MANILA WATER COMPANY INC.

Ground Floor Administration Bldg.
489 Katipunan Road, Balara,
Quezon City

SEWERAGE MASTER PLAN & FEASIBILITY STUDY FOR THE MARIKINA RIVER BASIN

INTERIM REPORT

JANUARY 2008

NJS CONSULTANTS CO., LTD.
CEST, INCORPORATED

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2008 – 600 - 14

January 31, 2008

EVANGELINE MATIBAG-CLEMENTE
Department Manager
Wastewater Department
Manila Water Company, Inc.
Balara, Quezon City

Attention : **RONALD R. MUANA**
Associate Manager – Project Development

Subject : **INTERIM REPORT**
Sewerage Master Plan and Feasibility Study for the Marikina River Basin

Dear Ms. Matibag-Clemente;

We are pleased to submit herewith five (5) copies of the Interim Report for the Sewerage Master Plan and Feasibility Study for the Marikina River Basin

All information, analysis and recommendations in the Interim Report are preliminary and may change in the Master Plan Report.

Thank you.

Very truly yours,

FERDINAND S. ASUNCION
Team Leader

SEWERAGE MASTER PLAN AND FEASIBILITY STUDY FOR THE MARIKINA RIVER BASIN

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Section 1.0

INTRODUCTION

1.0 INTRODUCTION

The Interim Report presents the initial analysis and findings of the Study Team for the Sewerage Master Plan and Feasibility Study for the Marikina River Basin, hereinafter referred to as the Study.

The Study commenced in end-November 2007 and is scheduled to be completed within five (5) months. The Master Plan Report will be submitted by the end of February 2008 and the Feasibility Study Report, by the end of April 2008.

Aside from this section, the Interim Report contains, five other sections covering the following topics:

Section 2 Existing Conditions

Includes a discussion of the study area: political/administrative boundaries, topography, drainage systems, water quality, health and land use, and existing water supply and sewerage facilities

Section 3 Wastewater and Pollution Generation Projections

Presents the projections for population, water demand, wastewater quantity and BOD generation, by city/municipality and for each of the defined catchment areas for the Marikina River Basin.

Section 4 Preliminary Sewerage Planning for Marikina

Presents preliminary strategies for implementing combined sewerage systems in Marikina.

Section 5 Cost Database

Presents partial updates of the 2004 Master Plan cost database for capital and operational cost for sewers, pumping stations, and sewage treatment plants.

Section 6 Modeling

Provides an overview of the proposed model that will be adopted for projecting water quality along Marikina River.

All information, analysis and recommendations in this Interim Report are preliminary and may change in the Master Plan Report.

Section 2.0

EXISTING CONDITIONS

2.0 EXISTING CONDITIONS

2.1 The Study Area

The study area is the Marikina River Basin, a major drainage catchment in the province of Rizal and northeastern Metro Manila, consisting of lands with direct run-off and sub-watersheds with waterways that flow into Laguna Lake through the Manggahan Floodway and the Napindan Channel where it eventually connects with the Pasig River basin that drains into Manila Bay. The river basin of concern is part of the greater Laguna Lake Watershed. **Figure 2.1** shows the location of the delineated river basin.

2.1.1 *Political and Administrative Boundaries*

The Marikina River Basin, which covers 555.88km², encompasses the jurisdiction of Rizal province to include Antipolo City and Cainta to the east, and Rodriguez (formerly Montalban) to the north. Included also is the City of Marikina, and the extreme northeastern portion of Quezon City and Pasig City. Parts of Mandaluyong City and San Jose Del Monte City are also within the study area, considering the natural drainage of the watershed, however these two cities will not be included as main areas of concerns for the purpose of this study.

Table 2.1 presents the percentage of area covered by the river basin in relation to actual land area of each city/municipality identified.

Table 2.1 Marikina River Basin Coverage Area

City/Municipality	Total Administrative Land Area (Km²)	Actual Land Area Covered by River Basin (Km²)	Percentage of Land Area Covered (%)
1. Rodriguez, Rizal	360.55	218.58	60.62
2. Antipolo, Rizal	293.49	206.52	70.36
3. San Mateo, Rizal	53.74	53.74	100
4. Marikina City	23.48	23.48	100
5. Pasig City	33.77	8.90	26.35
6. Quezon City	129.84	33.05	25.45
7. Mandaluyong City	11.30	0.51	4.51
8. San Jose Del Monte	115.77	11.08	9.57

2.1.2 *Bio-Physical Profile*

Topography

The topography of the river basin is predominantly rolling to mountainous, particularly in the extreme north and central east portions of the catchment. These mountain ranges include the Sierra Madre mountain ranges entering Bulacan extending to Rizal, while to the west is the capitol hills of Quezon City. Bounded by these mountain ranges is the flat to nearly flat areas of the Marikina Valley that extends from the foothills of

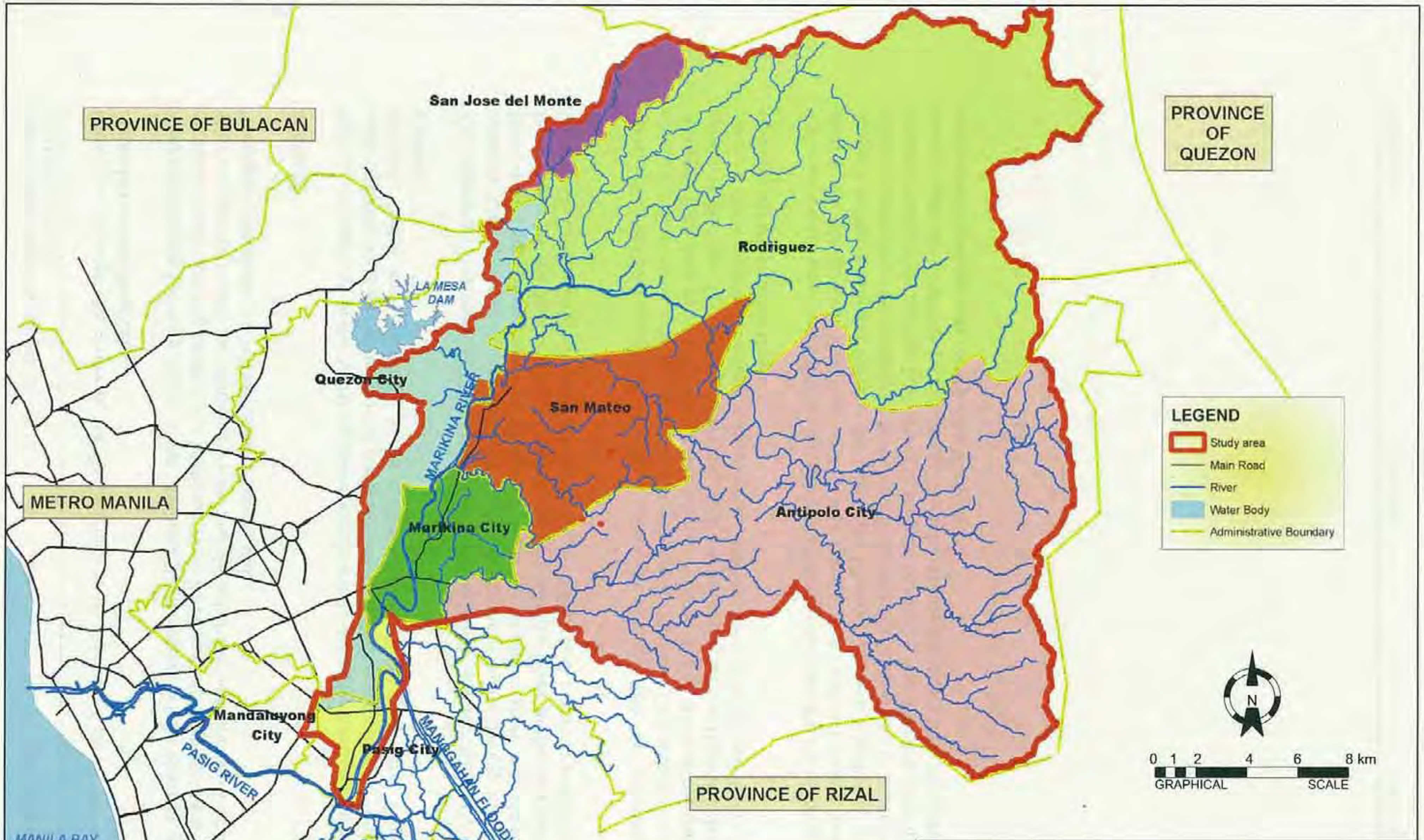


FIGURE 2.1. THE STUDY AREA

Rodriguez, through the center of the Basin which is in Marikina City all the way to Napindan area in Pasig City.

Running through the river basin is the Marikina Fault System which consists of two main-northeast trending faults - the Marikina West Fault and the East Marikina Fault. The fault system bound the Marikina Valley and the adjoining settlements of Antipolo, Rodriguez, San Mateo as well as eastern Metro Manila.

Drainage

The major waterway is the Marikina River, which winds generally south-westward for some 50.57km from its headwaters in Antipolo City and Rodriguez cutting through the Marikina Valley and eventually to its confluence with Pasig River and Napindan Channel.

The Marikina River starts out from the waters of Boso-Boso, and Tayabasan Creeks in Antipolo City to the southeast, while to the North are the rivers of Tanog, Puroy, and Montalban. Four major lowland tributaries feeds the Marikina river with additional flows, these are the Maly Creek, Ampid River, and Nangka River in the east bank and the Payatas Creek (assigned name for the purpose of this study) coming from the west bank.

Although could be considered as another catchment separate from the river basin of concern, Balinti creek which drains the east portion of Marikina City and the center of Antipolo City does have an effect on the Marikina River due to the existing drainage system in the area. Specifically where the creek intersects the Marcos Highway drainage canal, a flood control structure is in place to redirect flow to Marikina River during medium to high weather flows.

Two waterways serve as outfall for the Marikina River aside from the Pasig River. The first is the Manggahan Floodway which was constructed to divert excess water to Laguna de Bay while the latter is the Napindan Channel wherein a hydraulic control system was built at the confluence with both Pasig and Marikina rivers to regulate flow between Pasig River and the lake. Flow in the said channel is tide affected; lake directed during high tide while bay bound during low tide. **Figure 2.2** shows both the man-made and natural drainage ways within the Study Area.

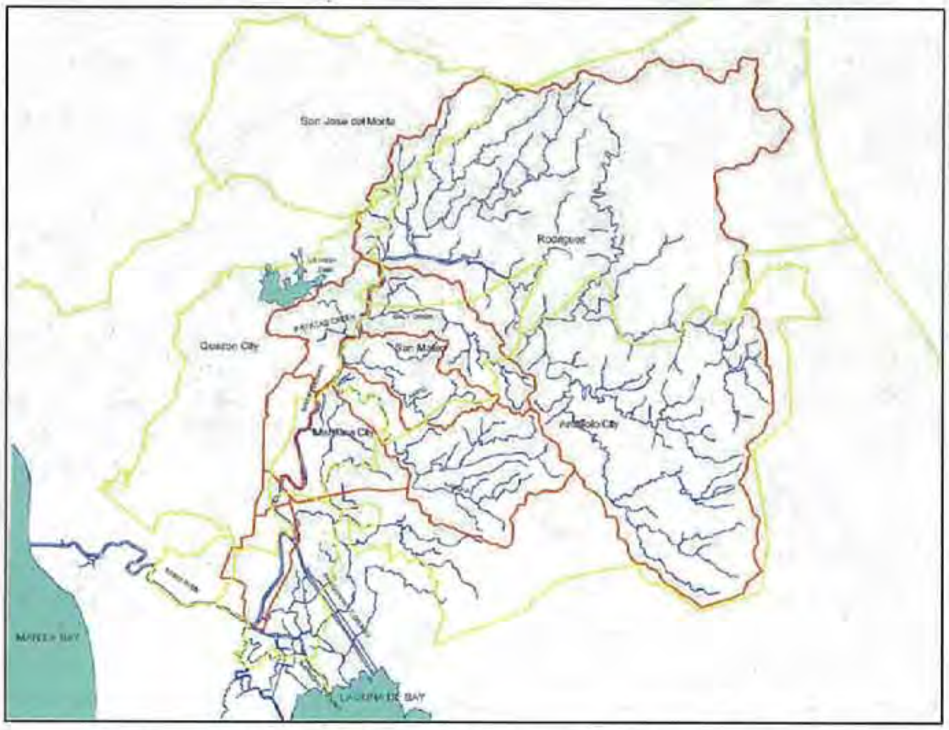


Figure 2.2 Natural Drainage within Study Area

Sub-Basin/Catchment

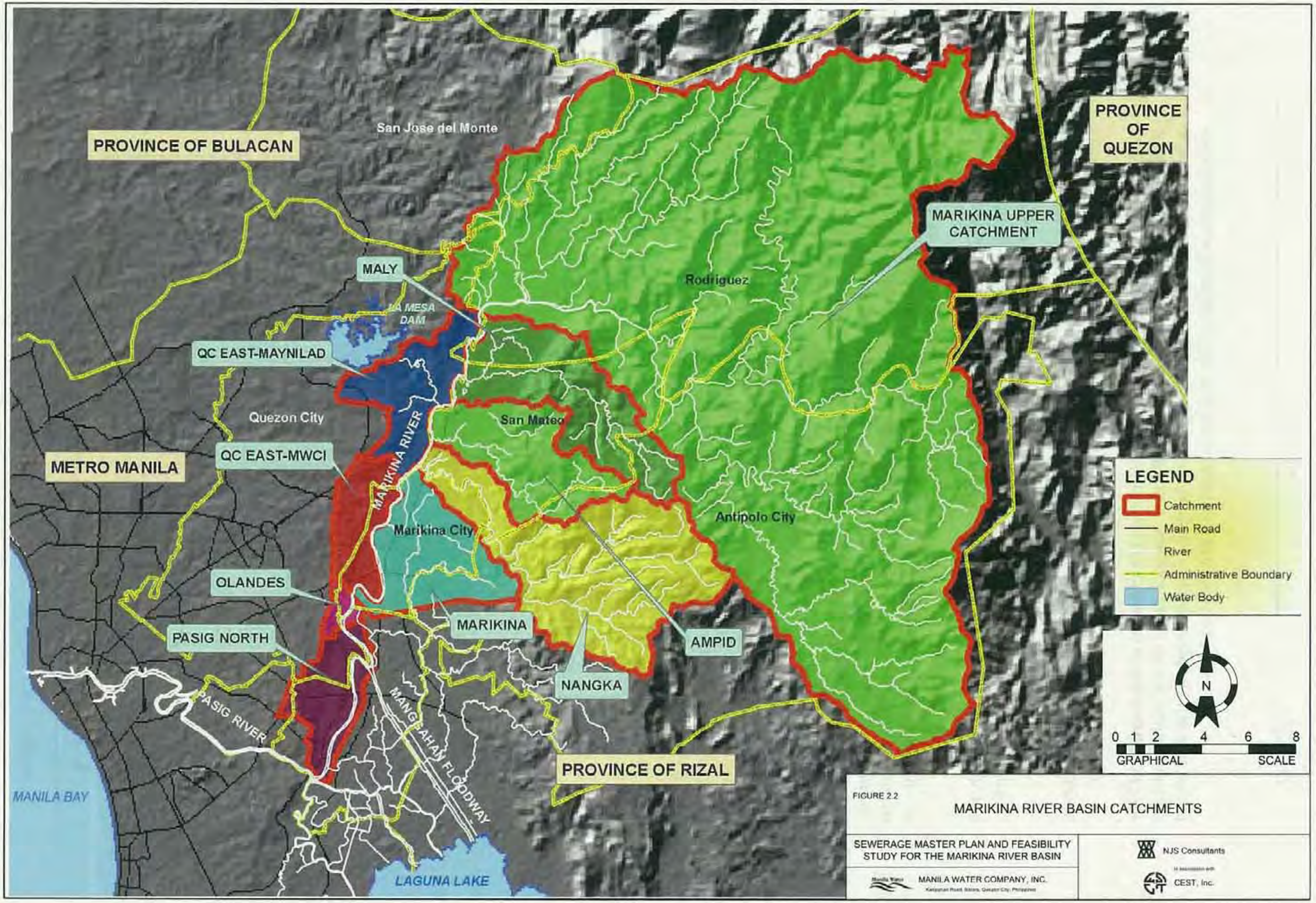
For the purpose of this study the Consultants have delineated the river basin into 9 sub-basins/catchments consisting of 4 catchments west of the Main Marikina River and 5 in the east (see **Figure 2.3**). The watershed approach was adopted wherein the natural drainage ways influenced the delineation. Some of the catchments were defined also following the major waterways directing drainage flow from the creeks toward the main river. Details of each sub-basin/catchment are as follows:

1. Marikina Upper Catchment includes the Boso-Boso, and Tayabasan Creeks that drains through the forest land area of Antipolo City from the southeast portion of the catchment. It is joined by the Tanog, Puroy and Montalban Rivers from the north draining the portion of the Southern Sierra Madre Mountains in the municipality of Rodriguez. Its total land area is 380.68 km^2.

2. Maly Catchment, covering about 31.04 km^2, with Maly Creek passing through the municipalities of San Mateo and Rodriguez, the City of Antipolo and a small portion of Quezon City.

3. Ampid Catchment with an area of 23.66 km^2, with Ampid River traversing the town center of San Mateo and a small portion of the northeastern part of Antipolo City.

4. Nangka Catchment, the biggest among the lowland catchments of the Marikina River Basin, with an approximate area of 53.89 km^2. Nangka River as the main tributary which traverses the eastern barangays of Antipolo City through to the residential subdivisions of Marikina City and the commercial areas of San Mateo.


PROVINCE OF BULACAN
San Jose del Monte
PROVINCE OF QUEZON
MARIKINA UPPER CATCHMENT
Rodriguez
MALY
LA MESA DAM
QC EAST-MAYNILAD
Quezon City
San Mateo
MARIKINA RIVER
METRO MANILA
QC EAST-MWCI
Marikina City
Antipolo City
OLANDES
MARIKINA
AMPID
PASIG NORTH
NANGKA
PASIG RIVER
MANGGAHAN FLOODWAY
PROVINCE OF RIZAL
MANILA BAY
LAGUNA LAKE
LEGEND
Catchment
Main Road
River
Administrative Boundary
Water Body
N
0 1 2 4 6 8
GRAPHICAL SCALE
FIGURE 2.2
MARIKINA RIVER BASIN CATCHMENTS
SEWERAGE MASTER PLAN AND FEASIBILITY STUDY FOR THE MARIKINA RIVER BASIN
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5. Marikina Catchment with a total area of 22.28 km^2 covers most of Marikina to include its city center and commercial areas. The headwaters of the Balinti Creek (two creeks which eventually joins in Brgy. San Roque, Marikina) is situated in the Catchment, it eventually drains into the Manggahan Channel but flows are sometimes diverted to the Marikina River as previously discussed.

6. Pasig North Catchment, covering the narrow areas starting from the Marikina Pasig boundary all the way to Pasig River to the east while to the west are the areas bounded by the major roads to include Shaw Boulevard, EDSA, and Boni Serrano Avenue. The total area of the catchment is 13.35 km^2.

7. Olandes Catchment with a total area of about 2.25 km^2 was delineated separately since it was already identified and included in the MTSP Master Plan. This covers Barangay Industrial Valley Complex (IVC) and Olandes, Marikina City.

8. QC East - MWCI Catchment is bounded by the Marikina River to the east, Marcos Highway to the south, to the west by the Katipunan -Tandang Sora Avenue , and by Coomonwealth and the Batasan Hills in the north. It's area covers approximately 11.26 km^2.

9. QC East - Maynilad with a total area of 17.47 km^2 is bounded by the areas north of QC East - MWCI and areas southeast of La Mesa Dam reservoir sloping towards Marikina River. Situated in the Catchment is the Payatas Dumpsite whose natural drainage way is the Payatas Creek.

Climate

The climate in the subject area falls under the Type I of PAGASA's Modified Corona's Climate Classification. This is characterized by two distinct seasons; wet from May to December and dry from January to April. The rainfall regime is influenced by monsoon that causes a seasonal variation in precipitation. Total annual rainfall in the area is 2,641 mm. The warmest month is May, with a mean annual temperature of 26.4 ^0C while the coolest month is March with a temperature of 20.8 for areas in Rodriguez and Antipolo City wherein temperature is lower by about 3 ^0C (*Antipolo City Socio-Economic Profile, 2006*) compared to the lower areas of Marikina, Pasig and Quezon City.

Water Quality

The Marikina River is classified as Class C River by DENR, wherein its water is defined as suitable for the growth of fish and other aquatic resources; recreational use for secondary contact sport such as boating; and after treatment, can be used as industrial water for manufacturing processes (DAO 34). One of the primary water quality criteria for Class C water is its Biochemical Oxygen Demand (BOD), which should not increase the maximum 10mg/l (DAO 34).

Based from the data, between 2001-2003 as recorded by the Environmental Management Bureau (EMB) on three different sampling points (see **Table 2.2**), the average BOD of the river did not meet the water quality guidelines for Class C waters. It exceeded the 10mg/l limit of BOD on two of three sampling points - along Bonifacio Drive in Marikina and along Rosario in Pasig. These two sampling points are taken from two urbanized cities, Marikina and Pasig, having greater population and more industries, as compared to the lone sampling point that at least satisfied the 10 mg/l limit, which was taken from the developing Rodriguez town in Rizal. Locations of the sampling points are shown in **Figure 2.4.**

Table 2.2 Biological Oxygen Demand (BOD) Data for Marikina River (mg/l)

Year	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
EMB Sampling point number: 1 Location: Rodriguez, Rizal												
2001	9	3	2	2	13	7	4	1	7	8	5	n/d
2002	4	4	n/d	10	22	4	5	12	10	10	10	n/d
2003	4	6	4	n/d	32	n/d	8	12	n/d	18	n/d	25
Ave.	6	4	3	6	22	6	6	8	9	12	8	25
	Jan-May: 8						Jun-Dec: 10					
	Jan-Dec: 9											
EMB Sampling point number: 3 Location: Bonifacio Drive, Marikina												
2001	12	5	4	4	5	21	6	5	2	7	12	n/d
2002	9	19	n/d	18	20	17	3	15	15	22	6	n/d
2003	15	18	6	n/d	27	n/d	14	8	n/d	31	n/d	n/d
Ave.	12	14	5	11	17	19	8	9	9	20	9	n/d
	Jan-May: 12						Average Jun-Dec: 12					
	Jan-Dec: 12											
EMB Sampling point number: 4 Location: Rosario, Pasig												
2001	9	7	4	4	13	23	5	3	10	10	12	n/d
2002	12	18	n/d	32	21	14	6	13	23	20	3	n/d
2003	13	2	14	n/d	18	n/d	5	15	n/d	20	n/d	21
Ave.	11	9	9	18	17	19	5	10	17	17	8	21
	Jan-May: 13						Jun-Dec: 14					
	Jan-Dec: 13											

n/d: no data available
Source: DENR-EMB

MWCI recently conducted one time water quality sampling of Marikina River and selected outfalls from major canals, industrial establishments and public markets. These samplings were part of the Marikina River Basin Pre-Feasibility Study (June 2007) which was a prelude to this Project.

Results of the March 2007 water quality sampling (see **Figure 2.5** for locations of sampling points) as presented in **Table 2.3** shows relatively high BOD concentrations for all the establishment outfalls observed specifically in the public markets of Marikina which registered as high as 530mg/L. As for the natural drainage ways, results grabbed from the Marikina River at Wawa Dam shows low BOD concentrations which is within the DENR guidelines, while Tumana River showed considerably high BOD concentrations which is expected since it cuts through the densely populated areas of Marikina City.

Table 2.3 Summary of March 2007 sample points and results

River and River Outfalls

Catchment	Sampling Point	pH[1]	Temp[1]	TSS[2], mg/L	DO[4], mg/L	BOD[5], mg/L	COD[6], mg/L	Total Coliform[7], MPN/mL	Fecal Coliform[7], MPN/mL
Montalban Watershed	Wawa Dam	8.12	-	17	8.3	5	-	>5x10[7]	>23x10[7]
Rodriguez	CJ Resort - outfall	7.820	27.1	31	> 1	130	176	> 2419.6	> 2419.6
	CJ resort	7.872	26.8	14	6.67	12	25	> 2419.6	> 2419.6
San Mateo	San Mateo	7.636	26.2	21	0.85	55	74	> 2419.6	> 2419.6
Marikina	Riverbanks	7.765	28.5	14	< 1	40	41	> 2419.6	> 2419.6
	Purefoods	9.130	28.5	17	< 1	28	70	> 2419.6	> 2419.6
	Sampaguita	7.743	28	31	< 1	49	52	> 2419.6	> 2419.6
	Tumana - outfall	8.019	28.1	44	< 1	509	730	> 2419.6	> 2419.6
	Tumana River	7.835	28.7	26	< 1	113	286	> 2419.6	> 2419.6

Market Outfalls

Catchment	Sampling Point	pH[1]	Temp[1]	TSS[2], mg/L	DO[4], mg/L	BOD[5], mg/L	COD[6], mg/L	Total Coliform[7], MPN/mL	Fecal Coliform[7], MPN/mL
Marikina	Concepcion Market	7.4	26.5	72	<1	560	630	> 2419.6	> 2419.6
	Tumana Market	7.4	26.5	109	<1	530	1220	> 2419.6	> 2419.6
	Flor Mini Market	6.9	26.5	120	<1	580	1500	> 2419.6	> 2419.6
	TMD Market	6.9	26.5	114	< 1	540	858	> 2419.6	> 2419.6

Method Used: [1]Electrometric, [2]Gravimetric, [3]Volumetric, [4]Azide Modification, [5]Respirometric, [6]Close-Reflux, [7]Enzyme Substrate

Source: Manila Water Company, Inc. (MWCI)

FIGURE 2.4

EMB WATER QUALITY SAMPLING POINTS

SEWERAGE MASTER PLAN AND FEASIBILITY STUDY FOR THE MARIKINA RIVER BASIN

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FIGURE 2.5
MWCI (MARCH 2007) WATER QUALITY SAMPLING POINTS

SEWERAGE MASTER PLAN AND FEASIBILITY STUDY FOR THE MARIKINA RIVER BASIN

MANILA WATER COMPANY, INC.

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2.1.3 *Socio-Economic Profile*

Demography

Antipolo has the largest population among all the municipalities of Rizal. It now stands, as per the 2000 census, at around 470,866, a 26.6% increase from the census conducted in 1995. The 2007 population is projected to be roughly around 786,291 at growth rate equivalent to 7.6%. The municipalities of San Mateo and Rodriguez have populations of 135,603 and 115,167 respectively (NSO 2000 Census of Population).

Quezon City, the most populous city in Metro Manila, listed 2,173,831 people in their area for NSO 2000 Census of Population, which is about 21.89% of the total population of the entire Metro Manila. It is noted that the density in the city is 135 persons per hectare. Marikina City, on the other hand, is among the smallest municipalities of Metro Manila in terms of land area, and has a population of 391,170 as of the 2000 Census of Population. Pasig and Mandaluyong has populations of 505,058 and 278,474 respectively and combined for a total of 7.87% of the Metro's overall population.

Meanwhile, the municipality of San Jose del Monte in Bulacan has about 315,807 of residing people on their municipality, based on the 2000 Census of Population conducted by the National Statistics Office.

Health

Generally, the areas covered have high fertility rate with an average of 10 per 1000 population and death rate of 2 per 1000 population. When it comes to mortality rate (one of the general indicators of health), there is high infant mortality.

Although decreasing in the past 5 years, communicable diseases are still predominant causes of mortality and morbidity. The leading causes of morbidity are acute respiratory infection/pneumonia/bronchitis, heart disease, hypertension, acute gastroenteritis/diarrhea, skin problem, diarrhea, cancer, pulmonary disease, measles, pulmonary tuberculosis, urinary tract infection, dog bite, measles and malnutrition. The leading causes of mortality are heart disease, cancer (all forms), hypertension, pneumonia, pulmonary tuberculosis and vehicular accident.

