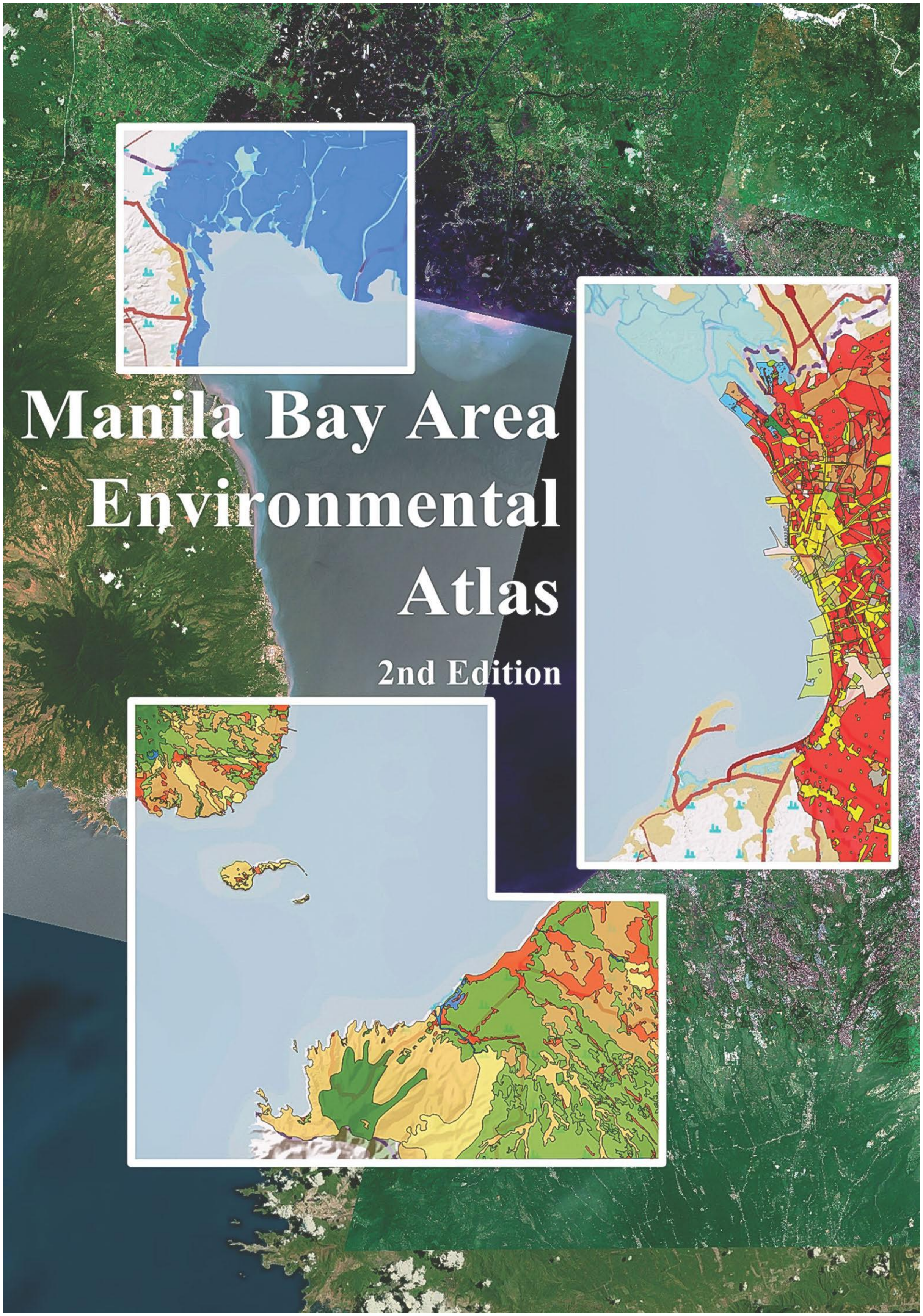
Manila Bay Area Environmental Atlas

2nd Edition



MANILA BAY AREA ENVIRONMENTAL ATLAS

2nd Edition

September 2015

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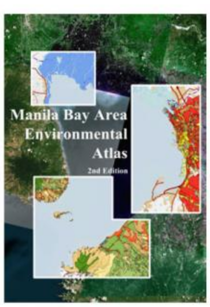
ABOUT THE COVER

MANILA BAY FROM SPACE



The Cover is a view of the Manila Bay Area from space. The image is a mosaicked SPOT 5 satellite image taken from 2004 to 2008. SPOT is one of the numerous imaging satellites that orbit the earth collecting photos in regular intervals. The satellite images support many applications ranging from agriculture to forestry, geology, biodiversity, hydrology, oceanography, urban planning, and hazard monitoring among others.

The Cover design of the Manila Bay Area Environmental Atlas - 2nd Edition highlights the Remote Sensing (RS) and Geographic Information System (GIS) technologies' capability to generate and integrate various geospatial data to produce a more comprehensive geographic representation. The Land Use map of NCR and the Land Cover maps of Pampanga and Cavite were overlaid to the satellite image to provide a glimpse of what can be seen from the Atlas.

The satellite images serve as the main source of geospatial information. From these images, the extent of forest area and its classification can be extracted; topography, agricultural lands, built up areas, water bodies, and grasslands can be identified. Utilizing these images and using RS and GIS technologies, the Land Cover map of the Philippines was generated and the Topographic maps at 1:50,000 scale were updated.

MANILA BAY AREA ENVIRONMENTAL ATLAS

2nd Edition

Republic of the Philippines
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

Message

In responding to the challenge of making the Manila Bay clean enough for recreational and other uses, we are pleased to note many independent initiatives, in addition to concerted efforts of government entities. However, if we are to achieve the results we want within a reasonable timeframe, we need not just a convergence of efforts and resources, but also a scientifically sound and methodical approach.

These provide the rationale for the updating of the Manila Bay Area Environmental Atlas, or MBEA. Eight years have passed since the 2007 edition of the MBEA, and six years since the Supreme Court issued in December 2008 a writ of continuing mandamus for the cleanup of the Manila Bay.

The updating of the 2007 MBEA will apply spatial analysis to all efforts for the cleanup, preservation and rehabilitation of the Bay. Given its programmatic approach, this publication will serve as a reference for policy-makers in formulating timely and relevant laws and policies. The updated MBEA will also be useful for students and professionals in writing academic papers. Additionally, this Atlas can guide financial institutions, volunteer groups and the corporate sector in implementing area-specific initiatives and corporate social responsibility programs.

I commend the Manila Bay Coordinating Office (MBCO) and the National Mapping and Resource Information Authority (NAMRIA) for initiating the updating of the Manila Bay Environmental Atlas. This is another delivery on our commitment to provide better ecological services to the country.

Congratulations and Mabuhay!

RAMON J.P. PAJE
Secretary

PREFACE

THE MANILA BAY AREA ENVIRONMENTAL ATLAS (MBEA)

The Manila Bay Area Environmental Atlas (MBEA) is a collection of data and information presented in thematic and composite maps, graphs and tables describing the characteristics and ecological condition of the Manila Bay Area.

Each map is accompanied by a textual description supported with matrices or tabulated data holdings. Included within the text are related definitions and findings, socioeconomic significance, risks and challenges that affect mentioned regions. Photographs are also included in the document for visual appreciation of the featured areas and landmarks.

OBJECTIVES

The MBEA is intended to be a source of data and information for policy formulation, planning, decision-making, monitoring, and overall management of the Manila Bay Area, as embodied in the 2011-2015 Operational Plan for the Manila Bay Coastal Strategy (OPMBCS).

It is designed to enhance awareness on the different natural resources and 'engineered' structures and facilities in the Manila Bay Area, their current environmental status, and the impact of different uses and users of Manila Bay. National Government Agencies (NGAs), Local Government Units (LGUs), Non-Governmental Organizations (NGOs), private sector, the academe and other stakeholders implementing on-the-ground activities will find the atlas a valuable source of information.

UPDATING OF THE 2007 MBEA

In keeping with the demand for geospatial data holdings, the Manila Bay Coordinating Office (MBCO), in close cooperation with the National Mapping and Resource Information Authority (NAMRIA) embarked on the updating of the 2007 MBEA. When compared to the 2007 manuscript, the MBEA - 2nd Edition focuses more on socioeconomic and environmental trends, as well as the emerging issues in the Manila Bay Area. Rigorous discussions on Land Cover, Water Quality of Water Bodies, Water Supply and Sanitation, Solid Waste, Hazard-Prone Areas and Climate-related Trends were included in this edition to expound on the dynamics of the Bay's ecosystem. All these emerging issues and responses were linked to the passage of the En Banc Decision for Manila Bay, its impacts and resulting trends emanating from said legislation. Providing trends analyses will help NGAs, LGUs and other stakeholders better align and accomplish their rehabilitation efforts for Manila Bay.

A participatory approach was employed in the updating process as the listed data requirements were provided by different agencies/offices. To focus on the latter requirements, a core group composed of the following agencies/offices was established.

1. Department of Environment and Natural Resources (DENR)
   a. Manila Bay Coordinating Office (MBCO), including the Site Management Offices (SMOs) from Regions III, IVA and NCR
   b. National Mapping and Resource Information Authority (NAMRIA)
   c. Environmental Management Bureau (EMB)
   d. Forest Management Bureau (FMB)
   e. Biodiversity Management Bureau (BMB)
   f. Laguna Lake Development Authority (LLDA)
   g. Pasig River Rehabilitation Commission (PRRC)
   h. National Water Resources Board (NWRB)
   i. National Solid Waste Management Commission (NSWMC)
2. Department of Agriculture (DA)
   a. Bureau of Soils and Water Management (BSWM)
   b. Bureau of Fisheries and Aquatic Resources (BFAR)
   c. National Fisheries Research and Development Institute (NFRDI)
3. Metropolitan Waterworks and Sewerage System (MWSS)
4. Local Water Utilities Administration (LWUA)
5. Philippine Ports Authority (PPA)
6. Department of Science and Technology (DOST) – Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA).

Prior to its publication, the MBEA final output was approved by the Project Steering Committee.

SCOPE AND LIMITATIONS OF THE UPDATED MBEA

Recognizing data availability, all holdings were sourced from varying timelines (2007-2015) preceding the publication of the 2007 MBEA. Trends analyses were still performed for this edition with the differences in temporal scales.

Likewise, much of the data holdings provided in the updated MBEA are from secondary sources. Some data holdings require updating and validation to make them more appropriate for immediate or near-future decision-making. These data sets include water resources, pollution loading from various sources, land conversion and areas vulnerable to risks.

ACKNOWLEDGEMENTS

The Manila Bay Area Environmental Atlas - 2nd Edition focuses more on environmental trends and its analyses, taking off from the interventions made after the promulgation of the MMDA, et.al. versus Concerned Residents of Manila Bay (G.R. Nos. 171947-48) rendered by the Supreme Court last 18 December 2008.

The updating of the 2007 MBEA was specifically conducted to identify the following:

- Current impacts of climate change extremes to the MBA, i.e. typhoon, flooding, storm surge, sea level rise and other potential risks in the near future; and
- Present development activities being implemented within the MBA over the past six years.

These goals were attained with the paramount support and untiring commitment of the MBEA Core Technical Working Group member-agencies/offices during the updating process:

- Department of Environment and Natural Resources (DENR)

  (Manila Bay Coordinating Office, Manila Bay Site Management Offices in Regions III, IVA and NCR, National Mapping and Resource Information Authority, Environmental Management Bureau, Biodiversity Management Bureau, Forest Management Bureau, National Water Resources Board, Pasig River Rehabilitation Commission, Laguna Lake Development Authority, River Basin Control Office and National Solid Waste Management Commission - Secretariat)
- Department of Agriculture (DA)

  (Bureau of Soils and Water Management, National Fisheries Research and Development Institute, Bureau of Fisheries and Aquatic Resources)
- Metropolitan Waterworks and Sewerage System (MWSS)
- Manila Water Company, Inc. (MWCI)
- Maynilad Water Services, Inc. (MWSI)
- Philippine Ports Authority (PPA)
- Department of Science and Technology (DOST)

  (Philippine Atmospheric Geophysical and Astronomical Services Administration)

The guidance and technical inputs of Dr. Robert Jara, PEMSEA as well as the following boundary partners during the initial stage of the project are highly commended:

- Metro Manila Development Authority (MMDA)
- National Housing Authority (NHA)
- Department of Interior and Local Government (DILG)
- Department of Public Works and Highways (DPWH)
- Philippine Coast Guard (PCG)
- National Historical Commission of the Philippines (NHCP)
- Department of Tourism (DOT)
- Housing and Land Use Regulatory Board (HLURB)
- University of the Philippines – National Science Research Institute (UP-NSRI)
- Provincial Governments of Bataan, Bulacan, Nueva Ecija, Pampanga and Tarlac (Region III)
- Provincial Governments of Cavite, Laguna and Rizal (Region IV-A)
- 16 cities and 1 municipality comprising the National Capital Region (NCR)

Also, the technical and administrative support, particularly the coordination and creative tasks performed by selected personnel from NAMRIA and MBCO, is likewise appreciated. Their creative inputs for the design and layout, as well as the copyediting of the MBEA - 2nd Edition have greatly contributed to the completion of this project.

Lastly, the joint leadership and supervision of Dr. Peter N. Tiangco, CESO I, Administrator, NAMRIA as well as Executive Director Noel Antonio Gaerlan, DENR-MBCO and Director Febrina Damaso, Support Services Branch (SSB), NAMRIA, is greatly acknowledged for recognizing the importance of geospatial information in MBA's rehabilitation efforts.

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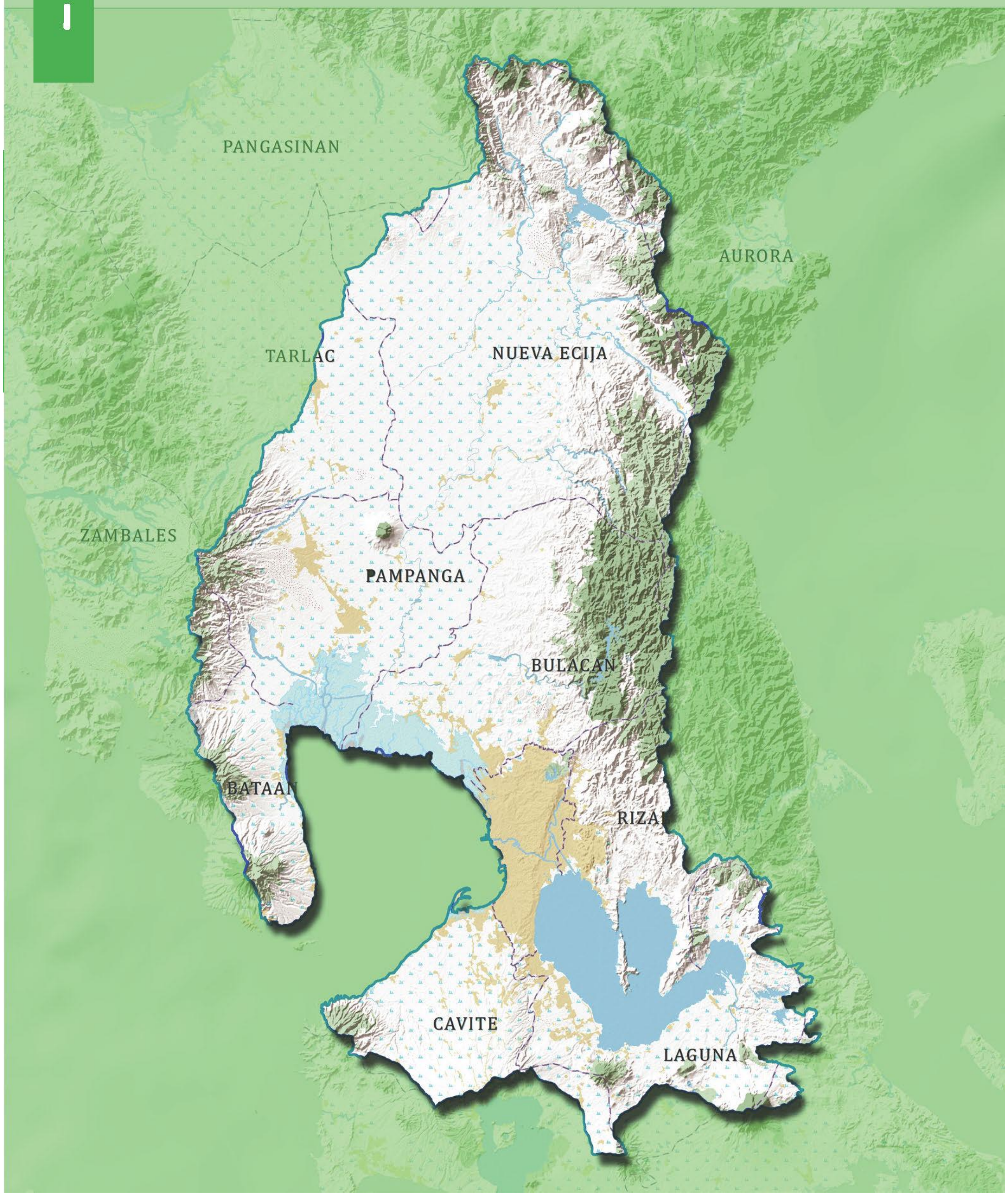
PART I

INTRODUCTION



The updated Manila Bay Area Environmental Atlas (2nd Edition) will follow the spatial coverage of the Manila Bay Area (MBA) cited in the 2007 MBEA. The MBA refers to 'Manila Bay and its surrounding watersheds found in the three administrative regions in the main island of Luzon: the National Capital Region (NCR), the Central Luzon Region and the CALABARZON or the Southern Tagalog Region' (Manila Bay Area Environmental Atlas, 2007).

Manila Yacht Club

ADMINISTRATIVE BOUNDARIES

The Manila Bay Area (MBA) has a total area of 1,994 square kilometers with a coastline of 190 kilometers comprising three regions, namely the NCR, Regions III and IV-A. Map 1 shows the administrative boundary of the MBA, while Maps 2 to 10 presents the provincial boundary maps of the eight provinces (Nueva Ecija, Pampanga, Tarlac, Bataan, Bulacan, Cavite, Rizal and Laguna), as well as the NCR.

For this publication, small contiguous parts from the provinces of Quezon, Nueva Vizcaya, Aurora, Zambales and Batangas contained within the watershed area were not included in this edition.

GEOGRAPHICAL LOCATION

The Manila Bay waters is found between 120° 28' E and 121° 15' E and 14° 16' N and 15° N. The entire MBA is found between 120° 14'and 121° 24' E and 13° 58' N and 16° 8' N (Manila Bay Environmental Atlas, 2007).

MBA is primarily bounded by various mountain ranges, including the Sierra Madre (east), Caraballo (north), Zambales (northwest) and Bataan (west). The West Philippine Sea and the province of Batangas borders the MBA in southwest and south, respectively.

Daranak Falls

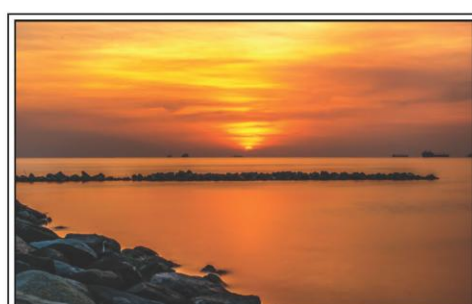
The entire watershed area is drained by 16 major river systems, namely the Angat River, Bocaue River, Guagua River, Marilao River, Meycauayan River, Obando River, Pampanga River, Sta. Maria River and Talisay River (Region III); Canas River, Imus River, Rio Grande River and Ylang-Ylang River (Region IV-A) and Meycauayan-Valenzuela River, Navotas-Malabon-Tullahan-Tinejeros River, Paranaque River and Pasig River (NCR). The above listing mentions nine more than the declared river systems in the 2007 MBEA.

Pampanga River

IMPORTANCE OF THE MANILA BAY AREA

The vast expanse and the surrounding lands of Manila Bay offer historical, cultural, economic and social significance for Filipinos. Its natural endowments and characteristics, as well as its land and sea attributes, provide food, livelihood, recreation, tourist destinations and other various uses.

Navotas Fish Port



Manila Bay Sunset

Economically, the MBA significantly contributes a large percentage to the country's gross domestic product (GDP). Table 1 highlights the increasing contribution of the MBA regions to the country's total economic output.

Table 1. Gross Regional Domestic Product in 2007 - 2008 (1985 base year), 2009 - 2013 (2000 base year) of the Manila Bay Areas

Regions	2007	2008	2009	2010	2011	2012	2013
NCR	32.6	33.0	35.8	35.7	35.6	35.7	36.3
Region III	8.3	8.3	8.8	9.0	9.3	9.2	9.0
Region IV-A	12.1	11.9	17.1	17.7	17.4	17.4	17.4
Total Contribution to National GDP	53.0	53.2	61.7	62.4	62.3	62.3	62.7

Source: National Statistical Coordination Board - Regional Highlights

From 2007 to 2013, NCR was the top contributor to the country's total GDP followed by Region IV-A and Region III. The aggregate contributions of the MBA constitute almost two thirds of the total GDP. In 2013, 62% of the country's GDP is accounted for by MBA.

INSTITUTIONALIZING THE MANILA BAY ENVIRONMENTAL AGENDA

The increasing economic importance of the MBA since the 2007 MBEA has induced positive impacts on tourism, food, livelihood, and employment opportunities. Conversely, such urban growth has also placed pressure on the MBA's ecological balance. Notably, even the aesthetic value of the Manila Bay can no longer be enjoyed due to pollution and the presence of illegal structures. These affect more than 34 million people living along and within the MBA.

Despite the various laws enacted defining tasks and responsibilities of various agencies toward environmental protection, the waters of Manila Bay have remained grossly polluted. As a response, the Supreme Court, in its opinion that the protection and rehabilitation of Manila Bay required more comprehensive and feasible solutions, rendered a Writ of Continuing Mandamus to clean-up, preserve and rehabilitate the Manila Bay (thru General Register Nos. 171947-48) last December 2008

Box 1. The General Register Nos. 171947-48

On 18 December 2008, the Supreme Court, in recognition of the state's mandate to provide for a balance and healthful ecology, rendered the Writ of Continuing Mandamus, directing thirteen (13) agencies to clean up, rehabilitate, and preserve Manila Bay, restore and maintain its waters to SB level (Class B sea waters per Water Classification Tables under DENR Administrative Order No. 34 [1990]) to make them fit for swimming, skin-diving, and other forms of contact recreation.

As the lead agency for the En Banc Decision, the Department of Environment and Natural Resources (DENR) was tasked by the SC - Manila Bay Advisory Committee (MBAC) to formulate the Operational Plan for the Manila Bay Coastal Strategy (OPMBCS). The OPMBCS has identified four (4) major areas of concern on which projects, programs and activities (PPAs) for the Manila Bay Environmental Agenda will be based. These include Liquid Waste Management, Solid Waste Management, Informal Settlers Management and Habitat and Resources Management. Technical Working Groups (TWGs) were also created to institutionalize the focus areas within the 13 defendant-agencies.

Box 2. The Supreme Court - Manila Bay Advisory Committee

The Manila Bay Advisory Committee (SC-MBAC) is the institutional response of the Supreme Court of the Philippines in verifying the veracity and truthfulness of compliance reports of the 13 national government agencies tasked by the En Banc Decision through General Register Nos. 171947-48 (MMDA, et.al. versus Concerned Residents of Manila Bay) to clean-up, preserve and rehabilitate the Manila Bay. Said Committee was created last October 2009.

It is chaired by Justice Presbitero J. Velasco, Jr., with Justice Bienvenido L. Reyes as vice chair. Its members include Justice Jose Portugal P. Perez, Justice Jose Catral Mendoza, Court Administrator Jose Midas P. Marquez, Dr. Elisea G. Gozun, and Dir. Gil S. Jacinto.

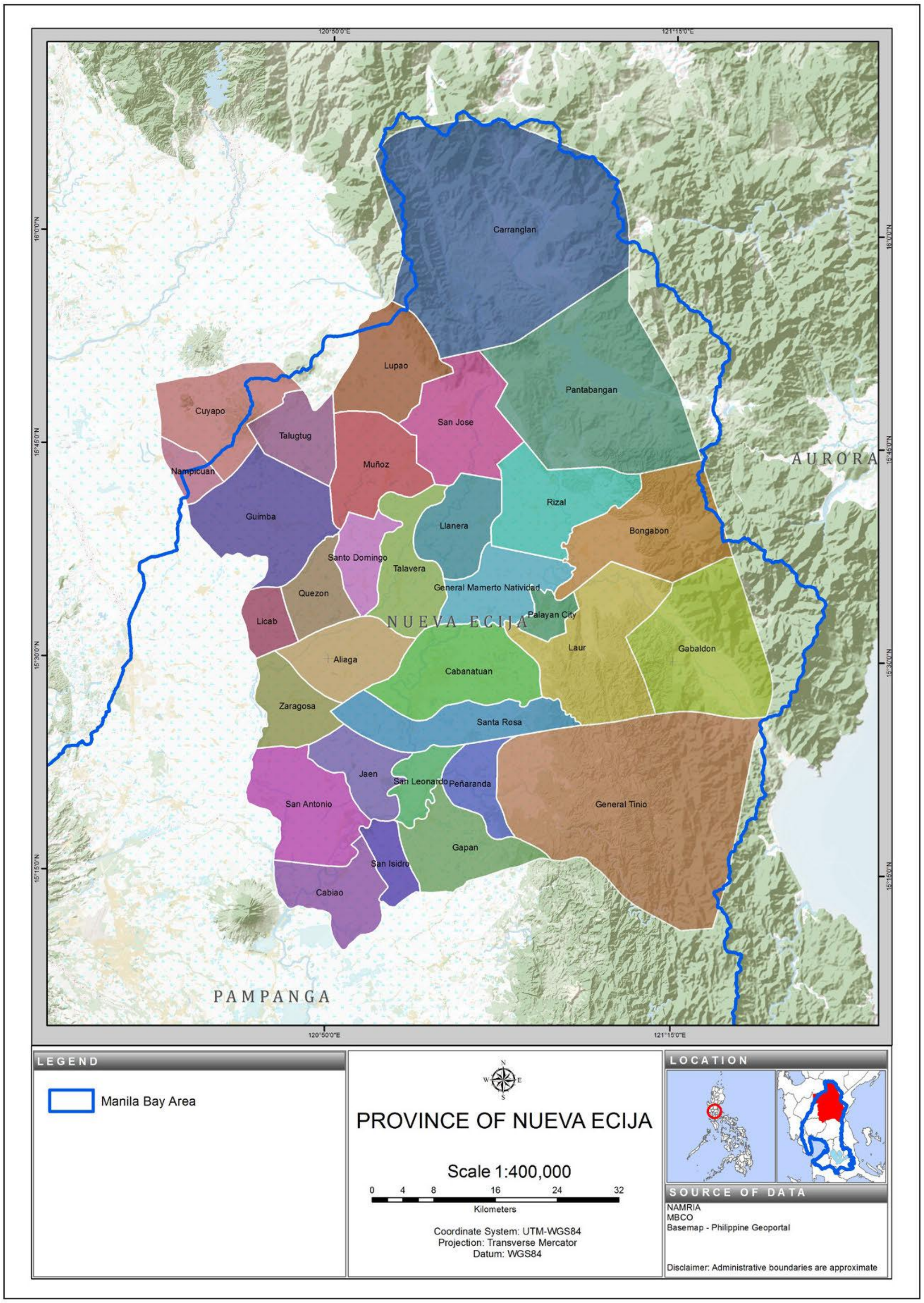
The updating of the 2007 Manila Bay Area Environmental Atlas was made to supplement these initiatives by providing timely and scientifically-verified inputs for policy making and program implementation. This publication will likewise undergo continuous updating to reflect the continuously changing needs of the Manila Bay and all abutting river systems.

SC-MBAC Hearing

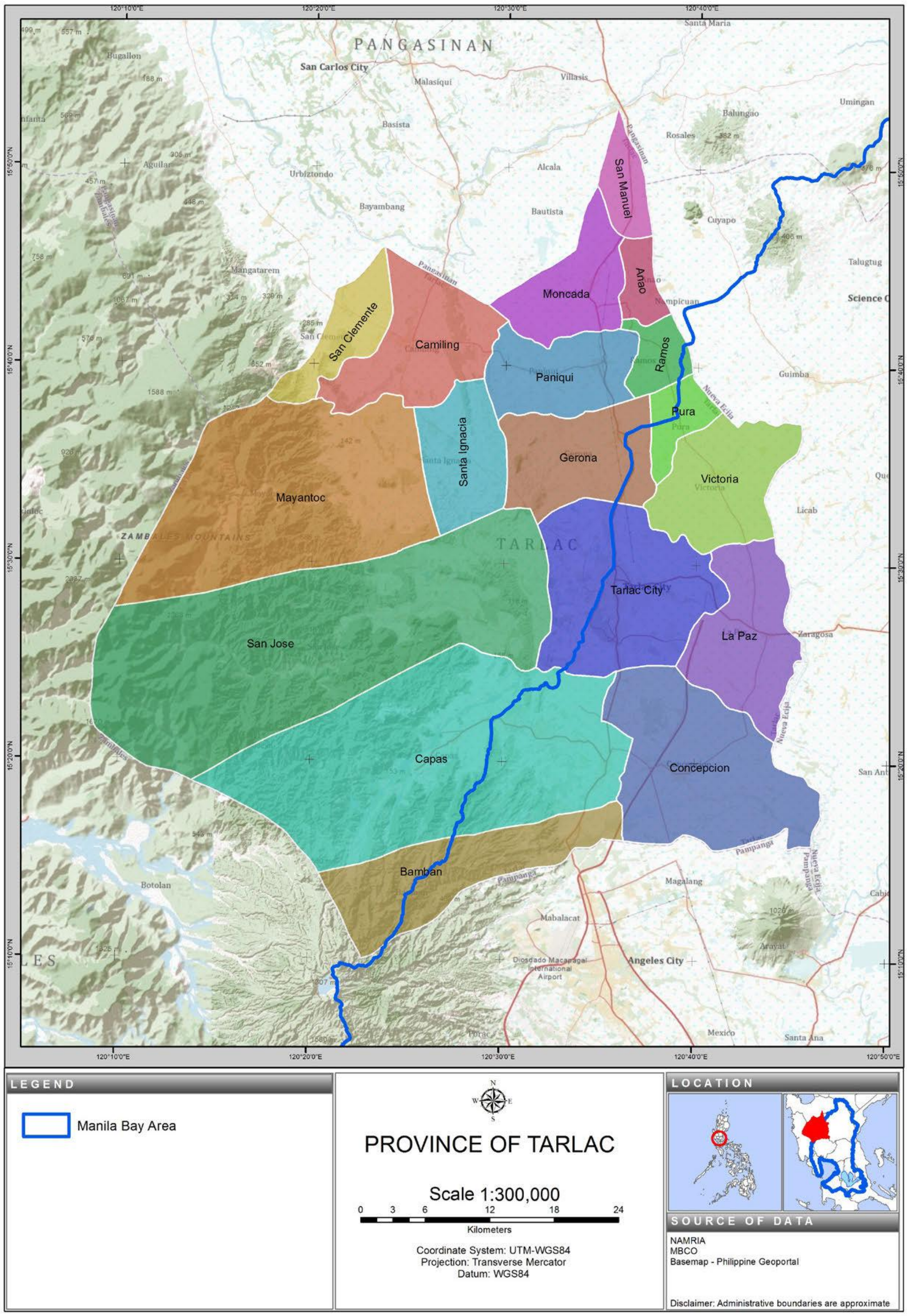
Map 1


PANGASINAN
TARLAC
NUEVA ECIJA
AURORA
ZAMBALES
PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Laguna De Bay
Baler Bay
Dingalan Bay
Polillo Strait
Casiguran Sound
Lopez Bay
LEGEND
Manila Bay Area
Provincial Boundary
Road
MANILA BAY AREA
Scale 1:800,000
0 5 10 20 30 40 50 60
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 2


120°50'0"E
121°15'0"E
16°0'0"N
15°45'0"N
15°30'0"N
15°15'0"N
Carranglan
Lupao
Pantabangan
Cuyapo
Talugtug
San Jose
Muñoz
Nampicuan
Guimba
Rizal
Llanera
Bongabon
Santo Domingo
Talavera
General Mamerto Natividad
Quezon
Palayan City
Licab
NUEVA ECIJA
Laur
Gabaldon
Aliaga
Cabanatuan
Zaragosa
Santa Rosa
AURORA
Jaen
San Leonardo
Peñaranda
General Tinio
San Antonio
Gapan
San Isidro
Cabiao
PAMPANGA
LEGEND
Manila Bay Area
PROVINCE OF NUEVA ECIJA
Scale 1:400,000
0 4 8 16 24 32
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 3


PANGASINAN
TARLAC
San Manuel
Anao
Moncada
San Clemente
Camiling
Ramos
Paniqui
Pura
Santa Ignacia
Gerona
Victoria
Mayantoc
Tarlac City
La Paz
San Jose
Capas
Concepcion
Bamban
LEGEND
Manila Bay Area
PROVINCE OF TARLAC
Scale 1:300,000
0 3 6 12 18 24
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
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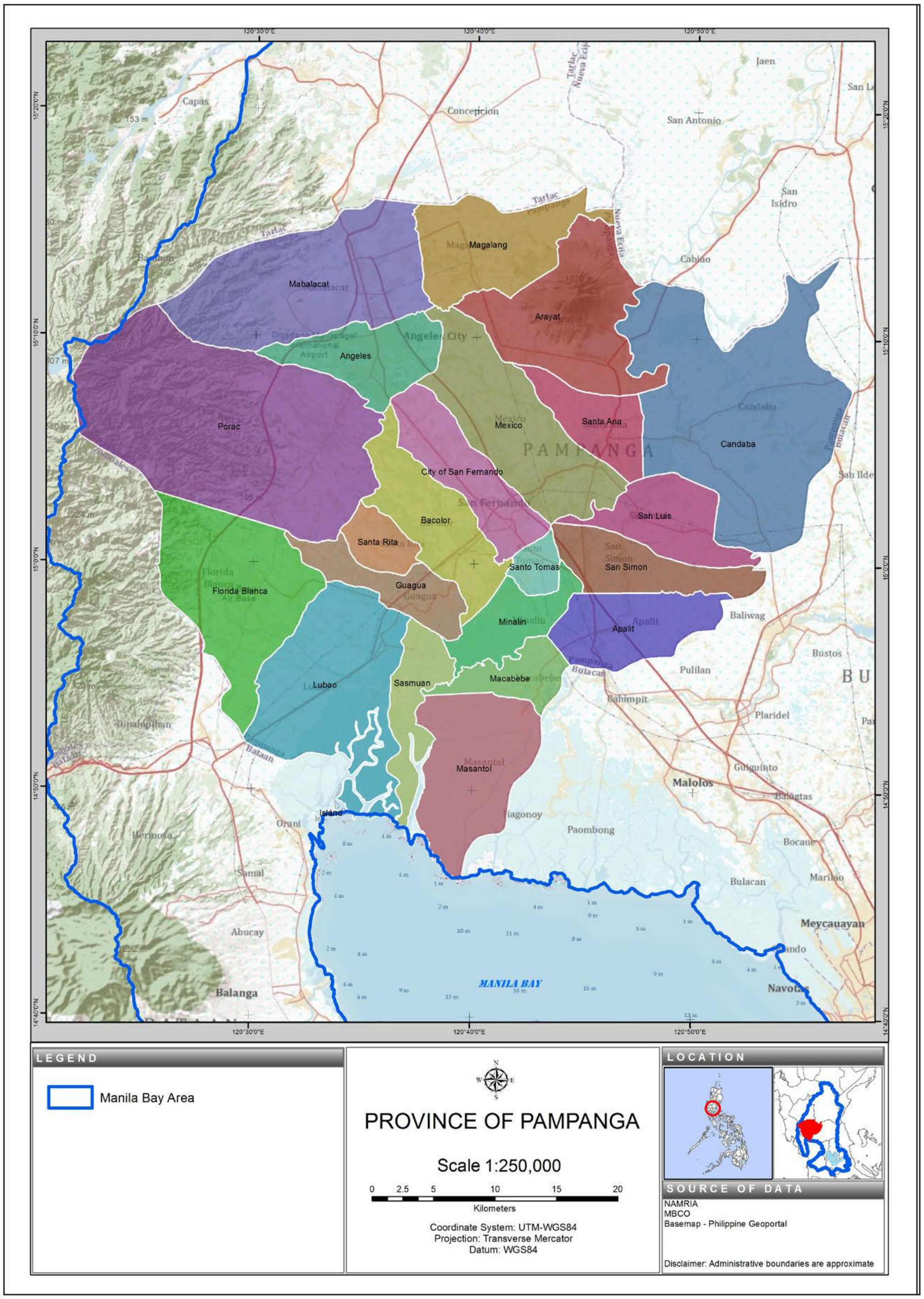
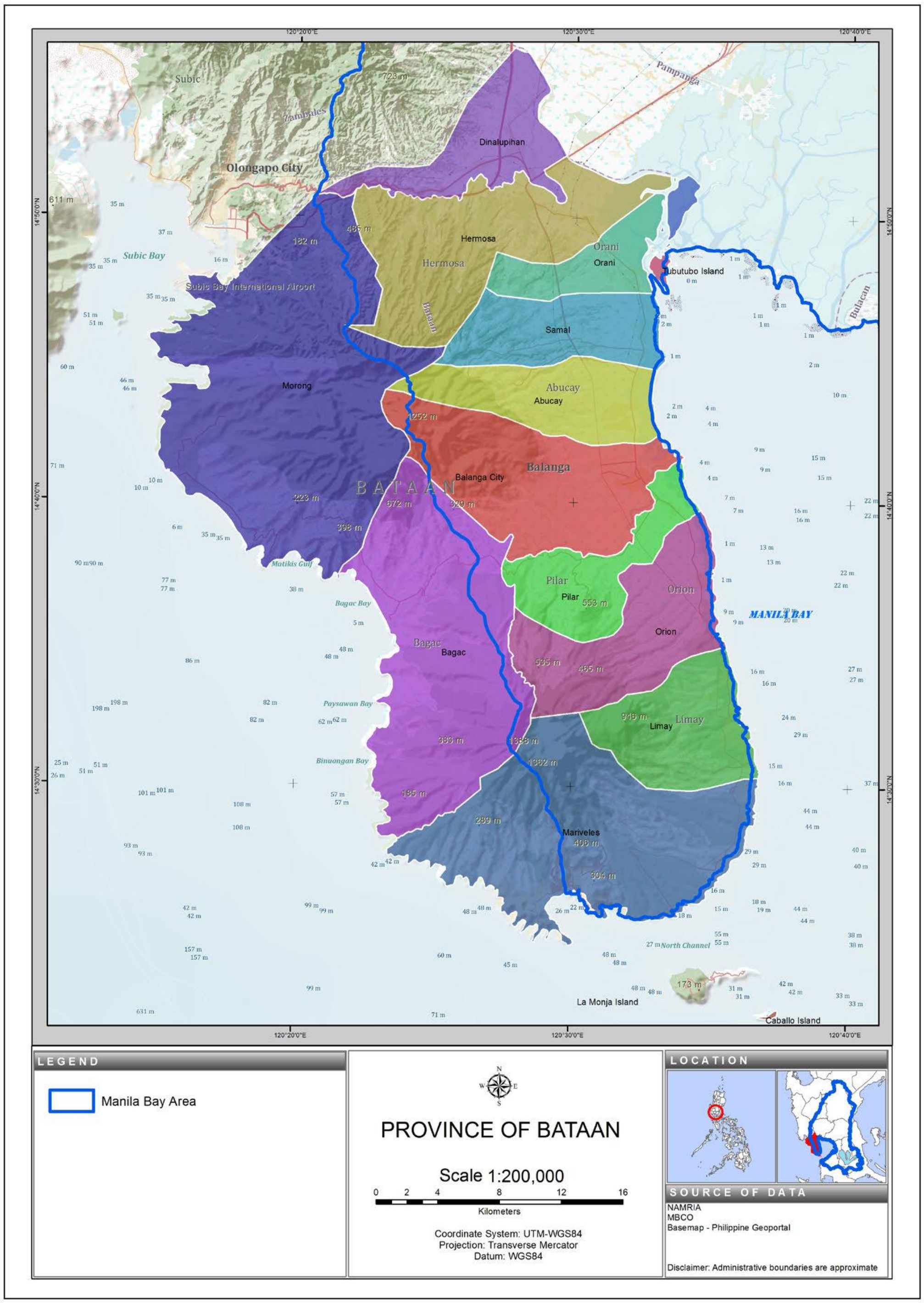
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 4


Mabalacat
Magalang
Arayat
Angeles
Porac
Mexico
Santa Ana
Candaba
City of San Fernando
Bacolor
Santa Rita
San Luis
San Simon
Santo Tomas
Florida Blanca
Guagua
Minalin
Apalit
Lubao
Sasmuan
Macabebe
Masantol
MANILA BAY
LEGEND
Manila Bay Area
PROVINCE OF PAMPANGA
Scale 1:250,000
0 2.5 5 10 15 20
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 5


Dinalupihan
Hermosa
Orani
Samal
Abucay
Morong
Balanga City
Balanga
BATAAN
Pilar
Orion
Bagac
Limay
Mariveles
Olongapo City
Subic Bay
Subic Bay International Airport
MANILA BAY
Tubutubo Island
La Monja Island
Caballo Island
North Channel
LEGEND
Manila Bay Area
PROVINCE OF BATAAN
Scale 1:200,000
Kilometers
Coordinate System: UTM-WGS84
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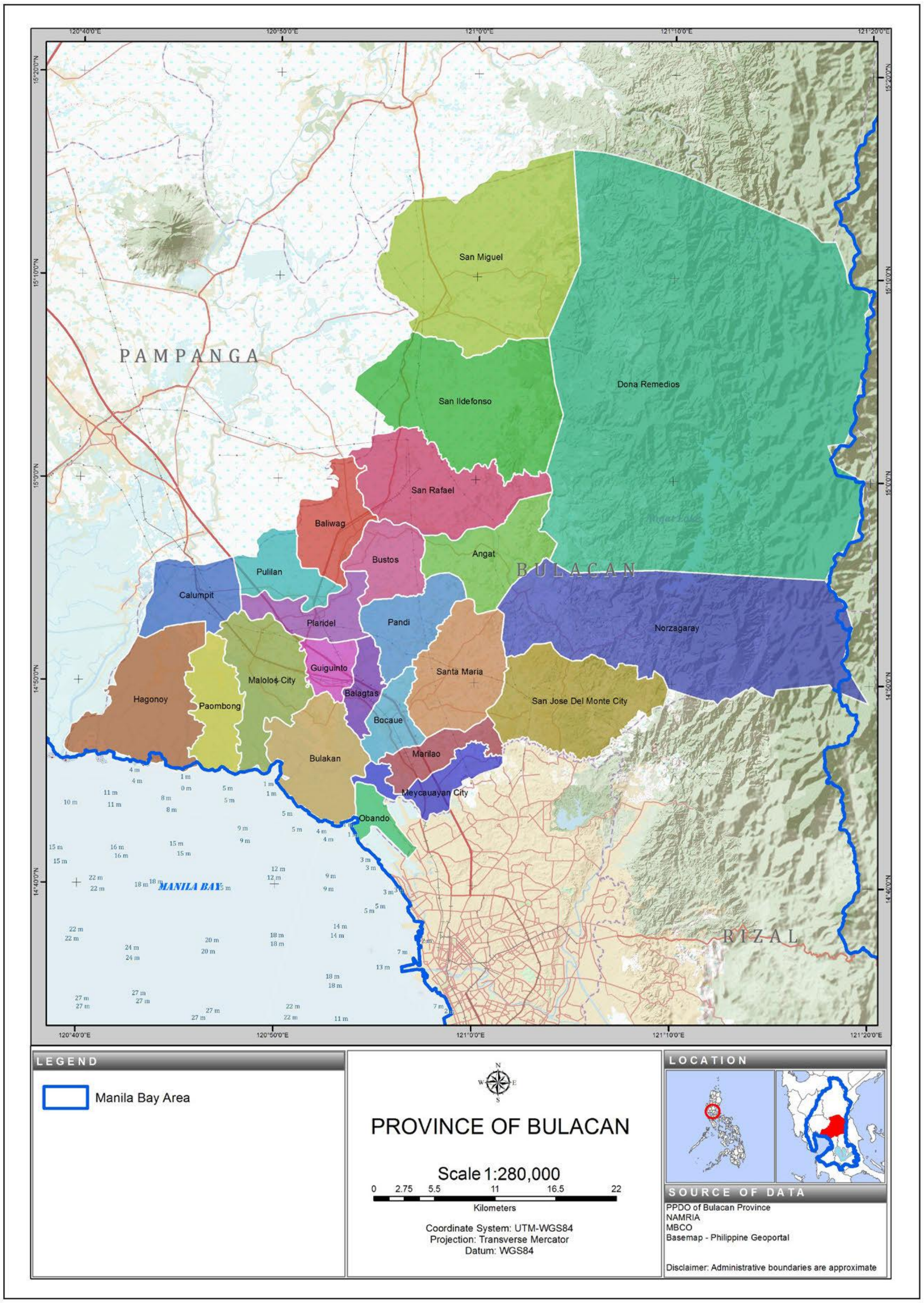
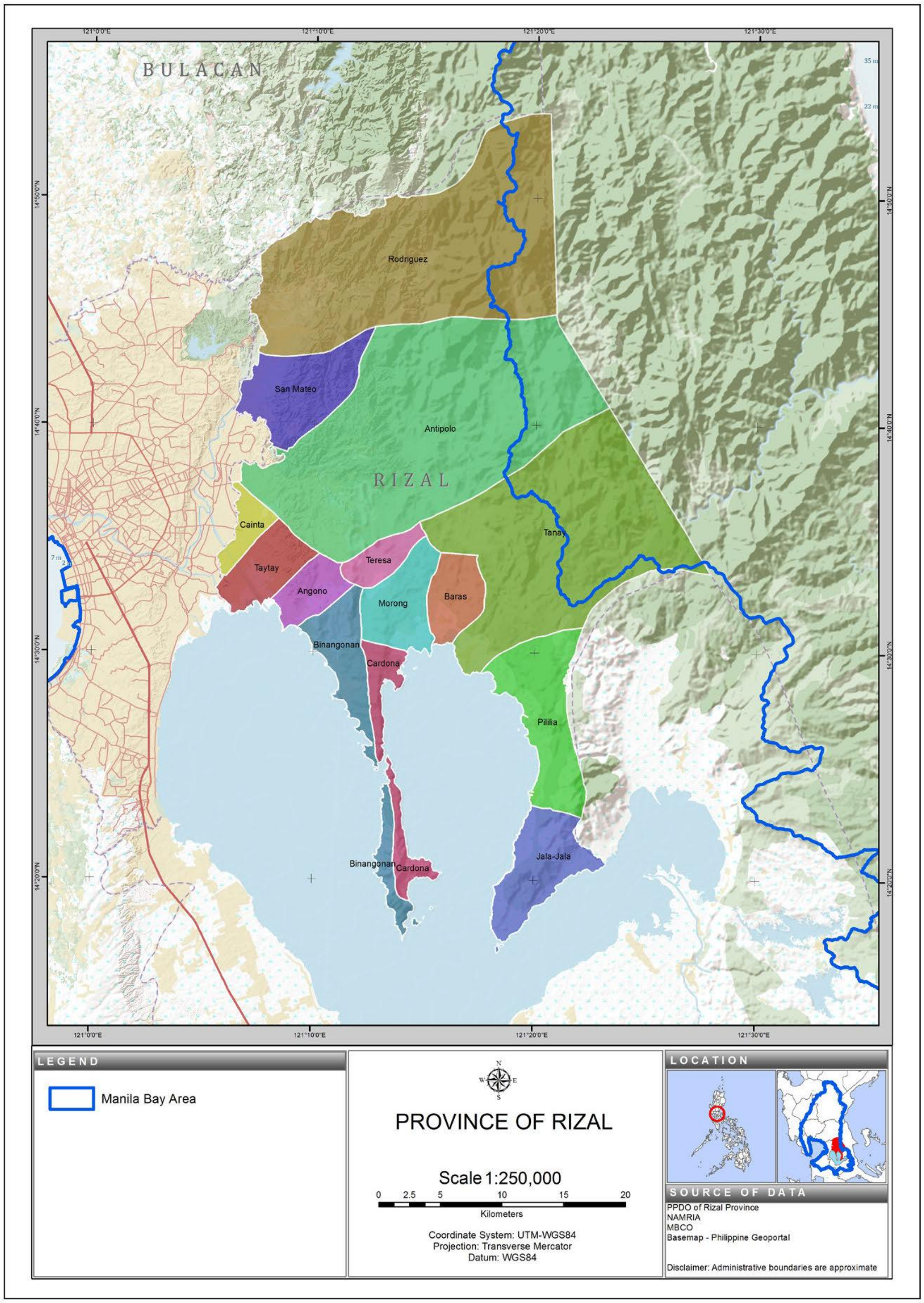
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

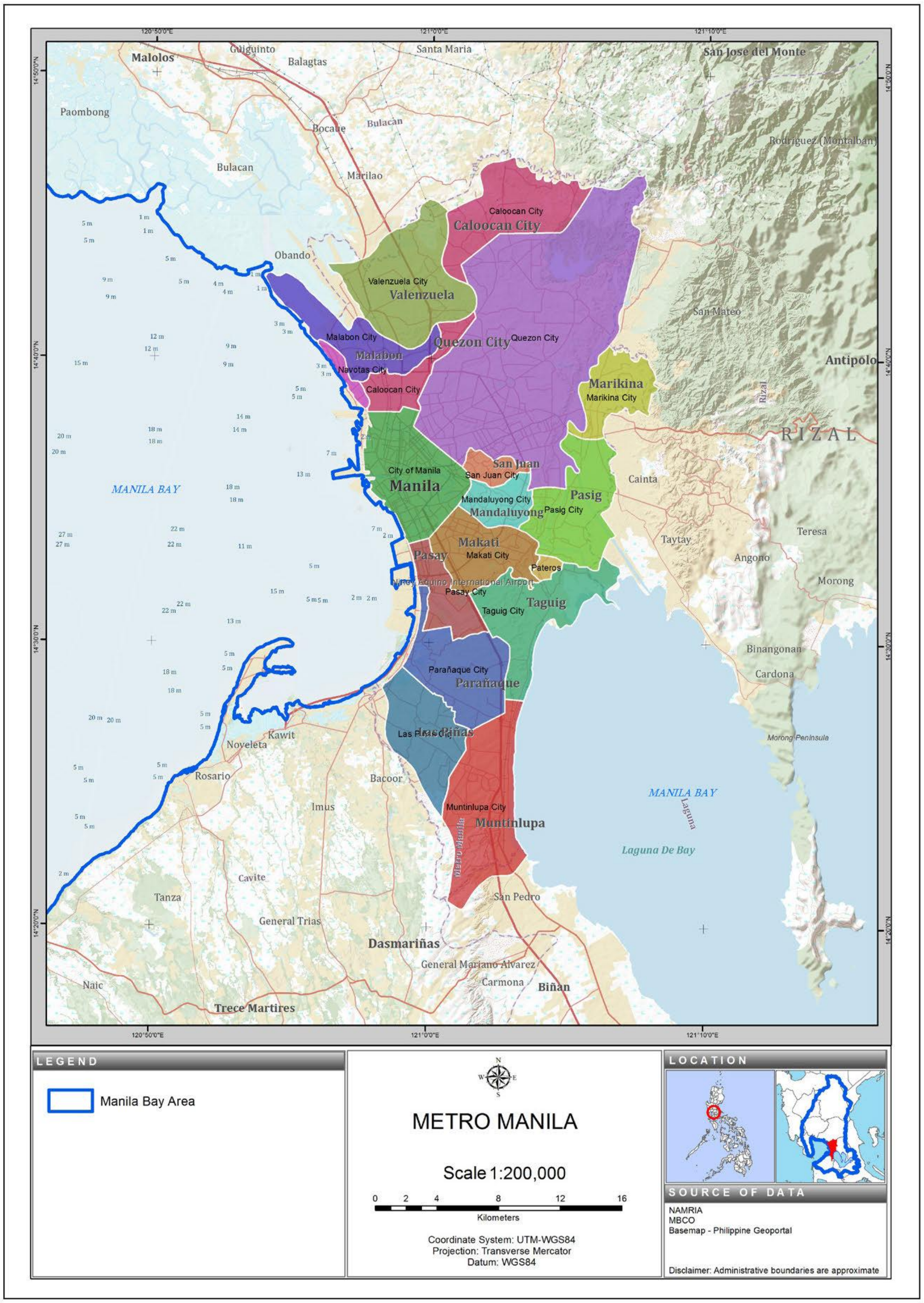
Map 6


PAMPANGA
BULACAN
RIZAL
MANILA BAY
San Miguel
Dona Remedios
San Ildefonso
San Rafael
Baliwag
Angat
Bustos
Pulilan
Calumpit
Plaridel
Pandi
Norzagaray
Guiguinto
Malolos City
Hagonoy
Paombong
Balagtas
Santa Maria
San Jose Del Monte City
Bocaue
Bulakan
Marilao
Meycauayan City
Obando
LEGEND
Manila Bay Area
PROVINCE OF BULACAN
Scale 1:280,000
0 2.75 5.5 11 16.5 22
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
PPDO of Bulacan Province
NAMRIA
MBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 7


BULACAN
RIZAL
Rodriguez
San Mateo
Antipolo
Cainta
Taytay
Teresa
Angono
Morong
Baras
Tanay
Binangonan
Cardona
Pililia
Jala-Jala
LEGEND
Manila Bay Area
PROVINCE OF RIZAL
Scale 1:250,000
0 2.5 5 10 15 20
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
PPDO of Rizal Province
NAMRIA
MBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 8


Malolos
Guiguinto
Balagtas
Santa Maria
San Jose del Monte
Paombong
Bocaue
Bulacan
Rodriguez (Montalban)
Bulacan
Marilao
Obando
Caloocan City
Caloocan City
Valenzuela City
Valenzuela
Malabon City
Malabon
Navotas City
Quezon City
Quezon City
San Mateo
Antipolo
Marikina
Marikina City
Caloocan City
Rizal
RIZAL
City of Manila
Manila
San Juan
San Juan City
Cainta
MANILA BAY
Mandaluyong City
Mandaluyong
Pasig
Pasig City
Makati
Makati City
Taytay
Teresa
Angono
Pasay
Pateros
Morong
Pasay City
Taguig
Taguig City
Binangonan
Cardona
Parañaque City
Parañaque
Kawit
Noveleta
Morong Peninsula
Rosario
Bacoor
MANILA BAY
Laguna
Imus
Muntinlupa City
Muntinlupa
Laguna De Bay
Cavite
Tanza
San Pedro
General Trias
Dasmariñas
General Mariano Alvarez
Naic
Carmona
Biñan
Trece Martires
120°50'0"E
121°0'0"E
121°10'0"E
14°50'0"N
14°40'0"N
14°30'0"N
14°20'0"N
LEGEND
Manila Bay Area
METRO MANILA
Scale 1:200,000
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Kilometers
Coordinate System: UTM-WGS84
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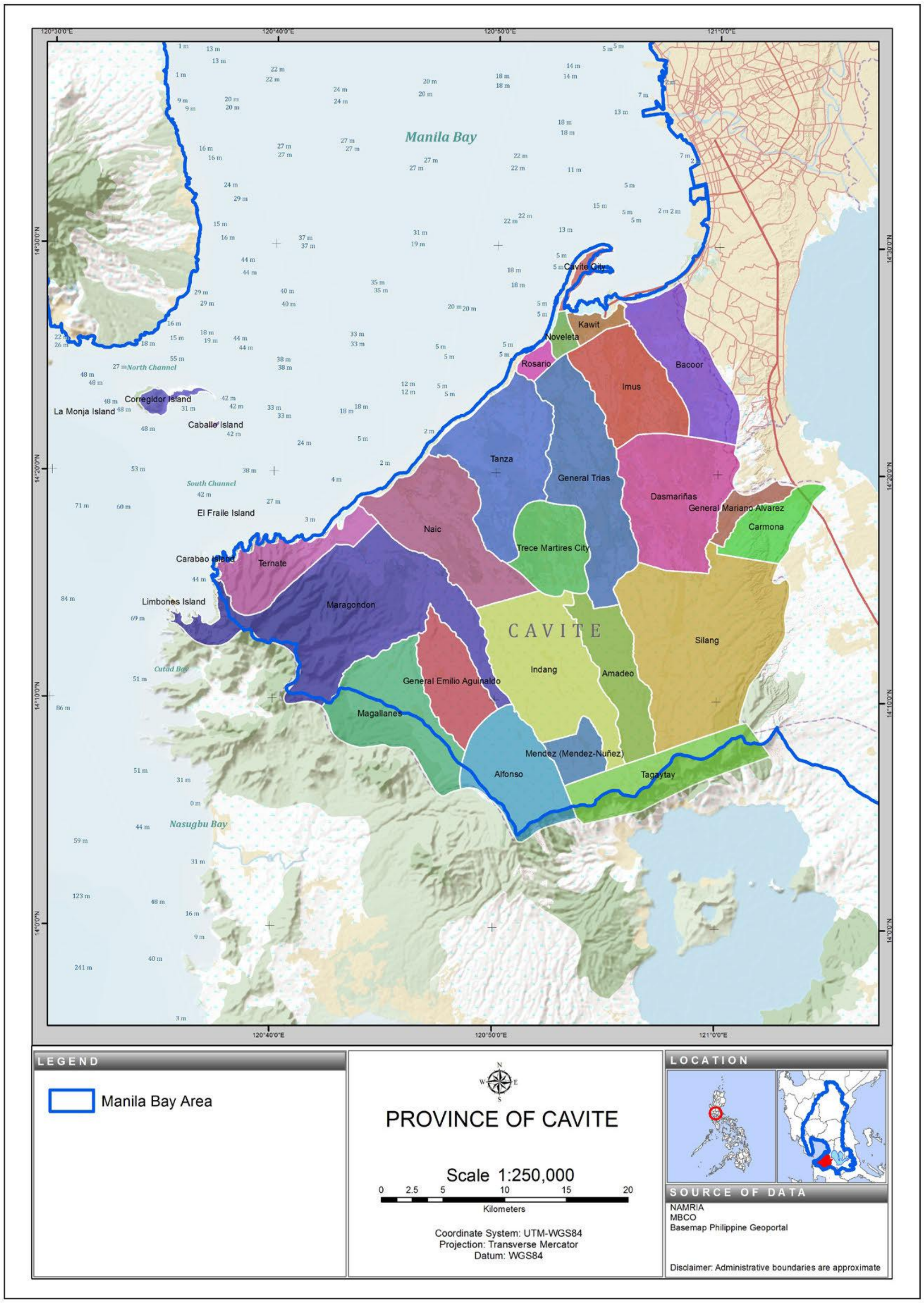
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 9


Manila Bay
North Channel
South Channel
Nasugbu Bay
Cutad Bay
Corregidor Island
La Monja Island
Caballo Island
El Fraile Island
Carabao Island
Limbones Island
Cavite City
Kawit
Noveleta
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Bacoor
Imus
Tanza
General Trias
Dasmariñas
General Mariano Alvarez
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Ternate
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CAVITE
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Kilometers
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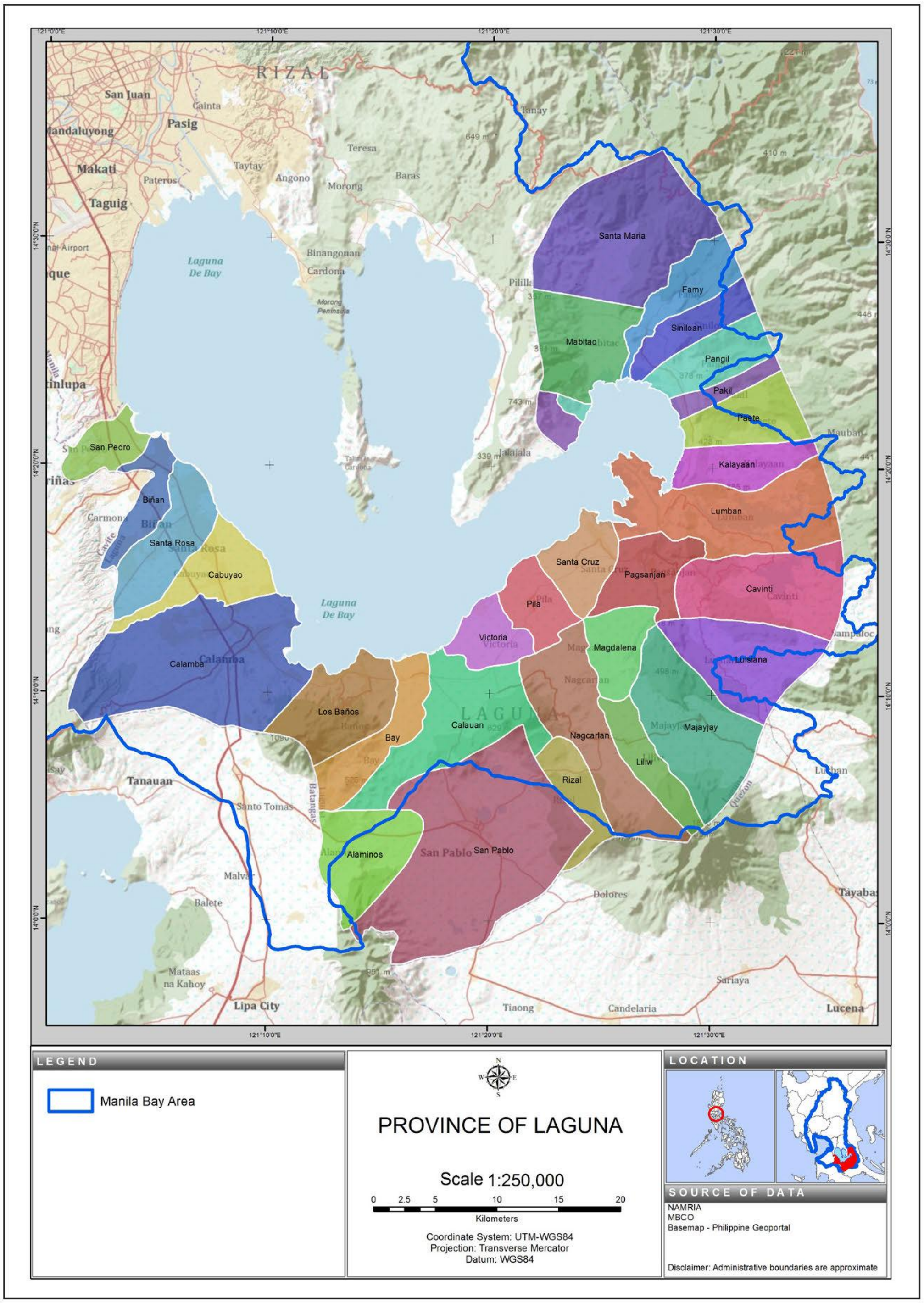
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
Basemap Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 10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Taguig
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Cainta
Taytay
Angono
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Morong
Baras
Binangonan
Cardona
Morong Peninsula
Tanay
Pililla
Jalajala
Laguna De Bay
Muntinlupa
San Pedro
Biñan
Santa Rosa
Cabuyao
Calamba
Carmona
Cavite
Los Baños
Bay
Calauan
Victoria
Pila
Santa Cruz
Pagsanjan
Magdalena
Nagcarlan
Majayjay
Liliw
Rizal
San Pablo
Alaminos
Santa Maria
Famy
Siniloan
Mabitac
Pangil
Pakil
Paete
Kalayaan
Lumban
Cavinti
Luisiana
Mauban
Sampaloc
Lucban
Tayabas
Quezon
Dolores
Sariaya
Candelaria
Tiaong
Lucena
Lipa City
Mataas na Kahoy
Balete
Malvar
Santo Tomas
Tanauan
Batangas
LAGUNA
121°0'0"E
121°10'0"E
121°20'0"E
121°30'0"E
14°30'0"N
14°20'0"N
14°10'0"N
14°0'0"N
LEGEND
Manila Bay Area
PROVINCE OF LAGUNA
Scale 1:250,000
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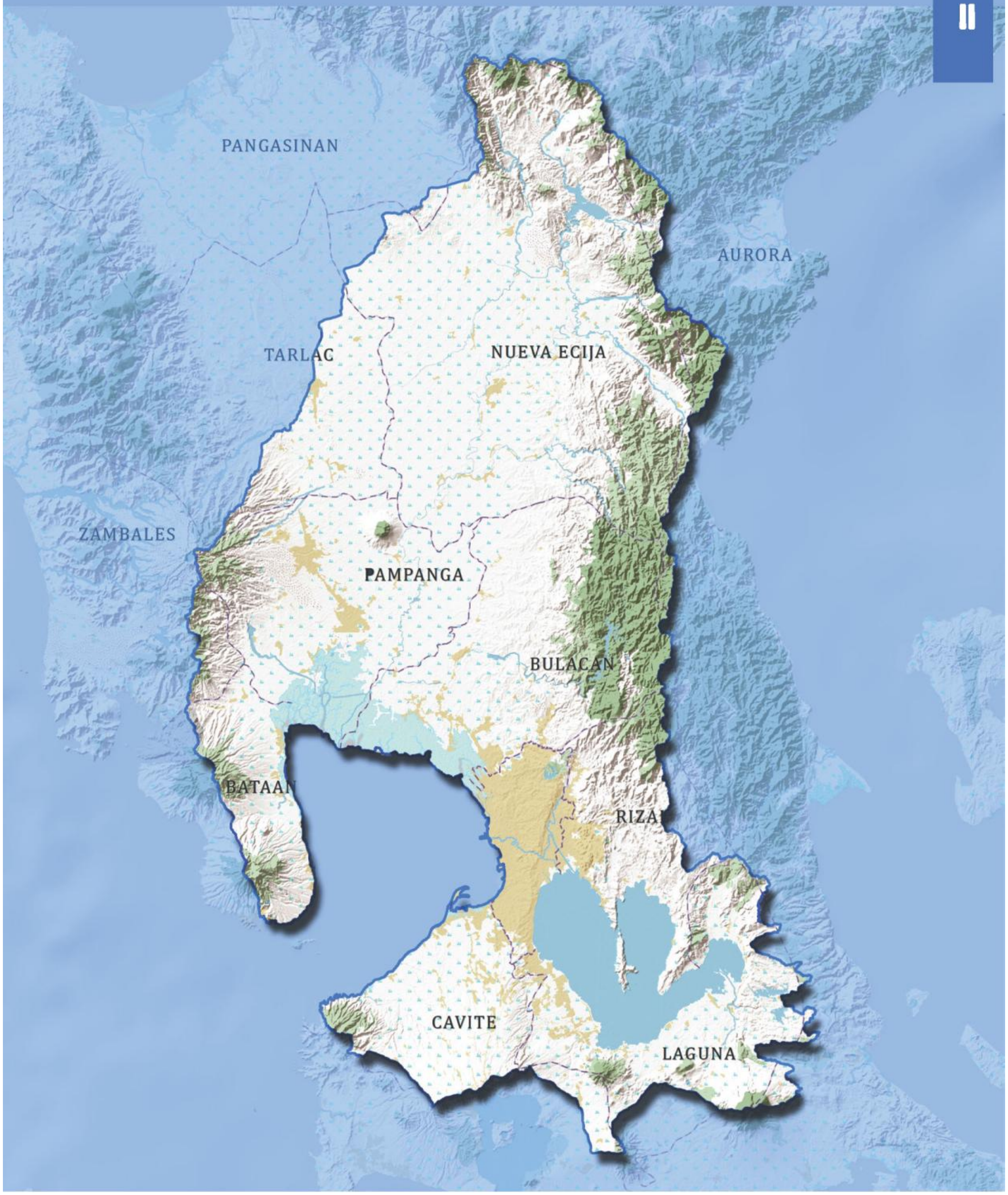
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

TRENDS AND EMERGING ISSUES ON DEMOGRAPHY AND SOCIO-ECONOMIC STATUS IN THE MANILA BAY AREA

PART II



A. DEMOGRAPHY

POPULATION

Historical data shows a fourfold increase of the population of the Manila Bay Area in the years between1960 and 2000. Since then, it has continuously increased due to the steady inflow of migrants from across all regions in the country. In 2010, the total population of MBA is estimated at 37 million, an 11% increase from the 2000 population of 33 million.

The National Capital Region remains to be the most populous area within MBA, followed by the provinces of Cavite and Bulacan. Rapid population growth in the aforementioned is attributed to the influx of migrant workers seeking employment and other opportunities.

Densely populated Metro Manila

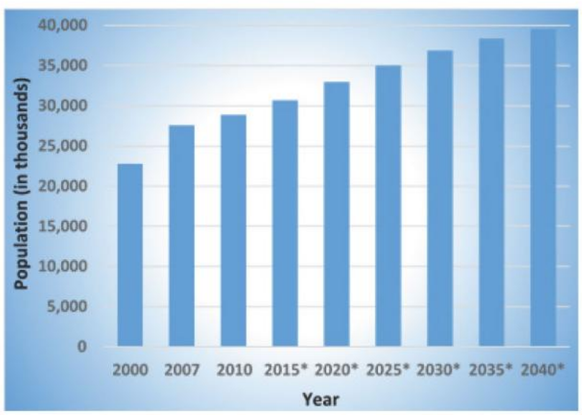
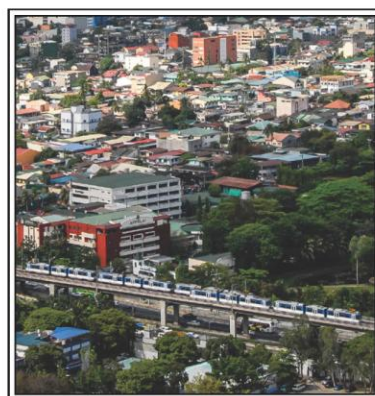


Figure 1. Total population in the Manila Bay Area (2000-2040)



Increasing demand for transport services with increasing population

Table 2. Total Population per province* in the MBA

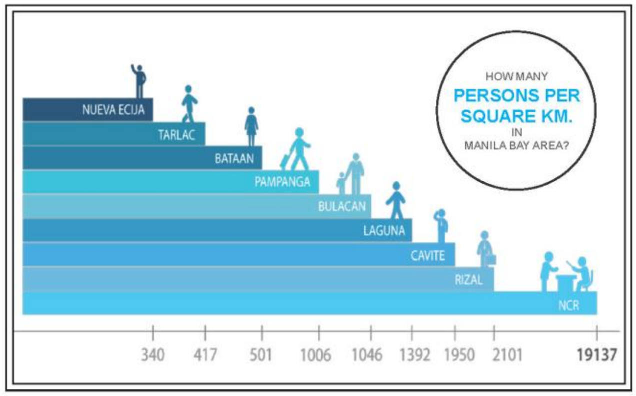
Region/ Province	2000	2007	2010	2015*	2020*	2025*	2030*	2035*	2040*
Nueva Ecija	1,659,883	1,843,853	1,955,373	2,121,500	2,264,400	2,392,200	2,500,700	2,590,000	2,658,600
Tarlac	1,068,783	1,243,449	1,273,240	1,381,700	1,477,300	1,564,700	1,640,200	1,702,000	1,749,800
Pampanga	1,618,759	1,911,951	2,014,019	2,476,000	2,656,800	2,823,900	2,971,200	3,092,800	3,185,100
Bataan	557,659	662,153	687,482	733,800	788,400	837,600	879,400	914,500	940,000
Bulacan	2,234,088	2,822,216	2,924,433	3,364,600	3,746,900	4,125,400	4,489,300	4,830,500	5,141,900
Rizal	1,707,218	2,298,691	2,484,840	2,463,500	2,678,300	2,880,200	3,061,900	3,219,100	3,349,300
Metro Manila	9,932,560	11,491,464	11,796,873	12,220,500	12,775,900	13,216,700	13,545,900	13,740,300	13,788,000
Cavite	2,063,161	2,856,765	3,090,691	3,324,000	3,747,900	4,181,300	4,604,300	5,008,700	5,383,700
Laguna	1,965,872	2,473,530	2,669,847	2,626,800	2,824,800	3,005,400	3,162,200	3,292,300	3,395,200
TOTAL	**22,807,983**	**27,604,072**	**28,896,798**	**30,712,400**	**32,960,700**	**35,027,400**	**36,855,100**	**38,390,200**	**39,591,600**

Source: NSO (Population coverage including parts of selected LGUs in Bataan, Cavite, Laguna, Nueva Ecija, Rizal and Tarlac outside the delineated MBA boundary)
** NSO 2000 census-based population projection (medium series)*

POPULATION DENSITY AND GROWTH RATE

Increasing economic opportunities and better access to social welfare services are the pull factors for the increasing population density in the MBA. Based on NSO's 2010 Census of Population and Housing (CPH), the three regions comprising MBA registered the highest combined population densities in the Philippines. The National Capital Region (NCR) alone holds 19,137 persons per square kilometer - a 60 fold increase from the national density of 308 persons per square kilometer. Regions IVA (CALABARZON) and III (Central Luzon) have also exceeded the national density. Figure 2 to 10 presents the population density by province for 2010.

While these figures translate to a large supply of labour force for various economies of scale, providing equal employment opportunities for all remain a challenge.



Source: NSO, 2010 Census of Population and Housing

AGE-SEX STRUCTURE

Strong similarities were observed with the distribution by age and sex in the MBA for 2000 and 2010. Figures 2-10 presents an expansive population for all of the provinces within the Manila Bay Area - as depicted by wider bases. These structures reveal a larger population in the younger age groups - represented by both young dependents and the working age group - as compared to the old dependent population.

On the other hand, the sex ratio in the MBA for 2010 stands at 99 males for every 100 females. According to the 2010 CPH, slight differences can be observed when compared to the national sex ratio of 102 males per 100 females. Resulting statistics were affected by the larger female population in the NCR (96 males per 100 females).

Lastly, the dependency ratio of the MBA (48 dependents per 100 persons in the working-age group) is relatively lower than the overall dependency ratio of the Philippines for 2010 (61 dependents per 100 persons in the working-age group).

Decreasing dependency ratio in the MBA since 2000 is tantamount to the increasing labor participation rate in the major growth centers in the NCR, as well as Regions III and IVA.

People working in urban areas waiting to catch their bus

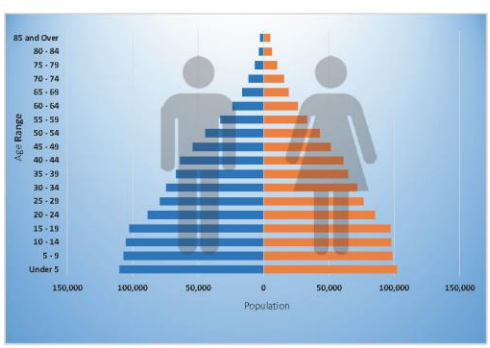


Figure 2. Age-Sex Structure of Population in Nueva Ecija (2010)

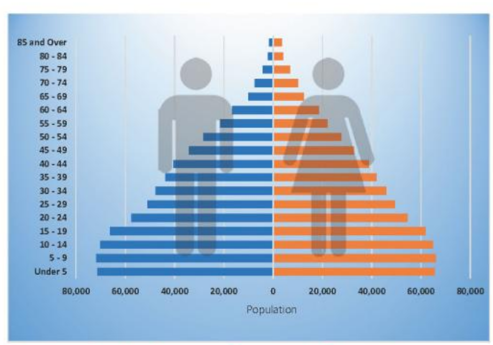


Figure 3. Age-Sex Structure of Population in Tarlac (2010)

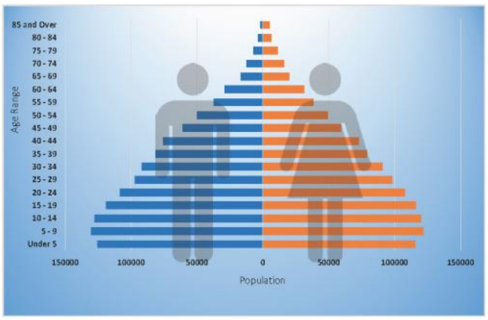


Figure 4. Age-Sex Structure of Population in Pampanga (2010)

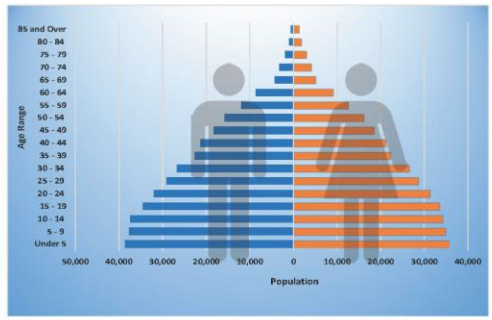


Figure 5. Age-Sex Structure of Population in Bataan (2010)

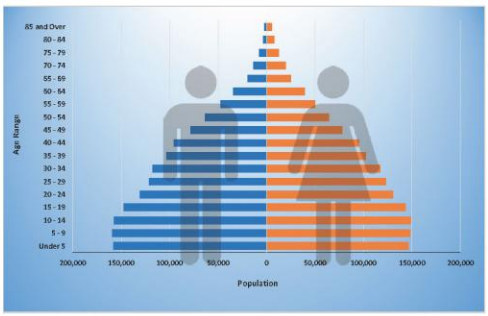


Figure 6. Age-Sex Structure of Population in Bulacan (2010)

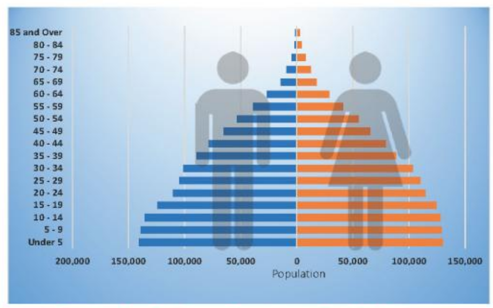


Figure 7. Age-Sex Structure of Population in Rizal (2010)

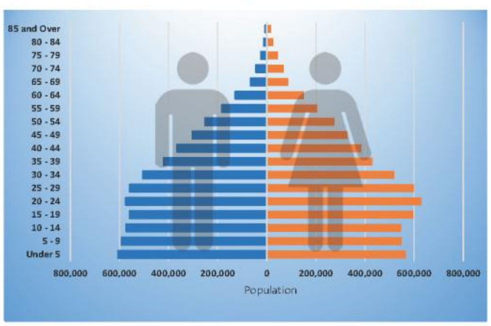


Figure 8. Age-Sex Structure of Population in NCR (2010)

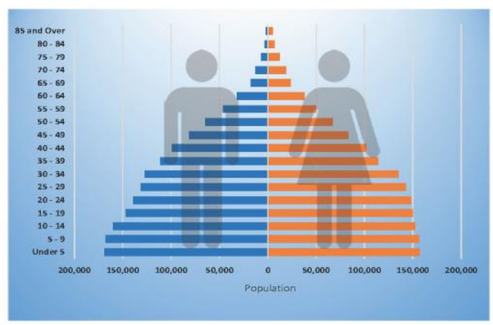


Figure 9. Age-Sex Structure of Population in Cavite (2010)

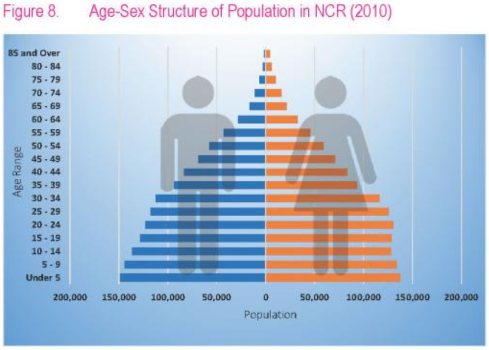


Figure 10. Age-Sex Structure of Population in Laguna (2010)

RELIGION

Roman Catholicism remains to be the dominant religion in the MBA. This is followed by other Christian denominations, Protestants, Iglesia ni Cristo, Aglipayan, El Shaddai and Islam/Muslim.

LANGUAGE

The 'Tagalog' (also known as 'Filipino') and its dialectal variations remain to be the main spoken and written language in the Manila Bay Area. The predominance of native Tagalog speakers can be attributed to the media of instruction (Filipino and English) used in primary and secondary schools.

Aside from Tagalog, Kapampangan, Ilocano, Pangasinan and Chabacano are also used by a considerable number of the population.

POVERTY INCIDENCE AND THE HUMAN DEVELOPMENT INDEX (HDI)

Analyzing poverty incidence in the Philippines is mirrored through the Human Development Indices (HDIs) of each province. According to the United Nations Development Programme (UNDP), the HDI 'is a summary measure of human development, computed using the average achievement in the three basic dimensions: a long and healthy life, knowledge, and a decent standard of living' (UNDP, 2007). With ideal marks closer to 1, the HDI rests on income as means to achieve human development and not an end result.

The 1997-2009 HDIs, as analyzed in the 2012/2013 Philippine Human Development Report (PHDR) presents relatively higher indices in all nine provinces within the MBA, including the NCR. Six out of the ten highest listed provinces are located in the watershed area, namely Rizal (0.734), Cavite (0.709), Bulacan (0.699), Bataan (0.698), Laguna (0.695) and Pampanga (0.634). The concentration of social and economic opportunities in the MBA are the main reasons for such increase.

Despite the 'improving human development' in the MBA, the UNDP still highlights inequality and disparity on the social strata as major barriers for optimal growth.

INFORMAL SETTLEMENTS

The United Nations Human Settlement Programme (UN-Habitat) defines informal settlements 'as areas where groups of housing units have been constructed on land that the occupants have no legal claim to, and where housing is not in compliance with current planning and building regulations' (HUDCC, 2014). According to the Housing and Urban Development Coordinating Council (HUDCC), tangential to improving economic growth and increasing natural birth rates are the pervasiveness of informal settlements - particularly in major urban centers.

From 2000, the Manila Bay Area saw an increasing number of informal settlements - particularly in danger areas (such as along and within the waterways) as well as private and government-owned properties. Table 3 provides a detailed inventory of informal settler families (ISFs) within MBA.

A wide number of Informal settlements are found along waterways

Quiapo Church

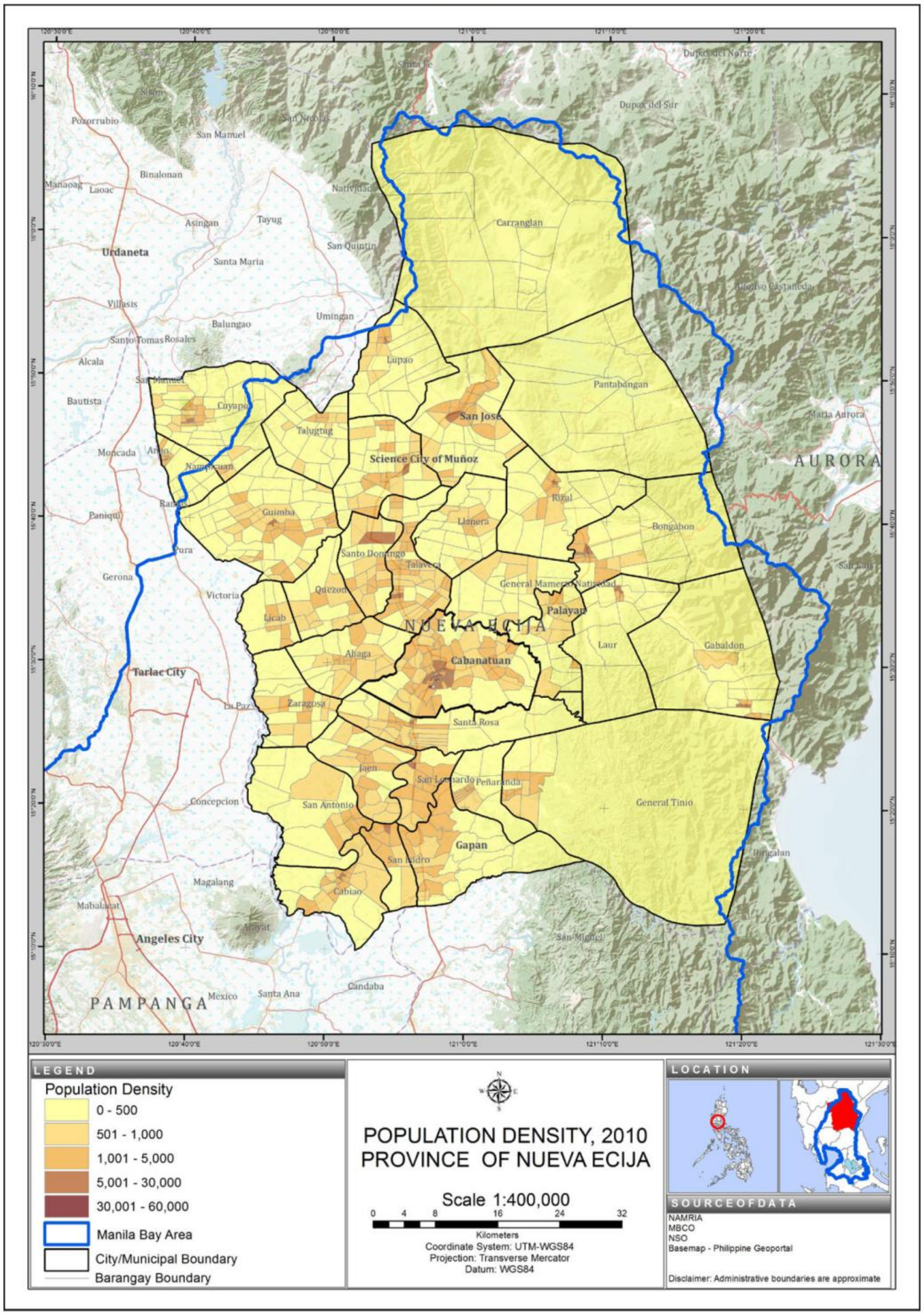
Table 3. Inventory of ISFs within the MBA

Major Indicator	Location	Baseline (as of 2012)	Adjusted Baseline (as of 3rd Quater 2014)
Along coastal, shorelines and other waterways		80,576	119,662
	NCR	65,723	65,723
	1.Caloocan	6,074	6,074
	2.Las Piñas	3,116	3,116
	3.Malabon	3,991	3,991
	4.Makati	1,827	1,827
	5.Mandaluyong	662	662
	6.Manila	2,726	2,726
	7.Marikina	505	505
	8.Muntinlupa	3,686	3,686
	9.Navotas	7,342	7,342
	10.Parañaque	914	914
	11.Pasay	4,200	4,200
	12.Pasig	8,777	8,777
	13.Pateros	2,029	2,029
	14.Quezon City	11,434	11,434
	15.San Juan	1,375	1,375
	16.Taguig	3,672	3,672
	17.Valenzuela	3,393	3,393
	Region III	6,819	15,248
	1.Bulacan	1,256	1,927
	2.Pampanga	1,073	6,167
	3.Tarlac	643	900
	4.N. Ecija	2,945	4,279
	5.Bataan	902	1,975
	Region IV-A*	8,034	38,691
	1.Rizal	6,006	10,541
	2.Cavite	739	16,583
	3.Laguna	1,289	11,567
Other concerned areas for immediate rehab	Navotas Fishport Compound	850	1,154
	Protected Areas (Pas), Key Biodiversity Areas (KBAs) and Critical Habitats (CHs)	-	To be identified

* Adjusted baseline for Region IV-A as of 2nd Quarter of CY 2014

A number of interventions are being implemented by various housing institutions to address these concerns. A common meeting point will need to be established to harmonize all pipeline measures.

Map 11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Population Density
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1,001 - 5,000
5,001 - 30,000
30,001 - 60,000
Manila Bay Area
City/Municipal Boundary
Barangay Boundary
POPULATION DENSITY, 2010
PROVINCE OF NUEVA ECIJA
Scale 1:400,000
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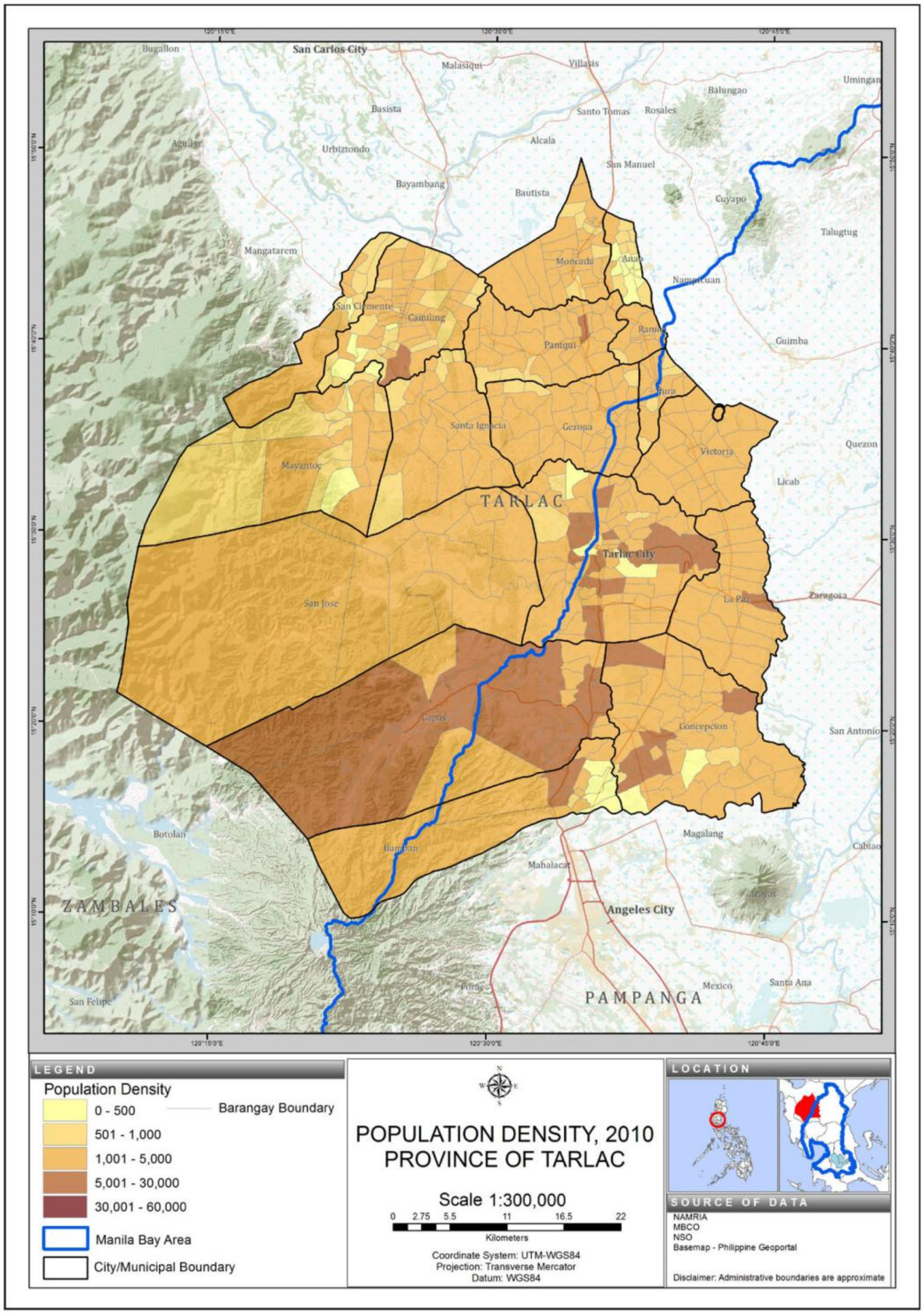
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCEOFDATA
NAMRIA
MBCO
NSO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate
NUEVA ECIJA
AURORA
PAMPANGA
Carranglan
Pantabangan
Lupao
San Jose
Science City of Muñoz
Talugtug
Cuyapo
Nampicuan
Guimba
Rizal
Llanera
Bongabon
Santo Domingo
Talavera
General Mamerto Natividad
Quezon
Palayan
Licab
Aliaga
Cabanatuan
Laur
Gabaldon
Zaragosa
Santa Rosa
Jaen
San Leonardo
Peñaranda
General Tinio
San Antonio
Gapan
San Isidro
Cabiao
Urdaneta
Tarlac City
Angeles City
Concepcion
Magalang
Mexico
Santa Ana
Candaba
San Miguel
Dingalan
Maria Aurora
Dupax del Sur
Dupax del Norte
San Quintin
Umingan
Balungao
Tayug
Asingan
Santa Maria
Binalonan
San Manuel
Pozorrubio
Laoac
Manaoag
Villasis
Santo Tomas
Rosales
Alcala
Bautista
Moncada
Paniqui
Gerona
Victoria
Pura
Ramos
Anao
La Paz
Mabalacat
Arayat

Map 12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Villasis
Balungao
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Rosales
Aguilar
Urbiztondo
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Bayambang
Bautista
Cuyapo
Talugtug
Mangatarem
Moncada
Anao
San Clemente
Camiling
Pantqui
Guimba
Santa Ignacia
Gerona
Victoria
Quezon
Mayantoc
Licab
TARLAC
Tarlac City
San Jose
La Paz
Zaragosa
Capas
Concepcion
San Antonio
Botolan
Magalang
Cabiao
Bamban
Mabalacat
ZAMBALES
Angeles City
Mexico
Santa Ana
San Felipe
PAMPANGA
LEGEND
Population Density
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1,001 - 5,000
5,001 - 30,000
30,001 - 60,000
Barangay Boundary
Manila Bay Area
City/Municipal Boundary
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PROVINCE OF TARLAC
Scale 1:300,000
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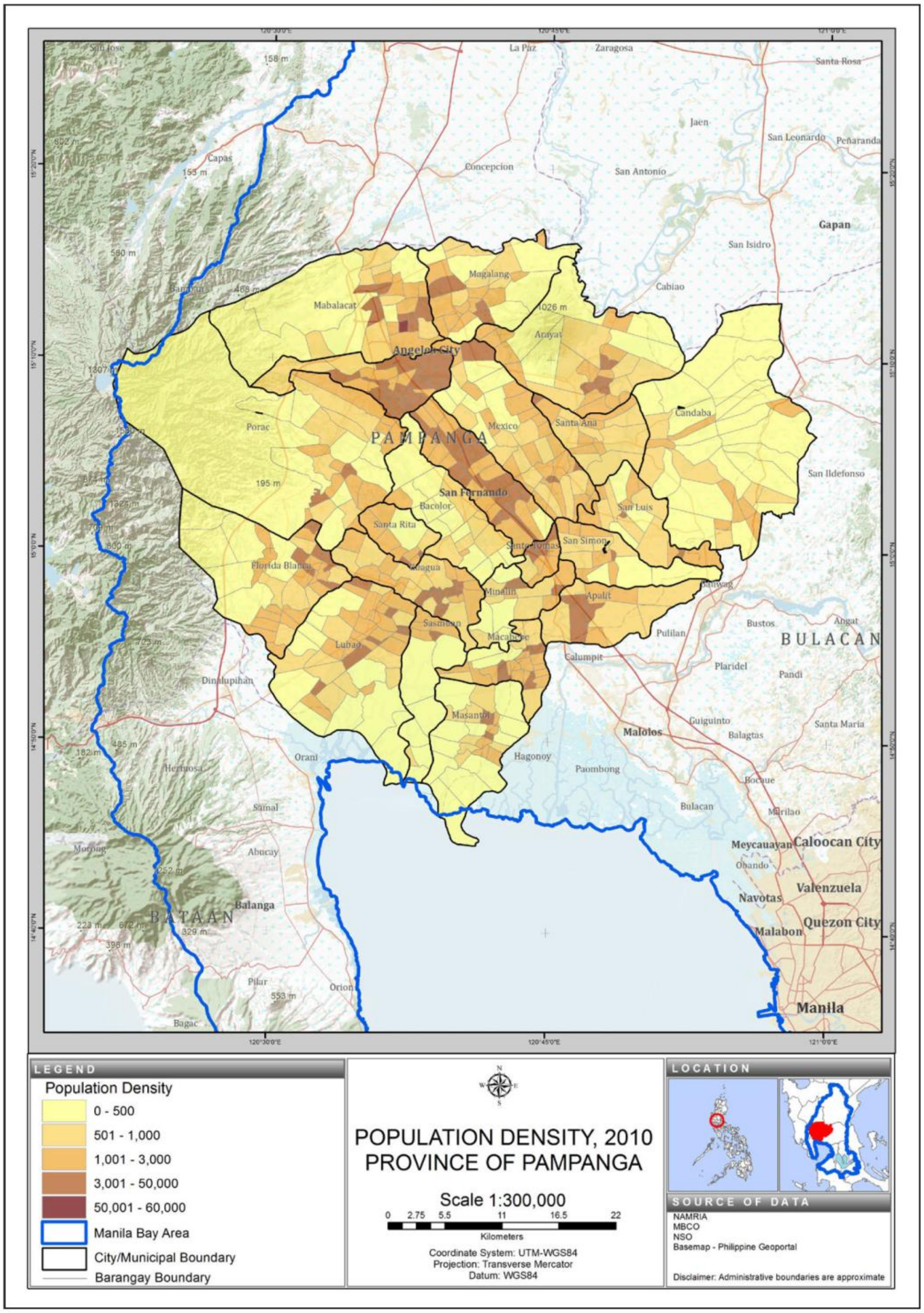
MBCO
NSO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 13


POPULATION DENSITY, 2010
PROVINCE OF PAMPANGA
LEGEND
Population Density
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50,001 - 60,000
Manila Bay Area
City/Municipal Boundary
Barangay Boundary
Scale 1:300,000
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Datum: WGS84
LOCATION
SOURCE OF DATA
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MBCO
NSO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate
PAMPANGA
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BATAAN
Mabalacat
Magalang
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Arayat
Porac
Mexico
Santa Ana
Candaba
San Fernando
Bacolor
San Luis
Santa Rita
San Simon
Florida Blanca
Guagua
Minalin
Apalit
Sasmuan
Lubao
Macabebe
Masantol
Calumpit
Malolos
Hagonoy
Paombong
Manila
Quezon City
Valenzuela
Caloocan City
Malabon
Navotas
Gapan
San Isidro
Concepcion
San Antonio
Jaen
San Leonardo
Peñaranda
Santa Rosa
Zaragosa
La Paz
Capas
Cabiao
San Ildefonso
Pulilan
Plaridel
Bustos
Angat
Pandi
Guiguinto
Balagtas
Santa Maria
Bocaue
Marilao
Bulacan
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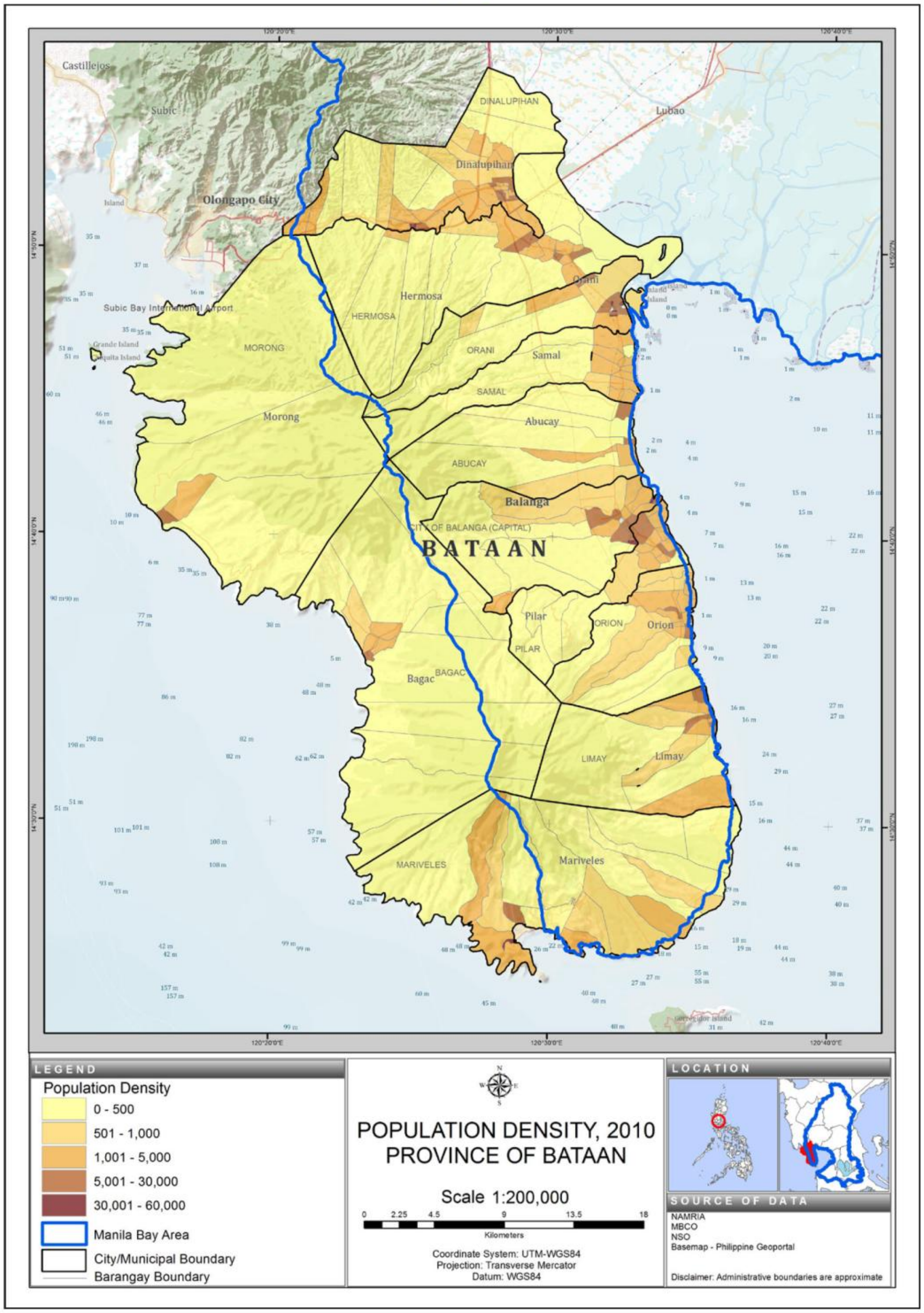
Obando
Dinalupihan
Hermosa
Orani
Samal
Abucay
Balanga
Pilar
Orion
Bagac

Map 14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Population Density
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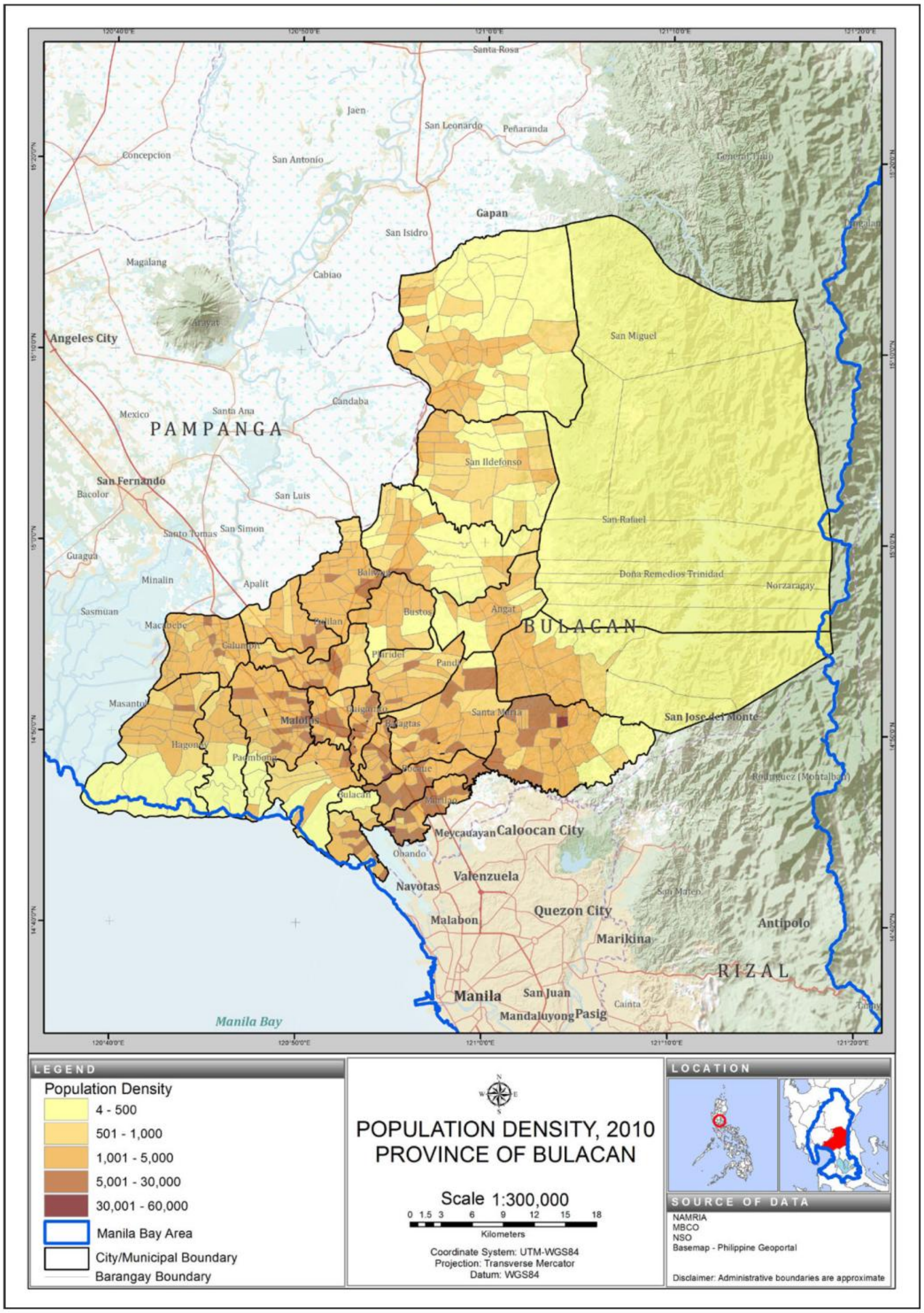
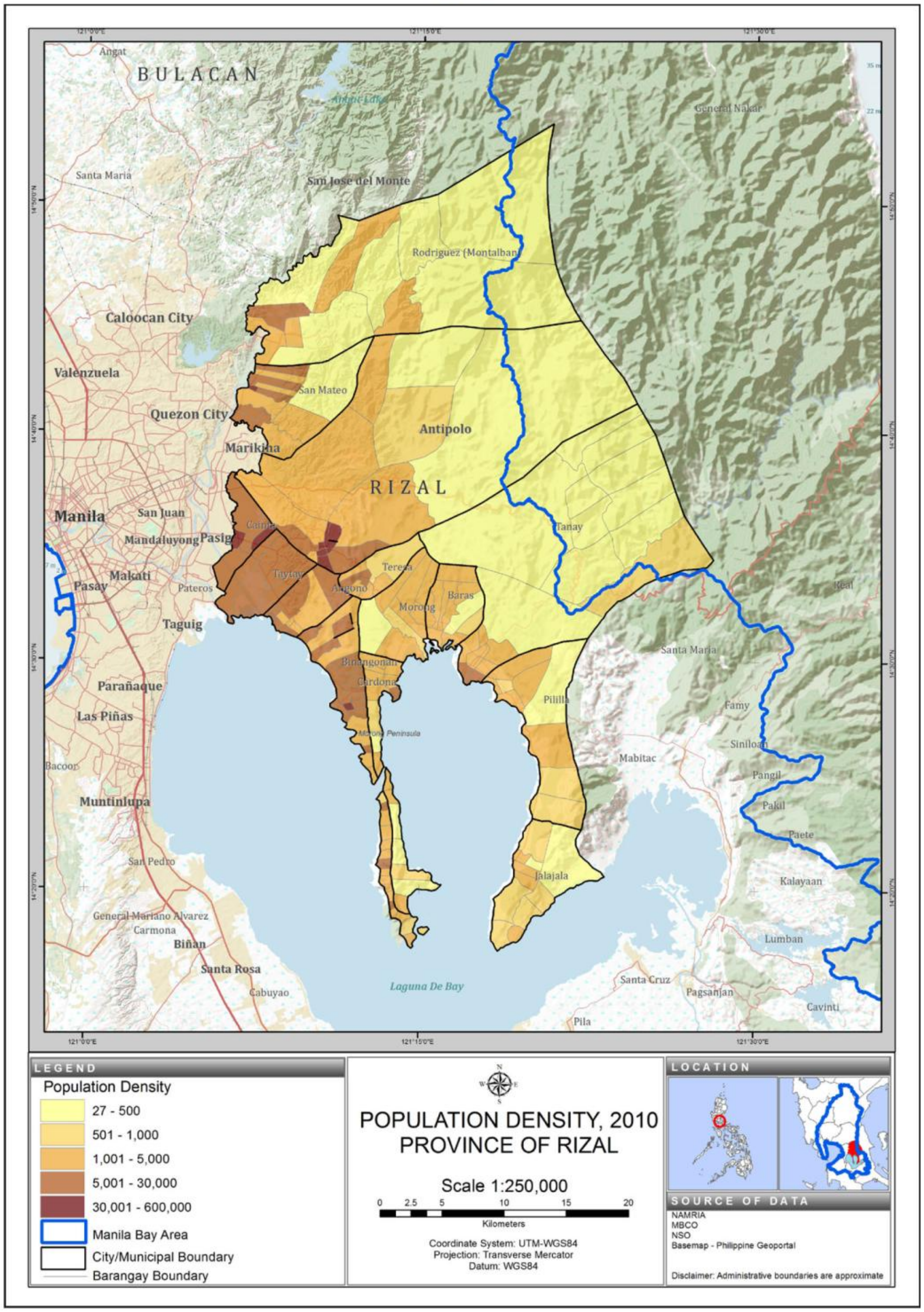
5,001 - 30,000
30,001 - 60,000
Manila Bay Area
City/Municipal Boundary
Barangay Boundary
POPULATION DENSITY, 2010
PROVINCE OF BATAAN
Scale 1:200,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
NSO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate
BATAAN
DINALUPIHAN
HERMOSA
MORONG
ORANI
SAMAL
ABUCAY
CITY OF BALANGA (CAPITAL)
PILAR
ORION
BAGAC
LIMAY
MARIVELES
Olongapo City
Subic Bay International Airport
Lubao

Map 15


PAMPANGA
BULACAN
RIZAL
Manila Bay
Angeles City
San Fernando
Malolos
Caloocan City
Quezon City
Valenzuela
Malabon
Navotas
Manila
San Jose del Monte
San Miguel
San Ildefonso
San Rafael
Doña Remedios Trinidad
Norzagaray
LEGEND
Population Density
4 - 500
501 - 1,000
1,001 - 5,000
5,001 - 30,000
30,001 - 60,000
Manila Bay Area
City/Municipal Boundary
Barangay Boundary
POPULATION DENSITY, 2010
PROVINCE OF BULACAN
Scale 1:300,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
NSO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 16


BULACAN
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Santa Maria
San Jose del Monte
General Nakar
Rodriguez (Montalban)
Caloocan City
Valenzuela
San Mateo
Quezon City
Antipolo
Marikina
RIZAL
Manila
San Juan
Mandaluyong
Pasig
Tanay
Makati
Pasay
Pateros
Taytay
Angono
Teresa
Morong
Baras
Taguig
Binangonan
Cardona
Pililla
Santa Maria
Famy
Siniloan
Parañaque
Las Piñas
Bacoor
Muntinlupa
Mabitac
Pangil
Pakil
Paete
San Pedro
Jalajala
Kalayaan
General Mariano Alvarez
Carmona
Biñan
Lumban
Santa Rosa
Cabuyao
Laguna De Bay
Santa Cruz
Pagsanjan
Cavinti
Pila
LEGEND
Population Density
27 - 500
501 - 1,000
1,001 - 5,000
5,001 - 30,000
30,001 - 600,000
Manila Bay Area
City/Municipal Boundary
Barangay Boundary
POPULATION DENSITY, 2010
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Scale 1:250,000
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Kilometers
Coordinate System: UTM-WGS84
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LOCATION
SOURCE OF DATA
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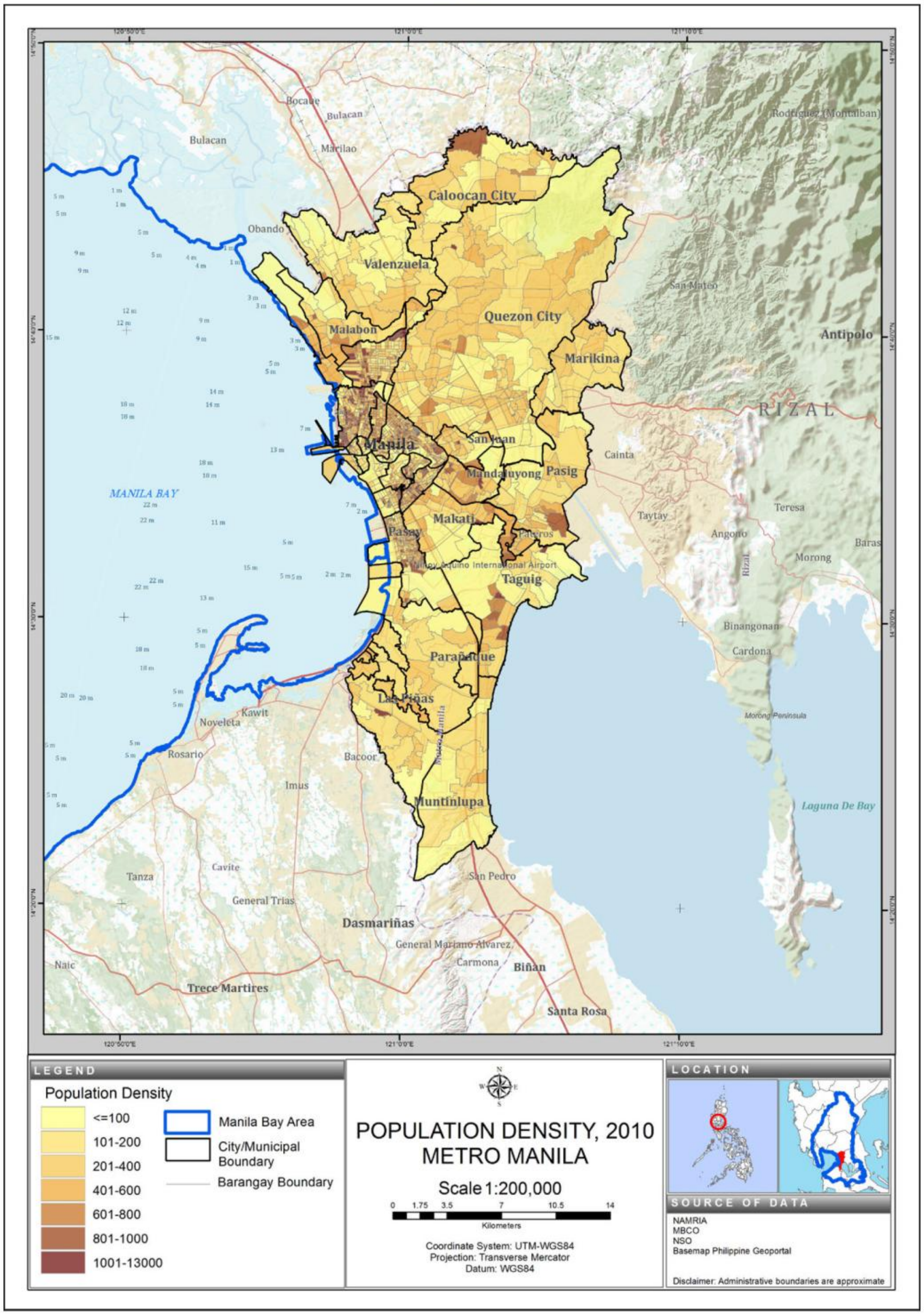
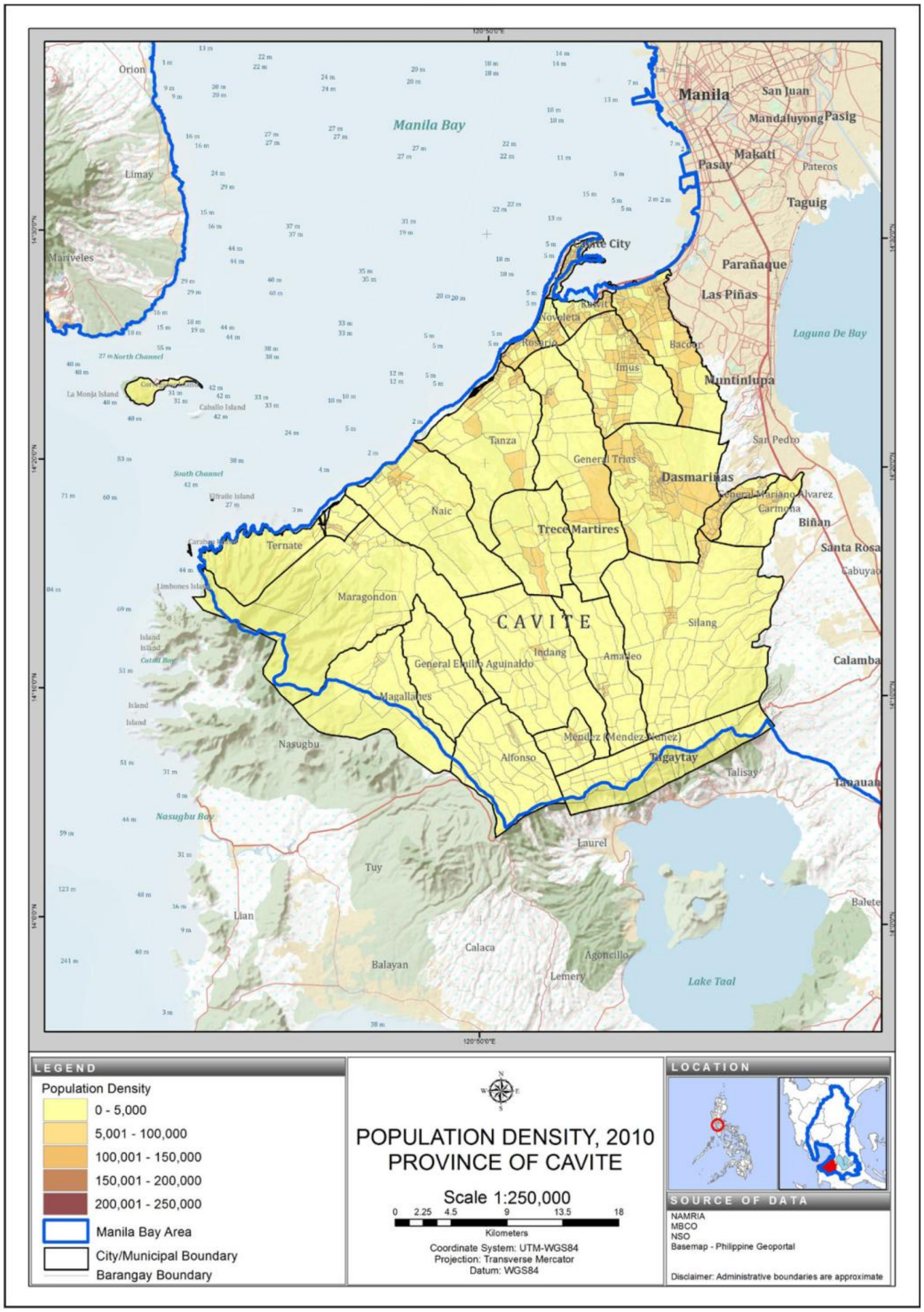
MBCO
NSO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 17


Bulacan
Bocaue
Marilao
Obando
Caloocan City
Valenzuela
Malabon
Quezon City
Marikina
Antipolo
RIZAL
San Mateo
Rodriguez (Montalban)
Manila
San Juan
Mandaluyong
Pasig
Cainta
Taytay
Angono
Teresa
Morong
Baras
Makati
Pateros
Pasay
Ninoy Aquino International Airport
Taguig
MANILA BAY
Binangonan
Cardona
Morong Peninsula
Parañaque
Las Piñas
Kawit
Noveleta
Rosario
Bacoor
Imus
Muntinlupa
Laguna De Bay
San Pedro
Tanza
Cavite
General Trias
Dasmariñas
General Mariano Alvarez
Carmona
Biñan
Naic
Trece Martires
Santa Rosa
LEGEND
Population Density
<=100
101-200
201-400
401-600
601-800
801-1000
1001-13000
Manila Bay Area
City/Municipal Boundary
Barangay Boundary
POPULATION DENSITY, 2010
METRO MANILA
Scale 1:200,000
0 1.75 3.5 7 10.5 14
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
NSO
Basemap Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 18


Manila Bay
Orion
Limay
Mariveles
Manila
San Juan
Mandaluyong
Pasig
Makati
Pasay
Pateros
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Parañaque
Las Piñas
Laguna De Bay
Kawit
Noveleta
Rosario
Bacoor
Imus
Muntinlupa
Tanza
General Trias
Dasmariñas
San Pedro
General Mariano Alvarez
Carmona
Biñan
Santa Rosa
Naic
Trece Martires
Ternate
Maragondon
CAVITE
Silang
Indang
Amadeo
General Emilio Aguinaldo
Magallanes
Calamba
Mendez (Mendez Nuñez)
Tagaytay
Alfonso
Nasugbu
Talisay
Tanauan
Laurel
Tuy
Lian
Balete
Calaca
Balayan
Agoncillo
Lemery
Lake Taal
North Channel
South Channel
La Monja Island
Caballo Island
Nasugbu Bay
LEGEND
Population Density
0 - 5,000
5,001 - 100,000
100,001 - 150,000
150,001 - 200,000
200,001 - 250,000
Manila Bay Area
City/Municipal Boundary
Barangay Boundary
POPULATION DENSITY, 2010
PROVINCE OF CAVITE
Scale 1:250,000
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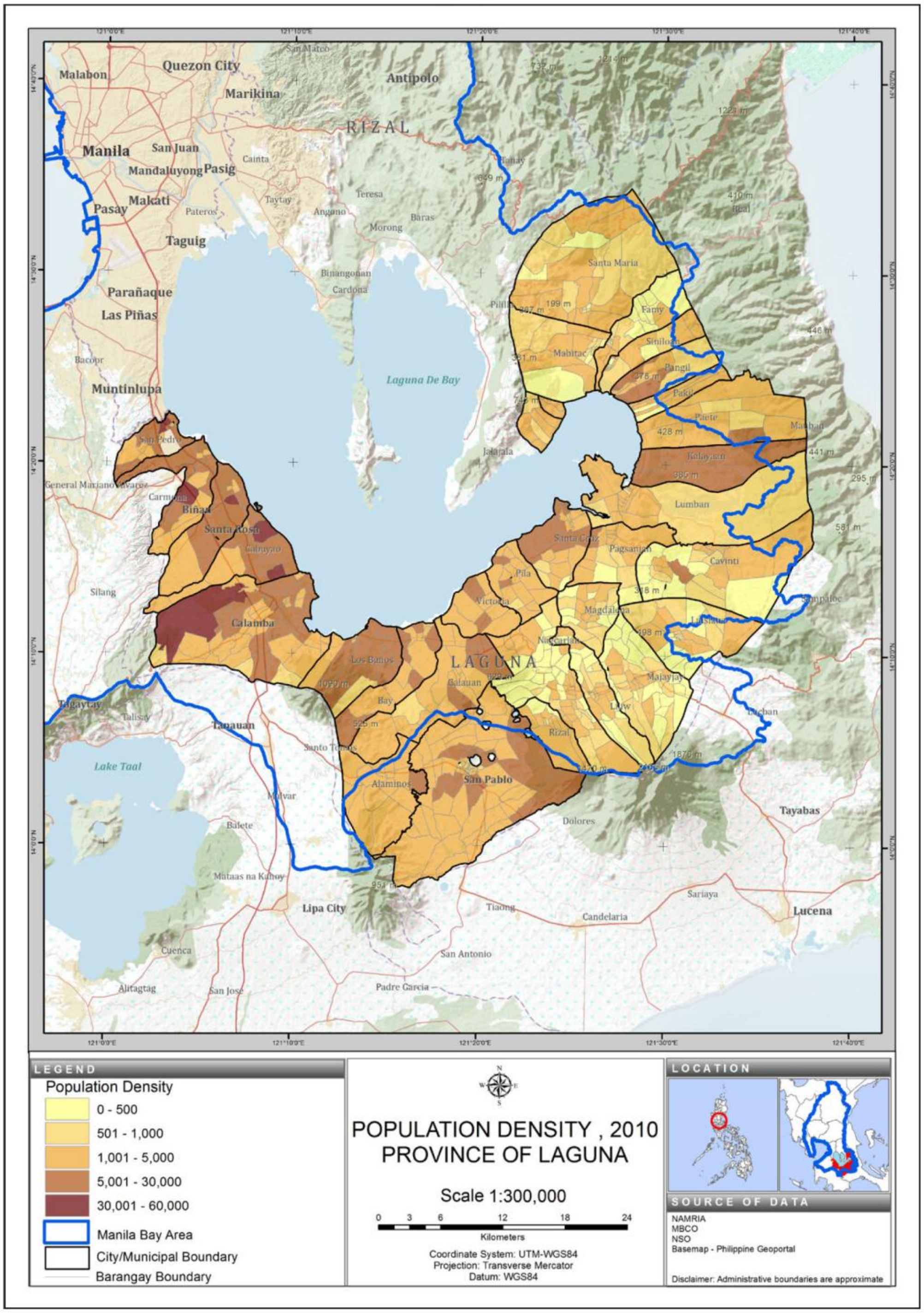
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
NSO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 19


POPULATION DENSITY , 2010
PROVINCE OF LAGUNA
Scale 1:300,000
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Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LEGEND
Population Density
0 - 500
501 - 1,000
1,001 - 5,000
5,001 - 30,000
30,001 - 60,000
Manila Bay Area
City/Municipal Boundary
Barangay Boundary
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
NSO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate
Quezon City
Malabon
Marikina
Antipolo
RIZAL
Manila
San Juan
Mandaluyong
Pasig
Cainta
Makati
Pasay
Pateros
Taytay
Angono
Teresa
Morong
Baras
Taguig
Binangonan
Cardona
Parañaque
Las Piñas
Bacoor
Muntinlupa
Laguna De Bay
Santa Maria
Famy
Siniloan
Mabitac
Pangil
Pakil
Paete
Kalayaan
Lumban
Cavinti
Pagsanjan
Santa Cruz
Pila
Victoria
Magdalena
Majayjay
Liliw
Rizal
Nagcarlan
LAGUNA
Calauan
Bay
Los Baños
Calamba
Cabuyao
Santa Rosa
Biñan
San Pedro
Carmona
General Mariano Alvarez
Silang
Tagaytay
Talisay
Tanauan
Santo Tomas
Alaminos
San Pablo
Lake Taal
Malvar
Balete
Mataas na Kahoy
Lipa City
Cuenca
Alitagtag
San Jose
Padre Garcia
San Antonio
Tiaong
Candelaria
Dolores
Sariaya
Tayabas
Lucena
Luisiana
Lucban

B. LAND COVER

The land cover of the Manila Bay Watershed, whether forest or non-woody plants, play unique roles on the watershed's complex ecosystems. Generally, forest cover is the most significant as it serves diverse ecological functions among them, as hosts to a variety of flora and fauna, soil protection, water supply, regulation of mean base water flow, modify local climate condition and maybe diurnal effect on the Bay itself.

The land cover maps and corresponding statistics (see Table 1) of the Bay area available for the periods 2003 and 2010 provide a synoptic view of the extent and distribution of the various land cover categories. Said maps depict a mosaic of forest and non-forest areas. Forest categories consist mainly of closed, open and mangrove forests.

The 2003 land cover map (Map 20) was based on the interpretation of Landsat ETM data with spatial resolution of 30 meters. The 2010 land cover map (Map 21) was mostly based from AVNIR-2 and SPOT 5 with a spatial resolution of 10-meter and its preliminary interpretations were field validated.

The land cover categories consisting of 14 classes were jointly formulated by the NAMRIA and Forest Management Bureau in conjunction with implementation of the National Forest Assessment and in accord with international reporting requirements or protocols.

Based on the 2003 and 2010 Land Cover Maps, the Bay watershed is degraded in terms of forest cover and coverage. Significant forests could only be observed on the eastern boundary of Bulacan (part of Sierra Madre Mountain) and the eastern side of Rizal (Southern part of Sierra Madre) and Bataan National Park.

A comparative analysis of the said land cover data reveals that there was decrease in both the two forest types, namely closed forest cover of about 26,762 hectares or 34.98%, and open forest to about 17,664 or 12.56%. The decrease in forest cover (both closed and open) could be attributed to human interventions (hypothetical, in the absence of empirical data) like increasing demands for more resources and rapid urbanization. Most of these forest had been converted to shrublands and wooded grasslands in the 2010. However, over the past seven years, the efforts of the government which focused on mangrove rehabilitation project had paid off and resulted to 199 hectares or 47.23% increase in mangrove areas. Moreover, land resources devoted to perennial crop production had been almost steadily maintained and well–managed.

On the other hand, as urbanization boost in the past years, areas for built-up had increased by about 96.13%, equivalent to 104,683 hectares. Areas for annual crop (decreased by 4.87%), open/barren (decreased by 85.62%) and grasslands (decreased by 42.92%) had been the primary subject for this urbanization process.

With this evident results observed in the analysis undertaken, there is however, concern on the accuracy of the comparative analysis results as the 2003 Land Cover Maps being used as baseline data were not field validated. It is emphasized that field validation of the preliminary interpretation of Land Cover based on satellite data is a necessary component activity to ensure accuracy of the final land cover data.

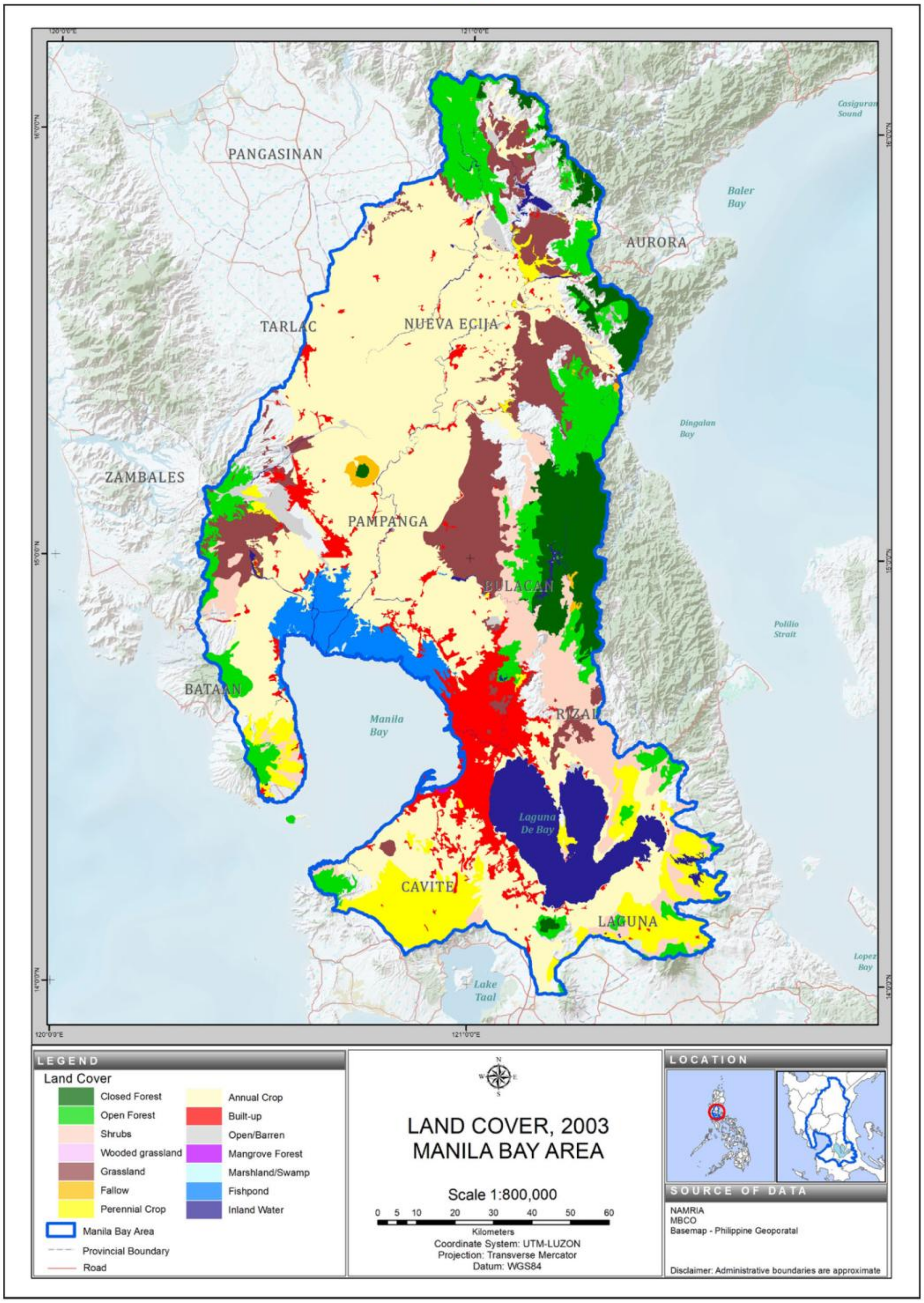
Table 4. Statistical Comparison of 2003 and 2010 Land Cover Map within the MBA

Land Cover 2003		Land Cover 2010		Difference	Percentage (Increase/ Decrease)
Classification	Area (has.)	Classification	Area (has.)		
Closed Forest	76,501	Closed Forest	49,739	(26,762)	-34.98
Open Forest	140,646	Open Forest	122,982	(17,664)	-12.56
Mangrove Forest	421	Mangrove Forest	620	199	47.23
Perennial Crop	109,360	Perennial Crop	114,962	5,602	5.12
Built-up	108,893	Built-up	213,576	104,683	96.13
Annual Crop	674,406	Annual Crop	641,555	(32.851)	-4.87
Shrubs	103,390	Shrubs	115,600	12,210	11.81
Fallow	5,386	Fallow	1,311	(4,075)	-75.67
Wooded Grassland	125,485	Wooded Grassland	143,025	17,540	13.98
Grassland	148,099	Grassland	84,532	(63,567)	-42.92
Open Barren	21,590	Open Barren	3,104	(18,486)	-85.62
Fishpond	50,706	Fishpond	61,318	10,612	20.93
Marshland	46	Marshland	1,164	1,118	2,448.11
Inland Water	287,435	Inland Water	302,372	14,937	5.20
Grand Total	1,852,363		1,855,859		

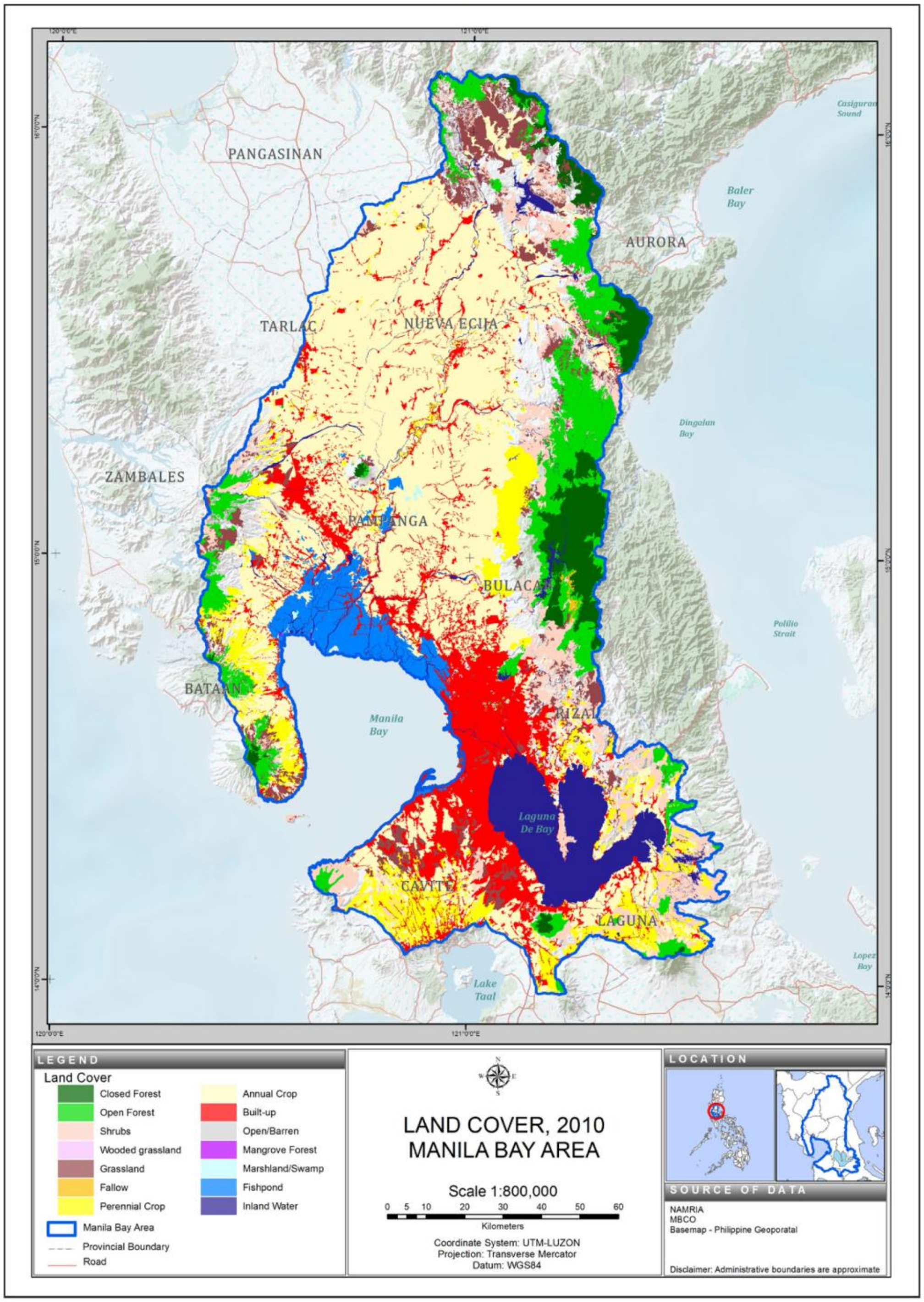
Agricultural area in Pampanga

Forest area in Rizal Province

Map 20


PANGASINAN
AURORA
TARLAC
NUEVA ECIJA
ZAMBALES
PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Laguna De Bay
Lake Taal
Baler Bay
Dingalan Bay
Polillo Strait
Casiguran Sound
Lopez Bay
120°0'0"E
121°0'0"E
LEGEND
Land Cover
Closed Forest
Open Forest
Shrubs
Wooded grassland
Grassland
Fallow
Perennial Crop
Annual Crop
Built-up
Open/Barren
Mangrove Forest
Marshland/Swamp
Fishpond
Inland Water
Manila Bay Area
Provincial Boundary
Road
LAND COVER, 2003
MANILA BAY AREA
Scale 1:800,000
0 5 10 20 30 40 50 60
Kilometers
Coordinate System: UTM-LUZON
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
Basemap - Philippine Geoporatal
Disclaimer: Administrative boundaries are approximate

Map 21


PANGASINAN
AURORA
TARLAC
NUEVA ECIJA
ZAMBALES
PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Casiguran Sound
Baler Bay
Dingalan Bay
Polillo Strait
Manila Bay
Laguna De Bay
Lake Taal
Lopez Bay
120°0'0"E
121°0'0"E
14°0'0"N
LEGEND
Land Cover
Closed Forest
Open Forest
Shrubs
Wooded grassland
Grassland
Fallow
Perennial Crop
Annual Crop
Built-up
Open/Barren
Mangrove Forest
Marshland/Swamp
Fishpond
Inland Water
Manila Bay Area
Provincial Boundary
Road
LAND COVER, 2010
MANILA BAY AREA
Scale 1:800,000
0 5 10 20 30 40 50 60
Kilometers
Coordinate System: UTM-LUZON
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
Basemap - Philippine Geoporatal
Disclaimer: Administrative boundaries are approximate

C. LAND AND SEA USE

SUB-WATERSHEDS DELINEATION

The entire watershed of the Manila Bay Area is sub-divided into four major watersheds, namely Pampanga river basin, Bataan watershed, Pasig river basin and Cavite watershed (DA-BSWM, 2011).

The whole Pampanga River Basin and its tributaries have an estimated area of 1,192,460 hectares, and is considered the largest watershed draining to the Manila Bay. It stretches as far as Nueva Vizcaya in the north, Aurora in the east and Pangasinan in the west.

The Pasig River Basin is the second largest river that drains into the Manila Bay with an estimated area of 357,133 hectares.

The Talisay River, Balsic River and their neighboring river systems compose the Bataan watershed. It has an estimated area of 141,449 hectares.

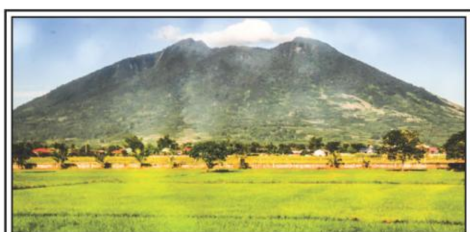
The Cavite watershed consists of the various rivers that drain directly to the Manila Bay. It has an estimated area of 235,744 hectares.

LAND USE AND VEGETATION

In the land use mapping survey in 2011, five general land uses were mapped in the Manila Bay Watershed (Arellano, et al, 2011 in DA- BSWM, 2011). Majority (42%) of the watershed area is devoted to agricultural use, mainly on crop and livestock production. Forest/woodland areas comprise 11% of the region/watershed while about 21% is grassland/shrub land. The remaining 22% is for miscellaneous use (see Table 5).

The agricultural land uses for the entire Manila Bay Area, the agricultural crop distribution and the specific crop uses per watershed are shown in Figure 11-12.

The Pampanga River Basin is predominantly agricultural (652,062ha., 55%) and devoted to crop production, fishpond, and livestock/poultry production. Its crop production and livestock/poultry production areas encompass the provinces of Nueva Ecija, Tarlac, Pampanga, and majority of Bulacan. The fishpond areas are concentrated in Pampanga and the adjacent area of Bulacan.



