Chapter-III
Action Plan on Water Supply

Improvement target of MCWD water utility is to achieve the management of water supply system meeting with service standards providing in terms of water quality and quantity. Improvement items are proposed as the action plan which can solve the gap between the present situations (referred to Chapter-II) and what MCWD should be in the target year 2015.

This plan was composed of following sections with major purposes.

Chapter III-1: Planning Fundamentals

It is aimed to settle the fundamental indicators for abstraction of required items to be improved by the action plan. It includes the demand projection and the demand-supply water balance as main examinations.

Chapter III-2: Requirements for Technical Improvement

The aims of this section are to increase water supply volume to meet projected water demand in 2015 and to achieve water supply service level. Process of designing study is to examine (1) design concept, (2) design criteria and (3) comparison of alternative designs.

Chapter III-3: Requirements for Managerial Improvement

Required items were proposed that can manage and operate properly the improved water supply system and facility for maintain the water supply services.

Chapter III-4: Initial Environmental Examination

Subjects of study and required formalities are examined before implementation of the improvement projects.

Chapter III-5: Project Implementation

This part includes; (1) the cost estimation of the improvement projects and (2) the selection of priority projects. The annual plan of priority projects was examined and proposed.

Chapter III-6: Financial Feasibility

Financial conditions for implementing the priority projects and financial improvement by the implementation of priority projects were examined.

III-1 Planning Fundamentals

III-1.1 Water Demand Projection

(1) General Background

Water demand projection is a fundamental factor for determining the scale of a water supply system in the target year. While the target year for the improvement plan of water supply and sanitation in Metropolitan Cebu is set at 2015, the water demand projection for the further 15 years (i.e. until 2030) is also carried out in order to view the long-term water supply and sanitation situations in the project area. It is noted, however, the long-term demand projection should be regarded only as a referential future scenario.

The existing studies of water demand projection in recent years include MCWD demand projec-

tion and Water Resources Management Action Plan for Central Cebu 2005-2030 (Water Remind Project) as follows:

- MCWD demand projection
  This projected the total and niche demand in the MCWD franchise area up to 2028. However, the basic assumptions employed in the study are old dated (e.g. population data: 2000 NSO census, other parameters: 1995 survey result) and need to be updated.
- Water Remind Project
  The Project includes a water demand projection in Central Cebu up to 2030, which is the latest demand study among others. However, the baseline data of population rely on the 2000 NSO census, and some discrepancies are found in the population projections compared to the 2007 NSO census data.

Utilizing latest available data, this section will review the water demand projection conducted by such existing studies.

In general, existing consumption data of the water users are served as a baseline of the demand projection. MCWD classifies the water users into three main categories, namely, domestic, commercial and industrial, and government institutions. Therefore, water demand in these three categories is projected separately, and summing up the respective demand, the total demand is estimated.

In addition, both the total and niche water demand are projected in accordance with the following definition (referred to Figure III-01).

- Total Demand
  Water demand in the whole MCWD franchise area of 4 cities and 4 municipalities
- Niche Demand
  Water demand in the existing service area of MCWD plus that in the un-served areas where peoples are willing and/or opt to connect to MCWD

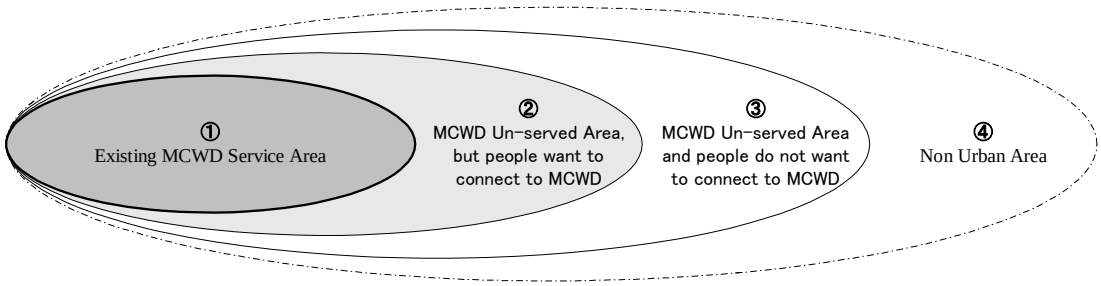


Figure III-01 Definition Image of Total and Niche Water Demand

The total demand is not directly related to the MCWD's business because there are a lot of private water venders and water supply facilities in addition to MCWD in Metropolitan Cebu and a considerable number of households and commercial establishments rely on water from such vendors/facilities. On the other hand, the niche demand will give the basis of the future scale of MCWD's water supply systems.

The methodology of demand projection is summarized as presented in Figure III-02.

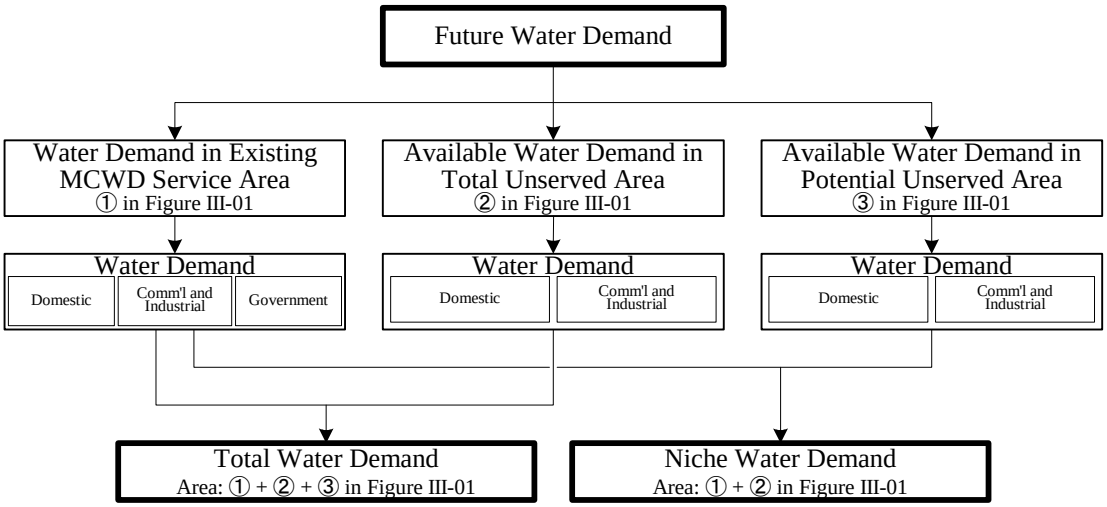


Figure III-02 Methodology of Water Demand Projection

(2) Domestic Water Demand

< Population Projection >

- Total Population

Table III-01 (next page) shows the population transition of Metropolitan Cebu in the past 12 years based on the NSO census data. The population of Metropolitan Cebu has increased from 1.30 million in 1995 to 1.85 million in 2007, which gives an average annual growth rate of 3.0%.

However, the annual growth rate from 2000 to 2007 has decreased compared to that from 1995 to 2000 in all cities and municipalities. This implies that the population growth has certain saturation due to the limited habitable space.

The Water Remind Project assumes the population growth rate during 2005-2030 to be 1.6-3.2% depending on the cities and municipalities considering that the growth in the dense areas will decline (saturated growth), while in the less dense areas the growth rates will be fairly constant.

Table III-01 Population and Its Growth Rate in Past 12 Years

LGUs	Census Record			Average Annual Growth Rate (%)		
	1-Sep-95	1-May-00	1-Aug-07	1995-2000	2000-2007	1995-2007
Cebu City	662,299	718,821	798,809	1.77	1.46	1.58
Lapu-lapu City	173,744	217,019	292,530	4.88	4.20	4.47
Mandaue City	194,745	259,728	318,575	6.36	2.86	4.22
Compostela	26,499	31,446	39,167	3.73	3.07	3.33
Consolacion	49,205	62,298	87,544	5.18	4.80	4.95
Cordova	26,613	34,032	45,066	5.41	3.95	4.52
Lilo-an	50,973	64,970	92,181	5.33	4.94	5.10
Talisay City	120,292	148,110	179,359	4.56	2.67	3.41
Total	1,304,370	1,536,424	1,853,231	3.57	2.62	2.99

Source: NSO census

Regarding Cebu City and Talisay City, however, the assumed growth rates are considered as overestimated because these rates exceed the actual growth rates during 2000-2007.

Therefore, the actual growth rate during 200-2007 is adopted in the population projection for Cebu City and Talisay City, while assumptions in the Water Remind Project have been employed for other cities and municipalities. Thus, the future population is projected as presented in Table III-02.

Table III-02 Population Projection

LGUs	2007	2010	2015	2020	2025	2030	Assumed Growth Rate
Cebu City	798,809	834,300	897,000	964,400	1,036,900	1,114,900	1.46 %
Lapu-lapu City	292,530	321,100	375,200	438,300	512,100	598,300	3.16 %
Mandaue City	318,600	344,300	391,800	445,900	507,400	577,500	2.62 %
Compostela	39,167	42,500	48,700	55,900	64,000	73,400	2.77 %
Consolacion	87,544	91,800	99,500	107,700	116,700	126,400	1.61 %
Cordova	45,066	47,600	52,000	56,900	62,200	68,100	1.81 %
Lilo-an	92,200	98,900	111,100	124,800	140,300	157,600	2.36 %
Talisay City	179,359	194,100	221,400	252,600	288,200	328,800	2.67 %
Total	1,853,231	1,974,600	2,196,800	2,446,700	2,728,000	3,045,000	2.19 %

The population in Metropolitan Cebu will increase from 1.8 million in 2007 to 2.2 million in 2015, and to 3.0 million in 2030. Cebu City will be the most populated area, followed by the cities of Lapu-lapu and Mandaue. Figure III-03 (next page) shows the visual comparison on population growth of the study area in past and projection.

- Service Population

According to MCWD data (Concessionaire Breakdown Summary), the number of domestic concessionaires in 2007 is 111,898 including communal and subdivision connections. Assuming that every residential connection has an average household member of 5.1, and every communal connection has an average of 52 household users with an average household size of 5.1, the service population in 2007 is estimated at 646,406. This gives a service ratio of 35% against the total population.

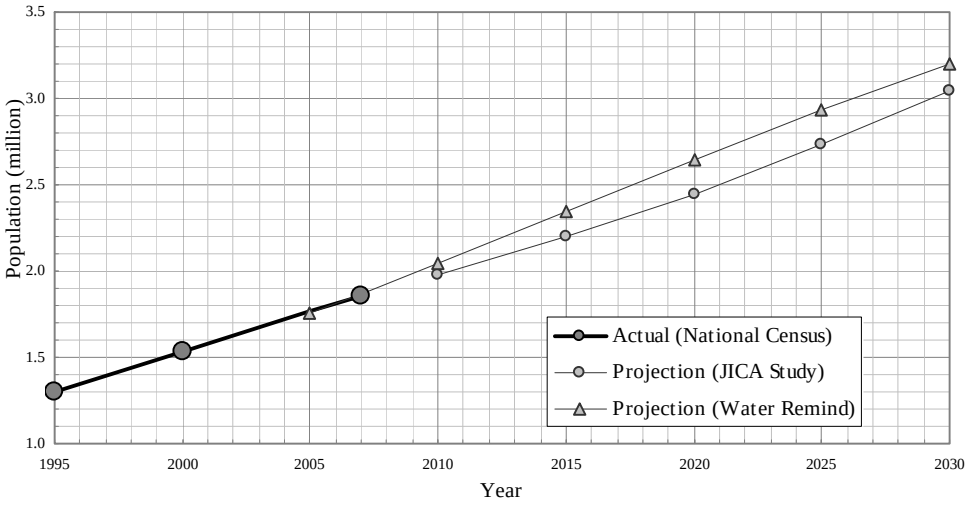


Figure III-03 Population Projection of Metropolitan Cebu

A result of the Household Survey conducted February 2009 shows that 33% households of MCWD non-served area want to connect to MCWD. However, out of the 33% households,

7% households are located in the areas where connection to the MCWD network is difficult due to a topographical reason. For the remaining 26% households, MCWD should expand the service area so that they will be able to have the water supply services in the near future. In estimating the niche domestic water demand, therefore, it is assumed that 26% people of MCWD non-served area will be served by MCWD in the target year of 2015.

In the long-term, this percentage is assumed to further increase by 5% in every 5 years, and the service coverage rate in 2030 is assumed to reach to more than 50%, which is a proposed long-term target of MCWD's coverage.

This proposed target is considered as relevant when compared with a trial estimate based on the past trend as shown in Table III-03.

Table III-03 Trial Estimate of Service Population based on Past Record

Description		Total Population	Service Population	Remarks
Past Record	2000	1,536,424	458,792	*1: 36,787 connection x 5.1 *2: 5.0% × 2.19/2.72 *3: 646,406 × (1.04^{23}-1) Therefore service population in 2030 is estimated at about 1,592,000, which is almost same as the proposed target.
	2007	1,853,231	646,406	
	Increase during 2000-2007	316,807 (2.72%/year)	*1187,614 (5.0%/year)	
Trial Estimate based on Record	Increase during 2007-2030	1,191,769 (2.19 %/year)	*3946,000 (*24.0 %/year)	

Thus, the MCWD service population is estimated at 947 thousand in 2015 and 1,563 thousand in 2030 indicating a MCWD service ratio of 43% and 51%, respectively, as shown in Table III-04 (next page).

In addition, the Household Survey shows that about 40% households of MCWD non-served area are receiving water from neighboring MCWD water consumers. According to the survey, such households are distributed in every area surveyed although the distribution is concentrated in Cebu City and Mandaue City.

Table III-04 Projection of MCWD Service Population

LGUs	2007 Existing	2010	2015	2020	2025	2030
Cebu City	385,499	385,499	432,174	518,489	566,116	622,609
Lapu-lapu City	45,585	74,239	131,285	168,112	215,396	275,514
Mandaue City	109,186	133,638	182,536	214,241	254,136	304,005
Compostela	4,299	5,343	7,892	10,114	13,278	17,753
Consolacion	25,061	32,002	44,415	50,844	58,418	67,218
Cordova	8,314	12,400	19,672	23,473	27,929	33,185
Lilo-an	30,115	33,317	42,756	52,476	72,370	83,149
Talisay City	38,347	54,545	85,941	105,194	129,293	159,175
Metropolitan Cebu	646,406	730,982	946,671	1,142,944	1,336,936	1,562,609
Total Population	1,853,231	1,974,600	2,196,800	2,446,700	2,728,000	3,045,000
Service Coverage	34.9 %	37.0 %	43.1 %	46.7 %	49.0 %	51.3 %

This means there exist further 427 thousand people who use MCWD water indirectly as shown in Table III-05, and accounting this population to be a beneficiary, the virtual MCWD service ratio in 2007 is estimated at 58%.

Table III-05 Estimated No. of HHs and Population of Indirect MCWD Users

①, No. of residential connections in 2007	Neighbouring Barangays of MCWD Service Area in 2007			
	②, Total No. of HHs in Barangays	③=②-①, No. of HHs un-served	④=③×40%, 40% of un-served HHs	⑤=④×5.1, 40% of un-served Population
111,631	320,867	209,236	83,694	426,839

< Per Capita Consumption >

Per capita consumption is a basic parameter for the projection of domestic water demand. Table III-06 shows the record of per capita consumption in recent years.

Table III-06 Per Capita Consumption (Lpcd)

Category of Users	2005	2006	2007	2008	Remarks
Residential	175	175	168	170	Served Population in 2007: 569,319
Communal	16	17	17	15	Served Population in 2007: 60,200

Source: MCWD data

The per capita consumption of residential connections varies in a range of 170-175 Lpcd. As mentioned earlier, this consumption includes that of 40% households of MCWD non-served area. This means that one domestic MCWD user is supplying water to 0.75 household in MCWD non-served area, on average. A result of the Household Survey also shows that these households are using water of 30 Lpcd on average. Assuming that 30 Lpcd is provided by neighboring MCWD water consumers, out of 170-175 Lpcd of residential concessionaires consumption, 147-152 Lpcd is used for their own consumption while balancing 23 Lpcd is supplied to the neighboring non-served people using hoses and containers, etc.

On the other hand, about 10% of the domestic users rely on the communal connections and the per capita consumption is very small showing 15-17 Lpcd, because a small number of communal faucets (in most cases, one to two) are shared by a large number of households. According to the Household Survey, about 70% of communal users have other type of water sources, and they are consuming the total water volume of 25 Lpcd on average.

Regarding the future per capita consumption, its growth would not be expected because the people's water use is considered saturated under the strained situation of developing water resources in Metropolitan Cebu.

In summary, the per capita consumption presented in Table III-07 is adopted for the available domestic water demand.

Table III-07 Adopted Per Capita Consumption for Domestic Demand Projection

Category of Users	Per Capita Consumption	Remarks
Residential	150 Lpcd	90% of available service population
Communal	25 Lpcd	10% of available service population

< Domestic Water Demand Projection >

The available domestic water demand is projected based on the established per capita consumption and available un-served population of MCWD. Adding the water consumption in the existing MCWD service area, the domestic water demand is estimated. Tables III-08 and III-09 show the result of the total domestic water projection and the niche demand.

Table III-08 Total Domestic Water Demand (m^3/day)

LGUs	2007	2010	2015	2020	2025	2030
Cebu City	51,870	56,750	65,372	74,639	84,608	95,333
Lapu-lapu City	30,992	34,920	42,359	51,035	61,182	73,035
Mandaue City	26,278	29,816	36,278	43,786	52,242	61,881
Compostela	1,024	1,282	1,802	2,465	3,294	4,349
Consolacion	7,842	8,427	9,486	10,613	11,851	13,184
Cordova	4,612	4,961	5,566	6,240	6,968	7,780
Lilo-an	2,768	3,968	6,420	9,590	13,702	17,264
Talisay City	17,697	19,724	23,478	27,768	32,663	38,245
Metropolitan Cebu	143,083	159,848	190,760	226,135	266,509	311,071
Existing MCWD	98,705	98,705	98,705	98,705	98,705	98,705
Total Demand	241,788	258,553	289,465	324,840	365,214	409,776

Table III-09 Niche Domestic Water Demand (m^3/day)

LGUs	2007	2010	2015	2020	2025	2030
Cebu City	0	6,418	18,286	24,835	32,603	41,722
Lapu-lapu City	0	3,940	11,784	16,847	23,349	31,615
Mandaue City	0	3,343	10,027	14,361	19,815	26,632
Compostela	0	143	491	795	1,227	1,839
Consolacion	0	949	2,646	3,525	4,560	5,763
Cordova	0	559	1,553	2,072	2,681	3,400
Lilo-an	0	438	1,728	3,057	5,776	7,250
Talisay City	0	2,214	6,506	9,138	12,432	16,517
Metropolitan Cebu	0	18,002	53,020	74,630	102,444	134,738
Existing MCWD	98,705	98,705	98,705	98,705	98,705	98,705
Niche Demand	98,705	116,707	151,725	173,335	201,149	233,443

The total domestic demand in Metropolitan Cebu will increase from 242,000 m^3/day in 2007 to 289,000 m^3/day in 2015, and to 410,000 m^3/day in 2030. On the other hand, the niche domestic demand will increase from 99,000 m^3/day in 2007 to 152,000 m^3/day in 2015, and to 233,000 m^3/day in 2030

(3) Commercial and Industrial Water Demand

The water consumption of MCWD commercial and industrial concessionaires is shown in Table III-10. While the number of connections is decreasing, the water consumption is leveling off, but it has increased in 2008. The commercial and industrial sector in Metropolitan Cebu did not perform considerable growth in recent years. At the same time, it did not show a same increase in water demand as presented in Table III-10. For this reason, the Water Remind estimates the future demand density growth rate of commercial and industrial as 3.2% and 0.69%, respectively.

Table III-10 Water Consumption of Commercial and Industrial Concessionaires

Parameters	2005	2006	2007	2008	Average Growth Rate 2005-2008
No. of Connections	3,529	3,439	3,381	3,369	-1.5 %
Water Demand (m^3/day)	15,157	15,490	15,160	16,714	3.3 %

From the MCWD records, about 13% of the total volume of water was delivered for commercial

and industrial purposes. Many industries still operate their own wells but little information is available on the total water usage.

According to the Establishment Survey conducted in February 2009, 12.8% of the non-MCWD water users want to connect to MCWD. Furthermore, 80% of non-MCWD water users are using water from private wells but 40% of the private wells were drilled without permission. NWRB will strictly regulate such illegal groundwater abstraction in the future. Assuming that the private well users without permission will eventually be served by MCWD, the following percentage of non-MCWD users are expected to be transferred to MCWD consumers.

- 12.8% + 87.2% × 80% × 40% = 40% (in 2015)

Regarding the water demand, even if these water users connect to MCWD, they would keep having the other sources. According to the Establishment Survey, the average daily consumption of MCWD users was as follows:

- MCWD plus other sources: 25.0 m^3/day
- MCWD only: 17.2 m^3/day (68.8 % of the above)

Therefore, 70% of water demand in such users is assumed to be transferred to MCWD. Together with this assumption, the commercial and industrial water demand is estimated utilizing the conditions assumed by the Water Remind Project as presented in Table III-11.

