This mix provides for operational security while giving a balance between the economics, the cheaper land reclamation and reforestation, and environmental considerations, co-incineration which overall is environmentally the best disposal path. These disposal paths will have to be investigated in detail and confirmed during the execution of the strategy. Annex 10.5 gives a detailed description of the provisionally selected disposal paths by WWTP and year while the following table provides a summary overview.

Parameter	Unit	2011	2014	2015	2016	2017	2018	2019	2020	2021	2037
Bacău											
Composting (35 %)	%	0%	18%	45%	50%	50%	50%	50%	50%		
	t Wet Sludge	0	1,936	5,429	6,046	6,039	6,031	6,023	6,014	0	0
Landfilling Chimei Landfill (35 % DS)	%	100%	82%	55%	50%	50%	50%	50%	50%		
	t Wet Sludge	9,434	8,700	6,677	6,046	6,039	6,031	6,023	6,014	0	0
Co-Incineration	%									50%	50%
	t DS/y	0	0	0	0	0	0	0	0	1,910	1,836
Reforestation, Land Reclamation	%									50%	50%
	t DS/y	0	0	0	0	0	0	0	0	1,910	1,836
Moineşti											
Composting (35 %)	%				41%	42%	42%	47%	46%		
	t Wet Sludge	0	0	0	826	833	839	932	920	0	0
Landfilling Chimei Landfill (35 % DS)	%	100%	100%	100%	59%	58%	58%	53%	54%		
	t Wet Sludge	1,506	1,785	2,012	1,184	1,173	1,164	1,069	1,077	0	0
Co-Incineration	%									50%	50%
	t DS/y	0	0	0	0	0	0	0	0	317	304
Reforestation, Land Reclamation	%									50%	50%
	t DS/y	0	0	0	0	0	0	0	0	317	304
Buhuşi											
Composting (35 %)	%				43%	44%	44%	49%	49%		
	t Wet Sludge	0	0	0	826	833	839	932	920	0	0
Landfilling Chimei Landfill (35 % DS)	%	100%	100%	100%	57%	56%	56%	51%	51%		
	t Wet Sludge	1,329	1,691	1,907	1,079	1,070	1,061	966	975	0	0

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Parameter	Unit	2011	2014	2015	2016	2017	2018	2019	2020	2021	2037
Co-Incineration	%									50%	50%
	t DS/y	0	0	0	0	0	0	0	0	301	290
Reforestation, Land Reclamation	%									50%	50%
	t DS/y	0	0	0	0	0	0	0	0	301	290
Darmaneşti											
Composting (35 %)	%										
	t Wet Sludge	0	0	0	0	0	0	0	0	0	0
Landfilling Chimei Landfill (35 % DS)	%	100%	100%	100%	100%	100%	100%	100%	100%		
	t Wet Sludge	691	1,238	1,396	1,395	1,393	1,392	1,391	1,389	0	0
Co-Incineration	%									50%	50%
	t DS/y	0	0	0	0	0	0	0	0	221	214
Reforestation, Land Reclamation	%									50%	50%
	t DS/y	0	0	0	0	0	0	0	0	221	214
Târgu Ocna											
Composting (35 %)	%										
	t Wet Sludge	0	0	0	0	0	0	0	0	0	0
Landfilling Chimei Landfill (35 % DS)	%	100%	100%	100%	100%	100%	100%	100%	100%		
	t Wet Sludge	660	884	996	995	993	992	990	989	0	0
Co-Incineration	%									50%	50%
	t DS/y	0	0	0	0	0	0	0	0	157	150
Reforestation, Land Reclamation	%									50%	50%
	t DS/y	0	0	0	0	0	0	0	0	157	150
Caraboaia WTP - CF Facility											
Landfilling Chimei Landfill (35 % DS)	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total sludge weight (35 % DS)	t Wet Sludge	4,866	2,196	2,918	3,086	3,200	3,315	3,431	3,512	3,592	3,942
Baraţi WTP - Non-CF Facility											
Landfilling Chimei Landfill (35 % DS)	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Parameter	Unit	2011	2014	2015	2016	2017	2018	2019	2020	2021	2037
Total sludge weight (35 % DS)	t Wet Sludge	0	2,760	3,457	3,492	3,527	3,562	3,597	3,631	3,664	3,957

Table 7-28: Summary of provisionally selected disposal paths per agglomeration

Disposal Path		2011	2014	2015	2016	2017	2018	2019	2020	2021	2037
Landfilling Chimei Landfill (35 % DS)	t Wet Sludge/ y	18,488	19,253	19,364	17,278	17,396	17,518	17,466	17,585	7,256	7,900
Capacity 35 % DS	t Wet Sludge/ y	20,599	19,253	19,364	17,278	17,396	17,518	17,466	17,585	17,722	7,900
Composting (35 % DS)	t Wet Sludge/ y	0	1,936	5,429	7,697	7,705	7,709	7,886	7,854	0	0
Capacity Composting (35 %)	t Wet Sludge/ y		1,936	5,429	7,697	7,705	7,709	7,886	7,853		
Co-Incineration	t DS/y	0	0	0	0	0	0	0	0	2,906	2,794
Capacity	t DS/y	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Reforestation, Land Reclamation	t DS/y	0	0	0	0	0	0	0	0	2,906	2,794
Capacity	t DS/y	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table 7-29: Summary of provisionally selected disposal paths per County

Short-term Disposal Path: - *2011 to 2014*

- Solid Waste Landfill (81 - 99 % of sludge)
- Composting plus final disposal guaranteed by contractor (1 - 9 % of sludge)

Middle-term Disposal Paths: - *2015 to 2020*

- Solid Waste Landfill - provisionally selected disposal route (69 - 78 % of sludge)
- Composting plus final disposal guaranteed by contractor (22 - 31 % of sludge)
- Co-Incineration (dependent on successful negotiations)
- Bio-Gas Production with subsequent land filling (dependent on successful negotiations)

Long-term Disposal Paths: - *2021 and thereafter*

- Solid Waste Landfill
- **Co-Incineration** – provisionally selected disposal route (50 % of sludge)
- Bio-Gas Production with subsequent land filling (dependent on successful negotiations)
- Agriculture

- **Reforestation** – provisionally selected disposal route (25 % of sludge)
- **Land Reclamation** – provisionally selected disposal route (25 % of sludge)

Specifically, the short-term urban sludge disposal will be:

Bacău WWTP:

- The sludge will go to the central County Chimiei Street landfill and to the composting plant.

Buhuşi WWTP:

- The sludge will go to the central county Chimiei Street landfill.

Moineşti North WWTP:

- The sludge will go to the central county Chimiei Street landfill.

Târgu Ocna WWTP:

- The sludge will go to the central county Chimiei Street landfill.

The present concept (earlier considerations were otherwise) for the sludge disposal of the ISPA financed Baraţi WTP is to discharge the liquid sludge into the Bacău Agglomeration wastewater collection system. If this plan is realized the WTP sludge would become by far the largest industrial discharger to the Bacău WWTP, one which also contains heavy metals which cannot be eliminated. This concept must be reversed back to earlier plans to dewater the sludge onsite. The capital (WWTP) and operational (WWTP and sewer system) costs associated with discharging into the wastewater collection system are significantly higher than dewatering at the WTP site and transporting this sludge to a landfill.

The dewatered sludge from both WTPs will go to the Chimiei Street landfill over the whole planning period. This sludge cannot be utilized in any other way; it is mainly mineral with significant heavy metal concentrations.

Annex 10.5 depicts the sludge quantities for each WWTP and WTP with their tentatively selected disposal routes.

At this point in time, however, it is not at all possible to state which of the disposal paths in the long-term best meets the ***objectives*** set down by the County, the Romanian Ministry of Environment and Forests and the EU. This will only be possible after several years of operation of the CF facilities to be built, the implementation of the recommended harmonization of the legal and administrative regulations dealing with wastewater and sludge management in Romania (given below), and further intensive investigations and negotiations.

It should also be stated that the ***objectives*** for the sludge disposal procedures may and probably will not be the same at this time between the ROC and MoEF. It is imperative that all parties agree on the ***objectives*** to be used in determining the sludge disposal procedures before any meaningful decisions can be made.

The Regional Operator is responsible to execute the tasks defined in the strategy but needs to be supported by the local councils and, in some areas, the local County OSPA, APM and ROMSILVA offices. Tasks are also defined for the Ministry of Environment and Forests to support and enhance the strategy implementation at the local level. These important improvements in the legislative and administrative procedures are outside of the realm of the Cohesion Fund activities but have been defined here as very important steps in improving the sludge disposal management in Romania.

The strategy itself is a structured set of activities designed to lead to an optimal sludge disposal management procedure. The figures in Annex 10.6, 10.7 and 10.8 depict the flow of these activities and decisions. The process flow diagrams show the relationship of the tasks involved the strategy. The tasks necessary to implement the activities shown in Annex 10.6, 10.7 and 10.8 are as follows.

Strategy Implementation Steps

I. First Step Activities – <u>completed by 2012</u>

A. Planning Procedures

Local Authorities responsible for execution of activities in consensus with the MoEF and the EU

1. Determine sludge disposal objectives and priorities

2. Determine the measures or criteria for disposal procedure evaluation

B. Industrial Dischargers [12]

Regional Operator responsible for execution of activities

1. Setup Inventory

   complete in detail and with ongoing updating

2. Modify Contracts

   implement a unified contract for all the agglomerations making adjustments after changes in NTPA-002, MO 344/2004, etc

3. Setup Discharge Data Base

   ==> *must have dedicated staff !!*

4. Monitor Industrial Discharges

   ongoing expanded program for agricultural sludge management

C. Sludge [13]

Regional Operator responsible for execution of activities

1. Setup Data Base

   ==> *must have dedicated staff !!*

2. Monitor Sludge

- establish unified sampling procedures
- carry out parallel laboratory analyses of samples to establish the uncertainty limits of the laboratory results

[12] See Chapter 6.9 Action Plan to Manage Industrial Dischargers

- carry out an ongoing program according to MO 344/2004 to establish quality standards needed for agricultural, land reclamation and forestry use of sludge

II. Second Step Activities – completed by 2018

Regional Operator responsible for execution of most activities

A. Co-Incineration

Negotiate possible contract(s)

- Lafarge Ciment cement factory in Hoghiz
- Carpatcement cement factory in Bicaz
- General Energetic biomass-power plant in Pângărați

B. Bio-Gas Production

Negotiate possible contract

- Scandinavian Biogas

C. Agriculture

1. Determination of Usable Areas

   according to MO 344/2004, an ICPA and OSPA activity

2. Agricultural Use Field Trials

   according to MO 344/2004, an ICPA and OSPA activity

3. Negotiate Possible Contracts with Agricultural Operators

D. Forestry

1. Determination of Reforestation Areas

   a National Forest Authority, Bacău Forest Directorate (Regia Națională a Pădurilor-Romsilva, Direcția Silvică Bacău) activity in cooperation with local councils

2. Reforestation Field Trails

   according to MO 344/2004, an ICPA activity

3. Negotiate Funding

   with the Ministry of Environment and Forests and the Ministry of Agriculture and Rural Development to have funds provided from the State budget according to the Forestry Code, Law 46/2008

E. Land Reclamation

1. Determination of Reclamation Sites/Areas

   an ICPA, OSPA and APM activity

2. Reclamation Field Trials

   according to MO 344/2004, an ICPA and OSPA activity

3. Negotiate Funding

   with the Ministry of Environment and Forests and the Ministry of Agriculture and Rural Development to have funds provided from the State budget according to Article 41 of the Land Reclamation Law, Law 138/2004

III. Third Step Activities – completed by 2020

Regional Operator responsible for execution of activities

A. CO_2 and Energy Balance Study

B. Select Disposal Scheme

   using multi-objective decision making procedure[13] which includes monetary and non-monetary criteria to select a scheme which can include simultaneously several disposal paths, considering the goals of

   - disposal security
   - environmental security
   - affordability

C. Implement Selected Disposal Scheme

D. Post-Implementation Monitoring – continuing

   - environment
   - economics

E. Plan Modification – continuing

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[13] For example: Keil, S. 2009. Preparation of a sludge disposal strategy for Prahova County / Romania, Diplomarbeit, Bauhaus-Universität Weimar, Weimar, Germany

The middle and long-term urban-sludge disposal alternatives must be coordinated with the solid-waste disposal from large scale, intensive animal production units in the County.

It should also be clearly noted that the optimal disposal procedure for urban sludge is not necessarily the cheapest when all the goals of society are brought into the evaluation.

A harmonization is needed of several Romanian regulations having to bear on sludge management. These activities are outside the scope of this study but have been defined here as they are necessary to improve the effectiveness of the sludge disposal procedures. They will enable an effective management of the industrial dischargers for proper WWTP operation that will produce a sludge which can be used in agriculture, land reclamation and reforestation (see Chapter 6.10 for these recommendations).

At the national level several actions will be necessary to ensure an effective sludge disposal in the future, they are as follows:

1. The Ministry of Agriculture and Rural Development (Ministerul Agriculturii şi Dezvoltării Rurale) must ensure, as specified in Ministerial Order 344/2004, Chapter 3, §3.a, that there is a significant increase in the number of certified laboratories in Romania which can carry out the required analyses of MO 344/2004.

   Presently there is not enough laboratory capacity to carry out all the tests which would be required if there is any significant use of urban sludge in agriculture. In fact, there is not enough laboratory capacity at present to handle the analyses necessary if wastewater system operators regularly monitored all the NTPA-002 limits.

2. The Ministry of Agriculture and Rural Development (Ministerul Agriculturii şi Dezvoltării Rurale) must ensure, as specified in Ministerial Order 344/2004, Chapter 3, §3.b, that the funding is provided such that the national Research Institute for Soil Science and Agrochemistry (Institutul de Cercetări pentru Pedologie şi Agrochimie) and the County Soil Science and Agrochemestry Office (Oficiul de Studii Pedologice şi Agrochimice), can prepare special soil science reports which identify the land suitable for the use of urban sludge and carry out follow-on evaluations of the cultures at these sites, i.e., field trials.

   The necessary studies to determine where sludge might be utilized in agriculture have not yet been completed in the County and, therefore, no meaningful evaluation of agricultural use of sludge can be made at this time. Until these soil science and agronomic studies are carried out the use of sludge in agriculture represents nothing more than a theoretical concept.

   Follow-on field trials are essential to demonstrate the advantages of sludge application to the land owners and to determine the technical and economic consequences of its use. Without this the public acceptance will remain at its present low level. The same can be said for the areas of land reclamation and reforestation.

7.12 Conclusions

There are significant deficiencies in the present sludge management in Bacău County; none of the WWTPs treating domestic wastewater are presently disposing of their sludge compliant with Romanian regulations. The limited number of quality analyses available indicate that, with proper management of the industrial dischargers, the sludge would be appropriate for agricultural, forestry and land reclamation uses. ***There exist several good possible disposal routes for sludge in the County.*** Cost estimates have been prepared for five of the six of these possible procedures. A strategy has been spelled out which will lead to an environmentally and economically balanced and secure disposal plan.

The proposed strategy provides a road map to identify the ***optimal*** long-term disposal procedures considering the various ***objectives*** of the County, Romania and the EU. The execution of this strategy will function like an Action Plan to structure the County's future sludge management.

The performance indicators for urban sludge management in the CF agglomerations given below show the only possible disposal path which is available at the time the CF construction will be complete, 2015. Later disposal paths cannot definitely be selected at this point.

No.	Performance Indicators	Unit	TOTAL / AVERAGE	
			Before Project	After Project 2015
3.8.2	Sludge volume (wet sludge)	1000 m³/a	incomplete data	22.5
3.8.2.1	Dry solids content (sludge total)	1000 t DS/a	no data	7.9
3.8.3	Sludge quality			
3.8.3.1	Dry solids content	%	no data	35
3.8.3.2	Total number of parameters NOT-compliant with RO/EU regulations	number	no data	no data
3.8.4	Sludge disposal and reuse			
3.8.4.1	Sludge reuse in agriculture	1000 t DS/a	no data	0
3.8.4.2	Sludge reuse in reforestation	1000 t DS/a	no data	0
3.8.4.3	Sludge composting	1000 t DS/a	no data	1.7
3.8.4.4	Sludge disposal at sanitary landfill	1000 t DS/a	no data	6.2
3.8.4.5	Sludge incineration	1000 t DS/a	no data	0
3.8.4.6	Other - lagoons + drying beds	1000 t DS/a	incomplete data	0
3.8.4.7	Sludge reuse in agriculture	% of 3.8.2	no data	0
3.8.4.8	Sludge reuse in reforestation	% of 3.8.2	no data	0
3.8.4.9	Sludge composting	% of 3.8.2	no data	22
3.8.4.10	Sludge disposal at sanitary landfill	% of 3.8.2	no data	78

No.	Performance Indicators	Unit	TOTAL / AVERAGE	
			Before Project	After Project 2015
3.8.4.11	Sludge incineration	% of 3.8.2	no data	0
3.8.4.12	Other - lagoons + drying beds	% of 3.8.2	incomplete data	0
3.8.6	Sludge storage capacity in months (i.p. for agricultural reuse)	months	no data	6
3.8.7	Total volume of sludge end-disposed in compliance with EU directives	m³/d	no data	61.6

Table 7-30: Performance indicators urban sludge management – Bacău County

CHAPTER 8

DESIGN PARAMETERS

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8 DESIGN PARAMETERS

The table below recaps the Romanian and European standards used to develop this Feasibiity Study:

STAS SR 1343-1/2006	Calculation of drinking water supply quantities in urban and rural sites. Standard was issued based on the following references: STAS 1343/2 – 1989, STAS – 1478-1990, SR EN 805-2000, SR EN 1508:2000, SR 10898:2005, listed below.
STAS 1343/2 – 1989	Calculation of water supply quantities for industrial field-
SR EN 805-2000	Water Supply. Provision for components and systems located outside buildings.
SR EN 1508:2000	Water Supply. Provisions regarding the water storage system and components.
SR 10898:2005	Water Supply and Sewage. Fundamentals and vocabulary.
STAS 3051-91	Sewerage Systems. Channels of external sewerage systems
STAS 4163-1	Water Supplies. Distribution networks. Design specification.
STAS 4163-2	Water Supplies. Distribution Networks. Calculation prescriptions.
STAS 1846-1:2007	Sewage outside the buildings. Design Specification. Section 1. Calculation of sewage waste water flows.
STAS 1846-2:2007	Sewage outside the buildings. Section 2. Design Specification. Calculation of storm water flows.
NTPA-011/2002	Technical norms concerning the collecting, treatment and discharge of urban waste waters, which corresponds with the EU directive 98/15/EEC
NTPA-002/2002	Condition on discharge of waste water into the sewage system or directly into the recipient stream.
NTPA –001/2002	Allowable limits assigned to the pollutants load of effluents (both for urban and industrial waste water) at discharging directly into the recipient stream.
Law 458/ 8. 07.2002	Regarding the drinking water quality corroborated with Law 311/ 28.o6.2004, which corresponds with the EU directive98/83EC

Table 8-1: Recap of Romanian and European Standards

The basic design criteria have been prepared based on the followings:

- The planning horizon of the Master Plan is 2037;
- The Accession Treaty is granting Romania transition periods to reach compliance with the EU acquis:
  - Compliance with the Directive 98/83/EC on drinking water quality shall be achieved by 2015;
  - Compliance with the Directive 91/271/EEC on urban wastewater collection, treatment and discharge shall be provided as follows:
    - Phase 1 – 2015: Towns, municipalities and agglomerations over 10,000 p.e.;
    - Phase 2 – 2015 to 2018: All agglomerations between 2,000 and 10,000 p.e.;
    - Phase 3 – 2037: any agglomerations below 2,000 p.e.;
- The population size of the localities.

8.1 Population Development

According to official statistics, population growth has been negative in Romania and the Eastern Region since 1990. The population in the country decreased from 23.2 million people in 1990 to 21.6 million in 2006. That is an annual average shrinkage of –0.43%. The decline is due to two main factors: negative natural growth and a strong net emigration, mainly to Western Europe.

Over the same period, the North-East Region, including Bacau County, has a much lower shrinkage rate (0.08%) than whole Romania (0.43%). In Bacau County specifically, the population has decreased with an annual average shrinkage rate of 0.12% from a value of 736,347 inhabitants in 1990 to 721,848 inhabitants in 2007.

All recently published population forecasts, including forecasts published by the INS in 2004 and 2005, predict a continuation of the declining demographic trend for Romania, including all its eight Development Regions and 41 Counties. In these forecasts, total population at the national level is predicted to fall from roughly 21.6 million in 2005 to somewhere between 19 and 20 million inhabitants in 2025, depending on the chosen scenario.

The Consultant has chosen to base its demographic forecast for the Project Region Bacau County on a conservative future scenario, taking as reference the recently published INS and Eurostat forecasts and the population trends predicted also for other

Eastern European countries. For the period 2007-2037, the predicted average annual growth rate for Bacau County is -0.15% p.a. In line with the official population forecast made for urban and rural areas in the Eastern Region (INS, 2005), the population growth rate in both urban and rural areas of Bacau County are predicted to be negative (urban: -0.26% p.a., rural: -0.07% p.a.).

The following table shows a summary of the population development for each of the 5 priority agglomerations:

Year:	2008	2010	2015	2020	2025	2037
Agglomeration Bacau	197,013	196,394	194,863	193,299	191,013	183,710
Agglomeration Moinesti	23,902	23,814	23,602	23,391	23,095	22,178
Agglomeration Buhusi	19,644	19,571	19,397	19,223	18,981	18,227
Agglomeration Darmanesti	11,508	11,465	11,364	11,262	11,120	10,678
Agglomeration Targu Ocna	12,118	12,073	11,965	11,859	11,709	11,244
Total Inhabitants CF Agglom.	264,184	263,317	261,191	259,033	255,917	246,036
Difference [%]	0%	-0.3%	-0.8%	-0.8%	-1.2%	-2.4%
Difference to 2008 [%]	0%	-0.3%	-1.1%	-1.9%	-3.1%	-6.9%

Table 8-2: Population Development

Details for each year can be found in annex 2.1. All agglomerations have a decrease from 2008. The change from 2008 till 2015 is 1.1 % and very low compared to a usual design margin of 20 %. Until 2037 predicted decrease is 6.9 %.

