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MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT

The Project for Strengthening Capacity of Water Environmental Management in Vietnam

Water Quality Monitoring plan of Saigon river, Ho Chi Minh city

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CHAPTER 1. INTRODUCTION

1.1 Introduction

Systematic water quality monitoring in Vietnam is a relatively new activity and the national strategy for monitoring was set out by the Ministry of Natural Resources and Environment (MONRE) through the publishing of Decision No. 16/2007/QD-TTg of January 29, 2007, Approving the General Planning on the National Network of Natural Resources and Environment Observation.

The Master Plan for the years up to 2020, approved by the Prime Minister together with his January 29 Decision, aims to build a comprehensive, advanced and modern national network of natural resource and environment observation stations, meeting the demand for basic information and data on the environment, water resources and hydrometeorology.

The network is also expected to assist effectively the treatment of environmental pollution, the forecast, warning, prevention and mitigation of damage caused by natural disasters, for the strong and sustainable national socio-economic development.

The specific objectives set for the years 2007-10 were to:

- Reorganize the management and administration apparatus and train more observers;
- Amend and make comprehensive observation regulations, processes and criteria;
- Consolidate and modernize, step by step, existing natural resource and environment observation stations; and
- Build and put into operation at least one-third of the proposed stations.

For the period 2011-15 period the objectives are to:

- Continue consolidating and modernizing existing observation stations;
- Build and put to operation at least half of the remaining stations; and
- Upgrade the natural resource and environment database.

For the final period, 2016-20, the objectives are to:

- Complete the building of, and put to efficient operation, all observation stations under the Plan;
- Raise the capability of observers, technicians and managers to satisfy the requirements of the national network of natural resource and environment stations.

The major tasks to be undertaken which will enable the implementation of the Master Plan include:

- To prepare and issue legal documents, econo-technical processes, regulations and norms related to the observation, collection, management and supply of information and data on natural resources and environment according to uniform standards to be applied nationwide;

- To promulgate more preferential policies to encourage persons engaged in natural resource and environment observation and survey, especially those working in deep-lying, remote, border and island areas;

- To standardize the profession of natural resources and environment observers;

- To step up scientific research, develop and apply advanced technologies, and enhance human resource training; and

- To expand and enhance international cooperation in the domain of natural resource and environment observation.

The implementation of the Master Plan will be effected by MONRE at the National level and the individual DONRE at the Provincial Level. At the National level the monitoring will focus on trans-national boundary water quality, and at provincial boundaries. At the provincial level the DONRE will focus on strategic locations within the province.

At the present time the details of the provincial Water Quality Monitoring Plans are prepared by a team of experts at the request of the Peoples' Committees. The plans are circulated for comment and then issued as a guideline to the respective DONRE for them to turn into a monitoring program and subsequently implement.

1.2 Purpose of this document

The purpose of this document is to define the basis for the monitoring carried out at City level by the Ho Chi Minh City's Centre for Environmental Monitoring and Analysis, under Environmental Protection Agency, Department of Natural Resources and Environment . The document has been compiled as part of a training workshop to develop the capacity of the DONRE staff for the design and implementation of monitoring plans and programs. The workshop was part of the JICA funded Project for Strengthening Capacity of water Environmental Management in Vietnam carried out in 2011/2013. The document defines the environmental problems relating to water quality in the province, the purpose of the monitoring to be carried out, references all the methodologies to be used during the monitoring, the rational for selecting the contaminants to be measured and the reasons for the selected sampling stations. It also defines the statistical test to be used to interpret the data and what procedures will be used to handle concentrations which are below the Limit of Detection and how to identify rogue or outlier values.

By drawing all of the above information into one document it provides immediate access to all of the fundamental assumptions made at the planning stage and a reference to all of the technical procedures used during the monitoring process.

1.3 The DQO Process

The DQO Process is a series of logical steps that guides project managers or scientific staff in the planning of resource-effective collection of environmental data. It can be used to plan the compiling of existing data and the collection of data into the future as in the case of water quality monitoring

The process is flexible and iterative, and can be applied to both the decision-making process (e.g., compliance/non-compliance with a standard) and estimation (e.g., determining the mean concentration level of a contaminant in the environment).

The DQO process is described in full in Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4[i]. In August 2011 the staff of the DONRE were given a 1-day introduction to the DQO process as part of the training program.

The DQO Process is used to establish performance and acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study. Use of the DQO Process leads to efficient and effective expenditure of resources; agreement between stakeholders on the type, quality, and quantity of data needed to meet the project goal; and the full documentation of actions taken during the development of the project.

CHAPTER 2. STATEMENT OF THE PROBLEM

2.1 Water quality status of Saigon river

Saigon river originates from Dau Tieng reservoir, Tay Ninh province with total length of 256km. It is one of the import water sources for Tay Ninh, Binh Duong, Binh Phuoc provinces and especially HCMC (accounting for 68% of the basin's population). The economic potential of Saigon river is very considerable, especially to some economic sectors as follows:

- Supplying water for agricultural land, 12.000ha for HCMC alone.

- Supplying water for domestic use, industry and services in municipalities, industrial zones with approximate total volume of 330.000 m^3/day, subject to increase to 930.000m^3/day in 2020.

- Utilizing the river for water navigation and aquaculture.

However, the Saigon river flows through populated areas, with fast development of industry and services therefore the basin has to receive a huge amount of wastewater everyday, leading to the derogation of river water quality during the last few years. The issues of water quality of Saigon river can be summarized in the table below:

Table 1: Water quality issues of Saigon river

Water quality issue	Location	Possible causes	Source of information
Low DO concentration	In almost monitoring locations, DO does not meet QCVN 08:2008, level A1 (6mg/l), even does not meet B1 (4mg/l) in some locations.	Not mentioned in the report	Report of Environmental Quality of HEPA, 2011
Oil and grease concentration exceeds QCVN 08:2008, level A1 (0.01mg/l)	In all monitoring locations	Due to the water navigation in Saigon river, oil and grease being washed out from the surface, and untreated wastewater containing oil and grease, discharging to canal system and then Saigon river	Report of Environmental Quality of HEPA, 2011
High coliform count	Does not meet A1 (<2500MPN/100ml) in most locations and even B1 (<7500MPN/ml) in some locations	Due to untreated domestic wastewater	Report of Environmental Quality of HEPA, 2011
Organic and microbiological pollution in some canals discharging to Saigon river: BOD, COD, coliform count are much higher than QCVN 08, level B2	Nhieu Loc – Thi Nghe, Tham Luong – Vam Thuat, Tan Hoa – Lo Gom, Tau Hu – Ben Nghe canals	Due to untreated or poorly-treated industrial and domestic wastewater, water leachate from landfill sites....	Report of Environmental Quality of HEPA, 2011

2.2 Overview of the monitoring plan

2.2.1 Objectives of monitoring plan

The Saigon Water Quality Monitoring Plan is established to answer these questions:

- Principle question: In which parts of the river, the water quality does not meet the QCVN for desired purposes.
- Secondary question No. 1: Does the water quality change over the length of the river?
- Secondary question No. 2: Does the water quality in a specific location change over time? For example, after the installation of a wastewater treatment plant or an implementation of a pollution control measure, is the water quality becoming better?

