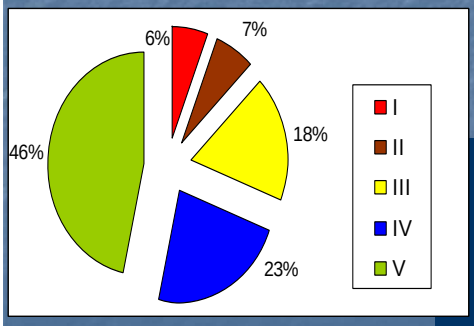
- The most frequent is ***snow melting in combination with high river water level, which*** appears in the lower parts of the major watercourses. The most affected areas are the Brajčinska and Golema Rivers. High underground water level is customary for the spring period, particularly for Resen field when interaction of surface and underground water creating ponds in above areas is noticeable. Flows of the Brajčinska and Golema Rivers bigger than 15 m^3/s contribute to this condition.

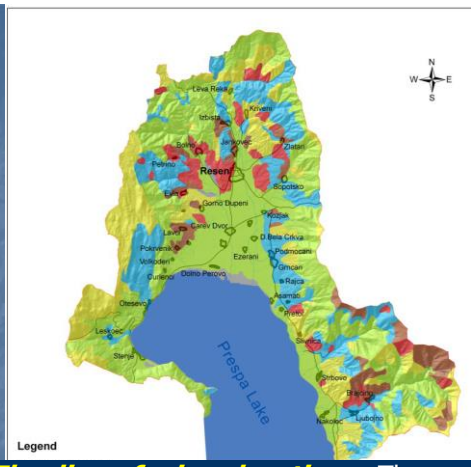
- ***Floods of bigger rivers*** appear when river flows are larger than 40 m3/s. Three floods of this type have been recorded over the past century, the most noticeable ones being in 1942, 1962 and 1979. The watershed of the Golema Reka River produced the largest flooded area; downstream of Resen, all the way to it's mouth into the lake. The Brajcinska River has a bigger destructive power, rolling massive blocks from Baba Mountain, and unlike the Golema River, which brings more eroded material. The maximum water flows of the Brajcinska River (Qmax = 45.7 m3/s), and the Golema River (36.7 m3/s) were recorded in November 1962 flood.

- ***Lake water entering inhabited places and agricultural land floods*** took place in the past century, in 1942/43 and 1963, flooding the villages of Nakolec, Asamati, Ezerani, Perovo and large areas of agricultural land. The lake level reached its highest value of 851.93 m a.s.l. (Macedonian levels).The most important recorded floods happened on: November 1962, November 1963, and November 1979.

EROSION AND TORRENTS

- Average annual erosion coefficient of the basin is total of **Z = 0.33 – IV cat.**





Flooding of micro-locations . The high-intensity short-term rains activate dry ravines very fast, bringing huge quantities of eroded material and effusing in the villages and agricultural land. The most dangerous torrents are situated on the eastern coast (the Dolno Dupenska River, the Podmočanska/Avatska River, etc.).

Sediments and siltation of the lake

Sediment Production on the basin

E = 260 352 m^3/ y ; Esp = 456 m^3/km^2 y [4,5 t/ha.ann]

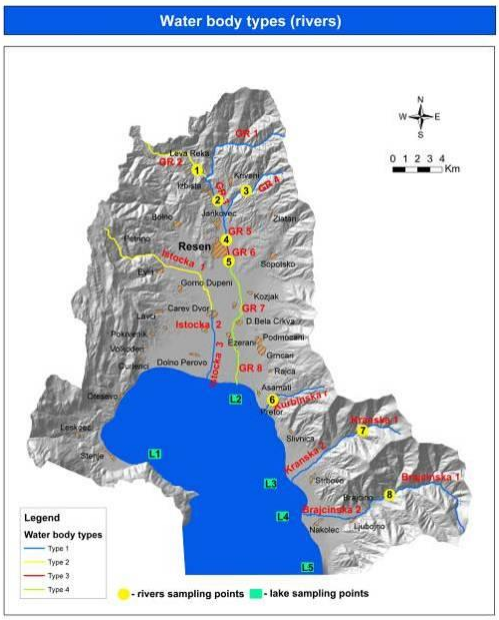
Sediment yield (income to the lake)

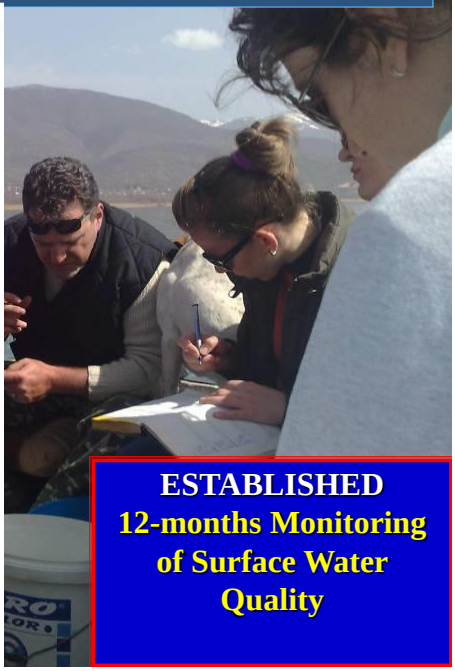
G = 163 536 m^3/ y ; Gsp = 286 m^3/km^2 y [2,8 t/ha.ann]

Damages: Mechanical pollution, transport of nutrients (N, P) from agriculture land, transport of other pollutants etc.

	River name	Basin area A [km^2]	Eros.coeff Z	Sedim.prod W [m^3/y]
1	Golema Reka	166,86	0,32	71 991
	Leva Reka	*31,50*	*0,35*	*15 184*
2	Istocka Reka	89,00	0,41	55 091
	Bolnska Reka	*42,43*	*0,40*	*25 246*
3	Brajcinska Reka	71,70	0,46	49 420
4	Kranska Reka	35,40	0,30	12 409

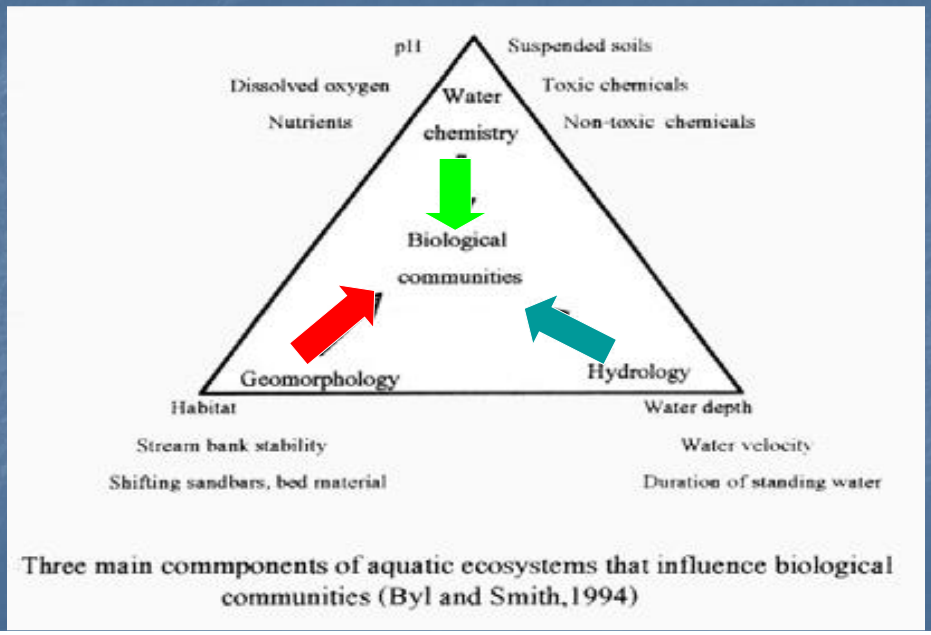
MACRO PRESPA LAKE





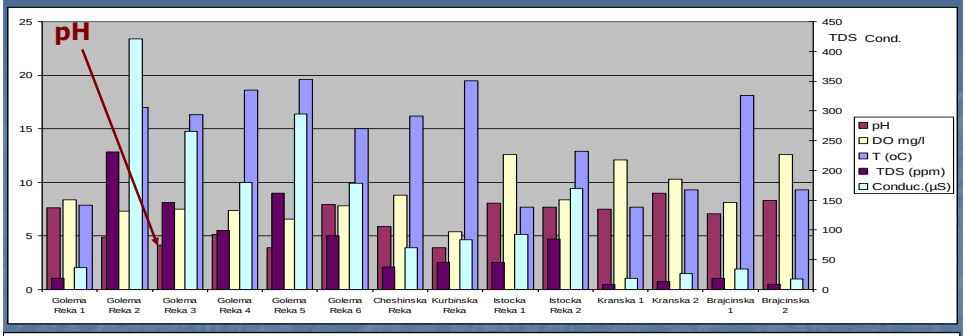
ESTABLISHED
12-months Monitoring of Surface Water Quality

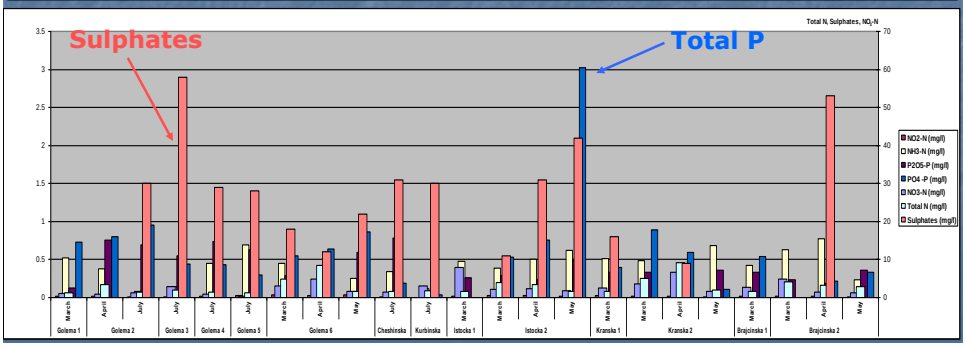
Physical and Chemical Parameters <-------> Biological communities



Three main commponents of aquatic ecosystems that influence biological communities (Byl and Smith,1994)

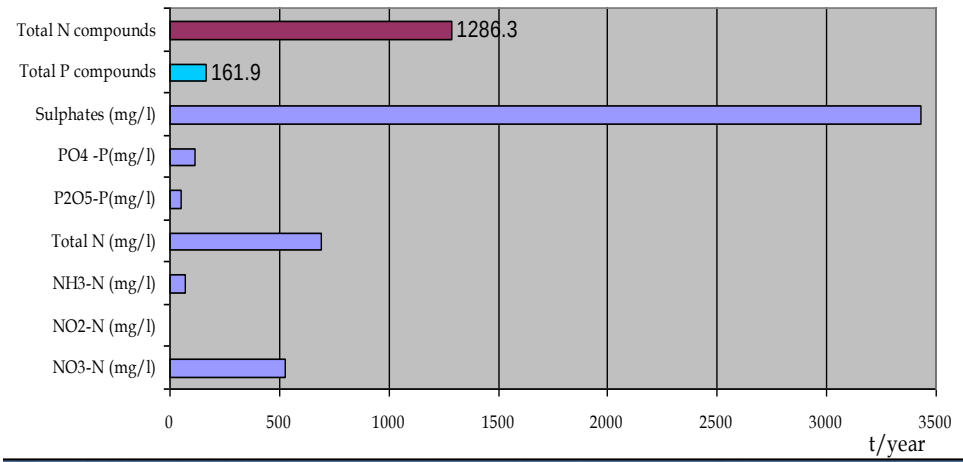
RIVERS – basic physic-chemical parameters