8.2 Water Supply

In this FS, the systems have been calculated and designed based on the two following general principles:

- Total water demand = Domestic Demand + Non Domestic Demand + Real Losses (+ Fire Extinction Demand for design networks and reservoirs)
- Design Margin: Approximately 20 %

8.2.1 Domestic Water Demand

According to the Romanian Standard SR 1343-1:2006, the specific domestic demand design value shall range between 100-120 l/day per capita.

It is however assumed that current specific consumptions of domestic water will be reduced / increased to the levels here below after introducing water metering and cost covering tariffs (Consumption Elasticity rate). Therefore, the Specific Water Consumption rates considered in this feasibility study are:

- House Connection (HC): **46-123 litres/capita/day**

Yard and public tap connections are not considered in designs of the present study. The lowest value is the existing value in water supply zone Buhusi in 2007, the highest values are predicted for the year 2037. It must be said that the existing specific consumptions in 2007 till 2009 are based on the domestic water invoiced.

The value used for designs is 110 l/cd and is the same as defined in the guide for water FS. According our experience and also to the performed measurements it is a well fitting value, a justification based on existing domestic consumptions is shown in chapter 8.2.3.

According to STAS 1343-1/2006, the Daily and Hourly variation coefficients of the water demand depend on the specific climate for the locality under consideration and on the number of inhabitants of the locality. For this study, these variation coefficients have been determined accordingly and fixed at:

- Daily variation coefficient (average value) – Kday = **1.25**
- Hourly variation coefficient (average value) – Khour = **1.40**

The values are the same as defined in the guide for water FS, according our experience they are well fitting values. It is to be noted that these figures (Specific Water Consumption and Daily and Hourly variation coefficients) have been validated in the field in the framework of flow measurement campaigns, see annex 3.3 of present FS and chapter 2.9 of the Masterplan.

The following table shows a summary of the domestic demand for each of the 5 priority water supply zones for a design connection rate of 100%:

Domestic Demand [m³/d]	2008	2010	2015	2020	2025	2037
Domestic Water Demand Bacau	20,446	19,724	18,878	19,849	20,672	22,553
Specific Demand [l/cd]	104	100	97	103	108	123
Domestic Water Demand Moinesti	2,098	2,060	1,979	2,079	2,164	2,357
Specific Demand [l/cd]	88	87	84	89	94	106
Domestic Water Demand Buhusi	923	900	1,612	1,694	1,762	1,920
Specific Demand [l/cd]	47	46	83	88	93	105
Domestic Water Demand Darmanesti	703	699	956	1,004	1,045	1,138
Specific Demand [l/cd]	61	61	84	89	94	107
Domestic Water Demand Targu Ocna	921	918	1,019	1,070	1,114	1,213
Specific Demand [l/cd]	76	76	85	90	95	108
Total Dom.Demand CF Agglom.	25,091	24,301	24,445	25,697	26,757	29,181
Difference [%]	0%	-3.2%	0.6%	5.1%	4.1%	9.1%
Difference to 2008 [%]	0%	-3.2%	-2.6%	2.4%	6.6%	16.3%

Table 8-3: Domestic Demands at 100 % Connection Rate

These demands are based on the number of population and a design connection rate of 100 % which will be more or less achieved within the period 2015-2020 for all priority water supply zones. Therefore these values are useful for design purposes.

The specific demand 2007 till 2009 values were provided by the operator and are the billed quantities.

The applied average domestic design flow for all priority water supply zones is 10.59 mil m³/year or 29,013 m³/d, it results from 2009 population multiplied with 110 l/cd. On the other hand there is a design margin of 20% respected by dimensioning the facilities and networks to be on the safe side. This is shown in the next figure:

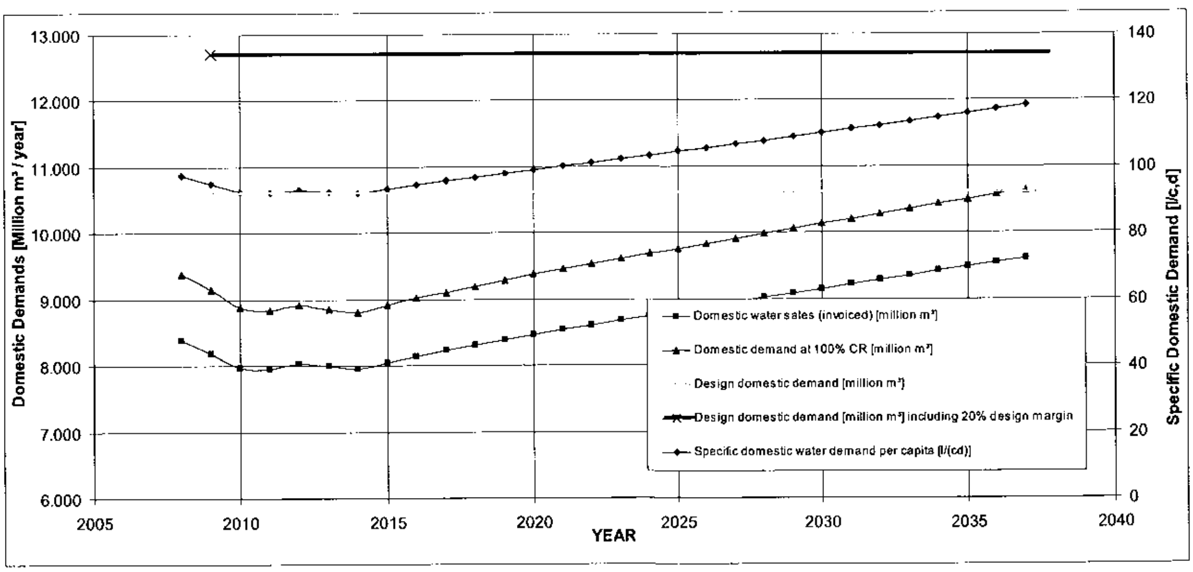

Figure 8-1: Domestic Demands for all CF Agglomerations

8.2.2 Non-domestic Water Demand

Non-domestic water demand includes public water demand and industrial water demand (including commercial demand and agriculture). Public demand refers to the water demand of public facilities such as schools, hospitals, offices of local and central authorities etc.

As all priority water supply zones do not have separate potable and non-potable water supply and distribution systems, it must be assumed that all of the non-potable water requirements, except industrial process water, must be satisfied out of the potable water supply system. Accordingly, the public water supply also includes water for urban green areas, street cleaning and flushing of sewers.

For designs within this FS a population related non-domestic demand which is distributed on the supply areas according the population distribution and additional (bulk) non-domestic demands were calculated separately. Based on experience in other European countries however, the population related non-domestic specific demands were assumed to be:

- **50 l/c/d** for urban areas (20 l for public and 30 l for small industries)
- **25 l/c/d** for rural areas (10 l for public and 15 l for small industries)

A justification of these values based on existing consumptions is shown in chapter 8.2.3.

The following additional (bulk) non-domestic design demands are recommended to be applied separately for each CF Agglomeration in Bacau County:

Bacau: 50 l/s; Other agglomerations: 5 l/s each

The following table shows the non-domestic flows as they were applied in CBA (2008 existing values and assumed elasticity):

Non Domestic Demand [m³/d]	2008	2010	2015	2020	2025	2030	2037
Non Domestic Water Demand Bacau	10,433	9,009	8,356	8,782	9,230	9,701	10,401
Non Domestic Water Demand Moinesti	746	731	675	692	709	727	753
Non Domestic Water Demand Buhusi	129	239	223	234	246	258	277
Non Domestic Water Demand Darmanesti	128	128	130	131	132	134	136
Non Domestic Water Demand Targu Ocna	748	751	758	766	774	782	793
Total Dom.Demand CF Agglom.	12,184	10,858	10,142	10,605	11,091	11,602	12,359
Difference [%]	0%	-10.9%	-6.6%	4.6%	4.6%	4.6%	6.5%
Difference to 2008 [%]	0%	-10.9%	-16.8%	-13.0%	-9.0%	-4.8%	1.4%

Table 8-4: Non-domestic flows from CBA

Within the network analyses bulk consumers were applied at their location and with their measured demands for 2008. These demands were cross-checked with specific values from STAS, which for example are:

- Industries: 40 l/employee,d
- Hospitals: 300 l/bed,d
- Hotel: 200 l/bed,d
- School: 50 l/pupil,d

8.2.3 Total Demand, Losses and Verification:

The following table shows a summary of the specific demand values:

Estimation Water Demand			
		Quantity [l/cd]	
	Type of Demand	Urban	Rural
1	Domestic water demand	110	110
2	Non-domestic water demand		
2.1	Non-domestic water demand - population related		
2.1.1	Non-domestic demand public	20	10
2.1.2	Non-domestic demand commercial+small industries	30	15
2.2	Non-domestic water demand - large industries		
	Separate estimation considering large industries for each CF agglomeration		
3	Total demand - population related	160	135
4	Water Losses [% of total water demand - population related + large industries] *		
4.1	Aged systems	50%	50%
4.2	Systems fully rehabilitated or built within last years*	25%	25%
4.3	New systems	15%	15%
5	Factors		
5.1	Factor peak day/medium day	1.25	1.25
5.2	Factor peak hour/daily demand	1.4	1.4
* ... For partly rehabilitated systems or mixed systems estimate intermediate values case to case			

Table 8-5: Total Specific Demands

The domestic specific demand of 110 l/c,d can be verified by existing consumptions of the years 2007-2009, which were in Bacau County:

- City Bacau: 104 l/c,d
- Moinesti: 87-88 l/c,d (single value 90 in March-April 2010)
- Buhushi: 45-47 l/c,d (single value 114 incl nondomestic in February 2010)
- Darmanesti: 59-61 l/c,d
- Targu Ocna: 76 l/c,d

The values of Buhushi, Darmanesti and Targu Ocna are lower but may increase in the following years according to increasing supply-quality and life-standard. Present values of population related demands in western European cities are at the same levels as the applied design values.

Real (physical) losses

The Romania Standard SR 1343-1/2006 states one should use 15 % losses for new distribution systems and 30 % for "modernized and extended" systems. We consider 15 % for extensions and parts rehabilitated in the present project, 25 % for existing systems built within the last 10 years and 50 % for aged systems.

As design value a level of approx. 25-30 % technical losses were taken in consideration. This value is to assume because of parallel rehabilitation measures which will be financed by any other funds. Details can be found in Annex 3.6 FS.

Fire fighting

The flows for fire fighting were considered for the following parameter according to STAS:

Population	No Simultaneous Fire	Hydrants [l/s]	
		1 – 4 floors	4 floors
< 10'000	1	5 - 10	10 - 15
10.000 ≤ pop. ≤ 200.000	2	10 - 30	15 - 40
200'000	3	-	≥ 55

Table 8-6: Fire Flows

The following duration for drinking water use during fire fighting activities were considered:

- Duration for external fire extinction: Tie = **3 hours**;
- Duration for internal fire extinction: Tii = **10 minutes**;
- Number of simultaneous fires:
  - 10.000 ≤ water supply zone ≤ 200.000 people: **2**;
  - Water supply zone > 200.000 people: **3**;
- Flows for external fire extinction: Qie = **10-20 l/s** (according size)

Load cases fire-fighting were combined with maximum hourly flow on a medium day in network analyses. Also untouchable volumes are foreseen in reservoirs.

8.2.4 Hydro-geological Data

Present FS for Bacau County does not include rehabilitation of wellfields or other groundwater sources.

8.2.5 Water Quality and Treatment:

The quality of drinking water for human consumption is defined by the Drinking Water Law 458/2002, amended by Law no. 34/2005.

In defining these basic design criteria, it was considered that the drinking water quality standards must be compliant with the EC DWD 98/83/EC. Recent analyses are presented in Chapter 5.

Within Bacau County ground water and surface water is used as raw water for potable water production. The quality of the water sources has been evaluated in the course of MP elaboration. For the assessment of the surface water sources the EU Council Directive 75/44/EEC concerning the quality required of surface water intended for the abstraction of drinking water has been used.

According to the Council Directive 75/44/EEC surface water quality is divided into three categories, A1, A2, and A3, which correspond to the appropriate standard methods of treatment:

- Category A1 surface water needs a simple physical treatment and disinfection, e.g. rapid filtration and disinfection.
- Category A2 surface water needs a normal physical and chemical treatment, extended treatment and disinfection, e.g. pre-chlorination, coagulation, flocculation, decantation, filtration, disinfection (final chlorination).
- Category A3 surface water needs an intensive physical and chemical treatment and disinfection, e.g. chlorination to break-point, coagulation, flocculation, decantation, filtration, adsorption (activated carbon), disinfection (ozone, final chlorination).

The design principles for the surface water treatment applied for the measures descript within the FS are summarized below.

<u>Surface water treatment</u>

As only surface water sources inline with category A1 and A2 has been determined in Bacau County following surface water treatment processes will be used:

- Oxidation
- Coagulation / flocculation (including an additional powder activated carbon treatment for emergency cases)
- Sedimentation
- Filtration
- Disinfection (chlorination)

The sludge generated in the water treatment plant will also have to be treated. Typical process steps are:

- Gravity thickening
- Dewatering by centrifuges

The process is illustrated in the figure below.

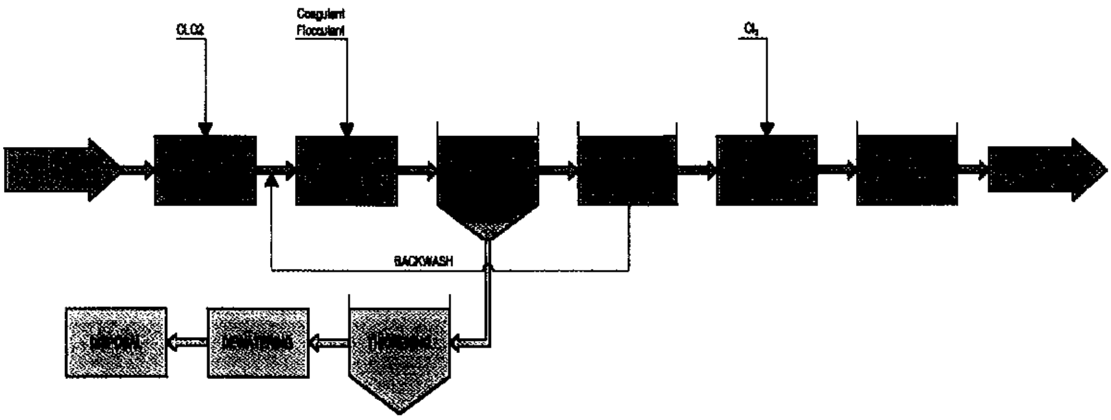

Figure 8-2: Typical surface water treatment process

<u>Oxidation</u>

Physical-chemical oxidation is used in the treatment of surface waters for a range of purposes:

- Precipitation of dissolved compounds like iron, manganese and sulphides;
- Assisting of the downstream coagulation-flocculation process;
- Breaking down of organic compounds especially those responsible for colour, odour and taste;
- Elimination of ammonia nitrogen;
- Conversion of non-biodegradable substances into substances that can be assimilated by bacteria.

For the oxidation of raw water following reagents can be added to the raw water:

- Chlorination (pre-chlorination),
- Chlorine dioxide (ClO_2),
- Ozone (O_3),
- Potassium permanganate.

Due to the potential risk of the formation of THM and HAA by-products from a competing reaction with the organic matter present the pre-chlorination of raw water is not recommended. As the focus of the treatment of surface water is more on the destruction

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of algae and other organic compounds causing odour and taste chloride dioxide is proposed to be used for the oxidation process.

Selected design figures for design:

Chloride dioxide dosing rate	1.2 - 1.4	mg/l

Coagulation - Flocculation

The coagulation/flocculation process aims at removing colloidal suspended pollutants that can not be settled naturally due to their suspension stability in water.

Coagulation is the destabilisation of colloidal particles through addition of a chemical reagent, the coagulant (e.g. ferric chloride, polyaluminiumchloride, etc.).

The formation of bigger flocs that can settle from microflocs is called flocculation. The flocculation can be enhanced by adding flocculants (e.g. synthetic polymers) to the water.

Selected design figures for design:

Coagulant dosing rate	7 - 32	mg/l
Powder activated carbon*	max. 20	mg/l
Velocity gradient coagulation	up to 1,000	s^{-1}
Polymer dosing rate	0.1 – 0.2	mg/l
Velocity gradient flocculation	up to 100	s^{-1}

*powder activated carbon treatment is only used for emergency cases, see chapter 10

Sedimentation

Sedimentation is the method most frequently used for separating suspended solids and colloids. The latter first have to be aggregated into flocs by an upstream coagulation-flocculation process. The sedimentation avoids overloading and frequent blockage of the downstream filter units.

Selected design figures for design:

Hydraulic surface loading rate	≤ 1	m/h

Filtration

Rapid filtration will be designed as single layer sand filters. Small treatment plants ($Q \leq 50$ l/s) preferably will be equipped with pressure filters, water treatment plants with higher treatment capacity open gravity filters can be used as well. The design filter velocity is typically ranging between 7 m/h (open gravity filter) and 20 m/h (pressure filter).

Selected design figures for design:

Filter velocity	7	m/h	(open gravity filter)
	20	m/h	(pressure filter)

Disinfection

As according to Romanian regulation free chlorine will have to be provided in the supply network chlorine has to be used for disinfection. Chlorine can be added to the treated water in liquid form (sodium hypochlorite, NaOCl), granular or powder form (calcium hypochlorite, $Ca(OCl)_2$) or gaseous form. The use of $Ca(OCl)_2$) should be limited to emergency cases while the use of NaOCl is limited to small water treatment plants. For the disinfection with gaseous chlorine typically a vacuum chlorination system is used which is available for a wide range of plant capacities. As gaseous chlorine is currently widely used throughout Romania it is recommended to use this process for disinfection for all WTP's.

Selected design figures for design:

Chlorine dosing rate	0.5 - 1.5	mg/l

8.2.6 Distribution Network:

- Velocity: Usual < 2 m/s;
- Design flow is the maximum hourly flow, following 2 load-cases are calculated:
    - Medium Day + Fire Fighting
    - Maximum Day
- Recommended pipe material:
    - For diameters up to DN 250 mm: HDPE welded or Ductile Iron with locked connection system
    - For diameters above DN 300 mm: Steel welded with PE coating and cement mortar lining or Ductile Iron with locked connection system

(Note: widely used GRP pipes are not recommended because of difficult tension resistant coupling)

- Software for modelling: WATERCAD
- Roughness coefficients (Darcy-Weisbach):
    - Network extensions and HDPE networks built within approximately the last 10 years: 0.4 mm
    - Main pipes new and built within approximately the last 10 years: 0.1 mm
    - Old networks and main pipes: 1 mm or larger if reasons are given (example known incrustations)
- Friction loss calculation method: Darcy-Weisbach equation including calculation of the Darcy-Weisbach friction factor with the Colebrook-White equation

8.3 Wastewater

Except for electromechanical equipment, civil works in the WW sector (sewer systems, tanks and PS of WWTP etc.) generally have a minimum lifetime of 30 years.

The overall project horizon is ca. 30 years until the year 2037. The dimensions of wastewater discharge and treatment structures like sewer pipes (life age 50 years) and the civil parts of WWTP (tanks, channels, pipes etc. life age 30 years) are predominantly hydraulically determined. Consequently the Consultant strongly recommends as to base the design of long-term investments on widely accepted and verified design parameters and not on a short-term inventory of the existing situation.

8.3.1 Wastewater Flows and Loads Agglomeration Bacau

8.3.1.1 Existing Situation Wastewater Flow

In Bacau flow measurements have been executed in the sewer network. Details of the measurements are documented in Annex 4.4.1. The following table summarizes the main results.

Date	**Unit**	**Average**
Connected Capita	cap	**143,100**
Minimun Sewage Night Flow per Capita [1)]	l/s/1000 cap	**0.60**
Minimum Night Flow	l/s	**456**
Minimum Sewage Night Flow	l/s	**86**
Infiltration Flow	l/s	**370**
Daily Infiltration Flow	m³/d	**32,009**
Daily Wastewater Flow incl. Infiltration	m³/d	**51,971**
Daily Sewage Flow	m³/d	**19,962**
Daily specific Sewage Flow	l/cap/d	**139**
Infiltration as Surplus on Sewage Flow	%	**164**
Total level of infiltration (BDO Table)	%	**62**
Infiltration per metre existing sewer network	l/m/d	**232**

Table 8-7: Results of Flow Measurements Bacau

8.3.1.2 Design Parameters Wastewater Flow

The following table shows the specific domestic wastewater production that was applied for the design of the wastewater systems in the agglomeration Bacau.

Area	Spec. Water Consumption	Wastewater Return Factor	Spec. Wastewater Discharge
	l/cap/day	--	l/cap/day
Rural [1]			
Domestic Water Demand	110	1.00	110
Non-Domestic Demand Public	10	0.90	9
Non-Domestic Demand Commercial + Small Industries	15	0.90	13.5
Total Rural			**133**
Urban [1]			
Domestic Water Demand	110	1.00	110
Non-Domestic Demand Public	20	0.90	18
Non-Domestic Demand Commercial + Small Industries	30	0.90	27
Total Urban			**155**

Table 8-8: Hydraulic Design Parameters Agglomeration Bacau

[1] Identification of rural / urban areas acc. to official Romanian population data.

Discussion of Design Parameters:

- **Return Factor:** The Return factor of 1.0 for domestic wastewater is stipulated in the Romanian design guideline STAS 1343-1/2006.

- **Domestic Water Consumption:** The domestic water consumption of 110 l/cap/d is stipulated in the STAS 1343-1/2006. The specific water demand and the wastewater return factor may be lower than applied design parameters now (in a max. range of 15 %), but to the Consultants point of view will most probably increase in the coming years due to a changed lifestyle and income of the major part of the Romanian population.

  This is reflected in the CBA where the domestic wastewater flow reaches a level of 110 l/cap/day in the year 2026, which is well within the design period of the WWTP and sewer system.

- **Infiltration:** The Consultant will apply a measured daily infiltration of 32,000 m³/d for the existing network and the "before project" situation. To avoid hydraulic oversizing of the WWTP, target infiltration values after network rehabilitation (combined effects of rehabilitation of existing networks and new systems with low infiltration) were used for the final design horizon.

8.3.1.3 Existing Situation Pollution Loads

Existing pollution concentrations and loads have been measured. The results are shown in Annex 4.4.1. The following table summarizes the results for the existing situation.

