# LEBANON WATER AND WASTEWATER SECTOR SUPPORT PROGRAM

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

Executive Summary

May 2015

# USAID/LEBANON WATER AND WASTEWATER SECTOR SUPPORT PROGRAM

## Water Supply and Wastewater Systems Master Plan

## Executive Summary

**Prepared for the Bekaa Water Establishment**

**By KREDO s.a.l.**

## Foreword

*As part of the USAID – Lebanon Water & Wastewater Sector Support Program (LWWSS), KREDO was commissioned by DAI to develop a Water Supply and Wastewater Systems Master Plan within the Service Area of the Bekaa Water Establishment for the planning horizon of 2035. A detailed assessment of the existing situation was carried out and Capital Investment Plans and Priority Action Plans for water supply and wastewater systems were developed to provide full service to the population of the Bekaa which was projected to reach 1.5 million residents in 2035. All technical recommendations were aligned with the National Water Sector Strategy adopted by the Lebanese Government and proposed works were optimized to reduce operation & maintenance and energy costs. Detailed cost estimates were developed by project components, types of work and cazas.*

*In order to increase the coverage of potable water service by the BWE, from two thirds of the population and localities to full coverage, it was estimated that the BWE would need a total capital investment of $429 million USD by 2035 in addition to about $113 million USD which The Council for Development and Reconstruction has already committed on projects under study, tendering or construction. System-wide production, distribution and subscribers metering was also urgently recommended.*

*In order to increase the provision of wastewater collection and treatment services, from less than one third of the population to almost 97% coverage, it was estimated that the BWE would need a total capital investment of $714 million USD by 2035 out of which the Council for Development and Reconstruction has already committed about $261 million USD on projects under planning, study, tendering or construction.*

*Action plans for short, medium, and long term investments were proposed with more than 55% of all investments needed in the immediate short range, noting the pent up demand and the very high cost of environmental degradation.*

*The following executive summary presents the main findings and recommendations for the Capital Investment Plans and Priority Action Plans for water supply and wastewater systems.*

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| | |
|---|---|
| BWE | BEKAA WATER ESTABLISHMENT |
| CAS | CENTRAL ADMINISTRATION OF STATISTICS |
| CDR | COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION |
| DAI | DEVELOPMENT ALTERNATIVES, INC. |
| GIS | GEOGRAPHIC INFORMATION SYSTEM |
| K&A | KHATIB & ALAMI |
| LRA | LITANI RIVER AUTHORITY |
| MEW | MINISTRY OF ENERGY AND WATER |
| O&M | OPERATION AND MAINTENANCE |
| USAID | UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT |
| WHO | WORD HEALTH ORGANIZATION |
| WTP | WATER TREATMENT PLANT |
| WWTP | WASTEWATER TREATMENT PLANT |

# 1 INTRODUCTION

On December 1st, 2012 KREDO was 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 study was to establish water supply and wastewater master plans for the year 2035 planning horizon 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. Two additional components were added to the study: (i) the survey and assessment of existing irrigation infrastructures under the jurisdiction of the BWE and the preparation of terms of reference for the development of an irrigation master plan; (ii) the update, development and population of an extensive GIS database for the BWE integrating all the works done under this study. The deliverables of the study were submitted under separate cover and are:

1. Inception Report
2. Water Supply System Assessment Report
3. Wastewater System Assessment Report
4. Irrigation Services Assessment Report
5. TOR for Irrigation Systems Master Plan
6. Updated GIS database
7. Water Supply Capital Investment Plan and Priority Action Plan
8. Wastewater Capital Investment Plan and Priority Action Plan

This report summarizes the result of the works carried out to develop the Master Plan and the recommendations for the 2035 planning horizon for water supply and wastewater capital investment plans and proposed priority action plans. It is presented in two parts, the first part presenting the water supply systems and the second part the wastewater systems.

The Bekaa Water Establishment (BWE) was created alongside the other regional water authorities in Lebanon as a result of Law 221/2000 and its subsequent applicable application decrees. The BWE has faced major challenges, more so than the other three Water Establishments, due to the status of neglect of the water supply, wastewater and irrigation infrastructure it took over after years of civil strife and due the lack of information about the extent and status of this infrastructure. The situation was compounded by dire financial conditions and lack of capital and operational funding.

An estimated 1,000,000 Lebanese reside in the 4,000 square kilometers of the Bekaa that fall under BWE jurisdiction. Only 240 out of 330 towns and villages of the Bekaa are currently connected to the various BWE public water supply networks, representing about two thirds of the population, the remainder being served by ad-hoc systems or not at all. The BWE has roughly 80,000 subscribers that receive potable water supply service, which is provided on the basis of a yearly flat rate per gage size. Those subscribers are unevenly distributed across the service areas with medium to very low fees collection rates.

No more than 30% of the Bekaa households are currently connected to a wastewater collection and treatment system, in spite of the large efforts of the CDR and USAID in the last 20 years related to wastewater service.

In addition to potable water supply and wastewater services, the BWE is also responsible for providing irrigation water for those parts of its service area falling outside the jurisdiction of Litani River Authority in the Bekaa and Baalbeck-Hermel Mohafazats.

The National Water Sector Strategy, issued by the MOEW and adopted by the Council of Ministers in 2010, has set among its strategic objectives that all inland wastewater must be treated and the effluent reused. This has added a significant challenge in the management of current and future treated wastewater discharges, since all of the BWE service area falls within this inland status.

# 2 WATER SUPPLY SYSTEMS

## 2.1 Existing Situation

A data collection campaign was carried out to gather all existing information about potable water supply sources, storage, treatment, and distribution infrastructure in the service area of the BWE. It consisted of: (i) the review of information available in the electronic databases and hardcopy archives of the BWE; (ii) the collection and analysis of those studies and reports that have been prepared regarding projects that are planned or under construction; and (iii) extensive field visits to assess the condition of those parts of the infrastructure that are visible such as reservoirs, springs, well heads, and treatment stations. The results of this campaign were presented in a separate document during 2013 in the Water Supply System Assessment Report. The current situation can be summarized as follows:

1. The BWE currently operates a patchwork of potable water supply systems constituted from the different water boards and local committees that were consolidated into the regional water establishment by law 221/2000. Most of these systems are more than 30 years of age, with some dating from before the civil war.
2. The CDR has invested, over the last twenty years, an estimated $150 million USD in the potable water infrastructure of the Bekaa. Of this investment amount, nearly 90% of these investments were concentrated on systems supplying Baalbeck City and the neighboring villages, as well as Yammouneh and Hermel. The remainder was invested in the West Bekaa region. The largest funding contribution to these projects was secured through the World Bank and the Kuwait Fund.
3. The CDR is currently in the process of constructing or tendering large projects targeted at the rehabilitation, replacement and extension of networks in the Cazas of West Bekaa, Rachaiya and Zahle.
4. Of the 330 or so towns and villages in its service area, 240 representing slightly more than two thirds of the population are currently served by the BWE. Some of the remaining villages rely on systems operated by municipal or local informal authorities.
5. The BWE operates more than 196 independent potable water supply systems of variable sizes. Of this total, up to 36 systems are supplied from small, medium or large local springs, whereas the other 160 systems are supplied from an estimated 238 wells. Small village systems are typically supplied from a single well whereas larger systems are supplied by groups of wells. The BWE also operates one water treatment plant and a several pumping or boosting stations. All distribution storage is provided by approximately 338 existing reservoirs with another 31 under

construction. The total distribution network length is estimated at 3,000 km including parts under construction.

## 2.2 Projection of Water Demand

Population projections for the Bekaa were developed for each city, village and locality based on the extensive housing stock survey carried out by the Central Administration for Statistics (CAS), as well asother sources of information which were presented in the relevant reports. The projected volumes of water for every locality, village, town and region were calculated based on the population projections using an estimated 180 liters per capita per day inclusive of all water uses as per the recommendations of the National Water Sector Strategy (NWSS) for the year 2013, and increasing linearly to 195 liters per capita per day at the planning horizon of 2035.

Table 2-1 presents the estimated current and projected daily water demand per Caza based on the water demand per capita per day and the projected populations to be served by the year 2035 design horizon.

***TABLE 2-1: ESTIMATED CURRENT AND PROJECTED DAILY WATER DEMAND PER CAZA***

| Caza | Year 2013 | | Year 2025 | | Year 2035 | |
|---|---|---|---|---|---|---|
| | Estimated Population | Water Demand ($m^3$/d) | Projected Population | Water Demand ($m^3$/d) | Projected Population | Water Demand ($m^3$/d) |
| **Hermel** | 83,131 | 14,964 | 102,367 | 19,245 | 121,762 | 23,744 |
| **Baalbeck** | 416,483 | 74,967 | 512,875 | 96,421 | 610,035 | 118,957 |
| **Zahle** | 364,149 | 65,547 | 448,426 | 84,304 | 533,377 | 104,009 |
| **West Bekaa** | 134,798 | 24,264 | 165,992 | 31,206 | 197,441 | 38,501 |
| **Rachaiya** | 60,342 | 10,862 | 74,309 | 13,970 | 88,382 | 17,234 |
| **Total** | **1,058,903** | **190,603** | **1,303,969** | **245,146** | **1,550,997** | **302,444** |

* The water demand rates of each locality in the Bekaa Cazas for the years 2013, 2025, and 2035 are calculated based on the following formulas:

$$\text{Daily Water Demand (2013) } (\mathrm{m}^3/\mathrm{d}) = 0.180 m^3/cap/d \times \text{ Population (2013)}$$

$$\text{Daily Water Demand(2025) } (\mathrm{m}^3/\mathrm{d}) = 0.188 m^3/cap/d \times \text{ Population (2025)}$$

$$\text{Daily Water Demand (2035) } (\mathrm{m}^3/\mathrm{d}) = 0.195 m^3/cap/d \times \text{ Population (2035)}$$

The total required storage capacity per locality, village or town considered was also calculated including balancing storage, breakdown storage and firefighting storage.

## 2.3 Recommended Improvements to Water Supply Systems

A significant part of the Bekaa population is not currently served by a potable water supply system operated by the BWE, whereas the rest is served with varying degrees of quality and reliability. The objective of the present study was to recommend improvements or changes to the water supply systems, which would allow the BWE, by the design horizon of 2035, to provide quality and reliable potable water supply services, to all of the projected Bekaa population whether currently served by existing systems or not, in a technically efficient, cost effective, power-wise, and environmentally sustainable fashion.

Until the adoption by the Council of Ministers of Resolution 35 dated 17/10/2010 of the NWSS, no systematic strategy had existed in Lebanon for the management of water resources and the provision of a potable water supply to the population. Water supply and distribution systems developed historically in an organic fashion around population centers as the needs increased. Local springs were tapped when available and wells were dug when the need increased. The MEW adopted an expedient and practical approach of equipping villages with one or two wells and a distribution reservoir that would supply the local network. This was done also to avoid the technical and political complications of developing large systems that supply multiple localities and different communities from one single large spring that may be considered by locals, albeit erroneously, as theirs to use as they wish. As a result of this approach, many contiguous systems are not connected, and many others rely on pumping water from wells in spite of the presence of an ample supply from a large surface water source in a nearby locality.

Projects recently constructed or planned for construction by the CDR reflect this mixed approach. The Baalbeck system relies on groups of wells and so does the proposed extension to the Zahle systems, whereas the systems under construction in West Bekaa and Rachaiya are centrally supplied from the Chamsine spring and the Ain El Zarqa (Litani).