Agricultural area at the foot of Mt. Arayat in Pampanga

In the Cavite watershed, nearly 58% (137,835 ha) are for agricultural use, mostly crop production and a small percentage for fishpond. Its agricultural areas are found in the upland municipalities of Gen Emilio Aguinaldo, Indang, Amadeo, Silang up to Tagaytay in the province of Cavite, and in the municipality of Bay stretching towards the eastern side of the province of Laguna. The small percentage of fishpond is mostly located in Kawit, Noveleta, Bacoor, and in the areas of Las Pinas and Paranaque.

Bataan sub-watershed's agricultural area (43,216 ha., 31% of the subwatershed) is largely dedicated to crop production. Less than three hectares are fishpond areas along the coast of Orani, Samal, Abucay, Pilar, Orion, and Balanga City.

In the Pasig sub-watershed, the agricultural areas are largely croplands followed by fishpond, and a relatively small area (260 ha) for livestock/poultry production. Its croplands are mostly in the area of Bulacan and Rizal; and the fishpond areas are in Bulacan and Malabon in Metro Manila.

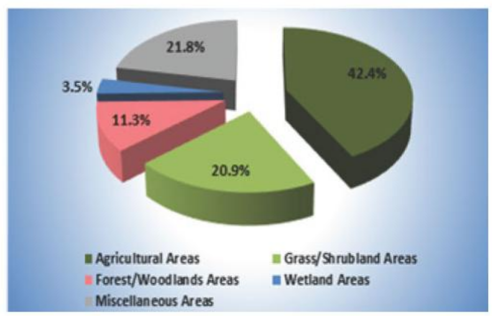


Figure 11. General Land Use of the Manila Bay Area by Watershed (2011)

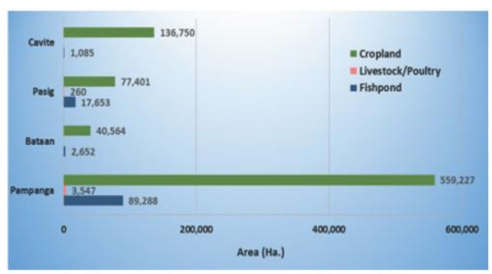


Figure 12. Agricultural Land Uses by Subwatershed (2011)

Table 5. Land Use of the Manila Bay Area by watershed (2011)

Description	Pampanga		Bataan		Pasig		Cavite		Total	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Agricultural	562,774	47	40,564	29	77,661	22	136,750	58	817,750	42
Grass/Shrubland	232,854	20	56,873	40	101,066	28	12,724	5	403,518	21
Forest/Woodland	163,340	14	36,555	26	3,238	1	14,987	6	218,120	11
Wetland	44,060	4	2,652	2	17,811	5	2,098	1	66,620	3
Miscellaneous	189,432	16	4,805	3	157,357	44	69,184	29	420,778	22
	1,192,460	100	141,449	100	357,133	100	235,744	100	1,926,786	100

Source: BSWM

SOIL TAXONOMY

The soils of the sub-watersheds are presented in Map 23. It is based on the Food and Agriculture Office (FAO) taxonomic classification. Their characteristics are discussed below.

1. Cambic Arenosols - These soils show little diagnostic pedogenic horizon such as color differentiation as in cambic horizon. They may be found in virtually any climatic types in the humid tropics in recent geomorphic surfaces. These soils are mainly marine, alluvial, lacustrine and aeolian material of mixed mineralogy in timing forming landscape. These materials have soils that are relatively young or sandy deposit that naturally drains excess water from its surface. They are most found and extensively mapped at Cavite and Nueva Ecija province.

2. Dystric Cambisols - These soils are well-drained, low base saturation clayey soils usually moist with pedogenic horizon of alteration of parent materials. These soils occur in the uplands, hilly lands with relief varying from rolling to hilly of more than 100 cm above sea level. These are formed on shale/sandstone rocks and have slope ranging from 3 to 8 percent. These soils are moderately deep to deep with isohyperthermic and udic soil moisture regime. These soils are mostly found extensively in Pampanga and Laguna Provinces.

3. Dystric Nitisols - These soils are low bases and have subsurface horizon of alluvial clay accumulation, that are deep to very deep clayey soils developed from basalt, andesite and other igneous volcanic material occurring an gently sloping to very steep high hills and mountains. These soils are mostly found in Nueva Ecija Province.

4. Eutric Cambisols - These soils have high base saturation, usually shallow to moderately deep, well-drained clayey soils developed from weathered shale/sandstone, andesite and other volcanic materials occurring on gently sloping to very steep high relief hills and mountains. These soils are mostly found at Cavite and Nueva Ecija provinces.

5. Eutric Fluvisols - These soils are shallow to moderately deep, well-drained coarse loamy soils of mixed mineralogy. They occur on level to nearly level lower river terraces on the alluvial landscape. They are subject to slight flooding. These soils have low to moderate inherent fertility with udic soils moisture regime. These soils are found mostly at Laguna, Pampanga and Nueva Ecija province.

6. Eutric Gleysols - These soils have high base saturation that are shallow to moderately deep, somewhat poorly to poorly drained coarse loamy soils of mixed mineralogy. They occur on level to nearly level on lower river terraces of the alluvial landscape. They are subject to moderate to severe flooding. These soils have low to moderate inherent fertility with aquic soil moisture regime. These soils are found mostly in Pampanga province.

7. Eutric Regosols – These soils are from unconsolidated materials, exclusive of those that are coarse textured or show soil stratifications as in fluvic properties. They have a base saturation of more than 50 percent (NH4OAc). They are found both on alluvial plain and residual terraces and formed from young sediments from alluvial materials affected by slight to moderate flooding in lowland and erosion on the upland. They are mostly found at Nueva Ecija and Pampanga Provinces.

8. Gleyic Cambisols - These soils are shallow to moderately deep soils, somewhat to poorly drained loamy skeletal with mixed mineralogy occupying level to gently sloping broad alluvial plain, residual terraces and collu-alluvial fan. Generally they are subjected to none to slight flooding with seasonal saturation due to fluctuation of water table and excess run-off from higher adjacent areas. They are mostly found at Pampanga and Nueva Ecija Provinces.

9. Haplic Kastanozems - These soils are moderately deep to deep, moderately well-drained occupying materials with petrocalcic horizon within 100 cm of the mineral soil surface. The majority of these soils have developed under a grassy and forest vegetation mostly found in Cavite and Laguna Provinces.

10. Haplic Phaeozems - These soils are thick, dark colored, humus rich, and consist of the underground decomposition of organic residues and highly weathered volcanic ash and high supply of bases. The most majority of these soils developed under a grassy vegetation mostly found at Cavite and Laguna Provinces.

11. Humic Acrisols - These soils occur in the undulating to very steep volcanic, metamorphic and dioritic hills and mountains. They are also found in the undulating to rolling low hills in the upland. These soils are moderately deep to deep with well-drained soils profile. These are extremely weathered soils and provide low supply of bases. The productivity of these soils are relatively poor. These soils are found in the mountain eastern part of Pampanga, Laguna and Rizal Province.

12. Ochric Andosols - These soils are moderately deep to deep soils somewhat poorly to poorly drained occupying the undulating to very steep volcanic mountain with materials mostly weathered volcanic ejecta. Presence on the top of a thin organic layer with andic soil properties. These soils are found near or adjacent to Arayat and Pinatubo and Taal volcanoes including Tagaytay ridge.

13. Orthic Acrisols - These soils are moderately deep to deep well-drained soils found on the undulating to very steep volcanic, metamorphic and dioritic mountains. These are extremely weathered soils and provide low to medium supply of bases. Soil reaction varies from moderately acid to strongly acid. These soils are found mostly in the Nueva Ecija, Aurora and Nueva Viscaya Province, the northeastern mountainous part of the watershed.

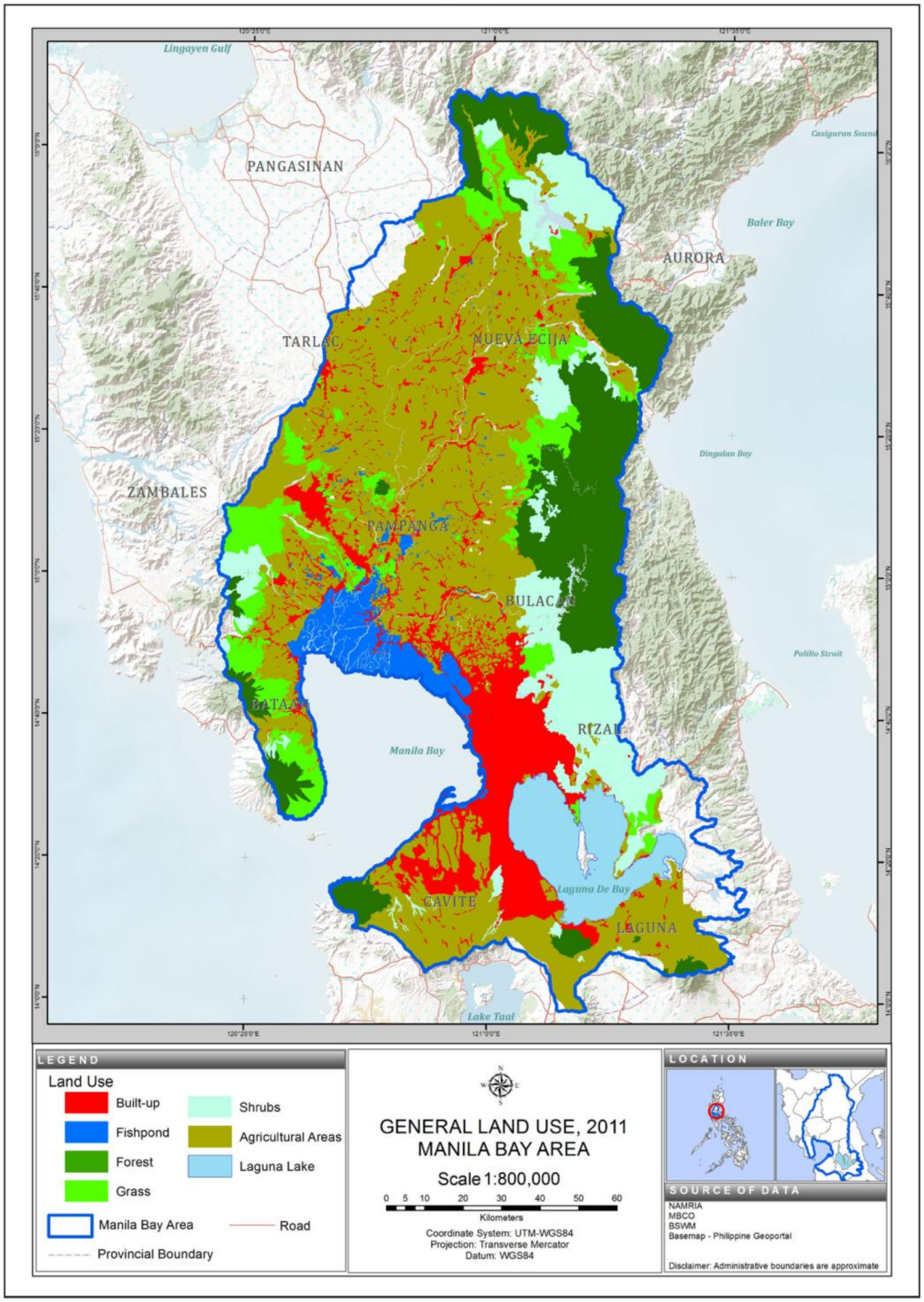
14. Orthic Luvisols - These soils are moderately deep to deep, somewhat poorly to poorly drained soils with high bases and have subsurface horizon with illuvial clay accumulation with moderate to high fertility. They have soil reactions that varies from slightly acid to neutral. These soils are mostly found in the upper terraces and mapped extensively in Pampanga, Nueva Ecija and Bataan Provinces.

15. Thionic Fluvisols - These are young soils found in the active tidal flat formed from fluvio-marine sediments of swamps and marshes derived from alluvial materials. These are soils that have sulfidic materials within 50 cm of the mineral soil surface. They are poorly drained soils, may sometimes complete submergence mostly found in saline estuarine plains in Pampanga.

16. Vertic Cambisols – These soils are shallow to moderately deep somewhat poorly drained occupying the level to gently sloping broad alluvial plain, residual terraces and collu-alluvial fan. These soils have presence of cracking and slickensides or wedge-shape within 125 cm of the mineral soil surface. They are dominantly found in Pampanga and Nueva Ecija Provinces.

17. Vertic Luvisols - These soils are moderately deep to deep soils somewhat poorly drained formed from clayey alluvium with high base saturation and moderate to high fertility. They have soil reactions that vary from slightly acid to neutral and have subsurface horizon with illuvial clay accumulation; slickensides within 125 cm of the mineral soils surface. They are mostly found in the Bulacan and Nueva Ecija provinces.

Map 22


Lingayen Gulf
PANGASINAN
Casiguran Sound
Baler Bay
AURORA
TARLAC
NUEVA ECIJA
Dingalan Bay
ZAMBALES
PAMPANGA
BULACAN
Polilio Strait
BATAAN
RIZAL
Manila Bay
Laguna De Bay
CAVITE
LAGUNA
Lake Taal
LEGEND
Land Use
Built-up
Fishpond
Forest
Grass
Shrubs
Agricultural Areas
Laguna Lake
Manila Bay Area
Road
Provincial Boundary
GENERAL LAND USE, 2011
MANILA BAY AREA
Scale 1:800,000
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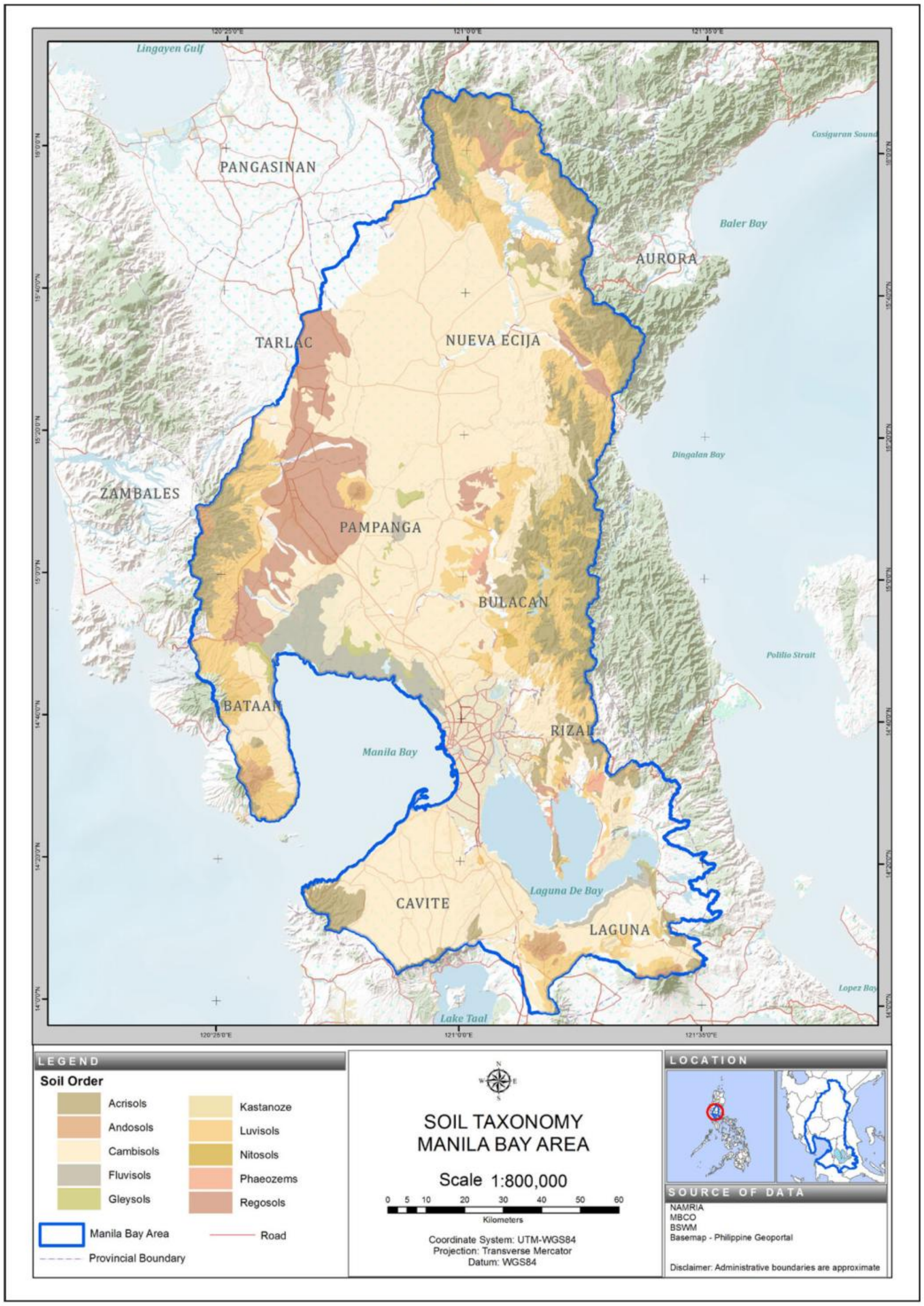
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 23


Lingayen Gulf
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AURORA
TARLAC
NUEVA ECIJA
Dingalan Bay
ZAMBALES
PAMPANGA
BULACAN
Polillo Strait
BATAAN
RIZAL
Manila Bay
Laguna De Bay
CAVITE
LAGUNA
Lopez Bay
Lake Taal
120°25'0"E
121°0'0"E
121°35'0"E
LEGEND
Soil Order
Acrisols
Andosols
Cambisols
Fluvisols
Gleysols
Kastanoze
Luvisols
Nitosols
Phaeozems
Regosols
Manila Bay Area
Road
Provincial Boundary
SOIL TAXONOMY
MANILA BAY AREA
Scale 1:800,000
0 5 10 20 30 40 50 60
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

C.1 FISHERIES AND AQUACULTURE

Fishponds and shellfish growing areas were established in the country primarily to improve the fish production for human consumption and national export, creating employment and commercially viable business ventures in rural areas where such opportunities are relatively limited. Enclosing the Manila Bay Area, aquaculture structures proliferate mainly along, Bataan, Bulacan, and Pampanga in Region III, Cavite in Region IV-A, and in the northern Metro Manila coastlines. However, existence of fishpond operations in these provinces are continually threatened by natural calamities, degrading water supply, proliferation of invasive species, and industrial conversions and urbanization.

As shown in Table 6 and Figure 13, aquaculture and fisheries production in the Manila Bay Area show a fluctuating trend. The highest production was managed in 2008 with 498,681 MT. Region III has been the highest producing region for the past eight years.

AQUACULTURE AND FISHPOND AREAS ALONG MANILA BAY

Brackish water fish farming is the most common type of aquaculture employed by fish farmers in the provinces around Manila Bay. There are a limited number of fish farmers who are engaged in fresh and marine water aquaculture. The municipalities of Hermosa in Bataan; Hagonoy, Malolos and Bulakan in Bulacan; Sasmuan, Guagua and Lubao in Pampanga have the most number and largest area of fish ponds due to their proximity to Manila Bay and several river tributaries (Pampanga river system) that supply both saltwater and freshwater to the ponds. In some municipalities that have no access to any river tributaries, like Orion and Limay in Bataan, freshwater is sourced from the ground.

Table 6. Aquaculture and Fisheries Production in the Manila Bay Area in Metric Tons (2007-2014)

Region	Aquaculture and Fisheries Production (in MT)							
	2007	2008	2009	2010	2011	2012	2013	2014
Region III	235,695	252,469	248,694	239,596	232,861	232,989	215,620	219,098
NCR	90,762	84,828	68,724	93,565	80,015	83,069	118,696	118,106
Region IV-A	151,190	161,384	148,748	154,987	161,349	165,694	105,037	114,348
Total	477,647	498,681	466,166	488,148	474,225	481,752	439,354	451,552

Source: Philippine Statistics Authority

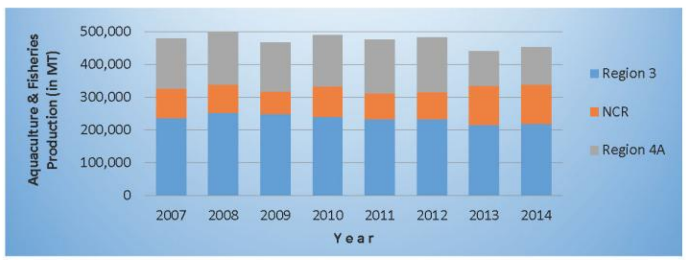


Figure 13. Aquaculture and Fisheries Production in the Manila Bay Area in Metric Tons (2007-2014)

FISHERIES PRODUCTION IN THE REGION

Table 7. Volume of Production by Subsector in Manila Bay Area in Metric Tons (2007-2014)

Province/Subsector	2007	2008	2009	2010	2011	2012	2013	2014
Pampanga	143,111	155,481	162,950	159,528	156,834	155,755	162,455	163,723
Commercial Fisheries	DNA	DNA	DNA	DNA	DNA	DNA	DNA	DNA
Municipal Fisheries	11,967	11,563	11,793	10,925	11,211	11,822	12,188	12,479
Aquaculture	131,144	143,918	151,157	148,603	145,623	143,934	150,267	151,244
Bataan	29,582	29,875	25,444	23,373	23,234	22,424	22,667	26,098
Commercial Fisheries	4,920	4,099	1,693	DNA	DNA	DNA	DNA	3,364
Municipal Fisheries	10,978	11,767	10,370	10,328	10,881	10,639	10,624	10,801
Aquaculture	13,684	14009	13,381	13,045	12,351	11,785	12,042	11,933
Bulacan	47,835	51,769	45,867	44,355	40,791	41,879	42,550	41,481
Commercial Fisheries	1,050	978	522	469	475	329	352	378
Municipal Fisheries	4,223	3,983	2,649	2,698	2,795	1,920	1,929	1,677
Aquaculture	42,562	46,808	42,696	41,187	37,520	39,630	40,269	39,426
Metro Manila	90,765	84,828	68,724	93,565	80,015	86,207	123,948	DNA
Commercial Fisheries	81,895	77,424	62,371	86,042	70,685	77,238	116,079	DNA
Municipal Fisheries	6,017	4,350	4,215	5,295	6,621	6,166	5,252	DNA
Aquaculture	2,850	3,053	2,137	2,229	2,709	2,804	2,617	DNA
Cavite	15,736	15,166	11,126	15,164	16,687	17,541	17,329	14,808
Commercial Fisheries	4,409	3,709	3,805	5,599	5,821	5,082	5,656	6,824
Municipal Fisheries	3,911	2,798	2,113	2,960	3,312	2,780	2,296	2,174
Aquaculture	7,417	8,659	5,207	6,606	7,554	9,679	9,377	5,809

Legend: DNA – data not available
Source: Philippine Statistics Authority

COMMERCIAL FISHERIES

Commonly caught fishes in this subsector include sardines, mackerel, mullet, threadfin bream and squid. Table 7 showed a decreasing trend of the commercial fisheries in the provinces of Bataan and Bulacan, while an increasing trend was observed in Metro Manila and Cavite. Pampanga has no commercial fishing area therefore, no production data was recorded.

The volume of fish production of Cavite and Metro Manila is increasing primarily because of the presence of large commercial boat landings in these areas. Most of the large landing sites, markets and processing plants are located in these provinces. The large commercial fishing vessels extract most of the stocks from the commercial waters.

Commercial fishing vessels, Navotas Fish Port

MUNICIPAL FISHERIES

Municipal fisheries, which include marine and inland fisheries, generally occupy the second spot next to aquaculture subsector, barring Cavite and Metro Manila. Blue crab, mackerel, mullet, roundscad, threadfin bream, caesio and squid are the most common species caught in marine municipal waters while tilapia, goby, mudfish, carp, mullet, prawn and catfish are most commonly caught in inland municipal waters.

Generally, there is a decreasing trend in the production of the municipal fisheries subsector from 2007 to 2014, most notably in the province of Bulacan. This can be due to the increasing fishing efforts and the continual use of prohibited fishing methods such as trawls, fine mesh nets and blast fishing in the attempt to increase the fish production which eventually results to decline of fish stock in the area.

Fishing for daily subsistence

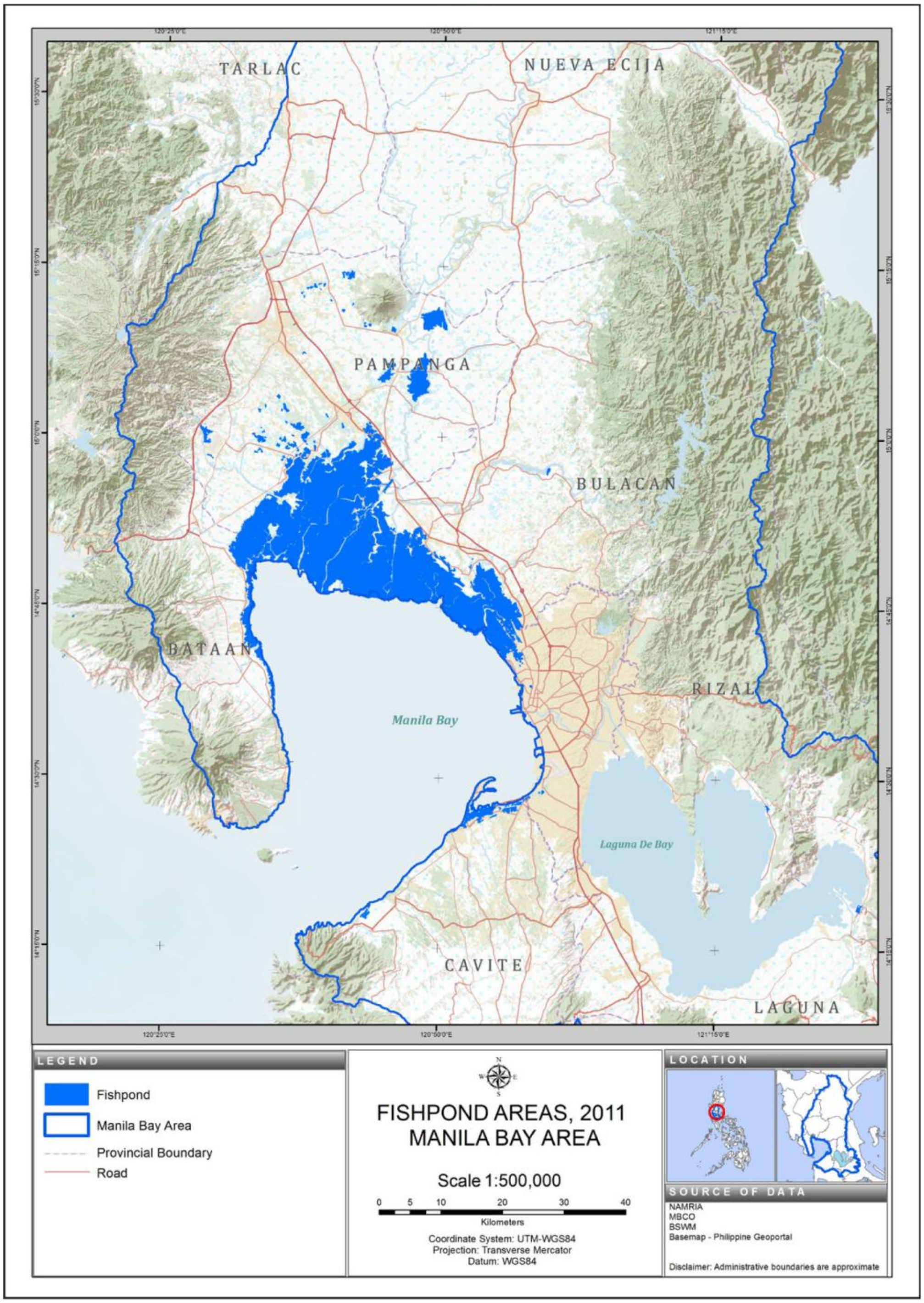
AQUACULTURE

Among other fishery subsectors, aquaculture in different provinces, except in Metro Manila, remain the top contributor to the fishery production of Manila Bay Area from 2007 to 2014. The most popular culture species in the Manila Bay Area are milkfish, tilapia, mudcrab, shrimp/prawn, oyster and mussel. Overall, there is a decreasing trend in the aquaculture production of provinces, except in Pampanga. This is primarily attributed to the proliferation of invasive species, for instance, Sarotherodon melanotheron or commonly called Tilapiang Gloria, which competes with culture species for space, food and nutrients. Another reason could be the occurrence of natural calamities such as typhoons and floods that cause damage to the fishponds as well as the organisms being cultured. Degrading quality of water sources leads to the increased mortality rate of cultured organisms. Even massive fish kills could be a factor to this decreasing production. Moreover, in some areas, fishponds are being converted into subdivisions and other infrastructures.

On the other hand, in Pampanga, increasing trends are observed. This is most likely due to the intensification of aquaculture practices by fish farmers, such as the use of fertilizer, commercial feeds and other chemicals that augments production. However, when used excessively could contribute to water pollution.

Large commercial fishing vessel

Map 24


TARLAC
NUEVA ECIJA
PAMPANGA
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BATAAN
RIZAL
Manila Bay
Laguna De Bay
CAVITE
LAGUNA
LEGEND
Fishpond
Manila Bay Area
Provincial Boundary
Road
FISHPOND AREAS, 2011
MANILA BAY AREA
Scale 1:500,000
0 5 10 20 30 40
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

C.2 AGRICULTURE

From 2007 to 2014, the MBA's agricultural area has grown to an estimated 0.9 million hectares harvested/planted to various crops, namely: rice, corn, coconut, mango, sugarcane and other crops particularly banana, ampalaya, eggplant, onion, squash, stringbeans, tomato, watermelon, cassava, mongo, pineapple and cashew, among others (Figure 14). The spatial distribution of the agricultural crops by geolocation within the watershed is presented in Figure 15. Nueva Ecija has extensively grown the most agricultural crops followed by Tarlac, Pampanga, Laguna, Bulacan, Cavite, Bataan and Rizal, in descending order of magnitude. The availability of water for irrigation largely determines the areas cultivated to agricultural crops. The presence of Pantabangan Dam in Nueva Ecija, Ipo Dam and Bustos Dam in Bulacan significantly contribute to agricultural development in the Manila Bay Area.

The Manila Bay Area has 0.7 million ha harvested to rice (palay); these represent 85% of the regional total (Regions III and IVA) equivalent to 15% of the national total (Annex 6). The Manila Bay Area contributes 3.8 million MT of rice (palay); these account to about 90% of the total regional volume of production, equivalent to 20% of the national rice production in 2014 (Annex 8).

Moreover, the Manila Bay Area has at least 40,000 ha harvested with corn from 2007 to 2014. It contributed 0.4 million MT to the corn industry which account to 71% of the regional total, equivalent to 3% of the national total volume of production. Annex 8 presents the volume of rice and corn production from 2007 to 2014.

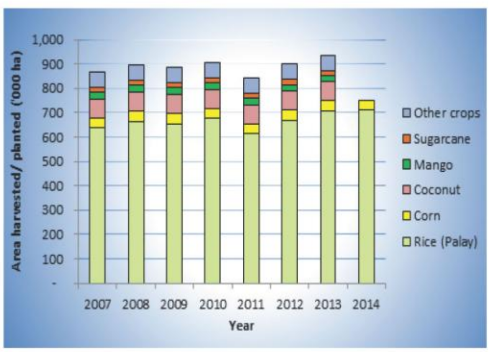


Figure 14. Area Harvested/Planted to Various Crops in the Manila Bay Area (2007-2014)

Agricultural fields dominates Pampanga's landscape

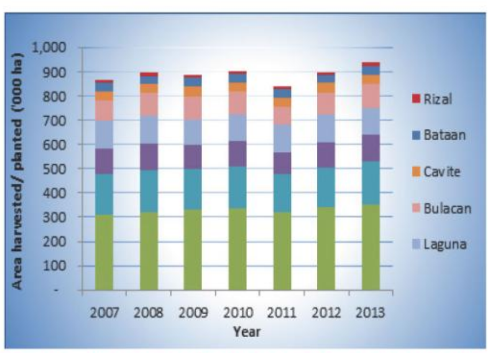
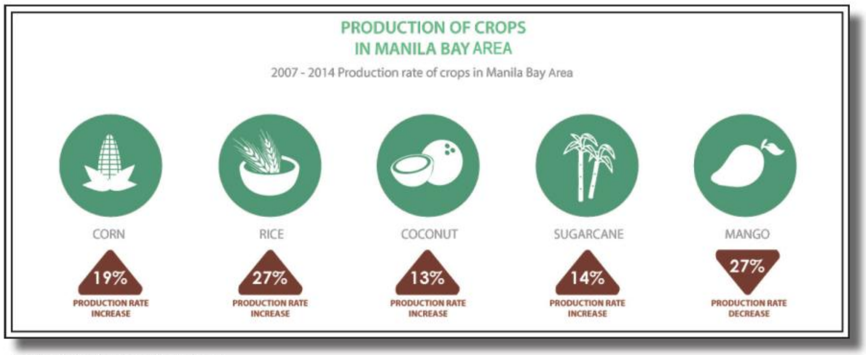


Figure 15. Area Harvested/Planted to Various Crops in the Manila Bay Area by Geolocation (2007-2013)

Rice field in Laur, Nueva Ecija

Aside from rice and corn, the Manila Bay Area is also devoted to valuable production of coconut, mango and sugarcane. There are about 78,000 ha planted with coconut, 28,000 ha with mango and 20,000 ha with sugarcane (Annex 7). These areas produced 167,000 MT of coconut with husk, almost 60,000 MT of mango and 1.1 million MT of sugarcane in 2013 (Annex 9). Additionally, about 63,000 hectares in the Manila Bay Area are planted with other crops such as fruit trees, vegetables, legumes, and root crops.



Source: Philippine Statistics Authority

LIVESTOCK PRODUCTION

By its very definition, livestock (and its industry and production) are identified as domesticated animals raised in an agricultural setting to produce commodities such as food, fiber and labor. Often coupled with the poultry industry, livestock production has provided a large percentage of food sourcing amongst the growing requirement of Filipinos. According to the DA - Bureau of Animal Industry (BAI), 31% of the total agricultural production in the country is sourced from the livestock sector, particularly the industries for hogs (pigs), cattle, goats and carabaos.

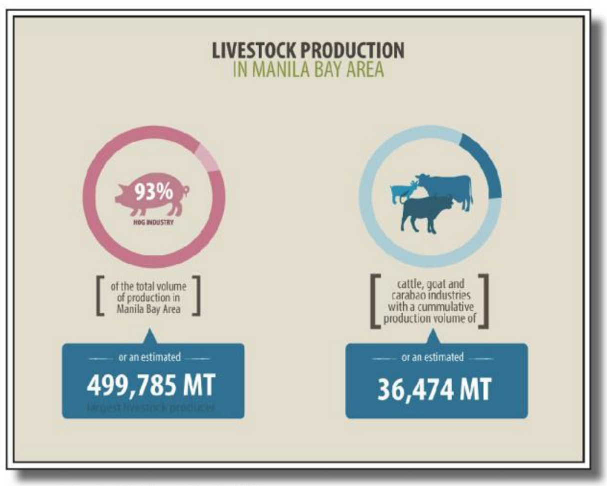
Within the Manila Bay Area, the provinces of Bulacan and Tarlac (Region III), as well as Rizal (Region IV-A) produced the largest volumes of livestock (in metric tonnes) from 2011 to 2014. As of July 2014, the province of Bulacan produced an estimated 241,000 MT – most of which were conveyed through an array of markets in Region III and NCR. This represents 45% of the total volume of livestock production for the entire MBA, which registers an estimated 536,000 MT.

The hog industry is considered the largest livestock producer valuating 93% of the total volume of production, or an estimated 499,785 MT - with the provinces of Bulacan, Tarlac and Laguna producing majority inventories for 2014. This is followed by the cattle, goat and carabao industries with a cumulative production volume of 36,474 MT.

Trends reveal that the steady increase in production will continue with the strong dependence of the populace on these various meat products.

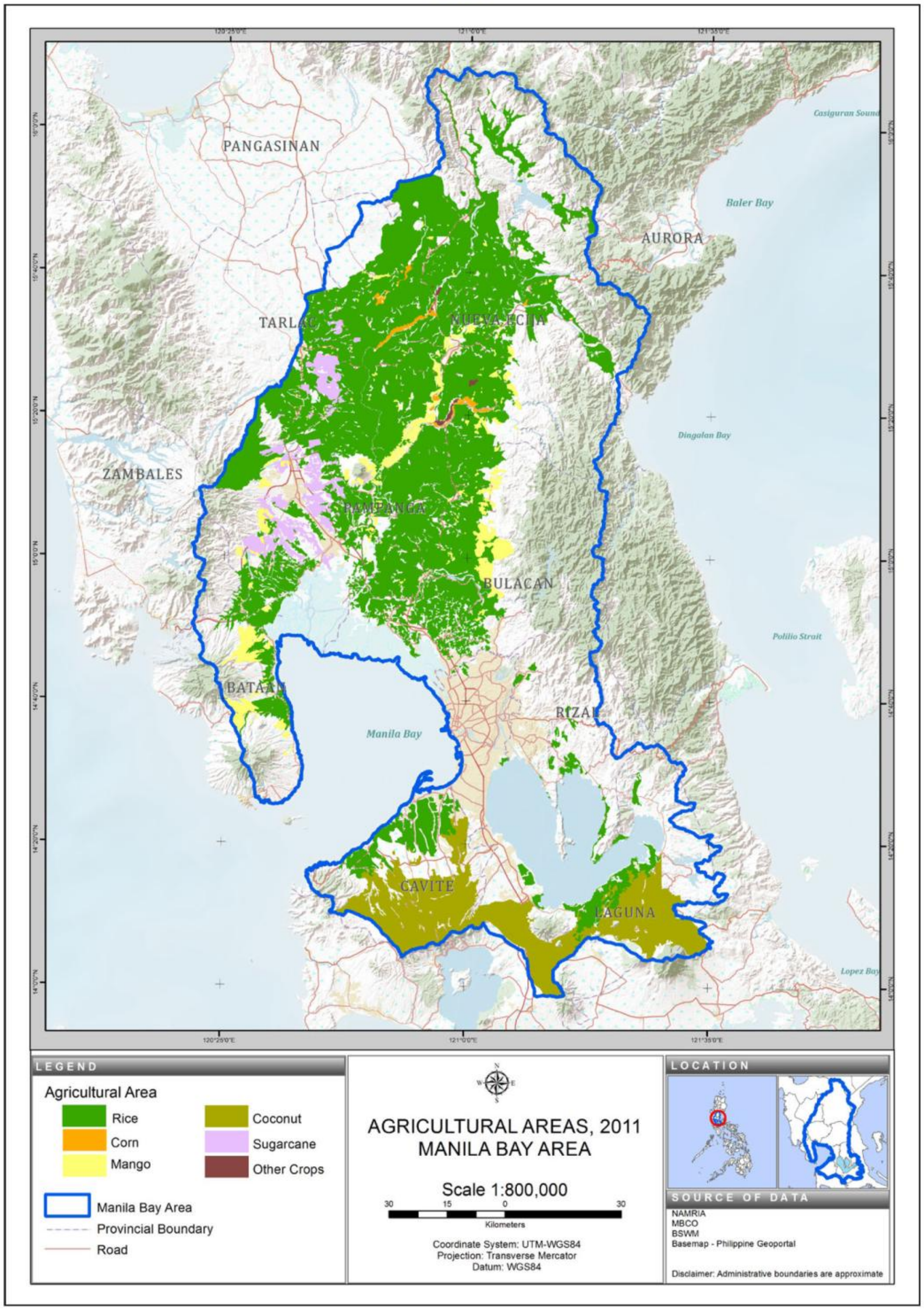
Aside from food sources, the eminent growth in the livestock sector will contribute to the uplifting of socioeconomic conditions in rural areas through provisions in livelihood and employment.

Map 26 provides the location of commercial livestock areas within the MBA. Not reflected in this map are the backyard livestock sectors.



Source: Philippine Statistics Authority, 2014

Map 25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Baler Bay
Casiguran Sound
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ZAMBALES
PAMPANGA
BULACAN
Dingalan Bay
Polillo Strait
BATAAN
Manila Bay
RIZAL
CAVITE
LAGUNA
Lopez Bay
LEGEND
Agricultural Area
Rice
Corn
Mango
Coconut
Sugarcane
Other Crops
Manila Bay Area
Provincial Boundary
Road
AGRICULTURAL AREAS, 2011
MANILA BAY AREA
Scale 1:800,000
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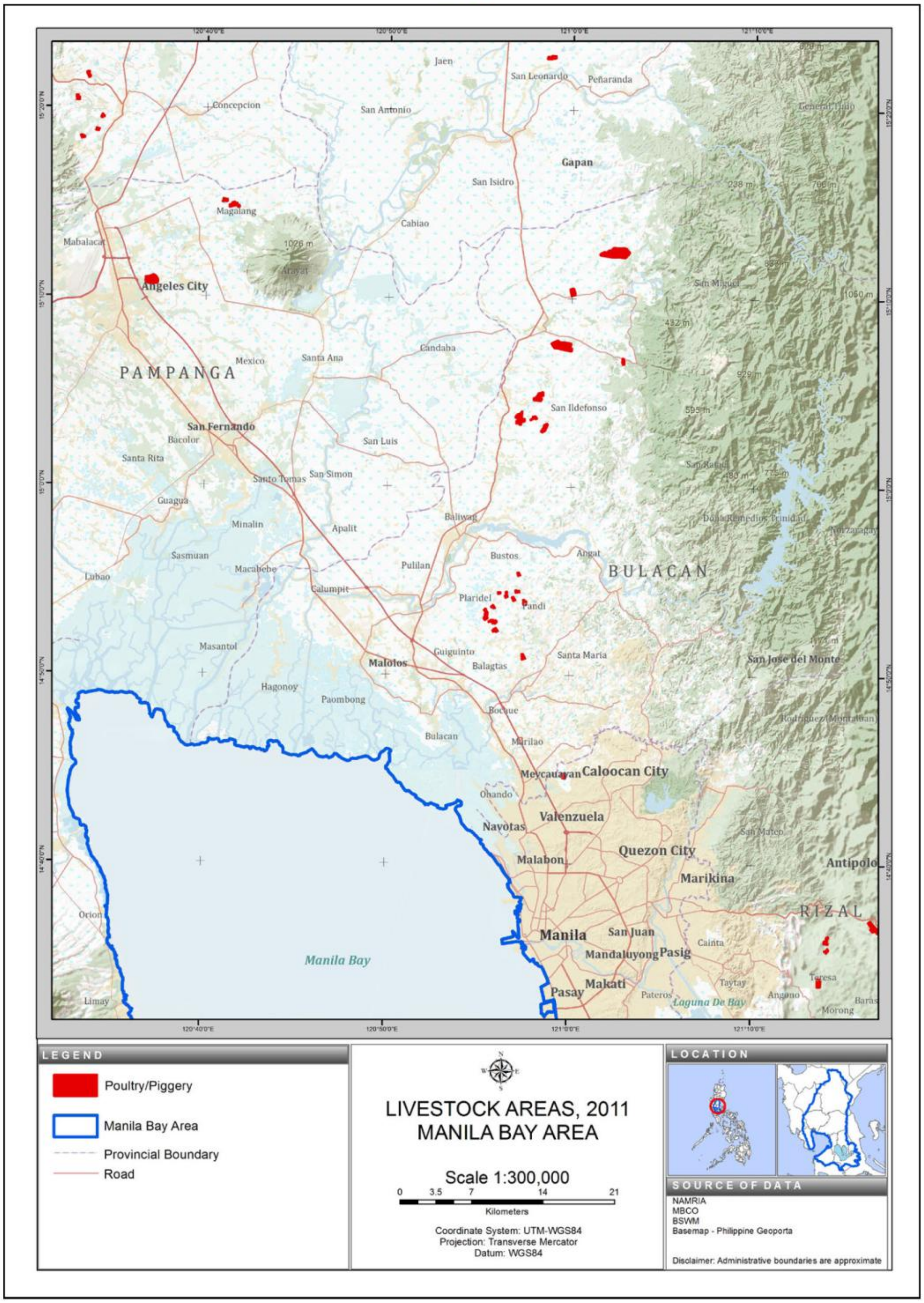
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 26


LEGEND
Poultry/Piggery
Manila Bay Area
Provincial Boundary
Road
LIVESTOCK AREAS, 2011
MANILA BAY AREA
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Kilometers
Coordinate System: UTM-WGS84
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Datum: WGS84
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Disclaimer: Administrative boundaries are approximate
PAMPANGA
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Jaen
San Leonardo
Peñaranda
Gapan
San Isidro
Cabiao
Magalang
Mabalacat
Angeles City
Arayat
San Miguel
Candaba
Mexico
Santa Ana
San Ildefonso
San Fernando
Bacolor
Santa Rita
San Luis
Santo Tomas
San Simon
Guagua
Minalin
Apalit
Baliwag
Sasmuan
Macabebe
Bustos
Angat
Lubao
Pulilan
Calumpit
Plaridel
Pandi
Masantol
Guiguinto
Malolos
Balagtas
Santa Maria
San Jose del Monte
Hagonoy
Paombong
Bocaue
Bulacan
Marilao
Meycauayan
Caloocan City
Obando
Valenzuela
Navotas
Quezon City
Malabon
Marikina
Antipolo
Orion
Manila
San Juan
Cainta
Mandaluyong
Pasig
Makati
Taytay
Pasay
Pateros
Angono
Teresa
Morong
Limay
Doña Remedios Trinidad
General Tinio
Rodriguez (Montalban)
San Mateo
San Rafael

C.3 BUILT-UP AREAS

With rapid urbanization, the Manila Bay Area has continuously housed an increasing concentration of built-up areas. According to the World Bank's study on East Asia's Changing Urban Landscape, 56% of the built-up areas in the country is found in the MBA – a considerable percentage of which are residential, commercial and industrial complexes. Said study covered 85 cities and municipalities in the MBA, excluding the cities of Angeles (Pampanga) and Tarlac (Tarlac).

As of 2010, a total of 1,300 square kilometers in the MBA are considered built-up areas (World Bank 2010). This presents a 2.2% increase per year from 2000 to 2010. Such increases are characterized by densely populated settlements growing exponentially outside the administrative boundary of NCR. Almost all of the spatial growth (94%) occurred in the neighboring provinces, as the NCR is already built up by 2000. Pull factors driving this growth include the agglomerations of manufacturing, mining and quarrying, as well as construction and utilities in Regions III and IVA. Also included are the financial intermediations and service-oriented facilities in the NCR.

Most of these commercial and industrial areas are spatially integrated through the super regions established by the Arroyo Administration in 2006, including the Metro Luzon Urban Beltway.

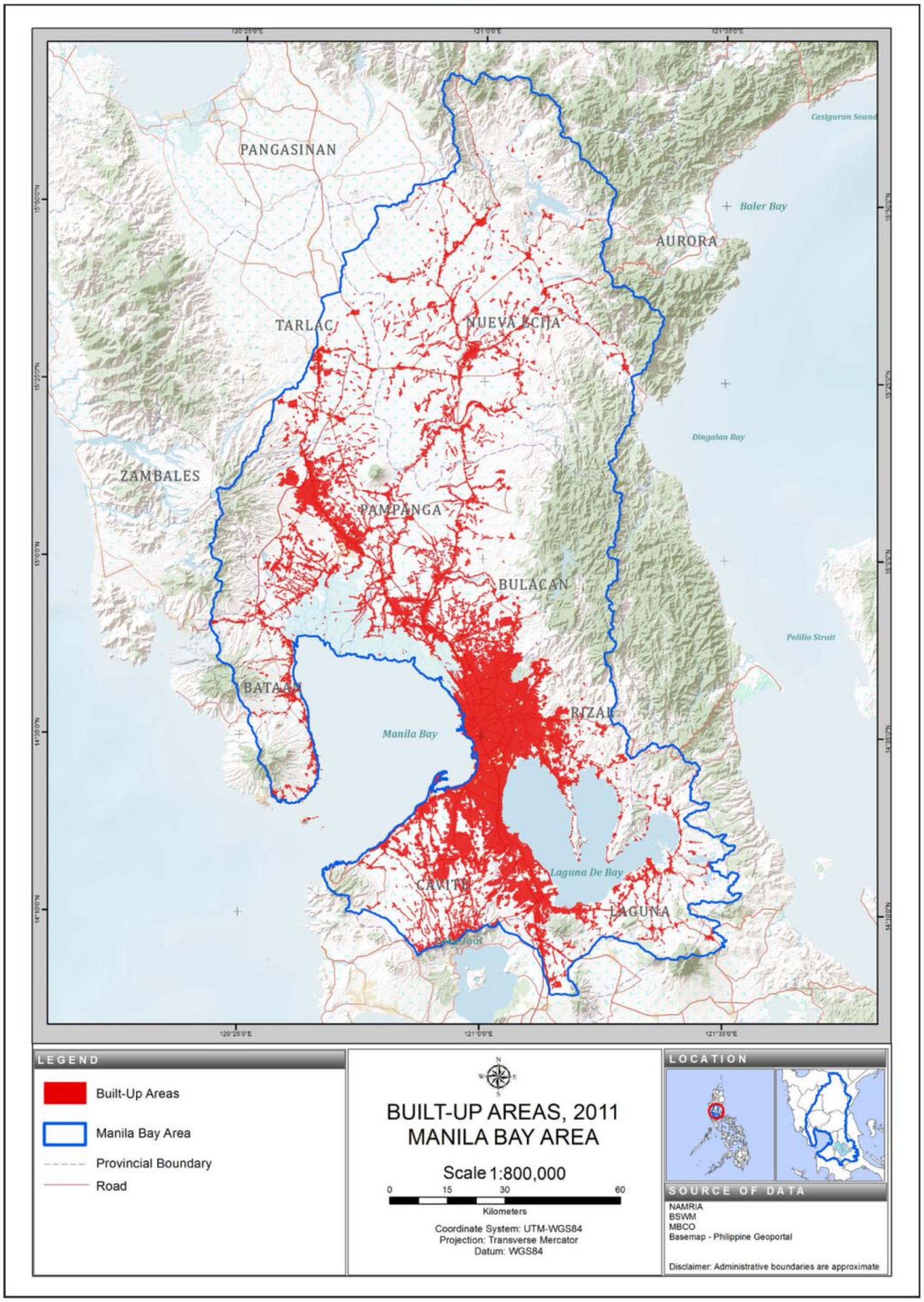
Box 3. The Luzon Urban Beltway

The Luzon Urban Beltway is one of the four (4) super regions of the country. This region is envisioned to make Metro Luzon a globally competitive urban, industrial and service center with a high quality of life for the people. A globally competitive urban beltway is characterized by efficient power cost; labor productivity and industrial peace; seamless access and efficient movement of goods and people; logistics/supply chain management; and efficient telecommunication.

In the Luzon Urban Beltway, Region III is considered as a globally competitive human resource transshipment and logistics hub in the Asia-Pacific Region, developed industrial heartlands, seamless and integrated physical access. The National Capital Region (NCR) is seen as the major business and transaction center in the Asia-Pacific region. Region IV-A (CALABARZON) is envisioned as livable industrial region with well-planned town clusters supported by modern intermodal transportation and digital infrastructure. The provinces of Mindoro and Marinduque (MIMA) in Region IV-B (MIMAROPA) are seen as a gateway to Southern Philippines and food basket of Metropolitan Manila and the CALABARZON.

Bonifacio Global City, financial district of Taguig City

Map 27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Casiguran Sound
Baler Bay
Dingalan Bay
Polillo Strait
Manila Bay
Laguna De Bay
LEGEND
Built-Up Areas
Manila Bay Area
Provincial Boundary
Road
BUILT-UP AREAS, 2011
MANILA BAY AREA
Scale 1:800,000
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Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
BSWM
MBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

C.4 CONSERVATION, PROTECTED AREAS AND KEY BIODIVERSITY AREAS

BIODIVERSITY IN MANILA BAY

Scaling the coastal waters and muddy beds of Manila Bay up to the freshwater tributaries and wetlands within its catchment system, the Manila Bay Area accommodates an eclectic assemblage of biological diversity from endemic and migratory communities to globally vulnerable and threatened species, as well as ecologically important terrestrial and marine ecosystems. It has numerous species of mangroves and associated beach forests trees, vast area of coral cover, fish biomass, 67 total species of invertebrate macrobenthos, and four species of marine turtles among the rich representations of its marine ecosystem. Going inland, migratory birds of different species frequent the wetlands and tidal flats as staging node in their seasonal flyway. Wetlands intersperse the whole watershed in the forms of lakes, reservoirs, swamps, caves and marshlands. Aside from the river systems, there are 27 identified wetland ecosystems within the Bay Area. Map 29 presents the key Biodiversity Areas within the MBA.

Ecological functions of biodiversity provide the necessary life support system for humans. Mangroves are proven efficient carbon sequesters. Together with corals, they form part of the natural defenses of the coast and coastal communities. Wetlands rich in biodiversity filter water with contaminants and provide various resources for human provisions on top of the ecosystem's goods and services from its marine counterpart. Thus, the biodiversity status and conditions in the Bay Area reflects the environmental state of the Bay, particularly that of water quality.

The call for prioritizing biodiversity conservation and management is as apt and timely as a pressing concern for all stakeholders for the rehabilitation of the Manila Bay.

Flocks of migrating birds frequent Manila Bay during winter season

Wawa Dam

RIDGE-TO-REEF ECOSYSTEMS AND HABITATS

Inland Wetland Ecosystems

Wetlands are areas of marsh, peat or water whether natural or temporary, with water that is static, flowing, fresh, brackish or salt; the depth of which at low tide does not exceed six meters. It is classified into coastal wetlands – including tidal flat, reef flat, seagrass bed, saline lagoon and mangrove, inland wetlands - estuary, river, marsh, swamp forest and lake and human-made wetlands - irrigated rice field, fishpond, and dam.

The Manila Bay Area hosts a wide variety of wetlands. Based on an initial inventory of inland wetlands in Mainland Luzon, 17 inland wetlands are within the MBA. Ten of these are lakes which make up 58.82% of the total land area. Lakes within MBA cover an estimated 90,580.59 has – the largest of which is the Laguna de Bay covering an estimated 90,183 has. These ecosystems can be found within the provinces of Tarlac, Laguna and Rizal.

Aside from lakes, reservoirs and swamps are also found within the MBA. Man-made reservoirs or dams located in the provinces of Nueva Ecija, Bulacan, Laguna and Rizal constitute 35.29% of inland wetlands with an approximate area of 6,902.58 has. The largest among the identified reservoirs is the Pantabangan Dam in Nueva Ecija with an approximate area of 3,527.50 has.

The Candaba Swamp in the provinces of Pampanga and Bulacan is the only swamp identified within the MBA.

Coastal and Marine Habitats

The coastal areas of the MBA are presented with mangroves, mudflats, corals and seagrasses. Collectively, these habitats contribute to sand formation and deposition, reduction of water energy and motion, regulation of the chemical composition of coastal waters and sediments, regulation of run-off and stabilization of bottom sediments, maintenance of coastal fertility, regulation of biological control mechanism, maintenance of migration and nursery habitats, and enhancement and maintenance of coastal ecosystem and genetic diversity.

Other Ecosystems

Caves are natural holes or opening extending from the surface of the Earth to the underground, large enough for a person to pass. It includes any natural pit, sinkhole, subterranean passage and other features extending from a cave entrance (Philippine Cave Primer, 2013). A total of eleven classified caves are located in the provinces of Bulacan, Laguna and Rizal.

CONSERVATION INITIATIVES

There are a number of protected areas under the National Integrated Protected Areas System (NIPAS) within the MBA. As per RA 7586 (National Integrated Protected Areas System Act of 1992), protected areas refer to identified portions of land and water set aside by reason of their unique physical and biological significance, managed to enhance biological diversity and protected against destructive human exploitation.

Map 28 provides the location and extent of all the 13 PAs within the MBA.

Box 4. The Las Piñas-Paranaque Critical Habitat and Ecotourism Area

The Las Piñas-Parañaque Critical Habitat and Ecotourism Area (LPPCHEA) is a nature reserve situated south of Manila Bay. Open to the general public, the area offers visitors a welcome respite from all the buzz and fuss of urban living, all without leaving the city.

Established in 2007 thru Presidential Proclamation No. 1412 as amended, LPPCHEA is the first critical habitat to be declared in the country. Covering around 175 hectares of wetland ecosystem, LPPCHEA consists of two (2) islands—Freedom Island and Long Island—with mangroves, ponds and lagoons, mudflats, salt marshes, and mixed beach forest all over.

On March 15, 2013 LPPCHEA was recognized as a wetland of international importance by the Ramsar Convention because of the critical role it plays in the survival of threatened, restricted-range and congregatory bird species. It is the sixth Ramsar Site in the country to date.

An important resting and refueling stop for migratory birds using the East Asian–Australasian Migratory Flyway, LPPCHEA hosts around 41 species of migratory birds in the area, with some coming from as far as China, Japan and Siberia.

During migration season—i.e., between the months of August and April each year—the area is transformed into a feeding and resting area for migratory birds making their way to the warmer regions of the globe. During these times, the number of birds seen roosting and feeding in the area reach as high as 5,000 heads per day according to surveys conducted by the Department of Environment and Natural Resources-National Capital Region (DENR-NCR) and Wild Bird Club of the Philippines (WBCP).

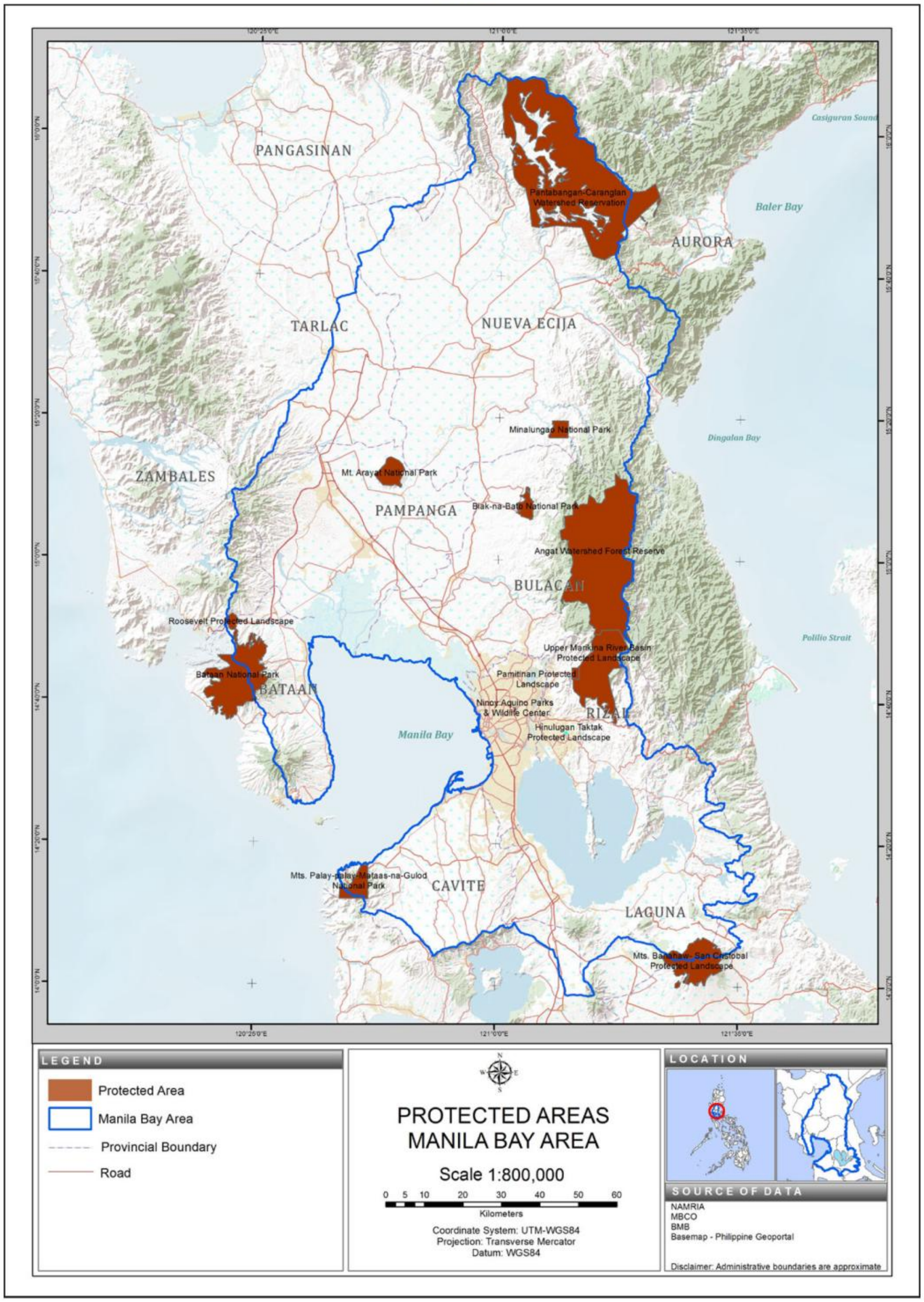
With its verdant landscape, calm lagoons, and diverse collection of wild birds, the area gives visitors a chance to commune with nature, study, or simply marvel at life's majestic creations. Guests are introduced to a diverse variety of ecosystems as they take a trek inside the area. With more than 36 hectares of mangrove forest, by far the most extensive among the remaining mangrove areas in Manila Bay, LPPCHEA truly lives up to its reputation as the region's last coastal frontier.

Table 8. Wetlands within the Manila Bay Area

Wetland/No.	Administrative Location	Inflow	Outflow	Mid Coordinate		Approximate Area
				Longitude	Latitude	
Lakes						90,627.59
Region III						
Lake Canarin	Victoria, Tarlac	Pampanga River	Manila Bay	120°42'6.10"	15°35'46.92"	103.39
Lake Ladiaoan	San Clemente, Tarlac	x	x	120°25'56.16"	15°45'9.11"	11.60
Canarem Lake	San Jose, Tarlac	Pampanga River	Manila Bay	120°26'2.43"	15°29'16.16"	59.43
Tambo Lake	Capas, Tarlac	Pampanga River	Manila Bay	120°22'16.67"	15°17'40.54"	91.98
Region IV-A						
Lake Calibato	San Pablo City, Laguna	Prinsa River	Calauan River (Laguna Lake)	121°22'39.5"	14°06'11.2"	47.58
Mohikap Lake	San Pablo City, Laguna	x	x	121°20'03.8"	14°07'18.4"	18.68
Palakpakin Lake	San Pablo City, Laguna	Prinsa River	Calauan River (Laguna Lake)	121°20'23.8"	14°06'37.7"	51.98
Pandin Lake	San Pablo City, Laguna	Prinsa River	Calauan River (Laguna Lake)	121°22'04.2"	14°06'49.8"	24.83
Lake Yambo	San Pablo City, Laguna	Prinsa River	Calauan River (Laguna Lake)	121°21'59.4"	14°07'08.1"	35.12
Tadlac Lake (Aligator)	Los Baños, Laguna		Laguna Lake	121°12'23.1"	14°10'58.0"	23.32
Laguna Lake	Lakshore Cities and Municipalities of Rizal, Laguna and NCR	Rizal and Laguna RS	Pasig River (Manila Bay)	121°15'48.4"	14°23'41.6"	90,159.68
Swamps						9,706.98
Region III						
Candaba Swamp	Candaba, San Luis, Sta. Ana, Arayat, Pampanga and Cabiao, Nueva Ecija	Pampanga River	Manila Bay	120°51'43.42"	15°7'13.99"	9,706.98
Reservoirs						6,902.58
Region III						
Pantabangan Reservoir	Pantabangan, Nueva Ecija	x	Pampanga River/Manila Bay	121° 6'33.00"	15°48'56.00"	3,527.50
Angat Reservoir	Norzagaray and Doña Remedios Trinidad, Bulacan	Catmon River	Ipo River/Meycauyan River/ Manila Bay	121° 9'39.00"	14°54'37.00"	2,221.51
Ipo Reservoir	Norzagaray, Bulacan	Angat Dam	Angat River/Meycauyan River/Manila Bay	121° 8'50.00"	14°52'30.00"	104.45
Region IV-A						
Caliraya Reservoir	Lumban, Cavinti and Kalavaan, Laguna	x	Laguna Lake	121°31'15.48"	14°17'37.53"	1,047.84
Wawa Reservoir	Rodriguez, Rizal	Upper Marikina River	Marikina River/ Manila Bay	121°11'30.53"	14°43'40.41"	1.29

Source: Biodiversity Management Bureau

Map 28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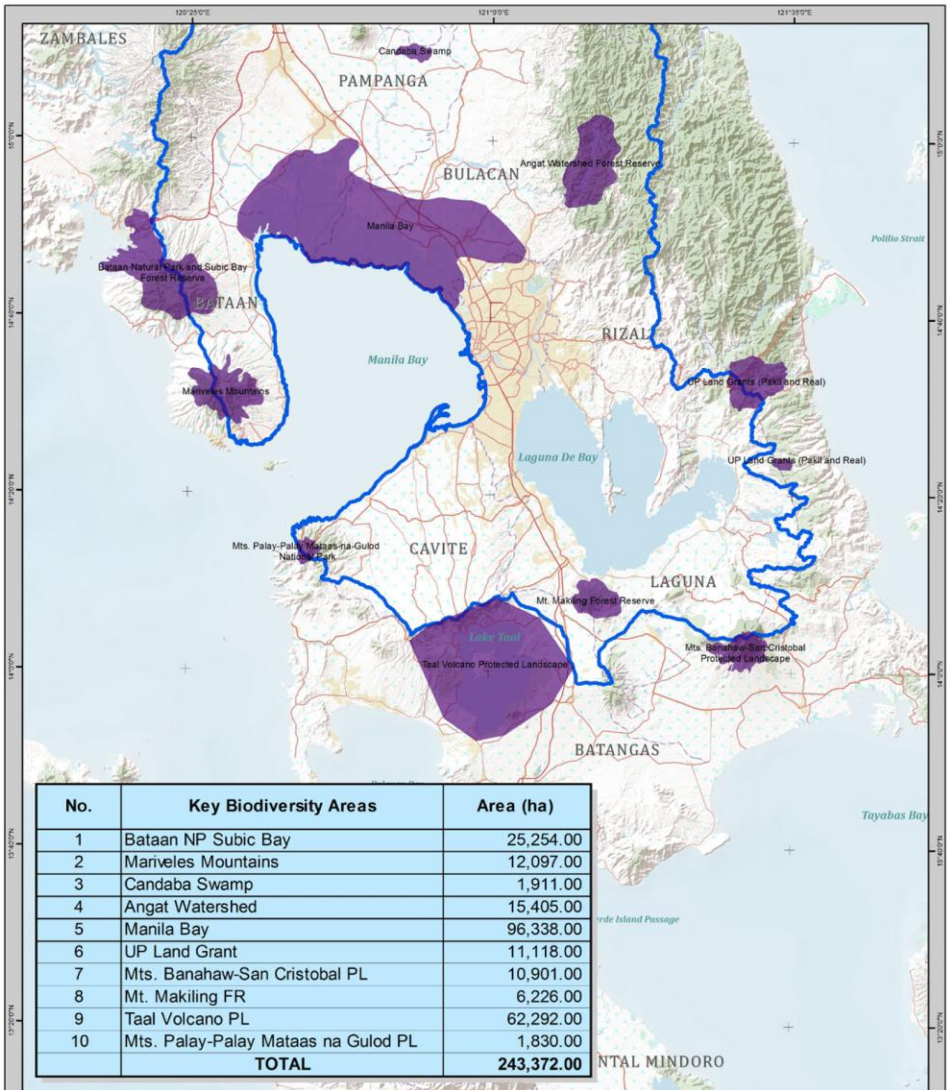
Manila Bay
Baler Bay
Dingalan Bay
Polillo Strait
Casiguran Sound
Pantabangan-Carangalan Watershed Reservation
Minalungao National Park
Mt. Arayat National Park
Biak-na-Bato National Park
Angat Watershed Forest Reserve
Roosevelt Protected Landscape
Bataan National Park
Upper Marikina River Basin Protected Landscape
Pamitinan Protected Landscape
Ninoy Aquino Parks & Wildlife Center
Hinulugan Taktak Protected Landscape
Mts. Palay-palay-Mataas-na-Gulod National Park
Mts. Banahaw-San Cristobal Protected Landscape
LEGEND
Protected Area
Manila Bay Area
Provincial Boundary
Road
PROTECTED AREAS
MANILA BAY AREA
Scale 1:800,000
0 5 10 20 30 40 50 60
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 29



No.	Key Biodiversity Areas	Area (ha)
1	Bataan NP Subic Bay	25,254.00
2	Mariveles Mountains	12,097.00
3	Candaba Swamp	1,911.00
4	Angat Watershed	15,405.00
5	Manila Bay	96,338.00
6	UP Land Grant	11,118.00
7	Mts. Banahaw-San Cristobal PL	10,901.00
8	Mt. Makiling FR	6,226.00
9	Taal Volcano PL	62,292.00
10	Mts. Palay-Palay Mataas na Gulod PL	1,830.00
	TOTAL	**243,372.00**

LEGEND

- Key Biodiversity Area
- Manila Bay Area
- Provincial Boundary
- Road

KEY BIODIVERSITY AREAS MANILA BAY AREA

Scale 1:700,000

0 4.25 8.5 17 25.5 34 42.5 51 59.5 Kilometers

Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84

LOCATION

SOURCE OF DATA

NAMRIA
MBCO
BMB
Basemap - Philippine Geoportal

Disclaimer: Administrative boundaries are approximate

C.5 HISTORICAL, CULTURAL AND TOURISM SITES

A wide number of national and local tourism sites are found within the Manila Bay Area. Aside from its scenic natural resources, these sites also imbibe a sense of historical and cultural appreciation and significance amongst many Filipinos. Likewise, they provide valuable sources of income and employment with the influx of tourists from all over the world.

There was a five-fold increase in travellers from 2005 (1,065,717) to 2010 (5,992,445). Table 9 shows the distribution of regional travellers in the MBA for 2010. Such growth is attributed to the sustained campaigns by the government to boost domestic and international tourism. According to the National Statistical Coordination Board (NSCB), the increasing tourist arrivals in 2010 contributed to an estimated 5.8% share of the country's GDP.

The Department of Tourism (DOT) has plans of improving tourism infrastructures to further its contribution to job creation and revenue generation.

Manila Cathedral

Table 9. Distribution of Regional Travellers to the Manila Bay Area (2010)

Region/ Province/ City	Foreign Travellers	Overseas Filipinos	Domestic Travellers	Total
NCR	1,465, 405	15,466	815,604	2,296,475
Region III	73,539	3,661	176,112	253,312
Bataan	2,439	213	18,266	20,918
Bulacan	1,856	27	51,177	53,060
Nueva Ecija	1,657	-	9,894	11,151
Pampanga	62,987	1,902	82,102	146,991
Tarlac	4,600	1,519	14,673	20,792
Region IV-A	395,783	545	3,046,330	3,442,658
Cavite	302,301	-	982,733	1,284,934
Laguna	93,482	545	2,063,597	2,157,624
Rizal	-	-	-	-
TOTAL	1,934,727	19,672	4,038,046	5,992,445

Source: DOT

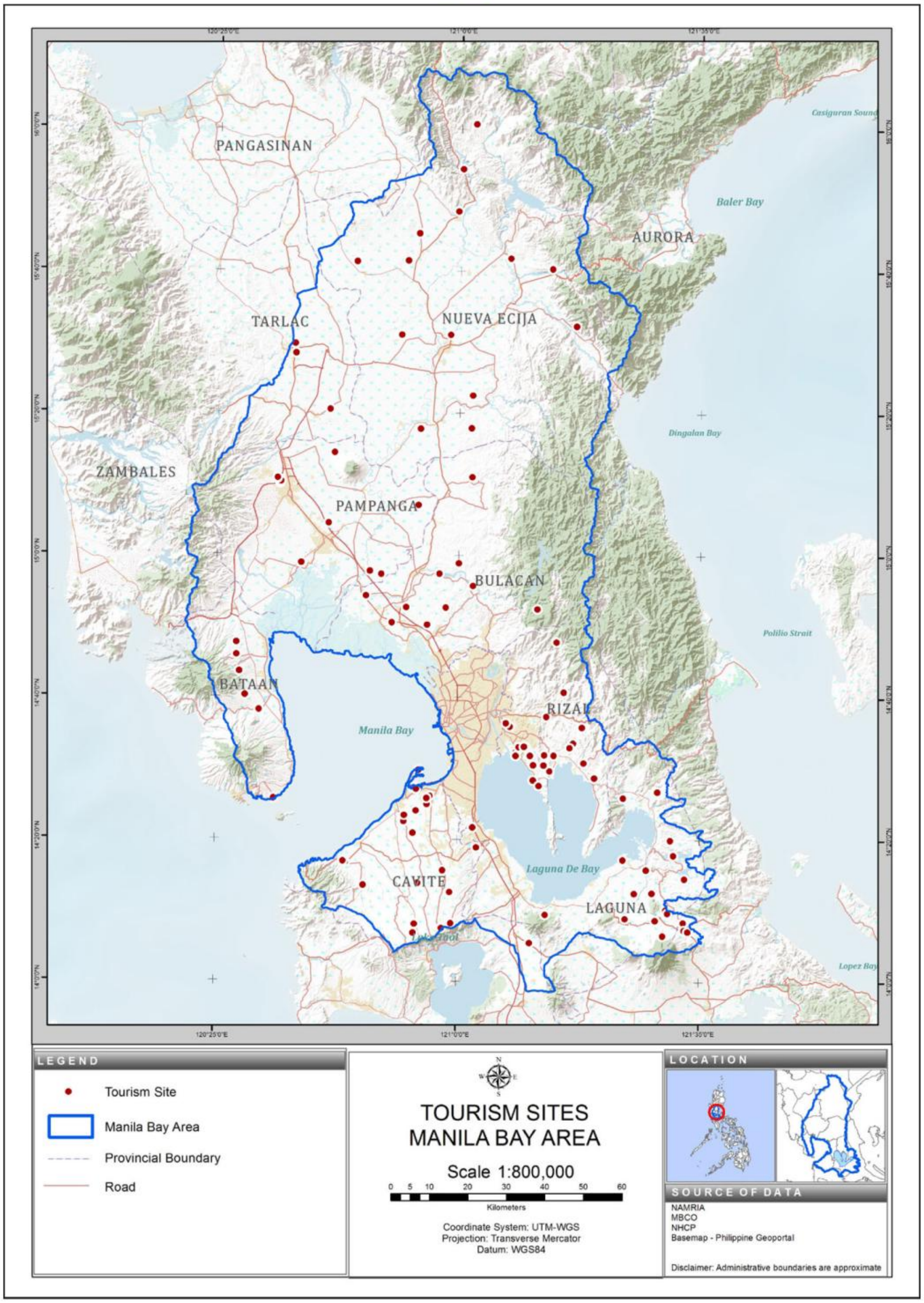
Emilio Aguinaldo Shrine in Kawit, Cavite

One of the major sources for revenue in the tourism industry are provided by economic activities from nationally identified historical, cultural and tourism sites, including recreation, accommodation and other related services. Annex 12 provides an exhaustive listing of these sites within the MBA, while the Historical, Cultural and Tourism Sites Map presents the geographical locations of these landmarks. Said listing is not reflective of sites identified by LGUs and other institutions.

Dambana ng Kagitingan on Mt. Samat, Bataan

Balanga Espada Historical Monument, Balanga, Bataan

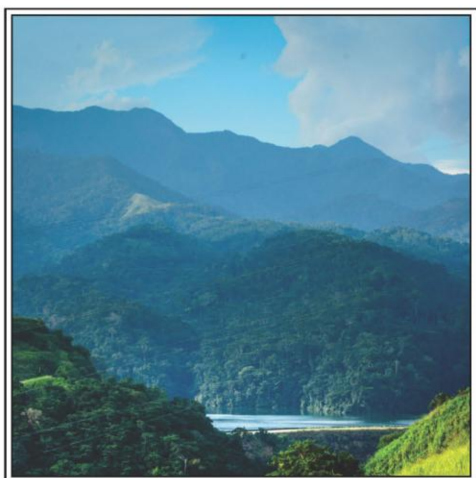
Map 30


PANGASINAN
TARLAC
NUEVA ECIJA
AURORA
ZAMBALES
PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Casiguran Sound
Baler Bay
Dingalan Bay
Polillo Strait
Manila Bay
Laguna De Bay
Lopez Bay
LEGEND
Tourism Site
Manila Bay Area
Provincial Boundary
Road
TOURISM SITES
MANILA BAY AREA
Scale 1:800,000
0 5 10 20 30 40 50 60
Kilometers
Coordinate System: UTM-WGS
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
NHCP
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

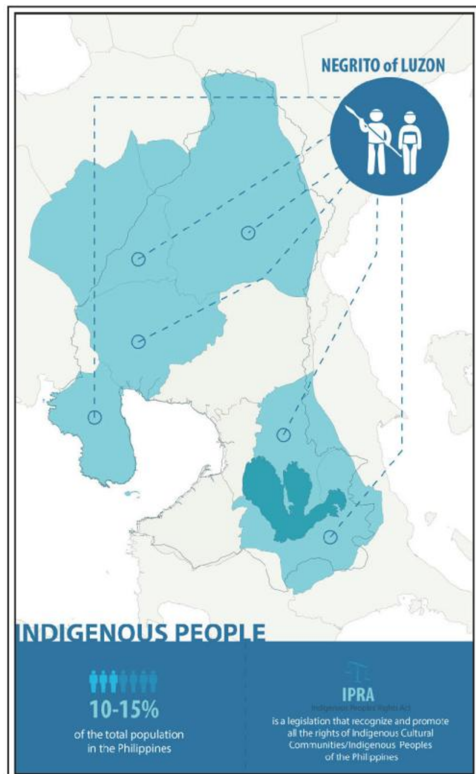
C.6 ANCESTRAL LANDS IN THE MANILA BAY AREA

A number of ancestral lands duly designated by the National Commission for Indigenous People (NCIP) are also found within the Manila Bay Area. These lands are home to several groups of indigenous people, including Ayta, Dumagat, Bugkalot and Igorot - commonly found in the rolling mountains of Nueva Vizcaya, Nueva Ecija, Bulacan, Zambales and Bataan within the MBA watershed boundary.

Through the years, increasing urban agglomeration threatens the communities' customs, traditions and livelihood. Placing priority in ancestral domain rights remains a challenge for MBA's growing economies. Map 31 provides the location of these ancestral lands within the MBA.



Most of the IPs in the MBA live in upland areas



Map 31


NUEVA VIZCAYA
QUIRINO
Lingayen Gulf
Casiguran Sound
PANGASINAN
Baler Bay
AURORA
TARLAC
NUEVA ECIJA
Dingalan Bay
ZAMBALES
PAMPANGA
BULACAN
Polillo Strait
BATAAN
RIZAL
Manila Bay
Lamon Bay
CAVITE
LAGUNA
Calauag Bay
Lopez Bay
LEGEND
Ancestral Land
Manila Bay Area
Provincial Boundary
Road
ANCESTRAL LANDS
MANILA BAY AREA
Scale 1:850,000
0 5 10 20 30 40 50 60 70
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

C.7 PORTS AND SHIPPING

The Philippine Ports Authority (PPA) is tasked to oversee, manage and administer the operation, construction and maintenance of ports in accordance with its charter the PD 857 (as amended). The PPA plays a major role in the ports and shipping industry. Since the Philippines is an archipelagic country, most of the goods that enter our country pass through the ports, not to mention the local movement of goods.

The ports in the Manila Bay Area include the Manila International Container Terminal (MICT) and PMO-NCR South Harbor which are the country's gateways to international shipping and trade, as well as the PMO-NCR North Harbor and the Port of Limay. The MICT is the country's premier container port with an average annual capacity of 1.8 m. twenty-foot equivalent units (TEUs).

PMO-NCR SOUTH HARBOR

Location

The PMO-NCR South Harbor is located at the south of Manila Port and situated at the Northeast shoulder of Manila Bay, southeast of Luzon island in Manila with coordinates: Latitude 14°36.2'N Long. 120°58.0'E.

Total Area

The territorial area of PMO-NCR South Harbor has been expanded eastward up to Bonifacio Drive by 27 hectares from 58 hectares to a total of 85 hectares excluding the wharf zone by virtue of EO No. 321 dated March 17, 1988. It is divided into the Old Port Zone (OPZ) and Expanded Port Zone (EPZ). It has a shore line that is protected by some 10,000 ft of rock barriers enclosing approximately 600 hectares of anchorage. Harbor limits are clarified and defined in EO 361 dated August 16, 1996.

Land Access

The main access to PMO-NCR South Harbor traffic is through Bonifacio Drive, Port Area, Manila. Cargo traffic is via three gates: 1, 4 and 6. PMO-NCR South Harbor is operated by Asian Terminals, Inc. (ATI) under contract with the Philippine Ports Authority (PPA).

PMO-NCR NORTH HARBOR

Location

The PMO-NCR North Harbor is located at Lat. 14°37.2'N, Long. 120°57.5'E, along the shores of Tondo Dist., Manila, Northeast of MICT.

Land Access

PMO-NCR North Harbor is adjacent to Radial 10 which runs parallel to the port from the foot of Delpan Bridge to Pier 18. Road Access can be through any of the following gates located at the streets perpendicular to Radial 10 which are the Zaragoza Gate, Moriones Gate, Pacheco Gate, MSW Entry/Exit Gates and MICT Old Access Rd. These can be used to enter and leave North Harbor.

Entrance Channel/Turning Basin

The navigational approach to the port is marked by an entrance buoy and the length of its channel is 1.5 miles and has a depth of 7 meters.

Port Area

PMO-NCR North Harbor has a total port area of 52.47 hectares and a quay length of 5,200 meters.

Port Facilities

Controlling Draft – 5-6 meters

All terminals at PMO-NCR North Harbor can support RORO type of operations,.

PMO-NCR North Harbor is presently operated by the Manila North Harbor Port, Inc. (MNHPI) under contract with PPA.

Passenger Terminal Building

Presently, the MNHPI also operates a modern passenger terminal.

PMO-NCR South Harbor

PMO-BATAAN/AURORA

Location

The PMO-Bataan/Aurora is situated at National Road Brgy Lamao, Limay, Bataan with a Latitude of 120°38'0"E and Longitude of 14°30'0" N. Ports under PMO-Limay are located in the southernmost shores of the Bataan Peninsula.

Port Limits

Total land area is 768,198 sq.m. Port Zone Delineation.

Land Access

PMO-Bataan/Aurora is 147 km from Manila and accessible by land through following points: via Roman Super Highway North Luzon Expressway, Olongapo-Gapan Rd & Subic-Clark-Tarlac Expressway.

Port Facilities

This includes a reinforced concrete pier and multi-purpose wharf; a roll-on roll- off ramp with a width of 12 m; a cemented roadway with a length of 175 m; a hanging covered walk; a mooring tee head of 25 tons and 6 sets of V-500 rubber dock fenders.

MANILA INTERNATIONAL CONTAINER TERMINAL (MICT)

MICT is operated and managed by International Container Terminal Services, Inc. (ICTSI) under contract with PPA which is involved in the management, operation and development of port terminals worldwide. The MICT contract covers the rendition of efficient port services, development of port facilities and provision of modern cargo handling equipment and operating systems.

Around 64% of total foreign cargo traffic passing through Manila is handled by MICT.

Location

MICT lies between North Harbor and South Harbor extending westward into the Manila Bay at the mouth of Pasig River. Latitude of 14°33.25'N, Longitude 120°55.45'E

Port Limits

Based on the NAMRIA benchmark, the bearings and distances of the MICT limits are described as follows:

LINE DISTANCE (meters)	BEARINGS	
1-2	S 89°38'32"W	363.81
2-3	S 82°37' 26"W	1,371.42
3-4	N 12°19'04"W	390.09
4-5	N 57°46'55" W	625.76
5-6	N 57°12'19"W	331.11
6-7	N 87°18'08"W	189.10
7-8	N 07°28'33"W	359.40
8-9	S 85°05'31" E	90.35
9-10	N 30°00'19"E	123.26
10-11	N 30°21'29"E	480.59
11-12	N 30°21'00"E	544.41
12-13	S 81°56'51"E	822.96
13-14	S 35°01'28"E	1,710.06
14-1	S 35°01'08"E	670.14

International Container Terminal Services, Inc.

Navigational Approach

The harbour entrance to MICT features a channel 2km long and 350 m wide at the open gap between Northwest and Southwest Breakwater. The entrance to the MICT inner basin is lit at night by flashing green and red lights.

A total of 2kms of breakwater with an average height of 3m from Mean Low Low Water (MLLW) bounds MICT's inner basin of approximately 284 hectares. There are 800 meters of breakwater protecting the northwest boundaries and 1200 meters of breakwater protecting southwest boundaries of MICT.

Land Access

One land access to MICT is through Manila's Road 10 (6 lanes) with a right turn into the MICT South Access Road (6 lanes). Another land access is through the Isla Putting Bato Road (4 lanes) through the domestic port of North Harbor. The MICT Access Road (2 lanes) is used by empty trucks going through and out of the terminal.

PRIVATE PORTS

There are about fifty eight (58) private ports operating in the Manila Bay Area with permits from PPA.

FERRY TERMINALS

There are ferry terminals such as the Port of Orion in Bataan and the Private ferry terminal of the Mall of Asia (MOA) and the CCP Bay Terminal in Pasay which is a DOTC-managed port. Presently, there are also ferry boats plying the Pasig River (downstream and upstream).

AIDS TO NAVIGATION/NAVIGATIONAL SAFETY

The Philippine Ports Authority currently operates a Vessel Traffic Management System (VTMS) in Manila Port. The VTMS covering the Manila Bay area was put up to ensure the safe navigation of all vessels passing through the Manila Bay.

Table 10. Total Number of Ships (Domestic and Foreign Vessels) Calling at the Ports of Manila Bay Area (2004-2012)

PORT	2004	2005	2006	2007	2008	2009	2010	2011	2012
North Harbor	23,013,752	21,077,269	20,850,485	19,636,481	15,811,770	15,884,681	17,207,751	17,806,136	19,402,011
South Harbor	29,450,095	34,962,961	33,755,513	33,622,426	33,495,088	35,659,849	40,816,716	44,067,826	40,317,702
MICT	28,378,266	28,115,259	28,561,664	32,403,748	32,731,357	32,197,569	32,225,795	34,377,129	
Limay	14,054,430	13,344,540	14,272,505	14,161,872	13,025,332	12,835,625	13,969,732	13,779,702	14,686,908

Table 11. Volume of Liquid and Solid Wastes Collected from the Ports of the Manila Bay Area (2009-2013)

PORT	Volume of Waste Collected (in cu. M.)									
	2009		2010		2011		2012		2013	
	Liquid	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid	Liquid	Solid
North Harbor	22.3	1,102.92	234.47	1,165.27	0.8	977.78	0	1,126.14	0	545.43
South Harbor	505.62	1,892.30	214.19	2,405.66	3,052.00	3,301.85	142.50	2,703.68	51.25	775.18
MICT	757.23	364.06	263.64	543.09	373.98	528.58	741.3	492.98	107	211.39
Limay	279.19	366	5.4	384.34	52.18	307.12	16.45	468.62	4.33	188.49
TOTAL	1,564.34	3,725.28	717.70	4,498.36	3,478.96	5,115.33	900.25	4,791.42	162.58	1,720.49

C.8 AIRPORTS, ROADS AND RAILWAYS

AIRPORTS

Airports continue to play vital roles in the global movement of people, goods and services. Such facilities have brought in 3.5 million visitors in 2010, earning a gross receipt of PhP 520 million or 5.8% GDP – a considerable number coming to and fro the Manila Bay Area (DOT, 2012).

To date, the MBA caters to two international and one domestic airports. International airports, namely the Ninoy Aquino International Airport (NAIA) and the Clark International Airport (CIA) are considered the country's main gateway facilities and have continuously received increasing passenger movement. In most cases, these are linked to domestic airports across the MBA to serve intra- and inter-regional transport routes.

Plans are underway for the construction of additional airport facilities and modal transfers as part of the country's sustained goal of becoming a prime tourist destination in Asia - one of which is the New Manila International Airport which is expected to accommodate a greater number of visitors in the coming years.

Ninoy Aquino International Airport

ROADS

The growing intricacies of road networks have continuously integrated an array of political and socioeconomic spaces in the MBA. The benefits of easing movement have vastly contributed to the sustained economic growth experienced in the region.

As of 2014, the MBA has a total road network of 5,999.60 km; 1,147.14 km for NCR, 2,344.70 km for Region III and 2,507.76 km for Region IV-A. This shows a rough nine percentage increase from 2007, which can be attributed to the expansion of human settlements and the development of regional growth centers.

Of the total road network, 1,156.58 km are considered primary roads; 2,353.02 km as secondary and 2,490 km as tertiary roads. These networks are traversed by an increasing number of registered vehicles in the MBA. As of 2013, 4,192,745 registered vehicles (private, for hire, government, diplomatic, tax-exempt) were listed by the Land Transportation Office (LTO) within the MBA –1,065,361 of which are utility vehicles; 914,410 are cars and SUVs; 2,007,585 are motorcycles and tricycles; 184,382 are trucks and trailers; and 20,998 are buses. The posted numbers in NCR grow exponentially during daytime with the influx of people working or doing other transactions in the metropolis. Based on the DOTC-LTO dataset, the figures for Region IV represented both CALABARZON and MIMAROPA.

As a response to growing transport demands, the DPWH has proposed the widening of existing roads and the construction of expressway networks, bypasses and ring roads within regional cities. Some of the priority projects listed under the High Standard Highway

Roxas Boulevard

(HSH) Network include the Central Luzon Expressway (Phases I and II), North Luzon Expressway East (Phases I and II), C-6 Expressway, C-5/ FTI/Skyway Connector Road, CALA Expressway (North and South Sections), Calamba-Los Banos Toll Expressway and South Luzon Expressway Extension (DPWH, 2010).

RAILWAYS

The MBA is also being serviced by extensive rail transport systems managed by the Department of Transportation and Communications (DOTC), through its Light Rail Transit Authority (LRTA) and the Philippine National Railways (PNR).

Table 12. Proposed and Existing Urban Rail Network within MBA

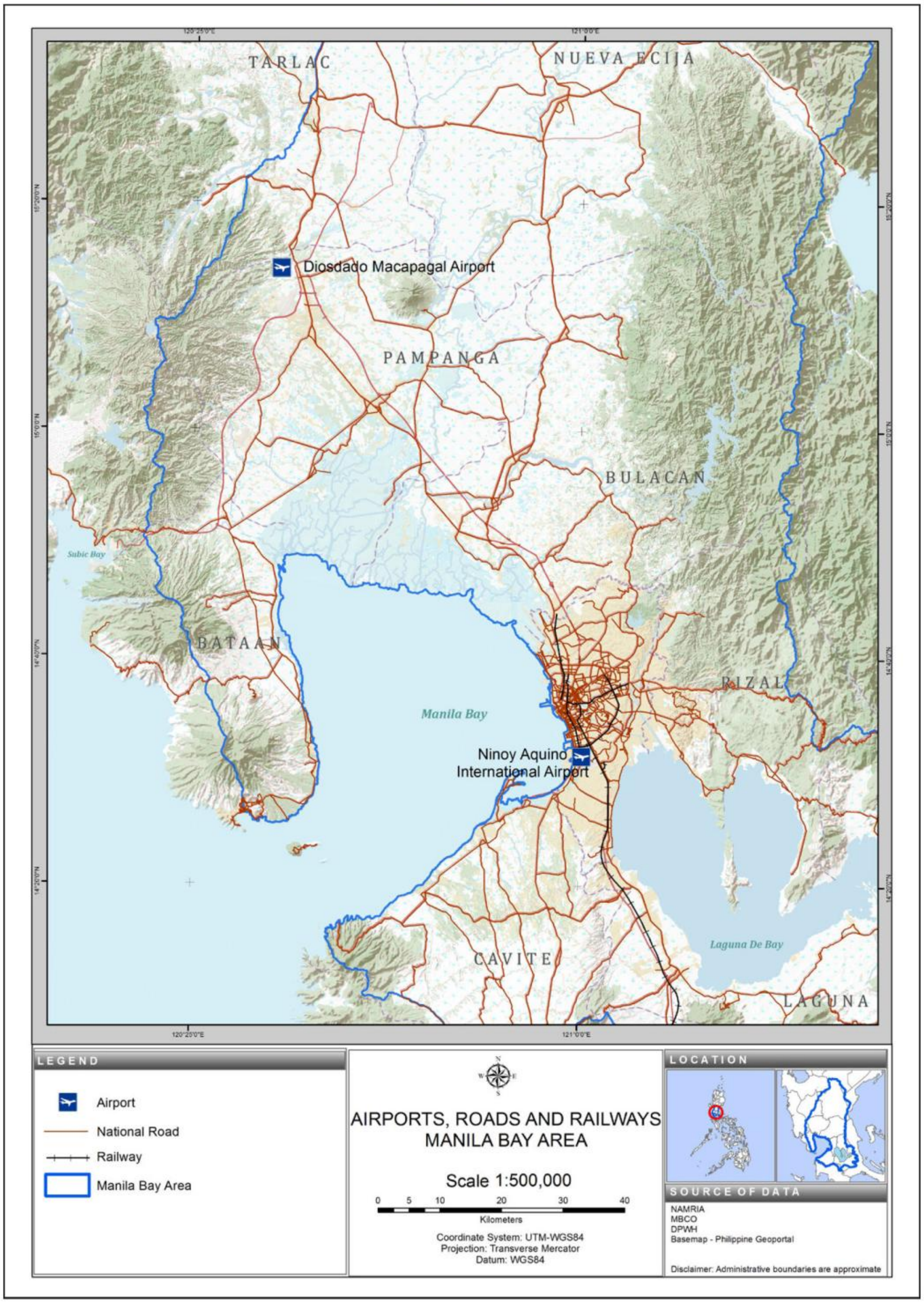
Rail Network	Line	Distance	Status
Manila Light Rail Transit System	LRT-1	19.65 km (12.21 mi)	Operational since 1984
	LRT-2	13.8 km (8.6 mi)	Operational since 2003
Manila Metro Rail Transit System	MRT-3	16.9 km (10.5 mi)	Operational since 1999
	MRT-7	23 km (14.4 mi)	Proposed since 2002
Philippine National Railways		56 km (35 mi)	Temporarily closed
University of the Philippines (Diliman) Automated Guideway Transit System		6.9 km (4.3 mi)	Proposed since 2011

Source: Department of Transportation and Communications (DOTC)

Amidst such improvements, congestion in urban areas is still a problem, particularly for NCR and the adjacent provinces of Bulacan, Cavite, Laguna and Rizal. There is a need to either increase the system capacity or decrease the demand for motorized transport.

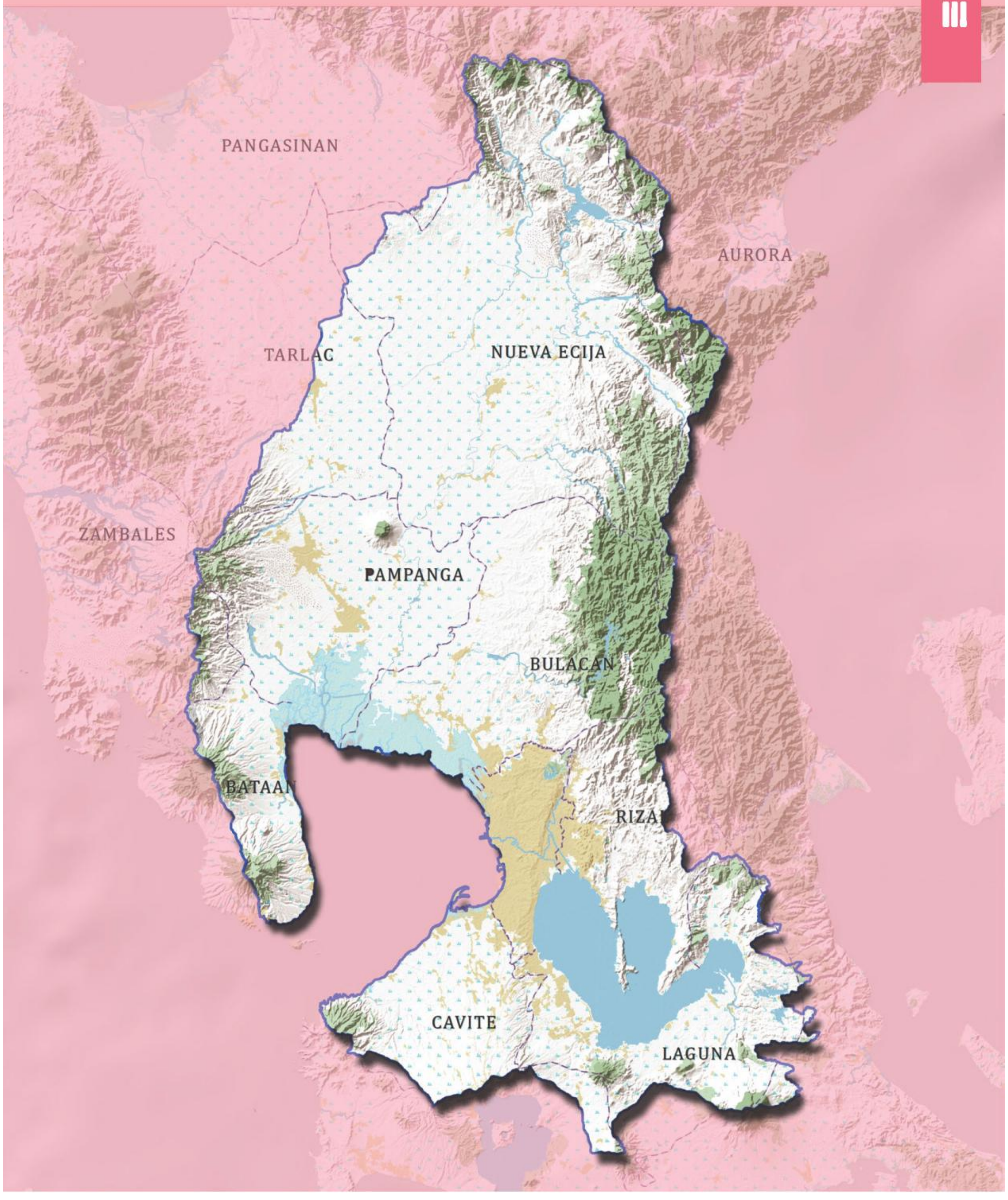
MRT-3

Map 32


TARLAC
NUEVA ECIJA
Diosdado Macapagal Airport
PAMPANGA
BULACAN
Subic Bay
BATAAN
RIZAL
Manila Bay
Ninoy Aquino International Airport
Laguna De Bay
CAVITE
LAGUNA
LEGEND
Airport
National Road
Railway
Manila Bay Area
AIRPORTS, ROADS AND RAILWAYS
MANILA BAY AREA
Scale 1:500,000
0 5 10 20 30 40
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
DPWH
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

PART III

TRENDS AND EMERGING ISSUES ON THE HEALTH OF THE MANILA BAY ECOSYSTEM



A. GROUNDWATER

A.1 AVAILABILITY

Based on the NWRB permit database (as of 2013), of the eight provinces encompassing Manila Bay Area, Nueva Ecija has the highest safe yield of almost 80,000 liter per second (lps) with an additional 70,000 lps available for allocation. Conversely, the provinces of Bataan, Cavite and Rizal have the lowest withdrawal rate of less than 10,000 liter per second (lps) and apportioned almost half of it, as shown in Figure 16 below. Further, Metro Manila has already exceeded its groundwater extraction limit which resulted to the issuance of moratorium of water permit application and processing in 2009.

Generally, the Manila Bay Area has sufficient groundwater available for various uses. However, seasonal variations and biased geographic distribution is considerable which resulted in water shortages in highly populated areas particularly in Metro Manila (Figures 17 to 25).

The NWRB is currently undertaking groundwater data collection activities in compliance to its commitments on the Restoration of Habitats and Resources Management in the Manila Bay Area as part of the Medium Term (2011-2015) Operational Plan for the Manila Bay Coastal Strategy (OPBCMS). Based on the data collected between 2011 and 2013, most Manila Bay Area provinces are experiencing groundwater level decreases within the range of 2 cm to more than 10 meters i.e. static and pumping water level, as shown in Map 35.

Chloride values exceeding the Philippine National Standards for Drinking Water (PNSDW) of 250mg/l are evident in various areas of Bulacan, Candaba in Pampanga and in some coastal parts of Metro Manila and Cavite. Generally, the nitrate values from randomly selected deepwells across the region yielded safe or within the PNSDW limit.

The National Water Resources Board (NWRB) is continuously updating its groundwater permit database to assess the groundwater availability of the country. As the government policy-making body for water, the NWRB is periodically reviewing existing policies to identify gaps and drafting and issuing new policies in order to have an effective resource regulation and efficient management of the resource adhering to the principles of sustainable development.

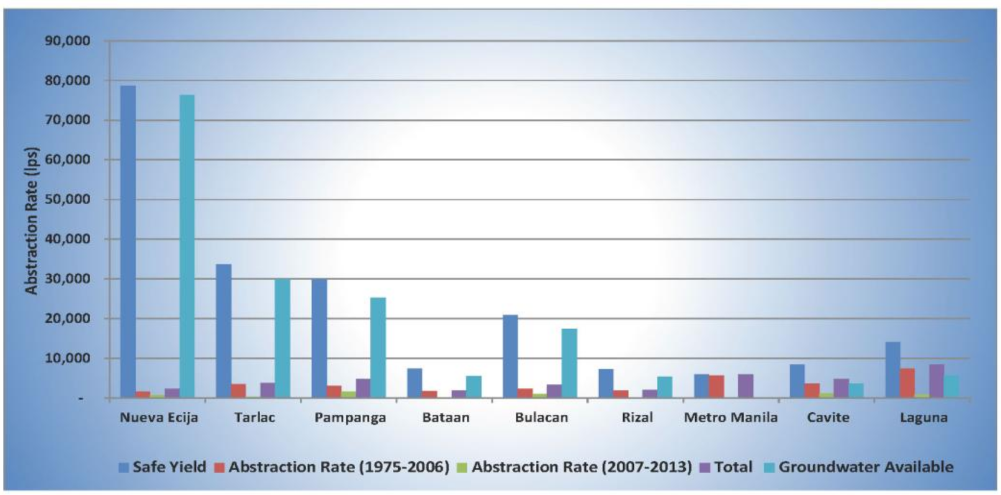


Figure 16 Groundwater Abstraction in the Manila Bay Area

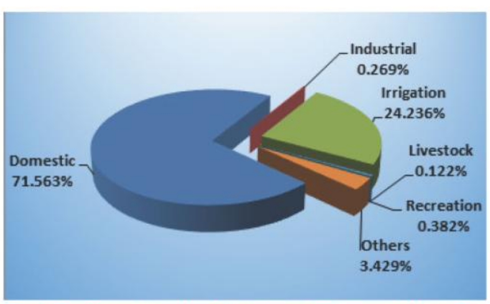


Figure 17. Groundwater Use Allocation in the Province of Nueva Ecija (2013)

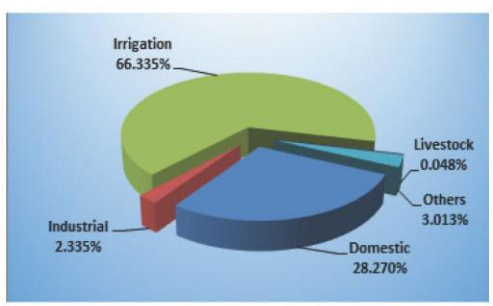


Figure 18. Groundwater Use Allocation in the Province of Tarlac (2013)

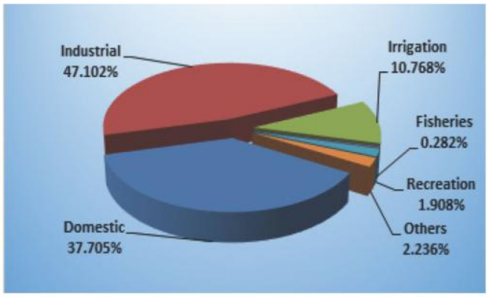


Figure 19. Groundwater Use Allocation in the Province of Pampanga (2013)

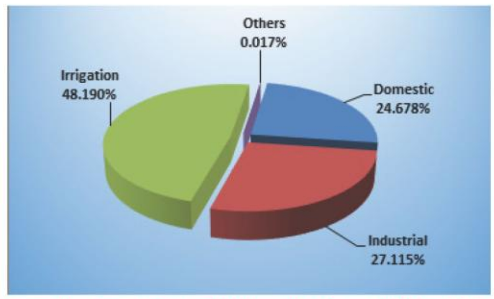


Figure 20. Groundwater Use Allocation in the Province of Bataan (2013)

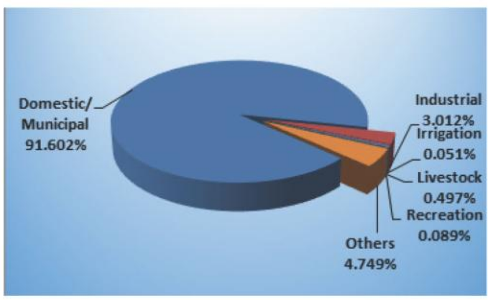


Figure 21. Groundwater Use Allocation in the Province of Bulacan (2013)

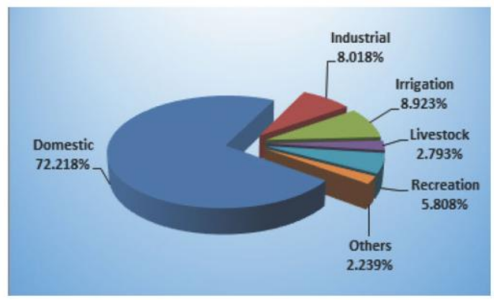


Figure 22. Groundwater Use Allocation in the Province of Rizal (2013)

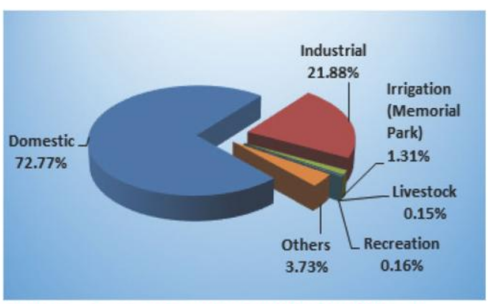


Figure 23. Groundwater Use Allocation in Metro Manila (2013)

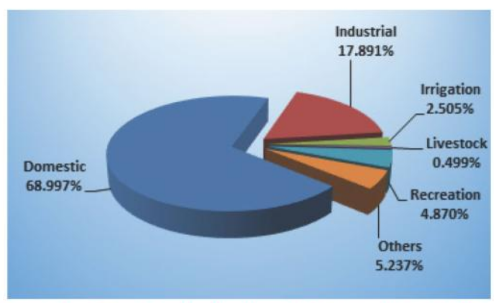


Figure 24. Groundwater Use Allocation in the Province of Cavite (2013)

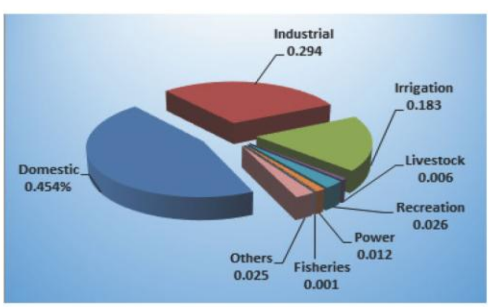


Figure 25. Groundwater Use Allocation in the Province of Laguna (2013)

A. 2 ABSTRACTION

Groundwater abstraction refers to water taken from the ground and considered sustainable as long as it does not exceed the natural renewable flow or safe yield level of aquifers.

In Metro Manila and nearby provinces, Maynilad Water Services Incorporated (MWSI) for the west zone and Manila Water Company Incorporated (MWCI) for the east zone are water supply providers. Groundwater accounts for only 3% of their total water supply sources.

Over-extraction of groundwater systems is now a pressing problem in Metro Manila and nearby provinces especially in the coastal areas where heavy pumpage has been going on for decades. These have been demonstrated by the lowering of piezometric heads throughout the region, which suggest that we have been mining our groundwater.

Since over pumping leads to seawater intrusion of the aquifer and land subsidence, it is imperative that we determine the sustainable extraction levels and regulate pumping in areas whose aquifers' safe yield have already been exceeded. This can be attained with the improvement of the database on yield potential and recharge rates to our aquifers.

Actual monitoring of groundwater level, water quality and discharge measurement (photo by NWRB staff, 2013)

The indiscriminate groundwater abstraction resulting in saltwater intrusion was evident in coastal areas of Metro Manila, Bulacan and Cavite.

The total groundwater withdrawal in the Manila Bay Area legally registered with the NWRB totals 34,899.07 lps from 4,459 groundwater users of December 2013 compared to 27,636.91 lps from 3,557 users in December 2004.

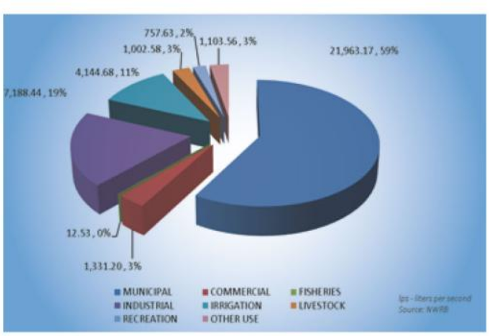


Figure 26. Total Volume and Percent of Groundwater Granted by Purpose within the Manila Bay Area (Dec, 2013)

Shallow wells, scattered around Metro Manila and nearby provinces, are likewise being used to an undetermined extent and are turning out low yields with doubtful quality.

Typical shallow well in the region, photo by NWRB staff, 2012.

The total groundwater abstraction for Metro Manila alone is 5,884.77 lps compared to 5,467.88 lps in 2004 (NWRB database December 2013), an abstraction rate increase of 7.6% in seven years or about 1.1 % per year. The low percentage of the abstraction rate increase can be attributed to the issuance of a 2009 moratorium in Metro Manila and to the strict monitoring of legal as well as illegal groundwater users in the region.

Monitoring of legal and illegal deepwells, photo by NWRB staff 2013

In the Pampanga river basin, which comprises almost 60 % of the Manila Bay Area, the present amount of groundwater withdrawal legally registered with the NWRB totaled 12,838.768 lps compared to 7,249.36 lps in 2004 or an increase of 77 %.

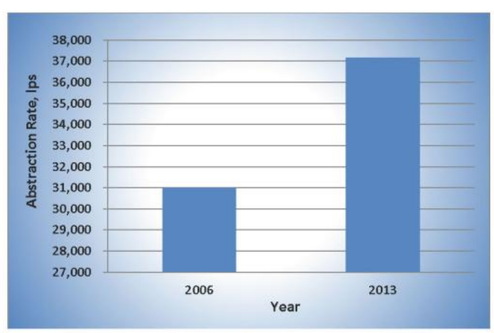


Figure 27. Water Abstraction Rate in the Manila Bay Area in 2006 and 2013

The amount of groundwater abstracted legally is 10.7 % of the groundwater safe yield.

Based on the preceding discussions on the quantity, quality and economic aspects of groundwater abstraction, the Pampanga River basin is far beyond from groundwater depletion except in the Pampanga delta where groundwater issues are often observed in deep wells. In Metro Manila including Bulacan province and the coastal areas of Cavite, the groundwater situation is deteriorating.

The NWRB is undertaking measures to efficiently manage the country's limited groundwater resource. These include:

- Extensive monitoring of both legal and illegal deep wells to quantify the actual abstraction of groundwater from the aquifer systems;
- Strict implementation of the policy developed for critical areas or water constraint areas, develop formula for raw water pricing policy;
- Conduct water resource assessments for critical cities of the country;
- Review of the Water Code of the Philippines and its Implementing Rules and Regulation
- Conduct IEC campaign on water conservation and protection and Integrated Water Resources Management (IWRM); and
- Active participation in water conservation and protection campaigns in collaboration with other government and private organizations.

A. 3 SALINITY

Generally, areas closer to the sea are the first to be affected by the landward movement of seawater flowing into areas of reduced aquifer pressures due to excessive groundwater withdrawals. Wells previously pumping freshwater will pump brackish groundwater progressively until the quality (Cl>250 mg/L) exceeds the desirable limit for drinking water.

The saline water intrusion phenomenon is attributed to the insufficient and/or declining groundwater recharge rate, geological conditions and difference of density between saline and freshwater. This problem is usually induced by the overexploitation of groundwater. The Ghyben-Herzberg principle states that for every one (1) meter of drawdown of groundwater pumping in unconfined aquifer, a corresponding rise of 40 times the drawdown created will be affected by the freshwater-seawater interface.

The Manila Bay is saline with fresh water input from 46 rivers emanating from the provinces of Bataan, Pampanga, Bulacan, Metro Manila and Cavite.

In the Pampanga delta, salt water intrusion is often observed in deep wells. In these areas, groundwater development should be conducted based on the results of adequate underground surveys. Saline water is also observed in inland parts of Nueva Ecija, Pampanga, Bulacan and Laguna. In the provinces of Tarlac and Bulacan, deep groundwater often has high levels of iron and manganese. Thus, the groundwater quality needs to be checked prior to any groundwater development. A treatment system may be necessary.

Figure below shows the areas where the values of chloride exceed the Philippine National Standard for Drinking Water (PNSDW) limits of 250 mg/L based on the data collected from 2011-2012.

During periods of rising seawater, particularly high tides, seawater moves inland at the surface through rivers/streams like Pasig River. The Napindan structure built for purpose of blocking the tidal inflow of seawater was believed to be ineffectively functioning . Tidal inflows of seawater contribute to the existence of high salinity groundwater around Pasig and its vicinity with electrical conductivity (EC) reaching more than 2000 uS/cm. The areas with EC values less than 2000 uS/cm are categorized as groundwater with low salinity; the areas with EC values from 2000-5000uS/cm are categorized as brackish groundwater of various use; the areas with EC values 5000-10000 uS/cm are categorized as brackish groundwater of limited use and groundwater with EC values >10000 uS/cm are categorized as saline and unusable groundwater.

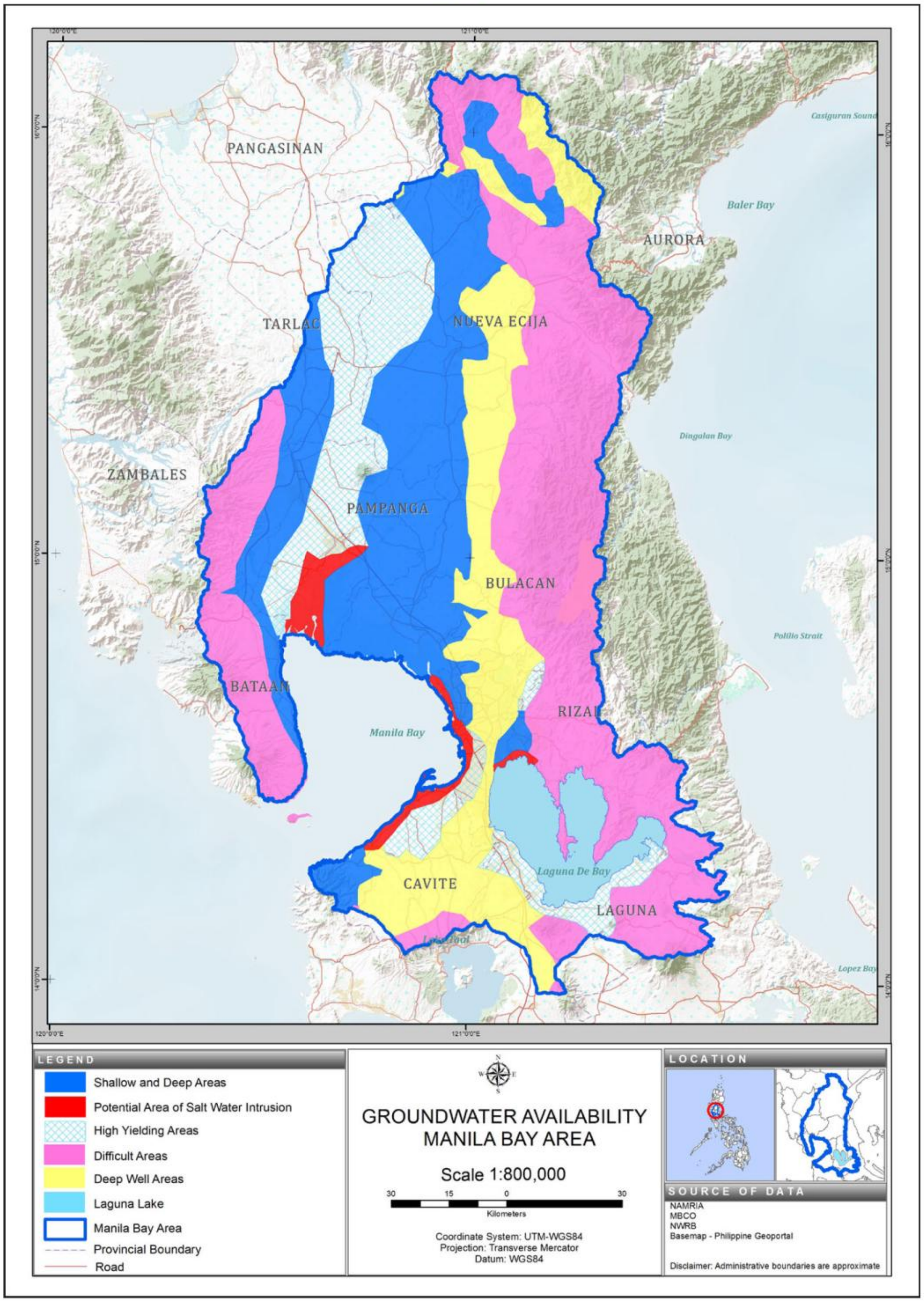
As of December 2013, the well inventory of NWRB groundwater database show 4,459 well permittees inside the Manila Bay Area. These wells have a total allocated flow of approximately 34,899.07 liters/second. A previous NWRB study estimated the allocated withdrawal from registered wells represent only 40% of the actual groundwater withdrawal from the study area. 60% remain unregistered.

The NWRB implemented and recommended measures to prevent further lowering of groundwater level that trigger landward movement of saline water. Some of which include a declaration of moratorium over all critical areas, establishment of monitoring wells to extensively monitor the movement of groundwater level, the development of alternative surface water sources to augment the increasing water demand, and further study on the optimum safe groundwater levels to maintain equilibrium between fresh and saline water.

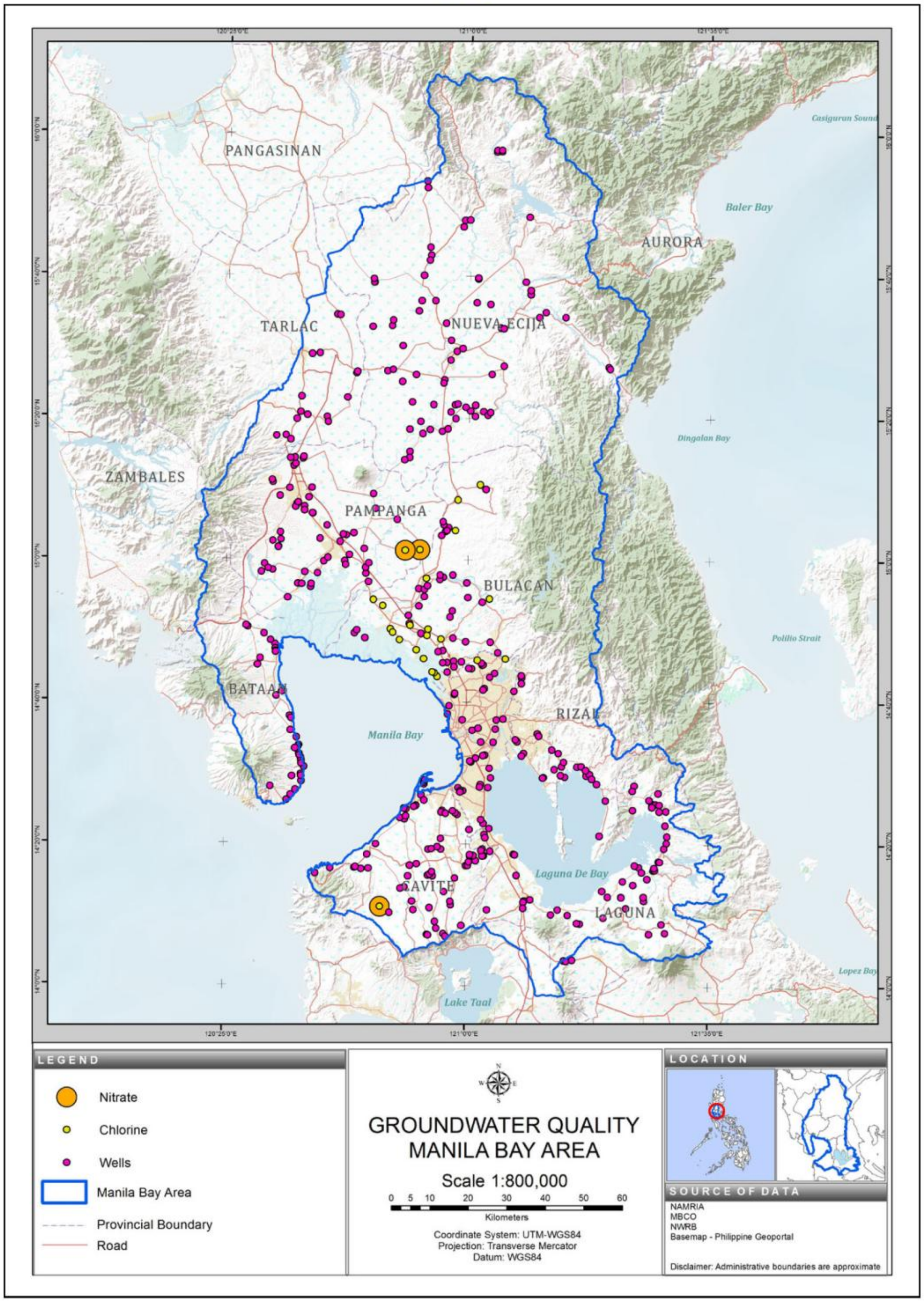
The extensive and previously unregulated groundwater abstractions mainly from coastal areas around Metro Manila have resulted in both the decline in well yield and deterioration of groundwater quality. For instance, due to the prevailing negative hydraulic gradient, over pumping created a condition where the seawater has moved inland and contaminated freshwater wells. It has also depleted the shallow aquifers.

The present level of saline intrusion places the aquifer of the NCR in alarming danger.

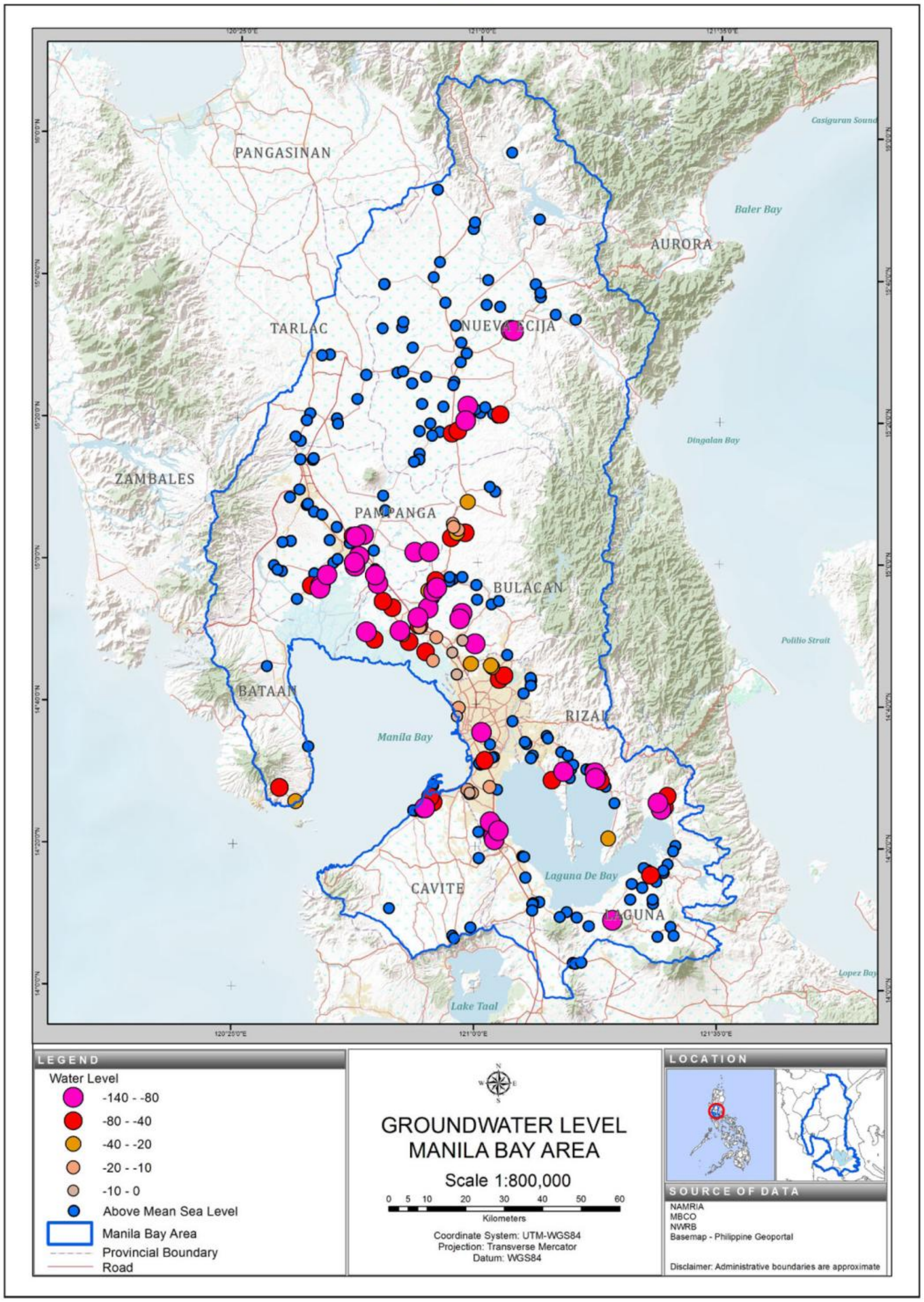
Map 33


PANGASINAN
AURORA
TARLAC
NUEVA ECIJA
ZAMBALES
PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Casiguran Sound
Baler Bay
Dingalan Bay
Polillo Strait
Manila Bay
Laguna De Bay
Lopez Bay
LEGEND
Shallow and Deep Areas
Potential Area of Salt Water Intrusion
High Yielding Areas
Difficult Areas
Deep Well Areas
Laguna Lake
Manila Bay Area
Provincial Boundary
Road
GROUNDWATER AVAILABILITY
MANILA BAY AREA
Scale 1:800,000
30 15 0 30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
NWRB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

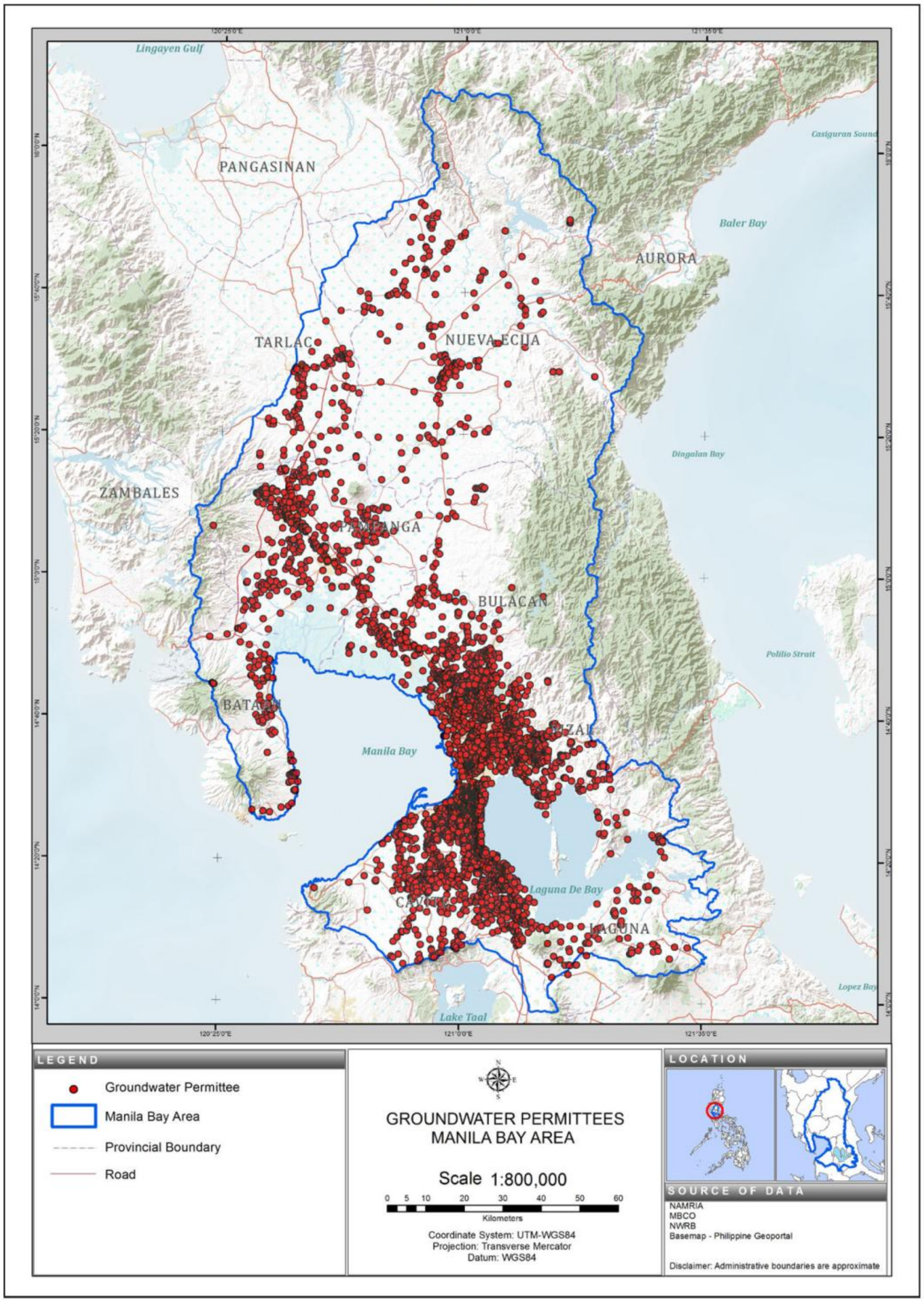
Map 34


PANGASINAN
TARLAC
NUEVA ECIJA
AURORA
ZAMBALES
PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Laguna De Bay
Lake Taal
Baler Bay
Dingalan Bay
Casiguran Sound
Polillo Strait
Lopez Bay
LEGEND
Nitrate
Chlorine
Wells
Manila Bay Area
Provincial Boundary
Road
GROUNDWATER QUALITY
MANILA BAY AREA
Scale 1:800,000
0 5 10 20 30 40 50 60
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
NWRB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

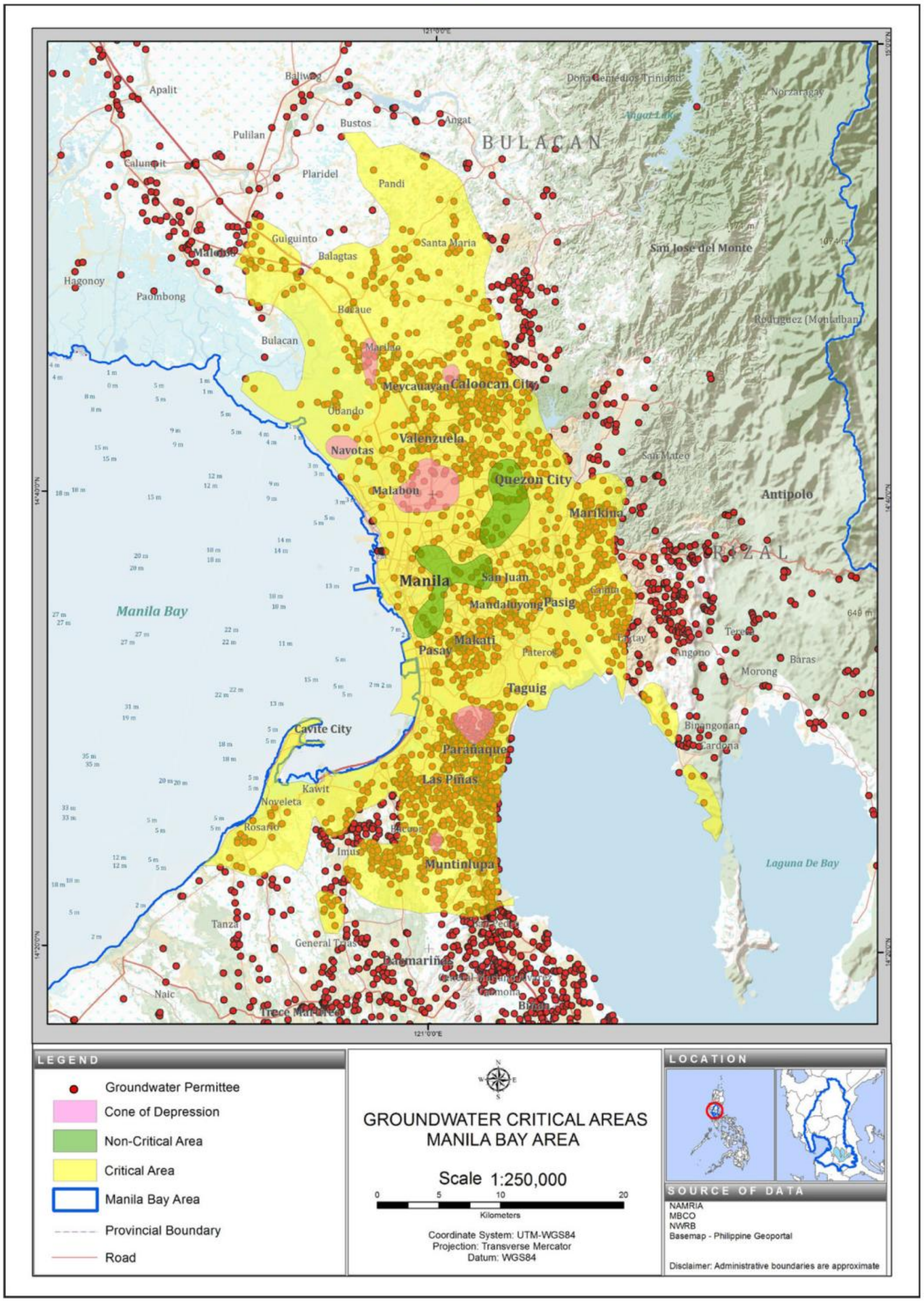
Map 35


PANGASINAN
TARLAC
NUEVA ECIJA
AURORA
ZAMBALES
PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Laguna De Bay
Lake Taal
Baler Bay
Dingalan Bay
Casiguran Sound
Polillo Strait
Lopez Bay
LEGEND
Water Level
-140 - -80
-80 - -40
-40 - -20
-20 - -10
-10 - 0
Above Mean Sea Level
Manila Bay Area
Provincial Boundary
Road
GROUNDWATER LEVEL
MANILA BAY AREA
Scale 1:800,000
0 5 10 20 30 40 50 60
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
NWRB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 36


Lingayen Gulf
PANGASINAN
TARLAC
NUEVA ECIJA
AURORA
Baler Bay
Casiguran Sound
Dingalan Bay
ZAMBALES
PAMPANGA
BULACAN
BATAAN
Manila Bay
RIZAL
Polillo Strait
CAVITE
Laguna De Bay
LAGUNA
Lake Taal
Lopez Bay
LEGEND
Groundwater Permittee
Manila Bay Area
Provincial Boundary
Road
GROUNDWATER PERMITTEES
MANILA BAY AREA
Scale 1:800,000
0 5 10 20 30 40 50 60
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
NWRB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 37


GROUNDWATER CRITICAL AREAS
MANILA BAY AREA
LEGEND
Groundwater Permittee
Cone of Depression
Non-Critical Area
Critical Area
Manila Bay Area
Provincial Boundary
Road
Scale 1:250,000
0 5 10 20
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
NWRB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate
Manila Bay
Laguna De Bay
BULACAN
RIZAL
Manila
Quezon City
Caloocan City
Valenzuela
Malabon
Navotas
Marikina
San Juan
Mandaluyong
Pasig
Makati
Pasay
Pateros
Taguig
Parañaque
Las Piñas
Muntinlupa
Cavite City
Antipolo
San Jose del Monte
Meycauayan
Malolos
Hagonoy
Paombong
Bulacan
Obando
Marilao
Bocaue
Balagtas
Guiguinto
Plaridel
Pulilan
Calumpit
Apalit
Baliwag
Bustos
Angat
Pandi
Santa Maria
Norzagaray
Kawit
Noveleta
Rosario
Imus
Bacoor
Tanza
General Trias
Naic
Dasmariñas
Morong
Baras
Teresa
Binangonan
Cardona
San Mateo
Cainta
Taytay
Angono

B. WATER QUALITY OF INLAND WATERS

The water quality of inland waters is indicated by the physico-chemical parameters, namely biochemical oxygen demand (BOD), dissolved oxygen (DO), total suspended solids (TSS), nitrate-nitrogen, total phosphorus and heavy metals. The biological parameters are assessed in terms of the total coliform and fecal coliform content of the water. All river systems within MBA, as shown in Map 38, are being monitored using the enlisted parameters.

Water quality monitoring for the 16 major river systems within the MBA is regularly conducted by the EMB through its regional offices in Regions III, IVA and NCR. Independent monitoring activities are also being performed by the BSWM, LLDA and PRRC for other inland water bodies. For the quarterly monitoring by the Bureau of Soils and Water Management (BSWM) from 2012-2014, the entire watershed of Manila Bay was sub-divided into four (4) sub-watersheds, namely: the Pampanga River Basin, Bataan Watershed, Cavite Watershed and the Pasig River Basin.

Map 40 to 103 feature the geolocation of all sampling stations for the major river systems within MBA, as well as the Pampanga River Basin, Bataan-Pasig-Cavite Watersheds, Pasig River (through PRUMS) and Laguna de Bay.

Monitoring activities are furthered once a particular watershed, river basin or water resource region are designated as Water Quality Management Areas (WQMAs) by the DENR, in coordination with the National Water Resources Board (NWRB). Map 39 shows the location of selected WQM Areas within the MBA.

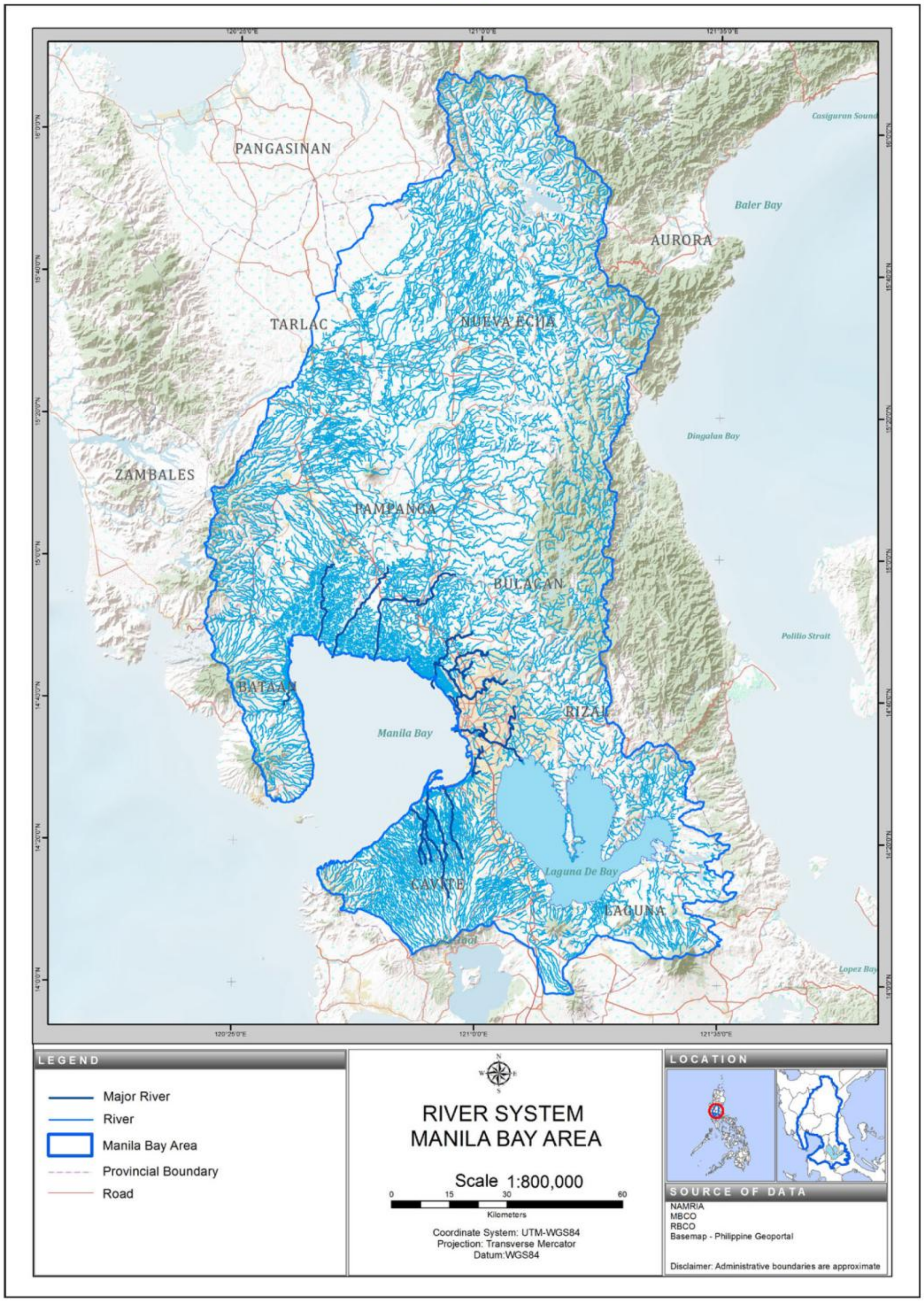
Box 5. Water Quality Management Areas

Water Quality Management Areas (WQMAs) are physiographic units, such as watersheds, river basins or water resources regions with similar hydrological, hydrogeological, meteorological or geographic conditions which affect the physicochemical, biological and bacteriological reactions and diffusions of pollutants in the water bodies, or otherwise share common interest or face similar development programs, prospects or problems.

