WATER SUPPLY AND WASTEWATER SYSTEMS MASTER PLAN
FOR THE BEKAA WATER ESTABLISHMENT

WASTEWATER CAPITAL INVESTMENT PLAN & PRIORITY ACTION PLAN REPORT

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THIS DOCUMENT IS PREPARED BY DAI/KREDO UNDER THE LEBANON WATER AND WASTEWATER SECTOR SUPPORT PROGRAM (LWWSS) FUNDED BY USAID

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BMLWE	BEIRUT AND MOUNT LEBANON WATER ESTABLISHMENT
BWE	BEKAA WATER ESTABLISHMENT
CAS	CENTRAL ADMINISTRATION OF STATISTICS
CDM	CAMP DRESSER & MCKEE
CDR	COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION
DAI	DEVELOPMENT ALTERNATIVES, INC.
DAHNT	DAR AL HANDASAH NAZIH TALEB AND PARTNERS
FAO	FOOD AND AGRICULTURAL ORGANIZATION
GIS	GEOGRAPHIC INFORMATION SYSTEM
K&A	KHATIB & ALAMI
LRA	LITANI RIVER AUTHORITY
MEW	MINISTRY OF ENERGY AND WATER
MOA	MINISTRY OF AGRICULTURE
NWSS	NATIONAL WATER SECTOR STRATEGY
O&M	OPERATION AND MAINTENANCE
TOC	TOTAL ORGANIC CARBON
TSS	TOTAL SUSPENDED SOLIDS
USAID	UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
WHO	WORD HEALTH ORGANIZATION
WWTP	WASTE WATER TREATMENT PLANT

1 INTRODUCTION

1.1 Background

On December 1st, 2012 KREDO has been commissioned by DAI to carry out the project entitled "Development of a Water Supply and Wastewater Systems Master Plan within the Service Area of the Bekaa Water Establishment" as part of the USAID – Lebanon Water Wastewater Sector Support Program (LWWSS). The scope of the current study is to establish water supply and wastewater master plans in order to support the Bekaa Water Establishment (BWE) decision-makers in the preparation of a rational infrastructure development and capital investment plan for water supply, water distribution, wastewater collection and wastewater treatment systems, as well as elements of an irrigation system. More specifically, this report addresses Tasks B.2, B.3, and B.4 of the terms of reference for the wastewater component encompassing the following activities:

Task B.2:

Forecast the volume of wastewater to be generated and needing to be treated.

B.2.1 Based on the projected water supply demand for each of the major service areas within the BWE as developed under A.2.3, determine volume of wastewater projected to go to treatment under average and peak flow conditions.

Task B.3:

Recommended specific improvement to the wastewater systems.

B.3.1 Develop alternative recommended improvements to the wastewater systems in the BWE service area that are consistent with the National Water Sector Strategy of the Government and the Strategic Goals of BWE, As stated in its 2012-2016 Business Plan.

B.3.2 Present the alternative recommendations to the management of BWE for review and final approval.

B.3.3 Prepare an action plan, based on the finally approved improvements that will prioritize the steps and actions to be undertaken for each improvement. The priority action plan will detail the activities and deliverables based in a well-defined time frame.

Task B.4:

Estimate the capital cost for each finally approved improvement and the timing of the use of capital for each improvement.

B.4.1 Prepare a separate capital cost estimate for each "new capital improvement" that is approved by the management of BWE. New capital improvements shall be those improvements that perform a function or service that did not previously exist in the current system, or that significantly changes the capacity of an existing asset.

B.4.2 Prepare s schedule for the timing of the use of capital for each new capital improvement under A.4.1.

B.4.3 Prepare a separate capital cost estimate for each "capital repair or replacement, or capital renewal improvement" that is approved by the management of BWE. Capital repair or replacement or capital renewal improvements shall be those improvements that return an existing asset to its design intent as well as improve its efficiency.

B.4.4 Prepare a schedule for the timing of the use of capital repair or replacement, or capital renewal improvement under ***A.4.3***.

B.4.5 Develop cost estimates for the operation and maintenance (power, fuels, lubricants, and routine maintenance consumables) of the wastewater system facilities that will make up the future capital plan of the BWE within the planning period.

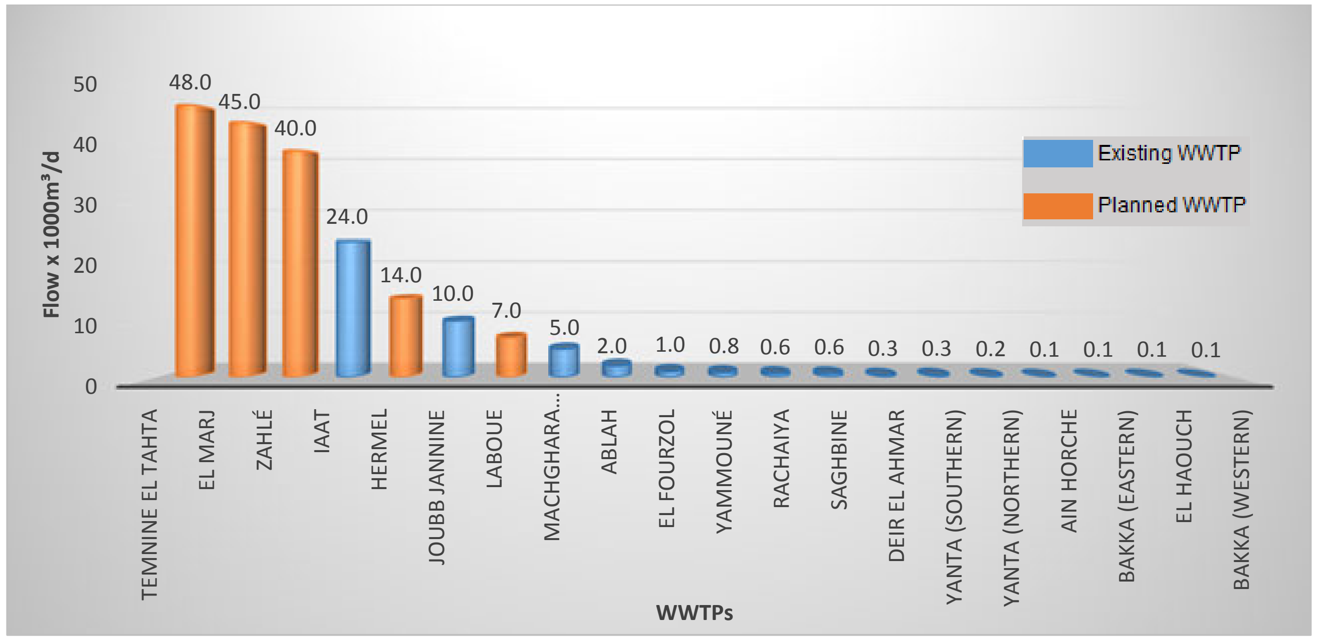
This report presents the recommendations for improvements to the Bekaa wastewater system for the 2035 planning horizon along with the associated cost estimate. These recommendations include improvements to the existing sewer network system and wastewater treatment plants as well as recommendations for new facilities to service areas not currently connected to a wastewater treatment plant and/or a sewer system. It is divided in 8 chapters. Chapter 1 gives a general overview of the activities undertaken in order to arrive at the description of the current status of the wastewater sector in the Bekaa. Chapters 2 presents the wastewater flow projections for the horizon years 2025 and 2035 based on the population estimates presented in an earlier report. Chapter 3 describes the strategy adopted for the siting, sizing, and selection of the treatment process. Chapters 4 and 5 give overviews of the effluent reuse and biosolids management issues, respectively, including proposed guidelines that should be adopted by the MEW. In Chapter 6 the adopted schemes are described. They include existing facilities, facilities to be expanded and improved, and new facilities that are proposed along with their location, service area, and treatment process, as well as new sewer lines that need to be installed in unsewered villages. Chapter 7 gives the cost estimates of all proposed facilities and the cost of the improvements to the existing facilities. Chapter 8 proposes a priority action plan and concluding remarks.

1.2 Existing Situation

During the first year, a data collection campaign was carried out to gather all existing studies and reports that have been prepared regarding sewage collection and wastewater treatment in the Bekaa and the results of this campaign were presented in the Wastewater System Assessment Report dated November 2013. The main findings of this report are as follows:

1- Few cities and villages (25% corresponding to 49% of the population) actually do have a sewer network, and only for a handful of those is the network in good condition. Some are operational but in bad condition while others are not functional.
2- The CDR is currently planning or executing a sewer network for some areas in the Bekaa (14% of the villages corresponding to 11% of the population). However these remain limited. The best served area until now is the city of Baalbeck which has an extensive network linked to the Iaat wastewater treatment plant. As for the city of Zahle, it has a functional network which is currently being linked through a main collector to the wastewater treatment plant, also under construction.
3- Large areas of the Bekaa remain without any sewer system, either existing or planned (61% of the villages corresponding to 40% of the population). These localities still rely on septic tanks which are often old, substandard, seeping, or overflowing which causes a major pollution threat to the groundwater.
4- Only a handful of sewer systems are currently linked to wastewater treatment plants. The rest are discharging raw sewage into water bodies or valleys, with some being diverted to agricultural land so that the wastewater can be used for irrigation. This situation is causing a major pollution threat to the environment and a health threat to the Bekaa population.
5- A small number of wastewater treatment plants currently exist in the Bekaa. The combined population served by these wastewater treatment plants is a small fraction of the Bekaa population as a whole (only 25%). Except for the Iaat WWTP serving the city of Baalbeck and its surroundings, the Joubb Jannine and Machghara WWTPs, these are small facilities serving one or more small villages. Some of these WWTPs are operational (mostly at below capacity) but need improvements to various degrees. Others are not functioning properly and need to be replaced.
6- The CDR is currently planning or building a small number of large wastewater treatment plants aimed at population centers. These would cover 40% of the Bekaa population. The remaining 35% of the Bekaa population (representing 68% of the Bekaa villages) are not served by any existing or planned wastewater treatment plant.

Figure 1-1 shows the design capacity of the existing wastewater treatment plants and those planned by the CDR for the year 2020 horizon. The four WWTPs planned by the CDR are all medium to large capacity and target the larger population centers of the Bekaa. Zahle WWTP is currently under construction. Of the existing fifteen WWTPs Iaat, Joubb Jannine, Yammouné and Saghbine have been built by the CDR under World Bank and Islamic Development Bank funding. The remaining WWTPs were funded by USAID under different projects extending from the mid-nineties until 2012 in cooperation with local beneficiary municipalities.



* A very small WWTP was built by USAID in Rachaiya. The CDR plans to build a larger WWTP which is still at the conceptual stage.

FIGURE 1-1: EXISTING AND PLANNED WWTPS AND THEIR DESIGN CAPACITY IN THE BEKAA

The NWSS adopted by the Council of Ministers upon recommendation of the Ministry of Energy and Water under Resolution No 2 dated 9/3/2012 and the National Strategy for the Wastewater Sector (NSWS) adopted by resolution No. 35, date 17/10/2012 states that the sector targets for 2011-2020 are the following:

- Increase the present wastewater collection coverage (60%) and treatment (8%) to 80% collection and treatment by 2015, and 95% collection and treatment by 2020.
- Pre-treatment of all industrial wastewater by 2020.
- Increase reuse of treated effluent from zero percent in 2010 to 20% of treated wastewater by 2015, and 50% by 2020.
- Secondary treatment and reuse of all inland wastewater by 2020, and secondary treatment and reuse by 2020 of coastal wastewater where reuse is economically justified.
- Full recovery of all O&M costs by 2020 following the 'polluter pays' principle and full recovery for BOT projects.

The NSWS specifies that national guidelines and criteria for wastewater treatment and reuse will be reviewed and issued jointly by an inter-ministerial committee, and that specific studies of plants will be undertaken to assess the technical and economical reuse potential for each.

2 WASTEWATER FLOWS

In the absence of measurements concerning the exact quantities of sewage flows which vary substantially with the time of the day, of the week, and of the year the estimation of the sewage flow to be adopted in the current study for the 2035 horizon year will be based on estimates of water consumptions, as has been the case for previous similar studies in Lebanon. Usually, the amount of generated wastewater is considered to be 85% of the aggregated water consumption to account for water that is not returned to the sewer system due to watering flowers or gardens, washing paved areas, or other external uses of the metered water consumption, with 10% added to account for infiltration as per applicable international standards and local design practice noting the presence of a high water table in the plain areas of the Bekaa during the three months wet season. The MEW National Water Sector Strategy (NWSS) uses the following figures for a moderate demand scenario in 2010:

160 L/capita/day for rural areas demand (140 for low demand scenario, 180 for high demand scenario);

180 L/capita/day for urban areas demand (160 for low demand scenario, 200 for high demand scenario);

30% of domestic demand for industrial demand (or 51 L/cap/d on average).

400 L/person/day for tourism demand;

The latest BWE Business Plan estimated the following range of values for water usage in areas similar to those in Lebanon:

Household	90 – 120 L/cap/day
Commercial	25 – 30 L/cap/day
Institutional	15 – 20 L/cap/day
Industrial	30 – 40 L/cap/day
Total	160 – 210 L/cap/day

Based on the above mentioned data, the BWE decided to apply an aggregate norm for water demand per capita (i.e., no separate consideration is made for the different types of consumers), once connections are metered and billed, of 180 l/c/d, which is the middle range of total values found in other similar countries, but lower than the aggregate value of the NWSS which comes up to 221L/cap/day inclusive of all domestic and industrial demand. One of the reasons for this lower value being that the Business Plan aims at remaining conservative in terms of profitability and hence is concerned with not overstating sales once meters are installed and billing is based on metered consumption.

Based on the above it is proposed to adopt an all-inclusive water demand of 180 L/cap/day for the year of preparation of the NWSS, i.e. 2010, for both urban and rural populations in the Bekaa noting the rapid urbanization and rural exodus towards the main cities. If the NWSS moderate scenario for water demand projection is adopted it then gives the following demand values until the design horizon:

Year	2010	2015	2020	2025	2030	2035
Demand (L/cap/day)	180	174	167	176	185	195

The dip in the NWSS forecasted demand is a result of the projected effect of water conservation measures to be introduced by 2020 (plumbing retrofits, high-efficiency toilets and showerheads, dual flush toilets, high-efficiency cloth washers, complete retrofit of large commercial and industrial consumers, public awareness campaigns, etc.) and due to a more conscientious use of the water by the consumers after meters are installed. For the sake of simplicity the present study will adopt 180 L/cap/day for the current aggregate water demand and 195 L/cap/day as the aggregate value for water demand for the year 2035. The aggregate value for water demand for the year 2025 is subsequently calculated as 188 L/cap/day. The wastewater generated per capita is obtained as 85% of the water demand per capita at the given design year increased by 10% to account for infiltration. Hence, the wastewater generation rate for the 2035 design horizon is then calculated as $0.85*195*1.1 \approx 183$ L/cap/day based on an aggregated water demand/consumption rate of 195 L/cap/day.

The resulting wastewater flows generated by each locality within a caza are calculated and listed in Tables 2-1 to 2-5 here below. It is important to note that many of the localities in the Bekaa have a fluctuating population whereby the occupancy is much higher in the summer than the winter, and consequently the summer generated wastewater flow is larger. The maximum population estimates as calculated in the previous reports, which would correspond to the full summer population, are used for the calculation of wastewater flows. In Tables 2-1 to 2-5, many localities do not have a listed population and hence no generated wastewater flow because these localities are part of another cadastral area and their population is accounted for in the population estimates of the cadastral locality to which they belong.

TABLE 2-1: GENERATED WASTEWATER FLOWS FOR ALL CAZAS

Caza	Year 2013		Year 2025		Year 2035	
	Estimated Population	Wastewater Generation Rate (m^3/d)	Projected Population	Wastewater Generation Rate (m^3/d)	Projected Population	Wastewater Generation Rate (m^3/d)
Hermel	83,131	13,991	102,367	17,995	121,762	22,201
Baalbeck	416,483	70,095	512,875	90,154	610,035	111,225
Zahle	364,149	61,287	448,426	78,825	533,377	97,248
West Bekaa	134,798	22,687	165,992	29,179	197,441	35,999
Rachaiya	60,342	10,156	74,309	13,063	88,382	16,115
Total	**1,058,903**	**178,214**	**1,303,969**	**229,212**	**1,550,997**	**282,786**

* The wastewater generation rates of each locality in the Bekaa cazas for the years 2013, 2025, and 2035 are calculated based on the following formulas:

$$\text{Wastewater Generation Rate (2013) (m}^3\text{/d)} = 0.180 m^3/cap/d \times \text{Population (2013)} \times 0.85 \times 1.1\ (infiltration)$$

$$\text{Wastewater Generation Rate (2025) (m}^3\text{/d)} = 0.188 m^3/cap/d \times \text{Population (2025)} \times 0.85 \times 1.1\ (infiltration)$$

$$\text{Wastewater Generation Rate (2035) (m}^3\text{/d)} = 0.195 m^3/cap/d \times \text{Population (2035)} \times 0.85 \times 1.1\ (infiltration)$$

TABLE 2-2: GENERATED WASTEWATER FLOWS FOR HERMEL CAZA

CAZA OF HERMEL							
No.	**Town Name**	**Year 2013**		**Year 2025**		**Year 2035**	
		Estimated Population	**Wastewater Generation Rate (m³/d)**	**Projected Population**	**Wastewater Generation Rate (m³/d)**	**Projected Population**	**Wastewater Generation Rate (m³/d)**
1	Bestane	1,126	190	1,387	244	1,650	301
2	Boueida	1,801	304	2,217	390	2,637	481
3	Brissa	676	114	832	147	990	181
4	Charbiné (Sh)	1,917	323	2,361	416	2,808	512
5	Chouaghir el Faouka	3,381	570	4,164	732	4,952	903
6	Chouaghir el Tahta (Chouaghir El Faouka)	---	---	---	---	---	---
7	Fissane	1,200	202	1,478	260	1,758	321
8	Haouch es sayed aali	676	114	832	147	990	181
9	Haret el Maaser (Zighrine)	---	---	---	---	---	---
10	Hariqa	338	57	416	74	495	91
11	Hay Bdita (Zighrine)	---	---	---	---	---	---
12	Hermel	37,606	6,330	46,310	8,141	55,083	10,044
13	Hermel Jbab*	---	---	---	---	---	---
14	Jmeira	225	38	277	49	330	61
15	Jouar el Hachich	3,000	505	3,694	650	4,394	802
16	Maaïsra (El) (Zighrine)	---	---	---	---	---	---
17	Maaser (Zighrine)	---	---	---	---	---	---
18	Mazraart el Faqih (Zighrine)	---	---	---	---	---	---
19	Mazraat Beit el Toch	451	76	555	98	660	121
20	Mazraat Soujod	225	38	277	49	330	61
21	Merjhine	1,890	319	2,327	410	2,768	505
22	Nahr el Aiin	676	114	832	147	990	181
23	Nasriye (en)	225	38	277	49	330	61
24	Ouadi el Faara*	450	76	554	98	659	121
25	Ouadi et Tourkman	300	51	369	65	439	81
26	Qanafez & Haouchariye	1,200	202	1,478	260	1,758	321
27	Qasr	15,000	2525	18,472	3248	21,971	4006
28	Qouakh	868	147	1,068	188	1,271	232
29	Ras Baalbeck el Gharbi	257	44	316	56	376	69
30	Sahet el Mai	5,000	842	6,157	1,083	7,324	1,336
31	Soueiss	508	86	625	110	743	136
32	Wadi Bnit*	---	---	---	---	---	---
33	Wadi el Karm*	---	---	---	---	---	---
34	Wadi el Nira*	---	---	---	---	---	---
35	Wadi el Ratl	420	71	517	91	615	113

CAZA OF HERMEL							
No.	Town Name	Year 2013		Year 2025		Year 2035	
		Estimated Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)
36	Zighrine (& Boule)	3,427	577	4,220	742	5,019	916
37	Zoueitini	288	49	355	63	422	77
	Total	**83,131**	**13,991**	**102,367**	**17,995**	**121,762**	**22,201**

* Vacant land or localities that have a very small number of houses (<10).

TABLE 2-3: GENERATED WASTEWATER FLOWS FOR BAALBECK CAZA

CAZA OF BAALBECK							
No.	Town Name	Year 2013		Year 2025		Year 2035	
		Estimated Population	Wastewater Generation Rate (m^3/d)	Projected Population	Wastewater Generation Rate (m^3/d)	Projected Population	Wastewater Generation Rate (m^3/d)
1	Aaddous	327	56	402	71	478	88
2	Aain Bnayé*	---	---	---	---	---	---
3	Aalaq Tell (Boudai)	---	---	---	---	---	---
4	Aamichki (Baalbeck)	---	---	---	---	---	---
5	Aaqidieh*	---	---	---	---	---	---
6	Aarsal	27,064	4,555	33,328	5,859	39,642	7,228
7	Ain (El)	9,878	1,663	12,164	2,139	14,469	2,639
8	Ain Bourdai	916	155	1,127	199	1,341	245
9	Ain el Jaouzé*	---	---	---	---	---	---
10	Ain Es Saouda *	---	---	---	---	---	---
11	Ainata	2,000	337	2,463	433	2,929	535
12	Amhazié *	---	---	---	---	---	---
13	Baalbeck	90,873	15,294	111,904	19,671	133,104	24,269
14	Bajjajé (El)	916	155	1,127	199	1,341	245
15	Barqa	1,124	190	1,385	244	1,647	301
16	Bechouat	1,800	303	2,217	390	2,637	481
17	Bednayel	11,233	1,891	13,832	2,432	16,453	3,000
18	Beit Chama	4,315	727	5,314	935	6,321	1,153
19	Beit Mcheik (Ramasa & Qeld El Sabeh)	2,400	404	2,955	520	3,515	641
20	Beliqa	60	11	74	14	88	17
21	Boudai	9,139	1,539	11,254	1,979	13,386	2,441
22	Britel	13,604	2,290	16,753	2,945	19,927	3,634
23	Btedaai	1,301	219	1,602	282	1,906	348
24	Chaaibé *	---	---	---	---	---	---
25	Chaat	6,425	1,082	7,912	1,391	9,411	1,716
26	Chlifa	2,067	348	2,545	448	3,027	552
27	Chmistar	14,750	2,483	18,164	3,193	21,605	3,940
28	Dar el Wasseaa	444	75	547	97	651	119
29	Deir el Ahmar	6,366	1,072	7,839	1,378	9,324	1,700
30	Deir Mar Maroun	96	17	119	21	141	26
31	Douris	10,842	1,825	13,351	2,347	15,880	2,896
32	Fekehe	11,747	1,978	14,465	2,543	17,206	3,138
33	Flaoue	2,251	379	2,772	488	3,297	602
34	Hadet (El)	6,039	1,017	7,437	1,308	8,846	1,613
35	Halbata	509	86	626	111	745	136

CAZA OF BAALBECK							
No.	Town Name	Year 2013		Year 2025		Year 2035	
		Estimated Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)
36	Ham	546	92	672	119	800	146
37	Haouch Barada	487	82	600	106	714	131
38	Haouch ed Dahab	96	17	119	21	141	26
39	Haouch en Nabe	1,472	248	1,813	319	2,157	394
40	Haouch er Rafqa	7,164	1,206	8,822	1,551	10,493	1,914
41	Haouch Snaid	1,537	259	1,892	333	2,251	411
42	Haouch Tell Safiyé	1,269	214	1,563	275	1,859	339
43	Harbata	4,321	728	5,321	936	6,329	1,154
44	Harfouche (Qlaile (el))	---	---	---	---	---	---
45	Hizzine	2,067	348	2,545	448	3,027	552
46	Hortaala	3,796	639	4,674	822	5,560	1,014
47	Iaat	4,406	742	5,426	954	6,454	1,177
48	Jabboulé (Bajjajé (El))	---	---	---	---	---	---
49	Jdeidé (Fekehe)	---	---	---	---	---	---
50	Jebaa	557	94	686	121	816	149
51	Jenta	471	80	580	102	690	126
52	Kfar Dabach	996	168	1,226	216	1,459	267
53	Kfardaane	2,597	438	3,198	563	3,803	694
54	Kharayeb	203	35	250	44	297	55
55	Khoder (El)	4,958	835	6,105	1,074	7,262	1,325
56	Khraibé (El)	1,231	208	1,516	267	1,804	329
57	Kneissé	1,713	289	2,110	371	2,509	458
58	Laboué	12,341	2,077	15,197	2,672	18,076	3,296
59	Maaraboun	1,478	249	1,820	320	2,164	395
60	Machaitiye	120	21	148	27	176	33
61	Majdaloun	899	152	1,108	195	1,317	241
62	Maqné	3,164	533	3,897	686	4,635	846
63	Masnaa Bednayel (Bednayel)	---	---	---	---	---	---
64	Mazraat Beit Ghousain	200	34	246	44	293	54
65	Mazraat Beit Slaibi	800	135	985	174	1,172	214
66	Mazraat ed Dallil (Kfardaane)	---	---	---	---	---	---
67	Mazraat es Syad	300	51	369	65	439	81
68	Moqraq	1,740	293	2,143	377	2,549	465
69	Mousraye	498	84	613	108	729	133
70	Nabha	5,113	861	6,296	1,107	7,489	1,366

CAZA OF BAALBECK							
No.	Town Name	Year 2013		Year 2025		Year 2035	
		Estimated Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)
71	Nabi Chbat (En)	43	8	53	10	63	12
72	Nabi Chit (En)	13,438	2,262	16,549	2,909	19,684	3,589
73	Nabi Osmane (En)	4,096	690	5,044	887	5,999	1,094
74	Nabi Rchad	1,800	303	2,217	390	2,637	481
75	Nahlé	6,000	1,010	7,389	1,299	8,788	1,603
76	Ouadi el Aaoss *	---	---	---	---	---	---
77	Qaa (El)	8,791	1,480	10,826	1,903	12,877	2,348
78	Qaa Baayoun (Qaa (El))	---	---	---	---	---	---
79	Qaa Jouar Maqiye	2,843	479	3,501	616	4,164	760
80	Qaa Ouadi El Khanzer	439	74	541	96	643	118
81	Qarha	493	83	607	107	721	132
82	Qasrnaba	6,302	1,061	7,760	1,365	9,230	1,683
83	Qeddam	720	122	886	156	1,054	193
84	Qlaile (el)	120	21	148	27	176	33
85	Ram (El)	2,000	337	2,463	433	2,929	535
86	Ras Baalbeck	7,000	1,179	8,620	1,516	10,253	1,870
87	Ras el Aassi *	---	---	---	---	---	---
88	Riha	792	134	976	172	1,161	212
89	Saaidé	1,681	283	2,070	364	2,462	449
90	Safra	1,800	303	2,217	390	2,637	481
91	Sbouba	664	112	818	144	972	178
92	Seraaine el Gharbieh/ Hallanieh (Seraaine El Tahta)	---	---	---	---	---	---
93	Seraaine el Tahta	9,000	1,515	11,083	1,949	13,183	2,404
94	Serraain el Faouka (Seraaine El Tahta)	---	---	---	---	---	---
95	Sifri (Khoder (El))	---	---	---	---	---	---
96	Slouqi	70	12	86	16	102	19
97	Talia	2,393	403	2,947	519	3,505	640
98	Taoufiqié (Moqraq)	---	---	---	---	---	---
99	Taraya	5,707	961	7,028	1,236	8,360	1,525
100	Taybeh (Et)	1,933	326	2,380	419	2,831	517
101	Temnine el Faouqa	4,567	769	5,624	989	6,689	1,220
102	Temnine el Tahta	9,621	1,620	11,848	2,083	14,092	2,570
103	Tfail	503	85	620	109	737	135
104	Wadi Faara (Faara)	---	---	---	---	---	---
105	Yahfoufa	685	116	844	149	1,004	184

CAZA OF BAALBECK							
No.	**Town Name**	**Year 2013**		**Year 2025**		**Year 2035**	
		Estimated Population	**Wastewater Generation Rate (m^3/d)**	**Projected Population**	**Wastewater Generation Rate (m^3/d)**	**Projected Population**	**Wastewater Generation Rate (m^3/d)**
106	Yammouné	2,420	408	2,980	524	3,545	647
107	Younine	11,661	1,963	14,360	2,525	17,080	3,115
108	Zabboud	1,199	202	1,477	260	1,757	321
109	Zraieb	676	114	832	147	990	181
110	Zrazir	2,000	337	2,463	433	2,929	535
	Total	**416,483**	**70,095**	**512,875**	**90,154**	**610,035**	**111,225**

* Vacant land or localities that have a very small number of houses (<10).

TABLE 2-4: GENERATED WASTEWATER FLOWS FOR ZAHLE CAZA

CAZA OF ZAHLE							
No.	Town Name	Year 2013		Year 2025		Year 2035	
		Estimated Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)
1	Aanjar/Haouch Moussa	11,409	1,921	14,050	2,470	16,712	3,048
2	Ablah	9,653	1,625	11,887	2,090	14,139	2,578
3	Ain Kfar Zabad	3,245	547	3,995	703	4,752	867
4	Ali en Nahri	12,603	2,122	15,520	2,729	18,460	3,366
5	Barr Elias	23,070	3,883	28,410	4,994	33,792	6,162
6	Betyas *	---	---	---	---	---	---
7	Bouarej	3,009	507	3,705	652	4,407	804
8	Chebrqieh	27	5	33	6	39	8
9	Chtaura	4,407	742	5,428	955	6,456	1,178
10	Deir el Ghazal	1,446	244	1,780	313	2,117	386
11	Deir Zanoun (Barr Elias)	---	---	---	---	---	---
12	Delhamiye	1,756	296	2,163	381	2,572	469
13	Faaour	3,200	539	3,941	693	4,687	855
14	Fourzol (El)	10,435	1,757	12,850	2,259	15,284	2,787
15	Haouch el Ghanam	990	167	1,220	215	1,451	265
16	Haouch es Siyadi	27	5	33	6	39	8
17	Haouch Handari *	---	---	---	---	---	---
18	Haouch Qaissar	27	5	33	6	40	8
19	Hay el Fikani (Raite)	---	---	---	---	---	---
20	Hazerta	5,400	909	6,650	1,169	7,910	1,443
21	Hoshmosh	214	37	264	47	314	58
22	Jdita	10,392	1,749	12,797	2,250	15,222	2,776
23	Kfar Zabad	6,178	1,040	7,608	1,338	9,050	1,651
24	Ksara	471	80	580	102	690	126
25	Maallaqa	10,511	1,770	12,943	2,276	15,395	2,807
26	Maallaqa Aradi	25,281	4,255	31,132	5,473	37,029	6,752
27	Majdel Aanjar	23,675	3,985	29,155	5,125	34,678	6,323
28	Maksé	3,352	565	4,127	726	4,909	896
29	Massa	2,126	358	2,617	461	3,113	568
30	Mazraa (El)	525	89	646	114	769	141
31	Mraijat (El)	2,896	488	3,567	628	4,243	774
32	Nabi Ayla	1,585	267	1,952	344	2,321	424
33	Nasireh (Nasriyet Rizk)	---	---	---	---	---	---
34	Nasriye	64	11	79	14	94	18
35	Nasriyet Rizk	1,499	253	1,846	325	2,196	401

CAZA OF ZAHLE							
No.	Town Name	Year 2013		Year 2025		Year 2035	
		Estimated Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)
36	Niha	2,008	338	2,472	435	2,941	537
37	Ouadi Ed Dellem	2,056	347	2,532	446	3,011	549
38	Qaa er Rim	3,336	562	4,107	722	4,886	891
39	Qabb Elias	21,625	3,640	26,629	4,681	31,674	5,775
40	Qoussaya	1,500	253	1,847	325	2,197	401
41	Quommol	92	16	113	20	134	25
42	Raite	5,000	842	6,157	1,083	7,324	1,336
43	Ramtaineh	70	12	86	16	102	19
44	Rayak- Haouch Hala	19,274	3,244	23,735	4,173	28,232	5,148
45	Saadnayel	16,540	2,784	20,368	3,581	24,226	4,418
46	Taalabaya - Jalala	27,244	4,586	33,550	5,898	39,905	7,276
47	Taanayel (Deir)	1,778	300	2,189	385	2,604	475
48	Tell el Akhdar	123	21	152	27	180	33
49	Terbol	7,860	1,323	9,679	1,702	11,512	2,099
50	Touaite	819	138	1,009	178	1,200	219
51	Zahlé	74,618	12,559	91,887	16,152	109,295	19,928
52	Zebdol	733	124	903	159	1,074	196
	Total	**364,149**	**61,287**	**448,426**	**78,825**	**533,377**	**97,248**

* Vacant land or localities that have a very small number of houses (<10).

TABLE 2-5: GENERATED WASTEWATER FLOWS FOR WEST BEKAA CAZA

CAZA OF WEST BEKAA							
No.	Town Name	Year 2013		Year 2025		Year 2035	
		Estimated Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)
1	Ain El Tine	3,303	556	4,067	715	4,838	883
2	Ain Zebdé	1,076	182	1,325	233	1,576	288
3	Aaitanit	1,151	194	1,417	250	1,686	308
4	Aammiq	1,103	186	1,358	239	1,616	295
5	Aana	2,100	354	2,586	455	3,076	561
6	Baaloul	2,886	486	3,554	625	4,227	771
7	Bab Mareh	493	83	607	107	722	132
8	Dakoué (El) (Salmiyeh El Rachidiye)	626	106	771	136	917	168
9	Deir Ain ej Jaouzé	27	5	33	6	40	8
10	Deir Tahnich	75	13	92	17	110	21
11	Fadar El Faouka *	---	---	---	---	---	---
12	Fadar El Tahta *	---	---	---	---	---	---
13	Ghazze	6,949	1,170	8,557	1,505	10,178	1,856
14	Hammara (Manara)	---	---	---	---	---	---
15	Harimet es Soghra	112	19	138	25	164	30
16	Haouch El Harime	2,115	356	2,604	458	3,098	565
17	Jeziré (El)	246	42	303	54	360	66
18	Joubb Jannine	10,016	1,686	12,334	2,169	14,671	2,675
19	Kamed el Loz	10,000	1,683	12,314	2,165	14,647	2,671
20	Kefraiya	2,441	411	3,006	529	3,575	652
21	Khiara (El)	1,300	219	1,601	282	1,904	348
22	Khirbet Qanafar	4,500	758	5,541	974	6,591	1,202
23	Lala	7,000	1,179	8,620	1,516	10,253	1,870
24	Libbaya	4,754	801	5,854	1,030	6,963	1,270
25	Loussa *	---	---	---	---	---	---
26	Machghara	15,655	2,635	19,278	3,389	22,930	4,181
27	Maidoun	958	162	1,180	208	1,403	256
28	Manara	4,600	775	5,665	996	6,738	1,229
29	Mansoura	3,000	505	3,694	650	4,394	802
30	Marj (El)	7,324	1,233	9,019	1,586	10,728	1,956
31	Ouaqf (El) *	---	---	---	---	---	---
32	Qaraaoun (El)	6,500	1,094	8,004	1,407	9,521	1,736
33	Qelia	1,767	298	2,176	383	2,588	472
34	Raouda	3,000	505	3,694	650	4,394	802
35	Saghbine	3,828	645	4,714	829	5,607	1,023

CAZA OF WEST BEKAA							
No.	Town Name	Year 2013		Year 2025		Year 2035	
		Estimated Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)
36	Sohmor	7,902	1,330	9,731	1,711	11,574	2,111
37	Saouiri	8,026	1,351	9,884	1,738	11,756	2,144
38	Sltan Yaqoub El Aradi	54	10	66	12	79	15
39	Sltan Yacoub el Fouqa	4,310	726	5,308	934	6,313	1,152
40	Sltan Yaqoub el Tahta (Sltan Yacoub el Fouqa)	---	---	---	---	---	---
41	Tell Ez Zaazaa (Khiara)	---	---	---	---	---	---
42	Tell Znoub	830	140	1,022	180	1,216	222
43	Yohmor el Beqaa	4,214	710	5,189	913	6,172	1,126
44	Zellaya	557	94	686	121	816	149
	Total	**134,798**	**22,687**	**165,992**	**29,179**	**197,441**	**35,999**

* Vacant land or localities that have a very small number of houses (<10).

TABLE 2-6: GENERATED WASTEWATER FLOWS FOR RACHAIYA CAZA

CAZA OF RACHAIYA							
No.	Town Name	Year 2013		Year 2025		Year 2035	
		Estimated Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)
1	Aaiha	3,500	590	4,310	758	5,127	935
2	Aain Arab	664	112	818	144	972	178
3	Aakabe (El)	2,227	375	2,743	483	3,262	595
4	Ain Aata	2,308	389	2,842	500	3,380	617
5	Ain Horche	1,007	170	1,239	218	1,474	269
6	Aita El Foukhar	2,420	408	2,980	524	3,545	647
7	Bakka	1,215	205	1,497	264	1,780	325
8	Bakkifa	1,719	290	2,116	372	2,517	459
9	Beit Lahia	996	168	1,226	216	1,459	267
10	Bire (El)	5,600	943	6,896	1,213	8,202	1,496
11	Dahr el Ahmar	2,259	381	2,782	490	3,309	604
12	Deir el Aachayer	1,108	187	1,365	240	1,623	296
13	Ezzé (Bire (El))	---	---	---	---	---	---
14	Haloua	150	26	185	33	220	41
15	Haouch El Qinnaabe	1,500	253	1,847	325	2,197	401
16	Kaoukaba	1,215	205	1,497	264	1,780	325
17	Kfar Qouq	3,200	539	3,941	693	4,687	855
18	Kfardenis	1,708	288	2,103	370	2,502	457
19	Kfarmechki	1,173	198	1,444	254	1,717	314
20	Khirbet Rouha	4,267	719	5,255	924	6,250	1,140
21	Majdel Balhiss	1,419	239	1,747	308	2,078	379
22	Mazraat Deir el Aachayer *	---	---	---	---	---	---
23	Mazraat Jaafar (Haouch El Qinnaabe)	---	---	---	---	---	---
24	Mazraat Salsata *	---	---	---	---	---	---
25	Mdoukha	1,306	220	1,609	283	1,913	349
26	Mhaidthé (El)	1,697	286	2,090	368	2,486	454
27	Nabaat *	---	---	---	---	---	---
28	Qennabé (Haouch El Qinnaabe)	---	---	---	---	---	---
29	Rachaiya (Rachaya el Wadi)	---	---	---	---	---	---
30	Rachaya el Faouka (Rachaya el Wadi)	---	---	---	---	---	---
31	Rachaya El Kouasbe (Rachaya el Wadi)	---	---	---	---	---	---
32	Rachaya el Wadi	8,277	1,394	10,193	1,792	12,124	2,211
33	Rafid (Er)	4,979	838	6,132	1,078	7,293	1,330

CAZA OF RACHAIYA							
No.	Town Name	Year 2013		Year 2025		Year 2035	
		Estimated Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)	Projected Population	Wastewater Generation Rate (m³/d)
34	Tannoura	1,007	170	1,239	218	1,474	269
35	Yanta	3,421	576	4,213	741	5,011	914
	Total	**60,342**	**10,156**	**74,309**	**13,063**	**88,382**	**16,115**

* Vacant land or localities that have a very small number of houses (<10).