Following the recommendations of the NWSS and those of the BWE, priority was given to water supply from principal and reliable surface springs in the Bekaa whereby: (i) additional volumes would be extracted from springs currently used for potable water and (ii) springs currently used for irrigation only would be partially or totally diverted to potable water supply. In the absence of surface water springs, groundwater would be tapped to provide the required water supplies. Redevelopment of existing wells to increase yield or the drilling of new wells would be required. The approach recommended by the NWSS would ultimately reduce the cost of energy used for pumping from wells and would safeguard the groundwater reserves to be used strategically and not be systematically depleted.

A plan was developed for each village, group of villages, or service area, to meet the water needs by either improving the existing systems, combining or extending existing service areas and systems, or modifying the water supply schemes to include new sources of supply.

Spring sources for water supply based on current and projected needs were surveyed for the whole service area of the BWE with the objective of obtaining the largest amount of potable water supply from those large reliable surface springs, thus saving on water pumping from wells and reducing the number of small systems. Historical data was obtained from the LRA and used in the analysis. It was assumed that potable water supply has the priority over current irrigation use and historical water rights, if any. Large spring based systems that are under construction by the CDR such as the West Bekaa and Rachaiya systems were adopted as is. It is suggested that existing wells operated by the BWE in areas to be supplied from large springs should be maintained as back up. It is also suggested that small springs currently in use and whose safe yield could not be assessed be maintained in the systems.

Each water supply system was divided into three functional parts as generally illustrated by Figure 2-1 and described as follows:

1) The distribution systems, which are constituted by a multi-tiered piping network covering the inhabited areas of each locality delivering potable water to each and every home by gravity from a local or regional reservoir located at the required elevation.
2) Storage and distribution reservoirs, which are located optimally at a naturally elevated high ground convenient to one or more inhabited areas. These reservoirs supply water and maintain pressure through the distribution networks they serve. Elevated water tanks are used when needed in flat terrain.
3) The water supply system, which is constituted by a source of water, such as a spring catchment or well, the submersible pumps, the pumping stations, booster stations, treatment plants, and the gravity or pressure transmission pipes that supply the storage and distribution reservoirs.

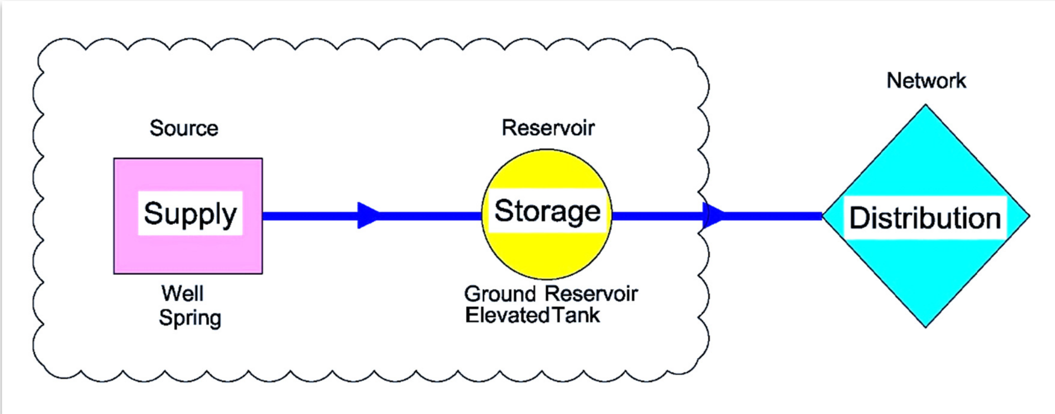



***FIGURE 2-1: GENERAL SCHEMATIC OF A WATER SYSTEM***

The status of the distribution networks was reviewed previously in the Assessment Report and the required improvements were tabulated. They are presented in this report by locality and region with recommendations for extension, replacement, or new construction. Their lengths, dimensions, and cost were estimated. It is estimated that a total of 4,308 km of distribution networks would be required by the year 2035 to serve the Bekaa service area. About one third of the existing 3,003 km would need replacement or rehabilitation by 2035, while the total length of new networks to be constructed has been determined to be about 1,305 km during the period extending from 2015 to 2035.

Table 2-2 presents the length of water network to be either rehabilitated or replaced, as well as the length of water network to be added as new water network by Caza.

***TABLE 2-2: SUMMARY OF THE WATER NETWORK LENGTHS IN THE BEKAA IN 2035***

| Caza | Total Length Needed for Water Network (m) | Length of Existing Water Network (Includes Under construction) (m) | Length of Existing Water Network to be Rehabilitated or Replaced (m) | Length of Proposed Water Network (m) |
|---|---|---|---|---|
| **Hermel** | 259,887 | 109,315 | 109,315 | 150,572 |
| **Baalbeck** | 2,099,177 | 1,736,402 | 742,115 | 362,775 |
| **Zahle** | 871,592 | 474,652 | 155,595 | 396,940 |
| **West Bekaa** | 635,959 | 409,559 | 24,441 | 226,400 |
| **Rachaiya** | 441,796 | 273,293 | 0 | 168,503 |
| **Whole Bekaa** | **4,308,411** | **3,003,221** | **1,031,466** | **1,305,190** |

Existing distribution storage capacities were reviewed and new distribution reservoirs were suggested where required based on the projected storage demand. The locations for the new reservoirs were identified on the GIS to provide the necessary ground elevations that can guarantee and maintain required minimum pressures for supplying the distribution networks. These locations were then used to estimate the transmission pipeline lengths. Where no location with the required natural ground elevation was identified within reasonable distance from the served area, an elevated water tank was suggested.

Schematics and/or preliminary conceptual designs were developed for the water supply schemes and their transmission lines showing the proposed modifications, if any, and the required new facilities. A total of 13 spring based systems were proposed combining existing facilities such as reservoirs, catchments, pumping stations and treatment plants with new proposed facilities. These spring based systems are presented, by service area, as listed below:

Hermel Service Area:

- Ain El Hawr and Ras El Meil springs system
- Ain El Zarqa spring system

Baalbeck Service Area:

- Laboue spring system
- Yammoune spring system (existing system to be extended to Baalbeck)
- Oyoun Orghosh system (existing system)
- Yahfoufa spring system

Zahle Service Area:

- Anjar spring system
- Qaa El Rim spring system
- Qabb Elias spring system
- Chamsine spring (exsiting system with extension under construction)

West Bekaa Service Area:

- Ain El Zarqa (Litani) system part 1 (under construction)
- Aana-Amiq spring system

Rachaiya Service Area:

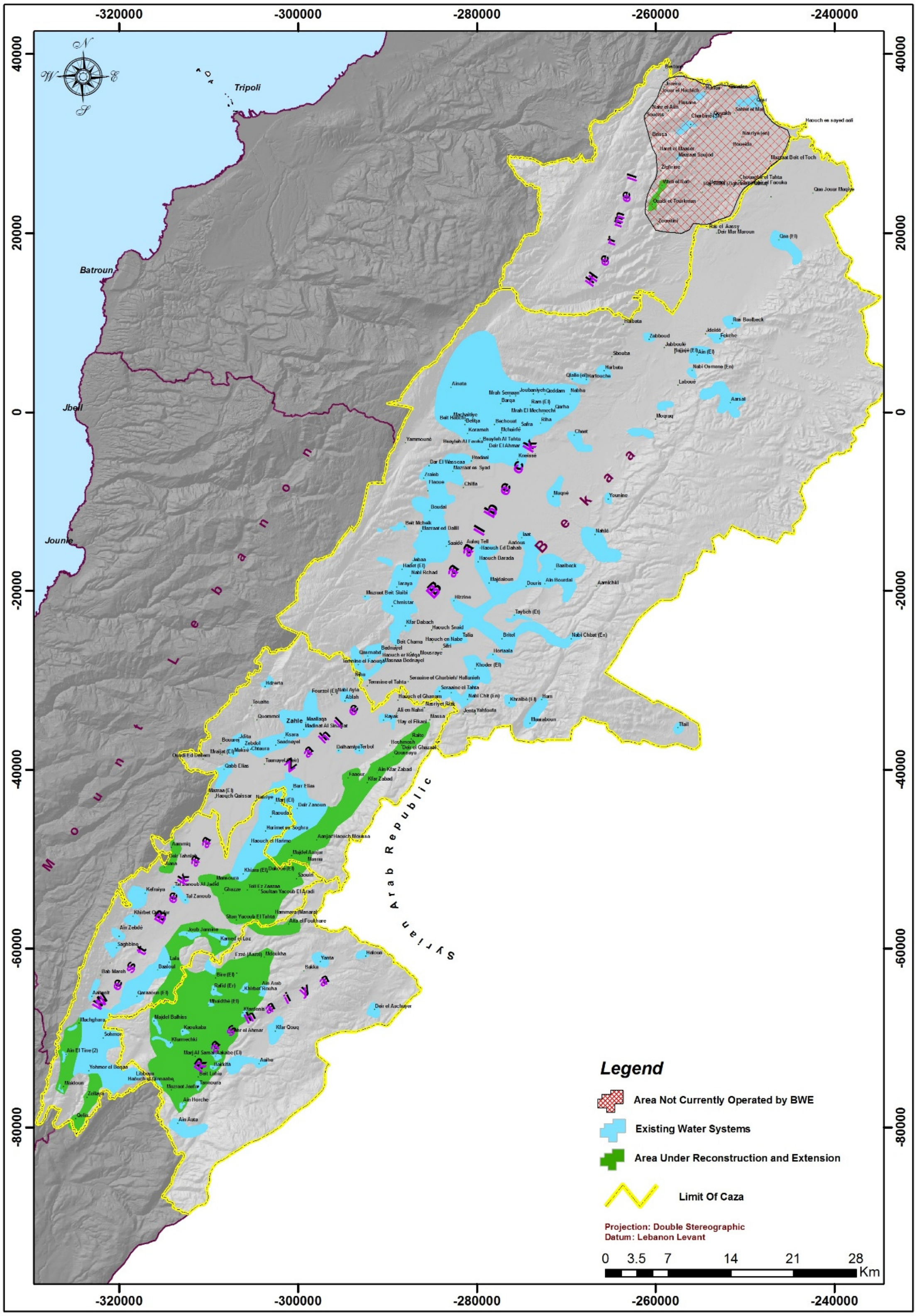
- Ain El Zarqa (Litani) system part 2 (under construction)

In addition to these 13 medium to large spring-based supply systems, there are 6 small systems that combine spring and well supply, and 31 independent well-based small systems serving one or more villages were proposed with the improvements needed to meet the projected 2035 water needs. Most of the well-based systems are existing ones requiring upgrades and extensions. The BWE currently operates 160 well-based systems of various sizes and 36 spring-based systems. These systems partially cover the geographical service area of the BWE, leaving part of the population of the Bekaa without access to formal potable water service. This situation was presented in the Assessment Report. The proposed systems in the master plan cover the totality of the geographic service area of the BWE and allow all its residents equal access to potable water services.