Parameter	Date	Jan. 08	Feb. 08	Mrz. 08	Apr. 08	Mai. 08	Jun. 08	Jul. 08	Aug. 08	Sep. 08	Okt. 08	Nov. 08	Dez. 08	Average
pH	-	-	-	-	-	-	-	-	-	-	-	-	-	-
COD	mg/l	283	268	257	272	242	245	258	247	249	242	254	281	258
BOD_5	mg/l	80	86	83	83	83	84	82	83	86	87	85	89	84
TSS	mg/l	166	164	184	145	130	135	131	131	129	135	137	146	144
N	mg/l	24.5	22.8	25.6	26.6	28.0	27.8	26.2	25.0	27.3	25.9	27.2	25.0	26.0
P	mg/l	2.8	2.7	2.6	2.6	2.6	2.6	2.9	2.7	3.0	2.9	3.0	2.7	2.8
Flow	m^3/d	73,440	73,526	72,490	74,650	67,306	72,576	75,514	66,917	63,936	59,616	63,158	55,728	68,238
Parameter	Date	Jan. 08	Feb. 08	Mrz. 08	Apr. 08	Mai. 08	Jun. 08	Jul. 08	Aug. 08	Sep. 08	Okt. 08	Nov. 08	Dez. 08	Average
COD	kg/d	20,805	19,710	18,618	20,332	16,297	17,747	19,468	16,559	15,907	14,404	16,057	15,633	17,628
BOD_5	kg/d	5,849	6,326	6,026	6,216	5,556	6,117	6,170	5,572	5,498	5,173	5,352	4,979	5,736
TSS	kg/d	12,174	12,076	13,373	10,854	8,719	9,803	9,870	8,794	8,216	8,056	8,638	8,129	9,892
N	kg/d	1,799	1,676	1,852	1,986	1,884	2,017	1,978	1,674	1,746	1,542	1,715	1,392	1,772
P	kg/d	208	196	188	196	174	192	222	179	193	174	191	150	188

Table 8-9: Existing Pollution Loads Agglomeration Bacau

8.3.1.4 Design Parameters Pollution Loads

The following table compares widely accepted design values for pollution loads with the measured specific values.

Parameter	Theoretical Design Value	Measured value	% of theoretical value
	g/p.e./d	g/p.e./d	%
COD	120	123	103
BOD_5	60	40	67
TSS	70	69	99
N	11	12	113
P	1.80	1.32	73

Table 8-10: Design Loads Agglomeration Bacau

The results show that for BOD_5 the measured specific pollution loads in g/p.e./d are within an accuracy of ± 15 % of the theoretical design values.

8.3.2 Wastewater Flows and Loads Agglomeration Comanesti-Moinesti

The wastewater flows and loads only apply to the settlements Moinesti and Gazarie. Comanesti is not part of the CF project.

8.3.2.1 Existing Situation Wastewater Flow

In Moinesti flow measurements have been executed in the sewer network. Details of the measurements are documented in Annex 4.4.2. The following table summarizes the main results.

Date	Unit	Average
Connected Capita	cap	**16,060**
Minimun Sewage Night Flow per Capita [1]	l/s/1000 cap	**0.25**
Minimum Night Flow	l/s	**26**
Minimum Sewage Night Flow	l/s	**4**
Infiltration Flow	l/s	**22**
Daily Infiltration Flow	m³/d	**1,925**
Daily Wastewater Flow incl. Infiltration	m³/d	**5,517**
Daily Sewage Flow	m³/d	**3,591**
Infiltration as Surplus on Sewage Flow	%	**54**
Daily specific Sewage Flow	l/cap/d	**224**

Table 8-11: Results of Flow Measurements Moinesti

8.3.2.2 Design Parameters Wastewater Flow

The following table shows the specific domestic wastewater production that was applied for the design of the wastewater systems in the agglomeration Breaza.

Area	Spec. Water Consumption	Wastewater Return Factor	Spec. Wastewater Discharge
	l/cap/day	**--**	**l/cap/day**
Rural [1]			
Domestic Water Demand	110	1.00	110
Non-Domestic Demand Public	10	0.90	9
Non-Domestic Demand Commercial + Small Industries	15	0.90	13.5
Total Rural			**133**
Urban [1]			
Domestic Water Demand	110	1.00	110
Non-Domestic Demand Public	20	0.90	18
Non-Domestic Demand Commercial + Small Industries	30	0.90	27
Total Urban			**155**

Table 8-12: Hydraulic Design Parameters Moinesti

[1] Identification of rural / urban areas acc. to official Romanian population data.

Discussion of Design Parameters:

- **Return Factor:** The Return factor of 1.0 for domestic wastewater is stipulated in the Romanian design guideline STAS 1343-1/2006.
- **Domestic Water Consumption:** The domestic water consumption of 110 l/cap/d is stipulated in the STAS 1343-1/2006. The specific water demand and the wastewater return factor may be lower than applied design parameters now (in a max. range of 15 %), but to the Consultants point of view will most probably increase in the coming years due to a changed lifestyle and income of the major part of the Romanian population.

  This is reflected in the CBA where the domestic wastewater flow reaches a level of 110 l/cap/day in the year 2025, which is well within the design period of the WWTP and sewer system.
- **Infiltration:** The Consultant will apply a measured daily infiltration of 1,925 m^3/d for the existing network. To avoid hydraulic oversizing of the WWTP, target infiltration values after network rehabilitation (combined effects of rehabilitation of existing networks and new systems with low infiltration) were used for the final design horizon.

8.3.2.3 Existing Situation Pollution Loads

Existing pollution concentrations and loads have been measured. The results are shown in Annex 4.4.2. The following table summarizes the results for the existing situation.

Parameter	Date	02.08.10	03.08.10	04.08.10	05.08.10	Average
COD	mg/l	312	324	317	376	332
BOD_5	mg/l	160	148	159	144	153
TSS	mg/l	184	178	213	154	182
N	mg/l	21.0	19.5	18.7	22.2	20.4
Flow	m^3/d	5,497	5,307	5,931	5,241	5,494

Parameter	Date	02.08.10	03.08.10	04.08.10	05.08.10	Average
COD	kg/d	1,716	1,718	1,878	1,970	1,821
BOD_5	kg/d	877	786	941	757	840
TSS	kg/d	1,011	945	1,263	807	1,007
N	kg/d	115	103	111	116	112

Table 8-13: Existing Pollution Loads Moinesti

8.3.2.4 Design Parameters Pollution Loads

The following table compares widely accepted design values for pollution loads with the measured specific values.

Parameter	Theoretical Design Value	Measured value	% of theoretical value
	g/p.e./d	g/p.e./d	%
COD	120	113	94
BOD_5	60	52	87
TSS	70	63	90
N	11	7	63
P	1.8	--	--

Table 8-14: Design Loads Moinesti

The results show that the measured specific pollution loads in g/p.e./d are well within an accuracy of ± 10 % of the theoretical design values. Hence the theoretical pollution loads were selected for the WWTP design.

8.3.3 Wastewater Flows and Loads Agglomeration Buhusi

8.3.3.1 Existing Situation Wastewater Flow

In Buhusi flow measurements have been executed in the sewer network. Details of the measurements are documented in Annex 4.4.3. The following table summarizes the main results.

Date	Unit	Average
Connected Capita	cap	**10,700**
Minimun Sewage Night Flow per Capita 1)	l/s/1000 cap	**0.10**
Minimum Night Flow	l/s	**4**
Minimum Sewage Night Flow	l/s	**1**
Infiltration Flow	l/s	**3**
Daily Infiltration Flow	m³/d	**270**
Daily Wastewater Flow incl. Infiltration	m³/d	**903**
Daily Sewage Flow	m³/d	**656**
Daily specific Sewage Flow	l/cap/d	**61**
Infiltration as Surplus on Sewage Flow	%	**42**
Total level of infiltration (BDO Table)	%	**27**
Infiltration per metre existing sewer network	l/m/d	**11**

Table 8-15: Results of Flow Measurements Buhusi

8.3.3.2 Design Parameters Wastewater Flow

The following table shows the specific domestic wastewater production that was applied for the design of the wastewater systems in the agglomeration Buhusi.

Area	Spec. Water Consumption	Wastewater Return Factor	Spec. Wastewater Discharge
	l/cap/day	--	l/cap/day
Rural [1]			
Domestic Water Demand	110	0.90	99
Non-Domestic Demand Public	10	0.90	9
Non-Domestic Demand Commercial + Small Industries	15	0.90	14
Total Rural			**122**
Urban [1]			
Domestic Water Demand	110	0.90	99
Non-Domestic Demand Public	20	0.90	18
Non-Domestic Demand Commercial + Small Industries	30	0.90	27
Total Urban			**144**

Table 8-16: Hydraulic Design Parameters Agglomeration Buhusi

[1] Identification of rural / urban areas acc. to official Romanian population data.

Discussion of Design Parameters:

- **Return Factor:** Basically a return factor of 1.0 for domestic wastewater is stipulated in the Romanian design guideline STAS 1343-1/2006. Since a domestic wastewater production of 110 l/cap/d is only achieved in the year 2031 (CBA), the Consultant recommends to use a return factor of 0.90 for the design in the agglomeration Buhusi.

- **Domestic Water Consumption:** The domestic water consumption of 110 l/cap/d is stipulated in the STAS 1343-1/2006. The specific water demand and the wastewater return factor may be lower than applied design parameters now but will most probably increase in the coming years due to a changed lifestyle and income of the major part of the Romanian population.

  This is reflected in the CBA where the domestic wastewater flow reaches a level of 110 l/cap/day in the year 2031, which is well within the design period of the WWTP and sewer system.

- **Infiltration:** The Consultant will apply a assumed daily infiltration for the existing network. To avoid hydraulic oversizing of the WWTP, target infiltration values after network rehabilitation (combined effects of rehabilitation of existing networks and new systems with low infiltration) were used for the final design horizon.

8.3.3.3 Existing Situation Pollution Loads

Existing pollution concentrations and loads have been measured. The results are shown in Annex 4.4.3. The following table summarizes the results for the existing situation.

Parameter	Date	26.5.10	27.5.10	Average
pH	-	10700.0	7.5	5353.8
COD	mg/l	402	352	377
BOD_5	mg/l	0	0	0
TSS	mg/l	235	231	233
N	mg/l	0	0	0
Flow	m^3/d	862	1,220	1,041

Parameter	Date	26.5.10	27.5.10	Average
COD	kg/d	346	429	388
BOD_5	kg/d	0	0	0
TSS	kg/d	202	282	242
N	kg/d	0	0	0

Table 8-17: Existing Pollution Loads Buhusi

8.3.3.4 Design Parameters Pollution Loads

The following table compares widely accepted design values for pollution loads with the measured specific values.

Parameter	Theoretical Design Value	Measured value	% of theoretical value
	g/p.e./d	**g/p.e./d**	**%**
COD	120	102	85
BOD_5	60	0	0
TSS	70	64	91
N	11	0	0
P	1.80	-	-

Table 8-18: Design Loads Buhusi

The results show that the measured specific pollution loads in g/p.e./d are well within an accuracy of ± 15 % of the theoretical design values. Hence the theoretical pollution loads were selected for the WWTP design.

8.3.4 Wastewater Flows and Loads Agglomeration Darmanesti

8.3.4.1 Existing Situation Wastewater Flow

Since there is no existing sewerage network in Darmanesti agglomeration, flow measurements have not been executed.

8.3.4.2 Design Parameters Wastewater Flow

The following table shows the specific domestic wastewater production that was applied for the design of the wastewater systems in the agglomeration Darmanesti.

Area	Spec. Water Consumption	Wastewater Return Factor	Spec. Wastewater Discharge
	l/cap/day	--	l/cap/day
Rural 1)			
Domestic Water Demand	110	0.90	99
Non-Domestic Demand Public	10	0.90	9
Non-Domestic Demand Commercial + Small Industries	15	0.90	14
Total Rural			**122**
Urban 1)			
Domestic Water Demand	110	0.90	99
Non-Domestic Demand Public	20	0.90	18
Non-Domestic Demand Commercial + Small Industries	30	0.90	27
Total Urban			**144**

Table 8-19: Hydraulic Design Parameters Agglomeration Darmanesti

1) Identification of rural / urban areas acc. to official Romanian population data.

Discussion of Design Parameters:

- **Return Factor:** Basically a return factor of 1.0 for domestic wastewater is stipulated in the Romanian design guideline STAS 1343-1/2006. Since a domestic wastewater production of 110 l/cap/d is only achieved in the year 2031 (CBA), the Consultant recommends to use a return factor of 0.90 for the design in the agglomeration Darmanesti.
- **Domestic Water Consumption:** The domestic water consumption of 110 l/cap/d is stipulated in the STAS 1343-1/2006. The specific water demand and the wastewater return factor may be lower than applied design parameters now but will most probably increase in the coming years due to a changed lifestyle and income of the major part of the Romanian population.

This is reflected in the CBA where the domestic wastewater flow reaches a level of 110 l/cap/day in the year 2031, which is well within the design period of the WWTP and sewer system.

- **Infiltration:** The Consultant will apply a assumed daily infiltration for the existing network. To avoid hydraulic oversizing of the WWTP, target infiltration values after network rehabilitation (combined effects of rehabilitation of existing networks and new systems with low infiltration) were used for the final design horizon.

8.3.4.3 Existing Situation Pollution Loads

Since there is no existing sewerage network in Darmanesti agglomeration, no chemical analyses have been executed.

8.3.4.4 Design Parameters Pollution Loads

Since no reasonable chemical analyses could be executed, the consultant recommends to use the following standard design values.

Parameter	Theoretical Design Value
	g/p.e./d
COD	120
BOD_5	60
TSS	70
N	11
P	1.80

Table 8-20: Design Loads Agglomeration Darmanesti

8.3.5 Wastewater Flows and Loads Agglomeration Targu Ocna

8.3.5.1 Existing Situation Wastewater Flow

In Targu Ocna flow measurements have been executed in the sewer network. Details of the measurements are documented in Annex 4.4.5. The following table summarizes the main results.

Date	Unit	Average
Connected Capita	cap	**6,600**
Minimun Sewage Night Flow per Capita [1)]	l/s/1000 cap	**0.10**
Minimum Night Flow	l/s	**10**
Minimum Sewage Night Flow	l/s	**0.7**
Infiltration Flow	l/s	**9**
Daily Infiltration Flow	m³/d	**802**
Daily Wastewater Flow incl. Infiltration	m³/d	**1,183**
Daily Sewage Flow	m³/d	**381**
Daily specific Sewage Flow	l/cap/d	**58**
Infiltration as Surplus on Sewage Flow	%	**211**
Total level of infiltration (BDO Table)	%	**68**
Infiltration per metre existing sewer network	l/m/d	**52**

Table 8-21: Results of Flow Measurements Targu Ocna

8.3.5.2 Design Parameters Wastewater Flow

The following table shows the specific domestic wastewater production that was applied for the design of the wastewater systems in the agglomeration Targu Ocna.

Area	Spec. Water Consumption	Wastewater Return Factor	Spec. Wastewater Discharge
	l/cap/day	**--**	**l/cap/day**
Rural [1)]			
Domestic Water Demand	110	1.00	110
Non-Domestic Demand Public	10	0.90	9
Non-Domestic Demand Commercial + Small Industries	15	0.90	13.5
Total Rural			**133**
Urban [1)]			
Domestic Water Demand	110	1.00	110
Non-Domestic Demand Public	20	0.90	18
Non-Domestic Demand Commercial + Small Industries	30	0.90	27
Total Urban			**155**

Table 8-22: Hydraulic Design Parameters Agglomeration Targu Ocna

[1)] Identification of rural / urban areas acc. to official Romanian population data.

Discussion of Design Parameters:

- **Return Factor:** Basically a return factor of 1.0 for domestic wastewater is stipulated in the Romanian design guideline STAS 1343-1/2006.
- **Domestic Water Consumption:** The domestic water consumption of 110 l/cap/d is stipulated in the STAS 1343-1/2006. The specific water demand and the wastewater return factor may be lower than applied design parameters now but will most probably increase in the coming years due to a changed lifestyle and income of the major part of the Romanian population.

  This is reflected in the CBA where the domestic wastewater flow reaches a level of 110 l/cap/day in the year 2026, which is well within the design period of the WWTP and sewer system.
- **Infiltration:** The Consultant will apply a measured daily infiltration of 802 m³/d for the existing network. To avoid hydraulic oversizing of the WWTP, target infiltration values after network rehabilitation (combined effects of rehabilitation of existing networks and new systems with low infiltration) were used for the final design horizon.

8.3.5.3 Existing Situation Pollution Loads

Existing pollution concentrations and loads have been measured. The results are shown in Annex 4.4.5. The following table summarizes the results for the existing situation.

Parameter	Date	Jan. 09	Feb. 09	Mrz. 09	Apr. 09	Mai. 09	Jun. 09	Jul. 09	Aug. 09	Sep. 09	Okt. 09	Nov. 09	Dez. 09	Average
pH	-	6.5	6.6	6.6	6.6	6.5	6.5	6.6	6.6	6.6	6.5	6.5	6.6	6.6
COD	mg/l	461	462	445	425	431	442	437	460	462	425	448	452	446
BOD_5	mg/l	289	291	290	288	292	294	290	286	292	288	293	295	291
TSS	mg/l	397	401	418	462	421	435	457	431	463	431	442	508	439
N	mg/l	58.0	56.0	61.0	65.0	62.0	57.0	60.0	59.0	56.0	60.0	62.0	65.0	60
P	mg/l													
Flow	m³/d	1,250	1,398	1,403	1,187	1,312	1,514	1,403	1,293	1,470	1,267	1,383	1,451	1,361
Parameter	Date	Jan. 09	Feb. 09	Mrz. 09	Apr. 09	Mai. 09	Jun. 09	Jul. 09	Aug. 09	Sep. 09	Okt. 09	Nov. 09	Dez. 09	Average
COD	kg/d	576	646	624	504	565	669	613	595	679	538	620	656	611
BOD_5	kg/d	361	407	407	342	383	445	407	370	429	365	405	428	384
TSS	kg/d	496	561	586	548	552	659	641	557	681	546	611	737	528
N	kg/d	73	78	86	77	81	86	84	76	82	76	86	94	75
P	kg/d	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8-23: Existing Pollution Loads Agglomeration Targu Ocna

8.3.5.4 Design Parameters Pollution Loads

The following table compares widely accepted design values for pollution loads with the measured specific values.

Parameter	Theoretical Design Value	Measured value	% of theoretical value
	g/p.e./d	g/p.e./d	%
COD	120	93	77
BOD5	60	58	97
TSS	70	80	114
N	11	11	104
P	1.80	0.00	0

Table 8-24: Design Loads Agglomeration Targu Ocna

The results show that for BOD_5, the measured specific pollution loads in g/p.e./d are well within an accuracy of ± 15 % of the theoretical design values. The Consultant recommends to apply the standard design values for the WWTP design.

8.3.6 Waste Water Flows Future Extensions

8.3.6.1 Non-Domestic Wastewater

If no different values for industrial wastewater production were available, the following specific values were applied.

Industrial areas with low water consumption:

Area based per hectare catchment area: 0.5 [l/s/ha]

Industrial areas with medium to high water consumption:

Area based per hectare catchment area: 1.0 [l/s/ha]

8.3.6.2 Infiltration Water

Generally the tightness of new sewers should be checked during commissioning of the works, hence there should not be any infiltration at the start of operation.

Since the project horizon covers a time period of 30 years the Consultant recommends to account for a certain amount of infiltration water for the hydraulic dimensioning of the pipes. The design values for infiltration in future network extensions are as follows:

Domestic areas: 50 % of domestic wastewater

Industrial areas: 0 %

8.3.6.3 Dry Weather Peak Flow

For the calculation of the dry weather peak flow, the daily variation with the determination of the specific peak discharge have to be taken into account. The hourly peak discharges [m³/h] from experience lie between 1/10 (small settlements) and 1/16 (big cities) of the daily value [m³/d].

The following table shows a compilation of above mentioned peak factors and corresponding values that are based on the 24 hours average flow based on the size of the agglomeration.

Agglomeration Size	Peak Flow Factor related to daily flow	Peak Flow Factor related to 24hrs average flow
capita	--	--
10,000 – 50,000	1 / 12	2.0
50,000 – 250,000	1 / 14	1.7
> 250,000	1 / 16	1.5

Table 8-25: Peak factors for domestic wastewater

Industrial wastewater and infiltration water are assumed to be constant. The maximum dry weather flow is calculated as follows:

$$Q_{dw,max} = Q_{Dom,max} + Q_{Ind24} + Q_{Inf,24} \quad [l/s]$$

With:

$Q_{Dom,max}$ = Max. domestic wastewater flow [l/s]

Q_{Ind24} = 24 hours average industrial wastewater flow [l/s]

Q_{Inf24} = 24 hours average infiltration flow [l/s]

8.3.7 Storm Water Overflows - Agglomeration Bacau

8.3.7.1 Network Model

For the assessment of overflow discharges, the Consultant applied the "Storm Water Management Model 5.0, U.S. Environmental Protection Agency".which is a dynamic rainfall-runoff simulation model used for single event or long-term (continuous) simulation of runoff quantity from primarily urban areas.

The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff. The routing portion of SWMM transports this runoff through a system of pipes, channels, storage/treatment devices, pumps, and regulators.

8.3.7.2 Rainfall Data

For the modeling time-variant, synthetic model rainfalls (Euler II) based on peak rainfall statistics acc. to STAS 9470/73 were developed.

Bacau is located in rainfall zone No. 2. The relevant rainfall duration (average concentration time on subcatchments + max. flow time in sewer system) was determined to be 240 minutes. In accordance with the importance class of Bacau agglomeration the threshold rain for the assessment of local floodings was selected as follows:

Return frequency:	1/2 - 1/3	years
Rainfall intensity:	230 - 255	l/s/ha
Rainfall duration:	240	min

8.3.7.3 Network Data

The simplified network model included the following components:

Total Catchment Area:	2,261	ha
Impervious Area:	727	ha
% Impervious:	32	%
Total No. of Catchment Areas:	528	--
Total No. of Pipes:	2,256	--
Total network Length:	174.3	km

The future sewer network will include 11 combined sewer overflows. The main overflows from the combined network are:

- CD Serbanesti: CD Serbanesti is upstream of PS Serbanesti on the left river bank of Bistrita River.
- CD Izvoare: CD Izvoare is located at Izvoare street on the right river bank of Bistrita River.
- CD WWTP: CD WWTP is located downstream of the stormwater tanks at Bacau WWTP.
- CD Industry: CD industry is located close to an industrial site (eastern projection of Narciselor street).