3 WASTEWATER TREATMENT ALTERNATIVES

3.1 Strategy

As discussed in Chapter 1, a significant part of the Bekaa population is not currently served by a wastewater treatment plant and is not connected to a sewer system. The present study aims at providing wastewater treatment service to all of the Bekaa population not currently served by existing facilities or facilities already planned by the CDR. The following assumptions and/or constraints are used in the study:

- The wastewater inflow is domestic in nature. Industrial wastewater shall be pre-treated at the facility before being discharged into the municipal sewer.
- Stormwater drainage is independent of the domestic sewer system.
- The minimum distance between a WWTP and a residential area is 250m.
- The electrical current is available 24 hours per day. However reliance on electricity is avoided in small remote communities.
- A peak hour factor of 1.7 is used for the sizing of the sewer pipes.
- WWTPs are located such as to favor flow by gravity. Pumping is avoided as much as possible.
- Land availability is not a major issue in the Bekaa. However, as priority is given to locating the WWTP such as to avoid pumping, finding an appropriate plot in the recommended area might be problematic. Hence the strategy adopted is to avoid processes that require excessively large surface areas.
- Environmentally acceptable and compliant with discharge standards according to the Barcelona Protocol based on the Barcelona convention which was signed in 2000 by the Lebanese government (refer to Table 3.2).

The parameters used to locate the WWTP, decide which communities it will serve and which process should be selected, are:

- Location of the villages compared to each other;
- Population density;
- Topography;
- Generated wastewater flow;
- The process capital cost and its operation and maintenance cost.

The adopted procedure is as follows:

The communities are divided in the following six categories:

A1: Villages located on the same slope such as the topography allows for their sewers to be collected together without the need for a pumping station;

A2: Nearby villages located on opposite slopes or a single village spread on two opposite slopes;

B1: Villages located less than 5 km from each other;

B2: Remote village located at more than 5 km from any other agglomeration;

C1: Low population density (<=100 per/ha) with spread out individual dwellings;

C2: Medium population density (Between100 and 250 per/ha) with one or two story dwellings built close to each other;

C3: High population density (>=250 per/ha) with multi-story dwellings.

The wastewater treatment systems selected for the various combinations of the above listed categories are as follows:

TABLE 3-1: SELECTION OF WASTEWATER TREATMENT SYSTEMS

Topography	Location	Population densities	Wastewater treatment system
A1	B1	C1	Individual Septic tank and leach field
A1	B1	C2	One treatment plant/many villages
A1	B1	C3	One treatment plant/many villages
A2	B1	C1	Individual Septic tank and leach field
A2	B1	C2	Multiple treatment plants with villages on same slope grouped together.
A2	B1	C3	Multiple treatment plants with villages on same slope grouped together.
A1	B2	C1	Individual Septic tank and leach field
A1	B2	C2	One treatment plant/village
A1	B2	C3	One treatment plant/ village
A2	B2	C1	Individual Septic tank and leach field
A2	B2	C2	Two Treatment plants/village
A2	B2	C3	Two Treatment plants/ village

Table 3-2 below lists the standards applicable for discharge into surface water with a minimum flow of 0.1 cubic meters per second during discharge.

TABLE 3-2: ENVIRONMENTAL LIMIT VALUES FOR DISCHARGING IN SURFACE WATERS (BARCELONA LBC PROTOCOL)

Parameter	ELV for existing facilities	ELV for new facilities
pH	5 – 9	6 – 9
Temperature	30°C	30°C
BOD_5 mgO_2/L	100	25
COD mgO_2/L	250	125
Total Phosphorous mgP/L	16	10
Total Nitrogen, mgN/L[1]	40	30
Suspended Solids mg/L	200	60
AOX	5	5
Detergents mg/L	3	3
Coliform Bacteria 37°C in 100 ml[2]	2,000	2,000
Salmonellae	absence	absence
Hydrocarbons mg/L	20	20
Phenol index mg/L	0.3	0.3
Oil and Grease mg/L	30	30
Total Organic Carbon (TOC) mg/L	75	75
Ammonia (NH_4^+) mg/L	10	10
Silver (Ag) mg/L	0.1	0.1
Aluminium (Al) mg/L	10	10
Arsenic (As) mg/L	0.1	0.1
Barium (Ba) mg/L	2	2
Cadmium (Cd) mg/L	0.2	0.2
Cobalt (Co) mg/L	0.5	0.5
Chromium total (Cr) mg/L	2	2
Hexavalent Chromium (Cr^{VI}) mg/L	0.5	0.2
Copper total (Cu) mg/L	1.5	0.5
Iron total (Fe) mg/L	5	5
Mercury total (Hg) mg/L	0.05	0.05
Manganese (Mn) mg/L	1	1
Nickel total (Ni) mg/L	2	0.5
Lead total (Pb) mg/L	0.5	0.5
Antimony (Sb) mg/L	0.3	0.3
Tin total (Sn) mg/L	2	2
Zinc total (Zn) mg/L	5	5
Active Cl_2 mg/L	1	1
Cyanides (CN^-)mg/L	0.1	0.1
Fluoride (F^-) mg/L	25	25
Nitrate (NO_3) mg/L	90	90
Phosphate (PO_4^{3-}) mg/L	5	5
Sulphate (SO_4^{2-}) mg/L	1,000	1,000
Sulphide (S^{2-})mg/L	1	1

[1] *Sum of Kjeldahl-N (organic N + NH_3), NO_3-N, NO_2-N*
[2] *For discharges in close distance to bathing water a stricter ELV could be necessary.*

The procedure for selecting the treatment process is based on a trade-off between cost and the required land area for the three considered processes namely stabilization ponds, trickling filters, and activated sludge. Tables 3-3 To 3-5 give the cost breakdown for stabilization ponds, trickling filters, and activated sludge respectively, for a population size varying between 500 and 100,000 capita. The land cost was assumed to be an average of USD 25/m^2.

The construction cost includes excavation, leveling, fill disposal, all concrete works, water proofing, the fence, and the administrative building.

The equipment cost includes the electrical installations, mechanical equipment, fittings and accessories, electrical panels, wiring, and automated controls.

The total capital investment initial cost is the sum of the land cost, the construction cost and the equipment cost. This cost is based on local prices for similar work constructed over the last 15 years benchmarked against international rates.

The operation and maintenance cost includes spare parts for equipment, machinery, and vehicles, chemicals, desludging operations, sludge transportation.

The cost of electrical power per year is calculated as the product of the estimated power consumption times the current public utility rate of 0.12 USD/KWh.

The 20-Year cost comparison value is calculated using the following equation:

[(Construction Cost/Applicable Depreciation Life (50 years)) + (Equipment Cost/Applicable Depreciation Life (12 years)) + Annual O&M Cost + Annual Power Cost] x 20 Years + Land Cost.

TABLE 3-3: COST OF THE STABILIZATION POND TREATMENT PROCESS

Population (1)	Area required (m²/cap) (2)	Total Area required (m²) (3)	Land Cost (USD) (4)	Construction cost (USD) (5)	Equipment Cost (USD) (6)	Capital investment Initial cost (USD) (7) = (4)+ (5)+ (6)	Operation and maintenance cost (USD/yr) (8)	Power consumption (KWH/yr) (9)	Power cost (USD/yr) (10) = (9)*0.12	20 Year Comparison Cost (USD) (11) = (4) + [(5)/50 + (6)/12 + (8)+(10)] * 20 yrs.
500	4	2,000	50,000	19,000	5,000	74,000	8,000	2,400	288	231,693
1,000	4	4,000	100,000	34,000	9,000	143,000	11,000	3,000	360	355,800
2,000	4	8,000	200,000	62,000	16,000	278,000	16,000	3,600	432	580,107
5,000	4	20,000	500,000	145,000	35,000	680,000	28,000	6,000	720	1,190,733
10,000	4	40,000	1,000,000	250,000	60,000	1,310,000	51,000	12,000	1,440	2,248,800
20,000	4	80,000	2,000,000	440,000	100,000	2,540,000	96,000	18,000	2,160	4,305,867
50,000	4	200,000	5,000,000	900,000	200,000	6,100,000	232,000	24,000	2,880	10,390,933
100,000	4	400,000	10,000,000	1,400,000	300,000	11,700,000	444,000	36,000	4,320	20,026,400

TABLE 3-4: COST OF THE TRICKLING FILTER TREATMENT PROCESS

Population (1)	Area required (m²/cap) (2)	Total Area required (m²) (3)	Land Cost (USD) (4)	Construction cost (USD) (5)	Equipment Cost (USD) (6)	Capital investment Initial cost (USD) (7) = (4)+ (5)+ (6)	Operation and maintenance cost (USD/yr) (8)	Power consumption (KWH/yr) (9)	Power cost (USD/yr) (10) = (9)*0.12	20 Year Comparison Cost (USD) (11) = (4) + [(5)/50 + (6)/12 + (8)+(10)] * 20 yrs.
500	0.75	375	9,375	42,667	21,333	73,375	8,960	4,320	518	251,557
1,000	0.75	750	18,750	82,667	41,333	142,750	17,360	8,640	1,037	488,645
2,000	0.70	1,400	35,000	160,000	80,000	275,000	28,800	17,280	2,074	849,813
5,000	0.70	3,500	87,500	383,333	191,667	662,500	63,250	43,200	5,184	1,928,958
10,000	0.60	6,000	150,000	733,333	366,667	1,250,000	110,000	86,400	10,368	3,461,805
20,000	0.60	12,000	300,000	1,440,000	720,000	2,460,000	194,400	172,800	20,736	6,378,720
50,000	0.50	25,000	625,000	3,400,000	1,700,000	5,725,000	408,000	432,000	51,840	14,015,133
100,000	0.50	50,000	1,250,000	6,666,667	3,333,333	11,250,000	700,000	864,000	103,680	25,545,822

TABLE 3-5: COST OF THE ACTIVATED SLUDGE TREATMENT PROCESS

Population (1)	Area required (m²/cap) (2)	Total Area required (m²) (3)	Land Cost (USD) (4)	Construction cost (USD) (5)	Equipment Cost (USD) (6)	Capital investment Initial cost (USD) (7) = (4)+ (5)+ (6)	Operation and maintenance cost (USD/yr) (8)	Power consumption (KWH/yr) (9)	Power cost (USD/yr) (10) = (9)*0.12	20 Year Comparison Cost (USD) (11) = (4) + [(5)/50 + (6)/12 + (8)+(10)] * 20 yrs.
500	0.75	375	9,375	52,667	26,333	88,375	11,060	12,096	1,452	324,570
1,000	0.60	600	15,000	100,000	50,000	165,000	21,000	22,464	2,696	612,253
2,000	0.50	1,000	25,000	186,667	93,333	305,000	33,600	41,472	4,977	1,026,762
5,000	0.40	2,000	50,000	433,333	216,667	700,000	71,500	95,040	11,405	2,242,545
10,000	0.35	3,500	87,500	800,000	400,000	1,287,500	120,000	172,800	20,736	3,888,887
20,000	0.30	6,000	150,000	1,466,667	733,333	2,350,000	198,000	311,040	37,325	6,665,388
50,000	0.25	12,500	312,500	3,333,333	1,666,667	5,312,500	400,000	691,200	82,944	14,082,492
100,000	0.23	23,000	575,000	6,000,000	3,000,000	9,575,000	630,000	950,400	114,048	22,855,960

WASTEWATER CAPITAL INVESTMENT PLAN AND PRIORITY ACTION PLAN

As can be seen from Tables 3-3 to 3-5 and Figure 3-1 stabilization ponds are always the least costly solution, be it in terms of total capital cost (land cost plus capital cost) or operation cost. However, the land area required is substantial and becomes impossible to find and locate for large populations as compared to trickling filters or activated sludge. Trickling filters and activated sludge are both mechanized processes that are more expensive than stabilization ponds but require less land. For a population of 100,000 trickling filters land requirement is about 12.6% and activated sludge land requirement is about 6% of the land requirement for stabilization ponds respectively. Trickling filters are however a simpler process that is less expensive than activated sludge in terms of equipment and operations. For a population of 2000, the land required for trickling filters is less than 20% that of stabilization ponds which require a sizable 8000m^2 at the same capital investment initial cost. It is therefore proposed to limit the use of stabilization ponds to localities of less than 2000 inhabitants, noting that those localities would typically be isolated and would have ample land available.

The cost of activated sludge treatment process per capita is higher than that of trickling filters at small service populations. Both processes accrue economies of scale with the increase in the size of the service population. The capital investment initial cost as well as the 20 year comparison cost of activated sludge both drop below the cost of trickling filters at a service population above 50,000. It is therefore proposed to use trickling filters to service populations up to 50,000 beyond which activated sludge would be selected. All of the numbers presented are in constant dollars calculated on the basis of 2013-2015 prices.

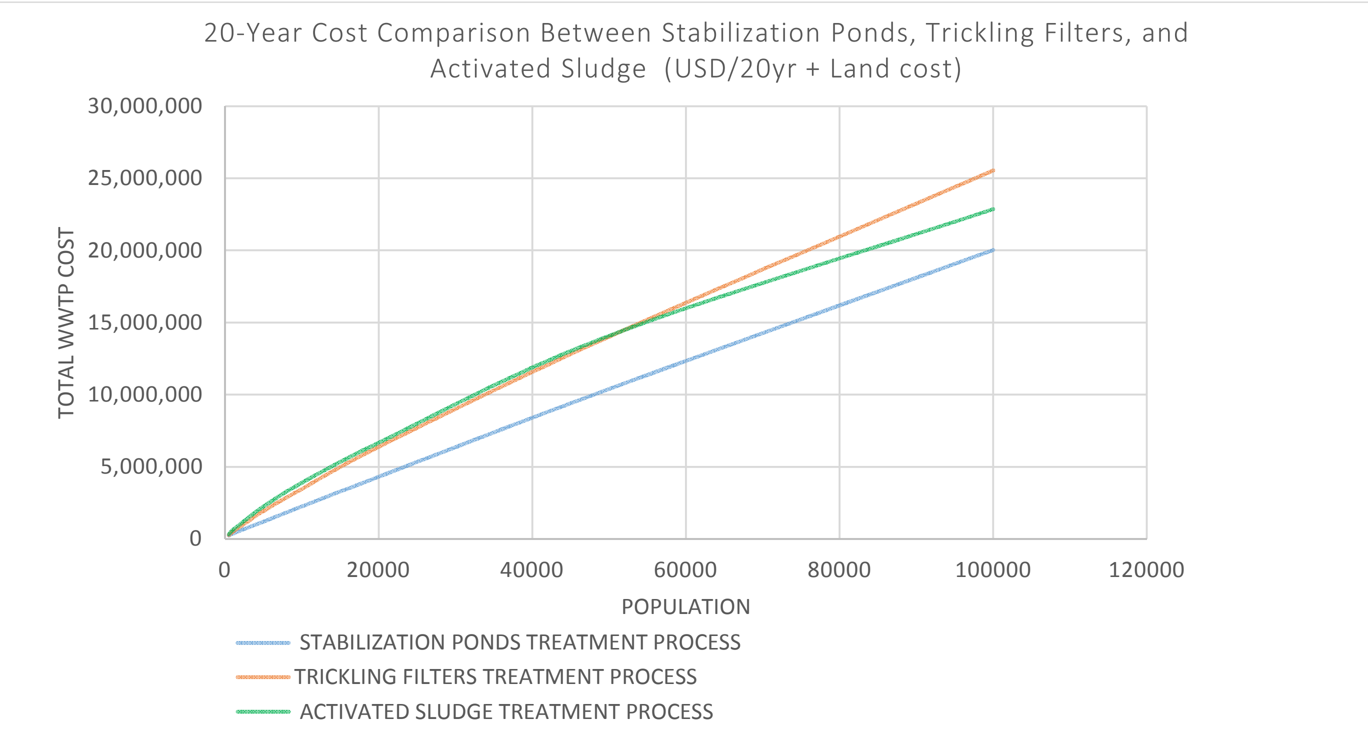


FIGURE 3-1: 20-YEAR COST COMPARISON BETWEEN STABILIZATION PONDS, TRICKLING FILTERS, AND ACTIVATED SLUDGE

3.2 Treatment processes

3.2.1 Septic tanks with leach fields

Septic tanks are watertight containers which remove large solids and greases, provide anaerobic digestion of the solids, and storage of the sludge and scum. Septic tanks do not remove large numbers of bacteria and viruses.

Septic tanks are constructed of Reinforced concrete and bricks. Baffles are placed within the tank to improve solids settling and prevent the scum layer of lightweight solids, fats and greases from floating out of the tank with the effluent. The settled solids are biologically digested by bacteria which live in environments without air (anaerobic bacteria). Some of the products of anaerobic digestion are gases, including methane, carbon dioxide, and hydrogen sulfide, which has an odor similar to that of rotten eggs. The gases are vented from the septic tank through the household plumbing vents. Inorganic and non-biodegradable materials cannot be digested by the microorganisms in the septic tank, and accumulate in the sludge or scum layers. The sludge and scum layers must be removed periodically to prevent the accumulated solids and greases from flowing into the soil absorption system and clogging the soil pores.

The required volume of the septic tank for a household depends on the number of occupants as listed here below:

Persons Served per household	Volume of Septic Tank
6 persons	3.2 m^3
9 persons	5 m^3
12 persons	6.3 m^3

Effluent from the septic tank flows by gravity or is pumped to a leach field for disposal. The wastewater effluent is absorbed by soil particles and moves both horizontally and vertically through the soil pores. The dissolved organic material in the effluent is removed by bacteria which live in the top 3 m of the soil. As the effluent moves through the soil, the temperature and chemical characteristics of the wastewater change and create an unfavorable habitat for most bacteria and viruses. Therefore, as the septic tank effluent moves through the soil, organic material and microorganisms are removed. The wastewater generally percolates downward through soil and eventually enters a groundwater aquifer. A portion of the wastewater moves upwards by capillary action and is removed at the ground surface by evaporation and transpiration of plants.

A leach field consists of a series of perforated distribution pipelines placed in 0.3 to 1 m wide trenches 0.3 to 1.5m deep located at least 30m away from any drinking water source. The length of the trenches depends on the permeability of the soil but should not exceed 20m and be at least 1 to 2 m apart (for a typical medium rate of percolation soil a minimum 5m² of leach field area are needed per capita). The perforated pipe is placed on top of gravel which is also used to backfill around the pipe. The gravel promotes drainage and reduces root growth near the pipeline. Untreated building paper or straw is placed over the gravel to prevent fine soil particles from migrating into the gravel. The building paper or straw does not reduce the evapotranspiration of the wastewater. A minimum topsoil cover is placed over the gravel to protect the leach field, prevent contact with the wastewater and reduce infiltration from rain and snow.

Septic tanks should be inspected and pumped regularly, ideally every 3 years, and percolation tests should be conducted during the wet season prior to installing a new system.

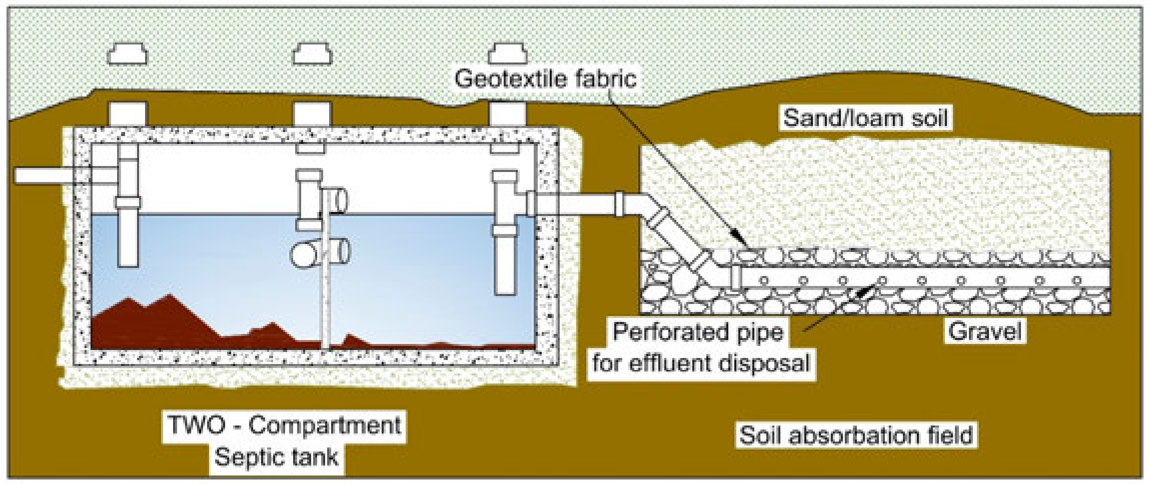


FIGURE 3-2: SEPTIC TANK

3.2.2 Stabilization ponds or facultative pond

Stabilization ponds are simple natural ponds where oxygen is transferred directly into the water across the surface area without the need for any equipment. This natural method of aeration is slow and as a result, ponds treat sewage slowly, with a long detention time hence resulting in large required land surfaces. If the time and area are available, stabilization ponds are very economical facilities to maintain. The ponds can be used individually, or linked in a series for improved treatment. There are three types of ponds, (1) anaerobic, (2) facultative and (3) aerobic (maturation), each with different treatment and design characteristics. To prevent scum formation, excess solids and garbage from entering the ponds, pre-treatment (with grease traps and manual medium screen) are essential to maintain the ponds. The anaerobic pond reduces solids and BOD as a pre-treatment stage. The pond is a fairly deep man-made pond where the entire depth of the pond is anaerobic. Anaerobic ponds are built to a depth of 2 to 5m and have a relatively short detention time of 1 to 7 days. The actual design will depend on the wastewater characteristics and the loading. Anaerobic bacteria convert organic carbon into methane and in the process, remove up to 60% of the BOD. The effluent from the anaerobic pond is then transferred to the facultative pond, where further BOD is removed. A facultative pond is shallower than an anaerobic pond and both aerobic and anaerobic processes occur within the pond. The top layer of the pond receives oxygen from natural diffusion, wind mixing and algae driven photosynthesis. The lower layer is deprived of oxygen and becomes anoxic or anaerobic. Settle able solids accumulate and are digested on the bottom of the pond. The aerobic and anaerobic organisms work together to achieve BOD reductions of up to 75%. The pond should be constructed to a depth of 1 to 2.5m and have a detention time between 5 to 30 days. Following the anaerobic and the facultative ponds can be any number of aerobic (maturation) ponds to achieve a highly polished effluent. It is the shallowest of the ponds, usually constructed to a depth between 0.5 to 1.5m deep to ensure that the sunlight penetrates the full depth for photosynthesis. Maturation ponds are designed for pathogen removal. Dissolved oxygen in the pond is provided by natural wind mixing and by photosynthetic algae that release oxygen into the water. If used in combination with algae or reed beds, this type of pond is effective at removing the majority of nitrogen and phosphorus from the effluent to prevent leaching, the ponds should have an impermeable liner. The liner can be clay, asphalt, compacted impervious soil, or a polymer liner. To protect the pond from runoff and erosion, a protective berm should be constructed around the pond using the excavated material.

To maintain these ponds operational, they must be desludged once every 10 to 20 years. The sludge dredged from these ponds would be dried on the gravel drying beds provided for this purpose. A fence should be installed to ensure that people and animals stay out of the area and excess garbage does not enter the ponds. Vegetation or macrophytes that are present in the pond should be removed as it may provide a breeding habitat for mosquitoes and prevent light from penetrating the water column. Stabilization ponds are among the most common and efficient methods of wastewater treatment and are especially appropriate for rural communities that have large, open unused lands. They work best in warm, sunny climates. In the case of cold climates, the retention times and loading rates can be adjusted so that efficient treatment can be achieved.

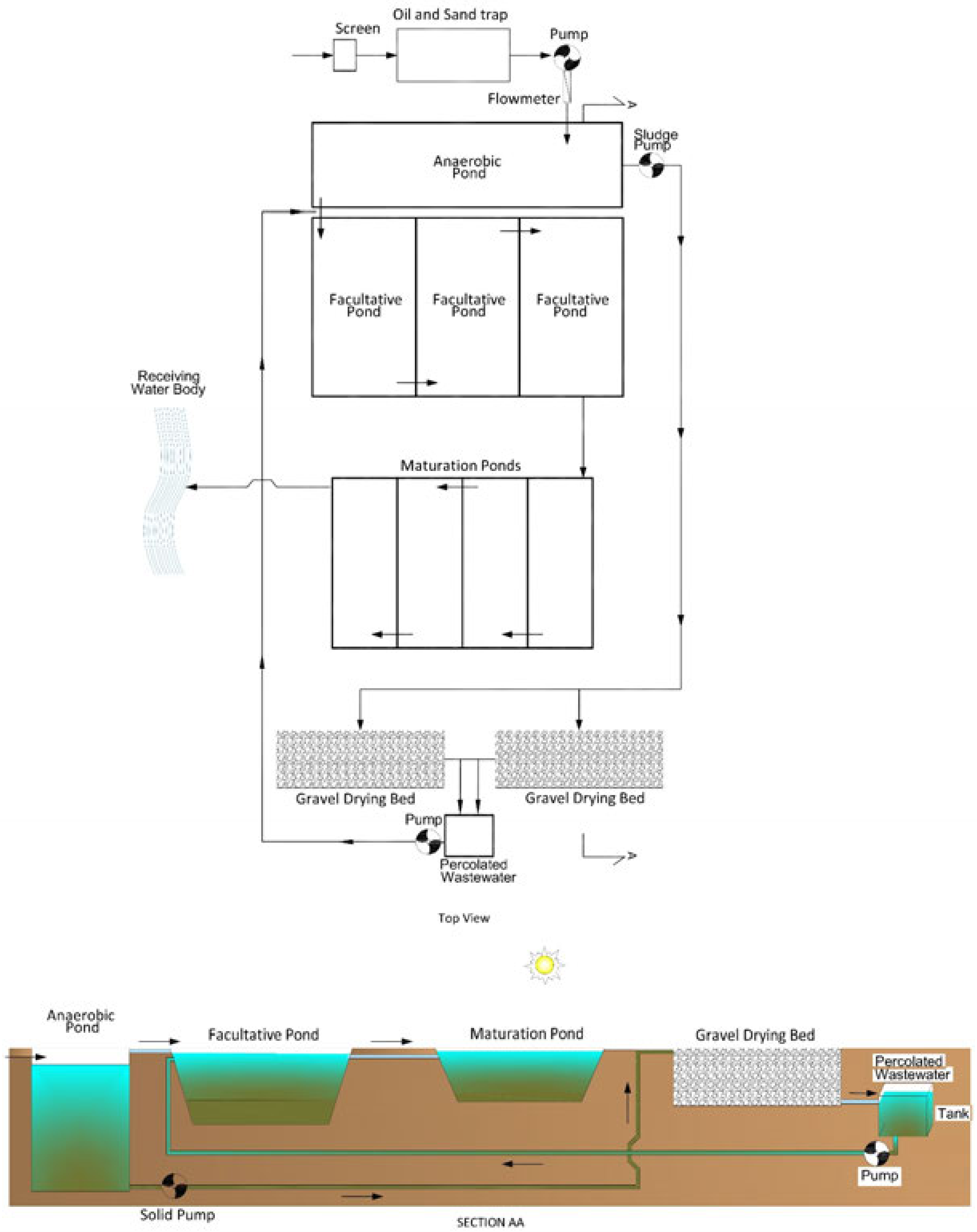


FIGURE 3-3: PROCESS OF THE STABILIZATION POND SYSTEM

3.2.3 Trickling filters

A trickling filter or biofilter consists of:

1- A screen unit of 2.5 cm clear opening to catch the bulk materials (nylon bags, socks, cups…)
2- A grit chamber to remove all the dense inorganic materials (such as sand, soil, plastics and glass)
3- A flow meter to measure instantaneous and cumulative flows.
4- A primary clarifier to settle the dense organic materials. Those materials will be pumped to the sludge holding tank by a solids pump. The effluent will be pumped up to the top of the trickling filter tank. The primary clarifier tank is an open tank.
5- A trickling filter to digest the organic material dissolved in the wastewater. The trickling filter is a basin or tower filled with support media such as stones, plastic shapes, or wooden slats. It is designed to remove BOD. In the trickling filter wastewater is applied over the media. Microorganisms become attached to the media and form a biological layer or fixed film. Organic matter in the wastewater diffuses into the film, where it is metabolized. The organisms aerobically decompose the solids producing more organisms and stable wastes, which either become part of the slime or are discharged back into the wastewater flowing over the media. The wastewater continues through the filter to the underdrain system where it is collected and carried out of the filter. At the same time air flows through the filter and oxygen is transferred from the air to the wastewater and slime to maintain the aerobic conditions. The thickness of the biofilm increases as new organisms grow. Periodically, portions of the film slough off the media.
6- A secondary clarifier to settle all the digested organic matters. Those materials will be pumped to the sludge holding tank by a solid pump. The effluent will be pumped to the water body.
7- A sludge holding tank to thicken and store the sludge. The thickened sludge will be diverted to the drying bed and both percolated and supernatant water will be pumped back to the entrance of the WWTP.
8- A drying bed to dewater the sludge. It is a basin filled of porous materials to permit the water to percolate and to catch the sludge at the top. Sludge drying beds will be designed as drainage beds filled with gravels and cultivated with reeds to reduce the area required to the minimum and then the dried sludge and the reeds will be skimmed periodically. All the drained water will be drawn back to the plant entrance for recirculation.

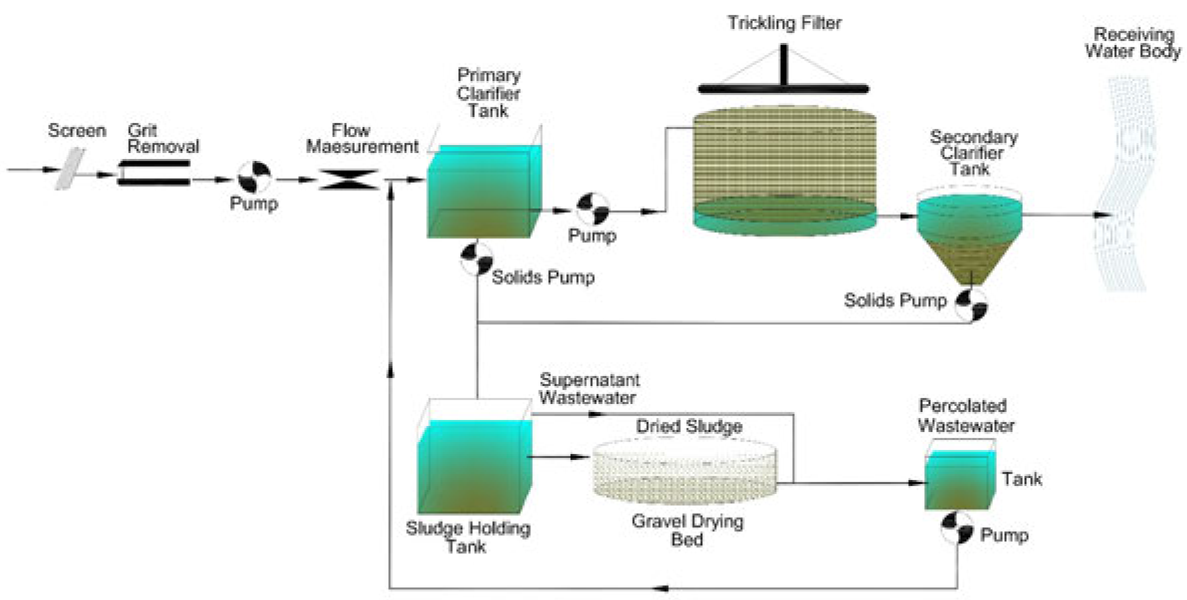


FIGURE 3-4: PROCESS OF THE TRICKLING FILTER SYSTEM

3.2.4 Activated sludge

An Activated Sludge consists of:

1- A screen unit of 2.5 cm clear opening to catch the bulk materials (neylon bags, socks, cups…)
2- A grit chamber to remove all the dense inorganic materials (such as sand, soil, plastics and glass).
3- A flow meter to measure instantaneous and cumulative flows.
4- A primary clarifier to settle the dense organic materials. Those materials will be pumped to the sludge holding tank by a solids pump. The effluent will enter the aeration tank. The primary clarifier tank is an open tank
5- An aeration tank to reduce the organic matters. The contents of the aeration tank are mixed vigorously by aeration devices which also supply oxygen to the biological suspension. Aeration devices commonly used include submerged diffusers that release compressed air and mechanical surface aerators that introduce air by agitating the liquid surface. Hydraulic retention time in the aeration tanks usually ranges from 3 to 8 hours but can be higher with high BOD5 wastewaters. During the aeration the activated sludge organisms use the available organic matter as food producing stable solids and more organisms. The suspended solids produced by the process and the additional organisms become part of the activated sludge. The solids are then separated from the wastewater in the secondary clarifier tank. The solids are returned to the influent of the aeration tank (return activated sludge). Periodically the excess solids and organisms are removed from the system (waste activated sludge). Failure to remove waste solids will result in poor performance and loss of solids out of the system over the settling tank effluent weir. Following the aeration step, the microorganisms are separated from the liquid by sedimentation and the clarified liquid is secondary effluent. A portion of the biological sludge is recycled to the aeration basin to maintain a high mixed-liquor suspended solids (MLSS) level. The remainder is removed from the process and sent to sludge processing to maintain a relatively constant concentration of microorganisms in the system. In order obtain the desired level of performance in an activated sludge system, a proper balance must be maintained between the amount of food (organic matter), organisms (activated sludge) and oxygen (dissolved oxygen).
6- A secondary clarifier to settle all the digested organic matters. 90% of those materials will be recirculated and pumped back to the aeration tank. 10% of those materials will be pumped to the sludge holding tank by a solid pump. The effluent will be pumped to the water body.
7- A sludge holding tank to thicken and store the sludge. The thickened sludge will be diverted to the drying bed and both percolated and supernatant water will be pumped back to the entrance of the WWTP.

8- A drying bed to dewater the sludge. It is a basin filled of porous materials to permit the water to percolate and to catch the sludge at the top. Sludge drying beds may be designed as drainage beds filled with gravels and cultivated with reeds to reduce the area required to the minimum and then the dried sludge and the reeds would be skimmed periodically. All the drained water would be drawn back to the plant entrance for recirculation.

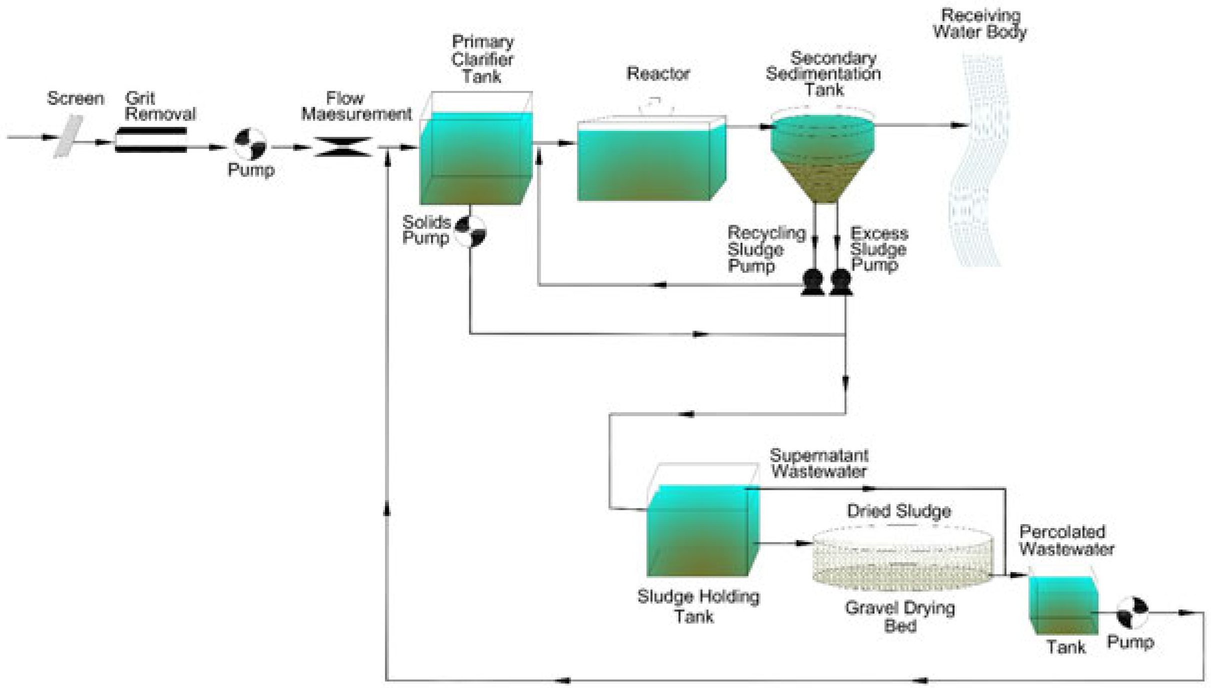


FIGURE 3-5: PROCESS OF THE ACTIVATED SLUDGE SYSTEM

3.3 Biosolids treatment

All treatment methods produce sludge the quantity and quality of which depend on the method of treatment adopted. Depending on the size and type of the treatment process large amounts of sludge may be generated with an associated treatment cost that adds up to a substantial percentage of the plant overall operating cost. Sludge is high in water content, in oxygen demand, in nutrients, but also contains pathogens, heavy metals, and organic pollutants. Hence further treatment is required for stabilizing organic matter, reducing the volume and improving its filtration ability for easy dewatering before it can be safely used in agriculture and/or for land application. Stabilizing the organic matter to various degrees can be achieved by employing further digestion (aerobic or anaerobic), composting, co-composting with solid waste streams, heat treatment, chlorine oxidation or lime stabilization.

Reduction in volume of the raw sludge can be achieved by the following processes applied alone or in combination:

- Sludge thickening in stirred tanks or centrifugation which reduces water content by up to 50%;
- Mechanical dewatering using filter plate press, filter belt press, centrifuge or vacuum filtration resulting in a solids contents of up to 25%;
- Thickening using polymers as coagulants (gravity thickening) resulting in settled flocs having a solids content of 5-10%;
- Drying beds resulting in a solids content of about 60-70%. However drying beds are not effective in wet and cold climates and they require large surface areas.