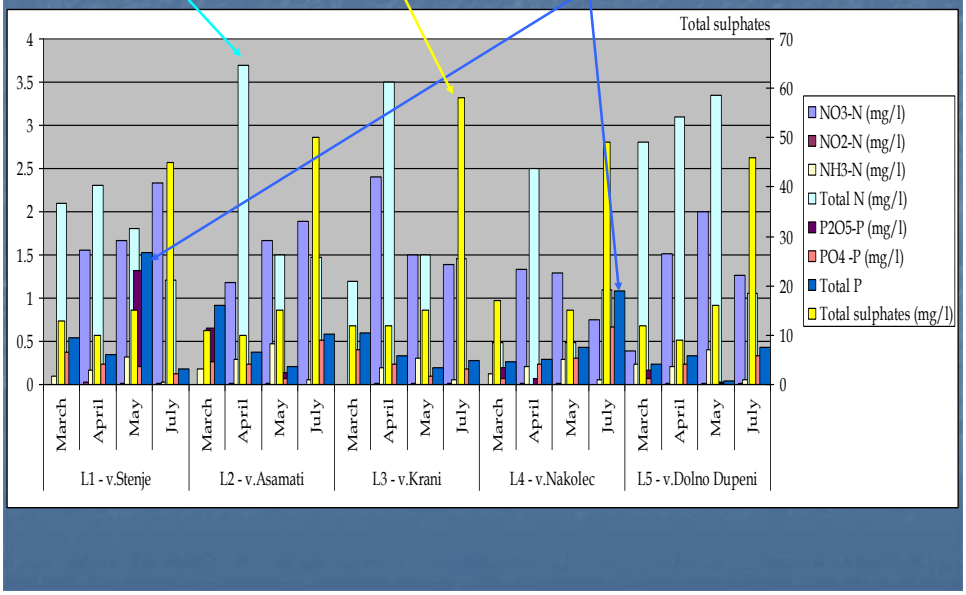


RIVERS – nutrient load to Prespa Lake

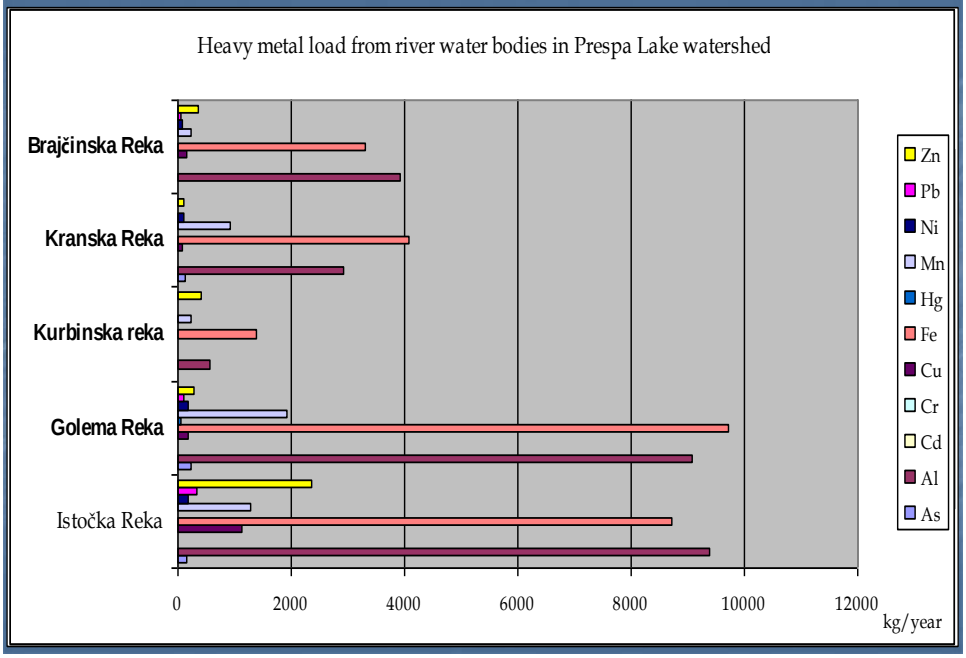
Total input of nutrients from rivers into Prespa Lake