The rest of the overflows consist of emergency overflows at wastewater pumping stations.

8.3.7.4 Results

The results of the modeling are presented in the following tables for the before project / after project situation.

AGGLOMERATION BACAU - ASSESSMENT OF OVERFLOW DISCHARGES - BEFORE IMPLEMENTATION							
Overflow	Q_{WW}	Max. admissible Q_{Rain}	Max. Capacity Q_{WW} + Q_{Rain}	f = 1/1 years i = 195 l/s/ha t = 240 min	f = 1/2 years i = 230 l/s/ha t = 240 min	f = 1/3 years i = 255 l/s/ha t = 240 min	f = 1/5 years i = 265 l/s/ha t = 240 min
				Discharge at Overflow	Discharge at Overflow	Discharge at Overflow	Discharge at Overflow
-	l/s	l/s	l/s	l/s	l/s	l/s	l/s
CD_Serbanesti	30	195	225	732	948	1,141	1,445
CD_Izvoare	514	3,442	3,957	2,747	3,864	4,489	5,461
CD_Stormwater_Tank	2	58	60	4,109	4,179	4,379	4,588
CD_Industry	180	211	391	3,103	3,289	3,452	3,829
CD_Ciprian_Porembescu	5	45	50	20	26	31	37
CD_Rozelor	2	81	83	70	85	103	131
CD_Magura	8	17	25	115	125	125	129
CD_Arcade	20	86	106	41	57	67	81
CD_Gheraiesti	1	27	28	17	38	41	51
CD_Triumfului	1	44	63	79	97	116	137
CD_Muncii	1	26	27	86	101	115	133

AGGLOMERATION BACAU - ASSESSMENT OF OVERFLOW DISCHARGES - AFTER IMPLEMENTATION							
Overflow	Q_{WW}	Max. admissible Q_{Rain}	Max. Capacity Q_{WW} + Q_{Rain}	f = 1/1 years i = 195 l/s/ha t = 240 min	f = 1/2 years i = 230 l/s/ha t = 240 min	f = 1/3 years i = 255 l/s/ha t = 240 min	f = 1/5 years i = 265 l/s/ha t = 240 min
				Discharge at Overflow	Discharge at Overflow	Discharge at Overflow	Discharge at Overflow
-	l/s	l/s	l/s	l/s	l/s	l/s	l/s
CD_Serbanesti	50	176	225	598	802	953	1,188
CD_Izvoare	603	3,353	3,957	2,773	3,841	4,510	5,476
CD_Stormwater_Tank	2	58	60	4,043	4,200	4,327	4,548
CD_Industry	212	178	391	3,079	3,306	3,557	3,699
CD_Ciprian_Porembescu	19	31	50	18	21	26	32
CD_Rozelor	2	81	83	68	83	104	130
CD_Magura	12	13	25	115	125	126	128
CD_Arcade	20	86	106	41	57	68	81
CD_Gheraiesti	1	27	28	10	19	36	44
CD_Triumfului	1	62	63	79	97	116	137
CD_Muncii	2	25	27	86	100	113	129

Increase of discharge After / Before Project	f = 1/1 years i = 195 l/s/ha t = 240 min	f = 1/2 years i = 230 l/s/ha t = 240 min	f = 1/3 years i = 255 l/s/ha t = 240 min	f = 1/5 years i = 265 l/s/ha t = 240 min
CD_Serbanesti	-18%	-15%	-16%	-18%
CD_Izvoare	1%	-1%	0%	0%
CD_Stormwater_Tank	-2%	0%	-1%	-1%
CD_Industry	-1%	1%	3%	-3%
CD_Ciprian_Porembescu	-10%	-16%	-16%	-13%
CD_Rozelor	-3%	-3%	1%	-1%
CD_Magura	0%	0%	1%	-1%
CD_Arcade	0%	0%	0%	0%
CD_Gheraiesti	-42%	-49%	-13%	-14%
CD_Triumfului	0%	0%	0%	0%
CD_Muncii	0%	-2%	-2%	-3%

The increase of overflow discharge After / Before project with less than 10 % is insignificant. Furthermore no jump in spill-over frequency (i.e. decrease of frequency from 1/2 to 1/1 years) can be observed.

8.3.8 Storm Water Overflows - Agglomeration Buhusi

For the modeling time-variant, synthetic model rainfalls (Euler II) based on peak rainfall statistics acc. to STAS 9470/73 were developed.

Buhusi is located in rainfall zone No. 2. The relevant rainfall duration (average concentration time on subcatchments + max. flow time in sewer system) was determined to be 120 minutes. In accordance with the importance class of Buhusi agglomeration the threshold rain for the assessment of local floodings was selected as follows:

Return frequency:	1/2 - 1/3	years
Rainfall intensity:	230 - 255	l/s/ha
Rainfall duration:	120	min

8.3.8.1 Network Data

The simplified network model included the following components:

Before Project:

Combined System:

Total Catchment Area:	187	ha
Impervious Area:	48	ha
% Impervious Area:	26	%

Separate System:

Total Catchment Area:	0	ha
Total Before Project	187	ha

After Project:

Combined System:

Total Catchment Area:	187	ha
Impervious Area:	48	ha
% Impervious Area:	26	%

Separate System:

Total Catchment Area:	575	ha
Total After Project	762	ha

The future sewer network will include 1 combined sewer overflow 400 – 500 m upstream of the WWTP.

8.3.8.2 Results

The results of the modeling are presented in the following tables for the before project / after project situation.

AGGLOMERATION URLATI - ASSESSMENT OF OVERFLOW DISCHARGES - BEFORE IMPLEMENTATION							
Overflow	Q_{WW}	Max. admissible Q_{Rain}	Max. Capacity $Q_{WW} + Q_{Rain}$	f = 1/1 years i = 195 l/s/ha t = 120 min	f = 1/2 years i = 230 l/s/ha t = 120 min	f = 1/3 years i = 255 l/s/ha t = 120 min	f = 1/5 years i = 265 l/s/ha t = 120 min
				Discharge at Overflow	Discharge at Overflow	Discharge at Overflow	Discharge at Overflow
-	l/s	l/s	l/s	l/s	l/s	l/s	l/s
CD1	24	4,376	4,400	1,358	1,565	1,738	1,923

AGGLOMERATION URLATI - ASSESSMENT OF OVERFLOW DISCHARGES - AFTER IMPLEMENTATION							
Overflow	Q_{WW}	Max. admissible Q_{Rain}	Max. Capacity $Q_{WW} + Q_{Rain}$	f = 1/1 years i = 195 l/s/ha t = 120 min	f = 1/2 years i = 230 l/s/ha t = 120 min	f = 1/3 years i = 255 l/s/ha t = 120 min	f = 1/5 years i = 265 l/s/ha t = 120 min
				Discharge at Overflow	Discharge at Overflow	Discharge at Overflow	Discharge at Overflow
-	l/s	l/s	l/s	l/s	l/s	l/s	l/s
CD1	54	4,346	4,400	1,552	1,690	1,738	1,779

Increase of discharge After / Before				14%	8%	0%	-8%

The increase of overflow discharge After / Before project with less than 10 % is insignificant. Furthermore no jump in spill-over frequency (i.e. decrease of frequency from 1/2 to 1/1 years) can be observed.

8.3.9 Storm Water Treatment

Stormwater treatment comprises the treatment of discharge from relief structures in existing combined systems during rainfall. The main stormwater structures in combined systems are:

Combined Sewer Overflows (CSO):

To be located where the critical flow Qcrit can be conveyed and the stormwater treatment is implemented subsequently in a storage structure further downstream. At CSOs no stormwater treatment (i.e. settling) is implemented. The throttle discharge at the CSO should ensure a minimum mix ratio of throttle discharge / daily mean dry weather flow of 7 / 1.

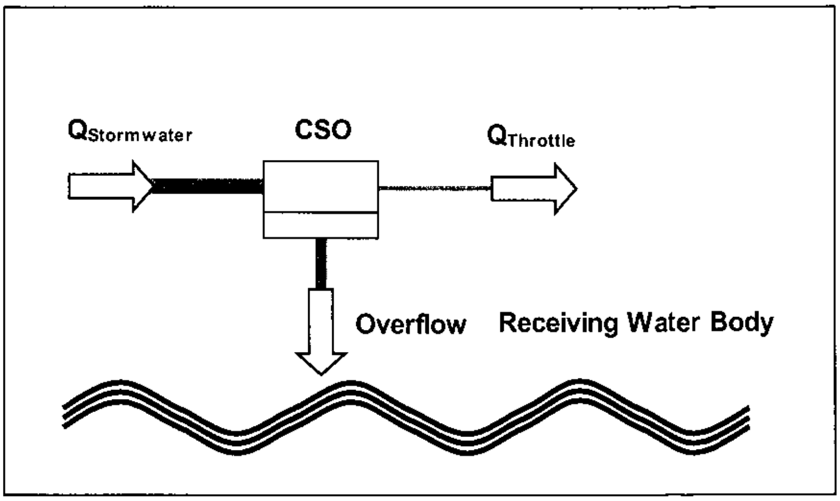

Figure 8-3: Example for Combined Sewer Overflow (CSO)

Stormwater Tanks Retaining the First Flush of Stormwater (STRFF):

STRFF include mechanical settling of wastewater pollutants. They store a certain amount of water and are not affected by overflow water, hence settling conditions for the stored volume are not disturbed. If the maximum storage capacity of a STRFF is exceeded, surplus water is discharged without any treatment. STRFF retain the first flush of stormwater and are to be planned for the discharge of non-prerelieved drainage areas with a flow time of 15 – 20 min.

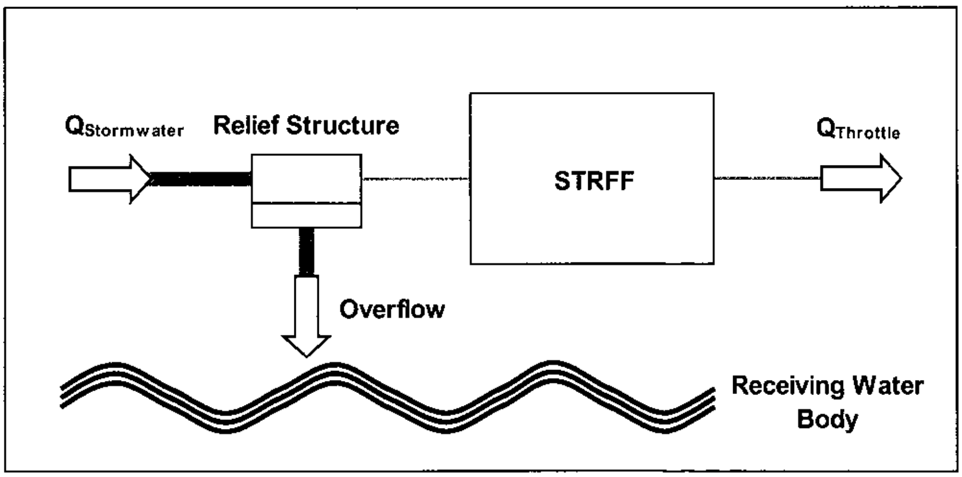

Figure 8-4: Example for STRFF in main stream

Stormwater Tanks with Overflow for Settled Combined Water (STOSC):

At STOSCs the overflow water that is discharged to the receiving water body after filling of the retention volume passes the tank and thus is treated mechanically. STOSC shall be selected if the flow time exceeds 15 – 20 min.

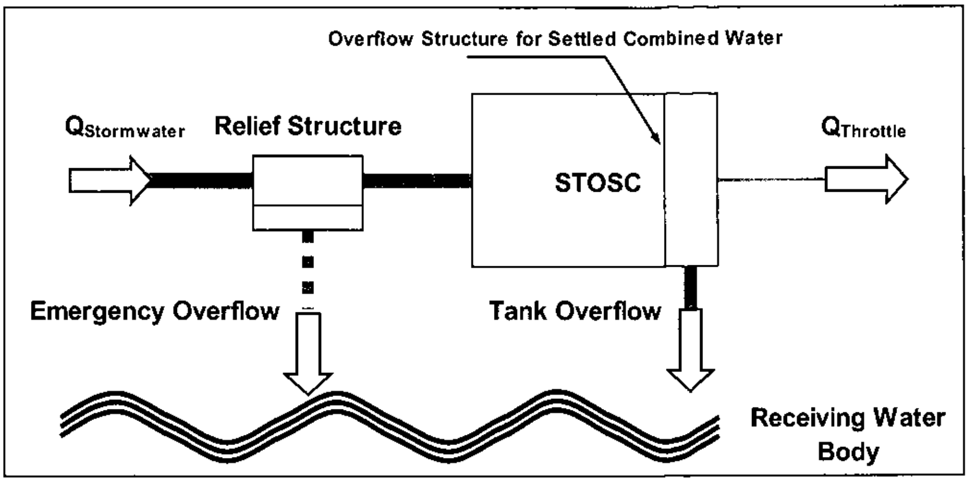

Figure 8-5: Example for STOSC in main stream

Sewers with Storage Capacity and Overflow (SSCO):

Sewers with storage capacity and top-end overflow (SSCTO) function as stormwater tanks retaining the first flush of stormwater. Sewers with storage capacity and bottom-end overflow (SSCBO) function as stormwater tanks with overflow for settled combined wastewater in the main stream without emergency overflow. The following figure shows an example for a SSCTO.

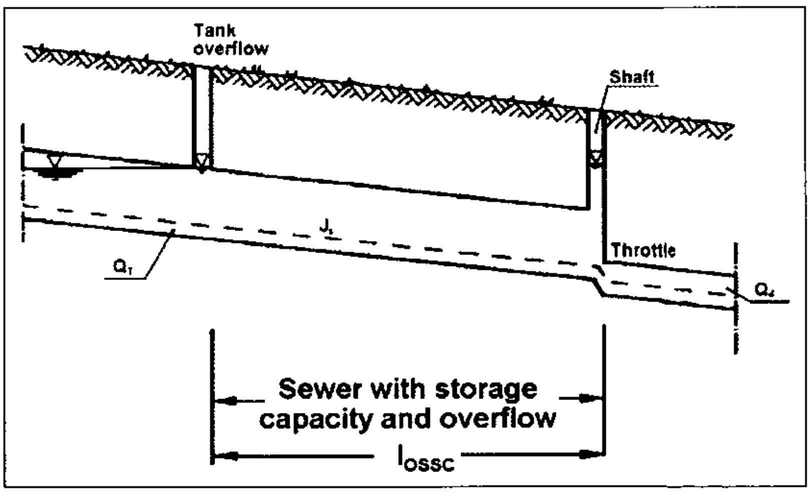

Figure 8-6: Example for sewer with storage capacity and top overflow

The following figure shows an example for a SSCBO.

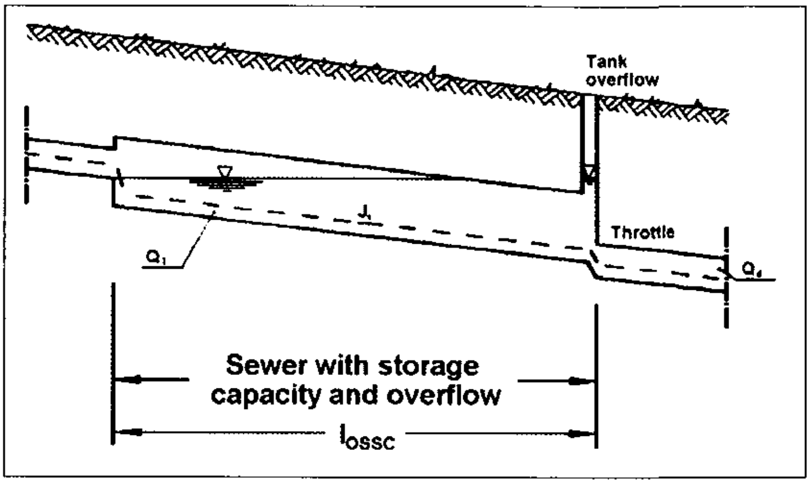

Figure 8-7: Example for sewer with storage capacity and bottom overflow

Design Criteria for Combined Sewer Overflows:

At the throttle of CSOs generally a mix ratio between the rainfall and dry weather component ≥ 7 should be maintained.

M	=	$(Q_{Throttle} - Q_{dw24}) / Q_{dw24}$	≥	7	[-]
$Q_{Throttle,min}$	=	$(M + 1) * Q_{dw24}$			[l/s]

The CSO should convey the critical combined water flow downstream to subsequent catchment areas.

Q_{crit}	=	$Q_{dw24} + Q_{rcrit} + \Sigma Q_{Throttles}$	≥	$Q_{Throttle,min}$	[l/s]

With:

Q_{dw24} = 24 hours average dry weather flow incl. infiltration

Q_{rcrit} = Critical storm water run-off from immediate and intermediate areas

$Q_{crit} = r_{crit} * A_{impervious}$

r_{crit} = 7.5 [l/s/ha] if flow time $t_f > 120$ min

$r_{crit} = 15 + 120 / (t_f + 120)$ [l/s/ha] if flow time $t_f \leq 120$ min

$\Sigma Q_{Throttles}$ = Sum of all upstream throttle discharges

Design criteria for Stormwater Tanks and Sewers with Storage Capacity:

In the FS the design of storm water tanks and sewers with storage capacity was based on a specific Volume V_{Spec} [m^3/h_{Ai}]. The Volume is related to the impervious catchment area of the stormwater tank.

V_{Spec} = 30 [m^3/h_{Ai}] (Estimated value)

Stormwater Tanks should be designed in such a way that in the overflow to the receiving water body a mix ratio between the rainfall and dry weather component ≥ 7 is maintained (annual average values).

150

$M = (Q_{ro} + Q_{rS24}) / Q_{dw24} \geq 7$ [-]

With:

Q_{ro} = Mean rainwater flow during overflows [l/s]

Q_{rS24} = Rainwater flows from separate areas [l/s]

Q_{dw24} = 24 hours average dry weather flow incl. infiltration [l/s]

8.3.9.1 Separate Systems

Basically no storm water should enter the separate system but inflow in sewer manholes from surface run-off cannot be prevented a 100 %. For this reason, the Consultant recommends to account for a certain amount of storm water in separate systems.

The stormwater share in the separate system is already included in the infiltration surcharge.

8.3.10 Wastewater Collection System

8.3.10.1 Network Design General

New sewers were designed to accommodate the peak flow of the year 2037.

Pipe material for pipes with a diameter smaller than 600 mm are preferably HDPE/PVC, for diameters larger than 600mm GRP/Concrete.

The following table shows the global values for operational pipe roughness applied for the hydraulic design of wastewater networks. The different parameters and values correspond to each other and reflect the same hydraulic roughness. The global operational roughness includes friction losses and local losses incurred by manholes and any other inaccuracies.

Parameter		Value	Unit
Existing Pipes			
Absolute Roughness	k_b	1.50	mm
Mannings Roughness	k_{St}	75	$m^{1/3}/s$
Mannings Coefficient	n	0.013	--
New Pipes			
Absolute Roughness	k_b	1.00	mm

Parameter		**Value**	**Unit**
Mannings Roughness	k_{St}	82	$m^{1/3}/s$
Mannings Coefficient	n	0.012	--

Table 8-26: Sewage pipe roughness

With:

n = $k_b^{1/6}/26$ [-] k_b in meter

k_{St} = 1 / n [$m^{1/3}/s$]

In order to avoid deposits in the pipes the minimum wall traverse stress in sewer pipes should not fall below 1.00 N/m². The following table shows the limiting values for a deposit-free operation of sewage pipes in a separate system with:

h_T/D: Degree of filling

J_c: Critical Slope

V_c: Critical Velocity

τ_{min}: Minimum Wall Traverse Stress

Circular x-section d	$h_T/d \geq 0.10$			$h_T/d \geq 0.20$			$h_T/d \geq 0.30$			$h_T/d \geq 0.50$		
	J_c	V_c	τ_{min}	J_c	V_c	τ_{min}	J_c	V_c	τ_{min}	J_c	V_c	τ_{min}
mm	‰	m/s	N/m^2	‰	m/s	N/m^2	‰	m/s	n/m^2	‰	m/s	N/m^2
150	*)	*)	*)									
200	*)	*)	*)									
250	*)	*)	*)									
300												
350										1.18	0.52	1.01
400										1.16	0.56	1.13
450										1.14	0.60	1.26
500							1.22	0.53	1.03	1.12	0.64	1.37
600							1.20	0.59	1.20	1.09	0.71	1.61
700				1.30	0.55	1.07	1.16	0.63	1.36	1.07	0.78	1.83
800				1.26	0.58	1.20	1.14	0.69	1.53	1.05	0.84	2.06
900				1.25	0.63	1.33	1.12	0.73	1.69	1.03	0.90	2.27
1000				1.23	0.67	1.45	1.11	0.78	1.86	1.01	0.95	2.49
1100	1.49	0.52	1.02	1.21	0.69	1.57	1.09	0.82	2.01	1.00	1.00	2.70
1200	1.46	0.54	1.09	1.19	0.73	1.69	1.08	0.87	2.17	0.99	1.05	2.91

Table 8-27: Limiting values for deposit-free operation of separate systems

Maximum velocity is set to 3 m/s in order to minimize abrasion and to ensure enough depth to transport floating solids.

The following table shows maximum and design capacities of pipes at a minimum slope for h/D ≥ 0.10 and an absolute roughness of k_b = 1.5 mm for circular pipes. To facilitate aeration of sewage pipes and to prevent air entrainment combined with the risk of surcharging of the pipe the Consultant recommends to apply a maximum pipe filling of 90 % for design purposes.