Table III-11 Assumptions for Commercial and Industrial Demand Projection

Descriptions	Assumptions
Total commercial area in 2005 Total industrial area in 2005	370 ha 350 ha
Commercial demand density in 2005 Industrial demand density in 2005	29.26 m^3/ha/day 129.37 m^3/ha/day
Annual Demand Growth Rate during 2005-2030 • Commercial Demand • Industrial Demand	 3.20 % 0.69 %
Percentage of available commercial/ industrial demand within non-MCWD users for Niche Demand	2007: 0.0 % 2015: 40.0 % × 0.7 = 28 % 2030: 60.0 % × 0.7 = 42 %

In Tables III-12 and III-13, the total and niche estimated water demand of commercial and industrial activities are presented respectively.

Table III-12 Total Commercial and Industrial Water Demand (m^3/day)

LGUs	2007	2010	2015	2020	2025	2030
Cebu City	23,858	24,795	26,603	28,411	30,671	32,932
Lapu-lapu City	19,721	20,247	21,288	22,329	23,630	24,932
Mandaue City	21,562	21,973	22,808	23,644	24,671	25,699
Compostela	745	795	890	986	1,123	1,260
Consolacion	515	548	616	685	781	877
Cordova	937	986	1,096	1,205	1,356	1,507
Lilo-an	1,967	2,082	2,315	2,548	2,863	3,178
Talisay City	6,411	6,658	7,164	7,671	8,288	8,904
Metropolitan Cebu	75,715	78,082	82,781	87,479	93,383	99,287

Table III-13 Niche Commercial and Industrial Water Demand (m^3/day)

LGUs	2007	2010	2015	2020	2025	2030
Cebu City	8,475	10,189	13,551	15,034	16,710	18,747
Lapu-lapu City	3,416	5,183	8,420	9,638	10,915	12,453
Mandaue City	1,831	3,946	7,705	9,007	10,305	11,855
Compostela	118	189	334	404	491	598
Consolacion	31	85	195	246	309	386
Cordova	150	238	415	497	597	720
Lilo-an	120	326	735	919	1,138	1,404
Talisay City	1,019	1,611	2,740	3,208	3,716	4,331
Metropolitan Cebu	15,160	21,767	34,094	38,953	44,181	50,494
% of Total Demand	20.0 %	27.9 %	41.2 %	44.5 %	47.3 %	50.9 %

The total demand in Metropolitan Cebu will increase from 76,000 m^3/day in 2007 to 83,000 m^3/day in 2015, and to 99,000 m^3/day in 2030. The percentage of commercial and industrial water demand served by MCWD will increase from 20% in 2007 to 41% in 2015, and 51% in 2030, showing a growth similar to the population in service coverage.

(4) Government Institutions Water Demand

Recent water consumption of government institutions is shown in Table III-14. Although the water consumption tends to increase slightly, the number of connections is decreasing. Basically, MCWD serves water to all the institutions. Therefore, the demand is regarded as constant, at 2,300 m^3/day.

Table III-14 Water Consumption of Government Institutions

Parameters	2005	2006	2007	2008	2009-2030
No. of Connections	189	184	181	173	----
Water Demand (m^3/day)	1,678	1,858	2,087	2,304	2,300

(5) Results of Water Demand Projection

< Total and Niche Water Demand Projection >

Tables III-15 and III-16 summarize the result of total and niche water demand projection, respectively.

The total demand in Metropolitan Cebu is projected to increase from 320,000 m^3/day in 2007 to 375,000 m^3/day in 2015, and to 511,000 m^3/day in 2030. On the other hand, the niche demand will increase from 116,000 m^3/day in 2007 to 188,000 m^3/day in 2015, and to 286,000 m^3/day in 2030.

< Comparison of Demand Projection >

Table III-17 shows the comparison of demand projection results between the JICA Study and MCWD existing projection and the Water Remind Project.

The total demand projection results in 2015 and 2030 of this Study are slightly different from those of Water Remind Project due to the adoption of lowered population growth rate.

The projected niche demand in 2015 shows almost the same volume as that of the MCWD existing demand projection, however, its breakdown is different between the two projections. In general, the existing MCWD projection has a tendency to underestimate the future water demand.

Table III-15 Result of Total Water Demand Projection (m^3/day)

Total Demand		2007	2010	2015	2020	2025	2030
Cebu City	Residential, Communal	51,870	56,750	65,372	74,639	84,608	95,333
	Commercial and Industrial	23,858	24,795	26,603	28,411	30,671	32,932
	Total	75,728	81,545	91,975	103,050	115,279	128,265
Lapu-lapu	Residential, Communal	30,992	34,920	42,359	51,035	61,182	73,035
	Commercial and Industrial	19,721	20,247	21,288	22,329	23,630	24,932
	Total	50,713	55,167	63,647	73,364	84,812	97,967
Mandaue	Residential, Communal	26,278	29,816	36,278	43,786	52,242	61,881
	Commercial and Industrial	21,562	21,973	22,808	23,644	24,671	25,699
	Total	47,840	51,789	59,086	67,430	76,913	87,580
Compostela	Residential, Communal	1,024	1,282	1,802	2,465	3,294	4,349
	Commercial and Industrial	745	795	890	986	1,123	1,260
	Total	1,769	2,077	2,692	3,451	4,417	5,609
Consolacion	Residential, Communal	7,842	8,427	9,486	10,613	11,851	13,184
	Commercial and Industrial	515	548	616	685	781	877
	Total	8,357	8,975	10,102	11,298	12,632	14,061
Cordova	Residential, Communal	4,612	4,961	5,566	6,240	6,968	7,780
	Commercial and Industrial	937	986	1,096	1,205	1,356	1,507
	Total	5,549	5,947	6,662	7,445	8,324	9,287
Lilo-an	Residential, Communal	2,768	3,968	6,420	9,590	13,702	17,264
	Commercial and Industrial	1,967	2,082	2,315	2,548	2,863	3,178
	Total	4,735	6,050	8,735	12,138	16,565	20,442
Talisay City	Residential, Communal	17,697	19,724	23,478	27,768	32,663	38,245
	Commercial and Industrial	6,411	6,658	7,164	7,671	8,288	8,904
	Total	24,108	26,382	30,642	35,439	40,951	47,149
Total	Residential, Communal	143,083	159,848	190,760	226,135	266,509	311,071
	Commercial and Industrial	75,716	78,084	82,780	87,479	93,383	99,289
	Total	218,799	237,932	273,540	313,614	359,892	410,360
Demand Adjustment	Residential, Commercial	98,705	98,705	98,705	98,705	98,705	98,705
	Government	2,300	2,300	2,300	2,300	2,300	2,300
Total Demand		319,804	338,937	374,545	414,619	460,897	511,365

Table III-16 Result of Niche Water Demand Projection (m^3/day)

Niche Demand		2007	2010	2015	2020	2025	2030
Cebu City	Residential, Communal	0	6,418	18,286	24,835	32,603	41,722
	Commercial and Industrial	8,475	10,189	13,551	15,034	16,710	18,747
	Total	8,475	16,607	31,837	39,869	49,313	60,469
Lapu-lapu	Residential, Communal	0	3,940	11,784	16,847	23,349	31,615
	Commercial and Industrial	3,416	5,183	8,420	9,638	10,915	12,453
	Total	3,416	9,123	20,204	26,485	34,264	44,068
Mandaue	Residential, Communal	0	3,343	10,027	14,361	19,815	26,632
	Commercial and Industrial	1,831	3,946	7,705	9,007	10,305	11,855
	Total	1,831	7,289	17,732	23,368	30,120	38,487
Compostela	Residential, Communal	0	143	491	795	1,227	1,839
	Commercial and Industrial	118	189	334	404	491	598
	Total	118	332	825	1,199	1,718	2,437
Consolacion	Residential, Communal	0	949	2,646	3,525	4,560	5,763
	Commercial and Industrial	31	85	195	246	309	386
	Total	31	1,034	2,841	3,771	4,869	6,149
Cordova	Residential, Communal	0	559	1,553	2,072	2,681	3,400
	Commercial and Industrial	150	238	415	497	597	720
	Total	150	797	1,968	2,569	3,278	4,120
Lilo-an	Residential, Communal	0	438	1,728	3,057	5,776	7,250
	Commercial and Industrial	120	326	735	919	1,138	1,404
	Total	120	764	2,463	3,976	6,914	8,654
Talisay City	Residential, Communal	0	2,214	6,506	9,138	12,432	16,517
	Commercial and Industrial	1,019	1,611	2,740	3,208	3,716	4,331
	Total	1,019	3,825	9,246	12,346	16,148	20,848
Total	Residential, Communal	0	18,002	53,020	74,630	102,444	134,738
	Commercial and Industrial	15,160	21,767	34,095	38,953	44,181	50,494
	Total	15,160	39,769	87,115	113,583	146,625	185,232
Demand Adjustment	Residential, Communal	98,705	98,705	98,705	98,705	98,705	98,705
	Government	2,300	2,300	2,300	2,300	2,300	2,300
Niche Demand		116,165	140,774	188,120	214,588	247,630	286,237

Table III-17 Comparison of Demand Projection (m^3/day)

Projects		2007	2010	2015	2020	2025	2030
Total Demand MCWD	Residential, Communal	126,272	134,427	148,872	164,476	181,360	199,480
	Commercial	77,011	84,647	99,173	116,348	136,415	160,128
	Adjustment	71,839	71,838	71,839	71,839	71,839	71,840
	Total	275,122	290,912	319,884	352,663	389,614	431,448
Total Demand Water Remind	Residential, Communal	201,200	226,219	278,233	330,247	388,068	445,890
	Commercial	75,715	78,082	82,781	87,479	93,384	99,288
	Total	276,915	304,301	361,014	417,726	481,452	545,178
Total Demand JICA 2009	Residential, Communal	143,083	159,848	190,760	226,135	266,509	311,071
	Commercial	75,716	78,084	82,780	87,479	93,383	99,289
	Adjustment	101,005	101,005	101,005	101,005	101,005	101,005
	Total	319,804	338,937	374,545	414,619	460,897	511,365
Niche Demand MCWD	Residential, Communal	18,125	19,282	21,331	23,540	26,162	28,713
	Commercial	77,011	84,647	99,173	116,348	136,415	160,128
	Adjustment	71,839	71,839	71,839	71,839	71,840	71,839
	Total	166,975	175,768	192,343	211,727	234,417	260,680
Niche Demand JICA 2009	Residential, Communal	0	18,002	53,020	74,630	102,444	134,738
	Commercial	15,160	21,767	34,095	38,953	44,181	50,494
	Adjustment	101,005	101,005	101,005	101,005	101,005	101,005
	Total	116,165	140,774	188,120	214,588	247,630	286,237

(6) Non-Revenue Water

According to MCWD data, the rate of NRW to the production water is 29.0% in 2008, which consists of unbilled authorized consumption of 0.2%, commercial losses of 0.8% and physical losses of 28.0%. Most of the physical losses are caused by leakage from pipelines of the MCWD network. Regular and systematic leakage control and repair can reduce the losses and thus the gross water demand.

MCWD aims to reduce system losses by 10% over the next 8 years. In line with this target, the NRW rate will be reduced to 20% in 2015. After 2015, the NRW rate is assumed to be reduced by 0.2% per year and reach to 17% in 2030 as shown in Table III-18.

Table III-18 NRW Rate Assumption

	2007	2008	2010	2015	2020	2025	2030
Rate of NRW (%)	30.0	29.0	25.0	20.0	19.0	18.0	17.0

(7) Gross Water Demand Projection

Table III-19 shows a result of the gross water demand projection. The MCWD gross demand will increase from 166,000 m^3/day in 2007 to 235,000 m^3/day in 2015, and to 345,000 m^3/day in 2030. On the contrary, the future gross demand of non-MCWD area will be leveling off or only slightly increase from 204,000 m^3/day in 2007 due to the expansion of MCWD service area.

Tables III-20 and III-21 shows the respective breakdown of gross water demand in Cebu Area and Mactan Area. In Mactan Area, it is predicted that the water demand in MCWD service area will be more than doubled in 2015 and more than fourfold against the consumption in 2007.

Table III-19 Gross Water Demand Projection 1: Total (m^3/day)

Category of Demand Projection			2007	2010	2015	2020	2025	2030
MCWD	Revenue Water	Domestic	98,705	116,707	151,725	173,335	201,149	233,443
		Commercial & Industrial	15,160	21,767	34,095	38,953	44,181	50,494
		Government	2,300	2,300	2,300	2,300	2,300	2,300
		Sub-total	116,165	140,774	188,120	214,588	247,630	286,237
	Non-Revenue Water		49,785	46,925	47,030	50,335	54,357	58,626
	MCWD Total		165,950	187,699	235,150	264,923	301,987	344,863
Non MCWD	Domestic		143,083	141,845	137,740	151,505	164,066	176,333
	Commercial & Industrial		60,556	56,317	48,685	48,526	49,202	48,795
	Non-MCWD Total		203,639	198,162	186,425	200,031	213,268	225,128
Grand Total			369,589	385,861	421,575	464,954	515,255	569,991

Table III-20 Gross Water Demand Projection 2: Cebu Area (m^3/day)

Category of Demand Projection			2007	2010	2015	2020	2025	2030
MCWD	Revenue Water	Domestic	90,367	103,871	130,051	146,077	166,780	190,089
		Commercial & Industrial	11,594	16,346	25,260	28,818	32,669	37,321
		Government	2,300	2,300	2,300	2,300	2,300	2,300
		Sub-total	104,261	122,517	157,611	177,195	201,749	229,710
	Non-Revenue Water		44,683	40,839	39,403	41,564	44,287	47,050
	MCWD Total		148,944	163,356	197,014	218,759	246,036	276,760
Non MCWD	Domestic		115,817	114,801	111,489	121,488	130,283	138,872
	Commercial & Industrial		43,464	40,505	35,136	35,127	35,728	35,529
	Non-MCWD Total		159,281	155,306	146,625	156,615	166,011	174,401
Grand Total			308,225	318,662	343,639	375,374	412,047	451,161

Table III-21 Gross Water Demand Projection 3: Mactan Area (m^3/day)

Category of Demand Projection			2007	2010	2015	2020	2025	2030
MCWD	Revenue Water	Domestic	8,338	12,836	21,674	27,258	34,368	43,353
		Commercial & Industrial	3,566	5,421	8,835	10,135	11,512	13,173
		Government	--	--	--	--	--	--
		Sub-total	11,904	18,257	30,509	37,393	45,880	56,526
	Non-Revenue Water		5,102	6,086	7,628	8,771	10,072	11,578
	MCWD Total		17,006	24,343	38,137	46,164	55,952	68,104
Non MCWD	Domestic		27,266	27,044	26,250	30,017	33,782	37,461
	Commercial & Industrial		17,092	15,812	13,549	13,399	13,474	13,266
	Non-MCWD Total		44,358	42,856	39,799	43,416	47,256	50,727
Grand Total			61,364	67,199	77,936	89,580	103,208	118,831

III-1.2 Water Sources Appraisal and Availability

(1) Water Sources Appraisal

Several plans of water source development had been prepared as measure for improvement of water supply services in Metropolitan Cebu since water supply utility was turned over to MCWD from Osmena in 1974. The life-cycle cost estimation of different water source development scheme was briefly reviewed as it was, using source of the Water Remind. Three kinds of measure were compared such as; (1) surface water, (2) groundwater and (3) seawater. Table III-22 shows project impact in each measure. Investment and operating costs were estimated as shown in Table III-23 based on the assumptions in Table III-22.

Table III-22 Impact of Water Source Measures

Measures			Estimated Impact	
Water Source	Intake	Remarks (watershed/ transmitted)	Possibility	Volume
Surface Water	Mananga Dam	69 km^2 in Mananga WRMU, within MCWD	Technically **High**, but Official Formality **Low**	69,500
	Lusaran Dam	55 km^2 in Lusaran WRMU, by Tunnel		97,200
	Kot-kot Dam	33 km^2 in Koy-kot WRMU, within MCWD		40,200
	Luyang Dam	37 km^2 in Luyang WRMU, by Pipeline		22,100
Groundwater	Deep Well	Approximately 80 to 100 m in depth, within MCWD	**High**	500
Seawater	Desalination	Located at Mactan Island, RO Treatment	**Very High**	15,000

Source: Financial Report, Water Remind Project, December 2005
Note: Dam plan for surface water development with highest dam height was adopted. Unit of volume is m^3/day.

Table III-23 CAPEX and OPEX Estimation

Measures			Estimated Cost per Facility (PHP)	
Water Source	Intake	Duration of Construction Years	CAPEX (millions)	OPEX (millions/year)
Surface Water	Mananga Dam	Duration of 2-years was assumed.	1,011	70
	Lusaran Dam		383	77
	Kot-kot Dam		481	59
	Luyang Dam		751	59
Groundwater	Deep Well	Duration of 1-year was adopted.	3.6	0.4
Seawater	Desalination	Duration of 2-years was required.	901	134

Source: Financial Report, Water Remind Project, December 2005
Note: Duration of construction year was estimated without regulatory approvals.

All measures were contrasted on the basis of their cost/m^3. The life-cycle cost including all costs over 25-years project life were divided by the total production volume of water. This cost ignores escalation of average delivery charges and its timing. Preliminary estimates had been made of additional two indicators namely; (1) Net Present Value - NPV and (2) Benefit Cost Ratio - BCR. Table III-24 shows these three (3) indicators.

Development priority shall be given in due order of groundwater, surface water and seawater. On the premises of above, groundwater should be developed as much as possible at the first. For the short term strategy, water shortage should be covered by de-salination even it is not fundamental measures. At the same time, surface water development is recommended to promote immediately for long term measures.

Table III-24 Unit Cost and Benefit Estimation

Measures		Life-cycle Cost (PHP/m^3)		NPV (Net Present Value)	BCR (Benefit Cost Ratio)
Water Source	Intake	minimum	maximum	PHP millions	Ratio
Surface Water	Mananga Dam	5.2	6.9	344 to 554	1.2 to 1.4
	Lusaran Dam	2.9	3.0	1,891 to 1,904	2.8 to 3.2
	Kot-kot Dam	5.4	6.1	298 to 425	1.3 to 1.4
	Luyang Dam	7.8	13.1	482 to 75	0.6 to 0.9
Groundwater	Deep Well	2.8	2.8	11 to 13	2.7 to 2.8
Seawater	Desalination	34.8	36.6	1,498 to 1,338	0.2

Source: Financial Report, Water Remind Project, December 2005
Note: Unit costs for surface water development were estimated without regulatory approvals and residential removal. NPV of deep well development is depending on the number of well to be included.

(2) Concept of Water Sources Development

According to the Census 2007, about 71% of provincial population lives in Metropolitan Cebu, adversely the same jurisdiction occupies only 12% of provincial area. To solve the water crisis of this imbalance, the national regulators and the government agencies shall take the action for the macro-cosmic management of water resources; e.g. the active committee of "the Cebu Island Water Resources Management." Otherwise, the society and economy in Metropolitan Cebu have a burden of negative bequest continuously and will transfer it to the next generation again.

On this situation, MCWD will improve its water supply services with best effort and compliance. Availability of water sources development was studied with following concepts.

- Groundwater:
  Potential will be estimated using groundwater modeling (predictive simulation) under the condition of current groundwater regulation. Feasible well development was examined within the groundwater potential for the action plan. Potential groundwater will be developed by the prospect of long-term horizon.
- Surface Water:
  Existing surface source availability will be estimated by historical intake amount and feasible measure with due consideration of the 5-year return period. New surface water source is not included into the action plan, because of non-suitability expected. MCWD is recommended to promote the dam development plan depending on the progress of bulk water supply scheme.
- Bulk Water:
  Importation amount of existing bulk water source will be adopted for the action plan with due consideration of status contract quo and current supplying record. New bulk water supply plan (Carmen for instance) is depending on progress of the third party; therefore it will not be included in this action plan.
- Water Balance:
  Remaining balance of water source availability against demand for the action plan (year 2015) will be fallen on the seawater through the de-salination plant. Shortage water source for the long term plan (year 2030) may be fallen on the water importation from outside of MCWD franchise area such as bulk water supply scheme or surface water development.

Brief workflow of study on water sources availability is presented in Figure III-04.

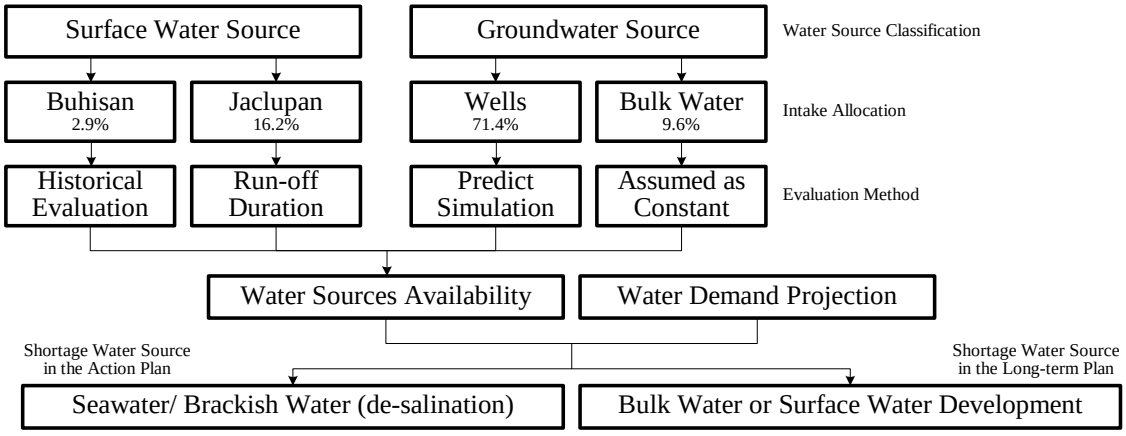


Figure III-04 Workflow of Water Sources Availability (numerical value is as of Dec-08)

(3) Water Sources Availability

Availability of MCWD water sources is estimated according to existing conditions (facility and intake records) and expertise standpoints (field exploration and model simulation). Following are development target of each water source.

