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Podgorica Water and wastewater Development Project

Project Preparation Study

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Contents

Appendix A - Mathematic modelling of Podgorica water supply distribution network

PURPOSE AND CONTENT OF THE PROGRAM PACKAGE FOR CONTINUAL SIMULATION OF SYSTEM OPERATION "EPANET"

Computer simulation of the water network was undertaken using the software package EPANET. EPANET performs extended period simulation of hydraulic and water quality behaviour within pressurized pipe networks. A network consists of pipes, nodes (pipe junctions), pumps, valves and storage tanks or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network during a simulation period comprised of multiple time steps. In addition to chemical species, water age and source tracing can also be simulated.

Running under Windows, EPANET provides an integrated environment for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats. These include colour-coded network maps, data tables, time series graphs, and contour plots.

Hydraulic Modelling Capabilities

EPANET contains a state-of-the-art hydraulic analysis engine that includes the following capabilities:

- places no limit on the size of the network that can be analyzed
- computes friction headloss using the Hazen-Williams, Darcy-Weisbach, or Chezy-Manning formulas
- includes minor head losses for bends, fittings, etc.
- models constant or variable speed pumps
- computes pumping energy and cost
- models various types of valves including shutoff, check, pressure regulating, and flow control valves
- allows storage tanks to have any shape (i.e., diameter can vary with height)
- considers multiple demand categories at nodes, each with its own pattern of time variation
- models pressure-dependent flow issuing from emitters (sprinkler heads)
- can base system operation on both simple tank level or timer controls and on complex rule-based controls.

MODELLING

During preparation of the model of Podgorica water supply system, following stages were carried out:

- system identification;
- analysis of the fluctuations in water consumption in both space and time;
- model calibration;
- analysis of operation of water supply system in normal and extraordinary circumstances.

System identification

Existing model of Podgorica water supply system was created for ViK Podgorica in 1998 for the purposes of preparing a design of the water supply distribution system of Podgorica. 'Our' new model is created based on the existing model. Geometric elements of the existing model have been successfully converted from software WESNET to the software EPANET.

With the assistance of the ViK staff and using database contained in the GIS, geometric elements (pipe length, inner diameter and material pipe was made of, etc-) were updated to reflect the existing Podgorica water supply network.

Model also includes features of the pumps installed at all water sources, i.e. the actual Q-H curves and efficiency curves.

Analysis of water production and consumption

The main source of data on water production are data from the annual reports on operations of the PE ViK Podgorica for 2007 and 2008, which include the data on the water production of each pumping station i.e. water source.

Data on consumption were obtained from PE ViK Podgorica, and are based on consumption read from the customers' water meters that are checked once a month. PE ViK Podgorica has information sorted by meter reading areas of Podgorica, as well as customer categories within these regions, which provides good insight in the spatial distribution of water consumption. Meter reading areas are shown in the general appendixes of this Annex. Consumption per categories is evenly distributed on nodes of each area.

Consumers were classified in the following categories:

- Citizens that live in individual houses;
- Citizens that live in the apartment blocks;
- Industry;
- Small business;
- Institutions.

Registered water consumption by consumer categories and regions for 2008 as well as assumed consumption for 2009 and 2035 is given in the appendix B of this Annex. Percentage participation of each region within the consumer category for 2008 was also applied to the distribution of consumption for 2009 and 2035.

PE ViK Podgorica still does not read consumer meters of the Zeta region, so the water consumption of the Zeta region is defined on the basis of the existing population and their water demand based on data from the 2003 census, obtained by the Republic Statistical Office, as well as on the basis of assumed growth in population and water consumption (Chapter 6.; Figure 6.3).

Data were obtained from PE ViK Podgorica on consumption of some major water consumers, so the nodes containing their places of connection are accurately defined.

The design of Podgorica water supply distribution system from 1998 defined the coefficient of fluctuation in monthly production/consumption of water in the water supply system of Podgorica from that time, which is 1.30. Based on the data on monthly fluctuations in water production for 2008, it was found that the coefficient

completely corresponds to the current water supply system of Podgorica, so for the purposes of this model $K_{max\ month}$ = 1.30 is adopted.

Based on experiences from several water supply systems with characteristics similar to those of Podgorica system, coefficient of daily fluctuations in production/consumption was adopted in relation to monthly average and amounts to 1.15, so the maximum daily fluctuation coefficient was obtained compared to the average annual production/consumption of water:

$K_{max\ daily}$ = 1.30 x 1.15 = 1.5

With the average daily water production in 2008 being 108,157 m3, maximum daily production is:

$Q_{max\ daily}$ = 1.5 x 108,157 = 162,235 m3/day (1878 l/s), which roughly corresponds to the maximum registered daily production/consumption of water in the system of 1845 l/s.

Charts of hourly fluctuations in consumption for different consumer categories were taken from existing model and updated according to the existing data. Losses in the system are treated as separate category, and chart of hourly fluctuations for losses corresponds to the charts of hourly fluctuations in water production.

Model Calibration

Rough model calibration was done based on the operating mode of pumping station for two days:

- For maximum consumption - operating mode on 29th July 2009;
- For the average consumption - operating mode on 13th March 2009.

The results of the model faithfully enough reflect the behaviour of the actual system. Appendixes of this Annex include comparative charts of observed and computed values of pressures and flows at certain measuring locations.

Water supply system analysis

Program package EPANET calculates linear losses according to one of the following formulae:

- Hazen-Williams;
- Darcy-Weisbach;
- Chézy-Manning;

Author of the model decided to use the Darcy-Weisbach formula.

Calibrated model is used as the basis for the study of the water supply system in different operating modes. Conclusions drawn based on modelling are critically evaluated by experts of the PE ViK Podgorica itself.

Because of the extensiveness of the documentation, this annex will not include results of hydraulic calculation of all analysed operating modes, but only of those chosen by the author and with consultation with experts of PE ViK Podgorica.

Models presented:

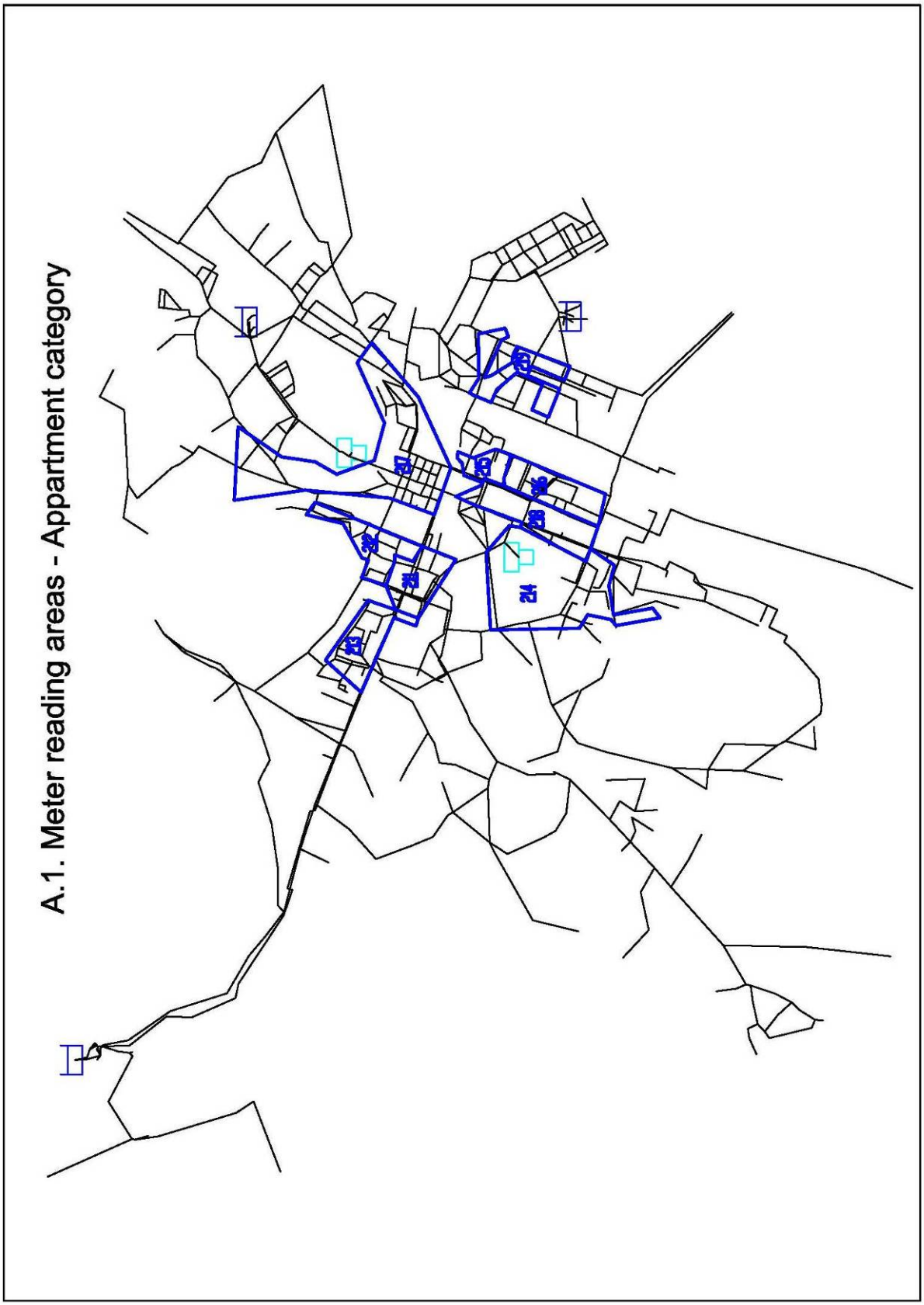
1. Existing water supply system for the regime of the average daily water consumption for 2009;

2. Existing water supply system for the regime of maximum daily water consumption for 2009;
3. Water supply system with reconstructed PS Old Mareza, for the regime of maximum daily water consumption for 2009;
4. Phase I of the development of water supply system - Option 1, for the regime of maximum daily water consumption for 2009;
5. Phase I of the development of water supply system - Option 2, for the regime of maximum daily water consumption for 2009;
6. Long-term development of water supply system for the regime of maximum daily water consumption for the 2035;

The majority of the modelling considered the 2009 demands as these are the most onerous hydraulically, as future demand is projected to fall. To ensure that investment in new facilities is not wasted the Long Term Development Model was used to verify the future performance of the planned works. Since the majority of the flow from Mareza will continue to be supplied to the city through the new reservoir and rising main, the value and sizing of the proposed elements were confirmed.

General Annexes

A. Meter reading areas
A.1. Apartment category
A.2. Individual houses category
A.3. Industry and Institution categories
A.4. Small Business category
B. Average consumption per meter reading areas
C. Average consumption in Zeta and Malesija
D. Average consumption of big consumers
E. Distribution of consumption based on influence zones of tanks
F. Proposed tank volumes


A.1. Meter reading areas - Appartment category
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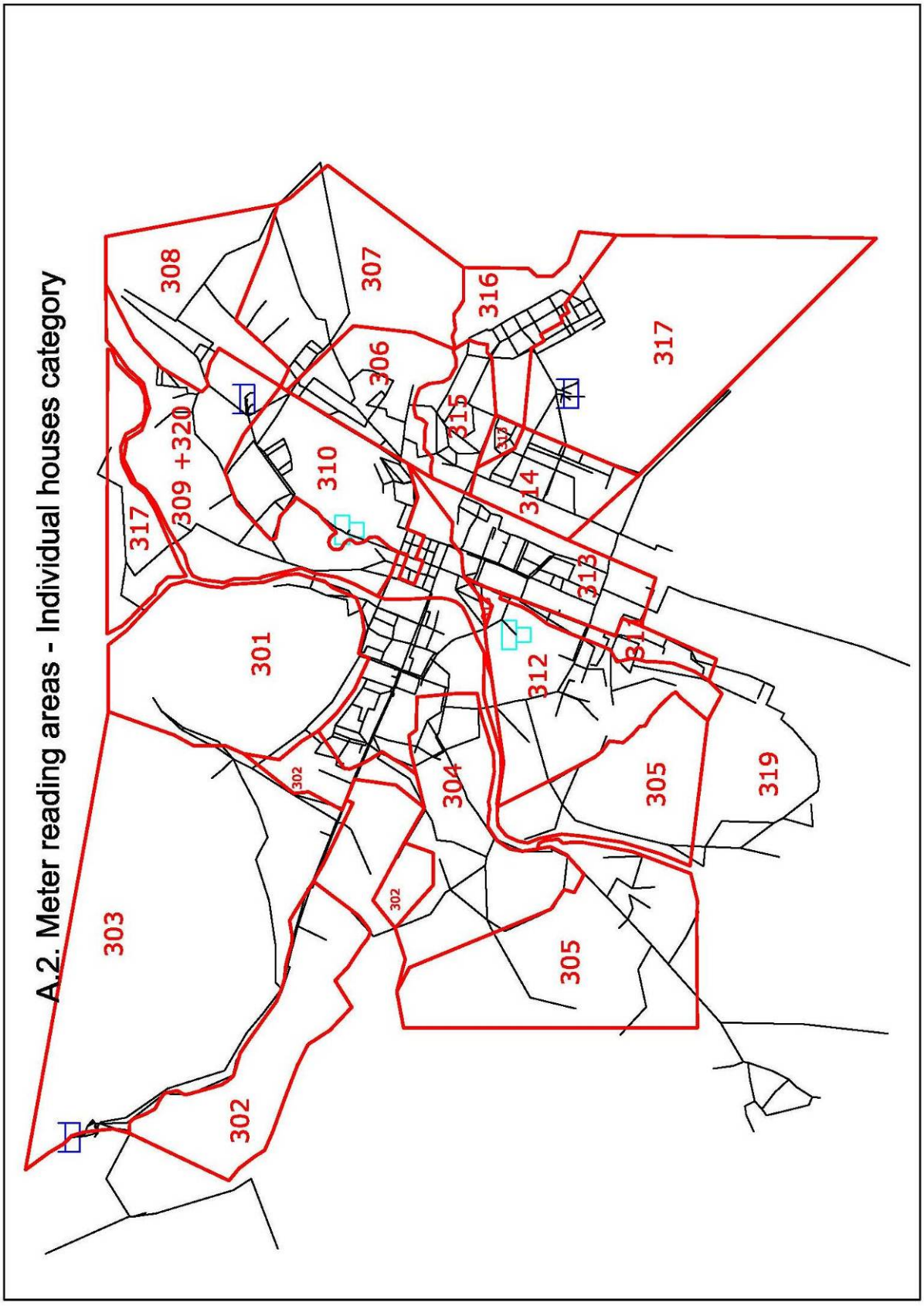
A.2. Meter reading areas - Individual houses category
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A.3. Meter reading areas - Industry and Institution categories

B. AVERAGE CONSUMPTION DISTRIBUTION

Category		Area codes	2008			2009		2035	
			m³/yr	%	m³/day	m³/day	l/s	m³/day	l/s
Domestic	Apartments	211	656,363	13%	1,798	1,887	21.84	1,956	22.63
		212	590,060	11%	1,617	1,697	19.64	1,758	20.35
		213	732,494	14%	2,007	2,106	24.38	2,182	25.26
		214	636,040	12%	1,743	1,829	21.17	1,895	21.93
		215	538,921	10%	1,476	1,550	17.94	1,606	18.58
		216	598,731	11%	1,640	1,722	19.93	1,784	20.65
		217	491,138	9%	1,346	1,412	16.35	1,463	16.94
		218	563,101	11%	1,543	1,619	18.74	1,678	19.42
		219	421,727	8%	1,155	1,213	14.04	1,257	14.54
		Total Apartments	**5,228,575**	**43%**	**14,325**	**15,035**	**174.01**	**15,579**	**180.31**
	Individual houses	301	382,867	6%	1,049	1,101	12.74	875	10.12
		302	457,099	7%	1,252	1,314	15.21	1,044	12.09
		303	545,739	8%	1,495	1,569	18.16	1,247	14.43
		304	301,924	4%	827	868	10.05	690	7.98
		305	376,879	5%	1,033	1,084	12.54	861	9.96
		306	363,857	5%	997	1,046	12.11	831	9.62
		307	278,353	4%	763	800	9.26	636	7.36
		308	187,119	3%	513	538	6.23	427	4.95
		309	488,583	7%	1,339	1,405	16.26	1,116	12.92
		310	361,585	5%	991	1,040	12.03	826	9.56
		311	278,502	4%	763	801	9.27	636	7.36
		312	381,711	6%	1,046	1,098	12.70	872	10.09
		313	276,188	4%	757	794	9.19	631	7.30
		314	381,377	6%	1,045	1,097	12.69	871	10.08
		315	333,293	5%	913	958	11.09	761	8.81
		316	344,714	5%	944	991	11.47	787	9.11
		317	116,609	2%	319	335	3.88	266	3.08
		318	397,602	6%	1,089	1,143	13.23	908	10.51
		319	299,084	4%	819	860	9.95	683	7.91
		320	192,878	3%	528	555	6.42	441	5.10
		328	89,952	1%	246	259	2.99	205	2.38
		330	62,994	1%	173	181	2.10	144	1.67
		Total w/o Zeta	-	-	-	-	-	**15,759**	**182.40**
		Zeta	-	-	-	-	-	3,482	40.30
		Juzna Malesija	-	-	-	-	-	936	10.84
		Gornja Malesija	-	-	-	-	-	378	4.38
		Total Ind. houses	**6,898,909**	**57%**	**18,901**	**19,838**	**229.61**	**20,556**	**237.91**
		Domestic TOTAL	**12,127,484**		**33,226**	**34,873**	**403.62**	**36,134**	**418.22**
Unbilled		Zeta	2,474,928		6,781	5,996	69.40	0	0.00
		Danilovgrad	1,866,838		5,115	5,115	59.20	6,480	75.00
Industry	Large	110	113,722	6%	312	314	3.64	397	4.59
		120	134,672	7%	369	372	4.31	470	5.44
		130	241,668	12%	662	668	7.73	844	9.76
		140	136,075	7%	373	376	4.35	475	5.50
		150	323,678	16%	887	894	10.35	1130	13.08
		160	148,686	7%	407	411	4.75	519	6.01
		170	200,862	10%	550	555	6.42	701	8.11
		180	86,691	4%	238	239	2.77	303	3.50
		181	35,137	2%	96	97	1.12	123	1.42
		190 leftover	357,942	18%	981	989	11.44	1249	14.46
		Big consumers	255,994	13%	701	707	8.18	894	10.34
		Total Large Ind.	**2,035,127**	**79%**	**5,576**	**5,621**	**65.06**	**7,103**	**82.21**
	Small business	511	60,799	11%	167	168	1.94	212	2.46
		512	52,467	9%	144	145	1.68	183	2.12
		513	27,041	5%	74	75	0.86	94	1.09
		514	43,470	8%	119	120	1.39	152	1.76
		515	67,824	12%	186	187	2.17	237	2.74
		516	14,759	3%	40	41	0.47	52	0.60
		517	164,764	30%	451	455	5.27	575	6.66
		518	107,853	20%	295	298	3.45	376	4.36
		529	14,025	3%	38	39	0.45	49	0.57
		Total Small Bus.	**553,002**	**21%**	**1,515**	**1,528**	**17.68**	**1,930**	**22.34**
		Construction	*142,678*	*6%*	*391*	*394*	*4.56*	-	-
		Industry TOTAL	**2,588,129**		**7,091**	**7,149**	**82.74**	**9,034**	**104.56**
Institutions		410	22,496	2%	62	64	0.75	95	1.10
		420	32,566	3%	89	93	1.08	138	1.60
		430	19,969	2%	55	57	0.66	85	0.98
		440	46,639	4%	128	134	1.55	198	2.29
		450	50,388	4%	138	144	1.67	214	2.47
		460	89,384	7%	245	256	2.97	379	4.39
		470	67,820	5%	186	194	2.25	288	3.33
		480	46,177	4%	127	132	1.53	196	2.27
		481	13,497	1%	37	39	0.45	57	0.66
		490 leftover	167,435	13%	459	480	5.56	710	8.22
		Big consumers	720,934	56%	1,975	2,067	23.92	3,059	35.41
		Institution TOTAL	**1,277,305**		**3,499**	**3,662**	**42.38**	**5,420**	**62.73**
Losses		Unbilled leftover	251,944		690	147	1.70	0	0.00
		Losses	18,748,047		51,365	50,844	588.48	19,023	220.17
		Losses + unbilled leftover	18,999,991		**52,055**	**50,991**	**590.18**	**19,023**	**220.17**
		Podgorica losses	**17,738,694**		**48,599**	**47,606**	**551.00**	**18,518**	**214.33**
Tuzi		**Tuzi losses**	1,261,297	7%	3,456	3,385	39.18	505	5.84
		Tuzi consumption	550,213		1,507	1,576	18.25	1,343	15.54
		Tuzi production	**1,811,510**		**4,963**	**4,961**	**57.42**	**1,847**	**21.38**
PODG & TUZI PRODUCTION			**39,477,353**		**108,157**	**108,179**	**1252.08**	**76,091**	**880.68**

Note: Red figures according to Chapter 6.; Figure 6.3:

C. Average Consumption for Zeta, Gornja Malesija and Donja Malesija

	Population			Consumption (l/s)	
	2003 (according to census)	2009	2035	2009	2035
Specific consumption (l/ca/day)	-	-	-	234.89	156.65
Zeta	**16,152**	**17,455**	**22,227**	**47.45**	**40.30**
Balabani 1	342	370	471	1.00	0.85
Balabani 2	411	444	566	1.21	1.03
Balabani 3	280	303	385	0.82	0.70
Berislavci	497	537	684	1.46	1.24
Bijelo Polje 1	483	522	665	1.42	1.21
Bijelo Polje 2	409	442	563	1.20	1.02
Bistrice	379	410	522	1.11	0.95
Botun 1	509	550	700	1.50	1.27
Botun 2	229	247	315	0.67	0.57
Vranjina	221	239	304	0.65	0.55
Vukovci 1	298	322	410	0.88	0.74
Vukovci 2	119	129	164	0.35	0.30
Golubovci 1	217	235	299	0.64	0.54
Golubovci 2	329	356	453	0.97	0.82
Golubovci 3	159	172	219	0.47	0.40
Golubovci 4	261	282	359	0.77	0.65
Golubovci 5	831	898	1144	2.44	2.07
Golubovci 6	331	358	455	0.97	0.83
Golubovci 7	292	316	402	0.86	0.73
Golubovci 8	342	370	471	1.00	0.85
Golubovci 9	439	474	604	1.29	1.10
Goricani 1	248	268	341	0.73	0.62
Goricani 2	430	465	592	1.26	1.07
Goricani 3	437	472	601	1.28	1.09
Goricani 4	424	458	583	1.25	1.06
Gostilj	193	209	266	0.57	0.48
Kurilo	117	126	161	0.34	0.29
Ljajkovici 1	105	113	144	0.31	0.26
Ljajkovici 2	255	276	351	0.75	0.64
Ljajkovici 3	147	159	202	0.43	0.37
Mataguzi 1	401	433	552	1.18	1.00
Mataguzi 2	314	339	432	0.92	0.78
Mataguzi 3	383	414	527	1.13	0.96
Mataguzi 4	339	366	467	1.00	0.85
Mahala 1	384	415	528	1.13	0.96
Mahala 2	586	633	806	1.72	1.46
Mahala 3	329	356	453	0.97	0.82
Mitrovici	280	303	385	0.82	0.70
Mojanovici 1	487	526	670	1.43	1.22
Mojanovici 2	624	674	859	1.83	1.56
Mojanovici 3	618	668	850	1.82	1.54
Mojanovici 4	366	396	504	1.08	0.91
Ponari 1	166	179	228	0.49	0.41
Ponari 2	130	140	179	0.38	0.32
Srpska 1	384	415	528	1.13	0.96
Srpska 2	336	363	462	0.99	0.84
Susunja	291	314	400	0.85	0.73
Plavnica (small industry)				2.0	2.0
Beglake (small industry)				2.00	2.00
Juzna Malesija	**4,343**	**4,693**	**5,976**	**12.76**	**10.84**
Vladni	652	705	897	1.92	1.63
Vranj 1	558	603	768	1.64	1.39
Vranj 2	477	515	656	1.40	1.19
Vuksanlekici	542	586	746	1.59	1.35
Dresaj	159	172	219	0.47	0.40
Dusici	425	459	585	1.25	1.06
Kotrabudan 1	196	212	270	0.58	0.49
Kotrabudan 2	178	192	245	0.52	0.44
Podhum	303	327	417	0.89	0.76
Sukuruc 1	567	613	780	1.67	1.41
Sukuruc 2	286	309	394	0.84	0.71
Gornja Malesija	**1,754**	**1,896**	**2,414**	**5.15**	**4.38**
Arza	165	178	227	0.48	0.41
Barlaj	80	86	110	0.24	0.20
Drume 1	247	267	340	0.73	0.62
Drume 2	283	306	389	0.83	0.71
Nabon	72	78	99	0.21	0.18
Skorac	349	377	480	1.03	0.87
Spinja	237	256	326	0.70	0.59
Trabojin	125	135	172	0.37	0.31
Helmnica	196	212	270	0.58	0.49
Total	**22,249**	**24,044**	**30,617**	**69.40**	**55.51**

Note 1: Specific consumption according to Chapter 6.; Figure 6.3;

Note 2: Consumption for Plavnica and Beglake according to Concept Design for Water supplying of Zeta and Malesija, JP ViK Podgorica

D. AVERAGE CONSUMPTION OF BIG CONSUMERS

Category		Consumer	2008			2009		2035	
			m^3/yr	%	m^3/day	m^3/day	l/s	m^3/day	l/s
Industry	Large - 190	Hotel Crna Gora	55,101	21.5%	151	152	1.76	192	2.23
		AD Plantaze - Vinarski podrum	40,222	15.7%	110	111	1.29	140	1.62
		AD Plantaze - Kuce Rakica	31,895	12.5%	87	88	1.02	111	1.29
		Duvanski kombinat	49,778	19.4%	136	137	1.59	174	2.01
		Hemomont doo	35,781	14.0%	98	99	1.14	125	1.45
		Aerodromi CG	25,726	10.0%	70	71	0.82	90	1.04
		MUP RCG	17,491	6.8%	48	48	0.56	61	0.71
		Total - Big consumers	**255,994**	41.7%	**701**	**707**	**8.18**	**894**	**10.34**
		Total - area 190	**613,936**	-	**1,682**	**1,696**	**19.63**	**2143**	**24.80**
Institutions	Large - 490	Kasarna Masline	245,630	34.1%	673	704	8.15	1042	12.06
		Nova bolnica i stara bolnica	279,145	38.7%	765	800	9.26	1185	13.71
		Univerz. Centar V. Vlahovic	53,095	7.4%	145	152	1.76	225	2.61
		Studentski dom Restoran 2	36,808	5.1%	101	106	1.22	156	1.81
		Decija bolnica 1 i 2	56,639	7.9%	155	162	1.88	240	2.78
		Dom ucenika i studenata	27,630	3.8%	76	79	0.92	117	1.36
		Studentski blok 2	21,987	3.0%	60	63	0.73	93	1.08
		Total - Big consumers	**720,934**	81.2%	**1,975**	**2,067**	**23.92**	**3,059**	**35.41**
		Total - area 490	**888,369**	-	**2,434**	**2,547**	**29.48**	**3770**	**43.63**

Note: Total for Big consumers and areas 190 and 490 according to B. AVERAGE CONSUMPTION DISTRIBUTION

E. Distribution of consumption based on influence zones of tanks

Category		Area codes	2009	Consumption Distribution (m^3/day)				
			m^3/day	Vrsak & Ljubovic	Gorica	Masline	Momisici	Tuzi
Domestic	Apartments	211	1,887	1,887				
		212	1,697	1,697				
		213	2,106	2,106				
		214	1,829	1,829				
		215	1,550	1,550				
		216	1,722	1,722				
		217	1,412		1,412			
		218	1,619	1,619				
		219	1,213			1,213		
	Private houses	301	1,101				1,101	
		302	1,314				1,314	
		303	1,569				1,569	
		304	868	868				
		305	1,084	1,084				
		306	1,046		1,046			
		307	800		800			
		308	538		538			
		309	1,405		1,405			
		310	1,040		1,040			
		311	801	801				
		312	1,098	1,098				
		313	794	794				
		314	1,097			1,097		
		315	958			958		
		316	991			991		
		317	335		34	302		
		318	1,143					1,143
		319	860	860				
		320	555		555			
		328	259					259
		330	181			181		
Industry	Large	110	487		487			
		120	545	272	272			
		130	840	840				
		140	549	549				
		150	1,067	1,067				
		160	584	584				
		170	728		728			
		180	412	412				
		181	97					97
		Big consumers	707	707				
	Small	511	168	168				
		512	145	145				
		513	75	75				
		514	120	120				
		515	187			187		
		516	41		41			
		517	455	228	228			
		518	298	298				
		529	39					39
Institutions		410	124		124			
		420	153	77	77			
		430	117	117				
		440	194	194				
		450	204	204				
		460	316	316				
		470	254		254			
		480	192	192				
		481	39					39
		Big consumers	2,067	1,363	704			
Total consumption			**46,077**	**25,842**	**9,745**	**4,929**	**3,985**	**1,576**
Losses (46% PG & 68% Tuzi)			**39,441**	**22,120**	**8,341**	**4,219**	**3,411**	**3,385**
Total production (w/o Zeta and Danilovgrad)			**85,519**	**47,963**	**18,086**	**9,149**	**7,395**	**4,961**

F. Volume of the Major Service Reservoirs

Storage Requirements	Min (m^3/day) for 2009.y.				
	(hours)	Vrsak & Ljubovic	Gorica	Masline	Momisici
Total production (w/o Zeta and Danilovgrad)	-	47,963	18,086	9,149	7,395
Balancing	3	5,995	2,261	1,144	924
Provision for shutdowns	6	11,991	4,522	2,287	1,849
Firefighting	2	3,997	1,507	762	616
Volume required	11	21,983	8,289	4,193	3,390
Volume proposed	-	23,000	10,000	5,000	5,000

Storage Requirements	Max (m^3/day) for 2035.y.				
	(hours)	Vrsak & Ljubovic	Gorica	Masline	Momisici
Total production (w/o Zeta and Danilovgrad)	-	36,478	12,690	5,712	4,208
Balancing	4	6,080	2,115	952	701
Provision for shutdowns	12	18,239	6,345	2,856	2,104
Firefighting	2	3,040	1,057	476	351
Volume required	18	27,358	9,517	4,284	3,156
Volume proposed	-	23,000	10,000	5,000	5,000

1. EXISTING WATER SUPPLY SYSTEM FOR THE REGIME OF THE AVERAGE DAILY WATER CONSUMPTION FOR THE YEAR 2009

Geometric elements:

- Number of Junctions 932
- Number of Reservoirs 16
- Number of Tanks 5
- Number of Pipes 1132
- Number of Pumps 22
- Number of Valves 2

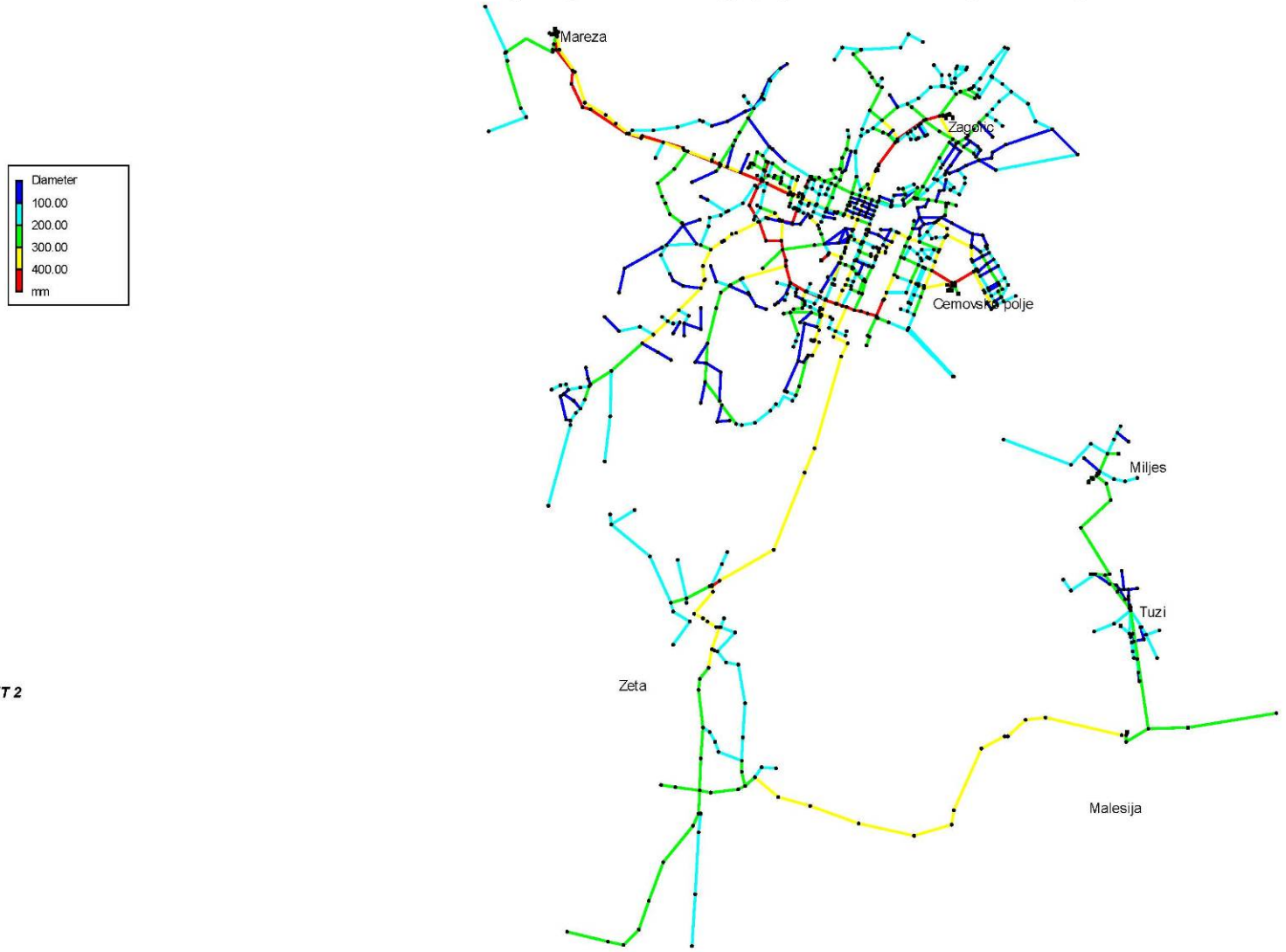
Comments of the operating mode:

- Operating mode on 13th March 2009;
- Average daily consumption - 100%;
- Isolated system VLEKICI – closed pipes 146 and 148;
- Tank Sipcanik is closed;
- Valve Zeta_PRV setting is 45m;

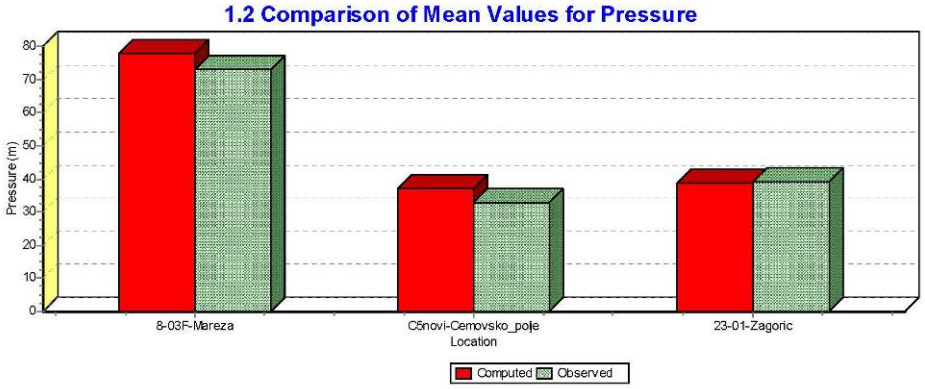
Appendixes:

1.1. Water supply network of the system;
1.2. Calibration report – pressures;
1.3. Calibration report – flows;
1.4. Reservoir Ljubovic water level fluctuation;
1.5. Pressure fluctuations for the characteristic nodes of the system;
1.6. Pumps functioning of the PS Old Mareza and PS New Mareza;
1.7. Pumps functioning at the water sources Zagoric and Cemovsko field;
1.8. Pumps functioning of the PS Decici and water source Miljes;
1.9. Diagram of energy consumption per m3 of all PS;
1.10. The percentage of pump use of all PS;
1.11. Tabular report of energy consumption;
1.12. Pressure Contour plot at 7 PM.

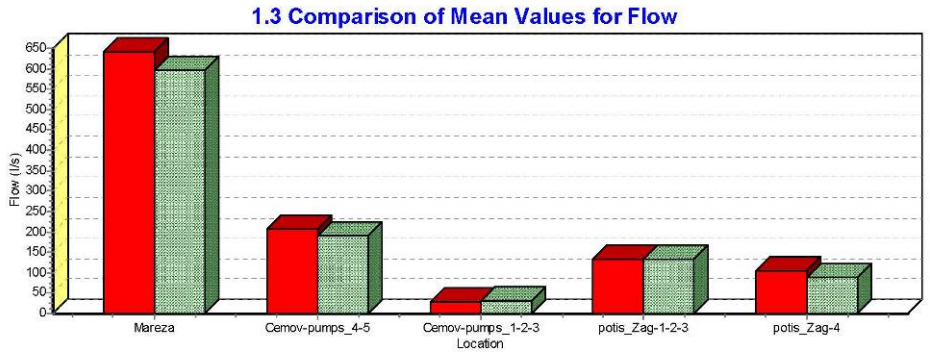
1.1 Existing Podgorica Water Supply System 2009 - Average Consumption



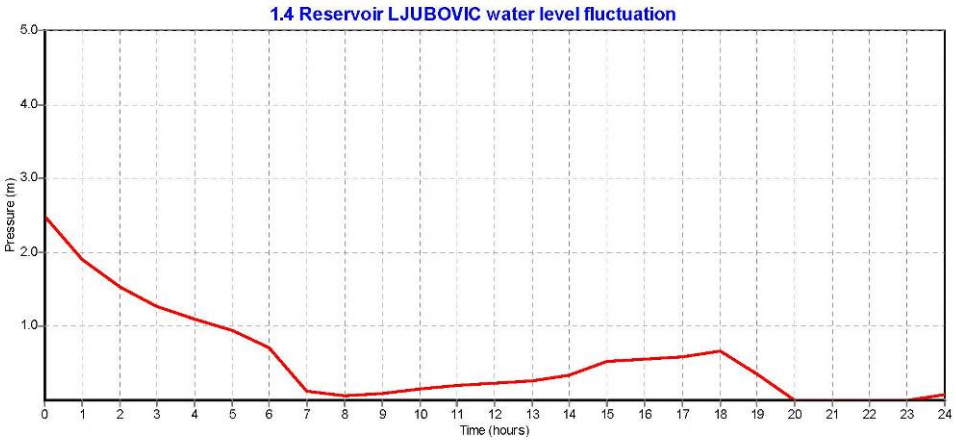
Existing Podgorica Water Supply System 2009 - Average Consumption



Existing Podgorica Water Supply System 2009 - Average Consumption

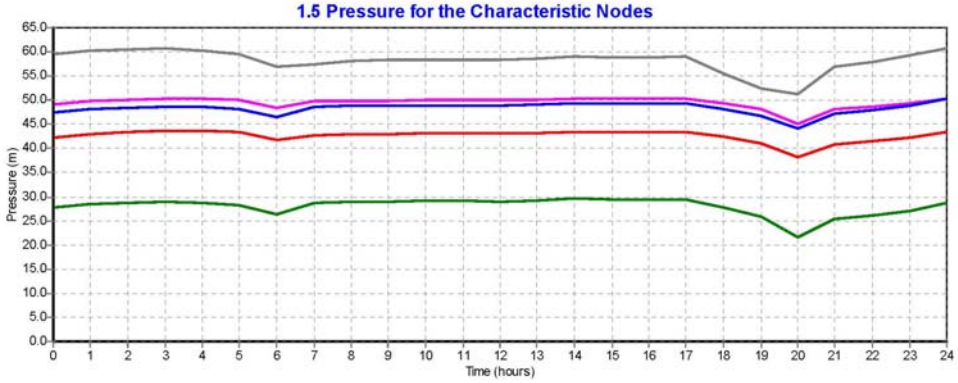


Existing Podgorica Water Supply System 2009 - Average Consumption



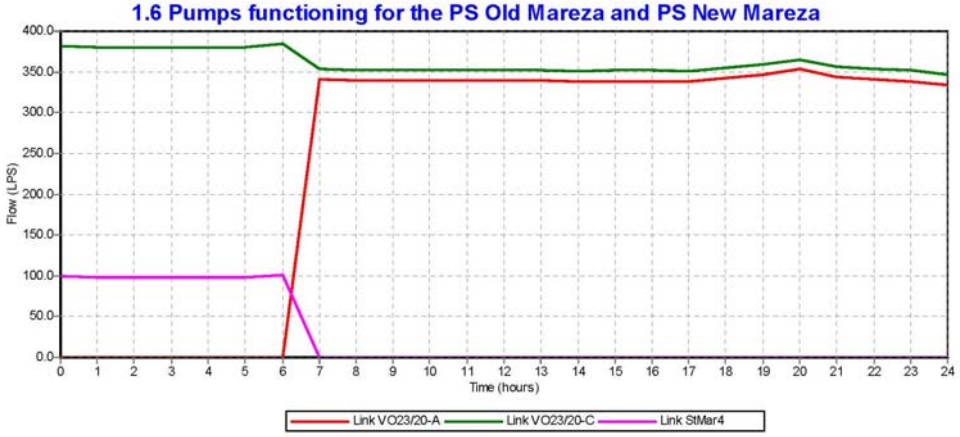
Existing Podgorica Water Supply System 2009 - Average Consumption

1.5 Pressure for the Characteristic Nodes



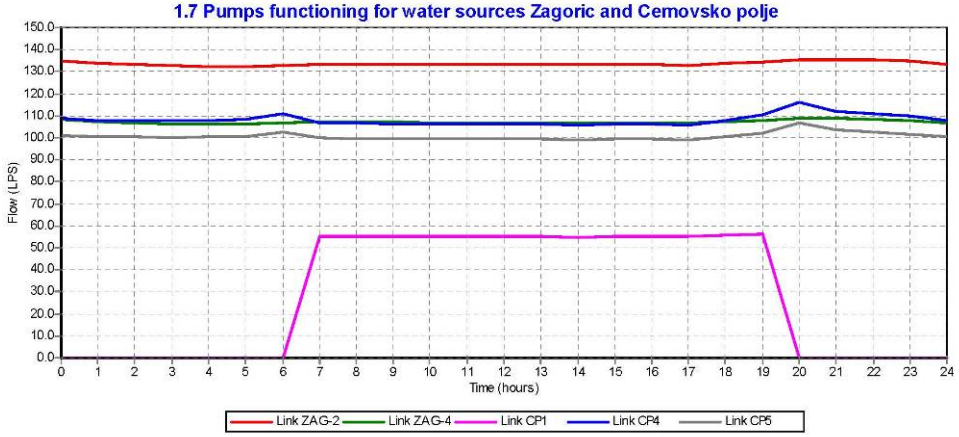
Existing Podgorica Water Supply System 2009 - Average Consumption