These questions can be applied when there is enough budget and data. If there is not enough budget and data, it is only necessary to answer the primary question.

2.2.2 Actions may be taken to answer the question

The Centre for Environmental Monitoring and Analysis is an unit under the management of HCMC Environmental Protection Agency, HCM DONRE. The Centre has the following duties and rights:

- *To develop, operate, manage the air, surface water, groundwater quality monitoring network of the city.*
- *To develop, utilize the environmental quality database of the city.*
- *To unify the management of environmental monitoring and survey data; to develop the archive and update mechanism of data; to develop the pollution source map to support the prediction of environmental trend.*
- *To prepare periodical or unplanned monitoring report on the operation of tasks assigned*

Therefore, to answer these questions above about water quality status of Saigon river, the Centre will implement different tasks such as monitoring planning, data archiving and analysis and report preparation.

2.3 Resources for the monitoring plan

2.3.1 Budget for the monitoring plan

The budget allocated for Saigon-Dong Nai surface water quality in 2012 is VND2,152,960,000

2.3.2 Members of monitoring planning team

Danh sách nhân viên với thông tin về nhiệm vụ/kỹ năng thuộc Trung tâm Quan trắc và Phân tích môi trường thành phố Hồ Chí Minh được tóm tắt trong bảng sau:

Table 2: Members of monitoring planning team

Division	Position	Name	Duty
Monitoring	Head	Nguyen Thanh Huy	General Management

and Analysis Section	Deputy Head	Dang Thi Tuyet Loan	Manager of surface water and groundwater monitoring group
	Deputy Head	Tran Minh Ngoc	Manager of hydrological, coastal and aquatic animals monitoring
	Staff	Nguyen Vo Qui Chau	Development of planning, data processing, report preparation (river water), supervision of river water monitoring.
	Staff	Ma Thi Nguyet Thanh	Development of planning, sampling, data processing, report preparation of groundwater monitoring
	Staff	Do Thi Thu Hang	Development of planning, data processing, report preparation (river water), supervision of hydrological monitoring
	Staff	Truong Hong Ha	Development of planning, data processing, report preparation (river water), supervision of coastal water monitoring
	Staff	Doan Thai Duy	Development of planning, data processing, report preparation (river water), supervision of groundwater level monitoring

2.3.3 Time allocated for other activities

Besides the tasks assigned for monitoring activities in general, staff of the Centre has several other activities such as:

- Annual environmental events: Earth Hour (30/3), World Environment Day (5/6), Clean Up the World (third week of September every year)…Each event takes some time to prepare
- Training courses to improve professional capacities (2-3 times per year)
- National Holidays: Tet, King Hung festival, April 30th, September 2nd, New Year holidays.

2.3.4 Field equipment and laboratory instrumentation

Currently there is no laboratory in HCMC Centre for Environmental Monitoring and Analysis. From 1996 until now, the Centre has received some equipment an instruments from 03 projects: Project VIE 96/023 of UNDP and DANIDA, the Norway Project in 2002, the HEI project, USA in 2007, 2008. However, currently, some equipment and instruments have reached the end of life, some need to upgraded or repaired.

Table 3: List of equipment and instruments of HCMC Centre for Environmental Monitoring and Analysis

No.	Section/Instrument	Country of origin	Used since	Quantity	Condition
I	**Analysis instrument**				
1	Scale made from granite	Vietnam	2007	1	Good
2	Ultrasonic washer	U.S.A	2007	1	Good
3	Personal dust sample	U.S.A	2007	5	Usable
4	Dụng cụ vi tiêm mẫu	Germany	2007	3	Good
5	Glass pipet 10ml	Germany	2007	1	Good
6	Automatic humidity and temperature measurer	U.S.A	2007	5	Usable
7	GPS	U.S.A	2007	2	Good
8	Precision scale AEL - 403M Shimadzu 321 – 40316, SN-D007944	Japan		1	Usable
9	Spectrograph Hach DR 2000	U.S.A		1	Usable
10	Precision scale Model SE2-Satorius 2.1g/0.01mg	U.S.A	2007	1	Good
11	Chromatograph Ion Diodes	U.S.A		1	Needs to replace the shaft and make calibration
12	Oven LINN VMK 135-S/N DF 007944	Germany	1997	1	Usable
13	Freezer	Japan	2007	1	Usable
14	Water distiller	U.S.A	2007	1	Usable
II	**Field equipment**				
15	Dust sample SIBATA large volume (900l/ph) HVC 500	Japan	1997	1	Usable but calibration is needed
16	Dust sample SIBATA large volume (500l/ph) HVC 500	Japan	2005	1	Usable but calibration is needed
17	Noise measurer Extech	Taiwan – Mỹ	2004	1	Usable
18	Air sample Desaga	Japan	2005	1	Usable but calibration is needed
19	Standardized air pump	U.S.A	2007	3	Usable
20	G3500R Electric generator	Japan		2	Usable
21	MP1 pump and accessories	Denmark		1	Usable

Cleary, the equipment listed above cannot meet the requirement of the annual monitoring work. Currently, sample are being analyzed by an external laboratory.

CHAPTER 3. REQUIRED DATA AND INFORMATION FOR DEVELOPMENT THE MONTITORING PLAN

3.1 Natural and social features of Saigon river basin

3.1.1 Saigon – Dong Nai river system

Saigon river basin is a part of Saigon – Dong Nai river basin. Besides two major rivers Saigon and Dong Nai, the city has an intensive canal system, such as Lang The, Bau Nong, Rach Tra, Ben Cat, An Ha, Tham Luong, Cau Bong, Nhieu Loc – Thi Nghe, Ben Nghe, Lo Gom, Kenh Te, Tau Hu, Kenh Doi canal systems in Saigon river, canal system in Nha Be and Can Gio districts in the South of the city and other irrigation systems, forming an intensive river and canal system as shown in the figure.

