2011

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

FINAL REPORT

CAUSENI

Tehno Consulting & Design

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ELECTRONIC APPENDIX

Flow Measurements Reports
Pressure Measurements Reports
Power Measurements Reports
Leak Detection Reports
Other Measurement Protocols

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 (WSSPIU)
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 Causeni facilities description, historical data, Auditors findings, site measurements data, analyses and ECM proposals.

Our energy audit team visited Causeni 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 Causeni. 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
Replacement of submersible pump in the well no. 2	127,458	229,424	198,660	0.9	**1**
Replacement of submersible pump in the well no. 1	40,909	73,636	145,860	2.0	**2**
Replacement of pump at D. Cantemir BPS	1,478	2,660	7,000	2.6	**3**
Transformer replacement at WWTP	9,000	16,200	54,000	3.3	**4**
Water supply distribution network optimization	63,080	113,545	1,540,000	13.6	**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.

Three ECMs have been shortlisted for 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
Replacement of submersible pump in the well no. 2	127,458	229,424	18.8%	198,660	**1**
Replacement of submersible pump in the well no. 1	40,909	73,636	6.0%	145,860	**3**

ECM description	Annual energy savings, kWh	Annual energy savings, MDL	Savings in % compared to total power consumption	Capital investment cost, MDL	Ranking
Water supply distribution network optimization	63,080	113,545	9.3%	1,540,000	**2**

Total investment amount for selected Causeni ECMs is **116,250 USD[1].**

[1]Excluding investments covered by the NWSSP

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, Ungheni, Floresti and Causeni.

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 Causeni. 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 ofECM 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 Causeni.

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

Table 1-1 Agreed EMP Investments for Causeni

Ranking	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	Contribution from credit, USD
1	**Replacement of submersible pump in the well no. 2**	127 458	679 229	18.8%	198 660	0.9	
2	**Water supply distribution network optimization**	63 080	679 229	9.3%	1 540 000	13.6	*41 982**

3	**Replacement of submersible pump in the well no. 1**	40 909	679 229	6.0%	145 860	2

* Current works for rehabilitation of PS 2 contain installation of two new pumps proposed in ECM 5. Therefore the amount of 500,000 MDL for re-equipment of PS 2 is covered by WB credit.

The overall amount of proposed EMP investments for Causeni is 1,384,520 MDL or **116,250 USD** (USD exchange rate 11.91).

Consultant will prepare the following submittals for the selected ECMs:

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

2. WATER SERVICES IN THE TOWN OF CAUSENI

2.1 General

The Town of Causeni is located in the South-Eastern part of Moldova, some 80 km from Chisinau. The Town of Causeni is the administrative and commercial center of agricultural rayon (district) with about 93,000 inhabitants.

*Figure 2-1**Location of Causeni***

Causeni is located in a valley at an altitude of 10-45 m above sea level with some distant areas in the South reaching up to 90-110 m a.s.l. Elevated hill areas surround Causeni.
The BotnaRiver, a tributary to the NistruRiver, flows (SW-NE) through the City centre dividing Town in two parts – Northern and Southern. The railroad runs through the City.

2.2 Service Area Definition

The town of Causeni is provided with water services by a municipal operator (I.M. Apa-Canal Causeni) covering main part of the town, and several private operators covering isolated areas in the south of Causeni.

Northern service area is geographically divided into two regions – Valul lui Traian (area of private houses located at 25-50 m a.s.l.) and Micro (private houses and 4-5-floor apartment blocks located at 10-25 m a.s.l.).

Central area is located at some 10-45 m a.s.l. and includes two 9-floor buildings, area of 4-5-floor blocks and private houses.

The industrial area currently relies on privately owned deep wells and only several minor water consumers in the area are provided with water services by Apa-Canal.

The areas supplied by private operators, as well as uncovered regions, are located in the southern part at a relatively elevated hill (some 45-110 m a.s.l.).

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

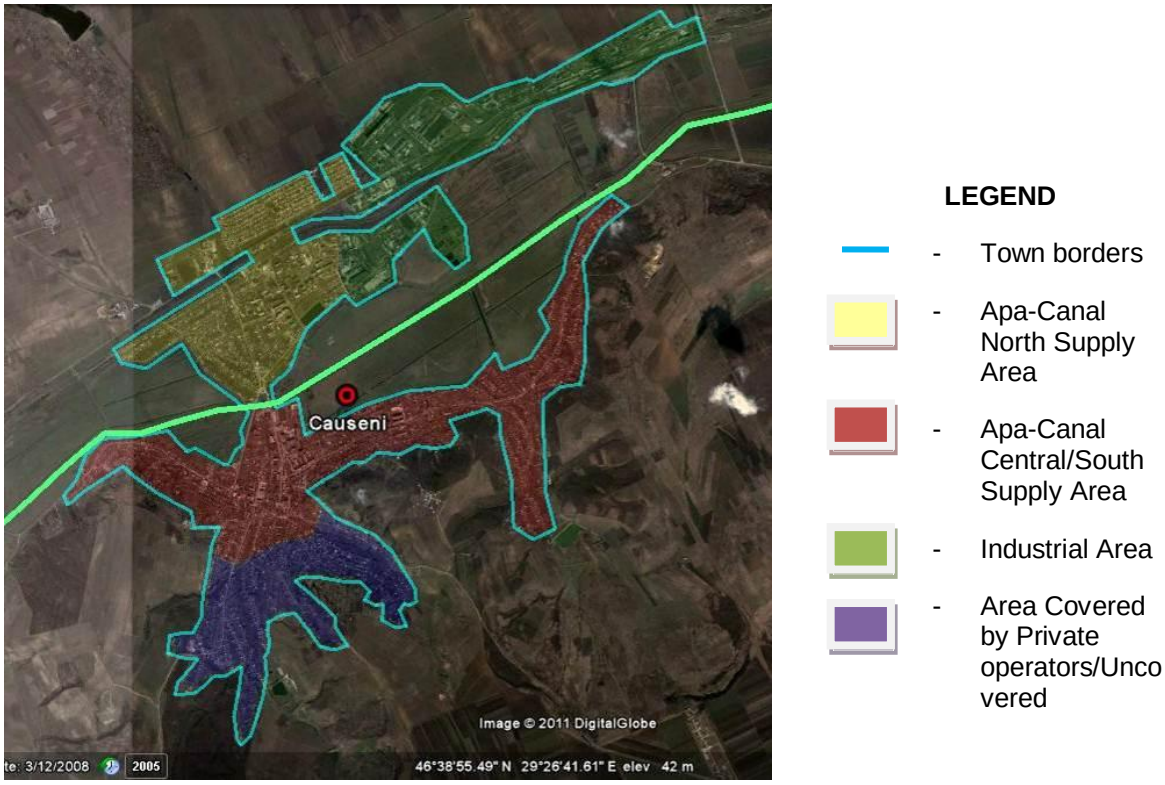


*Figure 2-2**Estimated Extent of Water Service Areas in Causeni***

This study covers Apa-Canal operations only. The uncovered areas are expected to be provided with water by private operators due to suitable geographical location, or other possibilities of future water supply 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 CauseniTown, as of January1 by Years**[2]

Town/Year	2005	2006	2007	2008	2009	2010	2011
Causeni	20.6	20.5	20.5	19.9	19.9	19.9	19.9

As shown in the table, the official population number of the Town has been being constant over the last 4 years. Considerable 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[3].

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

Notwithstanding the official statistical data, and taking into account high level of immigration, the real number of population (and consequently consumers) living in Causeni is expected to be considerably lower. According to CauseniCity Hall, currently the Town counts some 17,500 people.

2.4 Customers

2.4.1 Water Supply

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

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

Service Area	No of Customers (Contracts)	Estimated No. of population (people)
North - Valul lui Traian		
Households	418	1,177
North - Micro		
Households	1,755	4,942
Center/South		
Households	3,082	8,681
TOTAL	**5,255**	**14,800**

As can be seen from the Table, the major number of consumers is located in the city center. In total, some 74% of the area population is provided with water by Apa-Canal Causeni.

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

2.4.2 Sewerage

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

Table 2-3 ***Sewerage Household Customers – Apa-Canal Causeni***

Service Area	No of Customers (Contracts)	Estimated No. of population (people)
North - Valul lui Traian		
Households	-	-
North - Micro		
Households	1,327	3,393
Center/South		
Households	1,622	4,147
TOTAL	**2,949**	**7,540**

As can be noticed from the previous Tables, some 38% of total population and only some 51% of total water consumers are provided with sewerage services.

2.5 Preliminary Water Balance

Historical water balance for 2008-2010 (Apa-Canal Causeni data)

[3] Central Intelligence Agency, the World Factbook

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

Year		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total, m3
2008	Produced	41,447	33,659	35,017	34,256	40,563	40,852	43,424	45,904	40,827	39,517	40,717	48,728	**484,910**
	Billed	13,093	12,808	14,271	12,549	17,168	16,449	16,870	17,725	16,357	15,230	14,696	13,196	**180,412**
2009	Produced	52,404	42,236	47,247	50,905	54,351	55,496	57,895	59,441	55,510	56,035	52,078	58,310	**641,907**
	Billed	13,896	13,038	12,791	16,021	16,762	18,692	17,425	18,528	17,474	16,030	15,366	13,774	**189,797**
2010	Produced	58,110	55,134	53,345	52,736	58,172	62,697	63,257	72,648	58,845	58,996	58,741	57,902	**710,582**
	Billed	14,010	13,706	17,298	15,822	19,937	18,213	15,614	17,609	17,780	15,029	15,088	14,137	**194,244**

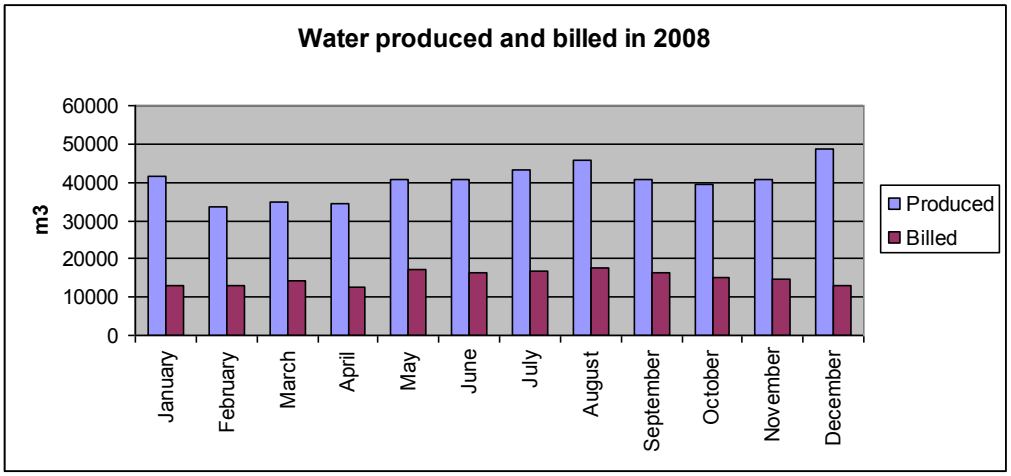


Figure 2-3 ***Reported Water Balance for 2008***

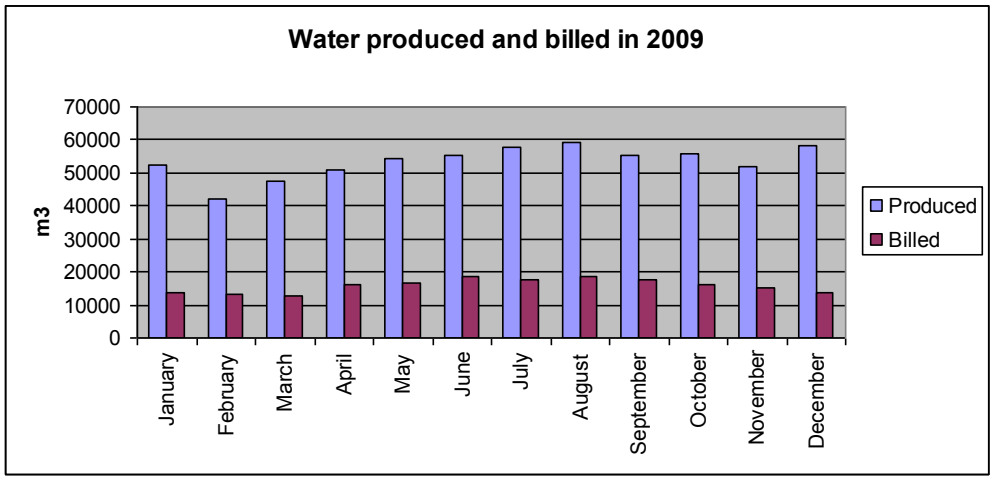


Figure 2-4 ***Reported Water Balance for 2009***

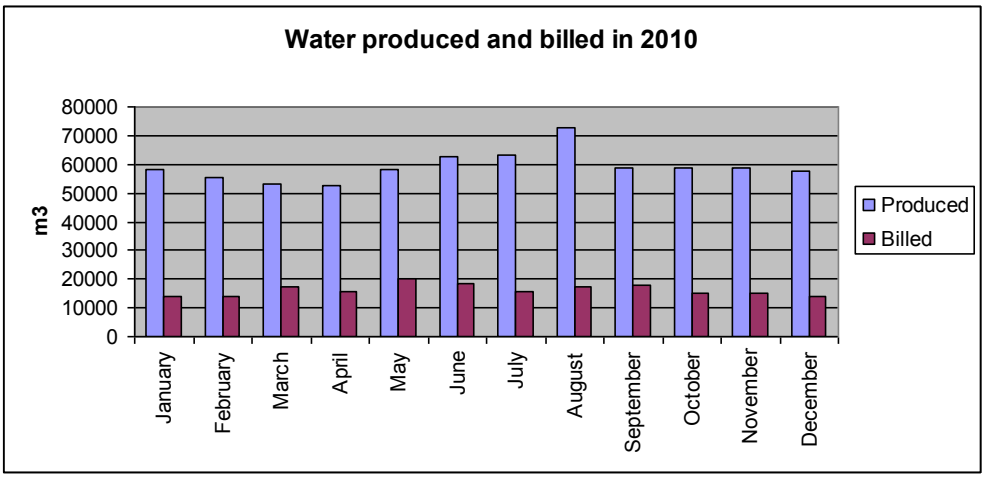


Figure 2-5 ***Reported Water Balance for 2010***

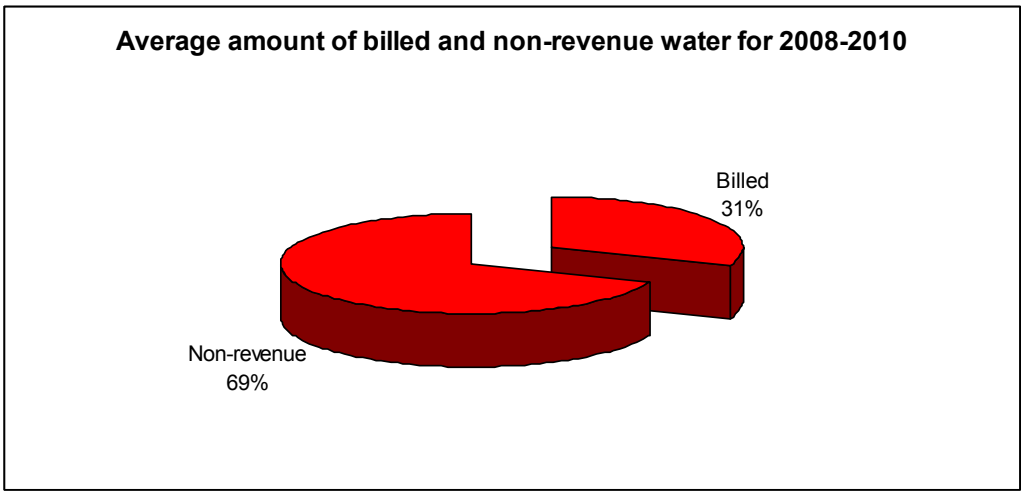


Figure 2-6 ***Reported Water Balance for 2008-2010***

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.