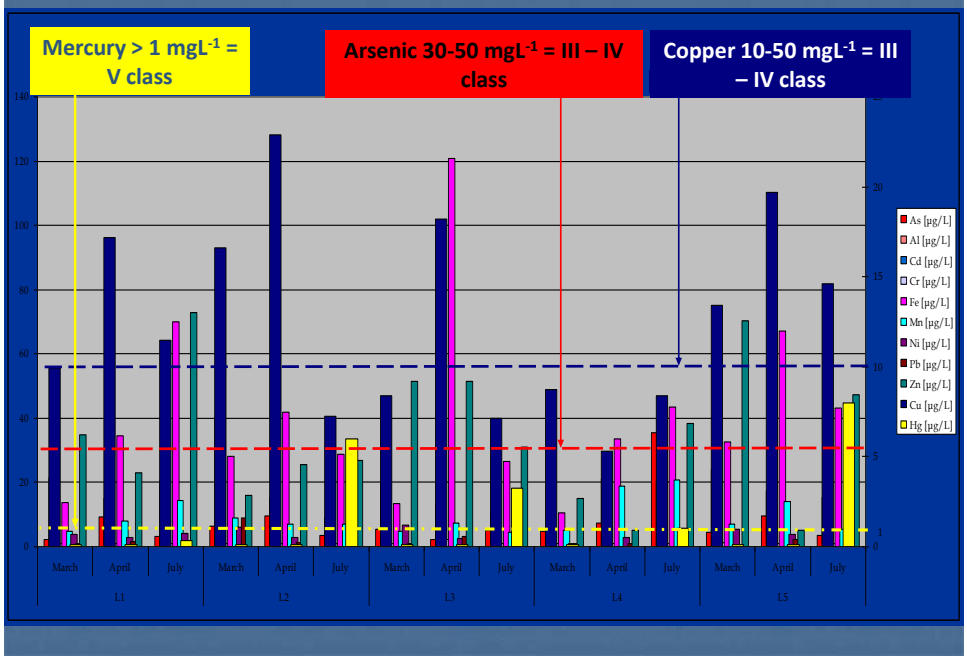
PRESPA LAKE – Nutrients status



RIVERS – heavy metals load to Prespa Lake

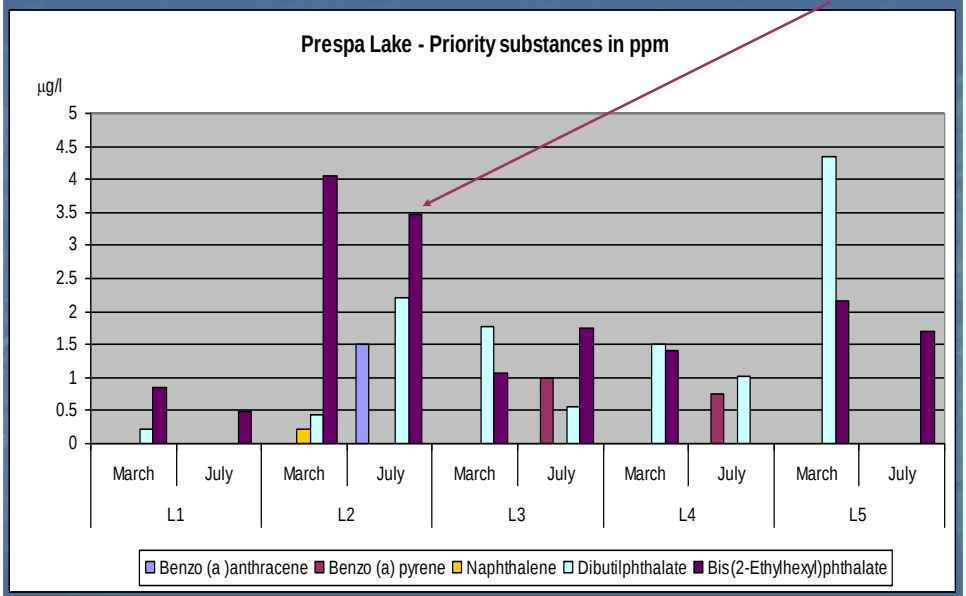


PRESPA LAKE – Heavy metals

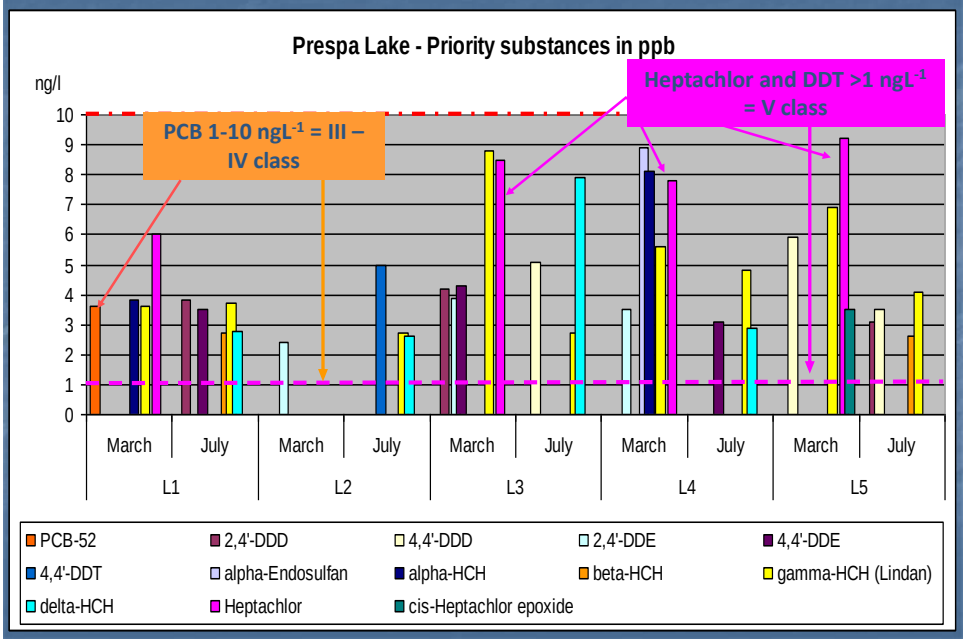


PRESPA LAKE – Priority substances

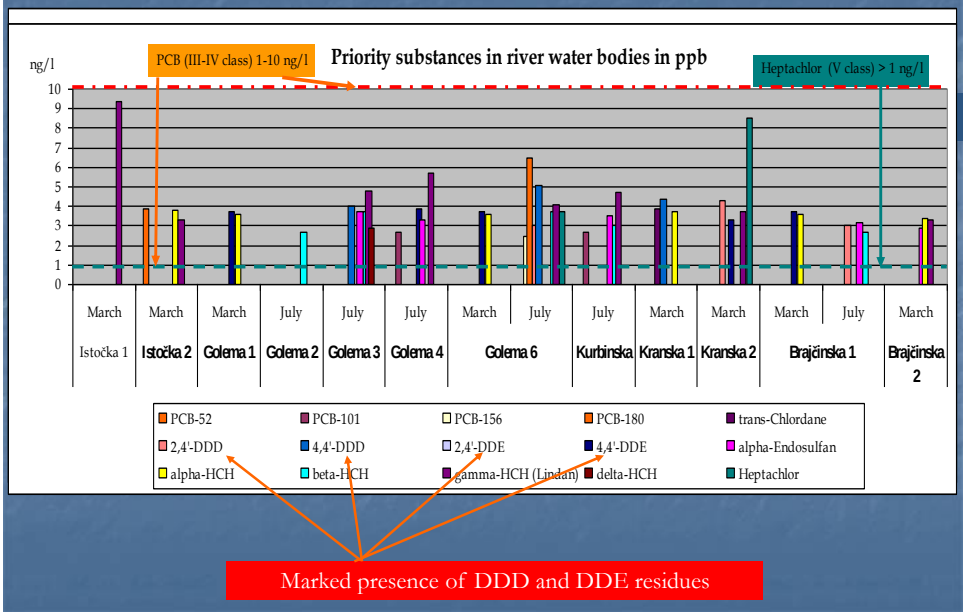
Phthalates dominate as in rivers



PRESPA LAKE – Priority substances

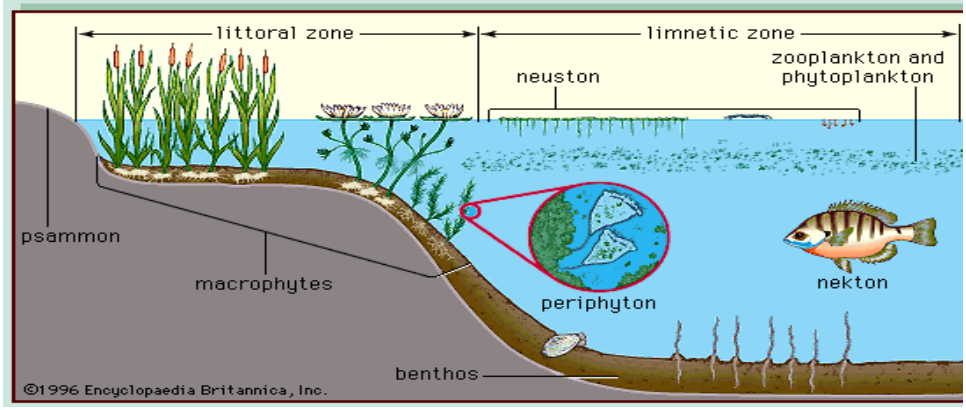


RIVERS – priority substances



Determining the water quality through biological elemenths

Algae
Macrozoobenthos
Macrophyta
Fishes



Field sampling

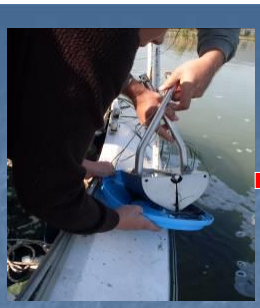
Collection of bottom fauna samples was performed by several different devices:

Ekman grab, sediment corer, triangle bottom dredge and hand net. Macroinvertebrate standard methods applicable to lakes were used (ISO 9391:1995 and ISO 7828:1985).

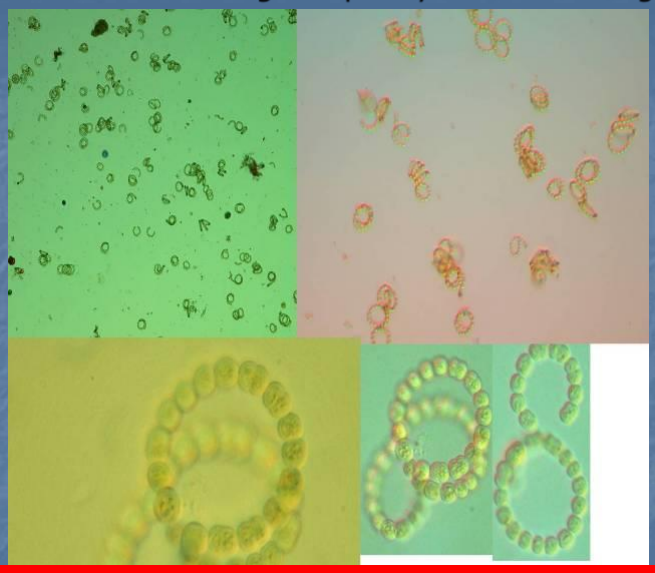
- P =a2
- a=15
- P = 225 cm2
- A = k • ind.m2
- **A = 44,45 •ind.m2**

- [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]

Concerning to the main tributaries of Prespa Lake, benthic invertebrates samples were collected with a Surber sampler or hand-net following standard methodology for collection of bottom fauna (ISO 8265:1988 and ISO 7828:1985)

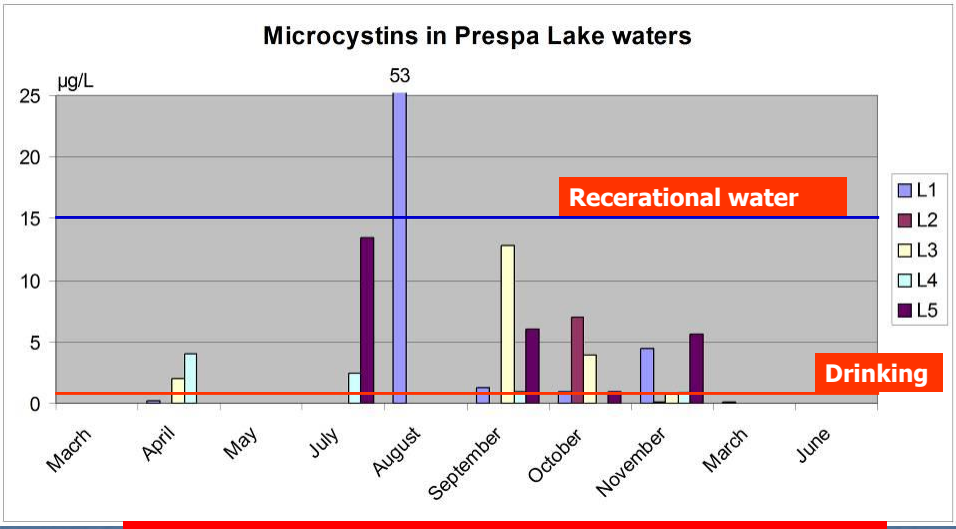


PRESPA LAKE – Ecological quality elements - algae



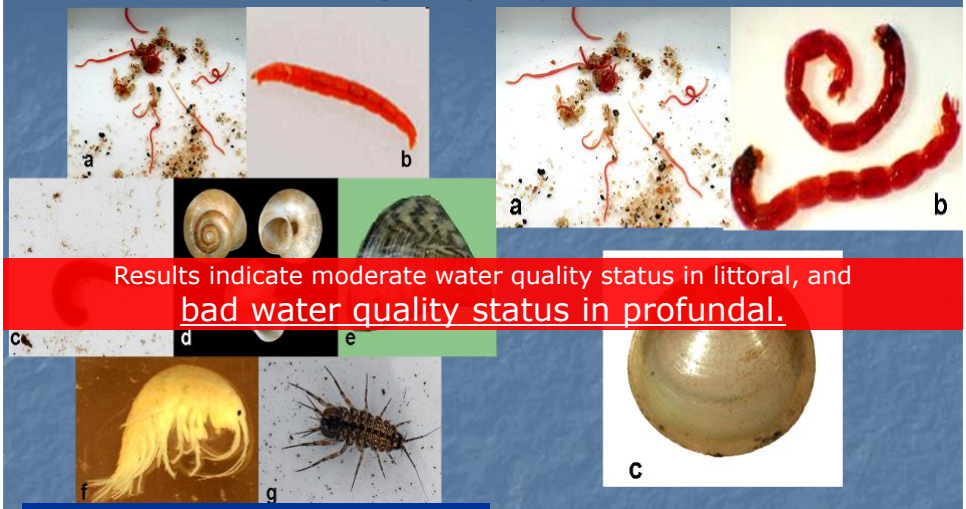
Mass development of Anabaena affinis
INDICATION OF ACCELERATED EUTROPHICATION AND ***BAD WATER QUALITY STATUS*** *DURING SUMMERS*

CYANOTOXINS – toxins produced by blue-green algae in mass development – **'water blooms'**



Allowed (safe) concentrations according to WHO –
1 μgL^{-1} – drinking waters
10-20 μgL^{-1} – recreational waters

PRESPA LAKE – Ecological quality elements - zoobenthos



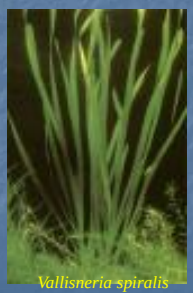
Results indicate moderate water quality status in littoral, and bad water quality status in profundal.

Dominant taxa in littoral:
a) ***Potamothrix hammoniensis,*** b) ***Dicrotendipes nervosus,*** c) ***Erpobdella lineata,*** d) ***Valvata piscinalis,*** e) ***Dreissena polymorpha,*** f) ***Gammarus triacanthus,*** g) **Asellus aquaticus**

Dominant taxa in profundal:
a) ***Potamothrix hammoniensis,*** b) ***Chironomus plumosus,*** c) ***Pisidium sp.***

PRESPA LAKE – Ecological quality elements - macrophytes

Myriophyllum spicatum



Vallisneria spiralis

	Species
1.	*Phragmites australis* (Cav.) Trin. ex Steud.
2.	*Phalaris arundinacea* L.
3.	*Typha latifolia* L.
4.	*Typha angustifilia* L.
5.	*Typha laxmannii*
6.	*Shoenoplectus lacustris* (L.) Palla
7.	*Scirpus sylvaticus* L.
8.	*Heleocharis pallustris* R.Br.
9.	*Cyperus longus* L.
10.	*Alisma plantago - aquatica* L.
11.	*Bidens tripartita* L.
12.	*Rorippa amphibia* (L.) Bess.
13.	*Callitriche verna* L.
14.	*Hydrocharis morsus-ranae* L.
15.	*Lemna minor* L.
16.	*Lemna trisulca* L.
19.	*Potamogeton perfoliatus* L.
20.	*Potamogeton pectinatus* L.
21.	*Potamogeton lucens* L.
22.	*Potamogeton crispus* L.
23.	*Potamogeton pussilus* L.
24.	*Potamogeton gramineus* L.
25.	*Zannichellia palustris* L.
26.	*Myriophyllum spicatum* L.
27.	*Ceratophyllum demersum* L.
28.	*Ceratophyllum submersum* L.
29.	*Vallisneria spiralis* L.
30.	*Najas major* All.
31.	*Najas minor* All.
32.	*Utricularia neglecta* Lehm.

Results point to moderate status.

Hydrocharis morsus-ranae

Phragmites australis

PRESPA LAKE – Ecological quality elements - fishes

Rutilus rubilio prespensis Kar.

Barbus prespensis Kar.

Alburnus alburnus belvica Kar.

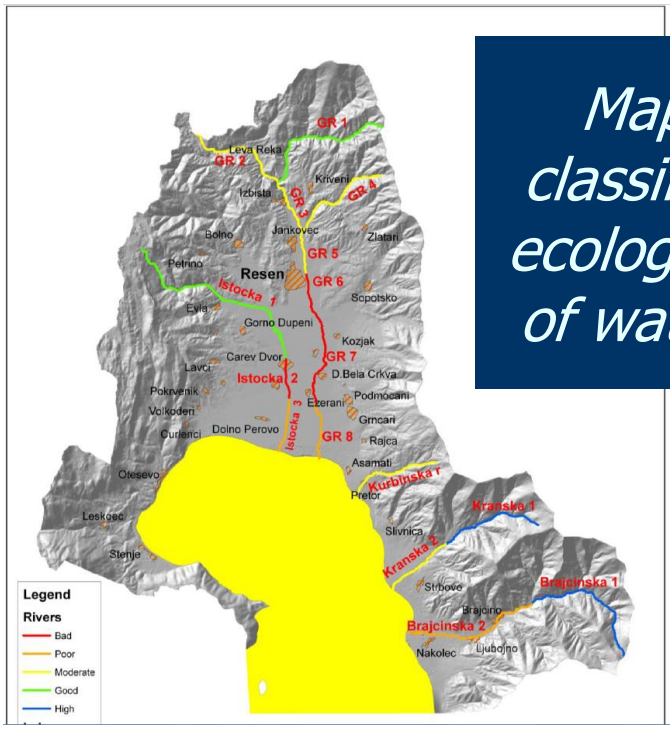
AUTOCHTHONOUS
Alburnoides prespensis Karaman 1924
Alburnus belvica Karaman 1924
Anguilla anguilla (Linn 1758)
Barbus prespensis Karaman 1924
Chondrostoma prespense Karaman 1924
Cobitis meridionalis Karaman 1924
Cyprinis carpio Linnaeus 1758
Pelasgus prespensis Karaman 1924
Rutilus prespensis Karaman 1924
Salmo peristericus Karaman 1938
Squalius prespensis Fowler 1977

Chondrostoma prespensis Kar.