< Groundwater >

As a planning basis from the latest national census year, production of groundwater source was estimated at annual average of 118,300 m^3/day in 2007.

- Operation Well: 119 wells (98 production + 11 observation + 10 under rehabilitation)
- Well Depth: most of well has a depth of 70 mbgl to 110 mbgl
- Intake Portion: 104 well tapping Limestone aquifers, otherwise combination of Limestone and Alluvial

Groundwater potential was studied applying predicted simulation using groundwater model, namely the Cebu-GWM-09. As a result of this modeling study, groundwater potential in MCWD franchise area was estimated at 176,000 m^3/day. Details are referred to Chapter III-1.3 in this main report and Chapter I, Part-B in the supporting report.

< Surface Water >

Buhisan Dam

Production capacity of Buhisan Dam is assumed at 4,700 m^3/day. Buhisan dam was completed in 1912 and has following features.

- Design Capacity: 10,000 m^3/day
- Dam Height: 27 m (approximately)
- Storage Volume: 1.3 million m^3
- Watershed Area: 6.1 km^2

Specific intake of Buhisan watershed in 80% of exceedance is analyzed and calculated at 0.4 mm/day (× 6.1 km^2/ watershed = 2,440 m^3/day). Currently, storage volume is decreased until 0.6 million m^3 (approximately 46% of original design) caused by siltation. Amount of monthly intake seems to be correlated to monthly rainfall.

Average monthly intake amount using records between Jan-95 to Dec-08 is estimated at 4,820 m^3/day in wet season (May to Oct) and 4,730 m^3/day in dry season (Nov to Apr). Main cause of intake reduction was maintenance drainage annually to reduce siltation sediments.

Jaclupan Infiltration Galleries

Production capacity from Jaclupan Infiltration Galleries is adopted at 40,000 m^3/day with precise improvement of the intake facility. Operation of Jaclupan has started since Oct-97 with following features.

- Design Capacity: 40,000 m^3/day
- Infiltration Well: 21 wells (15 production + 6 observation)
- Height of Weir: 5.4 m (from the grade line to the overflow top)
- Watershed Area: 69 km^2

Average monthly intake amount from this facility is estimated at 24,600 m^3/day using records from Oct-97 until Dec-08. Major problems seem to be; (1) riverbed seepage under the weir

which reduces storage volume, (2) siltation on the filtration surface which reduces permeation velocity and (3) physical clogging at well surrounding which increases well loss.

Following rehabilitation plan is proposed with phased progress. The baffle sheet pile measure is adopted in this action plan. Detailed drawing is referred to the supporting report.

* riverbed seepage under the weir
  - ✓ study: riverbed flow (construction of observation 2 wells with pumping test)
  - ✓ measure: baffle sheet pile (tentatively 30 m in depth × 60 m wide)
* siltation on the filtration surface
  - ✓ study: water level sounding during well production
  - ✓ measure: air back-washing, additional flash-out waterway
* physical clogging at well surrounding
  - ✓ study: step drawdown test at production well, water quality examination
  - ✓ measure: well rehabilitation (physical, chemical or combination method)

There is run-off gauging station at Mananga River which is located at about 5 km up-stream from Jaclupan Infiltration field. Specific run-off in 80% of exceedance is analyzed and calculated at 2.1 mm/day (× 69 km^2/ watershed = 144,900 m^3/day).

< Bulk Water Source >

Expected intake amount is set up at merely 23,000 m^3/day. To date, MCWD has four (4) contracts of water purchase with tree (3) bulk suppliers. These input points and amounts are;

* Foremost by wells: to Lagtang Reservoir with 5,500 m^3/day
* Abejo (south) by wells: to Distribution Pipeline with 5,500 m^3/day
* Abejo (north) by wells: to Distribution Pipeline with 7,000 m^3/day
* Mactan Rock by de-salination: to Distribution Pipeline with 5,000 m^3/day

Amounts of water sources availability in Table III-25 are adopted for the action plan. It is noted that groundwater potential is estimated at 176,000 m^3/day, however up to 158,000 m^3/day would be developed by the year 2015. Water source allocation to meet the demand in 2015 has a limitation, if the relativity of places in groundwater potential and demand density are analyzed.

Table III-25 Water Sources Availability in Action Plan

Surface Water		Groundwater (Brackish)		Total
Buhisan Dam	Jaclupan Infiltration	Own Wells	Bulk Water	
4,700 m^3/day	40,000 m^3/day	158,000 m^3/day	23,000 m^3/day	225,700 m^3/day
2 %	17 %	74 %	7 %	100 %

III-1.3 Groundwater Potential

Detailed information in this section is referred to Part-B of the Chapter-I in the Volume-III Supporting Report, while primary data can be referred to the Volume-IV Data CD.

(1) Application of the Cebu-GWM-09

Groundwater modeling was used for this study, name of which is the Cebu-GWM-09. Groundwater potential was simulated using the Cebu-GWM-09 and present groundwater regulation. Features of groundwater model are;

* Groundwater modeling is a science-based process that develops tools (i.e. the models) to predict the behavior of the hydrogeologic environment,

- The model represents a "living" planning tool that allows planners to assess the groundwater system, and update it as new information becomes available,
- This helps developers and regulators make defensible decisions about the potential impacts that might occur to the system, and
- The model can be as simple or as complex as the study objectives require.

It is noted that the model is not actual representation and has following limitations.

(a) Soft-ware

FDM (finite difference method) soft-ware was procured beyond the advantage of FEM (finite element method) such as unsaturated-flow, flexible boundary geometry, variable-scale meshing and so on.

(b) Due Scope of Work

It took about 8 months since the commencement of this study until completion of potential evaluation using the groundwater model. Among the said period, modeling works shared 2 months including model calibration.

(c) Reproductivity of Locality

Limestone is distributed in the study area as a dominant geology. Corroded limestone formation has been distinguished with topographic features of cone karst, sinkhole, cave, etc. The soft-ware being used for this study has no conduit flow model.

(d) Data Non-available

Following items are feedback information from this modeling study.

- ✓ Water Balance from Water Remind could not be verified
- ✓ Un-known Non-MCWD Well Information
- ✓ Non-verification Area

(2) Criteria on Groundwater Potential

Metropolitan Cebu was designated as water crisis area in terms of saltwater intrusion by NWRB. According to latest groundwater regulation, extent of saltwater intrusion was not monitored and considered. Guideline of such regulation mentions;

- Critical area is restricted by topographical conditions (below 70 masl).
- Water sources with salinity level 210 mg/L shall be required to reduce their volume of extraction, and shall be subject to strict monitoring.
- If the salinity level exceeds 250 mg/L, the well shall be closed immediately.

Although groundwater availability in alluvial aquifers (coastal area) is still applicable, groundwater potential was studied with target aquifer of only limestone (hilly area). It was reflected that several MCWD wells in alluvial area had been abandoned due to groundwater quality aggravation because of worse saltwater intrusion.

Social acceptance is one of issues for maintaining of saltwater intrusion. Benefits from groundwater development shall be allotted within its social fairly. Compliance of regulation is most important criterion, on the other hand, review of such regulation shall be held in the public hearing for social acceptance. Additionally, groundwater potential was studied on the particular occasion of "without artificial protection". It means that measures using under ground fence or

well injection (see Figure III-05) are not considered in this study.

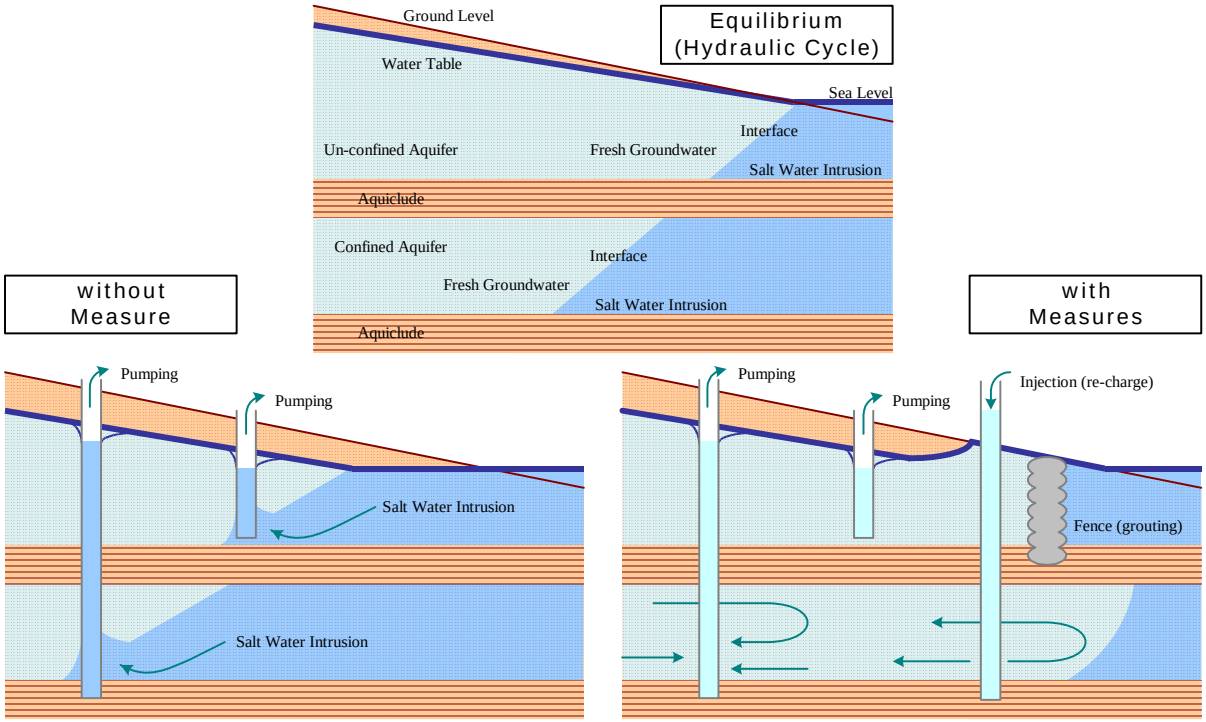


Figure III-05 Image of Groundwater Potential Study

(3) Groundwater Modeling

The Cebu-GWM-09 was built according to order below.

- Simulation Code
  SEAWAT version 4 (USGS, 2008) was applied.

- Conceptual Model
  Groundwater model was built according to following concepts (see model domain and water components in Figure III-06).
  - ✓ Target Aquifer: Alluvial and Limestone
  - ✓ Inflow to Aquifer: Recharge and Return Flow
  - ✓ Outflow from Aquifer: Abstraction inducing seawater intrusion

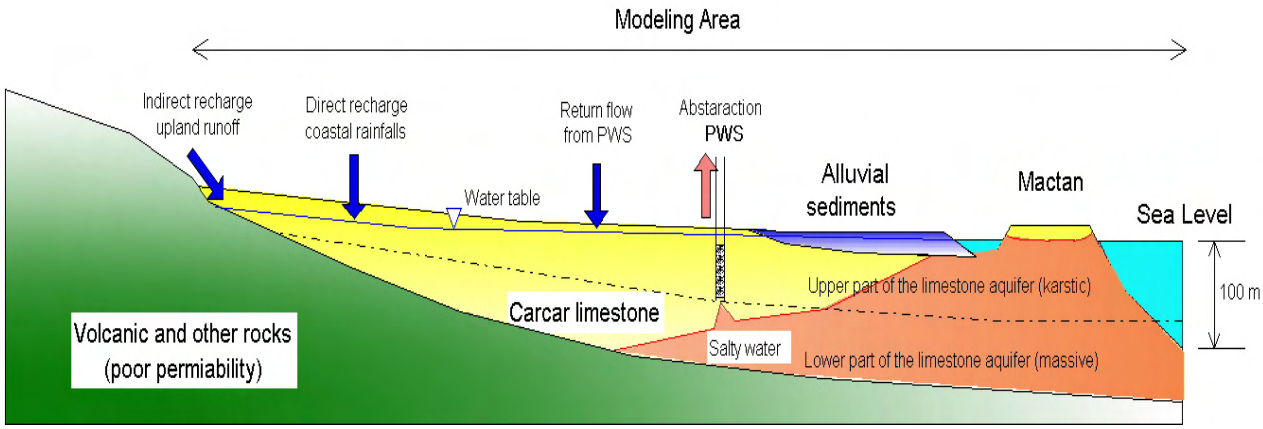


Figure III-06 Conceptual Model

- Model Domain
  Groundwater models are divided into 4 districts (see Table III-26 and Figure III-07).

Table III-26 Modeling Districts

District	WRMUs
Northern	Compostela, Kot-kot, Lilo-an and Cansaga
Central	Butuanon, Cebu
Southern	Mananga, Minglanilla-Talisay
Mactan	Mactan

Figure III-07 Relation Map of Study Area, WRMUs and Model Domain

- Modeling Procedures (see Figure III-08 and below): Water components obtaining from the Water Remind were effectively used for model building.
  - ✓ Initial Term 980-1979: constant stress
  - ✓ Calibrated Term 1980-2004: transient stress
  - ✓ Predict Term 2005-2030: transient stress)

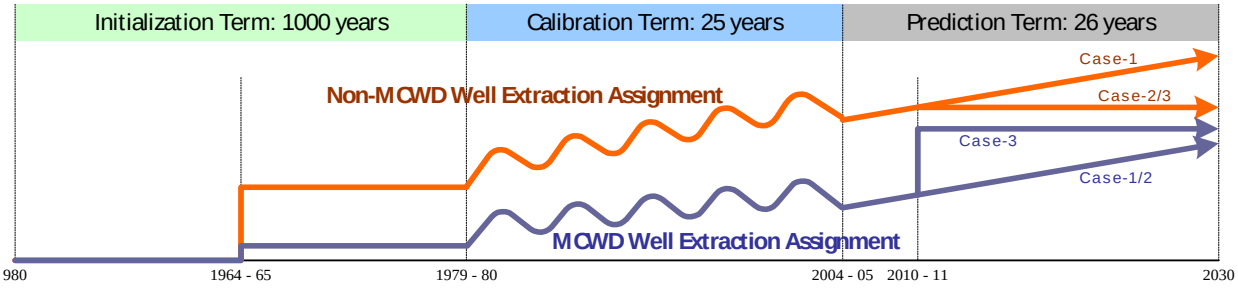


Figure III-08 Temporal Discretization adopted for Modeling Work

- Fluid Density
  Seawater: Cl concentration of 19,000 mg/L (density of 1.025 g/cm^3)
  Freshwater: Cl concentration of 20 mg/L (density of 1.000 g/cm^3)

- Zoning of Aquifer Properties (see Figure III-09)
  Aquifer properties (permeability and storativity) were assigned into the zones which were pre-

pared based on the geological classifications.

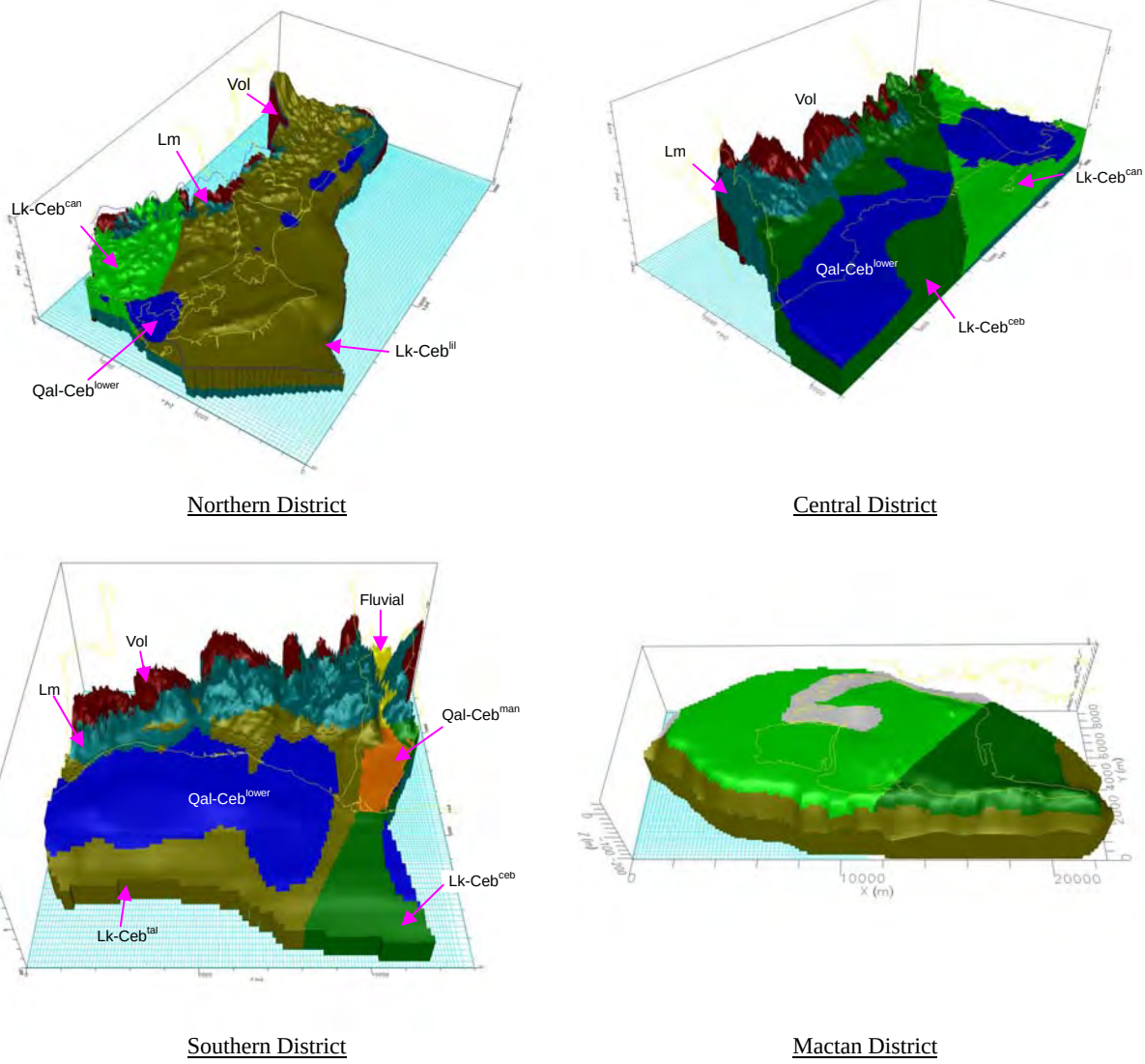


Figure III-09 Zoning of Aquifer Properties

- Boundary Conditions

  ✓ Flow boundary was assigned constant value (h=0 m) at sea floor and sea side boundary corresponding to 200 mbsl.
  ✓ Groundwater withdrawal and recharge rate were set monthly hydraulic stress based on MCWD production records and previous study results of Water Remind Project.
  ✓ Transport boundary was assumed to be constant concentrations 19,000 mg/L of Cl at sea side boundary and 20 mg/L of Cl at uphill boundary.
  ✓ Inflow concentration was applied to recharge with 20 mg/L of Cl and inflow from sea floor with 19,000 mg/L of Cl.
  ✓ Influence of two existing perennial river (Mananga river, Kot-kot river) was incorporated in recharge rate based on Water Remind study.

- Transient Hydraulic Stress

  Water balance obtaining from the Water Remind Project was adopted. Detailed data are referred to the supporting report.

- Calibration

  < Calibration Target >

  Calculated values were compared with historical data of Cl concentration and WL elevation within 1980-2004. Monitoring points of model results were set to the mid-point of screen elevation.

  < Calibrated Parameter >

  Aquifer property and its zoning, and additional groundwater extraction by wells were adjusted according to calibration targets.

(4) Predictive Simulation

Groundwater potential was predicted by the Cebu-GWM-09 simulation according to following order (details are referred to the supporting report).

- Time Frame

  From January 2005 until December 2030: 26 years (312 months)

- Applied Stress

  Natural recharge obtaining from the Water Remind Project was utilized. Predicted rainfall pattern is presented in Figure III-10. Standard deviations pattern of monthly rainfall were estimated by standard deviation of annual rainfall.

- Applied Scenario

  Scenario-1: MCWD wells and Non-MCWD wells will extract groundwater amount according to population growth rate continuously until year 2030.

  Scenario-2: MCWD wells will extract groundwater according to population growth rate continuously until year 2030. However, Non-MCWD wells will be regulated after 2011 with constant extraction rate.