The reported volumes of the collected wastewater are presented in the Table below.

Table 2-5 ***Collected wastewater for 2008-2010***

	2008	2009	2010
Received Wastewater, thou m^3	130.6	116.1	140.2
Including from households	76.1	75.0	85.5
Water supplied/billed to households, m^3	159.4	167.1	169.3
Household sewerage return rate, %	**48%**	**45%**	**51%**

Overall the wastewater return rate remains low reflecting the much lower level of development of wastewater services.

3. WATER SUPPLY SYSTEM

3.1 General

The existing water supply network including different water production locations has been presented in the annex drawing WSS_Audit-Causeni-001.

The town of Causeni is provided with water from one groundwater intake through Main pumping station PS 2 feeding two separate service areas – North and Center (including South).

The Northern part of the Town is supplied by gravity from an elevated water tank fed by the PS2. A part of private houses are also connected directly to the pressure main from the PS 2.

Central part of the Town is supplied by direct pumping from the Main PS. Central system also includes 3 booster PS, supplying multi-storey buildings in the area.

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

3.2 Water Production

Water intake consists of one wellfield located in the western part of the City center, along the right bank of the Botna River. The wellfield area is located at ground elevation of some 9-11 m a.s.l. and includes ten (10) deep wells, out of which only two (Wells No1 and 2) are in regular use and one (Well No3) is decommissioned in 2010 due to the water debit reduction. All operated deep wells have submersible pumps, type ЭЦВ, manufactured in Moldova.

According to existing well passports, all wells are fed from the same aquifer.All submersible pumps in use lift water at a constant pressure head directly into two (2) existing water tanks from the Main PS, at elevation of 11 m a.s.l.

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

Table 3-1Design parameters of the existing pumping equipment at the Main water intake

Well No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Operating	Depth of installation
					P	Voltage	Speed	cosφ	In		
			m^3/h	m	kW	V	rpm		A	hrs /day	m
1	ЭЦВ 8-25-100	1	25	100	11.0	3x400	3000	0.83	24.2	24	63
2	ЭЦВ 10-63-110	1	63	110	32.0	3x400	3000	0.84	67.4	18	63

As can be seen from the Table above, design heads of the pumps in use are oversized (100-150 m), having to pump water from geodetic height of -30 m to 11 m a.s.l. (Main PS water tanks elevation). Furthermore, pump motors are oversized as compared to the modern pump equipment.

All submersible pumps are operated manually.Both wells are not equipped with water meters and pressure gauges.

Electrical Description

All transformers, except one at the WWTP belong to the power provider “Union Fenosa” and are not subject to the present Energy Audit. Low voltage cables, switchgears and control panels are owned

by Apa-Canal Causeni. It was noted that reactive power compensation is missing at all pumping installations.

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.

Monthly energy in kWh for each Facility equipped with power meters:

Table 3-2 ***Reported Energy Consumption for 2008***

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
PS 2 incl. well no 2	43,620	33,300	33,648	36,024	39,822	41,322	45,840	45,066	46,878	42,600	39,822	48,012	**495,954**
Office	74	71	66	34	1						23	63	**332**
SPS "Micro" Main	3,180	2,840	2,240	2,580	2,600	320	1,940	3,440	2,180	2,540	2,280	2,300	**28,440**
Auto park	1,485	1,359	921	884	610	328	384	361	387	975	1,629	1,218	**10,541**
Reservoir 3000 m3	66	60	52	108	50	73	70	117	88	93	82	40	**899**
WWTP	2,748	2,770	2,049	1,667	1,584	1,187	924	1,209	1,884	1,254	3,461	2,237	**22,974**
SPS "Stadion"	2,138	1,430	1,532	1,416	1,578	1,410	1,340	1,337	980	1,389	1,142	2,772	**18,464**
BPS " D Cantemir"	456	557	413	457	596	565	582	814	599	664	737	742	**7,182**
BPS "Causeni Vechi"	397	316	317	254	414	392	394	387	443	360	369	458	**4,501**
SPS "Causeni Vechi"			23	11				27	24			90	**175**
BPS "Stefan cel Mare"			261	302	482	105	449	469	422	416	436	453	**3,795**
Well no 3							5,595	4,596	5,662		257	720	**16,830**
												Overall power consumption for 2008, kWh	**610,087**

Table 3-3 ***Reported Energy Consumption for 2009***

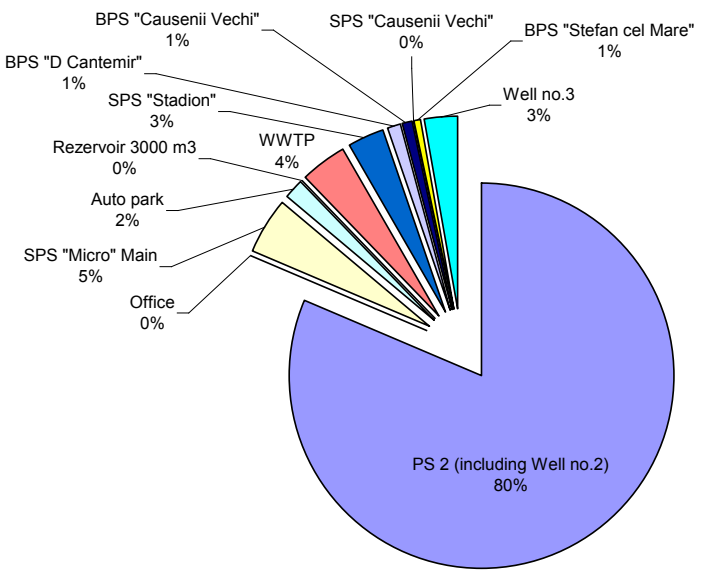
Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
PS 2 incl. well no 2	43,518	37,158	33,474	43,338	43,776	43,290	47,436	41,136	42,696	42,330	42,234	43,080	**503,466**
Office	65	59	38	39							33	82	**316**
SPS "Micro" Main	3,960	2,880	3,020	4,200	3,420	2,880	3,240	3,160	3,400	4,080	3,320	3,820	**41,380**
Auto park	1,650	1,252	1,964	1,231	750	322	449	340	437	936	1,299	1,503	**12,133**
Reservoir 3000 m3	54	4	51	83	84	42	80	37	216	95	47	43	**836**
WWTP	2,380	1,230	1,538	2,088	1,217	1,087	878	1,030	1,494	2,831	661	707	**17,141**
SPS "Stadion"	6,001	2,670	2,971	3,086	1,877	1,881	3,174	2,478	1,828	1,898	2,052	2,696	**32,612**
BPS " D Cantemir"	598	546	448	758	637	534	746	562	643	760	662	745	**7,639**
BPS "Causeni Vechi"	541	374	354	407	466	406	377	308	355	492	459	523	**5,062**
SPS "Causeni Vechi"	166	134			75	-134							**241**
BPS"Stefan cel Mare"	527	524	454	736	661	627	783	710	637	804	870	894	**8,227**
Well no 3		9,000	478	807	1,950	7,946	7,776	6,637	2,534	18,844	404	16,176	**72,552**
												Overall power consumption for 2009, kWh	**701,605**

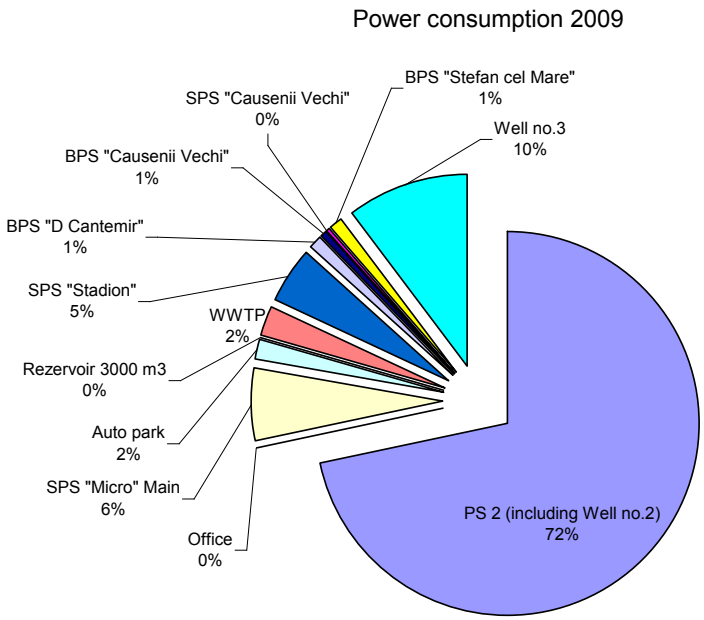
Table 3-4 ***Reported Energy Consumption for 2010***

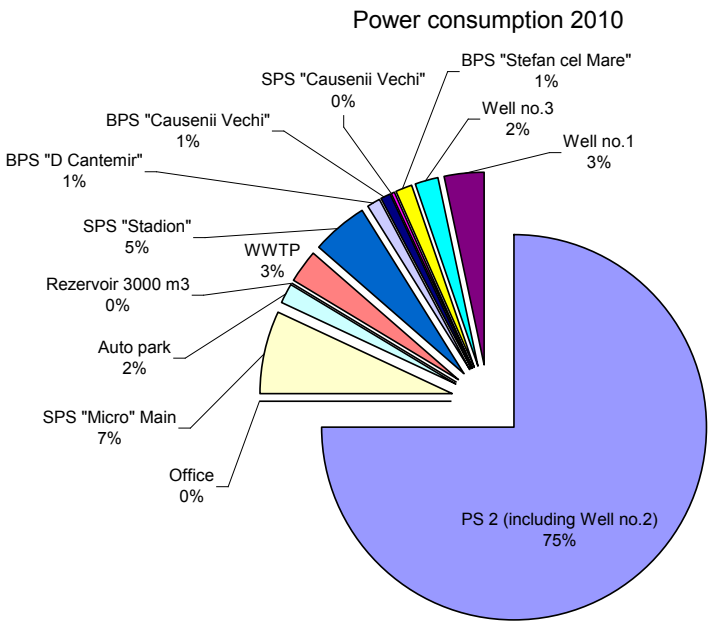
Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
PS 2 incl. well no 2	41,298	35,730	36,504	42,774	41,154	44,292	43,110	45,024	42,438	44,454	45,522	46,500	**508,800**
Office	64	66	63	10	1		1	1		1	48	82	**337**
SPS "Micro" Main	4,320	1,480	5,440	5,920	4,920	3,320	3,860	4,440	4,940	1,640	3,840	3,460	**47,580**
Auto park	1187	1,328	1,043	877	526	363	403	360	512	1,442	1,101	1,967	11,109
Reservoir 3000 m3	32	14	28	24	72	76	59	109	93	81	56	223	867
WWTP	2,275	1,516	2,011	1,052	961	1,051	1,690	1,344	1,856	3,698	661	684	**18,799**
SPS "Stadion"	3,659	1,866	3,468	2,499	2,361	2,469	2,205	2,705	2,997	2,497	2,458	2,737	**31,921**
BPS " D Cantemir"	755	650	740	634	1,406			253	416	431	385	486	**6,156**
BPS "Causeni Vechi"	507	487	623	476	535	506	450	584	528	548	485	611	**6,340**
SPS "Causeni Vechi"			49	63	84	375	420	171	358	363	233	275	**2,391**
BPS"Stefan cel Mare"	788	739	686	622	686	666	712	588	727	785	270	897	**8,166**
Well no 3	1214		3	201	2	2	7,415	7	74	291	15	5,261	**14,485**
Well no 1						2,652	4,521	7,020	716	7,369			**22,278**
												Overall power consumption for 2010, kWh	**679,229**

The below graphs illustrate the distribution of power consumption in 2008-2010:

Power consumption 2008







It is easy to notice that the most of the energy is consumed by the PS 2 + well no.2. Due to the common power meter installed at pumping station, power consumption of well no 2 is not separated.