Results point to **bad status of the lake.**

Leuciscus cephalus prespensis Kar.

ALLOCHTHONOUS
Carassius gibelio Bloch 1782
Ctenopharyngodon idella Valenciennes 1844
Gambusia holbrooki Girard
Hypophthalmichthys molitrix Valenciennes 1844
Lepomis gibbosus Linnaeus 1758
Oncorhynchus mykiss Walbaum 1792
Parabramis pekinensis (Basilewsky 1855)
Pseudorasbora parva Temmini&Schlegel 1846
Rhodeus amarus (Bloch 1782)
Salmo letnica Karaman 1924
Silurus glanis Linnaeus 1758
Tinca tinca Linnaeus 1758



Map of the classification of ecological status of water bodies

THE FINAL STATUS OF DELINEATED WATER BODIES

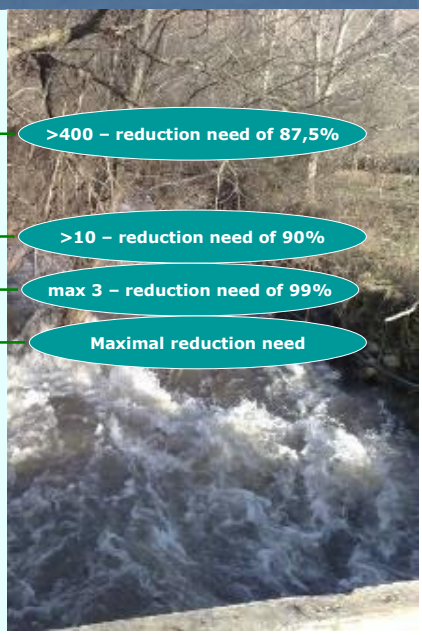
WATER BODY NAME	WB TYPE	STATUS					ACTION NEEDED UNDER	
		High	Good	Moderate	Poor	Bad	UWWTD or ND	WFD
SURFACE Water Bodies - RIVERS								
Istočka Reka 1	1		Good				no	no
Istočka Reka 2	1					Bad	yes	yes
Istočka Reka 3	1				Poor		yes	yes
Golema Reka 1	1		Good				no	no
Golema Reka 2	1			Moderate			yes	yes
Golema Reka 3	1			Moderate			yes	yes
Golema Reka 4	1			Moderate			yes	yes
Golema Reka 5	1			Moderate			yes	yes
Kurbinska Reka 1	1			Moderate			yes	yes
Kranska Reka 1	1	High					no	no
Kranska Reka 2	1			Moderate			yes	yes
Brajčinska Reka 1	1	High					no	no
Brajčinska Reka 2	1				Poor		yes	yes
SURFACE WATER BODIES – HEAVILY MODIFIED WB								
Golema Reka 6	1h					Bad	yes	yes
SURFACE WATER BODIES – ARTIFICIAL WB								
Golema Reka 7	1a					Bad	yes	yes
Golema Reka 8	1a				Poor		yes	yes
SURFACE WATER BODIES – LAKE								
PRESPA LAKE	1L			Moderate			yes	yes

Reference conditions

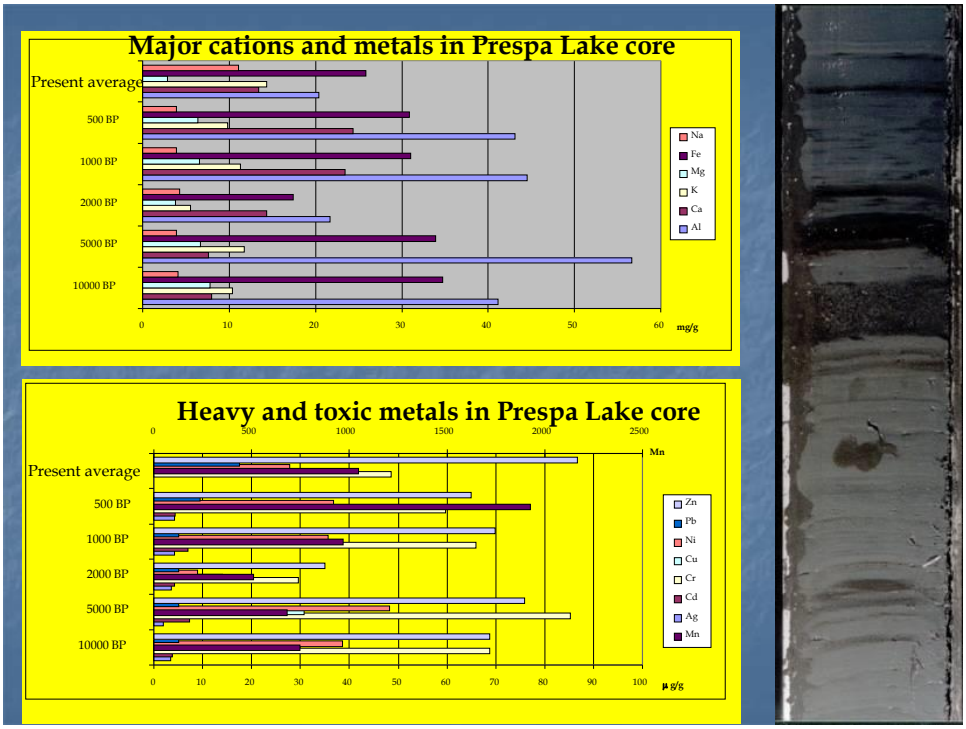
- **Reference conditions for Rivers**
  sample point in the headwater – near the spring
- **Reference conditions for lakes –**
  core sampling

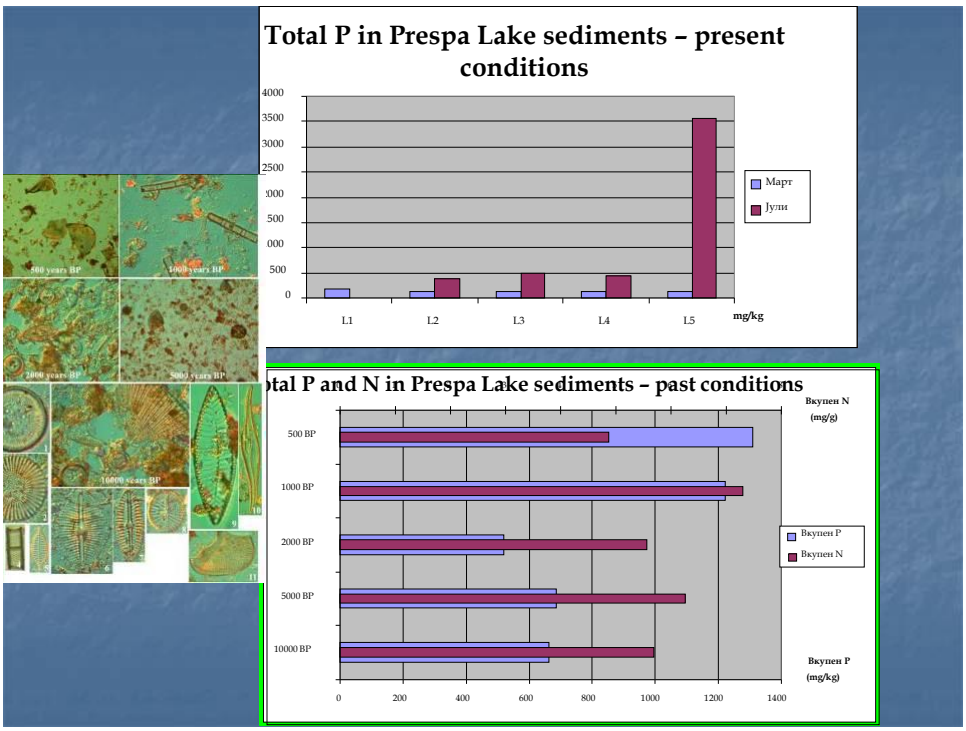
WHERE SHOULD THE WATER BODIES BE – THE REFERENCE CONDITIONS FOR RIVERS IN PRESPA LAKE WATERSHED

Reference conditions for the rivers in Prespa Lake watershed	
Parameter (units)	Value
Dissolved oxygen (mg/l)	>9
Conductivity (µs/cm)	<50
pH	6-7
NH_x-N (mg/l)	<0.05
NO_x-N (mg/l)	<0.6
Total N (mg/l)	<1.0
PO_4-P (mg/l)	<0.020
Total P (mg/l)	<0.030
Toxic heavy metals and priority substances (µg/l)	<0.001
Dominant algae - diatoms	Diatoms: *Meridion circulare, Meridion circulare var. constricta, Diatoma hyemalis, Diatoma mesodon, Eunotia spp., Staurosirella pinnata, Hannea arcus, Psammothidium daonense, Amphipleura pellucida, Decussata hexagona, Luticola nivalis, Diadesmis perpusila, Krsticiella ohridana, Pinnularia sudetica.* Red algae: *Lemanea fluviatilis.*
Dominant benthic invertebrates	*Heptagenia sulphurea, Baetis rhodani, Baetis alpinus, Baetis fuscatus, Baetis vernus, Potamophylax latipennis, Capnia vidua, Brachyptera risi, Nemoura cinerea, Austropotamobius torrentium, Asacus astacus*
DSFI index - invertebrates	≥7



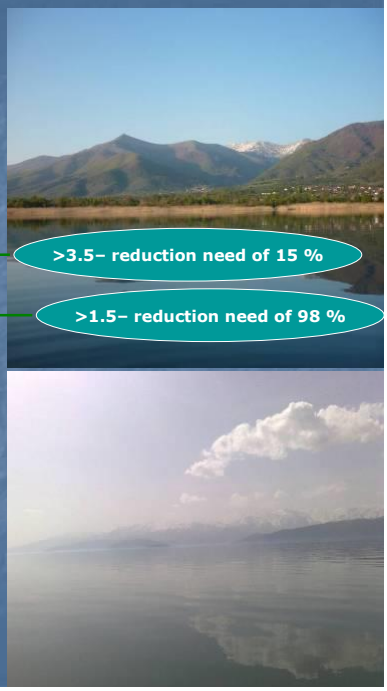
REFERENCE CONDITIONS FOR PRESPA LAKE – CORE SAMPLING


Major cations and metals in Prespa Lake core
Present average
500 BP
1000 BP
2000 BP
5000 BP
10000 BP
0
10
20
30
40
50
60
mg/g
Na
Fe
Mg
K
Ca
Al
Heavy and toxic metals in Prespa Lake core
0
500
1000
1500
2000
2500
Mn
Present average
500 BP
1000 BP
2000 BP
5000 BP
10000 BP
0
10
20
30
40
50
60
70
80
90
100
µ g/g
Zn
Pb
Ni
Cu
Cr
Cd
Ag
Mn