The strategy adopted in the current study is to produce stabilized sludge that is dewatered without any mechanical or chemical processes. Essentially, the least costly solution of drying beds with underdrains is recommended for all proposed wastewater treatment plants at this point since the ultimate sludge treatment process to be adopted depends on the final disposal method. As explained in more details in chapter 5, the end use of the sludge is an issue that is not well resolved yet. Ideally land application should prevail in the Bekaa but that disposal option requires an extensive administrative and legislative set-up that might be difficult to implement in Lebanon in the short term. In the event land application is not possible, then direct landfilling of the dewatered sludge or incineration may need to be considered.

4 EFFLUENT REUSE

4.1 Regulatory context

As mentioned in Chapter 1, the NSWS specifies that all inland waters have to be reused by 2020. As this study is concerned with the Bekaa wastewater which is all considered inland waters, it implies that all the effluent produced in the existing and future treatment plants should be reused and not disposed of in water bodies. However, the NSWS also states that national guidelines and criteria for wastewater treatment and reuse will be reviewed and issued jointly by an inter-ministerial committee, and that specific studies of plants will be undertaken to assess the technical and economical reuse potential for each. Hence as of this study, there is no specification as to what is considered effluent reuse, and no national guidelines or standards to regulate its usage. There is also no knowledge about whether effluent reuse will be economical for all the Bekaa treatment plants. Guidelines are necessary for the planning and safe implementation of wastewater reuse for irrigation and to promote the development of best practices. These have to consider the specific local conditions such as the quality of the effluent, the climate, the type of crops and their rotation patterns, agricultural practices, and existing soil types, and they have to suggest different uses for the effluent.

Until the NSWS becomes law and the guidelines for the effluent reuse are set, the disposal of the wastewater treatment effluent is governed by Ministerial Decision 1/8 (dated 1/3/2001) of the Ministry of Environment. This decision established National Standards for Environmental Quality (NSEQ) which set upper limit values (ELV) for wastewater discharges from existing and new facilities in the sea and surface water bodies, knowing that the ELV for the existing facilities will automatically expire when the Barcelona LBC protocol will be ratified by Lebanon.

However, the MEW has made it clear that this study should take into account the NSWS effluent reuse criteria whenever these are set. The selected treatment processes effected before these effluent reuse criteria are set should abide by the criteria for discharge into water bodies until further notice. This report will give general recommendations geared towards a potential reuse of the effluent.

4.2 Previous studies

A project entitled “The re-use of treated effluent and sludge generated at the Baalbeck Wastewater Treatment Plant” (Project UTF/LEB/019/LEB) was carried out by the FAO for the CDR between 2009 and 2011.The objective of the project was to enhance the reuse of treated effluent and sludge in Lebanon, taking into account the different stakeholders, through capacity building and awareness creation, as well as the development of national guidelines. The study compiled international guidelines for the reuse of treated effluent adopted by various countries, namely Algeria, Cyprus, Egypt, France, Greece, Israel, Italy, Jordan, Kuwait, Morocco, Oman, Palestine, Saudi Arabia, Spain, Syria, Tunisia, Turkey, and Yemen. It is interesting to note that so far no regulation of wastewater reuse exists at a European level, and hence every country has its own specific regulations, laws, or recommendations. The study also discusses the different existing approaches to protecting public health and the environment. Specifically the California standards and the WHO guidelines are compared as they represent two different schools of thought on water quality requirements. The California standards are very stringent on faecal coliform bacteria, while the WHO experts considered such a conservative attitude on health unjustifiable in developing countries and emphasize mostly the importance of helminth eggs. The study recommends that water quality standards should be adapted to reflect the local conditions as they are relative to the level of economic development.

Another study entitled “Best management practice guideline for wastewater facilities in karstic areas of Lebanon” was conducted by BGR (the German Federal Institute for Geosciences and Natural Resources) in 2011 within the project “Protection of Jeita Springs”. It focused on the site selection and design process selection for wastewater treatment plants and gave criteria for wastewater and sludge reuse and management as well as monitoring of the treated effluent and sludge quality and effects of wastewater reuse and sludge application. The study also stressed the importance of education and public awareness. It stated that many reuse schemes failed due to overestimation of demand as expectation of higher acceptance in the population for reuse water was assumed. Also, it emphasized the fact that wastewater reuse might involve some pumping costs that need to be paid by farmers, and hence early consultation of all stakeholders is needed to ensure that the selection of the appropriate technology is based on demand, on user’s preference, and on sound economic considerations. The awareness campaign should especially focus on educating the stakeholders about the importance of control measures for safe usage of the effluent.

4.3 Proposed guidelines

The decision for the best reuse application should be done on a case by case basis for each wastewater treatment plant, as factors such as the geographical, geological, and hydrogeological conditions, marketability of possible crops, availability of space for effluent storage along with its associated cost, and the cost of distribution and pumping should be taken into consideration. In addition, issues of acceptability of the water by farmers and potential consumer confidence in food products grown using effluent water should play a role in the decision.

Care should be taken to avoid the spread of diseases. Main pathways for disease spread is through direct contact with reclaimed wastewater by farm workers, unplanned access by the public, indirect infections through consumption of contaminated food, spread of aerosols during irrigation, and contamination of downstream water sources through infiltration or runoff. To reduce risks and maximize protection, several measures have to be taken most important of which are: reducing pathogens concentrations through wastewater treatment; restricting use to cooked, processed, or fodder crops; marking of plots irrigated with reclaimed water; specifying how long before harvest reuse water can be applied; specifying restrictions on land on which reuse can be used (buffer zones separating it from dwellings, water bodies, etc.); controlling the exposure through the adoption of proper occupational health measures; and restricting the irrigation methods and timing (spray and sprinkler irrigation systems present the highest risks to consumers if irrigated crops are eaten raw and unwashed).

As part of the FAO study, guidelines for Lebanon were developed after discussions with various stakeholders and the draft decision to be approved by the appropriate ministries was prepared (the decision has not been approved yet and national guidelines have not been issued). Also, two training workshops on the reuse of effluent and sludge including the application of the developed guidelines were held in 2009 and 2010 and attended by various identified stakeholders. An awareness campaign including the production of pamphlets, an awareness workshop attended by personnel from the MEW, MOA, LRA, CDR, and the BMLWE, and an awareness campaign for the Bekaa farmers was conducted.

The proposed wastewater reuse guidelines can be summarized as follows:

- A bacterial limit value of 1000 C.F./100 ml as proposed by the WHO;
- Irrigation of crops eaten raw is not allowed;
- The effluent should be classified in three categories as listed in table 4-1 below and its reuse in irrigation depends on the category to which it belongs.

TABLE 4-1: PROPOSED EFFLUENT QUALITY CRITERIA FOR LEBANON (FAO, 2010)

Parameter	Category		
	I	II	III
BOD_5 (mg/l)	25	100	100
COD (mg/l)	125	250	250
TSS (mg/l)	60	200	200
pH	6 - 9	6 - 9	6 – 9
Cl_2 residual (mg/l)	0.5 - 2	0.5 - 2	0.5 – 2
$N\text{-}NO_3$ (mg/l)	5-30	5-30	5-30
Faecal Coliforms (in 100 ml)	<200	<1000	None required
Helminth ova (in 1 liter)	<1	<1	<1

It is proposed to adopt Category I quality criteria for the effluent as it is the only one that meets the irrigation reuse requirements for the Bekaa. Secondary treatment can achieve the required effluent quality. The allowed irrigation uses are detailed in Table 4-2.

TABLE 4-2: EFFLUENT ALLOWED USE FOR CATEGORY I IN LEBANON (FAO 2010)

Effluent Category I	Allowed Use
Secondary treatment	1- Fruit trees and crops that are eaten cooked 2- Parks, public gardens, lawns, golf courses and other areas with direct public exposure. 3- In case of stabilization pounds, The TSS limit value is 100 mg/l 4- Wooded areas, and other areas with limited public access, road sides outside urban areas 5- Landscape impoundments: ponds, water bodies and ornamental streams, where public contact with water is not allowed. 6- Irrigation of cereals and oleaginous seeds, fiber, and seed crops 7- Crops for canning industry, industrial crops 8- Plant nurseries, ornamental nurseries, wooden areas, green areas with no access to the public

In addition to controlling the effluent quality and where it can be used, good irrigation practices need to be followed to minimize risks to the environment and to the farmer. These are based on the water quantity, water quality and management practices. The limits on the concentration of many chemicals in the irrigation water will be determined by crop requirements. The nutrients, mainly nitrogen, potassium, and phosphorus should be present in the right concentrations or they can damage the crops. Typically wastewater often contains high concentrations of nitrogen which can cause overstimulation of growth leading to low-quality produce. In addition the amount of nitrogen needed depends on the stage of growth of the plant. In some cases, blending of the effluent with freshwater is needed to avoid excessive nitrogen application. Other chemicals such as boron and lithium which are used in household detergents and greases can harm some types of trees such as citrus and stone fruits if present in the wastewater.

Heavy metals which might be present in the effluent due to infiltration of industrial wastewater are only partly removed by wastewater treatment. They tend to accumulate in soils when water containing trace elements is applied to the crops and can be toxic to the plants beyond a certain threshold level.

The type of irrigation method used is also important as it affects the concentration of certain chemicals in the wastewater due for example to evapotranspiration. The irrigation systems allowed for each use are as listed in Table 4-3.

TABLE 4-3: ALLOWED IRRIGATION SYSTEMS (FAO, 2010)

	Water Category	Subsurface Irrigation	Drip Irrigation	Bubbler Irrigation	Mini sprinkler	Sprinkler	Surface Irrigation
Crops eaten cooked	I	Yes	Yes	Yes			
Parks, public gardens , lawns, golf courses and other areas *with unlimited public exposure*	I	Yes	Yes	Yes	Low angle sprinklers	Sprinkling preferably to be practiced at night and when people are not around.	
Fruit trees *	I - II - III	Yes	Yes	Yes	Yes	Yes except water category III with a buffer zone of about 300 meters.	Yes
Lawns, wooded areas, and other areas *with limited public access,* road sides outside urban areas	II	(a)	(a)	Yes	Yes	Allowed with a buffer zone of about 300 meters.	Yes
Landscape impoundments: water bodies and ornamental streams, where public contact with water is not allowed	II	(a)	(a)	Yes	Yes	Allowed with a buffer zone of about 300 meters.	Yes
Fodder crops**	II	(a)	(a)	Yes	Yes	Allowed with a buffer zone of about 300 meters.	Yes
Irrigation of cereals and oleaginous seeds, fiber, & seed crops	III	(a)	(a)	Yes	Yes	Allowed with a buffer zone of about 300 meters.	Yes
Crops for canning industry, industrial crops	III	(a)	(a)	Yes	Yes	Allowed with a buffer zone of about 300 meters.	Yes
Plant nurseries, ornamental nurseries, wooden areas, green areas with no access to the public	III	(a)	(a)	Yes	Yes	Allowed with a buffer zone of about 300 meters.	Yes

* No fruits to be collected from the ground, in case where crops get wetted irrigation should stop one week before harvesting.
** For fodder crops, irrigation is recommended to stop at least one week before harvesting and no milking animals should be allowed to graze on pastures irrigated with sewerage.
(a) Irrigation system allowed if adequate filtration system protect the material of irrigation and drippers against the plugging.

4.4 Monitoring and Control

One of the most important components of any effluent reuse program is the monitoring, control, and enforcement of regulations. Details about the frequency and sampling techniques should be included in every specifications regarding effluent reuse. These should depend on the potential impact of the effluent reuse and not on the wastewater treatment plant size. Indicator parameters such as BOD_5, COD, TSS, total N, Total P, TOC, E. coli, helminth eggs, and faecal coliforms should be analyzed frequently (for example for every 10,000 m^3), whileother parameters such as Na, Ca, Mg, K, Cl, SO_4, B, Li, Cd, Cr, Cu, Hg, Ni, Pb, NO_3, and PO_4 can be analyzed less frequently (for example for every 50,000 m^3). Sampling frequency has to be increased during the first two years of operation of a WWTP. In addition to sampling, crops intended for human consumption have to be controlled and measures to ensure crop restrictions are respected and irrigation practices comply with management guidelines should be set in place. Also fertilizer needs have to be adjusted to take into account nutrients added through reclaimed wastewater depending on crop needs.

It is important to note that currently, laboratories in the Bekaa are not equipped to handle the large number of samples that would be generated from the WWTPs, nor do they have the capacity to measure all the parameters required. Hence, in parallel with the implementation of the new master plan for the Bekaa, a number of well-equipped laboratories have to be established in order to carry out adequate sampling programs.

4.5 Recommendations for the Bekaa

In the current master plan, wastewater plants are located as described in chapter 3 such as to maximize the use of gravity by the incoming influent without considering the reuse of the wastewater for irrigation as an optimization constraint. As guidelines for the reuse of the effluent become available economical solutions would be investigated at that time in the relevant design feasibility studies. Unlike the sludge which can be transported from the WWTP to another plant, to a storage center, or to a centralized sludge treatment/ transformation plant, the liquid effluent cannot be transported off-site to be combined with the effluent of another plant because of the large quantity produced. Hence each plant has to dispose of its effluent independently. Consequently, the feasibility study for each WWTP should take into account the following:

1- The effluent quality produced which plays a major role in determining its end use;
2- The quantity of effluent produced to determine on-site storage needs;
3- The location of the plant with respect to urban agglomerations, agricultural land, forests, industries, highways, etc. This location, in conjunction with the quality and the quantity of the effluent will help determine the most appropriate use for the effluent, namely: urban reuse such as in parks, playgrounds, toilet flushing, fire protection, ornamental fountains, golf courses, and highway medians; agricultural reuse on food crops or non-food crops; recreational use such as impoundments for fishing and boating; environmental reuse such as augmenting stream flows and constructing wetlands; and industrial reuse primarily for cooling systems, boiler-feed water, process water;
4- The topographical location of the plant which will determine pumping needs of the effluent from the WWTP to the area where reuse will take place. It is essential for this pumping cost to be taken into consideration in the feasibility study for the reuse as it can tremendously increase the cost and render reuse economically unfeasible;
5- The type of crops planted in the agricultural areas in the vicinity of the plant, along with the crop management plans;
6- The groundwater conditions in the WWTP area in order to evaluate recharge potential. This could be to potable or non-potable aquifers. For potable aquifers, a site-specific risk assessment would need to be carried out to determine the impact of the recharge on the quality of the groundwater;
7- The geotechnical and hydrogeological conditions of the WWTP site is required in order to design on-site storage facilities in case it is needed.

5 BIOSOLIDS MANAGEMENT

In order for the sludge to be safely used for land application, concentration of heavy metals and pathogens should not exceed allowable limits. Pathogens levels depend on the treatment method adopted, while heavy metals are usually the controlling factor in biosolids use in agriculture as they tend to accumulate in soils. Sludge treatment methods include processes such as composting, aerobic digestion, anaerobic digestion, lime stabilization, and thermal drying. Depending on the level of treatment the produced sludge is either stabilized or hygienized.

5.1 Previous studies

A notable absence in the NSWS is any mention of the reuse of the sludge issued from the wastewater treatment plants. However three previous studies have tackled the issue. The FAO and BGR studies mentioned in Chapter 4, and a European Bank funded master plan entitled: “Etude du plan directeur pour la valorisation ou l’élimination des boues d’épuration” managed by the CDR and conducted in 2001-2003 by the Joint Venture TECSULT/KREDO. The latter study aimed at recommending a disposal method for all the sludge to be produced by the wastewater treatment plants included in the 1982 Wastewater Master Plan, with a priority given for reuse in agriculture. The horizon year of the study was 2020.

The KREDO/TECSULT master plan evaluated in detail the available land that can be potentially used for sludge application according to the strict criteria and constraints proposed within the framework of the study. These criteria and constraints concern the application rate, time interval between sludge application and harvest, topography, soil types, distance to dwellings, and type of crops. The crops selected for land application were as follows: olive trees, fruit trees, citrus fruits, bananas, fodder plants, cotton, wheat, barley, and corn. All these crops are either non-food producing crops or are food-producing but not in contact with the soil. For the Bekaa, it was found that 34% of the stabilized sludge (called biosolids) produced by the wastewater treatment plants in the year 2020 could be applied to land. The waiting time between land application and harvesting limits substantially the type of crops and consequently the land where sludge can be applied. Thermal drying allows the destruction of pathogens and the elimination of the waiting time required between sludge application and harvesting, hence permitting land application on all types of crops. If the sludge was treated further by thermal drying in specially designed plants which transform it into a granular form (pellets) with a solid content of about 90%, then all the sludge produced in the Bekaa would be suitable for land application. The study also states that stocking centers should be provided to keep the sludge during the periods where land application is not possible. These periods depend on the type of crops, weather condition (rain and ice), waiting time between application and harvest. Generally speaking storage should be provided for an 8 to 9 months period for stabilized sludge. It was proposed to locate the stocking centers on the same site as the wastewater treatment plants. The study also reviewed the legal Lebanese context, the regulations governing sludge reuse in the US, Canada, and the EU and proposed a legislative framework to control the sludge quality and oversee the biosolids land application which is adapted for Lebanon. Very stringent health and safety procedures recommendations were also devised for all three stages of sludge reuse, namely stocking, land application, and post land-application.

In order for a sludge reuse program to be successfully implemented in the Bekaa, recommendations of the above mentioned master plan could be adopted with modifications where necessary to accommodate the current wastewater treatment master plan. An updated land use map showing current cropping patterns would allow the confirmation of the existing potential for biosolids reuse in agriculture.

The FAO project mentioned in Chapter 4 gives a brief overview of the US regulation and the EU directive on sludge reuse in agriculture, as well as a more detailed summary of the Syrian regulation as it is deemed to be a good example of what could be adopted in Lebanon.

5.2 Proposed Guidelines

As mentioned earlier the Tecsult/Kredo biosolids master plan included a detailed section on the legislative framework of sludge reuse. This covered all aspects of the issue such as responsibilities of each party, the information that should be included in studies carried out before any permit for reuse in agriculture is granted, details of the monitoring and surveillance program that should be implemented, a proposal for a decree to be adopted by the government including all articles and annexes.

Also as part of the FAO study, guidelines for the reuse of sludge were proposed for Lebanon. These were essentially the same as the Syrian regulation. However they are not comprehensive enough and do not cover all the different aspects inherent to the reuse of sludge. The present study recommends the adoption of the Tecuslt/Kredo proposed regulation and legislative framework which was approved by the CDR. Its main elements are summarized here below.

The authorities responsible for the sludge reuse in agriculture are: the BWE as a producer and manager of the wastewater and sludge; the Ministry of Interior and Municipalities since municipalities have to conduct the investigation prior to issuing each land application permit; the Ministry of Agriculture who by law is responsible for any import, production, and distribution of fertilizers (biolsolids are used as fertilizers), the Ministry of Environment which is responsible for overseeing wastewater treatment and any resulting product; the Ministry of Public Health since sludge reuse has health implications; the sludge producer who can be either a private or a public entity is responsible for abiding by the terms and conditions set forth in the sludge decree; and the Mohafez who is responsible for issuing the permits for all sludge handling, storage, or processing facilities.

In order for any sludge reuse program to be implemented, the sludge producer should abide by the following:

- The agronomical benefit of sludge reuse should be demonstrated for each type of sludge with a good knowledge of their concentration in nitrogen, phosphorous, and/or calcium;
- Demonstrate it is not harmful to the environment and public health;
- The whole process should be transparent and fully traceable, which means that the sludge producer should be able to tell at any one point where the sludge came from, when it was produced, the concentration of the main trace-elements it contains, the sludge quantities applied to the soil, the lots where the sludge was used, the crops on which it was used, etc.;
- The decree governing the reuse of sludge in agriculture should be fully respected;
- A collective insurance should cover the farmers using the sludge to make sure they are compensated for any potential damage they incur because of the sludge use;
- The sludge producer is responsible for the sludge until the elimination of the waste and should hire an agronomist to oversee the operation and prepare the authorization permit that should be submitted to the relevant authorities.
- A yearly inventory of the quantity and quality of sludge used should be prepared and submitted to the Mohafez;
- A monitoring program covering the quality of the sludge produced, the quality of the soils where it is applied, and the sludge treatment methods adopted should be implemented. The parameters and frequency of the monitoring program are specified in the decree.

A comprehensive study should be carried out by the sludge producer prior to the implementation of a sludge reuse program as described in the decree. This study should include:

- The product characteristics (quality and quantity);
- Identification of the constraints related to the natural and human environment;
- The soil characteristics and description of the crops considered in the study perimeter;
- The social and environmental context;
- Mode of operation (location and volume of temporary storage facilities, time frame of land application, etc.);
- A description of the land application methods in relation with agricultural practices;
- Maps of zones where sludge can be potentially applied;
- Agreement with the landowners whose plots will be used;
- Details of the monitoring program and the assessment of the overall agronomical balance;
- Identification of the persons morally and physically responsible for the land application program.

This document should be submitted to the Mohafez or any authority to be later designated for approval at least one month before the start of the operations.

During operations, a monitoring ledger containing information about sludge origin, concentrations of trace-elements and organic compounds, dates of land application, quantities placed on the soil, the plots used, and the crops on which sludge was applied should be kept up to date. Also, at the end of each year, a summary of the land application campaign should be prepared and submitted to the Mohafez. This summary should include among others: record of the quantity and quality of sludge applied; quantities of fertilizing elements brought by the sludge to each cultural unit and results of soil analysis.

The main constraints governing the land application of sludge are presented in the tables here below.

TABLE 5-1: MAXIMUM ALLOWABLE CONCENTRATION OF TRACE ELEMENTS IN THE SLUDGE

Trace elements	Maximum concentration in the sludge (mg/kg MS)	Maximum accumulated flux from the sludge in 10 years (g/m2)
Cadmium	10	0.015
Chrome	1 000	1.5
Copper	1 000	1.5
Mercury	10	0.015
Nickel	200	0.3
Lead	800	1.5
Zinc	3 000	4.5
Chrome + Copper + Nickel + Zinc	4 000	6

TABLE 5-2: MAXIMUM ALLOWABLE CONCENTRATION OF ORGANIC TRACE COMPOUNDS IN THE SLUDGE

Organic Compounds	Maximum allowable concentration (gm/kg MS) in the sludge		Maximum accumulated flux from the sludge in 10 years (mg/m2)	
	General case	Application on grazing land	General case	Application on grazing land
Total of 7 major PCB (1)	0.8	0.8	1.2	1.2
Fluoranthene	5	4	7.5	6
Benzo (b) fluoranthene	2.5	2.5	4	4
Benzo (a) pyrene	2	1.5	3	2

(1) PCB 28, 52, 101, 118, 138, 153, 180.

TABLE 5-3: MAXIMUM ALLOWABLE CONCENTRATION OF TRACE ELEMENTS IN THE SOIL

Trace elements in the soil	Maximum allowable concentration (mg/kg MS)
Cadmium	2
Chrome	150
Copper	100
Mercury	1
Nickel	50
Lead	100
Zinc	300

TABLE 5-4: MAXIMUM ALLOWABLE ACCUMULATED FLUX OF TRACE ELEMENTS IN GRAZING LAND FROM THE SLUDGE

Trace elements	Maximum accumulated flux from the sludge in 10 years (g/m^2)
Cadmium	0.015
Chrome	1.2
Copper	1.2
Mercury	0.012
Nickel	0.3
Lead	0.9
Zinc	3
Selenium	0.12
Chrome + Copper + Nickel + Zinc	4

TABLE 5-5: LAND APPLICATION CONSTRAINTS (WATER AND SOIL PROTECTION)

Prohibited Zones(1)

A. Radius of 30 m around spring, individual well, or individual surface water intake;
B. Radius of 30 m around groundwater intake or surface water intake servicing 2 or more dwellings;
C. River bed or pond bed and 30 m on each side of this bed or around this bed;
D. Water course bed, non-cultivated ditch, and 5 m on each side of this bed or around it;
E. Radius of 5 m around a swamp having a minimum surface area of 10000 m2 or of a pond;
F. Frozen and snowy soils;
G. Soils with a history of gullying;
H. Soils less than 50 cm thick if the ammonia nitrogen in the residue exceeds 10% of the total nitrogen;
I. Soils with a slope > 9%
J. Phosphorus: residues containing more than 0.5% total P_2O_5 and ash cannot be applied on plots where the level of phosphorus is excessively high;
K. Phosphorus: residues containing more than 1% total P_2O_5 and ash cannot be applied on plots where the level of phosphorus is high or excessively high;

Restrictions

A. Residue should be incorporated in the 48 hours following application if the soil is barren with some possible exceptions(possible exceptions: forest; used as mulch)

TABLE 5-6: ADDITIONAL LAND APPLICATION CONSTRAINTS FOR STABILIZED NON-HYGIENIZED SLUDGE

Prohibited Zones

A. River or pond bed and the area at a 10 m radius around or a 10 m wide corridor on each side
B. Water source or any water catchment facility and a 90 m radius around. For collective facilities, the radius is increased to 500 m [(1)].
C. Ditch and a 10 m wide corridor on each side of the ditch [(2)].
D. Property line and the area with a 10 m radius around it [(2)].
E. Road and the area with a 10 m radius around it [(2)].
F. Residential zone and the area with a 500 m radius around it.
G. Commercial or public facility and the area with a 200 m radius around the limit of the property.
H. Recreational zone and an area with a 200 m radius around it.
I. Dwelling or isolated structure and the area with a 90 m radius around the limit of the property.
J. Bogs and organic soils (with organic content exceeding 30%)
K. Soils located in flood areas

Restrictions

A. Air-spraying of liquid residue should be done at less than 1 m from the soil, except in forests
B. Marking in forests of zones where sludge is applied
C. Inform personnel dedicated to transport, land application, and soil treatment of appropriate health and security measures that should be followed.

(1) Distance can be increased if a hydrogeological study shows that land application will harm the quality of the groundwater
(2) Distances specified in C, D, and E in the Prohibited Zones section can reduced by one half if the residue is solid et has a dry solids content exceeding 15% or if the residue is liquid but application is done by injection into the soil.

TABLE 5-7: LAND APPLICATION WAITING PERIODS

Crops		Sludge Type	
Types	Categories	Stabilized	Hygienised
Grassland, forage crops, non-food crops	1	6 weeks	3 weeks [(b)]
Food crops in the soil	2	36 months	10 months [(b)]
Food crops above the soil but in contact with the soil	3	18 months	10 months [(b)]
Food crops not in contact with the soil	4	30 days	Before burgeoning[(b)]
Fruit trees	5	30 days	No restriction

[(b)]Without restriction for hygienised sludge that has been treated by thermal drying at a minimum temperature of 80°C and having reached a dry solids content of 90%

TABLE 5-8: NUMBER OF SLUDGE SAMPLES TESTED DURING THE FIRST YEAR

Tons of land applied dry matter (excluding lime)	<32	32 to 160	161 to 480	481 to 800	801 to 1600	1601 to 3200	3201 to 4800	>4800
Agronomic value of sludge	4	8	12	16	20	24	36	48
As, B	--	--	--	1	1	2	2	3
Trace-elements	2	4	8	12	18	24	36	48
Organic compounds	1	2	4	6	9	12	18	24

TABLE 5-9: NUMBER OF SLUDGE SAMPLES TESTED ROUTINELY EVERY YEAR

Tons of land applied dry matter (excluding lime)	<32	32 to 160	161 to 480	481 to 800	801 to 1600	1601 to 3200	3201 to 4800	>4800
Agronomic value of sludge	2	4	6	8	10	12	18	24
Trace-elements	2	2	4	6	9	12	18	24
Organic compounds	--	22	2	3	4	6	9	12

5.3 Recommendations for the Bekaa

In the current wastewater treatment master plan for the Bekaa, the sludge produced by the various treatment plants is stabilized and dried in non-mechanical drying beds with drainage without any further treatment as its end use is not yet set. Site specific wastewater treatment plant feasibility studies should determine in due time the final reuse options for the stabilized sludge in the vicinity of the WWTP within the framework of the Tecsult/Kredo sludge master plan and other studies referenced above as well as in accordance with agricultural development plans, actual agricultural needs, and the availability of solid waste disposal facilities. Co-composting for use as fertilizer or soil amendment and disposal by incineration of sludge can be integrated in the solid waste management scheme adopted by the Lebanese Government in the Bekaa and would eventually be assessed at the feasibility study stage.

6 PROPOSED SCHEME

The first ever attempt at master planning wastewater collection and treatment in Lebanon dates back to the National Waste Management Plan developed By CDM and K&A for the CDR in 1982 under funding by the UNDP and the WHO. Based on the population at the time and the growth projections the master plan proposed to only collect and treat the wastewater generated by the larger population centers such as Zahle, Baalbeck, Joub Janine, Hermel, Rachaya, Aarsal and the environmentally critical area around the Qaraoun lake perimeter. 14 WWTPs were proposed. The master plan population projections were updated in 1994 by K&A for the MOE and the recommendations for the Bekaa essentially maintained the same. The CDR wastewater infrastructure planning, funding, design and construction efforts have been more or less aligned with this master plan during the last twenty years.

A master plan to locate wastewater treatment plants that would serve all of the population of the Bekaa was developed by Dar Al Handasah-Taleb & Partners in 1994 for the Ministry of Housing and Cooperatives. Its strategy was based on collection by gravity and treatment by stabilization ponds. It proposed 67 WWTPs across the Bekaa located optimally close to the populations served. The proposal was consolidated into a second alternative containing 50 WWTPs. The plan was abandoned given the high land area requirement and the unavailability and difficulty of locating and expropriating open land of sufficient area.

6.1 Current Condition Assessment

There are fifteen WWTPs in the Bekaa of which Iaat (serving Baalbeck area), Joubb Jannine, Yammouné and Saghbine have been built by the CDR under World Bank and Islamic Development Bank funding. The remaining WWTPs were funded by USAID under different projects extending from the mid-nineties until 2012 in cooperation with local beneficiary municipalities, varying in size of population served from the very small (<1000 capita) to medium sized (c.a. 50,000 capita).

Existing facilities were visited during the course of this project and an assessment of their operational status was carried out as described in the previously submitted Wastewater Systems Assessment Report. The measures that need to be taken to improve the operation of these WWTP were included in the previous report. The cost estimate of these measures for each caza is tabulated in the corresponding sections in Chapter 7. As a result of the master planning exercise and based on technical and economical considerations it is proposed to expand the service area and hence the capacity of some of the existing WWTPs whereas it is also proposed to replace or integrate the service areas of some smaller WWTPS into larger ones for economies of scale.

Six WWTPs are planned by the CDR for its 2020 horizon and are all medium to large capacity targeting the larger population centers of the Bekaa (Zahlé, Hermel, Temnine El Tahta, Laboue, El Marj, and Rachaya). Zahle WWTP is currently under construction whereas Hermel, Temnine El Tahta and El Marj are at different stages of design and funding. Laboue and Rachaya are at a conceptual stage.

6.2 Rational for Location of Wastewater Treatment Plants

A scheme was developed to collect and treat the wastewater generated by the population of the Bekaa by the year 2035 in order to meet the NWSS targets and the standards of the Lebanese Government based on:

- the economic criteria for treatment process selection;
- the constraints for designing and locating WWTPs;
- the operations and maintenance assumptions;

all presented in 3.1 above.

For each caza, all localities not already served by an existing or a planned WWTP were considered for service, and all but small remote villages were connected to a proposed treatment plant.

CDR planned WWTPs and their collector lines which are at different stages of design or execution, namely Zahle, Hermel, Temnine El Tahta and El Marj, were adopted unaltered as it may be counterproductive for the BWE to propose belated modifications to these facilities.

WWTPs were located/based on the principle of maximizing gravity flow to avoid pumping stations. The design horizon for the WWTPs is 2035. The main collector conveying the wastewater flow from the various villages to the plant is considered to be part of the plant, while the sewer networks inside the villages are considered to be an independent entity from the plant. Proposed facilities along with their location, the villages they serve, their design flow, treatment process, and the specifics of their main collector line are tabulated for each caza. It is worth noting that the caza of Hermel and Zahle are almost entirely covered by treatment plants already planned by the CDR.

A first alternative based on 57 WWTPs of various sizes was investigated and discussed with the BWE. As a result of these discussions a second alternative based on 36 WWTPs was developed combining treatment plants where possible by building gravity collector/interceptor lines between villages in order to reduce long term O&M costs and staffing and management problems. The added capital cost of building interceptors would be offset by the economies of scale in the treatment and the long term savings in the operation. Pumping stations were avoided and the alternative with the least number of gravity fed plants was selected. The final scheme is constituted by 6 existing plants (to be maintained with or without expansion), 4 planned or under construction by the CDR, and 26 newly proposed plants for a total of 36 WWPT's serving the needs of the Bekaa through the planning period. The proposed consolidated 26 WWTPs were located such as to avoid pumping altogether. Upon the development of detailed designs and the selection of the final location for the plants depending on land availability and other practical constraints, such locations may end up being different from those suggested in this plan; in that situation some level of pumping for at least part of the wastewater flow entering the plant may be required.

6.3 Wastewater Treatment Technologies Selection and Application

Three types of treatment processes were selected: stabilization ponds for a population size up to 2,000 inhabitants; trickling filters for a population size up to 50,000; and activated sludge for larger population sizes. As a result of the analysis of the cost of treatment technologies presented in Chapter 3 it was obvious that stabilization ponds are always the least costly solution, be it in terms of total capital cost (land cost plus capital cost) or operation cost. However, given the substantial land area requirements it was practically impossible to find and locate open areas at candidate WWTP locations to serve the larger populations of the Bekaa. Trickling filters and activated sludge are both mechanized processes that are more expensive than stabilization ponds but require less land. For a population of 100,000 trickling filters land requirement is about 12.6% and activated sludge land requirement is about 6% of the land requirement for stabilization ponds respectively. Trickling filters are however a simpler process that is less expensive than activated sludge in terms of equipment and operations.

For a population of 2000, the land required for trickling filters is less than 20% that of stabilization ponds which require a sizable 8000m^2 at the same capital investment initial cost. It was therefore proposed to limit the use of stabilization ponds to localities of less than 2000 inhabitants, noting that those localities would typically be isolated and would have ample land available.

Based on the economic analysis detailed in Chapter 3 comparing the initial capital investment cost as well as the 20 year total cost in constant dollars of trickling filters versus activated sludge it was proposed to use trickling filters to service populations up to 50,000 beyond which activated sludge, becoming less expensive, would be selected.

Villages not covered by any planned or proposed treatment plants are recommended to be serviced by individual septic tanks with leach fields. These are listed for each caza in the corresponding section. It is worthy to note that existing septic tanks are generally not connected to a proper leach field in the Bekaa and overflow in the nearby open land. Some have perforated sidewalls or bottoms to promote direct leaching to the surrounding soil.

6.4 Rational for Determining the Need for Networks

Plans showing all existing sewer networks were included in the assessment report. The condition of these networks was established according to their age and the municipalities' description of their status. Tables listing sewer network length and condition in villages are included for each caza. They divide the sewer network condition in four categories: Very Good, Good, Medium, and Bad. Sewers in bad condition are assumed to need replacement, while sewers in medium condition are assumed to need rehabilitation. Existing sewers sometimes do not cover the whole area of the village, and hence villages were divided in three categories: well covered (>80%), partially covered (50 - 80%), and poorly covered (<50%).

The length of the pipes needed for new networks is roughly estimated for each village based on GIS analysis of the populated areas. The total length needed for each caza includes extensions to existing sewer networks as well as new networks for villages not currently serviced by sewers. The cost of this total length of sewers is estimated in Chapter 7 along with the cost of replacement of existing sewers in bad condition and the rehabilitation of sewers in medium condition. Table 6-1 presents a summary of the sewer network lengths needed per caza broken down in categories. A total of approximately 4,200 km of networks would be needed by 2035 with 3,200 km of new networks to be built by the design horizon.

TABLE 6-1: SUMMARY OF THE SEWER NETWORK LENGTHS IN THE BEKAA IN 2035

Caza	Total Length of Sewer Network Needed (m)	Length of Existing Sewer Network (m)	Length of Proposed Sewer Network (m)	Length of Sewer Network to be Rehabilitated (m)	Length of Sewer Network to be Replaced (m)
Hermel	231,951	5,031	226,920	---	5,031
Baalbeck	2,030,787	408,526	1,622,261	6,093	25,375
Zahle	859,911	150,531	709,379	89,197	35,524
West Bekaa	627,635	195,942	431,693	15,239	---
Rachaiya	439,366	56,192	383,174	---	6,230
Total	**4,189,650**	**816,222**	**3,373,427**	**110,529**	**72,160**

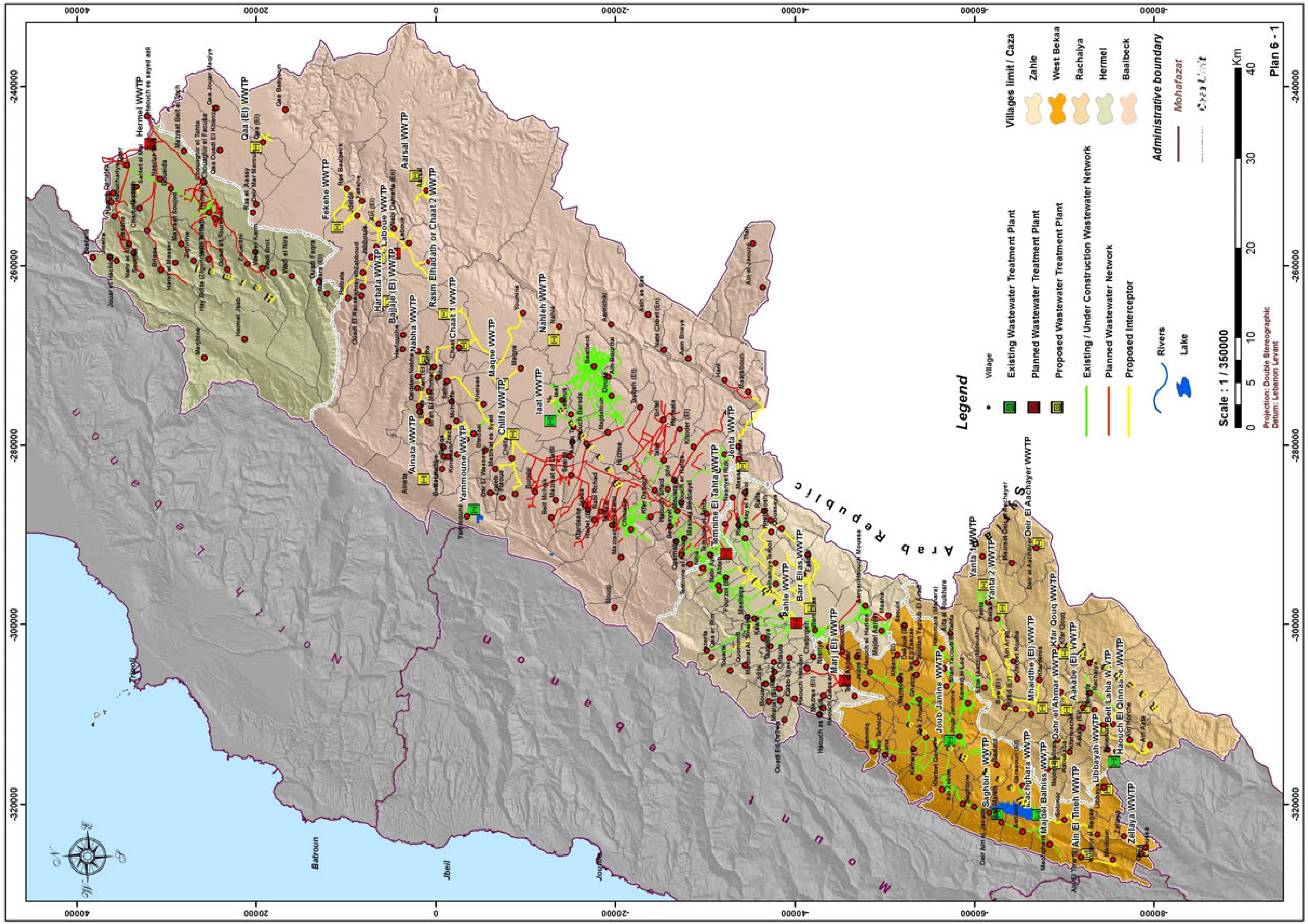
Plan 6-1 shows all wastewater systems for the entire Bekaa Mohafaza and Plan 6-2 shows all the service areas of existing, planned, and proposed WWTPs for the entire Bekaa Mohafaza.