Pipe Diameter	Critical Slope at h/D ≥ 0.10	Max. Flow Full Filling	Degree of Filling For Design	Absolute Roughness	Degree of Filling min. h/D	Design Flow	Min. Flow for h/D ≥ 0.10
mm	m/m	m³/s	h/D	mm	--	m³/s	m³/s
200	0.0042	0.022	0.90	1.50	0.20 [1)]	0.022	0.0005
250	0.0034	0.035	0.90	1.50	0.20 [1)]	0.035	0.0008
300	0.0054	0.072	0.90	1.50	0.10	0.071	0.0016
350	0.0046	0.100	0.90	1.50	0.10	0.099	0.0022
400	0.0040	0.133	0.90	1.50	0.10	0.132	0.0029
450	0.0036	0.171	0.90	1.50	0.10	0.170	0.0038
500	0.0032	0.214	0.90	1.50	0.10	0.212	0.0047
600	0.0027	0.317	0.90	1.50	0.10	0.315	0.0070
700	0.0023	0.439	0.90	1.50	0.10	0.436	0.0097
800	0.0020	0.585	0.90	1.50	0.10	0.580	0.0129
900	0.0018	0.751	0.90	1.50	0.10	0.745	0.0166
1000	0.0016	0.942	0.90	1.50	0.10	0.935	0.0208
1200	0.0015	1.448	0.90	1.50	0.10	1.437	0.0320

Table 8-28: Design capacities of pipes at minimum gradients for h/D ≥ 0.10
[1)] minimum h/D for DN 200 – 250 is 0.20 -

The minimum pipe diameters were:

- 300 mm for combined sewers system
- 250 mm for separate sewer systems
- 300 mm for rain collectors
- 200 mm for house connections (Blocs)
- 150 mm for house connections (single houses)

The minimum cover to any sewer was normally 1.5 m unless the site conditions dictated a lesser cover, but at least the depth of frost assigned for the area under consideration.

Manholes and inspection chambers were designed at every change in alignment, at every change of grade and direction at every change of sizes. Spacing for all manholes is done according to STAS 3051-91. Cleanout manholes was designed every 60 m for sewers ≤ 400 mm, and every 120 m for larger diameters.

8.3.10.2 Pumping Stations

The wastewater pumping stations will generally be equipped with centrifugal pumps. Decision on dry well or wet well installation has to be taken case by case. For smaller pumping stations even pre-fabricated wet-well pumping stations can be considered.

The following figure shows an example for dry well installation.

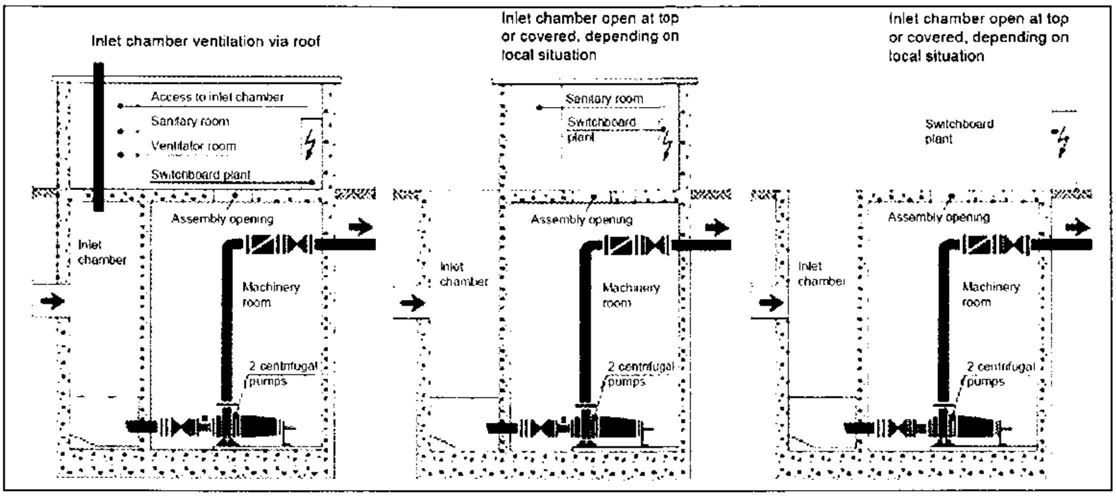

Figure 8-8: Example for Dry Well Pumping Station

The following figure shows an example for wet well installation.

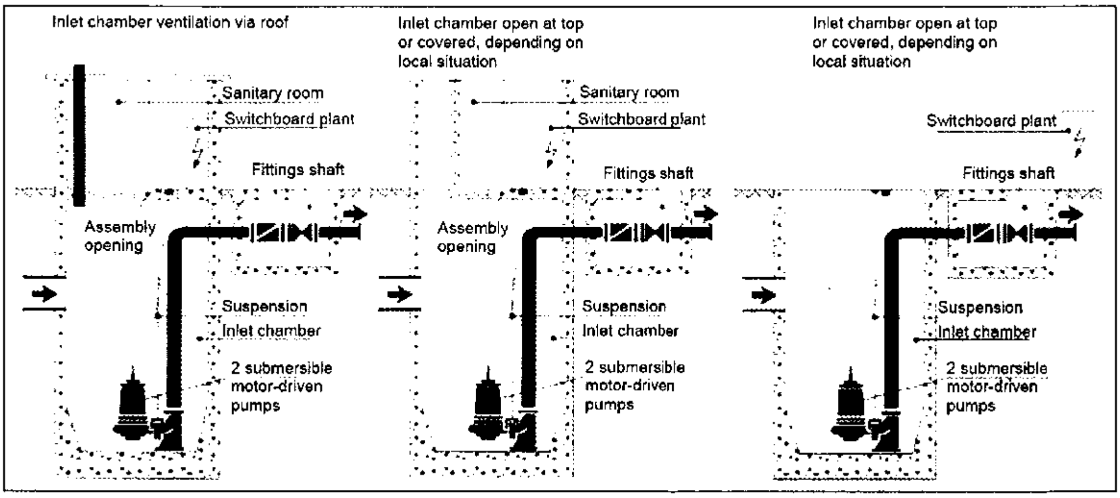

Figure 8-9: Example for Wet Well Pumping Station

The following general design criteria were applied for the wastewater pumping station:

- **Redundancy:** As a minimum, one stand-by pump shall be installed (1 + 1).
- **Prevention of Clogging:** Minimum free passage for impellers and fittings is 100 mm, minimum inner diameter for pressure lines is 80 mm.
- **Pumping Cycles:** Depending on the motor capacity the number of cycles shown in the following table should not be exceeded. The volume of the inlet chamber with fixed switch-on and switch-off levels has to be calculated accordingly.

Motor Capacity	Pumping Cycles
kW	1/h
≤ 4	15
≤ 7.5	15
≤ 11	12
≤ 30	12
> 30	≤ 10

Table 8-29: Recommended Pumping Cycles

In any case, the supplier's recommendations for delivered pumps have to be followed.

- **Impeller Types:** The following impeller types are generally used for wastewater pumping stations.

Impeller Type	Operation Pressure
	bar
Single Vane Impeller	up to 4
Spiral Impeller	up to 6
Multiple Canal Impeller	up to 10
Vortex Impeller	up to 10

Table 8-30: Wastewater Impeller Types

- **Screens:** In case of important pumping stations and combined wastewater networks, the necessity of coarse screens for pump protection has to be considered.

- **Emergency Power Supply:** Generally energy supply should be from the low voltage network 400 / 230 V, 50 Hz. Depending on the failure probability of the power supply system and the size and importance of the pumping station in the drainage system an emergency power supply system (i.e. Diesel Generator) has to be installed.

- **SCADA System:** The low voltage switchboard plant shall be installed safe from flooding. Modern switchboards include PLCs for pump operation. Process parameters to be monitored are operating hours [h], Voltage [V], Power [A]. Additionally pumps sump levels [m] and flow rate [l/s] can be monitored, depending on the size and importance of the pumping station. For important pumping stations the possibility of a remote control (i.e. dial-up line) should be analysed (at least for malfunction messages).

- **Pressure Pipes:** Pressure pipes should generally be designed with a flow velocity ≥ 1.1 m/s. The following pipe roughness was applied for hydraulic design. Head losses were calculated separately.

Parameter		Value	Unit
Roughness (i.e., PE-HD, PVC, Steel)	k_b	0.25	mm
Mannings Roughness	k_{St}	104	$m^{1/3}/s$
Mannings Coefficient	n	0.0097	--

Table 8-31: Pressure pipe roughness

- **Pigging Systems:** For the purpose of pipeline cleaning the installation of pigging systems should be considered.
- **Ventilation:** Where the pump pit is below the ground surface, mechanical ventilation is required, so arranged as to independently ventilate the pump if screens or mechanical equipment requiring maintenance or inspection. In pits over 4 m deep, multiple inlets and outlets are desirable. Damper should not be used on exhaust or fresh air ducts and fine screens or other obstructions in air ducts should be avoided to prevent clogging. Switches for operation of ventilation equipment should be marked and located conveniently. All intermittently operated ventilating equipment shall be interconnected with the respective pit lighting systems, which shall override any automatic controls.

8.3.10.3 Assessment of Hydrogen Sulphide Corrosion (H_2S) Risk

H_2S corrosion depends on the dissolved Sulphide concentration in the wastewater. Sulphide can be discharged directly i.e. by industries or it may be generated by anaerobic bacteria within the sewers. Boundary conditions supporting the generation of sulphide are mainly:

- Low pH value of the sewage ($pH < 7$);
- High oxygen demand in the sewage (high BOD_5 concentration);
- High sewage temperatures that accelerate biological activity;
- Flat sewers that tend to sedimentation of biodegradable organic components;
- Long detention times in sewer systems combined with anaerobic conditions.

Generally H_2S problems in wastewater systems originate from long gravity sewer systems or pumping stations with long pressure pipes.

To assess the risk of H_2S formation in the sewer networks the Consultant applied the POMEROY model which is mainly based on BOD_5 content, wastewater temperature, hydraulic conditions and detention time in respective sewer pipes.

If a H_2S risk is unavoidable, corrective measures can be as follows.

Design measures at gravity sewers:

- Maintain critical slope for deposit-free sewer operation (see chapters above).
- Maintain minimum manhole distance (i.e. 60 m) to support aeration of sewers.
- In areas with high sulphide concentration turbulences at manholes etc. should be avoided to prevent gas stripping.

Design measures at pumping stations:

- The discharge into the pumps sump should be hydraulically smooth without turbulences.
- For the pump sump cement with high resistance against sulphide should be used.
- Enclosed inlet chambers must be equipped with an efficient ventilation.
- The volume of the pump sump must be optimized to avoid long detention times. To account for low inflows at the beginning of the planning horizon, switch-on and switch-off levels have to be adjusted with the objective not to exceed a filling time of 5 minutes (maximum operation cycles to be followed).
- Pressure lines shall be designed in such a way that a minimum wall shear force of 3.9 N/m^2 is maintained which prevents the formation of biological slime. The wall shear force is calculated as follows:

  $T = \rho * I_E * rhy * g$ $[N/m^2]$

  With:

  ρ = density of water 1,000 $[kg/m^3]$
  I_E = hydraulic gradient [m/m]
  r_{hy} = hydraulic radius, A/lu [m]
  g = gravity 9.81 $[m/s^2]$

  With pipe diameters in the range of 80 – 200 mm and a flow velocity > 1.1 m/s the required wall shear force usually can be maintained.
- The discharge of the pressure line into the gravity system should be without turbulences.

Possible operational measures are:

- Frequent flushing of sewer pipes affected by sedimentation.
- Application of metallic salts (Fe) to transfer the sulphide into an undissolved phase.
- Oxygen supply for the wastewater through application of pressurized air, pure oxygen (O_2), hydrogen peroxide (H_2O_2) or Nitrate.
- Flushing of pressure pipes with pressurized air.

8.3.11 Wastewater Treatment

8.3.11.1 Effluent Standards

Effluent standards for wastewater treatment plants (WWTP) subject to this FS are set out in the Urban Wastewater Treatment Directive 91/271/EEC which has been implemented in the Romanian standard NTPA 001 – 011. The following table summarizes respective effluent standards.

Parameter	Plant Size	Effluent Concentration	Minimum percentage of reduction
	p.e. [1]	mg/l	%
Biochemical Oxygen Demand (BOD_5 at 20 °C), without nitrification	--	25	
Chemical Oxygen Demand (COD)	--	125	
Total Suspended Solids (SS)	2,000 – 10,000	60	70
	> 10,000	35	90
Total Phosphorus (P_{tot})	10,000 – 100,000	2	80
	> 100,000 or sensitive areas	1	80
Total Nitrogen (N_{tot})	10,000 – 100,000	15	70 - 80
	> 100,000 or sensitive areas	10	70 - 80

Table 8-32: NTPA 001-011 WWTP Effluent Standards

1) One p.e. (population equivalent) = 60 g BOD_5/cap/day

8.3.11.2 Wastewater Treatment Technology and Design Parameter

In general WWTP will have the following main treatment steps:

- Mechanical treatment
- Biological waste water treatment
- Sludge treatment

Generally applied treatment parameters are in line with Romanian design standards for urban wastewater treatment installations and constructions – Mechanical Treatment (NP 032-1999), Biological Treatment (NP 088-03), Advanced Treatment (NP 107-04) and Sludge Treatment.

The maximum hydraulic load from combined sewer systems allowed in the WWTP is:

$Q_{WWTP,max} = 2 * (Q_{Dom,max} + Q_{Ind24}) + Q_{Inf,24}$ [l/s]

With:

$Q_{Dom,max}$ = Max. domestic wastewater flow [l/s]

Q_{Ind24} = 24 hours average industrial wastewater flow [l/s]

Q_{Inf24} = 24 hours average infiltration flow [l/s]

The following table summarizes the main wastewater treatment technologies and design parameters for the mechanical treatment, applied in this FS.

Process Step	Description	Design Parameter	Value / Unit
Inflow Pumping Station	Centrifugal Pumps in wet-well or dry-well installation, minimum 1 stand-by pump (1 + 1)	Min / Max Flow Max. Pressure Head	l/s m
Screens	Mechanically cleaned coarse (width 6 – 150 mm) or fine (width < 6 mm) screens with compaction installation. 1 line with 100 % capacity and by-pass channel or 2 lines with 100 % capacity each.	Max Flow	l/s
Flow Measurement	Venturi or Parshall Flumes, MID	Min / Max Flow	l/s
Grit and Grease removal	Aerated Grit and Grease Chamber.	Detention Time Horizontal Flow Velocity	10 – 20 min max. 0.20 m/s
Primary Sludge Sedimentation	Primary Sedimentation Tanks (Circular)	Detention Time Dry Weather Overflow Rate Side Depth	1.5 h 1.5 m³/m²/h 2.00 - 2.50 m

Table 8-33: WWTP Mechanical Treatment Design Parameters

The following table summarizes the main wastewater treatment technologies and design parameters for the biological treatment, applied in this FS.

Description	Process Step	Design Parameter	Value / Unit
Activated Sludge Tank (Sludge Treatment Anaerobic Digestion)	Elimination of Organics and Nutrients	Design Temperature Mixed Liquor Suspended Solids in Activated Sludge Tank (MLSS)	12 °C 3 - 5 g/l
Activated Sludge Tank (Simultaneous Aerobic Stabilization (Extended Aeration), no Primary Sedimentation)	Elimination of Organics and Nutrients	Design Temperature Total Sludge Age Mixed Liquor Suspended Solids in Activated Sludge Tank (MLSS)	12 °C 25 days 3 - 5 g/l
Fine Bubble Aeration Systems with Pressurized Air, Water Depth 5.00 m	Oxygen Supply for Biomass	Dissolved Oxygen Concentration in Mixed Liquor Oxygen Transfer Coefficient Oxygen Uptake in Pure Water depending on Water Depth Standard Aeration Efficiency Pure Water	2.0 mg/l 0,70 – 19 g O_2/m³/m 2.65 kg O_2/kWh
Secondary Sedimentation Tanks	Settling of Biomass	Sludge Volume Index without / with Primary Sedimentation Return Ratio for Sludge	100 - 150 l/kg Dry Weather 1.5 – Storm Flow 0.75 –

Description	Process Step	Design Parameter	Value / Unit
		Sludge Volume Overflow Rate Hydraulic Overflow Rate Sludge Thickening Time	≤ 500 l/m²/h ≤ 1.6 m³/m²/h 2.0 h

Table 8-34: WWTP Biological Treatment Design Parameters

8.3.12 Sludge Digestion and Disposal

8.3.12.1 Sludge Stabilization / Digestion

For sludge stabilization / digestion generally two processes exist:

- Simultaneous aerobic sludge stabilization (extended aeration)
- Sludge stabilization with anaerobic digestion

Since there is a strong link between wastewater treatment and pertaining sludge stabilization / digestion, both processes were described in the chapter before.

The following table shows a compilation of general sludge data and sludge stabilization / digestion design parameters.

Description	Process Step	Design Parameter	Value / Unit
Primary Sludge from Sedimentation Tanks, Retention Time dry weather 1.5 h	Primary Sedimentation	Spec. Sludge Amount Dry Solids Content Organic Matters Primary Sludge Flow	39 g/p.e./d 3.5 % 70 % 1.1 l/p.e./d
Excess Sludge from Activated Sludge Tank, Total Sludge Age 13 - 15 d	Activated Sludge tank, Anaerobic Digestion	Spec. Sludge Amount Dry Solids Content Organic Matters Excess Sludge Flow	33 g/p.e./d 0.8 % 65 % 4.5 l/p.e./d
Excess Sludge from Activated Sludge Tank, Total Sludge Age 25 d, no Primary Sedimentation Tanks	Activated Sludge tank, Extended Aeration	Spec. Sludge Amount Dry Solids Content Organic Matters Excess Sludge Flow	63 g/p.e./d 0.8 % 60 - 65 % 7.9 l/p.e./d
Sludge from Chemical Phosphorus Precipitation	Precipitation Sludge, Both Types of Stabilization / Digestion	Spec. Sludge Amount Dry Solids Content Organic Matters Excess Sludge Flow	7 g/p.e./d 0.8 % 55 - 65 % 1.0 l/p.e./d
Total Sludge Amount, Sludge Age 13 - 15 days	Total Raw Sludge, Anaerobic Digestion	Spec. Sludge Amount	79 g/p.e./d
Total Sludge Amount at Digestor Effluent, 55 % Elimination of Organic Matters	Total Final Sludge Anaerobic Digestion	Spec. Sludge Amount	49 g/p.e./d
Total Sludge Amount from Simultaneous Aerobic Stabilization	Total Final Sludge Extended Aeration	Spec. Sludge Amount	70 g/p.e./d
Simultaneous Aerobic Stabilization (Extended	Sludge Stabilization	Total Sludge Age	25 days

Description	Process Step	Design Parameter	Value / Unit
Aeration) in Activated Sludge Tank, no Primary Sedimentation			
Digestion of Primary and Secondary Sludge in Anaerobic Tanks	Sludge Digestion	Design Temperature Feed Dry Solids Content Reaction Time Max. Organic Loading Elimination Rate for Organic Matters	36 °C 6 % 20 days 2.5 - 3.0 kg oDS/m³/day 55 %
Installation of Cogeneration Units for Biogas Utilization	Biogas Utilization	Calorific Value Biogas Spec. Gas Production Electrical Efficiency Cogeneration Unit Thermal Efficiency Cogeneration Unit	6.4 kWh/m³ 15 l/p.e./d 32 % 55 %

Table 8-35: Sludge Stabilization / Digestion Design Parameters

8.3.12.2 Sludge Dewatering

To reduce the volume of the sludge, generated at different process steps of WWTP the following methods are applied:

<u>Gravity Thickening:</u>

Gravity Sludge Thickeners:

Primary sludge and secondary sludge from smaller WWTP (up to 20,000 p.e. due to huge secondary sludge flows) are thickened in Gravity Thickeners. Gravity Thickeners can be operated as batch or continuous flow tanks.

<u>Mechanical Thickening / Dewatering:</u>

Rotary Drum Sieves:

Rotary drum sieves are often applied at WWTP > 20,000 p.e. for the thickening of secondary sludge before anaerobic digestion.

Belt Filter Press:

A belt filter press dewaters by applying pressure to the biosolids to squeeze out the water. Belt filter presses are often used for the final dewatering of WWTP sludge before final disposal. Staffing requirements, operation and maintenance, start and shut down of the aggregates are relatively simple compared to centrifuges or chamber filter presses. For good dewatering performance the sludge must be conditioned with polymer.

Centrifuges:

Centrifugation is a high speed process that uses the force from rapid rotation of a cylindrical bowl to separate wastewater solids from liquid. For good dewatering performance the sludge must be conditioned with polymer.

Recessed-Plate Filter Presses:

Recessed-Plate Filter Presses or Diaphragm Filter Presses are operated in a batch modus with cycle times of 1.5 – 3 hours. If the sludge is conditioned with lime and ferric chloride high dry solids contents of 30 – 40 % can be achieved for anaerobic digested sludge.

The following table shows a compilation of sludge dewatering design parameters.

Description	Process Step	Design Parameter	Value / Unit
Gravity Thickener for Primary Sludge	Gravity Thickening	Retention Time Area Solids Loading Effluent Solids Concentration	2 – 3 days 60 kg DS/m²/d 6 %
Gravity Thickener for Secondary Sludge	Gravity Thickening	Retention Time Area Solids Loading Effluent Solids Concentration	2 – 3 days 40 kg DS/m²/d 2.5 %
Rotary Drum Sieve for Secondary Sludge	Mechanical Thickening	Polymer Requirements Effluent Solids Concentration	3 g/kg DS 6 %
Belt Filter Press for Anaerobic Digested Sludge	Mechanical Dewatering	Dry Feed Solids Polymer Requirements Effluent Solids Concentration	3 – 6 % 6 g/kg DS 20 %
Belt Filter Press for Simultaneous Aerobic Stabilized Sludge	Mechanical Dewatering	Dry Feed Solids Polymer Requirements Effluent Solids Concentration	3 – 6 % 6 g/kg DS 18 %
Centrifuges for Anaerobic Digested Sludge	Mechanical Dewatering	Dry Feed Solids Polymer Requirements Effluent Solids Concentration	3 – 6 % 6 g/kg DS 22 %
Centrifuges for Simultaneous Aerobic Stabilized Sludge	Mechanical Dewatering	Dry Feed Solids Polymer Requirements Effluent Solids Concentration	3 – 6 % 6 g/kg DS 20 %
Recessed-Plate Filter Presses or Diaphragm Filter Presses	Mechanical Dewatering	Dry Feed Solids FeCl3 plus Polymer (plus optional Lime) Effluent Solids Concentration	3 – 6 % 120 – 180 g/kg DS 3.5 – 4.5 g/kg DS (100 - 300 g/kg DS) 30 - 40 %

Table 8-36: Sludge Dewatering Design Parameters

8.3.12.3 Sludge Disposal

The framework of possible sludge disposal options is set out in chapter 7. As far as the WWTP design is concerned, the plant has to provide appropriate sludge treatment, dewatering and storage facilities to support the preferred sludge disposal strategy.

