2011

Energy Audit of Water and Wastewater Utilities in 6 towns of Moldova

Final Report

CAHUL

Tehno Consulting & Design

December 2011

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ABBREVIATIONS

Selected Definitions:	Abbreviation / Synonym Definition
A.S.L.	Above Sea Level
BPS	Booster Pumping Station
WB	World Bank
IDA	International Development Association
Client	Water Supply and Sanitation Projects Implementation Unit
Auditor/Consultant	Tehno Consulting & Design
EE	Energy Efficiency
ECM	Energy Conservation Measures
EEP	Energy Efficiency Program
EMP	Energy Management Program
PS	Pumping Station
SPS	Sewage Pumping Station
MSPS	Main Sewerage Pumping Station
NWSSP	National Water Supply and Sanitation Project
RWTP	Raw Water Treatment Plant
WWTP	Waste Water Treatment Plant
O&M	Operation and Maintenance
BoQ	Bill of Quantities
VSD	Variable Speed Drive
HVAC	Heating, Ventilation, and Air Conditioning
WSS	Water Supply and Sanitation

EXECUTIVE SUMMARY

Present Energy Audit report summarizes Apa-Canal Cahul facilities description, historical data, Auditors findings, site measurements data, analyses and ECM proposals.

Our energy audit team visited Cahul and collected historical water and energy usage data, as well as the existing equipment operating data. As a result of the site measurements we identified several ECM, which in our opinion will provide feasible opportunities for significant energy savings.

The feasibility of each proposed ECM was estimated through a payback analysis. The simple payback period was determined after establishing Engineer's estimation of capital investments, O&M equipment costs, projected annual energy savings estimates, and the potential value of energy tariff.

Recommended ECMs

The following table presents the ranking of recommended ECMs identified for Apa-Canal Cahul. The ECMs are ranked on a simple payback period basis.

ECM description	Annual energy savings, kWh	Annual energy savings, MDL	Capital investment cost, MDL	Simple payback period, years	Ranking
Hydraulic optimization of PS 3 city pumping zone	94,754	170,557	599,775	3.5	**3**
Hydraulic optimization of PS 3 Spirin pumping zone	92,067	165,721	427,350	2.6	**2**
Installation of new pump at PS 5	29,591	53,264	31,020	0.6	**1**
Installation of new sludge pump at WWTP	19,710	35,478	218,625	6.2	**4**
Hydro-turbine at WWTP	32,850	59,000	567,600	9.6	**5**

Recommended ECMs to be included in the EMP

In order to prioritize investments from different Project towns, the indicator for relative energy saving as % of total energy consumption of each separate water utility was used as the most fair and important indicator. Thereby, the investments bringing the highest relative reduction in energy consumption in the respective towns were prioritized. This selection criterion was applied as primary one, while the secondary criterion of simple payback period was applied after preliminary sorting.

Two ECMs have been shortlisted for the EMP investment package:

ECM description	Annual energy savings, kWh	Annual energy savings, MDL	Savings in % compared to total power consumption	Capital investment cost, MDL	Ranking
Hydraulic optimization of PS 3 city pumping zone	94,754	170,557	**9.5%**	599,775	**1**
Hydraulic optimization of PS 3 Spirin pumping zone	92,067	165,721		427,350	**2**

Total investment amount for selected Cahul ECMs is **86,241 USD.**

1. INTRODUCTION

The IDA provided financing in the amount of 0.9 mln USD which will be used for investments to raise energy efficiency in 6 (six) water and wastewater utilities of Moldova. The EEP is expected to demonstrate and disseminate through energy audits and following investments the potential for increasing energy efficiency in municipal water and wastewater operations.

The program finances energy audits, hydraulic regime optimizations, and the selective rehabilitation of electromechanical equipment (equipment replacement) which are expected to increase energy efficiency in municipal water and wastewater operations in the cities Balti, Cahul, Orhei, Causeni, Floresti and Ungheni.

This Final Audit Report summarizes findings, proposals, planned activities, schedule for completion of audit components, staffing and submission deadlines of audit reports and other deliverables for Energy Audit of Water and Wastewater Utilities in 6 towns of Moldova.

The contract has been let for open international tendering for consultancy services. The contract was awarded to Tehno Consulting & Design and became effective on 20th June 2011. The duration of the services is expected to be 6 months.

1.1 Draft Audit Report

In previous Draft Audit Report the Consultant has introduced his assessment of energy conservation measures and investment needs in the city of Cahul. The Report includes conditional and operational analysis of existing water and wastewater facilities and energy conservation measures, as well as a financial assessment of the proposed investments.

The report also includes the Consultants proposal of ECM measures for the future EMP investments.

Furthermore, this Report includes the output from the Baseline Studies as presented in the Consultants Inception Report.

There is one separate report for each of the six cities covered by the project.

1.2 Final Audit Report

Present Final Audit Report includes comments and suggestions to the Draft Report from the World Bank experts, WSSPIU and Apa-Canal Cahul.

The meeting with stakeholders was held on December 07, 2011. The agreed shortlist of EMP investments for Cahul contains the following:

Table 1-1 *Agreed EMP Investments for Cahul*

The proposed ECM description	Annual energy savings, kWh	Annual energy Consumption of Water Utility, kWh	Savings in %, as compared to total consumption	Capital investment cost, MDL	Simple payback period, years
Hydraulic optimization of PS 3: **- Spirin pumping zone** **- city pumping zone**	186 821	1 958 300	***9.5%***	1 027 125	3.1

The overall amount of proposed EMP investments for Cahul is 1,027,125 MDL or **86,241 USD** (USD exchange rate 11.91).

Consultant will prepare the following submittals for the selected ECM:

- BoQ and Cost estimate for Goods, Works and associated services;
- Technical Specifications for Goods and Works within proposed EMP;
- Draft EMP schedule of implementation

2. WATER SERVICES IN THE TOWN OF CAHUL

2.1 General

The Town of Cahul is located in the Southern part of Moldova, some 160 km from Chisinau. The Town of Cahul is the sixth largest city in Moldova and is the administrative and commercial center of agricultural rayon (district) with about 124,800 inhabitants.

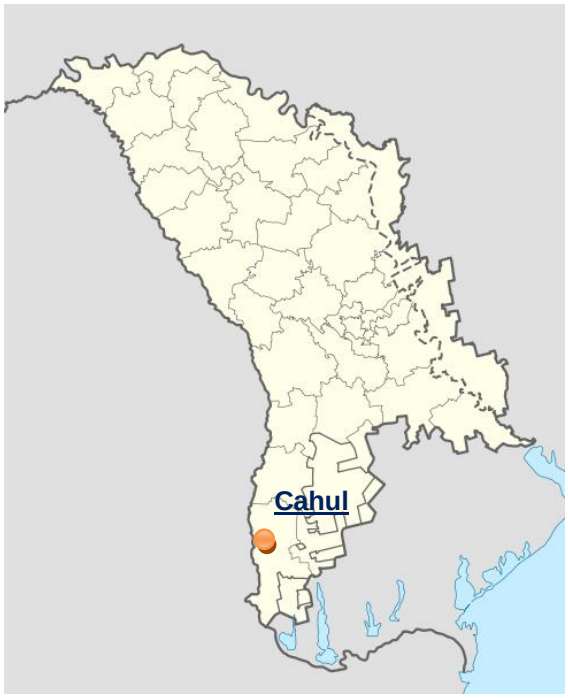

Figure 2-1 *Location of Cahul*

Cahul is located along the Prut River at the altitudes of 5-105 m above sea level, highest regions being situated in the Eastern part of Cahul.

The Prut River, a tributary to the Danube River, flows (N-S) along the City.

The train station serves the city and provides direct rail connections to Chisinau. Cahul is connected by national roads with Chisinau, Giurgiulesti, Oancea (Romania) and Reni (Ukraine). Cahul is also a border checkpoint to Romania.

2.2 Service Area Definition

The Town of Cahul is provided with water services by a municipal operator (I.M. Apă-Canal Cahul) covering main part of the town.

The whole Town represents multi-pressure zones service area with private houses and multi-storey building districts located in central part of the Town. The service area is located at 10-110 m a.s.l. and is supplied from one Main PS (PS2) and three network PSs.

There are no other booster PSs used in the system.

The estimated extent of water services in Cahul is presented in the following figure:

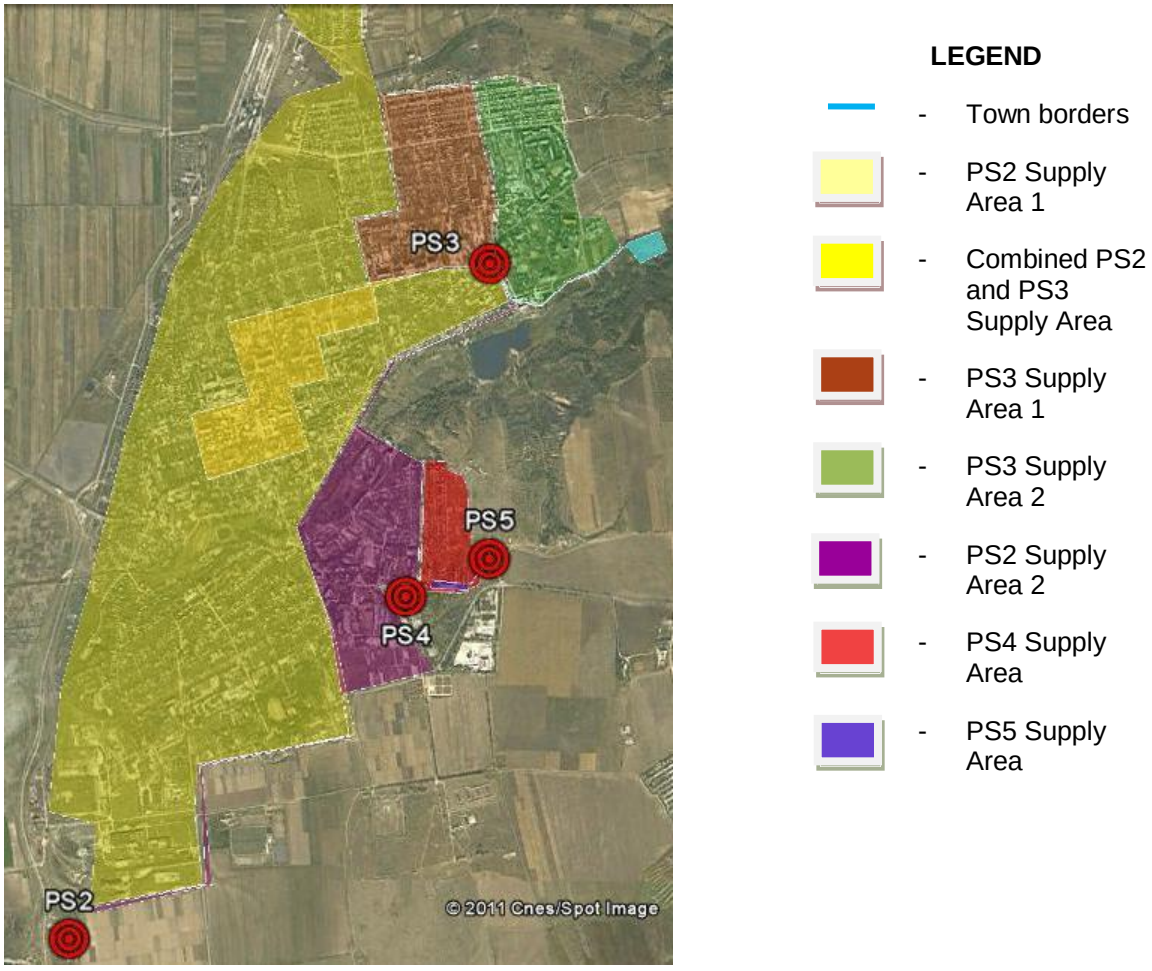

Figure 2-2 *Estimated Extent of Water Service Areas in Cahul*

This study covers Apa-Canal operations only. The possibilities of future water supply of uncovered areas by Apa-Canal shall be studied separately.

2.3 Population

The official population records for the Town are summarized in the table below:

Table 2-1 *Resident population in Cahul Town, as of January1 by Years*[1]

	2005	2006	2007	2008	2009	2010	2011
Cahul Rayon	125.8	125.7	124.1	123.8	124.4	124.4	124.8
Cahul City	42.1	42	40.5	40.3	40.7	40.7	41

[1] National Bureau of Statistics of the Republic of Moldova

As shown in the table, the official population number of the Town has been being rather stable over the last 5 years. Significant changes (especially growth) in population are not expected in the next years, as the average population growth rate for Moldova is estimated at -0.072% for 2011[2].

Notwithstanding the official statistical data, and taking into account high level of immigration, the real number of population (and consequently consumers) living in Cahul is expected to be considerably lower.

2.4 Customers

The number of water contracts (connections) by supply areas operated by the Apa-Canal is summarized in the following table.

Table 2-2 *Water Supply Customers – Apa-Canal Cahul*

Service Area	No of Customers (Contracts)	Estimated No. of population (people)
Households (by supply areas)		
PS2	6,787	17,083
PS3 – Spirin Area	1,512	3,780
PS3 – XV District	2,960	7,402
PS4	966	2,414
PS5	345	862
Economic Agents	470	
Budgetary Institutions	38	
TOTAL	**13,078**	**31,541**

As can be seen from the Table, the major number of consumers are private households. In total, some 77% of the official area population is provided with water by Apa-Canal Cahul.

This Audit Report covers ECMs for current consumption conditions only and does not envisage any considerable future extensions in terms of consumers.