Total P in Prespa Lake sediments – present conditions
4000
3500
3000
2500
500
0
L1
L2
L3
L4
L5
mg/kg
Март
Јули
tal P and N in Prespa Lake sediments – past conditions
500 BP
1000 BP
2000 BP
5000 BP
10000 BP
0
200
400
600
800
1000
1200
1400
Вкупен N
(mg/g)
Вкупен P
Вкупен N
Вкупен P
(mg/kg)

THE REFERENCE CONDITIONS FOR PRESPA LAKE

Reference conditions for Prespa Lake	
Parameter (units)	Value
Dissolved oxygen (mg/l)	6-7 (surface); >4 (bottom)
Conductivity (µs/cm)	200-300
pH	7-8
NH_x-N (mg/l)	<0.05
NO_x-N (mg/l)	<1.0
Total N (mg/l)	<3.0
PO_4-P (mg/l)	<0.005
Total P (mg/l)	0.015-0.025
Chlorophyll *a* (µg/l)	<3.8
Secchi depth (m)	>5
Dominant algae	Diatoms, Chrysophytes, Green coccoid algae, Xanthophytes, Charophytes. No cyanobacteria or 'water blooms' by any algal group.
Dominant benthic invertebrates	Snails, Clamps, Dragon flies, Mayflies, Caddis flies, Leeches, Sponge, Amphipods, Decapods. No Chironomids or Tubificids indicators for eutrophic conditions.
BQI index Diversity index H	>3 2.33-3.00



ECONOMIC ANALYSIS

Table17. Municipal and industrial water supply, consumption and revenue

	Covered Area	Number	Water Consumption m3	Price MKD/ha	Cost MKD
Population connected to public WS system	Resen	13.600	720.000	22,3	16.056.000
Population with self-supply	16 villages	4.000	200.000	22,3	4.460.000
WS – industry & companies	Resen	300	180.000	37,73	6.791.400

Table 19. Revenues from water delivered to users

Description	Monthly Quantities In m3	Current Price	Monthly Revenues	In %
Citizens	43.765 м^3	16.25 MKD/м^3	711.181 MKD/мес	69.56%
Companies	11.317 м^3	27.50 MKD/м^3	311.217 MKD/мес	30.44%
Total:	**55.082** м^3		**1.022.398 MKD/мес**	**100.00%**

PROGRAMME OF MEASURES

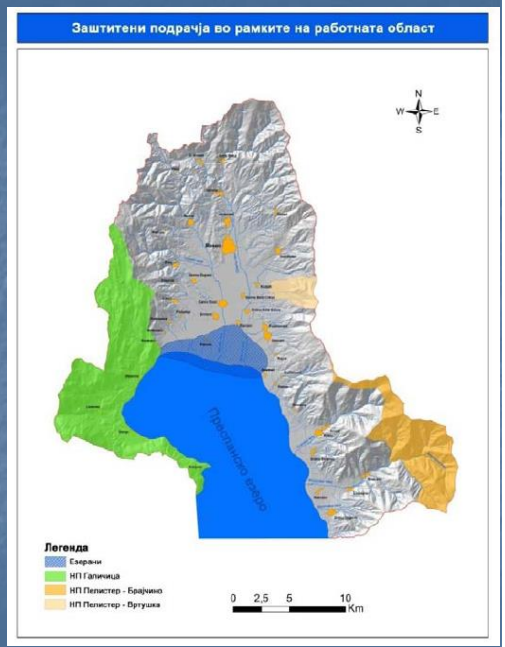
analysis, prioritization & implementation plan

- **Protection zones**
- **Environmental Objectives**
  - General
  - Water bodies
  - Indicators
- **Programme of Measures**
  - Problem analysis & causes
  - Gap analysis
  - Programme of measures
  - Possible implementation strategies
- **Implementation Strategy in a Macedonian context**
  - Приоретизација
  - Sensitivity analysis
  - Necessary preparatory measures
  - Legal obligations
  - Analysis of alternative implementation strategies
  - Implementation schedule
  - Environmental effects

Protection zones

- Law on nature
- Law on water
- Other legislation related to: forest, defense, etc

- **Law on Nature:**
- National Parks (IUCN II);
  - NP Galicica
  - NP Pelister
- IUCN – IV – wetland Ezerani
- Prespa Lake (in 2002 recognized as Ramsar site)
- Other wetlands



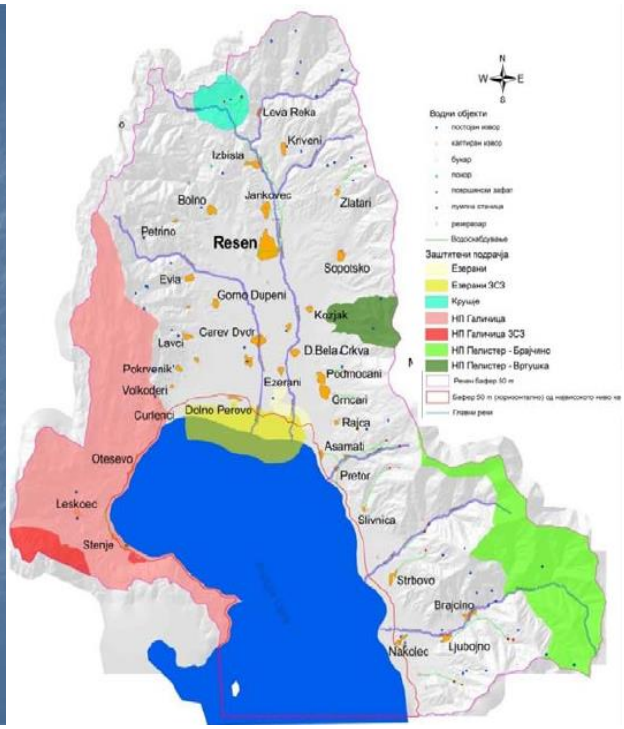
Law on water – Water protection Zones

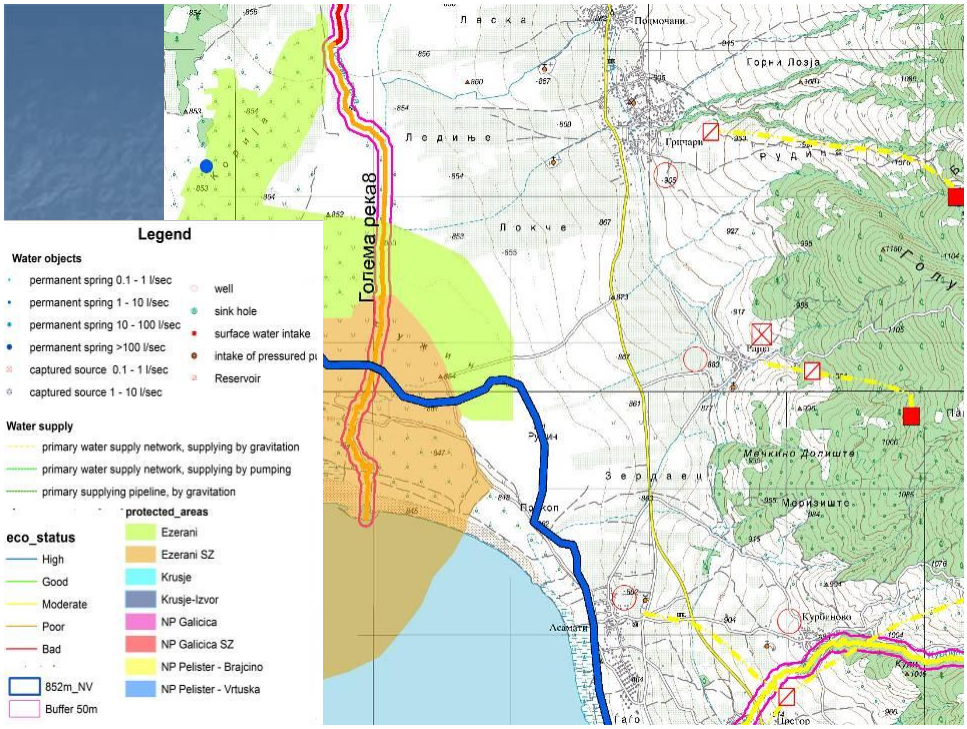
- **Water Protection Zones (chapter III):**

- WBs intended for human consumption
- WBs designated as recreational waters
- WBs sensitive to urban waste waters discharge
- WBs designated for the protection as natural heritage where the maintenance or improvement of the status of water is an important factor
- Nitrate venerable zones
- intended for protection of aquatic plant and animal species or water dependant,

- Chapter V – Adverse impact of water
  - Article 3 – Maintenance of surface water
  - Article 4 – Erosive zones

Map of all protected zones (already established and proclaimed and additional (some of them) under opinion of the GTI team





ENVIRONMENTAL OBJECTIVES

- **The objective is that all water bodies should achieve "Good status".**
- **In addition, any deterioration in the existing status of both surface waters and groundwater is to be prevented.**
- TDA, 2010

- For protected areas – other EOs

ENVIRONMENTAL OBJECTIVES

For the surface water bodies:

- **EO 1: Improvement of environmental conditions ensuring good water and soil quality for human health and for the ecosystem by 2025 (long-term)**
- **EO 2: To control water levels (prevent losses) and promote sustainable use (short-term & continuous)**
- EO 3: To ensure sustainable fisheries (mid-term)
- EO 4: Reducing pesticide/fertilizer loadings, waste from packaging and pressure from agriculture (short-term & continuous)
- EO 5: Reduction of physical pressures (short-term & continuous)

For the groundwater bodies: *(*These include the abovementioned Environmental Objectives 1, 2, 4 and 5, as well as the following objectives):

- EO 6: The drinking water supply is to be based on pure groundwater without the need for more than simple treatment (long-term); To ensure that the water supplied to the population only contains nitrate in natural concentrations (short-term & continuous).
- EO 7: The groundwater resource must be safeguarded against overexploitation (mid-term).
- EO 8: The groundwater must be protected against contamination (short-term & continuous); there must be no pesticides or other hazardous substances in groundwater used for the supply of drinking water (short-term & continuous).

For protected areas (PA):

.....

Environmental objectives 1 and 2, being the most important, have been adopted as guidance for further elaboration of the Prespa WMP and as a basis for the development of the Program of Measures and the 6-year implementation plan.