Records from the Municipal Health Offices indicate that diseases resulting from pollution of water resources such as diarrhea, gastro-enteritis, and skin diseases are among the top ten causes of morbidity in coastal barangays. In 2000, the municipality of Rodriguez reported 1,348 cases of gastroenteritis, second to upper respiratory ailments as one of the town's leading cause of morbidity (**Table 2.4**). The city health office of Marikina reported 1,167 cases of diarrhea and 902 cases of allergic dermatitis in the year 2004 (**Table 2.5**). In 2006, 837 reported cases of gastrointestinal disorders were listed in Antipolo City, which is seventh leading cause of morbidity in the country, while 1,582 cases of skin disorders were listed (**Table 2.6**). In San Mateo, acute water diarrhea affected 750 people, the second leading cause of morbidity at the town and skin diseases, which tallied 274 cases in the municipality (**Table 2.7**).

The DOH has actually cited acute watery and acute bloody diarrheas as two of the leading causes of morbidity in the Philippines. Along with these are pneumonia, malaria, typhoon fever, schistosomiasis, measles, dengue hemorrhage fever, hepatitis and leprosy.

Table 2.4 Ten Leading Causes of Morbidity Rodriguez, Rizal Year 2000

Cause	Number
1. Upper Respiratory	6,385
2. Gastroenteritis	1,348
3. Hypertension	461
4. Urinary Tract Infection	299
5. Pneumonia	298
6. Pulmonary Tuberculosis	261
7. Dog bite	221
8. Measles	153
9. Dengue	55
10. Malaria	44
TOTAL	**9,525**

Source : Rodriguez Health Office

Table 2.5 Ten Leading Causes of Morbidity Marikina City Year 2004

Cause	Number
1. Acute Nasopharyngitis	26,834
2. Acute Pharyngitis	8,638
3. Acute Bronchitis	2,475
4. Pneumonia	1,484
5. Urinary Tract Infection	1,401
6. Non Infectious Diarrhea	1,167
7. Asthma	1,164
8. Mild Hypertension	978
9. Dogbite	909
10. Allergic Dermatitis	902
Others	30,064
TOTAL	**76,016**

Source : Marikina Health Office

Table 2.6 Ten Leading Causes of Morbidity Antipolo City Year 2006

Cause	Number
1. Acute Respiratory Infection	10,348
2. Dog bite	1,981
3. Acute Lower Respiratory	1,627
4. Skin Disorder	1,582

5. Parasitism	1,150
6. Urinary Tract Infection	849
7. Gastrointestinal Disorder	837
8. Pulmonary Tubercolosis	784
9. Influenza	675
10. Muskolo – skeletal pain	592
TOTAL	**20, 425**

Source : San Mateo Health Office

Table 2.7 Ten Leading Causes of Morbidity San Mateo, Rizal Year 2006

Cause	Number
1. Upper Respiratory Infection at Upper Coryza	10,348
2. Acute Water Diarrhea	1,981
3. Physical Injuries	1,627
4. Skin Disease	1,582
5. Asthma	1,150
6. Essential HPN	849
7. Pulmonary Tubercolosis	837
8. Pneumonia	784
9. Malaria	675
10. Mumps	592
TOTAL	**20, 425**

Source : Antipolo City Health Office

Industries and Commercial Establishments

Quezon City

Quezon City is the most populous city in the Metropolis. Being the former capital of the country, it has been a well developed and highly urbanized city. Located here are among the largest companies and infrastructures of different industries, specifically tourism (malls and activity centers), entertainment (television networks), manufacturing and service rendering. However, the study area for this project does not cater much of these industries, except for the Business District of Eastwood City, which houses malls, condominium and office buildings and other business establishments.

Marikina

Marikina is one of the fastest rising cities in the Metro in terms of industrial development. The city mainly caters manufacturing companies, specifically footwear. Out of 847 manufacturing firms, 31.62% or 267 are shoe shops which are located in different barangays, 25.03% or 212 are into food/bakery, 3.42% are into garments, and slipper shop and bag making with 3.66% and 5.90%, respectively.

Marikina is host to some of the biggest manufacturing and processing firms in the country to date. Prominent companies include Fortune Tobacco Corp. - cigarette manufacturing, Purefoods Corporation - meat processing, Noritake Mariwasa - ceramics manufacturing, Manila Bay Spinning Mills, Inc. - thread and hosiery, Philippine Cocoa Corp. - confectioners, Tower Steel - manufacturing of G.I. sheet, Armscor Corp. - firearms and ammunition, Havi Food Services Phil., Inc. etc.

Large commercial establishment in Marikina City includes malls, hotels and activity centers. In particular, the Riverbend Hotel, Riverbanks Center and the soon-to-be finished SM City Marikina.

Pasig City

Pasig is fast becoming as one of the most commercialized city in the Metro from being mainly a residential-industrial town. Located within the heart of the city is Ortigas Center, which is considered as one of the premiere business center in the metropolis. Industrial centers which are mostly located along the Marikina River are now slowly being developed into high-end residential as well as commercial establishments.

Mandaluyong City

The City of Mandaluyong houses several of the country's premiere malls as part of their coveted tourism industry. However, the study area only includes a small part of this city, specifically Brgy. Wack-Wack Greenhills, accommodating an executive village, condominium buildings and the Wack-Wack Golf and Country Club.

Antipolo City

Agriculture is the dominant industry in Antipolo aside from tourism. This includes vast farm lands and the several livestock, poultry and fishing farms and slaughterhouses. In relation to this, the city also hosts manufacturing industries that complement the agro-industry. Known industries include Foremost (piggery / feeds), Robina (piggery / poultry), and VST (slaughterhouse). Aside from these, Antipolo has also housed the industry of mining and quarrying. It is noted that the non-metallic aggregate quarrying industry supplies around 60% of the aggregate construction material needs of Metro Manila. To date, there are nine primary mining companies in Antipolo, including Rapid City and Development Corporation, Mountain Rock Corp. (Unirock) and Solid Integrated Co., Inc.

Businesses, which aid the tourism industry, are very much eminent in the city, particularly resorts, hotels, malls, marketplaces, golf courses and other commercial establishments. Among the most prominent are Hinulugang Taktak falls, Villa Virginia Resort, Cloud 9 Celestial Inn, Valley Golf and Country Club, Masinag Market, Wrigley's Philippines and Shopwise Antipolo.

San Mateo

Slowly, San Mateo is one of the growing towns of Rizal, in terms of population and development. And along with this, the different industries start to arise in this part of the region. The most common industry here is trading, which includes retail, wholesale and eateries. The agricultural industry is by-far, still, one of the major industries of San

Mateo, taking into account the large agricultural and forest area allotted for the said industry. Also, poultry and piggery has also been a huge industry for this town, particularly along Maly. The construction industry is also making its strides within the town because of the continuous development of San Mateo. Such industry includes hardware stores, contractors and subdivision developers, and is concentrated mainly within the Barangay Ampid.

Rodriguez

Rodriguez is described as the northernmost and largest town of Rizal, with most of its area still dedicated to forest lands and grass lands. This then shows that the town still relies heavily on the agricultural industry. However, the municipality is more on pushing the development of the livestock and poultry industry, which are less land-intensive and enjoys a major proximity market in the Metro. Because of its geographic condition, Rodriguez then improves its mining industry. Quarrying has been constantly developing, because of the urban trend of Rodriguez; and the most common of them includes Montalban Millex Aggregates Quarry.

Manufacturing has been focused on Barangay San Jose and the southern part of Rodriguez, an example locator is Lyon Textile Mills, Incorporated. Tourism industry is also starting to boom in this municipality, as tourist and historical spots are being developed and preserved respectively in the area. Among these includes the newly constructed Avilon Montalban Zoological Park, located at Barangay San Isidro.

2.1.4 *Land Use*

General

Land use plans were taken from socio-economic profiles and development plans as obtained from the different municipalities and cities' planning and development offices that are covered by the study area. **Figures 2.6a - 2.6b** show the difference of usage of land areas based on actual and approved land uses. Description of land uses for each of the covered cities and municipalities are as follows:

Quezon City

The latest land use plan available calls for the increase in residential areas by as much as 17% from its previous actual area in 1995. The continuous migration of people towards the city further increases the allotted land area for residential purposes. Commercial land use area increased by over 700 hectares due to several commercial establishments being proposed. Several development projects that will further urbanize the city are underway, including additional industrial and institutional areas. This includes the development of the Cubao Business District, Payatas Urban Development Zone, Eastwood City Cyberpark and the North Triangle Business District to name a few. The changes in land use area are referred to in **Table 2.8**.

Table 2.8 Quezon City Land Use

Classification	Actual Land Use, 1995 Area (ha)	Approved Land Use, 2002 Area (ha)
Residential	6350	7429
Commercial	580	1291
Industrial	769	954
Institutional	928	1153
Open Space and Reservoir	2700	na
Utility	225	2600*
Socialized	na	74
Special Dev't Zone	na	261
Parks/Recreational	na	437
Cemeteries	71	213
Roads and Waterways	na	1698
Military	205	na
Vacant	4284	na
Total	**16,112**	**16,112**

Source:Quezon City Planning and Development Office
Note: na means such classification was not adopted
*area for UTILITY in proposed land use deemed miscalculated

Marikina

In reference to **Table 2.9**, there had been no significant changes between the approved land use of 2000 and the actual land use of 1999. The continuous relocation of various industries towards Marikina has its land use geared towards industrial development. Most of these are situated in parts of barangays Parang and Marikina Heights.

The city's Central Business District (CBD) is situated along the Riverbanks Mall. It houses hotels, activity centers, food stalls, shopping centers and the like. Across this district, on the other side of the river will rise SM City Marikina, and is seen to be completed by the end of 2008. This district is dubbed as the Business, Food and Finance Triangle. (Marikina CLUP/MTSP, 2005)

Table 2.9 Marikina Land Use

Classification	Actual Land Use, 1999 Area (ha)	Approved Land Use, 2000 Area (ha)
Residential	813.06	801.45
Commercial	132.82	243.81
Industrial	280.57	295.65
Institutional	72.60	95.23
Parks/Open Spaces/ Recreation	61.91	50.08
Mixed-Use Zone	155.22	0
Cemeteries	37.89	37.89
Cultural Heritage	0.25	0.25

Area for Priority Development	179.02	179.02
Socialized Housing	40.96	41.28
Agricultural	1.90	1.90
Roads	373.80	403.44
Total	**2,150**	**2,150**

Source:Marikina City Planning and Development Office

Pasig City

Referring to the Approved Land Use of 2002 (**Table 2.10**), the city has increased its residential areas to accommodate the increase in population and migration of people into the City. Accompanying such increase is the conversion of industrial zones to commercial areas, which are mostly located in Brgy. Kapitolyo. Meanwhile, industrial areas situated along Marikina River, which include locations in Manggahan, Ugong and Rosario are proposed to be converted in mixed-use and commercial zones. Pasig is also allocating a new land use that is applicable to areas near the rivers, specifically along Marikina and Pasig Rivers, calls for the development of a 10m river easement.

Table 2.10 Pasig City Land Use

Classification	Actual Land Use, 2000	Approved Land Use, 2002
	Area (ha)	Area (ha)
Residential	1865	2015
Commercial	220	680
Industrial	470	215
Institutional	31	25
Mixed-Use Zone	na	120
Agricultural	24	na
Parks / Recreational	25	45
Open Spaces	466	na
Total	**3,100**	**3,100**

Source:Pasig City Planning and Development Office
Note: na means such classification was not adopted

Mandaluyong City

Around 22% of land area is added for Mandaluyong's residential use. The increase is in deep contrast with the industrial and institutional land use of the city, which had significantly decreased its areas by 71% and 68% respectively. Only a few more areas for commercial establishments were allocated. Adjacent to the Ortigas Business District, a Medium Industrial Zone will be developed, which will be a center for commercial activities. Part of the zone will be the area bounded by Shaw Blvd., Mandaluyong-Pasig boundary, EDSA and Pasig River. Similar to Pasig, a certain land area that will cater to calls of 10m easement from the Pasig and San Juan Rivers will be allocated by the San Juan municipal government. The other changes in land use area are noted on **Table 2.11**.

Table 2.11 Mandaluyong Land Use

Classification	Actual Land Use, 2000	Approved Land Use, 2000
	Area (ha)	Area (ha)
Residential	383.94	490.40
Commercial	191.91	221.92
Industrial	67.58	19.84
Institutional	111.16	35.04
Parks / Recreational	368.61	109.92
Road Networks		129.70
Cemetery		8.64
Vacant		110.56
Total	**1,123.2**	**1,123.2**

Source:Mandaluyong City Planning and Development Office

Antipolo City

Antipolo has urbanized rapidly over the past years. This trend has drawn lots of people towards the city and has resulted to the enormous change in the city's land use, particularly that of the residential, wherein the city government is expecting a 47.75% increase in population (see **Table 2..12**). Commercial land use is focused in the town proper and Brgy. Mayamot, while industrial land use extends from Brgy. Mayamot up to the southern edges of Baras, Angono and Teresa. Existing commercial and industrial activities is still underdeveloped, however the city government have plans to convert forest and agricultural areas into commercial and industrial zones. This trend is evident in the city's approved land use of 2006 wherein there is a significant decrease of around 71% of agricultural lands and 14% of forest lands. The city has designated two types of commercial land uses, the major and minor commercial areas, wherein the major commercial areas are also referred to as its Central Business District. The CBDs are planned to be established around the town proper and in Bgy. Mayamot around Marcos highway-Sumulong highway junction.

Table 2.12 Antipolo City Land Use

Classification	Actual Land Use, 2006	Approved Land Use, 2006*
	Area (ha)	Area (ha)
Residential	5136.61	9830
Commercial	299	424
Industrial	113.91	1517
Institutional	38.47	86
Agro-Industrial	169.56	759
Parks / Recreational	110.48	103
Cemetery	28.01	248
Sanitary Landfill	81.15	78
Other Urban Development	na	678
Agricultural	7839.03	2268
Forest/Woodland	8220.04	21299
Grassland/Shrubland	16625.37	

Quarry/Mining	233.08	183
Tourism	16.31	73
Laiban Dam Reservoir	na	1365
Total	**38,911**	**38,911**

Source:Antipolo City Planning and Development Office
Note: na means such classification was not adopted
*based on both urban and general land use plans

San Mateo, Rizal

San Mateo tripled its allocated land area for residential usage in anticipation of the increase in population and migration of people towards the municipality; this is shown in **Table 2.13**. As the town progresses and urbanization continues, San Mateo is also shedding off its natural forest and grassland to accommodate proposed infrastructures for commerce and industries. The municipality has allocated more than 1000 hectares of land for industrial development, 1000% more than the actual land use plan of 1996. Some of the upland areas of San Mateo have already been set aside for mining activities, mostly quarrying

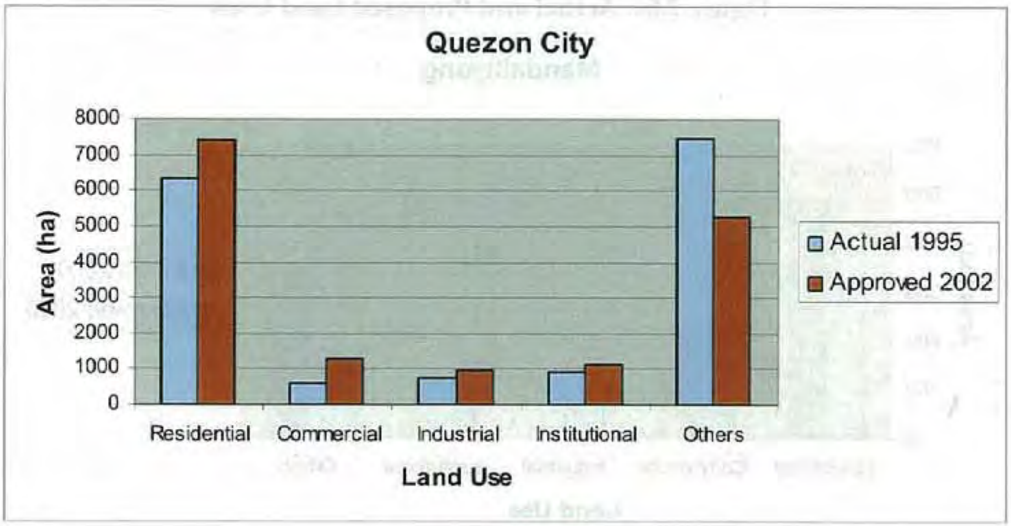
Table 2.13 San Mateo Land Use

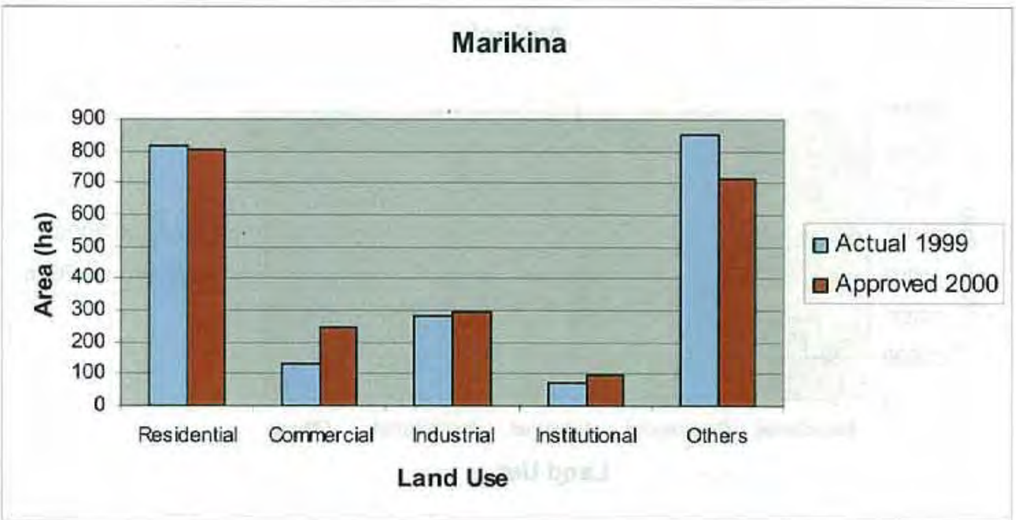
Classification	Actual Land Use, 1996*	Approved Land Use, 2000*
	Area (ha)	Area (ha)
Residential	513.15	1775.75
Commercial	22.23	40.71
Industrial	99.12	1332.95
Institutional	33.06	6.19
Agricultural	381.17	473.77
Forest Woodland	639.48	1566.47
Grassland	3603.83	
Mining	na	29.73
Others	na	41.34
Total	**5,292.05**	**5,292.05**

Source:San Mateo Planning and Development Office
Note: na means such classification was not adopted
*based on rough computations on map data

Rodriguez, Rizal

In the absence of land use plans and up-to-date socio-economic profile, Rodriguez's land use can be observed as still having large expanse of forested areas and grasslands. This is based from conduct of site visits, ocular inspections, and analysis of satellite imagery maps. However the municipality has been attracting many people to reside on its town, the main reason why several residential areas are being established. More commercial and industrial areas are yet to be developed as the municipality continues to progress.


Quezon City
8000
7000
6000
5000
4000
3000
2000
1000
0
Area (ha)
Residential
Commercial
Industrial
Institutional
Others
Land Use
Actual 1995
Approved 2002


Marikina
900
800
700
600
500
400
300
200
100
0
Area (ha)
Residential
Commercial
Industrial
Institutional
Others
Land Use
Actual 1999
Approved 2000

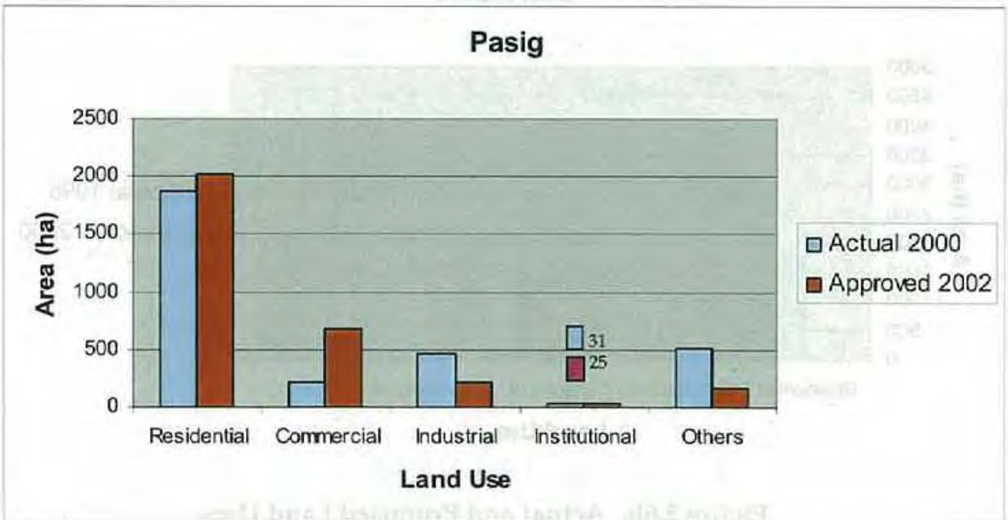
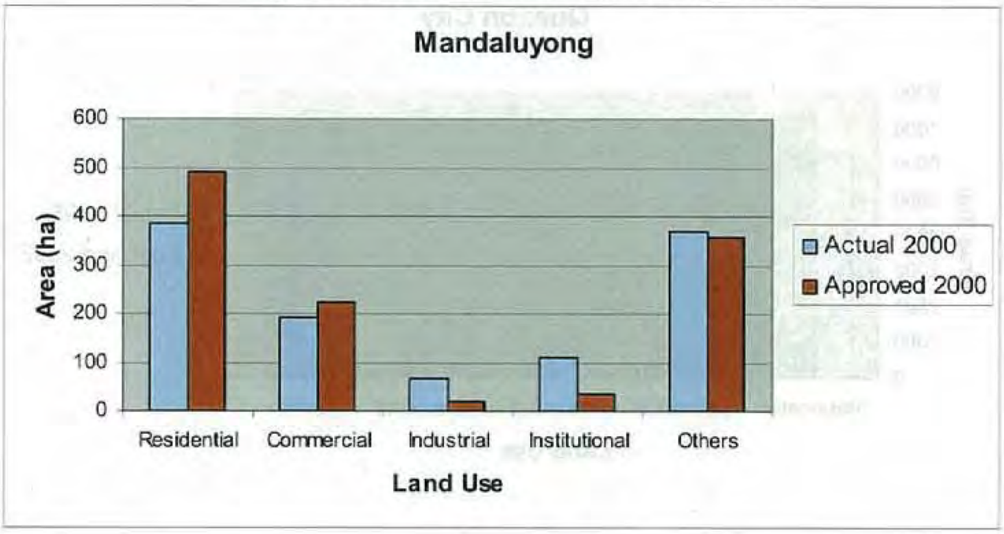
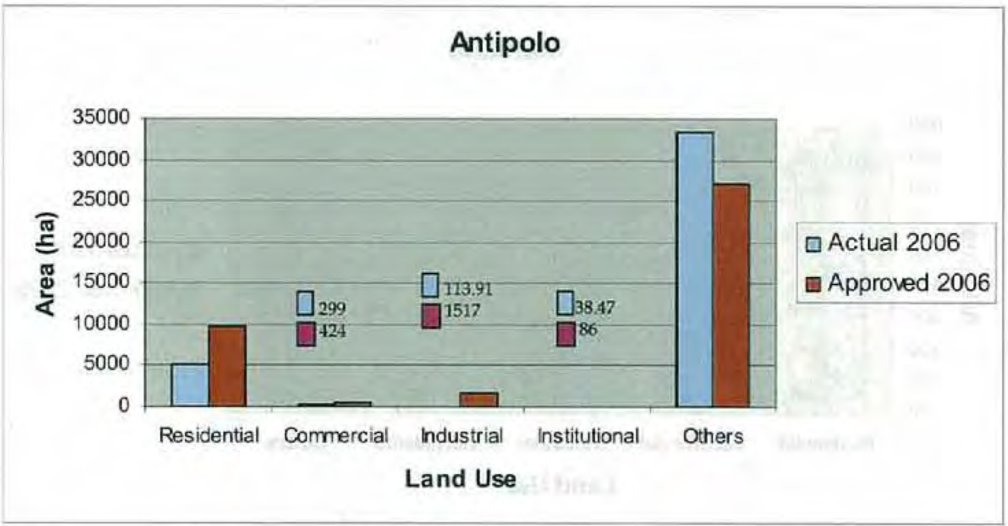

Pasig
2500
2000
1500
1000
500
0
Area (ha)
31
25
Residential
Commercial
Industrial
Institutional
Others
Land Use
Actual 2000
Approved 2002

Figure 2.6a. Actual and Proposed Land Uses





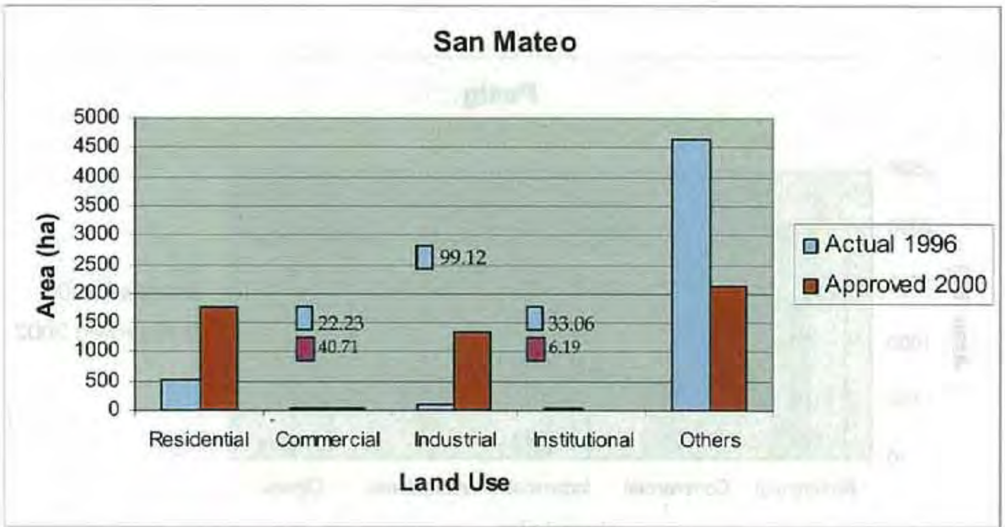


Figure 2.6b. Actual and Proposed Land Uses

2.1.5 *Existing Facilities*

Water Supply

The water supply for the study area is being supplied by the two MWSS concessionaires; most is served by MWCI, while MWSI covers only the five identified barangays within the Quezon City area. The MWCI portion is divided into four business areas; (1) Marikina Business Area (Mar-BA) covering the city of Marikina, and the municipalities of Rodriguez and San Mateo, (2) Antipolo Business Area (ABA) servicing the city of Antipolo and parts of Cainta, (3) Balara Business Area (Bal-BA) for portions within Quezon City, and (4) Pasig Business Area (PBA) covering the lower portions of the river basin.

Both Mar-BA and ABA are part of MWCI's "Expansion Business Areas". The Mar-BA has around 7,600 service connections with a billed volume of 98 MLD wherein service coverage is 100% in Marikina City, 80% in Rodriguez, and 79% in San Mateo all as of end 2006. For the same period ABA has serviced 100% of its service area in Cainta, 42% of Antipolo and only 10% of Baras.

The Bal-BA which covers almost half of Quezon City has already covered 100% of its service coverage wherein it has accounted for more than 71,000 service connections with a billed volume of roughly 147 MLD all as of end 2006. For the same period PBA has already covered 100 % of Pasig, 71% of Cainta, 53% of Taytay, 40% of Angono, and 0.2% of Binangonan with a total service connection of around 90,000.

Sanitation and Sewerage Systems

To date, there are existing Sewerage Treatment Plants (STPs) across Antipolo City, particularly in Karangalan Village wherein there are three operational plants. The combined capacity of these treatment plants is 2,888 m^3/day and serves a population of around 18,088.