The number of contracts for wastewater is summarized in the following table.

Table 2-3 *Sewerage Customers – Apa-Canal Cahul*

Service Area	No of Customers (Contracts)	Estimated No. of population (people)
Total Customers	7,517	27,818

As can be noticed from the previous Tables, some 68% of total official population and only some 88% of total water consumers are provided with sewerage services.

[2] Central Intelligence Agency, the World Factbook

2.5 Preliminary Water Balance

The following table derives from information provided by the Apa-Canal.

Table 2-4 *Reported Water Balance in Cahul for 2008-2010*

	2008	2009	2010
Water Abstracted	2,048.3	2,135.3	1,917.6
Water Produced (System Input)	1,812.6	1,852.1	1,617.6
Transmission/treatment losses	235.7	283.2	300.0
Total Water Billed	988	927.3	860.2
Including huseholds	787.5	785.4	675.7
Non-Revenue Water	52%	57%	55%
Total received wastewater	1,208.1	1163.8	1144.4
Including huseholds	450.6	452.2	410.8
% household sewerage return	57%	58%	61%

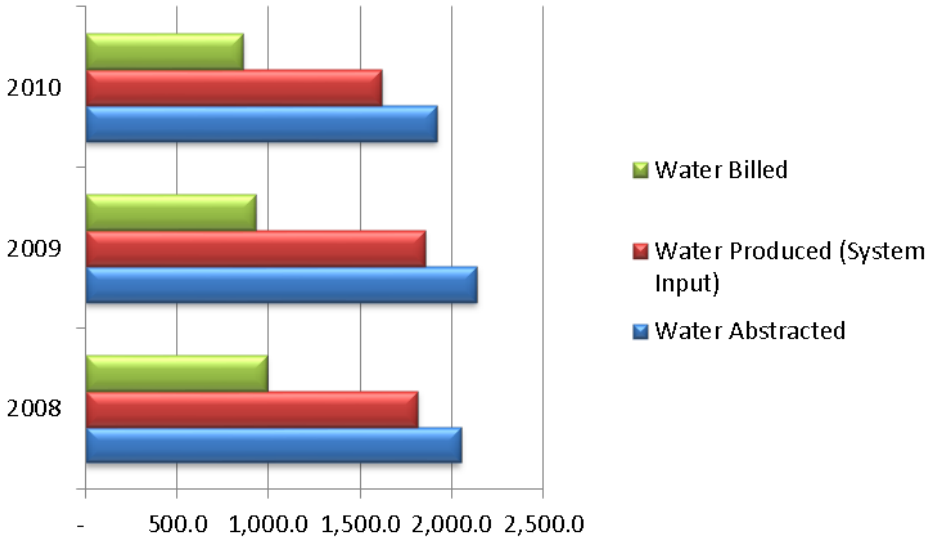

Figure 2-3 *Reported Water Balance for 2008-2010*

In respect of the water supply system, it is of note that the non-revenue water rate as estimated on the basis of the reported values has substantially high values of produced water. High NRW rates are subject to this Energy Audit and a general NRW analysis is presented in the following Sections.

Also, considerably high amounts of water losses for transmission/treatment are subject to further Audit Analysis.

Overall the wastewater return rate is relatively high as compared to the other water utilities covered by this Study. However, it remains low reflecting the lower level of development of wastewater services.

3. WATER SUPPLY SYSTEM

3.1 General

The town of Cahul is provided with water from one surface water intake through Main pumping station (PS2) feeding the town through two parallel pressure mains. The abstracted water is delivered by PS1 to the WTP, wherefrom it is pumped by PS2 in the town networks.

Central and Eastern parts of the Town are supplied by three (3) town PSs, mainly covering multi-storey buildings in the area. No separate booster PSs are used to provide water to multi-storey buildings.

Most of networks and pressure mains are in poor condition due to its age and heavy use, generating high amounts of leakages.

3.2 Water Production

Surface water intake is located on the Prut River, some 5 km West from the Town border. PS1 located some 150 m from the Prut River abstracts surface water directly from the river and delivers it to the WTP. The abstraction point is organized at an altitude of some 10 m a.s.l.

During the summer low flow season, the geodetic height for pumps suction seldom reaches its critical value and pumps from the PS1 cannot abstract the water, working in cavitation. Therefore, Apa-Canal has decided to install an "on-water" coastal pumping station in order to cover pressure gap during low-level periods.

The abstraction facilities were built in 1970 and haven't been cleaned/repaired since. During the walk-through analysis, the Consultant noticed high level of raw water turbidity, which is considered to negatively influence the raw water quality and consequently the whole treatment process.

General data on installed pumping equipment at the PS1 are presented in the following Table.

Table 3-1 *Design parameters of the existing pumping equipment at the PS1 in Cahul*

No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Control Panel	Operating	Year of instal-lation
					P	Voltage	Speed	cosϕ	In			
			m^3/h	m	kW	V	rpm		A		hrs /day	
1	300D-20	1	1200	40	250	380						1986
2	300D-20	1	1200	40	315	380						1986
3	ASP200BS-75/4	1	480	40	75	380	1480	0.90	134	Y		2006
4	ASP200BS-75/4	1	480	40	75	380	1480	0.90	134	Y		2006

Existing pressure main from the PS1 are from 1970's and is made of DN700 reinforced concrete pipes and are considered to be in a poor condition. The other parallel pressure main made of DN700 steel is taken out of operation. Being at the end of life cycle, pressure pipelines can generate considerable amounts of leakages in future and need to be monitored. The amount of leakages from the pressure main will be measured under this Energy Audit Study.

Historical Energy Consumption

The present section represents historical energy usage and associated Apa-Canal costs. It is important to establish at least 3 years patterns of mainly electric, as well as gas usage, if relevant, in order to be able to identify areas in which energy consumption can be reduced.

Energy consumption in kWh for each facility is shown in the following figure:

Table 3-2 *Reported Energy Consumption by Cahul Water Utility for 2008-2010*

	2008	2009	2010
		Water Supply	
PS1	468.9	560.3	442.7
PS2	750.2	752.8	718.1
PS3 Spirin	199.1	222.6	250.4
PS3 Dist15	87.5	131.5	94.2
PS4	55.1	54.3	52.0
PS5	29.5	29.7	31.1
		Sewerage	
Main SPS	288.4	277.4	268.5
Local SPS	11.7	11.4	14.2
South SPS	3.2	3.1	2.8
WWTP	99.3	101.9	84.3

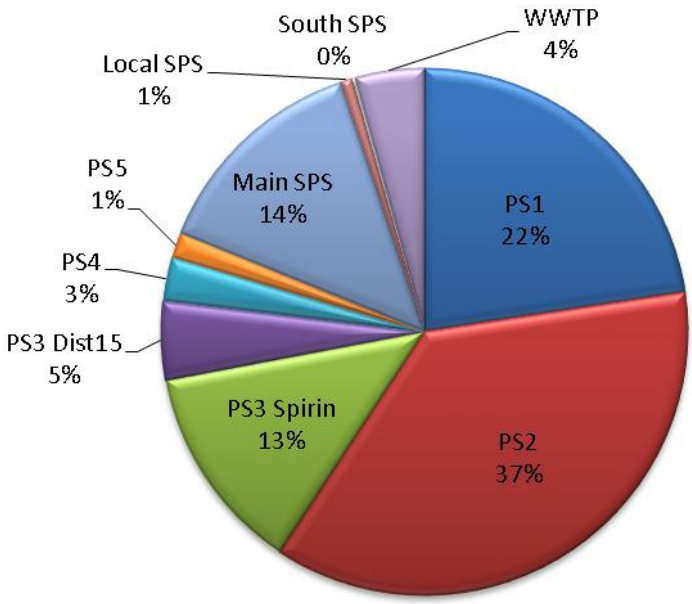

Figure 3-1 *Shares of energy consumption reported by Cahul Water Utility for 2010*

As can be seen from the Table above, the main energy consuming facilities are PS2 (37%), PS1 (22%), PS3 (18% in total) and the Main SPS (14%). The main focus of this Energy Audit will be aimed at these major energy consumers.

The following summary of water pumping stations historical energy consumption for 2010 registered by Apa-Canal is provided in the Table below.

Table 3-3 *Reported historical energy consumption for water pumping in 2010*

	Energy Consumed in 2010, thou kWh											
Name	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
PS1	43.6	37.9	31.3	28.7	31.7	32.6	35.0	46.5	35.0	35.6	38.2	46.6

PS2	62.6	55.8	56.3	51.4	53.6	56.2	56.5	70.4	61.3	66.7	60.6	66.7
PS3 Spirin	20.8	18.2	21.1	18.8	20.3	19.8	20.4	21.2	20.1	20.7	24.1	24.9
PS3 Dist15	6.2	6.5	6.7	6.1	7.8	7.9	8.1	9.1	8.4	8.2	9.3	9.9
PS4	4.7	6.7	4.7	3.8	4.0	3.8	3.8	4.4	3.6	4.2	3.8	4.5
PS5	3.1	2.5	2.4	2.0	2.3	2.2	2.4	2.4	2.3	2.2	3.1	4.2

This Table shows that the highest energy consumption is registered during summertime. The Consultant has carried out its assignment, including site measurements, during the most energy consuming period of operation.

The following summary of PS1 historical energy consumption for 2010 registered by Apa-Canal is provided in the Figure below.

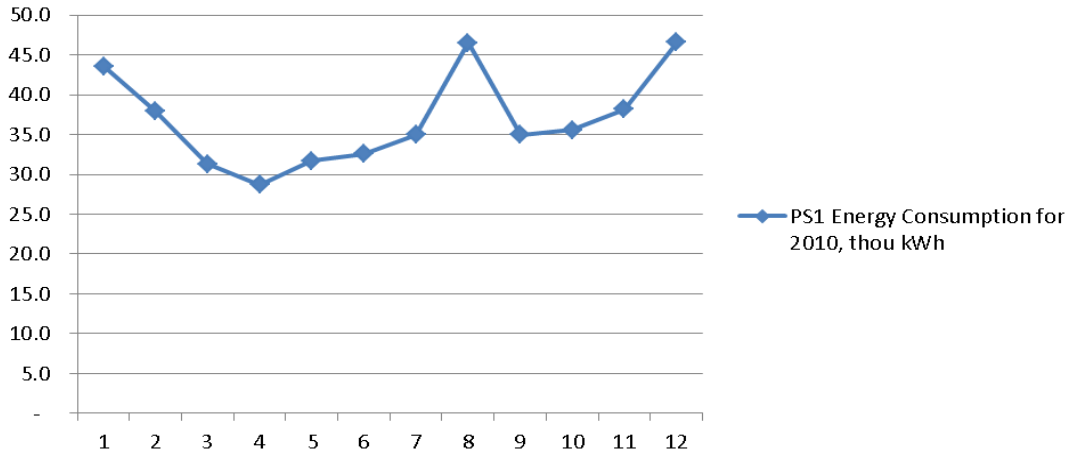

Figure 3-2 *Reported PS1 Energy Consumption for 2010*

3.3 Water Treatment

Since the only source of water is the Prut River, a comprehensive water treatment is done to provide drinking water quality to the customers. All treatment is done at the Water Treatment Plant located at the Southern border of the Town.

The WTP design capacity is 17,400 m^3/day. Currently, it is used at up to some 10,000 m^3/day only.

The existing treatment chain consists of:

- Vertical Mixers – 2 units;
- Chemical Tanks and pumps (coagulation and chlorination process);
- Clarifiers – 4 units;
- Rapid Filters – 8 units;
- Chlorination Plant;
- Treated Water Tanks – 3 units of V=2,000 m^3 each;
- Main Pumping Station (PS2)

Raw water quality, turbidity in particular, from the Prut River is significantly variable during the year, achieving its highest values of up to some 2,000 mg/l during the spring high-water season. The existing WTP is designed to treat the inlet raw water of considerably lower turbidity and basically is at a permanent risk of failure and consequent contamination of water. In order to mitigate possible pollution risks and to

ensure efficient treatment of water, a number of preliminary pre-treatment settlers along the Prut bank were designed and partially built during the Soviet times. Currently, these settlers are not in use, resulting in high operating costs for treatment of the raw water at the existing WTP.

Main energy consuming installations at the WTP are:

- the Main PS, used to pump treated water to the town network and backwash rapid filters, and
- Chemical pumps used for coagulant and chlorine feeding.

Most of the chemical pumps in use are in poor condition and require urgent replacement.

After backwashing of rapid filters, the drained water is not recycled and is discharged directly into the sewerage network. This waste of water is considered to be inefficient energy solution and needs to be addressed in the next Chapters.

The existing WTP was planned to be rehabilitated under the National Water Supply and Sanitation Project, financed by the World Bank. However, due to the last WB assessments, it has been proposed to build a new WTP. No clear decision has been made during the Consultant's assignment. Therefore, some of Consultant's measurements and recommendations are expected to refer to the existing WTP.

3.4 Water Pumping – Main PS (PS2)

The Main PS (also known as PS2) is used to provide water to the whole Town of Cahul. Pumping equipment includes one main pump group built of 3 parallel pumps of types ASP125D-75/4. The pumps intake water from three (3) underground water tanks with capacity of 2,000 m^3 each, located at the WTP territory, and pump water through two parallel pressure mains to the service area, as follows:

- One pressure main is made of steel DN500 pipes and supplies directly central distribution network. This network is also connected to the PS3 inlet tank;
- The other pressure main is made of steel DN500 pipes and is used to convey water to the inlet tanks from the PS4 and PS3. Also, a small western part of the town (Lipovanca District) is supplied directly from this pressure main.