ENVIRONMENTAL OBJECTIVES – WATER BODIES

Name	Current status	Action needed?	Objectives	
			Rivers	HMWB & AWB
Istocka 1	Good			
Istocka 2	Bad	Y	Good	
Istocka 3	Poor	Y	Good	
Golema 1	Good			
Golema 2	Moderate	Y	Good	
Golema 3	Moderate	Y	Good	
Golema 4	Moderate	Y	Good	
Golema 5	Moderate	Y	Good	
Golema 6	Bad	Y		Good potential
Golema 7	Bad	Y		Good potential
Golema 8	Poor	Y		Good potential
Kurbinska	Moderate	Y	Good	
Kranska 1	High			
Kranska 2	Moderate	Y	Good	
Brajcinska 1	High			
Brajcinska 2	Poor	Y	Good	

ENVIRONMENTAL OBJECTIVES - INDICATORS

Overall Objecti1	Improvement of environmental conditions to ensure good water and soil quality for human health and ecosystem by 2025.
Indicator	Measurable decline in levels of the main pollutant groups and pressures in water, sediment and biota
1a:	Good surface water quality: -Reduce / prevent further eutrophication/organic pollution -Reduce / prevent further hydromorphological changes -Reduce / prevent further habitat fragmentation -Maintain biological water quality (phytoplankton, macrophytes, invertebrates and fish) - Reduce / prevent hazardous substances pollution
1b:	Good groundwater quality: -Control water abstraction -Reduce / prevent water pollution from point and non-point sources -Maintain good physical and chemical characteristics
1c:	Good ecological potential for HMWB and AWB: -Reduce / prevent further eutrophication/organic pollution -Reduce / prevent further hydromorphological changes -Reduce / prevent further habitat fragmentation -Improve biological water quality (phytoplankton, macrophytes, invertebrates and fish) - Reduce / prevent hazardous substances pollution

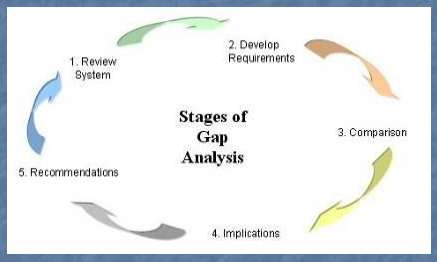
Overall Objective 2:	Sustainable and efficient water utilization for maintenance/control of Lake Prespa water level and groundwater table
Indicator	Measurable and sustained water utilization
2a:	Introduce water conservation and demand management: - Irrigation abstraction - Drinking water abstraction - Abstraction of water for industry

Programme of measures

- in-depth expert investigation and study
- All identified measures have been scrutinized and checked for environmental effectiveness, extent, contribution to specific objectives, cost (economic and financial) and social effects

Problem and GAP Analysis

- **Problem Analysis** ← causes



- **Gap analysis (current VS desired)**
  - In addition:
    - **Legal framework & policies**
    - **Organizational setup & capacity**
    - **Management systems & procedures**

Programme of measures

The measures are grouped as follows:

- **water used for abstraction of drinking water** (to improve the reliability and quality of drinking water)
- Measures for **controlling the abstraction and impoundment of water**
- for **point source discharges** and other activities which have an impact on the status of water
- to prevent or reduce the impact **of accidental pollution incidents**
- to **reduce the priority substances** (to eliminate the discharge of priority substances)
- for **bodies of water unlikely to achieve good quality status** (to improve HMWBs)
- to minimize irrigation water use and **minimize pollution by**
- **For reducing adverse imapct of water**
- Details of the **supplementary measures** identified as necessary in order to meet water quality environmental objectives (Eutrophication of Prespa Lake)
- **Register of further detailed plans and programs** for the Prespa Lake basin dealing with particular water issues

Programme of measures

45 measures identified…

Analyzed in detail for:

- Priority
- Responsible institution
- Schedule/duration of implementation
- Indicators
- Cost (CBA, NPV, cost-effectiveness…)
- Impact to waterbodies / ecosystems (Rivers, Lake, HMWB, Artificial , Wetlands, Groundwater, Terrestrial/natural Habitats)
- Expected effects (Nitrogen, Phosphorus, Physical Pressure, Natural Habitats, Priority substances, Water supply security, Harmful impacts of water, Other)

Programme of measures – prioritization - MCA

The 45 measures have been ranked and prioritized in accordance with the following:

- Environmental effectiveness
- Legal requirement, and
- Multi-criteria analysis (MCA) score (highest score) according to the following criteria:
  - Legal requirement 0-20 points
  - Environmental extent 0-10 points
  - Environmental effect 0-10 points
  - Security & resources preservation 0-20 points
  - Prevention of harmful impacts 0-5 points
  - Economic benefits 0-10 points
  - Financial costs 0-10 points
  - Social benefits 0-15 points
- **Total** **0-100 points**

Technical ranking of measures

Rank	Score	ID	Programme of Measures	Legal requirements	Cost		Implementation Period /Duration [y]
					Total [10^3 €]	Annual [10^3 €]	
1	68,3	23	Regulate irrigation wells	Yes	200		3
2	66,2	22	Regulate irrigation intake from rivers	Yes	0		3
3	65,3	426	Develop green cover in orchards	-	300		6
4	63,3	34	Erosion control	-	7,500		18
5	63,0	421	Upgrade irrigation schemes	-	300		5
6	62,3	422	Closure of illegal dumping sites and establishment of a controlled sanitary landfill	-	250		2
7	62,2	413	Upgrade industrial wastewater treatment	Yes			12

Programme of measures – sensitivity analysis

Ranking of measures has been checked with different weights to particular criteria

- **Environmental** (impact, extent, security or preservation of resource, protection from harmful effects of water)
  - 16/20.
- **Socio-economic** (economic benefit, financial costs, social benefits)
  - 10/20.

Based on the sensitivity analysis, it can be concluded that the proposed set of measures in Alternative 1 is robust and well balanced with the set of criteria & weights agreed with the stakeholders.

Programme of Measures	Priorti	Respon-sible institu-tion	Implemented by:	Indicators	[EURO]
Measure 414c- Construction of WWTP for smaller agglomerations (<2000 PE) in the region	3	USG Resen	PCEP	- WWTP rehabilitated & improved treatment	2,500,000

Waterbodies and terrestrial natural habitats affected by the measure						Expected Effects							
Rivers	Lake	HMUB, Artificial	Wetlands	Groundwater	Terrestrial natural Habitats	Nitrogen	Phosphorus	Physical Pressure	Natural Habitats	Priority substances	Water supply security	Harmful impacts of water	Other
						Reduction of input	Reduction of input	Reduction	Re-establishment and improvement of quality	Reduction of input	Safe & timely supply	Reduction	
+++	+++	+++	+++	+++		+++	+++		+++	+			

Possible Implementation Strategies

Три (3) алтернативи…

- A '***Business as Usual***' *Strategy ,*
- A ***Water Framework Directive Implementation Strategy*** in which all the 45 measures are implemented in full accordance with the WFD, ensuring the achievement of the environmental objectives**.**
- A *Realistic Implementation Strategy* in which some of the above 45 measures are implemented based on the availability of economic resources, manpower and skills. → **Prioritization**

Programme of measures - prioritization

Ранг	Бодови	ID	Програма на мерки / Мерки	Трошоци: Вложув. ['000 €]	Трошоци: Год. ['000 €]	Период имплем. /Трајење [год]	Предлог алтернат.: 0 BaU	1 R	2 WFD	Почеток
1	68.3	23	Регулација на бунари за наводнување	200		3				
2	68.2	22	Регулација на зафати на реки за наводнување	0		3				
3	65.3	426	Компостирање во овоштарници	300		6				
4	63.3	34	Противерозивни мерки	7,500		18				
5	63	421	Надградување на системот за наводнување	300		5				
6	62.3	422	Затворање на дивите депонии и изградба на контролирана санитарна депонија	250		6				
7	62.2	413	Изградба на системите за прочистување на индустриските води			12				
8	62	414a	Надградба на колекторот за отпадни води во Езерани	500		2				
9	61.7	62	Рехабилитација на рибниците и конструкција на затварач/капија на Голема река	250		3				
10	61.5	33	Противерозивни планови базирани на процена на ризиците од ерозија и транспорт	500		6				
11	61.5	61	Имплементација на планови за управување на заштитените подрачја: Пелистер, Галичица и Езерани	0		3/cont				
12	61.3	431	Имплементација на РДВ мониторинг на Преспанското езеро		20	3/cont				
13	60.3	411	Имплементација на IPPC	0		3/cont				
14	58.8	424	Едукација на фармерите за добри земјоделски и еколошки практики вклучувајќи компостирање на отпадот од овоштарниците	100		2				
15	58.7	31	Подготовка на планови за ризици од поплави и нивно спречување	250		3				
16	57.8	423	Пилот проект за еколошки сигурно користење на фертилизери и пестициди	100		2				
17	57.7	24	Внесување на системот капка по капка на 4,000 ha	4,000		4+4				
18	55.4	22b	Изградба на брана на Чешинска река	30,000		6				
19	55.2	432b	Определување на подрачја за мониторинг и референција		40	2/cont				
20	53.8	418	Изградба на управувањето со рибарењето базирано на процена на квотот и уловот	150		3/cont				
21	53.7	25	Оформување на база на податоци за наводнување	100		2				
22	53	32	Имплементација на контролни мерки против поплави	5,000		12				
23	53	414c	Изградба на прочистителни станици за отпадни води за помали агломерации (<2000 ЕЖ)	2,500		13				
24	52.5	53	Воведување на инвентаризација на приватните бунари	200		2/cont				
25	52.2	427	Надградување на капацитетот на фармерите за соодветно одлагање на опасен отпад и користење на пестициди	50		2				
26	[illegible]	56	[illegible]	[illegible]		[illegible]				

Necessary preparatory measures

Based on the assessments described above and taking into account the following factors:

- the as yet insufficiently developed and inconsistent legal and regulatory framework;
- the lack of fully clarified roles and responsibilities in the organisational structure; and
- the need to improve institutional capacity,

Prespa Lake Watershed Management Plan will be implemented on the basis of a two-tier strategy:

The first priority will be to implement measures that address the enabling environment—the institutional roles and management instruments – i.e. the preparatory measures.

1. While the legal and regulatory framework is being put into place and as the organisational structures and institutional capacities are developed, more technical measures will be implemented in a structured "learning-by-doing" process.

Necessary preparatory measures

The preparatory measures to be addressed in relation to the Macedonian context:

- The Enabling Environment
  - Policies
  - Legislative Framework
  - Financing and Incentive Structure
- Institutional Roles
  - Creating and Organisational Structure
  - Building Institutional Capacity
- Management Instruments
  - Social Change Instruments
  - Regulatory Instruments
  - Economic Instruments

Possible Implementation Strategies

3 alternatives (3 алтернативи)

- A `***Business as Usual***' *Strategy*
- A ***Water Framework Directive Implementation Strategy*** in which all the 45 measures are implemented in full accordance with the WFD, ensuring the achievement of the environmental objectives**.**
  = 52 million €
-
- A ***Realistic Implementation Strategy*** in which some of the above 45 measures are implemented based on the availability of economic resources, manpower and skills.
  = 14.5 million €

Analysis of Alternative Implementation Strategies

Effects – Environmental objectives

Objectives	Sub-objective	Indicators	Alternatives		
			"0" No action	1 Realistic	2 Full WFD
Overall Objective 1: Improvement of environmental conditions ensuring good water and soil quality for human health and ecosystem by 2025 Indicator: Measurable decline in levels of the main pollutant groups and pressures on water, sediment and biota	1a: Good surface water quality:	Reduce/prevent further eutrophication/organic pollution			
		Reduce/prevent further hydromorphological changes			
		Reduce/prevent further habitat fragmentation			
		Maintain biological water quality (phytoplankton, macrophytes, invertebrates and fish)			
		Reduce/prevent hazardous substances pollution			
	1b: Good groundwater quality:	Control water abstraction			
		Reduce/prevent water pollution from point and non-point sources			
		Maintain good physical and chemical characteristics			
	1c: Good ecological	Reduce/prevent further eutrophication/organic pollution			
		Reduce/prevent further hydromorphological changes			
		Reduce/prevent further habitat			

Environmental effects

Name	Current status	Action ?	Objectives		Alternatives		
			Rivers	HMWB & AWB	"0" No action	1 Realistic	2 Full WFD
Istocka 1	Good				Good	Good	Good
Istocka 2	Bad	Y	Good		Bad	Moderate	Good
Istocka 3	Poor	Y	Good		Poor	Moderate	Good
Golema 1	Good				Good	Good	Good
Golema 2	Moderate	Y	Good		Moderate	Good	Good
Golema 3	Moderate	Y	Good		Moderate	Good	Good
Golema 4	Moderate	Y	Good		Moderate	Good	Good
Golema 5	Moderate	Y	Good		Moderate	Good	Good
Golema 6	Bad	Y		Good potential	Bad	Moderate	Good
Golema 7	Bad	Y		Good potential	Bad	Moderate	Good
Golema 8	Poor	Y		Good potential	Poor	Moderate	Good
Kurbinska	Modeate	Y	Good		Moderate	Good	Good
Kranska 1	High				High	High	High
Kranska 2	Moderate	Y	Good		Moderate	Good	Good
Brajcinska 1	High				High	High	High
Brajcinska 2	Poor	Y	Good		Poor	Moderate	Good
Lake Prespa	Moderate		Good		Poor	Good	Good

ECONOMIC ANALYSIIS

- **Cost-based valuation method** –

based on the assumption that the cost of maintaining an environmental benefit is a reasonable estimate of its value.