Also a Septage Treatment Plant is located in Brgy. Guitnangbayan in San Mateo, Rizal. It has treatment capacity of 586 m^3/day and serves a total of around 2 million people in areas of Marikina, San Mateo and Antipolo.

Based on the 2000 Census of Housing, roughly around 87% of the population encompassed by the Study Area within Metro Manila had individual septic tanks (ISTs) while only 80% for areas in the province of Rizal, this is summarized in **Table 2.14**.

Table 2.14 2000 Census of ISTs within the Study Area

City/Municipality	No. of Households with Septic Tanks	Total No. of Households	% of Households with Septic Tank
Marikina City	70,111	80,160	87%
Quezon City	408,548	480,624	85%
Pasig City	93,541	107,835	87%
Mandaluyong City	52,284	59,682	88%

Antipolo City	66,547	97,415	68%
San Mateo, Rizal	21,724	28,162	77%
Rodriguez, Rizal	17,304	24,524	71%

Source:2000 Census of Housing

Based on the previous observations under the Manila Third Sewerage Project (MTSP) Master Plan formulation, a lot of septic tanks are not accessible for desludging, having no proper manholes, structures having been built over tanks or tanks being built on very narrow to impassable roads. Many of the septic tanks, particularly in NCR, have no absorption fields since there are limited open areas in the highly built up study area. Some of the septic tanks have a final stage chamber that is unlined at the bottom, allowing some, albeit limited, degree of percolation. Most of the time, the septic tank effluent is directed to the storm drainage system.

Solid Waste Management

Within the river basin are three of Metro Manila's major disposal sites for solid waste; these are Payatas Dumpsite in Quezon City, Montalban Landfill in Rodriguez, and the San Mateo Landfill in San Mateo.

The recently opened 19ha Montalban Landfill, an extension to its former landfill, caters the solid wastes being gathered within the province of Rizal. The garbage collected from some municipalities within the National Capital Region, however, is still being dumped at the old 14ha Montalban Landfill. The 15ha open dumpsite of Payatas is situated at the Northeastern district of Quezon City, and half kilometer away from the Novaliches Reservoir. The dumpsite still holds and receives garbage from the entire City of Quezon, the most populous city in the whole of Metro Manila. The San Mateo Landfill, which formerly received the waste products of the entire Metropolis, has been ordered for closure in 2000 after massive opposition from residents, environmentalists and church leaders.

Meanwhile, the City of Marikina manages Material Recovery Facilities (MRF) in its 16 barangays that aids in garbage disposal and segregation of bio and non-biodegradable materials that the city has collected.

Section 3.0
WASTEWATER AND POLLUTION GENERATION PROJECTIONS

3.0 WASTEWATER AND POLLUTION GENERATION PROJECTIONS

3.1 Population

The population growth for MWCI covered areas is based on MWCI projections[1] up to Year 2023. Population for areas under MWSI[2] is based on Year 2000 Census of barangay populations and assumed growth rate is 2% up to Year 2008, at which the population is assumed to have reached the saturation level. For San Jose Del Monte, the barangay population projections[3] were based on a 2007 water supply expansion study prepared for the San Jose Del Monte Water District.

The following table shows the study area population projections by city/municipality:

Table 3.1 Basin Population Projections by City/Municipality

City/Town	2008	2013	2018	2023
Marikina	649,610	690,046	724,718	752,811
Rodriguez	90,290	169,796	224,627	280,579
San Mateo	130,557	178,622	204,435	220,764
Quezon City	414,292	422,738	429,981	435,849
Antipolo	135,783	182,647	383,487	400,529
Pasig	114,123	114,695	115,269	115,847
San Jose Del Monte	5,953	7,755	10,152	10,152
Mandaluyong	750	796	836	869
Total	**1,541,358**	**1,767,096**	**2,093,505**	**2,217,401**

In Year 2008, in terms of basin population, Marikina and Quezon City accounts for 42% and 27% of the total basin population. Only 9% of the basin population is within Antipolo City. The other cities/municipalities share of the population is even less.

By Year 2023, the total basin population will grow by more than 44%. While all cities and town is projected to experience growth, the main population growth areas are Antipolo (195%), Rodriguez (211%), and San Mateo (69%). San Jose Del Monte is also projected to have a significant population growth (71%), but in absolute number, is

[1] Source: Wastewater Department, MWCI
[2] MWSI assumptions/projections will be confirmed
[3] San Jose Del Monte Water Supply Feasibility Study, 2007, CEST Inc.

negligible. On the other hand, Marikina's population will grow by only 16% by Year 2023, and Quezon City, by 5%.
Still, by Year 2023, Marikina and Quezon City will account for the majority of the basin population (34% and 20%, respectively). However, Antipolo City's population will reach more than 400 thousand, or 18% of the 2023 basin population.

In terms of the different catchments (see **Tables 3.2** and **3.3**), the population in the Marikina Catchment accounts for 30% of the total 2008 basin population. QC East (MWSI) and QC East (MWCI), accounts for 13% and 19%, respectively, of the 2008 basin population. The Nangka Catchment population share is 12%.

By year 2023, following the population growth patterns as discussed above, the Nangka Catchment population will grow to account for 18% of the total basin population. The Marikina Upper Catchment (Rodriguez and upstream) population share will likewise increase to 15% from 8%. On the other hand, the share of the basin population of the Marikina Catchment will decrease to 25%. Similarly, for QC East (MWSI) and QC East (MWCI), it will decrease to 10% and 14%, respectively.

3.2 Water Demand and Wastewater Quantity

Water consumption demand in the future will follow mainly the pattern in population growth, as well as the appreciation of commercial and industrial developments in the different parts of the study area. For the study, water consumption projections were based on MWCI[4] demand projections, on a barangay level, for residential and commercial-industrial client groups. For the interim report, areas in Antipolo not served yet by MWCI were excluded in the analysis, and water demand and wastewater volume estimates presented hereunder is therefore conservative. A spatial analysis of the MWCI service area in Antipolo will be conducted.

Tables 3.4 and **3.5** show the projections for water demand and gross sewage production for each of the nine (9) defined catchment areas.

In 2008, it is estimated that the catchments Marikina, QC East (MWSI) and QC East (MWCI) will produce 145,780 m3/day of wastewater, out of the basin total of 234,410 m3/day. Wastewater volume from the Nangka Catchment will also be substantial, at around 21,000 m3/day.

By 2023, the Marikina Catchment will remain the main source of sewage in the Marikina Basin, with an estimated 84,000 m3/day sewage production. Substantial increase in sewage production is expected in the Nangka Catchment (to 70,000 m3/day) and Upper Marikina (to 68,000 m3/day). QC East (MWSI) and QC East (MWCI) will contribute 62,000 m3/day and 49,000 m3/day of sewage, respectively.

In 2023, out of the estimated 70,000 m3/day sewage flow from the Nangka Catchment, 49,000 m3/day or 70% will come from Antipolo City.

[4] Source: Wastewater Department, MWCI

Table 3.2 Population Projections by Catchment Area (2008-2023)

Year	Population by Catchment									
	Pasig North	Olandes	QC East-MWCI	QC East-Maynilad	Marikina	Nangka	Ampid	Maly	Marikina Upper	Total
2008	122,779	49,789	200,142	296,358	466,837	182,701	64,107	41,569	117,076	1,541,358
2013	124,646	52,314	212,600	298,836	502,659	227,657	98,156	50,485	199,742	1,767,096
2018	126,322	54,486	223,282	300,938	535,847	393,038	115,260	58,649	285,683	2,093,505
2023	127,779	56,256	231,937	302,919	558,568	411,354	124,091	64,301	340,194	2,217,401

Table 3.3 Share of Population by Catchment Area (2008-2023)

Year	Population by Catchment (in %)									
	Pasig North	Olandes	QC East-MWCI	QC East-Maynilad	Marikina	Nangka	Ampid	Maly	Marikina Upper	Total
2008	7.97%	3.23%	12.98%	19.23%	30.29%	11.85%	4.16%	2.70%	7.60%	100%
2013	7.05%	2.96%	12.03%	16.91%	28.45%	12.88%	5.55%	2.86%	11.30%	100%
2018	6.03%	2.60%	10.67%	14.37%	25.60%	18.77%	5.51%	2.80%	13.65%	100%
2023	5.76%	2.54%	10.46%	13.66%	25.19%	18.55%	5.60%	2.90%	15.34%	100%

Table 3.4 Water Demand Projections by Catchment (2008-2023)

Year	Water Demand Projections by Catchment (in mld)									
	Pasig North	Olandes	QC East-MWCI	QC East-Maynilad	Marikina	Nangka	Ampid	Maly	Marikina Upper	Total
2008	44.19	9.85	42.28	73.75	66.19	26.21	8.40	5.52	16.62	293.01
2013	46.23	10.67	46.15	74.90	74.74	34.88	13.10	8.69	34.56	343.93
2018	178.28	16.55	55.17	77.08	93.80	66.88	20.93	14.09	63.89	586.67
2023	57.28	13.96	61.14	78.12	104.89	87.67	24.15	16.48	85.57	529.27

Table 3.5 Gross Sewage Projection by Catchment (2008-2023)

Year	Gross Sewage Production Projections by Catchment (in mld)									
	Pasig North	Olandes	QC East-MWCI	QC East-Maynilad	Marikina	Nangka	Ampid	Maly	Marikina Upper	Total
2008	35.35	7.88	33.82	59.00	52.96	20.97	6.72	4.42	13.30	234.41
2013	36.99	8.54	36.92	59.92	59.79	27.90	10.48	6.95	27.65	275.14
2018	142.63	13.24	44.13	61.66	75.04	53.50	16.74	11.27	51.11	469.34
2023	45.83	11.17	48.92	62.50	83.91	70.14	19.32	13.18	68.46	423.42

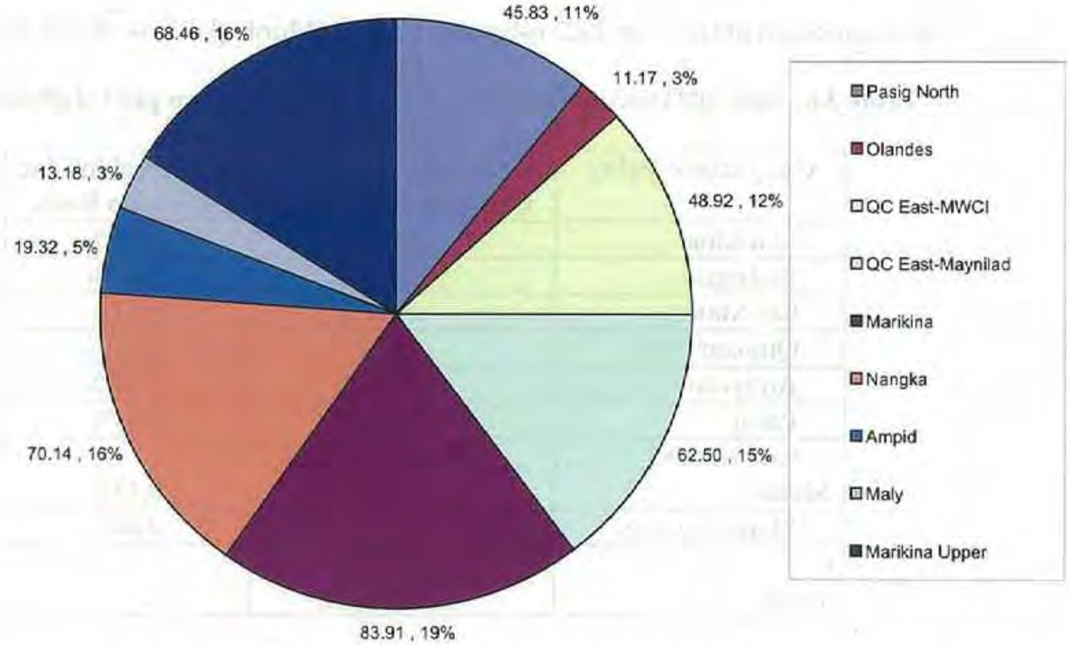


Figure 3.1 Estimated 2023 Sewage Production (mld)

3.3 Gross Pollution (BOD) Generation

Estimated gross pollution generation expressed in BOD kg/day were estimated for the study area. The estimates considered both domestic, commercial and industrial sources. For domestic sources, BOD per capita was assumed at 40 g/c/d. This will be reviewed later on in the Master Plan.

In this section, for planning purposes, gross pollution generation from domestic sources is defined as the BOD of untreated wastewater at the source. Treatment through on-site facilities (e.g. septic tanks), percolation of wastewater to the ground, and natural treatment through different water channels (e.g. creeks) is neglected.

For commercial and industrial sources, partial sewage treatment is assumed, considering that some industrial sources operate their own sewage treatment facilities, and MWCI is not expected to directly, or indirectly (through effluent trading) to replace such facilities. Given the difficulty in obtaining from EMB and LLDA useful data such as discharge permits and compliance monitoring permits, for the interim report, an effluent quality of 60 mg/l, average for all commercial and industrial sources was assumed. This is reflective of an LLDA report that only 75% of firms surveyed complied with the effluent standards.

Pollution loading, particularly to the Marikina River will be evaluated in detail in the water quality modeling exercise.

Based on the assumptions discussed above, the estimated gross pollution generation is 64,300 kg-BOD/day in Year 2008 and by Year 2023, this is expected to rise to 95,900 kg-BOD/day.

The breakdown of the Year 2023 estimates by City/Municipality is shown hereunder:

Table 3.6 Year 2023 Estimated Gross Pollution Generation per City/Municipality

City/Municipality	Gross Pollution Generation (kg/day)	% of total for the Marikina Basin
Marikina	31,756	33.13%
Rodriguez	12,119	12.64%
San Mateo	9,421	9.83%
Quezon City	19,559	20.40%
Antipolo	17,234	17.98%
Pasig	5,315	5.54%
San Jose Del Monte	411	0.43%
Mandaluyong	43	0.04%
Total:	**95,859**	

The estimated gross pollution generation by catchment is shown in **Table 3.7** and **Figures 3.2** and **3.3**. In Year 2008, 30% of the basin sewage pollution or 19,000 kg-BOD/day will be generated within the Marikina Catchment. This is followed by the QC East Maynilad catchment, with 12,800 kg-BOD/day. The Nangka Catchment will contribute only 7,400 kg-BOD/day.

By Year 2023, the Marikina Catchment will remain the biggest pollution generator among the nine (9) catchments. It is estimated that 23,700 kg-BOD/day (25%) will come from this catchment. By this year, we will also see that BOD generation from the Nangka Catchment will increase to 17,545 kg-BOD/day (18%).

In 2023, out of the estimated 17,545 kg-BOD/day generation from the Nangka Catchment, 11,271 kg-BOD/day or around 64% will come from Antipolo City.

Table 3.7 BOD Generation Projections per Catchment

Year	Pollution Generation Projections by Catchment (in BOD kg/day)				
	Pasig North	Olandes	QC East-MWCI	QC East-Maynilad	Marikina
2008	5,555	2,085	8,410	12,761	19,013
2013	5,697	2,205	8,991	12,873	20,629
2018	6,015	2,358	9,710	13,005	22,486
2023	6,195	2,461	10,197	13,107	23,650

Year	Pollution Generation Projections by Catchment (in BOD kg/day)				
	Nangka	Ampid	Maly	Marikina Upper	Total
2008	7,438	2,607	1,696	4,773	64,338
2013	9,350	4,018	2,084	8,233	74,081
2018	16,481	4,848	2,507	12,145	89,556
2023	17,545	5,264	2,777	14,663	95,859

Figure 3.2. Gross Pollution Generation by Catchment (Year 2008)

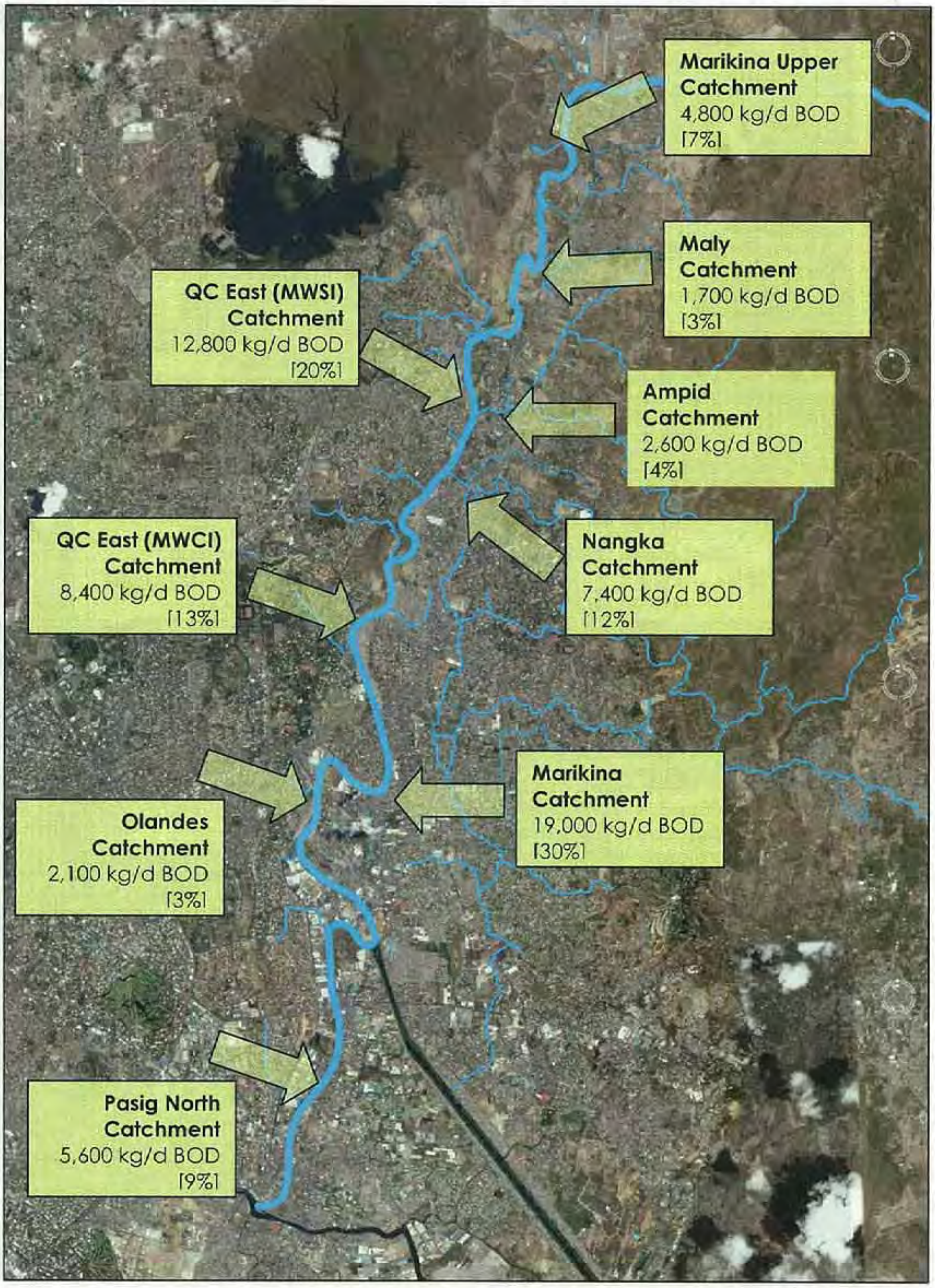
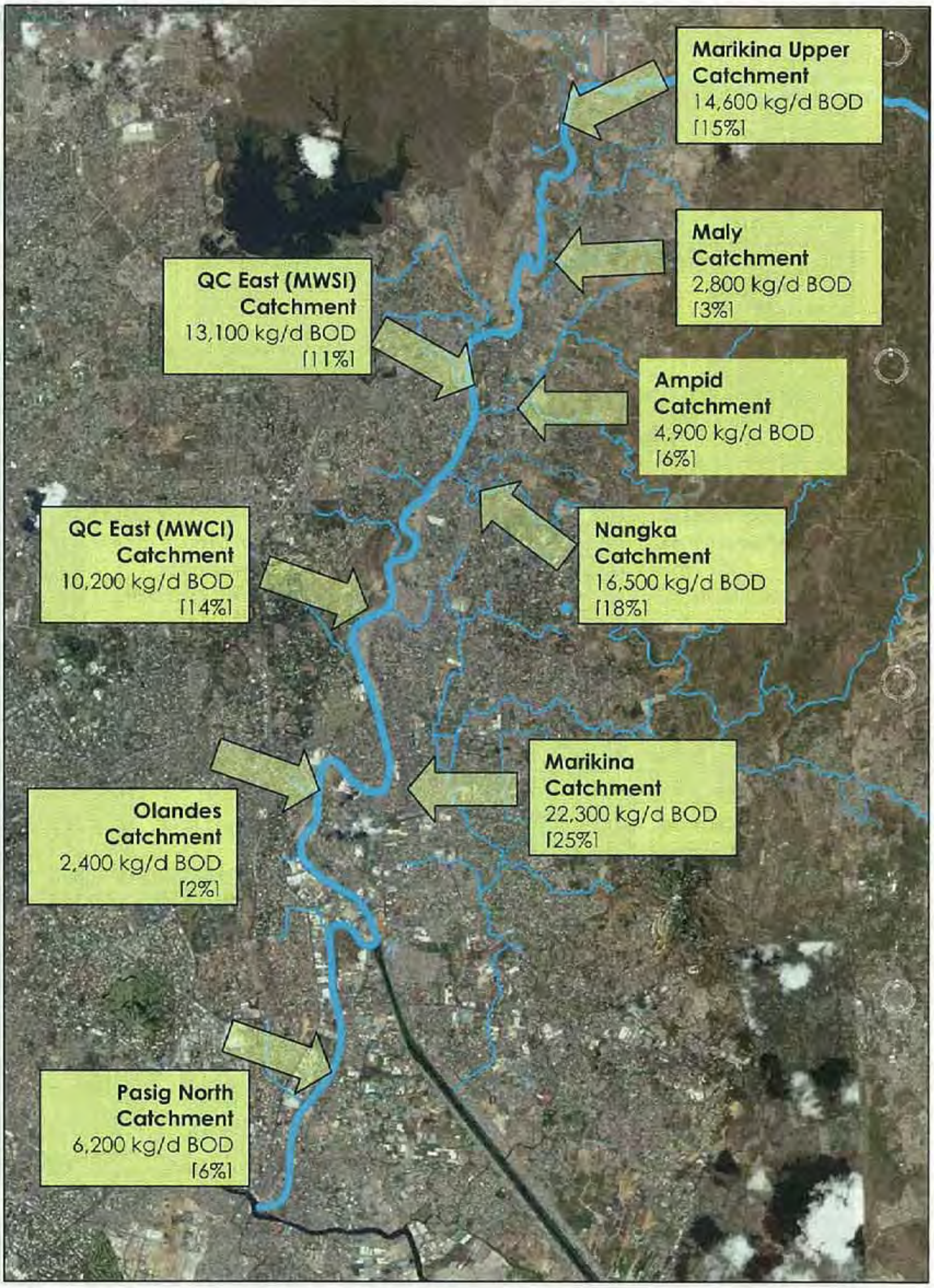


Figure 3.3. Gross Pollution Generation by Catchment (Year 2023)



Section 4.0

PRELIMINARY SEWERAGE PLANNING FOR MARIKINA

4.0 PRELIMINARY SEWERAGE PLANNING FOR MARIKINA

4.1 Planning Inputs

In the preparation of the Master Plan for the Marikina Sewerage System, data and relevant information were obtained from the local government unit (LGU) of the city. Among these data are the following:

- Digitized Surface Run-off Map with catchment area delineation
- Surface Run-off Map with manually delineated catchment area
- Flood Control Drainage System Map
- Digitized Contour Map based on NAMRIA data with the road network shown
- Digitized Surface Run-off Map showing flow direction details
- Marikina City New Barangay Boundaries

4.2 Initial field investigations of major drainage outfalls and alternative STP sites

The Project Team conducted three separate site visits (January 9 and 14, 2008) to ground validate major drainage outfalls and inspect initially identified STP sites within Marikina City.

Figure 4.1 presents the photographs of the major drainage outfalls with key plan while **Figure 4.2** shows the location of identified STP sites with corresponding photographs relative to the drainage layout plan.

Marikina-LGU's assessment of Consultant's identified STP sites are as follows:

1. For identified sites located in Nangka River, Concepcion Uno rice field, and vacant lot behind LRT2 depot; areas not possible since privately owned, same with area located at the tip of were SM Marikina is situated.

2. For the wide access road (Fernando Ave.) beside Marikina Bridge; possible but only in the area where the Chinese gazebo is located.

<u>Description of Identified STP Sites</u>

Details of each site including initial findings and assessment are as follows:

Note: The term social acceptability is deemed a concern when the site is just adjacent to a community. No direct consultations have been made.

FIGURE 4.1

MAJOR DRAINAGE OUTFALLS OF MARIKINA CITY

SEWERAGE MASTER PLAN AND FEASIBILITY STUDY FOR THE MARIKINA RIVER BASIN

MANILA WATER COMPANY, INC.

NJS Consultants

CEST, Inc.

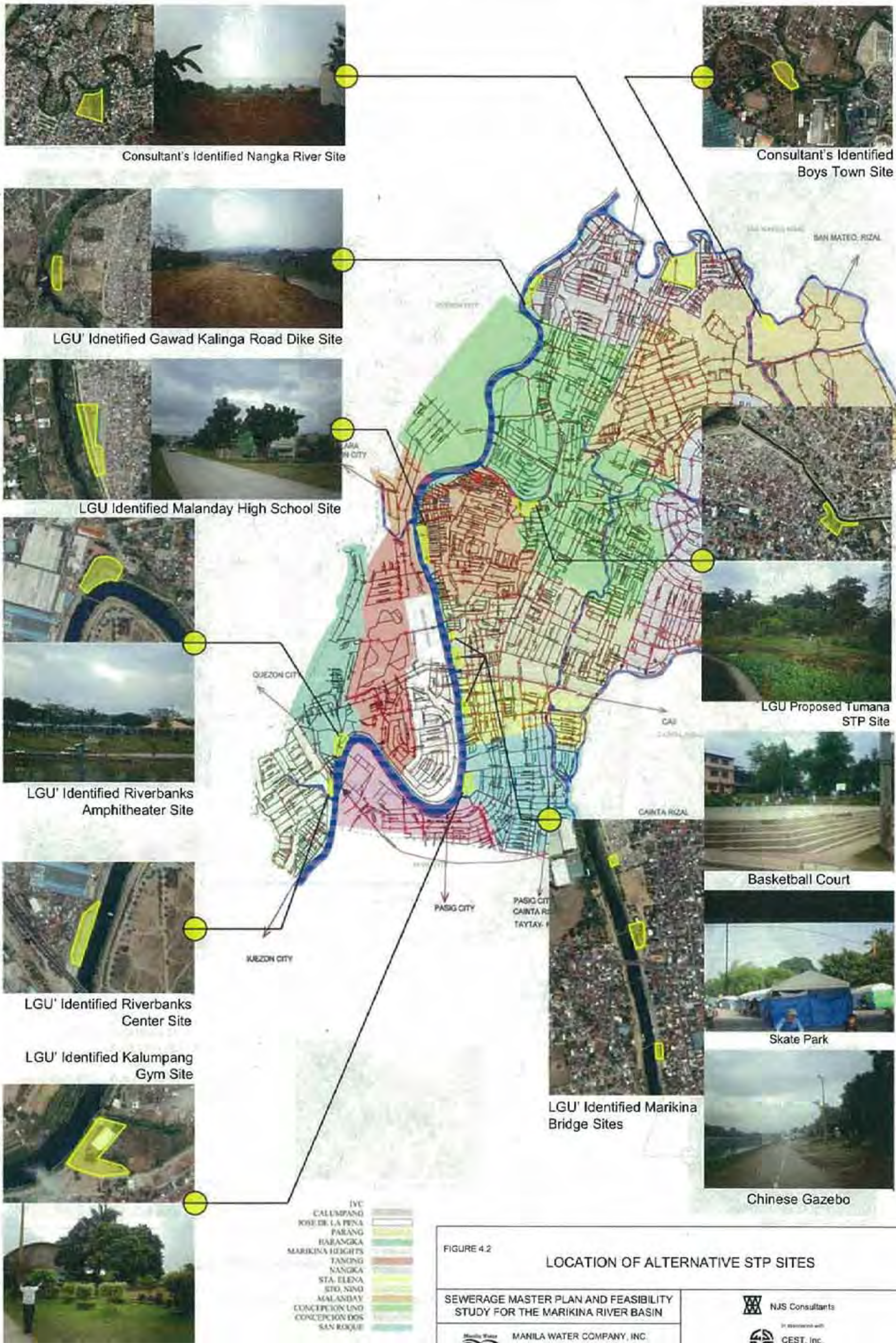


FIGURE 4.2

LOCATION OF ALTERNATIVE STP SITES

SEWERAGE MASTER PLAN AND FEASIBILITY STUDY FOR THE MARIKINA RIVER BASIN

MANILA WATER COMPANY, INC.