1.6 Pumps functioning for the PS Old Mareza and PS New Mareza

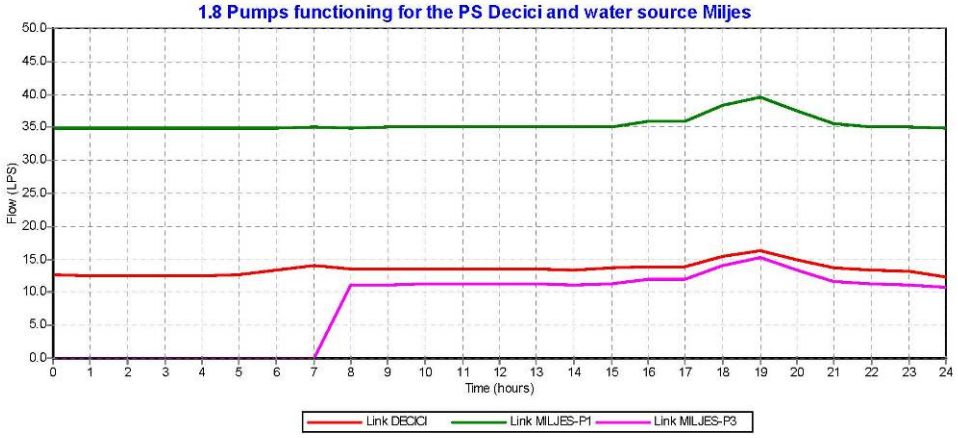


Existing Podgorica Water Supply System 2009 - Average Consumption

1.7 Pumps functioning for water sources Zagoric and Cemovsko polje

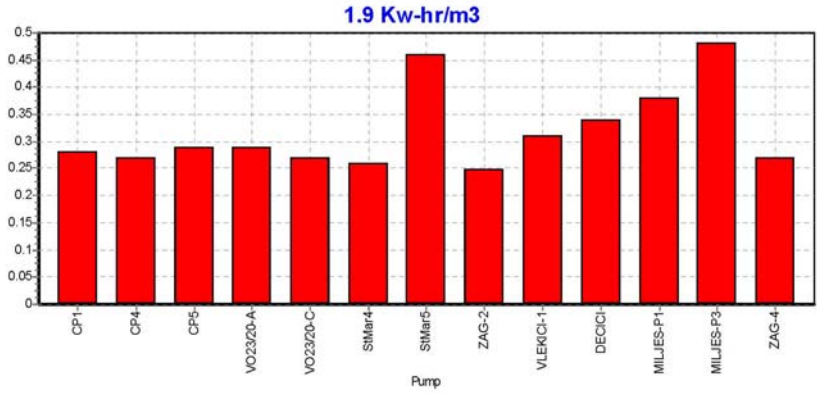


Existing Podgorica Water Supply System 2009 - Average Consumption



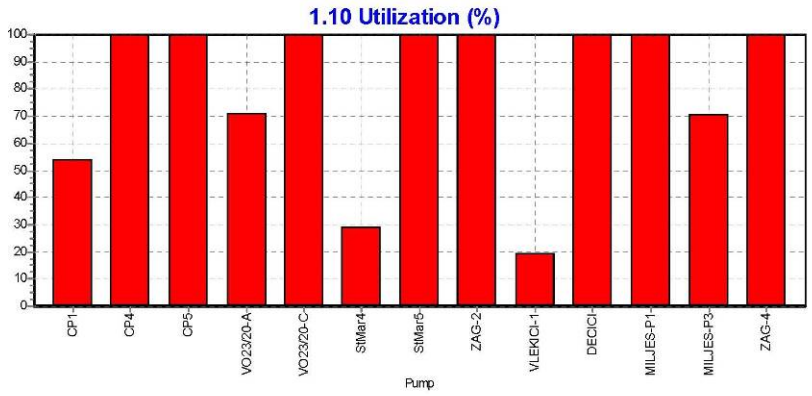
Existing Podgorica Water Supply System 2009 - Average Consumption

Energy Report



Existing Podgorica Water Supply System 2009 - Average Consumption

Energy Report



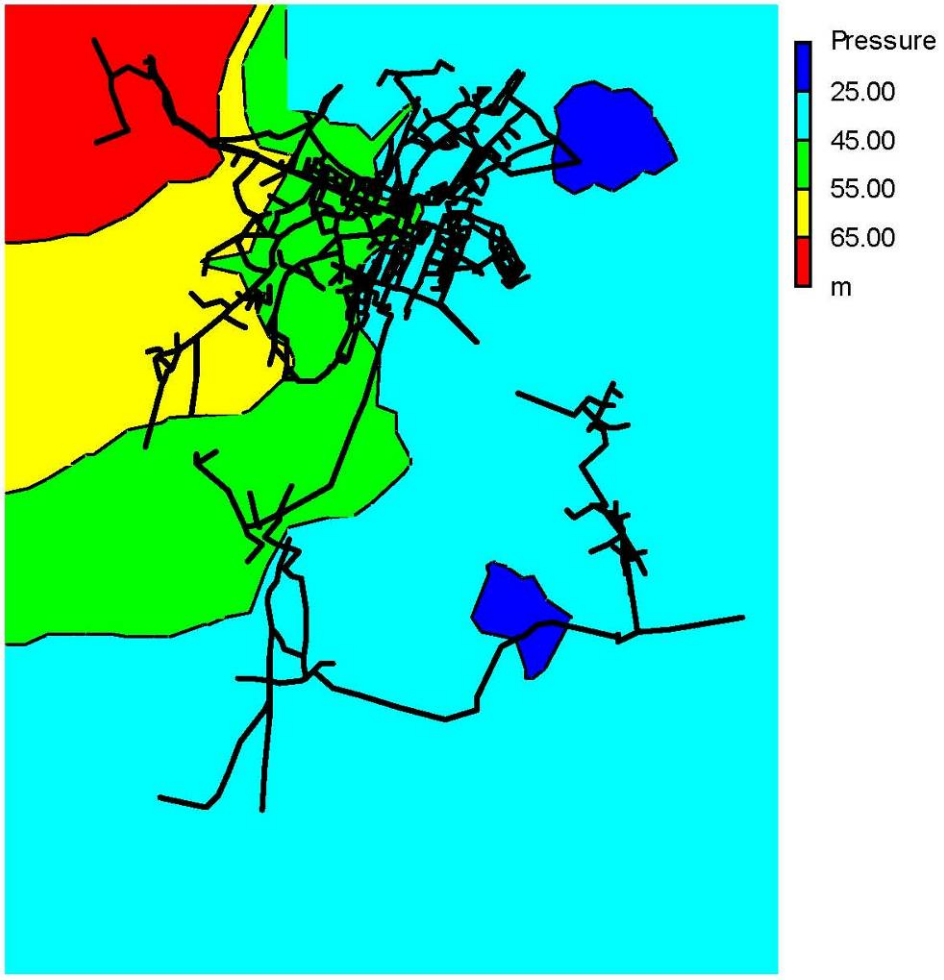
Existing Podgorica Water Supply System 2009 - Average Consumption

Energy Report

Pump	Percent Utilization	Average Efficiency	Kw-hr /m3	Average Kwatts	Peak Kwatts	Cost /day
CP1	54.17	77.98	0.28	55.18	55.24	86.08
CP2	0.00	0.00	0.00	0.00	0.00	0.00
CP3	0.00	0.00	0.00	0.00	0.00	0.00
CP4	100.00	78.27	0.27	105.95	106.30	305.13
CP5	100.00	71.53	0.29	106.59	106.93	306.99
VO23/20-A	70.83	74.95	0.29	355.84	356.19	725.91
VO23/20-B	0.00	0.00	0.00	0.00	0.00	0.00
VO23/20-C	100.00	76.48	0.27	355.36	356.07	1023.43
VO23/20-D	0.00	0.00	0.00	0.00	0.00	0.00
StMar6	0.00	0.00	0.00	0.00	0.00	0.00
StMar4	29.17	73.83	0.26	91.40	91.47	76.78
StMar5	100.00	63.52	0.46	98.74	98.74	284.37
StMar3	0.00	0.00	0.00	0.00	0.00	0.00
ZAG-1	0.00	0.00	0.00	0.00	0.00	0.00
ZAG-2	100.00	74.53	0.25	122.33	122.62	352.31
ZAGOR-B3	0.00	0.00	0.00	0.00	0.00	0.00
VLEKICI-1	19.44	77.38	0.31	70.09	70.31	39.25
DECICI	100.00	72.46	0.34	16.79	17.61	48.36
MILJES-P1	100.00	79.75	0.38	49.12	49.29	141.45
MILJES-P3	70.37	63.37	0.48	20.24	21.15	41.02
MILJES-P2	0.00	0.00	0.00	0.00	0.00	0.00
ZAG-4	100.00	71.07	0.27	104.36	104.89	300.56
Total Cost						3731.64
Demand Charge						0.00

1.11 Energy consumption

Existing Podgorica Water Supply System 2009 - Average Consumption



Day 1, 7:00 PM

1.12 Pressure contour plot at 7 PM

2. EXISTING WATER SUPPLY SYSTEM FOR THE REGIME OF MAXIMUM DAILY/HOURLY WATER CONSUMPTION FOR THE YEAR 2009

Geometric elements:

- Number of Junctions 932
- Number of Reservoirs 16
- Number of Tanks 5
- Number of Pipes 1132
- Number of Pumps 22
- Number of Valves 2

Comments of the operating mode:

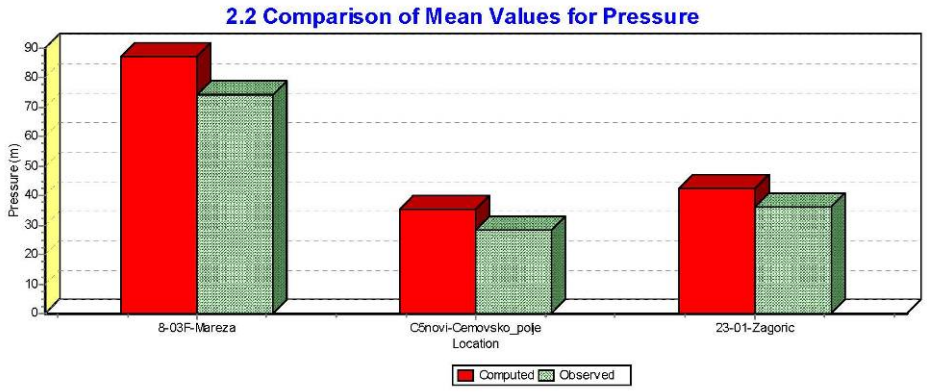
- Operating mode on 29th July 2009;
- Max daily consumption - 150% of the average daily consumption;
- Isolated system VLEKICI – closed pipes 146 and 148;
- Tank Sipcanik is closed;
- Valve Zeta_PRV setting is 45m;

Appendixes:

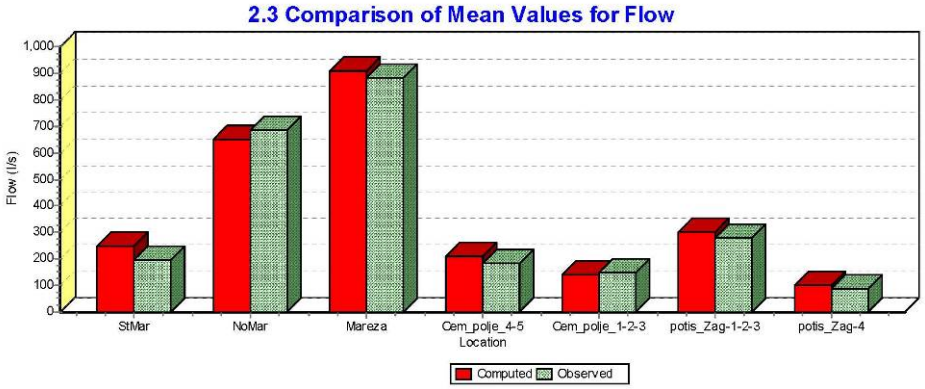
2.1. Water supply network of the system;
2.2. Calibration report – pressures;
2.3. Calibration report – flows;
2.4. Reservoir Ljubovic water level fluctuation;
2.5. Pressure fluctuations for the characteristic nodes of the system;
2.6. Diagram of functioning of the pumps PS Old Mareza and PS New Mareza;
2.7. Diagram of functioning of the pumps at the water source Zagoric;
2.8. Diagram of functioning of the pumps at the water source Cemovsko field;
2.9. Diagram of functioning of the pump PS Decici and water source Miljes;
2.10. Diagram of energy consumption per m3 of all PS;
2.11. The percentage of pump use of all PS;
2.12. Tabular report of energy consumption;
2.13. Pressure Contour plot at 7 PM;

2.1 Existing Podgorica Water Supply System 2009 - Qmax,d

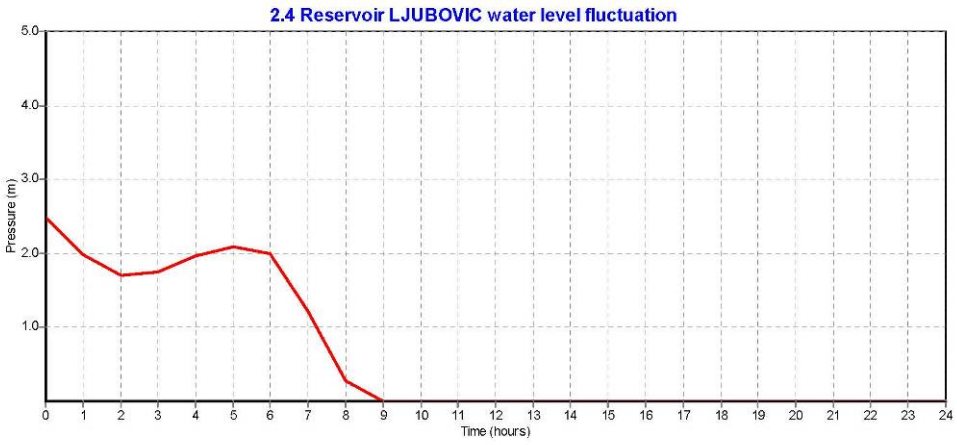
Existing Podgorica Water Supply System 2009 - Qmax,d



Existing Podgorica Water Supply System 2009 - Qmax,d



Existing Podgorica Water Supply System 2009 - Qmax,d



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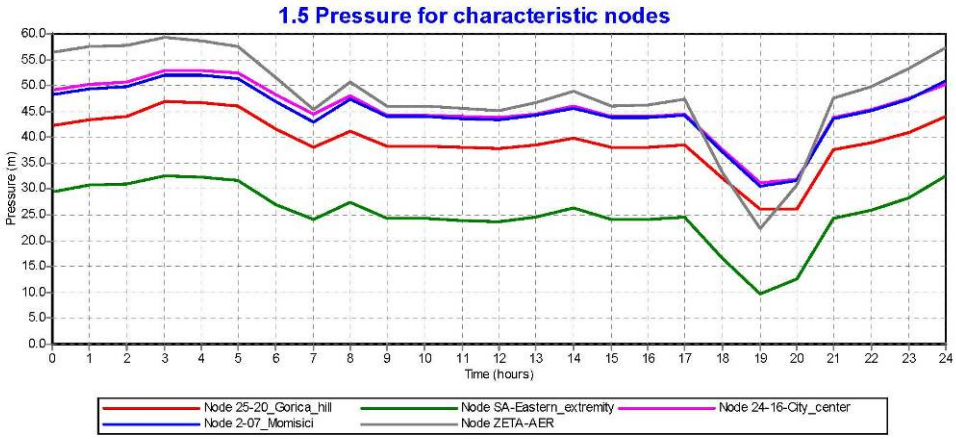
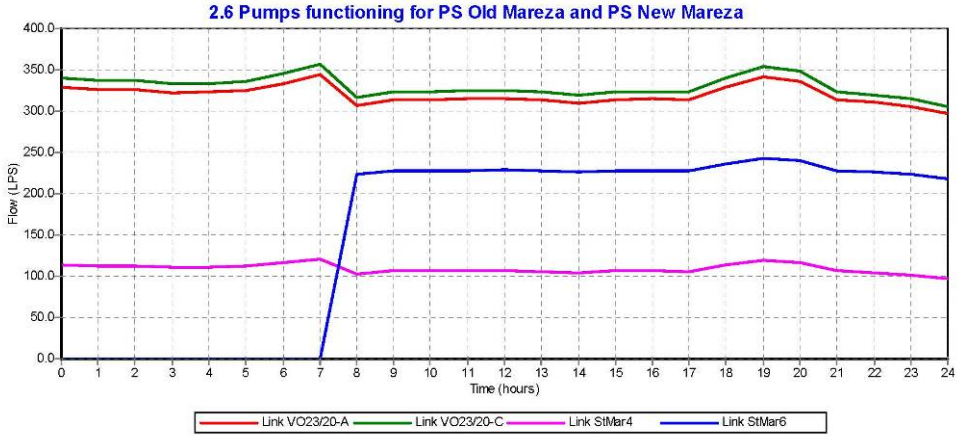
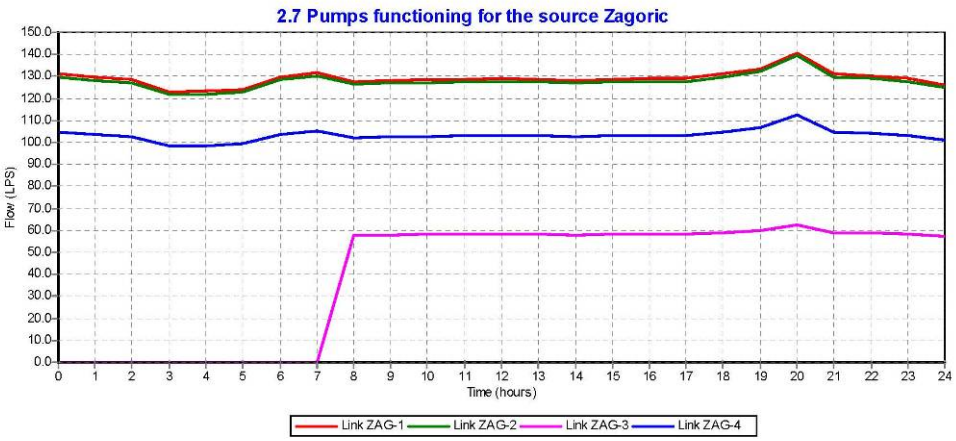
Existing Podgorica Water Supply System 2009 - Qmax,d



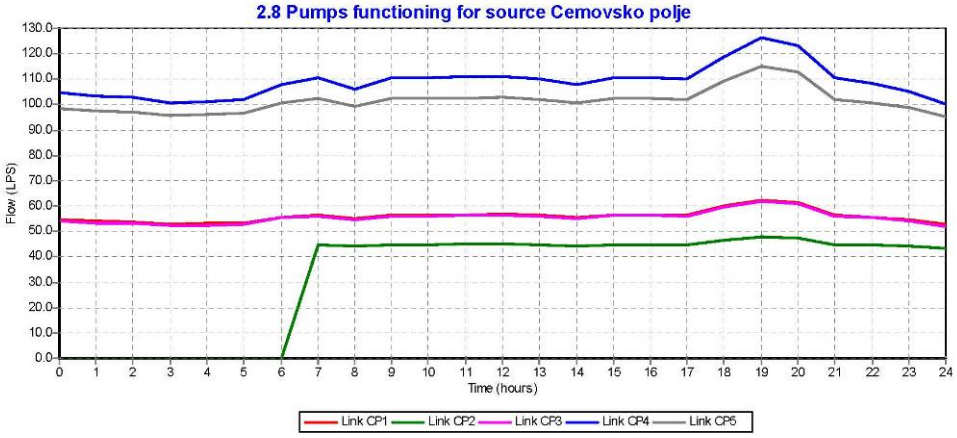
Existing Podgorica Water Supply System 2009 - Qmax,d



Existing Podgorica Water Supply System 2009 - Qmax,d

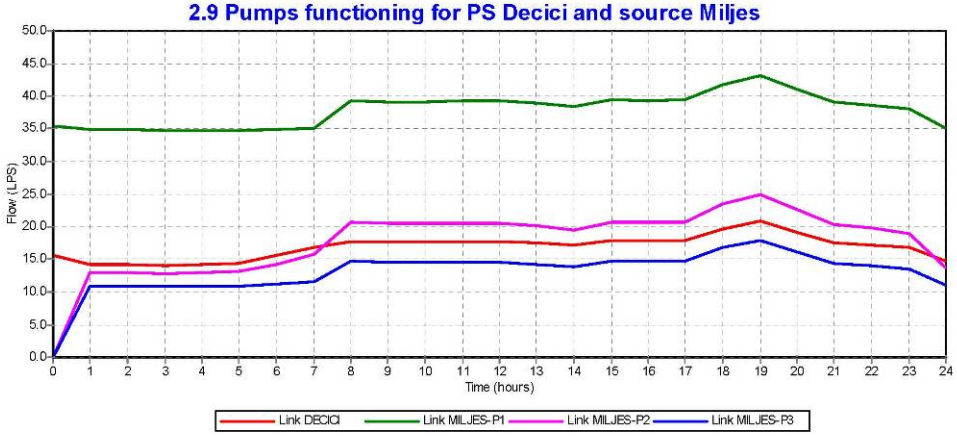


Existing Podgorica Water Supply System 2009 - Qmax,d



Existing Podgorica Water Supply System 2009 - Qmax,d

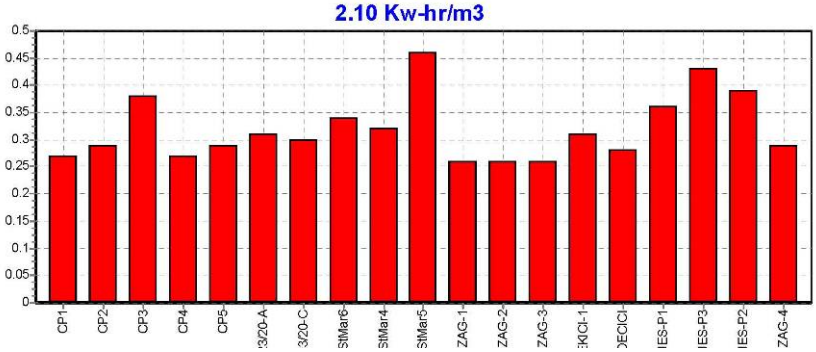
2.9 Pumps functioning for PS Decici and source Miljes