- **Necessity of Assessing Disproportionate Costs**

an approach for determining whether the total costs of the programme of measures are disproportionately costly is relevant for justifying derogation.

- In a **cost-effectiveness analysis**, the costs of a particular environmental measure are expressed in monetary units, while the environmental effect
- of the measure is expressed in physical units such as the reduction in the number of tonnes of nitrogen or phosphorus loaded in the aquatic
- environment.

- **The following assumptions were taken into account:**
- *A. The suggested measures are expected to be realized in the next 24 years, even though the period according to the ToR is 6 years. The period of realization is longer than the period in the ToR because there are a number of preconditions that need to be achieved in order for the measures to be realized.*
- B. The expense of each measure has been estimated/calculated by the expert team. Each expense is increased for running costs. Direct costs (made up of mainly financial and administrative costs) are included in all components of the economic assessment. Financial costs are the costs of providing and administering water services. Operating costs are all the costs incurred to keep an environmental facility running (e.g. material
- and staffing costs). The operating costs should take into account additional costs to ensure new capital investments. Maintenance costs are the costs of maintaining existing (or new) assets in good functioning order until the end of their useful life. Capital costs include new investments, the cost
- of new investment expenditures and associated costs (e.g. site preparation costs, start-up costs, legal fees). Associated costs are also substantial.
- For projections, the costs of new capital investments are spread over a number of years

- C. The **discount rate** used for the calculation of expenses is 6%. The factors taken into consideration in determining the discount rate include the following: the reference rate of the Central Bank of the Republic of Macedonia (4% at the moment of the determination of the discount rate); the annual rate of EURIBOR (2.14% at the moment of determining the discount rate); and the macroeconomic policy of the Republic of Macedonia, according to which the rate of inflation is expected to be between 3% and 5%

- D. The measures are divided into **two groups**.

- The first group of measures refers to water used for irrigation. The first group of users consists of farmers who will use the water for irrigation. In this group, one hectare of agriculture area is considered as the cost unit. The total irrigation area is 4,000 hectares.

- The second group of measures refers to the treatment of wastewater.
- The reason for this classification is to enable the distribution of the costs for the measures per unit. The second group of users consists of the legal
- entities that will be included in the treatment of wastewater, in which group households and legal entities are considered as cost units. There are 4,000 households and legal entities (companies and institutions) in the area.

- E. Two periods have been taken into consideration in determining the payback period: 40 years and 20 years.

- In the first case, the expenses for the implementation of the measures are expected to be recovered over a longer period, i.e. 40 years, which represents the average useful life of the dam.

- In the second case, if the measures are implemented by issuing concessions for operation of the dam or the establishment of PPP, the private investor is interested in recovering the investment in a shorter period and therefore the payback period is calculated as 20 years.

- F. The Annual Equivalent Cost (AEC) method allows for converting the Net Present Value (NPV) of a new capital expenditure into an annuity (or rental) which has the same value. This is done as follows:
- 1. By listing all capital expenditures as they are incurred;
- 2. By calculating the net present value of expenditures, using the chosen discount rate;
- 3. By converting this net present value into an annual equivalent cost (AEC)

Net present value (NPV) calculated for the two groups of measures f0r 2 alternatives

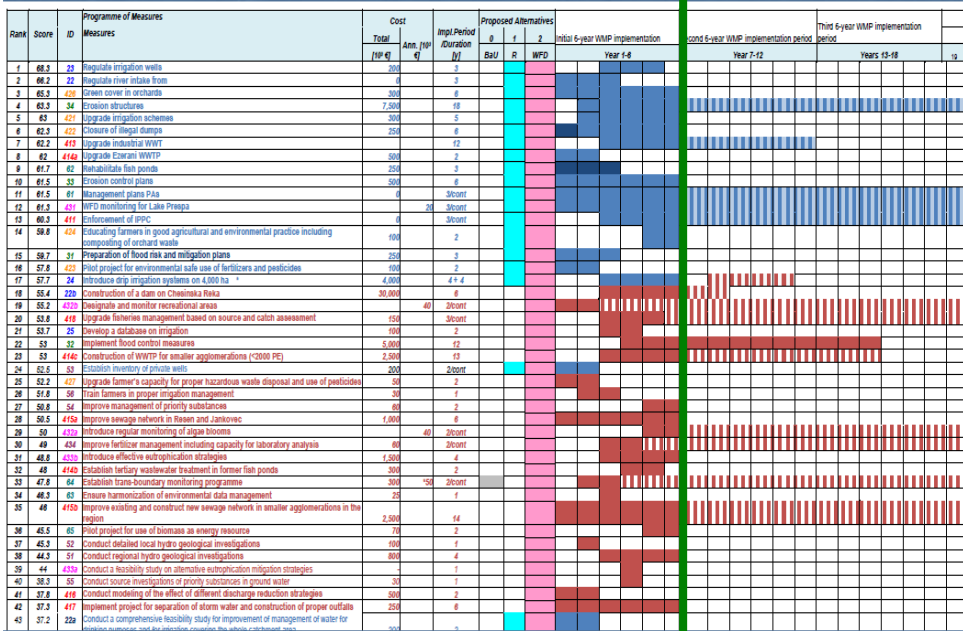
Table 29. NPV - group of measures on water supply & irrigation

Measures for treatment of water for irrigation	NPV ('000 €)	Repayment period 40 years		Repayment period 20 years	
		Annual equivalent cost ('000 €)	Annual cost per ha (4.000 ha) in €	Annual equivalent cost ('000 €)	Annual cost per ha (4.000 ha) in €
Alternative 1 - Full WFD Implementation	42.838	1.071	268	2.142	535
Alternative 2 -Realistic Implementation Strategy	11.035	276	69	552	138

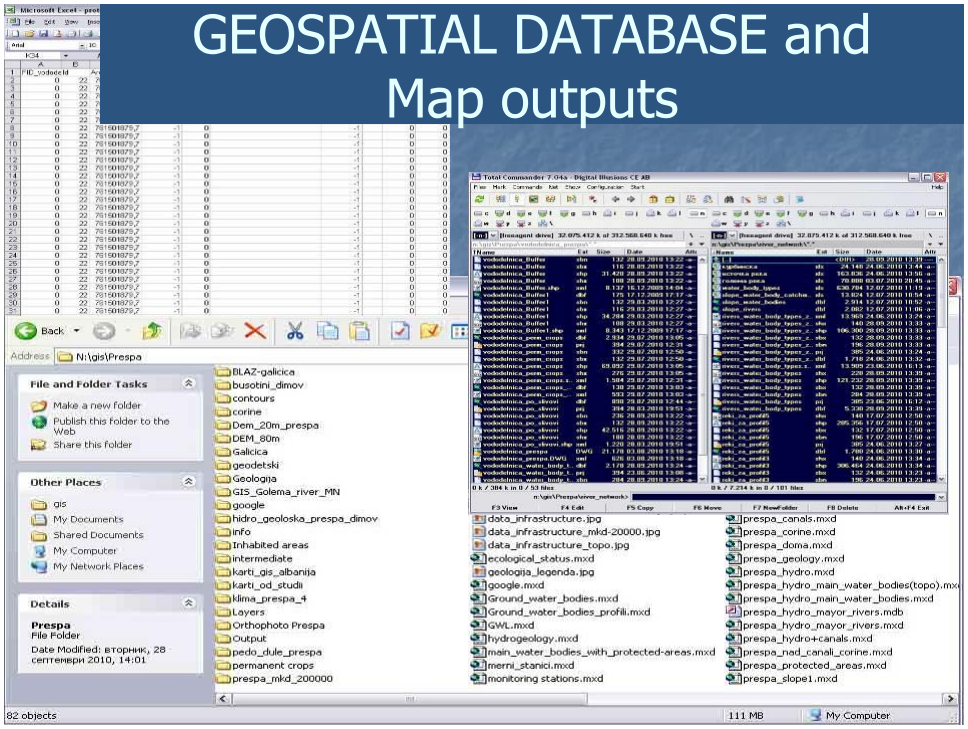
Table 30. NPV – group of measures for treatment of wastewater

Measures for treatment of wastewater	NPV ('000 €)	Repayment period 40 years		Repayment period 20 years	
		Annual equivalent cost ('000 €)	Monthly cost per entity (4.000) in €	Annual equivalent cost ('000 €)	Monthly cost per entity (4.000) in €
Alternative 1 - Full WFD Implementation	8.843	221	4,5	442	9
Alternative 2 -Realistic	472	12	0,2	24	0,5