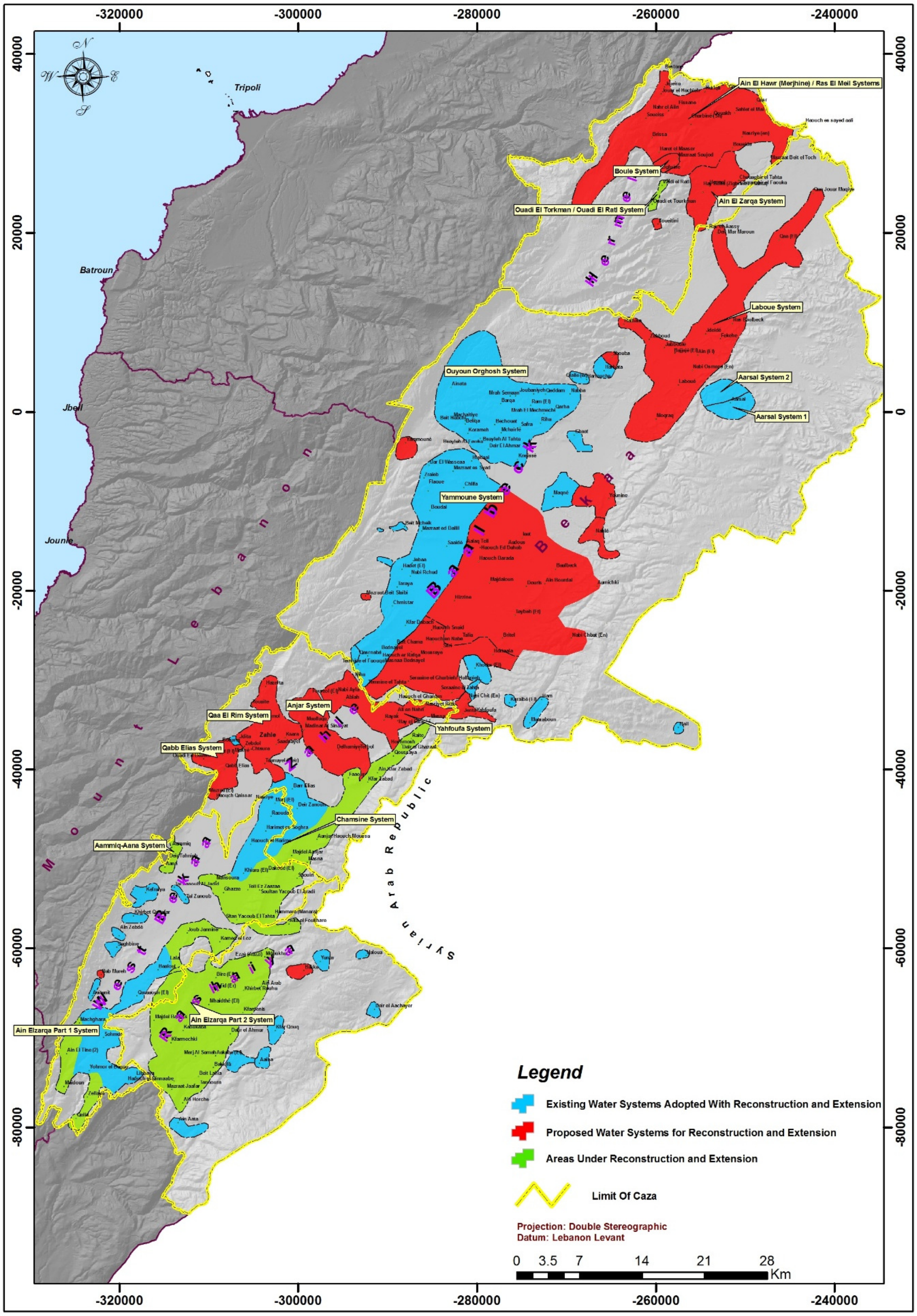
Detailed feasibility studies should be carried out to confirm the proposed new schemes and insure that all spring water sources have been properly accounted for before moving to the implementation phase. The BWE, in coordination with the LRA, should establish a program to monitor systematically all the springs in the Bekaa and update and complete their hydrological information.

Plan 2-1, attached, presents a general view of the current situation of the water supply systems over the area of the Bekaa in 2015.

Plan 2-2, attached, presents a general view of the water supply systems by the design horizon of 2035.




***PLAN 2-1: GENERAL VIEW OF THE CURRENT SITUATION OF THE WATER SUPPLY SYSTEMS OVER THE AREA OF THE BEKAA IN 2015.***




***PLAN 2-2: GENERAL VIEW OF THE WATER SUPPLY SYSTEMS BY THE DESIGN HORIZON OF 2035***

## 2.4 Cost Estimation and Priority Action Plan for Capital Investments

Detailed cost estimations, based on a breakdown of quantities and unit prices from a large database containing current and historical prices, were carried out for all proposed works and detailed information presented in the capital investment plan report. It is estimated that the BWE would need a total capital investment of $429 million USD by 2035 in addition to about $113 million USD which the CDR has committed on projects under construction and tendering to serve the 1.5 million projected population within its geographic service area. Most of these projects have been shown as under construction and their cost was not included in the estimation. However, one overlap remains in projects under tendering for the Zahle and West Bekaa service areas, which are valued at about $26 million USD. Upon completion, this value would be deducted from the required capital investment plan of the BWE.

In terms of the phasing of the investments, $344 million USD would need to be invested during the first ten years until 2025 at a yearly average of $35 million; then $40 million would be needed for the next five years; and then another $45 million during the last five years. Figure 2-2 presents the capital investment priority plan by priority level. The investments committed by the CDR are shown in a separate quadrant in dark green.

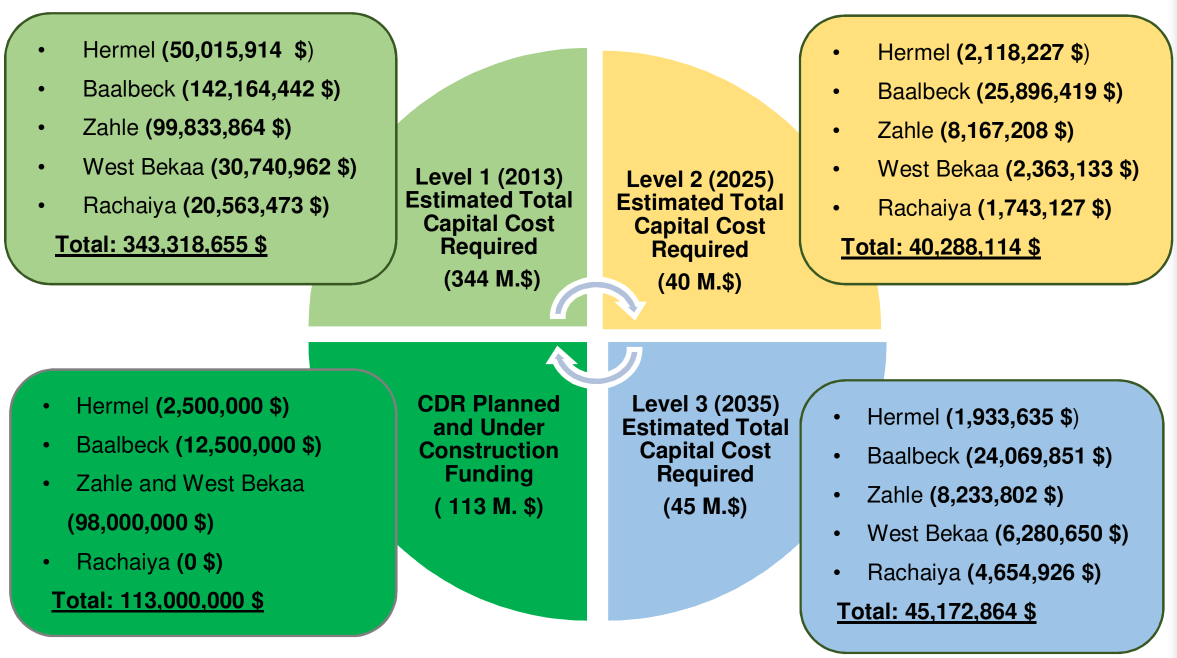



***FIGURE 2-2: CAPITAL INVESTMENT PRIORITY ACTION PLAN FOR THE BEKAA***

Figure 2-3 presents the estimated capital investment costs per caza and level of priority.

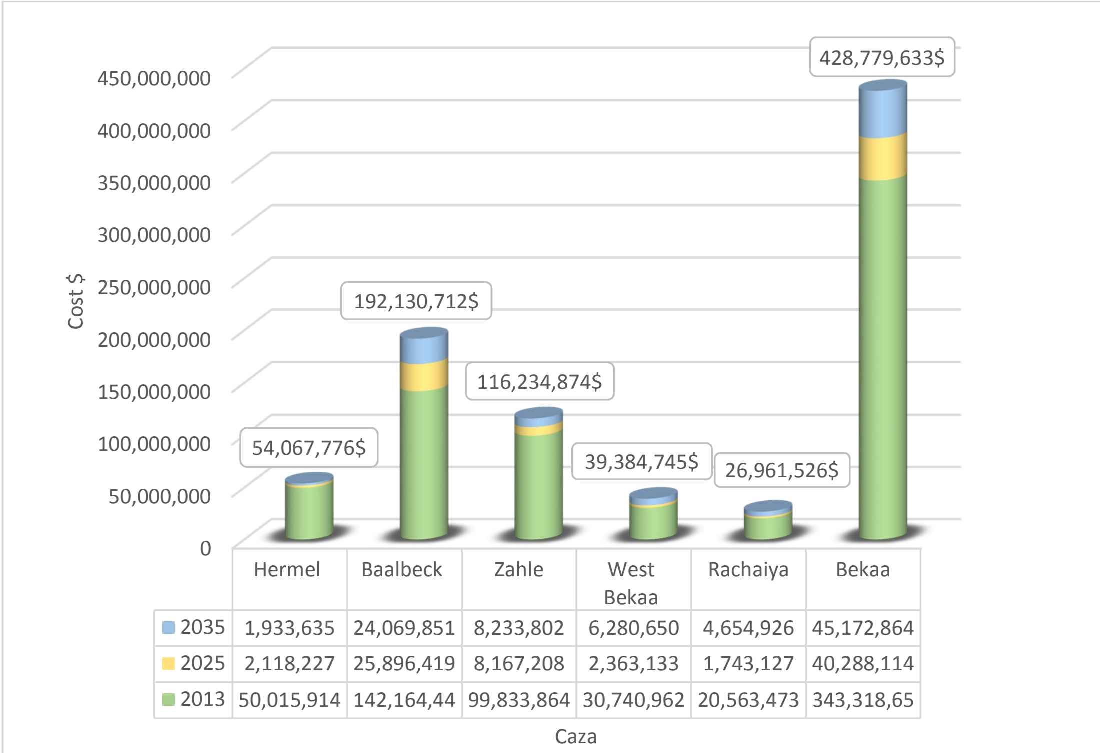



***FIGURE 2-3: ESTIMATED CAPITAL INVESTMENT COST WITH PRIORITY LEVELS IN BEKAA***

Figures 2-4 presents a breakdown of the capital investment costs per type of works per caza and for the entire Bekaa service area.