Though these 2 pressure mains supply different areas, they are connected to the same group of pumps from the PS2.

Additionally, PS2 is equipped with pumps to backwash the rapid filters from the WTP.

General data on installed pumping equipment are presented in the following Table.

Table 3-4 *Design parameters of the existing pumping equipment at the Main PS in Cahul*

Pump No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Control Panel	Operating	Year of instal-lation
					P	Voltage	Speed	cosϕ	In			
			m^3/h	m	kW	V	rpm		A		hrs /day	
1-3	ASP125D-75/4	3	320	60	75	3x400	1450	0.90	134	Y	24	2006
3A-4	300A -90	2	1,200	60	250	3x400				Y	Stand-by	1986
5	400A -190	1	1,800	30	160	3x400				Y	1	1970
6	400A -190	1	1,800	30	160	3x400				Y	Not working	1970

All pumps installed in 1970-1980's are in poor physical condition and are expected to have low energy efficiency rates.

In 2006, the Main PS was renovated under the Pilot Water Supply and Sanitation Project, financed by the World Bank. All pumps delivering water into town networks were replaced with modern ones.

It is of note that the pumps deliver water into two pressure mains, supplying different areas. However, both networks are connected to the PS3 inlet tank, located at altitude of some 72 m a.s.l.

Further Audit measurements are required in order to identify whether existing pumps operate in their best efficiency ranges. The detailed analysis is provided in the next Chapters.

Main PS Historical Energy Consumption

The following summary of historical energy consumption of the PS2 registered by Water Utility is provided in the Figure below.

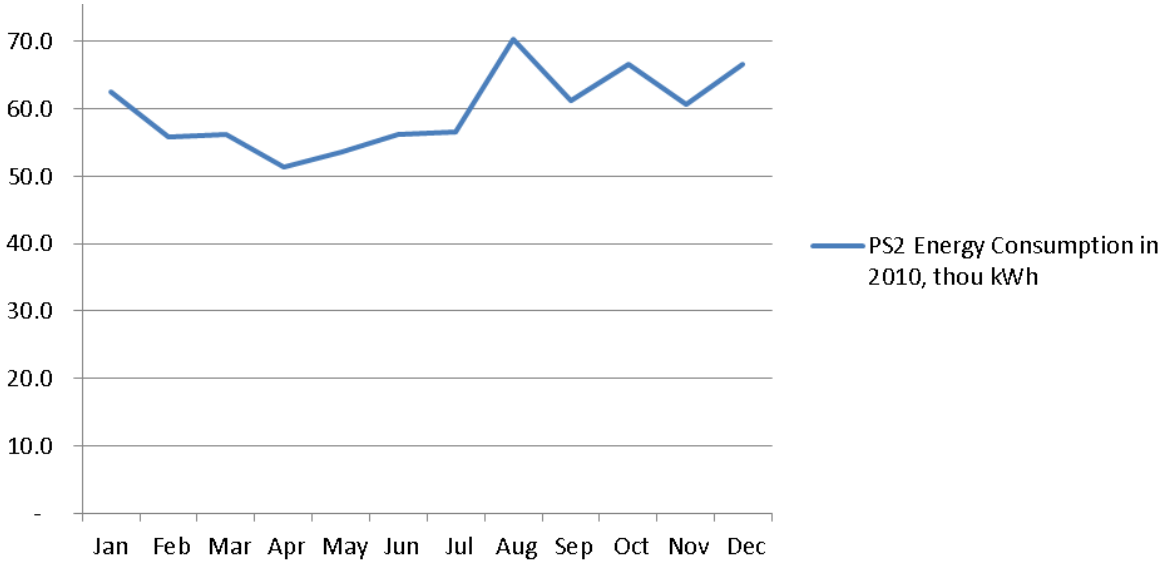

Figure 3-3 *Reported Historical Energy Consumption of the PS2 for 2010*

The detailed figures on energy consumption are provided in the previous Chapters.

Since the PS2 is one of the major energy consuming facilities in Cahul, it is subject to further Energy Audit analysis.

3.5 Cahul Town Pumping Stations (PS3, PS4 and PS5)

The in-town networks of Cahul are provided with water from four (4) pumping stations, as follows:

- Central Supply Area – covered by PS2 and partially by PS3 (XV district);
- Spirin District – supplied by PS3;
- XX District – supplied from PS4;
- Lapaevca District – supplied from PS5.

Pumping Station PS3

The treated water is delivered by the Main PS is stored at the PS3 inlet tanks with capacity of 1,000 m^3 each. This PS3 is equipped with 2 groups of pumps. First group is built of 3 parallel centrifugal pumps of type NP50/250V-22/2a, used to deliver water directly into Spirin District. This district includes private houses. It is of note that the pressure of 7.2 bar is used to supply the highest network points. However, a district of private houses has an excessive pressure, and Apa-Canal is reducing the pressure by a throttle valve.

The second group is used to supply water to the city center, XV District. This area consists of some twelve 9-floor buildings, 14 5-floor buildings and 949 one-level houses. Second group of pumps includes 3 parallel centrifugal pumps of type NP80/160-15/2aDM.

General data on installed pumping equipment at PS3 are presented in the following Table.

Table 3-5 *Design parameters of the existing pumping equipment at PS3 in Cahul*

Pump No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Control Panel	Operating	Year of instal-lation
					P	Voltage	Speed	cosϕ	In			
			m^3/h	m	kW	V	rpm		A		hrs /day	
1-3	NP50/250V-22/2a	3	75	72	22	380	2940	0.91	38.1	VSD	24	2005
4-6	NP80/160-15/2aDM	3	112	35	15	380	2910	0.91	27.2	VSD	24	2005

Both pumping groups from PS3 are operated permanently for up to 24 hours per day.

It is of note that PS3 covers central part of the town (XV District), which is also supplied directly from the PS2. Several streets have two parallel pipes from different pumping stations. Furthermore, the western loop from the PS3 supplied network doesn't have any main consumers. Still, the whole network loop is operated at the pressure of up to 6 bar with almost absent consumption. The possibilities of network optimization are subject to further Audit analysis.

Pumping Station PS4

PS4 receives water from the second pressure main from the PS2. The water is stored in collection tank and thereafter pumped to a XX District. The district includes multi-storey buildings and private houses. Also, PS5 tank is supplied from the PS4.

There is a group of 3 pumps operating 24 hours per day. General data on installed pumping equipment at PS4 are presented in the following Table.

Table 3-6 *Design parameters of the existing pumping equipment at PS4 in Cahul*

Pump No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Control Panel	Operating	Year of instal-lation
					P	Voltage	Speed	cos ϕ	In			
			m^3/h	m	kW	V	rpm		A		hrs /day	
1-3	COR3MVI 3204/CR	3	37.5	50	7.5	380	2900	0.89	13.8	VSD	24	2005

Booster pump set used for this PS4 works with frequency converter.

Pumping Station PS5

PS5 receives water from the network supplied by PS4. Initially, PS5 was designed to supply a currently building district. However, the construction process is expected to be long and PS5 currently supplies only three 9-storey buildings.

General data on installed pumping equipment at PS5 are presented in the following Table.

Table 3-7 *Design parameters of the existing pumping equipment at PS5 in Cahul*

Pump No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Control Panel	Operating	Year of instal-lation
					P	Voltage	Speed	cosϕ	In			
			m^3/h	m	kW	V	rpm		A		hrs /day	
1	2kM-6	1	20	22	5.5	380	2900	0.89	11	N	24	
2	2kM-6	1	20	22	5.5	380	2900	0.89	11	N	Stand-by	
3	3kM-6	1	45	30	15	380	2900	0.86	30	N	Stand-by	
4	3kM-6	1	45	30	15	380	2900	0.86	30	N	Stand-by	
5	1.5k-6	1	12	22	2.2	380	2900	0.87	5	N	Stand-by	

All pumps in use at PS5 are oversized for the current consumption and possibilities of optimizing the PS5 shall be analized in the next Sections on this Report.

No frequency converters are used for this PS5.

Cahul Town PSs Historical Energy Consumption

The following summary of historical energy consumption by the town pumping stations registered by Water Utility is provided in the Figure below.

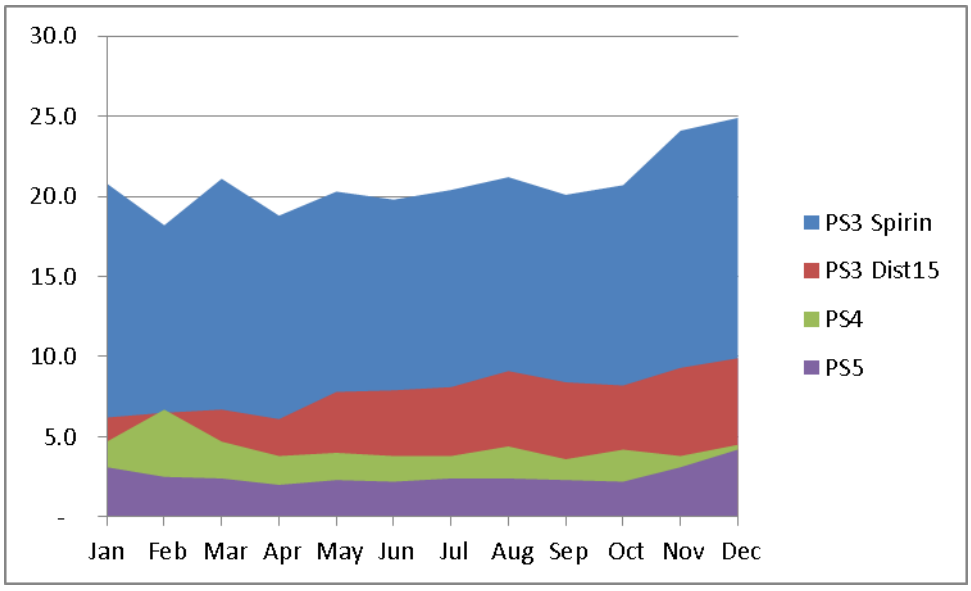

Figure 3-4 *Cahul town PSs- Reported Energy Consumption for 2010.*

The detailed figures on energy consumption are provided in the previous Chapters.

As can be seen, PS3 has the major energy consumption and it is subject to further Energy Audit.

3.6 Water Pumping – Booster PS

There are no booster pumping stations operated by Cahul Water Utility. All water is supplied to the consumers by the pumping stations described above.

3.7 Water Distribution Network

Town water distribution network is organized through several pressure zones covering all city consumers, as follows:

- Zone 1 - Central Supply Area – covered by PS2. Mixed area – private and multistorey buildings. Inlet pressure – 6 bar;
- Zone 2 – Central Area – XV District – covered by PS3. Area of multi-storey buildings. Inlet pressure – 3.5 bar;
- Zone 3 - Spirin District – supplied by PS3. Area of private hoses. Inlet pressure – 7.2 bar;
- Zone 4 - XX District – supplied from PS4. Mixed area – private and multistorey buildings. Inlet pressure – 5 bar.
- Zone 5 - Lapaevca District – supplied from PS5. Area of multi-storey buildings. Inlet pressure – 2.2 bar;

Networks from zones 1 and 2 are overlapping to some extent in the city center. Some network loops from the PS3 without any pressure demanding consumers are still kept under excessive pressure, reaching some 6 bar in the lowest network points. Network optimization is subject to further Audit analysis.
Main data about existing water pipelines are shown in the following Table.

Table 3-8 *Data on existing water pipelines in Cahul*

Material	Diameter mm / Length m											Total
	100	150	200	250	300	350	400	500	600	700	800	
Reinforced Concrete								2,900		4,100		**7,000**
Cast Iron	5,160	9,120	6,154		520							**20,954**
Steel	15,550	1,730	2,515		1,500		3,540	2,090		4,048		**30,973**
HDPE	11,735	5,980	2,285	400			1,105					**21,505**
Total (m)	**32,445**	**16,830**	**10,954**	**400**	**2,020**		**4,645**	**4,990**		**8,148**		**80,432**

In 2006, some 22 km of water distribution network pipelines were replaced under the Pilot WSSP, financed by the World Bank. Currently, the NWSSP continues renovation of existing water networks in Cahul. It is expected to replace some 15 km (out of 80 km) of network pipelines. Though some 45% of networks will be renovated in total, good energy saving potential is seen in the eastern part of the central network. Also, possible network optimization will be analyzed in the next Chapters.

It is expected that current leakage rate is relatively high and a selective Leak Detection Campaign to prevent network leakages in the most emergency segments is subject to further Audit.

Beginning of year 2011 there were 11,493 household-meters installed, including:

- 6,315 in private apartments;
- 4,680 in individual houses;
- 460 for commercial; and
- 38 for budget institutions.

The level of population within metering covers 87%. Level of metering for institutions and business entities is 98 %. All private apartment meters are size of DN 15 while size of meters installed at institutions and organizations vary from DN 15 to DN 50 depending on connection diameter. The water meters are of different types of accuracy (A-C), generating high errors in measurements.

4. SEWERAGE SYSTEM

4.1 General

Currently, Cahul sewerage collection system consists of four (4) drain areas and three (3) SPSs, pumping collected wastewater to the existing WWTP, located in the Southern part of the town at an elevation of 30 m a.s.l.

Given to the Town geographic situation, all wastewater is collected by gravity at the lowest points of the drain areas, delivered to the Main SPS and thereafter pumped to the WWTP.