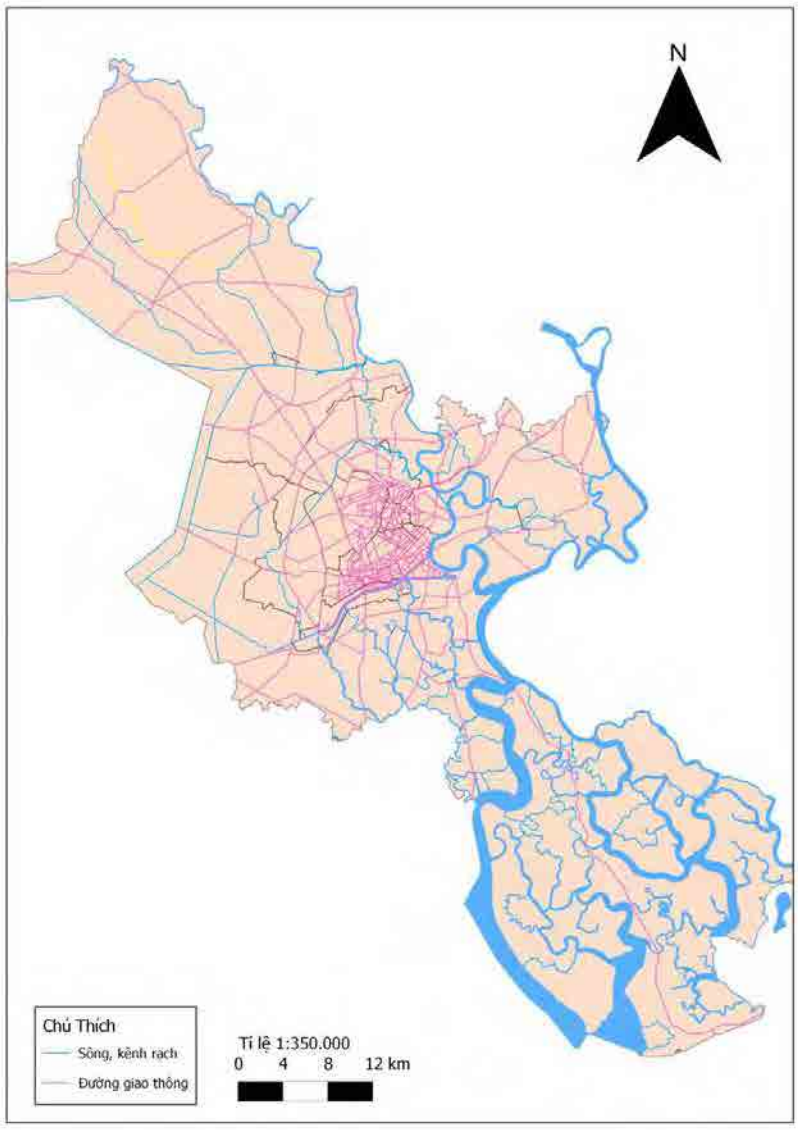

Figure 1: Map of main rivers and canals in Ho Chi Minh city

3.1.2 Conceptual model of the river basin

For the simplification, the river, canal system and other components such as municipalities, cities, industrial zones, water plants are simply demonstrated in the Conceptual model. The conceptual model gives the monitoring planner some initial ideas about the system they are going to work with, which areas to be focused on.

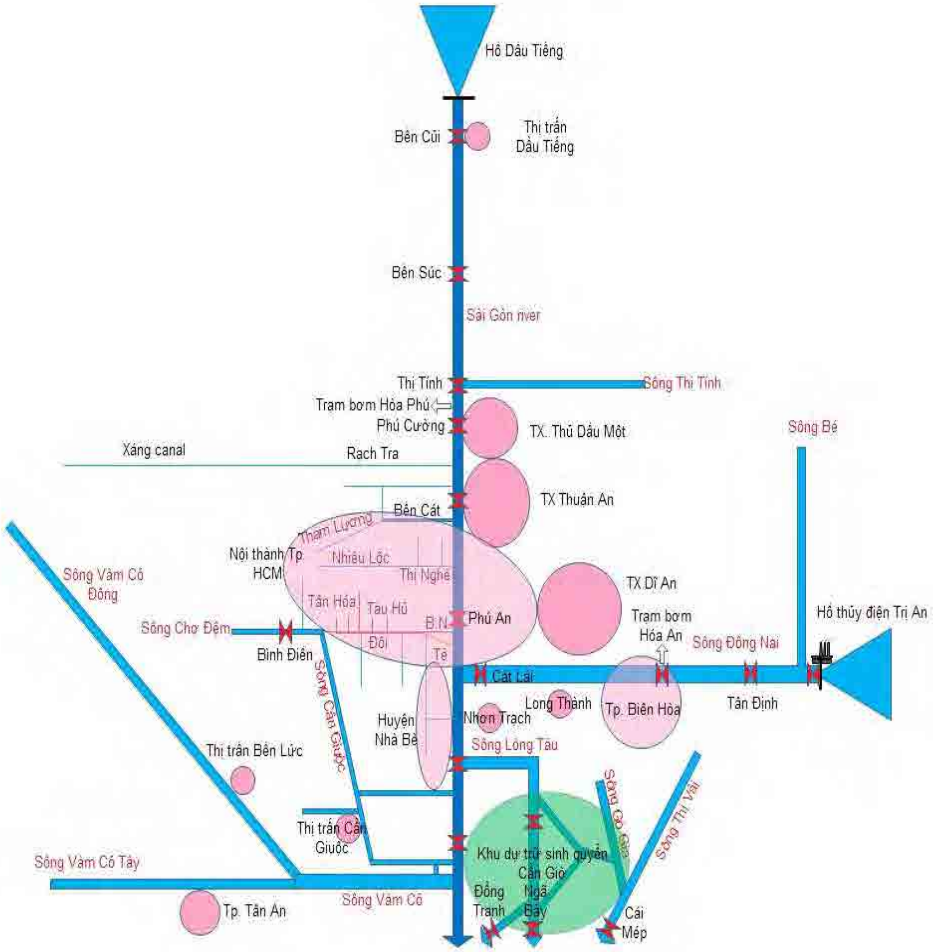

Figure 2: Conceptual model of river, canal system of HCMC and surrounding areas

3.1.3 Land use

According to the land use statistics of 2011, agricultural land accounts for 56.13% of land, non-agricultural land accounts for 43.59%, of which 11.46% is housing area. Details of land use of Ho Chi Minh city until 2011 is illustrated in Annex XX.

3.1.4 Population distribution

Tình hình phân bố dân cưa ở các quận, huyện của thành phố Hồ Chí Minh như sau (các quận, huyện in đậm là các quận, huyện có tiếp giáp với sông Sài Gòn)

Table 1: Population of HCMC by districts

District	Number of wards/communes	Area (km^2)	Population	Density (person/km^2)
District 1	10	8	187435	23429
District 2	11	50	140621	2812
District 3	14	5	188945	37789
District 4	15	4	183261	45815
District 5	15	4	174154	43539
District 6	14	7	253474	36211
District 7	10	36	274828	7634
District 8	16	19	418961	22051
District 9	13	114	263486	2311
District 10	15	6	232450	38742
District 11	16	5	232536	46507
District 12	11	53	427083	8058
Go Vap district	16	20	548145	27407
Tan Binh district	15	22	430436	19565
Tan Phu district	11	16	407924	25495
Binh Thanh district	20	21	470054	22384
Phu Nhuan district	15	5	175175	35035
Thu Duc district	12	48	455899	9498
Binh Tan district	10	52	595335	11449
Cu Chi district	21	435	355822	818
Hoc Mon district	12	109	358640	3290
Binh Chanh district	16	253	447291	1768
Nha Be district	7	100	103793	1038
Can Gio district	7	704	70697	100
Whole city	322	2096	7396445	3529

(Source: HCMC's Department of Statistics, 2010)

3.2 Hydro-meteorological data

Hydro-meteorological data is one of the important factors contributing to the development of a monitoring plan as rainfall and flow discharge greatly influence river water quality. When rain falls, pollutants are washed away from the ground/surface, sewer systems, cultivation fields ... into rivers, increasing contents of some pollutants. Additionally, when river water level is high, self-cleaning capacity of rivers is improved, leading to a change in river water quality. Therefore, on developing a monitoring plan, sampling and assessment of analysis results, seasonal factor of a study site and related hydro-meteorological conditions should be considered.