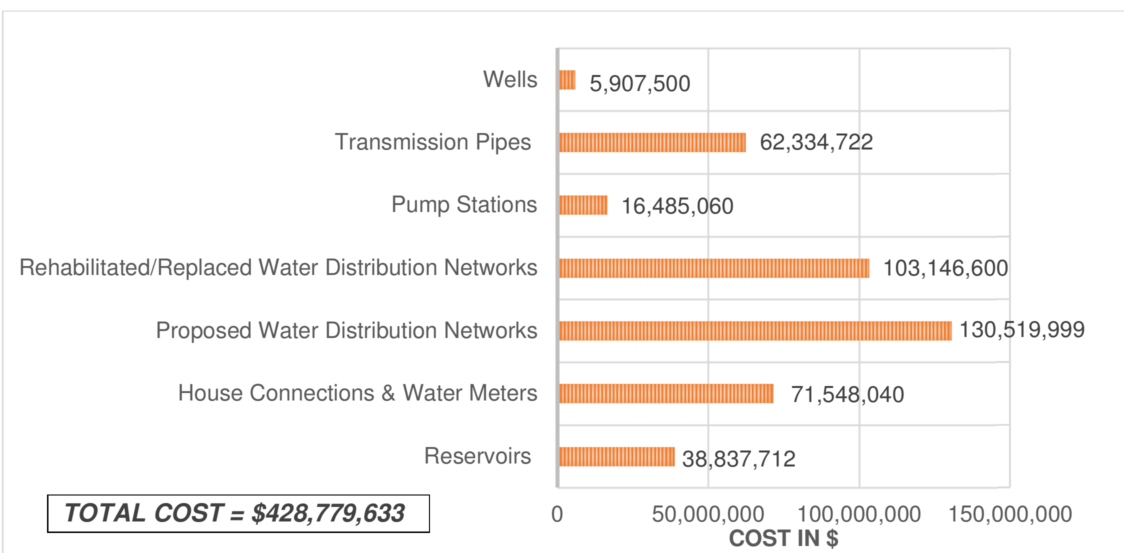



***FIGURE 2-4: THE DISTRIBUTION OF TOTAL COSTS FOR WATER FACILITIES AND NETWORKS IN THE BEKAA BY YEAR 2035***

These estimated costs are divided in Short Term Level 1, Medium Term Level 2, and Long Term Level 3 priorities presented under the current year of 2015 (based on the estimation carried in 2013) and the design horizon years of 2025 and 2035. The capital investments of the newly proposed schemes are assigned to the short term priority, given the lead time required for their study and construction and the expected dates of their entry into service. For budgeting purposes the short term priorities could be budgeted over the period extending from 2015 to 2025, the medium term priorities over the period from 2025 to 2030, and the long term priorities over the period from 2030 to 2035.

## 2.5 Capital Investment for Deployment of System Wide Metering

In order to get a good measure of control over its production, the BWE would need to deploy supply side metering to measure production and flow at critical nodes. Based on the survey of current assets presented in a separate report, the number of system meters required was estimated at 730 meters for the short term and an additional 490 by 2035. Assuming an average $5,000 per installed meter, the BWE would need to invest about $3.65 million USD to deploy a full metering control solution. In fact, the combination of SCADA and metering is worth studying and albeit the costs may reach double the estimate, it would probably pay for itself as the BWE moves all of its subscriber base to metered connections, especially with every new network being finalized. Production and system metering are a high priority and should be considered for execution in the short term.

As for the deployment of meters to subscribers, this should be carried out concurrently with the construction of new networks. Deployment of meters to existing networks should be considered carefully in light of the ability of the BWE to control non-revenue water and to enforce collection.

Successful customer side metering and subsequent tariff adjustment are contingent on the two essential conditions: (i) the availability of water supply or the ability of the BWE to supply sufficient and controlled amounts of water, (ii) the possibility of collecting subscriptions or enforcing the collection of subscription and water bills by the BWE, (iii) and the establishment of a unit at the BWE dedicated to the operation and management of the metering infrastructed. The average collection rate of the BWE falls below 50% in most of its service regions with very large disparities in collection among regions and villages. In some of the poorest communities the collection rates drop as low as 12%. Following the general recommendation of the MEW, it is proposed to install customer meters starting from those areas that have had their networks rehabilitated or rebuilt anew and where it is possible for the BWE to supply water in sufficient quantities with minimal losses. The promise of quality service combined with new networks would create the required incentive for subscribers to pay, and for unconnected or illegally connected households and businesses to subscribe and pay.

Plan 2-3 proposes a phasing plan in three levels of priority. All recently completed projects, projects under construction, such as in West Bekaa or Rachaiya, and projects slated for construction during the next year, such as Zahle, are priority level 1 to be provided with meters as completed networks come into operation. Priority levels 2 and 3 correspond to the priorities of capital investments in rehabilitation and extension of systems, and are tied into them. As newly rehabilitated or constructed networks come into service they should be provided with customer side metering to go along. The cost estimate of consumer metering is included in the capital cost of each proposed project.

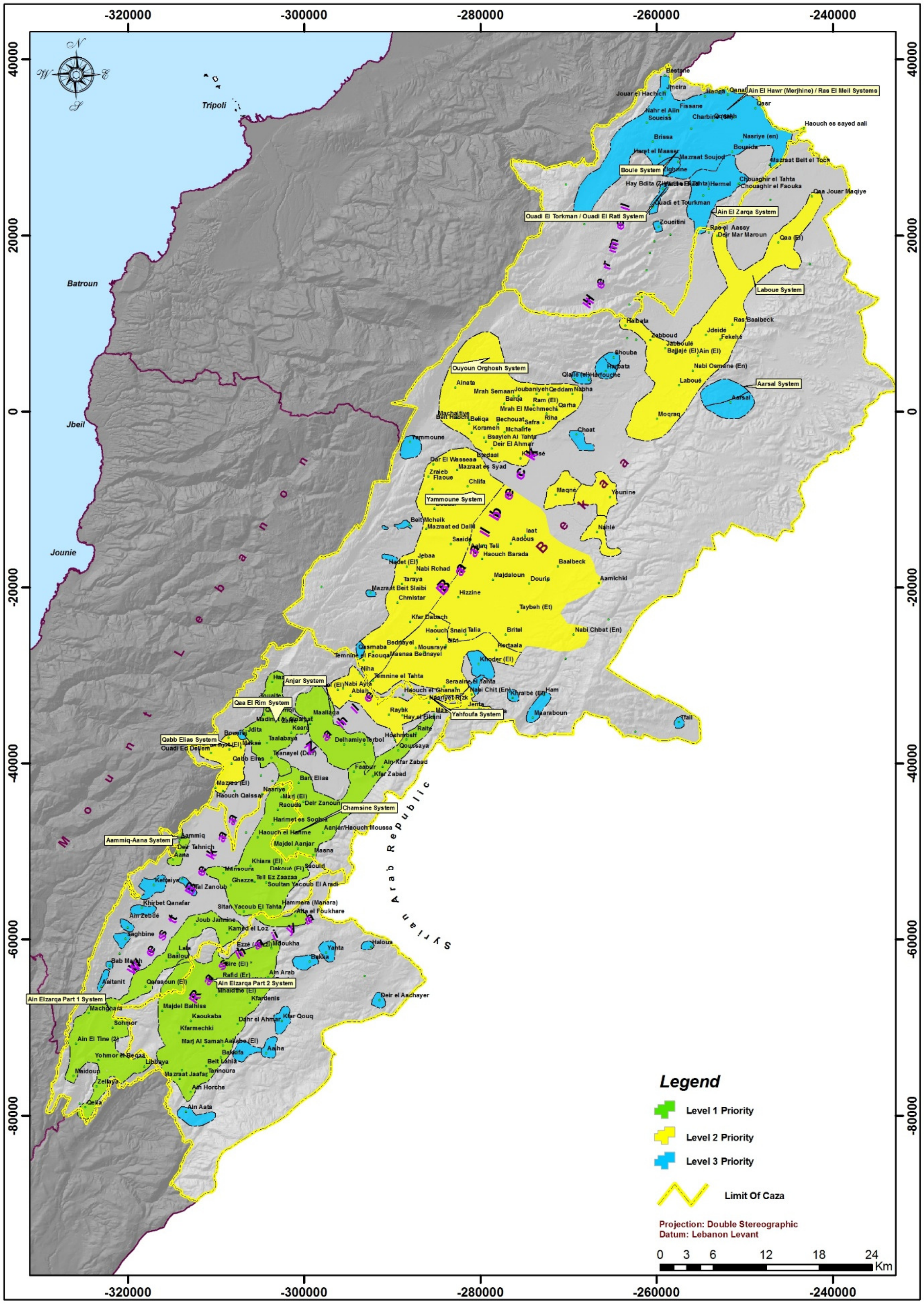
## 2.6 Concluding Remarks and challenges Faced by the BWE in the Water Sector

The BWE faces multiple challenges in the operation and management of its water supply and distribution systems. The main challenges can be summarized as follows:

- Old networks and infrastructure in need of rehabilitation or replacement
- Incomplete information on the engineering and operational characteristics of the systems it operates
- Service coverage does not reach all of the Bekaa population and localities
- Service interruptions and water shortages in many systems due to insufficient water supply or electrical power interruptions
- Non-revenue water represents a large fraction of the production
- Low to very low collection rates
- Severe shortage in human resources and the need for quality staff
- Dependence on central government financial support and international aid due to insufficient income and large systematic budget deficit

The current study has proposed a capital investment and priority action plan for the supply of water to the projected population of the Bekaa with 2035 as the planning horizon. The strategy under this capital investment plan for water supply has concentrated on combining systems where possible and on shifting as much of the supply sources from wells to springs in line with the NWSS and in order to reduce pumping and electrical power dependence to a minimum. Many of the existing wells would be kept as back up supply sources to be used only in emergencies or severe drought periods. The details of each proposed system and the transition from current supply sources to proposed sources are to be developed through specific detailed feasibility studies and their construction contingent on the availability of funds.

Independent of the implementation of the proposed capital investments, the issue of water metering is critical as it addresses the fundamentals of water utility management and it needs to be addressed separately and immediately. Metering is twofold: supply side and customer side. On the supply side it is necessary to meter production, main transmission lines, reservoir in/out flows, service nodes, and district nodes in order to measure production, control supply, and identify losses. On the customer side, it is necessary to meter subscribers' consumption for tariff setting and fair distribution of costs among consumers.