Generally the preferred sludge disposal option should be agricultural sludge re-use, provided that relevant EU and Romanian quality guidelines are met. Sludge can be spread on agricultural land as

- Wet sludge (DS ~ 6 %);

- Dewatered Sludge (DS 20 – 35 %);
- Dried Sludge (DS > 50 %).

Above mentioned sludge types require different storage facilities and capacities. Sludge generally can be spread during fall and spring, hence storage capacity for approximately 6 months has to be provided. Since sludge drying requires high energy input, this solution is not considered in the FS.

As short-term or medium-term solution landfill disposal could be necessary. For landfill disposal a dry solids content of 35 % DS is necessary.

The following table shows a compilation of sludge storage design parameters.

Description	Process Step	Design Parameter	Value / Unit
Sludge Storage Tank for Sludge from Simultaneous Aerobic Stabilization	Wet Sludge Storage	Storage Time Dry Solids Content Specific Sludge Amount Specific Volume Total Spec. Storage Volume (6 months)	6 months 6 % 65 g/p.e./d 1.1 l/p.e./d 200 l/p.e.
Sludge Storage Tank for Sludge from Anaerobic Digestion	Wet Sludge Storage	Storage Time Dry Solids Content Specific Sludge Amount Specific Volume Total Spec. Storage Volume (6 months)	6 months 6 % 49 g/p.e./d 0.82 l/p.e./d 150 l/p.e.
Sludge Storage Area Area with side walls (1.0 – 2.0 m), impervious base plate (concrete or asphalt), drainage pipes back to WWTP.	Dewatered Sludge Storage	Storage Time Dry Solids Content Sludge Density Required Storage Volume Dumping Height	6 months 20 -35 % 1.1 t/m³ 1 m³/t DS 1.5 – 2.0 m

Table 8-37: Sludge Storage Design Parameters

CHAPTER 9

OPTION ANALYSIS

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9 OPTION ANALYSIS

9.1 Water Supply Options

9.1.1 General

The basis of the presented feasibility study is a Masterplan, which was submitted in its final version end of 2008. The aim of the Masterplan was to identify areas with a common water supply based on technical and administrational considerations. In the case of Bacau County, there were 19 supply zones W01 – W19 identified.

Water Supply Area	Name	Cities/Communes	Population total 2007
W01	BACAU CITY + SURROUNDINGS	BACAU; MAGURA, LETEA VECHE; HEMEIUS	202,850
W02	MOINESTI TILL ONESTI	ARDEOANI, ASAU, BUCIUM, COMANESTI, DARMANESTI, DOFTEANA, GURA VAII, MAGIRESTI, MOINESTI, ONESTI, PARGARESTI, PODURI, STEFAN CEL MARE, TARGU OCNA, TARGU TROTUS, CASIN	189,109
W03	OITUZ - MANISTERIA CASIN	BOGDANESTI, MANASTIREA CASIN, OITUZ, PARGARESTI	18,485
W04	SLANIC-MOLDOVA	SLANIC-MOLDOVA	5,085
W05	FAGET - AGAS	AGAS, BRUSTUROASA, GHIMES-FAGET, PALANCA	19,103
W06	ZEMES	ZEMES	5,136
W07	BALCANI - SCORTENI	BALCANI, PARJOL, SCORTENI, SOLONT	21,362
W08	TAZLAU VALLEY	BARSANESTI, BERESTI-TAZLAU, BERZUNTI, HELEGIU, LIVEZI, NICOLAE BALCESCU (only locality LARCUTA), SANDULENI, SCORTENI (only locality FLORESTI), STRUGARI	37,018
W09	BUHUSI	BLAGESTI, BUHUSI, GARLENI, RACOVA	37,523
W10	DAMIENESTI - PLOPANA	DAMIENESTI, LIPOVA, NEGRI, ODOBESTI, PLOPANA, PRAJESTI, ROSIORI, SECUIENI, TRAJAN	23,637

W11	FARAOANI - LUIZI CALUGARA	FARAOANI, LUIZI-CALUGARA, NICOLAE BALCESCU, SARATA	22,285
W12	CLEJA - SASCUT	CLEJA, ORBENI, PARAVA, RACACIUNI, SASCUT, VALEA SEACA	37,297
W13	HORGESTI - UNGURENI	HORGESTI, PARINCEA, UNGURENI	12,619
W14	PANCESTI - DEALU MORII	CORBASCA, DEALU MORII, GAICEANA, HURUIESTI, PANCESTI, TATARASTI	21,461
W15	FILIPENI - RACHITOASA	COLONESTI, FILIPENI, IZVORU BERHECIULU, ONCESTI, RACHITOASA, STANISESTI, VULTURENI	19,908
W16	PODU TURCULUI - MOTOSENI	GLAVANESTI, MOTOSENI, PODU TURCULUI	12,500
W17	CAIUTI - URECHESTI	CAIUTI, COTOFANESTI, URECHESTI	12,606
W18	BUHOCI - GIOSENI	BUHOCI, GIOSENI, TAMASI	11,825
W19	FILIPESTI - SAUCESTI	BERESTI-BISTRITA, ITESTI, SAUCESTI	13,043
TOTAL			**722,852**

Table 9-1: Water Supply Areas Bacau County, Masterplan

The largest water supply areas are W01 and W02, which comprise more than 50% of the whole population of Bacau county.

W01 Bacau City and surroundings is supplied by WTP Caraboaia, whereas approx. half of the water is also withdrawn from groundwater sources (Hemeius, Margineni and Gheraiesti).

W02 is mainly supplied by the WTP Caraboaia which is also located in this Water Supply Area. Another water source in this zone is the WTP Ciobanus for City of Comanesti and some additional groundwater sources.

Water from WTP Caraboaia is pumped to the north and flows by gravity to the south.

The other Water Supply Areas are supplied by local groundwater sources. The total length of the existing networks is approximately 1,100 km, 50 % are located in urban cities. The average county-wide connection rate is 47 %, 340,000 of the 722,000 inhabitants are connected to water supply systems.

All cities predominantly have aged distribution networks with high water losses amounting to approximately 50 % of production. New networks built in the last years are generally in good condition.

This feasibility study is prepared for the 5 priority agglomerations identified in the Masterplan which apply for Cohesion Funds. But due to budget constraints and after a re-evaluation of the existing connection rate for water supply during this FS only 3 of 5 priority agglomerations will include investments for the water supply sector in this CF project.

These are WSZ Bacau, WSZ Moinesti and WSZ Buhusi.

The supply of the priority water supply zones referenced which are part of the CF project in water supply sector are shortly described in the following subchapter.

9.1.2 Strategic Options and Definition of Water Supply Zone Borders

9.1.2.1 Water Supply Zone Bacau

The Bacau water supply zone (orange line), which is mainly part of W01 is situated in the middle of Bacau county and is supplied by four sources : WTP Caraboaia, Margineni, Hemeius and Gheraiesti groundwater source. An overview map of Water Supply Area W01 is presented below. Details about the supply system can be found in chapter 5.

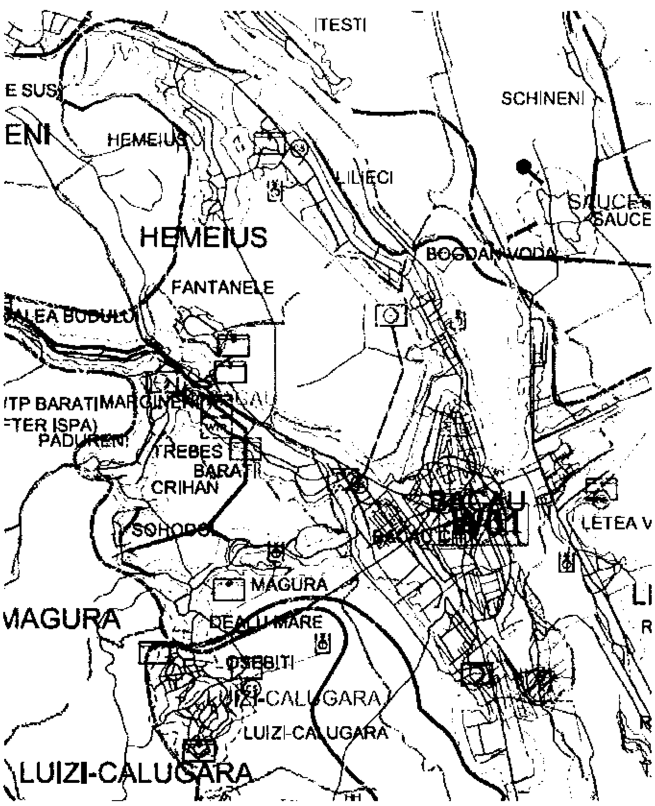

Figure 9-1: Overview Water Supply Zone Bacau

A scheme of the Bacau supply system is presented below.

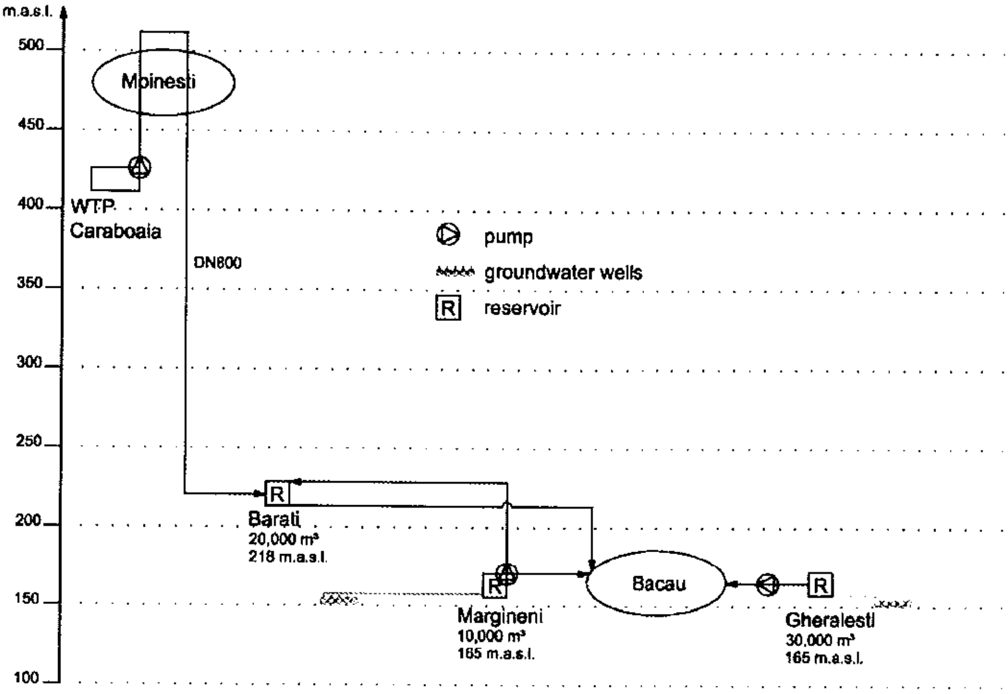

Figure 9-2: Bacau supply system

Although WTP Caraboaia supplies both Water Supply Areas W01 and W02, investments for Rehabilitation of WTP Caraboaia have been allocated only to priority WSZ Bacau.

Due to budget constraints and an existing connection rate of already 90% (re-evaluated during the feasibility study) investments for Bacau water supply network (extension and rehabilitation) have been cancelled.

9.1.2.2 Water Supply Zone Comanesti - Moinesti

The Comanesti - Moinesti water supply zone (orange line), which is a part of W02 is situated in the middle of Bacau county and is supplied only by WTP Caraboaia. An overview map of Water Supply Zone Moinesti is presented below. Details about the supply system can be found in chapter 5.

As described in chapter 3 only the settlements of Moinesti and Gazarie are considered.

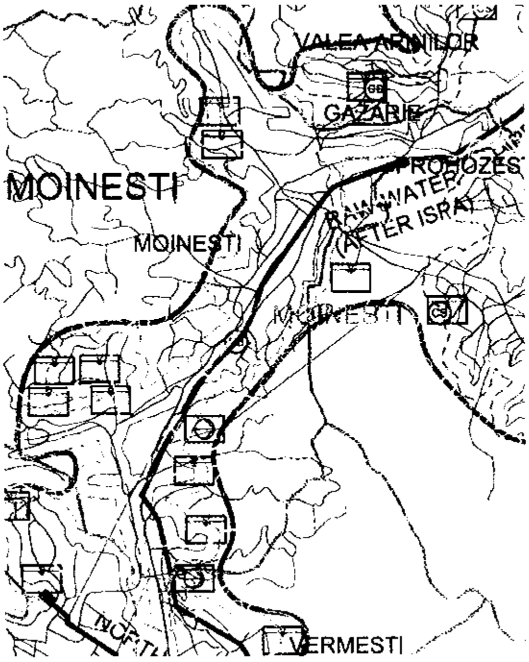

Figure 9-3: Overview Water Supply Zone Moinesti (northern part)

A scheme of the Moinesti supply system is presented below.

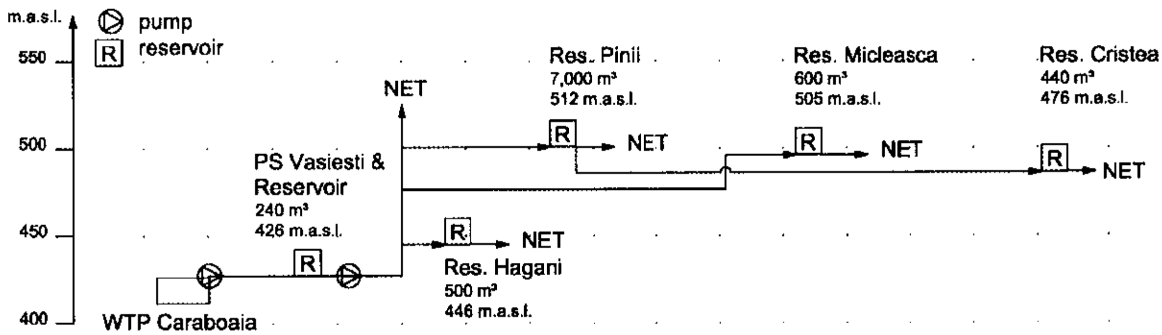

Figure 9-4: Moinesti supply system

In Moinesti investments for water supply network extensions will be spent. Therefore the connection rate for water supply will increase from 84% to 90%.

Due to budget constraints investments for rehabilitation of piping of the main RSV and the main pipe from PS Vermesti to main RSV have been cancelled.

9.1.2.3 Water Supply Zone Buhusi

The Buhusi water supply zone (orange line), which is a part of W09 is situated in the north of Bacau county and is supplied only by groundwater. An overview map of Water Supply Zone Buhusi is presented below. Details about the supply system can be found in chapter 5.

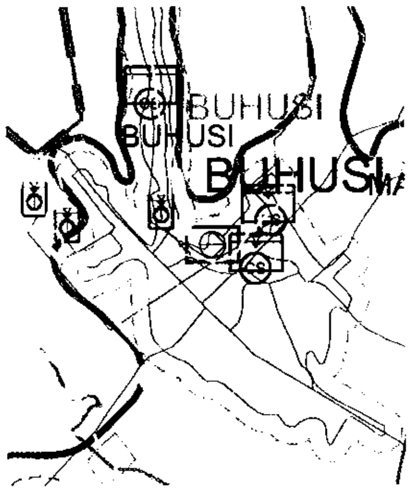

Figure 9-5: Overview Water Supply Zone Buhusi

A scheme of the Buhusi supply system is presented below.

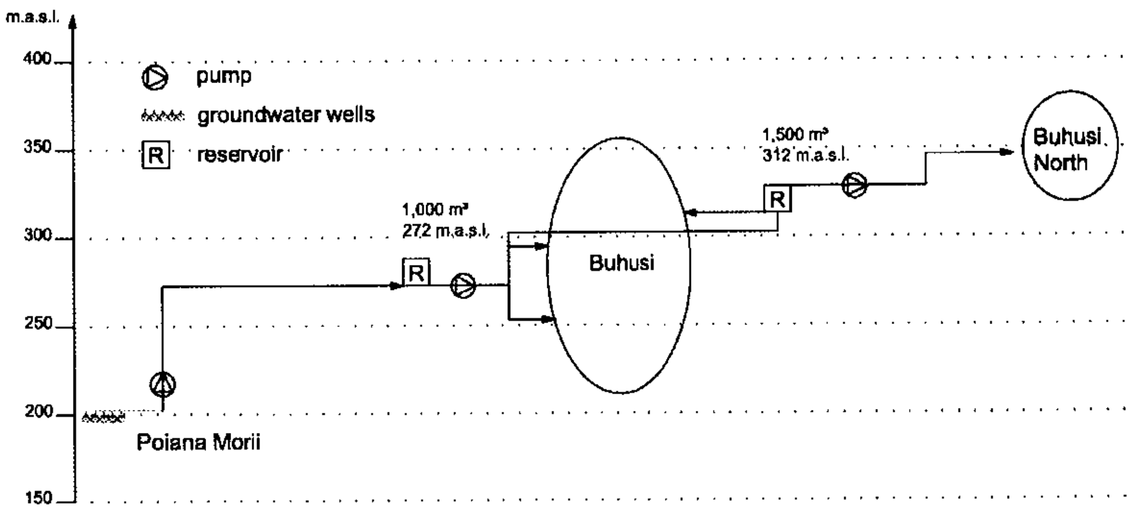

Figure 9-6: Buhusi supply system

In WSZ Buhusi investments for water supply network extensions will be spent. Therefore the connection rate for water supply will increase from 85% to 90%.

9.1.3 General Options

There are no general supply options to be analysed for Bacau county.

9.1.4 Options Water Supply

9.1.4.1 Water Abstraction

There are no measures for water abstraction foreseen.

9.1.4.2 Water Treatment

For WTP Caraboaia there is no option because the plant is already existing. Investments are spent in rehabilitation.

9.1.4.3 Water Storage

There are no measures for water storage foreseen.

9.1.4.4 Water Supply Network

There are no measures for water supply network rehabilitation foreseen. Investments will be spent in network extensions.

9.2 Wastewater Options

9.2.1 Strategic Options and definition of agglomeration borders

The technical solutions presented in this feasibility study are based on an option analysis executed in the master plan. The aim of the option analysis was to identify sufficiently concentrated areas for agglomeration definition. It had to be examined whether these agglomerations should be served by a separate WWTP or if they could be grouped to a cluster with one central WWTP.

This feasibility study is prepared for the priority agglomerations Bacau, Comanesti-Moinesti, Buhusi, Darmanesti and Targu Ocna identified in the master plan which apply for Cohesion Funds.

9.2.2 Options Agglomeration Bacau

9.2.2.1 General options

The agglomeration Bacau contains the capital Bacau City as well as the settlements Crihan, Padureni, Trebes, Valea Budului, Margineni, Barati, Letea Veche, Dealu Mare, Magura, Hemeius and Lilieci. Furthermore, the settlement Saucesti will join the cluster of Bacau in phase 2 (compliance date 2018) and the settlements Fantanele, Sohodol and Bogdan Voda in phase 3.

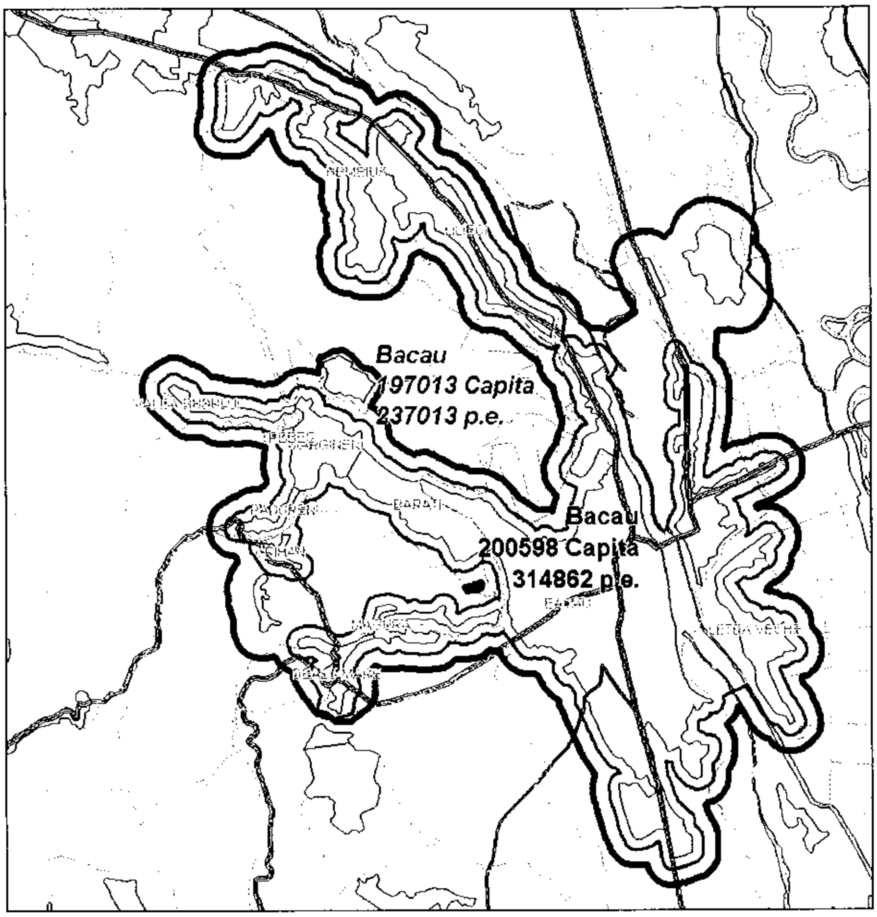

Diagram 9-1: Overview Map Bacau Agglomeration

In the master plan study, the goal of the option analysis has been to find the most economical solution, comparing the following 2 options:

Option 1: 1 WWTP 1 in Bacau for Bacau Agglomeration, 1 WWTP 2 at Saucesti and 1 WWTP 3 at Hemeius

Option 2: 1 central WWTP in Bacau for the whole cluster

9.2.2.1.1 Description of options

Option 1: 1 WWTP 1 in Bacau for Bacau Agglomeration, 1 WWTP 2 at Saucesti and 1 WWTP 3 at Hemeius

In option 1 the existing WWTP at Bacau (WWTP 1) will be rehabilitated and upgraded to treat the wastewater of Bacau City and the settlements Sohodol, Crihan, Padureni, Trebes, Valea Budului, Fantanele, Margineni, Barati, Letea Veche, Dealu Mare and Magura. In this option the possibility of new construction of 2 decentral WWTPs (WWTP 2, WWTP 3) at Saucesti, serving the settlements Saucesti and Bogdan Voda, and at Hemeius, connecting the settlements Hemeius and Lilieci, is analysed. In this option 2 pumping stations and pressure lines are necessary in Letea Veche and Magura.