The estimated extent of sewerage drain areas in Cahul is presented in the following figure:

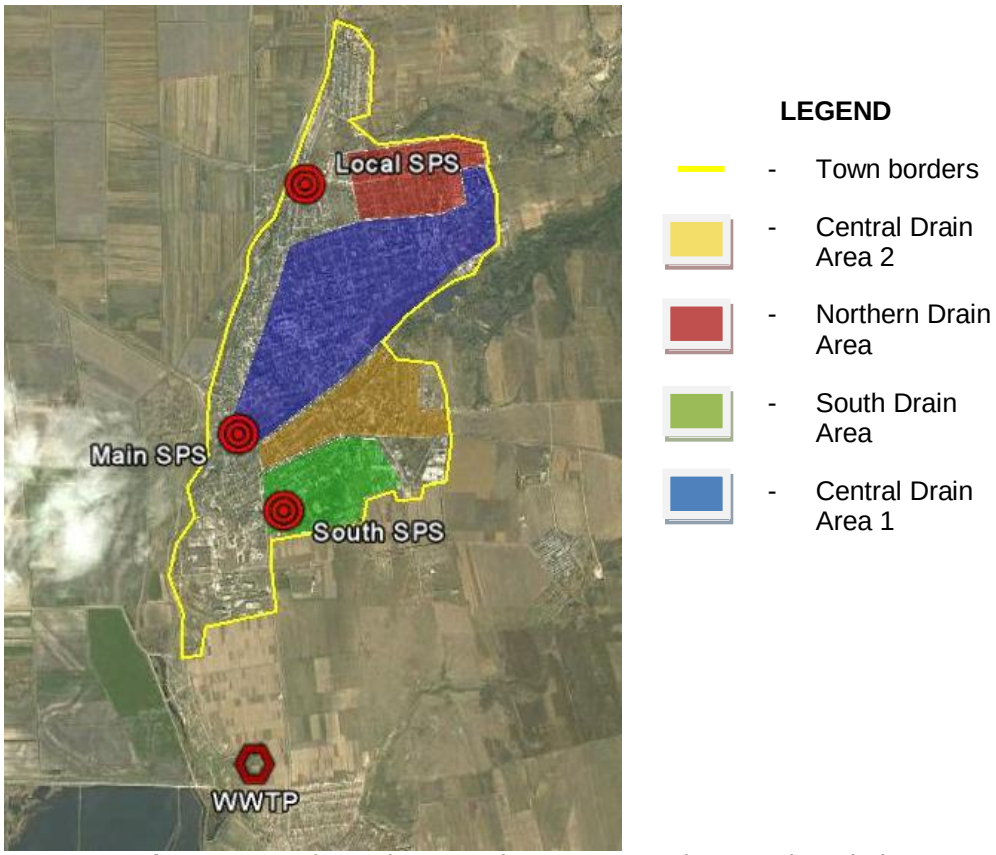

Figure 4-1 *Estimated Extent of Sewerage Drain Areas in Cahul*

Currently, some 68% of the official Town population and some 88% of water consumers are covered by the sewerage services. Detailed information on consumers is provided in the previous Chapters.

4.2 Wastewater Collection

Town wastewater collection is separated in four (4) main drain areas, thereof collected wastewater is led to the WWTP through three (3) sewerage pumping stations.

The areas are, as follows:

- Northern part – area of private households. Collected wastewater is designed to be pumped by the local SPS to the Main SPS inlet chamber;
- Central part 1 – area of mixed private houses and multi-storey buildings, located north of the stream (crossing town NE-SW). All wastewater is collected by gravity at the Main SPS;
- Central part 2 – area of mixed private houses and multi-storey buildings, located south of the stream (crossing town NE-SW). All wastewater is collected by gravity at the Main SPS;
- Southern part – area of private households. Collected wastewater is designed to be pumped by the Southern SPS to the Main SPS inlet chamber.

Main data on existing sewerage collectors are shown in the Table below:

Table 4-1 *Sewerage networks operated by Cahul Water Utility*

	Situation, description of collector	Pipe Material	Diameter mm	Length m	Year of construction
1	Pressure collector Main SPS - WWTP	PE	400	9,000	2006
2	Pressure collector from the local SPS to the Main SPS	Steel	300	5,500	1978
3	Gravity discharge collector from WWTP to the Prut River	Steel	500	7,000	1970
4	Gravity Sewers	Asbestos	400	1,010	1980
5		Asbestos	300	1,120	1980
6		Asbestos	300	1,750	1964
7		Ceramic	400	3,050	1964
8		Asbestos	300	2,110	1982
9		Ceramic	400	1,010	1982
10		Asbestos	300	750	1975
11		Ceramic	400	610	1975
12		Ceramic	400	2,360	1980
13		Asbestos	300	6,850	1978
		Ceramic	400	7,250	1982

The main sewerage network originates from the 1970-80's and has been partially renovated since. However, some parts of networks are worn out generating considerable amounts of leakages. It is assumed that a certain amount of groundwater infiltrations occur in the lower areas of the networks, dissolving pollutant content of the wastewater.

In 2006, the Pilot WSSP renovated some 19 km of pressure and gravity main sewers.

The existing sewerage gravity collection scheme is considered to be rather efficient and only interventions to the existing pumping equipment are subject to the Audit Report.

4.3 Wastewater Pumping

In total, there are three (3) wastewater PSs in use in Cahul Town. General data on installed wastewater pumps in use are presented in the following Table.

Table 4-2 Design parameters of the existing sewerage pumping equipment in Cahul

PS	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Operating	Year
					P	Voltage	Speed	cosϕ	In		
			m^3/h	m	kW	V	rpm		A	hrs /day	
South SPS	СД 50/12	2	50	12	7.5	380					
Local SPS	CM100-65-250/4	1				380					
Local SPS	CM125-80-315/4	1	80	32	7.5	380					
Local SPS	ФГ 144/46	3	140	46	7.5, 22	380	1450				
Main SPS	ФГ 144/46	2	140	46	37	380	1450				
Main SPS	FA 15.77 Z	2	221	50	65	380	1460	0.85	129		

4.4 Wastewater Treatment

The existing WWTP receives wastewater from the whole Town of Cahul, and is located some 1.5 km South of the town, left bank of the Prut River. The WWTP inlet is situated at the elevation of some 32 m a.s.l.

The WWTP is fed with wastewater from the Main SPS.

Treatment chain is designed for 13,700 m^3/day and consists of two stages, as follows:

1. Mechanical tretament stage, including
   - Inlet Chamber
   - Grit Removal
   - Primary Clarifiers – 8 units
2. Biological treatment stage:
   - Trickling filters – 3 units
   - Secondary clarifiers – 3 units
   - Sludge drying beds
   - Chlorination plant.

Currently, both mechanical and biological treatment steps are in use. However, a poor condition of existing infrastructure is of note.
The existing WWTP is considered to be in a working condition. However, according to the WB Feasibility Study "construction of new Cahul WWTP and continue of enlargement of the existing sewerage network could be considered as a most important medium-term investment in terms of renovation of sewerage system"[3]. In given circumstances, when there is no clear decision whether the

[3] Feasibility Study for Cahul, 2007. SWECO International AB, financed by the World Bank

existing WWTP shall be renovated or rebuilt, and the existing energy consumption is significantly high, the Consultant is of opinion that some urgent renovations are needed in short-term. Therefore, the existing WWTP is considered to be subject to this Audit Report.

Sewerage System Historical Energy Consumption

The following summary of sewerage facilities historical energy consumption for 2010 registered by Apa-Canal is provided in the Table below.

Table 4-3 *Sewerage system energy consumption in Cahul for 2010*

Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Main SPS	25.6	21.4	22.3	20	21.3	19.3	23.3	24	21.8	22.3	22	25.2
Local SPS	1	1	1.2	1.1	1	1.3	1	0.9	0.9	1.4	1.5	1.9
South SPS	0.4	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.4	0.3	0.3
WWTP	10.5	6	6.2	5.9	6.7	6.9	7	7.1	7.2	6.9	6.4	7.5

The energy consumption is shown in the Figure below:

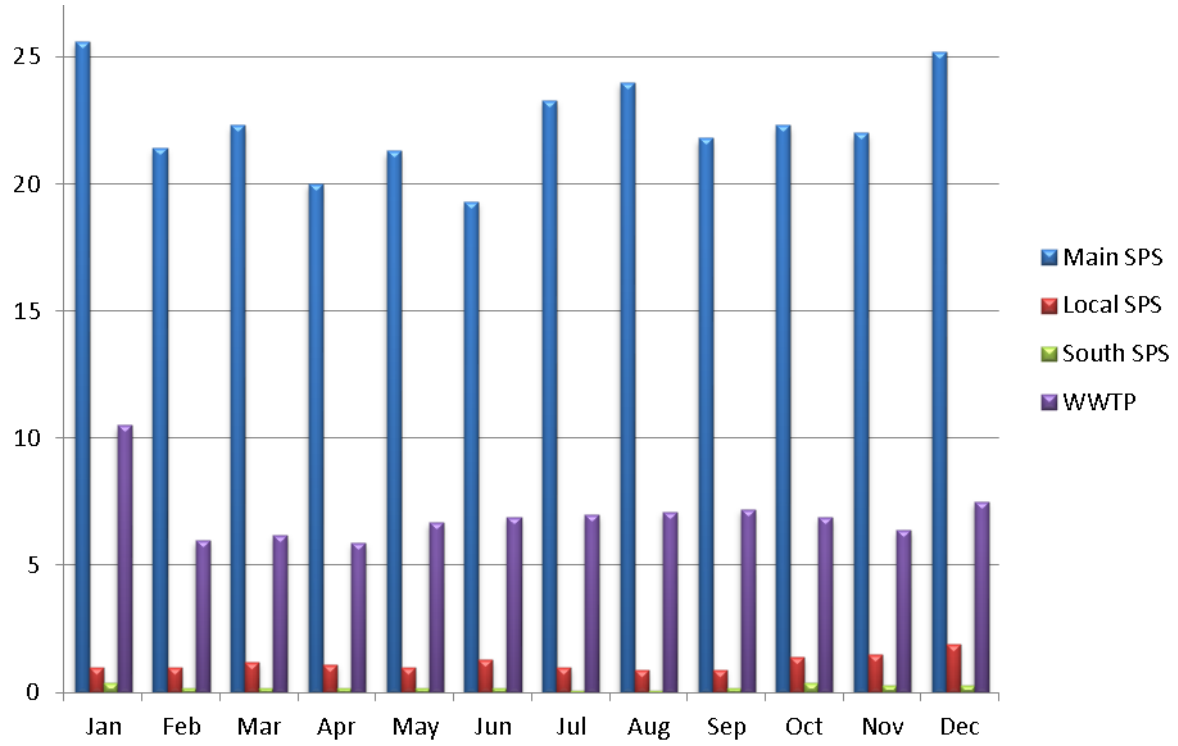

Figure 4-2 *Reported Energy Consumption for Sewerage Facilities for 2010*

As can be seen, the major energy consuming facility within sewerage operations is the Main SPS. This SPS is subject to further Energy Audit analysis.

5. OTHER FACILITIES

The following transformer stations are used for power supply of the WSS facilities.

Table 5-1 *Transformers used for WSS in Cahul*

Facility	Transformer	Operating
PS1	2 x 400 KVA	400KVA
PS2	560 + 630 KVA	630 KVA
PS3	250 + 160 KVA	250 KVA
PS4	250 + 40 KVA	40 KVA
PS5	40 + 160 KVA	40 KVA
Local SPS	25 + 160 KVA	25 KVA
Main SPS	160 + 400 KVA	160 KVA
WWTP	250 + 400 KVA	250 KVA

All existing transformer stations were renovated in order to comply with actual low power demands. As can be seen from the Table above, smaller transformers were installed by the old ones. Currently, the new transformers are in use, while the old ones are used as reserve.

New transformers are not considered to be subject to this Energy Audit.

6. SITE MEASUREMENTS

6.1 Methodology

In order to assess the operating efficiency of the existing water and waste water systems and their elements and to identify energy saving potential, a comprehensive site measurement campaign was organized by the Consultant. The measurement campaign was carried out in August – September 2011.

The Consultant has performed flow measurements at the Prut water source, all water and sewage pumping stations, as well as WWTP.

We have also carried out flow measurements of individual water and sewage pumps to register actual pump flow rate to evaluate actual performance of pumping equipment.

Energy consumption of individual pumps was measured in details by a power analyzer. Actual power, as well as reactive, apparent, power factor, voltages and current on each phase have been measured and registered.

The Consultant's team used pressure measurements equipment at individual pumps suction and pressure sides in order to evaluate actual performance of pumps and pressure piping.

Flow Measurement Sites

Flow measuring equipment was installed at the following sites:

- PS 1;
- RWTP inlet pipeline;
- PS 2 pipeline to city service area;
- PS 2 pipeline to PS 3;
- PS 3 service area 3,5 bar;
- PS 3 service area 7,2 bar;
- PS 4 pipeline to pressure service area;
- PS 5 pipeline to pressure service area;
- SPS district discharge pipeline;
- SPS Main discharge pipeline;
- WWTP sludge pumps

Flow measurements protocols are presented in the electronic external Appendix to this Report.

Pressure measurements sites

Electronic pressure transducers were installed at the following sites:

- PS 2 discharge pipe to city and PS 3 service area;

Pressure measurements protocol can be found in the electronic external Appendix to this Report.

Pressure manometers were installed at:

- SPS district discharge pipeline;
- SPS Main discharge pipeline;
- WWTP sludge pumps

Other pressure measurements have been done using existing pressure gauges.