6.5 Service Coverage under CDR and Master Plan Study Investment Program

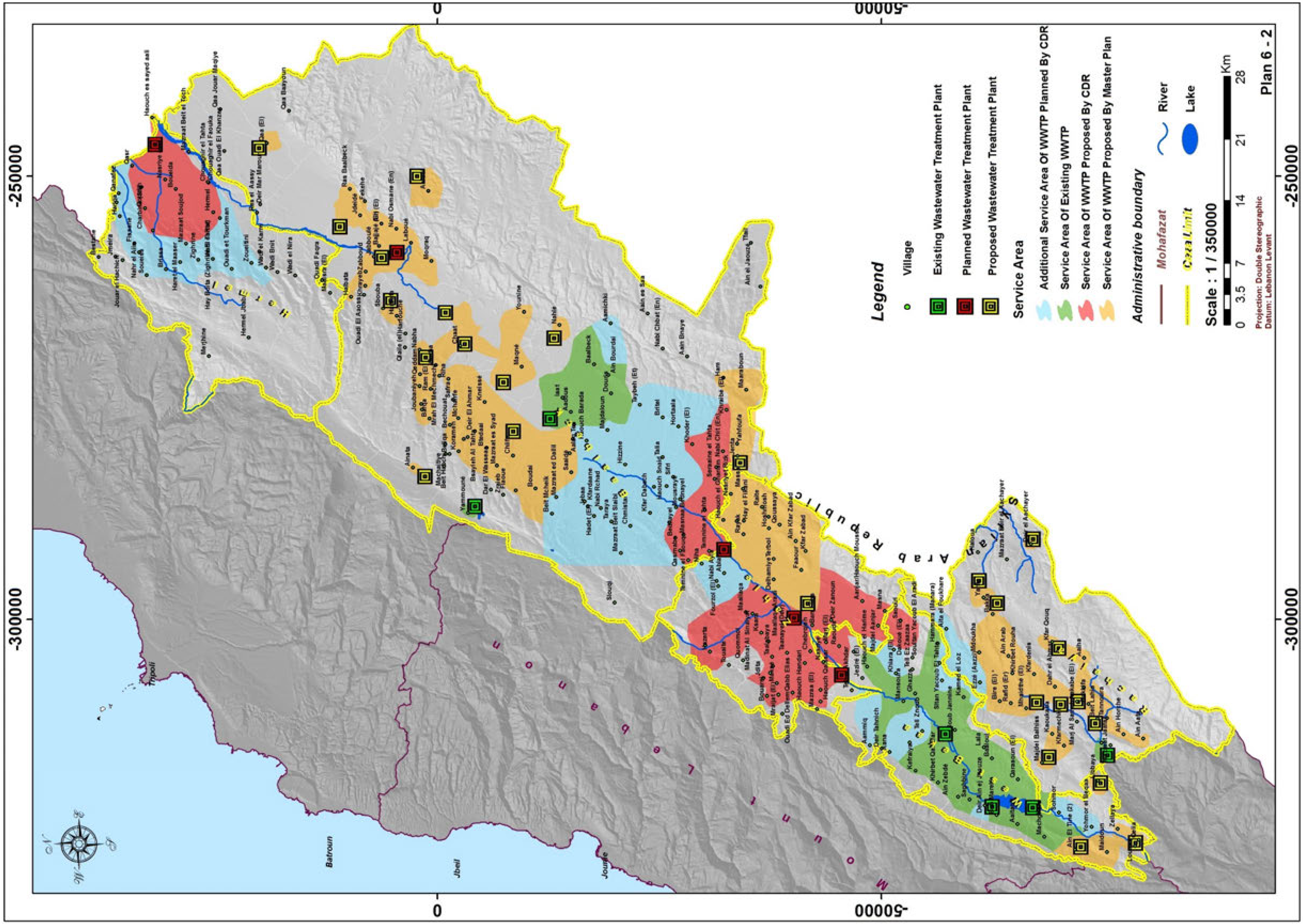
The first 10 WWTPs, existing, under construction or planned by the CDR, with their proposed treatment capacity extensions, would serve about 70% of the population by 2035. The 26 additionally proposed plants under this study would serve another 27% of the population by 2035. The remaining 3% of the population by 2035 corresponds to sparsely populated remote villages where it is proposed to convert existing bottomless septic tanks and raw discharge reservoirs into properly designed individual or communal septic tanks with leach fields. A summary of the service coverage reached by Caza is presented in Table 6-2 for the 2035 projected population. The proposed master plan is presented caza per caza in the following sections of this chapter.

TABLE 6-2: SUMMARY OF THE SERVICE COVERAGE REACHED IN THE BEKAA IN 2035

Caza	Population Served by Existing WWTPs	Population Served by CDR Planned WWTPs	Population Served by Proposed WWTPs	Total Served Population By Master plan	Total 2035 Forecasted Population	Percent Service Coverage (%)
Hermel	---	76,499	34,426	110,925	121,762	91.1
Baalbeck	134,693	198,410	256,824	589,927	610,035	96.7
Zahle	---	425,619	99,709	525,328	533,377	98.5
West Bekaa	85,027	26,878	84,949	196,854	197,441	99.7
Rachaiya	4,092	---	84,060	88,152	88,382	99.7
Total	**223,812**	**727,406**	**559,968**	**1,511,186**	**1,550,997**	**97.4**



PLAN 6-1: WASTEWATER SYSTEMS FOR THE BEKAA



PLAN 6-2: WWTPS AND THEIR SERVICE AREAS IN THE BEKAA

6.6 Hermel Caza

The Hermel caza is sparsely populated with two large agglomerations, namely the cities of Hermel and Qasr. It has a rugged topography which renders the accessibility of many villages quite difficult. One WWTP is currently planned by the CDR and it will serve most of the caza population. The remaining communities not served by this WWTP are all very small and remotely located. Hence no additional plants will be proposed in the current study for the caza of Hermel. However, the two small localities of Sahlet el Maii located right next to the main sewer interceptor of the planned Hermel WWTP are not served by the plant and hence it is proposed to connect them to the interceptor. The proposed length of the pipe needed for this connection is 2.5 km.

The Hermel caza is poorly served by existing sewers. Only the city of Hermel currently has sewers (5.03 km covering <50% of the city) that are in bad condition and need to be replaced.

The total length of new sewers needed in the caza of Hermel is 227 km and the total length of sewers needed to be replaced is 5 km.

Table 6-3 and Plan 6-3 summarize the information regarding the planned facilities in Hermel.

Table 6-4 shows the status of the existing network as well as the lengths of the proposed and existing wastewater network in the villages of Hermel.

TABLE 6-1: WASTEWATER TREATMENT PLANTS IN HERMEL CAZA

Caza	WWTP Name with Local Coordinates	Status and Type	Population Served	Estimated Capacity (m³/d)	Area Required (m²)	Village Served	Proposed Length of Interceptor Sewers (km)				
							ø=300	ø=400	ø=500	ø=600	Total
Hermel	**Hermel WWTP** **X = -246337.46** **Y = 31822.86**	Planned Activated Sludge	110,925	14,000 + 6,250 (Additional)	9,125	Haouchariye, Wadi el Ratl, Ouadi et Tourkman, Nasriye (en), Mazraat Soujod, Nahr el Aiin, Qouakh Qanafez, Qasr, Fissane, Chouaghir El Tahta & El Faouka, Sahet el Mai, Soueiss, Zouaitini, Zighrine, Haouch es sayed Aali, Hariqa, Boueida, Brissa, Hay Bdita, Hermel.	2.5	---	---	---	2.5

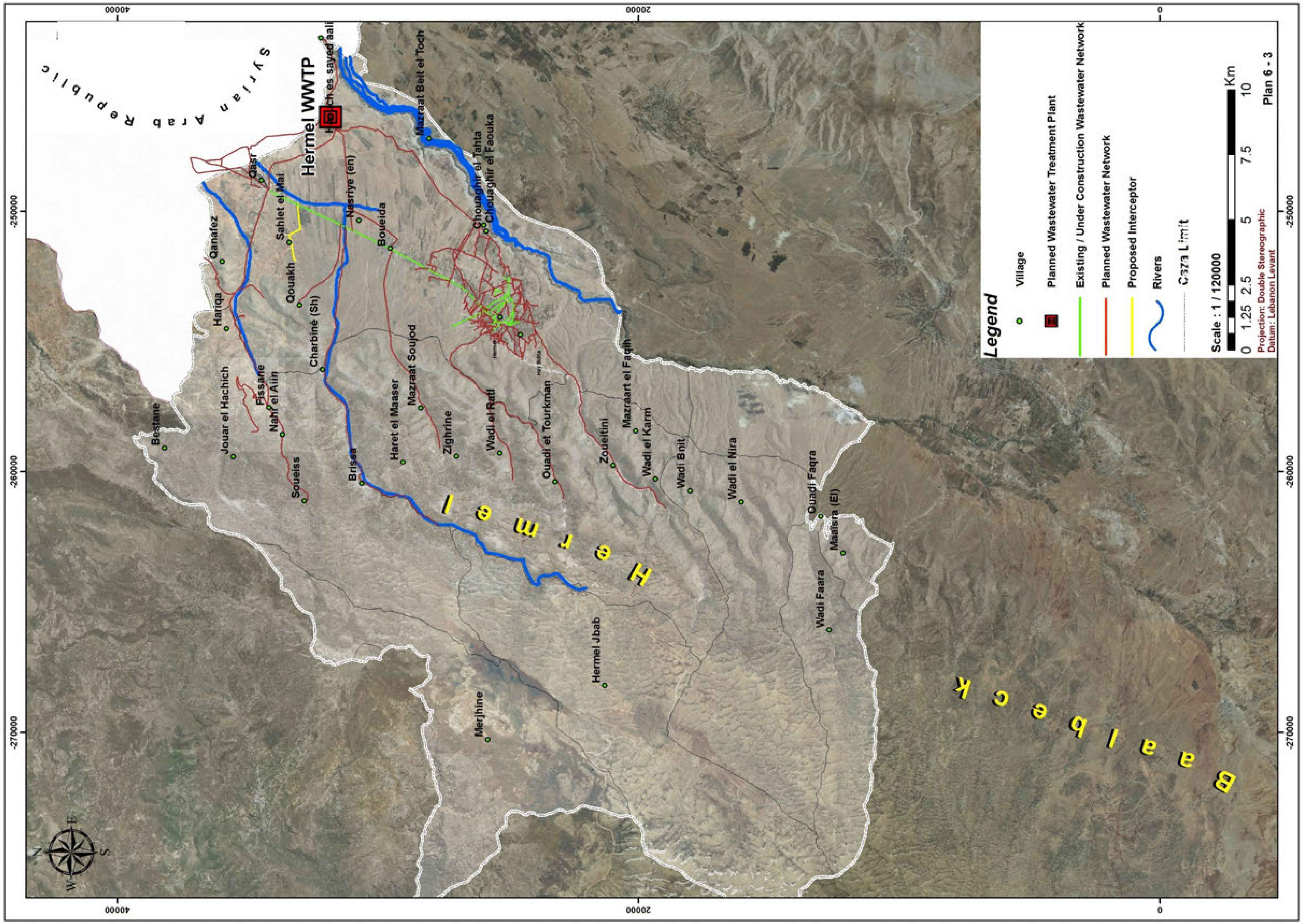
TABLE 6-2: LENGTHS OF EXISTING AND PROPOSED WASTEWATER NETWORK FOR HERMEL CAZA

Caza	Village Name	Total Length needed for sewer network (m)	Length of Existing Sewer Network (m)	Existing Sewer Network Condition	Existing Sewer Network Coverage	Existing Sewer Network Requirements	Length of Proposed Sewer Network (m)	Septic Tank Requirements
Hermel	Bestane	---	---	---	---	---	---	Yes
	Boueida	5,497	---	---	---	---	5,497	No
	Brissa	8,028	---	---	---	---	8,028	No
	Charbiné (Sh)	3,952	---	---	---	---	3,952	No
	Chouaghir el Faouka	6,295	---	---	---	---	6,295	No
	Chouaghir el Tahta (Chouaghir El Faouka)	---	---	---	---	---	---	No
	Fissane	9,199	---	---	---	---	9,199	No
	Haouch es sayed aali	1,437	---	---	---	---	1,437	No
	Haret el Maaser (Zighrine)	---	---	---	---	---	---	No
	Hariqa	1,372	---	---	---	---	1,372	No
	Hay Bdita	5,195	---	---	---	---	5,195	No
	Hermel	93,365	5,031	B	P.C	Replacement	88,334	No
	Hermel Jbab*	---	---	---	---	---	---	Yes
	Jmeira	---	---	---	---	---	---	Yes
	Jouar el Hachich	---	---	---	---	---	---	Yes
	Maaïsra (El)	---	---	---	---	---	---	Yes
	Maaser	---	---	---	---	---	---	Yes
	Mazraart el Faqih	---	---	---	---	---	---	Yes
	Mazraat Beit el Toch	---	---	---	---	---	---	Yes
	Mazraat Soujod	1,343	---	---	---	---	1,343	No
	Merjhine	---	---	---	---	---	---	Yes
	Nahr el Aiin	1,732	---	---	---	---	1,732	No
	Nasriye (en)	10,414	---	---	---	---	10,414	No
	Ouadi el Faara*	---	---	---	---	---	---	Yes
	Ouadi et Tourkman	2,793	---	---	---	---	2,793	No
	Qanafez (Including Haouchariye, Mrah El Zakbe)	7,250	---	---	---	---	7,250	No
	Qasr	41,733	---	---	---	---	41,733	No
	Qouakh	4,093	---	---	---	---	4,093	No

Caza	Village Name	Total Length needed for sewer network (m)	Length of Existing Sewer Network (m)	Existing Sewer Network Condition	Existing Sewer Network Coverage	Existing Sewer Network Requirements	Length of Proposed Sewer Network (m)	Septic Tank Requirements
	Ras Baalbeck el Gharbi	---	---	---	---	---	---	Yes
	Sahet el Mai	2,166	---	---	---	---	2,166	No
	Soueiss	2,554	---	---	---	---	2,554	No
	Wadi Bnit*	---	---	---	---	---	---	Yes
	Wadi el Karm*	---	---	---	---	---	---	Yes
	Wadi el Nira*	---	---	---	---	---	---	Yes
	Wadi el Ratl	2,441	---	---	---	---	2,441	No
	Zighrine (& Boule)	18,800	---	---	---	---	18,800	No
	Zoueitini	2,292	---	---	---	---	2,292	No
	Total	**231,951**	**5,031**	**---**	**---**	**---**	**226,920**	**---**

* Vacant land or locality that has a very small number of houses (<10)

W.C = Well Covered
M.C = Partially Covered
P.C = Poorly Covered
V.G = Very Good Condition
G = Good Condition
M = Medium Condition
B = Bad Condition



PLAN 6-3: WASTEWATER SYSTEMS FOR CAZA OF HERMEL

WASTEWATER CAPITAL INVESTMENT PLAN AND PRIORITY ACTION PLAN

6.7 Baalbeck Caza

The Baalbeck caza is densely populated with a number of large agglomerations, the largest of which is the city of Baalbeck. The topography is mostly mild with wide plains and gentle slopes converging towards a lower region located between the eastern and western mountain ranges. There are three existing wastewater treatment plants located in Iaat, Yammoune, and Deir El Ahmar serving 28% of the population, but only 7 % of the villages. The Deir El Ahmar plant was deemed to be non-operational in the Wastewater Assessment Report and the villages it served were connected to the Chlifa proposed WWTP. In addition to the existing plants, A DAHNT recent study commissioned by the CDR recommended two plants in Temnine El Tahta and Maaraboun and proposed two more in Boudai and Jenta. The Temnine El Tahta plant was adopted by the CDR in its 2020 plan, while a decision is pending on the other three. The present study recommends that Temnine El Tahta and Jenta be adopted.

The Baalbeck caza is poorly served by existing sewers with 50% of the population, corresponding to 17% of the villages having existing sewer networks. Additional networks are planned by the CDR for an additional 10% of the population.

Thirteen additional treatment plants are proposed to be built in Aarsal, Ainata, Bajjajé, Chaat, Chlifa, Fekehe, Harbata, Jenta, Maqnne, Nabha, Nahle, Qaa, and Rasm El Hadath. All of these plants are trickling filters, and they all rely on gravity flow without pumping. The CDR plan for 2020 has listed Laboue for a WWTP but it is still at a conceptual stage and it is proposed include it in the Bajjajé proposed scheme.

The villages in the caza of Baalbeck that will not be served by any WWTP and hence have to rely on septic tanks are the following: Aain Bnayé, Aaqidieh, Ain el Jaouzé, Ain Es Saouda, Beliqa, Chaaibé, Dar el Wasseaa, Deir Mar Maroun, Haouch ed Dahab, Harfouche, Machaitiye, Mazraat Beit Matar, Mazraat Beit Slaibi, Nabi Chbat (En), Ouadi El Aaoss, Qaa Baayoun, Qaa Jouar Maqiye, Qaa Ouadi El Khanzer, Qlaile (el), Ras el Aassi, Safra, Slouqi, Tfail, Wadi Faara, Zraieb and Zrazir.

As for the existing plants, when comparing their current capacity with the 2035 projected wastewater generated flow, a deficit is recorded for the Iaat plant, while the Yammoune plant was found to be overdesigned. Hence an extension of the Iaat plant is recommended using the same design process, namely activated sludge. The additional capacity is the difference between the current plant capacity and the projected 2035 needed capacity. It is important to note that Iaat is functioning currently at below its capacity as it is not receiving all the generated wastewater due to the lack of an appropriate sewer network. Table 6-5 below and Plan 6-4 summarize the information regarding the existing and proposed facilities in Baalbeck. Improvements needed to enhance the operation of the existing plants were described in the Wastewater System Assessment Report, and their associated costs are included in Chapter 7. Table 6-6 shows the status of the existing network as well as the lengths of the proposed and existing wastewater network in the villages of Baalbeck. The total length of new sewers needed for the caza of Baalbeck is 1,622 km and the total lengths of existing sewers needed to be replaced and rehabilitated are 25.5 km and 6.1 km respectively.

TABLE 6-3: WASTEWATER TREATMENT PLANTS IN BAALBECK CAZA

Caza	WWTP Name	Status and Type	Population Served	Estimated Capacity (m³/d)	Area Required (m²)	Village Served	Proposed Length of Interceptor Sewers (km)			
							Collector Added (300 mm)	Collector Added (400 mm)	Collector Added (500 mm)	Collector Added (600 mm)
Baalbeck	**Aainata WWTP** **X = -259098.50** **Y = 6308.01**	Proposed Trickling Filter	2,929	550	2,050	Ainata	1.9	---	---	---
	Bajjajé (El) WWTP **X = -259098.50** **Y = 6308.01**	Proposed Trickling Filter	47,815	8,650	24,050	Kharayeb,Nabi Osmane (En) ,Laboue, Ain (El), Zabboud, Halbata, Jdeide (15% from Fekehe), Jabboule, Bajjaje (El), Taoufiqie, Amhazie, Moqraq	21.7	9	7.8	1.2
	Aarsal 1 WWTP **X =-254098.49** **Y = 2058.68**	Proposed Trickling Filter	39,642	7,200	21,170	Part Aarsal by tunnel and other part by gravity	11.55	---	---	---
	Chaat 1 WWTP **X = -268871.39** **Y = -3065.03**	Proposed Trickling Filter	5,427	990	50,534	Part of Chaat, Qarha	9.3	0.8	---	---
	Chlifa WWTP **X = -278723.66** **Y = -8549.10**	Proposed Trickling Filter	40,578	7,400	21,560	Chlifa, Hfayer, Mazraat es Syad, Btedaai, Mazraat Beit Ghousain, Bechouat, Deir El Ahmar, Bsayle Elfawqa, Bsayle ElTahta, Kneisse, Riha, Boudai, Saaide, Aalaq Tell, Mchayrfeh, Flaoue	23.50	17.62	6.2	3.15
	Fekehe WWTP **X = -255639.99** **Y = 11045.18**	Proposed Trickling Filter	24,878	4,550	74,289	Fekehe, Part Jdeide (85%Pop Fekehe), Ras Baalbeck	8.2	4.8	1.6	1.1
	Harbata WWTP **X = -263945.47** **Y = 5293.96**	Proposed Trickling Filter	7,301	1,350	4,820	Harbata, Sbouba	4.70	---	---	---
	Iaat WWTP **X = -277283.97** **Y = -12692.58**	Existing Activated Sludge	159,116	24,000 + 5000 (Additional)	7,835	Baalbeck, Iaat, Haouch Tell Safiye, Aaddous, Douris, Ain Bourdai, Aamichki	---	---	---	---
	Jenta WWTP **X = -282270.12** **Y = -34114.27**	Proposed Trickling Filter	4,658	850	3,261	Yahfoufa, Jenta, Maaraboun, Ham	14,135	---	---	---

Caza	WWTP Name	Status and Type	Population Served	Estimated Capacity (m³/d)	Area Required (m²)	Village Served	Proposed Length of Interceptor Sewers (km)			
							Collector Added (300 mm)	Collector Added (400 mm)	Collector Added (500 mm)	Collector Added (600 mm)
	Maqne WWTP X = -272010.86 Y = -8627.38	Proposed Trickling Filter	21,715	3,950	12,810	Maqne, Younine	14.79	---	---	---
	Nabha WWTP X = -270388.26 Y = 1311.3	Proposed Trickling Filter	13,119	2,400	7,870	Nabha, Qeddam, Ram (El), Joubanieh, Mrah El Aouja, Mrah Semmaan, Barqa	10.46	2.8	0.6	---
	Nahle WWTP X = -268222.73 Y = -13124.54	Proposed Trickling Filter	8,788	1,600	5,485	Nahle	2	---	---	---
	Qaa WWTP X = -246738.77 Y = 20076.37	Proposed Trickling Filter	12,877	2,350	7,725	Qaa (El)	4.10	1.1	---	---
	Rasm Elhadath or Chaat 2 WWTP X = -265340.39 Y = -874.98	Proposed Trickling Filter	4,706	850	3,300	Rasm Al Hadath (Part of Chaat)	5.8	---	---	---
	Temnine El Tahta WWTP X = -292056.93 Y = -32290.50	Planned Activated Sludge	198,410	48,000	---	Hortaala, Nabi Chit (En), Nabi Rchad, Masnaa Bednayel, Mazraat ed Dallil, Majdaloun, Kfar Dabach, Kfardaane, Qasrnaba , Taybeh (Et), Talia, Taraya, Chmistar, Sifri, Serraaine el Faouka, Seraaine el Tahta, Khoder (El), Khraibe (El), Haouch Snaid, Haouch er Rafqa, Haouch Barada, Haouch en Nabe, Hizzine, Hadet (El), Jebaa, Temnine el Faouqa, Temnine el Tahta, Beit Mcheik, Beit Chama, Britel, Bednayel, Seraaine el Gharbieh/ Hallanieh, Mousraye	---	---	---	---
	Yammoune WWTP X = -287188.60 Y = -4227.54	Existing Activated Sludge	3,545	800	---	Yammoune	---	---	---	---

TABLE 6-4: LENGTHS OF EXISTING AND PROPOSED WASTEWATER NETWORK FOR BAALBECK CAZA

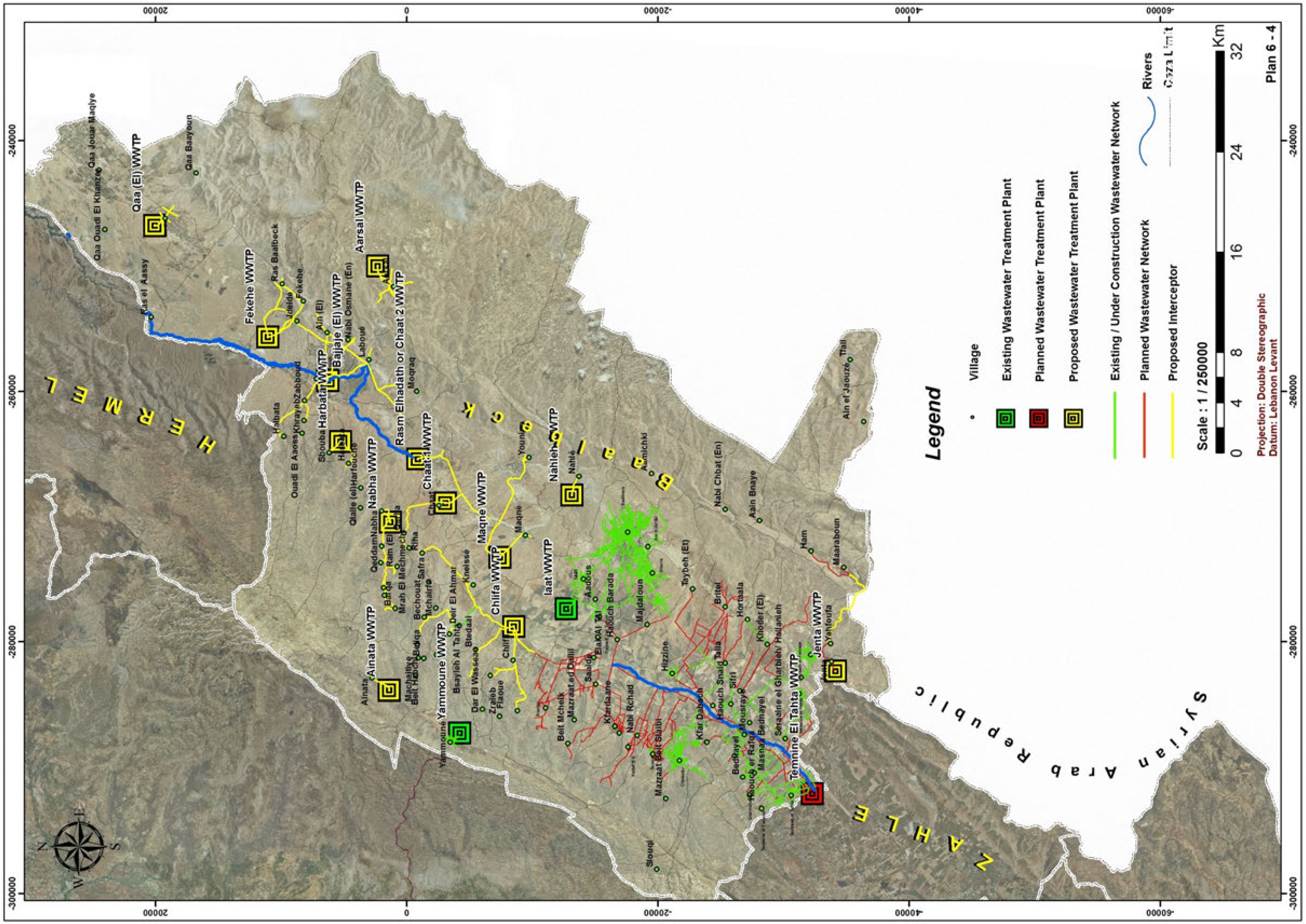
Caza	Village Name	Total Length needed for sewer network (m)	Length of Existing Sewer Network (m)	Existing Sewer Network Condition	Existing Sewer Network Coverage	Existing Sewer Network Requirements	Length of Proposed Sewer Network (m)	Septic Tank Requirements
Baalbeck	Aaddous	1,524	---	---	---	---	1,524	No
	Aain Bnayé	---	---	---	---	---	---	Yes
	Aalaq Tell	11,464	---	---	---	---	11,464	No
	Aamichki (Baalbeck)	---	---	---	---	---	---	No
	Aaqidieh	---	---	---	---	---	---	Yes
	Aarsal	107,694	---	---	---	---	107,694	No
	Ain (El)	50,691	---	---	---	---	50,691	No
	Ain Bourdai	16,671	11,734	G	W.C	None	4,937	No
	Ain el Jaouzé	---	---	---	---	---	---	Yes
	Ain Es Saouda	---	---	---	---	---	---	Yes
	Ainata	15,676	---	---	---	---	15,676	No
	Amhazié*	---	---	---	---	---	---	No
	Baalbeck	294,433	160,107	G	W.C	None	134,326	No
	Bajjajé (El)	5,246	---	---	---	---	5,246	No
	Barqa	18,427	---	---	---	---	18,427	No
	Bechouat	22,025	---	---	---	---	22,025	No
	Bednayel	28,894	15,188	V.G	P.C	None	13,706	No
	Beit Chama	16,767	4,525	V.G	W.C	None	12,242	No
	Beit Mcheik	5,114	---	---	---	---	5,114	No
	Beliqa	---	---	---	---	---	---	Yes
	Boudai	52,962	---	---	---	---	52,962	No
	Britel	121,056	---	---	---	---	121,056	No
	Btedaai	13,241	---	---	---	---	13,241	No
	Chaaibé	---	---	---	---	---	---	Yes
	Chaat	24,812	---	---	---	---	24,812	No
	Chlifa	10,259	---	---	---	---	10,259	No
	Chmistar	60,034	41,918	G	W.C	None	18,116	No
	Dar el Wasseaa	---	---	---	---	---	---	Yes
	Deir el Ahmar	44,244	3,992	G	P.C	None	40,252	No
	Deir Mar Maroun	---	---	---	---	---	---	Yes
	Douris	66,404	44,121	G	W.C	None	22,283	No
	Fekehe	54,212	---	---	---	---	54,212	No
	Flaoue	9,810	---	---	---	---	9,810	No
	Hadet (El)	36,635	---	---	---	---	36,635	No
	Halbata	5,133	---	---	---	---	5,133	No
	Ham	7,990	---	---	---	---	7,990	No
	Haouch Barada	5,213	---	---	---	---	5,213	No
	Haouch ed Dahab	---	---	---	---	---	---	Yes
	Haouch en Nabe	9,277	---	---	---	---	9,277	No
	Haouch er Rafqa	14,779	10,128	V.G	M.C	None	4,651	No

Caza	Village Name	Total Length needed for sewer network (m)	Length of Existing Sewer Network (m)	Existing Sewer Network Condition	Existing Sewer Network Coverage	Existing Sewer Network Requirements	Length of Proposed Sewer Network (m)	Septic Tank Requirements
	Haouch Snaid	16,363	4,769	V.G	W.C	None	11,594	No
	Haouch Tell Safiyé	12,377	5,481	V.G	W.C	None	6,896	No
	Harbata	17,280	---	---	---	---	17,280	No
	Harfouche	---	---	---	---	---	---	Yes
	Hizzine	15,740	3,245	G	M.C	None	12,495	No
	Hortaala	46,889	---	---	---	---	46,889	No
	Iaat	35,735	23,511	V.G	W.C	None	12,224	No
	Jabboulé	7,698	---	---	---	---	7,698	No
	Jdeidé	8,389	---	---	---	---	8,389	No
	Jebaa	6,222	---	---	---	---	6,222	No
	Jenta	1,508	---	---	---	---	1,508	No
	Kfar Dabach	7,960	---	---	---	---	7,960	No
	Kfardaane	22,689	---	---	---	---	22,689	No
	Kharayeb *	---	---	---	---	---	---	No
	Khoder (El)	11,520	---	---	---	---	11,520	No
	Khraibé (El)	8,134		---	---	---	8,134	No
	Kneissé	7,475	---	---	---	---	7,475	No
	Laboué	64,690	---	---	---	---	64,690	No
	Maaraboun	5,076	---	---	---	---	5,076	No
	Machaitiye	---	---	---	---	---	---	Yes
	Majdaloun	4,688	---	---	---	---	4,688	No
	Maqné	20,496	---	---	---	---	20,496	No
	Masnaa Bednayel (Bednayel)	---	---	---	---	---	---	No
	Mazraat Beit Matar	---	---	---	---	---	---	Yes
	Mazraat Beit Slaibi	---	---	---	---	---	---	Yes
	Mazraat ed Dallil	6,815	---	---	---	---	6,815	No
	Mazraat es Syad	11,245	---	---	---	---	11,245	No
	Moqraq	---	---	---	---	---	---	Yes
	Mousraye	2,519	---	---	---	---	2,519	No
	Nabha	44,981	---	---	---	---	44,981	No
	Nabi Chbat (En)	---	---	---	---	---	---	Yes
	Nabi Chit (En)	37,758	19,316	V.G	M.C	None	18,442	No
	Nabi Osmane (En)	25,796	---	---	---	---	25,796	No
	Nabi Rchad	18,881	---	---	---	---	18,881	No
	Nahlé	18,834	---	---	---	---	18,834	No
	Ouadi el Aaoss	---	---	---	---	---	---	Yes
	Qaa (El)	36,708	---	---	---	---	36,708	No
	Qaa Baayoun	---	---	---	---	---	---	Yes
	Qaa Jouar Maqiye	---	---	---	---	---	---	Yes
	Qaa Ouadi El Khanzer	---	---	---	---	---	---	Yes
	Qarha	6,498	---	---	---	---	6,498	No

Caza	Village Name	Total Length needed for sewer network (m)	Length of Existing Sewer Network (m)	Existing Sewer Network Condition	Existing Sewer Network Coverage	Existing Sewer Network Requirements	Length of Proposed Sewer Network (m)	Septic Tank Requirements
	Qasrnaba	17,994	8,665	G	W.C	None	9,329	No
	Qeddam	5,797	---	---	---	---	5,797	No
	Qlaile (el)	---	---	---	---	---	---	Yes
	Ram (El)	10,659	---	---	---	---	10,659	No
	Ras Baalbeck	22,342	---	---	---	---	22,342	No
	Ras el Aassi	---	---	---	---	---	---	Yes
	Riha	4,223	---	---	---	---	4,223	No
	Saaidé	16,753	---	---	---	---	16,753	No
	Safra	---	---	---	---	---	---	Yes
	Sbouba	3,347	---	---	---	---	3,347	No
	Seraaine el Gharbieh/ Hallanieh	15,508	---	---	---	---	15,508	No
	Seraaine el Tahta	75,666	14,065	G	M.C	None	61,601	No
	Serraain el Faouka (Seraaine El Tahta)	---	---	---	---	---	---	No
	Sifri *(Khoder (El))	---	---	---	---	---	---	No
	Slouqi	---	---	---	---	---	---	Yes
	Talia	20,911	---	---	---	---	20,911	No
	Taoufiqié	24,555	---	---	---	---	24,555	No
	Taraya	30,508	6,093	M	P.C	Rehabilitation	24,415	No
	Taybeh (Et)	22,300	---	---	---	---	22,300	No
	Temnine el Faouqa	18,570	11,161	B	P.C	Replacement	7,409	No
	Temnine el Tahta	19,050	14,214	B	P.C	Replacement	4,836	No
	Tfail	---	---	---	---	---	---	Yes
	Wadi Faara	---	---	---	---	---	---	Yes
	Yahfoufa	2,330	---	---	---	---	2,330	No
	Yammouné	8,328	6,293	V.G	W.C	None	2,035	No
	Younine	42,167	---	---	---	---	42,167	No
	Zabboud	8,128	---	---	---	---	8,128	No
	Zraieb	---	---	---	---	---	---	Yes
	Zrazir	---	---	---	---	---	---	Yes
	TOTAL	**2,011,953**	**408,526**				**1,622,261**	

Vacant land or locality that has a very small number of houses (<10)

W.C = Well Covered
M.C = Partially Covered
P.C = Poorly Covered
V.G = Very Good Condition
G = Good Condition
M = Medium Condition
B = Bad Condition



PLAN 6-4: WASTEWATER SYSTEMS FOR CAZA OF BAALBECK

6.8 Zahle Caza

The Zahle caza has a mostly flat topography and includes large agglomerations such as the city of Zahlé and those of Aanjar and Majdel Aanjar.

There are two existing small wastewater treatment plants located in Ablah and Fourzol, and a large one under construction for the city of Zahlé and surroundings. The small locality of Hazerta is currently not linked to the Zahlé plant although the main interceptor of the plant passes by the lower part of the village. It is proposed to link all of Hazerta to the Zahlé WWTP. When comparing the capacity of the existing plants in Ablah and Fourzol with the 2035 projected wastewater generated flow, a substantial deficit is recorded for both plants. Instead of upgrading the small WWTPs when their capacity is exceeded it is proposed to decommission them at the time and divert the wastewater generated by the population they serve to the main Zahle WWTP. The additional capacity is the difference between the current plant capacity and the projected 2035 needed capacity. It is important to note that both plants are functioning currently at below their capacity as they are not receiving all the generated wastewater due to the lack of an appropriate sewer network, or due to the fact that planned pumping stations are not operational yet. The existing plants serve only 16% of the caza population and the Zahle plant will serve around 44% of the population.

One large WWTP is planned by the CDR in El Marj to serve a number of localities including Majdal Aanjar, Chtaura, and Qabb Elias. This plant does not rely solely on gravity flow and includes pumping stations. An additional plant is proposed in the current study for the caza of Zahle as well as proposed future extensions to the Zahle WWTP currently under construction.

Very few communities in the caza, namely the villages of Betyas, Mazraa (El), Nasriye, Ouadi Ed Dellem, Quommol, Ramtaineh, Tell el Akhdar and Touaite will rely on septic tanks.