Option 2: 1 central WWTP in Bacau for the whole cluster

In option 2 the existing old WWTP in Bacau will be removed and the already started construction of a new WWTP will be continued. The new WWTP will be designed to treat the wastewater of the whole cluster Bacau. In this case 3 pumping stations and pressure lines are needed in Lilieci, Letea Veche and Magura.

9.2.2.1.2 Screening of options

Existing assets	Description of key deficiencies	Identification of options	First screening	Justifications for selection
WWTP Bacau Existing sewer network in Bacau	- Effluent quality does not meet requirements of UWWTD because no efficient Nitrogen and Phosphorous removal is existing - Poor condition of electro-mechanical equipment and of civil structures	1) 1 WWTP in Bacau, 1 decentral WWTP in Saucesti, 1 decentral WWTP in Hemeius	rejected	Advantages: - Only 2 pumping stations and pressure lines necessary Disadvantages: - Higher NPV than option 2 because of higher investment and operational costs - 3 WWTPs to operate
		2) 1 central WWTP in Bacau	retained	Advantages: - Only 1 WWTP to operate - Lowest NPV due to lowest investment and operational costs Disadvantages: - 3 pumping stations and pressure lines necessary Justification for selection: Lowest NPV

Table 9-2: Screening of options Bacau Cluster

9.2.2.1.3 Detailed evaluation of options

A detailed analysis of options was executed including construction of decentral WWTPs at Saucesti and Hemeius. These two agglomerations of a size of 2,208 p.e. and 1,706 p.e. respectively are included in the cluster Bacau and are located relatively close to Bacau City. Option 2, which proposes the continuation of the new construction of a central WWTP in Bacau, including tertiary treatment, and the connection of the settlements Lilieci, Letea Veche and Magura via 3 pumping stations and pressure mains has been identified as the most economic solution with the lowest specific NPV. This is due to lower investment costs and slightly lower operational costs for one central WWTP compared to option 1 with a central WWTP and two decentral WWTPs.

9.2.2.1.4 Financial and economic evaluation

The following table shows the financial evaluation of the compared options.

BC_031_Bacau	Option 2/ Final cost	Option 1
P.E.	314,862	314,862
Investment Sum	45,787,616	52.926.853
specific costs Investment Sum	145	168
	100.0%	**115.6%**
Operation cost	2,952,416	3,026,789
	100.0%	**102.5%**
Discounted Present Value	94,112,507	102,710,793
spec. NPV Euro/p.e.	299	326
	100.0%	**109.1%**

Table 9-3: Financial and economic evaluation of the options – Bacau

9.2.2.1.5 Selected option

Following the above explained aspects the Consultant recommends option 2 as favourable solution for the feasibility study.

9.2.2.2 Technical options

The WWTP in Bacau City comprises a mechanical stage, built in 1968, and two biological (activated sludge) treatment steps, constructed in 1978 and 1990. There is no sludge treatment at the moment and tertiary treatment was not considered during the new design of the plant. Therefore, the continuation of the construction of the new WWTP and its upgrading for tertiary treatment is proposed. The biological treatment will consist of aeration tanks for nitrification / denitrification and the sludge treatment will comprise gravity sludge thickening, mechanical sludge dewatering and anaerobic digestion with a gas storage tank, a cogeneration unit and a gas flare.

9.2.2.2.1 Combined or Separate Sewer Network

The existing sewer network of Bacau City is a combined system, hence wastewater and storm water are transported in the same pipes.

To maintain reasonable and economic pipe diameters, combined systems require relief and storm water treatment structures where storm water that exceeds a certain percentage of dry weather flow is discharged directly into the receiving water body without biological treatment. Both, the large pipes and the relief structures cause high costs.

The punctual discharge of storm water intensifies flood currents and local hydraulic stress in the aquatic system. Pollutants contained in the storm water (diluted wastewater) cause significant drops in oxygen concentration and lead to an entry of nutrients in the water body. Furthermore the relief of storm water from combined systems leads to adverse aesthetic effects (most evident at river banks) due the discharge of coarse material (paper, plastics etc.).

In separate systems wastewater is transported in sewer pipes with smaller diameters without relief structures and storm water is collected separately in pipes or open ditches and infiltrated locally or discharged to receiving water bodies. Storm water retention / treatment basins are possible where required.

Basically separate systems are more reasonable from an ecological and economic point of view provided that enough space for a double pipe system (or pipe plus ditch) is available and that a local infiltration of storm water (depending on soil properties and ground water level) or a discharge to a water body is possible in adequate distance.

Furthermore it should be mentioned that CF only finances separate systems.

In Bacau Cluster all extensions foreseen for CF are located in areas, where the pre-conditions for the economic installation of a separate sewer system are fulfilled. Consequently the separate system was selected for network extensions. Furthermore, hydraulic rehabilitation of approximately 40.4 km of the existing combined system in Bacau City is foreseen.

9.2.2.2.2 Relining or Replacement of Sewer Pipes

Relining is a method to rehabilitate pipes that have lost their hydraulic capacity due to damages. An increase of hydraulic capacity is not possible with this rehabilitation method.

Since CF only finances measures that are justified by an increase of connection rate, the Consultant only considered rehabilitation of existing networks in those cases where an increase of hydraulic capacity of the existing pipes was necessary due to additional flow caused by network extensions. In these cases only a replacement of the existing pipes with increased diameter leads to the anticipated result.

9.2.2.2.3 Rehabilitation or new construction of a WWTP

As mentioned earlier, a new WWTP in Bacau City was planned to be completed in 2009. Therefore, the continuation of the new construction of this plant and its extension for 320,000 p.e. and upgrade for tertiary treatment is recommended.

9.2.2.2.4 Rational for Selection of WWTP Type

During FS stage investment programs for agglomerations ≥ 10,000 p.e. have to be developed, thus tertiary treatment with nitrogen and phosphorus elimination are mandatory. Consequently the Consultant applied the activated sludge treatment system for the biological treatment, except for WWTPs with rehabilitation of already existing trickling filters. The Consultant used the ATV-DVWK A 131 for the design of the WWTP.

Concerning sludge stabilization the activated sludge process provides the following two major solutions:

1. Sludge stabilization with anaerobic digestion:

The wastewater treatment process of WWTP with anaerobic digestion generally consists of primary sedimentation tanks, activated sludge tanks (sludge age ca. 14 d) and secondary sedimentation tanks. Primary sludge and secondary sludge (excess sludge plus precipitation sludge) are discharged to the sludge treatment process which mainly consists of a dewatering step of the raw sludge (DS ca. 5 %), the anaerobic digestion and a final sludge dewatering (DS 20 - 30 % depending on final disposal of sludge). The dewatered sludge is then disposed of.

The biogas, produced in the anaerobic digesters, is often used for the production of electric and thermal energy (cogeneration units) in combination with gas holding tanks and gas flares.

The following figure shows a flow scheme of a WWTP with anaerobic digestion.

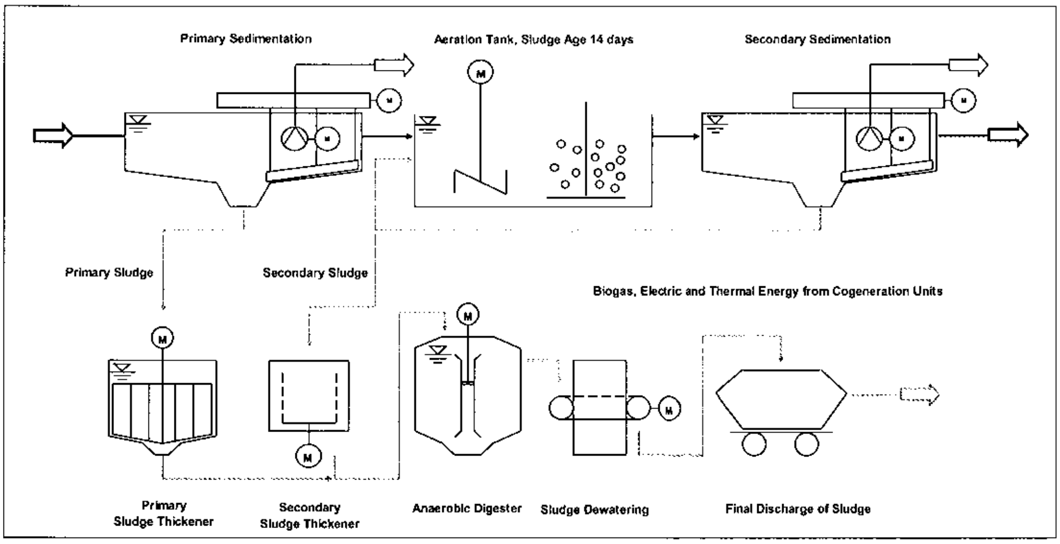

Figure 9-7: WWTP with Anaerobic Digestion

2. Simultaneous aerobic sludge stabilization (extended aeration):

The wastewater treatment process of a WWTP with simultaneous aerobic stabilization generally consists of activated sludge tanks (sludge age 25 d, no primary sedimentation tank) and secondary sedimentation tanks. The stabilization of the secondary sludge (excess sludge plus precipitation sludge) is included in the aeration tanks. The secondary sludge is then discharged to the sludge dewatering process which mainly consists of a storage / dewatering step of the raw sludge (DS ca. 5 %) and a final sludge dewatering (DS 20 - 30 % depending on final disposal of sludge). The dewatered sludge is then disposed of.

The following figure shows a flow scheme of a WWTP with simultaneous aerobic stabilization.

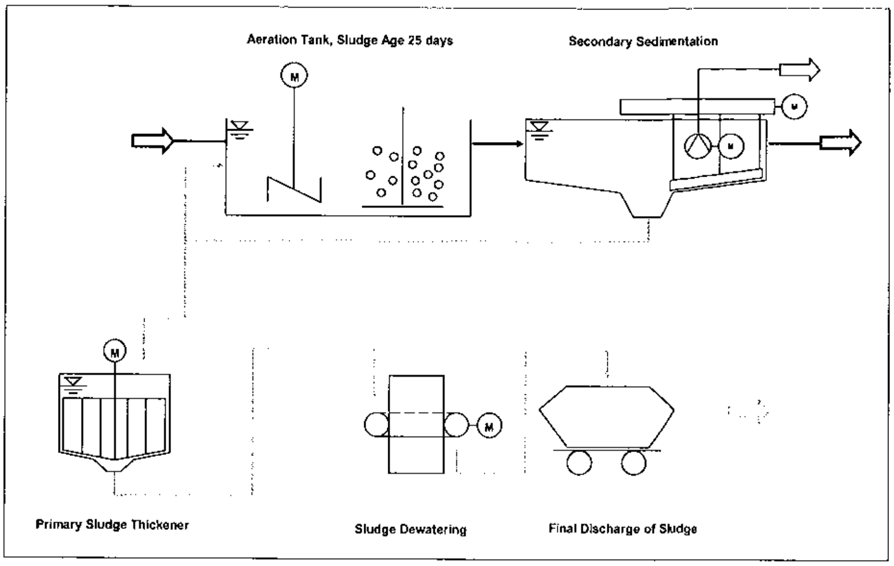

Figure 9-8: WWTP with Extended Aeration

Which of the both treatment processes is the most economic solution depends on the plant size. Based on experience from Western European countries the following thresholds can be applied:

Simultaneous Aerobic Sludge Stabilization:	≤	50,000	p.e.
Anaerobic Digestion:	>	50,000	p.e.

Due to the size of the WWTP Bacau only anaerobic sludge digestion is technically and economically reasonable.

9.2.2.2.5 In-situ construction or compact WWTP

As the planned WWTP in Bacau has a capacity of 320,000 p.e., the installation of compact plants is no option.

9.2.2.2.6 Different locations and discharge points for WWTPs

Considering the existing configuration of the sewer network of the Bacau Agglomeration, the location of the WWTP Bacau is optimal and represents the solution with the least negative effects. The Bacau City WWTP has sufficient space for the required extensions to allow implementation of tertiary treatment.

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9.2.3 Options Agglomeration Comanesti-Moinesti

9.2.3.1 General options

The agglomeration of Comanesti-Moinesti comprises the towns Comanesti and Moinesti and the localities Lunca Asau, Asau, Straja, Ciobanus, Podei and Gazarie.

Comanesti, Lunca Asau, Asau, Straja, Ciobanus and Podei did not join the IDA and ROC, thus are not eligible to be included in the CF project.

Only Moinesti and Gazarie signed the contract with the IDA and ROC and consequently are included in the CF project. Zemes, which is located north of Moinesti and is part of the clustered agglomeration is also part of the IDA and ROC and will be connected after 2018.

The following sub-chapters only take into consideration the options for Moinesti, Gazarie and Zemes.

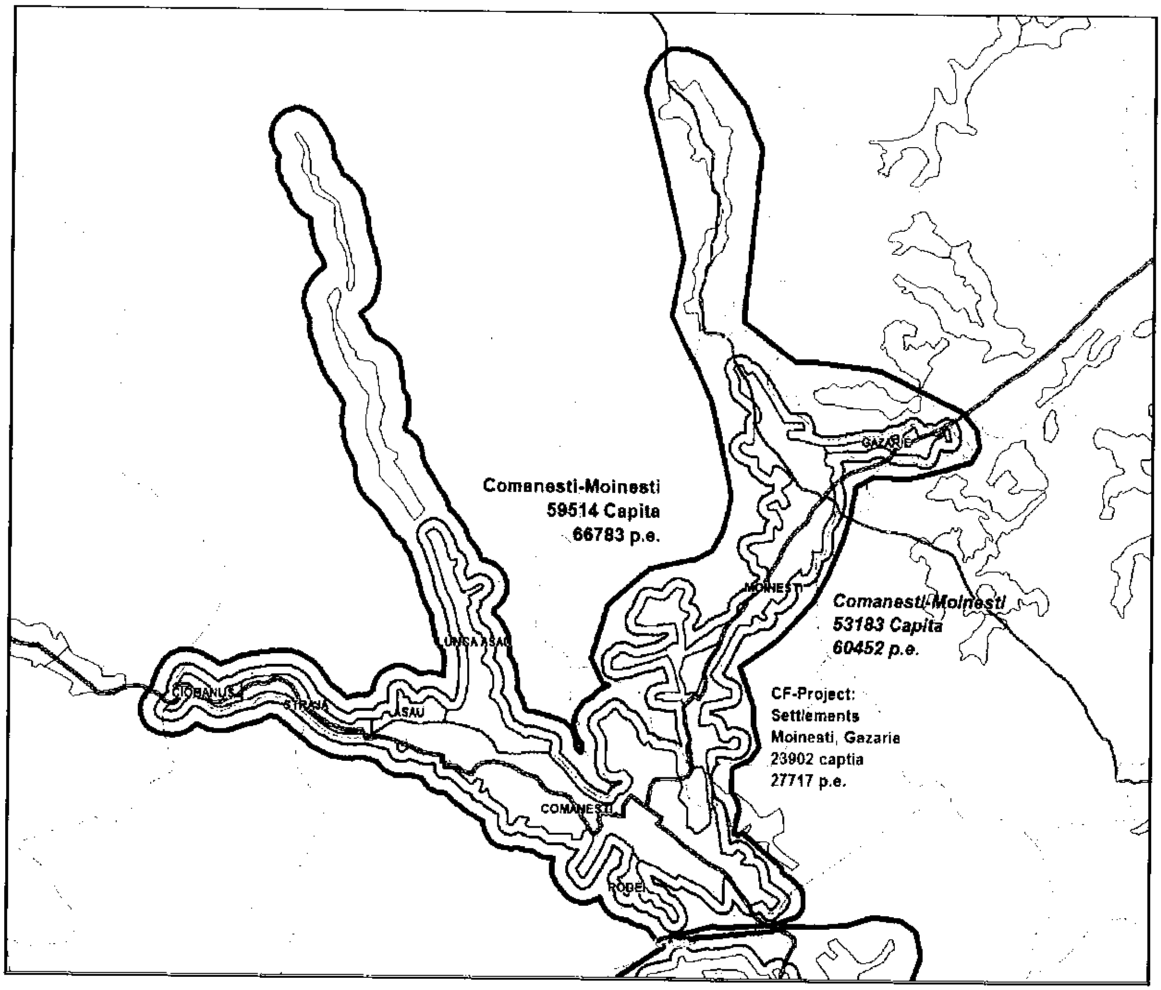

Diagram 9-2: Overview Map Comanesti-Moinesti Agglomeration

For Moinesti and Gazarie the following 2 options have been analysed:

Option 1: 1 central WWTP in Moinesti North with 3 PS

Option 2: 1 WWTP in Moinesti North and 1 WWTP in Moinesti South

9.2.3.1.1 Description of options

Option 1: 1 central WWTP in Moinesti with 3 PS

In option 1 the central WWTP in Moinesti North will be extended and rehabilitated. 3 pumping stations will be constructed in Moinesti South with a pressure head of 50 m, 50 m and 30 m respectively as well as one pumping station in Gazarie. 4 pressure lines with a total length of approximately 8,100 m will be needed.

Option 2: 1 WWTP in Moinesti North and 1 WWTP in Moinesti South

Option 2 considers the full rehabilitation and extension of the existing WWTP in Moinesti North and the construction of a second WWTP in Moinesti South. In this case only one pumping station in Gazarie and a pressure line with a length of approximately 2,800 m will be necessary.

9.2.3.1.2 Screening of options

Existing assets	Description of key deficiencies	Identification of options	First screening	Justifications for selection
WWTP Moinesti North Existing sewer network Moinesti North	- Effluent quality does not meet requirements of UWWTD because no efficient Nitrogen and Phosphorous removal is existing - Poor condition of electro-mechanical equipment and of civil structures	1) 1 central WWTP in Moinesti North with 3 PS	rejected	Advantages: - Only 1 WWTP to operate Disadvantages: - 3 pumping stations in Moinesti South and one in Gazarie necessary - Higher NPV compared to option 2 due to operational costs
		2) 1 WWTP in Moinesti North and 1 WWTP in Moinesti South	retained	Advantages: - Only 1 pumping station in Gazarie necessary - Lower Investment costs - Lower NVP Disadvantages: - Justification for selection: Lowest NPV

Table 9-4: Screening of options Moinesti Cluster

9.2.3.1.3 Detailed evaluation of options

A detailed analysis of options was executed including construction of 3 pumping stations in Moinesti South to connect to the rehabilitated and extended WWTP in Moinesti North and the construction of a new WWTP in Moinesti South and the rehabilitation and extension of the existing WWTP in Moinesti North. Option 2 has been identified as the most economic solution with the lowest specific NPV.

9.2.3.1.4 Financial and economic evaluation

The following table shows the financial evaluation of compared options.

	Option 1	Option 2
	Agglo Moinesti (3 PS)	Agglo Moinesti (2 WWTP)
	Moinesti South	Moinesti South
	Moinesti North	Moinesti North
	Zemes	Zemes
	Gazarie	Gazarie
	Sum	Sum
P.E.	31,719	31,719
Investment Sum	17,814,902	17,491,511
specific costs Investment Sum	562	551
	100.0%	**98.2%**
Operation cost	504,573	504,638
	100.0%	**100.0%**
Discounted Present Value	26,919,238	26,667,953
spec. NPV Euro/p.e.	849	841
	100.0%	**99.1%**

Table 9-5: Financial and economic evaluation of the options - Moinesti

9.2.3.1.5 Selected option

Following the above explained aspects the Consultant recommends Option 2 as favourable solution for the feasibility study.

9.2.3.2 Technical options

Several technical aspects have been taken into consideration during the master plan and the actual feasibility study. In the following these aspects are described in more detail.

9.2.3.2.1 Combined or Separate Sewer Network

In Moinesti Agglomeration all extensions foreseen for CF are located in areas, where the pre-conditions for the economic installation of a separate sewer system are fulfilled (see explanations Bacau Agglomeration). Consequently the separate system was selected for network extensions. Furthermore, approximately 6 km of the existing combined network in Moinesti North will be rehabilitated.

9.2.3.2.2 Relining or Replacement of Sewer Pipes

Since CF only finances measures that are justified by an increase of connection rate, the Consultant only considered rehabilitation of existing networks in those cases where an increase of hydraulic capacity of the existing pipes was necessary due to additional flow caused by network extensions. In these cases only a replacement of the existing pipes with increased diameter leads to the anticipated result.

9.2.3.2.3 Rehabilitation or new construction of a WWTP

The WWTP Moinesti was constructed in 1967 and rehabilitated in 1995 and 2002. It comprises mechanical as well as biological treatment in biological trickling filters. For sludge treatment cold digestion in Imhoff-tanks, sludge stabilisation and sludge drying beds were foreseen. Due to the poor condition of civil structures and electro-mechanical equipment, a full rehabilitation of the WWTP at the same location and extension for tertiary treatment is necessary to fulfil the requirements with respect to physical condition of civil, mechanical and electrical components as well as treatment capacity and effluent quality.

9.2.3.2.4 Rational for Selection of WWTP Type

For Moinesti WWTP tertiary treatment is required, consequently the Consultant proposes the rehabilitation of 1 trickling filter for biological treatment and a chemical precipitation unit for phosphorous removal.

Since with the existing trickling filters a simultaneous aerobic sludge stabilization process is not feasible, the plant will be equipped with a sludge digestion tank for sludge treatment.

9.2.3.2.5 In-situ construction or compact WWTP

Compact WWTPs have a size to serve up to 2,000 p.e.. There is the possibility to arrange two or three of these compact plants, but as the design capacity of the WWTP in Moinesti is 32,000 p.e. the use of compact plants is not reasonable.

9.2.3.2.6 Different locations and discharge points for WWTPs

Only the site of the existing WWTP in Moinesti North is available for the rehabilitation and extension of the WWTP. Considering the existing configuration of the sewer network in Moinesti Agglomeration, the location of the WWTP Moinesti is optimal and represents the solution with the least negative environmental effects.

