REPUBLIC OF MOLDOVA

APA CANAL CHISINAU

CHISINAU WATER SUPPLY & SEWAGE TREATMENT - FEASIBILITY STUDY

Contract No: C21156/ECWC-2010-01-01



Revised Draft Inception Report – APPENDICES

Experts Reports

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seureca A Subsidiary of VEOLIA ENVIRONNEMENT

In association with and Business Consulting Institute

European Bank for Reconstruction and Development and EU Neighbourhood Investment Facility

Appendix 1

Water Demand Study

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LIST OF ABBREVIATIONS AND ACRONYMS

ACC	Apa Canal Chisinau
BCI	Business Consulting Institute
EBRD	European Bank for Reconstruction and Development
ESCP	Ecole Centrale Paris
GDP	Gross Domestic Product
LPCD	Litre Per Capita and Per Day
PSU	Primary Sampling Units

EXECUTIVE SUMMARY

The presentation of the various tasks to be achieved shows the complexity of the approach, based on the necessity of gathering a lot of pieces of information coming from many sources, i.e.: (i) ad hoc surveys quantitative (household survey) and semi-quantitative (large summers survey); (ii) statistics on population, on water consumption and on economy; (iii) spatial development within the study area.

All these pieces of information will be set in order and their consistency will be checked. Then two separate calculations will be made, one for domestic demand (related to households) and the other for non-domestic demand (for administrative bodies and economic agents).

Present and future population have been calculated per small geographic area, in order to be able to calculate the water demand for each of these areas. At present, in 2009, the study area comprises of 811,000 persons overall, of which 630,800 live in the 5 districts of Chisinau City and 91,000 in rural areas. In the past as well as in the future, the population will experience a slight decline due mostly to net out-migration: in year 2034, the study are will comprise of 791,000 inhabitants, of which 604,800 live in the 5 districts of Chisinau City and 91,000 in rural areas. In the meantime, this distribution of the population throughout the city will have changed, and more than 100,000 persons will have shifted from the city centre to peripheral areas.

A household survey is to be carried out in order to assess, among others, households affordability (based on the share of the family budget devoted to water purchase and sanitation) and willingness to pay for an improved service in water and sanitation, but also average water consumption, cost of water and other public utilities, expenditures and income, etc. Also mode of water supply and sanitation, as well as households' satisfaction and expectations will be studied. The method will be quantitative, and a questionnaire with mostly closed questions. Concretely, a statistically representative sample 1,000 households selected at random all over the study area will be interviewed at their home (face to face).

A large consumer survey is being prepared in order to identify the specific features, expectations and intentions of these organisations, the consumption of which has a major influence on the total non-domestic consumption (and water supply company's turnover). They will be asked questions on their activity, their mode(s) of water supply, water consumption and cost, the water quality requirements, the mode of sanitation and cost, the planned development of their organisation and their expectations in terms of water and sanitation (quantities, quality and cost). The method will be semi-quantitative / semi-qualitative. Concretely, the 50 larger consumers in the study area will be identified and interviewed (face to face).

This basic information will give an accurate understanding of their present and future water consumption, and consequently of an important percentage of the non-domestic demand in the study area.

Commercial statistics are derived from the ACC and INFOCOM data bases. So far, just few basic data were analysed and presented in this report (in-depth analysis of these data is a vital task that will be achieved later, when the final appropriate files are made available, and their consistency checked with the original files).

Over the last 10 years, the billed water consumption decreased significantly, from 64.6 million m^3 in 2000 to 46.3 in 2010, i.e. a 28% decrease over the 10-year period. In 2009, 77% of the billed consumption was domestic.

A first estimate of the per capita consumption, based on a very rough (and large) estimate of the population served, gives a fairly low figure: 111 litres for domestic consumption, or 143 if including also the non-domestic.

Economic data deal mostly with macro-economic data (past and future evolution of GDP per economic sector), with micro economic data and with households standard of living.

With the existing data (2009), the share of water and sanitation was 1.1% of the average households, which seems fairly low (as compared to the EBRD standards). A quick approach of affordability for water and sewerage leads to an affordable amount of 118 lei per month for “average households”, and 109 lei per month for poorer households; these amounts would correspond to respectively 11.3 and 9.4 lei/m^3 (assuming respective per capita consumption of 130 and 110 litres).

DETAILED REPORT

1. OVERALL APPROACH

1.1. STRATEGIC OPTIONS

1.1.1. STUDY AREA

1.1.1.1. Overall

The study area covers a non-homogeneous area that corresponds to various Apa Canal activities: (water supply and/or sewerage and/or only maintenance of networks) as well as various residence areas (large towns, small towns, rural). It comprises of 5 areas:

- Chisinau municipality:
  - Chisinau City, with 5 districts, and the larger population (about 630,800 persons in 2009)
  - Chisinau urban, with 6 small towns outside the city limits
  - Chisinau rural, with 28 villages
- Outside Chisinau Municipality:
  - urban, with 2 small towns
  - rural, with 7 villages

Table 1: Study area, per zone, and population

Geographic Zone	# districts/ towns/ villages	Population (in 2009)	Percentage
Chisinau Municipality			
City (5 districts)	5	630,800	78 %
Urban (small towns)	7	55,982	7 %
Rural	30	69,892	9 %
Sub-total (Chisinau Municipality)	**-**	***756,674***	***94 %***
Outside Chisinau Municipality			
Urban (small towns)	2	33,598	4 %
Rural	7	20,876	2 %
Sub-total (Outside Chisinau Mun)	**-**	***54,474***	***6 %***
Study Area			
Total	**-**	**811,148**	**100 %**

Source: Estimates derived from *Urban Development Plan*

The distribution of population shows the respective importance of the various areas. Of course Chisinau City accounts for 78%, but small towns as well as rural areas account for respectively 11% and 11%.

1.1.1.2. Small geographic areas

Many divisions of the study area exist, such as the City districts, the Census districts and sub-districts, etc. Each of these divisions is used by the corresponding administration body in order to present statistical data that it produces.

Of course the geographic areas to be considered should be compatible with Apa Canal areas, i.e. with water consumption statistics. This is the reason why the sectors within the city as well as towns and villages outside the city are the basic geographic areas for the water demand study.

Accordingly, all the data that will be presented in our study will be distributed per such areas, irrespective of the activity of Apa Canal (providing water services or not, sewerage services or not).

1.1.2. TYPES OF WATER

All types of water shall be taken into account, irrespective of the:

- Source: ACC / another water supply company / a private well or borehole (“sonda”) / etc.
- Usage of the water: cold water or hot water
- Type of treatment, including no treatment i.e. raw water (”apa bruta”) or partially treated (“apa tehnica”)

This means that it includes not only the water supplied by ACC or another local water supply company, but also the water coming from private wells as well as from tanker trucks (if any).

The reason for doing so is twofold: in the future, ACC may be lead to supply all the quantities of water that their customers use. Also, the water demand should cover also the needs for sanitation (i.e. volumes of water that are discharged into the natural habitat).

1.2. RATIONALE

Among various aspects of water demand, there is one that is very important: the use of water. In fact, the methods for forecasting water demand and to plan its supply are completely different, when dealing with domestic or non-domestic water (even if both depend, to a large extent, upon the offer of water).

1.2.1. DOMESTIC DEMAND

The domestic water is defined as the water that is consumed by private households, i.e. either at home or outside, but for private purposes. Domestic demand depends:

- For the present time: on the socio-economic situation of households as well as on the presence of individual metering at home and on the water tariff.

- For the future: on demographic pressure and urban development policy, changes in people's consumption habits due to metering and willingness to consume more and to pay for this, as well as on the ACC investment programme and tariff policy.

According to ACC water consumption statistics, this category is defined as “Populatie”.

1.2.2. NON-DOMESTIC DEMAND

It is important to consider the evolution principles of the various types of non-domestic consumers. That is why we will consider the 2 “ACC sectors” and 3 subcategories according to the size of the consumer:

ACC billed water statistics distinguish 2 categories:

- Administrative organisations (“organizatii budgetare”): corresponds mostly to administrative bodies, as well as to public education organisations.
- Economic activities (“agenti economici”), which are the major non domestic water consumers in the study area. It includes all public and private health organisations, private schools.

Size of consumer:

- “Proximity” consumers are accounting for all the small activities, either public (dispensaries and primary health centres, kindergartens and primary schools) or private (vicinity activities such as workshops, small shops and local services, handicraft, etc.). These activities may belong to any of the previous categories. In fact, the existence of small non-domestic activities is usually generated by the presence of population: the corresponding water demand is strongly linked to the domestic water consumption in the area, and pertaining quantities should be derived from it (for this, it is possible to apply a certain percentage to the domestic demand).
- “Large consumers” may be the major non-domestic water consumers in the study area. Their future water consumption should be derived from the information that they usually give directly in the course of a specific interview.

  For the requirements of our study, they are defined as the 50 largest water consumers, identified in the ACC customer data base.
- “Medium range” consumers are an intermediary category between large and proximity consumers. Their consumption is given by difference, and its evolution is strongly linked to the future economic growth (per sector).

The evolution of this demand is affected by the water tariff, as well as by the general evolution of the national and local economy; but also by specific consumption strategies, such as the investment policy of large companies that have already a plant in the study area, the willingness of new companies to build plants in the study area, etc.

1.2.3. DOMESTIC / NON-DOMESTIC DEMAND IN THE STUDY AREA

A quick analysis of the billed water consumption in the study area in 2009 shows that:

- the domestic consumption accounts for 77%, which is a fairly high level
- the administrative bodies for 5%
- the economic agents for 18%

This shows how important the domestic demand is, and how the carrying out of an in-depth household survey is vital. As compared to other large cities in the region, the situation in Chisinau differs: slightly from Bucharest but much from Prague, where respectively 73.5% and 58% of the billed quantities of water are domestic.

1.3. METHODOLOGY

In the chart below[1], two different patterns are described, one for each broad group of consumers, one for the domestic demand (that of the households, i.e. population), the other for the non-domestic demand (administrative bodies, and economic activities). The detailed operations (numbered on the chart) are the following:

1.3.1.1. Overall

1. Study area: definition of the limits. This will have major influence on domestic as well as non-domestic water demand
2. Commercial statistics : analysis of the customer data bases (ACC and INFOCOM), in order to derive pieces of information on the past and present situation:
   - Mode of water supply (domestic) and type of sanitation (and elements of calculation)
   - Domestic consumption (and possibly per capita consumption)
   - Proximity non-domestic consumption
   - Large consumers, and their consumption
   - Medium range consumers, and their consumption
3. Population and urban development: present situation and future evolution, per geographic zone

1.3.1.2. Domestic Demand, per geographic zone

4. Household survey[2].

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1 **Source**: *L'analyse des besoins : la demande en eau* - Exposé présenté à l'ESCP dans la cadre du Mastère spécialisé "Management des Projets Internationaux" - G. Roger, février 2005

2 It is a quantitative sample survey (1.000 households).

5. Cost of water : derived from the household survey, but consistent with the commercial statistics
6. Mode of water supply[3], per geographic zone: present (derived from the household survey), and future (assumption chosen in close coordination with decision makers)
7. Per capita consumption, per geographic zone: present (derived from the household survey), and future (assumption chosen in close coordination with decision makers)
8. Domestic demand (per geographic zone), present and future: calculated from elements 1, 2, 3, 6 and 7

1.3.1.3. Non-domestic Demand, per geographic zone

9. Proximity demand, present and future, per geographic zone: linked with the total domestic demand, and consistent with commercial statistics
10. Large consumers, consistent with commercial statistics
11. Large consumers survey: present and future demand, per geographic zone
12. Medium range consumers, per geographic zone: based on macroeconomic statistics (growth rates of GDP per sector, for existing activities) and future urban development (for activities to be created)
13. Non-domestic demand (per geographic zone): calculated from elements 1 and 2, 9 to 12

1.3.1.4. Total Demand

14. Total demand (domestic + non-domestic), per geographic zone = sum of elements 8 to 13

1.4. DETAILED PRESENTATION

A detailed presentation will be given in this report on the following part of our study:

- Household survey
- Large consumers' survey
- Commercial statistics
- Urban planning and population
- Economics

[3] Distribution of population per mode of water supply, irrespective of the source

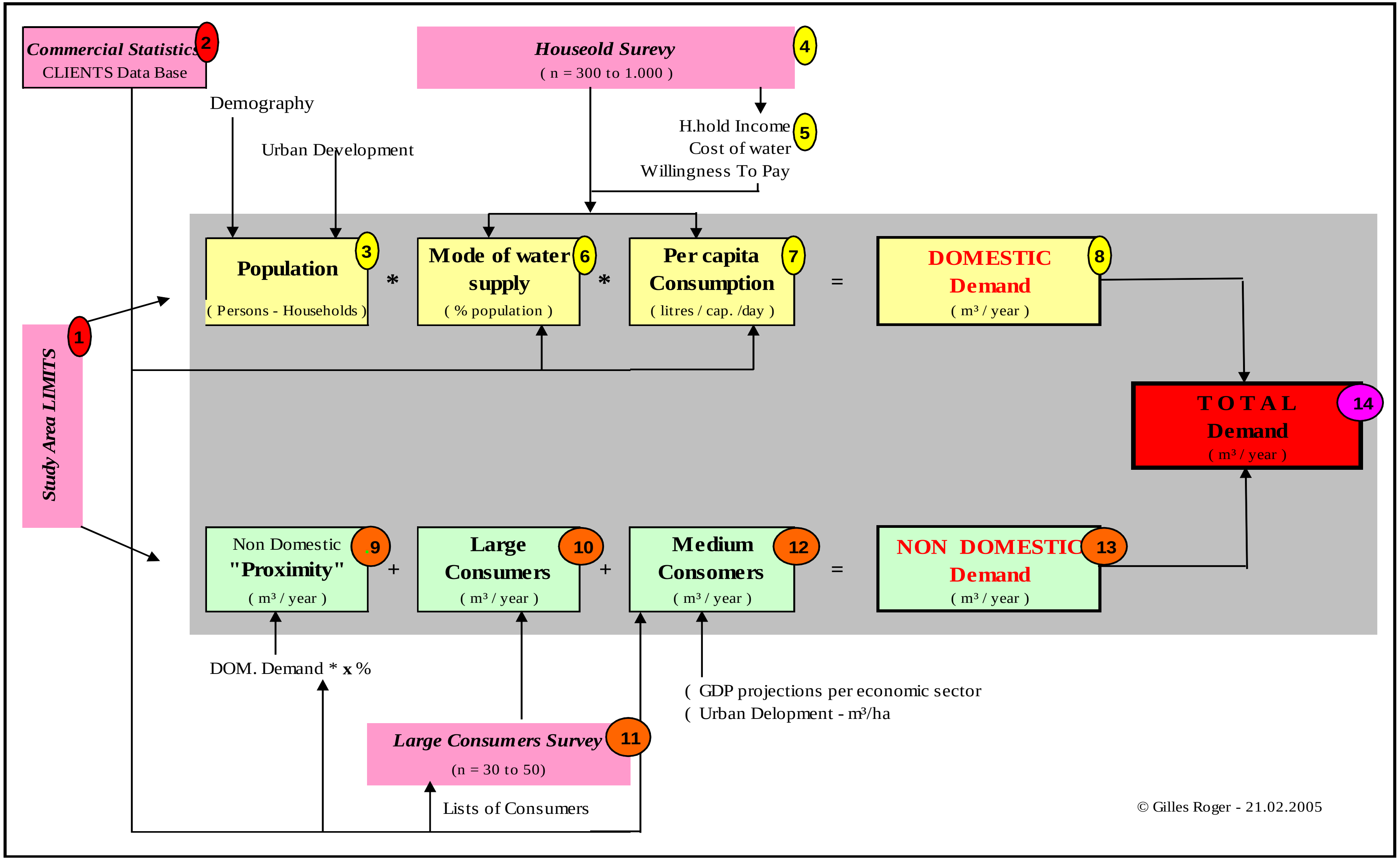


Figure 1: Water demand study detailed plan

2. POPULATION AND URBAN DEVELOPMENT

A detailed study on population and urban development per small geographic area has been carried out, in order to be the basis of the domestic water demand. This study was based on the major existing studies:

- Results of the 2004 Population Census
- Chisinau Statistical Yearbooks
- Municipal Spatial Development Plan
- Chisinau Municipality General Urban Plan
- Chisinau Urban Development Concept
- Chisinau Economic Recovery Plan
- Etc.

2.1. POPULATION

A table is presented in Annex 1 with the present and future population in the study area, per geographic area: each district of Chisinau, and each small town and village inside Chisinau Municipality and in surrounding rayons.

- In 2004[4], date of the last population census, the population of the study area was 766,354 persons, of which 589,449 (i.e. 77% of the total) belonged to Chisinau city.
- In 2009, the last estimate published by the National Bureau of Statistics states that there are 756,700 persons in Chisinau Municipality: 630,800 for Chisinau City, 56,000 for suburban areas and 69,900 for rural areas.

2.1.1. PAST EVOLUTION

Chisinau Municipality population experienced a significant decline that started early in the '90s and continuing from now. Chisinau city's population decreased by around 12% between 1989 and 2004. Such decline was mostly the consequence of relatively intensive emigration waves over the last 20 years

From 2004 till now, the recent evolution results much more from an "administrative adjustment" of around +5% (due to undercounts during the 2004 census) than from an unexpected change in the growth tendency (the natural increase has remained very small: for instance, around 0.2% in 2009).

[4] Exact date is: 01.01.2010

2.1.2. Future Evolution

The major determinants of Chisinau population growth are: a fairly low fertility, an ageing population and net out-migration (affecting mostly people in working age). These will result in higher mortality and declining number of births.

Hence the population of the study area is expected to decline very slightly from 811,148 inhabitants in 2009 to 790,959 in 2034. The rural population will remain the same: around 91,000 persons.

Table 2: Population of the study area, per geographic zone: evolution 2004-2034

Geographic Zone	2004	2009	2014	2019	2024	2029	2034
Chisinau Municipality							
City (5 districts)	589,449	630,800	637,513	632,191	627,115	619,543	604,858
Urban (outside city)	54,759	55,982	57,900	57,857	57,834	57,832	57,851
Rural ("sate")	13,347	13,422	13,419	13,380	13,340	13,301	13,262
Rural ("commune")	54,667	56,470	57,293	57,122	56,950	56,780	56,610
Sub-total	***712,222***	***756,674***	***766,126***	***760,549***	***755,240***	***747,457***	***732,581***
Outside Chisinau Municipality							
Urban	33,361	33,598	36,017	36,798	37,596	37,596	37,596
Rural	20,771	20,876	20,907	20,845	20,782	20,782	20,782
Sub-total	***54,132***	***54,474***	***56,924***	***57,642***	***58,378***	***58,378***	***58,378***
Study Area							
Total	**766,354**	**811,148**	**823,050**	**818,192**	**813,618**	**805,834**	**790,959**

Source: *Chisinau Municipality: Urban Development Tendencies (demography & land use)* – G. Ivascenco, for the Chisinau Water Supply & Sewerage Treatment, Feasibility Study – February 2011

2.2. Urban Development

2.2.1. At Present

Chisinau city covers an area of 12,301 hectares of which:

- Housing (commercial and social infrastructure) accounts for 4,584 ha, i.e. 37%
- Green areas for 2,801 ha, i.e. 23%, and 28% if including the 652 ha of agriculture land
- Industry, transport and communication for 2,778 ha, i.e. 23% (of these, 2,631 ha correspond to the old industrial "platforms" inherited from the Soviet past of the city).
- Reserve fund for 940 ha, as well as natural protection and health for 413 ha and hydro resources for 134 ha.

In Chisinau City the average density is 51.7 inhabitants per hectare, at present. Densities per small geographic area are presented on a map in Annex 2.

2.2.2. FUTURE EVOLUTION

Chisinau will follow a polycentric development strategy, aiming at:

- De-concentration of the commercial and social functions from the city centre to suburban development residential areas towards: airport rayon, Budesti-2, Colonita, Buiucani, Ghidighici, Stauceni
- De-industrialisation within the city and evacuation of industrial functions: the Bic river area is targeting the transformation of old industrial areas into diverse recreation and leisure functions

Maps No 1 and 2 here after, show the urban development strategies for the next 25 years for Chisinau territorial:

1. development strategy
2. polycentric strategy

But the overall density is expected to decline slightly over the next 30 years (49.6 inhabitants per ha in 2034) due to:

- Densification in areas within the city limits the North West, and especially in the South West
- Movement of population from the city centre towards new zones located in the peripheral outside the present city limits, especially in the North East and South East

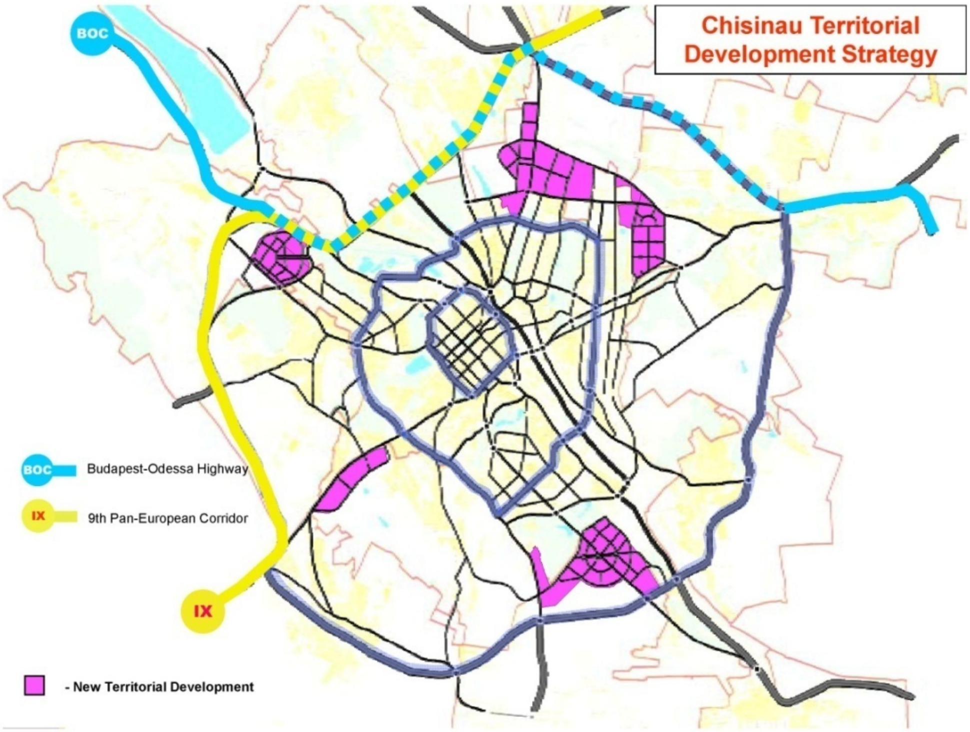


Figure 2: Chisinau Territorial Development Strategy

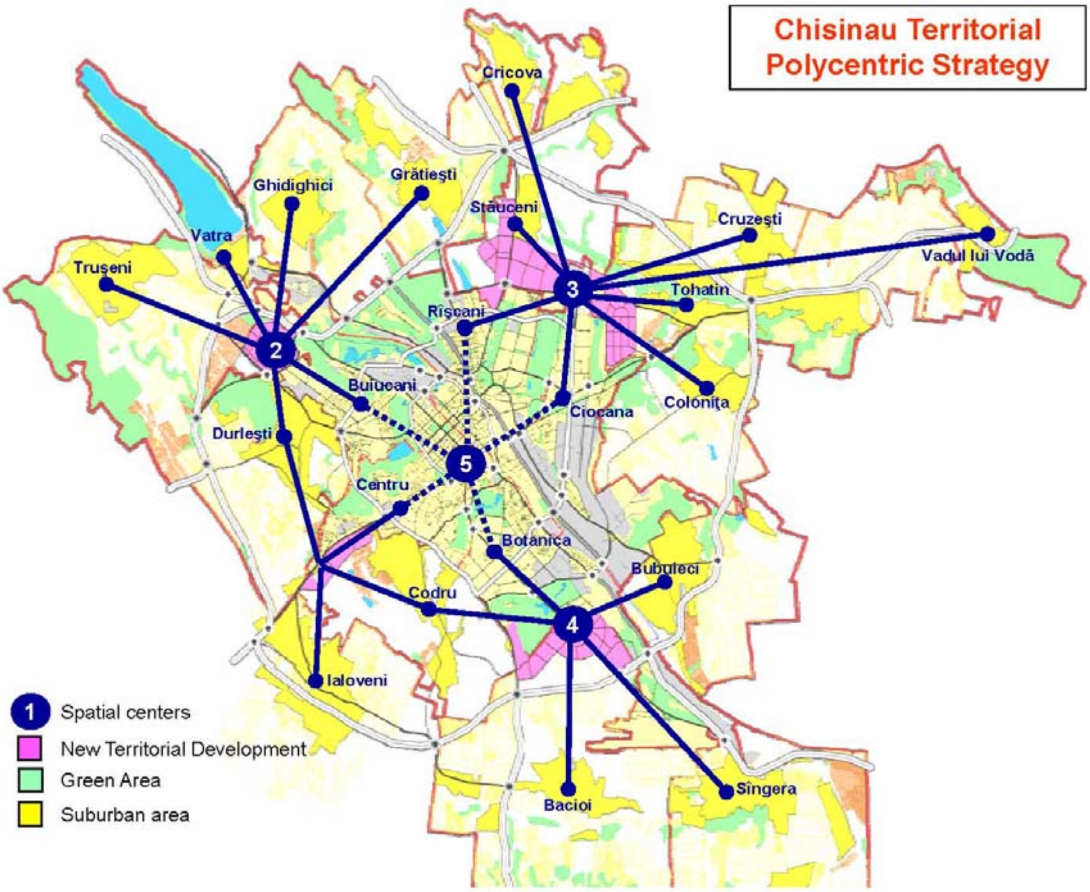


Figure 3: Chisinau Territorial Polycentric Strategy

3. HOUSEHOLDS SURVEY ON AFFORDABILITY AND WILLINGNESS TO PAY

3.1. OBJECTIVES

The survey will be carried out in the project area (urban and rural) in order to catalogue the wastewater facilities in use as well as the water facilities, to assess levels of service and common problems, and to describe the attitudes and opinions of citizens towards the services and systems for water supply and waste water.

3.1.1. GENERAL OBJECTIVE

The general objective of the household survey is to assess the level of facilities and service in the project area, and the public's opinion on the existing water and wastewater services including affordability and willingness to pay for improved service.

3.1.2. SPECIFIC OBJECTIVE

The specific objective of the household survey is the collection of quantitative data (for description of the situation, statistical analysis and interpretation) and qualitative data (for a more causal and in-depth interpretation).

Data that will be collected at the household level will concern:

- Number of persons in the household
- Income and expenditure / Households' affordability
- Mode of water supply
- Water consumption and cost water
- Share of household income devoted to water purchase / benchmark
- Satisfaction of water service
- Expectations about possible improvements
- Type of wastewater facility in use at present (behaviour and practices), and cost
- Satisfaction of wastewater service (if any)
- Opinion on quality of environment
- Willingness to pay: price to be charged for improved services

3.1.3. Use of the Survey Results

The household survey is conducted in order to feed the other team members of the project with recent and reliable data, in order to help them in developing both the technical and financial aspects of the Water Supply and Sewerage Feasibility Study:

- Water demand and sanitation assessment
- Tariff policy, and financial planning: affordability and assessment of willingness to pay
- Specify which service should be proposed to the various segments of the population: present (description of existing on-site facilities, of existing problems) and future (identification of type of service preferred by the public)
- Marketing and social water and sanitation policy

Of course all the recommendations of the project should help ACC, as well as all the water management institutions to improve the quality of the service proposed to their clients and their effectiveness (technically, economically and socially).

3.1.4. Tasks to Be Achieved in Order to Obtain the Results

The tasks to be carried out from beginning till the end are the following:

- Preparation : mostly design of questionnaire and sample design
- Data collection in the field
- Coding, data capture, and editing
- Tabulation and analysis
- Report writing

3.2. The Questionnaire

3.2.1. Principles

Type of interview: face to face, in the dwelling of the respondent.

Statistical unit to be interviewed: household member responsible for expenditures in the household.

Duration of interview: 45 minutes, on average.

Number of questions and issues in the questionnaire will limit to:

- Maximum response time of an average of 45 minutes. Questionnaire includes an Income and Expenditure section (responses need to be recorded as amounts, not as categories): approximately 20 minutes

- About 200 variables: if one additional essential question is to be included, then another (second priority) question shall be removed from the existing questionnaire
- No more than 5 open-ended questions (used only for causal analysis, and/or to capture spontaneous answers).

The team has tried to be as comprehensive as possible, and then to ask as many questions as possible. But, in the same time, time and budget are limited: hence, a standard has been defined as a maximum in order to limit the duration of the interview (no more than 45 minutes) so that each interviewer interviews 8 households every day, on average.

Discussion with stakeholders

As soon as the first draft questionnaire was ready, it was discussed with the company in charge of the field work (CBS - AXA) and consequently modified. This amended version (in English) was put in the appropriate format and languages (Romanian and Russian).

It should be acknowledged that long lasting technical discussions between the socio-economist, the survey team and the engineers have already been organised, and that observations from the field (especially about the existing types of toilet facility) have been taken into consideration.

Pilot testing

A pilot survey was conducted in order to test the questionnaire in the field: the purpose of the pilot survey was to test: clarity of wording and questions and their relevance to the situation in the field. About 21 interviews are to be carried out.

Based on the pilot testing results the team modified the instruments and submitted to Water Demand Specialist the final version for approval before beginning data collection in the field.

3.2.2. CONTENT

The questionnaire (in Annex 3) is composed of several sections:

Household and housing

- Area: urban/rural
- Housing: type of housing, number of rooms, area, type of ownership
- Household: number of persons (per age), number of households in same dwelling
- Respondent: sex, age

Water

- Water supply taps and household appliances
- Mode of water supply (per usage), storage equipment

- Water consumption, per main use: either connected to network (from the bill), or not connected (estimate)
- Water cost: amount, mode of billing, etc.
- Satisfaction of quality of service provided

Other public utilities (for benchmarking)

- Electricity
- Solid waste disposal
- Satisfaction of quality of service provided
- Priority/Importance of various public utilities

Wastewater

- Type of toilet facility
- Type of wastewater facility, per type of wastewater (grey and black) equipment
- Wastewater discharge points
- Satisfaction of quality of service provided
- Households not connected to the sewerage network (mostly septic tank users):
  - Emptying of tank: frequency, cost, place of disposal of sludge, problems, etc.
  - Place of disposal of overflow
  - Preference for septic tank or sewer: (i) if sewerage network: cost of connection, monthly cost; (ii) if septic tank: cost of improved emptying system for septic tanks
- Households connected to the sewerage network:
  - Cost (amount, mode of billing, etc.), problems (bottlenecks, inconveniences and failures), opinion
  - Willingness to pay for improved sewer system (i.e. with treatment of wastewater)
- Test of opinions on sanitation and discharge of wastewater in natural habitat

Living conditions

- Income
- Expenditure
- Major household assets

3.3. THE SAMPLE

3.3.1.1. Objectives

The base area from which a sample shall be drawn is Chisinau Municipality and some localities from suburban rayons, which include:

- Within Chisinau Municipality limits:
  - 5 sectors of Chisinau city: Centru, Buiucani, Rascani, Ciocana and Botanica,
  - 6 cities
  - 13 rural localities
- Outside Chisinau Municipality limits:
  - cities of Straseni and Ialoveni
  - 7 rural localities of Straseni, Anenii-Noi and Criuleni rayons

The study area is considered as a whole, irrespective of the type of settlement (urban or rural), or of the level of water and/or sanitation service (served/not served by a public utility, connected/ not connected to a sewerage network, or of socioeconomic level (income, household assets, etc.)

The survey methodology, including sample size and sampling rates, shall aim at obtaining statistical representativeness of the various settlement categories and of the various housing categories.

The sample will be designed in order to obtain results that will be statistically significant:

- for each of the 5 sectors of Chisinau city,
- for urban settlements of Chisinau municipality,
- for rural settlements of Chisinau municipality
- Other localities from the outside zone of Chisinau.

A random sample of households shall be drawn for each stratum.

3.3.2. PRINCIPLES

The principles for the design are the following:

- ***Large sample size:*** a large sample should be surveyed in order to obtain statistically significant results at a detailed geographic level. It is planned to interview 1,000 households scattered in more than 60 “sampling points” (Polling Stations). The number of 1,000 is an optimum between the ambition of reducing the sampling error and the budgetary constraint.
- ***Stratification:*** the 9 strata. The sample will comprise minimum 100 households interviewed in each 9 strata. This number of 100 is considered as an optimum, between scientific and field constraints.

- Of course, the proportionality to the population of each municipality will not be respected (the sample is not proportionally distributed with the strata size), in order to represent correctly the various areas. But, for tabulation and analysis, it will very easy to "reweigh the sample" in order to obtain an average for the study area, which includes the adequate proportionality.

3.3.3. Sample Design

The stratification of the sample has been carried out by equal distribution on layers. For each stratum there is pre-established the sample size according with the following table:

Table 3: Sample design by study areas

#	Stratum	Sample Size
Chisinau Municipality		
1	Centru Sector	125
2	Buiucani Sector	125
3	Riscani Sector	125
4	Ciocana Sector	125
5	Botanica Sector	125
6	Other urban localities	100
7	Rural localities	100
Outside Chisinau Municipality		
8	2 cities	100
9	7 villages	100
Study Area		
Total		**1,125**

Consequently the selection is made in two stages.

First stage: Selection of Primary Sampling Units

100 Primary Sampling Units (PSU) are randomly selected.

The PSU's are Polling Stations territories (approximate size of census units). Polling stations territories enable the most reliable sample selection, due to the fact that, for these units, the most complete data are available (dwelling register and addresses).

Polling stations territories are defined by street name(s) and dwelling numbers. The total number of selected polling stations will be 204 from a total of 321 in the study area:

- 28 PSUs in every sector (strata 1-5)
- 19 in the cities from Chisinau Municipality (stratum 6)
- 21 villages from Chisinau Municipality (stratum 7)
- 15 in 2 cities outside of Chisinau Municipality (stratum 8)
- 9 in 7 villages outside of Chisinau Municipality (stratum 9)

Table 4: Number of Polling Stations (PSU) and households, per Municipality

#	Stratum	PSU Polling stations (2010)	Households (Census 2004)	PSUs selected for the survey
Chisinau Municipality				
1	Centru Sector	44	30,654	28
2	Buiucani Sector	41	37,238	28
3	Riscani Sector	54	48,194	28
4	Ciocana Sector	37	36,145	28
5	Botanica Sector	66	57,985	28
6	Other urban localities	21	13,611	19
7	Rural localities	34	19,213	21
Outside Chisinau Municipality				
8	2 cities	15	10,191	15
9	7 villages	9	6,783	9
	Study Area			
Total		**321**	**260,014**	**204**

PSU's will be selected using a statistical step, established by dividing the total number of voting sections by the number of voting sections included in the sample.

This procedure will be not applied in the strata 6 and 9, in case of which the low number of sections allows to include all the sections from the strata data. In the case of these strata the numbers of interviews will be proportionally divided by their amount (the number of electors included in the official voting lists).

Second stage: Selection of Secondary Sampling Units

The statistical units to be interviewed (and then selected) are households, defined as a group of people who live in the same dwelling and share expenditure and food.

In each selected PSU (polling station unit), a fixed number of sample households will be selected: 5 households.

The sampling method will be selection of households: systematic sample with random choice of the starting point and equal steps of choice.

3.3.4. STATISTICAL RELIABILITY

The statistical reliability will be computed according to the size of the sample. The confidence interval varies differently when the observed variable is an average or a proportion, but no reference is made to the size of the total population:

- ***average:*** the value of the average "m" has 95% chances of being included in the following confidence interval

  m +/- (1.96 σ / square root of n)

Where "σ" is the standard deviation of the observed variable and "n" is the sample size.

- ***proportion:*** the value of the proportion "p" has 95% chances of being included in the following confidence interval

  p +/- [1.96 square root of ((p*q)/n)]

  Where "q" is equal to (1-p) and "n" is the sample size.

So, the larger the sample size is, the larger will be the accuracy, and the smaller will be confidence interval. The observed value has:

- 66% chances of being situated within the interval observed value $\pm\ \sigma$
- 95% chances within the interval observed value $\pm\ 2\sigma$

Table 5: Accuracy of a theoretical sample, according to its size and the type of observed variable

Sample size (a)	Confidence intervalle (95%)	Relative error ($\pm$, in %)
Average – Household size of 3.1[b)]		
100	[4.79 – 6.01]	12.3
125	[4.85 – 5.95]	10.9
1,000	[5.21 – 5.59]	3.9
Proportion – p = 10%		
100	[0.04 – 0.16]	58.8
125	[0.05 – 0.15]	52.6
1,000	[0.08 – 0.12]	18.6
Proportion – p = 50%		
100	[0.40 – 0.60]	19.6
125	[0.41 – 0.59]	17.5
1,000	[0.47 – 0.53]	6.2

(a) Number of interviewed households

(b) Calculations were made with a size of 3.1 persons, and a σ of 3

In our study area:

- For an average (such as the household size defined in the table above), the relative error is 3.9% for the overall study area, whereas it becomes 10.9% if taking 9 strata into consideration with 125 households sample or 12.3% if taking into consideration with a sample of 100 households.
- For a distribution of 10% vs 90%, for example 10% of households from a village are connected to piped water supply system, the relative error is 18.6% for the overall study area, whereas it becomes 52.6% if taking 9 strata into consideration with 125 households sample or 58.8% if taking into consideration with a sample of 100 households.

- For a distribution of 50% vs 50%, the relative error is 6.2% for the overall study area, whereas it becomes 17.5% if taking 9 strata into consideration with 125 households sample or 19.6% if taking into consideration with a sample of 100 households.

3.4. Field Work

3.4.1. Selection and Training of Interviewers and Supervisors

Interviewers and supervisors are recruited from the most experienced workers and interviewers from CBS-AXA. Criteria for selection of the interviewers and supervisors are: qualification, communicativeness, experience in field work and familiarity with the area in which the survey is carried out.

The number of interviewers and supervisors who will be trained is always large enough to ensure enough interviewers for fieldwork including drop rate.

Training of interviewers is carried out short before the beginning of the field work. All interviewers and supervisors / coordinators attend training. The training is organised in CBS-AXA central office. The training includes:

- Detailed overview of the object of the survey
- Overview of the questionnaire
- Interviewing method with special focus on sensitive questions and possible difficulties during the interview, including the instructions related to guaranteeing the confidentiality of response
- Detailed instructions of respondent selection and fieldwork procedure.

The training sessions are organised in formal classroom training as well as in mock interviews.

Interviewers are provided with detailed written instructions of respondent selection and fieldwork procedure.

3.4.2. Interviewers' Fieldwork Procedure

Interviewers follow the written instruction in the choice of starting point (dwelling address) and the road (sampling interval - interviewers walk).

- Interviewer goes to the dwelling addresses from the list he/she is provided with. While entering in the dwelling, he/she follows the procedure of choosing the apartment he/she was instructed in at the training, and has it in the written instruction (e.g. only one apartment in the building can be visited; which floor to go, and how to select the apartment, etc.)

- After choosing the apartment, interviewer will choose as respondent the person who is in charge of revenue management, as well as of paying bills.
- Non response situations
  - No one at home: interviewer comes back 2 to 3 times in another time of day. If without success, interviewer notes it with all details in the interviewer's diary
  - Refused by the person who opens the door : interviewer does not come again, and notes it with all details in the interviewer's diary
  - Respondent not available: same as under "no one at home"
  - Respondent refuses the interview: respondent is NOT replaced by another person from the same household. Interviewer notes it with all details in the interviewer's diary

Interviewers take notes in their Interviewers Diary in which they write down all basic information about each of the interview.

Interviewers inform the supervisors about any problems in his/her work, either in selecting the respondent, or in conducting the interview.

3.4.3. FIELDWORK QUALITY CONTROL

In order to ensure high quality of fieldwork the following procedures are regularly applied:

Interviewers

Every interviewer keeps interviewers' diary which contains all basic information on the concrete interview realisation, or reasons for the interview not being successfully realised

Interviewers' Diary contains the following survey management information:

- Sampling point of the interview, date of interview
- Time of the start and end of the interview
- Location where interview was realised: region, urban/rural code (village, small town, central town);
- Interviewer code (a unique number is assigned to each individual interviewer)
- Number of visits (number of calls) required to complete interview
- Non-response (full description of the non-response occasion)

Field coordinator/Supervisor

Every completed questionnaire is checked by the field coordinator/supervisor to make sure that the questionnaire has been properly done.

Field control

Fieldwork control shall ensure quality of data collection in the field. The survey team performs fieldwork control, directly, by multi checking with the respondent. At least 25% of randomly selected questionnaires completed by each interviewer will be checked by phone. Another 10% of PSU's randomly selected questionnaire will be revisited and checked by face-to-face interview.

Fieldwork control verifies the following aspects of interviewers' work:

- Whether the interview has actually taken place
- Proper application of the sampling plan in selecting the respondents
- Approximate duration of the interview
- Proper administration of various sections of the questionnaire
- Interviewers general adherence to professional standards

3.5. Data Processing

3.5.1. Data Entry and Control

During the fieldwork, the team develops the data entry template as well as the plan of data analysis.

The data entry form in MS Access is prepared. This program automatically generates SPSS format. One advantage is that the data entry programme enables identification of all (user defined) inconsistencies, so that 100% logical control is performed during data entry process. In this way additional check of fieldwork quality is performed. All inconsistencies are checked and if there are any indications that the interview was not conducted in the proper way, the same procedure is followed as in case of identified improper administration of questionnaire during fieldwork control.

3.5.2. Weighting Procedure

Rim-weighting (ranking ratio) procedure will be used. The distribution of the population per stratum and medium of residence will be used, in order for the sample to reflect structure of the universe.

3.5.3. Data Analyses

Four variables should be systematically used for tabulation and analysis:

- Geographical, including the 9 strata and the 2 media of residence (urban/rural). A unique variable with 18 modalities may be created and used.
- Income/expenditure quintiles
- Connected to water network/ Non connected
- Connected to sewerage network/ Non connected

This means that each of the 9 strata will be accurately described, considering all the aspects of water supply and sanitation; within each medium of residence, each stratum will be considered separately in order to identify the differences and similarities, about the existing situation as well as the people expectations.

Conclusions and recommendations will be derived from the analysis, and will be the first step for the following phases of the study: tariff study, connection policy, etc.

Concretely, the processing team will prepare a template that provides basic statistics for each question in every questionnaire and template.

3.6. ORGANISATION

3.6.1. THE TEAM

The team will be composed of an international expert, a local engineering company and a market research company:

- International expert, in charge of the questionnaire design, some follow-up, and in-depth analysis
- Local engineering company (BCI) in charge of the follow-up of the work being achieved by the market research company
- Local market research Company: CBS-AXA, which is the largest full service marketing research, media and public opinion polling company in the Republic of Moldova.

3.6.2. TIME SCHEDULE

The figure below presents the schedule (end of week No 13 corresponds to March 31st). So far, the initial time schedule has been met.

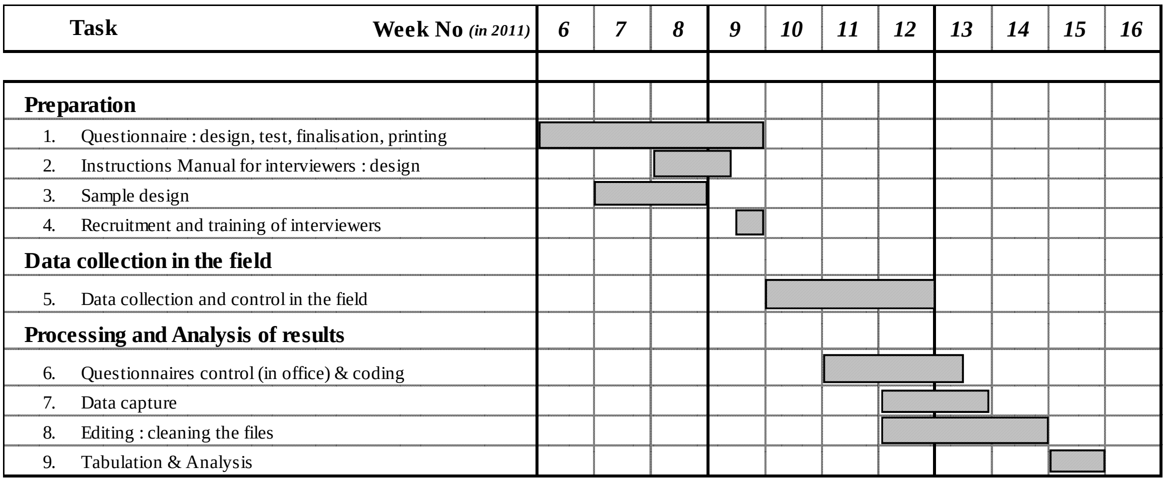


Figure 4: Time schedule of the household survey

4. LARGE CONSUMERS SURVEY

4.1. RATIONALE

It is necessary to have an accurate understanding of the non-domestic water consumption. The large consumers have a major influence on the evolution of this consumption, but their influence is the consequence of their own policy much more than of any other factor.

At present, the non-domestic water consumption represents on average 22% of the total water consumed in the study area. But this percentage does not pertain exactly to the total non-domestic consumption since quantities of water that are produced by industries (thanks to their own private boreholes) and consumed by them, are not included in the ACC billed water statistics.

A special attention will be paid to the company that supplies hot water (Thermocom, CET 1 and 2), since an important part of the domestic water consumption is hot water.

The following method is being applied:

4.2. FIRST STEP: STATISTICAL ANALYSIS

A statistical study was carried out: the list of the 200 major consumers as per the customer data base of ACC was analysed. The evolution of their consumption over the last 10 years will be analysed. This analysis will be give information for:

- The final selection of the 50 large consumers (this number is specified in the Terms of Reference of our study). The 50 largest consumers account for 47% of the total non-domestic water consumption. The rest of the non-domestic consumption is equivalent to 17% of the domestic consumption.
- The preparation of the consumer survey itself: it is better to have, prior to the interview, some information about the organizations to be interviewed.

4.3. SECOND STEP: LARGE CONSUMERS SURVEY

Significant time will be spent for the carrying out of the consumer survey (among others because of pollution aspects of industrial activities).

4.3.1. OBJECTIVES

The objectives of the survey are to produce information relating to non-domestic consumption and demand, which does not exist now. For example, there are major pieces of information about water consumption which are not known, such as:

- Alternative modes of water supply (such as private wells), quantities consumed and pertaining cost;

- Needs of the large consumers, in terms of quantity (volumes supplied), quality of service, and waste water disposal;
- Future development of their activity in Chi during the next years.

4.3.2. METHODOLOGY

The methodology will be mostly qualitative, since the number of interviewed large consumers will be small.

Type of interview:

- Face to face interviews, mostly with open ended questions
- Duration of interview: no more than 2 interviews per day (including at least one hour of written debriefing after each interview)
- Difficult task because various types of information are to be gathered: (i) technical on water and sanitation; (ii) financial (water consumption, and possibly production from own private wells; cost of water and sanitation); (iii) strategic (about the future of the organisation)

The questionnaire (see annex 5):

It is in fact a topic guide, i.e. a list of open ended questions on various topics rather than a list of closed questions. It is based on the experience gained during a few tentative interviews, as well as during the survey itself so that it will be possible to enter into details on specific issues related to this or that type of activity.

The following aspects of water consumption will be studied and discussed:

- Features of the organisation : area of the unit, seasonal variations of activities, number of employees, etc., future development of the economic sector as well as for the organization itself
- Present: mode(s) of water supply, quantities consumed (per mode of water supply) and/or produced (by own private source) / unmet demand, cost of water (from the various sources), (possibly) type of treatment unit for waste waters, opinion on quality of service
- Future: water demand (quantities and quality), willingness to change modes of water supply and/or of sanitation, wished evolution of the quality of service as well as of the tariff (opinion on the link between the quality of service and the tariff), etc.
- Institutional aspects : present mode of operation and management of water supply and sanitation, and wished evolution

Interviewers' profile

- Totally independent from ACC
- Reasonably qualified, with strong ability to discuss with high level staff of organisations

- At least one or two high level members of our team may act as interviewers: doing so, they would be in a good position for understanding well the difficulties of the interviews and find best ways to cope with them

5. COMMERCIAL STATISTICS

5.1. METHODOLOGY

5.1.1. OVERALL APPROACH

The available information relating to water consumption (domestic, and non domestic per major consumer group) will be reviewed, mainly information from ACC about quantities and connections, in order to better define what is the service offered by ACC. This includes:

- A global analysis of the evolution of the monthly statistics about consumption and connections, over a period of several years. Efforts will be made to clarify what is the average domestic per capita consumption (LPCD), when the consumption is metered and when it is not.
- Possibly an analysis of the statistics on a significant geographical level. This analysis is carried out in order to try to quantify geographical differences in the per capita consumption in various situations such as collective or individual metering: this will enable to estimate the impact of metering on demand.
- This information will be crosschecked with the results of the household survey (under progress, at present), especially connection rates and LPCDs.
- A review of the largest consumers will be carried out, in order to make a distinction between the larger and the smaller ones (the average consumption of which is much smaller). This analysis will be used also as a preparatory work for the survey.

5.1.2. HOT WATER

A special attention will be paid to the consumption of hot water by households (for heating and other uses). Special efforts will be made to clarify what is the average domestic per capita hot water consumption (LPCD), and whether there is a significant difference when the consumption is metered and when it is not.

5.2. THE 2 CUSTOMER DATA BASES

An important wok has started with the ACC customer data base as well as the INFOCOM[5] data base, especially in order to reconcile them, in order to derive as much information on billed water consumption as possible. Special attention will be paid to the

[5] INFOCOM is a municipal company, different from ACC, that is in charge of the meter reading of part of the water connections and billing to the households.

metered consumption versus non-metered consumptions that were estimated with norms (that are much higher than the metered consumptions).

This work will produce data both on water consumption and sewerage, not only per year but also per month:

- Volumes, not only of supplied water but also of charged effluents,
- Amounts billed

Already some basic data are available for year 2010:

5.3. Domestic and Non-Domestic Water Consumption

5.3.1. Hot Water

The first comments are about:

- The very high share of the domestic consumption in the total: 77% for water, and 78 % for sewerage. This has major methodological consequences on our study, since major efforts shall be devoted to studying the domestic consumption
- The share of the 50 larger non-domestic consumers in the non-domestic consumption is fairly low: less than 50%, when usually it reaches 65%, maybe more. The consequence will have major methodological consequences, and special attention will be paid to medium range and small non-domestic consumers.

Table 6: Water consumption billed by ACC area

Category	WATER			SEWERAGE		
	m^3/year	m^3/day	%	m^3/year	m^3/day	%
Population	35,833,182	98,173	77	32,820,111	89,918	78
Administration	2,437,099	6,677	5	2,528,268	6,927	6
Economic Agents	8,042,478	22,034	17	6,971,542	19,100	16
Thermocon	*413,994*	*1,134*	*1*	*141,123*	*387*	*0*
CET 1	*132,004*	*362*	*0*	*88,789*	*243*	*0*
CET 2	*1,665,285*	*4,562*	*4*	*354,186*	*970*	*1*
s/total	*2,211,283*	*6,058*	*5*	*584,098*	*1,600*	*1*
TOTAL	**46,312,759**	**126,884**	**100**	**42,319,921**	**115,945**	**100**

Source: Unpublished data, from ACC (Directia relatii cu client)

5.3.2. Per Capita Consumption

It is too early to make an accurate calculation. But a first estimate can be calculated, as far as 2 conditions are brought together:

- The billed consumption is known (refer to Table 6): in 2009, 115,945 m^3 per day overall (population, budget organisations -i.e. administration bodies- and economic agents), and 89,918 m^3 as domestic consumption.
- The corresponding population is known (refer to Table 1): the total population of the study area is estimated 811,148 persons by end of year 2009.
- The per capita consumption would be, if we assume that 100% of the population of the study area is supplied with water by ACC:
  - Domestic 111 litres per capita per day
  - Total 143 litres per capita per day

Of course these consumptions will be verified thanks to our household survey that will cover the various zones of our study area: city of Chisinau, as well as other urban areas, and rural areas.

5.4. PAST EVOLUTION

The analysis of the recent past changes in the water consumption should give major information on the tendencies and/or of the elasticity of consumption in relation the water tariff.

The time series that presents the consumption statistics on water consumption during the last 10 years is in Annex 4. The evolution as shown in the graphs hereafter (volumes, and growth rates) needs explanation, because no clear yearly tendency appears in the growth rates (apart from an overall 28% decrease over the period, from 64.6 million m^3 in 2000 to 46.3 in 2010):

- Domestic consumption: decrease between 2000 and 2003 is followed by increase until 2007, and then decrease. The possible effects of the several increases in the tariff since year 2000 will be studied. The decrease between 2000 and 2001 was abysmal: -20% in one year, without a clear explanation (so far). This decrease changed the balance between domestic and non-domestic consumption: the domestic accounted for 93% of the total billed consumption against 77% in 2010.
- Non-domestic consumption has decreased over the 10-year period, but the evolution has differed according to the status of the consumer: (i) the consumption of the economic agents has varied, but in the end its level has remained similar; (ii) the consumption of the administration bodies has decreased over the 10 year-period that ends with a consumption divided by 2.4.

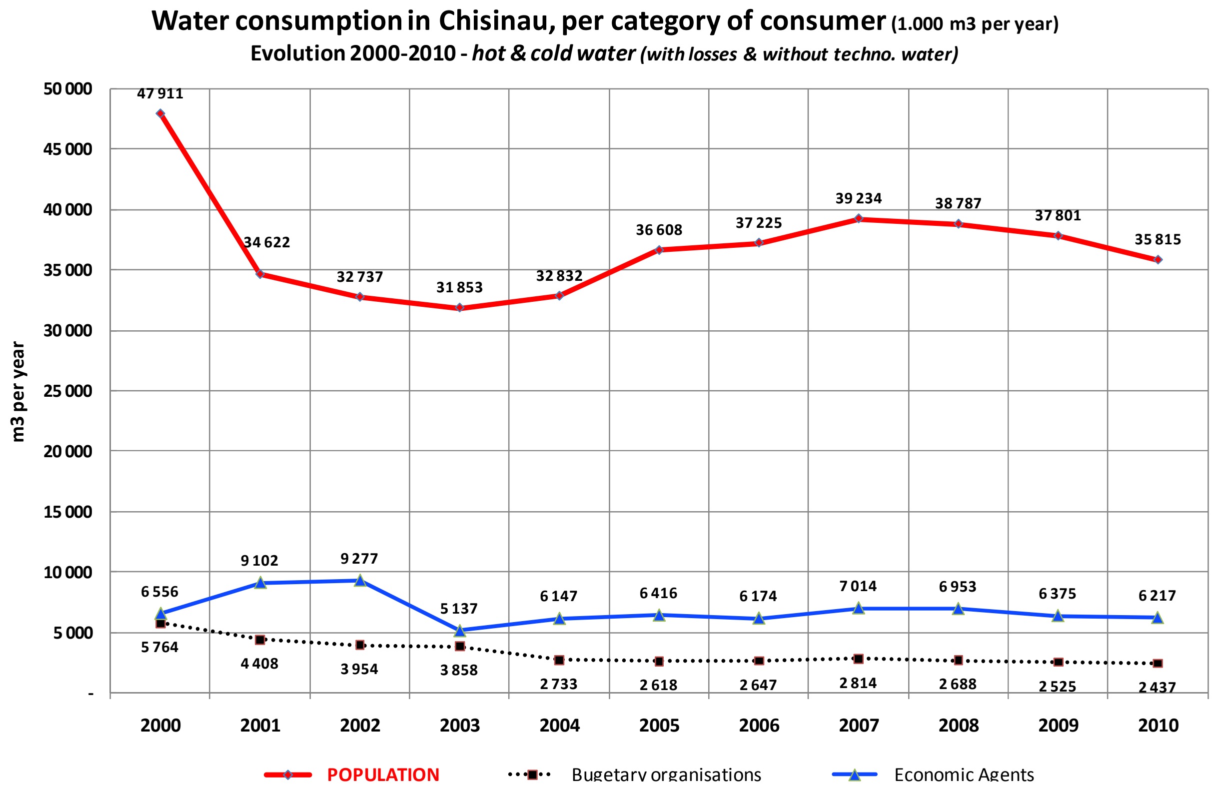


Figure 5: Water consumption in Chisinau, per category of consumer

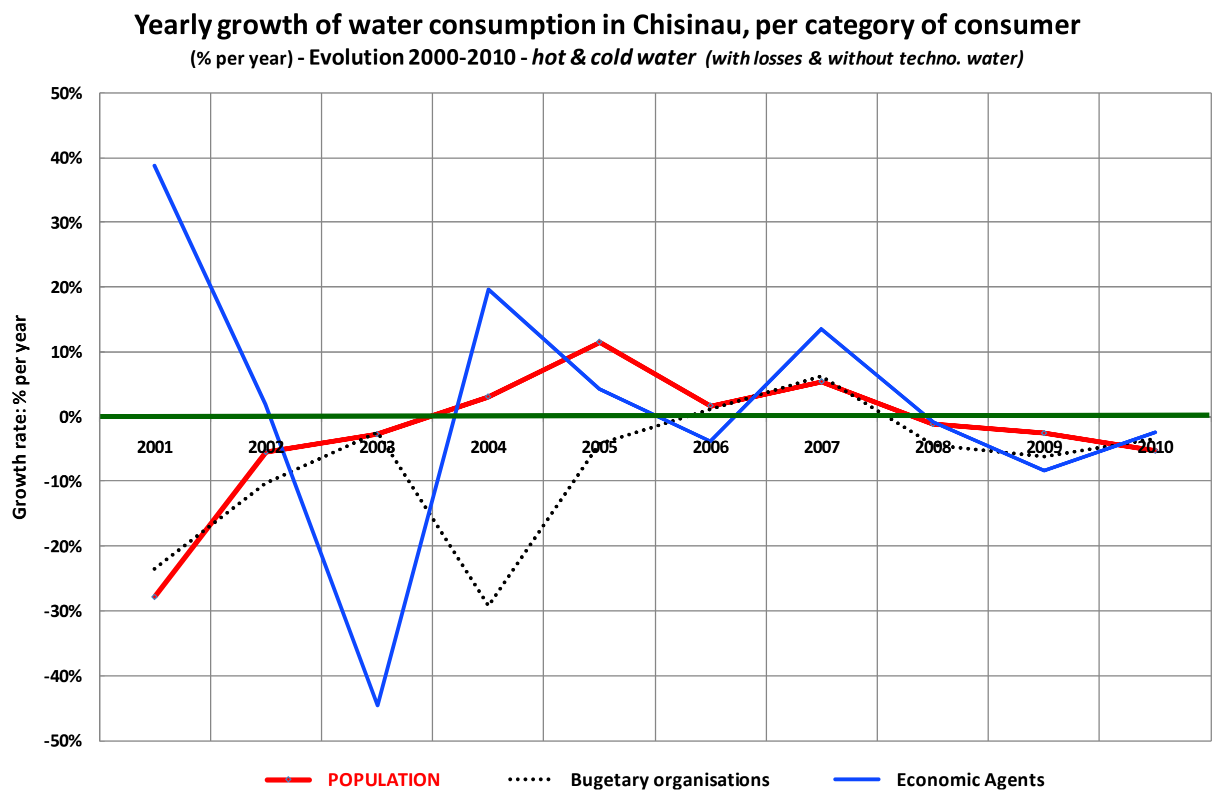


Figure 6: Yearly growth of water consumption in Chisinau, per category of consumer

6. ECONOMY

6.1. OBJECTIVES

The objective of this chapter is twofold:

- Macroeconomic: gather basic information for the economic approach of the present and future non-domestic water demand (of medium range consumers) - mostly past and future evolution of GDP per economic sector-
- Microeconomic: specify households' affordability, i.e. capacity to pay for an improved water and sanitation service

6.2. DOCUMENTS REVIEW

Several documents with Moldovan economy were reviewed, among others:

- Household Budget Survey (HBS): *Aspecte privind nivelul de trai al populatiei în 2008 - Biroul National de Statistica al Republicii Moldova [Aspects of the standard of living of population in Moldova (results of the Household Budget Survey) - National Bureau of Statistics of the Republic of Moldova]* - Chisinau, 2009

  The same report is available for year 2009. But, both for years 2008 and 2009, the expected sample size was 9,768 households, the actual number that was interviewed was only 5,532 in 2008 and 5,456 in 2009 from which respectively 709 and 630 were selected in Chisinau Municipality.

- Economy in Chisinau: Financing Capital Governments in Transitional Countries: the case of Chisinau - by Mihai Roscovan and Doina Melnic
- Website of the National Bureau of Statistics of Moldova (www.statistica.md)

6.3. EBRD RECOMMENDATIONS ON AFFORDABILITY

The manual on Measuring household affordability in energy and water / user guide gives the following definition of affordability:

Utility bills are "unaffordable" when they exceed the present threshold. EBRD's affordability thresholds are the following:

- *10% of household income/expenditure for electricity,*
- *10% for heating and*
- *5% for water [and sewerage together].*

Depending on the availability of household data and/or user preferences we calculate affordability ratios for: households with average income, households with lowest income (decile I, II and III) and vulnerable social groups (pensioners, etc.).

6.4. First Findings

6.4.1. Living Conditions

Thanks to the results published in the 2009 HBS, we know the percentage of households who have access to the following utility or have the following equipment:

	Urban areas	**Chisinau Mun.**
Aqueduct	90.5%	97.8%
Bathroom / shower	76.0	90.4
Sewerage system	84.9	95.8
Water closet	72.5	87.8
Hot water	63.5	85.7
of which central system	*22.1*	*43.0*
Central heating	42.3	70.4
Own heating system	29.1	19.8

6.4.2. Actual Share of Family Budget Devoted to Water and Sanitation

From some results published in the 2009 HBS, we have an idea of the share of the consumption expenditures devoted to some public utilities:

Aqueduct and sewerage	1.1%
Hot water	0.3%
Electricity	4.0%
Gas (natural and liquefied)	3.5%

6.4.3. Quick Approach of Households Affordability, with Existing Data

From some results published in the 2009 HBS, a first estimate of the households' capacity to pay for water and sewerage can be calculated. For this estimate, we use a "3% norm of affordability" that means that "average households" should not devote more than 3% of the family budget to water purchase (a 5% norm may be substituted to the 3%, for poorer households: since water is a vital need these households).

For Chisinau Municipality:

- **Affordability for average households:**

Per capita disposable income 1,716 lei / capita / month

Size of household	2.69 persons
Household income	4,617 lei

The “3% norm of affordability” leads to an affordable amount of **138 lei per month** that would be the maximum that the average households could devote to water purchase and sewerage.

Pricing approach: assuming that the daily domestic per capita consumption is 130 litres (overall, i.e. cold and hot water), the monthly consumption of an average household would be around 10.5 m^3. Accordingly, **the average price for 1 m^3 would be 13.2 lei**, to be compared to the present tariff (9.19 lei).

For urban areas in Moldova:

- **Affordability overall:**

Per capita income	1,477.1 lei / capita / month
Size of household	2.57 persons (our assumption, since the data is not published)
Household income	3,973 lei

The “3% norm of affordability” leads to an affordable amount of **119 lei per month** that would correspond to an average price of **11.3 lei for 1 m^3** (assuming a per capita consumption of 130 litres per day).

- **Affordability for poorer urban households (1st quintile):**

Per capita income	622.3 lei / capita / month
Size of household	3.5 persons (our assumption, since the data is not published)
Household income	2,178 lei

The “5% norm of affordability” leads to **109 lei per month** that would that would correspond to an **average price of 9.4 lei for 1 m^3** (assuming a per capita consumption of 110 litres per day).

- **Deciles of income**:

1st decile	523.6 lei / capita / month
2nd decile	698.3
3rd decile	812.6

The same calculations will be made as soon as additional data related to Chisinau Municipality are made available to us: household income per decile, household size per decile, etc.

6.4.4. UPDATING HOUSEHOLDS’ AFFORDABILITY

These data will be supplemented and updated with:

- More recent data coming from the 2010 HBS, and specific of Chisinau Municipality
- Results of the household survey that is being carried out at present, for our water demand study

Annexes

LIST OF ANNEXES

Annex 1 Study Area and Population Figures, per Geographic Area

STUDY AREA - Population per town and village, from 2004 until 2034

Rayon / Municipality	Secteur	Commune	Village		WATER Served by ACC	Sewerage	Who maintains the network	Population 2004	POPULATION 2009	2014	2019	2024	2029	2034	POPULATION GROWTH RATE *(average % per year)* 2004-2009	2009-2014	2014-2019	2019-2024	2024-2029	2029-2034
CHISINAU	**Chisinau CITY** : *5 districts (present)*				yes	yes	ACC	*589,449*	*630,800*	*633,694*	*621,529*	*587,787*	*548,523*	*504,671*	*1.37*	*0.09*	*-0.39*	*-1.11*	*-1.37*	*-1.65*
	Botanica			1	yes	yes	ACC	156,613	171,200	170,149	166,708	156,949	147,547	137,027	1.80	-0.12	-0.41	-1.20	-1.23	-1.47
	Buiucani			1	yes	yes	ACC	107,809	110,900	108,869	105,592	98,931	92,398	85,404	0.57	-0.37	-0.61	-1.29	-1.36	-1.56
	Centru			1	yes	yes	ACC	90,508	93,400	92,536	89,976	84,404	78,760	72,568	0.63	-0.19	-0.56	-1.27	-1.37	-1.62
	Ciocana			1	yes	yes	ACC	101,808	117,500	127,015	128,522	125,465	116,856	106,638	2.91	1.57	0.24	-0.48	-1.41	-1.81
	Rascani			1	yes	yes	ACC	132,711	137,800	135,124	130,731	122,038	112,963	103,035	0.76	-0.39	-0.66	-1.37	-1.53	-1.82
	Chisinau City : *New Territories*			1	yes	yes	ACC	0	0	3,819	10,662	39,327	71,020	100,187			22.80	29.83	12.55	7.12
	Chisinau CITY : *TOTAL*				yes	yes	ACC	589,449	630,800	637,513	632,191	627,115	619,543	604,858	1.37	0.21	-0.17	-0.16	-0.24	-0.48
	Botanica	Bacioi	Bacioi Village	4	no	no	no	8,644	8,703	8,737	8,711	8,685	8,659	8,633	0.14	0.08	-0.06	-0.06	-0.06	-0.06
			Braila	4	no	no	no	905	919	923	920	917	914	912	0.31	0.08	-0.06	-0.06	-0.06	-0.06
			Frumusica	4	no	no	no	555	467	469	467	466	465	463	-3.39	0.08	-0.06	-0.06	-0.06	-0.06
			Straisteni	4	no	no	no	514	501	503	501	500	498	497	-0.51	0.08	-0.06	-0.06	-0.06	-0.06
		Sangera	Dobruja Village	3	yes	yes	yes	3,279	3,247	3,172	3,162	3,153	3,144	3,135	-0.20	-0.47	-0.06	-0.06	-0.06	-0.06
			Revaca	3	no	no	no	976	988	965	962	959	957	954	0.24	-0.47	-0.06	-0.06	-0.06	-0.06
			Sangera City	2	yes	yes	yes	7,354	7,503	7,978	8,086	8,196	8,306	8,419	0.40	1.24	0.27	0.27	0.27	0.27
		Galata Village - Aeroport City			yes	yes	ACC													
	Buiucani	Condrita	Condrita	3	no	no	no	658	662	703	701	699	697	695	0.12	1.20	-0.05	-0.05	-0.05	-0.05
		Durlesti	Durlesti City	2	yes	yes	ACC	15,395	16,206	16,778	16,545	16,316	16,090	15,867	1.03	0.70	-0.28	-0.28	-0.28	-0.28
		Ghidighici	Ghidighici Village	3	yes	yes	ACC	5,094	5,140	5,161	5,146	5,131	5,116	5,101	0.18	0.08	-0.06	-0.06	-0.06	-0.06
		Ghidighici	Pruncul	3	yes	yes	ACC													
		Truseni	Dumbrava Village	4	yes	yes	ACC	406	418	421	420	418	417	416	0.58	0.14	-0.06	-0.06	-0.06	-0.06
			Truseni	4	no	no	no	7,546	7,890	7,945	7,921	7,897	7,874	7,850	0.90	0.14	-0.06	-0.06	-0.06	-0.06
		Vatra	Vatra City	2	yes	yes	ACC	3,296	3,304	3,361	3,252	3,147	3,045	2,946	0.05	0.34	-0.66	-0.66	-0.66	-0.66
	Centru	Codru	Codru City	2	yes	yes	ACC	14,277	14,399	14,399	14,490	14,581	14,674	14,766	0.17	0.00	0.13	0.13	0.13	0.13
		Codru	Costiujeni Village	2	yes	yes	ACC		n/a											
	Ciocana	Bubuieci	Bac Village	4	yes	no	ACC	1,074	1,086	1,067	1,064	1,060	1,057	1,054	0.22	-0.36	-0.06	-0.06	-0.06	-0.06
			Humulesti	4				230	235	231	230	229	229	228	0.43	-0.36	-0.06	-0.06	-0.06	-0.06
			Bubuieci Village	4	yes	yes	ACC	5,444	5,942	5,837	5,819	5,802	5,785	5,768	1.77	-0.36	-0.06	-0.06	-0.06	-0.06
		Budesti	Budesti Village	4	yes	no	ACC	4,497	4,555	4,673	4,659	4,645	4,631	4,618	0.26	0.51	-0.06	-0.06	-0.06	-0.06
			Vaduleni	4	yes	yes	ACC	539	551	565	564	562	560	559	0.44	0.51	-0.06	-0.06	-0.06	-0.06
		Colonita	Colonita Village	3	yes	yes	ACC	3,340	3,385	3,419	3,409	3,399	3,388	3,378	0.27	0.20	-0.06	-0.06	-0.06	-0.06
		Cruzesti	Ceroborta	4	no	no	no	36	43	44	44	44	44	44	3.62	0.50	-0.06	-0.06	-0.06	-0.06
			Cruzesti Village	4	yes	yes	ACC	1,619	1,648	1,690	1,685	1,680	1,675	1,670	0.36	0.50	-0.06	-0.06	-0.06	-0.06
			Bunet Village	4	yes	no	no	57	48	51	51	51	51	51	-3.38	1.31	-0.06	-0.06	-0.06	-0.06

Rayon / Municipality	Secteur	Commune	Village		WATER Served by ACC	Sewerage	Who maintains the network	Population 2004		2009	2014	2019	2024	2029	2034	2004-2009	2009-2014	2014-2019	2019-2024	2024-2029	2029-2034
										POPULATION						POPULATION GROWTH RATE *(average % per year)*					
CHISINAU		Tohatin	Cheltuitor Village	4	yes	no	ACC	332		335	358	356	355	354	353	0.18	1.31	-0.06	-0.06	-0.06	-0.06
			Tohatin de Jos Village	4	yes	yes	ACC		n/a												
			Tohatin Village	4	yes	yes	ACC	2,098		2,166	2,312	2,305	2,297	2,290	2,283	0.64	1.31	-0.06	-0.06	-0.06	-0.06
		Vadul lui Voda	Vadul lui Voda City	2	yes	yes	ACC	4,559		4,531	4,594	4,431	4,274	4,122	3,975	-0.12	0.28	-0.72	-0.72	-0.72	-0.72
	Riscani	Ciorescu	Ciorescu	4	no	no	no	5,525		5,460	5,893	5,875	5,857	5,840	5,822	-0.24	1.54	-0.06	-0.06	-0.06	-0.06
			Faurești	4	no	no	no	466		456	492	491	489	488	486	-0.43	1.54	-0.06	-0.06	-0.06	-0.06
			Goian	4	no	no	no	1,105		1,112	1,200	1,197	1,193	1,189	1,186	0.13	1.54	-0.06	-0.06	-0.06	-0.06
		Cricova	Cricova	2	no	no	no	9,878		10,039	10,790	11,052	11,321	11,596	11,878	0.32	1.45	0.48	0.48	0.48	0.48
		Gratiesti	Gratiesti Village	4	yes	yes	ACC	4,689		4,743	4,656	4,642	4,628	4,614	4,600	0.23	-0.37	-0.06	-0.06	-0.06	-0.06
			Hulboaca Village	4	yes	no	ACC	1,553		1,567	1,538	1,534	1,529	1,524	1,520	0.18	-0.37	-0.06	-0.06	-0.06	-0.06
		Stauceni	Goianul Nou Village	4	yes	yes	ACC	629		626	631	629	628	626	624	-0.10	0.17	-0.06	-0.06	-0.06	-0.06
			Stauceni Village	4	yes	yes	ACC	6,204		6,999	7,058	7,037	7,016	6,995	6,975	2.44	0.17	-0.06	-0.06	-0.06	-0.06
Anenii Noi		Floreni	Floreni Village	6	yes	no	no	3,713		3,721	3,727	3,715	3,704	3,704	3,704	0.04	0.03	-0.06	-0.06	0.00	0.00
		Maximovca	Maximovca Village	6	yes	no	no	1,783		1,790	1,793	1,787	1,782	1,782	1,782	0.08	0.03	-0.06	-0.06	0.00	0.00
Criuleni		Balabanesti	Balabanesti Village	6	yes	yes	ACC	2,081		2,108	2,111	2,105	2,099	2,099	2,099	0.26	0.03	-0.06	-0.06	0.00	0.00
		Cosernita	Cosernita	6	yes	no	ACC	1,444		1,523	1,525	1,521	1,516	1,516	1,516	1.07	0.03	-0.06	-0.06	0.00	0.00
		Onitcani	Onitcani	6	yes	no	no	2,089		2,065	2,068	2,062	2,056	2,056	2,056	-0.23	0.03	-0.06	-0.06	0.00	0.00
		Slobozia Dusca	Slobozia Dusca	6	yes	no	no	2,655		2,661	2,665	2,657	2,649	2,649	2,649	0.05	0.03	-0.06	-0.06	0.00	0.00
Ialoveni		Ialoveni	Ialoveni	5	yes	yes	ACC	15,041		15,233	16,330	16,684	17,046	17,046	17,046	0.25	1.40	0.43	0.43	0.00	0.00
Straseni		Straseni	Straseni	5	no	yes	no	18,320		18,365	19,687	20,114	20,550	20,550	20,550	0.05	1.40	0.43	0.43	0.00	0.00
		Cojusna	Cojusna	6	no	yes	no	7,006		7,008	7,019	6,997	6,977	6,977	6,977	0.01	0.03	-0.06	-0.06	0.00	0.00
TOTAL STUDY AREA								766,354		811,148	823,050	818,192	813,618	805,834	790,959	1.14	0.29	-0.12	-0.11	-0.19	-0.37

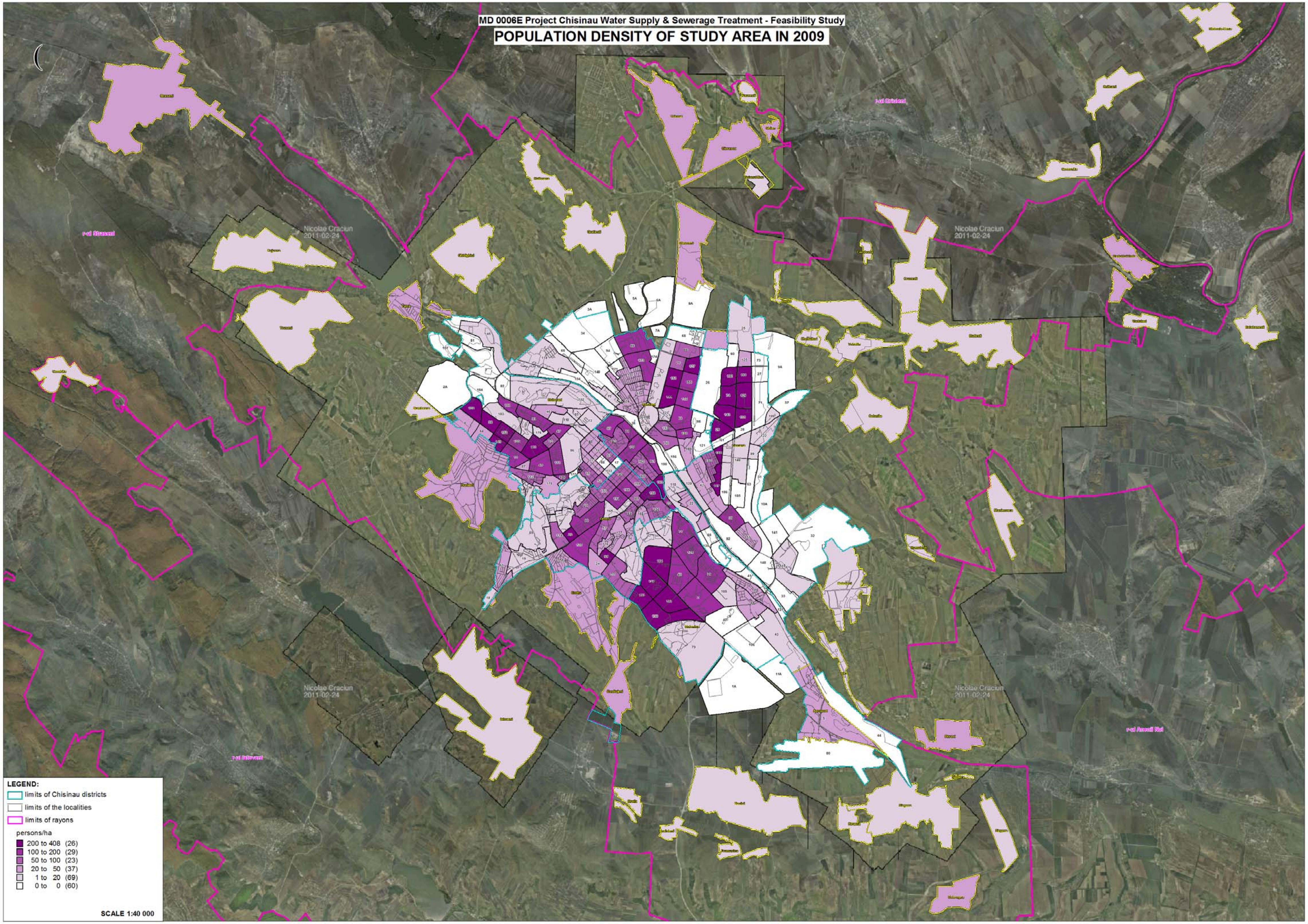
Sources: Limits of study area: Seureca (derived from APACAL lists)

Population 2004: National Population Census

Population 2009 and after: Urban planner's report ***(provisional data, to be assessed and confirmed)***

Codes			#	2004	2009	2014	2019	2024	2029	2034						
	1	Chisinau city	6	589,449	630,800	637,513	632,191	627,115	619,543	604,858	1.37	0.21	-0.17	-0.16	-0.24	-0.48
	2	Chisinau urban (outside city)	7	54,759	55,982	57,900	57,857	57,834	57,832	57,851	0.44	0.68	-0.02	-0.01	0.00	0.01
	3	Chisinau rural ("sate")	6	13,347	13,422	13,419	13,380	13,340	13,301	13,262	0.11	0.00	-0.06	-0.06	-0.06	-0.06
	4	Chisinau rural ("commune")	24	54,667	56,470	57,293	57,122	56,950	56,780	56,610	0.65	0.29	-0.06	-0.06	-0.06	-0.06
	5	Outside Chisinau - urban	2	33,361	33,598	36,017	36,798	37,596	37,596	37,596	0.14	1.40	0.43	0.43	0.00	0.00
	6	Outside Chisinau - rural	7	20,771	20,876	20,907	20,845	20,782	20,782	20,782	0.10	0.03	-0.06	-0.06	0.00	0.00
				766,354	**811,148**	**823,050**	**818,192**	**813,618**	**805,834**	**790,959**	1.14	0.29	-0.12	-0.11	-0.19	-0.37

Annex 2 Study Area: Population Densities in 2009 (Map A3 Size)


MD 0006E Project Chisinau Water Supply & Sewerage Treatment - Feasibility Study
POPULATION DENSITY OF STUDY AREA IN 2009
r-ul Straseni
r-ul Criuleni
r-ul Ialoveni
r-ul Anenii Noi
Nicolae Craciun 2011-02-24
LEGEND:
limits of Chisinau districts
limits of the localities
limits of rayons
persons/ha
200 to 408 (26)
100 to 200 (29)
50 to 100 (23)
20 to 50 (37)
1 to 20 (69)
0 to 0 (60)
SCALE 1:40 000

Annex 3 Household Survey Questionnaire

Study on

WILLINGNESS TO PAY FOR WATER AND SANITATION

in CHISINAU

Hello, my name is…………………, I work for a market survey company whose name is CBS-AXA. At present, we are conducting a study on water and sanitation on behalf of APACANAL and funded by EBRD, and we intend to pay much attention to your expectations. This is why I'd like to interview you.

All the gathered information is strictly confidential

Municipality / Raion :	Sector / Town / Village:	Urban........................... ❑ 1 Rural............................ ❑ 2
Enumeration District:	Household n° :	

M. [ ] 1 U/R [ ] 2

ED [ ] 3

H.h. [ ] 4

1. Housing

Q.1. For how long have you been living in your dwelling : ....(less than 6 months .... ❑ 1
(more than 6 months .... ❑ 2

STOP [ ] 5

Q.2. Type of housing
. apartment.. ❑ 1 . other (*specify*) .... ❑ 3
. private house .... ❑ 2 ....
[ ] 6

- **Floor** where your accommodation is located :.. [ ] 7

Q.3. What is the number of rooms in your dwelling
(excluding bathroom, toilet, kitchen, terrace) .... [ ] 8

Q.4. What is the overall area of the dwelling .... [ ] 9

Q.5. Are you running an economic activity in your premises :......... yes ❑ .... no ❑ 2 [ ] 10
If NO *(answer 2)* ➲ ***Go to Q.6.***

- **If YES** :
(. grocery .... ❑ 1 (. cafe, restaurant .... ❑ 4
(. repair shop (shoes, etc)❑ 2 (. hair dresser .... ❑ 5
(. car repair................. ❑ 3 (. other shop (*specify*) .... ❑ 6
[ ] 11

Q.6. Do you have a garden, or agricultural land that you cultivate? ....Yes ❑ 1 .... No ❑ 2 [ ] 12
If NO *(answer 2)* ➲ ***Go to Q.7.***

- **If YES** : which area : ....are [ ] 13

Q.7. What is the status of your property (land and building)…
. state .... ❑ 1 . rented.. ❑ 3
. private .... ❑ 2 . other(*specify*).. ❑ 4
[ ] 14
If STATE *(answer 1)* ➲ ***Go to Q.8.***

Interviewer : .... Date :	Supervisor : .... Date :	Coder : .... Date :	Capture....................................... Date : ....

- **If rented** or **privately owned :**
  (rent (or instalment, if purchase on credit)..Lei / MONTH 15

Q.8. How many persons are usually living in the dwelling? *(including residing employees)* : 16
- adults 17
- children (3-15 years)... 18
- babies (less than 3years) 19

Q.9. How many families are usually living in the dwelling? ... 20

Q.10. Person who answers the questions:

Q.10.a. male.. ❑ 1 woman.................................. ❑ 2 21

Q.10.b. age .... years 22

Q.11. What is the education level of the head of household? 23

. primary (1-4)	❑ 1	. secondary professional	❑ 4
. general obligatory (5-9)	❑ 2	. college	❑ 5
. secondary general (10-12)	❑ 3	. university and above	❑ 6

AT PRESENT

2. Water

Q.12. How many taps *with running water* do you have *(write "0" if none)*
- inside your dwelling 24
- outside your dwelling, but in the premises 25

Q.13. From where do you get water *(mainly! only one response per type of use)*, for…

	Eat/Dr.	Dish w.	Shower	Toilet	Laundry	Other*
. Piped water in house (w. network)............	❑ 1	❑ 1	❑ 1	❑ 1	❑ 1	❑ 1
. Piped water in yard (w. network)............	❑ 2	❑ 2	❑ 2	❑ 2	❑ 2	❑ 2
. Public tap (piped water outside yard)	❑ 3	❑ 3	❑ 3	❑ 3	❑ 3	❑ 3
. Protected dug well	❑ 4	❑ 4	❑ 4	❑ 4	❑ 4	❑ 4
. Unprotected dug well, or spring..............	❑ 5	❑ 5	❑ 5	❑ 5	❑ 5	❑ 5
. Tanker-truck	❑ 6	❑ 6	❑ 6	❑ 6	❑ 6	❑ 6
. Lake, River, Stream	❑ 7	❑ 7	❑ 7	❑ 7	❑ 7	❑ 7
. Rainwater..	❑ 8	❑ 8	❑ 8	❑ 8	❑ 8	❑ 8
. Other *(specify)*......................................	❑ 9	❑ 9	❑ 9	❑ 9	❑ 9	❑ 9

Eat/Dr. 26
Dish w. 27
Pers.w 28
Laun. 29
W.C. 30
Other 31
Mixed 32

Q.14. Do you have any water storage equipment at home?...................... Yes ❑ 1 .... Non ❑ 2 33

If NO *(answer 2)* ➲ ***Go to Q.15.***

- **If YES:** What is the TOTAL storage capacity .... : ....litres 34

Q.15. Do you have a booster pump...Yes ❑ 1 ....No ❑ 2 35

If NO *(answer 2)* ➲ ***Go to Q.16.***

Q.16. Are there any places at home with leaking water?................................ Yes ❑ 1 ....No ❑ 2 36

Q.17. The water that you use is provided by: 37

(APACANAL.. ❑ 1
(the local community .... ❑ 2
(a private source (well, other)... ❑ 3

(*) Irrigation - Livestock, poultry, etc. ....
....

Households* CONNECTED *to piped water system
(answers 1 or 2 to Q.13)

Q.18. Is water available continuously, 24 hours in a day, 7 days in a week?

. Yes, all year long .... ❑ 1 . No .... ❑ 3
. Yes, but not in dry season .... ❑ 2 . Other *(specify)* .... ❑ 4

38

Q.19. Frequency of service interruptions (i.e. water cuts, shortages):

. Every day .... ❑ 1 . A few times in a year .... ❑ 4
. Several times every week .... ❑ 2 . Never .... ❑ 5
. Several times every month .... ❑ 3 . Other *(specify)* .... ❑ 6

39

- **If service interruptions EVERY DAY** *(answer 1)* :
  usually, water is available for how long in a day ? .... hours

40

Q.20. Is your water connection equipped with a water meter?

. Yes: for my dwelling only .... ❑ 1 ***Go to Q.20.a.***
. Yes: shared by several households .... ❑ 2 ***Go to Q.20.b.***
. No .... ❑ 2 ***Go to Q.21.***

41

a. If INDIVIDUAL METER *(answer 1)* :

- how many meters in your dwelling 42
- was your meter checked by a registered company ....Yes ❑ 1..........No ❑ 2 43

If NO *(answer 2)* ➲ ***Go to Q.21.***

▪ **If YES** : specify year when this check was achieved? 44

Go to Q.21.

b. If COLLECTIVE METER *(answer 2)* :

- how many dwellings for the meter 45

Q.21. Do you know your water consumption? .... Yes ❑ 1 ....No ❑ 2 46

If NO *(answer 2)* ➲ ***Go to Q.22.***

- **If YES** *(copy the water bill)*:
  - Consumption cold water (monthly average, from your water bill) .... m^3 47
  - Consumption hot water (monthly average, from your water bill) .... m^3 48

Q.22. Do you pay for your water? .... Yes ❑ 1 .... No ❑ 2 49

If NO *(answer 2)* ➲ ***Go to Q.22.b.***

a. If YES :

- Which amount did you pay for cold water .... Lei 50
- Which amount did you pay for hot water (excluding heating) .... Lei 51
- Specify the price paid per m^3 .... Lei/m^3 52
- Did the above mentioned cost include SEWERAGE? .... Yes ❑ 1......No ❑ 2 53

▪ **If Yes**: which amount did you pay for SEWERAGE .... Lei/month 54

b. If NO : Why don't you pay the water that you consume ?

I cannot afford to pay .... ❑ 1 I don't receive bills .... ❑ 3
I do not want to pay .... ❑ 2 Service is free .... ❑ 4

55

Q.23. Is the billing of your water based on

Your actual water consumption (in m^3) .... ❑ 1 According to size of household/flat .... ❑ 4
Fixed price .... ❑ 2 Other *(specify)* .... ❑ 5
According to number of family members. ❑ 3 ....

56

Q.24. Do you encounter financial difficulties in paying your water bill…

serious difficulties .... ❑ 1 no difficulties .... ❑ 3
some difficulties (from time to time) .... ❑ 2

57

Q.25. What happens if you don't pay your bill…

Interruption of service ❑ 1 Nothing ❑ 3
Warning, without further consequence ❑ 2 Other *(specify)* ❑ 4 — 58

Q.26. Do you drink regularly *(every day)* this piped water, at home?
- you, and other adults ... Yes ❑ 1 ... No ❑ 2 — 59
- your children (3-15 years) ... Yes ❑ 1 ... No ❑ 2 — 60
- your babies (less than 3 years) ... Yes ❑ 1 ... No ❑ 2 — 61

Households NOT CONNECTED to a piped water system
(answers 3, 4, 5, 6, 7 or 8 to Q.13)

Q.27. How long does it take to go to your main water source, get water and come back
- In metres ... metres — Dist. 62
- In minutes *(usually)* ... minutes/day — Time 63

Q.28. How do you fetch water for your household?
(ourselves (household members) ❑ 1
(we pay somebody to carry water ❑ 2 — 64

- **If « WE PAY TO CARRY »** *(answer 2)*: how much do you pay ... Lei/MONTH — 65

Q.29. Quantities consumed

("Count the BUCKETS")	Eat/Dr.	Dish.w.	Shower	Cloth.w	Other
. Type of container *(litres)*	:..........	....	....	....	....
. How many cont./ travel	:..........	....	....	....	....
. How many travels per day	:..........	....	....	....	....
. How many times per week	:..........	....	....	....	....
Total consumed (/week) :	....	....	....	....	....

(. overall ... litres /WEEK — l./w. 66

Q.30. Cost (. overall ... Lei /MONTH — Lei 67

Q.31. Do you drink regularly *(every day)* this non-piped water, at home?
- you, and other adults ... Yes ❑ 1 ... No ❑ 2 — 68
- your children (3-15 years) ... Yes ❑ 1 ... No ❑ 2 — 69
- your babies (less than 3 years) ... Yes ❑ 1 ... No ❑ 2 — 70

ALL Households

Q.32. Do you treat *usually* the water that you finally drink to make it safer? Yes ❑ 1 ... No ❑ 2 — 71

If NO *(answer 2)* ➲ ***Go to Q.33.***

- **If YES** : which treatment:

. boil ❑ 1 . solar disinfection ❑ 4
. filter (ceramic, sand, etc.) ❑ 2 . let it stand and settle ❑ 5 — 72
. add chlorine ❑ 3 . other *(specify)* ❑ 6

Q.33. Do you buy regularly BOTTLED WATER for eating and drinking? ... Yes ❑ 1 ... No ❑ 2 — 73
- **If NO** *(answer 2)* ➲ ***Go to Q.34.***
- **If YES** : **TOTAL** bought bottled water

QUANTITIES ... litres / **MONTH** — 74
COST ... Lei / **MONTH** — 75

Q.34. What is the level of satisfaction *(if several sources of water, i.e. piped water + water from another source, refer mostly to piped water)*:

	Very satisfied	**Rather** satisfied	**Rather NOT** satisfied	**NOT at all** satisfied	**N.C.**	
1. Water pressure	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	76
2. Taste	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	77

3.	Smell	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	78
4.	Colour / Turbidity (particles)	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	79
5.	Healthiness (potability)	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	80
6.	Quantities (distributed)	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	81
7.	Duration of service (in a day)	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	82
8.	Continuity of service (/cuts)	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	83
9.	Timeliness	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	84
10.	Cost of water : amount paid/spent	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	85
11.	Accuracy of meter reading	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	86
12.	Bill: periodicity	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	87
13.	Information of customers	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	88
14.	Answer to clients complaints	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	89
15.	**OVERALL quality of service**	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	90

Q.35. Which major improvement is needed most for your existing water supply service ?

.... 91

Q.36. Do you think that your water involves a health risk for…

- the adults	Yes ❑ 1	No ❑ 2	N.C. ❑ 3	92
- the children (3-15 years)	Yes ❑ 1	No ❑ 2	N.C. ❑ 3	93
- the babies (less than 3 years)	Yes ❑ 1	No ❑ 2	N.C. ❑ 3	94

3. Sewerage / Sanitation (wastewater)

Q.37. Does your dwelling have a bathroom (shower, bathtub, shower cabin): 95

. Yes, with running water .... ❑ 1
. Yes, without running water .... ❑ 2
. No .... ❑ 3

Q.38. Your used water (for bathing, washing, cooking) is usually discharged into… 96

Piped sewerage system ❑ 1	Drain to the street ❑ 4
Septic tank/cesspool (individual) ❑ 2	To your own yard ❑ 5
Septic tank/cesspool (shared) ❑ 3	Other *(specify)* ❑ 6

Q.39. What kind of toilet facility do members of your household usually use? 97

Pour flush latrine with running water ❑ 1	Improved pit latrine ❑ 4
Pour flush latrine without running water ❑ 2	Other *(specify)* ❑ 5
Simple latrine outside the dwelling ❑ 3	No facility ❑ 6

If NO FACILITY *(answer 6)* ➲ ***Go to Q.47.***

Q.40. Do you share this toilet facility with other households? .... Yes ❑ 1 .... No ❑ 2 98

Q.41. The water from your toilet (excreta) is usually discharged into… 99

Piped sewerage system ❑ 1	Drain to the street ❑ 4
Septic tank/cesspool (individual) ❑ 2	To your own yard ❑ 5
Septic tank/cesspool (shared) ❑ 3	Other *(specify)* ❑ 6

Households WITH A SEPTIC TANK
(answers 2 or 3 to Q.38. and/or answers 2 or 3 to Q.41)

Q.42. Has the septic tank ever been emptied .... Yes ❑ 1 .... No ❑ 2 100

If NO *(answer 2)* ➲ ***Go to Q.43.***

- **If YES :**

a. Frequency : you empty the tank every .... MONTHS 101

b. When your tank is full, which of the following systems do you use:

- Emptying truck (vacuum pump) ❑ 1 — *Go to Q.42.c.*
- Manual emptying, by hired labour ❑ 2 — *Go to Q.42.c.*
- Manual emptying, by non-paid persons ❑ 3 — *Go to Q. 42.d.*
- Filling up the tank, and digging another one ❑ 4 — *Go to Q. 42.d.*

102

c. How much do you pay for this work? .... Lei 103

d. Where is the sludge disposed of:

- On the land ❑ 1
- Bury it ❑ 2
- Dump it ❑ 3
- Taken away by company ❑ 4
- Other *(specify)* ❑ 5
- Don't know ❑ 6

104

Q.43. Do you have problems with your septic tank

- Blockage ❑ 1
- Bad smell ❑ 2
- Wastewater coming into the house ❑ 3
- Leakage outside the house (in the yard) ❑ 4
- Other *(specify)* ❑ 5 ....

105

Q.44. Where does the overflow from the septic tank go to

- Infiltration pit ❑ 1
- Surface drain ❑ 2
- No overflow ❑ 3
- Other *(specify)* ❑ 4

106

Households CONNECTED TO A SEWERAGE SYSTEM
(answer 1 to Q.38 and/or answer 1 to Q.41)

Q.45. If you report a wastewater problem, how quickly is the problem solved:

- inside your premises .... days 107
- outside your premises .... days 108

Q.46. The amount that you pay, do you consider that it is in line with the provided service…

- Too high ❑ 1
- As expected ❑ 2
- Too low ❑ 3
- Don't know ❑ 4

109

ALL Households

Q.47. *In the close surroundings of your dwelling*, do you suffer from:

Neighbours' waste water (e.g. overflow of septic tanks)	Yes ❑ 1	No ❑ 2	110
Presence of mosquitoes	Yes ❑ 1	No ❑ 2	111
Bad smell (occasionally)	Yes ❑ 1	No ❑ 2	112

Q.48. *In general*, do you feel concerned with possible negative health and environment impact (on the soil, river) due to wastewater?

- Very concerned ❑ 1
- Rather concerned ❑ 2
- Rather not concerned ❑ 3
- Not at all concerned ❑ 4

113

Q.49. Are you satisfied with :

	Very satisfied	**Rather** satisfied	**Rather** NOT satisfied	NOT **at all** satisfied	
Your sanitation (wastewater) system	❑ 1	❑ 2	❑ 3	❑ 4	114
Cost (monthly)	❑ 1	❑ 2	❑ 3	❑ 4	115
Healthiness	❑ 1	❑ 2	❑ 3	❑ 4	116
Quality of your local environment	❑ 1	❑ 2	❑ 3	❑ 4	117

Q.50. Which improvements are needed most for your existing sanitation (wastewater) service?

a. ....

.... 118

b. ....

4. Other public utilities

Q.51. Is your dwelling supplied with GAS from the city network? .... Yes ❑ 1 .... No ❑ 2 119

Q.52. Consumption of gas *(from the last bill, or estimate if no bill)*

	WINTER	SUMMER	
. Quantities	....	....	W 120 / S 121
. Amount paid (average)	....Lei	....Lei	

Q.53. Is your dwelling equipped with ELECTRICITY ? .... Yes ❑ 1 .... No ❑ 2 122

If NO *(answer 2)* ➲ ***Go to Q.55.***

Q.54. Consumption of electricity *(from the last bill)*

	WINTER	SUMMER	
. Quantities	....	....	W 123 / S 124
. Amount paid (average)	....Lei	....Lei	

Q.55. Is your dwelling equipped with :

(. centralised heating system .... ❑ 1

(. own heating system / autonomous heating .... ❑ 2 125

Q.56. Is your dwelling equipped with a hot water central system................ Yes ❑ 1 .... No ❑ 2 126

Q.57. How do you dispose of SOLID WASTE in your household ?

. Collection by scavengers .... ❑ 1	. Bury in yard .... ❑ 4
. Neighbourhood collection (local disposal) ❑ 2	. Compost .... ❑ 5
. Burn at home .... ❑ 3	. other *(specify)* .... ❑ 6

127

If NO COLLECTION *(answer 3-6)* ➲ ***Go to Q.58.***

- **If Collection** *(answer 1)* : do you pay for the service....................... Yes ❑ 1 .... No ❑ 2

If NO *(answer 2)* ➲ ***Go to Q.58.***

- How much .... Lei 128
- How often .... MONTH 129

Q.58. Are you satisfied with your:

	Very satisfied	**Rather** satisfied	**Rather NOT** satisfied	**NOT at all** satisfied	
Electricity supply	❑ 1	❑ 2	❑ 3	❑ 4	130
Waste water disposal	❑ 1	❑ 2	❑ 3	❑ 4	131
Solid waste disposal system.........................	❑ 1	❑ 2	❑ 3	❑ 4	132
Heating system..	❑ 1	❑ 2	❑ 3	❑ 4	133

Q.59. As compared to each other public utility in the list below, what is the importance of improving the quality of the following public utilities ?

	Very important	**Rather** important	**Rather NOT** important	**NOT at all** important	
Electricity	❑ 1	❑ 2	❑ 3	❑ 4	134
Water supply	❑ 1	❑ 2	❑ 3	❑ 4	135
Waste water disposal	❑ 1	❑ 2	❑ 3	❑ 4	136
Solid waste disposal.......................................	❑ 1	❑ 2	❑ 3	❑ 4	137
Heating system..	❑ 1	❑ 2	❑ 3	❑ 4	138
Roads	❑ 1	❑ 2	❑ 3	❑ 4	139

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IN THE FUTURE

5. Water: Future

INTERVIEWER : Explain possible future improvement of quality of water service

In the future…

Potable water may be supplied in your area, under the following conditions:

clean water, good pressure, availability of water 24 hours per day, 7 days per week

Of course, such improvements would involve additional costs for the community, and this cots should be recovered

Households NOT CONNECTED to APACANAL water supply network
(answers 3, 4, 5, 6, 7 or 8 to Q.13)

Q.60. Would you want to continue using your existing water source? ...... Yes ❑ 1...............No ❑ 140

- **If YES:** Why 141

Q.61. Would you accept to pay for a house water connection? .... Yes ❑ 1..........No ❑ 2 142

If NO *(answer 2)* ➲ ***Go to Q.63.***

- **If YES:** How much .... : .... Lei 143

The **installation fee** *of a connection to the APACANAL water network is 3,300 Lei.*

What would you do?

Q.62. Under this price, would you accept to pay for an APACANAL water connection?.. Yes ❑ 1........ No ❑ 2 144

If NO *(answer 2)* ➲ ***Go to Q.63.***

b. If NO:. what would be the maximum you would accept to pay .... Lei 145

Households CONNECTED to APACANAL water supply network, without an individual meter *(answer 1 or 2 to Q.13,* ***and*** *answer 3 to Q.21)*

Q.63. Would you want to have an individual meter? .... Yes ❑ 1..........No ❑ 2 146

- **If NO:** Why 147

Q.64. Would you accept to pay for an individual meter? .... Yes ❑ 1..........No ❑ 2 148

If NO *(answer 2)* ➲ ***Go to Q.65.***

- **If YES:** How much .... : .... Lei 149

....
....
....
....

ALL Households

Q.65. How much water do you think your family needs, per day? (. same as now........................❑ 1 (. more......................................❑ 2 150

Q.66. Would you be willing to **consume more** water than now? ....Yes ❑ 1 ....No ❑ 2 151

If NO *(answer 2)* ➲ ***Go to Q.67.***

• **If YES**, how much *(litres per week)* .... : 152

Q.67. For the improved water service, you would receive regularly a bill with a certain amount :

- **BEYOND which amount**, do you consider that it is **TOO EXPENSIVE**: i.e. that, beyond this amount, you would not pay? ....Lei/MONTH 153
- **BEYOND which amount**, do you consider that it is **RATHER EXPENSIVE**: i.e. that this amount seems to be a little too much?..Lei/MONTH 154
- **WHAT AMOUNT** could be considered as **RATHER CHEAP**: i.e. that this amount seems to be reasonable ? ....Lei/MONTH 155
- **UNDER WHICH** amount, do you think that the bill is **TOO CHEAP**: i.e. that, under this amount, the minimum quality could not be secured? ....Lei/MONTH 156

6. Sanitation: Future

INTERVIEWER : Explain possible future improvement of sanitation conditions

An improved SEWERAGE SYSTEM consists in 2 processes on used waters *(water from kitchen shower, etc.), and excretas :*

- *Not only* ***Collection of wastewater****, thanks to a collective network of special pipes*
- *But also,* ***Treatment of waste water****, in order to be able to discharge "clean water" into the river*

Would this service be offered to you:

- *The connection to the network would be charged to you*
- *The sanitation service would be billed to you regularly, just like water*

Households NOT CONNECTED to a sewerage system
(answer 1 to Q.39 or answer 1to Q.42)

Q.68. Do you consider that the installation of an improved sewerage system in your area (collection of wastewater and treatment before discharge) would be…

Very useful...❑ 1 Rather Not useful...❑ 3
Rather useful..❑ 2 Not useful at all..❑ 4 157

Q.69. Would you like to be connected to a sewer system, assuming that it is possible ? .... (Yes ❑ 1 (No ❑ 2 158

Q.70. Would you accept to pay for the installation of a connection to the APACANAL sewer system? ....(Yes ❑ 1 (No ❑ 2 159

- ***If NO*** *(answer 2)* ➲ ***Go to Q.72.***
- **If YES:** how much .... : ....Lei 160

....
....

The **installation fee** *of a connection to the sewerage network is 6.000 Lei.*

What would you do?

Q.71. Under this price, would you accept to pay for a connection to the sewerage APACANAL network? .... Yes ❑ 1 .... No ❑ 2 | 161

If NO *(answer 2)* ➲ ***Go to Q.72.***

- **If NO:** What would be the maximum you would accept to pay .... Lei | 162

ALL Households

Q.72. Do you think that it is justified to pay regularly a bill for an improved water and sewerage service?

Absolutely normal	❑ 1	Unjustified	❑ 3
Normal	❑ 2	Unacceptable	❑ 4

163

If UNACCEPTABLE *(answer 4)* ➲ ***Go to Q.74.***

Q.73. For the improved sewerage service, you would receive regularly a bill with a certain amount (that will come in addition to that of water) :

- **BEYOND which amount**, do you consider that it is **TOO EXPENSIVE**: i.e. that, beyond this amount, you would not pay? .... Lei/MONTH | 164
- **BEYOND which amount**, do you consider that it is **RATHER EXPENSIVE**: i.e. that, beyond this amount, you would not pay? .... Lei/MONTH | 165
- **WHAT AMOUNT** could be considered as **RATHER CHEAP**: i.e. this amount seems to be reasonable ? .... Lei/MONTH | 166
- **UNDER WHICH** amount, do you think that the bill is **TOO CHEAP**: i.e. that, under this amount, the minimum quality could not be secured? .... Lei/MONTH | 167

LIVING CONDITIONS

7. Assets – Income

Q.74. How many household members who live in the dwelling *usually* work (and get an income)? | 168

....

Q.75. Household conveniences *(in working order)*

	Yes	No	
. TV set	❑ 1	❑ 2	169
. Internet connection	❑ 1	❑ 2	170
. Computer	❑ 1	❑ 2	171
. Refrigerator	❑ 1	❑ 2	172
. Automatic washing machine	❑ 1	❑ 2	173
. Mechanic washing machine	❑ 1	❑ 2	174
. Vacuum cleaner	❑ 1	❑ 2	175
. Land line telephone	❑ 1	❑ 2	176
. Mobile telephone	❑ 1	❑ 2	177
. Bicycle	❑ 1	❑ 2	178
. Car	❑ 1	❑ 2	179

....

....

Q.76. Expenditures of the family :

	per day	per week	per month	
(. food & drinks :	....	....	....	180
(. rent & housing charges :	....	....	....	181
(. central heating :	....	....	....	182
(. public utilities :	....	....	....	183
(. transportation :	....	....	....	184
(. tel., tv :	....	....	....	185
(. clothing & footwear :	....	....	....	186
(. medical care :	....	....	....	187
(. education :	....	....	....	188
(. entertainment :	....	....	....	189
(. other (loans, transfers,..) :	....	....	....	190

➔ **TOTAL (NET)**: .... Lei /month 191

(. savings, investments, life insurance, etc. .... : ....

Q.77. What is the **monthly income** of the family ?

	Occupation	Income	SPC CM 192
• salaries	:	............Lei /m.	193
• remittances	:	............Lei /m.	194
• pensions/social insurance:	....	............Lei /m.	195
• in-kind	:	............Lei /m.	196
• other	:	............Lei /m.	197

➔ **TOTAL** : .... Lei /month 198

Q.78. Do you remember that the water tariff changed recently? .... Yes ❑ 1 .... No ❑ 2 199

If NO *(answer 2)* ➲ ***Go to Q.79.***

- **If YES:**
  - specify the year when it happened 200
  - did the tariff .... Increase ❑ 1 .... Decrease ❑ 2 201
  - how much was the old tariff (including sewerage) .... Lei/m^3 202

Q.79. Following this change, did your water consumption .... (remain the same .... ❑ 1 203

(increase .... ❑ 2

(decrease .... ❑ 3

If REMAIN THE SAME *(answer 1)* ➲ ***END***

- **If YOUR WATER CONSUMPTION CHANGED** *(answer 2 or 3)*:
  - specify what was your water consumption at that time .... m^3/month 204

Comments - INTERVIEWER, FILL IN THE CONTROL SHEET

NAME OF INTERVIEWED PERSON ....

TELEPEHONE ....

....

....

....

....

....

....

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....

....

Annex 4 Statistics on Water Consumption During the Last 10 Years

Apa furnizată de către S.A. "Apă-Canal Chişinău"

Specificare	UM	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
VOLUM TOTAL (tratată şi brută)	**mii m3**	**64,576**	**52,896**	**50,796**	**45,984**	**45,863**	**49,378**	**49,689**	**52,339**	**50,917**	**48,680**	**46,313**
VOLUM APĂ TRATATĂ (potabilă şi tehnologică)	**mii m3**	**64,576**	**52,896**	**50,796**	**45,984**	**45,863**	**49,378**	**49,572**	**52,104**	**50,894**	**48,651**	**46,287**
repartizat clienţilor finali	mii m3		52,896	50,796	45,984	38,692	40,370	41,907	43,983	42,635	41,717	40,187
nerepartizat clienţilor finali	mii m3		-	-	-	7,172	9,008	7,664	8,121	8,259	6,934	6,099
• apă rece	mii m3		42,634	39,101	39,369	40,702	39,577	39,139	41,571	40,582	39,447	37,475
• apă p-u încălzire	mii m3		5,498	6,867	1,478	1,009	6,064	6,907	7,491	7,846	7,254	6,994
• apă tehnologică	mii m3		4,764	4,828	5,137	4,151	3,736	3,526	3,042	2,465	1,950	1,818
APA POTABILĂ (calda si rece)	**mii m3**	**60,232**	**48,132**	**45,968**	**40,848**	**41,712**	**45,642**	**46,046**	**49,062**	**48,428**	**46,701**	**44,469**
Populaţia	**mii m3**	**47,911**	**34,622**	**32,737**	**31,853**	**32,832**	**36,608**	**37,225**	**39,234**	**38,787**	**37,801**	**35,815**
1) ÎMGFL	**mii m3**		-	-	-	-	**18,207**	**18,099**	**18,099**	**18,096**	**17,053**	**15,951**
2) APLP	**mii m3**		-	-	-	-	**7,499**	**7,482**	**7,715**	**7,652**	**7,353**	**7,287**
3) CCL	**mii m3**		-	-	-	-	**4,066**	**3,970**	**4,061**	**3,993**	**3,755**	**3,531**
5) Locuinţe departamentale	**mii m3**		-	-	-	-	**2,497**	**2,485**	**2,766**	**2,839**	**2,949**	**2,787**
6) Sectorul particular	**mii m3**		-	-	-	-	**4,289**	**4,722**	**5,917**	**5,464**	**5,941**	**5,487**
7) Apartamente	**mii m3**		-	-	-	-	**49**	**467**	**675**	**743**	**750**	**773**
Organizaţiile bugetare	**mii m3**	**5,764.3**	**4,408**	**3,954**	**3,858**	**2,733**	**2,618**	**2,647**	**2,814**	**2,688**	**2,525**	**2,437**
Agenţii economici	**mii m3**	**6,556**	**9,102**	**9,277**	**5,137**	**6,147**	**6,416**	**6,174**	**7,014**	**6,953**	**6,375**	**6,217**
a) Sistemul termoenergetic	**mii m3**	**631**	**5,239**	**5,388**	**879**	**715**	**710**	**539**	**671**	**675**	**534**	**476**
1) SA Termocom	mii m3		4,126	4,968	749	604	607	434	589	593	464	414
pierderi la reţele	*mii m3*		*1,451*	*1,086*	*-*	*21*	*312*	*243*	*508*	*507*	*381*	*348*
2) SA CET 1	mii m3		53	62	51	40	49	40	32	34	22	13
3) SA CET 2	mii m3		1,060	358	79	71	54	66	51	48	47	49
b) Alţi clienţi	**mii m3**	**5,925**	**3,863**	**3,889**	**4,258**	**5,431**	**5,705**	**5,634**	**6,343**	**6,278**	**5,841**	**5,741**
APA TEHNOLOGICĂ	**mii m3**	**4,345**	**4,764**	**4,828**	**5,137**	**4,151**	**3,736**	**3,526**	**3,042**	**2,465**	**1,950**	**1,818**
Complexul termoenergetic	**mii m3**	**2,113**	**4,613**	**4,346**	**3,885**	**3,249**	**2,729**	**2,451**	**1,951**	**2,040**	**1,873**	**1,735**
2) SA CET 1	mii m3		99	930	722	584	536	474	436	482	378	119
3) SA CET 2	mii m3		3,299	3,221	3,163	2,665	2,193	1,977	1,515	1,559	1,495	1,616
SA Moldcarton	**mii m3**		**33**	**396**	**1,174**	**845**	**956**	**1,017**	**1,042**	**368**	**2**	**-**
Populaţia	**mii m3**		-	-	-	-	-	-	-	-	-	**2**
Alţi clienţi	**mii m3**	**2,232**	**118**	**86**	**78**	**57**	**51**	**58**	**49**	**57**	**75**	**81**
APA BRUTĂ	**mii m3**	**-**	**-**	**-**	**-**	**-**	**-**	**118**	**234**	**23**	**29**	**26**
informativ, consum propriu (ACC)	**mii m3**		**3,176**	**867**	**762**	**662**	**627**	**645**	**1,301**	**2,086**	**1,456**	**1,654**

Specificare	UM	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
VENIT TOTAL (apă tratată şi brută)	**mii lei**		**203,121**	**210,776**	**194,591**	**203,834**	**206,470**	**203,975**	**238,722**	**289,287**	**306,232**	**408,806**
VENIT APĂ TRATATĂ (potabilă şi tehnologică)	**mii lei**		**203,121**	**210,776**	**194,591**	**203,834**	**206,470**	**203,728**	**238,228**	**289,193**	**306,134**	**408,728**
repartizat clienţilor finali	mii lei		203,121	210,776	194,591	189,778	188,815	188,706	210,782	252,688	269,002	359,568
nerepartizat clienţilor finali	mii lei		-	-	-	14,056	17,655	15,022	27,446	36,505	37,132	49,160
• apă rece	mii lei		153,309	158,395	153,035	160,821	157,428	154,997	185,745	238,984	255,355	339,291
• apă p-u încălzire	mii lei		12,024	13,788	3,261	2,247	12,355	14,106	25,141	35,867	39,029	57,275
• apă tehnologică	mii lei		37,788	38,593	38,294	40,766	36,686	34,625	27,342	14,342	11,750	12,162
APA POTABILĂ	**mii lei**		**165,333**	**172,182**	**156,296**	**163,068**	**169,784**	**169,103**	**210,886**	**274,851**	**294,384**	**396,566**
Populaţia	**mii lei**		**60,529**	**64,853**	**69,723**	**64,351**	**71,655**	**72,961**	**127,797**	**171,438**	**194,901**	**288,667**
Organizaţiile bugetare	**mii lei**		**44,969**	**43,558**	**37,840**	**30,027**	**28,989**	**29,227**	**24,763**	**29,946**	**29,083**	**30,951**
Agenţii economici	**mii lei**		**59,835**	**63,771**	**48,733**	**68,690**	**69,139**	**66,915**	**58,326**	**73,467**	**70,400**	**76,947**
1) SA Termocom	mii lei		16,115	16,086	4,720	6,636	3,945	2,634	2,447	3,193	3,109	3,642
pierderi la reţele	*mii lei*		*3,307*	*2,143*	*-*	*40*	*612*	*476*	*1,693*	*2,243*	*2,155*	*2,806*
APA TEHNOLOGICĂ	**mii lei**		**37,788**	**38,593**	**38,294**	**40,766**	**36,686**	**34,625**	**27,342**	**14,342**	**11,750**	**12,162**
Complexul termoenergetic	**mii lei**		**36,435**	**34,251**	**28,041**	**31,908**	**26,799**	**24,064**	**17,484**	**11,895**	**11,337**	**11,609**
2) SA CET 1	mii lei		193	7,124	4,958	5,735	5,267	4,650	3,826	2,808	2,260	795
3) SA CET 2	mii lei		25,192	25,211	23,083	26,173	21,532	19,414	13,659	9,087	9,078	10,814
SA Moldcarton	**mii lei**		**294**	**3,507**	**9,553**	**8,299**	**9,387**	**9,988**	**9,465**	**2,147**	**14**	**-**
Populaţia	**mii lei**		**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**11**
Alţi clienţi	**mii lei**		**1,059**	**835**	**701**	**560**	**501**	**573**	**393**	**300**	**399**	**542**
APA BRUTĂ	**mii lei**		**-**	**-**	**-**	**-**	**-**	**247**	**494**	**94**	**98**	**78**
informativ, consum propriu (ACC)	**mii lei**		**18,545**	**3,834**	**3,969**	**2,628**	**2,583**	**2,741**	**7,415**	**13,765**	**9,609**	**11,151**
TARIF MEDIU (apă tratată şi brută)	**lei/m3**		**3.84**	**4.15**	**4.23**	**4.44**	**4.18**	**4.11**	**4.56**	**5.68**	**6.29**	**8.83**
TARIF MEDIU (potabilă şi tehnologică)	**lei/m3**		**3.84**	**4.15**	**4.23**	**4.44**	**4.18**	**4.11**	**4.57**	**5.68**	**6.29**	**8.83**
repartizat clienţilor finali	lei/m3		3.84	4.15	4.23	4.90	4.68	4.50	4.79	5.93	6.45	8.95
nerepartizat clienţilor finali	lei/m3		-	-	-	1.96	1.96	1.96	3.38	4.42	5.35	8.06
• apă rece	lei/m3		3.60	4.05	3.89	3.95	3.98	3.96	4.47	5.89	6.47	9.05
• apă p-u încălzire	lei/m3		2.19	2.01	2.21	2.23	2.04	2.04	3.36	4.57	5.38	8.19
• apă tehnologică	lei/m3		7.93	7.99	7.46	9.82	9.82	9.82	8.99	5.82	6.02	6.69
APA POTABILĂ	**lei/m3**		**3.44**	**3.75**	**3.83**	**3.91**	**3.72**	**3.67**	**4.30**	**5.68**	**6.30**	**8.92**
Populaţia	**lei/m3**		**1.75**	**1.98**	**2.19**	**1.96**	**1.96**	**1.96**	**3.26**	**4.42**	**5.16**	**8.06**
Organizaţiile bugetare	**lei/m3**		**10.20**	**11.02**	**9.81**	**10.99**	**11.07**	**11.04**	**8.80**	**11.14**	**11.52**	**12.70**
Agenţii economici	**lei/m3**		**6.57**	**6.87**	**9.49**	**11.18**	**10.78**	**10.84**	**8.32**	**10.57**	**11.04**	**12.38**
a) Sistemul termoenergetic	**lei/m3**		**3.68**	**3.86**	**6.88**	**11.03**	**7.20**	**7.10**	**4.74**	**6.09**	**7.33**	**9.31**
1) SA Termocom	lei/m3		3.91	3.24	6.31	10.98	6.50	6.07	4.16	5.39	6.70	8.80
pierderi la reţele	*lei/m3*		*2.28*	*1.97*	*-*	*1.96*	*1.96*	*1.96*	*3.33*	*4.42*	*5.65*	*8.06*
2) SA CET 1	lei/m3		2.28	11.09	10.30	11.30	11.30	11.30	8.86	11.14	11.47	12.70
3) SA CET 2	lei/m3		2.88	11.26	10.06	11.30	11.30	11.30	8.90	11.14	11.54	12.70
b) Alţi agenţi economici	**lei/m3**		**10.50**	**11.05**	**10.03**	**11.19**	**11.22**	**11.20**	**8.69**	**11.05**	**11.38**	**12.63**
APA TEHNOLOGICĂ	**lei/m3**		**7.93**	**7.99**	**7.46**	**9.82**	**9.82**	**9.82**	**8.99**	**5.82**	**6.02**	**6.69**
APA BRUTĂ	**lei/m3**		**-**	**-**	**-**	**-**	**-**	**2.10**	**2.11**	**4.05**	**3.34**	**2.96**
informativ, consum propriu (ACC)	**lei/m3**		**5.84**	**4.42**	**5.21**	**3.97**	**4.12**	**4.25**	**5.70**	**6.60**	**6.60**	**6.74**

Annex 5 Large Consumer Survey Questionnaire

CHISINAU Water Supply & Sewage Treatment – Feasibility Study

NON DOMESTIC LARGE CONSUMERS SURVEY

OBJECTIVES of the survey

APACANAL intends to improve the water supply conditions in its service area, and to propose appropriate solutions. For this, it is necessary to carry out detailed studies. The scope of these studies is to define actions that have to be taken for the future coming years in quantity and quality.