*PLAN 2-3: WATER SYSTEMS CUSTOMERS METERING PRIORITES IN THE BEKAA*

# 3 WASTEWATER SYSTEMS

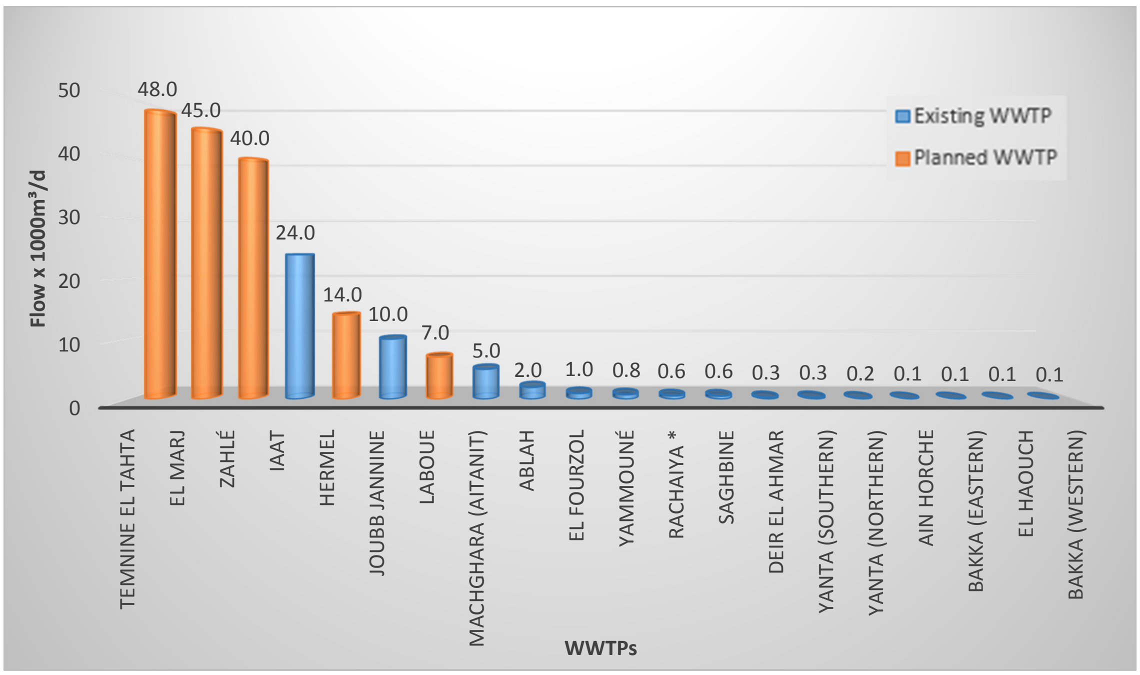
## 3.1 Existing Situation

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. Field visits were conducted to all existing facilities and the results were presented in the Wastewater System Assessment Report in 2013. The main findings of this report were 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 sewer networks for some areas in the Bekaa (14% of the villages corresponding to 11% of the population). However these investments 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 to the groundwater and a potential health threat to the resident population.
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 WWTP's at Joubb Jannine and Machghara are small facilities serving one or more small villages. Some of these WWTP's 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 major 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 3-1 shows the design capacity of the existing wastewater treatment plants and those planned by the CDR for the year 2020 horizon. The six WWTP's 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 WWTP's, Iaat, Joubb Jannine, Yammouné and Saghbine have been built by the CDR under World Bank and Islamic Development Bank funding. The remaining WWTP's 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 3-1: EXISTING AND PLANNED WWTPS AND THEIR DESIGN CAPACITY IN THE BEKAA***

### 3.2 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. The generated flows of wastewater were 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 month wet season.

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 population estimates calculated in the corresponding reports, which would correspond to the full summer population, were used for the calculation of wastewater flows.

Table 3-1 presents the estimated current and projected generated wastewater flows per Caza based on the water demand per capita per day and the projected populations to be serviced by the year 2035 design horizon.

**TABLE 3-1: 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:

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

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

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

### 3.3 Wastewater Treatment Alternatives

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 aimed 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 were used in the study:

- The wastewater inflow is domestic in nature. Industrial wastewater shall be pre-treated at the facility of the generator 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 power supply 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.
- WWTP's 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.

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

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

The procedure for selecting the treatment process was 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.

## 3.4 Proposed Scheme

The first 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. In that master plan, 14 WWTP's were proposed. The master plan population projections were updated in 1994 by K&A for the MOE and the recommendations for the Bekaa essentially remainded 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 WWTP's across the Bekaa located optimally close to the populations served. The proposal was consolidated into a second alternative containing 50 WWTP's. The plan was abandoned given the high land area requirement and the unavailability and difficulty of locating and expropriating open land of sufficient area.

### 3.4.1 Current Condition Assessment

There are fifteen WWTP's 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. As a result of the master planning process and based on technical and economic considerations, it is proposed to expand the service area and hence the capacity of some of the existing WWTP's, whereas it is also proposed to replace or integrate the service areas of some smaller WWTP's into larger ones for economies of scale.

Six WWTP's are planned by the CDR for its 2020 horizon and are all medium to large capacity facilities 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.

### 3.4.2 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:

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

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 WWTP's 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.

WWTP's were located based on the principle of maximizing gravity flow to avoid pumping stations. The design horizon for the WWTP's was 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 lines 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 WWTP's of various sizes was investigated and discussed with the BWE. As a result of these discussions, a second alternative based on 36 WWTP's 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 flow 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. CDR planned WWTP's (Rachaiya and Laboue) which are still at conceptual stage have been included in the proposed new WWTP's with modifications. The proposed consolidated 26 WWTP's 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.

### 3.4.3 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. Based on the cost analysis developed in the study, the 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, 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, under the study, by any planned or proposed treatment plants are recommended to be serviced by individual septic tanks with leaching 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 leaching field in the Bekaa and often overflow in the nearby open land. Some have perforated sidewalls or bottoms to promote direct leaching to the surrounding soil.

### 3.4.4 Rational for Determining the Need for Networks

Plans showing all existing sewer networks were included in the assessment report and included in the GIS database. The condition of these networks was established according to their age and the descriptions provided by the municipalities of the description of their status. Tables listing sewer network length and condition in villages are included for each caza. The sewer network conditions were divided into 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. Table 3-2 presents a summary of the sewer network lengths needed per caza broken down in categories of new, rehabilitate and replace. A total of approximately 4,200 km of networks would be needed by 2035 with 3,400 km of new networks to be built by the design horizon.

***TABLE 3-2: 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** |

### 3.4.5 Service Coverage under CDR and Master Plan Study Investment Program

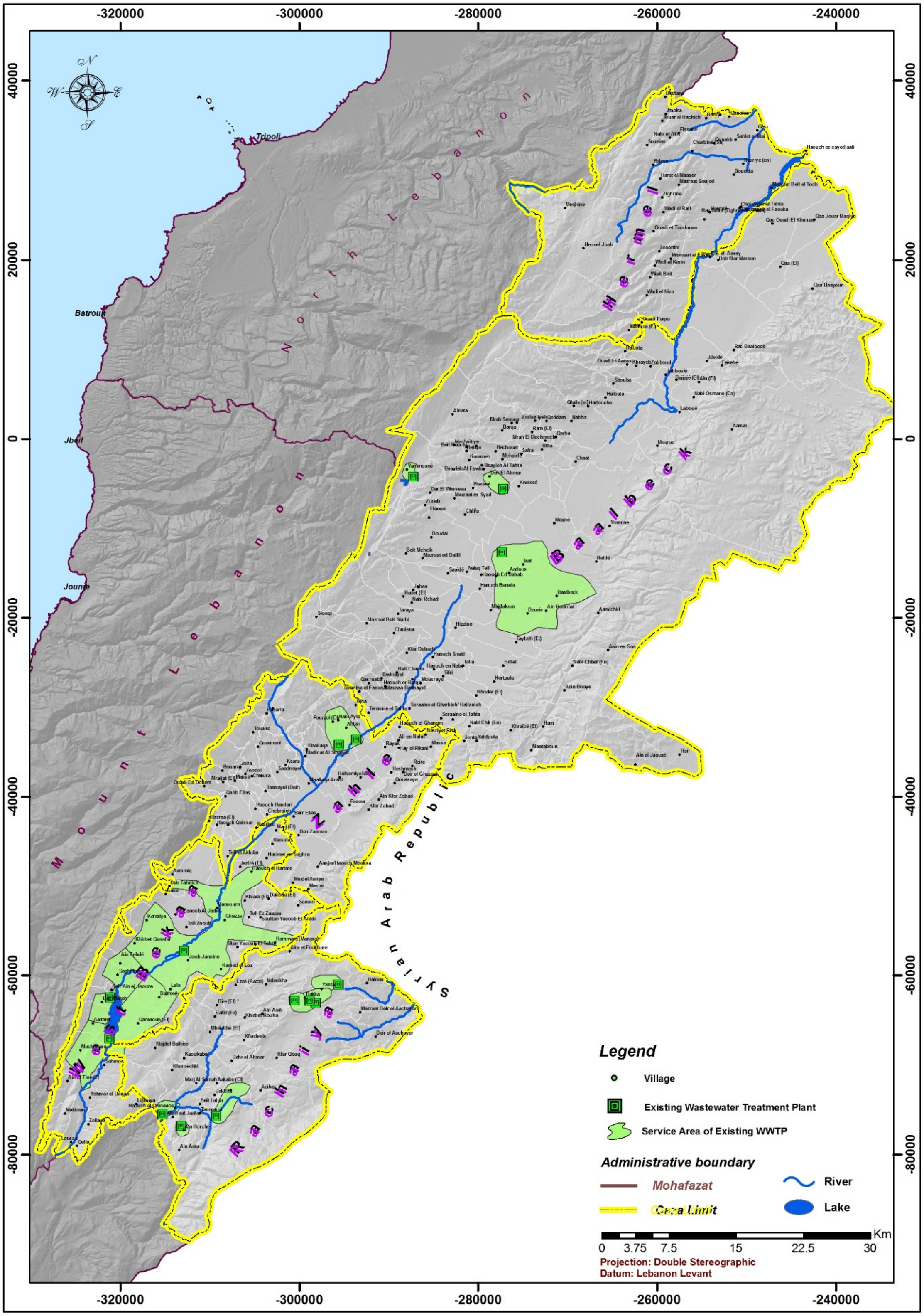
The first 10 WWTP's, which are either existing, under construction or planned by the CDR, with their proposed treatment capacity extensions, would serve about 70% of the population by 2035. The 26 additionally proposed plants under this study would serve another 27% of the population by 2035. The remaining 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 leaching fields. A summary of the service coverage reached by Caza is presented in Table 3-3 for the 2035 projected population.