Besides the national hydro-meteorological monitoring network, HCMC also has a network being managed by DONRE, consisting of 16 rainfall gauging stations and 15 hydrological stations. All these 15 hydrological stations are located at the same location with water quality sampling points. This would give a big advantage to analyze the correlation between the river flow and water quality.

3.2.1 The hydro-meteorological monitoring network

Table 2: List of rainfall gauging stations

No.	Name	Location
1	Binh Chanh	Hamlet No. 3, Tan Tuc commune, Binh Chanh district
2	Can Gio	Hamlet Mieu 3, Can Thanh commune, Can Gio district
3	Cat Lai	Khu A, Thạnh Mỹ Lợi, Q.2
4	Cu Chi	Tien hamlet, Than Thong Hoi commune, Cu Chi district
5	Hoc Mon	Hoc Mon town, Hoc Mon district
6	Le Minh Xuan	Hamlet No. 7, Le Minh Xuan commune, Binh Chanh district
7	Long Son	Ngai Thang, Binh An, Thuan An commune
8	Pham Van Coi	Hamlet No.3, Pham Van Coi commune, Cu Chi district
9	An Phu	Hamlet An Hoa, An Phu commune, Cu Chi district
10	Tam Thon Hiep	An Phuoc, Tam Thon Hiep commune, Can Gio district
11	XM Thu Duc	Hanoi highway, Phuoc Long ward, District 9
12	Nha Be	Hamlet 7, Phu Xuan commune, Nha Be district
13	Tan Son Hoa	Tan Binh district
14	Thu Dau Mot	So Sao ward, Thu Dau Mot city, Binh Duong province
15	Bien Hoa	Bien Hoa city, Dong Nai province
16	Vung Tau	Vung Tau city, Ba Ria – Vung Tau province

Table 3: List of hydrological monitoring stations

No		River	X	Y	Location
1	Ben Suc	Saigon	658440	1233670	200m downstream from Ben Suc bridge
2	Thi Tinh confluence	Thị Tính	676150	1221890	at Ong Co bridge (Binh Duong province), about 1200m from confluence between Thi Tinh river and Saigon river
3	Phu Cuong	Sài Gòn	680210	1214070	1km upstream from Thu Dau Mot

					market, Binh Duong province
4	Binh Phuoc	Saigon	687640	1201240	800m from Dai Han – National Highway 13 intersection
5	Phu An	Saigon	686800	1191870	500m downstream from Thu Thiem ferry port and 50m downstream from Caric factory
6	Hoa An	Dong Nai	694780	1212700	at Hoa An bridge, 100m downstream of Hoa An water intake
7	Cat Lai	Dong Nai	696840	1190300	1.5km upstream from Cat Lai ferry port
8	Nha Be	Nha Be	693070	1181330	500m upstream from Nha Be – Long Tau confluence
9	Binh Dien	Cho Dem	674760	1183480	200m downstream of Binh Dien bridge, Binh Chanh district, HCM city
10	Tam Thon Hiep	Long Tau	704250	1173170	800m from Tac Roi confluence
11	Vam Sat	Nha Be	691680	1164300	100m downstream of Vam Sat river mouth (Vam Sat hamlet, Vam Sat commune, Can Gio district).
12	Vam Co	Vam Co	688050	1158870	1.5km upstream from Vam Co river mouth
13	Dong Tranh river mouth	Dong Tranh	703240	1155120	1km upstream from Cat Lai confluence
14	Nga Bay river mouth	Nga Bay	713590	1159560	1km upstream from Ong Tien river
15	Cai Mep river	Cai mep	719980	1163070	1km upstream from Nga Tu canal

Parameters measured: Cross section, hourly water level (24/24), flow velocity at 2 layers, discharge calculation

Measurement regime: Once a month, each time in 49 consecutive hours during highest water.