Existing Podgorica Water Supply System 2009 - Qmax,d

Energy Report

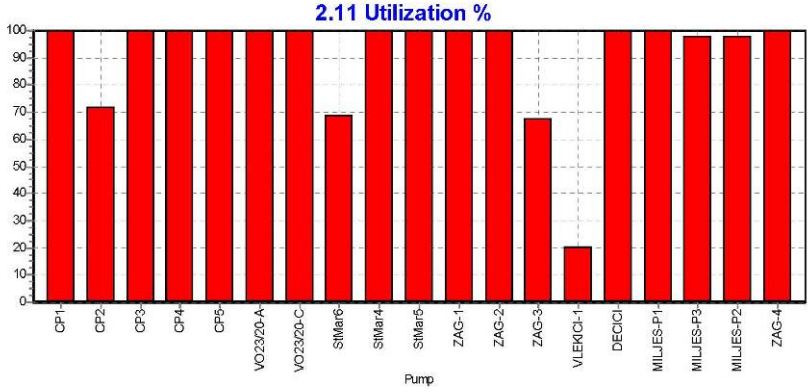
2.10 Kw-hr/m3



Existing Podgorica Water Supply System 2009 - Qmax,d

Energy Report

2.11 Utilization %



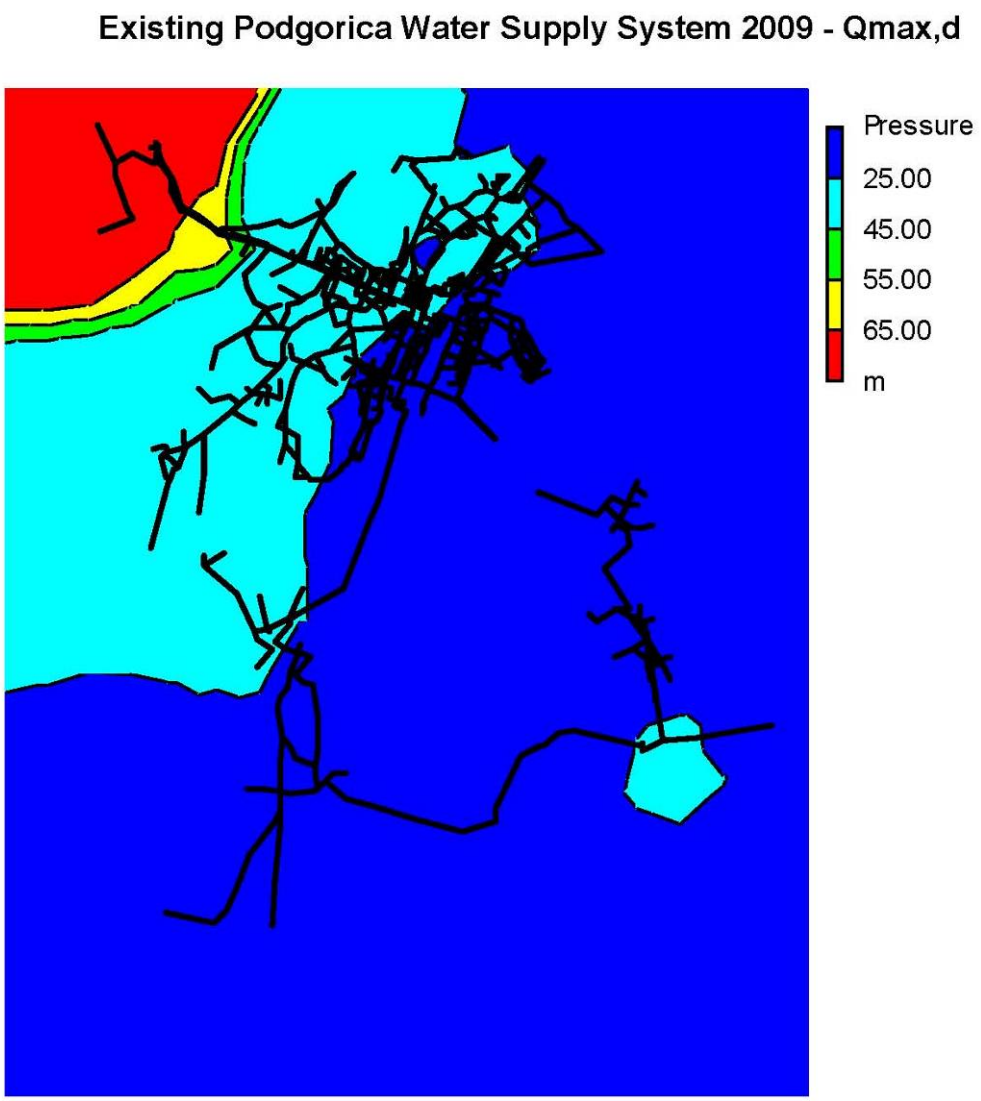
Existing Podgorica Water Supply System 2009 - Qmax,d

Energy Report

Pump	Percent Utilization	Average Efficiency	Kw-hr /m3	Average Kwatts	Peak Kwatts	Cost /day
CP1	100.00	77.53	0.27	54.95	55.34	158.26
CP2	71.88	70.17	0.29	46.86	47.79	97.00
CP3	100.00	55.75	0.38	76.46	77.34	220.21
CP4	100.00	78.16	0.27	105.53	106.61	303.94
CP5	100.00	71.66	0.29	105.82	106.92	304.76
VO23/20-A	100.00	76.39	0.31	356.80	356.97	1027.58
VO23/20-B	0.00	0.00	0.00	0.00	0.00	0.00
VO23/20-C	100.00	78.79	0.30	356.55	357.02	1026.87
VO23/20-D	0.00	0.00	0.00	0.00	0.00	0.00
StMar6	68.75	69.82	0.34	280.43	281.85	555.25
StMar4	100.00	72.69	0.32	126.67	131.00	364.82
StMar5	100.00	63.52	0.46	98.74	98.74	284.38
StMar3	0.00	0.00	0.00	0.00	0.00	0.00
ZAG-1	100.00	76.33	0.26	121.44	125.62	349.75
ZAG-2	100.00	76.86	0.26	121.14	125.47	348.88
ZAG-3	67.71	75.00	0.26	55.72	56.43	108.66
VLEKICI-1	20.41	77.34	0.31	70.13	70.31	41.21
DECICI	100.00	61.90	0.28	16.72	17.59	48.14
MILJES-P1	100.00	78.11	0.36	49.03	49.32	141.22
MILJES-P3	97.82	65.91	0.43	20.70	21.60	58.32
MILJES-P2	97.82	73.00	0.39	25.32	28.06	71.34
ZAG-4	100.00	71.37	0.29	105.80	106.89	304.69
Total Cost						5815.27
Demand Charge						0.00

2.12 Energy consumption

Page 1



2.13 Pressure Contour plot at 7 PM

Page 1

3. WATER SUPPLY SYSTEM WITH RECONSTRUCTED PS OLD MAREZA, FOR THE REGIME OF MAXIMUM DAILY WATER CONSUMPTION FOR THE YEAR 2009

Geometric elements:

- Number of Junctions 934
- Number of Reservoirs 16
- Number of Tanks 5
- Number of Pipes 1134
- Number of Pumps 23
- Number of Valves 2

Comments of the operating mode:

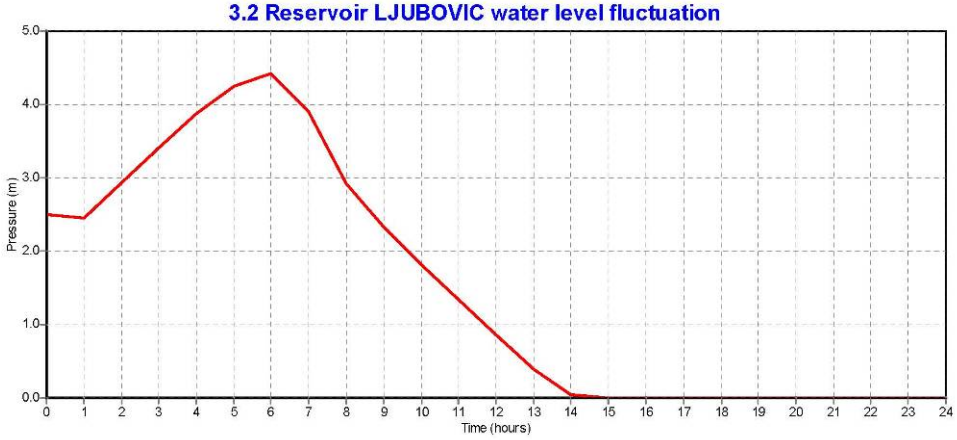
- Max daily consumption - 150% of the average daily consumption;
- Partly isolated system VLEKICI – closed pipeC31-C27;
- Tank Sipcanik is closed;
- Valve Zeta_PRV setting is 45m;

Appendixes:

3.1. Water supply network of the system;
3.2. Reservoir Ljubovic water level fluctuation;
3.3. Diagram of daily fluctuations in pressures in the characteristic nodes of the system;
3.4. Diagram of functioning of the pumps PS Mareza-3 and PS New Mareza;
3.5. Diagram of functioning of the pumps at the water source Zagoric;
3.6. Diagram of functioning of the pumps at the water source Cemovsko field;
3.7. Diagram of functioning of the pump PS Decici, water source Miljes and PS Vuksanlekici-1;
3.8. Diagram of energy consumption per m3 of all PS;
3.9. The percentage of pump use of all PS;
3.10. Tabular report of energy consumption;
3.11. Pressure Counter plot at 7 PM;

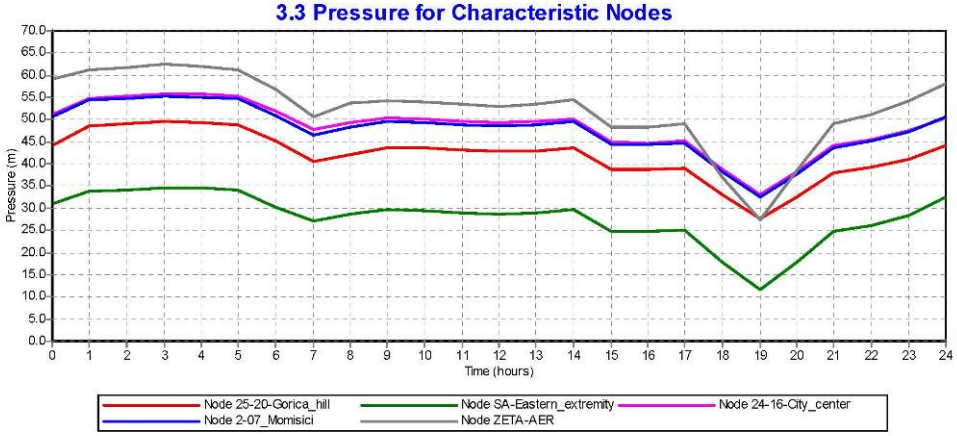
3.1 Podgorica Water Supply System 2009 - Qmax,d - Reconstructed PS Old Mareza

3.2 Reservoir LJUBOVIC water level fluctuation



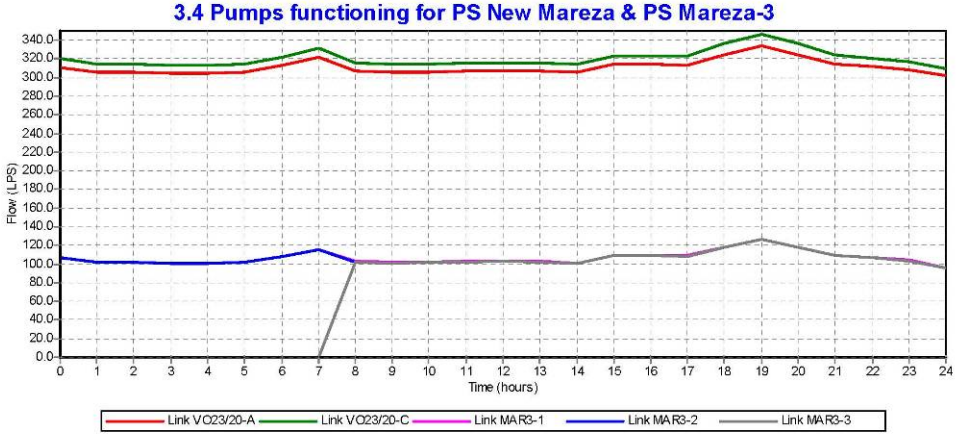
Podgorica Water Supply System 2009 - Qmax,d - Reconstructed PS Old Mareza

3.3 Pressure for Characteristic Nodes

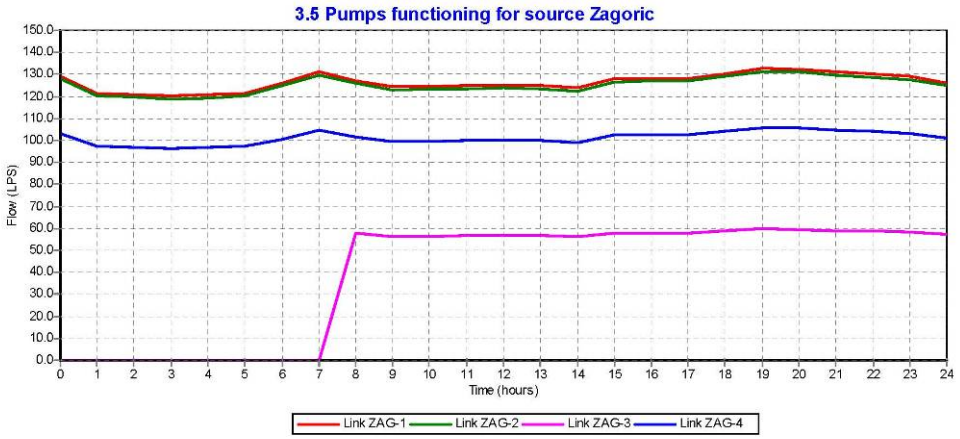


Podgorica Water Supply System 2009 - Qmax,d - Reconstructed PS Old Mareza

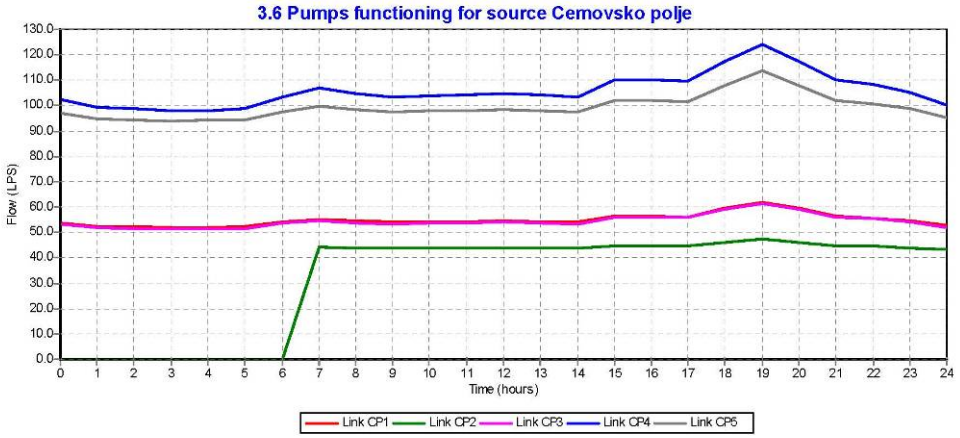
3.4 Pumps functioning for PS New Mareza & PS Mareza-3



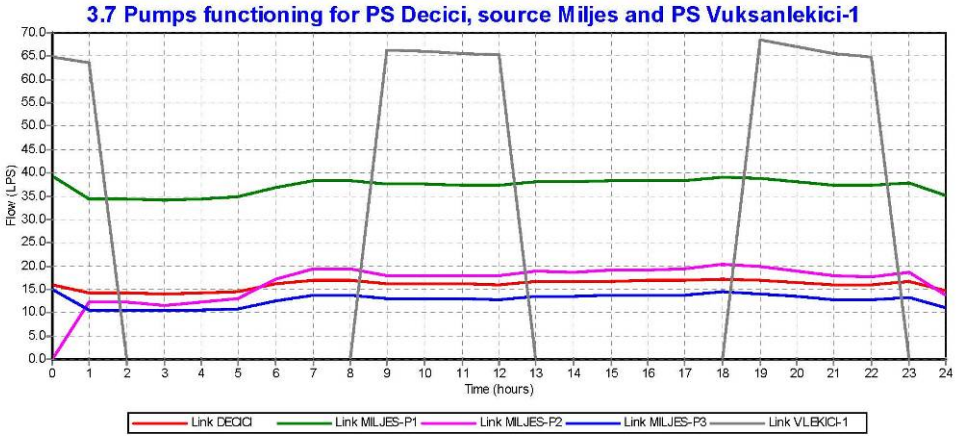
Podgorica Water Supply System 2009 - Qmax,d - Reconstructed PS Old Mareza



Podgorica Water Supply System 2009 - Qmax,d - Reconstructed PS Old Mareza

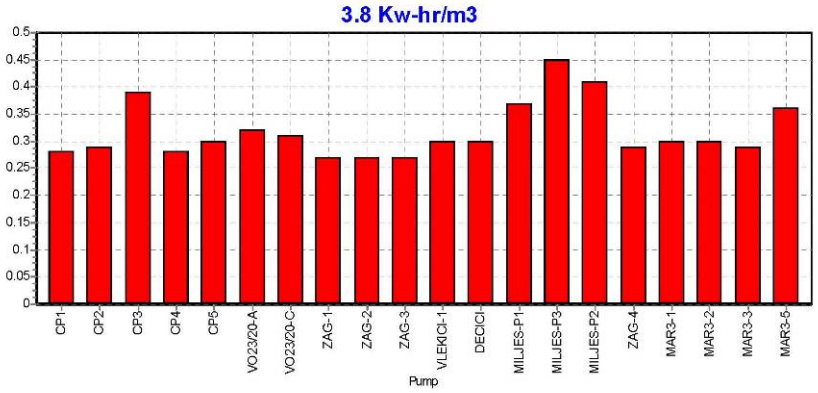


Podgorica Water Supply System 2009 - Qmax,d - Reconstructed PS Old Mareza



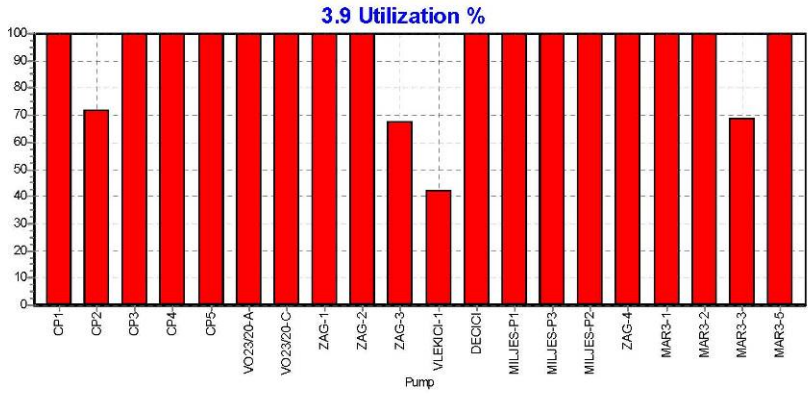
Podgorica Water Supply System 2009 - Qmax,d - Reconstructed PS Old Mareza

Energy Report



Podgorica Water Supply System 2009 - Qmax,d - Reconstructed PS Old Mareza

Energy Report

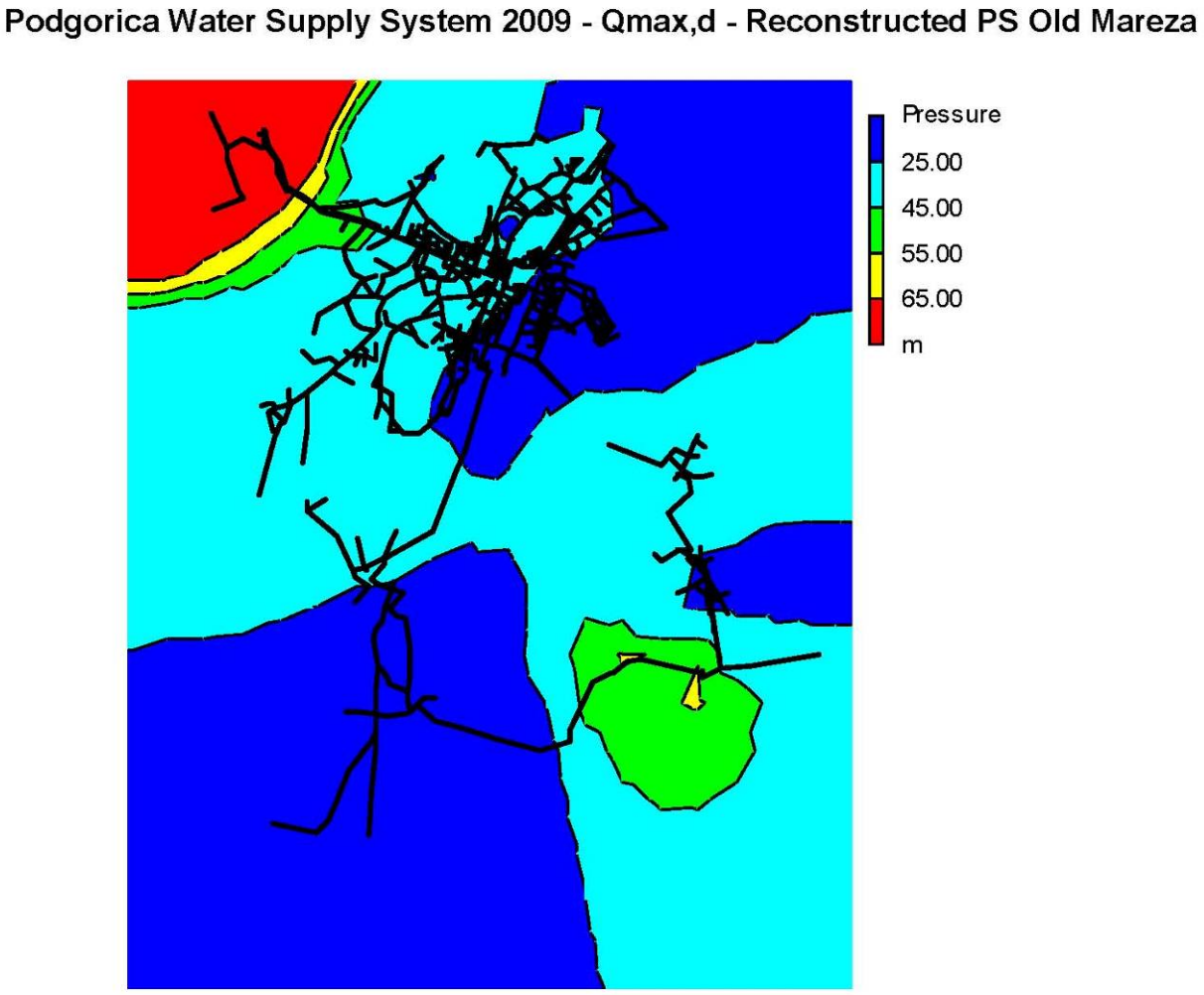


Podgorica Water Supply System 2009 - Qmax,d - Reconstructed PS Old Mareza

Energy Report

Pump	Percent Utilization	Average Efficiency	Kw-hr /m3	Average Kwatts	Peak Kwatts	Cost /day
CP1	100.00	77.94	0.28	55.09	55.35	158.66
CP2	71.88	71.11	0.29	47.14	47.84	97.59
CP3	100.00	55.87	0.39	76.77	77.62	221.11
CP4	100.00	77.86	0.28	105.94	106.62	305.10
CP5	100.00	72.10	0.30	106.07	106.92	305.49
VO23/20-A	100.00	76.91	0.32	356.85	356.98	1027.73
VO23/20-B	0.00	0.00	0.00	0.00	0.00	0.00
VO23/20-C	100.00	79.07	0.31	356.86	357.02	1027.77
VO23/20-D	0.00	0.00	0.00	0.00	0.00	0.00
ZAG-1	100.00	77.45	0.27	120.74	122.35	347.74
ZAG-2	100.00	77.92	0.27	120.41	122.16	346.78
ZAG-3	67.71	75.00	0.27	56.35	57.16	109.88
VLEKICI-1	42.06	76.43	0.30	70.84	71.19	85.81
DECICI	100.00	64.95	0.30	17.45	17.61	50.25
MILJES-P1	100.00	78.92	0.37	49.24	49.35	141.81
MILJES-P3	100.00	65.06	0.45	20.48	21.07	59.00
MILJES-P2	100.00	72.66	0.41	24.55	26.37	70.71
ZAG-4	100.00	71.63	0.29	106.29	106.93	306.12
MAR3-1	100.00	81.73	0.30	113.74	123.15	327.56
MAR3-2	100.00	81.72	0.30	113.71	123.09	327.48
MAR3-3	68.75	81.88	0.29	114.24	123.08	226.20
MAR3-4	0.00	0.00	0.00	0.00	0.00	0.00
MAR3-5	100.00	75.00	0.36	75.83	75.83	218.39
Total Cost						5761.17
Demand Charge						0.00