***TABLE 3-3: SUMMARY OF THE SERVICE COVERAGE REACHED IN THE BEKAA IN 2035***

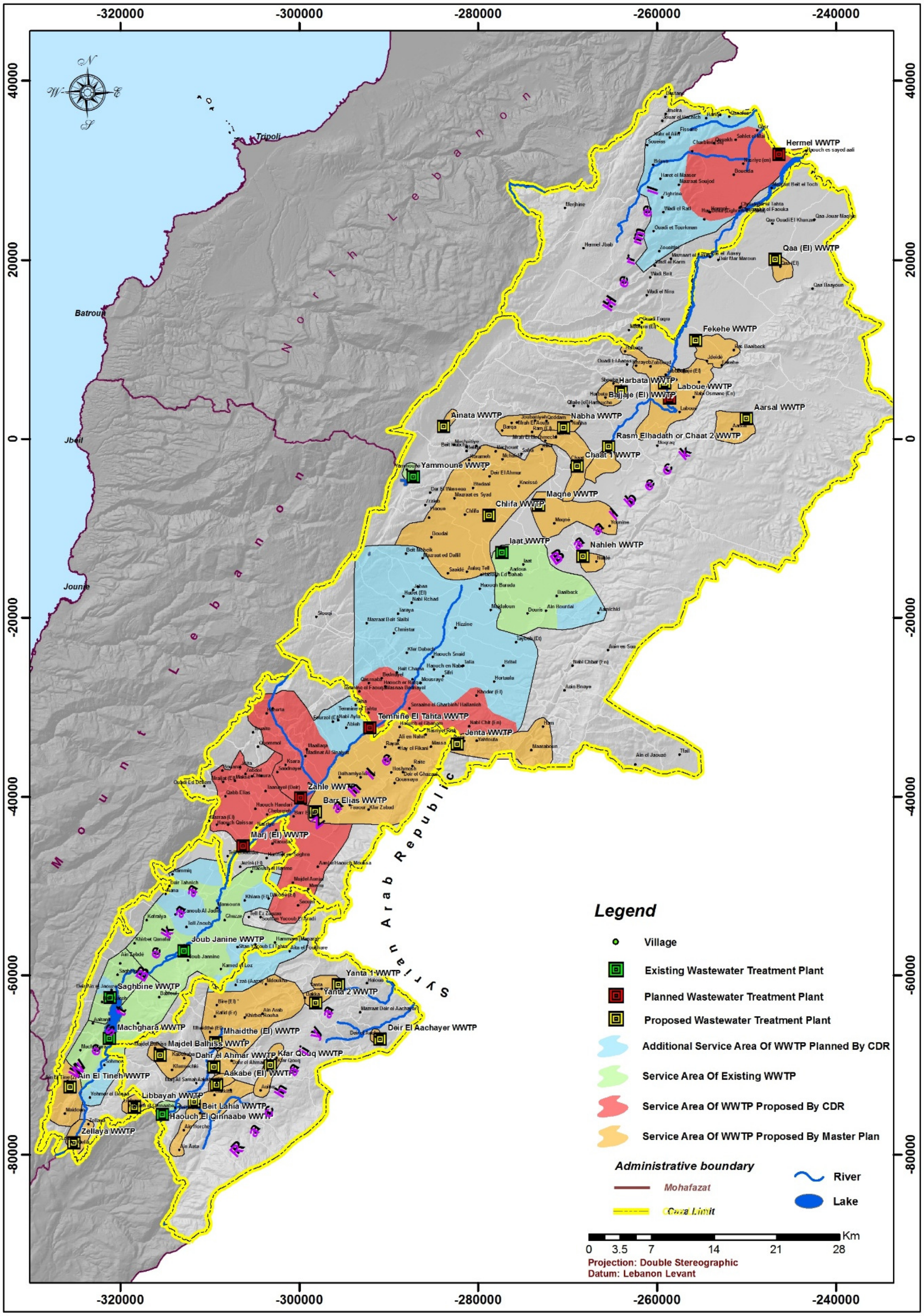
| Caza | Population Served by Existing WWTPs | Population Served by CDR Planned WWTPs | Population Served by Proposed WWTPs | Total Served Population By Master plan | Total 2035 Forecasted Population | Percent Service Coverage (%) |
|---|---|---|---|---|---|---|
| **Hermel** | --- | 76,499 | 34,426 | 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 3-1 attached presents a general view of the current situation of the wastewater systems over the area of the Bekaa in 2015.

Plan 3-2 attached presents a general view of the wastewater systems by the design horizon of 2035.




**PLAN 3-1: WASTEWATER SYSTEMS FOR THE BEKAA**




**PLAN 3-2: WWTPs AND THEIR SERVICE AREAS IN THE BEKAA**

## 3.5 Cost Estimate

The different cost components of WWTP's were calculated per type of treatment process and for service populations between 500 and 100,000 capita. A twenty year lifetime cost was also calculated to compare the total costs and select the most economical process function for the population served. The capital and operational cost components were used to estimate the capital investment and operation and maintenance costs for the proposed WWTP's. These cost components are:

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

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 electro-mechanical equipment. The operation and maintenance yearly costs as well as the power cost were calculated separately for each WWTP.

The cost of sewer collection networks and the cost of interceptor lines proposed to collect the wastewater and convey it to the WWTP's was estimated as a function of pipe diameter and diameters were estimated based on projected flows.

The capital investment and operation and maintenance costs for the 26 additional proposed WWTP's, beyond the ones planned by the CDR, as well as the proposed additions in capacity to existing and planned WWTP's, were detailed in the relevant report. 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 3-2. 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 and reducing the reliability of the collection systems.

The capital investments in sewer networks were also detailed caza by caza and broken down by 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.

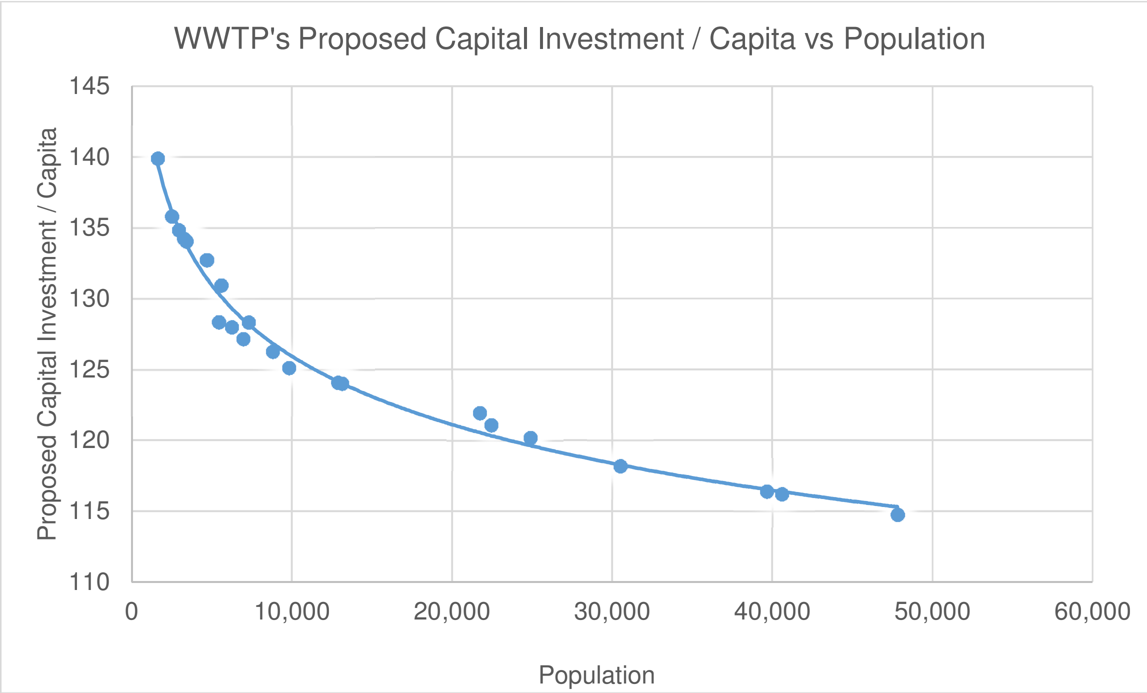



***FIGURE 3-2: CAPITAL INVESTMENT FOR PROPOSED WWTP's/ CAPITA vs POPULATION***

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 3-4. They are worth an estimated net total of 261 million USD (276 million USD total as per Table 3-4 out of which 15 million USD are earmarked for water projects. 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 exist. Of these, it was estimated that about 91 million USD would be reserved for the construction of the WWTP's 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 and 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 WWTP's, 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 estimates presented are in constant dollars calculated on the basis of 2013-2015 prices.

***TABLE 3-4: SUMMARY OF TOTAL COST OF CDR PLANNED PROJECTS IN THE BEKAA***

| List of CDR Projects in Beqaa Caza until year 2020 (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 (1) | 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 (2) | 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. (3) | 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 (4) | 29,142,755 | Italian Protocol 97 | 24,326,714 | 4,816,041 | --- |
| | 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 (5) | 47,250,000 | Italian Protocol | 47,250,000 | --- | Waiting for the approval of the funding agency to start the bid. |

| List of CDR Projects in Beqaa Caza until year 2020 (Under execution and preparation ) | | | | | | |
|---|---|---|---|---|---|---|
| Caza | Project Name | Cost ($) | Source of External Funding | Amount of External Funding ($) | Amount of Local Funding* ($) | Comments |
| | | | | | | |
| | 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 (6) | 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.

(1) Corresponds to Hermel WWTP
(2) Corresponds to Laboue WWTP
(3) Corresponds to Temnine El Tahta WWTP
(4) Corresponds to Zahle WWTP
(5) Corresponds to El Marj WWTP
(6) Corresponds to Rachaiya WWTP

Table 3-5 presents a summary of the capital cost of the WWTP's and networks showing the value of the CDR planned funding caza by caza. The last line of Table 3-5 shows the funding gap or the remaining capital cost to be secured by the BWE for the completion of the proposed master plan.

***TABLE 3-5: 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 3-3 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.

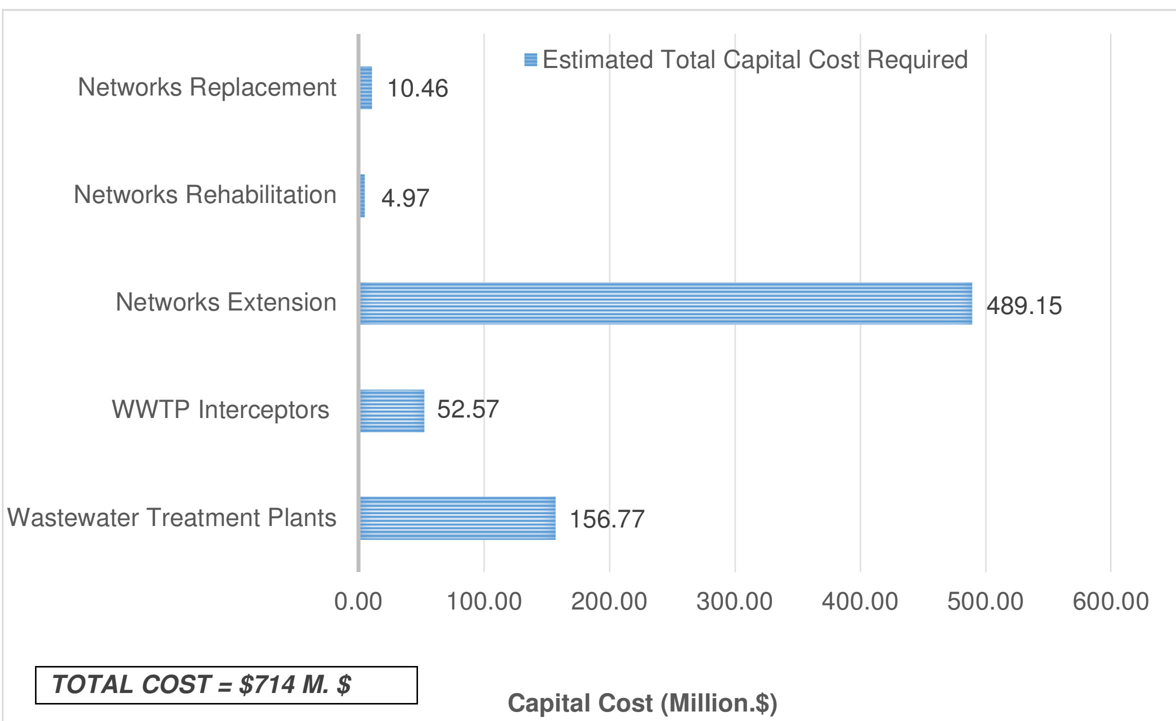



***FIGURE 3-3: THE DISTRIBUTION OF COSTS FOR WWTPS AND NETWORKS IN THE BEKAA BY YEAR 2035***

## 3.6 Priority Action Plan and Concluding Remarks

### 3.6.1 Overview of Wastewater Master Plan

A master plan for wastewater collection and treatment has been proposed for the Bekaa that 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 wastewater flow to the WWTP's 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 small number of remote and sparsely populated villages that will rely on properly designed septic tanks with leaching fields. Detailed cost estimates were developed for all the cost components of the WWTP's 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.