  Scenario-3: Non-MCWD wells will be regulated after 2011. Optimal MCWD wells will extract potential extraction amount starting from Jan-2011 until Dec-2030 with compliance of groundwater regulation.

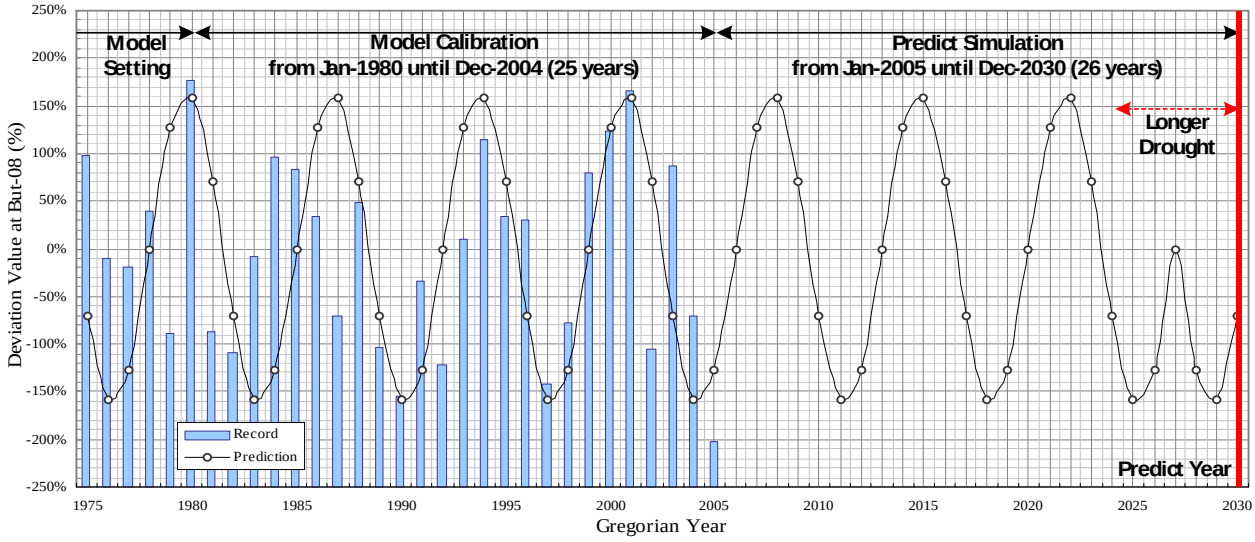


Figure III-10 Predicted Annual Rainfall Pattern

- Groundwater Potential

Following Table III-27 indicates groundwater potential by the present compliance (Cl < 200 mg/L). As a contrast of current situation, groundwater developments in "Northern District" and "Mactan District"are evaluated as over extraction.

Table III-27 Groundwater Potential in MCWD Franchise LGUs

Model			Predict Simulation as Potential				Development Plan			
District	WRMUs	Q-07	Exist.	Q-add	Q-30	Location	Additional Q		Total Q	
Northern	Compostela	799	0	14,800	14,800	-	14,001			
	Kot-kot	4,042	0	0	0	-	**-4,042**			
	Lilo-an	6,076	0	3,000	3,000	-	**-3,076**	**-8,163**	32,600	
	Cansaga	29,846	0	3,700	14,800	North	**-15,046**			
			0	11,100		South				
Central	Butuanon	28,986	0	17,000	30,600	North	1,614	41,451	109,800	175,840
			0	13,600		South				
	Cebu	39,363	0	24,000	79,200	Cebu River	39,837			
			0	55,200		Others				
Southern	Mananga	5,528	0	12,000	12,000	-	6,472	24,672	30,200	
	M-Talisay	0	0	18,200	18,200	-	18,200			
Mactan	Mactan	3,671	1,080	2,160	3,240	-	**-431**	**-431**	3,240	

Note: Unit of Q (discharge amount in 2007 and 2030) is m^3/day. Mapping information is referred to the Section-III, Part-B of Chapter-I in the Volume-III Supporting Report.
Remarks: Following are meaning of abbreviations.

Q-07:	Intake amount from the MCWD production wells in 2007.
Exist:	Production amount from existing MCWD wells which was diverted for predictive simulation.
Q-add:	Intake amount of optimal well fields other than existing MCWD wells for predictive simulation.
Q-30:	Intake amount for predictive simulation continuously extracted from 2011 until 2030.
Additional-Q:	Available additional intake amount based on the existing well intake in 2007.
Total-Q:	Groundwater development potential for MCWD portion.

III-1.4 Water Demand and Supply Balance

(1) Present Water Balance in MCWD Service Area

The water volume of about 166,000 m^3/day was supplied by MCWD in 2007 on average. The water sources are comprised of groundwater, surface water and bulk water supply. The break-down of the supplied water volume by water source is as shown in Table III-28.

Out of 166,000 m^3/day of the supplied volume, groundwater has a share of 71% (118,300 m^3/day) while surface water occupies 19% (31,700 m^3/day). As to Jaclupan, although the pump capacity was designed at 40,000 m^3/day, present abstraction volume stays only 27,000 m^3/day due to the leakage from storage sediments and the siltation in the infiltration pond. Protection of riverbed leakage is essentially desired in order to secure the design capacity. MCWD purchases bulk water from the three concessionaires. The total contract water volume is 15,000 m^3/day but 16,000 m^3/day was actually purchased on average.

Table III-28 Supplied Water Volume in 2007 by Water Source (m^3/day)

Water Source	Groundwater	Surface Water		Bulk Water	Total
	Local Wells	Buhisan	Jaclupan	3 Concessionaires	
Supplied Volume	118,300	4,700	27,000	16,000	166,000

The water balances in 2007 are estimated as presented in Table III-29. In Mactan Area, MCWD owns 5 wells and about 3,500 m^3/d is being abstracted in total. Bulk water is purchased from Mactan Rock Inc. and its contract volume is 5,000 m^3/day. Thus, it is estimated that a water volume of 8,500 m^3/day is imported from Cebu Area.

Table III-29 Water Balance in 2007 (m^3/day)

Area	Demand		Supply	
Cebu Area	Domestic	90,367	Well	114,800
	Commercial & Industrial	11,594	Buhisan	4,700
	Government	2,300	Jaclupan	27,000
	NRW	44,683	Bulk Water	11,000
			Export to Mactan	-8,500
	Total	148,944	Total	149,000
Mactan Area	Domestic	8,338	Well	3,500
	Commercial & Industrial	3,566	Bulk Water	5,000
	Government	--	Import from Cebu	8,500
	NRW	5,102		
	Total	17,006	Total	17,000
MCWD Total	Domestic	98,705	Well	118,300
	Commercial & Industrial	15,160	Buhisan	4,700
	Government	2,300	Jaclupan	27,000
	NRW	49,785	Bulk Water	16,000
	Total	165,950	Total	166,000

Note: New bulk water was contracted from June 2009 with importing amount of 7,000 m^3/day.

(2) Water Balance in MCWD Service Area in 2015

According to results of the groundwater flow simulation, the groundwater potential of MCWD extraction in the MCWD area is estimated at 176,000 m^3/day, which means additional groundwater source of 57,700 m^3/day is possible to be developed in the future. Furthermore, the simulation shows that this maximum potential can be utilized only in the case that wells, including existing and new ones, are optimally aligned in the well fields.

Also, it is predicted that a total of 158,000 m^3/day groundwater (additional 39,700 m^3/day) can be utilized by 2015 in combination with abandonment of old dated existing wells. Thus, the available groundwater potential is very scarce, and therefore, making best use of other available water sources in the MCWD area, the water balance between demand and supply has to be kept as follows:

- Jaclupan intake capacity shall be recovered to 40,000 m^3/day by possible rehabilitation.
- The amount of bulk water imported from the 3 concessionaires shall be maintained.
- Further the supply shortage shall be filled by desalination of seawater in Mactan Area.
- The volume of water exported to Mactan from the main island shall be limited according to the design capacity of bridge crossing pipelines.

The water balances in 2015 are thus proposed as presented in Table III-30. As reference figures, Tables III-31 and III-32 are prepared the annual horizons of water balance until 2015 for entire MCWD area and only Mactan area.

Table III-30 Water Balance in 2015 (m^3/day)

Area	Demand		Supply	
Cebu Area	Domestic	130,051	Well	154,500
	Commercial & Industrial	25,260	Buhisan	4,700
	Government	2,300	Jaclupan	40,000
	NRW	39,403	Bulk Water	18,000
			Export to Mactan	-20,100
	Total	197,014	Total	197,100
Mactan Area	Domestic	21,674	Well	3,500
	Commercial & Industrial	8,835	Bulk Water	5,000
	Government	--	Import from Cebu	20,100
	NRW	7,628	De-salination	9,600
	Total	38,137	Total	38,200
MCWD Total	Domestic	151,725	Well	158,000
	Commercial & Industrial	34,095	Buhisan	4,700
	Government	2,300	Jaclupan	40,000
	NRW	47,030	Bulk Water	23,000
			De-salination	9,600
	Total	235,150	Total	235,300

Table III-31 Water Balance in Short/ Middle Term Horizon: Entire Area (m^3/day)

Water Balance		2007	2010	2011	2012	2013	2014	2015
Demand		165,950	187,699	197,189	206,679	216,170	225,660	235,150
Supply	Well	118,300	120,300	126,000	134,000	142,000	150,000	158,000
	Buhisan	4,700	4,700	4,700	4,700	4,700	4,700	4,700
	Jaclupan	27,000	40,000	40,000	40,000	40,000	40,000	40,000
	Bulk Water	16,000	23,000	23,000	23,000	23,000	23,000	23,000
	De-salination	--	--	3,500	5,000	6,500	8,000	9,600
	Total	166,000	188,000	197,200	206,700	216,200	225,700	235,300

Table III-32 Water Balance in Short/ Middle Term Horizon: Mactan Area (m^3/day)

Water Balance		2007	2010	2011	2012	2013	2014	2015
Demand		17,006	24,343	27,102	29,861	32,619	35,378	38,137
Supply	Well	3,500	3,500	3,500	3,500	3,500	3,500	3,500
	Bulk Water	5,000	5,000	5,000	5,000	5,000	5,000	5,000
	Import from Cebu	8,500	15,900	15,100	16,400	17,700	18,900	20,100
	De-salination	--	--	3,500	5,000	6,500	8,000	9,600
	Total	17,000	24,400	27,100	29,900	32,700	35,400	38,200

(3) Water Balance in MCWD Service Area in Long-Term Horizon

As stated earlier, the maximum available aquifer in MCWD area is estimated at 176,000 m^3/day. Assuming that the capacity of the proposed desalination facility in Mactan is fixed at 9,600 m^3/day, the maximum available water sources within MCWD area will be 253,300 m^3/day. This means that the water sources within MCWD area will only meet the water demand by 2018, and thereafter, new water sources need to be sought outside the MCWD area.

In 2030, the amount of additional water sources that is required to be imported from outside MCWD area is estimated at 91,600 m^3/day. In addition, an amount of 50,000 m^3/day needs to be

exported from Cebu main island to Mactan area as shown in Table III-33. This export amount of 50,000 m^3/day is exceeded the design capacity of bridge crossing pipelines.

Table III-33 Water Balance in 2030 (m^3/day)

Area	Demand		Supply	
Cebu Area	Domestic	190,089	Well	172,500
	Commercial & Industrial	37,321	Buhisan	4,700
	Government	2,300	Jaclupan	40,000
	NRW	47,050	Bulk Water	18,000
			Export to Mactan	-50,000
			Outside MCWD Area	91,600
	Total	276,760	Total	276,800
Mactan Area	Domestic	43,353	Well	3,500
	Commercial & Industrial	13,173	Bulk Water	5,000
	Government	--	Import from Cebu	50,000
	NRW	11,578	De-salination	9,600
	Total	68,104	Total	68,100
MCWD Total	Domestic	223,443	Well	*1**176,000**
	Commercial & Industrial	50,494	Buhisan	4,700
	Government	2,300	Jaclupan	40,000
	NRW	58,626	Bulk Water	23,000
			De-salination	9,600
			Sub-total	*2**253,300**
			Outside MCWD Area	*3**91,600**
	Total	344,863	Total	344,900

Note *1: Maximum of available groundwater within MCWD Area
*2: Maximum of available water sources within MCWD Area
*3: Additional water of 91,600 m^3/day will be required to be imported from outside MCWD Area.

As reference figures, Table III-34 (next page) is prepared the annual horizons of water balance until 2030 for entire MCWD area and only Mactan area.

According to the Water Remind Project, several candidate projects for the additional water sources development were proposed such as groundwater development in the North (Luyang, Carmen, Danao) and the South (Pangdan), surface water development in Luyang-Carmen, Lusaran dam, and Kot-kot dam.

Table III-34 Water Balance in Long Term Horizon (m^3/day)

Water Balance		MCWD Service Area Total				Mactan Area			
		2015	2020	2025	2030	2015	2020	2025	2030
Demand		235,150	264,923	301,987	344,863	38,137	46,164	55,952	68,104
Supply	Well	158,000	176,000	176,000	176,000	3,500	3,500	3,500	3,500
	Buhisan	4,700	4,700	4,700	4,700	--	--	--	--
	Jaclupan	40,000	40,000	40,000	40,000	--	--	--	--
	Bulk Water	23,000	23,000	23,000	23,000	5,000	5,000	5,000	5,000
	Import from Cebu	--	--	--	--	20,100	28,200	37,900	50,000
	De-salination	9,600	9,600	9,600	9,600	9,600	9,600	9,600	9,600
	Outside MCWD Area	--	11,799	48,700	91,600	--	--	--	--
	Total	235,300	265,000	302,000	344,900	38,200	46,200	56,000	68,100

.....

III-2 Requirements in Technical Improvement

III-2.1 Design Concept and Criteria

The aims of improvement plan on water supply system and facility are;

- to increase water supply volume to meet water demand in 2015 and
- to achieve water supply service level under above water supply situation.

(1) Design Concept of Water Supply System

Following concepts are maintained to the system design as shown in Figure III-11.

* gravity water supply and
* distribution block water supply.

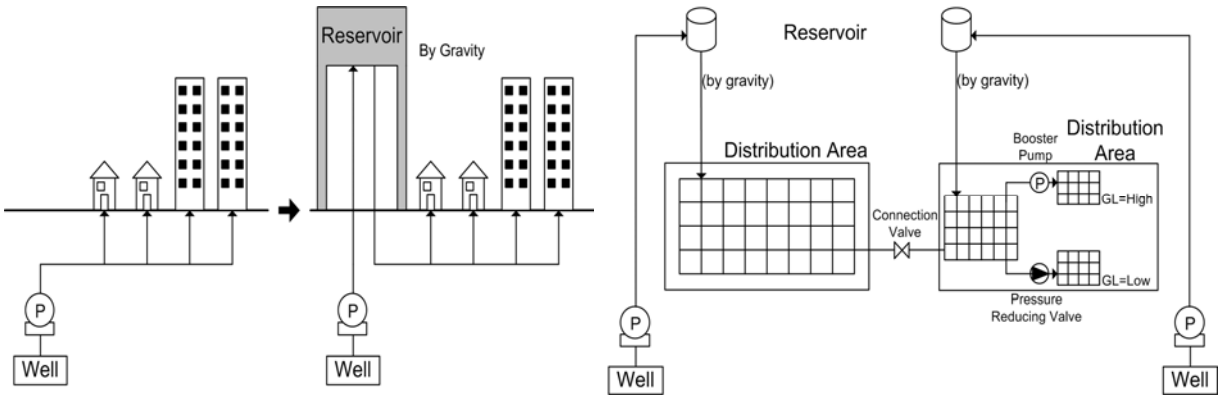


Figure III-11 Design Concepts: Gravity (left) **and Distribution Block** (right)

< Gravity Water Supply System >

Gravity water supply is more energy saving system than direct pump-feeding system, since the latter system is required to operate fluctuated pumping according to demand variation for maintaining of the minimum water supply pressure. On the other hand, the former system is required to operate constant pumping since the reservoir has a function of buffer to the demand variation. Mactan Island has no hilly area suitable to select the ground reservoir site for gravity water supply; therefore elevated tank shall be designed.

Additionally, the risk of suspended water supply can be reduced when emergency power off is occurred because the stand-by generator is not equipped at MCWD intake facility in generally.

< Distribution Block Water Supply System >

Present complex water supply system is proposed to be revised to block distribution system so that water flow can be easily controlled.

(2) Design Criteria of Water Supply Facility

Design standards for water supply system, facility and service level were referred to following materials. The JWWA Guideline was applied for designing of water treatment process.

* MCWD Technical Standards Manual 2003 (TSM-03),
* Philippines National Standard for Drinking Water 2007 (PNSDW-07),
* NWRB Groundwater Regulation (BO-No.002-1106/ 2006 and No.004-0507/ 2007), and
* JWWA (Japan Waterworks Association) Facility Design Guideline 2000.

There might be possibility that following water quality parameters from well and de-salination exceed the maximum level of PNSDW-07. The extent of water quality aggravation is limited according to the past MCWD records and engineering experiences. Also, proper process of water treatment for those parameters makes the much higher cost of unit water production. It was employed that water blend method would be maintained before water supply to the users in the view point of financial feasibility.

Parameter (mg/L)	Expected Level	PNSDW-07
* Boron (B):	<1.0	<0.5
* Nitrate (NO_3):	<60	<50
* Hardness (as $CaCO_3$):	<400	<300
* Total Dissolved Solid (TDS):	<600	<500

During the planning period, following softwares were applied as planning tools for judgment of present situation and predictive simulation.

* Groundwater Flow: Visual-MODFLOW 2009 (for estimation of development potential)
* Pipeline Hydraulics: WaterCAD-5000 (for analysis of water supply pressure)

Major criteria obtaining from the TSM-03 are described below, which were adopted for facility designing.

< Design Flow>

There are three types of design flow;

- ✓ Daily Average Flow (DAF),
- ✓ Daily Maximum Flow (DMF), and
- ✓ Hourly Maximum Flow (HMF).

DMF and HMF are usually calculated by DAF figure multiplying peak factor, mainly corresponding to the service population. Peak factor ratio DMF: DAF can be estimated by the TSM showing below. Peak factor ratio DMF: DAF is estimated at 1.2 (maximum population in the distribution block was projected at 224,730 in 2015).

Service Population	DMF: DAF
✓ 30,000 >	1.30: 1.00
✓ 30,000 < to ≤ 200,000	1.25: 1.00
✓ 200,000 <	1.20: 1.00

Peak factor ratio HMF: DMF is also estimated at 1.5 according to following formula in the TSM.

- ✓ HMF (m^3/hour) × 24 hours ÷ DMF (m^3/day) = 2.2 - 0.3 × log (population/1,000) = 1.5

MCWD adopts the peak factor ratio HMF: DMF of 1.8 applying population served of more than 20,000 in the LWUA design standard (see Figure III-12 in next page). According to engineering experiences of MCWD, this figure seems adequate for Metropolitan Cebu area where tourism and commercial industry are main category of non-domestic water supply.

As a result, following peak factors between DAF, DMF and HMF (= DMF 1.2 × 1.8 ≅ 2.2) are adopted for facility design.

- ✓ DAF: DMF: HMF= 1.0: 1.2: 2.2

< Reservoir Capacity >

Following formula to estimate the capacity of fill and draw reservoir is available in the TSM.

$T = 0.224 - 0.0416 \times \log (P/1,000)$

Where; T: Storage (days)
P: Population Served (capita)

As estimation results, following relation was analyzed.

Population	Reservoir Capacity (equivalent to hours DAF)
✓ 200,000:	3 hours × DAF (m^3/day)
✓ 20,000:	4 hours × DAF (m^3/day)
✓ 2,000:	5 hours × DAF (m^3/day)

In this improvement plan, design concepts of the water supply system are (1) gravity water supply and (2) distribution block water supply system as shown in next section. Therefore, reservoir should have performances of;

(a) water buffer from the daily supply fluctuation, and
(b) risk reduction of suspended water supply when power source is cut-off.

Reservoir volume can be calculated by daily fluctuation curve for buffer capacity estimate. The TSM does not include the typical daily fluctuation. Accordingly, such data obtaining from LWUA design standard was adopted for estimate. In Figure III-12, HMF/DAF ratio (daily fluctuation) and storage (water level equivalent to hour DAF) are put together.