Table 6-7 below and Plan 6-5 summarize the information regarding the existing and planned facilities in Zahlé. Improvements needed to enhance the operation of the existing plants were described in the Wastewater System Assessment Report, and their associated costs are included in Chapter 7.

Table 6-8 shows the status of the existing networks as well as the lengths of the proposed and existing wastewater network in the villages of Zahlé. The total length of new sewers needed for the caza of Zahlé is 709.5 km and the total lengths of sewers needed to be replaced and rehabilitated are 35.5 km and 89 km respectively.

TABLE 6-5: WASTEWATER TREATMENT PLANTS IN ZAHLE CAZA

Caza	WWTP Name	Status and Type	Population Served	Estimated Capacity (m³/d)	Area Required (m²)	Village Served	Proposed Length of Interceptor Sewers (km)			
							Collector Added (300 mm)	Collector Added (400 mm)	Collector Added (500 mm)	Collector Added (600 mm)
Zahle	**Bar Elias WWTP X = -298121.49 Y = -41891.93**	Proposed Activated Sludge (Previously Planned by CDR)	86,731	15,810	20,215	Nasireh, Massa, Qoussaya, Kfar Zabad, Ain Kfar Zabad, Ali en Nahri, Rayak, Raite, Deir el Ghazal, Dalhamiye, Hay el Fikani, Houch El-Ghanam, Hoshmosh, Terbol, Faaour	21.2	13.6	2.9	8.9
Zahle	**El Marj WWTP X = -306230.75 Y = -45520.5**	Planned Activated Sludge	233,918	45,000	---	Istabl, Marj (El), Saouiri, Nasriyet Rizk, Makse , Mraijat (El) , Majdel Aanjar, Masnaa, Qabb Elias, Aanjar, Chtaura, Chebrqieh, Zebdol, Deir Zanoun, Haouch Handari, Haouch Qaissar, Jdita, Taanayel (Deir) , Taalabaya, Bouarej, Barr Elias,Haouch es Siyadi, Raouda.	---	---	---	---
Zahle	**Zahle WWTP X = -299805.74 Y = -40143.31**	Under Construction Activated Sludge	234,116	40,000 + 2,700 (Additional)	4,280	Zahle, Niha, Nabi Ayla, Ksara, Qaa er Rim, Fourzol (El), Saadnayel, Hazerta, Ablah, Maallaqa, Madinat Al Sinaiyat, Maallaqa Aradi	3.7	8.0	---	---

TABLE 6-6: LENGTHS OF EXISTING AND PROPOSED WASTEWATER NETWORK FOR ZAHLE CAZA

Caza	Village Name	Total Length needed for sewer network (m)	Length of Existing Sewer Network (m)	Existing Sewer Network Condition	Existing Sewer Network Coverage	Existing Sewer Network Requirements	Length of Proposed Sewer Network (m)	Septic Tank Requirements
Zahle	Aanjar/Haouch Moussa	29,603	21,733	G	W.C	---	7,870	No
Zahle	Ablah	14,417	13,107	M	M.C	Rehabilitation	1,310	No
Zahle	Ain Kfar Zabad	14,037	---	---	---	---	14,037	No
Zahle	Ali en Nahri	17,114	---	---	---	---	17,114	No
Zahle	Barr Elias	71,364	24,630	M	W.C	Rehabilitation	46,734	No
Zahle	Betyas	---	---	---	---	---	---	Yes
Zahle	Bouarej	8,140	---	B	W.C	Replacement	8,140	No
Zahle	Chebrqieh*	---	---	---	---	---	---	No
Zahle	Chtaura	6,921	---	---	---	---	6,921	No
Zahle	Deir el Ghazal	13,521	12,293	B	W.C	Replacement	1,228	No
Zahle	Deir Zanoun	18,503	2,739	M	W.C	Rehabilitation	15,764	No
Zahle	Delhamiye	7,754	---	---	---	---	7,754	No
Zahle	Faaour	14,894	---	---	---	---	14,894	No
Zahle	Fourzol (El)	21,173	19,248	B	W.C	Replacement	1,925	No

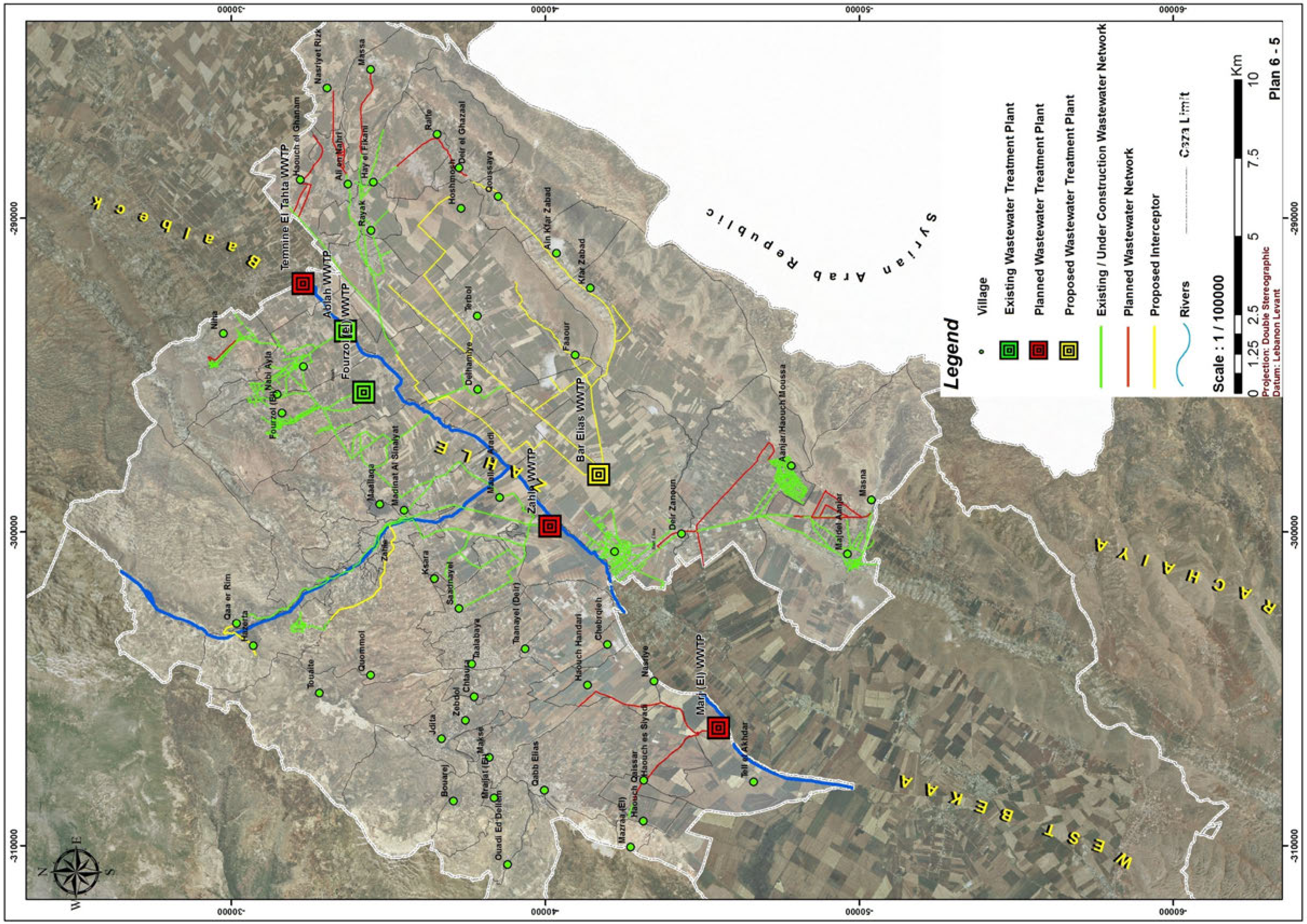
Caza	Village Name	Total Length needed for sewer network (m)	Length of Existing Sewer Network (m)	Existing Sewer Network Condition	Existing Sewer Network Coverage	Existing Sewer Network Requirements	Length of Proposed Sewer Network (m)	Septic Tank Requirements
	Haouch el Ghanam	427	---	---	---	---	427	No
	Haouch es Siyadi	1,134	---	---	---	---	1,134	No
	Haouch Handari	---	---	---	---	---	---	Yes
	Haouch Qaissar	611	555	M	P.C	Rehabilitation	56	No
	Hay el Fikani	2,061	1,874	B	W.C	Replacement	187	No
	Hazerta	19,902	3,899	M	W.C	Rehabilitation	16,003	No
	Hoshmosh	3,123	---	---	---	---	3,123	No
	Jdita	15,953	---	B	W.C	Replacement	15,953	No
	Kfar Zabad	41,244	---	---	---	---	41,244	No
	Ksara	3,250	---	---	---	---	3,250	No
	Maallaqa - Karak Nouh	19,943	---	---	---	---	19,943	No
	Maallaqa Aradi (Mallaqa)	---	---	---	---	---	---	No
	Majdel Aanjar	84,872	18,847	M	P.C	Rehabilitation	66,025	No
	Maksé	4,664	4,240	M	W.C	Rehabilitation	424	No
	Massa	24,044	---	---	---	---	24,044	No
	Mazraa (El)	---	---	---	---	---	---	Yes
	Mraijat (El)	9,479	---	M	W.C	Rehabilitation	9,479	No
	Nabi Ayla	4,486	4,078	V.G	M.C	None	408	No
	Nasireh	---	---	---	---	---	---	Yes
	Nasriye*	---	---	---	---	---	---	No
	Nasriyet Rizk	11,385	---	---	---	---	11,385	No
	Niha	11,125	8,945	M	W.C	Rehabilitation	2,180	No
	Ouadi Ed Dellem	---	---	---	---	---	---	Yes
	Qaa er Rim	10,708	2,109	B	W.C	Replacement	8,599	No
	Qabb Elias	27,260	---	G	W.C	None	27,260	No
	Qoussaya	11,354	---	---	---	---	11,354	No
	Quommol	---	---	---	---	---	---	Yes
	Raite	22,865	---	---	---	---	22,865	No
	Ramtaineh	---	---	---	---	---	---	Yes
	Rayak- Haouch Hala	24,230	5,882	M	P.C	Rehabilitation	18,348	No
	Saadnayel	13,815	6,353	M	W.C	Rehabilitation	7,462	No
	Taalabaya - Jalala	19,933	---	---	---	---	19,933	No
	Taanayel (Deir)	2,781	---	---	---	---	2,781	No
	Tell el Akhdar	---	---	---	---	---	---	Yes
	Terbol	7,856	---	---	---	---	7,856	No
	Touaite	---	---	---	---	---	---	Yes
	Zahlé	214,651	---	---	---	---	214,651	No
	Aradi							

WASTEWATER CAPITAL INVESTMENT PLAN AND PRIORITY ACTION PLAN

Caza	Village Name	Total Length needed for sewer network (m)	Length of Existing Sewer Network (m)	Existing Sewer Network Condition	Existing Sewer Network Coverage	Existing Sewer Network Requirements	Length of Proposed Sewer Network (m)	Septic Tank Requirements
	Al-Rassieh							
	Barbara							
	Haouch El-Oumara Aradi							
	Haouch El-Oumara							
	Haouche Al-Zaraan							
	Mar Antonios							
	Mar Elias							
	Mar Gerios							
	Medan							
	Ouadi El-Aarayech							
	Saidet Al Najda							
	Zebdol	9,314	---	---	---	---	9,314	No
	Total	**859,911**	**150,531**				**709,379**	

* Vacant land or locality that has a very small number of houses (<10)

W.C = Well Covered
M.C = Partially Covered
P.C = Poorly Covered
V.G = Very Good Condition
G = Good Condition
M = Medium Condition
B = Bad Condition



PLAN 6-5: WASTEWATER SYSTEMS FOR CAZA OF ZAHLE

WASTEWATER CAPITAL INVESTMENT PLAN AND PRIORITY ACTION PLAN

6.9 West Bekaa Caza

The West Bekaa caza has a mixed topography with some flat areas and many hills and valleys. Villages are typically far away from each other. There are three existing wastewater treatment plants located in Joubb Jannine, Machghara, and Saghbine serving a large number of villages corresponding to 61 % of the population and 41% of the caza villages. Unlike the proposed scheme in this report some of these plants use lifting stations to convey the wastewater from the various villages. The West Bekaa caza is well served by existing sewers with 69% of the population, corresponding to 55% of the villages having sewer networks.

Three additional treatment plants, all using the trickling filters process and gravity flow are proposed to be built in Ain et Tine, Libbaya, and Zellaya to serve all of the remaining villages save seven very small localities namely: Fadar El Faouka and Tahta, Harimet es Soghra, Jezire (El), Ouaqf (El), Sultan Yaqoub El Aradi and Tell Ez Zaazaa. As for the existing plants, when comparing their current capacity with the 2035 projected wastewater flow, a substantial deficit is recorded for all three. This is due to the population growth as well as to the extension of the service areas of these WWTPs. Hence an extension of the existing plants is recommended using the same design process, namely activated sludge for Joubb Jannine and Saghbine, and trickling filters for Machghara. The extra needed capacity is the difference between the current plant capacity and the projected 2035 needed capacity. It is important to note that some plants maybe functioning currently at below their capacity as they are not receiving all the generated wastewater due to the lack of an appropriate sewer network, or due to the fact that planned pumping stations are not operational yet as is the case for the Joubb Jannine plant. Table 6-9 below and Plan 6-6 summarize the information regarding the existing and proposed facilities in West Bekaa. Improvements needed to enhance the operation of the existing plants were described in the Wastewater System Assessment Report, and their associated costs are included in Chapter 7. Table 6-10 shows the status of the existing network as well as the lengths of existing and proposed wastewater networks in the villages of West Bekaa. The total length of new sewers needed in the caza of West Bekaa is 432 km and the total length of sewers to be rehabilitated is 15 km.

TABLE 6-7: WASTEWATER TREATMENT PLANTS IN WEST BEKAA CAZA

Caza	WWTP Name	Status and Type	Population Served	Estimated Capacity (m^3/d)	Area Required (m^2)	Village Served	Proposed Length of Interceptor Sewers (km)			
							Collector Added (300 mm)	Collector Added (400 mm)	Collector Added (500 mm)	Collector Added (600 mm)
West Bekaa	**Ain Et Tineh WWTP** **X = -325556.08** **Y = -72475.56**	Proposed Trickling Filter	6,241	1,150	3,745	Maidoun and Ain El Tine	5	1.1	---	---
	Joub Janine WWTP **X = -312853.73** **Y = -57251.89**	Existing Activated Sludge	92,842	10,000 + 6,950 (Additional)	10,315	Aita el Foukhar, Mansoura, Manara/ Hammara, Lala, Kafraiya, Kamed el Loz, Ghazze, Aammiq, Aana, Sltan Yacoub el Fouqa , Sltan Yaqoub el Tahta, Deir Tahnich, Dakoue (El), Khiara (El), Khirbet Qanafar, Houch el Harime, Tell Znoub elJdide, Tell Znoub, Joubb Jannine, Ezze	---	---	---	---
	Saghbine WWTP **X = -321101.63** **Y = -62480.13**	Existing Activated Sludge	7,945	560 + 890 (Additional)	1,760	Saghbine, Bab Mareh, Ain Zebde, Deir Ain ej Jaouze.	---	---	---	---
	Zellaya WWTP **X = -325134.33** **Y = -78677.77**	Proposed Trickling Filter	3,404	620	2,383	Qelia,Zellaya, Loussa	3.3	0.3	---	---
	MACHGHARA WWTP **X = -321161.95** **Y = -67051.11**	Existing /Proposed Trickling Filter	56,110	5000 + 5250 (Additional)	16,095	Machghara, Baaloul, Qaraaoun (El), Sohmor, Yohmor and Aaitanit	6.3	4.33	---	---
	Libbaya WWTP West **X = -319617.01** **Y = -74072.49**	Proposed Trickling Filter	6,963	1,270	4,178	Libbaya	3.6	---	---	---

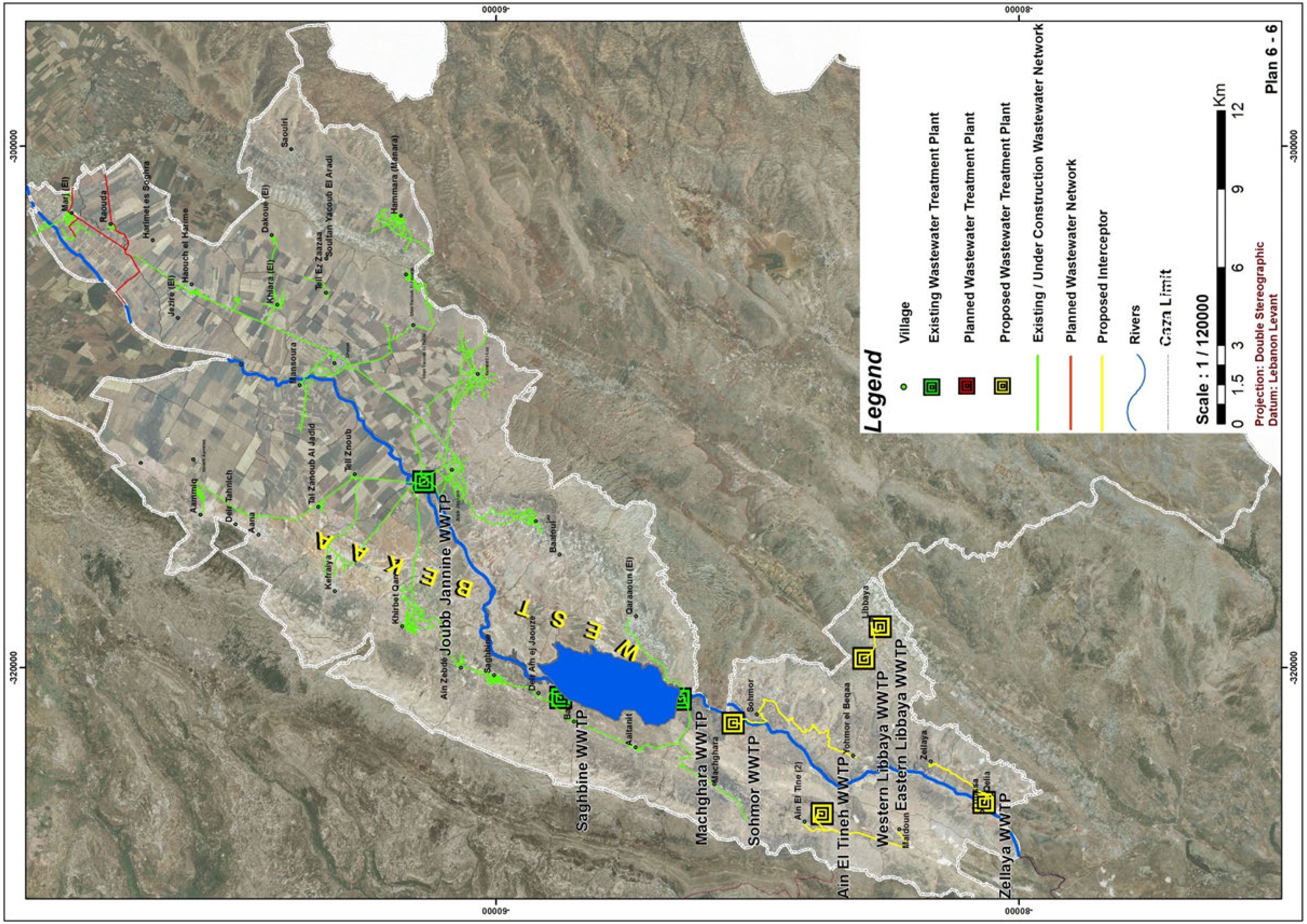
TABLE 6-8: LENGTHS OF EXISTING AND PROPOSED WASTEWATER NETWORK FOR WEST BEKAA CAZA

Caza	Village Name	Total Length needed for sewer network (m)	Length of Existing Sewer Network (m)	Existing Sewer Network Condition	Existing Sewer Network Coverage	Existing Sewer Network Requirements	Length of Proposed Sewer Network (m)	Septic Tank Requirements
West Bekaa	Ain El Tine	9,411	---	---	---	---	9,411	No
	Ain Zebdé	10,537	4,531	V.G	W.C	None	6,006	No
	Aaitanit	8,183	7,439	V.G	W.C	None	744	No
	Aammiq	5,961	4,313	V.G	W.C	None	1,648	No
	Aana	10,409	2,299	V.G	W.C	None	8,110	No
	Baaloul	16,590	---	---	---	---	16,590	No
	Bab Mareh	3,837	3,489	V.G	W.C	None	348	No
	Dakoué (El)	10,201	2,085	V.G	W.C	None	8,116	No
	Deir Ain ej Jaouzé	1,174	1,067	V.G	W.C	None	107	No
	Deir Tahnich	2,929	---	---	---	---	2,929	No
	Fadar El Faouka	---	---	---	---	---	---	Yes
	Fadar El Tahta	---	---	---	---	---	---	Yes
	Ghazze	35,233	10,965	V.G	P.C	None	24,268	No
	Hammara (Manara)	31,098	11,883	V.G	W.C	None	19,215	No
	Harimet es Soghra	---	---	---	---	---	---	Yes
	Haouch El Harime	21,301	6,532	G	P.C	None	14,769	No
	Jeziré (El)	---	---	---	---	---	---	Yes
	Joubb Jannine	50,544	24,441	G	P.C	None	26,103	No
	Kamed el Loz	38,377	21,203	V.G	M.C	None	17,174	No
	Kefraiya	22,965	9,782	G	W.C	None	13,183	No
	Khiara (El)	9,935	7,312	V.G	W.C	None	2,623	No
	Khirbet Qanafar	20,284	18,440	V.G	W.C	None	1,844	No
	Lala	12,489	11,354	V.G	M.C	None	1,135	No
	Libbaya	17,716	---	---	---	---	17,716	No
	Loussa*	---	---	---	---	---	---	No
	Machghara	26,241	5,264	V.G	W.C	None	20,977	No
	Maidoun	8,769	---	---	---	---	8,769	No
	Manara	---	---	---	---	---	---	No
	Mansoura	11,542	3,965	V.G	M.C	None	7,577	No
	Marj (El)	55,004	10,704	M	W.C	Rehabilitation	44,300	No
	Ouaqf (El)	---	---	---	---	---	---	Yes
	Qaraaoun (El)	4,988	4,535	M	W.C	Rehabilitation	453	No
	Qelia	11,877	---	---	---	---	11,877	No
	Raouda	4,374	1,347	V.G	W.C	None	3,027	No
	Saghbine	13,111	8,145	V.G	W.C	None	4,966	No
	Sohmor	44,415	---	G	W.C	None	44,415	No
	Saouiri	49,017	---	---	---	---	49,017	No
	Sltan Yaqoub El Aradi	---	---	---	---	---	---	Yes

Caza	Village Name	Total Length needed for sewer network (m)	Length of Existing Sewer Network (m)	Existing Sewer Network Condition	Existing Sewer Network Coverage	Existing Sewer Network Requirements	Length of Proposed Sewer Network (m)	Septic Tank Requirements
	Sltan Yacoub el Fouqa	6,311	5,738	V.G	W.C	None	573	No
	Sltan Yaqoub el Tahta	22,693	3,487	G	M.C	None	19,206	No
	Tell Ez Zaazaa	---	---	---	---	---	---	Yes
	Tell Znoub	6,184	5,622	V.G	W.C	None	562	No
	Yohmor el Beqaa	18,840	---	V.G	W.C	None	18,840	No
	Zellaya	5,095	---	---	---	---	5,095	No
	Total	**627,635**	**195,942**				**431,693**	

* Vacant land or locality that has a very small number of houses (<10)

W.C = Well Covered
M.C = Partially Covered
P.C = Poorly Covered
V.G = Very Good Condition
G = Good Condition
M = Medium Condition
B = Bad Condition



PLAN 6-6: WASTEWATER SYSTEMS FOR CAZA OF WEST BEKAA

WASTEWATER CAPITAL INVESTMENT PLAN AND PRIORITY ACTION PLAN

6.10 Rachaiya Caza

The Rachaiya caza has a mountainous topography and is characterized by small isolated villages. The Rachaiya caza is not well served by existing sewers with 30% of the population only, corresponding to 26% of the villages having sewer networks. There are seven existing small treatment plants in Ain Horche, Eastern Bakka, Western Bakka, Haouch El Qinnaabe, Rachaya, Northern Yanta, and Southern Yanta. These however are small plants serving only 22% of the population and 14% of the caza villages. All of these small plants were built more than ten years ago to serve small villages. Some have been eliminated in the proposed scheme and their service areas consolidated into neighboring ones, while a few were retained or replaced.

Nine additional treatment plants, eight of which using the trickling filters process and one using the stabilization ponds process are proposed to be built in Aakabe, Beit Lahia, Dahr el Ahmar, Deir El Aachayer, Kfar Qouq, Majdel Balhiss, El Mhaidthé, Northern Yanta, and Southern Yanta to serve all but six villages, namely the villages of Mazraat Jaafar, Mazraat Salsata, Mazraat Deir El Aachayer, Nabbaat, Qennabe and Halloua. All the proposed plants use gravity flow and hence no pumping stations are needed. The WWTP included in the CDR 2020 plan was not considered as it is at a conceptual stage. It is recommended that the CDR adopts the proposed scheme for Rachaiya.

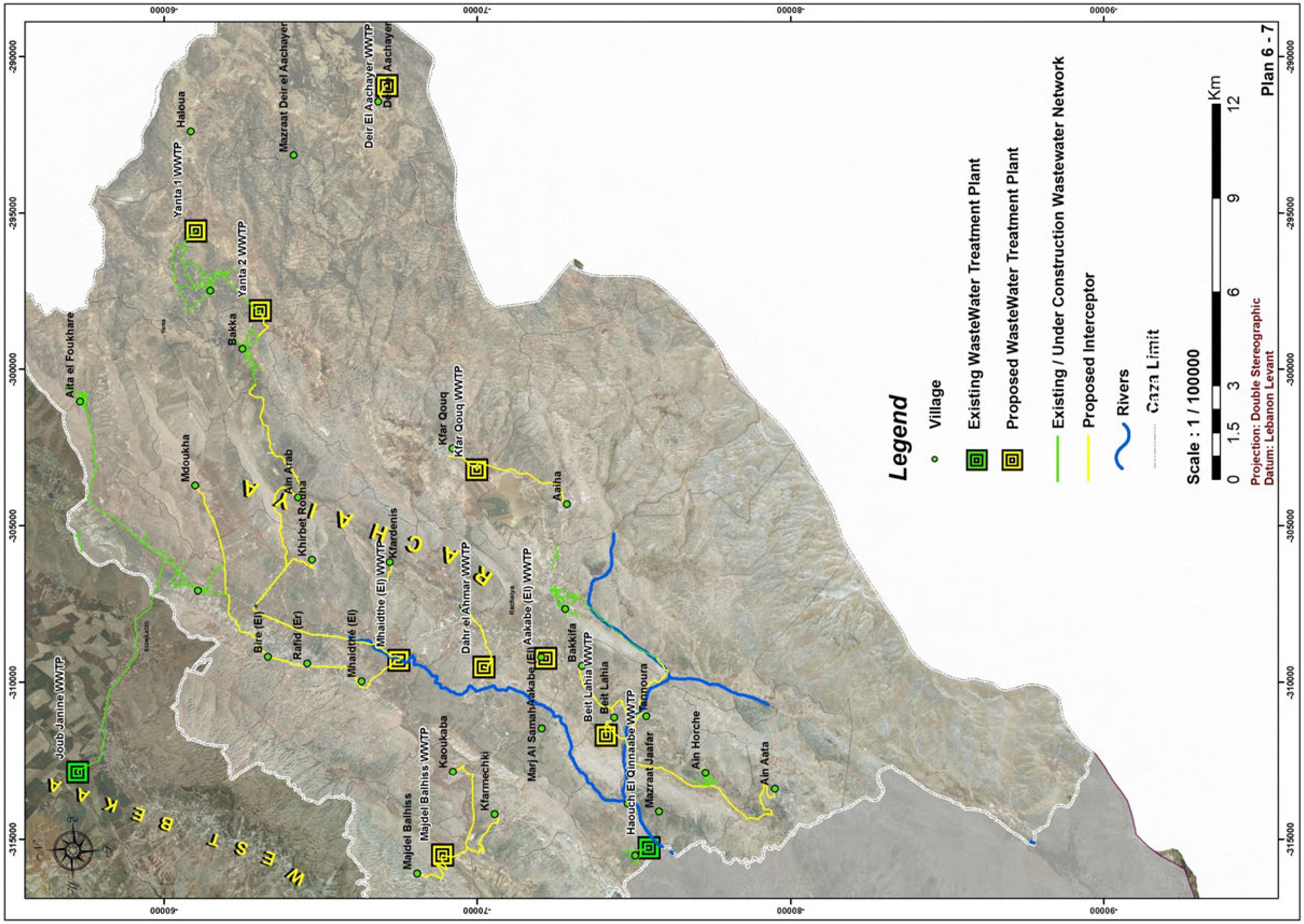
As for the retained existing plant, when comparing its current capacity with the 2035 projected wastewater generated flow, a substantial deficit was recorded for Haouch El Qinnaabe. Hence an extension of the existing plant is recommended using the same design process, namely stabilization ponds. The additional capacity is the difference between the current plant capacity and the projected 2035 needed capacity. It is important to note that in some cases plants may be functioning currently at below their capacity as they are not receiving all the generated wastewater due to the lack of an appropriate sewer network. Table 6-11 below and Plan 6-7 summarize the information regarding the existing and proposed facilities in Rachaiya. Improvements needed to enhance the operation of the existing plants were described in the Wastewater System Assessment Report, and their associated costs are included in Chapter 7. Table 6-12 shows the status of the existing network as well as the lengths of the proposed and existing wastewater network in the villages of Rachaiya. The total length of new sewers needed in the caza of Rachaiya is 383 km and the total length of sewers needed to be replaced is 6.2 km.

TABLE 6-9: WASTEWATER TREATMENT PLANTS IN RACHAIYA CAZA

Caza	WWTP Name	Status and Type	Population Served	Estimated Capacity (m^3/d)	Area Required (m^2)	Village Served	Proposed Length of Interceptor Sewers (km)			
							Collector Added (300 mm)	Collector Added (400 mm)	Collector Added (500 mm)	Collector Added (600 mm)
Rachaiya	**Aakabe WWTP X = -309218.19 Y = -72187.00**	Proposed Trickling Filter	3,262	600	2,280	Aakabe (El)	0.2	---	---	---
	Dahr el Ahmar WWTP X = -309502.72 Y = -70209.32	Proposed Trickling Filter	3,309	600	2,315	Dahr el Ahmar	2.5	---	---	---
	Deir el Aachayer WWTP X = -290910.04 Y = -67115.21	Proposed Stabilization Ponds	1,623	300	6,490	Deir Aachayer	0…7	---	---	---
	Haouch El Qinnaabe WWTP X = -315268.27 Y = -75486.61	Existing Stabilization Ponds	2,197	100 + 300 (Additional)	6,600	Haouch El Qinnabe	---	---	---	---
	Kfar Qouq WWTP X = -303189.47 Y = -69987.29	Proposed Trickling Filter	9,814	1,800	5,910	Aaiha, Kfar Qouq	4.8	---	---	---
	Majdel Balhiss WWTP X = -315487.56 Y = -68898.93	Proposed Trickling Filter	5,576	1,000	3,790	Majdel Balhiss, Kfarmechki, Kaoukaba	7.9	1.0	---	---
	Yanta 1 WWTP X = -295552.6 Y = -61023.5	Proposed Trickling Filter	2,505	460	1,755	Part of Yanta	---	---	---	---
	Yanta 2 WWTP X = -298094.78 Y = -63077.55	Proposed Trickling Filter	3,395	620	2,380	Part of Yanta, East Bakka	1.09	---	---	---
	Mhaidthé (El) WWTP X = -309283.25 Y = -67499.36	Proposed Trickling Filter	30,508	5,560	16,650	Mdoukha, Khirbet Rouha, Rafid (Er) , Bire (El) , Kfardenis, Mhaidthe (El) , Aain Arab, West Bakka	22.8	4.62	---	---
	Beit lahia WWTP X = -311673.62 Y = -74115.77	Proposed Trickling Filter	22,428	4,100	12,740	Beit lahia, Tannoura, Bakkifa, Ain Horche, Ain Aata and Rachaiya	12.3	4.3	1.7	---

TABLE 6-10: STATUS OF THE EXISTING SEWER NETWORK IN RACHAIYA CAZA

Caza	Village Name	Total Length needed for sewer network (m)	Length of Existing Sewer Network (m)	Existing Sewer Network Condition	Existing Sewer Network Coverage	Existing Sewer Network Requirements	Length of Proposed Sewer Network (m)	Septic Tank Requirements
Rachaiya	Aaiha	19,046	---	---	---	---	19,046	No
	Aain Arab	5,853	---	---	---	---	5,853	No
	Aakabe (El)	24,728	---	---	---	---	24,728	No
	Ain Aata	20,607	---	---	---	---	20,607	No
	Ain Horche	5,417	3,137	G	W.C	None	2,280	No
	Aita El Foukhar	10,536	---	V.G	W.C	None	10,536	No
	Bakka	11,658	6,230	B	---	Replacement	5,428	No
	Bakkifa	2,486	---	---	---	---	2,486	No
	Beit Lahia	1,634	---	---	---	---	1,634	No
	Bire (El)	14,315	---	V.G	P.C	None	14,315	No
	Dahr el Ahmar	28,649	---	---	---	---	28,649	No
	Deir el Aachayer	9,540	---	---	---	---	9,540	No
	Ezzé (Aazzi)	17,279	11,995	V.G	P.C	None	5,284	No
	Haloua	---	---	---	---	---	---	Yes
	Haouch El Qinnaabe	3,870	2,580	V.G	M.C	None	1,290	No
	Kaoukaba	15,674	---	---	---	---	15,674	No
	Kfar Qouq	36,324	---	---	---	---	36,324	No
	Kfardenis	17,552	---	---	---	---	17,552	No
	Kfarmechki	21,795	---	---	---	---	21,795	No
	Khirbet Rouha	41,758	---	---	---	---	41,758	No
	Majdel Balhiss	12,824	---	---	---	---	12,824	No
	Mazraat Deir el Aachayer	---	---	---	---	---	---	Yes
	Mazraat Jaafar	---	---	---	---	---	---	Yes
	Mazraat Salsata	---	---	---	---	---	---	Yes
	Mdoukha	11,147	---	---	---	---	11,147	No
	Mhaidthé (El)	17,217	---	---	---	---	17,217	No
	Nabaat	---	---	---	---	---	---	Yes
	Qennabé	---	---	---	---	---	---	Yes
	Rachaiya	35,621	17,453	V.G	P.C	None	18,168	No
	Rachaya el Faouka							
	Rachaya El Kouasbe							
	Rachaya el Wadi							
	Rafid (Er)	27,469	---	---	---	---	27,469	No
	Tannoura	10,090	---	---	---	---	10,090	No
	Yanta	16,277	14,797	V.G	---	None	1,480	No
	Total	**439,366**	**56,192**				**383,174**	



PLAN 6-7: WASTEWATER SYSTEMS FOR CAZA OF RACHAIYA

WASTEWATER CAPITAL INVESTMENT PLAN AND PRIORITY ACTION PLAN

7 COST ESTIMATE

The different cost components of WWTPs were calculated and presented in Ch.3 per type of treatment process and for service populations between 500 and 100,000 capita. A twenty years lifetime cost was also calculated to compare the total costs and select the most economical process function of population served. The capital and operational cost components presented in Ch.3 are used to estimate the capital investment and operation and maintenance costs for the Proposed WWTPs presented in Ch.6. These cost components are:

- Land Cost
- Capital Cost – Construction/Civil Works
- Capital Cost – Equipment
- Operation and Maintenance Cost

The land cost was assumed to be an average of USD25/m^2 although the prices in the Bekaa can vary substantially as a function of location and land use. The construction/civil works cost includes among others excavation, leveling, fill disposal, all concrete and steel works, water proofing, finishing, fencing, and the administrative building. The equipment cost includes among others the electrical installations, mechanical equipment, fittings and accessories, electrical panels, wiring, and automated controls. The operation and maintenance cost includes labor cost, spare parts for equipment, fuel consumption, machinery, vehicles, chemicals, de-sludging operations, and sludge transportation.

Based on the prices listed in Ch. 3 a capital investment initial cost was calculated for each new proposed WWTP and for each proposed extension to an existing WWTP. This initial capital investment cost includes the cost of land, civil works and electromechanical equipment. The operation and maintenance yearly costs as well as the power cost were calculated separately for each WWTP.

In order to estimate the cost of sewer collection networks and the cost of interceptor lines proposed to collect the wastewater and convey it to the WWTPs an all-inclusive unit cost for network sewer pipes was estimated as a function of pipe diameter. Those unit costs are listed in Table 7-1 below. The cost calculation took into consideration all cost elements included in the construction of a network in order to obtain an average cost per finished linear meter. The following cost elements were included: asphalt cutting; trench excavation; disposal of excavation material; procurement and transport of GRP or PVC pipes depending on diameter; pipe installation; procurement and transport of surround and backfilling material; installation and compaction; full pavement reinstatement with procurement, transport and compaction of base course and asphalt concrete; and the construction of manholes at an average spacing of 25 m. The calculated unit costs do not include house connections which are usually paid for directly by the service subscriber.

The proposed interceptor lines were sized according to the flow they are conveying to the WWTP, and their proposed size was used to estimate the total cost of the interceptor lines based on their length and the corresponding linear meter unit cost from Table 7-1. As for the networks inside the villages, given the absence of detailed designs, an average cost of $145/m was used to cover all possible sizes that may be required. This unit price corresponds to that of the 30 cm-diameter pipe that may be considered the average size of pipes to be used in the detailed design of a future sewer network in a typical locality in the Bekaa. In effect the most common sizes encountered there are the 25, 30, and 40 cm pipes. Following common practice it is proposed to estimate the total cost for rehabilitation of a given existing network as the cost of replacing 30% of it by a new network at the average cost of $145/m. The cost of maintenance of wastewater networks was estimated at 0.5% of the construction cost.

TABLE 7-1: ALL-INCLUSIVE COST OF NETWORK SEWER PIPES PER LINEAR METER

Pipe diameter (cm)	Cost/m
15	$115
20	$125
25	$135
30	$145
40	$155
50	$165
60	$200
70	$210
80	$220
90	$230

The capital investment and operation and maintenance costs for the 26 additional proposed WWTPs beyond the ones planned by the CDR, as well as the proposed additions in capacity to existing and planned WWTPs are detailed in the following sections for each caza. Of these 26 proposed WWTP's, 24 are based on trickling filters, one on stabilization ponds, and one on activated sludge. The capital investment cost per capita for each proposed WWTP was calculated and is plotted in Figure 7-1. The cost varies from $140/capita to about $115/capita showing expected economies of scale. The schemes presented are optimized as further consolidation of treatment plants would require pumping and long pressurized mains driving up the cost higher and reducing the reliability of the collection systems.