### 3.6.2 Challenges of Delayed Action and Setting of Priorities

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 WWTP's, and the sewers 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 WWTP's 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 year 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.

### 3.6.3 Capital Investment Estimates by Phase and Caza

Figures 3-4, 3-5 and 3-6 present the Priority Level assignment for each of the proposed wastewater treatment plants presented in the Master Plan. The color of the capital cost bar distinguishes in which caza the WWTP is located.

Figure 3-4, 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 include the cost of the interceptor sewers needed to transport the wastewater from the villages/municipalities they serve to the WWTP.

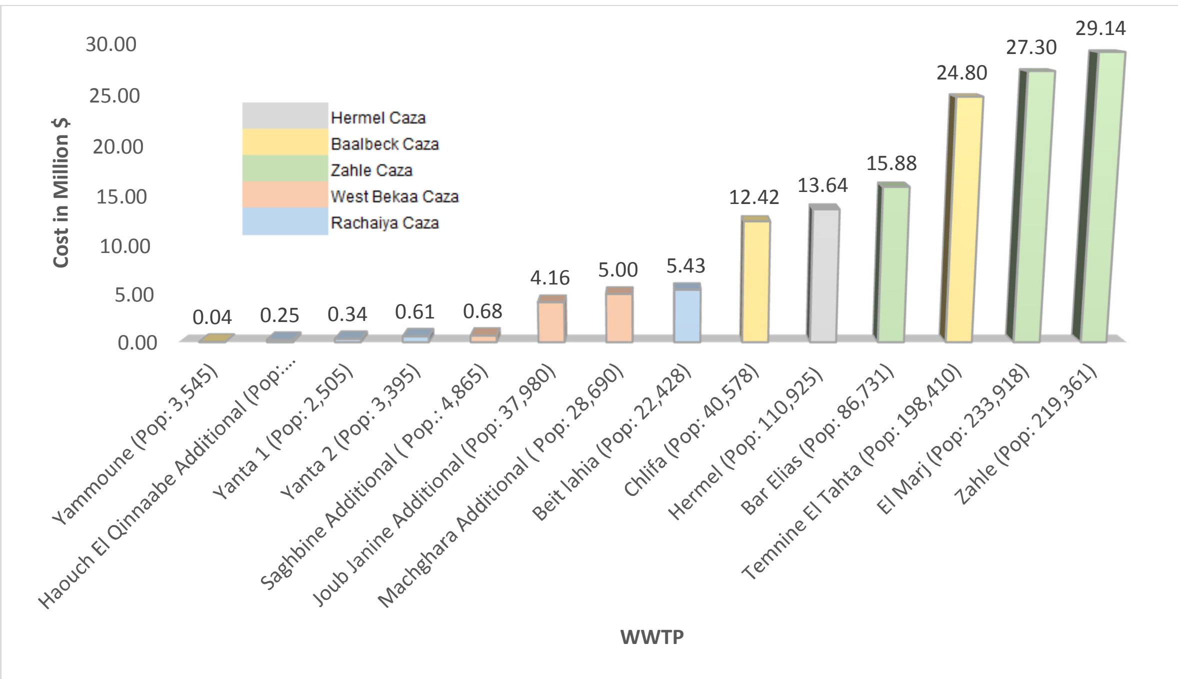



**FIGURE 3-4: COST ESTIMATION OF WWTPS AND THEIR CONNECTING INTERCEPTORS – LEVEL 1 PRIORITY**

Figure 3-5 similarly presents the Level 2 Priority WWTP's that are proposed in the Master Plan for Medium Term Action ((2025-2030); and Figure 3-6 similarly presents the Level 3 Priority WWTP's assigned to Long Term Action (2030-2035).

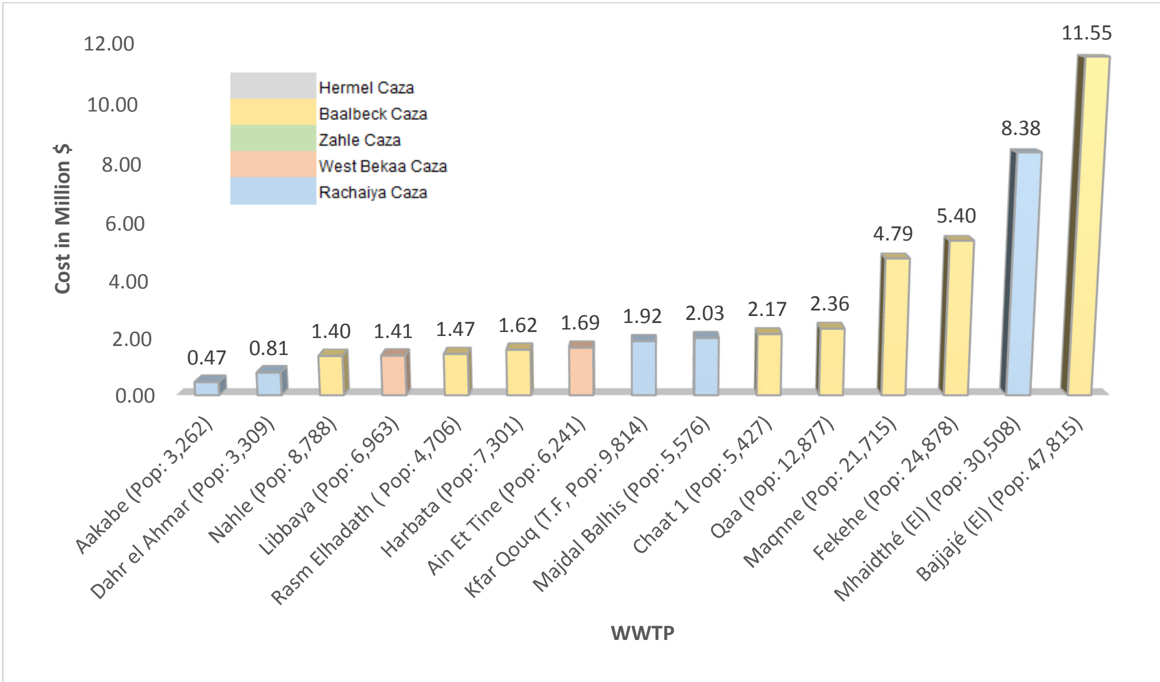



***FIGURE 3-5: COST ESTIMATION OF WWTPS AND THEIR CONNECTING INTERCEPTORS – LEVEL 2 PRIORITY***

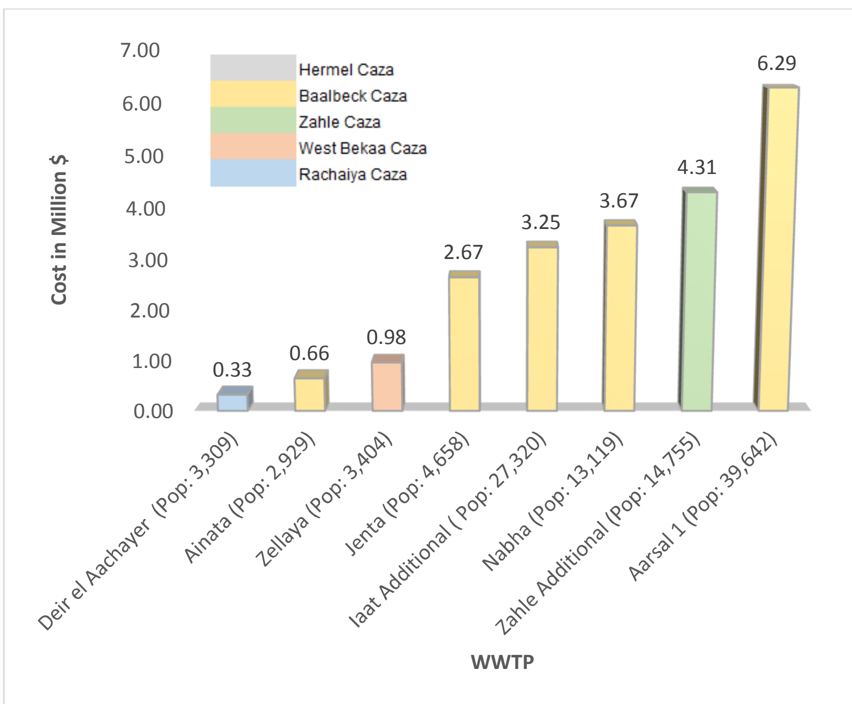
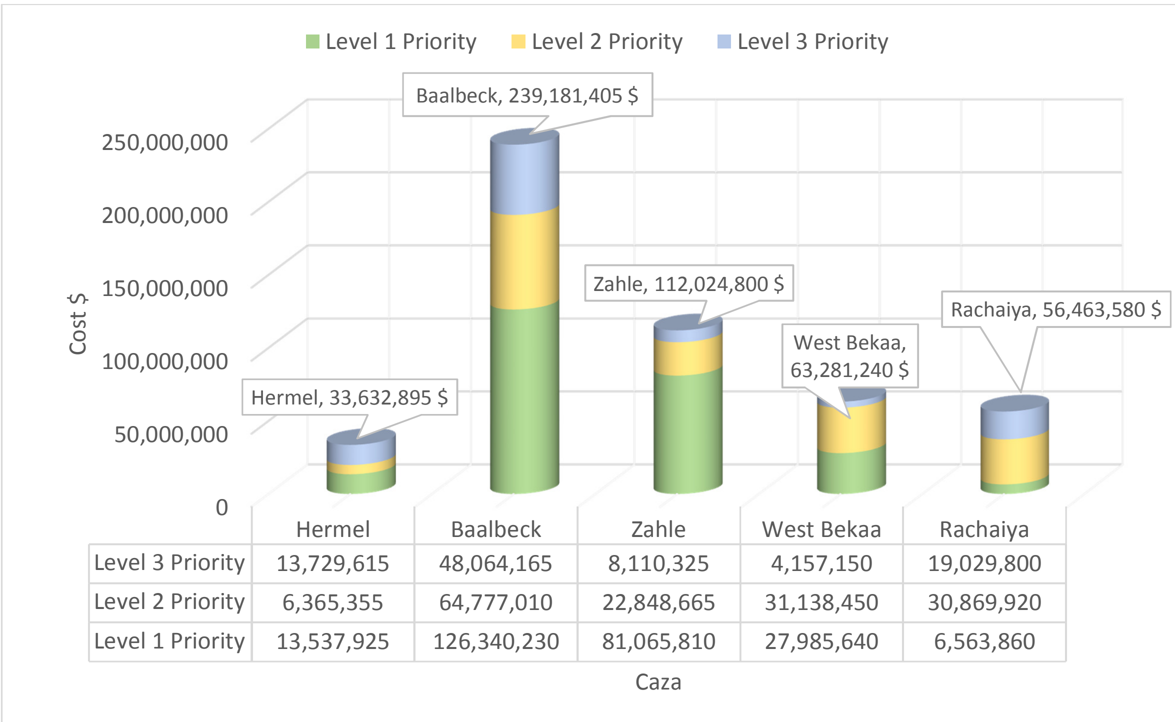