3.10 Energy consumption



3.11 Pressure contour plot at 7 PM

4. PHASE I OF THE DEVELOPMENT OF WATER SUPPLY SYSTEM - OPTION 1, FOR THE REGIME OF MAXIMUM DAILY WATER CONSUMPTION FOR THE YEAR 2009

Geometric elements:

- Number of Junctions 942
- Number of Reservoirs 16
- Number of Tanks 5
- Number of Pipes 1143
- Number of Pumps 23
- Number of Valves 3

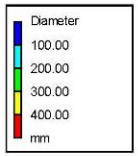
Comments of the operating mode:

- Max daily consumption - 150% of the average daily consumption;
- Tank LJUBOVIC - 20.000m3;
- Inlet pipeline DN800 for tank Ljubovic L=9200m;
- Outlet pipeline DN800 for tank Ljubovic L=900m;
- FCV Mareza_valve setting is 500 l/s;
- Partly isolated system VLEKICI – closed pipeC31-C27;
- Tank Sipcanik is closed;
- Valve Zeta_PRV setting is 45m;

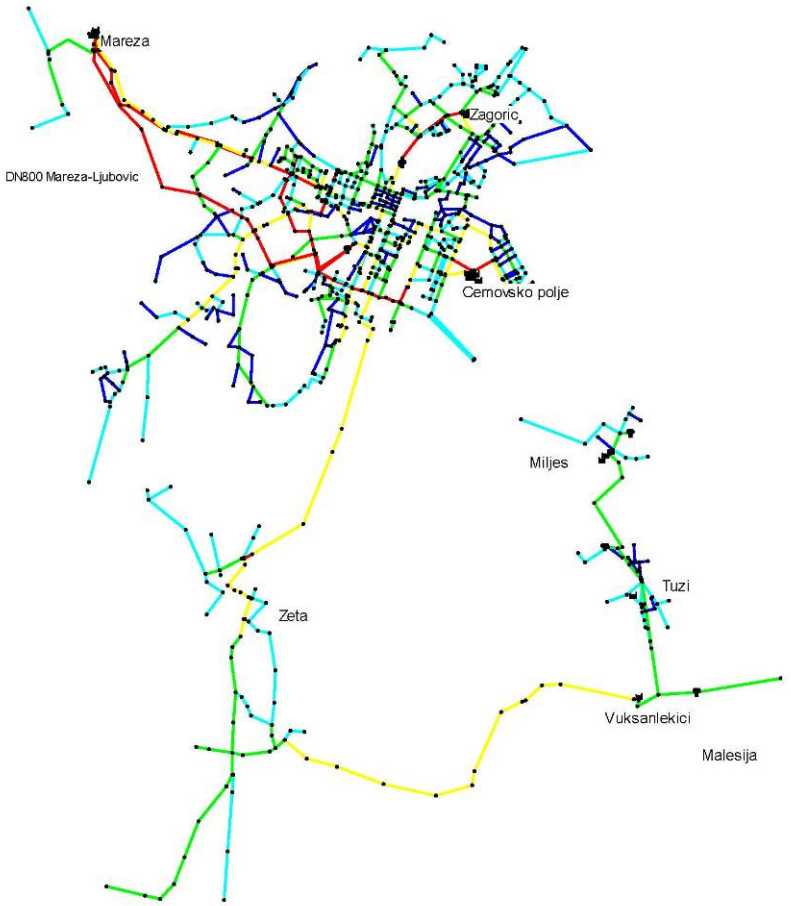
Appendixes:

4.1. Water supply network of the system;
4.2. Reservoir New Ljubovic water level fluctuation;
4.3. Diagram of daily fluctuations in pressures in the characteristic nodes of the system;
4.4. Diagram of functioning of the pumps PS Mareza-3 and PS New Mareza;
4.5. Diagram of functioning of the pumps at the water source Zagoric;
4.6. Diagram of functioning of the pumps at the water source Cemovsko field;
4.7. Diagram of functioning of the pump PS Decici, water source Miljes and PS Vuksanlekici-1;
4.8. Diagram of energy consumption per m3 of all PS;
4.9. The percentage of pump use of all PS;
4.10. Tabular report of energy consumption;
4.11. Pressure Counter plot at 7 PM;

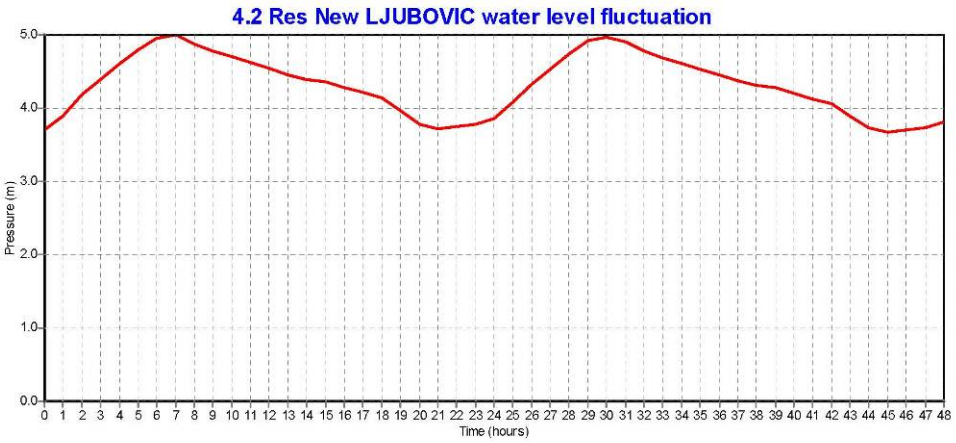
4.1 Podgorica WS System 2009 - Qmax,d - Phase I of the development - Option I



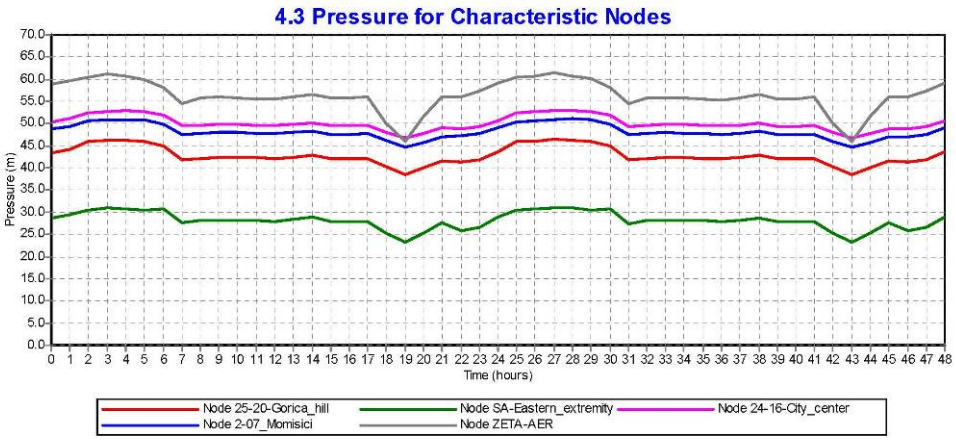
Note: Tank Ljubovic - 20.000m3



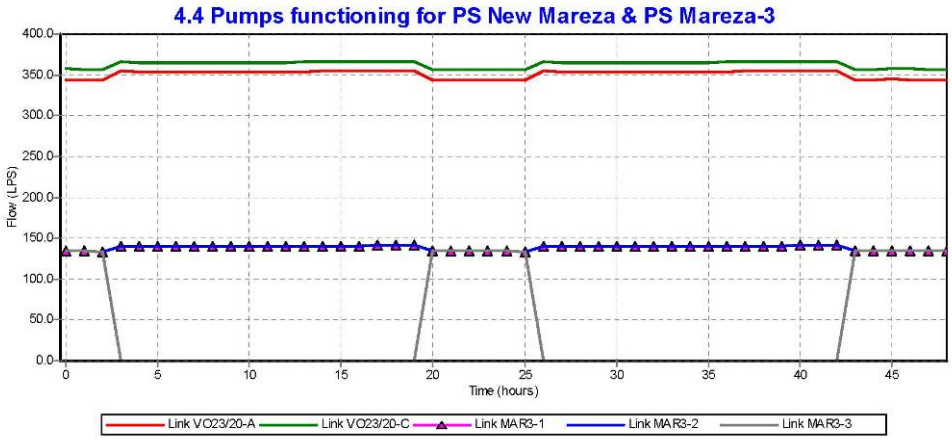
Podgorica WS System 2009 - Qmax,d - Phase I of the development - Option I



Podgorica WS System 2009 - Qmax,d - Phase I of the development - Option I



Podgorica WS System 2009 - Qmax,d - Phase I of the development - Option I



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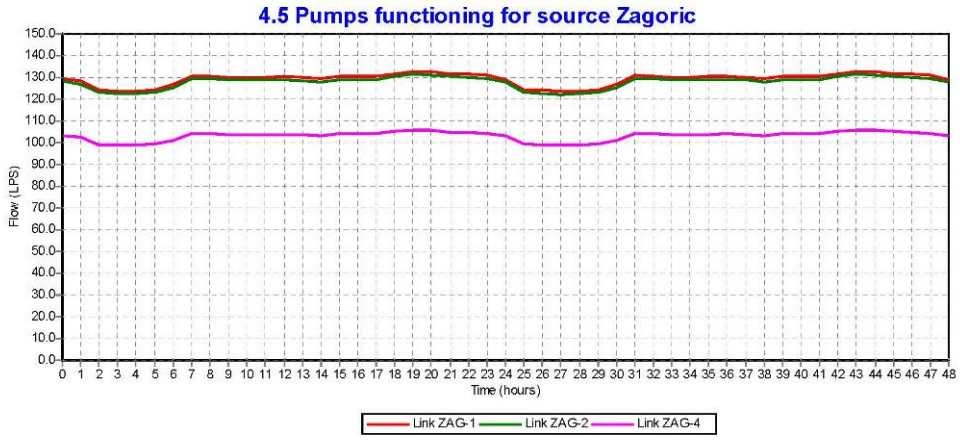
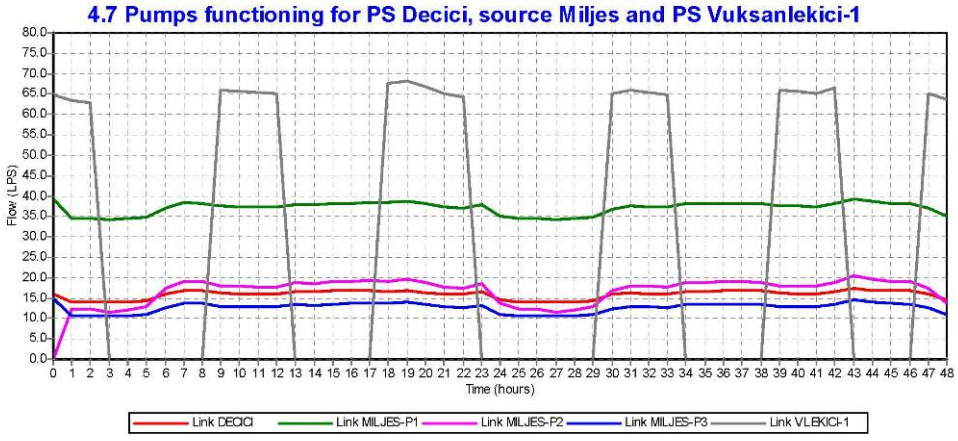
Podgorica WS System 2009 - Qmax,d - Phase I of the development - Option I



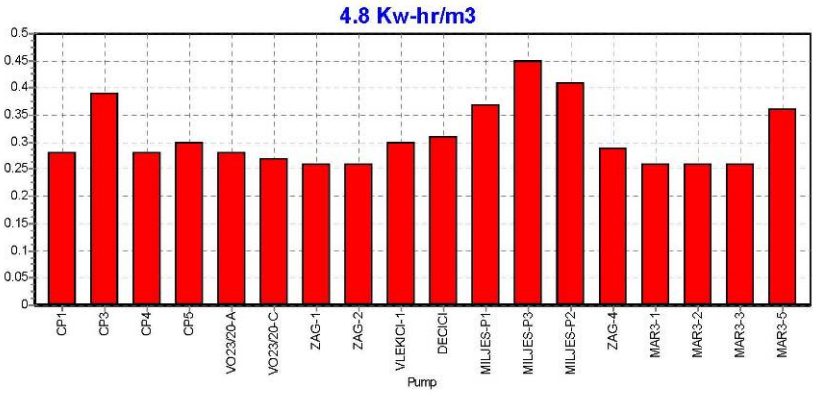
Podgorica WS System 2009 - Qmax,d - Phase I of the development - Option I



EPANET 2

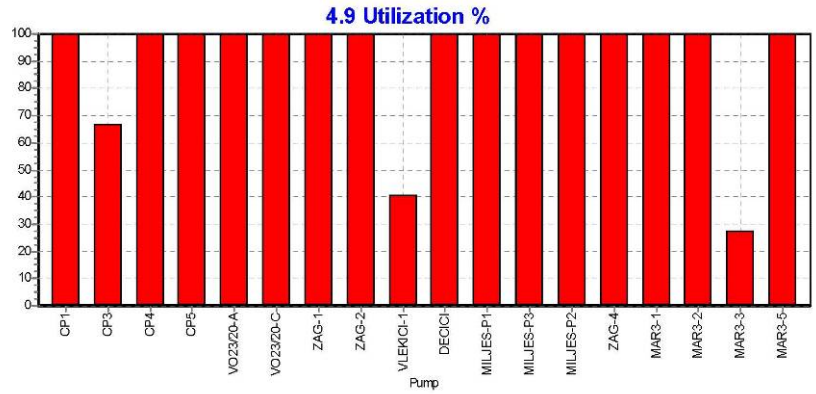
Podgorica WS System 2009 - Qmax,d - Phase I of the development - Option I

Energy Report



Podgorica WS System 2009 - Qmax,d - Phase I of the development - Option I

Energy Report



EPANET 2

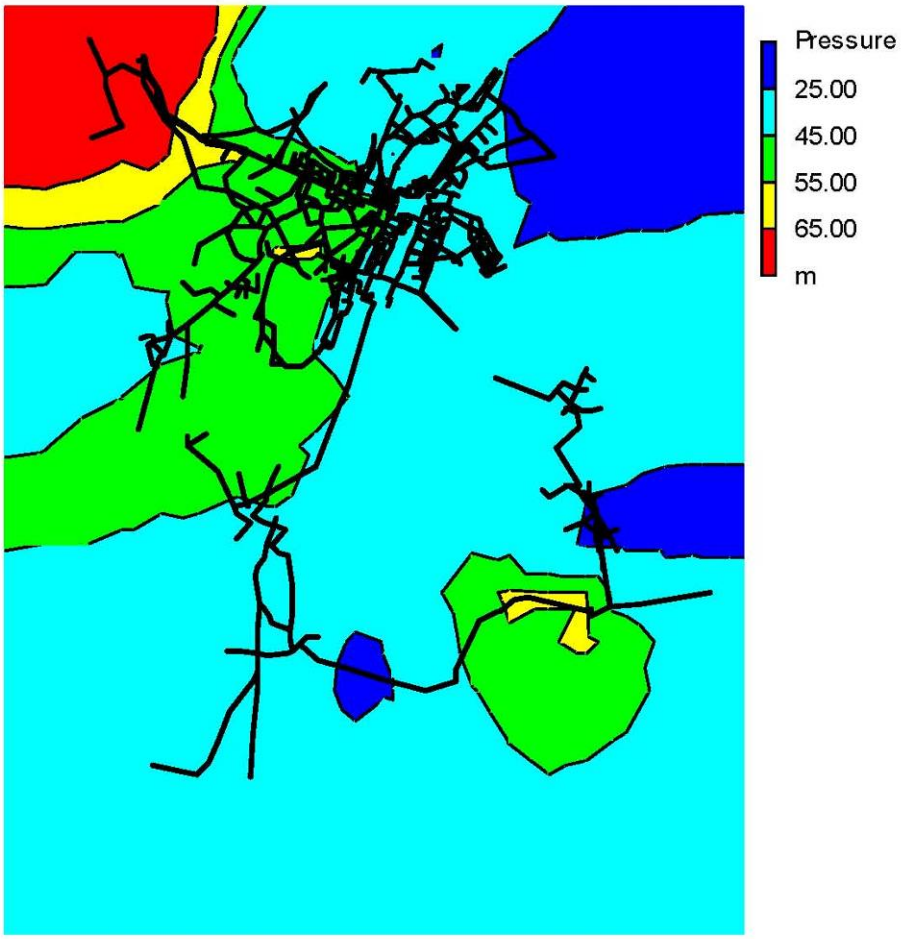
Podgorica WS System 2009 - Qmax,d - Phase I of the development - Option I

Energy Report

Pump	Percent Utilization	Average Efficiency	Kw-hr /m3	Average Kwatts	Peak Kwatts	Cost /day
CP1	100.00	78.07	0.28	55.20	55.31	158.98
CP2	0.00	0.00	0.00	0.00	0.00	0.00
CP3	66.67	56.27	0.39	76.59	77.11	147.05
CP4	100.00	78.11	0.28	106.19	106.54	305.83
CP5	100.00	71.79	0.30	106.75	106.92	307.44
VO23/20-A	100.00	74.42	0.28	354.67	355.73	1021.44
VO23/20-B	0.00	0.00	0.00	0.00	0.00	0.00
VO23/20-C	100.00	76.56	0.27	355.50	355.89	1023.83
VO23/20-D	0.00	0.00	0.00	0.00	0.00	0.00
ZAG-1	100.00	76.37	0.26	121.45	122.30	349.79
ZAG-2	100.00	76.88	0.26	121.16	122.09	348.95
ZAG-3	0.00	0.00	0.00	0.00	0.00	0.00
VLEKICI-1	40.34	76.57	0.30	70.78	71.10	82.23
DECICI	100.00	65.13	0.31	17.45	17.61	50.26
MILJES-P1	100.00	78.96	0.37	49.24	49.35	141.80
MILJES-P3	100.00	64.95	0.45	20.48	21.07	58.98
MILJES-P2	100.00	72.59	0.41	24.53	26.46	70.63
ZAG-4	100.00	71.38	0.29	105.92	106.93	305.04
MAR3-1	100.00	79.92	0.26	127.47	129.70	367.11
MAR3-2	100.00	79.94	0.26	127.45	129.69	367.05
MAR3-3	27.38	81.04	0.26	126.47	126.56	99.74
MAR3-4	0.00	0.00	0.00	0.00	0.00	0.00
MAR3-5	100.00	75.00	0.36	75.83	75.83	218.39
Total Cost						5424.55
Demand Charge						0.00

4.10 Energy consumption

Podgorica WS System 2009 - Qmax,d - Phase I of the development - Option I



Day 1, 7:00 PM

4.11 Pressure Contour plot at 7 PM

5. PHASE I OF THE DEVELOPMENT OF WATER SUPPLY SYSTEM - OPTION 2, FOR THE REGIME OF MAXIMUM DAILY WATER CONSUMPTION FOR THE YEAR 2009

Geometric elements:

- Number of Junctions 944
- Number of Reservoirs 16
- Number of Tanks 6
- Number of Pipes 1146
- Number of Pumps 23
- Number of Valves 4

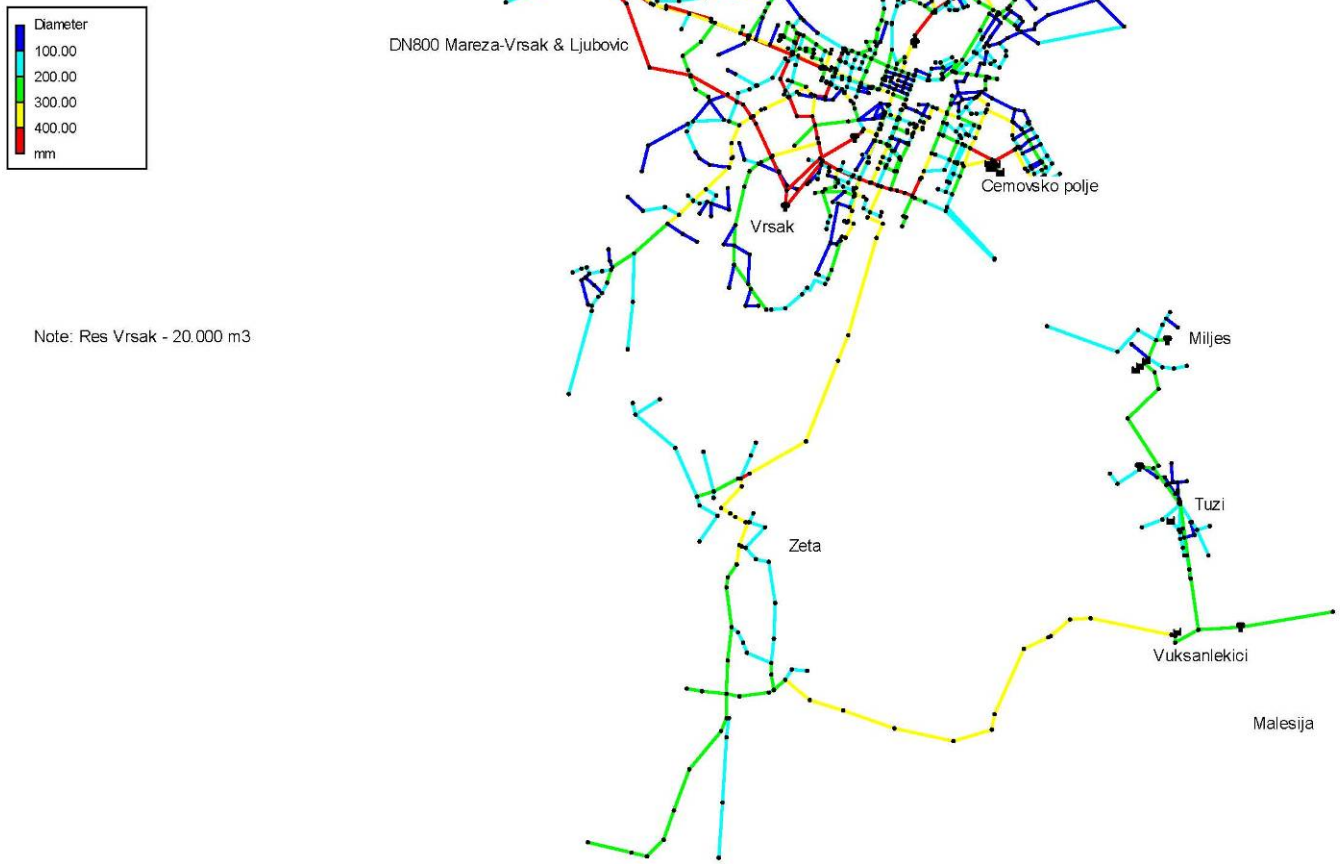
Comments of the operating mode:

- Max daily consumption - 150% of the average daily consumption;
- Tank VRSAK on 96mnm - 20.000m3;
- Inlet pipeline DN800 for tanks Vrsak and Ljubovic L=7700m;
- Outlet pipeline DN800 for tank Vrsak L=1700m;
- Inlet pipeline DN700 for tank Vrsak L=300m
- Inlet pipeline DN400 for tank Ljubovic L=2300m;
- FCV Mareza_valve setting is 500 l/s;
- TCV Vrsak_valve setting according to tank Ljubovic level;
- Partly isolated system VLEKICI – closed pipeC31-C27;
- Tank Sipcanik is closed;
- Valve Zeta_PRV setting is 45m;

Appendixes:

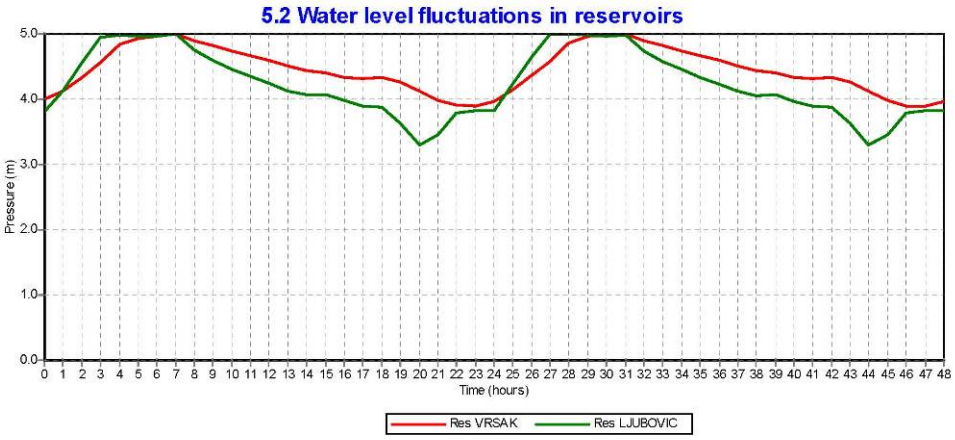
5.1. Water supply network of the system;
5.2. Diagram of daily fluctuations in water levels in reservoirs;
5.3. Diagram of daily fluctuations in pressures in the characteristic nodes of the system;
5.4. Diagram of functioning of the pumps PS Mareza-3 and PS New Mareza;
5.5. Diagram of functioning of the pumps at the water source Zagoric;
5.6. Diagram of functioning of the pumps at the water source Cemovsko field;
5.7. Diagram of functioning of the pump PS Decici, water source Miljes and PS Vuksanlekici-1;
5.8. Diagram of energy consumption per m3 of all PS;
5.9. The percentage of pump use of all PS;
5.10. Tabular report of energy consumption;
5.11. Pressure Counter plot at 7 PM;

5.1 Podgorica WS System 2009 - Qmax,d - Phase I of development - Option II

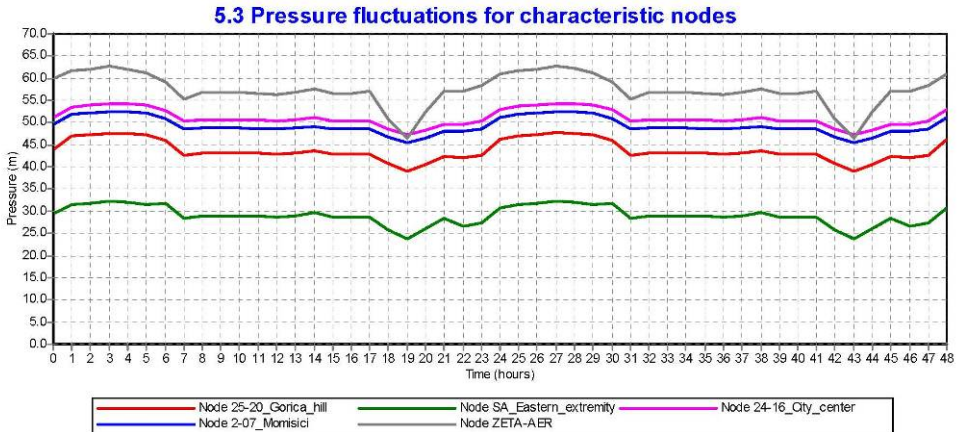


Note: Res Vrsak - 20.000 m3

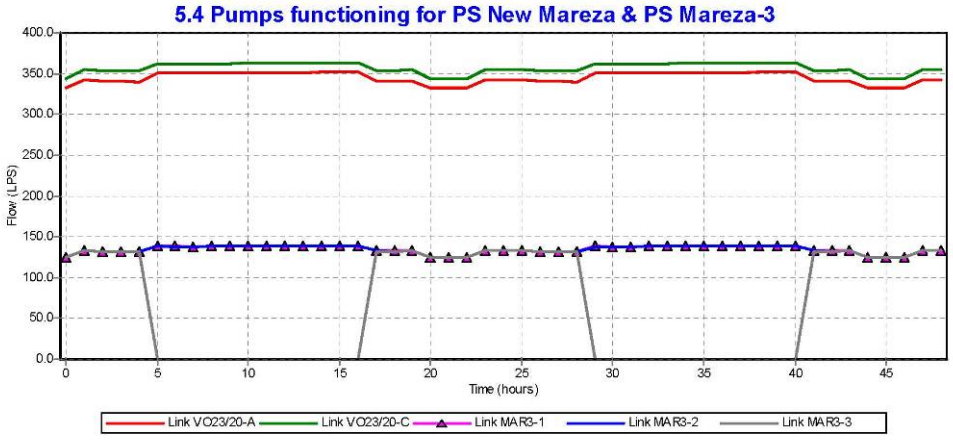
Podgorica WS System 2009 - Qmax,d - Phase I of development - Option II



Podgorica WS System 2009 - Qmax,d - Phase I of development - Option II

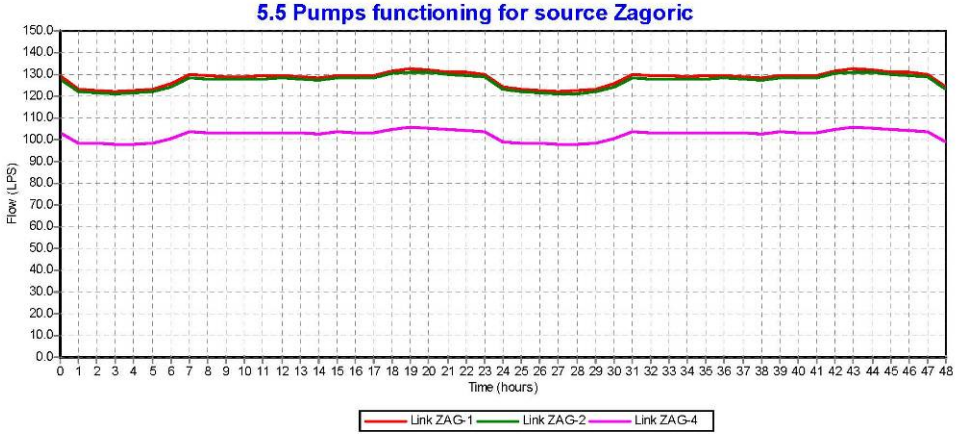


Podgorica WS System 2009 - Qmax,d - Phase I of development - Option II



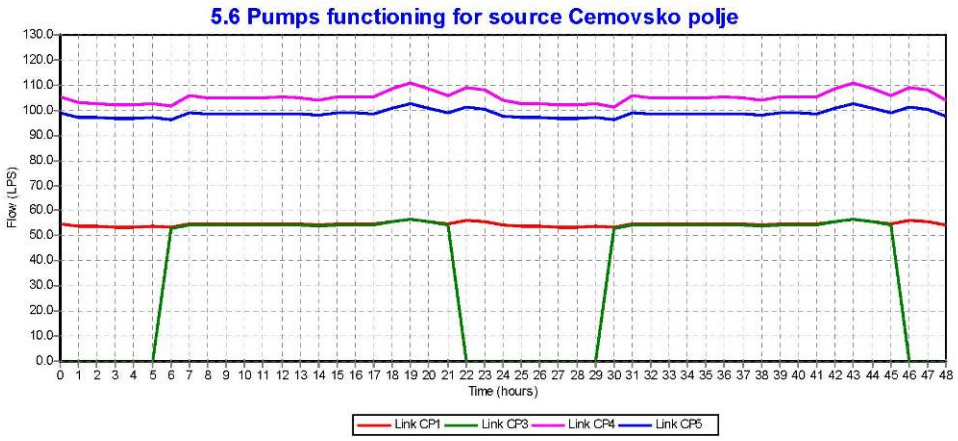
Podgorica WS System 2009 - Qmax,d - Phase I of development - Option II

5.5 Pumps functioning for source Zagoric



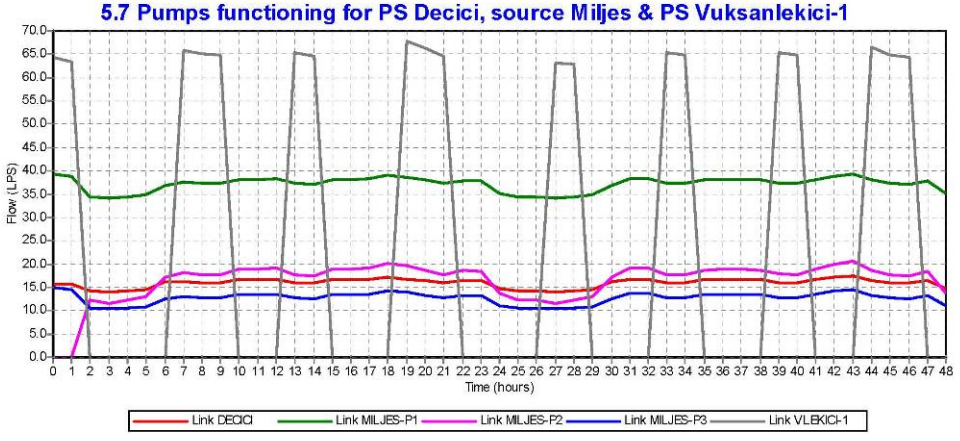
Podgorica WS System 2009 - Qmax,d - Phase I of development - Option II

5.6 Pumps functioning for source Cemovsko polje



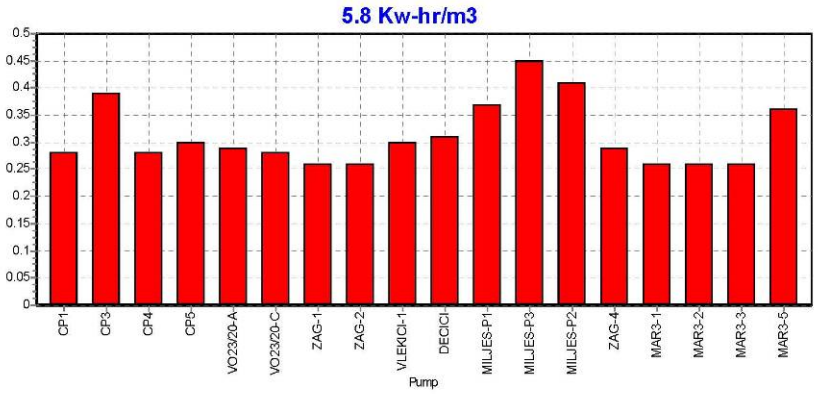
Podgorica WS System 2009 - Qmax,d - Phase I of development - Option II

5.7 Pumps functioning for PS Decici, source Miljes & PS Vuksanlekici-1



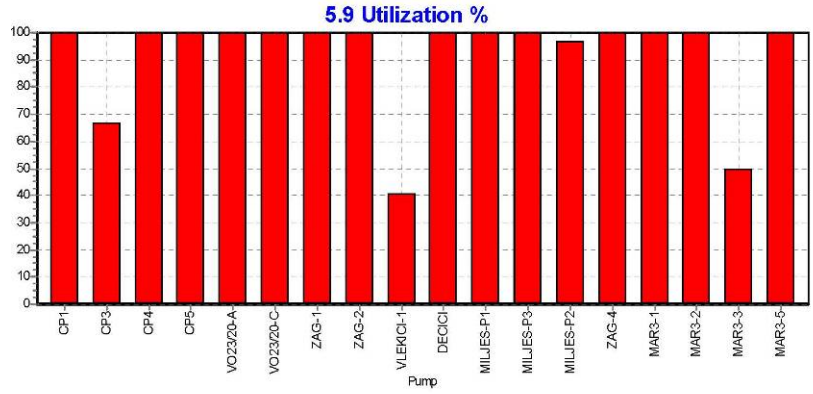
Podgorica WS System 2009 - Qmax,d - Phase I of development - Option II

Energy Report



Podgorica WS System 2009 - Qmax,d - Phase I of development - Option II

Energy Report



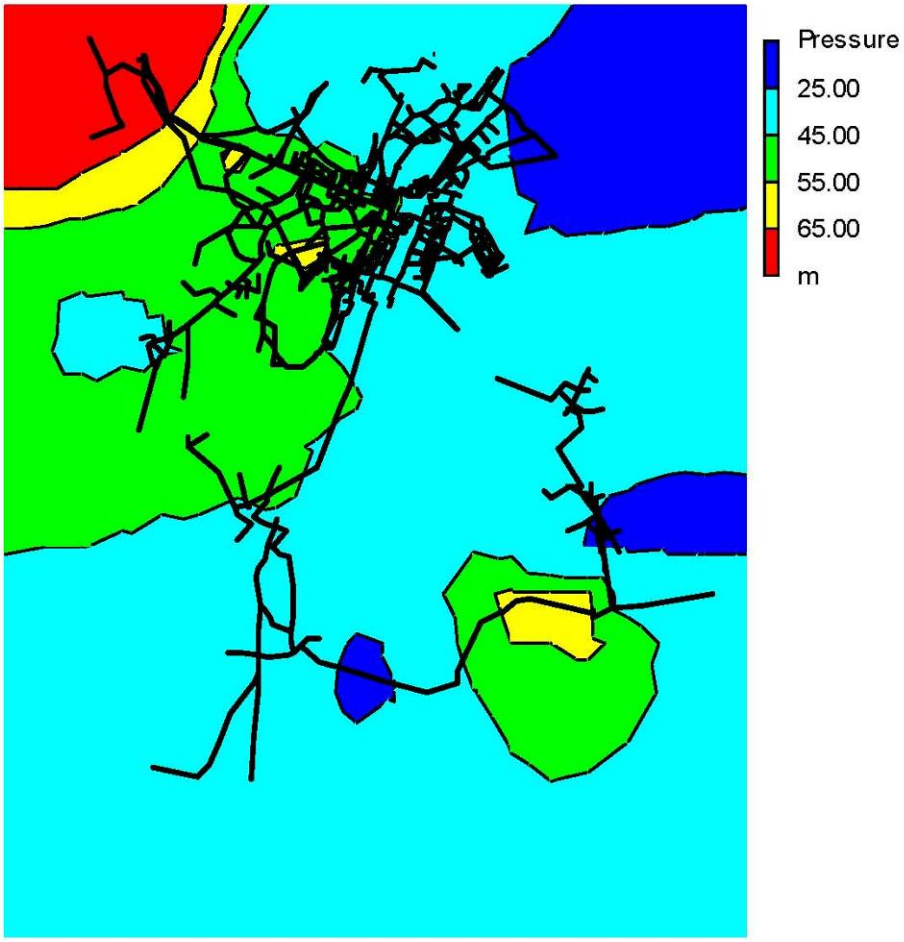
Podgorica WS System 2009 - Qmax,d - Phase I of development - Option II

Energy Report

Pump	Percent Utilization	Average Efficiency	Kw-hr /m3	Average Kwatts	Peak Kwatts	Cost /day
CP1	100.00	78.21	0.28	55.24	55.33	159.09
CP2	0.00	0.00	0.00	0.00	0.00	0.00
CP3	66.67	56.23	0.39	76.72	77.25	147.31
CP4	100.00	77.96	0.28	106.31	106.59	306.16
CP5	100.00	72.00	0.30	106.72	106.93	307.37
VO23/20-A	100.00	74.78	0.29	355.32	356.69	1023.33
VO23/20-B	0.00	0.00	0.00	0.00	0.00	0.00
VO23/20-C	100.00	77.21	0.28	355.62	356.73	1024.17
VO23/20-D	0.00	0.00	0.00	0.00	0.00	0.00
ZAG-1	100.00	76.73	0.26	121.23	122.27	349.15
ZAG-2	100.00	77.23	0.26	120.93	122.06	348.27
ZAG-3	0.00	0.00	0.00	0.00	0.00	0.00
VLEKICI-1	40.58	76.61	0.30	70.75	71.07	82.69
DECICI	100.00	65.09	0.31	17.47	17.61	50.31
MILJES-P1	100.00	78.91	0.37	49.24	49.35	141.81
MILJES-P3	100.00	65.11	0.45	20.51	21.18	59.06
MILJES-P2	96.80	72.75	0.41	24.58	26.49	68.53
ZAG-4	100.00	71.47	0.29	106.06	106.88	305.45
MAR3-1	100.00	80.70	0.26	124.82	128.76	359.48
MAR3-2	100.00	80.71	0.26	124.79	128.74	359.39
MAR3-3	49.94	81.63	0.26	124.82	125.93	179.51
MAR3-4	0.00	0.00	0.00	0.00	0.00	0.00
MAR3-5	100.00	75.00	0.36	75.83	75.83	218.39
Total Cost						5489.45
Demand Charge						0.00

5.10 Energy consumption

Podgorica WS System 2009 - Qmax,d - Phase I of development - Option II



Day 1, 7:00 PM

5.11 Pressure Contour plot at 7 PM

6. LONG-TERM DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE REGIME OF MAXIMUM DAILY WATER CONSUMPTION FOR THE YEAR 2035.

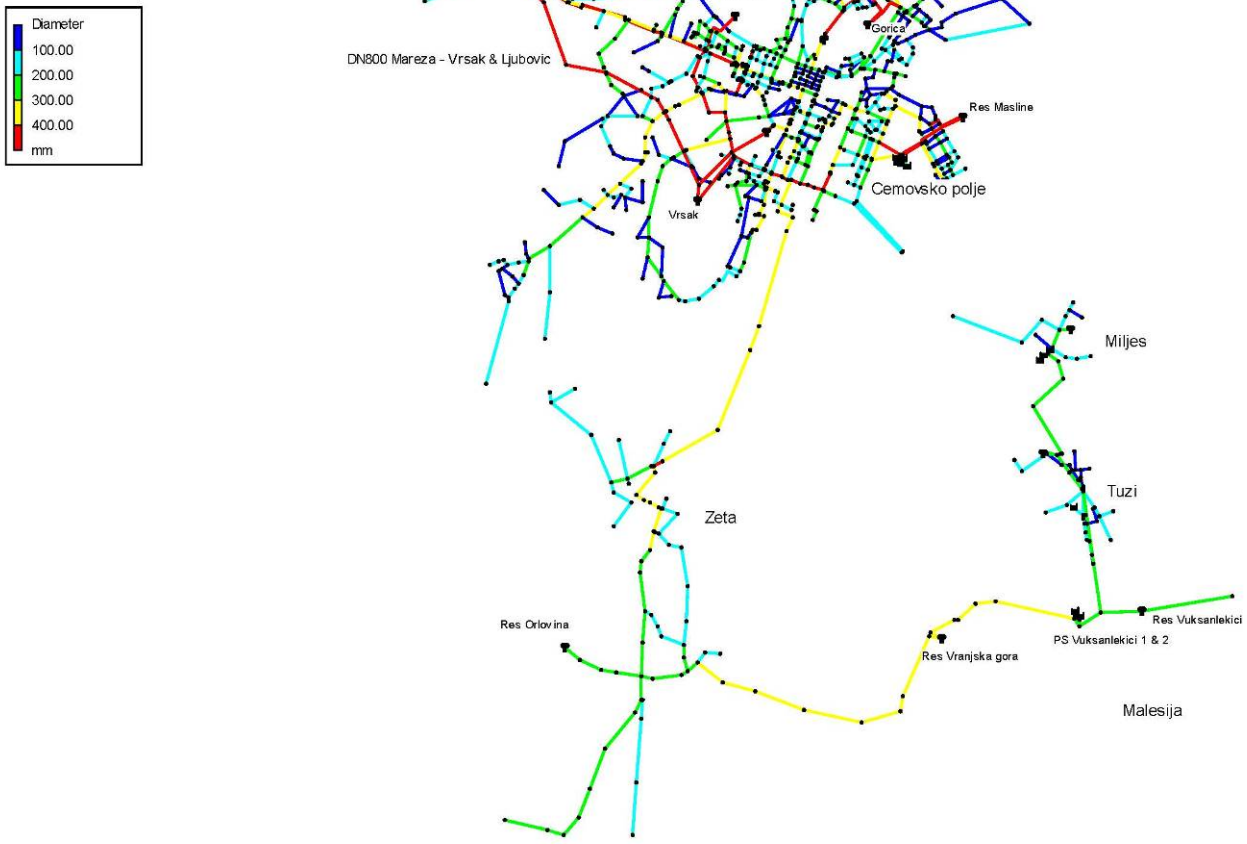
Geometric elements:

- Number of Junctions 948
- Number of Reservoirs 17
- Number of Tanks 11
- Number of Pipes 1156
- Number of Pumps 24
- Number of Valves 6

Comments of the operating mode:

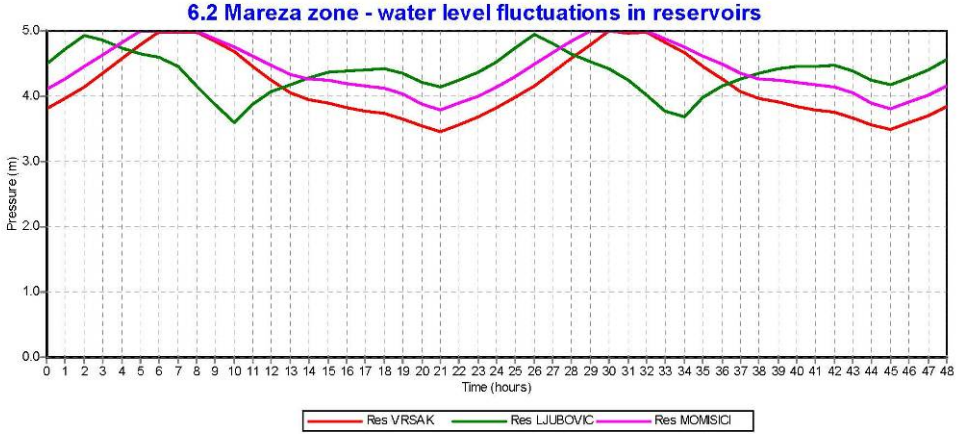
- Max daily consumption - 150% of the average daily consumption;
- Tank VRSAK - 20.000m3;
- Inlet pipeline DN800 for tanks Vrsak and Ljubovic L=7700m;
- Outlet pipeline DN800 for tank Vrsak L=1700m;
- Inlet pipeline DN700 for tank Vrsak L=300m;
- Inlet pipeline DN400 for tank Ljubovic L=2300m;
- FCV Mareza_valve setting is 460 l/s;
- Link Dovod Ljubovic setting according to tank Ljubovic level;
- Tank GORICA - 10.000m3;
- Inlet pipeline DN400 for tank Gorica L=1200m;
- Outlet pipeline DN500 for tank Gorica L=1000m;
- Tank MASLINE - 5.000m3;
- Inlet pipeline DN400 for tank Masline L=1500m;
- Outlet pipeline DN500 for tank Masline L=900m;
- Tank MOMISICI - 5.000m3;
- Inlet/outlet pipeline DN400 for tank Momisici L=600m;
- Tank Sipcanik - 400m3;
- Inlet pipeline DN250 for tank Sipcanik L=400m;
- Valve_Tuzi PRV setting is 50m;
- Frequent regulation at Miljes-P1;
- Added tanks and PS according to the Concept Design of water supplying of Zeta and Malesija: ORLOVINA – 2000m3; VRANJSKA GORA – 800m3; PS VLEKICI-2;
- Valve Zeta_PRV setting is 45m;
- Valve PRV_D. Gorica setting is 40m;
- Three independent zones are created: Mareza, Zagoric and Cemovsko polje.