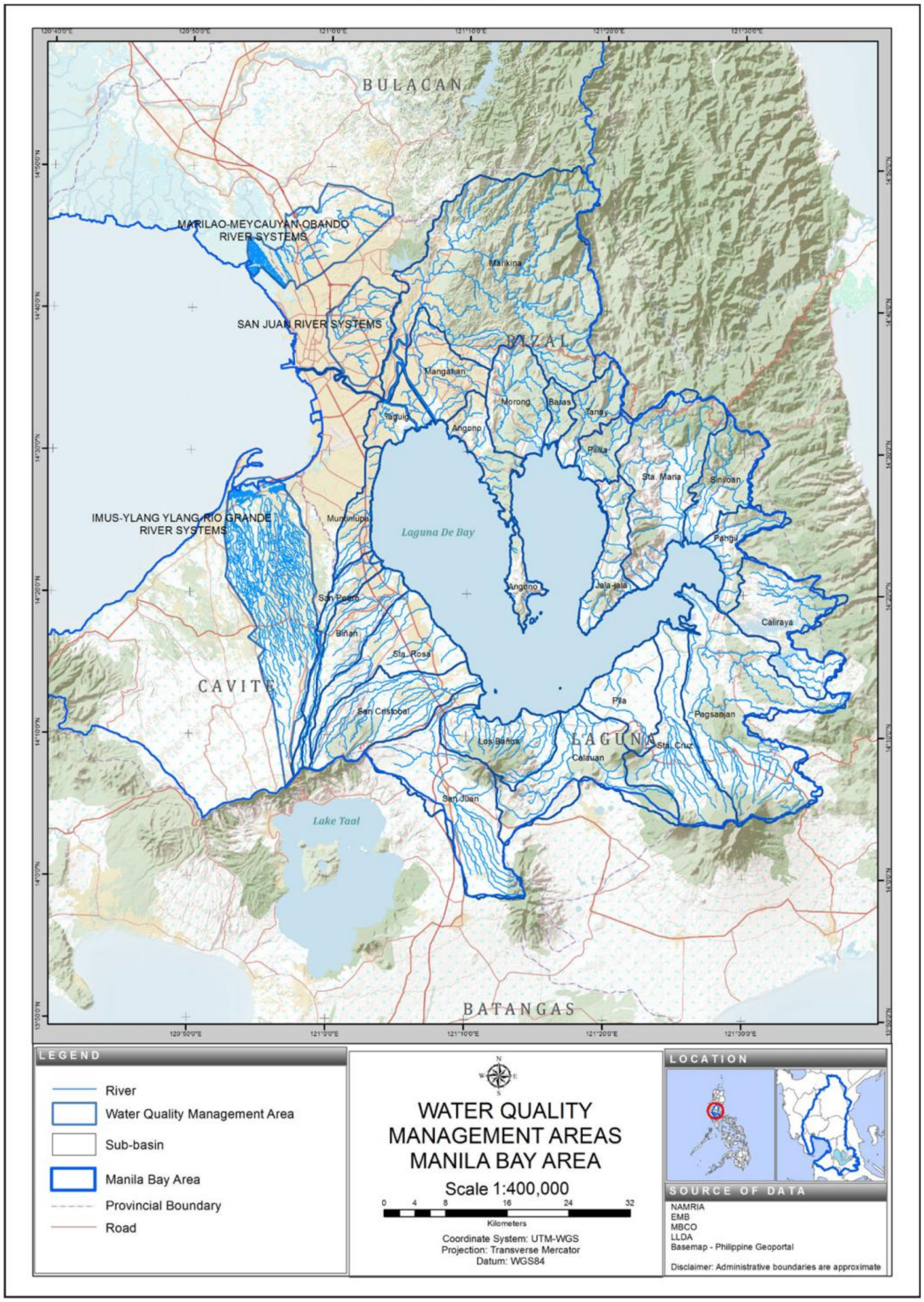
The objective of the WQMA is to protect, thru stakeholders collaboration, the water body and its tributaries by keeping their water quality within the Water Quality Guidelines or Criteria conforming to the water body's classification (e.g., Class C or Class SC) or even improve the quality to higher classification (e.g., from C to B or SC to SB). A WQMA Action Plan will be prepared in order to address water quality issues and problems in the area and later result to the improvement or better water quality of the said water body.

Said management area shall be governed by a governing board composed of representatives of mayors and governors of member LGUs, and representatives of relevant national government agencies, duly registered non-governmental organization, water utility sector, and business sector. The DENR representative through the EMB shall chair the governing board. In the case of the LGUs with memberships on more than one (1) management board, the LGU shall designate only one (1) single representative for all the management areas where it is a member.

Map 38


PANGASINAN
TARLAC
NUEVA ECIJA
AURORA
ZAMBALES
PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Laguna De Bay
Baler Bay
Dingalan Bay
Polillo Strait
Casiguran Sound
Lopez Bay
LEGEND
Major River
River
Manila Bay Area
Provincial Boundary
Road
RIVER SYSTEM
MANILA BAY AREA
Scale 1:800,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum:WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
RBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 39


BULACAN
MARILAO-MEYCAUYAN-OBANDO RIVER SYSTEMS
SAN JUAN RIVER SYSTEMS
IMUS-YLANG YLANG RIO GRANDE RIVER SYSTEMS
RIZAL
CAVITE
LAGUNA
BATANGAS
Laguna De Bay
Lake Taal
Marikina
Mangahan
Morong
Baras
Tanay
Taguig
Angono
Pililla
Sta. Maria
Siniloan
Muntinlupa
Pangil
Jala-jala
San Pedro
Biñan
Sta. Rosa
Cavinti
Caliraya
San Cristobal
Pila
Pagsanjan
Los Baños
Calauan
Sta. Cruz
San Juan
LEGEND
River
Water Quality Management Area
Sub-basin
Manila Bay Area
Provincial Boundary
Road
WATER QUALITY MANAGEMENT AREAS MANILA BAY AREA
Scale 1:400,000
0 4 8 16 24 32
Kilometers
Coordinate System: UTM-WGS
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
EMB
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

B.1 MAJOR RIVERS SYSTEMS

Selected river systems in the Manila Bay Area discharging into Manila Bay are monitored to determine their compliance with the water quality criteria. These river systems are monitored on the following parameters: DO, BOD, pH, TSS, Nitrates, Phosphates, Chlorides, Ammonia, Cadmium, Lead, and Oil and Grease.

In the NCR, three (3) river systems are monitored namely: Parañaque-Zapote River, Navotas-Malabon-Tullahan-Tenejeros and Meycauayan-Valenzuela river systems. In Region III, eight (8) rivers system including Marilao-Meycauayan-Obando and its tributaries coming from adjacent areas in Bulacan (Sta.Maria and Bocaue), Guagua, Talisay and Angat rivers while in Region IV-A, Imus, Cañas, Ylang-Ylang and Rio Grande rivers are monitored.

Maps 40 to 60 show the trends (2011- 1st Quarter 2015) in the parameters monitored for all river systems.

PHYSICO-CHEMICAL PARAMETERS

Biochemical Oxygen Demand

The DENR has set BOD criterion at 7 mg/L. Observations in the rivers of Region III from 2011-2014 showed an increasing BOD trend in the rivers of Guagua, Obando, Marilao, Bocaue, and Meycauayan. The same trend continued in Marilao, Bocaue, and Meycauayan rivers in the first quarter of 2015. No observations are available for the other rivers. The NCR Rivers are shown to have high BOD beyond the set criterion in all observation periods. In Region IV-A, Imus River consistently showed high BOD while specific stations in Ylang-ylang River and Rio Grande have unusually high BOD.

Dissolved Oxygen

Most of the rivers monitored in the NCR and Region III showed poor water quality. Zero DO in all rivers monitored at the NCR and low levels of DO in Region III are observed. The low DO levels are the result of the discharges of untreated domestic and industrial waste. In Metro Manila, only 18% of the population is served by a sewerage system and the remaining population rely only on septic tanks inappropriately designed, thus contributing high pollution load in the waterways.

Potential Hydrogen

Data from 2011 to the first quarter of 2015 showed pH levels of the major rivers of NCR and Region IV-A are within the limits set by DENR. The same is true for Region III, however there is a significant increase in the pH level in Bocaue River as of the first quarter of 2015. No further data is available for the rest of the Region III rivers.

Total Suspended Solids

Rivers monitored in Region III and Region IV-A showed declining levels of TSS except for a significant shoot-up in Ylang-Ylang Bridge station. In the NCR, an increasing trend in the levels of TSS are shown in Multinational and Ibayo stations along the Paranaque River; McArthur and Gov. Pascual along NMTT; and in Meycauyan, Pugad Baboy, and Lingunan stations along the Meycauayan-Valenzuela River System. The level of allowable TSS based on the DENR criteria is 50 mg/L (Malaysian standard).

Phosphates

The rivers of Region III, NCR, and Region IV-A contain levels of phosphate beyond the allowable limit of 0.4 mg/L. With the exception of the Talisay and Pampanga rivers, an increasing level of phosphate is observed in the rivers of Region III from 2012-2014. In the first quarter of 2015, an increasing level of phosphate is observed in the rivers of Marilao, Bocaue, and Meycauayan while no data is available for the other rivers. The NCR rivers have a generally high phosphate content between 5-10 mg/L. In Region IV-A, a decline is shown in 2013 in Imus River, Ylang-ylang River, and Rio Grande River but peaked once again in 2014 and continued into the first quarter of 2015.

Nitrates

The nitrate content in the rivers of Region III are below the set limit of 10 mg/L from 2012 to 2014. In the first quarter of 2015, the same is true for Meycauayan, Bocaue, and Marilao rivers whereas no data is available for Guagua, Talisay, Angat, Sta. Maria, and Obando rivers. In NCR, data showed generally increasing levels of nitrate slightly above the recommended limit. No data is available for the rivers of Region IVA.

Chloride

The presence of chloride in the rivers of Region IV-A was observed in from 2013 through the first quarter of 2015. DENR criterion has set the limit of chloride in water at 350 mg/L. Data from the observation periods mentioned showed generally allowable content of chloride in the rivers of Region IV-A. However, specific stations showed unusually high observations particularly the Island Cove Bridge station along Imus River and the Noveleta Bridge station along Ylang-ylang River. Stations along the Canas River which also showed unusually high observations are shown to have improved in the first quarter of 2015 having values within the allowable limit.

Ammonia

In the ASEAN standard, ammonia level in water is set at 0.07 mg/L. The rivers of Region III based on the 2012-2014 observations have high ammonia content above the set criterion. This trend is observed for the rivers of Marilao, Bocaue, and Meycauayan in the first quarter of 2015 while no data is available for the other rivers. In the Region IV-A rivers, ammonia levels are observed to be beyond the set limit in the year 2013. The succeeding year showed observations below the set limit except for Ylang-ylang and Rio Grande rivers. However, in addition to Ylang-Ylang and Rio Grande, high levels of ammonia beyond the set limit are observed along Canas River in the first quarter of 2015.

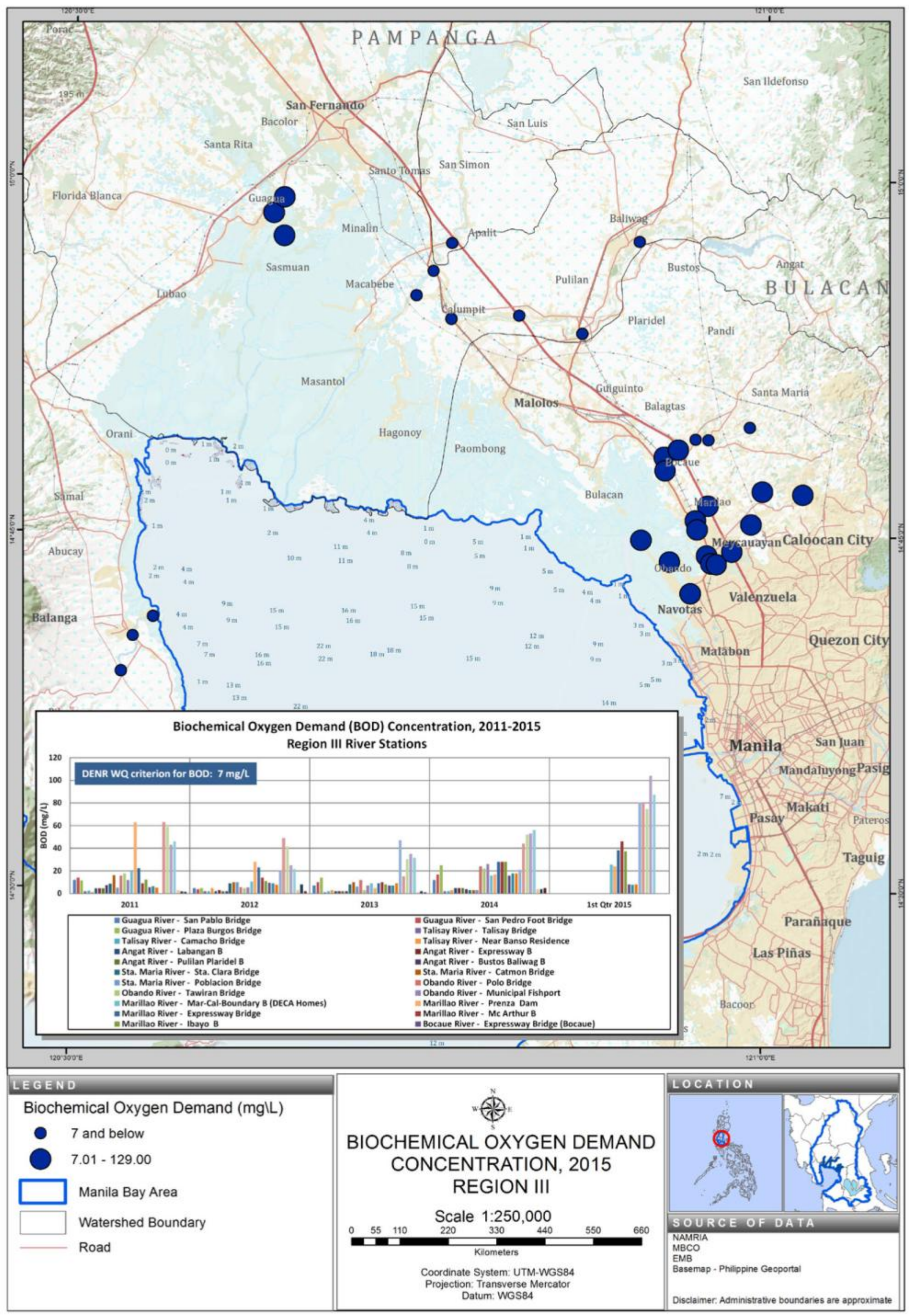
Oil and Grease

Oil and grease content in water according to the DENR criterion is set to 2 mg/L. In the observations from 2011 through the first quarter of 2015, notably high levels of oil and grease are present at an increasing rate in the rivers of NCR.

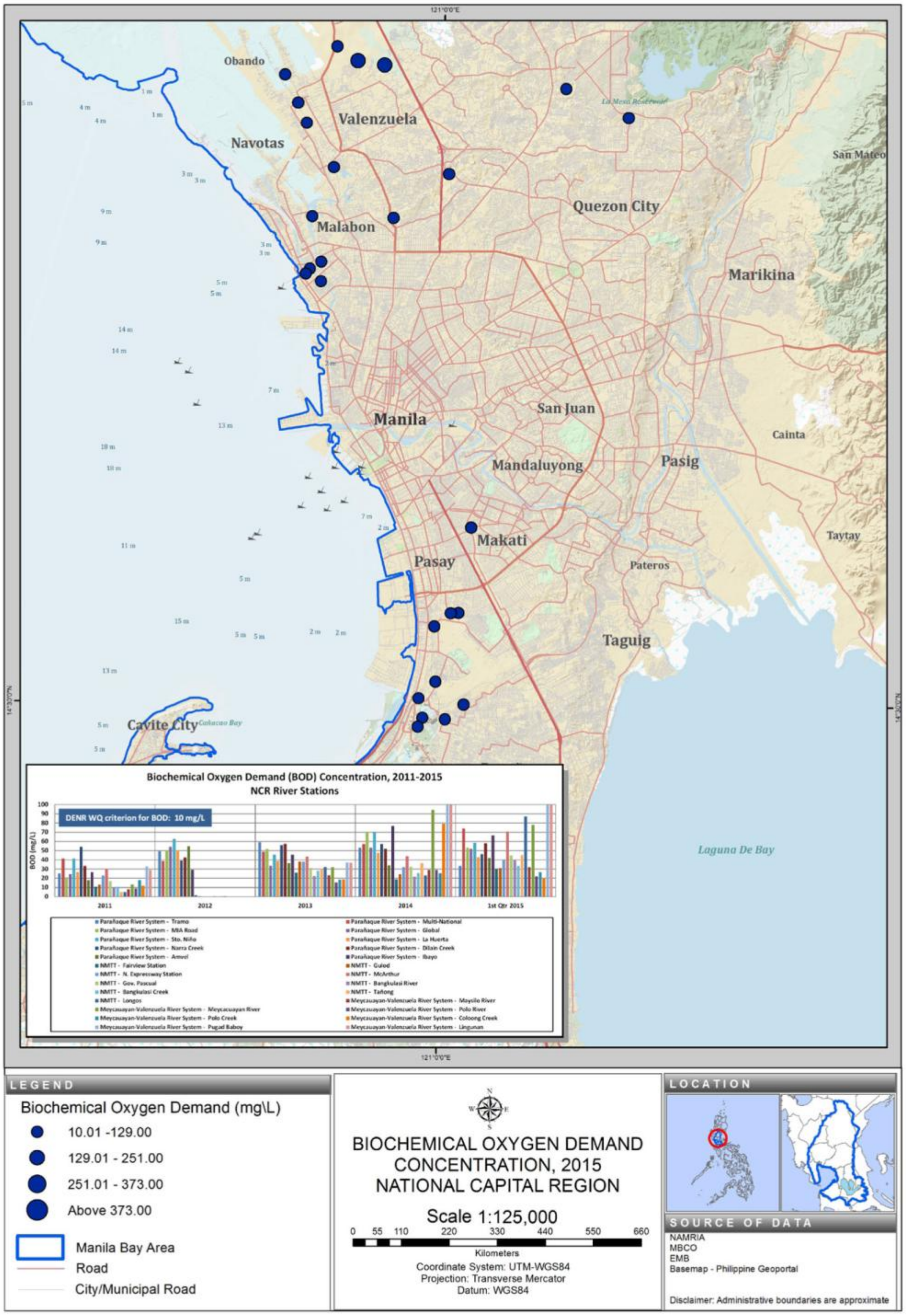
Heavy Metals

Results of the 2011 monitoring of the major river systems in Region III showed below detection limits of cadmium and lead in its waters.

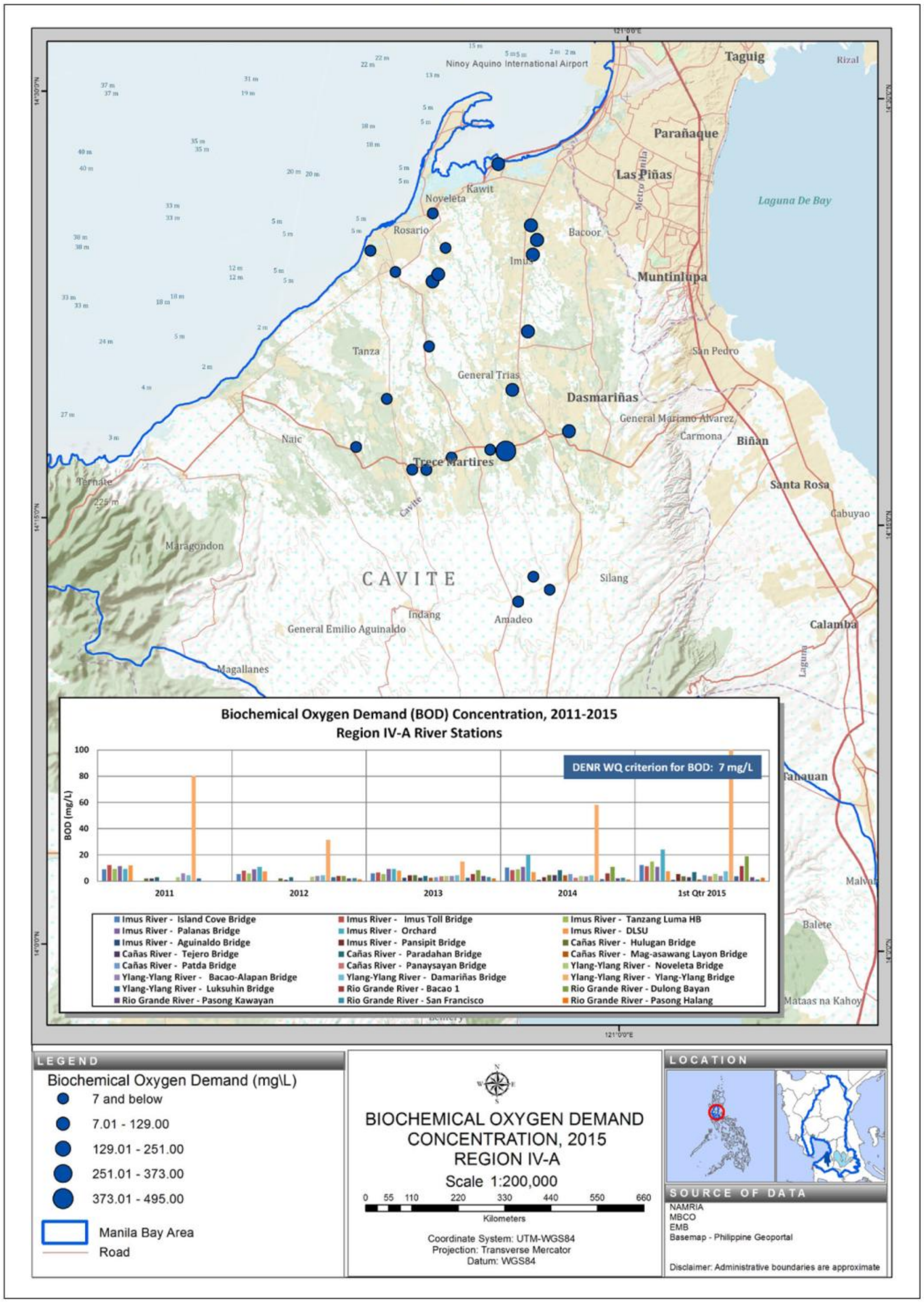
Map 40


PAMPANGA
BULACAN
San Fernando
Bacolor
Santa Rita
Florida Blanca
Guagua
Sasmuan
Lubao
Minalin
Santo Tomas
San Simon
San Luis
Apalit
Macabebe
Calumpit
Masantol
Hagonoy
Paombong
Malolos
Baliwag
Pulilan
Plaridel
Bustos
Angat
Pandi
San Ildefonso
Santa Maria
Guiguinto
Balagtas
Bocaue
Bulacan
Marilao
Meycauayan
Caloocan City
Obando
Navotas
Valenzuela
Malabon
Quezon City
Manila
San Juan
Mandaluyong
Pasig
Makati
Pasay
Pateros
Taguig
Parañaque
Las Piñas
Bacoor
Orani
Samal
Abucay
Balanga
Biochemical Oxygen Demand (BOD) Concentration, 2011-2015
Region III River Stations
DENR WQ criterion for BOD: 7 mg/L
BOD (mg/L)
2011
2012
2013
2014
1st Qtr 2015
Guagua River - San Pablo Bridge
Guagua River - Plaza Burgos Bridge
Talisay River - Camacho Bridge
Angat River - Labangan B
Angat River - Pulilan Plaridel B
Sta. Maria River - Sta. Clara Bridge
Sta. Maria River - Poblacion Bridge
Obando River - Tawiran Bridge
Marillao River - Mar-Cal-Boundary B (DECA Homes)
Marillao River - Expressway Bridge
Marillao River - Ibayo B
Guagua River - San Pedro Foot Bridge
Talisay River - Talisay Bridge
Talisay River - Near Banso Residence
Angat River - Expressway B
Angat River - Bustos Baliwag B
Sta. Maria River - Catmon Bridge
Obando River - Polo Bridge
Obando River - Municipal Fishport
Marillao River - Prenza Dam
Marillao River - Mc Arthur B
Bocaue River - Expressway Bridge (Bocaue)
LEGEND
Biochemical Oxygen Demand (mg\L)
7 and below
7.01 - 129.00
Manila Bay Area
Watershed Boundary
Road
BIOCHEMICAL OXYGEN DEMAND CONCENTRATION, 2015 REGION III
Scale 1:250,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

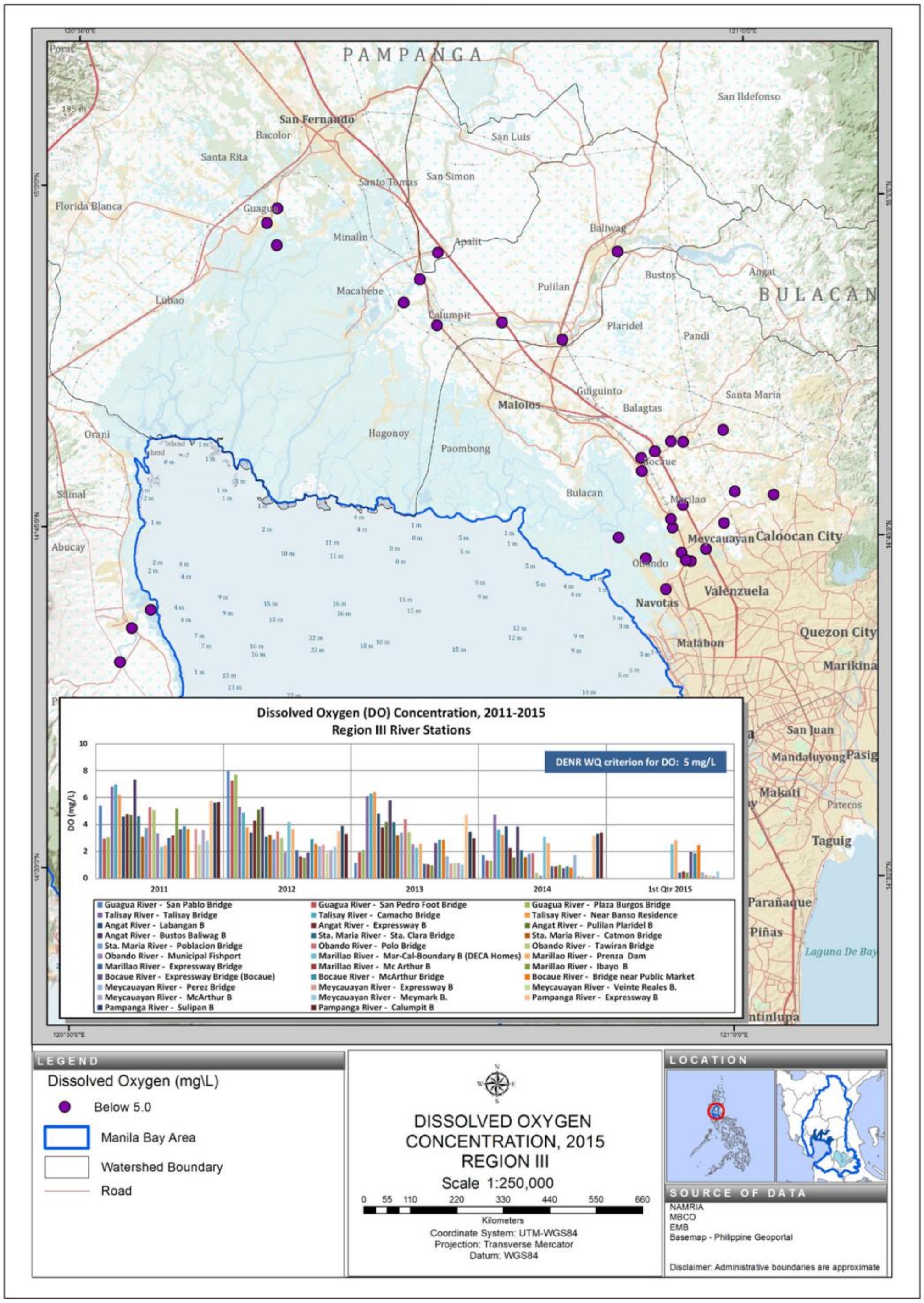
Map 41


Obando
Valenzuela
Navotas
Malabon
Quezon City
San Mateo
Marikina
Manila
San Juan
Mandaluyong
Pasig
Cainta
Makati
Taytay
Pasay
Pateros
Taguig
Cavite City
Laguna De Bay
Biochemical Oxygen Demand (BOD) Concentration, 2011-2015
NCR River Stations
DENR WQ criterion for BOD: 10 mg/L
BOD (mg/L)
2011
2012
2013
2014
1st Qtr 2015
LEGEND
Biochemical Oxygen Demand (mg\L)
10.01 -129.00
129.01 - 251.00
251.01 - 373.00
Above 373.00
Manila Bay Area
Road
City/Municipal Road
BIOCHEMICAL OXYGEN DEMAND CONCENTRATION, 2015 NATIONAL CAPITAL REGION
Scale 1:125,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

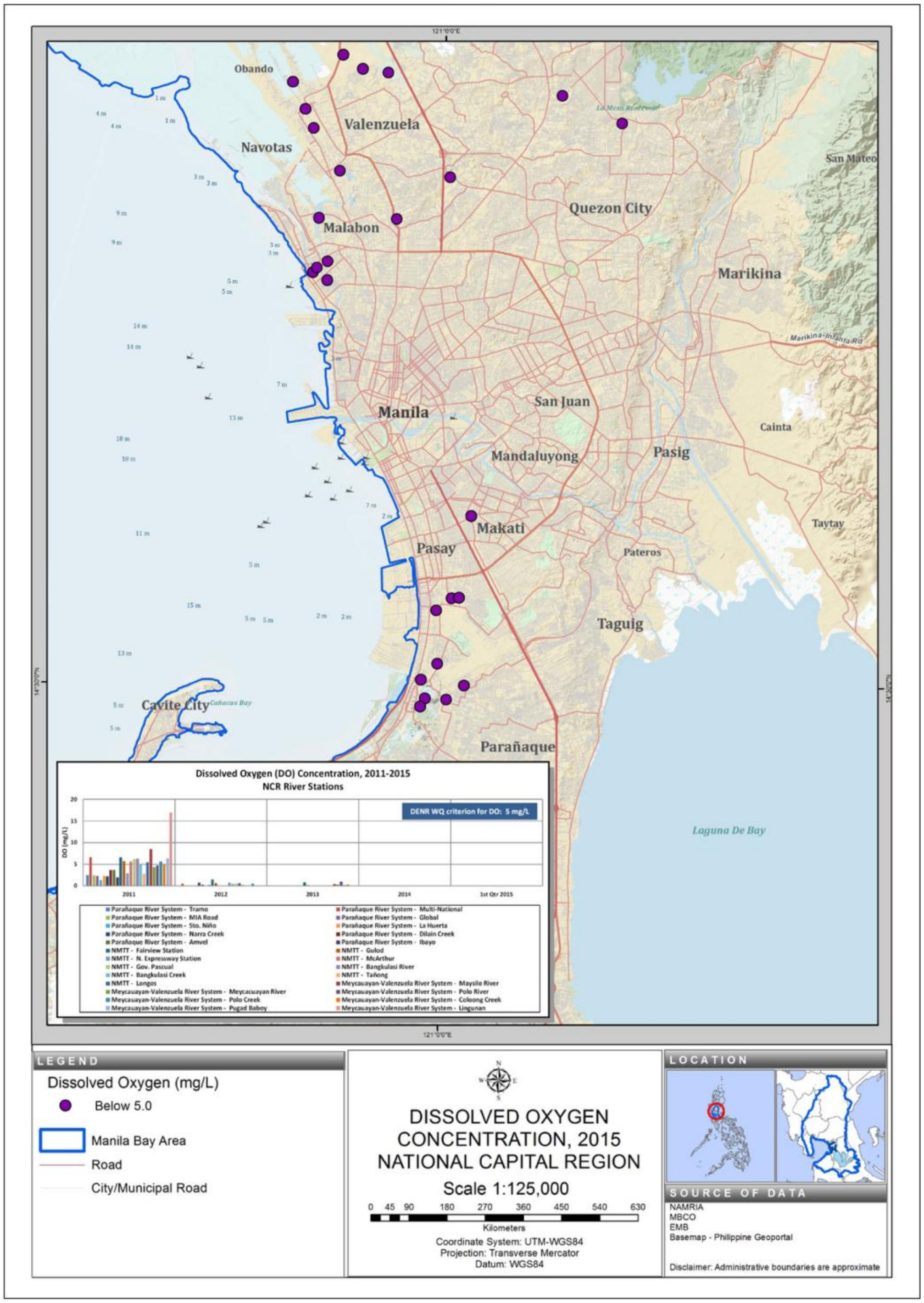
Map 42


Ninoy Aquino International Airport
Taguig
Rizal
Parañaque
Las Piñas
Laguna De Bay
Kawit
Noveleta
Rosario
Bacoor
Imus
Muntinlupa
San Pedro
Tanza
General Trias
Dasmariñas
General Mariano Alvarez
Carmona
Biñan
Naic
Trece Martires
Santa Rosa
Ternate
Cabuyao
Maragondon
CAVITE
Silang
Indang
Amadeo
General Emilio Aguinaldo
Calamba
Magallanes
Biochemical Oxygen Demand (BOD) Concentration, 2011-2015
Region IV-A River Stations
BOD (mg/L)
DENR WQ criterion for BOD: 7 mg/L
2011
2012
2013
2014
1st Qtr 2015
Imus River - Island Cove Bridge
Imus River - Palanas Bridge
Imus River - Aguinaldo Bridge
Cañas River - Tejero Bridge
Cañas River - Patda Bridge
Ylang-Ylang River - Bacao-Alapan Bridge
Ylang-Ylang River - Luksuhin Bridge
Rio Grande River - Pasong Kawayan
Imus River - Imus Toll Bridge
Imus River - Orchard
Imus River - Pansipit Bridge
Cañas River - Paradahan Bridge
Cañas River - Panaysayan Bridge
Ylang-Ylang River - Damariñas Bridge
Rio Grande River - Bacao 1
Rio Grande River - San Francisco
Imus River - Tanzang Luma HB
Imus River - DLSU
Cañas River - Hulugan Bridge
Cañas River - Mag-asawang Layon Bridge
Ylang-Ylang River - Noveleta Bridge
Ylang-Ylang River - Ylang-Ylang Bridge
Rio Grande River - Dulong Bayan
Rio Grande River - Pasong Halang
Balete
Mataas na Kahoy
121°0'0"E
LEGEND
Biochemical Oxygen Demand (mg\L)
7 and below
7.01 - 129.00
129.01 - 251.00
251.01 - 373.00
373.01 - 495.00
Manila Bay Area
Road
BIOCHEMICAL OXYGEN DEMAND
CONCENTRATION, 2015
REGION IV-A
Scale 1:200,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

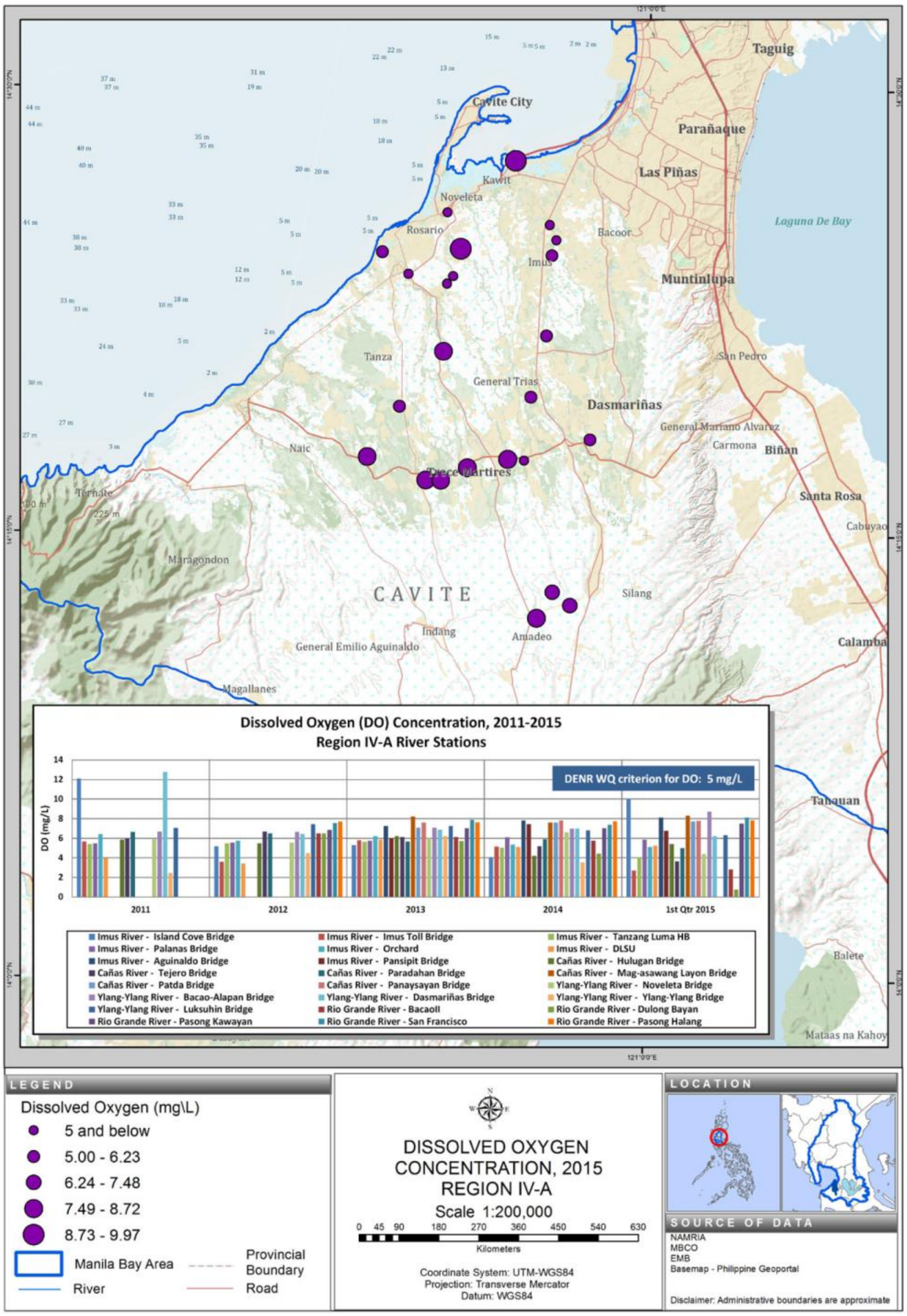
Map 43


PAMPANGA
BULACAN
San Fernando
Bacolor
Santa Rita
San Luis
Santo Tomas
San Simon
Florida Blanca
Guagua
Minalin
Apalit
Baliwag
Macabebe
Lubao
Pulilan
Bustos
Angat
Calumpit
Plaridel
Pandi
San Ildefonso
Guiguinto
Malolos
Balagtas
Santa Maria
Orani
Hagonoy
Paombong
Bocaue
Samal
Bulacan
Marilao
Abucay
Meycauayan
Caloocan City
Obando
Navotas
Valenzuela
Quezon City
Malabon
Marikina
San Juan
Mandaluyong
Pasig
Makati
Pateros
Taguig
Parañaque
Piñas
Laguna De Bay
Dissolved Oxygen (DO) Concentration, 2011-2015
Region III River Stations
DENR WQ criterion for DO: 5 mg/L
DO (mg/L)
2011
2012
2013
2014
1st Qtr 2015
Guagua River - San Pablo Bridge
Guagua River - San Pedro Foot Bridge
Guagua River - Plaza Burgos Bridge
Talisay River - Talisay Bridge
Talisay River - Camacho Bridge
Talisay River - Near Banso Residence
Angat River - Labangan B
Angat River - Expressway B
Angat River - Pulilan Plaridel B
Angat River - Bustos Baliwag B
Sta. Maria River - Sta. Clara Bridge
Sta. Maria River - Catmon Bridge
Sta. Maria River - Poblacion Bridge
Obando River - Polo Bridge
Obando River - Tawiran Bridge
Obando River - Municipal Fishport
Marillao River - Mar-Cal-Boundary B (DECA Homes)
Marillao River - Prenza Dam
Marillao River - Expressway Bridge
Marillao River - Mc Arthur B
Marillao River - Ibayo B
Bocaue River - Expressway Bridge (Bocaue)
Bocaue River - McArthur Bridge
Bocaue River - Bridge near Public Market
Meycauayan River - Perez Bridge
Meycauayan River - Expressway B
Meycauayan River - Veinte Reales B.
Meycauayan River - McArthur B
Meycauayan River - Meymark B.
Pampanga River - Expressway B
Pampanga River - Sulipan B
Pampanga River - Calumpit B
LEGEND
Dissolved Oxygen (mg\L)
Below 5.0
Manila Bay Area
Watershed Boundary
Road
DISSOLVED OXYGEN
CONCENTRATION, 2015
REGION III
Scale 1:250,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

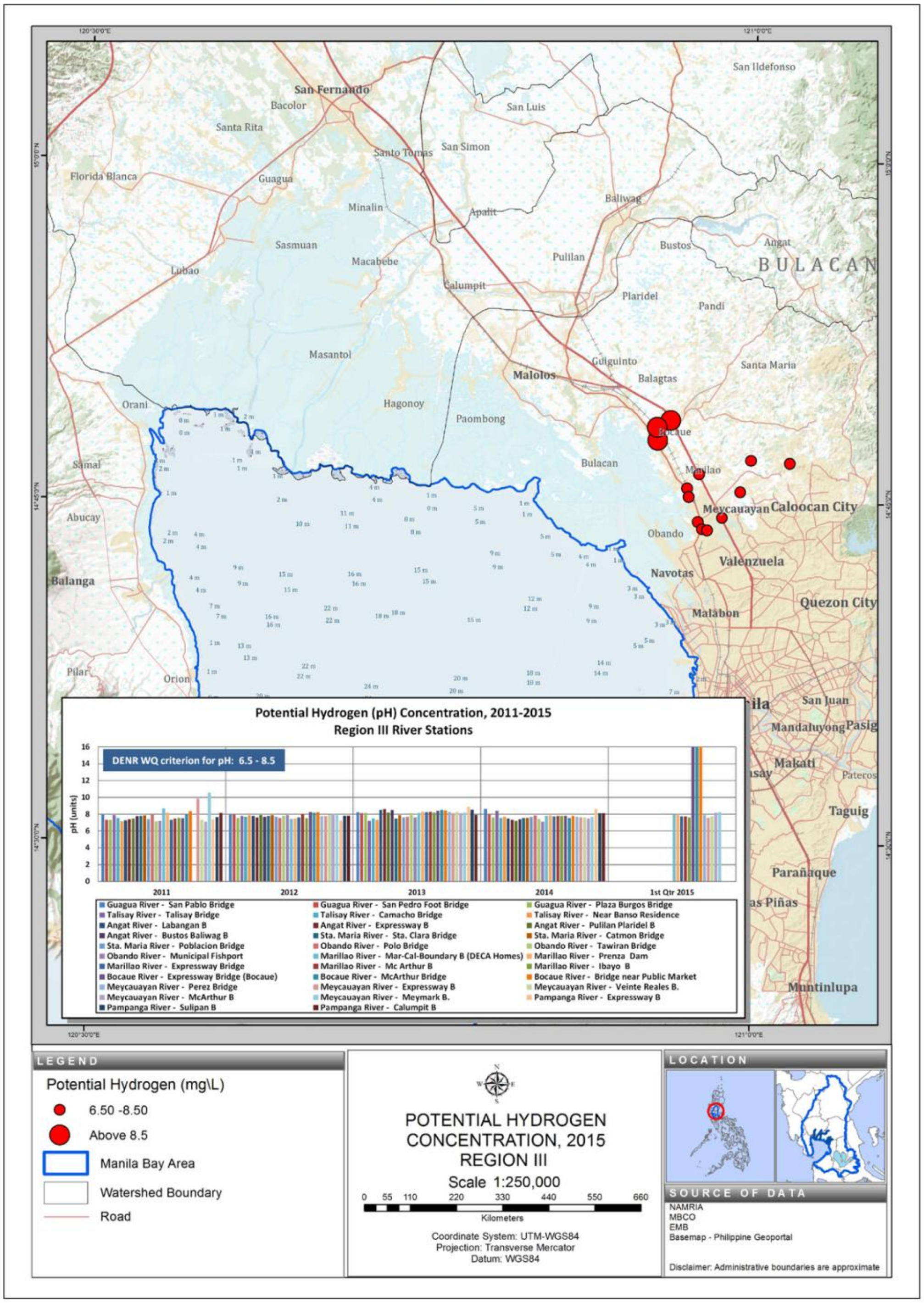
Map 44


Obando
Valenzuela
Navotas
Malabon
Quezon City
San Mateo
Marikina
Manila
San Juan
Mandaluyong
Pasig
Cainta
Taytay
Makati
Pasay
Pateros
Taguig
Cavite City
Cañacao Bay
Parañaque
Laguna De Bay
Dissolved Oxygen (DO) Concentration, 2011-2015
NCR River Stations
DO (mg/L)
DENR WQ criterion for DO: 5 mg/L
2011
2012
2013
2014
1st Qtr 2015
Parañaque River System - Tramo
Parañaque River System - MIA Road
Parañaque River System - Sto. Niño
Parañaque River System - Narra Creek
Parañaque River System - Amvel
NMTT - Fairview Station
NMTT - N. Expressway Station
NMTT - Gov. Pascual
NMTT - Bangkulasi Creek
NMTT - Longos
Meycauayan-Valenzuela River System - Meycacuayan River
Meycauayan-Valenzuela River System - Polo Creek
Meycauayan-Valenzuela River System - Pugad Baboy
Parañaque River System - Multi-National
Parañaque River System - Global
Parañaque River System - La Huerta
Parañaque River System - Dilain Creek
Parañaque River System - Ibayo
NMTT - Gulod
NMTT - McArthur
NMTT - Bangkulasi River
NMTT - Tañong
Meycauayan-Valenzuela River System - Maysilo River
Meycauayan-Valenzuela River System - Polo River
Meycauayan-Valenzuela River System - Coloong Creek
Meycauayan-Valenzuela River System - Lingunan
LEGEND
Dissolved Oxygen (mg/L)
Below 5.0
Manila Bay Area
Road
City/Municipal Road
DISSOLVED OXYGEN CONCENTRATION, 2015 NATIONAL CAPITAL REGION
Scale 1:125,000
0 45 90 180 270 360 450 540 630
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

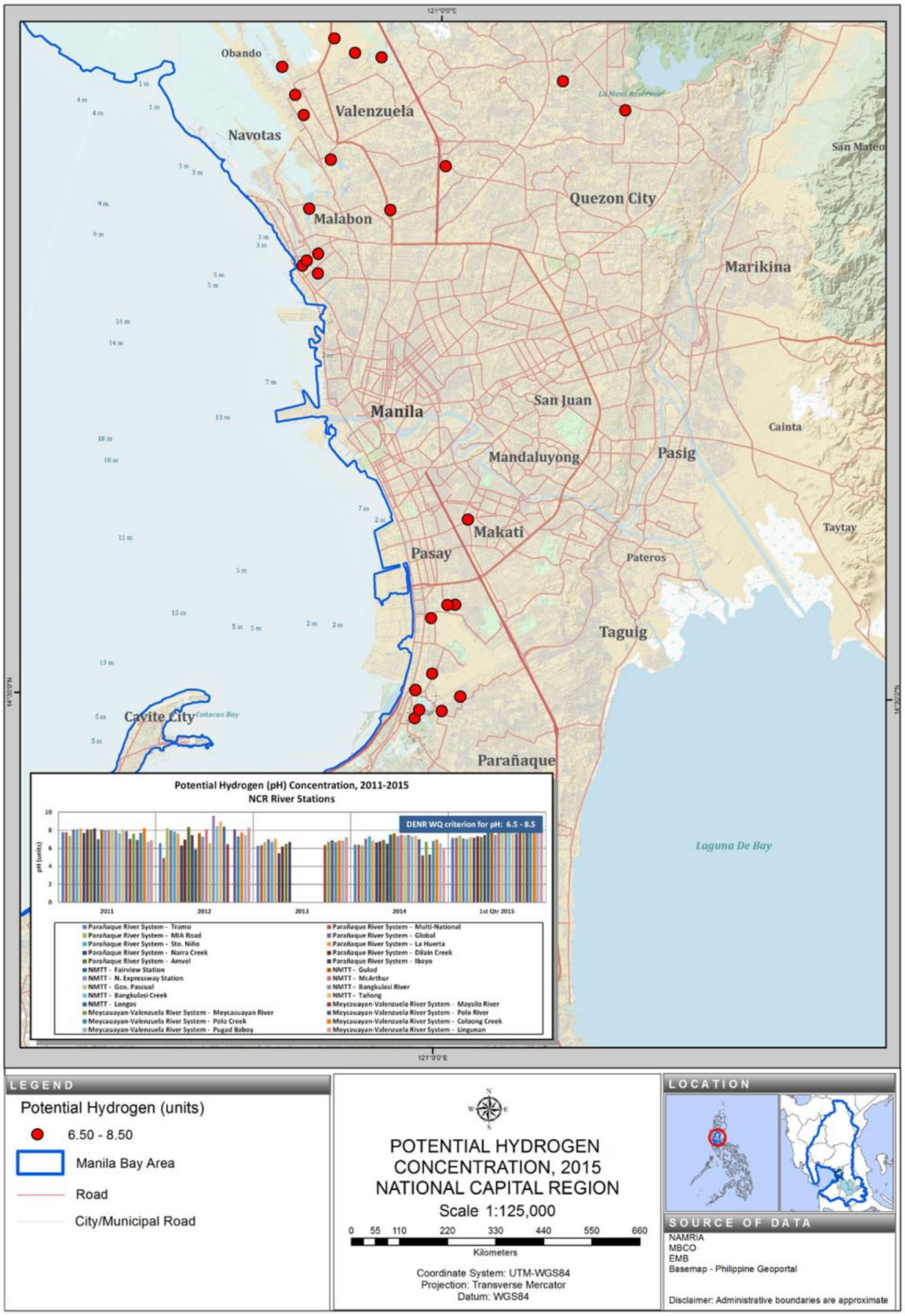
Map 45


Taguig
Cavite City
Parañaque
Kawit
Las Piñas
Noveleta
Laguna De Bay
Rosario
Bacoor
Imus
Muntinlupa
Tanza
San Pedro
General Trias
Dasmariñas
General Mariano Alvarez
Carmona
Biñan
Naic
Trece Martires
Ternate
Santa Rosa
Cabuyao
Maragondon
CAVITE
Silang
Indang
Amadeo
General Emilio Aguinaldo
Calamba
Magallanes
Tanauan
Balete
Mataas na Kahoy
Dissolved Oxygen (DO) Concentration, 2011-2015
Region IV-A River Stations
DENR WQ criterion for DO: 5 mg/L
DO (mg/L)
2011
2012
2013
2014
1st Qtr 2015
Imus River - Island Cove Bridge
Imus River - Imus Toll Bridge
Imus River - Tanzang Luma HB
Imus River - Palanas Bridge
Imus River - Orchard
Imus River - DLSU
Imus River - Aguinaldo Bridge
Imus River - Pansipit Bridge
Cañas River - Hulugan Bridge
Cañas River - Tejero Bridge
Cañas River - Paradahan Bridge
Cañas River - Mag-asawang Layon Bridge
Cañas River - Patda Bridge
Cañas River - Panaysayan Bridge
Ylang-Ylang River - Noveleta Bridge
Ylang-Ylang River - Bacao-Alapan Bridge
Ylang-Ylang River - Dasmariñas Bridge
Ylang-Ylang River - Ylang-Ylang Bridge
Ylang-Ylang River - Luksuhin Bridge
Rio Grande River - Bacaoll
Rio Grande River - Dulong Bayan
Rio Grande River - Pasong Kawayan
Rio Grande River - San Francisco
Rio Grande River - Pasong Halang
LEGEND
Dissolved Oxygen (mg\L)
5 and below
5.00 - 6.23
6.24 - 7.48
7.49 - 8.72
8.73 - 9.97
Manila Bay Area
River
Provincial Boundary
Road
DISSOLVED OXYGEN CONCENTRATION, 2015
REGION IV-A
Scale 1:200,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

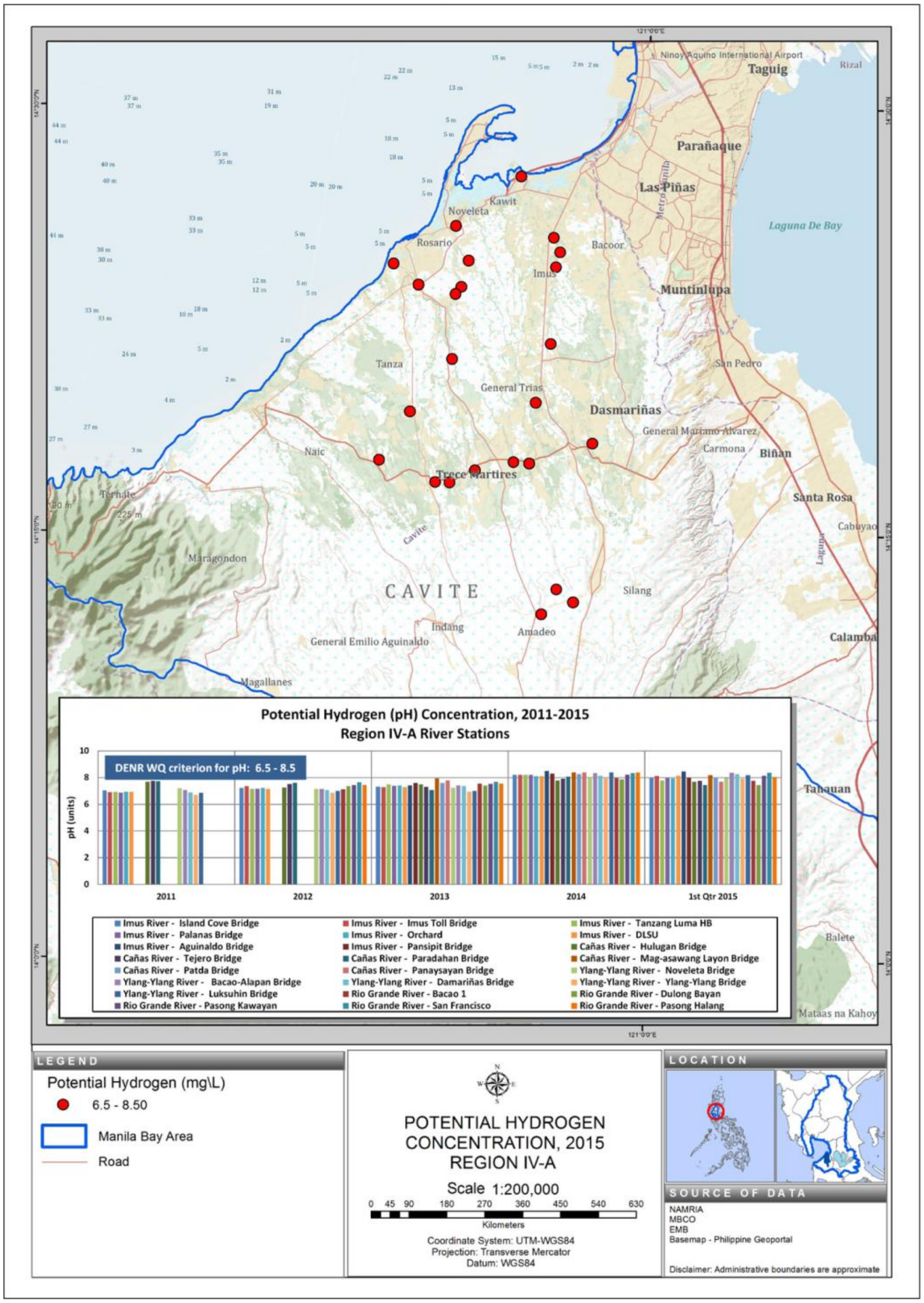
Map 46


San Fernando
Bacolor
Santa Rita
San Luis
Santo Tomas
San Simon
Florida Blanca
Guagua
Minalin
Apalit
Baliwag
Sasmuan
Macabebe
Pulilan
Bustos
Angat
BULACAN
Lubao
Calumpit
Plaridel
Pandi
Masantol
Guiguinto
Santa Maria
Malolos
Balagtas
Orani
Hagonoy
Paombong
Bocaue
Samal
Bulacan
Marilao
Abucay
Meycauayan
Caloocan City
Obando
Valenzuela
Balanga
Navotas
Malabon
Quezon City
Pilar
Orion
San Juan
Mandaluyong
Pasig
Makati
Pateros
Taguig
Parañaque
Las Piñas
Muntinlupa
San Ildefonso
Potential Hydrogen (pH) Concentration, 2011-2015
Region III River Stations
DENR WQ criterion for pH: 6.5 - 8.5
pH (units)
2011
2012
2013
2014
1st Qtr 2015
Guagua River - San Pablo Bridge
Guagua River - San Pedro Foot Bridge
Guagua River - Plaza Burgos Bridge
Talisay River - Talisay Bridge
Talisay River - Camacho Bridge
Talisay River - Near Banso Residence
Angat River - Labangan B
Angat River - Expressway B
Angat River - Pulilan Plaridel B
Angat River - Bustos Baliwag B
Sta. Maria River - Sta. Clara Bridge
Sta. Maria River - Catmon Bridge
Sta. Maria River - Poblacion Bridge
Obando River - Polo Bridge
Obando River - Tawiran Bridge
Obando River - Municipal Fishport
Marillao River - Mar-Cal-Boundary B (DECA Homes)
Marillao River - Prenza Dam
Marillao River - Expressway Bridge
Marillao River - Mc Arthur B
Marillao River - Ibayo B
Bocaue River - Expressway Bridge (Bocaue)
Bocaue River - McArthur Bridge
Bocaue River - Bridge near Public Market
Meycauayan River - Perez Bridge
Meycauayan River - Expressway B
Meycauayan River - Veinte Reales B.
Meycauayan River - McArthur B
Meycauayan River - Meymark B.
Pampanga River - Expressway B
Pampanga River - Sulipan B
Pampanga River - Calumpit B
120°30'0"E
121°0'0"E
LEGEND
Potential Hydrogen (mg\L)
6.50 -8.50
Above 8.5
Manila Bay Area
Watershed Boundary
Road
POTENTIAL HYDROGEN
CONCENTRATION, 2015
REGION III
Scale 1:250,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

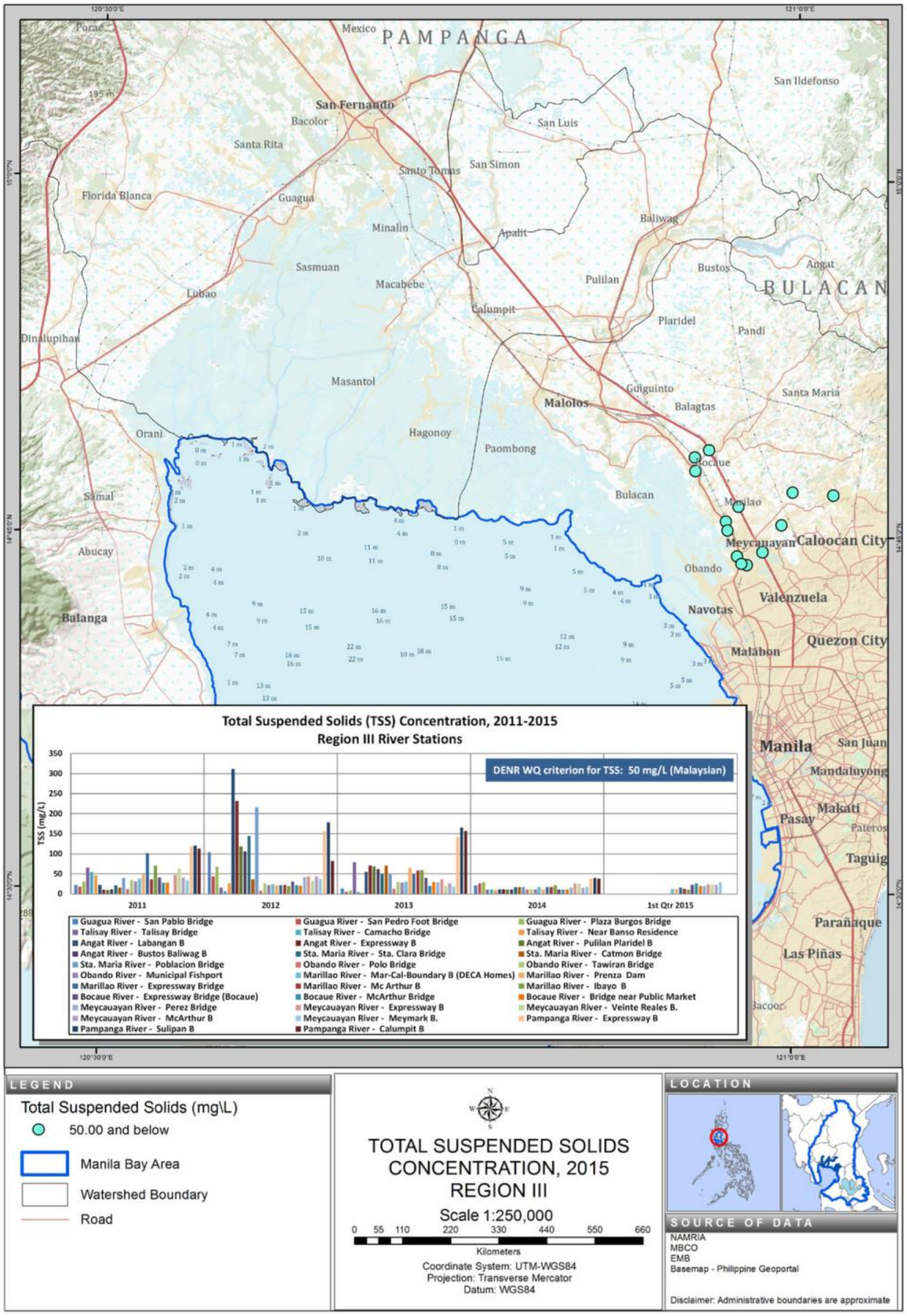
Map 47


Obando
Valenzuela
Navotas
Malabon
Quezon City
La Mesa Reservoir
San Mateo
Marikina
Manila
San Juan
Mandaluyong
Pasig
Cainta
Taytay
Makati
Pasay
Pateros
Taguig
Cavite City
Cañacao Bay
Parañaque
Laguna De Bay
121°0'0"E
14°30'0"N
Potential Hydrogen (pH) Concentration, 2011-2015
NCR River Stations
pH (units)
DENR WQ criterion for pH: 6.5 - 8.5
2011
2012
2013
2014
1st Qtr 2015
Parañaque River System - Tramo
Parañaque River System - MIA Road
Parañaque River System - Sto. Niño
Parañaque River System - Narra Creek
Parañaque River System - Amvel
NMTT - Fairview Station
NMTT - N. Expressway Station
NMTT - Gov. Pascual
NMTT - Bangkulasi Creek
NMTT - Longos
Meycauayan-Valenzuela River System - Meycacuayan River
Meycauayan-Valenzuela River System - Polo Creek
Meycauayan-Valenzuela River System - Pugad Baboy
Parañaque River System - Multi-National
Parañaque River System - Global
Parañaque River System - La Huerta
Parañaque River System - Dilain Creek
Parañaque River System - Ibayo
NMTT - Gulod
NMTT - McArthur
NMTT - Bangkulasi River
NMTT - Tañong
Meycauayan-Valenzuela River System - Maysilo River
Meycauayan-Valenzuela River System - Polo River
Meycauayan-Valenzuela River System - Coloong Creek
Meycauayan-Valenzuela River System - Lingunan
LEGEND
Potential Hydrogen (units)
6.50 - 8.50
Manila Bay Area
Road
City/Municipal Road
POTENTIAL HYDROGEN
CONCENTRATION, 2015
NATIONAL CAPITAL REGION
Scale 1:125,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

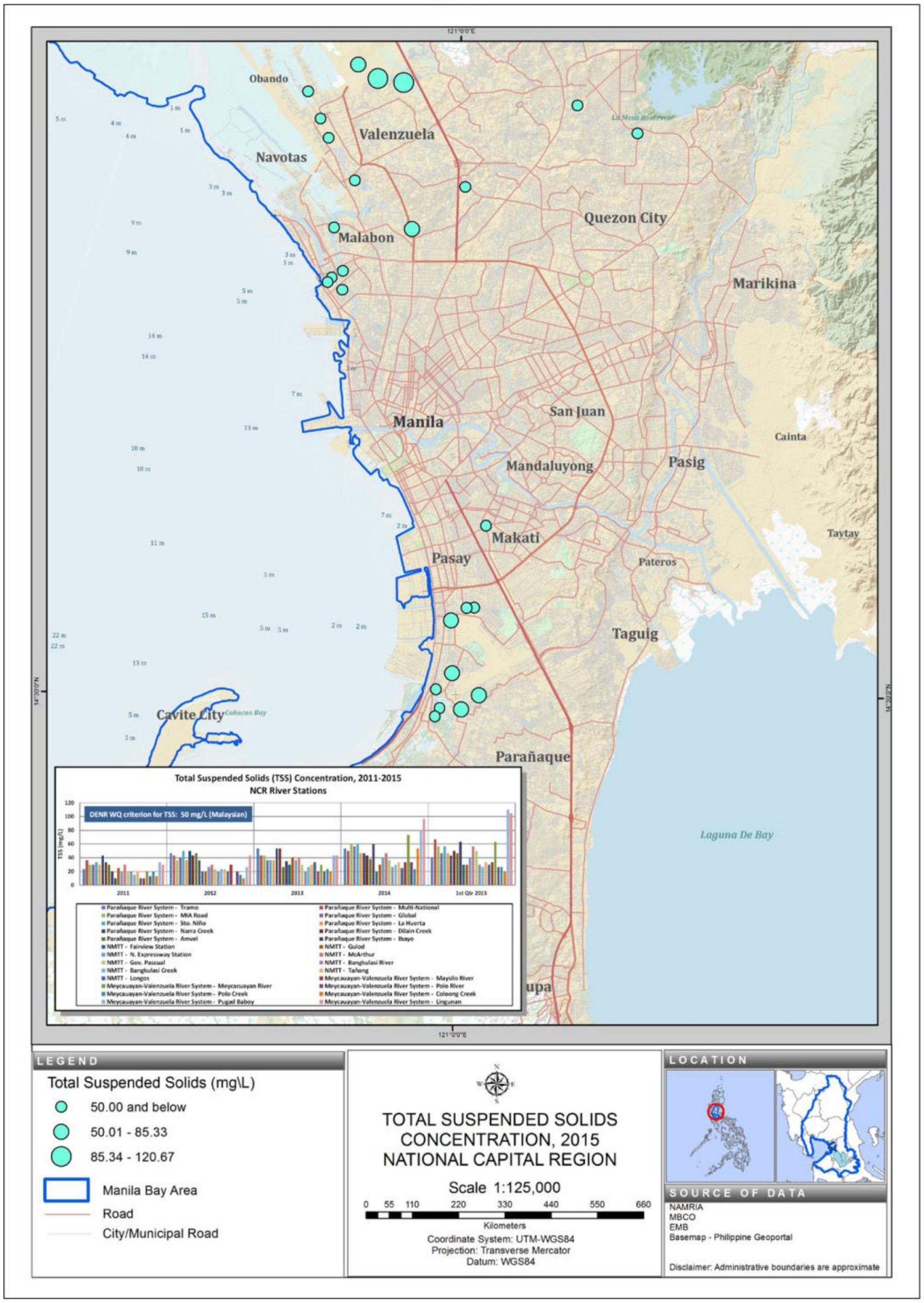
Map 48


Potential Hydrogen (pH) Concentration, 2011-2015
Region IV-A River Stations
DENR WQ criterion for pH: 6.5 - 8.5
pH (units)
2011
2012
2013
2014
1st Qtr 2015
Imus River - Island Cove Bridge
Imus River - Palanas Bridge
Imus River - Aguinaldo Bridge
Cañas River - Tejero Bridge
Cañas River - Patda Bridge
Ylang-Ylang River - Bacao-Alapan Bridge
Ylang-Ylang River - Luksuhin Bridge
Rio Grande River - Pasong Kawayan
Imus River - Imus Toll Bridge
Imus River - Orchard
Imus River - Pansipit Bridge
Cañas River - Paradahan Bridge
Cañas River - Panaysayan Bridge
Ylang-Ylang River - Damariñas Bridge
Rio Grande River - Bacao 1
Rio Grande River - San Francisco
Imus River - Tanzang Luma HB
Imus River - DLSU
Cañas River - Hulugan Bridge
Cañas River - Mag-asawang Layon Bridge
Ylang-Ylang River - Noveleta Bridge
Ylang-Ylang River - Ylang-Ylang Bridge
Rio Grande River - Dulong Bayan
Rio Grande River - Pasong Halang
CAVITE
LEGEND
Potential Hydrogen (mg\L)
6.5 - 8.50
Manila Bay Area
Road
POTENTIAL HYDROGEN
CONCENTRATION, 2015
REGION IV-A
Scale 1:200,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

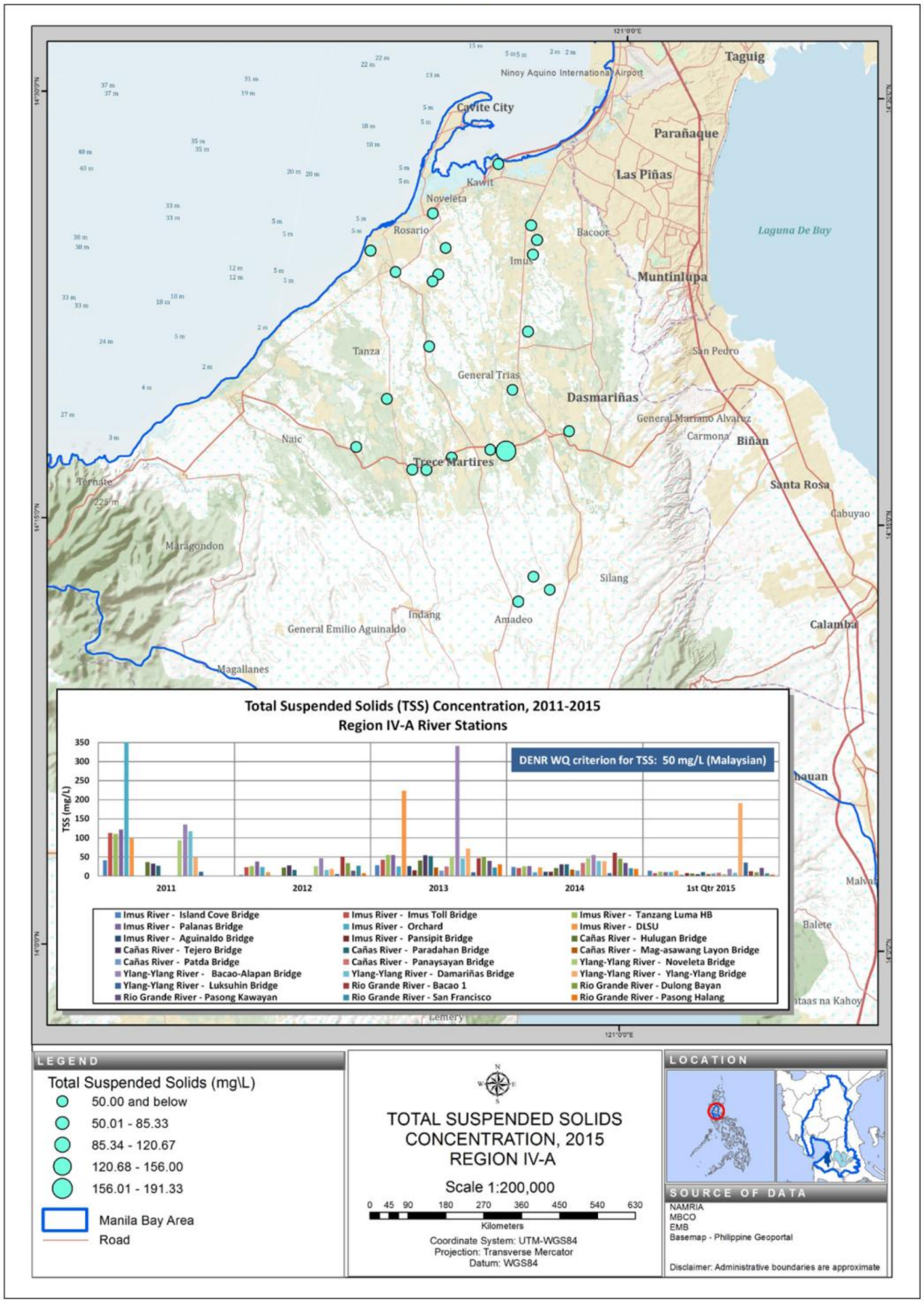
Map 49


PAMPANGA
BULACAN
San Fernando
Bacolor
Santa Rita
Mexico
San Luis
Santo Tomas
San Simon
Florida Blanca
Guagua
Minalin
Apalit
Baliwag
Sasmuan
Macabebe
Calumpit
Pulilan
Bustos
Angat
Lubao
Plaridel
Pandi
Dinalupihan
Masantol
Malolos
Guiguinto
Balagtas
Santa Maria
San Ildefonso
Orani
Hagonoy
Paombong
Bocaue
Samal
Bulacan
Marilao
Abucay
Meycauayan
Caloocan City
Obando
Valenzuela
Navotas
Balanga
Malabon
Quezon City
Manila
San Juan
Mandaluyong
Makati
Pasay
Pateros
Taguig
Parañaque
Las Piñas
Bacoor
Total Suspended Solids (TSS) Concentration, 2011-2015
Region III River Stations
DENR WQ criterion for TSS: 50 mg/L (Malaysian)
TSS (mg/L)
350
300
250
200
150
100
50
0
2011
2012
2013
2014
1st Qtr 2015
Guagua River - San Pablo Bridge
Guagua River - San Pedro Foot Bridge
Guagua River - Plaza Burgos Bridge
Talisay River - Talisay Bridge
Talisay River - Camacho Bridge
Talisay River - Near Banso Residence
Angat River - Labangan B
Angat River - Expressway B
Angat River - Pulilan Plaridel B
Angat River - Bustos Baliwag B
Sta. Maria River - Sta. Clara Bridge
Sta. Maria River - Catmon Bridge
Sta. Maria River - Poblacion Bridge
Obando River - Polo Bridge
Obando River - Tawiran Bridge
Obando River - Municipal Fishport
Marillao River - Mar-Cal-Boundary B (DECA Homes)
Marillao River - Prenza Dam
Marillao River - Expressway Bridge
Marillao River - Mc Arthur B
Marillao River - Ibayo B
Bocaue River - Expressway Bridge (Bocaue)
Bocaue River - McArthur Bridge
Bocaue River - Bridge near Public Market
Meycauayan River - Perez Bridge
Meycauayan River - Expressway B
Meycauayan River - Veinte Reales B.
Meycauayan River - McArthur B
Meycauayan River - Meymark B.
Pampanga River - Expressway B
Pampanga River - Sulipan B
Pampanga River - Calumpit B
120°30'0"E
121°0'0"E
LEGEND
Total Suspended Solids (mg\L)
50.00 and below
Manila Bay Area
Watershed Boundary
Road
TOTAL SUSPENDED SOLIDS CONCENTRATION, 2015 REGION III
Scale 1:250,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

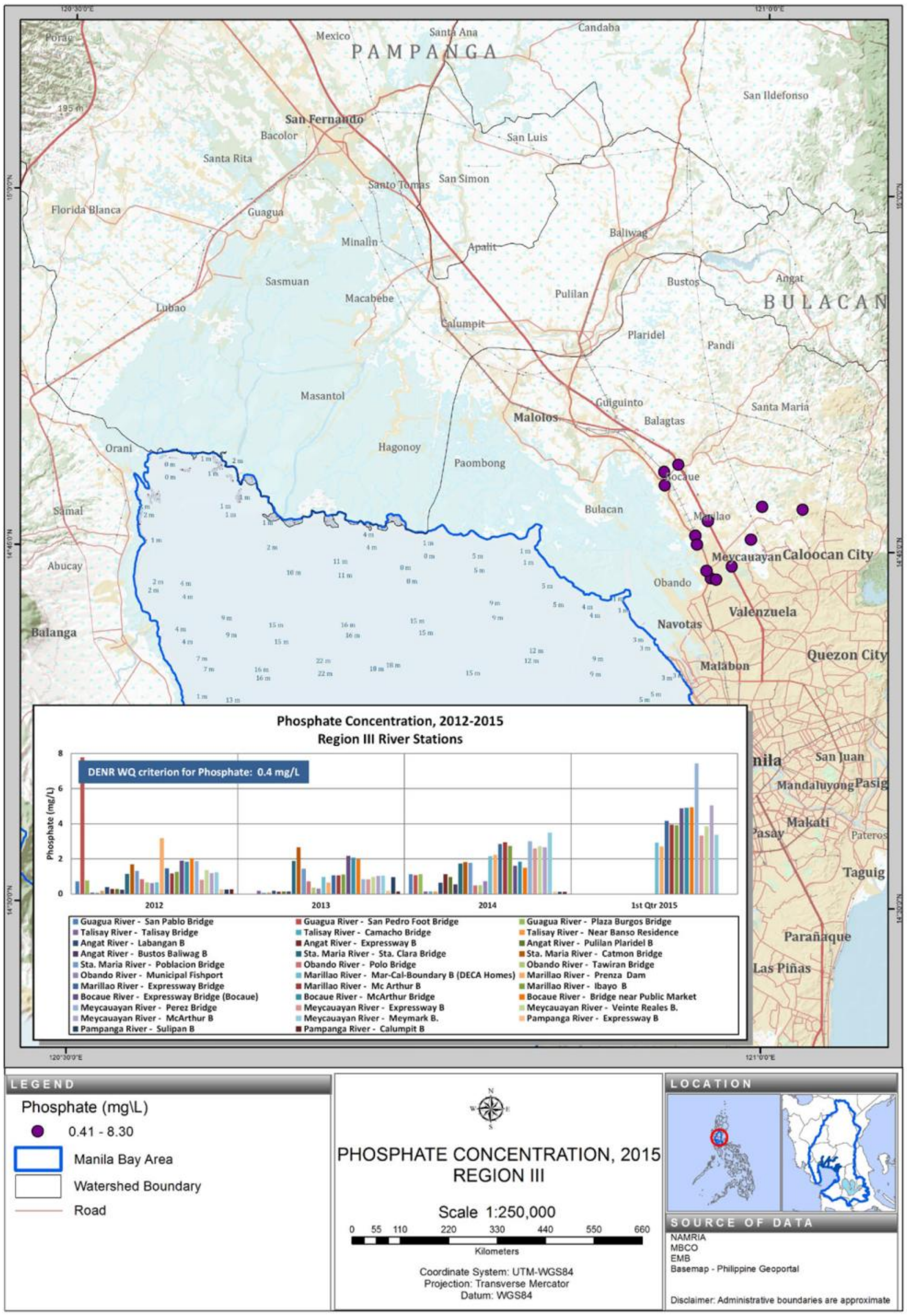
Map 50


Obando
Valenzuela
Navotas
Malabon
Quezon City
Marikina
Manila
San Juan
Mandaluyong
Pasig
Cainta
Taytay
Makati
Pasay
Pateros
Taguig
Cavite City
Cañacao Bay
Parañaque
Laguna De Bay
La Mesa Reservoir
121°0'0"E
14°30'0"N
Total Suspended Solids (TSS) Concentration, 2011-2015
NCR River Stations
DENR WQ criterion for TSS: 50 mg/L (Malaysian)
TSS (mg/L)
2011
2012
2013
2014
1st Qtr 2015
Parañaque River System - Tramo
Parañaque River System - MIA Road
Parañaque River System - Sto. Niño
Parañaque River System - Narra Creek
Parañaque River System - Amvel
NMTT - Fairview Station
NMTT - N. Expressway Station
NMTT - Gov. Pascual
NMTT - Bangkulasi Creek
NMTT - Longos
Meycauayan-Valenzuela River System - Meycacuayan River
Meycauayan-Valenzuela River System - Polo Creek
Meycauayan-Valenzuela River System - Pugad Baboy
Parañaque River System - Multi-National
Parañaque River System - Global
Parañaque River System - La Huerta
Parañaque River System - Dilain Creek
Parañaque River System - Ibayo
NMTT - Gulod
NMTT - McArthur
NMTT - Bangkulasi River
NMTT - Tañong
Meycauayan-Valenzuela River System - Maysilo River
Meycauayan-Valenzuela River System - Polo River
Meycauayan-Valenzuela River System - Coloong Creek
Meycauayan-Valenzuela River System - Lingunan
LEGEND
Total Suspended Solids (mg\L)
50.00 and below
50.01 - 85.33
85.34 - 120.67
Manila Bay Area
Road
City/Municipal Road
TOTAL SUSPENDED SOLIDS
CONCENTRATION, 2015
NATIONAL CAPITAL REGION
Scale 1:125,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

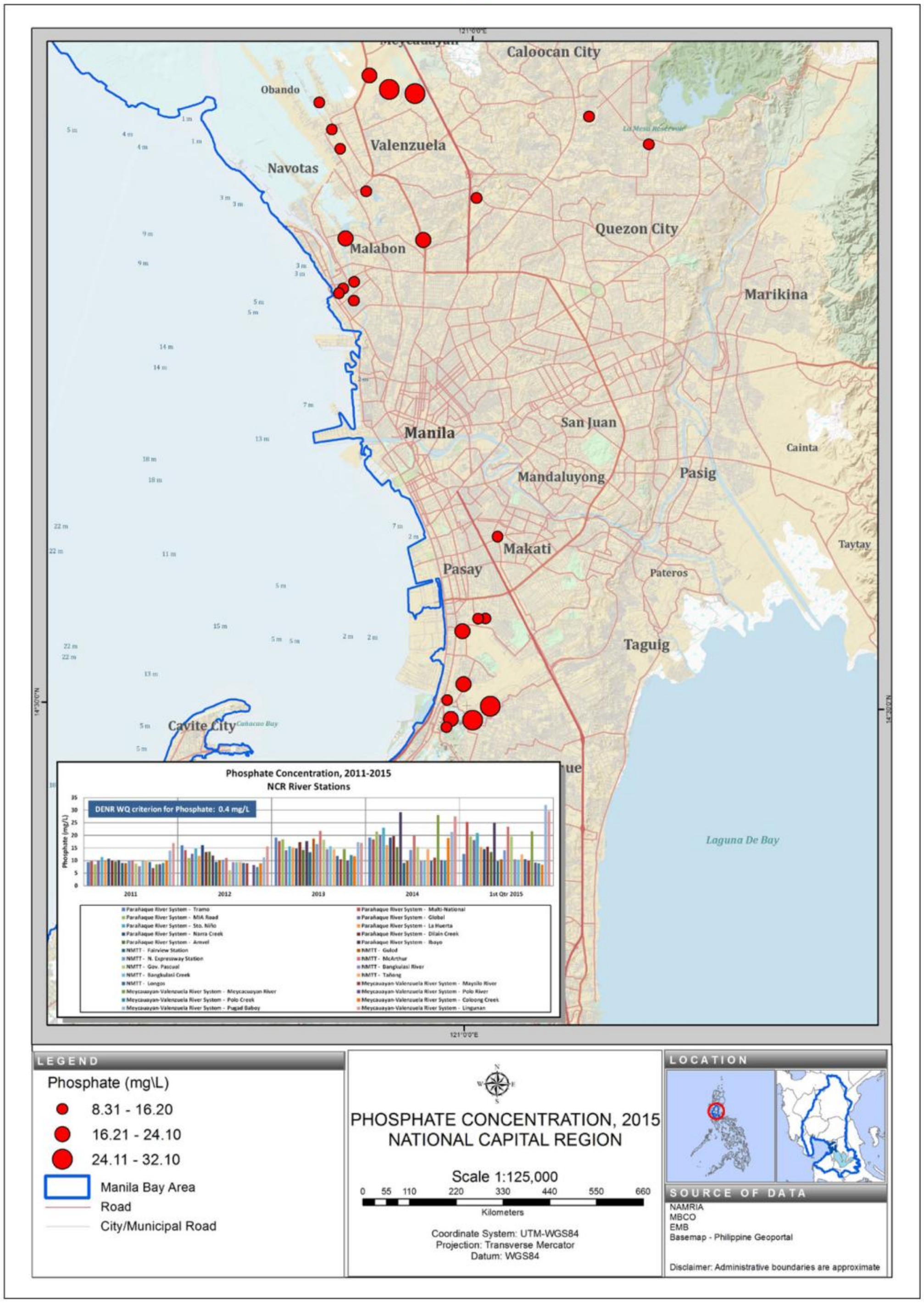
Map 51


Taguig
Ninoy Aquino International Airport
Cavite City
Parañaque
Las Piñas
Kawit
Noveleta
Rosario
Bacoor
Imus
Laguna De Bay
Muntinlupa
Tanza
San Pedro
General Trias
Dasmariñas
General Mariano Alvarez
Carmona
Biñan
Naic
Trece Martires
Santa Rosa
Ternate
Cabuyao
Maragondon
Silang
Indang
Amadeo
General Emilio Aguinaldo
Calamba
Magallanes
Total Suspended Solids (TSS) Concentration, 2011-2015
Region IV-A River Stations
TSS (mg/L)
DENR WQ criterion for TSS: 50 mg/L (Malaysian)
2011
2012
2013
2014
1st Qtr 2015
Imus River - Island Cove Bridge
Imus River - Imus Toll Bridge
Imus River - Tanzang Luma HB
Imus River - Palanas Bridge
Imus River - Orchard
Imus River - DLSU
Imus River - Aguinaldo Bridge
Imus River - Pansipit Bridge
Cañas River - Hulugan Bridge
Cañas River - Tejero Bridge
Cañas River - Paradahan Bridge
Cañas River - Mag-asawang Layon Bridge
Cañas River - Patda Bridge
Cañas River - Panaysayan Bridge
Ylang-Ylang River - Noveleta Bridge
Ylang-Ylang River - Bacao-Alapan Bridge
Ylang-Ylang River - Damariñas Bridge
Ylang-Ylang River - Ylang-Ylang Bridge
Ylang-Ylang River - Luksuhin Bridge
Rio Grande River - Bacao 1
Rio Grande River - Dulong Bayan
Rio Grande River - Pasong Kawayan
Rio Grande River - San Francisco
Rio Grande River - Pasong Halang
LEGEND
Total Suspended Solids (mg\L)
50.00 and below
50.01 - 85.33
85.34 - 120.67
120.68 - 156.00
156.01 - 191.33
Manila Bay Area
Road
TOTAL SUSPENDED SOLIDS CONCENTRATION, 2015 REGION IV-A
Scale 1:200,000
0 45 90 180 270 360 450 540 630
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

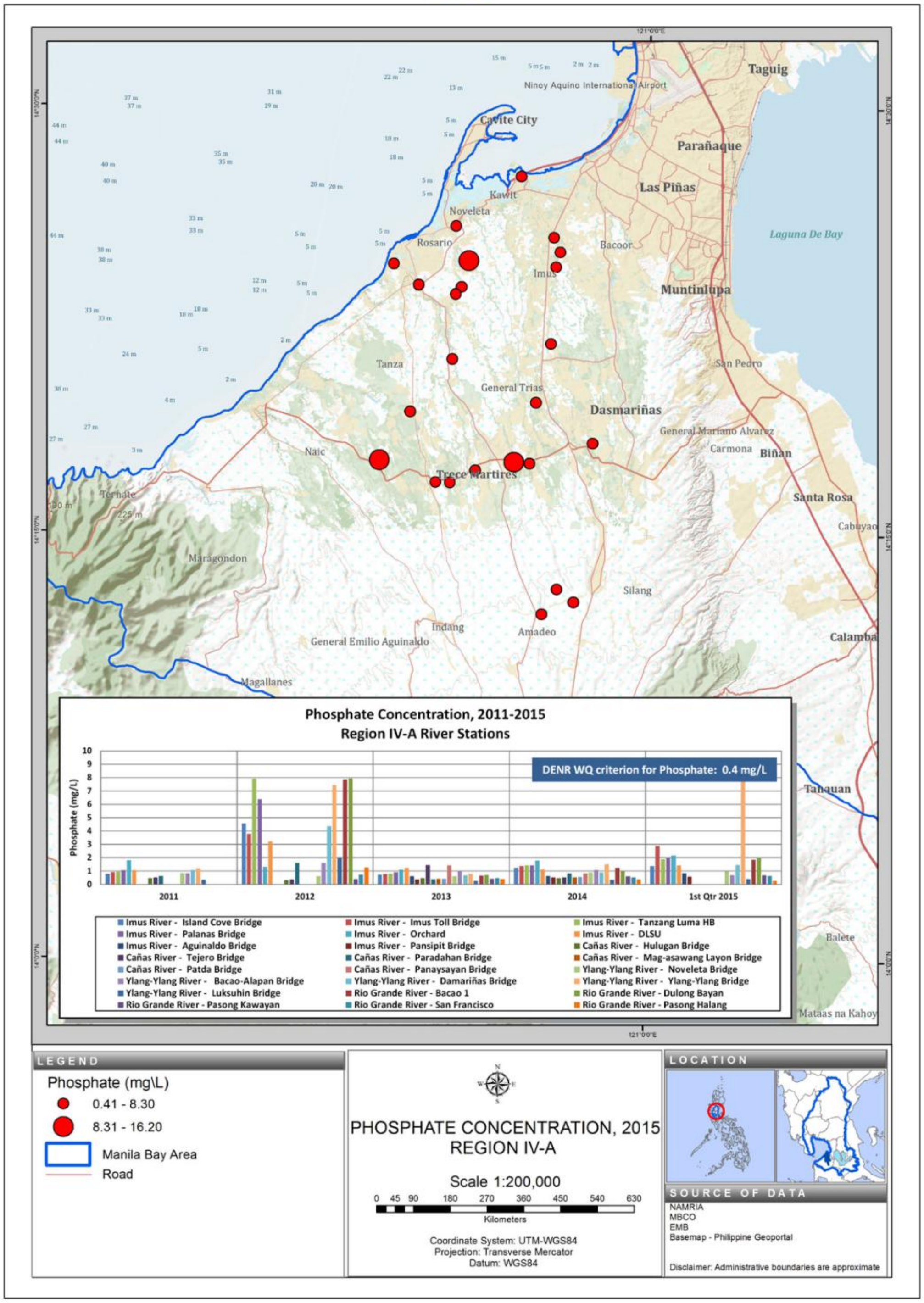
Map 52


PAMPANGA
BULACAN
San Fernando
Bacolor
Santa Rita
Santo Tomas
San Simon
San Luis
Mexico
Santa Ana
Candaba
San Ildefonso
Florida Blanca
Guagua
Minalin
Apalit
Baliwag
Sasmuan
Macabebe
Pulilan
Bustos
Angat
Lubao
Calumpit
Plaridel
Pandi
Masantol
Malolos
Guiguinto
Balagtas
Santa Maria
Orani
Hagonoy
Paombong
Bocaue
Samal
Bulacan
Marilao
Abucay
Meycauayan
Caloocan City
Obando
Valenzuela
Balanga
Navotas
Malabon
Quezon City
Manila
San Juan
Mandaluyong
Pasig
Makati
Pasay
Pateros
Taguig
Parañaque
Las Piñas
Phosphate Concentration, 2012-2015
Region III River Stations
DENR WQ criterion for Phosphate: 0.4 mg/L
Phosphate (mg/L)
0
2
4
6
8
2012
2013
2014
1st Qtr 2015
Guagua River - San Pablo Bridge
Guagua River - San Pedro Foot Bridge
Guagua River - Plaza Burgos Bridge
Talisay River - Talisay Bridge
Talisay River - Camacho Bridge
Talisay River - Near Banso Residence
Angat River - Labangan B
Angat River - Expressway B
Angat River - Pulilan Plaridel B
Angat River - Bustos Baliwag B
Sta. Maria River - Sta. Clara Bridge
Sta. Maria River - Catmon Bridge
Sta. Maria River - Poblacion Bridge
Obando River - Polo Bridge
Obando River - Tawiran Bridge
Obando River - Municipal Fishport
Marillao River - Mar-Cal-Boundary B (DECA Homes)
Marillao River - Prenza Dam
Marillao River - Expressway Bridge
Marillao River - Mc Arthur B
Marillao River - Ibayo B
Bocaue River - Expressway Bridge (Bocaue)
Bocaue River - McArthur Bridge
Bocaue River - Bridge near Public Market
Meycauayan River - Perez Bridge
Meycauayan River - Expressway B
Meycauayan River - Veinte Reales B.
Meycauayan River - McArthur B
Meycauayan River - Meymark B.
Pampanga River - Expressway B
Pampanga River - Sulipan B
Pampanga River - Calumpit B
120°30'0"E
121°0'0"E
LEGEND
Phosphate (mg\L)
0.41 - 8.30
Manila Bay Area
Watershed Boundary
Road
PHOSPHATE CONCENTRATION, 2015
REGION III
Scale 1:250,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

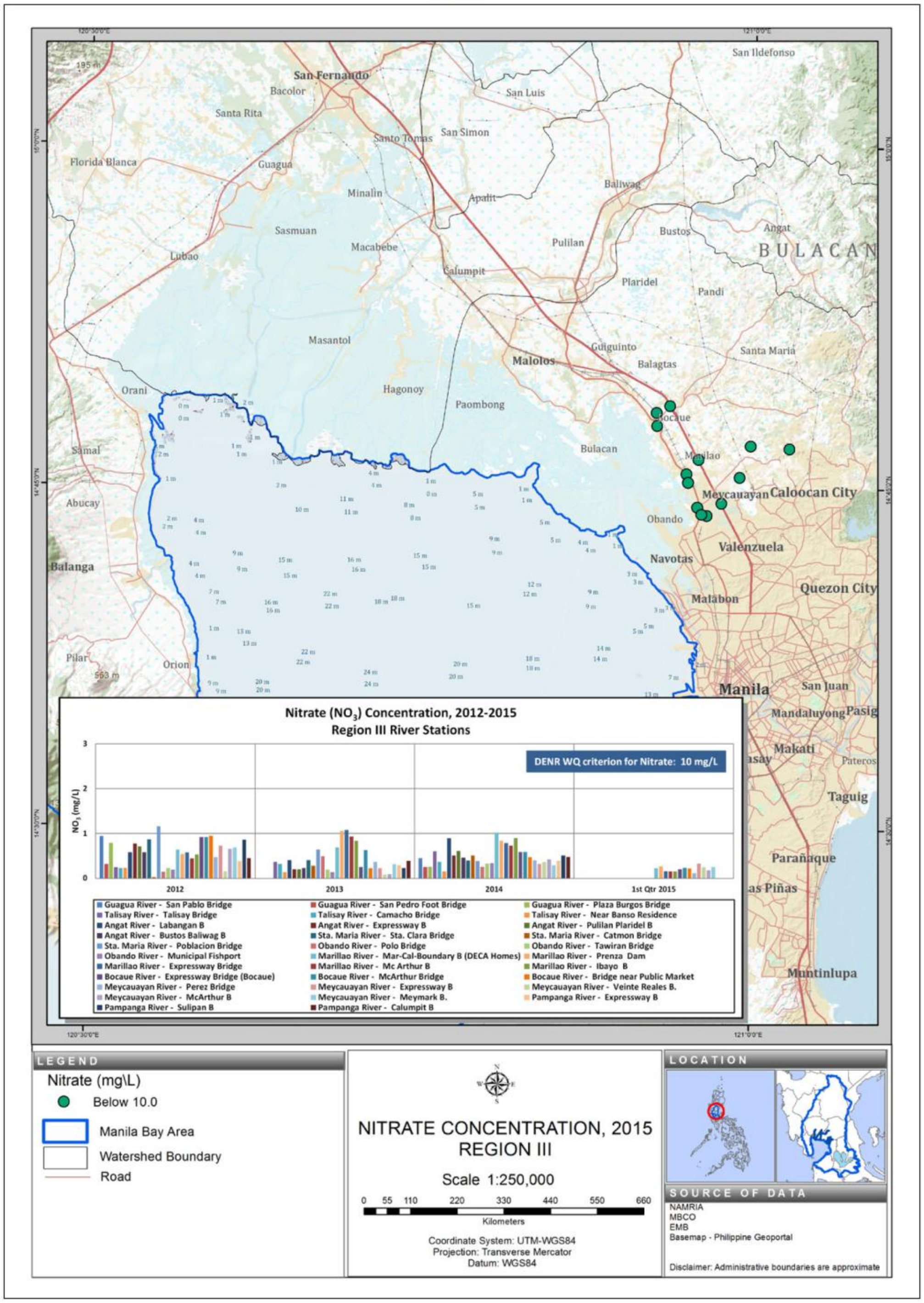
Map 53


Caloocan City
Obando
Valenzuela
Navotas
Quezon City
Malabon
Marikina
Manila
San Juan
Cainta
Mandaluyong
Pasig
Makati
Taytay
Pasay
Pateros
Taguig
Cavite City
Laguna De Bay
Phosphate Concentration, 2011-2015
NCR River Stations
DENR WQ criterion for Phosphate: 0.4 mg/L
2011
2012
2013
2014
1st Qtr 2015
LEGEND
Phosphate (mg\L)
8.31 - 16.20
16.21 - 24.10
24.11 - 32.10
Manila Bay Area
Road
City/Municipal Road
PHOSPHATE CONCENTRATION, 2015
NATIONAL CAPITAL REGION
Scale 1:125,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

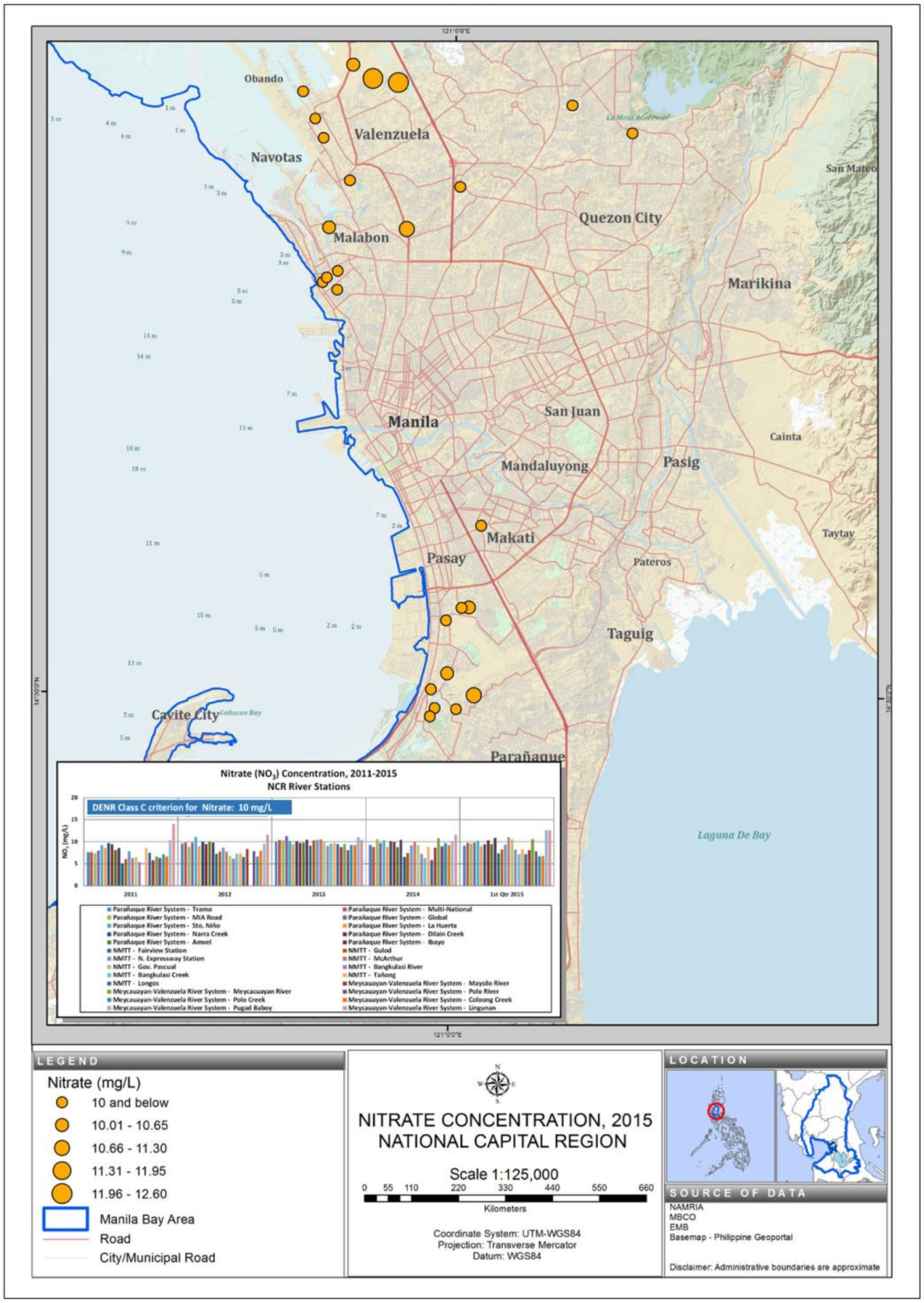
Map 54


Phosphate Concentration, 2011-2015
Region IV-A River Stations
DENR WQ criterion for Phosphate: 0.4 mg/L
Phosphate (mg/L)
2011
2012
2013
2014
1st Qtr 2015
Imus River - Island Cove Bridge
Imus River - Palanas Bridge
Imus River - Aguinaldo Bridge
Cañas River - Tejero Bridge
Cañas River - Patda Bridge
Ylang-Ylang River - Bacao-Alapan Bridge
Ylang-Ylang River - Luksuhin Bridge
Rio Grande River - Pasong Kawayan
Imus River - Imus Toll Bridge
Imus River - Orchard
Imus River - Pansipit Bridge
Cañas River - Paradahan Bridge
Cañas River - Panaysayan Bridge
Ylang-Ylang River - Damariñas Bridge
Rio Grande River - Bacao 1
Rio Grande River - San Francisco
Imus River - Tanzang Luma HB
Imus River - DLSU
Cañas River - Hulugan Bridge
Cañas River - Mag-asawang Layon Bridge
Ylang-Ylang River - Noveleta Bridge
Ylang-Ylang River - Ylang-Ylang Bridge
Rio Grande River - Dulong Bayan
Rio Grande River - Pasong Halang
Taguig
Parañaque
Las Piñas
Cavite City
Ninoy Aquino International Airport
Kawit
Noveleta
Rosario
Imus
Bacoor
Laguna De Bay
Muntinlupa
Tanza
General Trias
Dasmariñas
San Pedro
General Mariano Alvarez
Carmona
Biñan
Naic
Trece Martires
Santa Rosa
Ternate
Cabuyao
Maragondon
Silang
Indang
Amadeo
General Emilio Aguinaldo
Calamba
Magallanes
Tanauan
Balete
Mataas na Kahoy
LEGEND
Phosphate (mg\L)
0.41 - 8.30
8.31 - 16.20
Manila Bay Area
Road
PHOSPHATE CONCENTRATION, 2015
REGION IV-A
Scale 1:200,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

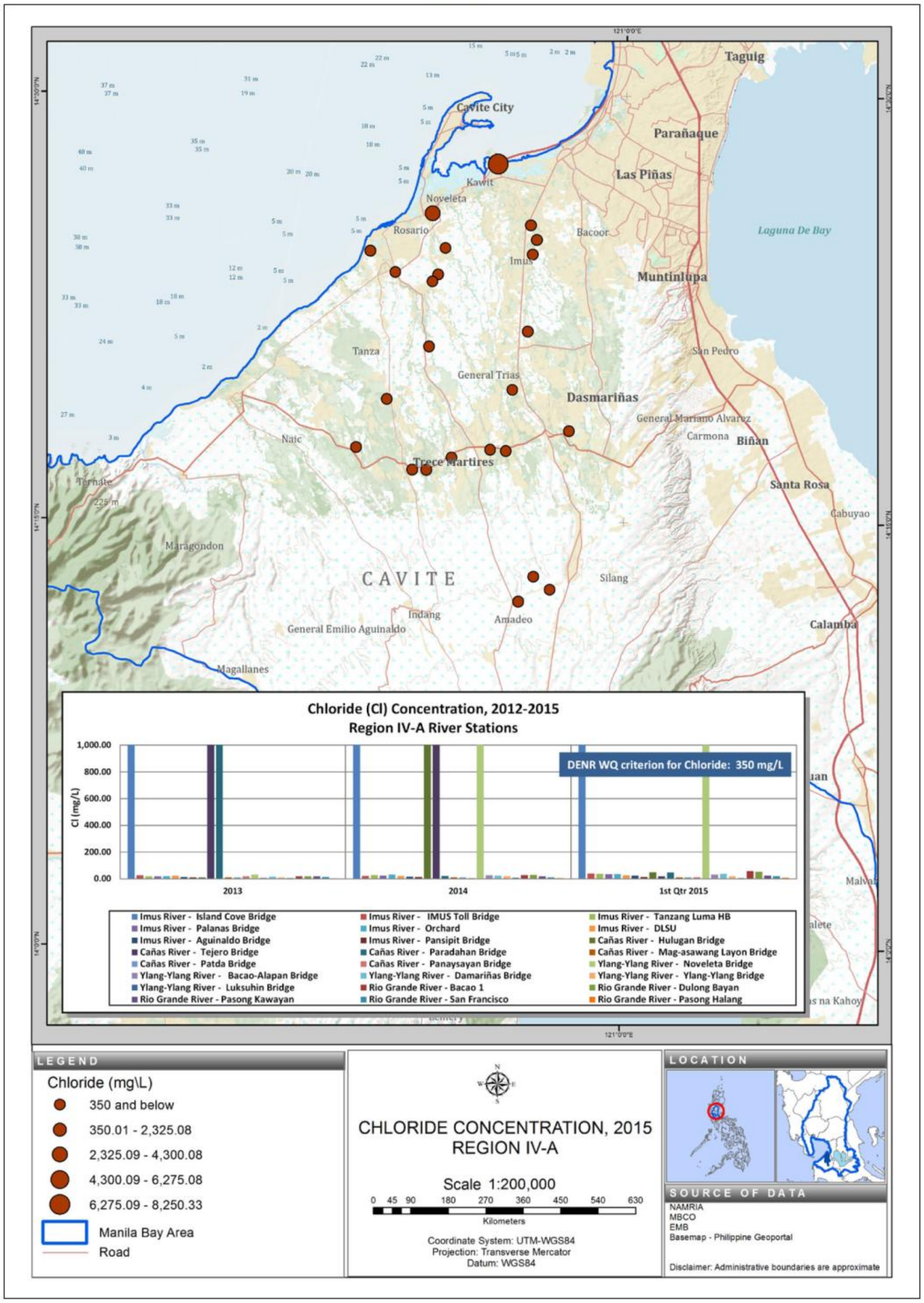
Map 55


Nitrate (NO3) Concentration, 2012-2015
Region III River Stations
DENR WQ criterion for Nitrate: 10 mg/L
NO3 (mg/L)
2012
2013
2014
1st Qtr 2015
Guagua River - San Pablo Bridge
Guagua River - San Pedro Foot Bridge
Guagua River - Plaza Burgos Bridge
Talisay River - Talisay Bridge
Talisay River - Camacho Bridge
Talisay River - Near Banso Residence
Angat River - Labangan B
Angat River - Expressway B
Angat River - Pulilan Plaridel B
Angat River - Bustos Baliwag B
Sta. Maria River - Sta. Clara Bridge
Sta. Maria River - Catmon Bridge
Sta. Maria River - Poblacion Bridge
Obando River - Polo Bridge
Obando River - Tawiran Bridge
Obando River - Municipal Fishport
Marillao River - Mar-Cal-Boundary B (DECA Homes)
Marillao River - Prenza Dam
Marillao River - Expressway Bridge
Marillao River - Mc Arthur B
Marillao River - Ibayo B
Bocaue River - Expressway Bridge (Bocaue)
Bocaue River - McArthur Bridge
Bocaue River - Bridge near Public Market
Meycauayan River - Perez Bridge
Meycauayan River - Expressway B
Meycauayan River - Veinte Reales B.
Meycauayan River - McArthur B
Meycauayan River - Meymark B.
Pampanga River - Expressway B
Pampanga River - Sulipan B
Pampanga River - Calumpit B
San Fernando
Bacolor
Santa Rita
San Luis
Santo Tomas
San Simon
San Ildefonso
Florida Blanca
Guagua
Minalin
Apalit
Baliwag
Sasmuan
Macabebe
Pulilan
Bustos
Angat
BULACAN
Lubao
Calumpit
Plaridel
Pandi
Masantol
Malolos
Guiguinto
Balagtas
Santa Maria
Orani
Hagonoy
Paombong
Bocaue
Samal
Bulacan
Marilao
Abucay
Meycauayan
Caloocan City
Obando
Balanga
Valenzuela
Navotas
Quezon City
Malabon
Pilar
Orion
Manila
San Juan
Mandaluyong
Pasig
Makati
Pateros
Taguig
Parañaque
Las Piñas
Muntinlupa
LEGEND
Nitrate (mg\L)
Below 10.0
Manila Bay Area
Watershed Boundary
Road
NITRATE CONCENTRATION, 2015
REGION III
Scale 1:250,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

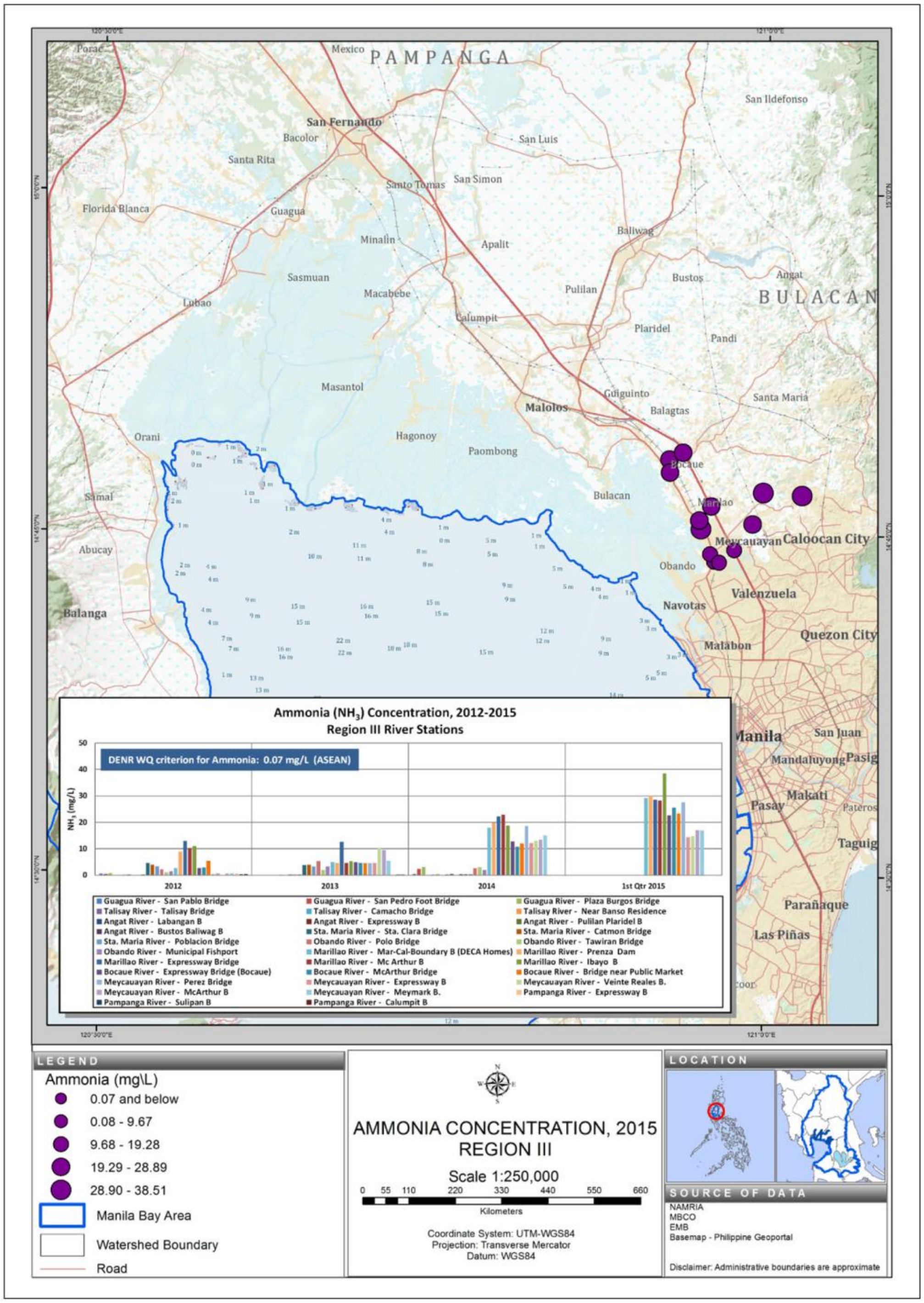
Map 56


Obando
Valenzuela
Navotas
Malabon
Quezon City
San Mateo
Marikina
Manila
San Juan
Mandaluyong
Pasig
Cainta
Taytay
Makati
Pasay
Pateros
Taguig
Cavite City
Cañacao Bay
Parañaque
Laguna De Bay
121°0'0"E
14°30'0"N
Nitrate (NO_3) Concentration, 2011-2015
NCR River Stations
DENR Class C criterion for Nitrate: 10 mg/L
NO_3 (mg/L)
0
5
10
15
20
2011
2012
2013
2014
1st Qtr 2015
Parañaque River System - Tramo
Parañaque River System - MIA Road
Parañaque River System - Sto. Niño
Parañaque River System - Narra Creek
Parañaque River System - Amvel
NMTT - Fairview Station
NMTT - N. Expressway Station
NMTT - Gov. Pascual
NMTT - Bangkulasi Creek
NMTT - Longos
Meycauayan-Valenzuela River System - Meycacuayan River
Meycauayan-Valenzuela River System - Polo Creek
Meycauayan-Valenzuela River System - Pugad Baboy
Parañaque River System - Multi-National
Parañaque River System - Global
Parañaque River System - La Huerta
Parañaque River System - Dilain Creek
Parañaque River System - Ibayo
NMTT - Gulod
NMTT - McArthur
NMTT - Bangkulasi River
NMTT - Tañong
Meycauayan-Valenzuela River System - Maysilo River
Meycauayan-Valenzuela River System - Polo River
Meycauayan-Valenzuela River System - Coloong Creek
Meycauayan-Valenzuela River System - Lingunan
LEGEND
Nitrate (mg/L)
10 and below
10.01 - 10.65
10.66 - 11.30
11.31 - 11.95
11.96 - 12.60
Manila Bay Area
Road
City/Municipal Road
N
NITRATE CONCENTRATION, 2015
NATIONAL CAPITAL REGION
Scale 1:125,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

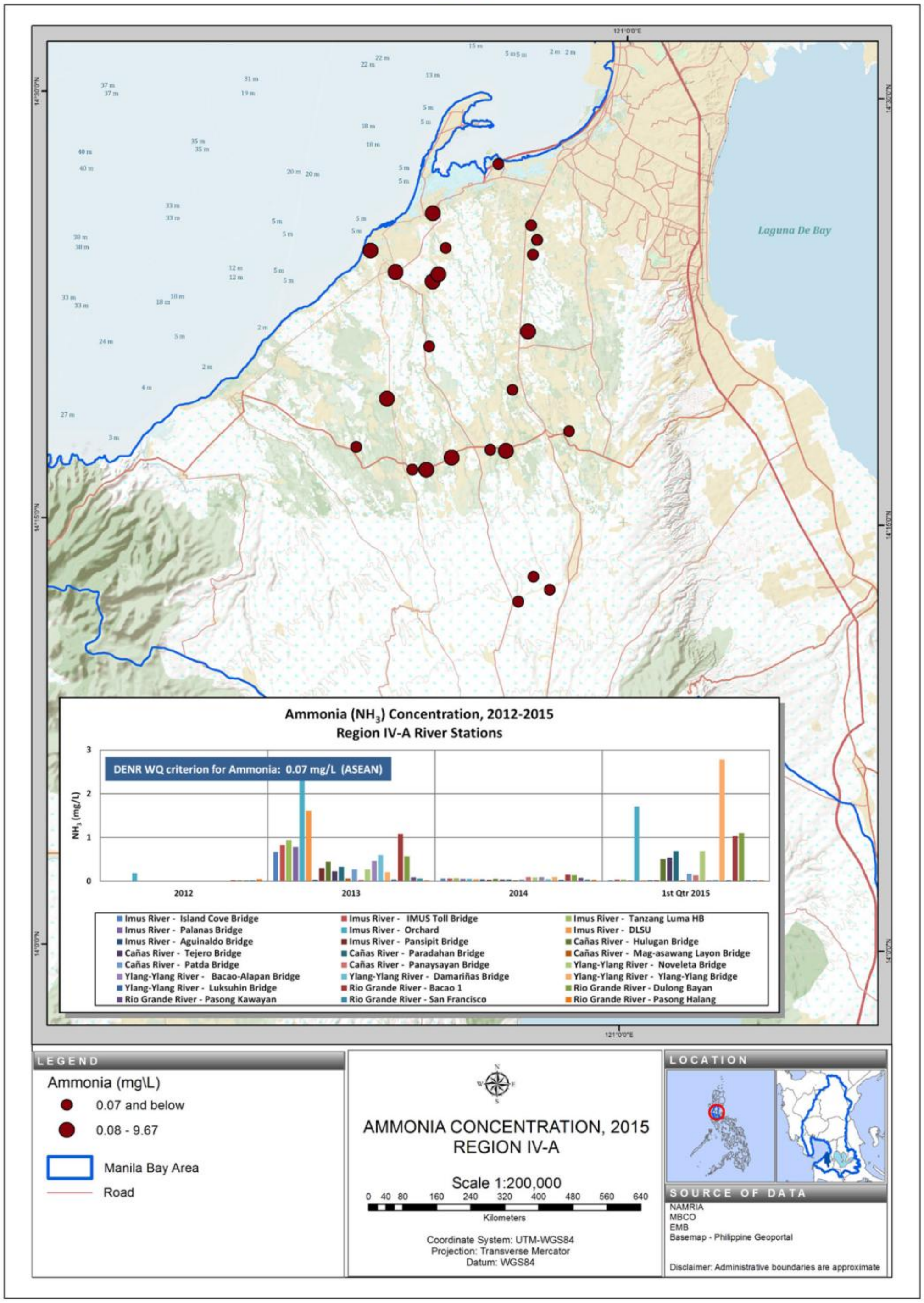
Map 57


Taguig
Cavite City
Parañaque
Las Piñas
Kawit
Noveleta
Rosario
Bacoor
Laguna De Bay
Imus
Muntinlupa
Tanza
San Pedro
General Trias
Dasmariñas
General Mariano Alvarez
Carmona
Biñan
Naic
Trece Martires
Ternate
Santa Rosa
Cabuyao
Maragondon
CAVITE
Silang
Indang
Amadeo
General Emilio Aguinaldo
Calamba
Magallanes
Chloride (Cl) Concentration, 2012-2015
Region IV-A River Stations
DENR WQ criterion for Chloride: 350 mg/L
Cl (mg/L)
1,000.00
800.00
600.00
400.00
200.00
0.00
2013
2014
1st Qtr 2015
Imus River - Island Cove Bridge
Imus River - IMUS Toll Bridge
Imus River - Tanzang Luma HB
Imus River - Palanas Bridge
Imus River - Orchard
Imus River - DLSU
Imus River - Aguinaldo Bridge
Imus River - Pansipit Bridge
Cañas River - Hulugan Bridge
Cañas River - Tejero Bridge
Cañas River - Paradahan Bridge
Cañas River - Mag-asawang Layon Bridge
Cañas River - Patda Bridge
Cañas River - Panaysayan Bridge
Ylang-Ylang River - Noveleta Bridge
Ylang-Ylang River - Bacao-Alapan Bridge
Ylang-Ylang River - Damariñas Bridge
Ylang-Ylang River - Ylang-Ylang Bridge
Ylang-Ylang River - Luksuhin Bridge
Rio Grande River - Bacao 1
Rio Grande River - Dulong Bayan
Rio Grande River - Pasong Kawayan
Rio Grande River - San Francisco
Rio Grande River - Pasong Halang
121°0'0"E
LEGEND
Chloride (mg\L)
350 and below
350.01 - 2,325.08
2,325.09 - 4,300.08
4,300.09 - 6,275.08
6,275.09 - 8,250.33
Manila Bay Area
Road
CHLORIDE CONCENTRATION, 2015
REGION IV-A
Scale 1:200,000
0 45 90 180 270 360 450 540 630
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

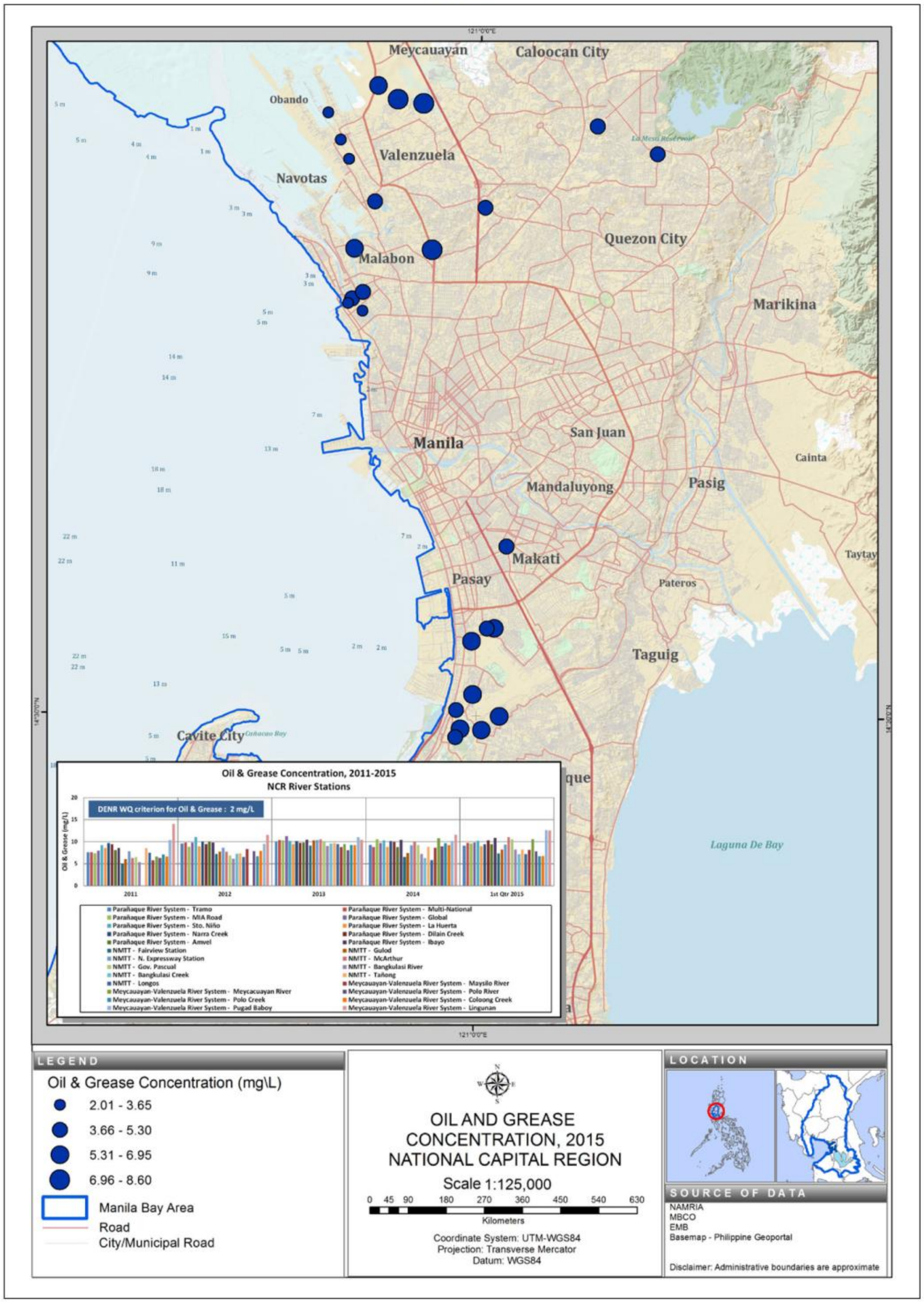
Map 58


PAMPANGA
BULACAN
Porac
Mexico
San Fernando
Bacolor
San Ildefonso
San Luis
Santa Rita
Santo Tomas
San Simon
Florida Blanca
Guagua
Minalin
Apalit
Baliwag
Sasmuan
Macabebe
Pulilan
Bustos
Angat
Lubao
Calumpit
Plaridel
Pandi
Masantol
Malolos
Guiguinto
Balagtas
Santa Maria
Orani
Hagonoy
Paombong
Bocaue
Samal
Bulacan
Marilao
Abucay
Meycauayan
Caloocan City
Obando
Valenzuela
Navotas
Balanga
Malabon
Quezon City
Manila
San Juan
Mandaluyong
Pasig
Makati
Pasay
Pateros
Taguig
Parañaque
Las Piñas
Ammonia (NH_3) Concentration, 2012-2015
Region III River Stations
DENR WQ criterion for Ammonia: 0.07 mg/L (ASEAN)
NH_3 (mg/L)
50
40
30
20
10
0
2012
2013
2014
1st Qtr 2015
Guagua River - San Pablo Bridge
Guagua River - San Pedro Foot Bridge
Guagua River - Plaza Burgos Bridge
Talisay River - Talisay Bridge
Talisay River - Camacho Bridge
Talisay River - Near Banso Residence
Angat River - Labangan B
Angat River - Expressway B
Angat River - Pulilan Plaridel B
Angat River - Bustos Baliwag B
Sta. Maria River - Sta. Clara Bridge
Sta. Maria River - Catmon Bridge
Sta. Maria River - Poblacion Bridge
Obando River - Polo Bridge
Obando River - Tawiran Bridge
Obando River - Municipal Fishport
Marillao River - Mar-Cal-Boundary B (DECA Homes)
Marillao River - Prenza Dam
Marillao River - Expressway Bridge
Marillao River - Mc Arthur B
Marillao River - Ibayo B
Bocaue River - Expressway Bridge (Bocaue)
Bocaue River - McArthur Bridge
Bocaue River - Bridge near Public Market
Meycauayan River - Perez Bridge
Meycauayan River - Expressway B
Meycauayan River - Veinte Reales B.
Meycauayan River - McArthur B
Meycauayan River - Meymark B.
Pampanga River - Expressway B
Pampanga River - Sulipan B
Pampanga River - Calumpit B
120°30'0"E
121°0'0"E
LEGEND
Ammonia (mg\L)
0.07 and below
0.08 - 9.67
9.68 - 19.28
19.29 - 28.89
28.90 - 38.51
Manila Bay Area
Watershed Boundary
Road
AMMONIA CONCENTRATION, 2015
REGION III
Scale 1:250,000
0 55 110 220 330 440 550 660
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 59


Laguna De Bay
Ammonia (NH3) Concentration, 2012-2015
Region IV-A River Stations
DENR WQ criterion for Ammonia: 0.07 mg/L (ASEAN)
NH3 (mg/L)
3
2
1
0
2012
2013
2014
1st Qtr 2015
Imus River - Island Cove Bridge
Imus River - Palanas Bridge
Imus River - Aguinaldo Bridge
Cañas River - Tejero Bridge
Cañas River - Patda Bridge
Ylang-Ylang River - Bacao-Alapan Bridge
Ylang-Ylang River - Luksuhin Bridge
Rio Grande River - Pasong Kawayan
Imus River - IMUS Toll Bridge
Imus River - Orchard
Imus River - Pansipit Bridge
Cañas River - Paradahan Bridge
Cañas River - Panaysayan Bridge
Ylang-Ylang River - Damariñas Bridge
Rio Grande River - Bacao 1
Rio Grande River - San Francisco
Imus River - Tanzang Luma HB
Imus River - DLSU
Cañas River - Hulugan Bridge
Cañas River - Mag-asawang Layon Bridge
Ylang-Ylang River - Noveleta Bridge
Ylang-Ylang River - Ylang-Ylang Bridge
Rio Grande River - Dulong Bayan
Rio Grande River - Pasong Halang
LEGEND
Ammonia (mg\L)
0.07 and below
0.08 - 9.67
Manila Bay Area
Road
AMMONIA CONCENTRATION, 2015
REGION IV-A
Scale 1:200,000
0 40 80 160 240 320 400 480 560 640
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 60


Meycauayan
Caloocan City
Obando
Valenzuela
Navotas
Quezon City
Malabon
Marikina
Manila
San Juan
Cainta
Mandaluyong
Pasig
Makati
Taytay
Pasay
Pateros
Taguig
Cavite City
Laguna De Bay
Oil & Grease Concentration, 2011-2015
NCR River Stations
DENR WQ criterion for Oil & Grease : 2 mg/L
Oil & Grease (mg/L)
2011
2012
2013
2014
1st Qtr 2015
LEGEND
Oil & Grease Concentration (mg\L)
2.01 - 3.65
3.66 - 5.30
5.31 - 6.95
6.96 - 8.60
Manila Bay Area
Road
City/Municipal Road
OIL AND GREASE CONCENTRATION, 2015
NATIONAL CAPITAL REGION
Scale 1:125,000
0 45 90 180 270 360 450 540 630
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

B.2 PASIG RIVER

The Pasig River is the main river in Metro Manila that connects Laguna de Bay and Manila Bay. It is approximately 27 km long with an average width of 91 meters and a depth ranging from 0.5 to 5.5 meters. The stretch of the Pasig River has an average depth of 1.3 meters. The deepest portions (4.5 meters) are located between Guadalupe Bridge and C6 Bridge, while the most shallow portion is at the mouth of Manila Bay. The average water volume is 6.6 million m3. During low flow from March to May, the discharge volume is 12 m3/sec, while from October to November the discharge volume reaches 275 m3/sec. It is considered a tidal estuary because of the interchange of water during low tide from Laguna de Bay and high tide from Manila Bay (Pasig River Rehabilitation Commission, 2006).

The main Pasig River passes through five cities (Taguig, Pasig, Makati, Mandaluyong and Manila, and one municipality, Taytay). The river has four major tributaries (Marikina, Pateros-Taguig, Napindan and San Juan) and 43 minor tributaries mostly located in the city of Manila (Pasig River Rehabilitation Commission, 2014).

The Pasig River Unified Monitoring Stations (PRUMS) project is an inter-agency initiative to integrate a monitoring program for the Pasig River. Last 23 January 2009, four agencies: EMB – Central Office, EMB – National Capital Region, LLDA and PRRC, finalized the monitoring stations along the Pasig River System (Pasig River Rehabilitation Commission, 2009).

The Pasig River Unified Monitoring Stations project is currently composed of 14 sites starting from the Pasig River's headwater at C6/Napindan Station up to the mouth of Manila Bay. Eight monitoring sites represent the upstream portion: C6/Napindan, Bambang, Vargas, Marikina, Buayang Bato, Guadalupe Ferry Station, Guadalupe Nuevo, Guadalupe Viejo, whereas the downstream portions are composed of five sites: Sevilla Bridge, Lambingan Bridge, Havana Bridge, Jones Bridge, and Manila Bay. The original 13 stations were selected based on the commonalities of the monitoring stations of each agency, the control and most affected section of the river, and the population and number of commercial and industrial significant discharges. In 2010, another downstream station, Nagtahan, was added.

PHYSICO-CHEMICAL PROPERTIES

Biochemical Oxygen Demand

From 2009 up to present, the BOD dramatically increased, particularly in monitoring sites near residential, industrial and commercial areas. The high BOD concentration can be attributed to the constant discharging of domestic and industrial wastes, as well as solid wastes (Map 61).

Dissolved Oxygen

From 2009-2014, the DO concentration of Pasig River did not pass the Class C and SB criteria. The low DO concentration caused the reduction of aquatic life present in the Pasig River. From 2009 onwards, the stations with the lowest dissolved oxygen are Guadalupe Nuevo, Guadalupe Viejo, Sevilla and Havana Bridge. These stations are mostly surrounded by residential and commercial establishments, which correlates to the amount of domestic waste being discharged into the river (Map 62).

Phosphate

Phosphate is one of the nutrients necessary for primary productivity but its excess can lead to eutrophication. For Class C water quality, the standard for phosphate is 0.4 mg/L. The elevated levels of phosphate during 2011 – 2013 for Buayang Bato, Guadalupe Nuevo and Viejo, Sevilla Bridge and Havana Bridge can be accounted to the low dissolved oxygen (Map 64). Phosphorus movement from the sediments in river beds increases as dissolved oxygen is depleted (Hu et al., 2001).

Nitrate

Nitrate is the other nutrient needed for primary productivity. The DENR AO No. 34 standard for nitrate levels is 10 mg/L. For 2009, the nitrate level for Sevilla Bridge, Lambingan Bridge and Havana Bridge exceeded the standard, whereas for 2011 – 2013, the nitrate levels for Buayang Bato exceed the standards but is observed to be decreasing (Map 63). The high nitrate levels can be accounted to the decomposition of organic matter, as indicated by the high BOD level.

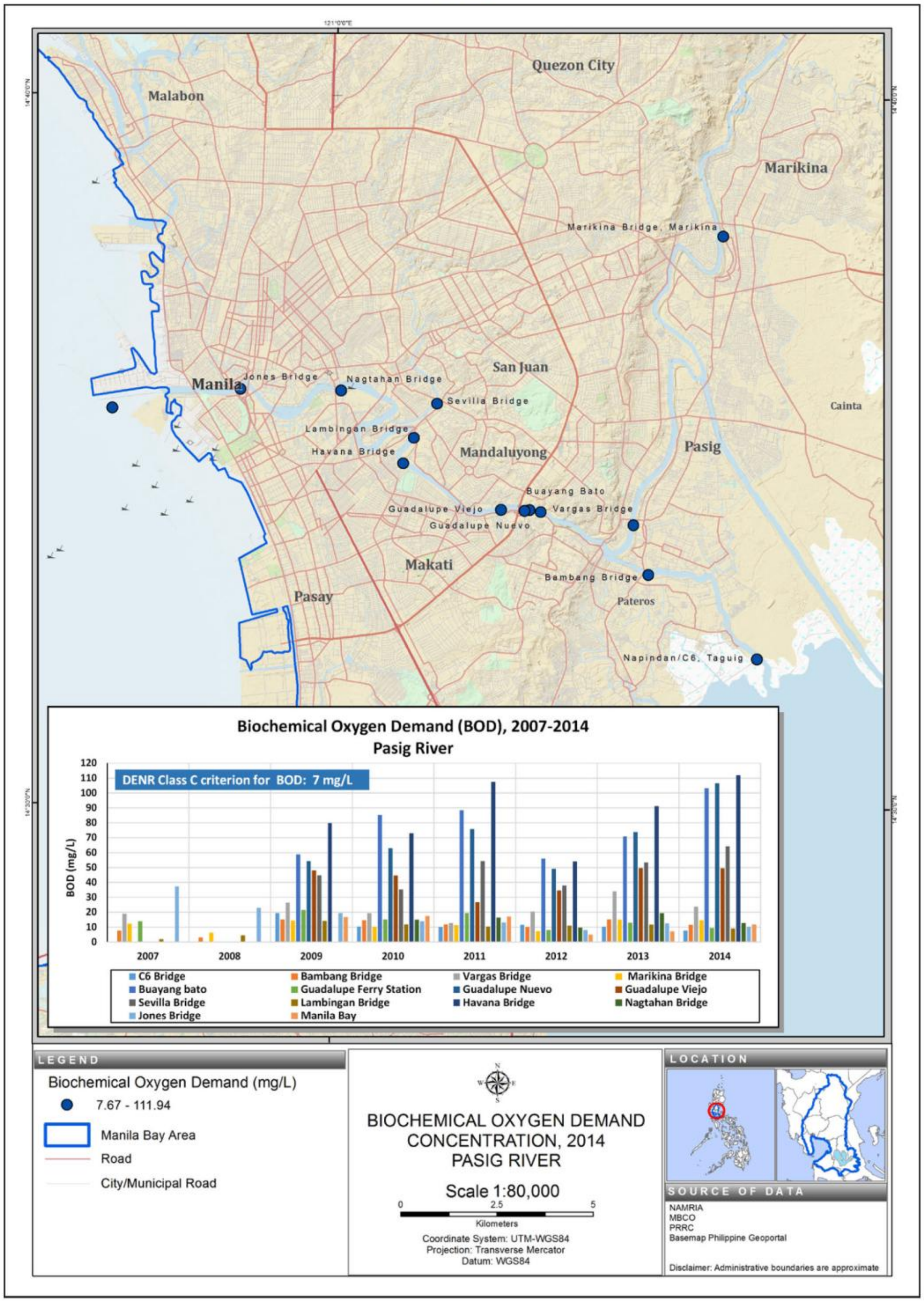
Heavy Metals

The high cadmium concentration can come from industrial effluents, phosphate fertilizers, iron and steel production, cement production and municipal solid waste incineration. For the years 2011 – 2013, all stations exceed the cadmium level for Class C water. Chromium can come from industry effluents that are involved in electroplating, paint, ink, wood preservatives, leather tanning and textiles (Map 66). Most of the stations conform to the Class C standard, except for the episodic increase for Guadalupe Nuevo, Guadalupe Viejo, Sevilla Bridge and Hanava Bridge for two non-consecutive years. The presence of lead can come from the discharge of agricultural, municipal, and industrial wastewater (Map 67). From 2009 - 2011, all stations, especially the upstream stations exceed the Class C standard. A decrease in the level is observed from 2013 – 2014, with several stations conforming to the standard. From 2009 to 2014, the mercury concentration had consistently conformed with the Class C and SB criteria in DENR AO No. 34 (Map 68).

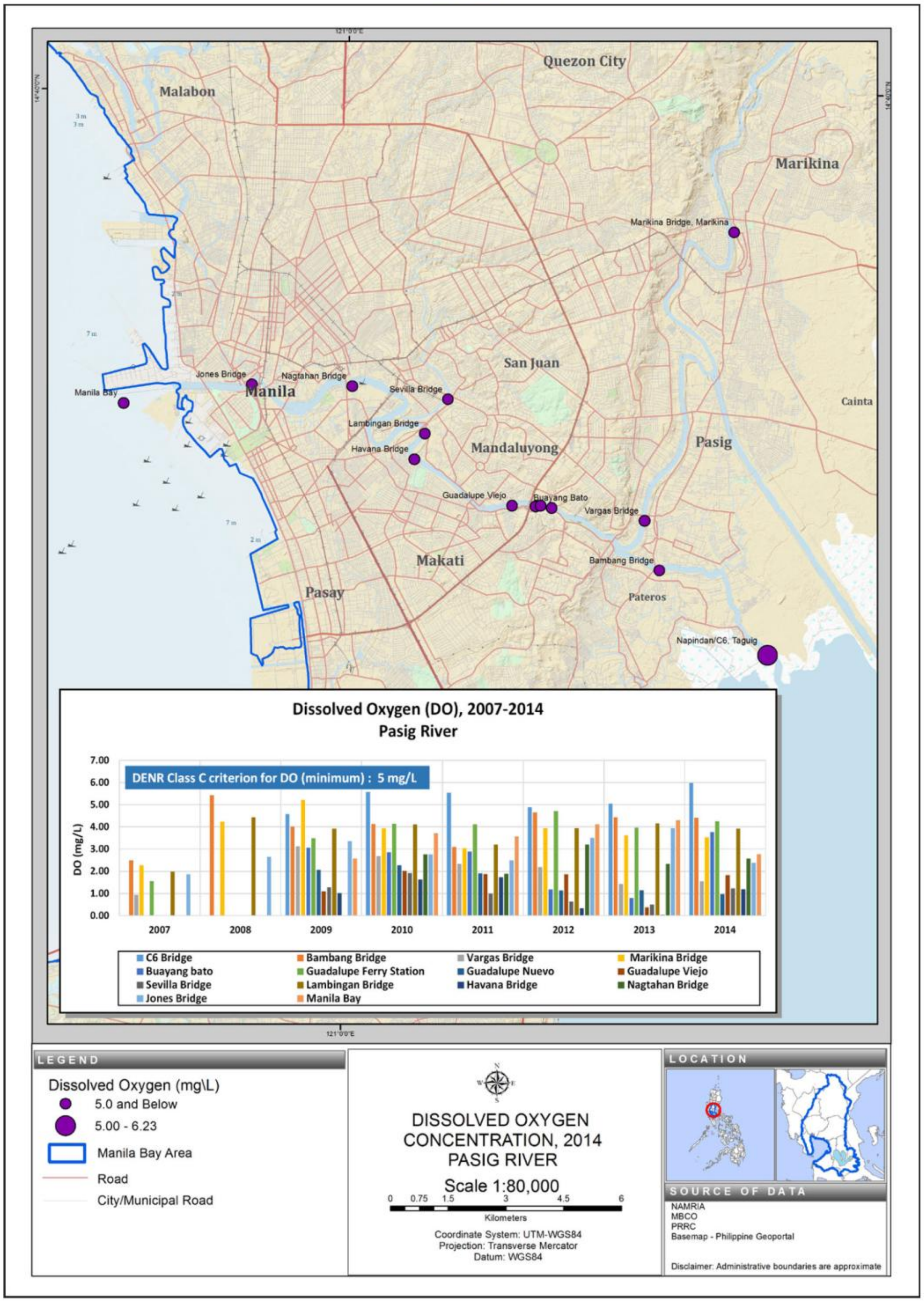
BACTERIOLOGICAL PARAMETERS

The total coliform indicates the presence of disease-causing bacteria and is a primary measure for the suitability of water for contact recreation. Total coliform, that includes fecal coliform, indicate anthropogenic impact like domestic wastewater, livestock and poultry manure, and sanitary landfills. All the stations exceed the Class C and SB criteria for total coliform. Consistently, the Guadalupe Nuevo has the highest concentration of coliform, being surrounded by commercial and residential areas that contribute to the high fecal pollution (Map 69).