***FIGURE 3-6: COST ESTIMATION OF WWTPS AND THEIR CONNECTING INTERCEPTORS – LEVEL 3 PRIORITY***

To graphically reflect the phasing of capital investments in sewer networks, by investment amount and by caza, Figure 3-7 has been color coded to distinguish Priority Levels as follows:

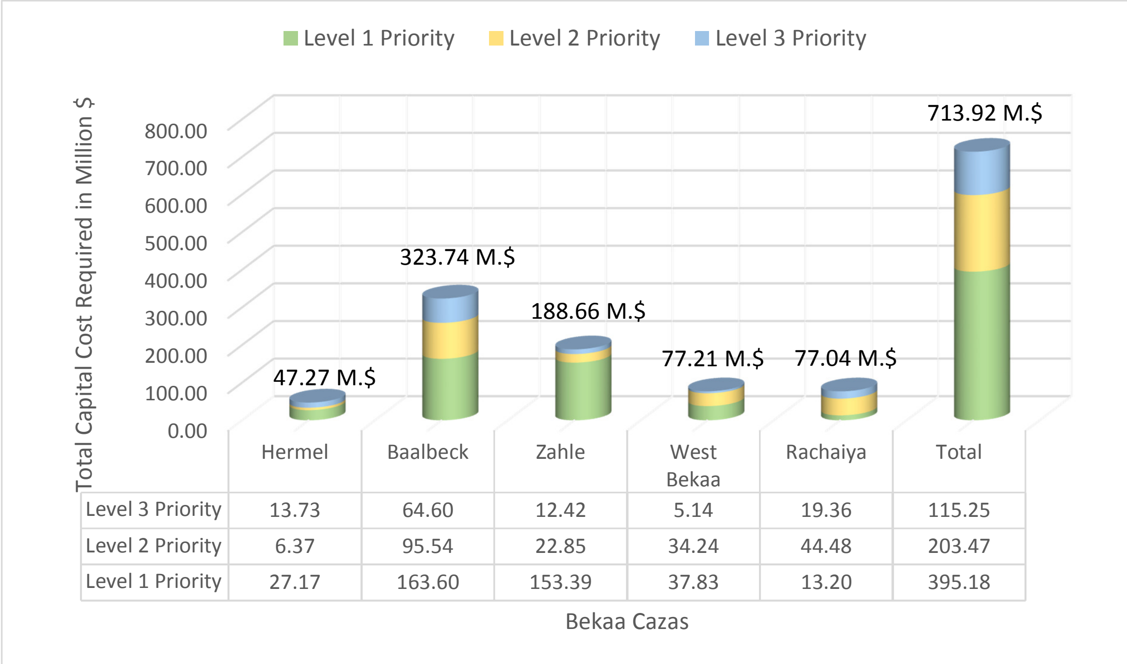
- Level 1 – Green
- Level 2 – Yellow
- Level 3 – Blue




| | 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 3-7: ESTIMATED CAPITAL COST WITH PRIORITY LEVELS FOR THE SEWER NETWORKS IN THE BEKAA***

Figure 3-8 uses the same color coding as Figure 3-7 to present the total capital investment in WWTP's 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 3-8: ESTIMATED CAPITAL COST WITH PRIORITY LEVELS IN THE BEKAA BY YEAR 2035 FOR WASTEWATER SECTOR***

The following Figures 3-9, 3-10, and 3-11 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.

Figures 3-9 shows the number of WWTP's 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.

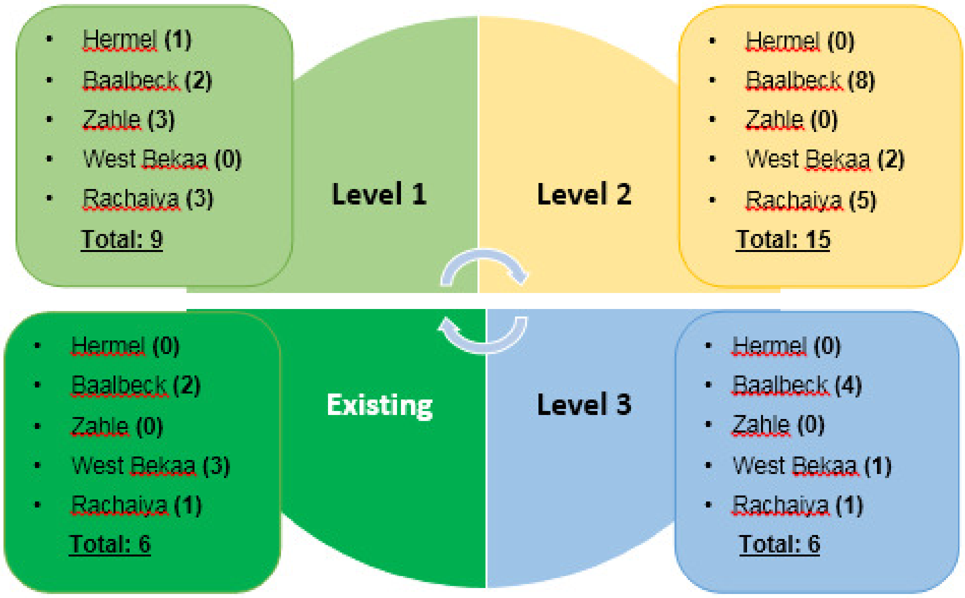



***FIGURE 3-9: PRIORITY LEVEL OF THE BEKAA WWTPs***

Figures 3-10 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 residents of the Bekaa or two thirds of the year 2035 design population, will be served 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 leaching field systems.

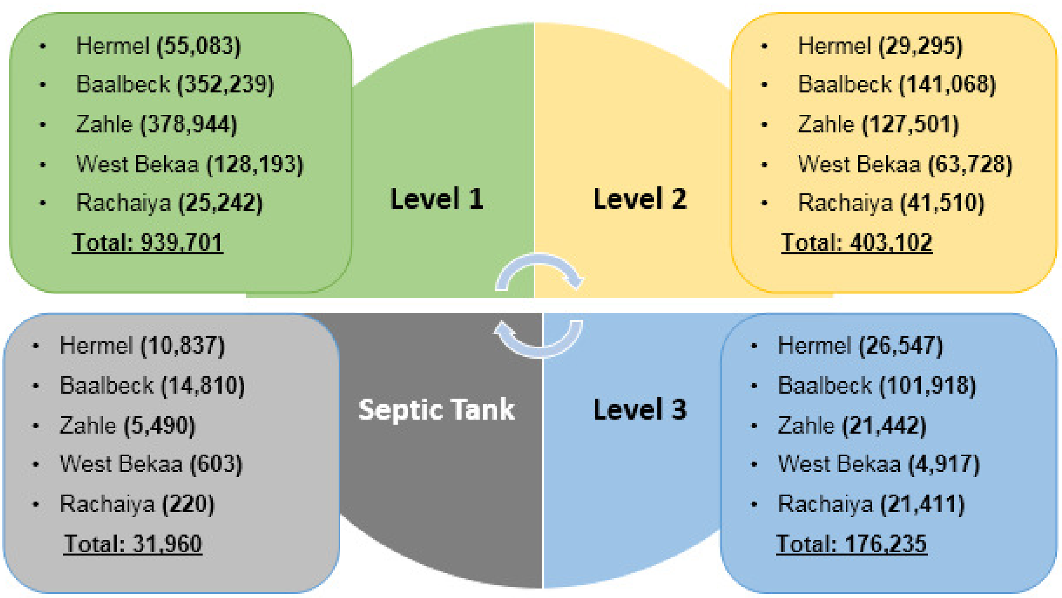



***FIGURE 3-10: POPULATION SERVED BASED ON PRIORITY LEVEL OF THE BEKAA WWTPs***

Figures 3-11 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.

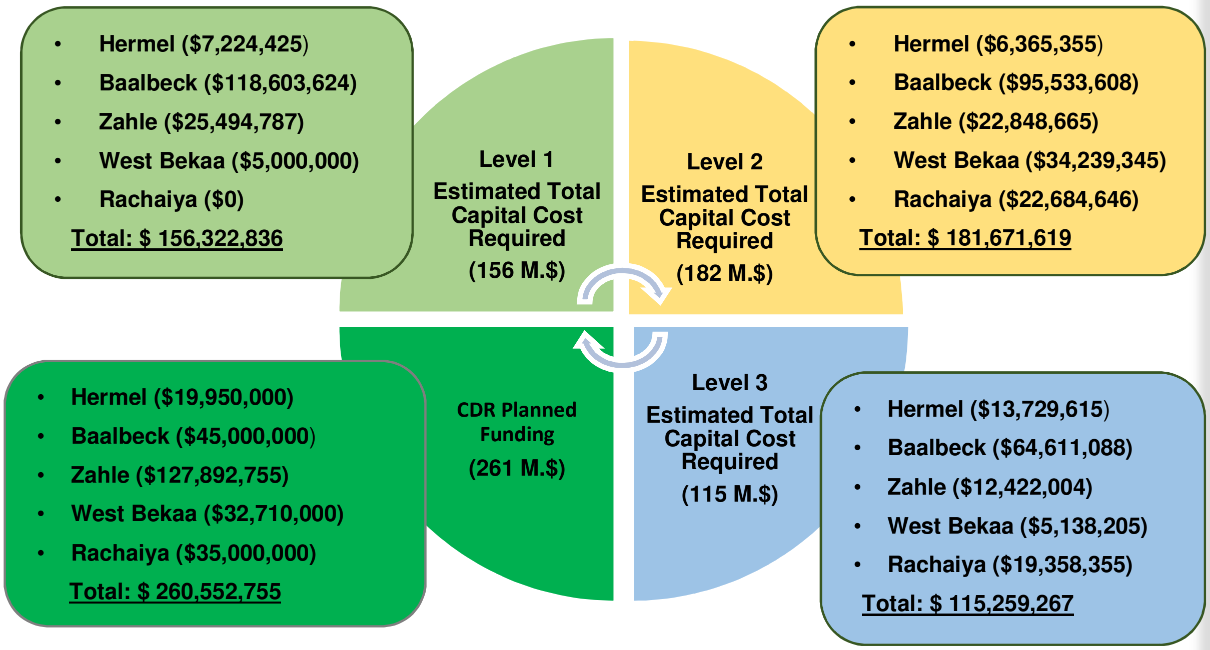



***FIGURE 3-11: PRIORITY ACTION PLAN FOR THE BEKAA MOHAFAZA***

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 year 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. 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 are estimated at around 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.

### 3.6.4 Cost Impacts to Residents

The BWE is mandated by its legal statutes to lay out strategies and develop a 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/year to above $40 USD/capita/year with an average of about $30 USD/capita/year. This cost includes the operations and maintenance estimated at about $10 to $12 USD/capita/year 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 per year.

### 3.6.5 Organizational and Management Issues

Concurrently with the activities recommended under this study, the BWE must address pressing organizational and management issues which can be summarized as follows:

- The BWE would need to develop its human resources to operate and manage the wastewater systems by amending its organizational structure to include wastewater services, developing job descriptions, hiring, training and retaining qualified personnel;
- The BWE would need to set out its sector management strategy, layout practices and develop the detailed procedures for operating and maintaining the wastewater infrastructure;
- The BWE would also need to adopt systematic business planning that integrates cost recovery strategies, external funding contributions and provides for a new tariff structure.

Most of these organizational and management challenges need to be also addressed in the water sector.