6.1 Podgorica Water Supply System 2035 - Qmax,d - Long term development



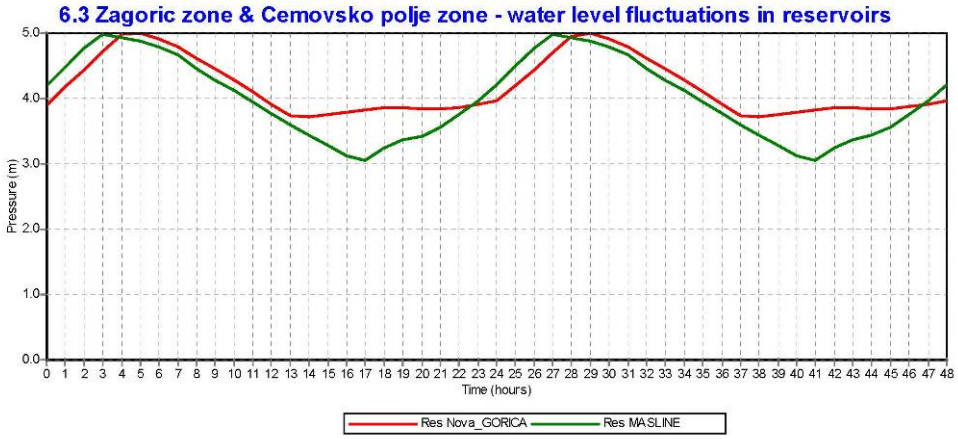
Podgorica Water Supply System 2035 - Qmax,d - Long term development

6.2 Mareza zone - water level fluctuations in reservoirs



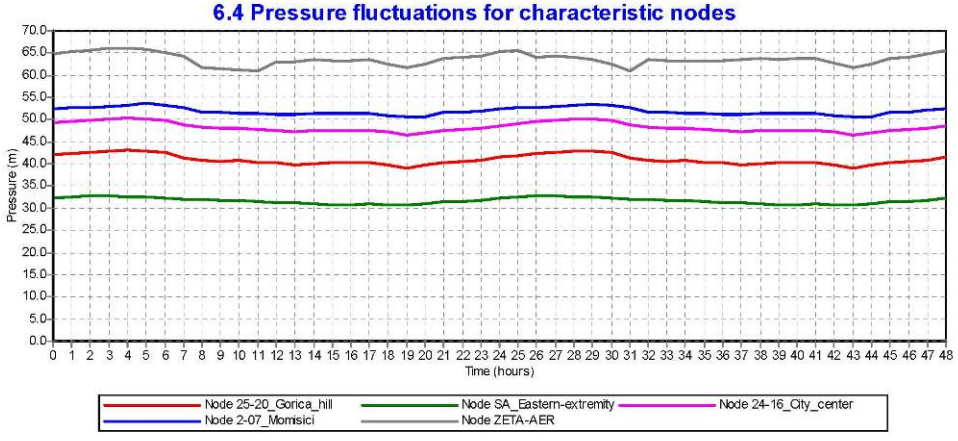
Podgorica Water Supply System 2035 - Qmax,d - Long term development

6.3 Zagoric zone & Cemovsko polje zone - water level fluctuations in reservoirs

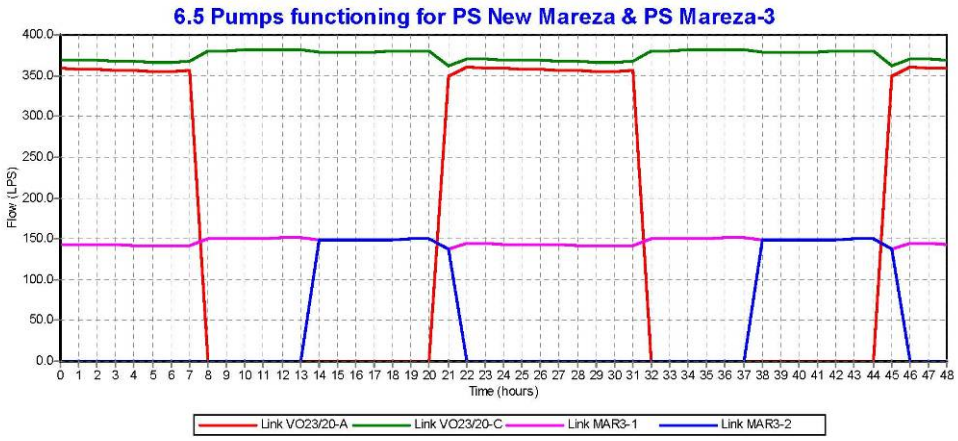


Podgorica Water Supply System 2035 - Qmax,d - Long term development

6.4 Pressure fluctuations for characteristic nodes



Podgorica Water Supply System 2035 - Qmax,d - Long term development



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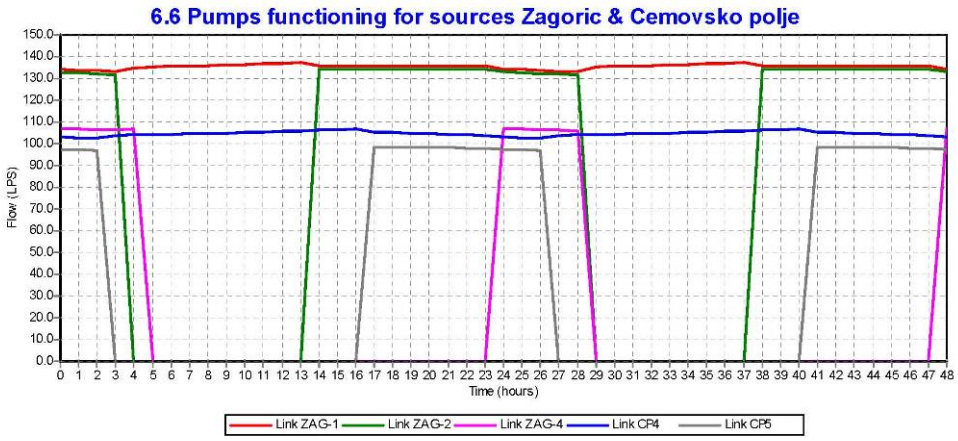

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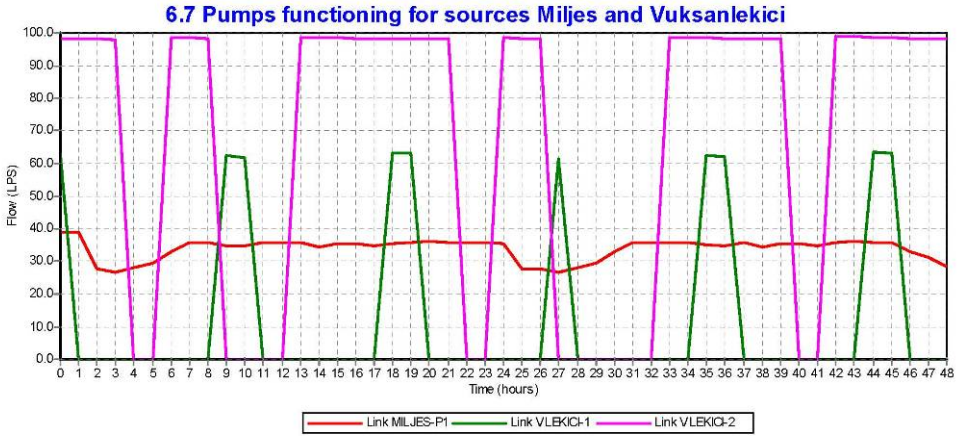
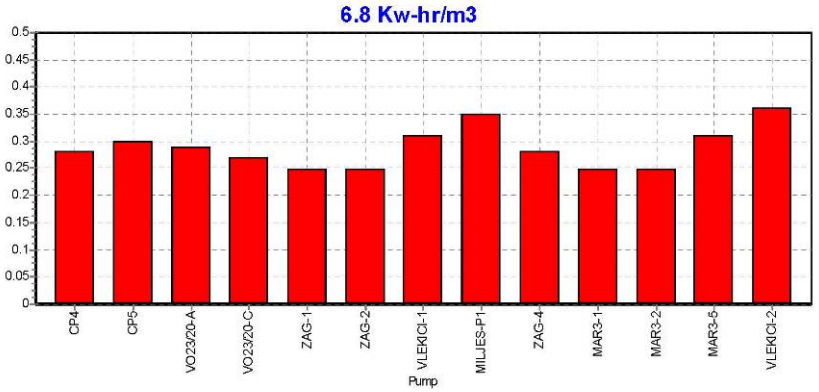


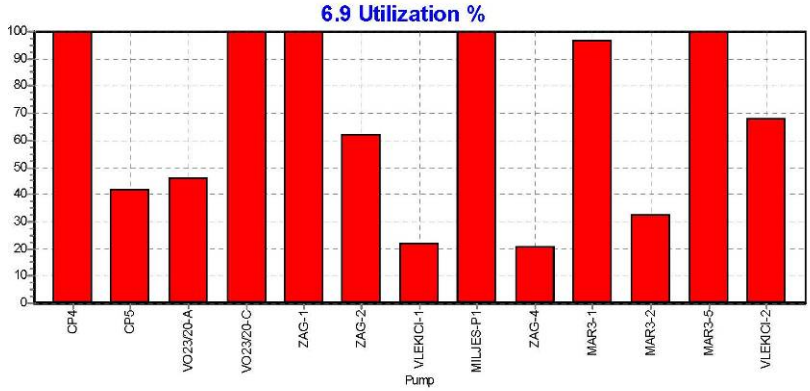
Podgorica Water Supply System 2035 - Qmax,d - Long term development

Energy Report



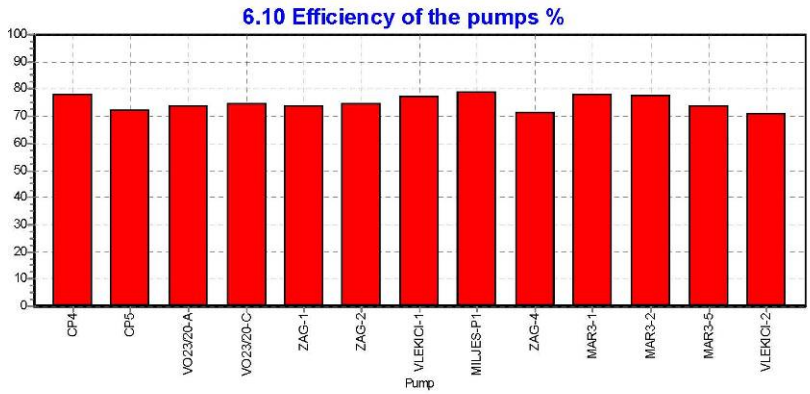
Podgorica Water Supply System 2035 - Qmax,d - Long term development

Energy Report



Podgorica Water Supply System 2035 - Qmax,d - Long term development

Energy Report

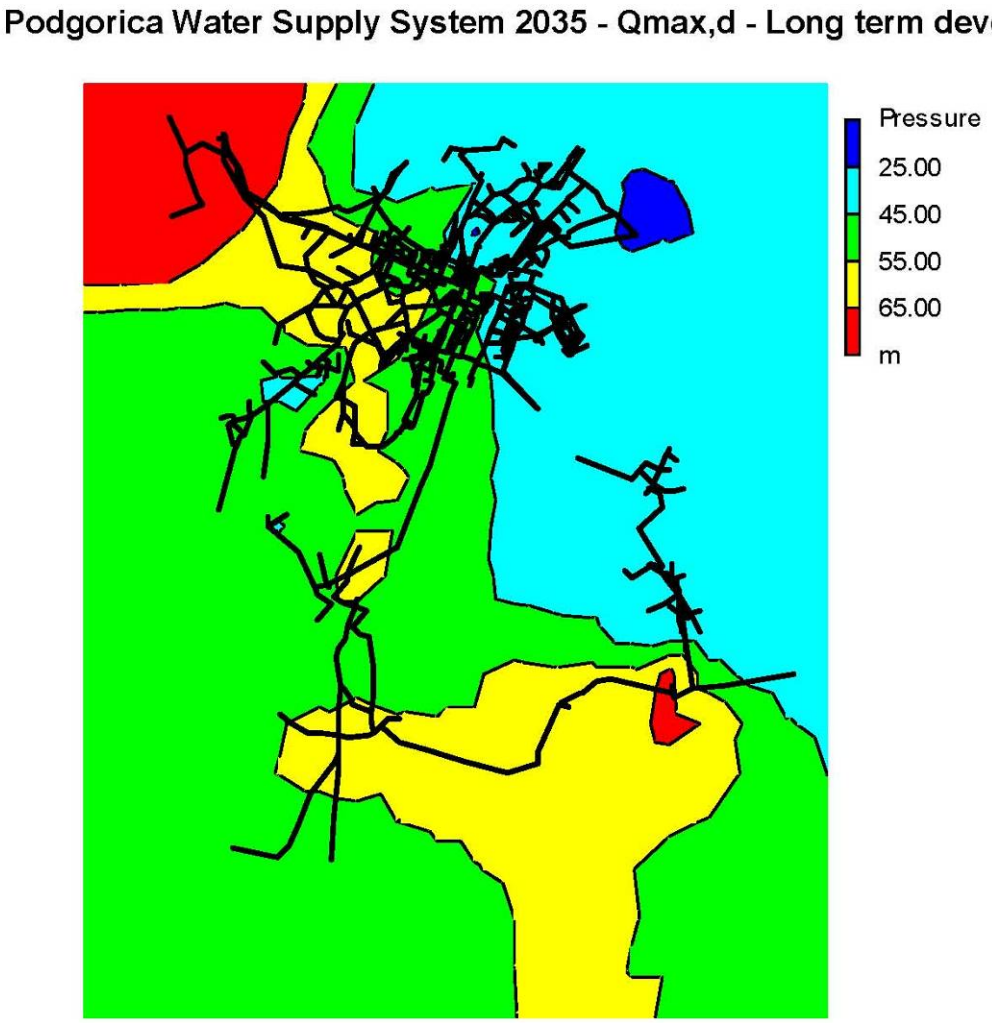


Podgorica Water Supply System 2035 - Qmax,d - Long term development

Energy Report

Pump	Percent Utilization	Average Efficiency	Kw-hr /m3	Average Kwatts	Peak Kwatts	Cost /day
CP1	0.00	0.00	0.00	0.00	0.00	0.00
CP2	0.00	0.00	0.00	0.00	0.00	0.00
CP3	0.00	0.00	0.00	0.00	0.00	0.00
CP4	100.00	77.91	0.28	106.38	106.56	306.38
CP5	41.80	72.18	0.30	106.75	106.84	128.51
VO23/20-A	45.83	73.92	0.29	353.15	355.05	466.16
VO23/20-B	0.00	0.00	0.00	0.00	0.00	0.00
VO23/20-C	100.00	74.77	0.27	354.22	355.63	1020.17
VO23/20-D	0.00	0.00	0.00	0.00	0.00	0.00
ZAG-1	100.00	73.90	0.25	122.43	122.67	352.60
ZAG-2	61.89	74.50	0.25	122.34	122.44	218.08
ZAG-3	0.00	0.00	0.00	0.00	0.00	0.00
VLEKICI-1	22.01	77.22	0.31	70.26	70.60	44.53
DECICI	0.00	0.00	0.00	0.00	0.00	0.00
MILJES-P1	100.00	78.97	0.35	42.13	49.08	121.34
MILJES-P3	0.00	0.00	0.00	0.00	0.00	0.00
MILJES-P2	0.00	0.00	0.00	0.00	0.00	0.00
ZAG-4	20.83	71.37	0.28	104.78	105.30	62.87
MAR3-1	96.69	78.18	0.25	131.67	133.28	366.66
MAR3-2	32.44	77.59	0.25	130.02	132.78	121.48
MAR3-3	0.00	0.00	0.00	0.00	0.00	0.00
MAR3-4	0.00	0.00	0.00	0.00	0.00	0.00
MAR3-5	100.00	74.00	0.31	84.45	84.45	243.20
VLEKICI-2	67.81	70.92	0.36	126.22	127.22	246.49
Total Cost						3698.47
Demand Charge						0.00

6.11 Energy consumption



6.12 Pressure Contour plot at 7 PM

Appendix B - Regulation on protection zones

Pursuant to Article 57, paragraph 5 of the Law on Waters (Official Gazette of RM "No. 27/07), Ministry for Agriculture, Forestry and Water Management with the approval of the Ministry of Health, Ministry of Spatial Planning and Environment and the Ministry of Economy, adopted the

REGULATION

on determination and maintenance of zones and belts

of sanitary protection of water sources and limitations in these areas

("Official Gazette of Montenegro, no. 66/09 of 2 October 2009).

I GENERAL PROVISIONS

Article 1

This regulation prescribes the manner of determining and maintaining zones and belts of sanitary protection of water sources to be used or can be used to supply drinking water and limitations in these areas.

The provisions of this Regulation also apply to the objects of the drinking water supply system.

II DETERMINATION OF THE ZONES OF SANITARY PROTECTION AND LIMITATIONS IN THESE ZONES

Article 2

Determination of the sanitary protection of sources is carried out depending on the type of source.

Types of sources in terms of this Regulation are:

1. groundwater sources in confined aquifers;

2. sources in karst (carbonate) aquifers and with extraction:
   - From surface (catchment);
   - From the underground (wells, boreholes, tunnels, etc.);

3. source with extraction of surface waters from:
   - Reservoirs and lakes;
   - Open watercourses;
   - Seas.

Article 3

Sanitary Water Source Protection Zones in relation to the protection regime are:
- Zones of strict protection regime - and the protection zone (immediate protection zone);
- Zone of limited protection regime - II protection zone (inner protection zone);
- Zone Control - III protection zones (outer protection zones);

For sources for supplying drinking water up to 200 people determination of the protection zone III is not necessary, and for the sources that supply drinking water to 20 residents II and III protection zone is not to be determined.

1. Groundwater sources in confined aquifers

a) I protection zone

Article 6

I Protection zone of groundwater sources in confined aquifers is determined for protection of water sources, water extracting facilities and their immediate environment from pollution and other negative impacts.

Boundaries of the I protection zone must be at least 10 m away from all facilities for water extraction.

Article 7

In the areas of I protection zone, with the implementation of necessary measures, there may be located water intake and facilities for artificial charge of groundwater, reservoirs, pump stations, installations for the improvement of water quality, break-pressure tanks, substations, commercial buildings, access and internal roads and other facilities that are necessary for operation of the facility for supply of drinking water.

Article 8

In I protection zone can be carried out only activities that are related to extraction, purification and transport of water in the system of water supply.

Article 9

In I protection zone access is allowed only to persons working in facilities in the area, to the relevant inspectors and other persons with the permission of the owner or user of the facility for drinking water supply.
Area of I protection zone must be protected from unauthorized access with protective fence.
Water intake user must adequately mark I protection zone and note warning on prohibition of unauthorized approach.

b) II protection zone

Article 10

II protection zone is determined in order to reduce the risk of radiological, chemical, microbiological and other possible pollution of groundwater and other harmful effects that may occur at the source.

Limit II zones of protection depends on the source yield:
- The source whose yield is <10 l/s, the boundary line is located at a distance of 10 m from the border of I zone and,
- The source whose yield is 10-50 l/s, the boundary line is located at a distance of 50 m from the border of I zone;
- The source whose yield > 50 l/s, the boundary line is located at a distance of at least 50 m from the border of I zone, which is determined based on the geological composition of the terrain and potential pollutants.