PoM – implementation schedule

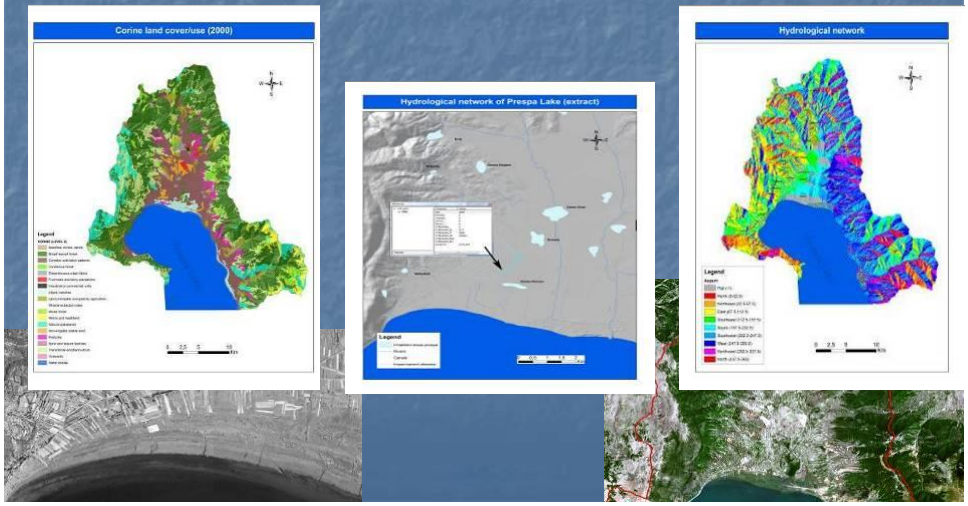


Additional - GEOSPATIAL DATABASE and Map outputs

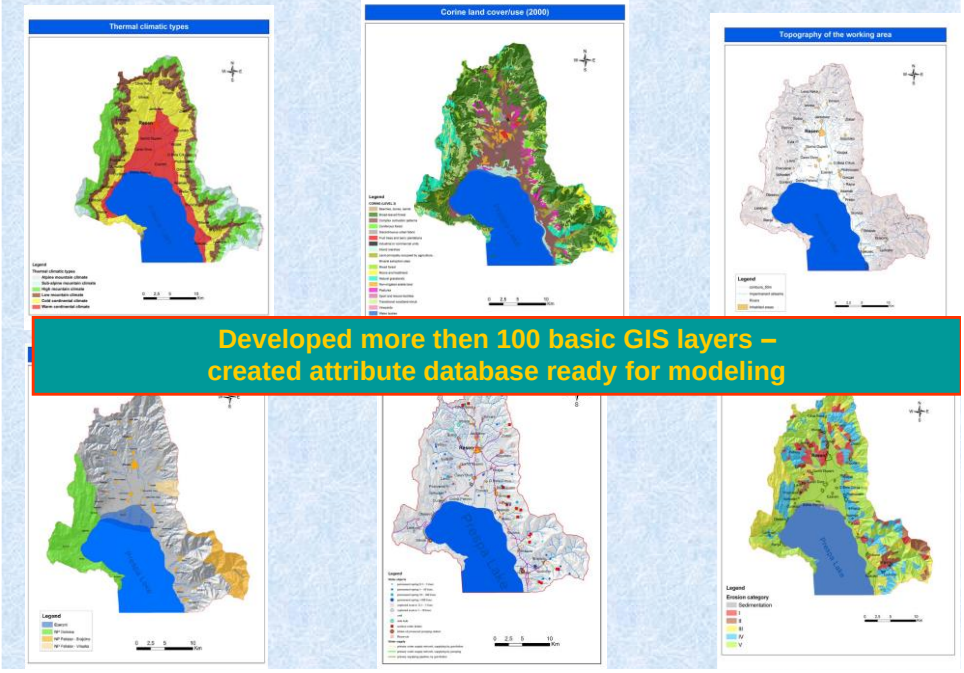


GIS - preparatory work

(scanning, gepreferencing, vectorization, basig geospatial analyses, creation attributive tables,
Remote sensing analysis, , satellite image, aerial photoses, digitalization in GIS environment)



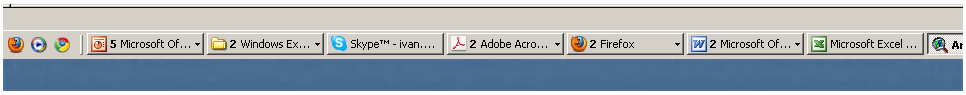
GIS/Database Achievements (part)



**Developed more then 100 basic GIS layers –
created attribute database ready for modeling**

Attributes of Pedologija_200.shp

Shape	Id	Pedo_kod	Pedo_tip	Tekst_kl	Area	Perimeter	Soil_type
Polygon	0	4	varovnicko dolomitna crnica	Loam	1.469	2.088	
Polygon	0	32	rendzina	clay Loam	4.640	4.960	Rendzinic soil
Polygon	0	4	varovnicko dolomitna crnica	Loam	1.088	9.040	
Polygon	0	5	ranker + lesivizirana	sandy Loam	1.425	2.382	
Polygon	0	6	kafeava pocva vrz varovnik i d	Loamy clay	3.377	4.593	
Polygon	0	2	cimetni + lesivizirani	sandy Loam	5.118	1.001	Cinamonic soil + loess
Polygon	0	25	ranker	sandy Loam	3.266	8.993	
Polygon	0	25	ranker	sandy Loam	1.815	2.712	
Polygon	0	6	kafeava pocva vrz varovnik i d	Loamy clay	1.999	1.716	Distric cambisoil
Polygon	0	21	kafeava sumska pocva	sandy Loam	1.019	7.053	
Polygon	0	8	lesivirana	clay Loam	1.777	6.443	
Polygon	0	8	lesivirana	clay Loam	2.632	8.227	
Polygon	0	17	deluvijalna	Loam	1.751	4.937	Deluvial soil
Polygon	0	17	deluvijalna	Loam	1.991	7.595	Deluvial soil
Polygon	0	8	lesivirana	clay Loam	1.610	6.820	
Polygon	0	8	lesivirana	clay Loam	2.383	7.519	
Polygon	0	8	lesivirana	clay Loam	3.550	4.824	
Polygon	0	17	deluvijalna	Loam	2.903	9.475	Deluvial soil
Polygon	0	17	deluvijalna	Loam	4.489	1.152	Deluvial soil
Polygon	0	17	deluvijalna	Loam	1.111	2.361	Deluvial soil
Polygon	0	17	deluvijalna	Loam	1.647	3.048	Deluvial soil
Polygon	0	29	regosol	Loam	1.411	5.202	Regosoil
Polygon	0	29	regosol	Loam	9.127	2.940	Regosoil
Polygon	0	25	ranker	sandy Loam	9.307	8.031	
Polygon	0	25	ranker	sandy Loam	4.312	1.012	
Polygon	0	30	varovnicko dol. crnica + kaf. pi	Loam	9.229	2.288	
Polygon	0	2	cimetni + lesivizirani	sandy Loam	1.086	1.906	Cinamonic soil + loess
Polygon	0	22	mocurlivo glejni pocvi	Loamy clay	1.111	1.351	
Polygon	0	19	aluvijalni	sandy Loam	6.087	1.066	Aluvial soil
Polygon	0	21	kafeava sumska pocva	sandy Loam	2.802	1.838	



What is WBID
(Water Body Identification card)

- For each water body is prepared ID card
- ID card contain all necessary information for each surface or ground water body.

- Geospatial information
- Hydrology and Hydromorphology
- Water quality (biology or chemistry issues)

ID card - Pdf file

Hyperlink – GIS

Hyperlink - Web

Content of ID card of surface water bodies (river, artificial water body, heavily modified water body)

- *- Geographical features*
- *- Hydrological characteristic:*
- *- Land use*

- *- Typology system A*
- *- Hydromorphological and morphological elements supporting the biological elements*
- *- Typology system B – optional data*
- *- Connection with other water bodies*

- *- Quality elements – Rivers – Biological elements*
- *- Chemical and physicochemical elements supporting the biological elements - general*
- *- Chemical and physicochemical elements supporting the biological elements – specific pollutants*

SWB – GOLEMA REKA 7

Figure 1-25. Golema Reka 7 sampling site.

Geographical features:

Represent the River Golema Reka part after the HMWB in Resen city till the protected area "Ezerani".

Figure 1-26. Location of the water body

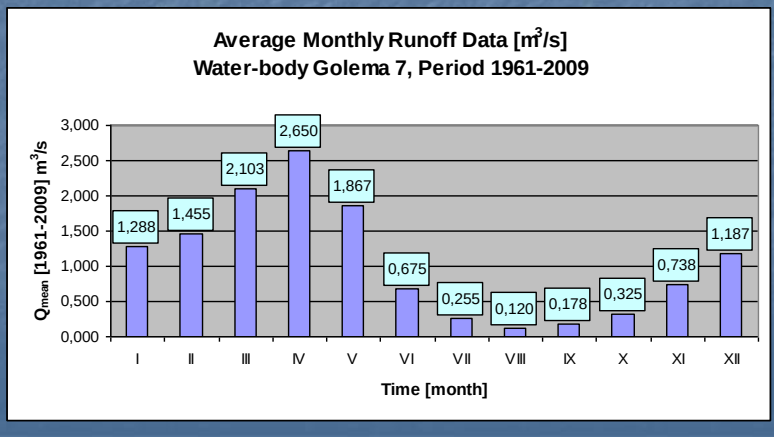
Coordinates	X [m]	Y [m]	K [m asl]
Starting point	502293	4548917	880
Mean point	503317	4545530	869
Ending point	502717	4542042	855

Length of the water body: 8,034 km;

Cumulative length: 24,996 km

Hydrological characteristics:

Area	*Rainfall*	*Hydrological regime Flow (m^3/s)*			*Runoff module*
F (km^2)	P_{avg} (mm)	Q_{max} year	Q_{mean} year	Q_{min} year	(l/s/km^2)
170.30	691.15	40.6	1.070	0.020	6.28



Land use

Code	Land cover/use type	Area [ha]	Cumulative Area [ha]
311	Broad-leaved forest	2581,45	8615,60
242	Complex cultivation patterns	2165,40	3413,45
312	Coniferous forest	169,90	264,35
112	Discontinuous urban fabric	40,38	244,96
222	Fruit trees and berry plantations	101,11	174,78
121	Industrial or commercial units	1,36	23,09
411	Inland marshes	0,86	0,86
243	Land principally occupied by agriculture, with significant areas of natural vegetation	191,45	625,50
131	Mineral extraction sites	9,83	9,91
313	Mixed forest	495,27	703,48
321	Natural grasslands	69,55	207,70
211	Non-irrigated arable land	188,57	276,67
231	Pastures	471,28	767,47
324	Transitional woodland-shrub	659,71	1694,44
	total	7146,15	17022,27

Typology system A:

Name	Golema 7
Eco-region	6
Altitude	M
Size	M
Geology	S
Type	1a

Hydromorphological and morphological elements supporting the biological elements

hydrological regime	Q_{min}^{year}=0.020 m^3/s; Q_{max}^{year}=40.6 m^3/s
quantity and dynamics of water flow:	$Q_{avg.}^{year}$=33705000 m^3; $Q_{avg.}^{year}$=1.070 m^3/s
connection to groundwater bodies	
river continuity	There are no artificial barriers that aresignificantly affecting the continuity of flow.
river depth and width variation	$H_{avg.}$ =0.20 m-0.80 m, $B_{avg.}$ =15.00-20.00 m
structure and substrate of the river bed	Artificial;
structure of the riparian zone	Riparian vegetation >> wetland

Typology system B – optional data

1	*distance from river source*	24,996 km
2	*energy of flow*	$\frac{V^2}{2 \times g} = 0.027$ m
3	*mean water width*	15 m
4	*mean water depth*	0.4 m
5	*mean water slope*	*3.1 ‰*
6	*form and shape of main river bed*	trapezoidal shape of cross-section with 1: m= 1: 1.5
7	*river discharge (flow) category*	free water flow
8	*mean air temperature*	9,26
9	*Precipitation*	691,15 mm

Connection with other water bodies

Rivers	-
Lakes	-
Wetlands	**Ezerani**
HMWB	**Golema 6**
Artificial water bodies	**Golema 8**

Quality elements – Rivers – Biological elements

1	**Composition and abundance of algae**	**Ulnaria ulna, Fragilaria capucina, Meridion circulare, Fragilaria pinnata, Navicula phyllepta, Achnanthidium lanceolatum, Amphora pediculus, Achnanthidium jackii, Reimeria sinuata, Navicula lanceolata, Surirella pinnata, Nitzschia linearis, Nitzschia macedonica. Mass development of the filamentous bottom dwelling Pseudoanabaena limnetica.**
2	**Composition and abundance of benthic invertebrate fauna**	**Bithynia tentaculata; Bithynia leachii; Tubifex tubifex; Pentapedilum exectum; Chironomus riparius; Cricotopus bicinctus; Erpobdella octoculata**

Chemical and physicochemical elements supporting the biological elements – general

1	*Thermal conditions*	Normal
2	*Oxygenation conditions*	Variable
3	*Salinity*	Increased
4	*Acidification status*	Alkaline variable
5	*Nutrient conditions*	Increased

Chemical and physicochemical elements supporting the biological elements – specific pollutants

Pollution by all priority substances	YES
Pollution by other substances (significant quantities)	Yes
Pollutant 1	Bis(2-Ethylhexyl)phthalate
Pollutant 2	Alfa-HCH
Pollutant 3	4,4'-DDE
Pollutant 4	Al
Pollutant 5	Fe
Pollutant 6	Mn
Pollutant 7	Zn
Pollutant 8	Ni
Pollutant 9	Cu
Pollutant 10	As


Thank you for your attention