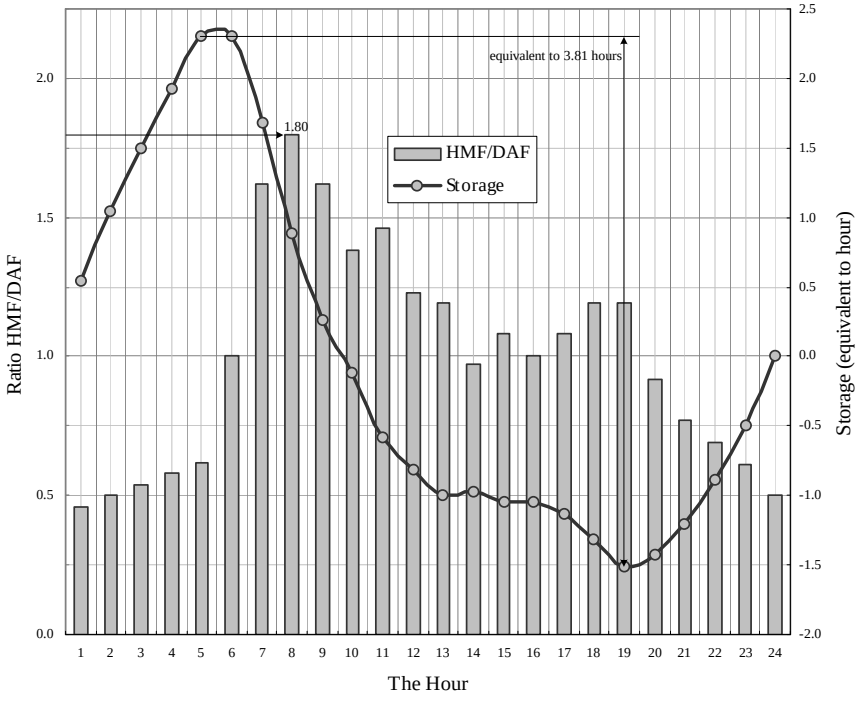


Figure III-12 Reservoir Capacity Calculation using LWUA Standard (Served Pop. > 20,000)

Based on the daily fluctuation and storage displacement, design volume can be estimated at 3.81 hour DAF. Standing on the safe side, surplus 1-hour at both sides (low and high water level in the reservoir) was added to the designed capacity of 3.81 hours-equivalent. Therefore, design volume of 6 hour equivalent DAF is adopted.

< Water Supply Pressure >

The TSM mentions following requirements of line pressure head for design purpose during the HMF condition (exceptional case of firefighting). On this condition, minimum head of 0.07 MPa (equivalent to 10 psi or 7 m H_2O) is adopted for hydraulic pipeline analysis. In case of less water supply pressure area, booster pump station will be considered.

Area	Minimum	Maximum
✓ Urbanized:	0.14 MPa (20 psi or 14 m H_2O)	0.69 MPa (100 psi or 70 m H_2O)
✓ Less-urbanized:	0.07 MPa (10 psi or 7 m H_2O)	0.69 MPa (100 psi or 70 m H_2O)

< Water Treatment >

Since design criteria for water treatment plant (WTP) and de-salination plant are not guided in the Philippine (both LWUA and MCWD), facility of WTP and de-salination plant were mainly designed applying standards of the JWWA guideline.

III-2.2 Allocation for Water Sources and Water Supply

(1) Formation of Distribution Block

With due consideration of following localities, 6 distribution blocks is proposed as shown in Figure III-13, names of which are CLC (LGUs' capital figure of Consolacion, Lilo-an and Compostela), Casili (Mandaue), Talamban (northern Cebu), Tisa (southern Cebu), Lagtang (Talisay) and Mactan (Lapu-lapu and Cordova), respectively.

- local demand density in 2015,
- location and volume of existing reservoirs,
- present hydraulic capacity of distribution pipeline network, and
- LGU boundaries (for sector monitoring).

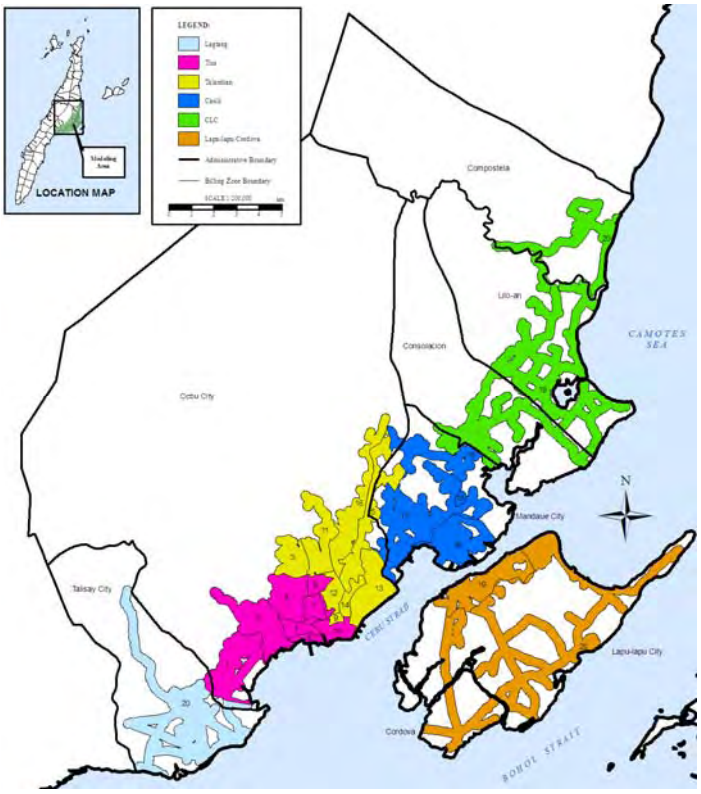


Figure III-13 Formation of 6 Distribution Blocks

(2) Water Demand of each Distribution Block in 2015

At the first, service population in each distribution block is estimated using the result of service population projection by LGUs in Chapter III-1 and existing MCWD domestic consumption in Cebu city as shown in Table III-35.

Table III-35 Service Population by Distribution Block

Distribution Block	2015	2030	Remarks
CLC	95,063	168,120	Compostela, Li-loan, Consolacion
Casili	182,536	304,005	Mandaue City
Talamban	207,444	298,852	48% of Cebu City
Tisa	224,730	323,757	52% of Cebu City
Lagtang	85,941	159,175	Talisay City
Mactan	150,957	308,699	Lapu-lapu City, Cordova
Total	946,671	1,562,608	-

Projected demand of Cebu city is divided into two distribution blocks at Talamban and Tisa in proportion to water consumption of MCWD billing zones in December 2008. Water demand projection by distribution blocks is described in Table III-36.

Table III-36 Water Demand Projection by Distribution Blocks (m^3/day)

Distribution Blocks	Dec-2008	2015	2030
CLC	9,590	15,409	26,513
Casili	16,444	32,258	53,002
Talamban	35,108	46,539	61,022
Tisa	37,099	48,764	62,940
Lagtang	6,453	14,641	26,234
Mactan	13,186	30,509	56,526
Total	117,871	188,120	286,237

Since above stated water demand is consumption base volume, NRW has to be added to the figure. As it was mentioned in previous section, 20% of NRW in 2015 and 17% in 2030 are projected. Finally, water demand (supply volume) is calculated as shown in Table III-37

Table III-37 Distribution Block Demand (m^3/day)

Area	Dec-2008		2015		2030	
Distribution	w/o NRW	with NRW (30%)	w/o NRW	with NRW (20%)	w/o NRW	with NRW (17%)
CLC	9,590	13,701	15,409	19,261	26,513	31,943
Casili	16,444	23,491	32,258	40,323	53,002	63,858
Talamban	35,108	50,154	46,539	58,173	61,022	73,521
Tisa	37,099	52,986	48,764	60,956	62,940	75,831
Lagtang	6,453	9,219	14,641	18,301	26,234	31,607
Mactan	13,186	18,836	30,509	38,136	56,526	68,104
Total	117,871	168,387	188,120	235,150	286,237	344,864

(3) Allocation for Water Source and Water Supply

Due to the regional imbalance of water source and water demand, water source in 2015 has to be transferred to distribution blocks via reservoirs according to water demand in 2015.

The amount of water sources available in each distribution block at 2015 was estimated according to potential study and promised progress of well clearance from the LGUs. Table III-38 indicates the amounts of water demand and supply (sources) with their surplus.

Table III-38 Water Demand and Supply Available in 2015

Distribution Block	Categories	Water Demand	Water Supply	Surplus within DB
1-CLC	Demand 2015	19,261		
	To Reservoir from wells		14,557	
	Direct Feeding by wells		9,041	
	Bulk (Abejo North)		7,000	
	Balance	19,261	30,598	11,337
2-Casili	Demand 2015	40,323		
	To Reservoir from wells		9,918	
	New Wells		18,700	
	Balance	40,323	28,618	-11,705
3-Talamban	Demand 2015	58,173		
	To Reservoir from wells		20,825	
	Direct Feeding by wells		29,439	
	New Wells		22,800	
	Balance	58,173	73,064	14,891
4-Tisa	Demand 2015	60,956		
	To Reservoir from wells		6,902	
	Direct Feeding by wells		15,030	
	Buhisan-Tisa		4,700	
	Jaclupan: Existing		27,000	
	New Jaclupan: Improved		13,000	
	Balance	60,956	66,632	5,676
5-Lagtang	Demand 2015	18,301		
	To Reservoir from wells		6,218	
	Direct Feeding by wells		1,320	
	Bulk (Abejo South and Foremost)		11,000	
	Balance	18,301	18,538	237
6-Mactan	Demand 2015	38,136		
	Direct Feeding by wells		3,827	
	Bulk (Mactan Rock)		5,000	
	New De-salination		9,600	
	Balance	38,136	18,427	-19,709

Note: New wells between Tisa and Talamban flow to Talamban, while that between Talamban and Casili flow to Casili according to the balance of demand and supply.

As shown in Table III-38, the water balance in distribution block can be categorized into three groups shown below.

Water Balance	Distribution Block
Supply (Source) > Demand	CLC, Talamban and Tisa
Supply (Source) = Demand	Lagtang
Supply (Source) < Demand	Casili and Mactan

Within the 6 distribution blocks, water allocation is required to meet the balance of demand and supply in 2015 as shown in Figure III-14. Examination result of water sources connection and inter-reservoir transmission was provided in Figure III-15 as the water flow diagram in 2015.

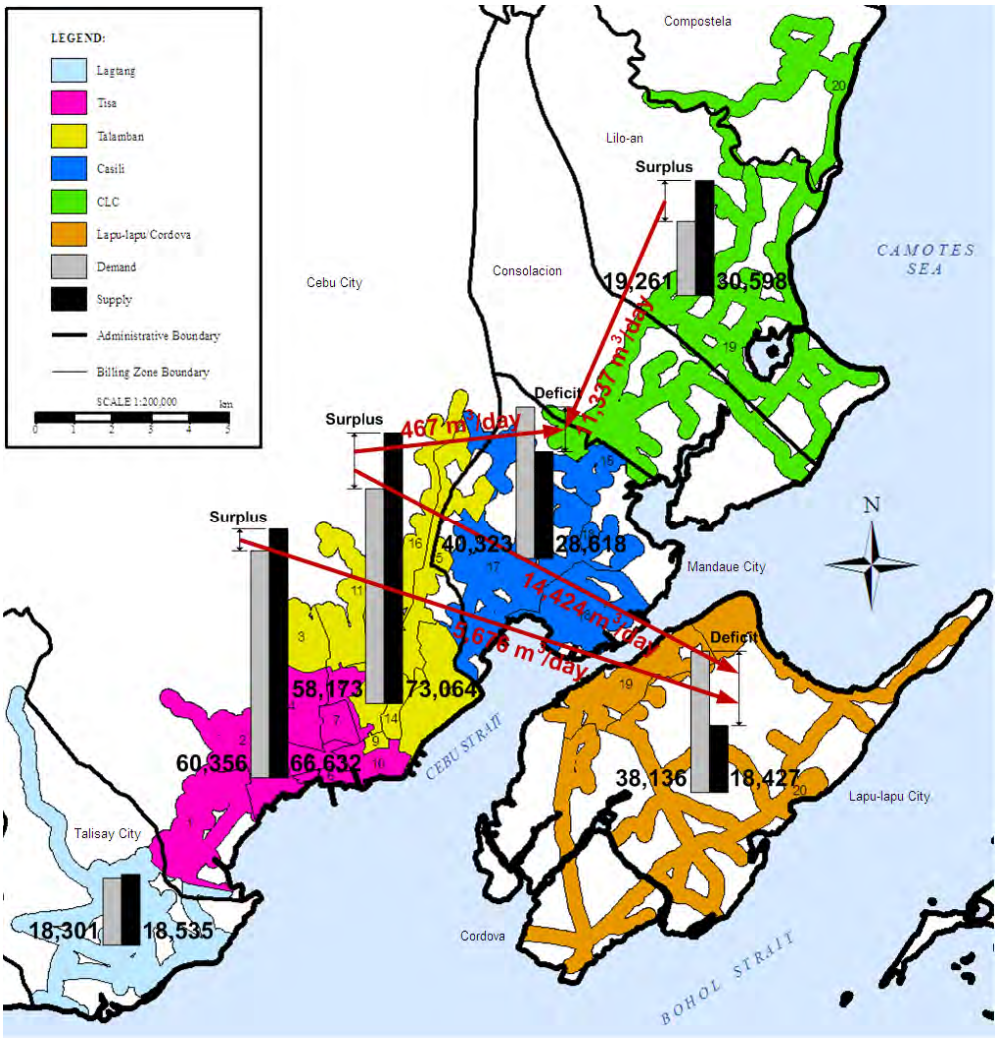


Figure III-14 Allocation for Water Source and Water Supply

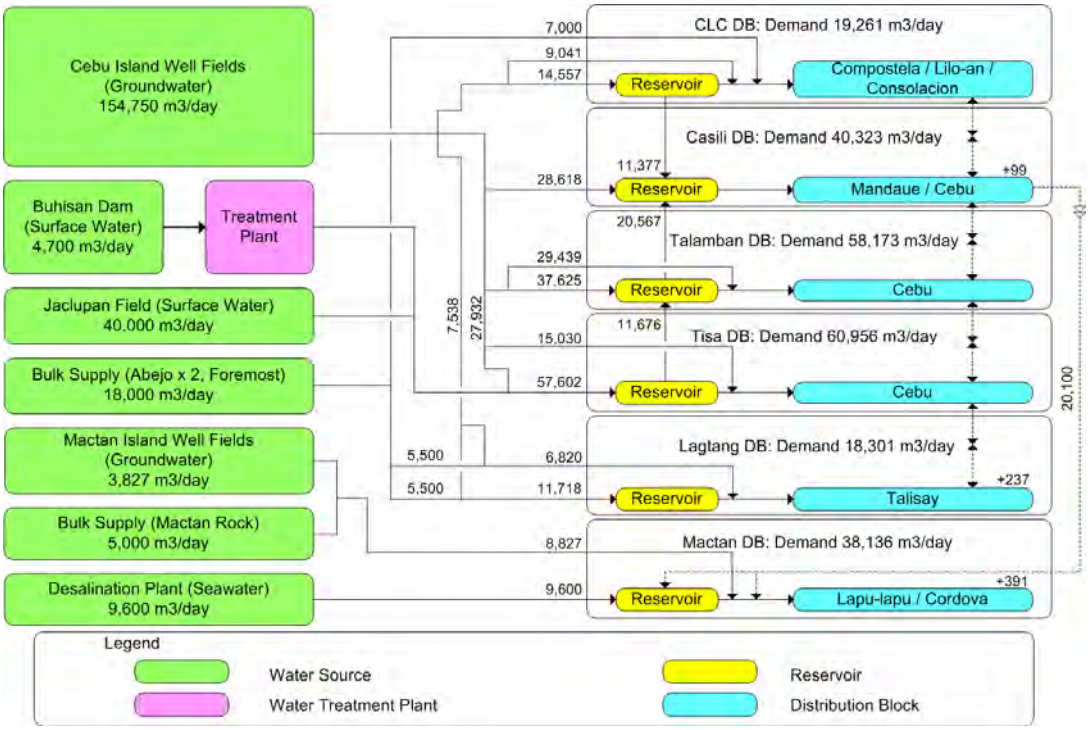


Figure III-15 Water Source and Demand Balance in 2015

III-2.3 Improvement of Water Supply Facilities

(1) Well Development

Development plan is conceptualized with following procedures.

- Present intake amounts were classified into (1) continuous production, (2) reduced production and (3) abandoned according to problem analysis in terms of qualitative and quantitative,
- Present non-operating wells for stand-by and on-going construction were suggested to be operating intake facilities in 2015 based on formality progress of MCWD,
- Groundwater deficit between supply potential and projected demand is planned by new development with due consideration of (1) groundwater potential by predictive simulation and (2) economical site location for the installation cost of raw water pipeline, and
- New wells will be connected to reservoir economically with overall flow allotment concept.

< Scope of Work >

Scope of groundwater development work is described in Table III-39. Well development plan includes new well construction with intake facility and existing well rehabilitation. Well structures, intake pump capacity and pipeline length were fundamentally estimated using particular specifications.

Table III-39 Scope of Groundwater Development Work

Well		Development		Intake Facility		
Type	Statement in 2010 and 2015	Rehab.	Const.	House	M/E	Pipe
Production	Construction by 2015	-	Yes	Yes	Yes	Yes
	Existing in 2010 up to 2015	Yes	-	Excluded		
	Existing by 2015 from Stand-by in 2010	Yes	-			
Stand-by	Existing in 2010 up to 2015	Not Applicable				
Monitoring	Existing in 2010 up to 2015	Conservation Plan		Not Applicable		
	Existing by 2015 from Production in 2010					

Note: M/E means that mechanical and electrical works.

< Particular Consideration >

New Well Development

"Optimal Groundwater Development by Predictive Simulation in the Cebu-GWM-09" was referred to design the production new well to be constructed. Major problems of groundwater environment and well operation in Metropolitan Cebu are;

- ✓ Saltwater Intrusion: allows the normal fresh-water and salt-water interface to move both inland and nearer the ground surface.
- ✓ Nitrate Contamination: causes from the human waste water without treatment or malfunction of septic tank, and no drainage system in hilly subdivisions.
- ✓ Chemical Incrustation: results from the precipitation of carbonates (principally calcium, solution of limestone) in the proximity of the well screen.
- ✓ Sand Contents: are mainly caused by either corrosion or incrustation of well screen, and poor well velocity design (or over-pumping).

Hydrogeological information from the well construction would be very helpful to manage the

project. Following data shall be additionally investigated during the construction period.

- ✓ Sieve Analysis
- ✓ Geo-physical Logging
- ✓ Pumping Test with Water Quality Examination
- ✓ Interface Depth Sounding with Water Quality Examination

Existing Well Rehabilitation

Major purpose of well rehabilitation is to recover the well efficiency (or to reduce well loss). Among the survey methods and measures, following works are included in the action plan.

- ✓ Step Drawdown with Sand Contents Test
- ✓ Well Rehabilitation by chemical and physical methods

< New Well Development >

Number of new well development is shown in Table III-40 and location of them is indicated in Figure III-16 together with the standard well design. Bill of quantity (BOQ) for new well development is shown in Table III-41.

Table III-40 New Well Development in the Action Plan

Distribution Block (LGUs)	Well Field (WRMUs)	Well No. (well)	Expected Yield (m^3/day)	Abstraction by Field (m^3/day)
Casili DB (Mandaue/ Cebu)	Cansaga South	9	300	2,700
	Butuanon North	16	1,000	16,000
Talamban DB (Cebu)	Cebu North	8	600	4,800
	Cebu River	20	600	12,000
	Cebu South	10	600	6,000
Total		63	-	41,500

Note: Prioritization of well development shall be given to abstraction by well field (well number can be adjusted).

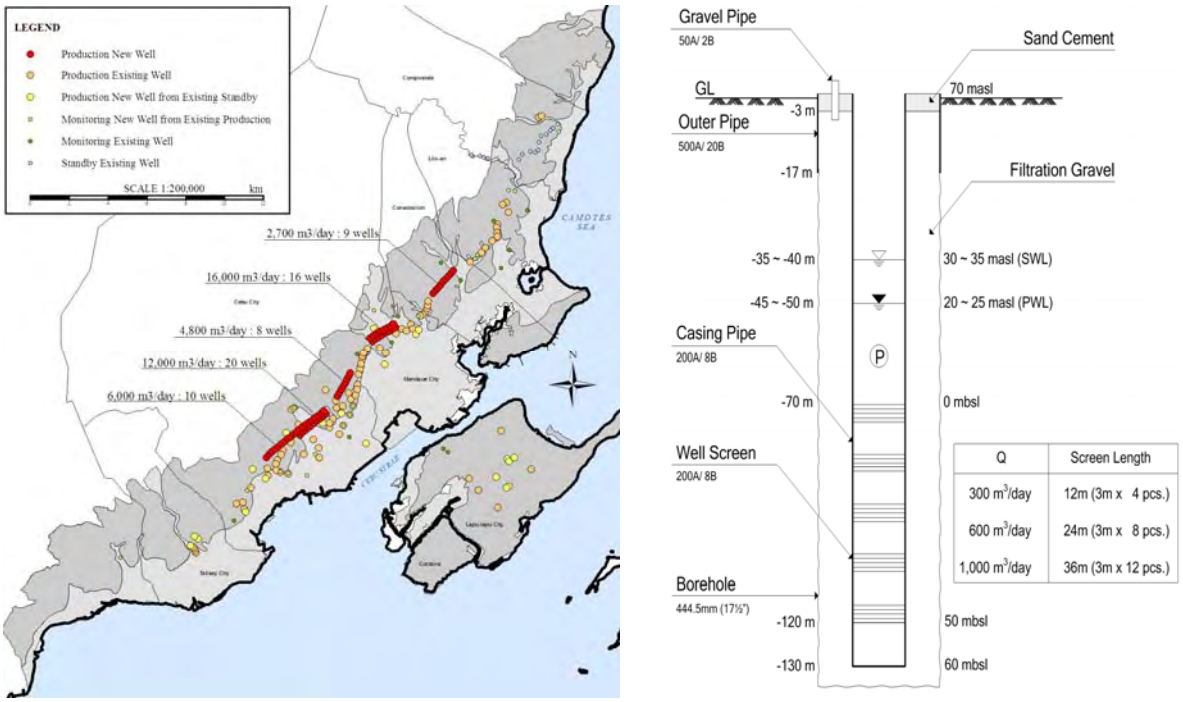


Figure III-16 Location Map and Standard Design for New Well Development

Table III-41 BOQ of New Well Development

Category	Quantity	
New Well	✓ 200A diameter × 130 m in depth with well screen of 12 m	9 wells
	✓ 200A diameter × 130 m in depth with well screen of 24 m	38 wells
	✓ 200A diameter × 130 m in depth with well screen of 36 m	16 wells
	Total	63 wells
Submersible Intake Pump	✓ 300 m^3/day (0.21 m^3/min.) × 60 m total head	9 pumps
	✓ 600 m^3/day (0.42 m^3/min.) × 65 m total head	38 pumps
	✓ 1,000 m^3/day (0.70 m^3/min.) × 60 m total head	16 pumps
	Total	63 pumps
	Note: Length of riser pipe per well is 60 m (63 sites).	
Raw Water Pipeline	✓ Casili DB	12.5 km
	✓ Talamban DB	19.0 km
	Total	Branch: 31.5 km

< Existing Well Rehabilitation >

Number of existing well rehabilitation is shown in Table III-42. Particular specifications are described below.