NJS Consultants

CEST, Inc.

LGU-Marikina Identified STP Sites

(1) Riverbanks Amphitheater STP Site

Location: Riverbanks, Brgy. Barangka
Approx. Lot Area: 7,760 sq.m. (including road)
Possible Catchment: Barangays Barangka, Tanong, and Jose Dela Pena

Brief description:
The area is currently used for holding of special events and shows. The LGU has plans to elevate the stage by 3 meters to counter-act the height of the water level.

Brief assessment:
The need for pilings and river protection is evident.

Pros:

- Proximity to major drainage outfalls
- Larger area compared to other alternative sites

Cons:

- Approval needed from the LGU allowing land use change
- Limited buffer zone
- High cost in construction cost

(2) Kalumpang Gym STP Site

Location: Kalumpang Gym, Brgy. Kalumpang
Approx. Lot Area: 5,370 sq.m. (including road)
Possible Catchment: Barangays Kalumpang and San Roque

Brief description:
The area has an open space of about 4,355 sq.m. (including the access road) and a covered courts (gym) of approximately 1,015 sq.m. The LGU has plans to renovate the covered courts from ground up including the construction of a Barangay Hall in the vacant space.

Water level does not reach the proposed area (except the access road) except under extreme weather conditions. Water level in the access road could rise up to more than 6 meters. (*Source: Mr. Anaki*)

Brief assessment:

The need for pilings and river protection is evident. Options will be either locating under the gym or in the open space or utilizing the entire area altogether. In able to catch flow from Kalumpang (Marcos Highway drainage outfall) an approximate 1,800 (along riverbanks road) or 1,400 (cross meter long forcemain would have to be laid-out.

Pros:
- Proximity to major drainage outfalls
- Adequate lot area and buffer zone

Cons:
- Social acceptability concern
- No assurance of the future development plans for the area
- Would require pumping to receive more sewage flows
- Possible high cost in construction cost

(3) STP Sites within Marikina Bridge

Possible Catchment: Barangays Kalumpang and San Roque
Location: Along Riverbanks (Fernando Ave.) below Marikina Bridge, Brgy. Sto. Nino and Sta. Elena

Basketball Court

Skate Park

Chinese Gazebo

3a. Skate Park (Brgy. Sto. Nino)
Approx. Lot Area: 6,280 sq.m. (including road)

Brief Description:
Public land used for recreation (Skate Park).

Brief Assessment:
The need for pilings and river protection is evident. River water level reaches the area and could rise up to 3 meters.

Pros:
- Higher elevation as compared to 3b and 3c
- Proximity to major drainage outfalls
- Adequate lot area and buffer zone

Cons:
- Social acceptability concern
- Possible high cost in construction cost

3b. ***Basketball Court (Brgy. Sto. Nino)***
Approx. Lot Area: 1,540 sq.m. (including road)

Brief Description:
Public land used for recreation (open basketball court). River water level reaches the area and could rise up to 3 meters.

Brief Assessment:
The need for pilings and river protection is evident.

Pros:
- Proximity to major drainage outfalls
- Land availability

Cons:
- Social acceptability
- Inadequate lot area and buffer zone
- Possible high cost in construction cost

3b. ***Chinese Gazebo (Brgy. Sta. Elena)***
Approx. Lot Area: 2,490 sq.m.

Brief Description:
Situated in the middle of the area is a Chinese Gazebo while most of the open space is used for parking and as access road. Water level reaches the area and could rise up to 3 meters.

Brief Assessment:
The need pilings and river protection is evident.

Pros:
- Proximity to major drainage outfalls
- Land availability

Cons:
- Social acceptability
- Inadequate lot area and buffer zone
- Possible high cost in construction cost

(4) Tumana STP Site

Location: Tumana Creek, Brgy. Malanday
Approx. Lot Area: 2,900 sq.m. (to be verified with Engineering office)
Possible Catchment: Barangays Malanday and Concepcion Uno

Brief description:
The area is a vacant lot within the resettlement area of Brgy. Malanday. Construction of an access road leading to the area is currently on-going.

Brief assessment:
STP site can be accommodated on an above-ground design. Area seems to be inadequate considering the high flows that the proposed site must treat. To secure more space, resettlement may be required.

Pros:
- Adjacent to Tumana creek
- Possible above-ground design

Cons:
- Social acceptability concern
- Inadequate lot area and buffer zone

(5) Malanday High School STP Site

Location: Purok 4, Malanday High School, Brgy. Malanday
Approx. Lot Area: 10,135 sq.m.
Possible Catchment: Barangays Malanday and Concepcion Uno

Brief description:
The area has an open space of about 10,135 sq.m. (including the access road and open grounds of the school) and a three story high school building of approximately 2,500 sq.m.

Brief assessment:
The need for river protection is evident. The drainage outfall is already 3 meters below ground level from the adjacent road and would probably be more than 10 meters below from the actual ground level of the proposed site.

Pros:
- Proximity to drainage outfall
- Lot area
- Land availability

Cons:

- Social acceptability (it is within the school premises)
- Inadequate buffer zone
- Depth of drainage outfall in relation to ground level
- Possible high construction cost

(6) Gawad Kalinga Road Dike STP Site

Location: Gawad Kalinga Riverbanks Access Road, Brgy. Nangka
Approx. Lot Area: 6,200 sq.m.
Possible Catchment: Barangays Nangka and Parang

Brief description:
The proposed site is situated right in the access road which is an elevated earth embankment rising more than 10 meters above Marikina River. Drainage outfalls are more than ten meters below ground level of the proposed site.

Brief assessment:
Extensive river protection is evidently required.

Pros:

- Proximity to drainage outfall
- Land area (if the whole stretch of the newly constructed road is considered) and adequate buffer zone
- Less susceptible to flooding compared to other sites
- Land availability

Cons:

- Depth of drainage outfall in relation to ground level
- Possible high construction cost

(7) Nangka River STP Site

Location: Brgy. Nangka
Approx. Lot Area: More than 30,000 sq.m.
Possible Catchment: Barangays Nangka and Parang

Brief description:
The identified site is situated at the bank of Nangka River and is privately owned. A major drainage line cuts through the lot with its outfall at Nangka River.

Brief assessment:
No major works in terms of site development is required, however intercepting the flows would require pumping since drainage line is deep.

Pros:
- Proximity to drainage outfall
- No major site development works required
- Land area and adequate buffer zone

Cons:
- Depth of drainage outfall in relation to ground level
- Privately owned

(8) Boys Town STP Site

Location: Manila Boys Town, Brgy. Parang
Approx. Lot Area: More than 10,800 sq.m.
Possible Catchment: Barangay Parang

Brief description:
The identified site is situated at the inside the Manila Boys Town, which is owned and under the jurisdiction of the City of Manila.

Brief assessment:
No major works in terms of site development is required.

Pros:
- Proximity to drainage outfall
- No major site development works required
- Land area and adequate buffer zone

Cons:
- Depth of drainage outfall in relation to ground level
- Privately owned

4.3 Sub-catchment definition for combined sewerage system

The whole Marikina basin was subdivided into catchment areas based on their proximity to the nearest alternative STP sites, the topography of the area, the location of the creeks, the main drainage canals/pipes, and main storm drainage outfalls.

Two options are presented, and are differentiated mainly by the assumed number of STP sites that can be acquired. The sub-catchments are color-coded for a clearer and readily recognizable presentation.

Option 1

There are a total of seven (7) locations of STPs for Option No. 1, serving eleven (11) pre-defined sub-catchment areas. The main feature of this option are the presence of two STPs at the Nangka River on the Marikina side (Proposed STP Nos. 6 & 7); and an STP is proposed at the San Roque - Sta. Elena outfall to serve that area (Proposed STP No. 2).

Option 2

There are four (4) locations of STPs for Option No. 2 serving (10) pre-defined sub-catchment areas. The main features of this option are: that the area traversed by the Nangka River will have their sewage treated at STP No. 3 along the Marikina River, together with the immediate area surrounding that STP. In this way the use of STP No. 3 at this site is maximized (albeit analysis later show the area is inadequate). Another feature of this option is that the San Roque - Sta. Elena area will now be channeled to the Proposed STP No. 1 along the Marikina River thus again maximizing the use of this STP.

4.3.1. *Common Features of the Options*

Common between the two options is that there are two big catchment area delineation in comparison to the other areas. One is the central part of the Marikina basin (specifically Malanday, Sto. Nino and Concepcion) which is proposed to be served by the proposed STP No. 3 near the Marikina bridge. The other is the Marikina Heights which we will be served by the proposed STP No. 4 at the creek near Tumana. The existing drainage laterals and sub-laterals which are now interconnected with the existing main drainage lines will be utilized to feed the sewage collected in their sub-areas to the existing main lines which will act as the main sewage lines / interceptor lines.

Laterals serving Concepcion 1 & 2 will drain into the creek which will be pumped up to the main drainage outfall leading to the proposed STP No. 3 near the Marikina bridge.

4.3.2. *Special Considerations*

One special consideration is that based on the topographic orientation of a creek at the Antipolo area, adjacent to Marikina, this creek drains into or continues on as a creek in the Marikina area. Therefore this will be absorbed by the proposed STP No. 3 near the Marikina bridge.

The other special consideration is that a sizable area adjacent to the Marcos highway which includes the Vermont Park Executive Village and the Masinag area, they are already part of Antipolo) geographically slopes towards the Marcos highway, such that sewage flows will ultimately be carried by an existing drainage line along the highway. When this happens, sewage will have to be treated at the first STP of Marikina since the existing drainage line in these vicinities are connects to a forced main, which will be constructed along the Marcos highway.

4.3.3. *Combined Flow Scheme*

Following the combined scheme wherein the drainage lines are also used to carry the sewage flows, drainage lines were selected to function as the main sewer lines. These main lines are proposed to carry the sewage flows to the different STPs. The basis for the selection of a particular line were the flow directions indicated on the Surface Run-off Map and the existing drainage lines and outfalls in the Flood Control Drainage System Map. Sub-catchment areas will have secondary lines that will feed into these main lines. Although basically flow towards the STP will be by gravity along these main lines, for flows from the creek that will discharge into them, pumps will be needed to lift up the sewage flows. There are three pump site locations along the creek.

4.3.4. *Delineation of Sub-catchment*

Details of the delineated catchment areas are presented in the table below. The delineation of the catchment areas for the two options are presented in detail in **Figures 4.3** and **4.4**.

Table 4.1 Sub-catchment description for Option No. 1

Sub-catchment	Area (ha)	Sub-catchment Area Description	Remarks
CA-1	150.6	Calumpang – SanRoque Area located adjacent to Marcos Highway	Drains to Proposed STP No. 1
CA-2	110.9	J. dela Pena Area located at the west bank of the Marikina River	Drains to Proposed STP No. 1
CA-3	133.3	Sta. Elena and San Roque Area	Forced Main towards Proposed STP No. 2 from the creek
CA-4	566	Malanday – Sto. Nino – Concepcion 1 & 2 Area	Drains to Proposed STP No. 3
CA-5	279.2	Marikina Heights Area	Drains to creek near Tumana which drains to Proposed STP No. 4
CA-6	150.4	Lower part of Parang Area and lower part of Tumana Area	Drains to creek near Tumana which drains to Proposed STP No. 4
CA-7	161	Upper part of Tumana Area and whole of Nangka Area	Drains to Proposed STP No. 5
CA-8	92.1	Upper part of Parang Area	Drains to Proposed STP No. 6
CA-9	280.9	Upper part of Marikina Heights and whole of Fortune Area	Drains to Proposed STP No. 7
CA-10A	132.9	The area bounded by Marcos Highway on the south and Sumulong Highway on the north with the following subdivisions within the east delineation boundary: Broadway Pines Subdivision-north of Sumulong Highway and Texas Cockpit Arena south of the highway ; approx. 2/3 of Vermont Royale Executuve Village; the west boundary is the creek at Sta Elena San- Roque area in Marikina with St, Gregory and U.E. Villages within the western boundary.	Drains to Balinit Creek which drains to proposed STP No. 3
CA-10B	398.4	The area north of Marcos Highway which includes part of Vermont Royale Executive Village, the whole of Vermont Park Executive Village; Mayamot and Masinag Area of Antipolo which includes the Sumulong and Marcos Highway intersection; and further east the following subdivisions: Summerville, Oro Vista and PenaFrancia	Drains to proposed STP No. 1

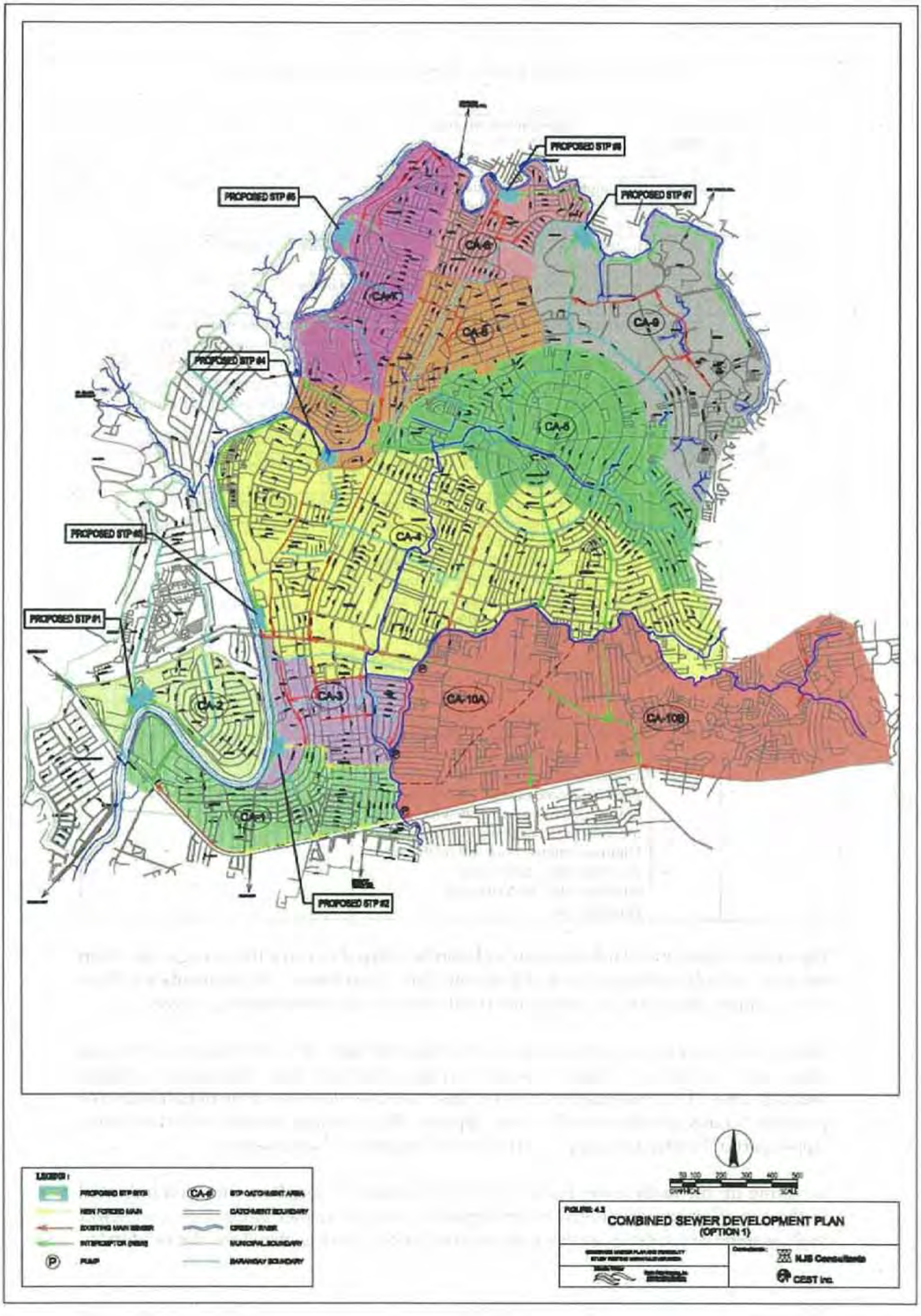
Table 4.2 Sub-catchment description for Option No. 2

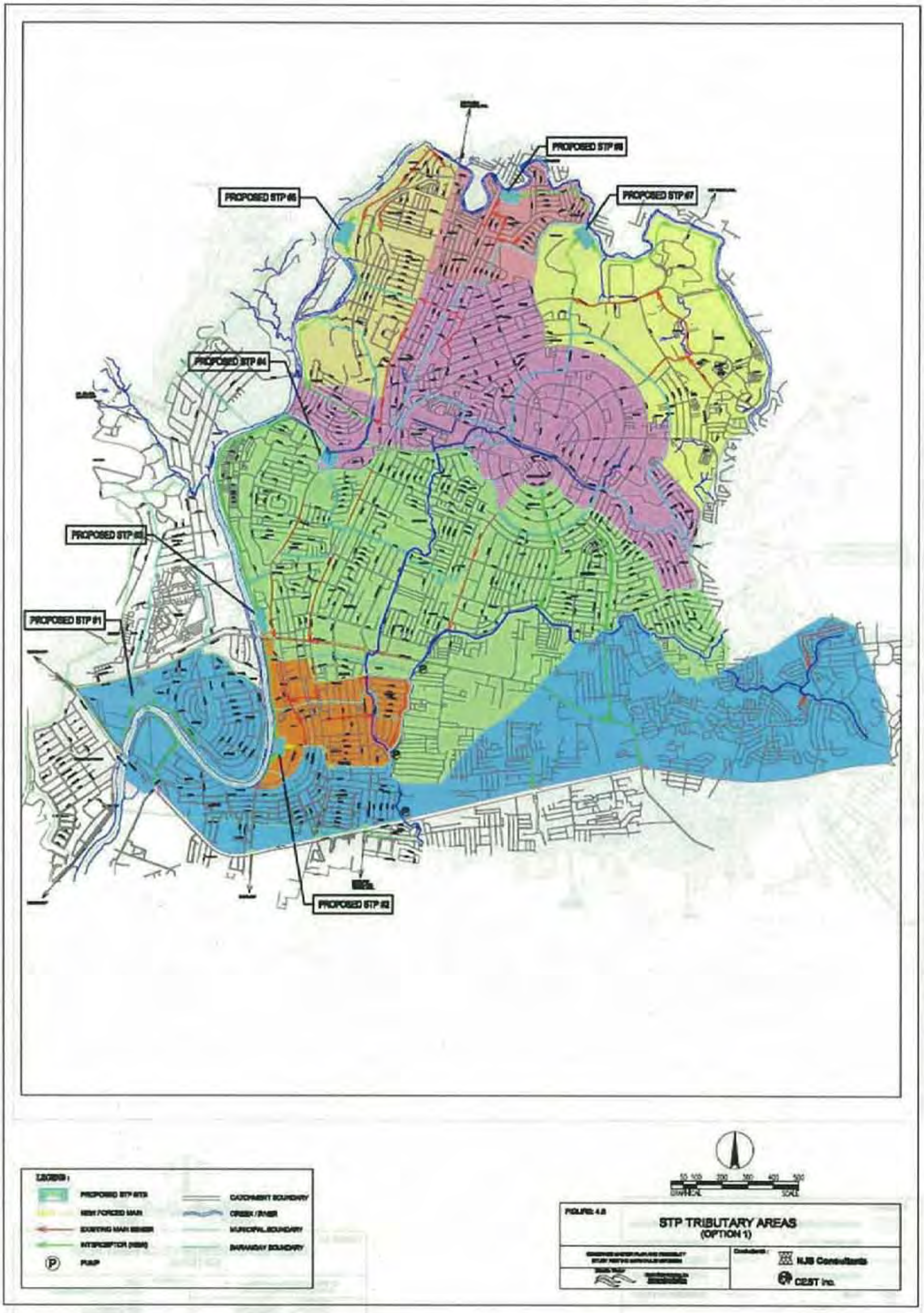
Sub-catchment	Area (ha)	Sub-catchment Area Description	Remarks
CA-1	283.9	Calumpang - SanRoque Area located adjacent to Marcos Highway and Sta. Elena and San Roque Area	Drains to Proposed STP No. 1
CA-2	110.9	J. dela Pena Area located at the west bank of the Marikina River	Drains to Proposed STP No. 1
CA-3	566	Malanday - Sto. Nino - Concepcion 1 & 2 Area	Drains to Proposed STP No. 2
CA-4	279.2	Marikina Heights Area	Drains to creek near Tumana which drains to Proposed STP No. 3
CA-5	150.4	Lower part of Parang Area and lower part of Tumana Area	Drains to creek near Tumana which drains to Proposed STP No. 3
CA-6A	161	Upper part of Tumana Area and whole of Nangka Area	Drains to Proposed STP No. 4
CA-6B	92.1	Upper part of Parang Area	Drains to Proposed STP No. 4
CA-6C	280.9	Upper part of Marikina Heights and whole of Fortune Area	Drains to Proposed STP No. 4
CA-7A	132.9	The area bounded by Marcos Highway on the south and Sumulong Highway on the north with the following subdivisions within the east delineation boundary: Broadway Pines Subdivision-north of Sumulong Highway and Texas Cockpit Arena south of the highway ; approx. 2/3 of Vermont Royale Executuve Village; the west boundary is the creek at Sta Elena San- Roque area in Marikina with St, Gregory and U.E. Villages within the western boundary.	Drains to Balinit Creek which drains to proposed STP No. 3
CA-7B	398.4	The area north of Marcos Highway which includes part of Vermont Royale Executive Village, the whole of Vermont Park Executive Village; Mayamot and Masinag Area of Antipolo which includes the Sumulong and Marcos Highway intersection; and further east the following subdivisions: Summerville, Oro Vista and PenaFrancia	Drains to proposed STP No. 1

The creeks within the Marikina basin will also be utilized to carry the sewage flow from the different sub-catchment areas. Obviously flows from these creek segments will have to be pumped into the main sewer lines if only to avoid deep intercepting sewers.

There will be new separate interceptor lines that will have to be constructed along the easement of the River enroute to the STPs in some locations since there are no existing drainage lines. These interceptor lines will also catch the flows from the outfall lines that presently drains directly into the river. Specifically these are located at Fortune area, Upper part of Parang area, upper part of both Nangka and Tumana areas.

In setting up the main sewer lines, there were instances where flow direction indicated in the run-off map were towards the opposite direction (either along the main sewer itself or some of the drainage line that will feed to it). There is therefore the need to lay


PROPOSED STP #1
PROPOSED STP #2
PROPOSED STP #3
PROPOSED STP #4
PROPOSED STP #5
PROPOSED STP #6
PROPOSED STP #7
CA-1
CA-2
CA-3
CA-4
CA-5
CA-6
CA-7
CA-8
CA-9
CA-10A
CA-10B
LEGEND :
PROPOSED STP SITE
NEW FORCED MAIN
EXISTING MAIN SEWER
INTERCEPTOR (NEW)
PUMP
STP CATCHMENT AREA
CATCHMENT BOUNDARY
CREEK / RIVER
MUNICIPAL BOUNDARY
BARANGAY BOUNDARY
50 100 200 300 400 500
GRAPHICAL SCALE
FIGURE 4.2
COMBINED SEWER DEVELOPMENT PLAN
(OPTION 1)
Consultants:
NJS Consultants
CEST Inc.


PROPOSED STP #5
PROPOSED STP #6
PROPOSED STP #7
PROPOSED STP #4
PROPOSED STP #3
PROPOSED STP #1
PROPOSED STP #2
LEGEND :
PROPOSED STP SITE
NEW FORCED MAIN
EXISTING MAIN SEWER
INTERCEPTOR (NEW)
PUMP
CATCHMENT BOUNDARY
CREEK / RIVER
MUNICIPAL BOUNDARY
BARANGAY BOUNDARY
50 100 200 300 400 500
GRAPHICAL SCALE
FIGURE 4.8
STP TRIBUTARY AREAS
(OPTION 1)
Consultants :
NJS Consultants
CEST Inc.