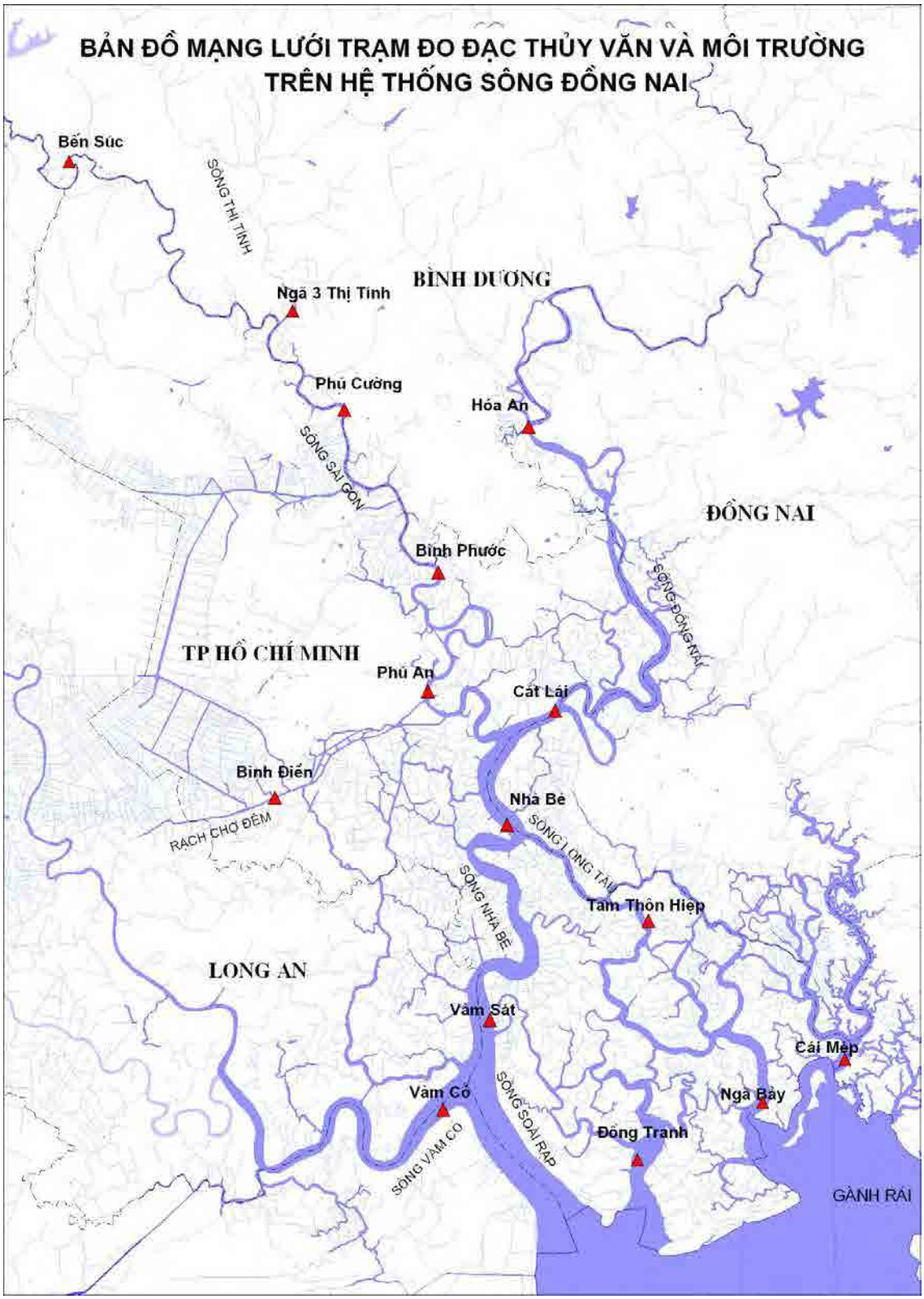

Figure 3: Map of hydrological measuring stations

3.2.2 Hydro-meteorological features

3.2.2.1 Temperature and rainfall

Located in tropical savanna climate zone, temperature in HCMC is high around the year and having two distinct rainy and dry seasons. Rainy season starts from May until November, while dry season starts from December to April of next year. On average, HCMC has from 160 to 270 hours of sunshine each month, with average temperature of 27°C, with maximum temperature of 40°C and minimum temperature of 13.8°C. Every year, there are 330 days when daily temperature falls between 25 to 28°C. Annual rainfall is 1,949mm, there are 159 rainy days per year on average, mostly from May to November, accounting for 90% of total rainfall, especially during June and September.

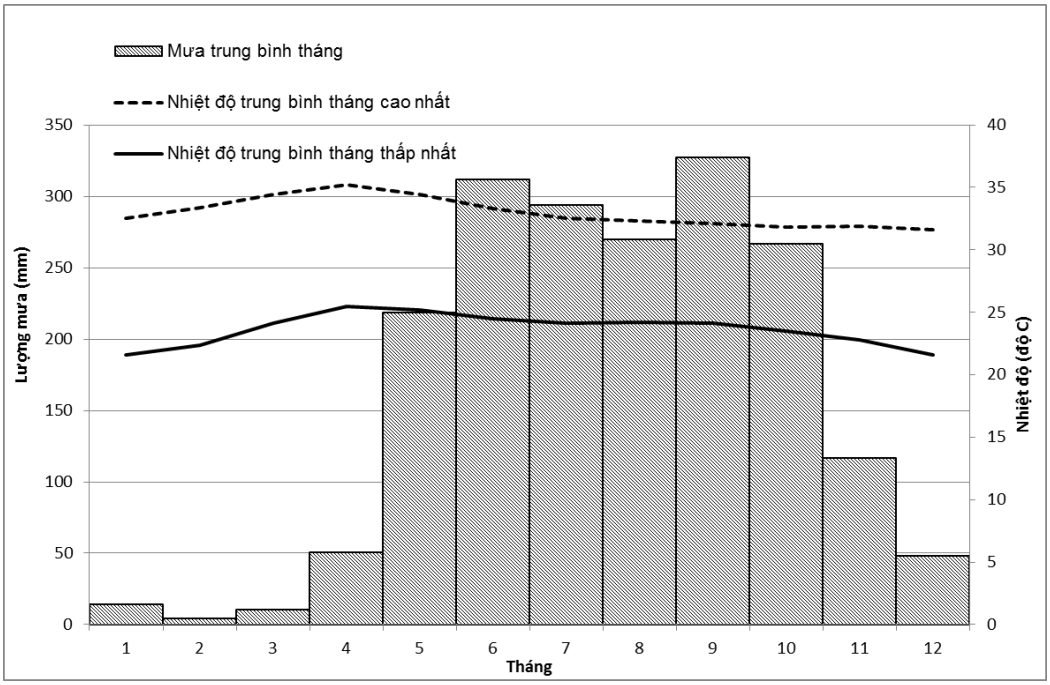

Figure 4: Rainfall and temperature data of Tan San Nhat station (1906-1990 data, Source WMO, 2012)

3.2.2.2 Hydrology

[No information available yet]

3.3 Locations of pumping stations & water plants

Table 4: List of pumping stations & water plants

Name	Location	Purpose	Supplying raw water for water plant?	being monitored or not?
Hoa An intake	Dong Nai river	Drinking water	Yes	Yes
Hoa Phu intake	Saigon river	Drinking water	Yes	Yes
Hoc Mon groundwater plant	District 12	Drinking water		No
Binh Hung	Binh Chanh	Drinking water		No

groundwater plant				
Go Vap groundwater plant	Go Vap	Drinking water		No
Binh Tri Dong groundwater plant	Binh Tan	Drinking water		No

3.4 Water works in Saigon river system

3.5 Potential pollution sources

3.5.1 Industrial and processing zones

According to the development plan, until 2020, HCMC will have 24 export processing (EP) zones, industrial zones (IZ) with total area of 6,152.8ha. Currently, HCMC Export Processing Zones Authorities (HEPZA) is managing 3 EPs and 13 IZs with total area of 3,748.49ha. According to the design, EPs and IPs all have the centralized waste water treatment plan, with incoming water from enterprises located inside IPs and EPs must meet Level B of QCVN24:2008. Therefore, it the wastewater treatment systems of these EPs and IPs operate in accordance with the approved designs, the treated wastewater will not be potential pollution sources of Saigon river.

Until August 2012, according to HCMC DONRE, HEPZA and Environmental Police Department (PC49) – HCMC Public Securities, HCMC is the first province of Vietnam with 100% of EPs and IPs having centralized wastewater treatment system with total treatment capacity of 63.000m3 per day and actual treatment volume is 43,000 to 44,000 m3 per day. All IPs in HCMC have invested in stable wastewater treatment systems and being operated properly. However, during the inspections of authorities and complains from local residents, there are still some enterprises discretely discharging untreated wastewater into the environment, therefore the risk of river being polluted by untreated industrial wastewater is still existing.

Locations of active EPs, IPs are illustrated with stars in Figure 5. Information about these EPs and IPs can be found in website of HEPZA: http://www.hepza.gov.vn

3.5.2 Industrial clusters

According to Saigon Marketing newspaper (July 2012), currently HCMC has total 16 industrial clusters (IC) but only 3 of them having investors, the status of the others is unclear. Unmanaged ICs are potential pollution sources because normally they are located inside populated resident area and doing business in polluted sectors (poultry and cattle farming, texting, dyeing, ironing, etc), especially most of ICs do not have centralized wastewater treatment system.

Locations of some ICs are illustrated with ■ in Figure 5, based on the locations described in website of HCMC's Department of Industry and Trade.