In general, average 3-yearApa-Canal Causeni power consumption is presented in below graph:

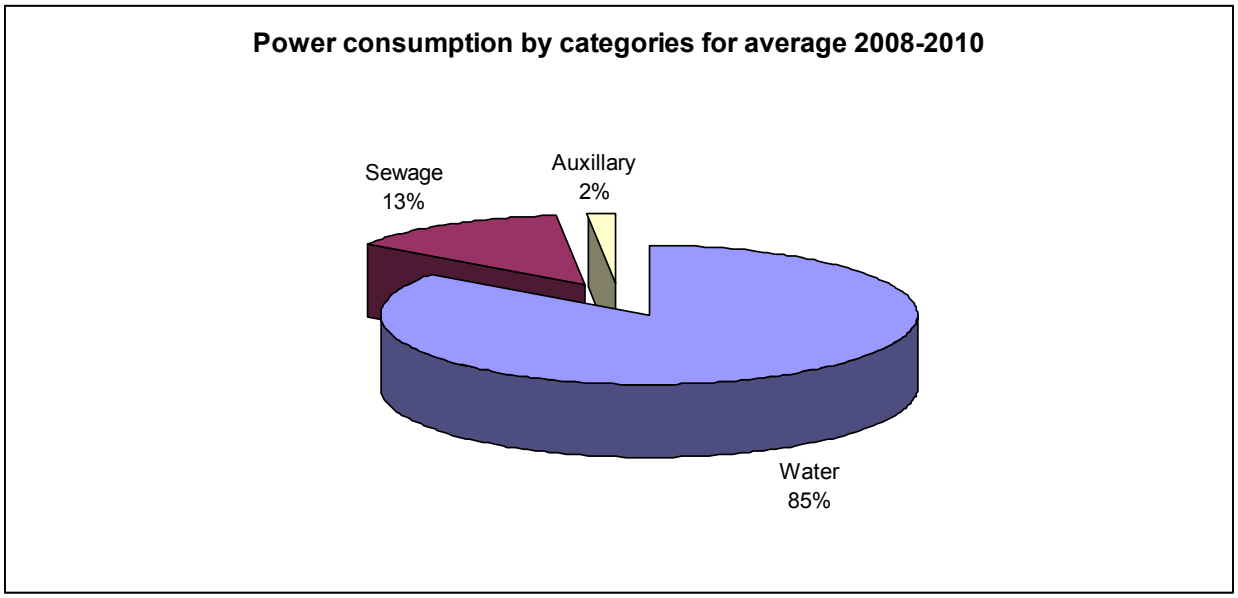


*Figure 3-1**Causeni Apa-Canal Energy Consumption by categories***

3.3 Water Treatment

The only treatment method used is chlorination to underground water reservoirs within Main PS. There is existing chlorination plant located at pumping station Main PS site but it is worn out and is taken out of use. Dilution and dozing of chlorine solution is irregularly done manually directly to the water tanks.

A new chlorination plant at the PS 2 is planned to be built within next months under the National Water Supply and Sanitation Project, financed by the World Bank. This brand-new equipment is not a subject to this Audit Report.

3.4 Water Pumping – PS 2

In this Section detailed description of existing pumping facilities is provided.

The Main PS (also known as PS2) is used to provide water to the whole Town of Causeni. Pumping equipment is separated into two (2) main groups, supplying water to two (2) separate service areas – North and Center (South). The third group of pumps is used as reserve.

All pumps intake water from two (2) tanks, having volume of 150 m^3 and 250 m^3, located at the Main PS area, at some 11 m a.s.l.

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

Table 3-5Design parameters of the existing pumping equipment at the Main PS in Causeni

Pump No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Operating
					P	Voltage	Speed	cosϕ	In	
			m^3/h	m	kW	V	rpm		A	hrs /day
1	K100-65/250	1	100.0	80.0	45.0	3x400	2,900			8
2-3	DAB booster set 2 (+1) K 30/800 T	2	18-63	44-17	8.3	3x400	2,900		14.0	1 x 18
4	KV 6/7 T (from DAB booster set)	1	2-8.5	62-15	1.6	3x400	2,850		2.9	18
5-6	K100-65-2006/2-5	2	100	32	15.0	3x400	2,900		28.0	as reserve

First group of pumps consists of only 1 centrifugal pump, which lifts water through a DN300 steel pressure main to the elevated tank (3,000 m^3 at 61 m a.s.l.) in the North of Causeni, therefrom water is led by gravity to the North supply area.

The pump K 100-65/250 is regularly used for some 8-10 hours per day. No various speed drive motor is used for this pump. Pump is operated at a constant head and all operation is done manually. Pump is started when the water level in the northern uphill tank reaches its lowest level and it is shut off once the tank gets full. Tank water levels are controlled manually without any automation system.

The pressure main from the Main PS to the elevated tank is made mainly of steel pipes of DN300, having length of some 3.7km. During last years, Apa-Canal Causeni replaced some pipeline segments with DN200 steel pipes, having total length of some 60 m. These segments generate additional head losses along the pressure main.

In general, the whole pressure main is in obsolete condition, producing high number of bursts and consequently water leakages. In addition, a number of consumers along the pressure main are connected directly to the pressure pipeline, affecting the stability of hydraulic conditions during pumping process.

There is no check valve installed on the pressure main, allowing back-flowing from the elevated tank to the Main PS tanks.The pump is equipped with a manometer. No flow-meters are in use for this pump.

Second group of pumps from the Main PS is formed of 3 centrifugal pumps in parallel, which supply water directly to the network from the City center. The group of DAB pumps was installed in 2005 and is regularly used for up to 18 hours per day.

The group is operated automatically by individual pressure switches at each pump in function of network pressure. Currently, it is set up to maintain network pressure at some 2.6 bar. No various speed drive motors are used for the DAB pump group. The elevated areas and multi-storey buildings use separate booster stations in order to increase the water pressure. The only monitoring instrument is pressure gauge installed on discharge pipe.

Pressure main to the City center is made of DN250 steel pipes and is in obsolete condition. However, it is currently being replaced with a new DN225 HDPE pipeline, under the NWSSP.

Also, a new additional connection from the Main PS to the southern part of the network is planned to be built in the next months, in order to ensure water supply to the City. Additional water main will be a DN200 HDPE pipeline, which is expected to balance pressure in the central network and to increase pressure in distant antennas from the eastern part of the Town (Causenii Vechi).

It is of note that the NWSSP envisages renovation of the existing Main PS, including replacement of existing pumps. This Audit is expected to recommend the most suitable solution for such replacement.

As the Main PS is the main energy consumer in Causeni WSS, all pumps installed at the Main PS are subject to further analysis, presented in the next Chapters.

Historical Energy Consumption of PS 2

It is of note that Apa-Canal Causeni doesn't have separate electric meters for each group of pumps. Therefore, only summed data on energy consumption are available.

The following summary of historical energy consumption registered by Apa-Canal is provided in the belowgraph:

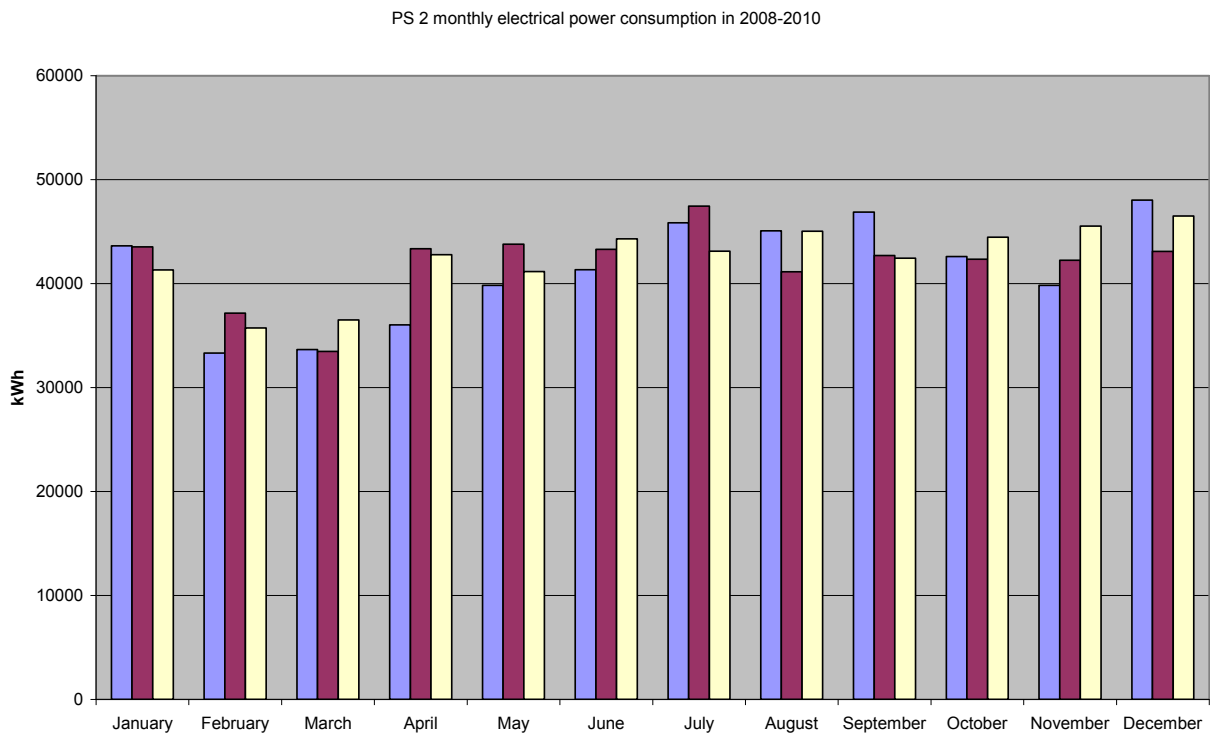


*Figure 3-2**Historical Energy Consumption of the PS2 in Causeni***

Due to lack of separate electric meters for each of deep wells in operation, it becomes impossible to analyze historical energy consumption of the separate pump groups at the Main PS. However, analyzing the summed energy consumption of the Main PS and Deep Well No2, rather stable energy consumption during the whole year is of note.

3.5 Water Pumping – Booster PS

In this Section detailed description of existing booster pumping facilities is provided.

In total, there are three (3) booster pumping stations in Causeni:

- D. Cantemir BPS;
- Stefan cel Mare BPS;

- Causenii Vechi BPS.

All booster PS are located in the central part of the Town, supplied directly from the second pump group (DAB) from the Main PS.

D. Cantemir Booster PS

D. Cantemir BPS is located in the City center, at 32, D. Cantemir Street, and is used to provide water to two (2) 9-floor apartment buildings.

The main plan of the D. Cantemir BPS service area is shown in the next Figure.

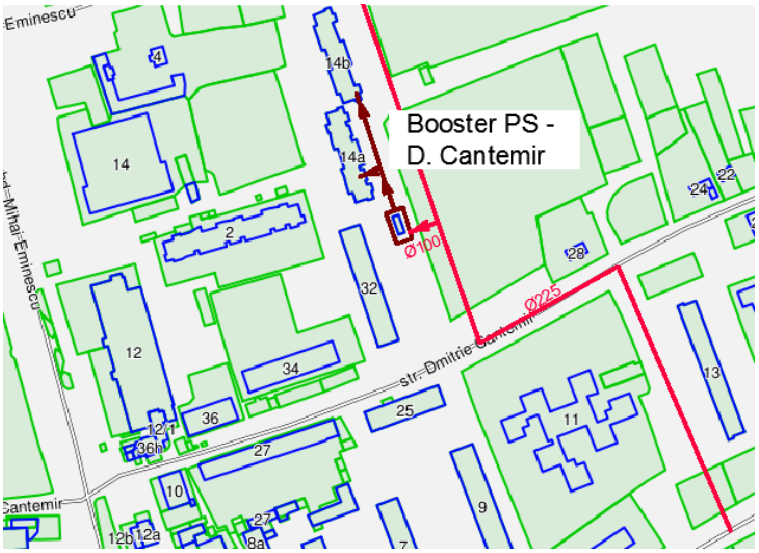


*Figure 3-3**D. Cantemir BPS Service Area***

General data on installed pumping equipment at D. Cantemir BPS are presented in the following Table:

Table 3-6Design parameters of the existing pumping equipment at Cantemir BPS in Causeni

Pump No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Operating
					P	Voltage	Speed	cosϕ	In	
			m^3/h	m	kW	V	rpm		A	hrs /day
1	**K8/18**	1	8.0	18.0	1.5	380	2,900	0.85	NA	18

The pump K 8/18 is regularly used in order to assure the pressure for 2 nine story adjacent blocks. No various speed drive motor is used for this pump. Pump is operated at a constant head and all operation is done manually. Pump is started when the pressure at the highest end-user is not enough for an adequate water supply.

The pressure main from the Cantemir BPS to the buildings is made of steel pipes of DN100, having length of some 100 m. The pressure main is worn out.

The only monitoring instrument installed is pressure gauge on the discharge pipe.

Stefan cel Mare Booster PS

St. cel Mare BPS is located in the City center, at 69, Stefan cel Mare Street, and is used to provide water to four (4) 5-floor apartment buildings and four (4) 2-floor buildings.

The main plan of the St. cel Mare BPS service area is shown in the next Figure.

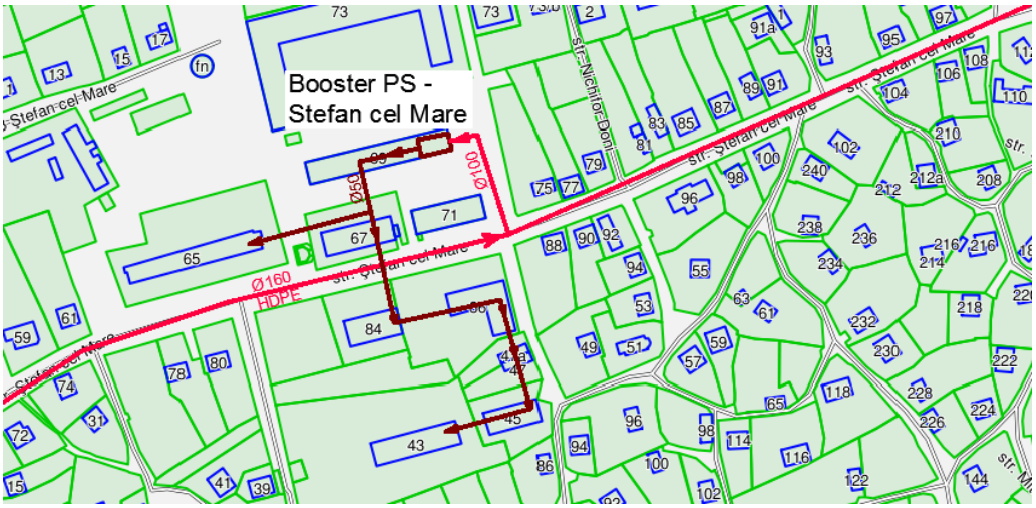


*Figure 3-4**Stefan cel Mare BPS Service Area***

General data on installed pumping equipment at St. cel Mare BPS are presented in the following Table.

Table 3-7Design parameters of the existing pumping equipment at St. cel Mare BPS in Causeni

Pump No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Operating
					P	Voltage	Speed	cosφ	In	
			m^3/h	m	kW	V	rpm		A	hrs /day
1	**K 20/18**	1	20.0	18.0	2.2	380	2,900	0.87	NA	18

The pump K 20/18 is regularly used in order to assure the pressure during peak hours. No various speed drive motor is used for this pump. Pump is operated at a constant head and all operation is done manually. Pump is started when the pressure at the highest end-user is not enough for an adequate water supply.