Electrical power measurements sites

The power measurements were performed at the following sites:

- PS Prut;
- PS 1 pump no.4 ASP 200BS-75/4;
- PS 2 pump no.1 ASP 1250-75/4
- PS 2 pump no.2 ASP 1250-75/4
- PS 2 pump no.3 ASP 1250-75/4
- PS 3 Pump no.1 city NP 80/160
- PS 3 Pump no.2 city NP 80/160
- PS 3 Pump no.3 city NP 80/160
- PS 3 Pump no.2 Spirin NP 50/250V
- PS 3 Pump no.3 Spirin NP 50/250V
- PS 4 Pump no.1 COR3M VI 3204/CR
- PS 4 Pump no.2 COR3M VI 3204/CR
- PS 4 Pump no.3 COR3M VI 3204/CR
- PS 5 Pump no.1 2 kM-6
- PS 5 Pump no.2 2 kM-6
- SPS district pump FG 144/46
- SPS Main pump FA 15.77 Z
- WWTP sludge pump no.6
- WWTP sludge pump no.7

Detailed power characteristic of each measurement point contains:

- frequency,
- phase voltage on each phase,
- linear voltage on each phase,
- current of each phase,
- active power consumption for each phase and all phases,
- reactive power consumption for each phase and all phases
- apparent power consumption for each phase and all phases
- power factor of each phase and all phases
- displacement factor or cos φ of each phase and all phases.

Power measurements protocols can be found in the electronic external Appendix to this Report.

Equipment used for site measurements

Power analyzer	**Qualistar CA 8334 (Chauvin-Arnoux)**
Portable flow meter	**Prosonic Flow 93T (Endress + Hausser)**
Fixed-installation flow meter big size	**DigitalFlow DF868 (GE Measurement&Control Solutions)**
Pressure transducer	**Cerabar T PMP 131 (Endress + Hausser)**
Data storage	**Memorgaph M RSG40 (Endress + Hausser)**

Non-contact infrared thermometer	**OS562 (Omega Engineering)**
Leak detection correlator	**LC – 2500 (Fuji Tecom)**
Acoustic leak detector	**DNR – 18 (Fuji Tecom)**
Pipe locator	**SR – 20 (Seek Tech)**

All equipment used complies with the accuracy requirements and international technical standards.

6.2 Site measurement and analyses

Flow measurements at PS 1 – trunk main to RWTP

The measurements at the outlet pipeline of PS 1 were performed on September 07, 2011. In parallel flow measurements at the inlet pipeline of RWTP have been done in order to determine losses in the trunk main. Below graph illustrates the flow difference between the outlet PS 1 and inlet RWTP:

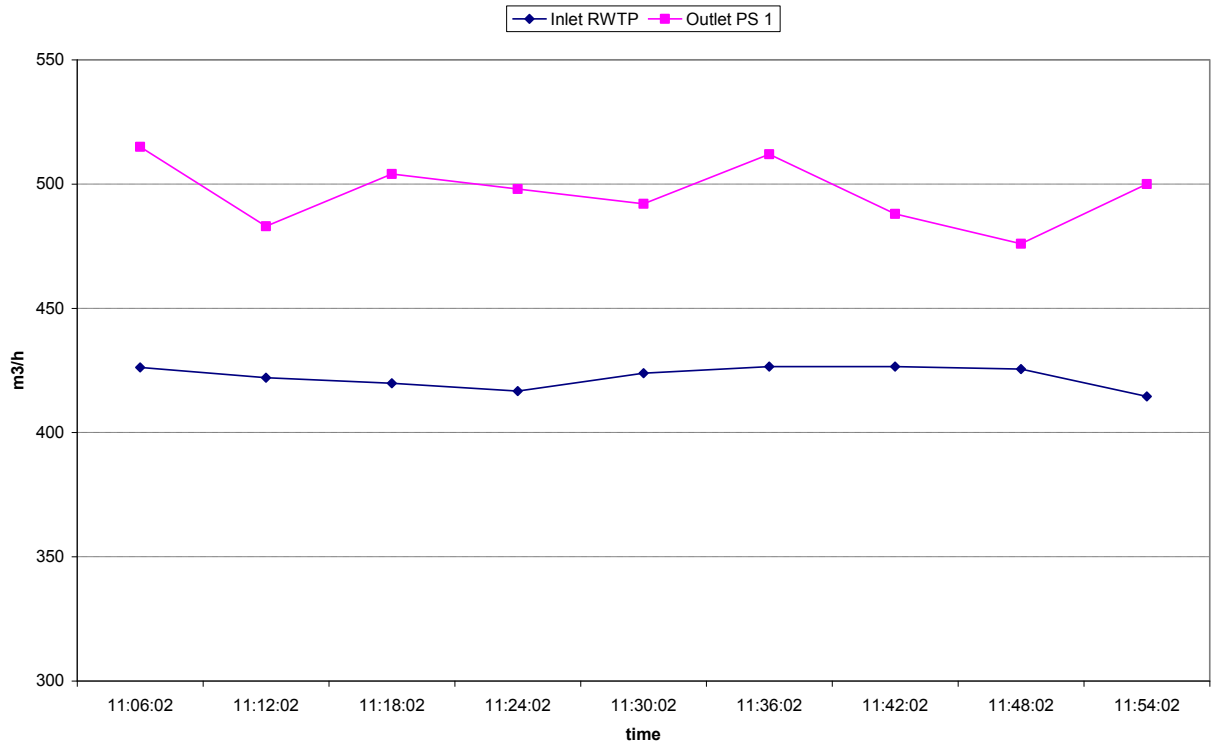

Figure 6-1 *Flow measurements at PS 1 – trunk main to RWTP*

The average water loss in the trunk main is 74 m^3/h:

Table 6-1 *Flow measurements at PS1*

Time	RWTP inlet	PS 1 outlet	Loss, m3/h	Average loss, m3/h
11:06:02	426.2	515	88.8	**74**
11:12:02	422.1	483	60.9	
11:18:02	419.8	504	84.2	
11:24:02	416.7	498	81.3	

11:30:02	423.9	492	68.1
11:36:02	426.5	512	85.5
11:42:02	426.5	488	61.5
11:48:02	425.5	476	50.5
11:54:02	414.5	500	85.5

Such a high water loss in the trunk main multiplied by 12 pumping hours of PS 1 gives approx. 900 m^3/day. During pump stoppage 15 m^3/h is wasted (see below graph), what is equal to 180 m^3/day.

We estimate that more than **1,000 m^3/d** is wasted between PS 1 and RWTP.

We strongly recommend fixing leaks on the trunk main. Due to the complexity of works on reinforced concrete pipes we do not propose ECMs for this particular case.

Flow measurements at RWTP inlet

The long term measurements at the inlet pipeline started September 06, at 18:00 and finished September 07 at 18:36. Time interval between instant flow readings – 6 minutes. Below graph illustrates the daily flow pattern of inlet flow at RWTP:

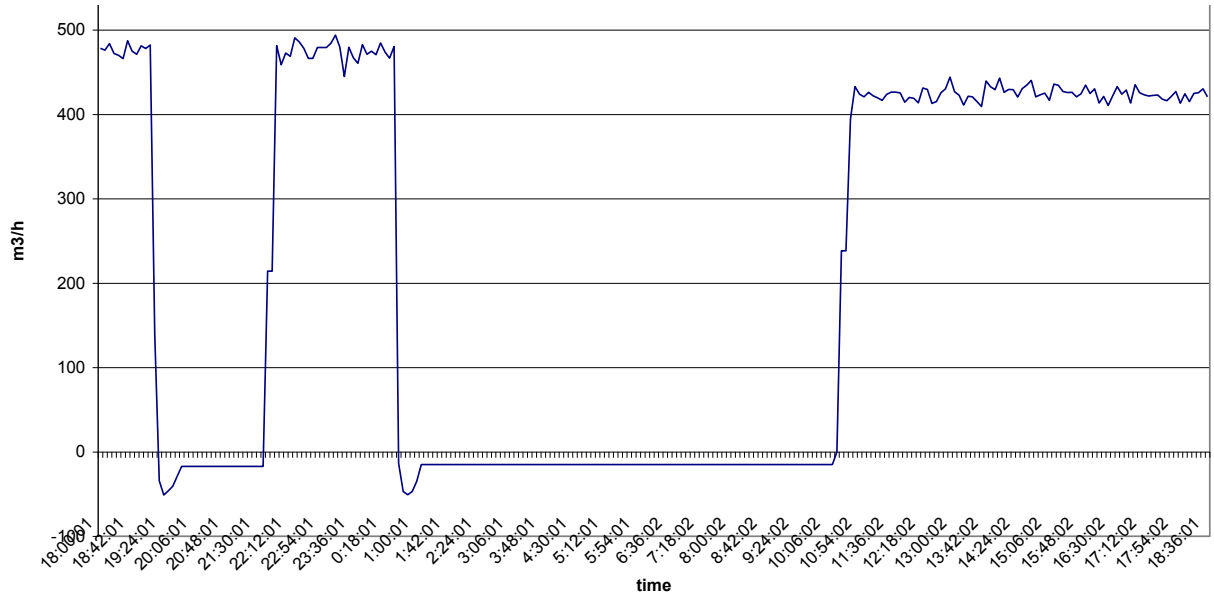

Figure 6-2 *Flow measurements at RWTP inlet*

Normally pumps at PS 1 are stopped during the night in order to keep water balance at RWTP. The backflow also proves that trunk main between PS 1 and RWTP is leaking.

Flow measurements at PS 2 – city

The measurements at the outlet pipeline DN300 at PS 2 started September 06 18:00 and finished September 07 18:00. Time interval between instant flow readings – 6 minutes. Below graph illustrates the flow pattern into city distribution network:

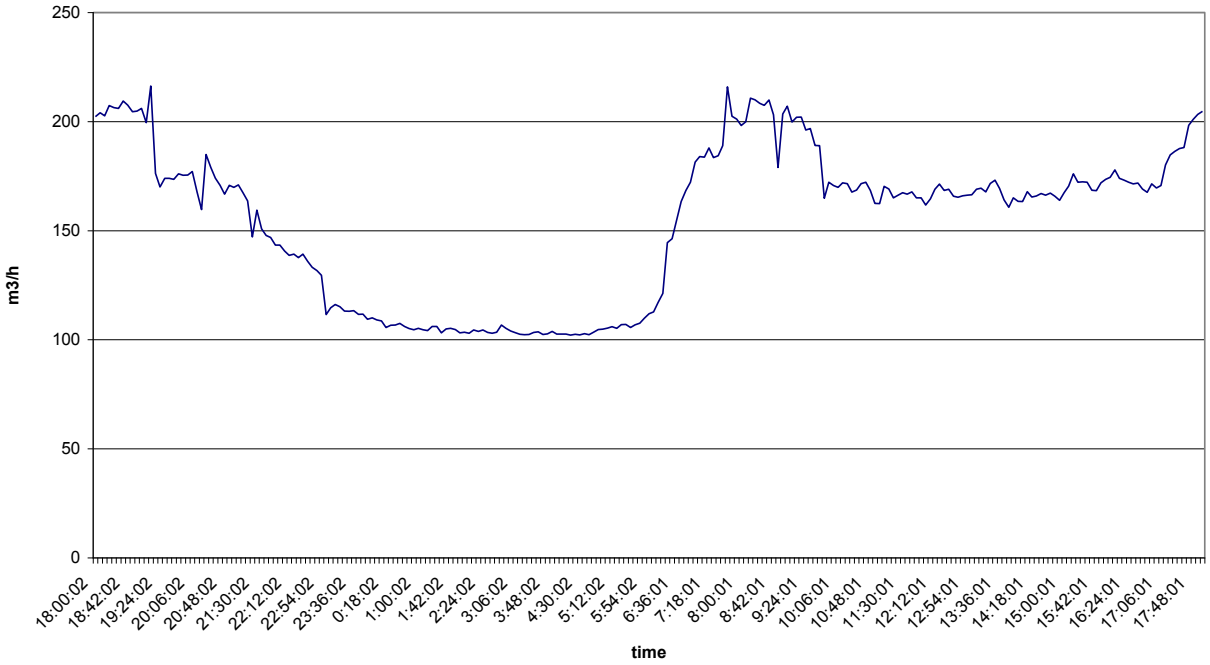

Figure 6-3 *Flow measurements at PS 2 – city*

The maximum consumption peak is around 200 m3/h. Night flow is around 100 m3/h.