The capital investments in sewer networks are also detailed caza per caza in the following sections and broken down per type: network extension, network replacement, network rehabilitation and WWTP main interceptor.

A total capital cost for each system composed of a WWTP and its connected networks was also calculated as the sum of all capital costs. A total yearly cost for each system was calculated as the sum of two components: (i) the operation and maintenance cost of the WWTP and the networks connected to it and

(ii) the cost of depreciation for the WWTP equipment, the WWTP civil works and the networks. The equipment was depreciated over 12 years and the civil works and networks over 50 years. Hence the total yearly cost presented per system would represent the yearly revenue needs to operate the system and to contribute to the capital reserve accounts that must be maintained by the BWE in order to provide for capital renewal and capital repair and replacement.

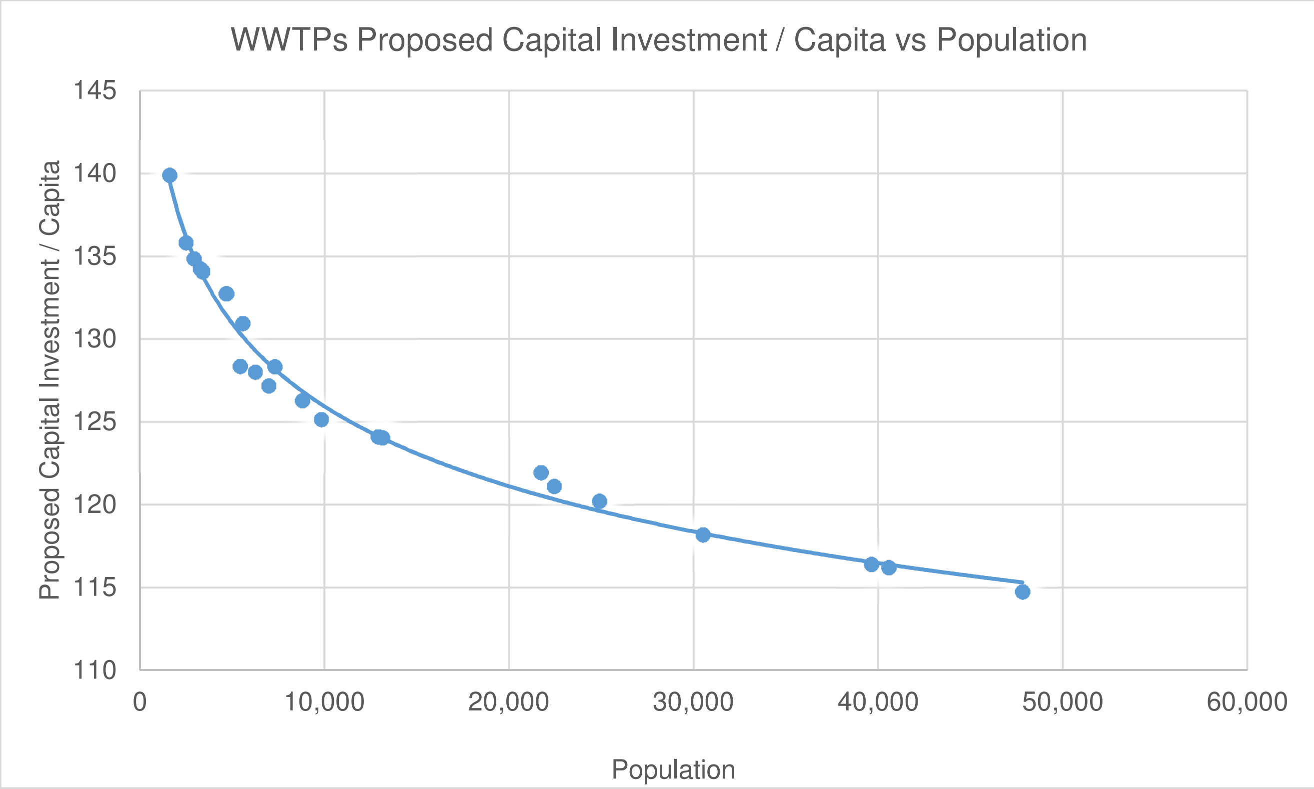


FIGURE 7-1: CAPITAL INVESTMENT FOR PROPOSED WWTP's/ CAPITA vs POPULATION

The CDR planned projects until 2020 for each caza of the Bekaa, their estimated cost and source of funding as well as their status are presented in Table 7-2. These projects have been integrated into the master planning exercise of Ch. 6 as to their treatment capacity and service area. They are worth an estimated total of 261 million USD. No breakdown for the estimated costs of the CDR planned projects was made available due to the early stages at which many of these projects are. Of these it was estimated that about 91 million USD would be reserved for the construction of the WWTPs and the remaining 170 million USD would be reserved for the construction of sewer networks. The value of the WWTP for each project planned by the CDR was estimated using the cost components presented in Ch.3 and the projected service population of 2035. The balance of the planned funding for each project was assigned to the construction of new networks.

The total capital cost for the construction of planned and proposed WWTPs, the construction of new sewer networks, and the extension/rehabilitation and capacity increase of the existing wastewater infrastructure would sum up to an estimated 714 million USD by the design horizon of 2035. The CDR plans on securing about 261 million USD by the year 2020 which would leave the BWE to secure the remaining capital investments estimated at 453 million USD. All of the numbers presented are in constant dollars calculated on the basis of 2013-2015 prices. Table 7-3 presents a summary of the capital cost of the WWTPs and networks showing the value of the CDR planned funding caza per caza. The last line of Table 7-3 shows the funding gap or the remaining capital cost to be secured by the BWE for the completion of the proposed master plan. The capital costs details are presented caza per caza in the following sections of this chapter. Figure 7-2 presents a more detailed summary of the distribution of these capital costs per type of work showing that more than 75% of all capital costs are to be invested in the construction of new collection networks and interceptors about 22% of the total capital cost would go to the construction of WWTPs.

TABLE 7-2: SUMMARY OF TOTAL COST OF CDR PLANNED PROJECTS IN THE BEKAA

List of CDR Projects in Beqaa Caza until year 2019 (Under execution and preparation)						
Caza	**Project Name**	**Cost ($)**	**Source of External Funding**	**Amount of External Funding ($)**	**Amount of Local Funding* ($)**	**Comments**
Hermel	Construction of WWTP and wastewater networks in Hermel and nearby villages	19,950,000	Italian Protocol	19,550,000	400,000	Under Study
	Completion of water and wastewater projects	2,500,000	Saudi Fund (promised)	2,500,000	---	Included in the Saudi financing agreement.
	Total	**22,450,000**		**22,050,000**	**400,000**	
Baalbeck	Construction of WWTP and wastewater networks in Laboue and nearby villages	15,000,000	---	---	15,000,000	The study is being updated
	Completion of water and wastewater projects	2,500,000	Saudi Fund (promised)	2,500,000	---	Included in the Saudi financing agreement.
	Completion of water and wastewater projects in Baalbeck Caza	10,000,000	---	---	10,000,000	The study tender will be launched soon
	Construction of WWTP and wastewater networks in the northern and mid Bekaa in the Litani basin.	30,000,000	Arab Fund for Economic and Social Development	22,500,000	7,500,000	The new loan has been signed but is awaiting execution.
	Total	**57,500,000**		**25,000,000**	**32,500,000**	
Zahle	Construction of wastewater treatment plant in Zahle	29,142,755	Italian Protocol 97	24,326,714	4,816,041	---

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List of CDR Projects in Beqaa Caza until year 2019 (Under execution and preparation)						
Caza	**Project Name**	**Cost ($)**	**Source of External Funding**	**Amount of External Funding ($)**	**Amount of Local Funding* ($)**	**Comments**
	Continuation of the wastewater network in Zahle	26,000,000	World Bank (promised)	26,000,000	---	---
	Construction of WWTP and wastewater networks in Anjar, Majdel Anjar, Bar Elias, Chtaura, Mraijat, Marj, and nearby villages- First Phase	47,250,000	Italian Protocol	47,250,000	---	Waiting for the approval of the funding agency to start the bid.
	Construction of WWTP and wastewater networks in Anjar, Majdel Anjar, Bar Elias, Chtaura, Mraijat, Marj, and nearby villages- Second Phase	19,000,000	World Bank (promised)	19,000,000	---	---
	Continuation of the wastewater network project in the villages that are linked to the WWTPs of Fourzol-Ablah-Aaitanit	6,500,000	---	6,500,000	---	---
	Total	**127,892,755**		**123,076,714**	**4,816,041**	
West Bekaa	Continue the second phase of the wastewater project in the West Bekaa	32,710,000	Islamic Development Bank	32,710,000	5,000,000	The Financing agreement was approved by the Lebanese Parliament
	Total	**32,710,000**		**32,710,000**	**5,000,000**	
Rachaiya	Construction of WWTP and wastewater networks in Rachaiya and nearby villages	30,000,000	Kuwait Fund	30,000,000	---	The funding is proposed to the Kuwait Fund
	Continuation of the wastewater network in Rachaiya	5,000,000	---	---	5,000,000	The study tender will be launched soon
	Total	**35,000,000**		**30,000,000**	**5,000,000**	

* Local funding corresponds to the direct contribution of the Lebanese Government to the CDR yearly budget.

TABLE 7-3: SUMMARY OF THE TOTAL CAPITAL COST FOR EACH CAZA IN THE BEKAA REGION

Caza	**Estimated Capital Cost of WWTPs and their Interceptors ($)**		**Estimated Capital Cost of Networks * ($)**		**Estimated Total Capital Cost ($)**	
	CDR Funded	**Master Plan**	**CDR Funded**	**Master Plan**	**CDR Funded**	**Master Plan**
Hermel	9,500,000	13,636,500	10,450,000	33,632,895	19,950,000	47,269,395
Baalbeck	24,800,000	84,566,915	20,200,000	239,181,405	45,000,000	323,748,320
Zahle	56,438,000	76,633,411	71,454,755	112,024,800	127,892,755	188,658,211
West Bekaa	0	13,923,429	32,710,000	63,281,240	32,710,000	77,204,669
Rachaiya	0	20,579,420	35,000,000	56,463,580	35,000,000	77,043,000
Total Capital Cost	**90,738,000**	**209,339,675**	**169,814,755**	**504,583,920**	**260,552,755**	**713,923,595**
Remaining Capital Cost	**118,601,675**		**334,769,165**		**453,370,840**	

* The Estimated Capital Cost of Networks includes the sum of the capital costs of Network Extensions, Network Rehabilitations and Network Replacements. The breakdown of the capital cost of networks is provided for each Caza under its Section.

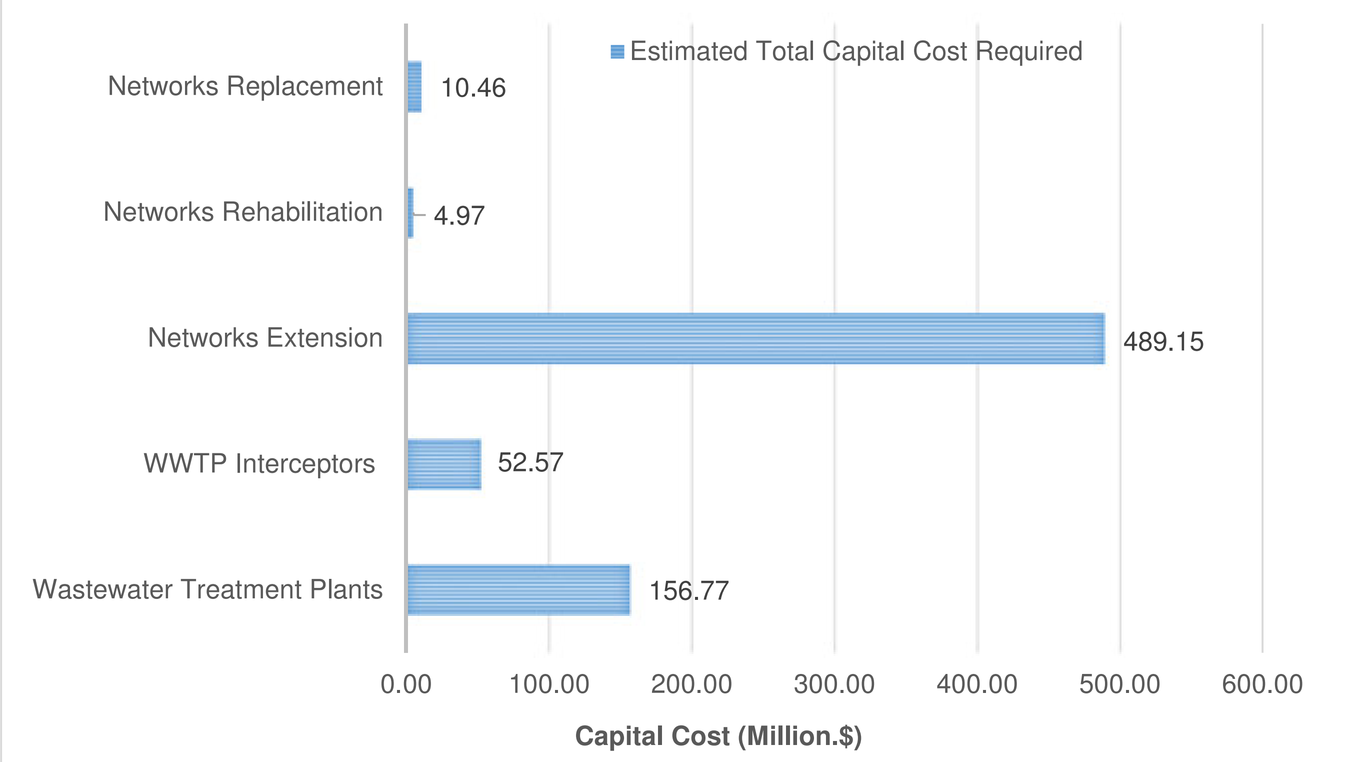

FIGURE 7-2: THE DISTRIBUTION OF COSTS FOR WWTPS AND NETWORKS IN THE BEKAA BY YEAR 2035

7.1 Hermel Caza

7.1.1 Capital Cost of Proposed WWTP's, Interceptor Sewers and Collection Networks

Table 7-4 presents a summary of the capital costs for the caza of Hermel by major element of proposed work. The total length of network extensions or new networks is 227 kilometers.

TABLE 7-4: SUMMARY OF CAPITAL COST FOR HERMEL BY MAJOR ELEMENT OF CAPITAL INVESTMENT

<table>
<tr><th colspan="4">Hermel</th></tr>
<tr><th>Major element</th><th>Total Capital Cost Required ($)</th><th>CDR Planned Funding ($)</th><th>Remaining Capital Cost Required ($)</th></tr>
<tr><td>Wastewater Treatment Plant</td><td>13,274,000</td><td rowspan="2">9,500,000</td><td rowspan="2">4,136,500</td></tr>
<tr><td>Network Interceptors</td><td>362,500</td></tr>
<tr><td>Network Extensions</td><td>32,903,400</td><td rowspan="3">10,450,000</td><td rowspan="3">23,182,895</td></tr>
<tr><td>Network Rehabilitations</td><td>---</td></tr>
<tr><td>Network Replacements</td><td>729,495</td></tr>
<tr><td>Total</td><td>47,269,395</td><td>19,950,000</td><td>27,319,395</td></tr>
</table>

Table 7-5 presents in detail the capital cost by major cost element as well as the details of the operation and maintenance cost for the WWTP. The capital cost of the CDR planned WWTPs was not included but the O&M costs were estimated. The total length and capital cost for the networks include those parts that are planned to be funded by the CDR.

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TABLE 7-5: CAPITAL COST BY MAJOR ELEMENT BASED ON THE PLANNED WWTP FOR THE CAZA OF HERMEL

Caza	WWTP Name	Status & Type	Population Served	Capacity (m³/d)	Area Required (m²)	Land Cost (USD) (1)	Construction cost (USD) (2)	Equipment Cost (USD) (3)	Capital investment Initial cost (USD) (4)= (1)+(2)+(3)	Operation and maintenance cost (USD/yr) (5)	Power consumption (KWH/yr)	Power cost (USD/yr) (6)	Network Capital Cost ($) (10)			Proposed Interceptors Cost (USD) (11)	Total Capital Cost ($) (12) = (4)+(10)+(11)	Total Yearly Cost (USD/yr) (13)*	Village Served
													Extension (7)	Replacement (8)	Rehabilitation (9)				
Hermel	**Hermel WWTP X = -246337.46 Y = 31822.86**	Planned Activated Sludge	110,925	14,000 + 6,250 (Additional)	9,125 (Additional)	228,133 (Additional)	(4,070,792)** 2,363,911 (Additional)	(1,556,664)** 1,181,956 (Additional)	3,774,000 (Additional)	680,255	1,007,035	120,844	32,903,400	729,495	---	362,500	37,769,395	2,007,896	Haouchariye, Wadi el Ratl, Ouadi et Tourkman, Nasriye (en), Mazraat Soujod, Nahr el Aiin, Qouakh Qanafez, Qasr, Fissane, Chouaghir El Tahta & El Faouka, Sahet el Mai, Soueiss, Zouaitini, Zighrine, Haouch es sayed Aali, Hariqa, Boueida, Brissa, Hay Bdita, Hermel
	Total	---	---	---	**9,125**	**228,133**	**2,363,911**	**1,181,956**	**3,774,000**	**680,255**	**1,007,035**	**120,844**	**32,906,880**	**729,495**	**---**	**362,500**	**37,769,395**	**2,007,896**	---

*** The total yearly cost is constituted of the sum of the depreciation of WWTP equipment cost over 12 years, the depreciation of WWTP civil works, networks and interceptors costs over 50 years, yearly power cost, yearly operation and maintenance cost of the networks and interceptors and the reservation of the capital renewal.**

(13) = (2 + 7 + 8 + 9 + 11+ replacement cost of sewers to be maintained as per chapter 6 + estimated cost of replacement of existing or planned WWTP civil works)/50 + (3 + estimated cost of replacement of existing or planned WWTP civil works)/12 + (5) + (6) + (7 + 8 + 9 + 11 + replacement cost of sewers to be maintained as per chapter 6) * 0.5%.

**** Estimated cost of replacement of equipment and civil works for existing and CDR planned WWTPs for depreciation calculation purposes.**

7.2 Baalbeck Caza

7.2.1 Rehabilitation and Improvement of Existing WWTP's

Based on the Assessment Report previously prepared, specific actions were recommended to improve the operation and performance of the existing WWTPs. Table 7-6 presents the cost estimate of the specific improvements to the existing WWTPs in the caza of Baalbeck.

TABLE 7-6: COST OF IMPROVEMENT TO EXISTING BAALBECK WWTPs

Caza	WWTP Name	Descriptions	Cost ($)
Baalbeck	*Iaat*	Four dissolved oxygen sensors to control the system for aeration	45,000
		Construction of drying beds as gravel drainage system	35000
		Improving the WWTP access road	90,000
	Yammouneh	Two dissolved oxygen sensors to control the system for aeration	22,500
		Reparation of the lifting pump station to work automatically	18,000

7.2.2 Capital Cost of Proposed WWTP's, Interceptor Sewers and Collection Networks

Table 7-7 presents a summary of the capital costs for the caza of Baalbeck by major element of proposed work. The total length of network extensions or new networks is 1,622 kilometers.

TABLE 7-7: SUMMARY OF CAPITAL COST FOR BAALBECK BY MAJOR ELEMENT OF CAPITAL INVESTMENT

Baalbeck			
Major element	**Total Capital Cost Required ($)**	**CDR Planned Funding ($)**	**Remaining Capital Cost Required ($)**
Wastewater Treatment Plants	56,155,547	24,800,000	59,766,915
Network Interceptors	28,411,368		
Network Extensions	235,227,845	20,200,000	218,981,405
Network Rehabilitations	274,185		
Network Replacements	3,679,375		
Total	**323,748,320**	**45,000,000**	**278,748,320**

Table 7-8 presents in detail the capital cost by major cost element as well as the details of the operation and maintenance cost for the WWTP. The capital cost of the CDR planned WWTPs was not included but the O&M costs were estimated. The total length and capital cost for the networks include those parts that are planned to be funded by the CDR.

TABLE 7-8: CAPITAL COST BY MAJOR ELEMENT BASED ON THE EXISTING, PLANNED, AND PROPOSED WWTPs FOR THE CAZA OF BAALBECK

Caza	WWTP Name	Status & Type	Population Served	Capacity (m³/d)	Area Required (m²)	Land Cost (USD) (1)	Construction cost (USD) (2)	Equipment Cost (USD) (3)	Capital investment Initial cost (USD) (4)= (1)+(2)+(3)	Operation and maintenance cost (USD/yr) (5)	Power consumption (KWH/yr)	Power cost (USD/yr) (6)	Network Capital Cost ($) (10)			Proposed Interceptors Cost (USD) (11)	Total Capital Cost ($) (12) = (4)+(10)+(11)	Total Yearly Cost (USD/yr) (13)*	Village Served
													Extension (7)	Replacement (8)	Rehabilitation (9)				
Baalbeck	Ainata WWTP X = -283799.85 Y = 1406.72	Proposed Trickling Filter	2,929	550	2,050	51,250	229,160	114,580	394,990	39,470	25,305	3,037	2,273,020	---	---	268,688	2,936,698	120,179	Ainata
	Bajjajé (El) WWTP X = -259098.50 Y = 6308.01	Proposed Trickling Filter	47,815	8,650	24,050	601,254	3,257,247	1,628,623	5,487,124	392,443	413,122	49,575	27,830,865	---	---	6,059,500	39,377,489	1,490,140	Kharayeb,Nabi Osmane (En) ,Laboue, Ain (El), Zabboud, Halbata, Jdeide (15% from Fekehe), Jabboule, Bajjaje (El), Taoufiqie, Amhazie, Moqraq
	Chaat 1 WWTP X = -268871.39 Y = -3065.03	Proposed Trickling Filter	5,427	990	3,255	81,380	410,175	205,088	696,643	71,405	46,890	5,628	942,210	---	---	1,471,700	3,110,553	162,672	Part of Chaat, Qarha
	Fekehe WWTP X = -255639.99 Y = 11045.18	Proposed Trickling Filter	24,878	4,550	14,115	352,871	1,758,703	879,351	2,990,925	229,132	214,947	25,794	12,316,735	---	---	2,412,200	17,719,860	731,602	Fekehe, Part Jdeide (85%Pop Fekehe), Ras Baalbeck
	Harbata WWTP X = -263945.47 Y = 5293.96	Proposed Trickling Filter	7,301	1,350	4,820	120,500	544,403	272,202	937,105	84,764	63,081	7,570	2,990,915	---	---	681,500	4,609,520	217,716	Harbata, Sbouba
	Iaat WW TP X = -277283.97 Y = -12692.58	Existing Activated Sludge	159,116	24,000 + 5,000 (Additio-nal)	7,835 (Additio-nal)	195,875 (Additio-nal)	(7,064,339)** 1,924,000 (Additional)	(2,499,123) ** 1,132,000 (Additional)	3,251,875 (Additional)	773,531	1,257,400	150,888	26,417,550	---	---	---	29,669,425	2,955,177	Baalbeck, Iaat, Haouch Tell Safiye, Aaddous, Douris, Ain Bourdai, Aamichki
	Nahle WWTP X = -268222.73 Y = -13124.54	Proposed Trickling Filter	8,788	1,600	5,485	137,125	648,493	324,247	1,109,865	98,668	75,928	9,111	2,730,930	---	---	290,000	1,399,865	223,293	Nahle
	Qaa WWTP X = -246738.77 Y = 20076.37	Proposed Trickling Filter	12,877	2,350	7,725	193,125	936,641	468,321	1,598,087	134,282	111,257	13,351	5,322,660	---	---	763,900	7,684,647	357,556	Qaa (El)
	Rasm Elhadath or Chaat 2 WWTP X = -265340.39 Y = -874.98	Proposed Trickling Filter	4,706	850	3,300	82,500	361,409	180,705	624,614	59,868	40,656	4,879	3,597,740	---	---	841,000	5,063,354	198,002	Rasm Al Hadath (Part of Chaat)
	Temnine El Tahta WWTP X = -292056.93 Y = -32290.50	Planned Activated Sludge	198,410	48,000	---	---	(11,649,598) **	(4,637,544) **	---	726,544	1,468,800	176,256	83,903,090	3,679,375	274,185	---	87,856,650	4,160,265	Hortaala, Nabi Chit (En), Nabi Rchad, Masnaa Bednayel, Mazraat ed Dallil, Majdaloun, Kfar Dabach, Kfardaane, Qasrnaba , Taybeh (Et), Talia, Taraya, Chmistar, Sifri, Serraaine el Faouka, Seraaine el Tahta, Khoder (El), Khraibe (El), Haouch Snaid, Haouch er Rafqa, Haouch Barada, Haouch en Nabe, Hizzine, Hadet (El), Jebaa, Temnine el Faouqa, Temnine el Tahta, Beit Mcheik, Beit Chama, Britel, Bednayel, Seraaine el Gharbieh/ Hallanieh, Mousraye
	Yammoune WWTP X = -287188.60 Y = -4227.54	Existing Activated Sludge	3,545	800	---	---	(303,396)**	(110,574) ** 40,500	40,500	53,119	69,060	8,287	295,075	---	---	---	335,575	110,939	Yammoune

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Caza	WWTP Name	Status & Type	Population Served	Capacity (m³/d)	Area Required (m²)	Land Cost (USD) (1)	Construction cost (USD) (2)	Equipment Cost (USD) (3)	Capital investment Initial cost (USD) (4)= (1)+(2)+(3)	Operation and maintenance cost (USD/yr) (5)	Power consumption (KWH/yr)	Power cost (USD/yr) (6)	Network Capital Cost ($) (10)			Proposed Interceptors Cost (USD) (11)	Total Capital Cost ($) (12) = (4)+(10)+(11)	Total Yearly Cost (USD/yr) (13)*	Village Served
													Extension (7)	Replacement (8)	Rehabilitation (9)				
	Chlifa WWTP X = -278723.66 Y = -8549.10	Proposed Trickling Filter	40,578	7,400	21,560	539,000	2,784,429	1,392,215	4,715,644	340,915	350,594	42,071	27,873,930	---	---	7,707,250	40,296,824	1,458,694	Chlifa, Hfayer, Mazraat es Syad, Btedaai, Mazraat Beit Ghousain, Bechouat, Deir El Ahmar, Bsayle Elfawqa, Bsayle ElTahta, Kneisse, Riha, Boudai, Saaide, Aalaq Tell, Mchayrfeh, Flaoue.
	Aarsal 1 WWTP X =-254098.49 Y = 2058.68	Proposed Trickling Filter	39,642	7,200	21,170	529,250	2,723,277	1,361,639	4,614,166	334,251	342,507	41,101	15,615,630	---	---	1,675,040	21,904,836	975,554	Part Aarsal by tunnel and other part by gravity
	Nabha WWTP X = -270388.26 Y = 1311.3	Proposed Trickling Filter	13,119	2,400	7,870	196,750	953,743	476,871	1,627,364	136,324	113,348	13,602	11,580,280	---	---	2,046,900	15,254,544	549,420	Nabha, Qeddam, Ram (El), Joubanieh, Mrah El Aouja, Mrah Semmaan, Barqa
	Maqnne WWTP X = -272010.86 Y = -8627.38	Proposed Trickling Filter	21,715	3,950	12,810	320,250	1,552,047	776,023	2,648,320	206,611	187,618	22,514	9,086,135	---	---	2,144,115	13,878,570	605,591	Maqne, Younine
	Jenta WWTP X = -282270.12 Y = -34114.27	Proposed Trickling Filter	4,658	850	3,261	81,515	357,873	178,937	618,325	59,323	40,245	4,829	2,451,080	---	---	2,049,575	5,118,980	198,737	Yahfoufa, Jenta, Maaraboun, Ham
	Total	**---**	**595,504**	**---**	**139,306**	**3,482,645**	**18,441,601**	**9,431,301**	**31,355,547**	**3,740,651**	**4,820,757**	**578,492**	**235,227,375**	**3,679,375**	**274,185**	**28,411,368**	**298,948,320**	**14,515,537**	**---**

*** The total yearly cost is constituted of the sum of the depreciation of WWTP equipment cost over 12 years, the depreciation of WWTP civil works, networks and interceptors costs over 50 years, yearly power cost, yearly operation and maintenance cost of the networks and interceptors and the reservation of the capital renewal.**

(13) = (2 + 7 + 8 + 9 + 11+ replacement cost of sewers to be maintained as per chapter 6 + estimated cost of replacement of existing or planned WWTP civil works)/50 + (3 + estimated cost of replacement of existing or planned WWTP civil works)/12 + (5) + (6) + (7 + 8 + 9 + 11 + replacement cost of sewers to be maintained as per chapter 6) * 0.5%.

**** Estimated cost of replacement of equipment and civil works for existing and CDR planned WWTPs for depreciation calculation purposes.**

7.3 Zahle Caza

7.3.1 Capital Cost of Proposed WWTP's, Interceptor Sewers and Collection Networks

Table 7-9 presents a summary of the capital costs for the caza of Zahle by major element of proposed work. The total length of network extensions or new networks is 709 kilometers.

TABLE 7-9: SUMMARY OF CAPITAL COST FOR ZAHLE BY MAJOR ELEMENT OF CAPITAL INVESTMENT

Zahle			
Major element	**Total Capital Cost Required ($)**	**CDR Planned Funding ($)**	**Remaining Capital Cost Required ($)**
Wastewater Treatment Plant	66,500,843	56,438,000	20,195,411
Network Interceptors	10,132,568		
Network Extensions	102,859,955	71,454,755	40,570,045
Network Rehabilitations	4,013,865		
Network Replacements	5,150,980		
Total	**188,658,211**	**127,892,755**	**60,765,456**

Table 7-10 presents in detail the capital cost by major cost element as well as the details of the operation and maintenance cost for the WWTP. The capital cost of the CDR planned WWTPs was not included but the O&M costs were estimated. The total length and capital cost for the networks include those parts that are planned to be funded by the CDR.

TABLE 7-10: CAPITAL COST BY MAJOR ELEMENT BASED ON THE PLANNED, AND UNDER CONSTRCUTION WWTPs FOR THE CAZA OF ZAHLE

Caza	WWTP Name	Status & Type	Population Served	Capacity (m^3/d)	Area Required (m^2)	Land Cost (USD) (1)	Construction cost (USD) (2)	Equipment Cost (USD) (3)	Capital investment Initial cost (USD) (4)=(1)+(2)+(3)	Operation and maintenance cost (USD/yr) (5)	Power consumption (KWH/yr)	Power cost (USD/yr) (6)	Network Capital Cost ($) (10)			Proposed Interceptors Cost (USD) (11)	Total Capital Cost ($) (12) = (4)+(10)+(11)	Total Yearly Cost (USD/yr) (13)*	Village Served
													Extension (7)	Replacement (8)	Rehabilitation (9)				
Zahle	Bar Elias WWTP X = -298121.49 Y = -41891.93	Proposed Activated Sludge (Previously Planned by CDR)	86,731	15,810	20,215	505,363	5,292,320	2,646,160	8,443,843	568,963	881,614	105,794	23,054,275	2,054,215	387,945	7,439,889	41,380,167	1,824,524	Nasireh, Massa, Qoussaya, Kfar Zabad, Ain Kfar Zabad, Ali en Nahri, Rayak, Raite, Deir el Ghazal, Dalhamiye, Hay el Fikani, Houch El-Ghanam, Hoshmosh, Terbol, Faaour
	El Marj WWTP X = -306230.75 Y = -45520.5	Planned Activated Sludge	233,918	45,000	---	---	(14,828,538) **	(5,958,332) **	---	1,240,000	1,600,000	192,000	39,824,685	---	2,172,240	---	41,996,925	3,358,687	Istabl, Marj (El), Saouiri, Nasriyet Rizk, Makse , Mraijat (El) , Majdel Aanjar, Masnaa, Qabb Elias, Aanjar, Chtaura, Chebrqieh, Zebdol, Deir Zanoun, Haouch Handari, Haouch Qaissar, Jdita, Taanayel (Deir) , Taalabaya, Bouarej, Barr Elias,Haouch es Siyadi, Raouda.
	Zahle WWTP X = -299805.74 Y = -40143.31	Under Construction Activated Sludge	234,116	40000 + 2700 (Additional)	4,280 (Additio-nal)	107,000 (Additio-nal)	(13,848,855) ** 1,008,000 (Additional)	(5,463,109) ** 504,000 (Additional)	1,619,000 (Additional)	1,247,395	1,646,176	197,541	39,980,995	3,096,765	1,453,680	2,692,679	48,843,119	3,434,558	Zahle, Niha, Nabi Ayla, Ksara, Qaa er Rim, Fourzol (El), Saadnayel, Hazerta, Ablah, Maallaqa, Madinat Al Sinaiyat, Maallaqa Aradi
	Total	---	554,765	---	24,495	612,363	6,300,320	3,150,160	10,062,843	3,056,358	4,127,790	495,335	102,859,955	5,150,980	4,013,865	10,132,568	132,220,211	8,617,769	---

*** The total yearly cost is constituted of the sum of the depreciation of WWTP equipment cost over 12 years, the depreciation of WWTP civil works, networks and interceptors costs over 50 years, yearly power cost, yearly operation and maintenance cost of the networks and interceptors and the reservation of the capital renewal.**

(13) = (2 + 7 + 8 + 9 + 11+ replacement cost of sewers to be maintained as per chapter 6 + estimated cost of replacement of existing or planned WWTP civil works)/50 + (3 + estimated cost of replacement of existing or planned WWTP civil works)/12 + (5) + (6) + (7 + 8 + 9 + 11 + replacement cost of sewers to be maintained as per chapter 6) * 0.5%.

**** Estimated cost of replacement of equipment and civil works for existing and CDR planned WWTPs for depreciation calculation purposes.**

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7.4 West Bekaa Caza

7.4.1 Capital Cost of Proposed WWTP's, Interceptor Sewers and Collection Networks

Table 7-11 presents a summary of the capital costs for the caza of Zahle by major element of proposed work. The total length of network extensions or new networks is 442 kilometers.

TABLE 7-11: SUMMARY OF CAPITAL COST FOR WEST BEKAA BY MAJOR ELEMENT OF CAPITAL INVESTMENT

West Bekaa			
Major element	**Total Capital Cost Required ($)**	**CDR Planned Funding ($)**	**Remaining Capital Cost Required ($)**
Wastewater Treatment Plant	10,402,625	---	13,923,429
Network Interceptors	3,520,804		
Network Extensions	62,595,485	32,710,000	30,571,240
Network Rehabilitations	685,755		
Network Replacements	0		
Total	**77,204,669**	**32,710,000**	**44,494,669**

Table 7-12 presents in detail the capital cost by major cost element as well as the details of the operation and maintenance cost for the WWTP. The capital cost of the CDR planned WWTPs was not included but the O&M costs were estimated. The total length and capital cost for the networks include those parts that are planned to be funded by the CDR.

TABLE 7-12: CAPITAL COST BY MAJOR ELEMENT BASED ON THE EXISTING AND PROPOSED WWTPs FOR THE CAZA OF WEST BEKAA

Caza	WWTP Name	Status & Type	Population Served	Capacity (m³/d)	Area Required (m²)	Land Cost (USD) (1)	Construction cost (USD) (2)	Equipment Cost (USD) (3)	Capital investment Initial cost (USD) (4)= (1)+(2)+(3)	Operation and maintenance cost (USD/yr) (5)	Power consumption (KWH/yr)	Power cost (USD/yr) (6)	Network Capital Cost ($) (10)			Proposed Interceptors Cost (USD) (11)	Total Capital Cost ($) (12) = (4)+(10)+(11)	Total Yearly Cost (USD/yr) (13)*	Village Served
													Extension (7)	Replacement (8)	Rehabilitation (9)				
West Bekaa	Ain Et Tine WWTP X = -325556.08 Y = -72475.56	Proposed Trickling Filter	6,241	1,150	3,745	93,625	470,203	235,102	798,930	74,853	53,922	6,471	2,636,100	---	---	894,400	4,329,430	198,582	Maidoun and Ain El Tine
	Joub Janine WWTP X = -312853.73 Y = -57251.89	Existing Activated Sludge	92,842	10,000 + 6950 (Additional)	10,315 (Additional)	257,880 (Additional)	(2.952.923) ** 2,598,924 (Additional)	(1,125,506) ** 1,299,462 (Additional)	4,156,266 (Additional)	597,073	913,293	109,595	26,101,015	---	---	---	30,257,281	2,257,444	Aita el Foukhar, Mansoura, Manara/ Hammara, Lala, Kafraiya, Kamed el Loz, Ghazze, Aammiq, Aana, Sltan Yacoub el Fouqa , Sltan Yaqoub el Tahta, Deir Tahnich, Dakoue (El), Khiara (El), Khirbet Qanafar, Houch el Harime, Tell Znoub elJdide, Tell Znoub, Joubb Jannine, Ezze
	Saghbine WWTP X = -321101.63 Y = -62480.13	Existing Activated Sludge	7,945	560 + 890 (Additional)	1,760 (Additional)	44,010 (Additional)	(209,832)** 425,267 (Additional)	(101,810) ** 212,633 (Additional)	681,910 (Additional)	100,067	140,841	16,901	173,855	---	---	---	855,765	222,685	Saghbine, Bab Mareh, Ain Zebde, Deir Ain ej Jaouze.
	Zellaya WWTP X = -325134.33 Y = -78677.77	Proposed Trickling Filter	3,404	620	2,383	59,575	264,520	132,260	456,355	44,923	29,411	3,529	2,460,940	---	---	524,700	3,441,995	139,405	Qelia,Zellaya, Loussa
	MACHGHARA WWTP X = -321161.95 Y = -67051.11	Existing Trickling Filter	56,110	5000 + 5250 (Additional)	16,095 (Additional)	402,375 (Additional)	(1,785,037) ** 2,014,149 (Additional)	(892,519) ** 1,007,075 (Additional)	3,423,599 (Additional)	451,503	484,790	58,175	14,684,875	---	204,075	1,579,704	19,892,253	1,201,726	Machghara, Baaloul, Qaraaoun (El), Sohmor, Yohmor and Aaitanit
	Libbaya WWTP West X = -319617.01 Y = -74072.49	Proposed Trickling Filter	6,963	1,270	4,178	104,450	520,743	260,372	885,565	81,604	60,160	7,219	2,568,820	---	---	522,000	3,976,385	198,206	Libbaya
	Total	---	**173,505**	---	**38,477**	**961,915**	**6,293,807**	**3,146,904**	**10,402,625**	**1,350,023**	**1,682,417**	**201,890**	**62,595,485 *****	---	**685,755*****	**3,520,804**	**77,204,669**	**4,218,049**	---

*** The total yearly cost is constituted of the sum of the depreciation of WWTP equipment cost over 12 years, the depreciation of WWTP civil works, networks and interceptors costs over 50 years, yearly power cost, yearly operation and maintenance cost of the networks and interceptors and the reservation of the capital renewal.**

(13) = (2 + 7 + 8 + 9 + 11+ replacement cost of sewers to be maintained as per chapter 6 + estimated cost of replacement of existing or planned WWTP civil works)/50 + (3 + estimated cost of replacement of existing or planned WWTP civil works)/12 + (5) + (6) + (7 + 8 + 9 + 11 + replacement cost of sewers to be maintained as per chapter 6) * 0.5%.