3.5.3 Landfill and solid waste processing sites

HCMC is managing three planned solid waste processing sites (besides Dong Thanh and Go Cat sites which were already shut down). Brief information about these sites is as follows (DONRE, 2012):

- Northwest solid waste processing zone: located in Cu Chi district, total area of 687ha, of which 336ha from land compensation, uncompensated land is about 351ha. Most of functional facilities have not been operating, only landfill site No. 2 (19.5ha) and 2 over 4 fertilizer-from-wastes manufacturer are operating.

- Da Phuoc solid waste processing and cemetery: located in Da Phuoc commune, Binh Chanh district. Total area is 613.88ha, under operation and waiting for approval of some adjustments in business license.

- Long An solid waste processing zone: located in Tan Lap commune, Thu Thua district, Long An province, with total area of 1,760ha (in which 850-980ha is green belt and isolation area and solid waste processing site occupies 580-730ha), still under development of infrastructure and planned to come into operation from 2013-2014.

If these landfill sites are not managed properly, they can become potential pollution sources of the river. According to the report of the project "Pollution sources control of Saigon river" (2012), Dong Thanh landfill site has a huge impact to water quality. This landfill site has a very narrow isolation ward to Saigon river therefore it is very difficult to control leachate to the river.

Locations of landfill sites, solid waste processing zones are illustrated with the symbol ▲ in Figure 5.

3.5.4 Outlets, confluences of canals with Saigon river

HCMC has an intensive river, ditch and canal network. The estimated length of the canal network of the city is different in accordance to authorities. According to HCMC DONRE, the current management of canals of the city is categorized into different levels, consisting of 909 drainage canals, 87 navigation canals, 2 navigation rivers for special use, 16 national navigation routes and 1,245 other canals with total length of 2,300km. Within HCMC proper, there are 5 main canal systems, with total length of 75km, including: Nhieu Loc – Thi Nghe, Tan Hoa – Lo Gom, Tau Hu – Kenh Doi; Kenh Te – Ben Nghe; Tham Luong – Ben Cat – Vam Thuat. These canal systems together with Saigon river (38km) have a very important role for drainage of HCMC proper. However, these canal systems are receiving tons of waste from households, boats, discharge gates, etc., forming a huge floating layer above the surface water.

When these canals and ditches join Saigon river, they will have bad impacts to water quality of Saigon river, therefore it is necessary to know the locations of discharge gate, the confluences of these canals with Saigon river in order to determine good sampling locations.

Locations of confluences between main canals, ditches with Saigon river are illustrated with ● in Figure Hình 5 (only major canals and ditches which can be seen from satellite image)

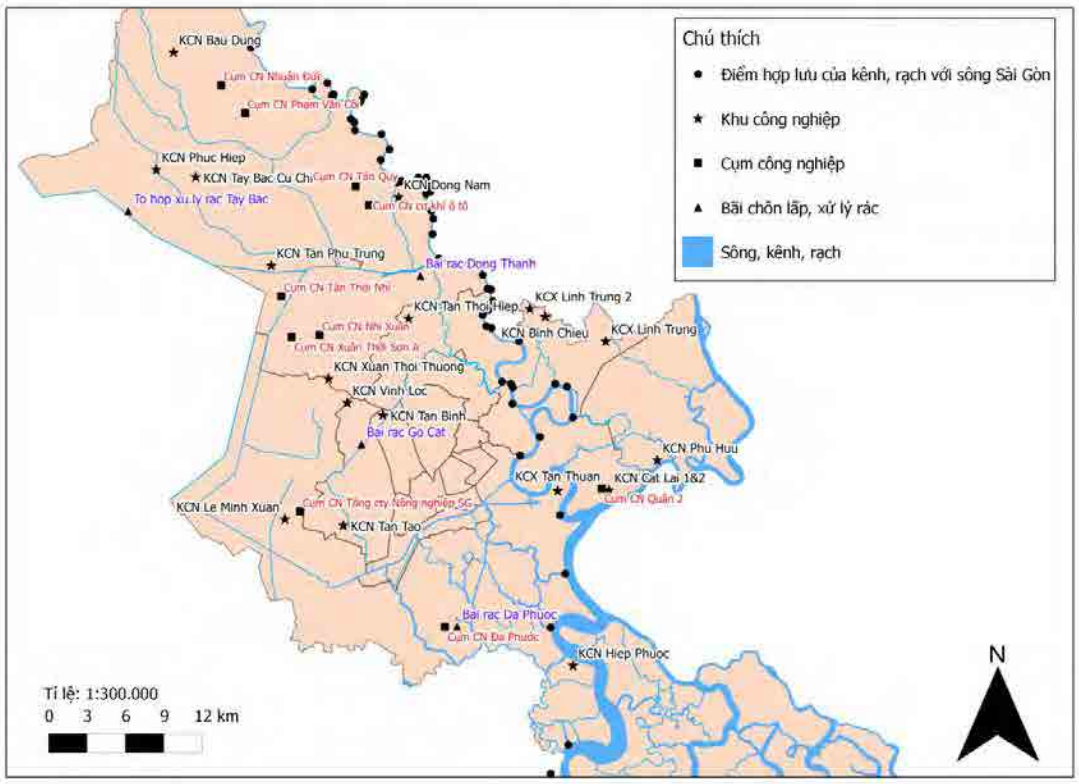

Figure 5: Locations of potential pollution sources

3.6 Sensitive receivers

Sensitive receivers are understood as places where human uses the water directly or indirectly for entertainment or production, e.g. bathing beaches, parks, natural reserves, aquaculture areas, etc., where water quality plays a very important role. In this context, the Saigon – Dong Nai river system flowing through HCMC has the following sensitive receivers:

Table 5: List of sensitive receivers

Name	Location	Purpose/Category	QCVN (A1, A2, B1, B2) applied
Dong Tranh river mouth	Confluence of Long Hoa and Ly Nhon river, 2-3km from Dong Hoa cape.	Aquaculture area	QCVN 10:2008/BTNMT
Long Tau river mouth	5-6km from Can Gio cape. Sampling point is 15m from the mangroves.	Aquaculture area inside the mangroves	QCVN 10:2008/BTNMT
Cai Mep river mouth	Confluence of Nga Ba river and Go Da river	Aquaculture inside the mangroves, receiving all wastewater from industrial activities from Dong Nai and Ba Ria – Vung Tau	QCVN 10:2008/BTNMT
Can Thanh flood plain	1.5km from Can Thanh cape	Aquaculture	QCVN 10:2008/BTNMT

Name	Location	Purpose/Category	QCVN (A1, A2, B1, B2) applied
30/4 flood plain	1.5 km from the bank	Aquaculture	QCVN 10:2008/BTNMT
Dong Hoa flood plain	1.5km from Dong Hoa cape to the sea	Aquaculture	QCVN 10:2008/BTNMT
Can Thanh park	near the shoreline	Recreation area	QCVN 10:2008/BTNMT
30/4 tourist area	near the shoreline	Recreation area	QCVN 10:2008/BTNMT
The Southern Pearl tourist area	near Dong Hoa coast, Long Hoa commune, Can Gio district	Recreation area	QCVN 10:2008/BTNMT