Flow measurements at PS 2 – PS 3

The measurements at the outlet pipeline DN300 from PS 2 to PS 3 started September 06 18:00 and finished September 07 18:00 in parallel with previous measurements. Time interval between instant flow readings – 6 minutes. Below graph illustrates the flow pattern of the trunk main:

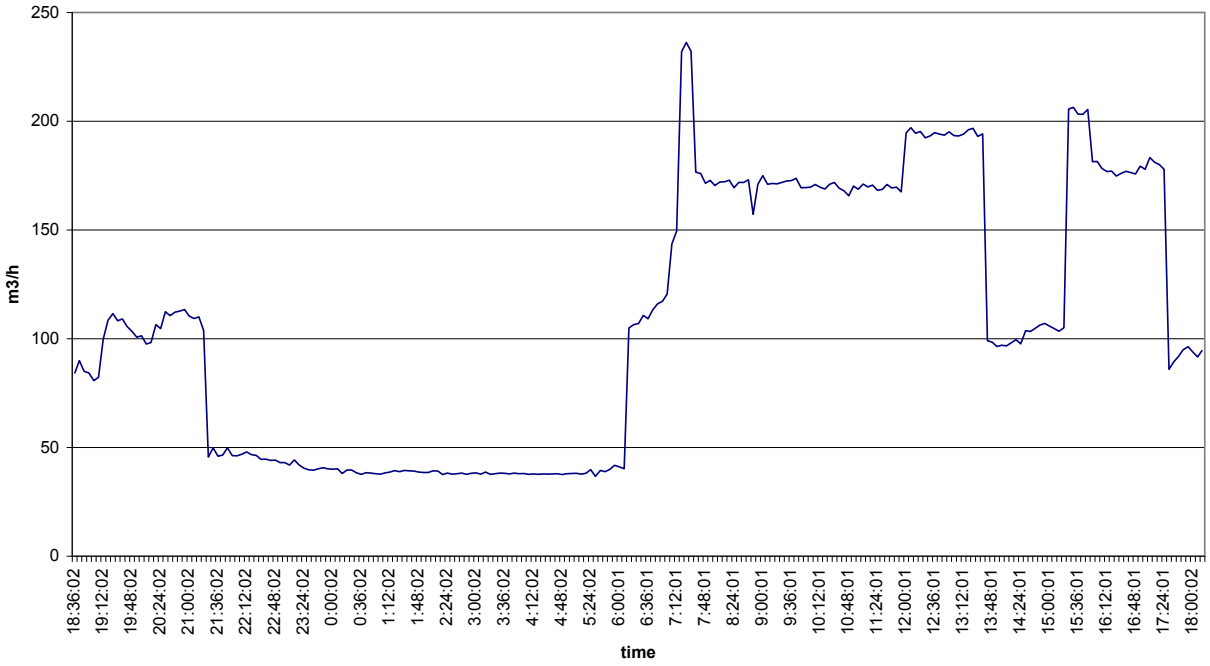

Figure 6-4 *Flow measurements at PS 2 – PS 3*

Flow peaks show intervals of reservoir filling at PS 3. Night flow is approx. 40 m3/h. High flows during the day when inlet valve of reservoir at PS 3 was closed indicate on connection of trunk main PS 2 – PS 3 and PS 2 pressure supply area.

Water balance at RWTP

We compared inlet and outlet flow at RWTP during the period of 6.5 hours in order to determine the water balance of treatment facilities:

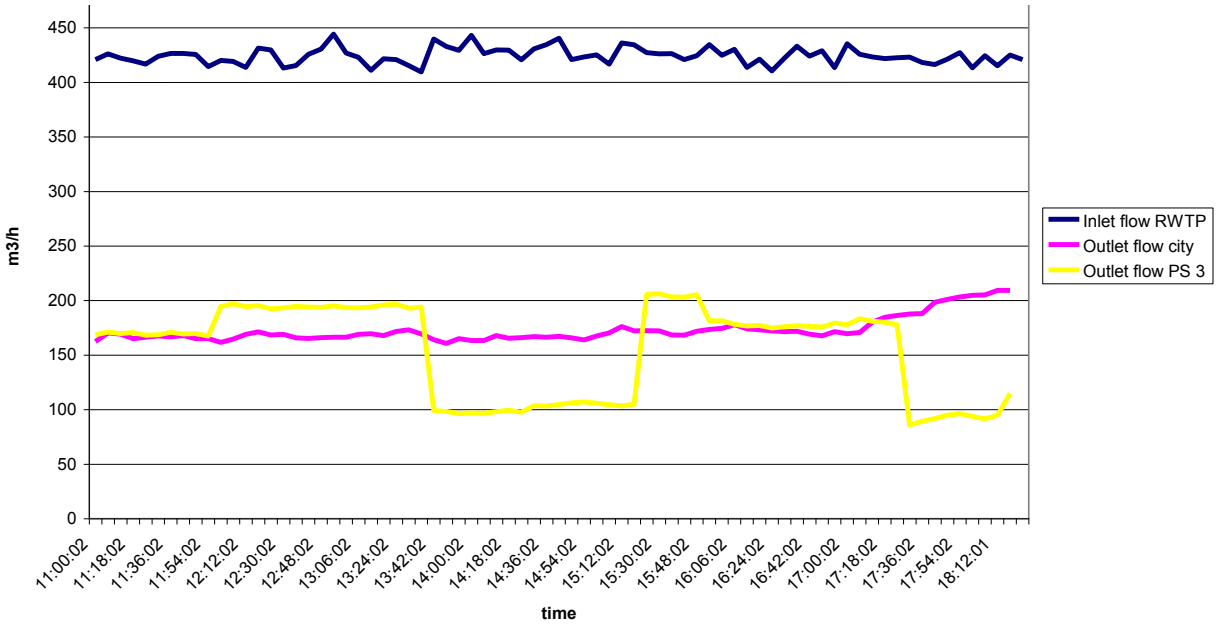

Figure 6-5 *Water balance at RWTP*

The incoming flow is significantly bigger than outflow of treated water. Apa Canal staff stops pumps at PS 1 during the night to reduce the raw water inlet to RWTP.

RWTP inlet		**3,091**
City outlet	m3	**1,262**
PS 3 outlet		**1,128**
Total outlet		**2,390**
Flow difference after 6.5 hours, m^3		**701**

We registered also amount of water for filters backwash. Normally filters backwash is being carried out during the night. For backwashing of 4 working filters it is used 521 m3 of clean water from collection reservoirs. The backwash water is discharged to the local sewage. In original design it was intended to recycle backwash water after settling of sediments in horizontal clarifiers. After erection of treatment facilities clarifiers were constructed lower than anticipated in the design. Therefore backwash water is not recycled since the beginning of RWTP operation.

Our study do not propose any solutions for backwash water recycle, since final decision on reconstruction of existing treatment works is not done.

Flow measurements at PS 3 – service area 3.5 bar

The measurements at the pressure pipeline of service area (District 15) started September 07 20:00 and finished September 12 16:24. Time interval between instant flow readings – 6 minutes. Below graph illustrates the flow pattern into the pressure network:

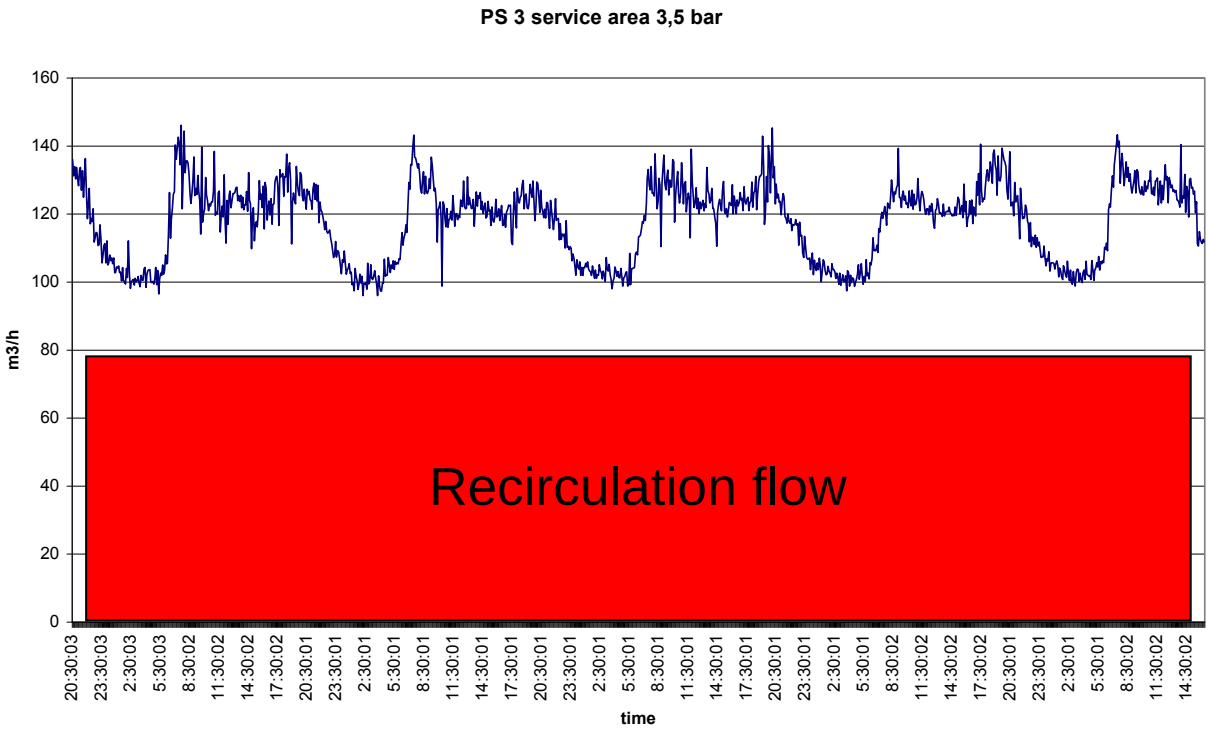

Figure 6-6 *Flow measurements at PS 3 – service area 3.5 bar*

The extremely high night flow indicates on recirculation of water between PS 3 supply area and PS 2 supply area. We consider the minimum amount of recirculated water around 80 m^3/h.

Flow measurements at PS 3 – service area 7.2 bar

The measurements at the pressure pipeline of service area (Spirin) started September 07 20:00 and finished September 12 15:54 in parallel with previous measurements. Time interval between instant flow readings – 6 minutes. Below graph illustrates the flow pattern into the pressure network:

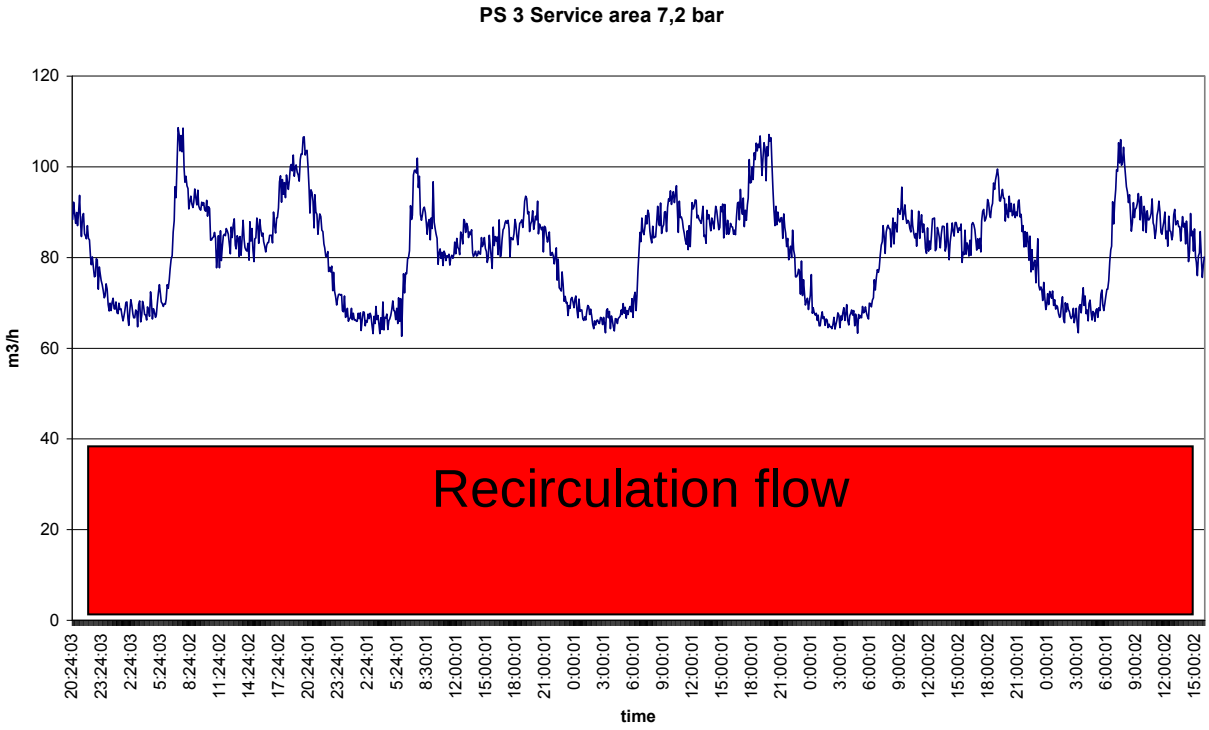

Figure 6-7 *Flow measurements at PS 3 – service area 7.2 bar*

We consider that this service area is also connected to recirculation contour, as very high night flow cannot be treated as leakage in relatively small area of water supply. Approximate amount of the recirculated water is 40 m^3/h.