The pressure main from the St. cel Mare BPS to the buildings is made of steel pipes of DN50, having length of some 300 m. The pressure main is mostly laid directly through the basements of the supplied buildings. The pressure main is worn out.

Causeni Vechi Booster PS

Causenii Vechi BPS is located in the western part of the city, directly in a network valve chamber at 170, Stefan cel Mare Street. The BPS is used to provide water to an isolated district of private houses.

The main plan of the Causenii Vechi BPS service area is shown in the next Figure.

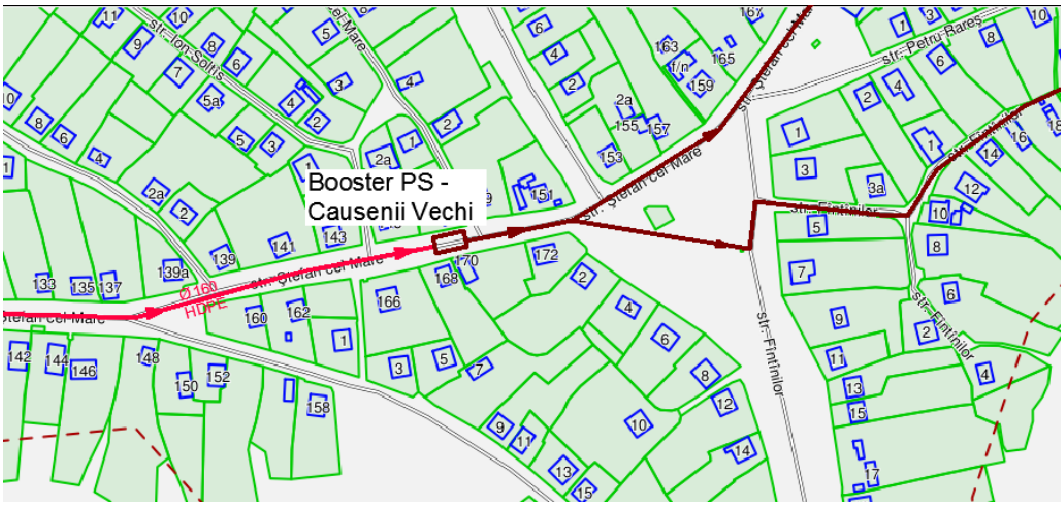


*Figure 3-5**Causenii Vechi BPS Service Area***

General data on installed pumping equipment at Causenii Vechi BPS are presented in the following Table.

Table 3-8Design parameters of the existing pumping equipment at Causenii Vechi BPS in Causeni

Pump No	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Operating
					P	Voltage	Speed	cosϕ	In	
			m^3/h	m	kW	V	rpm		A	hrs /day
1	**K8/18**	1	8.0	18.0	1.5	380	2,900	0.85	NA	18

The pump K8/18 is regularly used in order to assure the pressure in the service area during peak hours. No various speed drive motor is used for this pump. Pump is installed directly in a valve chamber and all operation is done manually.

All Booster PS are considered to have good energy conservation potential and are subject to further Audit Analysis.

3.6 Water Distribution Network

Town water distribution network is divided into two (2) separate supply areas – North and Central.

North supply area is provided with water by gravity from a 3,000 m^3 elevated tank, located north of the area at elevation of 61 m a.s.l. The area is geodetically divided into two regions:

- Valul lui Traian, located north uphill (25-50 m a.s.l.), close to the tank. The area of private houses;
- Micro, located at lower elevations (10-25 m a.s.l.). Area of mixed – private and multi-storey – buildings.

The whole area is supplied through a steel DN300 gravity water main. Due to oversized main pipeline and decreased water consumption (after installation of water meters), the gravity main's cross-section is not fully filled with water and the pipeline is operated in hydraulic conditions close to "sewer collector". Therefore, Valul lui Traian district suffers of lack of pressure and a number of houses are forced to be connected directly to the pressure main from the Main PS. This awkward arrangement actually makes the area reservoir useless for main part of Valul lui Traian district. Furthermore, households connected directly to the Main PS pressure main are exposed to increased pressures and

create significant head losses in pressure main, leading to gradual increase of the pump head needed. On the other hand, the elevated tank creates an excessive pressure in the lower area of Micro district and the pressure at Micro district is regulated by valve. This "wasting energy" arrangement is considered to have good energy conservation potential and is a subject to further Audit analysis.

Micro district consists mainly of private houses and some 20 4-and 5-floor buildings. Due to presence of multi-storey buildings, the whole area is provided with inlet pressure of approx. 3 bar, generating exceeding pressures (some 6 bar) in the lower regions by the BotnaRiver. The whole area is relatively flat (10-25 m a.s.l.) and most of consumers do not require such high pressure. The possibilities of network optimization shall be further analyzed by the Consultant.

Central supply area is provided with water by direct pumping from the Main PS. The outlet pressure at the Main PS is kept at 2.1-2.6 bar. Higher pressure produces bursts in the Town networks, due to obsolete condition of existing pipelines. Multi-storey buildings and some elevated areas are supplied by three (3) booster PSs, as described in the previous Sections.

Main data about existing water pipelines are shown in the following Table.

*Table 3-9**Data on existing water distribution network in Causeni***

Diameter, mm	< 10 years, km	10-20 years, km	20-30 years, km	30-40 years, km	40-50 years, km	> 50 years, km	Total km
			Steel				
32			3.10				
40			8.9				
50			6.0		5.5		
70			4.6				
100			0.4		7.5		
150			6.6		5.1		
200			0.2		5.4		
250			0.8		1.1		
300	1.1				2.5		
Sub-total	***1.1***		***30.6***		***27.1***		***58.8***
			Cast iron				
100			6.3	6.1			
150			2.0			3.5	
200			1.2		0.8		
250			2.8				
300			***12.3***	***6.1***	***0.8***	***3.5***	**22.7**
			Polyethylene				
50-100		3.9					
100		6.4					
Sub-total		***10.3***					***10.3***
Total							**91.8**

During the last years the water distribution network has not been renovated. Most of pipelines are worn out. The network is difficult to operate due to obsolete condition of installed valves.

The NWSSP has recently started renovation of existing water networks in Causeni. It is expected to replace some 10 km (out of 92 km) of network mains. Though only 10% of networks will be renovated, good energy saving potential is seen in the eastern part of the central network. It is expected that renovation of water main along Stefan cel Mare street, as well as connection of an additional supply pipeline, will increase pressure in the eastern antenna and will create room for optimization (or taking out of operation) of the existing booster PSs. These considerations will be analyzed in the next Chapters.

It is expected that current leakage rate is considerably 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 5,076 household-meters installed, including:

- 4,885 inhouseholds;
- 191 for economic agents;
- 21 for budgetary institutions.

The level of population within metering covers some 90%. Level of metering for institutions and business entities was reported at 100%. However, no business water consumers were reported by Apa-Canal, thus the presented data is questionable. All private apartment meters have 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, Causeni sewerage collection system consists of six (6) drain areas and six (6) SPSs, pumping collected wastewater to the existing WWTP, located in the North-Eastern part of the town at an elevation of 18 m a.s.l.

Given to the Town geographic situation, all wastewater is collected by gravity at the lowest points along the BotnaRiver, and thereafter pumped to the WWTP.

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

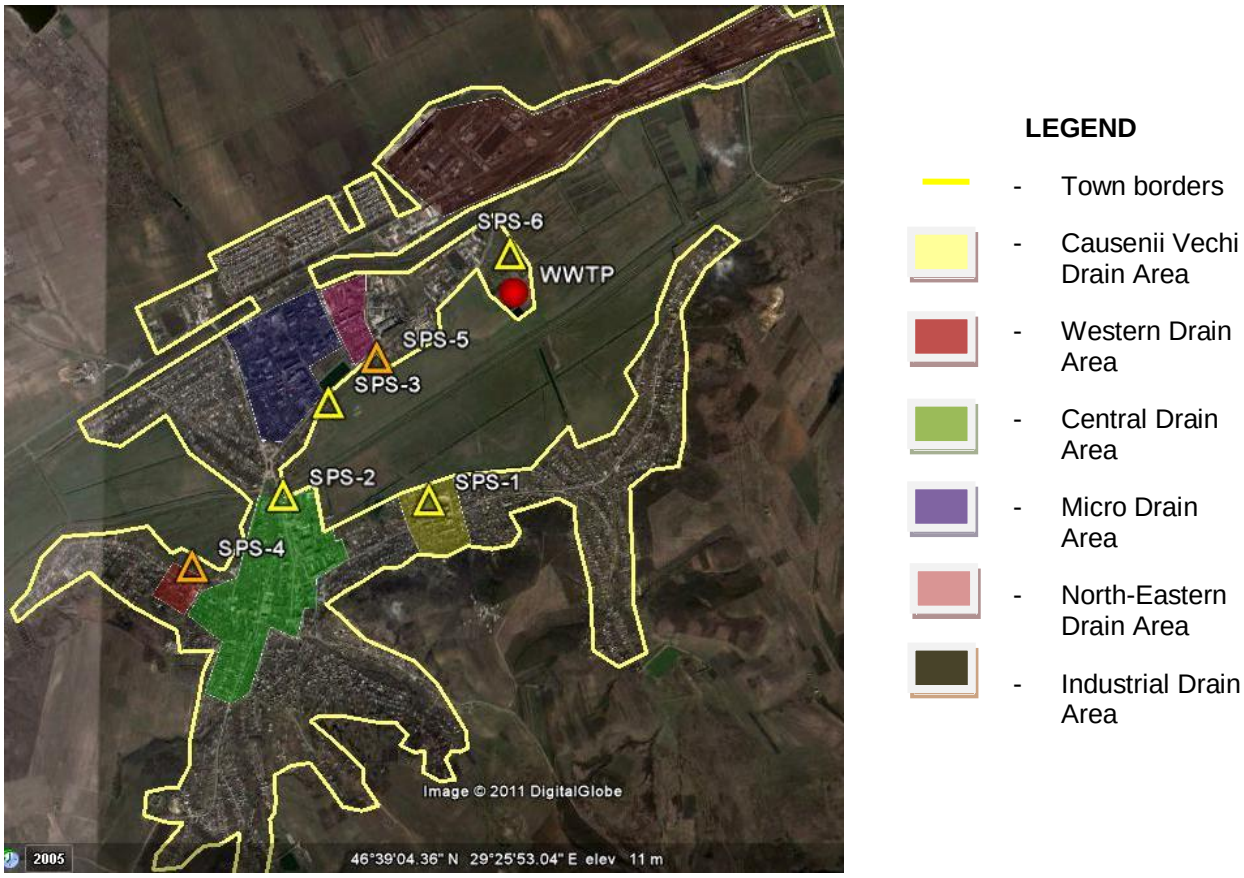


*Figure 4-1**Estimated Extent of Sewerage Drain Areas in Causeni***

As reported by Apa-Canal, only some 39% of the Town population and some 51% 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 six (6) main drain areas, thereof collected wastewater is led to the WWTP through six (6) sewerage pumping stations.

The areas are, as follows:

- Western part – area of private households. Collected wastewater is designed to be pumped by SPS4 to the gravity collector from the City center;
- Central part – area of mixed private houses and multi-storey buildings. All wastewater is collected at SPS2 (Stadion) and therefrom pumped to the SPS3 (Micro), which is actually the Main SPS for the existing WWTP;
- Causenii Vechi (western central part) – area of mixed private houses and multi-storey buildings. All wastewater is collected at the local SPS1 (Causenii Vechi) and therefrom pumped directly to the SPS3 (Micro);
- Micro (northern part) - area of mixed private houses and multi-storey buildings. Wastewater from the Micro district is drained to the SPS3 (Micro);
- North-Eastern area of private houses. Collected wastewater is designed to be pumped by SPS5 to the SPS3 (Micro);
- Industrial area, located in the north-eastern part of the Town. Wastewater is collected at the Industrial SPS, situated at the WWTP area.

Currently, two (2) existing pumping stations (SPS4 and SPS5) are not in use due to inadequate condition. Wastewater from the western drain area (SPS4) doesn't reach the main sewer collector, being transported to the WWTP by cesspool cleaning trucks. Wastewater from SPS5 drain area is discharged into SPS3 collector.

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

*Table 4-1**Data on existing sewerage networks in Causeni***

Description	Pipe Material	DN, mm	Length, km	Operation period, years
1	Asbestos	400	2.08	≥ 40
2	Asbestos	300	5.76	30-40
3	Cast iron	300	4.64	30-50
4	Asbestos	250	2.85	30-40
5	Cast iron	250	2.42	25-40
6	Ceramics	250	2.21	40-50
7	Asbestos	200	3.34	30-50
8	Cast iron	200	3.35	25-40
9	Ceramics	200	6.04	30-50
10	Asbestos	150	2.88	25-40
11	Ceramics	160	3.58	35-50
12	Asbestos	100	3.76	30-50
13	Cast iron	100	1.28	20-30
Total			**44.20**	

Including pressure collector (cast iron pipes):

Ø 300	**4,640 m**
Ø 350	**840 m**
Ø 100	**1,280 m**

The main sewerage network originates from the 1960's and has not been renovated since. Most parts of networks are worn out generating high amounts of leakages. However, it is assumed that a

considerable amount of groundwater infiltrations occur in the lower areas of the networks, dissolving pollutant content of the wastewater.

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

As mentioned above, there are six (6) wastewater PSs in use in Causeni. Currently, only four (4) SPSs are in use, while the SPS4 and SPS5 are taken out of operation and the SPS4 service area is relying mainly on latrines and some basic sewers, regularly cleaned by the cesspool trucks. The SPS6 located at the WWTP is used only for the industrial area effluent, having a seasonal schedule of operation.

General data on installed wastewater pumps in use are presented in the following Table.

Table 4-2Design parameters of the existing pumping equipment at SPSs in Causeni

PS	Model	Qty	Design Flow rate	Design Head	Design Motor Data					Operating
					P	Voltage	Speed	cosϕ	In	
			m^3/h	m	kW	V	rpm		A	hrs /day
Causenii Vechi SPS1	CM-100-65-250	1	62.5	12	4.0	3x400	2950	NA	NA	1.5
Stadion SPS2	CM-150-125-315-4	2	200	32	37	3x400	1450	0.86	NA	3.2
Micro SPS3	CM-150-125-315-4	3	200	32	37	3x400	1450	0.86	NA	4
SPS4	NA									
SPS5	NA									
WWTP SPS6	NA									

All existing SPSs in Causeni are in critical condition and most of data on existing pumping equipment were not available to the Consultant. All existing equipment is worn out and it is difficult to appreciate the level of its energy efficiency. Basically, due to its age and high level of use, all existing pumping equipment should be replaced by a modern one.