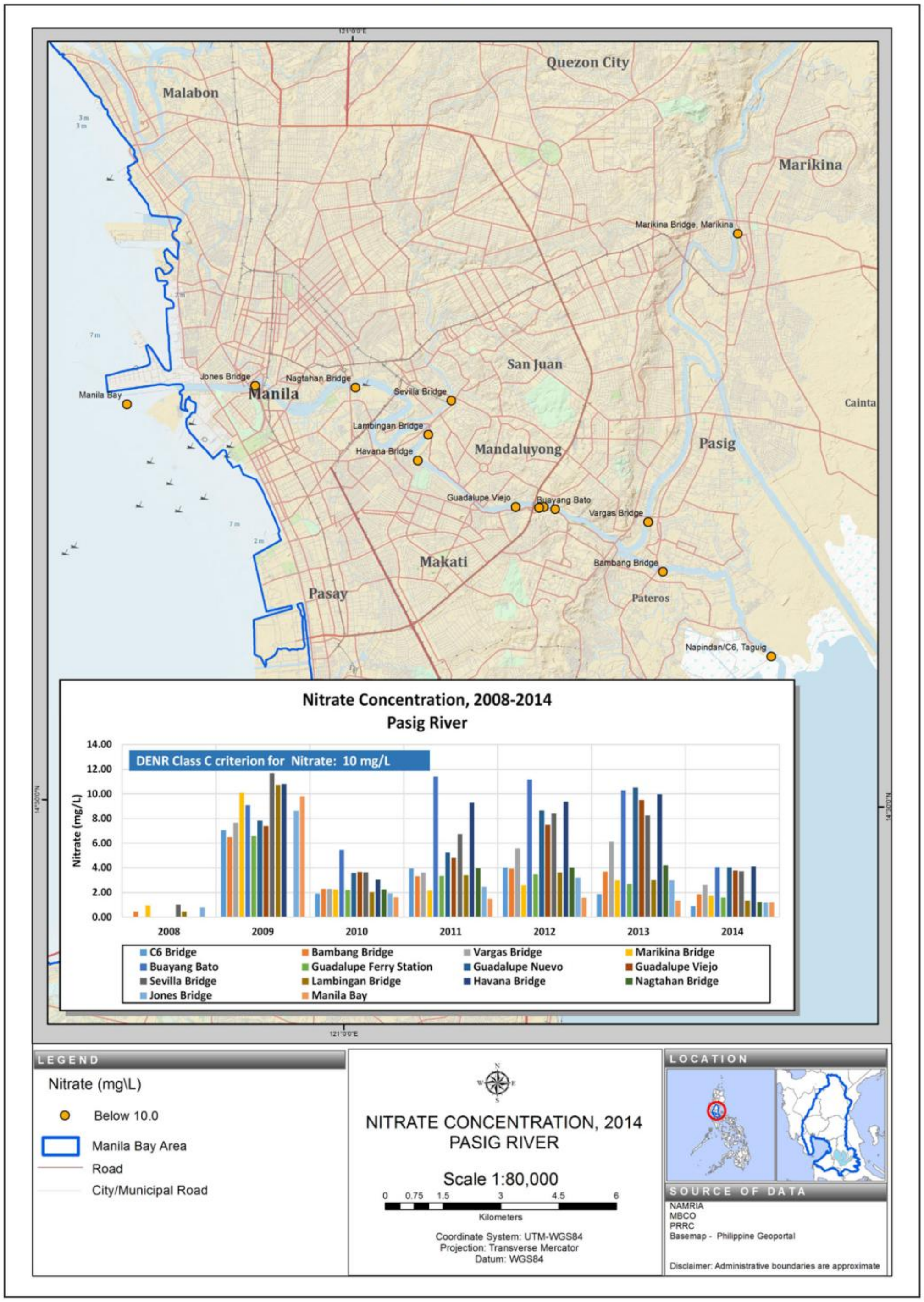
Map 61


Quezon City
Malabon
Marikina
Marikina Bridge, Marikina
San Juan
Manila
Jones Bridge
Nagtahan Bridge
Sevilla Bridge
Cainta
Lambingan Bridge
Havana Bridge
Mandaluyong
Pasig
Buayang Bato
Guadalupe Viejo
Vargas Bridge
Guadalupe Nuevo
Makati
Bambang Bridge
Pasay
Pateros
Napindan/C6, Taguig
Biochemical Oxygen Demand (BOD), 2007-2014
Pasig River
DENR Class C criterion for BOD: 7 mg/L
BOD (mg/L)
2007
2008
2009
2010
2011
2012
2013
2014
C6 Bridge
Bambang Bridge
Vargas Bridge
Marikina Bridge
Buayang bato
Guadalupe Ferry Station
Guadalupe Nuevo
Guadalupe Viejo
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Nagtahan Bridge
Jones Bridge
Manila Bay
LEGEND
Biochemical Oxygen Demand (mg/L)
7.67 - 111.94
Manila Bay Area
Road
City/Municipal Road
BIOCHEMICAL OXYGEN DEMAND
CONCENTRATION, 2014
PASIG RIVER
Scale 1:80,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PRRC
Basemap Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

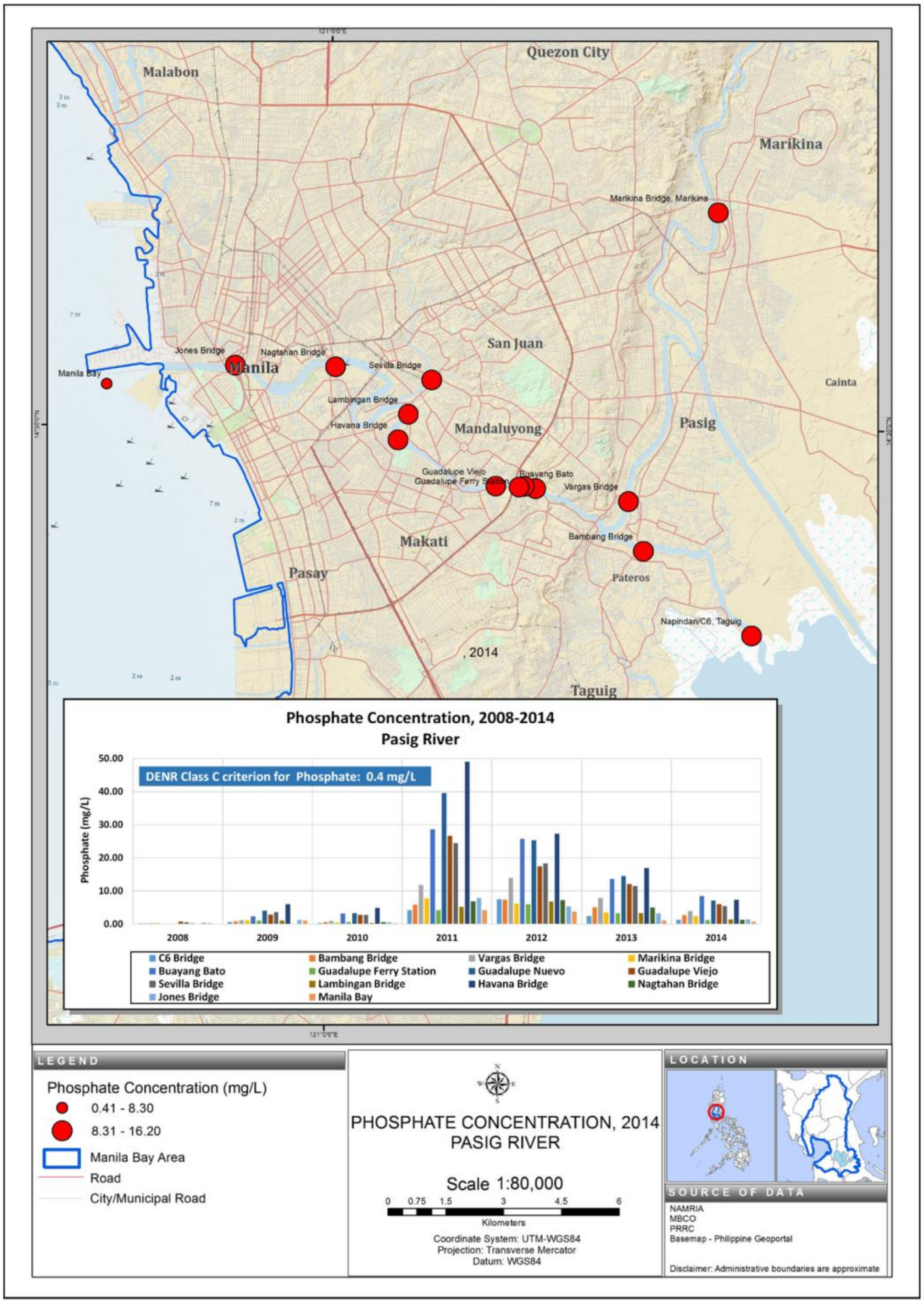
Map 62


Quezon City
Malabon
Marikina
Marikina Bridge, Marikina
San Juan
Cainta
Manila
Jones Bridge
Nagtahan Bridge
Sevilla Bridge
Manila Bay
Lambingan Bridge
Havana Bridge
Mandaluyong
Pasig
Guadalupe Viejo
Buayang Bato
Vargas Bridge
Makati
Bambang Bridge
Pateros
Pasay
Napindan/C6, Taguig
Dissolved Oxygen (DO), 2007-2014
Pasig River
DENR Class C criterion for DO (minimum) : 5 mg/L
DO (mg/L)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
2007
2008
2009
2010
2011
2012
2013
2014
C6 Bridge
Bambang Bridge
Vargas Bridge
Marikina Bridge
Buayang bato
Guadalupe Ferry Station
Guadalupe Nuevo
Guadalupe Viejo
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Nagtahan Bridge
Jones Bridge
Manila Bay
LEGEND
Dissolved Oxygen (mg\L)
5.0 and Below
5.00 - 6.23
Manila Bay Area
Road
City/Municipal Road
DISSOLVED OXYGEN
CONCENTRATION, 2014
PASIG RIVER
Scale 1:80,000
0 0.75 1.5 3 4.5 6
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PRRC
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

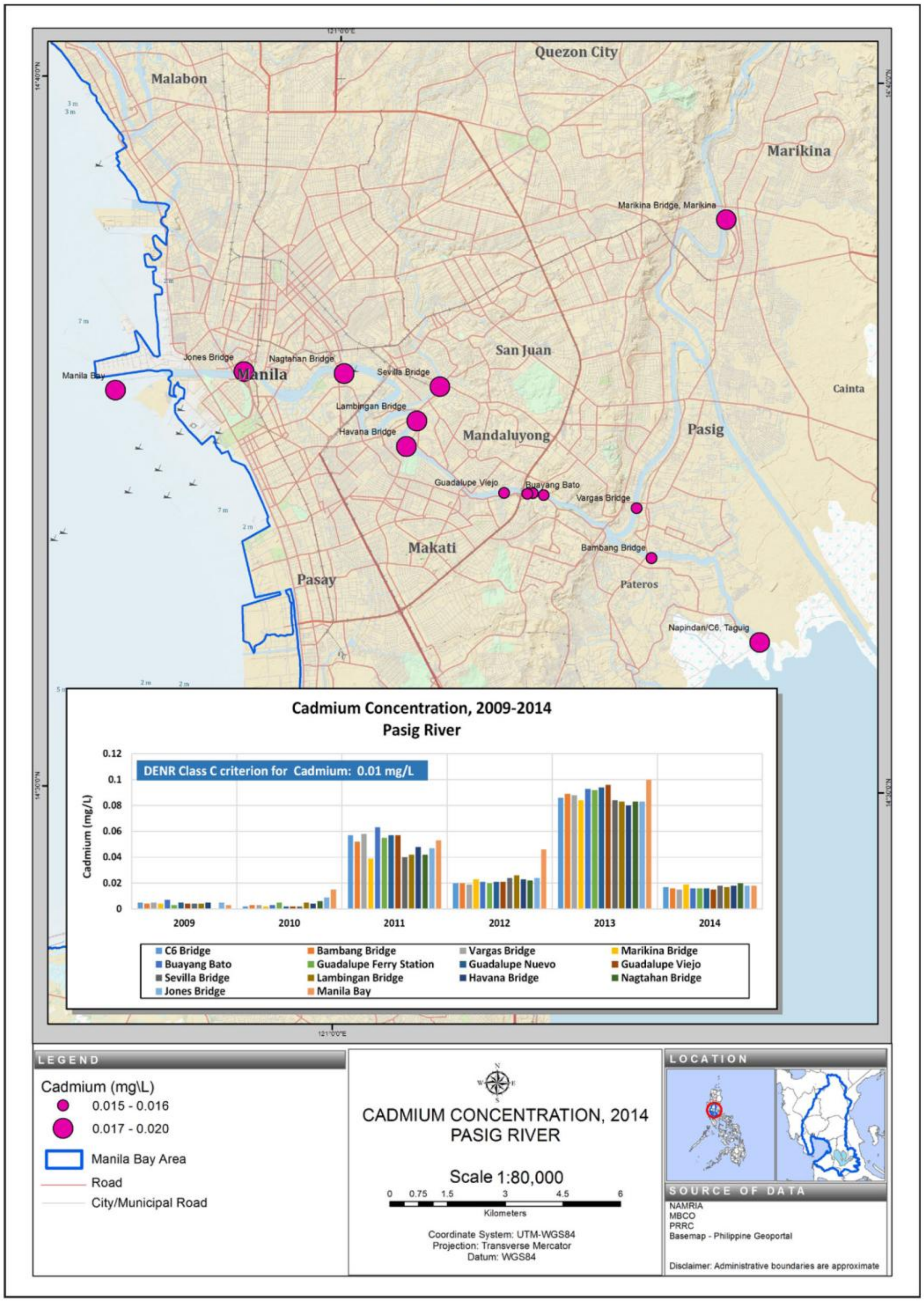
Map 63


Quezon City
Malabon
Marikina
Marikina Bridge, Marikina
San Juan
Jones Bridge
Nagtahan Bridge
Manila Bay
Manila
Sevilla Bridge
Cainta
Lambingan Bridge
Havana Bridge
Mandaluyong
Pasig
Guadalupe Viejo
Buayang Bato
Vargas Bridge
Makati
Bambang Bridge
Pasay
Pateros
Napindan/C6, Taguig
Nitrate Concentration, 2008-2014
Pasig River
DENR Class C criterion for Nitrate: 10 mg/L
Nitrate (mg/L)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
2008
2009
2010
2011
2012
2013
2014
C6 Bridge
Bambang Bridge
Vargas Bridge
Marikina Bridge
Buayang Bato
Guadalupe Ferry Station
Guadalupe Nuevo
Guadalupe Viejo
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Nagtahan Bridge
Jones Bridge
Manila Bay
LEGEND
Nitrate (mg\L)
Below 10.0
Manila Bay Area
Road
City/Municipal Road
NITRATE CONCENTRATION, 2014
PASIG RIVER
Scale 1:80,000
0 0.75 1.5 3 4.5 6
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PRRC
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

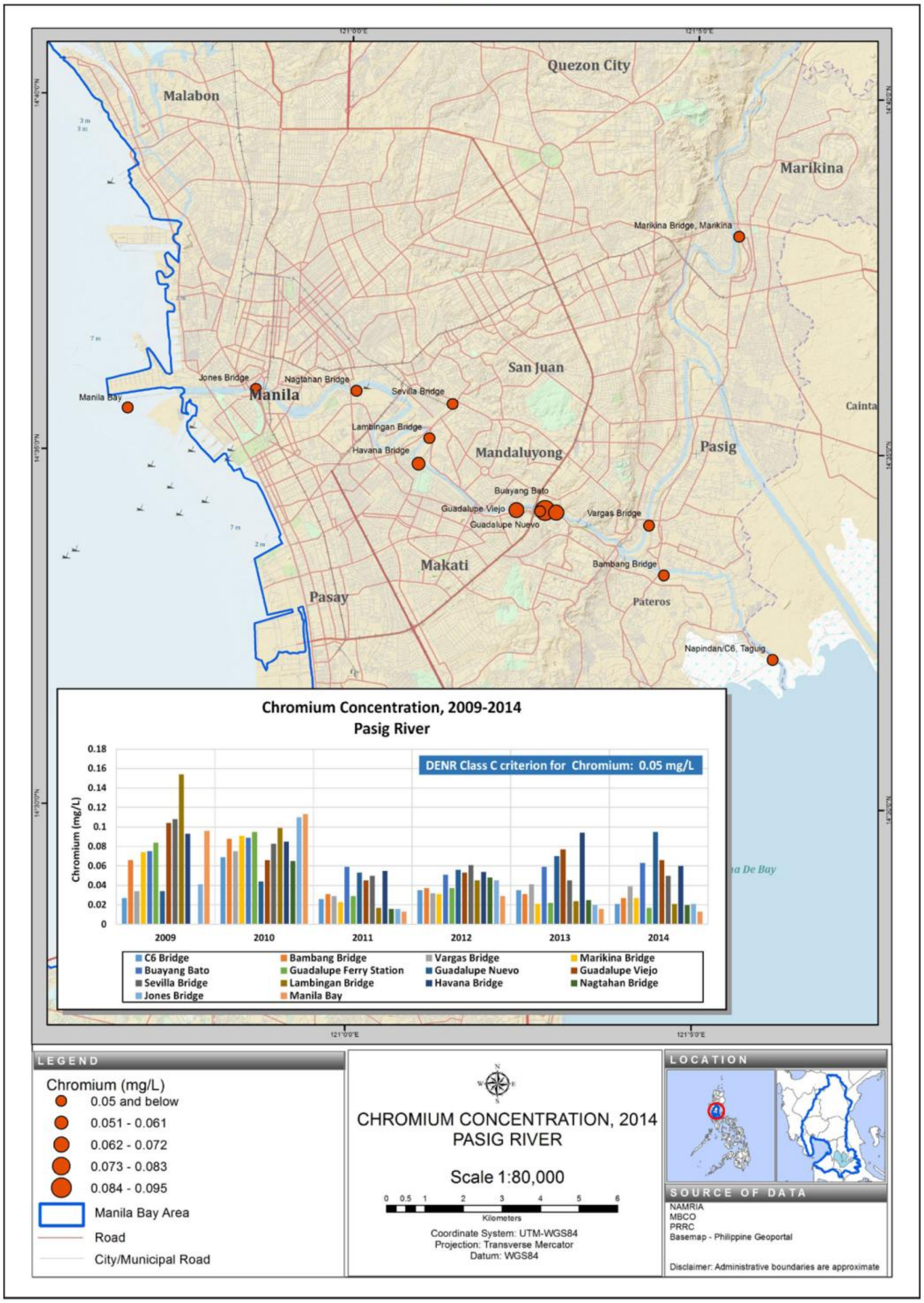
Map 64


Malabon
Quezon City
Marikina
Marikina Bridge, Marikina
San Juan
Cainta
Manila
Manila Bay
Jones Bridge
Nagtahan Bridge
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Mandaluyong
Pasig
Guadalupe Viejo
Guadalupe Ferry Station
Buayang Bato
Vargas Bridge
Bambang Bridge
Makati
Pasay
Pateros
Napindan/C6, Taguig
Taguig
, 2014
Phosphate Concentration, 2008-2014
Pasig River
DENR Class C criterion for Phosphate: 0.4 mg/L
Phosphate (mg/L)
50.00
40.00
30.00
20.00
10.00
0.00
2008
2009
2010
2011
2012
2013
2014
C6 Bridge
Bambang Bridge
Vargas Bridge
Marikina Bridge
Buayang Bato
Guadalupe Ferry Station
Guadalupe Nuevo
Guadalupe Viejo
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Nagtahan Bridge
Jones Bridge
Manila Bay
121°0'0"E
LEGEND
Phosphate Concentration (mg/L)
0.41 - 8.30
8.31 - 16.20
Manila Bay Area
Road
City/Municipal Road
PHOSPHATE CONCENTRATION, 2014
PASIG RIVER
Scale 1:80,000
0 0.75 1.5 3 4.5 6
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PRRC
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

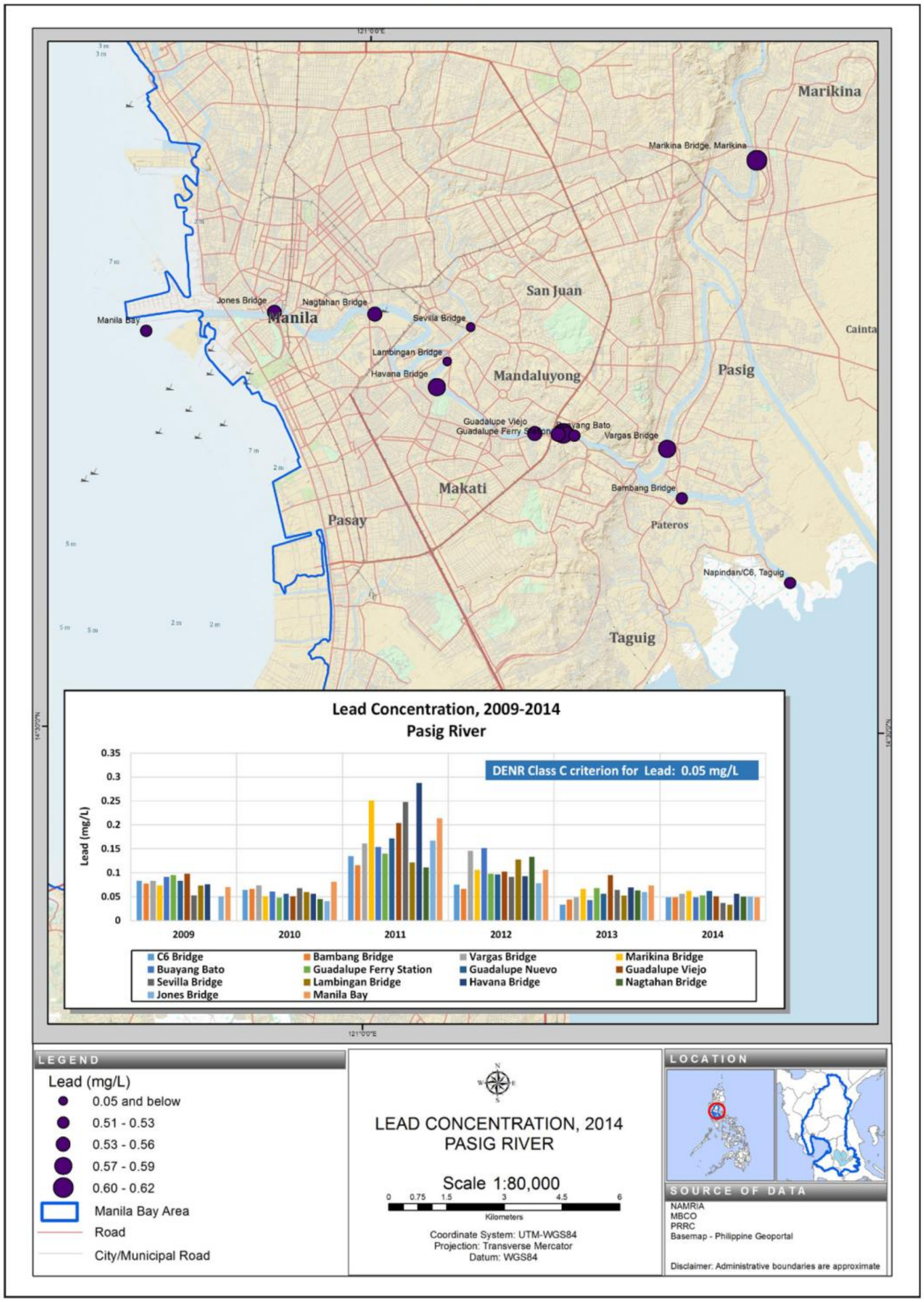
Map 65


Quezon City
Malabon
Marikina
Marikina Bridge, Marikina
San Juan
Cainta
Jones Bridge
Nagtahan Bridge
Manila
Manila Bay
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Mandaluyong
Pasig
Guadalupe Viejo
Buayang Bato
Vargas Bridge
Makati
Bambang Bridge
Pateros
Pasay
Napindan/C6, Taguig
Cadmium Concentration, 2009-2014
Pasig River
DENR Class C criterion for Cadmium: 0.01 mg/L
Cadmium (mg/L)
0.12
0.1
0.08
0.06
0.04
0.02
0
2009
2010
2011
2012
2013
2014
C6 Bridge
Bambang Bridge
Vargas Bridge
Marikina Bridge
Buayang Bato
Guadalupe Ferry Station
Guadalupe Nuevo
Guadalupe Viejo
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Nagtahan Bridge
Jones Bridge
Manila Bay
121°0'0"E
LEGEND
Cadmium (mg\L)
0.015 - 0.016
0.017 - 0.020
Manila Bay Area
Road
City/Municipal Road
CADMIUM CONCENTRATION, 2014
PASIG RIVER
Scale 1:80,000
0 0.75 1.5 3 4.5 6
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PRRC
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

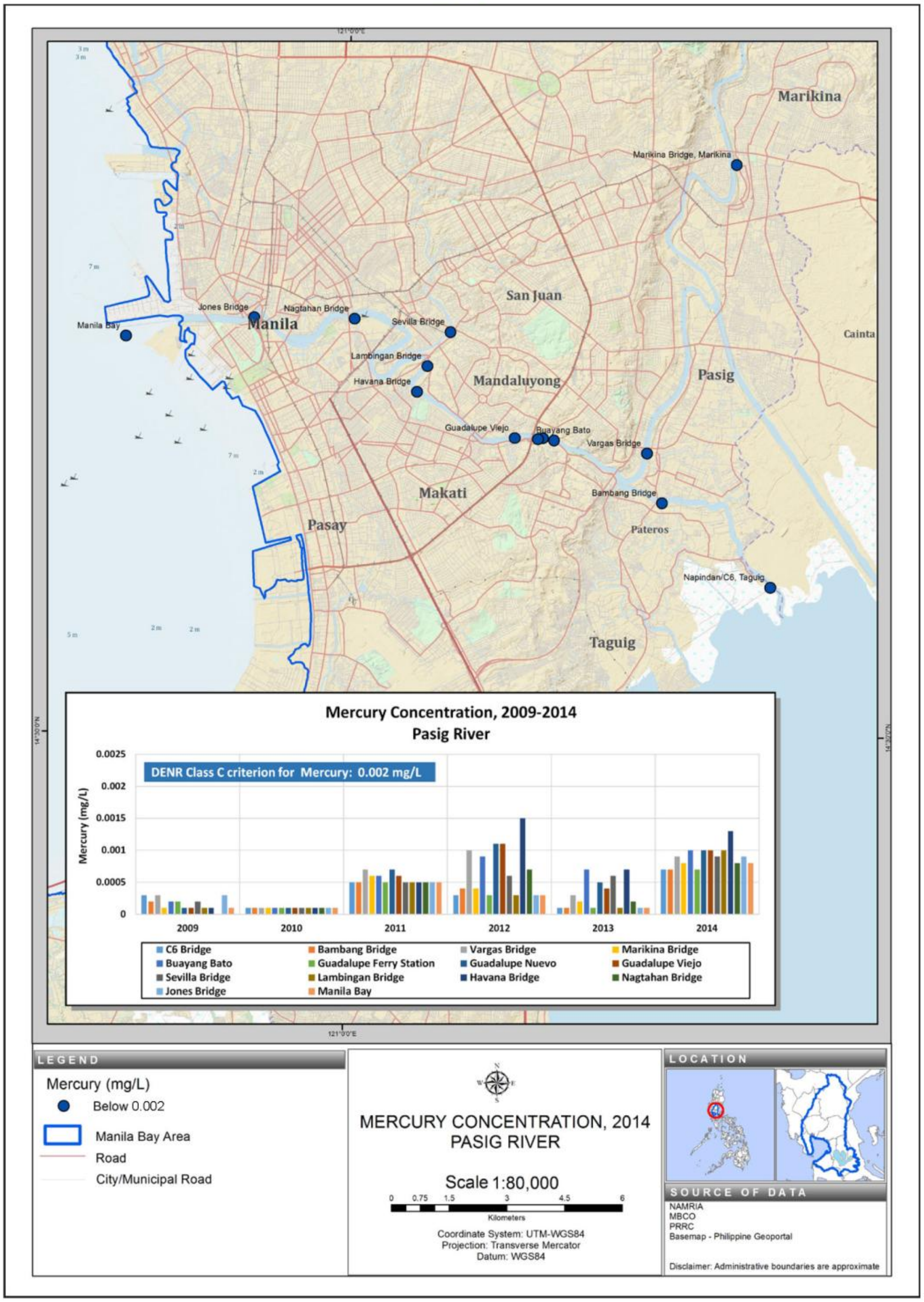
Map 66


Quezon City
Malabon
Marikina
Marikina Bridge, Marikina
San Juan
Jones Bridge
Nagtahan Bridge
Manila
Sevilla Bridge
Manila Bay
Cainta
Lambingan Bridge
Havana Bridge
Mandaluyong
Pasig
Buayang Bato
Guadalupe Viejo
Guadalupe Nuevo
Vargas Bridge
Makati
Bambang Bridge
Pasay
Pateros
Napindan/C6, Taguig
Chromium Concentration, 2009-2014
Pasig River
DENR Class C criterion for Chromium: 0.05 mg/L
Chromium (mg/L)
2009
2010
2011
2012
2013
2014
C6 Bridge
Bambang Bridge
Vargas Bridge
Marikina Bridge
Buayang Bato
Guadalupe Ferry Station
Guadalupe Nuevo
Guadalupe Viejo
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Nagtahan Bridge
Jones Bridge
Manila Bay
LEGEND
Chromium (mg/L)
0.05 and below
0.051 - 0.061
0.062 - 0.072
0.073 - 0.083
0.084 - 0.095
Manila Bay Area
Road
City/Municipal Road
CHROMIUM CONCENTRATION, 2014
PASIG RIVER
Scale 1:80,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PRRC
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

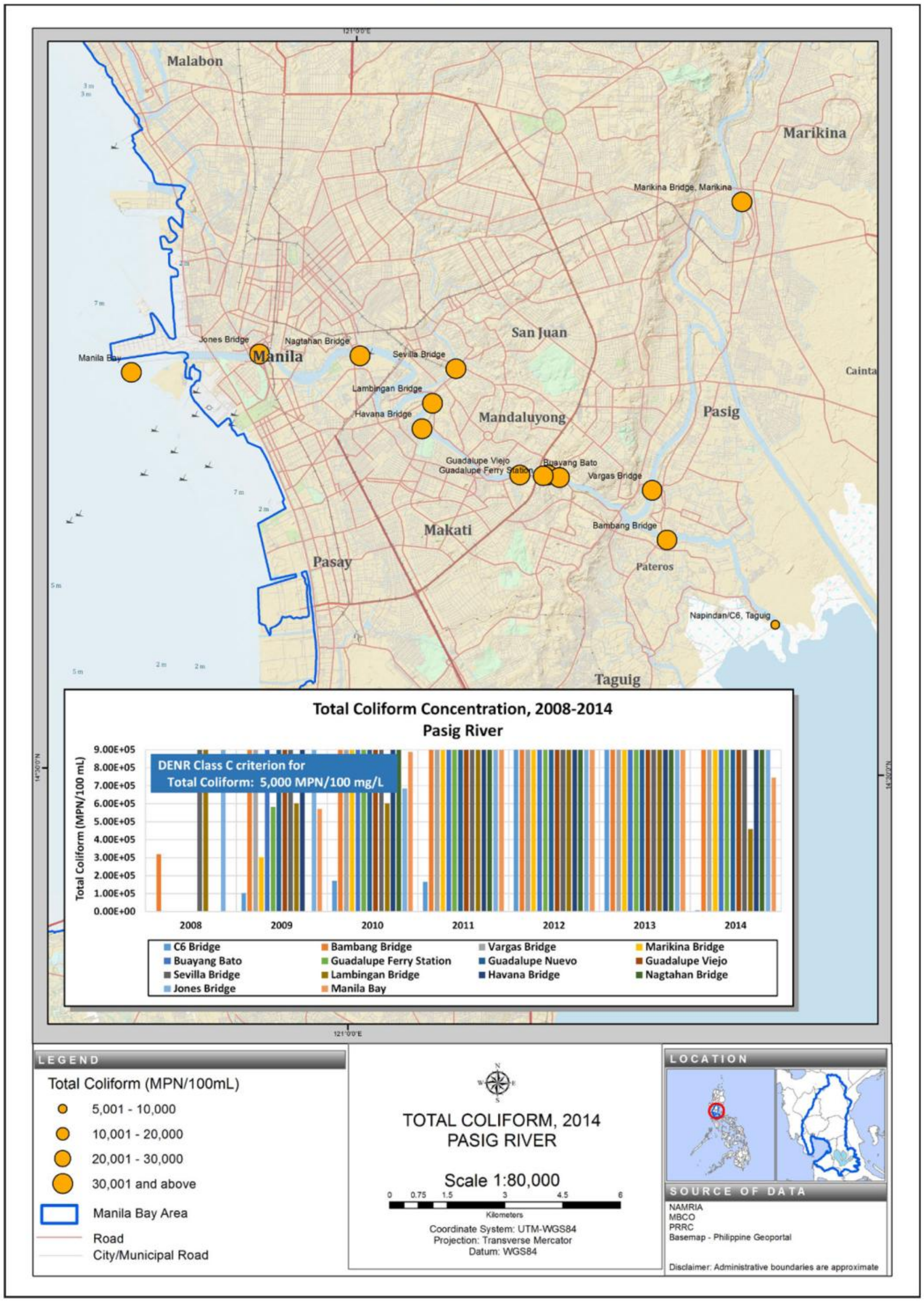
Map 67


Marikina
Marikina Bridge, Marikina
San Juan
Cainta
Jones Bridge
Nagtahan Bridge
Manila
Manila Bay
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Mandaluyong
Pasig
Guadalupe Viejo
Guadalupe Ferry Station
Buayang Bato
Vargas Bridge
Makati
Bambang Bridge
Pasay
Pateros
Napindan/C6, Taguig
Taguig
Lead Concentration, 2009-2014
Pasig River
DENR Class C criterion for Lead: 0.05 mg/L
Lead (mg/L)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2009
2010
2011
2012
2013
2014
C6 Bridge
Bambang Bridge
Vargas Bridge
Marikina Bridge
Buayang Bato
Guadalupe Ferry Station
Guadalupe Nuevo
Guadalupe Viejo
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Nagtahan Bridge
Jones Bridge
Manila Bay
121°0'0"E
LEGEND
Lead (mg/L)
0.05 and below
0.51 - 0.53
0.53 - 0.56
0.57 - 0.59
0.60 - 0.62
Manila Bay Area
Road
City/Municipal Road
LEAD CONCENTRATION, 2014
PASIG RIVER
Scale 1:80,000
0 0.75 1.5 3 4.5 6
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PRRC
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 68


Marikina
Marikina Bridge, Marikina
San Juan
Cainta
Jones Bridge
Nagtahan Bridge
Manila Bay
Manila
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Mandaluyong
Pasig
Guadalupe Viejo
Buayang Bato
Vargas Bridge
Makati
Bambang Bridge
Pasay
Pateros
Napindan/C6, Taguig
Taguig
Mercury Concentration, 2009-2014
Pasig River
DENR Class C criterion for Mercury: 0.002 mg/L
Mercury (mg/L)
0.0025
0.002
0.0015
0.001
0.0005
0
2009
2010
2011
2012
2013
2014
C6 Bridge
Bambang Bridge
Vargas Bridge
Marikina Bridge
Buayang Bato
Guadalupe Ferry Station
Guadalupe Nuevo
Guadalupe Viejo
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Nagtahan Bridge
Jones Bridge
Manila Bay
LEGEND
Mercury (mg/L)
Below 0.002
Manila Bay Area
Road
City/Municipal Road
MERCURY CONCENTRATION, 2014
PASIG RIVER
Scale 1:80,000
0 0.75 1.5 3 4.5 6
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PRRC
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 69


Malabon
Marikina
Marikina Bridge, Marikina
San Juan
Cainta
Jones Bridge
Nagtahan Bridge
Manila
Manila Bay
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Mandaluyong
Pasig
Guadalupe Viejo
Guadalupe Ferry Station
Buayang Bato
Vargas Bridge
Bambang Bridge
Makati
Pasay
Pateros
Napindan/C6, Taguig
Taguig
Total Coliform Concentration, 2008-2014
Pasig River
DENR Class C criterion for
Total Coliform: 5,000 MPN/100 mg/L
Total Coliform (MPN/100 mL)
9.00E+05
8.00E+05
7.00E+05
6.00E+05
5.00E+05
4.00E+05
3.00E+05
2.00E+05
1.00E+05
0.00E+00
2008
2009
2010
2011
2012
2013
2014
C6 Bridge
Bambang Bridge
Vargas Bridge
Marikina Bridge
Buayang Bato
Guadalupe Ferry Station
Guadalupe Nuevo
Guadalupe Viejo
Sevilla Bridge
Lambingan Bridge
Havana Bridge
Nagtahan Bridge
Jones Bridge
Manila Bay
121°0'0"E
LEGEND
Total Coliform (MPN/100mL)
5,001 - 10,000
10,001 - 20,000
20,001 - 30,000
30,001 and above
Manila Bay Area
Road
City/Municipal Road
TOTAL COLIFORM, 2014
PASIG RIVER
Scale 1:80,000
0 0.75 1.5 3 4.5 6
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PRRC
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

B.3 PAMPANGA RIVER BASIN

Sampling sites in the Manila Bay Area were identified with consideration primarily on the extent of agricultural areas and its likely influence to water quality within the area. Of the total 18 stations identified by BSWM, six sampling sites (SW 01 to SW 06) represent the Pampanga River Basin. The remaining nine sampling sites represent the Bataan Watershed (SW 07 and SW 08), Cavite Watershed (SW 11 to SW 15) and the Pasig River Basin (SW 09, SW 10, SW 16, SW 17 and SW 18).

Emphasis was placed in the monitoring of the Pampanga River Basin as it provides the largest freshwater influx going into Manila Bay.

PHYSICO-CHEMICAL PARAMETERS

Total Suspended Solids (TSS)

The DENR DAO No. 34 has set the criteria for TSS at 50 mg/L for Class A waters. The DA-AO No. 26 provided that the TSS for aquaculture production should be <1,000 mg/L, and <140 mg/L for crop productivity and protection of the environment. During the period 2011 to 2013, results of laboratory analysis for TSS ranged from 0 to 1.47 mg/L which are consistently far below the set limit. The baseline data in November 2011 appeared to be higher compared to the subsequent monitoring from 2012 to 2014 (Map 71).

Nitrate-Nitrogen (NO3-N) Concentrations

The NO3-N concentrations ranged from 0.15 to 13.40 ppm in the six sampling sites within the Pampanga River Basin (Map 72). Results from the laboratory analysis of NO3-N indicated low levels of concentration in four sites, i.e. below the criteria of 10 ppm for Class C (DENR DAO No. 34). No criterion was set for Class D. Two sites showed concentrations above the threshold of 10 ppm and these were noted in San Luis, Pampanga and Angat River, Bustos, Bulacan. The highest recorded NO3-N concentration was noted during the third quarter sampling in 2014 at San Luis, Pampanga. No sampling was done for the first and second quarters of 2014. Considering the baseline data in November 2011, the NO3-N concentrations have increased in all sites based on the monitoring results from 2012 to 2014.

Moreover, the DA AO No. 26 has set the limit of NO3-N at <0.067 for fresh water and < 0.40 for brackish water as harmful to aquatic resources. Thus, waters from all these six sites are not fit for freshwater fish culture considering the monitoring results from 2012 to 2014 (Map 72).

Total Phosphorus (TP) Concentrations

The TP concentrations ranged from 0 to 2.28 ppm within the Pampanga River Basin. The quarterly monitoring results showed that majority have TP concentrations less than 1 ppm. Thus far, only the Apalit, Pampanga site has relatively higher TP when compared to the five other sites. Notwithstanding, all sites have TP within the lower limit of 6 ppm for crop productivity and protection of the environment (DA AO No.26) based on all sampling events. Compared to the baseline in 2011, the monitoring results from 2012 to 2014 showed TP close to the baseline values except for Apalit, Pampanga and Angat River, Bustos, Bulacan (Map 73).

For Phosphate as Phosphorous (PO3), the DENR has set the criteria at 0.4 mg/L for Class C. On the other hand, the DA AO No. 26 has set the limit of Phosphate as Phosphorus at < 0.067 mg/L for freshwater and 0.2 to 0.4 mg/L for brackish aquaculture.

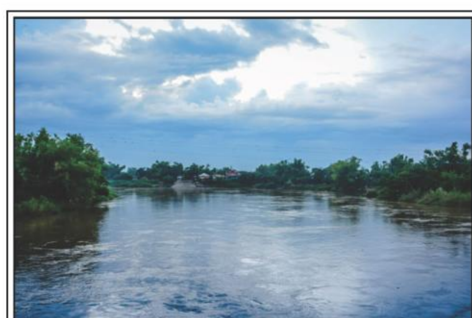
Heavy Metal Concentrations

Heavy metals, particularly lead (Pb), chromium (Cr), cadmium (Cd), arsenic (As) and mercury (Hg) were monitored from 2012 to 2014, to the extent possible. Water samples taken from six sampling sites in the Pampanga River Basin passed the criteria set for Class SB by the DENR DAO No. 34 at 0.05 mg/L for lead, 0.10 mg/L for chromium and 0.01 mg/L for cadmium. In the case of arsenic, water samples taken in five sites within Pampanga River Basin during the two quarters of 2014 exceeded the 0.05 mg/L criteria for Class SB. However, arsenic concentration recorded at 0.08 mg/L in Jaen, Nueva Ecija is still within the acceptable limit set for Class D water (Map 74).

BACTERIOLOGICAL PARAMETERS

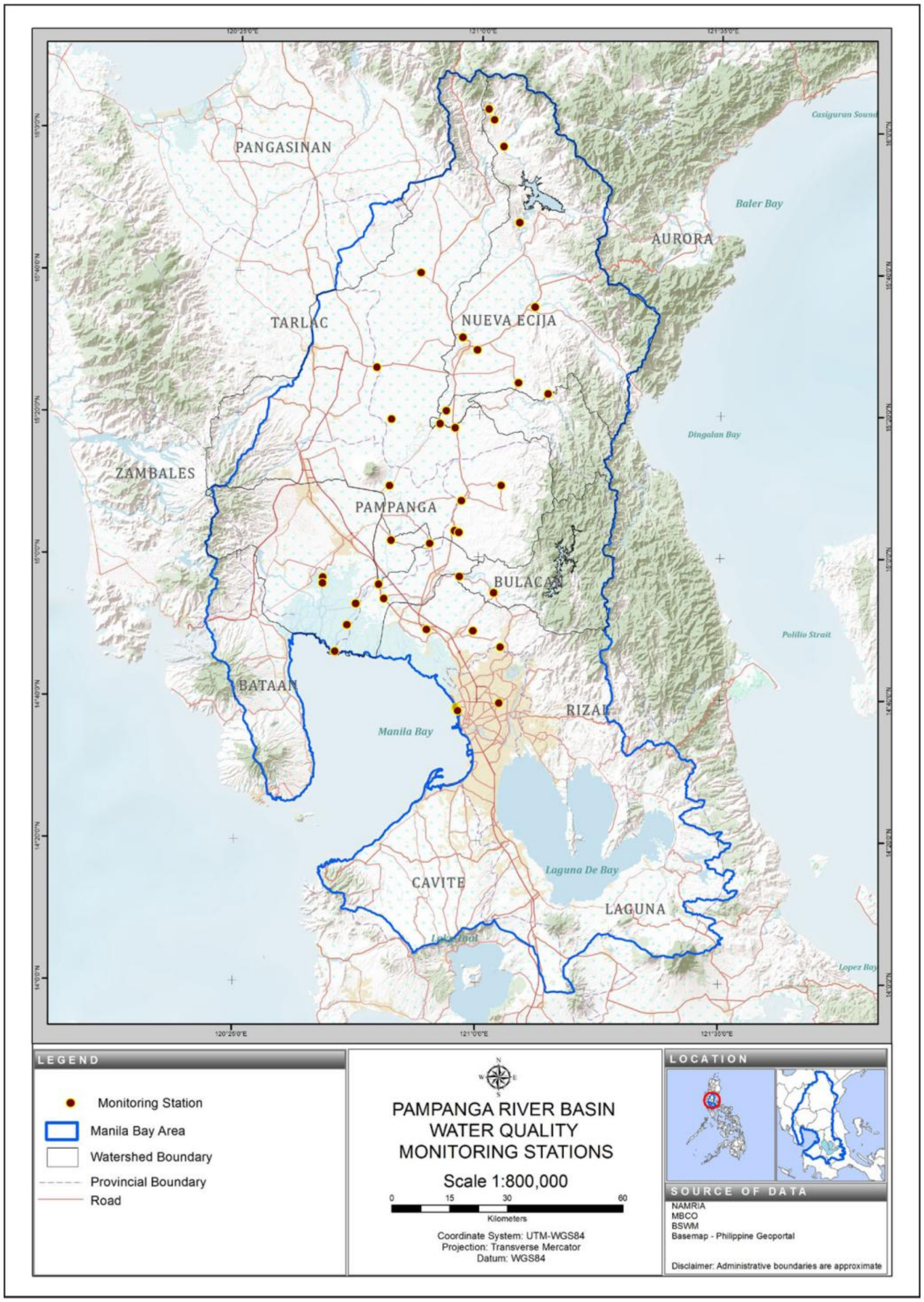
The quarterly data showed increased total coliform count in all the six sites relative to the baseline data in November 2011. All six sites failed to meet the DENR criteria set for total coliform at 1,000 MPN for Class B and 5,000 MPN for Class C considering values of 16,000 MPN/100 ml using the 5-tube table. High level of fecal coliform at certain periods was noted in all six sites with values exceeding the 200 MPN/100 ml criteria set by DENR for Class B. The DA AO No. 26 has also set fecal coliform count of < 200 MPN/100 ml as the limit for the protection of animals and human health (Map 79).

Bacolor, Pampanga

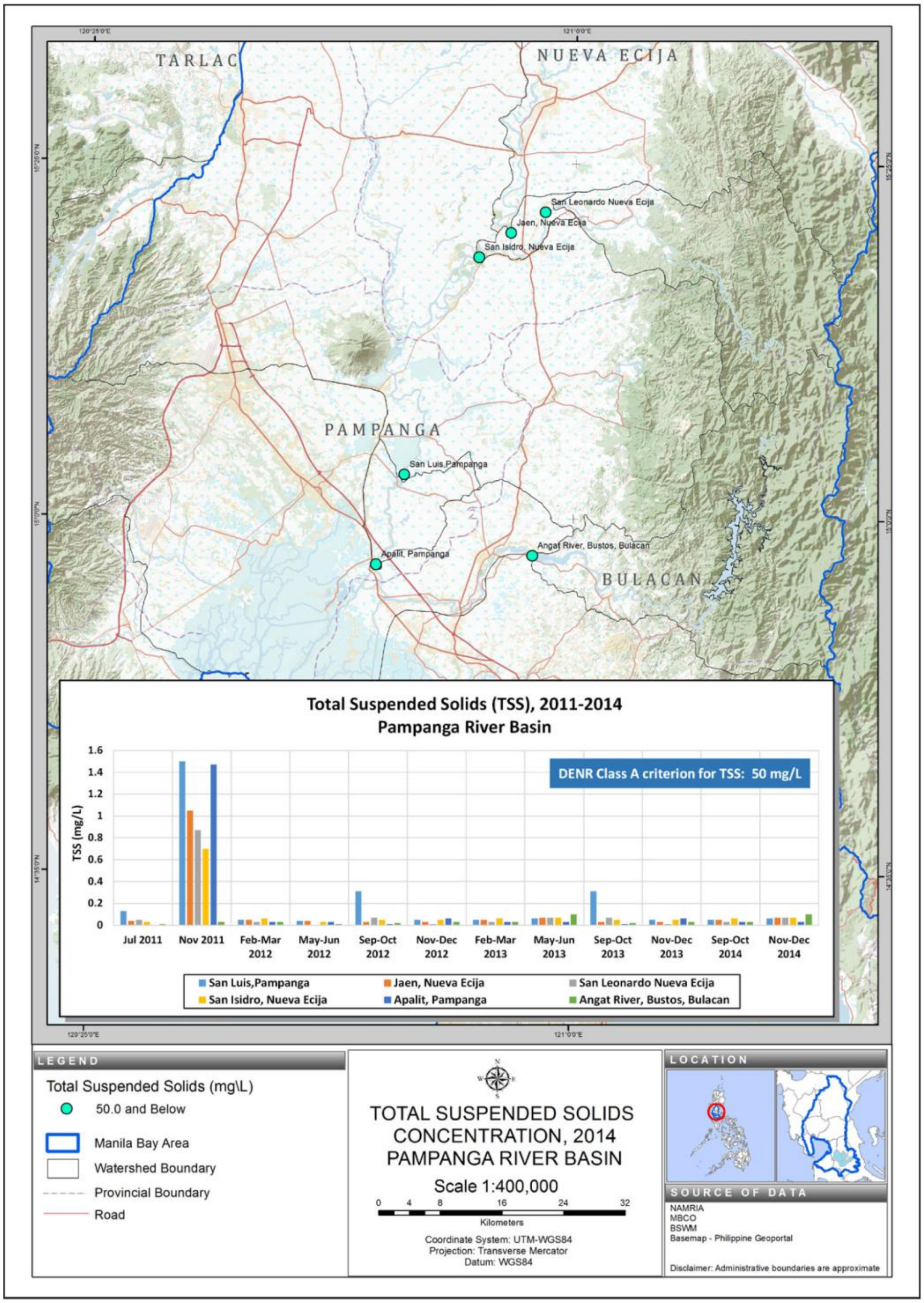


San Luis River, Pampanga

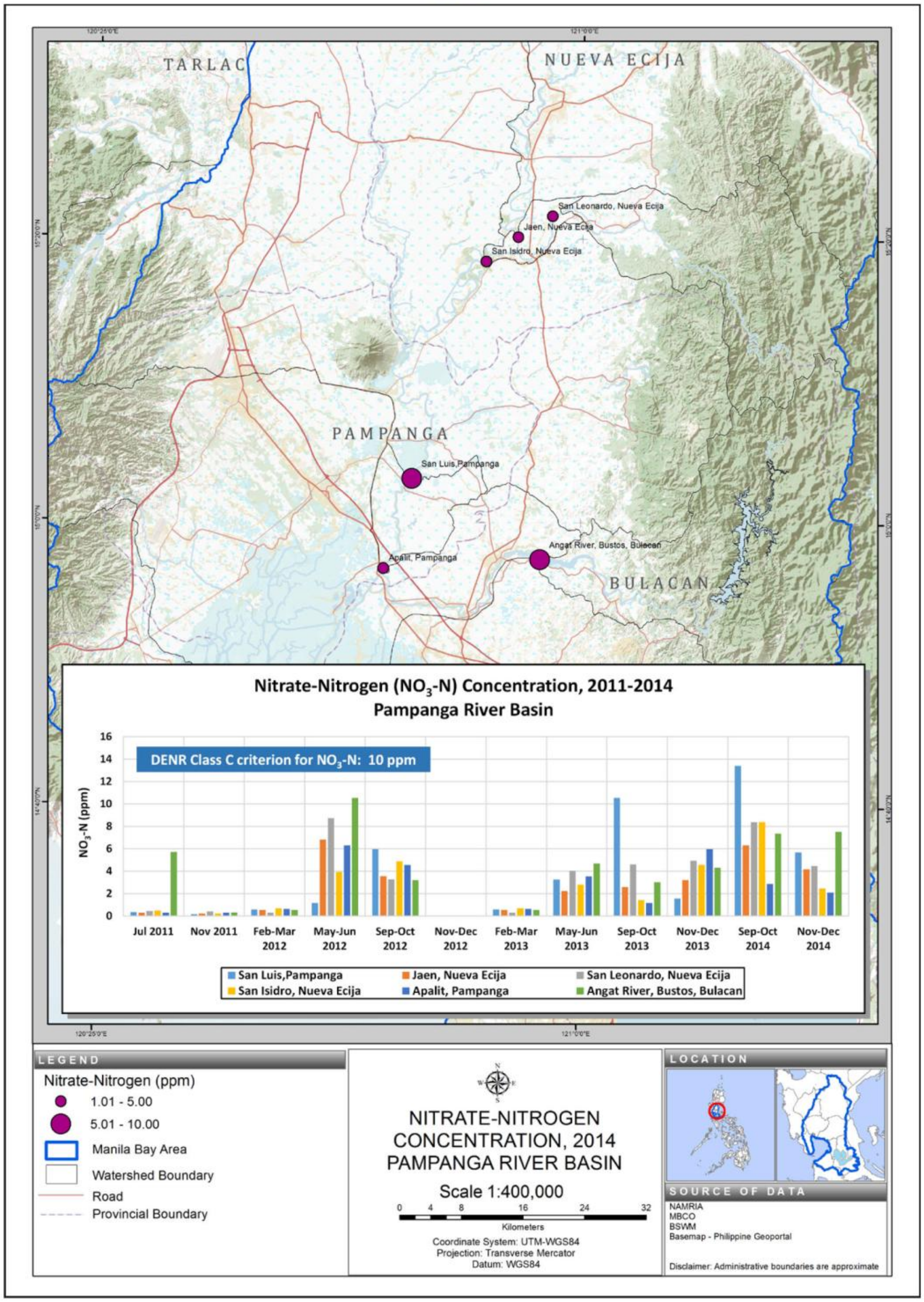
Map 70


PANGASINAN
TARLAC
NUEVA ECIJA
AURORA
ZAMBALES
PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Baler Bay
Dingalan Bay
Polillo Strait
Laguna De Bay
Casiguran Sound
Lopez Bay
LEGEND
Monitoring Station
Manila Bay Area
Watershed Boundary
Provincial Boundary
Road
PAMPANGA RIVER BASIN
WATER QUALITY
MONITORING STATIONS
Scale 1:800,000
0 15 30 60
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

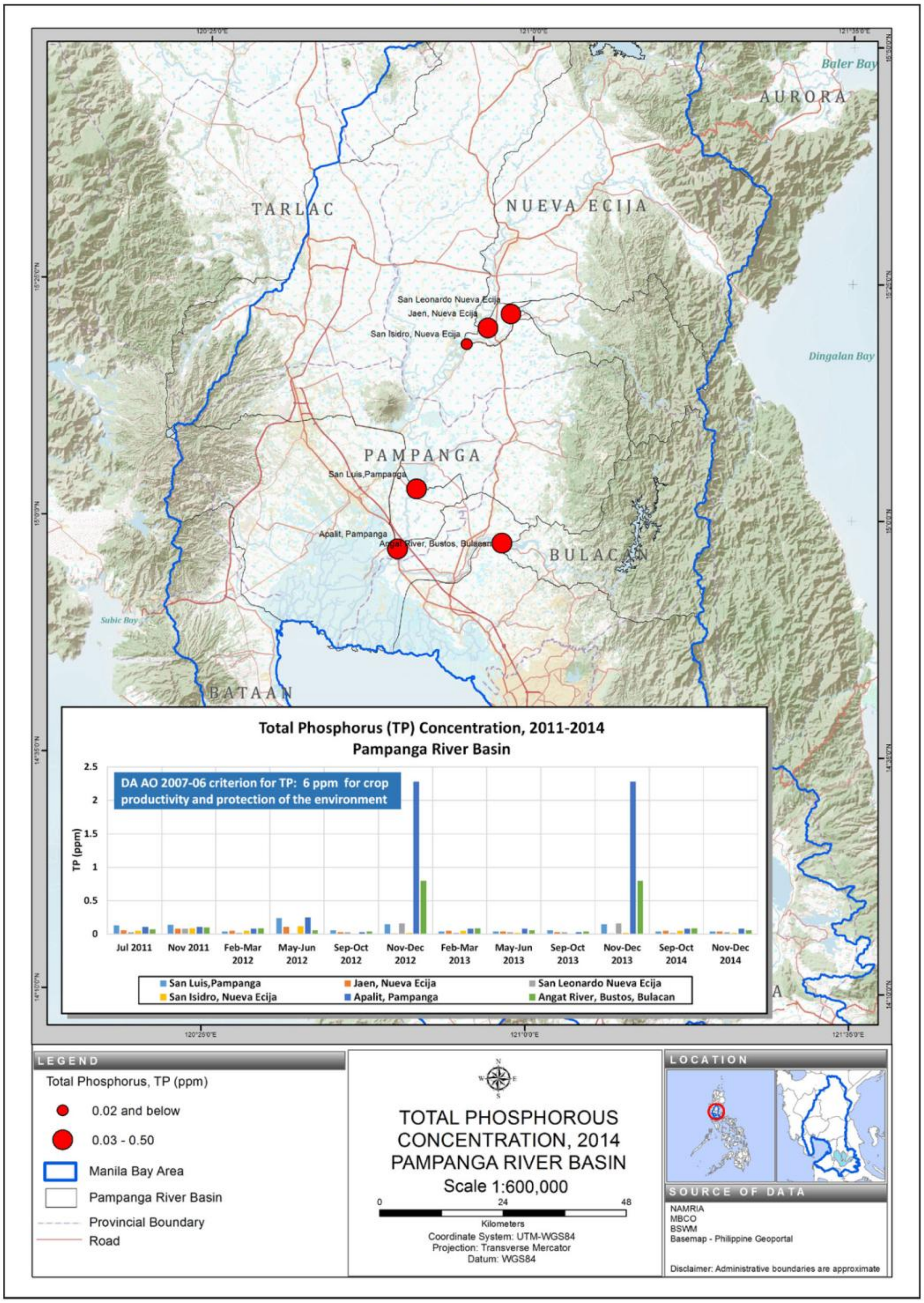
Map 71


TARLAC
NUEVA ECIJA
PAMPANGA
BULACAN
San Leonardo Nueva Ecija
Jaen, Nueva Ecija
San Isidro, Nueva Ecija
San Luis Pampanga
Apalit, Pampanga
Angat River, Bustos, Bulacan
Total Suspended Solids (TSS), 2011-2014
Pampanga River Basin
DENR Class A criterion for TSS: 50 mg/L
TSS (mg/L)
Jul 2011
Nov 2011
Feb-Mar 2012
May-Jun 2012
Sep-Oct 2012
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2013
Nov-Dec 2013
Sep-Oct 2014
Nov-Dec 2014
San Luis,Pampanga
Jaen, Nueva Ecija
San Leonardo Nueva Ecija
San Isidro, Nueva Ecija
Apalit, Pampanga
Angat River, Bustos, Bulacan
LEGEND
Total Suspended Solids (mg\L)
50.0 and Below
Manila Bay Area
Watershed Boundary
Provincial Boundary
Road
TOTAL SUSPENDED SOLIDS
CONCENTRATION, 2014
PAMPANGA RIVER BASIN
Scale 1:400,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

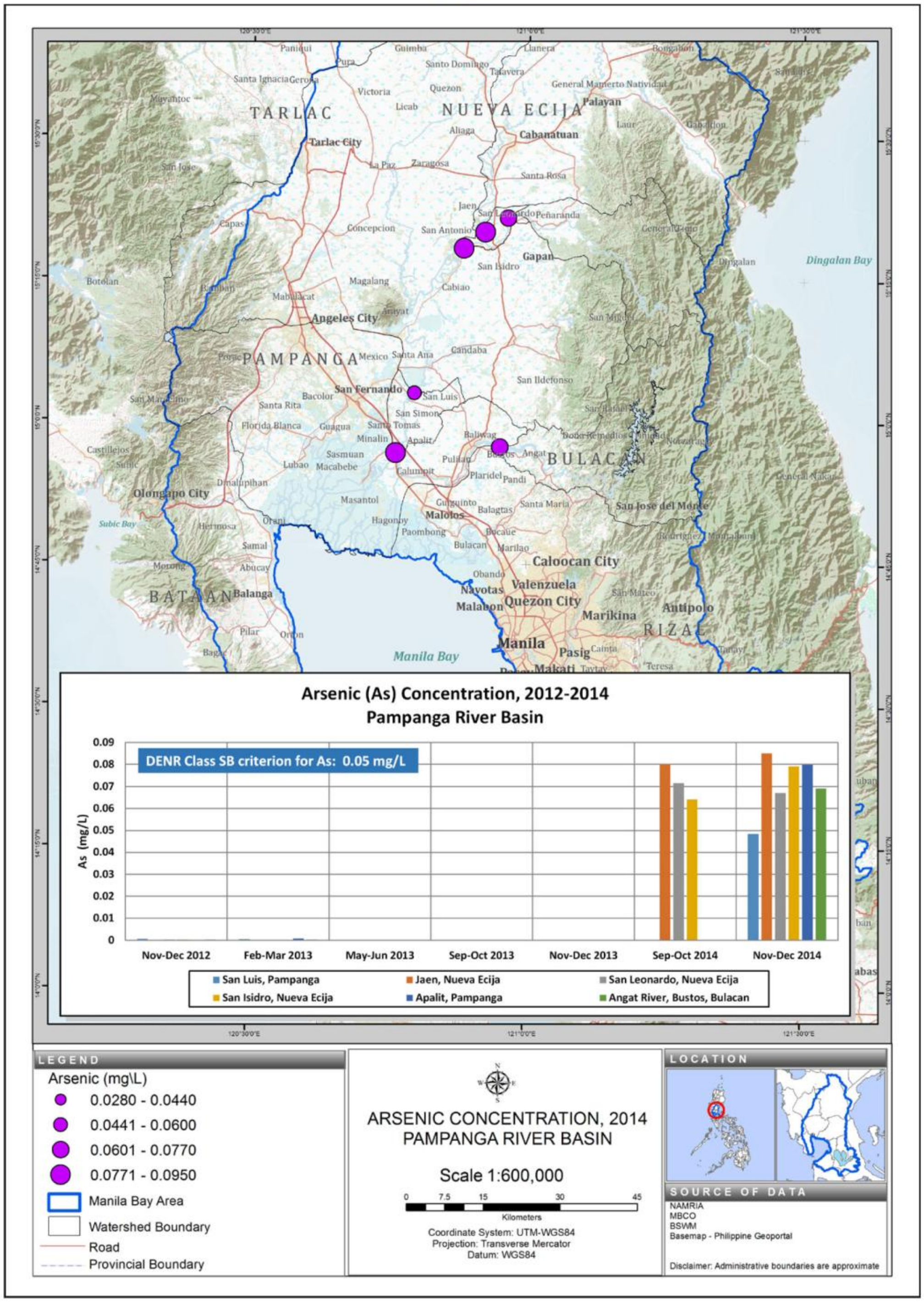
Map 72


TARLAC
NUEVA ECIJA
PAMPANGA
BULACAN
San Leonardo, Nueva Ecija
Jaen, Nueva Ecija
San Isidro, Nueva Ecija
San Luis,Pampanga
Angat River, Bustos, Bulacan
Apalit, Pampanga
Nitrate-Nitrogen (NO3-N) Concentration, 2011-2014
Pampanga River Basin
DENR Class C criterion for NO3-N: 10 ppm
NO3-N (ppm)
0
2
4
6
8
10
12
14
16
Jul 2011
Nov 2011
Feb-Mar 2012
May-Jun 2012
Sep-Oct 2012
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2013
Nov-Dec 2013
Sep-Oct 2014
Nov-Dec 2014
San Luis,Pampanga
Jaen, Nueva Ecija
San Leonardo, Nueva Ecija
San Isidro, Nueva Ecija
Apalit, Pampanga
Angat River, Bustos, Bulacan
LEGEND
Nitrate-Nitrogen (ppm)
1.01 - 5.00
5.01 - 10.00
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
NITRATE-NITROGEN
CONCENTRATION, 2014
PAMPANGA RIVER BASIN
Scale 1:400,000
0 4 8 16 24 32
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

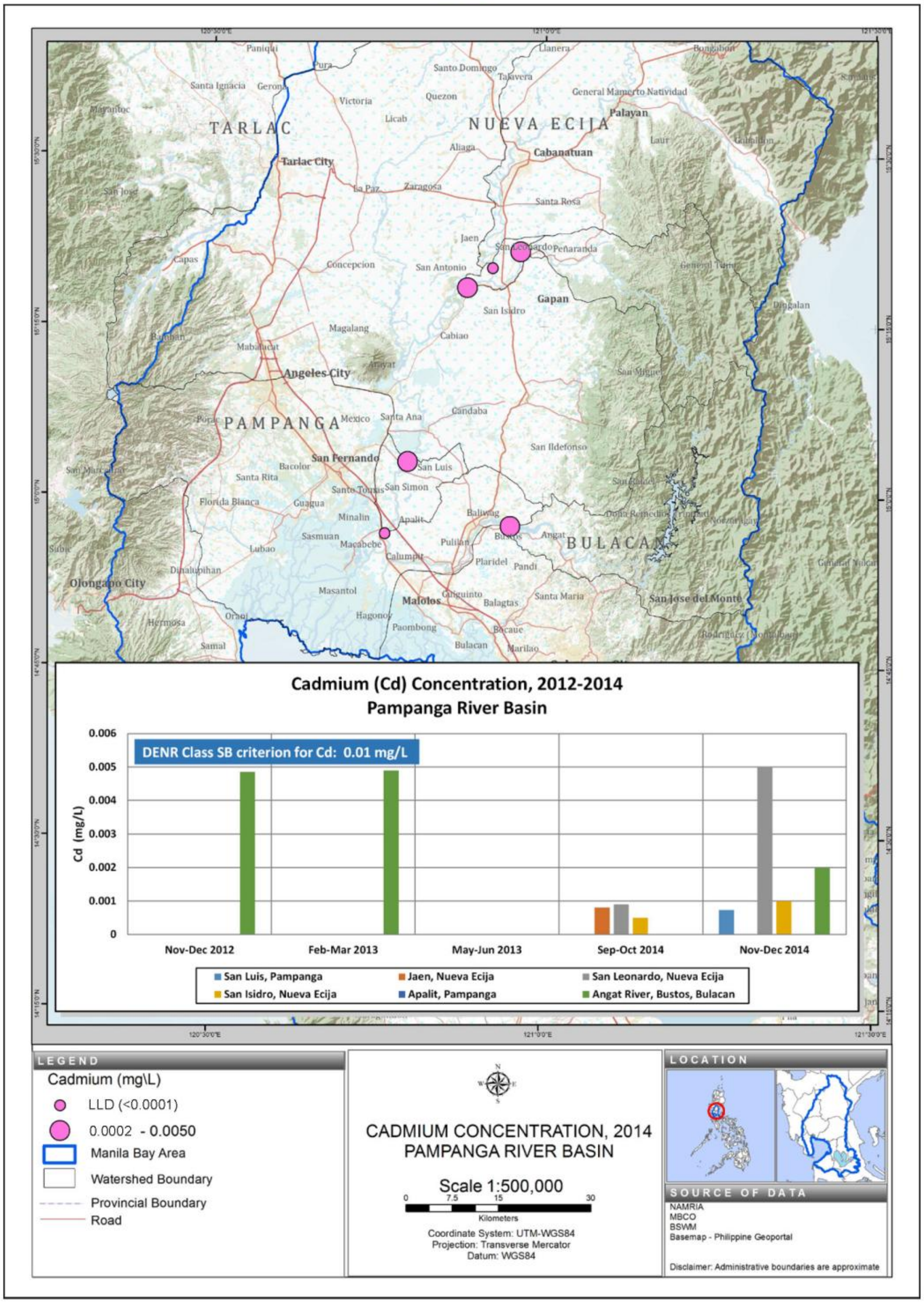
Map 73


Baler Bay
AURORA
TARLAC
NUEVA ECIJA
Dingalan Bay
San Leonardo Nueva Ecija
Jaen, Nueva Ecija
San Isidro, Nueva Ecija
PAMPANGA
San Luis,Pampanga
Apalit, Pampanga
Angat River, Bustos, Bulacan
BULACAN
Sabic Bay
BATAAN
Total Phosphorus (TP) Concentration, 2011-2014
Pampanga River Basin
DA AO 2007-06 criterion for TP: 6 ppm for crop productivity and protection of the environment
TP (ppm)
2.5
2
1.5
1
0.5
0
Jul 2011
Nov 2011
Feb-Mar 2012
May-Jun 2012
Sep-Oct 2012
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2013
Nov-Dec 2013
Sep-Oct 2014
Nov-Dec 2014
San Luis,Pampanga
Jaen, Nueva Ecija
San Leonardo Nueva Ecija
San Isidro, Nueva Ecija
Apalit, Pampanga
Angat River, Bustos, Bulacan
LEGEND
Total Phosphorus, TP (ppm)
0.02 and below
0.03 - 0.50
Manila Bay Area
Pampanga River Basin
Provincial Boundary
Road
TOTAL PHOSPHOROUS CONCENTRATION, 2014
PAMPANGA RIVER BASIN
Scale 1:600,000
0
24
48
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

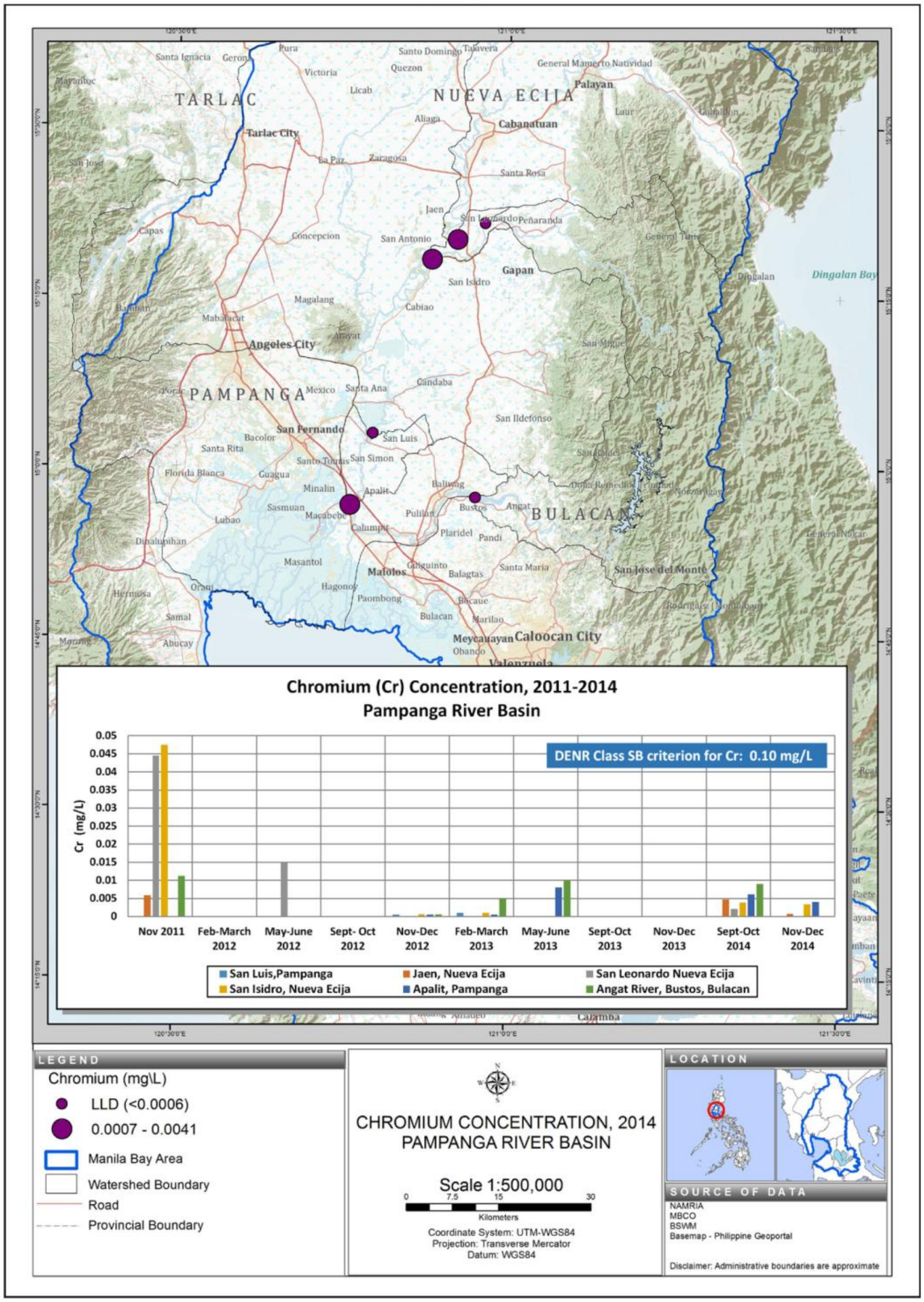
Map 74


TARLAC
NUEVA ECIJA
PAMPANGA
BULACAN
BATAAN
RIZAL
Tarlac City
Cabanatuan
Palayan
Gapan
San Isidro
San Antonio
Jaen
Peñaranda
Angeles City
San Fernando
San Luis
Apalit
Bustos
Malolos
Olongapo City
Caloocan City
Valenzuela
Quezon City
Navotas
Malabon
Marikina
Manila
Pasig
Makati
Antipolo
Manila Bay
Dingalan Bay
Subic Bay
Arsenic (As) Concentration, 2012-2014
Pampanga River Basin
DENR Class SB criterion for As: 0.05 mg/L
As (mg/L)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2013
Nov-Dec 2013
Sep-Oct 2014
Nov-Dec 2014
San Luis, Pampanga
Jaen, Nueva Ecija
San Leonardo, Nueva Ecija
San Isidro, Nueva Ecija
Apalit, Pampanga
Angat River, Bustos, Bulacan
LEGEND
Arsenic (mg\L)
0.0280 - 0.0440
0.0441 - 0.0600
0.0601 - 0.0770
0.0771 - 0.0950
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
ARSENIC CONCENTRATION, 2014
PAMPANGA RIVER BASIN
Scale 1:600,000
0 7.5 15 30 45
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

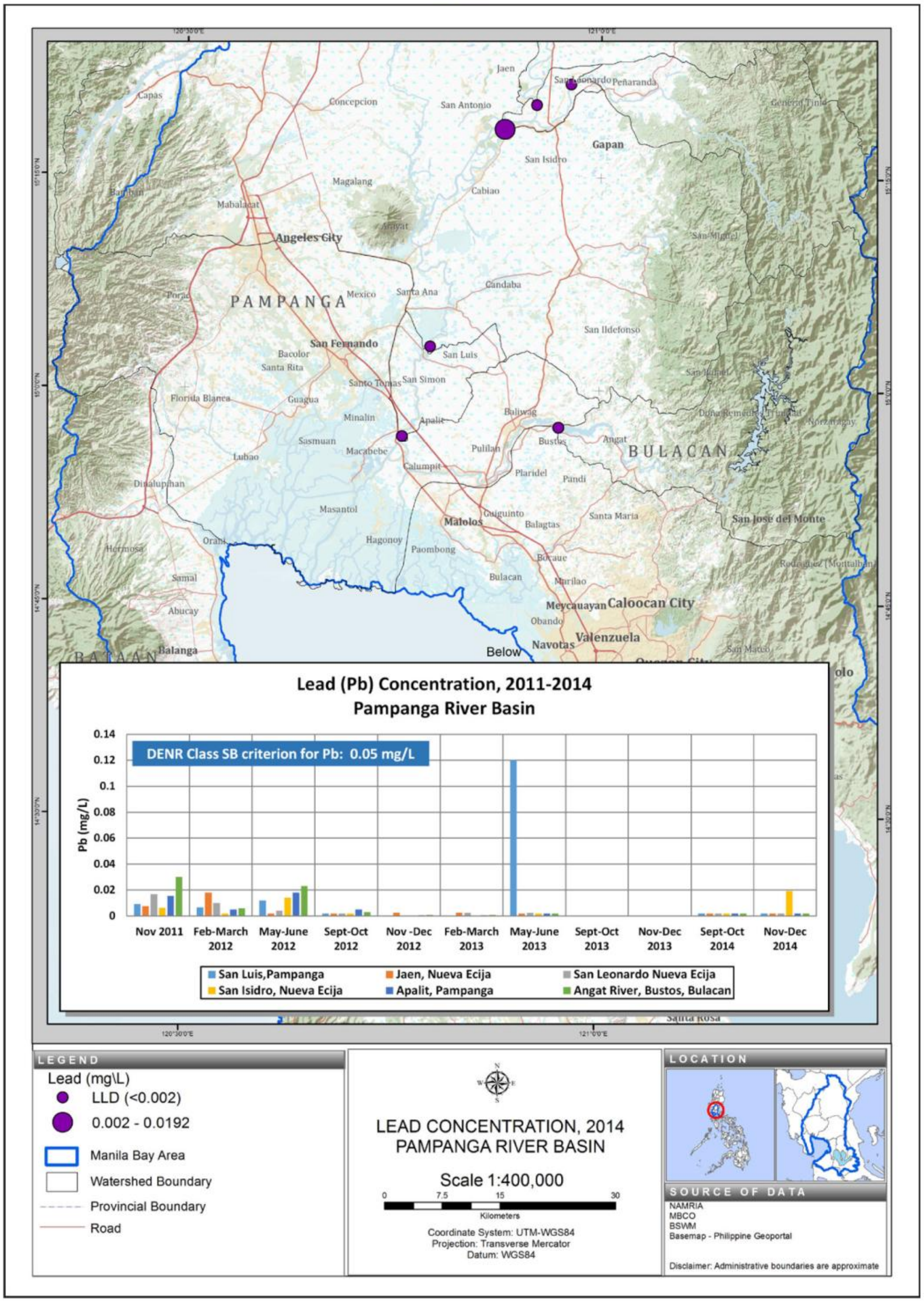
Map 75


Cadmium (Cd) Concentration, 2012-2014
Pampanga River Basin
DENR Class SB criterion for Cd: 0.01 mg/L
Cd (mg/L)
0.006
0.005
0.004
0.003
0.002
0.001
0
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2014
Nov-Dec 2014
San Luis, Pampanga
Jaen, Nueva Ecija
San Leonardo, Nueva Ecija
San Isidro, Nueva Ecija
Apalit, Pampanga
Angat River, Bustos, Bulacan
TARLAC
NUEVA ECIJA
PAMPANGA
BULACAN
Tarlac City
Cabanatuan
Palayan
Gapan
Angeles City
San Fernando
Malolos
Olongapo City
San Jose del Monte
LEGEND
Cadmium (mg\L)
LLD (<0.0001)
0.0002 - 0.0050
Manila Bay Area
Watershed Boundary
Provincial Boundary
Road
CADMIUM CONCENTRATION, 2014
PAMPANGA RIVER BASIN
Scale 1:500,000
0 7.5 15 30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

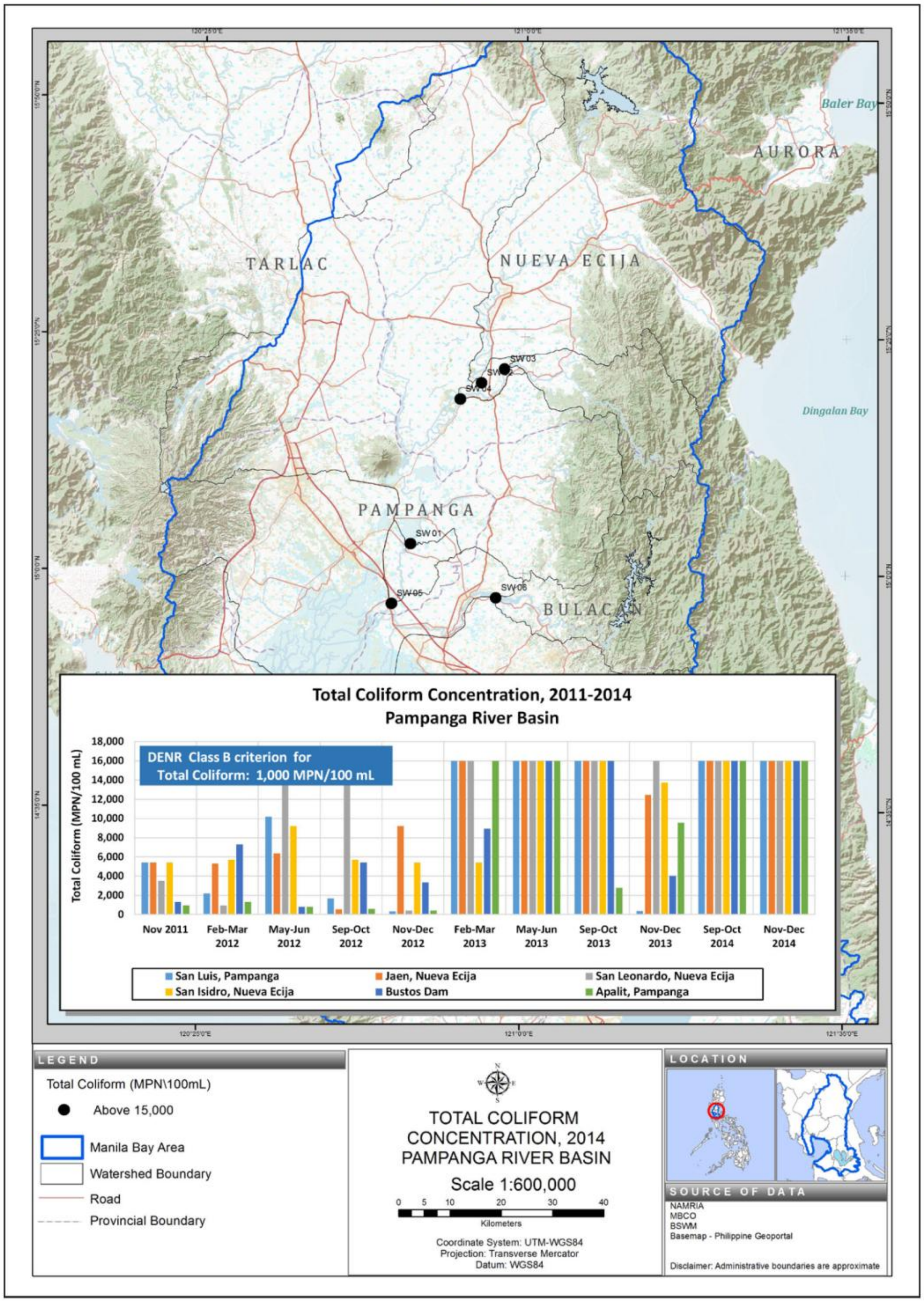
Map 76


TARLAC
NUEVA ECIJA
PAMPANGA
BULACAN
Tarlac City
Cabanatuan
Palayan
Santa Rosa
Jaen
San Leonardo
Peñaranda
San Antonio
San Isidro
Gapan
Cabiao
Concepcion
Magalang
Angeles City
Mabalacat
Arayat
Candaba
Mexico
Santa Ana
San Fernando
San Luis
Bacolor
Santa Rita
Santo Tomas
San Simon
Florida Blanca
Guagua
Minalin
Apalit
Sasmuan
Macabebe
Lubao
Calumpit
Baliwag
Pulilan
Bustos
Angat
Plaridel
Pandi
San Ildefonso
Dinalupihan
Masantol
Hagonoy
Malolos
Paombong
Guiguinto
Balagtas
Santa Maria
San Jose del Monte
Bulacan
Marilao
Meycauayan
Caloocan City
Obando
Valenzuela
Hermosa
Orani
Samal
Abucay
Dingalan
Dingalan Bay
Calamba
Chromium (Cr) Concentration, 2011-2014
Pampanga River Basin
Cr (mg/L)
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
DENR Class SB criterion for Cr: 0.10 mg/L
Nov 2011
Feb-March 2012
May-June 2012
Sept- Oct 2012
Nov-Dec 2012
Feb-March 2013
May-June 2013
Sept-Oct 2013
Nov-Dec 2013
Sept-Oct 2014
Nov-Dec 2014
San Luis,Pampanga
Jaen, Nueva Ecija
San Leonardo Nueva Ecija
San Isidro, Nueva Ecija
Apalit, Pampanga
Angat River, Bustos, Bulacan
LEGEND
Chromium (mg\L)
LLD (<0.0006)
0.0007 - 0.0041
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
CHROMIUM CONCENTRATION, 2014
PAMPANGA RIVER BASIN
Scale 1:500,000
0 7.5 15 30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

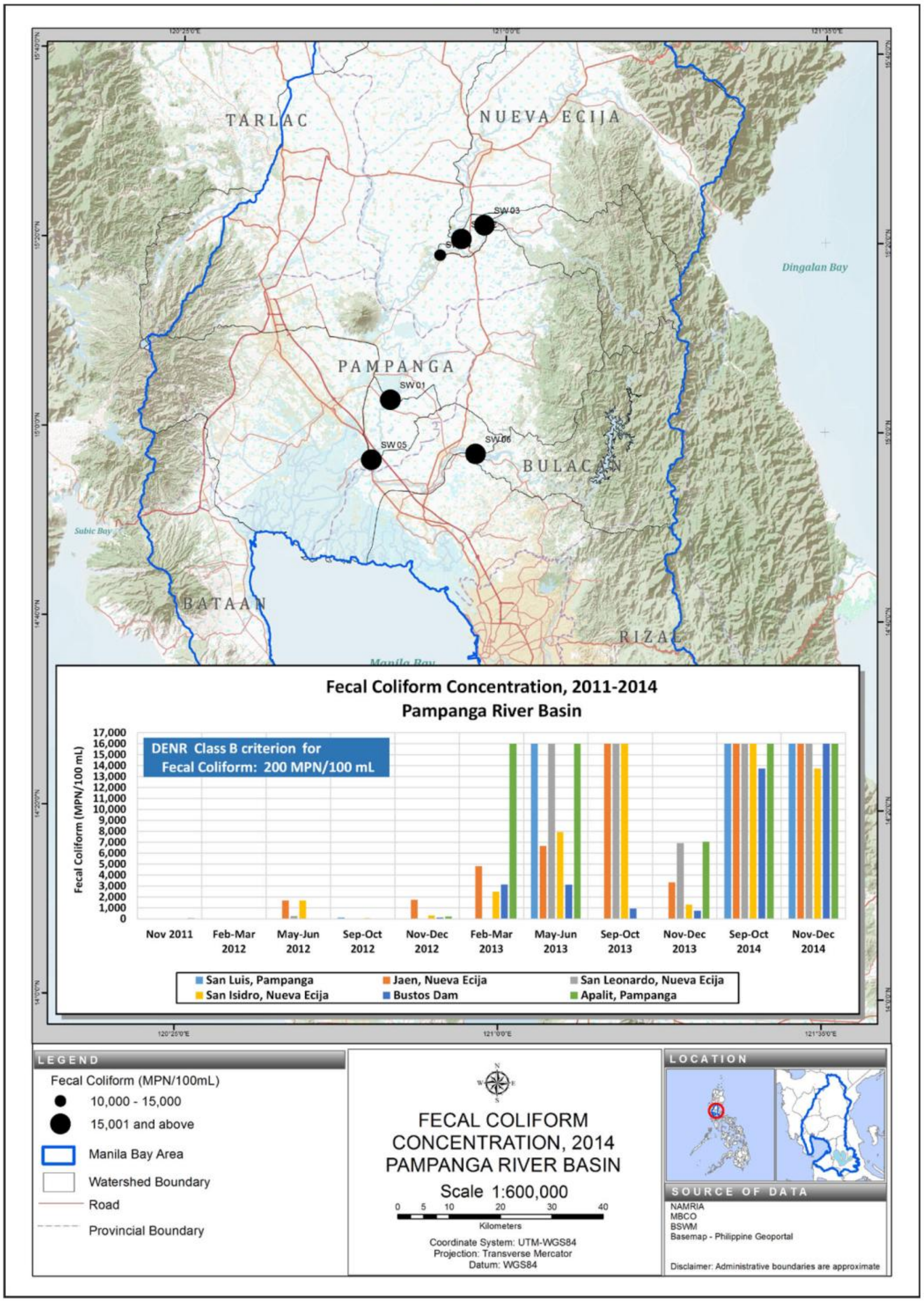
Map 77


Lead (Pb) Concentration, 2011-2014
Pampanga River Basin
DENR Class SB criterion for Pb: 0.05 mg/L
Pb (mg/L)
Nov 2011
Feb-March 2012
May-June 2012
Sept-Oct 2012
Nov -Dec 2012
Feb-March 2013
May-June 2013
Sept-Oct 2013
Nov-Dec 2013
Sept-Oct 2014
Nov-Dec 2014
San Luis,Pampanga
Jaen, Nueva Ecija
San Leonardo Nueva Ecija
San Isidro, Nueva Ecija
Apalit, Pampanga
Angat River, Bustos, Bulacan
PAMPANGA
BULACAN
Angeles City
San Fernando
Malolos
Caloocan City
Valenzuela
Gapan
LEGEND
Lead (mg\L)
LLD (<0.002)
0.002 - 0.0192
Manila Bay Area
Watershed Boundary
Provincial Boundary
Road
LEAD CONCENTRATION, 2014
PAMPANGA RIVER BASIN
Scale 1:400,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 78


Baler Bay
AURORA
TARLAC
NUEVA ECIJA
Dingalan Bay
PAMPANGA
BULACAN
SW 01
SW 03
SW 04
SW 05
SW 06
Total Coliform Concentration, 2011-2014
Pampanga River Basin
Total Coliform (MPN/100 mL)
DENR Class B criterion for
Total Coliform: 1,000 MPN/100 mL
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Nov 2011
Feb-Mar 2012
May-Jun 2012
Sep-Oct 2012
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2013
Nov-Dec 2013
Sep-Oct 2014
Nov-Dec 2014
San Luis, Pampanga
Jaen, Nueva Ecija
San Leonardo, Nueva Ecija
San Isidro, Nueva Ecija
Bustos Dam
Apalit, Pampanga
LEGEND
Total Coliform (MPN\100mL)
Above 15,000
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
TOTAL COLIFORM
CONCENTRATION, 2014
PAMPANGA RIVER BASIN
Scale 1:600,000
0 5 10 20 30 40
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 79


TARLAC
NUEVA ECIJA
PAMPANGA
BULACAN
BATAAN
RIZAL
Dingalan Bay
Subic Bay
Manila Bay
SW 01
SW 03
SW 05
SW 06
Fecal Coliform Concentration, 2011-2014
Pampanga River Basin
DENR Class B criterion for
Fecal Coliform: 200 MPN/100 mL
Fecal Coliform (MPN/100 mL)
17,000
16,000
15,000
14,000
13,000
12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Nov 2011
Feb-Mar 2012
May-Jun 2012
Sep-Oct 2012
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2013
Nov-Dec 2013
Sep-Oct 2014
Nov-Dec 2014
San Luis, Pampanga
Jaen, Nueva Ecija
San Leonardo, Nueva Ecija
San Isidro, Nueva Ecija
Bustos Dam
Apalit, Pampanga
LEGEND
Fecal Coliform (MPN/100mL)
10,000 - 15,000
15,001 and above
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
FECAL COLIFORM
CONCENTRATION, 2014
PAMPANGA RIVER BASIN
Scale 1:600,000
0 5 10 20 30 40
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

B.4 OTHER RIVER BASINS

TOTAL SUSPENDED SOLIDS (TSS)

Total suspended solids ranged only from 0 to 0.2 mg/L from water samples taken at Bataan, Cavite and Pasig River Basin (Map 80). These values were low relative to Pampanga River Basin, all of which are consistently below the threshold values as cited earlier.

NITRATE-NITROGEN (NO3-N) CONCENTRATIONS

The NO3-N concentrations ranged from 0.21 to 19.89 ppm in the 12 sampling sites within the Bataan, Cavite and Pasig River Basin (Map 81). In all sites, NO3-N concentrations have increased over time compared to the baseline values in 2011. NO3-N concentrations above the threshold of 10 ppm were noted in Bataan, Laguna and Rizal and these are considered harmful to aquatic resources. The high levels were exceptionally high in 2014 relative to the two years prior.

Furthermore, considering the DA AO 26 that set the limit of NO3-N at <0.067 for fresh water and < 0.40 for brackish water for aquaculture, waters coming from all 12 sites are not fitted for fish culture.

TOTAL PHOSPHORUS (TP) CONCENTRATIONS

The TP concentrations ranged from 0.002 to 2.3 ppm within the Bataan, Cavite and Pasig River Basin (Map 92). The Laguna sites showed TP of at least 2 ppm but still within the lower limit of 6 ppm for crop productivity and protection of the environment.

Compared to the baseline, TP concentrations have shown decreasing trends in four sites, namely: Hermosa and Balanga, Bataan; and Bay and Victoria, Laguna. On the other hand, the remaining eight sites have shown increased TP more than the baseline at certain times of monitoring.

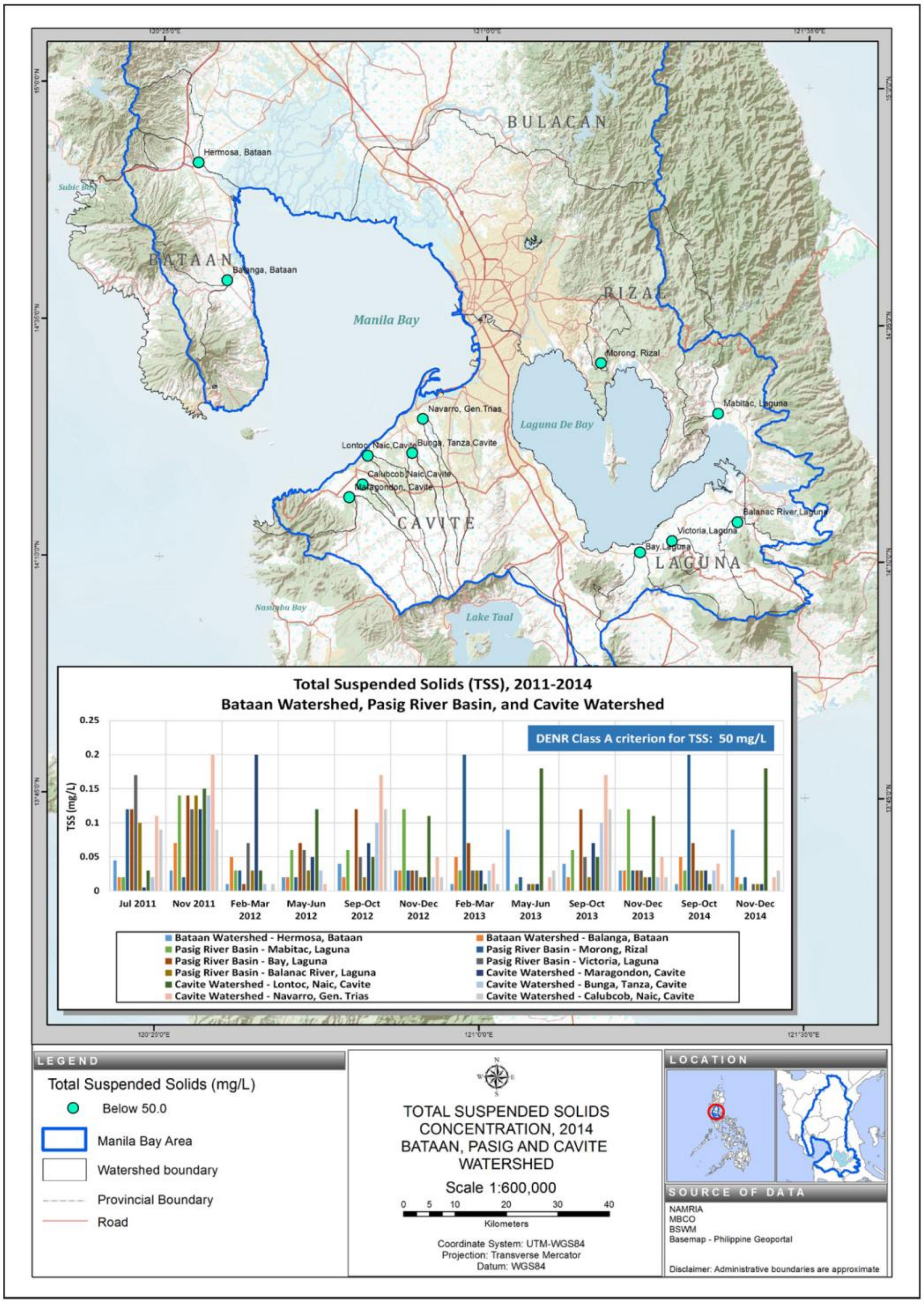
HEAVY METAL CONCENTRATIONS

Laboratory results showed that water samples taken from 12 sampling sites passed the criteria set for Class SB by the DENR DAO 90-34 at 0.05 mg/L for lead, 0.10 mg/L for chromium and 0.01 mg/L for cadmium. In the case of arsenic, some water samples from Bataan, Cavite and Laguna taken in two quarters of 2014 exceeded the 0.05 mg/L criteria for Class SB. Arsenic concentration of 0.095 mg/L recorded at Balanga, Bataan is still within the acceptable limit set for Class D water (Map 83).

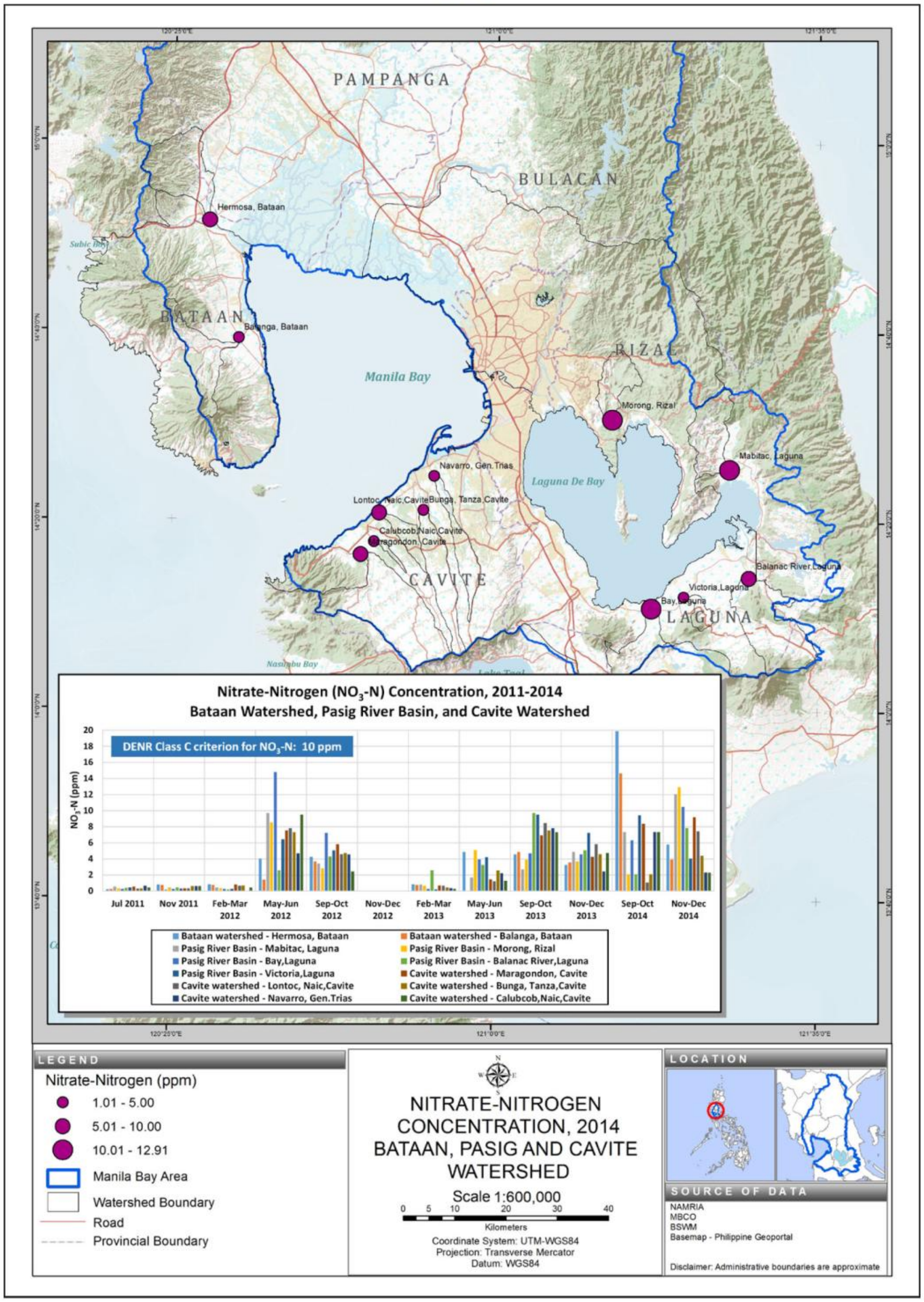
BACTERIOLOGICAL MONITORING RESULTS

Similarly, the total coliform count from the other sites within the Bataan, Cavite and Pasig River Basin failed to meet the DENR criteria of 1,000 MPN/100 ml for Class B and 5,000 MPN/100 ml for Class C. Fecal coliform levels exceeded the minimum criteria of 200 MPN/100 ml for Class B starting second quarter of 2012 (Map 88).

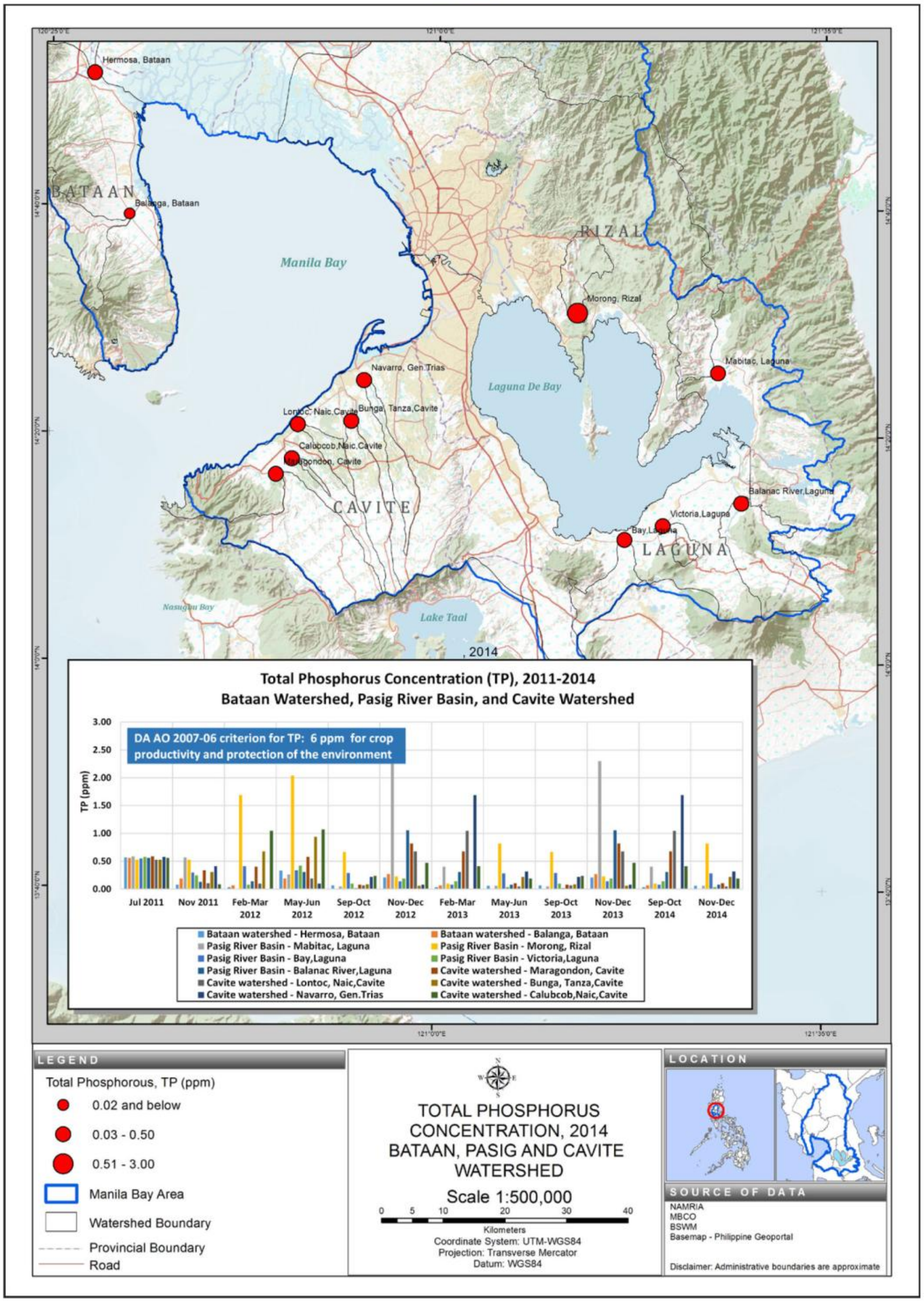
Map 80


BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Laguna De Bay
Lake Taal
Hermosa, Bataan
Balanga, Bataan
Morong, Rizal
Mabitac, Laguna
Navarro, Gen. Trias
Lontoc, Naic, Cavite
Bunga, Tanza Cavite
Calubcob Naic Cavite
Maragondon, Cavite
Balanac River, Laguna
Victoria, Laguna
Bay, Laguna
Total Suspended Solids (TSS), 2011-2014
Bataan Watershed, Pasig River Basin, and Cavite Watershed
DENR Class A criterion for TSS: 50 mg/L
TSS (mg/L)
0.25
0.2
0.15
0.1
0.05
0
Jul 2011
Nov 2011
Feb-Mar 2012
May-Jun 2012
Sep-Oct 2012
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2013
Nov-Dec 2013
Sep-Oct 2014
Nov-Dec 2014
Bataan Watershed - Hermosa, Bataan
Bataan Watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay, Laguna
Pasig River Basin - Victoria, Laguna
Pasig River Basin - Balanac River, Laguna
Cavite Watershed - Maragondon, Cavite
Cavite Watershed - Lontoc, Naic, Cavite
Cavite Watershed - Bunga, Tanza, Cavite
Cavite Watershed - Navarro, Gen. Trias
Cavite Watershed - Calubcob, Naic, Cavite
LEGEND
Total Suspended Solids (mg/L)
Below 50.0
Manila Bay Area
Watershed boundary
Provincial Boundary
Road
TOTAL SUSPENDED SOLIDS CONCENTRATION, 2014
BATAAN, PASIG AND CAVITE WATERSHED
Scale 1:600,000
0 5 10 20 30 40
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

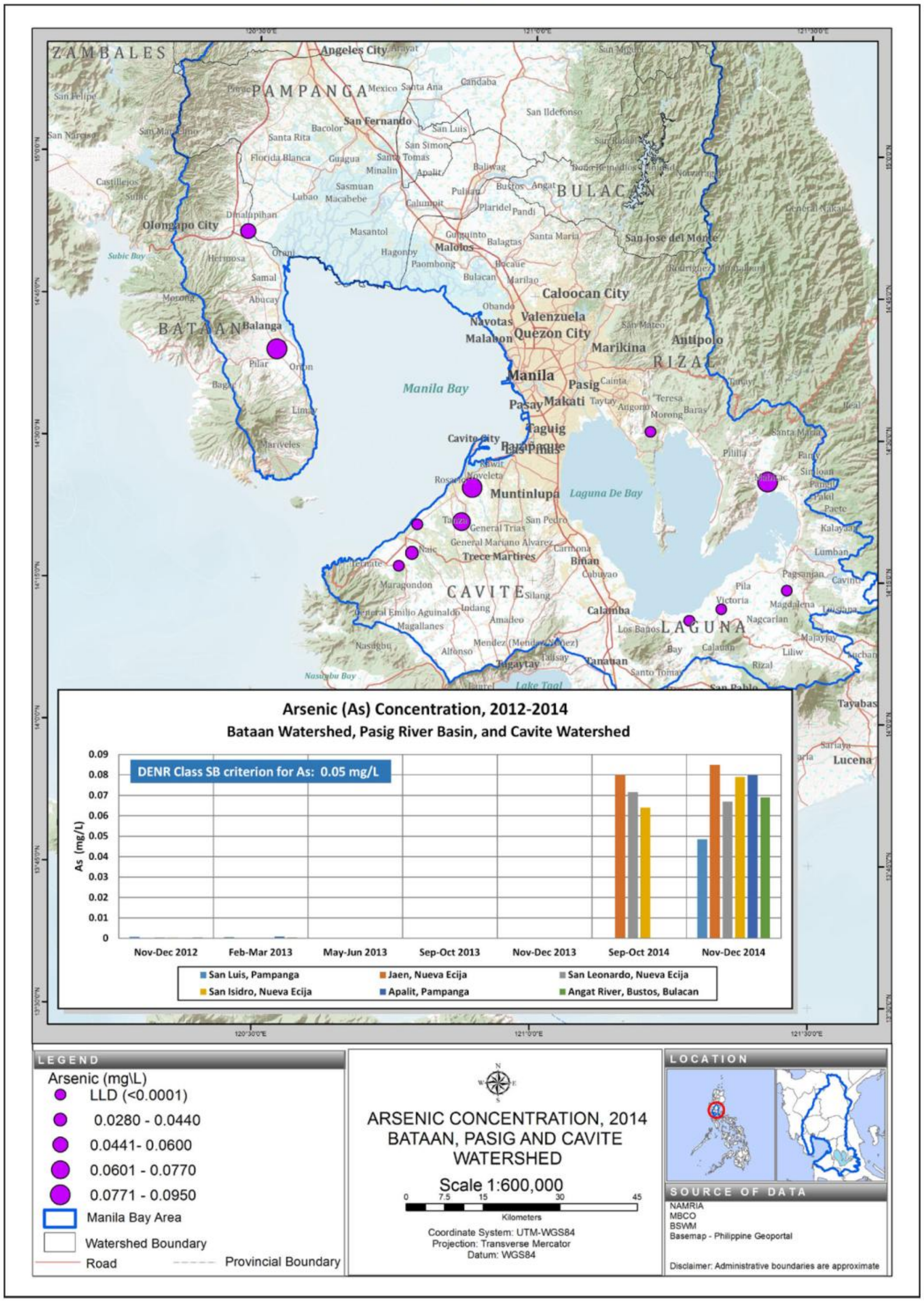
Map 81


PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Laguna De Bay
Hermosa, Bataan
Balanga, Bataan
Morong, Rizal
Mabitac, Laguna
Navarro, Gen.Trias
Lontoc, Naic,Cavite
Bunga, Tanza,Cavite
Calubcob,Naic,Cavite
Maragondon, Cavite
Balanac River,Laguna
Victoria,Laguna
Bay,Laguna
Nitrate-Nitrogen (NO_3-N) Concentration, 2011-2014
Bataan Watershed, Pasig River Basin, and Cavite Watershed
DENR Class C criterion for NO_3-N: 10 ppm
NO_3-N (ppm)
Jul 2011
Nov 2011
Feb-Mar 2012
May-Jun 2012
Sep-Oct 2012
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2013
Nov-Dec 2013
Sep-Oct 2014
Nov-Dec 2014
Bataan watershed - Hermosa, Bataan
Bataan watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay,Laguna
Pasig River Basin - Balanac River,Laguna
Pasig River Basin - Victoria,Laguna
Cavite watershed - Maragondon, Cavite
Cavite watershed - Lontoc, Naic,Cavite
Cavite watershed - Bunga, Tanza,Cavite
Cavite watershed - Navarro, Gen.Trias
Cavite watershed - Calubcob,Naic,Cavite
LEGEND
Nitrate-Nitrogen (ppm)
1.01 - 5.00
5.01 - 10.00
10.01 - 12.91
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
NITRATE-NITROGEN CONCENTRATION, 2014 BATAAN, PASIG AND CAVITE WATERSHED
Scale 1:600,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

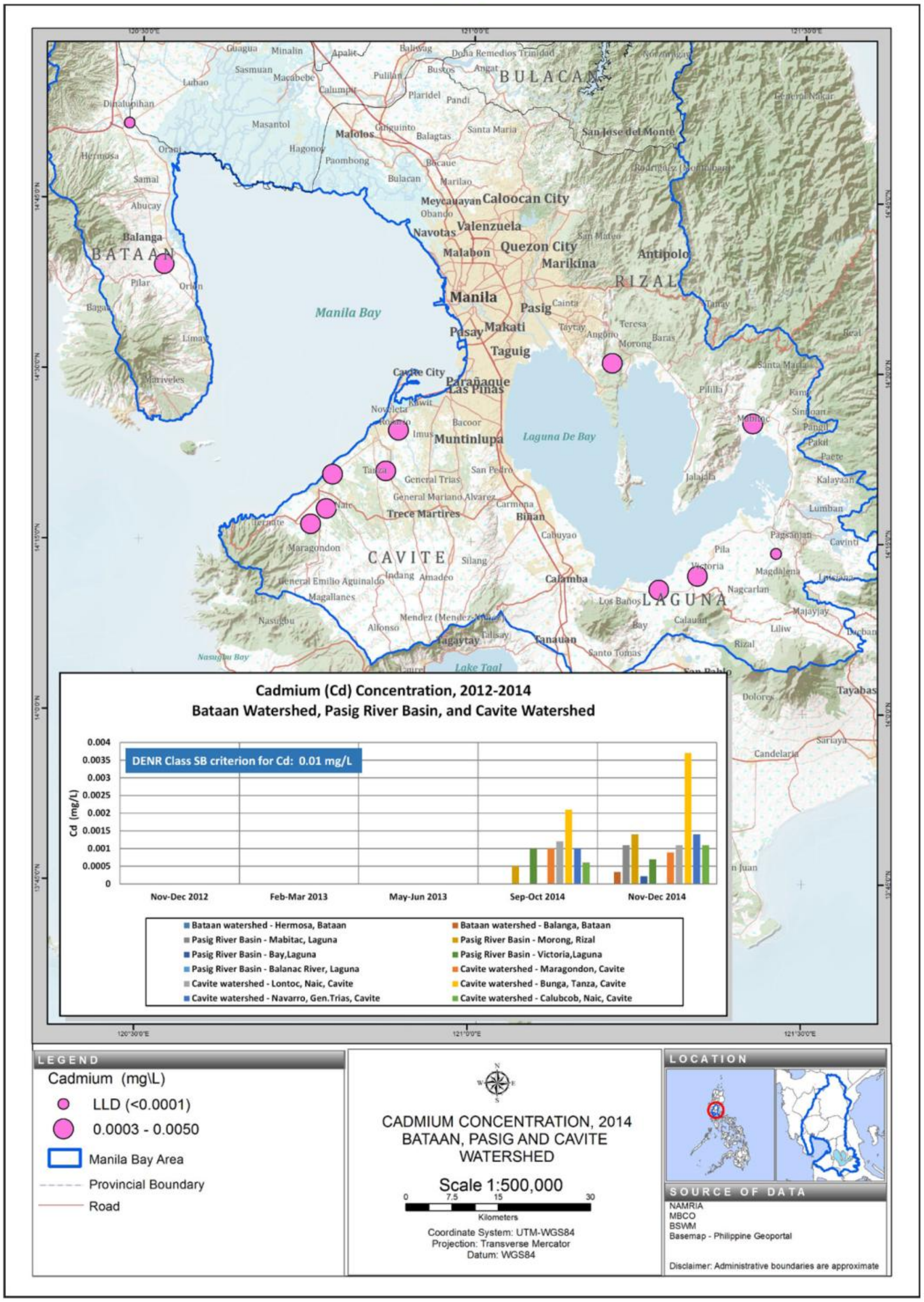
Map 82


Hermosa, Bataan
BATAAN
Balanga, Bataan
Manila Bay
RIZAL
Morong, Rizal
Mabitac, Laguna
Laguna De Bay
Navarro, Gen.Trias
Lontoc, Naic,Cavite
Bunga, Tanza,Cavite
Calubcob,Naic,Cavite
Maragondon, Cavite
CAVITE
Balanac River,Laguna
Victoria,Laguna
Bay,Laguna
LAGUNA
Lake Taal
Total Phosphorus Concentration (TP), 2011-2014
Bataan Watershed, Pasig River Basin, and Cavite Watershed
DA AO 2007-06 criterion for TP: 6 ppm for crop productivity and protection of the environment
TP (ppm)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Jul 2011
Nov 2011
Feb-Mar 2012
May-Jun 2012
Sep-Oct 2012
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2013
Nov-Dec 2013
Sep-Oct 2014
Nov-Dec 2014
Bataan watershed - Hermosa, Bataan
Bataan watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay,Laguna
Pasig River Basin - Victoria,Laguna
Pasig River Basin - Balanac River,Laguna
Cavite watershed - Maragondon, Cavite
Cavite watershed - Lontoc, Naic,Cavite
Cavite watershed - Bunga, Tanza,Cavite
Cavite watershed - Navarro, Gen.Trias
Cavite watershed - Calubcob,Naic,Cavite
121°0'0"E
121°35'0"E
LEGEND
Total Phosphorous, TP (ppm)
0.02 and below
0.03 - 0.50
0.51 - 3.00
Manila Bay Area
Watershed Boundary
Provincial Boundary
Road
TOTAL PHOSPHORUS CONCENTRATION, 2014 BATAAN, PASIG AND CAVITE WATERSHED
Scale 1:500,000
0 5 10 20 30 40
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

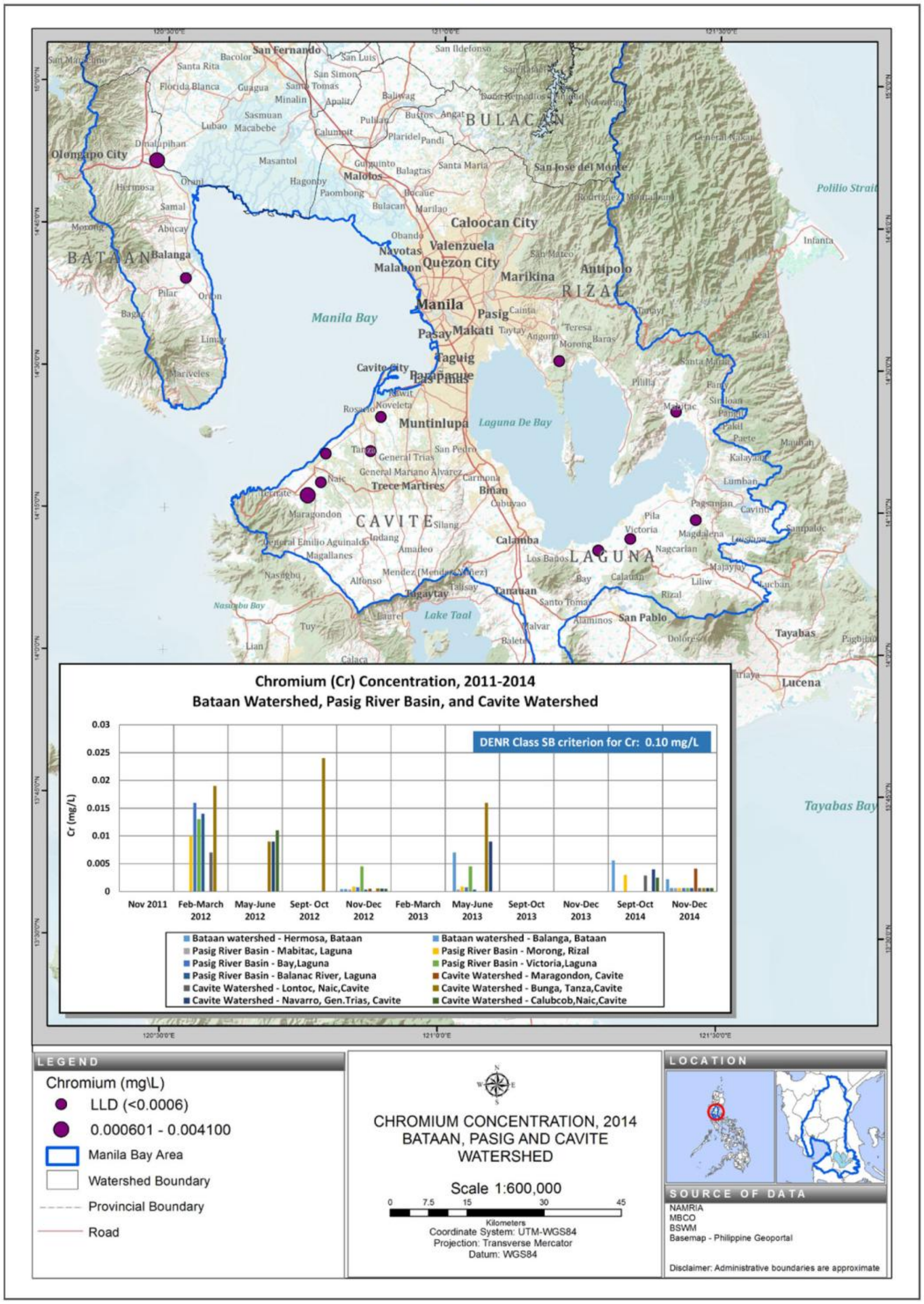
Map 83


Arsenic (As) Concentration, 2012-2014
Bataan Watershed, Pasig River Basin, and Cavite Watershed
DENR Class SB criterion for As: 0.05 mg/L
As (mg/L)
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2013
Nov-Dec 2013
Sep-Oct 2014
Nov-Dec 2014
San Luis, Pampanga
Jaen, Nueva Ecija
San Leonardo, Nueva Ecija
San Isidro, Nueva Ecija
Apalit, Pampanga
Angat River, Bustos, Bulacan
ZAMBALES
PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Laguna De Bay
Angeles City
San Fernando
Olongapo City
Balanga
Caloocan City
Valenzuela
Quezon City
Manila
Pasig
Makati
Muntinlupa
San Jose del Monte
Antipolo
Marikina
LEGEND
Arsenic (mg\L)
LLD (<0.0001)
0.0280 - 0.0440
0.0441- 0.0600
0.0601 - 0.0770
0.0771 - 0.0950
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
ARSENIC CONCENTRATION, 2014
BATAAN, PASIG AND CAVITE
WATERSHED
Scale 1:600,000
0 7.5 15 30 45
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

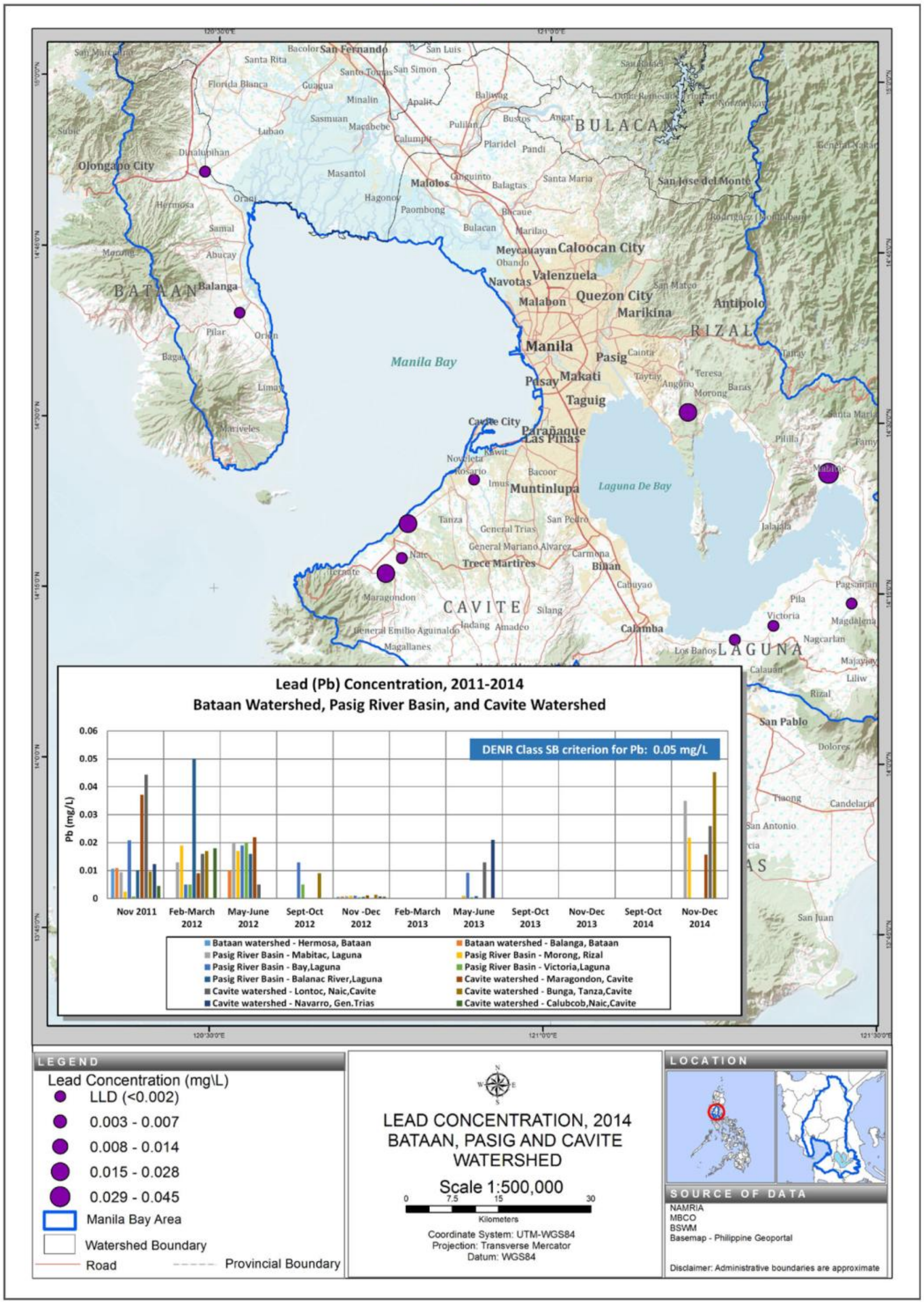
Map 84


Manila Bay
Laguna De Bay
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila
Quezon City
Caloocan City
Cadmium (Cd) Concentration, 2012-2014
Bataan Watershed, Pasig River Basin, and Cavite Watershed
DENR Class SB criterion for Cd: 0.01 mg/L
Cd (mg/L)
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2014
Nov-Dec 2014
Bataan watershed - Hermosa, Bataan
Bataan watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay,Laguna
Pasig River Basin - Victoria,Laguna
Pasig River Basin - Balanac River, Laguna
Cavite watershed - Maragondon, Cavite
Cavite watershed - Lontoc, Naic, Cavite
Cavite watershed - Bunga, Tanza, Cavite
Cavite watershed - Navarro, Gen.Trias, Cavite
Cavite watershed - Calubcob, Naic, Cavite
LEGEND
Cadmium (mg\L)
LLD (<0.0001)
0.0003 - 0.0050
Manila Bay Area
Provincial Boundary
Road
CADMIUM CONCENTRATION, 2014
BATAAN, PASIG AND CAVITE
WATERSHED
Scale 1:500,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

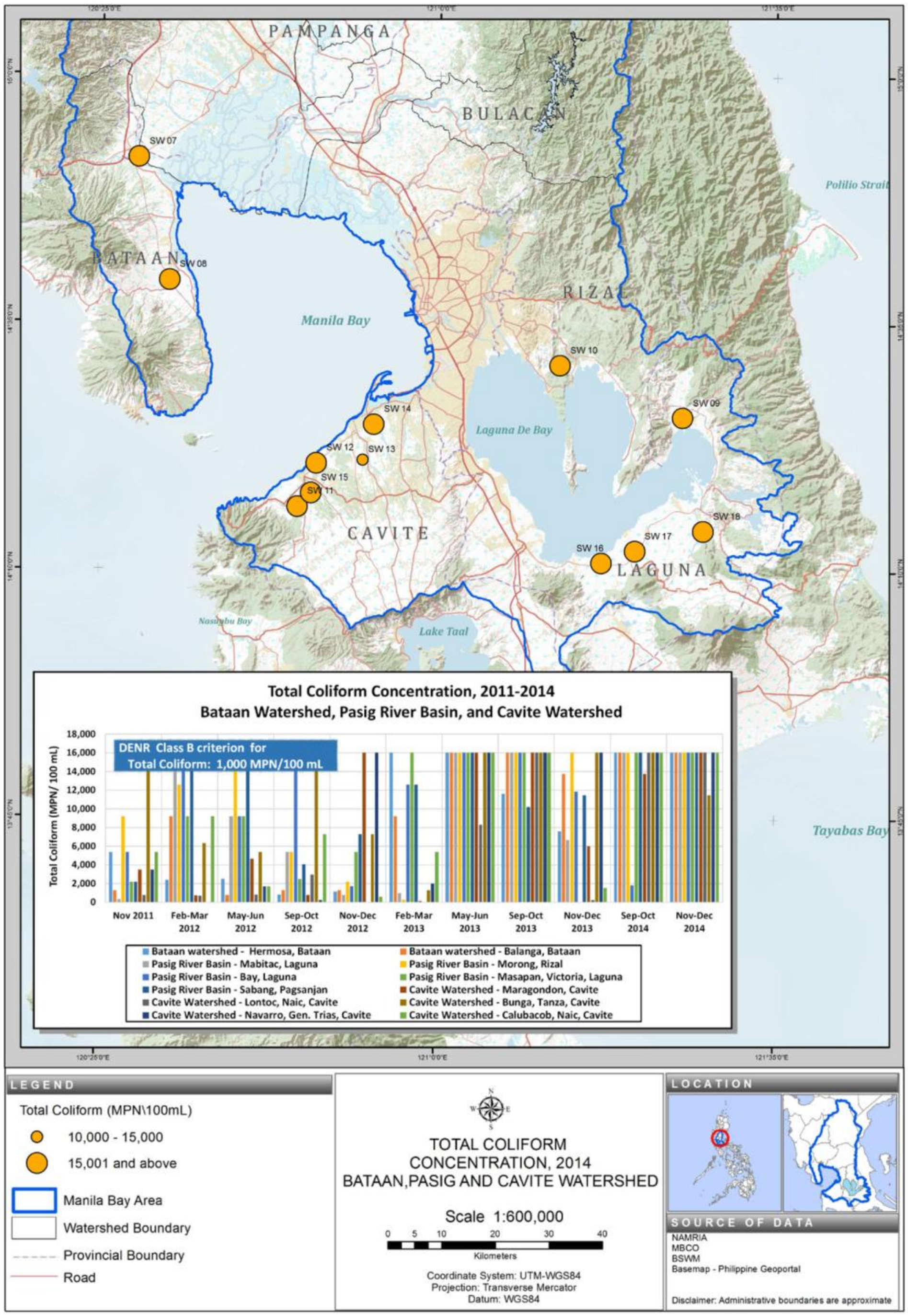
Map 85


Chromium (Cr) Concentration, 2011-2014
Bataan Watershed, Pasig River Basin, and Cavite Watershed
DENR Class SB criterion for Cr: 0.10 mg/L
Cr (mg/L)
0.03
0.025
0.02
0.015
0.01
0.005
0
Nov 2011
Feb-March 2012
May-June 2012
Sept-Oct 2012
Nov-Dec 2012
Feb-March 2013
May-June 2013
Sept-Oct 2013
Nov-Dec 2013
Sept-Oct 2014
Nov-Dec 2014
Bataan watershed - Hermosa, Bataan
Bataan watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay,Laguna
Pasig River Basin - Victoria,Laguna
Pasig River Basin - Balanac River, Laguna
Cavite Watershed - Maragondon, Cavite
Cavite Watershed - Lontoc, Naic,Cavite
Cavite Watershed - Bunga, Tanza,Cavite
Cavite Watershed - Navarro, Gen.Trias, Cavite
Cavite Watershed - Calubcob,Naic,Cavite
Manila Bay
Laguna De Bay
Lake Taal
Polillo Strait
Tayabas Bay
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila
Caloocan City
Quezon City
Valenzuela
Marikina
Pasig
Makati
Pasay
Taguig
Muntinlupa
Antipolo
Calamba
San Pablo
Lucena
Tayabas
Olongapo City
Balanga
Mariveles
Cavite City
Trece Martires
Tagaytay
San Fernando
Malolos
LEGEND
Chromium (mg\L)
LLD (<0.0006)
0.000601 - 0.004100
Manila Bay Area
Watershed Boundary
Provincial Boundary
Road
CHROMIUM CONCENTRATION, 2014
BATAAN, PASIG AND CAVITE WATERSHED
Scale 1:600,000
0 7.5 15 30 45
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

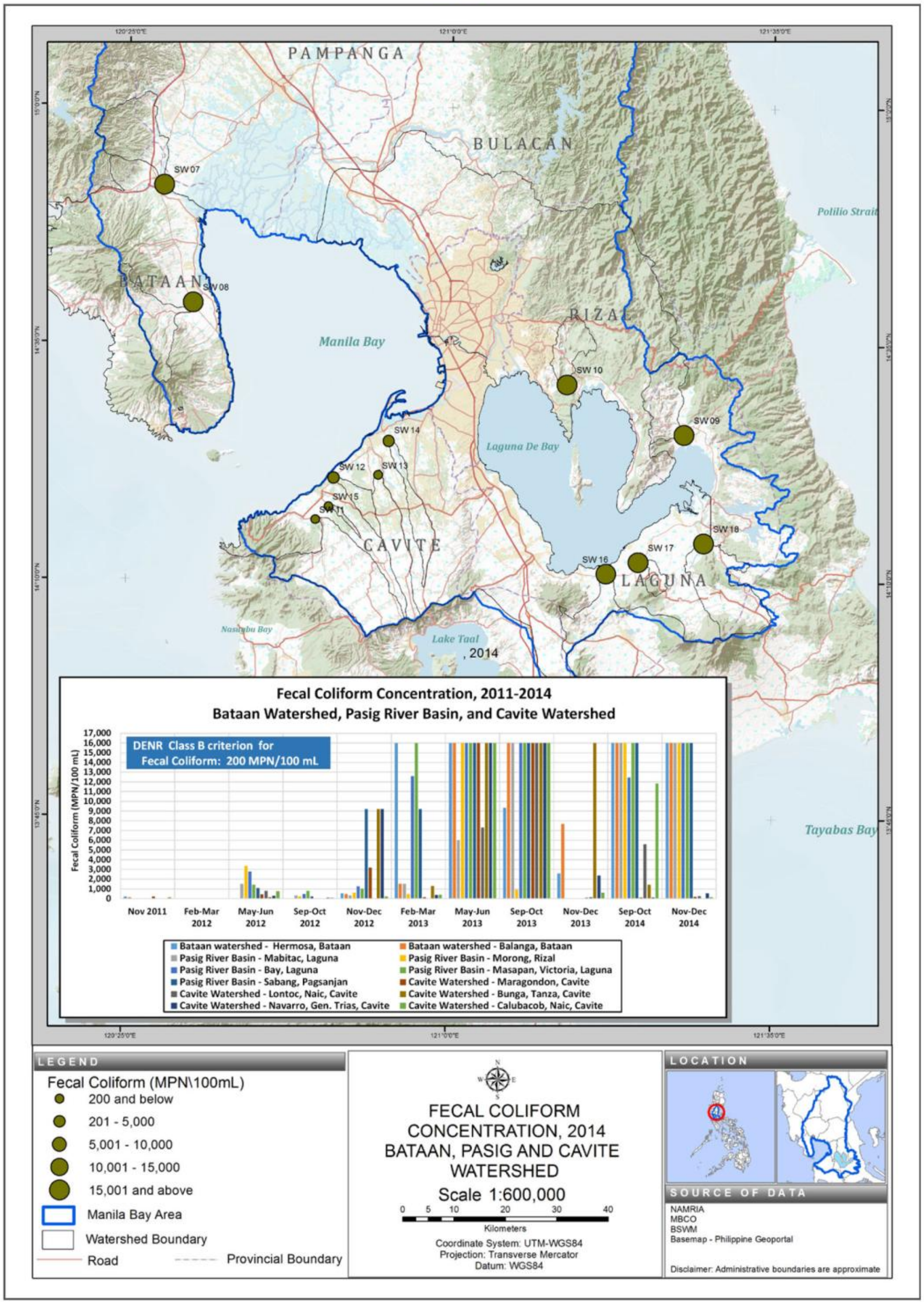
Map 86


Lead (Pb) Concentration, 2011-2014
Bataan Watershed, Pasig River Basin, and Cavite Watershed
DENR Class SB criterion for Pb: 0.05 mg/L
Pb (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
Nov 2011
Feb-March 2012
May-June 2012
Sept-Oct 2012
Nov -Dec 2012
Feb-March 2013
May-June 2013
Sept-Oct 2013
Nov-Dec 2013
Sept-Oct 2014
Nov-Dec 2014
Bataan watershed - Hermosa, Bataan
Bataan watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay,Laguna
Pasig River Basin - Victoria,Laguna
Pasig River Basin - Balanac River,Laguna
Cavite watershed - Maragondon, Cavite
Cavite watershed - Lontoc, Naic,Cavite
Cavite watershed - Bunga, Tanza,Cavite
Cavite watershed - Navarro, Gen.Trias
Cavite watershed - Calubcob,Naic,Cavite
Manila Bay
Laguna De Bay
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila
Caloocan City
Quezon City
Makati
Taguig
Pasig
Marikina
Antipolo
Muntinlupa
Calamba
Olongapo City
Cavite City
LEGEND
Lead Concentration (mg\L)
LLD (<0.002)
0.003 - 0.007
0.008 - 0.014
0.015 - 0.028
0.029 - 0.045
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
LEAD CONCENTRATION, 2014
BATAAN, PASIG AND CAVITE
WATERSHED
Scale 1:500,000
0 7.5 15 30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 87


PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Laguna De Bay
Lake Taal
Polillo Strait
Tayabas Bay
SW 07
SW 08
SW 09
SW 10
SW 11
SW 12
SW 13
SW 14
SW 15
SW 16
SW 17
SW 18
Total Coliform Concentration, 2011-2014
Bataan Watershed, Pasig River Basin, and Cavite Watershed
DENR Class B criterion for Total Coliform: 1,000 MPN/100 mL
Total Coliform (MPN/ 100 mL)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Nov 2011
Feb-Mar 2012
May-Jun 2012
Sep-Oct 2012
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2013
Nov-Dec 2013
Sep-Oct 2014
Nov-Dec 2014
Bataan watershed - Hermosa, Bataan
Bataan watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay, Laguna
Pasig River Basin - Masapan, Victoria, Laguna
Pasig River Basin - Sabang, Pagsanjan
Cavite Watershed - Maragondon, Cavite
Cavite Watershed - Lontoc, Naic, Cavite
Cavite Watershed - Bunga, Tanza, Cavite
Cavite Watershed - Navarro, Gen. Trias, Cavite
Cavite Watershed - Calubacob, Naic, Cavite
LEGEND
Total Coliform (MPN\100mL)
10,000 - 15,000
15,001 and above
Manila Bay Area
Watershed Boundary
Provincial Boundary
Road
TOTAL COLIFORM
CONCENTRATION, 2014
BATAAN,PASIG AND CAVITE WATERSHED
Scale 1:600,000
0 5 10 20 30 40
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 88


PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Laguna De Bay
Polilio Strait
Tayabas Bay
Lake Taal
SW 07
SW 08
SW 09
SW 10
SW 11
SW 12
SW 13
SW 14
SW 15
SW 16
SW 17
SW 18
Fecal Coliform Concentration, 2011-2014
Bataan Watershed, Pasig River Basin, and Cavite Watershed
DENR Class B criterion for Fecal Coliform: 200 MPN/100 mL
Fecal Coliform (MPN/100 mL)
Nov 2011
Feb-Mar 2012
May-Jun 2012
Sep-Oct 2012
Nov-Dec 2012
Feb-Mar 2013
May-Jun 2013
Sep-Oct 2013
Nov-Dec 2013
Sep-Oct 2014
Nov-Dec 2014
Bataan watershed - Hermosa, Bataan
Bataan watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay, Laguna
Pasig River Basin - Masapan, Victoria, Laguna
Pasig River Basin - Sabang, Pagsanjan
Cavite Watershed - Maragondon, Cavite
Cavite Watershed - Lontoc, Naic, Cavite
Cavite Watershed - Bunga, Tanza, Cavite
Cavite Watershed - Navarro, Gen. Trias, Cavite
Cavite Watershed - Calubacob, Naic, Cavite
LEGEND
Fecal Coliform (MPN\100mL)
200 and below
201 - 5,000
5,001 - 10,000
10,001 - 15,000
15,001 and above
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
FECAL COLIFORM CONCENTRATION, 2014
BATAAN, PASIG AND CAVITE WATERSHED
Scale 1:600,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

B.5 LAGUNA DE BAY

Laguna de Bay, with a total surface area of 900 km2, is the biggest lake and one of the most important inland bodies of water in the Philippines. The almost heart-shaped lake, located 13°55' to 14°50' N latitude and 20°50' to 121°45' E longitude at 15 kms. southeast of Manila, has three distinct bays, namely: West Bay, Central Bay and East Bay. Its southernmost portion is called the South Bay. Although shallow with an average depth of only 2.5 meters, the lake's water holding capacity is estimated at 2.19 billion m3. The lake's watershed area of 3,820 km2 straddles the whole provinces of Rizal and Laguna, and some towns in Batangas, Cavite, Quezon and cities in Metro Manila. Twenty-one major tributary river systems flow into the lake aside from other relatively small rivers and streams (Tongson, E. T. et al., 2012). The lake's only outlet is the Napindan Channel which is connected to Manila Bay via the Pasig River. Seawater backflow is a natural phenomenon in the lake and took place in some years in the past. The backflow is irregular, occasionally occurring in summer months whenever the lake level is lower than Manila Bay. As the Pasig River reverses its flow during the entry of saltwater due to the effect of tidal fluctuation in Manila Bay, the salinity of the water in the lake increases.