The objective of this "**LARGE CONSUMERS SURVEY**" is:

- to have a better knowledge of the relevant problems that you are facing, and
- to appreciate your future needs for improving the conditions of water supply in your area.

Thanks for your invaluable help.

This information is strictly confidential, and will not be used for private purposes.

NAME of unit:...

Address: ....

....

Telephone : ....

Person to contact :...

Interviewer :..................................	Supervisor :..................................	Coder :..................................
Date :..................................	Date :..................................	Date :..................................

1. THE UNIT

Q.1. Date of creation of the unit ....

1.1. Major activities and products

Q.2.

a. If **Hospital**: Beds *(number)* ....

b. If **Hotel**:
. Category ....
. Beds *(number)* ....
. Occupation rate .... (in WINTER ....%
(in SUMMER ....%
. Restaurant................................ Yes ❑ 1 .... No ❑ 2
. Garden..................................... Yes ❑ 1 .... No ❑ 2

c. If **School**: Students *(number)*........... (boarders ....
(non-boarders..................................
Days open *(number)* : ..... (per week ....
(per year..

d. If **Other**: Major activitius and products
....
....
....

Q.3. How many units do you have in Chisinau:..

a. ....
b. ....
c. ....
d. ....
e. ....
f. ....

Q.4. Area of the plot:

* Occupied by structures.. *hectares*
* Green areas and open space .... *hectares*
Total.. ***hectares***

1.2. Organisation of activities

Q.5. Closing-down of unit:

a. Weekly.. Yes ❑ 1 .... No ❑ 2

- **If YES**, how many days...

b. Yearly .... Yes ❑ 1 .... No ❑ 2

- **If YES**, at which periods?...

c. Overall, how many days do losing-downs last? ....

Q.6. Does your unit have seasonal activities... Yes ❑ 1 .... No ❑ 2

- **If YES,** specify (the periods ....
(the activities ....

Q.7. Are some activities entrusted to outside service providers
(for instance, laundry in hotels) .... Yes ❑ 1 .... No ❑ 2

- **If YES**, which activities ? ....

1.3. Employment

Q.8. Please specify the number of workers (managerial and operative) who have been working in your unit in year 2010:

- Working in the unit all year long..
- Seasonal staff: how many...
- Workers who live on site...

2. WATER

2.1. Source of water

Q.9. Number of connections to the APACANAL network : ....

Q.10. Date of first connection to the APACANAL network : ....

Q.11. Tariff category:..

Q.12. Water consumption broken down per source:

Use	APACANAL	Private well # 1	Private well # 2	Other *(specify)* ………………… …………………	Other *(specify)* ………………… …………………
a. WATER SOURCE					
% Fabrication (Process)	❑	❑	❑	❑	❑
% Cleaning	❑	❑	❑	❑	❑
% Cooling	❑	❑	❑	❑	❑
% Staff use: drinking, shower, toilets, etc.	❑	❑	❑	❑	❑
Other...	❑	❑	❑	❑	❑
b. VOLUME CONSUMED average (m^3)					
TOTAL : m^3 in 2010					
% Fabrication (Process)					
% Cleaning					
% Cooling					
% Staff use: drinking, shower, toilets, etc.					
Other...					
Total	**100 %**	**100 %**	**100 %**	**100 %**	**100 %**

c. If the unit uses its own wells/boreholes, specify:

	# 1	# 2	# 3	# 4	# 5
Depth of the well	....	....	....	....	....
Pump : (power	....	....	....	....	....
(flow rate (nominal)	....	....	....	....	....
Pumping (hours / day	....	....	....	....	....
(days / week	....	....	....	....	....
Date of commissioning	....	....	....	....	....
Active / Inactive	....	....	....	....	....

Q.13. Is water from the network available all day long, 7 days per week?

➢ **If NOT** : is it available

WINTER		SUMMER	
. Every day	❑ 1	. Every day	❑ 1
. Sometimes per week	❑ 2	. Sometimes per week	❑ 2
. Sometimes per month	❑ 3	. Sometimes per month	❑ 3
. Sometimes per year	❑ 4	. Sometimes per year	❑ 4
. Never	❑ 5	. Never	❑ 5

➢ During how many **hours in a day**, is water available .... hours

Q.14. Do you have water storage equipment: .... Yes ❑ 1 .... No ❑ 2

- **If YES** : How many tanks: ....
  TOTAL STORAGE CAPACITY: .... m^3
  Cleaned usually .... Yes ❑ 1 .... No ❑ 2
  Maintained usually .... Yes ❑ 1 .... No ❑ 2

Q.15. Do the supplied quantities fit with the total quantitative requirements of your unit: .... Yes ❑ 1 .... No ❑ 2

- **If NO** :
  ➢ Were you activities limited because of water problems, throughout the last 3 years .... Yes ❑ 1 No ❑ 2
    - **If YES,** when . Throughout the year .... ❑ 1
      . In summer, only.. ❑ 2

      During how many months, in a year: ....months

  ➢ What are your additional needs :
    - In winter .... m^3 *per day*
    - In summer .... m^3 *per day*

Q.16. SATISFACTION

	Very Satisfied	**Rather** Satisfied	**Rather not** satisfied	**Not at all** Satisfied
in WINTER				
Pressure	1	2	3	4
Continuity of service (/cuts)	1	2	3	4
Quantities supplied	1	2	3	4
in SUMMER				
Pressure	1	2	3	4
Continuity of service (/cuts)	1	2	3	4
Quantities supplied	1	2	3	4

Q.17. EXPECTATIONS ....

....

....

2.2. Quality of water

Q.18. Do you **c**onsider that the quality of the water supplied by APACANAL fits the requirements (quality standards) of your unit?

Water from APACANAL.. Yes ❑ 1 .... No ❑ 2

Water from another source.. Yes ❑ 1 .... No ❑ 2

Q.19. In order to meet your specific requirements about the quality of water that you use, do you have any **TREATMENT FACILITY** .... Yes ❑ 1.........No ❑ 2

- **If YES**, Which system: ....
  ....

Q.20. SATISFACTION

	Very Satisfied	**Rather** Satisfied	**Rather not** satisfied	**Not at all** Satisfied
***in* WINTER**				
Taste	1	2	3	4
Smell	1	2	3	4
Colour (/Turbidity)	1	2	3	4
Potability	1	2	3	4
***in* SUMMER**				
Taste	1	2	3	4
Smell	1	2	3	4
Colour (/Turbidity)	1	2	3	4
Potability	1	2	3	4

Q.21. EXPECTATIONS...
....
....

2.3. Cost of water

Q.22. The mode of billing that is applied by APACANAL, it is

. a flat rate.. ❑ 1
. according to metered consumption.. ❑ 2
. Other (*specify*) .... ❑ 3
....

Q.23. Is your APACANAL water connection equipped with a meter?

. Yes : individual connection .... ❑ 1
. Yes : collective connection.. ❑ 2
. No... ❑ 2

- **If YES** : list them
  1. ....Date of installation................................
  2. ....Date of installation................................
  3. ....Date of installation................................
  4. ....Date of installation................................
  5. ....Date of installation................................

- Is your meter running well?...Yes ❑ 1........No ❑ 2......NC ❑ 3
- Is the meter read regularly by a meter reader from APACANAL ? .Yes ❑ 1........No ❑ 2......NC ❑ 3
  . **If YES**, frequency of reading ....

Q.24. Does the tariff that is applied to your unit include a payment for **SANITATION (wastewater)** ?..Yes ❑ 1........No ❑ 2

Q.25. Do you receive a bill regularly?...Yes ❑ 1........No ❑ 2......NC ❑ 3

- **If YES** : How often.. **MONTH**

Q.26. Throughout the last 12 months, how much did you spend for water

(*in LEI*)

	APACANAL network	**Private Deepwell # 1**	**Private deepwell # 2**	**Other**	**Total**
Direct costs	....		-	....	....
Operation & maintenance (not including energy)	-		....	....	....
Energy	-		....	....	....
TOTAL	....		....	....	....

Reference period	....		....	....	....

LEI / m^3	....		....	....	....

Q.27. What % of your unit's turnover does water account for ....%

Q.28. The amount that was spent for water purchase: it is .... Too expensive....................❑ 1
. Normal...............................❑ 2
. Cheap.................................❑ 3

- **If TOO EXPENSIVE** Why...
  ....
  ....

Q.29. SATISFACTION

	Very Satisfied	**Rather** Satisfied	**Rather not** Satisfied	**Not at all** Satisfied
Accuracy of metering	1	2	3	4
Accuracy of reading	1	2	3	4
Billing : periodicity	1	2	3	4
Price: total amount of bills	1	2	3	4
Tariff	1	2	3	4

Q.30. EXPECTATIONS ....

....

....

....

2.4. Conclusion on water, at present

Q.31. What is your **MAJOR PROBLEM** related to water ....

....

....

....

Q.32. Which improvement of the water service seems to be 1st priority.......................................

....

....

....

Q.33. OVERALL SATISFACTION ON WATER

	Very Satisfied	**Rather** Satisfied	**Rather not** Satisfied	**Not at all** Satisfied
in WINTER	1	2	3	4
in SUMMER	1	2	3	4

3. SANITATION (wastewater)

3.1. Treatment

Q.34. The waste water produced by your unit is evacuated in :

Piped to the sewerage network .... ❑ 1   a septic tank .... ❑ 3
Private treatment unit .... ❑ 2   other *(specify)* .... ❑ 4

Q.35. If you have a SEPTIC TANK / cesspool

a. Capacity (overall, if several tanks).. m^3

b. Have it/they ever been emptied .... Yes ❑ 1 .... No ❑ 2

- **If YES :**
  - Periodicity : how often do you empty your tank.................... MONTHS
  - When your tank is full, you resort to the services of:
    - . vacuum tanker.................... ❑ 1
    - . manual emptying, by paid labour .... ❑ 2
    - . manual emptying, by non-paid labour.................... ❑ 3
  - How much do you pay for this work? .... Lei

c. Does it overflow........(from time to time .... ❑ 1
(often .... ❑ 2
(never .... ❑ 3

Q.36. If you have any EFFLUENT PRE-TREATMENT FACILITIES

a. Capacity of the plant .... m^3 of effluents

b. Date of commissioning ....

c. Technology ....
....
....

Q.37. Is your wastewater subjected to a special treatment,
before discharge into the natural habitat .... Yes ❑ 1 .... No ❑ 2

- **If YES**, Which one : ....
....
....

Q.38. Do you have a **WASTE WATER RECYCLING DEVICE**.................... Yes ❑ 1 .... No ❑ 2

- **If YES** : Type: ....
....

3.2. Discharge into the natural habitat

Q.39. Discharge points :

RECEPTOR	WASTEWATER			RAINWATER
	Production process	Cooling water	Staff waste water	
On land				
To a drain				
Infiltration				
Cesspool				
Evaporation basin				
To sewerage network				
Recycle				
Other..				
Total				

Q.40. Do you have separate systems for storm water and wastewater ?......................Yes ❑ 1 .... No ❑ 2

3.3. Quality of the environment

Q.41. In the close surroundings of your unit, do you suffer from:

Neighbours' wastewater .... Yes ❑ 1 .... No ❑ 2
Presence of mosquitoes .... Yes ❑ 1 .... No ❑ 2
Bad smell .... Yes ❑ 1 .... No ❑ 2
Other *(specify)* .... Yes ❑ 1 .... No ❑ 2
....
....

3.4. Conclusion on Sanitation

Q.42. What is the **MAJOR PROBLEM** of **SANITATION**...
....
....
....

Q.43. Which **IMPROVEMENT** of sanitation service deems to be 1st priority for you...
....
....

....

Q.44. SATISFACTION

	Very Satisfied	**Rather** Satisfied	**Rather not** Satisfied	**Not at all** Satisfied
SANITATION : overall	1	2	3	4

4. PROSPECTS of your unit

4.1. Problems your firm has to tackle with, at PRESENT

Q.45. What problems related to the **development of production and activity** does your unit experience?

For instance: *(Constraints limiting activity*

(Constraints limiting future development: e.g., shortage of water and or power in summer, bad roads and communication axes, etc.

(Competition between various plants located in other places in Moldova, or outside the country etc.

Prioritise: Which ones are the major problems?

What are the major criteria for investing in Chisinau, or in another area in the country?

....

....

....

....

....

....

Q.46. Among these problems, specify those that are related to **water**

....

....

....

....

....

....

4.2. FUTURE development of the activity of your unit

Q.47. Describe **the FUTURE DEVELOPMENT of your activities**

....

....

....

....

....

4.3. FUTURE water needs

The PRESENT needs of your unit are: .... *m^3 per day* (cf. Q.14, above)

Describe your FUTURE NEEDS, if APACANAL improves significantly the quality of its service
in less than one year:

Q.48. Specify the **changes that could take place in your unit** because of the increase in the quantities made available to your unit

a. ....

....

....

....

b. Would you stop producing water (with your own deepwells),
and/or the supply of water coming from other plants in your area, etc. ....Yes ❑ 1
No ❑ 2

Q.49. What quantities of water **(m^3** per day**)** would your unit be able to consume immediately

.... *m^3 per day*

Q.50. How many years would it take to reach the production capacity
corresponding to the quantities of water here above defined :.................................. years

Q.51. Specify the way your Investment P**rogramme Investment** will be implemented, and accordingly the water consumption will increase towards the "required quantities" above mentioned:

Year	**m^3 / day**
2 010	....
2 011	....
2 012	....
2 013	....
2 014	....
2 015	....
2 020	....
2 025	....
2 030	....

Q.52. In your unit, are any **actions planned to limit/reduce**
your future water consumption?...Yes ❑ 1 .... No ❑ 2

- **If YES** Which actions ? ....
  ....

Q.53. **PRICE OF WATER** : *in the future*, when the quality of service has improved significantly:

- What do you think of the future evolution of the water tariff?

  ....

  ....

  ....

- What would be a "reasonable" price?

  Average price per m^3:.. lei / m^3

Appendix 2

Proposals for the Disinfection of Potable Water

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1. BACKGROUND

1.1. CONTEXT - PURPOSE OF THE STUDY

As a result of non compliance with safety regulation in the current provision for chlorine gas disinfection of water at the Chisinau water treatment works, a requirement was included into the EBRD funded “Water Supply and Sewage Treatment in Chisinau Feasibility Study” Project, for the appointed consultant to consider urgently an alternative solution.

The consultant appointed by S.A. Apa Canal Chisinau, the final beneficiary, was Seureca.

The work by Seureca for this element of the Project entailed:

- An audit of the current situation at the treatment works;
- Specification for alternative solution choice and design;
- Description and comparison of the possible options, with cost estimates;
- A recommended solution with proposition of future activities

This study is aimed at enable ACC to take rapidly a decision and launch the implementation process. It does not include a comprehensive study of all the possible solutions for water disinfection, nor any detailed optimisation. Moreover, it is based on the current parameters for production and water quality, and does not take into account the forecasts of the Master Plan, as these forecasts are not yet available. Finally, it is limited to the main treatment plant. The study does not cover the other production sites or the possible options of booster chlorination in the network.

1.2. AUDIT OF THE CURRENT SITUATION

1.2.1. THE CHISINAU WATER TREATMENT PLANT

The city of Chisinau is supplied with drinking water from one main source, the river Nistru, covering nearly 95 % of the consumption. The raw water of the Nistru is pumped and transferred through a 12 km long pipe to a water treatment plant (WTP).

The treatment line is simple and that commonly found in surface water treatment works; it includes the following stages:

- Pre-chlorination;
- Static coagulation with injection of aluminium choro-hydroxyde or aluminium sulphate;
- Static flocculation with injection of polymer;
- Settling;

- Rapid dual media (activated carbon + zeolith) filtration, and
- Final disinfection with chlorine.

The initial design capacity of the plant was 330,000 m^3/d; the current production is around 200,000 m^3/d. The plant was built in three phases:

- First phase in 1972;
- Second phase in 1977, and
- A third phase in 1981.

No significant additional investments have been made since the construction of the third phase, with the consequence that the whole plant is today in a very bad condition and should be completely rehabilitated or reconstructed.

Apart from the issues with chlorine gas, the major weakness in the treatment process is within the coagulation/flocculation and settling phases. The coagulation and flocculation processes are merely static (no mechanical stirring), and their global efficiency of colloidal and dissolved compounds is probably low.

Further, there is no facility for drawing sludge off the bottom of the settling tanks. It is the lack of ability to extract efficiently the sludge that requires pre-chlorination in order to stop biological activity commencing within the sludge.

The necessity to remove sludge can expect to be a requirement within the long-term modifications to the works that are to be proposed within the Feasibility Study. In the short-term, i.e. prior to the commissioning of any modifications, pre-chlorination will continue to be a requirement. The quantity of chlorine required for pre-chlorination has been considered in this study, within the total quantity to be provided.

1.2.2. EXISTING CHLORINATION PLANT

Chlorine is currently dosed at a maximum rate of 2.0 mg/L for pre-chlorination, and 1.5 mg/L for the final disinfection. The latter takes place within a contact tank providing 2 hours contact time under current maximum flow conditions.

The total daily quantity of chlorine used varies between 350 and 1000kg/day, with an average of 600kg/day. The quantity used at any time is dependent upon flow rates and the condition of the raw water.

The chlorine residual at the outlet to the works varies between 0.3 and 0.5 mg/L of free chlorine, which is considered satisfactory. The total chlorine is not measured on site. The total chlorine in the network varies between 0.3 and 0.7 mg/L, and free chlorine between 0.05 and 0.15 mg/L. The presence of a significant concentration of combined chlorine in the network (chloramines) may be a clue of under dosage of chlorine at site.

The potential for high organic matter within the raw water, and if occurring from within the network, increases the risk of the formation of Trihalomethanes (THM's), which are caused by the reaction of chlorine on organic matter. THMs have been associated through epidemiological studies with some adverse health effects. Many governments set limits on the amount permissible in drinking water.

The chlorination plant at the works comprises two new Wallace & Tiernan chlorinators that can be considered to be satisfactory. There are also six old Russian chlorinators that, being in a poor condition, prevent the accurate dosing of chlorine; these chlorinators are used only for pre-chlorination (and as stand-by for post disinfection).

The hydro ejectors are located close from the injection points, which are quite far from the chlorinators. Hence, the chlorine gas lines are of excessive length whereas they should be the minimum possible. Even if these lines are normally under negative pressure, chlorine leakage could happen.

Figure 1: Chlorine Gas Drums with Long Gas Lines

Chlorine gas is heavy and, in the event of a leak, the gas will settle downwards. Chlorine gas detectors should be set at a low level. Set at a high level, as at the works, the detectors would not register a leak until it had involved a very high quantity of chlorine gas, venting to the atmosphere.

Figure 2: High Level Chlorine Gas Detectors

It is normal practice that, in the event of a chlorine leak, large-volume air blowers draw the chlorinated air out of the room, within which the leak is occurring, and pass the chlorinated air through large-flow downward flowing water “scrubbers” to “clean” the air of the chlorine gas, before allowing it to vent to the atmosphere outside of the building. Such “scrubbers” are not provided at the works. The neutralization system is composed of a set of sprinklers, that, in the event of detection of a leak, would spray a solution of sodium hyposulphite directly in the whole storage room. In the absence of any contact material, the efficiency of the system would probably be very low.

In addition to the above installation issues, there would appear to be insufficient, modern protective clothing available for emergency use, nor other normally accepted requirements such a wind sock to determine wind direction in the event of a leak.

1.2.3. REQUIRED EMERGENCY WORKS ON CHLORINATION

The use of chlorine for pre and post-chlorination entails storage of large quantities of liquid chlorine in conditions which do not meet the basic safety standards.

Moreover, the surrounding area is now dwelled, making illegal the storage of dangerous chemicals, including liquid chloride.

Therefore, the replacement of chlorine as disinfection agent is first priority task of ACC.

For compliance with the Construction Norms, fifteen days storage of chlorine is required to be maintained on site, as determined from the maximum rate of dosage - at the Chisinau works this equates to 11.4 tons.

With regard to the Industrial Safety Regulations for the storage of chlorine on a site:

- Minimum pure chlorine storage must not be more than 15 days, at maximum consumption;
- An Industrial Safety Declaration is required for more than 25 tons stored on a site;
- The minimum permitted distance between a 1 ton chlorine drum and the nearest housing area is 500 m, and
- The minimum distance when 60 kg bottles are used is to be 150 m.

Storage of chlorine of 11.4 tons at the works in 60kg bottles is not feasible, and chlorine drums are required. As the nearest dwellings are less than 500m, (see Figure 3) the storage of chlorine gas is not possible. An alternative that does not involve the storage of chlorine gas, on site, has to be found.

Figure 3: Proximity of Treatment Works (Chlorine Storage) to Housing

The requirement for the Construction Norms (minimum 30 days of storage, possibly reduced to 15 days) conflicts with the Industrial Safety (maximum 15 days of storage, to be reduced if possible). The only way to comply with both norms is to have always exactly 15 days of chemical storage on site.

1.3. DESIGN CRITERIA FOR THE NEW DISINFECTION SYSTEM

1.3.1. WATER QUALITY

Depending on the selected process, the efficiency of the disinfection is highly affected by some water quality parameters.

Ammonia: chlorine combines with ammonia to form chloramines, which should normally be avoided for disinfection. Free chlorine is obtained when all the ammonia has been completely oxidized by chlorine (break point chlorination). Ammonia concentration in the raw water is low (0.05 to 0.20 mg/L): breakpoint pre-chlorination would then require between 0.5 and 2.0 g/m^3 of chlorine – assuming that no ammonia is removed by the clarification process. Ammonia does not react with chlorine dioxide.

Iron and manganese also react with chlorine. Iron concentration is around 0.07 mg/L. Assuming that this iron is fully under Fe2+ form, its oxidation would consume 0.04 mg/L of chlorine. Manganese concentration is very low (less than 10 μg/L).

Organic matter ($KMnO_4$ oxidation) is comprised between 1.6 and 5.0 mgO_2/L in raw water, with a typical figure around 3.2 mg/L – and around 2.3 mg/L in distributed water. Organic matter reacts with chlorine and with chlorine dioxide. Reactions are complex and are liable to form dangerous by-products.

pH is comprised between 7.8 and 8.0; the efficiency of chlorine disinfection is much higher at low pH. Chlorine dioxide is not affected by high pH.

The mineralization of the water is medium range and close from the calco-carbonic equilibrium.

1.3.2. Moldovan norms and standards

The minimum free chlorine residual to be maintained throughout the water distribution network is 0.5 mg/L, for which break-point chlorination is required. Our understanding of the Moldovan law, pending a full assessment within the complete Feasibility Study, is that only chlorine is permitted as the residual agent. For example, our understanding would be that and alternative, such as chlorine dioxide, would not be permitted without a change in law.

1.3.3. By products

Depending on the reagent used for disinfection, some by products harmful for the human health may be formed. The following limitations, extracted from the EU norm, can be taken into account:

Table 1: Maximum concentration reagents authorized in distributed water

	Max concentration in distributed water	Origin
Chlorite (ClO_2-) and chlorate (ClO_3-)	0.2 mg/L	By product of chlorine dioxide production, if not correctly controlled.
Bromates (BrO_4-)	0,01 mg/L	May be formed during hydrolysis of brine for electrochlorination. By product of ozonation
T.H.M	0.1 mg/L	Formed by reaction of chlorine in organic matter

With regard to THM, the use of chlorine for continuous pre-chlorination is not recommended (and even now forbidden in most of geographical Western Europe), especially when the concentration of organic matter in the water is high.

In the case of Chisinau, the pre- disinfection may be necessary because of the long retention time of the water and of the accumulation of settled sludge in the sedimentation tanks. Cancelling the pre-chlorination, or any pre-oxidation would enhance microorganism growth in the bulk of sludge which is stored in the bottom of the settling tanks during long periods, resulting in anaerobic fermentation, bad smelling and odours.

It should be noted that priority rehabilitation works for the Chisinau water treatment plant should include the replacement of the existing settling tank, or, at least, their upgrading by implementation of a continuous desludging system. When these works are implemented, the use of pre-chlorination could be reduced, or cease.

1.3.4. Possible alternative to pure chlorine

Several alternatives to liquid chlorine are possible:

- Sodium hypochlorite, supplied in bulk solution;

- On site production of sodium hypochlorite, by electrolysis of brine;
- On site production of chlorine dioxide, and
- Calcium hypochlorite.

Actually, these processes use only two kinds of disinfection agent: chlorine (for sodium hypochlorite and calcium hypochlorite), and chlorine dioxide.

Some other processes (ozone, UV) may be used for disinfection, but do not have any remaining effect, and therefore cannot be implemented alone for drinking water production, unless the distribution network is short, totally safe and very accurately operated – which is not the case in Chisinau, at present.

1.3.5. Doses and contact time

The following residual concentrations and contact time are generally considered, for a water at pH 7.5 and 15 °C:

Table 2: Residual concentrations and contact time

	Chlorine (free chlorine)	Chlorine dioxide
Bactericide	0.1 to 0.2 mg/L during 15 to 20 minutes	0.1 to 0.2 mg/L during 5 to 10 minutes
Virulicide	0.3 to 0.5 mg/L during 45 minutes	0.3 to 0.5 mg/L during 30 minutes
C.T *	10 to 22 mg.min/L	10 to 15 mg.min/L

*C.T = product of dose (in mg/L) with contact time (in minutes).

The existing treated water storage allows a minimum contact time of 2 hours. Therefore, the required residual of 0.5 mg/L is ample for a complete disinfection.

1.3.6. Estimation of the disinfectant doses

Based in the available data about the water quality and the existing process efficiency, the required doses of chlorine and chlorine dioxide can be assessed. (For organic matter oxidation, these doses are based on average ratio).

Required maximum dose for chlorine:

- Residual : 0.5 mg/L
- Chlorine consumption for disinfection : 0.3 mg/L
- Chlorine consumed by organic matter oxidation : 1.1 mg/L
- Chlorine consumed by iron and manganese : 0.04 mg/L
- Chlorine consumed by ammonia : 1.6 mg/L

Maximum chlorine demand: 3.54 mg/L. This figure is slightly above the current maximum dosing rate.

The total injection would be split into: 2.0 mg/L for pre-chlorination, and 1.54 mg/L for post chlorination.

Required doses for chlorine dioxide:

- Chlorine dioxide residual : 0.3 mg/L
- Chlorine dioxide consumed by disinfection : 0.3 mg/L
- Chlorine dioxide consumed by ammonia : 0 mg/L
- Chlorine dioxide consumed by iron and manganese oxidation : 0,09 mg/L
- Chlorine dioxide consumed by organic matter oxidation: 1.4 mg/L

Maximum chlorine dioxide demand: 2.09 mg/L, rounded up at 2.1 mg/L.

To be split into: 1.1 mg/L in pre oxidation; 1.0 mg/L in final disinfection.

1.3.7. CAPACITY

The disinfection plant will be designed on the current maximum production of the site: 200,000 m^3/d – corresponding to a maximum 212,000 m^3/d of raw water.

Therefore, the maximum dosing capacity shall be:

In case of chlorine use:

- 17.67 kg/h for prechlorination
- 12.83 kg/h for post chlorination

In case of chlorine dioxide use:

- 9.72 kg/h for pre oxidation
- 8.33 kg/h for post disinfection

In order to get a safety margin for the accuracy of dosing, we suggest to base the design of the dosing facilities on the following figures:

Table 3: Nominal capacity of the disinfection plant:

	Cl_2	ClO_2
Pre treatment	20 kg/h	12 kg/h
Post treatment	15 kg/h	10 kg/h

1.3.8. OTHER TECHNICAL CONSTRAINTS AND SPECIFICATION

1.3.8.1. PE pipes attack by ClO_2

The distribution network of Chisinau includes about 450 km of HDPE pipes, including houses connection pipes. This represents 30 % of the total length.

The residual chlorine dioxide reacts with HDPE and causes a rapid ageing of the pipe. Studies recently carried out show that the average life of HDPE house connections is reduced to 5 years with a residual ClO_2 of 0.3 mg/L. ClO_2 oxidizes the superficial layer of the pipe, creating small slots; with the pressure, these slots results in breaking of the pipe.

Hence, it is not possible to use chlorine dioxide for post disinfection. *The residual agent must be chlorine*.

1.3.8.2. The THM issue

The THM are formed by reaction of chlorine on organic matter. The potential for THM formation depends on the type of organic matter: it is much higher for aromatic molecules, mainly present in fulvic acids. The percentage of aromatic molecule can be assessed by a specific analysis, the UV absorbance test, which is not available for Nistru water. Nevertheless, a rough estimation of the THM risk can be drawn from the available data (organic matter, pH, chlorine dose).

THM are formed in two stages: rapid reaction (0 to 2 hours of contact time) and long term reaction (6 hours and more). The most critical would be the potential for short term formation.

- Organic Matter in raw water: Maximum : 5.0 to 6.0 mgO_2/L – equivalent to 3.2 to 3.8 mgTOC/L
- Medium THM short term formation potential: 30 to 60 mg/L

There is a risk of non compliance with the EU norm of 100 mg/L in case of long residence time in the network.

Hence, we recommend to retain the pre chlorination, at least until the works that will probably be recommended in the Feasibility Study are commissioned.

1.4. POSSIBLE OPTIONS

Given the limitation on pure chlorine storage and the necessity of having a chlorine residual in treated water, the use of hypochlorite remains the only solution, at least for post disinfection. Hence, the solution for replacement of the existing plant must be selected among the following three options:

- Option 1: on site hypochlorite production by electrolysis (electro chlorination);
- Option 2: Bulk supply of sodium hypochlorite – (with possibly 60 kg pure chlorine bottles as stand-by facilities), and
- Option 3: combination of chlorine dioxide for preoxidation and sodium hypochlorite, supplied in bulk, for final disinfection.

2. OPTION 1: ELECTRO-CHLORINATION

2.1. GENERAL

2.1.1. PRINCIPLE OF ELECTROCHLORINATION

Electro-chlorination enables an on-site generation of sodium hypochlorite, addressing thus the issue of liquid gas storage.

The general principle of an on-site salt electrolyser system is to create a continuous electrical current through a solution of NaCl. Na+ is electrically attracted to the cathode and Cl- is electrically attracted to the anode.

Chemical reactions take place at the electrodes and give:

- caustic Soda (NaOH) at the cathode
- chlorine Cl_2 at the anode

Both of the chemical react together to produce sodium hypochlorite NaClO.

At the cathode, there is a production of hydrogen (H2), which has to be diluted or destroyed.

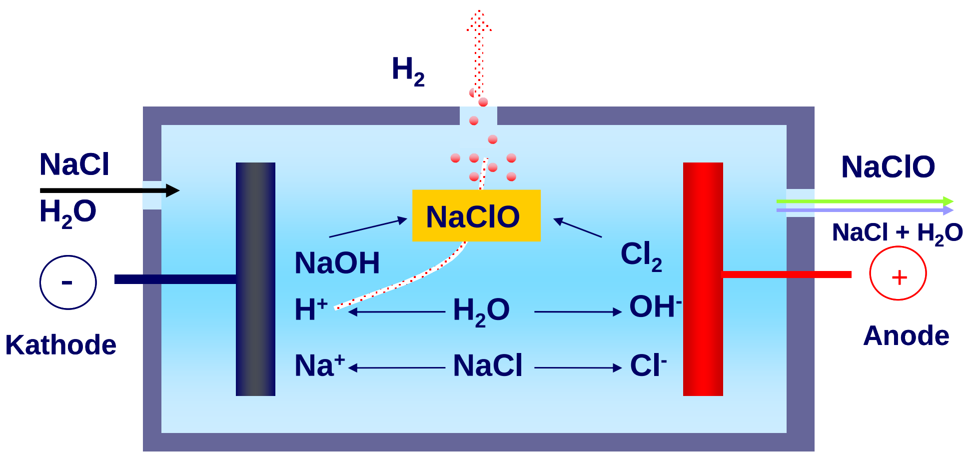

Figure 4: Principle of NaClO Production by Electrolysis

The production of the electrolyser is constant; then, a buffer capacity must be installed to smooth the variations of chlorine demand. The buffer tank allows for the design of the production plant to be at lower capacity than would be required to meet the peak chlorine demand.

2.1.2. DESCRIPTION OF AN ELECTROCHLORINATION PLANT

The electrolytic chlorination plant would comprise the following parts:

- Solid salt (NaCl) storage area;
- brine preparation/ dissolution silo;
- service water softener;
- electrolyser;
- sodium hypochlorite solution intermediate storage tank, including hydrogen dilution and discharge;
- final hypochlorite solution storage tank;
- dosing pumps;
- rectifier / transformer (converting alternative current to continuous current), and
- control system.

The electrolyser is fed with diluted brine (18 g/L). Dilution of brine is done on line (or in a small tank), downstream the brine storage tank.

The electrolyser cell is composed of several compartments separated by baffles; the brine flows through the compartments. A chain of reactions leads to the formation of sodium hypochlorite with a concentration of 6-8 g Cl/L.

After production, the sodium hypochlorite solution is stored in an intermediate tank fitted with blowhole to eliminate the remaining hydrogen.

The electrolyser is fitted with a thermometer and a brine flow meter. If the temperature suddenly rises or the brine flow decreases, the electrolyser is stopped.

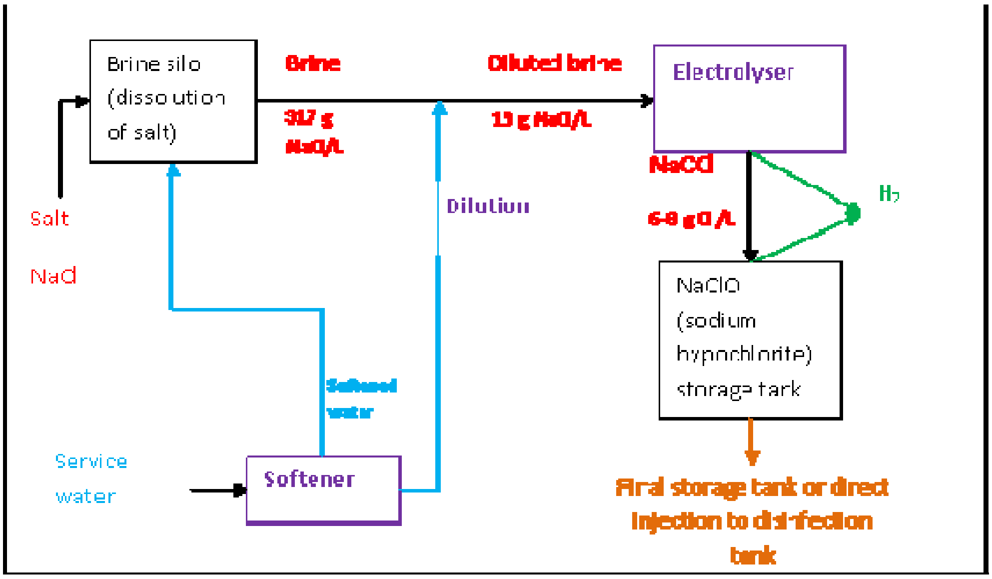

Figure 5: Diagram of the Electrolysis Process

Service water:

For a maximum efficiency of electrolysis, the temperature of the water must be between 10 and 25°C. Then, it could be required to heat the service water in winter.

Due to formation of NaOH and increase of pH, softened water must be used for brine preparation and dilution, to avoid scaling in the electrolysis cells. Water is softened by the system itself. Regeneration of the resin is done with brine; the cycle is automatic.

The complete assembly of one skid (electrolyser + softener) is shown in the following manufacturer's photograph:

Figure 6: Photograph of a Skid of Electrochlorination

Automatic cleaning:

An automatic acid cleaning system is mounted on the electrolyser itself and enables the cleaning of the electrode, when necessary. Indeed the little amount of calcium and magnesium of the salt would progressively depose on the electrode surface and disturb or damage them. The frequency of automatic acid cleaning is adjusted according to the salt quality. This system is then very important to ensure the production and a long shelf life of the electrodes.

2.2. PROCESS CALCULATION

Based on a production of 200 000 m3/d, with 6 % of water losses in the plant, the chlorine dosing capacity will be:

Dosing capacity:

- Prechlorination : 20 kg/h
- Disinfection : 15 kg/h

Consumption of Cl2:

- Maximum consumption of Cl2: 30.5 kg/h = 732 kg/day
- Average consumption of Cl2 : 21,2 kg/h = 509 kg/day

NaCl consumption:

The average efficiency of the electrolysis can be assessed at 3.0 kg of NaCl per kg of Cl_2 (with tubular electrolysers).

Therefore, the salt consumption will be:

- Maximum consumption : 2,2 ton NaCl/day
- Average consumption : 1,9 ton NaCl/day.

Corresponding to 58 tons of NaCl per month at average consumption.

Power consumption:

The energetic efficiency of the electrolyser can be assessed at: 4.1 kWatt.h/kgCl_2

The power consumption will be;

- Maximum consumption : 3,001 kWatt.h/d
- Average consumption : 2,087 kWatt.h/d

The maximum instantaneous power demand, including the pumps and the fans, and taking into account a power factor of 0.8, will be around 175 kVA.

Service water requirement:

The brine supplied to the electrolysers must be prepared with softened water, in order to avoid scaling on the electrodes.

The softened water consumption will be:

- Maximum consumption : 130 m^3/d
- Average consumption : 106 m^3/d

NaClO storage tanks:

The autonomy of the NaClO solution storage may be short, as the electrolysers can be turned on and off several times per day. A standard figure of 8 hours at maximum consumption can be considered for Chisinau.

- Maximum NaClO consumption : 5.16 m^3/h
- Minimum useful volume of storage: 42 m^3

2.3. BASIC DESIGN OF THE ELECTROCHLORINATION PLANT

The essential requirements for the process are:

- Big bags of solid salt storage area and handling device
- Two brine dissolution tanks, each of 50 m^3 capacity;
- Four brine transfer pumps to the electrolyser
- Four tubular electrolysers provided on skids for ease of movement;
- Four rectifiers;
- Four intermediate storage tanks;
- Two final hypochlorite storage tanks, and
- Six dosing pumps provided within two sets, each with two duty and one standby pump.
- One service water pump

2.3.1. NACL DELIVERY PLATFORM AND STORAGE

The salt will be delivered by truck, in big bags of 900 kg each. Each truck will deliver 20 big bags.

- Required autonomy : 15 days at maximum dose.
- Quantity of salt to be stored : 41 Tons
- Density of salt : 1.3
- Volume of salt to be stored : 31,5 m^3
- Required surface area : 40 m^2

The salt storage room shall be equipped with a travelling crane or a monorail to handle the salt bags. It shall b protected from rain and moisture (with sufficient ventilation).

2.3.2. NACL DISSOLVING TANK

The saturated brine has a concentration of 335 g/L of NaCl ; it shall be diluted to 18 g/L, corresponding to the optimum concentration in terms of efficiency (Cl_2/NaCl) and power consumption.

Saturated brine solution will be prepared in concrete tanks. Each tank shall be designed for 3 days operation at maximum salt consumption, to avoid as far as possible manual operation during week-ends. The water level in the tank will be automatically controlled by the electrolyser, so that the tank will always remain full.

- Number of tanks: 2
- Maximum loading of salt: 8 tons (9 big bags)

- Useful capacity of each tanks: 15 m^3 of brine

A sketch of a typical design of dissolution tanks is given hereafter:

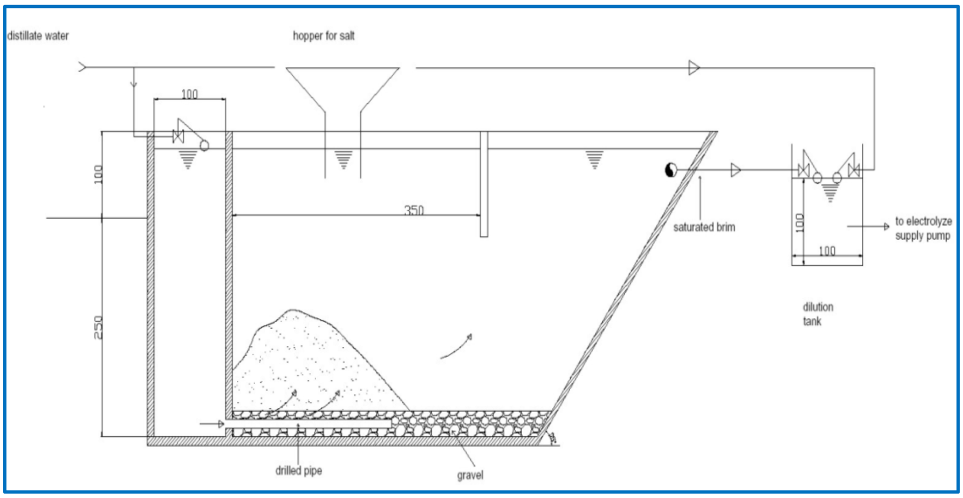

Figure 7: Typical Design of Brine Dissolution Tank

2.3.3. SERVICE WATER SOFTENER

The maximum daily consumption of softened water will be 130 m^3.

This water will be produced by 2 softeners per electrolyser (to be able to regenerate 1 softener without stopping the electrolyser).

2.3.4. ELECTROLYSERS

The maximum instantaneous chlorine demand is estimated at 30.5 kg/h. With the solution storage capacity, the production capacity can be under this figure. This preliminary design is based on a standard model of 10 kg/h capacity, mounted on skid; it could be optimized during the detailed design phase.

- number of electrolysers: 4 (3 + 1 stand-by)
- capacity of each electrolyser: 10 kg/h of Cl_2
- type of electrolysers: tubular cell electrolysers with automatic cleaning procedure of electrodes.
- Efficiency: 3.0 kg NaCl for 1 kilo of chlorine

2.3.5. SODIUM HYPOCHLORITE INTERMEDIATE STORAGE TANK

The objective of these tanks is to allow a safe and complete degassing of the hydrogen produced by the electrolysis process.

- Number of tanks: 4 (one per electrolyser)
- Volume : around 4 m^3 each

A venting system will be installed for dilution and final disposal in the atmosphere of the hydrogen. The dilution rate shall insure a maximum concentration of hydrogen in the air of 1 % - the lower safety limit being set at 4 %.

2.3.6. SODIUM HYPOCHLORITE FINAL STORAGE TANK

The sodium hypochlorite final storage gives flexibility to the operation, even if the production system can be start and stop immediately without any problem.

- Number if intermediate storage tanks : 2
- Capacity : 21 m^3
- Total height : 3.8 m
- Diameter : 3 m
- Material : HDPE or equivalent

The tanks shall be fitted with level gauge, overflow, sampling points and drainage valves.

In addition, an electrical heating system shall prevent freezing of the solution.

The tank shall also be protected against direct sun light and excessive heat.

2.3.7. DOSING PUMPS

The sodium hypochlorite solution will be injected in 4 different points: 2 injection points for preoxidation, and 2 others for post disinfection.

6 pumps must be installed: 2 +1 for preoxidation, 2 +1 for post disinfection. These pumps will have the following characteristics:

Preoxidation:

- Number of pumps : 3 (2 + 1)
- Maximum flow of the pump : 2000 L/h
- Nominal flow : 1667 L/h

Post disinfection:

- Number of pumps : 3 (2 + 1)
- Maximum flow of the pump : 1500 L/h
- Nominal flow : 1250 L/h

New dosing lines shall be installed (diameter: 1 ").

2.3.8. CIVIL WORKS

A new building shall be constructed for the electro chlorination. It will be composed of:

- A room for the rectifiers (AC – DC transformers); 4 rectifiers will be implemented. They will be located in a separate room from the electrolysers. The size of the room shall be at least 12 m x 3.5 m
- A room for solid salt storage (50 m²), with handling equipment
- Two concrete brine dissolving tanks
- A room for the electrolysers, the softeners, the NaClO intermediate storage tanks with H_2 venting, and the pumps to NaClO storage tanks, if needed (depending of final lay-out)). The size of the room shall be 12 m x 6 m.
- A room for the NaClO final storage tanks (2 tanks of 3 m diameter and 3.8 m high) and the dosing pumps.

It could be possible to implement the electrolysers plant in the existing chlorine storage building; this is subject to detail design studies. Within this report, for the cost comparison, a completely new building has been considered.

In addition to the building the required civil works will also include the construction of gutters to lay the new injection pipes.

2.4. QUALITY OF THE SALT

The quality of the salt used for electro chlorination must be high, otherwise

- the electrodes will rapidly clog by precipitation of salts if the content in Ca, Mg, and/or SO_4 is too high, and
- the concentration of bromide (BrO_3) in treated (drinking) water will be too high of the concentration of bromine (Br-) in salt is too high.

Calcium, magnesium, iron and iodine react at the electrode surface. The purity of the NaCl must be close to 99.8%.

The following limitations are recommended by the supplier of electrolysers:

- Calcium Ca^{2+} < 412 mg/kg
- Magnesium Mg^{2+} < 40.4 mg /kg
- Sulfate SO_4^{2-} < 1,147.5 mg/kg
- Manganese Mn^{2+}: traces only
- Suspended solid < 10 mg/kg

To avoid calcium and magnesium, all the water used for brine preparation and brine dilution in the cell is completely and automatically softened by the system. Double head water softener is mounted on the system and controlled automatically.

Finally, the bromide concentration of the salt must be less than 0.5 g Br / kg NaCl in order to respect the limitation of 0.01 mg/L of BrO_4 in the treated water.

2.5. CONCLUSION OF OPTION 1:

This process is safe, well known and widely used. It has been developed as an alternative to pure chlorine storage. Several reliable suppliers can be consulted to get offers in good competition conditions:

- Wallace and Tiernan (Siemens)
- Prominent
- Cifec
- Etc.

The implementation would require civil works, which shall be contracted separately. The electrolyser supplier can provide guide drawings for the civil works.

The electrolyser supplier can also provide assistance to erection and to commissioning of the equipment, and staff training.

The operation and maintenance would not be complex compared to the general requirements of a large water treatment plant. The critical point would be the supply of salt. At least two suppliers must be found, and the delivery way must be defined. The quality of the salt must be carefully monitored.

3. OPTION 2: BULK SUPPLY OF SODIUM HYPOCHLORITE

3.1. PRINCIPLE

Bulk supply of sodium hypochlorite can be an alternative to electrochlorination. It would require low investment – but operation costs will be much higher.

The main drawback of NaClO bulk supply is the rapid decaying of the solution with the time. This phenomenon limits the storage time and the concentration of the solution, especially during warm weather periods.

The option could include the use of bottled chlorine gas, as a standby facility.

3.2. PROCESS CALCULATIONS

3.2.1. DOSING RATES

The dosing rates are the same as for electro chlorination:

Dosing capacities:

- Prechlorination : 20 kg/h
- Disinfection : 15 kg/h

Consumption of Cl2:

- Maximum consumption of Cl_2: 30,5 kg/h = 732 kg/day
- Average consumption of Cl_2 : 21,2 kg/h = 509 kg/day

3.2.2. STORAGE OF BULK SODIUM HYPOCHLORITE

The active chlorine content of a solution of sodium hypochlorite progressively decreases because of the following reaction:

$ClO^- \rightarrow ClO_3^- + 2\ Cl^-$

This phenomenon has two important consequences:

1. The lack of accuracy on the dosage, when the solution becomes too old, and
2. The formation of chlorates (ClO_3^-), which are harmful for human health

The rate of decay highly depends on the temperature and on the concentration of the solution.

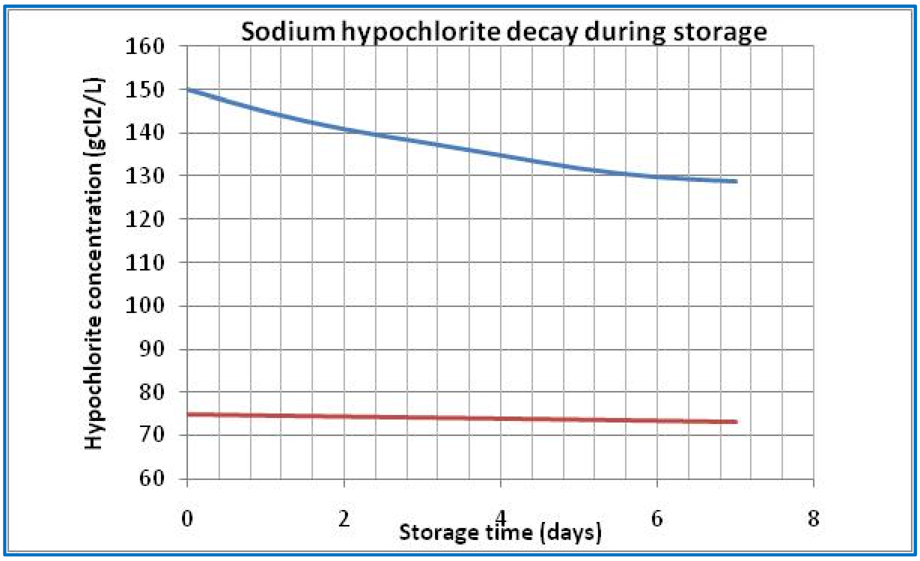

Figure 8: Decay of NaClO Solution at 30°C

The sodium hypochlorite cannot be stored at its nominal concentration (150 gCl_2/L) for the legal time of 15 days; otherwise the loss of active chlorine would make the dosing very inaccurate.

At 75 g/L, the rate of decay is much less, and could be acceptable. After 14 days of storage at30 °C, the loss of Cl_2 will be approximately 7% of the initial concentration, i.e. 0.5 % in concentration.

Hence, the storage facilities should include provisions for diluting the raw chemical when it is delivered to the plant. The total volume of storage must be designed on the base of the diluted solution.

3.2.3. DOSING OF BULK SODIUM HYPOCHLORITE

The required chlorine doses correspond to the following dosing flow:

Preoxidation:

- Maximum : 270 L/h
- Average : 160 L/s

Final disinfection:

- Maximum : 203 L/h
- Average : 100 L/h

3.3. BASIC DESIGN

The use of sodium hypochlorite, supplied in bulk, would require the construction of:

- A delivery platform for unloading the trucks

- Storage tanks of sufficient capacity, fitted with dilution system
- A new set of dosing pumps and injection pipes

3.3.1. DELIVERY PLATFORM

The sodium hypochlorite would be delivered on site by 20 tons capacity trucks. These trucks shall be weighed before and after unloading, to check the exact quantity of delivered product.

The unloading of the truck will be made by pumping.

- Capacity of the pump : 50 m^3/h
- Head : 12 m
- Type of pump : centrifugal – specially designed for corrosive chemicals.

3.3.2. STORAGE AND DILUTION

After each delivery of sodium hypochlorite at 14.5 % concentration, the operator shall dilute it up to a fix concentration of 7.25 %.

- Storage duration : 15 days
- Concentration of solution (minimum) : 74,5 gCl/L
- Maximum Cl_2 consumption : 760 kg/d
- Minimum storage capacity : 153 m^3

The storage shall consist in two tanks of 77 m^3 each capacity.

Assuming that the sodium hypochlorite would be delivered in 20 tons capacity trucks, corresponding to 16.6 m^3 (density 1.2), one truck every 3 days will be required at maximum consumption; and approximately one every five days at average.

Due to the high pH of the hypochlorite solution, the dilution will provoke precipitation of the calcium carbonate of the diluting water.

3.3.3. DOSING

As for electrolyser, 6 pumps must be installed: 2 +1 for pre-oxidation, 2 +1 for post disinfection. The solution being more concentrated the dosing pumps will be smaller. They will have the following characteristics:

Pre-oxidation:

- Number of pumps : 3 (2 + 1)
- Maximum flow of the pump : 170 L/h

- Nominal flow : 120 L/h

Post disinfection:

- Number of pumps : 3 (2 + 1)
- Maximum flow of the pump : 120 L/h
- Nominal flow : 100 L/h

4 new dosing lines shall be installed.

3.3.4. REQUIRED CIVIL WORKS

Assuming that the dosing pumps could be installed in the existing chlorine building, the civil work would include the following:

- Installation of the trucks weighing platform;
- Construction of the two storage tanks, protected from direct light sun and excessive heat; also protected against frost;
- Construction of new gutters to lay the dosing pipes, and
- Connection to the service water network.

The access road, and the internal alleys must be checked in order to insure that they can bear the 20 tons trucks in all conditions of weather; the manoeuvres of the trucks inside the plant must also be defined. Possibility of using of 60 kg bottles as stand-by facility

The 60 kg bottles of chlorine would be authorized on the site, as the houses are sufficiently far away (more than 150 m).

The flow of pure chlorine that can be extracted from a container under gas form is limited by the temperature drop resulting from the vaporization of the liquid chlorine. In addition, this flow must be lower than 10 % of the container capacity.

For the 60 kg bottles, the maximum flow would be:

$Q = (34 \times T + 270)$ g/h

With T= ambient temperature

In winter, at T= 5 °C (assuming that the building would be heated)

$Q = 440$ g/h

In summer, the flow would be limited by the rule of 10% at 600 g/h

Several bottles can be operated in parallel. However, the average chlorine demand of 21.2 kg/h would require 48 bottles, which is technically impossible.

The chlorine can also be extracted under liquid form, and then vaporized in an evaporator. In this case, the maximum flow is limited to 25 % of the bottle capacity, i.e. 15 kg/h.

With liquid extraction, four bottles could be connected, and four others as stand-by, with an automatic change-over device. In this case, the autonomy of the system would be 15 hours at maximum chlorine demand, which is very short and staff demanding (for handling the empty bottles and connecting new ones), but could be contemplated as a stand-by facility.

The required investments would be:

- Two liquid chlorine manifold;
- One automatic change-over;
- One chlorine evaporator;
- Connection to the existing Wallace and Tiernan chlorinators for post disinfection, and
- Two new chlorinators for the pre-oxidation.

In addition, the safety system shall be upgraded:

- Implementation of new chlorine sensors, in the chlorinator room;
- Modification of the chlorine pipes; moving of the ejectors in the dosing room (to have short pure chlorine pipes);
- Implementation of safety fans in the dosing room and in the storage room;
- Implementation of a neutralisation tower (with packing, NaOH tank and recirculation pump);
- Adequate protective clothing.

The implementation of the neutralization tower will required some civil works.

3.4. QUALITY OF SODIUM HYPOCHLORITE

The commercial solution of sodium hypochlorite often contents a too high concentration of bromates.

In order to respect the limitation of 0.01 mg/L of bromate in the treated water, the sodium hypochlorite (at 14.5% concentration) must content less than 30 mg/L of $NaBrO_3$.

In addition, the solution must respect the following limitation:

- Arsenic (As) < 30 mg/l
- Cadmium (Cd) < 15 mg/L
- Chrome (Cr) < 150 mg/L
- Mercury (Hg) < 3 mg/L
- Nickel (Ni) < 60 mg/L

3.5. CONCLUSION ON OPTION 2

This solution would be safe and simple to operate. The only difficulty would be the control of the dilution and of the actual concentration of the stored hypochlorite – especially in case of long retention time resulting from a low chlorine demand period.

The delivery chain of the sodium hypochlorite must absolutely be secured (with at least 2 or even 3 agreed and reliable suppliers, able to deliver the requested quantities with a steady quality). The quality of the product must be checked and guaranteed by the suppliers. Access to the site must be assured considering the weight and size of the delivery vehicles.

All the economical feasibility of this solution relies on the cost of sodium hypochlorite and the possibility of negotiating it for large quantities.

4. OPTION 3: COMBINATION OF CHLORINE DIOXIDE AND SODIUM HYPOCHLORITE IN BULK

4.1. GENERAL

The principle of this hybrid system would be to use as much as possible chlorine dioxide, which presents the advantage of being relatively cheap, and use sodium hydroxide only for the residual, as chlorine dioxide is not compatible with the HDPE found in the network.

Chlorine dioxide is produced on site by reaction of sodium chlorite ($Na(ClO)_2$) on hydrochloric acid (HCl).

4.2. PROCESS CALCULATION

4.2.1. DOSES

It must be noticed that the chlorine dioxide does not react with ammonia. Hence, the chlorine demand to reach the break point and achieve a free chlorine residual cannot be reduced to the residual concentration only.

The following doses can be expected:

ClO_2 for pre-oxidation:

- Chlorine dioxide consumed by iron and manganese oxidation : 0.09 mg/litre
- Chlorine dioxide consumed by organic matter oxidation : 1.4 mg/litre
- ClO_2 for disinfection : 0.3 mg/L

Requirement of chlorine dioxide: 1.8 mg/L

Cl_2 for disinfection only:

- To ensure the residual into supply : 0.5 mg/L
- For ammonia oxidation : 2.0 mg/L (average: 1.0 mg/L)

Requirement for chlorine as gas: 2.5 mg/L maximum, average of 1.5 mg/L

Then, the dosing capacities shall be:

ClO_2 for preoxidation:

- Maximum : 15.9 kg/h = 381 kg/day
- Average : 12.0 kg/h = 288 kg/day

Cl_2 for final disinfection:

- Maximum : 20.9 kg/h = 502 kg/day
- Average :11.3 kg/h = 271 kg/day

4.2.2. PREPARATION OF CHLORINE DIOXIDE

The chlorine dioxide is generated by reaction of sodium chlorite with hydrochloric acid:

$5\ NaClO_2 + 4\ HCl \rightarrow 4\ ClO_2 + 5\ NaCl + 2\ H_2O$

Remark: as chlorine dioxide is more volatile than chlorine, it could degas at the outlet weirs of the settler; hence, the doses shall be carefully controlled.

The efficiency of a chlorine dioxide generator could be about 98 %. Actually, a benchmarking made in 2000 on 170 generators operated in France has shown that the average efficiency was not more than 80 to 90 %.

Therefore, the reagents consumption for a production of 1 kg of ClO_2 will be:

- 2.04 kg of pure $NaClO_2$ – 8.17 kg of 25 % commercial solution
- 0.60 kg of pure HCl – 1.82 kg of 33% commercial solution.

The consumption of commercial solution would be:

Maximum:

- 778 kg/day of $NaClO_2$ commercial solution
- 694 kg/day of HCl commercial solution

Average:

- 587 kg/d of $NaClO_2$ commercial solution
- 524 kg/d of HCl commercial solution

4.2.3. INJECTION FLOWS

The chlorine dioxide solution has a concentration of approximately 2 g/l, (depending on the supplier's technology).

The injection flow will be:

- Average flow : 6 m^3/h, in two lines
- Maximum flow: 7.95 m^3/h, in two lines

The chlorine dioxide solution cannot be stored (problem of degassing) and therefore shall be directly injected.

4.3. BASIC DESIGN

The hybrid ClO_2/hypochlorite option would require the construction of:

- A ClO_2 production plant, with sufficient storage of sodium chlorite and acid;
- A delivery platform for unloading the trucks of hypochlorite;
- Hypochlorite storage tanks, fitted with dilution system, and

- A new set of dosing pumps and injection pipes

4.3.1. CHLORINE DIOXIDE PLANT

The chlorine dioxide plant would comprise the following elements:

- Chemical storage
- Chlorine dioxide preparation system
- Injection device

4.3.1.1. Chemical Storage

- HCl storage tank : useful volume : 10 m³ (11 Tonne of HCl)
- $NaClO_2$ storage tank : useful volume : 9.4 m³ (11.7 tonnes of $NaClO_2$ 25%)

These tanks shall be built in a specific area, with retention walls in case of leakage and possibility of neutralising any spillage of acid with caustic soda. The delivery points for the chemical trucks shall also be secured.

4.3.1.2. Chlorine dioxide production plant

The ClO_2 preparation plant would comprise the following parts:

- HCl dosing pump – pipes and fittings – flow meter;
- $NaClO_2$ dosing pump – pipes and fittings – flow meter, and
- Reaction chamber

The preparation system is normally supplied complete by the manufacturers.

4.3.2. SODIUM HYPOCHLORITE PLANT

Delivery platform for sodium hypochlorite

The sodium hypochlorite would still have to be delivered on site by 20 tons capacity trucks. The delivery platform would be the same as for the option 2, with unloading pump and weighting device. Storage and dilution:

As for option 2, the sodium hypochlorite at 14.5 % concentration shall be diluted up to a fix concentration of 7.25 %.

- Storage duration : 15 days
- Concentration of solution (minimum) : 74,5 gCl/L
- Maximum Cl_2 consumption : 502 kg/d
- Minimum storage capacity : 101 m^3

The storage shall consist in two tanks of 51 m^3 each capacity.

4.3.3. DOSING

As for the two other options, 6 pumps must be installed: 2 +1 for pre-oxidation, 2 +1 for post disinfection.

Pre-oxidation:

- Number of pumps : 5 (4 + 1)
- Maximum flow of the pump : 2,000 L/h
- Nominal flow : 1,875 L/h

Post disinfection:

- Number of pumps : 3 (2 + 1)
- Maximum flow of the pump : 60 L/h
- Nominal flow : 40 L/h

4 new dosing lines shall be installed.

4.3.4. REQUIRED CIVIL WORKS

4.3.4.1. For the sodium hypochlorite

Assuming that the dosing pumps could be installed in the existing chlorine building, the civil work would include the following:

- Installation of the trucks weighing platform;
- Construction of the two storage tanks, protected from direct light sun and excessive heat; also protected against frost;
- Construction of new gutters to lay the dosing pipes, and
- Connection to the service water network

The access road, and the internal alleys must be checked in order to insure that they can bear the 20 tons trucks in all conditions of weather; the manoeuvres of the trucks inside the plant must also be defined.

4.3.4.2. For the ClO_2 plant

A building for chemical storage and chlorine dioxide preparation units shall be constructed.

A new gutter for the dosing pipes shall be installed.

4.4. COMMERCIAL PRODUCTS

During the course of the preparation of this Study, the Consultant was invited to a presentation of Zxioz, a commercial variant of the use of chlorine dioxide. The presenters made a case for Apa Canal to adopt the product as an alternative for water disinfection. The product is one of several that available for disinfection; mostly in other than potable water applications.

This company proposes to deliver the two basic components in bulk, with some improvement in the composition, that enable to simply mix and dilute them in a fix proportion, without the use of a special reactor.

This does not really change the principle of chlorine dioxide on site preparation, except that the preparation is done by batch and not continuously, and that the investment cost would probably be lower.

It must be noticed that the reason for having developed continuous preparation is that chlorine dioxide degas very easily; hence, it is considered as a dangerous chemical for storage, even several hours only. On addition, the content of chlorite in the solution may increase with the time.

The immediate conclusion of the presentation was that the product would not be suitable for disinfection of the water into supply as the residual disinfectant would be chlorine dioxide, and not chlorine. In addition to the problem of PE pipe attack, our understanding is that by Moldovan law, only chlorine is acceptable as the residual disinfection agent. A change in law might be possible (but might not) but would take too long to achieve, considering the urgency of the situation that faces Apa Canal.

On making this point, the presenters suggested that their product be only used for pre-chlorination. Whilst this is a possibility, within the Study we have not considered the option further for the following reasons:

1. The use of the produce for pre-chlorination and another for disinfection into supply would add an unnecessary complication to the process;
2. The process is not widely adopted. Within the situation facing Apa Canal where the risk of failure in the selection of an option would not be acceptable, we would not recommend any such process without a full evaluation. The adopted solution should be tried and tested over many years of experience, and
3. In order to fully evaluate the process, as Consultant we would need a full technical breakdown of the process, and costs. We would require to evaluate several site references where the product is used in similar circumstances to those in Chisinau, to obtain process performance guarantees and to satisfy ourselves about the sustainability of the product quality and delivery. Such would not be possible with the time scale required for the submission of a Report of the quality required for the Board of Apa Canal to make a fully informed decision.

It should be stressed that the reason not to continue with an evaluation does not mean that such product would not be successful. We are saying that within the time period available to the Consultant, a full and proper appraisal cannot be made. Should Apa Canal decide that they would like the option fully appraised, and make adequate time available, we would make such an appraisal

4.5. CONCLUSION ON OPTION 3

This solution is the most complex from an operation point of view.

The treatment will suppose the supply and storage management of three different chemicals: sodium hypochlorite, sodium chlorite and hydrochloric acid. In addition, for safety reason, the hydrochloric acid must not be stored close from the sodium hypochlorite (as an accidental mix of these chemicals would bring about a strong degassing of chlorine)

Concerning water quality, the main problem created by the use of chlorine dioxide is the possible creation of chlorite (ClO_2^-).

The formation of chlorite is mainly due to poor adjustment of the two reagents used for chlorine dioxide production. If the HCl is dosed under the stoechiometric quantity, there is a residual of chlorite in the chlorine dioxide solution. Hence, it is mainly a problem of operation.

Chlorite may also be generated by reaction of chlorine dioxide with ferrous iron or manganese; these components are normally not present in meaningful quantities in Chisinau potable water.

Remark: the formation of chlorate (ClO_3) is also a risk of chlorine dioxide use, but only when chlorine dioxide is produced with chlorine. In the case of an hybrid solution, chlorate may be formed by reaction of the residual chlorine dioxide with the sodium hypochlorite injected for post disinfection.

5. COMPARISON OF THE OPTIONS

5.1. TECHNICAL COMPARISON

The technical comparison of the options covers two different aspects:

- The reliability and the quality of the treatment
- The difficulties and complexity of the operation and maintenance of the facilities.

Concerning the reliability of the treatment, the best option would be the electrochlorination, because of the steadiness of the product, provided that a safe and reliable supplier of salt is found. By comparison, the bulk supply of sodium hypochlorite presents the drawback of the decay of the solution: even if this phenomenon is widely mitigated by the dilution on site of the commercial product, it may be a source of operation or dosing error. On this aspect, Option 3 (hybrid solution) is obviously less satisfactory, because of the possibility of poor adjustment of the chlorine dioxide preparation, generating chlorite and chlorate, and also the necessity of a strict control of the chlorine dioxide residual in the distributed water, to avoid any chemical attack of the HDPE pipes. Chlorine dioxide also entails storage of pure acid.

With regard to the complexity of the operation and maintenance, the first ranked would be the bulk supply of sodium hypochlorite, as it does not require implementation of any sophisticated equipment on site; but this advantage is balanced by the limited possibility of site storage and the necessity of delivering all along the year large amounts of chemicals, whatever are the weather conditions. In comparison, electrochlorination would only require delivery and storage of solid salt. Once more, the hybrid option is less good on this aspect, as the supply of large quantities of sodium chlorite may be difficult (there are very few suppliers for this chemical). In addition, the control and tuning of chlorine dioxide generators are generally considered as complex.

Therefore, from a technical point of view, there is no significant gap between the Options 1 and 2, whereas the Option 3 is much less efficient.

5.2. COST ASSESSMENT

5.2.1. HYPOTHESIS ON UNIT COSTS

The following unit costs have been considered for the economical comparison:

Table 4: Unit costs considered for the economical comparison

Item	Unit	Cost
Exchange rate	Lei/€	16,2
Energy	Lei/kWatt.h	1,6
Salt, food grade quality, supplied in 900 kg big bags	€/MT	130
Sodium hypochlorite, 14.5 %, supplied in bulk	Lei/MT	4,150
Sodium chlorite supplied in bulk	€/MT	250

Item	Unit	Cost
Hydrochloric acid, supplied in bulk	€/MT	200
Yearly maintenance cost, as percentage of plants value	%	3

5.3. CAPITAL EXPENDITURES

5.3.1. OPTION 1: ELECTROCHLORINATION

The assessed capital cost (CAPEX) for the electrolysis option is shown in the following table:

Table 5: CAPEX Option 1

Item	Quantity	Unit Cost (EUR)	Total Cost (EUR)
Equipment:			
bags handling equipment	1	3,000	3,000
Dissolving silo	2	5,900	11,800
Brine transfer system	4	3,700	14,800
Electrolysers (on skid)	4	87,000	348,000
intermediate storage tank	4	4,500	18,000
final storage tank	2	7,500	15,000
exhaust fan	5	2,600	13,000
dosing pumps	6	5,100	30,600
dosing pipes and fittings	4	1,500	6,000
service water pipe and heating	1	2,500	2,500
Civil works:			
Building 100 m² - with heating	1	35,000	35,000
Biulding 150 m² - with heating	1	45,000	45,000
Electrical works			
Rectifiers	4	26,000	104,000
Cables	4	4,600	18,400
Services			
detailed engineering	1	41,000	41,000
packaging and transport	1	35,000	35,000
Erection	1	10,000	10,000
assistance to commissioning	15	1 ,200	18,000
Total investment			**769,100**

This evaluation of cost is based on an offer from Wallace & Tiernan for all the electrochlorination equipment and services, and on a rough assessment of quantities and unit cost for the civil works.

5.3.2. OPTION 2: BULK SUPPLY OF NACLO

The assessed capital cost (CAPEX) for the option is shown in the following table:

Table 6: CAPEX Option 2

Item	Quantity	Unit Cost (EUR)	Total Cost (EUR)
Equipment:			
NaClO storage tank - 77 m3	2	40,000	80,000
dosing pumps	6	1,500	9,000
dosing pipes and fittings	4	1,200	4,800
service water pipe	1	1,500	1,500
Civil works:			
Building 150 m² - with heating/AC	1	45,000	45,000
Electrical works			
-	1	5,000	5,000
Services			
detailed engineering	1	20,000	20,000
packaging and transport	1	15,000	15,000
Erection	1	5,000	5,000
assistance to commissioning	15	0	0
Total investment			**185,300**

In addition to these costs, the possibility of keeping the pure chlorine, stored in 60 kg bottles, as stand-by facility would require some investments; the cost of these investments is assessed in the following table:

Table 7: Investment for use of Cl2 in 60 kg bottles

Item	Quantity	Unit Cost (EUR)	Total Cost (EUR)
chlorine manifold with valves 6 connections	2	3,500	7,000
automatic changeover	1	7,000	7,000
chlorine evaporators	1	13,000	13,000
piping, valves and fittings	1	5,000	5,000
change of the ejectors location	1	3,000	3,000
new chlorine detectors	4	1,500	6,000
neutralisation tower	1	15,000	15,000
fans and air duct	4	2,000	8,000
Services			
detailed engineering	1	15,000	15,000

Item	Quantity	Unit Cost (EUR)	Total Cost (EUR)
packaging and transport	1	10,000	10,000
Erection	1	8,000	8,000
assistance to commissioning	1	0	0
Total investment			**97,000**

5.4. OPERATIONAL EXPENDITURES

5.4.1. OPTION 1:

The running costs of the electrolyser solution are summarized in the following table:

Table 8: Running costs Option 1 (180,000 m^3/d - 3.1 mgCl_2/L average)

Item	Unit	Quantity	Unit Cost (EUR)	Total Cost (EUR/year)
Power	kWatt.h/y	913,467	0.099	90,776
Salt	Ton/year	693	130	90,080
other chemicals (HCl)	Ton/year	1	250	250
maintenance				17,109
Total	**€/year**			**198,215**
	€/kgCl_2 equiv.			**0.94**

These costs, of course, highly depend on the salt cost. An average figure has been taken into account. A large part of the salt cost is due to transportation. Then, the final cost can be secured only when the route of the salt is defined.

5.4.2. OPTION 2: HYPOCHLORITE BULK SUPPLY

Table 9: Running costs Option 2 (180,000 m^3/d - 3.1 mgCl_2/L average)

Item	Unit	Quantity	Unit Cost (EUR)	Total Cost (EUR/year)
Power	kWatt.h/y	5, 560	0.099	5,223
NaClO 14.6 % purety	Ton/year	1,180	260	306,708
maintenance				1,920
Total	**€/year**			**313,851**
	€/kgCl_2 equiv.			**1.49**

The cost of hypochlorite has been based on an existing supply contract of ACC. Given the very large quantities that would be purchased in case this option is selected, the supply cost could probably be negotiated and decreased.

5.4.3. OPTION 3: HYBRID SOLUTION

Table 10: Running costs Option 3 (1.2 mgClO_2 + 2,0 mgCl_2/L average)

Item	Unit	Quantity	Unit Cost (EUR)	Total Cost (EUR/year)
Power	kWatt.h/y	kWatt.h/y	87,600	0.099
NaClO 14,5 % purety	Ton/year	738	260	191,933
$NaClO_2$ 25 %	Ton/year	683	800	546,216
HCl 33%	Ton/year	152	140	21,294
maintenance				4,860
Total	**€/year**			**773,008**
	€/kgCl_2 equiv.			**3,68**

Most of the cost of the hybrid solution is due to the sodium chlorite. The actual cost of this product must be checked.

5.4.4. "WHOLE LIFE" COST COMPARISON

Taking into account a 10 years period of operation, the global cost of each solution is summarized in the above table:

Table 11: Comparison of the global costs of the different options

		OPEX €/ g Cl_2 equiv	CAPEX €	TOTAL €/ g Cl_2 equiv
option 1	Electrochlorination	1,31	769,100	1,68
option 2a	NaCLO bulk supply	1,58	183,300	1,67
option 2b	NaCLO bulk supply, with 60 kg bottles as stand by	1,58	280,300	1,72
option 3a	Hybrid solution with site preparation of ClO2	3,81	267,400	3,94

5.5. IMPLEMENTATION SCHEDULE

A tentative implementation time schedule is given hereafter; it does not take into consideration the time to obtain approvals and permits required by the Moldovan law.

Option 1: Electrochlorination

Tasks:	weeks:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Consultation of suppliers		■	■	■	■																					
offer analysis / contract preparation						■	■																			
detailed design electrochlorination								■	■																	
manufacturing and supply of equipment								■	■	■	■	■	■	■	■	■	■	■	■	■	■					
consultation of CW company										■	■	■														
offer analysis, contract preparation for CW													■	■												
CW detailed design															■	■										
CW works															■	■	■	■	■	■	■	■	■			
Equipement erection																						■	■	■	■	
commissioning																										
start production																										

A total of 24 weeks would be necessary between the final choice of the option and the start up of production.

Option 2: NaClO bulk supply

Tasks:	weeks:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Consultation of suppliers		■	■																							
offer analysis / contract preparation				■	■																					
detailed design hypochlorite plant		■	■	■	■	■	■																			
manufacturing and supply of equipment								■	■	■	■	■	■	■	■	■	■									
consultation of CW company								■	■	■	■															
offer analysis, contract preparation for CW												■	■													
CW detailed design														■	■											
CW works														■	■	■	■	■	■	■						
Equipement erection																					■	■				
commissioning																							■			
start production																										

This option would require less time for implementation, as the manufacturing of the equipment would be shorter.

Option 3: Hybrid solution

Time schedule for option 3 would be similar to the one of option 1.

6. CONCLUSION

There is little technical difference between the options except for the more onerous reliance upon a supplier for the bulk purchase option. Taking the “whole life” cost of the options over the 10 year life of the equipment, within the accuracy of the evaluation, there is no difference between the on-site electrolysis and the bulk supply of NaClO.

The hybrid solution, with on site preparation of chlorine dioxide, seems much more expensive, because of the cost of the sodium chlorite. However, this figure must be checked. Nevertheless, for technical reasons, complexity of operation and lack of reliability, we would not recommend this option.

There are two other cost factors that may influence the decision of Apa Canal:

1. The site electrolysis option has the advantage that as, the OPEX cost will be an on-going charge against the water tariff, a lower OPEX is less of a burden on the water tariff and the budget derived from the tariff , and

2. The bulk supply option, although higher for operational costs, has a significantly lower capital cost. Apa Canal might prefer this option due the avoidance of having to obtain the necessary capital funding.

A critical issue with the bulk supply of any chemical will be the ability of the supplier to access the site in all weathers. The site is relatively remote and access is not by a well maintained road. During the preliminary discussions with chemical suppliers, it will be essential for them to visit the site and provide a guarantee of delivery. Nevertheless, Apa Canal will need to realize that, even with a guarantee and a bottle gas standby facility, there is a potential risk of failure of delivery during prolonged adverse weather conditions, with consequential risk of failure of the water supply to the city.

Finally, the use of bulk purchase of NaCIO is an interim option to overcome the immediate problem facing Apa Canal, whilst a later study, which might not include the need for pre-chlorination, could be effected at the required time within the Feasibility Study. The capital cost for the site electrolysis would be included into the global capital cost for all the required improvements and modifications at the works.

Considering all the issues, our recommendation would be for on-site electrolysis but we do recognise that other factors might require the Board to select the bulk supply option, with bottle chlorine gas a standby. Provided that the issue of access does not present an undue risk to Apa Canal, we would consider this option to be satisfactory and to provide a long-term sustainable water disinfection solution to Apa Canal.

Appendix 3

Chisinau Wastewater Treatment plant Assessment

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LIST OF ABBREVIATIONS AND ACRONYMS

ACC	Apa Canal Chisinau
BCI	Business Consulting Institute
BOD	Biochemical oxygen demand (5 days unless otherwise stated)
COD	Chemical oxygen demand
EBRD	European Bank for Reconstruction and Development
GHS	Greenhouse Gas
MLSS	Mixed liquor suspended solid
NH4	Ammonium
NO3	Nitrate
NO2	Nitrite
PE	People Equivalent
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solid
WW	Wastewater
WWTP	Wastewater treatment plant

Special note

All concentrations are expressed in mg/L unless otherwise stated. Besides, concentrations of nitrogen compounds and phosphorus compounds are expressed in mgN/L and mgP/L respectively.

EXECUTIVE SUMMARY

Chisinau wastewater treatment plant (WWTP) has been constructed in successive phases (the first phase of the WWTP was put into operation in September 1968) and is operated by Apa Canal Chisinau (ACC). The wastewater is discharged to the plant through three separated sewer mains. The wastewater flow rate to be treated amounts to approximately 152,000 m^3/d while the average concentrations have been estimated to 500 mgCOD/L and 208 mgBOD5/L. Consequently, the pollution load to be treated is comparable to the one of 525,000 People Equivalent (1 PE = 60 gBOD5/L/d).

Chisinau WWTP has been largely oversized and is currently running at only one third of its capacity; the wastewater treatment process features the conventional steps of a medium-load activated sludge plant, including the specificities of a “contact-stabilization” configuration. The lack of an appropriate sludge treatment line combined with the extremely poor conditions of the works and pieces of equipment and the absence of adapted online sensors and of control systems impede the optimal operation of the plant. As a consequence, the quality of the treated water is poor and is far from complying with what could be the discharge limits in the near future in the probable case where Moldova adapts its national regulation to the EU standards.

The bad conditions of the works combined with the lack of air treatment on site and the non-optimal current sludge management scheme increase also the odours.

Considering the poor condition of the existing works and the future stricter objectives in terms of treated water quality, it is recommended to plan the construction of an entire new WWTP. Emergency measures can be implemented to mitigate odours, such as covering sensitive works, installing small air extraction and treatment systems and cleaning idle channels. In the meantime, energy consumption of the plant could be optimised providing small adaptations are made.

As for the longer term, it is recommended to first address the sludge management scheme. Two options should be considered while keeping in mind the future total reconstruction of the plant. Conventional sludge thickening and dewatering is the cheaper and the easier while sludge digestion would necessitate a higher investment and a slightly longer implementation time. However this second option will significantly impact the operational expenses of the whole plant through the onsite generation of heat and electricity and in parallel reduce the greenhouse gas emissions. Eventually the identification of a sustainable final disposal option for the dehydrated sludge should be made by evaluating the current and future regulations and the local conditions for waste disposal (landfill, agricultural use, incineration, etc.).

The improvements brought by the construction of a new sludge treatment facility will allow to change the wastewater treatment process without modifying the hydraulic flow paths so that the plant can work as a low-load activated sludge process and so that the treated water quality is highly improved and gets closer to the EU discharge standards.

The construction of an entire new WWTP should be planned within 5 years to secure the sustainability of the wastewater treatment process while fully integrating the new facilities that could have previously been constructed (sludge treatment line and possibly pretreatment facility). The capital expenses for such a new plant would amount to approximately 70,000,000 Euros.

DETAILED REPORT

1. INTRODUCTION

1.1. BACKGROUND

1.1.1. PLANT LOCATION

The plant is located southeast of the city of Chisinau, on the left bank of the Bic River and at a distance of approximately 7 km from the city centre.

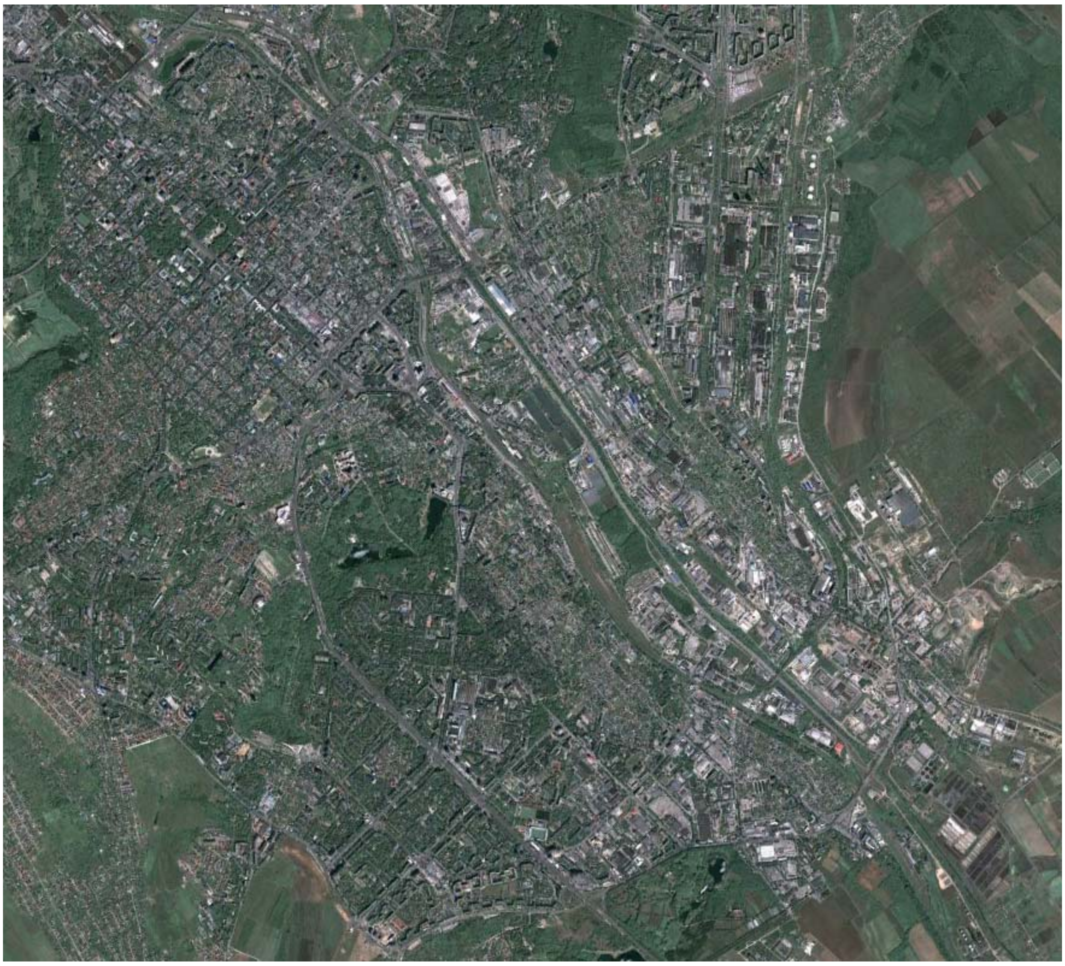


Figure 1: Aerial photography taken on 25/07/2009 of Chisinau city (Source: GoogleEarth)

Figure 2: Aerial photography taken on 25/07/2009 of Chisinau WWTP (Source: GoogleEarth, picture taken on 25/07/2009)

1.1.2. TREATMENT REQUIREMENTS

The ecological department is in charge of setting the allowed discharge limits which are presented in Annex 1. The latter ones significantly differ from the European Urban Waste Water Treatment Directive (UWWTD, 91/271/EEC). Generally speaking, the treatment requirements do not seem to be clearly defined because of the survival of ancient and quite unrealistic strict Russian norms in the mind of some people and because of the way the requirements are currently managed depending on the intrinsic characteristics of each WWTP (load, treatment process, age, etc.); this way of proceeding leads to the variation of the required treated water quality in time and space, which is in total opposition to the treatment philosophy implemented in the European union. In case the European Directive is applied to Chisinau WWTP, the treated wastewater should comply with the values presented in Table 1. It must be noted that the limits are expressed as maximum concentrations or minimum removal rates. The values presented in Table 1 will be considered for the design of the future Chisinau WWTP unless ACC asks for other requirements. Besides, the Bic River will be considered as a sensitive water body until the conclusions of the Environmental Impact Assessment are known.

Table 1: Discharge limits for Chisinau WWTP (in accordance with the EU regulation for WWTPs of a capacity greater than 100 000 PE).

	Max. concentration (mg/L)	Min. removal rate (%)
BOD5	25	80
COD	125	75
TSS	35	90
Ntotal*	10	70
Ptotal*	1	80

*in case the Bic River is categorized as a sensitive water body.

2. WASTEWATER CHARACTERIZATION

2.1. Sewerage System

The sewerage network is designed to be a separate system collecting only wastewater. However there are many evidences of stormwater intrusion into the sewerage network (wastewater flow increase at pumping stations and at WWTP inlet during rainfall events).

2.2. General

2.2.1. Municipal Wastewater

The wastewater from Chisinau is transferred to the WWTP by means of two main sewers running on each bank of the Bic River and discharging the wastewater into a first mixing chamber located at the North-Western end of the WWTP premises then to a second inlet chamber equipped with a by-pass and where the raw wastewater is mixed with various streams coming from:

- the sludge treatment (leachates)
- the secondary clarifiers (some recirculated activated sludge)
- the tanker unloading site (mainly discharge of industrial wastewater)

Figure 3: Photos of: Tanker at the WWTP site (left) & First mixing chamber (right)

2.2.2. Industrial Wastewater

Industrial wastewater is discharged all along the municipal sewerage network and mixed to the municipal wastewater. However a specific pipe collecting the wastewater from the industries around the WWTP discharges directly into the second mixing chamber or further downstream at the inlet to the sand removal tanks. In the latter case a flow meter allows to record the wastewater flow rate of this stream.

It is to be noted that none of the inlet chambers are covered and that the water discharged by the industrial pipe is an important source of odours (similar to those of brewery or winery effluents).

This pipe connects the Singera district which is included in the larger Botanica district of Chisinau to the WWTP. The precise nature of the water collected by this pipe is not known but the main activities in this district include food processing and cardboard manufacturing.

It has been mentioned that industrial sites have not pretreated their wastewater since 1994 although they should do it (depending on their specific discharge agreement with ACC). There is no identified industrial park in Chisinau. Industrial sites are scattered all around the city.

2.3. WASTEWATER FLOW RATES

Three flow meters - named K1, K2 and K3 - are installed at the inlet of the WWTP. K1 and K3 are located on each of the two pipes downstream the lifting pumps. The addition of K1 and K3 measurements display the "municipal" wastewater flow rate as defined above and equal Q1 in Figure 11. K2 refers to the "industrial" wastewater as defined above and equals Q2 in Figure 11.

ACC has provided the historical data of K1, K2 and K3 for year 2008 to 2010 with a time step of one hour as depicted in Figure 4 and Figure 5.

The analysis of these data has enabled to derive some key information as presented below.

- The total daily flow rate is approximately 152,000 m^3/d (Table 2).
- The total hourly flow rate is approximately 6,500 m^3/h (Table 2).
- The hourly peak factor is approximately 2 when looking only at "municipal" wastewater (Table 2).
- In contrast to the "municipal" wastewater flow, the "industrial" wastewater flow is very fluctuating (Figure 6).
- The "industrial" wastewater flow rate is between 1 % and 2 % of the total flow rate (Table 3).
- The total flow rate has decreased by approximately 5 % between 2008 and 2010 (Table 3).
- The "municipal" monthly flow rates vary by approximately 10 % during the year (Figure 7), which might be caused by stormwater intrusion.

However, one should keep in mind that these conclusions do not precisely reflect the raw wastewater characteristics since the "municipal" wastewater flow includes some recirculated activated sludge. If this stream is taken constant during the period 2008-2010, then the above mentioned trends are still valid.

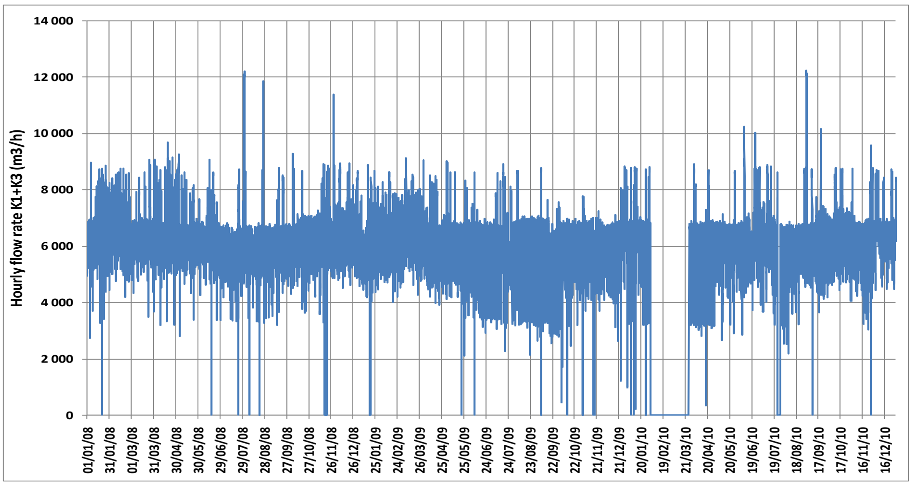


Figure 4: Hourly flow rate of "municipal" wastewater at the inlet of Chisinau WWTP from 01/01/2008 until 31/12/2010

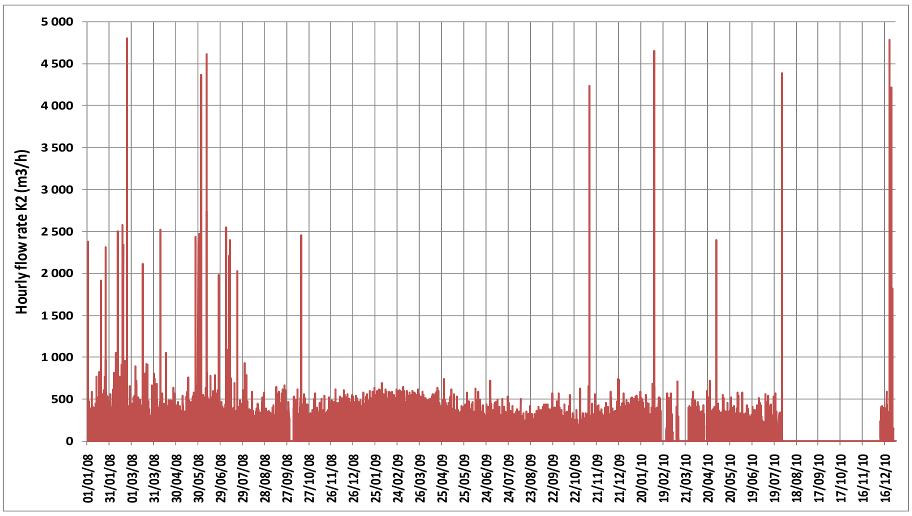


Figure 5: Hourly flow rate of "industrial" wastewater at the inlet of Chisinau WWTP from 01/01/2008 until 31/12/2010

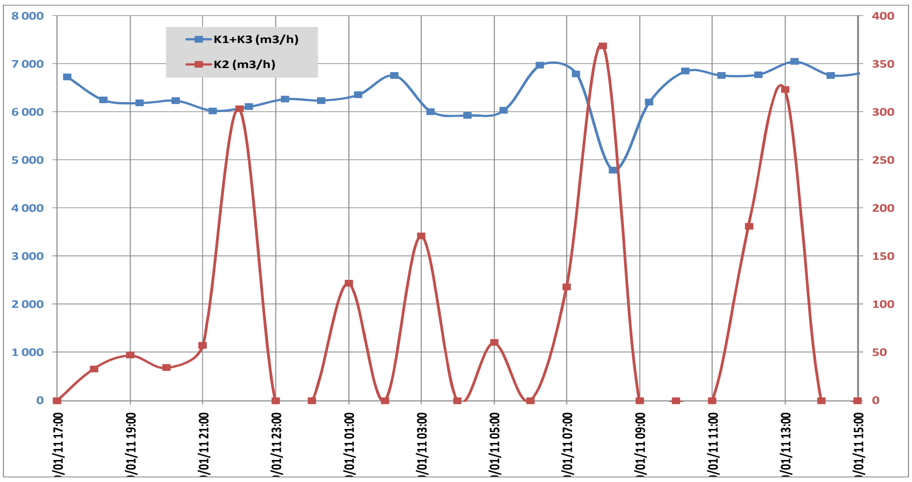


Figure 6: Wastewater flow rates evolution over a 24h period

Table 2: Minimum and maximum and average wastewater flow rates for the period 2008-2010

			Minimum (except 0)	Maximum	Average
K1 + K3 ("municipal")	Hourly flow rate	m3/h	234	12,242	6,250
	Daily flow rate	m3/d	61,047	227,098	149,424
	Monthly flow rate	m3/month	2,418,136	4,944,729	4,504,308
	Yearly flow rate	m3/y	52,965,192	55,718,154	54,051,694
K2 ("industrial")	Hourly flow rate	m3/h	32	4,800	213
	Daily flow rate	m3/d	160	11,256	2,328
	Monthly flow rate	m3/month	27,903	124,782	67,295
	Yearly flow rate	m3/y	652,782	1,017,835	790,342
K1+K2+K3 (total)	Hourly flow rate	m3/h	266	17,042	6,463
	Daily flow rate	m3/d	61,207	238,354	151,752
	Monthly flow rate	m3/month	2,446,039	5,069,511	4,571,603
	Yearly flow rate	m3/y	53,617,974	56,735,989	54,842,036

Table 3: Annual evolution of wastewater flow rates

	Flow rates K1+K3 (m3/y)	Flow rates K2 (m3/y)	Total (m3/y)
2008	55,718,154	1,017,835	56,735,989
2009	53,471,736	700,408	54,172,144
2010	52,965,192	652,782	53,617,974

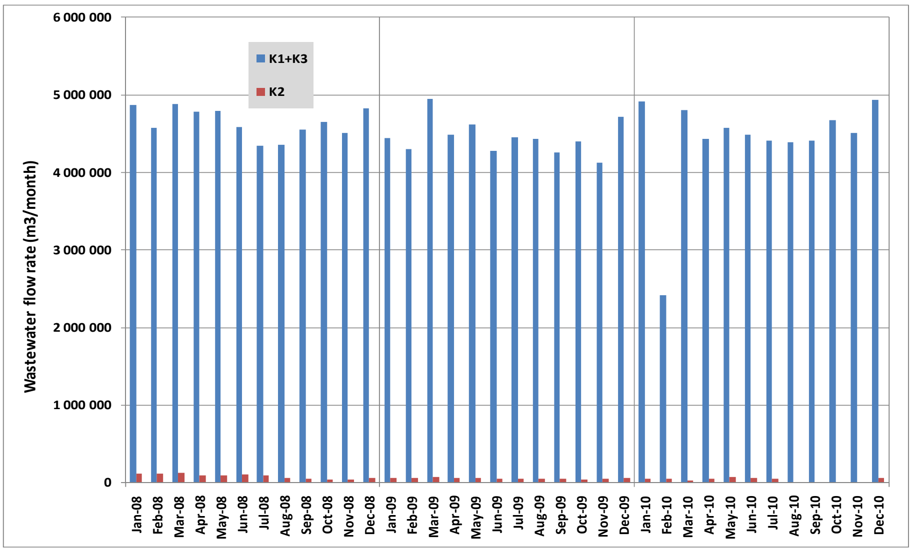


Figure 7: Monthly wastewater flow rates for the period 2008-2010 (the value recorded in February 2010 is doubtful).

2.4. WASTEWATER COMPOSITION

2.4.1. GENERAL

The sampling point used by ACC to monitor the quality of the incoming wastewater is located just upstream the sand removal tanks (Figure 11). The recorded data (Table 4 and Annex 3) then correspond to the stream that enters the treatment process but does not represent the quality of the raw wastewater due to the mixing with other streams as previously mentioned which especially increase the content of organic material and total suspended solids through the recirculation of settled sludge from the secondary clarifiers.

Table 4: Composition of the wastewater upstream the sand removal tanks (average values for the period running from 01/01/2010 until 30/09/2010)

		Inlet
COD	mg/L	739
BOD5	mg/L	338
TSS	mg/L	542
NK	mg/L	56
NH4	mg/L	46
P-PO4	mg/L	9
Temperature	°C	18.5
pH	-	7.3

From June 1st 2009 until June 24th 2009 the sludge recirculation from the secondary clarifiers to the second inlet chamber was stopped. The concentrations found at the sampling point are therefore thought to be more representative of the raw wastewater to be treated during this period. The average concentrations obtained during this period are presented in the following table.

Table 5: Composition of the wastewater upstream the sand removal tanks without sludge recirculation (average values for the period running from 01/06/2009 until 24/06/2010)

		Inlet
COD	mg/L	500
BOD5	mg/L	208
TSS	mg/L	278
NK	mg/L	NA
NH4	mg/L	NA
TP	mg/L	NA
Temperature	°C	19.0
pH	-	NA

2.4.2. MUNICIPAL AND INDUSTRIAL WASTEWATER COMPOSITIONS

A specific measurement campaign has been implemented in order to get a better picture of the raw wastewater to be treated. This preliminary campaign will be complemented by a more thorough and longer measurement campaign in the near future to confirm the first results presented herein.

The concentrations of relevant quality parameters have been analyzed every 2 hours at the entrance of the second inlet chamber - where the water is representative of the “municipal” stream before it is mixed with other streams - and at the outlet of the pipe discharging industrial effluents. The results are presented in Figure 8 and in Table 6. The main conclusions drawn from this study - which is thought to be representative of a usual situation since the flow rate was approximately 156,000 m^3/d on that particular day - are as follows.

- As expected, the “industrial” wastewater is by far more concentrated than the “municipal” wastewater for all parameters tested, except pH and Total phosphorus, with very high peaks (especially for COD and BOD5 and TSS).
- As expected, the variations of the concentrations are much higher for the “industrial” wastewater than for the “municipal” wastewater.

- The evolution of the concentrations in the “municipal” wastewater highlights one significant peak in early morning (around 7 AM).
- The contribution of the “industrial” load to the total load is below 3 % for all parameters except for BOD5 (5 %).

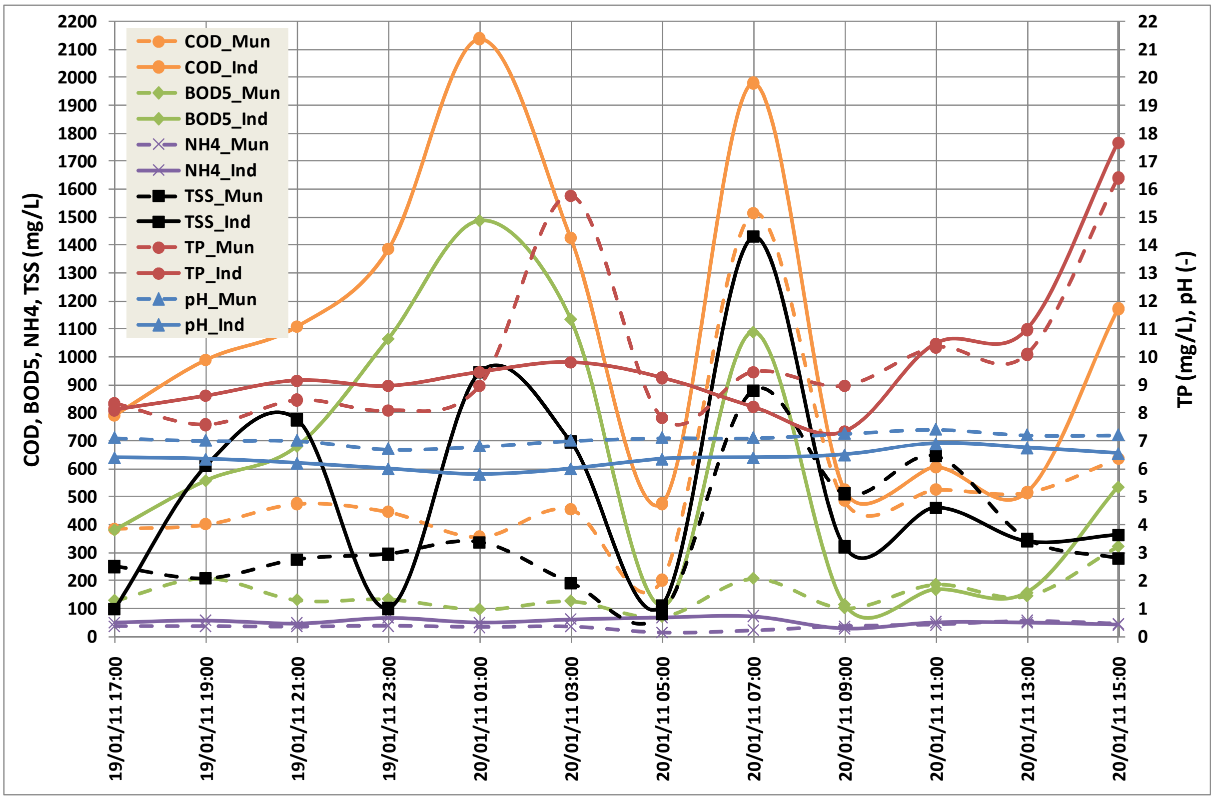


Figure 8: 24h evolution of the concentrations of the main water quality parameters in the “municipal” stream (dotted line) and in the “industrial” stream (dotted line).

Table 6: Analytical results of the preliminary measurement campaign (in italic) and associated load calculations and composite sample characteristics.

	pH	SS	COD	BOD5	NH4	Ptotal	Flow rate	SS	COD	BOD5	NH4	Ptotal
	-	mg/L	mg/L	mg/L	mg/L	mg/L	m3/h	kg/h	kg/h	kg/h	kg/h	kg/h
"municipal" wastewater												
19/01/2011 17:00	7.1	250	386	129	37.5	8.33	6733	1683	2599	869	253	56
19/01/2011 19:00	7	207	401	210	37.5	7.57	6186	1281	2481	1299	232	47
19/01/2011 21:00	7	275	475	131	36	8.45	6026	1657	2862	789	217	51
19/01/2011 23:00	6.7	295	446	134	39	8.07	6268	1849	2796	840	245	51
20/01/2011 01:00	6.8	337	356	97	34.5	8.96	6358	2143	2263	617	219	57
20/01/2011 03:00	7	191	455	127	36	15.8	6007	1147	2733	763	216	95
20/01/2011 05:00	7.1	81	202	71	15	7.82	6031	489	1218	428	91	47
20/01/2011 07:00	7.1	880	1515	208	22.5	9.46	6790	5975	10287	1412	153	64
20/01/2011 09:00	7.3	510	485	102	37.5	8.96	6205	3165	3009	633	233	56
20/01/2011 11:00	7.4	645	525	187	43.5	10.3	6761	4361	3550	1264	294	70
20/01/2011 13:00	7.2	349	515	145	55.5	10.1	7048	2460	3630	1022	391	71
20/01/2011 15:00	7.2	279	636	323	46.5	16.4	6827	1905	4342	2205	318	112
Average	**7.1**	**358**	**533**	**155**	**37**	**10**	**6437**	**2343**	**3481**	**1012**	**238**	**65**
Load (kg/d)								56227	83540	24283	5723	1552
"industrial" wastewater												
19/01/2011 17:00	6.4	97	792	381	50.7	8.1	17	2	13	6	1	0
19/01/2011 19:00	6.4	610	990	557	58.2	8.6	41	25	41	23	2	0
19/01/2011 21:00	6.2	775	1109	680	46.9	9.15	180	140	200	122	8	2
19/01/2011 23:00	6	100	1386	1064	67.5	8.95	0	0	0	0	0	0
20/01/2011 01:00	5.8	944	2138	1486	50.7	9.45	61	58	130	91	3	1
20/01/2011 03:00	6	696	1426	1134	61.9	9.8	86	60	123	98	5	1
20/01/2011 05:00	6.4	110	475	108	69.4	9.25	30	3	14	3	2	0
20/01/2011 07:00	6.4	1429	1980	1088	73.2	8.2	244	349	483	265	18	2
20/01/2011 09:00	6.5	321	525	115	28.1	7.32	0	0	0	0	0	0
20/01/2011 11:00	6.9	460	606	168	51	10.5	91	42	55	15	5	1
20/01/2011 13:00	6.8	340	515	157	50.7	11	162	55	83	25	8	2
20/01/2011 15:00	6.6	363	1172	534	43.2	17.7	0	0	0	0	0	0
Average	**6.4**	**520**	**1093**	**623**	**54**	**10**	**76**	**61**	**95**	**54**	**4**	**1**
Load (kg/d)								1465	2285	1299	106	17
Fraction of total load							1.2%	2.5%	2.7%	5.1%	1.8%	1.1%
Total												
19/01/2011 17:00		250	387	130	38	8	6750	1685	2612	875	253	56
19/01/2011 19:00		210	405	212	38	8	6227	1306	2521	1322	234	47
19/01/2011 21:00		290	493	147	36	8	6206	1797	3062	912	225	53
19/01/2011 23:00		295	446	134	39	8	6268	1849	2796	840	245	51
20/01/2011 01:00		343	373	110	35	9	6419	2200	2394	707	223	58
20/01/2011 03:00		198	469	141	36	16	6093	1207	2856	860	222	96
20/01/2011 05:00		81	203	71	15	8	6061	492	1233	431	93	47
20/01/2011 07:00		899	1531	239	24	9	7034	6324	10770	1678	171	66
20/01/2011 09:00		510	485	102	38	9	6205	3165	3009	633	233	56
20/01/2011 11:00		643	526	187	44	10	6852	4403	3605	1280	299	71
20/01/2011 13:00		349	515	145	55	10	7210	2515	3713	1047	400	73
20/01/2011 15:00		279	636	323	47	16	6827	1905	4342	2205	318	112
Average		**362**	**539**	**162**	**37**	**10**	**6513**	**2404**	**3576**	**1066**	**243**	**65**
Load (kg/d)								57692	85825	25581	5829	1569

These results allow to reconstruct a composite sample that represents the raw wastewater to be treated at the plant. The characteristics of the raw wastewater are presented in Table 7. One could note that they significantly differ from the ones presented in Table 4.

Table 7: Compositon of the raw wastewater (composite sample of “municipal” and “industrial” flows). Italic figures are estimates based on a TN/NH4 ratio of 3/2 and the pH values recorded in Table 4 and Table 6.

		Inlet
COD	mg/L	539
BOD5	mg/L	162
TSS	mg/L	362
NK	mg/L	*56*
NH4	mg/L	37
TP	mg/L	10
Temperature	°C	10 - 25
pH	-	*7.1*

A specific analytical campaign was performed in 2005. From September 26th until September 30th the wastewater at the entrance of the inlet chamber - assimilated to “municipal” wastewater – was sampled and analyzed every 3 h. The resulting average values (not flow-weighted) are provided in Table 8 while the evolution of the concentrations with time is presented in Figure 9 Table 8. The daily trends ado not appear very clearly although the usual pollution trend can be recognized when looking at COD only, a first increase in late morning followed by a second one in late afternoon and then a decrease during the night.

Table 8: Average compositon of the raw wastewater entering the inlet chamber (“municipal” flow) from 26/09/2005 until 30/09/2005. The values are not flow-weighted.

		Inlet
COD	mg/L	678
BOD5	mg/L	264
TSS	mg/L	525
NK	mg/L	NA
NH4	mg/L	40
PO4	mg/L	7
Temperature	°C	NA
pH	-	NA

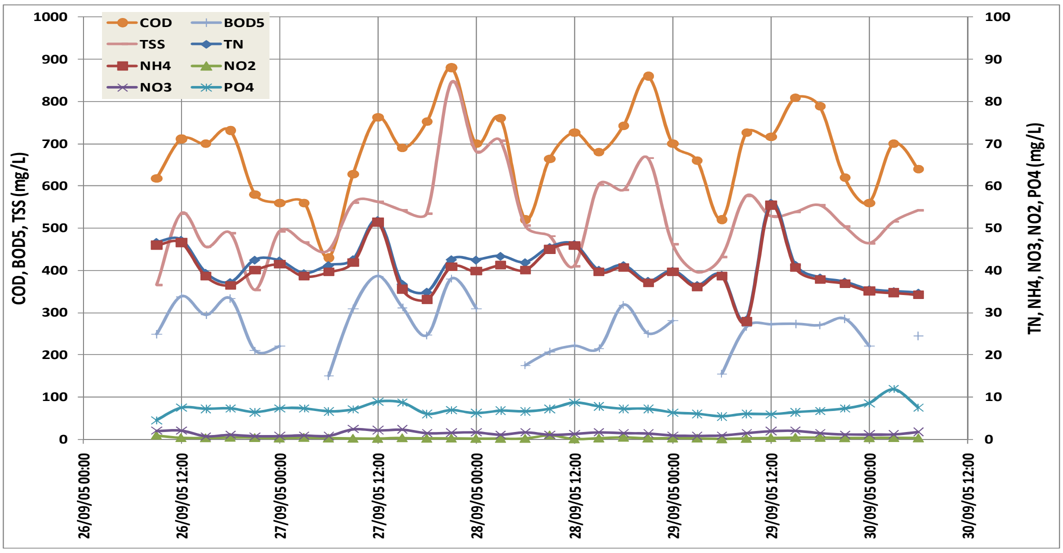


Figure 9: Evolution of various parameters in the raw “municipal” wastewater entering the inlet chamber from 26/09/2005 until 30/09/2005.

3. DESCRIPTION OF THE EXISTING WWTP

3.1. GENERAL PROCESS DESCRIPTION

The existing WWTP dates back from the 70s and was built in several stages although it is very likely that it has never worked at full capacity. Only about 50 % of the works are currently being used (Figure 10). The wastewater treatment process implemented at Chisinau WWTP is a medium load contact-stabilization activated sludge featuring the following treatment steps (in bold):

- Mixing chambers
- Fine screening
- Intermediate pumping
- Sand removal
- Primary settling
- Biological treatment (medium load contact-stabilization activated sludge)
- Secondary clarification
- Chlorination (not in use any longer)
- Discharge into the Bic River

The sludge treatment line initially included static thickeners and digesters and drying beds before final disposal. However the digesters have never been commissioned due to construction defaults and therefore this treatment line has never been in operation. The mixture of primary and biological sludge has been directly disposed onto drying beds instead, which caused serious odor problems. Geotubes have recently been installed to reduce these problems. The dehydrated sludge is currently disposed in a dumping site nearby the plant.

The current process flow diagram is presented in Figure 11. It clearly shows the specificity of Chisinau WWTP in terms of excess sludge management. Because it is not possible to thicken the excess biological sludge, the latter is transferred to the inlet chamber where it is mixed with raw wastewater. The biological sludge settles down in the primary settling tanks from where both sludge types are pumped together to the Geotubes. The current sludge management is dictated by practical reasons but is not recommended. The drawbacks of such a sludge management will be further discussed in the sections below.

Figure 10: Tanks in operation at Chisinau WWTP

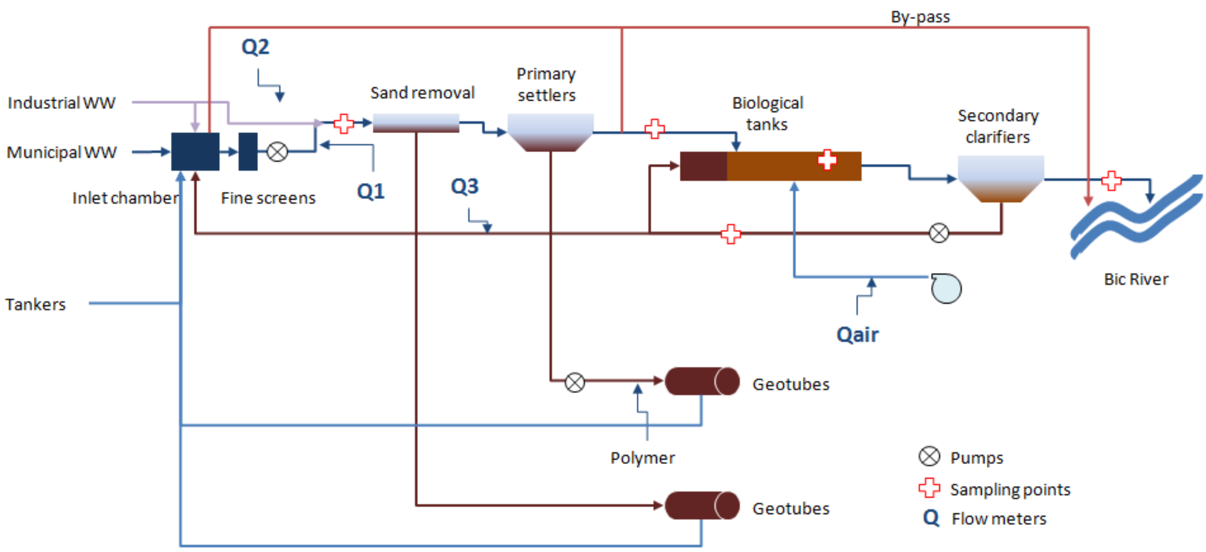


Figure 11: Process flow diagram of Chisinau WWTP

3.2. Overview of the Main Components of the WWTP

3.2.1. Inlet Chambers

Figure 12: Photos: First inlet chambers, where the two sewers from the city meet (left) & Second inlet chamber (right)

Figure 13: Photos: Second inlet chamber where all influents (industrial and municipal WW) are mixed together with a fraction of the recirculated sludge. The pipe discharges industrial WW. (left) & Inlet of the mixture [leachate from Geotubes + recirculated biological sludge + industrial WW discharged by trucks] at the inlet chamber. (right)

3.2.2. Pretreatment

The pretreatment building hosts the fine screens (6 pieces, 10.5 or 16 mm bar spacing, see Annex 5) and the lifting pumps.

The lifting pumps alternately feed on of the two pipes that connect the pretreatment building to the old grinding facility. Both pipes are equipped with an ultrasonic flow meter Danfoss 1400 DF. Five pumps are installed, for a total pumping capacity of 27,000 m^3/h (3 x 7,200 + 2 x 2,700).

There is no ventilation and no air treatment in the pretreatment building, as for the whole plant.

The old grinding installation is not in use any longer and the equipment has been dismantled. One discharge point of industrial wastewater is located at the entrance of the channels remaining from the grinding facility. It is equipped with a flow meter and is the preferred option to discharge the industrial wastewater – the other discharge point is at the second inlet chamber – according to the operators since they experienced some blocking of the screens when utilizing the discharge point of the second inlet chamber.

The only automatic sampler is to be found in the small building located between the old grinding facility and the sand removal tanks. The sampling runs on a time-based control. One sample is taken every hour.

Four sand removal tanks of an old design allow to collect sand particles. All of them are in use. They are operated in a cyclic way; two of them are fed at the same time while the two others are backwashed. The accumulated sand is backwashed at counter-current and further sent to dedicated Geotubes to be dehydrated. The collected volume of sand amounts to approximately 900 m^3 in two months (i.e. 5,400 m^3/year). This volume corresponds to around 11 L of sand per People Equivalent - on the basis of 60 gBOD5/PE and 30,000 kgBOD5/d – which is within the usual range (8 to 15 L/PE).

An airlift system allows to remove the sand that has accumulated in the hopper.

The pretreated wastewater is led from the sand removal tanks to the primary settlers via a large open channel.