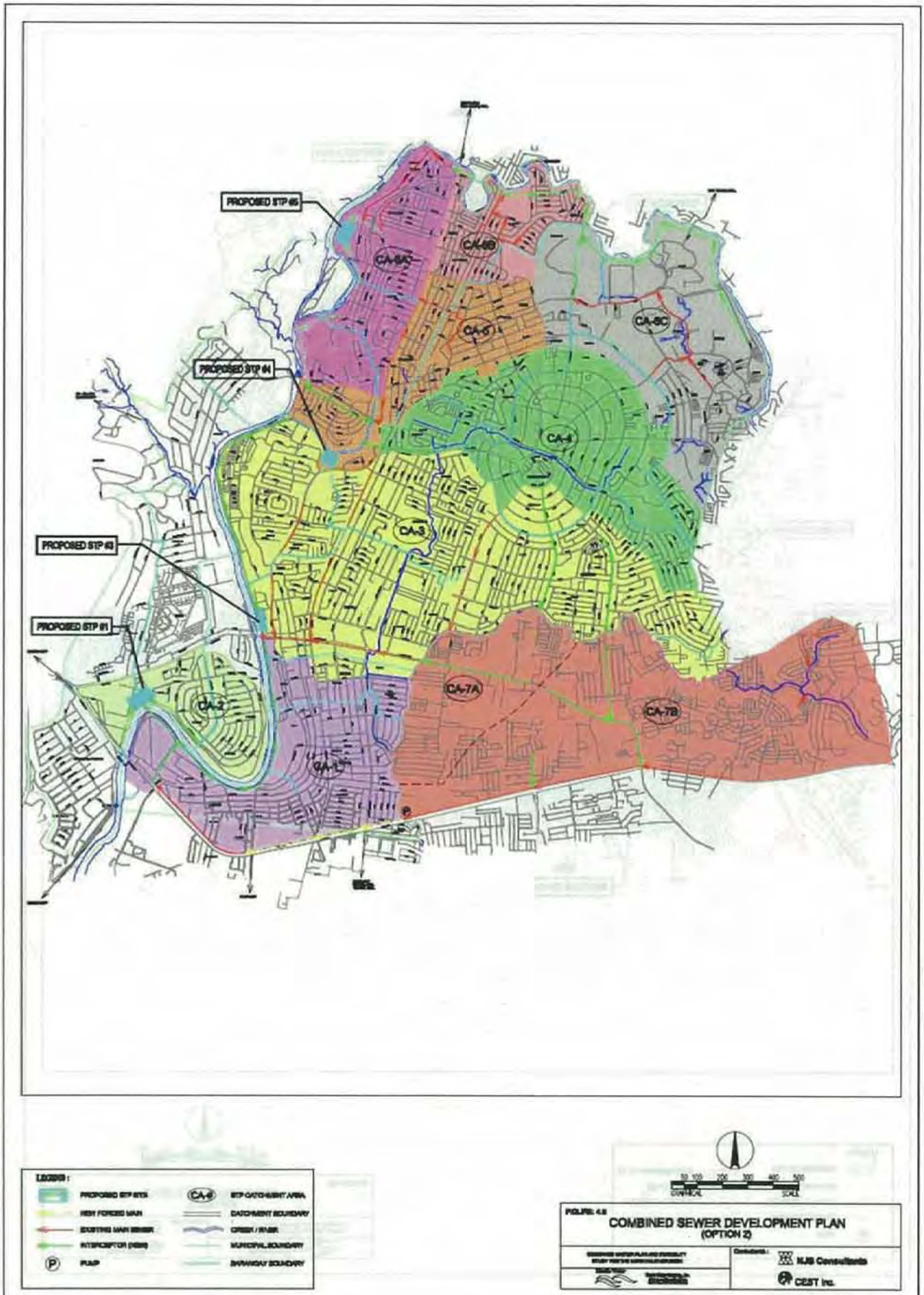
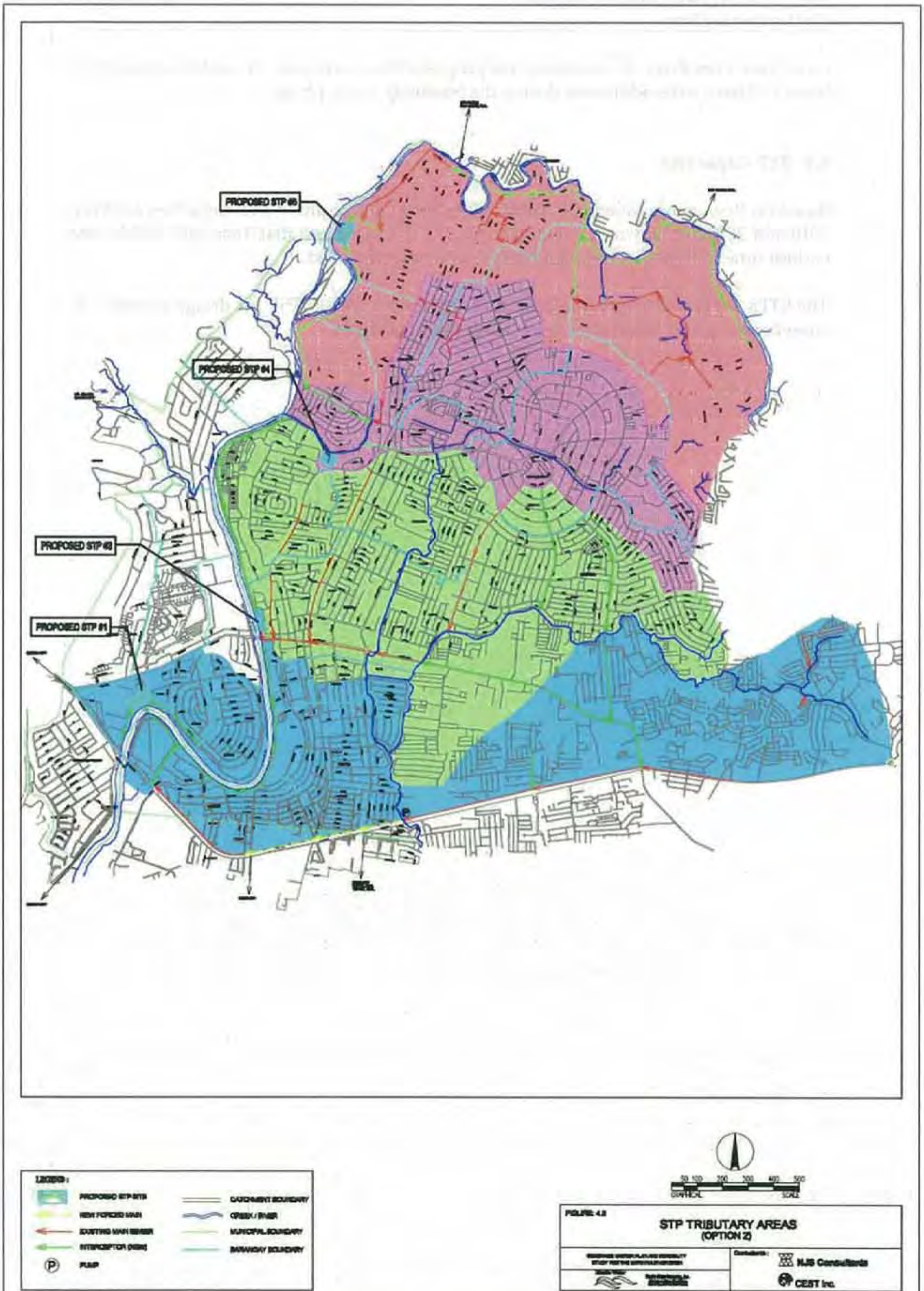


FIGURE: 4.8
COMBINED SEWER DEVELOPMENT PLAN
(OPTION 2)


PROPOSED STP #5
PROPOSED STP #4
PROPOSED STP #2
PROPOSED STP #1
LEGEND:
PROPOSED STP SITE
NEW FORCED MAIN
EXISTING MAIN SEWER
INTERCEPTOR (NEW)
PUMP
CATCHMENT BOUNDARY
CREEK / RIVER
MUNICIPAL BOUNDARY
BARANGAY BOUNDARY
50 100 200 300 400 500
GRAPHICAL SCALE
FIGURE: 4.2
STP TRIBUTARY AREAS
(OPTION 2)
Consultants:
NJS Consultants
CEST Inc.

down new lines that will conform to the proposed flow direction. The details concerning these will have to be addressed during the feasibility study phase.

4.4 STP Capacities

Based on flow computation (see **Table 4-3** and **4-4**), the required STP capacities for Year 2010 and 2023 are shown in Tables 4-5 and 4-6. It is assumed that Year 2010 will be the earliest time STPs in the Marikina Basin can be commissioned.

The STPs are based on a 1.5 x DWF flow, consistent with MTSP set design criteria. A conservative 5 m3/d/ha infiltration rate is also considered.

Table 4.3 Water and Sewage Flow Projections (Option 1)

CATCHMENT BLOCK No. NAME	TOTAL AREA COVERED hectare	INFILTRATION (@ 10.0 m3/ha/day) m3/day	YEAR 2008 CATCH. PROJ. POP. census	2008 TOTAL DAILY AVE. WATER USE m3/day Dom	C&I	Total	2008 DAILY AVE. SEWAGE FLOW m3/day Dom	C&I	Total	2008 DRY WEATHER FLOW with infiltraion (m3/day) Dom	C&I	Total	2008 DAILY PEAK SEWAGE FLOW with infiltraion (m3/day) Dom	C&I	Total	YEAR 2013 CATCH. PROJ. POP. census	2013 TOTAL DAILY AVE. WATER USE m3/day Dom	C&I	Total	2013 DAILY AVE. SEWAGE FLOW m3/day Dom	C&I	Total	2013 DRY WEATHER FLOW with infiltraion (m3/day) Dom	C&I	Total	2013 DAILY PEAK SEWAGE FLOW with infiltraion (m3/day) Dom	C&I	Total
1 CATCHMENT AREA 1																												
Calumpang	72.7	363	20,013	2,302	276	2,578	1,841	221	2,062	2,205	584	2,426	3,125	695	3,457	21,259	2,445	416	2,860	1,956	332	2,288	2,319	698	2,652	3,297	862	3,796
San Roque	55.9	280	14,422	1,875	225	2,100	1,500	180	1,680	1,779	460	1,959	2,529	550	2,799	15,320	1,992	339	2,330	1,593	271	1,864	1,873	550	2,144	2,669	686	3,076
Santolan, Pasig	12.1	60	2,665	400	68	468	320	54	374	380	115	434	540	142	621	2,678	402	88	490	321	71	392	382	131	452	542	166	648
Dela Paz, Pasig	9.9	50	437	83	14	97	66	11	78	116	61	127	149	67	166	439	83	18	102	67	15	81	116	64	131	150	72	172
Sub -Total CA-1	**150.6**	**753**	**37,537**	**4,659**	**583**	**5,242**	**3,727**	**467**	**4,194**	**4,480**	**1,219**	**4,947**	**6,344**	**1,453**	**7,044**	**39,696**	**4,922**	**861**	**5,782**	**3,937**	**689**	**4,626**	**4,690**	**1,442**	**5,379**	**6,659**	**1,786**	**7,692**
2 CATCHMENT AREA 2																												
Barangka	22.1	110	7,719	1,158	139	1,297	926	111	1,037	1,037	222	1,148	1,500	277	1,667	8,200	1,230	209	1,439	984	167	1,151	1,094	278	1,262	1,586	361	1,837
Tañong	37.4	187	4,894	636	76	713	509	61	570	696	248	757	950	278	1,042	5,199	676	115	791	541	92	633	727	279	819	998	325	1,136
Jesus Dela Peña	51.5	257	9,175	1,193	143	1,336	954	115	1,069	1,212	372	1,326	1,689	429	1,860	9,746	1,267	215	1,482	1,014	172	1,186	1,271	430	1,443	1,778	516	2,036
Sub -Total CA-2	**110.9**	**555**	**21,789**	**2,987**	**358**	**3,345**	**2,390**	**287**	**2,676**	**2,944**	**841**	**3,231**	**4,139**	**985**	**4,569**	**23,145**	**3,173**	**539**	**3,712**	**2,538**	**432**	**2,970**	**3,093**	**986**	**3,524**	**4,362**	**1,202**	**5,009**
3 CATCHMENT AREA 3																												
San Roque	64.0	320	16,508	2,146	258	2,404	1,717	206	1,923	2,037	526	2,243	2,895	629	3,204	17,535	2,280	388	2,667	1,824	310	2,134	2,144	630	2,454	3,055	785	3,521
Sta. Elena	52.7	264	9,477	1,232	148	1,380	986	118	1,104	1,249	382	1,368	1,742	441	1,919	10,067	1,309	222	1,531	1,047	178	1,225	1,311	442	1,489	1,834	531	2,101
Sto. Nino	16.6	83	4,722	614	74	688	491	59	550	574	142	633	820	171	908	5,016	652	111	763	522	89	610	605	172	693	866	216	999
Sub -Total CA-3	**133.3**	**667**	**30,707**	**3,992**	**479**	**4,471**	**3,194**	**383**	**3,577**	**3,860**	**1,050**	**4,243**	**5,457**	**1,241**	**6,032**	**32,618**	**4,240**	**721**	**4,961**	**3,392**	**577**	**3,969**	**4,059**	**1,243**	**4,636**	**5,755**	**1,532**	**6,620**
4 CATCHMENT AREA 4																												
Malanday	117.7	589	47,535	5,467	656	6,123	4,373	525	4,898	4,962	1,113	5,487	7,148	1,376	7,936	50,494	5,807	987	6,794	4,645	790	5,435	5,234	1,378	6,024	7,557	1,773	8,741
Sto. Nino	143.9	719	40,905	5,318	638	5,956	4,254	511	4,765	4,973	1,230	5,484	7,101	1,485	7,866	43,452	5,649	960	6,609	4,519	768	5,287	5,238	1,487	6,006	7,498	1,872	8,650
Concepcion Uno	115.5	578	35,326	4,063	488	4,550	3,250	390	3,640	3,828	968	4,218	5,453	1,163	6,038	37,525	4,315	734	5,049	3,452	587	4,039	4,030	1,164	4,617	5,756	1,458	6,636
Concepcion Dos	166.2	831	33,648	4,374	525	4,899	3,499	420	3,919	4,330	1,251	4,750	6,080	1,461	6,710	35,743	4,647	790	5,436	3,717	632	4,349	4,548	1,463	5,180	6,407	1,779	7,355
Marikina Heights	22.8	114	5,036	655	79	733	524	63	587	638	177	700	899	208	994	5,350	695	118	814	556	95	651	670	208	765	948	256	1,090
Sub -Total CA-4	**566.0**	**429,623**	**162,452**	**19,876**	**2,385**	**22,261**	**15,901**	**1,908**	**17,809**	**18,731**	**4,738**	**20,639**	**26,681**	**5,692**	**29,543**	**172,564**	**21,113**	**3,589**	**24,702**	**16,890**	**2,871**	**19,762**	**19,721**	**5,702**	**22,592**	**28,166**	**7,137**	**32,473**
5 CATCHMENT AREA 5																												
Concepcion Uno	34.0	170	10,385	1,194	143	1,338	955	115	1,070	1,125	284	1,240	1,603	342	1,775	11,031	1,269	216	1,484	1,015	173	1,187	1,185	342	1,357	1,692	429	1,951
Parang	37.4	187	11,290	1,298	156	1,454	1,039	125	1,163	1,226	312	1,351	1,745	374	1,932	11,993	1,379	234	1,614	1,103	188	1,291	1,291	375	1,478	1,842	469	2,124
Marikina Heights	178.3	892	39,472	5,131	616	5,747	4,105	493	4,598	4,997	1,384	5,489	7,049	1,631	7,788	41,929	5,451	927	6,377	4,361	741	5,102	5,252	1,633	5,994	7,433	2,004	8,545
Concepcion Dos	29.5	147	5,967	776	93	869	621	74	695	768	222	842	1,078	259	1,190	6,339	824	140	964	659	112	771	807	259	919	1,136	315	1,304
Sub -Total CA-5	**279.2**	**1,396**	**67,114**	**8,400**	**1,008**	**9,408**	**6,720**	**806**	**7,526**	**8,116**	**2,202**	**8,922**	**11,476**	**2,606**	**12,685**	**71,292**	**8,923**	**1,517**	**10,439**	**7,138**	**1,213**	**8,352**	**8,534**	**2,609**	**9,748**	**12,103**	**3,216**	**13,923**
6 CATCHMENT AREA 6																												
Concepcion Uno	69.8	349	21,339	2,454	294	2,748	1,963	236	2,199	2,312	584	2,548	3,294	702	3,647	22,667	2,607	443	3,050	2,085	355	2,440	2,434	703	2,789	3,477	881	4,009
Parang	72.5	362	21,854	2,513	302	2,815	2,011	241	2,252	2,373	604	2,614	3,378	724	3,740	23,214	2,670	454	3,123	2,136	363	2,499	2,498	725	2,861	3,566	907	4,111
Nangka	8.2	41	2,419	278	33	312	223	27	249	263	68	290	375	81	415	2,569	295	50	346	236	40	277	277	81	317	395	101	456
Sub -Total CA-6	**150.4**	**752**	**45,612**	**5,245**	**629**	**5,875**	**4,196**	**504**	**4,700**	**4,948**	**1,256**	**5,452**	**7,047**	**1,508**	**7,802**	**48,451**	**5,572**	**947**	**6,519**	**4,457**	**758**	**5,215**	**5,210**	**1,510**	**5,967**	**7,438**	**1,889**	**8,575**
7 CATCHMENT AREA 7																												
Nangka	92.8	464	27,419	3,153	378	3,532	2,523	303	2,825	2,987	787	3,289	4,248	918	4,702	29,126	3,349	569	3,919	2,680	456	3,135	3,144	920	3,599	4,483	1,147	5,167
Concepcion Uno	68.2	341	20,851	2,398	288	2,686	1,918	230	2,148	2,259	571	2,489	3,218	686	3,564	22,149	2,547	433	2,980	2,038	346	2,384	2,379	687	2,725	3,397	860	3,917
Sub -Total CA-7	**161.0**	**805**	**48,270**	**5,551**	**666**	**6,217**	**4,441**	**533**	**4,974**	**5,246**	**1,338**	**5,779**	**7,466**	**1,604**	**8,265**	**51,274**	**5,897**	**1,002**	**6,899**	**4,717**	**802**	**5,519**	**5,522**	**1,607**	**6,324**	**7,881**	**2,008**	**9,084**
8 CATCHMENT AREA 8																												
Nangka	80.5	403	23,797	2,737	328	3,065	2,189	263	2,452	2,592	665	2,855	3,687	797	4,081	25,278	2,907	494	3,401	2,326	395	2,721	2,728	798	3,124	3,891	996	4,484
Parang	11.6	58	3,487	401	48	449	321	38	359	379	96	417	539	116	597	3,704	426	72	498	341	58	399	399	116	457	569	145	656
Sub -Total CA-8	**92.1**	**461**	**27,284**	**3,138**	**377**	**3,514**	**2,510**	**301**	**2,811**	**2,971**	**762**	**3,272**	**4,226**	**912**	**4,678**	**28,982**	**3,333**	**567**	**3,900**	**2,666**	**453**	**3,120**	**3,127**	**914**	**3,580**	**4,460**	**1,140**	**5,140**
9 CATCHMENT AREA 9																												
Parang	244.0	1,220	73,568	8,460	1,015	9,476	6,768	812	7,580	7,988	2,032	8,800	11,372	2,438	12,591	78,148	8,987	1,528	10,515	7,190	1,222	8,412	8,410	2,442	9,632	12,004	3,053	13,838
Marikina Heights	36.9	185	8,168	1,062	127	1,189	849	102	951	1,034	286	1,136	1,459	337	1,612	8,676	1,128	192	1,320	902	153	1,056	1,087	338	1,240	1,538	415	1,768
Sub -Total CA-9	**280.9**	**1,404**	**81,736**	**9,522**	**1,143**	**10,665**	**7,618**	**914**	**8,532**	**9,022**	**2,319**	**9,936**	**12,831**	**2,776**	**14,202**	**86,824**	**10,115**	**1,720**	**11,834**	**8,092**	**1,376**	**9,468**	**9,498**	**2,780**	**10,872**	**13,542**	**3,468**	**15,606**
10 CATCHMENT AREA 10																												
Cupang, Antipolo	338.9	1,694	15,624	1,341	147	1,488	1,072	118	1,190	2,767	1,812	2,885	3,303	1,871	3,480	17,302	2,227	379	2,605	1,781	303	2,084	3,476	1,997	3,778	4,366	2,149	4,821
Mayamot, Antipolo	360.0	1,800	34,147	6,024	663	6,686	4,819	530	5,349	6,619	2,330	7,149	9,028	2,595	9,823	37,814	6,670	1,134	7,804	5,336	907	6,243	7,136	2,707	8,043	9,804	3,160	11,165
Sub -Total CA-10	**698.8**	**3,494**	**49,772**	**7,364**	**810**	**8,174**	**5,891**	**648**	**6,539**	**9,385**	**4,142**	**10,033**	**12,331**	**4,466**	**13,303**	**55,116**	**8,897**	**1,513**	**10,410**	**7,118**	**1,210**	**8,328**	**10,612**	**4,704**	**11,822**	**14,170**	**5,309**	**15,986**
GRAND TOTAL	**2,623**	**439,909**	**572,272**	**70,734**	**8,439**	**79,172**	**56,587**	**6,751**	**63,338**	**69,703**	**19,867**	**76,454**	**97,997**	**23,243**	**108,123**	**609,962**	**76,184**	**12,975**	**89,159**	**60,947**	**10,380**	**71,327**	**74,063**	**23,497**	**84,444**	**104,537**	**28,687**	**120,107**

Total Daily Ave. Water Use and Propoulation Projections based from MWCI Projections

Infiltration Factor (@ 10.0 m3/ha/day)	5.00
Sewage flow factor	0.80
Peak Factor	1.50

Table 4.3 Water and Sewage Flow Projections (Option 1)

PERIOD: YEAR 2018

CATCHMENT BLOCK No. NAME (1a) (1b)	TOTAL AREA COVERED hectare (2)	INFILTRATION (@ 10.0 m3/ha/day) m3/day (3)	CATCH. PROJ. POP. census (6a)	TOTAL DAILY AVE. WATER USE m3/day Dom (6b)	C&I (6c)	Total (6d)	DAILY AVE. SEWAGE FLOW m3/day Dom (6e)	C&I (6f)	Total (6g)	DRY WEATHER FLOW with infiltration (m3/day) Dom (6h)	C&I (6i)	Total (6j)	DAILY PEAK SEWAGE FLOW with infiltration (m3/day) Dom (6k)	C&I (6l)	Total (6m)
1 CATCHMENT AREA 1															
Calumpang	72.7	363	22,327	2,645	820	3,465	2,116	656	2,772	2,479	1,019	3,135	3,537	1,347	4,521
San Roque	55.9	280	16,090	2,155	668	2,823	1,724	534	2,258	2,003	814	2,538	2,865	1,081	3,667
Santolan, Pasig	12.1	60	2,691	416	150	566	333	120	452	393	180	513	559	240	739
Dela Paz, Pasig	9.9	50	441	86	31	118	69	25	94	119	75	144	153	87	191
Sub -Total CA-1	150.6	753	41,550	5,302	1,669	6,970	4,241	1,335	5,576	4,994	2,088	6,329	7,115	2,755	9,117
2 CATCHMENT AREA 2															
Barangka	22.1	110	8,612	1,331	412	1,743	1,065	330	1,395	1,175	440	1,505	1,707	605	2,202
Tañong	37.4	187	5,460	731	227	958	585	181	766	772	368	953	1,064	459	1,336
Jesus Dela Peña	51.5	257	10,236	1,371	425	1,796	1,097	340	1,437	1,354	597	1,694	1,902	767	2,412
Sub -Total CA-2	110.9	555	24,308	3,433	1,064	4,497	2,746	851	3,597	3,301	1,406	4,152	4,674	1,831	5,951
3 CATCHMENT AREA 3															
San Roque	64.0	320	18,417	2,466	765	3,231	1,973	612	2,585	2,293	932	2,905	3,279	1,237	4,197
Sta. Elena	52.7	264	10,572	1,418	439	1,855	1,133	351	1,484	1,396	615	1,747	1,963	790	2,489
Sto. Nino	16.6	83	5,268	706	219	924	564	175	739	647	258	822	930	345	1,192
Sub -Total CA-3	133.3	667	34,257	4,587	1,422	6,010	3,670	1,138	4,808	4,337	1,804	5,474	6,172	2,373	7,878
4 CATCHMENT AREA 4															
Malanday	117.7	589	53,031	6,282	1,947	8,230	5,026	1,558	6,584	5,614	2,147	7,172	8,127	2,926	10,464
Sto. Nino	143.9	719	45,635	6,111	1,894	8,006	4,889	1,516	6,404	5,608	2,235	7,124	8,053	2,993	10,326
Concepcion Uno	115.5	578	39,411	4,669	1,447	6,116	3,735	1,158	4,893	4,312	1,735	5,470	6,180	2,314	7,917
Concepcion Dos	166.2	831	37,539	5,027	1,558	6,585	4,022	1,247	5,268	4,853	2,078	6,099	6,863	2,701	8,733
Marikina Heights	22.8	114	5,619	752	233	986	602	187	789	716	300	902	1,017	394	1,297
Sub -Total CA-4	566.0	2,830	181,234	22,841	7,081	29,922	18,273	5,665	23,938	21,103	8,495	26,768	30,240	11,327	563,786
5 CATCHMENT AREA 5															
Concepcion Uno	34.0	170	11,586	1,372	425	1,798	1,098	340	1,438	1,268	510	1,608	1,817	680	2,327
Parang	37.4	187	12,595	1,492	463	1,955	1,194	370	1,564	1,381	557	1,751	1,978	742	2,533
Marikina Heights	178.3	892	44,036	5,897	1,828	7,725	4,718	1,462	6,180	5,609	2,354	7,072	7,968	3,085	10,162
Concepcion Dos	29.5	147	6,657	891	276	1,168	713	221	934	861	368	1,082	1,217	479	1,549
Sub -Total CA-5	279.2	1,396	74,874	9,653	2,992	12,645	7,722	2,394	10,116	9,118	3,790	11,512	12,980	4,987	16,570
6 CATCHMENT AREA 6															
Concepcion Uno	69.8	349	23,806	2,820	874	3,694	2,256	699	2,955	2,605	1,048	3,304	3,733	1,398	4,782
Parang	72.5	362	24,381	2,888	895	3,783	2,311	716	3,027	2,673	1,079	3,389	3,828	1,437	4,903
Nangka	8.2	41	2,698	320	99	419	256	79	335	297	120	376	424	160	543
Sub -Total CA-6	150.4	752	50,885	6,028	1,869	7,897	4,822	1,495	6,317	5,575	2,247	7,069	7,986	2,995	10,228
7 CATCHMENT AREA 7															
Nangka	92.8	464	30,589	3,624	1,123	4,747	2,899	899	3,798	3,363	1,363	4,262	4,812	1,812	6,160
Concepcion Uno	68.2	341	23,262	2,756	854	3,610	2,204	683	2,888	2,545	1,024	3,229	3,648	1,366	4,673
Sub -Total CA-7	161.0	805	53,851	6,379	1,976	8,357	5,103	1,582	6,685	5,908	2,387	7,490	8,460	3,178	10,833
8 CATCHMENT AREA 8															
Nangka	80.5	403	26,548	3,145	975	4,120	2,516	780	3,296	2,919	1,183	3,699	4,177	1,573	5,347
Parang	11.6	58	3,890	461	143	604	369	114	483	426	172	541	611	229	782
Sub -Total CA-8	92.1	461	30,436	3,606	1,118	4,724	2,885	894	3,779	3,345	1,355	4,239	4,787	1,802	6,129
9 CATCHMENT AREA 9															
Parang	244.0	1,220	82,074	9,723	3,014	12,737	7,778	2,411	10,189	8,998	3,631	11,409	12,887	4,837	16,504
Marikina Heights	36.9	185	9,112	1,220	378	1,599	976	303	1,279	1,161	487	1,463	1,649	638	2,103
Sub -Total CA-9	280.9	1,404	91,187	10,943	3,392	14,335	8,754	2,714	11,468	10,159	4,118	12,873	14,536	5,475	18,607
10 CATCHMENT AREA 10															
Cupang, Antipolo	338.9	1,694	18,902	2,782	862	3,644	2,225	690	2,915	3,920	2,384	4,609	5,032	2,729	6,067
Mayamot, Antipolo	360.0	1,800	41,310	8,332	2,583	10,915	6,666	2,066	8,732	8,466	3,866	10,532	11,799	4,899	14,898
Sub -Total CA-10	698.8	3,494	60,211	11,114	3,445	14,559	8,891	2,756	11,647	12,385	6,250	15,141	16,831	7,628	20,965
GRAND TOTAL	2,623	13,116	642,796	83,886	26,030	109,915	67,109	20,824	87,932	80,225	33,940	101,049	113,779	44,352	670,065