As a multi-use water resource, Laguna de Bay is used as source of irrigation water, industrial cooling water, hydroelectric power generation, transport route, source of animal feed, source of fish supply and domestic water supply, as well as a venue for recreation. The NSO reported that as of 2007, the total population around the lake was about 14.4 million. To ensure the viability of this vital resource, support is needed from the various lake stakeholders and other parties interested in its sustainable use. Likewise, proper management of the lake and its watershed areas must be intensified and sustained for environmentally-sound resources conservation.

Assessing the water quality is important to determine the suitability of the water body for its intended and beneficial uses, as well as to determine the condition of the aquatic ecosystems and to determine the effects of development from human interventions.

Routine monitoring of the water quality of lake and its tributaries has been in place since 1973. Through time, modifications of the program were made, including some changes in spatial and temporal coverage and the numbers of parameters monitored.

PHYSICO-CHEMICAL PARAMETERS

Biochemical Oxygen Demand

The DENR Class C water quality criterion for BOD set at 7 mg/L was observed in all of the monitored lake stations from 2009 to 2012 based on the computed annual average BOD concentrations. The results of the water quality monitoring in the tributary rivers from 2009 to 2012 showed that annual average BOD concentrations ranged from 1 mg/L (noted in Pagsanjan River station in 2009 and in Sta. Maria River – Upstream station in 2012) to 238 mg/L (recorded in Bagumbayan River station in 2010). It was observed that out of the 34 tributary river stations monitored, only 17 stations (Stns. 5u, 8u, 12, 13, 14, 15, 16, 17,17U, 18, 19, 19U, 20, 21, 22, 22U and 23) had all of the BOD annual averages conformed to the DENR Class C criterion. Those stations whose annual average BOD always exceeded the criterion were mostly in the West Bay area, namely: Stns. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 26 (Map 91).

Dissolved Oxygen

The lake's average annual DO levels in all monitored stations from 2009 to 2012 conformed to the DENR Class C criterion set at a minimum of 5 mg/L. Only 11 of the 34 tributary river stations monitored in 2009 to 2012 had all of the computed average annual DO concentrations passed the Class C criterion and these are Bay River (Stn. 13), Sta. Cruz River (Stn. 15), Pagsanjan River (Stn. 16), Pangil River Downstream (Stn. 17), Pangil River Upstream (Stn. 17U), Sta. Maria River Downstream (Stn 19), Sta. Maria River Upstream (Stn 19U), Jala- jala River (Stn. 20), Tanay River-Downstream (Stn. 22), Tanay River- Upstream (Stn 22U) and Morong River-Upstream (Stn. 24U). Those tributary river stations whose annual mean concentrations for DO continually failed the Class C criterion were Stns. 1 to 12, 21, 23, 25 and 26. For Stns. 14, 18 and 24, measured annual average DO concentrations occasionally passed the Class C criterion (Map 93).

Potential Hydrogen

The evaluation of the average annual pH levels in the lake from 2009 to 2012 showed that it was only in 2012 that the DENR Class C criterion of 6.5 to 8.5 was not met particularly in Stns. II (East Bay), IV (Central Bay) and XVI (West Bay-Sta Rosa) with pH 8.6; and in Stns. XV (West Bay- San Pedro), XVII (Central Bay-Fish Sanctuary) and XVIII (East Bay-Pagsanjan) with pH 8.7. In the tributary rivers, only Stn. 22U (Tanay River Upstream) had annual average pH concentration that failed the DENR Class C criterion at 8.6 in 2012 (Map 95).

Inorganic Phosphate

The results of the lake monitoring from 2009 to 2012 showed that all of the computed annual average inorganic phosphate concentrations failed the Class C criterion, with the exception of Stn. II (East Bay) and Stn. IV (Central Bay) in 2011. Among the 34 tributary river stations monitored from 2009 to 2012, all of the annual average inorganic phosphate concentrations in Stns. 1, 2, 3, 4, 4U, 5, 5U, 6, 7, 8, 8M, 8U, 9, 10, 11, 24, 24U, 25 and 26 exceeded the Class C criterion of 0.4 mg/L. On the other hand, those river stations whose annual average inorganic phosphate concentrations all conformed with the Class C criterion were Stns. 12, 14, 16, 17, 17U, 19, 19U, 20, 21, 22U and 23 (Map 97).

Nitrate

The average annual nitrate concentrations in all monitored stations in the lake and in the tributary rivers from 2009 to 2012 were far below the 10 mg/L DENR water quality criterion for Class C. The annual mean nitrate levels in the lake ranged from 0.038 to 0.407 mg/L while in the tributary rivers ranged from 0.1 to 6.8 mg/L. Among the 34 tributary river stations, Stn. 11 (San Juan River) continually had the highest annual mean nitrate concentration every year from 2009 to 2012 (Map 99).

BACTERIOLOGICAL PARAMETERS

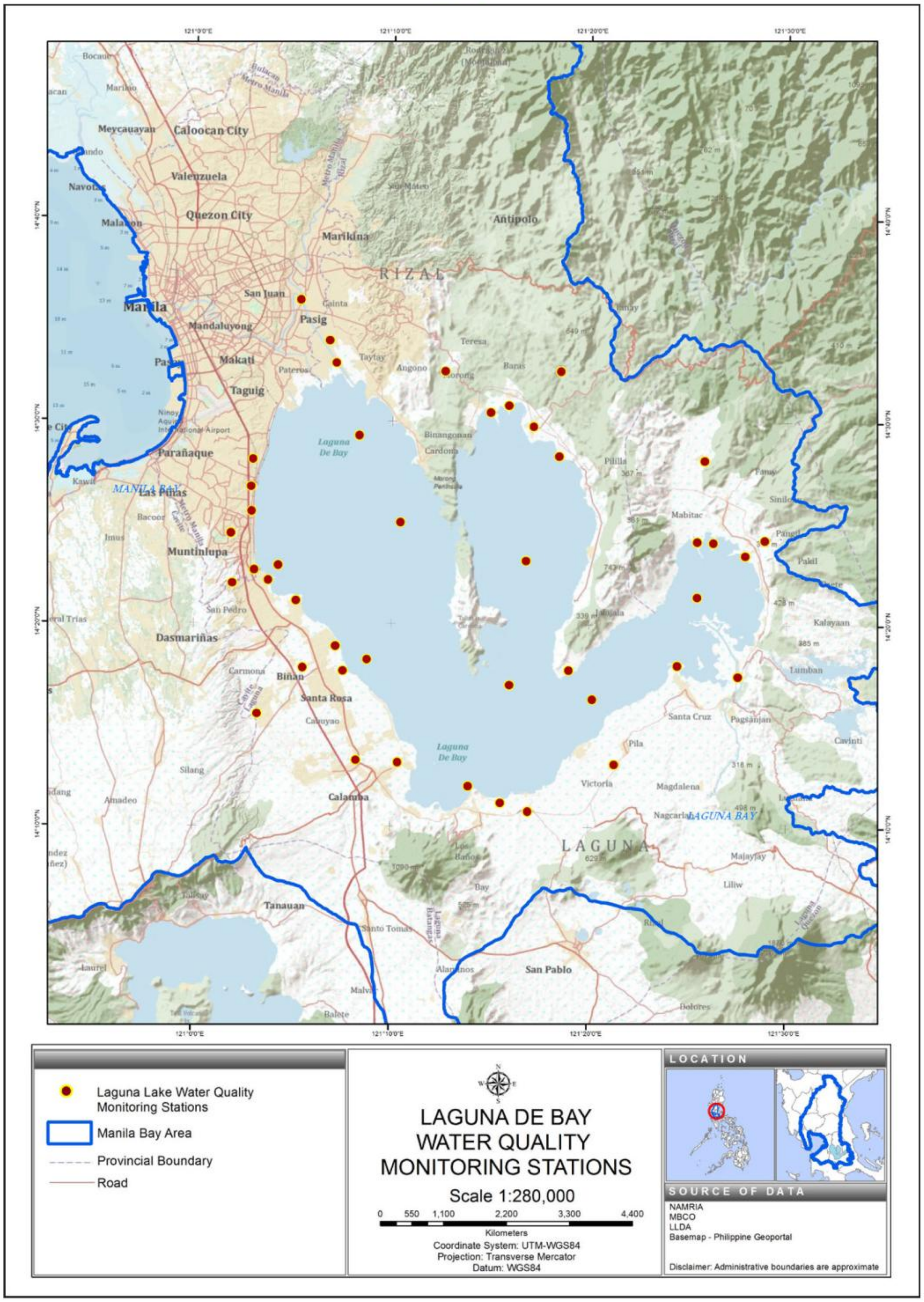
Total Coliform

The annual geomean total coliform concentrations in all lake stations from 2009 to 2013 which ranged from 55 to 2,100 MPN/100 ml passed the DENR Class C criterion. On the other hand, all river stations had annual geomean total coliform concentrations exceeding the 5,000 MPN/100 ml Class C criterion throughout the 4-year monitoring period with the lowest at 8,123 MPN/100 ml in Stn 17U (Pangil River Upstream) in 2012 and the highest at 1,423,305,032,753,950 MPN/100 ml in Stn. 2 (Bagumbayan River) in 2009 (Map 101).

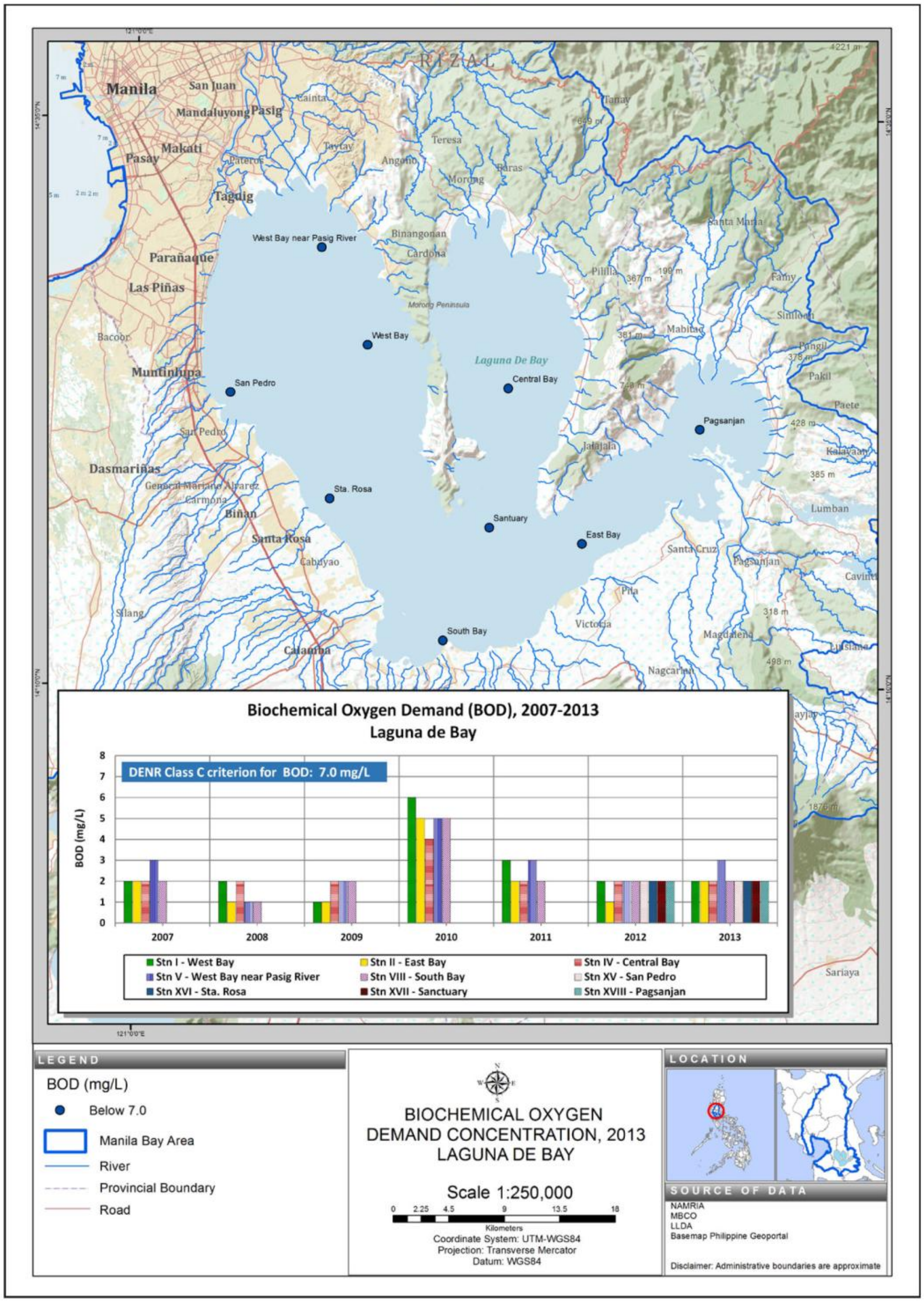
Fecal Coliform

Station VIII (South Bay) had the highest annual geomean fecal coliform levels in 2009, 2010 and 2011 among the lake stations monitored from 2009 to 2012 at 694, 157 and 534 MPN/ 100 ml, respectively. In 2012, Stn. XV (West Bay-San Pedro) recorded the highest annual geomean fecal coliform level of 217 MPN/100 ml. The lowest annual geomean fecal coliform level in all lake stations for the 4-year monitoring period was at 8 MPN/100 ml obtained in Stn. II (East Bay) in 2012. The tributary rivers had comparatively higher annual geomean fecal coliform levels in most of the stations compared to the lakes from 2009 to 2012 as the concentrations ranged from 2,524 MPN/100 ml to 1,117,310,629,006,070 MPN/100 ml. The lowest fecal coliform computed annual geomean was noted in Stn. 19U (Sta. Maria River- Upstream) in 2012 at 2,524 MPN/100 ml while the highest was in Stn. 2 (Bagumbayan River) in 2009 at 1,117,310,629,006,070 MPN/100 ml (Map 103).

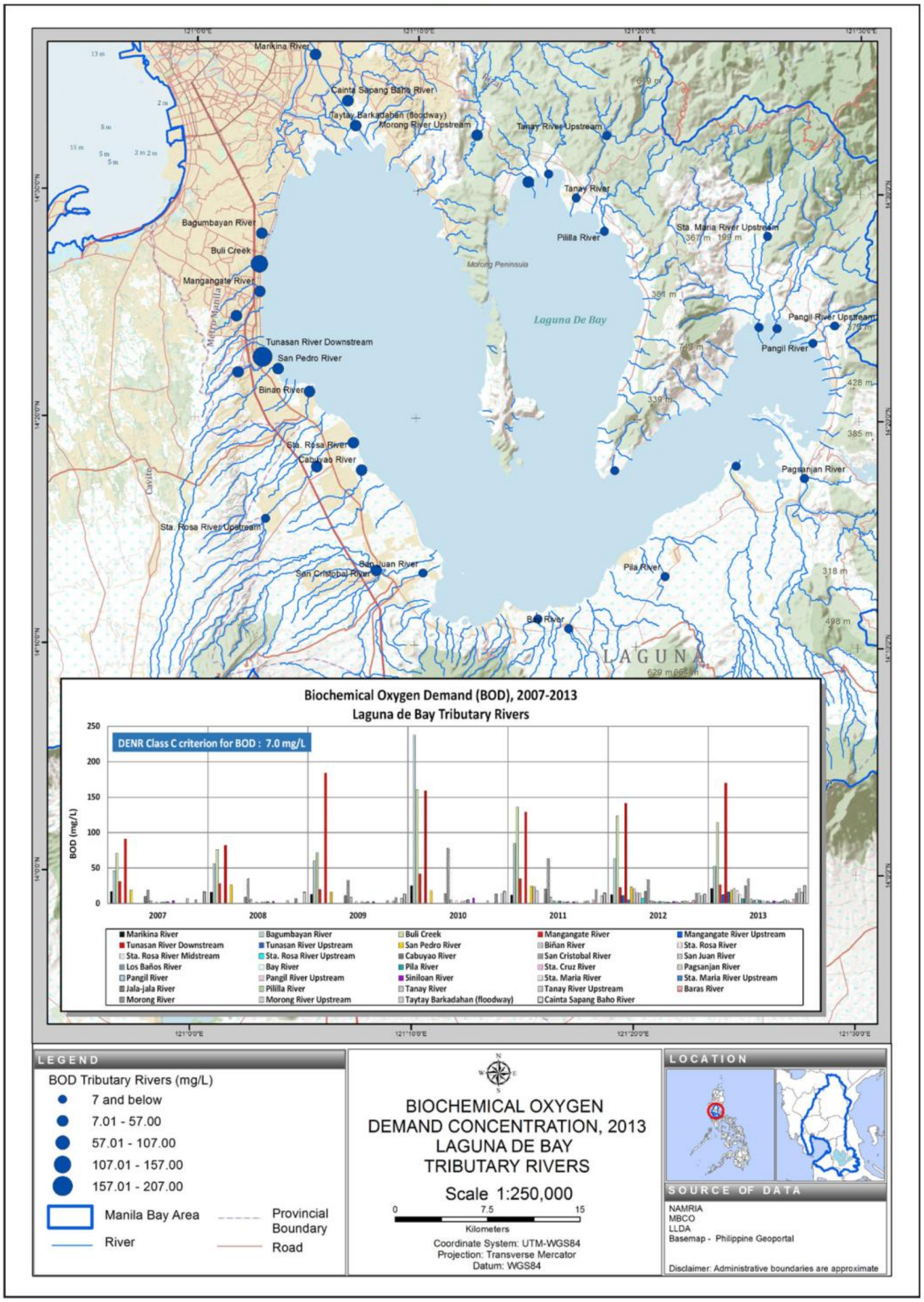
Map 89


Laguna Lake Water Quality Monitoring Stations
Manila Bay Area
Provincial Boundary
Road
LAGUNA DE BAY WATER QUALITY MONITORING STATIONS
Scale 1:280,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

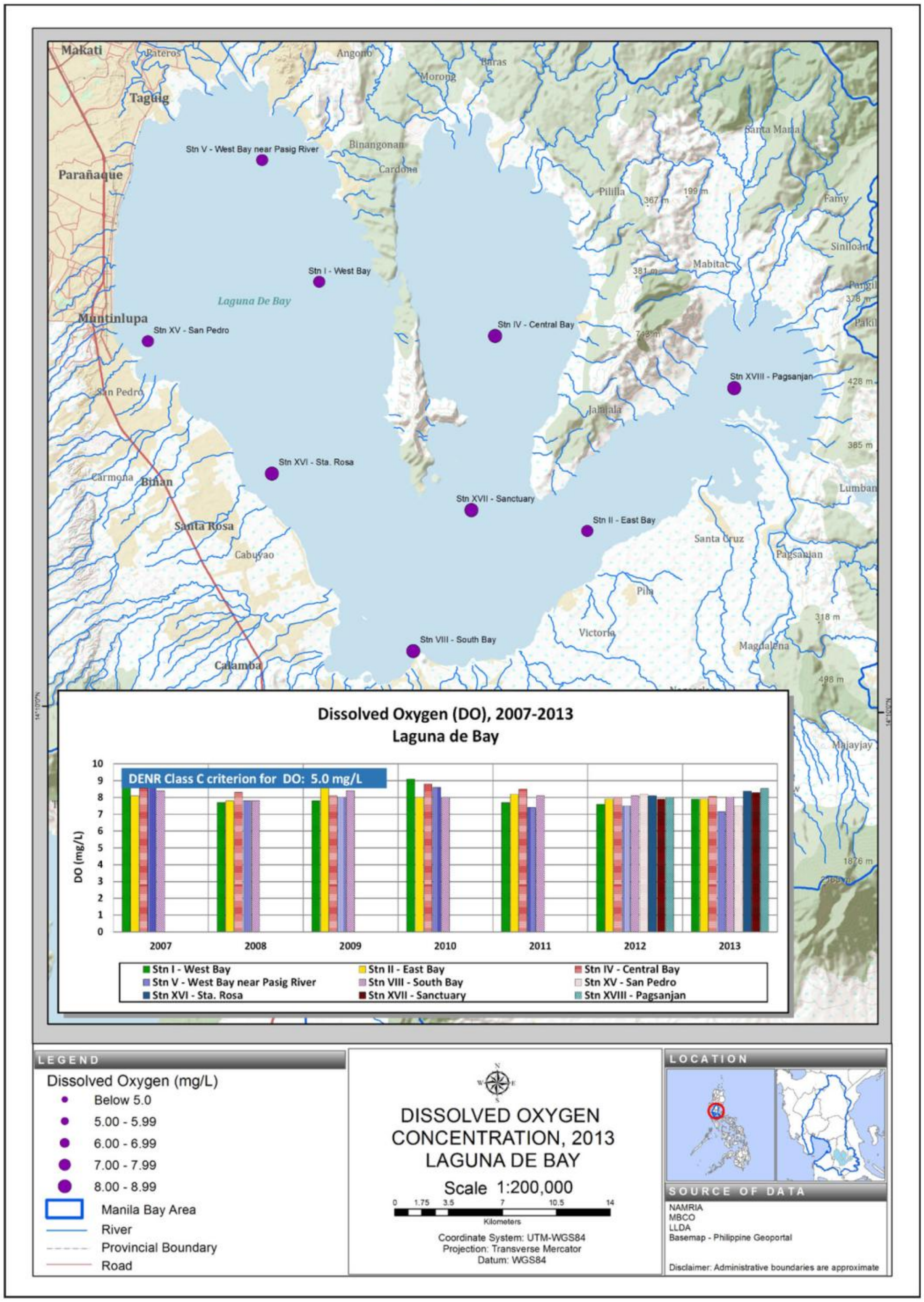
Map 90


Manila
San Juan
Mandaluyong
Pasig
Makati
Pasay
Taguig
Parañaque
Las Piñas
Bacoor
Muntinlupa
San Pedro
Dasmariñas
Carmona
Biñan
Santa Rosa
Cabuyao
Silang
Calamba
Cainta
Taytay
Angono
Teresa
Morong
Baras
Tanay
Binangonan
Cardona
Morong Peninsula
Pililla
Mabitac
Santa Maria
Famy
Siniloan
Pangil
Pakil
Paete
Kalayaan
Lumban
Cavinti
Santa Cruz
Pagsanjan
Pila
Victoria
Magdalena
Nagcarlan
Sariaya
Jalajala
Laguna De Bay
West Bay near Pasig River
West Bay
San Pedro
Central Bay
Pagsanjan
Sta. Rosa
Santuary
East Bay
South Bay
RIZAL
Biochemical Oxygen Demand (BOD), 2007-2013
Laguna de Bay
DENR Class C criterion for BOD: 7.0 mg/L
BOD (mg/L)
2007
2008
2009
2010
2011
2012
2013
Stn I - West Bay
Stn II - East Bay
Stn IV - Central Bay
Stn V - West Bay near Pasig River
Stn VIII - South Bay
Stn XV - San Pedro
Stn XVI - Sta. Rosa
Stn XVII - Sanctuary
Stn XVIII - Pagsanjan
LEGEND
BOD (mg/L)
Below 7.0
Manila Bay Area
River
Provincial Boundary
Road
BIOCHEMICAL OXYGEN
DEMAND CONCENTRATION, 2013
LAGUNA DE BAY
Scale 1:250,000
0 2.25 4.5 9 13.5 18
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

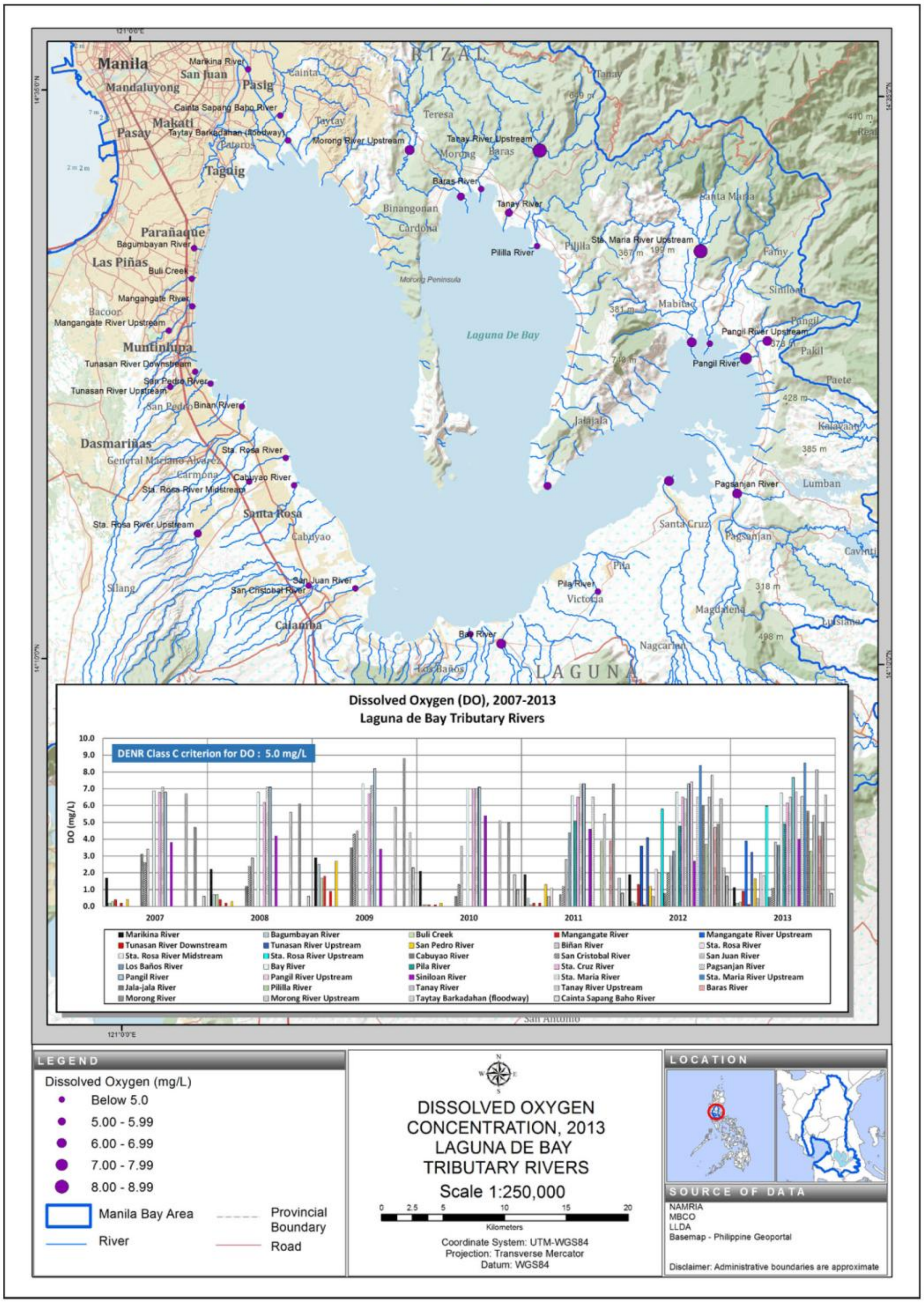
Map 91


Marikina River
Cainta Sapang Baho River
Taytay Barkadahan (floodway)
Morong River Upstream
Tanay River Upstream
Tanay River
Pililla River
Sta. Maria River Upstream
Bagumbayan River
Buli Creek
Mangangate River
Morong Peninsula
Laguna De Bay
Pangil River Upstream
Pangil River
Tunasan River Downstream
San Pedro River
Binan River
Sta. Rosa River
Cabuyao River
Pagsanjan River
Sta. Rosa River Upstream
San Juan River
San Cristobal River
Pila River
Bay River
LAGUNA
Biochemical Oxygen Demand (BOD), 2007-2013
Laguna de Bay Tributary Rivers
DENR Class C criterion for BOD : 7.0 mg/L
BOD (mg/L)
250
200
150
100
50
0
2007
2008
2009
2010
2011
2012
2013
Marikina River
Bagumbayan River
Buli Creek
Mangangate River
Mangangate River Upstream
Tunasan River Downstream
Tunasan River Upstream
San Pedro River
Biñan River
Sta. Rosa River
Sta. Rosa River Midstream
Sta. Rosa River Upstream
Cabuyao River
San Cristobal River
San Juan River
Los Baños River
Bay River
Pila River
Sta. Cruz River
Pagsanjan River
Pangil River
Pangil River Upstream
Siniloan River
Sta. Maria River
Sta. Maria River Upstream
Jala-jala River
Pililla River
Tanay River
Tanay River Upstream
Baras River
Morong River
Morong River Upstream
Taytay Barkadahan (floodway)
Cainta Sapang Baho River
LEGEND
BOD Tributary Rivers (mg/L)
7 and below
7.01 - 57.00
57.01 - 107.00
107.01 - 157.00
157.01 - 207.00
Manila Bay Area
River
Provincial Boundary
Road
BIOCHEMICAL OXYGEN DEMAND CONCENTRATION, 2013
LAGUNA DE BAY
TRIBUTARY RIVERS
Scale 1:250,000
0
7.5
15
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

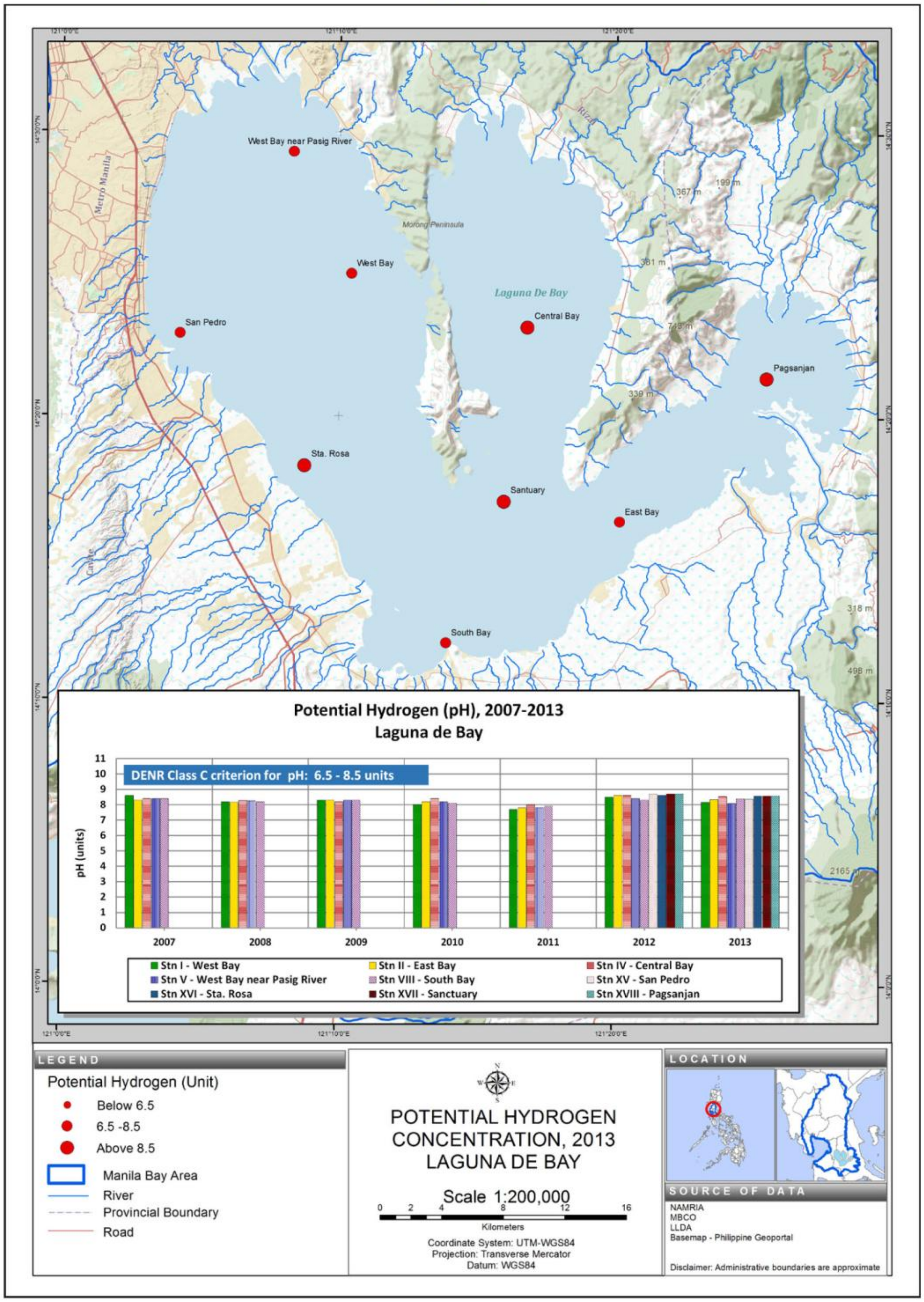
Map 92


Stn V - West Bay near Pasig River
Stn I - West Bay
Laguna De Bay
Stn XV - San Pedro
Stn IV - Central Bay
Stn XVIII - Pagsanjan
Stn XVI - Sta. Rosa
Stn XVII - Sanctuary
Stn II - East Bay
Stn VIII - South Bay
Makati
Pateros
Taguig
Parañaque
Muntinlupa
San Pedro
Carmona
Biñan
Santa Rosa
Cabuyao
Calamba
Angono
Morong
Baras
Binangonan
Cardona
Pililla
Mabitac
Santa Maria
Famy
Siniloan
Jalajala
Santa Cruz
Pagsanjan
Pila
Victoria
Magdalena
Majayjay
Lumban
Dissolved Oxygen (DO), 2007-2013
Laguna de Bay
DENR Class C criterion for DO: 5.0 mg/L
DO (mg/L)
0
1
2
3
4
5
6
7
8
9
10
2007
2008
2009
2010
2011
2012
2013
Stn I - West Bay
Stn II - East Bay
Stn IV - Central Bay
Stn V - West Bay near Pasig River
Stn VIII - South Bay
Stn XV - San Pedro
Stn XVI - Sta. Rosa
Stn XVII - Sanctuary
Stn XVIII - Pagsanjan
LEGEND
Dissolved Oxygen (mg/L)
Below 5.0
5.00 - 5.99
6.00 - 6.99
7.00 - 7.99
8.00 - 8.99
Manila Bay Area
River
Provincial Boundary
Road
DISSOLVED OXYGEN CONCENTRATION, 2013 LAGUNA DE BAY
Scale 1:200,000
0
1.75
3.5
7
10.5
14
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

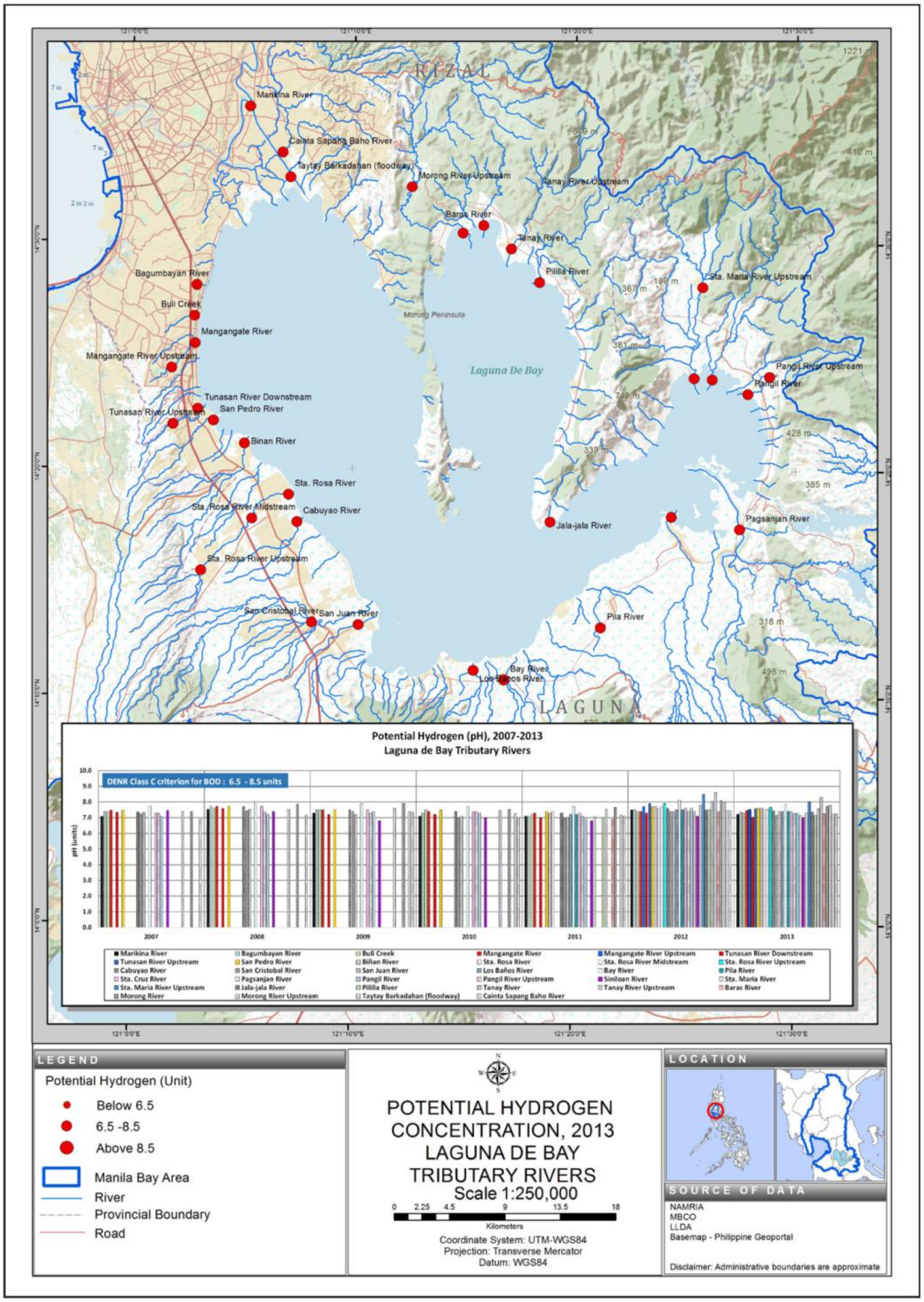
Map 93


Dissolved Oxygen (DO), 2007-2013
Laguna de Bay Tributary Rivers
DENR Class C criterion for DO : 5.0 mg/L
DO (mg/L)
Laguna De Bay
LEGEND
Dissolved Oxygen (mg/L)
Below 5.0
5.00 - 5.99
6.00 - 6.99
7.00 - 7.99
8.00 - 8.99
Manila Bay Area
River
Provincial Boundary
Road
DISSOLVED OXYGEN CONCENTRATION, 2013
LAGUNA DE BAY TRIBUTARY RIVERS
Scale 1:250,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

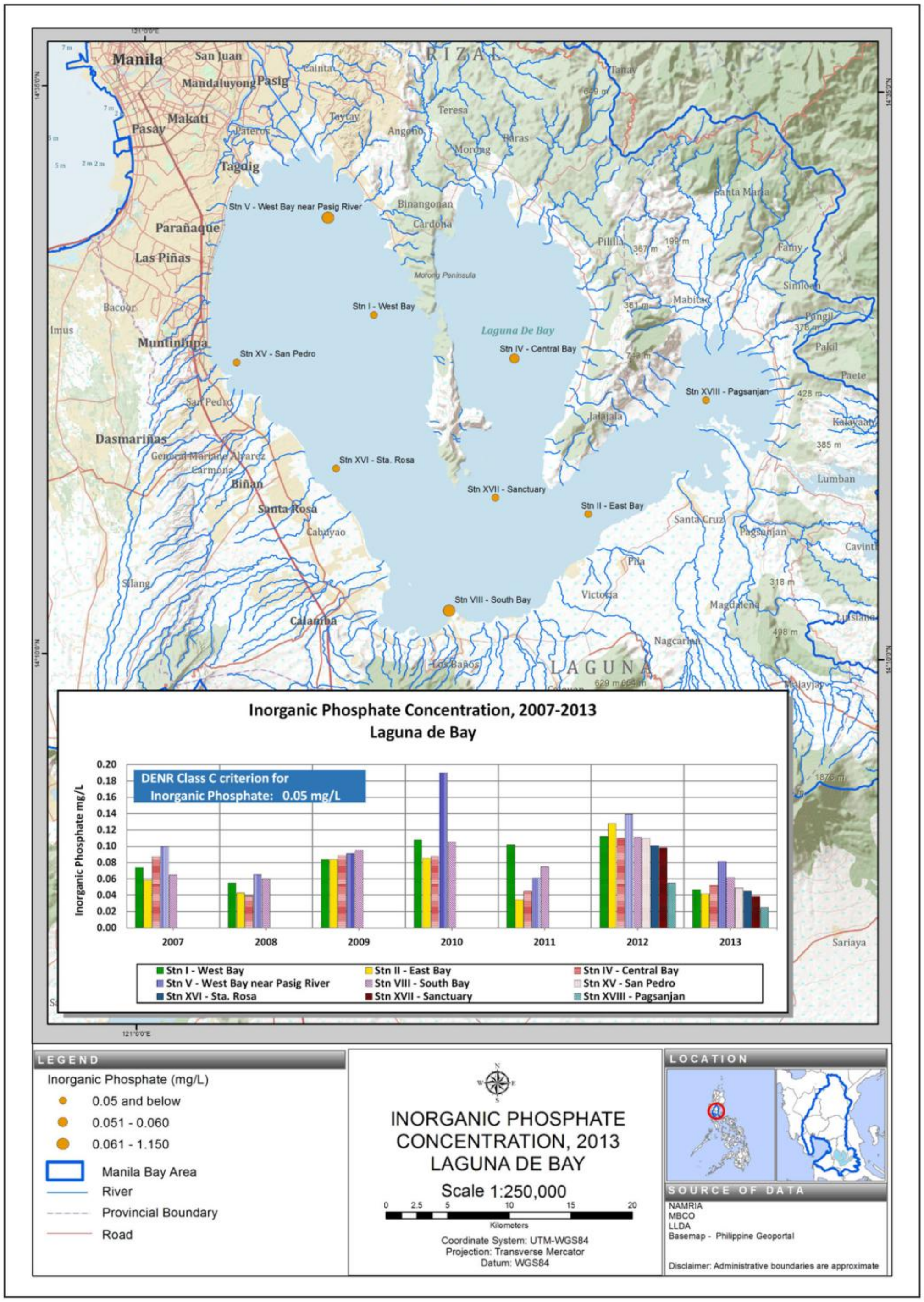
Map 94


West Bay near Pasig River
West Bay
San Pedro
Central Bay
Laguna De Bay
Morong Peninsula
Pagsanjan
Sta. Rosa
Santuary
East Bay
South Bay
Metro Manila
Rizal
Cavite
Potential Hydrogen (pH), 2007-2013
Laguna de Bay
DENR Class C criterion for pH: 6.5 - 8.5 units
pH (units)
11
10
9
8
7
6
5
4
3
2
1
0
2007
2008
2009
2010
2011
2012
2013
Stn I - West Bay
Stn II - East Bay
Stn IV - Central Bay
Stn V - West Bay near Pasig River
Stn VIII - South Bay
Stn XV - San Pedro
Stn XVI - Sta. Rosa
Stn XVII - Sanctuary
Stn XVIII - Pagsanjan
LEGEND
Potential Hydrogen (Unit)
Below 6.5
6.5 -8.5
Above 8.5
Manila Bay Area
River
Provincial Boundary
Road
POTENTIAL HYDROGEN
CONCENTRATION, 2013
LAGUNA DE BAY
Scale 1:200,000
0 2 4 8 12 16
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

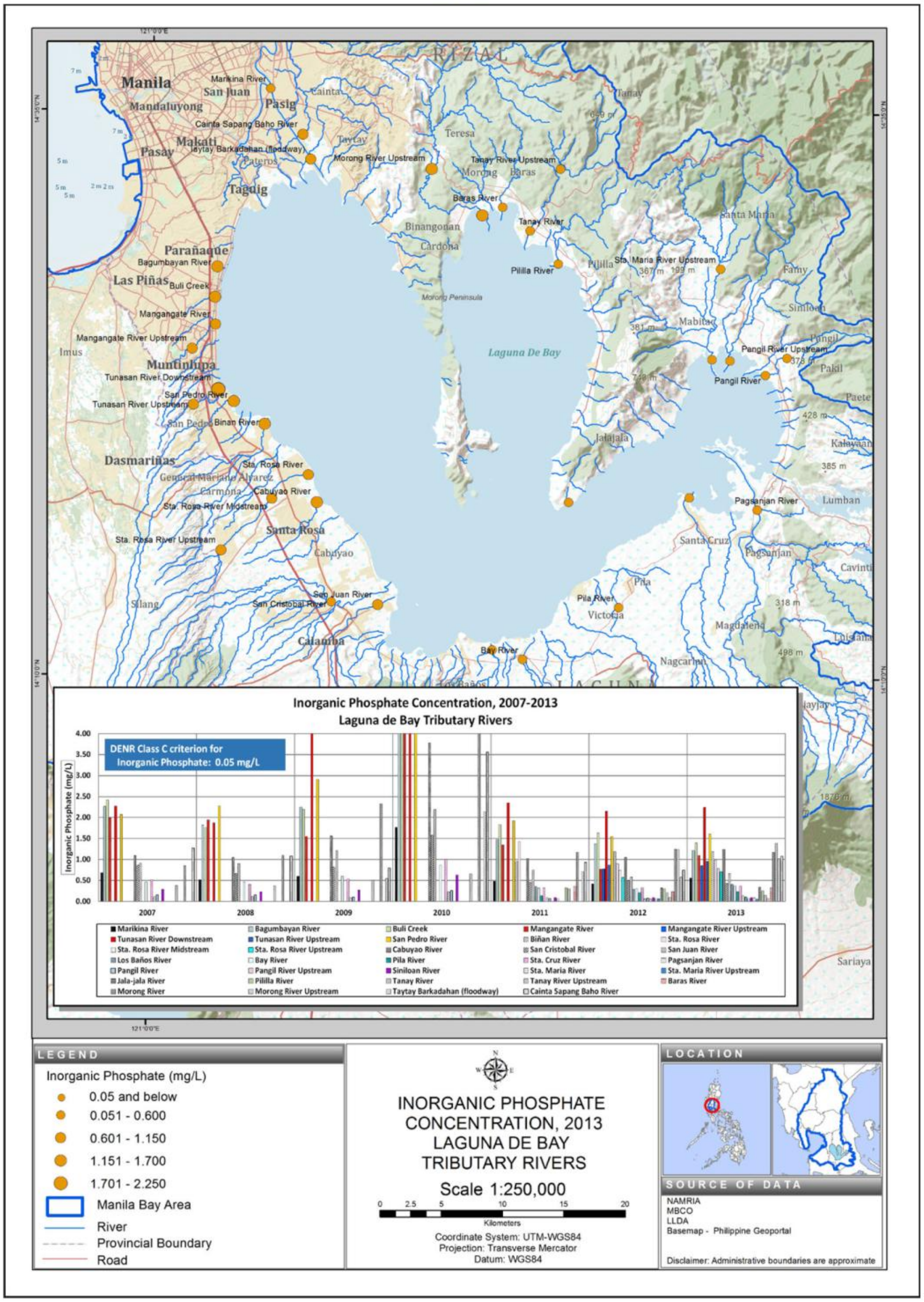
Map 95


RIZAL
LAGUNA
Laguna De Bay
Morong Peninsula
Marikina River
Cainta Sapang Baho River
Taytay Barkadahan (floodway)
Morong River Upstream
Tanay River Upstream
Baras River
Tanay River
Pililla River
Sta. Maria River Upstream
Bagumbayan River
Buli Creek
Mangangate River
Mangangate River Upstream
Tunasan River Downstream
San Pedro River
Tunasan River Upstream
Binan River
Sta. Rosa River
Sta. Rosa River Midstream
Cabuyao River
Sta. Rosa River Upstream
San Cristobal River
San Juan River
Bay River
Los Baños River
Pila River
Jala-jala River
Pagsanjan River
Pangil River Upstream
Pangil River
Potential Hydrogen (pH), 2007-2013
Laguna de Bay Tributary Rivers
DENR Class C criterion for BOD : 6.5 - 8.5 units
pH (units)
2007
2008
2009
2010
2011
2012
2013
Marikina River
Bagumbayan River
Buli Creek
Mangangate River
Mangangate River Upstream
Tunasan River Downstream
Tunasan River Upstream
San Pedro River
Biñan River
Sta. Rosa River
Sta. Rosa River Midstream
Sta. Rosa River Upstream
Cabuyao River
San Cristobal River
San Juan River
Los Baños River
Bay River
Pila River
Sta. Cruz River
Pagsanjan River
Pangil River
Pangil River Upstream
Siniloan River
Sta. Maria River
Sta. Maria River Upstream
Jala-jala River
Pililla River
Tanay River
Tanay River Upstream
Baras River
Morong River
Morong River Upstream
Taytay Barkadahan (floodway)
Cainta Sapang Baho River
LEGEND
Potential Hydrogen (Unit)
Below 6.5
6.5 -8.5
Above 8.5
Manila Bay Area
River
Provincial Boundary
Road
POTENTIAL HYDROGEN
CONCENTRATION, 2013
LAGUNA DE BAY
TRIBUTARY RIVERS
Scale 1:250,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

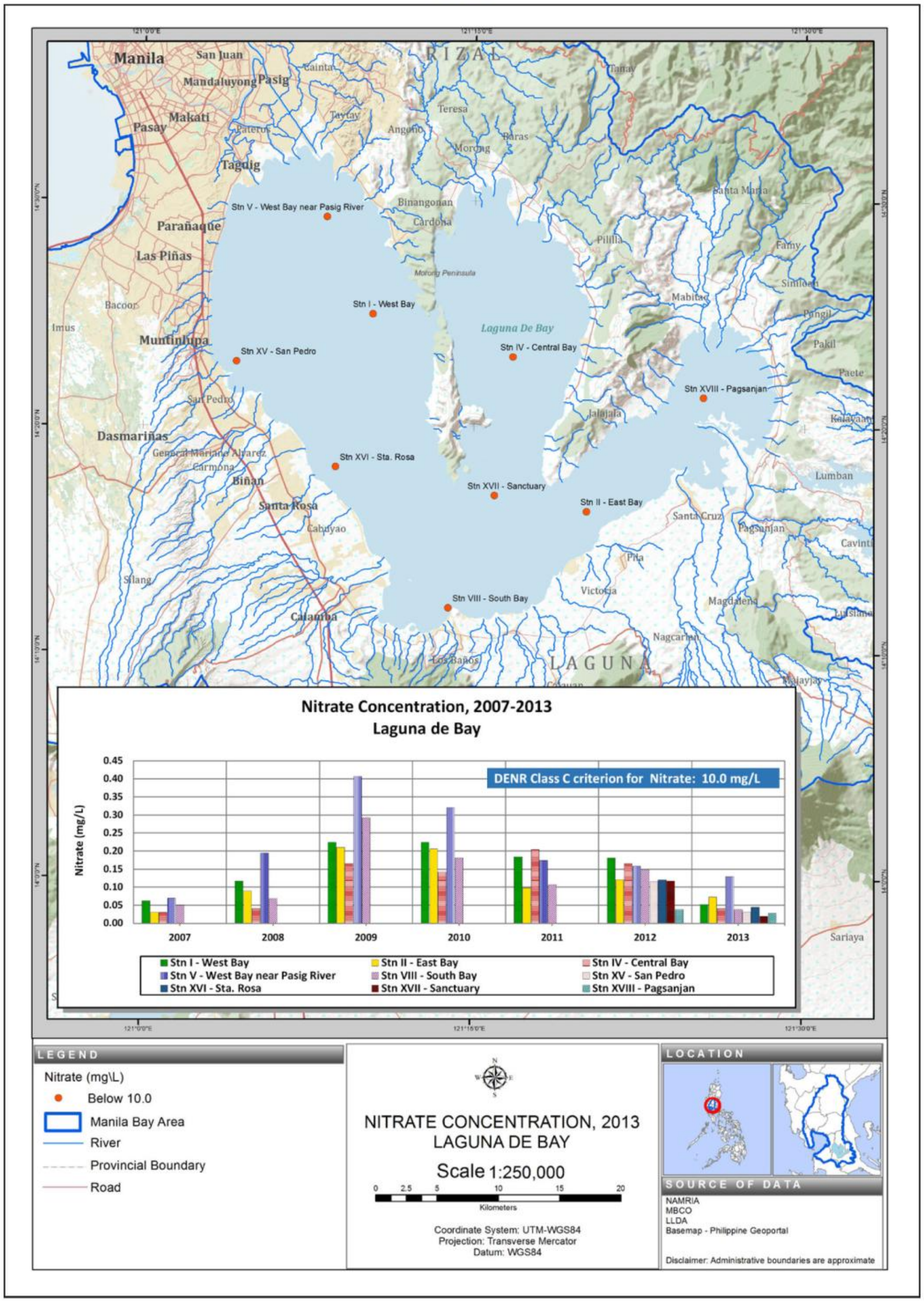
Map 96


Inorganic Phosphate Concentration, 2007-2013
Laguna de Bay
DENR Class C criterion for Inorganic Phosphate: 0.05 mg/L
Inorganic Phosphate mg/L
Stn I - West Bay
Stn II - East Bay
Stn IV - Central Bay
Stn V - West Bay near Pasig River
Stn VIII - South Bay
Stn XV - San Pedro
Stn XVI - Sta. Rosa
Stn XVII - Sanctuary
Stn XVIII - Pagsanjan
Laguna De Bay
Morong Peninsula
Manila
Pasay
Makati
Taguig
Parañaque
Las Piñas
Muntinlupa
Dasmariñas
Santa Rosa
Calamba
Los Baños
Santa Cruz
Pagsanjan
RIZAL
LAGUNA
LEGEND
Inorganic Phosphate (mg/L)
0.05 and below
0.051 - 0.060
0.061 - 1.150
Manila Bay Area
River
Provincial Boundary
Road
INORGANIC PHOSPHATE CONCENTRATION, 2013 LAGUNA DE BAY
Scale 1:250,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

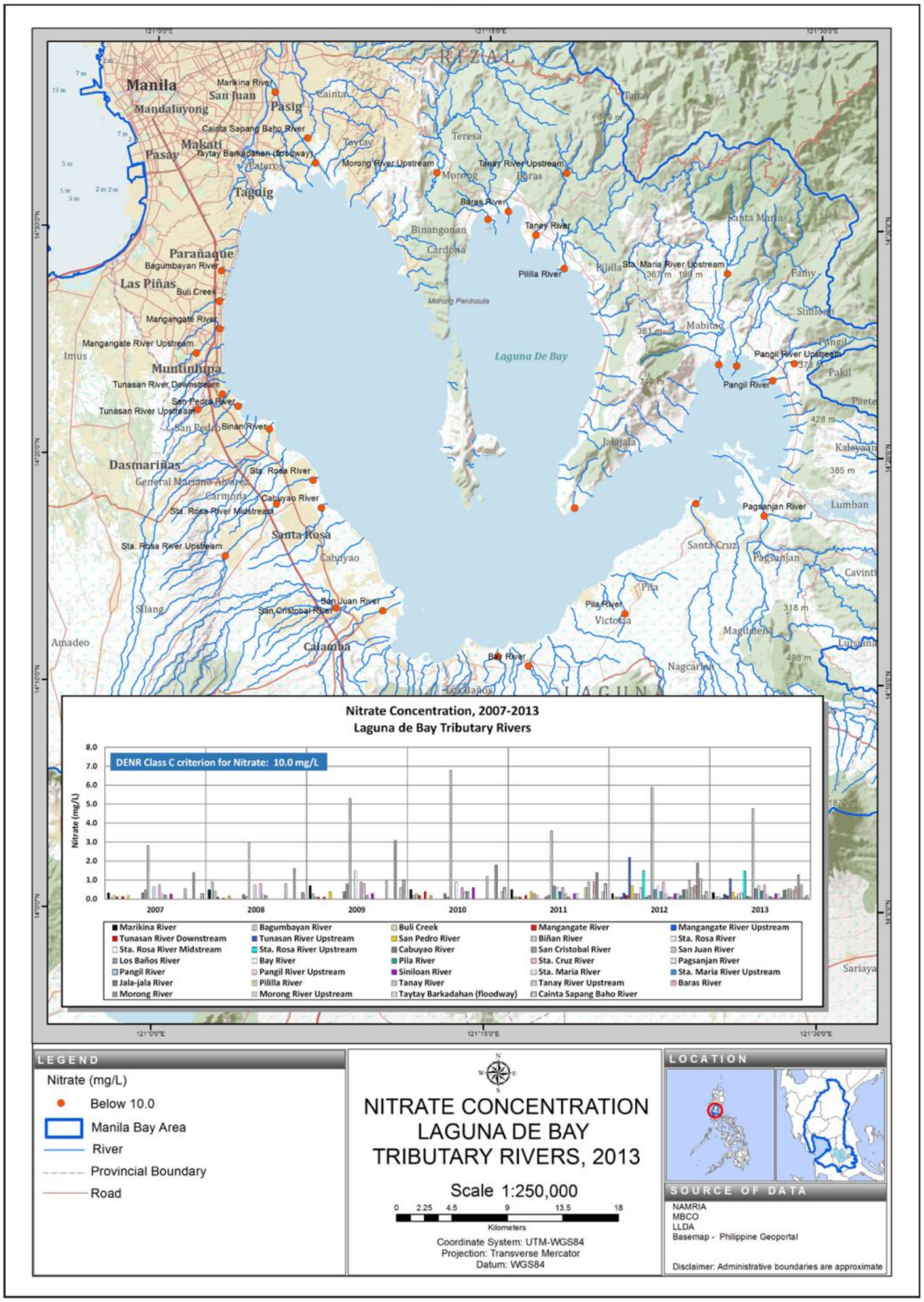
Map 97


Inorganic Phosphate Concentration, 2007-2013
Laguna de Bay Tributary Rivers
DENR Class C criterion for Inorganic Phosphate: 0.05 mg/L
Inorganic Phosphate (mg/L)
2007
2008
2009
2010
2011
2012
2013
Marikina River
Tunasan River Downstream
Sta. Rosa River Midstream
Los Baños River
Pangil River
Jala-jala River
Morong River
Bagumbayan River
Tunasan River Upstream
Sta. Rosa River Upstream
Bay River
Pangil River Upstream
Pililla River
Morong River Upstream
Buli Creek
San Pedro River
Cabuyao River
Pila River
Siniloan River
Tanay River
Taytay Barkadahan (floodway)
Mangangate River
Biñan River
San Cristobal River
Sta. Cruz River
Sta. Maria River
Tanay River Upstream
Cainta Sapang Baho River
Mangangate River Upstream
Sta. Rosa River
San Juan River
Pagsanjan River
Sta. Maria River Upstream
Baras River
Laguna De Bay
LEGEND
Inorganic Phosphate (mg/L)
0.05 and below
0.051 - 0.600
0.601 - 1.150
1.151 - 1.700
1.701 - 2.250
Manila Bay Area
River
Provincial Boundary
Road
INORGANIC PHOSPHATE CONCENTRATION, 2013 LAGUNA DE BAY TRIBUTARY RIVERS
Scale 1:250,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

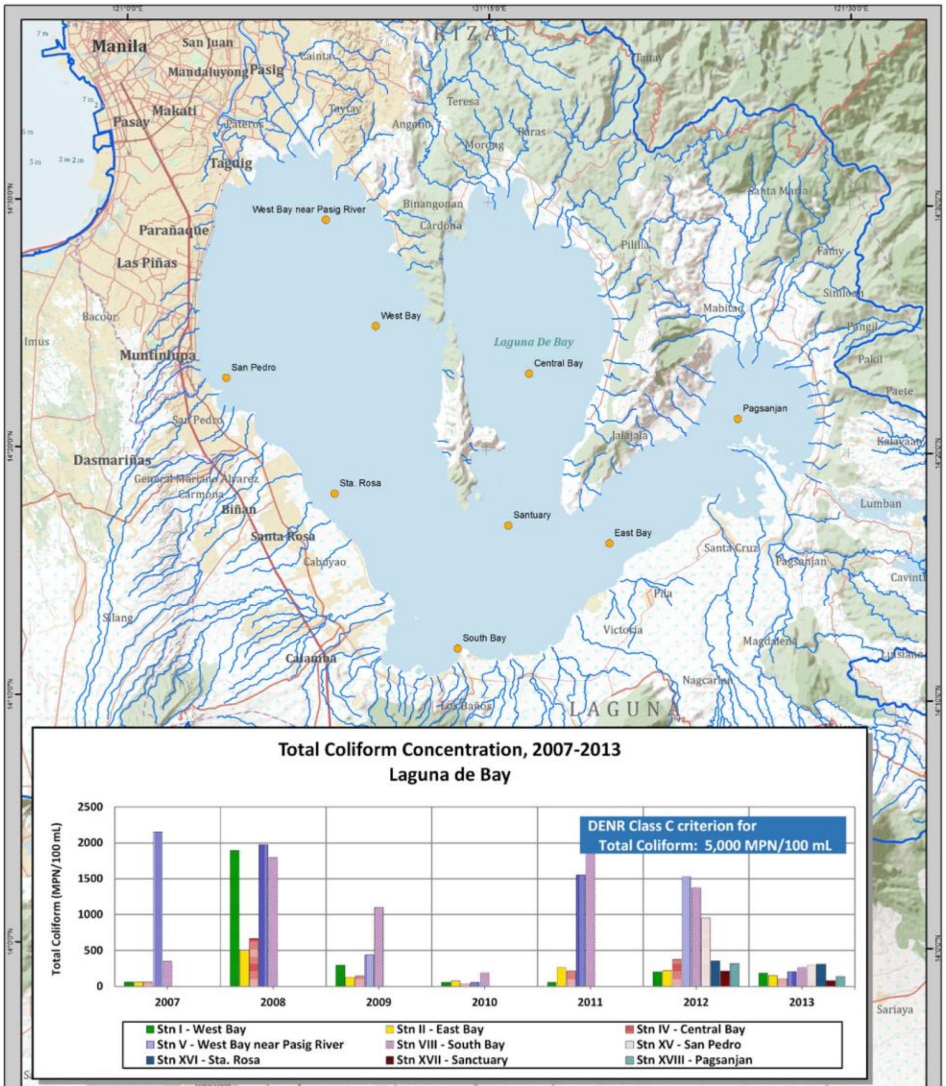
Map 98


Manila
San Juan
Mandaluyong
Pasig
Cainta
Makati
Pasay
Pateros
Taytay
Angono
Teresa
Morong
Baras
Tanay
Taguig
RIZAL
Stn V - West Bay near Pasig River
Binangonan
Cardona
Parañaque
Las Piñas
Morong Peninsula
Pililla
Santa Maria
Famy
Siniloan
Mabitac
Bacoor
Imus
Stn I - West Bay
Laguna De Bay
Pangil
Pakil
Muntinlupa
Stn XV - San Pedro
Stn IV - Central Bay
Paete
Stn XVIII - Pagsanjan
San Pedro
Jalajala
Kalayaan
Dasmariñas
General Mariano Alvarez
Carmona
Stn XVI - Sta. Rosa
Biñan
Lumban
Stn XVII - Sanctuary
Santa Rosa
Stn II - East Bay
Santa Cruz
Pagsanjan
Cabuyao
Cavinti
Pila
Silang
Victoria
Stn VIII - South Bay
Magdalena
Calamba
Nagcarlan
Los Baños
LAGUNA
Sariaya
Nitrate Concentration, 2007-2013
Laguna de Bay
Nitrate (mg/L)
DENR Class C criterion for Nitrate: 10.0 mg/L
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2007
2008
2009
2010
2011
2012
2013
Stn I - West Bay
Stn II - East Bay
Stn IV - Central Bay
Stn V - West Bay near Pasig River
Stn VIII - South Bay
Stn XV - San Pedro
Stn XVI - Sta. Rosa
Stn XVII - Sanctuary
Stn XVIII - Pagsanjan
LEGEND
Nitrate (mg\L)
Below 10.0
Manila Bay Area
River
Provincial Boundary
Road
NITRATE CONCENTRATION, 2013
LAGUNA DE BAY
Scale 1:250,000
0 2.5 5 10 15 20
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 99


Nitrate Concentration, 2007-2013
Laguna de Bay Tributary Rivers
DENR Class C criterion for Nitrate: 10.0 mg/L
Nitrate (mg/L)
2007
2008
2009
2010
2011
2012
2013
Marikina River
Bagumbayan River
Buli Creek
Mangangate River
Mangangate River Upstream
Tunasan River Downstream
Tunasan River Upstream
San Pedro River
Biñan River
Sta. Rosa River
Sta. Rosa River Midstream
Sta. Rosa River Upstream
Cabuyao River
San Cristobal River
San Juan River
Los Baños River
Bay River
Pila River
Sta. Cruz River
Pagsanjan River
Pangil River
Pangil River Upstream
Siniloan River
Sta. Maria River
Sta. Maria River Upstream
Jala-jala River
Pililla River
Tanay River
Tanay River Upstream
Baras River
Morong River
Morong River Upstream
Taytay Barkadahan (floodway)
Cainta Sapang Baho River
Laguna De Bay
LEGEND
Nitrate (mg/L)
Below 10.0
Manila Bay Area
River
Provincial Boundary
Road
NITRATE CONCENTRATION
LAGUNA DE BAY
TRIBUTARY RIVERS, 2013
Scale 1:250,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 100



LEGEND

Total Coliform (MPN/100mL)

- 5,000 and below
- Manila Bay Area
- River
- Provincial Boundary
- Road

TOTAL COLIFORM CONCENTRATION, 2013 LAGUNA DE BAY

Scale 1:250,000

0 2.25 4.5 9 13.5 18 Kilometers

Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84

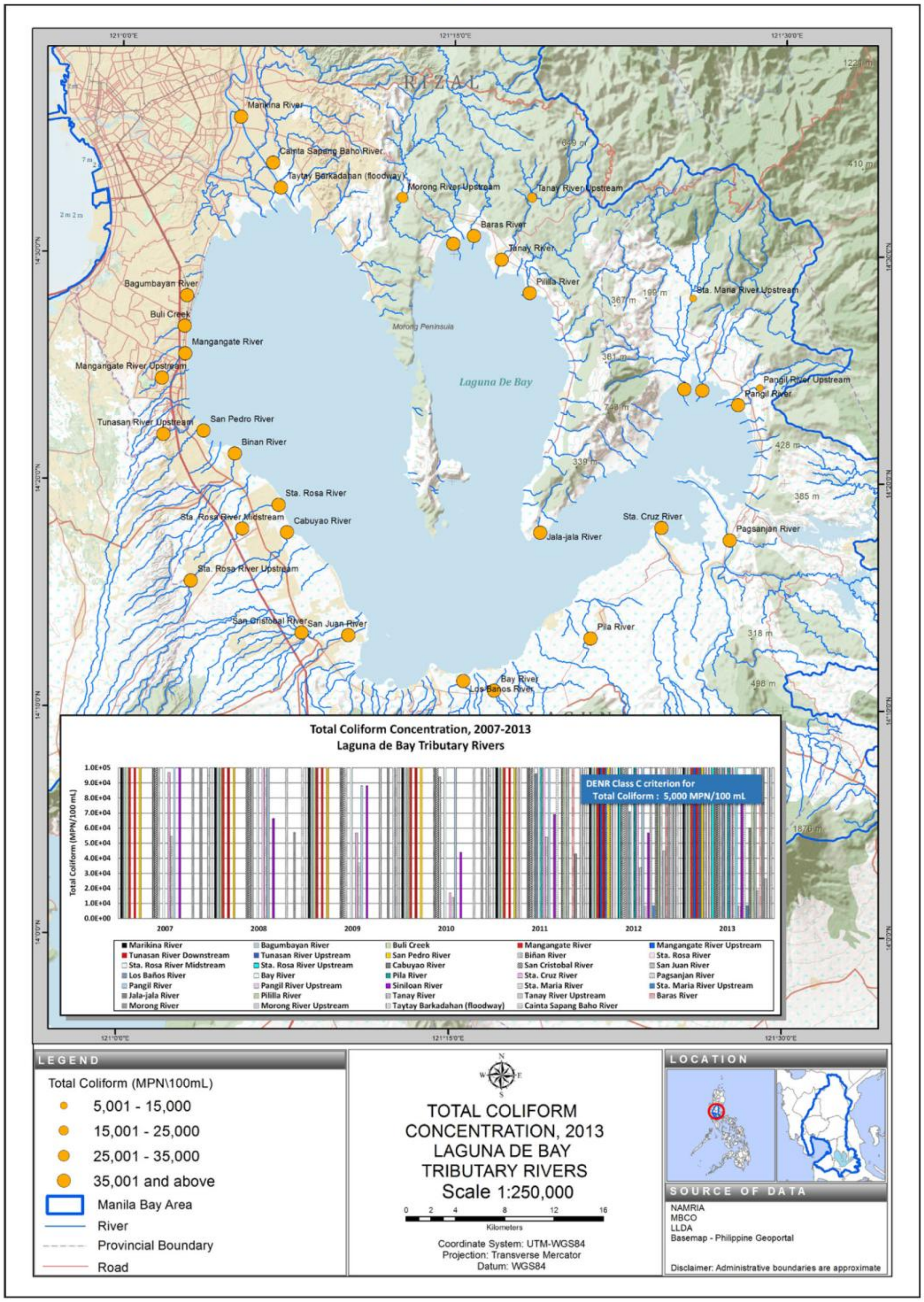
LOCATION

SOURCE OF DATA

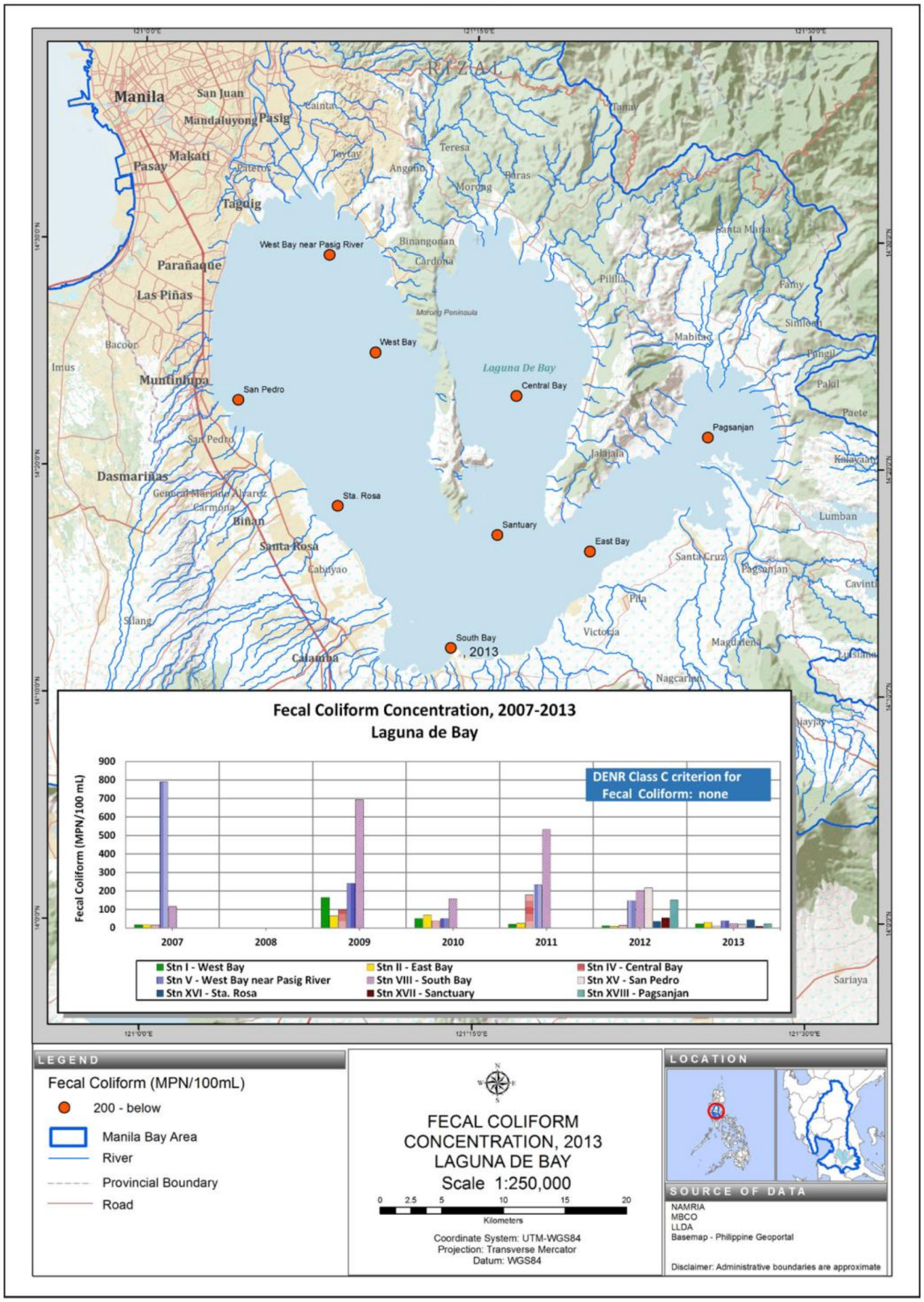
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal

Disclaimer: Administrative boundaries are approximate

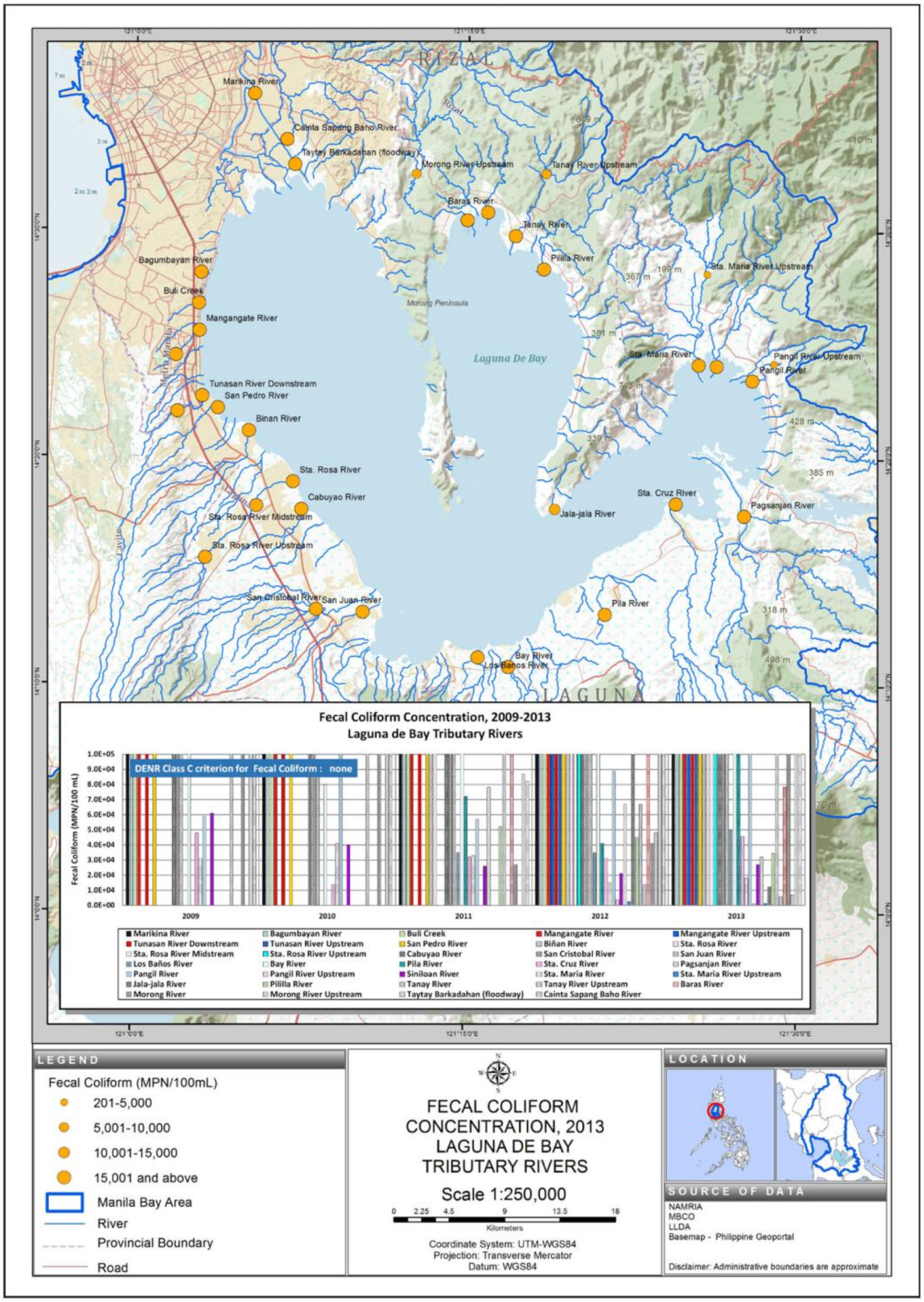
Map 101


RIZAL
Marikina River
Cainta Sapang Baho River
Taytay Barkadahan (floodway)
Morong River Upstream
Tanay River Upstream
Baras River
Tanay River
Pililla River
Sta. Maria River Upstream
Bagumbayan River
Buli Creek
Mangangate River
Mangangate River Upstream
Morong Peninsula
Laguna De Bay
Pangil River Upstream
Pangil River
Tunasan River Upstream
San Pedro River
Binan River
Sta. Rosa River
Sta. Rosa River Midstream
Cabuyao River
Sta. Cruz River
Jala-jala River
Pagsanjan River
Sta. Rosa River Upstream
San Cristobal River
San Juan River
Pila River
Bay River
Los Baños River
Total Coliform Concentration, 2007-2013
Laguna de Bay Tributary Rivers
Total Coliform (MPN/100 mL)
DENR Class C criterion for Total Coliform : 5,000 MPN/100 mL
2007
2008
2009
2010
2011
2012
2013
Marikina River
Bagumbayan River
Buli Creek
Mangangate River
Mangangate River Upstream
Tunasan River Downstream
Tunasan River Upstream
San Pedro River
Biñan River
Sta. Rosa River
Sta. Rosa River Midstream
Sta. Rosa River Upstream
Cabuyao River
San Cristobal River
San Juan River
Los Baños River
Bay River
Pila River
Sta. Cruz River
Pagsanjan River
Pangil River
Pangil River Upstream
Siniloan River
Sta. Maria River
Sta. Maria River Upstream
Jala-jala River
Pililla River
Tanay River
Tanay River Upstream
Baras River
Morong River
Morong River Upstream
Taytay Barkadahan (floodway)
Cainta Sapang Baho River
LEGEND
Total Coliform (MPN\100mL)
5,001 - 15,000
15,001 - 25,000
25,001 - 35,000
35,001 and above
Manila Bay Area
River
Provincial Boundary
Road
TOTAL COLIFORM CONCENTRATION, 2013
LAGUNA DE BAY
TRIBUTARY RIVERS
Scale 1:250,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 102


Fecal Coliform Concentration, 2007-2013
Laguna de Bay
Fecal Coliform (MPN/100 mL)
DENR Class C criterion for Fecal Coliform: none
2007
2008
2009
2010
2011
2012
2013
Stn I - West Bay
Stn II - East Bay
Stn IV - Central Bay
Stn V - West Bay near Pasig River
Stn VIII - South Bay
Stn XV - San Pedro
Stn XVI - Sta. Rosa
Stn XVII - Sanctuary
Stn XVIII - Pagsanjan
West Bay near Pasig River
West Bay
San Pedro
Central Bay
Pagsanjan
Sta. Rosa
Santuary
East Bay
South Bay
, 2013
Laguna De Bay
Morong Peninsula
Manila
San Juan
Mandaluyong
Pasig
Makati
Pasay
Taguig
Parañaque
Las Piñas
Muntinlupa
Dasmariñas
Biñan
Santa Rosa
Cabuyao
Calamba
Binangonan
Cardona
Santa Cruz
Pagsanjan
LEGEND
Fecal Coliform (MPN/100mL)
200 - below
Manila Bay Area
River
Provincial Boundary
Road
FECAL COLIFORM CONCENTRATION, 2013 LAGUNA DE BAY
Scale 1:250,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 103


RIZAL
LAGUNA
Laguna De Bay
Morong Peninsula
Marikina River
Cainta Sapang Baho River
Taytay Barkadahan (floodway)
Morong River Upstream
Tanay River Upstream
Baras River
Tanay River
Pililla River
Sta. Maria River Upstream
Bagumbayan River
Buli Creek
Mangangate River
Tunasan River Downstream
San Pedro River
Binan River
Sta. Rosa River
Cabuyao River
Sta. Rosa River Midstream
Sta. Rosa River Upstream
San Cristobal River
San Juan River
Bay River
Los Banos River
Pila River
Jala-jala River
Sta. Cruz River
Pagsanjan River
Sta. Maria River
Pangil River Upstream
Pangil River
Fecal Coliform Concentration, 2009-2013
Laguna de Bay Tributary Rivers
DENR Class C criterion for Fecal Coliform : none
Fecal Coliform (MPN/100 mL)
1.0E+05
9.0E+04
8.0E+04
7.0E+04
6.0E+04
5.0E+04
4.0E+04
3.0E+04
2.0E+04
1.0E+04
0.0E+00
2009
2010
2011
2012
2013
Marikina River
Bagumbayan River
Buli Creek
Mangangate River
Mangangate River Upstream
Tunasan River Downstream
Tunasan River Upstream
San Pedro River
Biñan River
Sta. Rosa River
Sta. Rosa River Midstream
Sta. Rosa River Upstream
Cabuyao River
San Cristobal River
San Juan River
Los Baños River
Bay River
Pila River
Sta. Cruz River
Pagsanjan River
Pangil River
Pangil River Upstream
Siniloan River
Sta. Maria River
Sta. Maria River Upstream
Jala-jala River
Pililla River
Tanay River
Tanay River Upstream
Baras River
Morong River
Morong River Upstream
Taytay Barkadahan (floodway)
Cainta Sapang Baho River
121°0'0"E
121°15'0"E
121°30'0"E
LEGEND
Fecal Coliform (MPN/100mL)
201-5,000
5,001-10,000
10,001-15,000
15,001 and above
Manila Bay Area
River
Provincial Boundary
Road
FECAL COLIFORM
CONCENTRATION, 2013
LAGUNA DE BAY
TRIBUTARY RIVERS
Scale 1:250,000
0 2.25 4.5 9 13.5 18
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
LLDA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

C. WATER QUALITY OF BATHING BEACHES

In a tropical country like the Philippines, summer means fiesta; outing and swimming time for Filipinos. Beaches are favorite destinations for summer outings. For people living in urban centers within the Manila Bay Area and those who can afford to travel, beaches away from the Manila Bay area are the place to go to. But for residents of Metro Manila who cannot afford the high cost of travelling, Manila Bay serves as an attractive alternative.

Summer months put the Manila Bay area in the news as people use the area for swimming and recreational activities. Mainstream media presents news segments featuring people swimming in the waters of Manila Bay along the coastline of the City of Manila and its neighboring areas. This occurs despite repeated warnings that the area is not fit for bathing and swimming.

The EMB regularly collects water samples along the coast of Manila Bay for coliform monitoring. Nineteen sampling points scattered in the provinces of Bataan and Cavite, and along the shores fronting the City of Manila, identified as swimming areas are monitored to determine which parts of the Manila Bay are safe for swimming activities. Map 104 shows the location of the 19 monitoring stations.

Data shows that total coliform in the Manila Bay area exceeds the standard set for bathing purposes.

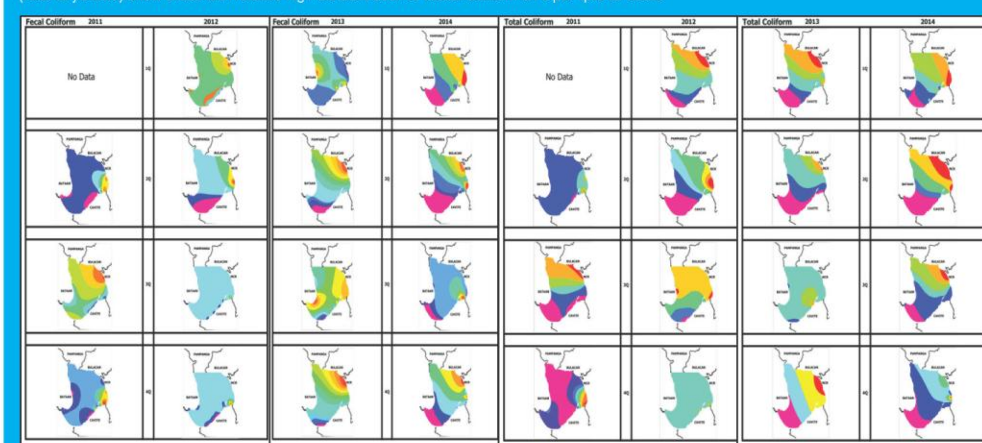
Sources of bacterial pollution include runoff from woodlands, pastures, and feedlots; septic tanks and sewage plants; and animals and wild fowl. Domestic animals contribute heavily to the bacterial population. Many coliform bacteria may be directly deposited into natural streams from waste in water and runoff from areas with high concentration of animals and humans. Built-up areas and agricultural areas devoted to animal raising can be associated with the increase in total coliform content in the area.

Coliform bacteria are a commonly used bacterial indicators of sanitary quality of foods and water. Coliforms can be found in the aquatic environment, in soil and on vegetation; they are universally present in large numbers in the feces of warm-blooded animals. While coliforms themselves are not normally causes of serious illness, they are easy to culture and their presence is used to indicate that other pathogenic organisms of fecal origin may be present. Such pathogens include disease-causing bacteria, viruses, or protozoa and many multicellular parasites. Coliform procedures are performed in aerobic or reduced oxygen conditions.

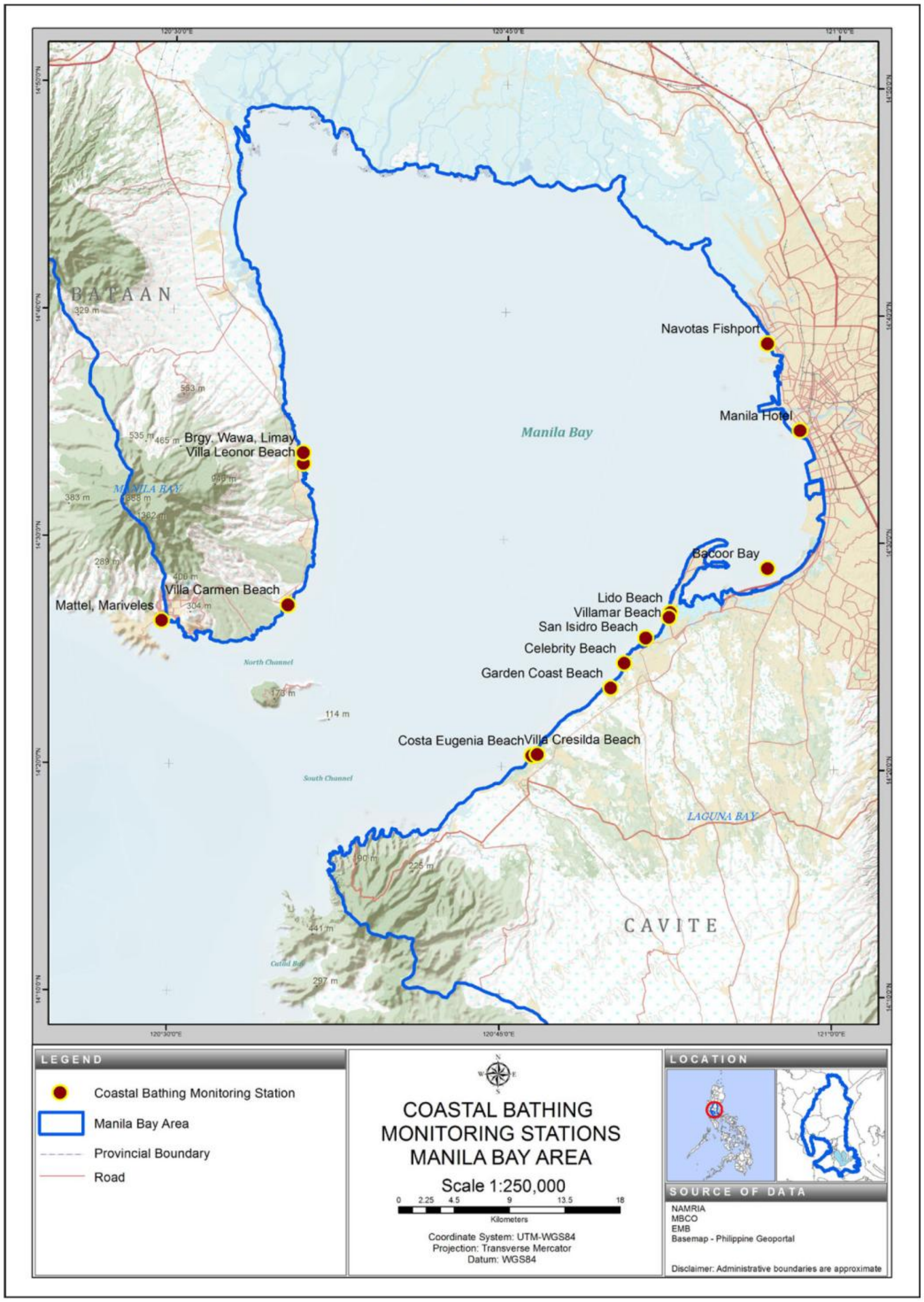
Box 6. Series of maps based on interpolated 2012, 2013 and 2014 data from nineteen sampling points within the Manila Bay water for fecal coliform

The figures are generated just to illustrate how the specific parameter is distributed within the area given the point values and using a specific interpolation model, it does not attempt to explain movements of the parameters to simulate the circulation pattern of the water body. It is neither generated to explicitly and categorically show which part of the watershed contributes significantly to the parameter being observed and where the organic pollutants are originating. Modeling movement and explaining the origin of pollutants requires extensive data and complex analysis. The resulting maps were generated using a very limited data based on incomplete sample data collection.

Map of sample data for faecal coliform for the four quarters of 2013 shows the spatial distribution of the parameter in the Manila Bay waters. Warm colors (reds to yellows) show areas with relative high concentration of faecal coliform on a per quarter basis.



Map 104


BATAAN
Manila Bay
Navotas Fishport
Manila Hotel
Brgy. Wawa, Limay
Villa Leonor Beach
Bacoor Bay
Villa Carmen Beach
Mattel, Mariveles
Lido Beach
Villamar Beach
San Isidro Beach
Celebrity Beach
Garden Coast Beach
Costa Eugenia Beach
Villa Cresilda Beach
North Channel
South Channel
LAGUNA BAY
CAVITE
LEGEND
Coastal Bathing Monitoring Station
Manila Bay Area
Provincial Boundary
Road
COASTAL BATHING
MONITORING STATIONS
MANILA BAY AREA
Scale 1:250,000
0 2.25 4.5 9 13.5 18
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

D. WATER QUALITY OF MARINE WATERS

Under the IEMP, bay-wide monitoring was systematically conducted from different sections of Manila Bay. The Bay was divided into 9 grids for sampling station identification. Table 13 describes the location of the 9 sampling stations.

The waters of Manila Bay was regularly monitored for its level of DO, pH, salinity, temperature, conductivity, and phosphate content. Shown in Table 14 are the results of the monitoring for 2014.

Decreasing trends of DO from top to bottom in all stations were observed in the bay. Surface and mid-depth DO conformed to the criteria of 5mg/L in all stations. However, only three (3) stations passed the DO criteria at the bottom.

High levels of pH ranging from 8.4 to 9.3 were observed in the bay. Potential hydrogen values are affected by the excess hydrogen H+ present in sea water. This excess hydrogen is affected by the carbon cycles in photosynthetic activities by phytoplankton and algae. The high pH value is attributed to photosynthetic action by phytoplankton and photosynthetic microorganisms since they have to break down carbonate ions consuming free hydrogen ions into aqueous carbon dioxide and water.

Table 13. Manila Bay Offshore Water Quality Monitoring Stations

Station Number	Coordinates: Latitude	Coordinates: Longitude	Depth (m)	Distance (km)	From
1	14°40'0.12"	120°50'32.6394"	11.7	14.68	Mouth of Pasig River
				7.56	Mouth of MMO River
2	14°40'39.1954"	120°45'40.32"	13.4	14.79	Mouth of MMO River
				10.23	Mouth of Angat River
				14.69	Mouth of Pampanga River
3	14°40'17.148"	120°37'29.2794"	9.9	11.04	Mouth of Pampanga River
				10.23	Mouth of Balanga River
				5.62	Mouth of Orion River
4	14°34'42.06"	120°37'53.0394"	22	4.29	Limay Town Proper
				5.85	Petron Limay Refinery
5	14°27'9"	120°37'33.9594"	38.8	3.44	Cabcaben Mariveles, Bataan
6	14°27'10.9794"	120°45'17.64"	30.5	10.46	Mouth of Ylang-Ylang River
7	14°28'4.2954"	120°50'27.9594"	18.1	6.46	Mouth of Ylang-Ylang River
				4.74	Cavite City
8	14°35'3.984"	120°45'43.56"	22.6	20.32	Mouth of Pasig River
				20.08	Mouth of MMO River
				20.29	Mouth of Angat River
				23.52	Mouth of Pampanga River
				24.96	Mouth of Balanga River
				17.70	Petron Limay Refinery
				21.48	Mouth of Ylang-Ylang River
9	14°35'26.952"	120°50'50.28"	17.7	10.12	Mouth of Pasig River
				13.90	Mouth of MMO River

Table 14. Physico-Chemical Characteristics (2014)

Station		DO (mg/L)	pH	Salinity	Temperature (°C)	Conductivity	Phosphate
1	Surface	8.57	8.43	2	29.5	31.6	1
	Mid	6.89	8.83	2.33	29.1	36.6	1.05
	Bottom	3.63	8.69	2.45	29.6	38.4	1.08
2	Surface	8.79	8.82	1.76	29.2	32.2	0.91
	Mid	7.46	8.96	2.38	29.1	37.2	1.05
	Bottom	4.73	8.76	2.47	29.4	38.6	1.08
3	Surface	10.77	8.72	0.71	29	10.6	0.97
	Mid	6.85	8.89	2.41	29.2	37.7	1.08
	Bottom	5.84	8.59	2.39	29.3	37.9	1.1
4	Surface	9.61	8.9	1.27	29.4	21.1	1.01
	Mid	7.84	8.95	2.44	29.4	38.1	0.94
	Bottom	6.39	8.82	2.49	29.5	38.9	1.09
5	Surface	8.92	9.04	2.61	31.3	40.6	1.01
	Mid	7.14	8.82	2.66	29.4	41.4	0.91
	Bottom	4.77	8.75	2.66	29.2	41.4	1.1
6	Surface	8.81	9.08	2.6	31.4	40.4	1.02
	Mid	7.18	8.96	2.59	31.2	40.4	0.88
	Bottom	5.99	8.8	2.67	29.6	41.4	8.98
7	Surface	10.25	9.22	2.58	32.2	40.2	0.92
	Mid	8.12	8.99	2.57	30.4	40.2	0.87
	Bottom	4.54	8.84	2.64	30	40.1	1.02
8	Surface	8.4	9.03	2.2	28.5	34.3	1.08
	Mid	7.01	8.94	2.44	29.2	37.9	1.09
	Bottom	7.48	8.95	2.46	29.1	38.2	1.12
9	Surface	7.82	8.7	1.63	28.8	25.9	0.86
	Mid	5.71	8.7	2.47	29.3	38.6	0.81
	Bottom	4.64	8.59	2.46	29.3	38.4	1.01

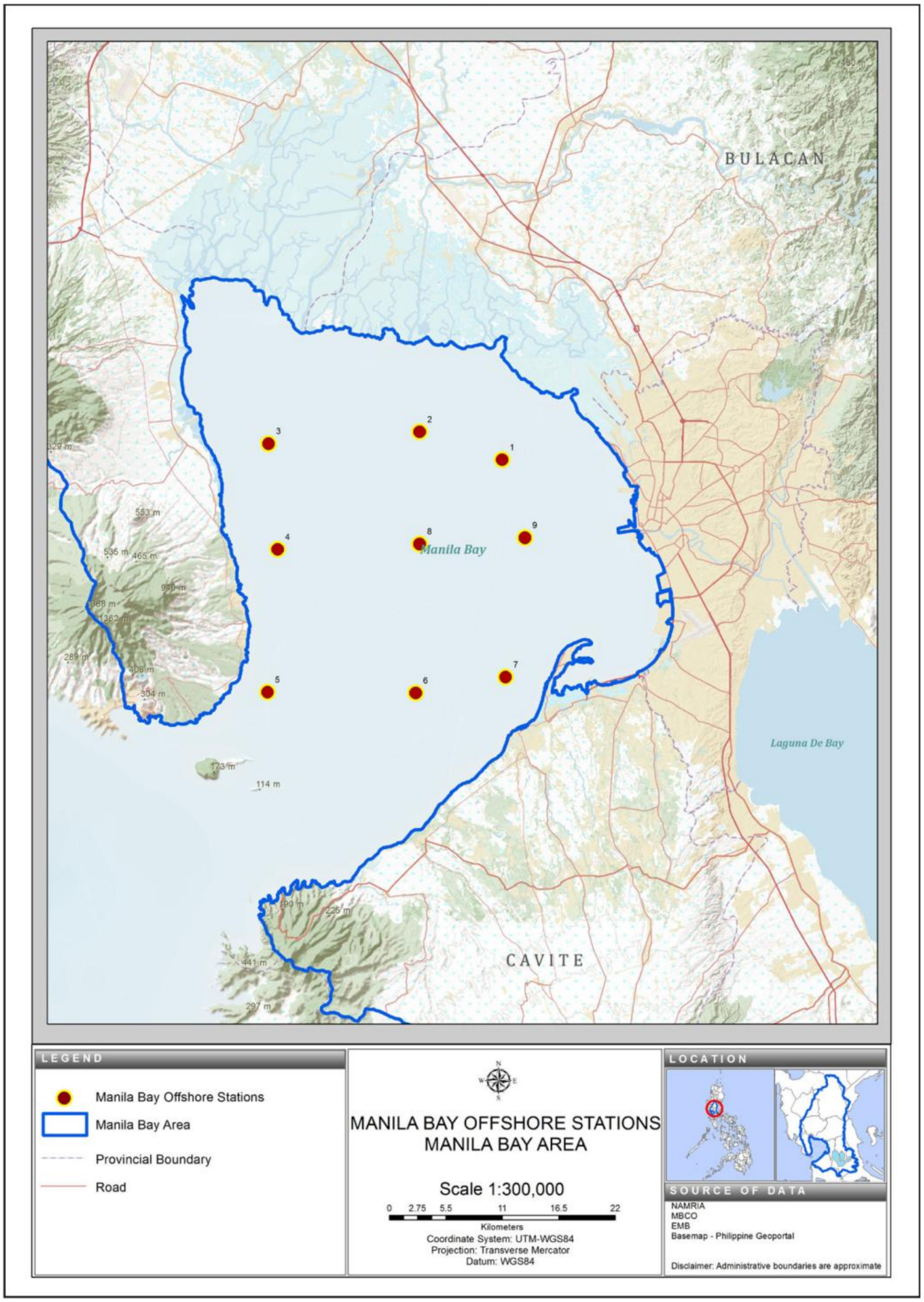
Box 7 Hypoxia in Manila Bay

Dissolved oxygen (DO) is an important aspect of the marine ecosystem that is essential for sustaining the majority of marine life. Hypoxia occurs when DO levels fall below 2 mg/L (or ~30% saturation). At these oxygen levels, animals generally begin to feel the effects of suffocation (Diaz and Rosenberg, 2008). In Manila Bay, Philippines, fisheries and aquaculture are major sources of livelihood (PEMSEA and MBEMP-MBIN, 2007), and they can be adversely affected by the occurrence of hypoxia. At its worst, hypoxia can cause mass mortality of fish and lead to the formation of dead zones where very little marine life can survive (Díaz and Rosenberg, 2008). Hypoxia and eutrophication have been previously observed in Manila Bay, with near-bottom DO levels in the bay falling to 1 mg/L (June 2008) and nutrient levels exceeding the ASEAN water quality criteria (Chang et al., 2009; Jacinto et al., 2006). The DENR water quality value for DO for Class SC waters is 5 mg/L (coastal and marine waters suitable for commercial and sustenance fishing and recreational use).

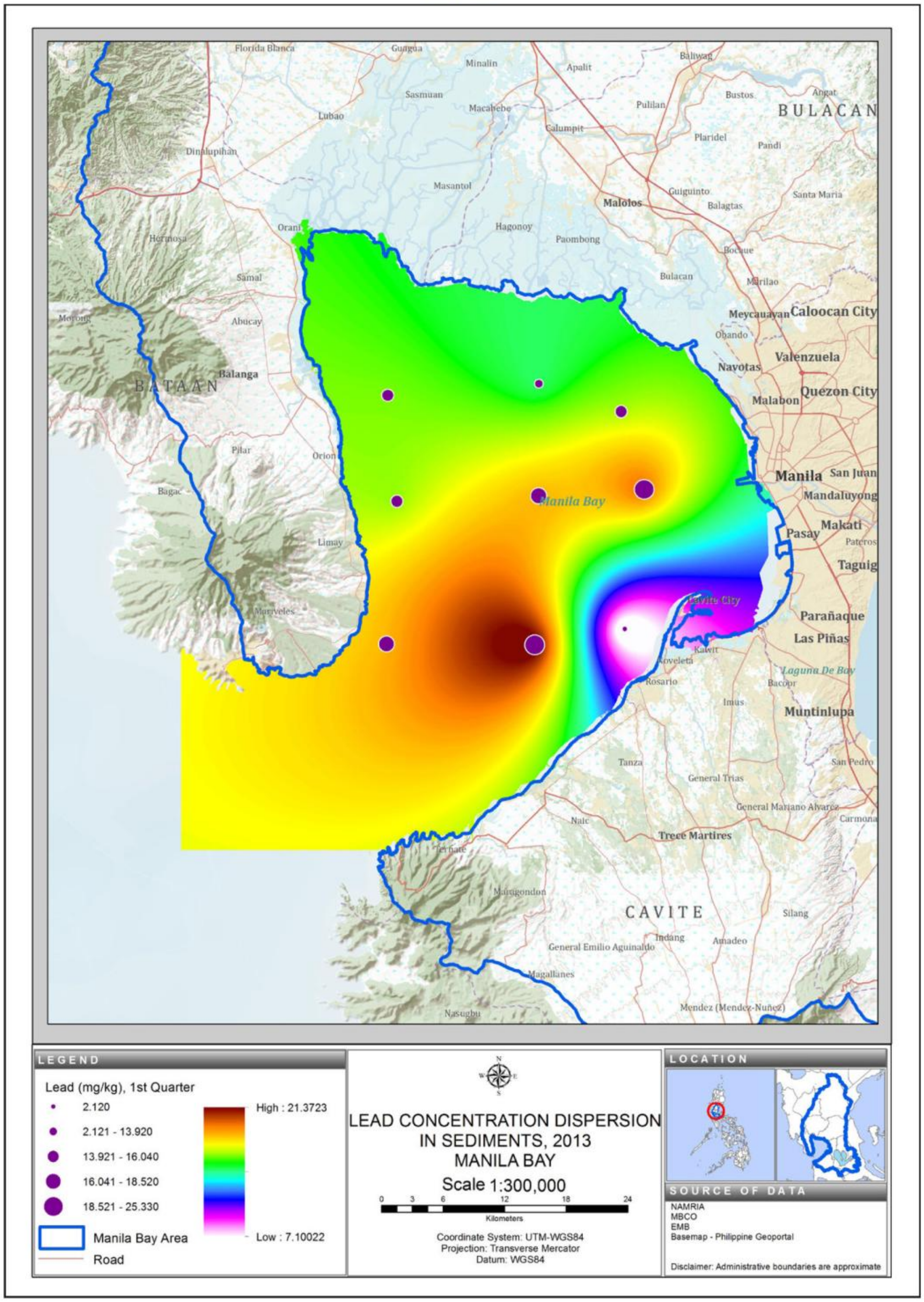
Five field surveys occupying 31 stations during the northeast monsoon (dry season) in February 2010 and February 2011 and the southwest monsoon (wet season) in July 2010, August 2011, and August 2012 were conducted to investigate the occurrence of hypoxia in Manila Bay.

Near-bottom DO levels for Manila Bay were as low as 0.12 mg/L in August 2012 during the wet season. Waters near the coast and up to the middle of the bay during the wet season surveys were hypoxic, with-bay wide averages falling to as low as 2.10 mg/L (Aug. 2011). Stratification of the water column especially during the wet season when there is a considerable discharge into the bay.

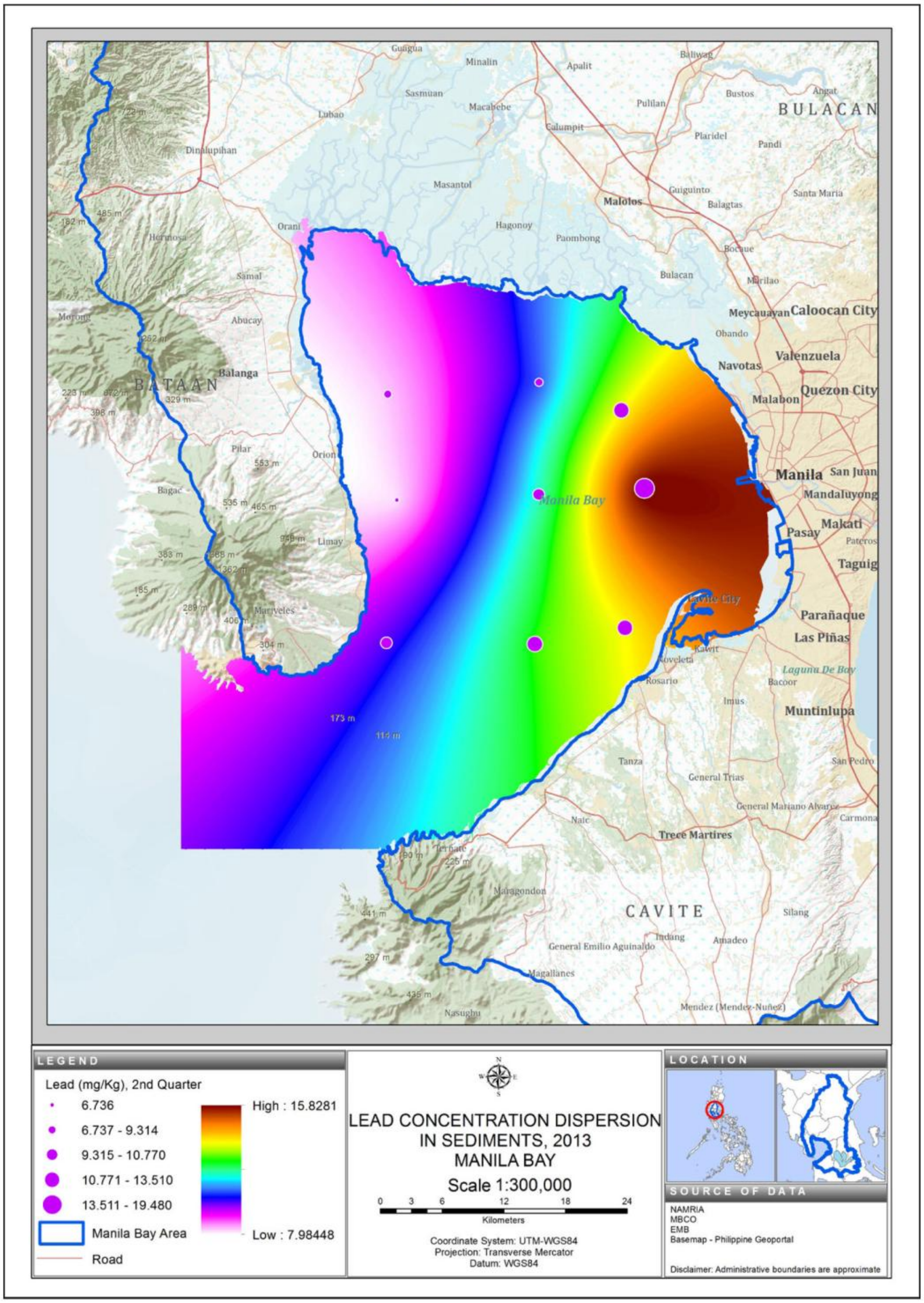
Map 105


BULACAN
CAVITE
Manila Bay
Laguna De Bay
1
2
3
4
5
6
7
8
9
LEGEND
Manila Bay Offshore Stations
Manila Bay Area
Provincial Boundary
Road
MANILA BAY OFFSHORE STATIONS
MANILA BAY AREA
Scale 1:300,000
0 2.75 5.5 11 16.5 22
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

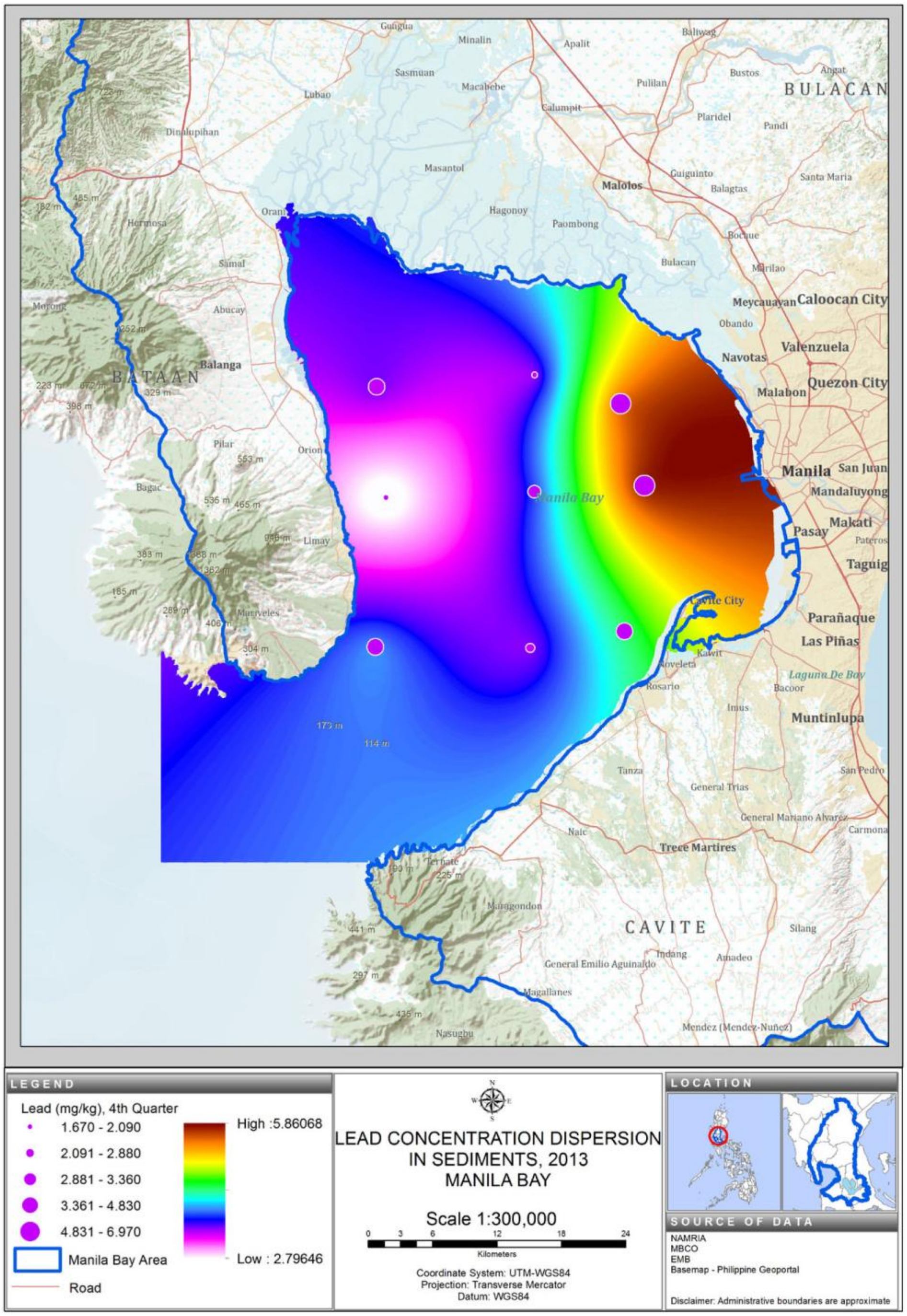
Map 106


BULACAN
BATAAN
CAVITE
Manila Bay
Cavite City
Manila
Caloocan City
Quezon City
Valenzuela
Navotas
Malabon
Mandaluyong
Makati
Pasay
Taguig
Parañaque
Las Piñas
Muntinlupa
Malolos
Trece Martires
LEGEND
Lead (mg/kg), 1st Quarter
2.120
2.121 - 13.920
13.921 - 16.040
16.041 - 18.520
18.521 - 25.330
High : 21.3723
Low : 7.10022
Manila Bay Area
Road
LEAD CONCENTRATION DISPERSION IN SEDIMENTS, 2013
MANILA BAY
Scale 1:300,000
0 3 6 12 18 24
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 107


LEGEND
Lead (mg/Kg), 2nd Quarter
6.736
6.737 - 9.314
9.315 - 10.770
10.771 - 13.510
13.511 - 19.480
High : 15.8281
Low : 7.98448
Manila Bay Area
Road
LEAD CONCENTRATION DISPERSION IN SEDIMENTS, 2013
MANILA BAY
Scale 1:300,000
0 3 6 12 18 24
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate
BULACAN
BATAAN
CAVITE
Manila Bay
Manila
Caloocan City
Valenzuela
Quezon City
Navotas
Malabon
San Juan
Mandaluyong
Pasay
Makati
Taguig
Parañaque
Las Piñas
Muntinlupa
Laguna De Bay
Malolos
Balanga
Trece Martires

Map 108


LEGEND
Lead (mg/kg), 4th Quarter
1.670 - 2.090
2.091 - 2.880
2.881 - 3.360
3.361 - 4.830
4.831 - 6.970
Manila Bay Area
Road
High :5.86068
Low : 2.79646
LEAD CONCENTRATION DISPERSION IN SEDIMENTS, 2013
MANILA BAY
Scale 1:300,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
EMB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate
BULACAN
BATAAN
CAVITE
Manila Bay
Manila
Quezon City
Caloocan City
Valenzuela
Malabon
Navotas
Makati
Pasay
Mandaluyong
San Juan
Taguig
Parañaque
Las Piñas
Muntinlupa
Malolos
Balanga
Cavite City
Trece Martires
Laguna De Bay

E. SEDIMENT QUALITY

SEDIMENT AND WATER QUALITY

Much has been said about the current state of water quality of the Manila Bay waters. Visual and olfactory signs which are used by the common people to gauge the water quality of the area may be a good indicator but it cannot give accurate information. Manifestations of the quality of the bay waters are obvious and cannot be ignored. Similar to an ailing human body, physical signs and symptoms can be seen but accurate laboratory tests need to be conducted to fully diagnose the ailment so that a proper remedy may be prescribed.

Here is where the monitoring and assessment of water quality play a vital role. The process of collecting data and analyzing them is integral in managing the water quality of the Manila Bay and its surrounding waters. The way we treat and utilize Manila Bay reflects how we value human health and the environment.

A good and efficient monitoring and assessment program should be able to define water quality problems, characterize existing and emerging problems, determine the magnitude and geographic extent of water conditions, provide the basis for designing and operating pollution prevention and mitigation programs, evaluate the effectiveness and compliance of water quality programs, identify trends in water quality over time and give an idea on the possible sources of pollutants.

Manila Bay acts as a natural sink for contaminants in runoff and drainage from the surrounding land especially as development and urbanization around the bay increases.

Over the years, water quality data has been collected and used as inputs to formulate plans and programs to address water quality problems of Manila Bay, but analyzing data to assess the health of the bay is never easy.

The type of pollutants and the magnitude of the outfall loadings are a complex function of: size and type of conurbation (commercial, residential , mixed); plumbing; urban land use; characteristics of storm events and accidental releases.

Wastewater contains many constituents and impurities arising from diffuse and point sources. Large sources are easily quantifiable and result from specific activities in the area that are along tributaries of Manila Bay water system. Contributions from small point sources, such as households and small business, are more difficult to identify and quantify, compared to point sources which are usually regulated. The area is also vulnerable to illegal discharges of pollutants.

This section attempts to look at some of the vital parameters, heavy metals (cadmium, chromium and lead) and coliform, and see how these affect the status of the health of the Manila Bay area. Qualitative assessment of these pollutants in the bay area will be made based on some available data. Land Cover Map surrogates for Land Use which is identified as one of the main stressors determining the water quality of the Manila Bay Area. Sources of the potentially toxic elements can be deduced from the Land Cover Map. Changes in land cover over time are deemed to correlate with the changes in potential toxic elements volume in the Manila Bay waters.

Data is systematically collected from nine grid sections for sampling identification.

HEAVY METALS

Cadmium (Cd), chromium (Cr) and lead (Pb) are potentially toxic elements that are being monitored to assess the state of water quality of Manila Bay.

Cadmium is a minor metallic element, one of the naturally occurring components in the earth's crust and waters, and present everywhere in our environment. The most significant early use of cadmium was as a sacrificial corrosion protection coating on iron and steel. Exposure to certain forms and concentrations of cadmium is known to produce toxic effects on humans. Long-term occupational exposure to cadmium at excess concentrations can cause adverse health effects on the kidneys and lungs. Chronic cadmium inhalation may result in impairment of pulmonary function with obstructive changes

The metal chromium is used primarily for making steel and other alloys due to its high resistance to corrosion and discoloration. Chromium compounds are used for chrome plating, the manufacture of dyes and pigments, leather and wood preservation, and treatment of cooling tower water. Smaller amounts are used in drilling muds, textiles, and toner for copying machines. Chromium is a naturally occurring element in rocks, animals, plants, soil, and volcanic dust and gases. Chromium is essential to normal glucose, protein, and fat metabolism and is thus an essential dietary element.

The most important industrial sources of chromium in the atmosphere are those related to ferrochrome production. Ore refining, chemical and refractory processing, cement-producing plants, automobile brake lining and catalytic converters for automobiles, leather tanneries, and chrome pigments also contribute to the atmospheric burden of chromium.

The respiratory tract is the major target organ for chromium (VI) toxicity, for acute (short-term) and chronic (long-term) inhalation exposures. Shortness of breath, coughing, and wheezing were reported from a case of acute exposure to chromium (VI), while perforations and ulcerations of the septum, bronchitis, decreased pulmonary function, pneumonia, and other respiratory effects have been noted from chronic exposure. Human studies have clearly established that inhaled chromium (VI) is a human carcinogen, resulting in an increased risk of lung cancer. Animal studies have shown chromium (VI) to cause lung tumors via inhalation exposure.

Lead is a chemical element in the carbon group. Lead is a soft, malleable and heavy post-transition metal. Lead has a shiny chrome-silver luster when it is melted into a liquid. It is also the heaviest non-radioactive element. Lead is used in building construction, lead-acid batteries, bullets and shot, weights, as part of solders, pewters, fusible alloys, and as a radiation shield. Use of lead as a fuel additive is now greatly reduced. If ingested, lead is poisonous to animals and humans, damaging the nervous system and causing brain disorders. Excessive lead also causes blood disorders in mammals. Lead is a neurotoxin that accumulates both in soft tissues and the bones.

SOURCES OF HEAVY METALS

Sources of metal pollution in the bay water system can be classified into three main categories: domestic, light industrial & commercial and urban runoff.

DOMESTIC SOURCES

Domestic sources of potentially toxic elements in waterways and in the bay are rarely quantified due to the difficulty in isolating them. Domestic sources include the potentially toxic elements discharged from the household to the waterways and corrosion from materials used in distribution and plumbing networks, tap water and detergents. Built-up areas depicted in the land cover map are attributed to be the domestic sources for the potentially toxic elements.

Table 15. Domestic sources of potentially toxic elements

Product Type	Cadmium (Cd)	Chromium (Cr)	Lead (Pb)
Cleaning products		√	
Cosmetics, shampoos	√		√
Fire extinguishers		√	
Fuels			√
Lubricants		√	√
Health Supplements		√	
Food Products			√
Oils and lubricants		√	√
Paints and pigments	√	√	√
Pesticides and garden products	√	√	√
Washing powders	√		√
Wood preservatives			√
Faeces and urine	√	√	√
Tap water	√	√	√
Water treatment	√	√	√

The main domestic sources of potentially toxic elements in waterways, in order of importance:

Cadmium: faeces > bath water > laundry > tap water > kitchen

Chromium: laundry > kitchen > faeces > bath water > tap water

Lead: plumbing > bath water > tap water > laundry > faeces > kitchen

The table suggests that people living within the watershed contribute to the state of the quality of the waters of Manila Bay. Washing clothes and dishes, use of toilets for bathing and defecating all discharge traces of cadmium, chromium and lead. With millions of people living within the Manila Bay area, even miniscule load per person per day of the potentially toxic heavy metals will, in time, have significant effect on the water quality of the bay.

COMMERCIAL SOURCES

Limited data is available for the potentially toxic element contribution from commercial sources and health care inputs (such as hospital and clinical wastes). Possible commercial sources of potentially toxic elements are essentially mapped within the built-up areas in the Land Cover Map.

Cadmium could originate from launderettes, small electroplating and coating shops, plastic manufacture, and also used in alloys, solders, pigments, enamels, paints, photography, batteries, glazes, artisanal shops, engraving and car repairs shops.

Chromium is present in alloys and is discharged from diffuse sources and products such as preservatives, dying, and tanning activities like leather processing.

Use of lead as a fuel additive is now greatly reduced. It is also used in batteries, pigments, solder, roofing, cable covering, lead jointed waste pipes and PVC pipes (as an impurity), ammunition and other sources.

URBAN RUNOFF

Runoff to waterways are potentially loaded with potentially toxic elements. Atmospheric inputs to the urban runoff depend on the nature of surrounding industries, on the proximity of major emission sources and the direction of the prevailing wind. Potentially toxic element loads can be five times greater in runoff near commercial activities, than in residential areas far from industrial emitters. Roof runoff and building runoff also contribute to the total loading and may be a source of considerable amounts lead and cadmium. Road and roof runoff sources are particularly important during storm events, which will allow flushing of potentially toxic elements and other pollutants from surfaces.

Weather plays a significant role in urban runoff. Roof runoff and building runoff also contribute to the total runoff loading and may be a source of considerable amounts of potentially toxic elements such as lead and cadmium. Road and roof runoff sources are particularly important during storm events, which will allow flushing of potentially toxic elements and other pollutants from surfaces. It is important to note that the metal species released are usually in a freely dissolved, bioavailable form. These sources are very variable, as every event is different and depends on traffic, materials and age of roofs and other surfaces, and meteorological and environmental conditions.

Pollutants are transported from the catchment over the roads to the drainage network in a variety of ways. One way is that soluble contaminants are dissolved in the runoff water. Another is that insoluble particles acting as sorbents for potentially toxic elements and organic contaminants are transported by the runoff water. Removal by air-dispersal is yet another way involving the transfer of the surface contaminants to the atmosphere either as dry particles or dissolved in surface water.

The main sources of pollution in urban precipitation runoff can be summarized as follows:

- Road and vehicle related pollution
- Degradation of roofing materials
- Construction
- Litter, vegetation and associated human activities
- Erosion of soil

Roads are a major sources of pollution in urban environments like NCR and contribute to water pollution both directly and indirectly (airborne pollutants generation). Sources of the organic and inorganic fraction of road-produced pollutants are summarized as follows:

- Vehicle lubrication systems losses
- Vehicle exhaust emissions
- Degradation of automobile tires and brakes
- Road maintenance
- Road surface degradation
- Load losses from vehicles (accidental spillages)
- Precipitation (wet deposition)
- Atmospheric deposition (dry deposition)

Potentially toxic elements in runoff occur from motor fuel combustion, brake linings, tire wear and road surface wear. Decrease of lead from motor fuel combustion is attributed to the phasing out of leaded fuel. Chromium is another metal emitted from vehicle exhaust pipes. Cadmium in road surface sediments can be attributed in the manufacturing of lubricating oil, Cd is present as an impurity of the original Zn. Brake lining wear contributes copper, nickel, chromium and lead to runoff. Tire abrasion contributes to the load of zinc, lead, chromium and nickel due to soot and metal oxides constituents. Cadmium in car tires is introduced during the vulcanization process.

With thousand kilometers of roads within the Manila Bay area and the millions of vehicles plying these roads, potentially toxic elements contribution from this sector are considered significant.

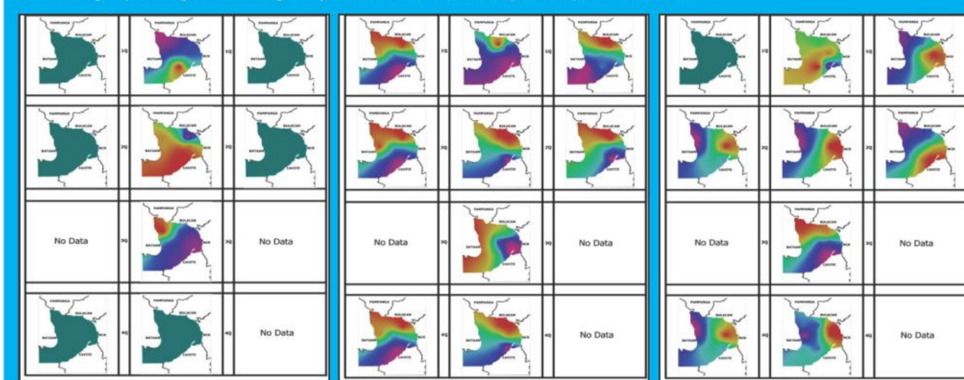
Transportation of surface particulates is sporadic in nature [Mitchell, 1985]. Metal levels tend to fall after periods of rain, while elevated concentrations have been recorded after prolonged dry periods. Also introduced in the movement patters are local storage and residence effects due to the intrinsic configurations and micro-topography of the road surface [Harrop, 1983].

Painted structures in urban environments is said to contribute to lead runoff. Lead concentration depends strongly on paint age and condition. Lead washes of older paints were much higher than that of freshly painted surfaces. Lead from surface washes are said to be 70% or greater in particulate lead form, suggesting the release of lead pigments from weathered paints. Surface paints can contribute high masses of lead into a watershed, targeting these structures for source preventive actions to curtail future lead input into the environment.

Rainwater can add its own absorbed and dissolved pollutants to the loads generated from other sources. Subsequent additional potentially toxic element loading come from roof, pavement and road surfaces. Traffic density and location of industry have a strong influence on the deposition of potentially toxic elements in precipitation.

Box 8. Series of maps based on interpolated 2012, 2013 and 2014 data from nine sampling points within the Manila Bay water for chromium, cadmium and lead.

The figures are generated just to illustrate how the specific parameter is distributed within the area given the point values and using a specific interpolation model, it does not attempt to explain movements of the parameters to simulate the circulation pattern of the water body. It is neither generated to explicitly and categorically show which part of the watershed contributes significantly to the parameter being observed and where the potentially toxic elements are originating. Modeling movement and explaining the origin of pollutants requires extensive data and complex analysis. The resulting maps were generated using a very limited data based on incomplete sample data collection. `



Box 9 PBDEs and PCBs in Manila Bay Area

Trends of PBDE and PCB deposition in Manila Bay

Two ~1 m radio-dated sediment cores, MB17 (N 14°36'21", E 120°45'4") and MB18 (N 14°35'54", E 120°41'44") were collected from Manila Bay in 2009 (Kwan et al., 2014). The radio-dated sediment cores reflected ~60 to 80 years of deposition, i.e., from 1931-2009 for MB17 and from 1940-2009 for MB18. The analysis of PBDEs and PCBs in the different layers of the sediment cores resulted in vertical profiles that showed increasing concentrations of PBDEs and PCBs toward the surface. These trends suggested increasing inputs of PBDEs and PCBs into Manila Bay in recent years, or at least until the time of sampling in 2009 (Kwan et al., 2014).

PCBs

The increasing inputs of PCBs into Manila Bay depicted by the profiles of the two sediment cores were contradictory to the decreasing trends of PCBs observed worldwide as an effect of the global ban in the 1970s. However, this increasing trend of PCB concentration in Manila Bay would be consistent with the 6 to 70 times higher concentrations of PCBs in the plastic resin pellets (which reflect PCBs in seawater) collected from Manila Bay (Cavite area) in 2009, than those from Malaysia and Vietnam (Kwan et al., 2014). In the study by Santiago and Rivas (2012) in 2009, PCBs were also detected in the waters of Manila Bay (6.1-9.8 ng/L); and in the Pasig River (0.9-32.8 ng/L) and Laguna Lake (3.0-10.9 ng/L), at concentrations higher than those reported for the coast of Hong Kong; the Pearl River Delta, Chao Phraya and Mekong Rivers; and in the Venice Lagoon respectively.

Inputs of PCBs to the catchment of Manila Bay may also be contributed by atmospheric deposition. PCBs were also detected in the passive air samples collected in the vicinity of the Cavite City Hall in 2011 and 2012, at concentrations of about 4 to 86 times higher than those obtained in Malaysia, Vietnam and Japan (Kwan et al., 2014). These results were consistent with the study on Global Atmospheric Passive Sampling (GAPS) conducted in December 2004 to March 2005 (Pozo et al., 2006), where the PCB air concentration in Metropolitan Manila (Quezon City) was the highest among the 41 global sampling sites.

The ongoing inputs of PCBs in Manila Bay could be due to a less effective regulation, inadequate management of PCB stockpiles including insufficient control of illegal recycling activities, e.g., retro filling of old transformers that may have caused leakage into the environment, or possible emission sources of PCBs, e.g., power plants were once located near the banks of the Pasig River and around the lakeshore of Laguna Lake.

Thus, the Philippines (specifically, the Metropolitan Manila Area) is a possible hot spot area of PBDE and PCB pollution.

Source: UP-NSRI

SURFACE SEDIMENTS OFFSHORE OF MANILA BAY

Surface sediments from nine offshore sites (Figure 28) along the Manila Bay were collected by the Environmental Management Bureau quarterly in 2012 and 2013. The sediments were analyzed for C and N concentration and isotope ratios at the foreign laboratory. Results were analyzed by Castaneda, et al (2013) and discussed below.

CONTRIBUTION OF TERRESTRIAL SOURCES TO THE NUTRIENT LOADING OF MANILA BAY

The $\delta^{13}C$ values of surface sediments collected offshore of Manila Bay are plotted against the C/N ratio in Figure 28. The plot shows that S6 and S7 are of a different group from the other sites. S6 and S7 are more proximate to the Cavite watershed. They exhibit higher C:N ratios and more enriched $\delta^{13}C$ value than that of marine origin. The range of values fall within the characteristic values for C4 plants, C4 soil and riverine materials. These results indicate increasing land use change in the catchment area since most of the surface sediments are coming from C4 sources which consist of corn, sugarcane and any warm-season crops that are now replacing the natural plantation in the area.

The other group of offshore sediments potentially affected by the Pampanga River Basin, based on location are S1, S2, S3, S4, and S9. The range of $\delta^{13}C$ values exhibited by these samples fall within the characteristic values for algae and submerged plants but also bordering along that of C3 soil and riverine materials. In the dry season, algal bloom in S2 and S5 must have significantly increased the nitrogen load in these areas so that the C:N ratio has shifted to much lower values.

The percent contributions of terrestrial and marine sources in offshore sites S1, S2, S3, S4, and S9 were estimated using the two-source and 1-tracer isotope mixing model. S5, S6, and S7 were not included since they belong to a different distribution, more likely affected by Cavite and Bataan watersheds. Terrestrial contribution range from 17% to 30% where S3 has the highest terrestrial contribution and S4 with the lowest. S1, S2, and S9 receive approximately the same terrestrial input at 21%, 24%, and 23%, respectively. S8, its $\delta^{13}C$ value taken as the reference value for marine end member, naturally has 100 % marine component. The terrestrial contributions are shown in Figure 29.

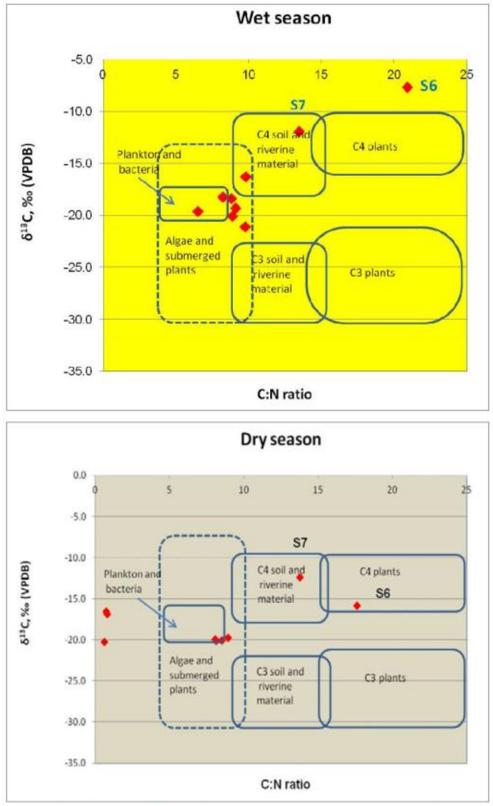


Figure 28. Plots of $\delta^{13}C$ vs. C:N ratio in offshore surface sediments during wet and dry seasons.

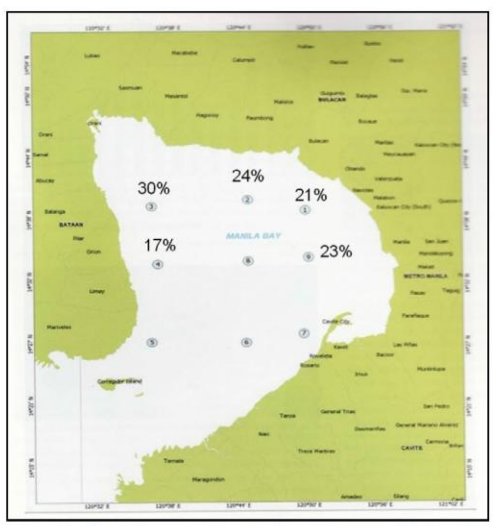


Figure 29. Percentage contributions of terrestrial sources into Manila Bay.

F. SOIL QUALITY

SOIL QUALITY

Soil quality within the sub-watersheds of the Manila Bay Area likely contribute to the water quality of the bay. Soil quality is indicated by the presence and level of heavy metals and pesticide residues. The baseline data is from July 2011 (DA-BSWM, 2012) and monitoring was done in 2012 and 2013. Sampling sites were identified primarily considering the extent of agricultural areas and its likely influence to water quality within the watersheds of Manila Bay.

Table 16 below shows the location of soil sampling sites for the soil chemical characterization. A GPS was used to locate the coordinates of the composite soil sites. The locations of these soil sampling sites are presented in Maps 109 to 125.

Table 16. Location of Selected Soil Sampling Sites

Code	Sub-watershed	Location	Longitude	Latitude
Pampanga River Basin				
S1A	SW01	Gapan San Isidro, N.E	120.953111	15.310611
S1B	SW01	Conception, Tarlac	120.727056	15.314694
S1C	SW01	Arayat, Pampanga	120.735861	15.24675
S1D	SW01	Cabia, N.E	120.805167	15.243611
S2A	SW02	Port Magsaysay	121.094306	15.443972
S3A	SW03	San Leonardo, N.E	120.972111	15.370972
S3B	SW03	San Leonardo, N.E	120.9365	15.347444
S4A	SW04	Peñaranda / Gen. Tinio, N.E.	121.026333	15.334472
S5A	SW05	Candaba, Pampanga	120.878111	15.046444
S6A	SW06	Bustos Dam, Bulacan	120.983528	14.928111
Bataan Watershed				
S7A	SW07	Hermosa, Bataan	120.490167	14.855333
S8A	SW08	Balanga, Bataan	120.524667	14.634667
S8B	SW08	Balanga, Bataan	120.504167	14.602667
Pasig River Basin				
S9A	SW09	Mabitac, Laguna	121.421417	14.45295
S10A	SW10	Morong, Rizal	121.209222	14.527111
S16A	SW16	Bay, Laguna	121.29145	14.175833
S17A	SW17	Victoria, Laguna	121.347583	14.1925
S18A	SW18	Majayjay, Laguna	121.460528	14.233944
S18B	SW18	Majayjay, Laguna	121.478556	14.180444
Cavite Watershed				
S11A	SW11	Maragondon, Cavite	120.779306	14.261167
S11B	SW11	Maragondon, Cavite	120.77325	14.275417
S12A	SW12	Naic and Tanza, Cavite	120.807667	14.345833
S13A	SW13	Tanza, Cavite	120.8613	14.336333
S14A	SW14	Gen. Trias, Cavite	120.908333	14.388167
S15A	SW15	Naic, Cavite	120.809483	14.286067

HEAVY METALS IN SOILS

The results of soil analyses on heavy metals and pesticides residues are presented in Annex 51. The heavy metals concentrations by sub-watersheds are shown in Maps 109 to 125.

The Philippines has no standard yet on soil quality. Hence, results are compared to soil and sediment standards based foreign literature (Table 17). Also, the allowable levels of heavy metals for organic fertilizers, compost, plant growth regulators and organic plant supplements were considered.

Table 17. Soil and Sediment Standards

Compound/ Element	Sediment*	Dutch Soil Standard	
		Target value**	Intervention value***
Lead (Pb)	75	85	530
Cadmium (Cd)		50	65
Chromium (Cr)	80	100	380
Copper (Cu)	65	36	190
Nickel (Ni)	40	35	210
Zinc (Zn)	200	140	720

* PEMSEA and MBEMP IEMP-TWG, 2006. Manila Bay: Environmental Atlas.

** This is assumed to be 1% of the Maximal Permissible Risk (MPR) level for ecosystem, where MPR is the concentration expected to be hazardous for 5% of the species in the ecosystem, or the 95% protection level.

*** The ecological Intervention Value is the concentration expected to be hazardous to 50% of the species in the ecosystem.

Table 18. Allowable level of heavy metals for organic fertilizers, compost, plant growth regulators and organic plant supplements (PNS/BAFPS 40:2013)

Heavy metals	Allowable level (mg/kg dry wt) (ppm dry wt)
Arsenic (As)	5
Zinc (Zn)	5
Lead (Pb)	250
Copper (Cu)	300
Chromium (Cr)	150
Nickel (Ni)	50
Mercury (Hg)	2
Cadmium (Cd)	5

The baseline level of lead in soils (2011) was generally higher than in 2012 and 2013 (Map 109 and 117). The highest lead concentration, observed at about 100 ppm in Bataan sub-watershed, is within threshold level considering allowable lead concentration for organic fertilizers set at 250 ppm.

Levels of chromium from soil samples taken in 2013 showed marked increase relative to 2011 particularly in all sites within the Pampanga River Basin, and some sites in the Bataan sub-watershed and in Pasig sub- watersheds (Maps 110 and 119). All observed values are within the allowable level of chromium set at 150ppm for organic fertilizer.

Nickel concentrations observed from soils were generally higher in 2011 than in recent years, most of which were above 50 ppm (Maps 111 and 120). The observed values in 2013 were far below the 50 ppm allowable for nickel in organic fertilizers applied as broadcast to the soil.

Cadmium concentrations from soils taken in 2013 were very low compared to the 2011 observed values ranging from 0.5 to 2 ppm (Map 118). So far, these values are far below the level set for cadmium in organic fertilizer applied to soils.

Arsenic concentration in soils taken in 2013 ranged from 1 to 12 ppm (Maps 112 and 121). The allowable arsenic in organic fertilizer which can be applied to soils is 5 ppm. Arsenic levels above 5ppm were observed in sites within the Bataan and Cavite sub-watersheds and the Pasig River Basin. The level of Arsenic in rice grain has become a recent concern, thus further study is necessary for health and safety.

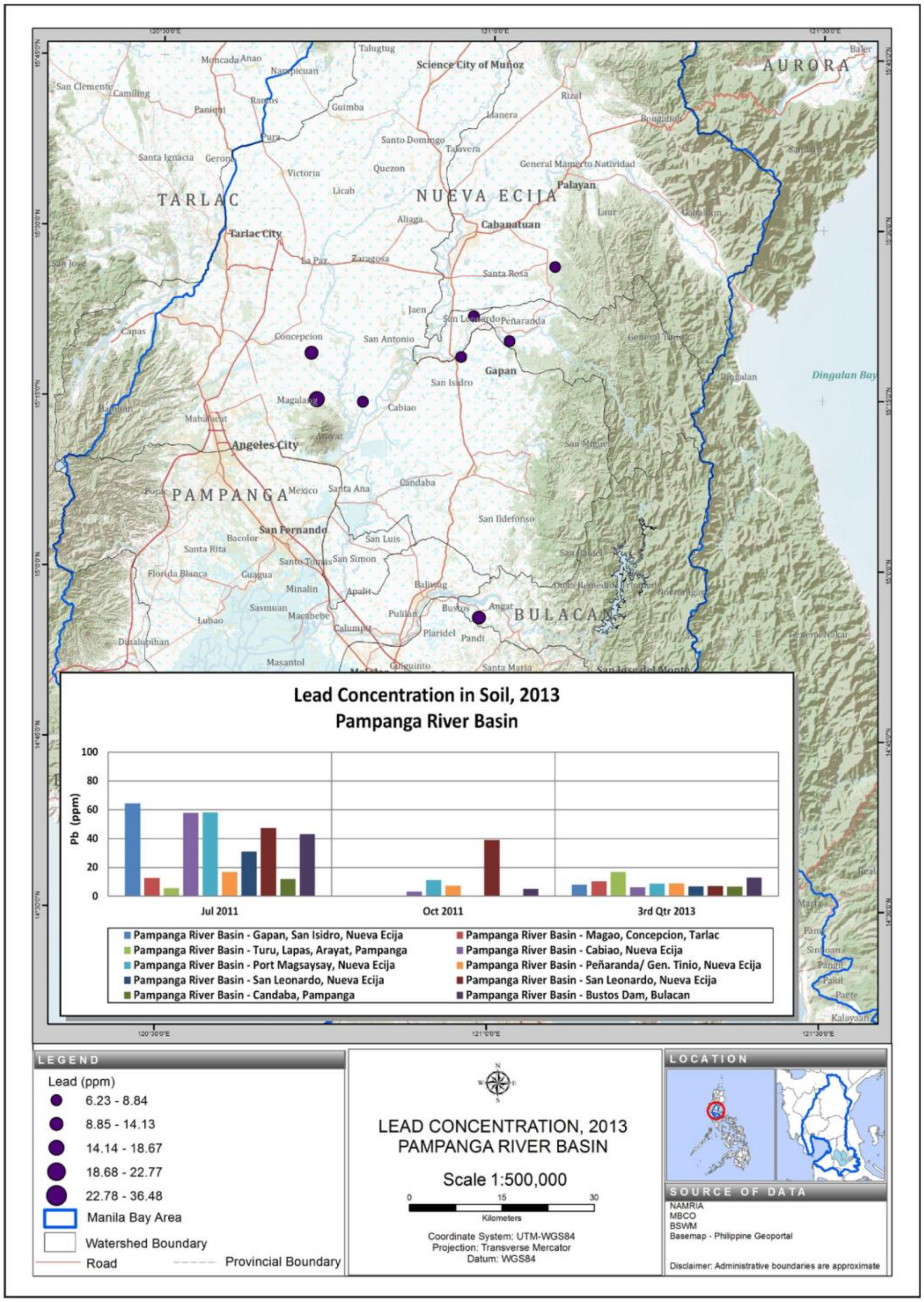
As shown in Maps 115 and 124, the level of copper in soils within the sites of Manila Bay Area showed values of approximately 30 to 160 ppm, all within the 300 ppm set for organic fertilizer applied to the soil.