Figure 14: Photos: Open channel which distributes the flow towards the parallel fine screens (inside the building) (left) & Lifting pumps downstream the fine screens (right)

Figure 15: Photos: Old grinding facility. Big pipe: one of the two coming from the coarse screening; small pipe: drainage of the primary settlers. (left) & Industrial WW inlet prior to the sand removal tanks (small pipe in the foreground) (right)

Figure 16: Photos: Sand removal tanks. The water normally flows from the front to the back. During backwashes the water flow backward and washes the sand away to a sand trap (in front of the tank; not shown in the picture). (left) & Open channel which connects the sand removal tanks to the splitting chamber located upstream the primary settlers. (right)

3.2.3. PRIMARY SETTLING TANKS

Among the 8 existing primary settling tanks, only are 4 in operation; the design is not the same for all settling tanks.

Table 9: Characteristics of the primary settlers

Primary settlers		
Total number	-	8
Number in operation	-	4
Diameter	m	40
Unit area	m2	1257
Total area	m2	5027

The settled sludge is removed by two centrifugal pumps (including one in stand-by). Each of them has a maximum pumping capacity of 450 m^3/h (Annex 5). Sludge extraction is manually commanded through the opening of a manual valve located on each sludge extraction pipe. Extraction is done for at least 1 to 1.5 h per day.

Figure 17: Photo: Decommissioned primary settling tank. (left) & Primary settling tank in operation. (right)

Figure 18: Photo: Hydraulic issue in one of the primary settling tank (inlet of the pretreated wastewater)

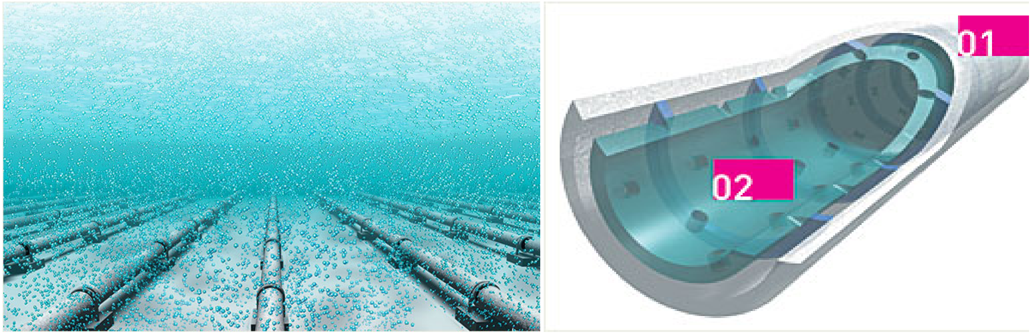
3.2.4. BIOLOGICAL TANKS

Among the 10 existing biological tanks, 6 are in operation. There are two sizes of tanks (Table 10) but all of them feature 4 or 2 narrow channels (plug flow conditions), the first of them being the stabilization zone (aerated) for the recirculated biological sludge and the others being the contact zone (aerated) where the flow coming from the primary settlers can be discharged by step feeding.

Table 10: Characteristics of the biological tanks

Biological tanks		
Total number	-	10
Large tanks		
Volume per tank	m3	22500
Water depth	m	5.2
Number in operation	-	2
Small tanks		
Volume per tank	m3	12500
Water depth	m	4.8
Number in operation	-	4
Total volume in operation	m3	95000

All tanks are equipped with fine bubble aeration diffusers (make: Ekoton, Figure 19) that were installed in 2002-2003.



> *"Structurally pipe aerator represents two tubes enclosed each other with an air backlash between them. On the internal punched pipe (02) made from polyvinylchloride (PVC) or low pressure polyethylene (LPP), air is supplied which then gets into tube space through apertures.*
>
> *The quantity of apertures is computed with the help of a special computer application and is optimal for sufficient and uniform distribution of incoming air.*
>
> *The external pipe (01) is made from high pressure polyethylene (HPP), which is proof to aggressive environments and has a porous basis providing a stream of small air bubbles in aerotank. Diameter of bubbles formed by EKOTON's external dispersive aerator layer is 2 - 3 mm (according to Average Performance Requirements, small bubbling aeration of 1-4 mm)."*

Figure 19: Ekoton fine bubble areation diffusers (source: www.ekoton.com)

The final cap at the end of each long diffuser can be blown up when air blowers are restarted, which leads to the flooding of the entire diffuser. The repair requires the emptying of the tank.

The centralized production of air includes 11 centrifugal air blowers (the oldest were manufactured in 1974; only 3 or 4 are generally in operation simultaneously, which confirms the oversizing of the air production facility. Each air manifold to the aeration tank is equipped with a pressure meter and a flow meter. A manual valve allows for the adjustment of the flow rate. There is no automatic control of the air production and distribution. The concentration of dissolved oxygen is manually checked once a day, but appears to be very high (Figure 20).

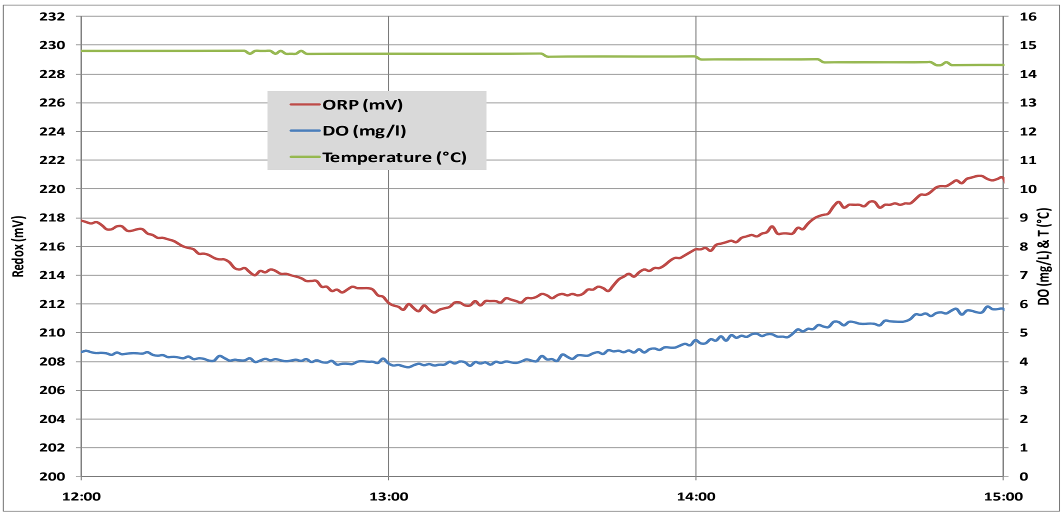


Figure 20: Dissolved oxygen, Oxidation Reduction Potential and temperature at the outlet of one biological tank on 07/02/2011.

The amperage of the air blowers can be modified as follows: 38 A gives 12,500 Nm^3/h and 44 A gives a maximum air flow rate of 18,000 Nm^3/h for each machine. However the operators are reluctant to turn on and off the blowers or to modify the amperage of the blowers because of their current poor conditions.


Figure 21: Photos: Decommissioned aeration channel. Note the aeration system at the bottom of the tank.(left) & Aeration channel (stabilization zone).


Figure 22: Photos: Decommissioned biological tanks. (left) & Biological tank with the discharge of recirculated sludge in the contact zone (foreground) and the discharge of mixed liquor from the stabilization zone in a common channel (in the background).(right).

3.2.5. SECONDARY CLARIFIERS

Among the 10 existing secondary clarifiers only 5 are in operation (Table 11). Mixed liquor recirculation is performed through an adjustable weir to a common sludge tank equipped with one pump (one stand-by pumping chamber). Twice a day a sample is taken at the weir of each clarifier. Depending on the MLSS concentration, the weir level is adjusted.

Table 11: Characteristics of the secondary clarifiers

Secondary clarifiers		
Total number	-	10
Total number in operation	-	5
Large tanks		
Diameter	m	50
Unit area	m2	1963
Total number	-	4
Number in operation	-	1
Small tanks		
Diameter	m	40
Unit area	m2	1257
Total number	-	6
Number in operation	-	4
Total area in operation	m2	6990

Excess biological sludge is drawn from the secondary clarifiers to the inlet chamber through a DN200 pipe equipped with a manual valve that allows to adjust the flow based on the reading of the flow meter installed on the same pipe.

Figure 23: Photos: Secondary clarifier in operation. In the forefront the manually controlled weir that allows the control of sludge withdrawal. (left) & Decommissioned secondary clarifier.(right).

Figure 24: Photos: Channel of clarified water. (left) & Clarified water exit point.(right).

3.2.6. STATIC THICKENERS

Four static thickeners of 1,600 m^3 each do exist (Table 12) but have probably never been used. They are not covered and no pump is installed in the splitting chamber.

Table 12: Characteristics of static thickeners

Static thickeners		
Total number	-	4
Total number in operation	-	0
Diameter	m	26
Unit area	m2	531

Figure 25: Photos: Static sludge thickener

3.2.7. DISINFECTION

The existing chlorination unit is no longer in use nor operational.

3.2.8. RECEIVING WATER BODY

The treated wastewater is discharged into the Bic River. This river is relatively small since its flow rate varies from approximately 1 to 220 m^3/s in Spring (Annex 2).

It is not possible to precisely know the treated water flow rate for no flow meter is installed at the outlet of the WWTP. Manual sampling is done once or twice a day to analyse the treated water quality.

Figure 26: Photos: Bic River seen from ACC headquarters (left) & Bic River in Chisinau city (right).

3.2.9. SLUDGE TREATMENT

The Geotubes were implemented in September 2009 by ACC as a quick and easy attempt to mitigate odor issues generated by the sludge drying beds. This proved to be quite efficient since it has been reported that this modification led to a significant reduction of odors.

There is a total of 93 Geotubes installed on site, which covers approximately 3.6 ha. Each of them has a capacity of 600 m^3 and cost 3,500 € each. This figure is comparable to the average salary of one worker which is about 3,600 €/year.

The dewatering cycle is about 2 months and one geotube is emptied every three days. Thus the OPEX of this dewatering system can be estimated as 420,000 €/year (120 Geotubes).

The sludge dryness is between 15% and 20% after dewatering in the geotube. Geotubes are opened and the dewatered sludge is taken away by trucks to a landfill site (2 ha) which is located 200 m far from the drying beds (32 ha). The landfill site is still within the plant boundary but was planned to be full in February 2011.

240,000 m^3 of sludge were transferred from the drying beds to the landfill site in 2010 to make room for the Geotubes.

The Geotubes generate approximately 87,000 m^3/y of sludge. At 20 % dryness this equals to 17,400 tDS/y or 48 tDS/d. This is coherent with the assumption that one Geotube (600 m^3, 20% dryness) is filled in 3 days (which gives a sludge production of approximately 40 tDS/d).

The leachates are collected via a drainage system and transferred to the second inlet chamber.

The Municipality of Chisinau owns the land of the WWTP. There is a project of building an incinerator for solid waste on the land currently occupied by sludge beds. The decision has been approved by the Municipality. Design studies are on their way.

A co-generation plant is operational on-site. It was built by a private investor (Energy investment group) who went bankrupt due to the increase in gas price. It was initially planned to use the biogas produced by the digesters. Then natural gas was used since no biogas could be produced. After the bankruptcy, the facility was taken by the bank. It is now the property of the bank and is not in use today.

Apa Canal would be authorized to produce the energy required to cover its own energy needs, but would not be authorized to sell the surplus to customers by the existing Moldovan laws.

Figure 27: Photos: Geotubes with sludge feeding line.

Figure 28: Photos: Opened Geotube prior to sludge handling. (left) & Sludge is taken out of the Geotubes and transported to a final disposal site nearby. (right).

3.2.10. ODOUR TREATMENT

No ventilation and subsequent odour treatment is currently implemented at Chisinau WWTP. Odour problems caused a lot of nuisances until the installation of Geotubes instead of sludge drying beds in September 2009. These nuisances have decreased since then but improvements can still be made to avoid persistent odours, especially in summer.

Some parts of the works (for example the ancient grinding facility and some channels around the biological tanks) have not been totally dredged and isolated, which results in the presence of stagnant water and sludge which can be the source of bad smells.

The two inlet chambers are not covered. The initial degassing of H2S and other odorant substances at this location is unavoidable.

The two inlet chambers are not covered. The initial degassing of H2S and other odorant substances at this location is unavoidable.

Figure 29: Photos: Stagnant sludge (left) & Wastewater in idle open channels (right).

3.3. PERFORMANCES

3.3.1. TREATED WATER QUALITY

The quality of the treated water is poor. The carbon removal rate is quite low (for COD and BOD), but this statement should be moderated by the fact that it is calculated based on recalculated inlet values. N and P removal are not targeted, which explains why the removal rates are very low.

Table 13: Treatment performances based on a synthetic raw wastewater (estimated based on the values presented above) and the quality of the treated effluent (average values for the period running from 01/01/2010 until 30/09/2010).

		Inlet	Outlet	Removal rate
COD	mg/L	500	172	66%
BOD5	mg/L	200	31	84%
TSS	mg/L	278	25	91%
TN	mg/L	60	39	35%
NH4	mg/L	40	32	20%
TP	mg/L	9	5	48%
Temperature	°C	10-25	18.5	-
pH	-	7.1	7.8	-

3.3.2. ENERGY CONSUMPTION

The total energy consumption of the plant amounts to approximately 50,000 kWh/d according to the operators. No energy record was made available. It has been reported that the pumping energy is about 90 kWh/1000 m^3 of treated water while the energy of aeration is 260 kWh/1000 m^3 of treated water. This means that the energy indicators are as follows:

- 0.35 kWh/m^3 of treated water
- 1.7 kWh/kg of removed BOD

The values of these ratios indicate that the energy efficiency of the plant is not bad, which is likely due to the very limited number of engines on site rather than to the optimization of the process control.

3.3.3. POLYMER CONSUMPTION

Some polymer (Floerger FL7670) is added to the sludge prior to its dewatering in the Geotubes to improve the dewatering process. The polymer dosing rate lies between 1.7 and 1.9 kg/tDS. The total polymer consumption is estimated at 70 - 80 kg/d.

3.4. LABORATORY

The laboratory located at the WWTP is part of a network of four laboratories managed by Jon Cascawal who is the Head of the laboratory service of ACC (created in 2008). All four labs are accredited.

The laboratory is well maintained and the staff is competent. The lack of financial means explains the presence of old pieces of equipment. The Russian analytical standards are applied to measure the usual water quality parameters.

Figure 30: Photos: Sampling bottles (left) & TSS measurement – filtration step (right).

3.5. CIVIL WORKS

IA has performed a preliminary assessment of the structure and of the equipment of the Chisinau WWTP in February 2011, following the template provided by T. Farrar. The original template featuring the grading system and the results of this assessment are provided below. The detailed results of this assessment are presented in Annex 6. They clearly show - when looking at the comments more than at the questionable associated grades - the poor condition of almost all pieces of equipment and of the structures.

Figure 31: Photos: Degraded concrete structure in one primary settler (left) & Vegetation has grown in idle channels (right).

3.6. EQUIPMENT

A comprehensive list of the pieces of equipment is presented in Annex 5. They are almost all in very poor conditions despite the efforts of the operating staff to maintain them in working conditions (Annex 6).

Figure 32: Photos: Lift pumps in the fine screen building (left) & Centrifugal blowers (right).

Figure 33: Photos: Examples of the electrical installation.

4. FUTURE DESIGN PROPOSALS

4.1. WASTEWATER TREATMENT

It is very likely that the future water quality requirements include the treatment of Carbon, Nitrogen and Phosphorus at Chisinau WWTP. Considering the availability of land and the local conditions (concentration and flow rate of the raw wastewater, cost of electricity, etc.), it is proposed to implement a low-load conventional activated sludge process.

4.2. SLUDGE TREATMENT

4.2.1. DIGESTION

Chisinau WWTP originally included t a digestion and cogeneration facility. This facility was never used to structural defaults of the digesters. Revamping the existing digesters is very likely to be more expensive than constructing new ones.

Chisinau WWTP is currently treating around 30,000 kg/d of BOD5 (i.e. 11,000 t/year), which corresponds to the production of 500,000 PE (60 gBOD/PE). The CAPEX of a new sludge digestion plant would be around 7,000 k€. This amount could be reduced in case the existing cogeneration plant – reported as being in good condition although not operating – is reused. Static thickeners upstream the digesters and a sludge dewatering line (centrifuges) downstream should be added to get a full sludge treatment line.

The total CAPEX of such a sludge treatment line would then amount to approximately 20,000 k€.

The implementation time of such a treatment line would be longer than the one required for sludge thickening and dewatering alone but sludge digestion would be very beneficial for the following reasons:

- Reduction of the final amount of sludge to be disposed of
- Energy generation (significant decrease of the OPEX of the plant or even energy self-sufficiency of the plant – to be assessed)
- Reduction of GHG emissions (and potential CDM project development)

However sludge digestion cannot be fully beneficial if restrictions apply in Moldova regarding gas handling and if specific regulations do not allow the production of energy on site. These issues should be further investigating prior to developing a sludge digestion project.

4.2.2. MECHANICAL DEWATERING

The traditional alternative to sludge digestion consists in dewatering the sludge to a dryness of 20 to 25 % depending on its final disposal by means of centrifuges. This dewatering stage is preferentially preceded by a thickening stage to increase the final dryness.

4.2.3. FINAL DISPOSAL

The final sludge disposal appears to be an issue in Chisinau where no sustainable solution has yet been identified. Further investigations are needed to select the most relevant alternative among incineration - possibly integrated to an on-going solid waste incineration project nearby the WWTP – landfill, agricultural land spreading, use in cement factories or in another industrial process to be identified. In particular, this will require the collection and review of the existing and future regulations related to these potential uses.

4.3. CDM OPPORTUNITY

Moldova is not part of the Annex I Parties of the United Nations Framework Convention on Climate Change and can therefore develop Clean Development Mechanism (CDM) projects with countries belonging to Annex I.

Table 14 presents the list of the CDM projects that were on-going in 2006. From this list, it appears that one project was already targeting Chisinau WWTP. It was developed by COWI A/S (Denmark) and intended to capture methane gas and generate electricity. This project led to the parallel development of a methodology that did not exist at that time. The methodology NM0038 was then created and further integrated into AM0013 and finally into the ACM0014, which is the latest version to be used.

The approved consolidated baseline and monitoring methodology ACM0014 targets the "mitigation of greenhouse gas emissions from treatment of industrial wastewater". This consolidated baseline and monitoring methodology is based on elements from various approved baseline and monitoring methodologies and proposed new methodologies. Among them, one can find the NM0038-rev "Methane Gas Capture and Electricity Production at Chisinau Wastewater Treatment Plant project, Moldova prepared by COWI A/S, Denmark".

Table 14: CDM projects in Moldova as of June 2006 (source: Survey on CDM Project Developments in Caucasus & Moldova, Fichtner, 2006)

Project	Location	CDM Methodology	Status
Methane Capture and Biogas-to-Energy Project for Poultry Farms	Floreni, nn (Chisinau region), Pirlita	AM0016+ AMS-I.D	PDD
Leak Reduction from Natural Gas Pipeline Compressor and Gate Stations	Moldova country-wide	NM0091	PDD meth review
Landfill Gas Capture and flaring at Chisinau Landfill	Chisinau Region	AM0011	PDD DOE validation
Methane Gas Capture and Electricity Production at Chisinau Wastewater Treatment Plant	Chisinau	NM0038	PDD meth review
Moldova Soil Conservation Project	Molodva country-wide	new metholdology	PDD meth review
Moldova Biomass Heating in Rural Communities Project	Molodva country-wide	AMS-I.C. AMS-II.E AMS-III.B	registered
Hydropower rehabilitation	Dubasari	AMS-I.D	Activity started
Moldova Biofuel Project	Molodva country-wide	new metholdology	???

Table 15: Registered CDM project in Moldova as of March 2011 (source: http://cdm.unfccc.int/)

Registered	Title	Methodology
20/01/2006	Moldova Biomass Heating in Rural Communities	AMS-I.C. ver. 6 AMS-II.E. ver. 6 AMS-III.B. ver. 6
29/01/2006	Moldova Energy Conservation and Greenhouse Gases Emissions Reduction	AMS-II.E. ver. 6 AMS-III.B. ver. 6
30/01/2009	Moldova Soil Conservation Project	AR-AM0002 ver. 1

The main objectives of NM0038 were described as follows. “The project activity consists of the treatment of primary sludge in digester(s) and the treatment of secondary sludge and the sludge residue from the digester(s) in dewatering facilities. Produced gas from the digesters shall according to the methodology be burned. The energy in the gas can be converted into electricity and heat, in combustion plants. Further the project activity consists of spreading the dewatered sludge i.e. on fields or in forests in order to prevent further anaerobic degradation.”

However, the CDM project targeting Chisinau WWTP has not been registered yet (Table 15), which seems to indicate that the project was abandoned considering the elapsed time since the start up of the project (2005).

It is proposed to investigate further the opportunity of a setting up a CDM project at Chisinau WWTP. These investigations should first provide answers to the following questions:

- Why has the first CDM project not yet been registered? Is the project abandoned? If yes, why?
- Could another CDM project be more successful? Would it be relevant and compatible with the treatment options of today and in the future?
- The assessment of the relevance of developing a CDM project should also take into consideration the following uncertainties:
- The future of Moldova with regards to EU integration (EU countries belong to the Annex I, which means that CDM project should be changed into a Joint Implementation (JI) project).
- The future management of the carbon market after 2012. It is very likely that similar mechanisms will replace CDM and JI projects but the organization of the market and of the trading schemes could be modified.

If the conditions proved to be favourable, a Project Identification Note (PIN) will be set up to present the CDM project.

5. PROPOSED ACTIONS FOR THE IMPROVEMENT OF THE WWTP OPERATION AND PERFORMANCES

5.1. GENERAL

It seems obvious that the full renovation of the existing structures of Chisinau WWTP is not a good option either economically or technically due to the advanced damage of the works and to the future treatment requirements. Eventually a new plant will have to be built. Also flows to the works will probably vary as i) new areas are connected to the wastewater collection network from within Chisinau and from the surrounding areas and ii) population and industrial activities will change with time

However the time required to get a new operational WWTP is likely to be more than 5 years. Solutions must then be found in order to secure the good operation of the existing – and possibly modified – WWTP until the construction of the new WWTP. In particular efforts should be made to reduce odours.

It should also be taken into consideration that a new sludge treatment facility must be implemented to solve the issue of sludge odour and sludge disposal. This new facility must be designed in such a way that it can be easily integrated into the future new WWTP. If the implementation time of this new sludge facility is more than 2 years it will be more cost-efficient to directly integrate it into the design of the new WWTP.

One should note that the easiest and fastest solution would consist in installing centrifuges to dewater the sludge prior to its disposal, whereas in the design of the future WWTP sludge digestion may be chosen as the best alternative for sludge treatment. In that case it would not really be cost-efficient to implement centrifuges in a first stage for only a couple of years of operation.

5.2. SHORT TERM ACTIONS (<6 MONTHS)

Action	**Resources needed** **(first estimates)**	**Effects**
Cover the following open structures and install an air extraction and activated carbon adsorption system for each of them: • First inlet chamber • Second inlet chamber	30 k€ for the air extraction and activated carbon adsorption system (2,000 m^3/h). 14 k€/year for the renewal of activated carbon.	Odour reduction
Isolate and empty and clean the idle channels • At the old grinding facility • Around the biological tanks.	One working week for the operating staff.	Odour reduction

Action	Resources needed (first estimates)	Effects
Optimize the aeration of the biological tanks	1 k€ for a portable DO probe. Setting up of a time-based air flow grid to account for the variations of the pollution load. Setting up some specific monitoring (1 h per day for one staff member).	Energy consumption reduction

5.3. Medium Term Actions (<2 years)

Action	Resources needed (first estimates)	Effects
Implement a thickening system for the biological sludge • Belt thickener or static thickener Implement a dewatering system for both sludge types (primary and biological, final dryness: >25%) and stop the operation of Geotubes. • Centrifuges Stop the recirculation of excess biological sludge to the primary settling tanks. Assess final sludge disposal strategies • Temporary storage + liming facility	15,000 k€ for static thickeners + centrifuges	Odour reduction General improvement of sludge management.
OR implement a thickening system followed by sludge digesters and a cogeneration plant and a sludge dewatering line.	20,000 k€	Odour reduction Energy production Sludge quantity reduction
Implement a sound strategy for final sludge disposal		Environmental benefits
Build a new pretreatment facility with odour control (biological filters).		Odour reduction
Optimize the biological process • Install automatic samplers at the right location (inlet and outlet, flow-based sampling) • Change the medium-load to a low-load activated sludge process by increasing the sludge age and		Improvement of the treated water quality.

Action	Resources needed (first estimates)	Effects
modifying the aerated/non aerated zones (**Erreur ! Source du renvoi introuvable.**).		

5.4. LONG TERM ACTIONS (> 2 YEARS)

Action	Resources needed (first estimates)	Effects
Design and build a new WWTP Proposed basis of design • Capacity: 500,000 PE • Hourly peak flow rate: 13,000 m^3/h (peak factor:2) • Treatment process: low load activated sludge with final disinfection and sludge thickening and dewatering	CAPEX: 70,000 k€	Compliance with EU regulations and long-lasting solution.

Annexes

LIST OF ANNEXES

Annex 1 Discharge Limit Concentrations to the Bic River

1.1. CONTEXT

Conditiile temporare de deversarilor limitat-admisibile in river Bic pentru statia de epurare buiologica municipalita Chisinau (valid from 11/02/2010 to 11/02/2013)

1.2. AGREED VALUES

		De facto	Approved
Flow rate	m3/h	9825.4	12614.44
Flow rate	m3/d	166834.6	220101.7
Flow rate	m3/y	56253000	80336200
TSS	mg/L	22.8	22.8
TS	mg/L	689.8	1000
BODt	mg/L	37.2	28.4
COD	mg/L	153.8	30
$PO_4$3-	mg/L	5.86	2
N-NO2	mg/L	0.027	0.08
N-NO3	mg/L	0.217	9.1
N-NH4	mg/L	26	8.1
$SO_4$2-	mg/L	118.8	150
Cl-	mg/L	66.9	300
Cu	mg/L	0.014	0.01
Ni	mg/L	0.0013	0.01
Zn	mg/L	0.018	0.03
Fe	mg/L	0.29	0.31
Cr3+	mg/L	0.021	0.025
Cr6+	mg/L	0.004	0.001
Grease soluble in ether	mg/L	1.16	1.4
Surfactants	mg/L	0.62	0.2
Phenol	mg/L	0.034	0.004
Petroleum products	mg/L	0.131	0.1

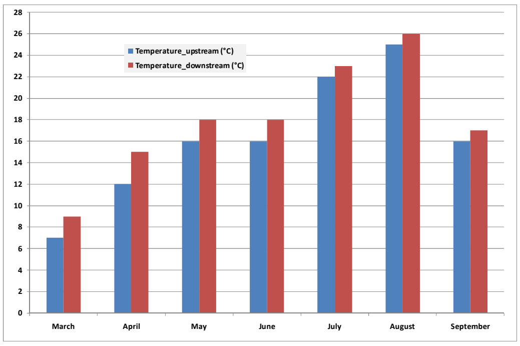
Annex 2 Characteristics of the Bic River

Bîc (Bâc or Byk) is a river in Moldova, a right tributary of Dniester. The upper flow of Bîc cuts a deep canyon in Codri Hills. The capital of Moldova, Chişinău, is situated by Bîc. A dam at Bîc by Chişinău holds the Chişinău Sea reservoir of area about 10 km². In summer Bîc often dries out and turns into a chain of lakes. Bîc is heavily polluted (Source: www.wikipedia.com).

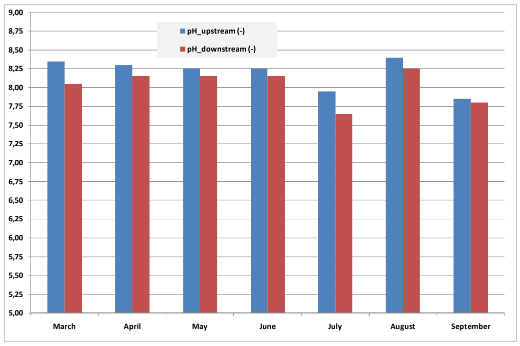
Key information about the Bic River is presented in the following table:

Origin	Codri
Mouth	Dniester
Basin countries	Moldova
Length	155 km
Average discharge	1 m³/s (annual mean) 220 m³/s (spring time)
Basin area	2,150 km²

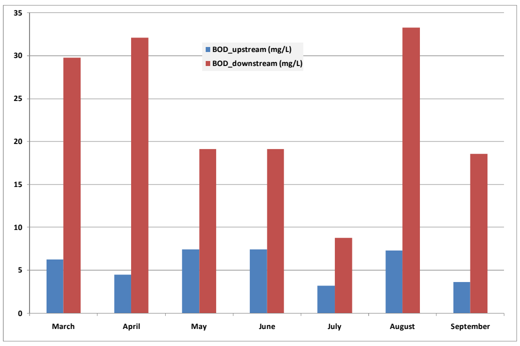
The graphs below present the monthly average values of relevant parameters with regards to the quality of the Bic River upstream and downstream the treated wastewater outfall of Chisinau WWTP.



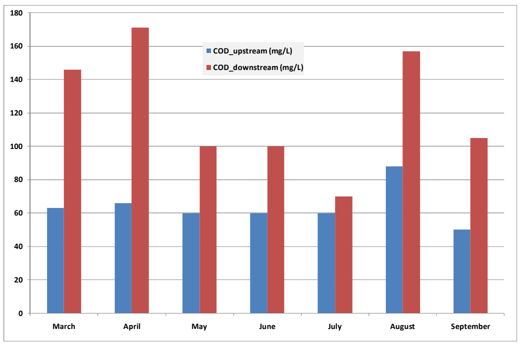
Temperature



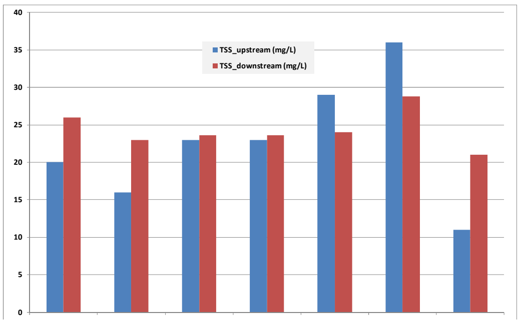
pH



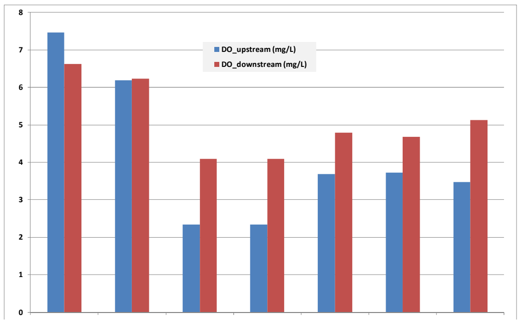
BOD5



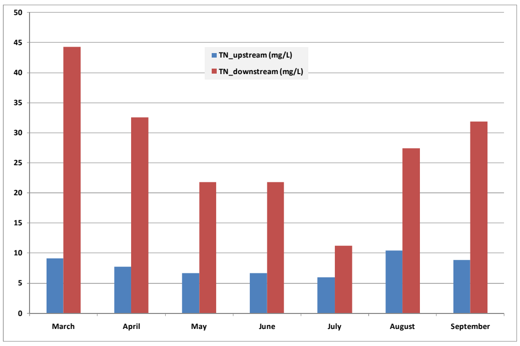
COD



TSS

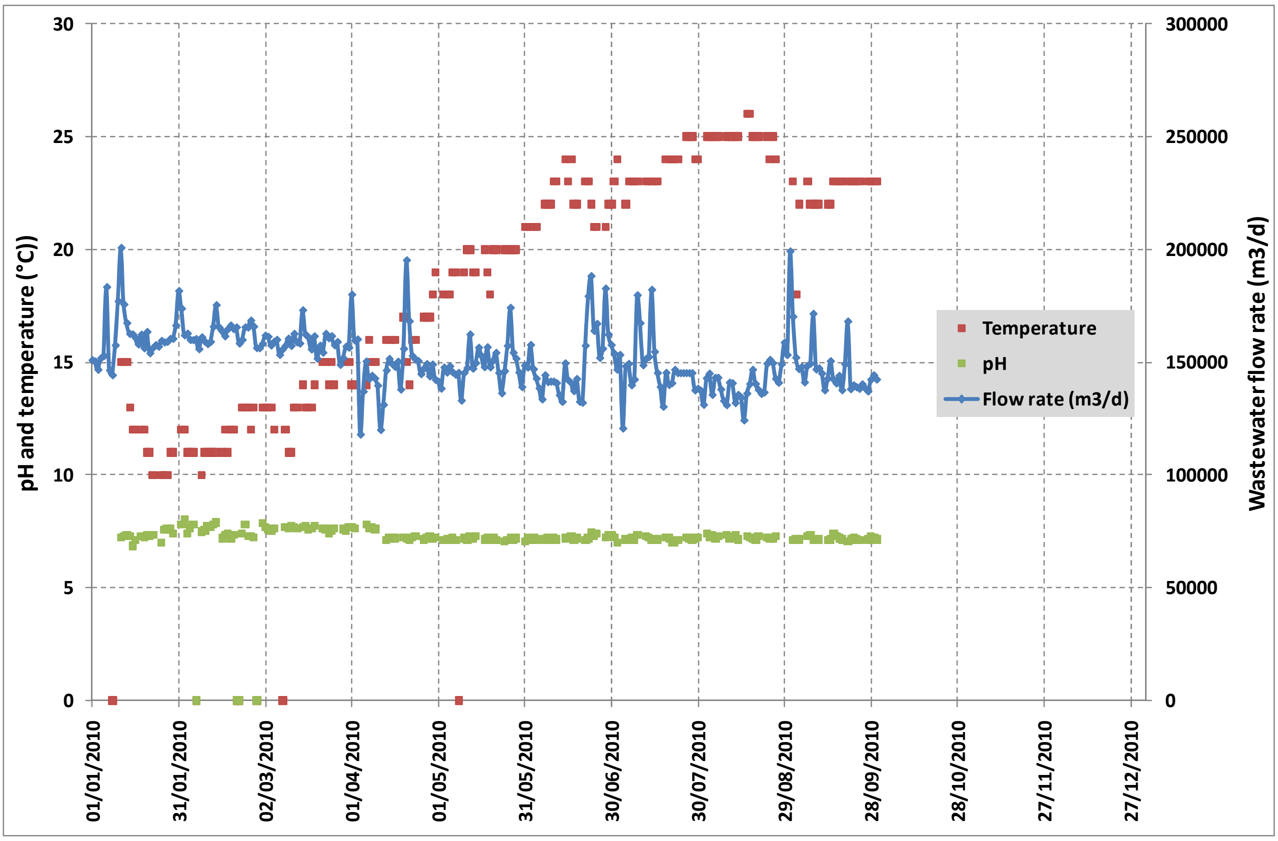


Dissolved oxygen

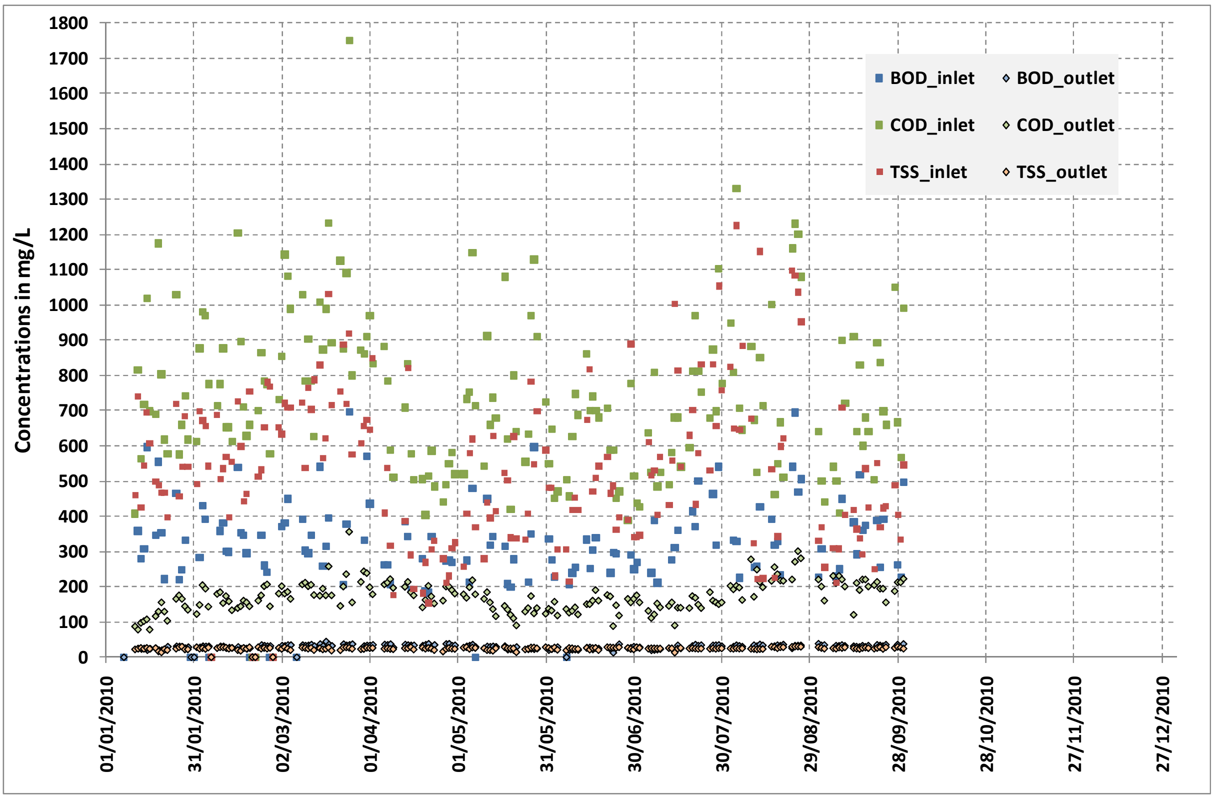


Total Nitrogen

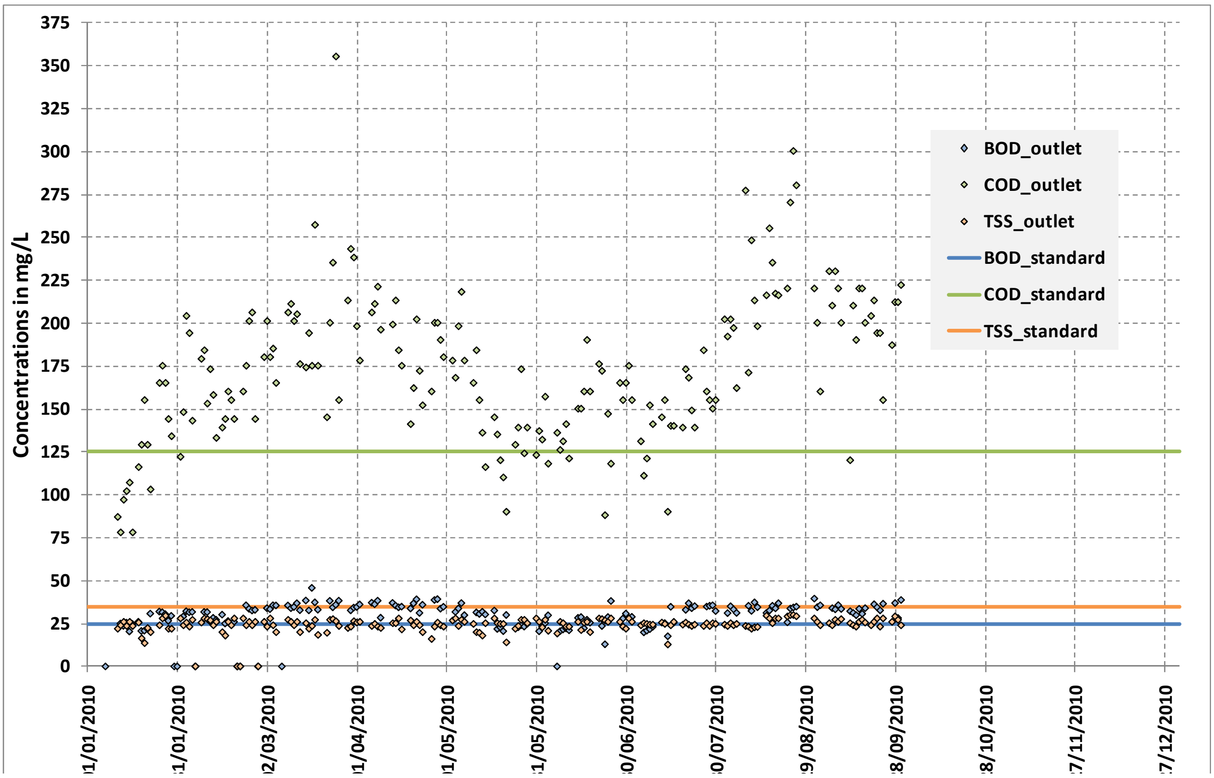
Annex 3 Wastewater Concentrations



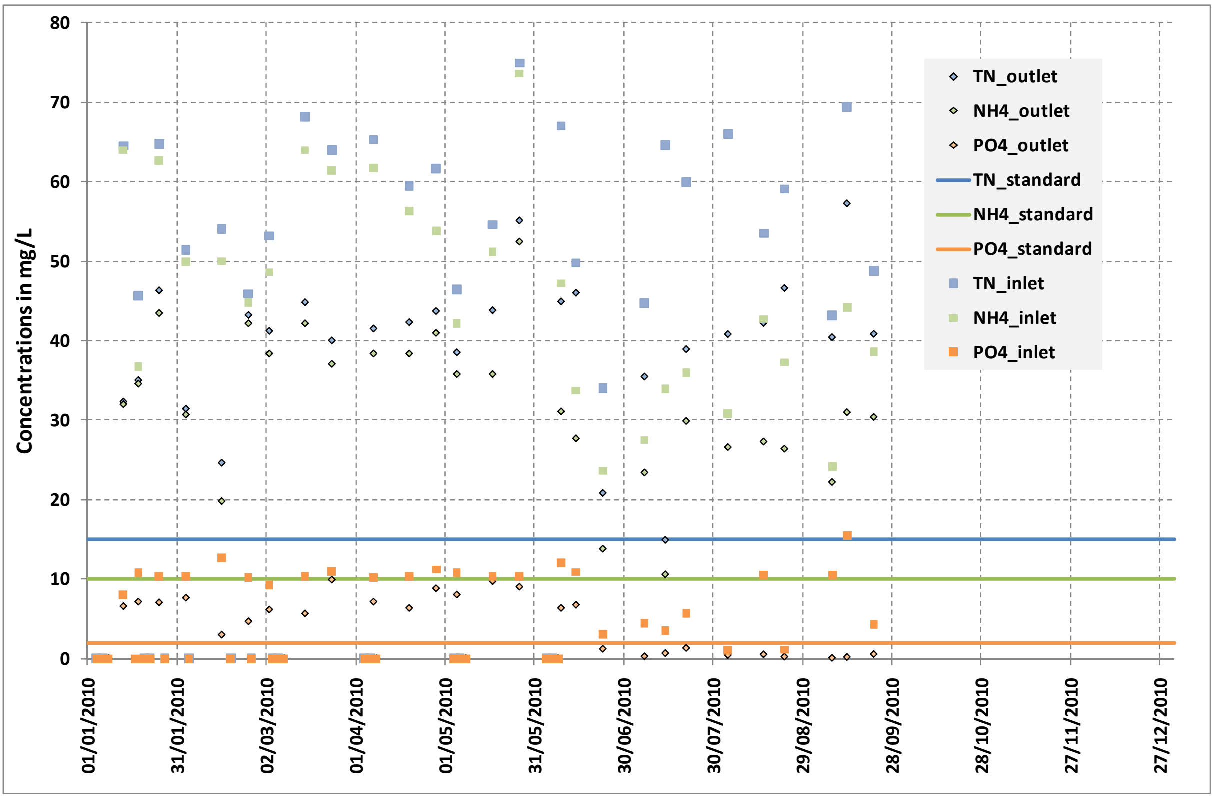
Evolution of pH, temperature and wastewater flow rate from 01/01/2010 until 30/09/2010, measured upstream the sand removal tanks



Evolution of BOD5, COD and TSS concentrations from 01/01/2010 until 30/09/2010, measured upstream the sand removal tanks and at the outlet of Chisinau WWTP.



Evolution of BOD5, COD and TSS concentrations from 01/01/2010 until 30/09/2010, measured at the outlet of Chisinau WWTP, together with the EU concentration thresholds.



Evolution of Total Nitrogen, ammonium and phosphate concentrations from 01/01/2010 until 30/09/2010, measured upstream the sand removal tanks and at the outlet of Chisinau WWTP, together with the EU concentration thresholds.

Annex 4 Other WWTPs Operated by ACC

Volumes of treated wastewater in 2010 (in m3 unless otherwise stated) are presented below.

Durlesti WWTP has been decommissionned. Today the wastewater is pumped to Chisinau WWTP.

	Chisinau	Vadu lui Voda	Durlesti	Colonita	Total ACC
January	4496819	73965	10773	8546	4590103
February	4556128	32000	7563	7749	4603440
March	4908560	39200	10385	8496	4966641
April	4452785	37200	9635	8113	4507733
May	4599675	48826	9795	8405	4666702
June	4481117	60410	10262	7831	4559620
July	4556008	66090	10354	8425	4640877
August	4411629	71176	10943	8128	4501876
September	4372946	86991	10569	7883	4478389
October	4669648	86568	10617	8130	4774963
November	4521048	45690	10166	8257	4585161
December	4950867	66202	9731	8556	5035356
Total 2010	**54977230**	**714318**	**120793**	**98519**	**55910859**
Average (m3/d)	**150623**	**1957**	**331**	**270**	**153180**

Annex 5 Pieces of Equipment

		year of manufacturing / year of installation	Current status	Brand name	Origin	Technical parameters Q,m3/h	H, m	x, mm	P,kW	Comments
	Zone SPP-2: Pretreatment building									
1	Screen N 2	XI 2005	in operation		Belgorod, Russia			10.5		РКЭ 1918
2	Screen N 5	XI 2005	in operation	Водомашоборудование	Belgorod, Russia			10.5		РКЭ 1918
3	Screen N 1	X, 1995	in operation	Водомашоборудование	Voronej, Russia			16		MT-6T
4	Screen N 3	XII, 1995	in operation/stand-by	Водомашоборудование	Voronej, Russia			16		MT-6T
5	Screen N 4	II,1997	in operation/stand-by	Водомашоборудование	Voronej, Russia			16		MT-6T
6	Screen N 6	II,1997	in operation	Водомашоборудование	Voronej, Russia			16		MT-6T
7	Pump	X,1990	in operation/stand-by	Уралгидромаш	Sîsert, Russia	7200	29		800	
8	Pump	III,1984	in operation/stand-by	Уралгидромаш	Sîsert, Russia	7200	29		800	
9	Pump	III,1984	in operation/stand-by	Уралгидромаш	Sîsert, Russia	7200	29		800	
10	Pump	VI,2006	in operation	Уралгидромаш	Sîsert, Russia	2700	26.5		400	
11	Pump	IX,2007	in operation	Уралгидромаш	Sîsert, Russia	2700	26.5		400	
	Zone SPN-1									
12	Pump	VIII,1988	in operation/stand-by		Rîbniţa, Moldova	450	22.5		75	3
13	Pump	VIII,1988	in operation/stand-by		Rîbniţa, Moldova	450	22.5		75	3
	Zone SPN-2									
14	Pump	VIII,1985	in operation/stand-by		Rîbniţa, Moldova	450	22.5		75	4
15	Pump	IV, 1987	in operation/stand-by		Russia	160	30		50	4
16	Pump	VIII,1988	in operation/stand-by		Rîbniţa, Moldova	450	22.5		75	4
17	Pump	IX, 2000	in operation/stand-by		Russia	250	125		75	4
	Zone SS-1: Biological treatment									
18	Blower N1	III, 1974	in reparation		Uzbekistan	18000	1.6		350	ТВ 300-1,6
19	Blower N2	III, 1974	stand-by		Uzbekistan	18000	1.6		350	ТВ 300-1,6
20	Blower N3	III, 1974	in operation		Uzbekistan	18000	1.6		350	ТВ 300-1,6
21	Blower N4	XII,2005	in reparation		Uzbekistan	18000	1.6		400	ТВ 300-1,6
22	Blower N5	IV, 2004	stand-by		Uzbekistan	18000	1.6		400	ТВ 300-1,6
23	Blower N6	VIII, 2006	stand-by		Uzbekistan	18000	1.6		400	ТВ 300-1,6
24	Blower N7	VI, 1990	stand-by		Uzbekistan	18000	1.6		350	ТВ 300-1,6
25	Blower N8	IV, 2004	stand-by		Uzbekistan	18000	1.6		400	ТВ 300-1,6
26	Blower N9	XII, 1975	in operation		Uzbekistan	18000	1.6		350	ТВ 300-1,6
27	Blower N10	XII, 1977	in operation		Uzbekistan	18000	1.6		350	ТВ 300-1,6
28	Blower N11	XII, 1977	stand-by		Uzbekistan	18000	1.6		350	ТВ 300-1,6
29	Pump N2	I, 1995	in operation/stand-by		Russia	2775	33		160	recirculated AS, СД 3200/33,2
30	Pump N4	X, 1990	in operation		Russia	2775	33		160	recirculated AS, СД 3200/33,3
31	Pump N5	III,1987	in operation/stand-by		Russia	3400	28		300	recirculated AS, СД 3200/33,4
32	Pump N3	IX, 2001	in operation		Russia	450	22		75	recirculated AS, CM 250/200-400
33	Pump N2	VII,1992	in operation/stand-by		Russia	125	47.6		45	Service water, CM100/6
34	Pump N3	VII,1992	in operation		Russia	125	47.6		11	Service water, CM100/6
35	Pump N1	XI, 2008	in operation		Russia	50	35		4	Service water, K80/65
36	Pump N4	II, 2009	in operation/stand-by		Russia	50	35		7	Service water, K35/30
37	Pump N1									8Ф12
38	Pump N3									8Ф12
39	Pump N1	XII,2003	in operation	ABS, AFL	Germany	3000	8		90	recirculated AS
40	Pump N2	XII,2003	in reparation	ABS, AFL	Germany	3000	8		90	recirculated AS
	Leachates									
41	Pump	III, 2009	in operation	Wilo ST580G14	Germany	380	10		9	
42	Pump	XII,2010	in operation	Wilo	Germany	50	8		2.25	

Annex 6 Audit of Civil Works

Grades:

0 – Unit is derelict or out of service due to major defects in structure or M&E plant. Could not be brought back into service with rehabilitation

1 – Unit is in extremely poor condition. Replacement would be a better solution than rehabilitation. M&W plant requires replacement.

2- Unit is in poor condition. M&E plant subject to infrequent failures that affect the treatment process e.g. no standby facility. With major rehabilitation life could be extended for 5 years

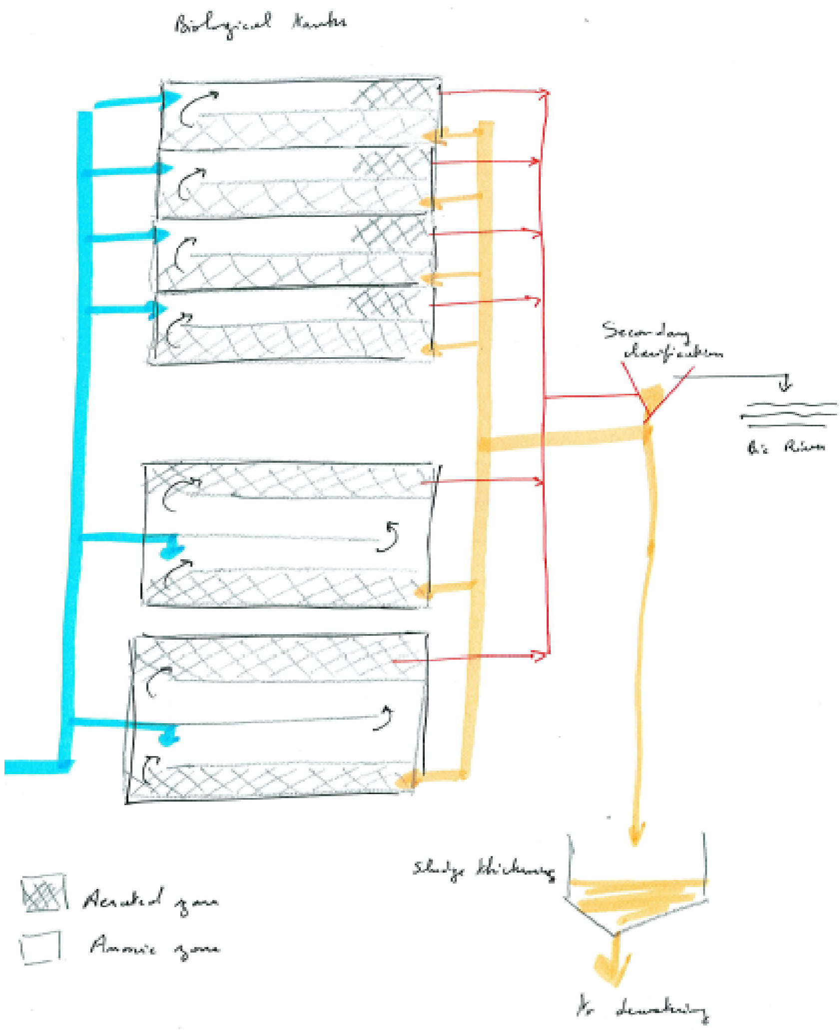
3 – As (2) but with rehabilitation, life could be extended for 10 years

4- Structure or M&E plant is old but not suffering from major defects or failures that affect the process i.e, there is standby facility or element is not critical to process . With rehabilitation works, the life could be extended by at least 10 years.

5- Structure or M&E plant is new or fairly new. Any rehabilitation required is merely decorative and does not affect the integrity of the structure. M&E plant subject to very infrequent failure or has adequate standby capacity.

Process unit or other identification	Element within unit	Condition of the structure	Condition of the M&E	Note to support grade - identification	Identification of safety issues	Where Grade is 2, 3, 4 or 5, description of work required to ensure availability of process unit for the next 5 years Description	Cost estimate
1.0 **Mechanical stage**							
1.1 Fist intake chamber	Construction, reinforced concrete, at the rate below 0,000	0					0
1.2 Second intake chamber	Construction, reinforced concrete, at the rate below 0,000	4		The concrete coating is partially damaged	Will influence the hydraulic isolation capacity of the construction	Execute repairs of the torcret coverage (plaster) with hydraulic isolation technology	
1.3	Valve with dn 200mm with electric actuation		1	There are cracks in the valve body. Reinforcement works are already in place.	Influences the technological security, impedes to stop the water flow	Necessity of replacement with new valves dn 2000mm P-2.5bar	28,000
1.4	Valve with dn 200mm with electric actuation		1	There are cracks in the valve body. Reinforcement works are already in place.	Influences the technological security, impedes to stop the water flow	Necessity of replacement with new valves dn 2000mm P-2.5bar	28,000
1.5	Electric valves - 3		3	Metal corrosion	Influences the technological security, impedes to stop the water flow	Requires major repairs of the metallic parts	14,000
2.0 **Pumping station no.2**							
2.1	Roof	3		The rainfall penetrates the roof decking	1.May cause a short circuit in the electric motors of the pumping aggregates. 2. Affects the structural strength of the walls	Demolition of the existing coating material. Preparation of the platform. Replacement of the roof coating material	7,000
2.2	Carpentry	3		The window frames are rotten	Affects the structure and the work safety	Demolition of the old window frames. Installation of the new window frames.	
2.3	Ventilation system		3	Damaged	Because of the metal corrosion it is not functional	Dismantling the old system. Installation of the ventilation system (fans, vacuum and discharge network).	22,000
2.4	Electric hoist-3.5t		3		Requires repairs		6,000
2.5	Mechanical screens		1	This unit is physically and morally outdated. The unit underwent many times major repairs	There are 6 mechanical screens, 2-frequently in use.	Demolition of 2 mechanical screens. Replacement of 2 mechanical screens with grinder	
2.6	Electric motor P-400kW - 3						15,000
3.0 **Pumping station no.1**		**0**					**0**
4.0 **The screens and grinders**		**0**					**0**
4.1 **The settling tanks (the building destinated for the settling tanks operation)**	Roof 30x 6=180m2	3		The rainfalls penetrate the roof decking	May cause a short circuit in the electrical motors of the pumping aggregates. Affects the structure and the work safety.	Demolition of the existing coating material. Preparation for the coating platform. Replacement of the roof coating material.	2,000
4.2	Parschall gutter	3		Cracks in the walls of the Parshall gutter.	The untreated wastewater penetrates completely the soil	Concrete works or torcret works with hydraulic isolation technology	11,000
4.3	Slide valves - 8		3	The trench related to the slide valve is obsolete and embedded in concrete	Affects the technological process of the settling tanks operation. It is difficult to be repaired because of the permanent water flow and because of the lack of alternatives	The trench related to the slide valve is embedded in concrete. Installation of the electric slide valves. Dismantling of the old slide valves	43,000
5.0 **Primary settling tanks (6, dn - 40m, H-4,5m, V-4500m3)**							
5.1 Technological equipment and utilities	Scraper bridge with adjustable blades-2		3	Advanced degree of wear, underwent some repairs before.	Technological malfunction. Worsening of the waste water treatment.	Dismantling of the scraper bridge with old adjustable blades. Construction works of the circular gutter for the water discharge from the primary settling tank. Replacement of the steel gutter reinforcing elements. Replacement of the sludge scraper.	94,000
6.0 **Aeration tanks**							
6.1 Aeration tanks - Aeration system	air pipes dn 100mm L 5000m		4	Advanced degree of wear. It's time for a major repairs	Technological malfunction. Under danger :the sludge discharge at the Geotubes platforms.	Removing the aeration tanks from the technological cycle and its empting. The inclusion of the air tanks in the technological process.	87,000
6.2 Slide valves– 24 ; 12 of them need major repairs.	Slide Valves- 12		5			Slide valves dismantling. Installation of the new slide valves	63,000
7.0 **Secondary clarifiers dn 40 m, dn 50m H- 4.5m**							
7.1	Scraper bridge– 2		4	High degree of corrosion	Exclusion of the settling tank from the technological cycle and the cleaning	Technological malfunction worsens the wastewater treatment process. Dismantling of the scarper bridge. Reinforcement and maintenance works for the water discharge gutter. Replacement of the water discharge gutter. Replacement of the scarper bridge. Put into operation.	94,000
7.2	Sludge pipeline dn 300mm L-2000m, steel material		4	Advanced degree of wear. It's time for major repairs	Technological malfunction. Air insufficiency for the technological process.	Major repairs by a specialized company	23,000
8.0 **Sludge pumping station**							
8.1	Sludge pump D-3200/33 - 1		4	Advanced degree of wear. It's time for major repairs	Technological malfunction.		5,000
8.2	Vertical sludge pump AFL - 2		4		Sludge pumping incapacity to the geotubes platform	Major repairs	19,000
8.3	Horizontal sludge pump - 1		4			Major repairs	4,000
9.0 **Air blowers unit**							
9.1	Blower D-300 - 4		4	Advanced degree of wear. It's time for major repairs	Technological malfunction. Incapacity to pump the sludge to the geotubes	Major repairs by a specialized company	10,000
10.0 **Energy department**							
10.1	Cable RDS 3-RD 66, L-1260M (*in Russian РДС 3 - РД 66, L-1260m*)		1	Advanced degree of wear. It's time for major repairs	Energy security of the item	Replacement	40,000
10.2	Cells - total - 40 (cell- is a part of the power transformer)		1	Advanced degree of wear. It's time for major repairs	Energy security of the item	Replacement	47,000
10.3	Replacement of 15						
10.4	Cable ASBL - 10-3x240 (*in Russian АСБЛ – 10-3x240*)		1	Advanced degree of wear. It's time for major repairs	Energy security of the item	Replacement	16,000
11.0 **Miscellaneous**							
11.1 The building for blowers		0					
11.2 The building-cooling tower through splash-out		5					
11.3 Annexe-building to the main pumping station		5					
11.4 Garage for 10 autovehicles		5					
11.5 Service building for the workers at the sludge beds		5					
11.6 Storage for materials		5					
11.7 Thermic point		5					
11.8 Chlorine storage unit		0					
11.9 Administrative building with laboratory and disinfection unit		5					
11.10 Checkpoint		5					

Annex 7 Proposed Process Modifications



Aerated stabilization zone (DO: 2 mg/L) 36250 m3

Contact zone – anoxic 39164 m3

Contact zone – aerated (1 mg/L) 19582 m3

Temperature: 10°C

SRT: 15 d

Recirculation: 100%

Outlet:

TN 26 mg/L

NO3 5 mg/L

Recirculation ratio could be increased to recirculate more NO3 to be further denitrified in the anoxic zones.

Mass load of the secondary clarifiers should be checked (increase of the MLSS concentration) and more secondary clarifiers could be put into operation if needed.

Appendix 4

Potable Water Network

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

OPERATION OF THE DRINKING WATER NETWORK

1. INTRODUCTION

To assess and improve the existing operation of Chisinau's drinking water network, a hydraulic model has to be built. This model will allow diagnosing operating conditions. The remedial measures which are urgently needed or can be easily implemented shall be recommended for improving the daily operation. The model will also be run to simulate future operating conditions under the medium or long term investment plan.

In order to build a comprehensive model of the water supply network, the model has to be confronted to reality and to be calibrated. To enable the comparison between the reality and the model, a measurement campaign will be performed on the network. The definition of the measurement campaign is carried out through the knowledge of the network and the understanding of its functioning.

The key-points of the network, such as inlets, outlets, tanks, pumping station and any regulating system have been visited. The aim of the visits was to understand the functioning of the system in order to:

- Define the measurement points to implement. The visits enable the definition of the number of flows and head to measure in the pumping stations;
- Define the measurement devices to install. The visits enabled as well the assessment of the sensor equipment of the stations and the specific needs for the measurement campaign;
- define the place to install the devices as well as the preliminary work, that will have to be implemented prior to the measurement campaign
- define the topographical measures to carry out in the city in order to know exactly the elevation of the points where pressure measures are taken

The information got from the visits lead to a first assessment and highlighted issues and potential improvements.

2. DESCRIPTION OF THE DRINKING WATER NETWORK

A detailed description of the drinking water network is provided in the annex 1. The key-points are presented below.

Two types of source of water are used to supply the water drinking water network managed by ACC:

- The main source is the Nistru River (water intake is located 18 km away from Chişinau), that supplies the water treatment plants of Chişinau and Nistru. Both water treatment plants have produced more than 97% of the potable water delivered to the network in 2010.
- Some wells are still operated in the city and the suburbs.
    - The water from the wells in the city (pumping station of Balşevsc) is mixed with the water from the network and then treated by the filtration and chlorination and supplies the zone 1 (lowest distribution zone).
    - The water from the wells of Ghidighici is treated by chlorination and supplies the zone 1. In Ghidighici village, other wells are operated by Apa Canal that supply an independent network.
    - In Sîngera city, 1 well Is functioning (formerly 2) in order to supply the lower part of the city in an independent network
    - The water from the wells in Ialoveni is treated by chlorination and supplies the independent water network in Ialoveni.
    - The village of Goianul Nou has been supplied by one well until March 2011, when the well has been shut down and the village supplied by Stauceni pumping station.

The water treatment plant of Nistru is supplied by raw water coming from the Nistru and supplies the cities Vadul Lui Voda, Coşerniţa, Tohatin and ultimately Chişinau through Ciocana tanks. In 2010, its production represented 14% of the total production of potable water.

The water treatment plant of Chişinau is supplied by raw water coming from the Nistru and supplies Chişinau water network. This is the main injection point in the water drinking network: 83% of the total production in 2010.

The raw water is transported from the Nistru intake to the water treatment plants through a raw water network, composed of 43.7km of pipelines. In the same way, the water from the wells located in Vadul Lui Voda was transported to the water treatment plant of Nistru via a specific network (11.9 km of steel pipes). Those wells are not operated anymore due to the poor quality of the water.

The technical water in Chişinau is delivered by gravity from the water treatment plant of Chisinau through another specific network, composed of 17.7 km of pipelines.

Finally, the potable water is supplied to the whole study area through around 1770 km of pipes, twenty pumping stations, twenty storage locations and around eighty boosters. The length of the network in the different part of the study area is described in the Table 2.1.

Table 2.1: Length of the network for different materials in the localities of the study area

Localities		pipe length (km)					
		steel	iron cast	abestos cement	concrete	HDPE	**Total**
raw and technical water	Groundwater intake in Vadul Lui Voda	11.9	-	-	-	-	**11.9**
	Technical water WTP	15.9	-	-	1.8	-	**17.7**
	Raw water	32.8	-	-	10.9	-	**43.7**
	sub total	**60.5**	**0**	**0**	**12.7**	**0**	**73.2**
potable water	Ciocana (Bubuieci, Bîc, Cruzeşti, Budesti)	108.9	106.0	0.3	12.3	33.6	**261.1**
	Botanica (Sîngera, Dobruja, Aeoport)	36.0	121.6	0.0	0.0	30.7	**188.3**
	Buiucani (Vatra, Pruncul)	74.4	128.5	0.6	3.8	36.4	**243.8**
	Rîscani (Stauceni, Goianul Nou)	124.5	136.6	1.5	5.6	87.4	**355.6**
	Centru	135.1	94.0	0.0	0.0	65.9	**295.0**
	Codru (Costiujeni)	71.8	37.8	-	3.1	20.3	**133.1**
	Coloniţa	-	-	-	-	2.2	**2.2**
	Durleşti	19.1	10.7	-	-	13.2	**43.0**
	Ghidighici	0.8	7.3	0.6	-	15.5	**24.2**
	Gratiesti (Hulboaca)	3.1	0.7	1.5	-	25.7	**31.0**
	Ialoveni	34.4	24.6	-	-	5.6	**64.5**
	Tohatin	30.8	1.3	0.3	-	5.9	**38.4**
	Vadul Lui Voda (Balabaneşti, Vaduleni)	59.3	29.5	0.5	-	1.4	**90.8**
	sub total	**698.4**	**698.5**	**5.3**	**24.7**	**343.9**	**1770.9**
Total		**758.9**	**698.5**	**5.3**	**37.4**	**343.9**	**1844.1**

The average age of the network is around 25 years (around 60% of the pipes are older than 20 years). According to an analysis of the material of the pipes laid during the last 10 years, the main materials used currently by Apa Canal seem to be steel for trunks; cast iron for the primary network and HDPE for the secondary and the tertiary network.

The city is built on seven hills and the elevation may vary strongly, between 35m at the lowest point and 230m at the highest. The main organization of the network is to pump to supply a distribution zone, as well as ground tanks. The tanks themselves supply water directly to the inlet of other pumping stations.

The organization of the pumping stations and of the related pressure zones is shown in the Figure 2.1. The network is organized in 6 pressure zones presented below:

- The pressure zone 1 supplies the lowest part of the city, located around the Bîc River and supplies as well the cities of Ghidighici and Codru.
- The pressure zone 2 is supplied by gravity and supplies the center of Chişinau as well as the main pumping stations.
- The other pressure zones are supplied by pumping stations and supplies the higher parts of the city, as well as high buildings.

The pressure delivered to the distribution zone is controlled at the pumping stations which are mainly equipped with variable speed drives. However some throttled valves are used at the pumping stations to adjust:

- Pressure to delivery pipes
- Inlet flow to the tanks

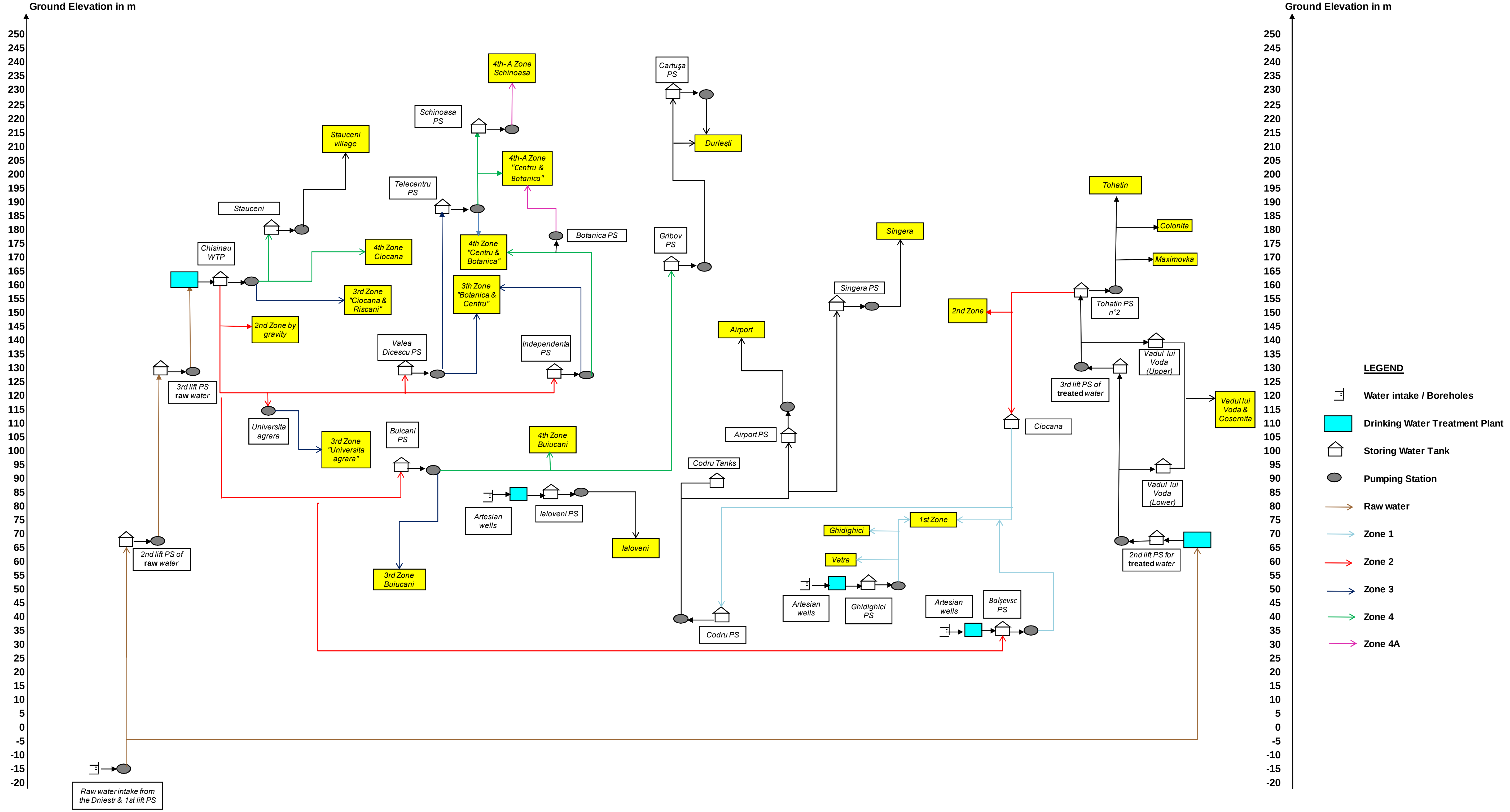
According to the seasonal or the daily variations of the water demand, the configuration of the pumping is adjusted through:

- The set point for delivery pressure,
- the number of the working pumps,
- the switching of the working pump, based on its power.

The boosters are used in Chişinau to supply the higher buildings. The boosters work generally 24 hours a day; most of the pumps are driven by an automatic variable speed drive, set on the delivery pressure in order to control the pressure especially during the night.

On the network, no valve is partially closed but six pressure reduction valves that are used locally to supply some lower buildings.

Figure 2.1: Layout of the water supply in Chisinau



3. PREPARATION OF THE MEASUREMENT CAMPAIGN FOR THE DRINKING WATER NETWORK

3.1. EQUIPMENT

The characteristics to be measured during the campaign are:

- The flow, supplied by the tanks and transiting through the key-points of the network. The flowmeters used during the campaign will be either the ultrasonic flowmeters already installed or the hydreka's hydrins electromagnetic insertion pipe flowmeters.
- The head, upstream and downstream of the system that will modify it. The head will also be measured in some significant points of the network. The head is measured through a level or a pressure sensor and the knowledge of the place's elevation

3.1.1. EXISTING EQUIPMENTS INSTALLED ON THE PUMPING STATIONS

The pumping stations are well equipped. Four types of captors can be found:

- The ultrasonic flowmeters on the inlets and the outlets. The flowmeters can be programmed and their data recorded once every ten minutes. The results from their flowmeters will therefore be used during the measurement campaign.
- The mechanical flowmeters, in some suburban pumping stations. These flowmeters may be enough on some small outlet where the index of the flowmeters will be noted at the beginning and the end of the measurement campaign.
- The data from the sensors (pressure and level) in the stations "Telecentru", "Botanica", "Valea Dicescu", "Ciocana" and "Universita agrara" can be recorded once every ten minutes. Therefore, they can be used for the measurement campaign.
- The sensors from all the other pumping stations display only the pressure or the level in the control room.

3.1.2. TEMPORARY EQUIPMENTS TO BE INSTALLED

The ultrasonic flowmeters are fixed outside of the pipes. The hydrins electromagnetic flowmeters have to be installed on a tap, to be inserted inside the pipe. The mechanical description of the flowmeter is shown below in the Figure 3.1. Their joint is 1 inch large and they have to be installed on a straight pipe. The upstream length of the straight pipe has to be at least ten times the diameter of the pipe and the downstream length 5 times the diameter. There is a pressure sensor integrated with the hydrins and at the same point, the flow and the pressure can be measured at the same time.

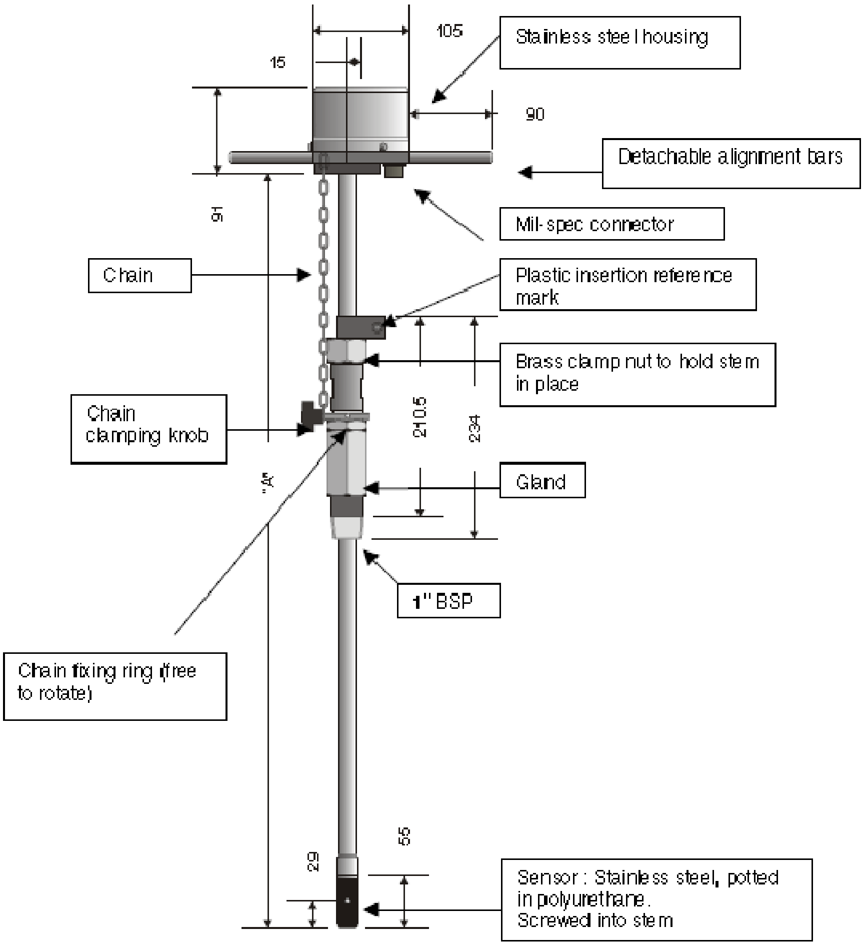


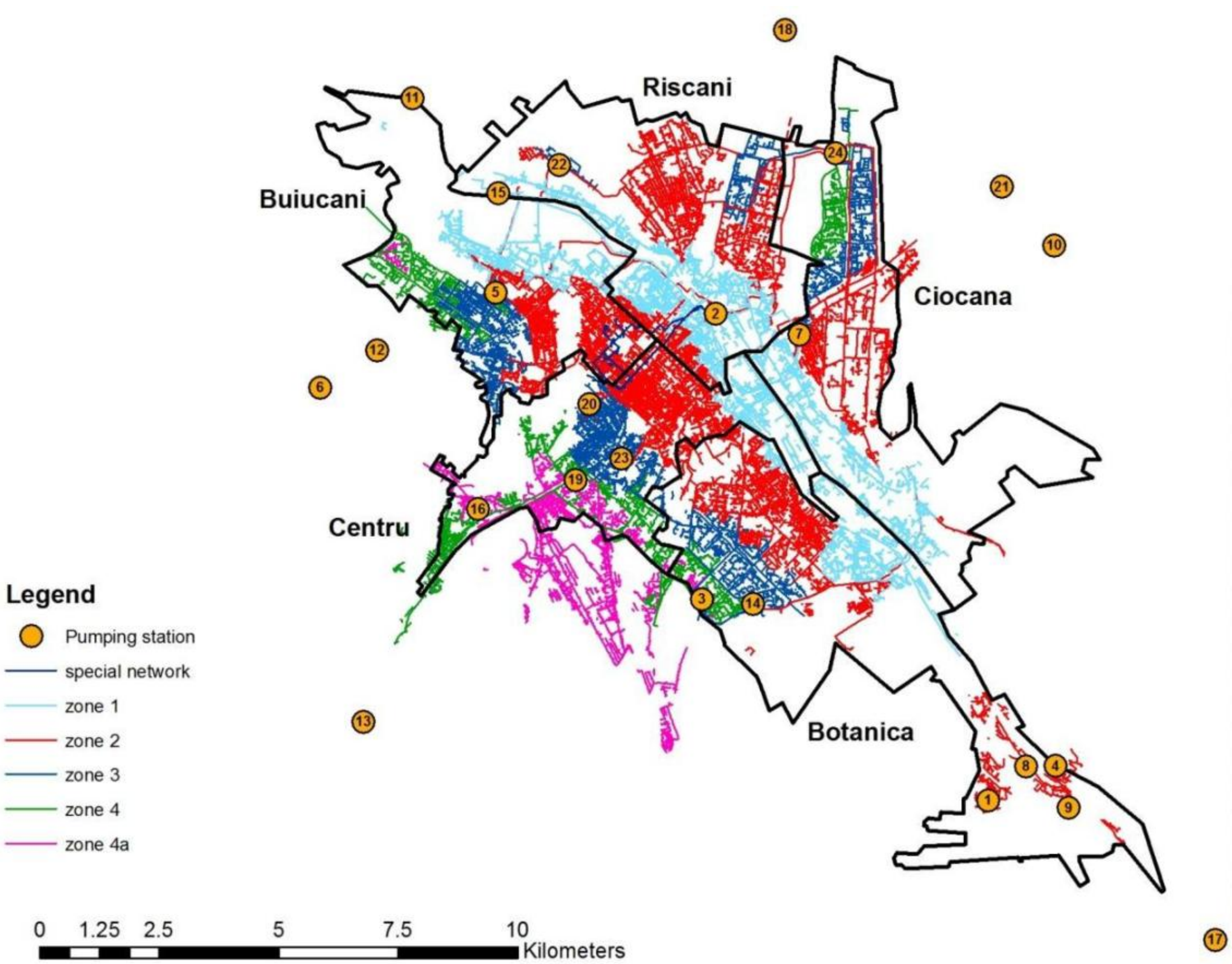
Figure 3.1: Hydrins

The temporary pressure sensors are installed on a tap and their joint is ¼ inch large. The level sensors however are immersed in the tanks and lie on the bottom.

3.2. VISITS OF THE PUMPING STATIONS AND TANKS

The visits of the pumping stations have enabled a better understanding of the network in Chişinau and in its suburbs. The map of the water network and the visited pumping stations and tanks is presented in the Figure 3.2. A detailed description of the visited pumping stations can be found in annex 2.

Figure 3.2: drinking water network in Chisinau



Pumping station	
N°	NAME
1	Aeroport
2	Balsevsc
3	Botanica
4	Bucurta
5	Buiucani
6	Cartusa
7	Ciocana
8	Codru
9	Codru Reservoirs
10	Colonita Reservoir
11	Ghidghici
12	Gribova
13	Ialoveni
14	Independenta
15	Petricani
16	Schinoasa
17	Sîngera
18	Stauceni
19	Telecentru
20	Timis Reservoir
21	Tohatin
22	Universita agrara
23	Valea Dicescu
24	WTP (Chisinau)

3.3. LIST OF THE MEASURES

The Table 3.1 summarizes the measures to be carried out during the measurement campaign for the model's needs. The equipment:

- "Q" refers to ultrasonic flowmeters
- "QP" refers to an hydrins,
- "C" refers to a mechanical flowmeter, which index will have to be noted at the beginning and the end of the campaign,
- "P" refers to a pressure sensor,
- "H" refers to a level sensor.
- "Topography" refers to a topographical measure because the point elevation is unknown.

Table 3.1: Measures to be taken during the campaign

hydraulic entities		equipment					topography
		Q	QP	C	P	H	
Zone 1		7	0	0	14	5	7
Zone 2		14	0	0	23	10	11
Zone 3	Buiucani	2	0	0	4	0	1
	Ciocana & Rîscani	4	0	0	6	2	1
	Centru & Botanica	4	0	0	8	3	2
Zone 4	Buiucani	2	1	0	5	2	1
	Ciocana	3	3	0	4	3	4
	Centru & Botanica	7	0	0	8	2	3
Zone 4A	Centru & Botanica	4	0	0	6	2	2
Suburban area	Codru	7	4	2	10	4	9
	Durleşti	0	3	1	3	2	7
	Ialoveni	2	0	0	5	2	3
	Vadul Lui Voda	6	0	7	12	5	6
TOTAL		**62**	**11**	**10**	**108**	**42**	**57**

As most of the data for the flow can be obtained through the flowmeters already in place in the pumping stations, a few hydrins need to be installed. The temporary equipments to install during the measurement campaign are summarized in the Table 3.2. The cells in blue are the measures that can be recovered with Apa Canal's equipment.

The details of the locations of the measures are to be found in annex 3.

Table 3.2: Temporary equipments to install during the measurement campaign

hydraulic entities	contributing station	equipment QP	equipment Q	equipment C	equipment P	equipment H
Zone 1	Ciocana		3		3	2
	Codru		1		1	1
	Ghidighici		2		1	1
	Balşevsc		1		1	1
	Network				8	
	TOTAL	0	7	0	14	5
Zone 2	WTP		4		1	3
	Indepenta		1		1	1
	U.agrara		2		2	
	Buiucani		2		2	1
	Balsevsc		1		1	1
	Valea Dicescu		1		1	1
	Tohatin		2			1
	Ciocana		1		1	2
	Network				14	
	TOTAL	0	14	0	23	10
Zone 3 Buiucani	Buiucani		2		2	
	Network				2	
	TOTAL	0	2	0	4	0
Zone 3 Ciocana - Rîscani	WTP		4		2	2
	Network				4	
	TOTAL	0	4	0	6	2
Zone 3 Centru - Botanica	Valea Dicescu		1		2	2
	Telecentru		1		1	1
	Indepenta		2		2	
	Network				3	
	TOTAL	0	4	0	8	3
Zone 4 Buiucani	Buiucani		2		2	1
	Gribov	1				1
	Network				3	
	TOTAL	1	2	0	5	2
FINAL TOTAL		**11**	**62**	**10**	**108**	**42**

hydraulic entities	contributing station	equipment QP	equipment Q	equipment C	equipment P	equipment H
Zone 4 Ciocana	WTP		3		2	2
	Stauceni	3				1
	Network				2	
	TOTAL	3	3	0	4	3
Zone 4 Botanica - Centru	Telecentru		2		1	1
	Indepenta		2		2	1
	Botanica		3		2	
	Network				3	
	TOTAL	0	7	0	8	2
Zone 4a Centru - Botanica	Telecentru		2		1	1
	Schinoasa		2		2	1
	Network				3	
	TOTAL	0	4	0	6	2
Codru & Sîngera	Codru		3	1	3	1
	Sîngera	1	4	1	2	1
	Codru Reservoirs					1
	Aeroport	3				1
	Network				5	
	TOTAL	4	7	2	10	4
Durleşti	Gribov	1		1	1	1
	Cartusa	2				1
	Network				2	
	TOTAL	3	0	1	3	2
Ialoveni	Ialoveni		2		2	2
	Network				3	
	TOTAL	0	2	0	5	2
Vadul Lui Voda	Nistru Treapta II				2	2
	Nistru Treapta IIa		3		4	1
	Tohatin		3	6	2	1
	Colonita					1
	Network			1	4	
	TOTAL	0	6	7	12	5

The pressure sensors that will be installed in the network are shown in the Annex 4, when they have been defined.

Once the measuring points for each hydraulic entity have been defined, the measurement campaign can be finalized. There will be six measurement campaigns, each campaign lasting two weeks. The details of the campaigns are given below in the Table 3.3, that takes into consideration the measures recovered from Apa Canal (for the pressure)

Table 3.3: definition of the measurement campaign

Weeks	Name of the hydraulic entities	equipments			
		QP	C	P	H
0 to 2	Zone 2	0	0	21	7
2 to 4	Zone 1 + Zone 4 "Buiucani"	1	0	19	5
4 to 6	Zone 3 "Buiucani" + Zone 3 "Ciocana & Rîscani" + Zone 3 "Centru & Botanica"	0	0	16	2
6 to 8	Zone 4 and 4a "Centru & Botanica" + Durlesti	3	1	13	4
8 to 10	Zone 4 "Ciocana" + Vadul Lui Voda	3	7	16	8
10 to 12	Codru + Ialoveni	4	2	15	6

3.4. PRELIMINARY WORK

In order to install the temporary equipments in the best conditions, some preliminary work will have to be carried out by Apa Canal. The Table 3.4 presents the pumping stations at which preliminary works need to be carried out and the following list explains the location and the nature of the works to be effected. When a tapping has to be installed for an hydrins on a pipe, the diameter of the tap needs to be at least 25mm. Similarly, the diameter for a tap for a pressure sensor needs to be at least 1/2''.

1. In Aeroport Pumping station, three hydrins need to be installed.
    - The first hydrins will be installed on the inlet, before the regulating valve. A manhole needs to be dug between the manhole of the regulating valve and the wall, and then a tapping is to be installed on the 200mm pipe.
    - The second hydrins will be installed on the delivery pipe in the new pumping station. A tapping needs to be performed on the 200mm pipe.
    - The third hydrins needs to be installed on the second outlet, the one passing through the old pumping station. A tapping will be installed on the 100mm pipe in the old pumping station.
2. In Cartuşa Pumping station, two hydrins need to be installed.
    - The first one has to be installed on the inlet. It will be installed before the regulating valve, on a 100mm pipe. A manhole needs to be dug and then a tapping to be performed.
    - The second one will be installed on the outlet (diameter 150mm), before the pipe is separated. There again, a manhole needs to be dug and a tapping to be performed.
3. In Ciocana Reservoirs, one pressure sensor will be placed upstream the regulating valve leading to the tank during the measurement campaign. In order to install this sensor, a small existing pipe needs to be removed and replaced by the sensor. Pressure sensors will also be placed at the outlets of the tanks. For two outlets, air valves will have to be replaced by the pressure sensors.
4. In Gribova Pumping station, two hydrins need to be installed.

- The first one is to be installed in the inlet, before the regulating valves. A manhole needs to be dug and a tapping to be performed on the pipe (which diameter is 133 mm)
- The second hydrins will be installed on the outlet, after the separation with the second outlet. A hole has to be dug as well and the tapping installed on the 100mm pipe.

5. In Sîngera Pumping station, one tapping for a pressure sensor upstream the regulating valve needs to be performed. This tapping will be performed in the manhole of the regulating valve (the diameter of the inlet pipe is 400mm). Moreover, one hydrins needs to be installed. The hydrins will be installed on one of the gravitational outlet, on which one there is no ultrasonic flowmeter. A manhole needs to be dug and a tapping to be performed on the pipe (150mm).
6. In Stauceni Pumping station, three hydrins need to be installed.
    - The first one on the inlet (which diameter is 400mm), upstream the regulating valve. A hole has to be dug between the manhole of the regulating valve and the wall of the station and a tapping performed.
    - The second and the third one are to be installed on the outlets (the two diameters are 300mm). There is no place inside the pumping station and therefore, two holes will have to be dug outside the building and a tapping performed.
7. In Telecentru Pumping station, the air valve in the manhole of the regulating valve will have to be replaced by a tap adapted to the pressure sensor used during the measurement campaign.
8. In the Pumping station of the water treatment plant of Nistru, two tappings for pressure sensor need to be performed. The tappings will be performed on the gravitational outlet to Vadul Lui Voda (diameter 300mm) and on the gravitational outlet to Coşerniţa (diameter 500mm). The tappings will be performed in the manhole of the two flowmeters.

Table 3.4: Pumping stations at which preliminary work need to be implemented

Pumping station		Work to be implemented	Pumping station		Work to be implemented
N°	NAME		N°	NAME	
1	Aeroport	yes	13	Independenţa	no
2	Balşevsc	no	14	Schinoasa	no
3	Botanica	no	15	Sîngera	yes
4	Buiucani	no	16	Stauceni	yes
5	Cartuşa	yes	17	Telecentru	yes
6	Ciocana	yes	18	Tohatin	no
7	Codru	no	19	Universita agrara	no
8	Codru Tanks	no	20	Valea Dicescu	no
9	Coloniţa Tank	no	21	WTP (Chisinau)	no
10	Ghidighici	no	22	WTP (Nistru)	yes
11	Gribova	yes	23	Booster n°47	no
12	Ialoveni	no			

3.5. TOPOGRAPHICAL MEASUREMENTS

It is very important to know the altimetric level of the points where the pressure sensors are installed. Therefore a topographical survey will have to be done to know precisely the elevations of the points, where the information does not exist.

The survey should take 57 topographical measures, whose list is given in the Table 3.5. The case in green represents pressure measuring points that have still to be determined.

Table 3.5: definition of the points for the topographical survey

hydraulic entities	contributing station	name	Topography	description
Zone 2	WTP	P3	1	downstream regulating valve.
	Buiucani	P6	1	upstream regulating valve
	Valea Dicescu	P8	1	upstream regulating valve
	Ciocana	P9	1	upstream regulating valve
	Network	P11	1	Pressure Control Point of the WTP's valve: Balsevsc
		P17	1	Booster n°32. Puskin 44/1
		P20	1	Pressure control Point Badiu/ Pogdorelinor
		P21	1	Pressure Control Point Studentilor/Florilor
		P22	1	Pressure Control Point Maleevici/ Puskin
		P23	1	On each side of the throttled valve
		P24	1	
Zone 1	Ciocana	P1	1	Valves partially open => downstream pressure at the outlet
		P2	1	
		P3	1	
	Codru	P6	1	upstream regulating valve
	Network	P12	1	Pressure Control Point Doga/ Aeromaenului
		P13	1	Pressure control point n°1. Uzinelor/ Vonlunterilor
		P14	1	Presure Control Point Petru Rares/Cosmonaut
Zone 4 Buiucani	Gribov	Q3P3	1	Inlet from Buiucani Zone 4
Zone 3 Buiucani	Network	P4	1	Pressure Control Point n°2: Alba Iula/ Sucevioa
Zone 3 Ciocana + Rîscani		P7	1	Pressure Control Point Studentilor/ Florilor
Zone 3 Centru	Telecentru	P3	1	Upstream regulating valve
	Network	P8	1	Pressure Control Point Cuza Voda/ Independenta
Zone 4 Botanica + Centru	Network	P8	1	Pressure Control Point Hincesti/ Aurel Viacu
		P9	1	Pressure Control Point Testemeanu/ Grenoble
		P10	1	Pressure Control Point zone 4 Botanica
Zone 4a Centru + Schinoasa	Network	P7	1	Pressure Control Point n°4. Str Ialoveni
		P8	1	Pressure Control Point zone 4a Schinoasa
Durlesti	Gribov	Q1P1	1	Outlet Cartusa
		P5	1	Downstream partially open valve
	Cartusa	Q2P2	1	Inlet before the loop
		Q3P3	1	Outlet before separations
		H2	1	2 reservoirs
	Network		2	To be determined
Zone 4 Ciocana	Stauceni	Q4P3	1	Inlet
		Q5P5	1	Outlet 1
		Q6P4	1	Outlet 2
		H3	1	Reservoir 1
Vadul Lui Voda	Nistru Treapta IIA	P3	1	Manhole of the flowmeter to Tohatin
		P5	1	Outlet to Cosernita
	Network		4	To be determined
Codru	Sîngera	Q5P5	1	Gravitational outlet 3
		P4	1	Upstream regulating valve
	Aeroport	Q9P8	1	Inlet
		Q11P11	1	Outlet (old pumping station)
	Network		5	To be determined
Ialoveni	Network	P3	1	Close to the valve between Ialoveni/Chisinau
		P4	1	At the (closed) reservoir de sos
		P5	1	In Moldova sector

4. PRELIMINARY ASSESSMENT

4.1. TANKS' CAPACITY

For a first evaluation of the network, the tanks' capacities have been assessed and summarized in the Table 4.1. They are compared to the average supplied volumes measured during four days in February 2011.

Table 4.1: storage capacity of the network

Name	elevation	supplied volume	storage volume	reserve	chlorination
		m^3/day	m^3	hours	
Aeroport PS	98.88	-	1 600	-	no
Balsevsc PS	38.95	2 328	4 000	41	yes
Botanica	177.5	1 008	-	0	no
Buiucani PS	103.82	20 160	14 000	17	yes
Cartusa PS	231	-	1 000	-	no
Ciocana	112	27 552	16 000	14	no
Codru PS	41.15	3 624	6 000	40	yes
Codru	82.36	-	1 200	-	no
Colonita	213	-	1 500	-	no
Ghidighici PS	53.08	1 728	4 000	56	yes
Gribov PS	168.3	-	500	-	no
Ialoveni PS	84.64	1 800	2 000	27	yes
Independenta PS	133	26 616	20 000	18	no
Schinoasa PS	219.96	1 800	6 000	80	yes
Sîngera PS	118.45	480	6 000	300	no
Stauceni PS	179	-	6 000	-	no
Telecentru PS	189.66	10 632	8 000	18	yes
Tohatin PS	160.8	25 128	16 000	15	no
Universita agrara	125.12	528	-	0	no
Valea Dicescu PS	128.49	15 960	11 000	17	no
WTP Chisinau	162.6	160 560	40 000	6	yes
WTP Nistru	130.15	28 200	4 500	4	yes
TOTAL	-	-	169 300	-	-

The '–' represents missing data

In 2010, the yearly average of supplied water is 208 860 m^3/day. The peak of supplied water happens in August with an average of 228 653 m^3/day. The total volume of the reservoirs is 169 300 m^3. The possible stored volume represents therefore around 80% of the average volume needed and around 75% of the volume needed in August. The existing storage capacity seems to be more than sufficient.

On the other hand, the residence time in some tanks (as in Sîngera) seems to be important, and the quality of the water may be impacted, especially if no chlorination is carried out.

4.2. PUMPING STATIONS' CAPACITY

In each pumping station, the pumping station capacity has been assessed as well and summarized in the Table 4.2. In the following table, the number of functioning pumps and of working pumps corresponds to observations obtained through the site visits of the pumping stations. The minimum and maximum of working pumps correspond to variations from winter to summer or from day to night.

Table 4.2: Working pumps in Chişinau

Name	Number of functioning pumps	working pumps at once		Pumps with a variable speed drive	Stand-by pumps	% of pumping capacity use
		min	max			
Aeroport PS	4	1	2	0	2	50%
Balsevsc PS	4	1		1	3	25%
Botanica	3	1		2	2	33%
Buiucani PS	7	1	3	3	4	43%
Cartusa PS	3	1	2	1	1	67%
Codru PS	7	1	3	3	4	43%
Ghidighici PS	4	0	1	2	3	25%
Gribov PS	1	0	1	0	0	100%
Ialoveni PS	7	1		2	6	14%
Independenta PS	8	2	4	2	4	50%
Schinoasa PS	4	1		2	3	25%
Sîngera PS	5	1	2	4	3	40%
Stauceni PS	4	1	1	4	3	25%
Telecentru PS	4	2		3	2	50%
Tohatin PS	5	1	2	2	3	40%
Universita agrara	4	0	1	1	3	25%
Valea Dicescu PS	5	1		2	4	20%
WTP Chisinau	10	2		4	8	20%
WTP Nistru Treapta II	6	1	2	0	4	33%
WTP Nistru Treapta IIa	5	1		0	4	20%
AVERAGE						**37%**

Almost all the pumping stations managed by Apa Canal are equipped with variable speed drives in order to deliver a constant pressure. The variable speed drives can drive one or several pumps, depending on the configuration of the station.

As described in the Table 4.2, the percentage of working pumps compared to functioning pumps is varying from 14% to 100% and is on average 37%.

Moreover, the number of stand-by pumps is high and Gribov is the only pumping station with no spare pumps.

4.3. REGULATION UPSTREAM THE TANKS

Six types of regulation, described below, may be found in Chişinau:

1) No regulation at all
2) Reducing of the flow by partially open valves that are set once
3) Regulation via an electric valve
4) Regulation via a manual valve
5) Manual regulation at the supplying pumping station by changing the working pumps, by switching off the pump or by closing a valve in the pumping station.
6) Regulation through the wells.

The different regulations found in the network are summarized in the Table 4.3, using the above classification.

Table 4.3: Regulation for the tanks in Chişinau water network

Name	Regulation type	Name	Regulation type
Aeroport PS	2 and 3	Ialoveni PS	6
Balsevsc PS	4 and 6	Independenta PS	3
Botanica PS	1	Schinoasa PS	3
Buiucani PS. Tanks 1 and 2	2 and 4	Sîngera PS	2 and 3
Buiucani PS. Tank 3	2	Stauceni PS	4
Cartusa PS	2, 3 and 5	Telecentru PS	2 and 3
Ciocana Tanks	2 and 3	Tohatin PS	2 and 5
Codru PS	3	Universita agrara PS	1
Codru Tanks	5	Valea Dicescu PS	2 and 4
Colonita Tanks	5	WTP Chisinau PS	1
Ghidighici PS	6	Lower "Vadul Lui Voda" tank	5
Gribov PS	3	Upper "Vadul Lui Voda" tank	5

For the pumping stations where there is a regulation just upstream the tanks, the singular headloss as well as the energy dissipated have been estimated. The results are presented in the Table 4.4 and

Table 4.5.

The calculation of the singular headloss generated by the regulation is evaluated according to the estimated head upstream the regulation:

Static head on the upstream network – linear headloss

Table 4.4: Calculations of the headloss created by regulation

Name	Headloss (m)	Regulated flow	Dissipated power
		m3/jour	kWh/day
Balsevsc PS	112	1 915	587
Botanica PS	0	1 008	0
Buiucani PS	35	5 000	471
Ciocana Tanks	32	27 552	2 433
Codru PS	47	3 624	466
Codru Tanks	46	1 040	130
Independenta PS	8	26 616	551
Schinoasa PS	18	1 800	87
Sîngera PS	1	480	1
Telecentru PS	11	10 632	330
Tohatin PS	8	25 128	517
Universita agrara PS	0	528	0
Valea Dicescu PS	8	15 960	361
TOTAL		121 283	5 934

The '–' represents non existing data

Table 4.5: calculations of the dissipated energy on the regulation valves

Name	Headloss (m)	Regulated flow	Dissipated power
		m^3/day	kWh/day
Balsevsc PS	112	1 915	587
Botanica PS	0	1 008	0
Buiucani PS	35	5 000	1 901
Ciocana Tanks	32	27 552	2 433
Codru PS	47	3 624	466
Codru Tanks	46	1 040	130
Independenta PS	8	26 616	551
Schinoasa PS	18	1 800	87
Sîngera PS	1	480	1
Telecentru PS	11	10 632	330
Tohatin PS	8	25 128	517
Universita agrara PS	0	528	0
Valea Dicescu PS	8	15 960	361
TOTAL		**136 443**	**7 363**

The

Table 4.5 shows the calculation of the energy dissipated by the regulation, when the data of pressure and flows were available. It shows that the energy dissipated by the regulation system is not negligible, even if it represents about 3% of the total pumping electricity consumption (around 70 million kWh/year).

4.4. PRESSURE DELIVERED AT THE PUMPING STATIONS

Table 4.6: Pressure delivered by the pumping stations of Chişinau

Name	Zone	Pressure		
		day	night	difference
Aeroport PS	airport	-	-	-
Balsevsc PS	zone 1	7.6	7.6	0
Botanica	zone 4a	6	6	0
Buiucani PS	zone 3	7	5.5	1.5
	zone 4	9.6	9.6	0
Cartusa PS	durlesti	-	-	-
Ciocana	gravity	-	-	0
Codru PS	Sîngera	9	9	0
	Codru	4	-	-
Ghidighici PS	zone 1	5.6	gravity	-
Gribov PS	Cartusa	-	-	-
Ialoveni PS	Moldova	6.8	-	-
	Ialoveni	10.2	-	-
Independenta PS	zone 3	6.2	5.5	0.7
	zone 4	9.6	8.4	1.2
Schinoasa PS	zone 4a	5.1	4.5	0.6
Sîngera PS	gravity	-	-	0
	Dobrogea	5.8	5.8	0
Stauceni PS	Stauceni	5.5	5.5	0
Telecentru PS	zone 4	4	4	0
	zone 4a	6.1	5.1	1
Tohatin PS	gravity	-	-	0
	Tohatin	8.5	8.5	0
	Colonita	-	-	-
Universita agrara	zone 3	5.5	gravity	-
Valea Dicescu PS	zone 3	7.5	6.7	0.8
WTP Chisinau	gravity	-	-	-
	zone 3	3.5	2	1.5
	Zone 4	3.9	3	0.9
WTP Nistru	Tohatin	-	-	-
	gravity	-	-	0
	gravity	-	-	0

The - represents missing data

Due to linear headlosses in the network, in about ten pumping stations the delivery pressure is adapted to the variations of water demand throughout the day. In this case, only two delivery pressures are used: one for the day and one for the night.

5. BEST PRACTICES

5.1. TANKS

Generally, it is assumed that the reservoirs in the network will ensure:

- Security and reliability of the water supply when the pumping station is stopped.
- Stable pressure and less water hammer,
- Power savings with optimisation of the sequence of pumping (filling at night to benefit from a lower power tariff),
- Optimisation of the future investments (diameter of the supply pipes can be designed for the daily peak flow instead of the hourly peak flow)

The capacity of one reservoir has to abide by the variations of the water demand. Moreover, the tanks have to ensure the continuity of the supply in case the upstream system has a failure (breakdown of the inlet pipe or shutdown of the supplying pumping station).

Generally, a reserve of 12 hours is considered enough to sustain security and supply. On the other hand, if the residence time exceeds 24 hours, the quality of the stored water may be degraded.

5.2. PUMPING STATIONS' CAPACITY

The pumping stations have to be able to deliver the peak flow of the peak day and the minimal flow with a good efficiency. In order to adapt the flow to the water demand, variable speed drives are good assets. Their frequency range is not always sufficient to supply a broad flow range. Therefore, it is recommended to install two or three identical pumps, one or two of which is equipped with a variable speed drive.

In addition to these pumps, one stand-by pump is advised to be installed.

5.3. REGULATION UPSTREAM THE TANKS

The regulation is used to control the flow entering the tank. The regulation system is generally specific, automated and is adapted to the energy dissipation. Such a system would enable automatically to sustain a sufficient upstream pressure and to maintain a fluctuating level in the tank within acceptable limits.

5.4. PRESSURE DELIVERED AT THE PUMPING STATIONS

Because of the variations of the water demand throughout the day, the delivery pressure is to be adjusted at the outlet of the pumping stations, to maintain a sufficient pressure at the critical points of the network.

The adjustments of the pressure enable to save energy and to minimize the leakage. In Chisinau, there are generally two set pressures (one during the day and one during the night), while continually adjusting the pressure to the delivered flow would allow an optimization of the energy.

6. WAY FORWARD

In the next phase of the project, a hydraulic model will be built in order to help the implementation of the best practices. The water supply network will be modelled using the software Epanet. The data obtained from the measurement campaign will help to calibrate the model and to obtain modelling results the closest possible to reality.

6.1. TANKS' CAPACITY

In the following phases of the project, the storage in regards of the peak water demand of each supply zone will be assessed, in order to check if the storage can meet the objective of 12 hours of provision.

According to the preliminary assessment, 5 tanks have a capacity superior to the daily supply volume. Therefore the time residence in these tanks may exceed 24 hours and the quality of the water may be impacted. This risk is increased as there is no chlorination (for example, it is the case in Sîngera).

The operation of the tanks will be assessed and some recommendations could be formulated to minimize the risks of the deterioration of the water quality:

- efficient circulation in the tanks;
- enhancing of the acceptable level fluctuations in the tanks;
- use only of a part of the tank capacity;
- temporary disconnection of tanks;
- definitive disconnection of the tanks, especially if the tank is in a poor state.

6.2. PUMPING STATIONS' CAPACITY

In the same way as for the tanks, the capacity of the pumping stations will have to be adjusted to the water demand. According to the preliminary assessment, almost all the pumping stations seem to be oversized. Indeed, in the pumping stations, less than 67% of the pumps are generally working at once.

Therefore, it seems to be interesting to study the replacement of the existing pumps by less powerful pumps, more adapted to the current water demand.

In some pressure zones supplied by several pumping stations, the possibility to shut down one of the pumping station will be studied. This solution would enable the other pumping stations to be operated according to their capacities.

6.3. REGULATION UPSTREAM THE TANKS

The hydraulic model will help to define:

- the optimized pressure upstream the regulation, ensuring an adjusted flow depending on the upstream water demand;
- the levels of the water variations in the tanks, that would ensure an adapted residence time.

6.4. ENERGY SAVING

The preliminary assessment enabled to point out some current practices in the functioning of the water supply network in order to save energy:

- Dismantlement of the pumps to supply instead by gravity the distribution zone, like in Ciocana;
- Disconnection of the tanks in order to take advantage of the upstream head at the inlet of the pumping station and to avoid the headloss in the regulation system. This solution has been implemented at Botanica and Universita agrara pumping stations.
- By-pass of the tanks for part of the pumps in order also to avoid headlosses.
- Modification of the limits of the pressure zone in order to shut down a pumping station or a booster and to save energy. This solution has been carried out between the pressure zone 1 and 2. The booster “str Izmaïl 100” supplied by the zone 1 has been shut down and replaced by a pressure reduction valve, supplied by the zone 2.

In the next phases, it will be interesting to study the possibility of implementation of these solutions elsewhere in the water supply system. The aim will be to limit the number of pumping stations, to enhance the supply by gravity and to minimize the headlosses generated by the regulations.

The design of the preserved pumping stations will be optimized in regards to the delivery pressure and flow. When it is appropriate, the rules for the set delivery pressure (driving the variable speed drive) will be studied and will be adjusted to the delivery flow.

Annexes

LIST OF ANNEXES

Annex 1 Description of the water supply system

1.1. GENERAL ORGANISATION

The water supply of Chişinău city is carried out primarily by the centralized system, supplied from two sources:

- the surface waters of the Nistru river, as a basic source;
- the groundwaters from the aquifers below the city's perimeter and groundwaters of the Nistru river basin.

The capture stations of the Nistru river water are located at a distance of about 20 km east of the city, in the downstream tail water of the Dubăsari reservoir, near the Vadu lui Vodă town. Water is drawn through three structures:

1. Water Intake Structure 1, floating, built in 1958, with a capacity of 75 000 m^3/day,
2. Water Intake Structure 2, built in 1971, operated in 1972, with a capacity of 480 000 m^3/day,
3. Catchment well field 3, including 65 artesian wells, build in 1983, with a capacity of 89 000 m^3/day,

The raw water transmission to the Chisinau treatment works, known as STA and built in 1971 (in operation in 1972), comprises the No2 water intake; the Pumping Stations Stage II and IIA together with four steel delivery mains diameters of 1000, 1200 and two of 1400 mm, of length 15.2km. Only two mains are in service at one time; their use is alternated due to reduced demand.

The Chisinau raw water transmission system is considered to require rehabilitation. The rehabilitation needs will be assessed within Phase B.

The transmission system from the Nistru treatment works to Tohatin is known as SAN. The system was constructed in 1958 and has undergone several modifications in the following years. The system draws water from the No1 intake and delivers it to the Nistru works (built in 1958 and upgraded in 1963-1964). Before 1972, the water was pumped directly from the Nistru Treatment Plant to Tohatin through the Pumping Station Stage II. In 1972, the Pumping Station Stage IIA was installed and the water was pumped from the Pumping station Stage II to the Stage IIA and then to Tohatin. Since 1995, the Pumping Station Stage IIA has been extended and the works pump into supply through the Pumping Stations Stage II, IIA and one delivery steel pipe of 800mm.

Since 1995, no upgrading or modifications have been made. For energy saving purposes, the old water intake system (floating intake + water intake 1958) is only used as back-system in case of necessity (maintenance or problem on the water intake No.2).

1.2. CATCHMENTS FROM GROUNDWATER SOURCES

Within the system of water supply of Chişinău the catchments from groundwater sources are the following:

1.2.1.1. *Abstraction " Petricani".*

On the territory of capture station 10 artesian wells are drilled. The wells were drilled in 1947-1952. The connecting and distribution networks are mounted with ductile iron pipes with the diameter of 300mm, which make three sections with the length of 600m,700m and 800m. In recent years the abstraction „Petricani" has not been working.

1.2.1.2. *Abstraction"Vatra"(Ghidighici Pumping station)*

On the territory of the capture station 12 artesian wells are drilled. The wells were drilled in 1967. The connecting and distribution networks are mounted with iron pipes:a diameter of 400 mm with a length of 1307 m and a diameter of 100 mm with a length of 550 m. The wells have been operated for 32 years.

By the abstraction „Vatra", 875 581 m^3 of water were captured in 2010.

1.2.1.3. *Abstraction " Balişevschi" (Downtown)*

On the territory of capture station 7 artesian wells are drilled and 6 of them are working. The connecting and distribution networks are mounted with ductile iron pipes and steel pipes with the following diameters and lengths: the iron pipe has a diameter of 200 mm and a length of 800m; the steel pipe has a diameter of 300 m and a length of 1500m. The connecting nodes of the capture system and the municipal networks include steel pipes: two pipes with a diameter of 400 mm and a length of 1200 m; another with a diameter of 80 mm and a length of 80 m; a fourth one with a diameter of 300 mm and a length of 245 m and a last one with a diameter of 400 mm and a length of 307 m.

By the abstraction „Balişevschi" 308 381 m^3 of water were captured in 2010.

1.2.1.4. *Abstraction " Ialoveni "*

On the territory of capture station 21 artesian wells are drilled and 8 of them are working. The wells were drilled in 1965-1967. The connecting and distribution networks are mounted with steel and iron pipes with a diameter of 400 mm and a length of 450 m for steel pipe; a diameter of 400mm and a length 850 m for iron pipe; The wells have been operated for 32 years.

By the abstraction „Ialoveni" 781 983 m^3 of water were captured in 2010.

1.2.1.5. Single catchments.

On the territory of Chişinău city, 22 single wells have been drilled. At the moment they work on the territory of the localities:

- Durleşti - 6 wells not working (preserved).
- Gratieşti - 4 wells not working (preserved).
- Sângera – 2 wells (only 1 working), captured 12 976 m^3 in 2010;
- Aeroport – 1 well not working;
- Munceşti - Burcută - 2 wells not working;
- Goianul Nou – 1 well, working, captured 20 124 m^3 in 2010;
- Vatra – 1 well, working, captured 9 961 m^3 in 2010.
- Satul Ghidighici – 7 wells, all working, captured 127 199 m^3 in 2010;
- Vadul lui Vodă –captured 11 533 m^3 in 2010.

In total, in 2010 181 793 m^3 of water have been captured from these signle catchments.

1.3. STORAGE TANKS.

For a normal operation, in the water supply system of Chişinău city 81 constructions were made for the water storage including: 61 drinking water tanks and 3 technical water tanks.

The tanks are located in the following locations:

- Tohatin – a tank with a volume of 10000m^3 and two tanks with a volume of 3000m^3 ;
- Ciocana – a tank with a volume of 10000m^3 and two tanks with a volume of 3000m^3 ;
- Balicevschi – two tanks with a volume of 2000m^3;
- Petricani – two tanks with a volume of 3000m^3 (not working);
- Ialoveni – two tanks with a volume of 1000m^3;
- Schinoasa –a tank with a volume of 6000m^3;

- Telecentru – a tank with a volume of 3000m^3, a tank with a volume of 5000m^3;
- Valea Dicescu – a tank with a volume of 2000m^3, a tank with a volume of 3000m^3, and a tank with a volume of 6000m^3;
- Botanica – a tank with a volume of 5000m^3 (not working);
- Codru – one tank with a volume of 6000m^3, two tanks with a volume of 600m^3;
- Aeroport – a tank with a volume of 1000m^3 and two tanks with a volume of 300m^3;
- Buiucani – a tank with a volume of 3000m^3, a tank with a volume of 6000m^3 and a tank with a volume of 5000m^3;
- Universitatea Agrară – a tank with a volume of 1000m^3 (not working);
- Sângera – two tanks with a volume of 3000 m^3 drinking water;
- Durleşti - two tanks with a volume of 250m^3, two tanks of 500 m^3 and three of 25 m^3 which are not working.
- Ghidighici - two tanks with a volume of 2000m^3.
- Stauceni – one tank with a volume of 6000m^3.
- the treatment station Nistru, 4 tanks with a volume of 1000 m^3 – (one of them not working), one with a volume of 1500 m^3;
- the water treatment station Chişinău, 4 tanks with a volume of 10000 m^3 – (one of them not working), two with a volume of 5000 m^3;
- on the territory of the abstraction „Burcuta", three tanks of 600 m^3 – not working;
- on the territory „Ferganscaia", two tanks of 10000 m^3;
- on the territory „Timiş", a tank of 10000 m^3, not working;
- On the territory of Coloniţa, three tanks of 500m^3.

The total volume of drinking water tanks is 204 175m^3.

Currently 13 drinking water tanks with the volume of 34 875 m^3 are not working, therefore the current storage of the 48 working tanks of Apa Canal is 169 300m^3.

1.4. THE PUMPING STATIONS

The pumping stations included in the water supply system of S.A: "Apă-Canal Chişinău" are meant to convey water:

- from the surface and ground sources to the treatment plants;

- from the treatment plants into the water distribution networks;
- the re-pumping of water in some districts of Chişinău city.

Within the water supply system of Chișinău city are working 93 pumping stations, water pumps and re-pumping stations of raw and drinking water. 11 stations are working on the distribution networks of drinking water. The 27 major pumping stations located on the distribution network and the adduction pipes are presented in the Table 1.12.

Table 1: The pumping stations located on the distribution network and the adduction pipes

Locality	Name	District
Chișinău	The pumping station Independenţei	Botanica
	The pumping station Codru	Botanica
	The pumping station Botanica	Botanica
	The pumping station Aeroport	Botanica
	The pumping station Burcuta	Botanica (not working)
	The pumping station Buiucani	Buiucani
	The pumping station Ghidighici	Buiucani
	The pumping station Universitatea Agrară	Buiucani
	The pumping station Petricani	Buiucani (not working)
	The pumping station Valea Dicescu	Centru
	The pumping station Telecentru	Centru
	The pumping station Schinoasa	Centru
	The pumping station Tohatin	Ciocana
	The pumping station Ciocana	Ciocana (not working)
	The treatment station Chişinău city	Ciocana
	The pumping station Balişevsk	Rîşcani
Sîngera	The pumping station Sîngera	
Ialoveni	The pumping station Ialoveni	
Durleşti	The pumping station Cartuşa	
	The pumping station Gribov	
Stăuceni	The pumping station Stăuceni	
Vadul lui Vodă	The pumping station step I	
	The pumping station, groundwater abstraction	
	The pumping station step II raw water	
	The pumping station step II drinking water	
	The pumping station step II – A raw water	
	The pumping station step II – A drinking water	

81 pressure booster stations for the buildings with 8 up to 16 floors are working on the territory of city, Table.2.