**** Estimated cost of replacement of equipment and civil works for existing and CDR planned WWTPs for depreciation calculation purposes.**

***** The Network Capital Extension and Rehabilitation Costs of Marj (EL), Saouri and Rawda are added to the Total Extension and Rehabilitation Costs in the West Bekaa caza and removed from those of Zahle where the Marj WWTP is located.**

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7.5 Rachaiya Caza

7.5.1 Rehabilitation and Improvement of Existing WWTP's

Based on the Assessment Report previously prepared, specific actions were recommended to improve the operation and performance of the existing WWTPs. Table 7-13 presents the cost estimate of the specific improvements to the existing WWTPs in the caza of Rachaiya.

TABLE 7-13: COST OF IMPROVEMENT TO EXISTING RACHAIYA WWTPs

Caza	WWTP Name	Descriptions	Cost ($)
Rachaiya	*Haouch El Qinnaabe*	Construction of two drying beds	20,000 $ Lump sum

7.5.2 Capital Cost of Proposed WWTP's, Interceptor Sewers and Collection Networks

Table 7-14 presents a summary of the capital costs for the caza of Zahle by major element of proposed work. The total length of network extensions or new networks is 384 kilometers.

TABLE 7-14: SUMMARY OF CAPITAL COST FOR RACHAIYA BY MAJOR ELEMENT OF CAPITAL INVESTMENT

Rachaiya			
Major element	**Total Capital Cost Required ($)**	**CDR Planned Funding ($)**	**Remaining Capital Cost Required ($)**
Wastewater Treatment Plants	10,436,507	0	20,579,420
Network Interceptors	10,142,913		
Network Extensions	55,560,230	35,000,000	21,463,580
Network Rehabilitations	---		
Network Replacements	903,350		
Total	**77,043,000**	**35,000,000**	**42,043,000**

Table 7-15 presents in detail the capital cost by major cost element as well as the details of the operation and maintenance cost for the WWTP. The capital cost of the CDR planned WWTPs was not included but the O&M costs were estimated. The total length and capital cost for the networks include those parts that are planned to be funded by the CDR.

TABLE 7-15: CAPITAL COST BY MAJOR ELEMENT BASED ON THE EXISTING AND PROPOSED WWTPs FOR THE CAZA OF RACHAIYA

Caza	WWTP Name	Status & Type	Population Served	Capacity (m³/d)	Area Required (m²)	Land Cost (USD) (1)	Construction cost (USD) (2)	Equipment Cost (USD) (3)	Capital investment Initial cost (USD) (4)= (1)+(2)+(3)	Operation and maintenance cost (USD/yr) (5)	Power consumption (KWH/yr)	Power cost (USD/yr) (6)	Network Capital Cost ($) (10)			Proposed Interceptors Cost (USD) (11)	Total Capital Cost ($) (12) = (4)+(10)+(11)	Total Yearly Cost (USD/yr) (13)*	Village Served
													Extension (7)	Replacement (8)	Rehabilitation (9)				
Rachaiya	Aakabe WWTP X = -309218.19 Y = -72187.00	Proposed Trickling Filter	3,262	600	2,280	57,000	253,949	126,974	437,923	43,292	28,184	3,382	3,585,560	---	---	29,000	4,052,483	152,698	Aakabe (El)
	Dahr el Ahmar WWTP X = -309502.72 Y = -70209.32	Proposed Trickling Filter	3,309	600	2,315	57,883	257,448	128,724	444,054	43,832	28,590	3,431	4,154,105	---	---	362,500	4,960,659	176,054	Dahr el Ahmar
	Deir el Aachayer WWTP X = -290910.04 Y = -67115.21	Proposed Stabilization Ponds	1,623	300	6,490	162,250	51,444	13,361	227,055	14,115	3,374	405	1,383,300	---	---	101,500	1,711,855	53,782	Deir Aachayer
	Haouch El Qinnaabe WWTP X = -315268.27 Y = -75486.61	Existing Stabilization Ponds	2,197	100 + 300 (Additional)	6,600 (Additional)	165,000 (Additional)	(15,026)** 52,424 (Additional)	(3,642)** 33,606 (Additional)	251,030 (Additional)	16,788	3,758	451	187,050	---	---	---	438,080	35,721	Haouch El Qinnabe
	Kfar Qouq WWTP X = -303189.47 Y = -69987.29	Proposed Trickling Filter	9,814	1,800	5,910	147,750	720,313	360,157	1,228,220	108,261	84,793	10,175	8,028,650	---	---	696,000	9,952,870	380,972	Aaiha, Kfar Qouq
	Majdel Balhiss WWTP X = -315487.56 Y = -68898.93	Proposed Trickling Filter	5,576	1,000	3,790	94,750	423,653	211,827	730,230	68,636	48,177	5,781	11,275,490	---	---	1,299,500	13,305,220	414,917	Majdel Balhiss, Kfarmechki, Kaoukaba
	Yanta 1 WWTP X = -295552.6 Y = -61023.5	Proposed Trickling Filter	2,505	460	1,755	43,863	197,594	98,797	340,254	34,599	21,643	2,597	107,300	---	---	---	447,554	78,884	Part of Yanta
	Yanta 2 WWTP X = -298094.78 Y = -63077.55	Proposed Trickling Filter	3,395	620	2,380	59,488	263,850	131,925	455,263	44,819	29,333	3,520	107,300	903,350	---	158,050	1,623,963	120,647	Part of Yanta, East Bakka
	Mhaidthé (El) WWTP X = -309283.25 Y = -67499.36	Proposed Trickling Filter	30,508	5,560	16,650	416,250	2,126,523	1,063,261	3,606,034	269,217	263,589	31,631	16,424,150	---	---	4,778,278	24,808,462	962,044	Mdoukha, Khirbet Rouha, Rafid (Er) , Bire (El) , Kfardenis, Mhaidthe (El) , Aain Arab, West Bakka
	Beit lahia WWTP X = -311673.62 Y = -74115.77	Proposed Trickling Filter	22,428	4,100	12,740	318,500	1,598,629	799,315	2,716,444	211,687	193,778	23,253	8,013,425	---	---	2,718,085	13,447,954	676,450	Beit lahia, Tannoura, Bakkifa, Ain Horche, Ain Aata and Rachaiya
	Total	---	84,617	---	60,909	1,522,733	5,945,828	2,967,947	10,436,507	855,246	705,217	84,626	55,560,230 ***	903,350	---	10,142,913	77,043,000	3,052,168	---

*** The total yearly cost is constituted of the sum of the depreciation of WWTP equipment cost over 12 years, the depreciation of WWTP civil works, networks and interceptors costs over 50 years, yearly power cost, yearly operation and maintenance cost of the networks and interceptors and the reservation of the capital renewal.**

(13) = (2 + 7 + 8 + 9 + 11+ replacement cost of sewers to be maintained as per chapter 6 + estimated cost of replacement of existing or planned WWTP civil works)/50 + (3 + estimated cost of replacement of existing or planned WWTP civil works)/12 + (5) + (6) + (7 + 8 + 9 + 11 + replacement cost of sewers to be maintained as per chapter 6) * 0.5%.

**** Estimated cost of replacement of equipment and civil works for existing and CDR planned WWTPs for depreciation calculation purposes.**

***** The Network Capital Extension Cost of Aita El Foukhar and Azzi are added to the Total Extension Cost in the Rachaiya caza and removed from that of West Bekaa where the Joub Jannine WWTP is located.**

8 PRIORITY ACTION PLAN AND CONCLUDING REMARKS

8.1 Overview of Wastewater Master Plan

A master plan for the wastewater collection and treatment has been proposed for the Bekaa in Ch. 6. It takes into account the existing wastewater treatment plants and sewers as well as the facilities and infrastructure planned by the CDR for the year 2020 horizon. Additional wastewater treatment plants are proposed to service the populations that will not be covered by either the existing or the planned facilities. These rely on gravity to convey the flow to the WWTPs in order to avoid the cost and complication of pumping. The combination of existing, planned, and proposed treatment plants and extensions to existing and planned plants would covers all of the Bekaa population by 2035 except for a a small number of remote and sparsely populated villages that will rely on properly designed septic tanks with leach fields. Detailed cost estimates were developed in Ch. 7 for all the cost components of the WWTPs and the sewer networks. The total capital investment in wastewater collection and treatment infrastructure was estimated at 714 million USD for the design horizon of 2035.

8.2 Challenges of Delayed Action and Setting of Priorities

Most of this infrastructure, 60% at least, should have already been built during the last 15 years to serve the larger population centers and reduce the rampant environmental degradation. The annual cost of environmental degradation in Lebanon was estimated at 3.4% of GDP in the year 2000. Its cumulative cost since, could have paid for most of the required infrastructure many times over for all of Lebanon. The political and economical situation of Lebanon has unfortunately prevented that from happening. The Lebanese Government has been operating without an approved budget since 2005 using make shift financing instruments. The national debt has risen from 40 to more than 60 billion USD or just about twice the GDP.

In the face of uncertainty in planning and taking stock of the historical track record of the last twenty years in Lebanon, it is proposed to use a realistic approach to prioritize and budget for the required infrastructure. The proposed improvements to existing sewer networks and WWTPs and the sewer and treatment plants to be constructed, whether planned by the CDR and/or additionally proposed in this master plan, have been classified under three priority levels in a Priority Action Plan. The levels of priority have been identified based on the following criteria:

- For an existing WWTP priority was given to the upgrading and/or construction/extension of the sewer network connecting the subscribers in its service area to it in order to reach full operating efficiency and recover capital investment;
- For an existing sewer network discharging raw sewage into a body of water, typically the Litani, Assi, or one of their tributaries, priority was given to the construction of the WWTP to reduce the negative environmental, health and socio-economic impacts;
- For unconnected villages and localities not in one of the situations above, priority was given to the larger agglomerations based on the projected number of inhabitants by the design horizon.

Based on these priority criteria the investment actions or proposed WWTPs and their networks have been grouped into three categories or level of priority:

- Level 1-Immediate Action (2015-2025)
- Level 2-Medium Term Action (2025-2030)
- Level 3-Long Term Action (2030-2035)

Given the large number of recommended level 1 actions a ten year execution horizon was realistically assigned. This period will see the combined activities of the CDR and the BWE in order to deliver about $395 million USD worth of works, $261 million USD being already planned by the CDR. A five years period was then assigned for the execution of each of level 2 and level 3 actions valued at $204 million USD and $115 million USD respectively.

8.3 Capital Investment Estimates by Phase and Caza

Figures 8-1, 8-2 and 8-3 present the Priority Level assignment for each of the proposed wastewater treatment plants (WWTP) presented in the Master Plan. The color of the capital cost bar distinguishes in which caza the WWTP is located.

Figure 8-1, below, presents the Level 1 Priority WWTP's that are proposed in the Master Plan for Immediate Action (2015-2025). The capital investments for each WWTP shown in this figure also includes the cost of the interceptor sewers needed to transport the wastewater from the villages/municipalities they serve to the WWTP.

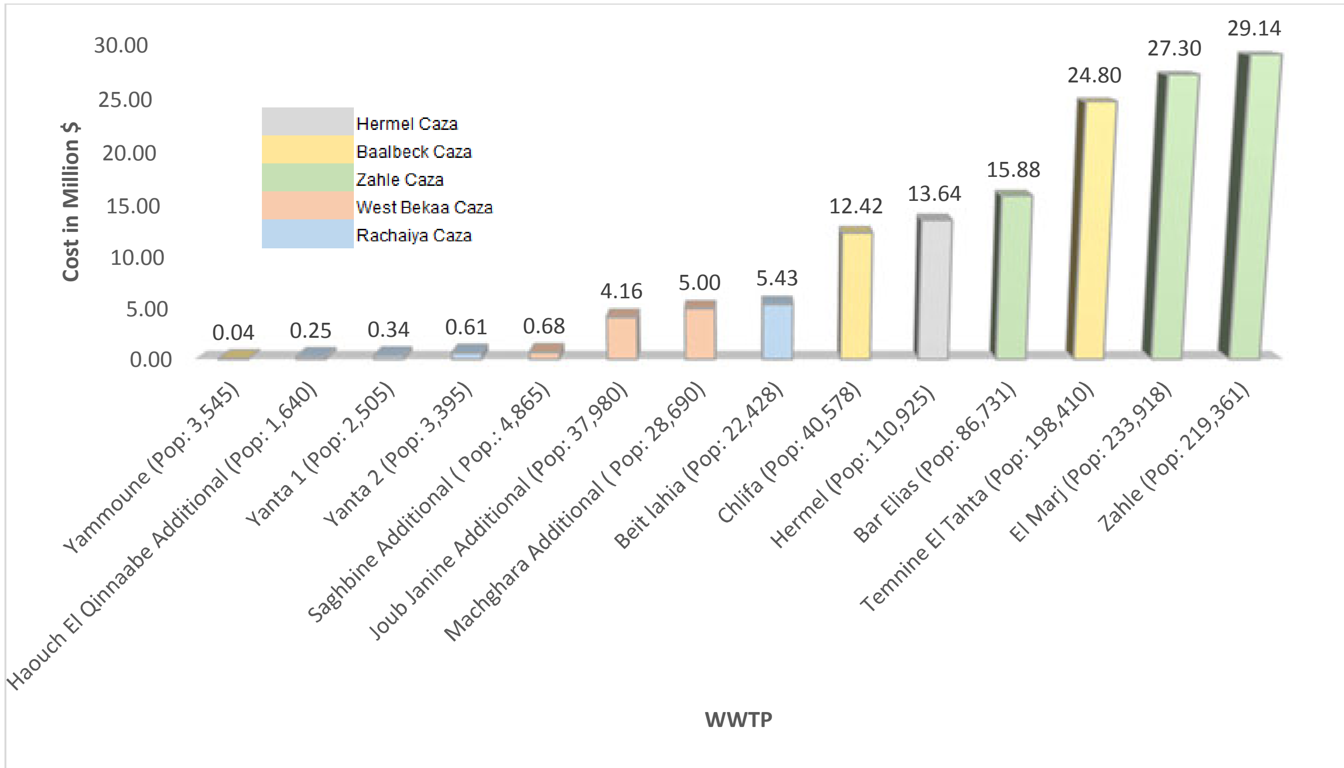

FIGURE 8-1: COST ESTIMATION OF WWTPS AND THEIR CONNECTING INTERCEPTORS – LEVEL 1 PRIORITY

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Figure 8-2 similarly presents the Level 2 Priority WWTP's that are proposed in the Master Plan for Medium Term Action ((2025-2030); and Figure 8-3 similarly presents the Level 3 Priority WWTP's assigned to Long Term Action (2030-2035).

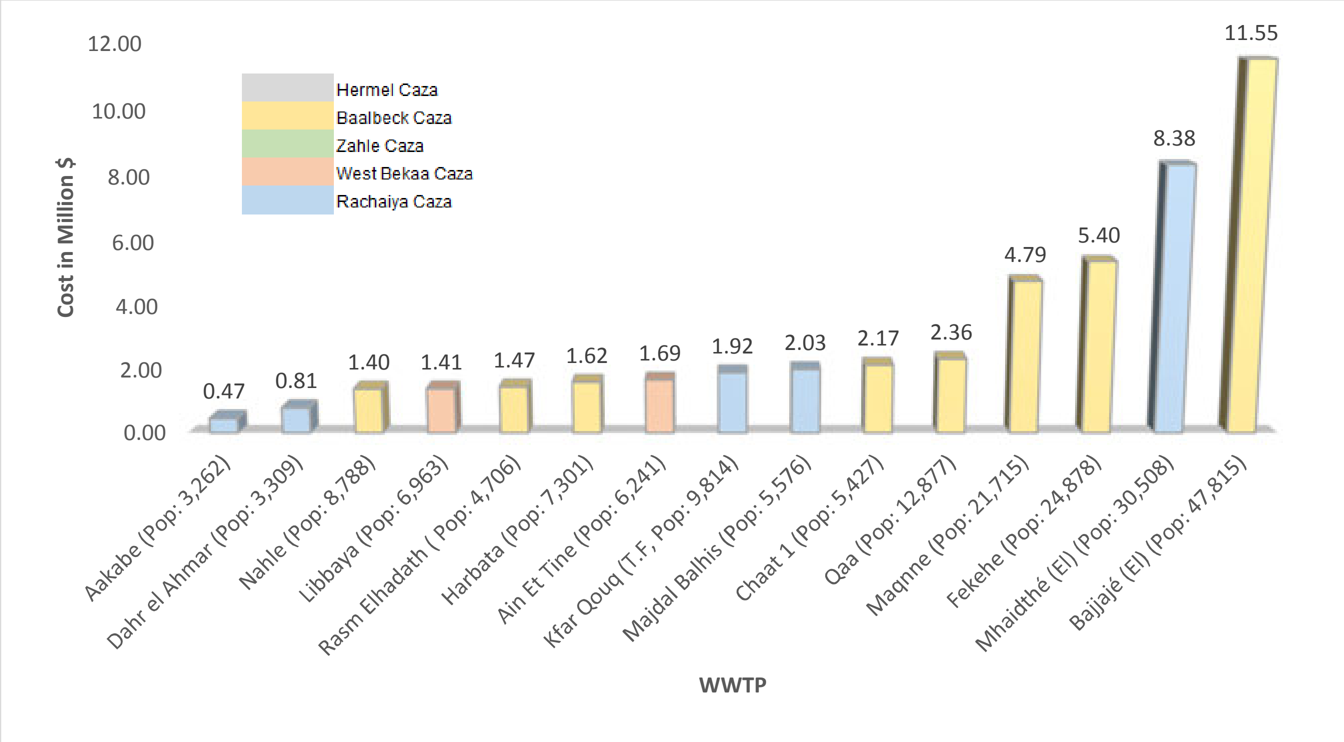


FIGURE 8-2: COST ESTIMATION OF WWTPS AND THEIR CONNECTING INTERCEPTORS – LEVEL 2 PRIORITY

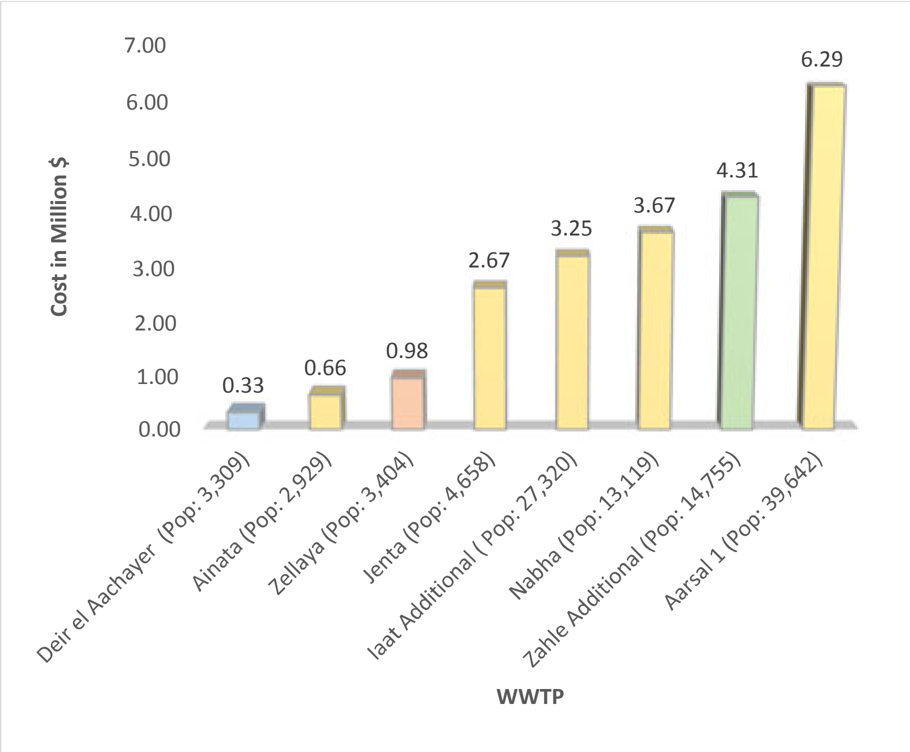
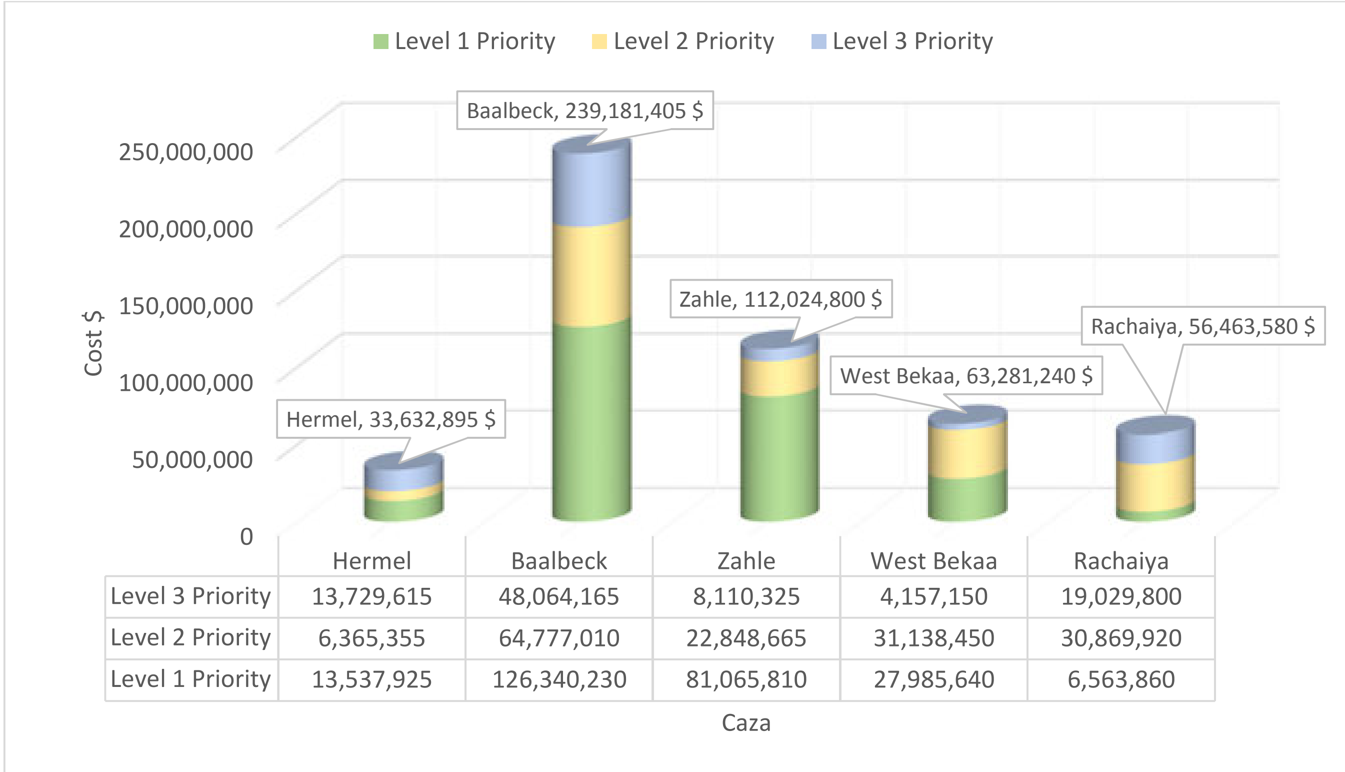


FIGURE 8-3: COST ESTIMATION OF WWTPS AND THEIR CONNECTING INTERCEPTORS – LEVEL 3 PRIORITY

To graphically reflect the phasing of capital investment for the supporting capital investments in sewer networks, by investment amount and by Caza, the following Figure 8-4 has been color coded to distinguish Priority Levels as follows:

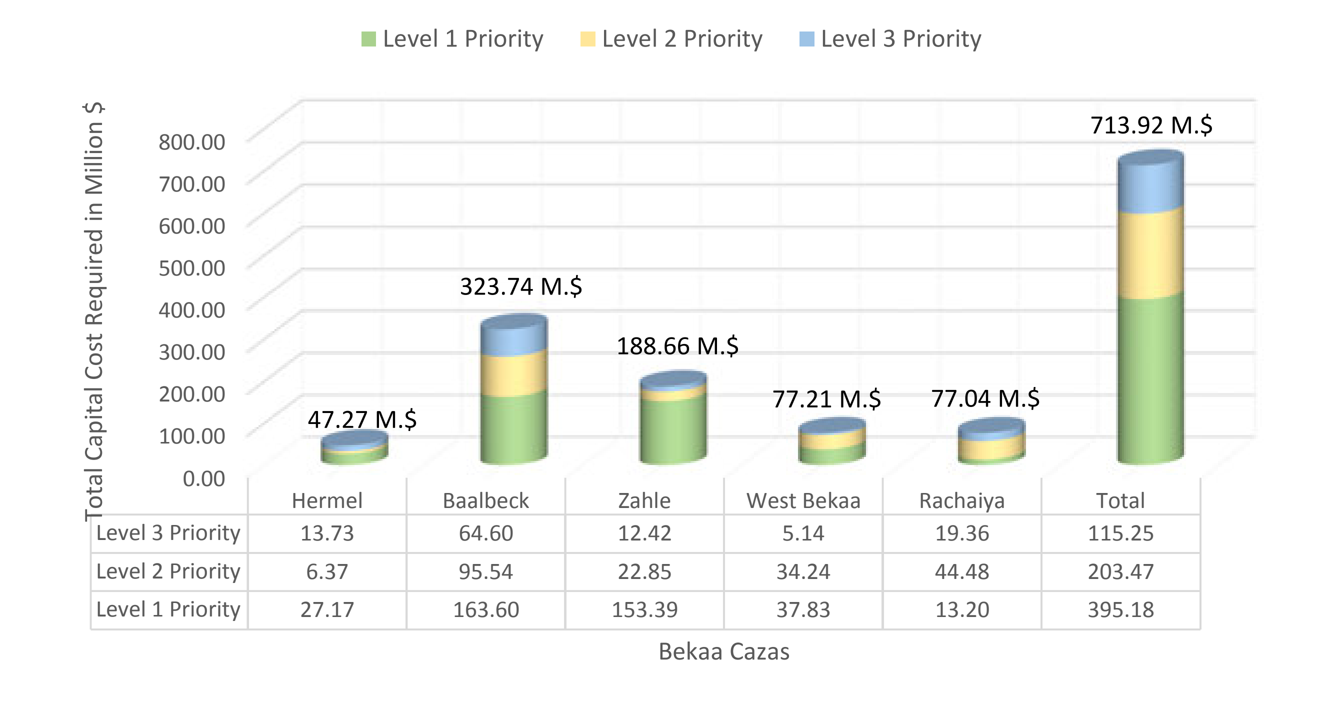
- Level 1 – Green
- Level 2 – Yellow
- Level 3 – Blue



	Hermel	Baalbeck	Zahle	West Bekaa	Rachaiya
Level 3 Priority	13,729,615	48,064,165	8,110,325	4,157,150	19,029,800
Level 2 Priority	6,365,355	64,777,010	22,848,665	31,138,450	30,869,920
Level 1 Priority	13,537,925	126,340,230	81,065,810	27,985,640	6,563,860

FIGURE 8-4: ESTIMATED CAPITAL COST WITH PRIORITY LEVELS FOR THE SEWER NETWORKS IN THE BEKAA

Figure 8-5 uses the same color coding as Figure 8-4 to present the total capital investment in WWTPs and networks by investment amount and by Caza.



	Hermel	Baalbeck	Zahle	West Bekaa	Rachaiya	Total
Level 3 Priority	13.73	64.60	12.42	5.14	19.36	115.25
Level 2 Priority	6.37	95.54	22.85	34.24	44.48	203.47
Level 1 Priority	27.17	163.60	153.39	37.83	13.20	395.18

FIGURE 8-5: ESTIMATED CAPITAL COST WITH PRIORITY LEVELS IN THE BEKAA BY YEAR 2035

The following Figures 8-6, 8-7, and 8-8 provide for an appreciation of the Capital Investment Program and its phasing by number of WWTP's to be implemented by phase; by the size of the population to be served by the capital investment in each phase; and the total amount of the capital investment in each phase.

Figure 8-6 shows the number of WWTPs to be built by caza and level of priority using the same color coding as above with the addition of a dark green quadrant to represent existing facilities.

FIGURE 8-6: PRIORITY LEVEL OF THE BEKAA WWTPs

Figure 8-7 presents the total population to be served by the end of activities of each priority level. At the end of level 1 priority actions almost one million resident of the Bekaa or two thirds of the year 2035 design population will be serviced by a wastewater system. It is important to note that the existing systems serve less than one third of the current population. About two to three percent of the year 2035 design population would have to rely on upgraded septic tank with leach fields.

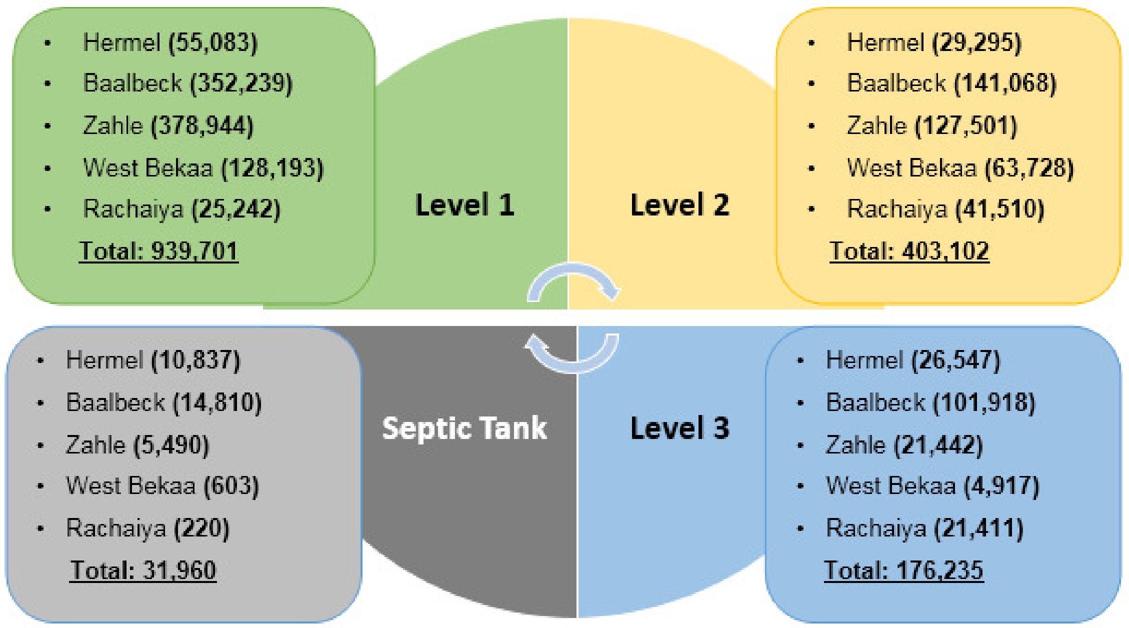


FIGURE 8-7: POPULATION SERVED BASED ON PRIORITY LEVEL OF THE BEKAA WWTPs

Figure 8-8 shows the estimated total capital cost required by caza and level of priority using the same color coding as above with the addition of a dark green quadrant to represent the $261 million USD investments planned by the CDR up to 2020. The CDR planned investments are part of level 1 priorities and the BWE will be responsible for securing the remaining level 1 investments.

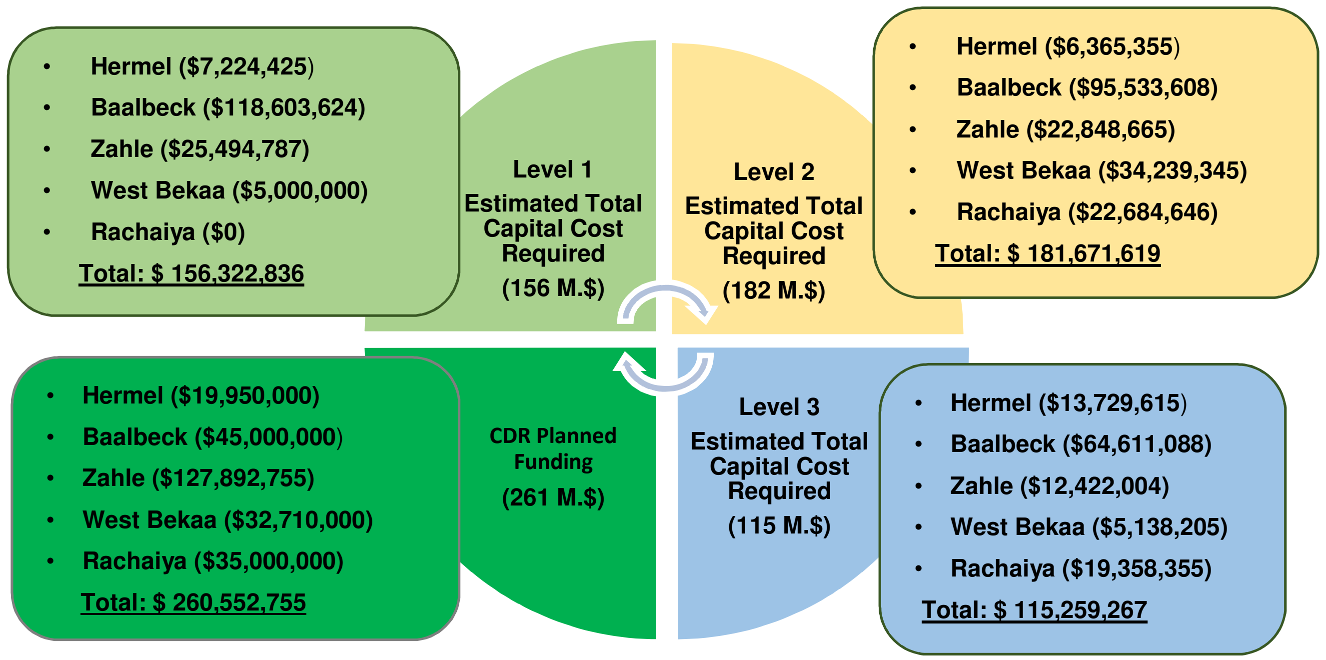


FIGURE 8-8: PRIORITY ACTION PLAN FOR THE BEKAA MOHAFAZA

8.4 Priority Action Plan by Localities

Tables 8-1 thru 8-5 provide a more detailed view as to the impact of the priorities on specific localities in each Caza. Again, the color coding has been maintained with the Green = Level 1, Yellow = Level 2, Blue = Level 3, and Dark green represents existing WWTPs. Clearly, for a village to be linked to a WWTP the WWTP must be in place and its immediate served locality will be a more urban center. Once the WWTP is operational, then the networks and interceptor sewers to smaller localities can be constructed.

It should be noted that not all localities will discharge to a WWTP. The localities that colored in Grey will be encouraged to install or modify existing on-lot systems to function as contemporary Septic Tank and Leaching Field Systems.

8.5 Concluding Remarks and Cost Impacts to Residents

The further prioritization of Level 1 priority actions could be carried out by the BWE in consultation and coordination with the MEW and the CDR based on the constraints and limitations of the prevailing political and economic situation in Lebanon.

For realistic budgeting purposes it is proposed to spread the value of Level 1 priorities, estimated at 395 million USD, evenly over the ten years period from 2015 to 2025. The CDR is planning to contribute 261 million USD by 2020 which would leave the BWE with 156 million USD over ten years or just about 15.6 million USD/year for starters. Coordination with the CDR would be paramount as to the confirmation that their planned works would be funded and constructed in due time. Depending on the success in executing works identified under level 1 priority, level 2 priority works will be scheduled. Level 2 priority works will estimated under the value of 182 million USD. For budgeting purposes, it is proposed to spend this value evenly over the period extending between 2025 and 2030 at an average yearly cost of 36.4 million USD/year. Level 3 priority may be assigned to the remaining period. It is recommended that the BWE reviews priorities and budgeting every 3 years based on the level of achievement.

The BWE is mandated by its legal statutes to lay out the strategies and develop the tariff structure that would allow it to deliver the services required while maintaining financial sustainability. The per capita total yearly cost can be calculated for each proposed system. The values vary from one system to another from slightly below $20 USD/capita to above $40 USD/capita with an average of about $30 USD/capita. This cost includes the operations and maintenance estimated at about $10 to $12 USD/capita and the capital reserve or capital recovery cost. For an average household of 4.6 people this would put the average subscription fee at $138 USD.

Concurrently with the activities recommended under this study, the BWE must develop its human resources to operate and manage the wastewater systems. It must also lay out a business plan that integrates cost recovery strategies, external funding contributions and a new tariff structure.