9.2.3.2.7 Separate or combined sludge dewatering

With regard to the sludge dewatering at the WWTPs Moinesti-North and Moinesti-South the following options were analyzed.

Option 1: Separate sludge dewatering with recessed plate filter press at WWTP Moinesti-North and Moinesti-South.

Option 2: Combined sludge dewatering for Moinesti-North and Moinesti-South at Moinesti-North. Sludge from Moinesti-South is transported at 2,5 % DS to Moinesti-North.

	Option 1	**Option 2**
Description	Dewatering at Monesti-North and Moinesti-South	Transport of sludge from Moinesti-South to Moinesti-North at 2.5 % DS, combined dewatering at Moinesti-North
P.E.	31,719	31,719
Investment Sum	247,977	75,169
specific costs Investment Sum	8	2
	100.0%	**30.3%**
Operation cost	37,704	38,363
	100.0%	**101.7%**
Discounted Present Value	946,863	701,054
spec. NPV Euro/p.e.	30	22
	100.0%	**74.0%**

Table 9-6: Financial and economic evaluation of the options

Option 2 was selected as the most economic option.

9.2.4 Options Agglomeration Buhusi

9.2.4.1 General options

The agglomeration of Buhusi comprises only the town Buhusi itself. The settlements Blagesti, Buda, Valea Lui Ion, Tardenii Mari and Racova will join the cluster in phase 2 (compliance date 2018).

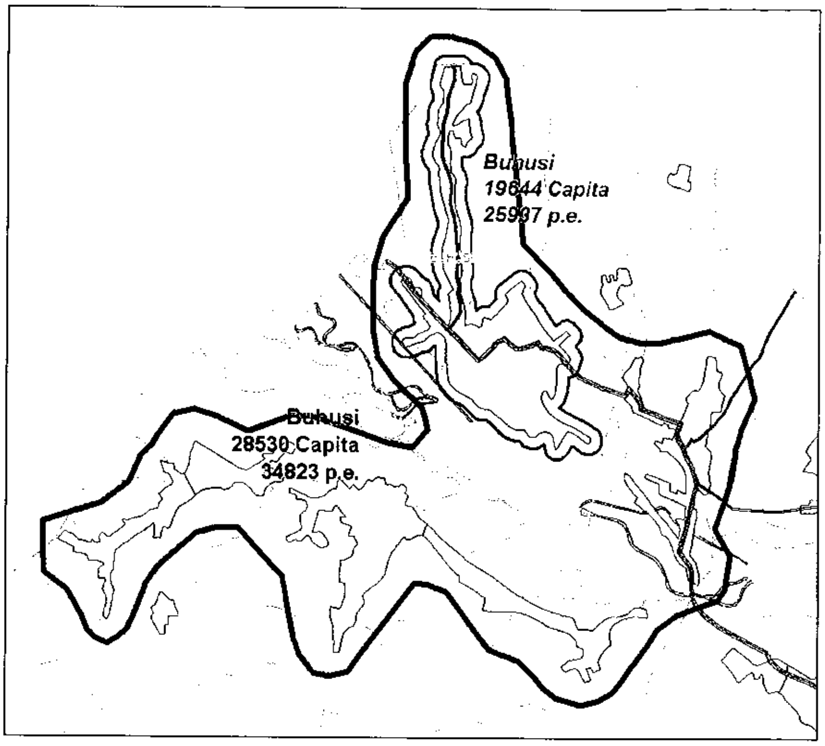

Diagram 9-3: Overview Map Buhusi Agglomeration

For Buhusi Cluster the following 2 options have been analysed:

Option 1: 1 WWTP 1 in Buhusi, 1 WWTP 2 in Blagesti, 1 WWTP 3 in Racova and 1 WWTP 4 in Valea Lui Ion

Option 2: 1 central WWTP in Buhusi

9.2.4.1.1 Description of options

Option 1: 1 WWTP 1 in Buhusi, 1 WWTP 2 in Blagesti, 1 WWTP 3 in Racova and 1 WWTP 4 in Valea Lui Ion

In option 1 the existing WWTP in Buhusi will be rehabilitated and extended to treat the wastewater of Buhusi Town. Additionally, decentral WWTPs will be constructed in Blagesti, serving the settlements of Blagesti and Buda, in Racova for the wastewater of Racova and in Valea Lui Ion, serving Valea Lui Ion and Tardenii Mari. In this case no pumping stations will be necessary.

Option 2: 1 central WWTP in Buhusi

In option 2 the existing central WWTP in Buhusi will be rehabilitated and extended to treat the wastewater of the entire cluster. For this option there will be a need for a pumping station in Buda and a pressure line connecting Buda to the WWTP in Buhusi in phase 2.

9.2.4.1.2 Screening of options

<table>
<tr><th>Existing assets</th><th>Description of key deficiencies</th><th>Identification of options</th><th>First screening</th><th>Justifications for selection</th></tr>
<tr><td rowspan="5">WWTP Buhusi
Existing sewer network Buhusi</td><td rowspan="5">- Effluent quality does not meet requirements of UWWTD because no efficient Nitrogen and Phosphorous removal is existing
- Poor condition of electro-mechanical equipment and of civil structures</td><td rowspan="2">1) 1 WWTP 1 in Buhusi, 1 WWTP 2 in Blagesti, 1 WWTP 3 in Racova and 1 WWTP 4 in Valea Lui Ion</td><td rowspan="2">rejected</td><td><u>Advantages:</u>
- No pumping station and pressure line necessary</td></tr>
<tr><td><u>Disadvantages:</u>
- 4 WWTPs to operate
- Higher NPV compared to option 2 because of higher investment and operational costs</td></tr>
<tr><td rowspan="3">2) 1 central WWTP in Buhusi</td><td rowspan="3">retained</td><td><u>Advantages:</u>
- Lower NPV compared to option 1 due to lower investment and operational costs
- Only 1 WWTP to operate</td></tr>
<tr><td><u>Disadvantages:</u>
- Pumping station in Buda and pressure line necessary</td></tr>
<tr><td><u>Justification</u> for selection:
Lowest NPV</td></tr>
</table>

Table 9-7: Screening of options Buhusi Cluster

9.2.4.1.3 Detailed evaluation of options

A detailed analysis of options including the construction of 4 WWTPs, one in Buhusi, the second in Blagesti, the third in Racova and the fourth in Valea Lui Ion, was carried out. All settlements are located relatively close to one another and to Buhusi Town. They are relatively small with a size of between 790 and 2,585 p.e.. Option 2 comprising the construction of a new central WWTP in Buhusi was identified as the most economic solution with the lowest specific NPV.

9.2.4.1.4 Financial and economic evaluation

The following table shows the financial evaluation of compared options.

	Option 2 / Final	**Option 1**
P.E.	34,823	34,823
Investment Sum	22,620,442	23,681,501
specific costs Investment Sum	650	680
	100.0%	**104.7%**
Operation cost	497,317	602,879
	100.0%	**121.2%**
Discounted Present Value	31,623,653	34,616,059
spec. NPV Euro/p.e.	908	994
	100.0%	**109.5%**

Table 9-8: Financial and economic evaluation of the options

9.2.4.1.5 Selected option

Following the above explained aspects the Consultant recommends option 2 as favourable solution for the feasibility study.

9.2.4.2 Technical options

Several technical aspects have been taken into consideration during the master plan and the actual feasibility study. In the following these aspects are described in more detail.

9.2.4.2.1 Combined or Separate Sewer Network

In Buhusi Agglomeration all extensions foreseen for CF are located in areas, where the pre-conditions for the economic installation of a separate sewer system are fulfilled (see explanations Bacau Agglomeration). Consequently the separate system was selected for network extensions. Furthermore, approximately 4.8 km of the existing combined network in Buhusi will be rehabilitated.

9.2.4.2.2 Relining or Replacement of Sewer Pipes

Since CF only finances measures that are justified by an increase of connection rate, the Consultant only considered rehabilitation of existing networks in those cases where an increase of hydraulic capacity of the existing pipes was necessary due to additional flow caused by network extensions. In these cases only a replacement of the existing pipes with increased diameter leads to the anticipated result.

9.2.4.2.3 Rehabilitation or new construction of a WWTP

The WWTP Buhusi was constructed in 1978 as a mechanical and biological treatment plant with trickling filters and cold digestion and sludge drying beds as sludge treatment. The condition of the civil structures and the electro-mechanical equipment is poor. Therefore, full rehabilitation of the WWTP and extension for nitrogen removal and sludge treatment are recommended.

9.2.4.2.4 Rational for Selection of WWTP Type

For Buhusi WWTP tertiary treatment is required, consequently the Consultant proposes the rehabilitation of the trickling filters for biological treatment and a chemical precipitation unit for phosphorous removal.

Since with the existing trickling filters a simultaneous aerobic sludge stabilization process is not feasible, the plant will be equipped with a sludge digestion tank for sludge treatment.

9.2.4.2.5 In-situ construction or compact WWTP

Compact WWTPs have a size to serve up to 2,000 p.e.. There is the possibility to arrange two or three of these compact plants. However, in the case of the WWTP in Buhusi with a design capacity of approximately 35,000 p.e. the use of compact plants is not feasible.

9.2.4.2.6 Different locations and discharge points for WWTPs

Considering the existing configuration of the sewer network in Buhusi Agglomeration, the location of the WWTP Buhusi is optimal and represents the solution with the least negative environmental effects.

9.2.5 Options Agglomeration Darmanesti

9.2.5.1 General options

The agglomeration Darmanesti includes the settlements Darmanesti, Darmaneasca and Lapos. The cluster will be joined in phase 3 by the settlements Salatruc, Pagubeni and Plopu. Due to the position of Darmanesti Agglomeration with no proximity to other relevant settlements and no possibility to connect it to other agglomerations by gravity, no option analysis was carried out.

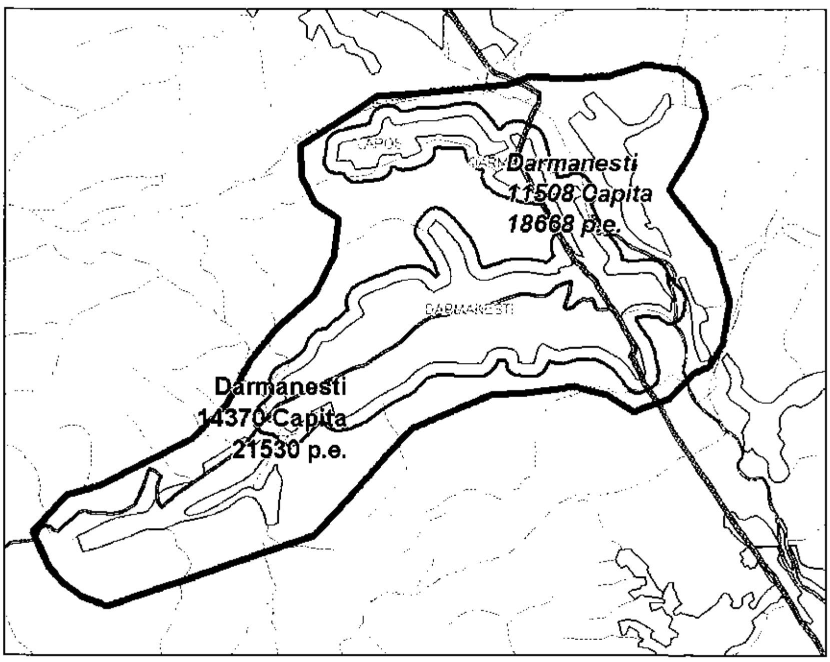

Diagram 9-4: Overview Map Darmanesti Agglomeration

9.2.5.2 Technical options

Several technical aspects have been taken into consideration during the master plan and the actual feasibility study. In the following these aspects are described in more detail.

9.2.5.2.1 Combined or Separate Sewer Network

In Darmanesti Agglomeration all extensions foreseen for CF are located in areas, where the pre-conditions for the economic installation of a separate sewer system are fulfilled (see explanations Bacau Agglomeration). Consequently the separate system was selected for network extensions.

9.2.5.2.2 Relining or Replacement of Sewer Pipes

Since CF only finances measures that are justified by an increase of connection rate, the Consultant only considered rehabilitation of existing networks in those cases where an increase of hydraulic capacity of the existing pipes was necessary due to additional flow caused by network extensions. In these cases only a replacement of the existing pipes with increased diameter leads to the anticipated result.

9.2.5.2.3 Rehabilitation or new construction of a WWTP

There is a WWTP located in the middle of Darmanesti Town which comprises only mechanical treatment and does not have sufficient capacity to treat the wastewater of the entire town. Because of the size and the location of the WWTP it is recommended to dismantle the old WWTP and build a new central WWTP in the south eastern part of the Darmanesti where there is already a communal site available.

9.2.5.2.4 Rational for Selection of WWTP Type

For Darmanesti WWTP tertiary treatment is required, consequently the Consultant selected the activated sludge treatment process with nitrification / denitrification for biological treatment and a chemical precipitation unit for phosphorous removal.

With a size of approximately 21,500 p.e. the Darmanesti WWTP is best suited for simultaneous aerobic sludge stabilization.

9.2.5.2.5 In-situ construction or compact WWTP

Compact WWTPs have a size to serve up to 2,000 p.e.. There is the possibility to arrange two or three of these compact plants, but as the design capacity of the WWTP in Onesti is approximately 21,500 p.e. the use of compact plants is not reasonable.

9.2.5.2.6 Different locations and discharge points for WWTPs

Due to the relocation of the WWTP in Darmanesti to the south eastern part of town, the discharge point will change. The new discharge point represents the solution with the least negative environmental effects.

9.2.6 Options Agglomeration Targu Ocna

9.2.6.1 General options

The agglomeration Targu Ocna includes the town Targu Ocna and Valcele. The cluster will be joined in phase 3 by the settlements Poieni and Bogata. Due to the position of Targu Ocna Agglomeration with no proximity to other relevant settlements and no possibility to connect it to other agglomerations by gravity, no option analysis was carried out.

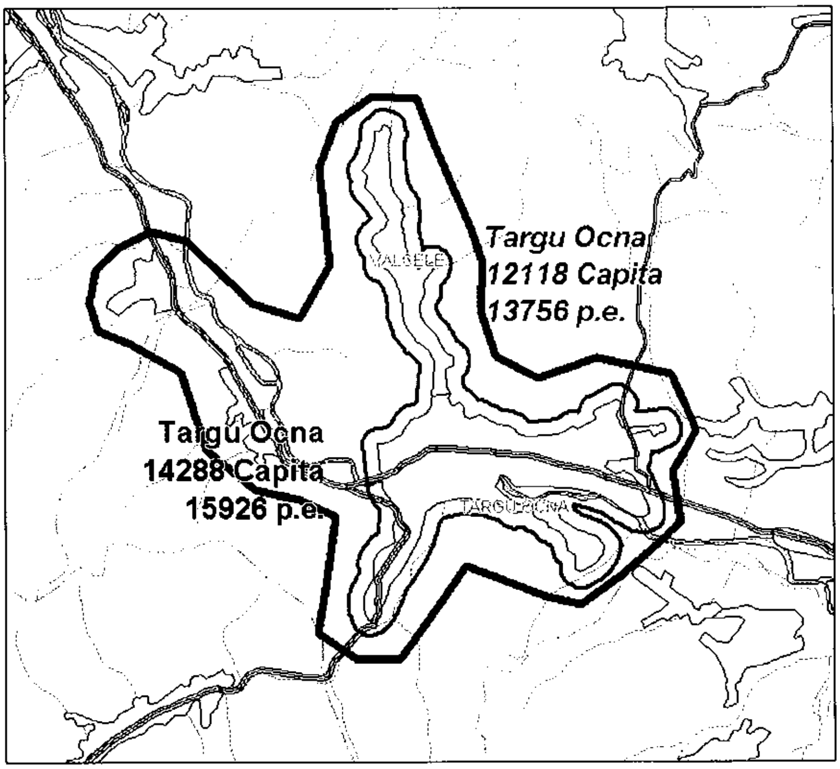

Diagram 9-5: Overview Map Targu Ocna Agglomeration

9.2.6.2 Technical options

Several technical aspects have been taken into consideration during the master plan and the actual feasibility study. In the following these aspects are described in more detail.

9.2.6.2.1 Combined or Separate Sewer Network

In Targu Ocna Agglomeration all extensions foreseen for CF are located in areas, where the pre-conditions for the economic installation of a separate sewer system are fulfilled (see explanations Bacau Agglomeration). Consequently the separate system was selected for network extensions. Furthermore, approximately 3.1 km of the existing combined network in Targu Ocna will be rehabilitated.

9.2.6.2.2 Relining or Replacement of Sewer Pipes

Since CF only finances measures that are justified by an increase of connection rate, the Consultant only considered rehabilitation of existing networks in those cases where an increase of hydraulic capacity of the existing pipes was necessary due to additional flow caused by network extensions. In these cases only a replacement of the existing pipes with increased diameter leads to the anticipated result.

9.2.6.2.3 Rehabilitation or new construction of a WWTP

There is a WWTP located in the eastern part of Targu Ocna, which was constructed from 1960 to 1070 and reconstructed after flood damage in 2002. It comprises mechanical and biological treatment in trickling filters as well as sludge treatment in Imhoff-tanks for cold digestion and sludge drying beds. Therefore, it is recommended to rehabilitate the existing plant and modify it for nitrogen removal and sludge treatment. Furthermore, flood protection is proposed.

9.2.6.2.4 Rational for Selection of WWTP Type

For Targu Ocna WWTP tertiary treatment is required, consequently the Consultant proposes the rehabilitation of the trickling filters for biological treatment and a chemical precipitation unit for phosphorous removal.

Since with the existing trickling filters a simultaneous aerobic sludge stabilization process is not feasible, the plant will be equipped with a sludge digestion tank for sludge treatment.

9.2.6.2.5 In-situ construction or compact WWTP

Compact WWTPs have a size to serve up to 2,000 p.e.. There is the possibility to arrange two or three of these compact plants, but as the design capacity of the WWTP in Targu Ocna is approximately 16,000 p.e. the use of compact plants is not reasonable.

9.2.6.2.6 Different locations and discharge points for WWTPs

Considering the existing configuration of the sewer network in Targu Ocna Agglomeration, the location of the WWTP Targu Ocna is optimal and represents the solution with the least negative environmental effects.

9.3 Summary of Option Analysis

9.3.1 Agglomeration Bacau

Wastewater

The cluster Bacau includes Bacau City and the settlements Crihan, Padureni, Trebes, Valea Budului, Margineni, Barati, Letea Veche, Dealu Mare, Magura, Hemeius and Lilieci. The settlement Saucesti will join the cluster in phase 2 and Fantanele, Sohodol and Bogdan Voda in phase 3. Bacau City already has a wastewater network and the WWTP Bacau was planned to be rehabilitated by 2009. However, so far only the preliminary treatment stages have been reconstructed.

The wastewater of the agglomeration will be discharged to the new central WWTP in Bacau with a capacity of 320,000 p.e.. The WWTP will comprise biological treatment in the form of activated sludge with nitrification and denitrification as well as chemical phosphorous precipitation. As sludge treatment anaerobic digestion with utilization of biogas and sludge dewatering will be used. The WWTP will be extended at the existing site without alteration of the discharge point.

In Bacau rehabilitation of approximately 40.4 km of the existing combined sewer network extensions as well as network extensions in Bacau City and new construction of sewerage networks in the other settlements are foreseen. 3 pumping stations, in Lilieci, in Letea Veche and in Magura including pressure lines are to be constructed.

9.3.2 Agglomeration Comanesti-Moinesti

Wastewater

The agglomeration Comanesti-Moinesti includes the town Moinesti and the settlement Gazarie. The cluster will be joined by the settlement Zemes in phase 3. There is a wastewater network and a WWTP in the north eastern part of Moinesti.

The existing WWTP in Moinesti will receive full rehabilitation and extension for tertiary treatment to treat the wastewater of the cluster. The treatment plant will use trickling filters as biological treatment and additionally chemical phosphorous removal. Sludge digestion is foreseen as sludge treatment.

3 pumping stations are necessary in Moinesti South with a pressure head of 30 m to 50 m. A fourth pumping station will be needed in Gazarie. All sewer network extensions will be implemented as separate systems. Furthermore, about 6 km of the existing network will be rehabilitated.

9.3.3 Agglomeration Buhusi

Wastewater

In phase 1 the agglomeration Buhusi only includes the settlement Buhusi itself. In phase 2 the settlements Blagesti, Buda, Valea Lui Ion, Tardenii Mari and Racova will join the cluster. A sewer network and a WWTP already exist in Buhusi.

Due to the poor state of the WWTP full rehabilitation and extension is required. The new WWTP Buhusi will have a capacity of approximately 35,000 p.e. and will use trickling filters as biological and sludge digestion as sludge treatment.

All sewer network extensions will be implemented as separate systems. Furthermore, about 4,8 km of the existing combined network will be rehabilitated. For connecting the settlement of Buda to the WWTP in phase 2 a new pumping station and pressure lines will be required.

9.3.4 Agglomeration Darmanesti

Wastewater

The agglomeration Darmanesti comprises the settlements Darmanesti, Darmaneasca and Lapos with Salatruc, Pagubeni and Plopu joining the cluster in phase 3. There is an existing sewer network in Darmanesti and also a WWTP exists, but it does not have sufficient capacity and is located in the middle of the town.

Therefore, the WWTP in Darmanesti will be dismantled and a new WWTP will be constructed in the south eastern part of the town. The plant will use the activated sludge treatment process with aerobic sludge stabilization.

All sewer network extensions will be implemented as separate systems. Pumping stations and pressure lines will be required in Plopu and Pagubeni in phase 2.

9.3.5 Agglomeration Targu Ocna

Wastewater

The agglomeration Targu Ocna includes the town Targu Ocna and Valcele. In phase 3 the cluster will be joined by the settlements Poieni and Bogata. Targu Ocna has a combined sewer network and a WWTP with trickling filters as biological treatment.

The WWTP in Targu Ocna will be rehabilitated and extended for tertiary and sludge treatment to fulfil the discharge requirements. The plant will continue to use trickling filters for biological treatment with an additional phosphorous precipitation unit and will apply sludge digestion as sludge treatment.

All sewer network extensions will be implemented as separate systems. A pumping station will be required in Targu Ocna in phase 1 and an additional one in Poieni in phase 3.

CHAPTER 10

PROJECT PRESENTATION

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