Table III-42 Rehabilitation of Existing Well by 2015

DB	Existing Well Situation in 2015			Abstraction % in 2015 by DB Supply Total*[1]
	Number of Well (well)	Total Abstraction (m^3/day)	Average Discharge (m^3/day/well)	
CLC	20	23,598	1,180	123%
Casili	6	9,918	1,653	25%
Talamban	35	50,264	1,436	86%
Tisa	22	21,932	997	36%
Lagtang	7	7,538	1,077	41%
Mactan	11	3,827	348	10%
Total	101	117,077	-	-

Note*[1]: Remaining portion of water sources is composed of surface water, new well development, de-salination plant, water source imported from and exported to, and bulk water supply. At CLC DB, production amount from existing wells exceeds demand volume, because remaining water is exported to Casili DB. On the other hand, groundwater source is only 10% in Mactan DB because of water sources exported from Cebu Island, bulk water imported from Mactan Rock and new water source of de-salination plant.

Step Drawdown with Sand Contents Test

This part can be referred to the new well development mentioned above. To evaluate the rehabilitation progress and its effect, the step drawdown with sand contents test shall be executed twice at pre and post well rehabilitation.

Well Rehabilitation Method

The aim of well rehabilitation is to recover the well efficiency. Benefits of well rehabilitation are to extend the well life (life-cycle cost) and to reduce the well loss (operating cost: electric power). To date, the production new well has been re-constructed instead of deteriorated old well. Following are proposed methodology and expected schedule of exiting well rehabilitation.

Both chemical and physical methods are adopted to remove plugging materials such as carbonate incrustation and fine particles. Additionally, well bottom dredging will be included for well cleaning using air-lifting method. With due consideration of surrounding wells and qualitative safety, following reagent is recommended to use for chemical rehabilitation.

- ✓ Polyphosphate: 7% to 10% of water weight in well with at least 24 hours on leave

Physical methods are referred to the MCWD Manuals. Depending on the well screen strength, individual or compound of following tools would be applied.

- ✓ Over-pumping (intermittent) and or Back-washing
- ✓ Mechanical Surging and or Brushing
- ✓ High-velocity Water and or Air Jetting

(2) Jaclupan Improvement

Improvement purpose of Jaclupan Infiltration Facility is to restore its design capacity of 40,000 m^3/day. Phasing investigation and improvement is recommended (referred to Chapter III-3.1). As an initial improvement, underground baffle wall is designed to reduce the riverbed water seepage for maintaining its water level as constant as possible if the amount of riverbed water flow is confirmed as additional potential.

Figure III-17 indicates the location of sheet pile. Detailed structures shall be design after soil investigation to confirm actual depth to the base rock of limestone.

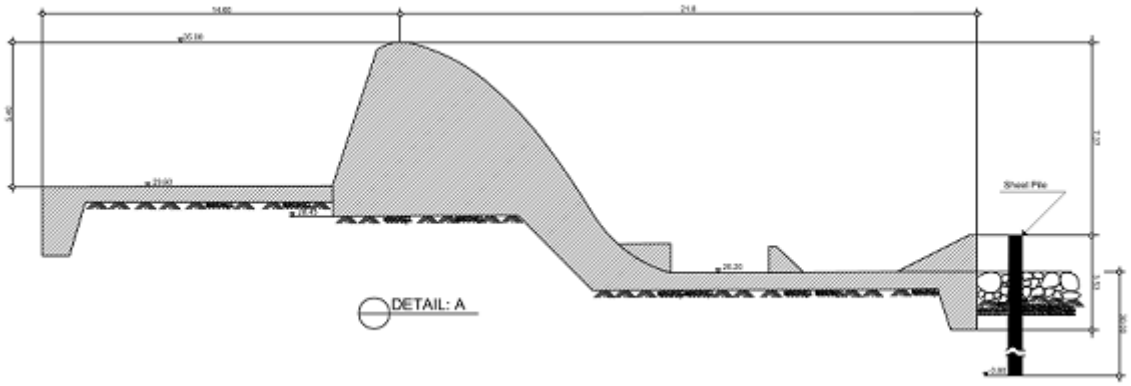


Figure III-17 Jaclupan Improvement

(3) Desalination Plant Development

In the year 2015, desalination plant in Mactan Island should produce and supply 9,600 m^3/day of membrane filtered water. Punta Engano area as shown in Figure III-18 (next page) was nominated as construction site of desalination plant. Available land area is sufficient for the plant capacity and it could be expanded when water source supply from Cebu is insufficient. This plant intakes seawater from Hilutungan Channel and discharging condensed seawater to Magellan Bay.

Site selection, intake and discharge method, and treatment process were determined with reference materials of JBIC study 2005 (Feasibility Study of Seawater Desalination Facility for Water Supply in Metro Cebu) and JICA study 2009 (Preparatory Survey on the Programme Grant Aid for Environment and Climate Change; Water Technology). Project outline of the both report is described in the supporting report. Proposed treatment process is drawn in Figure III-19 (next page).

Figure III-18 Proposed Location and Intake/ Discharge Routs of Desalination Plant

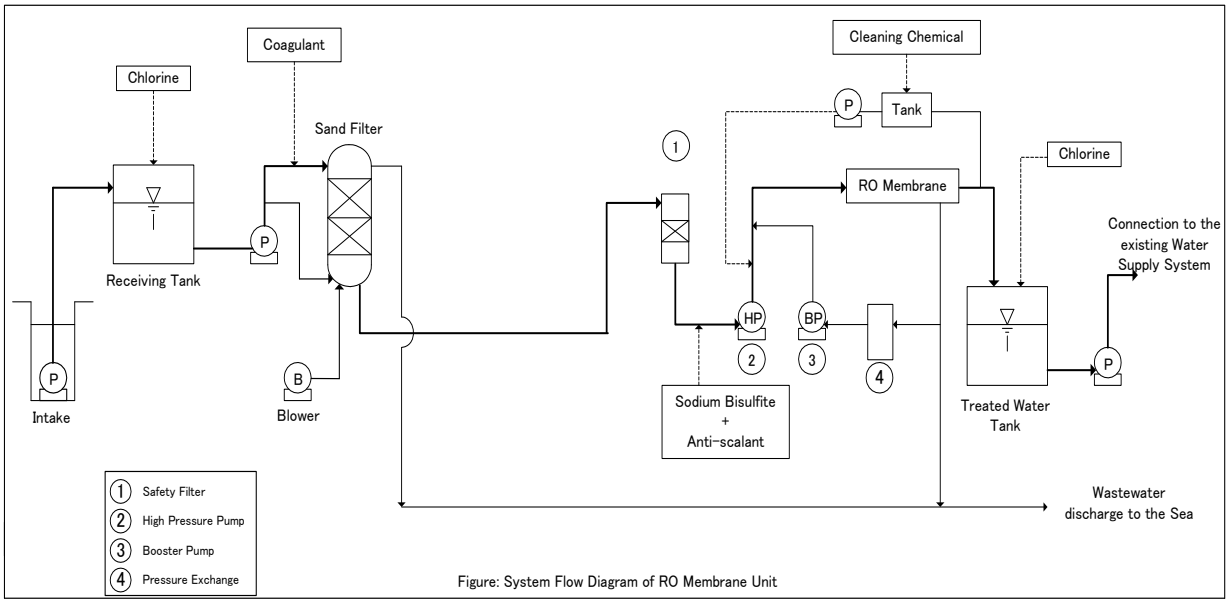


Figure III-19 Proposed Treatment Process of Mactan Desalination Plant

Treated water is transmitted to the new reservoir near existing elevated reservoir or temporarily to MEPZ reservoir. It is desirable for the treated water to mix with groundwater source, because slightly high concentration of Boron (B) is diluted and blended water quality would become permissive level of the PNSDW-07.

(4) Tisa WTP Improvement

Existing Tisa Filter Plant was constructed almost one century ago and its facilities are already deteriorated. Action plan components include renovation of the existing slow sand filter plant to the space-saving rapid sand filter plant to produce enough area for new reservoir. Design flow for the new treatment plant is 10,000 m^3/day based on the past operation data. Construction space for the rapid sand filtration is much smaller than the existing plant. The new reservoir for the Tisa distribution block could be constructed in the same compound of present Tisa WTP.

Although existing facility also equips rapid sand filter as stand-by facility or for emergency use, facility are already deteriorated and new construction is desirable. Treatment flow has varied

every month as monthly precipitation varies. Average flow is 4,700 m^3/day in 2015, maximum capacity should be 10,000 m^3/day based on the past performance. Treatment process flow is referred to Figure III-20.

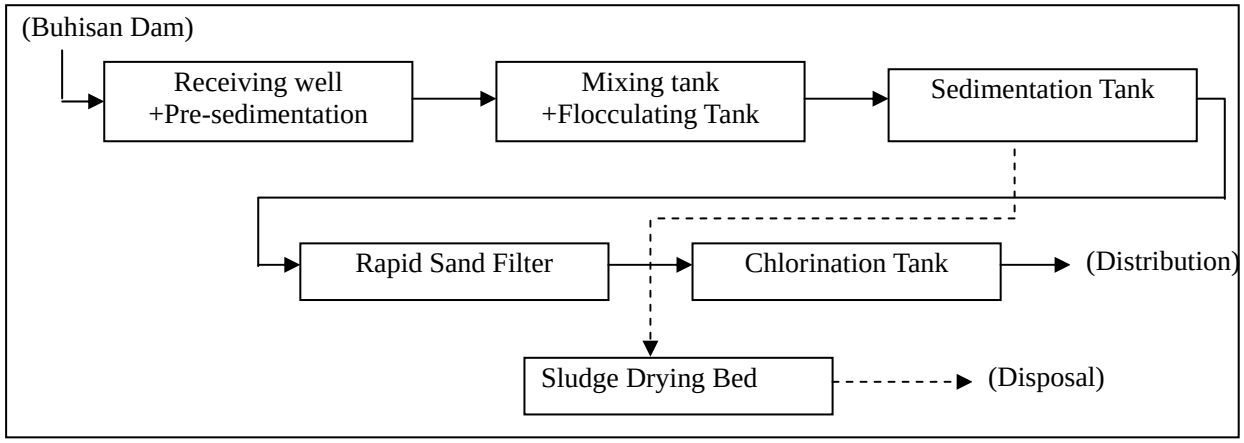


Figure III-20 Proposed Treatment Process for Tisa WTP

(5) Reservoir Development

Required volume of reservoir, existing capacity and additional volume are calculated in Table III-43;

Table III-43 Proposed Reservoir Volume

Distribution Block	DAF in 2015 (m^3/day)	Volume Estimation (m^3)			
		Estimated	Existing	Additional	Proposed
CLC	19,261	4,815	5,000	-	
Casili	40,323	10,081	5,000	5,081	5,000
Talamban	58,173	14,543	5,000	9.543	10,000
Tisa	60,956	15,239	5,000	10,239	10,000
Lagtang	18,301	4,575	5,000	-	
Mactan	38,136	9,534	*[1]5,200	4,334	4,000

Note*[1]: Volumes of reservoir at MEPZ is 3,200m^3 and Pusok is 2,000m^3.

Location of the each reservoir is;

- Casili: next to existing reservoir
- Talamban: next to existing reservoir
- Tisa: next to existing reservoir (within Tisa WTP)
- Mactan: next to existing elevated reservoir

(6) Transmission Pipe

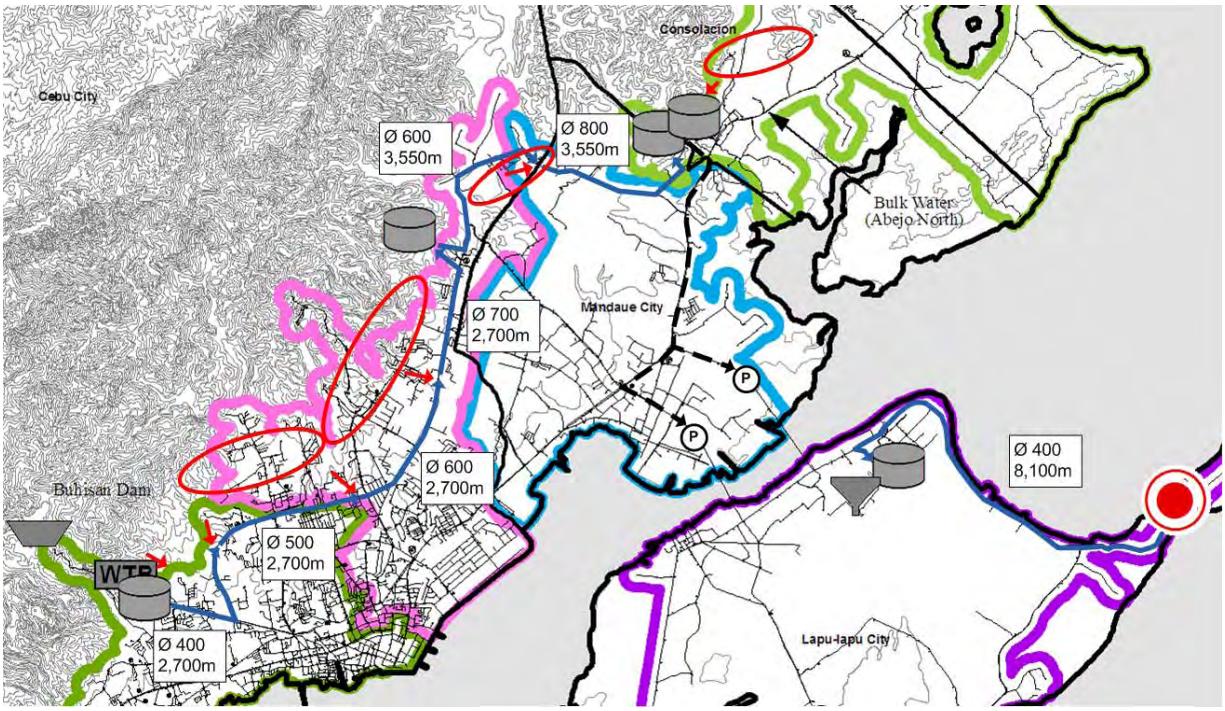
< Inter-Reservoir >

Water source is not distributed just in accordance with area-wise demand and supply-demand balance shall be re-arranged through the water allocation via inter-reservoir transmission. Excessive water source derived from CLC distribution block (DB) is transferred to Casili DB and exportation water to Mactan Island is forwarded from Tisa and Talamban DBs through Casili new reservoir and existing distribution pipeline.

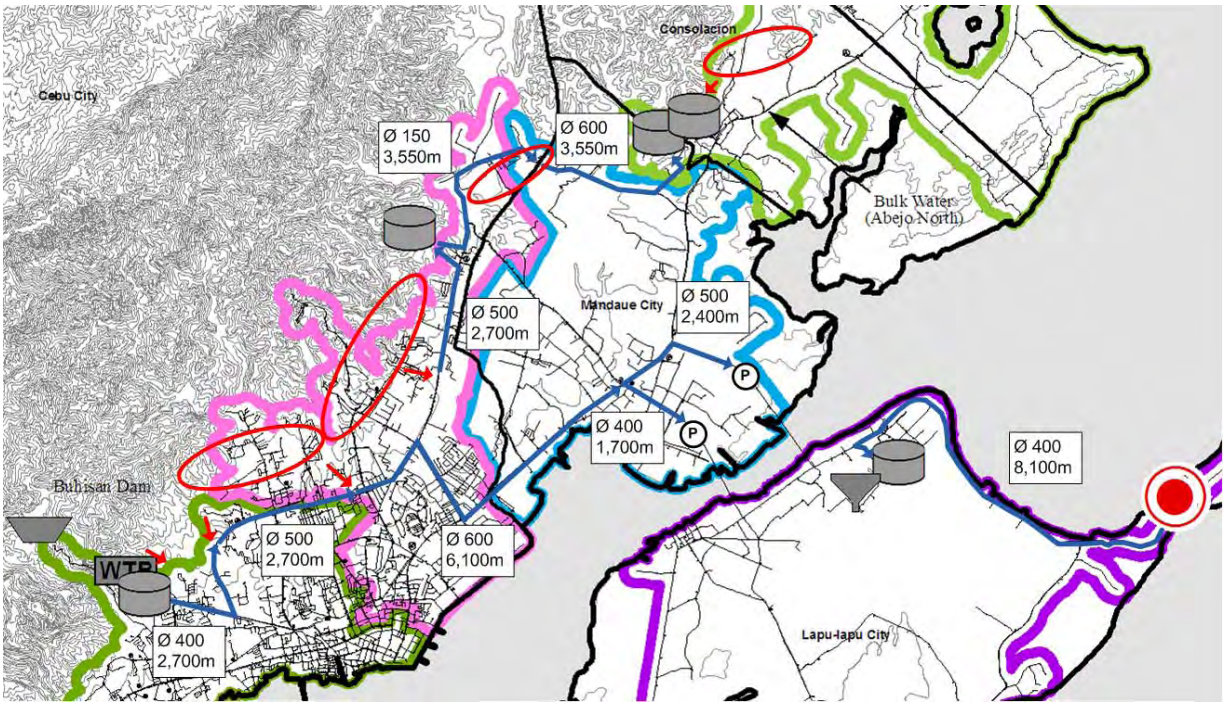
Although transmission pipe diameter is determined assuming additional groundwater source is

collected to own reservoir by another pipe route, it is economical to add new groundwater source on the proposed transmission route and BOQ of transmission line is revised considering on-the-way additional groundwater.

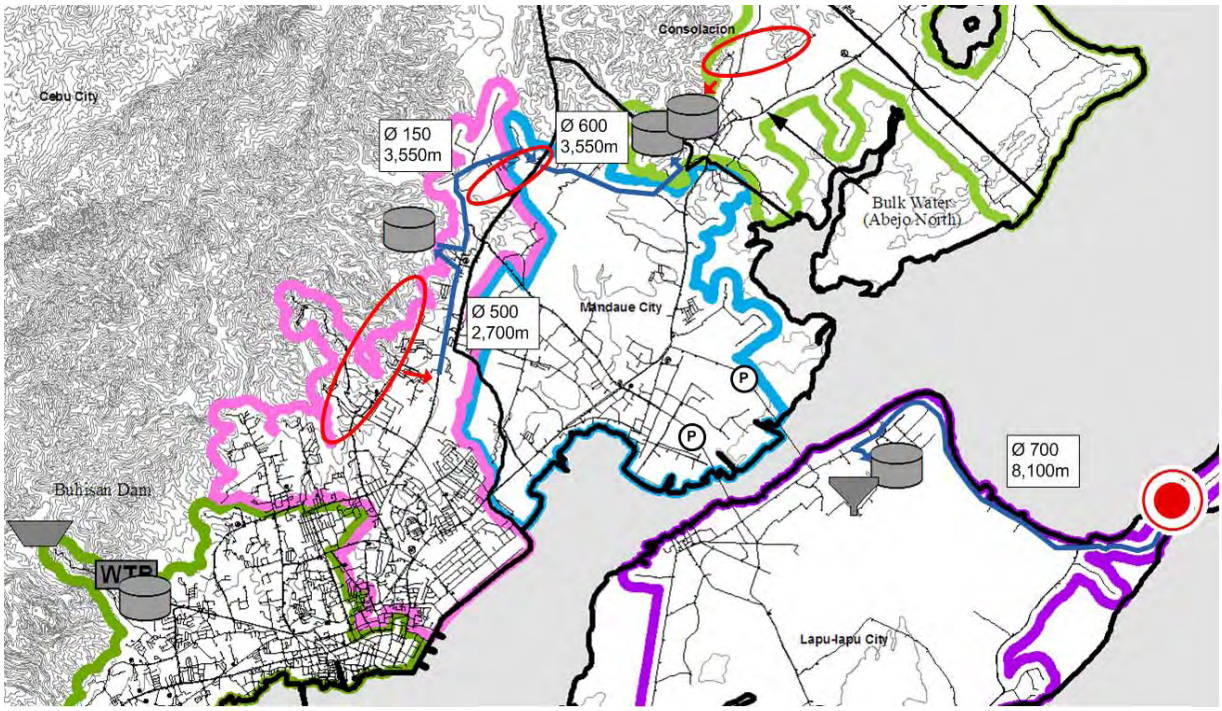
Trial cost estimation of revised pipeline route persuaded optional plans, which consist of independent and direct transmission line from Tisa and Talamban well field to new bridge-side booster and another groundwater source to reservoir line. Flow diagram is shown in the Figure III-21 with direct cost estimated by well, desalination and inter-reservoir pipeline.