TABLE 8-1: PRIORITY ACTION PLAN FOR LOCALITIES OF HERMEL CAZA (LEVEL 1 IN GREEN, LEVEL 2 IN YELLOW, AND LEVEL 3 IN BLUE)

Caza	Village Name	Total Length Needed for Sewer Collection Network (m)	Length of Existing Sewer Collection Network (m)	Length of Proposed Sewer Collection Network (m)	Estimated Population 2013	Estimated Population 2035	Wastewater Current Discharge	Wastewater Discharge in Year 2035	Required WWTP
Hormel	Boueida	5,497	---	5,497	1,801	2,637	Septic Tank	Hermel (Planned)	**Hermel** Activated Sludge (Planned by CDR)
	Brissa	8,028	---	8,028	676	990	Septic Tank	Hermel (Planned)	
	Charbiné (Sh)	3,952	---	3,952	1,917	2,808	Septic Tank	Hermel (Planned)	
	Chouaghir el Faouka	6,295	---	6,295	3,381	4,952	Septic Tank	Hermel (Planned)	
	Chouaghir el Tahta (Chouaghir El Faouka)	---	---	---	---	---	Septic Tank	Hermel (Planned)	
	Fissane	9,199	---	9,199	1,200	1,758	Septic Tank	Hermel (Planned)	
	Haouch es sayed aali	1,437	---	1,437	676	990	Septic Tank	Hermel (Planned)	
	Hariqa	1,372	---	1,372	338	495	Septic Tank	Hermel (Planned)	
	Hay Bdita	5,195	---	5,195	---	---	Septic Tank	Hermel (Planned)	
	Hermel	93,365	5,031	88,334	37,606	55,083	Assi River	Hermel (Planned)	
	Mazraat Soujod	1,343	---	1,343	225	330	Septic Tank	Hermel (Planned)	
	Nahr el Aiin	1,732	---	1,732	676	990	Septic Tank	Hermel (Planned)	
	Nasriye (en)	10,414	---	10,414	225	330	Septic Tank	Hermel (Planned)	
	Ouadi et Tourkman	2,793	---	2,793	300	439	Septic Tank	Hermel (Planned)	
	Qanafez (Including Haouchariye, Mrah El Zakbe)	7,250	---	7,250	1,200	1,758	Septic Tank	Hermel (Planned)	
	Qasr	41,733	---	41,733	15,000	21,971	Septic Tank	Hermel (Planned)	
	Qouakh	4,093	---	4,093	868	1,271	Septic Tank	Hermel (Planned)	
	Sahet el Mai	2,166	---	2,166	5,000	7,324	Septic Tank	Hermel (Planned)	
	Soueiss	2,554	---	2,554	508	743	Septic Tank	Hermel (Planned)	
	Wadi el Ratl	2,441	---	2,441	420	615	Hermel (Planned)	Hermel (Planned)	
	Zighrine (& Boule)	18,800	---	18,800	3,427	5,019	Hermel (Planned)	Hermel (Planned)	
	Zoueitini	2,292	---	2,292	288	422	Hermel (Planned)	Hermel (Planned)	
	Total of Hermel WWTP	**231,951**	**5,031**	**226,920**	**75,732**	**110,925**	**---**	**---**	
	Bestane	---	---	---	1,126	1,650	Septic Tank	Septic Tank	**Septic Tank**
	Haret el Maaser (Zighrine)	---	---	---	---	---	Septic Tank	Septic Tank	
	Hermel Jbab*	---	---	---	---	---	Septic Tank	Septic Tank	
	Jmeira	---	---	---	225	330	Septic Tank	Septic Tank	
	Jouar el Hachich	---	---	---	3,000	4,394	Septic Tank	Septic Tank	
	Maaïsra (El)	---	---	---	---	---	Septic Tank	Septic Tank	
	Maaser	---	---	---	---	---	Septic Tank	Septic Tank	
	Mazraart el Faqih	---	---	---	---	---	Septic Tank	Septic Tank	
	Mazraat Beit el Toch	---	---	---	451	660	Septic Tank	Septic Tank	
	Merjhine	---	---	---	1,890	2,768	Septic Tank	Septic Tank	
	Ouadi el Faara*	---	---	---	450	659	Septic Tank	Septic Tank	
	Ras Baalbeck el Gharbi	---	---	---	257	376	Septic Tank	Septic Tank	
	Wadi Bnit*	---	---	---	---	---	Septic Tank	Septic Tank	
	Wadi el Karm*	---	---	---	---	---	Septic Tank	Septic Tank	
	Wadi el Nira*	---	---	---	---	---	Septic Tank	Septic Tank	

TABLE 8-2: PRIORITY ACTION PLAN FOR LOCALITIES OF BAALBECK CAZA (LEVEL 1 IN GREEN, LEVEL 2 IN YELLOW, AND LEVEL 3 IN BLUE)

Caza	Village Name	Total Length Needed for Sewer Collection Network (m)	Length of Existing Sewer Collection Network (m)	Length of Proposed Sewer Collection Network (m)	Estimated Population 2013	Estimated Population 2035	Wastewater Current Disharge	Wastewater Discharge in Year 2035	Required WWTP
Baalbeck	Aarsal	107,694	---	107,694	27,064	39,642	Septic Tank	Aarsal 1 (Proposed)	**Aarsal 1** Trickling Filter (Proposed)
	Ainata	15,676	---	15,676	2,000	2,929	Septic Tank	Ainata(Proposed)	**Ainata** Trickling Filter (Proposed)
	Ain (El)	50,691	---	50,691	9,878	14,469	Septic Tank	Bajjaje (El) (Proposed)	**Bajjaje (El)** Trickling Filter (Proposed) (N.B: 15% of Fekehe Population will discharge wastewater into Bejjaje WWTP)
	Amhazié *	---	---	---	---	---	Septic Tank	Bajjaje (El) (Proposed)	
	Bajjajé (El)	5,246	---	5,246	916	1,341	Septic Tank	Bajjaje (El) (Proposed)	
	Halbata	5,133	---	5,133	509	745	Septic Tank	Bajjaje (El) (Proposed)	
	Jabboulé	7,698	---	7,698	---	---	Septic Tank	Bajjaje (El) (Proposed)	
	Laboué	64,690	---	64,690	12,341	18,076	Septic Tank	Bajjaje (El) (Proposed)	
	Moqraq	---	---	---	1,740	2,549	Septic Tank	Bajjaje (El) (Proposed)	
	Nabi Osmane (En)	25,796	---	25,796	4,096	5,999	Septic Tank	Bajjaje (El) (Proposed)	
	Taoufiqié (Moqraq)	24,555	---	24,555	---	---	Septic Tank	Bajjaje (El) (Proposed)	
	Zabboud	8,128	---	8,128	1,199	1,757	Septic Tank	Bajjaje (El) (Proposed)	
	Fekehe (15%)	---	---	---	1,762	2,581	Septic Tank	Bajjaje (El) (Proposed)	
	Kharayeb	---	---	---	203	297	Litani River	Bajjaje (El) (Proposed)	
	Total of Bejjaje WWTP	**191,937**	**---**	**191,937**	**32,644**	**47,815**	---	---	
	Qarha	6,498	---	6,498	493	721	Septic Tank	Chaat 1 (Proposed)	**Chaat 1** Trickling Filter (Proposed)
	Chaat	24,812	---	24,812	6,425	9,411	Septic Tank	Chaat 1 (Proposed) & Chaat 2 (Proposed)	**Chaat 2** Trickling Filter (Proposed)
	Aalaq Tell (Boudai)	11,464	---	11,464	---	---	Litani River	Chlifa (Proposed)	**Chlifa** Trickling Filter (Proposed)
	Bechouat	22,025	---	22,025	1,800	2,637	Septic Tank	Chlifa (Proposed)	
	Boudai	52,962	---	52,962	9,139	13,386	Litani River	Chlifa (Proposed)	
	Btedaai	13,241	---	13,241	1,301	1,906	Septic Tank	Chlifa (Proposed)	
	Chlifa	10,259	---	10,259	2,067	3,027	Septic Tank	Chlifa (Proposed)	
	Deir el Ahmar	44,244	3,992	40,252	6,366	9,324	Deir el Ahmar (Existing)	Chlifa (Proposed)	
	Flaoue	9,810	---	9,810	2,251	3,297	Septic Tank	Chlifa (Proposed)	
	Mazraat Beit Ghousain	---	---	---	200	293	Septic Tank	Chlifa (Proposed)	
	Mazraat es Syad	11,245	---	11,245	300	439	Septic Tank	Chlifa (Proposed)	
	Riha	4,223	---	4,223	792	1,161	Septic Tank	Chlifa (Proposed)	
	Saaidé	16,753	---	16,753	1,681	2,462	Litani River	Chlifa (Proposed)	
	Kneissé	7,475	---	7,475	1,713	2,509	Litani River	Chlifa (Proposed)	
	Total of Chlifa WWTP	**203,701**	**3,992**	**199,709**	**27,610**	**40,578**	---	---	

Caza	Village Name	Total Length Needed for Sewer Collection Network (m)	Length of Existing Sewer Collection Network (m)	Length of Proposed Sewer Collection Network (m)	Estimated Population 2013	Estimated Population 2035	Wastewater Current Disharge	Wastewater Discharge in Year 2035	Required WWTP
	Fekehe (85%)	#N/A	---	54,212	9,985	14,625	Septic Tank	Fekehe (Proposed)	**Fekehe** Trickling Filter (Proposed)
	Jdeidé (Fekehe)	8,389	---	8,389	---	---	Septic Tank	Fekehe (Proposed)	
	Ras Baalbeck	22,342	---	22,342	7,000	10,253	Septic Tank	Fekehe (Proposed)	
	Total of Fekehe WWTP	**#N/A**	**---**	**84,943**	**16,985**	**24,878**	---	---	
	Harbata	17,280	---	17,280	4,321	6,329	Septic Tank	Harbata (Proposed)	**Harbata** Trickling Filter (Proposed)
	Sbouba	3,347	---	3,347	664	972	Septic Tank	Harbata (Proposed)	
	Total of Harbata WWTP	**20,627**	**---**	**20,627**	**4,985**	**7,301**	---	---	
	Aaddous	1,524	---	1,524	327	478	Iaat (Existing)	Iaat (Existing)	**Iaat** Activated Sludge (Existing)
	Aamichki (Baalbeck)	---	---	---	---	---	Iaat (Existing)	Iaat (Existing)	
	Ain Bourdai	16,671	11,734	4,937	916	1,341	Iaat (Existing)	Iaat (Existing)	
	Baalbeck	294,433	160,107	134,326	90,873	133,104	Iaat (Existing)	Iaat (Existing)	
	Douris	66,404	44,121	22,283	10,842	15,880	Iaat (Existing)	Iaat (Existing)	
	Haouch Tell Safiyé	12,377	5,481	6,896	1,269	1,859	Iaat (Existing)	Iaat (Existing)	**Iaat** Additional Area
	Iaat	35,735	23,511	12,224	4,406	6,454	Iaat (Existing)	Iaat (Existing)	
	Total of Iaat WWTP	**427,144**	**244,954**	**182,190**	**108,633**	**159,116**	---	---	
	Ham	7,990	---	7,990	546	800	Septic Tank	Jenta (Planned)	**Jenta** Trickling Filter (Proposed - Previously Planned by CDR)
	Jenta	1,508	---	1,508	471	690	Septic Tank	Jenta (Planned)	
	Maaraboun	5,076	---	5,076	1,478	2,164	Septic Tank	Jenta (Planned)	
	Yahfoufa	2,330	---	2,330	685	1,004	Septic Tank	Jenta (Planned)	
	Total of Jenta WWTP	**16,904**	**---**	**16,904**	**3,180**	**4,658**	---	---	
	Maqné	20,496	---	20,496	3,164	4,635	Septic Tank	Maqne (Proposed)	**Maqne** Trickling Filter (Proposed)
	Younine	42,167	---	42,167	11,661	17,080	Septic Tank	Maqne (Proposed)	
	Total of Maqne WWTP	**62,663**	**---**	**62,663**	**14,825**	**21,715**	---	---	
	Barqa	18,427	---	18,427	1,124	1,647	Septic Tank	Nabha (Proposed)	**Nabha** Trickling Filter (Proposed)
	Nabha	44,981	---	44,981	5,113	7,489	Septic Tank	Nabha (Proposed)	
	Qeddam	5,797	---	5,797	720	1,054	Septic Tank	Nabha (Proposed)	
	Ram (El)	10,659	---	10,659	2,000	2,929	Septic Tank	Nabha (Proposed)	
	Total of Nabha WWTP	**79,864**	**---**	**79,864**	**8,957**	**13,119**	---	---	
	Nahlé	18,834	---	18,834	6,000	8,788	Septic Tank	Nahle (Proposed)	**Nahle** Trickling Filter (Proposed)
	Qaa (el)	36,708	---	36,708	8,791	12,877	Septic Tank	Qaa (el) (Proposed)	**Qaa (el)** Trickling Filter (Proposed)
	Hizzine	15,740	3,245	12,495	2,067	3,027	Litani River	Temnin El Tahta (Planned)	**Temnine El Tahta** Activated Sludge (Planned by CDR)
	Hortaala	46,889	---	46,889	3,796	5,560	Litani River	Temnin El Tahta (Planned)	
	Bednayel	28,894	15,188	13,706	11,233	16,453	Litani River	Temnin El Tahta (Planned)	
	Beit Chama	16,767	4,525	12,242	4,315	6,321	Litani River	Temnin El Tahta (Planned)	
	Beit Mcheik (Ramasa & Qeld El Sabeh)	5,114	---	5,114	2,400	3,515	Litani River	Temnin El Tahta (Planned)	
	Britel	121,056	---	121,056	13,604	19,927	Litani River	Temnin El Tahta (Planned)	

WASTEWATER CAPITAL INVESTMENT PLAN AND PRIORITY ACTION PLAN

Caza	Village Name	Total Length Needed for Sewer Collection Network (m)	Length of Existing Sewer Collection Network (m)	Length of Proposed Sewer Collection Network (m)	Estimated Population 2013	Estimated Population 2035	Wastewater Current Disharge	Wastewater Discharge in Year 2035	Required WWTP
	Chmistar	60,034	41,918	18,116	14,750	21,605	Litani River	Temnin El Tahta (Planned)	
	Hadet (El)	36,635	---	36,635	6,039	8,846	Litani River	Temnin El Tahta (Planned)	
	Haouch Barada	5,213	---	5,213	487	714	Litani River	Temnin El Tahta (Planned)	
	Haouch en Nabe	9,277	---	9,277	1,472	2,157	Litani River	Temnin El Tahta (Planned)	
	Haouch er Rafqa	14,779	10,128	4,651	7,164	10,493	Litani River	Temnin El Tahta (Planned)	
	Haouch Snaid	16,363	4,769	11,594	1,537	2,251	Litani River	Temnin El Tahta (Planned)	
	Jebaa	6,222	---	6,222	557	816	Litani River	Temnin El Tahta (Planned)	
	Kfar Dabach	7,960	---	7,960	996	1,459	Litani River	Temnin El Tahta (Planned)	
	Kfardaane	22,689	---	22,689	2,597	3,803	Litani River	Temnin El Tahta (Planned)	
	Khoder (El)	11,520	---	11,520	4,958	7,262	Litani River	Temnin El Tahta (Planned)	
	Khraibé (El)	8,134		8,134	1,231	1,804	Litani River	Temnin El Tahta (Planned)	
	Majdaloun	4,688	---	4,688	899	1,317	Litani River	Temnin El Tahta (Planned)	
	Masnaa Bednayel (Bednayel)	---	---	---	---	---	Litani River	Temnin El Tahta (Planned)	
	Nabi Chit (En)	37,758	19,316	18,442	13,438	19,684	Litani River	Temnin El Tahta (Planned)	
	Nabi Rchad	18,881	---	18,881	1,800	2,637	Litani River	Temnin El Tahta (Planned)	
	Qasrnaba	17,994	8,665	9,329	6,302	9,230	Litani River	Temnin El Tahta (Planned)	
	Seraaine el Gharbieh/ Hallanieh (Seraaine El Tahta)	15,508	---	15,508	---	---	Litani River	Temnin El Tahta (Planned)	
	Seraaine el Tahta	75,666	14,065	61,601	9,000	13,183	Litani River	Temnin El Tahta (Planned)	
	Serraain el Faouka (Seraaine El Tahta)	---	---	---	---	---	Litani River	Temnin El Tahta (Planned)	
	Sifri (Khoder (El))	---	---	---	---	---	Litani River	Temnin El Tahta (Planned)	
	Talia	20,911	---	20,911	2,393	3,505	Litani River	Temnin El Tahta (Planned)	
	Taraya	30,508	6,093	24,415	5,707	8,360	Litani River	Temnin El Tahta (Planned)	
	Taybeh (Et)	22,300	---	22,300	1,933	2,831	Litani River	Temnin El Tahta (Planned)	
	Temnine el Faouqa	18,570	11,161	7,409	4,567	6,689	Litani River	Temnin El Tahta (Planned)	
	Temnine el Tahta	19,050	14,214	4,836	9,621	14,092	Litani River	Temnin El Tahta (Planned)	
	Mazraat ed Dallil (Kfardaane)	6,815	---	6,815	---	---	Septic Tank	Temnin El Tahta (Planned)	
	Mousraye	2,519	---	2,519	498	729	Septic Tank	Temnin El Tahta (Planned)	
	Total of Temnine El Tahta WWTP	**724,454**	**153,287**	**571,167**	**135,361**	**198,410**	**---**	**---**	
	Yammouné	8,328	6,293	2,035	2,420	3,545	Yammoune (Existing)	Yammoune (Existing)	**Yammoune** Activated Sludge (Existing)
	Aain Bnayé*	---	---	---	---	---	Septic Tank	Septic Tank	**Septic Tank**
	Aaqidieh*	---	---	---	---	---	Septic Tank	Septic Tank	
	Ain el Jaouzé*	---	---	---	---	---	Septic Tank	Septic Tank	
	Ain Es Saouda *	---	---	---	---	---	Septic Tank	Septic Tank	
	Beliqa	---	---	---	60	88	Septic Tank	Septic Tank	
	Chaaibé *	---	---	---	---	---	Septic Tank	Septic Tank	
	Dar el Wasseaa	---	---	---	444	651	Septic Tank	Septic Tank	
	Deir Mar Maroun	---	---	---	96	141	Septic Tank	Septic Tank	
	Haouch ed Dahab	---	---	---	96	141	Septic Tank	Septic Tank	
	Harfouche (Qlaile (el))	---	---	---	---	---	Septic Tank	Septic Tank	

Caza	Village Name	Total Length Needed for Sewer Collection Network (m)	Length of Existing Sewer Collection Network (m)	Length of Proposed Sewer Collection Network (m)	Estimated Population 2013	Estimated Population 2035	Wastewater Current Disharge	Wastewater Discharge in Year 2035	Required WWTP
	Machaitiye	---	---	---	120	176	Septic Tank	Septic Tank	
	Mazraat Beit Slaibi	---	---	---	800	1172	Litani River	Septic Tank	
	Nabi Chbat (En)	---	---	---	43	63	Septic Tank	Septic Tank	
	Ouadi el Aaoss *	---	---	---	---	---	Septic Tank	Septic Tank	
	Qaa Baayoun	---	---	---	---	---	Septic Tank	Septic Tank	
	Qaa Jouar Maqiye	---	---	---	2,843	4,164	Septic Tank	Septic Tank	
	Qaa Ouadi El Khanzer	---	---	---	439	643	Septic Tank	Septic Tank	
	Qlaile (el)	---	---	---	120	176	Septic Tank	Septic Tank	
	Ras el Aassi *	---	---	---	---	---	Septic Tank	Septic Tank	
	Safra	---	---	---	1,800	2,637	Septic Tank	Septic Tank	
	Slouqi	---	---	---	70	102	Septic Tank	Septic Tank	
	Tfail	---	---	---	503	737	Septic Tank	Septic Tank	
	Wadi Faara (Faara)	---	---	---	---	---	Septic Tank	Septic Tank	
	Zraieb	---	---	---	676	990	Septic Tank	Septic Tank	
	Zrazir	---	---	---	2,000	2,929	Septic Tank	Septic Tank	

TABLE 8-3: PRIORITY ACTION PLAN FOR LOCALITIES OF ZAHLE CAZA (LEVEL 1 IN GREEN, LEVEL 2 IN YELLOW, AND LEVEL 3 IN BLUE)

Caza	Village Name	Total Length Needed for Sewer Collection Network (m)	Length of Existing Sewer Collection Network (m)	Length of Proposed Sewer Collection Network (m)	Estimated Population 2013	Estimated Population 2035	Sewer Current Discharge	Sewer Discharge in Year 2035	Required WWTP
Zahle	Ain Kfar Zabad	14,037	---	14,037	3245	4752	Septic Tank	Bar Elias (Planned)	**Bar Elias** Activated Sludge) (Proposed - Previously Planned by CDR)
	Ali en Nahri	17,114	---	17,114	12603	18460	Litani River	Bar Elias (Planned)	
	Deir el Ghazal	13,521	12,293	1,228	1446	2117	Litani River	Bar Elias (Planned)	
	Deir Zanoun	18,503	2,739	15,764	---	---	Septic Tank	Bar Elias (Planned)	
	Delhamiye	7,754	---	7,754	1756	2572	Litani River	Bar Elias (Planned)	
	Faaour	14,894	---	14,894	3200	4687	Septic Tank	Bar Elias (Planned)	
	Haouch el Ghanam	427	---	427	990	1451	Litani River	Bar Elias (Planned)	
	Hay el Fikani	2,061	1,874	187	---	---	Litani river	Bar Elias (Planned)	
	Hoshmosh	3,123	---	3,123	214	314	Septic Tank	Bar Elias (Planned)	
	Massa	24,044	---	24,044	2126	3113	Litani River	Bar Elias (Planned)	
	Nasireh	---	---	---	---	---	Litani River	Bar Elias (Planned)	
	Qoussaya	11,354	---	11,354	1500	2197	Septic Tank	Bar Elias (Planned)	
	Raite	22,865	---	22,865	5000	7324	Litani River	Bar Elias (Planned)	
	Rayak- Haouch Hala	24,230	5,882	18,348	19274	28232	Litani River	Bar Elias (Planned)	
	Terbol	7,856	---	7,856	7860	11512	Septic Tank	Bar Elias (Planned)	
	Total of Bar Elias WWTP	**181,783**	**22,788**	**158,995**	**59,214**	**86,731**	---	---	
	Aanjar/Haouch Moussa	29,603	21,733	7,870	11409	16712	Ghzayyel River	Marj (El) (Planned)	**Marj (El)** Activated Sludge (Planned by CDR)
	Barr Elias	71,364	24,630	46,734	23070	33792	Marj (El) (Ex)	Marj (El) (Planned)	
	Bouarej	8,140	---	8,140	3009	4407	Pat to the agricultural land - part to river in qab elias-part to jdita	Marj (El) (Planned)	
	Chebrqieh*	---	---	---	27	39	Marj (El) (Ex)	Marj (El) (Planned)	
	Chtaura	6,921	---	6,921	4407	6456	Septic Tank	Marj (El) (Planned)	
	Haouch es Siyadi	1,134	---	1,134	27	39	Septic Tank	Marj (El) (Planned)	
	Haouch Handari	---	---	---	---	---	Septic Tank	Marj (El) (Planned)	
	Haouch Qaissar	611	555	56	27	40	Septic Tank	Marj (El) (Planned)	
	Jdita	15,953	---	15,953	10392	15222	Septic Tank	Marj (El) (Planned)	
	Kfar Zabad	41,244	---	41,244	6178	9050	Septic Tank	Marj (El) (Planned)	
	Majdel Aanjar	84,872	18,847	66,025	23675	34678	Litani River	Marj (El) (Planned)	
	Maksé	4,664	4,240	424	3352	4909	Litani River	Marj (El) (Planned)	
	Mraijat (El)	9,479	---	9,479	2896	4243	Septic Tank	Marj (El) (Planned)	
	Qabb Elias	27,260	---	27,260	21625	31674	Septic Tank	Marj (El) (Planned)	
	Taalabaya - Jalala	19,933	---	19,933	27244	39905	Septic Tank	Marj (El) (Planned)	
	Taanayel (Deir)	2,781	---	2,781	1778	2604	Septic Tank	Marj (El) (Planned)	
	Zebdol	9,314	---	9,314	733	1074	Septic Tank	Marj (El) (Planned)	
	Nasriyet Rizk	11,385	---	11,385	1499	2196	Septic Tank	Marj (El) (Planned)	
	Total of Marj (El) WWTP	**344,658**	**70,005**	**274,653**	**141,348**	**207,040**	---	---	

Caza	Village Name	Total Length Needed for Sewer Collection Network (m)	Length of Existing Sewer Collection Network (m)	Length of Proposed Sewer Collection Network (m)	Estimated Population 2013	Estimated Population 2035	Sewer Current Discharge	Sewer Discharge in Year 2035	Required WWTP
	Ablah	14,417	13,107	1,310	9653	14139	Ablah (Ex)	Zahle (Under Construction)	**Zahle** Activated Sludge (Under Construction)
	Fourzol (El)	21,173	19,248	1,925	10435	15284	Fourzol WWTP(ex)	Zahle (Under Construction)	
	Hazerta	19,902	3,899	16,003	5400	7910	Berdawni river	Zahle (Under Construction)	
	Ksara	3,250	---	3,250	471	690	Berdawni river	Zahle (Under Construction)	
	Maallaqa - Karak Nouh	19,943	---	19,943	10511	15395	Berdawni river	Zahle (Under Construction)	
	Maallaqa Aradi (Mallaqa)	---	---	---	25281	37029	Berdawni river	Zahle (Under Construction)	
	Nabi Ayla	4,486	4,078	408	1585	2321	Ablah (Existing)	Zahle (Under Construction)	
	Niha	11,125	8,945	2,180	2008	2941	Ablah (Existing)	Zahle (Under Construction)	
	Qaa er Rim	10,708	2,109	8,599	3336	4886	Berdawni river	Zahle (Under Construction)	**Zahle** Additional Area
	Saadnayel	13,815	6,353	7,462	16540	24226	Berdawni river	Zahle (Under Construction)	
	Zahlé	214,651	---	214,651	74618	109295	Berdawni river	Zahle (Under Construction)	
	Total of Zahle WWTP	**333,470**	**57,739**	**275,731**	**159,838**	**234,116**	---	---	
	Betyas	---	---	---	---	---	Septic Tank	Septic Tank	**Septic Tank**
	Mazraa (El)	---	---	---	525	769	Septic Tank	Septic Tank	
	Nasriye*	---	---	---	64	94	Septic Tank	Septic Tank	
	Ouadi Ed Dellem	---	---	---	2056	3011	Septic Tank	Septic Tank	
	Quommol	---	---	---	92	134	Septic Tank	Septic Tank	
	Ramtaineh	---	---	---	70	102	Septic Tank	Septic Tank	
	Tell el Akhdar	---	---	---	123	180	Septic Tank	Septic Tank	
	Touaite	---	---	---	819	1200	Septic Tank	Septic Tank	

TABLE 8-4: PRIORITY ACTION PLAN FOR LOCALITIES OF WEST BEKAA CAZA (LEVEL 1 IN GREEN, LEVEL 2 IN YELLOW, AND LEVEL 3 IN BLUE)

Caza	Village Name	Total Length Needed for Sewer Collection Network (m)	Length of Existing Sewer Collection Network (m)	Length of Proposed Sewer Collection Network (m)	Estimated Population 2013	Estimated Population 2035	Wastewater Current Discharge	Wastewater Discharge in Year 2035	Required WWTP
West Bekaa	Ain El Tine	9,411	---	9,411	3303	4,838	Septic Tank	Ain El Tine (Proposed)	**Ain El Tine** Trickling Filter (Proposed)
	Maidoun	8,769	---	8,769	958	1,403	Septic Tank	Ain El Tine (Proposed)	
	Total of Ain El Tine WWTP	**18,180**	**---**	**18,180**	**4,261**	**6,241**	**---**	**---**	
	Aammiq	5,961	4,313	1,648	1103	1,616	Joub Jannine (Existing)	Joub Jannine (Existing)	**Joub Jannine** Activated Sludge (Existing)
	Aana	10,409	2299	8,110	2100	3,076	Septic Tank	Joub Jannine (Existing)	
	Dakoué (El)	10,201	2,085	8,116	626	917	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Deir Tahnich	2,929	---	2,929	75	110	Septic Tank	Joub Janine (Existing)	
	Ghazze	35,233	10,965	24,268	6949	10,178	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Hammara (Manara)	31,098	11,883	19,215	---	---	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Haouch El Harime	21,301	6,532	14,769	2115	3,098	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Joubb Jannine	50,544	24,441	26,103	10016	14,671	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Kamed el Loz	38,377	21,203	17,172	10000	14,647	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Kefraiya	22,965	9,782	13,183	2441	3,575	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Khiara (El)	9,935	7,312	2,623	1300	1,904	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Khirbet Qanafar	20,284	18,440	1,844	4500	6,591	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Lala	12,489	11,354	1,135	7000	10,253	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Manara	---	---	---	4600	6,738	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Mansoura	11,542	3,965	7,577	3000	4,394	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Sltan Yacoub el Fouqa	6,311	5,738	573	4310	6,313	Joub Jannine (Existing)	Joub Jannine (Existing)	**Joub Jannine** Additional Area
	Sltan Yaqoub el Tahta	22,693	3,487	19,206	---	---	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Tell Znoub	6,184	5,622	562	830	1,216	Joub Jannine (Existing)	Joub Jannine (Existing)	
	Total of Joub Jannine WWTP	**318,456**	**149,421**	**169,033**	**60,965**	**89,297**	**---**	**---**	
	Libbaya	17,716	---	17,716	4754	6,963	Septic Tank	Libbaya (Proposed)	**Libbaya** Trickling Filter (Proposed)
	Baaloul	16,590	---	16,590	2886	4,227	Septic Tank	Machghara (Existing)	**Machghara** Trickling Filter (Existing)
	Machghara	26,241	5,264	20,977	15655	22,930	Machghara (Existing)	Machghara (Existing)	
	Qaraaoun (El)	4,988	4,535	453	6500	9,521	Machghara (Existing)	Machghara (Existing)	
	Sohmor	44,415	---	44,415	7902	11,574	Septic Tank	Machghara (Existing)	**Machghara** Additional Area
	Aaitanit	8,183	7,439	744	1151	1,686	Saghbine(Existing) & Machghara (Existing)	Saghbine(Existing) & Machghara (Existing)	
	Yohmor el Beqaa	18,840	---	18,840	4214	6,172	Septic Tank	Machghara (Existing)	
	Total of Machghara WWTP	**119,257**	**17,238**	**102,019**	**38,308**	**56,110**	**---**	**---**	
	Marj (El)	55,004	10,704	44,300	7324	10,728	Septic Tank	Marj (El) (Planned)	**Marj (El) (In Zahle Caza)** Activated Sludge (Planned by CDR)
	Saouiri	49,017	---	49,017	8026	11,756	Septic Tank	Marj (El) (Planned)	
	Raouda	4,374	1,347	3,027	3000	4,394	Septic Tank	Marj (El) (Planned)	
	Total of El Marj WWTP	**108,395**	**12,051**	**96,344**	**18,350**	**26,878**	**---**	**---**	
	Bab Mareh	3,837	3,489	348	493	722	Saghbine(Existing)	Saghbine(Existing)	
	Deir Ain ej Jaouzé	1,174	1,067	107	27	40	Saghbine(Existing)	Saghbine(Existing)	

Caza	Village Name	Total Length Needed for Sewer Collection Network (m)	Length of Existing Sewer Collection Network (m)	Length of Proposed Sewer Collection Network (m)	Estimated Population 2013	Estimated Population 2035	Wastewater Current Discharge	Wastewater Discharge in Year 2035	Required WWTP
	Saghbine	13,111	8,145	4,966	3828	5,607	Saghbine(Existing)	Saghbine(Existing)	**Saghbine** Activated Sludge (Existing)
	Ain Zebdé	10,537	4,531	6,006	1076	1,576	Saghbine(Existing)	Saghbine(Existing)	**Saghbine** Additional Area
	Total of Saghbine WWTP	**28,659**	**17,232**	**11,427**	**5,424**	**7,945**	**---**	**---**	
	Loussa*	---	---	---	---	---	Septic Tank	Zellaya (Proposed)	**Zellaya** Trickling Filter (Proposed)
	Qelia	11,877	---	11,877	1767	2,588	Septic Tank	Zellaya (Proposed)	
	Zellaya	5,095	---	5,095	557	816	Septic Tank	Zellaya (Proposed)	
	Total of Zellaya WWTP	**16,972**	**---**	**16,972**	**2,324**	**3,404**	**---**	**---**	
	Fadar El Faouka	---	---	---	---	---	Septic Tank	Septic Tank	**Septic Tank**
	Fadar El Tahta	---	---	---	---	---	Septic Tank	Septic Tank	
	Harimet es Soghra	---	---	---	112	164	Septic Tank	Septic Tank	
	Jeziré (El) *	---	---	---	246	360	Septic Tank	Septic Tank	
	Ouaqf (El)	---	---	---	---	---	Septic Tank	Septic Tank	
	Sltan Yaqoub El Aradi	---	---	---	54	79	Septic Tank	Septic Tank	
	Tell Ez Zaazaa	---	---	---	---	---	Septic Tank	Septic Tank	

TABLE 8-5: PRIORITY ACTION PLAN FOR LOCALITIES OF RACHAIYA CAZA (LEVEL 1 IN GREEN, LEVEL 2 IN YELLOW, AND LEVEL 3 IN BLUE)

Caza	Village Name	Total Length Needed for Sewer Collection Network (m)	Length of Existing Sewer Collection Network (m)	Length of Proposed Sewer Collection Network (m)	Estimated Population 2013	Estimated Population 2035	Wastewater Current Discharge	Wastewater Discharge in Year 2035	Required WWTP
Rachaiya	Aakabe (El)	24,728	---	24,728	2,227	3262	Septic Tank	Aakabe (El) (Proposed)	**Aakabe (El)** Trickling Filter (Proposed)
	Ain Aata	20,607	---	20,607	2,308	3380	Septic Tank	Beit Lahia (Proposed)	**Beit Lahia** Trickling Filter (Proposed)
	Ain Horche	5,417	3,137	2,280	1,007	1474	Aain Horche (Ex)	Beit Lahia (Proposed)	
	Bakkifa	2,486	---	2,486	1,719	2517	Septic Tank	Beit Lahia (Proposed)	
	Beit Lahia	1,634	---	1,634	996	1459	Septic Tank	Beit Lahia (Proposed)	
	Rachaiya Rachaya el Faouka Rachaya El Kouasbe Rachaya el Wadi	35,621	17,453	18,168	8,277	12,124	Rachaiya (Existing)	Beit Lahia (Proposed)	
	Tannoura	10,090	---	10,090	1,007	1474	Septic Tank	Beit Lahia (Proposed)	
	Total of Beit Lahia WWTP	**75,855**	**20,590**	**55,265**	**15,314**	**22,428**	**---**	**---**	
	Dahr el Ahmar	28,649	---	28,649	2,259	3309	Septic Tank	Dahr El Ahmar (Proposed)	**Dahr El Ahmar** Trickling Filter (Proposed)
	Deir el Aachayer	9,540	---	9,540	1,108	1623	Septic Tank	Deir El Achayer (Proposed)	**Deir El Achayer** Stabilization Ponds (Proposed)
	Haouch El Qinnaabe	3,870	2,580	1,290	1500	2197	Haouch El Qinaabe (Existing)	Haouch El Qinaabe (Existing)	**Haouch El Qinaabe** Stabilization Ponds (Existing) **Haouch El Qinaabe** Additional Area
	Aita El Foukhar	10,536	---	10,536	2,420	3545	Joub Janine (Existing)	Joub Jannine (Existing)	**Joub Jannine (In West Bekaa Caza)** Activated Sludge (Existing)
	Ezzé (Aazzi)	17,279	11,995	5,284	---	---	Joub Janine (Existing)	Joub Jannine (Existing)	
	Total of Joub Jannine WWTP	**27,815**	**11,995**	**15,820**	**2,420**	**3,545**	**---**	**---**	
	Aaiha	19,046	---	19,046	3,500	5127	Septic Tank	Kfar Qouq (Proposed)	**Kfar Qouq** Trickling Filter (Proposed)
	Kfar Qouq	36,324	---	36,324	3,200	4687	Septic Tank	Kfar Qouq (Proposed)	
	Total of Kfar Qouq WWTP	**55,370**	**---**	**55,370**	**6,700**	**9,814**	**---**	**---**	
	Kaoukaba	15,674	---	15,674	1,215	1780	Septic Tank	Majdel Balhis (Proposed)	**Majdel Balhis** Trickling Filter (Proposed)
	Kfarmechki	21,795	---	21,795	1,173	1717	Septic Tank	Majdel Balhis (Proposed)	
	Majdel Balhiss	12,824	---	12,824	1,419	2078	Septic Tank	Majdel Balhis (Proposed)	
	Total of Majdel Balhis WWTP	**50,293**	**---**	**50,293**	**3,807**	**5,575**	**---**	**---**	
	Aain Arab	5,853	---	5,853	664	972	Septic Tank	Mhaidthe (El) (Proposed)	**Mhaidthe (El)** Trickling Filter (Proposed)
	Bire (El)	14,315	---	14,315	5,600	8202	Septic Tank	Mhaidthe (El) (Proposed)	
	Kfardenis	17,552	---	17,552	1,708	2502	Septic Tank	Mhaidthe (El) (Proposed)	
	Khirbet Rouha	41,758	---	41,758	4,267	6250	Septic Tank	Mhaidthe (El) (Proposed)	
	Mdoukha	11,147	---	11,147	1,306	1913	Septic Tank	Mhaidthe (El) (Proposed)	
	Mhaidthé (El)	17,217	---	17,217	1,697	2486	Septic Tank	Mhaidthe (El) (Proposed)	

WASTEWATER CAPITAL INVESTMENT PLAN AND PRIORITY ACTION PLAN

Caza	Village Name	Total Length Needed for Sewer Collection Network (m)	Length of Existing Sewer Collection Network (m)	Length of Proposed Sewer Collection Network (m)	Estimated Population 2013	Estimated Population 2035	Wastewater Current Discharge	Wastewater Discharge in Year 2035	Required WWTP
	Part of Bakka	5,428	---	5,428	1215	890	bakka 1 & 2 (Ex)	Mhaidthe (El) (Proposed)	
	Rafid (Er)	27,469	---	27,469	4,979	7293	Septic Tank	Majdel Balhis (Proposed)	
	Total of Mhaidthe (El) WWTP	**140,739**	**---**	**140,739**	**21,436**	**30,508**	**---**	**---**	
	Yanta	16,277	14,797	1,480	3,421	5011	Yanta 1 (Proposed) & Yanta 2 (Proposed)	Yanta 1 (Proposed) & Yanta 2 (Proposed)	**Yanta 1 & Yanta 2** Trickling Filter (Proposed)
	Part of Bakka	11,658	6,230	---	1,215	891	bakka 1 & 2 (Ex)	Yanta 2 (Proposed) & Mhaidthe (Proposed)	
	Total of Yanta 1 & Yanta 2 WWTPs	**27,935**	**21,027**	**1,480**	**4,636**	**5,902**	**---**	**---**	
	Haloua	---	---	---	150	220	Septic Tank	Septic Tank	**Septic Tank**
	Mazraat Deir el Aachayer	---	---	---	---	---	Septic Tank	Septic Tank	
	Mazraat Jaafar	---	---	---	---	---	Septic Tank	Septic Tank	
	Mazraat Salsata	---	---	---	---	---	Septic Tank	Septic Tank	
	Nabaat	---	---	---	---	---	Septic Tank	Septic Tank	
	Qennabé	---	---	---	---	---	Septic Tank	Septic Tank	