Observed values in the 2013 sampling showed that all sites within the Manila Bay Area have zinc concentrations above 5 ppm which was set for zinc in organic fertilizer. For the most part, zinc concentration is 40 ppm with highest value of about 180 ppm in Concepcion, Tarlac (Maps 116 and 125).

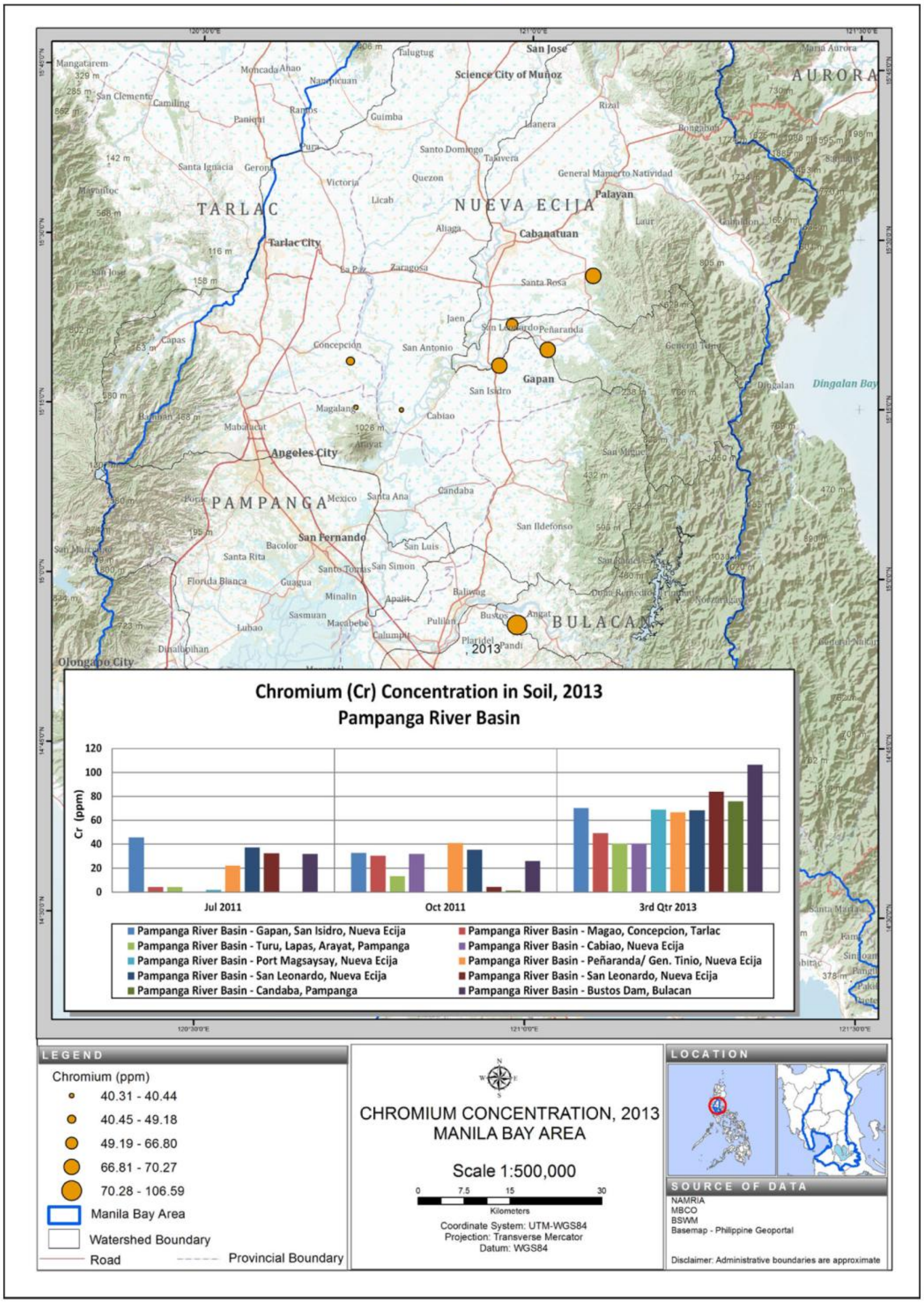
PESTICIDE RESIDUE ANALYSIS IN SOILS

Pesticides residue analyses for organochlorine, organophosphates and pyrethroids from soils samples were taken by the DA-BSWM in 2011 to 2013. All results revealed values below the limit of quantification at 0.005 mg/kg.

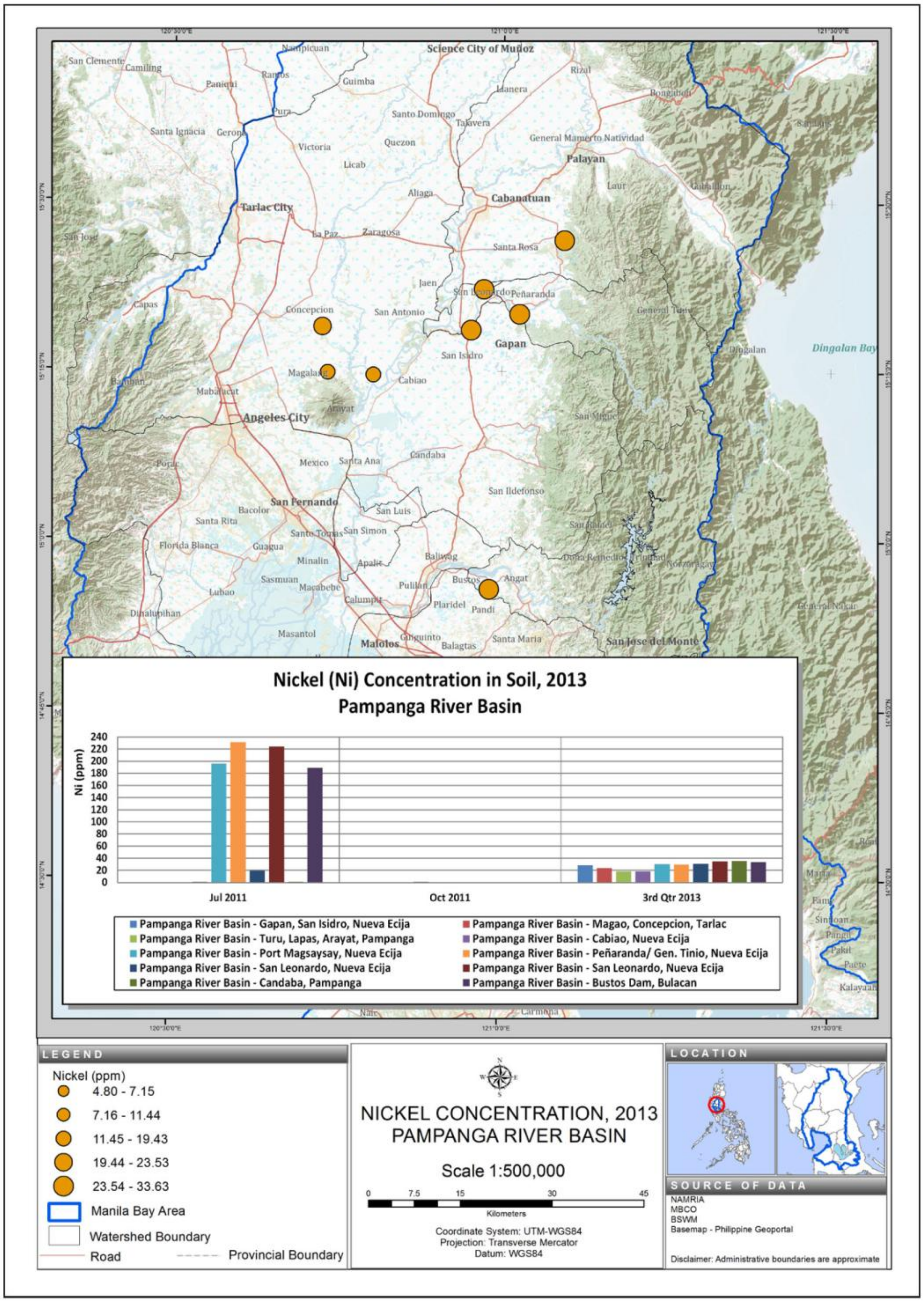
Map 109


Lead Concentration in Soil, 2013
Pampanga River Basin
Pb (ppm)
100
80
60
40
20
0
Jul 2011
Oct 2011
3rd Qtr 2013
Pampanga River Basin - Gapan, San Isidro, Nueva Ecija
Pampanga River Basin - Magao, Concepcion, Tarlac
Pampanga River Basin - Turu, Lapas, Arayat, Pampanga
Pampanga River Basin - Cabiao, Nueva Ecija
Pampanga River Basin - Port Magsaysay, Nueva Ecija
Pampanga River Basin - Peñaranda/ Gen. Tinio, Nueva Ecija
Pampanga River Basin - San Leonardo, Nueva Ecija
Pampanga River Basin - San Leonardo, Nueva Ecija
Pampanga River Basin - Candaba, Pampanga
Pampanga River Basin - Bustos Dam, Bulacan
TARLAC
NUEVA ECIJA
AURORA
PAMPANGA
BULACAN
Dingalan Bay
LEGEND
Lead (ppm)
6.23 - 8.84
8.85 - 14.13
14.14 - 18.67
18.68 - 22.77
22.78 - 36.48
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
LEAD CONCENTRATION, 2013
PAMPANGA RIVER BASIN
Scale 1:500,000
0
15
30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

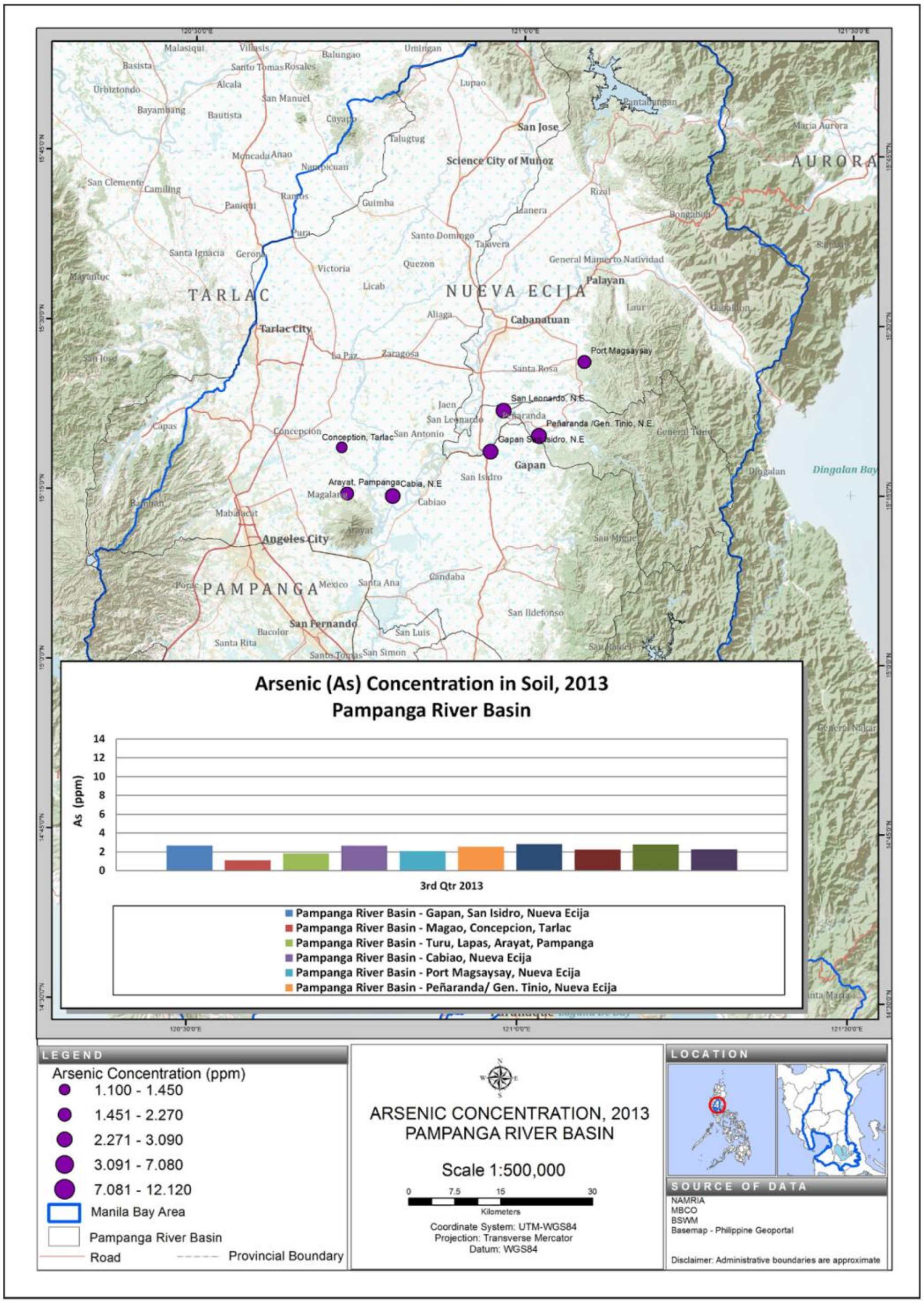
Map 110


Chromium (Cr) Concentration in Soil, 2013
Pampanga River Basin
Cr (ppm)
120
100
80
60
40
20
0
Jul 2011
Oct 2011
3rd Qtr 2013
Pampanga River Basin - Gapan, San Isidro, Nueva Ecija
Pampanga River Basin - Magao, Concepcion, Tarlac
Pampanga River Basin - Turu, Lapas, Arayat, Pampanga
Pampanga River Basin - Cabiao, Nueva Ecija
Pampanga River Basin - Port Magsaysay, Nueva Ecija
Pampanga River Basin - Peñaranda/ Gen. Tinio, Nueva Ecija
Pampanga River Basin - San Leonardo, Nueva Ecija
Pampanga River Basin - San Leonardo, Nueva Ecija
Pampanga River Basin - Candaba, Pampanga
Pampanga River Basin - Bustos Dam, Bulacan
TARLAC
NUEVA ECIJA
PAMPANGA
BULACAN
AURORA
LEGEND
Chromium (ppm)
40.31 - 40.44
40.45 - 49.18
49.19 - 66.80
66.81 - 70.27
70.28 - 106.59
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
CHROMIUM CONCENTRATION, 2013
MANILA BAY AREA
Scale 1:500,000
0
7.5
15
30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

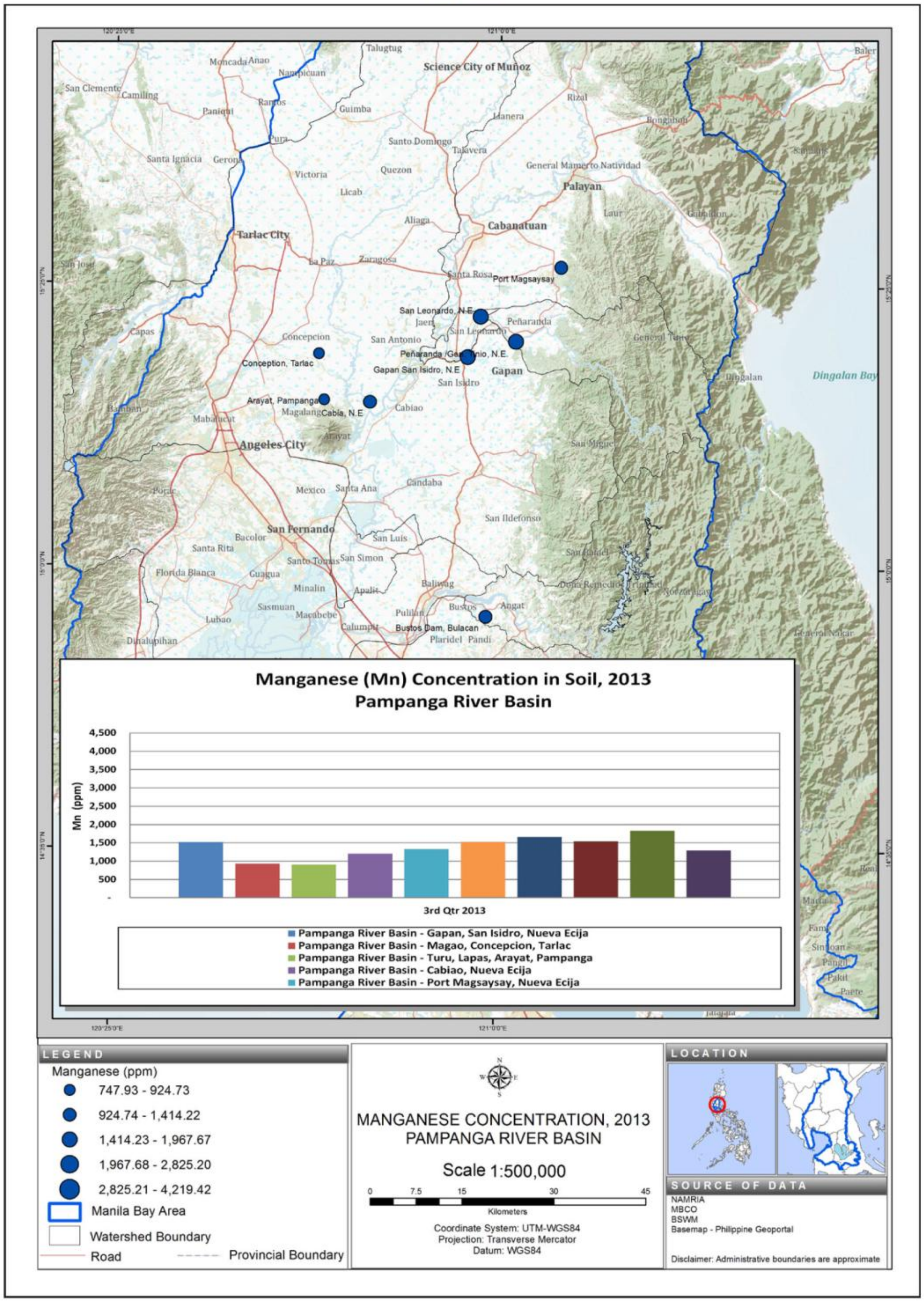
Map 111


Nickel (Ni) Concentration in Soil, 2013
Pampanga River Basin
Ni (ppm)
240
220
200
180
160
140
120
100
80
60
40
20
0
Jul 2011
Oct 2011
3rd Qtr 2013
Pampanga River Basin - Gapan, San Isidro, Nueva Ecija
Pampanga River Basin - Magao, Concepcion, Tarlac
Pampanga River Basin - Turu, Lapas, Arayat, Pampanga
Pampanga River Basin - Cabiao, Nueva Ecija
Pampanga River Basin - Port Magsaysay, Nueva Ecija
Pampanga River Basin - Peñaranda/ Gen. Tinio, Nueva Ecija
Pampanga River Basin - San Leonardo, Nueva Ecija
Pampanga River Basin - San Leonardo, Nueva Ecija
Pampanga River Basin - Candaba, Pampanga
Pampanga River Basin - Bustos Dam, Bulacan
Science City of Muñoz
Tarlac City
Cabanatuan
Palayan
Santa Rosa
Peñaranda
Gapan
San Isidro
Concepcion
San Antonio
Cabiao
Angeles City
San Fernando
Dingalan Bay
Malolos
San Jose del Monte
LEGEND
Nickel (ppm)
4.80 - 7.15
7.16 - 11.44
11.45 - 19.43
19.44 - 23.53
23.54 - 33.63
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
NICKEL CONCENTRATION, 2013
PAMPANGA RIVER BASIN
Scale 1:500,000
0
7.5
15
30
45
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

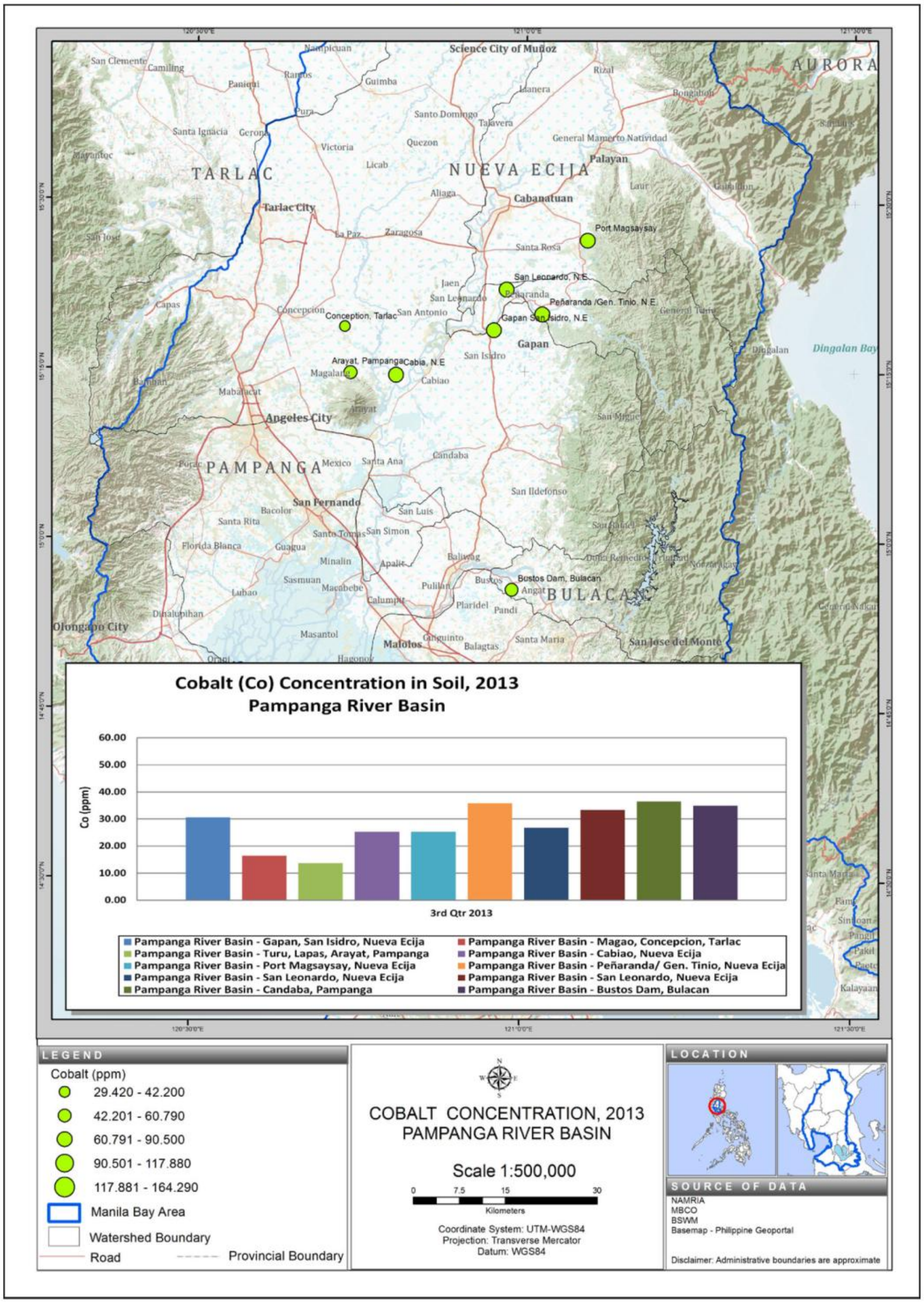
Map 112


Arsenic (As) Concentration in Soil, 2013
Pampanga River Basin
As (ppm)
14
12
10
8
6
4
2
0
3rd Qtr 2013
Pampanga River Basin - Gapan, San Isidro, Nueva Ecija
Pampanga River Basin - Magao, Concepcion, Tarlac
Pampanga River Basin - Turu, Lapas, Arayat, Pampanga
Pampanga River Basin - Cabiao, Nueva Ecija
Pampanga River Basin - Port Magsaysay, Nueva Ecija
Pampanga River Basin - Peñaranda/ Gen. Tinio, Nueva Ecija
TARLAC
NUEVA ECIJA
PAMPANGA
AURORA
Port Magsaysay
San Leonardo, N.E
Peñaranda /Gen. Tinio, N.E
Gapan San Isidro, N.E
Conception, Tarlac
Arayat, Pampanga
Cabia, N.E
Tarlac City
Cabanatuan
Science City of Muñoz
San Jose
Palayan
Gapan
Angeles City
San Fernando
Dingalan Bay
LEGEND
Arsenic Concentration (ppm)
1.100 - 1.450
1.451 - 2.270
2.271 - 3.090
3.091 - 7.080
7.081 - 12.120
Manila Bay Area
Pampanga River Basin
Road
Provincial Boundary
ARSENIC CONCENTRATION, 2013
PAMPANGA RIVER BASIN
Scale 1:500,000
0
7.5
15
30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

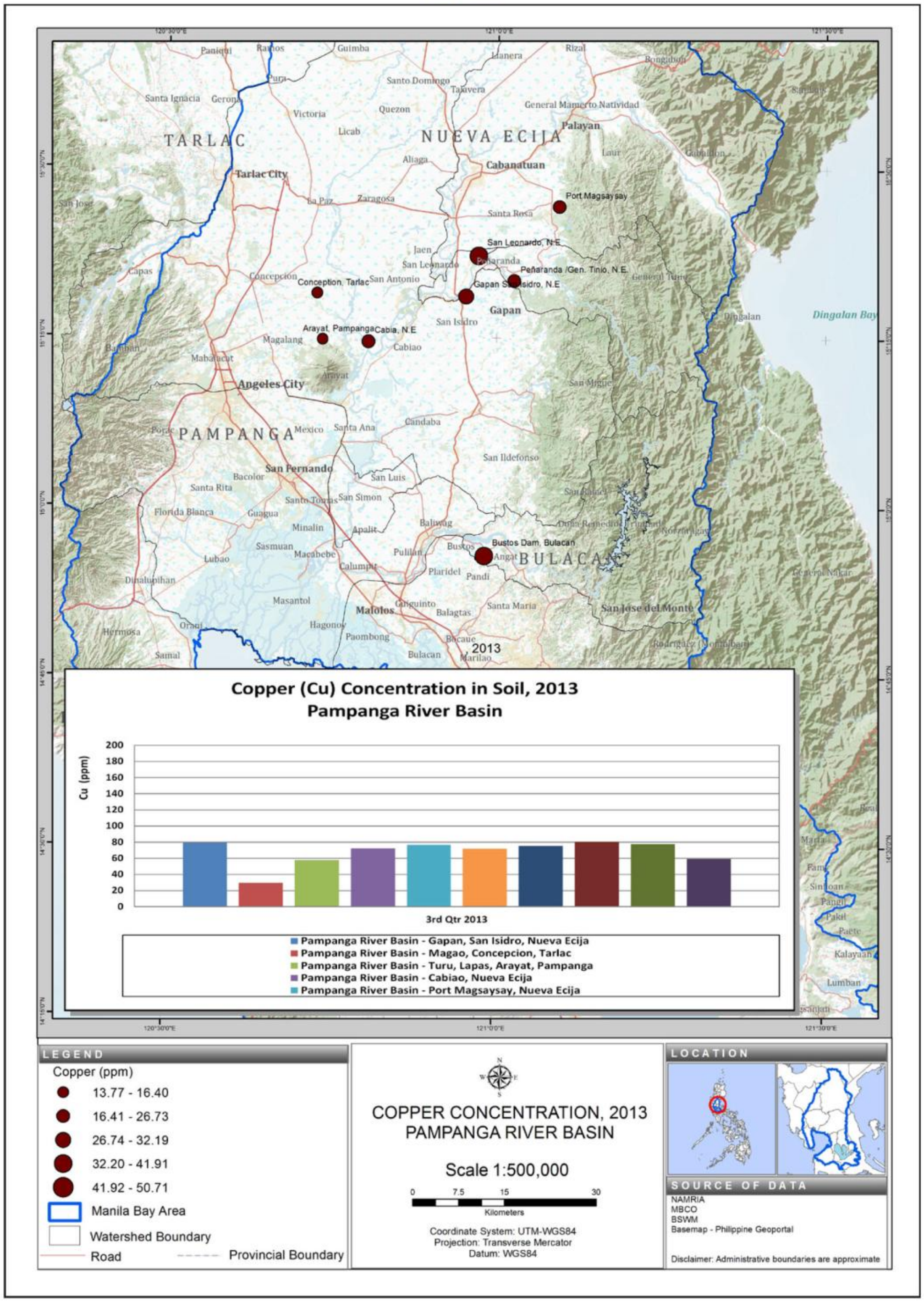
Map 113


Science City of Muñoz
Cabanatuan
Palayan
Tarlac City
Angeles City
San Fernando
Gapan
Dingalan Bay
Port Magsaysay
San Leonardo, N.E.
Peñaranda (Gen. Tinio), N.E.
Gapan San Isidro, N.E.
Conception, Tarlac
Arayat, Pampanga
Cabia, N.E
Bustos Dam, Bulacan
Manganese (Mn) Concentration in Soil, 2013
Pampanga River Basin
Mn (ppm)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
3rd Qtr 2013
Pampanga River Basin - Gapan, San Isidro, Nueva Ecija
Pampanga River Basin - Magao, Concepcion, Tarlac
Pampanga River Basin - Turu, Lapas, Arayat, Pampanga
Pampanga River Basin - Cabiao, Nueva Ecija
Pampanga River Basin - Port Magsaysay, Nueva Ecija
LEGEND
Manganese (ppm)
747.93 - 924.73
924.74 - 1,414.22
1,414.23 - 1,967.67
1,967.68 - 2,825.20
2,825.21 - 4,219.42
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
MANGANESE CONCENTRATION, 2013
PAMPANGA RIVER BASIN
Scale 1:500,000
0 7.5 15 30 45
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

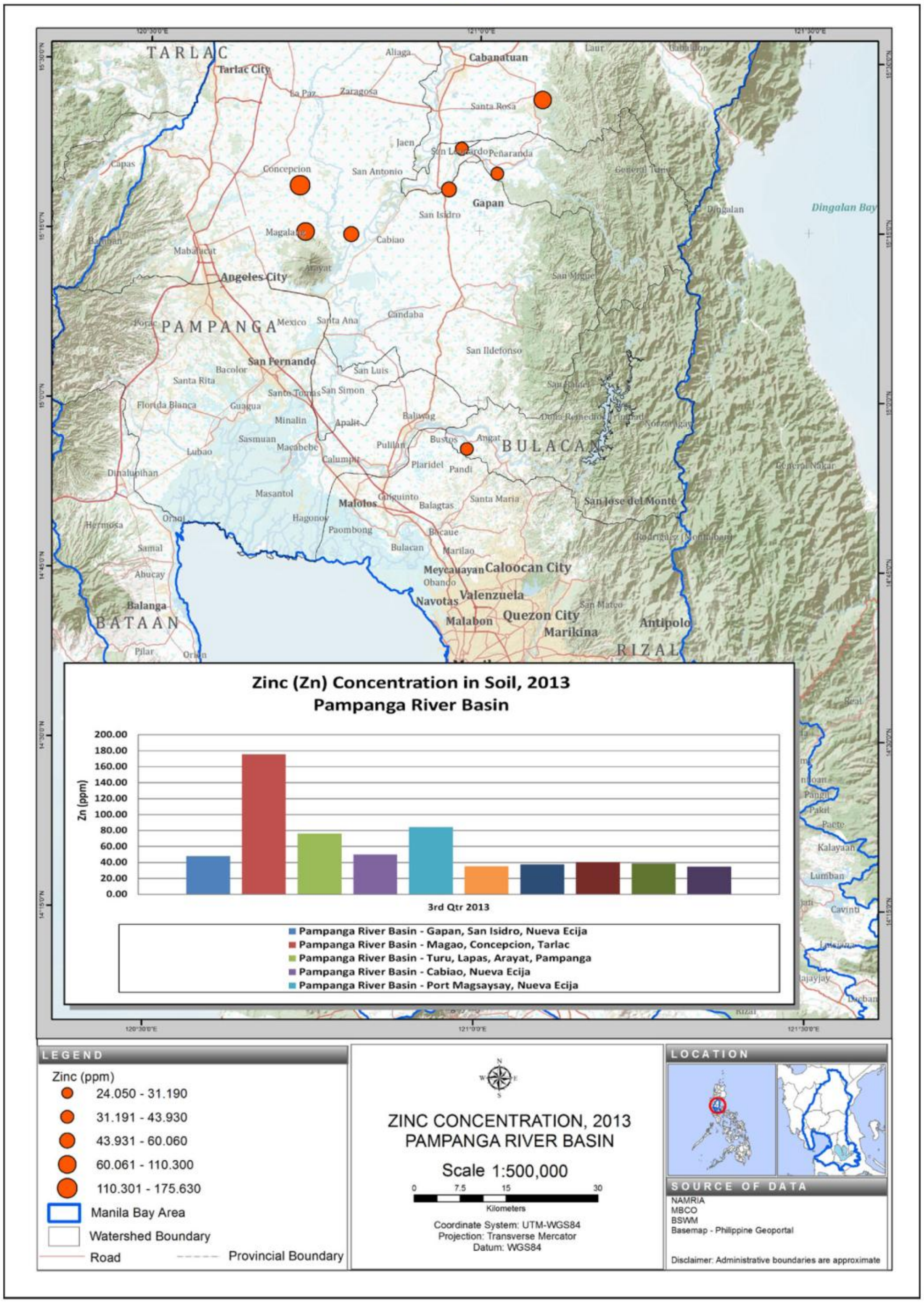
Map 114


Cobalt (Co) Concentration in Soil, 2013
Pampanga River Basin
Co (ppm)
60.00
50.00
40.00
30.00
20.00
10.00
0.00
3rd Qtr 2013
Pampanga River Basin - Gapan, San Isidro, Nueva Ecija
Pampanga River Basin - Magao, Concepcion, Tarlac
Pampanga River Basin - Turu, Lapas, Arayat, Pampanga
Pampanga River Basin - Cabiao, Nueva Ecija
Pampanga River Basin - Port Magsaysay, Nueva Ecija
Pampanga River Basin - Peñaranda/ Gen. Tinio, Nueva Ecija
Pampanga River Basin - San Leonardo, Nueva Ecija
Pampanga River Basin - San Leonardo, Nueva Ecija
Pampanga River Basin - Candaba, Pampanga
Pampanga River Basin - Bustos Dam, Bulacan
Port Magsaysay
San Leonardo, N.E.
Peñaranda /Gen. Tinio, N.E.
Gapan San Isidro, N.E
Conception, Tarlac
Arayat, Pampanga
Cabia, N.E
Bustos Dam, Bulacan
TARLAC
NUEVA ECIJA
PAMPANGA
BULACAN
AURORA
LEGEND
Cobalt (ppm)
29.420 - 42.200
42.201 - 60.790
60.791 - 90.500
90.501 - 117.880
117.881 - 164.290
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
COBALT CONCENTRATION, 2013
PAMPANGA RIVER BASIN
Scale 1:500,000
0
7.5
15
30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

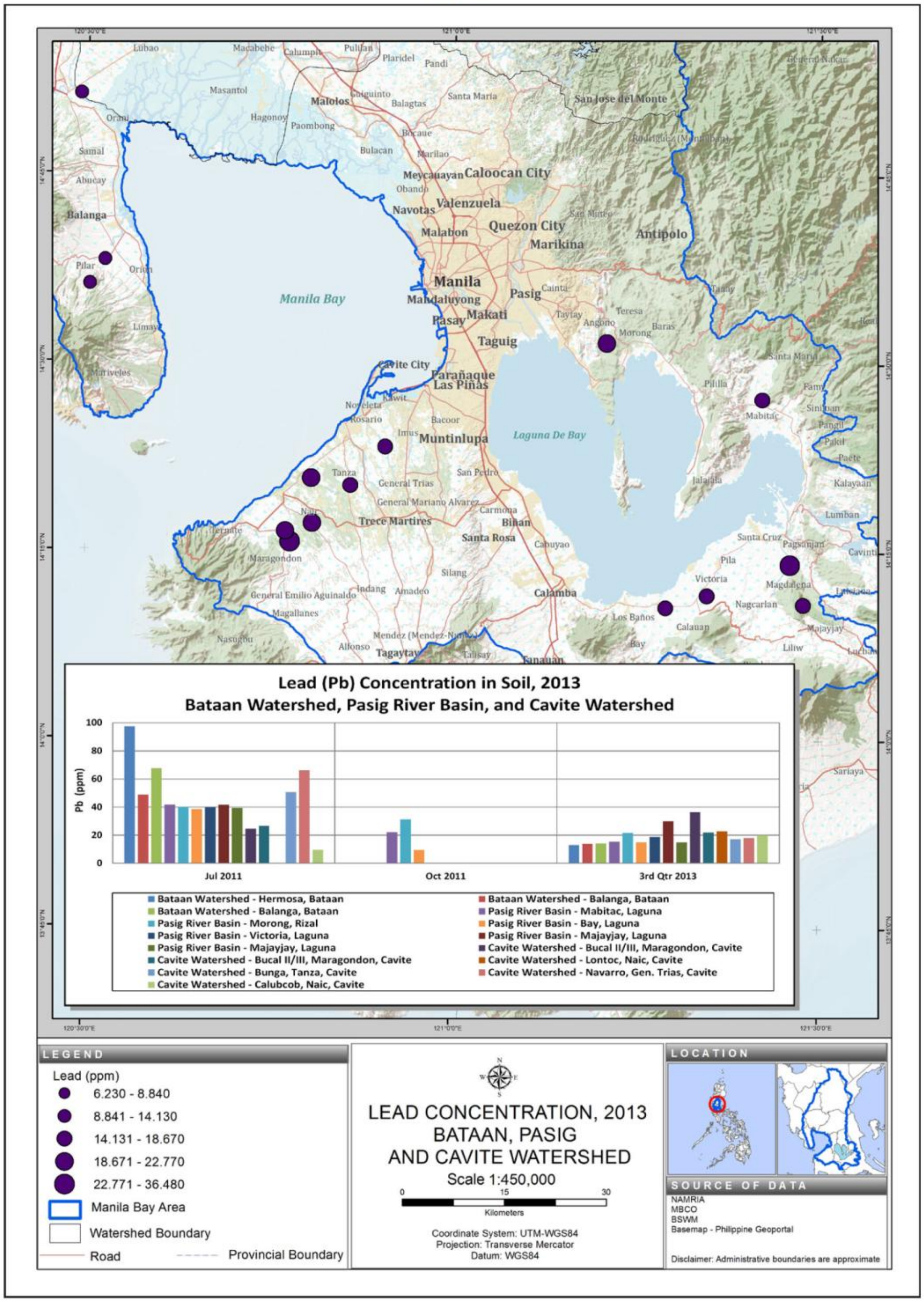
Map 115


Copper (Cu) Concentration in Soil, 2013
Pampanga River Basin
Cu (ppm)
200
180
160
140
120
100
80
60
40
20
0
3rd Qtr 2013
Pampanga River Basin - Gapan, San Isidro, Nueva Ecija
Pampanga River Basin - Magao, Concepcion, Tarlac
Pampanga River Basin - Turu, Lapas, Arayat, Pampanga
Pampanga River Basin - Cabiao, Nueva Ecija
Pampanga River Basin - Port Magsaysay, Nueva Ecija
LEGEND
Copper (ppm)
13.77 - 16.40
16.41 - 26.73
26.74 - 32.19
32.20 - 41.91
41.92 - 50.71
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
COPPER CONCENTRATION, 2013
PAMPANGA RIVER BASIN
Scale 1:500,000
0 7.5 15 30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate
TARLAC
NUEVA ECIJA
PAMPANGA
BULACAN
Tarlac City
Cabanatuan
Angeles City
San Fernando
Gapan
Malolos
Port Magsaysay
San Leonardo, N.E
Peñaranda /Gen. Tinio, N.E
Gapan San Isidro, N.E
Conception, Tarlac
Arayat, Pampanga
Cabia, N.E
Bustos Dam, Bulacan
Dingalan Bay
2013

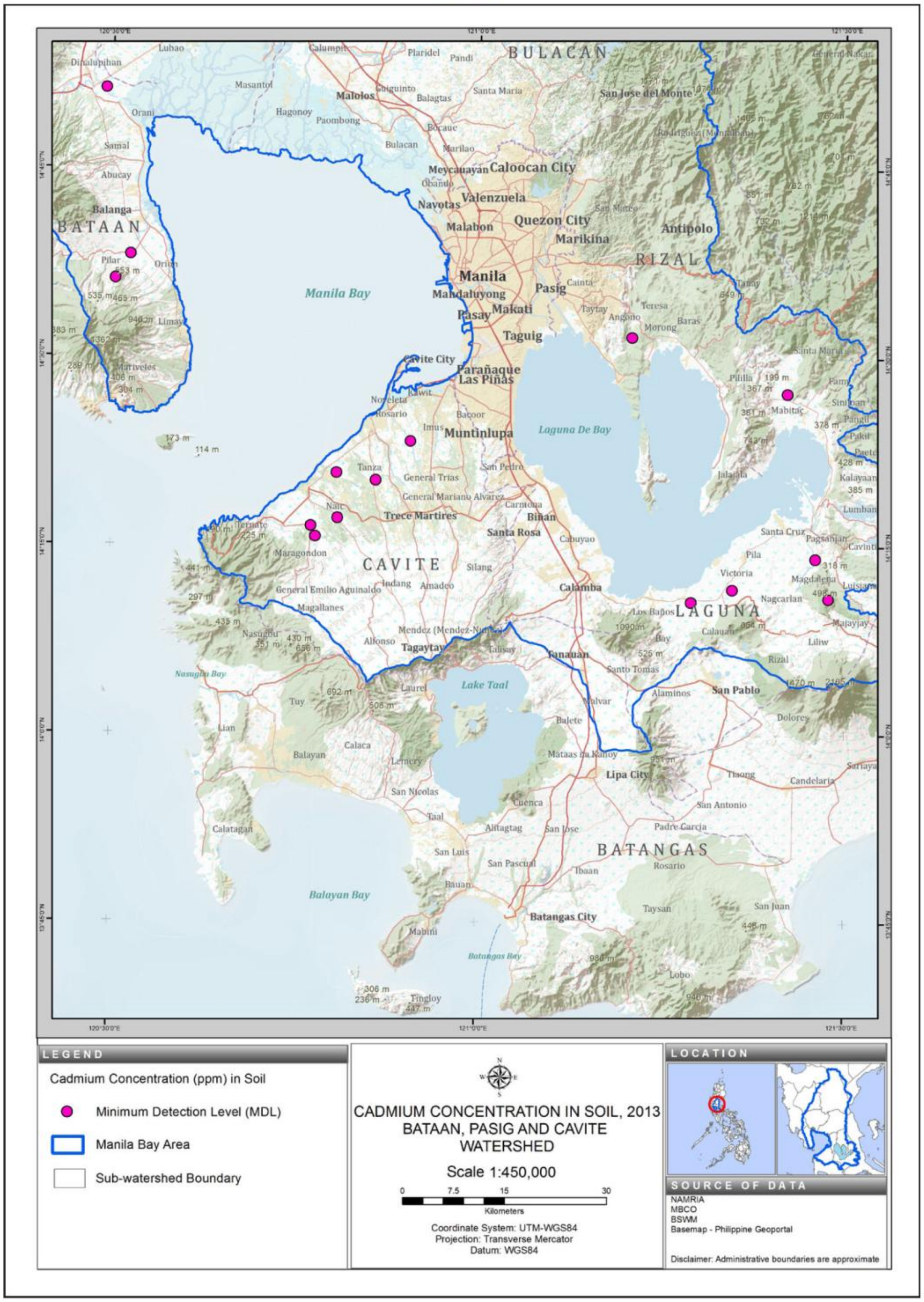
Map 116


Zinc (Zn) Concentration in Soil, 2013
Pampanga River Basin
Zn (ppm)
3rd Qtr 2013
Pampanga River Basin - Gapan, San Isidro, Nueva Ecija
Pampanga River Basin - Magao, Concepcion, Tarlac
Pampanga River Basin - Turu, Lapas, Arayat, Pampanga
Pampanga River Basin - Cabiao, Nueva Ecija
Pampanga River Basin - Port Magsaysay, Nueva Ecija
LEGEND
Zinc (ppm)
24.050 - 31.190
31.191 - 43.930
43.931 - 60.060
60.061 - 110.300
110.301 - 175.630
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
ZINC CONCENTRATION, 2013
PAMPANGA RIVER BASIN
Scale 1:500,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

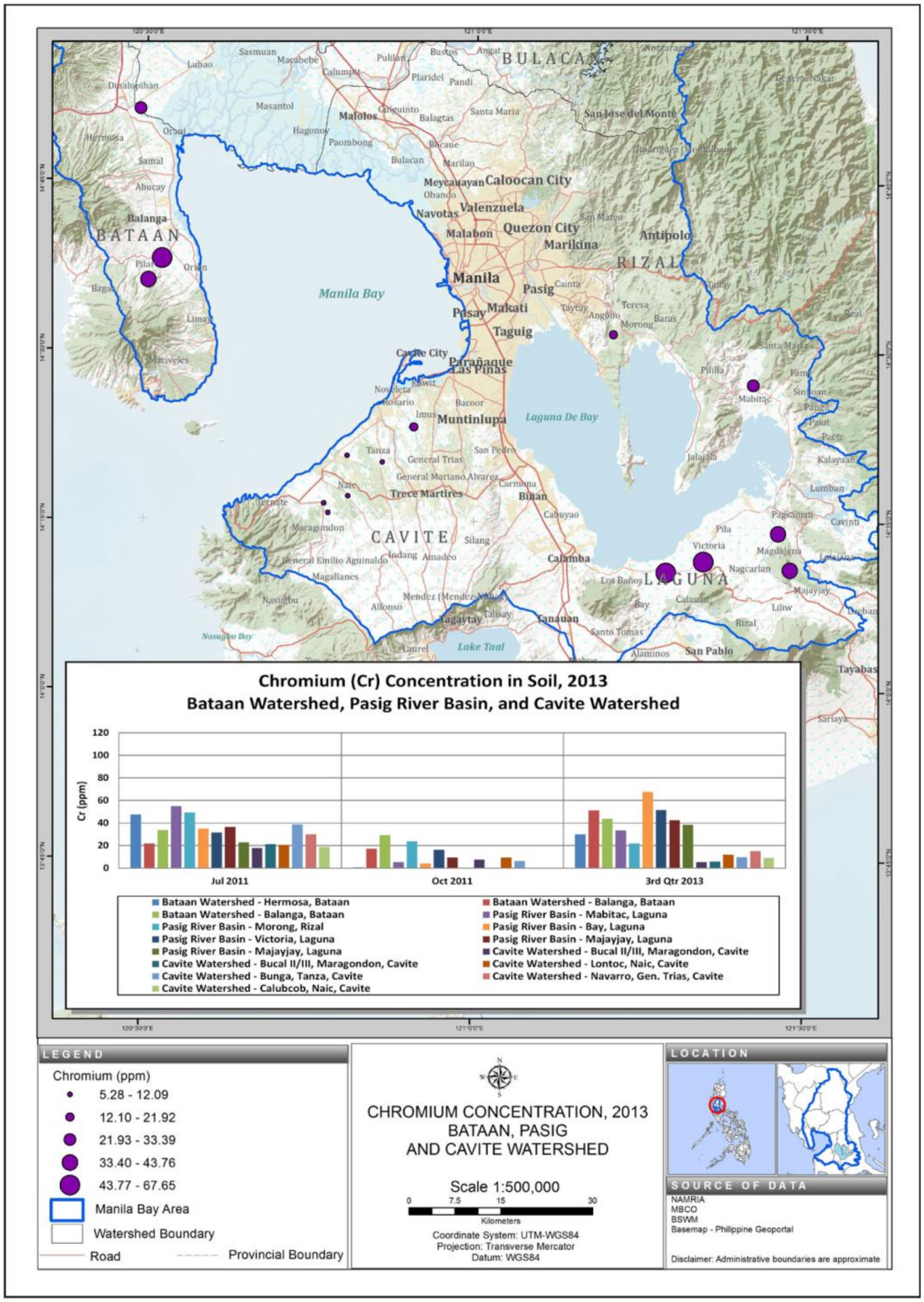
Map 117


Lead (Pb) Concentration in Soil, 2013
Bataan Watershed, Pasig River Basin, and Cavite Watershed
Pb (ppm)
100
80
60
40
20
0
Jul 2011
Oct 2011
3rd Qtr 2013
Bataan Watershed - Hermosa, Bataan
Bataan Watershed - Balanga, Bataan
Bataan Watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay, Laguna
Pasig River Basin - Victoria, Laguna
Pasig River Basin - Majayjay, Laguna
Pasig River Basin - Majayjay, Laguna
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Lontoc, Naic, Cavite
Cavite Watershed - Bunga, Tanza, Cavite
Cavite Watershed - Navarro, Gen. Trias, Cavite
Cavite Watershed - Calubcob, Naic, Cavite
Manila Bay
Laguna De Bay
Manila
Quezon City
Caloocan City
Valenzuela
Malabon
Navotas
Marikina
Pasig
Makati
Pasay
Mandaluyong
Taguig
Parañaque
Las Piñas
Muntinlupa
Antipolo
Balanga
Cavite City
Santa Rosa
Calamba
Trece Martires
Tagaytay
Malolos
San Jose del Monte
LEGEND
Lead (ppm)
6.230 - 8.840
8.841 - 14.130
14.131 - 18.670
18.671 - 22.770
22.771 - 36.480
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
LEAD CONCENTRATION, 2013
BATAAN, PASIG
AND CAVITE WATERSHED
Scale 1:450,000
0
15
30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

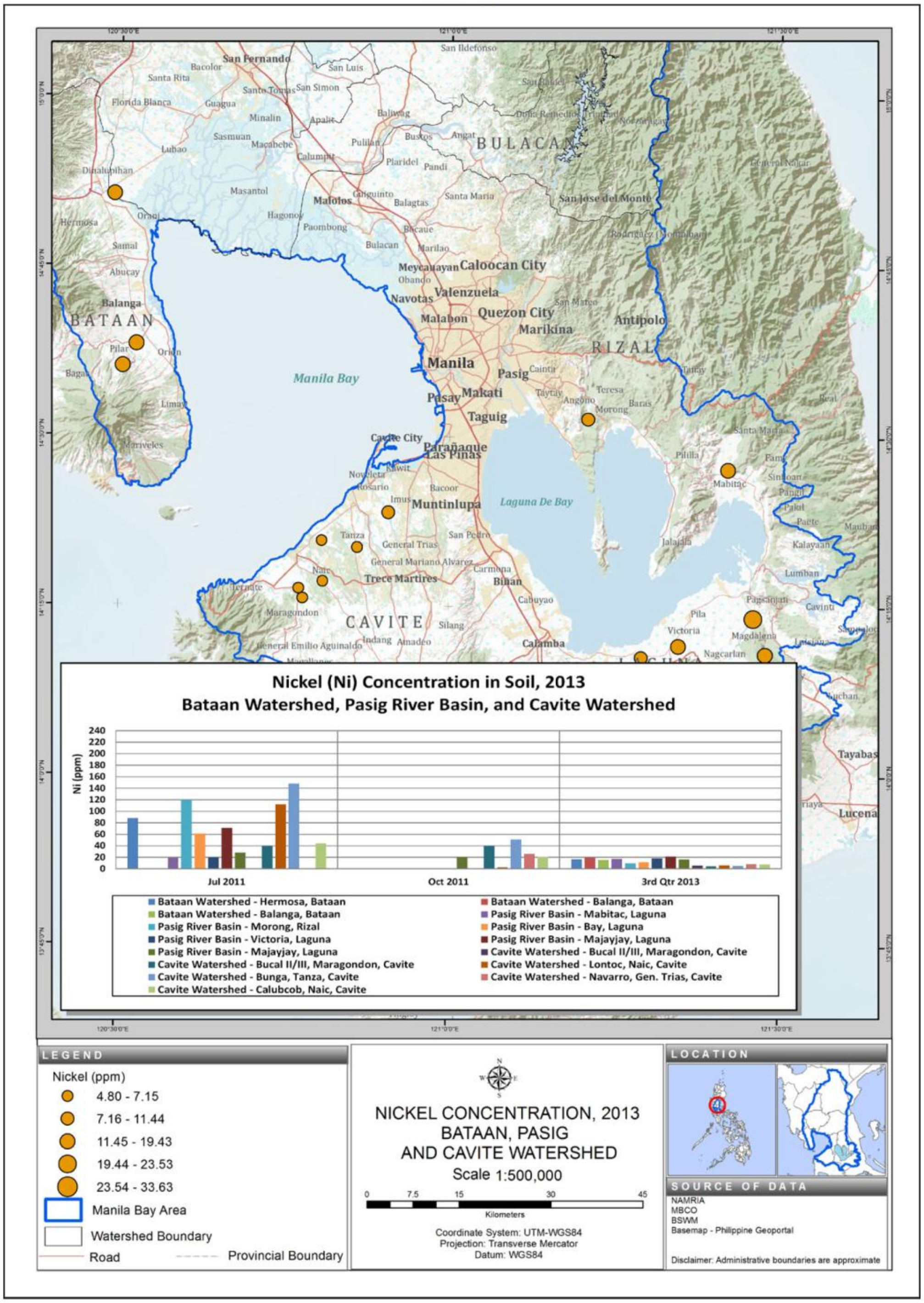
Map 118


LEGEND
Cadmium Concentration (ppm) in Soil
Minimum Detection Level (MDL)
Manila Bay Area
Sub-watershed Boundary
CADMIUM CONCENTRATION IN SOIL, 2013
BATAAN, PASIG AND CAVITE
WATERSHED
Scale 1:450,000
0
7.5
15
30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
BATANGAS
Manila Bay
Laguna De Bay
Lake Taal
Balayan Bay
Batangas Bay
Nasugbu Bay
Manila
Quezon City
Caloocan City
Valenzuela
Malabon
Navotas
Marikina
Pasig
Makati
Pasay
Taguig
Mandaluyong
Antipolo
Cavite City
Parañaque
Las Piñas
Muntinlupa
Malolos
Balanga
Tagaytay
Calamba
Santa Rosa
Biñan
San Pablo
Lipa City
Batangas City
Tanauan
Trece Martires

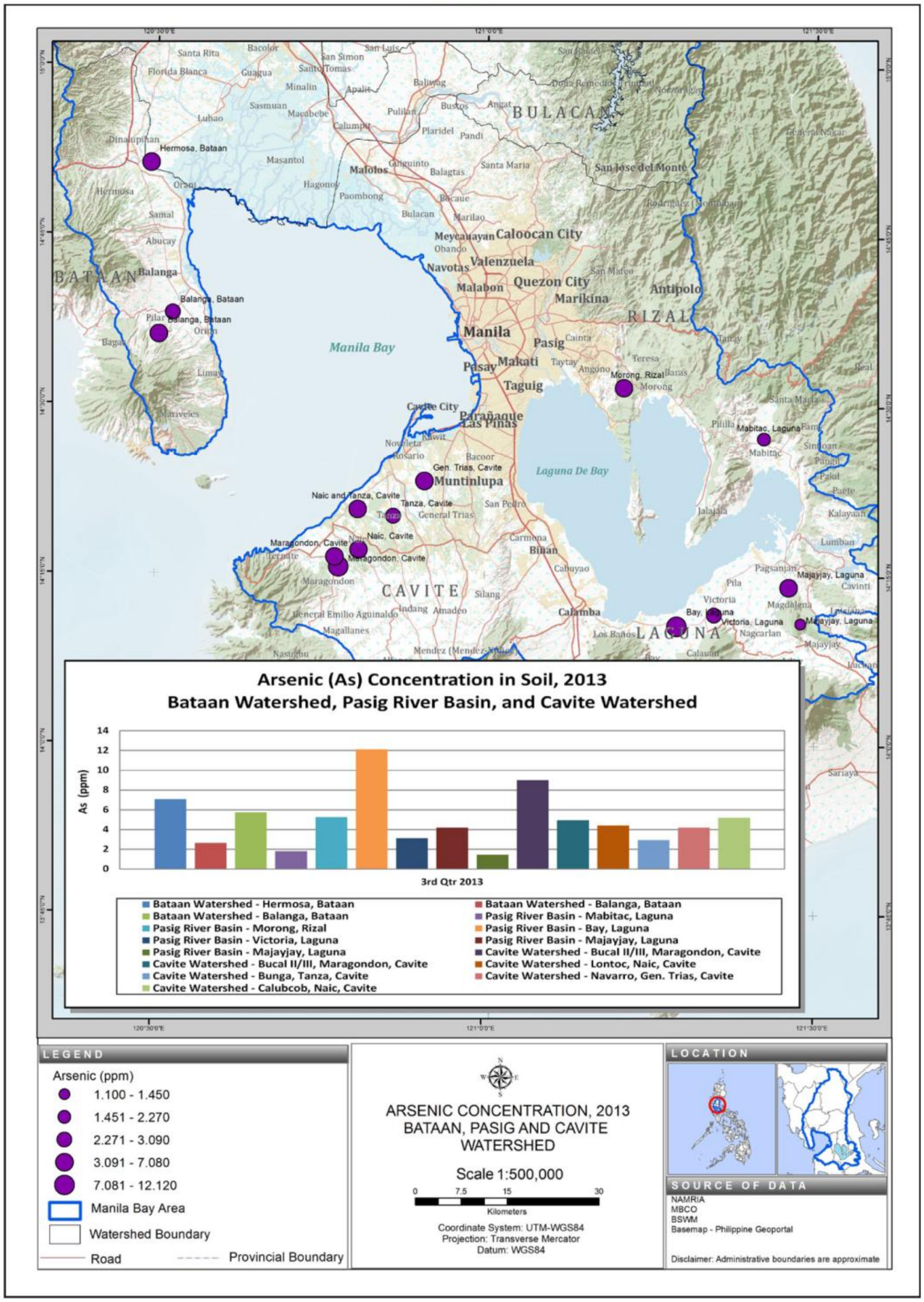
Map 119


Chromium (Cr) Concentration in Soil, 2013
Bataan Watershed, Pasig River Basin, and Cavite Watershed
Cr (ppm)
0
20
40
60
80
100
120
Jul 2011
Oct 2011
3rd Qtr 2013
Bataan Watershed - Hermosa, Bataan
Bataan Watershed - Balanga, Bataan
Bataan Watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay, Laguna
Pasig River Basin - Victoria, Laguna
Pasig River Basin - Majayjay, Laguna
Pasig River Basin - Majayjay, Laguna
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Lontoc, Naic, Cavite
Cavite Watershed - Bunga, Tanza, Cavite
Cavite Watershed - Navarro, Gen. Trias, Cavite
Cavite Watershed - Calubcob, Naic, Cavite
Manila Bay
Laguna De Bay
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila
Quezon City
Caloocan City
Makati
Pasig
Taguig
LEGEND
Chromium (ppm)
5.28 - 12.09
12.10 - 21.92
21.93 - 33.39
33.40 - 43.76
43.77 - 67.65
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
CHROMIUM CONCENTRATION, 2013
BATAAN, PASIG
AND CAVITE WATERSHED
Scale 1:500,000
0
7.5
15
30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

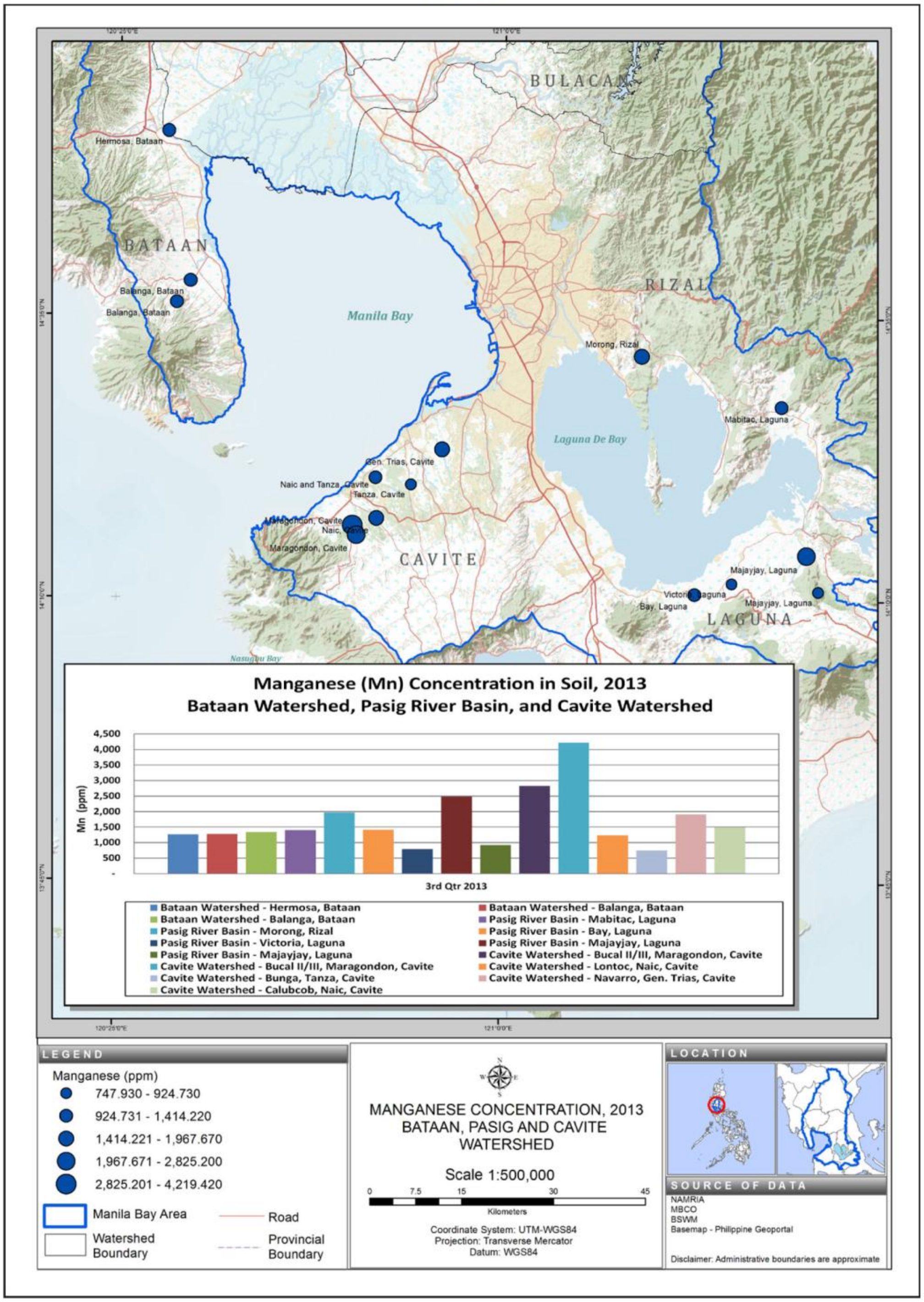
Map 120


Nickel (Ni) Concentration in Soil, 2013
Bataan Watershed, Pasig River Basin, and Cavite Watershed
Ni (ppm)
240
220
200
180
160
140
120
100
80
60
40
20
0
Jul 2011
Oct 2011
3rd Qtr 2013
Bataan Watershed - Hermosa, Bataan
Bataan Watershed - Balanga, Bataan
Bataan Watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay, Laguna
Pasig River Basin - Victoria, Laguna
Pasig River Basin - Majayjay, Laguna
Pasig River Basin - Majayjay, Laguna
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Lontoc, Naic, Cavite
Cavite Watershed - Bunga, Tanza, Cavite
Cavite Watershed - Navarro, Gen. Trias, Cavite
Cavite Watershed - Calubcob, Naic, Cavite
Manila Bay
Laguna De Bay
BATAAN
BULACAN
RIZAL
CAVITE
Manila
Quezon City
Caloocan City
LEGEND
Nickel (ppm)
4.80 - 7.15
7.16 - 11.44
11.45 - 19.43
19.44 - 23.53
23.54 - 33.63
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
NICKEL CONCENTRATION, 2013
BATAAN, PASIG
AND CAVITE WATERSHED
Scale 1:500,000
0 7.5 15 30 45
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

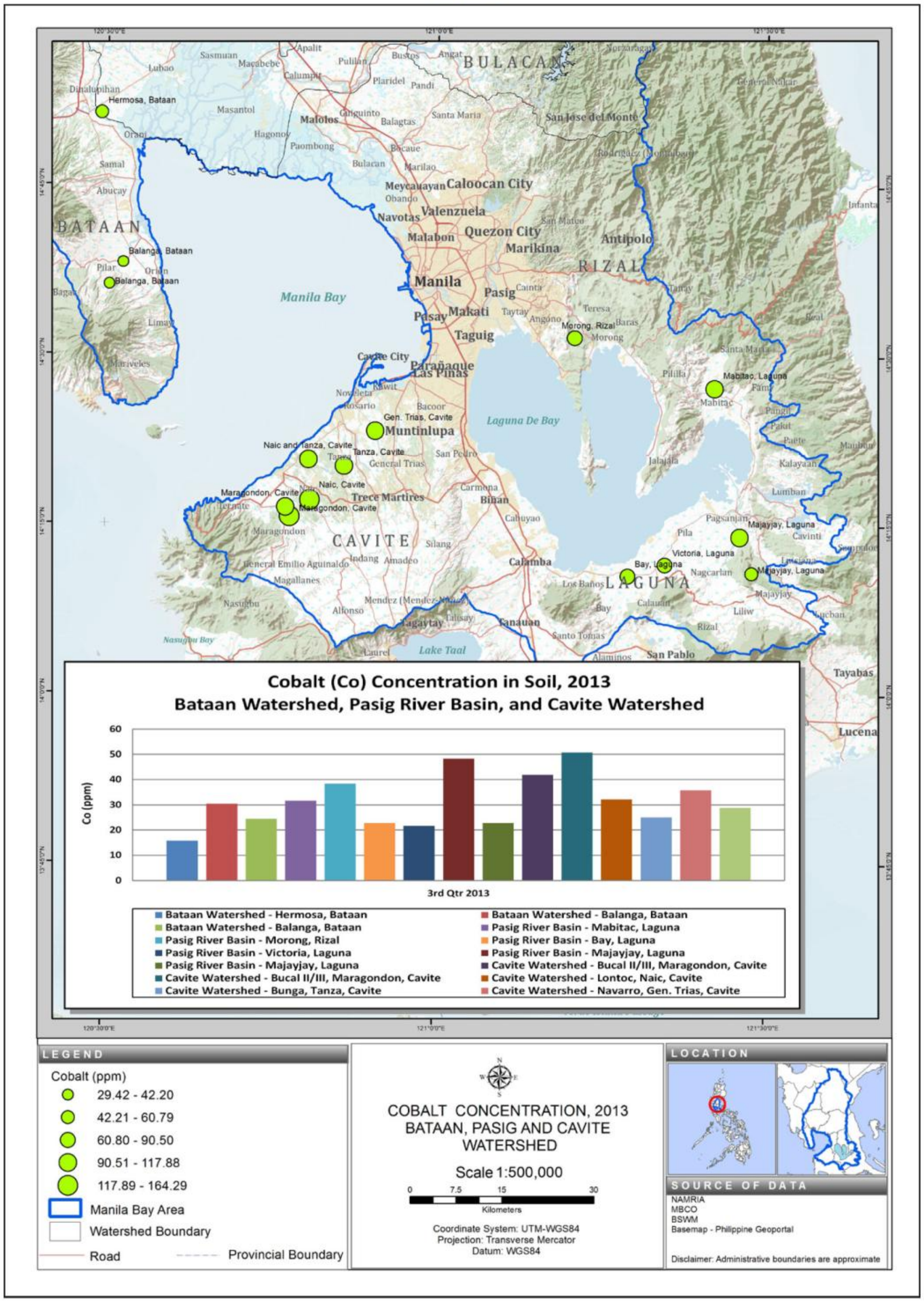
Map 121


Arsenic (As) Concentration in Soil, 2013
Bataan Watershed, Pasig River Basin, and Cavite Watershed
As (ppm)
14
12
10
8
6
4
2
0
3rd Qtr 2013
Bataan Watershed - Hermosa, Bataan
Bataan Watershed - Balanga, Bataan
Bataan Watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay, Laguna
Pasig River Basin - Victoria, Laguna
Pasig River Basin - Majayjay, Laguna
Pasig River Basin - Majayjay, Laguna
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Lontoc, Naic, Cavite
Cavite Watershed - Bunga, Tanza, Cavite
Cavite Watershed - Navarro, Gen. Trias, Cavite
Cavite Watershed - Calubcob, Naic, Cavite
Manila Bay
Laguna De Bay
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila
LEGEND
Arsenic (ppm)
1.100 - 1.450
1.451 - 2.270
2.271 - 3.090
3.091 - 7.080
7.081 - 12.120
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
ARSENIC CONCENTRATION, 2013
BATAAN, PASIG AND CAVITE
WATERSHED
Scale 1:500,000
0 7.5 15 30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

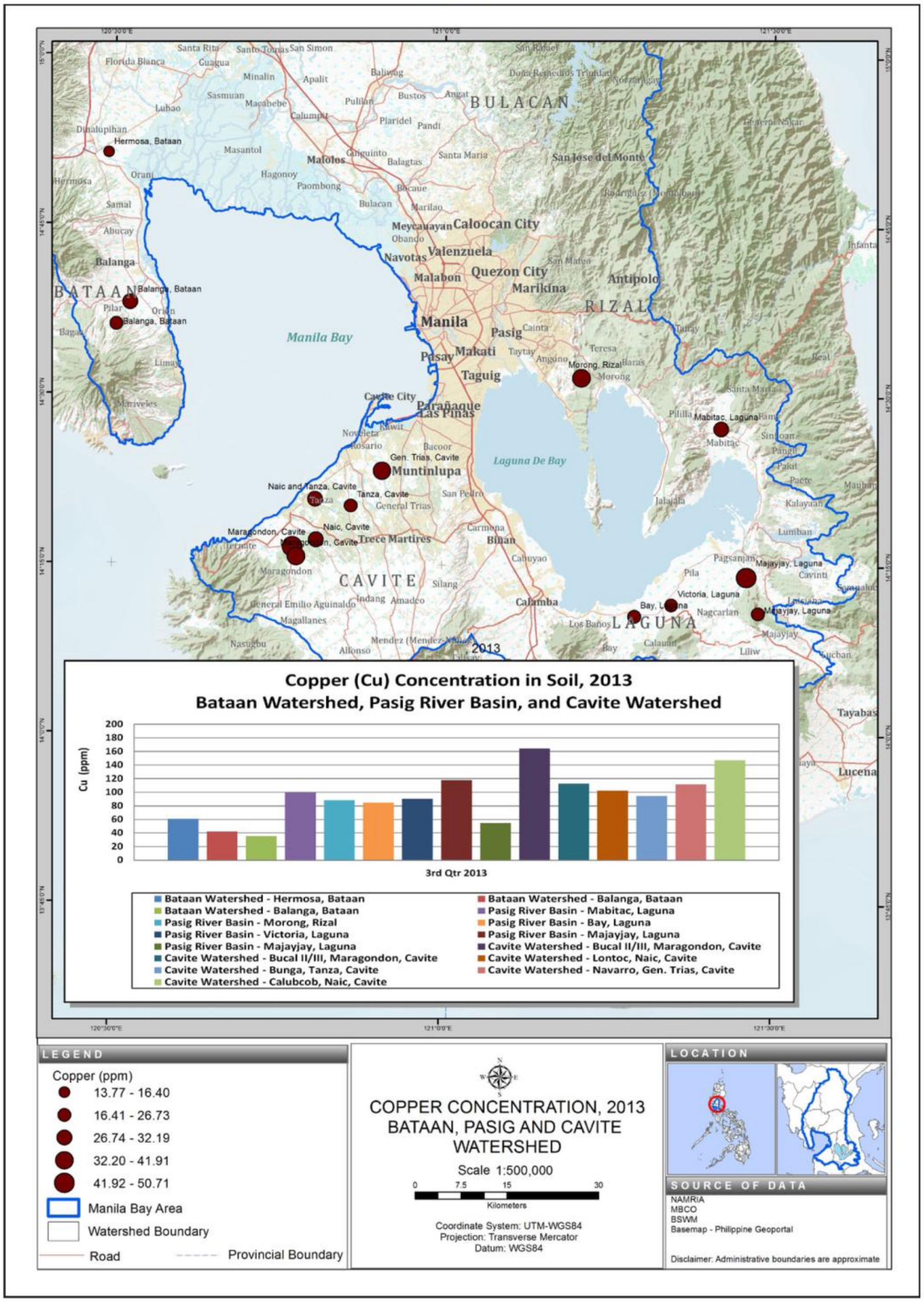
Map 122


BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Laguna De Bay
Hermosa, Bataan
Balanga, Bataan
Balanga, Bataan
Morong, Rizal
Mabitac, Laguna
Gen. Trias, Cavite
Naic and Tanza, Cavite
Tanza, Cavite
Maragondon, Cavite
Naic, Cavite
Maragondon, Cavite
Majayjay, Laguna
Victoria, Laguna
Bay, Laguna
Majayjay, Laguna
Manganese (Mn) Concentration in Soil, 2013
Bataan Watershed, Pasig River Basin, and Cavite Watershed
Mn (ppm)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
3rd Qtr 2013
Bataan Watershed - Hermosa, Bataan
Bataan Watershed - Balanga, Bataan
Bataan Watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay, Laguna
Pasig River Basin - Victoria, Laguna
Pasig River Basin - Majayjay, Laguna
Pasig River Basin - Majayjay, Laguna
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Lontoc, Naic, Cavite
Cavite Watershed - Bunga, Tanza, Cavite
Cavite Watershed - Navarro, Gen. Trias, Cavite
Cavite Watershed - Calubcob, Naic, Cavite
LEGEND
Manganese (ppm)
747.930 - 924.730
924.731 - 1,414.220
1,414.221 - 1,967.670
1,967.671 - 2,825.200
2,825.201 - 4,219.420
Manila Bay Area
Road
Watershed Boundary
Provincial Boundary
MANGANESE CONCENTRATION, 2013
BATAAN, PASIG AND CAVITE WATERSHED
Scale 1:500,000
0 7.5 15 30 45
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

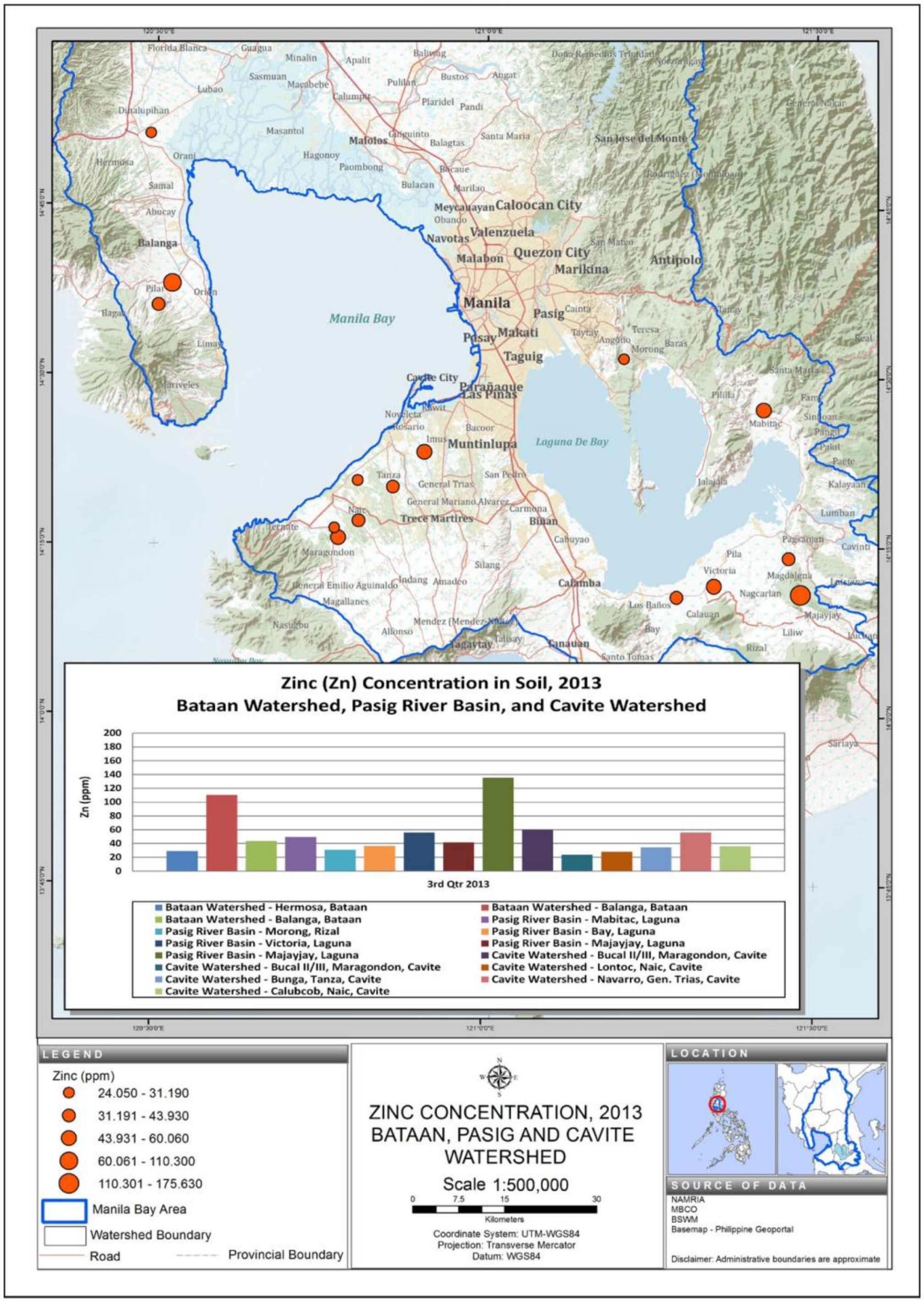
Map 123


Cobalt (Co) Concentration in Soil, 2013
Bataan Watershed, Pasig River Basin, and Cavite Watershed
Co (ppm)
3rd Qtr 2013
Bataan Watershed - Hermosa, Bataan
Bataan Watershed - Balanga, Bataan
Bataan Watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay, Laguna
Pasig River Basin - Victoria, Laguna
Pasig River Basin - Majayjay, Laguna
Pasig River Basin - Majayjay, Laguna
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Lontoc, Naic, Cavite
Cavite Watershed - Bunga, Tanza, Cavite
Cavite Watershed - Navarro, Gen. Trias, Cavite
Manila Bay
Laguna De Bay
BATAAN
CAVITE
LAGUNA
RIZAL
BULACAN
LEGEND
Cobalt (ppm)
29.42 - 42.20
42.21 - 60.79
60.80 - 90.50
90.51 - 117.88
117.89 - 164.29
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
COBALT CONCENTRATION, 2013
BATAAN, PASIG AND CAVITE WATERSHED
Scale 1:500,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 124


Copper (Cu) Concentration in Soil, 2013
Bataan Watershed, Pasig River Basin, and Cavite Watershed
Cu (ppm)
3rd Qtr 2013
Bataan Watershed - Hermosa, Bataan
Bataan Watershed - Balanga, Bataan
Bataan Watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay, Laguna
Pasig River Basin - Victoria, Laguna
Pasig River Basin - Majayjay, Laguna
Pasig River Basin - Majayjay, Laguna
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Lontoc, Naic, Cavite
Cavite Watershed - Bunga, Tanza, Cavite
Cavite Watershed - Navarro, Gen. Trias, Cavite
Cavite Watershed - Calubcob, Naic, Cavite
LEGEND
Copper (ppm)
13.77 - 16.40
16.41 - 26.73
26.74 - 32.19
32.20 - 41.91
41.92 - 50.71
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
COPPER CONCENTRATION, 2013
BATAAN, PASIG AND CAVITE
WATERSHED
Scale 1:500,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate
Manila Bay
Laguna De Bay
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA

Map 125


Zinc (Zn) Concentration in Soil, 2013
Bataan Watershed, Pasig River Basin, and Cavite Watershed
Zn (ppm)
200
180
160
140
120
100
80
60
40
20
0
3rd Qtr 2013
Bataan Watershed - Hermosa, Bataan
Bataan Watershed - Balanga, Bataan
Bataan Watershed - Balanga, Bataan
Pasig River Basin - Mabitac, Laguna
Pasig River Basin - Morong, Rizal
Pasig River Basin - Bay, Laguna
Pasig River Basin - Victoria, Laguna
Pasig River Basin - Majayjay, Laguna
Pasig River Basin - Majayjay, Laguna
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Bucal II/III, Maragondon, Cavite
Cavite Watershed - Lontoc, Naic, Cavite
Cavite Watershed - Bunga, Tanza, Cavite
Cavite Watershed - Navarro, Gen. Trias, Cavite
Cavite Watershed - Calubcob, Naic, Cavite
Manila Bay
Laguna De Bay
Manila
Quezon City
Caloocan City
Valenzuela
Malabon
Navotas
Marikina
Antipolo
Pasig
Makati
Pasay
Taguig
Cavite City
Parañaque
Las Piñas
Muntinlupa
Trece Martires
Biñan
Calamba
Balanga
Malolos
San Jose del Monte
LEGEND
Zinc (ppm)
24.050 - 31.190
31.191 - 43.930
43.931 - 60.060
60.061 - 110.300
110.301 - 175.630
Manila Bay Area
Watershed Boundary
Road
Provincial Boundary
ZINC CONCENTRATION, 2013
BATAAN, PASIG AND CAVITE
WATERSHED
Scale 1:500,000
0 7.5 15 30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
BSWM
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

G. WATER SUPPLY AND SANITATION

The water supply in the Manila Bay Area is being catered by two national government agencies, the Metropolitan Waterworks and Sewerage System (MWSS) and the Local Water Utilities Administration (LWUA). MWSS has the jurisdiction, supervision and control over all waterworks and sewerage systems within Metro Manila and some cities/towns in nearby provinces of Cavite and Rizal, while LWUA has jurisdiction over the remaining portions of the MBA.

For MWSS, the operation and maintenance of the waterworks and sewerage system was privatized under a Concession Agreement for 25 years. The service area of Metro Manila was subdivided into two (2) zones: the west concession area operated by Maynilad Water Services Inc. (MWSI) and the east concession by Manila Water Company Inc. (MWCI).

Similar operations are observed in LWUA with the passage of Presidential Decree No. 198 (as amended by Presidential Decree No. 768 and 1479, R. A. 9286) referred to as the "Provincial Water Utilities Act of 1973". Said law decentralized waterworks and sewerage system functions to local water districts. As of 2010, there are a total of 70 local water districts in the provinces of Laguna, Cavite, Bulacan, Pampanga and Bataan.

WATER SUPPLY SYSTEM

Metro Manila and select LGUs of Cavite and Rizal

The current water supply system of MWSS starts in Umiray River in General Nakar, Quezon, where raw water from the Umiray River is diverted to supplement the Angat Reservoir. From the Angat Dam and Reservoir, the raw water flows to Bustos Dam for NIA's irrigation and to Ipo Dam for MWSS' domestic water supply. From Ipo Dam, the raw water is conveyed through three tunnels and six aqueducts going to La Mesa Dam/Reservoir. For MWSI, raw water from the conveyances flows directly to the La Mesa Water Treatment Plants (LMWTP 1 and 2). For MWCI, stored raw water from La Mesa Dam/Reservoir goes to Balara Water Treatment Plants (BWTP 1 and 2). The total raw water allocation is distributed into 60-40 proportions wherein 60% (2,400 MLD) goes to MWSI and 40% (1,600 MLD) to MWCI.

For MWCI, a new water treatment plant - the East La Mesa Water Treatment Plant (150 MLD capacity) was recently constructed within the La Mesa Dam compound. This will serve a portion of Marikina City and the province of Rizal (municipalities of San Mateo and Rodriguez).

In addition to the current source at Angat Dam and Reservoir, MWSI constructed a water treatment plant (100 MLD capacity) in Putatan, Muntinlupa - extracting water from Laguna de Bay.

Remainder of Laguna, Cavite, Bulacan, Pampanga and Bataan

LWUA, through the Local Water Districts, obtain their raw water from dug, shallow or deepwells and springs. Some water districts utilize surface water as their source of supply whenever ground water is not sufficient or when the water quality is not acceptable. Water from these sources are either pumped directly to the distribution system or stored in reservoirs before releasing it to the consumers. Simple chlorination is done as a means of disinfection for well sources but complex filtration, coagulation and disinfection is done for surface water sources.

Every water district has its own distinct water sources, treatment process and disinfection facilities to address the particular need and situation in their respective area of responsibility. The LWUA on the other hand provides the technical and regulatory requirements.

Table 19. Status of Water Supply (2014)

	Manila Water East Zone	Maynilad West Zone	TOTAL
Service Area (Cities & Municipalities)	23	17	40
Total No. of Population Connected to Water Supply	6,385,030	9,115,434	15,500,464
Service Population	6,947,079	9,681,655	16,628,734
Water Supply Coverage	92 %	94 %	93.2%


MWSS
East La Mesa Water Treatment Plant

MWSS
Balara Water Treatment Plant

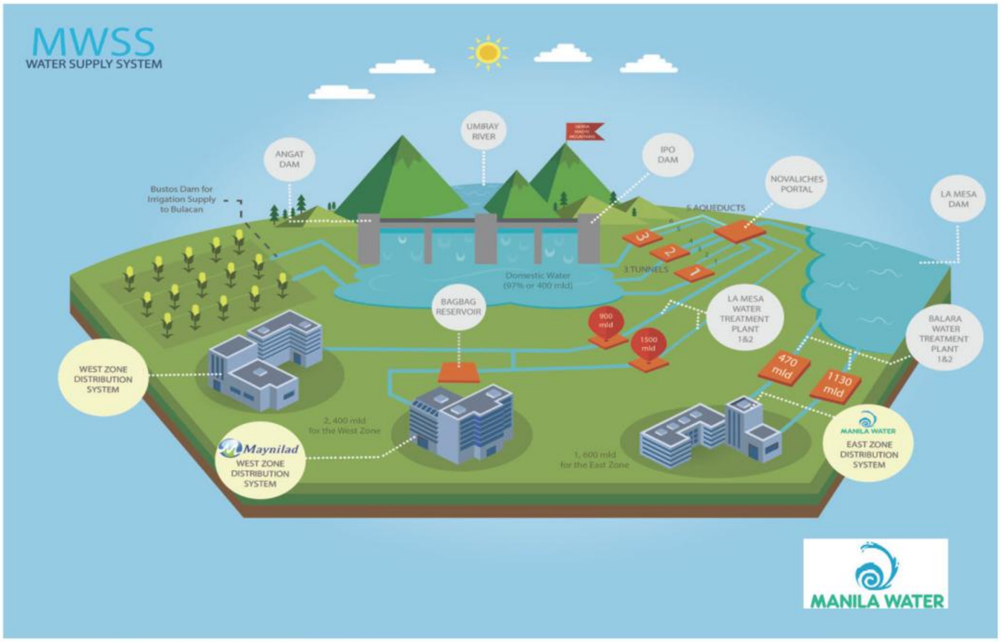


Figure 30. Water Trail from Source to Distribution System

SEWERAGE AND SANITATION

Apart from providing water supplies, MWSS and LWUA are also mandated to provide sewerage and sanitation services their designated areas. These include sewerage connections for domestic sewage and industrial effluents compatible with available treatment processes, as well as septic and sanitation cleaning services at regular intervals of 5-7 years.

These services were further prioritized when the Supreme Court (thru G.R. Nos. 171947-48) ordered MWSS and LWUA to provide, install, operate and maintain sewerage and sanitation facilities and the efficient and safe collection, treatment and disposal of sewage within its service area in the MBA.

Sewerage System

Existing sewerage systems of the MWSS were turned over to the two concessionaires during privatization. There is an estimated increase of 34.6 % in the population served by sewerage systems from 2011 (1.3 million) to 2014 (1.8 million), comprising 11.23% of the total population within the concession area.

A total of 41 sewage treatment facilities are found within the East Zone; three are on-going construction while one - the Magallanes STP - was turned over by MWSS upon privatization. For the West Zone, 19 STPs are currently operational: one is on-going construction and three facilities were turned-over by MWSS upon privatization.

Outside the MWSS concession area, only the Baliwag Water District in the province of Bulacan offers sewerage services. Additional sewerage plans are underway for Angeles (Pampanga) and San Jose del Monte (Bulacan). With the proposed expansion of DPWH's National Sewerage and Septage Management Program (NSSMP), additional LGUs within the MBA will be given access to establish their own sewerage systems.

Box 10. The National Sewerage and Septage Management Program (NSSMP)

The overall goal of the NSSMP is to improve the water quality and public health in the country's urban areas by 2020. It also aims to enhance the ability of the local implementers to build and operate water treatment systems for urban centers and work for the behavioral change and supporting environment needed for the systems to be effective and sustainable.

The NSSMP was approved by the NEDA Board in 2013, with 40% share/grant from the National Government and the remaining 60% to be shouldered by either LGU or WD. This project involves the development of sewerage systems in 17 identified Highly Urbanized Cities (HUCs), namely: Baguio, Angeles, Olongapo, Lucena, Puerto Princesa, Bacolod, Iloilo, Cebu, Lapu-lapu, mandaue, Tacloban, Zamboanga, Cagayan de Oro, Iligan, Davao, General Santos and Butuan.

Initially, the overall assessment of the program indicated that no eligible application from any of the LGUs, WDs and private service providers qualified for the program. To address the problem, the DPWH proposed the amendments to the NSSMP. The proposal was approved by the NEDA Board-Committee on Infrastructure in 27 October 2014 and is only awaiting the confirmation of the NEDA Board. The proposed amendments were the following:

1. Broaden the scope of the NG cost/grant to include septage projects;
2. Expand eligibility to non-HUCs and municipalities; and
3. Allow WDs to directly apply for the NG share/grant through LWUA

The proposal was taken up during the NEDA Board meeting during the first quarter of 2015 but was still for major revisions on the recommendations.

Meanwhile, LWUA continued training WDs and LWUA personnel on the development and implementation of sewerage systems.

Sanitation

The septage management programs of MWSS and LWUA aim to provide sanitation services to households not connected to sewerage systems and reliant on individual or communal septic tanks to deal with domestic wastewater. Said programs include desludging of septic tanks using vacuum truck units (VTU) and transporting collected septage to accredited treatment plants.

Table 20. Sanitation Services

	Manila Water	Maynilad
C. Sanitation	East Zone	West Zone
No. of Septic Tanks	194,808	300,979
Sanitation Coverage	71 %	47 %
Facilities		
No. of Septage Treatment Plants	2	2
Total Capacity (MLD)	1.40	0.94
No. of Desludging Tankers/ Vacuum Truck Units	77	30
No. of Mobile Dewatering Tankers	-	7
Manila Water		
Septage Treatment Plant (SpTP)	Capacity (MLD)	Status
North SpTP (Sn Mateo)	0.59	Operational
South (FTI-Taguig) SpTP	0.81	Operational
Maynilad		
Dagat-dagatan SpTP	0.45	Operational
Project 7 SpTP	0.24	Process Proving
South Septage	0.25	Proposed

In 2011, the total population within the concession area reached 15.7 million. It increased by 5.8 % in 2014, comprising a total population of 16.6 million.

With the investments made by the two concessionaires (Maynilad & Manila Water) on the construction of sewage treatment facilities, the total pollution loading treated was significantly increased by 41% within 4 years -- from 23,216 kg BOD/day in 2011 to 32,692 kg BOD/day as of 2014.

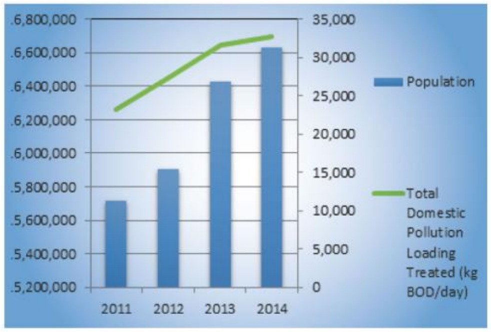
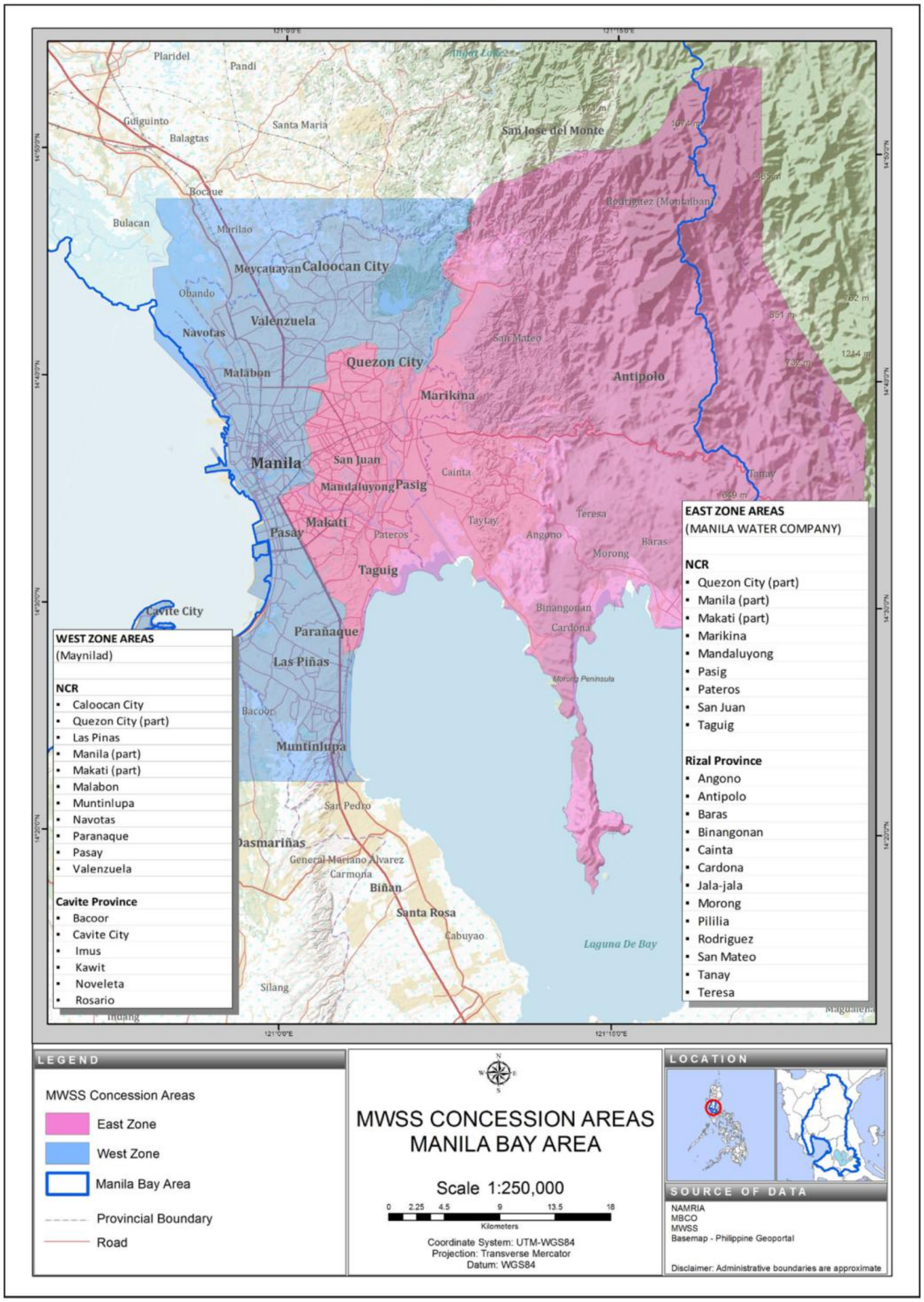


Figure 31. Total Domestic Pollution Loading Treated within the East and West Concession Areas

East Avenue Sewage Treatment Plant

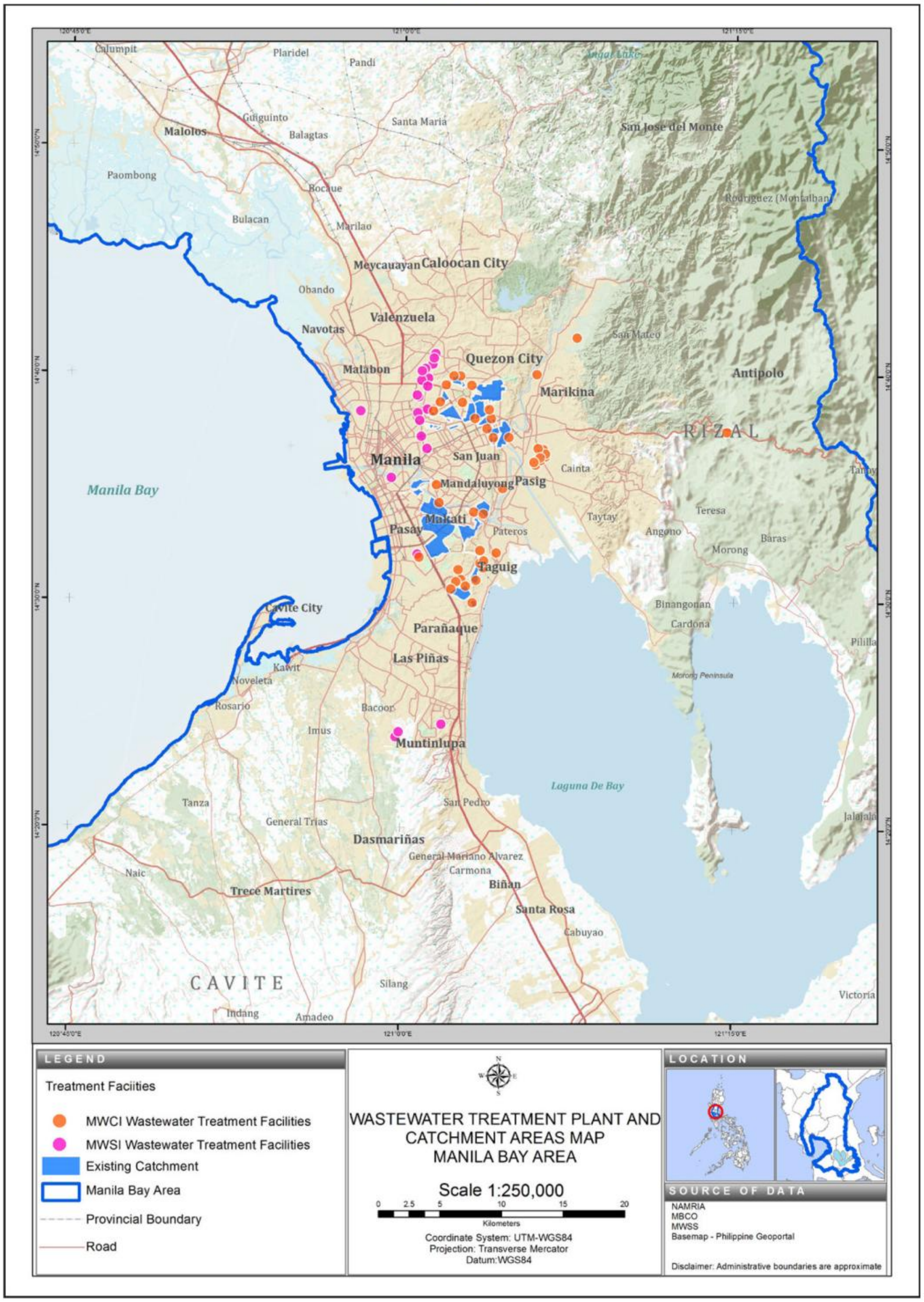
Maynilad's Alabang Sewage Treatment Plant

Map 126



Plaridel
Pandi
Guiguinto
Balagtas
Santa Maria
San Jose del Monte
Bocaue
Bulacan
Marilao
Rodriguez (Montalban)
Meycauayan
Caloocan City
Obando
Navotas
Valenzuela
San Mateo
Quezon City
Malabon
Antipolo
Marikina
Manila
San Juan
Mandaluyong
Pasig
Cainta
Tanay
Makati
Pasay
Pateros
Taytay
Angono
Teresa
Baras
Morong
Taguig
Binangonan
Cardona
Cavite City
Parañaque
Las Piñas
Morong Peninsula
Bacoor
Muntinlupa
San Pedro
Dasmariñas
General Mariano Alvarez
Carmona
Biñan
Santa Rosa
Cabuyao
Laguna De Bay
Silang
WEST ZONE AREAS
(Maynilad)
NCR
• Caloocan City
• Quezon City (part)
• Las Pinas
• Manila (part)
• Makati (part)
• Malabon
• Muntinlupa
• Navotas
• Paranaque
• Pasay
• Valenzuela
Cavite Province
• Bacoor
• Cavite City
• Imus
• Kawit
• Noveleta
• Rosario
EAST ZONE AREAS
(MANILA WATER COMPANY)
NCR
• Quezon City (part)
• Manila (part)
• Makati (part)
• Marikina
• Mandaluyong
• Pasig
• Pateros
• San Juan
• Taguig
Rizal Province
• Angono
• Antipolo
• Baras
• Binangonan
• Cainta
• Cardona
• Jala-jala
• Morong
• Pililia
• Rodriguez
• San Mateo
• Tanay
• Teresa
LEGEND
MWSS Concession Areas
East Zone
West Zone
Manila Bay Area
Provincial Boundary
Road
MWSS CONCESSION AREAS
MANILA BAY AREA
Scale 1:250,000
0 2.25 4.5 9 13.5 18
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
MWSS
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 127


WASTEWATER TREATMENT PLANT AND CATCHMENT AREAS MAP
MANILA BAY AREA
Scale 1:250,000
0 2.5 5 10 15 20
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum:WGS84
LEGEND
Treatment Faciities
MWCI Wastewater Treatment Facilities
MWSI Wastewater Treatment Facilities
Existing Catchment
Manila Bay Area
Provincial Boundary
Road
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
MWSS
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate
Manila Bay
Laguna De Bay
Calumpit
Plaridel
Pandi
Malolos
Guiguinto
Balagtas
Santa Maria
San Jose del Monte
Paombong
Bocaue
Bulacan
Marilao
Meycauayan
Caloocan City
Obando
Valenzuela
Navotas
Malabon
Quezon City
San Mateo
Antipolo
Marikina
RIZAL
Manila
San Juan
Mandaluyong
Pasig
Cainta
Makati
Pasay
Pateros
Taytay
Angono
Teresa
Morong
Baras
Taguig
Binangonan
Cardona
Cavite City
Parañaque
Las Piñas
Kawit
Noveleta
Rosario
Bacoor
Imus
Muntinlupa
Tanza
General Trias
Dasmariñas
San Pedro
General Mariano Alvarez
Carmona
Naic
Trece Martires
Biñan
Santa Rosa
Cabuyao
CAVITE
Silang
Indang
Amadeo
Victoria
Jalajala
Pililla
Morong Peninsula
Rodriguez (Montalban)
Tanay

H. SOLID WASTE

Solid Waste Management continues to be one of the most pressing issues affecting the overall ecological health of Manila Bay and its abutting river systems. The past decade saw increasing rates of waste generation and disposal in the Manila Bay Area. These figures are doubled in Highly Urbanized Cities (HUCs), particularly in the National Capital Region and the adjacent provinces of Regions III and IVA.

According to the NSWMC, the NCR produces a quarter of the country's total waste generation for 2011. Though management plans are in place, its continuous increase requires concerted efforts from all stakeholders. This may include stringent implementation of laws and policies, as well as putting forth an effective platform for technology and knowledge transfers.

SOLID WASTE GENERATION AND DISPOSAL IN METRO MANILA

The volume of solid waste disposed of in 2010 to 2011 for Metro Manila shows an irregular pattern. Nine LGUs, namely Caloocan City, Makati City, Mandaluyong City, Pasay City, Pasig City, Manila City, Malabon City, Navotas City and Las Piñas City showed a decrease of solid waste disposal by an average of 11%. Said decrease may be attributed to the effective implementation of solid waste segregation and recycling practices by the households of the cities. The other eight LGUs, namely Pateros, San Juan City, Marikina City, Taguig City, Quezon City, Muntinlupa City, Parañaque City and Valenzuela City showed an increase of 10.7%. This is attributed to the seeming gaps in the implementation of solid waste generation and recycling practices in the households of said localities.

From 2012 to 2013, there is an increasing trend in most of the LGUs in Metro Manila due to weather disturbances such as tropical storms and monsoon rains. It is also of note that the estimated waste generation per day in cubic meter shows a significant increase during the said years.

The average solid waste disposed showed an irregular pattern for the last five years from 2009-2013. The comparison on actual volume disposed from 2009-2013 reveal that there is an increase of 4% from 2009-2010, 3% decrease from 2010 to 2011 and 2% decrease from 2011 to 2012. However, from 2012 to 2013, there is a 6% increase of volume of solid wastes disposed in Metro Manila.

Figure 32 shows the volume of solid wastes disposed monthly from 2009-2013. It is noted that waste disposal is high in the months of January, March, May, and July and during the last quarter of each year. This is attributed to the holiday season activities for December and January and due to the occurrence of tropical storms and typhoons during the fourth quarter of each year. In 2009, for instance, a significant increase is shown for the month of October due to the post-Ondoy disposal operations. There is an increase for March and May during closing of school classes and summer vacation and July also records an increase during opening of classes. This implies that waste disposal is directly proportional to annual economic activities.

Solid wastes in Metro Manila are disposed of at the three MMDA-accredited disposal facilities located in Rodriguez, Rizal; Tanza, Navotas City; and Payatas, Quezon City. The biggest proportion of solid wastes is disposed of at the Rodriguez, Rizal Provincial Sanitary Landfill. Other SLFs include San Pedro, Laguna; Lingunan, Las Piñas City; and Pulang- lupa, Valenzuela City. Annex 52 shows the volume of solid wastes disposed at MMDA and LGU facilities from 2009-2013, while Map 128 features the location of all disposal facilities within the Manila Bay Area.

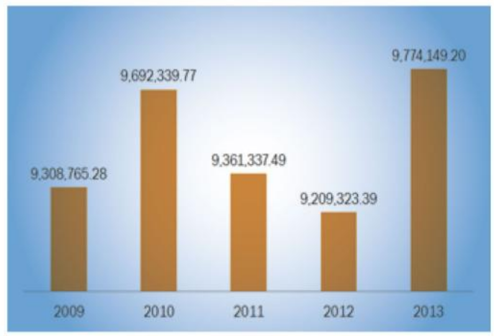


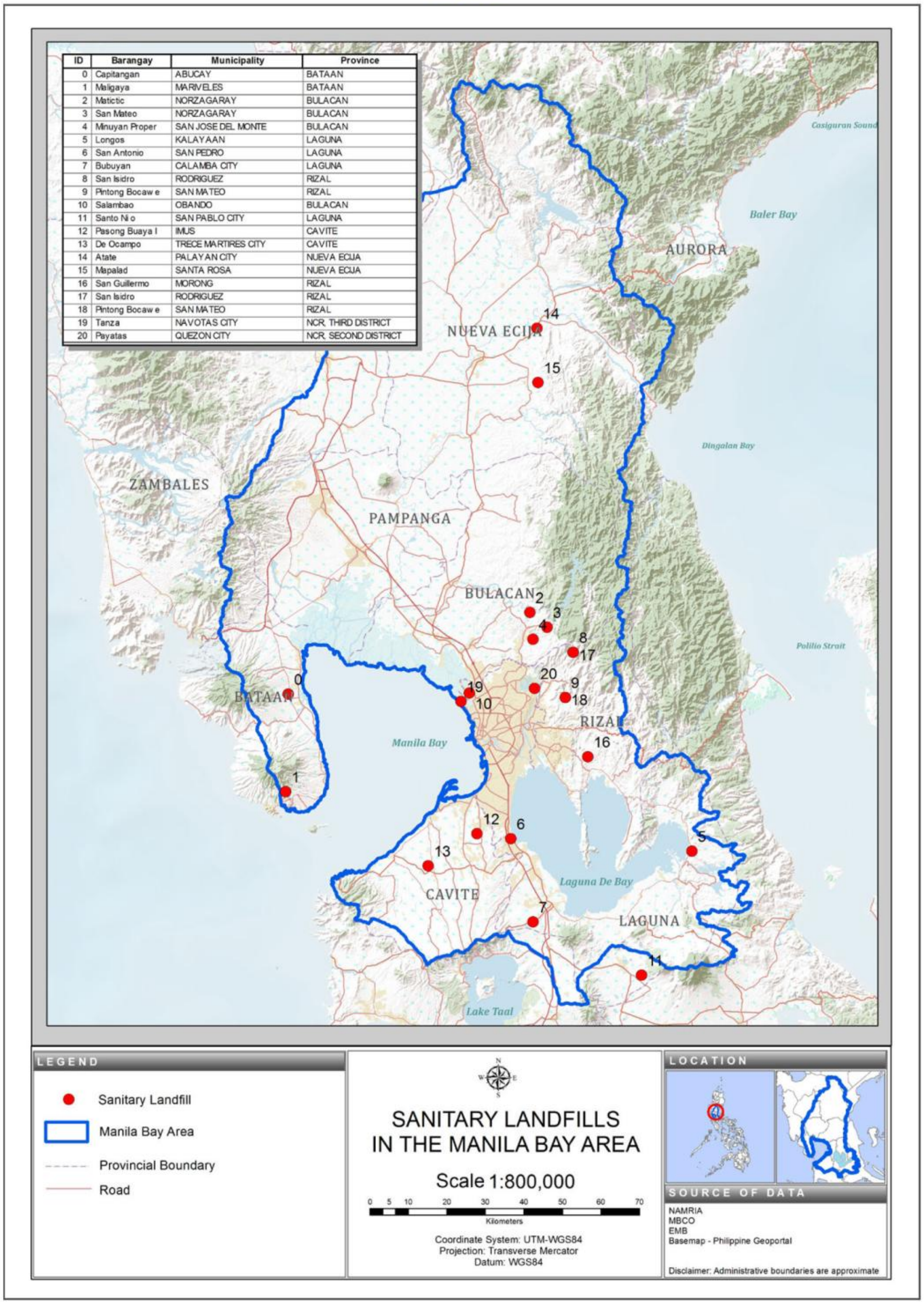
Figure 32. Actual volume of solid disposal in Metro Manila in cubic meters (2009-2013)
Source: MMDA Solid Waster Management Office

10-YEAR SOLID WASTE MANAGEMENT PLANS

The formulation of area- and issue-based plans are seen as an effective strategy for all LGUs to better manage their respective solid wastes. R.A. 9003 (Ecological Solid Wastes Management Act of 2000) mandates all LGUs to formulate their 10-Year SWMPs. Such plans are recommended to place primary emphasis on implementation of all feasible reuse, recycling, and composting programs while identifying the amount of landfill and transformation capacity that will be needed for solid waste which cannot be re-used, recycled, or composted.

According to the NSWMC, only 22 out of the 178 LGUs within the MBA have an approved plan. This translates to only 12% compliance rate as of second quarter of 2015. Technical assistance is being provided by NSWMC and DILG to fast track the approval of the remaining plans.

Map 128



ID	Barangay	Municipality	Province
0	Capitangan	ABUCAY	BATAAN
1	Maligaya	MARIVELES	BATAAN
2	Matictic	NORZAGARAY	BULACAN
3	San Mateo	NORZAGARAY	BULACAN
4	Minuyan Proper	SAN JOSE DEL MONTE	BULACAN
5	Longos	KALAYAAN	LAGUNA
6	San Antonio	SAN PEDRO	LAGUNA
7	Bubuyan	CALAMBA CITY	LAGUNA
8	San Isidro	RODRIGUEZ	RIZAL
9	Pintong Bocaw e	SAN MATEO	RIZAL
10	Salambao	OBANDO	BULACAN
11	Santo Ni o	SAN PABLO CITY	LAGUNA
12	Pasong Buaya I	IMUS	CAVITE
13	De Ocampo	TRECE MARTIRES CITY	CAVITE
14	Atate	PALAYAN CITY	NUEVA ECIJA
15	Mapalad	SANTA ROSA	NUEVA ECIJA
16	San Guillermo	MORONG	RIZAL
17	San Isidro	RODRIGUEZ	RIZAL
18	Pintong Bocaw e	SAN MATEO	RIZAL
19	Tanza	NAVOTAS CITY	NCR, THIRD DISTRICT
20	Payatas	QUEZON CITY	NCR, SECOND DISTRICT

I. HAZARD-PRONE AREAS

Completely surrounded by the 'Pacific Ring of Fire', the Philippines is not spared with the tumultuous hazards rampant in the Asia Pacific Region. Aside from its impact to the local economy and its natural resources, such catastrophes have also claimed millions of lives, particularly those habituating in highly susceptible areas.

As one of the most vulnerable areas for disasters, the Manila Bay Area exhibits significant imprints of various nature-induced hazards. These include ground rupture, ground shaking, liquefaction, tsunami, and rain-induced landslides.

Within the MBA is the Valley Fault System (VFS), an active fault consisting of two segments: the East Valley Fault and the West Valley Fault. The WVF, approximately 100-km. long transects the municipalities of Doña Remedios Trinidad, Norzagaray, and San Jose del Monte City in Bulacan; Rodriquez in Rizal Province; San Pedro City, Biñan City, Sta. Rosa City, Cabuyao City, and Calamba City in Laguna Province; Carmona, General Mariano Alvarez, and Silang in the Province of Cavite; and portions of Quezon City, Marikina City, Pasig City, Makati City, Taguig City, and Muntinlupa City. The EVF, about 10-km long traverses the municipalities of Rodriguez and San Mateo in the Province of Rizal. Map 129 plots the location of VFS within the MBA.

The Valley Fault System is considered to be the most perilous as it dissects through the densely populated NCR and the neighboring provinces. The MMEIRS study reveals that a 7.2 magnitude earthquake in NCR will cause heavy damage to infrastructures and lifelines, on top of potential civilian casualties.

As defined in RA 10121 (An Act Strengthening the Philippine Disaster Risk Reduction and Management System), vulnerability are the 'characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard'. The passage of science-based laws, as well as mainstreaming resilient infrastructure systems are some of the solutions to ease the potential impacts of impending disasters to MBA's growing populace.

The hazard maps presented here are the results of the hazard mapping conducted by the CSCAND agencies under the READY and GMMA READY projects. As part of the priority areas only the provinces of Pampanga, Bulacan, Rizal, Laguna, Cavite, and NCR were covered. No data is available for the provinces of Nueva Ecija , Tarlac, and Bataan.

Box 11. MMEIRS Study

Published in 2004, the Metropolitan Manila Master Plan for Earthquake Impact Reduction (MMEIRS) study outlined 18 earthquake damage scenarios which have potential damaging effect to Metropolitan Manila.

Of the 18 scenarios, three models (Model 08 – West Valley Fault's Magnitude 7.2; Model 13 – Manila Trench's Magnitude 7.9 and Model 18 – 1863 Manila Bay with Magnitude 6.5) were selected for damage analysis as these show typical and severe damages to Metropolitan Manila.

Simulating Model 08 (West Valley Fault's Magnitude 7.2) will lead to 170,000 collapsed residential houses, 340,000 partly-damaged residential houses, 34,000 casualties and 114,000 injuries. Fire will also break out and burnt an estimated of 1,710 hectares – adding an additional 18,000 casualties as a result of secondary disasters. Infrastructures and lifelines will also be heavily damaged (MMEIRS Final Report Volume 1, 2004)

GROUND RUPTURE

Ground rupture occurs when an active fault moves at depth and breaks through the ground surface transecting landforms and structures. Also called surface rupture, it can be a few or hundreds of kilometers long. Map 129 plots the location of ground rupture and fissures in the MBA.

GROUND SHAKING

Ground shaking is the primary cause of earthquake damage to man-made structures. It is a by-product of the friction produced between moving plates underneath the land surface or the movement of active faults. Map 130 shows the areas in the MBA affected by ground shaking.

LIQUEFACTION

Liquefaction is a phenomenon in which sediments or mass of soil underneath the water table substantially loses strength and stiffness as a result of strong shaking. Certain pedagogical charactersitics (e.g. grain size and stress level) are likewise considered as contributing factors.

This is further aggravated when an active fault line traverses the area, causing ruptures to the existing soil foundation. Liquefaction hotspots in the MBA, are shown in Map 131.

The MBEA's 1st Edition emphasized the importance of identifying, delineating and understanding the distribution of liquefaction-prone areas as basis for land use management strategies and engineering foundation designs.

TSUNAMI

In most cases, tsunamis are generated by under-the-sea seismic activities – which produces a series of sea waves with heights reaching above five meters. Communities living along the coastlines of Manila Bay are highly susceptible to this hazard. Historical data reveals the 1828 and 1863 earthquakes induced tsunamis of about two meters, engulfing the western portion of Luzon – particularly Metropolitan Manila. A careful combination of early warning systems and natural observances should be employed by LGUs to minimize potential damages to life and properties.

As illustrated in Map 132, the cities of Navotas, Malabon, Manila, Pasay, Parañaque, and Las Piñas in the NCR and the coastal cities/ municipalities of the Provinces of Bulacan and Cavite will be most affected by tsunamis.

RAIN-INDUCED LANDSLIDES

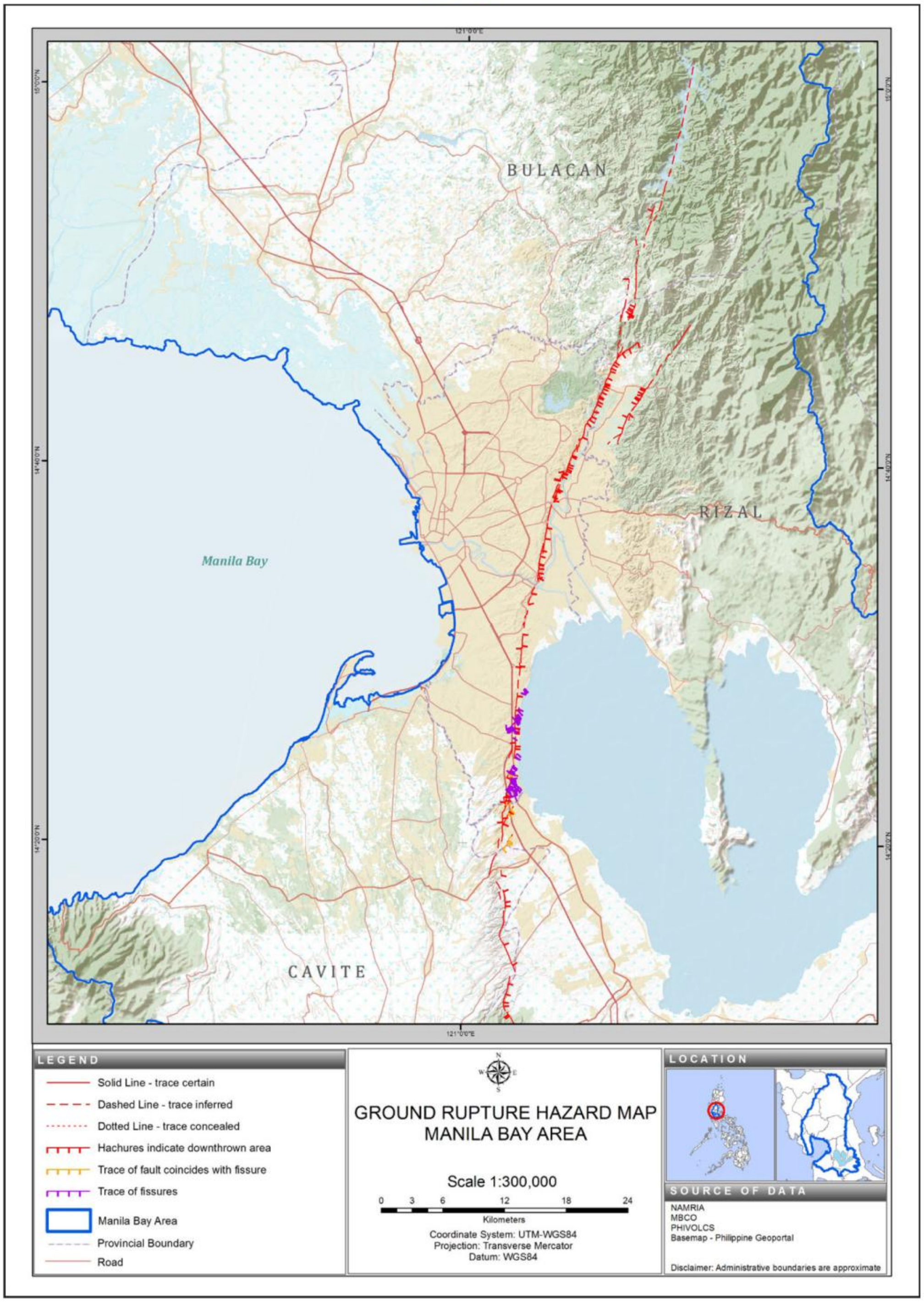
Landslides are defined as 'the movement of a mass of rock, debris or earth down a slope under the direct influence of gravity'. Aside from seismic activities, heavy downpours trigger landslides by saturating open spaces within soil particles – with the augmented soil mass catapulted downwards by gravity.

With a pronounced rainy season, selected areas within the Manila Bay Area are considered susceptible to rain-induced landslides. These areas are characterized by steep-sloping landforms with minimal to no vegetative cover. Presented in Map 133 is the susceptibility to rain-induced landslides of the provinces in the MBA.

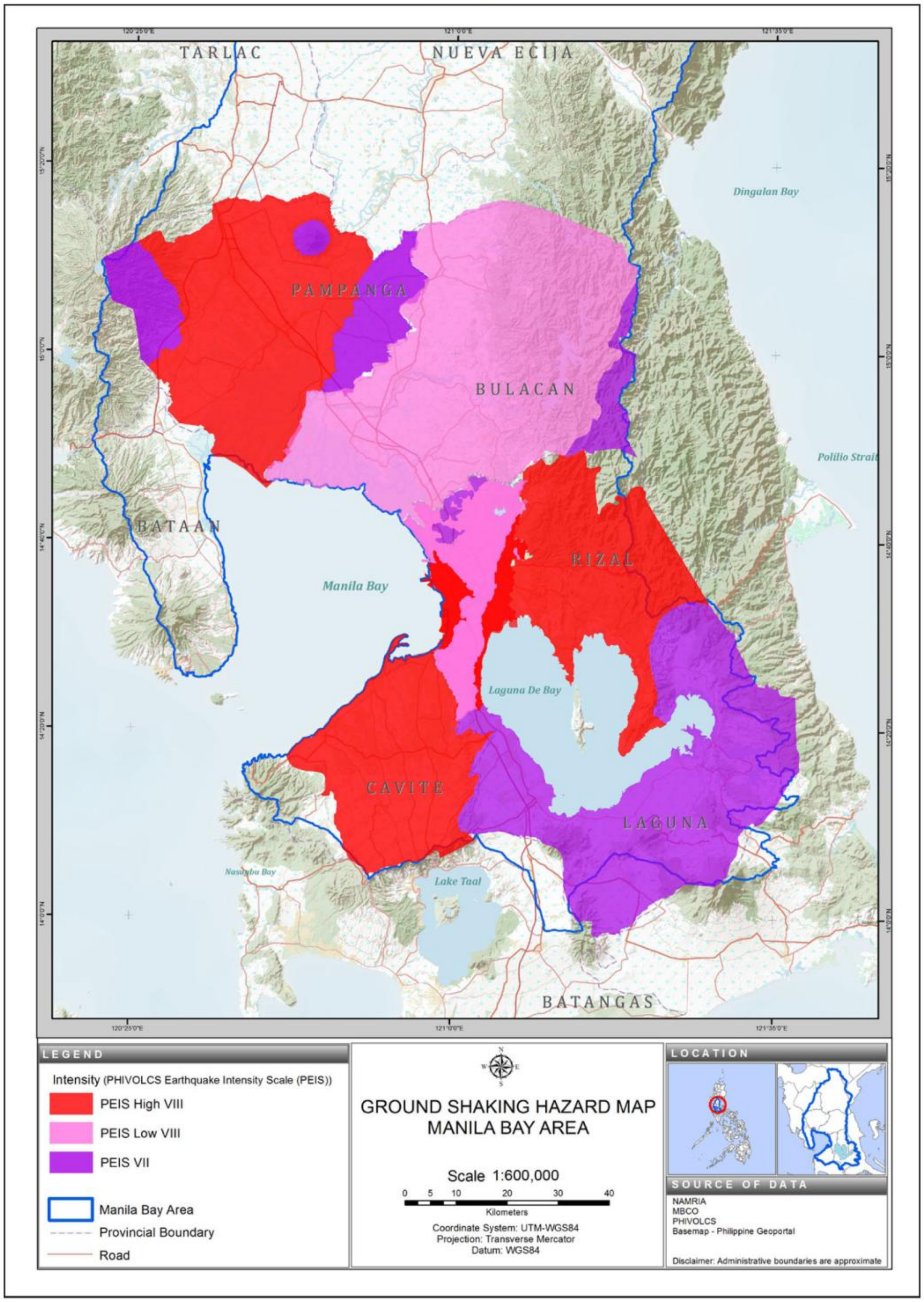
Proximity of rain-induced landslide prone areas to inland water bodies may also affect the latter's water quality by increasing its turbidity. (insert year) saw an increase in areas vulnerable to landslides due to increased land conversion.

These localities can employ engineering measures, including an array of slope stabilization techniques to mitigate further damages.

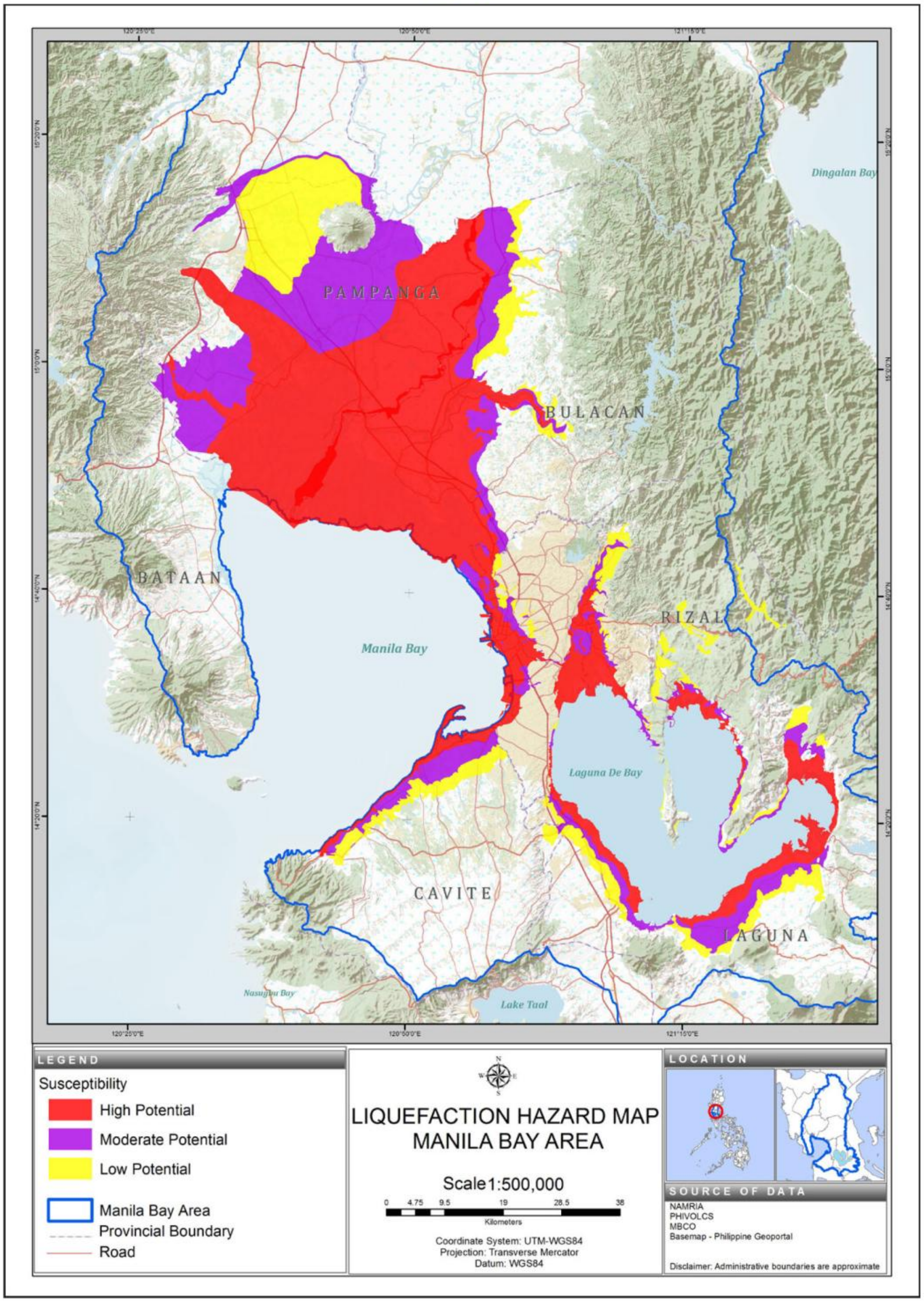
Map 129


BULACAN
RIZAL
Manila Bay
CAVITE
121°0'0"E
LEGEND
Solid Line - trace certain
Dashed Line - trace inferred
Dotted Line - trace concealed
Hachures indicate downthrown area
Trace of fault coincides with fissure
Trace of fissures
Manila Bay Area
Provincial Boundary
Road
GROUND RUPTURE HAZARD MAP
MANILA BAY AREA
Scale 1:300,000
0 3 6 12 18 24
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PHIVOLCS
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

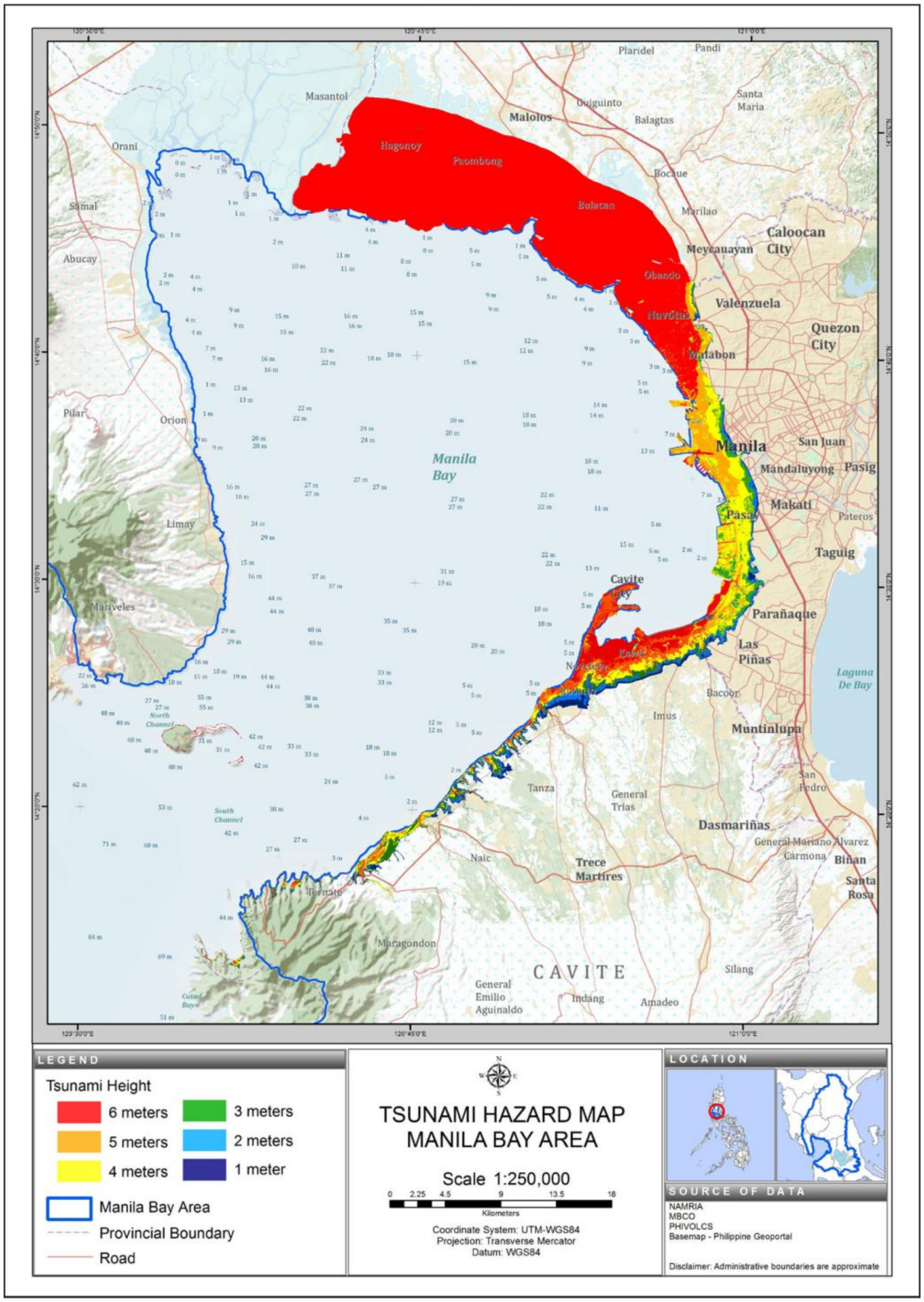
Map 130


TARLAC
NUEVA ECIJA
PAMPANGA
BULACAN
Dingalan Bay
Polillo Strait
BATAAN
Manila Bay
RIZAL
Laguna De Bay
CAVITE
LAGUNA
Lake Taal
BATANGAS
LEGEND
Intensity (PHIVOLCS Earthquake Intensity Scale (PEIS))
PEIS High VIII
PEIS Low VIII
PEIS VII
Manila Bay Area
Provincial Boundary
Road
GROUND SHAKING HAZARD MAP
MANILA BAY AREA
Scale 1:600,000
0 5 10 20 30 40
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PHIVOLCS
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

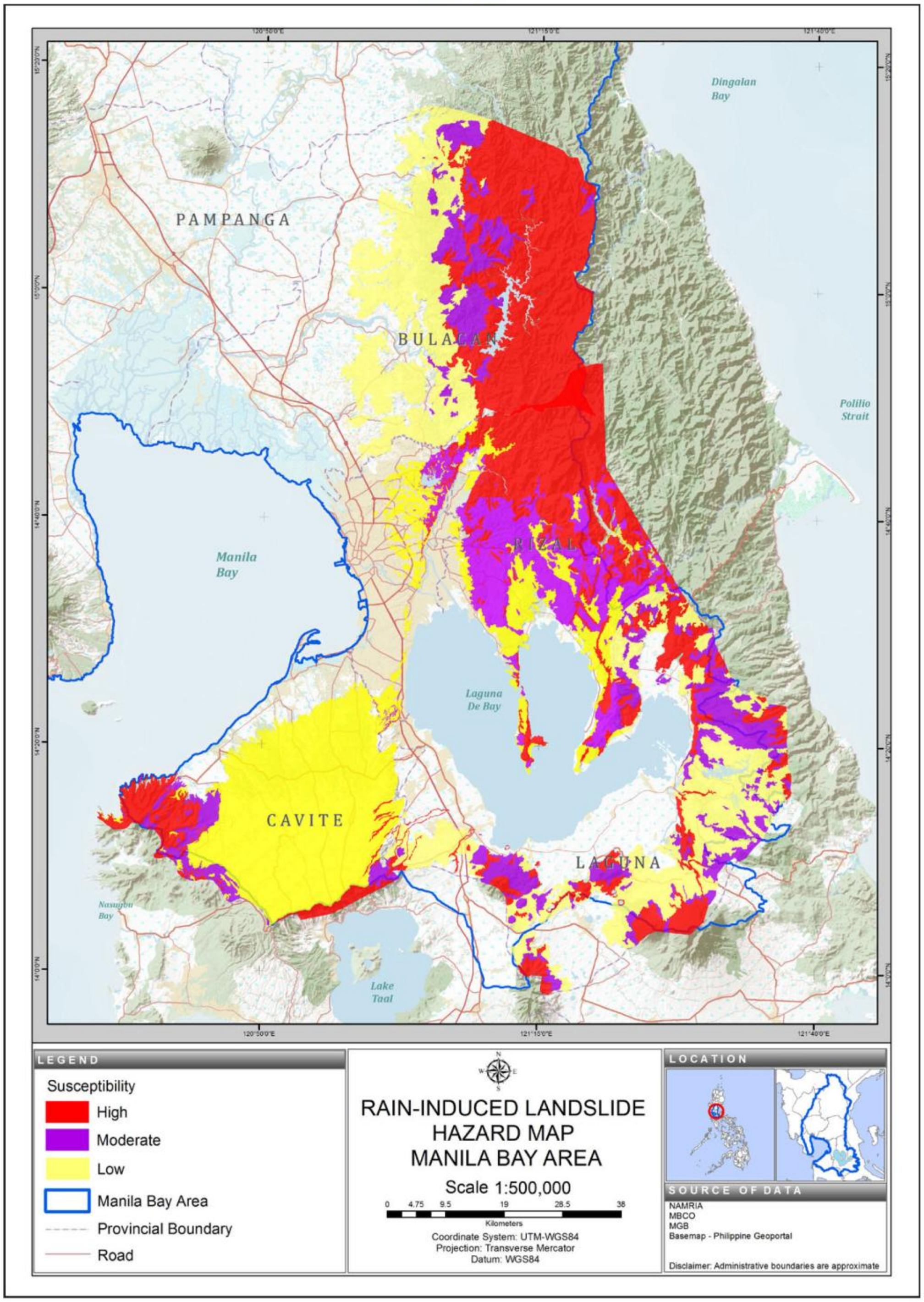
Map 131


PAMPANGA
BULACAN
BATAAN
RIZAL
CAVITE
LAGUNA
Manila Bay
Laguna De Bay
Dingalan Bay
Lake Taal
LEGEND
Susceptibility
High Potential
Moderate Potential
Low Potential
Manila Bay Area
Provincial Boundary
Road
LIQUEFACTION HAZARD MAP
MANILA BAY AREA
Scale 1:500,000
0 4.75 9.5 19 28.5 38
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
PHIVOLCS
MBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 132


Manila Bay
Malolos
Caloocan City
Quezon City
Valenzuela
Malabon
Navotas
Manila
San Juan
Mandaluyong
Pasig
Makati
Pasay
Taguig
Parañaque
Las Piñas
Bacoor
Muntinlupa
Cavite City
Kawit
Noveleta
Imus
Tanza
General Trias
Dasmariñas
Trece Martires
Naic
Ternate
Maragondon
CAVITE
Hagonoy
Paombong
Bulacan
Obando
Meycauayan
Marilao
Bocaue
Masantol
Orani
Samal
Abucay
Pilar
Orion
Limay
Mariveles
Laguna De Bay
LEGEND
Tsunami Height
6 meters
5 meters
4 meters
3 meters
2 meters
1 meter
Manila Bay Area
Provincial Boundary
Road
TSUNAMI HAZARD MAP
MANILA BAY AREA
Scale 1:250,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PHIVOLCS
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 133


PAMPANGA
BULACAN
RIZAL
CAVITE
LAGUNA
Dingalan Bay
Polillo Strait
Manila Bay
Laguna De Bay
Nasugbu Bay
Lake Taal
LEGEND
Susceptibility
High
Moderate
Low
Manila Bay Area
Provincial Boundary
Road
RAIN-INDUCED LANDSLIDE HAZARD MAP MANILA BAY AREA
Scale 1:500,000
0 4.75 9.5 19 28.5 38
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
MGB
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

J. CLIMATE RELATED TRENDS

The climate of the Philippines can be described using the Modified Corona's Climate Classification based on the mean monthly rainfall distribution in the country. Following this classification, the Manila Bay Area (MBA) can be grouped under three climate types: Type 1, 2, & 3 (Map 134). Predominantly, the western section of MBA falls under Climate Type 1 & 3 which is characterized by defined maximum rain period from July to September and dry season from November to April. Meanwhile, the easternmost portion of MBA has pronounced rainy season from November to April.

PAGASA STATIONS IN MBA

PAGASA maintains and operates an observation network throughout the country, which can be categorized as synoptic, agrometeorological, upper air, climatological, and rain stations. These stations perform different types of observations of weather parameters such as rainfall, temperature, wind direction and speed, atmospheric pressure, relative humidity, evaporation, and sunshine duration, to name a few.