Since PS 3 high pressure water distribution network and low pressure network supplied from PS 2 are located with central part of the city, we anticipate several interconnections between these two zones. As low pressure piping is connected to the inlet reservoir of PS 3, water recirculation chain is constantly running:

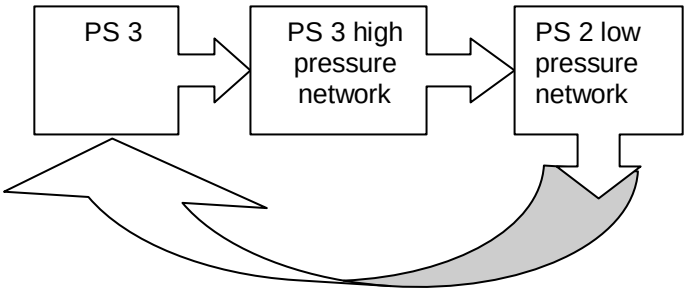

Figure 6-8 *Expected water recirculation at the PS3*

Below graph confirms that two areas of supply are interconnected:

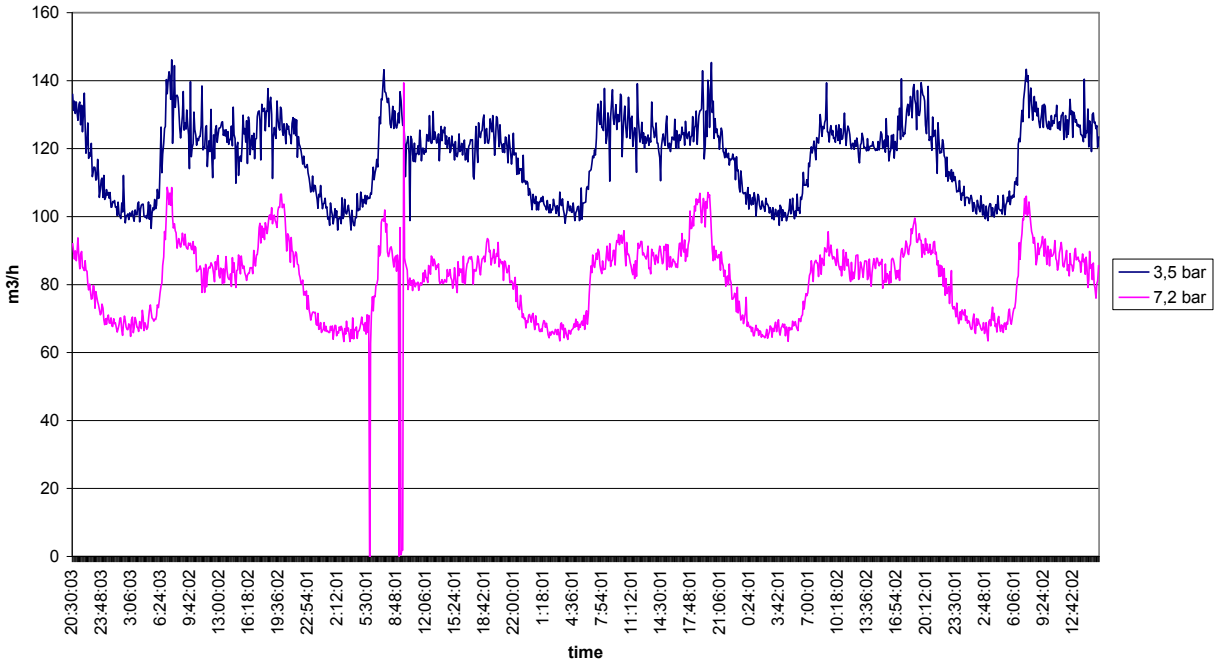

Figure 6-9 *Measured PS3 Flow Pattern*

Flow pattern of 3.5 bar supply area is identical to the flow pattern of 7.2 bar supply area.

Flow measurements at PS 4

The measurements were started on September 12 17:37 and finished on September 13 17:37. Time interval between instant flow readings – 1 minute. Below graph illustrates the flow pattern into the pressure network of PS 4:

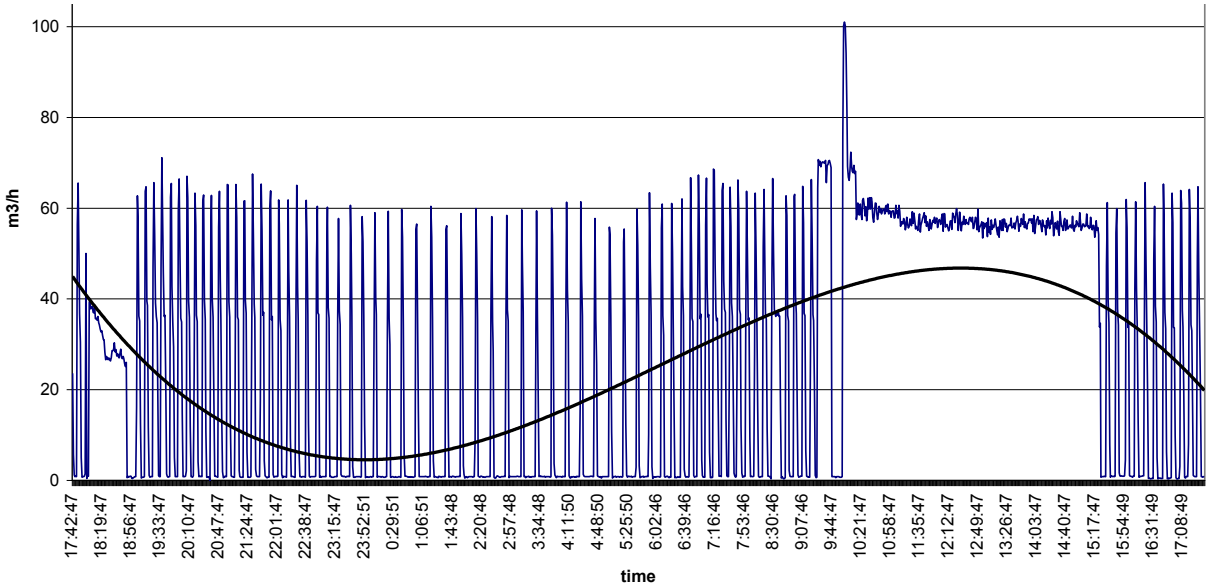

Figure 6-10 *Flow Measurements at the PS4*

Operating regime of PS 4 is “start – stop” and average daily flow is only 26 m3/h. Trend line illustrates the average flow pattern.

Measurements of operating parameters of pumping equipment

The summary table of design and actual operating parameters of the existing pumping equipment:

Table 6-2 *Design and measured actual operating parameters of the existing pumping equipment*

		PS 1		PS 2	
Design parameters	**Units**	**Pump 4**	**Pump 1**	**Pump 2**	**Pump 3**
Pump type		ASP 200BS-75/4	ASP 1250-75/4	ASP 1250-75/4	ASP 1250-75/4
Flow	m^3/h	480	320	320	320
Head	m	40	60	60	60
Impeller diameter	mm				
Shaft power	kW				
Pump Efficiency %	%				
Motor type					
Rated power	kW	75	75	75	75
Nominal voltage	V	380	380	380	380
Nominal current	A	134	134	134	134
Rotation Speed	rpm	1,480	1,480	1,480	1,480
Cos ϕ		0.9	0.9	0.9	0.9
Motor Efficiency %	%				
Measured parameters pump					
Actual flow	m^3/h	496.44	282	275	274
Suction pressure/dynamic level	m	2	0	0	0
Discharge pressure	m	34	53	52	51
Actual pump head	m	32	53	52	51
Active power consumption	kW	39.21	29.21	32.44	32.05
Reactive power consumption	kVAr	7.14	-7.07	4.16	4.53
Apparent power	VA	39.95	37.75	32.89	32.53
Power factor		0.98	0.78	0.98	0.98
Calculated pumping efficiency					
Hydraulic power	kW	43.26	40.70	38.94	38.06
Overall pumping efficiency	%	1.10*	1.39*	1.20*	1.19*
Pump Efficiency	%				
Specific power consumption	kW/m^3	0.08	0.10	0.12	0.12

* Efficiencies higher than one indicate on wrongly taken measurements.

Table 6-3 *Design and measured actual operating parameters of the existing pumping equipment*

Design parameters	Units	Pump 1 city	Pump 2 city	PS 3 Pump 3 city	Pump 2 Spirin	Pump 3 Spirin
Pump type		NP 80/160	NP 80/160	NP 80/160	NP 50/250V	NP 50/250V
Flow	m^3/h	112	112	112	75	75
Head	m	35	35	35	72	72
Impeller diameter	mm					
Shaft power	kW					
Pump Efficiency %	%					
Motor type						
Rated power	kW	15	15	15	22	22
Nominal voltage	V	380	380	380	380	380
Nominal current	A	26.5	26.5	26.5	38.1	38.1
Rotation Speed	rpm	2910	2910	2910	2940	2940
Cos ϕ		0.9	0.9	0.9	0.91	0.91
Motor Efficiency %	%					
Measured parameters pump						
Actual flow	m^3/h	111	112.5	112	79.55	80.3
Suction pressure/dynamic level	m	0	0	0	0	0
Discharge pressure	m	35	35	35	72	72
Actual pump head	m	35	35	35	72	72
Active power consumption	kW	16.38	17.12	16.79	25.26	26.06
Reactive power consumption	kVAr	6.26	6.92	6.56	11.05	11.42
Apparent power	VA	17.55	18.5	18.06	27.62	28.5
Power factor		0.93	0.92	0.93	0.91	0.91
Calculated pumping efficiency						
Hydraulic power	kW	10.58	10.72	10.68	15.60	15.75
Overall pumping efficiency	%	0.65	0.63	0.64	0.62	0.60
Pump Efficiency	%					
Specific power consumption	kW/m^3	0.15	0.15	0.15	0.32	0.32

Table 6-4 *Design and measured actual operating parameters of the existing pumping equipment*

			PS 4		PS 5	
Design parameters	**Units**	**Pump 1**	**Pump 2**	**Pump 3**	**Pump 1**	**Pump 2**
Pump type		COR3-MVI3204/CR	COR3-MVI3204/CR	COR3-MVI3204/CR	2 KM-6	2 KM-6
Flow	m^3/h	37.5	37.5	37.5	20	20
Head	m	50	50	50	22	22
Impeller diameter	mm					
Shaft power	kW					
Pump Efficiency %	%					
Motor type						
Rated power	kW	7.5	7.5	7.5	3.5	3.5
Nominal voltage	V	380	380	380	380	380
Nominal current	A					
Rotation Speed	rpm	1480	1480	1480		
Cos ϕ		0.9	0.9	0.9		
Motor Efficiency %	%					
Measured parameters pump						
Actual flow	m^3/h	37.21	26.83	27.5	4.92	4.4
Suction pressure/dynamic level	m	0	0	0	0	0
Discharge pressure	m	48	56	56	40	40
Actual pump head	m	48	56	56	40	40
Active power consumption	kW	8.18	7.85	7.47	3.87	4.66
Reactive power consumption	kVAr	5.13	5.03	5.06	3.15	2.55
Apparent power	VA	9.69	9.14	9.06	5	5.41
Power factor		0.84	0.83	0.82	0.77	0.88
Calculated pumping efficiency						
Hydraulic power	kW	4.86	4.09	4.19	0.54	0.48
Overall pumping efficiency	%	0.59	0.52	0.56	0.14	0.10
Pump Efficiency	%					
Specific power consumption	kW/m^3	0.22	0.29	0.27	0.79	1.06

Table 6-5 *Design and measured actual operating parameters of the existing pumping equipment*

		SPS distr	SPS Main				WWTP	
Design parameters	**Units**	**Pump 3**	**Pump 1**	**Pump 2**	**Pump 3**	**Pump 4**	**Pump 6 sludge**	**Pump 7 sludge**
Pump type			FG 144/46	FG 144/46	FA 15.77Z	FA 15.77Z	CD 250/22.5	CD 250/22.5
Flow	m^3/h		140	140	221	221	250	250
Head	m		46	46	55.5	55.5	22.5	22.5
Impeller diameter	mm							
Shaft power	kW							
Pump Efficiency %	%							
Motor type								
Rated power	kW		37	37	65	65		
Nominal voltage	V	380	380	380	380	380	380	380
Nominal current	A							
Rotation Speed	rpm							
Cos ϕ								
Motor Efficiency %	%							
Measured parameters pump								
Actual flow	m^3/h	138	117	115	270	270	128	93
Suction pressure	m	1	1	1	1	1	1	1
Discharge pressure	m	35	48	50	50	50	13	13
Actual pump head	m	34	47	49	49	49	12	12
Active power consumption	kW	25.81	38.24	37.51	71.02	68.98	18.96	10.74
Reactive power consumption	kVAr	15.1	24.62	22.5	46.85	47.57	11.82	5.98
Apparent power	VA	29.92	45.52	43.82	85.13	83.84	22.37	12.28
Power factor		0.86	0.84	0.85	0.83	0.82	0.85	0.88
Calculated pumping efficiency								
Hydraulic power	kW	12.78	14.98	15.35	36.03	36.03	4.18	3.04
Overall pumping efficiency	%	0.50	0.39	0.41	0.51	0.52	0.22	0.28
Pump Efficiency	%							
Specific power consumption	kW/m^3	0.19	0.33	0.33	0.26	0.26	0.15	0.12

7. PROPOSED ENERGY CONSERVATION MEASURES

7.1 Proposed ECM1 – Hydraulic optimization of PS 3 city pumping zone

Present situation

PS 3 presently operates to a large extend for recirculation of water between high pressure and low pressure areas of supply.

Proposed Improvement

In order to avoid recirculation of water in the future we propose to merge high and low pressure zones into one of low pressure sufficient to lift water to the 5 story blocks. Blocks of 9 stories shall be equipped with individual pumping installations to deliver water to the upper apartments.

Separate Costache-Negruzzi district will be supplied from PS 3 by booster pump set of three pumps in order to maintain all possible hydraulic regimes (analogue GHV30/15SV03F030T) with the following parameters:

Rated flow = 30 m^3/h

Rated head = 35 m

Motor rated power = 3 x 3 kW

Actual power at duty point = 2 x 3 kW

Pump set shall be equipped with frequency converter (for each pump) to maintain the minimum required pressure in the system at various water demands during the day and night.