CHAPTER 4. MONITORING PLAN

4.1 Monitoring network

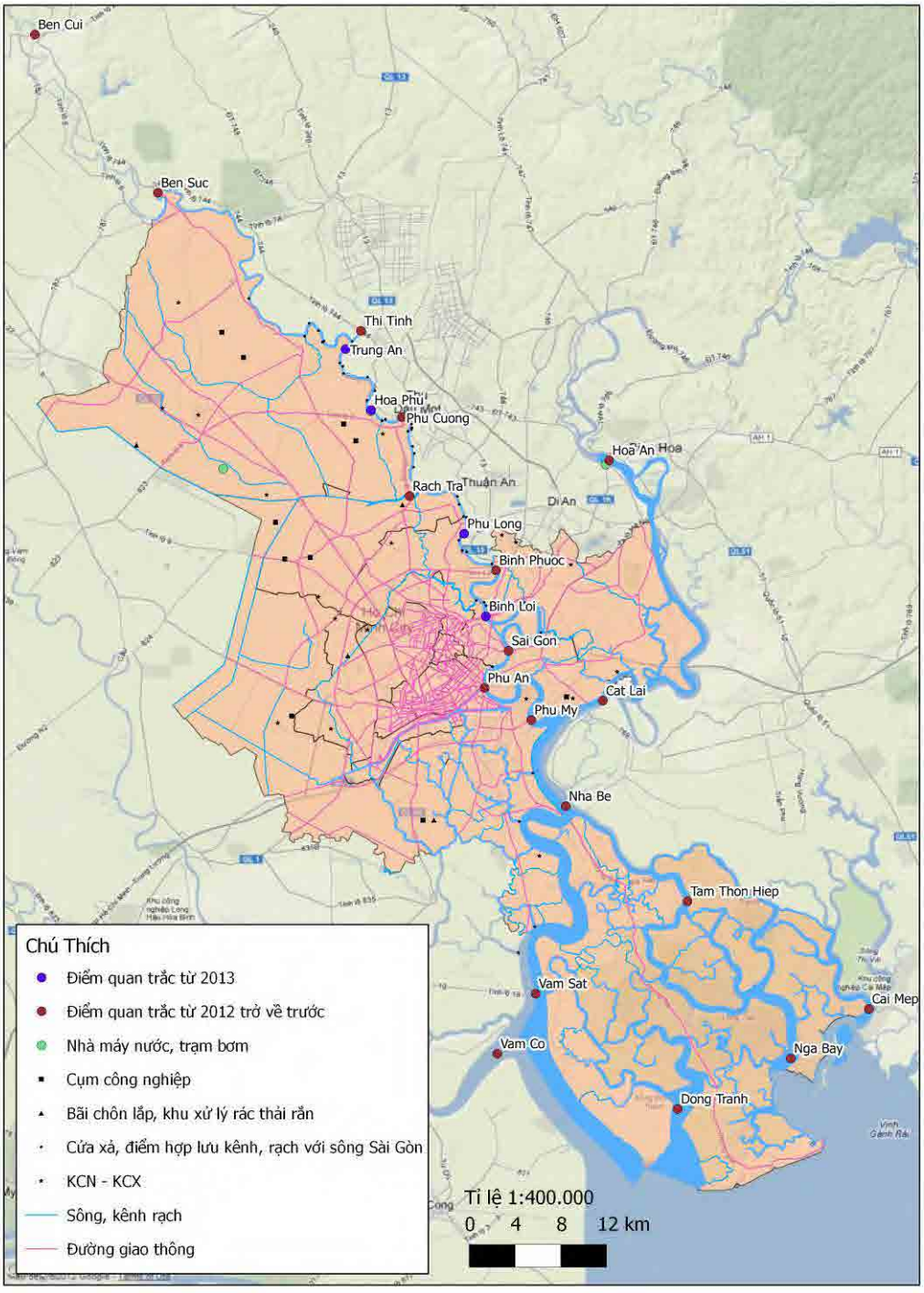

Figure 6: Water quality monitoring network of Saigon – Dong Nai river system in 201x

No	Name	Coordinates	Description	Reason for choosing	Action level

1	Ben Cui	X: 106.3552 Y: 11.2794	Dau Tieng bridge over Saigon river, between Ben Cui commune and Tay Ninh town, Tay Ninh province	Checking water quality in the most upstream part of Saigon river (Dau Tieng reservoir)	QCVN 08:2008 level A1
2	Ben Suc	X: 106.4517 Y: 11.1561	in Saigon river, 200m downstream of Ben Suc bridge	Checking water quality of Saigon river before entering HCMC territory	QCVN 08:2008 level A1
3	Thị Tính	X: 106.6111 Y: 11.0484	Ong Co bridge, Thi Tinh river (Binh Duong province), 1200 from confluence with Saigon river	Checking water quality of Thi Tinh river, flowing through a highly industrialized area before joining Saigon river	QCVN 08:2008 level A1
4	Trung An	X: 106.5990 Y: 11.0342	in Saigon river, 800m downstream of confluence of Thi Tinh – Saigon river. Location: Trung An commune, Cu Chi district (new sampling point from 2013)	Checking water quality of Saigon river right below the confluence with Thi Tinh river	QCVN 08:2008 level A1
5	Hòa Phú	X: 106.6191 Y: 10.9866	At Hoa Phu pumping station in Saigon river	Checking water quality at Hoa Phu pumping station	QCVN 08:2008 level A1
6	Phu Cuong	X: 106.6432 Y: 10.9812	Phu Cuong bridge in Saigon river	checking water quality of Saigon river before flowing through Thu Dau Mot city, Binh Duong province	QCVN 08:2008 level A1
7	Rach Tra	X: 106.6492 Y: 10.9195	Rach Tra bridge in Rach Tra river	checking water quality of Rach Tra river before joining Saigon river	QCVN 08:2008 level B1
8	Phú Long	X: 106.6921 Y: 10.8902	Phu Long bridge in Saigon river (new sampling point from 2013)	checking water quality after flowing through Lai Thieu ward, Di An township, Binh Duong province	QCVN 08:2008 level B1
9	Binh Phuoc	X: 106.7171 Y: 10.8616	Cầu Bình Phước bắc qua sông Sài Gòn	checking water quality trend	QCVN 08:2008 level B1