Option-1 (1,076 million PHP): Groundwater should be collected at Casili and be transferred to Mactan reservoir.



Option-2 (1,091 million PHP): Exportation to Mactan is divided into two transmission route from Tisa and Casili.



Option-3 (1,323 million PHP): Desalination capacity is increased (9,600 to 30,000 m^3/day) instead of Tisa groundwater.

Figure III-21 Optional Plans on the Route of Inter-reservoir Transmission

As an examination result, water of 11,676 m^3/day from Tisa reservoir is transferred to Talamban reservoir, adding on 8,891 m^3/day from Talamban well field, total 20,567 m^3/d is transferred to Casili DB reservoir. Of the volume, 20,100 m^3/day is delivered to Mactan Island through 1,000 mm in diameter pipe, two lines of 600 mm and 400 mm pipe and existing/ planned booster pump station.

< Desalination Plant >

Treated water from Mactan desalination plant is transmitted to the new reservoir next to the existing Pusok reservoir as shown in Figure III-22.

Figure III-22 Transmission Route from Desalination Plant

(7) Distribution Pipelines

< Fabrication of Distribution Blocks >

Proposed 6 distribution blocks can be separated by shutting the valves as shown in Figure III-23.

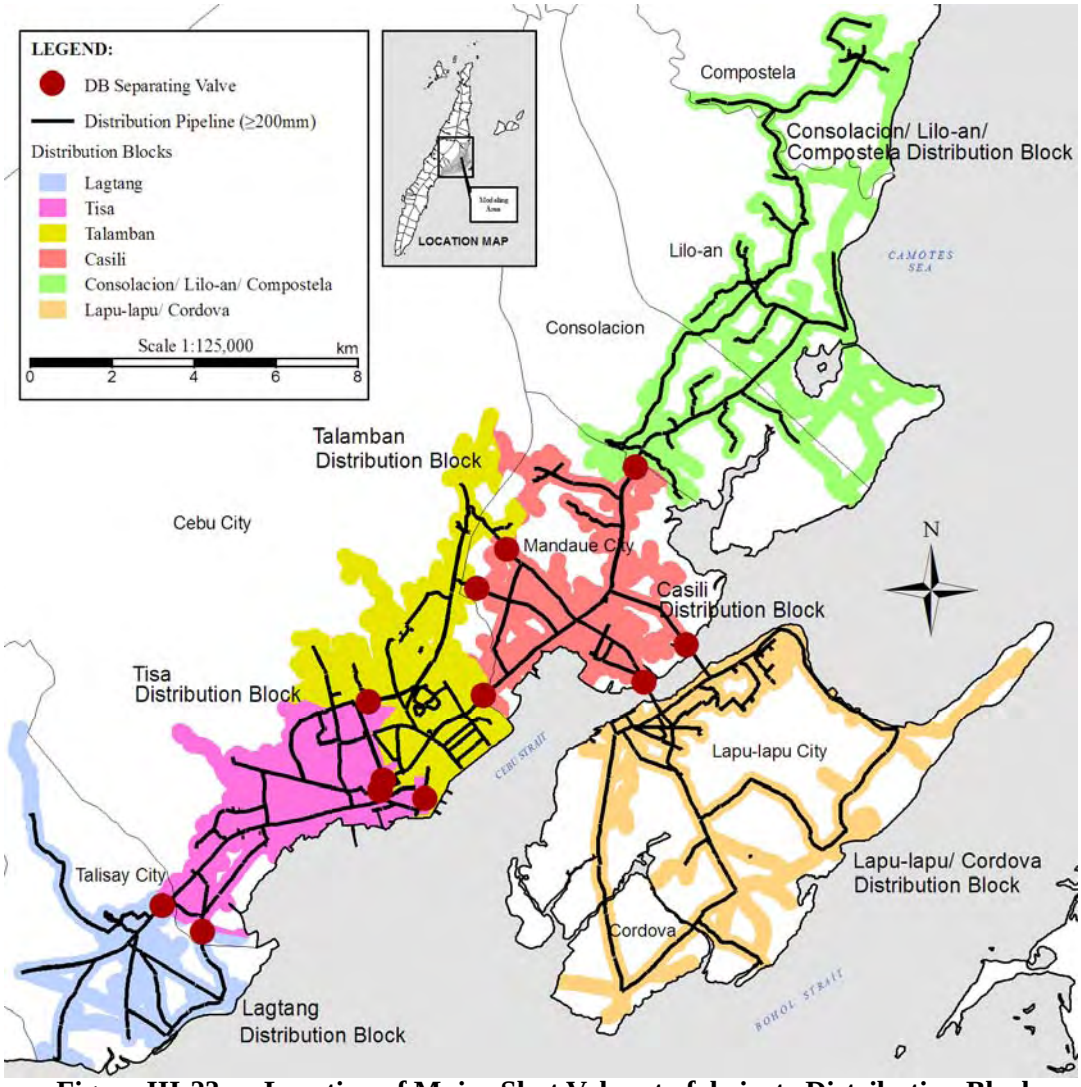


Figure III-23 Location of Major Shut Valves to fabricate Distribution Blocks

Basically, one distribution block is covered by one large reservoir but some well still injects groundwater provisionally. Small Compostela reservoir keeps covering its own municipality. Since existing Pusok reservoir in Mactan Island was designed as fill and draw type, it is desirable to replace by the gravity distribution reservoir with direct connection of transmission from Cebu Island.

< Distribution Pipeline Network Analysis >

Present pipeline network was evaluated and proposed networks was simulated using the software of hydraulic analysis namely WaterCAD. Modeling method of pipeline hydraulics is referred to Figure III-24.

Simulation code is Hazen-Williams. Value of friction coefficient (C=110; generally adopted) depends on the pipe condition of inner surface. This value takes into account all other head losses that may have been overlooked in the analysis for additive allowance.

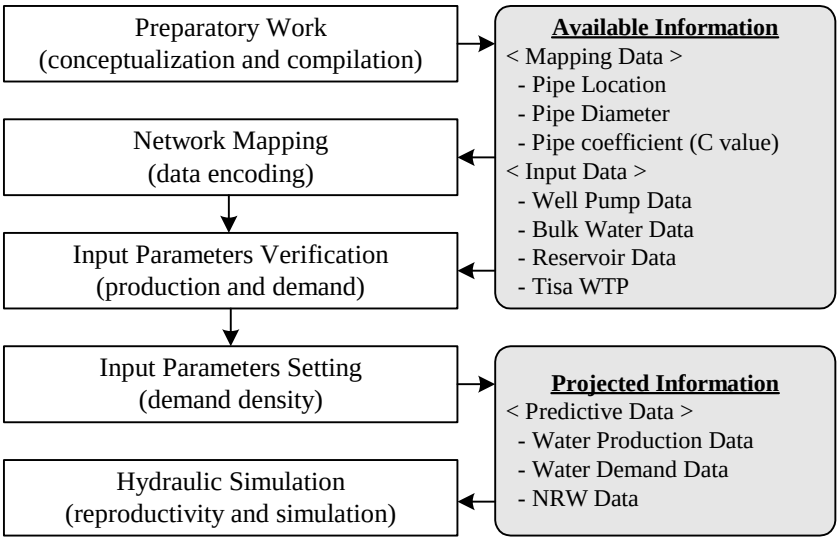


Figure III-24 Building Flow of Hydraulic Model

Table III-44 indicates the input demand values to hydraulic model.

Table III-44 Input Demand Parameter for Pipeline Hydraulic Analysis (2015)

DB	DAF (m^3/day)	DMF (m^3/day)	HMF (m^3/day)
CLC	19,261	23,113	42,374
Casili	40,323	48,388	88,711
Talamban	58,173	69,808	127,981
Tisa	60,956	73,147	134,103
Lagtang	18,301	21,961	40,262
Mactan	38,136	45,763	83,899

Note: DAF: DMF: HMF = 1.0: 1.2: 2.2

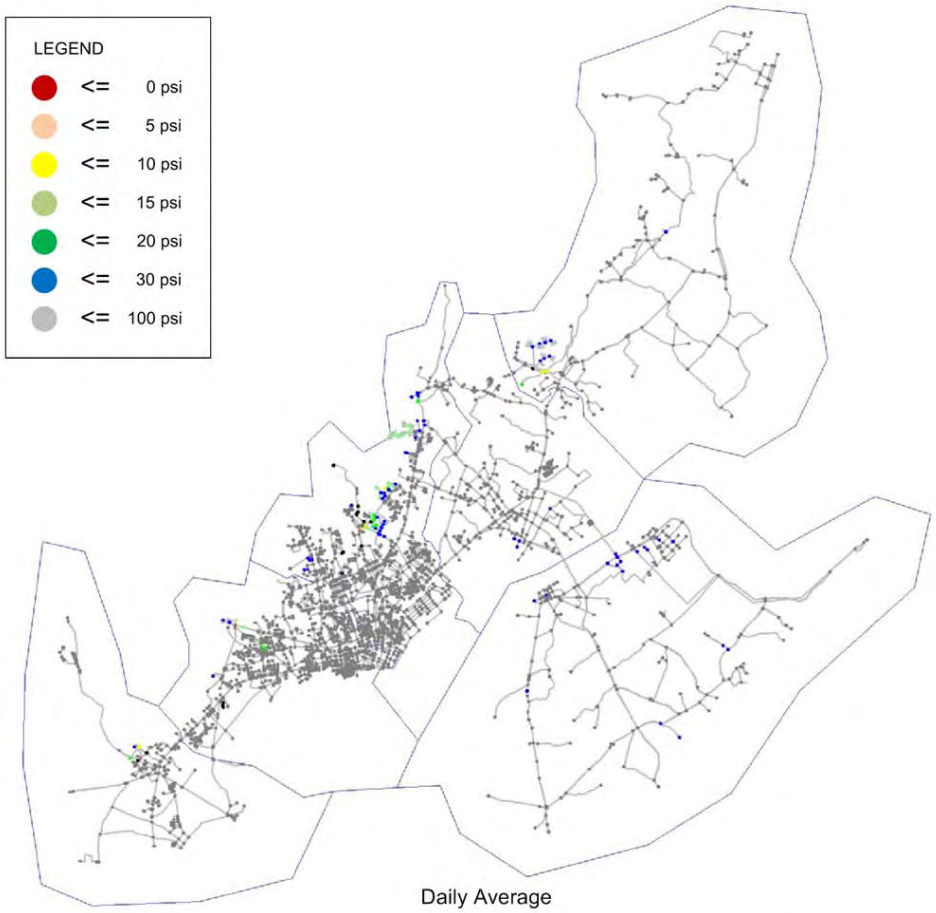
Results of hydraulic analysis by planned pipeline (2015) using input conditions of DAF, DMF and HMF are illustrated in Figure III-25. Basic information of planned pipeline in 2015 including MCWD plan in 2010 and Action Plan until 2015 are;

- No. of nodes: 2,890 (2,851 in Dec-2008)
- No. of pipes: 4,164 (3,551 in Dec-2008)

According to the figures mentioned above, most of pipes were planned as replacement and addition (the same node number with different pipe numbers). New expansion pipelines are limited. It can be seen that following node numbers which indicates below minimum pressure.

- DAF: 14 nodes (< 0.07 MPa),
- DMF: 15 nodes (< 0.07 MPa), and
- HMF: 92 nodes (< 0.07 MPa) with 9 negative nodes (red points in Figure III-26).

As results of this hydraulic analysis, this plan proposed the booster pump station at two (2) points. The on-going project of fill-and-draw reservoir with booster pump station was suggested by MCWD engineering department. In this regard, action plan for the said booster pump station was dropped off.



Daily Average

Daily Maximum

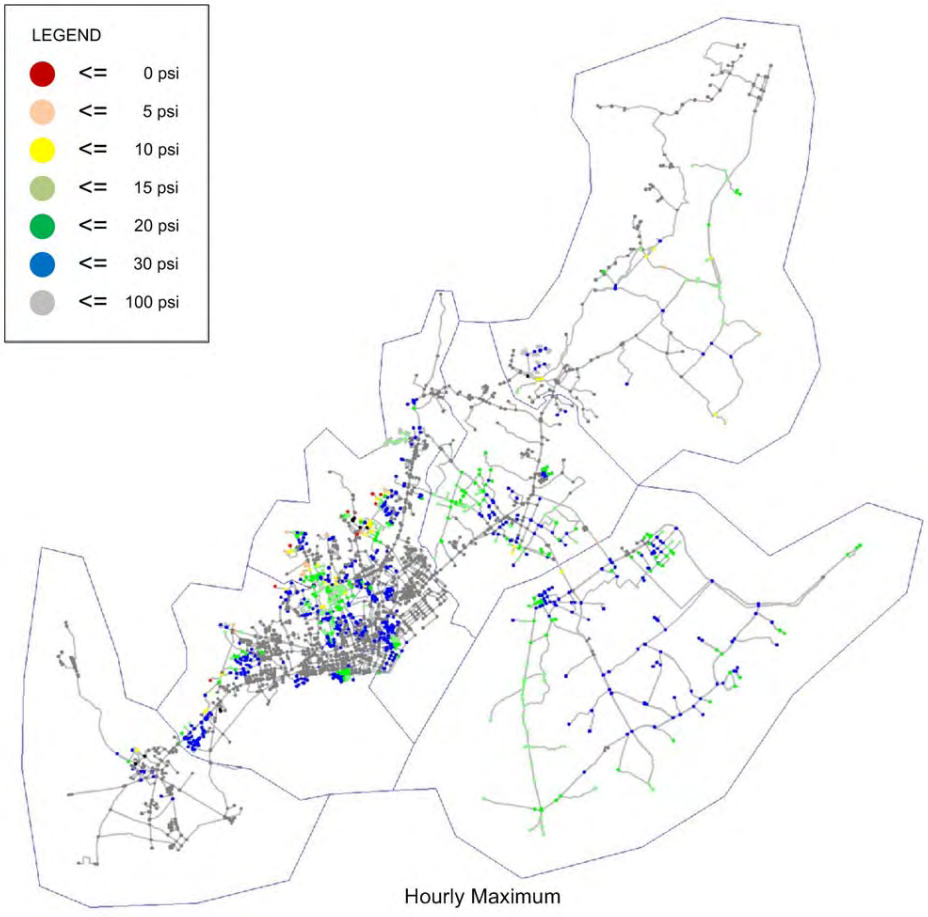


Figure III-25 Predictive Simulation of Improved Pipeline Network in 2015

III-2.4 Bill of Quantity by each Distribution Block

Table III-45 presents the overall project component (bill of quantity). BOQ in each distribution block is summarized in Tables III-46 to III-51 and also attached Figures III-26 to III-31.

Table III-45 Overall Project Component

Item	Description	Unit	Quantity
1-1	Well Intake Facilities Construction	well	63
1-2	Well Intake Facilities Rehabilitation	well	101
1-3	Juclapan Weir Rehabilitation	site	1
1-4	Tisa WTP Rehabilitation	site	1
1-5	Mactan Desalination Plant	site	1
2-1	Reservoir (V = 10,000 m^3)	site	2
2-2	Reservoir (V = 5,000 m^3)	site	1
2-3	Water Tower Construction (V = 2,000 m^3)	site	2
3-1	Raw Water Pipeline (100mm and 150mm)	m	31,500
3-2	Transmission Pipeline (400mm to 800mm)	m	26,788
3-3	Inter-reservoir Pump Station	site	2
3-4	Main Distribution Pipeline (300mm to 700mm)	m	32,206
3-5	Secondary Distribution Pipeline (75mm to 200mm)	m	37,014
3-6	Flow Meter Installation	site	6
4-1	NRW Reduction (referred to Chapter III-3)	LS.	1

Table III-46 CLC DB Improvement Project

Daily Average Demand (with NRW)		19,261 m^3/day
Main Facility	Groundwater Abstraction Well	
	Capacity (m^3/day)	Quantity
		0
	Well Rehabilitation	
		Quantity
		20
	Distribution Network	
	1) Pipe installation	
	Diameter (mm)	Length (m)
	75	249
	100	495
	150	5,119
	200	7,096
	300	5,657
	400	1,367

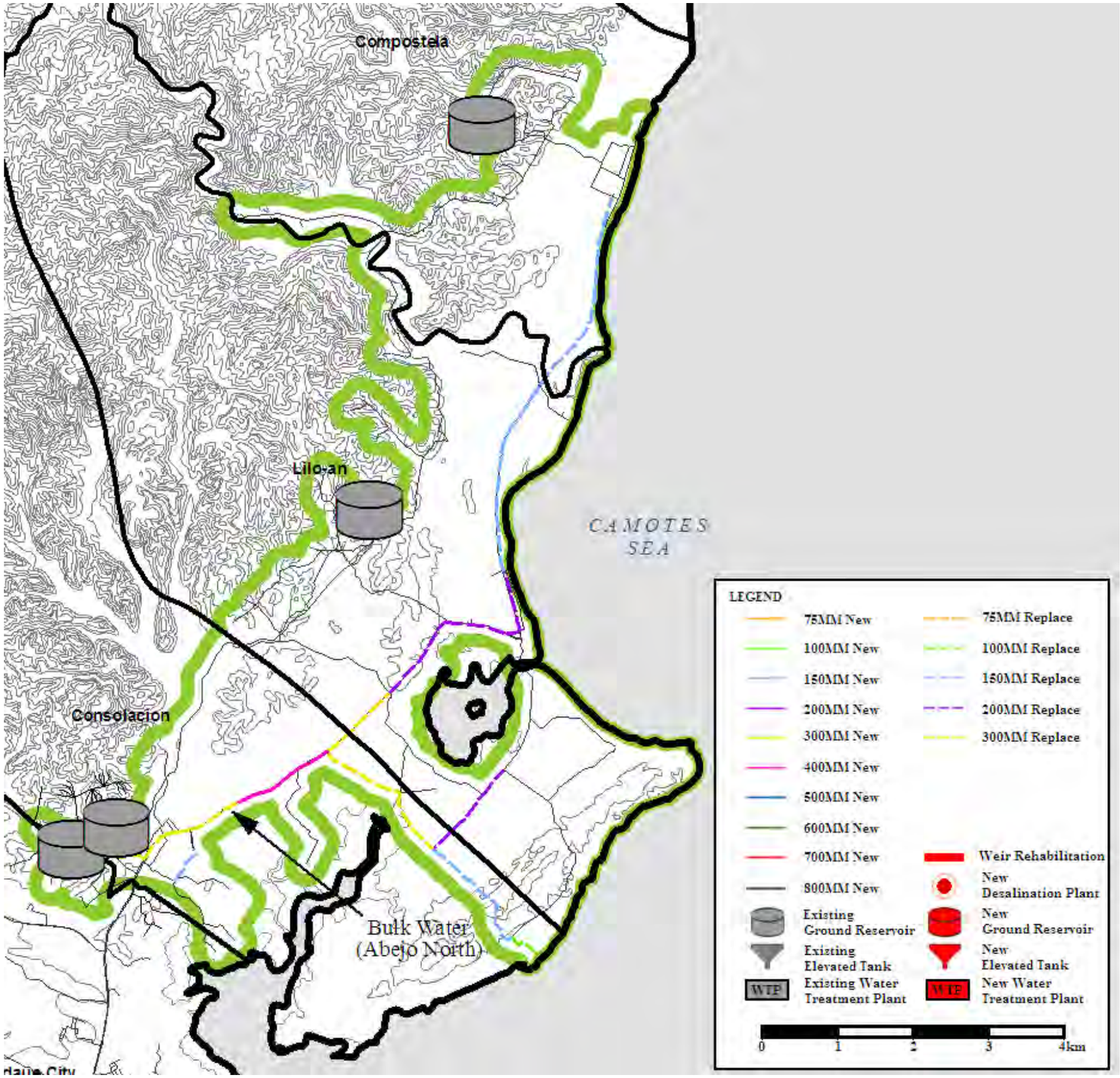


Figure III-26 CLC DB Improvement Project

Table III-47 Casili DB Improvement Project

Daily Average Demand (with NRW)			40,323 m^3/day
Main Facility	Groundwater Abstraction Well		
	Capacity (m^3/day)	Quantity	
	300 m^3/day/well	9	
	1,000 m^3/day/well	16	
	Well Rehabilitation		
		Quantity	
		6	
	Raw Water Line		
	1) Well to Inter-reservoir transmission line		
	Diameter (mm)	Length (m)	
	100	4,500	
	150	8,000	
	Transmission Line		
	1) Inter-reservoir transmission line		
	Diameter (mm)	Length (m)	
	600	3,550	
	800	3,550	
	2) Booster Pump for Transmission line		
	Capacity (m^3/hour)	Quantity	
	381	4+2 (Stand-by)	
	Distribution Network		
	1) Pipe installation		
	Diameter (mm)	Length (m)	
	75	691	
	100	575	
	150	2,786	
	200	4,119	
	300	2,098	
	400	773	
	500	190	
	Reservoir		
	Capacity (m^3)		
	5,000	1	