Table.2: The pressure boosting pumping stations

District	Location	District	Location	District	Location
Chişinău Botanica	Dacia 1/5		Suceviţa 18/3	Chișinău Ciocana	A. Russo 55/6
	Dacia 2		Constituţiei 8/1		P. Zadnipru 7/5
	Dacia 5/6		I. Neculce 14/1		P. Zadnipru 8/2
	Dacia 11/5		Milano 2/1		P. Zadnipru 15/5
	Dacia 21/5		C. Ieşilor 47/3		I. Vieru 5/4
	Cuza Vodă 14/1		Drumul Crucii 100/1		Budăi 2/4
	Dacia 38/12		C. Ieşilor 55/6		Mircea cel Bătrân 13/1
	Dacia 40/5		C. Ieşilor 61/2		com. Cruzeşti
	Dacia 42/3		Alba Iulia 202/4	Chișinău Rîşcani	Sf. Gheorghe 40/2
	Dacia 47/3		Constituţiei 6/1		Romană 2/4
	Valea Crucii 4/6		N. Iorga 9/1		Ismail 102/5
	Dacia 49/12		Milano 19/2		Puşkin 44/1
	Dacia 60/11		Călăraşi 78		Moscovei 3/7
	Dacia 67/2	Chișinău Centru	Drumul Schinoasei 1/6		Moscovei 8/2
	Independenţei 4/5		Grenoble 161/9		Moscovei 11/6
	Zelinschi 30/9		Mioriţa 3/10		Moscovei 14/4
	Grenoble 199/2		Mioriţa 5/9		Moscovei 22/3
	Cuza Vodă 1/6		Testemiţeanu 29/8		Studenţilor 7/6
	Cetatea Albă 141/3		Hânceşti 60/5		Florilor 2/3
	Decebal 19/1		Docuciaev 13/3		A. Doga 34/2
	Munceşti 56/1		Drumul Viilor 28/4		Aerodromului 7/6
	Munceşti 406/1		Sprâncenoaia 8/2		Albişoara 68/4
	Sângera Aerogării 35		31.aug.63		Albişoara 82/7
Chişinău Buiucani	Coca 19/1		Pietrarilor 6/1		C. Orheiului 113/3
	Coca 29/2	Chișinău Ciocana	Sadoveanu 2/6		Socolei 21/1
	Alba Iulia 194/4		Sadoveanu 4/13		Bogdan Voievod 10/2
	N.Costin 61/5		M. Drăgan 30/7		Gratieşti str. Prietenie 10

The Chișinău city has two centralized water supply systems, one for drinking water and one for technical water. The drinking water system is used to supply the population, socio-cultural objects and economic agents. The technical water is used for the supply of the power-stations CET-1 and CET-2, thermal stations, industrial enterprises, S.A. Moldcarton and for spraying.

1.5. DESCRIPTION OF THE NETWORK

The land where Chișinău city is located shows important variations of bench marks, so in the lowlands of the city located near the river Bîc the bench mark of the land is about 40 m, but in the highest areas the following bench marks are recorded:

- Schinoasa – 217,0 m;
- Telecentru – 187,90 m;
- Botanica – 174,0 m,
- Ciocana – 163,0 m.

The differences between the minimum bench mark and maximum bench marks of the land are between 120 and 180 m.

According to the existing regulations regarding the static pressure value in the water distribution networks, it must be between 1 and 6 atmospheres (0,1...0,6 MPa). To respect the values of the pressure in the pipes and taking into account the large differences between the bench marks of the land and the height of the buildings, the distribution network was divided into five pressure areas.

A part of the distribution network is working gravitationally, being supplied from the drinking water tanks located on the territory of the treatment station, situated at an altitude of 163,0 m, while the other part is working by pumping. The distribution network is interconnected.

The water supply of Chișinău city from the treatment station is made mainly through four main street pipes:

- the pipe „Paţaev” with a diameter of 1200 mm, made of reinforced concrete, length of 11,6 km transports the water gravitationally to the pumping station „Independenţei”;
- the pipe „Vostoc” with a diameter of 1200 mm, made of steel, length of 3,8 km, transports the water gravitationally to the sector „Ciocana”;
- the pipe „Oţel” with a diameter of 1200 mm, made of steel, length of 4,96 km, transports the water gravitationally;
- the pipe „Doina” with a diameter of 1000 mm, made of reinforced concrete, length of 6,1 km, transports the water by pumping up to the pumping station „Buiucani”.

These four main street pipes ensure the water supply of the pressure zone II of the city, with bench marks between 70 and 100 m and piezometry between 120 and 125 m.

For the pressure zone III supply, with bench marks between 100 and 150 m and a piezometry between 160 and 170m, the water is pumped from the tanks supplied by the pipes of zone II. The concerned pumping statios are „Universitatea Agrară”, „Buiucani”, „Valea Dicescu”, „Independenței” and the pumping station located on the territory of the water treatment plant of Chişinau.

For the pressure zone IV, with bench marks between 150 and 170 m and a piezometry between 200 and 210 m, the water is pumped by the pumping stations „Buiucani”, „Telecentru”, „Independenței” and the pumping station located on the territory of the water treatment plant of Chişinau.

For the pressure zone IV-A corresponds to the highest areas of the city, with an altitude superior to 170 m and a piezometry of 240 m, the water is pumped by the pumping stations „Telecentru”, „Schinoasa” and „Botanica”.

The pressure zone I is supplied mainly by water flowing by gravity from the tanks of „Ciocana” pumping station and by water pumped by the pumping stations „Balşevsc” and „Ghidighici.The zone 1 corresponds to bench marks between 40 and 70 m, with a piezometry between 90 and 100 m.

In some areas of the city the real pressure values exceed the pressure values imposed by the regulations, for exemple in the zone III of the districts Buiucani and Botanica, the pressure is 8 atmospheres, while in the zone IV of the same districts, the pressure values are between 9 and 10 atmospheres(0,9...1,0 MPa).

Issues related to the pressure and the flow in the morning appear in some parts of the network (pressure zone III). These problems are due to the network that is branched and oversized in some remote part of the city.

1.6. PHYSICAL DESCRIPTION OF THE PIPES

On the 01.12.2010, S.A. „Apă – Canal Chişinău” managed and served a length of 1844,09 km of pipes, distributed on districts according to the Table 3.

Table 3: The length of networks managed and served by S.A. „Apă – Canal Chişinău”

Nr.	The district	Managed networks, km	Abeyant networks and networks served by S.A. „Apă – Canal Chişinău”, km	Total
1	Rîșcani	354,300	32,247	**386,547**
2	Centru	333,881	25,646	**359,527**
3	Buiucani	292,522	18,405	**310,927**
4	Botanica	287,880	33,543	**321,423**
5	Ciocana	272,251	29,410	**301,661**
6	Vadul lui Vodă	133,730	0,69	**134,420**
7	STA technical water	17,690	-	**17,690**
8	Water Intake	11,892	-	**11,892**
TOTAL		**1704,146**	**139,941**	

The data on the total length of the water supply system of Chișinău presented in this report was based on the data provided in the document „ The explanatory memorandum regarding the calculation of the normatives of water losses and technological consumption for S.A. “Apă-Canal-Chişinău - Year 2011 ”. From the processing of these data, the total length of the pipes obtained is **1844,09 km**.

The pipes were classified by materials, diameters and their period of service.

From the comparison of data provided by the accounting service of S.A „ Apă-Canal Chişinău" with the data presented in the document „The explanatory memorandum regarding the calculation of the normatives of water losses and technological consumption for S.A. "Apă-Canal-Chişinău - Year 2011 " great differences in the length of pipes were found. In the document „The explanatory memorandum regarding the calculation of the normatives of water losses and technological consumption for S.A. "Apă-Canal-Chişinău - Year 2011 ", all the pipes with a diameter between 25 and 100mm were put in the category of the pipes with the diameter of 100. The differences may be explain by this assumption.

It is established that the information relating to pipes that make the water supply system, is not integrated into a general pattern and there is no doubt that it is updated, in this case it is less valuable and impossible to use with a view to an analysis for introducing the improvements in the system.

Taking into account that, the water distribution system was built and expanded over several decades, therefore a wide range of materials have been used for its achievement . In the 60's the most commonly used material for the water pipes was cast iron.Other materials, as cement, reinforced concrete and steel with a high carbon content were also used. During the 70s and the 80s, the steel was the preferred material for most pipes, and cast iron pipes were also widely used. Later the plastic materials came into use.

Because of this the water distribution system is composed of a mixture of pipes and tubes of different materials, types and sizes, which is not ideal and make it the most problematic part of the operation.

From the total length of water supply system of 1844,09 km, the distribution of the material is presented in the tables below:

Table 4: The length of the network according to type of material and diameter

Diameter Nominal	pipe length (km)					
	steel	cast iron	concrete	abestos cement	HDPE	**TOTAL**
50	-	-	-	-	22.28	22.28
63	-	-	-	-	43.10	43.10
75	-	-	-	-	5.23	5.23
90	-	-	-	-	33.63	33.63
100	289.99	126.25	-	1.52	-	417.76
110	-	-	-	-	91.26	91.26
125	0.13	-	-	-	13.24	13.36
150	72.39	89.88	-	0.04	-	162.31
160	-	-	-	-	35.88	35.88
180	-	-	-	-	16.23	16.23
200	49.43	73.44	-	1.92	23.76	148.55
225					0.27	0.27
250	26.57	52.42	-	-	33.58	112.56
300	63.96	210.84	-	1.44	-	276.24
315	-	-	-	-	18.56	18.56
350	3.76	-	-	-	-	3.76
400	27.39	55.73	-	0.14	6.00	89.26
500	67.57	58.81	5.46	0.08	-	131.92
600	25.71	26.46	-	0.16	-	52.34
630	-	-	-	-	0.88	0.88
700	12.79	-	-	-	-	12.79
800	27.58	1.42	0.57	-	-	29.56
900	7.89	3.24	-	-	-	11.13
1000	20.05	0.06	18.39	-	-	38.50
1200	42.96	-	13.02	-	-	55.97
1400	20.76	-	-	-	-	20.76
TOTAL	**758.92**	**698.55**	**37.43**	**5.31**	**343.89**	**1 844.09**

Table 5: Length of the network according to the material type and the operation period.

pipe length (km)							
material type	< 10 years	10 years	20 years	30 years	40 years	50 years	**TOTAL**
steel	63.8	167.4	228.0	244.6	55.1	0	758.9
cast iron	93.3	95.3	125.5	121.8	222.3	40.3	698.5
abestos cement	0	0	3.574	1.731	0	0	5.3
concrete	0	1.084	36.349	0	0	0	37.4
HDPE	325.9	15.8	2.1	0.1	0	0	343.9
ALL	**483.0**	**279.6**	**395.5**	**368.2**	**277.4**	**40.3**	**1844.1**

The following points can be noticed:

- the steel pipes without anticorrosive protection represent 41,15% (L = 758,917 km)
- cast iron – 37,88% (L = 698,548 km),
- polyethylene – 18,65% (L = 343,887 km),
- the remaining 2,32% are pipes made of cement and reinforced concrete.

There is also a large weighting of the pipes that were installed more than 20 years ago, as they represent 58,65% (L = 1081,477 km) of the total length of the network.

the weight of the pipes with a diameter inferior to 100 mm is compared to the total length of the network 33,90% (L = 624,98 km), with:

- steel pipes – 15,73% (L = 289,991 km);
- cast iron pipes – 6,85% (L = 126,245 km);
- polyethylene pipes – 11,32% (L = 208,744 km).

The total length of the steel pipes is 758,917 km. Within these steel pipes,

- the length of the pipes which have been operated for longer than 20 years is 527,67 km which represents 69,53%.
- The pipes with a diameter inferior to 100 mm represent a total length of 289,991 km (38,21% of the total of the network). The total length of those pipes which have been operated for longer than 20 years is 178,844 km which represents 61,67% of the pipes with a diameter inferior to 100mm.
- Regarding the main street pipes -with a diameter superior to 800 mm-, their total length is 119,229 km. The length of those pipes which have been operated for longer than 20 years is 98,639 km, which represents 82,73% of the pipes with a diameter superior to 800mm.

On another hand, The total length of the cast iron pipes is 698,548 km, and the length of the cast iron pipes which have been operated for longer than 40 years is 262,632 km, which represents 37,59%.

Moreover, the total length of the polyethylene pipes is 343,887 km, and the length of the plastic pipes which have been operated for less than 10 years is 325,866 km, which represents 94,76%.

The length distribution of the roads and the pipes of the distribution system depending on their age is:

- shorter than 10 years – 483,016 km – 26,19 % ;
- between 10 – 20 years – 279,597 km – 15,16% ;
- between 20 – 30 years– 395,532 km – 21,45%;
- between 30 – 40 years – 368,245 km – 19,98%;
- between 40 – 50 years – 277,407 km – 15,04%;
- beyond 50 years – 40,293 km – 2,18%.

It is interesting to note that the weight of the network older than 20 years is important. The pipes that have been laid during the last 10 years follow generally the pattern:

- the feeders and trunk pipes (with a diameter bigger than 700mm) are made of steel
- the primary network (diameters between 400 and 600mm) is composed mailny of cast iron
- the secondary and tertiary network (diameters smaller than 300mm) is composed mainly of HDPE.

Annex 2 Details of the visit of the pumping stations

1.1. THE PUMPING STATION OF THE WATER TREATMENT PLANT (CHIŞINAU)

The water treatment plant receives raw water from the intake in the Nistru River (with two pumping stations on the way). The water is then treated. After the filters, two outlets of technological water are supplying the city; one of them is not working anymore.

The water is then chlorinated and supplied to 5 tanks:

- The tank n°5 (which volume is 10 000m^3) is supplying by gravity the zone 2 and then the pumping station Independenţa by a pipe (which diameter is 1200mm). It is not connected to the other tanks or to the pumping station;
- The tanks n°1 and n°2 have a volume of 5 000m^3 each and are interconnected;
- The tanks n°3 and n°4 have a volume of 10 000m^3 each and are interconnected.

These 4 last tanks supply three gravitational outlets. The first outlet “Oţel” (the diameter is 1200mm) supplies the zone 2 and then the pumping station Buiucani; the flow is regulated electrically at the outlet by a valve (valve n°8). The regulation is set on the pressure measured in the network. The second outlet (diameter 1200mm), to “Vostoc”, supplies the zone 2 and then the Pumping station Valea Dicescu. The third outlet (diameter 1000mm) to “Doina” supplies the zone 2 and then the pumping station of Universitat agrara.

The 4 tanks supply as well two pumping blocks. The first block is composed of 5 pumps, two of which are equipped with one variable speed drive. One pump is working and supplies the zone 3 through 4 outlets: one outlet (diameter 500mm) to Rîscani is not functioning anymore; a second outlet to Rîscani (diameter 500mm) and two outlets to Ciocana (diameter 500 and 700mm).

The variable speed drive is regulated following the below pressure law:

- From 5.30a.m to 9.00a.m, the target pressure is 3.5 atmospheres;
- From 9.00a.m to 5.00p.m, the target pressure is 3.0 atmospheres;
- From 5.00p.m to 11.00p.m, the target pressure is 3.5 atmospheres;
- From 11.00p.m to 5.30a.m, the target pressure is 2.0 atmospheres.

The second block is composed of 5 pumps as well, two of which are drived by another variable speed drive. One pump is working and supplies the zone 4 with 3 outlets. One outlet (diameter 500mm) is supplying the pumping station of Stauceni, while the two others (diameters 500mm) are supplying Ciocana sector.

The variable speed drive is regulated following the below pressure law:

- From 5.30a.m to 9.00a.m, the target pressure is 3.9 atmospheres;
- From 9.00a.m to 5.00p.m, the target pressure is 3.4 atmosphere;
- From 5.00p.m to 11.00p.m, the target pressure is 3.9 atmospheres;
- From 11.00p.m to 5.30a.m, the target pressure is 3.0 atmospheres.

The station is well-equipped with captors and measuring devices. All the outlets and inlets are equipped with ultrasonic flowmeters, the five tanks are equipped with level sensors and each pump is provided with an upstream and a downstream pressure sensor. Moreover, pressure sensors have been placed at each delivery pipe.

There is no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 4 pressure sensors and 3 level sensors will be installed

- One level sensor will be installed in the tank n°5; one other in the tank n°3 or n°4; and the last one in the tank n°1 or n°2
- One pressure sensors on the suction pipe;
- Two pressure sensors on the delivery pipes;
- One pressure sensor downstream the regulating valve n°8. This sensor will be installed in the manhole of the regulating valve.

For the installation of the equipments, one topographical point needs to be taken at the manhole of the regulating valve. The only preliminary work to be implemented is the performing of one tapping for a pressure sensor in the manhole of the regulating valve.

During the measurement campaign, the configuration of the pumping station will be transformed in order for the ultrasonic flowmeter measuring the flow going to Stauceni to function. The valve n°14 and the valve on the suction pipe between the pumps 3 and 4 will have to be closed.

1.2. PUMPING STATION OF "VALEA DICESCU"

The pumping station of Valea Dicescu is supplied by water coming by gravity from the water treatment plant of Chişinau (zone 2) and supplies the zone 3 of Centru & Botanica.

The station is supplied by one pipe, which diameter is 1000mm, coming from the water treatment plant. The flow is regulated by an electric valve and the entering valves of the tanks are partially open. The two interconnected tanks (which volumes are 3000m^3 and 6000m^3) are supplied by the top and are connected to the suction pipes and to a bottom of a third tank (which volume is 2000m^3).

The pumping station is composed of 5 pumps, 2 of those are driven by one variable speed drive that is regulated by the pressure in the delivery pipe. One pump only is working. The delivery pressure is 7.2 atmospheres from 5 a.m to midnight and 6.7 atmospheres from midnight to 5 a.m.

The pump supplies one outlet of 700mm, that supplies the zone 3 and the pumping station Telecentru. A former outlet has been dismantled eight years ago.

The inlet and the outlets are equipped with ultrasonic flowmeters. Moreover, each tank is equipped with a level sensor, each pump is provided with an upstream and a downstream pressure sensor and one pressure sensor is placed on each outlet, in the manhole of the flowmeter.

There is no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 4 pressure sensors and 1 level sensor will be installed

- One level sensor will be installed in one of the interconnected tanks;
- One level sensor in the third tank.

- One pressure sensor on the suction pipe;
- One pressure sensor on the delivery pipes;
- One pressure sensor upstream the regulating valve. This sensor will be installed in the manhole of the regulating valve, on an existing tap.

For the installation of the equipments, one topographical point needs to be taken at the manhole of the regulating valve, but not any preparatory work will be implemented.

1.3. PUMPING STATION OF "TELECENTRU"

The station Telecentru supplies water to the zones 4 and 4a in Centru & Botanica from the zone 3 of "Centru & Botanica". The station is supplied by two pipes:

- The first one is coming from Independenţei and does not work anymore.
- The second one is coming from Valea Dicescu (belonging to the zone 3) and its diameter is 600mm.

The water fills then two interconnected tanks of 5000m^3 and 3000m^3 (whose bottom elevation is known) by the top. The flow is regulated by one manual valve and the entering valves of the tanks are partially open in order to make the tanks vary at the same time. Chlorination is effected in the tanks.

Both tanks supply the pumping station that is composed of 4 working pumps with two variable speed drives: one drives the pump n°4 and one that can drive the pump n°2 or the pump n°3. The variable speed drives are set to maintain a fixed delivery pressure.

The station is organized in two pumping blocks, thanks to one valve closed on the delivery pipe. The first block is composed of two pumps (n°4 and n°5) and supplies the zone 4 through two pipes (which diameters are 250mm and 400mm) with a pressure of 4 atmospheres.

The second pumping block is composed of two pumps (n°2 and n°3) and supplies the zone 4a through two pipes (diameters 250mm and 300mm). These two outlets merge in the zone and supply eventually the pumping station of Schinoasa. The regulating law for the variable speed drive is described below:

- From 5.00a.m to midnight, the target pressure is 6.1 atmospheres
- From midnight to 5.00a.m, the target pressure is 5.1 atmospheres.

The station is well-equipped with captors and measuring devices. All the outlets and inlets are equipped with ultrasonic flowmeters, both tanks are equipped with level sensors and each pump is provided with an upstream and a downstream pressure sensor. Moreover, pressure sensors have been placed with 3 of the outlet's flowmeters.

There is no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 3 pressure sensors and 1 level sensor will be installed

- One level sensor will be installed in one of the interconnected tanks;
- Two pressure sensors on the delivery pipes;

- One pressure sensor upstream the regulating valve. This sensor will be installed in the manhole of the regulating valve, in place of an air valve.

For the installation of the equipments, one topographical point needs to be taken at the manhole of the regulating valve. The only preparatory work to be implemented is the replacement of the air valve in the manhole of the regulating valve by a tap adapted to the pressure sensor to be installed during the measurement campaign.

1.4. PUMPING STATION OF SCHINOASA

The pumping station of Schinoasa supplies water to the zone 4a “Schinoasa” from the zone 4a “Centru & Botanica”.

The former supply pipe, coming from the zone 4 of Telecentru, is not functioning anymore. The pipe that currently supplies the pumping station is a former outlet that is isolated from the delivery pipe by a closed valve. The diameter of the pipe is 500mm and the flow is regulated by a manual valve located in the pumping station.

The water then supplies one tank of 6000m^3 that is supplied by the bottom with a check valve. Chlorination is performed at this place. The pumping station is composed of 4 pumps, 2 of them are driven by a variable speed drive. Only one of them is working and delivers a pressure of 5.1 atmospheres from 5.00a.m to 11p.m and a pressure of 4.5 atmospheres from 11.00p.m to 5.00a.m. There is one outlet pipe (diameter 500mm) that supplies water in the zone 4a.

The inlet and the outlet are equipped with ultrasonic flowmeters. The tank is equipped with one level sensor and the four pumps are equipped with upstream and downstream pressure sensors. Moreover, there is one pressure sensor at the inlet and at the outlet (in the pumping station). All the data from the sensors are displayed in the control room.

There is no need for additional flowmeter during the measurement campaign. One level sensor will be installed in the tank and 2 pressure sensors will be installed on the delivery pipe, on each side of the closed valve, on existing taps.

No topographical measurement is to be taken and no preliminary work is to be implemented.

1.5. PUMPING STATION OF “INDEPENDENŢA”

The Pumping station of Independenţa is supplied by water coming by gravity from the water treatment plant of Chişinau (zone 2) and supplies the zone 3 and 4 of Centru & Botanica.

The supply pipe (diameter 1000mm) supplies two tanks of 10000 m^3 in series. There is a manual regulating valve before entering the tanks that are supplied by the bottom with a check valve.

The pumping station is composed of two blocks of pumps:

The first block is supplied directly by the inlet pipe. It is composed of 4 pumps. One pump is driven by a variable speed drive; two pumps are working during the day and only one during the night (the one with the variable speed drive). There are two delivery pipes (diameters 500mm) that supply the zone 3 of Centru & Botanica. The delivery pressure is 6.2 atmospheres from 5.30a.m to 10.00p.m and 5.5 atmospheres during the rest of the time.

The second block is composed of 4 pumps. Only two of them are working. The pump n°3 is supplied directly by the inlet pipe and is driven by a variable speed drive. The pump n°8 is supplied by the tanks and works only during the day. There are two delivery pipes (diameters 500mm) that supply the zone 4 of Centru & Botanica. The delivery pressure follows the rule:

- From 5.30a.m to 10.00p.m, the target pressure is 9.6 atmospheres;
- From 10.00p.m to midnight, the target pressure is 9.0 atmospheres;
- From midnight to 3.00a.m, the target pressure is 8.4 atmospheres;
- From 3.00a.m to 5.30a.m, the target pressure is 9.0 atmospheres.

The inlet and the outlets are equipped with ultrasonic flowmeters. Moreover, each tank is equipped with a level sensor, each pump is provided with an upstream and a downstream pressure sensor. Moreover one pressure sensor is placed on each outlet towards the zone 3, in the manhole of the flowmeters.

There is no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 4 pressure sensors and 2 level sensors will be installed

- One level sensor will be installed in each tank (as they are in series);
- One pressure sensor on the suction pipe, on the side of the direct supply by the inlet pipe; the pressure upstream the regulating valve will be measured there.
- Two pressure sensors on the delivery pipes;

No topographical measurement is to be taken and no preliminary work is to be implemented.

1.6. PUMPING STATION OF “BOTANICA”

The pumping station of Botanica supplies some high buildings of the zone 4a of Centru & Botanica from the zone 4 of Centru & Botanica.

The supply pipe (diameter 500mm) is coming from the pumping station of Independenţa and supplies directly the suction pipe of the pumping station, without any headloss. The pumping station is composed of 3 pumps, 2 of which are driven by one variable speed drive. One pump is working and delivers a pressure of 6 atmospheres 24 hours a day. There are two delivery pipes, which diameters are 300mm and that supply the zone 4a.

The tank of the station has not been used for 5 years.

The inlet and the outlet are equipped with ultrasonic flowmeters.

There is no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 2 pressure sensors will be installed:

- One pressure sensor on the suction pipe,
- One pressure sensor on the delivery pipes;

No topographical measurement is to be taken and no preliminary work is to be implemented.

1.7. PUMPING STATION OF "UNIVERSITA AGRARA"

The pumping station of "universita agrara" is supplied by water coming by gravity from the water treatment plant of Chişinau (zone 2) and supplies the zone 3 "Universita agrara" that corresponds to the agricultural university.

The supply pipe (diameter 200mm) is coming from the water treatment plant (outlet "Doina") and supplies afterwards the pumping station of Buiucani". The pumps are directly supplied by the inlet pipe, without any regulation. The pumping station is composed of 4 pumps. 2 pumps are driven by one variable speed drive and one pump is working during the day. There is one delivery outlet (diameter 200mm) and the delivery pressure is 5.5 atmospheres.

During the night, the pump is switched off and the university is supplied by gravity.

The tank of the station is not used anymore.

The inlet and the outlet are equipped with ultrasonic flowmeters.

There is no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 2 pressure sensors will be installed:

- One pressure sensor on the suction pipe,
- One pressure sensor on the delivery pipes;

No topographical measurement is to be taken and no preliminary work is to be implemented.

1.8. PUMPING STATION OF "BUIUCANI"

The station Buiucani is supplied by water coming by gravity from the water treatment plant of Chişinau (zone 2) and supplies water to the zones 3 and 4 in Buiucani from the zone 3 of "Centru & Botanica". The station is supplied by two pipes:

- The first inlet is coming from the water treatment plant (outlet "Doina"), passing by the pumping station of "Universitata agrara". The pipe (diameter 500mm) is supplying by the top a tank of volume 3000m^3 (with a partially open valve) and the suction pipe directly. The flow going to the suction pipe is not regulated by any valve.
- The second inlet is coming as well from the water treatment plant (outlet "Oţel" that is regulated in the pumping station of the water treatment plant of Chişinau). The pipe (diameter 800mm) is supplying two tanks (volume 5000m^3 and 6000m^3) by the top. The flow is regulated by an electric valve and the valves at the entrance of the tanks are partially open.

Chlorine is injected in the tanks. The pumping station is composed of two blocks.

The first block is supplied directly by the inlet pipe and is composed of three pumps. Two pumps are driven by one variable speed drive and one pump is working during the day. There are two delivery pipes (diameters 400mm and 500mm) that supply the zone 3 with a pressure of 7 atmospheres.

During the night, the pump is switched off and the zone 3 is supplied by gravity, with a pressure of 5.5 atmospheres.

The second block is composed of four pumps. The pump n°4 is working, supplied directly by the inlet pipe and is driven by another variable speed drive. The three other pumps are supplied by interconnected tanks. One of them is working during the day. There are two delivery pipes (diameters 500mm) that supply the zone 4 of Buiucani with a delivery pressure of 9.6 atmospheres.

The inlet and the outlets are equipped with ultrasonic flowmeters. Moreover, each tank is equipped with a level sensor, each pump is provided with an upstream and a downstream pressure sensor. Moreover one pressure sensor is placed on each outlet, in the manhole of the flowmeters.

There is no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 5 pressure sensors and 1 level sensor will be installed

- One level sensor will be installed in one of the interconnected tanks;
- Two pressure sensors on the suction pipe
- Two pressure sensors on the delivery pipes;
- One pressure sensor upstream the regulating valve. This sensor will be installed in the manhole of the regulating valve, on an existing tap.

One topographical measurement is to be taken at the manhole of the regulating valve but no preliminary work is to be implemented.

1.9. Booster n°47: "Alba Iulia 202/4"

This booster is supplied by water from the zone 4 "Buiucani" and supplies the zone 4a of Buiucani, composed of a unit of buildings.

The inlet pipe (300mm) supplies four pumps. One of them is working, driven by a variable speed drive and supplies 3 outlets with a delivery pressure of 6 atmospheres in winter and 7 atmospheres in summer. One outlet (300mm) is going directly to a thermocom installation, while the two others (diameters 200mm) are supplying the neighbourhood.

The booster is equipped with one pressure sensor at the inlet, whose data are recorded at the dispatching centre.

During the measuring campaign, no flowmeters will be installed, due to lack of space and 2 pressure sensors will have to be installed, at the inlet and the outlet, on existing manometers.

1.10. Pumping station of "Gribov"

The station was formerly functioning with a well that has been closed. The station is supplied by water coming from the zone 4 of Buiucani and supplies the city of Durleşti and the pumping station of Cartuşa.

The inlet pipe (diameter 133mm) supplies two tanks (which volumes are 250m^3) by the top. Before each tank, there is a manual regulation valve. The tanks then supply a small tank -in which the pump is submerged- by the bottom. There are two outlets, the first one (100mm) supplying Cartuşa pumping station and the second one (80mm) supplying the neighbourhood. There is a pressure reducing valve on this second outlet.

When the tanks in Cartuşa are full, the pump is switched off in Gribov and the pumping station of Cartuşa is supplying the whole city of Durleşti.

The pumping station is equipped with level sensor in the tanks and with a mechanical flowmeter at the delivery pipe.

For the measurement campaign, two hydrins, one pressure sensor and one level sensor will have to be installed:

- The level sensor will be installed in one of the tank
- The pressure sensor downstream the pressure reducing valve. The sensor will be installed in the manhole of the valve, on an existing tap
- One hydrins will be installed at the inlet, before the separation of the pipes supplying the reservoirs.
- The other hydrins will have to be installed at the outlet. As there is no space between the pump and the separation of the outlets, the hydrins will be placed on the pipe of 100mm after the separation of the two pipes.

Before the measurement campaign, two holes must be dug where the hydrins will be installed and tappings performed on the mentioned pipes.

Four topographical points must be taken: two with the hydrins, one at the tank where the level sensor will be installed and one at the manhole of the pressure reducing valve.

1.11. PUMPING STATION OF "CARTUŞA"

The pumping station of Cartuşa is supplied by the pumping station of Gribov and supplies the city of Durleşti. The station was working previously with three wells that have been closed. There is a project of supplying this pumping station by water coming from Schinoasa pumping station.

The inlet pipe (100mm) supplies two tanks of 500m^3 by the top. The flow is regulated by a manual valve. The pumping station is supplied by the interconnected tanks. It is composed of three pumps, one of them driven by a variable speed drive. This pump is working in winter and an additional pump works in summer. There is one delivery pipe (150mm) that split hereafter in 7 branches. One of these branches is connected to the inlet, upstream the regulating valve, by a switch valve. This switch valve is open when the pump in Gribov is switched off and closed otherwise.

Two hydrins and one level sensor will have to be installed on the station.

- The level sensor will be installed in one of the tanks;
- The first hydrins will be installed on the inlet, before the regulating valve;
- The second hydrins will be installed on the outlet before the first branch line.

Before the measurement campaign, two holes must be dug for the hydrins, and tappings must be performed as well. Three topographical measures must be taken, two with the hydrins and one at the tank, in which the level sensor will be installed.

1.12. PUMPING STATION OF "STAUCENI"

This pumping station has been transmitted to Apa Canal two months ago, so some characteristics are still unknown (as the elevations of the pumping station and of the tank, the way the tank is supplied). There is an old chlorination building that is not used anymore. In March 2011, Stauceni Pumping station began to supply the village of Goianul Nou, formerly supplied by wells.

The pumping station of Stauceni is supplied by the zone 4 of the pumping station of the water treatment plant of Chişinau and supplies the village of Stauceni. The inlet pipe (400mm) supplies the tank of 3000m^3. The flow is regulated by a manual valve before entering the tank.

The pumping station is composed of four automatic pumps that are driven by one variable speed drive. The drive is programmed to work a defined amount of time with each pump and then switch to the next one. One pump is generally working but two pumps may work at the same time (especially in summer), depending on the consumption of water in Stauceni.

There are two outlets of 300mm that supplies Stauceni. The delivery pressure is 5.5 atmospheres.

The outlets are equipped with flowmeters that are different from the other flowmeters found in Chişinau, as a Danish team equipped the whole pumping station. One flowmeter is not working anymore and as they are not used to this equipment, they do not know how to repair it. The other flowmeter cannot be programmed and therefore cannot be used during the campaign. The outlets are equipped with pressure sensors and each pump is provided with a downstream pressure sensor.

During the measurement campaign, one level sensor and three hydrins will have to be installed on the station:

- One level sensor in the tank.
- One hydrins at the inlet, before the regulating valve, between the manhole of the valve and the wall of the estate.
- One hydrins on each outlet, outside of the station as there is no possible place inside the pumping station.

Before the measurement campaign 3 holes for the hydrins need to be dug and three tappings need to be performed on the pipes.

Moreover, four topographical points will need to be taken, one at each hole for the hydrins and one at the tank.

1.13. PUMPING STATION OF BALŞEVSC

The pumping station of Balşevsc is supplied by water coming by gravity from the water treatment plant of Chişinau (zone 2) and from 6 wells. The station supplies water to the zone 1.

The former outlet of Balşevsc is called “special pipe” as it was supplying the government buildings. These pipes are now supplied by the inlet of Balşevsc (zone 2).

Two inlet pipes (diameter 300mm) are coming from the wells and one inlet pipe (diameter 200mm) is coming from the network (zone 2 and regulated outlet “Oţel” at the water treatment plant). The flow coming from the network is regulated by a manual valve in the building. The water is then mixed and treated by filtration and chlorination. The water is then supplied to two tanks of 2000m^3 by the top.

The pumping station is composed of 5 pumps. One pump, driven by a variable speed drive, is working. There is one delivery pipe (diameter 200mm) that split in two pipes of 500mm and 600mm.

The drive is set on a delivery pressure of 7.6 atmospheres, while the pressure in the zone 2 in the network (at the inlet of the station) is 9.5 atmospheres.

The inlets and the outlets are equipped with ultrasonic flowmeters. Moreover, each tank is equipped with a level sensor, each pump is provided with an upstream and a downstream pressure sensor and one pressure sensor is placed on each outlet, in the manhole of the flowmeters.

There is no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 2 pressure sensors and 1 level sensor will be installed

- One level sensor will be installed in one of the interconnected tanks;
- One pressure sensor on the delivery pipe;
- One pressure sensor upstream the regulating valve. The sensor will be installed in the treatment building, on an existing tap.

No topographical measurement is to be taken and no preliminary work is to be implemented.

1.14. PUMPING STATION OF GHIDIGHICI

The pumping station of Ghidighici is supplied by water coming from 11 wells and supplies the zone 1 of Chişinau, as well as the villages of Vatra and Ghidighici.

There are two inlet pipes that supply two tanks of 3000m^3 by the top. The incoming flow is regulated by regulation valves at the outlet of the wells. Chlorine is injected in the tanks.

The pumping station is composed of 4 pumps, two of which are driven by one variable speed drive. One pump is working only during the day with the variable speed drive set on a delivery pressure of 5.6 atmospheres. There are two delivery pipes, one supplying the zone 1 of Chişinau (400mm) and one supplying the two villages of Vatra and Ghidighici (300mm).

During the night, the pump is switched off and the two villages are supplied by the zone 1 of Chişinau.

The inlets and the outlets are equipped with ultrasonic flowmeters. Moreover, each tank is equipped with a level sensor, each pump is provided with an upstream and a downstream pressure sensor and one pressure sensor is placed on each outlet, in the manhole of the flowmeters.

There is no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 1 pressure sensor and 1 level sensor will be installed

- One level sensor will be installed in one of the interconnected tanks;
- One pressure sensor on the delivery pipe

No topographical measurement is to be taken and no preliminary work is to be implemented.

1.15. PUMPING STATIONS OF THE "WATER TREATMENT PLANT OF NISTRU" (TREAPTA II AND TREAPTA IIA)

This pumping station is supplied by raw water coming from the Nistru (formerly, it has been supplied by 61 wells) and separated in two parts. One part is delivering the raw water to Chişinau's water treatment plant, by two successive pumping stations. The second part is pumping drinking water treated at the water treatment plant of Nistru. The water treated in the water treatment plant of Nistru is then supplied to Vadul Lui Voda, Coşerniţa and Tohatin Pumping station.

There are three tanks of 1000m^3 in the treatment plant; one of them is not working. The first stage of the pumping station, formed of two blocks, is supplied by these two reservoirs.

The first block, composed of three pumps (one of them is working), supplies the second stage of the pumping station, while the second block (one of them is working), composed as well of three pumps, supplies the tank of "lower Vadul Lui Voda". This tank supplies two outlets to Vadul Lui Voda and Coşerniţa by gravity. The delivered flow is regulated by two valves at the outlet of the tank. This tank is used only in winter. In summer the tank is closed and the two outlets are supplied by the tank of upper Vadul lui Voda.

The second stage of the pumping station is composed of five pumps. One of them is working during the day, and a smaller one during the night. The pump supplies then 2 outlets, one to Tohatin Pumping station and one to the tank of "upper Vadul Lui Voda", functioning only during the summer.

The three outlets are equipped with ultrasonic flowmeters. Moreover, each tank is equipped with a level sensor and each pump is equipped with upstream and downstream pressure sensor.

There is no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 6 pressure sensors and 3 level sensors will be installed

- One level sensor will be installed in one of the interconnected tanks of the water treatment plant;
- The two other level sensors will be installed in the tanks of upper and lower Vadul Lui Voda
- Two pressure sensors on the delivery pipe of the first stage of the pumping station;
- One pressure sensor on the suction pipe of the second stage of the pumping station
- One pressure sensor at the outlet to Tohatin, in the manhole of the flowmeter on an existing tap
- Two pressure sensors on the outlets to Vadul Lui Voda and Coşerniţa, with the flowmeters, after the regulating valves.

Before the measurement campaign, two tappings for pressure sensors have to be performed on the outlets to Vadul Lui Voda and Coşerniţa. The tappings will be performed in the manhole of the two flowmeters.

Four topographical measurements have to be taken:

- Two points at the manholes of the flowmeters;

- Two points at the two stages of the pumping station.

1.16. PUMPING STATION OF TOHATIN

The pumping station of Tohatin supplies water to the cities of Maximovca, Tohatin, Coloniţa and to the zone 2 of Chisinau from the water treatment plant of Nistru.

The inlet pipe (diameter 800mm) supplies 3 tanks by the top. The incoming flow is not regulated but reduced by partially open valves. Two tanks are formed of two cisterns of 1500m^3. The volume of the third tank is 10000m^3. Two outlets to the zone 2 of Chişinau are supplied by gravity by the tanks. The two outlets merge outside of the pumping station (after the flowmeters).

The pumping station is composed of two blocks, supplied by the three interconnected tanks. The first block is formed of 4 pumps with only one functioning. The pump supplies two delivery pipes. The first outlet (300mm) supplies the tanks of Coloniţa and of Maximovca. The tank of Maximovca is not managed by Apa Canal therefore there is a bulkmeter for Maximovca. The second outlet (200mm) supplies some houses in Tohatin. When the tanks in Coloniţa are full, this pump is switched off and the outlet to Tohatin is supplied by the water remaining in the pipe.

The second block is formed of two pumps driven by one variable speed drive. One pump is working in winter and the other pump (with higher characteristics) works during the summer. The block supplies one outlet to Tohatin. The variable speed drive is set on a delivery pressure of 8.5 atmospheres.

The inlet and four of the five outlets are equipped with ultrasonic flowmeters. Moreover, each tank is equipped with a level sensor and each pump is equipped with upstream and downstream pressure sensor.

During the measurement campaign, one hydrins needs to be installed on the last outlet, as well as 2 pressure sensors and 1 level sensor will be installed

- One level sensor will be installed in one of the interconnected tanks;
- Two pressure sensors on the delivery pipe;

Before the measurement campaign, one hole must be dug and one tapping must be performed on the outlet pipe, outside the buildings and inside the estate.

One topographical measurement has to be taken, with the hydrins.

1.17. TANKS OF COLONIŢA

The tanks of Coloniţa are supplied by the pumping station of Tohatin. The inlet pipe (300mm) supplies the three tanks of 400m^3 by the top. When the tanks are full, the operator calls the pumping station of Tohatin to switch off the pump. There are three outlets (diameters 200, 200 and 133mm) that supply Coloniţa village

Level sensors have been installed in each tank. During the measurement campaign, one level sensor will have to be installed in one of the tanks.

No topographical measurement is to be taken and no preliminary work has to be implemented.

1.18. Pumping station of Ciocana

The pumping station of Ciocana is supplied by water coming by gravity (zone 2) from the pumping station of Tohatin and supplies by gravity the zone 1.

The pumping station is not functioning anymore and Ciocana is only composed of tanks. The three tanks (volumes of 3000m^3, 3000m^3 and 10000m^3) are supplied by the top by one inlet pipe (diameter 600mm). The flow is regulated by an electric valve and the valves entering the tanks are partially open. Two tanks are interconnected, while the third one (volume 10000m^3) is independent.

There are 3 outlets to zone 1 with partially open valves separating them.

The inlet and the three outlets are equipped with ultrasonic flowmeters. Moreover, each tank is equipped with a level sensor.

There is no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 4 pressure sensors and 2 level sensors will be installed

- One level sensor will be installed in one of the interconnected tanks; and the other sensor in the tank n°3 (volume 10000m^3)
- One pressure sensor on each outlet, in the manhole of the flowmeter;
- One pressure sensor upstream the regulating valve. The sensor will be installed in the manhole of the regulating valve, replacing a small existing pipe.

Four topographical measurements are to be taken, at the manhole of the regulating valve and at the manholes of the outlet flowmeters.

In addition, three tappings for pressure sensors are to be performed on the outlet pipes, in the manholes of the flowmeters. In the manhole of the regulating valve, the pipe will have to be replaced by the pressure sensor.

1.19. Pumping station of "Codru"

The pumping station of Codru is supplied by water coming by gravity from the Pumping station of Ciocana (zone 1) and supplies water to the tanks of Codru and to the pumping stations of Sîngera and Aeroport city.

There is one tank (which volume is 6000m3) supplied by one pipe (diameter 500mm) coming from the Pumping station of Ciocana. The flow is regulated by a manual valve and the tank is supplied by the top. Chlorine is injected in the tank.

The pumping station, composed of seven pumps (3 of them are driven by a variable speed drive), is then supplied by the tank. The station is not operated the same way in winter and summer. In winter, one pump works and supplies four delivery pipes: Sîngera (325mm), Codru tanks (400mm), Aeroport city (250mm) and an Apa Canal building (80mm). The variable speed drive is set on a delivery pressure of 9 atmospheres. The pressure to Codru tanks is reduced by a valve (n°10) up to 4 atmospheres. When the tanks of Codru are filled, the valve n°10 is closed.

In summer, the pumping station is split in two blocks:

- The first block composed of two pumps (none of them driven by a variable speed drive) that works alternately or together supplies the pumping station of Sîngera.

- The second block is composed of 5 pumps (3 of them are driven by a variable speed drive), is supplying the tanks of Codru and the pumping station of Aeroport City.

The inlet and 3 of the 4 outlets are equipped with ultrasonic flowmeters. Moreover, the tank is equipped with a level sensor, each pump is provided with an upstream and a downstream pressure sensor and one pressure sensor is placed on each outlet, in the manhole of the flowmeters.

The outlet without flowmeter is the one supplying the building of Apa Canal. As the diameter of the pipe is 80mm, it is not possible to install an hydrins and the index of the mechanical of the building will have to be noted at the beginning and the end of the campaign.

There is therefore no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 4 pressure sensors and 1 level sensor will be installed

- The level sensor will be installed in the tank;
- Two pressure sensors on the delivery pipe;
- One pressure sensor on the delivery pipe to the tanks of Codru, downstream the regulating valve;
- One pressure sensor upstream the regulating valve leading to the tank. This sensor will be installed in the manhole of the regulating valve, on an existing tap.

One topographical measurement is to be taken at the manhole of the regulating valve but no preliminary work is to be implemented.

1.20. TANKS OF “CODRU”

The tanks of Codru are supplied by the pumping station of Codru. The two tanks of 500m^3 are supplied by the bottom. The inlet pipe and the outlet pipe is the same for both of them.

No equipment has been installed on the tanks. During the measurement campaign, one level sensor will have to be installed in one of the tanks.

No topographical measurement is to be taken and no preliminary work has to be implemented.

1.21. PUMPING STATION OF “AEROPORT CITY”

The pumping station of the airport is supplied by a pipe coming from the pumping station of Codru and supplies the airport and the buildings around the airport.

The security to access the site is high and the visit should therefore be prepared in advance, especially when some devices are brought on site. There is an old pumping station that has been dismantled and that is only used now has a transit pipe. There was as well an old well and an old water tower that are not used anymore.

The inlet pipe (diameter 200mm) supplies three tanks (which volumes are 300m^3, 100m^3 and 300m^3) by the top. The flow is regulated by a manual valve upstream the tanks and the entering valves of the tanks are partially open.

The pumping station is composed of 4 pumps that are supplied by the interconnected tanks. One pump is working in winter and two are working in summer. There are two delivery pipes. One pipe (diameter 100mm) is passing through the old pumping station and the diameter of the other is 200mm.

During the measurement campaign, three hydrins need to be installed, as well as 1 level sensor in one of the interconnected tanks.

- The first hydrins will be installed upstream the regulating valve, between the manhole of the valve and the estate wall.
- The second hydrins will be installed in the current pumping station, on the outlet of diameter 200mm
- The third hydrins will be installed on the second outlet, in the former pumping station.

Before the measurement campaign, one hole needs to be dug between the regulating valve and the estate's wall for the hydrins installed on the inlet. Moreover, three tappings need to be performed:

- The first tapping on the inlet pipe, in the hole previously dug.
- The second on the outlet pipe inside the current pumping station.
- The third one on the outlet pipe inside the former pumping station.

Moreover, two topographical measurements have to be taken: one at the inlet hydrins and the second at the former pumping station.

1.22. PUMPING STATION OF "SÎNGERA"

The pumping station of Sîngera was formerly supplying technical water and drinking water. Today, the technical water part of the station has been closed because of the closing down of the supplied factories. There is as well a former chlorination building.

The pumping station is supplied by water coming from the pumping station of Codru and supplies the cities of Sîngera and Dobrogea. The inlet pipe (diameter 400mm) supplies two tanks of 3000m^3 by the top. The flow is regulated by a manual valve and the valves leading to the tanks are partially open.

Three outlets to Sîngera (which diameters are 300mm, 300mm and 150mm) are supplied by gravity by the tanks.

The pumping station is composed of 5 pumps. In winter, the pumps 2 and 3 work alternately. Both of them are driven by one variable speed drive set on a delivery pressure of 5.8 atmospheres. In summer, the pumps 4 and 5 are working alternately or together. Both of them are driven by another variable speed drive set on a delivery pressure of 5.8 atmospheres.

The pumping station supplies 1 outlet to Dobrogea (diameters 300mm) and one outlet to Sîngera (diameter 50mm).

The inlet and 3 of the 5 outlets are equipped with ultrasonic flowmeters. Moreover, the tanks are equipped with level sensors, each pump is provided with an upstream and a downstream pressure sensor and one pressure sensor is placed on each outlet.

The outlets without flowmeter are

- The pipe of 50mm to Sîngera; the pipe is too small for a hydrins and is equipped with a mechanical flowmeter, which index will have to be noted at the beginning and the end of the measurement campaign.
- The pipe of 150mm that supplies by gravity Sîngera; this pipe was said to contain air.

There is therefore one hydrins to be installed on the gravity outlet to Sîngera. Moreover, 2 pressure sensors and 1 level sensor will be installed

- The level sensor will be installed in one of the interconnected tanks;
- One pressure sensor on the delivery pipe;
- One pressure sensor upstream the regulating valve. The sensor will be installed in the manhole of the regulating valve, on a yet tap to install.

Before the measurement campaign, one hole for an hydrins needs to be dug and a tapping performed on the gravity pipe to Sîngera. One other tap has to be installed for a pressure sensor in the manhole of the regulating valve. One topographical measurement is to be taken at the manhole of the regulating valve.

1.23. PUMPING STATION OF IALOVENI

The water network of Ialoveni is completely independent from the system of Chişinau. The pumping station is supplied by wells and supplies the city of Ialoveni.

Eigth of the twenty-one wells of Ialoveni are in a functioning state. The wells function alternately: during the winter, two wells are enough to supply water to Ialoveni, while 4 wells need to work at the same time during summer.

The wells supply then 2 tanks (which volumes are 1000m3) by two inlet pipes (diameters 400mm). The regulation of the flow is performed by switching on and off the pumps of the wells based on the level of the tanks. Chlorine is injected in the tanks in order to treat the water.

The pumping station is then supplied by the interconnected tanks. The station is composed of 6 pumps with 2 that never work and one pump working. Two pumps are driven by a variable speed drive, set on a delivery pressure of 10.2 atmospheres.

There are two outlets, one supplying the sector of Moldova (diameter 250mm) and one supplying Ialoveni (diameter 500mm), formerly connecting Ialoveni and Chişinau. The delivery pressure to Moldova sector is regulated by a pressure reducing valve in order for the pressure to be 6.8 atmospheres.

During the night, the pump in the pumping station is switched off and a submersible pump located in the tank n°1 is the one supplying Ialoveni and Moldova sector.

The two inlets from the wells and the two outlets are equipped with ultrasonic flowmeters. Moreover, each tank is equipped with a level sensor, each pump is provided with an upstream and a downstream pressure sensor. Moreover one pressure sensor is placed on each outlet, with the flowmeters. Some sensors are not working anymore and indicate negative pressure and do not have a display anymore in the control room.

There is no need for additional flowmeter to be implemented on this station during the measurement campaign. On the other hand, 2 pressure sensors and 2 level sensors will be installed

- One level sensor will be installed in each tank;
- One pressure sensor on the delivery pipe
- One pressure sensor on the outlet to Moldova sector, after the pressure reducing valve;

No topographical measurement is to be taken and no preliminary work is to be implemented.

Annex 3 Details of the measures to be implemented during the measurement campaign

Figure.1: Layout of the zone 1

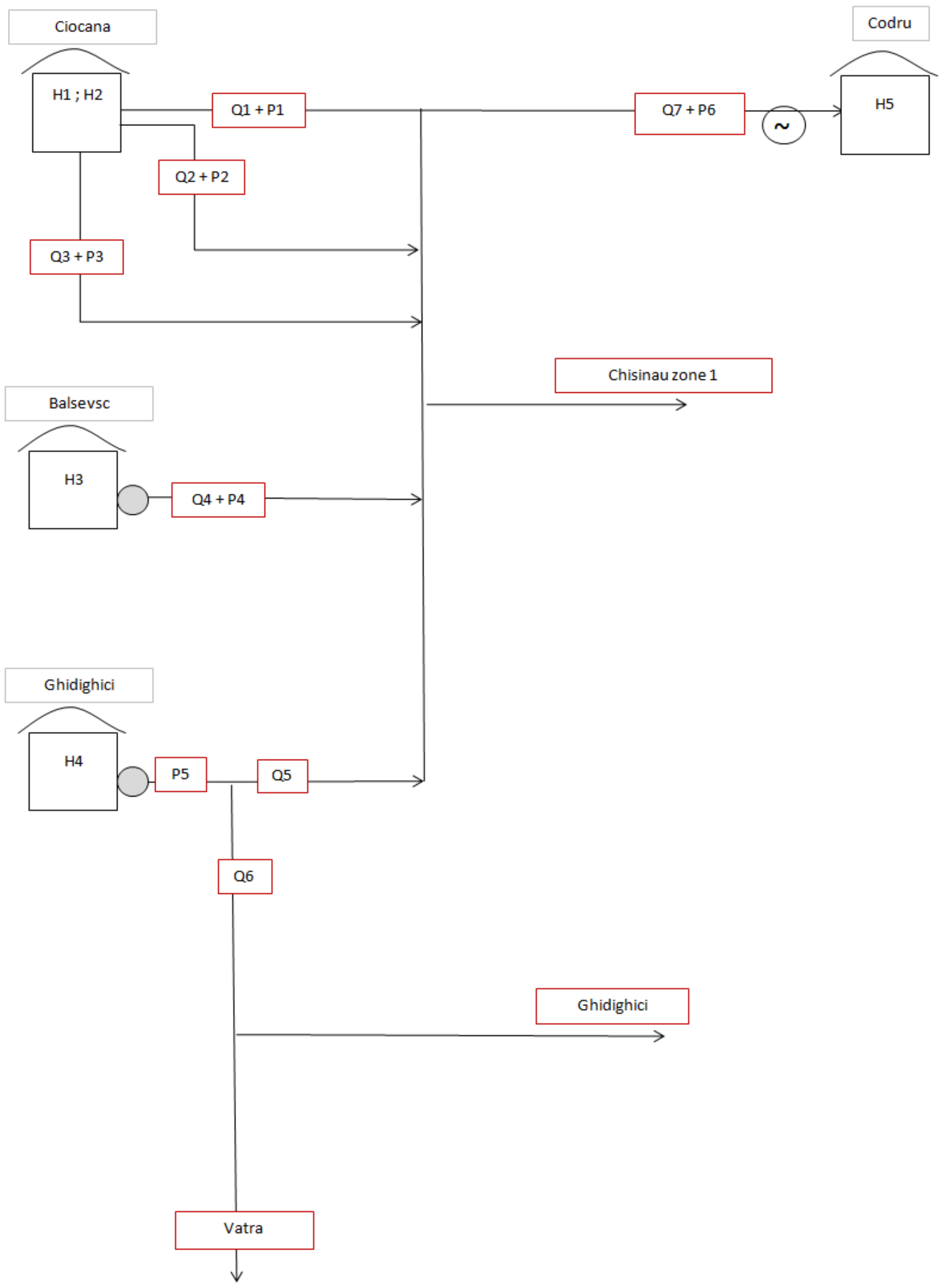


Table.6: equipment to be installed for the zone 1

hydraulic entities	contributing station	name	description	equipment				
				Q	QP	C	P	H
Zone 1	Ciocana	Q1	outlet 1	1				
		Q2	outlet 2	1				
		Q3	outlet 3	1				
		P1	Valves partially open => downstream pressure at the outlet				1	
		P2					1	
		P3					1	
		H1	Reservoirs 1 and 2					1
		H2	Reservoir 3					1
	Codru	Q7	inlet: K1 300 STA IN	1				
		P6	upstream regulating valve				1	
		H5	Reservoir					1
	Ghidighici	Q5	Outlet to Chisinau: K4 250 CHISIN	1				
		Q6	Outlet to Vatra: K2 150 VATRA	1				
		P5	delivery pressure				1	
		H4	2 reservoirs					1
	Balşevsc	Q4	outlet: K5 150 OUT Z-1	1				
		P4	delivery pressure				1	
		H3	2 reservoirs					1
	Network	P7	Booster N°22. Muncesti 406/1				1	
		P8	Booster N°46. Muncesti 56/1				1	
		P9	Booster n°45. Sf Gheorghe 40/2				1	
		P10	Booster n°34. Albisoara 82/7/4				1	
		P11	Booster n°62. Iesilor 47/3				1	
		P12	Pressure Control Point Doga/ Aeromaenului				1	
		P13	Pressure control point n°1. Uzinelor/ Vonlunterilor				1	
		P14	Presure Control Point Petru Rares/Cosmonaut				1	
	TOTAL			**7**	**0**	**0**	**14**	**5**

Figure 2: Layout of the zone 4 "Buiucani"

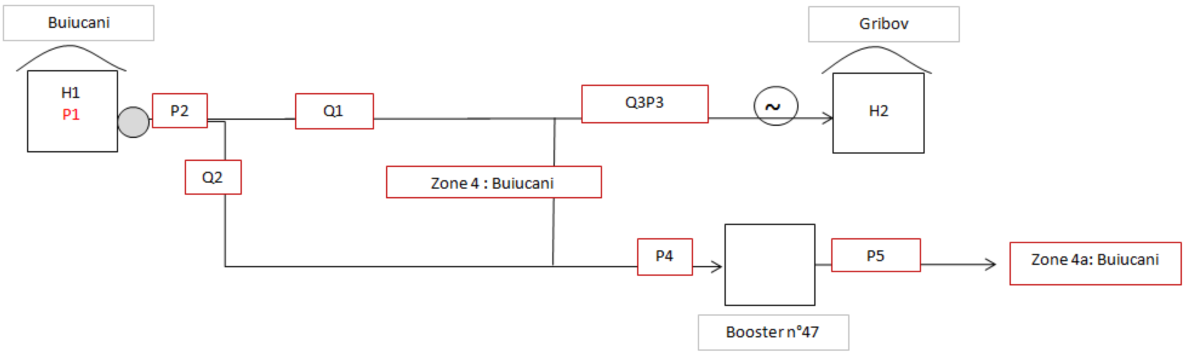


Table 7: equipments to be installed in the zone 4 "Buiucani"

hydraulic entities	contributing station	name	description	equipment				
				Q	QP	C	P	H
Zone 4 Buiucani	Buiucani	Q1	Outlet 1: K4 500 Z 4-4	1				
		Q2	Outlet 2: K2 500 Z 4-2	1				
		P1	suction pressure				1	
		P2	delivery pressure				1	
		H1	3 reservoirs					1
	Gribov	Q3P3	Inlet from Buiucani Zone 4		1			
		H2	2 reservoirs and 1 reservoir for the pump					1
	booster N°47. Alba Iulia 202/4	P4	suction pressure				1	
		P5	delivery pressure				1	
	Network	P6	Booster n°41. Nicolai Costin 61/5				1	
	TOTAL			**2**	**1**	**0**	**5**	**2**

Figure 3: Layout of the zone 2

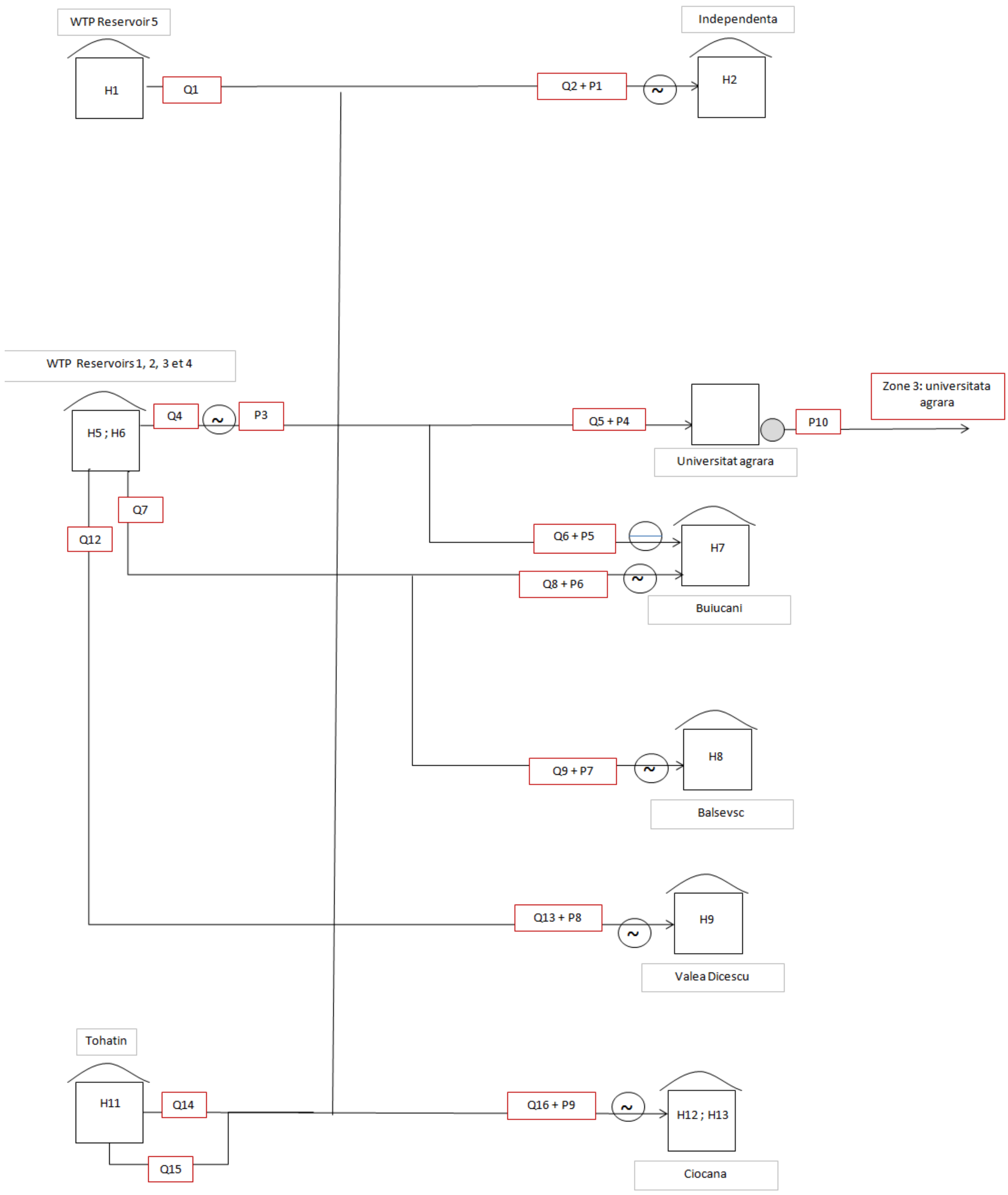


Table 8: equipments to be installed in the zone 2

contributing station	name	description	equipment				
			Q	QP	C	P	H
WTP	Q1	outlet Independenta: K8 DN1200 OPER	1				
	Q4	outlet otel: DN1200 IRINA (Q4)	1				
	Q7	outlet Doina: DN1000 IRINA (Q8)	1				
	Q12	outlet Vostoc: Q14 DN1200 IRIN	1				
	P3	downstream regulating valve.				1	
	H1	Reservoir 5					1
	H5	Reservoir 3 and 4					1
	H6	Reservoir 1 and 2					1
Indepenta	Q2	Inlet: K-1 1000 IN STA	1				
	P1	upstream regulating valve				1	
	H2	Upstream reservoir					1
Universitat agrara	Q5	Inlet: K1 200 STA IN	1				
	Q6	Outlet K2 DN200 Zone 3-1	1				
	P4	Suction Pressure				1	
	P10	Delivery Pressure				1	
Buiucani	Q6	Inlet Universita agrara: K6 OPER	1				
	Q8	Inlet WTP: K7 OPER	1				
	P5	Suction Pressure				1	
	P6	upstream regulating valve				1	
	H7	3 reservoirs					1
Balsevsc	Q9	Inlet: K3 200 IN Z-2	1				
	P7	upstream regulating valve				1	
	H8	2 reservoirs					1
Valea Dicescu	Q13	Inlet: Q1 OPER	1				
	P8	upstream regulating valve				1	
	H9	2 reservoirs					1
Tohatin	Q14	outlet: K4 800 OUT CHI	1				
	Q15	outlet: K5 600 OUT CHI	1				
	H11	3 reservoirs					1
Ciocana	Q16	inlet: K2 600 IN TOH	1				
	P9	upstream regulating valve				1	
	H12	Reservoirs 1 and 2					1
	H13	Reservoir 3					1
Network	P16	Booster n°53. Socolei 21/1				1	
	P11	Pressure Control Point of the WTP's valve: Balsevsc				1	
	P12	Booster n°59.Bogdan Voievod 10/2				1	
	P13	Booster n°43. Dragan 30/7				1	
	P14	Booster n°17 Cuza Voda 1/6				1	
	P15	Booster n°4. Decebal 19/1				1	
	P17	Booster n°32. Puskin 44/1				1	
	P18	Booster n°36. Coca 19/1				1	
	P19	Pressure reductor in Bîc				1	
	P20	Pressure control Point Badiu/ Pogdorelinor				1	
	P21	Pressure Control Point Studentilor/Florilor				1	
	P22	Pressure Control Point Maleevici/ Puskin				1	
	P23	Pressure control points on each side of the valve separating zone 2 Tohatin and zone 2 Vostoc				1	
	P24					1	
TOTAL			**14**	**0**	**0**	**23**	**10**

Figure 4: Layout of the zones 3 "Buiucani, Ciocana & Rîscani, Centru & Botanica"

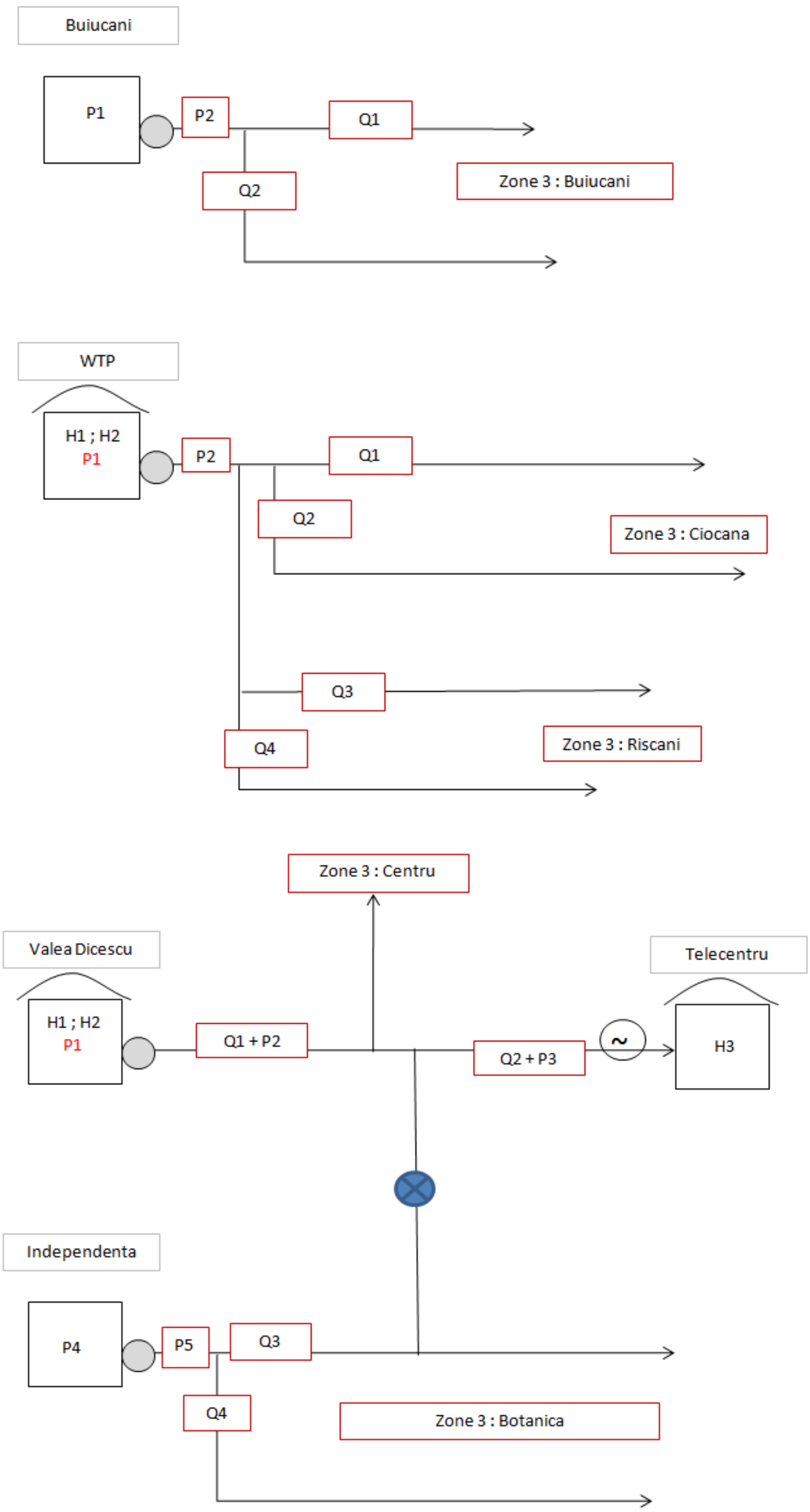


Table 9: Equipments to be installed in the different zones 3

hydraulic entities	contributing station	name	description	equipment				
				Q	QP	C	P	H
zone 3 Buiucani	Buiucani	Q1	Outlet 1: K5 400 Z 3-1	1				
		Q2	Outlet 2: KQ 300 Z 3-2	1				
		P1	suction pressure				1	
		P2	delivery pressure				1	
	Network	P3	Booster n°60. Constitutiei 8/1				1	
		P4	Pressure Control Point n°2: Alba Iula/ Sucevioa				1	
	TOTAL			**2**	**0**	**0**	**4**	**0**
Zone 3 Ciocana + Riscani	WTP	Q1	Outlet CC: Q10 DN700 OPER	1				
		Q2	Outlet CC1: Q11 DN500 OPER	1				
		Q3	Outlet RS1: 500 OUT RS-1	1				
		Q4	Outlet RS2: 500 OUT RS-2	1				
		P1	suction pressure				1	
		P2	delivery pressure				1	
		H1	Reservoirs 1 and 2					1
		H2	Reservoirs 3 and 4					1
	Network	P3	Booster n°48. Studentilor 7/6				1	
		P4	Booster n°50. Moscovei 11/6				1	
		P5	Booster n°58. Sadoveanu 2/6				1	
		P7	Pressure Control Point Studentilor/ Florilor				1	
	TOTAL			**4**	**0**	**0**	**6**	**2**
Zone 3 Centru + Botanica	Valea Dicescu	Q1	Outlet: Q2 OPER	1				
		P1	suction pressure				1	
		P2	delivery pressure				1	
		H1	Reservoirs 1 and 2					1
		H2	Reservoir 3					1
	Telecentru	Q2	Inlet: K1 500 IN V.DIC	1				
		P3	Upstream regulating valve				1	
		H3	Reservoirs 1 and 2					1
	Indepenta	Q3	Outlet 1: K5 500 Z3-1	1				
		Q4	Outlet 2: K3 500 Z3-2	1				
		P4	suction pressure				1	
		P5	delivery pressure				1	
	Network	P6	Booster n°40. Drumul Viilor 28/4				1	
		P7	Booster n°1. Dacia 2				1	
		P8	Pressure Control Point Cuza Voda/ Independenta				1	
	TOTAL			**4**	**0**	**0**	**8**	**3**

Figure 5: Layout of the zone 4 "Centru & Botanica"

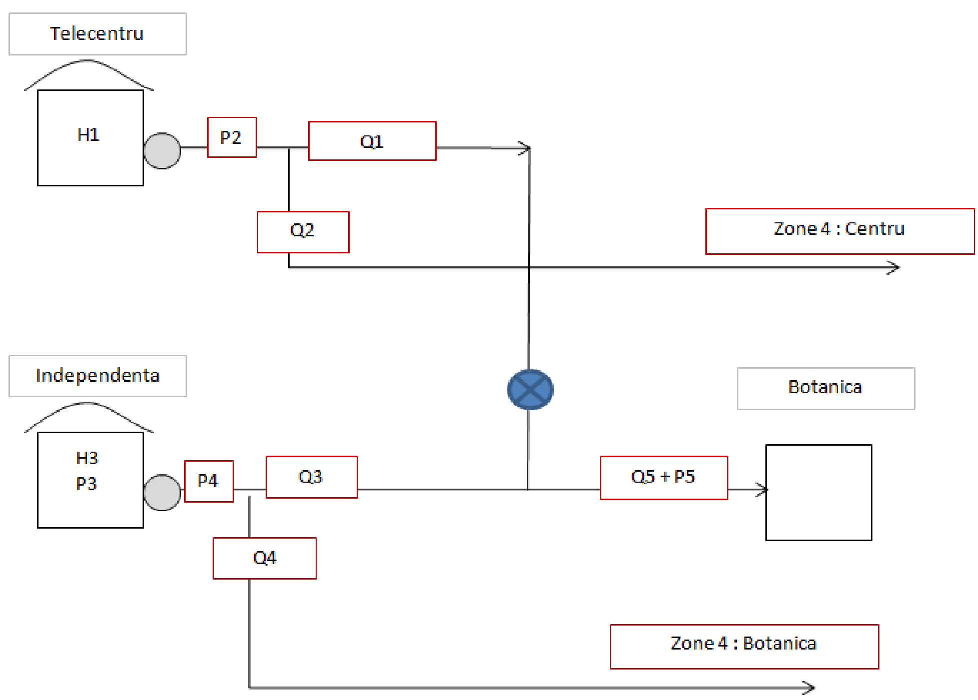


Table 10: Equipments to be installed in the zone 4 "Centru & Botanica"

hydraulic entities	contributing station	name	description	equipment				
				Q	QP	C	P	H
Zone 4 Botanica + Centru + Zone4a Botanica	Telecentru	Q1	Outlet 1: DN400 OPER	1				
		Q2	Outlet 2: DN250 OPER	1				
		P2	delivery pressure				1	
		H1	Reservoirs 1 and 2					1
	Indepenta	Q3	Outlet 1: Q3 D500 Z41 OP	1				
		Q4	Outlet 2: Q2 D500 Z42 OP	1				
		P3	suction pressure of the direct supply				1	
		P4	delivery pressure				1	
		H3	Reservoir 2					1
	Botanica (zone 4a Botanica)	Q5	Inlet: 150 S/P Z-4 IN	1				
		Q6	Outlet 1: 150 S/P Z-4-a1	1				
		Q7	Outlet 2: Q3 D300 OPER	1				
		P5	suction pressure				1	
		P6	Delivery pressure				1	
	Network	P8	Pressure Control Point Hincesti/ Aurel Viacu				1	
		P9	Pressure Control Point Testemeanu/Grenoble				1	
		P10	Pressure control Point of Zone 4 Botanica				1	
	TOTAL			**7**	**0**	**0**	**8**	**2**

Figure 6: Layout of the zone 4a "Centru & Botanica"

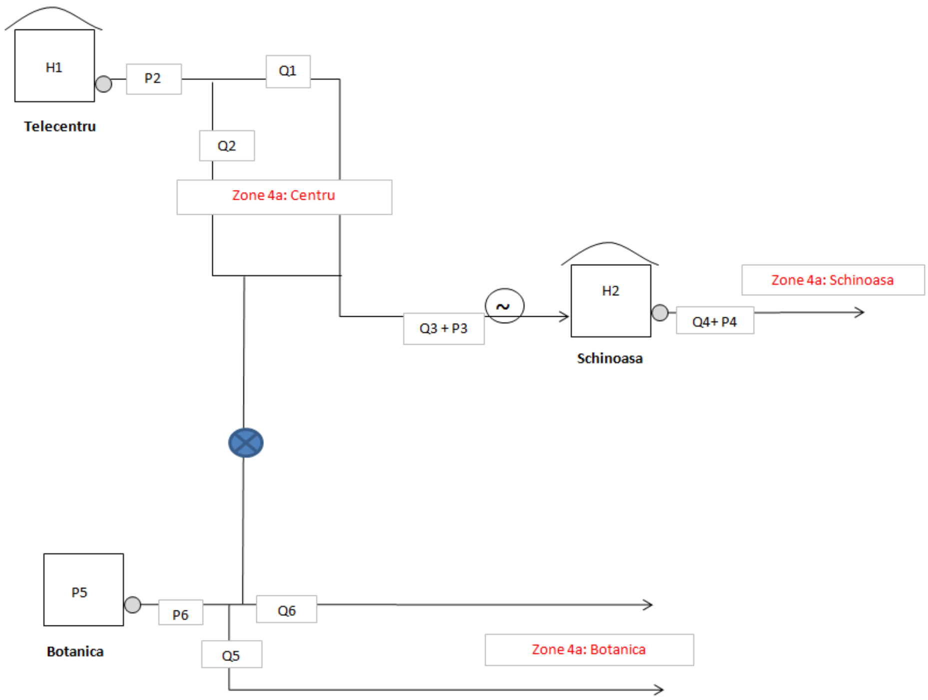


Table.11: Equipments to be installed in the zone 4a "Centru & Botanica"

hydraulic entities	contributing station	name	description	equipment				
				Q	QP	C	P	H
zone 4a Centru	Telecentru	Q1	Outlet 1: Q4 200 Z4a-1	1				
		Q2	Outlet 2: Q6 300 Z4a-2	1				
		P2	delivery pressure				1	
		H1	2 reservoirs					1
	Schinoasa	Q3	Inlet 1: DN300 OPER	1				
		Q4	Outlet 2: Q1 D500 OPER	1				
		P3	upstream regulating valve				1	
		P4	delivery pressure				1	
		H2	Reservoir					1
	Network	P6	Booster n°8. Drumul Schinoasei				1	
		P7	Pressure Control Point n°4. Str Ialoveni				1	
		P8	Pressure control Point in zone 4a Schinoasa				1	
	TOTAL			**4**	**0**	**0**	**6**	**2**

Figure.7: Layout of the zone "Durleşti"

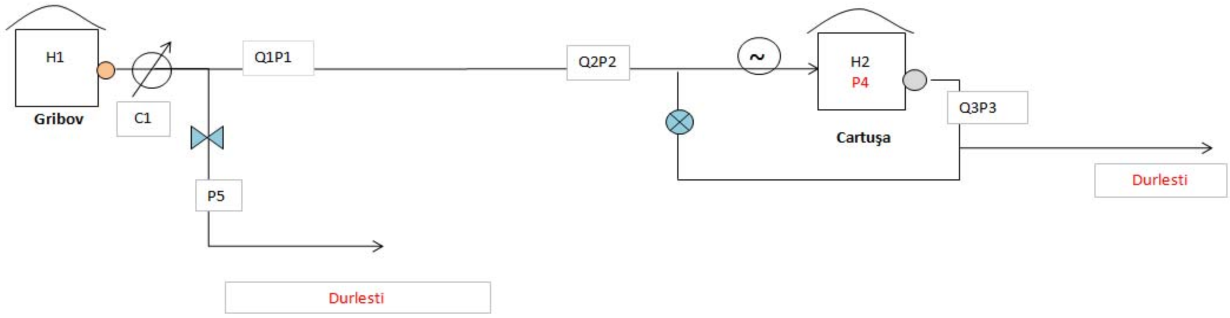


Table 12: Equipments to be installed in the zone "Durleşti"

hydraulic entities	contributing station	name	description	equipment				
				Q	QP	C	P	H
Durlesti	Gribov	Q1P1	Outlet Cartusa		1			
		C1	Outlet 80mm			1		
		P5	Downstream partially open valve				1	
		H1	2 reservoirs and 1 reservoir for the pump					1
	Cartusa	Q2P2	Inlet before the loop		1			
		Q3P3	Outlet before separations		1			
		H2	2 reservoirs					1
	Network		To be determined				2	
	TOTAL			**0**	**3**	**1**	**3**	**2**

Figure.8: Layout of the zone 4 "Ciocana"

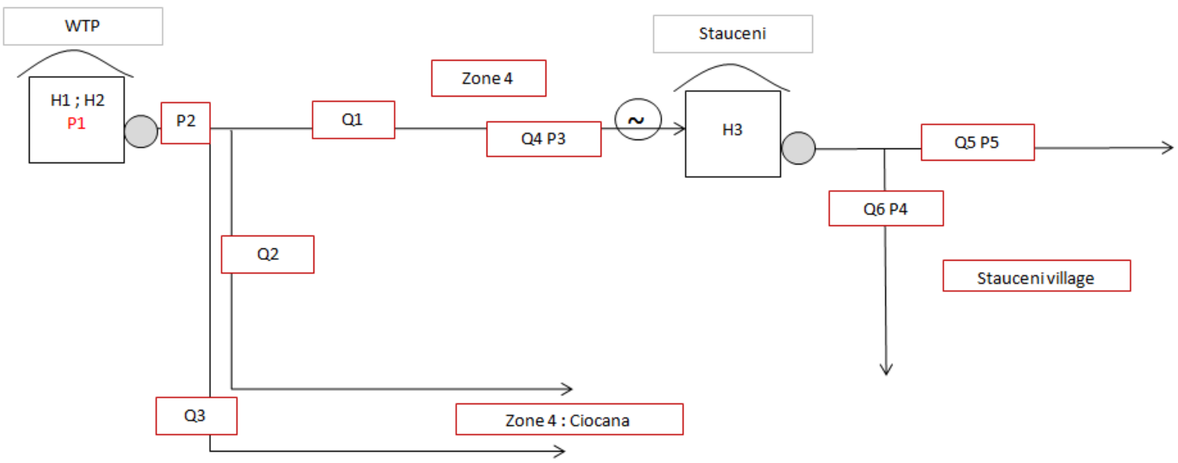


Table 13: Equipments to be installed in the zone 4 "Ciocana"

hydraulic entities	contributing station	name	description	equipment				
				Q	QP	C	P	H
Zone 4 Ciocana	WTP	Q1	Outlet Stauceni	1				
		Q2	Outlet CC2	1				
		Q3	Outlet CC3	1				
		P1	suction pressure				1	
		P2	delivery pressure				1	
		H1	Reservoirs 1 and 2					1
		H2	Reservoirs 3 and 4					1
	Stauceni	Q4P3	Inlet		1			
		Q5P5	Outlet 1		1			
		Q6P4	Outlet 2		1			
		H3	Reservoir 1					1
	Network	P5	Booster n°42. A. Russo 55/6				1	
		P6	Booster n°51. I Vieru 5/4				1	
	TOTAL			**3**	**3**	**0**	**4**	**3**

Table 14: Equipments to be implemented in the city of Ialoveni

hydraulic entities	contributing station	name	description	equipment				
				Q	QP	C	P	H
Ialoveni	Ialoveni	Q1	Outlet Ialoveni	1				
		Q2	Outlet Moldova	1				
		P1	suction pressure				1	
		P2	downstream partially open valve				1	
		H1	Reservoir 1					1
		H2	Reservoir 2 with submersible pump					1
	Network	P3	PCP n°5. Valve between Ialoveni-Chisinau				1	
		P4	At the (closed) reservoir de sos				1	
		P5	In Moldova sector				1	
	TOTAL			**2**	**0**	**0**	**5**	**2**

Figure.9: Layout of the zone "Ialoveni"

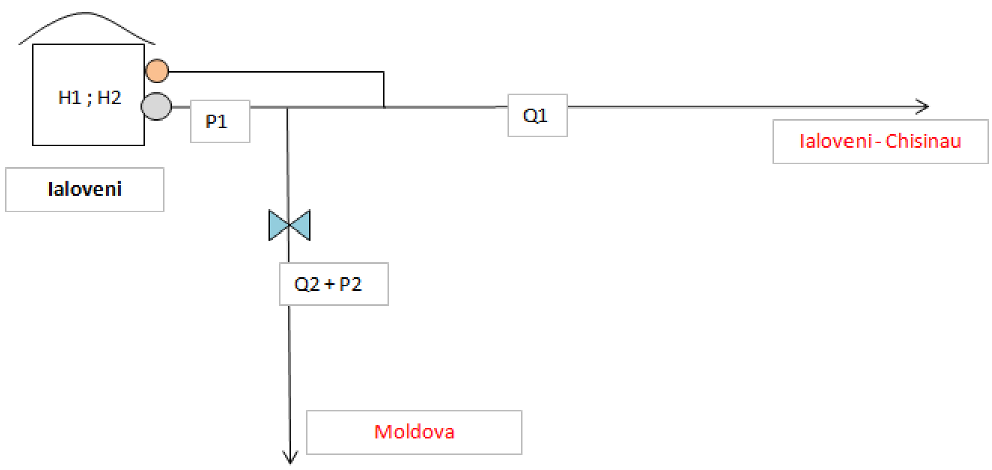
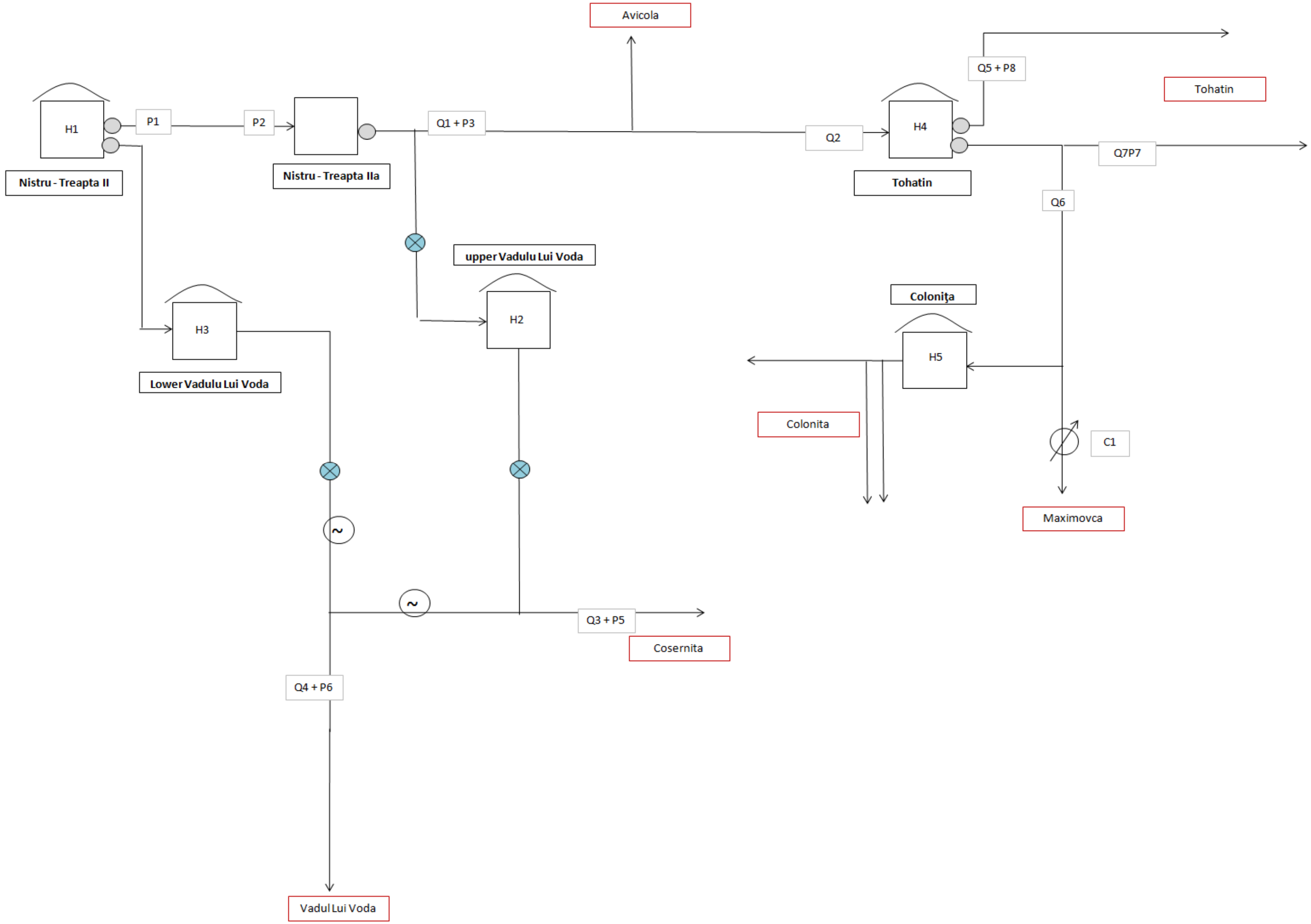


Table.15: Equipments to be installed in the zone "Vadul Lui Voda"

hydraulic entities	contributing station	name	description	equipment			
				QP	C	P	H
Vadul Lui Voda	Nistru Treapta II	P1	Delivery pressure to Treapta IIa			1	
		P4	Delivery pressure to Reservoir			1	
		H1	2 reservoirs upstream the pumping station				1
		H3	Reservoir "lower Vadul Lui Voda"				1
	Nistru Treapta IIA	Q1	Outlet Tohatin				
		Q3	Outlet Cosernita				
		Q4	Outlet Vadul Lui Voda				
		P2	Suction Pressure			1	
		P3	Delivery Pressure with the flowmeter			1	
		P5	Outlet to Cosernita			1	
		P6	Outlet to Vadul Lui Voda			1	
		H2	Reservoir "upper Vadul Lui Voda"				1
	Tohatin	C1	Outlet Tohatin		1		
		C2	Outlet Tohatin		1		
		C3	Outlet Tohatin		1		
		C4	Outlet Tohatin		1		
		C5	Outlet Tohatin		1		
		C6	Outlet Tohatin		1		
		Q2	Inlet				
		Q5	Outlet Tohatin				
		Q6	Outlet Cosernita and Maximovca				
		C7	Bulkmeter in Maximovca		1		
		P8	Delivery pressure to Tohatin			1	
		H4	3 reservoirs				1
	Colonita	H5	3 reservoirs				1
	Network		To be determined			4	
	TOTAL			**0**	**7**	**11**	**5**

Figure.10: Layout of the zone "Vadul Lui Voda

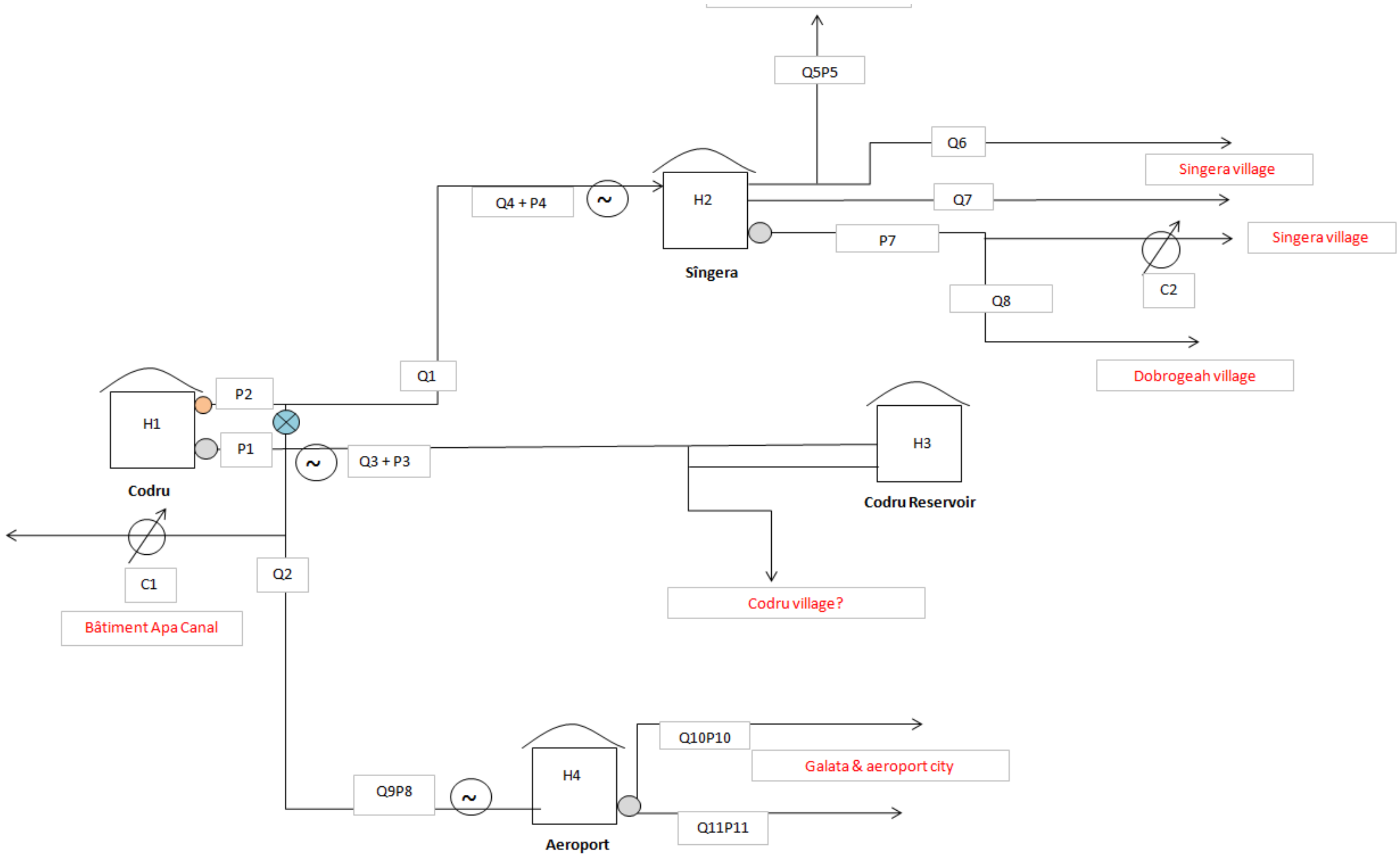


"

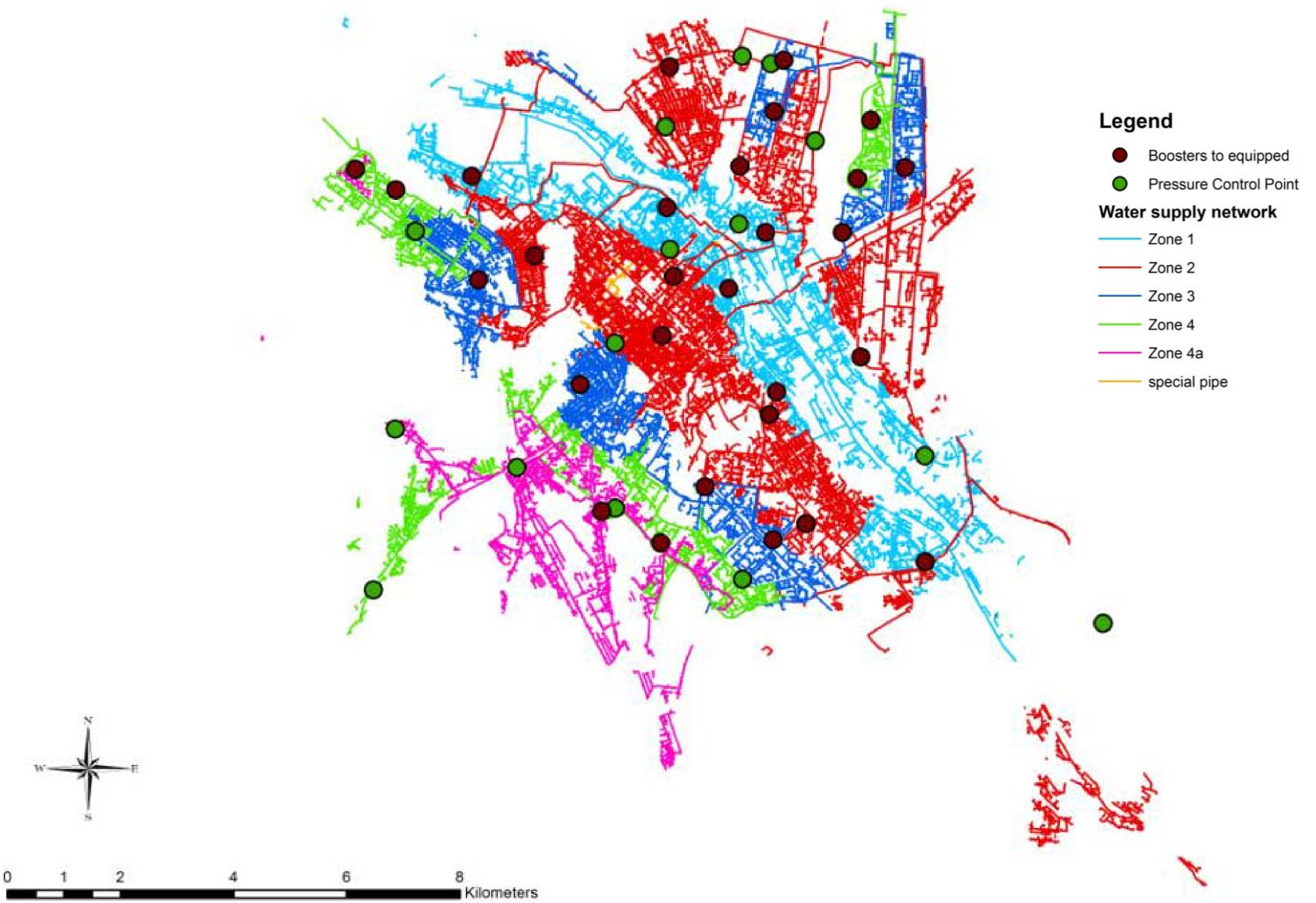
Table.16: Equipments to be installed in the zone "Codru"

hydraulic entities	contributing station	name	description	equipment				
				Q	QP	C	P	H
Codru & Sîngera	Codru	Q1	Outlet Sîngera	1				
		Q2	Outlet Aeroport	1				
		Q3	Outlet Codru reservoirs	1				
		P1	Delivery Pressure				1	
		P2	Delivery Pressure (only during summer)				1	
		P3	Downstream partially open valve				1	
		C1	Outlet 80mm to Apa Canal Building			1		
		H1	Reservoir					1
	Sîngera	Q4	Inlet	1				
		Q6	Gravitational outlet 1	1				
		Q7	Gravitational outlet 2	1				
		Q8	Outlet Dobrogeah	1				
		Q5P5	Gravitational outlet 3		1			
		C2	Outlet 5 (50mm) Sîngera			1		
		P4	Upstream regulating valve				1	
		P7	delivery pressure				1	
		H2	2 reservoirs					1
	Codru Reservoirs	H3	2 reservoirs					1
	Aeroport	Q9P8	Inlet		1			
		Q10P10	Outlet (new pumping station)		1			
		Q11P11	Outlet (old pumping station)		1			
		H4	3 reservoirs					1
	Network		To be determined				5	
	TOTAL			**7**	**4**	**2**	**10**	**4**

Figure 11: Layout of the zone "Codru & Sîngera"



Annex 4 Pressure sensors to be installed in the network


Legend
Boosters to equipped
Pressure Control Point
Water supply network
Zone 1
Zone 2
Zone 3
Zone 4
Zone 4a
special pipe
N
W
E
S
0 1 2 4 6 8
Kilometers

Appendix 5

Sewerage Network

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

ACC	ApaCanal
CAPEX	Capital Expenses
EBRD	European Bank for Reconstruction and Development
EHS	Environmental, Health and Safety
EMP	Environmental Management Plan
EMS	Environmental Management System
ESAP	Environmental and Social Action Plan
GIS	Geographic Information System
HSC	House Service Connection
IAS	International Accounting Standards
IR	Inception Report
KPI	Key Performance Indicators
LLI	Linear Leakage Index
MIS	Management Information System
O&M	Operation and Maintenance
OPEX	Operation Expenses
PSC	Public Service Contract
PIU	Project Implementation Unit
PMU	Project Management Unit
SPP	Stakeholders Participation Programme
SSF	Special Shareholders Fund
ToR	Terms of Reference
PS	Pumping Station
WWTP	Waste Water Treatment Plant
CCTV	Close Circuit TeleVision
O&M	Operation and Maintenance

1. WASTEWATER COLLECTION: ASSESSMENT OF THE CURRENT SITUATION

1.1. PRESENTATION OF THE SEWERAGE COLLECTION SYSTEM

1.1.1. ACC SEWAGE OBJECTIVES AND STUDY AREA

1.1.1.1. ACC responsibility

The sewerage system is designed to be separate. Indeed, within the ACC area of service, three types of sewerage collection networks can be found. They are collecting:

- “foul” flow i.e. sewage wastewater : the **wastewater network**
- stormwater generated by rainfall events: the **stormwater network**
- groundwater in order to lower the ground water table level within the city: the **drainage network**

The stormwater and drainage networks are connected and have the same outfalls. They are not supposed to be connected to the wastewater network.

In the older parts of Chisinau city, the 3 types of network can be found. Elsewhere, there is either only a “foul” wastewater collection system, both “foul” and stormwater systems, or none of them.

Apa Canal Chisinau is responsible only for the collection and treatment of “foul”, or sewage wastewater. The stormwater and groundwater collection systems are operated and maintained by a 100% Municipality-owned-company: “Exdrupo”.

Henceforward within this Section, the term “wastewater” shall apply only to “foul” or sewage wastewater. Commonly, the term “sewerage network” will be used to denote the sewer system for the collection of “foul” wastewater unless specific reference is made to surface or to ground water, or to their respective collection systems.

1.1.1.2. Sewerage service area

ACC sewerage system collects wastewater from Chisinau city but also from the suburbs and villages around Chisinau. In general, the service area of ACC includes most of the villages of Chisinau Municipality plus 9 cities or villages from other Rayons. The localities where ACC is in charge of the sewerage network are listed in the following table:

Table 1.1: ACC area of service for wastewater

<table>
<tr><th>Rayon / Municipality</th><th>Sector</th><th>Commune</th><th>Village/City</th><th>Population in 2004</th></tr>
<tr><td rowspan="23">Chisinau</td><td colspan="3">Chisinau City</td><td>589 450</td></tr>
<tr><td rowspan="3">Botanica</td><td colspan="2">Galata Village - Aeroport City</td><td>**</td></tr>
<tr><td rowspan="2">Sangera</td><td>Dobruja Village</td><td>3 280</td></tr>
<tr><td>Sangera City</td><td>7 350</td></tr>
<tr><td rowspan="5">Buiucani</td><td>Durlesti</td><td>Durlesti City</td><td>15 400</td></tr>
<tr><td rowspan="2">Ghidighici</td><td>Ghidighici Village</td><td>5 090</td></tr>
<tr><td>Pruncul</td><td>**</td></tr>
<tr><td>Truseni</td><td>Dumbrava Village</td><td>410</td></tr>
<tr><td>Vatra</td><td>Vatra City</td><td>3 300</td></tr>
<tr><td rowspan="2">Centru</td><td rowspan="2">Codru</td><td>Codru City</td><td>14 280</td></tr>
<tr><td>Costiujeni Village</td><td>**</td></tr>
<tr><td rowspan="7">Ciocana</td><td>Bubuieci</td><td>Bubuieci Village</td><td>5 440</td></tr>
<tr><td>Budesti</td><td>Vaduleni</td><td>540</td></tr>
<tr><td>Colonita</td><td>Colonita Village</td><td>3 340</td></tr>
<tr><td>Cruzesti</td><td>Cruzesti Village</td><td>1 620</td></tr>
<tr><td rowspan="2">Tohatin</td><td>Tohatin de Jos Village</td><td>**</td></tr>
<tr><td>Tohatin Village</td><td>2 100</td></tr>
<tr><td>Vadul lui Voda</td><td>Vadul lui Voda City</td><td>4 560</td></tr>
<tr><td rowspan="3">Riscani</td><td>Gratiesti</td><td>Gratiesti Village</td><td>4 690</td></tr>
<tr><td rowspan="2">Stauceni</td><td>Goianul Nou Village</td><td>630</td></tr>
<tr><td>Stauceni Village</td><td>6 200</td></tr>
<tr><td colspan="2">Criuleni</td><td>Balabanesti</td><td>Balabanesti Village</td><td>2 080</td></tr>
<tr><td colspan="4">Ialoveni</td><td>15 040</td></tr>
</table>

**: Missing data

The cities of Straseni (18 320 inhab.) and Cojusna (7 010 inhab.), in the rayon of Straseni, send their wastewater to ACC network, but their network and pumping stations are operated locally (not by ACC). At the time of writing, the pumping station of Straseni was not working. ACC accepts these wastewater volumes in its network against payment.

In terms of population, in ACC global service area (water and wastewater), the sewerage system serves:

- All Chisinau city (which itself represents 77% of the population in the global service area of ACC)
- About 2/3 of the cities and villages in Chisinau Municipality (which itself represents 16% of the population in the global service area)
- About 3/4 of the 9 cities and villages, outside Chisinau Municipality, but operated one way or another by ACC (which itself represents 7% of the population in the global service area)

However, even in the area with a wastewater network, not all population is connected. There are still some non-collective sewage systems (septic tanks). ACC is legally in charge of emptying the septic tanks and transporting the wastewater to the appropriate location, but does not deal with this issue at the present time. A private company is in charge of this service. Approximately, 20 % of the population served by ACC are not connected to the sewerage network and use septic tanks.

In the sewerage service area, ACC collects both domestic and industrial water.

It should be noted that the area is heterogeneous in term of land use, both urban and rural, and that it has an impact on the collection system structure and on the flow characteristics.

1.1.2. STRUCTURE OF THE WASTEWATER COLLECTION SYSTEM

Chisinau is built on 7 hills and is divided in 2 parts by the Bic river. When it is made possible by the topography, the wastewater is collected by gravity. When it is not possible, pumping stations and pressure pipes are used. Therefore, the collection system is made of:

- Gravity pipes
- Pressure pipes
- Pumping stations (PS)

1.1.2.1. Wastewater catchments

Within Chisinau, the flow is towards, and then via main collectors laid either side of the Bic River to Chisinau wastewater treatment plant (WWTP).

There are 3 other WWTP inside the service area in Goianul nou, Colonita and Vadul lui Voda.

The WWTP of Durlesti was decommissioned in 2010 and its wastewater sent through Cartusa pumping station to ACC sewerage network.

There are therefore 4 wastewater catchments in ACC service area:

- Chisinau city : 28 370 ha
- Vadul lui Voda. : 3 170 ha
- Colonita : 1 090 ha
- Goianul nou : 110 ha

1.1.2.2. Network structure

The wastewater network operated and maintained by Apa Canal, comprises approximately 985 km of sewers, of which 76 km are considered as “main collectors”.

The estimated length of sewers, within each Sector, is shown in the following Table:

Table 1.2 : Network length per sector

Location	Length of Sewer (km)
Râşcani	188
Centra	193
Buiucani	216
Botanica	204
Ciocana	138
Ialoveni	31
Vadul lui Voda	14
Total	**985**

The sewer lengths within each material are shown in the following Table:

Table 1.3 : Network length per material

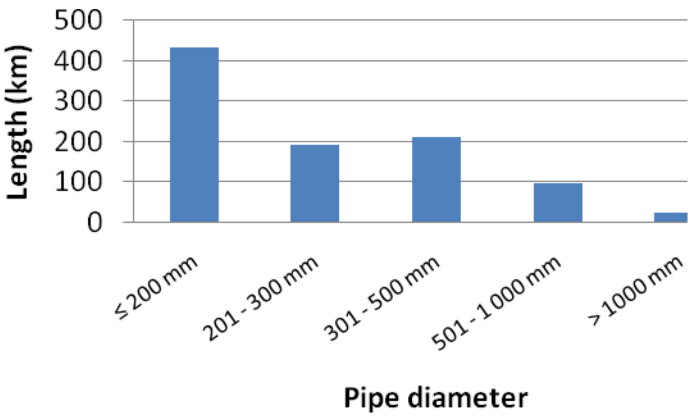
Sewer Material & Length (km)							
Vitrous Clay	Asbestos Cement	Unreinforced Concrete	Reinforced Concrete	Steel	Iron	HDPE & uPVC	Total
309	291	39	176	13	96	63	985

The above data on infrastructure date back from January 2011 and will be updated in parallel to the implementation of the GIS.

It appears that small pipes are mainly in ceramic and asbestos-cement. The bigger pipes are only in reinforced concrete.

The table shows that the small diameters represent the majority of the network length, corresponding to the tertiary network. There are a lot of big-size pipes, which suggests a possible oversizing or the presence of stormwater. The following figure summarises the length by category of diameter.

Figure 1.1: Pipes length by diameter category



According to ACC database, there are 25 559 manholes in the network, which means an average of **1 manhole every 38 m**.

The sewerage system was commenced in 1936, within the older city centre area, which is generally on the right bank of the Bic River. The latest pipes were laid in the 1970's and 1980's with the development of the city that took place during that period. There have been few sewers laid since that period. The average age of the pipes is 30 years old.

According to ACC database, the condition of the sewers varies between:

- very poor (39kms) for concrete sewers
- poor (479km) for the asbestos cement, reinforced concrete and steel
- reasonable (404km) for the vitreous clay and iron
- good (63km) for the HDP and PVC sewers

Table 1.4 : Degree of degradation

	Material						
	Ceramic	Asbesto-cement	Concrete	Reinforced concrete	Steel	Ductile Iron	Pehd / Pvc
Total length per material (km)	**304**	**285**	**39**	**176**	**12**	**94**	**44**
Degree of degradation	**58%**	**70%**	**100%**	**78%**	**75%**	**42%**	**14%**

The figures suggest that approximately half of the sewer network is in need of rehabilitation, some urgently.

1.1.2.3. Pressure pipes and pumping stations

Although most of the network is made of gravity pipes, some pressure pipes, at the oulet of the pumping stations, can be found in the sewerage system. The pressure pipes represent a length of about **83 km**.

There are 30 pumping stations (PS) operated by ACC. The pumping stations description and the complete characteristics of the pumps are given in Annexes 1 and 2.

Table 1.5 : List of the pumping stations with their average daily flows in 2007-2010

Municipality / Rayon	Sector	Name	ID	Average flow (m3/day)
CHISINAU	Botanica	PS CODRU	18	1 298
		PS SÎNGERA	19	1 904
		PS SÎNGERA ŞCOALA	21	N/A
	Buiucani	PS CHIMISTUL	15	168
		PS DURLEŞTI-CARTUŞA	Ca	131
		PS GHIDIGHICI	14	144
		PS PRUNCUL	13	440
		PS SCULENI	7	983
		PS V. LUPU	4	2 015
		PS VATRA	12	1 620
	Centru	PS COSTIUJENI	8	939
		PS DOC-CPL	20	294
		PS HÎNCEŞTI	6	272
		PS LERMONTOV	3	37
		PS MOTEL	10	2 707
		PS TRIFAN BALTĂ	Tr	43
		PS VIERU	9	1 842
	Ciocana	PS TOHATIN	16	348
		PS TOHATIN-2	To 2	43
		PS VADUL LUI VODA PRINCIPALA	26	1 516
		PS VADUL LUI VODA RAIONALA	27	515
	Riscani	PS GRĂTIEŞTI	17	396
		PS PETRICANI	11	933
		PS PETRICANI-27	5	1 338
		PS STĂUCENI VALE	St 1	248
		PS ZAICHIN-30/1	Za	27
IALOVENI		PS IALOVENI 1	22	1 586
		PS IALOVENI 2	23	1 917
		PS IALOVENI 3	24	143
CHISINAU	Chisinau-Ciocana	Chisinau WWTP	1	152 083

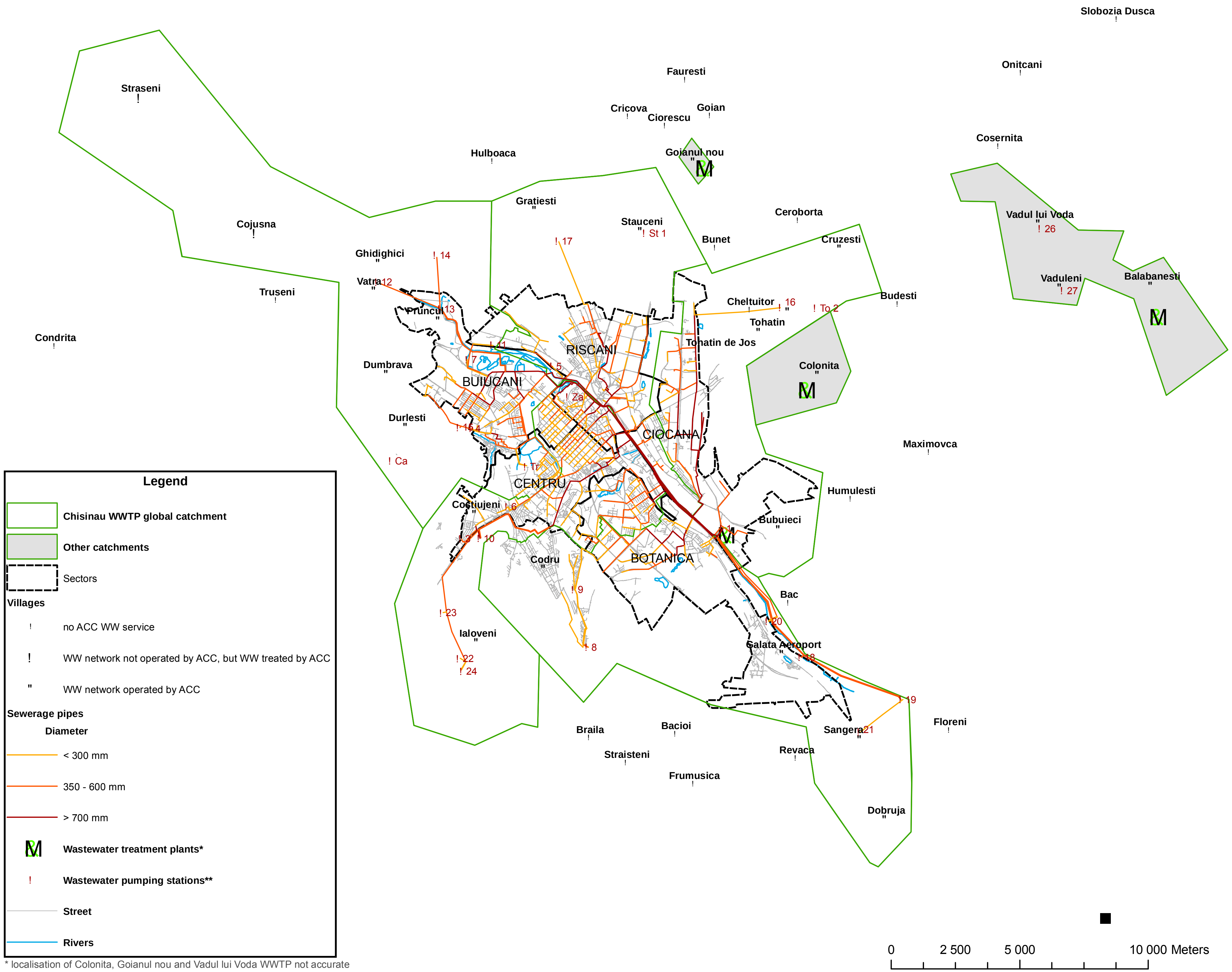
Most of the time, the pumping stations have several pumps operating under both automatic and manual control: pump start/stop is automatic using level sensors in the wet well. The operators manually switch the pumps between duty and standby. During rainfall events, extra pumps are put in duty. PS usually have 2 outlet pressure pipes and a coarse screen at the inlet (cleaned manually).

In the event of a power failure, until the connection to another power supply, wastewater is accumulated in storage tanks or sewers. Wastewater discharge into an adjacent field is not permitted.

1.1.3. General overview of the wastewater system

The following map summarizes the main information previously detailed.

Figure 1.2: Overview of ACC sewerage system



* localisation of Colonita, Goianul nou and Vadul lui Voda WWTP not accurate
** localisation of PS 26, 27 not accurate

Pumping stations		Flowrates
N°	Name	(m3/day)
1	Chisinau WWTP	152 083
3	PS LERMONTOV	37
4	PS V. LUPU	2 015
5	PS PETRICANI	933
6	PS HÎNCEŞTI	272
7	PS SCULENI	983
8	PS COSTIUJENI	939
9	PS VIERU	1 842
10	PS MOTEL	2 707
11	PS PETRICANI-27	1 338
12	PS VATRA	1 620
13	PS PRUNCUL	440
14	PS GHIDIGHICI	144
15	PS CHIMISTUL	168
16	PS TOHATIN	348
17	PS GRĂTIEŞTI	396
18	PS CODRU	1 298
19	PS SÎNGERA	1 904
20	PS DOC-CPL	294
21	PS SÎNGERA ŞCOALA	ND
22	PS IALOVENI 1	1 586
23	PS IALOVENI 2	1 917
24	PS IALOVENI 3	143
26	PS VADUL LUI VODA PRINCIPALA	1 516
27	PS VADUL LUI VODA RAIONALA	515
Ca	PS CARTUŞA-DURLEŞTI	131
St 1	PS STĂUCENI VALE	248
To 2	PS TOHATIN-2	43
Tr	PS TRIFAN BALTĂ	43
Za	PS ZAICHIN-30/1	27

1.2. DEFINITION OF THE FLOWS

1.2.1. FLOW QUALITY: TYPE AND CHARACTERISTICS OF WASTEWATER

ACC sewerage system is separate i.e. the wastewater network is designed to collect only foul water. The wastewater collected is of 2 types:

- **Domestic** wastewater
- **Industrial** wastewater

However, there are many evidence of intrusion of **additional water** into the wastewater network:

- Temporary additional water: during rainfall events, the flow increases in PS and WWTP. This shows the presence of **storm water**.
- Permanent additional water: At night, when human and industrial activities are minimum, the flow arriving at the WWTP is still important. This shows the presence of **intrusive water**.

The intrusive water can have different origins:

- Physical infiltration: groundwater penetrates the sewerage system through construction defects (dislocated pipes, cracks, collapses, leaking shaft walls and others). The physical infiltration has a considerable deteriorating effect on the structural state of the pipes.
- Natural inflows: water coming from natural water spring and underground drainage systems incorrectly connected to the sewerage system (systems for lowering the water level, buildings protection systems and others).
- Physical losses from water supply: water coming from leakages in the water supply network;

The additional waters should not be found in the network. The analysis of the measurement campaign results will lead to an estimation of the volumes of additional water. Recommendations will then be made, based on this estimation, in order to remove storm and intrusive water from the sewerage system.

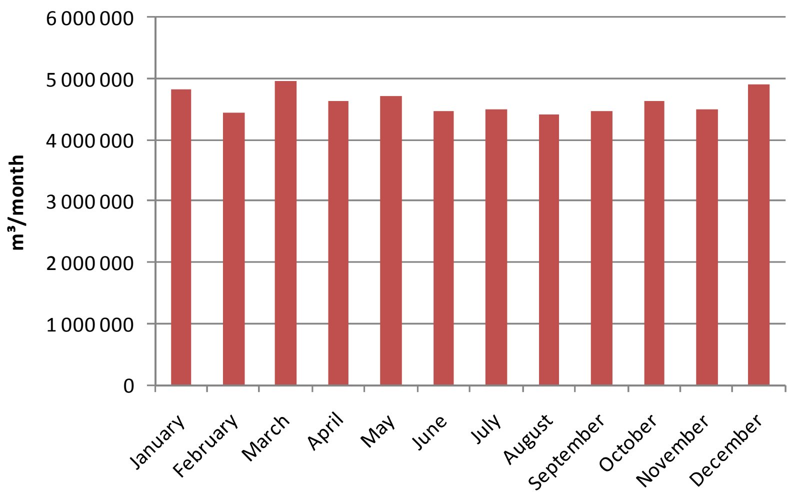
1.2.2. FLOW QUANTITY: FIRST GLOBAL FLOW BALANCE

The only available data regarding flow quantity are the measurements from the flowmeter at the entrance of the WWTP.