Currently, the NWSSP has started renovation works of two SPSs, Micro and Stadion, which are the majorpumping stations with the most energy consuming equipment in operation.The other existing SPSs consume less than 1% of the total energy consumption of Causeni Apa-Canal. Therefore, these SPSs are not considered to be subject to this Energy Audit.

As described above, collected sewerage from the SPS4 is transported and evacuated by cesspool cleaning trucks. For this purpose, one (1) truck owned by the Apa-Canal is used. All costs are supported by the Apa-Canal. Main data on transported volumes of the wastewater and related expenditures are presented in the following Table.

Table 4-3 Data on transported volumes and costs for evacuation of the sewerage from the SPS4

	Unit	SPS 4
SPS Location		50, Mateevici str.
No of population covered	people	41
No of SPS operating hours	h/day	-
No of truck routes per year (2011)		252
No of trucks in use	pcs	1

	Unit	SPS 4
Costs per one route	MDL	150
Costs per year (2011)	MDL/year	**37,800 MDL**

The Consultant has inspected the SPS4 facilities and all related infrastructure and concluded that:

- The SPS4 network covers a very limited number of consumers in the area, while the rest of water users rely on latrines and cover all associated costs for evacuation of the sewerage by themselves.
- The existing structure of the SPS4, as well as pressure pipeline are in obsolete condition and require a complete reconstruction.

Taking into consideration the need for sewerage extension in the area and complete reconstruction of the existing SPS4, the Consultant considers these investments as an infrastructure project rather than an energy conservation activity. Therefore, it is a subject for a different infrastructure project and it is not included in this Audit Study.

4.4 Wastewater Treatment

The existing WWTP receives wastewater from the whole Town, and is located in the North-Eastern part of the town, right bank of the BotnaRiver. The WWTP inlet is situated at the elevation of some 18 m a.s.l.

The WWTP is fed with wastewater from the SPS-3 (Micro) and SPS-6 (Industrial).

Treatment chain is designed for 10,000 m^3/day and consists of two (2) sand traps, ten (10) primary multistage settlers, two (2) trickling filters, eight (8) aeration tanks, two (2) secondary settlers, two (2) biological ponds, sludge pumping and blowers station, sludge disposal site, chlorination plant, and contact stabilization tank. Currently, only rudimentary mechanical treatment stage and biological ponds are in use.

It is very difficult to appreciate the efficiency of the existing facilities, since most of energy consuming installations are taken out of operation. The existing WWTP is considered to be in a critical condition and according to the WB Feasibility Study taking into consideration the condition of existing structures and machineries and insufficient process technology it could be recommended that the whole treatment plant will be replaced with new modern and more compact WWTP taken into account current and future wastewater flows and loads. For new WWTP there is a possibility to use area reservation next to the existing plant[4].

Nevertheless one remaining power transformer 1,000 kVA, 10/0.4 kV designed to cover the whole energy demand of working plant. Since most of power consuming equipment of WWTP does not operate transformer is constantly underloaded and Apa-Canal pays a high fee for no-load run of transformer.

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

5. OTHER ENERGY CONSUMPTION

The natural gas is used only for heating of the office building in winter period:

*Table 5-1**Reported Natural Gas Consumption***

2008	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Amount, MDL	4,004.7	2,854.38	1,991.43	657.17									**9,507.7**
Volume of natural gas, m3	1240	860	600	198									**2,898.0**

2009	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Amount, MDL	9,696.84	3,403.1	2,013.84	392.35							2,558.79	4,179.72	**22,244.6**
Volume of natural gas, m3	2,422	850	503	98							683	1,121	**5,677.0**

2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Amount, MDL	5,042.08	3,999.17	3,465.95	337.71							3,801.69	5,170.3	**21,816.9**
Volume of natural gas, m3	1,220	900	780	76							750	1,020	**4,746.0**

6. SITE MEASUREMENTS

6.1 Methodology

In order to assess the operating efficiency of the existing WSS and its elements and to identify energy saving potential, a comprehensive site measurement campaign was organized by the Consultant. All measurements were done by a professional team using most appropriate equipment and devices. The measurement campaign was carried out in August – September 2011.

The Consultant has performed flow measurementsat water sources, all outlet pipes of the PS2, inlet and outlet pipes of collection reservoirin order to evaluate water losses in transmission line of DN300 and distribution water network in the Northern and Southern supply areas.

We have also carried outflow measurements of individual pumpsto 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 teamusedpressure measurements equipment at individual pumps suction and pressure sides in order to evaluate actual performance of pumps and pressure piping.

Acoustic leak detection using correlator in selected pipelines of Causeni water distribution network has been performed.

Long-term flow measurement of water delivered to selected multistory blocks was also carried out.

Due to the on-going rehabilitation works at Causeni sewage pumping stations, which shall be completed by the end of 2011, Energy Audit of existing pumping equipment was not performed and site measurements at SPS were not done.

The existing WWTP technological part is not a subject to this Energy Audit and an additional energy efficiency study for a newly proposed treatment technology, including possibilities of energy generation, shall be done separately.

Flow Measurement Sites

Flow measuring equipment was installed at the following sites:

- Well No.1;
- Well No.2;
- PS 2 discharge pipeline to the reservoir 3,000 m^3;
- PS 2 discharge pipeline to the South supply area distribution network;
- Reservoir 3,000 m^3 inlet pipe;
- Reservoir 3,000 m^3 outlet pipe to the North supply area;
- BPS D. Cantemir discharge pipe to 2 blocks of 9 stories;
- BPS Causenii Vechi discharge pipe to 5 stories block district;

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 pipeline to the reservoir 3,000 m^3;
- PS 2 discharge pipeline to the South supply area distribution network.

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

Pressure manometers were installed at:

- Well no.1;
- BPS D. Cantemir discharge pipe to 2 blocks of 9 stories;
- BPS Causenii Vechi discharge pipe to 5 stories block district.

Electrical power measurements sites

The power measurements were performed at the following sites:

- Well No.1;
- Well No.2;
- PS 2 pump K 100/65-250 supplying reservoir 3,000 m^3;
- PS 2 pump "DAB1" K 30/800T supplying distribution network of the South area;
- PS 2 pump "DAB2" K 30/800T supplying distribution network of the South area;
- PS 2 pump "DAB3" KV 6/7T supplying distribution network of the South area;
- BPS D. Cantemir pump K 8/18 supplying 2 blocks of 9 stories;
- BPS Causenii Vechi pump K 8/18 supplying 5 stories block district;
- BPS Stefan cel Mare pump K 20/18 supplying rural area of Stefan cel Mare street.

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.

Also, the Consultant performed leak detection on selected pipelines of Causeni distribution network. Several leaks have been identified and confirmed by Apa-Canal staff. Leak detection protocols are included in the electronic external Appendix to this Report.

Auditor analyzed the situation on the metering volume of water delivered to selected households and industrial consumers using high-precision performance water meters.

Equipment used for site measurements

Power analyzer	**QualistarCA 8334 (Chauvin-Arnoux)**
Portable flow meter	**Prosonic Flow 93T (Endress + Hausser)**
Fixed-installation flow meter big size	**DigitalFlow DF868 (GE Measurement&Control Solutions)**
Fixed-installation flow meter small size	**Multical 61 (Kamstrup A/S)**

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 2 on discharge pipeline to the reservoir 3,000 m³

The measurements were started on August 02, 2011 at 19:00 and finished on August 04 at 18:48. The time interval between instant flow measurementswas set to 6 minutes. Both totalizers for direct flow and backflow have been activated.

Flow measurements at reservoir 3,000 m^3 inlet pipes started on August 02, 2011 at 18:00 and ended on August 04 at 19:54. The time interval between instant flow measurementswas 6 minutes. Both totalizers for direct flow and backflow have been activated.

Simultaneous flow measurements on the outlet pipe from PS 2 and inlet pipe to reservoir allowed us to determine losses in transmission pressure main of DN300.

Operating mode of pump K 100/65-250 delivering water to the reservoir is not continuous. Average pumping time is some 8 hours per day.

Discharge pipe is not equipped with check valve. Operator manually opens gate valve before pump start up and shuts off the valve before pump stop. It was noted that gate valve cannot be closed fully and during the period of pump stoppage a small backflow was registered.

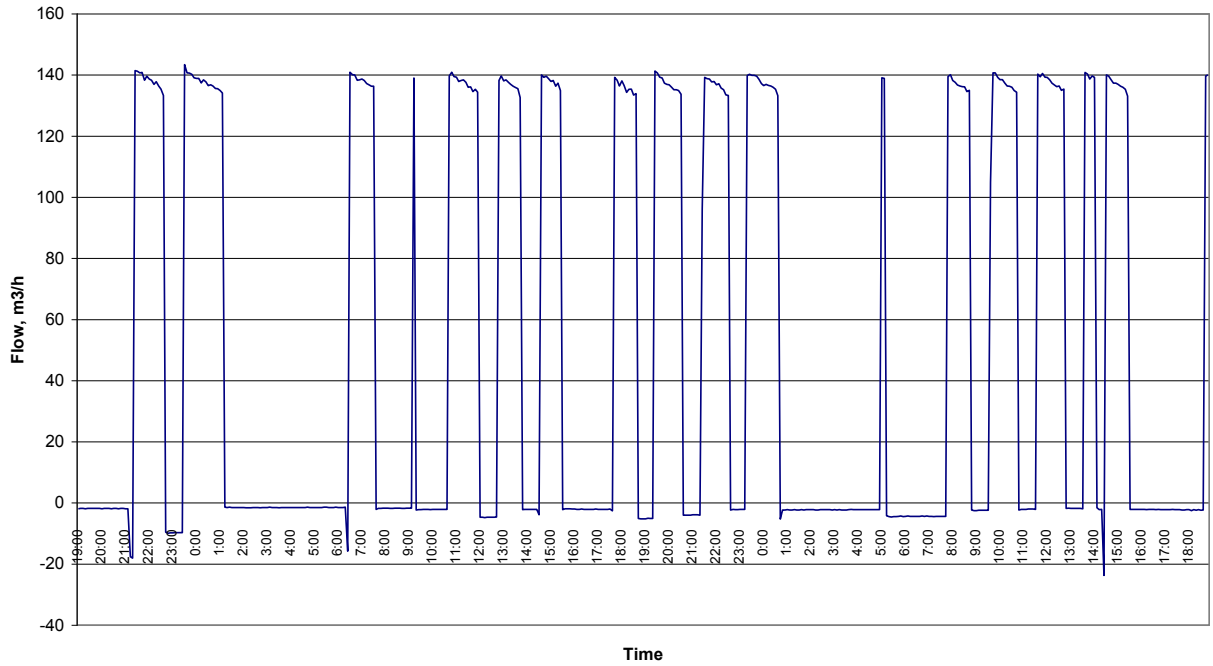


Figure 6-1Flow Measurements at the PS2 pressure pipe to the elevated reservoir

There are several individual house connection on transmission main and water consumption shall be taken into account in estimation of losses. We took night backflow from the reservoir to represent minimum losses in transmission main.

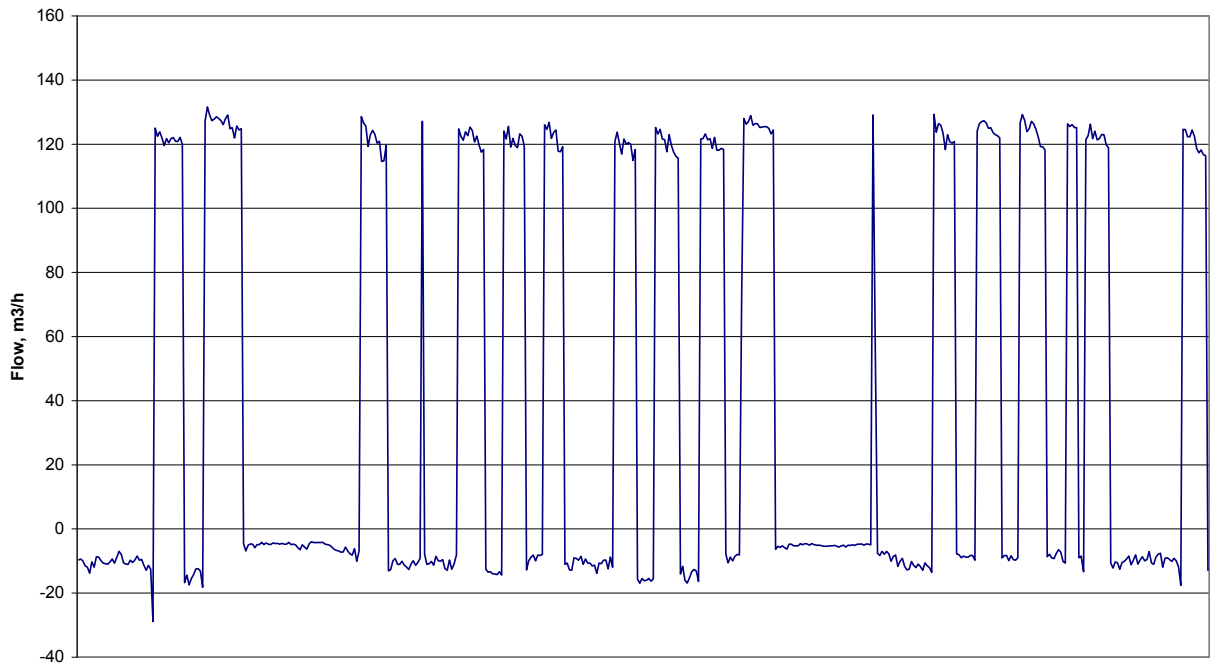


*Figure 6-2**Flow Measurements at the reservoir inlet***

Actual losses are deemed to be higher since pumping pressure is higher than static water pressure in the pipe. Even registered minimum losses are approx. 7% of water flow in the transmission main. The results of 2 days flow measurements are shown in table below:

Table 6-1Flow Measurements Results at the PS2-reservoir pressure main

	August 02-03, 2011	August 03-04, 2011
Daily flow outlet PS 2 - reservoir, m^3	1,149	1,223
Daily flow inlet reservoir, m^3	1,026	1,117
Losses + consumption, m^3/d	123	106
Daily backflow from reservoir, m^3	149	134
Daily backflow at PS 2, m^3	44	42
Losses + consumption backflow, m^3/d	105	92
Average night backflow from reservoir, m^3/h	-5.43	-5.19
Average night backflow at PS 2, m^3/h	-1.49	-2.30
Minimum losses in transmission pipe, m^3/h	-3.94	-2.89
Daily minimum losses, m^3/d	-94.52	-69.27
Losses percentage of total daily flow	**-8%**	**-6%**

The backflow at PS 2 which returns into reservoir varies between 1.49 m^3/h in the first day and 2.3 m^3/h in the second day. This could be easily avoided with low cost measures of installation of check valve and new gate valve on discharge pipe of the pump.