Within the MBA, there are ten (10) PAGASA weather stations as shown in Map 134, with long-term climate data. Two of these stations are classified as agrometeorological stations which are located inside the University of the Philippines, Los Banos (UPLB) compound and inside the People's Park, Tagaytay City (stopped operating in 2012 and replaced as Radar Station in the Palace in the Sky, Tagaytay City in 2013). The upper air station in Tanay, Rizal is conducting observations of the vertical profile of the atmosphere. The seven (7) other synoptic stations have fixed observations times for almost all meteorological parameters.

TROPICAL CYCLONE CLIMATOLOGY

From 1948-2013, the period 1991-2000 had the highest total number of tropical cyclones (TCs) that cross MBA accounting to 22 events. The period 2001-2010 registered the lowest count of TCs with 13 events. This suggests that in a decade, an average of 17 TCs usually cross the MBA.

Since 2011, there are only two TCs recorded: Tropical Storm Gorio (June 2013) and Typhoon Santi (October 2013).

From 1948- 2013, the months of October and November recorded the highest frequency of TCs crossing the MBA with both 25 events. It is noteworthy that from the period 1948-2013, there is no recorded TC from January to April.

In summary, there have been 106 recorded TCs in MBA where 50 TCs (47%) also crossed NCR. 30 out of 60 TCs (50%) occurring in September to November were in NCR. Statistically, this suggests that TCs recorded in MBA also have probability to cross NCR.

Statistically, TCs occurring in these months have higher chances of making landfall because of the southward displacement of ITCZ due to the intensification of Siberian High. This physical condition affects the zonal motion of TCs making the tracks move towards the country. The ITCZ is an area near the equator where trade winds converge and can trigger a low-level wind rotation leading to TC formation.

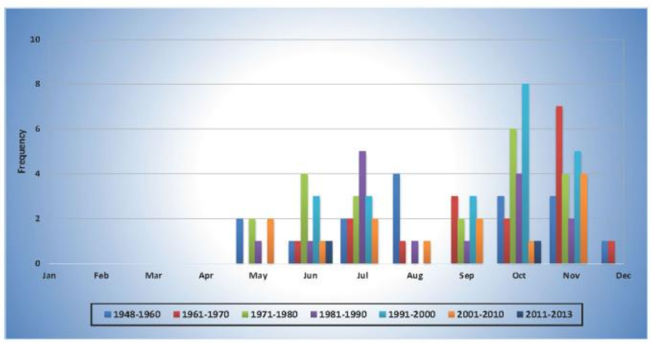


Figure 33. Mean Monthly Tropical Cyclone Frequency in the Manila Bay Area (1948-2013)

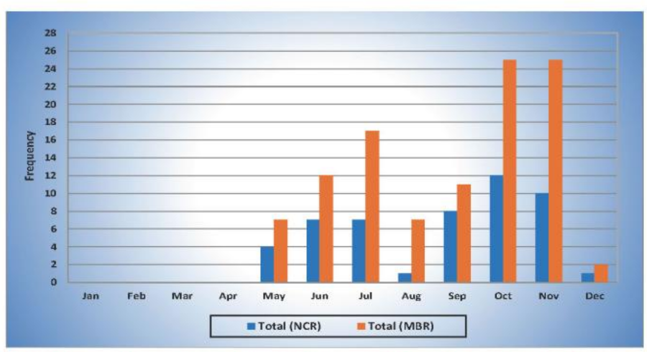


Figure 34. Tropical Monthly Tropical Cyclone Frequency in the Manila Bay Area (1948-2013)

CLIMATOLOGICAL NORMAL

In the foregoing discussion, a climatological normal for a given parameter is usually defined as the thirty-year (30-year) average of observations. This is updated every ten years. Currently PAGASA is using the 1981-2010 climatological normal values.

RAINFALL

There are ten (10) stations with available long-term rainfall data in MBA (refer to Figure 35). For the evolution of monthly rainfall, refer to Map 135 to 137.

On an annual timescale, average maximum rain periods are observed from May to November with rainfall values ranging from 200-530 millimeters. Short-term periods with less rainfall are experienced from January to March. Highest total (2790 mm) and average (233 mm) annual rainfall are observed in Tanay Upper-Air Station primarily because it is of higher elevation than the other stations. Notably, the lowest total (1856 mm) and average annual rainfall (155 mm) is recorded in Cabanatuan Station.

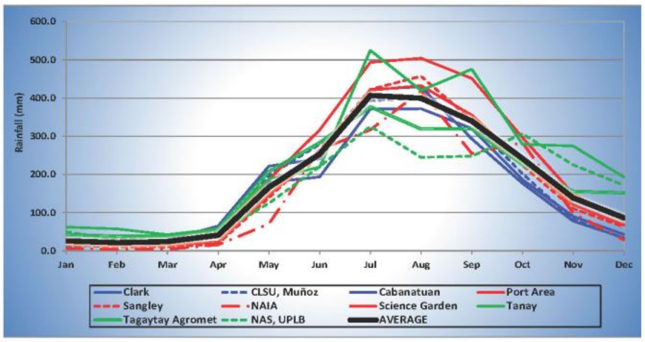


Figure 35. Mean Monthly Rainfall Cycle (1981-2010)

TEMPERATURE

For temperature observations, there are seven (7) synoptic stations within the MBA with long term data (refer to Figure 36).

Temperature in the Philippines does not significantly vary because of (1) of its location near the equator where solar heating is virtually equal throughout the year and (2) relative absence of highly elevated areas. With an increase in height or elevation, dry air becomes colder hence mountainous regions in the Philippines have colder temperatures compared to the lowland areas.

Mean temperature (TMEAN) is the average of minimum (TMIN) and aximum (TMAX) temperature, which means TMEAN is a measure of the hotness of air for the entire day. Annually, the hottest months in Manila Bay are observed in the months of March, April, and May (29.6°C) while coldest months are experienced from December to January (28°C). Of the seven PAGASA stations, NCR-based stations have the highest observations (27.7-28.4°C).

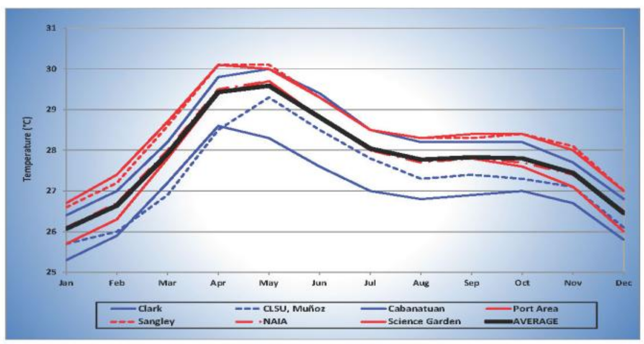


Figure 36. Mean Monthly Mean Temperature Cycle (1981-2010)

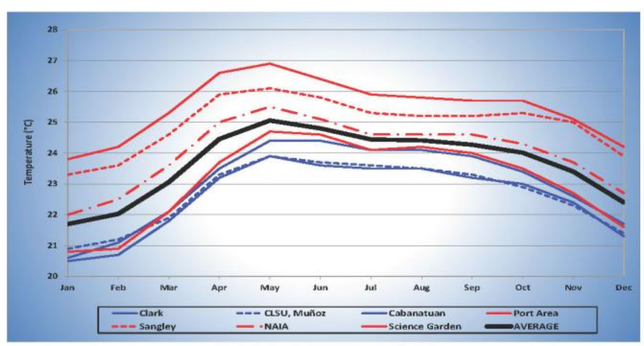


Figure 37. Mean Monthly Minimum Temperature Cycle (1981-2010)

MAXIMUM TEMPERATURE

TMIN is recorded during the coldest time of the day. Annually, the coldest months in MBA are observed in the months of January to February (21.7°C) while hottest TMIN is experienced from March to April (24.5°C). Among all stations, it can be noted that Port Area has the highest minimum temperature (TMIN) followed by Sangley and NAIA. At night, the ocean cools slower than the land and Manila Bay is closer to these stations relative to the other stations.

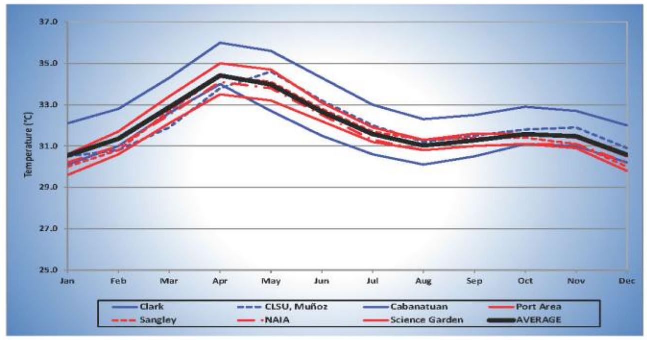


Figure 38. Mean Monthly Maximum Temperature Cycle (1981-2010)

CLIMATE TRENDS AND SCENARIOS

In a study of the climatology of different PAGASA stations across the country, it was discovered that extreme events in terms of daily rainfall and temperature have likely increased from 1951-2008.

This section will tackle only three stations in MBA included in the study: Cabanatuan, NAIA, and Science Garden.

Hot days are days with maximum temperature above the 1961-1990 mean 99th percentile while warm nights are days with minimum temperature above the 1961-1990 mean 99th percentile. The table above shows that both TMAX and TMIN within MBA are significantly increasing from 1951-2008 suggesting that warming is evident in the three stations.

Cold days are days with maximum temperature below the 1961-1990 mean 99th percentile while cold nights are days with minimum temperature below the 1961-1990 mean 99th percentile. The table below shows that the frequency of both TMAX and TMIN within MBA are decreasing where TMAX has more pronounced warming.

Table 21. Trends in Extreme Daily Temperature (1951-2008)

Station	Hot Days	Warm Nights	Cold Days	Cold Nights
Cabanatuan	Significantly Increasing	Significantly Increasing	Significantly Decreasing	Decreasing
NAIA	Increasing	Significantly Increasing	Significantly Decreasing	Decreasing
Science Garden	Increasing	Significantly Increasing	Significantly Decreasing	Decreasing

All stations in MBA are showing changes in rainfall with disagreement in trend. This suggests that rainfall may possibly become more variable in terms of frequency and intensity. The table above shows that Cabanatuan Station has an increasing extreme rainfall intensity and frequency while NAIA and Science Garden Stations have decreasing trend in rainfall frequency and intensity.

Table 22. Trends in Extreme Daily Rainfall (1951-2008)

Station	Extreme Intensity	Extreme Frequency
Cabanatuan	Increasing	Increasing
NAIA	Decreasing	Decreasing
Science Garden	Decreasing	Decreasing

SCENARIOS

A study was commissioned by PAGASA and FAO-AMICAF to perform statistical downscaling of three global climate models (BCM2, CNCM3, and MPEH5) and two emission scenarios (A1B and A2). Results obtained from the downscaling showed that there will be significant climate changes from 2011-2040 in terms of rainfall and temperatures relative to 1971-2000.

In the succeeding pages, projections will be discussed as a single value for seasonal rainfall and mean temperature for the entire MBA.

Table 23. Projected changes (%) in seasonal rainfall (2011-2040)

SEASON	Dec-Jan-Feb			Mar-Apr-May			June-July-Aug			Sept-Oct-Nov		
GCM/ SCENARIO	BCM2	CNCM3	MPEH5	BCM2	CNCM3	MPEH5	BCM2	CNCM3	MPEH5	BCM2	CNCM3	MPEH5
Precipitation (A1B)	12.6	34.3	30.0	-1.5	13.8	43.6	-2.7	16.5	14.3	8.5	16.1	14.7
Precipitation (A2)	15.8	24.9	23.8	-10.2	6.7	32.0	-2.1	8.0	7.4	11.1	4.4	24.4

Meanwhile, March-April-May (MAM) may possibly become wet as well as June-July-August (JJA) become even wetter.

Table 24. Projected (°C) in seasonal mean temperature (2011-20140)

SEASON	Dec-Jan-Feb			Mar-Apr-May			June-July-Aug			Sept-Oct-Nov		
GCM/ SCENARIO	BCM2	CNCM3	MPEH5	BCM2	CNCM3	MPEH5	BCM2	CNCM3	MPEH5	BCM2	CNCM3	MPEH5
TMEAN (A1B)	0.4	0.6	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.5	0.3
TMEAN (A2)	0.5	0.4	0.5	0.5	0.3	0.4	0.3	0.1	0.3	0.3	0.3	0.3

The table suggests positive climate change signals in TMEAN in all GCMs from 2011-2040 which suggests that warming is evident across MBA. TMEAN is projected to increase by as much 0.6°C in DJF and 0.1°C in JJA. This means that cold months might possibly become warmer.

As a reference, projected annual changes in rainfall and TMEAN in MBA will be provided as Map 135 to 137.

Box 12. Uncertainty in climate change projections

Global climate models (GCM) are simplified representation of all biogeophysical processes on earth in relation to the climate system. With this depiction of earth comes an uncertainty in the projecting future climate system. This denotes that projections for larger climate system have higher confidence compared to smaller climate system. To minimize errors associated with inherent variations and limitations of our understanding of climate, downscaling has been proposed as one of the methods increase temporal and spatial resolution of climate projections.

In general, uncertainties are associated with three primary sources: (1) natural climate variability, (2) emission of greenhouse gases, and (3) modelling uncertainty.

Natural Climate Variability

The climate system is composed of the geosphere and biosphere which internally varies from time to time and from place to place. It is quite a challenge to capture the dynamics of either large or small climate systems with time and spatial component.

Emission of greenhouse gases

Living things and industries have largely contributed to the increase in greenhouse gases (GHG). There is a great uncertainty on future emission of GHG especially those that are related to human activities. Special Report on Emission Scenarios (SRES) is used to model possible future trend in GHG based on different driving forces of future world such population, economy, technology, agriculture, culture, and climate change adaptation strategies. A1B and A2 are two of the more popular SRES denoting balance use of fossil and non-fossil fuel, and regionalistic future world, respectively.

Modelling uncertainty

GCMs are bounded by the current understanding of climate dynamics hence resulting to inadequate representation of both global and local climate systems. Downscaling is being performed to reduce biases in the projections but uncertainties still remain with the current limitation of computing.

In this note, there are different climate projections available for different purposes. Other than the projections indicated in this section, data are also available via PAGASA website

Box 13. Typhoon Ondoy Experience: Incidents of Climate Change Extremes

Tropical Storm Ondoy (International name-Typhoon Ketsana) was the second most devastating tropical cyclone in 2009 with a damage of $1.09 billion and 747 fatalities.

Metro Manila experienced the highest rainfall in history (see Figure 1), which caused widespread flooding in the cities of Manila, Caloocan, Marikina, Malabon, Muntinlupa, Quezon, Makati, Pasay, Pasig, Taguig, Valenzuela and San Juan. Flooding also occurred in the nearby provinces of Bulacan, Rizal, Laguna and other Southern Tagalog areas. Major roads were rendered impassable because of the huge flood currents and clogged cars. All flights were cancelled because of heavy rains.

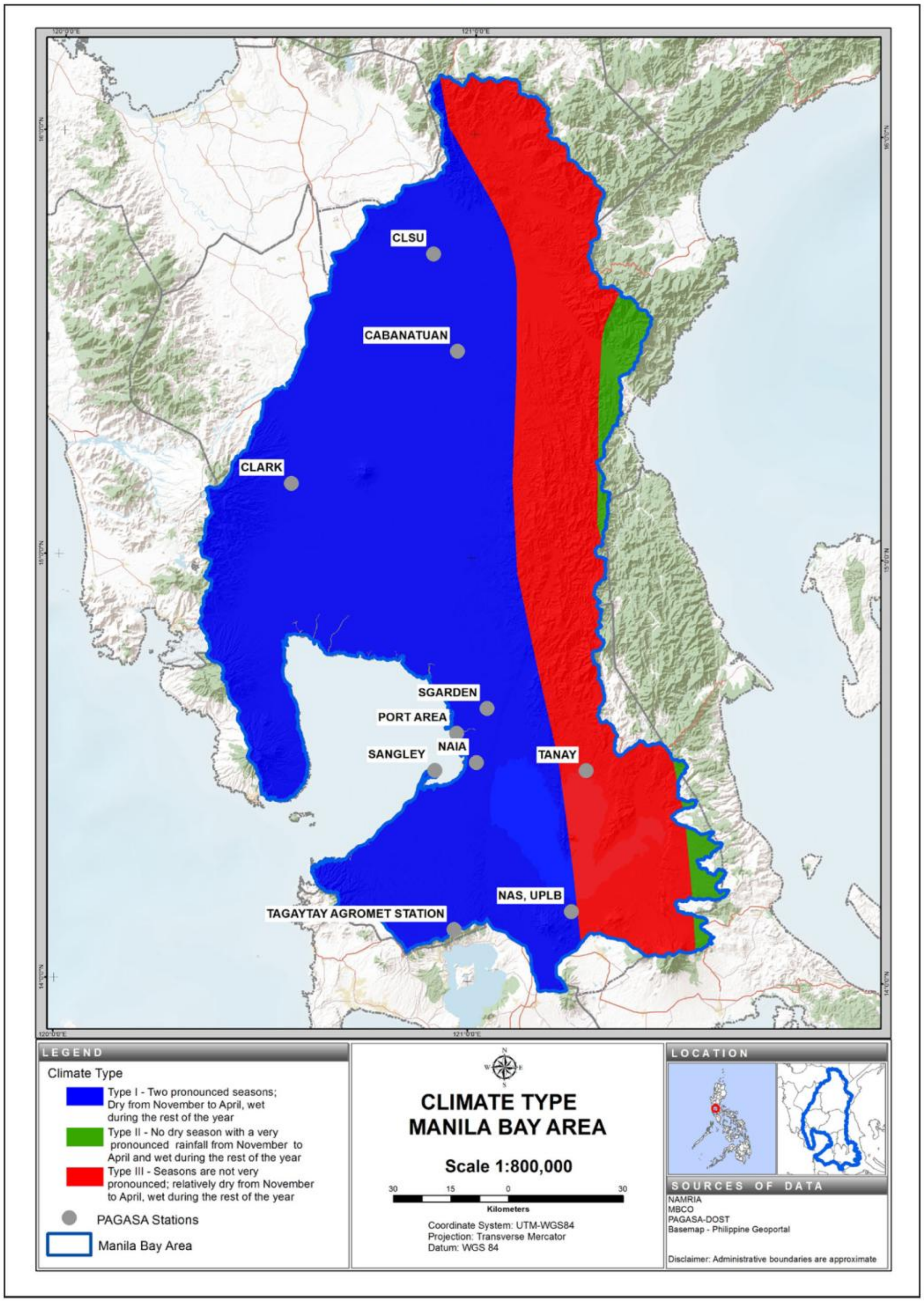
On the afternoon of September 26, 2009, an over-all state of calamity was declared in Metro Manila and the other 25 provinces hit by the storm.

Marikina City was the most devastated region in Metro Manila; almost all of the city's area was submerged in water up to ten feet deep and tons of knee-deep mud. During the typhoon, the Marikina River broke its banks and transformed streets into rivers.

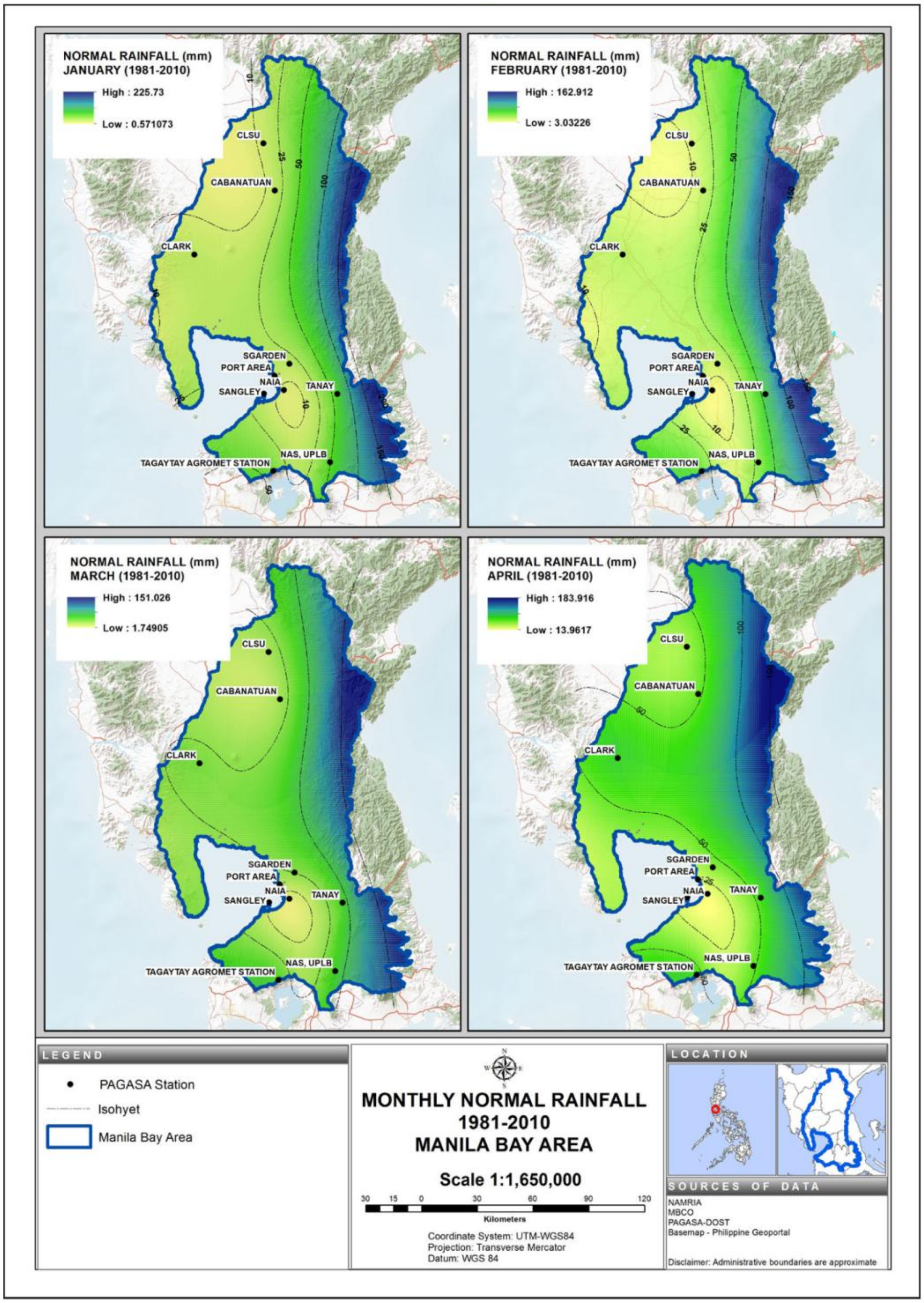
http://www.typhoonondoy.org/category/pictures/

NOEL CELIS/AFP/Getty Images

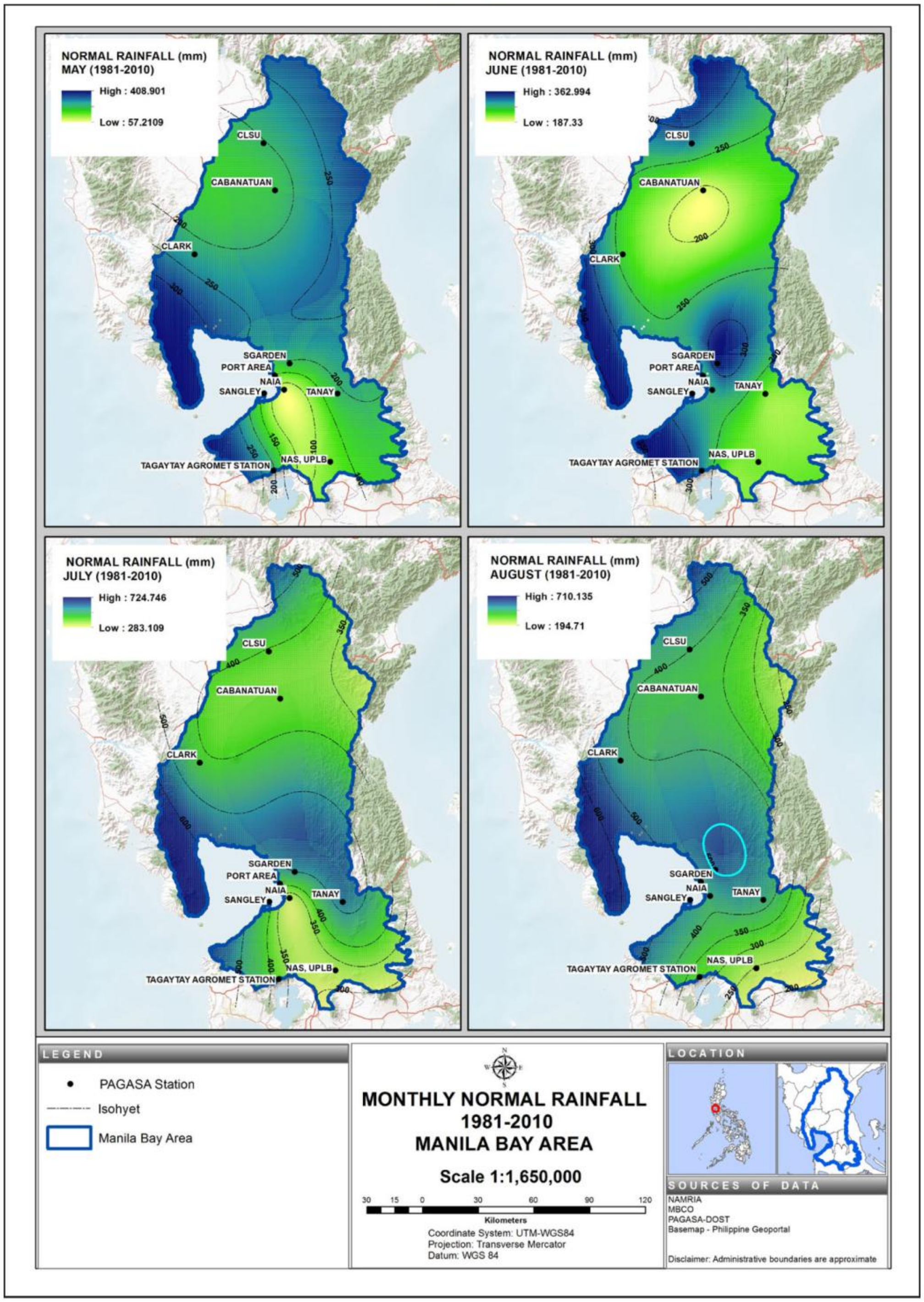
Map 134


CLSU
CABANATUAN
CLARK
SGARDEN
PORT AREA
NAIA
SANGLEY
TANAY
NAS, UPLB
TAGAYTAY AGROMET STATION
LEGEND
Climate Type
Type I - Two pronounced seasons; Dry from November to April, wet during the rest of the year
Type II - No dry season with a very pronounced rainfall from November to April and wet during the rest of the year
Type III - Seasons are not very pronounced; relatively dry from November to April, wet during the rest of the year
PAGASA Stations
Manila Bay Area
CLIMATE TYPE
MANILA BAY AREA
Scale 1:800,000
30 15 0 30
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS 84
LOCATION
SOURCES OF DATA
NAMRIA
MBCO
PAGASA-DOST
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

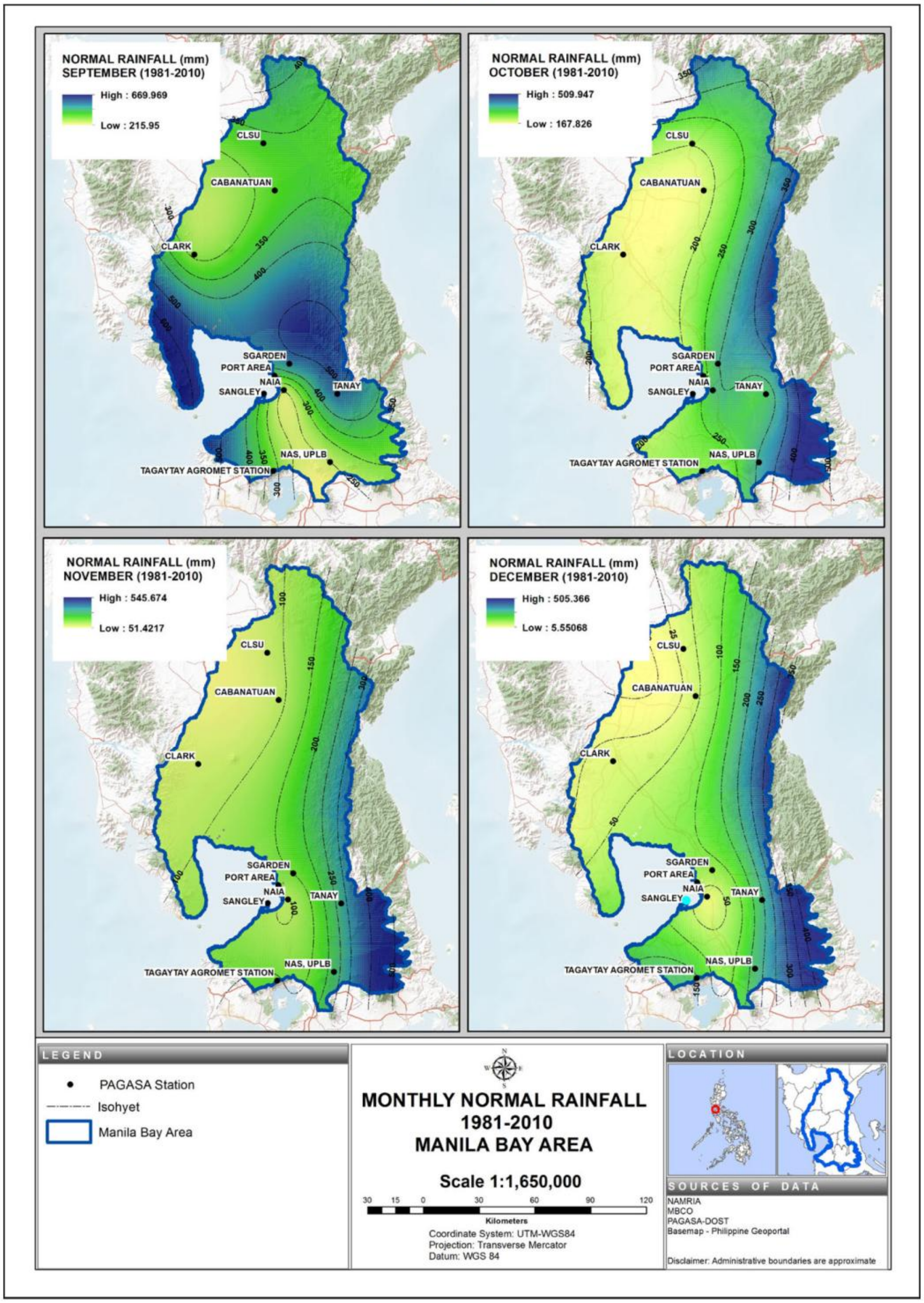
Map 135


NORMAL RAINFALL (mm)
JANUARY (1981-2010)
High : 225.73
Low : 0.571073
NORMAL RAINFALL (mm)
FEBRUARY (1981-2010)
High : 162.912
Low : 3.03226
NORMAL RAINFALL (mm)
MARCH (1981-2010)
High : 151.026
Low : 1.74905
NORMAL RAINFALL (mm)
APRIL (1981-2010)
High : 183.916
Low : 13.9617
CLSU
CABANATUAN
CLARK
SGARDEN
PORT AREA
NAIA
SANGLEY
TANAY
NAS, UPLB
TAGAYTAY AGROMET STATION
LEGEND
PAGASA Station
Isohyet
Manila Bay Area
MONTHLY NORMAL RAINFALL
1981-2010
MANILA BAY AREA
Scale 1:1,650,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS 84
LOCATION
SOURCES OF DATA
NAMRIA
MBCO
PAGASA-DOST
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

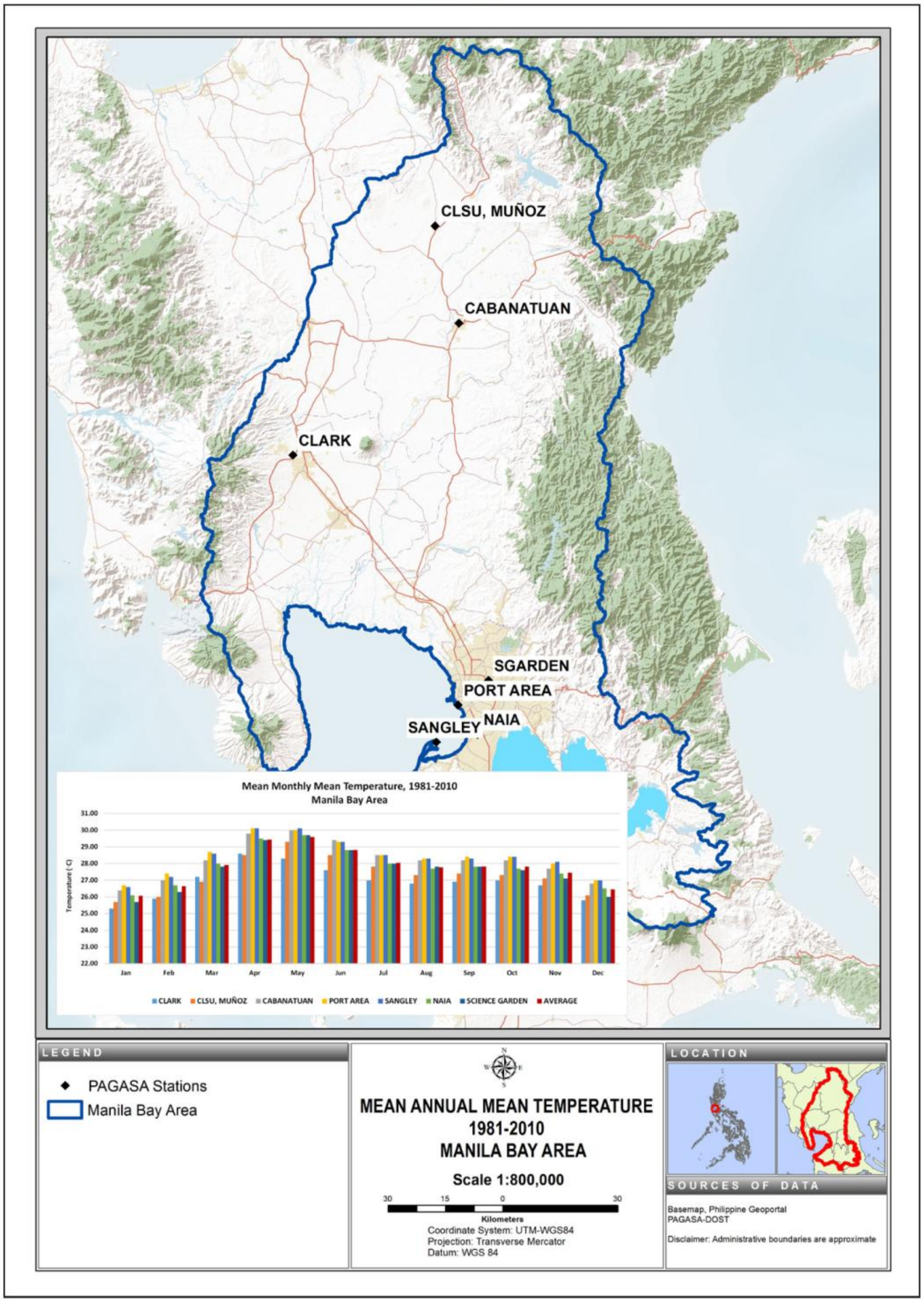
Map 136


NORMAL RAINFALL (mm)
MAY (1981-2010)
High : 408.901
Low : 57.2109
NORMAL RAINFALL (mm)
JUNE (1981-2010)
High : 362.994
Low : 187.33
NORMAL RAINFALL (mm)
JULY (1981-2010)
High : 724.746
Low : 283.109
NORMAL RAINFALL (mm)
AUGUST (1981-2010)
High : 710.135
Low : 194.71
CLSU
CABANATUAN
CLARK
SGARDEN
PORT AREA
NAIA
SANGLEY
TANAY
NAS, UPLB
TAGAYTAY AGROMET STATION
LEGEND
PAGASA Station
Isohyet
Manila Bay Area
MONTHLY NORMAL RAINFALL
1981-2010
MANILA BAY AREA
Scale 1:1,650,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS 84
LOCATION
SOURCES OF DATA
NAMRIA
MBCO
PAGASA-DOST
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

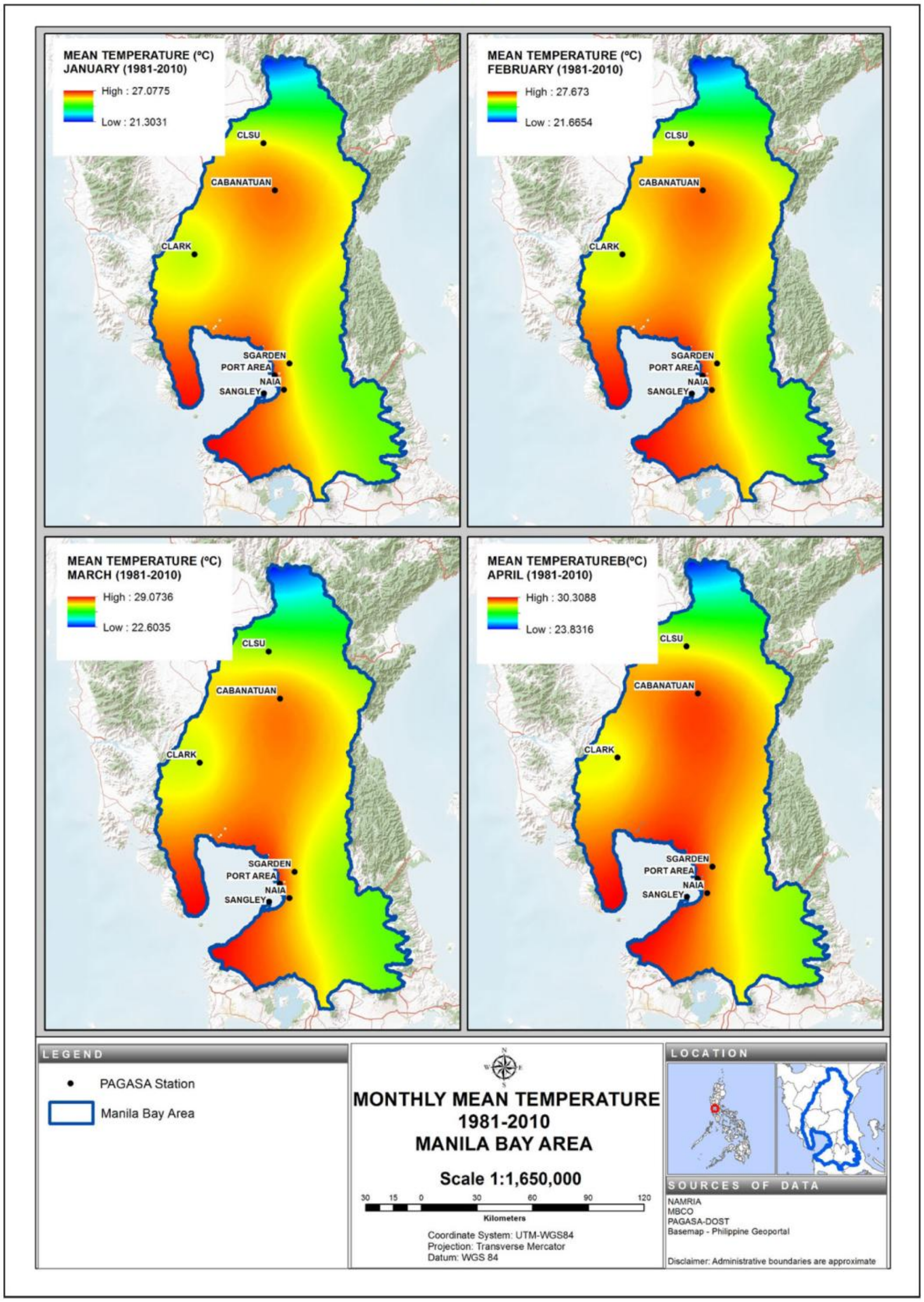
Map 137


NORMAL RAINFALL (mm)
SEPTEMBER (1981-2010)
High : 669.969
Low : 215.95
NORMAL RAINFALL (mm)
OCTOBER (1981-2010)
High : 509.947
Low : 167.826
NORMAL RAINFALL (mm)
NOVEMBER (1981-2010)
High : 545.674
Low : 51.4217
NORMAL RAINFALL (mm)
DECEMBER (1981-2010)
High : 505.366
Low : 5.55068
CLSU
CABANATUAN
CLARK
SGARDEN
PORT AREA
NAIA
SANGLEY
TANAY
NAS, UPLB
TAGAYTAY AGROMET STATION
LEGEND
PAGASA Station
Isohyet
Manila Bay Area
MONTHLY NORMAL RAINFALL
1981-2010
MANILA BAY AREA
Scale 1:1,650,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS 84
LOCATION
SOURCES OF DATA
NAMRIA
MBCO
PAGASA-DOST
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

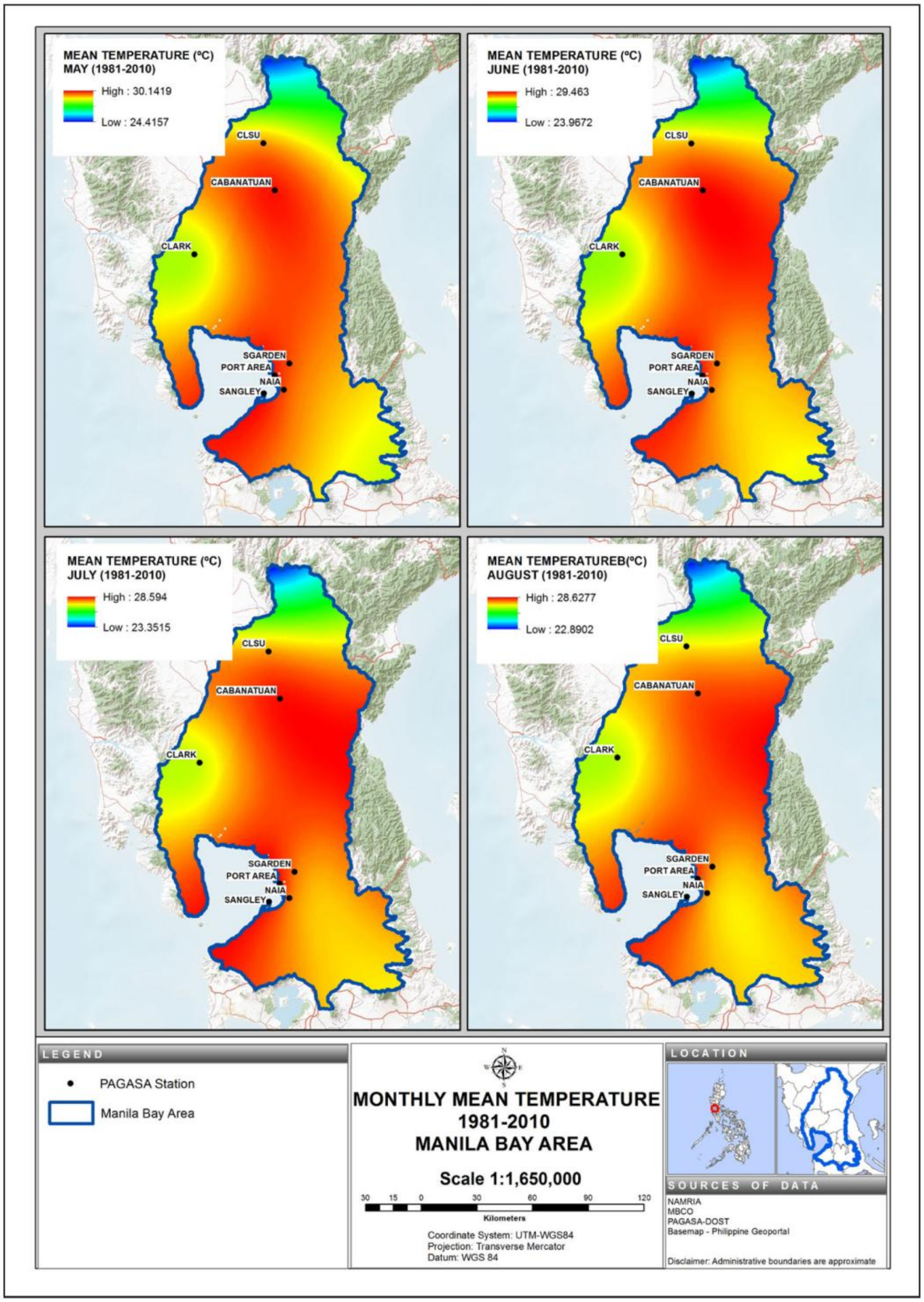
Map 138


CLSU, MUÑOZ
CABANATUAN
CLARK
SGARDEN
PORT AREA
NAIA
SANGLEY
Mean Monthly Mean Temperature, 1981-2010
Manila Bay Area
Temperature (°C)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
CLARK
CLSU, MUÑOZ
CABANATUAN
PORT AREA
SANGLEY
NAIA
SCIENCE GARDEN
AVERAGE
LEGEND
PAGASA Stations
Manila Bay Area
MEAN ANNUAL MEAN TEMPERATURE
1981-2010
MANILA BAY AREA
Scale 1:800,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS 84
LOCATION
SOURCES OF DATA
Basemap, Philippine Geoportal
PAGASA-DOST
Disclaimer: Administrative boundaries are approximate

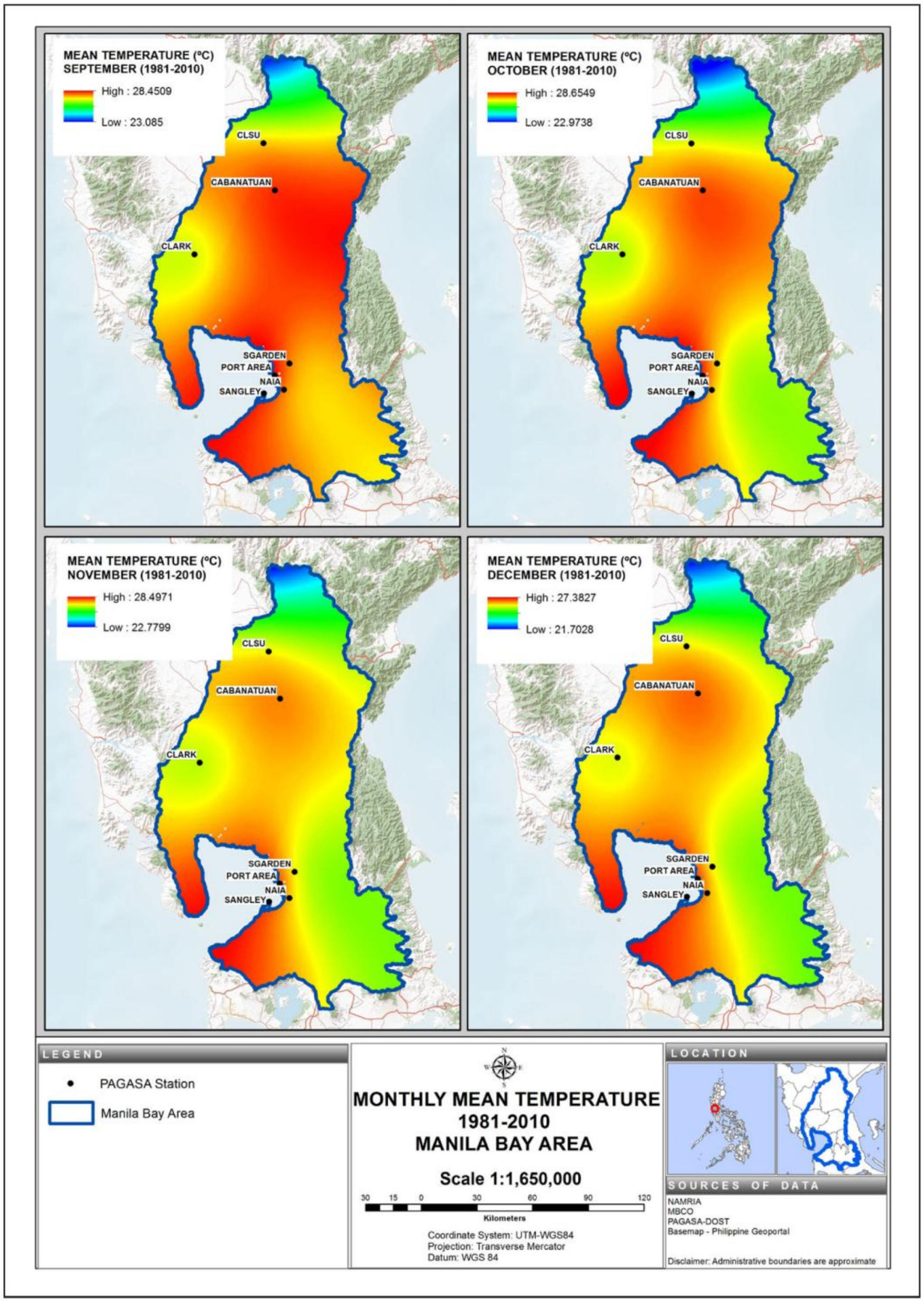
Map 139


MEAN TEMPERATURE (ºC)
JANUARY (1981-2010)
High : 27.0775
Low : 21.3031
MEAN TEMPERATURE (ºC)
FEBRUARY (1981-2010)
High : 27.673
Low : 21.6654
MEAN TEMPERATURE (ºC)
MARCH (1981-2010)
High : 29.0736
Low : 22.6035
MEAN TEMPERATUREB(ºC)
APRIL (1981-2010)
High : 30.3088
Low : 23.8316
CLSU
CABANATUAN
CLARK
SGARDEN
PORT AREA
NAIA
SANGLEY
LEGEND
PAGASA Station
Manila Bay Area
MONTHLY MEAN TEMPERATURE
1981-2010
MANILA BAY AREA
Scale 1:1,650,000
30 15 0 30 60 90 120
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS 84
LOCATION
SOURCES OF DATA
NAMRIA
MBCO
PAGASA-DOST
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

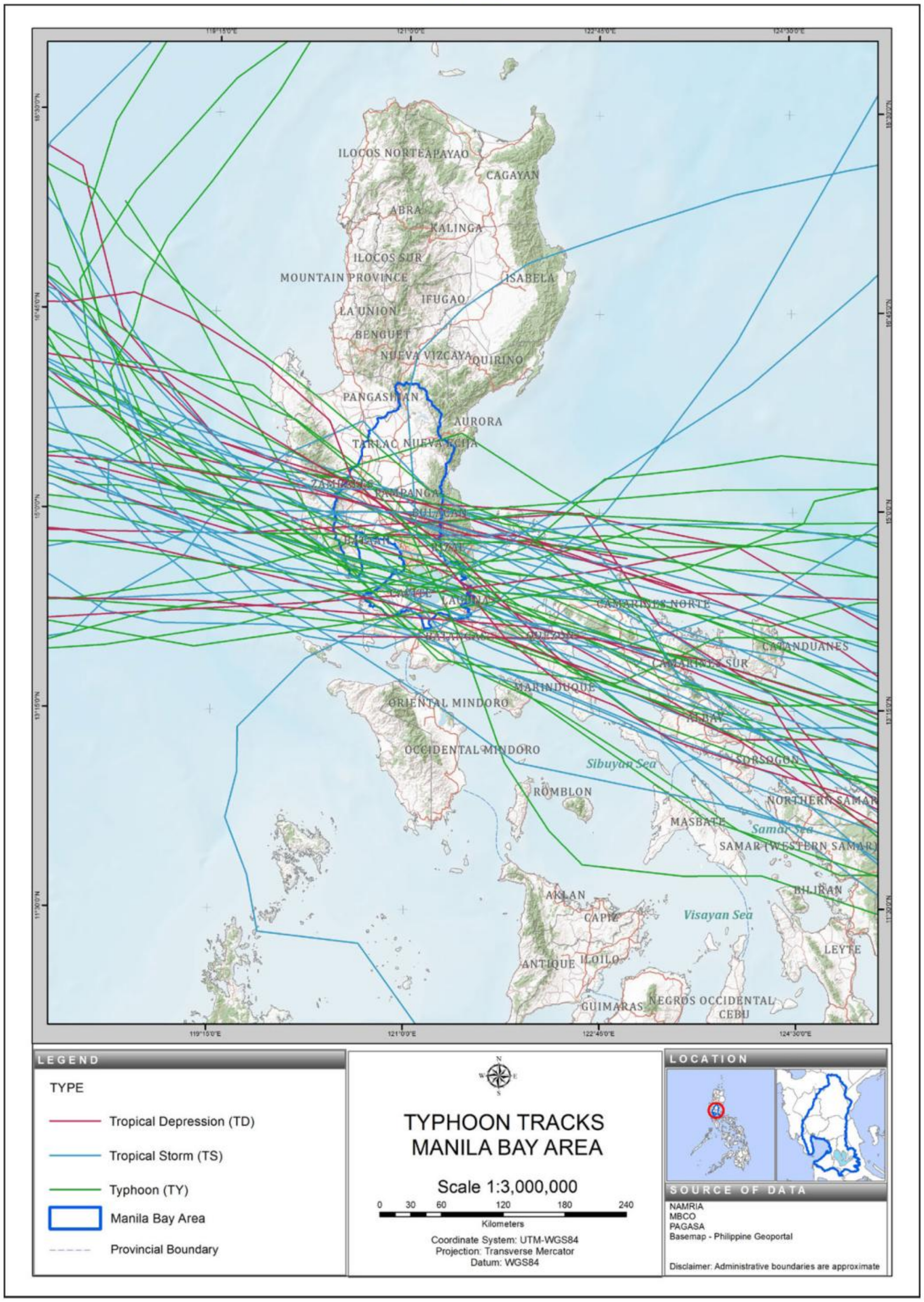
Map 140


MEAN TEMPERATURE (ºC)
MAY (1981-2010)
High : 30.1419
Low : 24.4157
MEAN TEMPERATURE (ºC)
JUNE (1981-2010)
High : 29.463
Low : 23.9672
MEAN TEMPERATURE (ºC)
JULY (1981-2010)
High : 28.594
Low : 23.3515
MEAN TEMPERATUREB(ºC)
AUGUST (1981-2010)
High : 28.6277
Low : 22.8902
CLSU
CABANATUAN
CLARK
SGARDEN
PORT AREA
NAIA
SANGLEY
LEGEND
PAGASA Station
Manila Bay Area
MONTHLY MEAN TEMPERATURE
1981-2010
MANILA BAY AREA
Scale 1:1,650,000
30 15 0 30 60 90 120
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS 84
LOCATION
SOURCES OF DATA
NAMRIA
MBCO
PAGASA-DOST
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

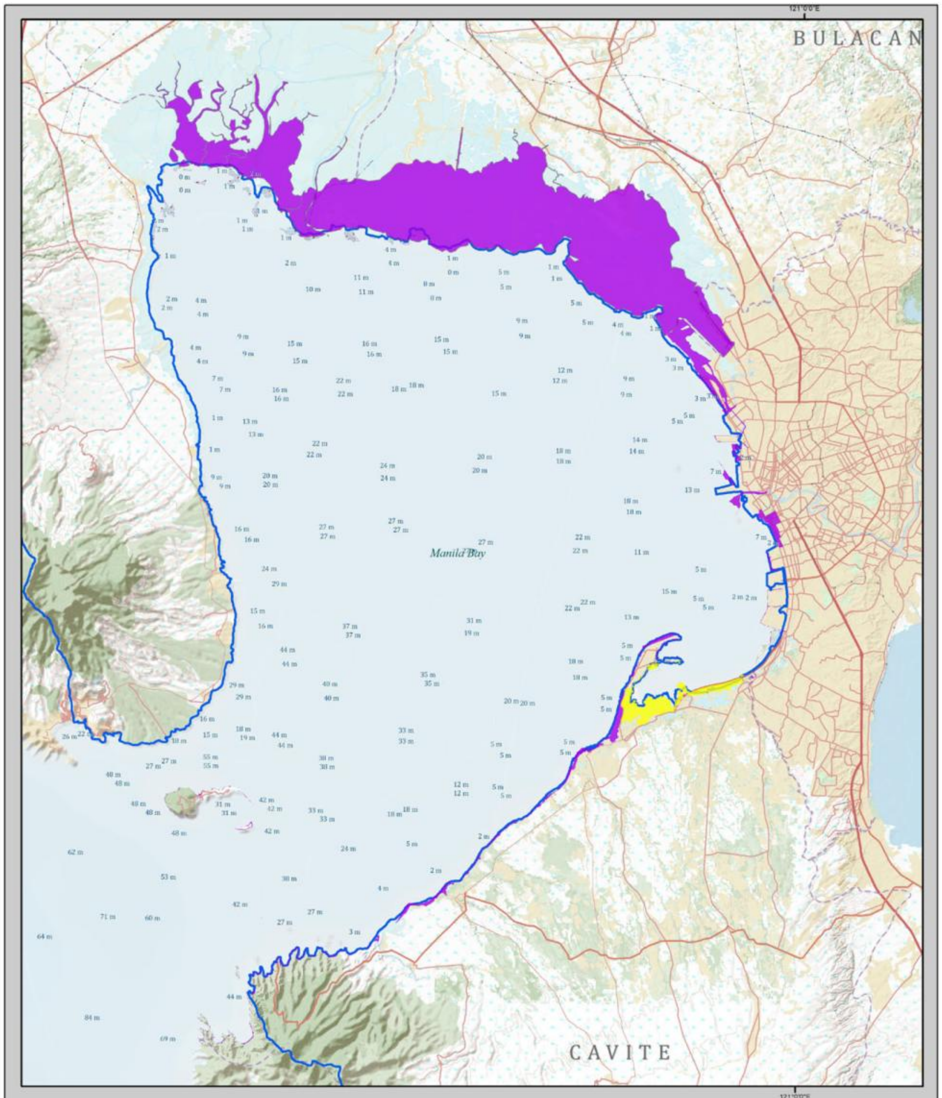
Map 141


MEAN TEMPERATURE (ºC)
SEPTEMBER (1981-2010)
High : 28.4509
Low : 23.085
MEAN TEMPERATURE (ºC)
OCTOBER (1981-2010)
High : 28.6549
Low : 22.9738
MEAN TEMPERATURE (ºC)
NOVEMBER (1981-2010)
High : 28.4971
Low : 22.7799
MEAN TEMPERATURE (ºC)
DECEMBER (1981-2010)
High : 27.3827
Low : 21.7028
CLSU
CABANATUAN
CLARK
SGARDEN
PORT AREA
NAIA
SANGLEY
LEGEND
PAGASA Station
Manila Bay Area
MONTHLY MEAN TEMPERATURE
1981-2010
MANILA BAY AREA
Scale 1:1,650,000
30 15 0 30 60 90 120
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS 84
LOCATION
SOURCES OF DATA
NAMRIA
MBCO
PAGASA-DOST
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 142


ILOCOS NORTE
APAYAO
CAGAYAN
ABRA
KALINGA
ILOCOS SUR
MOUNTAIN PROVINCE
ISABELA
IFUGAO
LA UNION
BENGUET
NUEVA VIZCAYA
QUIRINO
PANGASINAN
AURORA
TARLAC
NUEVA ECIJA
PAMPANGA
BULACAN
CAMARINES NORTE
CATANDUANES
CAMARINES SUR
MARINDUQUE
ORIENTAL MINDORO
OCCIDENTAL MINDORO
Sibuyan Sea
SORSOGON
ROMBLON
NORTHERN SAMAR
MASBATE
Samar Sea
SAMAR (WESTERN SAMAR)
BILIRAN
AKLAN
CAPIZ
Visayan Sea
LEYTE
ANTIQUE
ILOILO
GUIMARAS
NEGROS OCCIDENTAL
CEBU
LEGEND
TYPE
Tropical Depression (TD)
Tropical Storm (TS)
Typhoon (TY)
Manila Bay Area
Provincial Boundary
TYPHOON TRACKS
MANILA BAY AREA
Scale 1:3,000,000
0 30 60 120 180 240
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MBCO
PAGASA
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

Map 143



LEGEND

Susceptibility

- Inundations of 1m. surges
- Inundations of >1m. to 4m. surges
- Manila Bay Area
- Provincial Boundary
- Road

STORM SURGE HAZARD MAP
MANILA BAY AREA

Scale 1:250,000

0 2.5 5 10 15 20
Kilometers

Coordinate System: UTM-wgs84
Projection: Transverse Mercator
Datum: WGS84

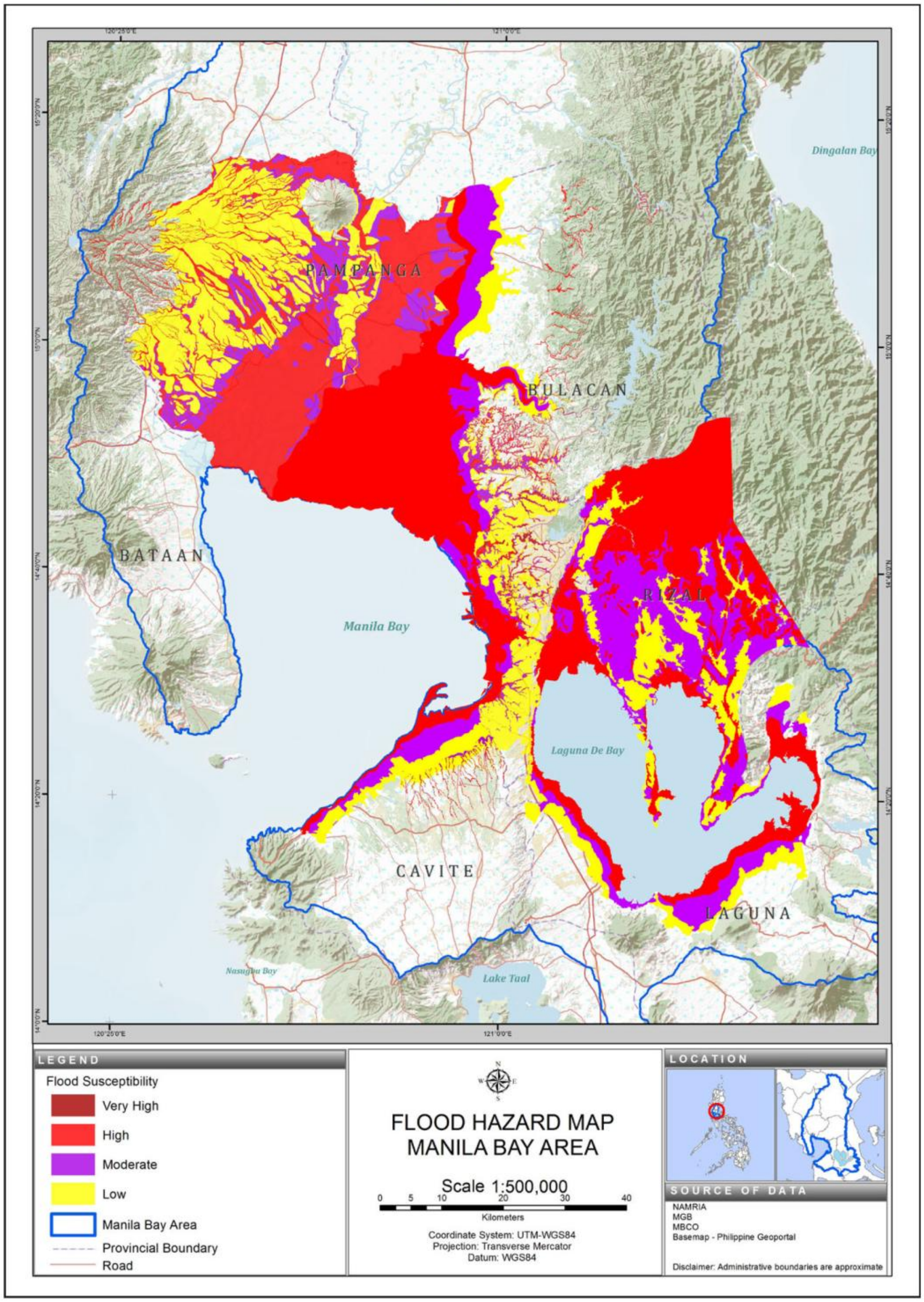
LOCATION

SOURCE OF DATA

NAMRIA
MBCO
PAGASA
Basemap - Philippine Geoportal

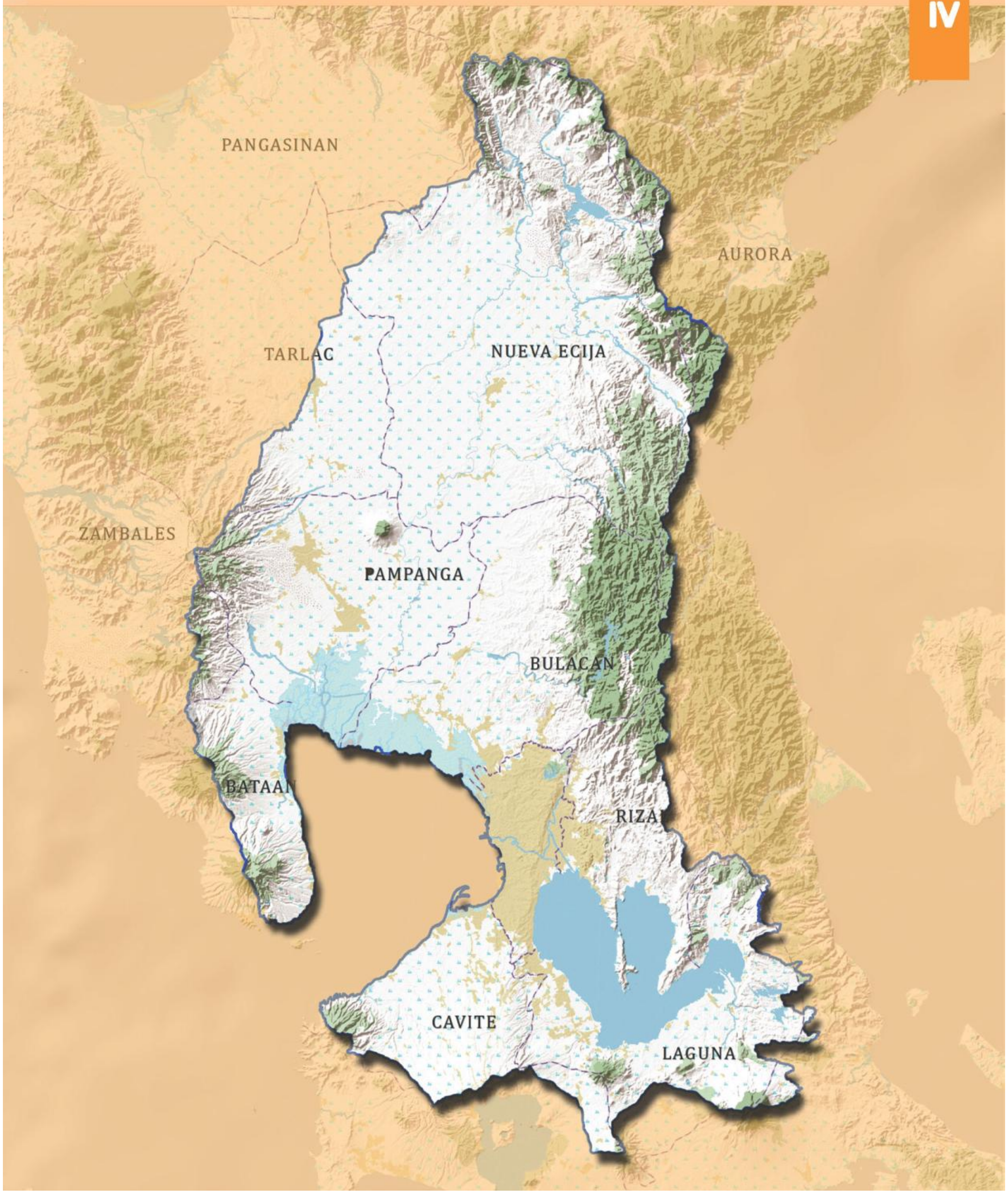
Disclaimer: Administrative boundaries are approximate

Map 144


PAMPANGA
BULACAN
BATAAN
RIZAL
Manila Bay
Laguna De Bay
CAVITE
LAGUNA
Dingalan Bay
Lake Taal
LEGEND
Flood Susceptibility
Very High
High
Moderate
Low
Manila Bay Area
Provincial Boundary
Road
FLOOD HAZARD MAP
MANILA BAY AREA
Scale 1:500,000
Kilometers
Coordinate System: UTM-WGS84
Projection: Transverse Mercator
Datum: WGS84
LOCATION
SOURCE OF DATA
NAMRIA
MGB
MBCO
Basemap - Philippine Geoportal
Disclaimer: Administrative boundaries are approximate

PART IV

WAY FORWARD



Following the publication of the 2007 MBEA, the Manila Bay Area has continuously boosted growing economies - producing more than half of the country's GDP. This growth has translated into an upgrade in transportation facilities, particularly ports, shipping, airports, roads and railways. Current statistics reveal such trend will continue with the establishment of regional growth centers outside the National Capital Region (NCR). Amidst such developments, these economies have also induced increasing socioeconomic and environmental constraints. To date, the MBA is considered one of the most-densely populated metropolitan regions in Asia, with relatively higher risks of urban decay. Without any interventions, the costs required to address population demands and its environmental challenges will eventually outweigh the benefits of growing economies.

Air pollution blanketing Metro Manila

ADDRESSING POPULATION DEMANDS

Continuous increase in population within the MBA after 2007 has put immense pressure on various production sectors, including fisheries, aquaculture and agriculture. The Updated MBEA also highlights the increase in built-up areas driven by the need for human settlements - as clearly presented in adjacent provinces of Regions III (Central Luzon) and IVA (CALABARZON). All these activities require massive land conversion, which puts areas of conservation and protection at greater risk. These, among many statistics presented by this edition can serve as reference for framing relevant actions by all stakeholders. While there is strength in numbers, enabling mechanisms should be put in place to ensure citizen participation.

MEETING ENVIRONMENTAL CHALLENGES

The trends and emerging issues on demography discussed in this manuscript lead to potential impacts on the health of the Manila Bay ecosystem. Untreated effluent discharges from domestic, commercial and industrial sources remain to be the main factor for the bay's deteriorating water quality. This is further aggravated by the increasing pollution loading from vessels and improperly disposed solid wastes. The updated MBEA also highlights the observed climate-related patterns and disaster-prone areas. This information provides useful references towards framing climate-smart and disaster resilient initiatives for the MBA. All of these environmental challenges are met through an array of pollution abatement measures employed by the government and private sectors. These include regular water and soil quality monitoring activities and water supply and sanitation projects. These are also complemented by several special studies conducted for Manila Bay and its abutting river systems.

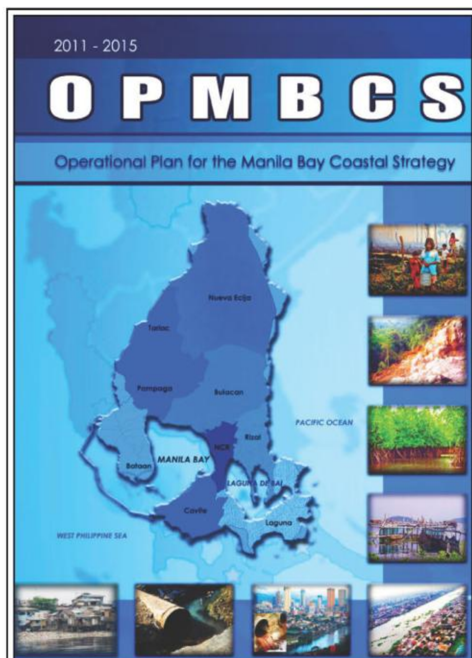
EXISTING MANAGEMENT PLANS AND INTERVENTIONS

Following the passage of the Supreme Court's En Banc Decision, the Manila Bay has been progressively marked with a reel of management plans and interventions – with the ultimate goal of bringing back its water quality, making it safe for contact recreation. It is through the 'Writ of Continuing Mandamus' that the defendant-agencies, as well as the other stakeholders have concretized measurable and time-bound strategies for the comprehensive rehabilitation program of Manila Bay.

The 2011-2015 OPMBCS and its 2013-2017 Comprehensive Implementation Plan (CIP)

The 2nd Edition of the OPMBCS (2011-2015) has provided a guiding framework for the NGAs, LGUs, academe, private sector and the communities in terms of how to approach the gargantuan tasks of rehabilitating the Manila Bay ecosystem. It entails the integration of practical lessons learned in the course of the implementation of the Manila Bay Environmental Management Project (MBEMP).

The Operational Plan has addressed priority issues/areas of concern on water pollution, habitats and resources, and partnership and governance. Each of these issues have a set of objectives and action plans with measurable targets, timeframes, and budgetary requirements. It also contains implementing arrangements - responsible agency/ sector/partner, enabling policies and laws, and financing strategy (OPMBCS, 2011).



The 2011-2015 OPMBCS

This Plan, as intended for adoption and implementation by national and local levels of government, communities, NGOs, the private sector, scientific and research institutions, and other stakeholders in the Manila Bay Area, was approved for adoption by the Manila Bay Project Coordinating Committee (MBPCC) on February 8, 2006 (OPMBCS, 2011).

Years after its implementation, the SC-MBAC has mandated the DENR to formulate an Implementation Plan enlisting all deliverables per focus area with defined timelines. The CIP, to be implemented from 2013-2017, will serve as one of SC-MBAC's monitoring and evaluation tools to assess the defendant-agencies' compliance.

Institutionalizing Efforts for Manila Bay

First introduced as the Manila Bay Environmental Management Project (MBEMP) in 2000, the urgency has catapulted DENR to establish an organization which will focus on the vast coordination works needed for compliance – the Manila Bay Coordinating Office. Through DENR AO 2011-01 (Strengthening the Manila Bay Coordinating Office), the MBCO was transferred from the River Basin Control Office (RBCO) to the Office of the Secretary – with the primary objective of facilitating an efficient and effective implementation of the OPMBCS.

It likewise serve as the liaison office between and amongst the defendant-agencies and the SC-MBAC.

Learning from Best Practices

Aside from the DENR as the lead agency, a number of best practices have been contributing towards the eventual restoration of the Manila Bay. Table 25 provides a summary of selected initiatives for the Manila Bay Environmental Agenda - categorized into three focus areas, namely Waste Management, Habitat Restoration and Partnership and Governance. In addition to said matrix, a wide number of projects, programs and activities are currently being implemented by other stakeholders.

Clean-up activities within Manila Bay

Table 25. Selected Best Practices for the Manila Bay Environmental Agenda

Intervention	Brief Description	Implementing Agency/Office
Waste Management		
Formulation of 10-Year Solid Waste Management Plans	As mandated by RA 9003 (Ecological Solid Waste Management Act of 2000), LGUs shall formulate their respective 10-Year SWMPs – with the Waste Analysis and Characterization Study (WACS) as a prerequisite. Said plan provides a framework for all LGUs to effectively manage their waste streams. The DILG, MMDA and DENR have extended technical and financial assistances to LGUs to fast track the formulation process.	LGUs, through the assistance of DILG, MMDA and DENR (NSWMC)
Installation of Trash Traps in Selected Waterways	Selected LGUs install trash traps to effectively manage floating debris from adjacent waterways.	LGUs, through the assistance of DENR
Provisions for Trash Boats in Selected LGUs	Selected LGUs were provided with trash boats by the DENR (MBCO) for the former to effectively collect floating debris from adjacent waterways and/or coastal areas.	DENR (MBCO)
Construction of Sanitary Facilities (Septage and Sewerage Systems)	The MWSS, through its water concessionaires (MWSI, MWCI), continuously construct sewer lines and wastewater treatment facilities – with the aim of 100% coverage for the entire concession area by 2037. Same intervention is implemented by LWUA for Water Districts. These sanitary facilities prevent the direct discharge of liquid waste into the receiving body of water.	MWSS (MWSI, MWCI), LWUA
Regular Desludging of Septic Tanks	The MWSS, and its water concessionaires also provide regular desludging activities every 5-7 years. Increased availing of households is parallel to lessen the direct discharge/spillover of liquid waste to the receiving body of water and/or groundwater.	MWSS (MWSI, MWCI)
Monitoring of soil and water pollution from point- and non-point sources of pollution	Comprehensive water quality monitoring activities to identify the sources of pollution. Soil and sediment quality are also being monitored by the BSWM and EMB in selected areas within the MBA.	DA (BSWM), DENR (EMB)
Regular Waterways Clean-up Activities	Regular clean-up activities are being organized by various institutions in selected waterways, as well as the coastal areas of Manila Bay. Aside from waste collection, the spirit of volunteerism and environmental stewardship is heightened through these ventures.	All stakeholders
Habitat Restoration		
Establishment of Various Ecotourism Projects	An array of ecotourism projects are established in Regions III and IVA, as well as NCR to promote sustainability while meeting the communities' economic demands	DENR (MBCO – Site Management Offices in Regions III, IVA and NCR, BMB)
Monitoring of Biodiversity Indicator Species within the Manila Bay Waters (marine turtle, avifauna, macrobenthos)	The BMB regularly monitors three indicator species within the MB waters. Inventories of the same provide an assessment of the overall health of the Bay waters, and its suitability for marine and aquatic life.	DENR (BMB)

Monitoring of Protected Areas and Key Biodiversity Areas within the MBA	Likewise, the BMB also monitors a number of PAs and KBAs within the MBA. Limits to anthropogenic activities are imposed within these areas to preserve its ecological integrity. This will also allow said area to attain optimal ecological balance – a crucial component in the rehabilitation efforts for Manila Bay.	DENR (BMB)
Mangrove Rehabilitation Projects	MBCO's SMOs in Regions III, IVA and NCR provide technical and administrative assistance to coastal LGUs to introduce a mangrove rehabilitation project. Not only does it function as a breeding ground for marine and aquatic life, mangroves also provide protection from storm surges.	DENR (MBCO – Site Management Offices in Regions III, IVA and NCR)
National Greening Program	Considered as one of the priority programs of the DENR, the National Greening Program aims to plant 1.5 billion trees in 1.5 million hectares by 2015. It is a massive forest rehabilitation program that would vastly benefit the watersheds within the MBA.	DENR (FMB)
Streambank Stabilization Initiatives	Together with selected LGUs, MBCO's SMOs in Regions III, IVA and NCR are to initiate a number of streambank stabilization measures to prevent streambanks from erosion. Heavy siltation of waterways, as an impact of erosion, will induce negative conditions for the living organisms. Redevelopment works are also partnered with these initiatives, including the construction of linear parks and other nature-based facilities.	DENR (MBCO – Site Management Offices in Regions III, IVA and NCR), PRRC, LGUs
Partnership and Governance		
Formulation of Area-Based Management Plans per River System	Issue- and Area-Based Management Plans are being formulated in all river systems within the MBA. These plans serve as a localized OPMBCS, where specific conditions are applied to come up with sensitized PPAs. MBCO's SMOs in Regions III, IVA and NCR provide technical assistance to LGUs in the formulation process.	DENR (MBCO – Site Management Offices in Regions III, IVA and NCR), LGUs
Institution of the Coastal Law Enforcement Alliance in Regions III, IVA and NCR (CLEAR)	With the very purpose of harmonizing all existing laws and policies on coastal law enforcement, CLEAR aspires to provide a common ground for effective response to various incidents affecting the bay's ecological health. CLEAR-NCR's benchmark practices are being followed by Regions III and IVA.	DENR (MBCO – Site Management Offices in Regions III, IVA and NCR), Selected Mandamus Agencies, LGUs
Proposed amendment of PD 1067 (Water Code of the Philippines)	With the leadership of NWRB, the PD 1067 is currently being amended to incorporate crucial aspects of climate change and water security – two important aspects that define Manila Bay's rehabilitation efforts.	NWRB
Conduct of Special Studies for Manila Bay	An array of special studies have been formulated by different agencies, with the goal of providing baseline data and explaining observed environmental phenomena within the MBA. Modelling studies and monitoring and evaluation tools are also being developed as a result of these studies. Upon completion, these studies will provide the necessary capacities for the DENR and its partner-agencies to determine pollution sources and better understand its behavior.	DENR (MBCO, LLDA, EMB), DA-BSWM, UP-NHRC, UP-MSI, PEMSEA
Techno-demonstrations for the reduction of pollution loading from various sources	Reduction of pollution load (crop and animal wastes) through recycling of wastes into liquid fertilizer and methane capture via fermentation (Portable Biogas Technology) Reduction of pollution load through recycling of wastes into vermicompost Reduction of pollution load through establishment of Integrated Upland Conservation (IUCF) Guided Farms via soil & water conservation technologies.	DA (BSWM)
Development of a Database Management System for Manila Bay	In line with the increasing demand for baseline data is the establishment of a database management system for Manila Bay. The MBCO currently houses a metadatabank system of all informal settlers, households, establishments and river systems within the MBA.	DENR (MBCO)
Launching of the 'Manila BAYanihan, Para sa Kalinisan' Advocacy Campaign	In support to the rehabilitation and protection of the Manila Bay, a unified advocacy brand logo was developed by the MBCO, with the assistance of the PIA and the 12 mandamus agencies. The advocacy brand identity is aimed at uplifting the awareness of all stakeholders on the environmental agenda for Manila Bay.	DENR (MBCO)

These, along with planned interventions in the future, will provide significant improvements for the ecological health of Manila Bay.

TOWARDS A SPATIALLY INTEGRATED AGENDA

Cleaning up, preserving and rehabilitating the Manila Bay to Class SB (DAO 34 Series of 1990), as mandated by the Court's En Banc Decision is still a long way to go. Though the emerging issues and trends present major challenges, various best practices have already gained grounds. With such measures addressing area- and issue-based concerns, an enabling platform to harmonize all strategies must be put in place.

One of the key identified strategies to achieve these goals is the optimal utilization of geospatial information. This form part of an umbrella approach to gather and manage baseline data holdings - which also include inventories of point and non-point sources of pollution. To suffice this needed outcome, the 2007 Manila Bay Area Environmental Atlas (1st Edition) has been updated with this edition.

The Updated Manila Bay Area Environmental Atlas (2nd Edition) provides a wide collection of geospatial data and information presented in thematic and composite maps, graphs and tables describing the characteristics and condition of the Manila Bay, including the major environmental issues. When compared to the 2007 MBEA, the updated manuscript tells a 'story' - the lessons of which can provide crucial inputs in framing necessary interventions for Manila Bay.

Moreover, this edition provides decision-makers with updated information to make the necessary policy directions for their stakeholders. It will also be useful for local government units (LGUs) in their planning process, particularly in the implementation of proper zoning and other land use instruments to ensure safety and protection of their constituents. Lastly, it should also be helpful for national government agencies (NGAs) to harmonize conflicting policies, plans and programs to ensure the sustainable development of the Manila Bay Area.

MBEA workshop held in NAMRIA Lecture Hall on September 17, 2014

With up-to-date maps, graphs and tables, this edition catalyzes movement towards a spatially integrated agenda for Manila Bay. This edition will also provide crucial inputs to the following:

- Developing a Decision Support System (DSS) through the integration of existing modelling studies
- Strengthening the Knowledge Management System (KMS), particularly improved database management for the Bay and the abutting river systems
- Setting up a refined Monitoring and Evaluation Scheme (MES) to assess existing efforts

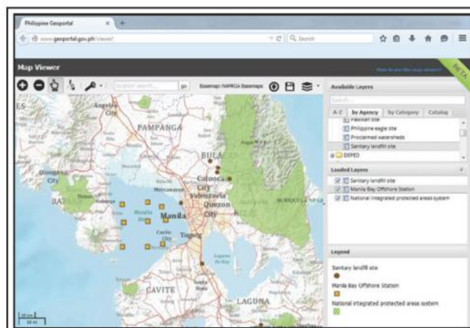
Alongside an inclusive partnership and governance strategy, the listed components will comprise the Manila Bay Master Plan - a follow through document to the 2011-2015 Operational Plan for the Manila Bay Coastal Strategy (OPMBCS). Similar with the 2007 MBEA, this edition and its inputs to the plan will provide a framework for enhanced river basin, coastal and ocean governance - and a model for the entire country.

PERCEIVED CHALLENGES AND RECOMMENDATIONS

All existing management plans and interventions for Manila Bay require an interjection of accurate and timely geospatial information. While the updating of the 2007 Manila Bay Area Environmental Atlas recognizes this need, specific challenges were encountered during its formulation process.

First, the availability of baseline data posted certain limitations on the probable topics to be reflected in this edition. An in-depth discussion of land and sea uses on the local level using the Comprehensive Land Use Plans (CLUP) and Zoning Ordinances will further magnify all enlisted issues. These include observed land conversion and forest degradation trends, as well as pollution incidences from vessels.

Extensive baseline data gathering from across all levels will suffice this requirement. This should be accompanied by the development of a repository system for geospatial data holdings to ensure easy access of raw data holdings. The Philippine Geoportal Project (PGP) by the DENR-NAMRIA currently serve this purpose.



The Philippine Geoportal

Second, the minimal utility of most stakeholders in utilizing geospatial information impeded the production of selected map holdings. This required additional time and resources for the MBEA Core Group members.

Aside from the Philippine Geoportal Project (PGP), NGAs and LGUs can build their respective GIS capacities by investing in various trainings and short courses. The DENR-NAMRIA, through its Geomatics Training Center, can offer extensive learning opportunities on basic and advanced GIS, among other modules. In addition, stakeholders can also utilize open source mapping platforms to mainstream geospatial data management in all identified services. Achieving such will provide these agencies with planning tools that will help them better plan all efforts for the Manila Bay Environmental Agenda.

Manila Bayanihan
Para sa KALINISAN

REFERENCES

Anida, A.H., Grospe, C.C., Merjilla, N., Estabillo, P.B.,Raquepo, C.M. and De Mata, L.D. (2012). Soil Physico-Chemical Characterization of Croplands within the Manila Bay System. In Bureau of Soils and Water Management. 2012. Assessment of Non-Point Source Pollution from Croplands of the Manila Bay System.

Biodiversity Management Bureau. (2014). Atlas of Inland Wetlands in Mainland Luzon. Quezon City, Philippines: Biodiversity Management Bureau (BMB) - Department of Environment and Natural Resources (DENR).

Bureau of Agricultural Statistics. (2015). Fisheries statistics of the Philippines 2013-2014 (Volume 21). Quezon City, Philippines: Bureau of Agricultural Statistics..

Bureau of Agricultural Statistics. (2013). Fisheries statistics of the Philippines 2010-2012 (Volume 20). Quezon City, Philippines: Bureau of Agricultural Statistics. 431 pp.

Bureau of Agricultural Statistics. (2012). Fisheries statistics of the Philippines 2008-2010 (Volume 19). Quezon City, Philippines: Bureau of Agricultural Statistics.

Bureau of Agricultural Statistics. (2012). Fisheries statistics of the Philippines 2007-2009 (Volume 18). Quezon City, Philippines: Bureau of Agricultural Statistics.

Bureau of Fisheries and Aquatic Resources. (2013). Philippine Fisheries Profile 2013. Quezon City, Philippines: Bureau of Fisheries and Aquatic Resources.

Castaneda, SS, Ramirez, JD, Sta Maria, EJ and Samar, ED. (2013). Assessment of Terrestrial and Marine Contribution to the Nutrient loading in Manila Bay using Carbon and Nitrogen Isotopes. In Bureau of Soils and Water Management and Philippine Nuclear Research Institute. Application of Stable Isotopes to the Assessment of Pollution Loading from Various Sources in the Pampanga River System into the Manila Bay, Philippines.

Chang, K.-H., Amano, A., Miller, T.W., Isobe, T., Maneja, R., Siringan, F., Imai, H., Nakano, S. (2009). Pollution Study in Manila Bay: Eutrophication and Its Impact on Plankton Community. Interdisciplinary Studies on Environmental Chemistry-Environmental Research in Asia 261–267.

Conservation International - Philippines, et.al. (n.d.) Priority Sites for Conservation in the Philippines: Key Biodiversity Areas. Quezon City, Philippines: Conservation International- Philippines, Biodiversity Management Bureau (BMB)- Department of Environment and Natural Resources (DENR) and Haribon Foundation.

Cruden, D.M. (1991) A Simple Definition of a Landslide. Bulletin of the International Association of Engineering Geology, No. 43, pp. 27-29. (As cited in United States Geological Survey website, n.d.)

Department of Environment and Natural Resources. (1990).

Department of Environment and Natural Resources. DENR Department Administrative Order 34 s. of 1990: Revised Water Usage and Classification/ Water Quality Criteria, Amending Section Nos. 68 and 69, Chapter III of the 1978 NPCC Rules and Regulations.

Department of Agriculture, DA Administrative Order No. 26, s. 2007. Guidelines on the Procedures and Technical Requirement for the Issuance of Certification Allowing the Pursuant to Section 22.C of R.A. 9275 Otherwise Known as the Phlippine Clean Water Act of 2004.

Department of Agriculture - Bureau of Soils and Water Management. 2012. Assessment of Non-Point Source Pollution from Croplands of Manila Bay System. ISBN 978-971-0583-13-3.

Department of Agriculture - Bureau of Soils and Management and Department of Science and Technology - Philippine Nuclear Research Institute. 2013. Application of Stable Isotopes to the Assessment of Pollution Loading from Various Sources in the Pampanga River System into the Manila Bay, Philippines. ISBN 978-971-0583-15-7.

Department of Agriculture - Bureau of Soils and Water Management. 2015. Soil and Water Quality Monitoring in Major Agricultural Areas within the Watersheds of Manila Bay, Phlippines, 2012-2014

Department of Environment and Natural Resources. (2010). Operational Plan for the Manila Bay Coastal Strategy. Quezon City, Philippines: Manila Bay Coordinating Office

Department of Environment and Natural Resources and Gala Exploration Club. (2012). Philippine Cave Primer. Quezon City, Philippines: Biodiversity Management Bureau

Department of Public Works and Highways. (2013). Strategic Infrastructure Policies and Programs. Manila, Philippines: Department of Public Works and Highways.

Department of Tourism. (2012). Distribution of Regional Travellers in the Philippines (January-December 2010). Manila, Philippines: Office of Tourism Development Planning- DOT

Department of Transportation and Communications. (2013). Datasets. Retrieved last 27 April 2015 from http://dotc.gov.ph/index.php/2014-09-02-05-02-46/2015-03-13-05-20-05

Diaz, R.J., Rosenberg, R. (2008). Spreading dead zones and consequences for marine ecosystems. Science (New York, N.Y.) 321, 926–9.

Earthquake Glossary – Liquefaction. (n.d.) In United States Geological Survey. Retrieved last 22 May 2015 from http://earthquake.usgs.gov/learn/glossary/?term=liquefaction

Environmental Management Bureau - Department of Environment and Natural Resources. (2008). Water Quality Monitoring Manual (Manual on Ambient Water Quality Monitoring) Volume 1. Environmental Management Bureau, Department of Environment and Natural Resources, Quezon City, Philippines. Chapters 6 & 7.

Food and Agriculture Organization. (n.d.) 1. Definitions. Retrieved last 18 May 2015 from http://www.fao.org/docrep/003/ x0596e/x0596e01e.htm

Flood Definitions. (n.d.) In United States Geological Survey. Retrieved last 22 May 2015 from http://ks.water.usgs.gov/flood- definitions

House of Representatives of the Philippines. (2014-23). Facts in Figures: The Philippine Tourism Industry. Manila, Philippines: Congressional Policy and Budget Research Department

Hu, W.F., et.al. (2001). Nutrient Release and Sediment Oxygen Demand in a Eutrophic Land-locked Embayment in Hong Kong. Environment International 26 (5–6), 369–375.

Human Development Network. (2013). 2012/2013Philippine Human Development Report. Manila, Philippines: Human Development Network. ISSN 0118-6361.

ICF Consulting Ltd., et.al. (2014, July). Developing a National Informal

Settlements Upgrading Strategy of the Philippines: Final Report: Manila, Philippines. ICF Consulting Ltd., Housing and Urban Development Coordinating Council, Cities Alliance/World Bank.

Jacinto, G.S., Velasquez, I.B., San Diego-McGlone, M.L., Villanoy, C.L., Siringan, F.P. (2006). Biophysical environment of Manila Bay-then and now, in: Wolanski, E. (Ed.), The Environment of Asia Pacific Harbours. Springer, Germany, pp. 293–307.

Jolankai, G. (1997). Basic River Water Quality Models: Computer-Aided Learning (CAL) Programme on Water Quality Modelling (WQMCAL version 1.1). In Technical Documents in Hydrology (No. 13). UNESCO.

Laguna Lake Development Authority. (2009-2012). Water Quality Assessment Report for Laguna Lake and River Tributaries. Laguna Lake Development Authority - Environmental Laboratory and Research Division (LLDA-ELRD).

Manila Water Company, Inc. (2014). Wastewater Master Plan. Quezon City.

Maynilad Water Services, Inc. (2014). Sewerage and Sanitation Road Map. Quezon City.

Metropolitan Waterworks and Sewerage System. (1997). Concession Agreement and Related Documents. Quezon City.

Metropolitan Waterworks and Sewerage System. (2014). Manila Bay Quarterly Accomplishment Report-3rd Quarter. Quezon City.

National Economic Development Authority. (2011). Philippine Development Plan 2011-2016 Results Matrices. Manila, Philippines: National Economic Development Authority. ISSN: 2243-7576

National Economic Development Authority. (2014). Philippine Development Plan 2011-2016 Midterm Update. Manila, Philippines: National Economic Development Authority. ISSN: 2243-7576

National Historical Commission of the Philippines. National Registry of Historic Sites and Structures in the Philippines. Retrieved last 12 May 2015 from http://nhcphistoricsites.blogspot. com/search/label/Level%20I

National Statistical Coordination Board. (2013). Gross Regional Domestic Product: 2010-2012. Manila, Philippines: National Statistical Coordination Board. ISSN-0119-4518

National Statistical Coordination Board. Resolution No. 11 Series of 2003(Approving and Adopting the Official Concepts and Definitions for Statistical Purposes of the Selected Sectors: Prices, Population, Housing and Tourism). Retrieved last 18 June 2015 from http://www.nscb.gov.ph/ resolutions/2003/11Annex.asp

National Statistical Office. (2012). 2010 Household Population by Age Group and Sex by Province and Highly Urbanized City: National Capital Region. Manila, Philippines: Philippine Statistical Authority. Retrieved from https://psa.gov.ph/ old/data/sectordata/2010/pr126602.pdf

National Statistical Office. (2012). 2010 Household Population by Age Group and Sex by Province and Highly Urbanized City: Region III (Central Luzon). Manila, Philippines: Philippine Statistical Authority. Retrieved from https://psa.gov.ph/ old/data/sectordata/2010/pr126606.pdf

National Statistical Office. (2012). 2010 Household Population by Age Group and Sex by Province and Highly Urbanized City: Region IV-A (CALABARZON). Manila, Philippines: Philippine Statistical Authority. Retrieved from https://psa. gov.ph/old/data/sectordata/2010/pr126607.pdf

National Statistical Office. (2012). 2010 Census of Population and Housing. Manila, Philippines: Philippine Statistical Authority

National Statistical Office. (2006). 2000 Census of Population and Housing. Manila, Philippines: Philippine Statistical Authority

Oak Ridge National Laboratory. (n.d.) Net Primary Productivity Methods. In Distributed Active Archive Center. Retrieved last 12 April 2015 from https://daac.ornl.gov/NPP/html_ docs/npp_est.html

Organisation for Economic Co-operation and Development. (2001, November 14). Glossary of Statistical Terms. Retrieved last 18 June 2015 from https://stats.oecd.org/glossary/detail.asp?ID=1351

Pasig River Rehabilitation Commission. (2006). Feasibility Study of Pasig River Dredging Project. Quezon City, Philippines.

Pasig River Rehabilitation Commission. (2009). Water Quality Status of Pasig River. Quezon City, Philippines.

Pasig River Rehabilitation Commission. 2014. Pasig River Rehabilitation Master Plan: The Strategic Development Framework for the Tributaries (2014-2016). Quezon City, Philippines.

PEMSEA and MBEMP-MBIN. (2007). Manila Bay Area Environmental Atlas. PEMSEA Technical Report 20, 182p. Global Environment Facility/United Nations Development Programme/International Maritime Organization Regional Programme on Building Partnerships in Environmental Management for Seas of East Asia (PEMSEA) and the Manila Bay Environmental Management Project (MBEMP)- Manila Bay Area Information Network (MBIN), Quezon City, Philippines. ISBN 978-971-812-021-7

Philippine Institute for Development Studies. (2010, February). Policy Notes: How Do Philippine Provinces Fare in Terms of Human Development? Makati, Philippines: Philippine Institute for Development Studies. No. 2010-01. ISSN 1656- 5266

Philippine Ports Authority. (2011). PPA Port Profile. Manila, Philippines: Management Information Services Department.

Philippine Ports Authority. (n.d.). Annual Port Statistics – 2009-2013. Retrieved last 26 April 2015 from www.ppa.gov.ph.

Presidential Decree 705 (Revising Presidential Proclamation 389, otherwise known as the Forestry Reform Code of the Philippines).

Primary Production. (n.d.) In Wikipedia. Retrieved last 12 April 2015 from https://en.wikipedia.org/wiki/Primary_production

Provincial Government of Bataan. Provincial Physical Framework Plan (2013-2020): (n.p.)

Provincial Government of Bulacan. Provincial Physical Framework Plan (2010-2030): (n.p.)

Provincial Government of Cavite. Provincial Physical Framework Plan (2011-2021): (n.p.)

Provincial Government of Laguna. Provincial Physical Framework Plan (2010-2020): (n.p.)

Provincial Government of Nueva Ecija. Provincial Physical Framework Plan (2014-2025): (n.p.)

Provincial Government of Pampanga. Provincial Physical Framework Plan (2011-2020): (n.p.)

Provincial Government of Rizal. Provincial Physical Framework Plan (2014-2020): (n.p.)

Provincial Government of Tarlac. Provincial Physical Framework Plan (2009-2017): (n.p.)

Rail Transport in the Philippines (n.d.). In Wikipedia. Retrieved last 27 April 2015 from https://en.wikipedia.org/wiki/Rail_ transport_in_the_Philippines

Republic Act No. 7279 (An Act to Provide for a Comprehensive and Continuing Urban Development and Housing Program, Establish the Mechanism for its Implementation, and for Other Purposes)

Republic Act No. 7586 (An Act Providing for the Establishment and Management of National Integrated Protected Areas System, Defining its Scope and Coverage, and for Other Purposes)

Republic Act No. 8371 (An Act to Recognize, Protect and Promote the Rights of Indigenous Cultural Communities/Indigenous People, Creating a National Commission of Indigenous People, Establishing Implementing Mechanisms, Appropriating Funds Therefor, and for Other Purposes)

Republic Act No. 8550 (An Act Providing for the Development, Management and Conservation of the Fisheries and Aquatic Resources, Integrating All Laws Pertinent Thereto, and for Other Purposes)

Republic Act No. 9003 (An Act Providing for an Ecological Solid Waste Management Program, Creating the Necessary Institutional Mechanisms and Incentives, Declaring Certain Acts Prohibited and Providing Penalties, Appropriating Funds Therefor, and for Other Purposes).

Republic Act No. 9275 (An Act Providing for a Comprehensive Water Quality Management and for Other Purposes).

Republic Act 10121 No. (An Act Strengthening the Philippine DisasterRisk Reduction and Management System, Providing for the National Disaster Risk Reduction and Management Framework and Institutionalizing the National Disaster Risk Reduction and Management Plan, Appropriating Funds Therefore and for Other Purposes).

Rempillo, J. (2009, October 12). Manila Bay Advisory Committee Meets on Bay Clean-up. Retrieved from http://sc.judiciary.gov.ph/microsite/manilabay/news/02-2009.php

Spatial Development Master Plan of the Laguna de Bay Basin: Land Use, Lake Water Use and Physical Development Plan. UP Planning and Development Research Foundation, Inc. (UP PLANADES). Laguna Lake Development Authority. Club Manila East Compound, Taytay, Rizal.2011

Soil Type and Shaking Hazard in the San Francisco Bay Area. (n.d.) In United States Geological Survey. Retrieved last 22 May 2015 from http://earthquake.usgs.gov/regional/nca/soiltype/

Supreme Court of the Philippines. (2009). Metro Manila Development Authority vs. Concerned Citizens of Manila Bay (General Register Nos. 171947-48). Promulgated last 15 February 2011.

Tongson E E., E. C. Hernandez, A. A. Faraon. Hydrologic Atlas of Laguna de Bay 2012. WWF-Philippines. Quezon City. 2012.

Tsunami Information. (2008, October 15). In Philippine Institute of Volcanologyand Seismology. Retrievedlast 22 May 2015 from http://www.phivolcs.dost.gov.ph/index.php?option=com_content&view=article&id=77&Itemid=129

United Nations Development Programme.(2007). Human Development Report 2007/2008. New York, USA: UNDP.

UP Planning and Development Research Foundation, Inc. (UP PLANADES). (2011). Spatial Development Master Plan of the Laguna de Bay Basin: Land Use, Lake Water Use and Physical Development Plan. Laguna Lake Development Authority. Club Manila East Compound, Taytay, Rizal.

Water Quality Assessment Report for Laguna Lake and River Tributaries. (2009-2012). Laguna Lake Development Authority Environmental Laboratory and Research Division (LLDA-ELRD) 2014. http://www.llda.gov.ph/#

World Bank Group. (2015). East Asia's Changing Urban Landscape: Measuring a Decade of Spatial Growth. Urban Development Series. Washington, DC: World Bank. doi: 10.1596/978-1- 4648-0363-5. License: Creative Commons Attribution CC BY 3.0 IGO

GLOSSARY

Administrative Boundary - consists of provincial and municipal boundaries

Ancestral Lands - land occupied, possessed and utilized by individuals, families and clans who are members of the ICCs/IPs since time immemorial, by themselves or through their predecessors-in-interest, under claims of individual or traditional group ownership, continuously, to the present except when interrupted by war, force majeure or displacement by force, deceit, stealth, or as a consequence of government projects and other voluntary dealings entered into by government and private individuals/corporations, including, but not limited to, residential lots, rice terraces or paddies, private forests, swidden farms and tree lots

Ancestral Domain - all areas generally belonging to ICCs/IPs comprising lands, inland waters, coastal areas, and natural resources therein, held under a claim of ownership, occupied or possessed by ICCs/IPs, by themselves or through their ancestors, communally or individually since time immemorial, continuously to the present except when interrupted by war, force majeure or displacement by force, deceit, stealth or as a consequence of government projects or any other voluntary dealings entered into by government and private individuals/corporations, and which are necessary to ensure their economic, social and cultural welfare. It shall include ancestral lands, forests, pasture, residential, agricultural, and other lands individually owned whether alienable and disposable or otherwise, hunting grounds, burial grounds, worship areas, bodies of water, mineral and other natural resources, and lands which may no longer be exclusively occupied by ICCs/IPs but from which they traditionally had access to for their subsistence and traditional activities, particularly the home ranges of ICCs/IPs who are still nomadic and/or shifting cultivators

Aquaculture - fishery operations involving all forms of raising and culturing fish and other fishery species in fresh, brackish and marine water areas

Atlas - a collection of maps, traditionally bound into book form, but also on CD-ROM, as well as geographic features and political boundaries; many often feature geopolitical, social, religious and economic statistics. The name "atlas" derives from the custom of adorning the cover or title page of such collections with a picture of Atlas, a Titan from Greek mythology, holding the Earth on his shoulders.

Biochemical Oxygen Demand - a measure of the approximate quantity of dissolved oxygen that will be required by bacteria to stabilize organic matter in wastewater or surface water. It is a semi-quantitative measure of the wastewater organics that are oxidizable by bacteria. It is also a standard test in assessing wastewater strength

Built-up Area - portion of the land area that is covered by the physical structures, such as houses, buildings, roads and bridges

Caves - natural holes or opening extending from the surface of the Earth to the underground, large enough for a person to pass. It includes any natural pit, sinkhole, subterranean passage and other features extending from a cave entrance

Controlled Dump - shall refer to a disposal site at which solid waste is deposited in accordance with the minimum prescribed standards of site operation

Demography - the statistical study of human populations especially with reference to size and density, distribution and vital statistics

Dependency Ratio - is the ratio of persons in the "dependent" ages (generally under age 15 and over age 64) to those in the "economically productive" ages (15-64 years) in the population. It is sometimes divided into the old-age dependency (the ratio of people aged 65 and older to those aged 15-64 years) and the child dependency (ratio of people under 15 to those aged 15-64 years)

Dissolved Oxygen - the amount of oxygen dissolved in a body of water as an indication of the degree of health of the water and its ability to support a balanced aquatic ecosystem

Ecological Balance - a state of dynamic equilibrium within a community of organisms in which genetic, species and ecosystem diversity remain relatively stable, subject to gradual changes through natural succession

Fecal Coliform - is a type of bacteria that usually occurs in ambient water as a result of the overflow of domestic sewage or non-point sources of human and animal waste. The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals

Fisheries - all activities relating to the act or business of fishing, culturing, preserving, processing, marketing, developing, conserving and managing aquatic resources and the fishery areas, including the privilege to fish or take aquatic resource thereof

Flood - an overflow or inundation that comes from a river or other body of water and causes or threatens to damage. Consequently, it is also described as any relatively high stream flow overtopping the natural or artificial banks in any reach of a stream

Geospatial Data - information set that describes, assesses and visually depicts physical features and geographically referenced activities on Earth

Gross Domestic Product - the total output produced within the geographical boundaries of the country regardless of the nationality of the entities producing the output

Gross Primary Productivity – the amount of chemical energy as biomass that primary producers create in a given length of time

Groundwater - sub-surface water that occurs beneath a water table in soils and rocks, or in geological formations

Ground Shaking - the primary cause of earthquake damage to manmade structures. When the ground shakes massively, buildings can be damaged or destroyed and their occupants may be injured or killed.

Indigenous People - a group of people or homogenous societies identified by self-ascription and ascription by others, who have continuously lived as organized community on communally bounded and defined territory, and who have, under claims of ownership since time immemorial, occupied, possessed and utilized such territories, sharing common bonds of language, customs, traditions and other distinctive cultural traits, or who have, through resistance to political, social and cultural inroads of colonization, non-indigenous religions and cultures, became historically differentiated from the majority of Filipinos. ICCs/IPs shall likewise include peoples who are regarded as indigenous on account of their descent from the populations which inhabited the country, at the time of conquest or colonization, or at the time of inroads of non-indigenous religions and cultures, or the establishment of present state boundaries, who retain some or all of their own social, economic, cultural and political institutions, but who may have been displaced from their traditional domains or who may have resettled outside their ancestral domains

Informal Settlements - 1) areas where groups of housing units have been constructed on land on which the occupants have no legal claim to, or occupy illegally; 2) unplanned settlements and areas where housing is not in compliance with current planning and building regulations (unauthorized housing).

Inland Water - an interior body of water or watercourse such as lakes, reservoirs, rivers, streams, creeks, etc. that have beneficial usage other than public water supply or primary contact recreation; tidal affected rivers or streams are considered inland waters for purposes of these regulations

Landslide - defined as "the movement of a mass of rock, debris, or earth down a slope". Landslides are a type of "mass wasting," which denote any down-slope movement of soil and rock under the direct influence of gravity. The term "landslide" encompasses five modes of slope movement: falls, topples, slides, spreads, and flows. These are further subdivided by the type of geologic material (bedrock, debris, or earth).

Land Conversion - the act of changing the current use of a piece of land into some other use

Land Cover – the observed (bio) physical cover on the Earth's surface

Land Use – the manner of allocation, utilization, management and development of land

Liquefaction – a process by which water-saturated sediment temporarily loses strength and acts as a fluid. This effect can be caused by earthquake shaking.

Liquid Waste - liquids that are discharged from residential, commercial and industrial sources that consist mostly of water along with other materials, i.e. human excretions, soap, fertilizers, etc.

Mandamus - a writ issued by a superior court commanding the performance of a specified official act or duty

Migrants - a person or group of persons who move from one place to another especially to find work

Nitrate –the most oxidized form of nitrogen and the end-product if the aerobic decomposition of organic nitrogenous matter

Net Primary Productivity – the net flux of carbon from the atmosphere into green plants per unit time. It refers to a rate process, i.e. the amount of vegetable matter produced per day, week or year.

Old Dependents - refers to population 65 years old and older at a specified time, and is depending on the working age group for support

Open Dump – a disposal area wherein the solid wastes are indiscriminately thrown or disposed of without due planning or consideration for environmental and health standards

Phosphate – one of the nutrients needed in primary productivity. It occurs naturally in the environment in small amounts. Its excess amounts are often the 'growth-limiting factor for plants as high levels can lead to algal blooms and excessive nutrients in the water.

Pollutant - any substance, whether solid, liquid, gaseous or radioactive, which directly or indirectly: (i) alters the quality of any segment of the receiving water body to affect or tend to affect adversely any beneficial use thereof; (ii) is hazardous or potentially hazardous to health; (iii) imparts objectionable odor, temperature change, or physical, chemical or biological change to any segment of the water body; or (iv) is in excess of the allowable limits, concentrations, or quality standards specified, or in contravention of the condition, limitation or restriction.

Potential Hydrogen – most commonly known as pH, is a measure of the hydrogen ion concentration, which indicates whether the water is acidic or basic.

Poverty Incidence - the number of households having an income below the poverty threshold

Protected Areas - identified portions of land and water set aside by reason of their unique physical and biological significance, managed to enhance biological diversity and protected against destructive human exploitation

Pull Factors - a positive aspect or condition that lures one to look for another home, country, region, organization, or religion. In migration, pull factors are those that encourage a population to move to a new place.

Push Factors - a negative aspect or condition that motivates one to leave, especially in one's country, region, organization, religion, etc. In migration, push factors are those that encourage a population to leave its home.

Regional Growth Centers - (Regional Agri-Industrial Growth Centers) are specific locations in each of the country's regions outside the National Capital Region (NCR) identified for development by providing it with the full range of infrastructure/utilities needed by industries to establish operations in the countryside. The RGCs are growth centers envisioned to strengthen complementary linkages between agriculture and industry; between urban centers and rural areas and their integration into a mutually reinforcing national system of production, distribution and exchange, and into the highly competitive international market.

Sanitary landfill - a waste disposal site designed, constructed, operated and maintained in a manner that exerts engineering control over significant potential environment impacts arising from the development and operation of the facility

Septage - the sludge produced on individual onsite wastewater disposal systems, principally septic tanks and cesspools

Sewage - water-borne human or animal wastes, excluding oil or oil wastes, removed from residences, building, institutions, industrial and commercial establishments together with such groundwater, surface water and storm water as maybe present including such waste from vessels, offshore structures, other receptacles intended to receive or retain waste or other places or the combination thereof

Sewerage - includes, but is not limited to, any system or network of pipelines, ditches, channels, or conduits including pumping stations, lift stations and force mains, service connections including other constructions, devices, and appliances appurtenant thereto, which includes the collection, transport, pumping and treatment of sewage to a point of disposal

Sex Ratio - the number of males per 100 females in a population

Soil Taxonomy – the practice of describing, categorizing and naming soils. It is widely used to communicate information about different kinds of soils, how they are used, their properties and where they are found.

Solid Waste - all discarded household, commercial waste, non-hazardous institutional and industrial waste, street sweepings, construction debris, agricultural waste, and other non-hazardous/non-toxic solid waste.

Total Coliform – a type of bacteria that indicates the presence of disease causing pathogens, and is a primary measure for determining the suitability of water for contact recreation

Tsunami – a series of sea waves commonly generated by under-the- sea earthquakes and whose heights could be greater than five meters. It occurs when the earthquake is shallow-seated and strong enough to displace parts of the seabed and disturb the mass of water over it

Urban Decay - gradual falling apart of a previously functional city or town. Urban decay may be caused by deindustrialization, economic breakdown, and failure of businesses, which in turn leads to increased crime rates, growing unemployment, and rising poverty in the area. This condition is evident from abandoned buildings, overrun sewers, trash and rubble on the streets, and desolate landscapes.

Urban Growth - the increase in the proportion of urban population over time, calculated as the rate of growth of the urban population minus that of the total population

Vulnerability – the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. Vulnerability may arise from various physical, social, economic and environmental factors such as poor design and construction of buildings, inadequate protection of assets, lack of public information and awareness, limited official recognition of risks and preparedness measures, and disregard for wise environmental management.

Watershed - a land area drained by a stream or fixed body of water and its tributaries having a common outlet for surface runoff

Wetlands - areas of marsh, peat or water whether natural or temporary, with water that is static, flowing, fresh, brackish or salt, the depth of which at low tide does not exceed six meters. It is classified into coastal wetlands – including tidal flat, reef flat, seagrass bed, saline lagoon and mangrove, inland wetlands - estuary, river, marsh, swamp forest and lake and human-made wetlands - irrigated rice field, fishpond, and dam.

Working Age Group - refers to population 15-64 years old at a specified time. The working age population is divided into persons in the labor force and persons not in the labor force.

Young Dependents - refers to population 0 to 14 years old at a specified time, and is depending on the working age group for support

ACRONYMS AND ABBREVIATIONS

AVNIR - Advanced Visible and Near Infrared Radiometer
BMB - Biodiversity Management Bureau
BOD - Biochemical Oxygen Demand
BSWM - Bureau of Soils and Water Management
BWTP - Balara Water Treatment Plant
CALABARZON - Cavite, Laguna, Batangas, Rizal and Quezon
CPH - Census of Population and Housing
CSCAND - Collective Strengthening on Community Awareness on Natural Disasters
CSS - combined sewerage system
DA - Department of Agriculture
DAO - Department Administrative Order
DENR - Department of Environment and Natural Resources
DILG - Department of the Interior and Local Government
DO - Dissolved Oxygen
DOST - Department of Science and Technology
DOT - Department of Tourism
DOTC - Department of Transportation and Communications
DPWH - Department of Public Works and Highways
EMB - Environmental Management Bureau
FAO-AMICAF - Food and Agriculture Organization - Analysis and Mapping of Impacts under Climate Change for Adaptation and Food Security
FC - fecal coliform
FMB - Forest Management Bureau
GCM - Global Climate Model
GDP - Gross Domestic Product
GHG - greenhouse gas
G.R. - General Register
HDI - Human Development Index
HLURB - Housing and Land Use Regulatory Board
HUDCC - Housing and Urban Development Coordinating Council
ICTSI - International Container Terminal Services, Inc.
ITCZ - Inter-Tropical Convergence Zone
Landsat ETM - Landsat Enhanced Thematic Mapper
LGUs - Local Government Units
LLDA - Laguna Lake Development Authority
LMWTP - La Mesa Water Treatment Plant
Lps - liters per second
LTO - Land Transportation Office
LWUA - Local Water Utilities Administration
MBA - Manila Bay Area
MBAC - Manila Bay Advisory Committee
MBCO - Manila Bay Coordinating Office
MBEA - Manila Bay Environmental Atlas
MICT - Manila International Container Terminal
MIMAROPA - Mindoro (Occidental and Oriental), Marinduque, Romblon and Palawan
MLD - million liters per day
MLLW - mean low low water
MMDA - Metropolitan Manila Development Authority
MNHPI - Manila North Harbour Port, Inc.
MPN - Most Probable Number
MRF - Materials Recovery Facility
MT - metric tonnes
MWCI - Manila Water Company, Inc.
MWSI - Maynilad Water Services, Inc.
MWSS - Metropolitan Waterworks and Sewerage System
NAMRIA - National Mapping and Resource Information Authority
NCR - National Capital Region
NFRDI - National Fisheries Research Development Institute
NGAs - national government agencies
NGOs - non-government organizations
NHA - National Housing Authority
NHCP - National Historical Commission of the Philippines
NIPAS - National Integrated Protected Areas System
NPAAD - Network of Protected Areas for Agricultural Development
NPP - net primary productivity
NSCB - National Statistical Coordination Board
NSO - National Statistical Office
NSWMC - National Solid Waste Management Commission
NWRB - National Water Resources Board
OPMBCS - Operational Plan for the Manila Bay Coastal Strategy
PAGASA - Philippine Atmospheric, Geophysical and Astronomical Services Administration
PBDE - Polybrominated diphenyl
PCB - Polychlorinated biphenyl
PCG - Philippine Coast Guard
PD - Presidential Decree
PEMSEA - GEF/UNDP/IMO Regional Programme on Building Partnerships in Environmental Management for the Seas of East Asia
PENRO - Provincial Environment and Natural Resources Office
pH - potential Hydrogen
PHDR - Philippine Human Development Report
PNSDW - Philippine National Standard for Drinking Water
PPA - Philippine Ports Authority
PPFPs - Provincial Physical Framework Plans
ppm - parts per million
PRRC - Pasig River Rehabilitation Commission
PRUMS - Pasig River Unified Monitoring System
PSA - Philippine Statistical Authority
RBCO - River Basin Control Office
RORO - Roll-On, Roll-Off
SLF - Sanitary Landfill
SPOT 5 - Satellite Pour l'Observation de la Terre
SRES - Special Report on Emission Scenarios
STP - Sewage Treatment Plant
TC - total coliform
TEU - twenty-foot equivalent units
TSS - Total Suspended Solids
TWG - Technical Working Group
UNDP - United Nations Development Program
UP-NIGS - University of the Philippines - National Institute for Geological Sciences
UP NSRI - University of the Philippines - National Science Research Institute
UTM - Universal Transverse Mercator
VTMS - Vessel Traffic Management System
VTU - vacuum truck units

ANNEXES

Annex 1. Value of Production by Subsector (2010-2014), Manila Bay Area: Bataan, Bulacan and Pampanga (In thousand pesos; source: Philippine Statistics Authority)

Province/Subsector	2010	2011	2012	2013	2014
Metro Manila	**DNA**	**DNA**	**6,260,153.31**	**8,005,600.83**	**5,599,087.01**
Commercial	DNA	DNA	5,578,739.11	7,433,755.51	4,855,116.60
Municipal	DNA	DNA	526,414.71	428,863.23	611,507.51
Aquaculture	DNA	DNA	154,999.49	142,982.09	132,462.90
Bataan	**2,053,066.79**	**2,173,682.64**	**2,171,205.85**	**2,311,334.50**	**2,486,475.83**
Commercial	DNA	DNA	DNA	DNA	123,503.87
Municipal	811,031.05	828,611.53	847,731.23	895,029.44	960,807.80
Aquaculture	1,242,035.74	1,345,071.11	1,323,474.62	1,416,305.06	1,402,164.16
Bulacan	**4,254,791.05**	**4,545,223.54**	**4,910,676.52**	**4,819,871.09**	**4,237,186.17**
Commercial	41,218.95	41,391.09	30,061.85	31,714.26	32,159.33
Municipal	121,218.72	133,802.42	96,604.51	130,318.62	111,740.73
Aquaculture	4,092,353.38	4,370,030.03	4,784,010.16	4,657,838.21	4,093,286.11
Pampanga	**18,031,158.62**	**17,982,833.60**	**18,517,978.74**	**19,914,343.30**	**20,336,674.75**
Commercial	DNA	DNA	DNA	DNA	DNA
Municipal	836,779.81	861,626.73	920,914.70	926,585.16	982,193.33
Aquaculture	17,194,378.81	17,121,206.87	17,597,064.04	18,987,758.14	19,354,481.42

Annex 2. Commercial Fisheries: Volume of Production by Species (2010-2014), Manila Bay Area (In metric tons; source: Philippine Statistics Authority)

Province/Species	2010	2011	2012	2013	2014
Bataan	DNA	DNA	DNA	DNA	3,364.24
Crevalle (Salay-salay)	DNA	DNA	DNA	DNA	2.02
Fimbriated sardines (Tunsoy)	DNA	DNA	DNA	DNA	3,358.70
Indo-pacific mackerel (Hasa-hasa)	DNA	DNA	DNA	DNA	2.02
Threadfin bream (Bisugo)	DNA	DNA	DNA	DNA	1.5
Bulacan	469.46	475.11	328.99	351.91	377.69
Anchovies (Dilis)	12.04	11.8	11.09	13.03	21.3
Blue crab (Alimasag)	46.57	55.97	47.36	48.5	55.06
Fimbriated sardines (Tunsoy)	40.01	52.53	30.28	35.35	39.55
Indian mackerel (Alumahan	29.25	19.85	9.7	7.95	14.4
Indian sardines (Tamban)	DNA	DNA	DNA	4.25	7.2
Indo-pacific mackerel (Hasa-hasa)	42.9	46.8	23.75	16.73	21.03
Mullet (Kapak)	55.83	51.7	39.45	38.8	49.97
Slipmouth (Sapsap)	33	37.95	18.9	23.6	26
Spanish mackerel (Tanigue)	3.1	3.33	0.96		
Squid (Pusit)	50.43	51.96	43.1	37.37	36.3
Threadfin bream (Bisugo)	60.5	63.55	37.55	43.66	38.85
Others	95.83	79.67	66.85	82.67	68.03

Annex 3. Marine Municipal Fisheries: Volume of Production by Species (2010-2014), Manila Bay Area (In metric tons;source: Philippine Statistics Authority)

Province/Species	2010	2011	2012	2013
Bataan	**10,250.90**	**10,801.45**	**10,553.99**	**10,533.20**
Acetes (Alamang)	100.49	101.07	137.08	132.22
Anchovies (Dilis)	77.42	83.42	99.27	99.74
Big-eyed scad (Matangbaka)	197.38	179.82	193.2	194.06
Bigeye tuna (Tambakol/ Bariles)	14.68	4.23	DNA	DNA
Blue crab (Alimasag)	769.71	821.3	790.06	809.85
Caesio (Dalagang-bukid)	4.74	8.27	16.39	16.48
Cavalla (Talakitok)	22.63	23.68	24.06	25.83

Province/Species	2010	2011	2012	2013
Crevalle (Salay-salay)	298.56	306.63	310.87	320.88
Eastern little tuna (Bonito)	26.66	26.69	45.29	46.67
Fimbriated sardines (Tunsoy)	322.13	374.02	429.86	425.43
Flying fish (Bolador)	8.35	9.46	14.68	11.39
Frigate tuna (Tulingan)	186.58	165.04	156.68	155.85
Goatfish (Saramulyete)	74.94	66.87	56.52	56.49
Grouper (Lapu-lapu)	24.89	25.65	31.53	32.97
Hairtail (Espada)	113.03	102.67	85.07	90.37

Continuation Annex 3.

Province/Species	2010	2011	2012	2013
Indian mackerel (Alumahan)	237.01	234.19	257.46	256.64
Indian sardines (Tamban)	10.14	9.39	7.66	6.97
Indo-pacific mackerel (Hasa-hasa)	2,214.16	2,273.24	2,015.26	1,874.31
Mullet (Kapak)	600.94	633.91	681.64	685.37
Parrot fish (Loro)	0.22	0.33	2.09	1.57
Porgies (Pargo)	8.24	8.54	12.68	13.62
Round herring (Tulis)	68.17	61.09	52.15	51.93
Rounscand (Galunggong)	375.37	403.59	368.14	389.67
Siganid (Samaral)	16.69	17.41	21.22	22.31
Skipjack (Gulayasan)	49.82	48.92	55.22	56.99
Slipmouth (Sapsap)	319.98	335.63	276.34	288.19
Snapper (Maya-maya)	33.5	34.61	48.87	50.54
Spanish mackerel (Tanigue)	49.31	45.56	61.18	63.87
Squid (Pusit)	173.35	176.47	188.49	186.28
Threadfin bream (Bisugo)	793.78	741.74	645.07	656.47
Yellowfin tuna (Tambakol/Bariles)	39.68	33.72	42.61	43.54
Others	3,018.35	3,444.29	3,427.35	3,466.70
Bulacan	**1,697.95**	**1,677.37**	**1,339.64**	**1,174.73**
Acetes (Alamang)	108.61	88.34	103.47	92.33
Anchovies (Dilis)	12.35	4.19	0.7	DNA
Blue crab (Alimasag)	210.68	188.52	118.95	122.45
Indian mackerel (Alumahan)	0.25	DNA	DNA	DNA
Indo-pacific mackerel (Hasa-hasa)	33.96	19.25	14.93	DNA
Mullet (Kapak)	96.98	78.21	73.8	82.85

Province/Species	2010	2011	2012	2013
Slipmouth (Sapsap)	DNA	5.4	DNA	2.8
Spanish mackerel (Tanigue)	0.51	0.28	0.15	DNA
Squid (Pusit)	15.1	17.4	2.05	DNA
Threadfin bream (Bisugo)	42.05	50.77	46.15	65.11
Others	1,177.46	1,225.01	979.44	809.19
Pampanga	**2,206.52**	**2,163.05**	**2,025.76**	**2,018.28**
Anchovies (Dilis)	136.64	137.51	125.35	126.63
Big-eyed scad (Matangbaka)	67.12	67.89	76.01	85.88
Blue crab (Alimasag)	141.02	135.05	125.15	132.48
Caesio (Dalagang-bukid)	140.86	130.82	121.34	111.2
Cavalla (Talakitok)	52.25	55.29	61.11	65
Crevalle (Salay-salay)	76.43	81.11	94.93	106.4
Frigate tuna (Tulingan)	130.63	120.27	104.84	108.36
Indian Mackerel (Alumahan)	119.54	112.34	123.09	128.32
Indian sardines (Tamban)	60.6	65.38	57.79	53.41
Indo-pacific mackerel (Hasa-hasa)	146.9	123.99	108.89	114.99
Mullet(Kapak)	132.64	137.66	133.96	131.43
Rounscad (Galunggong)	138.08	144.64	118.43	120.95
Skipjack (Gulyasan)	DNA	3.45	3.4	DNA
Slipmouth (Sapsap)	131.26	132.22	115.63	115.72
Snapper (Maya-maya)	DNA	3.98	13.58	DNA
Spanish mackerel (Tanigue)	120.19	115.98	105.44	106.41
Squid (Pusit)	150.68	143.08	127.01	122.14
Threadfin bream (Bisugo)	137.19	133.06	105.04	105.11
Others	324.49	319.33	304.77	283.85

Annex 4. Inland Municipal Fisheries: Volume of Production by Species (2010-2014), Manila Bay Area (In metric tons; source: Philippine Statistics Authority)

Province/ Species	2010	2011	2012	2013	2014
Bataan	**77.42**	**81.43**	**85.08**	**91.18**	**90.3**
Fish	67.71	71.62	75.72	80.97	80.71
Carp	0.33	0.39	0.33	0.35	
Catfish (Hito)	9.12	10.29	10.95	12.13	12.77
Freshwater goby (Biya)	15.05	14.91	16.08	15.7	14.98
Gourami	2.54	2.58	2.69	2.71	2.58
Mudfish (Dalag)	11.33	12.69	13.45	14.84	14.99
Mullet (Kapak)	8.36	8.85	8.8	9.51	9.24
Silver perch (Ayungin)	5.5	5.52	5.12	5.4	4.94
Tilapia	15.48	16.39	18.3	20.33	21.21
Crustaceans	6.15	6.12	6.29	7.2	7.14
Freshwater shrimp (Hipon)	6.15	6.12	6.29	7.2	7.14
Molluscs	3.56	3.69	3.07	3.01	2.45
Snail (Suso)	3.56	3.69	3.07	3.01	2.45
Bulacan	**1,000.20**	**1,118.03**	**579.87**	**754.33**	**800.49**
Fish	939.35	1,062.67	566.24	742.12	790.65
Carp	213.1	246.65	78.98	103.34	75.18

Province/ Species	2010	2011	2012	2013	2014
Catfish (Hito)	21.58	70.71	48.37	38.99	87.8
Catfish (Kanduli)	15.64	46.24	23.13	9.05	34.63
Climbing perch (Martiniko)	21.52	15.98	30.83	33.5	34.4
Eel (Igat)	1.14	1.73		1.12	1.56
Freswater goby (Biya)	31.95	9.82	3.24	19.77	13.02
Gourami	11.71	7.36	2.01	8.38	0.22
Milkfish (Bangus)	11.08	19.33	7.26		1.01
Mudfish (Dalag)	40.36	30.38	35.19	71.33	33.52
Mullet (Kapak)	106.69	69.81	16.2	20.11	30.83
Silver perch (Ayungin)	27.15	18.19	15.86	23.68	2.18
Tilapia	437.18	499.33	305.06	412.85	474.06
Big head carp	DNA	17.87	DNA	DNA	DNA
Other fishes	0.25	9.27	0.11		2.24
Crustaceans	56.25	52.36	13.63	12.21	9.84
Freshwater shrimp (Hipon)	1.12	10.05	3.57	3.8	9.39

Continuation Annex 4.

Province/ Species	2010	2011	2012	2013	2014
Lobster (Ulang)	31.75	15.31	2.34	2.44	0.45
Mud crab (Alimango)	1.68	5.58	0.22	0.2	DNA
Tiger prawn (Sugpo)	2.23	11.62	2.02	2.73	DNA
White Shrimp (Hipong Puti)	19.47	9.8	5.48	3.04	DNA
Molluscs	4.6	3	DNA	DNA	DNA
Shell (Kuhol)	1.74	1.5	DNA	DNA	DNA
Snail (Suso)	2.86	1.5	DNA	DNA	DNA
Pampanga	**8,718.74**	**9,047.84**	**9,795.76**	**10,170.03**	**10,447.71**
Fish	6,972.86	7,198.35	7,936.92	8,375.27	8,555.04
Carp	1,469.24	1,508.65	1,694.82	1,892.48	1,995.25
Catfish (Hito)	767.56	841.2	975.18	1,046.52	1,000.31
Catfish (Kanduli)	126.69	2.91	DNA	DNA	DNA
Freshwater goby (Biya)	520.85	564.61	495.78	560.79	551.89
Gourami	538.17	576.56	682.79	841.67	825.64

Province/ Species	2010	2011	2012	2013	2014
Mudfish (Dalag)	945.04	940.3	1,084.15	1,207.24	1,299.74
Silver perch (Ayungin)	369.1	407.66	360.2	359.06	323.27
Tilapia	1,682.18	1,767.32	2,003.44	1,797.90	2,037.10
Other fishes	554.03	589.14	640.56	669.61	521.84
Crustaceans	1,348.49	1,463.23	1,498.47	1,530.05	1,569.43
Freshwater crab (Talangka)	DNA	DNA	DNA	DNA	39.24
Freshwater shrimp (Hipon)	448.88	481.08	560.92	566.23	541.84
Lobster (Ulang)	829.48	982.15	937.55	963.82	988.35
White shrimp (Hipong Puti)	70.13	DNA	DNA	DNA	DNA
Molluscs	397.39	386.26	360.37	264.71	323.24
Freshwater clams (Tulya)	397.39	386.26	360.37	264.71	243.92
Snail (Suso)	DNA	DNA	DNA	DNA	79.32

Annex 5. Aquaculture: Volume of Production by Species (2010-2014), Manila Bay Area (In metric tons; source: Philippine Statistics Authority)

YEAR	2010	2011	2012	2013	2014
Bataan	**13,044.69**	**12,351.19**	**11,784.95**	**12,042.65**	**11,933.29**
Milkfish	8,613.67	8,228.66	8,152.02	8,290.63	8,316.00
Tilapia	1,421.80	1,440.9	1,397.38	1,481.61	1,487.46
Tiger prawn	970.16	897.81	888.87	901.2	879.98
Mudcrab	123.02	124.03	122.62	124.96	125.48
Endeavor prawn	106.66	107.98	110.68	114.99	118.28
White shrimp	44.73	46.3	47.95	49.99	51.1
Oyster	14.1	12.73	11.15	11.34	10.5
Mussel	1,717.86	1,438.28	1,007.98	1,014.14	890.47
Others	28.59	54.53	46.3	53.79	54.02
Bulacan	**41,187.01**	**37,520.40**	**39,630.31**	**40,268.66**	**39,426.42**
Milkfish	27,004.62	23,019.66	24,737.44	25,215.97	25,501.61
Tilapia	4,929.42	4,301.87	4,142.75	4,436.20	3,974.47
Tiger prawn	4,758.83	5,205.55	5,253.30	4,649.09	3,979.66
Mudcrab	82.61	71.71	59.38	70.17	73.27
Grouper	16.71	7.24	3.16	5.7	1.76
Catfish	286.93	255.64	292.45	331.34	325.98
Oyster	4,045.30	4,495.92	4,941.21	5,252.28	5,172.41
Others	62.59	162.81	200.62	307.91	397.26
Cavite	**6,605.74**	**7,554.29**	**9,679.36**	**9,377.24**	**5,808.93**
Tiger prawn	4.96	3.73	3.34	0.59	0.94
Milkfish	292,177.33	286,184.00	282,888.63	295,473.92	297,440.12
Tilapia	154,097.12	152,058.27	151,994.48	157,391.19	155,289.08
Oyster	975.84	994.44	1,426.79	1,938.89	1,487.78
Mussel	5,494.04	6,435.54	8,060.86	7,124.41	4,044.89
Pampanga	**148,603.08**	**145,622.73**	**143,933.62**	**150,266.78**	**151,244.19**
Milkfish	19,566.02	19,318.47	19,128.97	19,945.89	20,003.59
Tilapia	104,978.15	102,348.08	101,172.60	105,994.52	106,813.66
Tiger prawn	19,030.08	18,894.72	18,653.44	19,266.73	19,378.68
Mudcrab	3,926.82	3,956.67	3,833.03	3,896.91	3,865.39
White shrimp	325.97	337.45	324.68	314.37	305.27
Carp	81.74	78.47	84.58	80.42	84.34
Catfish	358.74	338.62	362.43	377.25	392.13
Gourami	61.87	64.38	70.45	70.92	67.86
Mudfish	248.2	260.25	276.86	291.93	305.56
Others	25.49	25.62	26.58	27.84	27.71

Annex 6. Area Harvested to Rice and Corn (2007-2014) (in metric tons; source: Philippine Statistics Authority)

Crop	Geolocation	Volume of Production (MT)							
		2007	2008	2009	2010	2011	2012	2013	2014
Palay	**Manila Bay Area**	636,220	661,938	653,705	676,189	614,843	669,971	705,018	711,102
	Nueva Ecija	274,850	285,905	295,840	299,844	286,821	304,189	315,376	318,284
	Tarlac	126,088	129,659	129,490	133,424	116,734	123,255	134,864	136,445
	Pampanga	85,158	85,910	74,236	84,746	68,826	84,257	90,965	91,611
	Bataan	29,940	30,294	30,764	31,604	31,117	31,133	32,290	32,328
	Bulacan	73,685	81,115	79,925	79,161	60,219	79,723	82,070	81,959
	Rizal	7,599	7,605	5,773	7,342	7,972	6,412	8,175	8,073
	Cavite	10,820	11,401	12,364	11,930	12,482	11,107	11,499	11,783
	Laguna	28,080	30,049	25,313	28,138	30,672	29,895	29,779	30,619
	Regions 3 & 4A	745,627	778,429	771,159	786,025	731,073	788,791	826,335	833,759
	% of regional total	85	85	85	86	84	85	85	85
	PHILIPPINES	4,272,889	4,459,977	4,532,310	4,354,161	4,536,642	4,690,061	4,746,091	4,739,672
	% of Philippines	15	15	14	16	14	14	15	15
Corn	**Manila Bay Area**	43,135	46,124	43,886	41,460	38,454	39,574	42,919	41,425
	Nueva Ecija	6,030	6,660	6,471	6,064	5,987	6,403	6,968	7,102
	Tarlac	19,591	22,382	19,874	18,720	16,467	16,853	18,528	18,212
	Pampanga	12,458	12,078	11,542	11,212	10,442	10,653	11,043	10,902
	Bataan	1,282	1,224	1,524	1,934	1,837	1,519	2,135	1,463
	Bulacan	729	758	863	919	938	1,002	1,088	1,167
	Rizal	171	234	236	312	335	484	530	551
	Cavite	1,234	1,045	1,944	1,173	1,292	1,418	1,408	1,021
	Laguna	1,640	1,743	1,432	1,126	1,156	1,242	1,219	1,007
	Regions 3 & 4A	76,553	82,758	80,953	72,664	70,694	73,561	78,057	78,053
	% of regional total	56	56	54	57	54	54	55	53
	PHILIPPINES	2,648,317	2,661,021	2,683,890	2,499,040	2,544,612	2,593,924	2,563,718	2,611,432
	% of Philippines	1.6	1.7	1.6	1.7	1.5	1.5	1.7	1.6

Annex 7. Area Harvested/Planted to Various Crops in the Manila Bay Area (2007-2013) (in hectares; source: Philippine Statistics Authority)

Crop	Geolocation	Area Harvested (ha)						
		2007	2008	2009	2010	2011	2012	2013
Coconut (with husk)	**Manila Bay Area**	77,695	77,714	77,701	77,701	77,681	77,666	77,642
	Nueva Ecija	136	143	143	143	143	143	142
	Tarlac	275	275	275	275	275	275	275
	Pampanga	54	54	54	54	54	54	54
	Bataan	845	850	845	845	845	830	800
	Bulacan	245	244	246	246	246	246	246
	Rizal	270	280	270	270	270	270	270
	Cavite	13,620	13,620	13,620	13,620	13,600	13,600	13,607
	Laguna	62,250	62,248	62,248	62,248	62,248	62,248	62,248
	Regions 3 & 4A	367,646	367,664	367,656	462,761	462,341	462,801	464,677
	% of regional total	21	21	21	17	17	17	17
	Philippines	3,359,777	3,379,741	3,401,500	3,575,944	3,561,981	3,573,806	3,550,491
	% of Philippines	2	2	2	2	2	2	2
Mango	**Manila Bay Area**	27,506	27,564	27,500	27,539	27,503	28,033	27,683
	Nueva Ecija	11,093	11,103	11,040	11,040	11,040	11,404	10,800
	Tarlac	3,455	3,455	3,455	3,455	3,455	3,455	3,455
	Pampanga	893	913	915	915	925	1,141	1,410
	Bataan	1,131	1,131	1,131	1,131	1,085	1,055	1,050
	Bulacan	8,815	8,835	8,832	8,840	8,840	8,840	8,835

Continuation Annex 7.

Crop	Geolocation	Area Harvested (ha)						
		2007	2008	2009	2010	2011	2012	2013
	Rizal	810	810	810	813	813	813	813
	Cavite	1,130	1,130	1,130	1,158	1,158	1,138	1,133
	Laguna	179	187	187	187	187	187	187
	Regions 3 & 4A	48,390	48,152	48,305	48,487	48,455	48,854	48,544
	% of regional total	57	57	57	57	57	57	57
	Philippines	184,174	186,770	188,139	189,437	187,073	188,617	187,838
	% of Philippines	15	15	15	15	15	15	15
Sugarcane	**Manila Bay Area**	16,784	19,795	18,227	18,443	19,470	21,371	20,125
	Nueva Ecija	60	50	45	45	45	40	42
	Tarlac	8,831	10,860	10,230	11,674	13,344	13,120	13,100
	Pampanga	7,320	8,294	7,174	5,950	5,350	6,990	5,755
	Bataan	128	128	128	128	68	58	53
	Bulacan	5	3	3	1	1	1	1
	Rizal	..	..	..	..	..	..	..
	Cavite	320	323	514	514	524	1,025	1,036
	Laguna	120	137	133	131	138	138	138
	Regions 3 & 4A	47,302	53,068	51,508	46,952	52,321	51,786	48,583
	% of regional total	35	37	35	39	37	41	41
	Philippines	382,956	397,991	404,034	354,878	439,698	433,301	437,068
	% of Philippines	4	5	5	5	4	5	5
Other crops	**Manila Bay Area**	64,763	63,342	63,414	62,512	62,387	62,812	63,188
	Nueva Ecija	17,928	16,682	16,970	17,200	17,224	17,158	17,201
	Tarlac	7,153	7,007	7,088	7,024	7,335	7,669	7,980
	Pampanga	3,597	3,561	3,562	3,543	3,196	3,296	3,319
	Bataan	1,490	1,506	1,507	1,500	1,440	1,514	1,439
	Bulacan	3,618	3,621	3,646	3,700	3,701	3,751	3,818
	Cavite	8,778	8,814	8,842	8,741	8,773	8,700	8,703
	Laguna	18,350	18,304	17,953	17,919	17,842	17,847	17,865
	Rizal	3,850	3,847	3,847	2,885	2,877	2,877	2,863

Annex 8. Volume of Rice and Corn Production in the Manila Bay Area (2007-2014) (in metric tons; source: Philippine Statistics Authority)

Crop	Geolocation	Volume of Production (MT)							
		2007	2008	2009	2010	2011	2012	2013	2014
Palay	**Manila Bay Area**	2,933,202	3,022,130	2,784,959	2,957,341	2,620,917	3,196,031	3,384,272	3,734,601
	Nueva Ecija	1,356,161	1,372,378	1,360,915	1,374,173	1,313,487	1,587,163	1,672,666	1,930,996
	Tarlac	557,943	550,552	491,233	562,180	450,757	549,299	585,077	638,906
	Pampanga	390,290	398,910	332,972	393,328	310,456	388,187	419,721	433,106
	Bataan	131,843	136,258	125,880	131,610	123,511	134,960	140,067	155,056
	Bulacan	304,849	353,101	300,277	298,376	227,607	351,307	366,927	372,110
	Rizal	28,782	31,476	23,500	27,933	30,509	25,667	28,732	27,243
	Cavite	38,685	41,697	39,119	46,614	38,482	38,495	42,177	46,280
	Laguna	124,649	137,758	111,063	123,127	126,108	120,953	128,905	130,904
	Regions 3 & 4A	3,333,531	3,442,432	3,188,502	3,348,604	3,015,276	3,609,879	3,821,253	4,170,732
	% of regional total	88	88	87	88	87	89	89	90
	Philip	16,240,194	16,815,548	16,266,417	15,772,319	16,684,062	18,032,525	18,439,420	18,967,826
	% of Philippines	18	18	17	19	16	18	18	20
Corn	**Manila Bay Area**	187,116	207,454	197,643	184,705	180,681	195,374	211,694	222,857
	Nueva Ecija	18,631	21,501	19,623	15,103	15,135	19,352	24,435	25,804
	Tarlac	106,448	118,472	110,684	102,666	100,888	110,633	112,107	122,226
	Pampanga	47,668	53,137	50,554	49,447	47,478	49,021	54,331	58,157
	Bataan	5,609	5,287	7,102	9,361	8,814	7,230	10,753	7,391
	Bulacan	1,415	1,635	1,895	2,532	2,267	2,580	3,270	3,666

Continuation Annex 8.