PERIOD: YEAR 2023

CATCHMENT BLOCK NAME	CATCH. PROJ. POP. census (7a)	TOTAL DAILY AVE. WATER USE m3/day Dom (7b)	C&I (7c)	Total (7d)	DAILY AVE. SEWAGE FLOW m3/day Dom (7e)	C&I (7f)	Total (7g)	DRY WEATHER FLOW with infiltration (m3/day) Dom (7h)	C&I (7i)	Total (7j)	DAILY PEAK SEWAGE FLOW with infiltration (m3/day) Dom (7k)	C&I (7l)	Total (7m)
1 CATCHMENT AREA 1													
Calumpang	23,193	2,851	998	3,849	2,281	798	3,079	2,644	1,162	3,442	3,785	1,581	4,982
San Roque	16,713	2,322	813	3,135	1,858	650	2,508	2,138	930	2,788	3,067	1,255	4,042
Santolan, Pasig	2,705	434	173	607	347	139	486	407	199	546	581	268	789
Dela Paz, Pasig	444	90	36	126	72	29	101	122	78	151	158	93	201
Sub -Total CA-1	43,055	5,697	2,020	7,718	4,558	1,616	6,174	5,311	2,369	6,927	7,590	3,177	10,014
2 CATCHMENT AREA 2													
Barangka	8,946	1,434	502	1,936	1,147	402	1,549	1,258	512	1,659	1,832	713	2,434
Tañong	5,672	788	276	1,064	630	221	851	817	408	1,038	1,133	518	1,464
Jesus Dela Peña	10,633	1,478	517	1,995	1,182	414	1,596	1,439	671	1,853	2,030	878	2,651
Sub -Total CA-2	25,250	3,700	1,295	4,995	2,960	1,036	3,996	3,515	1,591	4,551	4,995	2,109	6,549
3 CATCHMENT AREA 3													
San Roque	19,130	2,658	930	3,589	2,127	744	2,871	2,447	1,064	3,191	3,510	1,436	4,627
Sta. Elena	10,982	1,526	534	2,060	1,221	427	1,648	1,485	691	1,912	2,095	905	2,736
Sto. Nino	5,473	760	266	1,027	608	213	821	691	296	904	995	402	1,315
Sub -Total CA-3	35,585	4,945	1,731	6,676	3,956	1,385	5,341	4,623	2,051	6,007	6,601	2,744	8,677
4 CATCHMENT AREA 4													
Malanday	55,087	6,772	2,370	9,142	5,417	1,896	7,313	6,006	2,485	7,902	8,715	3,433	11,559
Sto. Nino	47,404	6,587	2,306	8,893	5,270	1,844	7,114	5,989	2,564	7,834	8,624	3,486	11,391
Concepcion Uno	40,939	5,032	1,761	6,794	4,026	1,409	5,435	4,503	1,987	6,013	6,616	2,691	8,730
Concepcion Dos	38,994	5,419	1,897	7,315	4,335	1,517	5,852	5,166	2,348	6,683	7,333	3,107	9,609
Marikina Heights	5,837	811	284	1,095	649	227	876	763	341	990	1,087	454	1,428
Sub -Total CA-4	188,260	24,621	8,617	33,238	19,697	6,894	26,591	22,527	9,724	29,421	32,375	13,171	42,716
5 CATCHMENT AREA 5													
Concepcion Uno	12,035	1,479	518	1,997	1,184	414	1,598	1,353	584	1,768	1,945	791	2,566
Parang	13,083	1,608	563	2,171	1,287	450	1,737	1,474	638	1,924	2,117	863	2,793
Marikina Heights	45,743	6,356	2,225	8,581	5,085	1,780	6,865	5,977	2,671	7,757	8,519	3,561	11,189
Concepcion Dos	6,915	961	336	1,297	769	269	1,038	916	416	1,185	1,301	551	1,704
Sub -Total CA-5	77,776	10,405	3,642	14,047	8,324	2,913	11,237	9,720	4,309	12,633	13,862	5,766	18,252
6 CATCHMENT AREA 6													
Concepcion Uno	24,729	3,040	1,064	4,104	2,432	851	3,283	2,781	1,200	3,632	3,997	1,626	5,273
Parang	25,326	3,113	1,090	4,203	2,491	872	3,362	2,853	1,234	3,725	4,098	1,670	5,406
Nangka	2,803	345	121	465	276	96	372	317	137	413	454	186	599
Sub -Total CA-6	52,858	6,498	2,274	8,772	5,198	1,819	7,017	5,950	2,572	7,770	8,549	3,481	11,278
7 CATCHMENT AREA 7													
Nangka	31,775	3,906	1,367	5,273	3,125	1,094	4,218	3,589	1,558	4,682	5,151	2,105	6,792
Concepcion Uno	24,164	2,970	1,040	4,010	2,376	832	3,208	2,717	1,173	3,549	3,905	1,588	5,153
Sub -Total CA-7	55,938	6,876	2,407	9,283	5,501	1,925	7,426	6,306	2,730	8,231	8,056	3,693	11,944
8 CATCHMENT AREA 8													
Nangka	27,578	3,390	1,187	4,577	2,712	949	3,661	3,115	1,352	4,064	4,471	1,827	5,895
Parang	4,041	497	174	671	397	139	536	455	197	594	654	266	863
Sub -Total CA-8	31,618	3,887	1,360	5,247	3,109	1,088	4,198	3,570	1,549	4,658	5,125	2,093	6,757
9 CATCHMENT AREA 9													
Parang	85,256	10,480	3,668	14,148	8,384	2,934	11,319	9,604	4,154	12,539	13,798	5,622	18,198
Marikina Heights	9,466	1,315	460	1,776	1,052	368	1,421	1,237	553	1,605	1,763	737	2,315
Sub -Total CA-9	94,721	11,796	4,128	15,924	9,436	3,303	12,739	10,841	4,707	14,144	15,559	6,359	20,513
10 CATCHMENT AREA 10													
Cupang, Antipolo	20,411	3,361	1,176	4,538	2,689	941	3,630	4,383	2,635	5,325	5,728	3,106	7,140
Mayamot, Antipolo	44,609	10,275	3,596	13,871	8,220	2,877	11,097	10,020	4,677	12,898	14,129	6,115	18,445
Sub -Total CA-10	65,021	13,636	4,773	18,409	10,909	3,818	14,727	14,403	7,312	18,221	19,857	9,221	25,585
GRAND TOTAL	670,083	92,061	32,247	124,308	73,648	25,798	99,446	86,765	38,914	112,563	123,589	51,813	162,286

Total Daily Ave. Water Use and Propoulation Projections based from MWCI Projections

Infiltration Factor (@ 10.0 m3/ha/day)	5.00
Sewage flow factor	0.80
Peak Factor	1.50

Table 4.4 Water and Sewage Flow Projections (Option 2)

CATCHMENT				PERIOD																									
				YEAR 2008													YEAR 2013												
BLOCK		TOTAL AREA COVERED	INFILTRATION (# 10.0 m3/ha/day)	CATCH. PROJ. POP.	TOTAL DAILY AVE. WATER USE m3/day			DAILY AVE. SEWAGE FLOW m3/day			DRY WEATHER FLOW with infiltraion (m3/day)			DAILY PEAK SEWAGE FLOW with infiltraion (m3/day)			CATCH. PROJ. POP.	TOTAL DAILY AVE. WATER USE m3/day			DAILY AVE. SEWAGE FLOW m3/day			DRY WEATHER FLOW with infiltraion (m3/day)			DAILY PEAK SEWAGE FLOW with infiltraion (m3/day)		
No.	NAME	hectare	m3/day	census	Dom	C&I	Total	Dom	C&I	Total	Dom	C&I	Total	Dom	C&I	Total	census	Dom	C&I	Total	Dom	C&I	Total	Dom	C&I	Total	Dom	C&I	Total
(1a)	(1b)	(2)	(3)	(4a)	(4b)	(4c)	(4d)	(4e)	(4f)	(4g)	(4h)	(4i)	(4j)	(4k)	(4l)	(4m)	(5a)	(5b)	(5c)	(5d)	(5e)	(5f)	(5g)	(5h)	(5i)	(5j)	(5k)	(5l)	(5m)
1	CATCHMENT AREA 1																												
	Calumpang	72.7	363	20,013	2,302	276	2,578	1,841	221	2,062	2,205	584	2,426	3,125	695	3,457	21,259	2,445	418	2,860	1,956	332	2,288	2,319	696	2,652	3,297	862	3,796
	San Roque	55.9	280	14,422	1,875	225	2,100	1,500	180	1,680	1,779	460	1,959	2,529	550	2,799	15,320	1,992	339	2,330	1,593	271	1,864	1,873	550	2,144	2,669	686	3,076
	Santolan, Pasig	12.1	60	2,665	400	68	468	320	54	374	380	115	434	540	142	621	2,678	402	88	490	321	71	392	382	131	452	542	166	648
	Dela Paz, Pasig	9.9	50	437	83	14	97	66	11	78	116	61	127	149	67	166	439	83	18	102	67	15	81	116	64	131	150	72	172
	San Roque	64.0	320	16,508	2,146	258	2,404	1,717	206	1,923	2,037	526	2,243	2,895	629	3,204	17,535	2,280	388	2,667	1,824	310	2,134	2,144	630	2,454	3,055	785	3,521
	Sta. Elena	52.7	264	9,477	1,232	148	1,380	986	118	1,104	1,249	382	1,368	1,742	441	1,919	10,067	1,309	222	1,531	1,047	178	1,225	1,311	442	1,489	1,834	531	2,101
	Sto. Nino	16.6	83	4,722	614	74	688	491	59	550	574	142	633	820	171	908	5,016	652	111	763	522	89	610	605	172	693	866	216	999
	Sub -Total CA-1	**263.9**	**1,420**	**68,244**	**8,651**	**1,062**	**9,713**	**6,921**	**850**	**7,771**	**8,340**	**2,269**	**9,190**	**11,801**	**2,694**	**13,076**	**72,315**	**9,162**	**1,582**	**10,744**	**7,330**	**1,265**	**8,595**	**8,749**	**2,685**	**10,015**	**12,414**	**3,318**	**14,312**
2	CATCHMENT AREA 2																												
	Barangka	22.1	110	7,719	1,158	139	1,297	926	111	1,037	1,037	222	1,148	1,500	277	1,667	8,200	1,230	209	1,439	984	167	1,151	1,094	278	1,262	1,586	361	1,837
	Tañong	37.4	187	4,894	636	76	713	509	61	570	696	248	757	950	278	1,042	5,199	676	115	791	541	92	633	727	279	819	998	325	1,136
	Jesus Dela Peña	51.5	257	9,175	1,193	143	1,336	954	115	1,069	1,212	372	1,326	1,689	429	1,860	9,746	1,267	215	1,482	1,014	172	1,186	1,271	430	1,443	1,778	516	2,036
	Sub -Total CA-2	**110.9**	**555**	**21,789**	**2,987**	**358**	**3,345**	**2,390**	**287**	**2,676**	**2,944**	**841**	**3,231**	**4,139**	**985**	**4,569**	**23,145**	**3,173**	**539**	**3,712**	**2,536**	**432**	**2,970**	**3,093**	**986**	**3,524**	**4,362**	**1,202**	**5,009**
3	CATCHMENT AREA 3																												
	Malanday	117.7	589	47,535	5,467	656	6,123	4,373	525	4,898	4,962	1,113	5,487	7,148	1,376	7,936	50,494	5,807	987	6,794	4,645	790	5,435	5,234	1,378	6,024	7,557	1,773	8,741
	Sto. Nino	143.9	719	40,905	5,318	638	5,956	4,254	511	4,765	4,973	1,230	5,484	7,101	1,485	7,866	43,452	5,649	960	6,609	4,519	768	5,287	5,238	1,487	6,006	7,498	1,872	8,650
	Concepcion Uno	115.5	578	35,326	4,063	488	4,550	3,250	390	3,640	3,828	968	4,218	5,453	1,163	6,038	37,525	4,315	734	5,049	3,452	587	4,039	4,030	1,164	4,617	5,756	1,458	6,636
	Concepcion Dos	166.2	831	33,648	4,374	525	4,899	3,499	420	3,919	4,330	1,251	4,750	6,080	1,461	6,710	35,743	4,647	790	5,436	3,717	632	4,349	4,548	1,463	5,180	6,407	1,779	7,355
	Marikina Heights	22.8	114	5,036	655	79	733	524	63	587	638	177	700	899	208	994	5,350	695	118	814	556	95	651	670	208	765	948	256	1,090
	Sub -Total CA-3	**566.0**	**429,623**	**162,452**	**19,876**	**2,385**	**22,261**	**15,901**	**1,908**	**17,809**	**18,731**	**4,738**	**20,639**	**26,681**	**5,692**	**29,543**	**172,564**	**21,113**	**3,589**	**24,702**	**18,890**	**2,871**	**19,762**	**19,721**	**5,702**	**22,592**	**28,166**	**7,137**	**32,473**
4	CATCHMENT AREA 4																												
	Concepcion Uno	34.0	170	10,385	1,194	143	1,338	955	115	1,070	1,125	284	1,240	1,603	342	1,775	11,031	1,269	216	1,484	1,015	173	1,187	1,185	342	1,357	1,692	429	1,951
	Parang	37.4	187	11,290	1,298	156	1,454	1,039	125	1,163	1,226	312	1,351	1,745	374	1,932	11,993	1,379	234	1,614	1,103	188	1,291	1,291	375	1,478	1,842	469	2,124
	Marikina Heights	178.3	892	39,472	5,131	616	5,747	4,105	493	4,598	4,997	1,384	5,489	7,049	1,631	7,788	41,929	5,451	927	6,377	4,361	741	5,102	5,252	1,633	5,994	7,433	2,004	8,545
	Concepcion Dos	29.5	147	5,967	776	93	869	621	74	695	768	222	842	1,078	259	1,190	6,339	824	140	964	659	112	771	807	259	919	1,136	315	1,304
	Sub -Total CA-4	**279.2**	**1,396**	**67,114**	**8,400**	**1,008**	**9,408**	**6,720**	**806**	**7,526**	**8,116**	**2,202**	**8,922**	**11,476**	**2,606**	**12,685**	**71,292**	**8,923**	**1,517**	**10,439**	**7,138**	**1,213**	**8,352**	**8,534**	**2,609**	**9,748**	**12,103**	**3,216**	**13,923**
5	CATCHMENT AREA 5																												
	Concepcion Uno	69.8	349	21,339	2,454	294	2,748	1,963	236	2,199	2,312	584	2,548	3,294	702	3,647	22,667	2,607	443	3,050	2,085	355	2,440	2,434	703	2,789	3,477	881	4,009
	Parang	72.5	362	21,854	2,513	302	2,815	2,011	241	2,252	2,373	604	2,614	3,378	724	3,740	23,214	2,670	454	3,123	2,136	363	2,499	2,498	725	2,861	3,566	907	4,111
	Nangka	8.2	41	2,419	278	33	312	223	27	249	263	68	290	375	81	415	2,569	295	50	346	236	40	277	277	81	317	395	101	456
	Sub -Total CA-5	**150.4**	**752**	**45,612**	**5,245**	**629**	**5,875**	**4,196**	**504**	**4,700**	**4,948**	**1,256**	**5,452**	**7,047**	**1,508**	**7,802**	**48,451**	**5,572**	**947**	**6,519**	**4,457**	**758**	**5,215**	**5,210**	**1,510**	**5,967**	**7,438**	**1,889**	**8,575**
6	CATCHMENT AREA 6																												
	Nangka	92.8	464	27,419	3,153	378	3,532	2,523	303	2,825	2,987	767	3,289	4,248	918	4,702	29,126	3,349	569	3,919	2,680	456	3,135	3,144	920	3,599	4,483	1,147	5,167
	Concepcion Uno	68.2	341	20,851	2,398	288	2,686	1,918	230	2,148	2,259	571	2,489	3,218	686	3,564	22,149	2,547	433	2,980	2,038	346	2,384	2,379	687	2,725	3,397	860	3,917
	Sub -Total CA-6	**161.0**	**805**	**48,270**	**5,551**	**666**	**6,217**	**4,441**	**533**	**4,974**	**5,246**	**1,338**	**5,779**	**7,466**	**1,604**	**8,265**	**51,274**	**5,897**	**1,002**	**6,899**	**4,717**	**802**	**5,519**	**5,522**	**1,607**	**6,324**	**7,881**	**2,008**	**9,084**
7	CATCHMENT AREA 7																												
	Nangka	80.5	403	23,797	2,737	328	3,065	2,189	263	2,452	2,592	665	2,855	3,687	797	4,081	25,278	2,907	494	3,401	2,326	395	2,721	2,728	798	3,124	3,891	996	4,484
	Parang	11.6	58	3,487	401	48	449	321	38	359	379	96	417	539	116	597	3,704	426	72	498	341	58	399	399	116	457	569	145	656
	Sub -Total CA-7	**92.1**	**461**	**27,284**	**3,138**	**377**	**3,514**	**2,510**	**301**	**2,811**	**2,971**	**762**	**3,272**	**4,226**	**912**	**4,678**	**28,982**	**3,333**	**567**	**3,900**	**2,666**	**453**	**3,120**	**3,127**	**914**	**3,580**	**4,460**	**1,140**	**5,140**
8	CATCHMENT AREA 8																												
	Parang	244.0	1,220	73,568	8,460	1,015	9,476	6,768	812	7,580	7,988	2,032	8,800	11,372	2,438	12,591	78,146	8,987	1,528	10,515	7,190	1,222	8,412	8,410	2,442	9,632	12,004	3,053	13,838
	Marikina Heights	36.9	185	8,168	1,062	127	1,189	849	102	951	1,034	286	1,136	1,459	337	1,612	8,676	1,128	192	1,320	902	153	1,056	1,087	338	1,240	1,538	415	1,768
	Sub -Total CA-8	**280.9**	**1,404**	**81,736**	**9,522**	**1,143**	**10,665**	**7,618**	**914**	**8,532**	**9,022**	**2,319**	**9,936**	**12,831**	**2,776**	**14,202**	**86,824**	**10,115**	**1,720**	**11,834**	**8,092**	**1,376**	**9,468**	**9,496**	**2,780**	**10,872**	**13,542**	**3,468**	**15,606**
9	CATCHMENT AREA 9																												
	Cupang, Antipolo	338.9	1,694	15,624	1,341	147	1,488	1,072	118	1,190	2,767	1,812	2,885	3,303	1,871	3,480	17,302	2,227	379	2,605	1,781	303	2,084	3,476	1,997	3,778	4,366	2,149	4,821
	Mayamol, Antipolo	360.0	1,800	34,147	6,024	663	6,686	4,819	530	5,349	6,619	2,330	7,149	9,028	2,595	9,823	37,814	6,670	1,134	7,804	5,336	907	6,243	7,136	2,707	8,043	9,804	3,160	11,165
	Sub -Total CA-9	**698.8**	**3,494**	**49,772**	**7,364**	**810**	**8,174**	**5,891**	**648**	**6,539**	**9,385**	**4,142**	**10,033**	**12,331**	**4,466**	**13,303**	**55,116**	**8,897**	**1,513**	**10,410**	**7,118**	**1,210**	**8,328**	**10,612**	**4,704**	**11,822**	**14,170**	**5,309**	**15,986**
	GRAND TOTAL	**2,623**	**439,909**	**572,272**	**70,734**	**8,439**	**79,172**	**56,587**	**6,751**	**63,338**	**69,703**	**19,867**	**76,454**	**97,997**	**23,243**	**108,123**	**609,962**	**76,184**	**12,975**	**89,159**	**60,947**	**10,380**	**71,327**	**74,063**	**23,497**	**84,444**	**104,537**	**28,687**	**120,107**

Total Daily Ave. Water Use and Propoulation Projections based from MWCI Projections

Infiltration Factor (@ 10.0 m3/ha/day)	5.00
Sewage flow factor	0.80
Peak Factor	1.50

Table 4.4 Water and Sewage Flow Projections (Option 2)

CATCHMENT			PERIOD																									
			YEAR 2018													YEAR 2023												
BLOCK	TOTAL AREA COVERED	INFILTRATION (@ 10.0 m^3/ha/day)	CATCH. PROJ. POP.	TOTAL DAILY AVE. WATER USE m^3/day			DAILY AVE. SEWAGE FLOW m^3/day			DRY WEATHER FLOW with infiltration (m^3/day)			DAILY PEAK SEWAGE FLOW with infiltration (m^3/day)			CATCH. PROJ. POP.	TOTAL DAILY AVE. WATER USE m^3/day			DAILY AVE. SEWAGE FLOW m^3/day			DRY WEATHER FLOW with infiltration (m^3/day)			DAILY PEAK SEWAGE FLOW with infiltration (m^3/day)		
No. NAME	hectare	m^3/day	census	Dom	C&I	Total	Dom	C&I	Total	Dom	C&I	Total	Dom	C&I	Total	census	Dom	C&I	Total	Dom	C&I	Total	Dom	C&I	Total	Dom	C&I	Total
1 CATCHMENT AREA 1																												
Calumpang	72.7	363	22,327	2,645	820	3,465	2,116	656	2,772	2,479	1,019	3,135	3,537	1,347	4,521	23,193	2,851	998	3,849	2,281	798	3,079	2,644	1,162	3,442	3,785	1,561	4,982
San Roque	55.9	280	16,090	2,155	668	2,823	1,724	534	2,258	2,003	814	2,538	2,865	1,081	3,667	16,713	2,322	813	3,135	1,858	650	2,508	2,138	930	2,788	3,067	1,255	4,042
Santolan, Pasig	12.1	60	2,691	416	150	566	333	120	452	393	180	513	559	240	739	2,705	434	173	607	347	139	486	407	199	546	581	268	789
Dela Paz, Pasig	9.9	50	441	86	31	118	69	25	94	119	75	144	153	87	191	444	90	36	126	72	29	101	122	78	151	158	93	201
San Roque	64.0	320	18,417	2,466	765	3,231	1,973	612	2,585	2,293	932	2,905	3,279	1,237	4,197	19,130	2,658	930	3,589	2,127	744	2,871	2,447	1,064	3,191	3,510	1,436	4,627
Sta. Elena	52.7	264	10,572	1,416	439	1,855	1,133	351	1,484	1,396	615	1,747	1,963	790	2,489	10,982	1,526	534	2,060	1,221	427	1,648	1,485	691	1,912	2,095	905	2,736
Sto. Nino	16.6	83	5,268	706	219	924	564	175	739	647	258	822	930	345	1,192	5,473	760	266	1,027	608	213	821	691	296	904	996	402	1,315
Sub -Total CA-1	283.9	1,420	75,807	9,889	3,091	12,980	7,911	2,473	10,384	9,331	3,892	11,804	13,287	5,128	16,996	78,640	10,642	3,751	14,393	8,514	3,001	11,515	9,933	4,420	12,934	14,190	5,921	18,691
2 CATCHMENT AREA 2																												
Barangka	22.1	110	8,612	1,331	412	1,743	1,065	330	1,395	1,175	440	1,505	1,707	605	2,202	8,946	1,434	502	1,936	1,147	402	1,549	1,258	512	1,659	1,832	713	2,434
Tañong	37.4	187	5,460	731	227	958	585	181	766	772	368	953	1,064	459	1,336	5,672	788	276	1,064	630	221	851	817	408	1,038	1,133	518	1,464
Jesus Dela Peña	51.5	257	10,236	1,371	425	1,796	1,097	340	1,437	1,354	597	1,694	1,902	767	2,412	10,633	1,478	517	1,995	1,182	414	1,596	1,439	671	1,853	2,030	878	2,651
Sub -Total CA-2	110.9	555	24,308	3,433	1,064	4,497	2,746	851	3,597	3,301	1,406	4,152	4,674	1,831	5,951	25,250	3,700	1,295	4,995	2,960	1,036	3,996	3,515	1,591	4,551	4,995	2,109	6,549
3 CATCHMENT AREA 3																												
Malanday	117.7	589	53,031	6,282	1,947	8,230	5,026	1,558	6,584	5,614	2,147	7,172	8,127	2,926	10,464	55,087	6,772	2,370	9,142	5,417	1,896	7,313	6,006	2,485	7,902	8,715	3,433	11,559
Sto. Nino	143.9	719	45,635	6,111	1,894	8,006	4,889	1,516	6,404	5,608	2,235	7,124	8,053	2,993	10,326	47,404	6,587	2,306	8,893	5,270	1,844	7,114	5,989	2,564	7,834	8,624	3,486	11,391
Concepcion Uno	115.5	578	39,411	4,669	1,447	6,116	3,735	1,158	4,893	4,312	1,735	5,470	6,180	2,314	7,917	40,939	5,032	1,761	6,794	4,026	1,409	5,435	4,603	1,987	6,013	6,616	2,691	8,730
Concepcion Dos	166.2	831	37,539	5,027	1,558	6,585	4,022	1,247	5,268	4,853	2,078	6,099	6,863	2,701	8,733	38,994	5,419	1,897	7,315	4,335	1,517	5,852	5,166	2,348	6,683	7,333	3,107	9,609
Marikina Heights	22.8	114	5,619	752	233	986	602	187	789	716	300	902	1,017	394	1,297	5,837	811	284	1,095	649	227	876	763	341	990	1,087	454	1,428
Sub -Total CA-3	566.0	2,830	181,234	22,841	7,081	29,922	18,273	5,665	23,938	21,103	8,495	26,768	30,240	11,327	563,786	188,260	24,621	8,617	33,238	19,697	6,894	26,591	22,527	9,724	29,421	32,375	13,171	42,716
4 CATCHMENT AREA 4																												
Concepcion Uno	34.0	170	11,586	1,372	425	1,798	1,098	340	1,438	1,268	510	1,608	1,817	680	2,327	12,035	1,479	518	1,997	1,184	414	1,598	1,353	584	1,768	1,945	791	2,566
Parang	37.4	187	12,595	1,492	463	1,955	1,194	370	1,564	1,381	557	1,751	1,978	742	2,533	13,083	1,608	563	2,171	1,287	450	1,737	1,474	638	1,924	2,117	863	2,793
Marikina Heights	178.3	892	44,036	5,897	1,828	7,725	4,718	1,462	6,180	5,609	2,354	7,072	7,958	3,085	10,162	45,743	6,356	2,225	8,581	5,085	1,780	6,865	5,977	2,671	7,757	8,519	3,561	11,189
Concepcion Dos	29.5	147	6,657	891	276	1,168	713	221	934	861	368	1,082	1,217	479	1,549	6,915	961	336	1,297	769	269	1,038	916	416	1,185	1,301	551	1,704
Sub -Total CA-4	279.2	1,396	74,874	9,653	2,992	12,645	7,722	2,394	10,116	9,118	3,790	11,512	12,980	4,987	16,570	77,776	10,405	3,642	14,047	8,324	2,913	11,237	9,720	4,309	12,633	13,882	5,766	18,252
5 CATCHMENT AREA 5																												
Concepcion Uno	69.8	349	23,806	2,820	874	3,694	2,256	699	2,955	2,605	1,048	3,304	3,733	1,398	4,782	24,729	3,040	1,064	4,104	2,432	851	3,283	2,781	1,200	3,632	3,997	1,626	5,273
Parang	72.5	362	24,381	2,888	895	3,783	2,311	716	3,027	2,673	1,079	3,389	3,828	1,437	4,903	25,326	3,113	1,090	4,203	2,491	872	3,362	2,853	1,234	3,725	4,098	1,670	5,406
Nangka	8.2	41	2,698	320	99	419	256	79	335	297	120	376	424	160	543	2,803	345	121	465	276	96	372	317	137	413	454	186	599
Sub -Total CA-5	150.4	752	50,885	6,028	1,869	7,897	4,822	1,495	6,317	5,575	2,247	7,069	7,986	2,995	10,228	52,858	6,498	2,274	8,772	5,198	1,819	7,017	5,950	2,572	7,770	8,549	3,481	11,278
6 CATCHMENT AREA 6																												
Nangka	92.8	464	30,589	3,624	1,123	4,747	2,899	899	3,798	3,363	1,363	4,262	4,812	1,812	6,160	31,775	3,906	1,367	5,273	3,125	1,094	4,218	3,589	1,558	4,682	5,151	2,105	6,792
Concepcion Uno	68.2	341	23,262	2,756	854	3,610	2,204	683	2,888	2,545	1,024	3,229	3,648	1,366	4,673	24,164	2,970	1,040	4,010	2,376	832	3,208	2,717	1,173	3,549	3,905	1,588	5,153
Sub -Total CA-6	161.0	805	53,851	6,379	1,978	8,357	5,103	1,582	6,685	5,908	2,387	7,490	8,460	3,178	10,833	55,938	6,876	2,407	9,283	5,501	1,925	7,426	6,306	2,730	8,231	9,056	3,693	11,944
7 CATCHMENT AREA 7																												
Nangka	80.5	403	26,548	3,145	975	4,120	2,516	780	3,296	2,919	1,183	3,699	4,177	1,573	5,347	27,578	3,390	1,187	4,577	2,712	949	3,661	3,115	1,352	4,064	4,471	1,827	5,895
Parang	11.6	58	3,890	461	143	604	369	114	483	426	172	541	611	229	782	4,041	497	174	671	397	139	536	455	197	594	654	266	863
Sub -Total CA-7	92.1	461	30,438	3,606	1,118	4,724	2,885	894	3,779	3,345	1,355	4,239	4,787	1,802	6,129	31,618	3,887	1,360	5,247	3,109	1,088	4,198	3,570	1,549	4,656	5,125	2,093	6,757
8 CATCHMENT AREA 8																												
Parang	244.0	1,220	82,074	9,723	3,014	12,737	7,778	2,411	10,189	8,998	3,631	11,409	12,887	4,837	16,504	85,256	10,480	3,668	14,148	8,384	2,934	11,319	9,604	4,154	12,539	13,796	5,622	18,198
Marikina Heights	36.9	185	9,112	1,220	378	1,599	976	303	1,279	1,161	487	1,463	1,649	638	2,103	9,466	1,315	460	1,776	1,052	368	1,421	1,237	553	1,605	1,763	737	2,315
Sub -Total CA-8	280.9	1,404	91,187	10,943	3,392	14,335	8,754	2,714	11,468	10,159	4,118	12,873	14,536	5,475	18,607	94,721	11,796	4,128	15,924	9,436	3,303	12,739	10,841	4,707	14,144	15,559	6,359	20,513
9 CATCHMENT AREA 9																												
Cupang, Antipolo	338.9	1,694	18,902	2,782	862	3,644	2,225	690	2,915	3,920	2,384	4,609	5,032	2,729	6,067	20,411	3,361	1,176	4,538	2,689	941	3,630	4,383	2,635	5,325	5,728	3,106	7,140
Mayamot, Antipolo	360.0	1,800	41,310	8,332	2,583	10,915	6,666	2,066	8,732	8,466	3,866	10,532	11,799	4,899	14,898	44,609	10,275	3,596	13,871	8,220	2,877	11,097	10,020	4,677	12,896	14,129	6,115	18,445
Sub -Total CA-9	698.8	3,494	60,211	11,114	3,445	14,559	8,891	2,756	11,647	12,385	6,250	15,141	16,831	7,628	20,965	65,021	13,636	4,773	18,409	10,909	3,818	14,727	14,403	7,312	18,221	19,857	9,221	25,585
GRAND TOTAL	2,623	13,116	642,796	83,886	26,030	109,915	67,109	20,824	87,932	80,225	33,940	101,049	113,779	44,352	670,065	670,083	92,061	32,247	124,308	73,648	25,798	99,446	86,765	38,914	112,563	123,589	51,813	162,286

Total Daily Ave. Water Use and Propoulation Projections based from MWCI Projections

Infiltration Factor (@ 10.0 m3/ha/day)	5.00
Sewage flow factor	0.80
Peak Factor	1.50

Table 4-5 Proposed STP Capacities for Option 1

STP Site No.	Initial capacity (m3/day)	2023 capacity (m3/day)	Initial Estimated Land Area	Comment
1	17,000	34,000	0.76 ha	Special STP Construction, for capacities less than 2023 capacity
2	9,000	9,000	0.53 ha	-
3	21,500	28,500	0.63 ha	Special STP Construction, for initial capacity
4	20,000	30,000	0.30 ha	Not viable, need to secure adjacent areas (Malanday High School site may be reconsidered)
5	8,000	12,000	0.60 ha	-
6	6,800	6,800	3 ha	Private land
7	15,000	20,000	0.7 ha	Private land

Table 4-6 Required STP Capacities for Option 2

STP Site No.	2008 capacity (m3/day)	2023 capacity (m3/day)	Initial Estimated Land Area	Comment
1	31,750	42,300	0.76 ha	Not viable
3	18,900	28,300	0.63 ha	Special STP construction, only initial capacity may be accommodated
4	20,000	30,000	0.30 ha	Not viable, need to secure adjacent areas (Malanday High School site may be reconsidered)
5	30,000	40,000	0.60 ha	Not viable, need to secure adjacent areas

4.5 Issues and Future Study Activities for Marikina

- STP area. Clearly, the identified STP sites are relatively small in area. All are less than a hectare in size, and with the proposed STP capacities, generally, the sites are inadequate. To remedy this, special STP construction involving deep reactor tanks, or multi-storey STPs, or membrane systems can be considered, but these will increase the capex substantially. Future activities in the Master Plan will include closer evaluation of the alternative STP sites, and discussion with Marikina LGU as to the maximum area that can be allocated to the STP.