1.2.2.1. Yearly fluctuation of the flow

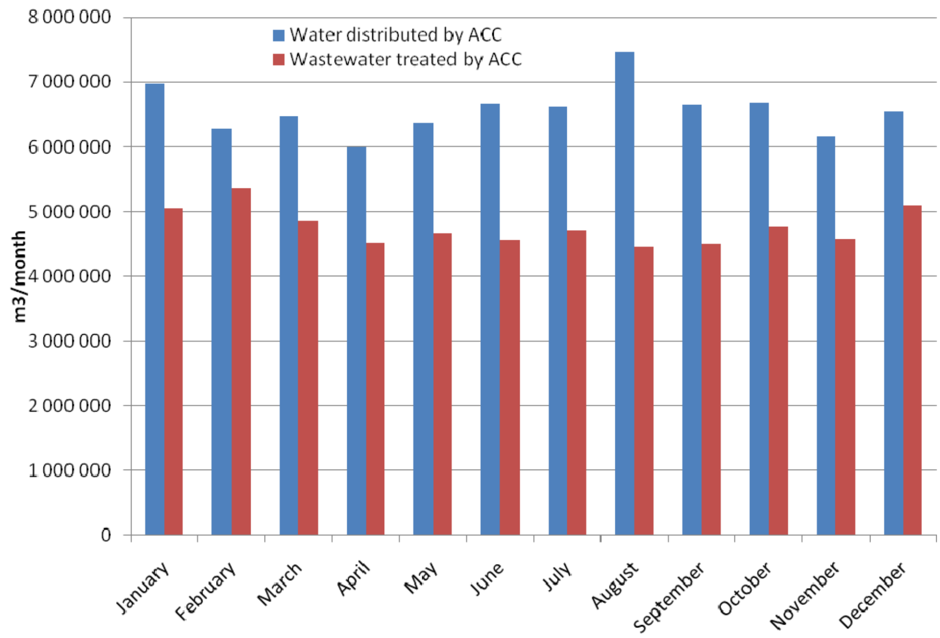
There is an average of **56 500 000 m³/y** arriving at the WWTP. There is no important fluctuation of the flow through the year that can be noted on the last 3 years records.

Figure 1.3: Average monthly flows (2007-2010)



The received volumes at the WWTP can be compared to the volume of water sent into the network.

Figure 1.4: Monthly water and wastewater volumes in 2010



There is a seasonal fluctuation of the water demand that does not appear clearly in wastewater.

Such a graph suggests that there are probably important leakages in the water system (difference between water volumes sent to the network and wastewater volumes arriving at the WWTP) and important intrusive water volumes in the sewerage system (no clear seasonal fluctuation of the wastewater volumes). The analysis will be completed with more information in the next step of the project.

Rainfall can also have an impact on the WWTP volumes, as some of it finds its way to the foul sewerage system.

Table 1.6: Monthly precipitations in 2008-2010

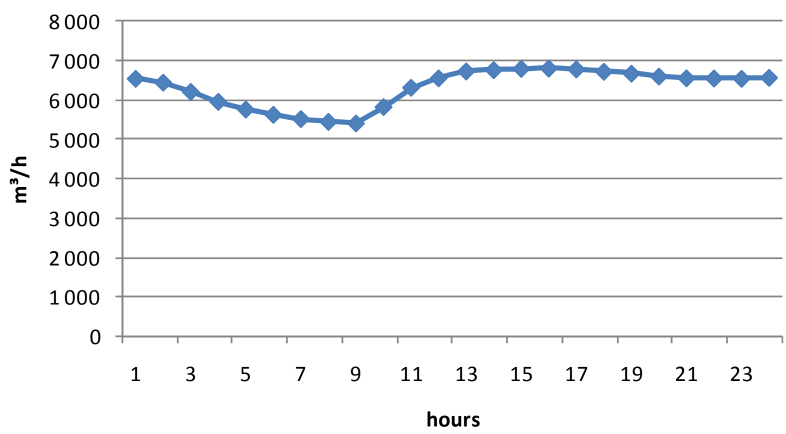
	Precipitation mm		
	2008	2009	2010
January	26	25	86
February	6	26	62
March	36	63	29
April	48	3	45
May	43	33	69
June	63	39	85
July	51	68	67
August	31	33	53
September	75	22	46
October	16	30	69
November	16	9	40
December	55	95	83
Total	**466**	**446**	**734**

There is no significant impact of the rainfall on the wastewater volumes at a monthly time step. The analysis will be completed with more information, on a finer time step, in the next phase of the project.

1.2.2.2. Daily flow

The daily flow at the WWTP is about **152 000 m³/d**. The flow pattern is repetitive and typical for a domestic wastewater with 2 peak flows.

Figure 1.5: Daily flow at the WWTP (average in 2007-2010)



However, when compared to a standard pattern, in Chisinau, the 2 peak flows, as well as the minimum flow, are moved forward in the day:

- the first peak, usually morning peak, happens early in the afternoon
- the evening peak, usually close to diner time, happens around 23h
- the minimum night flow, usually between 2 and 6 AM, happens around 10 AM.

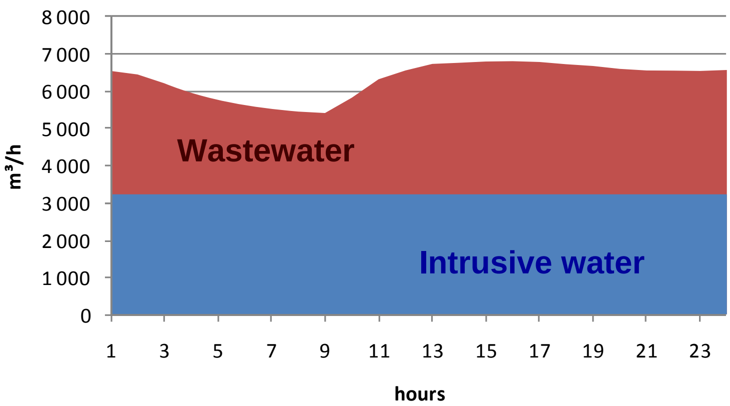
This time-lag is due to the fact that the collection catchment is big and that it takes time for the wastewater, discharged far away in Chisinau, to reach the WWTP. The other time-lag factor is the position of the flow meter: it is set in the WWTP after the inlet chamber and the pumping station. This creates a buffer effect in time and lowers the peak flow while increasing the minimum flow.

1.2.2.3. First estimate of intrusive water

The intrusive water volume can be estimated by the “night minima method”.

At night time, the activity, both human and industrial, is minimum. There should be almost no wastewater discharged in the wastewater system. Therefore, it is considered that most part of the minimum flow is intrusive. The figure usually used is between 80 and 90%. In the case of Chisinau, as there are a lot of industries and, in order to take into account the buffer effect, the assumption taken for this first estimate is low: only 60% of the minimum flow is considered as intrusive (this will be adjusted in the next step of the project).

Figure 1.6: Estimate of the intrusive water volume (average in 2007-2010)



Based on these assumptions, the intrusive water represents, at least, **51%** of the daily volume pumped and treated by ACC. This generates operational costs that could be avoided. The exact volumes of intrusive water will be assessed with the results of the measurement campaign.

1.3. O&M

These aspects are covered in a separate report entitled “Organization Report”.

1.4. MAIN ISSUES OF THE SEWERAGE SYSTEM

As part of the inception report, the present chapter aims at giving the first findings of the main problems that ACC faces with its sewerage system and of the main issues that will be assessed during the project.

On a day-to-day basis, the main problems of the sewerage system are the interventions that ACC has to make to remove blockages. These blockages have several causes presented in this chapter as well as other issues that need to be addressed.

1.4.1. COLLECTED WATER

1.4.1.1. Type of water collected

The wastewater collection systems are designed as “separate” systems. As indicated by the flows received at the wastewater treatment works during heavy rainfall, some surface water does find its way inevitably into the “foul” wastewater system, either by intent or by accident. The analysis of the flow shows the presence of intrusive water (more than 50 %). The type of water collected are :

- **Wastewater**, for which the network was designed
- **Additional water** that should not be found in the network :
  - **Storm water**
  - **Intrusive water**

The presence of additional water together with the wastewater generates extra operational cost: pumping and treatment. It can have another consequence: as the system has been designed for sewage only, there are no stormwater overflows. Therefore, in case of heavy rain, as stormwater does find its way into the sewage network, flooding might occur.

1.4.1.2. Quality of wastewater

Wastewater with abnormal quality

The wastewater collected is domestic and industrial. ACC checks the quality of the wastewater, but some irregular discharges occur:

- **Industrial toxic products**: it can be a threat for the network structure (corrosion), for the treatment and for the staff working on the sewers
- **Grease**: discharged by restaurants and the like into the sewerage system. Grease is a frequent cause of blockage
- **Hydrocarbon**: discharged by garages and the like into the sewerage system. Hydrocarbon is a heavy source of pollution
- **Miscellaneous**: it appears that not only wastewater is discharged in ACC network : solid wastes also are and they cause blockages

Only foul wastewater should be discharged in the network. The installation of grease and oil removal traps is compulsory by a regulation from the Ministry of Environment. The industrials should discharge wastewater respecting a quality defined by a norm, approved by the Municipal Council of Chisinau.

In all cases, not all properties or industrials are compliant. When an ACC intervention team identifies a related problem, a laboratory team is sent to investigate and to take samples for analysis. Apa Canal does have the necessary powers to fine, take to court or, in extreme cases, terminate the water supply to the offender.

Industrial wastewater

In order to check the compliance with the norms, technical inspectors from ACC regularly take samples of the wastewater discharged by each industry for analysis.

For some industries, pre-treatments have been implemented, but, most of the time, they do not function any more, due to a lack of maintenance.

Industries, whose wastewater has concentrations in pollutants higher than the norms, have special contracts with ACC defining the financial penalties for discharging their wastewater into the network. There are 4 major industries, with highly concentrated wastewater, that are allowed to discharge their wastewater by trucks directly into the wastewater treatment plant.

It was reported that some industries also discharge their wastewater illegally into the network, often in the suburbs of Chisinau City.

The list of the industries discharging their wastewater into the sewerage network and whose wastewater quality is controlled by ACC is given in Annex 3, as well as the volumes discharged. The industries discharging the biggest volumes of wastewater are given in the following table.

Table 1.7: 15 industries discharging the most important volumes of wastewater.

Sector	Customer number	Name of industry	Economic sector	WW Volume (m3/day)
Ciocana	5-647-33	S.A. "Efess Vitanta Moldova Brevery"8	Beer factory	254
Ciocana	5-620-33	S.A. "Combinatul de articole din carton"	Production of cardboard articles	143
Ciocana	5-645ps	S.A."Moldovahidromaş"	Pump factory	133
Ciocana	5-624ps	S.A. "Tutun"	Cigarette factory	124
Centru	6-442-33	SRL "Lemi Invest"	Supermarket, restaurants, car wash	115
Buiucani	3-684-33	"Aroma-Coniac"	Wine factory	104
Ciocana	5-637-33	Î.S. "Fabrica de sticlă"	Glass Container	100
Ciocana	5-607ps	S.R.L. "Coca Cola Balters"	Coca Cola factory	89
Botanica	35-435-33	SRL"Zernoff"	Production of spirits	87
Botanica	4-619-33	S.A."JLC"	Milk processing factory	84
Buiucani	3-942-33	"Proalfaservice"SRL	Offices	82
Botanica	4-618-33	S.A. "Franzeluta nr. 2"	Bakery	77
Ciocana	4-618-33	S.A. "Franzeluţa nr.4"	Bread factory	72
Ciocana	5-861-33	Î.C.S "Shan Lian International Group"SRL	Shopping Centre	68
Buiucani	3-707-33	Bucuria	Pastry goods	65

(source : documents from ACC called “industrii vizate in progr de prelevare a probelor si calitatea efluentului industrial 2009-2010 »)

The most important industries are located in Ciocana sector.

Wild discharge of septic tanks

Population connected to the sewerage network is about 633 000. Population in ACC service being 785 900 inhab, about 80% of the population served by ACC is connected to the sewerage network. The other 20 % of the population use septic tanks.

Due to a lack of vehicles, ACC has put in concession the service consisting in emptying the septic tanks. ACC has an agreement with a private company called “Solutio Grup” which provides trucks to empty the septic tanks. ACC only provides only a service of wastewater transportation, at a cost to this tanker company, for the tankers to safely discharge their collected waste.

The trucks should discharge the wastewater in the WWTP. In practical terms, part of the collected wastewater is discharged into the sewerage network and part of it in the WWTP.

1.4.2. STRUCTURAL STATE

Apa Canal O&M staff considers that the main problem with the sewerage network is the sewer blockages and collapses that are due to the condition of the pipes.

The sewerage system was commenced in 1936, within the older city centre area, which is mainly on the right bank of the Bic River. The latest pipes were laid in the 1970’s and 1980’s with the development of the city that took place during that period. There have been few sewers laid since that period.

ACC has no precise localisation of the main problematic zones, but the majority of interventions are in the city centre, which has the oldest and worst state network.

Worn pipes lead to frequent collapses. An old material has cracks through which roots can enter the pipes: according to ACC’s head of sewer department, roots in the pipes are one of the most frequent causes of blockage.

According to the list of interventions on the sewerage network, the main causes of blockages are :

- sludge deposits
- roots in the pipes

The most frequently replaced pipes are asbestos cement pipes, which are replaced by PVC pipes.

1.4.3. DESIGN OF THE SYSTEM

1.4.3.1. Design flow and risks of oversizing

According to the first data collected, the system was designed for a flow that was probably over-estimated and that has reduced since the implementation of the collecting system. This will be assessed during the project with the help of the measurement campaign and the hydraulic model.

If the system is oversized, then the velocity in the pipe can be too low to maintain the self cleaning conditions. Sedimentation/siltation then occurs, and deposit accumulates in the bottom of the pipes. This has 2 major consequences:

- Reduction of the pipe section: this is not a problem in normal condition, unless it completely blocks the pipe, but can become a problem if the flows increase, permanently with housing development or temporarily during specific high flow reasons such as an exceptional heavy storm, and the pipe section is not sufficient any more. The silting will also cause problems if the silting has hardened to a substance that cannot be eroded by the increased flow, and when a CCTV camera is tried to be passed through the sewer.

- Gas release: inside deposit, anaerobic conditions are maintained leading to fermentation and H_2S release.

1.4.3.2. Stormwater overflow

According to ACC, there is no illegal discharge of untreated wastewater into water courses or natural environment. This will be further inspected in the next step of the project.

1.4.3.3. Siphons under the Bic river

The Bic river is boarded by 2 sewer mains, one on each side of the river. Those mains were designed so that works could be done on partial sections of the pipes. Therefore, to unable water removal from the works section, siphons were constructed, connecting right and left bank sewers. Siphons were designed to be closed all the time and open only during the works phases.

However, currently the siphons are always completely open due to the difficulty of manoeuvring the valves. It means that the 2 main sewers are inter-connected without control. This might also generate some problems because siphons are very difficult to operate and maintain. They are sensible to siltation and sand deposit. If they are blocked, then they cannot easily be open again.

1.4.3.4. Connection rate

Approximately, 633 100 customers (81 % of the population that comprises the potential customer base) are considered to be connected to the Apa Canal maintained system. Ultimately, all customers should be connected to the main network.

1.4.4. Issues related to the O&M

1.4.4.1. Equipments

Most of the interventions occur on the pipes with a diameter smaller than 300 mm. This is because they are the most frequent pipes and also those with a small section subject to blockages.

When problems occur on bigger pipes, ACC maintenance teams face difficulties: hydrocleaning trucks can only clean up to 400 mm pipes. Interventions on big pipes are scarce because they are less at risk, but it should be noted that because ACC does not have the proper equipment for such interventions.

The hydrocleaning trucks are old and there working pressure dramatically decrease in the years: about 1/3 of their initial pressure. Therefore, they are no longer efficient enough.

Some vehicles are simply too big for interventions in the small streets.

There is no CCTV equipment available to inspect the pipes.

1.4.4.2. Available data

The operation of a network requires a good cartographic system. Currently, ACC has a good local knowledge of its system, but misses a central database with all the information. Data are available but in bits and pieces without a global view:

- A detailed sewer network paper plan is available for each Sector, but it is not always up-to-date and it is difficult to read. Moreover, the Sectors are not divided in a coherent hydraulic way (administrative division) and there is no global exhaustive map.
- Whilst considerable historical data are held concerning the network and the pumping stations, this is paper-based, and not readily available for use as a basis for asset rehabilitation/replacement programming or for work planning
- There is no precise localization of the major problematic zones

The GIS implemented in the frame of the project will give a solution to this problem.

2. WASTEWATER COLLECTION : PROPOSALS TO BE ELABORATED WITHIN PHASES B & C

In order to improve the knowledge of the wastewater flow and of the sewerage system, and in order to propose solutions to the issues faced by ACC, in the frame of the project, the following will be implemented:

- a measurement campaign
- an hydraulic model

2.1. MEASUREMENT CAMPAIGN

2.1.1. METHODOLOGY OF THE MEASUREMENT CAMPAIGN

2.1.1.1. Objectives of the measurement campaign

The measurement campaign has several purposes:

- To assess the volume of wastewater on a fine basis (sub-catchments)
- To define the daily profile of the wastewater discharge in the network (peak coefficient, daily volume...)
- To estimate the volume of additional intrusive water (infiltration water, river...) under dry weather conditions
- To collect data for the calibration of the hydraulic model

The objective is to assess the dry weather conditions. The storm water will not be taken into account, as the network is supposed to be a separate system and stormwater is not under ACC responsibility.

2.1.1.2. Presentation of the measuring equipment

The measurement campaign includes flow measures but also rain measures in order to remove the storm water flow from the calculation of the wastewater discharge: rainy days will be excluded from the period of analysis.

Flow measurements

The flow in the pipes is obtained by recording the fluctuation of both:

- Water level : with a piezometric sensor
- Velocity : with an ultrasonic sensor (Doppler)

Those are called level-speed measurements. The sensors are installed on a stainless steel plate fixed to the pipe by drilling. The measuring equipment is called a MAINSTREAM (Hydreka).

Figure 2.1: Speed and water level sensor – preparation and installation

In both cases, measurements are sent to a logger with a recording time step of 5 minutes. The logger is programmed with a special software (Winfluid) to record the measurements. For the Mainstream, the software computes the 2 measurements with the known section of the pipe in order to calculate the flow.

This flow measuring technique allows freeing the measurements from the problem of pipe filling and change in the flow direction.

The Mainstream needs to meet the following condition to operate correctly:

- Minimum speed around 0.05 m/s
- Minimum water level 3 to 5 cm
- No deposit (sand) on the sensors
- Water not too clear (speed sensor wouldn't work for drinking water)

A total of 6 mainstreams will be used.

Additionally, the flow will also be measured at the WWTP, on a 3 minutes time step basis. Those measurements will be made using the local "DigitalFlow DF868" equipment from GE Panametrics.

Rain measurements

The rain measurements are made with a rain gauge working with a tipping bucket of 0.2 mm. This way of measuring is very accurate and optimizes the recording.

The raindrops fall into a funnel and fill a small bucket. Every 0.2 mm of rain, the bucket is full and drops, emptying itself while giving an impulse to a logger. Then the bucket goes back to its normal position, waiting for the next 0.2 mm to come. The logger can also be programmed through the specific software Winfluid.

For the campaign, 2 rain gauges will be used. The position of the gauge will be chosen according to its position in the catchment and to its immediate surrounding (no tree or big building that might stop part of the rain).

Figure 2.2: Rain gauge on its support

2.1.1.3. Measurement campaign steps

In order to define the measurement campaign, the first step is to get an accurate map of the network and a good knowledge of the flow directions and hydraulic connections.

The second step is to define the measuring points and the measured catchments according to the theoretical knowledge of the network.

The third step will be to go on site and define the exact location (which manhole) where to put the equipment, considering the conditions for:

- Access
- Security
- State of the pipe (not too much deposit)
- State of the flow (sufficient water level, speed neither too low nor too high...)
- The hydraulic conditions (no angle, no vortex)

After finding an agreement on every point, the measurement campaign will be ready to start with installing the measuring equipment. Their working condition will be checked on a regular basis during the campaign (every week).

The campaign duration for having representative dry weather flows will be around 2 weeks (depending on the rain frequency).

After 2 weeks, the equipments will be removed and the measurements downloaded.

2.1.1.4. Planning of the measurement campaign

The detailed planning of the measurement campaign will be made later on the project. A specific measurement campaign will be carried out on each of the 5 major hydraulic catchments with 6 flow meters each.

2.1.2. Location of the measuring points

A first location of the measuring points was defined. It now needs to be validated on site.

The measuring points are selected in order to measure the widest area possible. When it is not possible to measure all the areas, the points are selected to measure a representative part of the network so that, later on, extrapolation can be done.

It may not be possible to install all the available equipment in some of the catchment areas for the following reasons:

- Bad or no access to the manholes
- Too high or too low level of wastewater into the network
- Too important velocity of the flow

The program of the measurement campaign will be detailed in the next step of the project.

2.2. HYDRAULIC MODEL

2.2.1. PRESENTATION AND OBJECTIVES OF THE HYDRAULIC MODEL

2.2.1.1. Hydraulic model objectives

In the case of Chisinau, the hydraulic model is developed to:

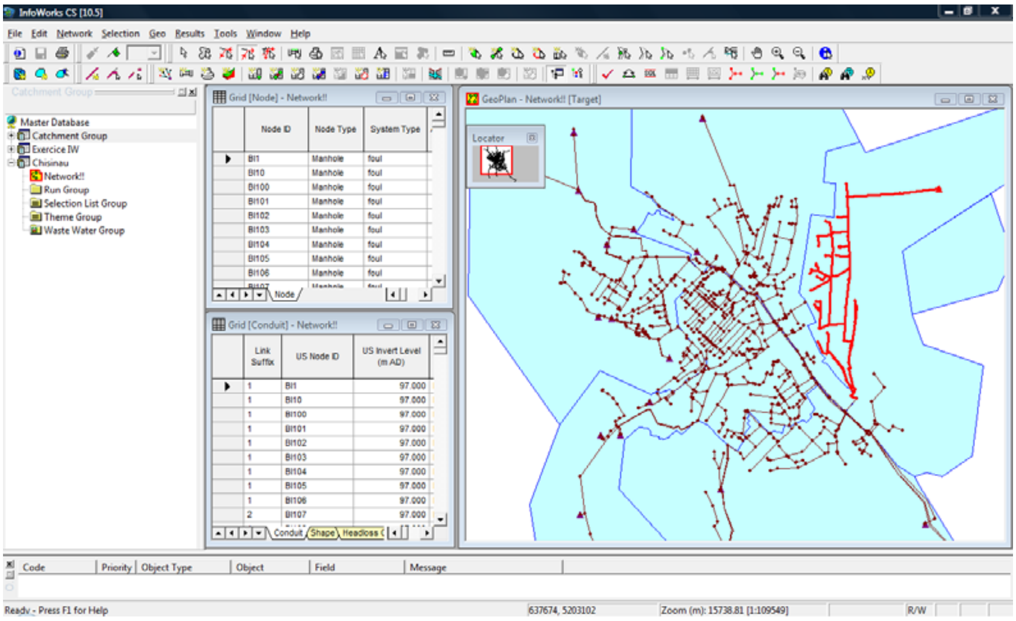
- Estimate the dry weather flow at any time of the day in any point of the network : flow, speed and level will be available at a very fine time step in every part of the modelled network (skeleton network)
- Calculate the maximum flow capacity of the pipes and identify the hydraulic black spots of the network (bottlenecks)
- Create and test scenarios in order to :
    - o Remediate the black spots
    - o Model an increase of the discharge based on the development scenario
    - o Model the connection of a new area to the central system

2.2.1.2. Presentation of the modelling tool

The software used during the project is Infoworks, developed by HR Wallingford. It is an international well-known software that combines:

- Computation of the pipe flow (hydraulic) based upon the *Barré de Saint Venant* equations for gravity flow and *Colebrook* equations for pressure flow. It can deal with pipes, pumps, weirs, valves...
- Computation of the rain (hydrology) not used in the present project (but it might be used later). A choice among several models is possible.
- Geographical interface that can communicate with a GIS

Figure 2.3: Infoworks interface



2.2.1.3. Modelling methodology

For all models (physical, mathematical, digital), the methodology applied is the same:

- First step : construction
- Second step : calibration
- Third step : diagnosis
- Fourth step : simulation of scenarios

At the time of writing, only the first step was started: the existing network was skeletonised into a hydraulic model, which means that it covers only the main collectors of the sewerage system.

Pipes and nodes were entered into the model but their characteristics are missing (elevation, diameter). This will be done in the next stage of the project. The model of Chisinau was constructed on the basis of the first information collected. It is made of:

- o 913 nodes (manholes)
- o 932 links (pipes)

The total length of Chisinau's network included in the model is 328 km. The skeletonised pipes and nodes are shown in the figure below (this first model will be subject to modification in the next phase of the project).

Figure 2.4: Chisinau's model

2.3. CCTV

2.3.1. Current Situation

As described in the “Organization Report”, currently, Apa Canal has a CCTV, with the ancillary equipment and mobile laboratory (IBAK) that it uses for the inspection of artesian wells only. Such an equipment would be suitable for sewers but the same equipment could not be used for both well and sewer surveys.

The real condition of the sewers is not known and the precise identification of problems is not possible. It is essential that Apa Canal has in place and invests in a sewer rehabilitation/replacement programme. Such a programme can only be prepared after a thorough examination and survey of the sewers, manholes, pumping stations and other assets. An essential requirement for the O&M of the sewers and for the preparation of the rehabilitation/replacement programme will be CCTV surveys of the sewers.

The company had a plan to buy new equipment specific for the wastewater. An option was considered whereby only the camera and cable would be changed, but using the same vehicle. The Ministry of Health gave its approval for such a configuration. Due to financial restriction, this project never went on. Such a configuration is possible but is not recommended because:

- there would always be a risk of cross-contamination
- the computer for analysis is not the latest available and needs updating
- the CCTV of sewers will be extensive and the equipment will be required full-time for sewer surveys.

It would be better to purchase totally separate equipment dedicated to wastewater only.

2.3.2. Proposition in the frame of the project

Within the subsequent Phases of the Feasibility Study, the Consultant is required to prepare the ACC team for a general sewerage CCTV survey. In order to achieve this task, several equipments will be bought, a global methodology will be presented and the ACC team will be trained. The details of this program will be defined after discussion with ACC.

2.3.2.1. Use of the current CCTV equipment

The current CCTV-IBAK autolaboratory is perfectly suitable for sewerage system. It is currently very rarely used and would be better used in the sewers.

The equipment for computing and recording the video and picture could be updated so as to record live and directly print the report after the inspection. Such an update (new computer, new screen and printer) corresponds to an investment of about **1 500 €.**

The CCTV-IBAK could be replaced in the artesian wells by a Gator Cam 3 that can be used down to 100 m deep (10 bars) in clear water. Gator Cam 3 is smaller, can fit in any vehicle and is easy-to-use. The specification for this CCTV equipment is:

- Drum of steel pipe with rotating contact, and 150 m cable
- Controller with video/photo storage on a up to 8 Gb Compact Flash card, editing the inspection report
- keyboard and monitor
- Tape measure for the inspection length

- Colour Camera, 50 mm diameter with horizontal view and auto focus
- Adapters for large diameters: 100 mm, 200 mm and over 200mm (max 300 mm without centralization in the pipeline)
- Battery 12Ah for maximum operation time 8h

Figure 2.5: Example of camera

The cost of this water equipment is estimated in total at **16 000 €.**

2.3.2.2. Quick View equipment

To be used in association with the CCTV for the sewer survey, the video equipments known as “Quick View” are proposed. They are cheaper, quicker and easier to use than full CCTV equipment. As they are simpler, they are also less detailed but are a very efficient first step in the inspection of the sewerage system. The following picture presents Quick View equipment:

Figure 2.6: Quick view equipment

The equipment comprises a rod with a video camera which is inserted into sewer manholes. The camera is pointed to inspect the internal bore of the incoming and outgoing sewer, and the manhole. The camera can focus, and thus inspect, up to 50 m from a chamber i.e. with each insertion into a chamber up to 100m of sewer can be inspected.

The required Specification for the equipment is:

- 1No Telescopic rod of length 19.5 m
- 1No 18x optical camera, with 12x digital zoom;
- Lighting system with 2 spotlights;
- Control system;
- Armoured cable 15m;
- Battery and charger;
- Rigid bag for transportation;
- Viewing and recording system;

The equipment cost is **13 500 €.**

In addition, a vehicle and other requirements such as safety barriers, road traffic cones and portable warning signs will be required for each team.

As the average distance between manholes is 40m, with the “Quick View” almost a complete preliminary exploratory survey of the sewers will be possible.

A two-men team with a Quick View equipment could make 15 to 20 surveys per working day (inspection of 600 to 800 m/d). At this speed, **with 5 teams, the inspection of the entire sewerage network (25 200 manholes) could be achieved in only 1 year** (250 working days).

2.3.2.3. Methodology

The “Quick View” could be used to survey the sewers and the identified problems. Depending upon the extent of damages, or the condition of the sewer or for any other problem for which a more detailed survey is required, a CCTV survey would be arranged.

Most of the time, CCTV will require a jeting/hydrocleaning prior to the inspection.

From the survey, the sewers in need for rehabilitation will be identified, the most appropriate solution determined and cost-estimated. Individual projects will be prioritised according to the seriousness of the current sewer condition and according to the consequences of a failure both for the operation of the sewer system and for other consequences, such as flooding or traffic disruption in the event of a collapse.

2.3.2.4. Conclusion

Full training programme in the use of the equipment and the interpretation of the images obtained is to be provided in the frame of the present project.

In the next step of the project, after having agreed with ACC on the number and characteristics of equipments to be purchased and the number of teams to be trained, a training program will be implemented based on the equipment bought by the project. Moreover, a global methodology will be provided for CCTV best practices in order to optimize O&M.

Annexes

LIST OF ANNEXES

Annex 1 Wastewater pumping stations characteristics

Characteristics of the wastewater pumping stations

City	Sector	N° (Autocad/ID)	NAME	Pump N°	Type	Flow rate in m3/h		Head in m		Power in kW	
						Nominal	Real	Nominal	Real	Nominal	Real
CHISINAU	Centru	10	PS MOTEL	1	SM200x150x500/4	420	400	80	80	160	150
				2	SM200x150x500/4a	400	380	75	70	160	119
				3	SM200x150x500/4a	400	380	75	70	160	109
				4	SM200x150x500/4a	400	380	75	70	160	109
	Buiucani	4	PS V. LUPU	1	FG216x24	217	216	20	18	22	24
				2	FG216x24	186	175	18	18	22	21
				3	FG216x24	207	197	18	18	22	18
	Centru	3	PS LERMONTOV	1	ȚMC16/27	20	16	27	26	3.2	3
	Buiucani	7	PS SCULENI	1	FG216x24	208	197	20	18	30	23
				2	FG216x24	216	216	24	18	30	27
				3	FG216x24	186	175	18	18	22	14.5
	Riscani	11	PS PETRICANI	1	FG144x10,5	147	144	11	6	11	8
				2	FG144x10,5	147	144	11	6	11	8
	Centru	9	PS VIERU	1	SD160x45(x2)	165	160	44	42	64	71
				2	SD160x45(x2)	164	160	44	42	64	73
	Centru	6	PS HÎNCEȘTI	1	FG216x24	207	197	21	17	22	17
				2	FG216x24	186	175	18	17	22	14.5
	Riscani	17	PS GRĂTIEȘTI	1	WILO FA 08.43E	40	20	24	13	4.8	4
				2	WILO FA 08.43E	40	20	24	13	4.8	4
	Centru	8	PS COSTIUJENI	1	SD160x45(x2)	165	160	45	40	74	74
				2	SD160x45(x2)	150	144	45	40	74	80
	Buiucani	12	PS VATRA	1	SD800x32	800	700	32	26	160	95
				2	SD800x32	800	700	32	26	160	95
				3	SM250x200x400	800	660	35	26	160	110
	Buiucani	13	PS PRUNCUL	1	FG216x24	216	210	24	13	30	22
				2	FG216x24	216	210	24	13	30	22
				3	FG216x24	216	210	24	13	30	22
	Ciocana	To 2	PS TOHATIN-2	1	FLYGT CP 3152 SH	18.1	18.1	59	45	15	13
				2	FLYGT CP 3152 SH	18.1	18.1	59	45	15	13
	Buiucani	15	PS CHIMISTUL	1	SM100x65x250/4	60	57	18	10	5.5	5
				2	SM100x65x200/4	55	50	10	10	4	3.5
	Botanica	18	PS CODRU	1	SM250x200x400	800	700	50	35	110	100
				2	SM200x150x500	400	380	45	35	100	90
				3	SM200x150x500	400	380	45	35	100	85
	Centru	20	PS DOC-CPL	1	FG144x46	144	135	46	16	30	21
				2	FG144x46	144	135	46	16	30	21
				3	FG144x46	144	140	46	16	30	22
	Botanica	19	PS SÎNGERA	1	SM250x200x400	800	750	37	35	160	150
				2	SM250x200x400	800	700	32	30	160	110
				3	SM250x200x400	800	700	32	30	160	110
				4	SM150x125x315	250	200	32	30	55	48
	Botanica	21	PS ȘCOALA SÎNGERA	1	FLYGT CP 3102 - 180	50.4	45	N/A	8.21	4.4	4.4
				2	FLYGT CP 3102 - 180	50.4	45	N/A	8.21	4.4	4.4
	Riscani	5	PS PETRICANI-27	1	NP3127HT	80	72	20	11	6	5.9
				2	NP3127HT	80	72	20	11	6	5.9
	Riscani	Za	PS ZAICHIN-30/1	1	TMC16/27	20	16	27		3.2	3.06
	Centru	Tr	PS TRIFAN BALTĂ	1	SE1.50.65	28	24	20	17.5	3	3
				2	SE1.50.65	28	24	20	17.5	3	3
	Buiucani	Ca	PS DURLEȘTI-CARTUȘA	1	SEV.80.80.110.2.51D	48	41	32	28	12.7	11
				2	SEV.80.80.110.2.51D	48	41	32	28	12.7	11
	Riscani	St 1	PS STĂUCENI VALE	1	DESMI DM2338	80	72	40	35	28	22
				2	DESMI DM2338	80	72	40	35	28	22
	Buiucani	14	PS GHIDIGHICI	1	SM100x65x250/4	65	65	20	15	5.5	4
				2	SM100x65x250/4	65	65	20	15	5.5	4
	Ciocana	16	PS TOHATIN	1	SD50x56(x2)	50	45	56	75	22	17
				2	SD50x56(x2)	50	45	56	75	22	17
IALOVENI		22	PS IALOVENI-1	1	SM 200/150/500/4	450	450	95	85	160	160
				2	SM 200/150/500/4	450	400	95	85	160	160
		23	PS IALOVENI-2	1	SM 200/150/500/4	N/A	400	95	87	160	140
				2	SM 200/150/500/4	N/A	400	95	87	160	140
		24	PS IALOVENI-3	1	SM 100-65-200/4	N/A	45	13	10	5	4
				2	SM 100-65-200/4	N/A	45	13	10	5	4
VADUL LUI VODA	Ciocana	26	PS VADUL LUI VODA PRINCIPALA	1	SM 150/125/315/4	N/A	200	N/A	22	N/A	25
				2	SM 150/125/315/4	N/A	200	N/A	22	N/A	25
	Ciocana	27	PS VADUL LUI VODA RAIONALA	1	SM 150/125/315/4	N/A	150	N/A	22	N/A	23
				2	SM 150/125/315/4	N/A	150	N/A	22	N/A	23

N/A : Data non available.

Annex 2 Wastewater pumping stations descriptions

FORM OF SEWAGE PUMPING STATION ID: CHIMISTUL

BASIN : **Date of visit:** 20/12/2010
Street :

Location

Characteristics P/ST

Lat =	47° 1'32.02"C	
Lon =	28°46'34.50"E	
Gr. level (m)=	98.7	м
Elev. Floor P/ST	92.57	м
Volume of reservoir	23.00	м3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	1 person
7	Does the gas detector react	NO

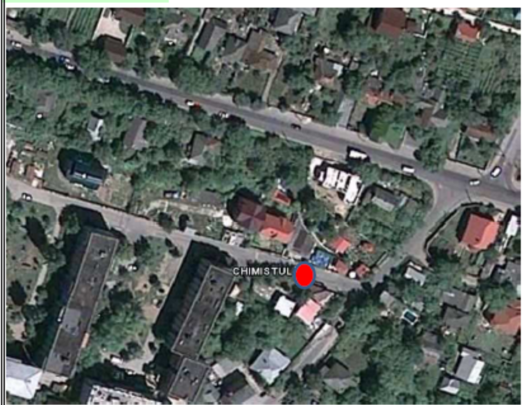
Brief characteristics of pumps

	Type	N real, kWt	N nom, kWt	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	SM100-65-250/4	5	5.5	57.0	60.0	10	18.0	93.4
P2	SM100-65-200/4	3.5	4	50.0	55.0	10	10.0	93.4

Photos pumps

P1-P2

GIS



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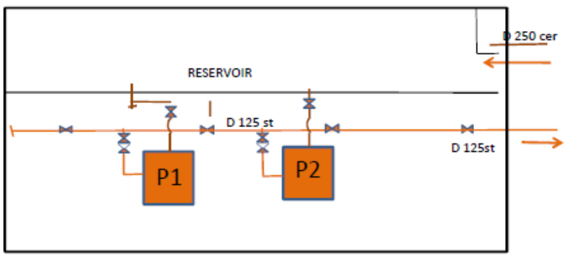


FORM OF SEWAGE PUMPING STATION ID: CPL

BASIN :
Street :
Date of visit: 17/12/2010

Location

Characteristics P/ST

Lat = 46°57'18.38"C
Lon = 28°55'53.54"E
Gr. level (m) = 30,656 м
Elev. Floor P/ST= 23,78 м

Volume of reservoir 165 м3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	1 person
7	Does the gas detector react	NO

Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Qreal (m3/h)	Qnom (m3/h)	Hreal (m)	Hnom (m)	pump axe (m)
P1	FG-144-46	21	30	135	144.0	16.0	46	24.49
P2	FG-144-46	21	30	135	144.0	16.0	46	24.48
P3	FG-144-46	22	30	140	144.0	16.0	46	24.48

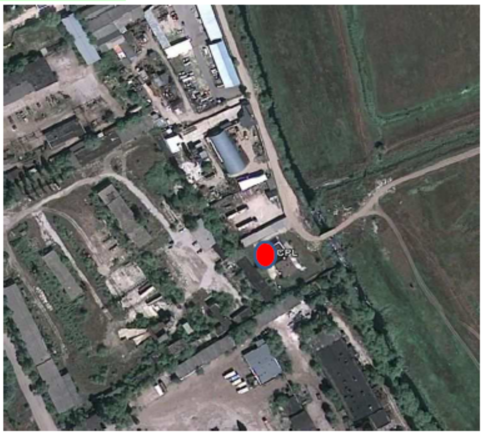
Photos pumps

P1

P2

P3

GIS



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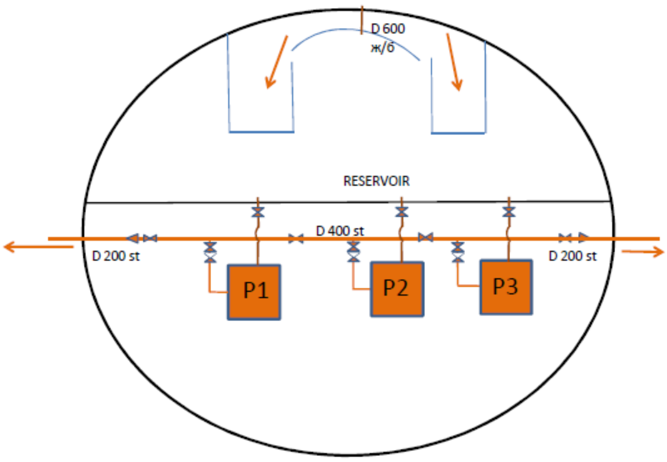


FORM OF SEWAGE PUMPING STATION ID: GHIDIGHICI

BASIN :
Street :

Date of visit: 20/12/2010

Location

Characteristics P/ST

Lat = 47° 5'9.59"C
Lon = 28°45'59.31"E
Gr. level (m)= 70.58 M
Elev. Floor P/ST= 65.51 M
Volume of reservoir 18.00 M3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	4 persons
7	Does the gas detector react	NO

Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	SM100-65-250/4	4	5.5	65.0	65.0	15	20.0	65.91
P2	SM100-65-250/4	4	5.5	65.0	65.0	15	20.0	65.79

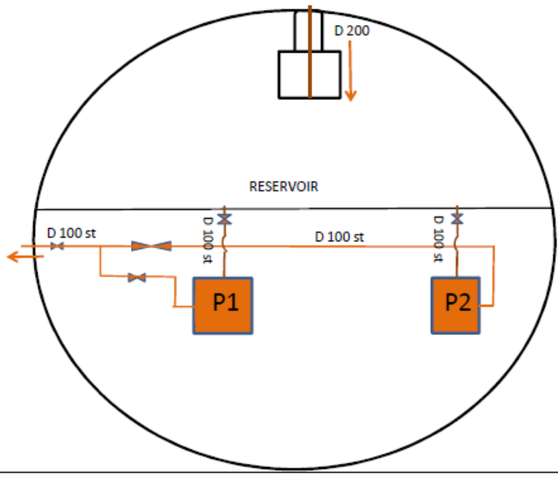
Photos pumps

P1

P2

GIS

Layout



FORM OF SEWAGE PUMPING STATION ID: GRATIESTI

BASIN :
Street :

Date of visit: 20/12/2010

Location

Characteristics P/ST

Lat =	47° 5'24.02"C
Lon =	28°49'44.64"E
Gr. level (m)=	87.63 м
Elev. Floor P/ST=	84.26 м
Volume of reservoir1	250 м3
Volume of reservoir2	165 м3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	4 persons
7	Does the gas detector react	NO

Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	WILO FA 08.43 E	4	4.8	20.0	40.0	13	24.0	84.62
P2	WILO FA 08.43 E	4	4.8	20.0	40.0	13	24.0	84.84

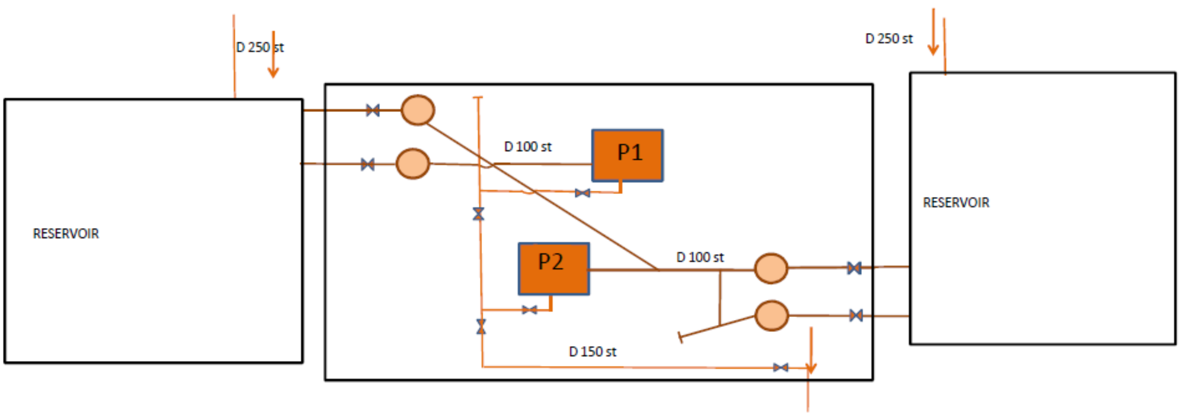
Photos pumps

P1

P2

GIS

Layout



FORM OF SEWAGE PUMPING STATION ID: HINCESHTI

BASIN : **Date of visit:** 21/12/2010

Street :

Location

Characteristics P/ST

Lat =	46°59'50.69"C	
Lon =	28°48'0.46"E	
Gr. level (m)=	199.09	м
Elev. Floor P/ST	192.28	м
Volume of reservoir	69.00	м3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	1 person
7	Does the gas detector react	NO

Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	FG216-24	17	22	197.0	207.0	17	21.0	192.56
P2	FG216-24	14.5	22	175.0	186.0	17	18.0	192.56

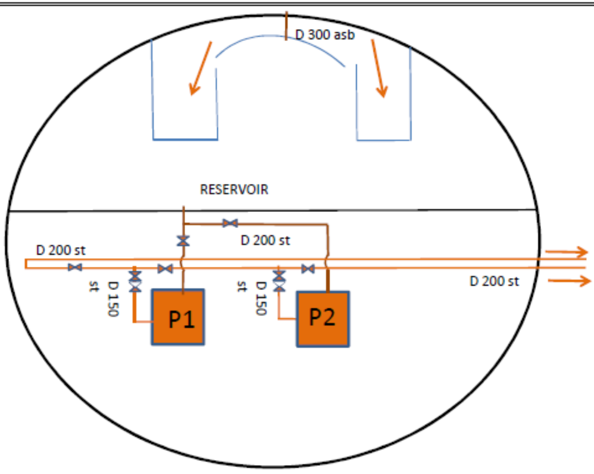
Photos pumps

P1

P2

GIS

Layout



FORM OF SEWAGE PUMPING STATION — ID: KNS-1_Ialoveni

BASIN :
Street :

Date of visit: 21/12/2010

Location

Characteristics P/ST

Lat =	46°56'41.06"C
Lon =	28°46'24.95"E
Gr. level (m)=	72(G) м
Elev. Floor P/ST	м
Volume of reservoir	200.00 м3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	4 persons
7	Does the gas detector react	NO

Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real, (m)	H nom, (m)	pump axe (m)
P1	SM 200/150/500/4	160	160	450.0	450.0	85	95.0	N/A
P2	SM 200/150/500/4	160	160	400.0	450.0	85	95.0	N/A
P3	SM 200/150/500/4	**not mentioned in ACC list 01.01.2011**						

Photos pumps

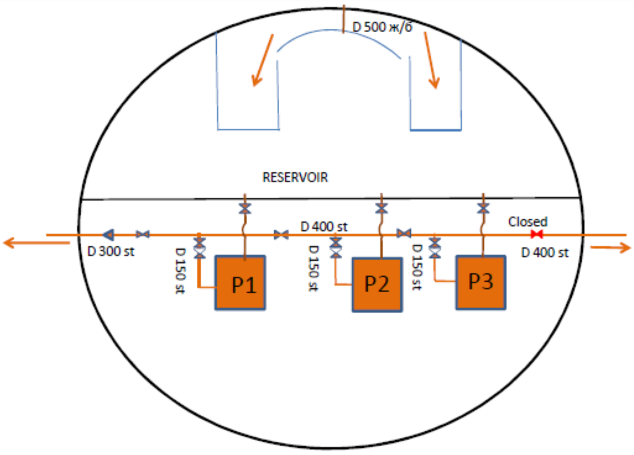
P1

P2

P3

GIS

Layout



FORM OF SEWAGE PUMPING STATION **ID:** **KNS-2_Ialoveni**

BASIN :
Street :
Date of visit: 21/12/2010

Location

Characteristics P/ST

Lat =	46°57'39.03"C	
Lon =	28°45'55.77"E	
Gr. level (m)=	125 (G)	M
Elev. Floor P/ST		M
Volume of reservoir	200.00	M3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	4 persons
7	Does the gas detector react	NO

Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	SM 200/150/500/4	140	160	400.0	N/A	87	95.0	
P2	SM 200/150/500/4	140	160	400.0	N/A	87	95.0	
P3	SM 200/150/500/4	not mentioned in ACC list 01.01.2011						

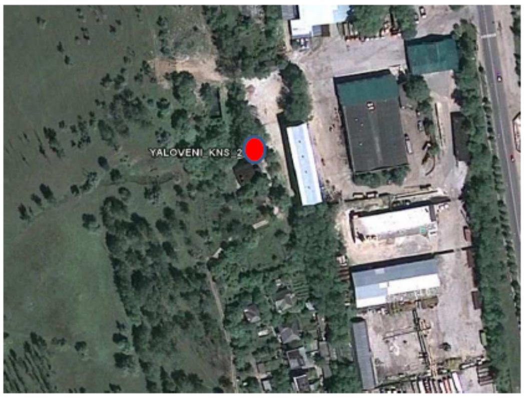
Photos pumps

P1

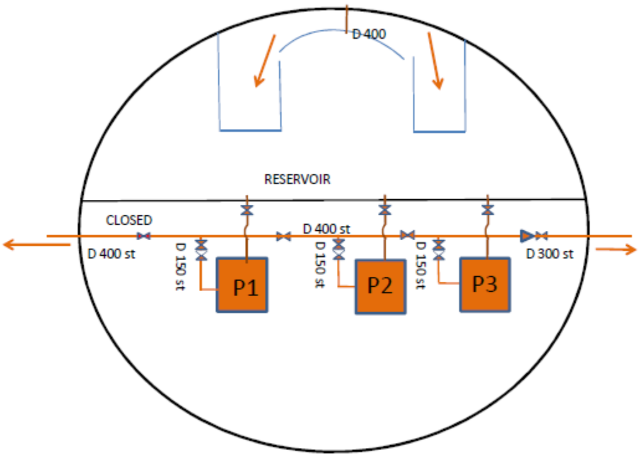
P3

P2

GIS



Layout



FORM OF SEWAGE PUMPING STATION **ID:** **HINCESHTI**

BASIN : **Date of visit:** 21/12/2010
Street :

Location

Characteristics P/ST

Lat =	46°56'24.77"C	
Lon =	28°46'30.64"E	
Gr. level (m)=	68 (G)	M
Elev. Floor P/ST		M
Volume of reservoir	15.00	M3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	1 person
7	Does the gas detector react	NO

Brief characteristics of pumps

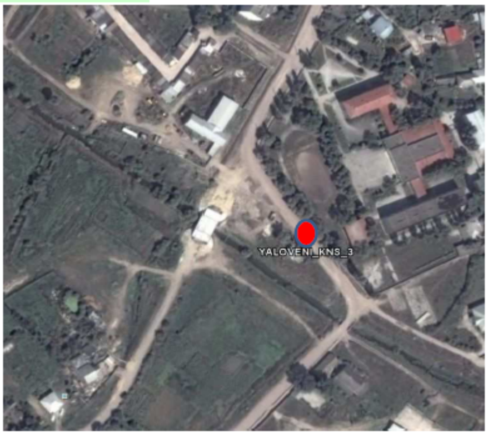
	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	SM 100-65-200/4	4	5	45.0	N/A	10	13.0	N/A
P2	SM 100-65-200/4	4	5	45.0	N/A	10	13.0	N/A

Photos pumps

P1

P2

GIS



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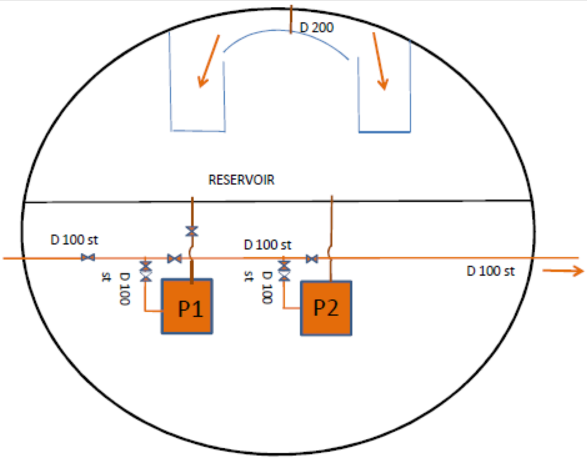


FORM OF SEWAGE PUMPING STATION ID: KODRU

BASIN :
Street :
Date of visit: 17/12/2010

Location

Characteristics P/ST

Lat = 46°56'32.54"C
Lon = 28°56'52.38"E
Gr. level (m) = 27(G) M
Elev. Floor P/ST= M

Volume of reservoir 200.00 M3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	4 persons
7	Does the gas detector react	NO

Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	SM 250-200-400	100	110	700	800.0	35.0	50	N/A
P2	SM 200-150-500	90	100	380	400.0	35.0	45	N/A
P3	SM 200-150-500	85	100	380	400.0	35.0	45	N/A

Photos pumps

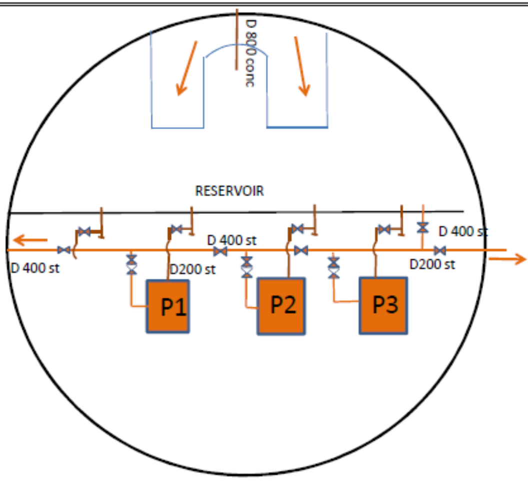
P1

P2

P3

GIS

Layout



FORM OF SEWAGE PUMPING STATION　ID: KOSTIUJENI

BASIN :
Street :
Date of visit: 17/12/2010

Location

Characteristics P/ST

Lat =	46°56'51.44"C	
Lon =	28°50'21.61"E	
Gr. level (m)=	68.48	M
Elev. Floor P/ST=	62.85	M
Volume of reservoir	66.00	M3

More information

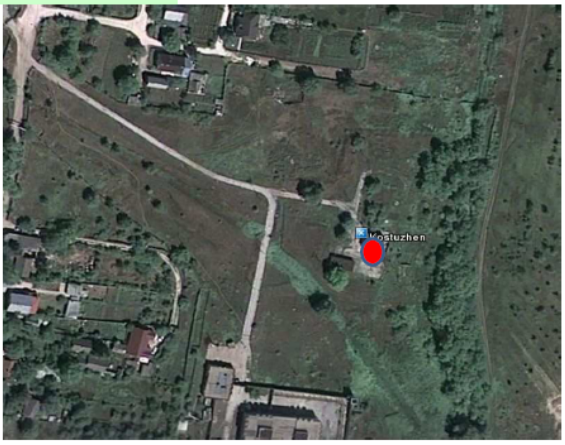
1	Description of the regulation	switch pumps
2	Existance of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	4 persons
7	Does the gas detector react	NO

Brief characteristics of pumps

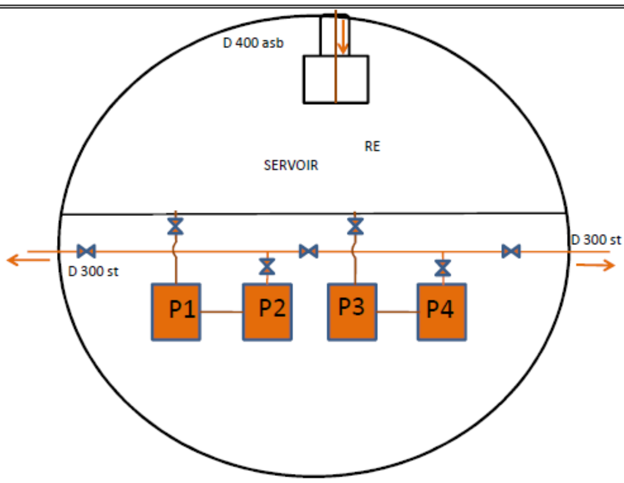
	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom, (m)	pump axe (m)
P1	SD-160-45	74	74	160.0	165.0	40	45.0	63.41
P2	SD-160-45	74	74	160.0	165.0	40	45.0	63.41
P3	SD-160-45	80	74	144.0	150.0	40	45.0	63.41
P4	SD-160-45	80	74	144.0	150.0	40	45.0	63.41

Photos pumps

GIS



Layout



FORM OF SEWAGE PUMPING STATION **ID:** **LERMONTOV**

BASIN : **Date of visit:** 21/12/2010
Street :

Location

Characteristics P/ST

Lat = 46°59'11.87"C
Lon = 28°46'34.46"E
Gr. level (m)= м
Elev. Floor P/ST м

Volume of reservoir 12.00 м3

More information

1	Description of the regulation	automatic P/St
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	0 person
7	Does the gas detector react	NO

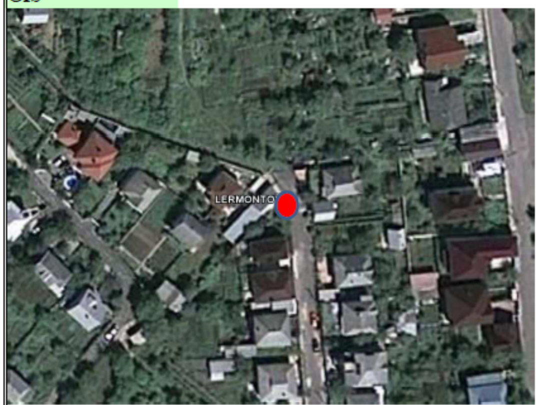
Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	TMC 16/27	3	3.2	16.0	20.0	26	27	N/A
P2	TMC 16/27	not mentioned in ACC list 01.01.2011						

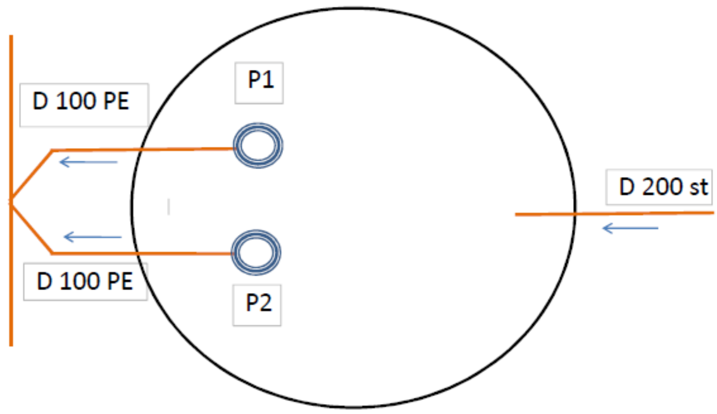
Photos pumps

P1-P2

GIS



Layout



FORM OF SEWAGE PUMPING STATION ID: MOTEL

BASIN : **Date of visit:** 15/12/2010
Street :

Location

Characteristics P/ST

Lat = 46°59'11.71"C
Lon = 28°47'8.17"E
Gr. level (m)= 161 (G) м
Elev. Floor P/ST м

Volume of reservoir 228 м3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	4 persons
7	Does the gas detector react	NO

Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	SM200-150-500/4	150	160	400.0	420.0	80	80	N/A
P2	SM200-150-500/4a	119	160	380.0	400.0	70	75	N/A
P3	SM200-150-500/4a	109	160	380.0	400.0	70	75	N/A
P4	SM200-150-500/4a	109	160	380.0	400.0	70	75	N/A

Photos pumps

GIS

Layout

FORM OF SEWAGE PUMPING STATION ID: PETRICANI

BASIN :
Street :

Date of visit: 21/12/2010

Location

Characteristics P/ST

Lat =	46°59'11.87"N	
Lon =	28°46'34.46"E	
Gr. level (m)=	43.13	м
Elev. Floor P/ST	36.57	м
Volume of reservoir	14.00	м3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	1 person
7	Does the gas detector react	NO

Brief characteristics of pumps

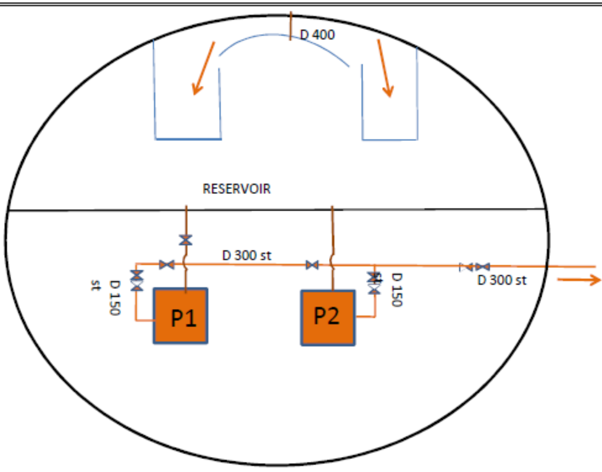
	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	FG144-10,5	8	11	144.0	147.0	6	11.0	37.2
P2	FG144-10,5	8	11	144.0	147.0	6	11.0	37.2

Photos pumps

P1-P2

GIS

Layout



FORM OF SEWAGE PUMPING STATION

ID: PETRICANI_27

BASIN :
Street :
Date of visit: 20/12/2010

Location

Characteristics P/ST

Lat =	47° 2'46.54"C	
Lon =	28°49'28.96"E	
Gr. level (m)=	42 (G)	M
Elev. Floor P/ST=		M
Volume of reservoir	48.75	M3

More information

1	Description of the regulation	automatic P/St
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	0 person
7	Does the gas detector react	NO

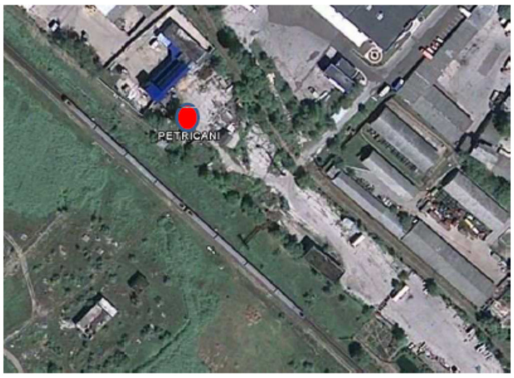
Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	NP3127HT	5.9	6	72.0	80.0	11	20	
P2	NP3127HT	5.9	6	72.0	80.0	11	20	

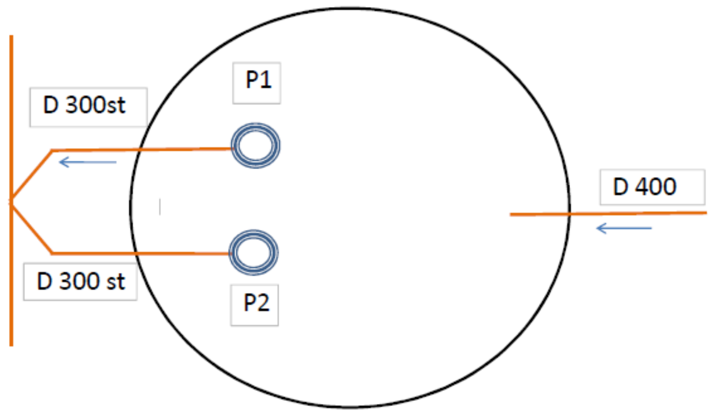
Photos pumps

P1-P2

GIS



Layout



FORM OF SEWAGE PUMPING STATION ID: PRUNCUL

BASIN :
Street :

Date of visit: 20/12/2010

Location

Characteristics P/ST

Lat =	47° 4'1.71"C	
Lon =	28°46'5.13"E	
Gr. level (m)=	50.57	M
Elev. Floor P/ST=	41.85	M
Volume of reservoir	48.00	M3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	1 person
7	Does the gas detector react	NO

Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	FG216-24	22	30	210.0	216.0	13	24.0	42.41
P2	FG216-24	22	30	210.0	216.0	13	24.0	42.41
P3	FG216-24	22	30	210.0	216.0	13	24.0	42.41

Photos pumps

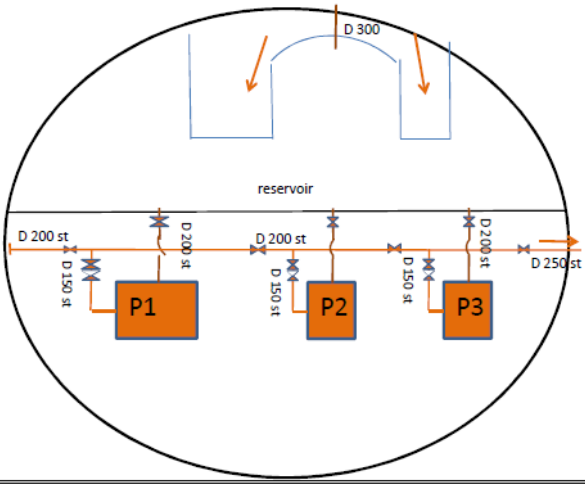
P1

P2

P3

GIS

Layout



FORM OF SEWAGE PUMPING STATION ID: SCULENI

BASIN : **Date of visit:** 20/12/2010
Street :

Location

Characteristics P/ST

Lat =	47° 2'57.04"C
Lon =	28°46'53.36"E
Gr. level (m)=	44.57 м
Elev. Floor P/ST=	38.15 м
Volume of reservoir	138.00 м3

More information

1	Description of the regulation	switch pumps
2	ExistEnce of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	4 persons
7	Does the gas detector react	NO

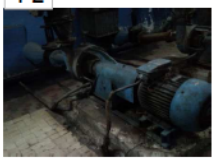
Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	FG-216-24	23	30	197.0	208.0	18	20.0	38.45
P2	FG-216-24	27	30	216.0	216.0	18	24.0	39.33
P3	FG-216-24	14.5	22	175.0	186.0	18	18.0	39.25

Photos pumps

P1

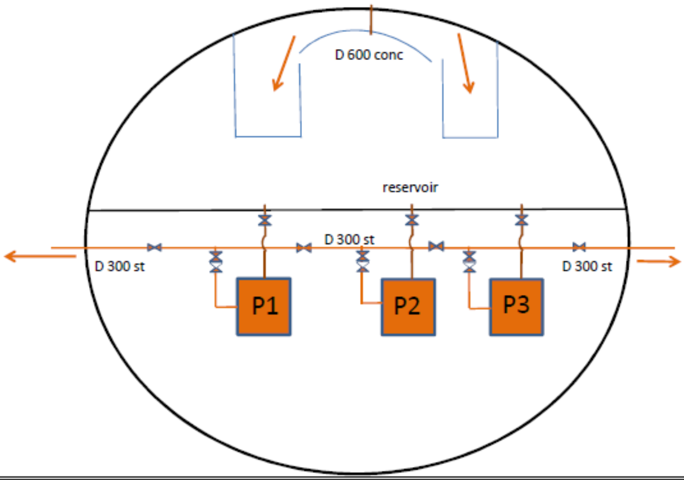
P2



P3

GIS

Layout



FORM OF SEWAGE PUMPING STATION **ID:** SINGERA_scool

BASIN :
Street :
Date of visit: 17/12/2010

Location

Characteristics P/ST

Lat = 46°54'56.30"C
Lon = 28°58'37.13"E
Gr. level (m)= 28 (G) M
Elev. Floor P/ST= M

Volume of reservoir 16.00 M3

More information

1	Description of the regulation	automatic P/St
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	0 person
7	Does the gas detector react	NO

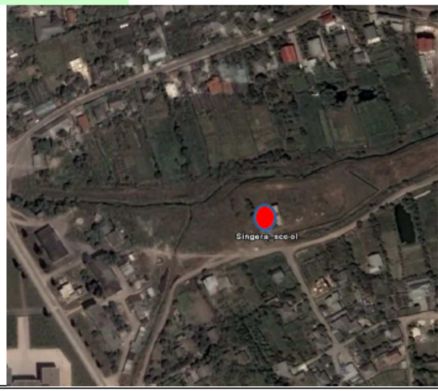
Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	FLYGT CP 3102 - 180	4.4	4.4	45.0	50.4	N/A	8.21	N/A
P2	FLYGT CP 3102 - 180	4.4	4.4	45.0	50.4	N/A	8.21	N/A

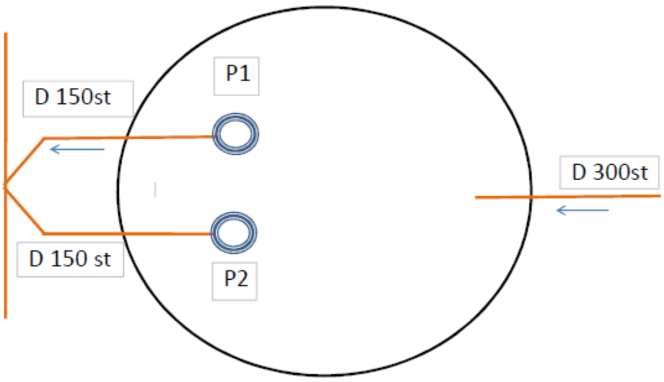
Photos pumps

P1-P2

GIS



Layout



FORM OF SEWAGE PUMPING STATION ID: SINGERA

BASIN :
Street :
Date of visit: 17/12/2010

Location

Characteristics P/ST

Lat = 46°55'35.97"C
Lon = 28°59'55.56"E
Gr. level (m)= 25(G) M
Elev. Floor P/ST= M

Volume of reservoir 210.00 M3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	4 persons
7	Does the gas detector react	NO

Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	SM 250-200-400	150	160	750	800	35	37	N/A
P2	SM 250-200-400	110	160	700	800	30	32	N/A
P3	SM 250-200-400	110	160	700	800	30	32	N/A
P4	SM 150-125-315	48	55	200	250	30	32	N/A

Photos pumps

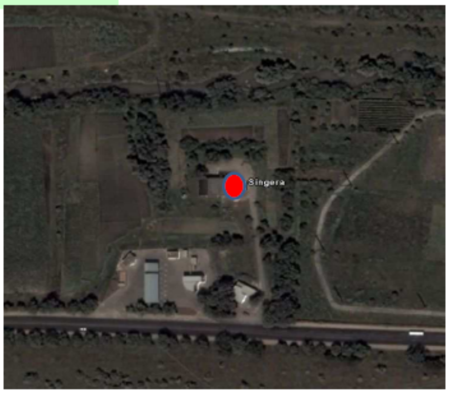
P1

P2

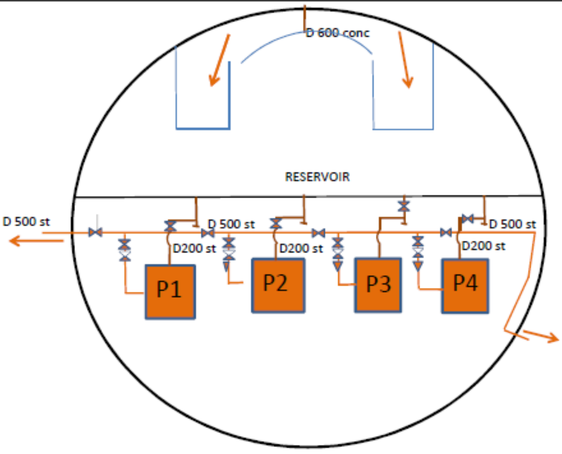
P3

P4

GIS



Layout



FORM OF SEWAGE PUMPING STATION ID: STOUCHENI_1

BASIN : **Date of visit:** 21/12/2010
Street :

Location

Characteristics P/ST

Lat = 47° 5'31.19"C
Lon = 28°52'25.62"E
Gr. level (m)= м
Elev. Floor P/ST м

Volume of reservoir 16.00 м3

More information

1	Description of the regulation	automatic P/St
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	1 persons
7	Does the gas detector react	NO

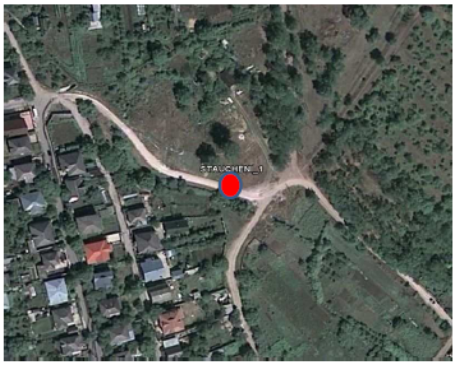
Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	DESMI DM2338	22	28	72.0	80.0	35	40	N/A
P2	DESMI DM2338	22	28	72.0	80.0	35	40	N/A

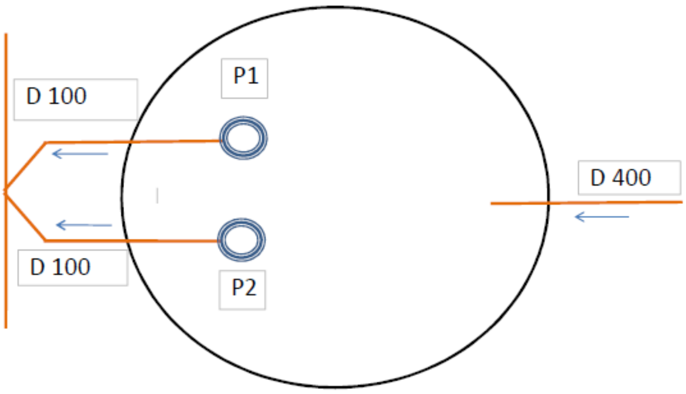
Photos pumps

P1-P2

GIS



Layout



FORM OF SEWAGE PUMPING STATION **ID:** **STOUCHENI_2**

BASIN : **Date of visit:** 21/12/2010
Street :

Location

Characteristics P/ST

Lat = 47° 5'1.54"C
Lon = 28°52'13.30"E
Gr. level (m)= M
Elev. Floor P/ST M

Volume of reservoir M3

More information

1 Description of the regulation
2 Existence of a speed variator /starter for the pump
3 Waterhammer protection
4 Collapse
5 Repair
6 Personal
7 Does the gas detector react

Brief characteristics of pumps

	Type	N nom (kWt)	N real (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
	equipment is not in operation							

Photos pumps

equipment is not in operation

GIS

Layout

equipment is not in operation

FORM OF SEWAGE PUMPING STATION ID: Tohatin1

BASIN : **Date of visit:** 16/12/2010
Street :

Location

Characteristics P/ST

Lat = 47° 3'53.33"C
Lon = 28°56'32.31"E
Gr. level (m) = 139 M
Elev. Floor P/ST 133.21 M

Volume of reservoir 43.00 M3

More information

1 Description of the regulation — switch pumps
2 Existence of a speed variator /starter for the pump — NO
3 Waterhammer protection — NO
4 Collapse
5 Repair
6 Personal — 4 persons
7 Does the gas detector react — NO

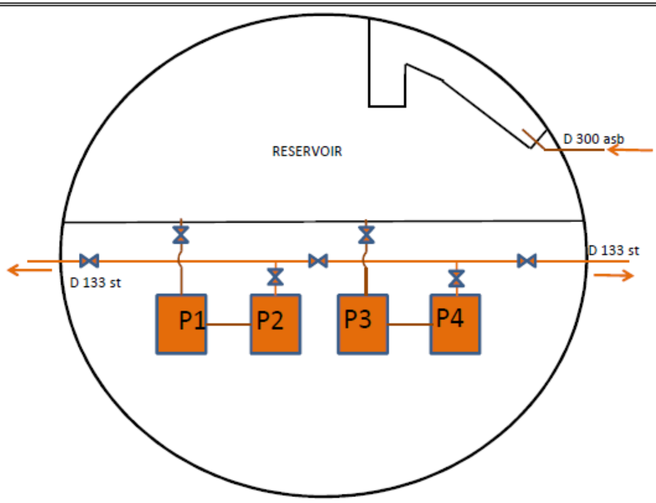
Brief characteristics of pumps

	Type	N real (kWt)	N nom. (kWt)	Q real (m3/h)	Q nom. (m3/h)	H real (m)	H nom. (m)	pump axe (m)
P1	SD-50-56	17	22	45	50	75	56	133.6
P2	SD-50-56	17	22	45	50	75	56	134.6
P3	SD-50-56	17	22	45	50	75	56	133.65
P4	SD-50-56	17	22	45	50	75	56	133.64

Photos pumps

GIS

Layout



FORM OF SEWAGE PUMPING STATION ID: Tohatin2

BASIN Date of visit: 16/12/2010
Street :

Location

Characteristics P/ST

Lat =	47° 3'51.64"C	
Lon =	28°57'36.74"E	
Gr. level (m) =	127(G)	M
Elev. Floor P/ST		M
Volume of reservoir	25	M3

More information

1	Description of the regulation	automatic P/St
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	0 person
7	Does the gas detector react	NO

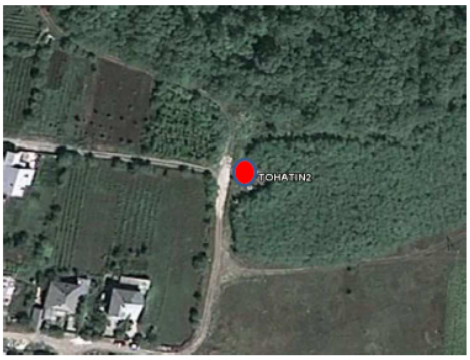
Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Qreal (m3/h)	Qnom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	FLYGT CP 3152 SH	13	15	18.1	18.1	45	59	N/A
P2	FLYGT CP 3152 SH	13	15	18.1	18.1	45	59	N/A

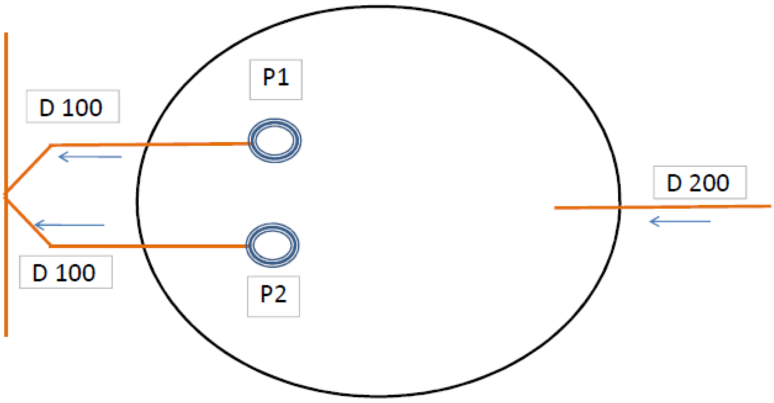
Photos pumps

P1 P2

GIS



Layout



FORM OF SEWAGE PUMPING STATION **ID:** **TRIFON_BALTE**

BASIN : **Date of visit:** 21/12/2010
Street :

Location

Characteristics P/ST

Lat = 47° 0'40.67"C
Lon = 28°48'36.36"E
Gr. level (m)= м
Elev. Floor P/ST м
Volume of reservoir 25.00 м3

More information

1	Description of the regulation	automatic P/St
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	0 person
7	Does the gas detector react	NO

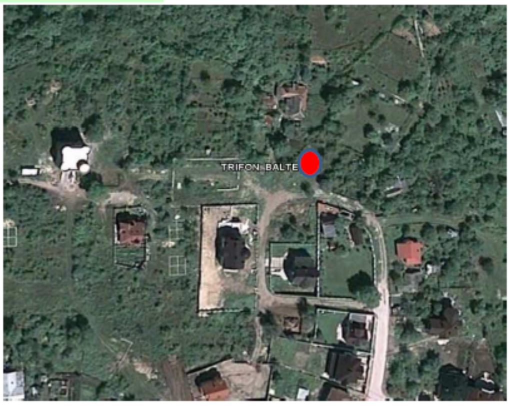
Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	SE1.50.65	3	3	24.0	28.0	17.5	20	N/A
P2	SE1.50.65	3	3	24.0	28.0	17.5	20	N/A

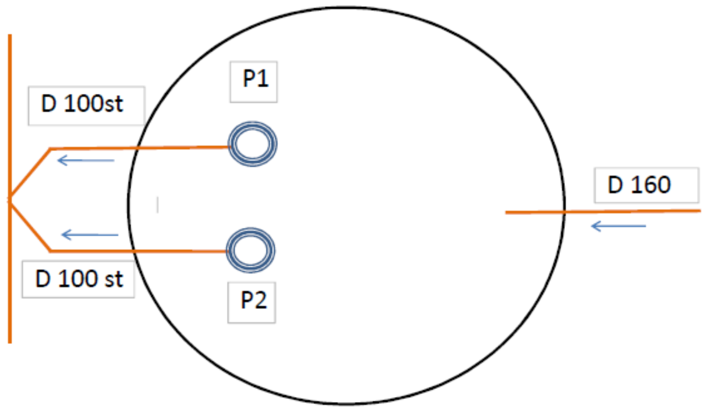
Photos pumps

P1-P2

GIS



Layout



FORM OF SEWAGE PUMPING STATION ID: VATRA

BASIN : **Date of visit:** 20/12/2010
Street :

Location

Characteristics P/ST

Lat =	47° 4'37.31"C
Lon =	28°44'10.52"E
Gr. level (m)=	53.25 M
Elev. Floor P/ST=	46.65 M
Volume of reservoir	210.00 M3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	1 person
7	Does the gas detector react	NO

Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	SD 800-32	95	160	700.0	800.0	26	32.0	47.2
P2	SD 800-32	95	160	700.0	800.0	26	32.0	47.21
P3	SM250-200-400	110	160	660.0	800.0	26	35.0	47.23

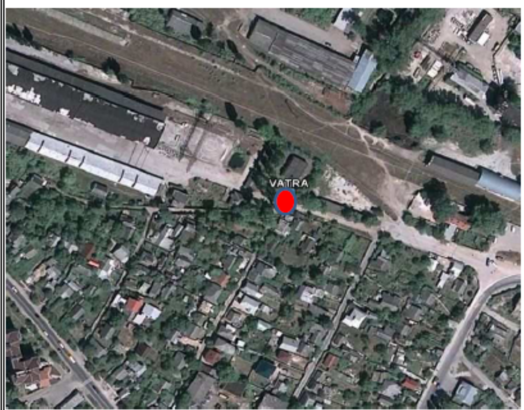
Photos pumps

P1

P2

P3

GIS



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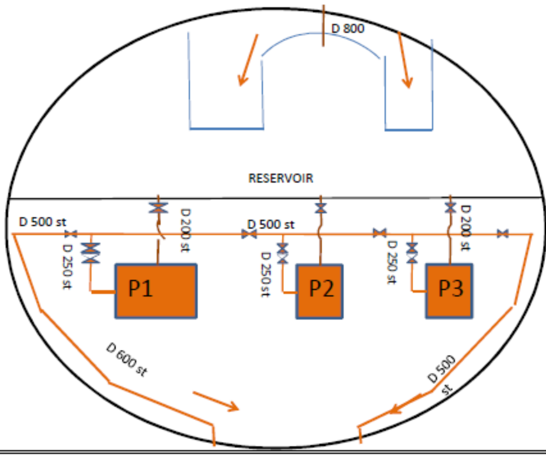


FORM OF SEWAGE PUMPING STATION   ID: VIERU

BASIN :
Street :

Date of visit: 17/12/2010

Location

Characteristics P/ST

Lat =	46°58'4.53"C	
Lon =	28°49'59.02"E	
Gr. level (m)= 1(	102.85	M
Elev. Floor P/ST=	96,95	M
Volume of reservoir	94.00	M3

More information

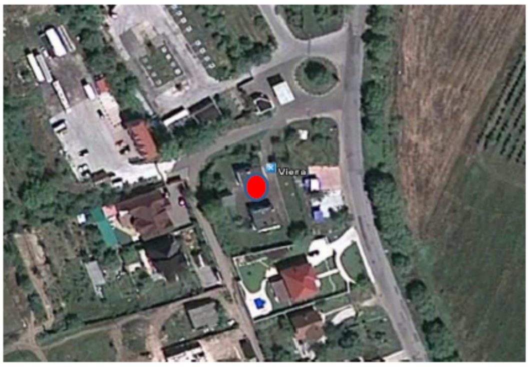
1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	4 persons
7	Does the gas detector react	NO

Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	SD-160-45	71	64	160.0	165.0	42.0	44	97.69
P2	SD-160-45	71	64	160.0	165.0	42.0	44	97.69
P3	SD-160-45	73	64	160.0	164.0	42.0	44	97.69
P4	SD-160-45	73	64	160.0	164.0	42.0	44	97.69

Photos pumps

GIS



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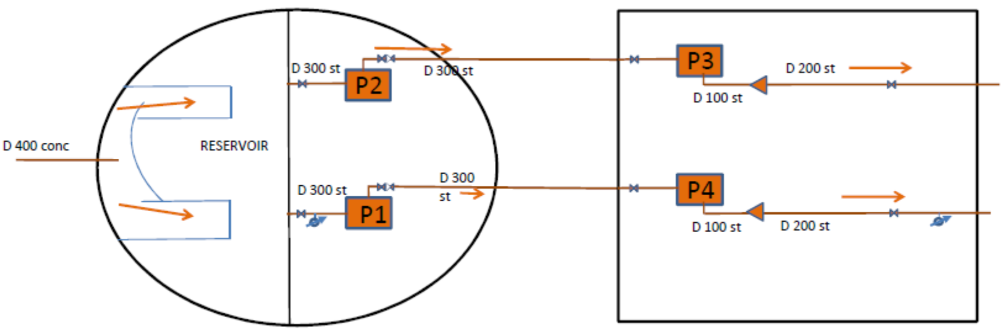


FORM OF SEWAGE PUMPING STATION ID: V_LUPU

BASIN :
Street :

Date of visit: 20/12/2010

Location

Characteristics P/ST

Lat =	47° 1'30.32"C
Lon =	28°46'57.72"E
Gr. level (m)=	105(G) м
Elev. Floor P/ST	м
Volume of reservoir	48.00 м3

More information

1	Description of the regulation	switch pumps
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	1 person
7	Does the gas detector react	NO

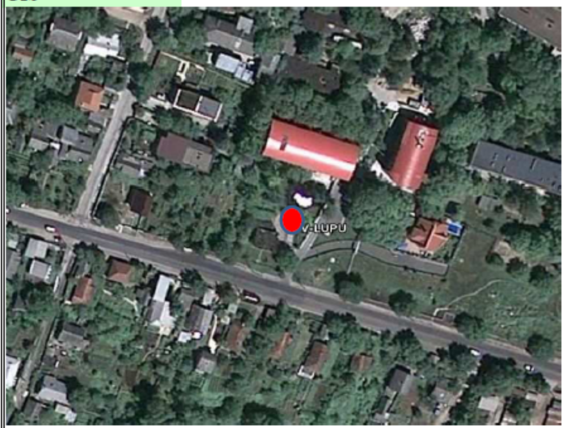
Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	FG216-24	24	22	216.0	217.0	18	20.0	N/A
P2	FG216-24	21	22	175.0	186.0	18	18.0	N/A
P3	FG216-24	18	22	197.0	207.0	18	18.0	N/A

Photos pumps

P1,P2,P3

GIS



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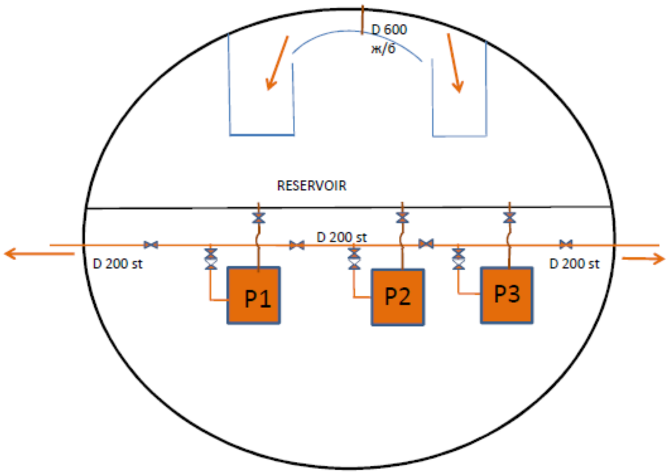


FORM OF SEWAGE PUMPING STATION ID: ZAIKIN

BASIN :
Street :
Date of visit: 20/12/2010

Location

Characteristics P/ST

Lat = 47° 2'7.40"C
Lon = 28°49'56.82"E
Gr. level (m)= 46 (G) M
Elev. Floor P/ST= M

Volume of reservoir 12.00 M3

More information

1	Description of the regulation	automatic P/St
2	Existence of a speed variator /starter for the pump	NO
3	Waterhammer protection	NO
4	Collapse	
5	Repair	planning
6	Personal	0 person
7	Does the gas detector react	NO

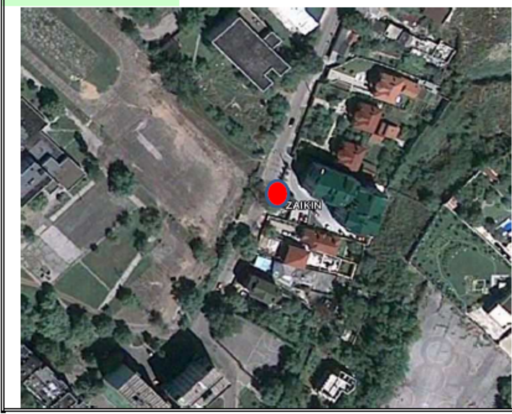
Brief characteristics of pumps

	Type	N real (kWt)	N nom (kWt)	Q real (m3/h)	Q nom (m3/h)	H real (m)	H nom (m)	pump axe (m)
P1	TMC16/27	3.06	3.2	16.0	20.0	26	27	N/A
P2	CMK 16/21	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Photos pumps

P1-P2

GIS



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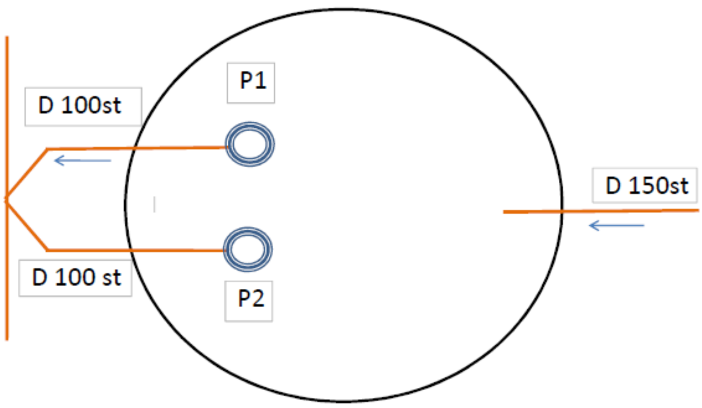

Annex 3 Industrial wastewater volumes discharged into the sewerage network in 2010

Sector	Contract number	Customer number	Name of industry	Adress	Economic sector	WW Volume (m3/month)
Botanica	38	35-435-33	SRL"Zemoff"	str.Grenoble, 161-A, str.Muncesti, 793/2	Production of spirits	2 598
Botanica	25	4-619-33	S.A."JLC"	N/A	Milk processing factory	2 526
Botanica	1	4-618-33	S.A. "Franzeluta nr. 2"	str.Sarmisegetusa, 30	Bakery	2 301
Botanica	2	4-618-33	S.A. "Franzeluţa nr.3"	str.Burebista, 78	Bakery	1 948
Botanica	58	15-674-33	Aeroport International Chişinau "	N/A	Aeronautical services	1 941
Botanica	62	9-627-33	SRL "Melodia"	Brăncuşi, 3	Shop	1 574
Botanica	1	4-618-33	S.A. "Franzeluţa"	Complexul energetic	Bakery	1 464
Botanica	56	3-94133	SRL "Trabo Plus"	N/A	Restaurant	1 379
Botanica	42	4-595-33	S.R.L. "Elat Rentservice"	str. Decebal, 99	Public services	1 253
Botanica	34	4-610-33	S.A. "Carnez"	str. Munceşti , 121	Sausage factory	1 162
Botanica	43	7-470-33	S.R.L. "Metro Cash 2"	srt.Dacia, 62	Supermarket	1 040
Botanica	50	9-684-33	S.R.L. "Vistarcom"	Decebal, 139	N/A	1 039
Botanica	53	5-292-33	SRL "Simco Euro"	Munceşti, 799	N/A	1 006
Botanica	6	35-431-33	SRL "Semizeu"Lion Gri"	N/A	Wine factory	868
Botanica	5	4-612-33	S.A. "Sigma"	N/A	Joint Services	773
Botanica	60	1-21833	S.R.L "Cvin"	Independenţei, 3/1, 12/5	Restaurant	771
Botanica	76	4-576-33	Î.M. "Parcul urban de autobuze"	str. Sarmizegetusa, 51	Joint Industry	767
Botanica	27	4-661-33	Î.S. "Moldresurse"	fil. nr.1, str. V. Bâcului, 5	Pastry	711
Botanica	8	6-217-33	SRL"Alex-Neosim"	str.Pădurii,21	The sausage production	655
Botanica	36	7980-33	S.R.L."GB şi Co"	str.Yimbrului,10-A	Wine factory	641
Botanica	48	4-841-33	SRL"Slavena Lux"	str.Valea Bicului, 1/1	The fish processing	617
Botanica	18	7-408-33	SRL"Logos Grup"	str.V.Bicului, 9	Refrigerators	614
Botanica	37	4-221-33	S.A."Hidrotehnica"	bd. Decebal	N/A	529
Botanica	10	4-691-33	CFM Direct. des. calat.	str.Muncesti, 273	Washing and dry cleaning services	504
Botanica	84	4-608-33	SRL "Vidar"	str. Decebal, 139	Offices	464
Botanica	30	3-268-33	Parcul troleibuze	nr. 2 str. Munceşti,	Electric transportation services	464
Botanica	28	4-565-33	S.R.L "Leutis"	str.Dacebal,5	Supermarket	463
Botanica	7	9-420-33	S.R.L. "Elita - 5 Auto"	bd. Dacia,55	Car wash	429
Botanica	3	4-600-33	FPC"Drancor"	str.Burebista,78 sondă	The ice cream production	417
Botanica	46	9-651-33	SRL"Stalma-Lux"	Dacia, 47/7	Shop nr.1	407
Botanica	77	4-308-33	S. A."Universal"	Zelinski,7	Car wash	398
Botanica	90	N/A	SRL."Harelson"	decebal,16	Restaurant	390
Botanica	80	4-625-33	I.S. "Combinatul auto nr.4"	str. Pădurii, 13	Joint Industry	389
Botanica	17	15-411-33	SA"Aeroport Catering"	Aeroport	Public catering	387
Botanica	14	35-431-33	SRL "Semizeu" (Colusvin)	N/A	Wine factory	384
Botanica	23	4-685-33	Î.R.I."Zimbru"	N/A	Car services	379
Botanica	85	N/A	SRL. "Start Wellness"	Dacia,31	Joint Industry	318
Botanica	79	N/A	SA "Dalia"	str. Zelinski, 4	Sewing Company	297
Botanica	91	4-836-33	SRL "Termoenergomontaj"	str. Sarmizegetusa, 94	N/A	294
Botanica	65	4-673-33	S.A. "UBC"	str.Muncesti,364	Automotive services	230
Botanica	52	1-21833	S.A. "Conserv -E"	Sarmizegetusa, 20/2 contract anexa	Restaurant	229
Botanica	81	35-212-33	SRL "Şteviprod"	Munceşti, 799	Joint Industry	227
Botanica	22	15-627-33	Compania aeriană Air Moldova	Aeroport contr	Aeronautical services	219
Botanica	29	1-337-33	SRL"FOOD Planet Restaurants"	bd.Dacia,21/1	Public catering	208
Botanica	47	N/A	SA "Nufarul"	Dacia, 47/6	Restaurant	207
Botanica	13	N/A	SRL "Semizeu" Sanin Plus	N/A	N/A	203
Botanica	82	N/A	SRL "BMB Wood"	Munceşti, 799N	Joint Industry	200
Botanica	45	35-444-33	SRL "Succes Victoria"	N/A	Restaurant	196
Botanica	57	4-668-33	SA "Cortina"	str. Bacioi Noi,14	N/A	175
Botanica	94	N/A	SRL. "Palmira AD"	Dacia,44	Mall	169
Botanica	33	9-487-33	S.R.L. "Rinor Grup"	str. Gr. Botanică, 2	Car wash	165
Botanica	20	4-538-33	S.R.L "Mikma"	str.Burebista, 3	Car wash	164
Botanica	16	35-431-33	SRL"Semizeu" (SRL "Vamcomplex")	N/A	Restaurant	162
Botanica	71	9-369-33	S.R.L."Vitla gaz"Vitla petrol	N/A	Petrol station. Car wash	162
Botanica	26	11-260-33	SRL "Puratos Mold"	str. Chişin., 54	N/A	158
Botanica	21	4-559-33	SRL Daily Wants	Premer SV Pădurii,21	Bakery	157
Botanica	41	9-634-33	S.R.L. "Autobatprim"	str. Munceşti, 364	Car services , car wash	155
Botanica	83	4-605-33	SRL"Interplast"	str.Padurii,6	Joint Industry	152
Botanica	93	N/A	SRL. "Delius	Îndependenţei, 3/1	Restaurant	147
Botanica	61	N/A	SRL "Privex Prim" SRL "Concept Grup"	N/A	Car wash	146
Botanica	9	15-526-33	IS"Mold ATSA"	Aeroport	Aeronautical services	145
Botanica	15	35-431-33	SRL"Semizeu" (First Line)	N/A	Wine factory	143
Botanica	69	4-408-33	SRL"Elex"	str.Muncesti,94	Car wash	143
Botanica	35	4-695-33	S.A. "Muncesti-Service"	str.Muncesti,273	Car wash	143
Botanica	55	6-486-33	SRL "Prosper Servrice" (Î.I. "TomailÎ Argo")	str. Calea Basarabiei,	Shop, car wash	141
Botanica	88	N/A	Î.S."Bucuria El"	Sarmizegetusa,9	Canteen	140
Botanica	95	N/A	SRL. "Megaparc"	Dacia,31	Pastry	132
Botanica	44	4-777-33	SRL "Şarm"	PCF	Restaurant	127
Botanica	64	4-603-33	Uzina "Giuvaier"	N/A	The production of gold jewelry	106
Botanica	59	N/A	SRL "Lucoil Moldova"(SRL "Vag Vit Com")	str. Munceşti, 366/1 (str. B. Bodoni, 57, ap. 6)	Car wash	102
Botanica	40	35-380-33	SRL "Nifest Com"	str.Padurii, 6	Car wash	98
Botanica	19	4-359-33	SRL"Fivils"	N/A	Fishing Industry	96
Botanica	31	9-654-33	SRL "Amfion Prim"	str. Munceşti, 62	Car wash	96
Botanica	68	2-663-33	SRL"Petrom Moldova"	str.Muncesti, 269; 273	Car wash	93
Botanica	11	4-021-34	SRL."Olmosdon Plus"	Autoboss	Car wash	89
Botanica	89	N/A	SA."Restauranul Doina"	Trandafirelor,6	Restaurant	84

Botanica	86	N/A	SRL. "Indmontaj"	Sarmizegetusa, 92	Joint Industry	76
Botanica	32	4-622-33	SRL "JC Auto"	str. Pădurii, 6/1	Car wash	76
Botanica	101	N/A	SRL. "Lentileta"	Decebal,34	Bar	69
Botanica	49	35-503-33	S.R.L. "Europlast Chsinau"	Munc., 797/A	The plastics production	54
Botanica	51	N/A	S.R.L "La placinte"	Sarmisegetusa contr	Restaurant	45
Botanica	92	N/A	SRL. "Luca lama"	Îndependenţei, 21	Bar, terrace	37
Botanica	102	N/A	SRL. "CitadelaCons"	Calea Basarabiei,42	Fish Processing	34
Botanica	54	9-342-33	SRL "Eurosim"	bd Dacia	Petrol station	30
Botanica	35	N/A	S.A."Carvit"	Munceşti 121	Waste transportation	22
Botanica	39	N/A	S.A. Moldavian Airlines	N/A	Aeronautical services	17
Botanica	96	N/A	SRL "Lavit"	N/A	Joint Industry	5
Botanica	4	4-228-33	AP"Neptun Nord"	Calea Basarabiei,42	The Fishing Industry	N/A
Botanica	24	6-488-33	S.A. "Moldcarton"	N/A	Cardboard factory	N/A
Botanica	63	N/A	SRL "Bemol Retail"	str.Dacia, 59/1	N/A	N/A
Botanica	66	4-660-33	S.R.L. "Supercom" SRL "Magic Cons"	N/A	Printing services	N/A
Botanica	67	4-604-33	S.A. "Alimcom"	N/A	The production of mayonnaise, pastry	N/A
Botanica	70	20-201-33	S.A. "Avicola ROSO SL"	N/A	Poultry	N/A
Botanica	72	4-624-33	S.R.L. "Moldcars"	N/A	Car services	N/A
Botanica	73	N/A	SRL "Infraservice"	Munceşti, 799	N/A	N/A
Botanica	74	4-376-33	SRL "Cenar"	str. Burebista	N/A	N/A
Botanica	75	9-709-33	SRL "Mobi Art Design" (SRL "Resentarix")	str. Munceşti, 799	N/A	N/A
Botanica	78	4-616-33	SA "Floare Carpet"	N/A	Carpet production	N/A
Botanica	87	N/A	SRL. "Uniplast"	Pădurii,	Joint Industry	N/A
Botanica	97	N/A	SRL. "MoldSTASS"	Calea Basarabiei, 5	Joint Industry	N/A
Botanica	98	N/A	SRL. "Fitness Com"	Dacia,31/1	Fitness center	N/A
Botanica	99	N/A	SRL "Agropiese TGR"	N/A	Car services, bar	N/A
Botanica	100	N/A	SRL. "Sandex Tehno"	Sarmizegetusa,12/1	Industrial Market	N/A

N/A : Data non available.

(source : documents from ACC called "industrii vizate in progr de prelevare a probelor si calitatea efluentului industrial 2009-2010 »)

Sector	Contract number	Customer number	Name of industry	Adress	Economic sector	WW Volume (m3/month)
Buiucani	6	3-684-33	"Aroma-Coniac"	str.Bucuriei	Wine factory	3 120
Buiucani	3	3-942-33	"Proalfaservice"SRL	N/A	Offices	2 461
Buiucani	1	3-707-33	Bucuria	MD-2004,str.Columna,162	Pastry goods	1 952
Buiucani	72	N/A	"Trabo-Plus"	N/A	Pizzeria	1 861
Buiucani	13	8-651-33	S.A."Pielart"	str.Calea Eşilor, 10	Pizzeria,	1 846
Buiucani	36	4-618-33	SA"Franzeluta nr.1"	strColumna,166	Bread factory	1 516
Buiucani	26	3-205-33	S.A."Autosolubritate"	str.27Martie, 14	Solid waste transportation	1 385
Buiucani	69	3-476-33	Complexul hotilier S.R.L. "Hotel "Codru"	N/A	Hotel Services	1 117
Buiucani	55	3-297-33	S.A. Jolly Alon	N/A	Hotel Services	999
Buiucani	18	3-429-33	S.R.I"Confort"	str.Mesager,19; MD-2069	Furniture factory	989
Buiucani	4	3-814-33	SRL"Negustorii"	MD 2069,str.I.Creang	Market	907
Buiucani	25	3-268-33	Parcul de troleibuse nr.1	N/A	Public transport	695
Buiucani	10	3-702-33	"SA Viorica Cosmetic"	str.Mesager,1 MD-2069	Production of detergents	669
Buiucani	60	N/A	C.T.I. "Capital" S.A.	Str. Ştefan cel Mare, 202	Offices	596
Buiucani	9	3-873-33	S.A "Autoforta"	str.Bucuriei,18	Auto services	583
Buiucani	57	N/A	S.A.Hotelul "Dacia"	N/A	Hotel Services	547
Buiucani	23	19-201-33	S.A."Aschim"	or Durle;ti str.T.Vladimirescu,70	Chemical plant	519
Buiucani	19	N/A	S.R.L. "Fourchette"	N/A	Contract, market	516
Buiucani	14	3-670-33	SA "Zorile"	N/A	Footwear production	432
Buiucani	62	N/A	S.C. "Î.M.C Market"	str. I Greango 78	Market	392
Buiucani	34	N/A	S.A. "Tirex Petrol"	Vatra, str.Plopilor,25	Petroleum base	389
Buiucani	88	8-306-33	S.A. "MOLDEXPO"	N/A	Restaurant	379
Buiucani	75	8-444-33	S.R.L. "Covoare Lux"	str. Calea Ieşilor, 10B	Shopping Centre	335
Buiucani	15	3-682-33	S.A."Taxiservice"	str.Calea Esilor,14	Auto Repair	333
Buiucani	67	N/A	S.R.L. "Ghelecec" S.R.L. "Infiniti"	N/A	Knitting manufacturing	317
Buiucani	41	3-838-33	SRL "Mavita"	str.Mesager, 3/1	Meat processing	308
Buiucani	12	3-706-33	S.A."Artima"	str.Calea Esilor,6	Textile factory	307
Buiucani	46	3-523-33	S.R.L. "Vega L"	str. Alba Iulia 7	N/A	299
Buiucani	27	3-530-33	S.R.L"Ferex"	str. M. Viteazul, 2A	Production of ravioli	287
Buiucani	47	3-718-33	"Centru de Modă"	str.St.cel Mare,182	Offices, bar	261
Buiucani	30	3-734-33	S.R.L. "Vispas şi Co"	hotelul	Hotel Services	256
Buiucani	95	3-229-33	S.R.L. "Colaj"	MD 2012_ str. Şt cel Mare, 103	Cinema	249
Buiucani	16	3-681-33	SA "Automototrans"	Bariera Sculeni,9	Sauna, Auto Repair	246
Buiucani	64	8-347-33	S.R.L. "Anturaj Nou"	str. Mesager, 11	Furniture factory	230
Buiucani	65	3-239-33	Teatrul Republican "Licurici"	str. Bucureşti, 64	Theatre	219
Buiucani	48	3-683-33	Combinatul poligrafic	N/A	Polygraphy	217
Buiucani	63	N/A	S.R.L. "Mageru Holding"	str. Ştefan cel Mare, 196	Lease the manufacturers	215
Buiucani	94	3-419-33	S.R.L. "Magurele"	MD 2051_ str. Paris, 47	Restaurant	211
Buiucani	86	3-318-33	S.A. "Casa Nunţi şi Noroc"	N/A	Restaurant	208
Buiucani	61	1-309-33	S.R.L."Kristina"	Mesager, 27, str.	Footwear production	203
Buiucani	105	3-956-33	S.R.L. "Standard Vin Plus"	N/A	Canteen	200
Buiucani	54	7-087-33	SRL"Ad-Rem"	N/A	Auto services	194
Buiucani	80	8-646-33	S.R.L."XAN"	str. Alexandrescu, 5 MD 2008	Hotel Services	192
Buiucani	17	3-812-33	SA"Euro-Alco"	MD-2004, str.Bucuriei,20	Wine factory	183
Buiucani	58	3-619-33	S.R.L."Capital com"	str I. Creangă, 66	Restaurant	183
Buiucani	102	7-550-33	S.R.L. "Reconscivil", "Linello"	str. Onisifor Gibu, 7/3	Shopping Centre	167
Buiucani	76	N/A	S.R.L."Iurie Borş"	N/A	Furniture factory	163
Buiucani	59	3-665-33	S.R.L."Escort Trans"	str. I Creangă, 6V	Offices	159
Buiucani	32	3-787-33	S.R.L "Lascaut Prim"	N/A	Car wash	149
Buiucani	49	3-359-33	S.R.L "Consta- Oil"	N/A	Car wash	132
Buiucani	20	3-698-33	SA "Topaz"	MD-2012,str.Cantemir,1	Metal clothing and METALOPLAST	132
Buiucani	42	N/A	S.R.L. "Şel şi Co"	N/A	WC	132
Buiucani	29	8-817-33	SRL "Armanda service"	N/A	Car wash	131
Buiucani	81	8-224-33	S.R.L."Mivarex"	str.Calea Ieşlor, 2/3	Agricultural Market	130
Buiucani	104	3-846-33	S.R.L. "Anjelica"	MD 2069; str. Balcani, 3	Canteen	128
Buiucani	101	7-073-33	S.R.L. "KVINT-Plus"	MD 2071; str. Alba Iulia, 190/1	Offices, restaurant	124
Buiucani	90	8-225-33	S.R.L. "Haruz Grup"	str Cogălniceanu, 62, MD 2009	Restaurant	121
Buiucani	91	8-292-33	S.R.L. "Lunalux Com"	str Petru Movilă 4, MD 2004	Hotel Services	121
Buiucani	79	N/A	S.R.L."MGM Muntean"	str. Alba Iulia 160 MD 2050	Car wash	120
Buiucani	77	3-390-33	S.R.L."Autodiscom"	str. Alba Iulia 156 MD 2050	Car wash	113
Buiucani	31	3-697-33	S.R.L. "Elan Poligraf"	str. Mesager,7	Polygraphy	112
Buiucani	43	8-240-33	S.R.L: "Valeolis"	N/A	Pizzeria	109
Buiucani	92	1 927 033	S.R.L. "Moldpresa"	str or. Durleşti, str. Ştefan Vodă, 3	Offices	103
Buiucani	97	3-827-33	S.R.L. "Virma"	MD 2069; str Calea Ieşilor, 26/1	Bar	103

Buiucani	24	3-687-33	S.R.L. "Fabrica de Beton şi Mortar"	N/A	N/A	100
Buiucani	98	3-813-33	S.R.L. "Mils"	MD 2069; str. Calea Ieşilor, 22	Bar	97
Buiucani	39	8-356-33	S.R.L. "Ghesadi"	str. Mesager,22	Furniture factory	96
Buiucani	5	3-528-33	S.R.L "Steaua Reds"	N/A	Knitting factory	95
Buiucani	89	3-385-33	S.R.L. "Chateau"	str B. Bodoni, 4, MD 2012	Restaurant	95
Buiucani	82	3-960-33	S.R.L."Ergolemn"	str.Calea Ieşlor, 59/1	Furniture factory	94
Buiucani	7	3-684-33	"Aroma-Vin"	str. T. Ciorba	Wine factory	93
Buiucani	103	3-351-33	S.A. "Casa Mare"	str. Aldea Teodorovici, 8	Restaurant	91
Buiucani	51	8-385-33	SRL "Pastunete	MD-2069,str.71/2	Car wash	90
Buiucani	68	3-287-33	S.R.L. "Agro Euro Market"	str. Alba Iulia, 198	Agricultural Market	81
Buiucani	11	8-887-33	S.R.L. "SVOD" Mega Complex	N/A	Restaurant	81
Buiucani	85	3-357-33	Î.S.A.P. "Dieta Vitas"	str. M. Dosoftei 144	Canteen	80
Buiucani	66	3-425-33	S.R.L. "Super Victoria"	N/A	Market	67
Buiucani	2	3-732-33	S.R.L. "Olplat Com"	str.31 august 1989, 117/1	Restaurant	67
Buiucani	78	N/A	S.R.L."Bucur Ala"	str. Alba Iulia 134	Car wash	64
Buiucani	71	19-350-33	P.F. Miţelea Pavel" S.R.L. "Patisier"	N/A	Pastry	62
Buiucani	84	3-760-33	S.R.L."Avanta"	str. Calea Ieşilor, 8B	Furniture factory	59
Buiucani	93	8-234-33	S.A."Lia"	N/A	Restaurant	58
Buiucani	100	8-644-33	S.R.L. "Marat Grup"	MD 2012; bd. Ştef cel Mare, 103	Bar	44
Buiucani	83	3-832-33	S.R.L."Ovico"	str. IonCreangă, 1	Furniture factory	44
Buiucani	96	3-433-3	S.R.L. "Dumbrava A"	MD 2069; str. Calea Ieşilor, 11/2	Bar	43
Buiucani	99	6-508-33	S.R.L. "Tumali Grup"	MD 2012; bd. Ştef cel Mare, 103	Bar	39
Buiucani	87	8-916-33	S.R.L. "Dobromax"	N/A	Car wash	25
Buiucani	73	3-816-33	S.R.L. "Colo"	str. Ion Pelivan, 15/1	N/A	21
Buiucani	53	8-248-33	"Imex Grup"	str.Bucuriei,1	Car wash	17
Buiucani	8	2-652-33	"Cazangeria de Vest"	str.Prunului,24	N/A	N/A
Buiucani	19	3-692-33	"SA Tracom"	N/A	Tractor Plant	N/A
Buiucani	21	23-519-33	S.A. "Interautoservice"	MD 2069; str Calea Ieşilor, 30	Hotel Services	N/A
Buiucani	22	19-203-33	S.A."Anticor"	N/A	Sauna	N/A
Buiucani	28	3-600-33	Niagara fitness Club S.R.L.	str. Ghidighici, 5; MD 2069	Fitness Club	N/A
Buiucani	35	23-206-33	SRL"Bojo Vin"	Vatra	Wine factory	N/A
Buiucani	37	N/A	Pompey trading house	Truşeni,	N/A	N/A
Buiucani	38	N/A	S.R.L."Nufărul"	N/A	N/A	N/A
Buiucani	40	3-972-33	S.R.L."Aralit"	N/A	N/A	N/A
Buiucani	44	3-809-33	S.R.L."Ditex"	MD-2051,str.Alba-Iulia,75/6	Car wash	N/A
Buiucani	45	3-238-33	Teatrul de operă şi ballet	N/A	N/A	N/A
Buiucani	50	1-762-33	S.A."Edilitate"	str. M.Eminescu, 49; str. Ghidighici, 11; MD 2012	Concrete Production	N/A
Buiucani	56	N/A	S.A. "ABC"	N/A	Hotel Services	N/A
Buiucani	70	3-233-22	USEFS	str. 31 azgust 1989	Swimming pool	N/A
Buiucani	74	3-865-33	S.R.L. "Caragon Com"	str. Bucuriei, 1	N/A	N/A
Buiucani	100	N/A	SA "Var Nest"	N/A	Lime production factory	N/A
Buiucani	101	N/A	S.R.L. "Scînteia"	Truşeni	Furniture factory	N/A
Buiucani	102	N/A	S.R.L. "Ştefaniţa"	Teatrul de Opera si Balet	N/A	N/A
Buiucani	103	N/A	S.R.L. "Lenaid"	Teatrul de opera şi Balet	N/A	N/A

N/A : Data non available.