Flow measurements at PS 2 on discharge pipeline to the South supply area distribution network

The measurements were started on August 02, 2011 at 19:00 and ended on August 04 at 18:48. The time interval between instant flow measurements was 6 minutes.

Below graph illustrates the 2 days flow into the distribution network:

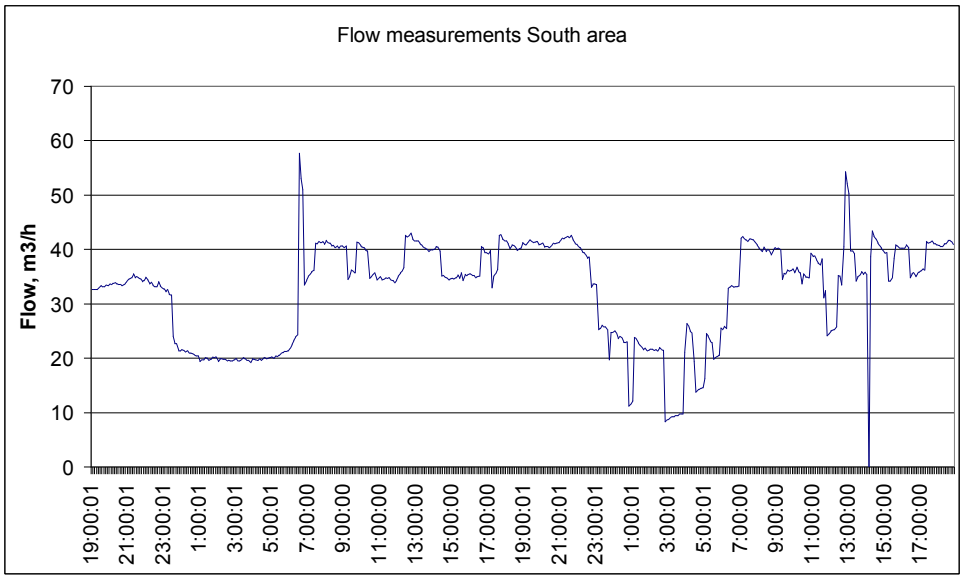


Figure 6-3Flow Measurements at the PS2 pressure pipe to the central/south area

Table 6-2Flow Measurements Results at the PS2-Central Town pressure main

	August 02-03, 2011	August 03-04, 2011
Daily flow PS 2 - South network, m^3/d	776	779
Maximum daily peak, m^3/h	57.7	54.3
Minimum night flow, m^3/h	19.2	8.7
Estimated losses in Central/South area, m^3/h	**8**	
Estimated daily losses in Central/South area, m^3/d	**192**	

Flow measurements at reservoir of 3,000 m³ on outlet gravity pipeline to the Northern supply area distribution network

The measurements were started on August 15, 2011 at 21:00 and finished on August 16 at 09:06. The time interval between instant flow measurements was 6 minutes.

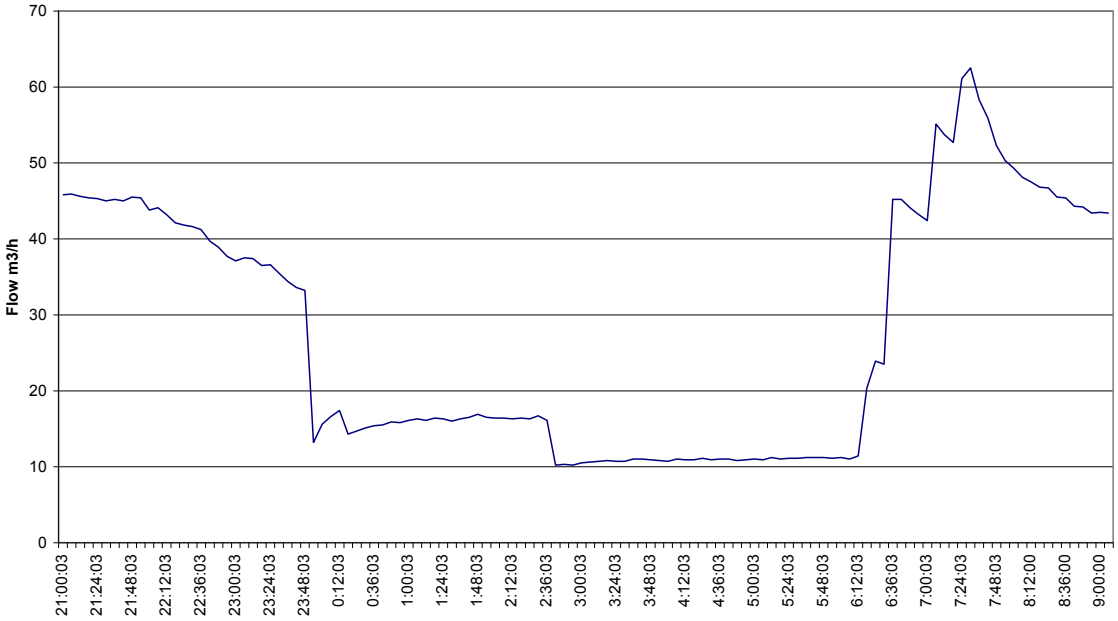


*Figure 6-4**Flow Measurements at the reservoir gravity outlet***

Registered maximum daily peak	62.5 m^3/h
Minimum night flow	10.2 m^3/h
Estimated losses in Northern area	10 m^3/h
Estimated daily losses in Northern area	240 m^3/d

Measurements of multistory block buildings water consumption

The long-term measurements were started on July 29, 2011 at 19:00 and ended on August 25 at 07:00. Fixed water meter was installed on the discharge pipe from D. Cantemir BPS feeding 2 nine-story block buildings. The time interval between flow readings was 1 hour.

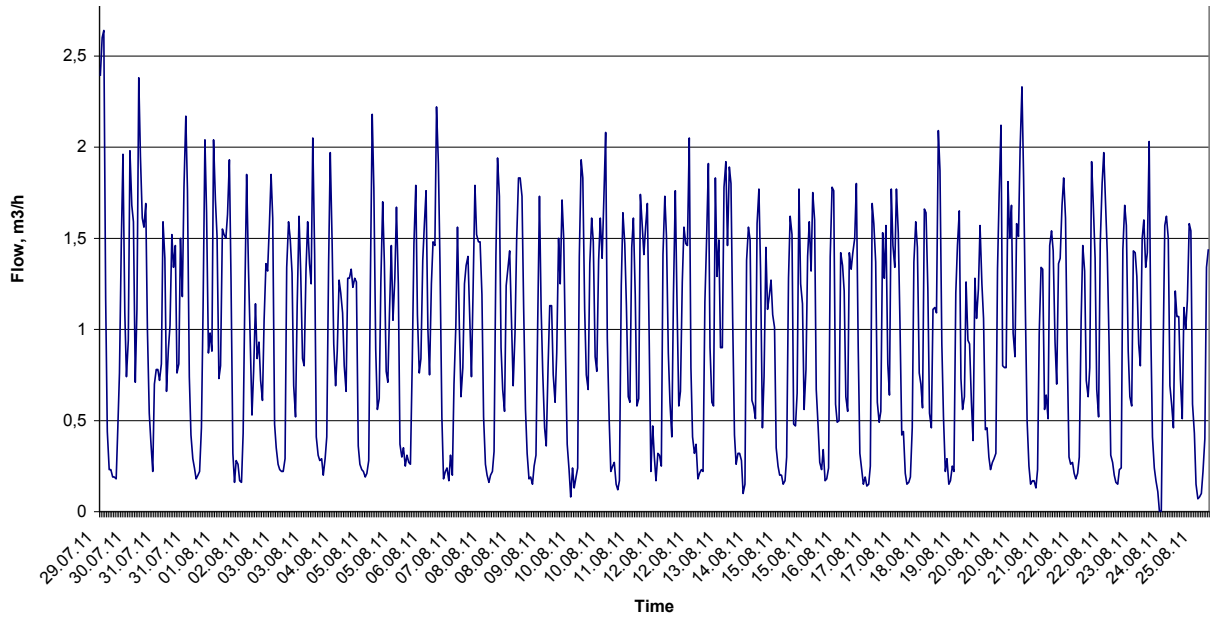


Figure 6-5Flow Measurements at the D. Cantemir BPS (9-story buildings, 14a, 14b)

Pressure measurements at PS 2

The measurements were started on August 02, 2011 at 19:00 and ended on August 04 at 18:48. The time interval between instant pressure measurements was 6 minutes.

Red graph illustrates discharge pumping pressure in the transmission pipeline to reservoir 3,000 m^3.

Blue graph shows pumping pressure in the outlet pipe to the South area distribution network from the DAB group of pumps.

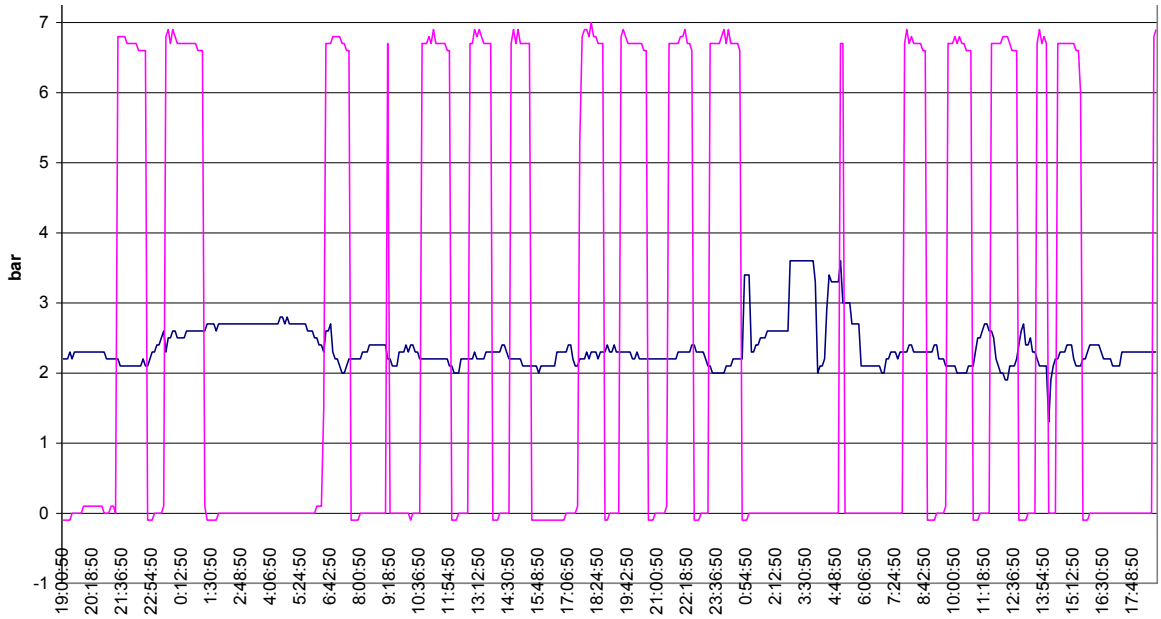


Figure 6-6 ***Pressure Measurements at the PS2***

Leak Detection

In order to demonstrate the existence of water leakages from the distribution networks, Leak Detection measurements for selected network segments were done by the Consultant.

It shall be mentioned that in order to have a clear picture on existing network leakages, a permanent comprehensive monitoring system should be in place. Having no adequate measurement and monitoring system in Causeni, the Consultant in cooperation with Apa-Canal Causeni has reduced its activities to a number of selected network segments for future measurements, having the main objective to identify possible existing leakages and to prove the poor condition of some "problematic" water pipes. Also, prior to leak detection, a pipe location activity was carried out.

Leak Detection team carried out field measurements in July 23-24, 2011. Though a considerable amount of water leakages was detected, still a large amount of leakages persist in Causeni. The identification of all existing water leakages was not a subject to this Energy Audit.

Summary data on the network leakages detected is presented in the following Table.

*Table 6-3**Detected Network Leakages***

No	Street	Measured Segment Length, m	Leakage Detected	Pipe located, m
1	Unirii 22	52	1	250
2	Unirii 24	55	1	55
3	Eminescu 105	15	1	150
4	Eminescu 8	81	0	173
5	Eminescu 50	25	1	250
6	Eminescu 1	-	0	250
Total			**4**	**1,128**

The obtained results demonstrate poor condition of existing pipelines, as well as existence of large amount of leakages. It is strongly recommended that Apa-Canal Causeni shall carry out a comprehensive leak detection campaign in order to reduce leakages.

Measured Current Water Balance

Water balance based on real measurements of losses in water supply system is shown in the following table.

*Table 6-4**Measured Current Water Balance in Causeni***

		Supply area		Real losses		Apparent losses	Revenue Water	Non-revenue water
				Transmis-sion	Distribution			
Water production, m3/day	2,002	North	1,223	69	240	1,000	570	1,432
		South	779	0	192			
Revenue water (billed)	**28%**							
Apparent losses	**47%**							
Real losses (measured)	**25%**							
Overall non-revenue water	**72%**							

Real or physical losses in transmission main and distribution network have been measured during flow measurements. Amount of water billed/consumed was known from the data provided by water

utilities. The difference between abstracted water from the source and consumed + real losses gave the amount of apparent losses.

We found that such a high percent of non-revenue water is due to the big apparent losses in the system, what represents illegal water usage, water theft and inaccurate measurements of domestic water-meters. We strongly recommend cuttingof all existing pipelines to those commercial agents, which are not any longer official water consumers of Apa-Canal Causeni. Special attention shall be put to pipeline to industrial area along Alba Iulia street in the Northern part of the Town.

Measurements of operating parameters of pumping equipment

Well No. 1

Well no. 1 is located approx. 1 km from PS 2. Pump ЭЦВ8-25-100 is installed at 63 m depth. Motor rated power is 11 kW. Rising pressure pipe is of DN80. Cast iron pipeline DN150 connects well to collection reservoir at PS 2.