- Initial Design Flow. Designing the STPs with a design flow less than 1.5xDWF will be evaluated. During wet weather flows, the combined system flows may be too weak to treat effectively in biological systems, and even the benefit of treatment of any amount of sewage during wet weather conditions may be minimal. The actual flow reaching the interceptors can also be evaluated, if it is decided that the STPs will only be effective during dry weather conditions. Capacity expansions can be made later on and be based on more extensive data on operating and performance conditions during the initial years.

- Consideration for upgrade to separate sewerage system in the future. Separate sewerage systems (the benefits and disadvantages of which will be discussed in the Final MP report) may be considered later on in the future. The alternative STP sites for combined system, can very well be the same STP sites to be considered for separate systems, considering the scarcity of candidate sites for STPs. The quality of sewage from combined systems is very much different from separate systems, and therefore, the treatment systems should be designed, to a reasonable extent, to be flexible to accommodate changes in the influent quality in the future.

- Phasing. Discussions will be made with MWCI with respect to the criteria for phasing-in investments for sewerage.

Section 5.0

COST DATABASE

5.0 COST DATABASE

5.1 General

Capital and operational costs were derived for various sewerage facilities. The main basis for the cost estimates is the MTSP cost estimates of April 2004 and updated as of January 2008. Costs for capacities outside the MTSP scope, in particular, facilities with capacities more than 10,000 m³/day, were derived using cost functions applied in previous MWSS studies (i.e., JICA Master Plan) and regional projects (Malaysia, Thailand and Vietnam). Constants for these cost functions were adjusted so that computed costs are comparable with derived local cost estimates.

The capital costs presented hereunder exclude engineering and supervision fees. All costs are now in 2008 constant prices.

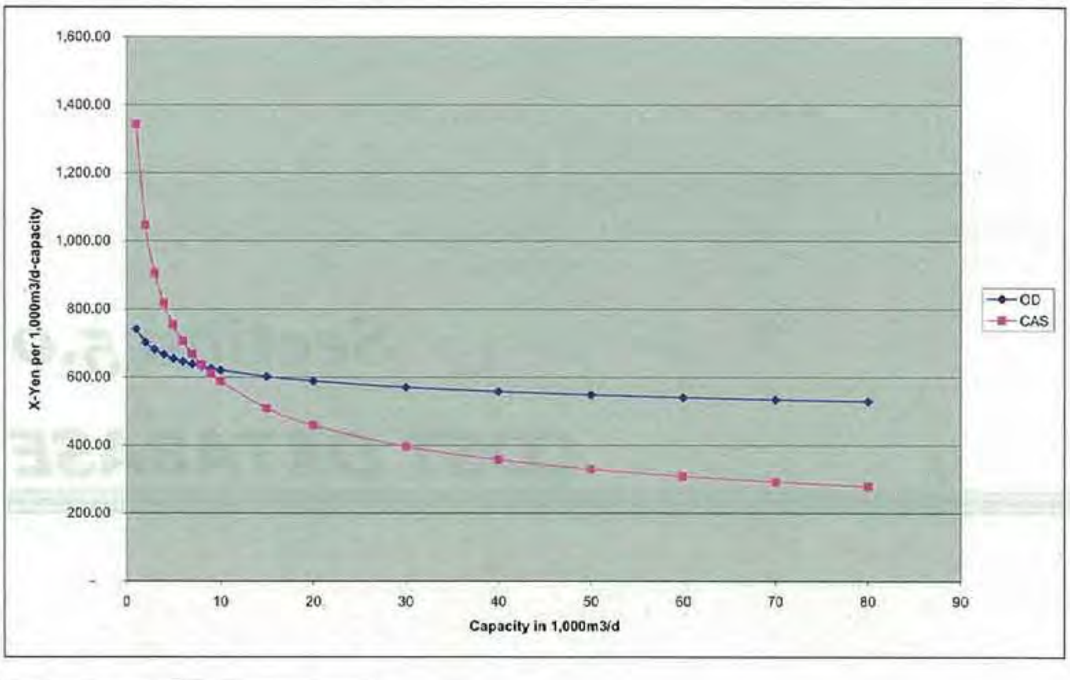
5.2 Capital Costs

5.2.1 *Pumping Station*[1]

Cost is derived based on the capacity (peak hour flow) of the pumping station. The cost function is as follows:

$C_{PS} =$ $6.09 \times Q^{0.598}$

where: Q_{PEAK} is peak hour sewage flow in m³/min. Costs are in peso million.



[1] For updating

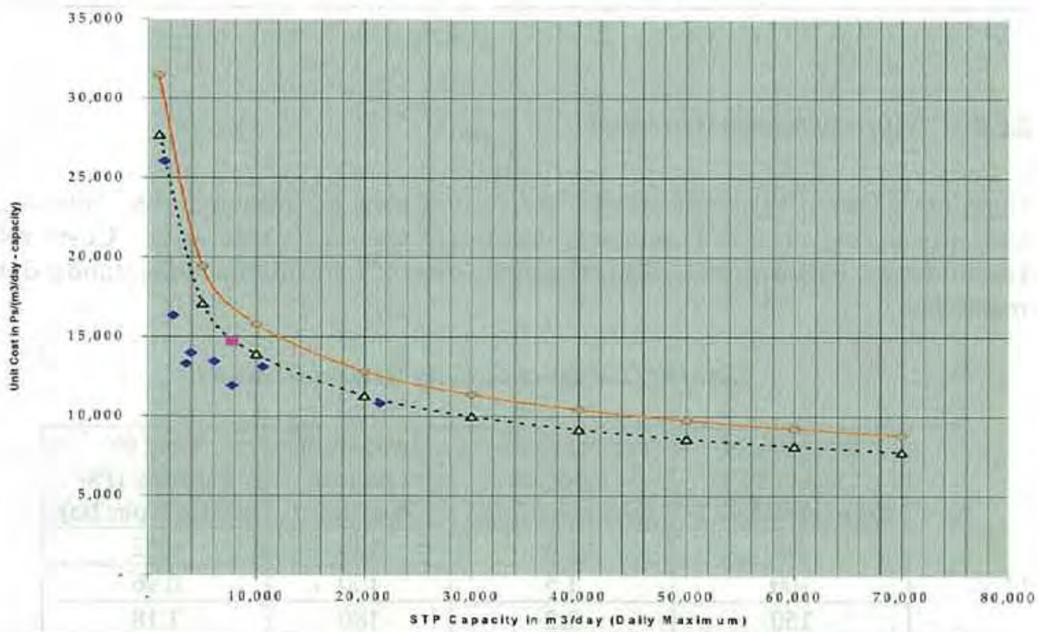
5.2.2 *Sewage Treatment Plants (STPs)*[2]

Costs for conventional activated sludge (CAS), oxidation ditch (OD), and sequencing batch reactor (SBR) treatment systems are estimated based on the capacity (maximum day flow) of the STP and are estimated based on the following derived cost functions:

$C_{CAS} = 0.25 \times Q^{0.7}$
$C_{OD} = 0.25 \times Q^{0.7}$
$C_{SBR} = 0.22 \times Q^{0.7}$

where: Q_{MAX} is daily maximum sewage flow in m^3/day. Costs are in peso million. Costs exclude sludge dewatering and disposal costs.

Figure 5.2.2 Sewage Treatment Plant Capital Costs



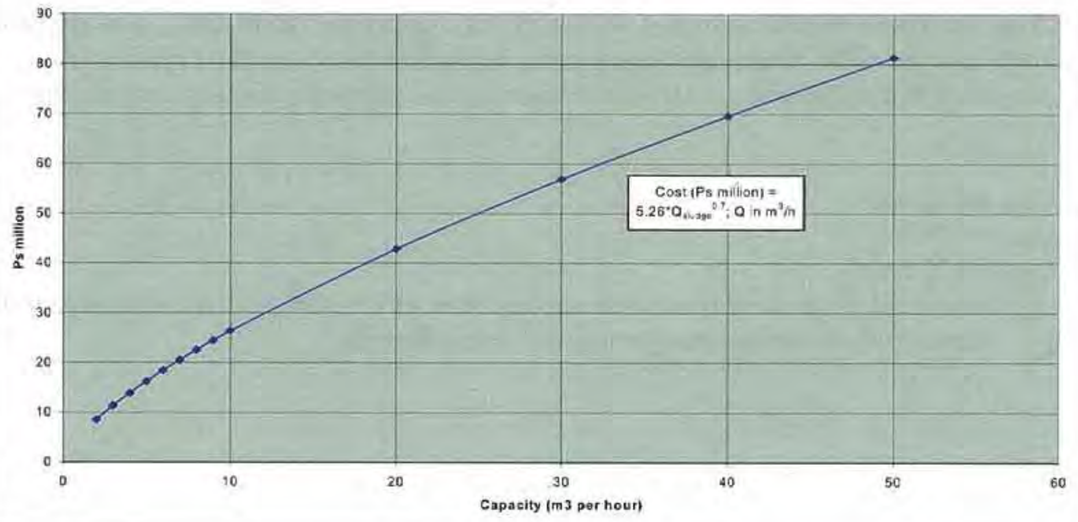
5.2.3 *Mechanical Dewatering*[3]

$C_{MECHDEW} = 5.26 \times (Q_{SLUDGE})^{0.7}$

where: Q_{SLUDGE} is quantity of waste sludge in m^3/h. Costs are in peso million.

[2] For updating
[3] For updating

Fig. 5.2.3 Mechanical Dewatering Capital Costs



5.2.4 *Gravity Sewers (Laterals)*

Costs for 200mm PVC sewer laterals are derived on a per hectare basis. Unit costs will vary depending on the population density of the catchment area. Costs reflected hereunder are based on an average depth of cover of 1.5m and includes standard 900mm manholes.

Table 5.2.1 Cost of Gravity Sewers (Lateral)

Household Density (households/ha)	Length of Laterals (m/household)	Length of Laterals (m/ha)	Cost of Laterals (Ps-million per ha)
50	2.5	125	0.82
100	1.5	150	0.96
150	1.2	180	1.18
250	0.8	200	1.30
350	0.6	210	1.36

5.2.5 *Gravity Sewers (Trunk)*

The following table presents the unit costs of sewers, in peso per linear meter, for sewer sizes ranging from 200mm to 1500mm pipes. Material of pipes is PVC/PE for diameters between 200mm and 450mm and RCP for bigger size pipes. Costs include pavement breaking and restoration, excavation and backfill, but excludes costs for manholes.

Table 5.2.2 Cost of PVC pipe per Linear Meter

Pipe Size Ø (in mm)	Depth of Cover (in m)	Cost per Meter (Ps)
200	0.90	4,912
200	1.50	5,173
200	2.00	21,808
200	2.50	24,382
200	3.00	26,956
200	3.50	29,531
200	4.00	32,105
250	0.90	6,083
250	1.50	6,363
250	2.00	23,251
250	2.50	25,841
250	3.00	28,431
250	3.50	31,021
250	4.00	33,611
300	0.90	6,305
300	1.50	6,603
300	2.00	23,746
300	2.50	26,351
300	3.00	28,956
300	3.50	31,562
300	4.00	34,167

Table 5.2.3 Cost of RC pipe per Linear Meter

Pipe Size Ø (in mm)	Depth of Cover (in m)	Cost Per Meter (in Ps)
375	0.90	5,624
375	1.50	5,950
375	2.00	22,349
375	2.50	24,977
375	3.00	27,606
375	3.50	30,235
375	4.00	32,863
450	0.90	6,352
450	1.50	18,390
450	2.00	23,464
450	2.50	26,116
450	3.00	28,768
450	3.50	31,420
450	4.00	34,072

Pipe Size Ø (in mm)	Depth of Cover (in m)	Cost Per Meter (in Ps)
900	1.50	30,174
900	2.00	32,966
900	2.50	35,758
900	3.00	38,549
900	3.50	41,341
900	4.00	44,133
1050	1.50	34,408
1050	2.00	37,246
1050	2.50	40,084
1050	3.00	42,923
1050	3.50	45,761
1050	4.00	48,599
1050	5.00	54,276
1050	6.00	59,952
1050	7.00	65,629

525	0.90	7,076
525	1.50	21,944
525	2.00	24,619
525	2.50	27,294
525	3.00	29,969
525	3.50	32,645
525	4.00	35,320
600	0.90	7,628
600	1.50	22,860
600	2.00	25,558
600	2.50	28,257
600	3.00	30,955
600	3.50	33,654
600	4.00	36,352
685	0.90	9,523
685	1.50	25,214
685	2.00	27,939
685	2.50	30,664
685	3.00	33,389
685	3.50	36,114
685	4.00	38,839
750	0.90	10,704
750	1.50	26,707
750	2.00	29,452
750	2.50	32,198
750	3.00	34,943
750	3.50	37,688
750	4.00	40,433

1050	8.00	71,305
1200	1.50	35,726
1200	2.00	38,611
1200	2.50	41,496
1200	3.00	44,381
1200	3.50	47,265
1200	4.00	50,150
1200	5.00	55,920
1200	6.00	61,690
1200	7.00	67,459
1200	8.00	73,229
1350	1.50	39,213
1350	2.00	42,145
1350	2.50	45,076
1350	3.00	48,008
1350	3.50	50,939
1350	4.00	53,871
1350	5.00	59,734
1350	6.00	65,596
1350	7.00	71,459
1350	8.00	77,322
1500	1.50	45,578
1500	2.00	48,556
1500	2.50	51,534
1500	3.00	54,512
1500	3.50	57,490
1500	4.00	60,468
1500	5.00	66,424
1500	6.00	72,380
1500	7.00	78,336
1500	8.00	84,292

Table 5.2.4 Cost of PE Pipe (SDR 24) in Linear Meter

Pipe Size Ø (in mm)	Depth of Cover (in m)	Cost Per Meter (in Ps)
250	0.90	5,668
250	1.50	5,947
250	2.00	22,836
250	2.50	25,611
250	3.00	28,234
250	3.50	31,274
250	4.00	33,951

Pipe Size Ø (in mm)	Depth of Cover (in m)	Cost Per Meter (in Ps)
350	0.90	7,485
350	1.50	7,801
350	2.00	25,198
350	2.50	28,027
350	3.00	30,683
350	3.50	33,801
350	4.00	36,516

300	0.90	6,473
300	1.50	6,771
300	2.00	23,914
300	2.50	26,716
300	3.00	29,355
300	3.50	32,434
300	4.00	35,130

400	0.90	9,146
400	1.50	9,482
400	2.00	27,132
400	2.50	29,988
400	3.00	32,660
400	3.50	35,819
400	4.00	38,553
450	0.90	10,714
450	1.50	12,891
450	2.00	28,973
450	2.50	31,855
450	3.00	34,545
450	3.50	37,744
450	4.00	40,497

5.2.6 *Force Mains*

The following table presents the unit costs of pressure force mains, in peso per linear meter, for sewer sizes ranging from 150mm to 1000mm pipes. Costs include pavement breaking and restoration, excavation and backfill.

Table 5.2.5 Cost of PE Pipe (SDR 11) in Linear Meter

Pipe Size Ø (in mm)	Depth of Cover (in m)	Cost Per Meter (in Ps)
150	1.20	4,673
200	1.20	6,550
250	1.20	8,550
300	1.20	10,110
400	1.20	15,416
450	1.20	18,611

Table 5.2.6 Cost of Steel Pipe in Linear Meter*

Pipe Size Ø (in mm)	Depth of Cover (in m)	Cost Per Meter (in Ps)
500	1.20	11,730
600	1.20	15,140
700	1.20	16,860
750	1.20	31,740
800	1.20	35,620
900	1.20	38,370
1000	1.20	44,330

*Note: not yet updated

5.2.7 *Pipe Jacking*

Costs presented hereunder are based on local pipe jacking contractor's cost estimates.

Table 5.2.7 Pipe Jacking Cost*

Pipe Size Ø (in mm)	Cost Per Meter (in Ps)
With steel casing and PE pipe as product pipe	
225mm Ø	23,570.00
300mm Ø	29,820.00
450mm Ø	36,190.00
Steel casing used as product pipe	
500mm Ø	28,190.00
600mm Ø	36,640.00
750mm Ø	39,030.00
900mm Ø	44,190.00
1000mm Ø	57,130.00
1200mm Ø	66,970.00
1350mm Ø	77,010.00
1500mm Ø	87,750.00

*Note: not yet updated

5.2.8 *Manholes and Inverted Siphons*[4]

Costs for 900mm to 1800mm manholes and inverted siphons are derived for different sewer depths as shown in the following table.

Table 5.2.8 Cost of Manholes and Inverted Siphons

Manholes	
900mm Ø	
2.0m depth	43,732
3.0m depth	52,399
4.0m depth	61,067
1200mm Ø	
2.0m depth	60,277

[4] For updating

3.0m depth	72,516
4.0m depth	85,059
1500mm Ø (900mm Ø pipe)	
2.0m depth	85,275
3.0m depth	102,124
4.0m depth	118,594
1500mm Ø (1050mm Ø pipe)	
2.0m depth	96,139
3.0m depth	112,988
4.0m depth	129,458
1800mm Ø (1200mm Ø pipe)	
3.0m depth	188,472
4.0m depth	232,290
5.0m depth	273,193
1800mm Ø (1350mm Ø pipe)	
3.0m depth	211,360
4.0m depth	255,178
5.0m depth	301,804
1800mm Ø (1500mm Ø pipe)	
3.0m depth	234,721
4.0m depth	283,388
5.0m depth	331,558
2100mm x 1200mm x 6m	431,145
Inverted Siphon	
For 2-600mm Ø and 900mm Ø pipe	1,458,692
For 2-900mm Ø and 1200mm Ø pipe	1,767,129

5.2.9 *Service Connection*[5]

Cost of 150mm PVC service connection from lateral sewers to property boundary lines is estimated as shown hereunder. Costs include replumbing and decommissioning IST.

3 m length: Ps 33,000 per connection
4 m length: Ps 46,000 per connection
5 m length: Ps 58,000 per connection

[5] For updating

5.2.10 *Vacuum Tankers*

Vacuum tankers for the collection of waste sludge from the smaller STPs and the collection of septage from septic tanks. Estimated costs are:

3 m^3 capacity: Ps 4,000,000
5 m^3 capacity: Ps 5,280,000
10 m^3 capacity: Ps 6,600,000

5.3 Operational Costs

The following unit operational costs are proposed to be applied in the master plan.

5.3.1 *Power Requirement for Sewage Treatment**

STPs (Activated Sludge, Oxidation Ditch, Sequencing Batch Reactor):
0.3 kWh/d/sewage flow in m^3 per day

5.3.2 *Power Requirement for Mechanical Dewatering*

Mechanical Dewatering for Activated Sludge:
0.027 kWh/d/sewage flow in m^3 per day

Mechanical Dewatering for Oxidation Ditch, SBR:
0.020 kWh/d/sewage flow in m^3 per day

5.3.3 *Alum*

Alum Requirement: 60 kg per ton-DS
Alum Cost: Ps 10 per kg

5.3.4 *Polymer*

Polymer Requirement: 6-10 kg per ton-DS
Polymer Cost: Ps 350 per kg

5.3.5 *Chlorine*

Chlorine Requirement: 0.03 kg per m^3
Chlorine Cost: Ps 83 per kg

5.3.6 *Sludge Disposal*

Costs of hauling dewatered sludge to lahar areas in Pampanga over a return distance of 170 km is placed at Ps 123/m^3.*

5.3.7 *Labor Cost*

Annual labor costs for different positions are as follows:

Plant Manager:	Ps 372,000
Maintenance Technician:	Ps 250,000
Operator:	Ps 205,000
Driver:	Ps 154,000
Laborer:	Ps 135,000

5.3.8 *M&E Maintenance Cost*

Annual M&E maintenance cost is estimated at 2% of capital costs.

5.3.9 *Sewer System Maintenance Cost*

Annual maintenance cost is estimated at 0.5% of the construction cost.

Section 6.0

WATER QUALITY MODELING FOR THE MARIKINA RIVER

6.0 WATER QUALITY MODELING FOR THE MARIKINA RIVER

6.1 Introduction

Water quality modeling has become an important tool in water quality management of rivers, coastal waters and groundwater systems. Water quality models are useful in providing insight into to the spatial characterization of water quality conditions that could not be done by expensive measurements and extensive monitoring.

Water quality modeling requires knowledge of various water quality problems and processes occurring in the receiving water body of interest. Perhaps equally important, is knowledge on hydrodynamic processes that affect the water quality of various water bodies. Here, the action of flow velocities, tides (and waves) and various physico-chemical data dictate to a large extent the dispersion and transformation that may occur for a particular water pollutant discharged into receiving waters. In addition, knowledge of hydro-meteorological processes is also needed as the contribution of rainfall, winds and solar radiation for example also affect the dispersion, fate and transformation of many, if not all, water pollutants such as sediments, thermal plume, oil spill, BOD, DO, nutrients, heavy metals and coliform bacteria.

6.1.1. Modeling BOD and TSS

Many important water quality problems are now simulated by existing computational models. Water quality models differ in complexity and method of solutions depending on the water pollution problem addressed. For instance, sediment transport in a coastal area and the associated resuspension and settling of particles are treated in a two-dimensional depth-averaged model whose aim is to understand the light extinction process that affects phytoplankton growth for example. Furthermore, a three-dimensional model of pollutant dispersion may also be preferred from a two-dimensional model because of the associated strong convection and vertical mixing in a small area of interest. A description of the potential use of water quality models in understanding some important water quality problems that occur in receiving water bodies are described below.

<u>**Siltation due to TSS increase**</u>

Siltation has become one of the biggest environmental problem in many water bodies due to rapid development and rampant denudation of watersheds, and the increased TSS loads from community and industrial sewerage systems. The problem does not only pose a big risk to water resources but also to commercial navigation. As silt loads are transported downstream to rivers, lakes and coastal seas, they contribute to water quality deterioration by virtue of the reduced light penetration and smothering of important biotic resources. An observer on flight can always see the brownish inland and coastal waters near river mouths after a moderate to strong rain episode. The sediment loads do not just hamper the growth of biota and organisms. Once deposited in water bodies, they also interfere with navigation due to a reduction of navigable depths near ports and harbors hampering sea commerce. Occasional dredging of the deposited sediments in rivers or coastal seas is not a practical alternative of water management because of the associated huge amount involved (e.g. too expensive). Furthermore, the disposal of dredged sediments represents another problem especially if contaminated with toxic metals like lead and cadmium for instance.

Sediment transport in natural waters is generally simulated and predicted using the general advection-diffusion equation. The sink or decay term is represented by the sedimentation flux which is assumed to be proportional to the settling velocity of sediment particles, the concentration of sediments and the probability of deposition. Several sediment fractions representing coarse and fine sediments discharged by the rivers can be assumed. The settling velocities of these sediment fractions can be obtained from the experimental studies or based on the well known Stoke's Law. The probability of sediment deposition is dependent on the total shear stress induced by currents and waves. If the total shear stress is above a critical shear stress for deposition, sediments may continue to be transported away by the currents and do not settle on the sediment bed. However, if the total shear stress is below the critical shear stress for deposition, settling of particles will occur in the marine environment. Where flocculation is significant, the effect of increased salinity (e.g. in estuaries) can be included in the estimation of the sedimentation flux.

The light extinction coefficient that characterizes the turbidity of water bodies is generally dependent on the contribution of the sediment fractions particularly the silt and clay range. The modeled light extinction can then be used as input into an ecological model for assessing the impact of silt and sediment loads. Alternatively, the Secchi depth can be determined from the modeled light extinction coefficient. Water transparency is thus modeled using either light extinction or Secchi depth.

Biochemical Oxygen Demand (BOD)

There are many important sources of oxygen-depleting substances in receiving water bodies. Various factories such as canneries are currently discharging biochemical oxygen demand (BOD) loads whose outfall concentrations exceed existing water quality standards. The decay and settling of organic matter represent an important mechanism for the depletion of oxygen and increased amount of suspended solids in the water column. Once deposited, the polluted sediments will not only be detrimental to the ecology of benthic organisms but will also sustain the deterioration of water quality due to resuspension and vertical fluxes back into the water column.