(source : documents from ACC called "industrii vizate in progr de prelevare a probelor si calitatea efluentului industrial 2009-2010 »)

Sector	Contract number	Customer number	Name of industry	Adress	Economic sector	WW Volume (m3/month)
Centru	63	6-442-33	SRL "Lemi Invest"	str. Arborilor, 17	Supermarket, restaurants, car wash	3 444
Centru	92	7-804-33	S.A."Nufărul"	M.Eminescu, 70	Washing and dry cleaning services	1 615
Centru	11	1-342-33	Magazinul Central "Unic"	Stef.cel.Mare, 8	Supermarket, restaurant	1 602
Centru	42	1-744-33	S.A. "Ionel"	str.Bulgară, 47	The light industry, garment factory, canteen	1 557
Centru	54	6-025-33	Î.S. "Gările St. Auto"	str. M. Varlaam, 58	Public services , Bus station, restaurant	1 310
Centru	32	1-651-33	S.R.L."Delmos-Grup" Cosmos	bd. Negruzzi, 2	Hotel Services	1 244
Centru	66	6-574-33	S.R.L."Leogrand"	str. M. Varlaam, 77	Hotel Services, restaurant, washing and dry cleaning services	1 239
Centru	94	9-684-33	S.C. "Vistarcom"	bd. Cantemir, 6	Supermarket	1 067
Centru	17	1-408-34	SA Moldtelecom	Şt.cel Mare, 10	Public services	778
Centru	37	1-692-33	SRL "Manolii"	Negruzzi,2/4	Supermarket, restaurant	769
Centru	43	1-750-33	S.A.Vibropribor	bd. Gagarin, 10	Mechanical factory, pastry, canteen	723
Centru	85	3-814-33	SRL "Negustorii"	str. V.Alecs., 6	Agricultural market, Bread factory	690
Centru	91	7-156-33	S.R.L."ICAM"	str. Tighina	Furniture manufacturing	687
Centru	20	1-435-33	S.R.L. "47th Parallel"	tr.Docuceaev, 6	Supermarket, Pastry	663
Centru	1	1-203-33	S.A. "Sanfarm-Prim"	Grenoble,149a	Pharmaceutical warehouse, canteen	634
Centru	26	1-918-34	S.A. "First Hotel"	bd. Negruzzi, 7	Hotel Services, restaurant	590
Centru	84	3-733-33	SRL "Paradis ZOO"	31 August, 117	Pastry	541
Centru	64	6-565-33	SRL "Leutis"	str. Puskin, 32	Supermarket, restaurant, pastry	532
Centru	12	1-343-33	S.A. "Gemeni"	bd. Ştefan-cel-Mare, 136	Supermarket, restaurant	506
Centru	72	6-796-33	S.A. "STAG Textile Industry "	str. Tighina, 49	Light industry, textile factory	487
Centru	97	20-251-33	SRL "Sandriliona"	Ialoveni, Alex.-cel bun, 30	Ice cream production	476
Centru	27	1-510-33	Î.S. Compl. "Casa Presei"	str. Puşkin, 22	Publishing office	470
Centru	57	6-217-33	S.R.L. "Alex Neosim"	str. Armenească	Restaurant	422
Centru	99	20-297-33	SRL "Cascad Vin",	Ialoveni, str. Moldova, 2	Wine factory	405
Centru	78	2-883-33	SRL "Lukoil Moldova", SRL "Nadif Trading"	str. Arborilor, 17	Restaurant	401
Centru	2	1-269-34	S.R.L."Food Planet Rest." McDonalds	St.cel Mare, 134	Public food stuffs	380
Centru	8	1-326-34	S.R.L. "Yamol Gr0up"	şos.Hinceşti,142	Car wash, auto services	377
Centru	49	1-856-33	SRL "Tititi si C"	N/A	Light industry, garment factory	372
Centru	39	1-739-33	S.R.L."Progres şi Co"	str. Tiraspol, 5	Agricultural market	360
Centru	70	6-777-33	SRL "Vila Verde"	str. Grenoble, 110	Hotel Services, restaurant, washing and dry cleaning services	338
Centru	133	20-256-33	C.V.C. Mileştii Mici	Ialoveni, s. Mileştii Mici	Wine factory	317
Centru	118	6-352-33	S.A. "Romaniţa"	şos. Hînceşti, 20	Supermarket, pastry	316
Centru	10	1-335-33	S.R.L."Capital Estate"	str. V. Pârcălab, 63	Hotel Services	307
Centru	65	6-572-33	S.R.L. "Vijelios"	str. Puşkin, 22	Pastry, restaurant	303
Centru	19	1-429-34	SRL "Finpar Invest"	str. Eminescu, 49/1	Hotel Services	300
Centru	61	6-371-33	SRL "Commax"	str.M.Varlaam, 63	Food stuffs , hall of meat	297
Centru	60	6-320-33	S.R.L."Dakeli"	str.Varlaam, 63	Food stuffs , hall of meat	275
Centru	86	3-941-33	SRL "Trabo Plus"	str. Tiraspol, 5 str. Asachi, 54	Pizzeria	273
Centru	55	6-154-33	SRL "SOHO Club"	str. Negruzzi, 2/4,	Restaurant	269
Centru	124	1-906 -33	F-ca text. maroch. "Codru"	str. Spicului, 6	Textile factory, restaurant	228
Centru	25	1-498-33	SRL "Colizei Vechi"	str. Tighina, 42	Hotel Services, market	210
Centru	34	1-682-33	SA "Moldacom"	str. Bucuresti, 67	Restaurant	208
Centru	59	6-256-33	S.R.L."Volare-Tur"	N/A	Hotel Services, restaurant	200
Centru	77	2-881-33	SRL "Şel şi Co"	str. M. Eminescu, 55	Restaurant	195
Centru	87	4-646-33	DMTC, Cantina Moldtelecom	str. Şt.-cel-Mare	Public services , canteen	190
Centru	68	6-741-33	SRL "Elenic Lux"	M. Eminescu, 64	Restaurant	183
Centru	126	6-032 -34	S.C. "Svetlanse"SRL	str. Bucureşti, 9	Hotel Services	182
Centru	117	6-696-33	S.R.L. "Almira"	sos. Hincesti, 140/4	Restaurant , furniture factory	182
Centru	105	N/A	S.R.L.."Staria"	str. 31 August ,78	Restaurant	179
Centru	18	1-429-33	S.R.L. "Green Hills Nistru"	bd. Şt.-cel-Mare, 77 str.31 August,78	Pastry, restaurant	178
Centru	75	6-935-33	SRL "Old Sity Summer Hall"	tr. Armen, 24/2	Restaurant	173
Centru	14	1-355-33	S.R.L. "Beer House"	str.Negruzzi, 6/2	Restaurant, brewing / beer factory	172
Centru	46	1-783-33	S.R.L. "Rentcentru"	N/A	Car wash	169
Centru	35	1-686-33	UAP din RM	str. Docuceaev, 1	Washing and dry cleaning services	163
Centru	38	2-799-33	SRL "Extremum"	str. Ismail, 94 bd. Cantemir, 5/2	Industrial Market	160
Centru	114	6-240-33	Asociaţia Internaţională Transport Auto "AITA"	bd. Cantemir, 3/1	Public services	151
Centru	73	6-819-33	S.R.L. "Atlantic"	str. Armenească	Supermarket	139
Centru	50	1-922-34	SRL "Bilarom"	bd. M. Varlaam,84	Restaurant	138
Centru	36	1-690-33	Universul	str.V. Pîrcălab, 45	Publishing office	132
Centru	79	2-883-33	SRL "Lukoil Moldova" SRL "Feralux"	str. Hînceşti, 94	Car wash	129
Centru	7	91j	SRL"MidarCom"	Varlaam,63	Canteen	126
Centru	110	1-761-33	S.R.L. "Equator Grup"	str. Bernardazzi, 56	Restaurant	122
Centru	4	1-303-33	S.A."Era Prim"	str. Tighina, 42	Washing and dry cleaning services	121
Centru	15	1-390-34	SRL "Fetescu - X"	str.Grenoble, 106	Restaurant, hairdressers	116
Centru	90	7-137-33	S.R.L "Lundas-Trans"	str.Grenobl147/2	Auto services	114
Centru	111	1-688-34	S.R.L. "Neotia"	str. Tiimiş, 19	Hotel Services	114
Centru	22	1-440-33	SRL "Agro Victoria"	str. Mioriţa, 11	Supermarket, Pastry	114
Centru	44	1-752-33	S.A. "Aselteh"	str. Miorita, 5	Experimental factory	114
Centru	41	1-742-33	S.R.L. "Gesti Grup"	str. Tighina, 49	Restaurant, Hotel Services	112
Centru	28	1-518-33	SRL "Selopa şi Co"	P. Halipa, 12/1	Coffee – house	112
Centru	119	3-523-33	SRL "Vega-L"	V. Alecsandri, 111	Restaurant	112
Centru	82	2-883-33	SRL "Lukoil Moldova", SRL "Autoermol"	str. Arborilor, 17	Car wash	104
Centru	52	1-949-33	S.R.L. "Gambrinus"	bd. Negruzzi, 4/2	Medical Services, canteen	99
Centru	6	1-318-33	Inst. înv. "CIPTI"	str. V. Ţepeş, 1	Public services	99
Centru	24	2-703-33	S.A"Tirex Petrol"	şos. Hînceşti, 151	Carwash	98
Centru	67	6-615-33	SRL"Roman şi Co"	str. Haiducilor, 44	Hotel Services, restaurant	97
Centru	9	2-663-33	SRL "Petrom Moldova"	şos. Hînceşti, 130/1	Car wash, auto services	95
Centru	83	3-392-33	SRL "Magicumitron"	str. 31 August, 78	Restaurant	94
Centru	58	6-243-33	S.A."Arus"	str. Ciuflea, 38	Hotel Services, restaurant	90
Centru	81	2-883-33	SRL "Lukoil Moldova", SRL "Continent"	str. Arborilor, 17	Car wash	85
Centru	107	7-711-33	S.R.L. "DAAC Autosport"	bd. Cantemir, 14	Car wash	84
Centru	136	N/A	S.R.L. "Comingi"	str. M. Varlaam, 63	Hall of meat	82

Centru	16	1-391-33	SRL "Cristivlad"	str.V.Alecsandri, 4	Restaurant, cinema	81
Centru	80	2-883-33	Paravent Grup	str. Melestiu,24/7	Car wash	79
Centru	53	1-984-33	S.R.L. "Bac Crețu"	str. Docuceaev, 13/1	Restaurant	77
Centru	13	1-345-34	SRL "Kiwiban"	str. Arborilor, 7	Hotel Services	76
Centru	48	1-840-33	SRL "Corina"	N/A	Hotel Services, restaurant	74
Centru	106	6-258-33	S.R.L. "Mesogios"	Armenească, 23	Hotel Services, restaurant, washing and dry cleaning services	73
Centru	71	6-782-33	S.R.L."Elit-Tur"	str. Anestiade,7	Hotel Services, restaurant	73
Centru	95	9-986-33	S.R.L. "Rex-Auto"	str. T. Strişcă, 1	Car wash	72
Centru	23	1-927-33	S.R.L."MoldCo"	str.31 August, 93	Restaurant	71
Centru	96	20-216-33	S.A. "Vinuri Ialoveni"	N/A	Wine factory	70
Centru	130	1-509-34	S.R.L. "Moldtrans Tur"	str. Grenoble, 128	Transport services	66
Centru	109	20-363-33	S.R.L. "Ruves Grup"	str. Al.-cel-Bun, 57	Restaurant	65
Centru	100	20-376-33	SRL "Ghervas Petrol"	Ialoveni, str. Testimițanu	Car wash	61
Centru	104	6-806-33	S.C. "Capitoles Lux" S.R.L.	str. M.Varlaam, 78	Restaurant	60
Centru	98	20-280-33	SRL "SAVV"	str. Al.cel Bun, 1	Car wash, bar	59
Centru	120	2-616 -33	SRL "Hotel Club Service"	str. Cogălniceanu, 6	Hotel Services	54
Centru	56	6-168-33	SRL "Bazatin Prest"	str. Miorița, 2/1	Car wash	53
Centru	113	20-300-33	Î.I. "Sergiu Baluțel"	str. 31 August, 34	Sausage production	49
Centru	123	1-663 -33	SRL "Eliban"	str. V. Alecsandri, 113	Restaurant	49
Centru	116	6-788-33	SRL "Slofarm"	str-la 2 S. Radauteanu, 5	N/A	48
Centru	127	6-178 -33	S.R.L. "Olimpus-85"	bd. Gagarin, 14	Gym	46
Centru	29	1-554-33	SRL "Bomalin"	V. Alecsandri, 61	Restaurant	46
Centru	40	1-421-33	SRL "Montrei"	str. M. Eminescu, 44/1	Restaurant	44
Centru	5	1-309-33	S.R.L. "Cristina mold-rom Simpex",	str. Armenească, 51	Public services , shop	41
Centru	69	6-747-33	SRL "Garnet Lux"	str-la 2, Rădăuțanu, 10/1	Car wash	40
Centru	3	1-289-33	Î.I. "Vacari Anatol"	str. Miorița, 6	Cafe bar, Public food stuffs	40
Centru	76	20-378-33	S.R.L. "Petrivar Service"	Ialoveni, str. V. Zarzăre, 25	Restaurant	40
Centru	30	1-617-33	S.R.L. "Alianța"	str. P. Halipa, 1	Restaurant	39
Centru	62	6-376-33	SRL"Potpuriu"	str. Ismail, 45	Restaurant	37
Centru	31	1-642-33	S.R.L. "Flona"	str. Hincesti, 53	Canteen	36
Centru	103	1-548-33	S.A.de tip închis "Agro-95"	str. Asachi, 27"A"	Supermarket	35
Centru	115	6-392-33	SRL "Bamon Ra"	str. Frumoasa, 71	Cafe bar	35
Centru	102	N/A	SRL "Soluțio Grup"	N/A	Liquid waste transport	34
Centru	47	1-798-33	S.R.L."Frunza Jugastro"	str. Armenească, 24	Restaurant	33
Centru	128	20-319 -33	S.R.L. "Orion"	Ialoveni, Alecs.-cel-Bun, 13	Car wash	32
Centru	122	20-214-33	Pers. fiz. "Frunza Valentin"	str. Alecs.-cel-Bun, 9/1	Restaurant	28
Centru	51	1-942-33	ÎI "V. Berlinchii"	bd. Gagarin, 10	Car wash	22
Centru	74	6-895-33	SRL "Triumf Unitried"	str. Arborilor, 9/2	Car wash	22
Centru	121	1-844 -33	SRL "Gheba Prim "	str. Ismail, 30	Restaurant	21
Centru	89	5-512-33	S.A. "Sălcioara Vascan"	str. Tighina, 49	Production of toilet paper	18
Centru	112	6-552-33	S.A. "Anghelina"	31 August, 29/1	WC	16
Centru	125	20-296 -33	Î.I. "Enachi Stanislav"	Ialoveni, str. Gh. Coşbuc, 1	Car wash	3
Centru	131	6-221-33	S.R.L. "F.V.I. Traian Invest"	str. Grenoble, 128	N/A	2
Centru	21	N/A	SRL "Modem"	str. Grenoble, 114	Carwash	N/A
Centru	33	1-666-33	S.A. "Național Vin"	N/A	Wine production	N/A
Centru	45	1-753-33	Hidropompa	bld.Gagarina, 2	Hotel Services	N/A
Centru	93	8-554-33	SRL "Iurs"	str. Bucuresti, 1/6 str. Hînceşti, 60/1	Agricultural market	N/A
Centru	101	194 j ps	Î.M. "Naturvins"	Ialoveni, str. Al.-cel-Bun, 43	Wine factory	N/A
Centru	129	N/A	S.R.L. "Daniela"	Ialoveni, Mileştii Mici	Car wash	N/A
Centru	132	N/A	Centrul național verificare prod. alcoolice	str. Grenoble, 128	Laboratory	N/A
Centru	134	N/A	S.R.L. Vinăria "Mileştii Mici"	Ialoveni, s. Mileştii Mici	Wine factory	N/A
Centru	135	N/A	S.R.L. "Rimus Auto"	str. Camenița, 4	Car wash	N/A

N/A : Data non available.

(source : documents from ACC called "industrii vizate in progr de prelevare a probelor si calitatea efluentului industrial 2009-2010 »)

Sector	Contract number	Customer number	Name of industry	Adress	Economic sector	WW Volume (m3/month)
Ciocana	15	5-647-33	S.A. "Efess Vitanta Moldova Brevery"8	str.Uzinelor,167	Beer factory	7 611
Ciocana	11	5-620-33	S.A. "Combinatul de articole din carton"	str. Transnistria, 18	Production of cardboard articles	4 295
Ciocana	2	5-645ps	S.A."Moldovahidromaş"	str. M.Manole, 7	Pump factory	3 994
Ciocana	7	5-624ps	S.A. "Tutun"	str. Izmail, 116	Cigarette factory	3 714
Ciocana	64	5-637-33	Î.S. "Fabrica de sticlă"	str. Transnistria, 20	Glass Container	2 993
Ciocana	3	5-607ps	S.R.L. "Coca Cola Balters"	str. Industrială, 5	Coca Cola factory	2 680
Ciocana	16	4-618-33	S.A. "Franzeluţa nr.4"	str.Uzinelor,1	Bread factory	2 158
Ciocana	25	5-861-33	Î.C.S "Shan Lian International Group"SRL	str. Sadoveanu, 42/6	Shopping Centre	2 047
Ciocana	61	5-655-33	S.A. "Glass Container Company"	str. Uzinelor, 201	Glass Container Company	1 535
Ciocana	21	5-847-33	S.R.L. "Olmosdon"	str. Varniţa, 8	Car wash	1 117
Ciocana	36	5-630-33	S.A. "Farmaco"	str. Vadul lui Vodă,2	Pharmaceutical Plant	849
Ciocana	13	3-268-33	R.T.E.C. "Parcul de troleibuse nr. 3"	str. Meşterul Monole, 8	Public Transportation	682
Ciocana	37	5-674-33	S.A. "Monolit"	str. Uzinelor, 169	Concrete Factory	598
Ciocana	5	5-618ps	S.A. "Vismos"	str. Uzinelor, 5	Wine factory	494
Ciocana	40	5-502-33	S.A. "Agro-Mondial"	str. G.Latină, 18	Agricultural market	494
Ciocana	63	5-638-33	S.A. "Alimentarmaş"	str. Meşterul Manole, 12	Manufacture of metal constructions, furniture	487
Ciocana	72	5-813-33	S.R.L. "Mondial Com"	str. Ciocana,10	Market, pastry	482
Ciocana	31	5-672ps	Î.C.S "Vistarcom"SRL	str. A.Russo, 28	Green Hils - Market	467
Ciocana	27	1-951-33	S.R.L. "Modem"	str. Ginta Latina, 8/3	Car wash	436
Ciocana	6	2-624-33	Î.S. "Mecagro" I.C.M.E.A.	str. Miron Costin, 7	Production of agricultural machinery	431
Ciocana	10	5-615ps	S.R.L. "Baswool"	str. Uzinelor, 206	Washing wool	409
Ciocana	22	5-211-33	S.R.L. "Confort - AM"	str. Varniţa, 6	Deposits, canteen	378
Ciocana	88	5-209-33	I.C.C. "Angrocoop"	str. Uzinelor, 9	Deposits	364
Ciocana	85	N/A	S.A. "Basvinex"	str. Uzinelor, 201	Wine factory (arenda de la Glas container compani)	362
Ciocana	45	5-204-33	S.R.L. "Grandfox"(Trabo-plus)	str. M.cel Bătrîn,12/2	Pizzeria, Offices, pretreatment station – 2 grease separators	348
Ciocana	17	5-217-33	S.A."Ciocana"	str. Mircea cel Bătrin, 6	Market -Fidesco	337
Ciocana	56	5-700-33	S.A. "FEC"	str. Uzinelor, 96	N/A	326
Ciocana	79	17-253-33	Stat.Balniara"Bucuria SIND"	or.V.Vodăstr.Balniară, 1	Sanatorium V.Vodă	315
Ciocana	30	5-738-33	S.R.L. "Vesi"	str. M. Manole, 9	Car wash	314
Ciocana	28	5-228-33	S.R.L. "Tirialbi"	str. Sadoveanu, 42/3	Deposits	276
Ciocana	49	N/A	S.R.L."Vinangro Comerţ"	str. Uzinelor, 2	Confectionery (arenda de la într.cerealiere)	252
Ciocana	80	2-703-33	S.R.L "Tirex Petrolt"	str. M.celBatrin,13/3 Columna,90	Car wash	248
Ciocana	1	5-419ps	S.R.L."Telemar"	str. Uzinelor, 21/1	Fish Processing	248
Ciocana	43	3-941-33	S.R.L. "Trabo-Plusl"	str. Mircea cel Batrin	Pizzeria	211
Ciocana	4	5-679-33	S.R.L. "Daron-Lux"	str. Varniţa, 14/1	Confectionery	210
Ciocana	12	5-821-ps	S.R.L. "Sanin"	str. Uzinelor, 21A	Chemical industry, film production	205
Ciocana	95	5-475-33	S.A."Dilastoflex"	N/A	Polyethylene production	182
Ciocana	32	40j	S.R.L. "Fegro"	str. A.Russo, 18/3	Fidesco - Market	180
Ciocana	42	5-366-33	S.R.L "Trial Sistem"	str. M.celBatrin, 30	Shopping Centre	178
Ciocana	65	5-805-33	S.R.L. "Spamol"	str. Sadoveanu, 42/3	Production of wood and metal constructions	175
Ciocana	33	5-644-33	S.A. "Utilajcom"	str.Industrială, 5	Wood and metal processing	174
Ciocana	9	5-633-33	S.A. "Beton Armat"	str. Uzinelor, 12	Concrete Factory merchandise	170
Ciocana	91	5-273-33	S.R.L."Daac Ciocana"	str.M.cel Bătrîn,5	Restaurant	158
Ciocana	23	5-642-33	S.A. "Rumeon"	str. Varniţa, 22	Car wash	154
Ciocana	35	2-883-33	S.R.L. "Lukoil Moldova"	str. Vadul lui Vodă, 110	Car wash	143
Ciocana	47	5-875-33	S.R.L. "SIMII"	str. M.Spataru,36	Pharmaceutical warehouse	130
Ciocana	38	19-215-33	S.R.L. "Bemol Retaill"	str. Spătaru,8/4	Car wash	126
Ciocana	54	5-824-33	S.R.L. "Incom - VLP"	str. Uzinelor, 88	Car wash	123
Ciocana	81	5-727-33	S.R.L. "Arbstuml"	str. M.Manole, 2/2	Bathroom,Sauna	120
Ciocana	94	5-295-33	S.R.L."Bandaira"	str.D.Latină,10	Car wash	119
Ciocana	34	5-864-33	S.R.L."Vedomplex"	str. M. Manole, 2/3	Car wash	118
Ciocana	92	5-273-34	S.R.L."Vadormet"	str.Transnistria,5/1	Pastry	115
Ciocana	46	2-883-33	S.A. "Lukoil Moldova"	str. G.Botanica, 26 Columna,92	Canteen	108
Ciocana	8	5-672ps	FPC "Santarm"S.A.	str. Uzinelor, 78	Offices, Market	105
Ciocana	86	520 533	S.R.L. "Etolaur"	str. Volontirilor, 16	Pastry	102
Ciocana	48	5-439-33	S.R.L. "Iujenatl"	str. M.cel Batrin,4/6	Offices, bar,cazino, hairdresser's, pharmacy	97
Ciocana	55	2-663-33	S.R.L. "Petrom Moldova"	str. M. Spătaru 11/1	Car wash	93
Ciocana	41	5-542-33	S.A. "Agat"	str. M. Sadoveanu, 42	N/A	88
Ciocana	44	5-277-33	S.R.L. "Sofilarexl"	str. Uzinelor, 12 b	Car wash	88
Ciocana	87	5-210-33	S.A. "Dacia Com"	str. Uzinelor, 7	Deposits	75
Ciocana	62	5-659-33	S.A. "Incomaş"	str. Transnistria 16/1	Manufacture of metal constructions	75
Ciocana	18	5-415-33	S.R.L. "Coloteia"	str. Uzinelor, 9/1	Sausage production	73
Ciocana	71	5-952-33	SRL "DIN Autoservice"	str.M. Spătaru, 8/2	Car wash	72
Ciocana	78	5-865-33	S.R.L "Maser Auto"	str. V.Vodă, 21/2	Car wash	70
Ciocana	83	5-503-33	S.R.L "LAL"	str.D.Latină, 20	Car wash, bar	58
Ciocana	89	5-447-33	Î.M.Moldo Italiană "Savi Plus"	str.Voluntarilor,15/2	Pastry	57
Ciocana	20	5-329-33	S.R.L. "Malexim"	str.Uzinelor,9/1	N/A	40
Ciocana	39	3-705-33	S.A. "Stejaur"	str. M.Dragan, 11 a	Deposits, Offices, furniture factory	39
Ciocana	75	5-437-33	S.R.L."Montes-Grup"	str.A.Russo, 65/1	Pizzeria	38

Ciocana	19	5-800-33	S.R.L. "Oliotera"	str. Industriala,14/1	Vegetable oil production	34
Ciocana	26	5-814-33	F.P.C. "Teraru" SRL	str. M.Dragan, 13/1	Car wash	34
Ciocana	77	5-202-33	S.R.L "Vertaldt"	str. M.Sadoveanu, 3	Restaurant Mugurel	26
Ciocana	57	5-512-33	Î.I. "Salcioara Vascan"	str. Meşterul Manole, 9	Deposits, Residential homes,	23
Ciocana	61	5-678-33	S.R.L. "Electrocon"	str. Meşterul Manole, 14/1	N/A	15
Ciocana	29	5-812-33	S.R.L."Onega - M"	str. M.Costin, 7	Waste disposal	11
Ciocana	82	5-389-33	S.R.L. "Aurel Albot"	str.M.Dragan, 2/2	Bar	8
Ciocana	24	1-7055ps	S.A. "Artizana Grup"	str. Uzinelor, 206	Wool processing	0
Ciocana	50	5-227ps	S.R.L. "RiR"	str. Industrială, 27	Sausage production	0
Ciocana	51	5-227ps	S.R.L. "RiR"	str. Industrială, 23	Production of alcohol/spirit	0
Ciocana	14	5-664-33	S.A. "Fabrica de drojdii"	str.Uzinelor,1/1	Yeast plant	N/A
Ciocana	52	5-812-33	Î.C.S."Saniteh Sanitary Ceramic"S.R.L.	str. Sadoveanu, 42	Production of ceramic sanitary	N/A
Ciocana	53	64j	SRL "Prosiritvest"	str.M. Manole, 9	Car wash	N/A
Ciocana	58	5-665ps	S.A. "Liftservice"	str. Transnistria, 10	N/A	N/A
Ciocana	59	5-671-33	S.A. "Romir"	str. Sarmisegetuza, 9	N/A	N/A
Ciocana	58	5-353-33	S.R.L. "Derang Plus"	str. T. Vladimirescu, 1/7	Car wash	N/A
Ciocana	59	2-652-33	CET-1	str. Vadul lui Vodă, 5	Electricity manufacturing	N/A
Ciocana	60	5-646-33	CET-2	str. Meşterul Manole, 3	Electricity manufacturing	N/A
Ciocana	66	5-619-33	S.A. "Macon"	str. Uzinelor, 104	Production of construction materials	N/A
Ciocana	67	5-760-33	S.R.L. "Silboris trans"	str. A. Russo 16/1	Car wash	N/A
Ciocana	68	5-635-33	S.A. "Midgard - Terra"	str. Transnistria, 6	N/A	N/A
Ciocana	69	5-631-33	S.A. "Inteh"	str. Meşterul Manole, 18	Manufacture of metal constructions	N/A
Ciocana	75	5-698-33	Î.M. "Rebhan Plastpac Ressan"	str. Industrială, 21	N/A	N/A
Ciocana	76	5-652-33	S.A. "Energoreparaţie"	str. Otovasca, 1	Electrical equipment repair	N/A
Ciocana	77	5-350-33	S.R.L. "Gana Ilen"	str. Uzinelor, 21A	N/A	N/A
Ciocana	70	5-629-33	S.A. "BSPS"	str. Uzinelor, 21	Design Institute	N/A
Ciocana	79	5-812-33	S.R.L. "Fabbri Inox"	str. Uzinelor, 21A	N/A	N/A
Ciocana	80	5-252-33	SRL"D-Invest Fecioara"	str. Dimo, 13	N/A	N/A
Ciocana	73	5-718-33	S.R.L. "Şans"	str. L.Bîcului, 28	Auto services	N/A
Ciocana	84	5-271-33	S.A. "Chivelvar"	str. M. Uzinelor,12	Fish processing	N/A
Ciocana	74	5-601-33	S.R.L "Servmont"	str. L.Bîcului, 28	Market	N/A
Ciocana	86	5-535-33	S.A."Avion"	str.M.Manole,12/2	Factory	N/A
Ciocana	87	5-259-34	S.R.L."Stroylux"	str.Uzinelor, 11	N/A	N/A
Ciocana	76	5-642-33	Î.M. "Exdrupo"	str. Varniţa, 22	N/A	N/A
Ciocana	84	5-479-33	S.A. "Torent-Elsa"	str. P.Zadnipru, 9/1	Restaurant	N/A
Ciocana	90	5-471-33	S.R.L."Maurt"	str. Voluntarilor, 15	Wine factory	N/A
Ciocana	93	2-320-33	S.R.L."Supraten"	str.Transnistria,5/1	Production of dry mixture	N/A
Ciocana	96	N/A	S.A."Romstal Trade"S.R.I.	N/A	Shop	N/A

N/A : Data non available.

(source : documents from ACC called "industrii vizate in progr de prelevare a probelor si calitatea efluentului industrial 2009-2010 »)

Sector	Contract number	Customer number	Name of industry	Adress	Economic sector	WW Volume (m3/month)
Riscani	24	7-470-33	Î.C.S. Metro "Cosh and Cary" S.R.L.	N/A	shopping mall	1 602
Riscani	20	1-705-33	Depoul de locomotive	str. Haltei, 6, MD-2023	locomotive repair center	1 294
Riscani	7	2-664-33	F.C.P. «Pegas» S.R.L	str. Petricani, 174, MD-2059	N/A	1 133
Riscani	22	2-358-34	Î.S.C. «Vedova Grup» S.R.L.	str. Tigina,12; MD2012	hotel complex «Turist», restaurant	928
Riscani	25	N/A	ÎS"Zarea"	str. A. Pan, 4 MD- 2024	hotel	852
Riscani	78	N/A	«Ungar»S.R.L.	str. Trandafirilor,43	N/A	819
Riscani	6	2-669-33	S.A. "Mezon"	bd. Moscovei, 21, MD-2068	production of oxygen, nitrogen, stainless centrifugal pumps, radio receiver, flowing water heating machinery, services in glass design for wine companies	815
Riscani	55	7-485-33	SC «Gara Nord»	MD2001 str.M.Varlaam,58	N/A	612
Riscani	52	2-799-33	F.S.P. «Extremum»	str.C.Basarabiei,7 MD-2024	market	512
Riscani	105	2-990-33	«Daac Hermess» SA	str. Petricani, 17	car test, car washing	506
Riscani	56	2-663-33	Î.C.S.«Petrom Moldova» SRL	Cale Orheiului, 109	N/A	497
Riscani	14	2-668-33	S.A."Art Met"	str. Feredelului, 12, MD-2005	mechanical factory	486
Riscani	72	2-851-33	«Succes-M»S.R.L.	str. Albisoiara, 84/6	restaurant «Lebăda Albă», renting	452
Riscani	106	2-298-33	«Viva şi Co» SRL	str. Alex.cel Bun, 83	restaurant, offices	446
Riscani	9	2-241-33	S.A"Art Nic"	bd. Moscovei,19; MD- 2068	shopping mall	437
Riscani	2	2-680-33	S.A. «Tipografia Centrală»	str. Florilor,1, MD-2068	N/A	428
Riscani	46	2-264-33	S.A. "Moldelina"	str. Petricani, 21, MD-2059	electrotechnical equipment	427
Riscani	67	2-675-33	«Cons Parcaj»S.R.L.	str. Ismail,112/1 MD-2023	hotel business, warehouse, offices	408
Riscani	34	N/A	SRL «East Auto Lada»	str. Chişinăului, 3	car technical centre «Ivieco»	399
Riscani	39	N/A	"Institutul Muncii"	str. Zimbrului, 10 MD- 2024	hotel, restaurant	395
Riscani	68	2-648-33	«Manejul de atletică uşoară» Î.S.	str.A Doga, 26 MD-2024	N/A	360
Riscani	71	2-257-33	SA «Universcom»	str. Petricani, 21/3	N/A	359
Riscani	8	3-229-33	S.R.L.« Colaj»	str.Srudenţilor, 7/5, MD- 2068	car service, restaurant, nightclub, bowling	359
Riscani	77	2-391-33	«Orhei» S.A.	str. Albisoara, 80/5a	shopping mall	344
Riscani	33	2-670-33	S.A. Electromaşina	str. Petru Rareş, 77	cleaning machine factory	340
Riscani	80	N/A	«Trabo Plus» S.R.L.	bd. Moscovei, 6	pizzeria	332
Riscani	3	2-591-33	S.R.L. VVP	str. Calea Moşilor, 31	car washing, bar, office, car service	326
Riscani	19	2-681-33	S.A."Cricova"	str.Petricani,25, MD- 2059	alcohol bottling factory	303
Riscani	16	2-730-33	S.R.L. «Tesla Energie»	str. Feredelului, 4, MD- 2005	warehouse: mobilă, renting: food shop, sauna, printing shop	298
Riscani	10	25-205-33	"Asamblor"	s.Gratieşti, str. Ion Vodă, 8, MD-2093	fish processing	290
Riscani	50	2-301-3	SA «Art Vest»	bd. Moscova, 2	N/A	287
Riscani	94	7-396-33	Î.I. «Cros Cebotarescu»	str.Albişoara, 44	MuzCafe	265
Riscani	51	5-353-33	S.R.L. «Derang Plus»	str.T.Vladimirescu, 25, MD-2024	car washing, car service	247
Riscani	108	2-385-33	F.P.C. «Europa Servis» SRL	Albişoara, 3	N/A	243
Riscani	95	3-259-33	Direcţia generală pentru administrarea clădirilor a Guvernului RM	str. Piaţa Marii Adunări Naţionale, 1(A.Russo,1	N/A	240
Riscani	47	2-364/1-33	S.R.L. "Salipetrier"	str. Petricani, 19/5, MD-2059	fish processing	231
Riscani	21	2-400-33	S.R.L."Garitudor"	str. Albişoara, 40/1, MD- 2005	mini market, restaurant	217
Riscani	43	7-353-33	SRL«Elisav Com»	str. Albişoarai, 21/2	N/A	215
Riscani	80	N/A	«Trabo Plus» S.R.L.	str. Ceucari, 2/8	pizzeria	207
Riscani	34	2-654-33	S.R.L. «East Auto Lada»	str.Cucorilor, 43; MD-2020	car service and base	199
Riscani	35	2-211-33	Farmavet S.A.	str. Petricani, 198, MD 2031	veterinarian pharmacy	193
Riscani	107	7-469-33	«Prometeu-T» SRL	str. Petricani, 33	agricultural warehouse, offices	190
Riscani	83	8-371-33	ÎMC Market	bd. Moscova, 9	shopping mall	190
Riscani	103	2-289-33	«Antares» SRL	bd. Moscova, 9/1	car lessons school	188
Riscani	11	1-269-34	SRL "FOOD Planet Restaurants" restaurant «Mcdonald s	str.Şt.cel Mare şi Sfânt, 134/1 (prelevare-srt.A.Russo,2)	restaurant	184
Riscani	80	N/A	«Trabo Plus» S.R.L	str. Crihan Anton, 3/1 MD2009	pizzeria	176
Riscani	18	2-881-33	SRL"Şel şi Co"	str.B.Bodoni,28, MD- 2005	N/A	172
Riscani	30	2-395-33	S.A."Poşta Veche"	str.C. Orheiului,105/1, MD- 2020	shopping mall, bar, restaurant «Elegance»	171
Riscani	26	7-090-33	«Regomit» S.R.L.	str. Gheorghe Cojbuc, 5a, MD-2005	car washing	170
Riscani	80	N/A	«Trabo Plus» S.R.L.	bd. G. Vieru, 20	pizzeria	167
Riscani	87	2-755-33	«Fortus» S.R.L.	bd. Renaşterii, 11	restaurant, bar, terrace	162
Riscani	97	7-088-33	SRL «Tetis Internaţional şi Co»	str.C.Orheiulu,103/3	pharmaceutical warehouse	157
Riscani	99	6-199-33	FC «Autocar Imex» SRL	str. C.Basarabiei, 2	market «Domus»	152
Riscani	58	2-672-33	S.A. «Inconarm»	str. Petricani, 84 MD2059,	restaurant, concrete & mortar factory	150
Riscani	101	7-543-33	«Expotroncom» SRL	str. A.Russo, 1	shopping mall	149
Riscani	88	7-544-33	S.C. «San Sheng» S.R.L.	str. Miron Costin, 13/5	Bar «Foişor»	149
Riscani	90	1-549-33	SRL «Şafranax»	str.Iazului, 3/1	cake shop	142
Riscani	5	2-633-33	S.A. « BTA 31»	str. Petricani, 94, MD-2059	car service, car washing, mini printing	132
Riscani	40	2-270-33	SA «Plovdiv»,	MD2068, bd. Mscovei, 6	renting: restaurant, bar, car washing, car service, shops	129
Riscani	91	7-008-33	«Alferal» S.R.L.	str. Kiev, 5/3	restaurant «Cavcazcia Pleniţa»	128
Riscani	57	7-137-33	S.R.L. «Lundas Trans»	str.Petricani, 5	bar, car washing, car service	124
Riscani	66	4-623-33	SA «Interautotrans»	str. Pădurii, 4 MD2002	N/A	121
Riscani	74	2-272-33	«Ferrum» S.R.L.	bd. G.Vieru, 21/1 MD2005	pizzeria	120
Riscani	92	2-773-33	«Cartal Mond» S.R.L.	str.Puşkin, 52	restaurant	119
Riscani	12	7-450-33	Î.I."Costiuc Natalia"	str.Florilor,3/2, MD-2064, str.I.Creangă,43, ap.24	car washing	118
Riscani	4	2-264-33	Î.S.A.P. «Rîşcani ŞC»	str. T.Vladimirescu,1 MD-2024	canteen	112
Riscani	34	N/A	SRL «East Auto Lada»	str. Cucorilor,14	shopping mall «Omega»	108
Riscani	61	4-359-33	S.C.«Fivils»S.R.L.	com. Grătieşti, M.Viteazul	chicken meat packaging	106
Riscani	23	2-682-33	S.A."Viitorul"	str. Botizatu, 13, MD- 2005	fabrica de mobilă	101
Riscani	27	2-683-33	Î.I. "Ovadenco"	bd. Moscovei, 23/1	bar "Coral"	98
Riscani	104	7-505-33	«Fidesco» SRL	str. Petricani, 19	hotel business, office	95
Riscani	44	N/A	SRL «Lascaut Prim»	str. A. .Botezatu, 10	car washing	91
Riscani	109	N/A	S.R.L. «Atirus Grup»	str.Petricani, 21/3	N/A	90
Riscani	75	2-576-33	«Martex» SRL	str. Puşkin, 44/1	restaurant	89
Riscani	44	3-785-33	SRL "Lascaut Prim"	str. C.Orheiului, 135	car washing	88
Riscani	86	2-637-33	«Varustun» S.R.L.	str. Petricani, 33 MD- 2059	warehouse, office, hotel	87
Riscani	73	2-583-33	ÎM «Fegro» S.R.L	str.B.Bodoni,57 MD-2001	shopping mall	84
Riscani	32	2-676-33	S.A."Tehnovin"	str. Studenţilor, 2/4, MD-2068	renting: beer & alcohols bottling, PVC windows factory	83
Riscani	41	7-573-33	S.R.L. "Valsercom service"	str. M.Viteazul, 18	car washing	82
Riscani	70	7-191-33	«Atfan Grup»S.R.L.	str.Caucaz, 22 MD-2001	N/A	81
Riscani	13	2-669-33	S.R.L."Estan Com"	str.M.Basarab,1	hotel business	80
Riscani	64	7-461-33	«Telsistel»S.R.L.	str.C.Orheiului, 22 MD-2020	restaurant «Golden Nica»	78
Riscani	54	2-336-34	«Trividi» SRL	Albişoara, 22/2	N/A	76
Riscani	15	7-959-33	Mezboier Î.I.	str.Socoleni,31 MD -2020	sausage factory	75
Riscani	98	2-319-33	SA «Speranţa Vest»	str.Columna, 104	N/A	74
Riscani	28	2-595-33	S.R.L. "Constanta"	str.Petru Rareş, 77/1	car washing, bar	68
Riscani	85	2-458-33	«Subil Grups» S.R.L.	str. M. Costin, 13/1	restaurant, bar «Balcan»)	61
Riscani	31	2-333-33	Î.I. "Costiţa Danici"	str. Mirceşti, 22/4	sausage factory	58
Riscani	82	7-545-33	Firma «Olivitta» SRL	str.C.Orheiului, 19A	Bar	54
Riscani	29	7-930-33	S.R.L. "Modern Gaz Service"	str. Albişoara; 19, MD- 2005	car washing, car test	52
Riscani	76	7-636-33	«Gherciu Petru» I.I.	str. Albisoara, 84/9	bar, shop	52
Riscani	45	2-703-33	«Tirex Petrol» SRL	Petricani, 206	N/A	42
Riscani	84	151433	«Agrofermotech» S.R.L.	str.C. Basarabiei, 18	restaurant, car washing	39

Riscani	63	7-733-33	Î.M. «AutoFrame-FM»S.R.L.	str. Socoleni, 18 MD-2020	car service, car washing	38
Riscani	60	7-971-33	«Neocrin Lux» SRL	str. Dimo, 28/1	N/A	33
Riscani	81	7-412-33	«Cocteil Com» S.R.L.	str.Kiev,9 str. Hipodromului, 9/1 MD2059	restaurant «La Crâşmă»	31
Riscani	17	2-980-33	S.R.L."Albertina"	str. Dimo, 13/2A; MD- 2068	importation and sale of meat	31
Riscani	93	6-097-33	«MGI Auto» S.R.L.	str. C.Basarabiei, 16/1	car washing	29
Riscani	102	2-268-33	«SOKO» SRL	str. A. Russo, 1/1	club	26
Riscani	53	2-668-34	SRL «Asigromex»	MD-2024 str. Zimbrului, 10	N/A	21
Riscani	100	2-373-33	«Vicaur-C» SRL	str. Luncii, 2/1	warehouse	18
Riscani	69	6-924-33	SC «Oltavim» SRL (Cafenea-Bar «Frumuşica)	str. C. Basarabiei, 16	N/A	16
Riscani	1	2-678-33	S.A. Piele	str Izmail, 99, MD-2023	N/A	N/A
Riscani	36	2-485-33	S.R.L. "Sinderela"	str. Miron Costin, 25; MD- 2068	chemical cleaning	N/A
Riscani	37	7-041-33	S.R.L."Saltica Lux"	str. Petricani, 3, MD- 2031	car washing	N/A
Riscani	38	7-594-33	SRL"Lecostan"	str.Calea Orheiului, 59 MD- 2059	restaurant	N/A
Riscani	42	2-698-33	S.R.L."Dar-Raiu"	str. Doina, 119	Internet-café "La Porţile Raiului"	N/A
Riscani	48	N/A	SRL «Sanverina»	str.Albisoara, 19	car washing	N/A
Riscani	49	1-706-33	Depoul de vagoane	str. Haltei, 6/2 MD-2023	N/A	N/A
Riscani	59	1-762-33	Firma de construcţie a drumurilor «Edilitate» S.A.	Cucorilor, 41	N/A	N/A
Riscani	62	2-645-33	S.A.«Nistru Lada-Autovaz»	str. C.Orheiului, 112	car service, chemical cleaning, car washing	N/A
Riscani	65	7-990-33	«Sovilerus» SRL	str. Puşkin, 39	restaurant	N/A
Riscani	79	N/A	«Ciclon Grup»S.R.L.	str. B.Voevod, 2/5 MD2068	restaurant «Crama Boierului», office	N/A
Riscani	89	7-596-33	SRL «Crâşmar Grup»	str.M.Viteazul, 18	recreation complex	N/A

N/A : Data non available.

(source : documents from ACC called "industrii vizate in progr de prelevare a probelor si calitatea efluentului industrial 2009-2010 »)

Appendix 6

Non-Revenue Water Analysis

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1. NON-REVENUE WATER

1.1. NON-REVENUE WATER IN CHISINAU: NORMATIVE APPROACH BY THE MOLDOVAN TECHNICAL UNIVERSITY

1.1.1. INTRODUCTION

Non-revenue water is calculated every year in Moldova for all water supply utilities by the Moldovan Technical University (MTU), through a normative approach published and approved in 1999 under the following title: “Metodica elaborarii normativelor de consum tehnologic al apei la intrepriderile prestatoare de servicii alimentare cu apa si canalizari a Republicii Moldova”.

The volume of losses obtained with this method is used afterwards in the yearly calculation of water tariffs, as this normative approach has a legal validity. The methodology developed under the aforementioned title was approved and registered in 1999 by two Moldovan ministries:

- Ministerul Dezvoltarii Teritoriului, Constructiilor si Gospodariei Comunale al Republicii Moldova;
- Ministerul Justitiei al Republicii Moldova;

The fact that the normative estimate of losses is used in the tariffs calculations highlights an important point: if losses are over-estimated by the MTU, when compared with the reality, tariffs will allow covering the costs of overall real losses and will create profits with the over-estimated volumes. If losses are under-estimated by the MTU, the contrary will happen and tariffs will not allow covering the costs of overall real losses, implying financial losses due to the under-estimated volumes.

Even though the losses are assessed thanks to an empirical and normative approach, the technical inputs needed by the calculation formulas are provided every year by the water supply utilities based on real operational data. The data provided for the year N is then used to calculate non-revenue water and tariffs for the year N+1.

Such data includes a detailed list of the utility’s existing assets (pipes, reservoirs, pumping stations, boreholes, treatment plants), leaks repaired during the year, billed volumes, number of water meters owned and operated by the utility, etc.

The following paragraphs will highlight the key-elements of water losses as calculated by the University’s normative approach and will compare normative results with water losses figures calculated by the Consultants based on the operational data provided by ACC in 2009 and 2010.

1.1.2. WATER BALANCE BASED ON THE NORMATIVE APPROACH

1.1.2.1. General Points

The normative approach calculates water losses for four (4) main components, always taking into consideration raw water, technological water (partially treated water) and potable water:

1. Water consumption during catchment, treatment and transport/distribution processes;

2. Water losses in treatment facilities;

3. Physical and commercial water losses in the transport/distribution process;

4. Water consumption for the utility's O&M needs and other external authorized use;

All major four (4) components include several items taken into account during the calculation of water volumes for consumption and losses:

Table 1: Water consumption during catchment, treatment and transport/distribution processes

<table>
<tr><td rowspan="2">Catchment process</td><td>Groundwater</td><td>Disinfection and washing of wells;
Pumping tests;
Water table reloading;</td></tr>
<tr><td>Surface water</td><td>Washing of filters/sieves;
Washing of suction chambers, piping, drainage and other elements of the catchment points;</td></tr>
<tr><td>Treatment process</td><td colspan="2">Disposal of sludge from flocculation and settling tanks;
Washing of settling tanks and filters/sieves;
Preparation of disinfectant (chlorine);
Preparation of reagents;
Disinfection and washing of reservoirs;
Washing of pipes located within the WTP compound;
Water consumption of the WTP laboratory for chemical and bacteriological tests, including water samplings for quality testing;
Cooling of electromechanical equipment such as pumps located within the WTP compound;</td></tr>
<tr><td>Transport/Distribution process</td><td colspan="2">Disinfection and washing of transport/distribution pipes and reservoirs;
Cooling of electromechanical equipment such as pumps in the network’s pumping stations;</td></tr>
</table>

Table 2: Water losses in treatment facilities

Unrepaired/invisible leaks on pipes within the WTP compound;
Detecting/emptying/disinfecting/washing pipes for leak repairs;
Infiltration/seepage in reservoirs and mixing-settling-filtering tanks;
Defective accessories such as valves within the WTP compound;

Table 3: Physical and commercial losses in the transport/distribution process

Physical losses	Unrepaired/invisible leaks; Detecting/emptying/disinfecting/washing pipes and accessories for repaired/visible leaks; Infiltration/seepage in reservoirs and tanks; Fountains and other public water distribution points;
Commercial losses	Metering under-registration; Theft, meter tampering/damage, incorrect estimates, illegal connections, etc; Authorized unbilled water use such as firefighting needs;

Table 4: Water consumption for the utility's O&M needs and other external authorized use

The calculation is based on normative estimates built with the following documents: **Normelor SniP 2.04.01-85 and Normelor SniP 2.04.02-84**

The Consultants will detail below the normative approach used to determine physical and commercial losses in the transport/distribution process, as the majority of water losses occur within the water supply network. The values calculated by the MTU will be compared to the figures obtained by the Consultants based on data (produced and billed volumes) provided by ACC.

1.1.2.2. Physical and commercial losses in the transport/distribution process

A- <u>PHYSICAL LOSSES as defined by the normative approach:</u>

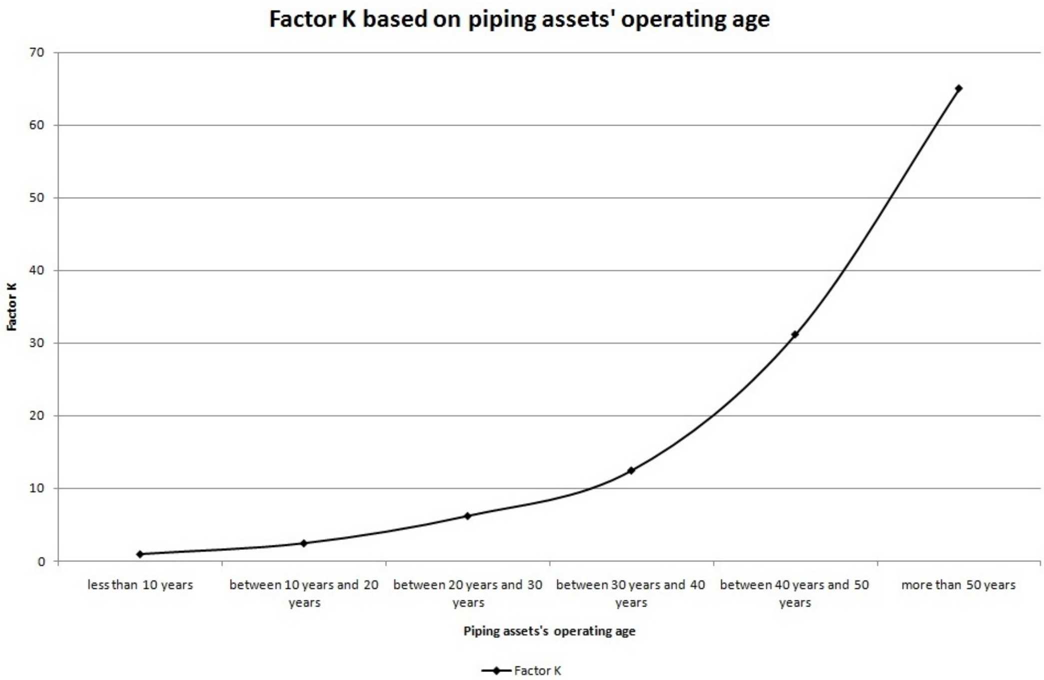
<u>For unrepaired/invisible leaks</u>, water losses are assessed thanks to calculations based on existing piping assets. The water utility provides a list of its network's piping assets including total length by material, diameter and operating age.

Two main factors in the normative approach determine the volume of losses allocated to unrepaired/invisible leaks:

- K factor, which depends on the operating age of the piping assets, with no dimensions;
- q factor, which depends on the material and the diameter of the piping assets, in m3/hr;

K factor increases with the operating age of the piping assets.

q factor increases with the diameter and the material: for the same diameter, the volume of losses will increase from steel/PE (lowest amount of losses) through ductile iron, asbestos cement and reinforced concrete (highest amount of losses).



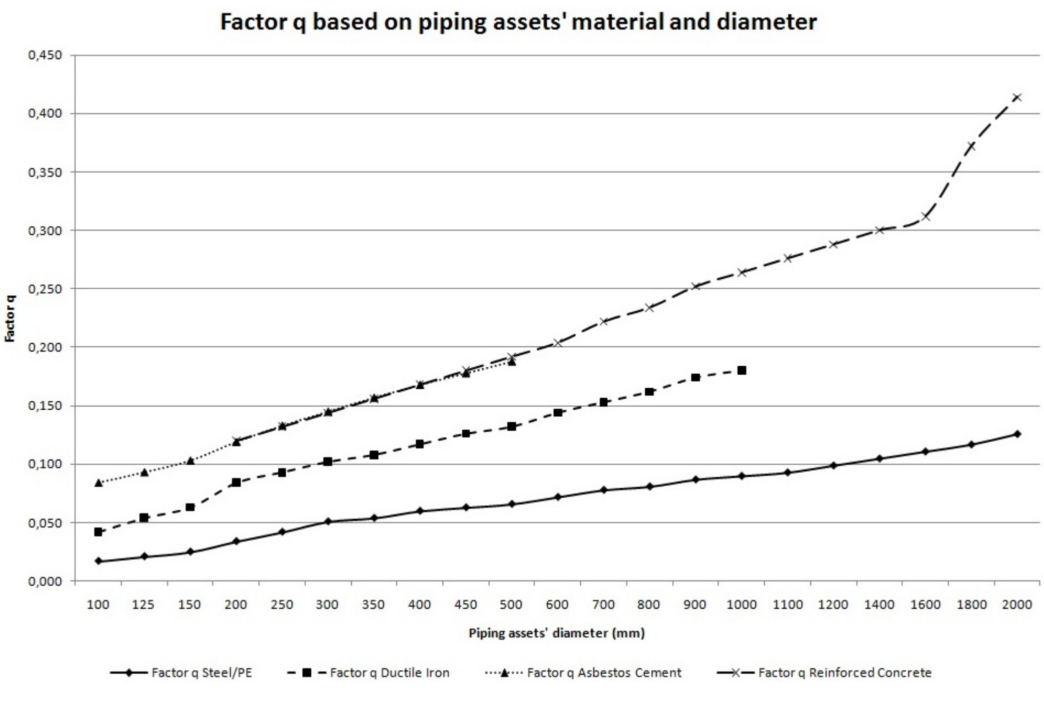


Figure 1: Graphic views of K factor and q factor

The volume of unrepaired/invisible losses is therefore calculated with the following formula: $\mathbf{V_{losses} = 24 \times 365 \times L_{iz} \times K_i \times q_{iz}\ (m^3)}$ with i being the piping assets' operating age and z the material.

An essential point of this normative approach for unrepaired/invisible leaks is that the q factor represents **admissible losses** within the water supply network.

<u>For repaired/visible leaks</u>, water losses are assessed thanks to calculations based on the yearly number of repaired leaks by diameter and type of leak.

Four (4) types of leaks are taken into account in the normative approach:

- *Rupturi*, or breaks;
- *Fisuri*, or cracks;
- *Suflur*i, or leaks due to watertightness failures of joints and seals;
- *Deteriorari*, or leaks on deteriorated accessories such as valves and hydrants;

For leaks considered as breaks, the total amount of water losses includes:

- Volume lost through the leak until its detection/location/repair;
- Volume lost through emptying the piping section where the break is located;
- Volume lost through the disinfection and washing processes of the piping section where the repair was carried out;

For leaks considered as cracks, watertightness failures of joints and seals, and deteriorated accessories such as valves and hydrants, the total amount of water losses includes only the volume lost through the leak until its detection/location/repair. This could be explained by the fact that cracks are usually repaired with a sleeve, watertightness failures are usually repaired by replacing defective joints and seals whereas deteriorated accessories are replaced by new items.

Volume lost through the leak until its detection/location/repair is calculated thanks to the following formula: $\mathbf{V_{losses} = 3600 \times \mu \times S \times t \times (2gP)^{\wedge 0.5}}$ with:

μ: consumption coefficient, equal to 0.6;

S: surface of the leak, in m^2;

t: leaking time, between 6 hours and 12 hours;

g: gravitational acceleration, equal to 9.81 m/s^2;

P: pressure in the network's section where the leak is located, in m;

<u>For leaks considered as breaks:</u>

S = 0.75 x 0.25 x (πD^2) = 0.59 D^2 (m^2), therefore $\mathbf{V_{losses} = 33873 \times D^2 \times P^{\wedge 0.5} (m^3)}$

<u>For leaks considered as cracks:</u>

S = 0.05 x 0.25 x (πD^2) = 0.04 D^2 (m^2), therefore $\mathbf{V_{losses} = 2298 \times D^2 \times P^{\wedge 0.5} (m^3)}$

<u>For leaks considered as watertightness failures of joints and seals, and deteriorated accessories such as valves and hydrants, the pipe diameter is not taken into consideration:</u>

S = 0.0002 m^2, therefore $\mathbf{V_{losses} = 11.4 \times P^{\wedge 0.5} (m^3)}$

For the same operating pressure, the volume of losses will therefore increase from leaks such as watertightness failures and deteriorated accessories (lowest amount of losses) to leaks such as breaks (highest amount of losses).

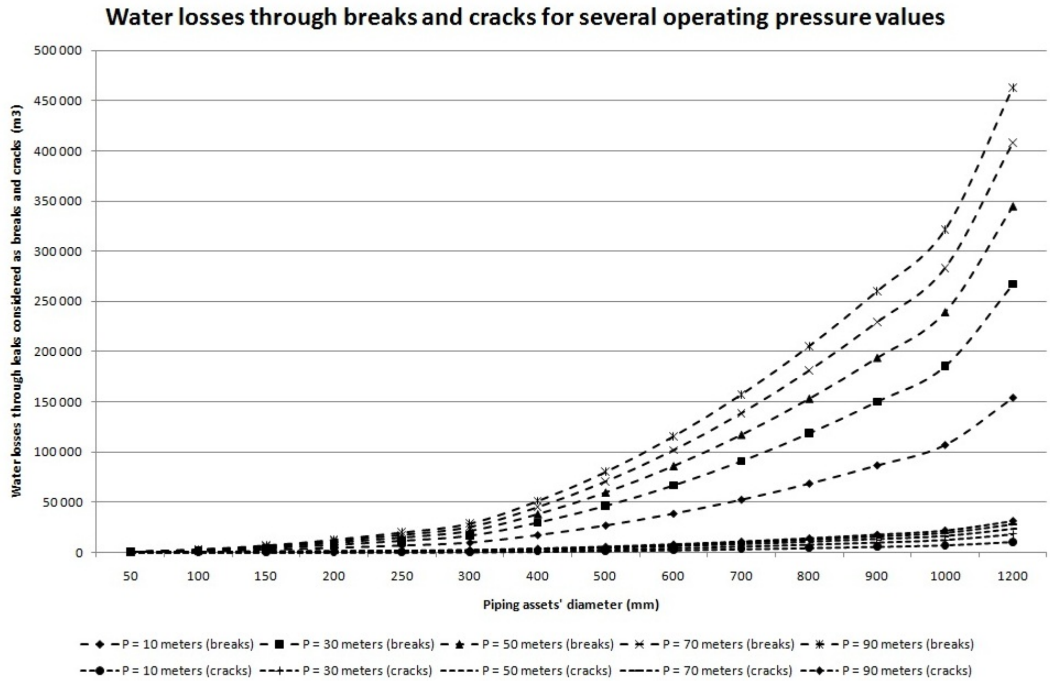


Figure 2: Graphic views of water losses for breaks and cracks

Infiltration/seepage in reservoirs and tanks is calculated for each reservoir and tank with the following formula: $\mathbf{V_{losses} = 0.003 \times 365 \times S\ (m^3)}$ with:

0.003: daily admissible infiltration/seepage losses through the reservoirs and tanks surfaces in contact with stored water (m^3/m^2);

S: reservoirs and tanks surfaces in contact with stored water (m^2);

Losses in fountains and other public water distribution points are calculated for each location for 24 hours with the following formula: $\mathbf{V_{losses} = K \times \mu \times S \times (2gP)^{\wedge 0.5}\ (m^3)}$ with:

K: deterioration probability of the public water distribution point, equal to 0.1;

µ: flow coefficient of the deteriorated public water distribution point, equal to 0.4;

S: surface of the inlet pipe's cross-section in m^2;

g: gravitational acceleration, equal to 9.81 m/s^2;

P: average network operating pressure in m (with a maximal value of 60m);

B- COMMERCIAL LOSSES as defined by the normative approach:

Metering under-registration is calculated by adding three separate items:

- The annual under-registration (below the starting flow) for all water meters installed on service connections supplying domestic housing blocks;
- The annual under-registration (below the starting flow) for all water meters installed on service connections supplying industrial, commercial and institutional customers;
- The annual under-registration (for all flows above the starting flow) for all water meters supplying all customers;

Commercial losses due to under-registration (below the starting flow) for devices metering the supply of domestic housing blocks are calculated with the following formula:

$\mathbf{V_{losses} = 4 \times 365 \times q_i \times N_i\ (m^3)}$ with:

4: minimal number of daily operating hours of the water meter;

q_i: starting flow in m^3/hr for the nominal diameter i;

N_i: number of water meters with a nominal diameter i;

Commercial losses due to under-registration (below the starting flow) for devices metering the supply of industrial, commercial and institutional customers are calculated with the following formula:

$\mathbf{V_{losses} = 8 \times 365 \times q_i \times N_i\ (m^3)}$

Commercial losses due to under-registration (for all flows above the starting flow) for devices metering the supply of all customers are calculated with the following formula:

$\mathbf{V_{losses} = (4 + 0{,}17 \times 17{,}5 / 2) \times 0.01 \times V_{billed}\ (m^3)}$ with:

V_{billed}: annual billed volumes based on metering devices (m^3)

0,17: admissible error in the dial after 1000 hours of operation of the water meter (%), as described in GOST 8.156-83;

4: maximal relative error after manufacturing or repairing of the water meter (%), as described in GOST 8.156-83;

17,5: time-period between two consecutive metrological checks of the water meter (thousand hours);

Volume losses due to theft, meter tampering/damage, incorrect estimates, illegal connections and other factors are assessed with the following formula:

$\mathbf{V_{losses} = K \times V_{billed}\ (m^3)}$

K: depends on the number of residents in the supply zone (%)

- 0.5% when there's less than 100 000 residents;
- 1% between 100 000 residents and 200 000 residents;
- 1.5% between 200 000 residents and 500 000 residents;

- 2% between 500 000 residents and 1 000 000 residents, which is the current range of population living in the Chisinau area supplied with water by ACC;

Authorized unbilled water use such as firefighting needs is calculated with the following formula: $V_{losses} = V_i + V_{in} + V_h$ (m^3) with:

V_i: annual water consumption used to extinguish fires (m^3)

V_{in}: annual water consumption used in firefighting training activities (m^3)

V_h: annual water consumption used to verify the operating conditions of fire hydrants and other firefighting devices (m^3)

1.1.2.3. Volume of losses in the water supply network obtained by the normative approach

The losses (physical and commercial) in the water supply system in 2009 and 2010 are calculated for the following items:

Table 5: Losses (physical and commercial) in the water supply system in 2009 and 2010

	Volume of losses in 2009 (m^3)	Volume of losses in 2010 (m^3)
(1)-Repaired leaks	15 203 775	14 915 030
(2)-Invisible leaks	12 114 839	12 658 685
(3)-Firefighting needs	4 257	6 967
(4)-Metering under-registration	4 276 153	3 994 811
(5)-Leakage and O&M of reservoirs/tanks	44 392	39 765
(6)-O&M of water catchments	25 712	16 946
(7)-Leakage and O&M of pumping stations	151 353	151 353
(8)-O&M of the sewerage system	227 439	255 292
(9)-Theft, illegal use, estimates errors	1 063 645	1 012 757
TOTAL	**33 111 565**	**33 051 606**

The MTU also provides an estimate of the water consumption used by ACC for operational purposes.

Table 6: Estimate of the water consumption used by ACC for operational purposes.

	Volume of consumption in 2009 (m^3)	Volume of consumption in 2010 (m^3)
(10)-ACC water consumption for operational purposes as estimated by the MTU	2 069 947	2 208 732

All these items can be summarized into the IWA format to allow a better comparison with the results obtained by the Consultants via the data provided by ACC. The IWA format will differentiate revenue water and non-revenue water. The following tables were obtained by adding the items located above:

- Authorized billed consumption = yearly billed volumes by ACC
- Unbilled measured and unmeasured consumption = (3)
- Operational use by ACC = (6) + (8) + (10)
- Metering under-registration = (4)
- Theft, meter tampering/damage, incorrect estimates, illegal connections = (9)
- Leaks on primary network assets (pumping stations and reservoirs/tanks) = (5) + (7)
- Visible/Repaired leaks = (1)
- Invisible/Unrepaired leaks = (2)

2009 IWA format (Source: MTU)								
Authorised billed consumption				48 680 403		Revenue Water	83 861 915	Input in the water supply system
Authorised unbilled consumption	Unbilled measured and unmeasured consumption		4 257	2 327 355	35 181 512	Non-Revenue Water		
	Operational use by ACC		2 323 098					
Apparent losses (commercial losses)	Metering under-registration		4 276 153	5 339 798				
	Theft, meter tampering/damage, incorrect estimates, illegal connections		1 063 645					
Real Losses (physical losses)	Leaks on primary network assets (pumping stations and reservoirs/tanks)		195 745	27 514 359				
	Burst losses	Visible/Repaired leaks	15 203 775					
		Invisible/Unrepaired leaks	12 114 839					

2010 IWA format (Source: MTU)								
Authorised billed consumption				46 312 760		Revenue Water	81 573 098	Input in the water supply system
Authorised unbilled consumption	Unbilled measured and unmeasured consumption		6 967	2 487 937	35 260 338	Non-Revenue Water		
	Operational use by ACC		2 480 970					
Apparent losses (commercial losses)	Metering under-registration		3 994 811	5 007 568				
	Theft, meter tampering/damage, incorrect estimates, illegal connections		1 012 757					
Real Losses (physical losses)	Leaks on primary network assets (pumping stations and reservoirs/tanks)		191 118	27 764 833				
	Burst losses	Visible/Repaired leaks	14 915 030					
		Invisible/Unrepaired leaks	12 658 685					

Table 7: 2009 and 2010 IWA format tables

The tables show that for 2010 the revenue water and the non-revenue water represented 57% and 43% of the input in the water supply system, while for 2009 they were equal to 58% and 42%.

The network's efficiency (1 – losses volumes / input volumes) is therefore equal to 61% in 2009 and to 60% in 2010.

In terms of losses (physical and commercial), the MTU estimated for 2009 a total of 32 854 157 m3 and for 2010 a total of 32 772 401 m3. Physical losses represent the majority of the volume of losses with approximately 85% of the total while commercial losses have a value of more or less 15% of the total.

Real losses (or physical losses) are particularly problematic as they incur unnecessary operational costs, lead to increased system capacity requirements and over-investments, limit the system's ability to meet legitimate demand and deprive consumers of a precious resource. Physical losses are usually monetised using the "marginal cost" of water production (except in cases of supply deficit when less leakage leads to increased water sales)...

Apparent losses (or non physical losses comprising of metering losses and customer losses) though they do not directly impact the utility's ability to deliver water to consumers, deprive the utility of much needed financial resources to meet financial equilibrium and develop, operate and maintain water supply assets. Consumers are thus indirectly affected. Commercial losses are usually monetised using water tariffs practised by the utility.

These figures do not differentiate potable water and technological water. It would more interesting to do a water balance separating these two types of water, as they are injected into two separate water supply networks.

The Consultants have done distinctive water balances for both water supply networks (potable on one side and technological on the other side) and a general water balance (potable + technological) to allow the comparison with the figures obtained by the MTU. All these water balances have been calculated with data provided by ACC coming from existing and operating flowmeters as well as from the official figures of billed volumes in 2009 and 2010.

1.2. Non-Revenue Water in Chisinau: the Consultant's Approach

1.2.1. Water Balance for Potable Water

Table 8: Water Balance for Potable Water

	Volume in 2009 (m^3)	Volume in 2010 (m^3)
Input into the potable water supply system	**79 616 377**	**76 234 350**
(1)-Groundwater	2 693 533	2 121 225
(2)-SAN	11 534 774	10 701 096
(3)-STA	65 388 070	63 412 029
Billed volumes for potable water (cold and hot)	**46 700 731**	**44 468 580**
Water losses + operational use + unbilled consumption	32 915 646	31 765 770
ACC operational use	1 254 574	1 424 190
Water losses + unbilled consumption	**31 661 072**	**30 341 580**
Network efficiency (%)	**60 %**	**60 %**
Losses (%)	**40 %**	**40 %**

1.2.2. WATER BALANCE FOR TECHNOLOGICAL WATER

Table 9: Water Balance for Technological Water

	Volume in 2009 (m^3)	Volume in 2010 (m^3)
Input into the technological water supply system	2 959 753	2 598 754
(1)-STA	2 959 753	2 598 754
Billed volumes for technological water	1 950 365	1 817 990
Water losses + operational use + unbilled consumption	1 009 388	780 764
ACC operational use	202 370	229 730
Water losses + unbilled consumption	807 018	551 034
Network efficiency (%)	**73 %**	**79 %**
Losses (%)	**27 %**	**21 %**

1.2.3. GLOBAL WATER BALANCE (POTABLE + TECHNOLOGICAL)

Table 10: Global Water Balance

	Volume in 2009 (m^3)	Volume in 2010 (m^3)
Input into the global supply system	82 576 130	78 833 104
Billed volumes for potable and technological water	48 651 096	46 286 570
Water losses + operational use + unbilled consumption	33 925 034	32 546 534
ACC operational use	1 456 944	1 653 920
Water losses + unbilled consumption	32 468 090	30 892 614
Network efficiency (%)	**61 %**	**61 %**
Losses (%)	**39 %**	**39 %**

The figures obtained by the Consultants can therefore be compared with those obtained by the MTU for 2009 and 2010:

Table 11: Comparison of Water Balances

	2009	2010
Water losses + operational use + unbilled consumption		
-MTU	35 181 512	35 260 338
-Consultants	33 925 034	32 546 534
Difference (m^3)	1 256 478	2 713 804
Difference (%)	4 %	8 %
ACC operational use		
-MTU	2 323 098	2 480 970
-Consultants	1 456 944	1 653 920
Difference (m^3)	866 154	1 059 884
Difference (%)	59 %	64%
Water losses + unbilled consumption		
-MTU	32 858 414	32 779 368
-Consultants	32 468 090	30 892 614
Difference (m^3)	390 324	1 886 754
Difference (%)	1 %	6 %

It can be noticed that water volumes used by ACC for operational purposes are heavily over-estimated by the normative approach, when compared to the real figures.

In terms of water losses and unbilled consumption, the only substantial difference can be noticed in the 2010 figures with a 6% over-estimation of losses due to visible and invisible leaks.

The network's efficiency calculated by the Consultants for the global water supply system (potable water + technological water) is the same as the MTU (around 60%-61%), even though there is a substantial difference for input volumes into the water supply system due to the over-estimation of ACC water consumption in 2009-2010 and the water losses in 2010:

Table 12: Network Efficiency

	2009	2010
Input into the global supply system		
-MTU	83 861 915	81 573 098
-Consultants	82 576 130	78 833 104
Difference (m^3)	1 285 785	2 739 994
Difference (%)	1.5 %	3.5 %

1.2.4. PRELIMINARY ASSESSMENT

1.2.4.1. Linear Losses Index

Though the efficiency is commonly used to gauge the performance of water networks, it is somewhat flawed for the following reasons:

- This indicator does not allow the comparison of networks with different sizes. For two networks displaying the same size or the same number of service connections and an identical volume of losses, the network with the highest consumption will have the better efficiency;
- The efficiency overrates water utilities with high levels of consumption and wastage;
- For identical volumes of losses, the efficiency diminishes as water consumption diminishes. Any water saving effort by the consumers will be reflected negatively by a declining efficiency without any specific action by the water utility to reduce the leakage volumes;

Therefore, another indicator that could be used is the linear losses index in m3/day/km, which represents the daily volume of losses per kilometre of network.

As a preliminary figure, the linear losses index for the potable water network and the technological water network are given in the following table for 2009 and 2010

Table 13: Linear losses index for the potable water network and the technological water network

	2009	2010
Annual water losses + unbilled consumption (potable) in m^3	**31 661 072**	**30 341 580**
Daily water losses + unbilled consumption (potable) in m^3	86 743	83 128
Length of network (potable) in km	1 770	1 770
LLI in m^3/km/day	**49**	**47**
Annual water losses + unbilled consumption (technological) in m^3	**807 018**	**551 034**
Daily water losses + unbilled consumption (technological) in m^3	2 211	1 510
Length of network (technological) in km	18	18
LLI in m^3/km/day	**123**	**84**

The LLI obtained for the potable and the technological water supply networks are very high when compared to figures used by Veolia Water in France to assess the condition of networks in urban areas:

Table 14: Figures used by Veolia Water in France to assess the condition of networks in urban areas

Quality \ Type of network	Rural	Intermediate	Urban
Good	LLI < 1.5	LLI < 3	LLI < 7
Satisfactory	1.5 < LLI < 2.5	3 < LLI < 5	7 < LLI < 10
Poor	2.5 < LLI < 4	5 < LLI < 8	10 < LLI < 16
Very Poor	LLI > 4	LLI > 8	LLI > 16

The values for both potable and technological networks are highly above the threshold of 16 m3/km/day used to rank urban networks within the “Very Poor” category.

The LLI values for the potable water network have remained more or less stable over the 2009-2010 period while the values for the technological water network have substantially decreased, even though it remains very high at 84 m3/km/day.

1.2.4.2. Linear Repairs Index

Over the last 5 years, an average of around 13 400 leaks were found and repaired every year (they were either found during on-site surveys or reported by customers). The yearly record of network repairs is given in the following chart.

More details are given in Appendix A. Even if the number of repaired leaks seems to be constant, leaks due to joints problems are increasing.

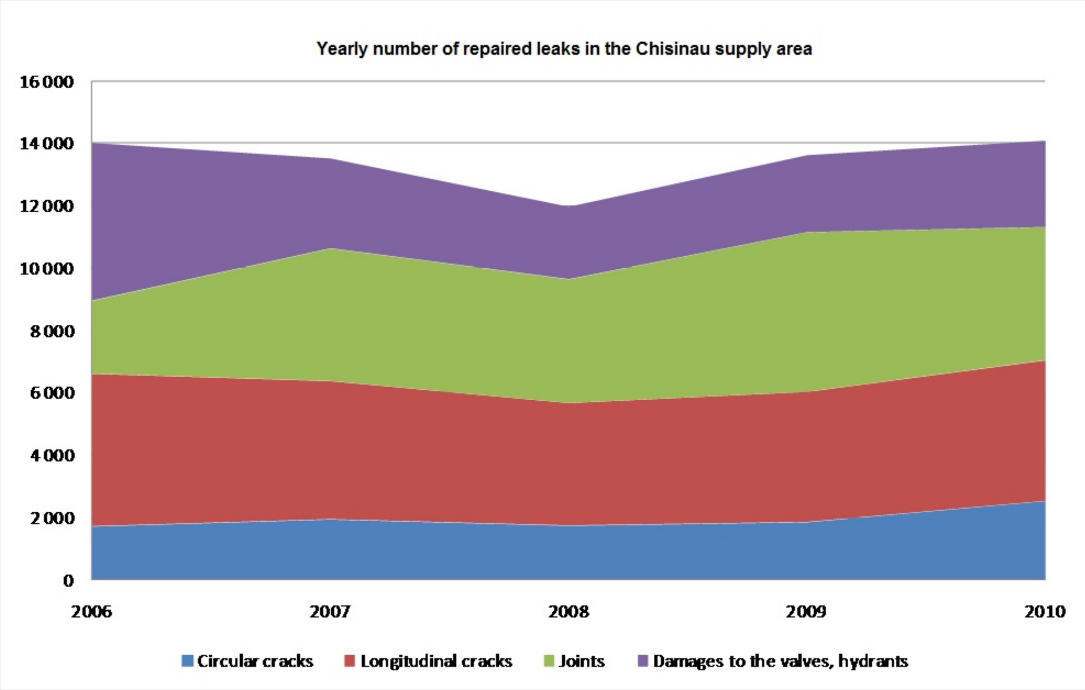


Figure 3: Yearly number of repaired leaks in the Chisinau supply area

Around 44% of leaks occur on pipes with diameters up to 100 mm. The Linear Repairs Index of these pipes is close to 9.4 repairs/km/year. This high value confirms that the network is very brittle and will need rehabilitation in certain parts of its total length instead of constant and costly repair activities that do no mitigate excessive leakage surges.

1.3. CONCLUSION

Efficiency and losses figures obtained by the MTU's normative approach and by the Consultants calculations based on ACC data are very close for the period 2009-2010 in the Chisinau supply area. The network's efficiency is thought to be around 61%.

The efficiency and the linear losses index for potable and technological water supply systems show that both networks are in poor conditions, with high amounts of water losses per kilometre of network.

However, even if the global volumetric figures are similar, it has not been possible to compare the detailed values of each type of losses (physical and commercial) between the normative approach and calculations based on ACC data.

Even though the Consultants agree with the range of water losses calculated with the MTU normative approach, the detailed amounts of each component (visible leaks, invisible leaks, metering under-registration, etc.) could be under-estimated or over-estimated. As every component has specific mitigation procedures, it is extremely important to assess precisely the extent of losses for each component.

ACC could seek to establish in a short-term plan a system of internal calculations based on operational data, as volumetric balances can be done in smaller sectors of the network.

More or less all pumping stations supplying a specific sector are equipped with flowmeters and dataloggers, and billed volumes can be obtained for that specific sector. A bi-annual or annual water balance could be done for each supply sector that would lead to more precise indicators for each zone.

For commercial losses such as the metering under-registration, the normative approach could be adapted to the current bulk of water meters used by ACC for billing purposes. The average error by type of meter and its diameter could be used as currently ACC owns and operates test benches used to determine the metrological accuracy of its water meters.

2. BEST PRACTISES FOR NRW REDUCTION

2.1. INTRODUCTION

The current status of NRW in the Chisinau water supply system, as operated by ACC, shows that 42% of production volumes do not create any revenue to the water utility.

NRW impacts negatively on ACC's financial revenue stream and limits the company's ability to generate revenue, enhance levels of service and achieve financial equilibrium.

Reducing such high levels of NRW needs the implementation of a strategic plan within the water utility involving all the key-departments of the operating structure. Such a strategic plan for NRW reduction can only be successful if preceded by the preliminary and detailed diagnosis of current NRW levels within the water supply system managed by ACC.

Asset improvement via network rehabilitation/augmentation has to go hand in hand with cost effective leak location, detection and repair activities to ensure optimal results for ACC. The revenue meters' metrological accuracy and operational robustness need to be constantly checked and maintained as they are the primary tool of the billing process in modern water utilities.

A NRW reduction action plan necessarily calls for transversal activities within ACC and thus, the organizational aspects which include change management are paramount to the successful implementation of the plan.

2.2. NRW REDUCTION ACTION PLAN

Whatever the techniques and procedures chosen to reduce NRW levels in the water supply system, a water utility should always seek to follow the improvements highlighted below:

- Optimization of Bulk Metering;
- Optimization of Meter Reading & Billing;
- Monitoring and Reduction of Authorized Unbilled Volumes;
- Permanent Leakage Detection, Location & Repair Activities;
- Reduction and Monitoring of Meter Under-Registration for Revenue Collection Increase;
- Reduction and Monitoring of Illegal and Unregistered Consumption;

Such improvements are usually based on the development of corrective/mitigation activities such as:

- Procurement and Change of Bulk Meters;

- Comprehensive Customer Survey to have a detailed knowledge of the end-users of the supplied water;
- Procurement of a new or improvement of current Customer Management & Billing System;
- Suppression of Authorized Unbilled Volumes, besides those used for operational purpose within the water utility, that should seek to rationalize its water usage;
- Permanent Leakage Detection, Location & Repair Activities, that should go hand by hand with the coordinate choice of the best materials and suppliers for the water supply system assets;
- Gradual Replacement of Defective Mains / Network Augmentation Works to reduce Bottlenecks;
- Regulation and Management of Pressure;
- Customer (Domestic and Non-Domestic) Meter Gradual Replacement Programme for metrological accuracy and robustness improvements;
- Gradual Suppression of Illegal Connections;
- Change Management - NRW Programme Manager;

2.2.1. PROCUREMENT AND CHANGE OF BULK METERS

Bulk flow meters are manufactured for the purpose of monitoring large flows of water for water system management and commercial billing purposes. ACC will start procuring, installing and changing bulk meters in all necessary and strategic locations, as a first step towards a successful NRW reduction action plan. This will lead to a full appraisal and knowledge of water production and transfer figures within the study area, taking into consideration that already part of ACC's water supply network has flow and pressure instrumentation, flow being measured and values stored thanks to ultrasonic flowmeters equipped with dataloggers.

2.2.2. COMPREHENSIVE CUSTOMER SURVEY

Customers databases usually contain errors (lack of quality control in the data input process and data updating process) and can therefore be partly obsolete. The second step towards a successful NRW reduction action plan is achieving an accurate customer database.

By auditing the existing customer database in ACC's main office, the Consultants will be able to submit to the Client a customer database refurbishment program, the first activity possibly being a comprehensive customer survey (customer census).

The knowledge of the type and the number of final water consuming endpoints (all of which should be metered) in the entire service area and by commercial branch and distribution system, will give a precise idea of how metered volumes are allocated to different types of customers.

The surveys should be aimed in priority at identifying and updating the number of non-domestic users (ICIs and administrations), which usually represent a significant percentage of volumes consumed.

Future water demand and masterplan studies will be more accurate when based on an updated and precise customer database that reflects the reality of endpoints water users.

2.2.3. Suppression of Authorized Unbilled Volumes

Depending on the estimated authorized unbilled volumes and the impacts on defined essential activities (ACC service water, fire-fighters, and charitable institutions) of decreasing/suppressing such volumes, ACC will endeavour to accurately meter these volumes. Measures aimed at optimizing (reducing/suppressing) these authorized unbilled volumes will be implemented after having conducted constructive discussions with the targeted users and stakeholders.

2.2.4. Permanent Leak Detection, Location & Repair Activities

ACC will initiate leak detection, location and repair activities in the sectors of the study area where high leakage volumes have been established. Techniques and procedures used in the Pilot Areas and imparted to ACC staff via intense training, as well as newly procured equipment, will allow ACC leak detection, location and repair teams and crews to replicate successfully such activities in these sectors and other leak proficient areas within the study area. This type of NRW mitigation activity will be precisely explained in a next section, as the Consultants and ACC will endeavour into a 300 km leak detection, location and repair campaign over several parts of the supply area, using acoustic techniques.

2.2.5. Gradual Replacement of Defective Mains

In parts of the network where leakage proficiency is high and where leak detection/location/repair is not cost effective over the medium to long term, a gradual and cost effective pipeline replacement programme will be undertaken. This could also be the opportunity for increasing pipe diameters in certain strategic locations to eliminate supply bottlenecks, satisfy to fire-fighting flow standards and allow distribution of additional volumes of water when future new production facilities are connected to the water supply system.

The leak detection and location activities will probably highlight certain sections of the network that are in deplorable conditions, therefore the repairs in these specific water mains will be pointless, underlying the need for rehabilitation/replacement works.

2.2.6. Customer Meter Gradual Replacement Programme

A gradual water meter replacement programme will allow introducing new water meters following the highest international metrological standards. By implementing Class C domestic meters, with the measuring technology adapted to existing supply conditions in the study area, ACC will ensure that under-registration and over-registration values won't affect domestic users and the Client's revenues.

ICIs customers should also be equipped with highly accurate water meters, to maximize revenue collection based on the fact that they are the largest users in the study area.

The gradual meter replacement programme will be coupled to the purchase or modernization of a water meter test bench, needed for monitoring of the metrological quality of installed and operating water meters of all sizes.

2.2.7. Gradual Suppression and Legalization of Illegal Connections

This being a critical and socially difficult activity to implement, preliminary discussions with all stakeholders in difficult areas should be carried out, before starting gradual suppression and legalization of illegal connections. This could be done for connections used for domestic purposes.

Strict suppression and regularization could be implemented right away for illegal connections used for commercial and other non-domestic purposes.

2.2.8. Change Management - NRW Programme Manager

NRW appraisal and reduction is by nature a transversal strategic activity within any water utility and as such, the role of the NRW project manager will be to directly manage core staff (NRW Unit) as well as coordinate intervention of staff belonging to other entities (commercial, operations etc.). The status of the NRW project manager should thus be in par with that of a Director and he should report directly to the utility's executive.

It is obvious that the above calls for organizational changes and that the successful implementation of change management is a key-element to the success of NRW reduction strategies.

2.3. Conclusion

A NRW Reduction Action Plan usually prioritizes actions according to:

1. The relative importance of the various components of NRW;
2. The cost/benefit ratio of the actions undertaken;

The overall NRW Reduction Action Plan must be technically feasible and economically viable and seek to achieve the Economic Level of Leakage (or E.L.L. see figure below). This ELL is specific to each utility and local context.

The rationale behind a NRW Reduction Action Plan is thus to implement a series of actions to achieve the E.L.L. and prioritize these actions according to their returns on investments (which obviously should be positive).

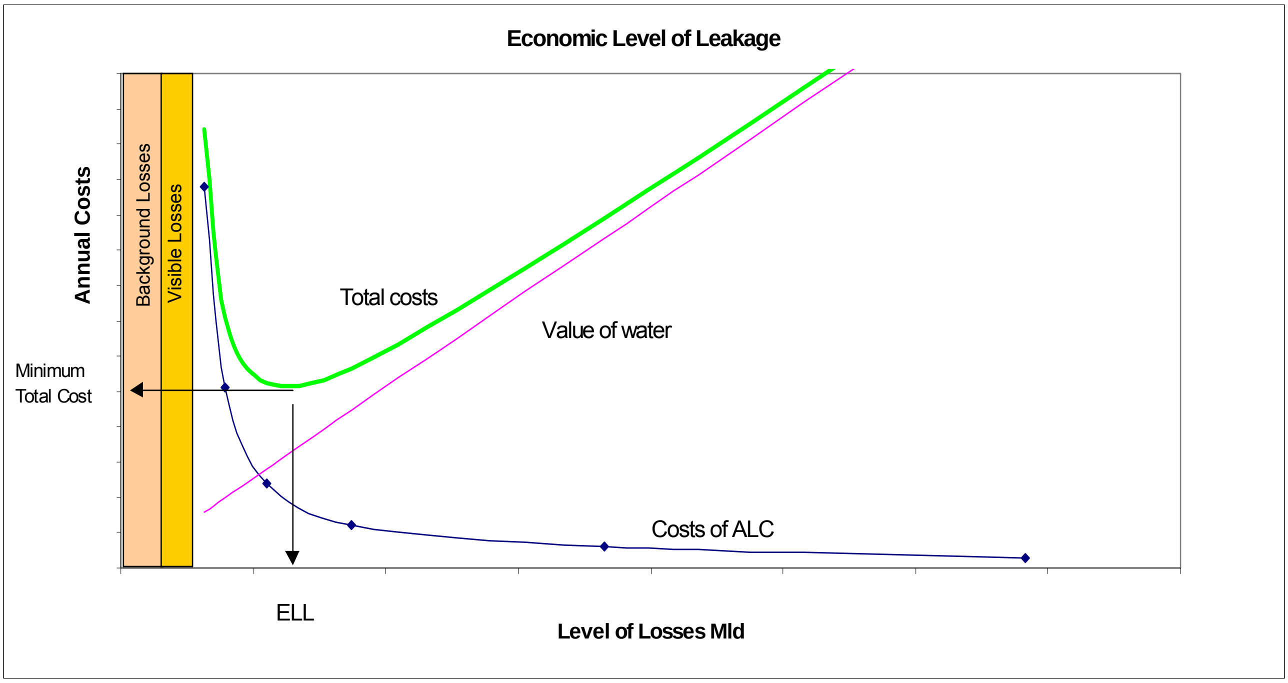


Figure 4: Economic level of leakage

The current high levels of NRW in the Chisinau supply area (around 42%) clearly justify the need for the implementation of a strategic NRW reduction action plan based on the main items aforementioned in this section.

3. LEAK DETECTION AND LOCATION ACTIVITIES

3.1. INTRODUCTION

The high values of losses (39% of the total input in 2010) in the overall water supply network (potable water and technological water) as well as the high amount of repaired leaks (14 066 interventions in 2010) justify the need of permanent leak detection, location and repair activities.

Water losses in the distribution system cause additional costs (besides the production/pumping costs and the financial losses due to unbilled and under-metered billed volumes), by damaging other utilities' networks (telephone, heating, natural gas and hot water) and as well as roads and other transportation infrastructures.

This two-year study plans to carry out these activities over a total length of 300 km in the Chisinau supply area. The objectives of such intense campaign are the following:

- Long term training of ACC staff on active leak detection and location activities for mitigation of underground/invisible leaks;
- Appraisal by ACC staff of acoustic leak detection and location techniques, well adapted to the local context in Chisinau (majority of metallic water mains, high operating pressures, regular access points to the network), by using acoustic correlation and acoustic ground listening;
- Analysis of located and repaired leaks' characteristics (frequency and distribution by material and length), estimate of losses' volumes depending on the type of leak, assessment of repair costs and techniques as well as the organizational aspects of leak detection and location activities within the ACC utility structure;
- Detailed analysis through the mapping of leaks repaired within the past five years in the Chisinau supply area and leaks found during the study activities to assess network rehabilitation works;

The Consultants have chosen seven (7) areas of interest in which will be carried out the leak detection and location activities with the technical methodology, organizational approach and equipment described in the following paragraphs.

3.2. TECHNICAL METHODOLOGY

3.2.1. CHOICE OF THE AREAS OF INTEREST

3.2.1.1. Global Approach

The seven (7) study areas have been chosen in collaboration with ACC within the Chisinau supply area by following these criteria:

- The area has to be isolated, being supplied by a single pumping station and not interconnected with other sectors;
- The pumping station discharge flows and pressures have to be monitored and values recorded with dataloggers;
- The area's assets' characteristics are well-known and available in short-scale maps to ease-up on-site operations;
- Valves can be easily operated to isolate portions of the network, if needed by the leak detection, location and repair activities;
- The area is sensed to have high values of losses due to underground/invisible unrepaired leaks;
- The total number of customers can be obtained and filtered by type;
- The total volume of billed water can be obtained and filtered by type;

3.2.1.2. List of Selected Study Areas

After applying the aforementioned criteria, the Consultants have decided to propose the following areas for the leak detection, location and repair activities. The estimated length of network operated in each area as well as the pressure zone and daily flow pattern graphs (with average daily flow and minimum night flow) are presented below.

i- Buiucani (Pressure Zone # 4), with 85 km of water mains

This study area is supplied thanks to two discharge mains from the Buiucani pumping station (PZ # 4-1 and PZ # 4-2). The discharge flow is monitored for each discharge water main with ultrasonic flowmeters and recorded with dataloggers.

Table 15: Flow data was provided by ACC for the time-period 14-02-2011 / 16-02-2011.

PZ #	Average daily flow (m^3/hr)	Minimum night flow (m^3/hr)	MNF / ADF
4-1	134	80	60 %
4-2	354	199	56 %

The minimal night flow is the lowest flow recorded during the night between 2:00 AM and 4:00 AM, which includes the area's physical losses (at their highest flow value as pressure reaches its maximum value) and the legitimate consumption (at its lowest flow value in areas with a majority of domestic customers). The ratio MNF / ADF can therefore give a first raw glance at the area's possibility of having high values of losses due to underground/invisible leaks.

The higher the ratio the highest is the possibility that the area contains numerous leaks accounting for large volumes of water losses.

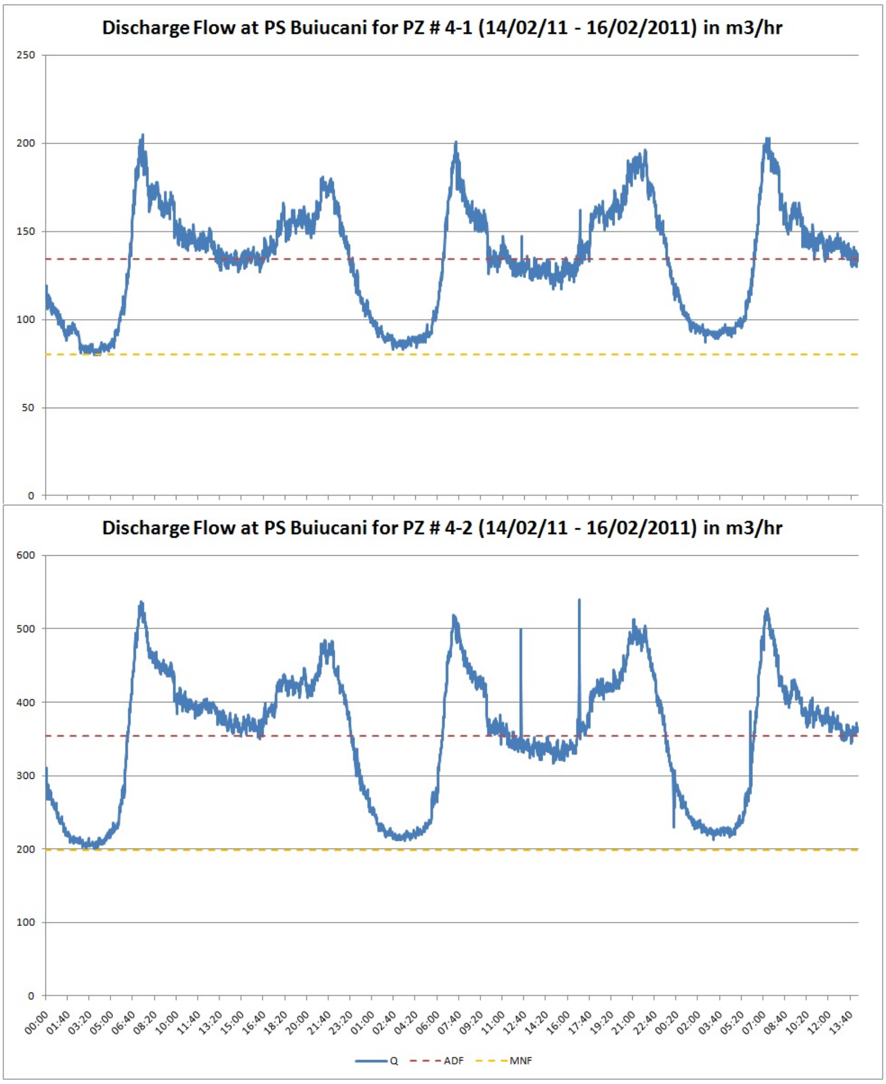


Figure 5: Discharge flows at Buiucani pumping station for pressure zone # 4

ii- Buiucani (Pressure Zone # 3), with 117 km of water mains

This study area is supplied thanks to two discharge mains from the Buiucani pumping station (PZ # 3-1 and PZ # 3-2). The discharge flow is monitored for each discharge water main with ultrasonic flowmeters and recorded with dataloggers.

Table 16: Flow data was provided by ACC for the time-period 14-02-2011 / 16-02-2011.

PZ #	Average daily flow (m^3/hr)	Minimum night flow (m^3/hr)	MNF / ADF
3-1	245	131	54 %
3-2	89	42	47 %

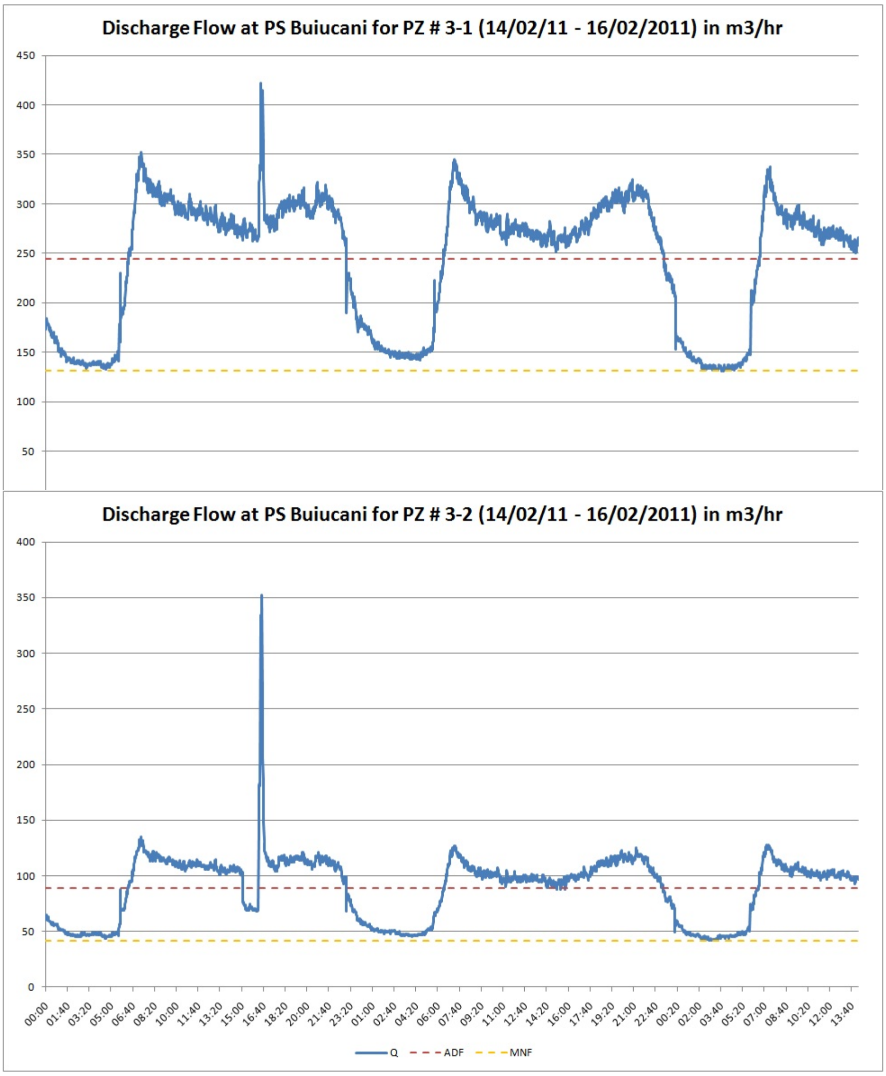


Figure 6: Discharge flows at Buiucani pumping station for pressure zone # 3

iii- <u>Schinoasa (Pressure Zone # 4a), with 10 km of water mains</u>

This study area is supplied thanks to one discharge main from the Schinoasa pumping station (PZ # 4a). The discharge flow is monitored with an ultrasonic flowmeter and recorded with a datalogger. This area will be used for the detailed DMA approach.

Table 17: Flow data was provided by ACC for the time-period 14-02-2011 / 16-02-2011.

PZ #	Average daily flow (m^3/hr)	Minimum night flow (m^3/hr)	MNF / ADF
4a	73	39	53 %

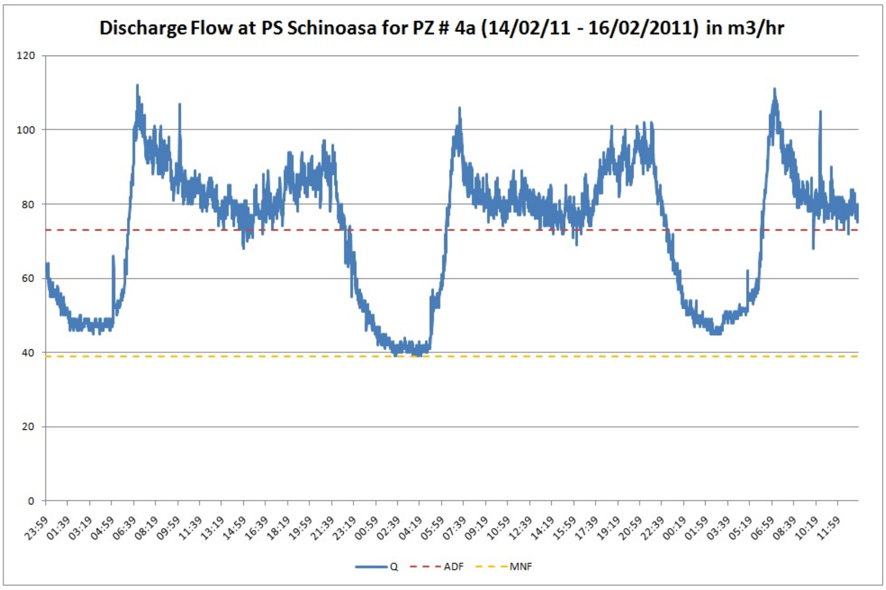


Figure 7: Discharge flows at Schinoasa pumping station for pressure zone # 4a

iv- <u>Independenta (Pressure Zone # 3), with 57 km of water mains</u>

This study area is supplied thanks to two discharge mains from the Independenta pumping station (PZ # 3-1 and PZ # 3-2). The discharge flow is monitored for each discharge water main with ultrasonic flowmeters and recorded with dataloggers.

Table 18: Flow data was provided by ACC for the time-period 14-02-2011 / 16-02-2011.

PZ #	Average daily flow (m^3/hr)	Minimum night flow (m^3/hr)	MNF / ADF
3-1	229	125	55 %
3-2	412	232	56 %

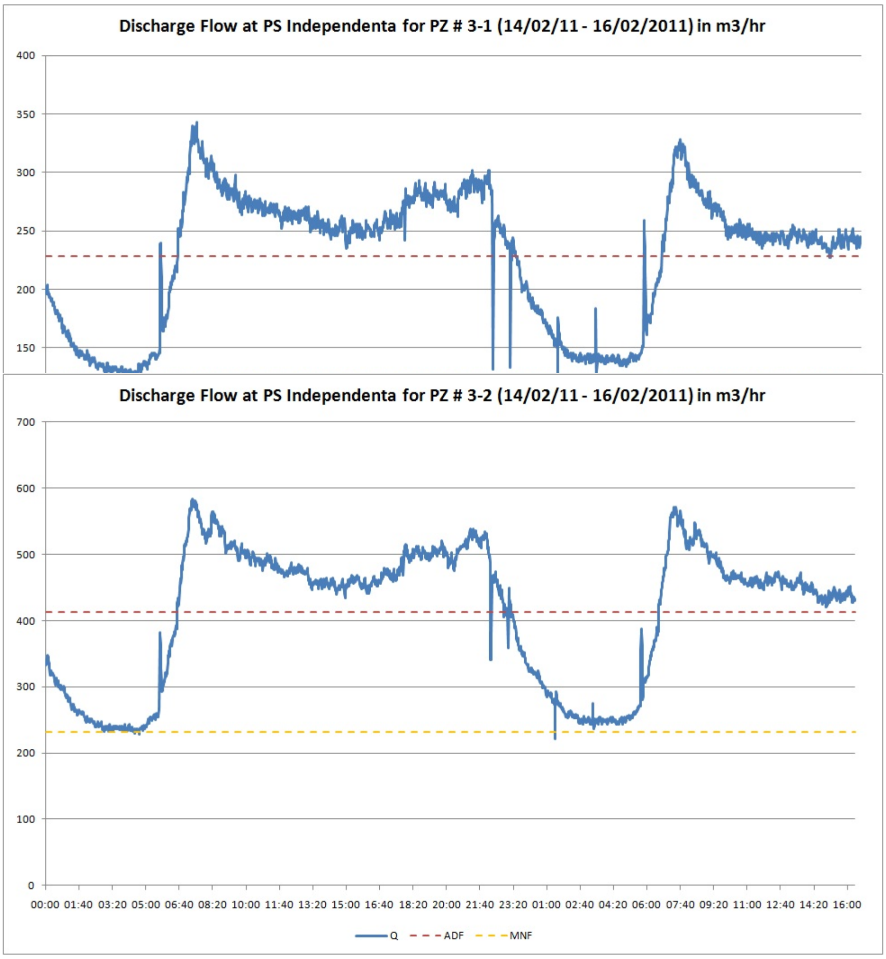


Figure 8: Discharge flows at Independenta pumping station for pressure zone # 3

v- Riscani (Pressure Zone # 3), with 20 km of water mains

This study area is supplied thanks to two discharge mains from the water treatment plant STA pumping station (PZ # 3-1 and PZ # 3-2). The discharge flow is monitored for each discharge water main with ultrasonic flowmeters and recorded with dataloggers. Currently, there is only one discharge water main being operated to supply this study area (the other discharge water main is closed as it can be seen in the following table with the flow equal to zero).

Table 19: Flow data was provided by ACC for the time-period 12-02-2011 / 14-02-2011.

PZ #	Average daily flow (m^3/hr)	Minimum night flow (m^3/hr)	MNF / ADF
3-1	178	59	33 %
3-2	0	0	0 %

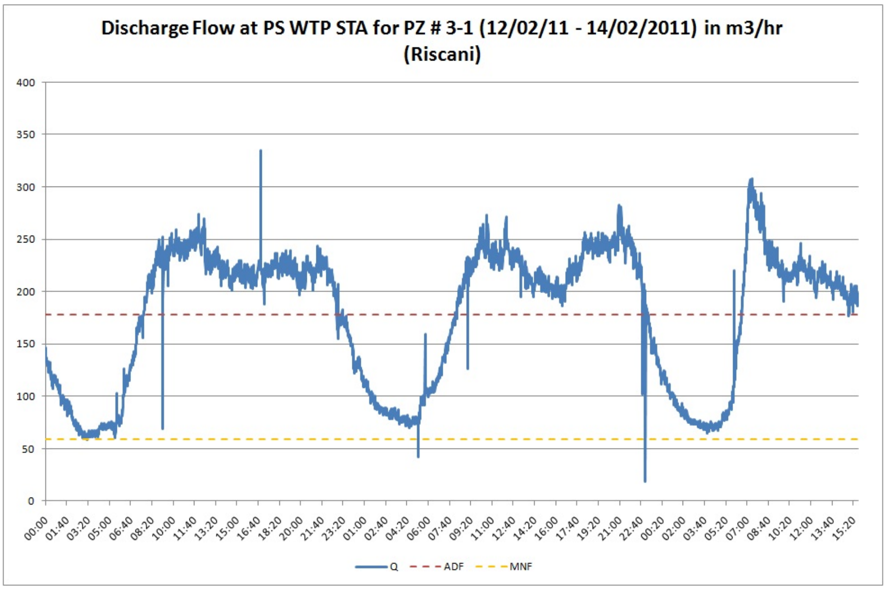


Figure 9: Discharge flows at the WTP STA pumping station for pressure zone # 3 (Riscani)

vi- <u>Ciocana (Pressure Zone # 3), with 43 km of water mains</u>

This study area is supplied thanks to two discharge mains from the water treatment plant STA pumping station (PZ # 3-1 and PZ # 3-2). The discharge flow is monitored for each discharge water main with ultrasonic flowmeters and recorded with dataloggers.

Table 20: Flow data was provided by ACC for the time-period 13-02-2011 / 16-02-2011.

PZ #	Average daily flow (m^3/hr)	Minimum night flow (m^3/hr)	MNF / ADF
3-1	458	233	51 %
3-2	202	99	49 %

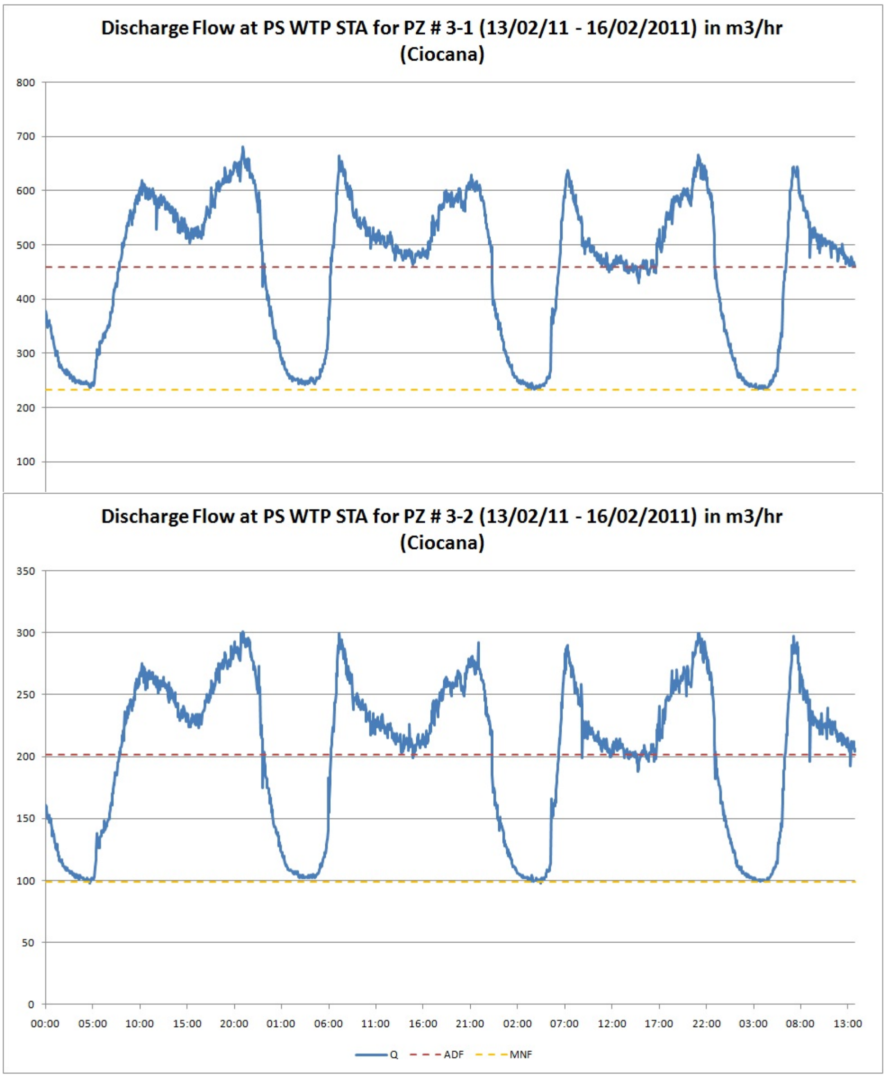


Figure 10: Discharge flows at the WTP STA pumping station for pressure zone # 3 (Ciocana)

vii- <u>Ciocana (Pressure Zone # 4), with 23 km of water mains</u>

This study area is supplied thanks to two discharge mains from the water treatment plant STA pumping station (PZ # 4-1 and PZ # 4-2). The discharge flow is monitored for each discharge water main with ultrasonic flowmeters and recorded with dataloggers.

Table 21: Flow data was provided by ACC for the time-period 12-02-2011 / 16-02-2011.

PZ #	Average daily flow (m^3/hr)	Minimum night flow (m^3/hr)	MNF / ADF
4-1	116	36	31 %
4-2	116	34	29 %

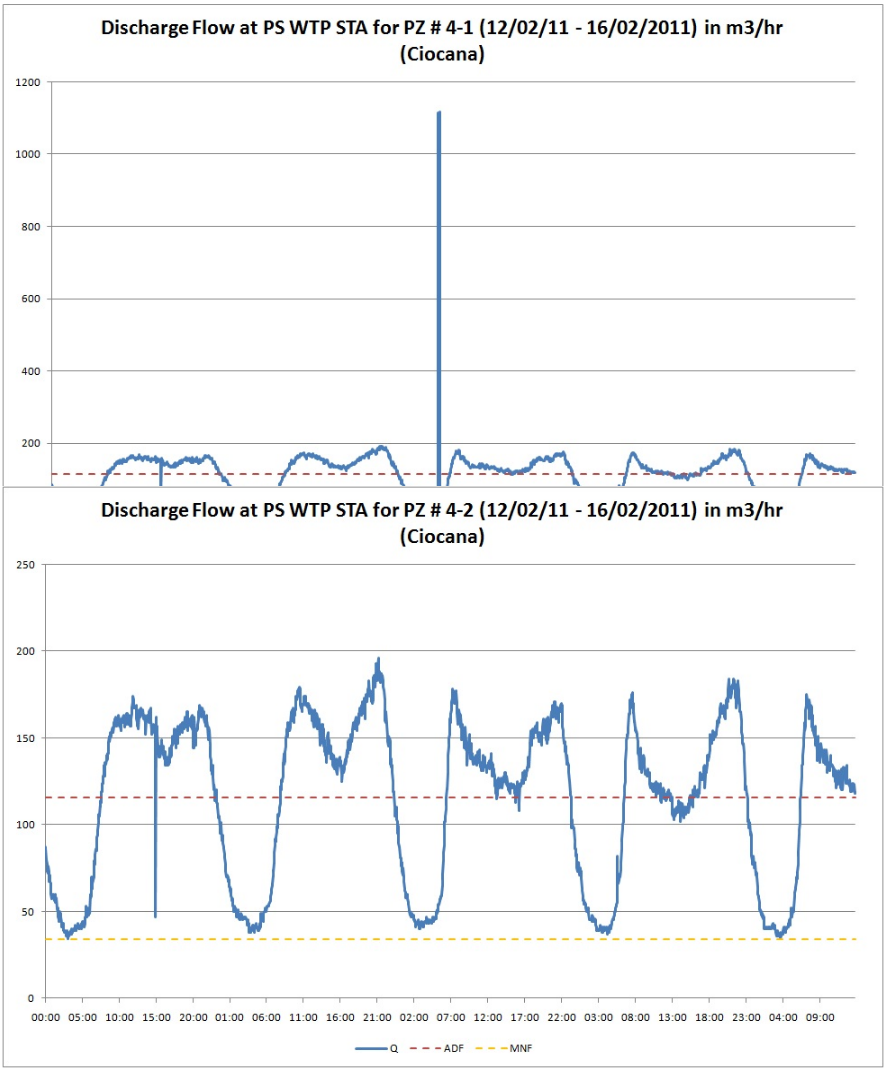


Figure 11: Discharge flows at the WTP STA pumping station for pressure zone # 4 (Ciocana)

The chosen areas for the leak detection, location and repair activities represent a total length of 355 km, which is above the 300 km targeted by the Terms of Reference. The Consultants therefore propose to cover partially the Buiucani area in the pressure zone # 3 (117 km of water mains) while fully executing works in the remaining six selected areas.

3.2.2. Detecting and Locating Leaks on the ACC Network

3.2.2.1. Global Approach

Among the mains goals of this study are the reduction of Non-Revenue Water. The reduction of NRW constitutes one of the two pillars of demand management (in parallel with wastage reduction) and is crucial for a utility such as ACC.

The reduction of leakage is achieved via pro-active and systematic leak detection, location and repair. At present, ACC crews are swamped with record number of visible leaks (7.5 repairs per km per year in 2010, 38 times the French average) and the utility is implementing a passive leakage reduction policy geared towards the localization and repair of reported visible leaks.

The Consultants and ACC will endeavour to carry out pro-active and systematic leak detection, location and repair activities in the seven study areas presented earlier in this report. The main lines of such effort are the following and will be executed in each selected area when possible:

- Primary assessment of losses through analysis of the recorded discharge flows, pressure patterns and consumed water volumes;
- If possible, pre-localization of losses through step-testing during night time to filter the network's sections that could include the majority of water losses;
- Leak detection and location through acoustic correlation and acoustic direct ground listening;
- Repair of leaks in a rhythm and intensity that can be supported by current ACC repair crews and annual operational budget;
- Secondary assessment of losses through analysis of the recorded discharge flows, pressure patterns and consumed water volumes, to evaluate the volumes gained thanks to the pro-active and systematic leak detection, location and repair activities;

i- <u>Measurement Program:</u>

The measurement program will consist of carrying out inflow and pressure measurements. Flows and pressures will be recorded and logged.

From all these data, the Consultants will calculate:

- The average daily inflow and its pattern over the day;
- The average pressure and its pattern over the day;
- The legitimate night consumption and minimal night flow;
- The average daily consumption;
- The average leakage level;

The components of leakage will then be assessed: background leakage and burst leakage.

Background leakage will be calculated initially using standard criteria such as network length, number of connections, average pressure. Later, once leaks have been repaired and a second measurement carried out, the estimate will be reviewed.

Burst leakage will be calculated deducting background leakage from average leakage level.

Then the different sectors will be ranked according to the above indicators.

ii- Step-Test Program

When possible and accepted by ACC, the Consultants will carry out step-tests in the selected areas, for effective pre-localization of losses. It is important to stress the fact that this activity requires night time work and short interruptions of water supply in the isolated sectors.

Performing a step test is one of the most effective ways of identifying a high leakage area within a water distribution network. It requires the establishment of zones where water can be supplied through a single meter, after all boundary and circulation valves have been closed.

It is usually carried out at night, since this is the time when consumption is lowest and most stable. Disruption to consumers is also minimised.

To perform the step test, a data logger is connected to the meter to record flow into the zone. Valves within the zone are closed in sequence, starting furthest away from the meter and working towards it. Closure of each valve isolates a specific section of the zone. As each valve is closed, the logger records the flow rate into the zone, from which the flow into the isolated section can be identified. Although there may be some legitimate consumption, a large drop will indicate the presence of a leak in that section, which will set priorities for acoustic leak detection and location activities.

iii- Leak Detection, Location and Repair Program:

According to the findings of the measurement campaign and after discussions with the client the Consultants will organize a leak detection and location study.

In this study the Consultants will determine:

- Priorities of intervention according to the data analysis;
- Appropriate methods and leak detection techniques to be used according to the local conditions. Training sessions will be organised for the ACC staff.

Ideally, the leak detection, location and repair activity will consist in locating and repairing all burst leakage so that only background leakage remains. In practice, the approach should be flexible, taking into account several criteria.

Among these criteria, the Consultants can highlight the following:

- Excess leakage level;
- Number of reported bursts;
- Current conditions of continuity of service;
- Cost of detection and repair;
- Value of the savings;

The leak detection, location and repair activities will give the opportunity to clarify some of these criteria. Particularly, the Consultants will endeavour to calculate the cost of detection according to the method and the local conditions as well as the costs of repairs.

Non-visible leak detection will be implemented using a leak noise correlator when it is possible (i.e. when easy access to valve chambers is granted and when their number and location is satisfactory). Otherwise, ground microphones will be used for examining the sub-study area's network by listening to potential leak noise with one to two meter intervals.

Regarding leak/burst repairs, ACC should ensure an effective procurement system for continuous supplying and storage of necessary pipe repair kits dealing with, for instance:

- Pipe cutters (for metallic and non-metallic pipes);
- Couplings, flange adapters, flanges (for metallic and non-metallic pipes);
- Repair sleeves (single or double clamped, stainless steel);
- Lengths of metallic and non-metallic pipes;
- Materials and aggregates for roads and chambers refurbishment;

ACC should also ensure the quality of workmanship during repair labours to avoid the recurrence of leaks in the same location after its repair.

Once the detection and location campaign and repair works have been completed, a second stage of measurements will be carried out to assess the impact of leak detection, location and repair activities. The results will be analysed in detail to determine the extent of achieved improvements and the percentage of completion for target values.

3.2.2.2. List of Equipment for Leak Detection and Location Activities

After selecting the seven study areas and carrying out site visits to some of them (Riscani and Independenta), the Consultants have confirmed that acoustic techniques can be used for leak detection and location activities, as the following criteria is generally met in all chosen areas within Chisinau:

- Majority of metallic water mains (steel and iron);
- High operating pressures;
- Access points to the network through chambers and manholes (boundary and circulation valves, connection points between the distribution water mains and the service mains)

Therefore, the following equipment has been selected for such activities:

Name	Quantity	Pictures
Portable Acoustic Correlator and Accessories	1	  
Portable Acoustic Ground Microphone and Accessories	2	  

Metallic Pipes Detector and Locator	1	 
Metallic Accessories Detector and Locator	1	
Big Wheel Odometer	1	

This list of equipment has to be completed with necessary security accessories (marking cones, reflecting waistcoats, flashlights for work inside chambers, etc.) and a universal toolkit (wrenches, pliers, screwdrivers, hammers, spanners).

3.2.2.3. Human and Logistical Resources

For daily operations of leak detection and location activities the following human resources are needed for the 300 km inspection:

- 1 Supervisor from the Consultants Team (Full-Time);
- 2 Leak Detection and Location Technicians from ACC (Full-Time) to be trained by the Consultants and that will carry out the fieldwork with the provided equipment in the selected areas;

- 1 Water Network Technician from ACC (Full-Time), responsible of giving access to chambers and manholes;
- 1 Driver from ACC (Full-Time), responsible of driving the leak detection and location team to and around the selected areas as well as securing the equipment left in the vehicle while the technicians carry out their fieldwork;

Partial back-office and fieldwork support will be provided by the Consultants Team and by ACC (PIU, Central Dispatch and Sectors Operational Water Network Units). Tasks and responsibilities are detailed in a further paragraph.

Preliminary theoretical and fieldwork training of ACC Leak Detection and Location Technicians will be given by a technician from the equipment suppliers. Detailed training and assistance will be provided by a technician from ANB (Apa Nova Bucarest, subsidiary of Veolia Water), to ensure that the approach of an international water utility is clearly transmitted to the ACC technicians, in an environment like Chisinau, which is similar to Bucarest.

The following logistical resources are needed for the 300 km inspection:

- 1 vehicle (break or wagon type) for transportation of the leak detection and location team and equipment;
- Storage area in ACC's main office for the provided equipment;
- Repairing kits and materials/aggregates as aforementioned;

The two technicians chosen by ACC should have an unaffected sense of hearing, as the basis of acoustic leak detection and location resides on the human capacity of filtering the leaks' noises within the neighbouring environment.