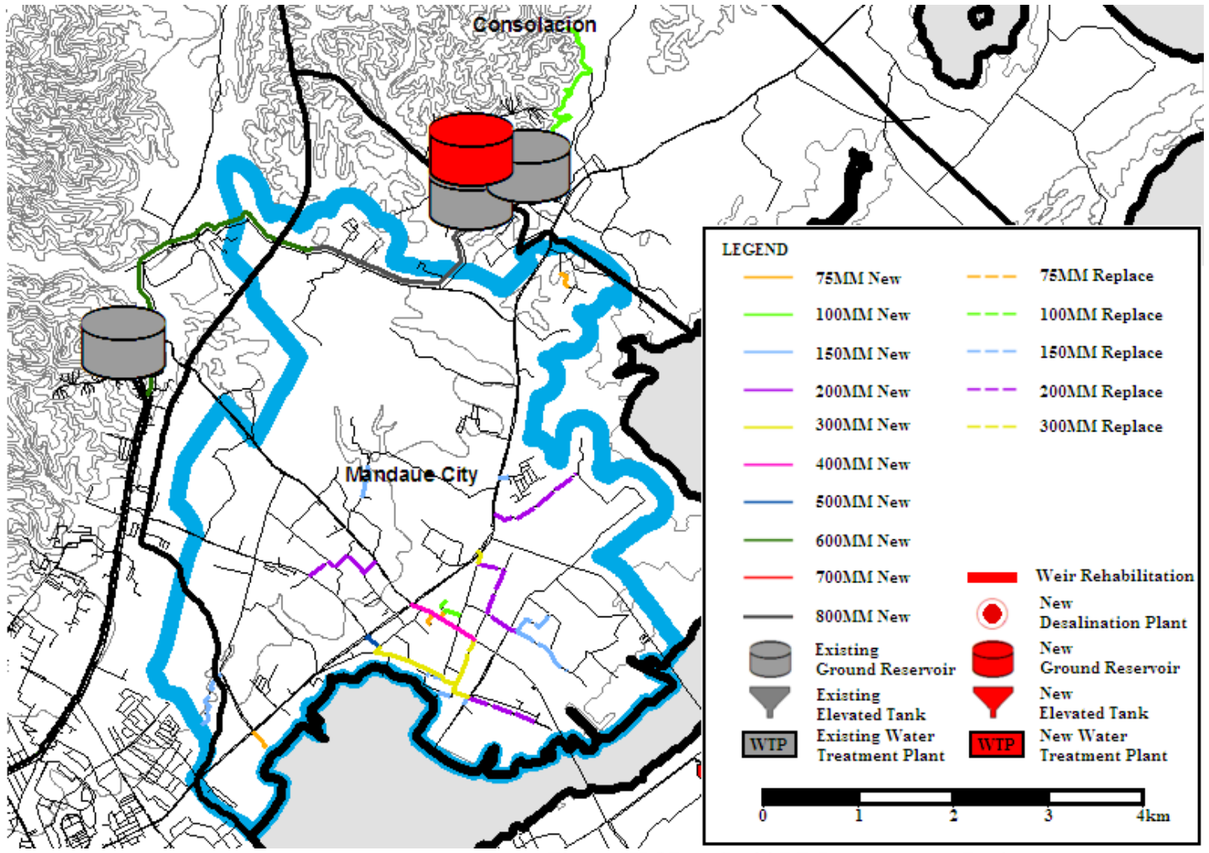


Figure III-27 Casili DB Improvement Project

Table III-48 Talamban DB Improvement Project

Daily Average Demand (with NRW)		58,173 m^3/day
Main Facility	Groundwater Abstraction Well	-
	Capacity (m^3/day)	Quantity
	600 m^3/day/well	38
	Well Rehabilitation	
		Quantity
		35
	Raw Water Line	
	1) Well to Inter-reservoir transmission line	
	Diameter (mm)	Length (m)
	150	19,000
	Transmission Line	
	1) Inter-reservoir transmission line	
	Diameter (mm)	Length (m)
	400	2,700
	500	2,700
	600	2,700
	700	2,700
	2) Booster Pump for Transmission line	
	Capacity (m^3/hour)	Quantity
	396	3+2(Stand-by)
	Distribution Network	
	1) Pipe installation	
	Diameter (mm)	Length (m)
	75	85
	100	408
	150	1,707
	200	3,491
	300	1,346
	400	102
	500	4,901
	600	1,021
	700	980
	2) Booster pump station	
	Capacity (m^3/h)	Quantity
	dropped	
	Reservoir	
	Capacity (m^3)	Quantity
	10,000	1

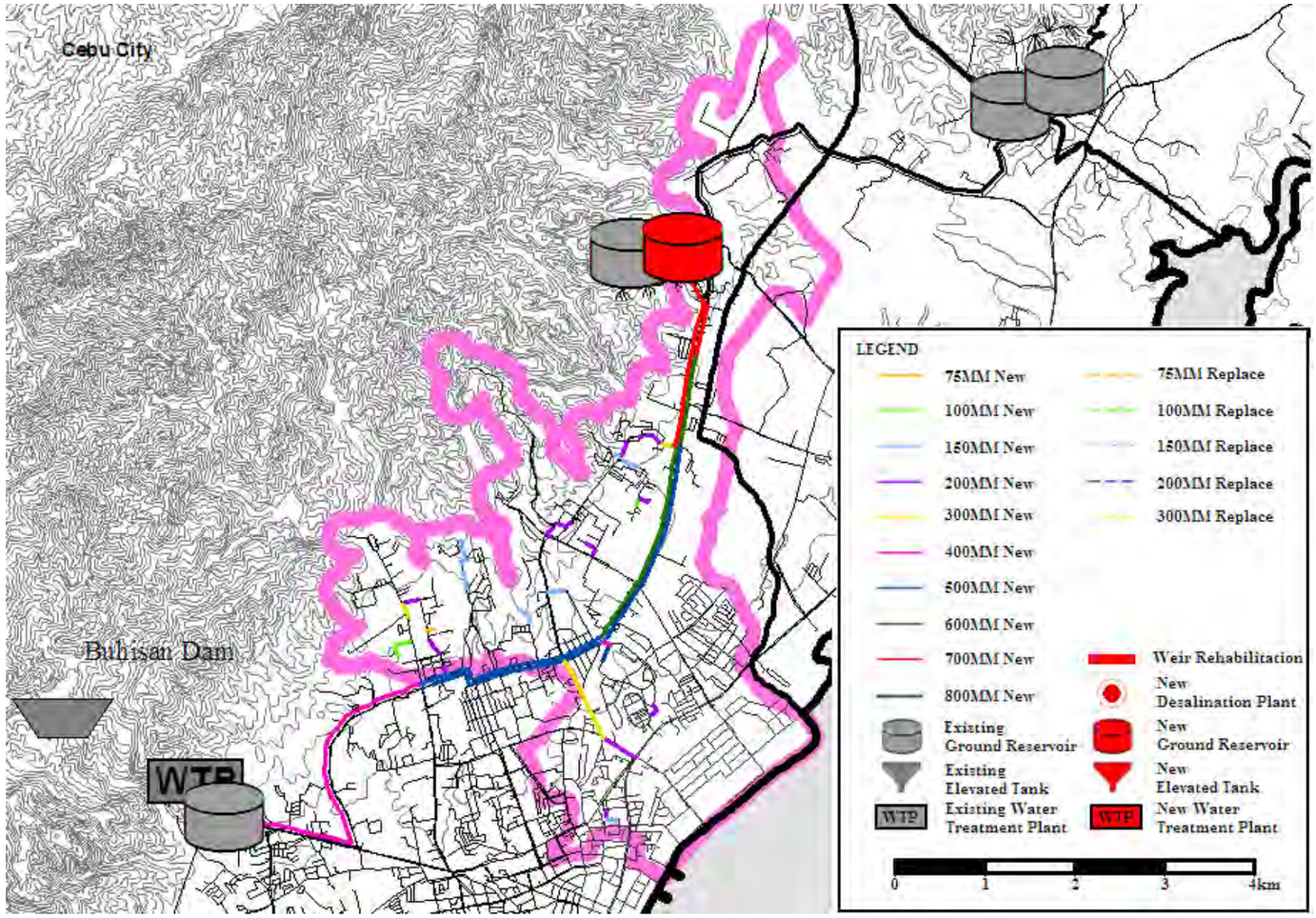


Figure III-28 Talamban DB Improvement Project

Table III-49 Tisa DB Improvement Project

Daily Average Demand (with NRW)		60,956 m^3/day
Main Facility	Groundwater Abstraction Well	
	Capacity (m^3/day)	Quantity
		0
	Well Rehabilitation	
		Quantity
		22
	Distribution Network	
	1) Pipe installation	
	Diameter (mm)	Length (m)
	75	359
	100	1,238
	150	713
	200	1,667
	300	257
	700	3,951
	Reservoir	
	Capacity (m^3)	Quantity
	10,000	1
	WTP improvement	
		Quantity
		1
	Jaclupan weir improvement	
	Capacity (m^3/day)	Quantity
		Lump sum

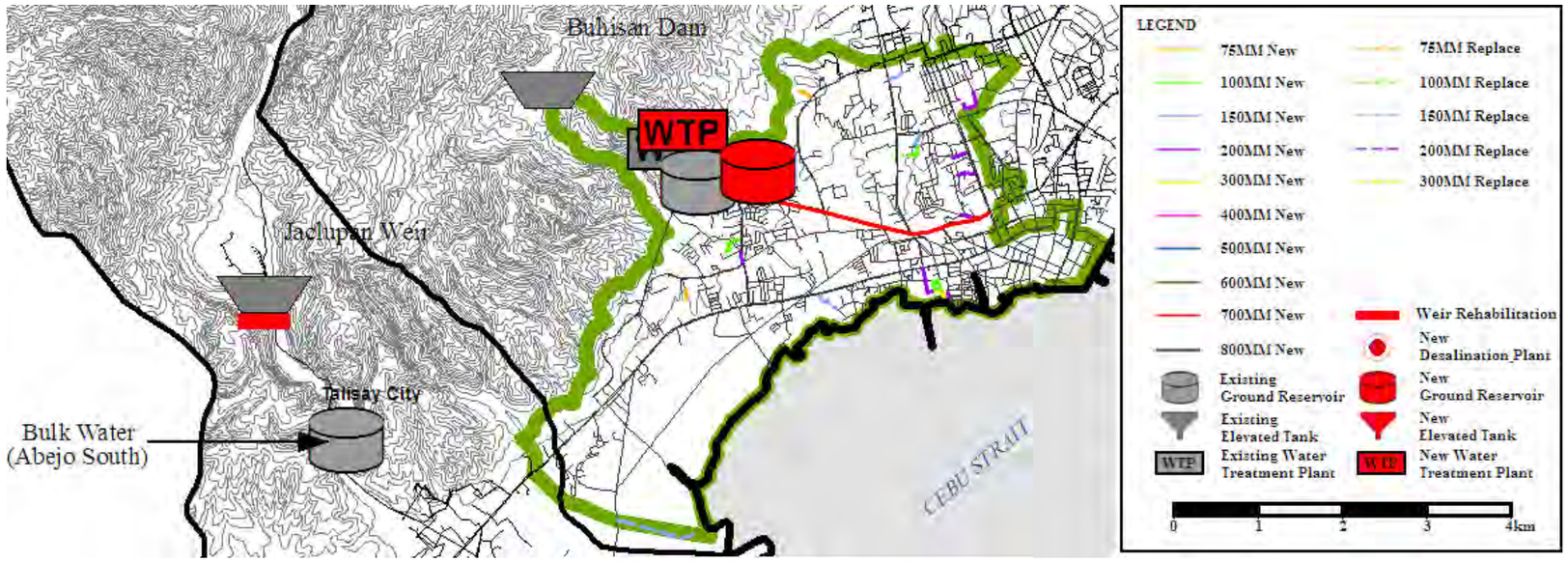


Figure III-29 Tisa DB Improvement Project

Table III-50 Lagtang DB Improvement Project

Daily Average Demand (with NRW)		18,301 m^3/day
Main Facility	Groundwater Abstraction Well	
	Capacity (m^3/day)	Quantity
		0
	Well Rehabilitation	
		Quantity
		7
	Distribution Network	
	1) Pipe installation	
	Diameter (mm)	Length (m)
	75	374
	100	386
	150	1,298

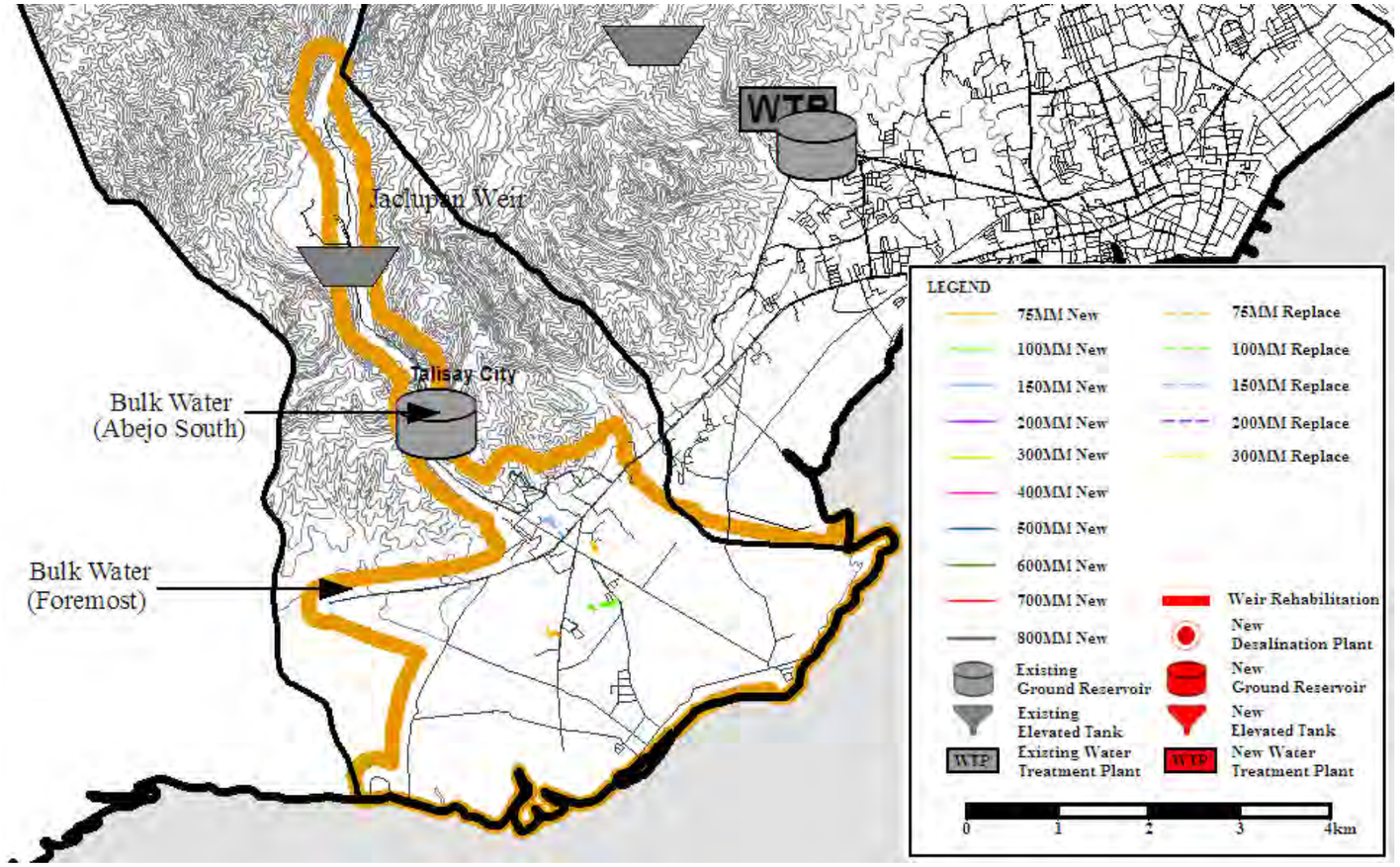


Figure III-30 Lagtang DB Improvement Project

Table III-51 Mactan DB Improvement Project

Daily Average Demand (with NRW)		38,136 m^3/day
Main Facility	Groundwater Abstraction Well	
	Capacity (m^3/d)	Quantity
		0
	Well Rehabilitation	
		Quantity
		11
	Transmission Line	
	1) Transmission line	
	Diameter (mm)	Length (m)
	400	8,100
	600	788
	Distribution Network	
	1) Pipe installation	
	Diameter (mm)	Length (m)
	75	137
	100	634
	150	3,100
	200	287
	300	6,589
	400	2,771
	700	203
	Reservoir	
	Capacity (m^3)	Quantity
	2,000	2
	Desalination Plant	
	Capacity (m^3/day)	Quantity
	9,600	1

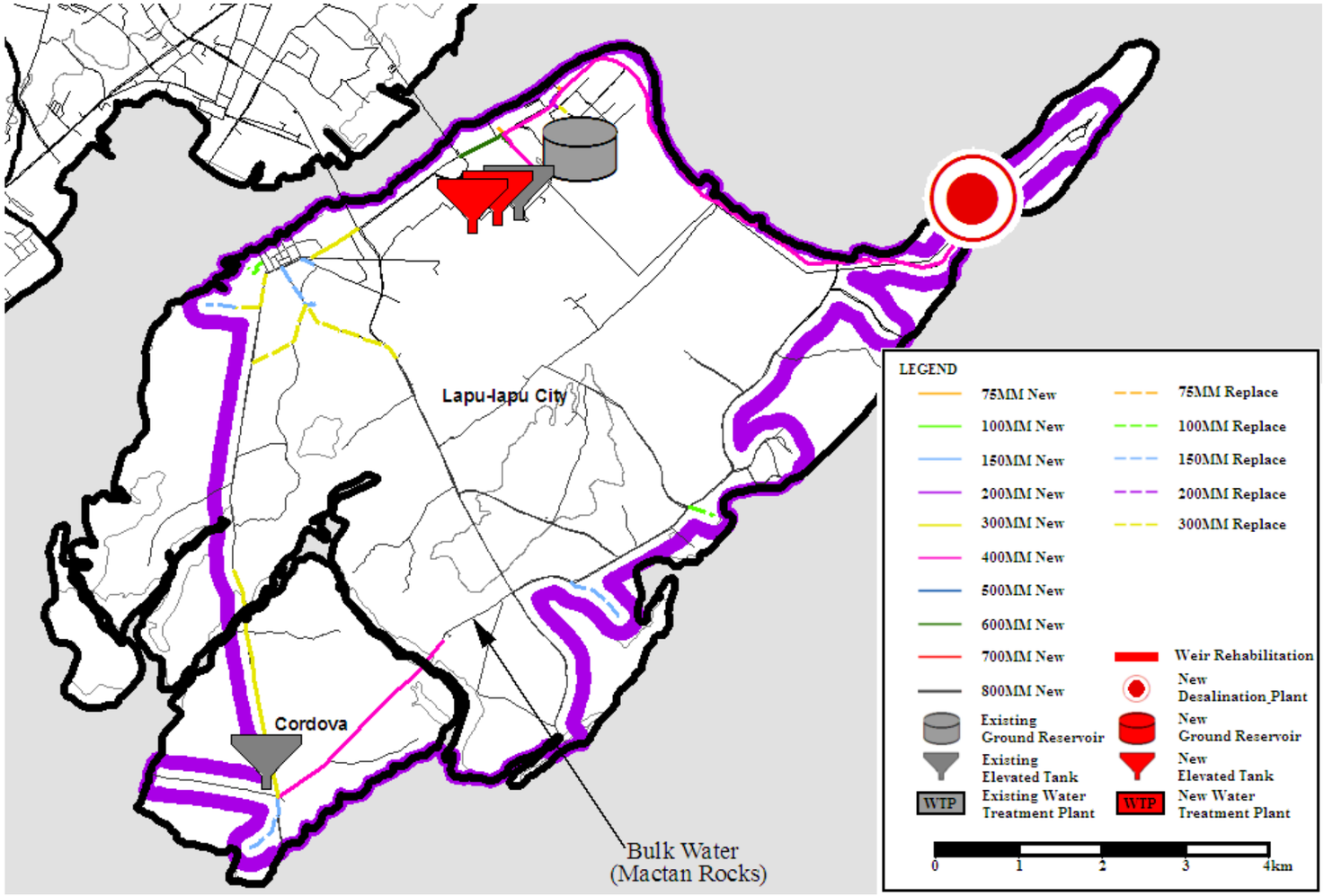


Figure III-31 Mactan DB Improvement Project

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