The transport, dispersion and decay of carbonaceous BOD (CBOD) in receiving water bodies can be simulated and predicted using available water quality models. The same advection-diffusion equation needs to be solved to determine the transport and fate of BOD. The sink or decay term in the conservation equation can be represented as a first order decay process and the settling term can be assumed to be proportional to the settling velocity of particulate discharges. First-order decay of BOD in the marine environment is proportional to a degradation constant k_d, and the ambient water temperature T as in $k_d\theta^{(T-20)}$ x BOD concentration. The coefficient θ varies weakly and is normally assumed to have a constant value of 1.047, while k_d can have a value that range from 0.15-0.2/day. On the other hand, the sink term attributed to settling is proportional to the settling velocity of particulate BOD represented by v_s and inversely proportional to the water depth h as in v_s/h. It should be noted that BOD consists of dissolved and particulate fractions. Only the particulate fraction will settle. Existing water quality models can assume some percentage of the total BOD load as particulate (e.g. 60 %). This can be easily adjusted but the overall effect on the model calculations will not be very significant. The settling velocity can be assumed to be in the silt range (i.e. 5×10^{-4} m/s). In general, a high BOD concentration is predicted by models especially near wastewater outfalls but an abrupt decrease in BOD occurs with increasing distances. However, the resuspension of deposited particulate BOD facilitates its transportation to greater distances away from potential sources.

6.1.2. *Objectives of the Water Quality Modeling*

Under the Master Plan, the water quality conditions in the Marikina River using existing water quality models will be determined under different conditions related to sewerage interventions. In particular, the use of an accepted regulatory water quality model such as those developed by the US Environmental Protecion Agency (e.g. WASP) will be developed to determine the BOD and TSS levels considering present and future point and non-point dischargers within the Marikian River Basin.

6.2 The WASP Model

6.2.1. *Overview*

WASP (Water Quality Analysis Simulation Program) which was developed by the US Environmental Protection Agency (USEPA), is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying sediments. It is a multi-dimensional modeling software that is able to simulate 1-Dimensional, 2-Dimensional, and 3-Dimensional spatial water quality problems. The time-varying processes of advection, dispersion, point and diffuse mass loading and boundary exchange are represented in the basic program. WASP can simulate conventional water quality like eutrophication and a number of toxic pollutants. The water quality program has a high-speed model processor.

A hydrodynamic model (DYNHYD) is also coupled in WASP for a combined simulation of water quality and quantity. The hydrodynamic code can simulate steady or unsteady free-surface flow. The hydrodynamics program simulates the movement of water while the water quality program, WASP, simulates the movement and interaction of pollutants within the water.

A windows-based preprocessor was also developed and incorporated into the modeling framework for modelers to have an easy preparation of compatible format data input. In addition, a post-processor was also attached into the overall program for easy viewing and interpretation of model results.

6.2.2. Model advantages and limitations

There are certain advantages of the WASP model over previously documented water quality models. Obviously, the main advantage of the model is its flexibility in that it can be used to compute the water quality of various water bodies ranging from rivers, lakes and coastal seas. It can be used in 4 spatial modes including, box-mode, 1-D, 2-D and 3-D simulation. It can also handle reversing flows due to tidal influence in rivers for example.

One of the limitations of the model is that it does not have a provision to handle tidal height as input data. Therefore, a user must be able to convert tidal data into discharge data. Another limitation is that it can not yet simulate some water quality processes and problems like speciation of toxic metals. In addition, the maximum number of segments is limited to 3000. Furthermore, the maximum number of time pairs is 4000. This is to optimize the model runtime.

6.2.3. *Spatial Discretization*

Like any other water quality, WASP requires spatial discretization or segmentation of the water body to be modeled before starting the numerical simulation and prediction of various water quality variables. There are important rules to be considered in the segmentation process including the following:

1. Spatial scale of the problem
   The spatial scale of the water body such as the actual river reach and embayment should be considered. One may be interested with the whole water body or just a portion only. The whole river basin network may also be considered.

2. Dimensionality and spatial discretization of segments
   The dimensionality should also be considered. The model can be used either in a box-mode, or 1-3 Dimensional mode. Horizontal scales may vary from tens of meters to tens of kilometers. The vertical scale could be tens of centimeters to several meters.

3. Physical components
   The physical components of the water body such as the presence of epilimnion or hypolimnion throughout the water column may also be considered.

6.2.4. *Embedded Water Quality Modules*

Under the present version of WASP (version 7), there are 7 distinct water quality modules that the user can select from. The modules include eutrophication, periphyton, simple toxicant, non-ionizing toxicant, organic toxicant, mercury and heat. The **eutrophication module** calculates various groups of nutrients, BOD, dissolved oxygen, and phytoplankton. The **periphyton module** is an extension of the eutrophication module in that it calculates same variables and simulates their impact on benthic algae and periphyton. Under the **simple toxicant module**, several species of metals and sediments are calculated. Here toxic metals such as Ag, Ba, Be, Cd, Co, Cu, Mo, Ni, Pb, Sb, Tl, V, Zn can be calculated using partitioning coefficients. In addition, As, Cr, Se, and Sn can also be computed if redox kinetics data are unavailable.

The **non-ionizing toxicant module** treats these reactive metals (As, Cr, Se, and Sn) if redox kinetics data are available. The **organic toxicant module** computes various organic compounds including PCB's and PAH. Here, equilibrium processes like sorption and ionization are included. In addition, kinetic processes like volatilization, photolysis, hydrolysis, bacterial degradation, oxidation and reduction are included. The **mercury module** treats mercury as a special metal. Specifically under this module, WASP models elemental mercury, divalent mercury, and methyl mercury. Finally, under the **heat module**, temperature, salinity, and coliform bacteria are simulated by WASP.

6.3 Model Implementation

6.3.1. Segmentation of the Marikina River System

Segments are the spatial component in which WASP solves the set of equations. Segments have volume, environmental and constituent concentrations associated with them. The segment data for the Marikina River will be discussed in the succeeding sub-sections.

6.3.2. Flows and Flow Functions

The stream flows from the upstream boundaries and tributaries of the Marikina River will be used as input in the simulation. Estimated and observed data will be used in the model.

6.3.3. Boundary concentrations

Observed concentrations of water pollutants like BOD and TSS in the upstream and downstream boundary of the area will be used in the model. In the absence of actual data, estimation will be carried out.

6.3.4. Pollution Loads

Waste loads may be entered into WASP for each of the systems for a given segment. The contribution of domestic and industrial loads will be considered. In addition, the contribution of the agricultural load to the total pollution load will be considered as well.

6.4 Physical Characteristics of the Study Area

6.4.1. Basin Map of the Marikina River

Using the topographic-bathymetric data derived from a 900-m grid distance of the Shuttle Radar Topographic Mission (SRTM 90), the watershed area of the Marikina River has been computed. Based on the elevation gradients and the direction of steepest slope in the area of interest, the catchment area of the Marikina River Basin was delineated. The result of the analysis is shown in the figure below. Based on the automated analysis, the basin area of the Marikina river system has been estimated to be about 556 km². The basin area is approximately delineated by the red line in **Figure 6.1** below.

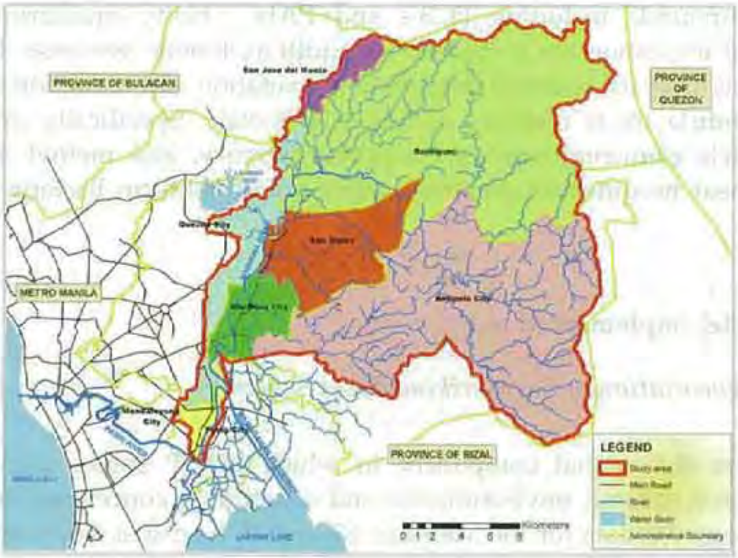


Figure 6.1 Basin delineation of the Study Area

6.4.2. Average Rainfall and Air Temperature

The amount of rainfall falling in a watershed largely determines the stream flow that will result as the net water volume when evaporation and seepage have been subtracted. On the other hand, the local temperature in the basin dictates to a large extent the evaporation that tends to reduce the total volume of water that may reach the stream. The average climate data insofar as rainfall and temperature are concerned are therefore important hydrologic parameters when hydrologic conditions of a given area are considered. These physical variables are discussed below.

The rainfall and temperature data in Science Garden had been used to characterize the Marikina River Basin. The Science Garden Meteorological Station of the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA) has by far the most complete data set and is nearest to the river of interest. The observations being made at the Angat Water Reservoir can complement the PAGASA data. The rainfall data in the Science Garden showed that the average rainfall within the areas ranged from 7 to over 500 mm (**Figure 6.2**). The highest rainfall occurs during the month of August whereas the lowest rainfall occurs during the month of April. For air temperature, the PAGASA data showed average values ranging from 25.1 to 29.2 °C with the warmest occurring during the summer month of May (**Figure 6.3**).

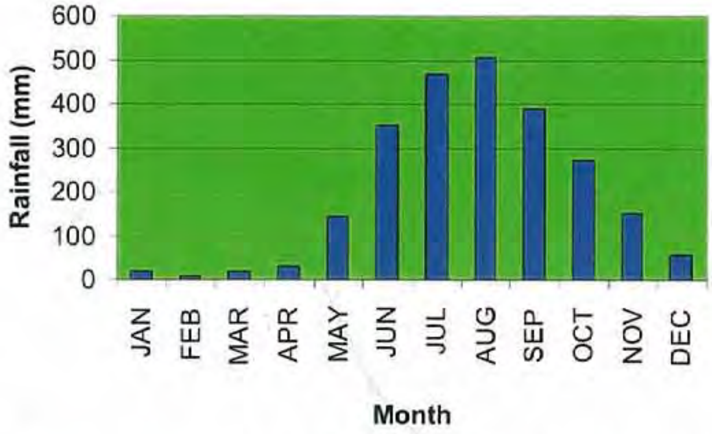


Figure 6.2 Average Rainfall (mm) in the Study Area

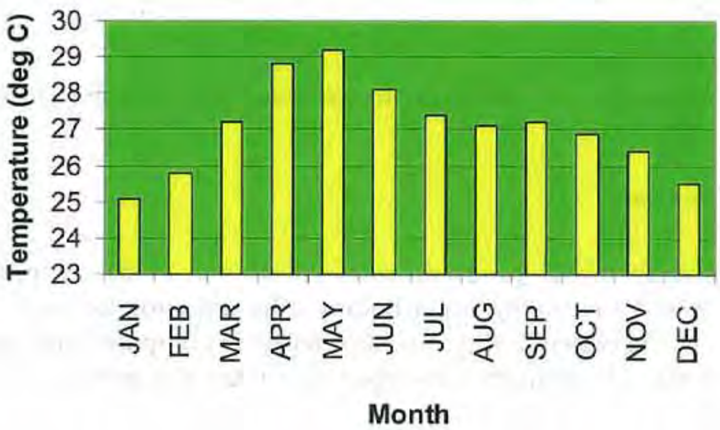


Figure 6.3 Average Temperature (°C) of the Study Area

6.4.3. *Stream Flows and Water Levels*

The hydrologic conditions occurring in a given area determines the transport of pollutants and their potential to be distributed or diluted. Water quality conditions are always dependent on the amount of water as the volumetric flows and depths in a given river basin for instance affect the physical and chemical transformation of the water pollutants that are discharged in receiving water bodies. It is therefore necessary that the hydrology of the study area be characterized adequately and accurately as possible.

The variable stream flow discharging into the Marikina River has been initially estimated based on the average rainfall data from the Science Garden Meteorological Station of PAGASA and the estimated watershed area of the basin. The result of the analysis is shown in **Figure 6.4**.

Figure 6.4 Average Stream Flow (m3/s) for the Study Area.

6.5 Waste Load

The water quality model needs accurate calculation of the pollution or waste loads discharging into the receiving water bodies. The pollution loads affect to a high degree the accuracy of the water quality model in terms of computed concentrations of various water pollutants. The estimation of input data related to pollution loads is discussed in this chapter.

6.5.1. Sources of Pollution

There are various sources of pollution for the study area ranging from industrial and municipal discharges, domestic and agricultural runoff. For the Marikina River System, the major contributors include industrial, domestic, and agricultural pollution sources.

6.5.2. Pollution Load Quantification

Pollution load estimation gives the amount of pollutant entering the water surface. It includes pollutants coming from point (industrial sources) and non-point sources (domestic and agricultural). The output data which are needed by the water quality model are pollutions loads in kg/day of specific pollutants like BOD and TSS that enter the water surface.

The computation of loads follows the 'unit load approach' in quantifying the emissions of various sources. This approach is based on the multiplication of Unit Loads (e.g., the population equivalent) with the number of units or emission variables (e.g., the number of inhabitants or extent of the agricultural area). The unit load should be specified for all substances under consideration. The estimation procedure is based on the following input variables:

Table 6.1 Pollution Loads for Different Types of Sources

Pollution/Waste Load	Unit Load	Emission Variable
domestic waste load	emission per inhabitant	number of inhabitants
industrial waste load	concentration in wastewater	discharge of wastewater
atmospheric deposition	deposition per unit area	surface area
tourism waste load	emission per tourist per day	number of tourists per day

The calculation of total pollution load is based on **WL = EF x EV** in which

WL	=	Waste Load [Mass/Time]
EF	=	Emission Factor which is a unit waste load [Mass/Time/unit]
EV	=	Emission Variable, which is expressed as pollutant source units like number of inhabitants, area of arable land, discharge flow rates of point sources.

Point Sources

The industries around the water body shall be considered as the major point sources. For the Industrial Waste loads, the computation shall be based on industrial discharge flow rates (m^3/day) per type of industry as the EV and typical effluent concentrations of pollutants (g/m^3 or mg/L) as EF. The values of the EV and EF can be culled from the compliance monitoring reports and SMR submitted to the EMB.

In addition, typical values from literature can also be used for the computation. One source of the EF for typical industries is the compilation by the LLDA consultants who made an analysis of local Philippine industry data. These data were gathered from the Pollution Control Division of the LLDA and consist of self-monitoring report data of 252 industries. The five pollutants that were analyzed were BOD, COD, TSS, Oil & Grease and Coliform. The result of the analysis is shown in **Table 6.2**.

Table 6.2 Industrial Emission Factors Derived from Self-Monitoring Reports of Industries around Laguna de Bay (LLDA 2005).

	Volume weighed averages per Industry Type	ind	BOD (mg/l)	BOD (mg/l)	COD (mg/l)	COD (mg/l)	TSS (mg/l)	TSS (mg/l)	Oil & Grease (mg/l)	Oil & Grease (mg/l)	Coliform (MPN/100ml)	Coliform (MPN/100 ml)
			Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
1	Food and Food Preparations	24	1248.0	13.0	2901.9	45.7	585.8	17.3	39.1	2.4	5.51E+23	3879
2	Pulp and Paper Processing	4	196.4	8.6	535.7	28.9	355.2	14.0	4.5	2.6	5.50E+03	868
3	Garments and other Consumer Manufac	6	-	13.2	21853.0	35.1	-	8.9	-	1.4	-	-
4	Livestock Production	7	-	-	-	-	-	-	-	-	-	-
5	Poultry Production	1	-	2.8	-	38.0	-	13.2	-	1.0	-	-
6	Beverages	9	714.5	12.0	1403.6	31.1	79.7	13.1	6.6	3.3	-	-
7	Electronics	60	85.7	55.9	336.5	68.4	59.7	13.6	4.5	2.0	1.05E+03	215
8	Metal Manufactures	8	130.0	6.0	317.0	27.1	35.0	5.7	49.5	2.2	-	130
9	Other Resource-Based Products (Oil-Ba	0	-	-	-	-	-	-	-	-	-	-
10	Chemicals and Industrial Manufactures	43	1739.9	17.8	2508.6	56.4	612.6	19.0	196.7	1.6	-	1265
11	Mineral products and Nonmetallic Miner	5	-	-	-	-	-	-	-	-	-	-
12	Services	10	235.3	9.8	395.9	30.7	83.4	14.8	6.8	1.6	3.40E+06	199
13	Furniture	1	-	-	-	-	-	-	-	-	-	-
14	Petrochemicals	1	-	17.0	-	-	-	8.0	-	1.0	-	-
15	Plastic Products	2	-	5.0	-	35.2	-	8.1	-	1.2	-	-
16	Petroleum Products	3	78.3	14.7	-	-	14.0	1.7	11.7	3.7	-	-
17	Economic Zones	8	13.9	10.9	33.9	39.5	154.4	16.0	1.5	2.2	0.00E+00	6187
18	Hotels and other Commercial Establishr	49	423.4	15.0	533.7	56.8	238.6	14.9	20.4	2.4	5.62E+06	984
19	Power Generation	2	1.0	81.6	30.0	213.0	8.0	73.7	1.0	6.4	5.00E+02	1600
20	Vehicle Parts and Services	9	309.5	21.6	880.0	44.5	268.6	20.8	19.0	1.6	-	-
21	Sanitary Services	0	-	-	-	-	-	-	-	-	-	-

Non-Point Sources

For the computation of non- point sources, three parameters were analyzed so far. These are BOD, coliform and nutrients including nitrogen and phosphorous. For the present study, only BOD and coliform loads are considered. The values of the emission factors were taken from literature (Chapra 1997). Domestic sewage is considered as the major source of BOD and coliform. To determine this, the actual population within the river basin was considered.

For BOD, the typical loading rates of Carbonaceous BOD (CBOD) for untreated domestic sewage for developing countries (as compared with the USA) is given in **Table 6.3** below. As shown, developing countries have a lower per capita BOD than the USA. The World Bank Environment Monitor reports a variable per capita BOD for urban and rural domestic sources.

Table 6.3 Typical loading rates for untreated domestic sewage (Chapra 1997)

Regional Areas	Per Capita Flow Rate (m^3 capita^{-1}d^{-1})	Per Capita Flow Rate (m^3 capita^{-1}d^{-1})	CBOD Concentration (mg L^{-1})
Developing Countries	0.19	60	320
U.S.A.	0.57	125	220

Source: World Bank Environment Monitor Report

Per capita generation rates for Total Coliform (TC) and Fecal Coliform (FC) for warm blooded animals are given in **Table 6.4**. Loading concentrations shall depend on water use. For domestic sewage, the per capita flow rate in the table can be used as an estimate of per capita water use.

Table 6.4 Per capita generation rates of intestinal bacteria for warm-blooded animals (Chapra 1997)

	Total Coliform	Fecal Coliform
Animal	(10^6 number capita^{-1} d^{-1})	
Human	100,000 - 400,000	2,000
Chicken		240
Cow		5,400
Duck		11,000
Pig		8,900

Using this table of per capita BOD and coliform, a table of domestic pollution loads for each the study area had been generated. The total pollution load estimated for Marikina is about 52073 kg/day. The actual domestic loads reaching the water body may be smaller than this due to purification, settling and decay within the sources. A constant factor of 0.7 (70%) had been multiplied with the derived loads to reflect a 30% decrease (due to these factors) upon reaching the receiving water bodies. The resulting BOD load is for Marikina River is about 36451 kg/day.

6.6 Water Quality Modeling for the Marikina River System

The modeling application for the study area using the WASP model is discussed in this chapter. Actual implementation of the water quality models for the required pollutants of interest like BOD and TSS is presented.

It should be noted that water quality modeling requires hydrologic modeling as well to be able to simulate the actual quantity of water that transports the pollutants. For this purpose, the 1-dimensional model set-up for the study area assumes a channel of rectangular cross-section so that the river width (B) is not a function of stream flow (Q). This is one limitation of the WASP model since it does not consider the potential flooding and drying of some area that may occur within the basin. In WASP, the volumetric flow rate Q dictates to a large extent the flow velocity V and the water depth D in the form $V = aQ^b$ and $D = cQ^d$. Here, a,b,c and d are coefficients for the hydrology part of the model which can be adjusted so that model results agree well with the monitoring data. During model calibration for both hydrologic and water quality conditions, these can be adjusted in a series of simulation runs so that simulated flow velocities and depths are reasonable and realistic enough.

6.6.1. *Basic Model Inputs*

Common to all water quality models is the need for basic input data before making a successful model simulation. Input data can be categorized into 3 main groups namely; hydrology, water pollution, and constants. Under hydrology, data like depth distribution or bathymetry of the areas of interest, water levels or tides, observed winds, rainfall, evaporation, and river discharges within the modeled rivers are needed. The hydrologic input data concerning depths can be digitized from the maps published by the National Mapping and Resources Information Authority (NAMRIA) and satellite images like the Shuttle Radar Topographic Mission (SRTM 90). For hydro-meteorological data like rainfall, evaporation, solar radiation, air temperature, observations made by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) in nearby stations are normally used. For stream flows of major rivers, the hydrological data of the Bureau of Research Standards (BRS) and the National Water Resources Board (NWRB) can be specified in the model.

Concerning input data on water pollution, waste loads emanating from industrial point-sources can be obtained from the Self-Monitoring Reports submitted to EMB. Non-point sources of pollution loads like domestic sources can be derived from the population of nearby communities multiplied by the per capita contribution to the pollution as presented above.

Under constants, water quality models require additional inputs such as an array of Manning or Chezy coefficients for bottom friction, spatially variable eddy viscosity coefficients and dispersion coefficients. For WASP, separate input data for the hydraulic coefficients that describe the flow velocities and water depths are required when one is using the gross flow and net flow options.

6.6.2. *Basic Model Outputs*

The basic outputs of the water quality model are time-series graphs showing the hydrodynamics of the area like flow velocity, water depths and concentrations of water pollutants. In areas where few stations are monitored on a monthly or quarterly basis, model outputs based on daily time series can be easily compared. The water quality model has adjustable time of saving outputs. The saving or printing time normally ranges from several minutes to several days.

6.6.3. *Model Calibration*

After setting up the water quality model in a specific water system through assembly of the appropriate input files, it is very important to 'calibrate' the model. Model calibration is a process wherein various input coefficients are adjusted or 'tuned' so that the output of the model agrees well with the observed data. Calibration is a procedure that leads to an optimization of the model coefficients which are generally site-specific. There are two ways in calibrating the water quality model and these are manual or trial and error method, and automatic parameter estimation. Under the trial and error method, the modeler repeatedly runs the water quality model until the coefficients used will give model results that fit well with the monitoring data. This is usually time consuming and often times becomes an endless procedure until the best model result will be obtained. The second method is automatic in the sense that an appropriate program is developed to calibrate the coefficients for each specific water pollution problem. In the absence of specific computer programs developed for the later, the usual trial and error method works just fine. The steps in the water quality model calibration include the following:

1. Adjust the hydraulic coefficients and the roughness coefficients in the hydrologic model. Note that $V = aQ^b$ and $D = cQ^d$.

2. Adjust the constants in the water quality model such as the decay rates, dispersion coefficients and other kinetic constants;

3. Compare model results with monitoring data (on both hydrology and water quality);

4. If model results go beyond the range of the monitoring data, then go back to Step 1.

The reliability of the model results can be assessed during model calibration by comparing them with the monitoring data. This is just qualitative approach whereby the modeler can visually compare the output of the model with the observed data.

A more appropriate scientific method is to use some statistical measures such as the mean of the residual errors (M) and the correlation coefficient (r) between model results and observed data. These are quantitative measures that can give reliable estimates of the accuracy of the model results. They can also guide the modeler as to whether the results of calculations are overestimating or underestimating the actual monitoring data:

6.6.4. *Water Quality Model Implementation*

Before making a water quality model simulation with WASP, several data input specification or simply data requirements are needed. These requirements include the model data set, time interval, print or save interval, segment characteristics, system data, parameter data, waste loads, environmental time functions, dispersive exchanges, flows, and boundary concentrations. The required data sets as applied to the water quality model simulations are discussed below. Preparation of the necessary input data is also discussed.

Model Data Set, Time and Print Interval

There are various important specifications before one can make a simulation in WASP. To simulate organic matter pollution and dissolved oxygen, the model type under data set should be set to eutrophication (EUTRO model). The time range for simulation can be set for a year. For the study area, this will depend on the availability of monitoring data. The time interval can be set as a fraction of a day. A short time interval is generally more acceptable to have more accurate results and to avoid numerical instability during model execution. Numerically unstable calculations give erroneous model results if the time step is not properly specified. For saving model outputs, the default unit is day and for a yearlong model simulation, this can be set at 1 day giving 365 data points in the model results.

Segment Information

Model segments and their characteristics are needed as basic inputs. The geometric properties of modeled water bodies can be derived using GoogleEarth. In particular, the segment length and width of Marikina River was digitized using the ruler of GoogleEarth as shown in the figure below. The segment volume can be derived if the segment depths are available. For big rivers, the SRTM-90 data on depths can be used. In the present application, variable depths from the upstream boundary to Napindan Station (downstream boundary) were used giving variable segment volumes in all the segments. The length of the segments was also determined using the Google Earth as shown below.

Figure 6.5 Estimating the Marikina River Width and Length

Figure 6.6 Segmentation for the Marikina River System.

The various segments differ in geometric and hydraulics characteristics. Changes with respect to water volume, depths, width, slope and roughness of each segment are encountered in real situations. Variations in the morphometry of the river segments are incorporated in the present water quality modeling work. The estimated segment properties are shown in **Table 6.5.**

Table 6.5 Estimated segment properties in the Study Area.

Segment	L (m)	Mean W	Volume
	m	(m)	(m3)
s1	580	48.5	42195
s2	1371	57.5	118249
s3	1035	60.5	93926
s4	829	61	75854
s5	908	55	74910
s6	879	44.5	58673
s7	758	36.5	41501
s8	398	46	27462
s9	578	50	43350
s10	1323	39	77396
s11	824	39	48204
s12	1248	40.5	75816
s13	997	39	58325
s14	528	37.5	29700
s15	2802	38.5	161816
s16	1394	32	66912
s17	1490	26	58110
s18	1514	26	59046
s19	1140	23	39330
s20	870	22	28710
s21	868	23.5	30597

6.7 Monitoring Needs

6.7.1. Hydrologic Conditions

The hydrologic characteristics of the study area are needed to fully understand the water flows and depths that dictate the changes that may occur with respect to the various water quality problems in the area. Monitoring data on the hydrological properties of the study area are also needed in the model calibration.

It is evident that the most important hydrologic information that the water quality model need is the variability of water flows and mean depths in the study area. As much as possible daily or monthly observed flows in several segments of the river be monitored. This will be used to compare with the data used in the coupled hydrologic model. Another important parameter of concern is the flow velocity. Temporal changes in the flow velocity in various segments will be modeled and therefore, data concerning this physical variable should be made available for calibration purposes. It should be noted that the model uses the simulated flow velocity in determining the advection and dispersion of water pollutants in the area of study. Lastly, the mean water depths in the study area should be measured as well. A one-time sampling for this variable is recommended to initialize the input data on water depths.

6.7.2. Water Quality Conditions

The most important water quality parameter to be monitored in the study area is the BOD concentration in the water column. The project needs a projection of the future BOD concentration and therefore the model needs the present BOD levels as baseline information to initialize the model. The baseline BOD level is also needed as starting point to make a comparison when analyzing modeling scenarios like increase in the BOD level due to non-treatment (e.g. no action policy) or decrease in the BOD level due to some percent reduction from the Sewerage Treatment Plant (STP option).

The TSS level should also be monitored as siltation of the study area is already becoming a major problem in the area due to occasional flooding of embankment. Due to deposited TSS loads in the river bed, the capacity of the river to transport a given quantity of water has decreased in recent years. Frequent flooding of low-lying areas is therefore becoming more prevalent.

The impact of BOD and TSS loads from domestic and industrial sources is a very important issue in the water quality of the study area. Accurate quantification of the BOD and TSS loads should therefore be carried out. Monitoring of industrial loads or determination from previous data can be carried out. The domestic and agricultural loads can be quantified through estimations based on literature.

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ANNEXES