Experience in the operation of water distribution networks is required to ensure that the technicians will rapidly adapt to the operating conditions of the inspected networks.

Finally, given that specific training in the field must be developed and applied for a long time (it is a profession based on sense of hearing and understanding of physics of sound propagation through various media), the maximum age should be lower than the retirement age by at least 20 years.

3.2.2.4. Data Gathering and Analysis

The Leak Detection and Location Team objective is to identify and locate hidden (invisible) leaks of water in the distribution network throughout the use of specific detection and location equipment.

At the end of each working day, the Team will fill in the Activity Report, which will include the following:

- One individual sheet for each detected and located leak (as provided in Appendix B in Romanian language);
- The length of inspected network (with acoustic correlator on one side and with ground microphone on the other side);

The Activity Report data will be filled into an Excel database for further analysis.

The detected and located leaks will be described in the aforementioned sheets and sent to the Central Dispatch to arrange their repairs. Part of the data in the sheet will be filled in after the repair is done.

The Excel file used as database by the Consultants will include the following information (the data will come from several sources as marked below):

Table 22: Structure of the Excel file used by the Consultant

Column header	Information provided by
Leak Sheet Number	Leak Detection and Location Team
Technician that found the leak	Leak Detection and Location Team
Operations Area	Leak Detection and Location Team
Date	Leak Detection and Location Team
Systematic or Urgent	Leak Detection and Location Team
Street Type	Leak Detection and Location Team
Street Name	Leak Detection and Location Team
Street Number	Leak Detection and Location Team
House	Leak Detection and Location Team
District	Leak Detection and Location Team
Crossing	Leak Detection and Location Team
Network Type	Leak Detection and Location Team
Network Pressure	Leak Detection and Location Team
Nominal Diameter	Leak Detection and Location Team
Material	Leak Detection and Location Team
Pavement Type	Leak Detection and Location Team
Other affected utilities networks	Leak Detection and Location Team
Date of submission to Central Dispatch	Leak Detection and Location Team
Date of Repair	ACC
Repair Sheet Number	ACC
Successful? Y/N	ACC
Comments	Leak Detection and Location Team / ACC
Landmark	ACC
Location	ACC
Failure Type	ACC
Failure Size [mm2]	ACC
Lost/Recovered Flow [m3/h]	Calculated values

Column header	Information provided by
Value of recovered water in a year	Calculated values
Remedy/Mitigation Techniques	ACC

In order to achieve interesting results in terms of gathering and analysis of the data arising from the leak detection and location activities, it is extremely important to ensure smooth and continuous interactions between all stakeholders.

3.3. ORGANIZATIONAL STRUCTURE

Planning and carrying out the leak detection and location activities fall under the Consultants' responsibility, but ACC must provide the necessary support, so that:

- The activities do not cause serious disturbances to the water distribution system operations;
- The activities avoid the possibility of an accident at work.

In order for detection and location of water leaks to be effective, efficient and useful for the study, it is imperative that:

- Information about found leaks (provided by the Leak Detection and Location Team) to be correlated with the information about repaired leaks (provided by the Sectors Operational Water Network Units);
- The time between the identification of a hidden leak and its repair to be as small as possible;
- The repair be executed with technical means to avoid recurrence (repair with wood cork, without pipe wall restoration, is not permitted);

The organizational structure for the 300 km campaign will be the following:

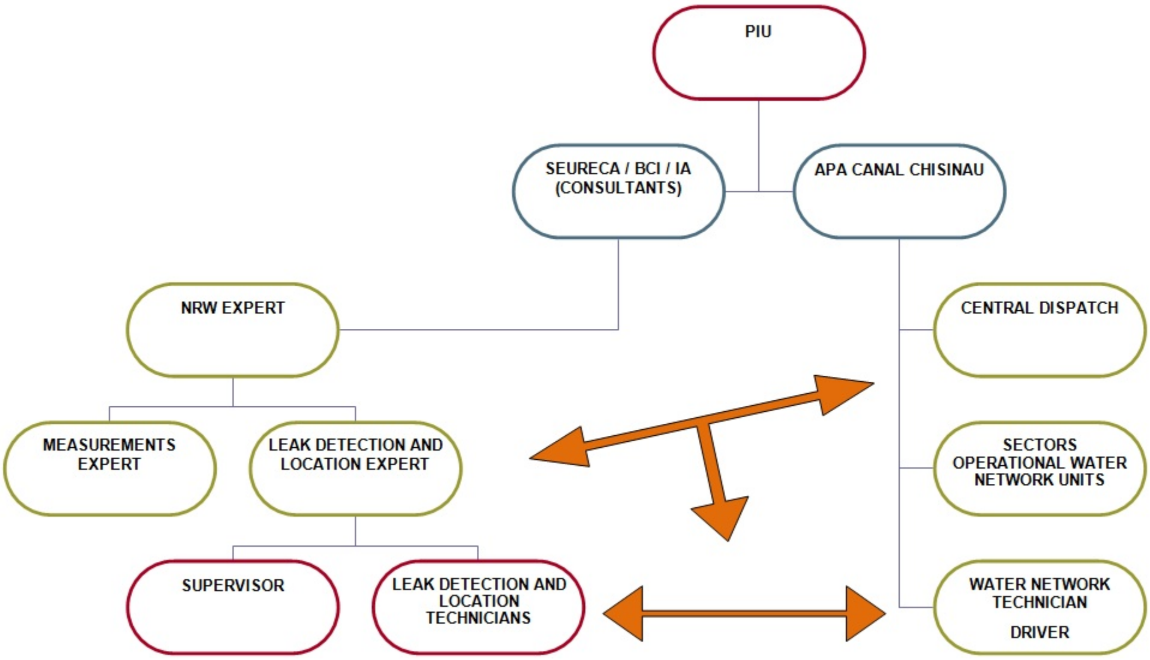


Figure 12: Organizational structure for the 300 km campaign

Table 23: Tasks and responsibilities are briefly summarized in the following chart:

Actions	Tasks / Comments	Performed by	Checked by	Recorded by
Selected areas hydraulic verification and analysis – Primary inspection of assets	Mapping	Leak Detection and Location Team	ACC	Leak Detection and Location Team / ACC
	Verification of monitoring devices (flow and pressure) – Gathering of list of consumers and billed volumes	ACC	Leak Detection and Location Team	ACC / Leak Detection and Location Team
	Visual inspection for visible leaks detection and location	Leak Detection and Location Team	ACC	ACC / Leak Detection and Location Team
	Visible leaks repairs	ACC	Leak Detection and Location Team	ACC
Step-Test	Step-Test exercise during night time	ACC / Leak Detection and Location Team	ACC	ACC / Leak Detection and Location Team
	Preliminary data analysis	Leak Detection and Location Team	ACC	Leak Detection and Location Team / ACC
Detection and location of hidden losses	Acoustic correlation and direct listening on each section, branch by	Leak Detection and Location Team / ACC	Leak Detection and Location	ACC

Actions	Tasks / Comments	Performed by	Checked by	Recorded by
	branch, fitting by fitting; Access to fittings, manholes and chambers;		Team	
Repairs of detected and located leaks	Excavation / Repair of damaged assets / Refurbishment of roads and chambers	ACC	Leak Detection and Location Team	ACC
Analysis of effects after repairs	ACC will immediately notify each repair	Leak Detection and Location Team will register the effect of each repair on the flow meter, marking also the leak position on a mapping support		

3.4. CONCLUSION

Due to the high values of losses in the overall water supply network, this 300 km leak detection, location and repair campaign will allow the Consultants evaluating the success of reduction of leakage achieved via pro-active and systematic activities.

ACC staff will gain training and experience in acoustic leak detection and location techniques and equipment. At the end of the study, ACC will be able to implement the necessary structure for pro-active and systematic activities, based on the organizational structure and operational costs the Consultants will provide for this type of activities.

The scope of leakage reduction for demand management is large and strategic, as currently more than 30.3 Mm^3 of potable water and 0.55 Mm^3 of technological water are lost every year through physical and commercial losses.

4. ASSESSMENT OF METERING UNDER-REGISTRATION

4.1. INTRODUCTION

The main purpose of reliable customer metering is to generate economic revenue. The accuracy of meters is also a key issue in water balance calculations. Customer meters require careful management to obtain representative and significant results.

An efficient organisation will recognize and will deal with important problems such as improper meter type and improper meter sizing, incorrect meter installation, meter encrustation, deterioration with age, flow rates lower than the minimal flow rate the meter can reliably register, insufficient maintenance/replacement, frequency of calibration, inability to obtain reading, and influence of meter reading cycles.

It is important to know the accuracy of the customer metering system, in order to assess the quality of the measurement, calculate the level of apparent losses, and identify the causes and the remedial means.

This is why a large survey must be carried out on a sample of domestic customers and a sample of large consumers (ICIs).

4.2. TESTING OF WATER METERS

The first task will consist in selecting the sample. For this purpose, the Consultants will use the ACC customer database or carry out a wide field survey to create a representative sample, considering criteria such as: age, size, type, brand, area, etc.

ACC will be in charge to remove temporarily the meters designed by the Consultants and to test them on its bench test according to the Consultant's specifications.

The size of the sample is basically determined as follows:

- For domestic water meters (ND < 40 mm), if 3 main brands have been installed within a period of 15 years: 25 meters have to be taken for each 3 years period or:

25 * 15/3 * 3 types = 375 meters to be tested on a test bench.

In addition, 50 customers will be indentified for establishing their consumption profile.

- For large customers (ND > 40 mm), datalogging on meters will be carried out taking into account the top 20 + 5 meters of each of the main types of water meters (hotels, restaurants, public/private/religious buildings, schools, industries…) and 5 meters within the over-sized ones.

Once the sample has been selected and field visits have been carried out to make sure that access conditions are appropriate, the Consultants will prepare a survey form which should include:

- Data reported in the database, so that, when going on the spot, it is possible to check their consistency;
- Data related to local situations such as: conditions of installation, daily supply time, pressure conditions, and any other factors which can influence the metering or the reading;

For domestic, large consumers and bulk meters, the operation can be basically conducted through 2 options with agreed and budgetary compatible equipments:

- A water meter test bench for water meters DN < 50mm;
- Accurate meters with dataloggers in series with installed meters for in-situ tests and comparison of gains/losses after a 3 month period;

In case of testing procedures on test bench, ACC should ensure the operation of the existing test bench, the removal of the meters and their reinstallation once completed the testing.

As a result, the Consultants will determine the features of the tested sample such as percentage of meter variance, accuracy curves for each meter age and total volume passed through the meter. Conclusions will be given about the quality of the meters according to the type and brands, and interpretation about the possible defects which have been observed. Recommendations about metering management will be established: calibration test frequency, replacement time schedule. These recommendations will be based on technical and economic criteria.

4.3. CONSUMPTION PROFILES

Another objective of the assessment is to obtain an adequate understanding of the consumption profile over time. This profile is influenced by the service conditions.

A survey on a sample of 50 domestic consumers will be carried out. The work will consist in recording the consumption for a 7 days period with in-situ meters with dataloggers. Measurements will be made by measuring water usage overtime using a short interval (1 minute for instance).

This measure will determine a pattern of consumption and an appreciation of the night time usage.

Two different methods can be used to obtain an instantaneous recording of the consumption during time:

- For small diameter water meters (ND < 75 mm): measurement with a pilot meter in replacement of the existing meter or directly installed in line with it (upstream or downstream);
- For large diameter water meters (ND ≥75 mm): the measurement campaign can be implemented using an external meter, preferably an ultrasonic flow meter;

As a direct output from the measurement campaigns, the Consultants will obtain a flow versus time curve. This data shall be processed using computerized tools in order to allocate the measured volumes according to different ranges of flow rates: it is then possible to switch from a view in "l/h per second" to a view in "% of volume per range of flow rates", which constitutes the “pattern of consumption” or, otherwise said, the allocation of consumption in function of flow.

Consumer profiles will then be classified by categories and compared to the theoretical accuracy curves of different classes and brands of water meters.

The final purpose of the analysis will be to roughly assess the percentage of consumption that the different classes of water meter are able to register/invoice according to the category of consumption pattern. The Consultants will be able eventually to make recommendations regarding the classes and brands which are best adapted to the consumption patterns of ACC’s customers.

4.4. CONCLUSION

Even though there is a large majority of ACC’s customers that are metered, the current metering policy in Chisinau is vague and complicated within its regulatory and legal boundaries. This assessment will allow clearing up current technical issues on metering, aiming to increase revenue collection thanks to better metrological results.

The revenue meters’ metrological accuracy and operational robustness need to be constantly checked and maintained as they are the primary tool of the billing process in modern water utilities.

Annexes

LIST OF ANNEXES

Annex 1 Number of Repaired Leaks

In the year 2010 were carried out 14 066 interventions in the Chisinau supply area (including suburbs) with the aim of repairing and abolishing leakage from adduction and distribution networks. According to the ACC Central Dispatch register, in 2010 there were leaks, deteriorations and damages on the following diameters, as listed in the table below.

Number of repaired leaks by diameter (mm) in 2010 in the Chisinau supply area

ND (in mm)	≤ 50	65-100	100-150	200-250	250-300	350-450	500-700	800-1000	1200-1400	TOTAL
Circular cracks	439	1101	349	373	65	96	51	33	19	2526
Longitudinal cracks	911	1388	479	675	677	143	193	55	-	4521
Joints	596	871	1221	655	697	131	65	13	-	4249
Damages to the valves, hydrants	812	697	409	360	171	208	101	12	-	2770
TOTAL	**2758**	**4057**	**2458**	**2063**	**1610**	**578**	**410**	**113**	**19**	**14066**

The total number of recorded interventions on the water supply system pipes and accessories over the last five years are shown in the table below.

Number of repaired leaks in 2006 – 2010

Accidents	2006	2007	2008	2009	2010	TOTAL
Circular cracks	1713	1937	1738	1849	2526	9763
Longitudinal cracks	4902	4442	3936	4186	4521	21987
Joints	2322	4235	3948	5096	4249	19850
Damages to the valves, hydrants	5057	2881	2322	2471	2770	15501
TOTAL	**13994**	**13495**	**11944**	**13602**	**14066**	**67101**

From the data analysis presented in the previous table it is established that there is a continuous growing trend of leaks repair interventions occurring in the water supply system, mainly caused by the age of existing pipes and the weakness of their structure/material.

When considering the total length of the water supply system, the pipes with a diameter below 100 mm represent 34% of the total and are generally characterized by a long service life. These pipes sizes have been related to the highest number of repair interventions carried out in recent years. The data related to the number of events related with pipes with diameters up to 100 mm are presented in the table below.

Number of repaired leaks on pipes with diameters up to 100 mm recorded in 2006 – 2010

Accidents	2006	2007	2008	2009	2010	TOTAL
Circular cracks	1031	334	1069	1134	1540	5108
Longitudinal cracks	2954	1790	1581	1677	2299	10301
Joints	1153	1459	1010	1073	1467	6162
Damages to the valves, hydrants	2670	1508	1021	1088	1509	7796
TOTAL	**7808**	**5091**	**4681**	**4972**	**6815**	**29367**

Over the last 5 years, around 44% of leak repair interventions occur on pipes having diameters up to 100 mm.

Appendix 7

Organization of the Company & Quality Management

LIST OF ABBREVIATIONS AND ACRONYMS

ACC	Apa Canal Chisinau
ANB	Apa Nova Bucharest
BPM	Business Process Management
CAPEX	Capital Expenses
CDS	Central Dispatch Office = Controller's Room
Div	Division
Dpt	Department
DW	Waste Water
DWTP	Drinking Water Treatment Plant
EBRD	European Bank for Reconstruction and Development
EHS	Environmental, Health and Safety
EMP	Environmental Management Plan
EMS	Environmental Management System
ESAP	Environmental and Social Action Plan
GIS	Geographic Information System
HSC	House Service Connection
IAS	International Accounting Standards
IR	Inception Report
IU	Implementation Unit
KPI	Key Performance Indicators
LLI	Linear Leakage Index
MIS	Management Information System
NPV	Net Present Value
O&M	Operation and Maintenance
OPEX	Operation Expenses
PIU	Project Implementation Unit
PMU	Project Management Unit
PRV	Pressure Reduction Valve
PS	Pumping Station
PSC	Public Service Contract
SPP	Stakeholders Participation Programme
SSF	Special Shareholders Fund
ToR	Terms of Reference
TPD	Technical and Production Directorate
VW	Veolia Water
WTP	Water Treatment Plant
WW	Drinking Water
WWTP	Waste Water Treatment Plant

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1. FOREWORD

1.1. TERMS OF REFERENCES

The terms of references of the Project associated to organization are the following:

Table 1-1: Terms of reference

Task	Relevant clause of ToR	Expert
Phase A.2. General Information		
General description of APA CANAL (objectives, tasks and services, organization, structure, responsibilities)	A.2. a)	Institutional Expert Water Utility Operational Expert
Phase A.6 Institutional and Economic Operation of Operator ACC		
ORGANIZATIONAL & OPERATIONAL - Analysis of the operator's management structure, competences and qualifications; - Analysis of the human resources and staff management; - Analysis of the operational targets and main instruments; - Audit of MIS	A.6.	Water Utility Op. Expert Human Resources Expert Water Utility Op. Expert MIS Specialist Local Env. Expert
Phase C.6 Institutional and Economic Operation		
Identification of necessary "operation" measures after completion of the rehabilitation works, incl. staff/equipment requirements, administrative and operation routines and proposals for assistance to operating units during start-up and initial operation. Preliminary Design and Terms of Reference for PIP programme elements (Consulting, Training etc.) Proposals for supporting actions and formulation of accompanying measures (training, professional advice) to secure proper "operation".	C.6.	Institutional Expert & Operational Expert

1.1. SCOPE OF WORK

The purpose of the first mission was to bring an input for the Inception Report. Following the terms of reference of the Project described above, the following investigations were undertaken:

- Assess, in conjunction with the HR expert, the effectiveness of the organization of the Company, the existing capacity and capability of the staff and the appropriateness and sufficiency of current training programmes;
- Calculate, based on provided data, appropriate performance indicators such as staff/connection, days training per year;
- Compare the current organization with those implemented in other big European Cities (Bucharest, Prague, Budapest,…).
- Make an analysis of the current staff structure of the Company (age, sex and age in the company).
- Make recommendations for a new organization (organization chart, staff levels);
- Propose a scenario of evolution of the staff structure for the next 10 years together with the recruitment needs;

- Build an action plan that should lead to the reduction of staff (automation of facilities, outsourcing of non core activities, pooling of resources, …).
- Quick review of existing quality management policy within the Company and related MIS;
- Investigate if there is any analytical accounting management already implemented in the Company for any kind of expenditures (staff, materials, vehicle) and any cost control management and propose an actions plan;
- Outline the best international practices in O&M;
- Define O&M KPI and set targets.

1.2. ON SITE MISSION AND OTHER INPUTS

The mission in Moldavia took place from Monday the 28th of February to Friday the 4th of March 2011.

The following meetings were appointed with the ACC:

- Monday:
  - General meeting with Consultant team and PIU
- Tuesday
  - Health and safety briefing
  - On field meeting on a leak repair site
  - Meeting with Deputy Director of Technical Department and Waste water Department Director
- Wednesday
  - On field meeting with technician from the dispatch room
  - Meeting with Control Room Director
  - Short visit of the Control Room and short interview of Control Room Operator and Dispatcher
- Thursday
  - Visit of Botannica Sector office (Drinking water network Team)
  - Meeting with PIU Director concerning Quality Management
  - Meeting with Deputy Director of Drinking Water Department

In terms of documents, the following were provided:

- Phone list of ACC
- Organizational chart of ACC
- Human Resources expert’s contribution to Inception Report
- Waste water engineer’s Memo’s on the existing situation
- Water engineer’s Memo’s on the existing situation
- Manual for Integrated Management
- Several examples of general and specific procedures
- Quality Management Programme for years 2010 and 2011

Other documents were asked for but were not provided for the Inception Report:

- Data (in Excel) regarding bursts from Control Room
- Detailed organizational chart for sectors and Controller Room

It shall be said that for the Inception Report, data provided was enough.

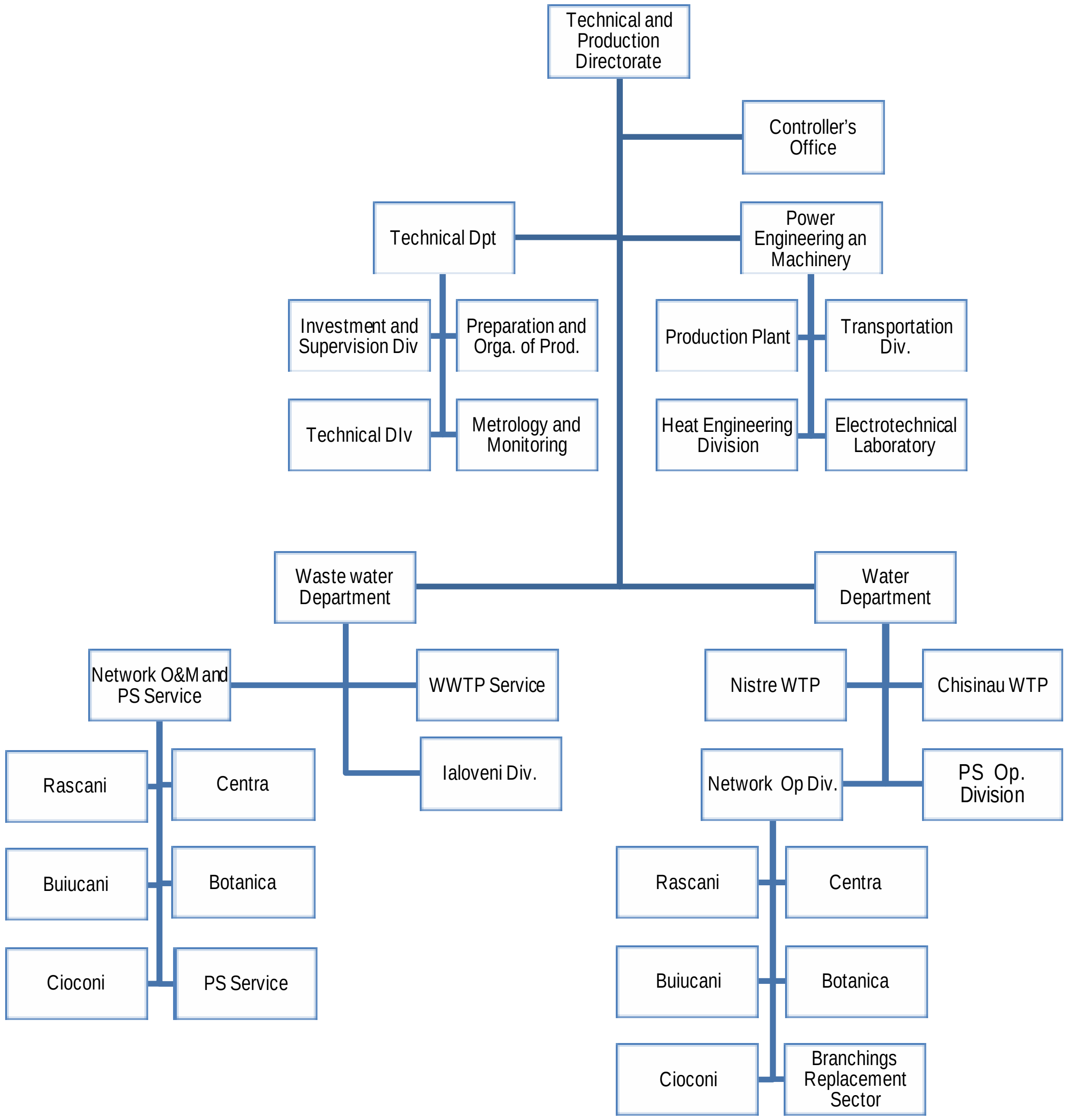
2. ORGANIZATION OF TECHNICAL AND PRODUCTION DIRECTORATE

2.1. "AS IS" SITUATION

2.1.1. GENERAL OVERVIEW

All the operations on the water supply and wastewater collection systems are entrusted to the Technical and Production Directorate (TPD) of ACC. The current organizational chart is provided below with comments.

Figure 2-1: Commented Organizational chart of Technical and Production Directorate



This organization chart shows a classic organization by function by opposition with an organization by division where every division hosts each functions. This type of organization is classic in Eastern Europe countries and can be summarized in three words: centralization, verticality and organized in silos.

Remark: It worth noting there that the only exception to this scheme is the Ialoveni Division hosted by the Waste water Department. There the Director[1] is in charge of operations in both drinking water and waste water.

2.1.1. GEOGRAPHICAL ORGANIZATION AND AREA OF ACTIVITY

Departments within the TPD are spread out in Chisinau. Offices are mainly implemented on plots with technical installations (pumping station, DWTP or WWTP).

The area of activity of ACC is larger than Chisinau city itself it covers several villages and small cities around Chisinau.

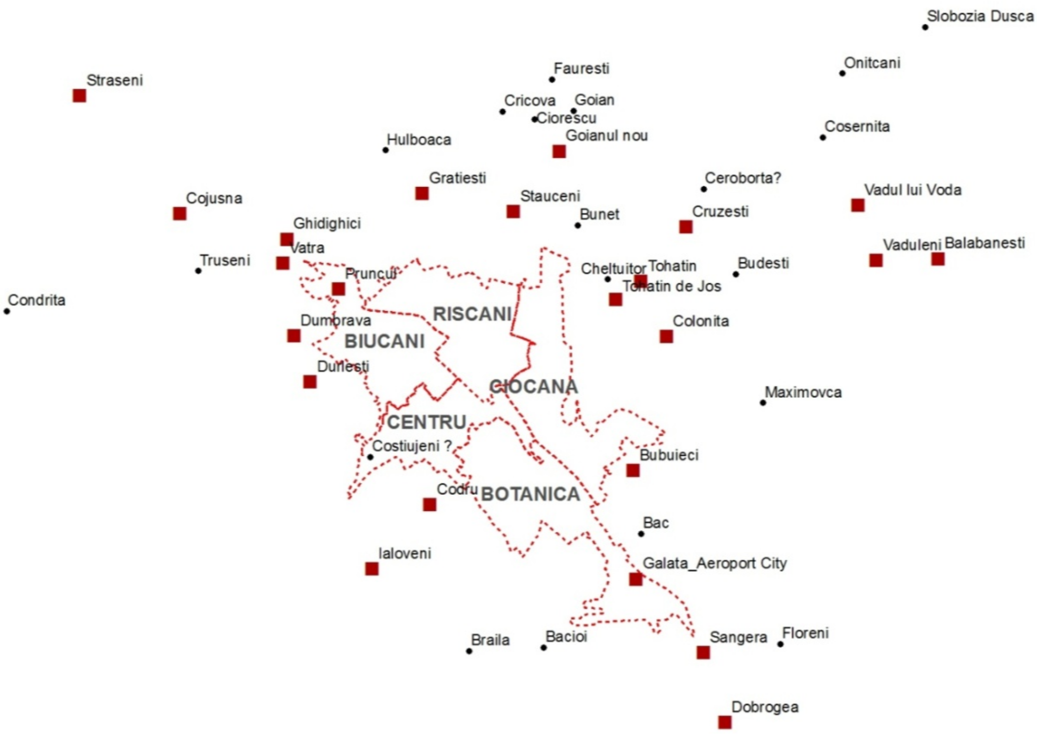
The following figures show the location of each Department within Chisinau and its vicinity and the area of activity of ACC:

Figure 2-2: Locations of Departments within Chisinau[2]

[1] This function is ensured directly by the Director of the Waste water Department.
[2] The source of offices addresses of is the phone list of ACC

As it can be seen, the only teams that are spread in Chisinau are the teams in charge of operations on the water network. In opposition to this, even if they are organised by sector, the teams in charge of waste water network are in the same building in the centre of Chisinau.

Figure 2-3: Perimeter of activity of ACC



■ : Village with WW and DW services ensured by ACC

● : Village with DW service ensured by ACC

Except Ialoveni, every village is entrusted to the nearest sector.

2.1.2. SERVICES ACTIVITIES

Activities and responsibilities are set for each service within the Quality Management documents. The following table summarized activities and responsibilities of each service within ACC based on interview:

Table 2-1: Services activities and staff (2010)

Department and Service	Main Activity(ies)	Staff	Type of staff[3]
Technical Dpt		**47**	**-**
Investment and Supervision Div	Monitor subcontracted works Work with the Municipality on its investment budget Prepare investment plans on the network (Ø>200mm => investment = CAPEX /w depreciation)	8	Engineer Economist
Preparation and Orga. of Prod.	Plan common repairs on the network (Ø<200mm => common repairs = OPEX) according to sectors and clients claims	10	Engineer

[3] The source of this information is ACC phone list. Head of Service, Head of Sector and unskilled worker are not mentioned.

Department and Service	Main Activity(ies)	Staff	Type of staff[3]
Technical Div	Work on technical conditions for new projects (service lines, extension.…) Perform fixed asset inventory and registration Manage technical library	17	Engineer
Metrology and Monitoring	Ensure accuracy and maintenance of metrology devices	12	Engineer Locksmith Storekeeper Economist
Water Department		**592**	
Nistre WTP	Operate intake and WTP	161	Engineer Economist Worker[4] Driver Dispatcher
Chisinau WTP	Operate WTP	65	Engineer Economist Dispatcher
Network Op Div.	-	208	Engineer Economist Dispatcher
• Sector (x5)	Operate and maintain valves Repair identified leaks Ensure the relation with the Municipality	-	Team Leader[5] Worker Operator
• Service Line Division	Execute internal works within the investment plant in every sector Execute works on service lines in every sector	-	Team Leader
PS Op. Division • Borehole pumps Service • Big pumps Service • “Hydrofore” service	Monitor (manually) pumps functioning Send monitored data to Controller’s Office (every hour) Operate pumps (start, stop, switch, etc.) Ensure common maintenance and upkeep Ensure planned maintenance every 6 months Manage reservoirs Clean reservoirs once a year	158	Engineer Economist Technician Storekeeper
Waste water Department		**320**	
Network O&M and PS Service	-	142	Engineer Economist
• Sector (x5)	Deal with blockages (manually and with specialized machinery) Execute repairs on the network Ensure the relation with the Municipality	-	Team Leader Worker
• PS Div.	Monitor (manually) pumps functioning Send monitored data to Controller’s Office (every hour) Operate pumps (start, stop, switch, etc.) Ensure common maintenance and upkeep Ensure planned maintenance every 6 months Execute small works on pipes	-	Electrician Engineer Electrician
WWTP Service	Operate WWTP	134	Engineer Economist Head of Process Operator
Ialoveni Div.	Operate waste water and drinking water system Ensure the relation with the Municipality	44	Engineer Team Leader Dispatcher
Controller Office	Receive and manage technical claims from customers Collect all data from staff on installations Coordinate operations on pumping stations Plan operations on pumping stations Collect data from teams about repairs on networks Perform the first diagnosis on networks (WW and DW) Operate valves for some water cuts Eliminate (manually) small blockage on WW network Inform and coordinate on field teams for network repair	**75**	Engineer Dispatcher Operator Electrician Welder Locksmith

[4] The term used for worker is Brigadier
[5] The term used for worker is Master

Department and Service	Main Activity(ies)	Staff	Type of staff[3]
	Coordinate and allocate plants to on-field team Perform leak detection planned campaigns (3 persons)		
Power Engineering an Machinery	-	**448**	Engineer
Production Plant	-	194	Engineer Economist
• Repair and Construction Service	Ensure civil engineering operations Work on network pipes (up to 30 m and/or 400 mm)	69	Head of site
• Electromechanic Service	Perform heavy maintenance on pumps (on site or at workshop such as recoiling)	29	Engineer
• Mechanism Service	*Manage heavy machineries (e.g. excavator) pool* *Operate heavy machineries (e.g. excavator) on field*	82	Engineer Dispatcher
Transportation Div.	*Manage vehicles pool* *Drive vehicles* *Repair vehicles*	194	Engineer Economist Mechanic Dispatcher Storekeeper Technician Driver
Heat Engineering Division	Operate 3 heating systems	48	Engineer Economist Dispatcher
Electrotechnical Laboratory	Repair and control cathodic protection of network Operate electrical installation	12	Engineer Technician

Italic: assumption

Remark: One can notice the presence of the Heat Engineering Division which is not part of the core business of ACC. It should be said here that this activity was given to ACC for the payment of an old debt. However, this activity was said to be not profitable.

2.2. SHORTCOMING AND BENCHMARK WITH ANB

2.2.1. SHORTCOMING

2.2.1.1. General organization

Concerning organization, there are PROS and CONS in each main types of organization (by function and by division). They are illustrated in the following chart:

Table 2-2: PROS and CONS for each type of organization

	Type of division	PROS	CONS
Structure by function as ACC	Specialized by function	• Clarity • Concentration of resources • Economy of scale • Development of specialized skills	• Highly centralized • Difficult transversal coordination and communication • Relative inertia
Structure with division	Divided according to: • Strategic business unit • Products • Market • Geographical area	• Decentralized structures • Efficient coordination within each activity • Easily adaptable structure	• Scattered resources • Diseconomy of scale • Difficult development of specialized skills

Concerning ACC, its vertical and activity oriented organization shows the classical limits of the above table:

- There are few transversal communications even in teams working in the same sectors. This situation is intensified by the fact that WW and DW teams are not in the same building for one sector.
- The strong centralization of ACC is illustrated by a very powerful Controller's Office that can be seen as the "brain" of the operations on the network knowing and managing everything. This left the operational teams with few responsibilities.
- The concentration of resources and the economy of scale are real in ACC. However, it is hard to see if it a constraints or a will as there is a lack of plants and on the other side, overstaffing does exist in some parts of the Company.
- In water utility business, the need for very skilled workers is rare (electrician, mechanic, etc...). As a consequence, the usefulness of the development of specialized skills is limited.

Having said this, it must be said that the idea of a universal ideal structure for one type of business or activity is a myth. Things are far more complex. And, in many ways, in terms network operations, ACC does respond very effectively to its main issues: repair burst on DW network and clean out blockages on WW network.

Theoretically, an organization can be seen either (1) as a response to the constraints of the environment or (2) as a construction to deliver a product or a service. ACC better fits with the (1).

2.2.1.1. Project enforcement and implementation

Within our project, it can be seen that some difficulties appears sometimes when resources are needed to start new project or experimentation. These difficulties find their roots in two things: teams are focused on unforeseeable technical factors (bursts, blockages, etc.) and organization is vertical with mono-activity services. They are intrinsic to the functional organization as daily operational activity and project activity do not share the same characteristics (time frame, repetitiveness...).

Table 2-3: Key differences between operation and project

Project activity	Operational activity
Non repetitive (one shot)	Repetitive
Irreversible decision	Reversible decision
High uncertainty	Low uncertainty
High influence from external parameters	High influence from internal parameters
Historical process	Stabilized process manageable with past experience and statistics
Negative cash flows	Positive cash flows

2.2.2. BENCHMARK WITH ANB

2.2.2.1. Forewords

Apa Nova Bucharest (ANB) was chosen as the main source of benchmark with Chisinau. The main reasons are the following:

- Chisinau and Bucharest are close to each other
- Moldavia and Romania share a common (partly) cultural and historical background
- ACC and ANB share a common (partly) cultural and historical background either
- ANB can be seen as a success in terms of reorganization

The sources of information for Apa Nova Bucharest situation and recent history are the following:

- Interviews of ANB staffs
- 2009 Annual Activity Report
- ANB website (http://www.apanovabucuresti.ro/)
- 2004 Handbook of Bernard Brunhes group: Succeed in Eastern countries
- PhD thesis of Claire BURLAT (University Lyon 2, France - 2010): Legitimacy of productive institutions in European democratic society including a monograph of Apa Nova Bucharest recent history

To put in perspective the activity of both companies, key figures of ACC and ANB are provided in the chart below:

Table 2-4: Key figures for ACC and ANB

	ACC / Chisinau	ANB / Bucharest 2009
Population of the City	770,000[6]	1,930,000[7]
Customers	*Missing data*	107,000
DW Treatment facilities	2	3 (Rosu, Arcuda and Crivina)
DW Pumping stations	11	8
Hydrofore and small PS	93	119
Reservoirs	81 (?)	20
Length of DW network	1,850 km	2,250 km
DW connections	*Missing data*	100,000
DW Operations and bursts treated	14,000	24,800
Length of WW network	950 km	2,000 km
WW Treatment facilities	1 (big)	1 (big under reconstruction)
WW Operations and blockages treated	28,900	50,700
Staffs	1,930	1,910

Italic: assumed or missing information

6 Population in 2004 for the study area
7 Population in 2007

2.2.2.2. Benchmark

In the frame of a contract with the Municipality, main changes in ANB had been enforced since 2000 by Veolia Water, international French water utility company, as it took in 2000 over the existing state control company. Some changes are reflected in the evolution of the organization.

Figure 2-4: Organizational evolutions for operations of ANB in 2000

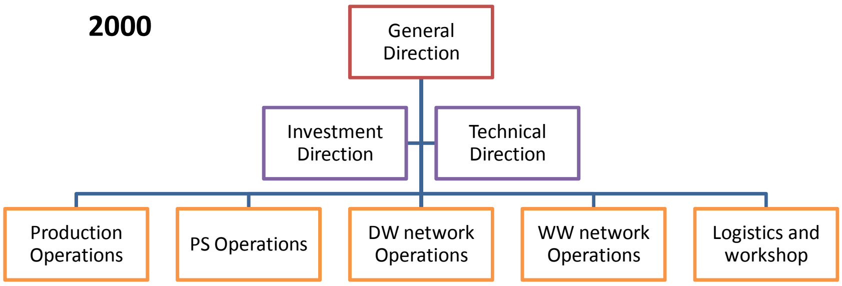
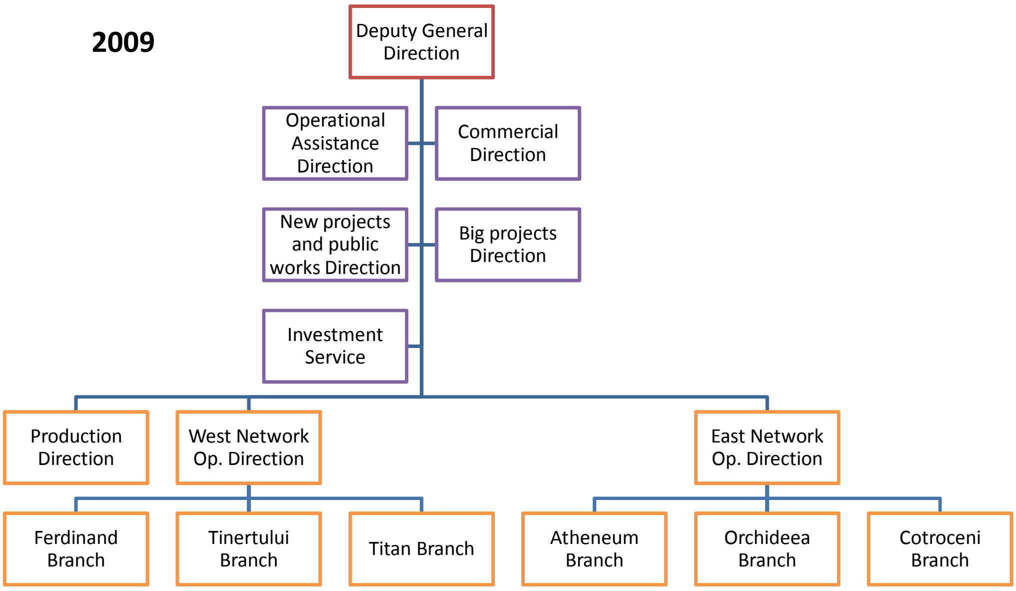


Figure 2-5: Organizational evolutions for operations of ANB in 2009



At the same time the Company's staff decreases from 5,560 in 2000, to 3,300 in 2002 and to 1,910 in 2009 thanks to more or less hard restructuring programmes.

Main changes occurred after a first restructuring programme between 2000 and 2002. These changes were drawn up during top management seminars[8] in 2002 and they were implemented step by step between 2002 and 2004. The main objectives identified and set during this seminar were:

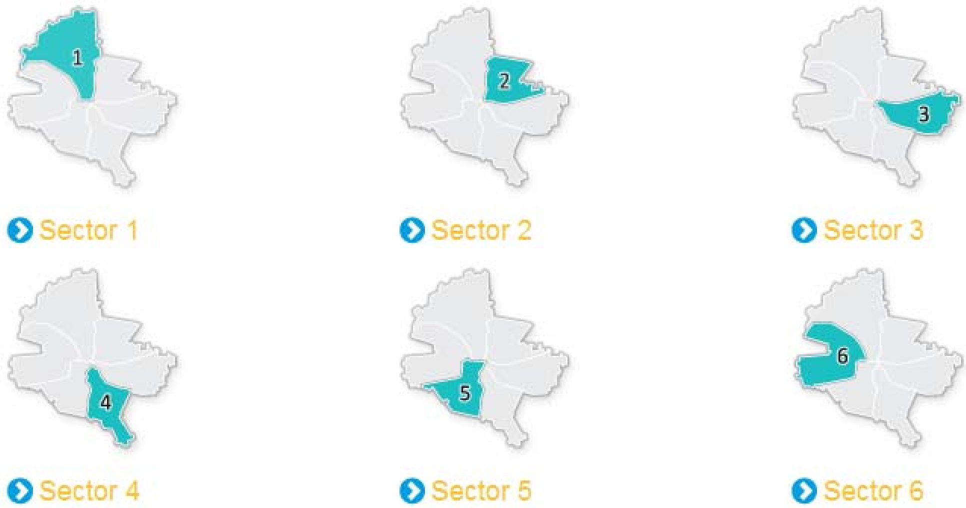
- Customer satisfaction with among key actions: correct evaluation of consumption, correct invoicing, realization of extension, correct tariffs

[8] These seminars were organized by a consulting firm Bernard Brunhes Consultants including interviews, SWOT analysis, team building, workshops...

- Municipality satisfaction with among key actions: respect of obligations, accompaniment of projects, communication
- Shareholders satisfaction or in ACC case, Donors satisfaction with among key actions: respect of the Business Plan
- Staffs satisfaction with among key actions: good practices, skills assessment, training programme, salary policy

In terms of organization, one can see that there was a shift from a centralized organization by function to a decentralized organization by division. The most emblematic change was the creation of 6 local branches or operational centers. They became responsible on their perimeter of network, pumping station and clients operations with the support of reinforced support services. Compared to the former organization, for each department operating on network, geographical area of activity is smaller, teams are reduced but responsibility on this perimeter is extended to the whole utility operations. It shall be said that this organization is extensively used by Veolia Water in the places where it operates.

Figure 2-6: Operational centers in ANB[9]



These operational centers were created to execute operations on WW and DW networks the closer to clients and to local authorities. They were locally responsible for the achievement of contractual objectives. Each operational center perimeter was defined according to administrative borders, one operational center covering two of them. In average, each operational center area includes 300,000 inhabitants in average. Before the generalization of this organization, a first experimentation was undertaken on one test area during two months.

[9] From ANB website.

2.3. RECOMMENDATIONS

2.3.1. TRIGGER AND FACILITATE PROJECTS

2.3.1.1. Trigger projects

Seureca's mission is a triggered project that includes other projects. However, it is a feasibility study that mainly aims at defining a master plan for massive investments in ACC.

Besides this, from their own staffs and Seureca's report, ACC may identify no or low costs measures that could improve immediately or within a short period its Operational Expenditures (OPEX). If so, these should be studied and then implement if economic calculations and experimentation prove that the first assumptions were right.

In addition to this, a midterm action could be to launch an innovation and continuous improvement programme involving all the staff of the company. These programmes are generally based on a bottom-up approach and aim at collecting good ideas and best practices from the operations and to disseminate them to all the company. These programmes rely on one coordinator who animates a network of local correspondents within the operational services. For some employees, one difficulty will be to convince them of the benefits of this approach i.e. finding a practical solution to identified problems, unaccustomed as they were to pointing out potential problems.

ANB recently launch this type of programme. The following keys to success were identified:

- full involvement of the managers
- involvement of all employees
- gathering of spontaneous ideas
- triggering innovation
- existence of a correspondents networks within each services and departments
- communication (emails, internal newspaper, intranet, cartoons, etc.)
- rewards (end-of-year bonus, employment of the month,
- implementation (via correspondents, quality management and communication)
- follow up and sharing

Criteria for the evaluation of a good idea could be the following: productivity, applicability and duplicability.

2.3.1.2. Facilitate and organize projects

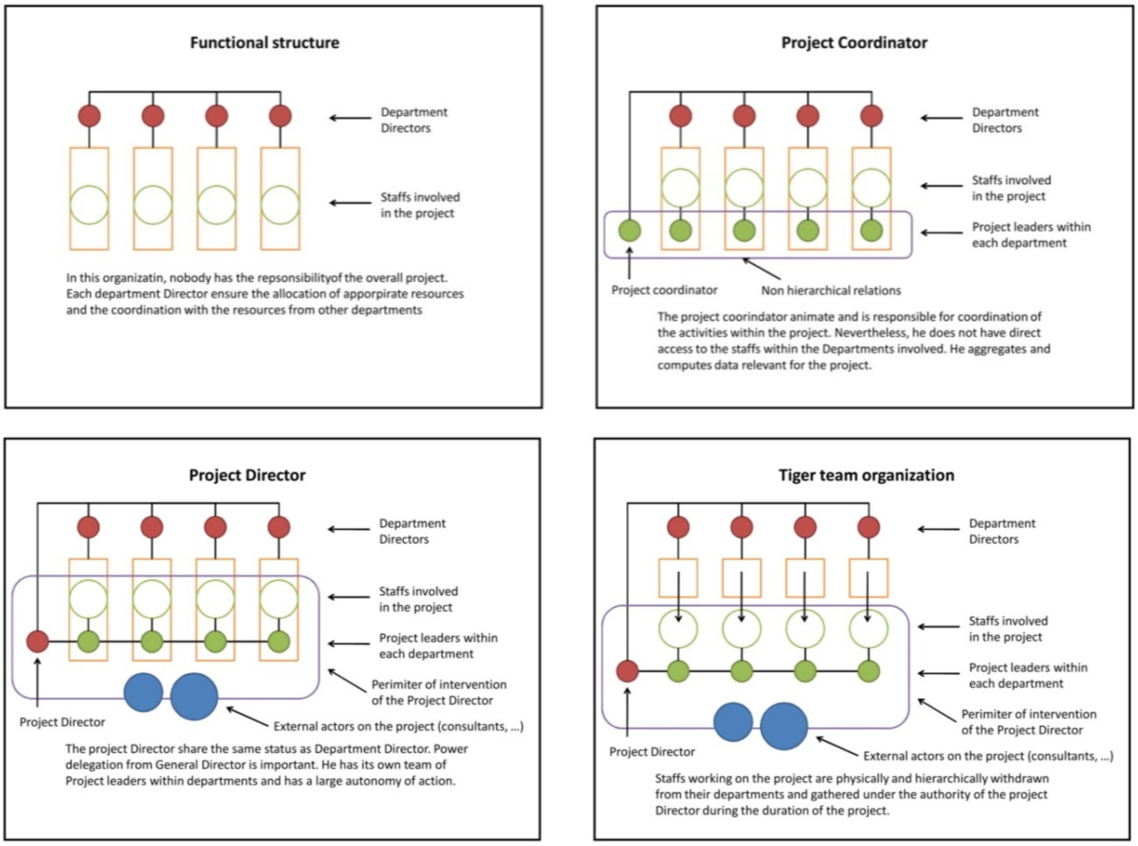
To overcome difficulties associated within projects implementation in organization by function, for each project functional organizations have recourse to transversal teams.

Depending on the importance of the project (through time[10]), several type of organization can be set up:

- Functional organization (shared coordination by Department Director)
- Lightweight project manager (Identified coordinator)
- Heavyweight project manager (Identified Project Director)
- Tiger team organization (Project is no longer integrated to usual department and staffs from department are dedicated to the project under the direct authority of a Project Director)

Those typical projects organizations are illustrated below.

Figure 2-7: Typical projects organizations



In ACC, the Project Implementation Unit along with Seureca's mission could be considered as a Tiger team organization as they work on a one shot project with massive investments done over a short time period. Projects within Seureca mission (leak detection, modelling, etc...) could be seen as Project coordinator organization at this stage. In further stage (project implementation), it could be interesting to have their organization evolve into Project Director or Tiger team organization. This may accelerate and facilitate the speed of the project. Moreover, it would enable transversal communication.

For each project, in addition to the organization, the followings should be defined:

- resources allocated (office, staffs, equipment)

[10] Organization of the project could be redefined as the project progresses; definition of specifications being, for exemple, in an organizational structure and projects development and enforcement with a Project Director organization.

- duration
- budget
- advancement indicators

It is worth saying that this project specific organization is generally forgotten in Manual of Integrated Management[11] as they are independently, by definition, out of the common life of the company. An example of paragraph introducing this notion into a Manual of Integrated Management in water utility business is given below:

Figure 2-8: Typical description of project organization within from a Manual of Integrated Management of Veolia Water in France within "Manage" process

Project Management: *Some themes, approved by the board of directors, are managed in a "project" mode as they are potential sources of technical progress, economical growth or productivity for the business unit. They generally require transversal teams. In this case, they are sponsored by one of the member of the board of directors and a Project Manager is named. A team is built. Its members meet regularly with their sponsor and make sure that the design and the execution of deliverables match the expectations and the implementation in operational teams is done properly.*

In addition to the positive effects expected from any project, one other positive side effect is that a transversal project is a vector for transversal and internal communication breaking the verticality of organization by functions like ACC.

2.3.2. ORGANIZATION ADJUSTMENTS

In terms of organization, short terms adjustments can be made to achieve specific goals without modifying the principles of current organization. Suggestions of evolution to achieve each goal are suggested below:

- Organization principles are maintained:
  - Subdivision in sectors should be kept at the bottom of the organization
  - Separation between DW and WW department should be maintained
  - Limited reallocation of operational staffs from one service to another
- Company focuses on core business:
  - Services out of core business should be put out off operations, analysed and prepared for outsourcing
  - Heat Engineering Division shall be sold to a company specialized in Heating system management
  - Plants and vehicles along with drivers can be allocated to each sectors or services they actually work with
  - Mutualised plants and vehicles can be allocated to Controller's Office to become an Operational Assistance Department
  - Mechanism and Transportation service shall become a service in charge of managing the pool of vehicle and repairing them

[11] From the table of contents of ACC Manual of Integrated Management, it cannot be found.

    - Electrotechnical Laboratory staffs should be integrated into the Electromechanic Department and Service Line Division for staffs specialized in cathodic protection
- Operations deals with operations:
    - From existing support departments, two (to three) services can be created: (1) Operational Assistance Department and (2a) Investments and New Projects and (2b) Public Works Department; the last two one can be merged eventually
    - Investment and Supervision Division and Technical Division could be integrated into the new Investments, New Projects and Public Works Department
    - Service Line Division could be integrated into the new Investments, New Projects and Public Works Department (positive side effect will be to shorten decision process and to coordinate easily internal and subcontracted public works operations)
    - Repair and Construction Service could be integrated into Investments and New Projects and Public Works Department (positive side effect will be to shorten decision process and to coordinate easily internal and subcontracted public works operations)
    - Controller's Office could integrate Preparation and Organization of Production Division and Metrology and Monitoring Division to become the new Operational Assistance Department
    - Electromechanic Service could be integrated into Operational Assistance Department (positive side effect will be to shorten decision process and to coordinate easily planned actions on PS)
    - Nistru and Chisinau WTP and WWTP Divisions could merged into one unique Production and Treatment Department
    - WW and DW Departments will then be focused on network operations
- Experimentation on organization must be studied:
    - Ialoveni Sector could be put out of the WW and DW division and be used as an experimentation the organization by division
    - First consolidation of sectors into three bigger branches can be studied or made (at least virtually for consolidation purpose):
        - Sector 1: Riscani + Ciocana + villages (east of Chisinau)
        - Sector 2: Centru + Biucani + villages (north west of Chisinau)
        - Sector 3: Botanica + (Ialoveni) + villages (south of Chisinau)

These adjustments in the organizations are reflected in the following charts:

Figure 2-9: Results from suggestions in terms of organization adjustment

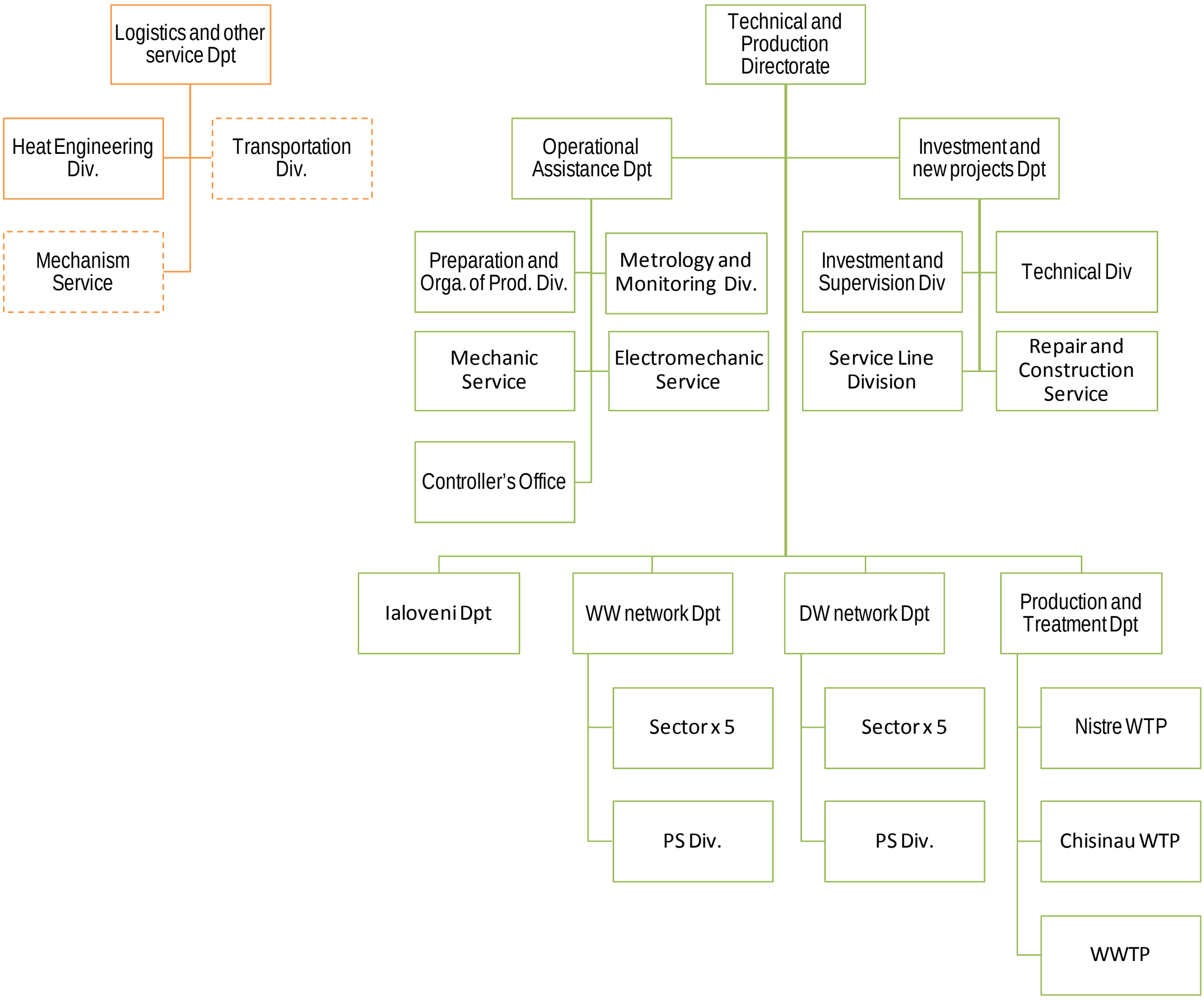


Figure 2-10: Consolidated organizational chart after suggestions integration

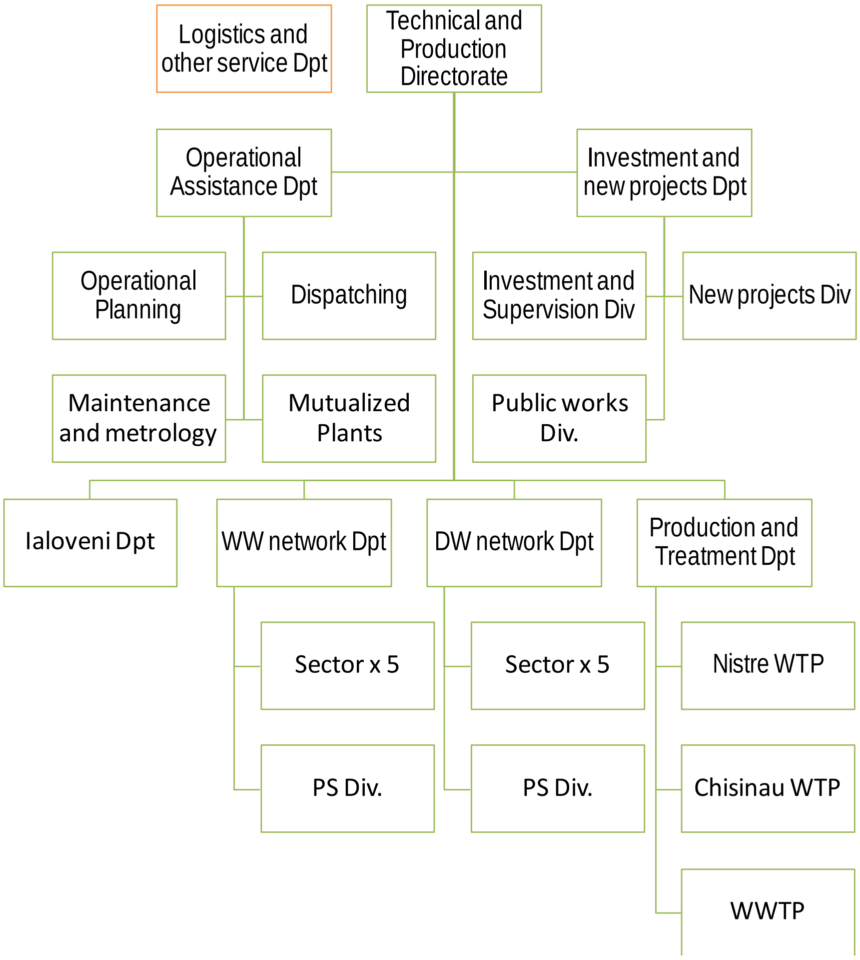
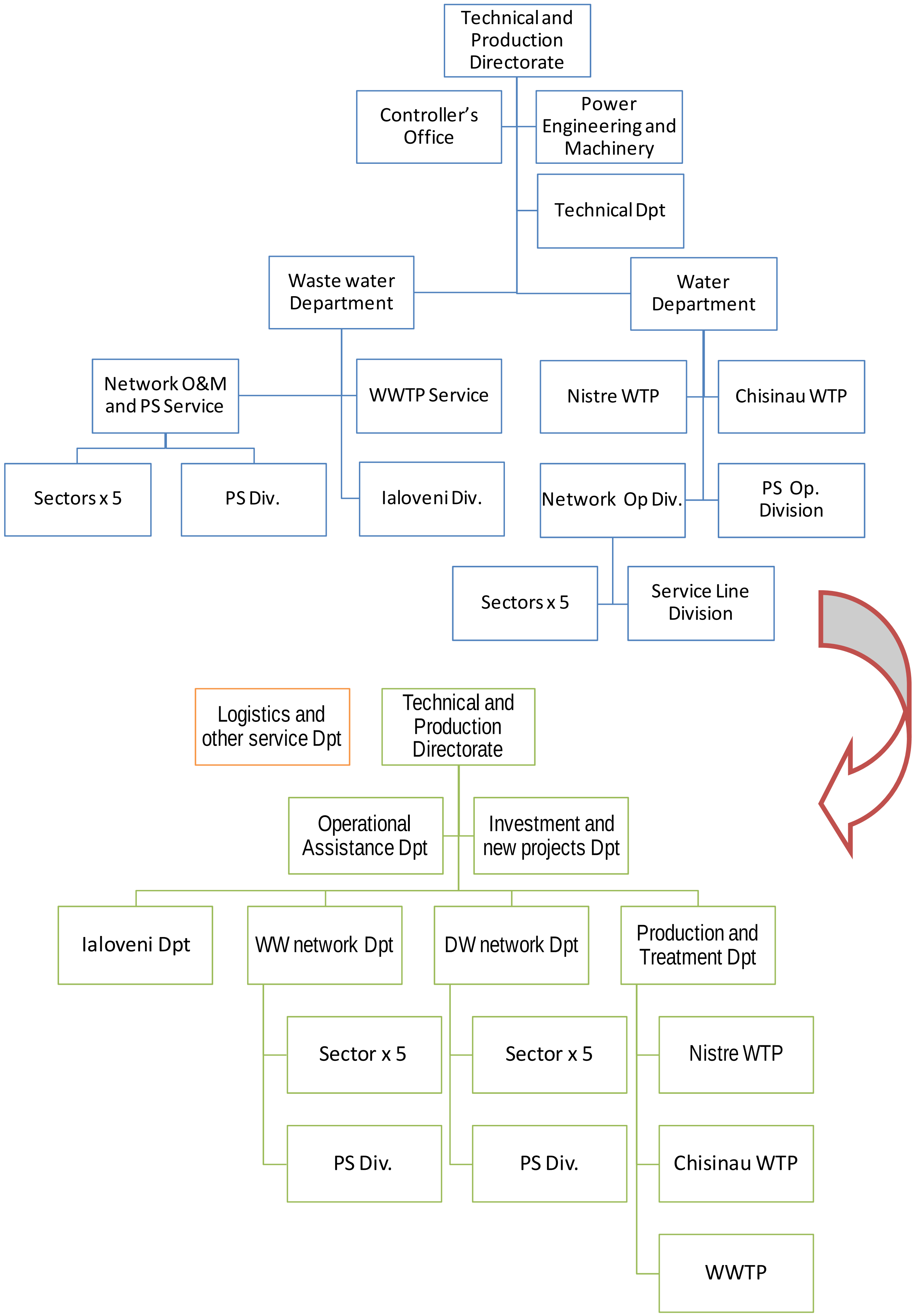


Figure 2-11: Compared simplified organizational charts (current to suggested)



From there two comments must be made:

- Human resources issues that can rise from these changes will be tackled by Human Resources expert's report;
- These first suggestions may need further analysis in the next phases of the project or as new elements appears.

2.3.3. REORGANIZE (FULLY) FOR A NEW PROJECT / MISSION

A full reorganization involving major changes in the fundamental principles of the current organization should be triggered by a new project or mission for the Company. It should be "powerful" enough to get the adhesion of the managers and staffs as it will have to overcome the formal and informal power and political networks within the Company.

In addition to this, this adhesion is very important because a shift in organization is generally accompanied with human resources changes (staff reallocation, new skills development, etc.), implementation of a new MIS, investment in new equipment, etc. that require the adhesion of the whole company.

As a consequence internal communication becomes a major issue as the whole company must be involved in terms of organization but also in terms of tools, skills, practices, etc... To deal with this issue, ANB organized top management seminars involving 20 to 40 managers of the Company and addressed a large number of issues.

For example, ANB organization based on decentralized operational centres relies on a skilled and autonomous middle management and multidisciplinary field operators.

3. PROCESSES, PROCEDURES AND QUALITY MANAGEMENT

3.1. "AS IS" SITUATION

ACC has a triple certification: ISO 9001: 2008, ISO 14001:2004 and OHSAS 18001:2007.

The Manual of Integrated Management and all the procedures associated are well documented and are regularly audited and reviewed. The table of contents of the Manual of Integrated Management is the following:

Figure 3-1: Table of contents of Manual of Integrated Management

CUPRINS

The activity and the main processes and procedures are summarized in the following figure from the Manual of Integrated Management:

Figure 3-2: Process map within ACC

One can see that four processes are identified:

- Management of activity
- Management of resources
- Realization and production including basis processes
- Measure, analyze and improve

In the Manual of Integrated Management, there are two types of procedures: general procedures and specific procedures. The first ones concern mainly non operational and management activity (Corrective action, Internal Audit, etc.) and the second ones concern activity that can be associated to operational and administrative services (Treat raw water, Repair, Operate Controller's Office, Treat Waste water, Register clients, Bill, Elaborate job description, Repair vehicles, etc.). Most of the procedures are built on the same model and address the following points:

- Scope
- Field of application
- Definitions
- Referent documentation
- Responsibility
- Procedures
    - Generality
    - Description (step by step)
    - Applicable norms
    - Performance indicators
- Linked or associated procedure
- Forms

Each year, an action plan is designed to improve Quality Management following the well known principles of continuous improvement and the following cycle Plan, Do, Check, Act (Deming Wheel). This actions plan tackles the following issues:

Table 3-1: Content of yearly action plan for ACC Quality Management improvement

Obiective generale	Obiective specifice	Activităţi	Responsabil	Termen	Resurse	Indicatori de performanţă	Analiza acţiunii

In terms of internal communication, all the procedures are available for the operators on the field. Quality Management at this level is entrusted to Middle Management and Team Leaders.
On the field, it seems that few communication (no poster for instance) is made on the subject. However, visit on the field suggested that the procedures are executed according to their description in the Manual of Integrated Management even if the supporting document seems to be mainly a bit virtual to operators as all the data are communicated to Controller's Office.
From our discussion with ACC representatives, it seems that few non-conformity forms were issued by operators and workers suggesting a limited appropriation of the Quality Management as a tool to improve their work.

3.2. BEST PRACTICES: BUSINESS PROCESS MANAGEMENT (BPM)

3.2.1. FOREWORDS AND SHORTCOMINGS

The ISO9001: 2008 certification demonstrates that ACC's Quality Management system complies with the norms and is mature.

Quality Management has to be integrated (1) in the daily operations and (2) in the management of the activity. (3) It should reflect how the company is operating, (4) be clients oriented and (5) implicate staffs in the improvement of operations.

From our discussions and visits, the following comments can be made on the four above mentioned points:

1. Daily operations are executed by specialized services with few transversal communications (apart from communication through controller's office). Managing with processes aims at breaking these borders between services.
2. It seems that the activity is mostly driven by budgetary constraints (which is normal) and that performance indicators are not used much as objectives. In procedures, performance indicators are not yet clearly identified.
3. Based solely on the process map of ACC, which is a simplified but pedagogical view, the operating activities (basis processes) is at the centre (more in the middle of) and are somehow encompassed by administrative activities. This latter outnumbers operations and are more detailed.
4. From the process map of the Company again, the notions of input and output (to clients) are quite absent showing the Company as a block.
5. Communication on that purpose is entrusted to managers and few technical objectives communicable to staffs are displayed. Moreover, the verticality of the structure limits sense of responsibility toward other services working along the process.

As a conclusion of this, even if processes are clearly indentified within the Company (in the Manual of Quality Management), the organization itself seems to overcome this intention. In a way, the Controller's Office concentrates all the "transversality" of the company, taking it from the operational services themselves. Because of that, the operational services keep on focusing on functions instead of processes. In most organizations, this functional working leads to these problems:

- Bottlenecks
- Repetition
- Bureaucracy
- No ownership
- Management frustration
- Too many steps
- Customer forgotten
- Opportunities for error or even corruption

3.2.2. BUSINESS PROCESS MANAGEMENT (BPM)

3.2.2.1. A bit of theory and definitions

The primacy of transversal process over functions appears as soon as the needs for transversal coordination took over gains from specialized function staffs.

One definition of a process is the following: a process is a group of activities organized in network, in series or in parallel that combine themselves, gather and use multiple resources, capacities and skills to produce an output valuable for a client.

To complement this first definition and in other words, it can be said that a process is:

- A series of related activities that "flow" through an organisation
- Not limited to a single function or department
- Something that can be viewed from end to end

The process management is organizing techniques by decomposition in different stages of completion of an economic operation. The management process aims to describe very precisely the modus operandi of the company in order to have a transverse view of the company (i.e. beyond the capabilities of management or activity as a whole).

The detailed process clearly defines:

- The role of each in the accomplishment of a task;
- The positioning of services between each other (concept of client / internal suppliers).

BPM allows:

- Everyone to know his role in the huge mass of work that the company makes every day;
- Giving a sense of responsibility to all stakeholders of the company. Indeed, an employee will not slow down (voluntarily) the value chain of the company because he knows that other links in the chain need that his work is done. If work is not done, the whole chain can identify the link blocking;
- Knowing the dysfunction of the business (time wasted in processing a given example) and determine the causes (bad tool, no data transmitted late or incomplete).

The process management can greatly increase the company's performance (by everyone's responsibility but also the identification of dysfunction), but the management process must be dynamic.

3.2.2.2. Process mapping and building

This business process management approach is in the form of strata.

The highest level corresponds to macro-processes of the Company such as the definition of the business strategy of the company, the preparation of the investment policy…

The presentation of the processes is often called "process map". The main interactions between processes are represented, so are shaped products (output product of a process and product entry in another process).

The intermediate level is a first declination of macro-processes. It includes a number of steps of the company management. The protagonists involved are the services or departments of the company, attached to the directions mentioned above.

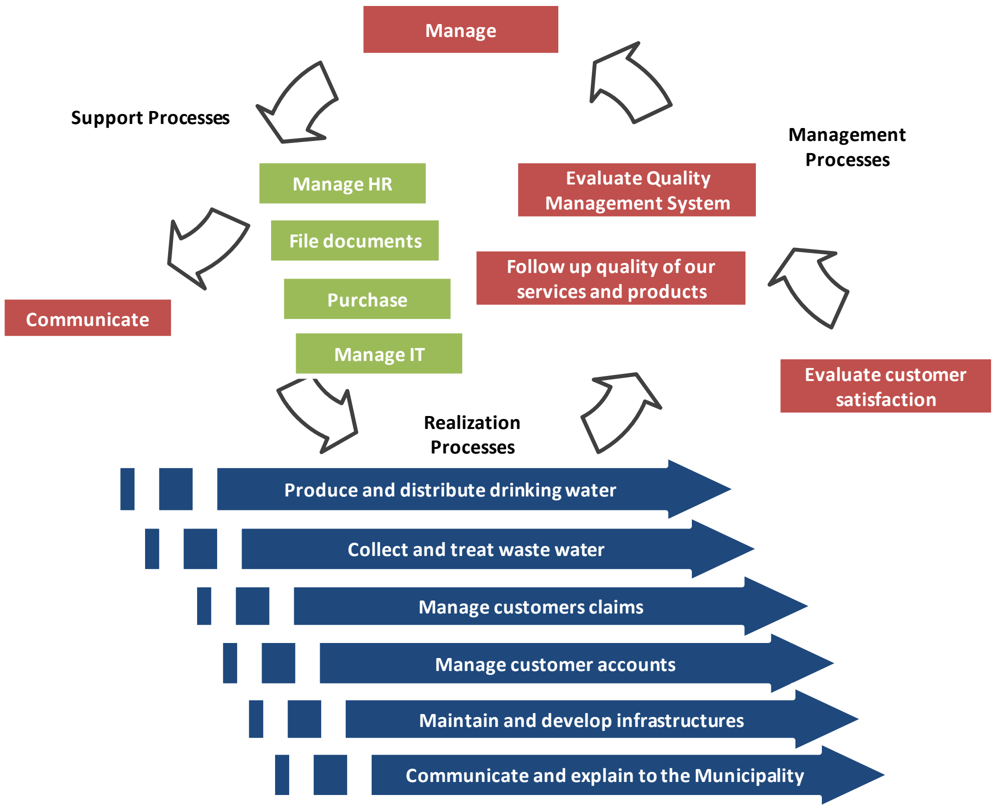
The finest level is the detailed process (procedures in the examples below). The latter is a sequence of operational tasks or decision-making processes. When the process is well designed, it is not limited to one service but goes across a number of services. This ensures a cross-functional approach of the actions to be undertaken.

3.2.2.1. Examples of process mapping from other water utilities

In water utility, in France, Veolia Water uses the following process mapping to cover all the parts of its activity. There are three major types of macro-processes (highest level):

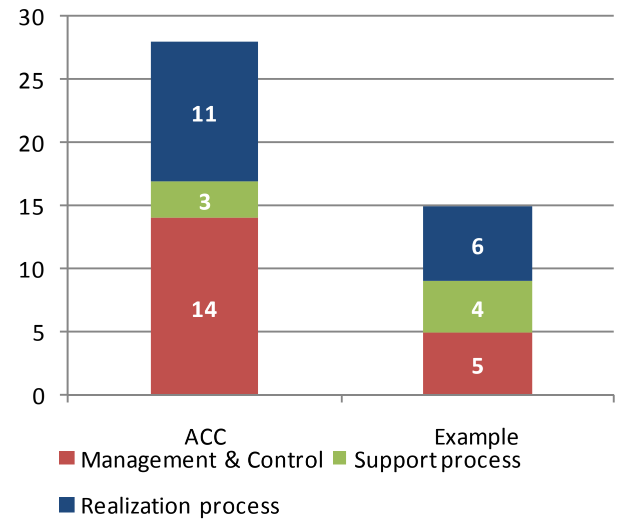
- "Management process": they describe the overall management of activities. They include the activities preparatory to determining the objectives and policies and those necessary for their deployment;
- "Support process": they describe the activities related to functional areas providing the means and resources necessary for the proper functioning of the company;
- "Realisation process" linked in part to the commercial activity and secondly to the performance of contracts (construction services, service delivery and billing).

Figure 3-3: Map of the macro-processes in water utility business in France



The following figure compares ACC structure and the provided example:

Figure 3-4: Compared breakdown of processes by type



At an intermediate level, each macro-process is described by and constructed with the following elements:

- Purpose
- Inputs
- Integrated activities (Associated procedures)
- Outputs
- Requirement to satisfy
- Performances indicators

This is illustrated by the following figures:

Figure 3-5: Example of macro-process – Management Process - Manage

MANAGE

Purpose	Input	Associated activities (= procedures)	Output	Requirement to satisfy	KPI
Take decisions needed to ensure the sustainability and the development of the company and have them enforced	FACTS: ▪ Economic, commercial and regulatory context ▪ Results from monitored KPI in other processes	- Perform management Review - Plan improvement actions - Perform contract review - Manage crisis - Manage preventive and corrective actions - Communicate within the Company	DECISIONS: ▪ Policy, objectives and targets ▪ Actions plan to improve quality and environment ▪ Programmes for simulation of crisis ▪ Organizational chart ▪ Budgets ▪ Commercial decisions : business development orientations, priorities, sign contracts and addendums ▪ Communication plans	▪ Business plan ▪ Demand from shareholders	▪ Turnover ▪ Operating profit ▪ Respect of budget ratio ▪ Level of satisfaction of the local authorities

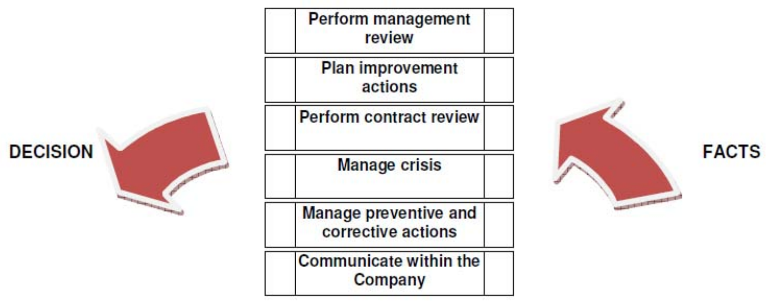


Figure 3-6: Example of macro-process – Support Process – Purchase

PURCHASE

Purpose	Input	Associated activities (= procedures)	Output	Requirement to satisfy	KPI
Provide goods and provision of services to the company at the best quality-price ratio	▪ Needs for goods and provision of services identified ▪ Knowledge of the market (catalogs, feedbacks, …)	- Control purchases and subcontractors (orders, providers follow up…) - Administrative follow up of orders and associated invoices - Manage warehouse and strategic products (reception, storage, preparation, inventory …) ▫ *Orders and markets*	▪ Selected, negotiated, delivered and provided goods and provisions of services	▪ Conformity of products and provision of services with characteristics and requirements (price, time limit …) defined in contracts and orders ▪ Reliability of data regarding purchases and stocks captured into the MIS	▪ N° of non-conformity by providers and type (time limit, price…) ▪ Respected time limits rate ▪ Respected storage max. and min. limits rate ▪ Orders according to instructions rate ▪ N° of providers that were cast doubt over (revision of agreements, competition…)

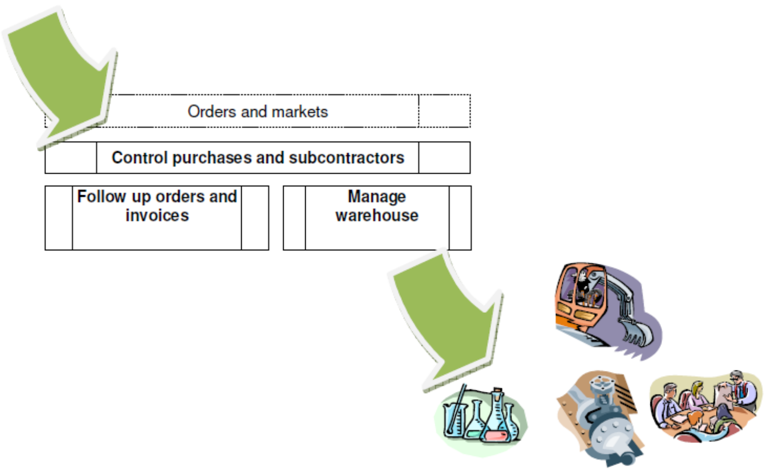


Figure 3-7: Example of macro-process – Realization Process – Collect and treat WW

WASTE WATER

Purpose	Input	Associated activities (= procedures)	Output	Requirement to satisfy	KPI
Ensure and control free gravity flow of waste water Protect the environment and preserve natural resources	▪ Collected water	- Control service lines connected to the waste water network (service lines control, discharge agreement …) - Manage collection and treatment of waste water (pumping efficiency, control…) - Service waste water network (inspection, cleaning-out, rehabilitation and repair on pipes, work and devices of the collection system) - Manage sludge and by-products ▫ *Organize on-duty operations* ▫ *Manage remote management* ▫ *Service electromechanical installations* ▫ *Manage control devices, test and calibration* ▫ *Manage plan and schemes of networks and installations*	▪ Discharge (water, sludge and by-products)	▪ Maximum concentration in discharge (water and sludge) ▪ Drop in number of incidents ▪ Drop in hours of service interruption ▪ Drop in leaks ▪ Drop and removal of untreated discharge into the environment ▪ Removal of blackspots ▪ Emergency plan set up for discharge deviation	▪ Collection rate ▪ Rate of non complying discharges ▪ Volumes discharges into the environment (=leaks) ▪ Cleaned-out length of network ▪ N° of cleaned-out works ▪ N° of treated blockages in emergency (on-duty) ▪ Tons of sludge and by-products evacuated ▪ Consumed energy ▪ N° of clients claims ▪ Level of satisfaction or the local authorities

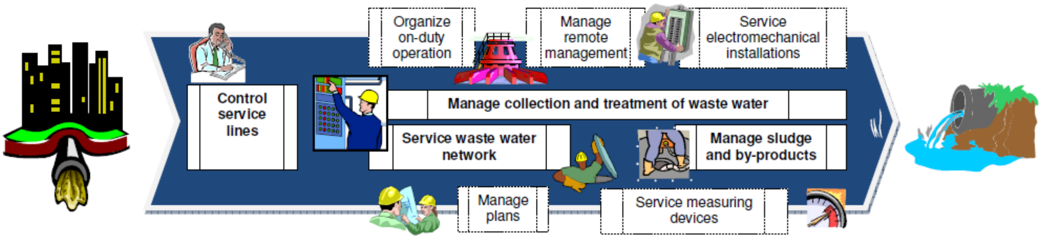
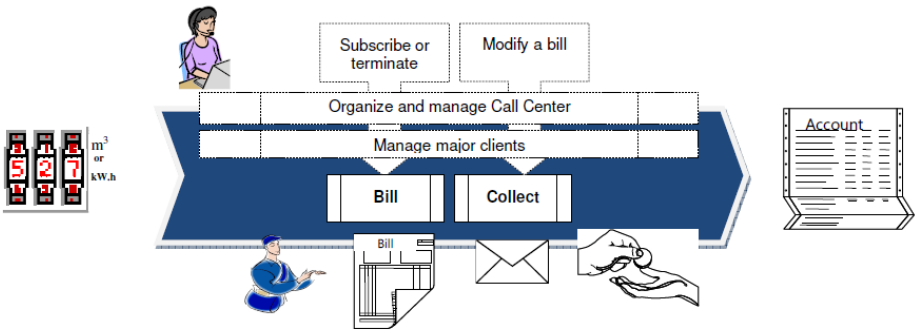


Figure 3-8: Example of macro-process – Realization Process – Manage clients accounts

CLIENTS ACCOUNTS

Purpose	Input	Associated activities (= procedures)	Output	Requirement to satisfy	KPI
Get the right amount at the right time	▪ Consumption index ▪ Tariffs data ▪ Feedbacks from banks and institutions ▪ Clients events: (transfer, exemption / relief…)	- Read meters - Bill (tariffs and prices sheets update, production and control of bills or works) - Collection and debt management - Paybacks ▫ *Organize and manage Call Center* ▫ *Manage major clients*	▪ Bills ▪ Letters and reminders ▪ Data in clients database regarding payments (received and expected) ▪ Bank transfers to Municipality and other institutions	▪ Relief and billing frequency ▪ Tariffs and prices sheets ▪ Amount and date of payment of paybacks ▪ Relevance of communication provided with the bills	▪ Collection rate ▪ Speed of billing and cash collection ▪ Respect of bills date of payment rate ▪ Wrong reminder rate ▪ N° of claims based on wrong index ▪ Payback time limit



In addition to this simplified charts, each macro-process (in the Manual of Management) is supported by more detailed specifications including the following:

- Scheme of the macro-process (like the ones presented above)
- Expectations from stakeholders
- Performance indicators
- Control over the process (description for each issue at stake in the process: the issue itself and the means set by the company to address it and in addition to this, outsourced process and subcontracted operations)
- Documentation associated
  - o General documentation
  - o Local Documentation
  - o Management Information System
- Interactions of the process with other processess

3.2.2.1. Communication and management

To gather staffs around quality management and quality improvement, as said before, it must be dynamic. As a consequence internal communication to every level is very important.

For management purpose, two aspects must be addressed: (1) master the process and keep up or improve performances (2) improve quality of provided services and implement key actions plans (new technology implementation, good practices dissemination, etc.).

A real example is provided below:

Figure 3-9: Examples of technical quantitative and qualitative objectives for process – Manage clients accounts

MANAGE CLIENTS ACCOUNTS

MASTER THE PROCESS

Themes	Performance indicators	Objectives
Water meters readings	Compliance with the water reading projected schedule: gap < 1 day / projected date	100%
	Number of unread meter	< 3 %
	Number of estimations per billing period	< 10%
	Number of bad debt caused by index errors	↗ / 2006
Billing	Compliance with the projected schedule: gap < 14 days / projected date	95%
	Billing error	Zero error
Collection	Comply unpaid bills target per year Unpaid bills > 3 months (all periods together) Unpaid bills > 3 months (over 12 months)	 2% (pp), 3% (quarter) 1% (pp), 1,5% (quarter)
Collection speed	Collection rate at D+20, Collection rate at D++50 Collection rate at D++100	55% (pp) 85% (pp), 75% (quarter) 96% (pp),95% (quarter)

IMPROVE

Speed of collection: Objectives in 2007: 45 days – Objective 2010: 25 days

- Put into practice national good practices
- Anticipate the elaboration of new tariffs
- Organize billing per lots (in progress)

Unpaid works services

- Set up an audit on local branches far from the objective

Back in France, in Veolia Water, these objectives are communicated and displayed in all operational services. And along with budget, these figures are monitored and discussed in periodical meetings.

This communication is also be enhanced by internal audit where dysfunctions can be raised and treated. Besides internal audit, the life of the Quality Management system can be observed by non-conformity and their associated analysis and treatment by Quality Management service. These last actions are done by the internal stakeholders of the process.

3.3. RECOMMENDATIONS

In the case of ACC, the Quality Management system is mature and certified. Moreover, procedures seem to be known and used by every stakeholder. However, even if processes are set up within the Quality Management System, it seems that it could be improved to:

- Be more clients oriented;
- Enhance transversal communication and awareness within the Company;
- Make staff more involved or responsible of their process;

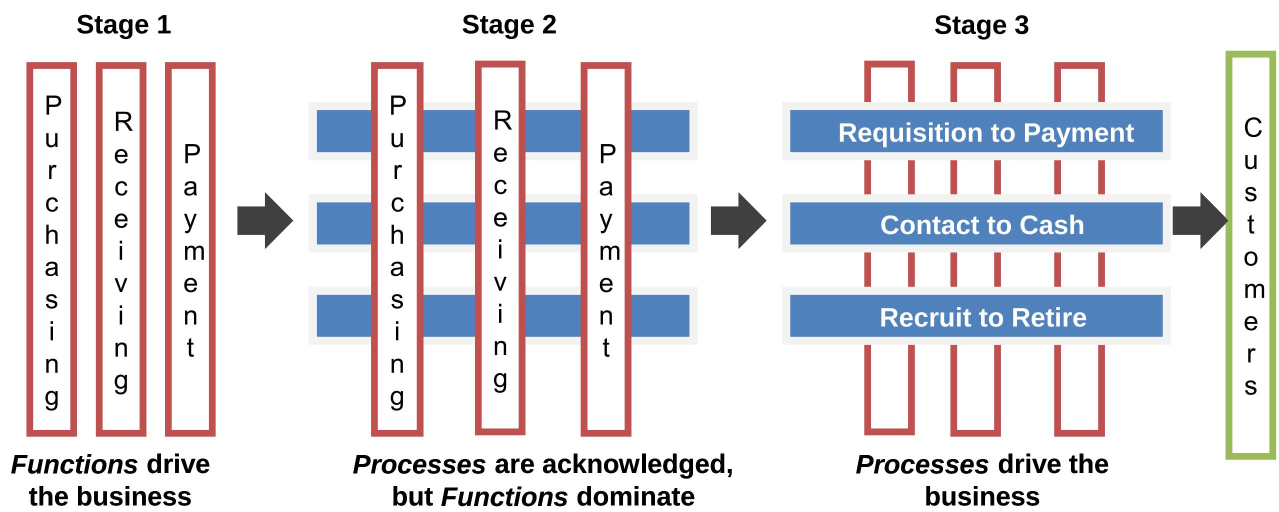
- Develop a sense of ownership and responsibility (toward the rest of the Company) over their part in the workflow;
- Set up technical objectives.

It is suggested to introduce Business Process Management (BPM) techniques following the steps described below.

1. Perform process mapping to y=update the existing one
2. Set responsibilities and objectives and communicate
3. Enforce BPM

These three steps to successful transition are illustrated in the following figure:

Figure 3-10: Successful steps for a transition from business driven by functions to business driven by processes



3.3.1. STEP 1: PERFORM MACRO-PROCESS MAPPING

The first stage of this work will allow redefining the mode of management in order to migrate to a process management system.

To begin with, process mapping should start with macro-processes. For this process mapping activity, it would be necessary to create an implementation unit (IU) responsible for restating all the existing macro-processes into new ones taking into account the benchmark and the comments provided before. This IU should be managed by a person in charge of the Quality Management system. He should work with designated correspondents in operational services and be accountable to a steering committee involving Directors of Department.

Once macro-processes are identified, the intermediate level of description should take into account the existing procedures and implement them into the new process map.

Once done, the process map should resume the current operating mode starting from the existing detailed analysis of the services to interactions between each entity.

3.3.2. STEP 2A: SET RESPONSIBILITIES, MONITOR AND COMMUNICATE

During this step, processes are acknowledged but business is still driven by functions.

The new process map should be introduced to managers and staff to initiate the migration to BPM.

For each macro-process, a referent should be named among the top managers of the business unit and in charge of the following tasks:

- Validate key performance indicators (KPI) to be set up to manage the process
- Analyse KPI values and objectives; this analysis being supported by local review of process and analysis of progress report, audits and corrective action plan
- Look after risky situations associated to the process
- Elaborate preventive at his level action plans to prevent risky situation from occurring
- Suggest priority actions and objectives
- Deal with specific issues that need to be planned at his level
- Receive all information regarding innovation and evolution of his process
- Validate every actions aiming at modifying general principles of the process

For each macro-process, KPI has to be monitored and informal objectives set. At this point, action plans could also be presented as improvements within processes and not within the operations of one service.

A communication at several levels within the Company could start.

3.3.3. STEP 2B: ANALYZE IN DETAILS KEY PROCESSES

To complement this communication and trigger improvement actions plans, more precise process mapping and process map analysis could be done at the finest level e.g. procedures.

Process mapping itself can be extremely valuable because it can identify improvements in a number of aspects in the work place, including:

- Increases understanding of the work process;
- Provides understanding of resource allocation;
- Documents training procedures;
- Tracks workflow;
- Increases staff awareness.

This task can start with existing procedures as, as we have experienced during our visits on the field, they are applied quite precisely on the field. From that starting point, flowcharts identifying each step and stakeholder can be done. This detailed process mapping should involve operators and workers along with middle management and team leader as they are the stakeholders of procedures.

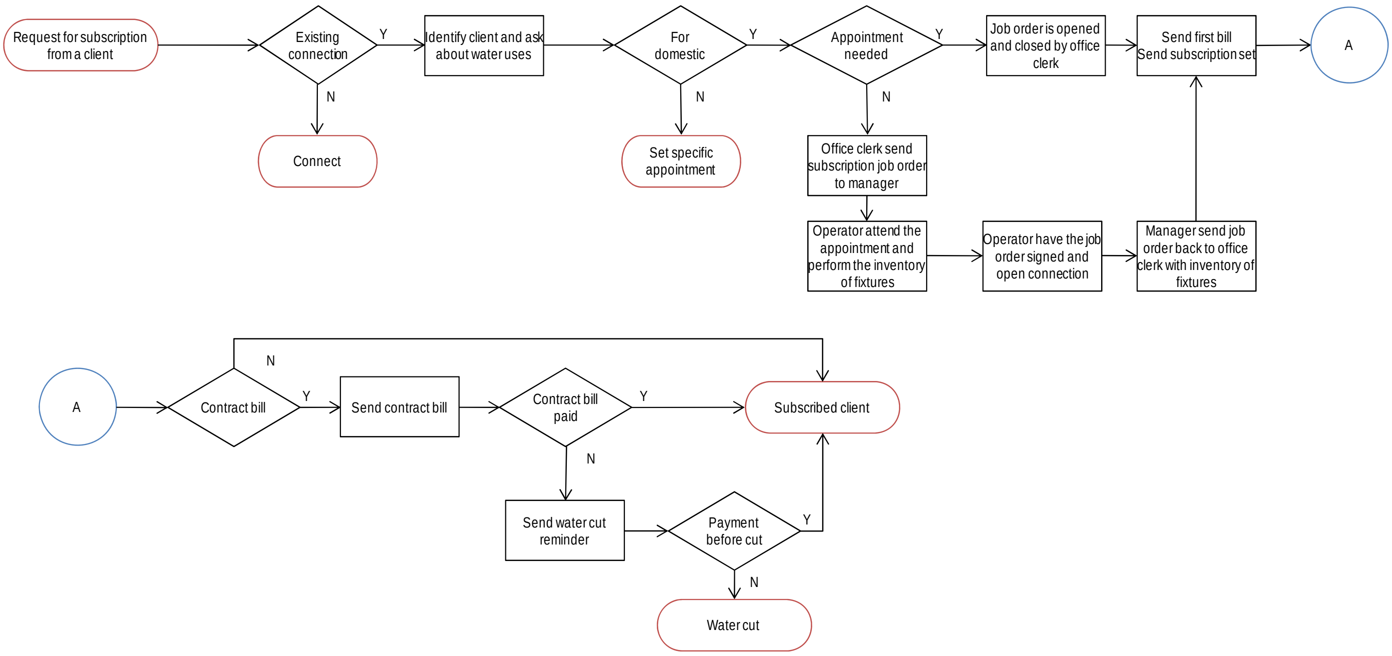
Then, basically, creating a process map consists in answering the following questions:

- Who are the customers of the process?
- Who performs each activity?
- What generates the process/task?
- What forms and reports are used?
- What computer systems and files are used?
- How do we do it? Why do we do it?
- What decisions are made in the process?
- What happens next? What sequence are the activities performed in?
- Who reviews it and when?
- How long does it take?
- What is the nature, frequency and cause of errors/problems?
- How are errors/problems/exceptions handled?
- What is the output? How many?
- Where does the output go?

Then the answers need to be put into the process map according to one of the following techniques: (1) Workflow and Process Dependency Modelling, (2) Flowcharting and (3) Cross-Functional Flowcharts

A typical flowchart is presented below.

Figure 3-11: Example of flowchart for the process subscribe



Once done, the process must be rechecked by looking at the following:

- Start, end points and customers should be clear
- Inputs and outputs should be identified
- Indicate title of person / area responsible for each task
- A person not familiar with the process should be able to easily understand the flow without any explanation
- The level of detail should be adequate to describe inefficiencies

Then, metrics should be added to the process map:

- Time - value, cycle, waiting, Keep In View (KIV), productive / non-productive
- Volumes - transactions/day, units/hour, %
- Rates or Costs - computed, fixed, per unit
- Equipment Used - cost
- Value Added - real value, business value, no-value

From this metrics, one can easily see contributive and non-contributive operations, bottleneck and idle time for instance.

Finally, the analysis of the process shall begin to find process opportunities for improvement. For this, classic solving problem methods can be used such as: cause and effect diagram (Ishikawa), 5Ws, value chain analysis, etc.

Sources of improvement can be new technology, suppression of operation with no added value, unnecessary paperwork, suppression of repetition/duplication of effort, unnecessary delays, reallocation of resources to suppress bottlenecks, etc.

At first, quick wins (low investment with immediate and/or significant benefit) should be identified and implemented as soon as possible.

3.3.4. STEP 3: ENFORCE BPM

Once the first two steps are done, BPM can be enforced into services with effective communication towards the staffs and from them in order to improve the processes themselves.

For that purpose, in addition to the referent mentioned before, for each processes identified, a local pilot for the process should be designated locally. His mission involves the following tasks:

- Review the processes in collaboration with the relevant people;
- Validate the processes with the departments concerned, where necessary;
- Deploy the objectives set and achieve the expected results;
- Assign and monitor performance indicators;
- Manage documentation relating to the processes (updating, accessibility, distribution, classification, filing);
- Check the correct application of the rules defined in the processes;
- Review and monitor the effectiveness of the processes by monitoring indicators, the satisfaction of those involved evaluation results (non-conformity, internal control, audits etc.);
- Monitor the process efficiency by evaluating the resources allocated;
- Take into account the technical, regulatory, economic and organizational changes in the processes.

At this step, for each macro-process, objectives should be set and monitored based on the KPI and results from previous years. Actions should be defined and discussed to achieve the objective. Evaluation of staff should be based on the achievement of these objectives. From there, the activity will be managed and controlled by the processes.

4. OPERATIONS ON WASTE WATER NETWORK

4.1. “AS IS” SITUATION

The following paragraphs will try to describe the situation of ACC regarding waste water network management. As today, the main operations concerns dealing with emergencies, we will focus on this part in the “As-Is” part at least. So this “As-Is” part will go over the following issues:

1. Available resources (staffs and plants)
2. Events on WW network (analysis of operations performed)
3. Response of ACC (procedure for the most common operation: dealing with blockage)

4.1.1. ON FIELD TEAMS ORGANIZATION, ON DUTY ACTIVITY AND PLANTS

Within operational services, the activity is organised in 12 hours shifts (8 am-8 pm-8 am) with reduced activity and staff at night.

In the following, we will focus on network operations (pipes and pumping stations). The following table summarized the activity of each service:

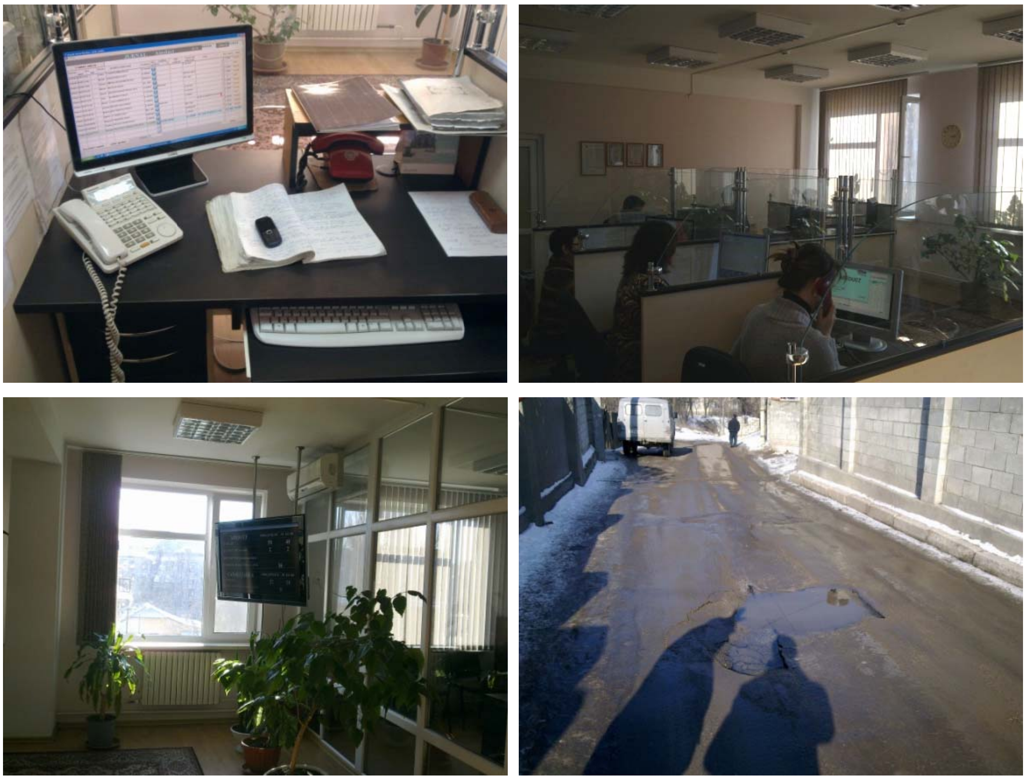
Table 4-1: Teams organization for operations on networks[12]

Department and Service	Teams organization	Staff	Key figures
Waste water Department	-	**320**	**-**
Network O&M and PS Service	-	142	-
• Sector (x5)	*Missing data for night and day shift* Total: 5 sectors x 8 staffs (in average)	-	950 km WW 28,900 inter.
Ialoveni Sector	*Missing data*	45	*Missing data*
Central Dispatch Service	-	**75**	-
Office team	8am-10pm: 3 operators (2 DW + 1 WW), 2 dispatchers (1 DW + 1WW) and 1 engineer 10pm-8am: 1 dispatcher and 1 engineer Total: 8 staffs	-	-
On field team	8am-8pm: 4 teams (2 DW + 2 WW) x 1 to 2 staffs (1 driver + 1 technician[13]) 8pm-8am: 3 teams (2 DW + 1 WW) x 1 to 2 staffs (1 driver + 1 technician[14]) Total: 7 teams x 1 to 2 staffs	-	1,700 km DW 14,000 bursts DW 950 km WW 28,900 inter. WW

Italic: assumed or missing information

[12] Data are mainly for year 2010
[13] From what we have seen during an intervention on the field during the day and on water network.
[14] From what we have seen during an intervention on the field during the day and on water network.

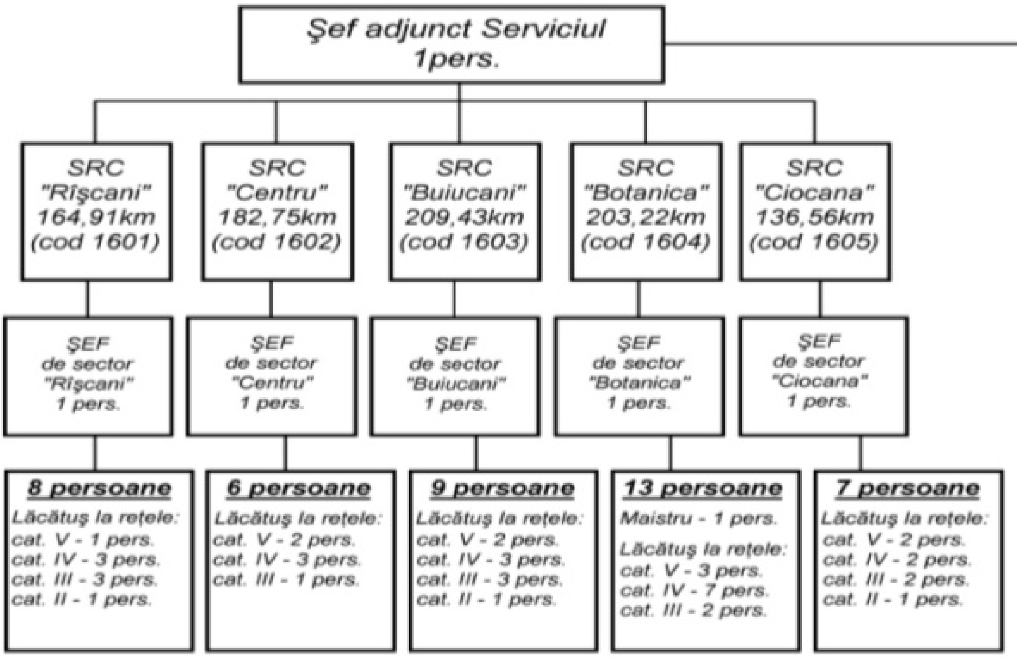
Figure 4-1: Views of the Central Dispatch Service (Office and Intervention)



At CDS, WW team (3 teams) does on annual average 26,4 first diagnoses per full day (24 hours), so 0,9 hours per diagnosis.

Organizational chart for WW network and PS department is provided below:

Figure 4-2: Organizational chart for WW network operations



Plants within allocated to the WW network and PS are presented below:

Table 4-2: ACC plants dedicated to WW operations and associated characteristics

Type	N°	Average worked days /yr	Total worked days per year	Average Life time
Crane	2	112	223	24
Hydrodynamic machine	3	161	484	27
Mobile workshop	8	183	1,462	20
Mud drains	6	143	856	20
Tipper	1	118	118	24
TOTAL	**20**	**157**	**3,143**	**21**

Figure 4-3: Examples of ACC Mud drains

Remark: no public works equipment was mentioned in the data collected besides the crane and the tipper. However, during interviews, one excavator was said to be allocated to WW department.

According to their functions, Hydrodynamic machine, Mud drains and Mobile workshop should have a maximized availability[15] rate for the Company. It is respectively 73%, 83% and 65% which can be considered as quite good according to their life time. However, their performances on the field could be poor.

For example, the jetting trucks (hydrodynamics machine) deliver a pressure of 25 bars to 40 bars; initial nominal pressure being 120 bars[16]. Current performances are too low to deal efficiently with blockages and perform clean out on Ø < 600 mm pipes. According to French manufacturer[17], pressure and flow from the jetting system should range between 50 to 200 bars for pressure and 80 to 400 l/min for flows.
On the field indeed, ACC teams face difficulties when they have to deal with blockages on Ø > 400 mm. For bigger pipes (Ø > 600 mm), ACC has no mean to perform appropriate clean out operation. Another issue is that plants are too big to operate in the small streets in the center of Chisinau.
Based on the above figures, the 3 jetting trucks (Hydrodynamic machine) operating at 300 ml / day x 161 working days could clean out 144 km of network per year, so 15% of the total length of WW network (950 km).

[15] In this case, Availability rate = Real Working Days / Total Working Days (220)
[16] No data regarding flows.
[17] Source: HUWER Website

In addition to this, there is not any dedicated CCTV equipment or equivalent to assess the structural conditions of the network in order to define precisely the need for rehabilitation and most effective techniques.

4.1.2. OPERATIONS

The WW network of Chisnau is a strict waste water collection system; storm water are managed by another system.

Figures regarding characteristics of the WW network are presented below:

Figure 4-4: Characteristic of the WW network

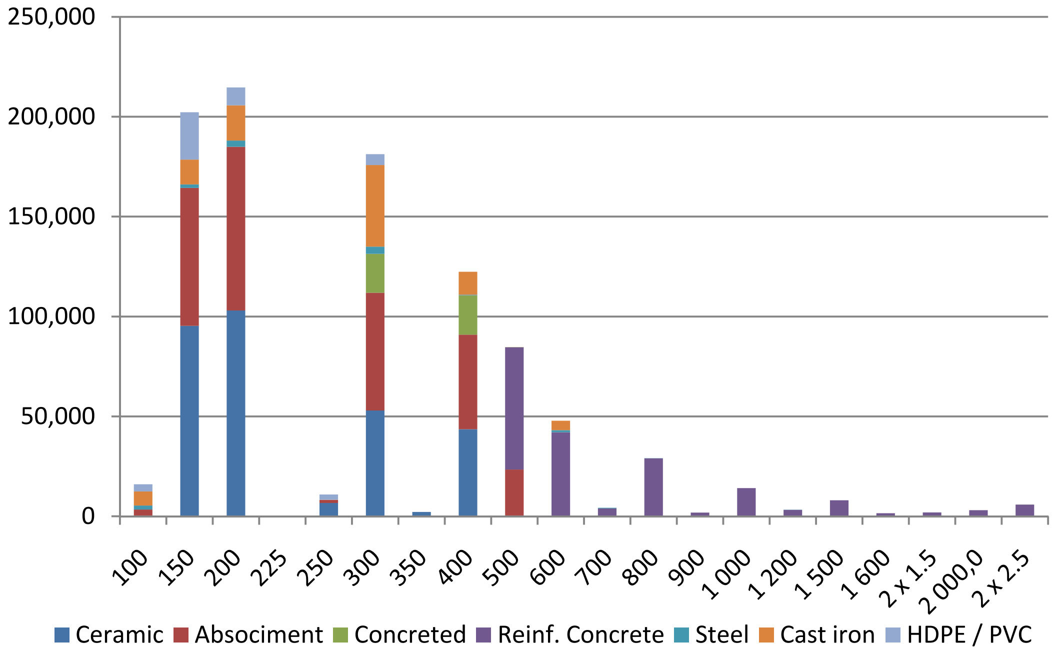


Table 4-3: Length WW of network per Sector

Sector	Length (km)
Botanica	166.7
Buiucani	187.5
Centru	214.2
Ciocana	204.4
Riscani	138.2
Vadul lui Vodă	30.9
Ialoveni	13.6
Total	**955.5**

This first set of data raises the following comments:

- 65% of the pipes have a diameter below Ø 300 mm;
- 90% of the pipes have a diameter below Ø 600 mm;
- 30% of the pipes are made of ceramic;
- 30% of the pipes are made of asbestos-cement;
- Lengths of network to be operated by sector within Chisinau are quite homogenous.

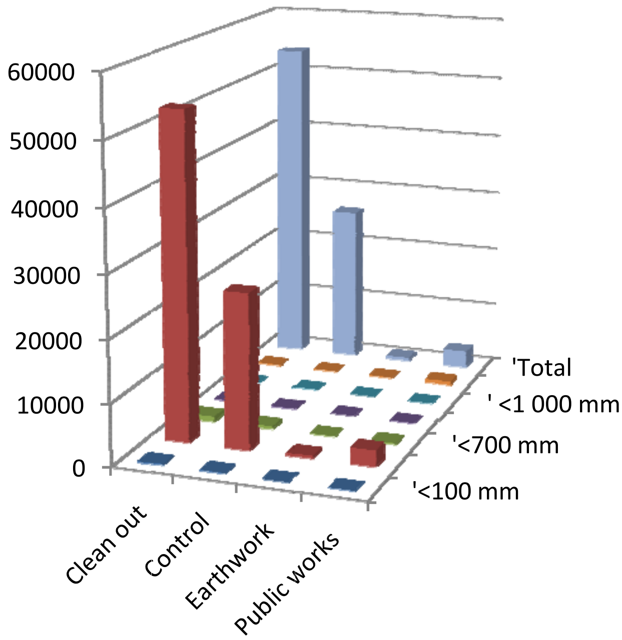
In addition to these elements, some interviewed persons of ACC mentioned the fact that the WW system may be oversized.

Figures relating diameter of pipes and type of operations are presented below:

Table 4-4: Cross analysis between operations and diameter of pipe in 2010

Operations	<100 mm	<300 mm	<700 mm	< 800 mm	<1 000 mm	<1 500 mm	Total
Clean out	176	52,490	839	59	17	119	**53,590**
Control	81	25,135	475	54	21	54	**25,776**
Earthwork	9	445	49	2	0	93	**506**
Public works	25	2,614	186	22	8	579	**2,859**
Total	**291**	**80,684**	**1,549**	**137**	**46**	**845**	**82,731**
% of operations	**0.4%**	**97.5%**	**1.9%**	**0.2%**	**0.1%**	**1.0%**	**100.0%**
% of total length	**1.7%**	**63.8%**	**27.4%**	**3.0%**	**1.7%**	**2.5%**	**100.0%**

Figure 4-5: Cross analysis between operations and diameter of pipe in 2010



Main information from these figures is that problems are concentrated (97,5%) on 150 mm ≤ Ø ≤ 300 mm pipes.

Operations on WW are summarized in the following tables:

Table 4-5: Breakdown of operations on WW network per type of network element and per sector

	2008				2009				2010				
Sector	Chamber	Connexion	Pipes	Total	Chamber	Connexion	Pipes	Total	Chamber	Connexion	Pipes	Total	Total

Sector	2008 Chamber	2008 Connexion	2008 Pipes	2008 Total	2009 Chamber	2009 Connexion	2009 Pipes	2009 Total	2010 Chamber	2010 Connexion	2010 Pipes	2010 Total	Total
Botanica	2,529	21	5,237	7,787	2,543	29	5,204	7,776	2,681	26	5,484	8,191	23,754
Buiucani	1,562	13	3,587	5,162	1,650	41	3,513	5,204	1,929	22	3,940	5,891	16,257
Centru	844	8	2,889	3,741	888	78	2,837	3,803	705	35	2,822	3,562	11,106
Ciocana	1,546	9	3,102	4,657	1,692	24	3,446	5,162	1,672	16	3,321	5,009	14,828
Riscani	1,617	14	3,493	5,124	1,605	45	3,303	4,953	2,067	40	3,706	5,813	15,890
Total	**8,098**	**65**	**18,308**	**26,471**	**8,378**	**217**	**18,303**	**26,898**	**9,054**	**139**	**19,273**	**28,466**	**81,835**

Figure 4-6: Breakdown of operations on WW network per type of operation and per sector

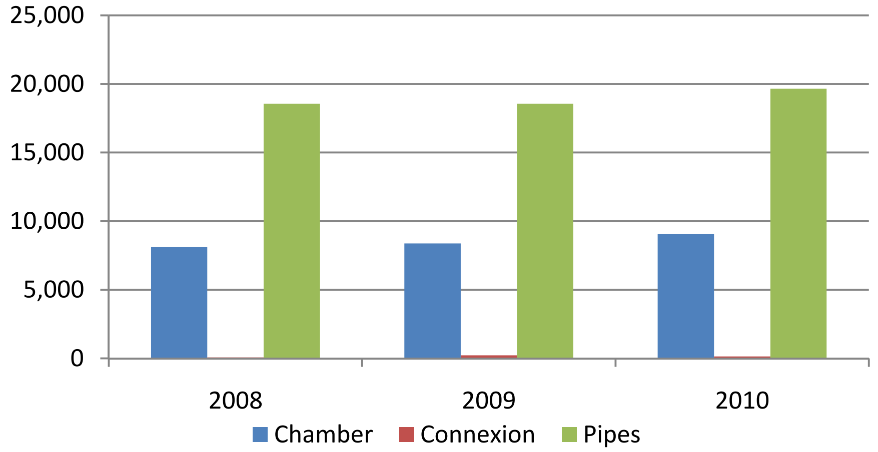


Table 4-6: Breakdown of operations on WW network per type of operation and per sector

Sector	2008 Clean out	2008 Control	2008 Earthworks	2008 Public works	2008 Total	2009 Clean out	2009 Control	2009 Earthworks	2009 Public works	2009 Total	2010 Clean out	2010 Control	2010 Earthworks	2010 Public works	2010 Total	Total
Botanica	5,170	2,308	55	253	**7,786**	5,206	2,355	42	173	**7,776**	5,376	2,497	71	247	**8,191**	**23,753**
Buiucani	3,361	1,575	26	197	**5,159**	3,385	1,600	24	194	**5,203**	3,891	1,796	35	166	**5,888**	**16,250**
Centru	2,232	1,246	35	226	**3,739**	2,246	1,295	36	225	**3,802**	2,042	1,352	26	141	**3,561**	**11,102**
Ciocana	2,969	1,461	30	194	**4,654**	3,347	1,638	18	159	**5,162**	3,291	1,584	16	112	**5,003**	**14,819**
Riscani	3,305	1,621	20	178	**5,124**	3,152	1,607	28	166	**4,953**	3,772	1,826	41	172	**5,811**	**15,888**
Total	**17,037**	**8,211**	**166**	**1,048**	**26,462**	**17,336**	**8,495**	**148**	**917**	**26,896**	**18,372**	**9,055**	**189**	**838**	**28,454**	**81,812**[18]

[18] Differences between this total and the one in the table above are due to unallocated operations to one category.

Figure 4-7: Breakdown of operations on WW network per type of operation and per sector

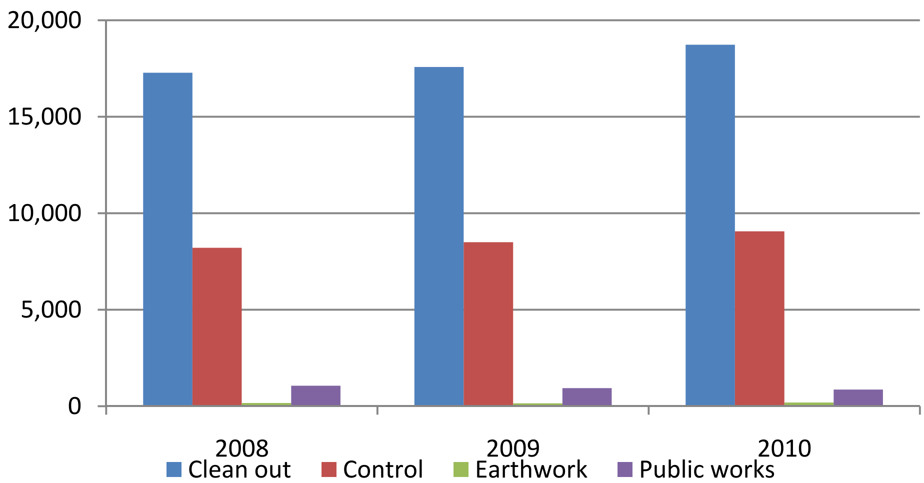
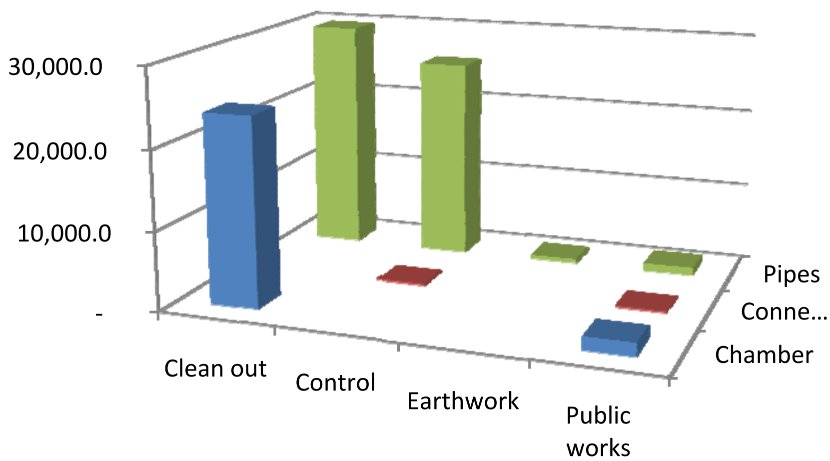


Table 4-7: Cross analysis between operations and elements of network for 2010

Sector	Chamber	Connexion	Pipes	Total	%
Clean out	23,887		29,703	**53,590**	**64.7 %**
Control		226	25,550	**25,776**	**31.1 %**
Earthworks			506	**506**	**0.6%**
Public works	1,658	214	987	**2,859**	**3.4%**
Total	**25,545**	**440**	**56,746**	**82,731**	**100%**
%	**30.9%**	**0.5%**	**68.6%**	**100%**	

Figure 4-8: Cross analysis between operations and elements of network in 2010



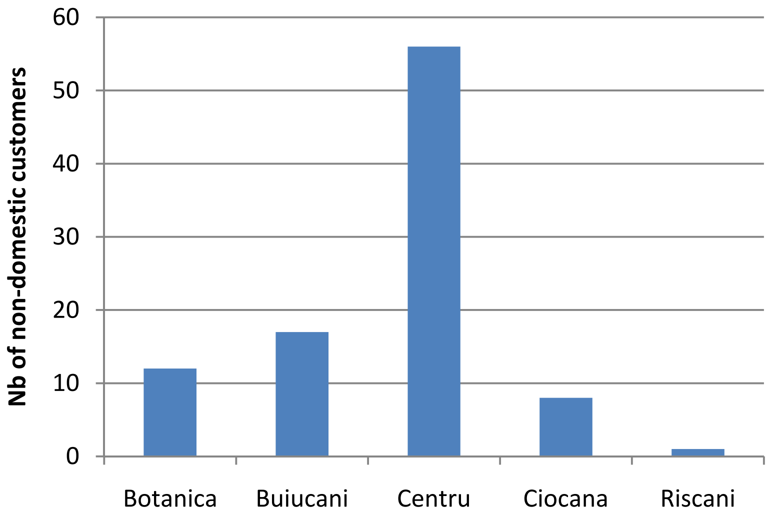
These charts raise the following comments:

- Very few intervention (clean out and control) are performed on connexion where are usually concentrated problems;
- Interventions are both concentrated on Clean out (65%) and on pipes (70%);
- In the past 3 years, Clean out along with Control operations are increasing constantly while public works operations are decreasing, suggesting a transfer

from one to another and a strong correlation between Clean out and Control operations;

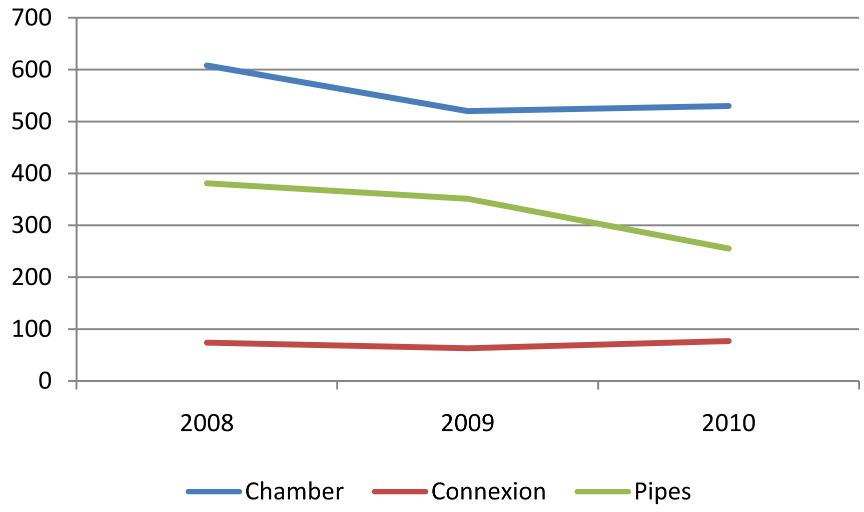
- Correlation between Clean out and Control operations suggests that they are linked and that each Clean out operations is associated (on the field and in the database) to a control operation;
- The previous comment is true for many other operations and if so, it may be difficult to trace events and to relate one events to several operation which could be interesting;
- If one considers that Public works operation is a medium term solution to blockage unlike unclogging which may be considered as a short term action, WW operations evolution is quite logic with a exponential trend for Clean out operations;
- Centru sector has:
    - the highest length of network
    - the smallest number of intervention
    - the highest number of restaurant (at least 3 times more than the others, see below)
    - suggesting that grease may not be the main source of clogging in Chisinau

Figure 4-9: Non domestic customers per Sector in the restaurant business



- In addition to this, as Public works decrease over the years (-30% on Public works operation on pipe), collapses of pipe may not be the main sources of clogging either;

Figure 4-10: Evolution of Public works operations broken down by elements of WW network over the past 3 years



- Considering previous elements, the fact that suction pumps and jetting system have relatively to very poor performances and finally the oversized pipes[19], the main reasons for clogging may be sedimentation in the network over time.