The measurements were taken on August 10, 2011

Registered flow	22.5 m^3/h
Dynamic water level from the wellhead	30.1 m
Pressure in discharge pipe	0.5 bar
Active power consumption	9.67 kW
Pumping efficiency (pump+motor)	**24 %**

Well no. 2

Well no. 2 is located at the territory of PS 2. Pump ЭЦВ 10-63-100 is installed at 63 m depth. Motor rated power is 32 kW. Rising pressure pipe is of DN100. Water is pumped directly to the collection reservoir.

The measurements were taken on August 10, 2011

Registered flow	84.2 m^3/h
Dynamic water level from the wellhead	33.25 m
Active power consumption	32.9 kW
Pumping efficiency (pump+motor)	**29 %**

PS 2. Pump K100/65-250

Pump delivers water to the reservoir of3,000 m^3. Motor rated power 45 kW.

The measurements were taken on August 10, 2011

Registered flow	120 m^3/h
Pressure in the discharge pipe	70 m
Pressure in suction pipe	-1 m
Active power consumption	42.95 kW
Pumping efficiency (pump+motor)	**54 %**

PS 2. Pump group DAB

The measurements were taken on August 10, 2011

Group of three pumps DAB supplies water to the Central/South area distribution network. Group consists of two big pumps K 30/800T and one small (jockey) pump KV 6/7 T.

DAB 1. Type K 30/800T

Registered flow	27 m^3/h
Pressure in the discharge pipe	21 m
Pressure in suction pipe	-1 m
Active power consumption	5.89 kW
Pumping efficiency (pump+motor)	**27 %**

DAB 2. Type K 30/800T

Registered flow	34 m^3/h
Pressure in the discharge pipe	24 m
Pressure in suction pipe	-1 m
Active power consumption	6.57 kW
Pumping efficiency (pump+motor)	**35 %**

DAB 3. Type KV 6/7 T

Registered flow	7.4 m^3/h
Pressure in the discharge pipe	1.8 m
Pressure in suction pipe	-1 m
Active power consumption	1.57 kW
Pumping efficiency (pump+motor)	**24 %**

D Cantemir BPS. Pump K 8/18

Motor rated power	1.5 kW
Registered flow	1.14 m^3/h
Pressure in the discharge pipe	40 m
Pressure in suction pipe	20 m
Active power consumption	1 kW
Pumping efficiency (pump+motor)	**6 %**

Causeni Vechi BPS. Pump K 8/18

Motor rated power	1.5 kW
Registered flow	2.68 m^3/h
Pressure in the discharge pipe	15 m
Pressure in suction pipe	31 m
Active power consumption	0.93 kW
Pumping efficiency (pump+motor)	**13 %**

Stefan cel Mare BPS. Pump K 12/20

Motor rated power 2.2 kW

Registered flow	No data.
Flow meter installation	was not possible
Pressure in the discharge pipe	15 m

Pressure in suction pipe	31 m
Active power consumption	1.6 kW

The summary dataon design and actual operating parameters of existing pumping equipment is shown in the Table below.

*Table 6-5**Data on pumps in use in Causeni Water Supply System***

Causeni		Wells		PS 2				Cantemir BPS	Causeni Vechi BPS	Stefan cel Mare BPS
Design parameters	**Unit**	**Well no 2**	**Well no 1**	**DAB 1**	**DAB 2**	**DAB 3**	**Pump to reservoir**			
Pump type		ЭЦВ 10-63-110	ЭЦВ 8-25-100	K 30/800T	K 30/800T	KV 6/7T	K 100/65-250	K 8/18	K 8/18	K 20/18
Flow	m3/h	63	25	36	36	5.4	100	8	8	20
Head	m	110	150	38	38	42.5	80	18	18	18
Impeller diameter	mm	-	-	NA	NA	NA	264	128	128	134
Number of impellers		5	7	1	1	7	1	1	1	1
Shaft power	kW	31.4		7.5	7.5	1.1	33	0.85	0.9	
Pump efficiency		0.62	0.6	0.63	0.63	0.55	0.67	0.62	0.62	
Pump + motor efficiency		0.54	0.49	0.53	0.53	0.45	0.60			
Motor type		ПЭДВ 32-219	ПЭДВ 11-180	-	-	-	NA	*АИР 80 А2*	*АИР 80 А2*	АИР 80В2
Rated power	kW	32	11	8.3	8.3	1.6	45	1.5	1.5	2.2
Nominal voltage	V	380	380	380	380	380	380	380	380	380
Nominal current	A	67.4	24.2	14	14	2.9	NA	NA	NA	NA
Rotation Speed	rpm	3000	3000	2900	2900	2900	2900	2900	2900	2900
Cos ϕ		0.84	0.83	0.85	0.85	0.76		0.85	0.85	0.87
Motor Efficiency		0.87	0.81	0.839	0.839	0.81	0.9	0.8	0.8	0.8
Measured parameters of pumps										
Actual flow	m3/h	84.2	22.5	27	34	7.4	120	1.14	2.68	-
Suction pressure/dynamic level	m	33.25	30.1	-1	-1	-1	-1	20	15	-
Discharge pressure	m	3	5	21	24	18	70	40	31	-
Actual pump head	m	42.25	37.1	22	25	19	71	20	16	-
Measured parameters motor										
Active power consumption	kW	32.9	9.67	5.89	6.57	1.57	42.95	1.00	0.93	1.60
Reactive power consumption	kVAr	22.37	8.78	3.96	4.18	1.31	22.74	1.37	0.89	1.63
Apparent power	VA	40.05	13.13	7.14	7.82	2.05	48.65	1.7	1.3	2.3
Power factor		0.82	0.74	0.82	0.84	0.76	0.88	0.59	0.72	0.7
Calculated pumping efficiency										
Hydraulic power	kW	9.69	2.27	1.62	2.31	0.38	23.20	0.06	0.12	0.00
Pumping efficiency (pump+motor)		0.29	0.24	0.27	0.35	0.24	0.54	0.06	0.13	0.00
Pump Efficiency		0.34	0.29	0.33	0.42	0.30	0.60	0.08	0.16	
Specific power consumption	kW/m3	0.39	0.43	0.22	0.19	0.21	0.36	0.88	0.35	

7. PROPOSED ENERGY CONSERVATION MEASURES

In this Section, Energy Conservation Measures are proposed, as per Consultant's ToR.

7.1 Proposed ECM1 - Replacement of submersible pump in the well No.2

Present situation

Well no.2 is located at the territory of PS 2. Well delivers water to the collection reservoirs of PS 2.

Existing submersible pump ЭЦВ 10-63-110 of 5 stages is equipped with motor ПЭДВ 32-219, having rated power of 32 kW. Pump is installed at 63 m depth. Rising pipes are of DN = 114 mm.

Measurements results

The measured actual pumping flow rate is Q =**84.2 m^3/h**.

The measured dynamic water level in the well is **33.25 m** from the wellhead level. Please note that water level measurements were taken in August 10, 2011 at the summer lowest water table of the aquifer.

It was not possible to measure the discharge pressure. Since water is pumped to the adjacent reservoir located at the same ground level and water table in the reservoir was **1 m** above the ground, the taken discharge pressure is **3 m** including the headloss in the pipeline between the well and reservoir. Taken headloss in the rising pipes DN100 L=63 m is **6 m** (q= 23.5 l/s; v = 2.3 m/s; 1000i = 95.4 m).

The overall pumping head is H = 33.25 + 3 + 6 = **42.25 m.**

The measured active power consumption in the operating regime P_{con} = **32.9 kW.**

Calculation of pumping efficiency

The calculated hydraulic power is P_{hyd} = Q x H/367.2 = **9.69 kW**

The actual pumping efficiency of existing submersible pump is P_{hyd} / P_{con} = **29 %**

The main reason of low pumping efficiency is in pump operation outside of its duty range. The actual pumping head of 42 m is far away from design head of 110 m. The actual flow of 84 m^3/h is much higher than design flow of 63 m^3/h. The working duty point is moved to the low efficiency area of pump curve.

Proposed Improvement

Since existing submersible pump operates at very low efficiency rate, we propose to replace existing inefficient pump with new pump Q = 80 m^3/h, H = 40 m (analogue Z875 3/2A-L6W with rated motor power of 13 kW).

Estimation of Savings

Estimated power consumption of existing pump	= 216,153 kWh/year
Estimated power consumption of new pump	= 88,695 kWh/year
Power saving	= 127,458 kWh/year
Assuming 1.8 MDL per 1 kWh	= **229,424 MDL/year**

The detailed estimation of savings is presented in the electronic Annex to this Report.

Estimation of investment cost

*Table 7-1**Estimated Investment Costs***

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
	Mechanical				
1	Submersible pump/motor set Q=80 m3/h H=40 m including submerged cable	pcs	1	3,600	3,600
2	Rising pipe 5"	m	50	50	2,500
3	Piping in the wellhead building DN150	set	1	300	300
4	Gate valve DN150	pcs	2	200	400
5	Check valve DN150	pcs	1	300	300
6	Water meter DN150	pcs	1	800	800
7	Pressure gauge mechanical	pcs	1	100	100
	Electrical				
8	Pump control unit	pcs	1	1,200	1,200
9	Earthing and cable connection	set	1	600	600
	Auxiliary				
10	Installation	Lump sum			1,000
11	Tools	set	1	200	200
12	Consumables	set	1	140	140
13	Mandatory spare parts	set	1	800	800
14	O&M manuals	set	1	100	100
	Grand total EUR				**12,040**
	Grand total MDL				**198,660**

Payback period	**= 0,9 years**

7.2 Proposed ECM2 - Replacement of submersible pump in the well no.1

Present situation

Well no.1 is located at the distance of approx. 1 km from PS 2. Well delivers water to the collection reservoirs of PS 2 through DN150 cast iron pipeline.

Existing submersible pump ЭЦВ 8-25-100 of 5 stages is equipped with motor ПЭДВ 11-180 of rated power of 11 kW.

Measurements results

The measured actual pumping flow Q =**22.5 m3/h**.

The measured dynamic water level in the well is **30.1 m** from the wellhead level. Please note that water level measurement were taken in August 10, 2011 at the summer lowest water table of the aquifer.

The measured discharge pressure is**0.5 bar**. Taken head loss in the rising pipes of DN80 L=63 m is **2 m** (q= 6.3 l/s; v = 0.89 m/s; 1000i = 18.8 m).

The overall pumping head is H = 30.1 + 5 + 2 = **37.1 m**

The measured active power consumption in the operating regime P_{con} = **9.67 kW.**

Calculation of pumping efficiency

The calculated hydraulic power P_{hyd} = Q x H/367.2 = **2.27 kW**

The actual pumping efficiency of existing submersible pump P_{hyd} / P_{con} = **24 %**

The main reason of low pumping efficiency is in pump operation outside of its duty range. The actual pumping head of 37 m is far away from design head of 100 m.

Proposed Improvement

Since existing submersible pump operates at very low efficiency rate, we propose to replace existing inefficient pump with new pump Q = 30 m^3/h, H = 38 m (analogue Z631 04-L6W with rated motor power of 5.5 kW).

Estimation of Savings

Estimated power consumption of existing pump	= 84,709 kWh/year
Estimated power consumption of new pump	= 43,800 kWh/year
Power saving	= 40,909 kWh/year
Assuming 1.8 MDL per 1 kWh	= **73,636 MDL/year**

The detailed estimation of savings is presented in the electronic Annex to this Report.

Estimation of investment cost

*Table 7-2**Estimated Investment Costs***

No.	Description	Unit	Qty	Unit price, EUR	Total price, EUR
	Mechanical				
1	Submersible pump/motor set Q=30 m^3/h H=38 m including submerged cable	pcs	1	2,000	2,000
2	Rising pipe 4"	m	50	40	2,000
3	Piping in the wellhead building DN100	set	1	200	200
4	Gate valve DN100	pcs	2	150	300
5	Check valve DN100	pcs	1	200	200
6	Water meter DN100	pcs	1	600	600
7	Pressure gauge mechanical	pcs	1	100	100
Electrical					
8	Pump control unit	pcs	1	1,000	1,000
9	Earthing and cable connection	set	1	500	500
	Auxiliary				
10	Installation	Lump sum			1,000
11	Tools	set	1	200	200
12	Consumables	set	1	140	140
13	Mandatory spare parts	set	1	500	500
14	O&M manuals	set	1	100	100
	Grand total EUR				**8,840**
	Grand total MDL				**145,860**
Payback period			**= 2 years**		

7.3 Proposed ECM3 - Replacement of pump at Cantemir BPS

Present situation

D. Cantemir BPS delivers water to 2 nine-stories blocks:

- D. Cantemir 14 a (72 apartments, 125 inhabitants)
- D. Cantemir 14 b (72 apartments, 120 inhabitants)

Existing pump K 8/18 is equipped with motor of 1.5 kW.

Measurements results

The pumping flow varied between 0.2 and 2.3m^3/h.

The measured instant flow is 1.14 m^3/h.

The measured suction pressure is20 m, discharge pressure is 40 m.

The overall pumping head is H = 40 – 20 = 20 m

The measured active power consumption in the operating regime P_{con} = **1 kW.**

Calculation of pumping efficiency

The calculated hydraulic power P_{hyd} = Q x H/367.2 = **0.06 kW**

The actual pumping efficiency of existing submersible pump is P_{hyd} / P_{con} = **6 %**

This is the most inefficient pumping regime. Pump delivers just 1/7 of rated flow.

Proposed Improvement

Since existing pump operates at extremely low efficiency rate, we propose to replace existing inefficient pump with new pump Q = 3 m^3/h, H = 20 m (analogue BLOCK BGM7/A with rated motor power of 0.75 kW).

Estimation of Savings

Estimated power consumption of existing pump	= 6,570 kWh/year
Estimated power consumption of new pump	= 5,092 kWh/year
Power saving	= 1,478 kWh/year
Assuming 1,8 MDL per 1 kWh	= **2,660 MDL/year**

The detailed estimation of savings is presented in the Annex 5 to this Report.

Estimation of investment cost

Dismantling of existing pump and valves	= 1,000 MDL
Supply and installation of new booster pump set	= 5,000 MDL
Valves and electrical connections	= 1,000 MDL
Total investment cost	**= 7,000 MDL**
Payback period	**= 2.6 years**

7.4 Proposed ECM4 - Transformer Replacement at the WWTP

Present Situation

There is one working transformer 10/0.4 kV 1,000 kVA at the WWTP. Second transformer is dismantled. Since WWTP is practically not operational and main power consumer is one sewage pump with motor of 37 kW and some lighting and heating for personnel, big transformer is under-loaded. WWTP transformer is owned by Apa-Canal Causeni and power meter is located at the high voltage side. Average monthly fee for no-load running is 750 kWh.