Crop	Geolocation	Volume of Production (MT)							
		2007	2008	2009	2010	2011	2012	2013	2014
	Rizal	407	762	718	944	980	1,135	1,340	1,660
	Cavite	2,729	1,975	3,413	1,944	2,497	2,559	2,654	1,704
	Laguna	4,209	4,685	3,654	2,708	2,622	2,864	2,804	2,249
	Regions 3 & 4A	264,839	286,234	269,194	258,099	246,051	269,231	302,930	315,199
	% of regional total	71	72	73	72	73	73	70	71
	Philippines	6,736,940	6,928,225	7,034,033	6,376,796	6,971,221	7,407,068	7,377,293	7,770,603
	% of Philippines	2.8	3.0	2.8	2.9	2.6	2.6	2.9	2.9

Annex 9. Volume of Production of Major Crops in the Manila Bay Area, 2007-2013 (in metric tons; source: Philippine Statistics Authority)

Crop	Geolocation	Volume of Production (MT)						
		2007	2008	2009	2010	2011	2012	2013
Coconut (with husk)	**Manila Bay Area**	146,659	143,538	153,861	153,402	155,885	161,157	166,680
	Nueva Ecija	727	748	765	766	767	772	758
	Tarlac	383	399	398	394	406	418	434
	Pampanga	185	192	189	195	198	206	211
	Bataan	3,470	3,676	3,852	3,911	3,783	3,691	3,564
	Bulacan	624	547	558	563	569	570	581
	Rizal	658	637	653	649	655	663	717
	Cavite	38,460	38,847	40,124	39,709	40,322	40,386	41,144
	Laguna	102,153	98,491	107,322	107,216	109,186	114,450	119,271
	Regions 3 & 4A	1,429,436	1,551,955	1,629,859	1,605,080	1,603,502	1,626,464	1,614,164
	% of regional total	10	9	9	10	10	10	10
	Philippines	14,852,927	15,319,527	15,667,565	15,510,283	15,244,609	15,862,386	15,353,200
	% of Philippines	1.0	0.9	1.0	1.0	1.0	1.0	1.1
Mango	**Manila Bay Area**	81,978	61,579	52,788	57,469	56,201	54,655	59,164
	Nueva Ecija	16,459	15,092	14,267	14,085	14,936	14,249	14,351
	Tarlac	19,645	18,266	17,614	16,401	16,882	16,750	19,061
	Pampanga	5,095	5,048	4,952	4,904	4,989	4,964	5,767
	Bataan	5,858	5,550	5,184	5,204	4,781	4,370	3,878
	Bulacan	23,311	10,621	4,010	10,238	7,945	6,444	8,878
	Rizal	1,149	1,146	995	1,023	1,190	1,176	1,137
	Cavite	9,889	5,354	5,291	5,100	4,961	6,203	5,586
	Laguna	573	502	476	514	516	498	506
	Regions 3 & 4A	129,555	109,201	100,838	109,315	122,681	115,044	124,792
	% of regional total	63	56	52	53	46	48	47
	Philippines	1,023,907	884,011	771,441	825,676	788,074	768,234	816,199
	% of Philippines	8	7	7	7	7	7	7
Sugarcane	**Manila Bay Area**	926,088	1,349,317	1,072,075	878,579	1,038,041	1,454,642	1,058,675
	Nueva Ecija	2,782	2,550	2,295	2,295	2,302	2,301	2,653
	Tarlac	542,581	807,951	618,777	557,837	691,601	878,031	727,647
	Pampanga	347,930	504,481	406,733	274,505	301,849	510,842	264,287
	Bataan	5,998	6,005	6,006	6,000	3,000	2,500	2,100
	Bulacan	220	132	89	30	20	15	14
	Rizal	..	..	..	..	..	..	..
	Cavite	17,145	17,384	27,933	27,875	28,731	50,942	52,964
	Laguna	9,432	10,814	10,241	10,036	10,538	10,011	9,010
	Regions 3 & 4A	3,097,506	3,779,134	2,825,831	2,506,670	3,131,393	3,312,822	2,780,955
	% of regional total	30	36	38	35	33	44	38
	Philippines	22,235,297	26,601,384	22,932,819	17,929,269	28,376,518	26,395,893	24,584,820
	% of Philippines	4	5	5	5	4	6	4

Annex 10. Livestock: Volume of Production by Animal Type, Geolocation and Year (source: DA-Bureau of Soils and Water Management)

Animal Type	Location	2010	2011	2012	2013	2014
Carabao	NCR					
	Bataan	293	308	340	385	390
	Bulacan	444	279	319	367	410
	Nueva Ecija	819	927	1126	1113	1210
	Pampanga	335	373	334	307	394
	Tarlac	1797	2124	2219	2321	2473
	Cavite	306	285	175	197	202
	Laguna	1318	1385	1307	1565	1721
	Rizal	491	460	612	692	571
Cattle	NCR					
	Bataan	169	198	216	223	505
	Bulacan	2800	2809	2016	2172	2256
	Nueva Ecija	4224	4589	5122	5197	5149
	Pampanga	650	688	552	609	606
	Tarlac	7058	6642	7172	7041	6216
	Cavite	2763	2704	2861	2885	2910
	Laguna	1899	2727	2547	2602	2594
	Rizal	512	587	621	666	695

Animal Type	Location	2010	2011	2012	2013	2014
Hog	NCR					
	Bataan	12241	11273	11725	12260	12560
	Bulacan	196911	208142	223763	231994	237353
	Nueva Ecija	26766	30471	31172	31416	32512
	Pampanga	16753	20031	23490	33877	36657
	Tarlac	14996	19162	27790	32028	39913
	Cavite	29593	31214	28701	27445	26326
	Laguna	43097	44527	44017	42912	39024
	Rizal	57307	57304	61729	66340	75440
Goat	NCR					
	Bataan	156	210	190	197	212
	Bulacan	408	465	501	539	568
	Nueva Ecija	2093	2104	2116	2065	2110
	Pampanga	171	245	262	340	414
	Tarlac	3671	4189	3821	3853	4328
	Cavite	235	227	219	226	227
	Laguna	293	239	270	289	271
	Rizal	38	42	49	45	42

Annex 11. List of Protected Areas in the Manila Bay Area (source: DENR - Biodiversity Management Bureau)

Region	Protected Area	Province (Municipality/City,Province)
National Capital Region	Ninoy Aquino Parks and Wildlife Center	Quezon City
Region III	Biak-na-Bato National Park	San Miguel, Bulacan
	Angat Watershed and Forest Range	Angat, Bulacan
	Roosevelt Protected Landscape and Seascape	Dinalupihan/Hermosa, Bataan
	Bataan National Park	Balanga, Bataan
	Arayat National Park	Arayat, Pampanga
	Minalungao National Park	General Tinio, Nueva Ecija
	Pantabangan-Caranglan Watershed	Pantabangan/Caranglan, Nueva Ecija
Region IV-A	Mts. Palay-Palay/Mataas na Gulod National Park	Ternate, Cavite
	Mts. Banahaw-San Cristobal Protected Landscape	Laguna/Quezon
	Upper Marikina River Basin Protected Landscape	Antipolo/Baras/Rodriguez/San Mateo/Tanay, Rizal
	Pamitinan Protected Landscape	Rodriguez, Rizal
	Hinulugan Taktak	Antipolo, Rizal

Annex 12. Listing of Nationally-Identified Historical, Cultural and Tourism Sites in the MBA (source: National Historical Commission of the Philippines, Department of Tourism)

Site	Location
National Historical Landmark	
Zapote Battlefield	Las Pinas, NCR
House of Nakpil-Bautista	Manila, NCR
Intramuros and its Walls	Manila, NCR
Birthplace of Antonio Luna	Manila, NCR
P. Burgos Elementary School	Pasay City, NCR
Cuartel de Santo Domingo	Laguna, Region IV-A
Corregidor	Cavite, Region IV-A
Battle of Imus	Cavite, Region IV-A
Birthplace of General Gregorio del Pilar	Bulacan, Region III
House of Vicente Manansala	Rizal, Region IV-A
Cry of Pugadlawin	Quezon City, NCR
Birthplace of Felix Manalo	Taguig, NCR
Capas Concentration Camp	Tarlac, Region III
Paciano Rizal House	Laguna, Region IV-A
Battle of Alapan	Cavite, Region IV-A
House of Baldomero Aguinaldo	Cavite, Region IV-A
Luneta Hotel	Manila, NCR
Birthplace of Father Jacinto Zamora	Manila, NCR
Bonifacio Trial House	Cavite, Region IV-A
House of Aquino Family	Tarlac, Region III
Manila Hotel	Manila, NCR
National Historical Site	
Deathplace of Dona Aurora Aragon Quezon	Nueva Ecija, Region III
Rizal Park (Bagumbayan)	Manila, NCR
Fort San Felipe	Cavite, Region IV-A
National Monument	
Juan Luna Monument	Manila, NCR
Bonifacio National Monument	Caloocan City, NCR
Fort Santiago	Manila, NCR
Liwasang Bonifacio	Manila, NCR
Mt. Samat National Shrine	Bataan, Region III
Quezon Memorial Shrine	Quezon City, NCR
Casa Real Shrine	Bulacan, Region III
Emilio Aguinaldo Shrine	Cavite, Region IV-A
Marcelo H. del Pilar National Shrine	Bulacan, Region III
Rizal Shrine Calamba	Laguna, Region IV-A
Pinaglabanan Memorial Shrine	San Juan City, NCR
Mabini Shrine PUP	Manila, NCR
Political Structures	
Malacanang Palace	Manila, NCR
The Session Hall of the Senate of the Philippines	Manila, NCR
Elks Club Building	Manila, NCR
Army and Navy Club Building	Manila, NCR
Religious Structures	
Baptistry of the Church of Calamba	Laguna, Region IV-A
Church of San Agustin	Manila, NCR
Church of San Sebastian	Manila, NCR
Church of Paete	Laguna, Region IV-A
Church of the Holy Sacrifice	Quezon City, NCR
Church of Abucay	Bataan, Region III
Church of Lubao	Pampanga, Region III
Barasoain Church	Bulacan, Region III
Nagcarlan Underground Cemetery	Laguna, Region IV-A
Mausoleo de los Veteranos de la Revolucion	Manila, NCR
Libingan ng mga Bayani	Taguig, NCR
Church of Sta. Maria	Bulacan, Region III
Church of Taytay	Rizal, Region IV-A
Church of Guagua	Pampanga, Region III
Church of Cainta	Rizal, Region IV-A
Church of Marilao	Bulacan, Region III
Church of Mabitac	Laguna, Region IV-A
Church of Lumbang	Laguna, Region IV-A
Church of General Trias	Cavite, Region IV-A
Church of Pakil	Laguna, Region IV-A
Church of Magalang	Pampanga, Region III
Church of Meycauayan	Bulacan, Region III
Church of Penaranda	Nueva Ecija, Region III
Church of Paranaque	Paranaque, NCR
Church of Mabitac	Laguna, Region IV-A
Church of Hermosa	Bataan, Region III
Ermita de Porta Baga	Cavite, Region IV-A
Nuestra Senora De La Paz Buenviaje	Rizal, Region IV-A
Church of Pillilia	Rizal, Region IV-A
Church of Tondo	Manila, NCR
Church of Quingua	Bulacan, Region III
Abbey of Our Lady of Montserrat	Manila, NCR
Church of Lilio	Laguna, Region IV-A
Church of Boso-Boso	Rizal, Region IV-A
Church of Samal	Bataan, Region III
Church of Morong	Rizal, Region IV-A
Church of Los Banos	Laguna, Region IV-A
Church of Baras	Rizal, Region IV-A
Church of Hagonoy	Bulacan, Region III
Church of Obando	Bulacan, Region III
Church of Taguig	Taguig, NCR
Church of Pandi	Bulacan, Region III
Elinwood Malate Church	Manila, NCR
Church of San Miguel	Manila, NCR
Church of Orani	Bataan, Region III
Church of Sta. Ana	Manila, NCR
Central United Methodist Church	Manila, NCR
Religious Structures	
Parish of Sta. Cruz, Tanza	Cavite, Region IV-A
Church and Monastery of Guadalupe	Makati City, NCR
Church of Bay	Laguna, Region IV-A
Church of Pasig	Pasig City, NCR
Church of Santo Cristo	Manila, NCR
Chapel of San Nicolas	Paranaque, NCR
Church of San Juan del Monte	Bulacan, Region III
Church of San Pedro, Makati	Makati City, NCR
Church of Pila	Laguna, Region IV-A
Church of Malate	Manila, NCR
Church of Tanay	Rizal, Region IV-A
Church of Nagcarlan	Laguna, Region IV-A
Church of Nuestra Senora de los Desamparados	Marikina City, NCR
Church of Quiapo	Manila, NCR
Roman Catholic Cathedral of Manila	Manila, NCR
Church of Nuestra Senora de Guia	Manila, NCR
Church of Binondo	Manila, NCR
Chapel of the Crucified Christ	Manila, NCR
Church of Sta. Cruz	Manila, NCR
Church of San Vicente de Paul	Manila, NCR
Church of Majayjay	Laguna, Region IV-A
Imus Cathedral	Cavite, Region IV-A
San Pablo Cathedral	Laguna, Region IV-A
Church of Kawit	Cavite, Region IV-A
Church of Pagsanjan	Laguna, Region IV-A
Arts and Cultural Structures	
President Diosdado P. Macapagal Museum and Library	Pampanga, Region III
Manila Bay and Waterfront from Del Pan Bridge to the Cultural Center of the Philippines	Manila, NCR
Old Legislative Building (now National Museum)	Manila, NCR
Town Center of Pila	Laguna, Region IV-A
Town Center of Malolos	Bulacan, Region III
Manila Metropolitan Theater	Manila, NCR
Cultural Center of the Philippines	Manila, NCR
Nature-Based	
Mehan Gardens	Manila, NCR
Pamitinan Cave	Rizal, Region IVA
Biak-na-Bato	Bulacan, Region III
Tagaytay Picnic Grove	Cavite, Region IVA
People's Park in the Sky	Cavite, Region IVA
Manila Ocean Park	Manila, NCR

Annex 13. Annual Average River Water Quality Monitoring (RWQM) of NCR, Region III and Region IV-A (2011) (source: DENR - Environmental Management Bureau)

	STATIONS	PARAMETER						
		DO, mg/L	BOD, mg/L	pH	TSS, mg/L	Nitrates, mg/L	Phosphates	Oil & Grease, mg/L
NCR	**Result of water quality monitoring of the Parañaque River System**							
	Tramo	2.5	25.3	7.8	23.3	7.6	9.4	3
	MIA Road	2.4	41.3	7.8	36.7	7.6	9.7	3.8
	Multi-National	6.6	20.7	7.4	30	7.4	8.5	2.5
	Global	2.3	24.7	8.1	30	8	9.9	3.7
	Sto. Niño	1.3	41.3	8.1	33.3	9.2	11.5	4.1
	La Huerta	2.3	26.7	8.19	30	8.6	9.8	3.5
	Narra Creek	2.2	54	7.7	43.3	9.7	10.8	4.1
	Dilain Creek	3.7	33.3	8.1	33.3	9.4	10	3.5
	Amvel	3.7	18	8.1	30	8.1	9.6	2.6
	Ibayo	1.9	26.7	8.2	20	8.6	10.2	2.9
		1 Station Passed	Failed	Passed	Passed	All Passed	Failed	Failed
	Result of water quality monitoring of the Navotas-Malabon-Tullahan-Tenejeros River Systems (NMTT)							
	Fairview Station	6.6	11	7	10	5	9.1	2
	Gulod	5.7	13	8.06	25	6.1	9	2.8
	N. Expressway Station	2.9	23	8	20	7.8	10.1	3.6
	McArthur	5.62	30	8	30	6.3	10.2	3
	Gov. Pascual	6.2	17	8.1	20	6.5	8.8	2.4
	Bangkulasi River	6.3	10	8.01	20	5.4	7.7	2.2
	Bangkulasi Creek	4.9	11	7.7	15	0	9.7	2.3
	Tañong	2.8	5	8	20	8.5	10.1	2.6
	Longos	5.4	5	7.9	10	7.5	9.45	2.1
		6 Stations Passed	3 Stations Passed	All Passed	All Passed	All Passed	Failed	1Station Passed
	Result of water quality monitoring of the Meycauayan-Valenzuela River System							
	Maysilo River	8.51	8	7.06	10	5.8	7	1.9
	Meycacuayan River	4.3	13.3	7.6	20	6.6	8.5	2.5
	Polo River	4.7	9	6.94	13	6.3	8.6	2.2
	Polo Creek	5.6	18	7.7	20	7.1	9.1	2.8
	Coloong Creek	4.9	12	8.25	13	6.6	10.1	2.4
	Pugad Baboy	6.35	33	6.71	33.33	10.37	14	3.6
	Lingunan	17	29	6.93	30	14	17	3
		3 Stations Passed	2 Stations Passed	Passed	All Passed	5 Passed	Failed	1 Stations Passed
	DENR Water Quality Criteria	5 mg/L	BOD 10mg/L	6.8-8.5	50 mg/L Malaysian criteria	10 mg/L (Applicable only to lakes or reservoirs)	0.4 mg/L	2 mg/L

	STATIONS	PARAMETER				
		DO, mg/L	BOD, mg/L	pH	TSS, mg/L	Phosphates
Region IV-A	**Result of water quality monitoring of the Imus River, Imus Cavite**					
	Island Cove Bridge	12.1	9	7.05	41.5	0.79
	Imus Toll Bridge	5.65	12.5	6.91	112.5	0.93
	Tanzang Luma HB	5.4	9.5	6.94	110.5	0.96
	Palanas Bridge	5.5	11.5	6.88	122	1.07
	Orchard	6.42	9.5	6.95	361	1.83
	DLSU	3.95	12	6.94	99.5	1.06
		5 Station Passed	3 Station Passed	Passed	1 Station Passed	Failed
	Result of water quality monitoring of the Cañas River, General Trias, Cavite					
	Hulugan Bridge	5.85	2	7.69	36.5	0.48
	Tejero Bridge	5.95	2	7.76	32.5	0.51
	Paradahan Bridge	6.65	3	7.73	27	0.64
		Passed	Passed	Passed	Passed	Failed
	Result of water quality monitoring of the Ylang-Ylang River, Novelete Cavite					
	Noveleta Bridge	5.9	3	7.2	93	0.85
	Bacao-Alapan Bridge	6.7	6	7.07	135.5	0.83
	Damariñas Brige	12.8	4.5	6.9	117.5	1.09
	Ylang-Ylang Bridge	2.45	80.5	6.69	48.5	1.2
	Luksuhin Bridge	7.05	2	6.85	11.5	0.35
		4 Stations Passed	4 Stations Passed	Passed	2 Stations Passed	1 Station Passed
	DENR Water Quality Criteria	5	7 (10)	6.5—8.5	50mg/L Malaysian	0.4mg/L

Continuation Annex 13.

	STATIONS	PARAMETER					
		DO, mg/L	BOD, mg/L	pH	Cd	Pb	TSS
Region III	**Result of water quality monitoring of the Guagua River, Guagua Pampanga**						
	San Pablo Bridge	5.41	12.25	7.95	0.004	0.05	22.25
	Sanpedro Foot Bridge	2.95	14	7.35	0.004	0.05	18.5
	Plaza Burgos Bridge	3.05	11.5	7.35	0.004	0.05	31.25
		1 Station Passed	Failed	Passed	Passed	Passed	Passed
	Result of water quality monitoring of the Talisay River, Bataan						
	Talisay Bridge	6.8	2	7.9	<0.004*	<0.05*	66.25
	Camacho Bridge	6.98	2.5	7.55	0.006	<0.05*	54.75
	Near Banso Residence	6.21	1.25	7.13	<0.004*	<0.05*	46
		Passed	Passed	Passed	Passed	Passed	1 Station Passed
	Result of water quality monitoring of the Angat River, Angat Bulacan						
	Labangan B	4.61	3	7.28	<0.004*	<0.05*	22.25
	Expressway B	4.75	2.5	7.4	<0.004*	<0.05*	10
	Pulilan Plaridel B	4.7	4.5	7.5	<0.004*	<0.05*	9.5
	Bustos Baliwag B	7.35	2	7.77	<0.004*	<0.05*	11.75
		1 Station Passed	Passed	Passed	Passed	Passed	Passed
	Result of water quality monitoring of the Sta.Maria River, Sta. Maria Bulacan						
	Sta. Clara Bridge	4.63	8.75	7.8	<0.004*	<0.05*	21.75
	Catmon Bridge	3.08	16.25	7.85	<0.004*	<0.05*	15.75
	Poblacion Bridge	3.75	5.25	7.44	<0.004*	<0.05*	40.5
		Failed	Passed	Passed	Passed	Passed	Passed
	Result of water quality monitoring of the Obando River, Obando Bulacan						
	Polo Bridge	5.27	16	7.95	<0.004*	<0.05*	12.55
	Tawiran Bridge	5.06	17.82	7.15	<0.004*	<0.05*	34.55
	Municipal Fishport	3.35	11.91	7.2	<0.004*	<0.05*	31.45
		2 Stations Passed	Failed	Passed	Passed	Passed	Passed
	Result of water quality monitoring of the Marillao River, Marillao Bulacan						
	Mar-Cal-Boundary B (DECA Homes Bridge Boundary of Marillao & Caloocan	2.33	19.36	8.69	<0.004*	<0.05*	38.27
	Prenza Dam	2.47	62.91	8.19	<0.004*	<0.05*	48.55
	Expressway Bridge	3.01	22.56	7.35	<0.004*	<0.05*	102.27
	Mc Arthur B	3.18	8.91	7.5	<0.004*	<0.05*	36.18
	Ibayo B	5.18	12.36	7.58	<0.004*	<0.05*	69.73
		1 Stations Passed	1 Stations Passed	Passed	Passed	Passed	3 Stations Passed
	Result of water quality monitoring of the Bocaue River, Bocaue Bulacan						
	Expressway Bridge (Bocaue)	3.65	5.73	7.53	<0.004*	<0.05*	40.82
	McArthur Bridge	3.89	6.36	8	<0.004*	<0.05*	27.73
	Bridge near Public Market	3.67	5.09	8.35	<0.004*	<0.05*	27.64
		Failed	Passed	1 Station Passed	Passed	Passed	Passed
	Result of water quality monitoring of the Meycauayan, Bulacan						
	Expressway B.	3.7	63	9.85	<0.004*	<0.05*	48
	Veinte Reales B.	2.5	59	7.35	<0.004*	<0.05*	64
	McArthur B.	3.6	43	7.1	0.005	<0.05*	41
	Meymark B.	2.8	46	10.55	<0.004*	<0.05*	34
	Polo Bride	4.5	21	7.45	0.009	<0.05*	16
		Failed	Failed	Passed	Passed	Passed	4 Stations Passed
	Result of water quality monitoring of the Pampanga River						
	Expressway B	5.78	2.8	7.4	0.004	0.05	118.4
	Sulipan B	5.63	1.8	7.65	0.004	0.05	120.4
	Calumpit B	5.67	1.6	8.15	0.004	0.05	113.2
	Near Paulino RS/F.P	5.5	2.25	7.5	0.004	0.05	123.75
	Villa Loures	5.77	1.75	77.9	0.004	0.05	119.5
		Passed	Passed	Passed	Passed	Passed	Failed
	CRITERIA	**5 mg/L**	**7(10) mg/L**	**6.5-8.5**	**0.01 mg/L**	**0.05 mg/L**	**50mg/L Malaysian**

*Below the detection limit

Annex 14. Annual Average River Water Quality Monitoring (RWQM) of NCR, Region III and Region IV-A (2012) (source: DENR - Environmental Management Bureau)

	STATIONS	PARAMETER						
		DO, mg/L	BOD, mg/L	pH	TSS, mg/L	Nitrates, mg/L	Phosphates	Oil & Grease, mg/L
NCR	**Result of water quality monitoring of the Parañaque River System**							
	Tramo	0	49.33	6.6	46.66	9.6	16	4.4
	MIA Road	0	38.67	4.91	43.33	9.83	14.133	4.567
	Multi-National	0.5	50.67	8.23	36.33	8.86	11.033	3.3
	Global	0	54	7.96	40	9.8	12.733	4.467
	Sto. Niño	0	62.67	7.88	50	11.03	14.8	4.333
	La Huerta	0	50.67	7.61	36.66	8.93	11.867	3.9
	Narra Creek	0.7	39.33	6.31	50	10.04	16.13	3.967
	Dilain Creek	0.23	42.67	6.97	43.33	9.49	13.4	3.9
	Amvel	0	54.67	8.37	46.66	10.03	13.557	3.567
	Ibayo	0.167	29.33	7.47	36.33	9.82	11.957	4.267
	Result of water quality monitoring of the Navotas-Malabon-Tullahan-Tenejeros River Systems (NMTT)							
	Fairview Station	1.467	16	5.9	7.2	9.533	2.233	20
	Gulod	0.6	17.33	7.66	7.73	10.267	2.433	20
	North Expressway Station	0	23.33	7.3	8.66	10.333	2.867	26.66
	McArthur	0	19.33	8.11	7.73	11	3.333	30
	Gov. Pascual	0	22.67	6.59	6.83	6.1	3.033	23.33
	Bangkulasi River	0.7	15.33	9.64	6.16	9.3	2.3	20
	Bangkulasi Creek	0.467	16	8.48	7.26	9.3	2.433	23.33
	Tañong	0.5	13.33	8.98	7.36	9.533	2.4	23.33
	Longos	0.63	10.67	8.41	6.56	9.133	2.067	20
	DENR Water Quality Criteria	DO 5 mg/L	BOD 10mg/L	6.8-8.5	10 mg/L (Applicable only to lakes or reservoirs)	0.4mg/L	2mg/L	50mg/L Malaysian

	STATIONS	PARAMETER					
		DO, mg/L	BOD, mg/L	pH	TSS, mg/L	Nitrates, mg/L	Phosphates
NCR	**Result of water quality monitoring of the Meycauayan-Valenzuela River System**						
	Maysilo River	0.167	23.33	6.45	30	8.33	8.86
	Polo River	0	20	8.135	20	7.85	8.25
	Polo Creek	0.45	20	7.355	15	6.65	7.45
	Coloong Creek	0	22	7.73	10	7.9	8.9
	Pugad Baboy	0	17.33	7.53	26.66	9.53	11.26
	Lingunan (Canumay Creek)	0	76	8.27	43.33	11.53	15.6
	DENR Water Quality Criteria	DO 5 mg/L	BOD 10mg/L	6.8-8.5	50 mg/L Malaysian	10 mg/L (Applicable only to lakes or reservoirs)	0.4mg/L

	STATIONS	PARAMETER					
		DO, mg/L	BOD, mg/L	pH	TSS, mg/L	Phosphates	NH3
Region IV-A	**Result of water quality monitoring of the Imus River, Imus Cavite**						
	Island Cove Bridge	5.2	5.5	7.22	3	4.576	0.003
	IMUS Toll Bridge	3.6	8	7.37	23	3.787	0.001
	Tanzang Luma HB	5.5	6	7.17	26	7.932	0.004
	Hanging Bridge (Palanas)	5.55	9	7.16	38	6.38	0
	Orchard	5.75	11	7.22	24	1.314	0.185
	DLSU	3.4	7.5	7.14	10	3.22	0
	Result of water quality monitoring of the Cañas River, General Trias, Cavite						
	Hulugan Wawa Bridge	5.5	2	7.26	22	0.323	<0.001
	Tejero Bridge	6.7	1	7.51	28	0.357	<0.001
	Paradahan Bridge	6.5	3	7.62	16	1.608	<0.001
	Result of water quality monitoring of the Ylang-Ylang River, Noveleta Cavite						
	Noveleta Bridge	5.55	3.5	7.14	26	0.62	0.004
	Bacao-Alapan Bridge	6.65	4	7.15	47	1.61	0
	Damariñas Bridge	6.45	4.5	7.075	16	4.38	0
	Ylang-Ylang Bridge	4.5	31.5	6.86	19	7.43	0
	Lucsuhin Bridge	7.45	3	7.02	5	2.03	0
	Result of water quality monitoring of the Rio Grande River System						
	Bacao 1	6.5	4	7.13	51	7.87	0.023
	Dulong Bayan	6.5	4	7.36	34	7.95	0.018
	Pasong Kawayan	6.85	2	7.44	14	0.4	0.013
	San Francisco	7.55	2.5	7.65	27	0.74	0.019
	Pasong Halang	7.7	1.5	7.43	8	1.27	0.05
	DENR Water Quality Criteria	5	7 (10)	6.5-8.5	50 mg/L Malaysian	0.4mg/L	0.07 mg/L ASEAN

Continuation Annex 14.

	STATION	PARAMETER						
		DO, mg/L	BOD, mg/L	pH	Amonia	Nitrates	TSS	Phosphates
Region III	**Result of water quality monitoring of the Guagua River, Guagua Pampanga**							
	San Pablo Bridge	8	5	8.02	0.588	0.947	104	0.721
	San Pedro Foot Bridge	7.25	4	7.94	0.537	0.324	44	7.784
	Plaza Burgos Bridge	7.71	5	7.54	0.791	0.791	68	0.763
	Result of water quality monitoring of the Talisay River, Bataan							
	Talisay Bridge	5.3	2	7.8	0.014	0.245	16	0.089
	Camacho Bridge	4.9	2	7.7	0.048	0.231	7	0.072
	Near Banzon Residence	3.8	5	7.9	0.282	0.235	27	0.172
	Result of water quality monitoring of the Angat River, Angat Bulacan							
	Labangan B	3.4	2	7.8	0.197	0.581	311	0.395
	Expressway B	4.3	3	7.6	0.184	0.777	232	0.29
	Pulilan Plaridel B	5.1	2	7.9	0.183	0.713	118	0.28
	Bustos Baliwag B	5.3	2	7.7	0.195	0.583	106	0.239
	Result of water quality monitoring of the Sta.Maria River, Sta. Maria Bulacan							
	Sta. Clara Bridge	3.1	9	7.8	4.698	0.871	145	1.155
	Catmon Bridge	3.2	10	7.9	3.997	0.027	36	1.69
	Poblacion Bridge	2.9	10	7.7	3.418	1.158	216	1.31
	Result of water quality monitoring of the Obando River, Obando Bulacan							
	Polo Bridge	3.48	5.66	7.54	2.18	0.149	8.66	0.836
	Tawiran Bridge	3	5	7.82	1.151	0.23	26.33	0.663
	Municipal Fish port	1.933	5.33	7.9	1.5	0.192	22	0.62
	Result of water quality monitoring of the Marilao River, Marilao Bulacan							
	Mar-Cal-Boundary B (DECA Homes Bridge Boundary of Marilao & Caloocan	4.167	10.67	7.466	2.738	0.641	24	0.66
	Prenza Dam	3.667	28	7.5	8.95	0.544	22	3.19
	Expressway Bridge	2.1	23.33	7.6	12.97	0.575	22	1.47
	Mc Arthur B	1.633	14	8.033	10.3	0.445	22.66	1.17
	Ibayo B	1.533	11	7.523	11.11	0.529	19.66	1.26
	Result of water quality monitoring of the Bocaue River, Bocaue Bulacan							
	Expressway Bridge (Bocaue)	1.9	9.33	8.26	2.72	0.92	30.66	1.89
	McArthur Bridge	2.93	9	8.16	2.94	0.92	22	1.83
	Bridge near Public Market	2.56	7.66	8.23	5.48	0.95	20.66	2.03
	Result of water quality monitoring of the Meycauayan, Bulacan							
	Perez Bridge	2.36	20	7.76	0.47	0.47	41.33	1.86
	Expressway B	2.5	49	7.76	0.73	0.73	43.33	0.81
	Veinte Reales B.	1.86	41.33	7.93	0.16	0.16	33	1.35
	McArthur B	2.1	25	8.03	0.66	0.66	43.33	1.19
	Meymark B.	2.33	21.67	7.9	0.69	0.69	37.66	1.23
	Result of water quality monitoring of the Pampanga River							
	Expressway B	3.5	3	7.25	0.586	0.378	157	0.267
	Sulipan B	3.9	8	7.84	0.319	0.864	179	0.256
	Calumpit B	3.3	2	7.83	0.371	0.449	82	0.272
	Near Paulino RS/F.P	3.87	2	7.74	0.365	0.432	118	0.267
	Villa Lourdes	3.61	3	7.82	0.378	0.402	137	0.262
	DENR Water Quality Criteria	**5 mg/L**	**7(10) mg/L**	**6.5-8.5**	**0.07mg/L ASEAN**	**10mg/L**	**50mg/L Malaysian**	**0.4mg/L**

Annex 15. Annual Average River Water Quality Monitoring (RWQM) of NCR, Region III and Region IV-A (2013) (source: DENR - Environmental Management Bureau)

Region	STATIONS	PARAMETER						
		DO, mg/L	BOD, mg/L	pH	TSS, mg/L	Nitrates, mg/L	Phosphates	Oil & Grease, mg/L
NCR	**Result of water quality monitoring of the Parañaque River System**							
	Tramo	0	59.33	6.29	53.33	10.03	19.16	5.63
	MIA Road	0	48.66	6.36	43.33	10.33	17.66	4.83
	Multi-National	0	51.66	6.69	43.33	10.3	18.36	4.96
	Global	0	33.66	7	36.66	11.26	14.06	4.2
	Sto. Niño	0	45.66	6.74	36.66	10.16	15.56	4.8
	La Huerta	0	38.66	7.07	36.66	9.433	15.23	3.76
	Narra Creek	0	56	5.47	53.33	10.1	14.76	5.3
	Dilain Creek	0	57.33	6.18	53.33	9.766	17.26	5.9
	Amvel	0	36.33	6.48	26.33	9.8	14.23	4.13
	Ibayo	0	45.66	6.7	35	10.46	17.66	5.56
	Result of water quality monitoring of the Navotas-Malabon-Tullahan-Tenejeros River Systems (NMTT)							
	Fairview Station	0.8	26		30	9.13	13.33	3.3
	Gulod	0.2	38		40	10.3	18.73	4.43
	North Expressway Station	0	38		36.67	10.33	16.5	4.63
	McArthur	0	43.66		40	10.5	21.8	4.8
	Gov. Pascual	0	31.33		30	10	18.17	4.1
	Bangkulasi River	0	22.33		20	9.03	14.5	2.7
	Bangkulasi Creek	0	28		26.67	9.6	15.7	3.3
	Tañong	0	30		30	9.73	14.47	3.5
	Longos	0	32.33		33.33	9.47	11.87	4.47
	Result of water quality monitoring of the Meycauayan-Valenzuela River System							
	Maysilo River	0.4	23.33	6.36	20	8.77	10.53	2.23
	Meycauayan River	0.3	32	6.73	30	9.47	14.63	4
	Polo River	0.96	15.33	6.89	20	8.03	10.03	1.7
	Polo Creek	0.2	18.67	6.69	23.33	9.3	12.17	2.7
	Coloong Creek	0.3	19	6.86	20	9.23	11.7	2.57
	Pugad Baboy	0	37.33	6.85	43.33	11	17.27	4.53
	Lingunan (Canumay Creek)	0	36.66	7.2	43.33	10.43	17.03	4.3
	DENR Water Quality Criteria	5 mg/L	10mg/L	6.8-8.5	50 mg/L Malaysian	10 mg/L (Applicable only to lakes or reservoirs)	0.4mg/L	2mg/L

Region	STATIONS	PARAMETER						
		DO, mg/L	BOD, mg/L	pH	TSS, mg/L	Phosphates	NH3	Chlorides, mg/L
Region IV-A	**Result of water quality monitoring of the Imus River, Imus Cavite**							
	Island Cove Bridge	5.3	6	7.31	28.33	0.74	0.67	2,227.33
	Imus Toll Bridge	5.8	6.67	7.29	43	0.78	0.83	24.67
	Tanzang Luma HB	5.63	5.33	7.5	55.33	0.8	0.94	17.67
	Hanging Bridge (Palanas)	5.73	9.33	7.38	55	0.9	0.78	17.67
	Orchard	6.2	9.33	7.42	24.67	1.1	2.8	19.33
	DLSU	5.87	8	7.29	224	1.24	1.61	23.33
	Aguinaldo Bridge	7.23	2.67	7.42	26	0.62	0.03	12.67
	Pansipit Bridge	6.03	4.33	7.6	15	0.37	0.3	11
	Result of water quality monitoring of the Cañas River, General Trias, Cavite							
	Hulugan Wawa Bridge	6.2	4.67	7.49	40.67	0.48	0.45	8.83
	Tejero Bridge	6.13	2.67	7.3	54.67	1.46	0.23	1,011.67
	Paradahan Bridge	5.67	4	7.07	52	0.39	0.33	1,152.67
	Mag-asawang Layon Bridge	8.23	2.67	7.95	22.33	0.43	0.06	9.33
	Patda Bridge	7.07	3	7.59	14.33	0.43	0.27	9
	Panaysayan Bridge	7.6	3.67	7.78	25.33	1.41	0.03	18.8
	Result of water quality monitoring of the Ylang-Ylang River, Noveleta Cavite							
	Noveleta Bridge	6.03	4	7.25	51.67	0.62	0.27	31
	Bacao-Alapan Bridge	7.07	4	7.42	341.33	0.99	0.47	8.33
	Damariñas Brige	6.87	4.33	7.37	46	0.67	0.6	15
	Ylang-Ylang Bridge	6.2	15	6.95	72.33	0.8	0.21	10.03
	Lucsuhin Bridge	7.23	2.67	7.01	10	0.27	0.04	6.63
	Result of water quality monitoring of the Rio Grande River System							
	BacaoII	6.13	5.33	7.56	46.67	0.65	1.08	17
	Dulong Bayan	5.7	8.33	7.39	49.33	0.71	0.57	17
	Pasong Kawayan	7.03	4	7.54	40	0.42	0.09	16.67
	San Francisco	7.9	3.33	7.67	22	0.48	0.06	14.73
	Pasong Halang	7.63	2	7.56	30.33	0.41	0.02	4.03
	DENR Water Quality Criteria	5 mg/L	7 (10) mg/L	6.5-8.5	50 mg/L Malaysian	0.4mg/L	0.07 mg/L ASEAN	350 mg/L

Continuation Annex 15.

	STATION	PARAMETER						
		DO, mg/L	BOD, mg/L	pH	Ammonia	Nitrates	TSS	Phosphates
Region III	**Result of water quality monitoring of the Talisay River, Bataan**							
	Talisay Bridge	6.1	1	7.2	0.07	0.37	79	0.18
	Camacho Bridge	6.3	2	7.5	0.14	0.32	5	0.07
	Near Banzon Residence	6.4	3	7.3	0.25	0.14	2	0.09
	Result of water quality monitoring of the Angat River, Angat Bulacan							
	Labangan Bridge	4.8	2	8.5	0.09	0.41	55	0.17
	Expressway Tibag Bridge	3.8	2	8.6	0.21	0.2	71	0.13
	Pulilan Plaridel Bridge	4.2	2	8.2	0.22	0.2	69	0.15
	Bustos-Baliwag Bridge	5.8	2	8.5	0.22	0.23	62	0.14
	Result of water quality monitoring of the Sta.Maria River, Sta. Maria Bulacan							
	Sta. Clara Bridge	4.17	8	7.5	3.93	0.41	50	1.88
	Catmon Bridge	3.18	10	7.9	3.98	0.28	71	2.65
	Poblacion Bridge	3.4	6	7.6	3.26	0.64	51	1.43
	Result of water quality monitoring of the Obando River, Obando Bulacan							
	Polo Bridge	4.4	12	7.7	5.36	0.49	13	0.72
	Tawiran Bridge	3.44	3	8.1	2.03	0.19	30	0.36
	Municipal Fish port	2.53	7	7.6	3.33	0.14	28	0.32
	Result of water quality monitoring of the Marilao River, Marilao Bulacan							
	Mar-Cal-Boundary B (DEC-CA Homes Bridge Boundary of Marilao & Caloocan	2.28	9	8.15	4.95	0.69	31	0.96
	Prenza Dam	2.57	5	8.3	4.64	1.06	65	0.65
	NLEX Bridge	1.07	9	8.25	12.69	1.08	49.33	1.06
	Mc Arthur B	1.04	10	8.3	4.66	0.93	58.66	1.06
	Ibayo B	0.96	8	8.2	5.27	0.84	59.33	1.11
	Result of water quality monitoring of the Bocaue River, Bocaue Bulacan							
	NLEX Bridge (Bocaue)	2.63	7	8.43	4.9	0.25	40	2.18
	McArthur Bridge	2.87	7	8.5	4.7	0.63	20	2.07
	Bridge near UVBAS Market	2.87	9	8.45	4.6	0.22	30	1.98
	Result of water quality monitoring of the Meycauayan, Bulacan							
	Perez Bridge	1.65	47.33	8.3	4.57	0.366	28.66	0.848
	NLEX Bridge	1.09	15.33	8.1	4.67	0.22	36	0.819
	Veinte Reales Bridge	1.15	30.33	8.3	10.39	0.082	20	0.96
	McArthur Bridge	1.14	35	8.1	9.49	0.088	26.66	1.023
	Meymart Bridge	1.02	31.66	8.2	5.45	0.315	17.66	1.041
	Result of water quality monitoring of the Pampanga River							
	Expressway Bridge	4.71	1	8.89	0.19	0.29	142	0.18
	Sulipan Bridge	3.46	2	8.54	0.22	0.23	166	0.95
	Calumpit Bridge	2.98	1	7.92	0.22	0.39	157	0.14
	Fishpond near Mercado Residence	3.56	1	8.24	0.23	0.43	154	0.13
	Villa Lourdes	3.48	1	8.27	0.18	0.37	145	0.13
	Result of water quality monitoring of Guagua River, Guagua, Pampanga							
	San Pablo near Brgy. Hall	1.15	7	8.22	-----	-----	14	-----
	Footbridge near Brgy. San Pedro	1.92	10	8.11	-----	-----	5	-----
	Plaza Burgos near GNC	2.12	14	8.13	-----		9	-----
	DENR Water Quality Criteria	**5 mg/L**	**7(10) mg/L**	**6.5-8.5**	**0.07mg/L ASEAN**	**10mg/L**	**50mg/L Malaysian**	**0.4 mg/L**

*Note: *Analysis were not conducted due to malfunction of instrument*

Annex 16. Annual Average River Water Quality Monitoring (RWQM) of NCR, Region III and Region IV-A (2014) (source: DENR - Environmental Management Bureau)

	STATIONS	PARAMETER						
		DO, mg/L	BOD, mg/L	pH	TSS, mg/L	Nitrates, mg/L	Phosphates	Oil & Grease, mg/L
NCR	Result of water quality monitoring of the Parañaque River System							
	Tramo	0	53.33	6.4	53.33	9.3	19.13	4.9
	MIA Road	0	57	6.4	50	8.73	18.43	4.5
	Multi-National	0	70	6.32	60	10.56	21.53	5.96
	Global	0	53.33	7.06	56.66	9.7	20.33	5.16
	Sto. Niño	0	69.66	7.34	60	10.3	23.1	5.33
	La Huerta	0	47.66	6.81	46.66	8.8	16.14	4.73
	Narra Creek	0	57	6.64	46.66	10.1	19.2	5.5
	Dilain Creek	0	52	6.77	43.33	9.93	19.76	5.03
	Amvel	0	34	6.94	38.3	8.73	15.3	3.43
	Ibayo	0	76.64	6.53	60	10.43	29.21	6.26
	Result of water quality monitoring of the Navotas-Malabon-Tullahan-Tenejeros River Systems (NMTT)							
	Fairview Station	0	19	7.52	20	6.56	9.06	3.09
	Gulod	0	24.66	7.67	30	7.46	9.8	2.7
	North Expressway Station	0	32.33	7.34	40	9.16	14.26	3.46
	McArthur	0	44	7.49	46.66	10	19.8	4.9
	Gov. Pascual	0	32.66	7.41	36.6	9.21	15.36	4.49
	Bangkulasi River	0	21.66	7.5	26.66	7.23	9.7	2.36
	Bangkulasi Creek	0	25.66	7.35	30	6.3	9.76	2.6
	Tañong	0	36.3	7.41	33.33	8.84	14.55	4.16
	Longos	0	23	7	25	5.83	9.83	2.4
	Result of water quality monitoring of the Meycauayan-Valenzuela River System							
	Maysilo River	0	29	5.2	33.3	8.66	11.16	4.32
	Meycauayan River	0	94.3	6.73	73.3	10.76	28.03	7.23
	Polo River	0	29	5.32	33.3	8.9	10.26	4.23
	Polo Creek	0	25.6	6.78	23.3	9.63	10.16	3.63
	Coloong Creek	0	79.3	6.96	53.3	9.23	18.9	3.76
	Pugad Baboy	0	125.5	6.55	80	10.16	21.46	7.9
	Canumay Creek	0	115.6	6.07	96.6	11.6	27.5	8.1
	DENR Water Quality Criteria	5 mg/L	10mg/L	6.8-8.5	50 mg/L Malaysian	10 mg/L (Applicable only to lakes or reservoirs)	0.4mg/L	2 mg/L

	STATIONS	PARAMETER						
		DO, mg/L	BOD, mg/L	pH	TSS, mg/L	Phosphates	NH3	Chlorides, mg/L
Region IV-A	Result of water quality monitoring of the Imus River, Imus Cavite							
	Island Cove Bridge	4.06	10.33	8.2	23.6	1.24	0.063	2742
	Imus Toll Bridge	5.13	8.33	8.2	20.7	1.37	0.062	22
	Tanzang Luma HB	5.03	9	8.2	25.7	1.41	0.072	27
	Hanging Bridge (Palanas)	6.1	11	8.2	26	1.41	0.054	24
	Orchard	5.36	19.66	8.1	9.66	1.79	0.058	32
	DLSU	5.1	7	8.1	22.66	1.13	0.051	22
	Aguinaldo Bridge	7.8	1	8.5	11	0.63	0.043	15
	Pansipit Bridge	7.43	3	8.3	11	0.53	0.031	13
	Result of water quality monitoring of the Cañas River, General Trias, Cavite							
	Hulugan Wawa Bridge	4.2	4.66	7.78	21	0.48	0.056	5498
	Tejero Bridge	5.2	4.66	7.91	30.6	0.52	0.037	2535
	Paradahan Bridge	5.9	8.33	8.09	30.6	0.81	0.036	21
	Mag-asawang Layon Bridge	7.6	4.33	8.39	17	0.52	0.017	10
	Patda Bridge	7.6	5.33	8.27	14	0.56	0.036	9
	Panaysayan Bridge	7.8	2.66	8.39	35	0.81	0.095	5
	Result of water quality monitoring of the Ylang-Ylang River, Noveleta Cavite							
	Noveleta Bridge	6.6	4	8.07	46.6	0.89	0.087	9997.33
	Bacao-Alapan Bridge	7	3.66	8.34	55.33	1.09	0.099	25.33
	Dasmariñas Brige	7	4.33	8.15	39.33	0.89	0.051	24
	Ylang-Ylang Bridge	3.5	58.33	8	38.66	1.52	0.097	19
	Lucsuhin Bridge	6.8	1.66	8.4	7.66	0.34	0.034	7.33
	Result of water quality monitoring of the Rio Grande River System							
	BacaoII	5.73	6	7.96	61.33	1.25	0.15	27.66
	Dulong Bayan	4.43	11	7.87	45.33	0.97	0.14	29.33
	Pasong Kawayan	7.04	2.33	8.21	34.22	0.61	0.08	18.33
	San Francisco	7.4	2.66	8.33	20	0.51	0.04	11
	Pasong Halang	7.73	1.33	8.39	18.66	0.37	0.03	5
	DENR Water Quality Criteria	5 mg/L	7 (10) mg/L	6.5-8.5	50 mg/L Malaysian	0.4mg/L	0.07 mg/L ASEAN	350 mg/L

Continuation Annex 16.

	STATIONS	PARAMETER						
		DO, mg/L	BOD, mg/L	pH	Ammonia	Nitrates	TSS	Phosphates
Region III	**Result of water quality monitoring of the Talisay River, Bataan**							
	Talisay Bridge	4.74	2	8.42	0.06	0.6	10	0.14
	Camacho Bridge	3.61	2	7.56	0.25	0.37	11	0.14
	Near Banzon Residence	3.23	3	7.7	0.39	0.15	9	0.15
	Result of water quality monitoring of the Angat River, Angat Bulacan							
	Labangan Bridge	3.87	5	7.5	0.01	0.89	12	0.64
	Expressway Tibag Bridge	2.23	5	7.34	0.28	0.51	12	1.12
	Pulilan Plaridel Bridge	1.56	5	7.21	0.54	0.61	11	0.96
	Bustos-Baliwag Bridge	3.84	4	7.38	0.069	0.46	11	0.55
	Result of water quality monitoring of the Sta.Maria River, Sta. Maria Bulacan							
	Sta. Clara Bridge	2.1	3	7.56	0.328	0.395	17	1.73
	Catmon Bridge	1.6	3	7.57	0.366	0.51	17	1.82
	Poblacion Bridge	1.8	3	7.68	0.372	0.386	17	1.77
	Result of water quality monitoring of the Obando River, Obando Bulacan							
	Polo Bridge	1.86	24	7.87	2.57	0.26	11	0.49
	Tawiran Bridge	0.41	22	7.47	3.03	0.33	12	0.51
	Municipal Fish port	0.18	26	7.1	2	0.34	12	0.73
	Result of water quality monitoring of the Marilao River, Marilao Bulacan							
	Mar-Cal Boundary B (decca Homes Bridge)	3.1	16	7.78	17.98	1.02	17	2.14
	Prenza Dam	2.6	17	7.85	19.9	0.84	11	2.24
	NLEX Bridge	0.9	28	7.75	22.25	0.79	17	2.84
	Mc Arthur B	0.9	28	7.78	22.92	0.73	17	2.95
	Ibayo B	1	28	7.78	18.73	0.9	21	2.74
	Result of water quality monitoring of the Bocaue River, Bocaue Bulacan							
	NLEX Bridge (Bocaue)	0.76	16	7.84	12.72	0.59	11	1.6
	McArthur Bridge	0.9	18	7.56	10.81	0.59	10	1.84
	Bridge near UVBAS Market	0.81	18	7.79	12	0.47	11	1.5
	Result of water quality monitoring of the Meycauayan, Bulacan							
	Perez Bridge	1.73	21	7.7	18.68	0.4	16	3
	NLEX Bridge	0.15	44	7.6	12.17	0.32	26	2.6
	Veinte Reales Bridge	0.17	52	7.6	13.07	0.36	25	2.72
	McArthur Bridge	0.05	53	7.5	13.46	0.42	15	2.66
	Meymart Bridge	0.06	56	7.7	15.04	0.29	18	3.5
	Result of water quality monitoring of Guagua River, Guagua, Pampanga							
	San Pablo near Brgy. Hall	1.74	12	8.62	0.56	0.45	21	1.13
	Footbridge near Brgy. San Pedro	1.32	17	8.02	2.46	0.25	26	1.08
	Plaza Burgos near GNC	1.31	25	7.63	3.06	0.26	29	1.13
	Result of water quality monitoring of Pampanga River							
	Expressway Bridge	3.13	4	8.6	0.19	0.39	38	0.13
	Sulipan Bridge	3.32	4	8.1	0.12	0.51	40	0.11
	Kalumpit Bridge	3.4	5	8.1	0.13	0.48	38	0.12
	Fish pond near paulino Mercado residence	2.41	6	7.7	0.12	0.18	14	0.12
	Resort near villa Lourdes	2.35	7	7.7	0.12	0.22	16	0.09
	DENR Water Quality Criteria	**5 mg/L**	**7(10) mg/L**	**6.5-8.5**	**0.07mg/L ASEAN**	**10mg/L**	**50mg/L Malaysian**	**0.4 mg/L**

Annex 17. Annual Average River Water Quality Monitoring (RWQM) of NCR, Region III and Region IV-A (First Quarter 2015) (source: DENR - Environmental Management Bureau)

	STATIONS	PARAMETER						
		DO, mg/L	BOD, mg/L	pH	TSS, mg/L	Nitrates, mg/L	Phosphates	Oil & Grease, mg/L
NCR	**Result of water quality monitoring of the Parañaque River System**							
	Tramo (1)	0	33.3	7.15	40	9.1	12.6	4.47
	MIA Road (8)	0	74	7.18	66.6	9.77	25.3	6.17
	Multi-National (6a)	0	53.3	7.43	56.6	9.6	19.5	5.8
	Global (5)	0	52	7.1	46.6	9.83	18.1	5.43
	Sto. Niño (6)	0	58.6	7.01	56.6	10.2	20.9	5.7
	La Huerta (7)	0	43	7.2	46.6	8.97	15.4	4.7
	Narra Creek (10b)	0	46	7.18	43.3	9.37	14.5	4.57
	Dilain Creek (10a)	0	58	7.35	50	10.3	15.5	5.53
	Amvel (4)	0	42	7.25	46.6	9.43	13.4	4.9
	Ibayo (6b)	0	66.6	7.44	63.3	10.9	25	6.87
	Result of water quality monitoring of the Navotas-Malabon-Tullahan-Tenejeros River Systems (NMTT)							
	Fairview Station	0	30.33	7.84	30	7.33	9.77	3.83
	Gulod	0	31	7.78	30	8.2	10.43	3.7
	North Expressway Station	0	39.67	7.48	40	9.33	14.1	4.27
	McArthur	0	70.67	7.7	56.67	11	23.5	7.3
	Gov. Pascual	0	44.67	7.78	50	10.53	19.5	5.73
	Bangkulasi River	0	40	7.86	30	8.2	10.4	3.2
	Bangkulasi Creek	0	33.33	7.82	26.67	7.13	10.33	3.03
	Tañong	0	45.33	7.63	33.33	8.2	12.37	4.4
	Longos	0	87.33	7.65	30	7.13	10.5	3.67
	Result of water quality monitoring of the Meycauayan-Valenzuela River System							
	Maysilo River	0	32	8.05	33.33	8.13	9.93	3.7
	Meycauayan River	0	78	8.02	63.33	10.56	21.57	6.46
	Polo River	0	22	8	26.66	7.8	9.2	3.46
	Polo Creek	0	26.66	8.2	26.66	6.7	8.86	3.3
	Coloong Creek	0	20	8.26	20	6.73	8.4	2.76
	Pugad Baboy *	0	163	7.97	110	12.6	32.1	8.2
	Canumay Creek **	0	173	7.86	105	12.55	29.7	8.6
	DENR Water Quality Criteria	5 mg/L	10mg/L	6.8-8.5	50 mg/L Malaysian	10 mg/L (Applicable only to lakes or reservoirs)	0.4mg/L	2 mg/L

* results are from March 28, 2015 sampling

** results are from January 28 and February 28, 2015

	STATIONS	PARAMETERS						
		DO, mg/L	BOD, mg/L	pH	TSS, mg/L	Phosphates	NH3	Chlorides, mg/L
Region IV-A	**Result of water quality monitoring of the Imus River, Imus Cavite**							
	Island Cove Bridge	9.97	12.33	7.99	14	1.39	0.02	8250.33
	Imus Toll Bridge	2.7	11.33	8.12	7.67	2.88	0.04	39.33
	Tanzang Luma HB	4.03	15	7.8	11	1.89	0.04	37
	Hanging Bridge (Palanas)	5.87	11	7.96	10.33	1.96	0.01	33.67
	Orchard	5.1	24	7.95	10.67	2.15	1.71	36
	DLSU	5.23	7.67	8.15	14.33	1.41	0.02	24.67
	Aguinaldo Bridge	8.1	1	8.45	2.67	0.83	0.02	23.33
	Pansipit Bridge	6.77	5.33	8	7.67	0.58	0.02	13.33
	Result of water quality monitoring of the Cañas River, General Trias, Cavite							
	Hulugan Wawa Bridge	5.4	3.67	7.7	6.33		0.51	48.33
	Tejero Bridge	3.63	3	7.76	4.67		0.54	16.67
	Paradahan Bridge	5	7	7.43	10.33		0.69	46.67
	Mag-asawang Layon Bridge	8.3	1.33	8.18	5.33		0.02	10
	Patda Bridge	7.73	4.33	8.01	7		0.17	10
	Panaysayan Bridge	7.77	3.67	7.7	8.33		0.13	11.67
	Result of water quality monitoring of the Ylang-Ylang River, Noveleta Cavite							
	Noveleta Bridge	4.37	5.67	7.96	5	0.97	0.69	4192
	Bacao-Alapan Bridge	8.73	4	8.36	18.67	0.69	0.02	30.67

Continuation Annex 17.

	STATIONS	PARAMETERS						
		DO, mg/L	BOD, mg/L	pH	TSS, mg/L	Phosphates	NH3	Chlorides, mg/L
Region IV-A	Dasmariñas Brige	6.23	7.67	8.26	8.67	1.46	0.03	36.67
	Ylang-Ylang Bridge	0	489	7.91	191.33	8.28	2.78	18.33
	Lucsuhin Bridge	6.3	3.67	8.19	35.33	0.41	0.02	6.33
	Result of water quality monitoring of the Rio Grande River System							
	BacaoII	2.83	11.67	7.76	13	1.84	1.03	58
	Dulong Bayan	0.77	19	7.45	9.67	1.95	1.1	51.67
	Pasong Kawayan	7.5	3.11	8.13	21.45	0.68	0.02	23.89
	San Francisco	8.1	1.33	8.36	7	0.63	0.02	19.33
	Pasong Halang	7.83	2.67	8.05	3.67	0.27	0.02	8.67
	DENR Water Quality Criteria	**5 mg/L**	**7 (10) mg/L**	**6.5-8.5**	**50 mg/L Malaysian**	**0.4mg/L**	**0.07 mg/L ASEAN**	**350 mg/L**

	STATIONS	PARAMETER						
		DO, mg/L	BOD, mg/L	pH	Ammonia	Nitrates	TSS	Phosphates
Region III	**Result of water quality monitoring of the Talisay River, Bataan**							
	Talisay Bridge	no data	no data	no data	no data	no data	no data	no data
	Camacho Bridge	no data	no data	no data	no data	no data	no data	no data
	Near Banzon Residence	no data	no data	no data	no data	no data	no data	no data
	Result of water quality monitoring of the Angat River, Angat Bulacan							
	Labangan Bridge	no data	no data	no data	no data	no data	no data	no data
	Expressway Tibag Bridge	no data	no data	no data	no data	no data	no data	no data
	Pulilan Plaridel Bridge	no data	no data	no data	no data	no data	no data	no data
	Bustos-Baliwag Bridge	no data	no data	no data	no data	no data	no data	no data
	Result of water quality monitoring of the Sta.Maria River, Sta. Maria Bulacan							
	Catmon Bridge	no data	no data	no data	no data	no data	no data	no data
	Poblacion Bridge	no data	no data	no data	no data	no data	no data	no data
	Sta. Clara Bridge	no data	no data	no data	no data	no data	no data	no data
	Result of water quality monitoring of the Obando River, Obando Bulacan							
	Polo Bridge	no data	no data	no data	no data	no data	no data	no data
	Municipal Fish port	no data	no data	no data	no data	no data	no data	no data
	Tawiran Bridge	no data	no data	no data	no data	no data	no data	no data
	Result of water quality monitoring of the Marilao River, Marilao Bulacan							
	Mar-Cal Boundary B (decca Homes Bridge)	2.54	25.64	7.95	29.11	0.22	12.33	2.92
	Prenza Dam	2.83	24	7.9	29.97	0.265	12.33	2.7
	NLEX Bridge	0.426	38.33	7.73	28.52	0.158	16.66	4.16
	Mc Arthur B	0.5	46	7.73	28.29	0.155	13.33	3.94
	Ibayo B	0.423	37.32	7.62	38.51	0.155	10.66	3.92
	Result of water quality monitoring of the Bocaue River, Bocaue Bulacan							
	NLEX Bridge (Bocaue)	1.96	7.94	44	22.6	0.202	22.67	4.88
	McArthur Bridge	1.85	7.87	32.67	25.62	0.234	25.67	4.9
	Bridge near UVBAS Market	2.48	7.97	49.3	23.29	0.218	20	4.94
	Result of water quality monitoring of the Meycauayan, Bulacan							
	Perez Bridge	0.45	80.5	7.89	27.56	0.12	20	7.44
	NLEX Bridge	0.235	80.67	7.58	14.36	0.328	23.67	3.33
	Veinte Reales Bridge	0.2	74.5	7.73	14.75	0.245	23	3.86
	McArthur Bridge	0.155	104	8.18	17.03	0.177	22.33	5.04
	Meymart Bridge	0.515	87.33	8.26	16.92	0.25	29	3.38
	Result of water quality monitoring of Guagua River, Guagua, Pampanga							
	San Pablo near Brgy. Hall	no data	no data	no data	no data	no data	no data	no data
	Footbridge near Brgy. San Pedro	no data	no data	no data	no data	no data	no data	no data
	Plaza Burgos near GNC	no data	no data	no data	no data	no data	no data	no data
	Result of water quality monitoring of Pampanga River							
	Expressway Bridge	no data	no data	no data	no data	no data	no data	no data
	Sulipan Bridge	no data	no data	no data	no data	no data	no data	no data
	Kalumpit Bridge	no data	no data	no data	no data	no data	no data	no data
	Fish pan near paulino Mercado residence	no data	no data	no data	no data	no data	no data	no data
	Resort near villa Lourdes	no data	no data	no data	no data	no data	no data	no data
	DENR Water Quality Criteria	**5 mg/L**	**7(10) mg/L**	**6.5-8.5**	**0.07mg/L ASEAN**	**10mg/L**	**50mg/L Malaysian**	**0.4 mg/L**

Annex 18. BOD Concentration, Pasig River (2007-2014) (source: PRRC)

BOD (mg/L)	2007	2008	2009	2010	2011	2012	2013	2014
C6 Bridge			19.33	10.54	10.21	11.5	10.25	7.67
Bambang Bridge	7.79	3.12	15.08	14.63	11.92	10.08	15.17	11.56
Vargas Bridge	19	No data	26.34	19.5	12.67	20.5	34	23.72
Marikina Bridge	12.29	6.25	14.5	10.29	11.44	7.33	14.92	14.67
Buayang bato			58.73	85.29	88.48	56	70.83	103.22
Guadalupe Ferry Station	14	No data	21.5	15.21	19.44	8	12.92	9.50
Guadalupe Nuevo			54.44	63	75.96	49.17	73.83	106.44
Guadalupe Viejo			48.04	44.5	26.71	34.67	49.67	49.44
Sevilla Bridge			44.73	35.38	54.38	37.92	53.33	64.22
Lambingan Bridge	1.99	4.44	14.19	11.92	10.42	11	11.75	9.06
Havana Bridge			79.98	72.88	107.5	54.08	91.08	111.94
Nagtahan Bridge				14.92	16.52	9.83	19.42	12.78
Jones Bridge	37.29	22.84	19.42	14	13.19	8.08	12.5	10.28
Manila Bay			16.71	17.58	17.13	5.08	7.17	11.94

Annex 19. Dissolved Oxygen Concentration, Pasig River (2007-2014) (source: PRRC)

Dissolved Oxygen (mg/L)	2007	2008	2009	2010	2011	2012	2013	2014
C6 Bridge			4.58	5.58	5.54	4.88	5.05	5.99
Bambang Bridge	2.49	5.43	4.01	4.13	3.1	4.65	4.44	4.41
Vargas Bridge	0.93	No data	3.12	2.69	2.33	2.19	1.43	1.55
Marikina Bridge	2.27	4.24	5.22	3.93	3.04	3.94	3.61	3.53
Buayang bato			3.06	2.87	2.89	1.18	0.8	3.77
Guadalupe Ferry Station	1.56	No data	3.5	4.15	4.12	4.72	3.97	4.25
Guadalupe Nuevo			2.07	2.28	1.9	1.14	1.15	0.97
Guadalupe Viejo			1.1	2.02	1.88	1.87	0.37	1.83
Sevilla Bridge			1.28	1.93	1	0.63	0.5	1.23
Lambingan Bridge	1.99	4.44	3.92	4.11	3.2	3.94	4.16	3.92
Havana Bridge			1.02	1.63	1.73	0.34	0.03	1.20
Nagtahan Bridge			ND	2.76	1.89	3.21	2.33	2.57
Jones Bridge	1.86	2.65	3.36	2.76	2.49	3.51	3.94	2.38
Manila Bay			2.57	3.71	3.57	4.12	4.3	2.77

Annex 20. Nitrate Concentration, Pasig River (2008-2014) (source: PRRC)

Nitrate (mg/L)	2008	2009	2010	2011	2012	2013	2014
C6 Bridge		7.065	1.912	3.933	4.017	1.869	0.904
Bambang Bridge	0.447	6.503	2.296	3.319	3.925	3.688	1.853
Vargas Bridge		7.655	2.296	3.590	5.567	6.125	2.608
Marikina Bridge	0.957	10.098	2.238	2.162	2.600	2.975	1.727
Buayang bato		9.083	5.461	11.399	11.167	10.275	4.058
Guadalupe Ferry Station		6.580	2.205	3.356	3.484	2.700	1.593
Guadalupe Nuevo		7.833	3.571	5.258	8.650	10.513	4.042
Guadalupe Viejo		7.388	3.678	4.804	7.500	9.496	3.774
Sevilla Bridge	1.009	11.673	3.643	6.748	8.408	8.250	3.722
Lambingan Bridge	0.463	10.740	2.046	3.406	3.608	3.021	1.347
Havana Bridge		10.808	3.037	9.285	9.367	9.967	4.116
Nagtahan Bridge			2.257	3.981	4.017	4.217	1.200
Jones Bridge	0.757	8.635	1.930	2.463	3.208	2.983	1.172
Manila Bay		9.808	1.614	1.479	1.563	1.343	1.199

Annex 21. Phosphate Concentration, Pasig River (2008-2014) (source: PRRC)

Phosphate (mg/L)	2008	2009	2010	2011	2012	2013	2014
C6 Bridge	0.2067	0.6575	0.3592	4.1725	7.5292	2.5017	1.2833
Bambang Bridge	0.206	0.7825	0.5383	5.8767	7.3617	5.0575	2.7189
Vargas Bridge	0.2767	1.2	0.9683	11.8225	13.96	7.8892	3.9278
Marikina Bridge	0.2767	1.135	0.4846	7.7475	6.195	3.5167	2.3011
Buayang bato	no data	2.29	3.1771	28.6671	25.775	13.6467	8.4667
Guadalupe Ferry Station	no data	1.055	0.6030	4.175	6.0475	3.3717	1.2211
Guadalupe Nuevo	no data	4.03	3.3754	39.5475	25.2933	14.5325	7.1411
Guadalupe Viejo	0.7733	2.82	2.7738	26.64	17.4075	12.0858	6.0389
Sevilla Bridge	0.49167	3.645	2.7721	24.4608	18.32	11.5333	5.4911
Lambingan Bridge	0.21	1.0425	0.375	5.2497	6.76583	3.36167	1.342
Havana Bridge	no data	6.055	4.8858	48.9879	27.3225	16.8791	7.3488
Nagtahan Bridge	0.2767	no data	0.5554	6.8546	7.2967	4.9933	1.2622
Jones Bridge	0.2767	1.3275	0.4675	7.8692	5.2858	3.2808	1.4022
Manila Bay	no data	1.025	0.245	4.2025	3.7233	1.1458	0.7433

Annex 22. Cadmium Concentration, Pasig River (2009-2014) (source: PRRC)

Cadmium mg/ L	2009	2010	2011	2012	2013	2014
C6 Bridge	0.005	0.002	0.057	0.020	0.086	0.017
Bambang Bridge	0.004	0.003	0.052	0.020	0.089	0.016
Vargas Bridge	0.005	0.003	0.058	0.019	0.088	0.015
Marikina Bridge	0.004	0.002	0.039	0.023	0.084	0.019
Buayang Bato	0.007	0.003	0.063	0.021	0.093	0.016
Guadalupe Ferry Station	0.003	0.005	0.055	0.020	0.092	0.016
Guadalupe Nuevo	0.005	0.002	0.057	0.021	0.094	0.016
Guadalupe Viejo	0.004	0.002	0.057	0.021	0.096	0.015
Sevilla Bridge	0.004	0.002	0.040	0.024	0.084	0.018
Lambingan Bridge	0.004	0.005	0.042	0.026	0.083	0.017
Havana Bridge	0.005	0.004	0.048	0.023	0.080	0.018
Nagtahan Bridge	-	0.006	0.042	0.022	0.083	0.020
Jones Bridge	0.005	0.009	0.047	0.024	0.083	0.018
Manila Bay	0.003	0.015	0.053	0.046	0.100	0.018

Annex 23. Chromium Concentration, Pasig River (2009-2014) (source: PRRC)

Chromium mg/ L	2009	2010	2011	2012	2013	2014
C6 Bridge	0.027	0.069	0.026	0.035	0.035	0.021
Bambang Bridge	0.066	0.088	0.031	0.037	0.031	0.027
Vargas Bridge	0.034	0.075	0.029	0.032	0.041	0.039
Marikina Bridge	0.074	0.091	0.023	0.031	0.021	0.027
Buayang Bato	0.075	0.089	0.059	0.051	0.059	0.063
Guadalupe Ferry Station	0.084	0.095	0.029	0.037	0.022	0.017
Guadalupe Nuevo	0.034	0.044	0.053	0.056	0.070	0.095
Guadalupe Viejo	0.104	0.066	0.045	0.053	0.077	0.066
Sevilla Bridge	0.108	0.083	0.050	0.061	0.045	0.050
Lambingan Bridge	0.154	0.099	0.017	0.045	0.024	0.021
Havana Bridge	0.093	0.085	0.055	0.054	0.094	0.060
Nagtahan Bridge	-	0.065	0.016	0.048	0.025	0.020
Jones Bridge	0.041	0.110	0.016	0.045	0.020	0.021
Manila Bay	0.096	0.113	0.013	0.029	0.016	0.013

Annex 24. Lead Concentration, Pasig River (2009-2014) (source: PRRC)

Lead mg/L	2009	2010	2011	2012	2013	2014
C6 Bridge	0.083	0.064	0.135	0.075	0.033	0.049
Bambang Bridge	0.077	0.066	0.116	0.066	0.044	0.049
Vargas Bridge	0.083	0.074	0.161	0.146	0.049	0.056
Marikina Bridge	0.073	0.051	0.251	0.106	0.066	0.062
Buayang Bato	0.091	0.061	0.154	0.152	0.043	0.049
Guadalupe Ferry Station	0.095	0.048	0.140	0.098	0.068	0.053
Guadalupe Nuevo	0.083	0.056	0.172	0.096	0.056	0.062
Guadalupe Viejo	0.098	0.051	0.204	0.102	0.095	0.051
Sevilla Bridge	0.053	0.068	0.248	0.091	0.064	0.037
Lambingan Bridge	0.073	0.060	0.121	0.128	0.052	0.033
Havana Bridge	0.076	0.056	0.288	0.093	0.069	0.056
Nagtahan Bridge	-	0.045	0.111	0.133	0.063	0.050
Jones Bridge	0.051	0.041	0.167	0.078	0.060	0.050
Manila Bay	0.070	0.081	0.214	0.106	0.073	0.049

Annex 25. Mercury Concentration, Pasig River (2009-2014) (source: PRRC)

Mercury mg/L	2009	2010	2011	2012	2013	2014
C6 Bridge	0.0003	0.0001	0.0005	0.0003	0.0001	0.0007
Bambang Bridge	0.0002	0.0001	0.0005	0.0004	0.0001	0.0007
Vargas Bridge	0.0003	0.0001	0.0007	0.0010	0.0003	0.0009
Marikina Bridge	0.0001	0.0001	0.0006	0.0004	0.0002	0.0008
Buayang Bato	0.0002	0.0001	0.0006	0.0009	0.0007	0.0010
Guadalupe Ferry Station	0.0002	0.0001	0.0005	0.0003	0.0001	0.0007
Guadalupe Nuevo	0.0001	0.0001	0.0007	0.0011	0.0005	0.0010
Guadalupe Viejo	0.0001	0.0001	0.0006	0.0011	0.0004	0.0010
Sevilla Bridge	0.0002	0.0001	0.0005	0.0006	0.0006	0.0009
Lambingan Bridge	0.0001	0.0001	0.0005	0.0003	0.0001	0.0010
Havana Bridge	0.0001	0.0001	0.0005	0.0015	0.0007	0.0013
Nagtahan Bridge	-	0.0001	0.0005	0.0007	0.0002	0.0008
Jones Bridge	0.0003	0.0001	0.0005	0.0003	0.0001	0.0009
Manila Bay	0.0001	0.0001	0.0005	0.0003	0.0001	0.0008

Annex 26. Total Coliform Concentration, Pasig River (2008-2014) (source: PRRC)

Nitrate (mg/L)	2008	2009	2010	2011	2012	2013	2014
C6 Bridge		1.03E05	1.71E05	1.66E05	3.60E06	2.87E06	8.16E03
Bambang Bridge	3.20E05	1.93E07	5.49E07	7.58E07	2.16E06	2.86E07	1.40E06
Vargas Bridge		1.42E06	3.86E07	1.10E07	3.74E06	5.51E07	3.66E06
Marikina Bridge	2.58E07	3.04E05	4.03E06	1.12E07	1.30E06	3.63E07	4.11E07
Buayang bato		3.51E09	2.26E09	2.40E08	2.69E08	8.05E09	1.17E08
Guadalupe Ferry Station		5.83E05	1.74E06	7.45E07	4.70E06	1.34E07	1.46E06
Guadalupe Nuevo		5.02E08	2.23E08	1.03E09	1.33E08	3.78E08	1.85E08
Guadalupe Viejo		4.29E08	1.24E08	1.05E08	1.73E08	8.00E09	6.79E07
Sevilla Bridge	4.45E07	1.37E07	2.14E07	1.25E09	5.61E07	7.05E07	3.78E07
Lambingan Bridge	4.10E06	6.03E05	6.02E05	5.39E07	1.33E06	7.16E06	4.60E05
Havana Bridge		1.08E07	3.71E07	1.81E09	1.74E08	3.04E08	4.19E07
Nagtahan Bridge			1.90E06	3.60E06	3.48E06	8.73E06	4.30E06
Jones Bridge	4.10E06	1.34E06	6.85E05	3.94E06	1.92E06	1.42E07	1.19E06
Manila Bay		5.72E05	8.88E05	2.53E06	5.76E06	1.36E06	7.46E05

Annex 27. Pampanga River Basin and Other Watersheds- Water Quality Monitoring Stations (source: DA-BSWM)

Sub_Watershed	Location	Code	Latitude	Longitude	Latitude	Longitude
Pampanga River Basin	San Luis, Pampanga	SW 01	15O 03' 02.30"	120O 47' 45.46"	15.051	120.796
Pampanga River Basin	Jaen, Nueva Ecija	SW 02	15O 20' 06.47"	120O 55' 19.85"	15.335	120.922
Pampanga River Basin	San Leonardo, Nueva Ecija	SW 03	15O 21' 35.28"	120O 57' 48.85"	15.360	120.964
Pampanga River Basin	San Isidro, Nueva Ecija	SW 04	15O 18' 22.46"	120O 53' 01.25"	15.306	120.884
Pampanga River Basin	Apalit, Pampanga	SW 05	14O 56' 42.29"	120O 45' 45.36"	14.945	120.763
Pampanga River Basin	Bustos, Bulacan	SW 06	14O 57' 23.87"	120O 57' 04.75"	14.957	120.951
Bataan Watershed	Hermosa, Bataan	SW 07	14O 51' 36.11"	120O 28' 48.11"	14.860	120.480
Bataan Watershed	Balanga, Bataan	SW 08	14O 39' 12.60"	120O 32' 03.70"	14.654	120.534
Pasig River Basin	Mabitac, Laguna	SW 09	14O 25' 34.10"	121O 25' 21.79"	14.426	121.423
Pasig River Basin	Morong, Rizal	SW 10	14O 30' 48.49"	121O 12' 38.20"	14.513	121.211
Pasig River Basin	Bay, Laguna	SW 16	14O 10' 51.20"	121O 17' 00.56"	14.181	121.283
Pasig River Basin	Victoria, Laguna	SW 17	14O 12' 05.62"	121O 20' 28.79"	14.202	121.341
Pasig River Basin	Balanac River	SW 18	14O 14' 07.51"	121O 27' 32.76"	14.235	121.459
Cavite Watershed	Maragondon, Cavite	SW 11	14O 16' 24.92"	120O 45' 30.17"	14.274	120.758
Cavite Watershed	Lontoc, Naic, Cavite	SW 12	14O 20' 49.45"	120O 47' 26.88"	14.347	120.791
Cavite Watershed	Tanza, Cavite	SW 13	14O 21' 08.86"	120O 52' 15.38"	14.352	120.871
Cavite Watershed	Gen. Trias, Cavite	SW 14	14O 24' 45.07"	120O 53' 22.78"	14.413	120.890
Cavite Watershed	Calubcob, Naic, Cavite	SW 15	15O 17' 48.12"	120O 46' 55.27"	15.297	120.782

Annex 28. Total Suspended Solids, Pampanga River Basin and Other Watersheds (2011-2014) (source: DA-BSWM)

Sub Watershed	Geolocation	Code	Jul 2011	Nov 2011	Feb-Mar 2012	May-Jun 2012	Sep-Oct 2012	Nov-Dec 2012	Feb-Mar 2013	May-Jun 2013	Sep-Oct 2013	Nov Dec 2013	Sep-Oct 2014	Nov-Dec 2014
Pampanga River Basin	San Luis, Pampanga	SW01	0.13	1.5	0.05	0.04	0.31	0.05	0.05	0.06	0.31	0.05	0.05	0.06
	Jaen, Nueva Ecija	SW02	0.04	1.05	0.05	0.04	0.03	0.03	0.05	0.07	0.03	0.03	0.05	0.07
	San Leonardo Nueva Ecija	SW03	0.05	0.87	0.03	0	0.07	0.01	0.03	0.07	0.07	0.01	0.03	0.07
	San Isidro, Nueva Ecija	SW04	0.03	0.7	0.06	0.03	0.05	0.05	0.06	0.07	0.05	0.05	0.06	0.07
	Apalit, Pampanga	SW05	0	1.47	0.03	0.03	0.01	0.06	0.03	0.03	0.01	0.06	0.03	0.03
	Angat River, Bustos, Bulacan	SW06	0.01	0.03	0.03	0.01	0.02	0.03	0.03	0.1	0.02	0.03	0.03	0.1
Bataan watershed Pasig River Basin	Hermosa, Bataan	SW07	0.045	0.03	0.01	0.02	0.04	0.03	0.01	0.09	0.04	0.03	0.01	0.09
	Balanga, Bataan	SW08	0.02	0.07	0.05	0.02	0.02	0.03	0.05	NS	0.02	0.03	0.05	0.02
	Mabitac, Laguna	SW09	0.02	0.14	0.03	0.06	0.06	0.12	0.03	0.01	0.06	0.12	0.03	0.01
	Morong, Rizal	SW10	0.12	0.02	0.03	0.02	0	0.03	0.2	0.02	0	0.03	0.2	0.02
	Bay, Laguna	SW16	0.12	0.14	0.01	0.07	0.12	0.03	0.07	0	0.12	0.03	0.07	0
Cavite watershed	Victoria, Laguna	SW17	0.17	0.12	0.07	0.06	0.05	0.03	0.03	0.01	0.05	0.03	0.03	0.01
	Balanac River, Laguna	SW18	0.1	0.14	0.03	0.03	0.02	0.02	0.03	0.01	0.02	0.02	0.03	0.01
	Maragondon, Cavite	SW11	0.005	0.12	0.2	0.05	0.07	0.02	0.03	0.01	0.07	0.02	0.03	0.01
	Lontoc, Naic, Cavite	SW12	0.03	0.15	0.03	0.12	0.05	0.11	0.01	0.18	0.05	0.11	0.01	0.18
	Bunga, Tanza, Cavite	SW13	0.02	0.14	0.01	0.03	0.1	0.02	0.03	0	0.1	0.02	0.03	0
	Navarro, Gen.Trias	SW14	0.11	0.2	NS	0.01	0.17	0.05	0.04	0.02	0.17	0.05	0.04	0.02
	Calubcob, Naic, Cavite	SW15	0.09	0.09	0.01	0	0.12	0.02	0.01	0.03	0.12	0.02	0.01	0.03

Annex 29. Nitrate-Nitrogen Concentration, Pampanga River Basin and Other Watersheds (2011-2014) (source: DA-BSWM)

Sub Watershed	Geolocation	Code	Criteria	Jul 2011	Nov 2011	Feb-Mar 2012	May-Jun 2012	Sep-Oct 2012	Nov-Dec 2012	Feb-Mar 2013	May-Jun 2013	Sep-Oct 2013	Nov Dec 2013	Sep-Oct 2014	Nov-Dec 2014
Pampanga River Basin	San Luis, Pampanga	SW01	10	0.34	0.15	0.58	1.16	5.97	0	0.58	3.24	10.54	1.54	13.4	5.66
	Jaen, Nueva Ecija	SW02	10	0.29	0.22	0.54	6.81	3.54	0	0.54	2.24	2.57	3.21	6.29	4.16
	San Leonardo Nueva Ecija	SW03	10	0.44	0.42	0.3	8.74	3.27	0	0.3	4.01	4.61	4.92	8.38	4.46
	San Isidro, Nueva Ecija	SW04	10	0.48	0.23	0.7	3.92	4.88	0	0.7	2.8	1.41	4.56	8.38	2.43
	Apalit, Pampanga	SW05	10	0.3	0.31	0.62	6.3	4.56	0	0.62	3.52	1.16	5.97	2.85	2.09
	Angat River, Bustos, Bulacan	SW06	10	5.72	0.32	0.53	10.54	3.21	0	0.53	4.68	3.03	4.31	7.34	7.51
Bataan watershed Pasig River Basin	Hermosa, Bataan	SW07	10	0.24	0.83	0.87	4.05	4.25	0	0.87	4.9	4.56	3.27	19.89	5.78
	Balanga, Bataan	SW08	10	0.28	0.78	0.78	1.41	3.67	0	0.78	NS	4.88	3.54	14.63	3.93
	Mabitac, Laguna	SW09	10	0.57	0.21	0.44	9.7	3.42	0	0.81	1.71	2.7	4.88	7.34	12.05
	Morong, Rizal	SW10	10	0.36	0.43	0.37	8.55	2.83	0	0.66	5.09	3.92	3.67	2.1	12.91
	Bay, Laguna	SW16	10	0.29	0.29	0.26	14.78	7.26	0	0.27	3.98	4.69	4.56	6.29	10.49
Cavite watershed	Victoria, Laguna	SW17	10	0.4	0.42	0.21	2.63	4.3	0	2.63	3.24	9.7	5.07	2.1	7.85
	Balanac River, Laguna	SW18	10	0.42	0.31	0.27	6.42	5.07	0	0.21	4.22	9.51	7.26	9.43	4.05
	Maragondon, Cavite	SW11	10	0.56	0.34	0.81	7.52	5.85	0	0.7	1.47	6.94	4.25	8.38	9.17
	Lontoc, Naic, Cavite	SW12	10	0.31	0.33	0.66	7.84	4.57	0	0.67	1.21	8.48	5.85	1.05	7.44
	Bunga, Tanza, Cavite	SW13	10	0.33	0.64	0.7	7.32	4.76	0	0.44	2.58	7.52	4.57	2.1	4.39
	Navarro, Gen.Trias	SW14	10	0.66	0.62	NS	4.69	4.56	0	0.37	2.24	7.84	2.44	7.34	2.32
	Calubcob, Naic, Cavite	SW15	10	0.42	0.64	0.44	9.51	2.44	0	0.26	1.29	7.32	4.76	7.34	2.29

Annex 30. Total Phosphorus Concentration, Pampanga River Basin and Other Watersheds (2011-2014) (source: DA-BSWM)

Sub Watershed	Geolocation	Code	Criteria	Jul 2011	Nov 2011	Feb-Mar 2012	May-Jun 2012	Sep-Oct 2012	Nov-Dec 2012	Feb-Mar 2013	May-Jun 2013	Sep-Oct 2013	Nov Dec 2013	Sep-Oct 2014	Nov-Dec 2014
Pampanga River Basin	San Luis, Pampanga	SW 01	6	0.13	0.14	0.04	0.24	0.06	0.15	0.04	0.04	0.06	0.15	0.04	0.04
	Jaen, Nueva Ecija	SW 02	6	0.06	0.08	0.05	0.11	0.03	0.01	0.05	0.04	0.03	0.01	0.05	0.04
	San Leonardo Nueva Ecija	SW 03	6	0.03	0.08	0.02	0.01	0.03	0.16	0.02	0.03	0.03	0.16	0.02	0.03
	San Isidro, Nueva Ecija	SW 04	6	0.05	0.09	0.05	0.12	0	0.02	0.05	0.02	0	0.02	0.05	0.02
	Apalit, Pampanga	SW 05	6	0.11	0.11	0.08	0.25	0.03	2.28	0.08	0.08	0.03	2.28	0.08	0.08
	Angat River, Bustos, Bulacan	SW 06	6	0.07	0.1	0.09	0.06	0.04	0.8	0.09	0.06	0.04	0.8	0.09	0.06
Bataan watershed Pasig River Basin	Hermosa, Bataan	SW 07	6	0.57	0.08	0.04	0.33	0.07	0.21	0.04	0.06	0.07	0.21	0.04	0.06
	Balanga, Bataan	SW 08	6	0.56	0.19	0.07	0.19	0.002	0.27	0.07	NS	0.002	0.27	0.07	0.002
	Mabitac, Laguna	SW 09	6	0.59	0.57	0.01	0.26	0.05	2.3	0.4	0.06	0.05	2.3	0.4	0.06
	Morong, Rizal	SW 10	6	0.53	0.53	1.69	2.04	0.67	0.23	0.1	0.82	0.67	0.23	0.1	0.82
	Bay, Laguna	SW 16	6	0.55	0.3	0.41	0.34	0.29	0.14	0.08	0.28	0.29	0.14	0.08	0.28
Cavite watershed	Victoria, Laguna	SW 17	6	0.58	0.25	0.08	0.42	0.1	0.19	0.14	0.04	0.1	0.19	0.14	0.04
	Balanac River, Laguna	SW 18	6	0.56	0.13	0.14	0.31	0.02	1.06	0.31	0.08	0.02	1.06	0.31	0.08
	Maragondon, Cavite	SW 11	6	0.59	0.34	0.4	0.58	0.08	0.82	0.68	0.11	0.08	0.82	0.68	0.11
	Lontoc, Naic, Cavite	SW 12	6	0.53	0.11	0.1	0.19	0.07	0.68	1.05	0.05	0.07	0.68	1.05	0.05
	Bunga, Tanza, Cavite	SW 13	6	0.53	0.31	0.68	0.94	0.09	0.06	0.01	0.22	0.09	0.06	0.01	0.22
	Navarro, Gen.Trias	SW 14	6	0.58	0.41	NS	0.1	0.22	0.08	1.69	0.32	0.22	0.08	1.69	0.32
	Calubcob, Naic, Cavite	SW 15	6	0.56	0.09	1.05	1.07	0.24	0.47	0.41	0.19	0.24	0.47	0.41	0.19

Annex 31. Arsenic Concentration, Pampanga River Basin and Other Watersheds (2012-2014) (source: DA-BSWM)

Sub Watershed	Geolocation	Code	Nov-Dec 2012	Feb-Mar 2013	May-Jun 2013	Sep-Oct 2013	Nov Dec 2013	Sep-Oct 2014	Nov-Dec 2014
Pampanga River Basin	San Luis, Pampanga	SW 01	0.00063	0.0005	<LLD (0.0001)	<0.003	<0.003	<LLD (0.0001)	0.0484
	Jaen, Nueva Ecija	SW 02	0.00017	0	<LLD (0.0001)	<0.003	<0.003	0.08	0.085
	San Leonardo Nueva Ecija	SW 03	0.00038	0.0001	0.0001	<0.003	<0.003	0.0715	0.067
	San Isidro, Nueva Ecija	SW 04	0.00037	0	<LLD (0.0001)	<0.003	<0.003	0.064	0.0791
	Apalit, Pampanga	SW 05	0.00008	0.0008	<LLD (0.0001)	<0.003	<0.003	<LLD (0.0001)	0.0798
	Angat River, Bustos, Bulacan	SW 06	0.00039	0.0004	<LLD (0.0001)	<0.003	<0.003	<LLD (0.0001)	0.069
Bataan watershed Pasig River Basin	Hermosa, Bataan	SW 07	0.00103		0.00103	<0.003	<0.003	<LLD (0.0001)	0.046
	Balanga, Bataan	SW 08	<MDL (0.00030)		<MDL (0.00030)	<0.003	<0.003	<LLD (0.0001)	0.095
	Mabitac, Laguna	SW 09	0.00061		0.00061	<0.003	<0.003	<LLD (0.0001)	0.084
	Morong, Rizal	SW 10	0.00331		0.00331	<0.003	<0.003	<LLD (0.0001)	<LLD (0.0001)
	Bay, Laguna	SW 16	0.01211		0.01211	<0.003	<0.003	<LLD (0.0001)	<LLD (0.0001)
Cavite watershed	Victoria, Laguna	SW 17	0.00078		0.00078	<0.003	<0.003	0.046	<LLD (0.0001)
	Balanac River, Laguna	SW 18	0.00057		0.00061	<0.003	<0.003	0.025	<LLD (0.0001)
	Maragondon, Cavite	SW 11	0.00188		0.00188	<0.003	<0.003	0.031	<LLD (0.0001)
	Lontoc, Naic, Cavite	SW 12	<MDL (0.00030)		<MDL (0.00030)	<0.003	<0.003	<LLD (0.0001)	<LLD (0.0001)
	Bunga, Tanza, Cavite	SW 13	0.00203		0.00203	<0.003	<0.003	0.044	0.0614
	Navarro, Gen.Trias	SW 14	0.00212		0.00212	<0.003	<0.003	0.031	0.083
	Calubcob, Naic, Cavite	SW 15	0.00029		0.00029	<0.003	<0.003	0.0525	0.028

Annex 32. Cadmium Concentration, Pampanga River Basin and Other Watersheds (2012-2014) (source: DA-BSWM)

Sub Watershed	Geolocation	Code	Nov-Dec 2012	Feb-Mar 2013	May-Jun 2013	Sep-Oct 2014	Nov-Dec 2014
Pampanga River Basin	San Luis, Pampanga	SW 01	<MDL (0.00012)	<MDL (0.00012)	<LLD(0.0001)	<LLD (0.0001)	0.00073
	Jaen, Nueva Ecija	SW 02	<MDL (0.00012)	<MDL (0.00012)	<LLD (0.0001)	0.0008	<LLD (0.0001)
	San Leonardo Nueva Ecija	SW 03	<MDL (0.00012)	<MDL (0.00012)	<MDL (0.00012)	0.0009	0.005
	San Isidro, Nueva Ecija	SW 04	<MDL (0.00012)	<MDL (0.00012)	<LLD (0.0001)	0.0005	0.001
	Apalit, Pampanga	SW 05	<MDL (0.00012)	<MDL (0.00012)	<LLD (0.0001)	<LLD (0.0001)	<LLD (0.0001)
	Angat River, Bustos, Bulacan	SW 06	0.00485	0.0049	<LLD (0.0001)	<LLD (0.0001)	0.002
Bataan watershed Pasig River Basin	Hermosa, Bataan	SW 07	<MDL (0.00012)		<MDL (0.00012)	<LLD (0.0001)	<LLD (0.0001)
	Balanga, Bataan	SW 08	<MDL (0.00012)		<MDL (0.00012)	<LLD (0.0001)	0.00034
	Mabitac, Laguna	SW 09	<MDL (0.00012)		<MDL (0.00012)	<LLD (0.0001)	0.0011
	Morong, Rizal	SW 10	<MDL (0.00012)		<MDL (0.00012)	0.0005	0.0014
	Bay, Laguna	SW 16	<MDL (0.00012)		<MDL (0.00012)	<LLD (0.0001)	0.00022
Cavite watershed	Victoria, Laguna	SW 17	<MDL (0.00012)		<MDL (0.00012)	0.001	0.0007
	Balanac River, Laguna	SW 18	<MDL (0.00012)		<MDL (0.00012)	<LLD (0.0001)	<LLD (0.0001)
	Maragondon, Cavite	SW 11	<MDL (0.00012)		<MDL (0.00012)	0.001	0.00089
	Lontoc, Naic, Cavite	SW 12	<MDL (0.00012)		<MDL (0.00012)	0.0012	0.0011
	Bunga, Tanza, Cavite	SW 13	<MDL (0.00012)		<MDL (0.00012)	0.0021	0.0037
	Navarro, Gen.Trias	SW 14	<MDL (0.00012)		<MDL (0.00012)	0.001	0.0014
	Calubcob, Naic, Cavite	SW 15	<MDL (0.00012)		<MDL (0.00012)	0.0006	0.0011

Annex 33. Chromium Concentration, Pampanga River Basin and Other Watersheds (2011-2014) (source: DA-BSWM)

Sub Watershed	Geolocation	Code	Nov 2011	Feb-Mar 2012	May-Jun 2012	Sep-Oct 2012	Nov-Dec 2012	Feb-Mar 2013	May-Jun 2013	Sep-Oct 2013	Nov Dec 2013	Sep-Oct 2014	Nov-Dec 2014
Pampanga River Basin	San Luis, Pampanga	SW 01	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	0.00046	0.001	LLD (<0.0006)	<0.05	<0.05	LLD (<0.0006)	LLD (<0.0006)
	Jaen, Nueva Ecija	SW 02	0.0059	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	<MDL (0.00030)	<MDL (0.00030)	LLD (<0.0006)	<0.05	<0.05	0.0047	0.0007
	San Leonardo Nueva Ecija	SW 03	0.0446	LLD (<0.0006)	0.015	LLD (<0.0006)	<MDL (0.00030)	<MDL (0.00030)	<MDL (0.00030)	<0.05	<0.05	0.0021	LLD (<0.0006)
	San Isidro, Nueva Ecija	SW 04	0.0475	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	0.00062	0.001	LLD (<0.0006)	<0.05	<0.05	0.0038	0.0034
	Apalit, Pampanga	SW 05	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	0.00051	0.0005	0.008	<0.05	<0.05	0.0061	0.004
	Angat River, Bustos, Bulacan	SW 06	0.0112	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	0.00059	0.0049	0.01	<0.05	<0.05	0.009	LLD (<0.0006)
Bataan watershed Pasig River Basin	Hermosa, Bataan	SW 07	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	0.00042		LLD (<0.0006)	<0.05	<0.05	0.0056	0.0022
	Balanga, Bataan	SW 08	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	0.00041		0.007	<0.05	<0.05	LLD (<0.0006)	LLD (<0.0006)
	Mabitac, Laguna	SW 09	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	0.00037		0.00037	<0.05	<0.05	LLD (<0.0006)	LLD (<0.0006)
	Morong, Rizal	SW 10	LLD (<0.0006)	0.01	LLD (<0.0006)	LLD (<0.0006)	0.00093		0.00093	<0.05	<0.05	0.003	LLD (<0.0006)
	Bay, Laguna	SW 16	LLD (<0.0006)	0.016	LLD (<0.0006)	LLD (<0.0006)	0.00074		0.00074	<0.05	<0.05	LLD (<0.0006)	LLD (<0.0006)
Cavite watershed	Victoria, Laguna	SW 17	LLD (<0.0006)	0.013	LLD (<0.0006)	LLD (<0.0006)	0.0045		0.0045	<0.05	<0.05	LLD (<0.0006)	LLD (<0.0006)
	Balanac River, Laguna	SW 18	LLD (<0.0006)	0.014	LLD (<0.0006)	LLD (<0.0006)	0.00033		0.00033	<0.05	<0.05	LLD (<0.0006)	LLD (<0.0006)
	Maragondon, Cavite	SW 11	LLD(<0.0006)	LLD (<0.0006)	LLD (<0.0006)	LLD (<0.0006)	0.00049		LLD (<0.0006)	<0.05	<0.05	LLD (<0.0006)	0.0041
	Lontoc, Naic, Cavite	SW 12	LLD (<0.0006)	0.007	LLD (<0.0006)	LLD (<0.0006)	<MDL (0.00030)		LLD (<0.0006)	<0.05	<0.05	0.0029	LLD (<0.0006)
	Bunga, Tanza, Cavite	SW 13	LLD (<0.0006)	0.019	0.009	0.024	0.00059		0.016	<0.05	<0.05	LLD (<0.0006)	LLD (<0.0006)
	Navarro, Gen. Trias	SW 14	LLD (<0.0006)	no flow	0.009	LLD (<0.0006)	0.00053		0.009	<0.05	<0.05	0.004	LLD (<0.0006)
	Calubcob, Naic, Cavite	SW 15	LLD (<0.0006)	LLD (<0.0006)	0.011	LLD (<0.0006)	0.00047		LLD (<0.0006)	<0.05	<0.05	0.0025	LLD (<0.0006)

Annex 34. Lead Concentration, Pampanga River Basin and Other Watersheds (2011-2014) (source: DA-BSWM)

Sub Watershed	Geolocation	Code	Nov 2011	Feb-Mar 2012	May-Jun 2012	Sep-Oct 2012	Nov-Dec 2012	Feb-Mar 2013	May-Jun 2013	Sep-Oct 2013	Nov Dec 2013	Sep-Oct 2014	Nov-Dec 2014
Pampanga River Basin	San Luis, Pampanga	SW 01	0.0093	0.0066	0.012	LLD (<0.002)	0.00037	0.0004	0.12	<0.01	<0.01	LLD (<0.002)	LLD (<0.002)
	Jaen, Nueva Ecija	SW 02	0.0076	0.018	LLD (<0.002)	LLD (<0.002)	0.00259	0.0026	<LLD (0.002)	<0.01	<0.01	LLD (<0.002)	LLD (<0.002)
	San Leonardo Nueva Ecija	SW 03	0.0168	0.01	0.004	LLD (<0.002)	<MDL (0.00014)	0.0024	0.0024	<0.01	<0.01	LLD (<0.002)	LLD (<0.002)
	San Isidro, Nueva Ecija	SW 04	0.0062	LLD (<0.002)	0.014	LLD (<0.002)	0.0003	0.0003	<LLD (0.002)	<0.01	<0.01	LLD (<0.002)	0.0192
	Apalit, Pampanga	SW 05	0.0154	0.005	0.018	0.005	0.00054	0.0005	<LLD (0.002)	<0.01	<0.01	LLD (<0.002)	LLD (<0.002)
	Angat River, Bustos, Bulacan	SW 06	0.0301	0.006	0.023	0.003	0.0008	0.0008	<LLD (0.002)	<0.01	<0.01	LLD (<0.002)	LLD (<0.002)
Bataan watershed Pasig River Basin	Hermosa, Bataan	SW 07	0.0107	LLD (<0.002)	LLD (<0.002)	LLD (<0.002)	0.00054		<LLD (0.002)	<0.01	<0.01	LLD (<0.002)	LLD (<0.002)
	Balanga, Bataan	SW 08	0.0109	LLD (<0.002)	0.01	LLD (<0.002)	0.00073		<LLD (0.002)	<0.01	<0.01	LLD (<0.002)	LLD (<0.002)
	Mabitac, Laguna	SW 09	0.0094	0.013	0.02	LLD (<0.002)	0.00086		<LLD (0.002)	<0.01	<0.01	LLD (<0.002)	0.035
	Morong, Rizal	SW 10	0.0024	0.019	0.017	LLD (<0.002)	0.00094		0.00094	<0.01	<0.01	LLD (<0.002)	0.0218
	Bay, Laguna	SW 16	0.0208	0.005	0.019	0.013	0.00092		0.0092	<0.01	<0.01	LLD (<0.002)	LLD (<0.002)
Cavite watershed	Victoria, Laguna	SW 17	0.0007	0.005	0.02	0.005	0.00044		0.00044	<0.01	<0.01	LLD (<0.002)	LLD (<0.002)
	Balanac River, Laguna	SW 18	0.0102	0.05	0.016	LLD (<0.002)	0.00057		0.00086	<0.01	<0.01	LLD (<0.002)	LLD (<0.002)
	Maragondon, Cavite	SW 11	0.0372	0.009	0.022	LLD (<0.002)	0.0011		<LLD (0.002)	<0.01	<0.01	LLD (<0.002)	0.0157
	Lontoc, Naic, Cavite	SW 12	0.0444	0.016	0.005	LLD (<0.002)	<MDL (0.00014)		0.013	<0.01	<0.01	LLD (<0.002)	0.026
	Bunga, Tanza, Cavite	SW 13	0.0096	0.017	LLD (<0.002)	0.009	0.00137		<LLD (0.002)	<0.01	<0.01	LLD (<0.002)	0.0452
	Navarro, Gen. Trias	SW 14	0.0123	no flow	LLD (<0.002)	LLD (<0.002)	0.00078		0.021	<0.01	<0.01	LLD (<0.002)	LLD (<0.002)
	Calubcob, Naic, Cavite	SW 15	0.0045	0.018	LLD (<0.002)	LLD (<0.002)	0.00062		<LLD (0.002)	<0.01	<0.01	LLD (<0.002)	LLD (<0.002)

Annex 35. Total Coliform Concentration, Pampanga River Basin and Other Watersheds (2011-2014) (source: DA-BSWM)

Sub Watershed	Geolocation	Code	Criteria	Nov 2011	Feb-Mar 2012	May-Jun 2012	Sep-Oct 2012	Nov-Dec 2012	Feb-Mar 2013	May-Jun 2013	Sep-Oct 2013	Nov Dec 2013	Sep-Oct 2014	Nov-Dec 2014
Pampanga River Basin	San Luis, Pampanga	SW 01	1,000	5,400	2,200	10,200	1,700	330	16,000	16,000	16,000	366	16,000	16,000
	Jaen, Nueva Ecija	SW 02	1,000	5,400	5,300	6,350	565	9,200	16,000	16,000	16,000	12,466	16,000	16,000
	San Leonardo Nueva Ecija	SW 03	1,000	3,500	940	16,000	16,000	400	16,000	16,000	16,000	16,000	16,000	16,000
	San Isidro, Nueva Ecija	SW 04	1,000	5,400	5,700	9,200	5,710	5,400	5,400	16,000	16,000	13,733	16,000	16,000
	Apalit, Pampanga	SW 05	1,000	1,300	7,300	790	5,400	3,350	8,943	16,000	16,000	4,030	16,000	16,000
	Angat River, Bustos, Bulacan	SW 06	1,000	940	1,300	790	574	416	16,000	16,000	2,766	9,566	16,000	16,000
Bataan watershed Pasig River Basin	Hermosa, Bataan	SW 07	1,000	5,400	2,426	2,546	853	1,120	16,000	16,000	11,600	7,600	16,000	16,000
	Balanga, Bataan	SW 08	1,000	1,300	9,200	790	1,300	1,300	9,200	16,000	16,000	13,733	16,000	16,000
	Mabitac, Laguna	SW 09	1,000	330	16,000	9,200	5,400	790	965	16,000	16,000	6,666	16,000	16,000
	Morong, Rizal	SW 10	1,000	9,200	12,600	16,000	5,400	2,200	275	16,000	16,000	16,000	16,000	16,000
	Bay, Laguna	SW 16	1,000	5,400	16,000	9,200	16,000	1,750	12,600	16,000	16,000	11,833	1,800	16,000
Cavite watershed	Victoria, Laguna	SW 17	1,000	2,200	9,200	9,200	2,496	5,400	16,000	16,000	16,000		16,000	16,000
	Balanac River, Laguna	SW 18	1,000	2,200	16,000	16,000	4,063	7,300	12,600	16,000	10,200	11,466	16,000	16,000
	Maragondon, Cavite	SW 11	1,000	3,500	760	4,666	790	16,000	130	16,000	16,000	6,000	13,733	16,000
	Lontoc, Naic, Cavite	SW 12	1,000	790	685	840	2,966	45	45	8,300	16,000	230	16,000	16,000
	Bunga, Tanza, Cavite	SW 13	1,000	16,000	6,333	5,400	16,000	7,300	1,300	16,000	16,000	16,000	16,000	11,466
	Navarro, Gen.Trias	SW 14	1,000	3,500		1,700	263	16,000	2,020	16,000	16,000	16,000	16,000	16,000
	Calubcob, Naic, Cavite	SW 15	1,000	5,400	9,200	1,700	7,300	565	5,400	16,000	16,000	1,530	16,000	16,000

Annex 36. Fecal Coliform Concentration, Pampanga River Basin and Other Watersheds (2011-2014) (source: DA-BSWM)

Sub Watershed	Geolocation	Code	Criteria	Nov 2011	Feb-Mar 2012	May-Jun 2012	Sep-Oct 2012	Nov-Dec 2012	Feb-Mar 2013	May-Jun 2013	Sep-Oct 2013	Nov Dec 2013	Sep-Oct 2014	Nov-Dec 2014
Pampanga River Basin	San Luis, Pampanga	SW 01	200	0	0	0	130	0	0	16,000	0	63	16,000	16,000
	Jaen, Nueva Ecija	SW 02	200	0	0	1,700	0	1,750	4,830	6,666	16,000	3,346	16,000	16,000
	San Leonardo Nueva Ecija	SW 03	200	0	0	273	0	0	0	16,000	16,000	6,933	16,000	16,000
	San Isidro, Nueva Ecija	SW 04	200	0	0	1,700	93	330	2,496	7,933	16,000	1,310	16,000	13,733
	Apalit, Pampanga	SW 05	200	0	0	0	0	130	3,133	3,131	920	740	13,733	16,000
	Angat River, Bustos, Bulacan	SW 06	200	93	0	0	0	215	16,000	16,000	0	7,066	16,000	16,000
Bataan watershed Pasig River Basin	Hermosa, Bataan	SW 07	200	220	0	0	0	560	16,000	16,000	9,333	2,596	16,000	16,000
	Balanga, Bataan	SW 08	200	130	45	0	0	460	1,495	16,000	16,000	7,666	16,000	16,000
	Mabitac, Laguna	SW 09	200	0	0	1,500	330	330	1,495	6,000	16,000	0	16,000	16,000
	Morong, Rizal	SW 10	200	0	0	3,350	220	636	460	16,000	920	0	16,000	16,000
	Bay, Laguna	SW 16	200	45	0	2,800	470	1,270	12,600	16,000	16,000	0	12,466	16,000
Cavite watershed	Victoria, Laguna	SW 17	200	0	45	1,433	790	1,045	16,000	16,000	16,000		16,000	16,000
	Balanac River, Laguna	SW 18	200	0	0	1,085	211	9,200	9,200	16,000	16,000	0	16,000	16,000
	Maragondon, Cavite	SW 11	200	220	0	446	0	3,170	147	16,000	16,000	101	125	174
	Lontoc, Naic, Cavite	SW 12	200	0	0	790	0	0	0	7,300	16,000	139	5,596	246
	Bunga, Tanza, Cavite	SW 13	200	0	0	131	45	9,200	1,300	16,000	16,000	16,000	1,430	32
	Navarro, Gen.Trias	SW 14	200	0		280	93	9,200	390	16,000	16,000	2,366	116	536
	Calubcob, Naic, Cavite	SW 15	200	130	45	770	105	220	426	16,000	16,000	633	11,833	133

Annex 37. Biochemical Oxygen Demand Concentration, Laguna de Bay (2007-2013) (source: LLDA)

Station	2007	2008	2009	2010	2011	2012	2013
Stn I - West Bay	2	2	1	6	3	2	2
Stn II - East Bay	2	1	1	5	2	1	2
Stn IV - Central Bay	2	2	2	4	2	2	2
Stn V - West Bay near Pasig River	3	1	2	5	3	2	3
Stn VIII - South Bay	2	1	2	5	2	2	2
Stn XV - San Pedro	*	*	*	*	*	2	2
Stn XVI - Sta. Rosa	*	*	*	*	*	2	2
Stn XVII - Sanctuary	*	*	*	*	*	2	2
Stn XVIII - Pagsanjan	*	*	*	*	*	2	2

Annex 38. Biochemical Oxygen Demand Concentration, Laguna de Bay Tributary Rivers (2007-2013) (source: LLDA)

Tributar Rivers	2007	2008	2009	2010	2011	2012	2013
Marikina River	17	16	13	25	12	12	21
Bagumbayan River	46	56	60	238	85	64	53
Buli Creek	71	76	72	161	136	124	115
Mangangate River	31	28	20	42	35	22	26
Mangangate River Upstream	*	*	*	*	*	11	12
Tunasan River Downstream	91	82	184	159	129	141	170
Tunasan River Upstream	*	*	*	*	*	5	16
San Pedro River	19	26	16	18	24	23	19
Biñan River	*	*	*	*	24	21	21
Sta. Rosa River	*	*	*	*	18	16	18
Sta. Rosa River Midstream	*	*	*	*	*	14	13
Sta. Rosa River Upstream	*	*	*	*	*	7	6
Cabuyao River	10	9	11	14	20	17	25
San Cristobal River	19	35	33	78	63	33	35
San Juan River	4	6	9	5	9	4	6
Los Baños River	*	*	*	*	4	3	4
Bay River	2	2	3	4	3	2	6

Tributar Rivers	2007	2008	2009	2010	2011	2012	2013
Pila River	*	*	*	*	3	3	5
Sta. Cruz River	2	2	3	3	3	2	4
Pagsanjan River	2	2	1	3	2	2	3
Pangil River	2	2	2	5	2	2	3
Pangil River Upstream	*	*	*	*	*	2	2
Siniloan River	4	3	3	7	2	3	4
Sta. Maria River	*	*	*	*	3	2	2
Sta. Maria River Upstream	*	*	*	*	*	1	2
Jala-jala River	*	*	*	*	*	3	3
Pililla River	*	*	*	*	3	3	6
Tanay River	7	4	4	4	3	3	4
Tanay River Upstream	*	*	*	*	*	2	2
Baras River	*	*	4	*	6	5	6
Morong River	5	7	8	13	20	14	14
Morong River Upstream	*	*	*	*	*	15	21
Taytay Barkadahan (floodway)	*	*	7	14	11	11	16
Cainta Sapang Baho River	17	16	13	17	15	13	26

Annex 39. Dissolved Oxygen Concentration, Laguna de Bay (2007-2013) (source: LLDA)

Station	2007	2008	2009	2010	2011	2012	2013
Stn I - West Bay	8.7	7.7	7.8	9.1	7.7	7.6	7.9
Stn II - East Bay	8.1	7.8	9	8	8.2	7.9	7.9
Stn IV - Central Bay	9.1	8.3	8.1	8.8	8.5	8	8.1
Stn V - West Bay near Pasig River	9.2	7.8	8	8.6	7.4	7.5	7.2
Stn VIII - South Bay	8.4	7.8	8.4	8	8.1	8.1	8.0
Stn XV - San Pedro	*	*	*	*	*	8.2	7.5
Stn XVI - Sta. Rosa	*	*	*	*	*	8.1	8.4
Stn XVII - Sanctuary	*	*	*	*	*	7.9	8.3
Stn XVIII - Pagsanjan	*	*	*	*	*	8	8.5

Annex 40. Dissolved Oxygen Concentration, Laguna de Bay Tributary Rivers (2007-2013) (source: LLDA)

Tributar Rivers	2007	2008	2009	2010	2011	2012	2013
Marikina River	1.7	2.2	2.9	2.1	1.9	1.9	1.1
Bagumbayan River	0.2	0.7	2.5	0.1	0.5	0.3	0.2
Buli Creek	0.3	0.7	1.7	0.1	0.1	0.2	0.3
Mangangate River	0.4	0.4	1.8	0.1	0.2	1.3	0.9
Mangangate River Upstream	*	*	*	*	*	3.6	3.9
Tunasan River Downstream	0.2	0.2	0.9	0.1	0.2	0.1	0.1
Tunasan River Upstream	*	*	*	*	*	4.1	3.2
San Pedro River	0.4	0.3	2.7	0.2	1.3	1.2	1.6
Biñan River	*	*	*	*	0.6	0.6	0.5
Sta. Rosa River	*	*	*	*	1.1	2.2	2.0
Sta. Rosa River Midstream	*	*	*	*	*	2	1.8
Sta. Rosa River Upstream	*	*	*	*	*	5.8	6.0
Cabuyao River	3.1	1.2	3.5	0.6	0.7	0.8	0.6
San Cristobal River	2.6	2.4	4.3	1.3	1.2	2	1.1
San Juan River	3.4	2.9	4.5	3.6	2.8	3	3.8
Los Baños River	*	*	*	*	4.4	3.3	3.7
Bay River	6.9	6.8	7.3	7	6.6	6.8	6.8
Pila River	*	*	*	*	5.1	4.8	4.9
Sta. Cruz River	6.8	6.2	6.7	7	6.5	6.5	6.2
Pagsanjan River	7.1	7.1	7.2	7	7.3	6.4	6.5
Pangil River	6.8	7.1	8.2	7.1	7.3	7.3	7.7
Pangil River Upstream	*	*	*	*	*	7.4	6.8
Siniloan River	3.8	4.2	3.4	5.4	4.6	2.7	4.0
Sta. Maria River	*	*	*	*	6.5	6.5	6.5
Sta. Maria River Upstream	*	*	*	*	*	8.4	8.5
Jala-jala River	*	*	*	*	*	6	5.7
Pililla River	*	*	*	*	3.9	3.7	3.3
Tanay River	6.7	5.6	5.9	5.1	5.5	6.5	5.4
Tanay River Upstream	*	*	*	*	*	7.8	8.2
Baras River	*	*	*	*	3.9	4.7	4.2
Morong River	4.7	6.1	8.8	5	7.3	4.9	5.0
Morong River Upstream	*	*	*	*	*	6.4	6.6
Taytay Barkadahan (floodway)	*	*	4.4	1.9	1.7	2.3	0.9
Cainta Sapang Baho River	0.6	0.6	2.3	1	0.8	1.8	0.8

Annex 41. Potential Hydrogen Concentration, Laguna de Bay (2007-2013) (source: LLDA)

Station	2007	2008	2009	2010	2011	2012	2013
Stn I - West Bay	8.6	8.2	8.3	8.0	7.7	8.5	8.2
Stn II - East Bay	8.3	8.2	8.3	8.2	7.8	8.6	8.3
Stn IV - Central Bay	8.4	8.3	8.2	8.4	8.0	8.6	8.5
Stn V - West Bay near Pasig River	8.4	8.3	8.3	8.2	7.8	8.4	8.1
Stn VIII - South Bay	8.4	8.2	8.3	8.1	7.9	8.3	8.4
Stn XV - San Pedro	*	*	*	*	*	8.7	8.4
Stn XVI - Sta. Rosa	*	*	*	*	*	8.6	8.6
Stn XVII - Sanctuary	*	*	*	*	*	8.7	8.6
Stn XVIII - Pagsanjan	*	*	*	*	*	8.7	8.6

Annex 42. Potential Hydrogen Concentration, Laguna de Bay Tributary Rivers (2007-2013) (source: LLDA)

Tributar Rivers	2007	2008	2009	2010	2011	2012	2013
Marikina River	7.1	7.5	7.3	7.1	7.1	7.5	7.2
Bagumbayan River	7.4	7.7	7.5	7.3	7.1	7.5	7.4
Buli Creek	7.4	7.6	7.5	7.5	7.2	7.4	7.3
Mangangate River	7.5	7.7	7.5	7.4	7.3	7.4	7.5
Mangangate River Upstream	*	*	*	*	*	7.7	7.5
Tunasan River Downstream	7.3	7.6	7.2	7.2	7.0	7.3	7.0
Tunasan River Upstream	*	*	*	*	*	7.9	7.6
San Pedro River	7.5	7.7	7.5	7.5	7.4	7.7	7.6
Biñan River	*	*	*	*	7.3	7.7	7.6
Sta. Rosa River	*	*	*	*	7.4	7.6	7.5
Sta. Rosa River Midstream	*	*	*	*	*	7.7	7.5
Sta. Rosa River Upstream	*	*	*	*	*	7.9	7.7
Cabuyao River	7.4	7.7	7.5	7.4	7.3	7.6	7.4
San Cristobal River	7.2	7.4	7.4	7.0	7.0	7.4	7.2
San Juan River	7.3	7.5	7.2	7.1	7.0	7.4	7.4
Los Baños River	*	*	*	*	7.2	7.5	7.4
Bay River	7.8	8.1	7.9	7.7	7.7	8.1	7.9
Pila River	*	*	*	*	7.2	7.5	7.4
Sta. Cruz River	7.3	7.7	7.5	7.4	7.3	7.6	7.4
Pagsanjan River	7.3	7.4	7.3	7.4	7.1	7.4	7.3
Pangil River	7.1	7.2	7.4	7.3	6.9	7.6	7.3
Pangil River Upstream	*	*	*	*	*	7.4	7.2
Siniloan River	7.5	7.4	6.8	7.0	6.8	7.1	7.0
Sta. Maria River	*	*	*	*	7.1	7.8	7.3
Sta. Maria River Upstream	*	*	*	*	*	8.5	8.0
Jala-jala River	*	*	*	*	*	7.5	7.4
Pililla River	*	*	*	*	7.0	7.5	7.2
Tanay River	7.4	7.5	7.6	7.5	7.6	8.1	7.6
Tanay River Upstream	*	*	*	*	*	8.6	8.3
Baras River	*	*	*	*	6.9	7.4	7.3
Morong River	7.4	7.9	7.9	7.5	7.7	8.1	7.7
Morong River Upstream	*	*	*	*	*	8.0	7.8

Annex 43. Inorganic Phosphate Concentration, Laguna de Bay (2007-2013) (source: LLDA)

Station	2007	2008	2009	2010	2011	2012	2013
Stn I - West Bay	0.074	0.055	0.084	0.108	0.102	0.112	0.047
Stn II - East Bay	0.058	0.043	0.084	0.085	0.035	0.128	0.042
Stn IV - Central Bay	0.088	0.039	0.089	0.088	0.045	0.11	0.052
Stn V - West Bay near Pasig River	0.100	0.065	0.091	0.19	0.061	0.139	0.081
Stn VIII - South Bay	0.065	0.060	0.095	0.105	0.075	0.111	0.062
Stn XV - San Pedro	*	*	*	*	*	0.11	0.049
Stn XVI - Sta. Rosa	*	*	*	*	*	0.101	0.045
Stn XVII - Sanctuary	*	*	*	*	*	0.098	0.038
Stn XVIII - Pagsanjan	*	*	*	*	*	0.055	0.025

Annex 44. Inorganic Phosphate Concentration, Laguna de Bay Tributary Rivers (2007-2013)

Tributar Rivers	2007	2008	2009	2010	2011	2012	2013
Marikina River	0.69	0.52	0.6	1.77	0.48	0.42	0.56
Bagumbayan River	2.27	1.82	2.25	8.32	1.48	1.37	1.22
Buli Creek	2.42	1.76	2.19	7.95	1.83	1.63	1.40
Mangangate River	2.00	1.95	1.55	6.36	1.35	0.77	1.09
Mangangate River Upstream	*	*	*	*	*	0.78	0.85
Tunasan River Downstream	2.28	1.87	4.56	17.43	2.35	2.15	2.24
Tunasan River Upstream	*	*	*	*	*	0.87	0.96
San Pedro River	2.08	2.28	2.91	8.56	1.93	1.55	1.61
Biñan River	*	*	*	*	0.96	1.19	1.19
Sta. Rosa River	*	*	*	*	1.43	0.9	0.99
Sta. Rosa River Midstream	*	*	*	*	*	0.74	0.79
Sta. Rosa River Upstream	*	*	*	*	*	0.57	0.71
Cabuyao River	1.09	1.05	1.56	3.78	1.02	1.05	1.24
San Cristobal River	0.87	0.67	0.82	1.58	0.46	0.5	0.43
San Juan River	0.91	0.90	1.21	2.19	0.75	0.58	0.67
Los Baños River	*	*	*	*	0.36	0.29	0.41
Bay River	0.46	0.47	0.6	0.87	0.32	0.31	0.37
Pila River	*	*	*	*	0.14	0.21	0.24
Sta. Cruz River	0.52	0.41	0.54	1	0.32	0.33	0.37
Pagsanjan River	0.11	0.12	0.1	0.23	0.09	0.06	0.14
Pangil River	0.16	0.16	0.1	0.26	0.07	0.08	0.10
Pangil River Upstream	*	*	*	*	*	0.06	0.07
Siniloan River	0.29	0.23	0.27	0.63	0.09	0.09	0.09
Sta. Maria River	*	*	*	*	0.07	0.07	0.09
Sta. Maria River Upstream	*	*	*	*	*	0.06	0.06
Jala-jala River	*	*	*	*	*	0.32	0.34
Pililla River	*	*	*	*	0.32	0.3	0.26
Tanay River	0.38	0.38	0.51	0.66	0.3	0.21	0.15
Tanay River Upstream	*	*	*	*	*	0.1	0.07
Baras River	*	*	*	*	0.36	0.24	0.32
Morong River	0.85	1.10	2.33	4.43	1.17	1.25	1.17
Morong River Upstream	*	*	*	*	*	1.24	1.39
Taytay Barkadahan (floodway)	*	*	0.55	2.14	0.71	0.58	1.02
Cainta Sapang Baho River	1.27	1.08	0.8	3.56	0.93	0.75	1.08

Annex 45. Nitrate Concentration, Laguna de Bay (2007-2013) (source: LLDA)

Station	2007	2008	2009	2010	2011	2012	2013
Stn I - West Bay	0.062	0.117	0.224	0.224	0.184	0.181	0.052
Stn II - East Bay	0.030	0.090	0.21	0.206	0.098	0.121	0.073
Stn IV - Central Bay	0.030	0.041	0.165	0.142	0.204	0.165	0.041
Stn V - West Bay near Pasig River	0.070	0.194	0.407	0.32	0.174	0.159	0.129
Stn VIII - South Bay	0.050	0.068	0.292	0.181	0.107	0.147	0.038
Stn XV - San Pedro	*	*	*	*	*	0.116	0.030
Stn XVI - Sta. Rosa	*	*	*	*	*	0.12	0.045
Stn XVII - Sanctuary	*	*	*	*	*	0.117	0.019
Stn XVIII - Pagsanjan	*	*	*	*	*	0.038	0.028

Annex 46. Nitrate Concentration, Laguna de Bay Tributary Rivers (2007-2013) (source: LLDA)

Tributar Rivers	2007	2008	2009	2010	2011	2012	2013
Marikina River	0.3	0.5	0.7	0.5	0.5	0.3	0.4
Bagumbayan River	0.1	0.9	0.3	0.2	0.1	0.1	0.1
Buli Creek	0.2	0.4	0.1	0.3	0.1	0.1	0.1
Mangangate River	0.1	0.1	0.1	0.2	0.1	0.1	0.0
Mangangate River Upstream	*	*	*	*	*	0.3	0.3
Tunasan River Downstream	0.1	0.0	0.1	0.4	0.2	0.2	0.2
Tunasan River Upstream	*	*	*	*	*	2.2	1.1
San Pedro River	0.2	0.2	0.4	0.2	0.4	0.7	0.4
Biñan River	*	*	*	*	0.3	0.3	0.1
Sta. Rosa River	*	*	*	*	0.2	0.3	0.3
Sta. Rosa River Midstream	*	*	*	*	*	0.6	0.3
Sta. Rosa River Upstream	*	*	*	*	*	1.5	1.5
Cabuyao River	0.3	0.2	0.4	0.3	0.1	0.1	0.1
San Cristobal River	0.5	0.2	0.8	0.1	0.2	0.2	0.1
San Juan River	2.8	3.0	5.3	6.8	3.6	5.9	4.8
Los Baños River	*	*	*	*	0.7	0.5	0.5
Bay River	0.6	0.8	1.5	0.9	0.6	0.7	0.7
Pila River	*	*	*	*	0.4	0.4	0.4
Sta. Cruz River	0.8	0.8	0.9	0.6	0.6	0.9	0.8
Pagsanjan River	0.3	0.2	0.8	0.4	0.3	0.3	0.2
Pangil River	0.2	0.2	0.2	0.4	0.1	0.1	0.1
Pangil River Upstream	*	*	*	*	*	0.1	0.1
Siniloan River	0.3		0.3	0.6	0.3	0.3	0.3
Sta. Maria River	*	*	*	*	0.3	0.3	0.3
Sta. Maria River Upstream	*	*	*	*	*	0.2	0.1
Jala-jala River	*	*	*	*	*	0.5	0.5
Pililla River	*	*	*	*	0.6	0.5	0.5
Tanay River	0.5	0.8	1	1.2	0.9	1	0.6
Tanay River Upstream	*	*	*	*	*	0.6	0.5
Baras River	*	*	*	*	0.9	0.7	0.7
Morong River	1.4	1.6	3.1	1.8	1.4	1.9	1.3
Morong River Upstream	*	*	*	*	*	1.1	0.8
Taytay Barkadahan (floodway)	*	*	0.6	0.4	0.4	0.2	0.1
Cainta Sapang Baho River	0.3	0.3	1	0.6	0.8	0.4	0.2

Annex 47. Total Coliform Concentration, Laguna de Bay (2007-2013) (source: LLDA)

Station	2007	2008	2009	2010	2011	2012	2013
Stn I - West Bay	60	1899	295	56	55	200	187
Stn II - East Bay	58	505	127	75	266	222	151
Stn IV - Central Bay	61	665	147	36	213	375	109
Stn V - West Bay near Pasig River	2151	1978	438	55	1552	1528	207
Stn VIII - South Bay	349	1793	1096	188	2100	1373	259
Stn XV - San Pedro	*	*	-	-	-	955	292
Stn XVI - Sta. Rosa	*	*	-	-	-	358	311
Stn XVII - Sanctuary	*	*	-	-	-	212	81
Stn XVIII - Pagsanjan	*	*	-	-	-	318	140

Annex 48. Total Coliform Concentration, Laguna de Bay Tributary Rivers (2007-2013) (source: LLDA)

Tributar Rivers	2007	2008	2009	2010	2011	2012	2013
Marikina River	2.4E+08	9.8E+07	2.80E+06	1.70E+06	4.90E+05	1.60E+06	2.02E+06
Bagumbayan River	3.2E+16	4.0E+15	1.40E+15	4.30E+06	7.30E+06	8.20E+06	1.32E+07
Buli Creek	2.4E+13	3.0E+14	9.60E+14	8.30E+06	2.80E+07	1.00E+07	1.83E+07
Mangangate River	4.5E+10	1.7E+10	3.00E+11	2.70E+06	6.00E+06	4.10E+06	9.58E+06
Mangangate River Upstream	*	*	*	*	*	3.30E+06	2.25E+06
Tunasan River Downstream	1.7E+11	1.8E+10	2.30E+11	1.10E+07	1.30E+07	2.30E+07	2.82E+07
Tunasan River Upstream	*	*	*	*	*	3.20E+05	4.10E+05
San Pedro River	7.8E+10	4.0E+10	2.70E+09	1.50E+06	1.70E+06	3.10E+06	6.65E+06
Biñan River	*	*	*	*	8.80E+05	3.10E+06	3.10E+06
Sta. Rosa River	*	*	*	*	9.20E+06	7.30E+06	5.78E+06
Sta. Rosa River Midstream	*	*	*	*	*	5.40E+06	5.75E+06
Sta. Rosa River Upstream	*	*	*	*	*	7.80E+05	7.30E+05
Cabuyao River	8.8E+06	1.1E+08	7.50E+07	1.70E+06	1.90E+06	2.40E+06	6.30E+06
San Cristobal River	9.0E+07	3.9E+07	1.20E+09	7.00E+06	3.20E+06	8.50E+06	1.13E+07
San Juan River	7.0E+05	4.8E+05	6.40E+05	9.40E+04	1.90E+05	4.70E+05	7.28E+05
Los Baños River	*	*	*	*	9.60E+04	7.10E+04	1.32E+05
Bay River	8.3E+05	4.4E+05	7.30E+05	1.10E+05	4.70E+05	4.10E+05	6.93E+05
Pila River	*	*	*	*	1.80E+05	1.40E+05	5.63E+05
Sta. Cruz River	9.7E+04	1.1E+05	5.70E+04	1.70E+04	1.10E+05	1.30E+05	1.32E+05
Pagsanjan River	5.5E+04	7.4E+05	3.70E+04	1.40E+04	5.40E+04	3.40E+04	1.07E+05
Pangil River	1.5E+05	1.3E+05	8.80E+04	3.00E+05	1.20E+05	1.70E+05	4.35E+05
Pangil River Upstream	*	*	*	*	-	8.10E+03	8.28E+03
Siniloan River	1.0E+05	6.6E+04	8.80E+04	4.40E+04	6.90E+04	5.70E+04	8.45E+04
Sta. Maria River	*	*	*	*	9.90E+04	1.00E+05	9.95E+04
Sta. Maria River Upstream	*	*	*	*	-	8.70E+03	8.68E+03
Jala-jala River	*	*	*	*	1.90E+05	6.70E+05	6.00E+04
Pililla River	*	*	*	*	2.10E+05	9.40E+04	5.00E+05
Tanay River	7.0E+05	4.9E+05	2.30E+05	5.20E+05	3.40E+05	2.20E+05	6.55E+05
Tanay River Upstream	*	*	*	*	-	4.50E+04	1.84E+04
Baras River	*	*	*	*	3.00E+05	3.90E+05	7.37E+05
Morong River	1.5E+05	5.7E+04	2.90E+05	1.90E+05	4.30E+04	1.70E+05	1.47E+05
Morong River Upstream	*	*	*	*	-	1.40E+05	2.63E+04
Taytay Barkadahan (floodway)	*	*	7.40E+05	4.50E+05	1.70E+05	4.50E+05	2.53E+05
Cainta Sapang Baho River	2.0E+10	2.5E+09	4.70E+06	1.70E+06	1.40E+06	2.60E+06	3.50E+06

Annex 49. Fecal Coliform Concentration, Laguna de Bay (2007-2013) (source: LLDA)

Station	2007	2008	2009	2010	2011	2012	2013
Stn I - West Bay	17		165	51	20	11	22
Stn II - East Bay	17		66	70	26	8	29
Stn IV - Central Bay	16		97	40	179	15	11
Stn V - West Bay near Pasig River	791		241	51	233	147	39
Stn VIII - South Bay	117.0		694	157	534	200	24
Stn XV - San Pedro	*	*	*	*	*	217	20
Stn XVI - Sta. Rosa	*	*	*	*	*	36	44
Stn XVII - Sanctuary	*	*	*	*	*	54	8
Stn XVIII - Pagsanjan	*	*	*	*	*	151	22

Annex 50. Fecal Coliform Concentration, Laguna de Bay Tributary Rivers (2007-2013) (source: LLDA)

Tributar Rivers	2007	2008	2009	2010	2011	2012	2013
Marikina River			1.50E+06	1.10E+06	2.00E+05	6.40E+05	8.84E+05
Bagumbayan River			1.10E+15	2.90E+06	4.70E+06	5.20E+06	5.59E+06
Buli Creek			6.80E+14	8.70E+06	1.40E+07	5.90E+06	6.17E+06
Mangangate River			1.30E+11	2.60E+06	1.60E+06	1.90E+06	2.48E+06
Mangangate River Upstream			*	*	*	1.90E+06	1.31E+06
Tunasan River Downstream			1.80E+11	1.10E+07	7.50E+06	1.20E+07	1.57E+07
Tunasan River Upstream			*	*	*	1.30E+05	2.17E+05
San Pedro River			1.80E+09	1.50E+06	7.90E+05	1.30E+06	1.37E+06
Biñan River			*	*	7.80E+05	7.00E+05	8.20E+05
Sta. Rosa River			*	*	2.40E+06	1.60E+06	1.93E+06
Sta. Rosa River Midstream			*	*	*	2.80E+06	9.83E+05
Sta. Rosa River Upstream			*	*	*	6.20E+05	4.93E+05
Cabuyao River			4.70E+07	1.50E+06	9.90E+05	1.40E+06	1.32E+07
San Cristobal River			1.10E+09	7.00E+06	2.00E+06	2.70E+06	3.97E+06
San Juan River			5.60E+05	8.60E+04	1.60E+05	1.90E+05	6.42E+05
Los Baños River			*	*	3.50E+04	3.50E+04	4.98E+04
Bay River			5.00E+05	8.00E+04	4.00E+05	1.50E+05	1.81E+05
Pila River			*	*	7.20E+04	4.10E+04	5.22E+05
Sta. Cruz River			4.80E+04	1.40E+04	3.20E+04	3.10E+04	4.58E+04
Pagsanjan River			3.10E+04	4.10E+04	3.30E+04	1.50E+04	1.81E+04
Pangil River			5.90E+04	2.40E+05	5.70E+04	8.90E+04	1.22E+05
Pangil River Upstream			*	*	*	3.90E+03	1.04E+03
Siniloan River			6.10E+04	4.00E+04	2.60E+04	2.10E+04	2.70E+04
Sta. Maria River			*	*	7.80E+04	6.70E+04	3.20E+04
Sta. Maria River Upstream			*	*	*	2.50E+03	1.41E+03
Jala-jala River			*	*	*	3.00E+05	1.23E+04
Pililla River			*	*	5.20E+04	4.50E+04	3.43E+04
Tanay River			1.40E+05	4.40E+05	1.70E+05	6.70E+04	1.75E+05
Tanay River Upstream			*	*	*	1.40E+04	5.80E+03
Baras River			*	*	1.70E+05	1.20E+05	7.85E+04
Morong River			2.20E+05	1.70E+05	2.70E+04	4.10E+04	1.41E+05
Morong River Upstream			*	*	*	4.80E+04	6.98E+03
Taytay Barkadahan (floodway)			6.40E+05	3.40E+05	8.70E+04	1.40E+05	1.11E+05
Cainta Sapang Baho River			2.80E+06	1.60E+06	8.20E+04	1.10E+05	1.67E+06

Annex 51. Results of Heavy Metal Analyses in Soil samples, Pampanga River Basin and Other Watersheds (2011- 2013) (source: DA-BSWM)

Sub-Watershed/ Soil Sample	Location	Heavy Metals (ppm)													
		Pb			Cd		Cr			Ni			As	Cu	Zn
		Jul 2011	Oct 2012	3Q 2013	Jul 2011	3Q 2013	Jul 2011	Oct 2012	3Q 2013	Jul 2011	Oct 2012	3Q 2013	3Q 2013	3Q 2013	3Q 2013
Pampanga River Basin															
S1A	Gapan, San Isidro, Nueva Ecija	64.318	<LLD*(0.006)	7.99	1.979	<MDL	45.728	32.8	70.27	0.3746	<LLD*(0.015)	28.21	2.67	79.38	47.98
S1B	Magao, Concepcion, Tarlac	12.639	<LLD*(0.006)	10.39	<LLD*(0.006)	<MDL	4.172	30.5	49.18	0.8304	<LLD*(0.015)	23.53	1.10	29.42	175.63
S1C	Turu, Lapas, Arayat, Pampanga	5.639	<LLD*(0.006)	16.91	<LLD*(0.006)	<MDL	4.073	13.5	40.31	<LLD*(0.015)	<LLD*(0.015)	18.14	1.82	57.67	76.32
S1D	Cabiao, Nueva Ecija	57.814	3.2	6.23	1.094	<MDL	<LLD*(0.006)	31.9	40.44	1.2577	1.2	18.19	2.66	72.30	50.12
S2A	Port Magsaysay, Nueva Ecija	57.984	11.2	8.67	<LLD*(0.006)	<MDL	2.014	<LLD*(0.0006)	68.99	196.02	<LLD*(0.015)	30.16	2.06	76.87	84.43
S3A	Peñaranda/ Gen. Tinio, Nueva Ecija	16.87	7.2	8.84	<LLD*(0.006)	<MDL	22.266	41.1	66.80	231.469	<LLD*(0.015)	29.48	2.55	71.89	35.43
S4A	San Leonardo, Nueva Ecija	30.925	<LLD*(0.006)	6.88	0.703	<MDL	37.244	35.4	68.36	19.326	<LLD*(0.015)	30.48	2.82	75.67	37.73
S4B	San Leonardo, Nueva Ecija	47.443	39.0	6.97	<LLD*(0.006)	<MDL	32.519	4.3	84.04	224.346	<LLD*(0.015)	34.90	2.24	80.67	40.46
S5	Candaba, Pampanga	11.964	<LLD*(0.006)	6.60	1.487	<MDL	<LLD*(0.006)	1.3	75.98	1.01	<LLD*(0.015)	35.38	2.78	77.52	38.65
S6A	Bustos Dam, Bulacan	42.963	5.0	12.87	<LLD*(0.006)	<MDL	31.84	26.0	106.59	189.257	<LLD*(0.015)	33.63	2.27	58.97	34.76
Bataan watershed															
S7A	Hermosa, Bataan	97.615	<LLD*(0.006)	12.93	1.322	<MDL	47.607	0.652	29.91	87.811	<LLD*(0.015)	17.01	7.08	60.79	29.08
S8A	Balanga, Bataan	48.93	<LLD*(0.006)	13.93	<LLD*(0.006)	<MDL	21.841	17.3	51.24	<LLD*(0.015)	<LLD*(0.015)	19.43	2.65	42.2	110.30
S8B	Balanga, Bataan	67.721	<LLD*(0.006)	14.13	1.985	<MDL	33.756	29.4	43.76	<LLD*(0.015)	<LLD*(0.015)	15.62	5.73	35.67	43.93
Pasig river basin															
S9A	Mabitac, Laguna	41.9	22.1	15.40	-	<MDL	54.9	5.4	33.39	19.2	<LLD*(0.015)	17.15	1.78	100.10	49.38
S10A	Morong, Rizal	40.304	31.3	21.74	<LLD*(0.006)	<MDL	49.33	23.8	21.92	120.198	<LLD*(0.015)	9.71	5.27	88.40	31.19
S16A	Bay, Laguna	38.7	9.6	14.93		<MDL	35.1	4.1	67.65	61.2	<LLD*(0.015)	11.44	12.12	84.66	36.62
S17A	Victoria, Laguna	40	<LLD*(0.006)	18.67		<MDL	31.5	16.4	51.56	20	<LLD*(0.015)	18.31	3.09	90.50	55.70
S18A	Majayjay, Laguna	41.6	<LLD*(0.006)	29.91	<LLD*(0.006)	<MDL	36.747	9.6	42.66	70.735	<LLD*(0.015)	21.31	4.18	117.88	41.70
S18B	Majayjay, Laguna	39.446	<LLD*(0.006)	14.99	<LLD*(0.006)	<MDL	22.792	<LLD*(0.0006)	38.5	28.165	20.8	16.09	1.45	54.77	135.61
Cavite watershed															
S11A	Bucal II/III, Maragondon, Cavite	24.615	<LLD*(0.006)	36.48	<LLD*(0.006)	<MDL	17.777	7.7	5.28	<LLD*(0.015)	<LLD*(0.015)	5.58	8.99	164.29	60.06
S11B	Bucal II/III, Maragondon, Cavite	26.629	<LLD*(0.006)	21.98	<LLD*(0.006)	<MDL	21.166	<LLD*(0.0006)	5.85	39.602	39.7	4.80	4.95	112.55	24.05
S12A	Lontoc, Naic, Cavite	<LLD (0.006)	<LLD*(0.006)	22.77		<MDL	20.7	9.4	12.09	112	2.4	6.10	4.38	102.45	27.95
S13A	Bunga, Tanza, Cavite	50.7	<LLD*(0.006)	17.04		<MDL	38.6	6.2	9.75	148	51.3	4.94	2.93	94.26	34.57
S14A	Navarro, Gen. Trias, Cavite	66.2	<LLD*(0.006)	18.00		<MDL	30	<LLD*(0.0006)	15.12	<LLD (0.015)	25.9	8.27	4.19	111.56	55.89
S15A	Calubcob, Naic, Cavite	9.7	<LLD*(0.006)	19.82		<MDL	18.7	<LLD*(0.0006)	9.04	44.2	21.0	7.15	5.18	147.01	36.09

Baseline - June 2011

LLD - Lower limit of detection (PCA 2011-2012)

MDL - Minimum detection level (UP-NIGS - 2013)

Annex 52. Actual Volume of Solid Waste Disposal in Metro Manila in cubic meters (2009-2013) (source: MMDA)

LGU/MMDA	2009	2010	2011	2012	2013
Caloocan	766,458.31	929,768.62	858,189.65	814,873.62	995,838.31
Makati	698,753.01	817,132.45	790,806.53	830,133.47	961,501.45
Mandaluyong	277,375.47	290,387.31	277,036.58	280,026.34	298,517.75
Pasay	348,973.83	408,752.90	199,234.26	200,761.22	219,407.67
Pasig	328,914.60	424,537.69	302,051.29	297,004.30	310,818.16
Pateros	14,801.02	15,107.47	18,064.98	18,396.43	21,434.93
San Juan	204,998.72	223,718.26	235,714.94	240,386.34	191,624.00
Taguig	273,789.61	260,856.74	307,938.52	295,821.87	336,291.79
Marikina	256,712.03	231,249.34	399,137.89	399,911.49	381,630.20
Manila	2,730,967.14	2,876,406.00	2,764,111.48	2,659,015.76	2,600,851.01
Malabon	186,277.15	190,852.90	177,619.96	169,108.95	167,783.91
Navotas	154,088.56	130,424.91	118,010.81	140,409.01	142,410.70
Quezon City	2,091,541.00	2,139,276.00	2,145,527.00	2,129,064.00	2,206,302.00
Muntinlupa	335,736.54	140,657.82	180,432.02	239,219.91	251,070.66
Las Piñas	201,737.00	204,614.00	86,925.00	190,080.30	139,209.46
Valenzuela	158,801.00	163,368.00	166,881.34	169,005.53	173,008.29
Parañaque	278,840.29	245,229.36	332,199.49	133,719.02	374,514.68
MMDA	-	-	1,455.75	2,385.83	1,933.80
TOTAL	**9,308,765.28**	**9,692,339.77**	**9,361,337.49**	**9,209,323.39**	**9,774,148.77**
Average Volume Per Day	**-**	**26,554**	**25,647**	**25,162**	**26,778**
Estimated Waste Generation/ Day in Cubic Meter		**34,698.55**	**38,801.91**	**40,268.65**	**41,861.07**

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