Estimation of investment cost

Table 7-1 *Estimation of Investment Costs*

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
	Mechanical				
1	Pumping booster set of 3 pumps Q=30 m3/h H=35 m	set	1	12,000	12,000
2	Piping and fittings	set	1	800	800
3	Gate valve DN100	psc	2	150	300
4	Gate valve DN80	psc	2	100	200
5	Check valve DN100	psc	2	200	400
6	Pressure gauge mechanical	psc	1	100	100
	Electrical				
7	Control panel + Frequency converter (Included in item 1)	psc			
8	Earthing and cable connection	set	1	1,000	1,000
	Auxillary				
9	Installation	Lump sum			1,000
10	Tools	set	1	200	200
11	Consumables	set	1	150	150

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
12	Mandatory spare parts	set	1	200	200
13	O&M manuals	set	1	100	100
	Grand total EUR				**16,450**
	Grand total MDL				**271,425**

We propose to install in each 9 story block along Stefan cel Mare street (in total 11 blocks) the new boosting pump Q = 3 m^3/h, H = 20 m (analogue BLOCK BGM 7/A) with rated motor power of 0.775 kW.

Estimation of investment cost

Table 7-2 *Estimation of Investment Costs*

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
	Mechanical				
1	Boosting pump set Q=3 m3/h H=20 m with hydrophore	psc	11	320	3,520
2	Piping, fittings and connection to the block plumbing	set	11	500	5,500
3	Ball valve DN50	psc	22	40	220
	Electrical				
4	Electrical connection to the internal block grid, power meter	set	11	400	440
5	Earthing	set	11	100	1,100
	Auxillary				
6	Installation	Lump sum	11	300	3,300
7	Mandatory spare parts	set	11	100	1,100
8	O&M manuals	set	1	100	100
	Grand total EUR				**19,900**
	Grand total MDL				**328,350**

7.2 Proposed ECM2 – Hydraulic optimization of PS 3 Spirin pumping zone

Present situation

Spirin district presently supplied by group of pumps 7.2 bar shall be disconnected from the low pressure network in order to stop recirculation.

Such high pumping pressure of 7.2 bar is needed to deliver enough pumping head to two 9 story blocks located on Spirin street.

Proposed Improvement

We propose to reduce pumping head and flow of Spirin pumping group to meet actual demand requirements without recirculation and head requirements to lift water to 5 story blocks at Spirin district. New booster pump set of two pumps in order to maintain all possible hydraulic regimes (analogue GHV20/33SV3G075T) with the following parameters:

Rated flow = 60 m^3/h

Rated head = 55 m

Motor rated power = 2 x 7.5 kW

Actual power at duty point = 13.6 kW

Pump set shall be equipped with frequency converter to maintain the minimum required pressure in the system at various water demands during the day and night.

Two 9 story blocks will be equipped with separate boosting pumping sets Q = 3 m^3/h, H = 20 m (analogue BLOCK BGM 7/A) with rated motor power of 0.775 kW.

Estimation of investment cost

Table 7-3 *Estimation of Investment Costs*

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
	Mechanical				
1	Pumping booster set of 2 pumps Q=60 m3/h H=55 m	set	1	16,000	16,000
2	Piping and fittings	set	1	800	800
3	Gate valve DN100	psc	3	150	450
4	Gate valve DN150	psc	3	200	600
5	Check valve DN100	psc	2	200	600
6	Pressure gauge mechanical	psc	1	100	100
	Electrical				
7	Control panel + Frequency converter (Included in item 1)	psc			
8	Earthing and cable connection	set	1	1,000	1,000
	Auxillary				
9	Installation	Lump sum			2,000
10	Tools	set	1	200	200
11	Consumables	set	1	150	150
12	Mandatory spare parts	set	1	200	200
13	O&M manuals	set	1	100	100
	Grand total EUR				**22,200**
	Grand total MDL				**366,300**
Boosting sets for two 9 story blocks					
	Mechanical				
1	Boosting pump set Q=3 m3/h H=20 m with hydrophore	psc	2	320	640
2	Piping, fittings and connection to the block plumbing	set	2	500	1,000
3	Ball valve DN50	psc	4	40	160
	Electrical				
4	Electrical connection to the internal block grid, power meter	set	2	400	800
5	Earthing	set	2	100	200
	Auxillary				
6	Installation	Lump	2	300	600

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
		sum			
7	Mandatory spare parts	set	2	100	200
8	O&M manuals	set	1	100	100
	Grand total EUR				**3,700**
	Grand total MDL				**61,050**

7.3 Proposed ECM3 – Installation of new pump at PS 5

Present situation

PS 5 presently supplies water to three adjacent nine story blocks. Initially pumping station was designed to serve new district of Cahul, which was not built. Existing pumping equipment is oversized and inefficient.

Efficiency of two existing pumps 2 KM-6 is 14% and 10%.

Proposed Improvement

We propose to install new pump, which will fit actual water demand and pumping head requirements (analogue 5 SV04F005T) with the following parameters:

Rated flow = 5 m^3/h

Rated head = 22 m

Motor rated power = 0.6 kW

Actual power at duty point = 0.492 kW

Estimation of investment cost

Table 7-4 *Estimation of Investment Costs*

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
	Mechanical				
1	Boosting pump Q=5 m^3/h H=22 m with hydrophore	psc	1	1,000	1,000
2	Piping, fittings and connection to the block plumbing	set	1	200	200
3	Ball valve DN50	psc	2	40	80
	Electrical				
4	Control panel (incl. in item 1)	set			
5	Earthing	set	1	100	100
	Auxillary				
6	Installation	Lump sum	1	300	300
7	Mandatory spare parts	set	1	100	100
8	O&M manuals	set	1	100	100
	Grand total EUR				**1,880**
	Grand total MDL				**31,020**

7.4 Proposed ECM4 – Installation of new sludge pump at WWTP

Present situation

Our measurements showed that existing sludge pumps are very inefficient. Efficiency of two existing pumps is 22% and 28%.

Proposed Improvement

We propose to install new sludge pump (analogue SE1.80.80.55.4.51D) with the following parameters:

Rated flow = 100 m^3/h

Rated head = 13 m

Motor rated power = 6.5 kW

Actual power at duty point = 5.5 kW

Estimation of investment cost

Table 7-5 *Estimation of Investment Costs*

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
	Mechanical				
1	Horizontal dry installation sludge pump Q=100 m3/h H=13 m	set	1	7,000	7,000
2	Piping and fittings	set	1	800	800
3	Gate valve DN150	psc	1	200	200
4	Gate valve DN100	psc	1	150	150
5	Check valve DN150	psc	1	300	300
	Electrical				
7	Pump control panel	psc	1	2,000	2,000
8	Cables and earthing	set	1	1,000	1,000
	Auxillary				
9	Installation	Lump sum			1,000
10	Tools	set	1	200	200
11	Consumables	set	1	200	200
12	Mandatory spare parts	set	1	300	300
13	O&M manuals	set	1	100	100
	Grand total EUR				**13,250**
	Grand total MDL				**218,625**

7.5 Economic Assessment of the Proposed ECMs.

Current Energy Consumption - before Improvements

Table 7-6 *Current Energy Consumption - before Improvements*

No	Site	Pump type	Before: Rated power, kW	Actual power, kW	Working hours per day	Energy used, kWh/year	Overall energy used, kWh/year
1	PS 3 city	NP 80/160	15	16.38	20	109,500.00	**197,100.00**
		NP 80/160	15	17.12	8	43,800.00	
		NP 80/160	15	16.79	8	43,800.00	
2	PS 3 spirin	NP 50/250	22	25.26	12	110,638.80	**224,781.60**
		NP 50/250	22	26.06	12	114,142.80	
3	PS 5	2 KM-6	3.5	3.87	24	33,901.20	
4	WWTP	CD 250/22.5		19	4	27,740.00	

Estimated Energy Consumption - after Improvements

Table 7-7 *Current Energy Consumption - after Improvements*

No	Site	After: Pump type (analogue)	Rated power, kW	Actual power, kW	Working hours per day	Energy used, kWh/year	Overall energy used, kWh/year
1	PS 3 city	BLOCK BGM 7/A (11 seturi)	8.525	8.525	16	49,786.00	**102,346.00**
		GHV30/15SV03F030T	3x3	6	24	52,560.00	
2	PS 3 spirin	GHV20/33SV3G075T	2x7.5	13.6	24	119,136.00	**132,714.00**
		BLOCK BGM 7/A (2 seturi)	1.55	1.55	24	13,578.00	
3	PS 5	5 SV04F005T	0.6	0.492	24	4,309.92	
4	WWTP	SE1.80.80.55.4.51D	6.5	5.5	4	8,030	

Estimated Energy Savings and simple payback period

Table 7-8 *Estimated Energy Savings and simple payback period*

ECM	Site	ECM effect: Energy savings, kWh/year	Tariff rate, MDL/kWh	Cost savings, MDL/year	Invesment cost, MDL	Payback period, years
1	PS 3 city	94,754.00	1.8	170,557	599,775	**3.5**
2	PS 3 spirin	92,067.60	1.8	165,721	427,350	**2.6**
3	PS 5	29,591.28	1.8	53,264	31,020	**0.6**
4	WWTP	19,710.00	1.8	35,478	218,625	**6.2**

7.6 Proposed ECM5 – Hydro-turbine at WWTP

Apa-Canal Cahul proposed to install one inline hydro-turbine on the treated water discharge pipe at WWTP.
Initial data:

- Pipe diameter 500 mm
- Pipe length between WWTP and Prut river 4 km
- Waste water flow 30 l/s
- Elevation difference 22 m

Hydro-turbines convert water force into mechanical shaft power, which can be used to drive an electricity generator, and further sludge recirculation pumps or other equipment.

The power available is proportional to the product of head and flow rate.

The general formula for any hydro system's power output is:

$P = \eta \cdot \rho \cdot g \cdot Q \cdot H$

Where:

- P is the mechanical power produced at the turbine shaft (Watts),
- η is the hydraulic efficiency of the turbine,
- ρ is the density of water (1000 kg/m^3),
- g is the acceleration due to gravity (9.81 m/s^2),
- Q is the volume flow rate passing through the turbine (m^3/s),
- H is the effective pressure head of water across the turbine (m).

For specified conditions available power output of inline hydro-turbine:

P = 0.7 x 1000 x 9.81 x 0.03 x 22 = 4532 W or **4.5 kW**

Estimation of investment cost

Table 7-9 *Estimation of Investment Costs*

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
	Mechanical				
1	Hydro-turbine generator set 5 kW 25 m head	set	1	20,000	20,000
2	Piping and fittings for connection DN500	set	1	800	800
	Electrical				
3	Control board	set	1	1,400	1,400
4	Cable and power line	Lump sum			2,000
	Auxillary				
5	Installation, setting and running-in	Lump sum			5,000
6	Construction of concrete chamber	Lump sum			5,000
7	O&M manuals	set	1	200	200
	Grand total EUR				**34,400**
	Grand total MDL				**567,600**

Simple payback period estimation:

- Operation time 20 hours/day
- Yearly power production 32,850 kWh
- Yearly cost of power produced (1.8 MDL for 1 kWh) 59,000 MDL

Payback period	**= 9.6 years**

7.7 Summary Proposed ECM

Table 7-10 *Summary Proposed ECMs*

ECM description	Annual energy savings, kWh	Annual energy savings, MDL	Capital investment cost, MDL	Simple payback period, years	Ranking
Hydraulic optimization of PS 3 city pumping zone	94,754	170,557	599,775	3.5	**3**
Hydraulic optimization of PS 3 Spirin pumping zone	92,067	165,721	427,350	2.6	**2**
Installation of new pump at PS 5	29,591	53,264	31,020	0.6	**1**
Installation of new sludge pump at WWTP	19,710	35,478	218,625	6.2	**4**
Hydro-turbine at WWTP	32,850	59,000	567,600	9.6	**5**

7.8 Summary reduction in Energy Consumption

The average reductions in energy consumption for each site were estimated in previous Sections. A summary is given in the table below.

Table 7-11 *Summary reduction in Energy Consumption*

Site	Estimated average yearly power demand (in kWh)	
	Before improvement	After improvement
PS 3 city	197,100	**102,346**
PS 3 Spirin	224,782	**132,714**
PS 5	33,901	**4,310**
WWTP	84,300	**31,740**
Total power consumption	540,083	**271,110**
Saving in kWh	**268,973**	
Overall saving in percent	**50%**	
Estimated savings of overall Apa-Canal power consumption (data of 2010 year 2,000,000 kWh)	**13%**	

7.9 Analysis of the Energy Saving Measures proposed by Apa-Canal and Recommendations

In the inception phase Apa Canal Cahul submitted to the Consultant a list of ECM proposed to be implemented within EMP:

Description	Existing equipment	Needed equipment	Estimated capital costs, USD	Expected yearly energy saving, kW	Expected yearly cost of saved energy, MDL
WWTP replacement of oversized transformer	1 transformer 250 kVA 10/0.4 kV 1 transformer 400 kVA 10/0.4 kV	2 transformers 100 kVA 10/0.4 kV	8,528	8,400	11,088
WWTP replacement of pumps at recirculation pumping station	Pumps CD250/22.5	Pump Q=150 m3/h H=20 m Control panel	37,500	26,900	35,508
WWTP mini hydropower station to be installed on treated water discharge pipe DN500 H=20 m	-	RGES-15 two sets	8,200	71,175	92,414

All items from the list except the first one generally correspond to our recommendations. We based our choice of equipment on actual measurements of working parameters of equipment.

We proposed even more ECMs to optimize operation of SP 3 and to reduce amount of water presently recirculated between different pressure pumping zones.