Article 11

In II protection zone works are forbidden as well as construction of facilities and conduction of activities that can pollute water sources, in particular:
- Release of untreated wastewater;
- Waste disposal, including disposal to sanitary landfills;
- Construction of industrial and chemical plants/facilities;
- Construction of roads without a system of controlled drainage and storm water treatment;
- Surface and underground exploitation of mineral resources;
- Agricultural production, except for production that doesn't include the use of artificial fertilizers, pesticides and herbicides (the production of healthy food);
- Livestock production, except for household needs;
- Construction of production facilities, storage and transportation of hazardous materials;
- Construction of the cemetery, or extension of existing;
- The construction of other objects that may threaten water quality.

Water intake user must appropriately mark II protection zone and point out the notification on water source protection zone.

V) III protection zone

Article 12

III protection zone is determined in order to reduce the risk of contamination of groundwater with hardly degradable radioactive and chemical substances.

Area of III protection zone includes the space outside the border of II zone to the border specified by terms of source exploitation and possibilities for its pollution.

Article 13

In III protection zone it is forbidden to conduct any works, construction of facilities and conduct activities that can pollute water sources, in particular:
- Release of untreated wastewater;
- Disposal of waste, except waste disposal to sanitary landfills;
- Construction of roads without a system of controlled drainage and storm water treatment;
- Construction of industrial and other facilities whose wastewater and other waste matter from technological process could contaminate the source.

2. Sources in karst (carbonate) aquifers

Article 14

Due to the specificity of karst aquifers and groundwater flows and the specific water regime of karst aquifers, the determination of zones of sanitary protection and protection measures for water sources in these aquifers are conducted by selective care approach, which fits into the plan for sustainable development, and has a function of reducing the risk of pollution of karst aquifers . In doing so it must be taken into account: time of possible transport of pollution, the regime of aquifers, form of charge and discharge of aquifer, especially in relation to previous position and state of aquifer.

a) I protection zone

Article 15

Determination, maintenance and restrictions in I zone of water source protection in karst aquifers is conducted according to provisions of Article 6 to 9 of this Regulation.

b) II protection zone

Article 16

Area of II protection zone for karst sources, is formed around I protection zone and includes the space from the boundary of I protection zone to the outer line of the II protection zone.

Article 17

The outer line of II protection zone of water sources in karst aquifers, with surface water extraction (catchment), is determined in accordance with the quantity and exploitation regime, hydro geological characteristics of the terrain of water source and watershed (river basin) and possibilities of pollution of the water source aquifer.

Article 18

The outer boundary of II protection zone of water sources in karst aquifers with water extraction from underground (wells, boreholes, tunnels, etc.), according to the research works, represents the limit from which polluted water can get into the influence zone of aquifer.

Article 19

The area of II protection zone of water source protection in karst aquifers is pursuant to the provisions of Article 11 of this Regulation.

v) III protection zone

Article 20

The area of III protection zone covers an area from external border of II protection zone, to the hydro geological watershed of karst springs.

Article 21

In III protection zone it is forbidden to conduct any works, construction of facilities and conduct activities that can pollute water sources, in particular:

- Economic and other activities that violate the natural regime of groundwater source recharge, unless special measures provide artificial recharge in quantity sufficient for compensation of the amount lost;

- Release of untreated wastewater;

- Disposal of waste, except waste disposal to sanitary landfills;

- Construction of roads without a system of controlled drainage and storm water treatment;

- Construction of industrial and other facilities whose waste water and other waste matter from the technological process could contaminate the source;

- Storage of oil (petroleum) and petroleum products;

- Storage of radioactive and chemical materials;

- Construction of the cemetery, or extension of existing;

- Other activities for which it is determined that may have negative effects on karst source.

Appendix C - Regulation for wastewater discharge

On the basis of article 79 paragraph 2 and article 84 paragraph 3 of Law on Waters ("Official Gazette of the Republic of Montenegro", No 27/07), Ministry of Agriculture, Forestry and Water Management, with previous opinions from Ministry of Tourism, Ministry for spatial planning and environment, Ministry of Health and the Ministry of Labour and Social Welfare, issued

REGULATION

on quality and sanitary technical conditions for waste water discharge to the recipient and public sewage, methods and procedures for wastewater quality inspections, minimum number of inspections and the content of reports on determined wastewater quality

("Official Gazette of the Republic of Montenegro", No 45/08, July, 31st 2008)

I GENERAL PROVISIONS

Article 1

This Regulation qualifies the quality and sanitary-technical conditions for waste water discharge to the recipient and public sewage, methods and procedures for wastewater quality inspections, minimum number of inspections and the content of reports on determined wastewater quality.

Article 2

In this Regulation, term wastewaters refer to waters that due to human activities changed their physical, chemical and biologic properties:

a) communal wastewaters;
b) industrial wastewaters;
c) cooling wastewaters;
d) radioactive wastewaters;
e) rain and storm waters;
f) street washing waters;
g) drainage waters.

Communal wastewaters are used waters from households or a mixture of used waters from households, used industrial waters, street washing waters and rain and storm waters.

Wastewaters from households are sanitary wastewaters from housing estates and other structures that are predominantly product of human metabolism and house activities.

Industrial wastewaters are wastewaters produced by production processes in industry and other economic activities, as well as polluted storm waters from industrial surfaces.

II QUALITY OF WASTEWATERS FOR DISCHARGE TO THE PUBLIC SEWAGE AND RECIPIENT

1. Quality Of Wastewaters For Discharge To The Public Sewage

Article 3

Maximum allowed concentrations of dangerous and detrimental substances in wastewaters that can be discharged to the public sewage:

No	Parameter	Measuring unit	Maximum allowed concentration (MAC)
1	pH		6-9
2	Temperature	ºC	40
3	Colour	mg/l Pt scale	20
4	Odour		noticeable
5	Sedimentary substances	ml/lh	10
6	Total suspended substances	mg/l	300
7	BOD_5	mgO_2/l	500
8	COD ($K_2Cr_2O_7$)	mgO_2/l	700
9	Aluminium	mg/l	4,0
10	Arsenic	mg/l	0,2
11	Copper	mg/l	1,0
12	Barium	mg/l	5,0
13	Boron	mg/l	4,0
14	Zink	mg/l	2,0
15	Cobalt	mg/l	2,0
16	Tin	mg/l	2,0
17	Cadmium	mg/l	0,1
18	Mercury	mg/l	0,01
19	Total chrome	mg/l	2,0
20	Chrome 6+	mg/l	0,2
21	Manganese	mg/l	4,0
22	Nickel	mg/l	2,0
23	Lead	mg/l	2,0
24	Selenium	mg/l	0,1
25	Silver	mg/l	0,5
26	Iron	mg/l	5,0
27	Vanadium	mg/l	0,1
28	Total phenols	mg/l	0,5
29	Fluorides	mg/l	5,0
30	Sulphites	mg/l	10
31	Sulphides	mg/l	1,0
32	Sulphates	mg/l	400
33	Chlorides	mg/l	500
34	Total phosphor	mgP/l	7
35	Active chlorine	mg/l	0,3
36	Ammonium ion (N)	mgN/l	15,0
37	Nitrites (N)	mgN/l	30,0
38	Nitrates (N)	mgN/l	50,0
39	Mineral oils	mg/l	10,0
40	Total oil and grease	mg/l	50

41	Aldehydes	mg/l	2,0
42	Alcohols	mg/l	10
43	Total aromatic hydrocarbons	mg/l	0,4
44	Total nitrated hydrocarbons	mg/l	0,1
45	Total halogen hydrocarbons	mg/l	1,0
46	Total organic phosphate pesticides	mg/l	0,1
47	Total organic chlorine pesticides	mg/l	0,05
48	Total active surface substances	mg/l	20,0
49	Total detergents	mg/l	4,0
50	Radioactivity	Bq/l	1,0

Article 4

Maximum concentrations for chemical substances that are not specified in Article 3 of this Regulation are determined according to valid EU standards.

2. Quality Of Wastewaters For Discharge To The Recipient

Article 5

Maximum allowed concentrations of dangerous and detrimental substances in wastewaters that can be discharged to surface waters:

No	Parameter	Measuring units	Maximum allowed concentration (MAC)	
			Water body category I	Water body categories II and III
1	pH		6,5-8,5	5,5-9
2	Temperature	ºC	30	40
3	Δt, not more than	ºC	2	3
4	Colour	mg/l Pt scale	5	10
5	Odour		without	noticeable
6	Sedimentary substances	ml/lh	0,5	2,5
7	Total suspended substances	mg/l	30	60
8	BOD_5	mgO_2/l	25	40
9	COD	mgO_2/l	90	125
10	Total organic carbon (TOC)	mgC/l	15	30
11	Aluminium	mg/l	3,0	3,5
12	Arsenic	mg/l	0,1	0,3
13	Copper	mg/l	0,5	0,5
14	Barium	mg/l	3,0	4,0
15	Boron	mg/l	2,0	2,5
16	Zink	mg/l	1,0	1,5
17	Cobalt	mg/l	1,0	1,25
18	Tin	mg/l	0,75	1,0
19	Cadmium	mg/l	0,01	0,02
20	mercury	mg/l	0,005	0,01
21	Total chrome	mg/l	1,25	1,5
22	Chrome 6+	mg/l	0,1	0,15
23	Manganese	mg/l	2,5	3,0
24	Nickel	mg/l	1,25	1,5
25	Lead	mg/l	0,5	0,75
26	Selenium	mg/l	0,03	0,04

27	Silver	mg/l	0,15	0,2
28	Iron	mg/l	2,0	3,0
29	Vanadium	mg/l	0,05	0,075
30	Total phenols	mg/l	0,1	0,2
31	Fluorides	mg/l	2,0	6,0
32	Sulphites	mg/l	2,0	4,0
33	Sulphides	mg/l	0,25	0,5
34	Sulphates	mg/l	20	50
35	Total phosphor	mgP/l	1	2
36	Active chlorine	mg/l	0,05	0,25
37	Total nitrogen	mgN/l	10	15
38	Mineral oil	mg/l	2,0	10
39	Total oil and grease	mg/l	10	30
40	Aldehydes	mg/l	1,0	1,5
41	Alcohols	mg/l	1,0	1,5
42	Total aromatic hydrocarbons	mg/l	0,05	0,1
43	Total nitrated hydrocarbons	mg/l	0,025	0,03
44	Total halogen hydrocarbons	mg/l	0,25	0,5
45	Total organic phosphate pesticides	mg/l	0,025	0,05
46	Total organic chlorine pesticides	mg/l	0,025	0,05
47	Total active surface substances	mg/l	4,0	5,0
48	Total detergents	mg/l	0,5	1,0
49	Radioactivity	Bq/l	0,5	0,75
50	Total coliform bacteria	TC/100ml	5000	10000
51	Faecal coliform bacteria	FC/100ml	1000	5000
52	Faecal streptococci	FS/100ml	100	2000
53	Presence of pathogen organisms		without	without

Only drainage and storm waters are discharged to the ground, i.e. underground waters, as far as the quality of these waters satisfy the border values from paragraph 1 of this article.

Article 6

Maximum concentrations for chemical substances and microbiological species that are not specified in Article 5 of this Regulation, but are discharged to the surface waters, are determined according to valid EU standards.

III SANITARY TECHNICAL CONDITIONS FOR WASTE WATER DISCHARGE TO THE RECIPIENT AND PUBLIC SEWAGE

1. Sanitary Technical Conditions for Waste Water Discharge to the Public Sewage

Article 7

Wastewater collection is done through specific systems, structures and devices that according to their purpose can be divided into:

- internal sewage system, consisting of connecting discharge line (connection), installation, structures and devices with constructions for collection, treatment and discharge of waste waters to the sewage;
- public sewage system, consisting of installations, structures and devices for collection, discharge and treatment of wastewaters from public surfaces and internal sewage;

Article 8

Collection installations, structures and devices, from Article 7 of this Regulation, are built and maintained in a manner that secures proper collection and treatment of projected wastewater quantities.

Article 9

Substances that jeopardise hydraulic regime of wastewater flow, stability of sewage structures, biochemical processes in sewage waters, predicted conditions for performing regular inspections and network repairs, or substances that increase exploitation costs and disable water treatment plant functioning are not discharged to the public sewage:

- waste, garbage from households, construction waste, glass, sludge, ashes, fibrous materials;
- husks, sedimentation, ferment, silage, skin, hair, butchery and animal body processing waste;
- oils and fat (substances that contain separable and emulsifying oils and animal and plant fat);
- liquid and solid compost;
- cement, lime, whitewash, gypsum, roughcast, potato starch, artificial resin, bitumen, tar;
- disinfection and cleaning agents, detergents and washing products that cause creating of enormous amounts of fume;
- substances that can form combustible and potentially explosive mixtures (separable, emulsifying and light fluids: benzene, heating fuel, lubricating oils, carbides that form acetylene, etc.);
- vapours and gasses (chlorine, hydrogen oxide sulphide, hydrocyanic acid and substances that form these gasses and vapour);
- aggressive or toxic substances (acids, alkali, salts, substances for plant treatment and pesticides, substances that react with wastewater to produce dangerous products or effects, chlorinated compounds: perchloroethylene, trichloroethylene, chloroform, Carbon tetrachloride, dichloroethylene, etc.);
- substances that can cause damages to the sewage system, that are toxic or form toxic substances, substances with bad odour or explosive gasses and vapours.

Article 10

Wastewaters from medical, veterinary and other institutions, business companies, other legal entities and enterprises that can be expected to contain pathogen organisms, causes of various infective diseases, are disinfected before discharging to the public sewage.

Article 11

Discontinuous discharge of industry wastewaters that can significantly disturb the flow and composition of wastewaters in the public sewage can be mitigated by applying adequate measure.

Article 12

When legal entity issues technical and sanitary conditions for wastewater discharge to the public sewage all specificities of sewage users (capacity production technology, quantity, composition and dynamics, wastewater discharge, recirculation possibilities, etc.) as well as values given in the Article 3 of this Regulation for all discharges to the public sewage are taken into consideration.

For each change of specificity from paragraph 1 of this Article, user of public sewage obtains new technical and sanitary conditions from legal entity that manages public sewage.

Article 13

If there is any danger from detrimental effects, wastewater discharge to the public sewage is done after pre-treatment, i.e. after applying adequate measures for elimination of these detrimental effects.

Pre-treatment from paragraph 1 of this Article, is done in a way that produces effluent with quality parameters in accordance with parameters from Article 3 of this Regulation, in order to protect public sewage, i.e. wastewater treatment plant.

Article 14

Household and industrial wastewaters are not discharged to the channels which collect and drain rain and storm waters (separate part of the public sewage).

Article 15

Into the separate part of the public sewage which collects and drains household wastewaters, following are not discharged:

- waters used for washing and watering streets and other public surfaces, car washing, waters from cold storages and other slightly polluted industrial waters, pollutant concentrations of which are below the value expected in effluent, that is treated in city wastewater treatment plant;
- cooling and other similar technologic waters, as well as rain and storm waters.

Article 16

In the arias where public sewage has not been built, construction of septic tanks can be carried out for both individual and industrial needs, in a way that secures wastewater quality from Article 3 of this regulation.

Septic tanks are constructed without outlets and overflows and with water-resistant bottom and walls, which is certificated by legal entity that manages public sewage.

Only:

- household wastewaters;
- industrial wastewaters that satisfy wastewater quality from Article 3 of this Regulation;
- radioactive wastewaters, if they are previously treated to the level from Article 3 of this Regulation,

are discharged to the septic tanks.

Rain, storm and surface waters are not discharged to the septic tanks.

Article 17

Septic tanks are emptied regularly, with appropriate equipment, by the legal entity that manages the public sewage or entity registered for performing these tasks.

Entities from paragraph 1 of this Article keep the records of septic tanks owners and users, and inform them before emptying the septic tanks.

Content of the septic tanks is discharged to the adequate public sewage structure, with the permission from the legal entity that manages the public sewage.

2. Sanitary Technical Conditions for Waste Water Discharge to the Recipient

Article 18

Wastewater discharge to the recipient is done through the sewage systems.

Article 19

Sewage systems for wastewater discharge to the recipient consist of public sewage system and sewage systems of business companies, other legal entities, entrepreneurs and citizens that are not connected to the public sewage system.

Article 20

Quality of wastewaters that are discharged to the recipient should be such as not to cause worsening of recipient quality regulated by Regulation on classification and categorisation of surface and underground waters ("Official Gazette of the Republic of Montenegro", No 2/07), at the location of discharge.

Article 21

Outfall structure of the sewage system is constructed in a way that provides quality wastewater mix that is discharged with the recipient waters, in order to meet the recipient quality demands from the Article 20 of this regulation.

Article 22

For wastewater discharge to the watercourses with predominantly low water level, outfall is extended over the bottom of the watercourse, below the level of the low water and stretches up to the mainstream.

For wastewater discharge to the watercourses with predominantly high water level, part of the channel at the outfall should be positioned in a way that does not disturb the normal flow of the channel contents, because of the hydraulic pressure of the water level.

Conditions for wastewater discharge to the watercourses, whose water level oscillates significantly, are collectors with two outfalls on different heights and diffusers with certain number of openings.

Wastewaters are not discharged to the watercourses with flow that downstream of wastewater discharge place cannot secure survival and development of downstream biocenosis, and neither to the watercourses that dry out.

Article 23

When discharging wastewaters to the lake or sea:

- opening of the collector's outfall is positioned on the adequate depth and shore distance, in accordance with wastewater quantity, treatment level and hydrological factors at the location of discharge;
- collector is positioned on the solid ground and secured with anchor blocks;
- at the discharge location, quality of wastewaters should be in accordance with Article 5 of this Regulation, for the purpose of the survival of dominant benthic biocenosis;
- diffusers with adequate numbers of openings are installed;
- discharge system functioning is checked systematically, according to the provided engineering and technical norms and effects of the extreme meteorological occurrence;
- the route and the place of underwater outfall end is visibly marked in an appropriate way.

IV METHODS AND PROCEDURES FOR WASTEWATER QUALITY INSPECTIONS, MINIMUM NUMBER OF INSPECTIONS AND THE CONTENT OF REPORTS ON DETERMINED WASTEWATER QUALITY

Article 24

Wastewater quality is tested for each outflow before mixing wastewaters with waters from sewage system or recipient, and when discharging to the lake or sea, it is tested at the inspection chamber before the underwater outfall.

Article 25

Testing wastewater quality is done by analysing samples according to the parameters from Articles 3 and 5 of this Regulation.

Article 26

Frequency of wastewater testing depends on wastewater discharge location and dilution ratio R, i.e. total wastewater quantity.

Dilution ratio R, is calculated as follows:

R = Qp · Cmdk / Qefi · Cefi

Qp – monthly small volume flow of the recipient (l/s, 95% security);
Qefi – wastewater quantity (l/s) in the moment of testing;
Cmdk – maximum allowed concentration of dangerous and detrimental substances (mg/l);
Cefi – concentration of dangerous and detrimental substances (mg/l) in the moment of testing.

Article 27

If wastewaters are discharged directly to the watercourse and if the dilution ratio is more than 10, wastewater testing is done at least once a month in accordance with technological processes, by collecting composite samples during 24 hours. Composite samples are derived from individual samples taken every 30 minutes with required wastewater flow metering in the moment of testing. Wastewater quality tests are done on four-hour samples, prepared in quantities proportional to the wastewater flow in the moment of sample collecting.

If wastewaters are discharged directly to the watercourse and if the dilution ratio R is less than 10, wastewater testing is done at least once a month in the same way as in paragraph 1 of this Article, and testing the prescribed parameters is additionally monitored on the basis of the program accorded to the technological production processes.

Article 28

If wastewaters are discharged directly to the sea or lake, or public sewage, manner of wastewater testing is determined depending on the total quantity and quality of wastewaters:

a) if the total wastewater quantity is less than 500 m^3/day, wastewaters are tested as described in paragraph 1 of Article 27 of this Regulation;
b) if the total wastewater quantity is more than 500 m^3/day, wastewaters are tested as described in paragraph 2 of Article 27 of this Regulation.

Article 29

Frequency of wastewater testing can be different than stated in the Articles 27 and 28 of this Regulation, if so determined by water licence, i.e. decision issued by water inspector, sanitary or environmental inspector.

Article 30

Wastewater samples are tested according to valid standard methods prescribed in the country and EU.

Article 31

Records on wastewaters sample collection are kept, and they include:

- sample collection date;
- sample collection location;

- name of the entity that samples are collected at;
- weather conditions in the moment of sample collection (water-level and relevant meteorological conditions);
- air temperature;
- wastewater temperature;
- wastewater odour;
- wastewater colour;
- wastewater flow in l/s;
- names, last names, and functions of persons present at the sample collecting.

Article 32

Business companies, other legal entities and entrepreneurs, who discharge wastewaters to the recipients and public sewage, provide keeping records of test frequency, quantity and composition of dangerous and detrimental substances in the following forms:

- Form A: records of wastewater discharge: basic data on legal entity, entrepreneur and recipient;
- Form B-1: records of wastewater discharge: continuous discharge;
- Form B-2: records of wastewater discharge: discontinuous discharge;
- Form C-1: records of wastewater discharge: composite sample testing results;
- Form C-2: records of wastewater discharge: individual daily sample testing results;
- Form D: records of wastewater discharge from communal treatment plants for wastewaters from settlements and cities.

Forms from paragraph 1 of this Article are attached to this Regulation and are part of it.

Legal entities authorised for wastewater quality testing submit filled-in forms to the orderer of the testing, and in the form of report of determined wastewater quality it is submitted to: the Ministry in charge of water works, Ministry in charge of environment protection, Ministry in charge of health, government body in charge of water management and government body in charge of hydro meteorological works, not later than one month after the testing.

Article 33

Systematic monitoring and control of quality of wastewaters discharged to the public sewage, i.e. recipient, are provided by legal entities and entrepreneurs that perform wastewater discharge.

Legal entity that manages the public sewage provides systematic monitoring of all industrial wastewater outflows, and has at its disposal data on sewage system users, and especially data on:

- Type, quantity and properties of all wastewater flows, discharged to the public sewage by the user;
- Type and manner of discharge;
- Existing plants and equipment for pollution reduction and pre-treatment.

Article 34

Public sewage users, on the request of legal entity that manages the public sewage, submit data on production, type and location of wastewater discharge to the public sewage, as well as data on all changes in production processes. For the purposes of setting the monitoring, public sewage users provide the legal entity that manages the public sewage insight with the documentation and other data significant for the wastewater discharge to the public sewage on spot.

V FINAL PROVISIONS

Article 35

On the day when this Regulation comes into effect, Regulation on wastewater quality and methods for its discharge to the public sewage and natural recipient ("Official Gazette of the Republic of Montenegro", No 10/97 and 21/97) ceases to be valid.

Article 36

This Regulation comes into effect on the eighth day of its publication in the "Official Gazette of the Republic of Montenegro.