The four categories that are defined in the previous charts are from a consolidation made for the purpose of this report. In fact, there are more the 80 type of operations. Half of them were used less than 10 times during the past 10 years. It goes up to 70% percent of them if only year 2010 is considered.

For Clean out and Control operations, more detailed information are provided below.

Table 4-8: Details analysis of clean out and control operations

Type of operations	2008	2009	2010	Total	% per type
Clean out	**17,284**	**17,575**	**18,731**	**53,590**	**100.0%**
Cleaning pipes roots	1	2	11	**14**	**0.0%**
Cleaning with jetting truck	2,017	1,809	1,790	**5,616**	**10.5%**
Extracting roots of the sewage well	387	394	703	**1,484**	**2.8%**
Extraction of sludge from the well	7,108	7,467	7,828	**22,403**	**41.8%**
Liquidation of clogging	7,771	7,903	8,378	**24,052**	**44.9%**
Pipe cleaning mud / roots	0	0	21	**21**	**0.0%**
Control	**8,213**	**8,502**	**9,061**	**25,776**	**100.0%**
Control service line	0	163	63	**226**	**0.9%**
Exterior examination with opening	8,208	8,331	8,991	**25,530**	**99.0%**
Exterior examination without opening	5	8	7	**20**	**0.1%**

This chart raises the following comments:

- Within Clean out operations, Extraction of sludge and Liquidation of clogging are the most frequent (86.7% of operations);

[19] This last information comes from interviews but has not been confirmed yet by modelling.

- Within Control operations, Exterior examination with opening operation is nearly the only Control operations (99%);
- As said before, the three operations may be associated to a single event;
- The numbers suggest the most frequent following series of events illustrated by the figure below;

Figure 4-11: Main assumed series of event for Control + Clean out operations

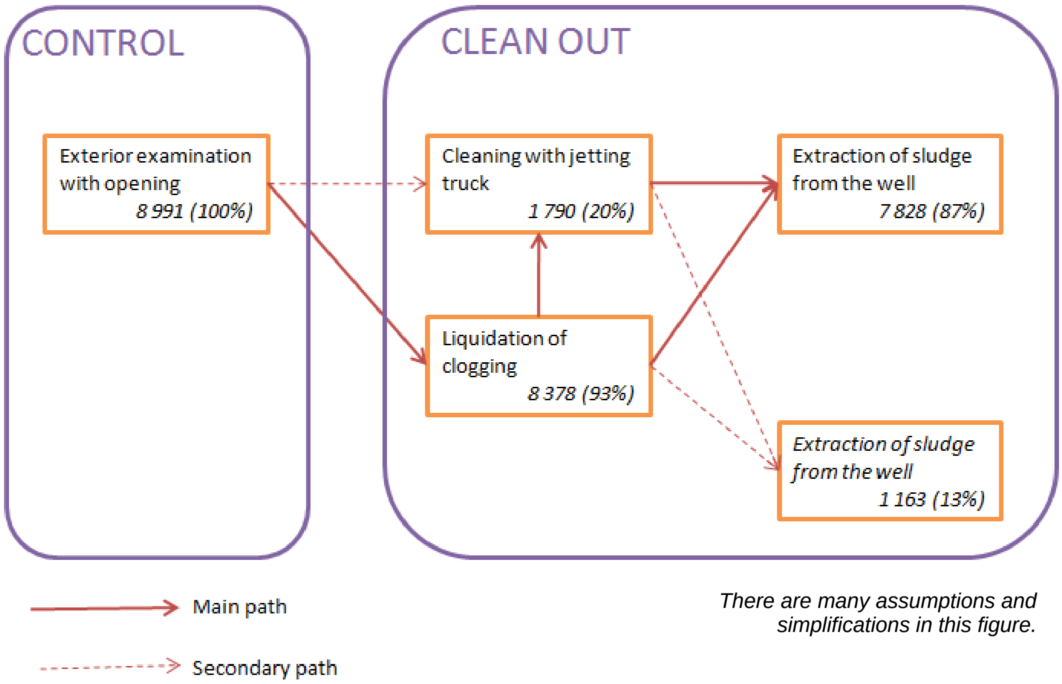
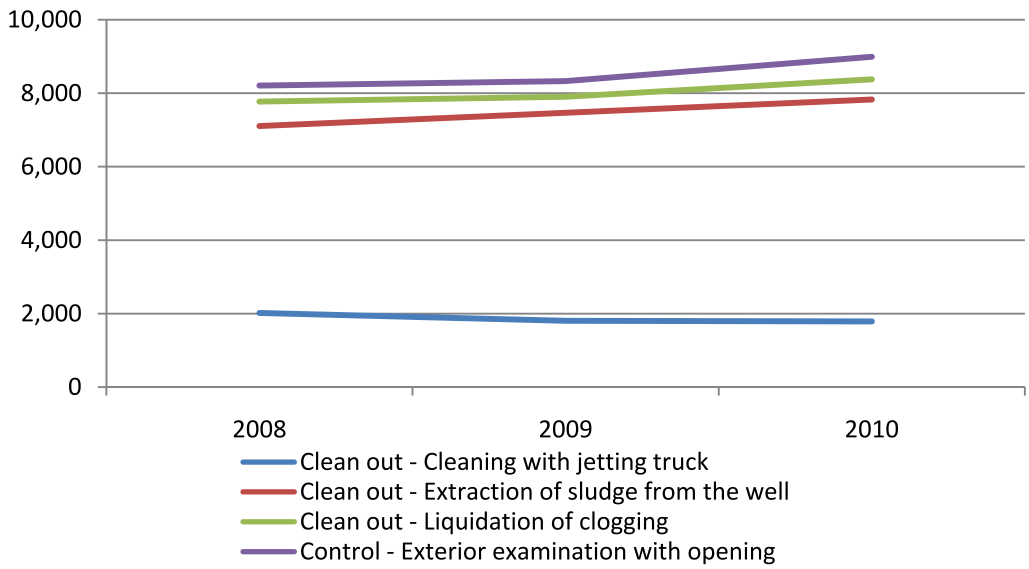


Figure 4-12: Illustration of correlation between the different type of operation



- If the series of events is correct, nearly 95% are liquidated manually and nearly 90% of material that caused the blockage are pumped out of the network;
- Based on Liquidation of clogging only, there is an average of 8.8 blockages / km.

4.1.3. PROCEDURE TO DEAL WITH BLOCKAGE / CLOGGING

All emergencies that occur in the WW network of Chisinau are flagged and resolved / managed /coorindated through the Central Dispatch Service (CDS).

Within this service operate two intervention teams dedicated to solving urgent problems, and each Sector has its own team for intervention.

The team are working in shift, and if it is necessary, the program may be extended by order. There is no backup personnel or equipments for the CDS.

In case of a large accidents the program of intervention teams, is modified by order, they work around the clock in two shifts of 12 hours until the accident will be remedied. If they do not have sufficient equipments to deal with the accident, by order, the technique is supplemented.

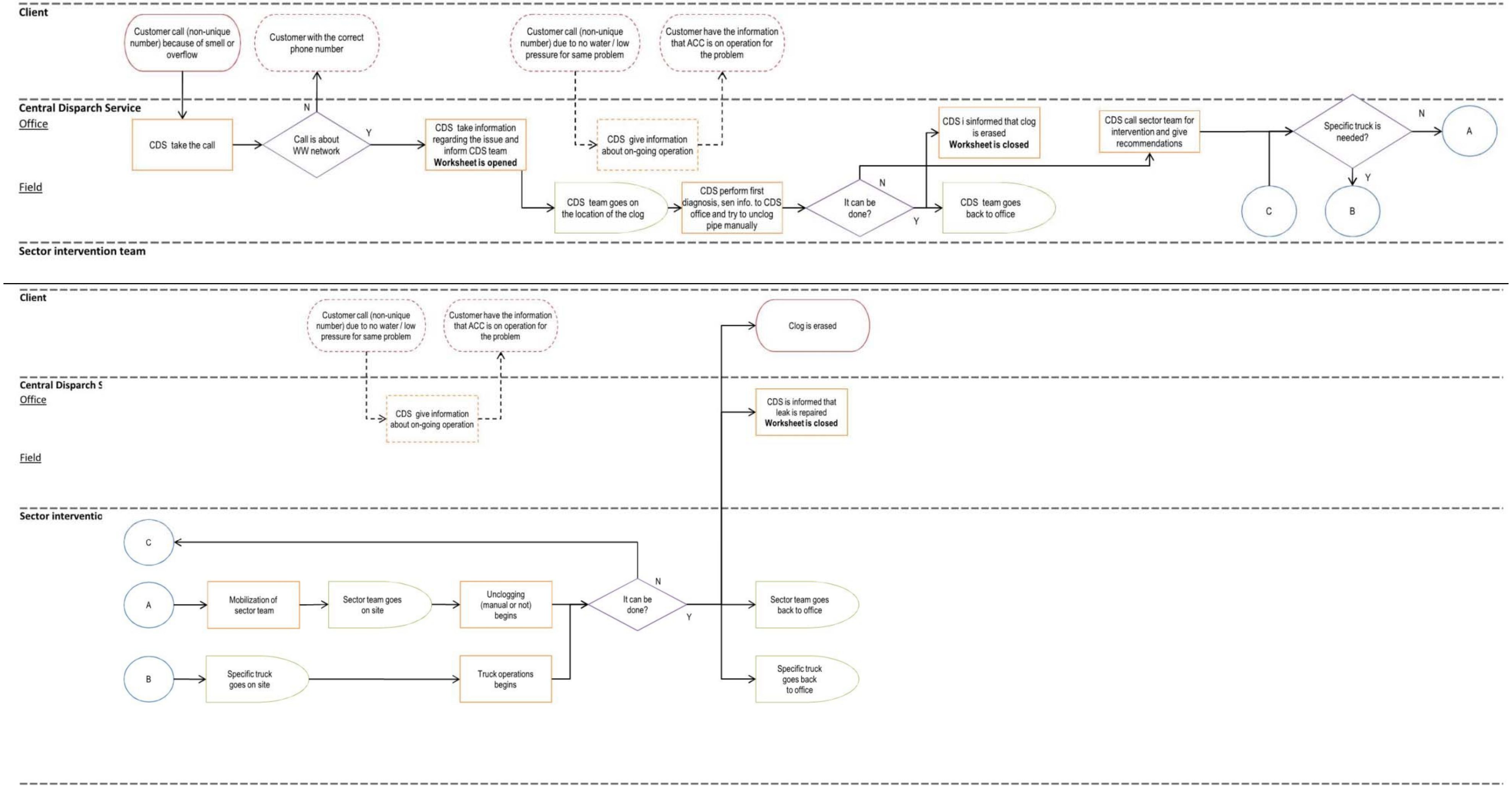
First, the intervention team from the CDS try to unclog the pipe with manual tools and if it cannot be done like this, the Sector team is called. Meanwhile, the CDS intervention team communicate information to CDS office.

The sector team either tries to unclog the pipe manually with more workforce, mobilize a mud drains or jetting truck.

Once the unclogging operation is done, information is transmitted to CDS.

The typical series of events based on intervews and on field visit can be schematilccaly illustrated by the workflow diagram presented below:

Figure 4-13: Workflow diagram for unclogging



4.2. Shortcoming and best practices

4.2.1. Shortcoming

First, the characteristics of the network are quite poor with 8.8 blockages / km which are at least 3 times above average value in Western countries.

Regarding equipments, Mud drains seem to have a good rate of occupancy as they operate on almost every liquidation of clogging. On the other hand, the three jetting trucks (hydrodynamic machine) do not operate at their full capacity. They do around 1,800 clean out operation per year in average. For 1,800 operations x 30 ml, they clean out a total of 54 km per year. A previous calculation (300 ml/day x 161 days x 3 trucks = 145 km) shows that they can do 3 times this length of network. However, it must be said that performances of these jetting trucks are quite poor.

Considering operations, WW operations are mainly reactive to events and not proactive. 9 inspections out of 10 lead to a liquidation of clogging operation, meaning that they are almost exclusively triggered by customers. As a consequence, it seems that there is no preventive action on WW network. The worst thing is that figures shows an increase in this type of operation and a transfer of resources from Public works to Clean out operations; therefore from medium term solutions to short term solutions.

In addition to this, there are very few inspections of service lines on a quantitative (mix of storm and waste water) or qualitative (control of non-domestic customer such as restaurant) point of view. Nevertheless, there are very few Clean out operations on service lines.

As for Public works operations, there are few of them and fewer if we consider pipe rehabilitation and investments are very limited. However, there is no dedicated CCTV for the WW network to perform precise assessment of pipe and select the most appropriate rehabilitation technique.

Concerning the data, there is too much type of operations and as far as we know, there is no relation to one single event that triggered the whole thing. Analysis is therefore very difficult.

4.2.2. Best practices

Best practices on WW network are summarized in the table below:

Table 4-9: Summary of Best practices for WW network operations

Issue	Actions
Control of inputs Separation of waste water from storm water should be monitored to assess the quantity of storm water coming into the network. Storm water leads to blockages by flushing waste	Monitoring can be done by periodical measure on WW network (done in the scope of Seureca's mission for modelling purpose) or by follow up of running time of pump Other elements can come from the operations database. Pipe with a lot of clogging due to grease will reveal an issue

Issue	Actions
into the network, to overconsumption of electricity at pumping station and to dysfunction at the WWTP.	regarding inappropriate discharge into WW network. Based on this information, area with specific problems can be identified and actions plans can be built. Actions plans consist in specific control (presence of pre-treatment in restaurant, right connexion for domestic service lines, good practices in waste management near market places, etc...). Once, control are done, communication and/or coercive actions plans must be enforced. Update GIS with on-field data.
WW network operation Operations should limit the nuisance to the neighbourhood by preventing flooding and odours by preventive actions.	Build preventive clean out campaigns based on historical data from GIS and modelling results. Operation should focus on planned (each year) preventive actions: 5% to 20% of total length cleaned out as preventive action. This preventive action can be associated with a follow up of on-going clogging. Based on historical data and/or modelling, blackspots are identified and a frequency rate for intervention is set. Curative actions should be limited afterward (0.5 - 3 blockages / km on Western network). Evacuate sludge in appropriate process. Update GIS with on-field data.
WW network assessment **WW network renewal/rehabilitation** Knowledge of the network allows the operator to enhance performance of operations and to target the most efficient rehabilitation. Network should undergo steady rehabilitation (<5% generally).	Create and update GIS. Create a modelling of the network. Build rehabilitation programmes based on historical data from GIS and results of modelling. CCTV is performed each year on x % (5% < x <10% generally) of the total length of the network Each year, a planning for CCTV inspection must be set along with preventive clean out operations planning. Rehabilitation programme (1% to 5% of total length of network) per year. Update GIS. Update modelling.

4.3. RECOMMENDATIONS

In the following paragraphs, few short to medium term actions are suggested to bring some improvement to operations with a limited payback time.

In addition to this, for long term actions purpose, ratios are suggested to have a first approach for the future structure of the WW network operational teams.

Recommendations regarding asset management and rehabilitation programmes will not be addressed by this report where focus is put on operations.

4.3.1. CREATE GIS AND ADJUST DATABASE

To enhance the comprehension of the WW network, GIS is a very powerful tool. It is even more powerful when data from the operations are integrated into it. This tool can be used by many stakeholders of WW network:

- Asset manager to prepare rehabilitation programmes based on characteristics of networks (age, depth, environment, etc.)
- Team leader to prepare preventive clean out campaigns based on historical operational data;
- Jetting truck operator to follow his programme;
- Operator to print out specific area of the network with updated data;

- Etc.

GIS issue is tackled by other reports, the reader is invited to the reading of these reports.

Concerning the existing database, it seems that it can be enhanced to ease the analysis of events and operations. The following improvements could be done:

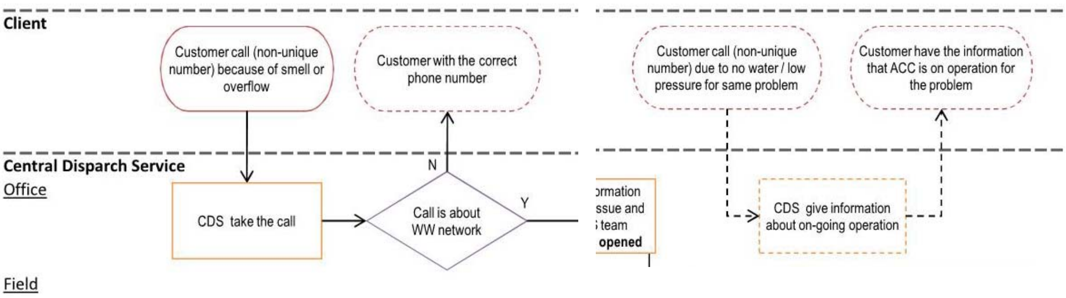
- Have one single number for each event;
- Associate the series of operations to one event;
- Reduce the number of operations available;
- Create additional details if needed (material, number of bricks added, presence of grease, presence of roots, etc.).

4.3.2. IMPROVEMENT OF CUSTOMERS CLAIMS MANAGEMENT

From the workflow diagram presented, it can be seen that operator's time is lost by dealing with:

1. customer's claims regarding commercial issues (particularly during billing periods);
2. additional calls for an on-going operation.

Figure 4-14: Details of workflow diagram for unclogging operation on WW network



To deal with (1), a simple solution could be to have a first automated filter before getting an operator on the phone. This automated filter should orientate customer according at least to their problems: commercial or technical. A more complex solution would be to have a unique Call Center where operators can deal with technical and commercial issues. In this case, dispatchers will have to be separated and linked to the process through Worksheets flow and a shared database.

To deal with (2), automated messages could be recorded by the Call Center when a major problem occurs. This message must be associated by an additional automated filter that would ask their Sector to customers and make them listen the message before they actually get an operator on the phone.

4.3.3. IDENTIFY, SOLVE OR KEEP BLACKSPOTS

From the existing database and operators' knowledge, it seems that blackspots could be identified quite quickly. It is suggested to do so with by doing a thorough analysis of historical data and discussion with Heads of Sector.

For each blackspot, an analysis should be done to identify the reasons of the recurrent blockages. Generally, it is either due to structural problems (confluence, opposite slope, local configuration, etc.) or problems associated to inputs into the network (grease, rain water, waste, etc.). Therefore, it can be solved by:

- Investment: Works (pipe rehabilitation, flush, etc.);
- Operations: Recurrent clean out (existing situation);
- Customer's relations: Actions plans toward customers with or without coercive actions.

To assess more effectively and precisely the issue at stake at blackspots, visual inspections should be done either by classical CCTV equipment or by punctual snapshots with specific equipment such as QuickView®.

Figure 4-15: QuickView® equipment[20]

[20] From IPEK website

Figure 4-16: Typical CCTV inspection truck[21]

Both techniques are complementary:

- QuickView®. should be used to identify and deal with very punctual problem and to define more precisely the parts of the network that need a CCTV inspection;
- CCTV should be used as a preliminary to define specifications for network rehabilitation programmes.

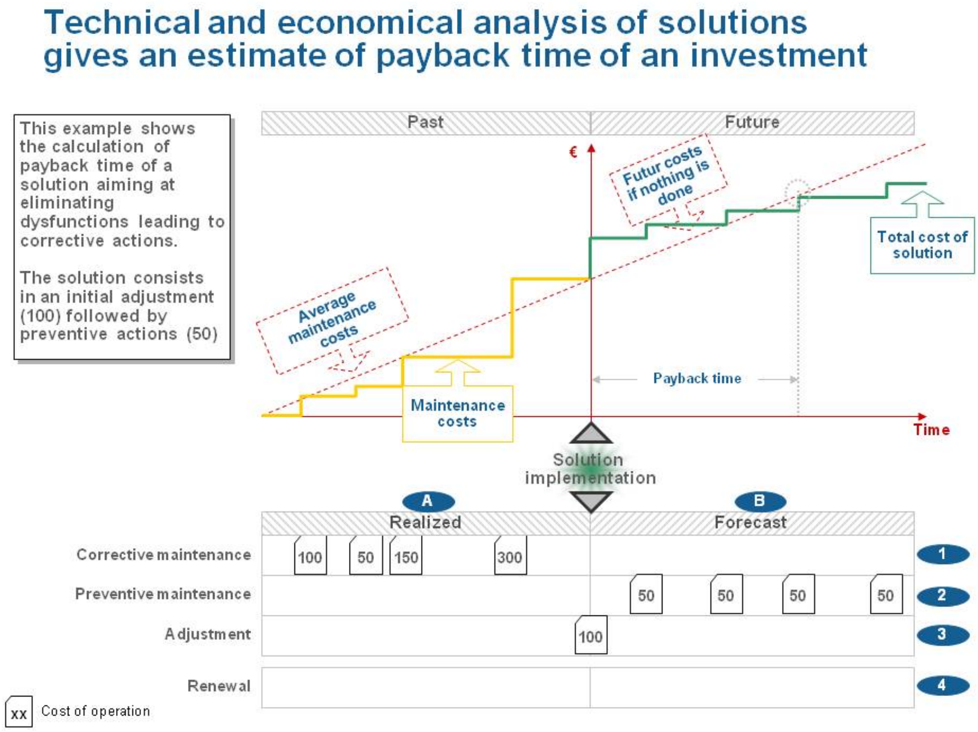
CCTV issue is tackled in details in another report, the reader is invited to the reading of these reports.

Each solution should be designed and cost estimated. From there, a Net Present Value analysis (NPV) could be done to identify the best solution.

A simplified view of NPV is explained in the following figure:

[21] From IPEK website

Figure 4-17: Simplified view of a technical and economical analysis[22]



4.3.4. PERFORM PREVENTIVE ACTIONS

As it is done to some point for DW network (see below), preventive clean out actions should be planned each year on WW network starting with blackspots.

It is recommended to have one or more dedicated teams to performed planned actions. The number of teams will be deduced according to the workload deduced from blackspots analysis.

Considering the length of the network, in first approach these teams should be mutualised at an upper level than Sectors. At sector level, teams will keep on dealing with emergencies but they will be in charge of managing the planned intervention in coordination with these mutualised teams.

In addition to clean out preventive campaign, a follow up of blackspots and other parts of the network should be done.

Teams in charge of preventive clean out must be equipped with both jetting and pumping system. In the case of ACC, there are two ways to do so:

- Buy a hydro-vacuum combination unit with both jetting and pumping systems
- Equip existing mud drains with small jetting system on trailers

These small units on trailers should be enough for ACC as:

- more than 90% of Clean out operations are done on Ø ≤ 300 mm pipes;

[22] This Figure is a real example of training done for Heads of Service an Team Leader in France.

- length between chambers is limited (less than 50 m in general).

Generally, such teams are able to do 300 ml to 500 ml per day of cleaning. This rate depends on the urbanization (decrease with density because of traffic and thinner street) and on the storage capacity (fixed or mobile partition or recycling system). The most recent combined units have a recycling system that enable them to work almost all day without stopping to refill water tank or discharge sludge tank.

For Centru sector, this small jetting system can be used to operate in smaller street if pumping system is not required. Otherwise, smaller equipment shall be used (see figure below).

Figure 4-18: Principle of combined jetting and pumping units

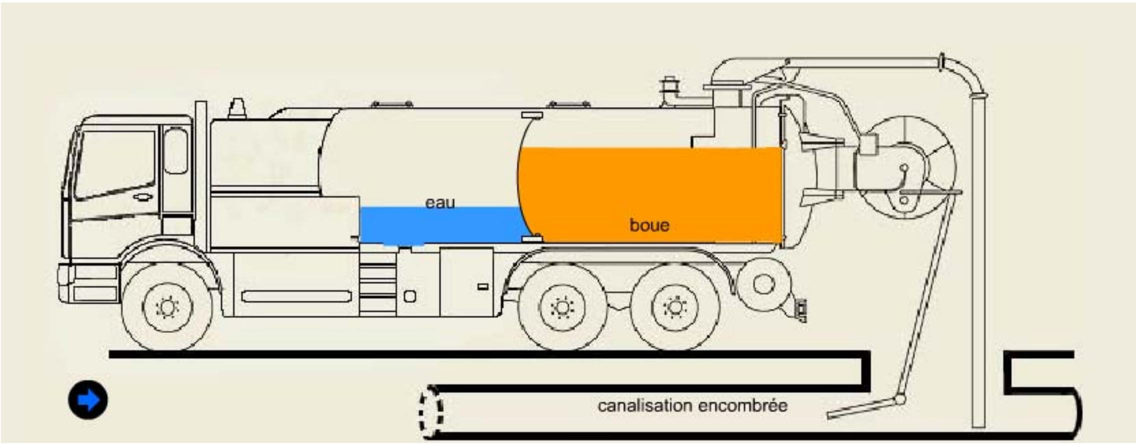


Figure 4-19: Jet unit on trailer or embarked

Figure 4-20: Light hydro vacuum combination unit

Figure 4-21: Hydro vacuum combination unit on truck

Cost estimate for each type of units is the following:

- Hydro-vacuum Combination unit: 180 k€ to 300 k€;
- Small jetting units on trailer: 20 k€ to 50 k€.

4.3.5. CLEAN OUT OPERATIONS ON BIG DIAMETER PIPES

For Ø > 800 mm pipes and siphons, specific plants or techniques are needed to clean them out:

- Mechanical clean out with very specific plants;
- Flushes in the network executed by Hydrass® valves (mobile or permanent) for example;
- Mechanic rolling balls that clean out by being dropped into the network;
- Etc.

Figure 4-22: Hydrass® Valve and rolling ball[23]

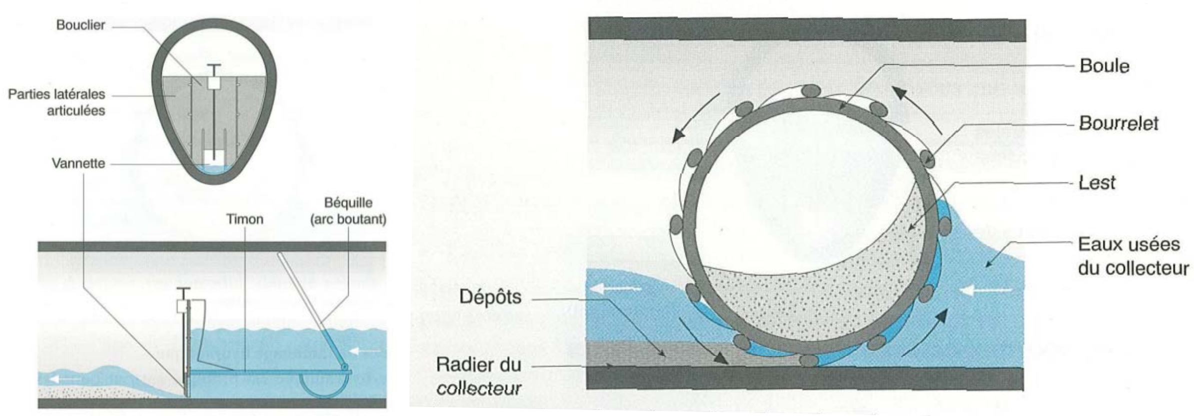
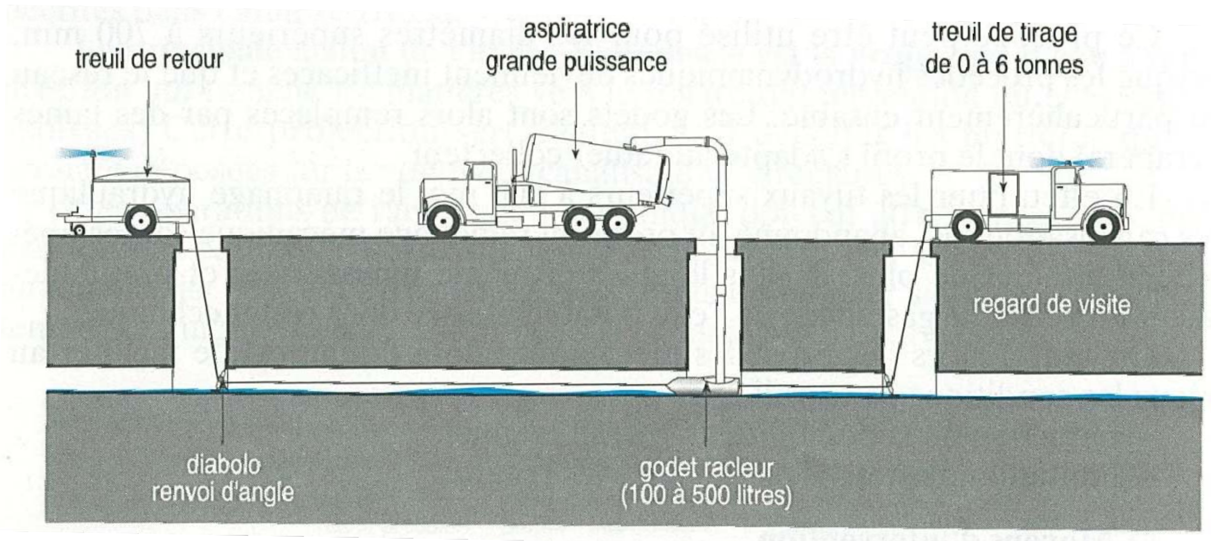


Figure 4-23: Illustration of mechanical clean out[24]



For these pipes, according to their needs for cleaning out, it may be interesting to subcontract these types of operations to specialized companies.

4.3.6. SET KEY PERFORMANCES INDICATORS

As said in previous report, operations should be driven by process. It implies that, in addition to the classic budgetary constraints, the activity should be evaluated according to the performances of each process.

For Collection and treatment of waste water, Best Practices suggest doing a follow up on the indicators presented below. In the list below, some are used to *describe the service* and others to <u>assess performances</u>:

- Customer
    - *Population associated to customer (#)*
    - *Nb of domestic customers (#)*
    - *Nb of non-domestic customers per type (#)*

[23] From <u>Memento du Gestionnaire de l'Alimentation en Eau et de l'Assainissement</u> of Tec&Doc
[24] From <u>Memento du Gestionnaire de l'Alimentation en Eau et de l'Assainissement</u> of Tec&Doc

    - *Number of WW service lines (#)*
- Installations characteristics
    - *Length of network – break down per type - (km)*
    - *Number of WWTP (#)*
    - *Nb of pumps (#)*
    - *Daily volume of water treated (m3/d)*
    - *Daily treatment capacity (m3/d)*
    - *Nb of discharge points – breakdown per type - (#)*
    - Treated water quality (on COD, BDO5, SS, NK, NGL, Pt)
    - Number of checkup (#)
    - Treatment output (%)
    - Average annual load (kg/j)
    - Concentration of discharge (mg/l)
    - Conformity of checkup (%)
- Network operations
    - Ml of CCTV network (ml and %)
    - Ml of preventive cleaned out network (ml and %)
    - Nb of blockages (#)
    - Nb of blockages on pipes (#)
    - Nb of blockages on pipes per km (#/km)
    - Nb of blockages on service lines (#)
    - Nb of blockages for 1,000 service lines (#/1,000)
    - Nb of other blockages (#)
    - Nb of control (# and %)
    - Nb of blackspots (#)
    - Dilution rate (%)
- Waste
    - T of waste extracted from network (t)
    - T of sludge extracted from WWTP (t)
- Electricity and reagents
    - Electricity consumption – breakdown per type - (Kwh)
    - Running time (h)
    - Reagent consumption (kg)
- Works and maintenance
    - Rehabilitated network (km and %)
    - Rehabilitated service lines (# and %)
    - GIS coverage (%)
    - Big maintenance operation (#)
- Project of improvement
    - Number of projects (#)
    - Implementation progress rate (%)

For the purpose of monitoring operations on WW network, it is suggested to restrict the number of KPI to the list below:

- Network operations
    - Ml of CCTV network (ml and %) – Good Practices: 2% to 10%
    - Ml of preventive cleaned out network (ml and %) - Good Practices: 5% to 20%

- Nb of blockages (#)
- Nb of blockages on pipes per km (#/km) - Good Practices: 0,5 to 3 #/km
- Nb of blockages per service lines (#/1,000) - Good Practices: 0,5 to 3 #/km
- Nb of control (# and %)
- Nb of blackspots (#)
- Dilution rate (%)

- Waste
  - T of waste extracted from network (t)
- Works and maintenance
  - Rehabilitated network (km and %) - Good Practices: 1% to 2%
  - GIS coverage (%) - Good Practices: 100% of network with patrimonial and operational data
- Project of improvement
  - Number of projects (#)
  - Implementation progress rate (%)

In addition to this performance indicators related to operations, Customer satisfaction associated with DW should be considered.

4.3.7. FEW FIGURES TO DESIGN WW NETWORK SERVICES

Key figures are given below for a first calculation of needs for staffs and plants and long-term projection. It cannot be emphasis enough that the context (age of installations for instance) and the qualification of staffs must be taken into account to have an adequate allocation of resources. Means of actions are detailed in the following table for several key operations:

Figure 4-24: Key figures for staffs and plants allocation for WW network operations

Actions	Technical rate
Inspection of the network Lifting cover and visual inspection or with QuickView® system. Ideally, inspection should cover the total length of network every year. However, focus must be put on blackspots and sensitive areas (high traffic) or elements.	Rate: 5 km/day or 2 h/km (see other report for the rate with QUICKView®) Staff: 1 team of 2 operators Plant: 1 wagon or vehicle
CCTV operation Inspection on 2% to 10% of the total length of network (preliminary clean out operations to be added).	Rate: 100 to 200 ml/day on existing network Staff: 1 team of 2 operators Plant: 1 CCTV wagon
Follow up of works and GIS update Follow up of new network lay down operations and integration into GIS.	Rate: 1 km of new network/day Staff: 1 team of 1 operators / surveyor and 1 draftsman Plant: -
Clean out operations (Ø ≤ 600 mm) These operations concern 5% to 20% of total length of network	Rate: 300 ml to 500 ml/day Staff: 1 team of 2 to 3 operators Plant: 1 Hydro vacuum Combination Unit
Dealing with blockages Blockages can range from 0.5 to 3 blockages / km on waste water network. Blockages can range from 2 to 3 blockages / 1,000 service lines.	Rate: 1 to 4 h/blockages Staff: 1 team of 2 to 3 operators Plant: 1 Hydro vacuum Combination Unit or Jetting Unit

Small public works operations such as making chamber covers level must be added to this.

5. OPERATIONS ON DRINKING WATER NETWORK

5.1. "AS IS" SITUATION

The following paragraphs will try to describe the situation of ACC regarding waste water network management. As today, the main operations concerns dealing with emergencies, we will focus on this part in the "As-Is" part at least. So this "As-Is" part will go over the following issues:

1. Available resources (staffs and plants)
2. Events on DW network (analysis of operations performed)
3. Response of ACC (procedure for the most common operation: dealing with leaks and bursts)

5.1.1. ON FIELD TEAMS ORGANIZATION, ON DUTY ACTIVITY AND PLANTS

Within operational services, the activity is organised in 12 hours shifts (8 am-8 pm-8 am) with reduced activity and staff at night.

In the following, we will focus on network operations (pipes and pumping stations). The following table summarized the activity of each service:

Table 5-1: Teams organization for operations on DW networks[25]

Department and Service	Teams organization	Staff	Key figures
Water Department	-	**592**	**-**
Network Op Div.	-	208	-
• Sector (x5)	*Missing data for night and day shift* Total: 5 sectors x 4 – 5 teams x 3 – 5 staffs	-	1,850 km DW 14,000 bursts
• Service Line Division	*Missing data*	-	1,850 km DW
Central Dispatch Service	-	**75**	-
Office team	8am-10pm: 3 operators (2 DW + 1 WW), 2 dispatchers (1 DW + 1WW) and 1 engineer 10pm-8am: 1 dispatcher and 1 engineer Total: 8 staffs	-	-
On field team	8am-8pm: 4 teams (2 DW + 2 WW) x 1 to 2 staffs (1 driver + 1 technician[26]) 8pm-8am: 3 teams (2 DW + 1 WW) x 1 to 2 staffs (1 driver + 1 technician[27]) Total: 7 teams x 1 to 2 staffs	-	1,700 km DW 14,000 bursts DW 950 km WW 28,900 inter. WW

Italic: assumed or missing information

This first table raises the following comments:

- On DW network, there is an annual average of 2 leaks per day per team;
- On DW network, there is 1 vehicle for 3-4 teams (day and night probably);
- At CDS, each DW team (4 teams) does on annual average 9.6 first diagnoses per full day, so 2.5 hours per diagnosis.

[25] Data are mainly for year 2010
[26] From what we have seen during an intervention on the field during the day and on water network.
[27] From what we have seen during an intervention on the field during the day and on water network.

In general, a team consist in 3 to 10[28] persons with different skills. The typical team is composed of:

- 1 foreman (team leader);
- 1 brigadier;
- 7 locksmiths;
- 1 welder
- + the drivers of the equipments

Figure 5-1: ACC DW Sector team at work on a Ø 500 mm

Unlike WW network, for DW network operations, there is a team dedicated to performing network rehabilitation internally.

Table 5-2: Plants within sectors and associated characteristics

Type	N°	Average age
Bulldozer	3	22
Excavator	15	17
Loader	1	6
Scrapper	1	12
Tractor	10	15
Trailer	5	16
Total	**35**	**16**

Figure 5-2: Tractor and heavy excavator (from production plant)

[28] Information are heterogeneous on that element.

Table 5-3: Plants within sectors and associated characteristics

Sector / Equipment	N°	Average Age
Botanica	**5**	**20**
Wagon	3	17
Water drains	2	25
Buiucani	**5**	**21**
Wagon	4	20
Water drains	1	22
Centru	**3**	**16**
Wagon	2	14
Water drains	1	21
Ciocana	**5**	**21**
Wagon	4	21
Water drains	1	22
Riscani	**4**	**18**
Wagon	3	16
Water drains	1	24
SIB	**2**	**21**
Wagon	2	21
Total	**24**	**20**

Figure 5-3: Examples of ACC Wagon at Botanica sector (exterior and interior)

Table 5-4: Equipment at Central Dispatch Service for leak detection purposes

Machine name	Type	Producer
Acoustic leak detector	Aqua – M 100 D	F.A.S.T. GmbH
Acoustic leak detector with correlation	Micro Call +	Palmer Environmental
Pressure recorder	Spectralog 1Pi	Biwater Industries Limited
Ultrasonic flowmeter Fluxus	ADM 6515	Katronik
Laboratory with the camera to inspect pipes and fountains	RAX 11.7	Ibak Helmut Hunger GmbH&Co
Pipe detector		
Metal detector	Ferotec 300	Hermann Sewerin GmbH

5.1.2. OPERATIONS

The length of networks managed and served by ACC is summarized in the following table:

Table 5-5: Length of network operated by ACC in 2010

Sector	Length (km)
Rîșcani	386.5
Centru	359.5
Buiucani	310.9
Botanica	321.4
Ciocana	301.7
Vadul lui Vodă	134.4
STA technical water	17.7
SSP SERC	11.9
TOTAL	**1844.0**

Remark: within the following charts, raw data were not available in Excel file. So, analyses could not be as precise as for WW operations.

Table 5-6: Accidents on DW network per category and diameter in 2010

Ø	Breaks	Rifts	Puffs	Damages to the valves, hydrants	Total	%
≤50	439	911	596	812	**2,758**	**20%**
65-100	1,101	1,388	871	697	**4,057**	**29%**
100-150	349	479	1,221	409	**2,458**	**17%**
200-250	373	675	655	360	**2,063**	**15%**
250-300	65	677	697	171	**1,610**	**11%**
350-450	96	143	131	208	**578**	**4%**
500-700	51	193	65	101	**410**	**3%**
800-1000	33	55	13	12	**113**	**1%**
1200-1400	19	-	-	-	**19**	**0%**
Total	**2,526**	**4,521**	**4,249**	**2,770**	**14,066**	**100%**
%	**18%**	**32%**	**30%**	**20%**	**100%**	

Figure 5-4: Accidents on DW network per category and diameter in 2010

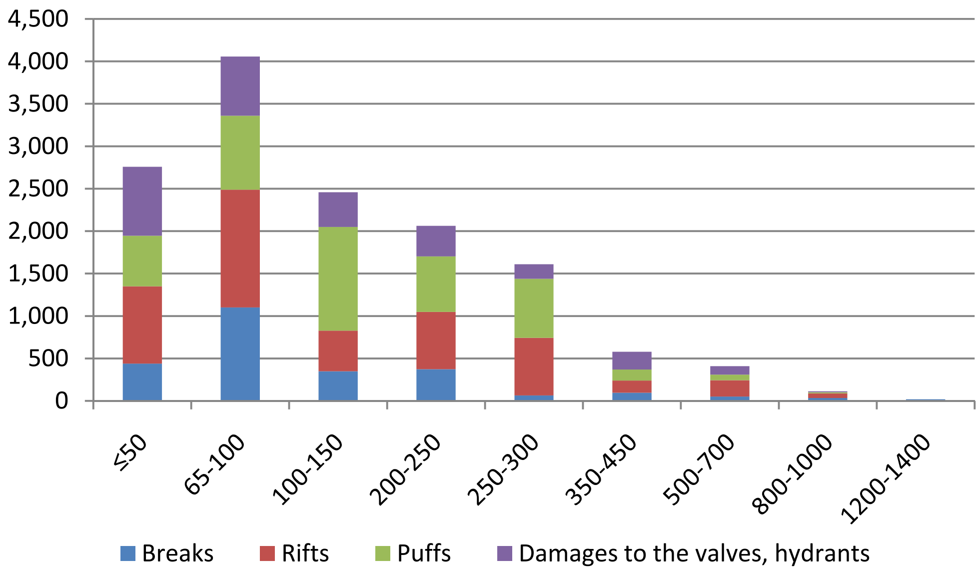
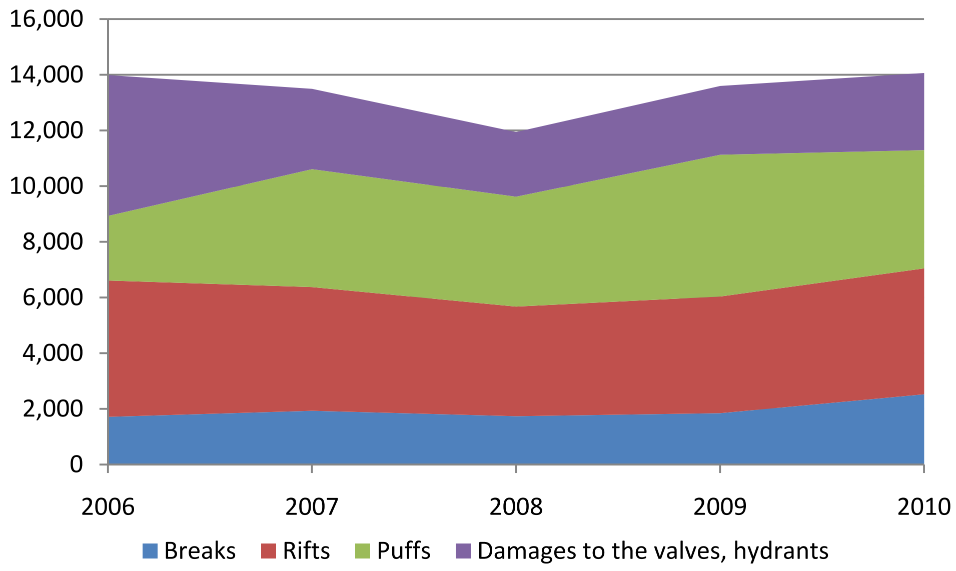


Table 5-7: Accidents on DW network per category from 2006 to 2010

Accidents	2006	2007	2008	2009	2010
Breaks	1,713	1,937	1,738	1,849	2,526
Rifts	4,902	4,442	3,936	4,186	4,521
Puffs	2,322	4,235	3,948	5,096	4,249
Damages to the valves, hydrants	5,057	2,881	2,322	2,471	2,770
Total	**13,994**	**13,495**	**11,944**	**13,602**	**14,066**

Figure 5-5: Accidents on DW network per category from 2006 to 2010



From the above charts, the following comments raise:

- Length of network per Sector are quite homogenous (340 km in average);
- Operations are quite homogenous according to pipe diameters (below 250 mm);
- Operations are quite homogenous according to type of operations: around 20% to 30%;
- 66% of events occur on Ø ≤ 150 mm pipes;

- Number of operations is quite steady over time (around 13,500 / year);
- There are 7.5 bursts / km (6 leaks / km for ANB) which are at least 7 times above average value in Western countries.

•

An additional comment can be made at this point. From several interviews and from the field visit, it was said and appears that some burst / leaks occur on previous repairs. This was explained by a lack of appropriate material to repair the leak in the first place. This lack of appropriate spare parts was raised several times during the mission; main reason being economic. However, it was recognized by ACC staffs that it was not good savings as there is a risk to execute an additional repair.

5.1.3. PROCEDURE TO DEAL WITH LEAKS AND BURST

All emergencies that occur in the water supply system of Chisinau are flagged and resolved / managed /coorindated through the CDS.

Within this service operate two intervention teams dedicated to solving urgent problems, and each Sector has its own team for intervention.

For each work of intervention, the following worksheet is prepared:

Figure 5-6: Typical worksheet

(denumirea întreprinderii, instituției)

FIŞA DE LUCRU - ACCES NR. ________
la executarea lucrărilor cu pericol sporit

din ____________ 200 __

I. FIŞA DE LUCRU

1. Executorului responsabil de lucrări ____________
cu echipa constituită din ________ persoane va executa următoarele lucrări:

(denumirea lucrărilor, locul executării)

2. Sunt necesare pentru executarea lucrărilor:
Materiale ____________
Instrumente ____________
Echipament de protecție ____________

3. Pentru executarea lucrărilor se vor asigura următoarele măsuri de protecție:

(se enumeră principalele măsuri, echipamente pentru asigurarea securității muncii)

4. Condițiile esențiale ____________

5. Lucrările au demarat la ora ______ min. ______ data ____________ 200 __
Lucrările au fost încheiate la ora ______ min. ______ data ____________ 200 __
Program de lucru ____________
(1, 2, 3, ture)

6. Conducătorul responsabil al lucrărilor este numit ____________
(funcția, numele de familie, prenumele)

7. Accesul a fost eliberat ____________
(funcția, numele de familie, prenumele)

The team are working in shift, and if it is necessary, the program may be extended by order. There is no backup personnel or equipments for the CDS.

In case of a large accidents the program of intervention teams, is modified by order, they work around the clock in two shifts of 12 hours until the accident will be remedied. If they do not have sufficient equipments to deal with the accident, by order, the technique is supplemented.

In case of the location of the leak is difficult, the CDS uses its leak detection equipment.

The time needed to find the location of leakage occurring in the DW network ranges between:

- 0.2 to 1.0 hours for breaks and rifts on the pipes with Ø > 600 mm,.
- up to 6 hours for breaks and rifts on pipes with Ø > 200 mm;
- 3 to 12 hours for breaks and rifts on pipes with Ø < 150 mm and for rifts and puffs depending on diameter.

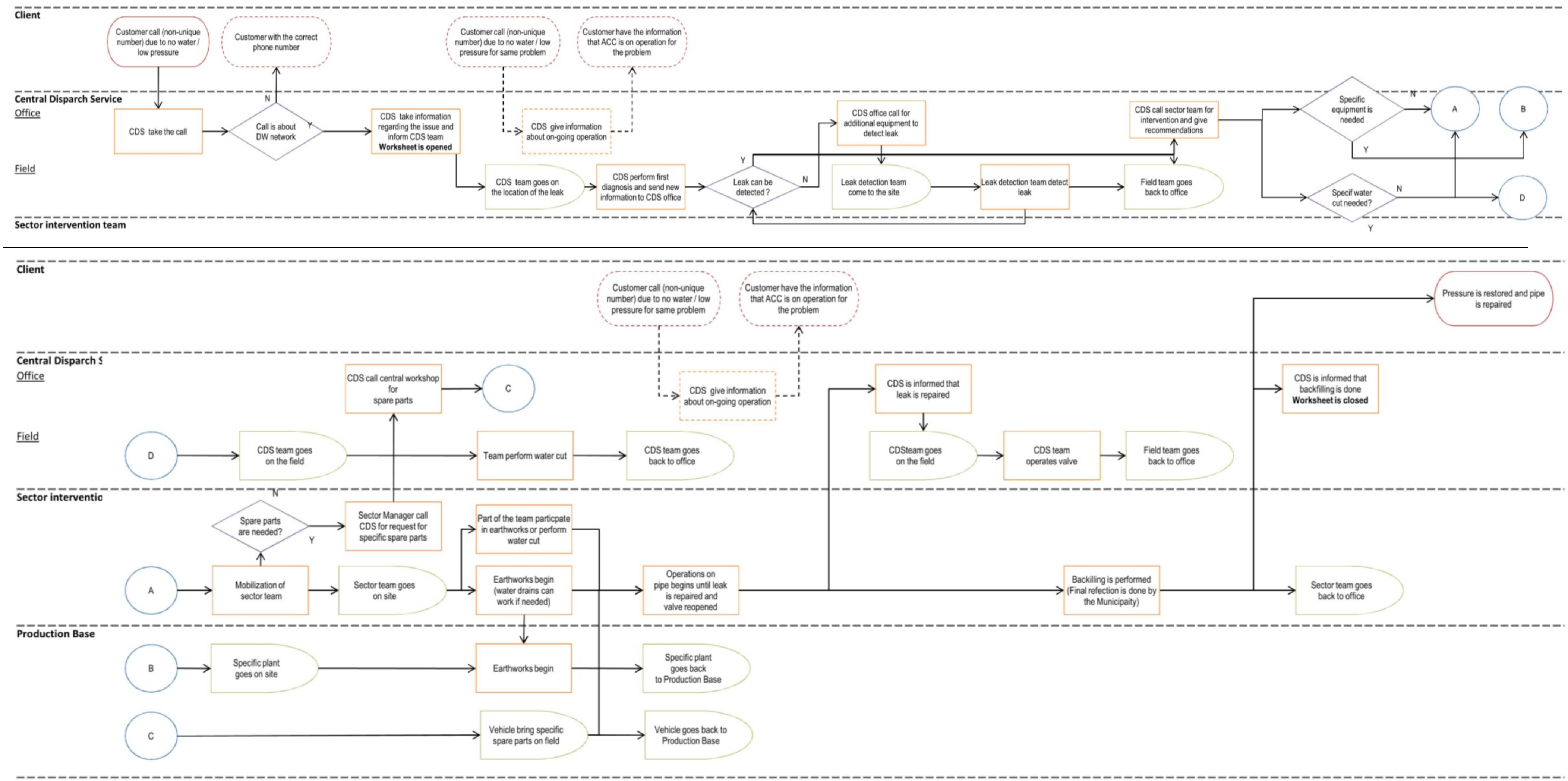
Remark: it must be said here that during the field visit, the CDS team detected quite easily (less than 5 mn on the field) a leak on a Ø 100 mm pipe. This tempers the above mentionned times.

After the water leaks was detected, the pipes (sections) are emptied for repairs.

After the reparations, the repaired pipes are washed and disinfected.

The typical series of events based on intervews and on field visit can be schematilccaly illustrated by the workflow diagram presented below:

Figure 5-7: Workflow diagram for burst/leak repairs



5.2. SHORTCOMING AND BEST PRACTICES

5.2.1. SHORTCOMING

First, the characteristics of the network are quite poor with an important amount of leaks and bursts per km and therefore physical losses.

Concerning equipments, besides their age and without any data regarding their occupancy rate, they seem to work properly as we have seen on the field. Nevertheless, their age suggests that it is about time to renew them. Same comments can be made about plants.

Considering operations, as WW operations, DW operations are mostly reactive to events and not proactive except for the activity of the Service Line sector.

Most of the repairs (66%) concern Ø ≤ 150 mm pipes. This type of pipes implies extensive search (3 to 12 hours) with leak detection equipment. It means that, the Leak Detection team is likely to be mobilized to address this issue.

In the workflow diagram, it seems that a lot of actions with few added value take place at the beginning of the process such as: collection and transmission of data, movement, etc.

Concerning the data, like WW operations, there is too much type of operations and as far as we know, there is no relation to one single event that triggered the whole thing. Analysis is therefore very difficult.

5.2.2. BEST PRACTICES

Best practices on DW network are summarized in the table below:

Table 5-8: Summary of Best practices for WW network operations

Issue	Actions
Monitoring of the network **DW network assessment**	Create and update GIS. Create a modelling of the network. Follow up of measures (volume and pressures) Follow up of events on the network (leaks and bursts). Update of the GIS (age, material and context of pipes). Follow up of events on specific installations. Update GIS with on-field data.
Common maintenance	Build and follow up actions with GIS. Perform common maintenance in association of the follow up. Operate air valves, purge, PRV, etc. Tighten up stuffing box. Level surface boxes. Maintain (visit and greasing) hydraulic elements and cathodic protection. Update GIS.
DW network operations	Manage water cut (with data from GIS). Perform earthworks.

Issue	Actions
	Repair leaks (using muff) and disinfect. Backfill with imported materials and rebuild road. Update GIS with on-field data.
DW service line operations	Build rehabilitation programmes based on data from GIS. Replace service lines made of lead. Renewal of service lines. Promote techniques without trench.
DW network assessment **DW network renewal/rehabilitation** Knowledge of the network allows the operator to enhance performance of operations and to target the most efficient rehabilitation. Network should undergo steady rehabilitation (<5% generally).	Build rehabilitation programmes based on historical data from GIS. Build modelling Each year, a planning for CCTV inspection must be set along with preventive clean out operations planning. Rehabilitation programme (1% to 5% of total length of network) per year. Update GIS.

Remark: Control of NRW and associated actions and water meters management are addressed in specific reports. The reader is invited to the reading of these reports.

5.3. RECOMMENDATIONS

In the following paragraphs, few short to medium term actions are suggested to bring some improvement to operations with a limited payback time.

In addition to this, for long term actions purpose, ratios are suggested to have a first approach for the future structure of the DW network operational teams.

Recommendations regarding asset management and rehabilitation programmes will not be addressed by this report where focus is put on operations.

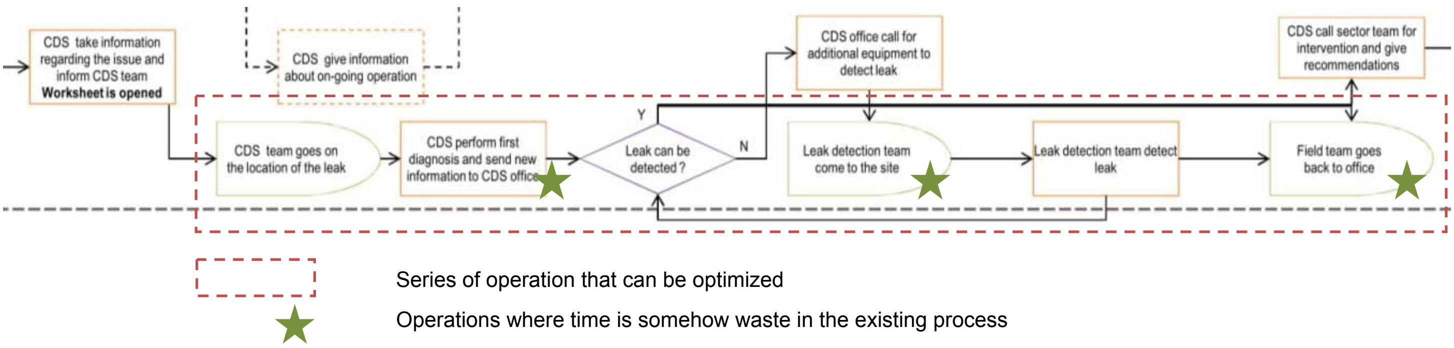
Some recommendations have already been made for WW operations and will not be developed in the following paragraphs:

- Create GIS and adjust Database;
- Improvement of customers claims management.

5.3.1. IMPROVE LEAK / BURST REPAIR PROCESS

In the workflow presented before, it appears that some time may somehow be wasted at the beginning to locate the leak (see details below).

Figure 5-8: Details of the DW repair process



The main problem of the existing process is that when the leak cannot be found visually, the first CDS team has to call CDS office to have the leak detection team join them on the field. To optimize the process, each CDS team could be equipped with leak and metal detection equipment to locate precisely the leak. Time saved concern the operation marked with a star in the above figure.

This optimization would be quite interesting for ACC as the leak detection process is the longest for Ø ≤ 100 mm pipes where leaks occurs the most.

A first simplified approach based only on time saved in travel results in h per year:

- 1 team of 2 people
- x 20 mn (0,3 h) of travel in average to reach the leak site x 2 (1 return travel)
- x 6,815 leaks on Ø ≤ 100 mm pipes (2010) x 20%[29]
- = 1,635 h = 1 full time staff

Positive side effect of this would be that a leak detection team could be dedicated to preventive campaigns without interruptions caused by emergencies.

5.3.2. INTENSIFY PREVENTIVE ACTIONS

Unlike WW network, preventive actions are undertaken to prevent leaks from occurring on DW network. These actions considered as internal investment and are undertaken by a specific “Sector” that performs rehabilitation / replacement on Ø ≤ 110 mm pipes up to 100 m[30].

As most of the leaks occur on these types of pipes, it is recommended to increase the activity of this sector with additional resources. It was quite understood that resources of all kind (plants, spare parts, money, etc.) is an issue for the short-term: 9 million LEI spent on 2010 out of a forecasted budget for investments of 45 million LEI.

Nevertheless, in the short, it seems that the investment programme can be improved to be more efficient by including more insight from historical data and making some simple payback analysis[31] (investment versus operational costs). Indeed, as we understood, investment programme is built through the following (simplified) path:

- Head of sector prepare rehabilitation programme;
- Department Director validate rehabilitation programme;
- Investment and Supervision Division review rehabilitation programme;
- Financial Director arbitrates according to financial resources.

At the very beginning of the process, it seems that no input from historical data computed by CDS is used to build the rehabilitation programme. One of the reason is that Head of Sector does not have the appropriate computer (up to date one considering the amount

[29] Optimistic assumption is made that 80% of leaks on Ø ≤ 100 mm pipes can be detected without leak detection equipment.
[30] From interviews.
[31] Payback analysis principles are presented in the previous chapter.

of data that need to be computed) to do so. As a consequence, the whole process is based, at each step, on subjective choices that may not be the more efficient.

In the future, it is recommended to use more efficiently those data and to allocate resources where the payback is the most important. To do so, the following process is suggested

- Head of Sector prepare their rehabilitation programmes based on their operational point of view in close collaboration with the people of CDS and Financial Services for the operational cost parts;
- Network O&M Department Director consolidates and reviews the projects from all sectors and ensures the homogeneity of assumptions;
- Investment and Supervision Division prepare the investments side of the rehabilitation programme with cost estimate of works;
- Network O&M Department Director consolidates all the costs, makes payback analysis, defines priorities and defends the projects in front of Technical Director;
- Technical Director consolidates all projects, set priorities and arbitrates between projects in collaboration with Financial Director.

Remark: This recommendation can be applied for WW network even if generally investments go first to DW supply and then to WW collection.

5.3.3. SET KEY PERFORMANCES INDICATORS

As said in previous report, operations should be driven by process. It implies that, in addition to the classic budgetary constraints, the activity should be evaluated according to performances of each process.

For Treatment and distribution of water, Best Practices suggest doing a follow up on the indicators presented below. In the list below, some are used to *describe the service* and others to assess performances:

- Customer
  - *Population associated to customer (#)*
  - *Nb of domestic customers (#)*
  - *Nb of non-domestic customers per type (#)*
  - *Number of DW service lines (#)*
  - *Connection rate for drinking (%)*
  - *Metered customer (%)*
  - *Percentage of people with more than 12 h of water per day (%)*
- Installations characteristics
  - *Length of network (km)*
  - *Number of treatment unit (#)*
  - *Nb of pumps (#)*
  - *Storage capacity (m^3)*
  - *Daily volume of water extracted (m^3/d)*
  - *Daily peak volume of water extracted (m^3/d)*
  - *Daily production capacity (m^3/d)*
  - *Water quality*

- o *Number of analysis performed – bacteriologic and physical and chemical - (#)*
- o *Conformity ratio – bacteriologic and physical and chemical - (%)*

- Volumes
    - o *Volume of water extracted (m^3/yr)*
    - o *Volume of water billed – breakdown per customer - (m^3/yr)*
    - o *Volume sold outside of the perimeter (m^3/yr)*
    - o *Average volume consumed per year per customer - (m^3/yr)*
    - o *Average volume consumed per month per customer - (m^3/yr)*
- Network efficiency
    - o <u>Network efficiency (%)</u>
    - o <u>Linear Leakage Index (LLI) (m^3/km)</u>
- Network operations
    - o <u>Nb of leaks (#)</u>
    - o <u>Nb of leaks on pipes (#)</u>
    - o <u>Nb of leaks per km (#/km)</u>
    - o <u>Nb of leaks on service lines (#)</u>
    - o <u>Nb of leaks for 100 service lines (#/km)</u>
    - o <u>Nb of other leaks (#)</u>
- Electricity and reagents
    - o <u>Electricity consumption (Kwh)</u>
    - o <u>Electricity consumption per m^3 (Kwh/m^3)</u>
    - o <u>Chlorine consumption (kg)</u>
- Works and maintenance
    - o <u>Rehabilitated network (km and %)</u>
    - o <u>Rehabilitated service lines (# and %)</u>
    - o <u>GIS coverage (%)</u>
    - o <u>Big maintenance operation (#)</u>
- Project of improvement
    - o <u>Number of projects (#)</u>
    - o <u>Implementation progress rate (%)</u>

For the purpose of monitoring operations on DW network, it is suggested to restrict the number of KPI to the list below:

- Network efficiency
    - o <u>Network efficiency (%)</u>
    - o <u>Linear Leakage Index (LLI) (m^3/km)</u>
- Network operations
    - o <u>Nb of leaks (#)</u>
    - o <u>Nb of leaks per km (#/km)</u>
    - o <u>Nb of leaks for 100 service lines (#/km)</u>
- Electricity and reagents
    - o <u>Electricity consumption (Kwh)</u>
    - o <u>Electricity consumption per m^3 (Kwh/m^3)</u>
    - o <u>Chlorine consumption (kg)</u>
- Works and maintenance
    - o <u>Rehabilitated network (km and %)</u>

  - Rehabilitated service lines (# and %)
  - GIS coverage (%)
- Project of improvement
  - Number of projects (#)
  - Implementation progress rate (%)

In addition to this performance indicators related to operations, Customer satisfaction associated with DW should be considered.

5.3.4. FEW FIGURES TO DESIGN DW NETWORK SERVICES

Key figures are given below for a first calculation of needs for staffs and plants and long-term projection. It cannot be emphasis enough that the context (age of installations for instance) and the qualification of staffs must be taken into account to have an adequate allocation of resources. Means of actions are detailed in the following table for several key operations:

Figure 5-9: Key figures for staffs and plants allocation for DW network operations

Actions	Technical rate
Detection of dysfunctions on the network / Surveillance and monitoring Follow up of inputs into the networks and other characteristics (e.g. pressure) Analyse data and set action plans Prepare periodical assessment Update GIS and modelling according to extension, rehabilitation and operations	Very dependent on implemented technology (e.g. remote management) and organization (e.g. CDS)
Detection of dysfunctions on the network / Leak detection activity Execute leak detection campaign (sounding survey, correlation, etc.) Perform step test and measurement campaign Assist operation punctually for leak location	Rate: 1 - 2 km/day (/w ground microphone) Staff: 1 team of 1 to 2 operator(s) Plant: 1 light vehicle or wagon
Common upkeep on equipment and accessories Maintenance of valves (check, PRV, purge, etc.) Maintenance of cathodic protection equipment	Rate: Test PRV: every 5 years -> 1 to 2 days Check valve: every 5 months -> few minutes Staff: 1 team of 1 to 2 operator(s) Plant: 1 light vehicle or wagon
Reparation / upkeep of service lines Repair / replacement of service lines	Rate: 1 to 2 service line/day Staff: 1 team of 3 to 4 staff (1 team leader, 1 plant driver, 1 – 2 workers) Plant: 1 wagon / truck + 1 excavator / backhoe (+1 trailer)
Reparation / upkeep of service lines Repair of pipes	Rate: 1 to 3 leaks/day Staff: 1 team of 3 to 4 staff (1 team leader, 1 plant driver, 1 – 2 workers) Plant: 1 wagon / truck + 1 excavator / backhoe (+1 trailer)

Small public works operations such as making surface box level must be added to this.

Appendix 8

Customer Services

Appendix 9

Geographic Information System (GIS) Report

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1. INTRODUCTION

1.1. OVERALL OBJECTIVE OF THE GIS

A geographic information system (GIS) captures, stores, analyzes, manages, and presents data that are linked to location. In other words, it is a cartographic tool where each graphic element is associated with its characteristics (for example a pipe with its age, dimensions, material, etc.).

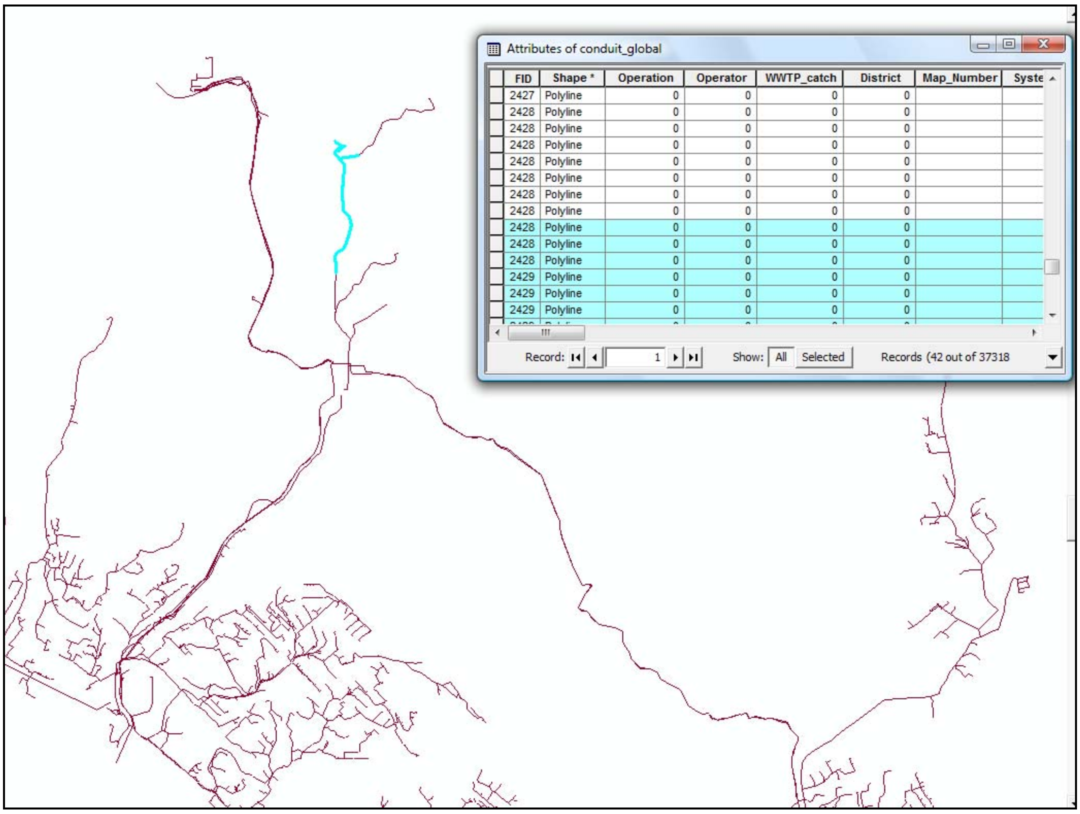

Figure 1: Example of GIS

Building the GIS of the water and sewerage networks would be a very interesting operating tool for ACC. A GIS is a tool that allows users to create interactive queries (user-created searches), analyze spatial information, edit data, maps, and present the results of all these operations.

Whilst hydraulic modelling is an operating tool used for planning (design) & emergency response and SCADA System aims to provide a live picture of the status of the system, the GIS is mainly use for asset management.

The Figure 3 hereafter summarizes the main objectives of a GIS.

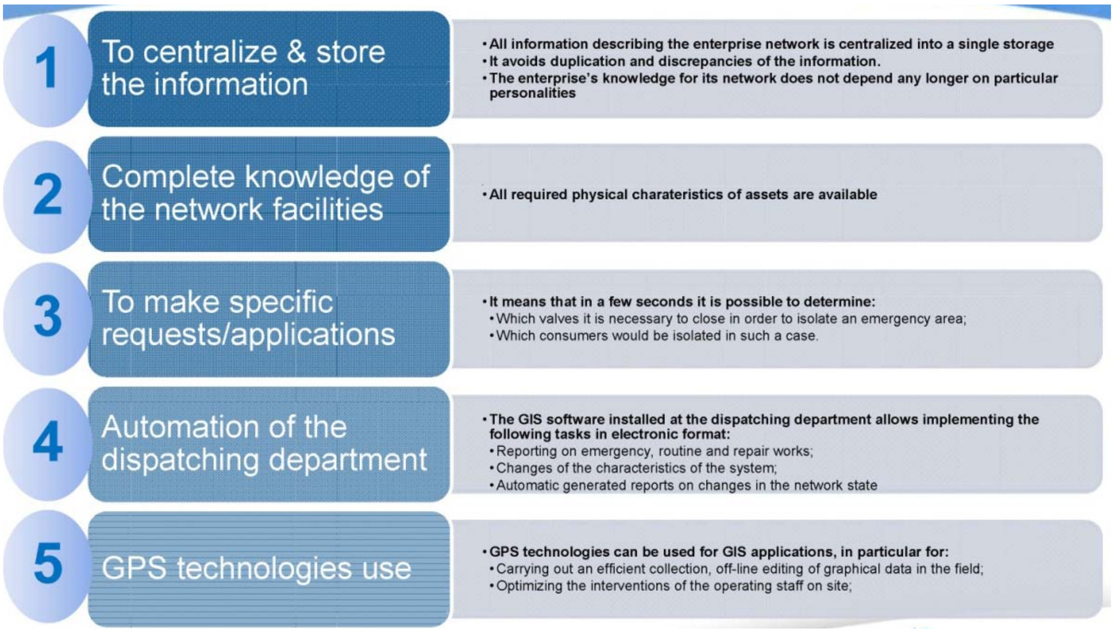

Figure 2: GIS Objectives

Therefore, the GIS should help ACC to have more accurate knowledge of the networks, to improve the operation by reporting and analyzing some key parameters, to anticipate problems, to schedule programme for maintenance and to value the assets.

1.2. ESTABLISHMENT OF A GIS

In the frame of the Project, the Consultant shall develop a Geographical Information System (GIS) for both the water supply system and the sewerage system operated by ACC.

The steps in the suggested implementation of the GIS include:

Phase 1: Construction of a Geographic Information System (GIS)

- Selection of GIS software
- Provision of equipment for producing the GIS
- Development of base maps
- Selection of items to be included in the initial GIS database
- Identification of items that may be added later to the GIS database
- Interface capabilities of the GIS database
- Data collection for the GIS

Phase 2: Operation and use of the GIS implemented in Phase 1:

- Suggestion of an organization and a strategy for GIS use;
- Training of ACC staff in the use of GIS.

1.3. OBJECTIVES OF THE REPORT

This report aims to:

- Present the activities carried out to date;
- Suggest an implementation strategy for Phase 1 taking into consideration the available information and the targets to be reached and the constraints set out in the ToR.

The different possible scenarios that have been presented to ACC during the meeting held in ACC office on January 20th are reminded.

2. CONSTRUCTION OF THE GIS

2.1. TECHNICAL SPECIFICATIONS

As per the Terms of Reference, the selected GIS software must comply with the following specifications:

- Compatibility with the RINEDAC system used by the Department of Architecture and Urbanism of Chisinau City Hall;
- Geospatial data storage of water and sewerage networks in the PostGis database;
- Support the projections provided in MOLDREF99 system and WGS84;
- Provide access to geospatial data system via WMS / WFS;
- Provide access to data, drafting and drawing geometry objects attributes of objects through the web- browser-ui;
- Provide access to data depending on access level set by the administrator;
- System interface in at least 2 languages (Romanian, Russian);
- No restrictions on number of users of the system implemented

Details and definitions are given below:

RINEDAC System

This is a local web-based GIS platform that aims to automate most of the work-flow of the Chisinau municipal Department of Architecture and Urbanism. The RINEDAC product, which represents the infrastructure networks of Chisinau city, is based on software elements such as postgis, php and linux. It permits editing of layers, searching by address, and viewing imagery.

MOLDREF99

This is a coordinate projection system that is currently used in Moldova. It is compatible with the latest revision of the World Geodetic System (WGS) standard, which is the WGS84 (dating from 1984, last revised in 2004, and valid up to about 2010). The WGS comprises a standard coordinate frame for the Earth, a standard spheroidal reference surface (ellipsoid) for raw altitude data, and a gravitational equipotential surface (geoid) that defines nominal sea level. WGS84 is the reference coordinate system that is used for Global Positioning System (GPS).

Web Map Service

The Web Map Service (WMS) is a standard protocol for serving over the Internet the georeferenced map images from a GIS database. The WMS protocol was developed by the Open Geospatial Consortium (OGC), which also developed the Web Feature Service (WFS) protocol, to allow requests for geographical features across the web using platform-independent calls. (One can think of geographical features as the "source code" behind a map. They are generally transported in the XML-based "GML" format, although other formats such as shapefiles may also be used.)

It is worth pointing out that the interface specifications (Web access in particular) are very advanced and limit the options proposed.

2.2. AUDIT OF THE CURRENT SITUATION AND OF THE AVAILABLE INFORMATION

Presently, neither ACC, nor the Municipality of Chisinau have developed a GIS. However some data are available and will be used for the construction of the GIS. They are listed below.

2.2.1. AVAILABLE DATA IN ACC

2.2.1.1. In digital format

AutoCAD drawings are available in ACC. They roughly cover:

- ~ 90% of the water network, which is about 1,800 km long
- ~ 25% only of the sewerage network, which is about 950 km long.

Unfortunately, only the diameter of the pipes is indicated. There is no other valuable information such as the material of the pipes, their age, condition, etc.

Furthermore, it has to be noted that all attributes are graphical (AutoCAD is only a "drawings software") and are not georeferenced.

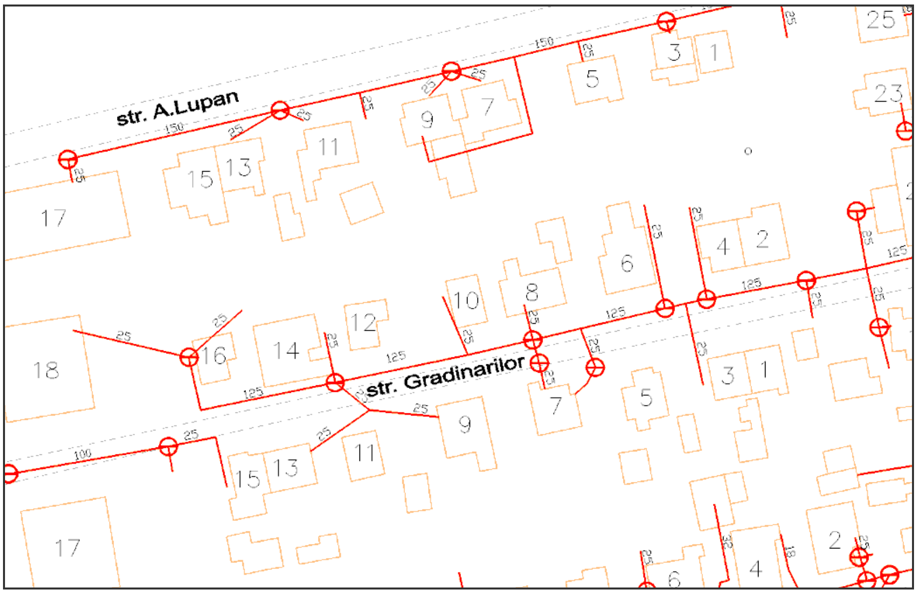

Figure 3: Example of a CAD drawing available in ACC (Network information)

Regarding the hydraulic facilities (water treatment plant, wastewater treatment plant and pumping stations), they are represented on the layout, but without any information except their names.

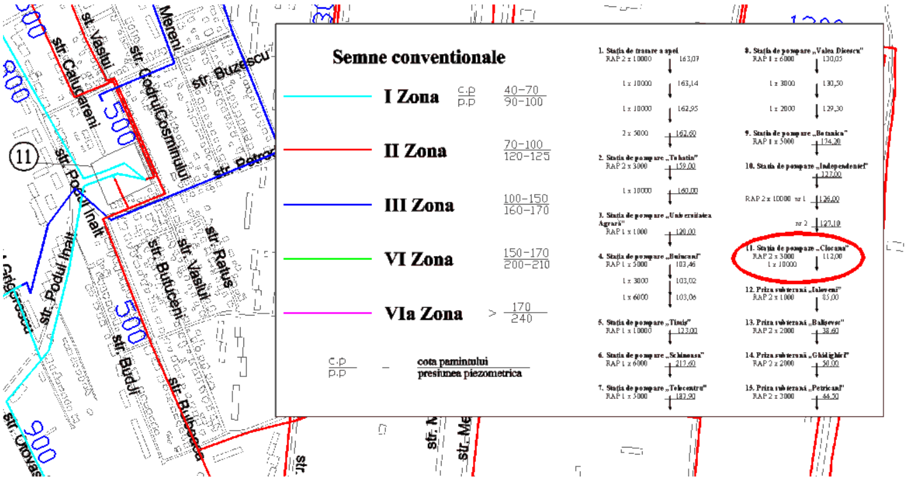

Figure 4: Example of a CAD drawing available in ACC (PS information)

It has to be noted that some of the cadastral maps (scale 1:500) from the City Hall (A3 format) have been scanned and are used by ACC as base maps in Autocad for drawing the water networks.

Figure 5: Cadastral map used by ACC as base maps

The city map in Mapinfo format is also available in the local coordinate system of 2001. That includes layers of streets, buildings, facilities. green areas, bodies of water (the source is GEOCAD)

2.2.1.1. In paper format

ACC has some copies of cadastral maps (scale 1:500) including the networks of the town. They have been provided by the Department of the Architecture and Urbanism from the City Hall Chisinau in 2000-2001. Unfortunately these cadastral maps from the City Hall have not been updated for more than 10 years.

ACC also owns longitudinal drawings and profiles of the existing network. They can be found in the Archive of the Technical Department.

2.2.1.2. Conclusion

Available data at ACC is neither complete nor current, particularly for the sewerage system. Furthermore it is only partially digitised.

2.2.2. AVAILABLE DATA IN THE MUNICIPALITY OF CHISINAU

The Department of Urbanism from the Chisinau City Hall is using the 'RINEDAC' application as a tool for storing the cadastral information, which allows the on-line editing on a WEB interface.

But, water and sewerage networks have not been digitised (only gas and telecommunication networks). There is no spatial or attribute information on water/wastewater networks.

The GIS used by the City Hall is constituted of layout elements made of the scanned images of the cadastral maps at the scale of 1:500, and of the aerial images at the scale of 1:2000 for the city and 1:5000 for the board regions (suburbs) – geo referenced in the Moldref99 Design System.

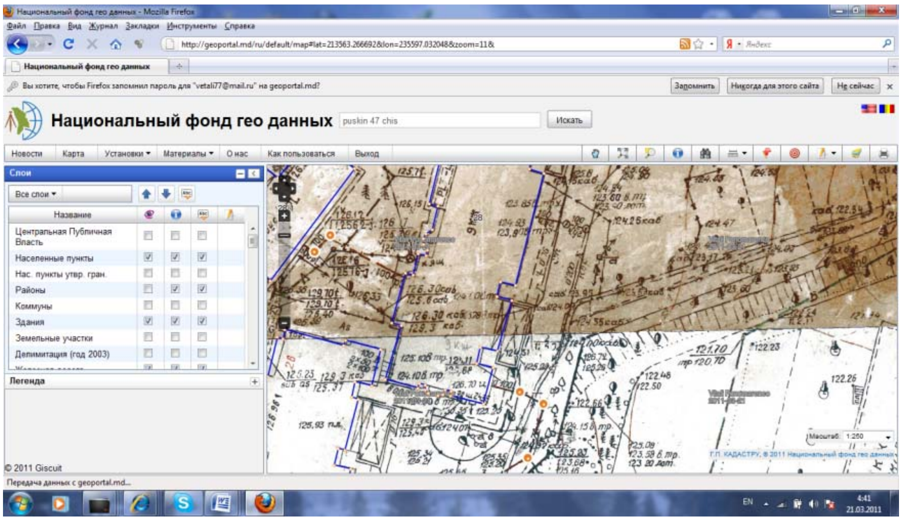

Figure 6: Rinedac

2.2.3. CONCLUSION

Based on the available data, the implementation of a GIS in ACC requires:

- For the water supply network: to transfer the digitised data from AutoCAD to the chosen software and to complete all the missing information (material, age, ...);
- For the sewerage network: to scan the cadastral maps (paper), to import them into the chosen software and to digitise the entire network.

2.3. RECOMMENDED STRATEGY FOR THE IMPLEMENTATION OF THE GIS

2.3.1. PROPOSED METHODOLOGY

Whatever the GIS software selected, the suggested methodology is as follows:

- Digitise the networks based on the scanned cadastral maps (1:500) georeferenced in Moldref99 System;
- Define the alphanumeric fields corresponding to the required attributes together with the Cadastre Agency in accordance with the sites data base developed together with the specialists of ApaCanal.
- Store the digital data on the Cadastre Agency server;
- Export the data in the required format (shp,dgn,dwg);
- Retrieve and edit the data with a GIS software.

It is worth laying the emphasis on the fact that the accuracy of digitised data would be about 0,40m and that the data base will be populated based on available data (no site survey) and validated by ACC.

The action plan for the first phase is detailed below. Note that the task managers indicated refer to the organisation chart presented

Figure 8.

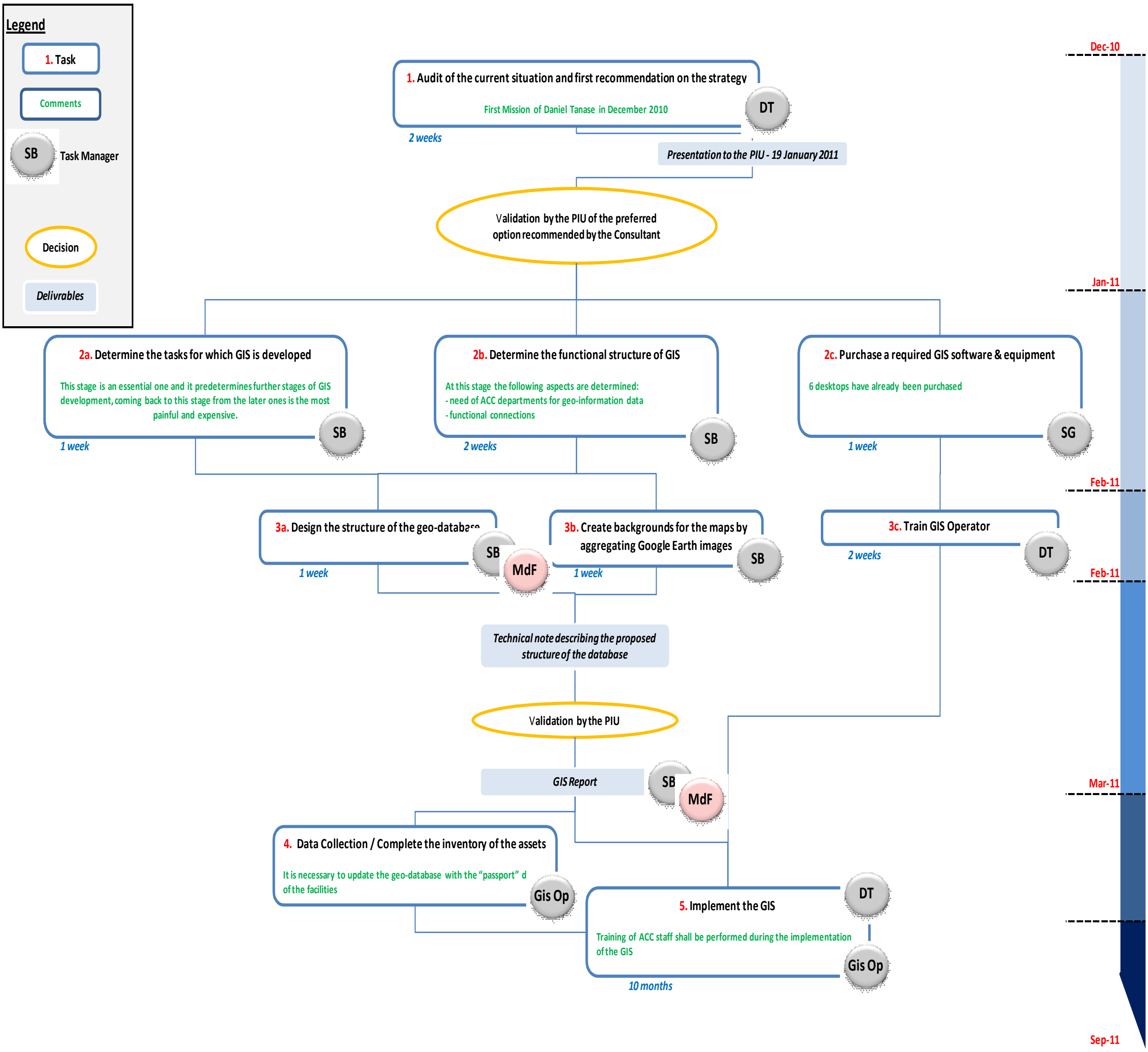

Figure 7: Proposed Action Plan for the Phase 1

2.3.2. ORGANISATION

2.3.2.1. Supervision

As shown on

Figure 8, Sergey Brazhynenko, as GIS Team Manager, is under the supervision of the Deputy Team Leader, Sylvain Gautier.

Then, the Consultant proposes to enhance the experience mobilized by involving the National Technical Direction of Veolia Water. Its support will be required to confirm the suitability of some options (Phase 1) and to define the strategy for the use of the GIS after its implementation (Phase 2).

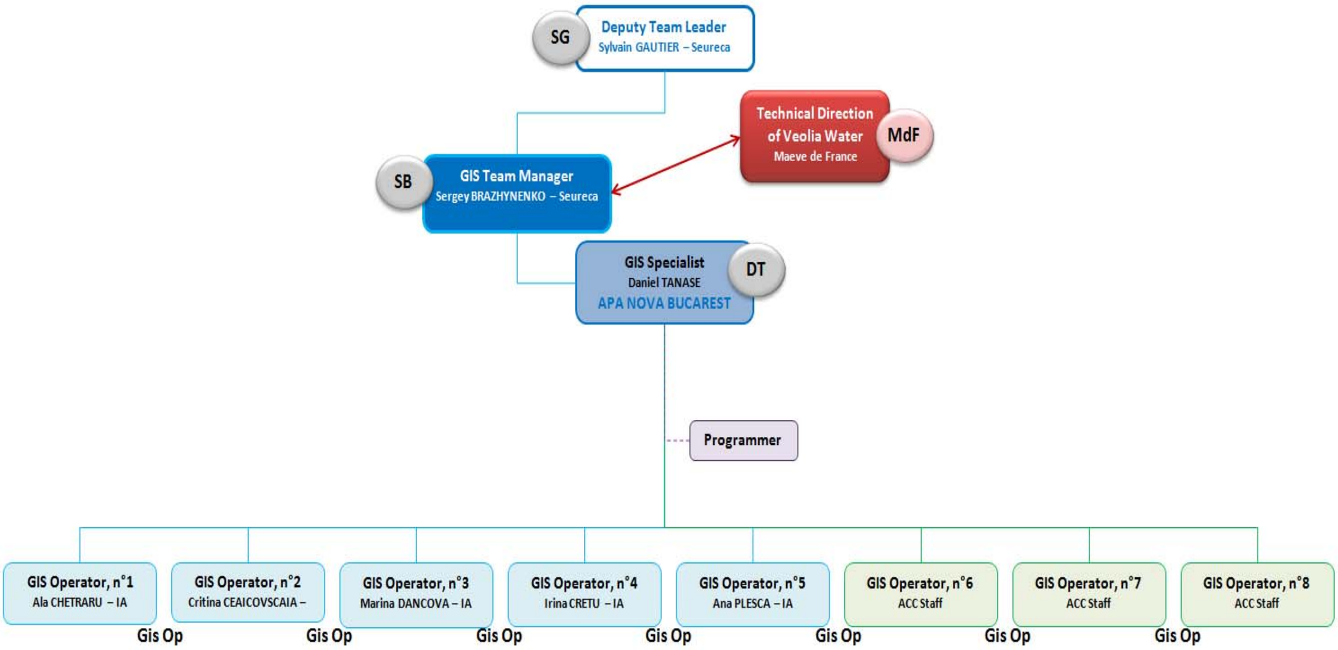

Figure 8: Organisation Chart of the GIS Implementation Team Project

2.3.2.2. GIS Operators

Taking into consideration the local context, the expected average ratio of input to the GIS is about 1.5 km/day/operator[1]. Therefore a team of 8 GIS operators (full-time) is required for the construction of the GIS, so it could be achieved within 10 months.

It has been agreed that 3 employees of ACC will join the team as GIS operators, so they will participate to the construction of the GIS. These employees will be trained at both the user and administrator level.

[1] This ratio includes digitization, construction of the database (attributes, …) and depends on the availability of data.

2.4. SELECTION OF GIS SOFTWARE

In our Methodology we proposed to use ESRI's Arcview software for the GIS, which is the most commonly used GIS in the water industry.

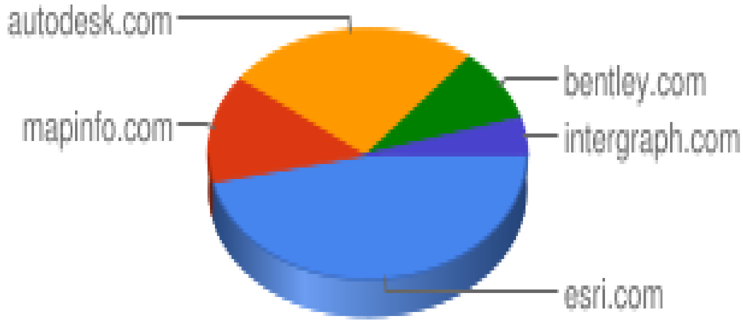

Figure 9: Most popular GIS software currently used in the World

However, taking into consideration the technical specifications set forth in the ToR and the financial constraints, one alternative is suggested.

Therefore a description and comparisons of two possible options is given below.

2.4.1. OPTION 1: RINEDAC + OPEN SOURCE SOFTWARE

2.4.1.1. General Description

The first suggested option consist in using the open source software QGIS, as shown on the Figure below.

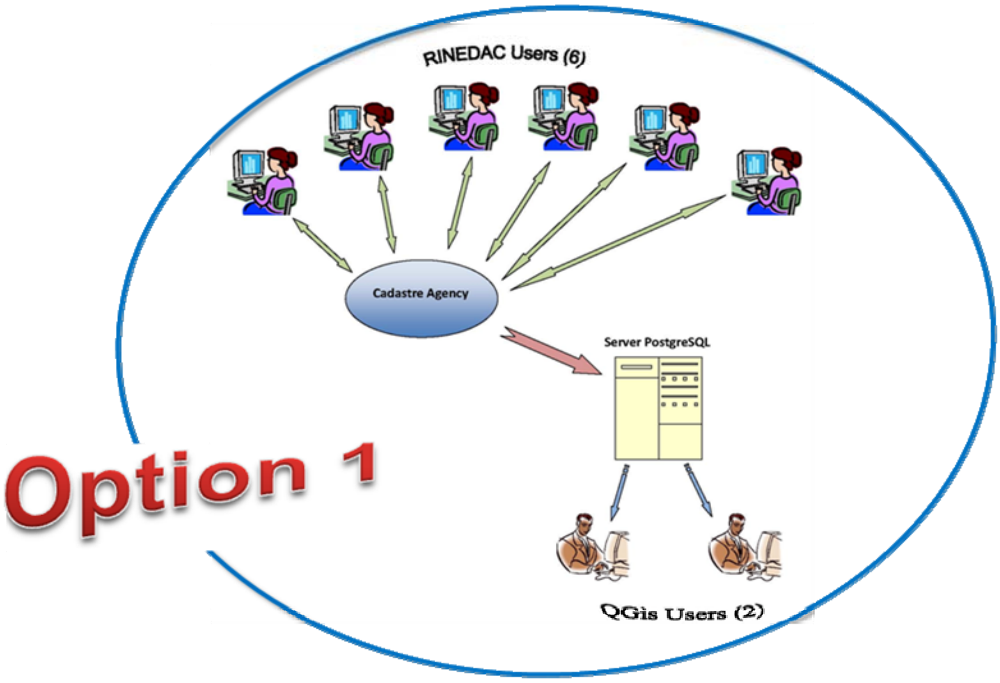

Figure 10: GIS Software Option 1: QGIS

QGIS (Quantum GIS) is one of the most common open source GIS. It is a community driven GIS project, licensed under the GNU General Public License. QGIS is an official project of the Open Source Geospatial Foundation (OSGeo). It supports numerous vector, raster, and database formats and functionalities.

QGIS is continually maintained by an international active group of GIS users and volunteer developers who regularly release updates and bug fixes. Currently, developers have converted Quantum GIS into 31 languages and the application is used internationally in academic and professional environments.

QGIS provides integration with other open source GIS packages, including PostGIS, GRASS, and MapServer to give users extensive functionality. It allows use of shapefiles, coverages, and personal geodatabases. MapInfo, PostGIS, and a number of other formats are supported in Quantum GIS. Web services, including Web Map Service and Web Feature Service, are also supported to allow use of data from external sources.

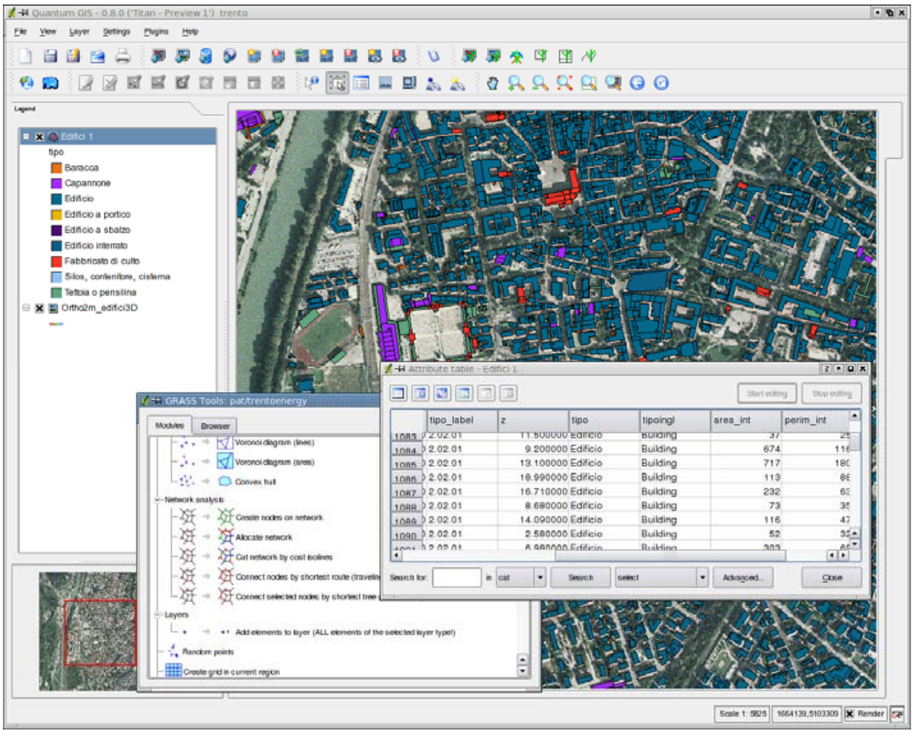

Figure 11: Quantum GIS 1.6Copiapo (last version)

2.4.1.2. Evaluation of PostGIS

Advantages of PostGIS:

Using an open source software is free and can be updated for free.

Then it has to be noted that because it is distributed as a free software application, QGIS can be reprogrammed to perform different or more specialized tasks. There are also plug-ins available to expand compatibility and functionality.

Drawbacks PostGIS:

Because it is community driven GIS project, a very skilled programmer is required to maintain such a software. It is worth pointing out that there is no open software support for a Corporate GIS.

Therefore, if this option is the preferred one, training needs for users/administrator shall be assessed carefully and provided by the Consultant.

2.4.1.3. Cost Estimates

Based on the assumption that the access to RINEDAC application costs 1,000 lei/user/month and taking into consideration the following exchange rates: 1EUR = 1.34USD and 1EUR=16.38Lei, the cost estimates for the Option 1 is presented in the table below:

Table 1: Cost Estimates – Option 1: QGIS

Item	Description	Unit Cost (EUR)	Quantity	TOTAL (EUR)
License	RINEDAC	61€/user/month	6 (15 months)	5,490
License	MS Windows server 2008 R2	1,000 €	1	1,000
Computer	-	750	8	6,000
Scanner A1	-	2,500	1	2,500
Server		from 1,200 €	1	1,200
TOTAL				**16,190**

2.4.1. OPTION 2: RINEDAC + ARCGIS

2.4.1.1. General Description

The second option consists in using ArcGIS as shown on the Figure below.

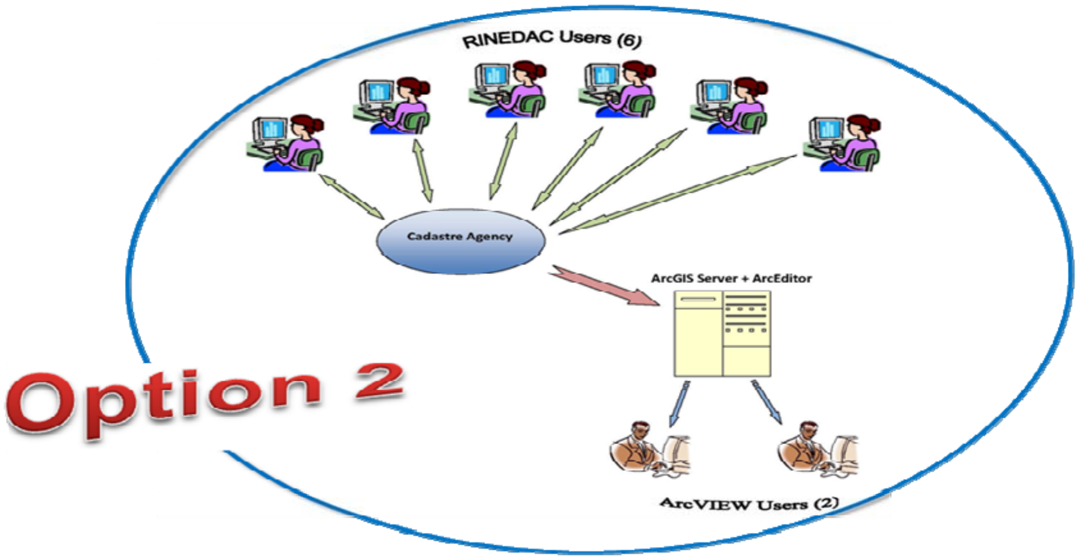

Figure 12: GIS Software Option 2: ArcGIS

ArcEdit is developed by ESRI, a US firm having distributing offices all over the world. ESRI's ArcGIS products support the Web Map Service (WMS) protocol mentioned above. ArcEdit also allows importation and exportation of data from or to any other GIS or CAD software.

2.4.1.2. Evaluation of ArcGIS

Advantages of ArcGIS:

The ESRI company, the developer of ArcGis software, has an extensive experience in providing support for worldwide companies.

In addition to this great popularity (see Figure 9), ArcGIS benefits from a wide analytical potential. It is also a powerful server decisions.

Drawbacks ArcGIS:

The main drawback of using ArcGIS is financial. As shown on Table 2, license for ArcGIS is very expensive. This makes the selection of this software a strategic decision for ACC management.

2.4.1.3. Cost Estimates

Based on the assumption that the access to RINEDAC application costs 1,000 lei/user/month and taking into consideration the following exchange rates: 1EUR = 1.34USD and 1EUR=16.38Lei, the cost estimates for the Option 1 is presented in the table below:

Table 2: Cost Estimates – Option 1: ArcGIS

Item	Description	Unit Cost (EUR)	Quantity	TOTAL (EUR)
License	RINEDAC	61€/user/month	6 (15 months)	5,490
License	ArcGIS (Standard)	33,500	1	33,500
License	MS Windows server 2008 R2	1,000 €	1	,1000
Computer	-	750	8	6,000
Server		from 1,200 €	1	1,200
Scanner A1	-	2,500	1	2,500
TOTAL				**49,690**

Note: cost for maintenance is not included in the above table.

2.4.2. CONCLUSION

During the presentation made on January 20th, the Consultant suggested to select the option 1, which complies with the ToR.

However, ACC informed the Consultant through a letter dated on March 16th that the option to be considered for the Project is the option 2.

It has to be noted that two presentations have been recently performed after this official decision, on the initiative of ACC, by Termokom ("Potok") and a representative of the Czech company ("Pragma" GIS).

2.5. PROVISION OF EQUIPMENT FOR PRODUCING THE GIS

The Consultant has equipped the 8 GIS operators with appropriate desktops and ACC has provided a room (working place) where the GIS operators will work. A scanner A1 is still needed. The Consultant has consulted several IT providers for this purpose.

Reportedly, ACC has signed a contract with the Cadastral Agency for the use of RINEDAC (8 licenses).

The cost of ArcGIS exceeds the amount set in the contract budget. ACC is presently looking at possible funds to complete the budget.

2.6. DEVELOPMENT OF BASE MAPS

The base maps currently used by ACC for the network maps contain too much information on the background which makes it difficult to read and use the maps.

Therefore, we have developed base maps by aggregating Google Earth images.

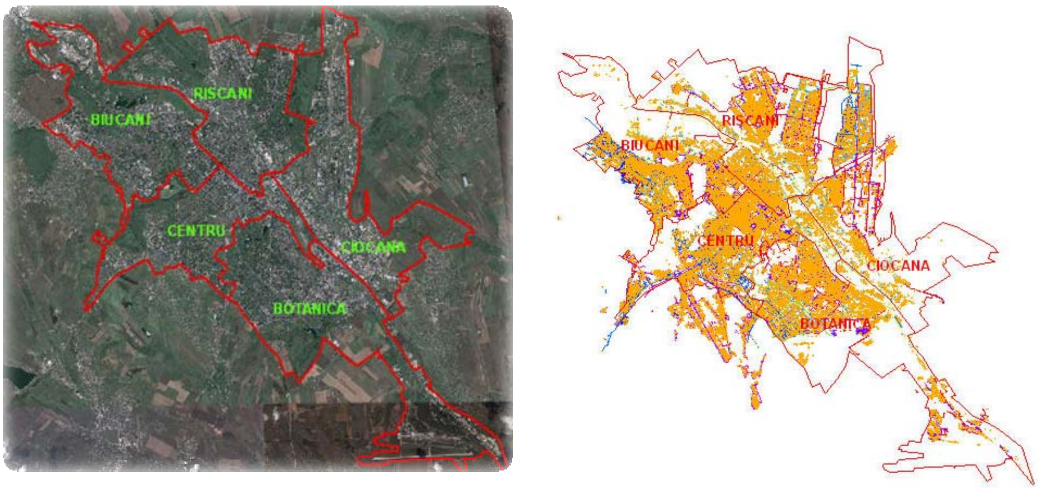

Figure 13: Google Earth images and CAD drawings

Then these images and the network converted in geodata base files have been imported in ArcGIS in MOLDREF99 coordinate system, as shown in the next figure.

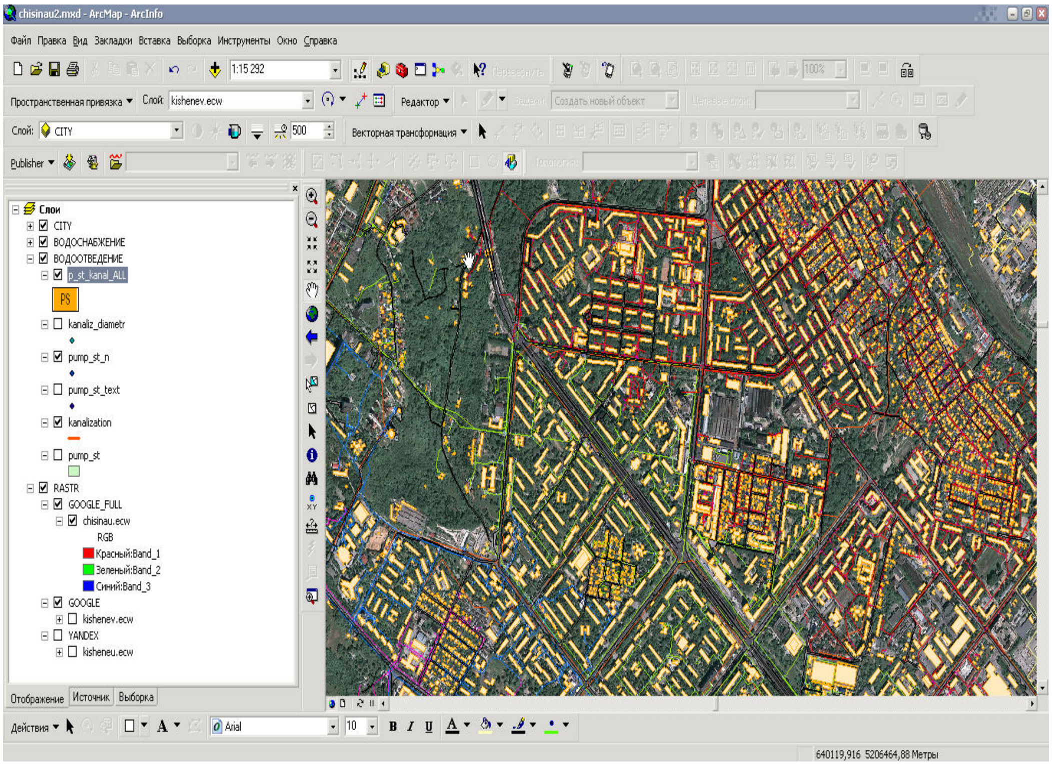

Figure 14: Import of Google Earth images & Shape files in ArcGIS and Mapinfo files

2.7. SELECTION OF ITEMS TO BE INCLUDED IN THE INITIAL GIS DATABASE

The Consultant is now discussing thoroughly with ACC the elements that are to be included in the GIS.

The main items to be included in the initial GIS are physical elements of the water and wastewater networks, notably:

- Pipelines
- Valve boxes and manholes
- Hydraulic fittings such as control valves, air release valves, pressure reducing valves, fire hydrants, standpipes
- Treatment plants
- Reservoirs
- Pumping stations
- Measurement equipment such as flow meters, pressure gauges

These elements should be included in the GIS and associated with their principal characteristics, such as dimensions, age, materials and so on.

The list of items that are suggested to be included into the data base of ACCis shown in the table below:

Table 3: Suggested items to be included in the GIS database

Water supply system		
Facilities of water supply system		
N	Elements	Type of the object
1	Water treatment plants	polygonal
2	Pumping stations	polygonal
3	Chlorination plants	polygonal
4	Reservoirs	polygonal
5	Chambers	polygonal
6	manholes	point
7	galleries	polygonal
8	wells	point
Elements of the water supply system		
9	Open valves	point
10	Valves	point
11	Fittings	point
12	Open fire hydrants	point
13	shutters	point
14	faucets	point
15	hydrants	point
16	pumps	table
17	Water meters	point
18	shell	linear
19	pipe	linear
General		
20	Events (failure)	point
21	Consumers	point

Waste Water System		
Facilities		
N	Elements	Тип объекта
1	Waste water treatment plants	polygonal
2	Pumping stations	polygonal
3	Reservoirs	polygonal
4	Chambers	polygonal
5	Manholes	point
6	Galleries	polygonal
7	Sinks	point
Elements of the waste water system		
8	Valves	point
9	Fittings	point
10	Shutters	point
11	Pumps	table
12	Shells	linear

13	pipes	linear
14	Outlets (discharges)	point
15	Gates	point
Общие		
16	Events (failure)	point

The attributes of each of the elements for the GIS data base of ACC is shown in details in the Appendix. The list and the attributes of each object shall be discussed and agreed with ACC.

The geographical database structure is at the design stage now. All the requirements of ACC regarding the structure and the contents of the geographical data base will be considered and agreed with ACC.

2.8. Identification of Items That May Be Added Later to the GIS Database

In addition to the items mentioned above, it will be useful to identify the other data items that the company may add at a later stage. Attention can thus be paid to ensuring that the GIS configuration is correctly adapted to later addition of such elements.

The database could be expanded in order to take into consideration such information as:

- **Event & Operating Management**:

GIS permits the identification of "black spots" with the damaged conduits that cause the most dysfunction of the system (blockages, leaks, service outages, etc.). Findings of the CCTV inspection of sewers can be automatically reported and stored into the GIS database. When selecting a pipe, one can see the picture of the internal pipe section. Diagnostics of sewage disruptions, such as sewer slope levels and frequency of cleaning operations, can be checked when facing flooding or blockages of sewers. The different maps can then be superposed. Frequency of cleaning of septic tanks can be stored in the GIS as well.

Furthermore, pipe bursts can also be reported and stored into the GIS database. Bursts, when located on the GIS, can be checked versus the pipe characteristics such as material, age, diameter (static data) and pressure levels, dynamic data such as maximum and variation of pressure levels. The last information may come either from a network of pressure loggers or based on calculations using hydraulic model

The events claimed by customers as well as preventive measure (replacement of material, etc) could also be indicated in the GIS. Operations on the valves, hydrants, air valves, burst repair, cleaning of sewers, cleaning of reservoirs can also be reported into the GIS.

- **Commercial**:

The data for each consumer can be managed using the GIS (the definition of the journeys for each meter reader, the data of consumption, the contract, history of claims,…).

For each street, it could be useful to enter some information such as:

- Number of customers (domestic, budget, commercial and industrial)
- Number of domestic water meters (year of installation, type, etc.)
- Number of water meters for non-domestic customers (year of installation, type, etc.)
- Number of stand-pipes in the street

In order to properly assess and monitor the performance of the systems, some key performance indicators (pressure in the network, continuity of supply, etc) could also be included, as well as other relevant information (big customer, bad payers, etc.).

- **Management of Metering Data**:

Customer water meters and their readings can be linked to the GIS. The level of consumption can be provided for any selected area at any time. The water balance may also be calculated if district metering areas have been equipped with flow meters. If equipped with remote reading systems (using radio or GSM communications), flow meters and water meters can read from the office. Data of pressure levels from sensors can be stored on a database connected to the GIS.

2.9. FUNCTIONAL STRUCTURE

Figure 15 presents the proposed functional structure.

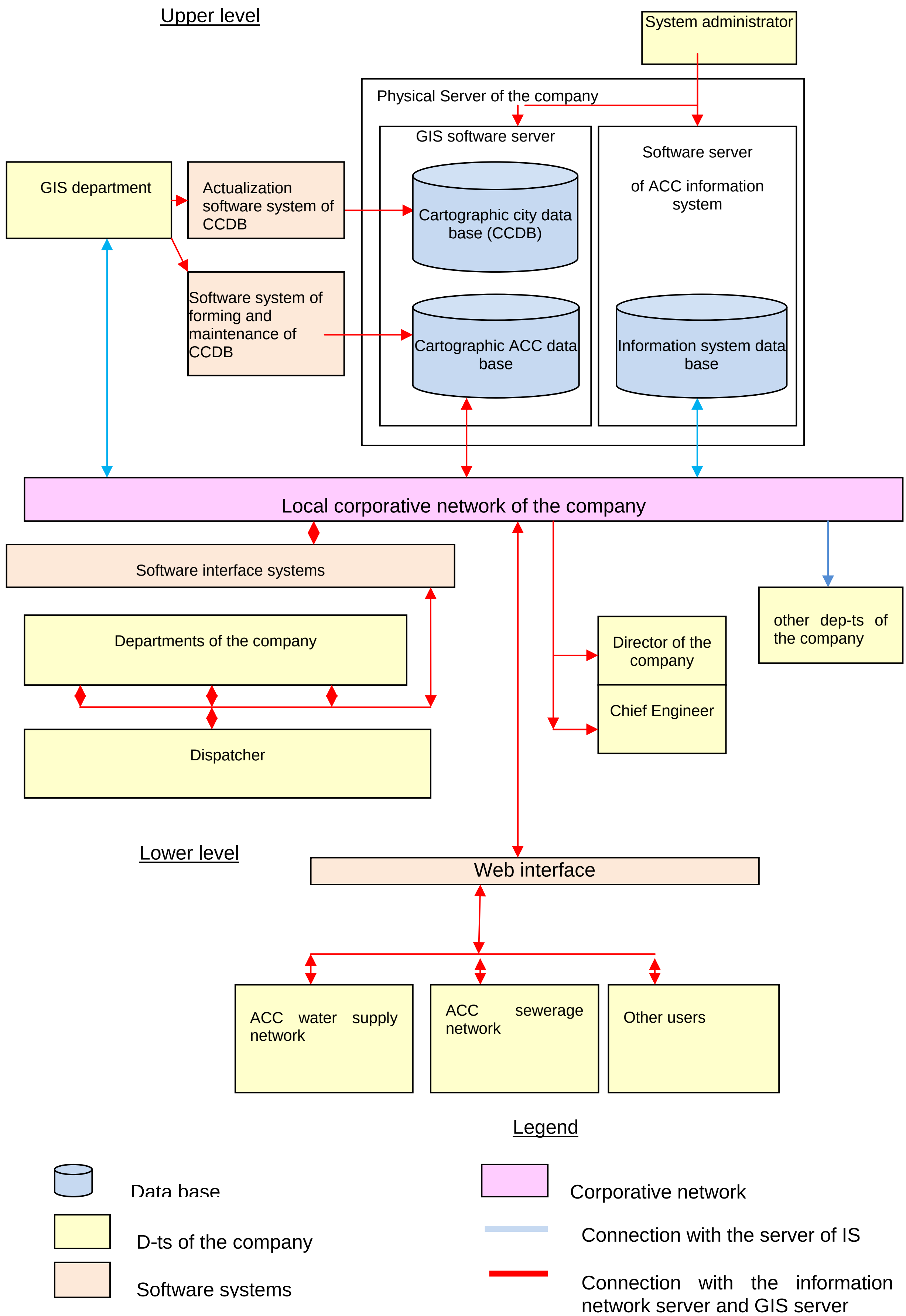

Figure 15: ACC Functional Structure