Proposed Improvement

It is proposed to replace the existing 1,000 kVA transformer with smaller one of 100 kVA. New transformer will cover actual needs of power at Causeni WWTP. Possible future rehabilitation of WWTP will require detailed calculation of required transformer capacity.

Estimation of Savings

Estimated power saving	750 kWh/month x 12 months	= 9,000 kWh/year
Assuming 1.8 MDL per 1 kWh		= **16,200 MDL/year**

Estimation of investment cost

Dismantling of one transformer 1,000 kVA 10/0.4 kV	= 5,000 MDL
Dismantling of high/low voltage switchgears	= 4,000 MDL
Supply and installation of one transformer 100 kVA 10/0.4 kV	= 35,000 MDL
Reconnection of high/low voltage cables	= 10,000 MDL
Total investment cost	**= 54,000 MDL**

Payback period	**= 3.3 years**

7.5 Proposed ECM5 - Water supply distribution network optimization

Present Situation

Northern part of Causeni is supplied from PS 2 via 3,000 m^3 reservoir. Water is pumped from elevation of 10 m to the reservoir benchmark of 61 m. Most of water consumers of Northern supply area are located at elevations between 12 and 25 m, except one rural area close to reservoir at elevations between 28 and 49 m. In the lowest part of Northern area pressures are more than 60 m and Apa-Canal staff throttles the valve to the low located districts in order to reduce excessive pressure.

Therefore existing pumping regime is deemed to be inefficient, since all water shall be lifted to the height of 61 mand then gravitated to the low located networks.

Proposed Improvement

Taking into consideration all mentioned above, the Consultant has examined different possibilities for network improvements, using hydraulic system modeling in EPANET. After a number of simulations adjusted to the current measured hydraulic conditions, the following proposal proved to be the most efficient. The hydraulic model details, as well as detailed scheme for the proposed network changes are presented in the Annex drawings.

*Figure 7-1**Proposed Network Changes in Causeni***

- ***Creation of a common central pressure zone through connection of existing northern and central parts of the network***

In order to reduce pressure in the northern service area it is proposed to connect it to the central low-pressure area through two pipelines, as follows:

1 – Gagarin Str. – Eminescu Str.: HDPE OD225, having length of about 300 m;

2 – Gagarin Str. – Alba Iulia Str. – Unirii Str.: HDPE D225, having length of about 850 m.

Both pipelines will be laid through existing two (2) parallel river crossings made of steel DN300 pipes. The existing steel pipes will be used as protection casings.

In accordance to the existing design requirements, the whole private houses supply area is proposed to be supplied from the PS 2 with pressures from 10 (at the highest points) to 26 m.

No network changes are expected to the central area network, since the proposed connection of the northern area will not significantly affect the existing hydraulic conditions of the central area. It will continue to be supplied from the PS 2 with 2.6 bar.

The purpose of the existing DN300 main pressure pipeline from the PS 2, which currently supplies the northern area reservoir, is proposed to be changed. Whole existing main pipeline will be separated by valves and used in different pressure zones, but on necessity the whole main will be able to be used as reserve pipeline to deliver water to the existing elevated tank.

A segment of this DN300 pressure main is proposed to be connected to the common low-pressure central network and used to supply private houses along M. Viteazul Street. A number of short segments of pipes (of up to 30-50 m each) need to be built in order connect the existing pressure main to the network.

The downstream segment from M. Viteazul Str. to the PS 2 is proposed to be disconnected, since it doesn't have any service connections.

- ***Creation of a high-pressure service area for multi-storey buildings in the Northern part of Causeni***

In order to provide multi-storey buildings with sufficient pressure, it is proposed to separate the area and deliver water by a new booster station (BPS1). The most suitable location for a new BPS1 is at Unirii Street, at the territory of the existing sewerage PS3 (Micro). This will allow reducing investment costs for new power supply infrastructure/transformers.

For the high-pressure area two (2) loops from the existing water network are proposed to be used. The loops shall be separated from the low-pressure areas by a number of valves. The exact limits between pressure zones are expected to be set by Apa-Canal.

The whole area is proposed to be supplied by a new booster pumping station, delivering pressure not less than 26 m at the highest network point. This will cover a 5-floor building pressure requirement.

- ***Creation of a separate service area for Valul lui Traian***

Since the Main PS is proposed to deliver water through to the city center and the existing northern DN300 pressure main will not be used to supply water to the northern part of the town, an isolated area of Valul lui Traian will require a separate new booster pumping station (BPS2).

This BPS2 is proposed to be built in the region of Tighina Highway/Spartacus Str. and it will serve the private houses from Valul lui Traian.

The whole area is proposed to be supplied by a new booster pumping station, delivering pressure not less than 10 m at the highest network point. This will cover a 1-floor private house pressure requirement.

The existing DN300 pressure main is proposed to be partially used as local pressure main from the new booster BPS2.

- ***New pumping equipment***

PS 2

Due to the necessity to create the common pressure zone of Northern and South areas with pressure 2.6 bar and flow of 110 m^3/h, we propose to install booster pump set of two pumps (one working and one standby) with the following parameters of each pump (analogue GHV20/125SV2G150T):

Rated flow	= 110 m^3/h
Rated head	= 27 m
Motor rated power	=15 kW
Actual power at duty point	=13.1 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.

BPS 1

Since proposed BPS will boost water to the 5 story blocks area, the water demand pattern is expected to vary dramatically. Therefore we propose to install booster pump set of three pumps in order to maintain all possible hydraulic regimes (analogue GHV30/15SV02F022T/T) with the following parameters:

Rated flow	= 36 m^3/h

Rated head = 20 m

Motor rated power = 3 x 2.2 kW

Actual power at duty point = 2 x 2.2 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.

Apa Canal Causeni proposed to allocate BPS 1 near SPS3 (Micro) taking into account availability of power and land.

It was additionally proposed to extend pressure pipeline DN200 from the new BPS 1 to the 5 story district of total length 600 m. Existing pipeline is in emergency condition and part of it has reduced diameter of 40 and 76 mm.

We recommend to replace pipe sections with reduced diameters as necessary measure to eliminate unneeded local head losses. All related expenses are not considered in estimation of investment costs.

For the future rehabilitation works replacement of entire section of 600 m will be necessary.

BPS 2

Since proposed BPS will boost water to the private households district with relatively small water consumption we propose to install booster pump set of two pumps (analogueGHV20/5SV05F007T/T) with the following parameters:

Rated flow = 7 m^3/h

Rated head = 26 m

Motor rated power = 1.5 kW

Actual power at duty point = 1.32 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.

Estimation of Savings

Estimated power consumption of existing pumping regime	= 188,471 kWh/year
Estimated power consumption of new pumping regime	= 131,890 kWh/year
Power saving	= 56,581 kWh/year
Reduction of leakages	= 6,500 kWh/year
Assuming 1.8 MDL per 1 kWh	= **113,546 MDL/year**

Estimation of investment cost

Construction of BPS 1	= 400,000 MDL
Construction of BPS 2	= 100,000 MDL
Re-equipment of PS 2	= 500,000 MDL
Construction of 1 250 m HDPE 225 mm pipeline	= 540,000 MDL
Total investment cost	**= 1,540,000 MDL**

Payback period	= 13.6 years

Summary ECM table of pumping modifications:

*Table 7-3**Current Energy Consumption - before Improvements***

No	Site	Before improvements					
		Pump type	Rated power, kW	Actual power, kW	Working hours per day	Energy used, kWh/year	Overall energy used, kWh/year
1	Well no.2	ЭЦВ 10-63-110	32	32.9	18	**216,153.00**	
2	Well no.1	ЭЦВ 8-25-100	11	9.67	24	**84,709.20**	
3	D. Cantemir BPS	K 8/18	1,5	1	18	**6,570.00**	
4	PS2 city	DAB1 K 30/800T	8.3	5.89	24	51,596.40	
		DAB3 KV 6/7T		1,57	20	11,461.00	**188,471.40**
	PS2 rezervoir	K 100/65-250	45	42.95	8	125,414.00	

*Table 7-4**EstimatedEnergy Consumption - after Improvements***

No	Site	After improvements					
		Pump type (analogue)	Rated power, kW	Actual power, kW	Working hours per day	Energy used, kWh/year	Overall energy used, kWh/year
1	Well no.2	Z875 3/2A-L6W	13	13.5	18	**88,695.00**	
2	Well no.1	Z631 04-L6W	5.5	5	24	**43,800.00**	
3	D. Cantemir BPS	BLOCK BGM 7/A	0.775	0.775	18	**5,091.75**	
4	PS 2 city	GHV20/125SV2G150T	15	13.1	24	**91,804.80**	
	BPS 2	GHV20/5SV05F007T/T	1.5	1.32	24	9,250.56	**131,890.56**
	BPS 1	GHV30/15SV02F022T	6.6	4.4	24	30,835.20	

It shall be noted, that PS2 is expected to be equipped with a chlorination plant to provide safe drinking water to the consumers. The construction of the chlorination plant is planned to be done under the NWSSP, financed by the World Bank. The detailed design was made available to the Consultant by WSSPIU, and the following comments are to be done:

- The proposed disinfection plant appears to be oversized, having storage capacity of 6,000 l that can cover chlorine demand for more than 1 year. The age of stored chlorine solution will negatively influence the disinfection process and will lead to increased consumption of chemicals;
- Capacity of the whole plant does not comply with the actual water flow rates. Basing on Auditor's preliminary rough estimations, the current system demand of chlorine solution is some 0.5 kg/h (considering the residual chlorine concentration of 0.5 mg/l);

Basing on mentioned considerations, it is recommended to review the design and to adopt more compact and modern chlorination equipment. This will considerably reduce the investment costs and chemicals consumption, having a good impact on operating costs.

7.6 Other ECM - Leak Detection Equipment

Besides direct infrastructure investments with an immediate impact on energy consumption, other activities to indirectly reduce energy consumption are recommended to be implemented by Apa-Canal. The main way to reduce the volume of pumped water is to reduce the considerably high amounts of network leakages. To this end, a set of leak detection and pipe location equipment is recommended to be procured. A set of equipment shall include, but not be limited to:

- Acoustic leak detector – 1 set;
- Correlator – 1 set;
- Portable flow meter – 1 set;
- Pipe/cable locator – 1 set.

It is expected that regular leakage monitoring will allow considerable reduction of real water losses, as well as partial identification of the apparent losses. However, it is rather difficult to precisely estimate the extent of reduction of water leakages, since this activity strongly depends on other external factors, e.g. funds available for repair works and pipes replacement.In long term, it is expected that leak detection equipment will help to reduce some 15% of existing real losses.

Estimation of costs for leak detection equipment

Acoustic leak detector	= 40,000 MDL
Correlator	= 160,000 MDL
Portable flow meter	= 130,000 MDL
Pipe/cable locator	= 50,000 MDL

Three monthsleak detection program would require employment of minimum two qualified engineers. Additional maintenance expenses would be transportation, excavation costs and repair of leaking pipes:

Salary	= 30,000 MDL
Transportation costs	= 10,000 MDL
Excavation	= 20,000 MDL

Pipes repair = 50,000 MDL

In total approximate capital investment costs for leak detection program would be 500,000 MDL,

Real loss reduction of 15% in Causeni distribution network will be approximately 36 m^3/day or 13,000 m^3/year.

Average specific energy consumption is 0.7 kWh per 1 m^3 of pumped water into the system of Causeni. Leak reduction of 13,000 m^3/year would save 9,100 kWh or **16,380 MDL** (1.8 MDL per 1 kWh).

The payback period of such measure is 30.5 years. Therefore this measure is not included in the proposed ECM list for Causeni.

In general procurement of leak detection equipment set is justified for bigger cities or in Causeni case it might be shared with adjacent localities.

7.7 Economic Assessment of the Proposed ECMs.

The calculated payback period for the proposed ECMs is presented in the following Table.

*Table 7-5**CalculatedPayback Period for the Proposed ECMs***

No	Site	ECM effect				
		Energy savings, kWh/year	Tariff rate, MDL/kWh	Cost savings, MDL/year	Invesment cost, MDL	Payback period, years
1	Well no.2	127,458.00	1.80	229,424.4	198,660	**0.9**
2	Well no.1	40,909.20	1.80	73,636.56	145,860	**2.0**
3	D. Cantemir BPS	1,478.25	1.80	2,660.85	7,000	**2.6**
4	PS 2 city BPS 2 BPS 1	63,080.84	1.80	113,545.51	1,540,000	**13.6**

7.8 Summary reduction in Energy Consumption

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

*Table 7-6**Estimated Energy Savings***

Site	Estimated average yearly power demand (in kWh)	
	Before improvement	After improvement
Well 2	216,153	**88,695**

Well 1	84,709	**43,800**
PS 2	188,471	**131,890**
WWTP (transformer no-load run fee)	9,000	**0**
Reduction of leaks due to the pressure drop in the Northern supply area	6,500	**0**
D Cantemir BPS	6,570	**5,092**
Total power consumption	511,403	**269,477**
Saving in kWh	**241,926**	
Overall saving in percent	**47%**	
Estimated savings of overall Apa-Canal power consumption (average 2008-2010 663,640 kWh)	**36%**	

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

In the inception phase Apa-Canal Causeni submitted to the Consultantalist of ECM proposed to be implemented within EMP:

*Table 7-7**Initially Proposed ECM by Causeni Apa-Canal***

No.	Description	Existing equipment	Needed equipment	Expected savings, %
1	Installation of submersible pump at borehole no.1	-	Q=25 m^3/h H=64 m	**-**
2	Replacement of submersible pump at borehole no.2	ЭЦВ 10-63-110	Q=70 m^3/h H=60 m	**25.5**
3	Replacement of submersible pump at borehole no.3	ЭЦВ 8-25-150	Q=25 m^3/h H=60 m	**51.6**

First two items from the list generally correspond to our recommendations. The flow and head parameter of initially chosen submersible pump are different from the proposed above. We based our choice of equipment on actual measurements of pumping flow and dynamic water level in the relevant well.

We consider replacement of submersible pump in well no 3 unnecessary, since Apa-Canal reported that the dynamic water level in the well no 3 has dramatically dropped. We propose to re-equip wells Nos. 1 and 2. Their common capacity shall be sufficient for present and future Causeni water demand.

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

ANNEXES

Final Report

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