10	Hoa An	X: 106.8059 Y: 10.9475	Hoa An bridge in Dong Nai river, 100m downstream of Hoa An pumping station	checking water quality at Hoa An pumping station	QCVN 08:2008 level A1
11	Binh Loi	X: 106.7091 Y: 10.8257	Binh Loi railway bridge in Saigon river (new sampling point from 2013)	checking water quality trend, impact of wastewater in general	QCVN 08:2008 level B1
12	Sai Gon	X: 106.7269 Y: 10.7988	Saigon bridge in Saigon river (since 2011)	Checking impact of municipal and industrial wastewater from some industrial entities in Ward No. 13, Binh Thanh district	QCVN 08:2008 level B1
13	Phu An	X: 106.7081 Y: 10.7698	in Saigon river, 500m downstream of old Thu Thiem ferry port	checking water quality trend, impact of Thi Nghe canal to Saigon river	QCVN 08:2008 level B1
14	Phu My	X: 106.7448 Y: 10.7448	Phu My bridge in Saigon river	Theo dõi diễn biến chất lượng nước trong quá trình xây dựng khu đô thị mới Thủ Thiêm	QCVN 08:2008 level B1
15	Cát Lái	X: 106.8009 Y: 10.7598	1.5km upstream of Cat Lai ferry port in Dong Nai river	checking water quality of Dong Nai river before joining Saigon river	QCVN 08:2008 level B1
16	Nha Be	X: 106.7718 Y: 10.6775	in Nha Be river, 500m upstream of confluence between Nha Ba – Long Tau rivers	checking water quality of Nha Be river before dividing into 2 distributaries	QCVN 08:2008 level B1
17	Tam Thon Hiep	X: 106.8673 Y: 10.6033	in Long Tau river, 800m upstream of Tac Roi confluence (opposite to Tam Thon Hiep village's market)	checking water quality of major shrimp farming area of Can Gio district	QCVN 08:2008 level B1
18	Vam Sat	X: 106.7482 Y: 10.5312	in Nha Be river, 100m upstream of confluence between Nha Be and Vam Sat rivers (Vam Sat village, Vam Sat commune)	checking water quality of Nha Be river before joining Vam Co river	QCVN 08:2008 level B1
19	Vam Co	X: 106.7182	in Vam Co river, 1.5km	checking water	QCVN 08:2008

		Y: 10.4842	upstream of confluence between Vam Co and Nha Be rivers	quality of Vam Co river before joining Nha Be river	level B1
20	Đồng Tranh	X: 106.8598 Y: 10.4411	in Dong Tranh river, Can Gio district, 1km downstream of Cat Lai confluence	checking water quality of river mouths in Can Gio district, measuring impact of sea level rise due to climate change	QCVN 08:2008 level B1
21	Nga Bay		in Nga Bay river, 1km upstream of confluence with Ong Tien river	checking water quality of river mouths in Can Gio district, measuring impact of sea level rise due to climate change	QCVN 08:2008 level B1
22	Cai Mep		in Cai Mep river, 1km downstream of Nga Tu canal	checking water quality of river mouths in Can Gio district, measuring impact of sea level rise due to climate change	QCVN 08:2008 level B1

4.2 Parameters

Parameters being measured include: pH, Temperature, Conductivity/Salinity, Turbidity, TSS, PO_4^{3-}, NH_4^+, DO, BOD5, COD, Ecoli, Coliform, Heavy metals (Pb, Hg, Cd, Cu, Mn), Oil and grease.

4.3 Time and frequency of monitoring

4.3.1 Sampling frequency

Samples are taken in day 01^{st}, 08^{th}, 15^{th}, 22^{nd} every month.

4.3.2 Diurnal boundary

During each sampling occasion, samples are taken twice a day corresponding to the highest and lowest water

4.3.3 Time frame of the monitoring plan

Event	Date	Preparatory period
Beginning of the monitoring program	01/01	

End of the monitoring program		31/12	
Main report	Annual report	15/ 01	20 days
Other reports	Monthly + Quarterly reports	15th of the month after	10 days
Reviewing the monitoring plan		from February to July every year	
Major holidays		Lunar new year	

Time allocated for other activities

Besides the tasks assigned for monitoring activities in general, staff of the Centre has several other activities such as:

- Annual environmental events: Earth Hour (30/3), World Environment Day (5/6), Clean Up the World (third week of September every year)…Each event takes some time to prepare
- Training courses to improve professional capacities (2-3 times per year)
- National Holidays: Tet, King Hung festival, April 30th, September 2nd, New Year holidays.

4.4 Practical constrains

Table 6: Practical constrains when implementing the monitoring program

Type of constrain		Description	Solution if possible
Internal constrains	Hiring local residents for sampling	Local residents are not trained on sampling procedure, thus it is difficult to control the quality of samples taken	Organizing short training course on sampling procedure
	Equipment	Some instruments are stale and not functioning anymore	waiting for the investment project of the laboratory
	Chemicals		
External constrains	Accessibility to the sampling points		
	Time for travelling		

4.5 Sampling methodologies and samples preservation

Samples are taken in the middle of the river, 30m below the surface.

The table below summaries the sampling methods for each parameter (information is provided by the consultant)

Table 7: Sampling methodologies and samples preservation

Parameters	Containers	Preservation	Volume (ml)	Optimal duration for preservation	Maximum duration for preservation
pH					
Temperature					
Turbidity					
TSS	polyethylene bottle	4 ^oC	200	24 hrs	7 days
DO	glass bottle	4 ^oC	113		
BOD_5 (20^oC)	polyethylene bottle	4 ^oC	1000	6 hrs	48 hrs
COD	polyethylene bottle	H_2SO_4 pH<2,4^oC	50	as soon as possible	7 days
Amoni NH_4^+	polyethylene bottle	H_2SO_4 pH<2.4^oC	50	as soon as possible	7 days
Phosphat PO_4^{3-}	glass bottle	4 ^oC	50	48 hrs	-
Salitnity (Cl-)	polyethylene bottle	4 ^oC	50	24 hrs	7 days
Lead (Pb)	polyethylene bottle polyethylene bottle	HNO_3 pH < 2.4 ^oC	50	as soon as possible	7 days
Cadmium (Cd)					
Copper (Cu)					
Chromium (Cr)					
Manganese (Mn)					
E. Coli	Sterilized glass bottle	4 ^oC	60	1 hrs	24 hrs
Coliform					
Dầu mỡ	glass bottle	H_2SO_4 pH<2.4^oC	1000	2 hrs	7 days

Sampling unit

The table below summaries sampling unit required for analysis, QA/QC volumes for each parameter (information is provided by the consultant)

Table 8: Sampling unit

Parameter	Volume for analysis (ml)	Volume for QA/QC (ml)	Backup volume (ml)	Total (ml)
pH	50	50	50	150
Temperature	50	50	50	150
Turbidity	50	50	50	150
TSS	200	200	200	600
DO	113	113	113	340
BOD_5	1000	1000	1000	3000
COD	50	50	50	150
Amoni (NH_4^+ as N)	50	50	50	150
Phosphat (PO_4^{3-} as P)	50	50	50	150
Salinity (Cl-)	50	50	50	150
Lead (Pb)	50	50	50	150
Cadmium (Cd)				
Copper (Cu)				

Chrome (Cr)				
Manganese (Mn)				
E. Coli	60	60	60	180
Coliform				
Oil and grease	1000	1000	1000	3000
Total volume for each sampling occasion				**8320 (ml)**

4.6 Analytical methods

Bảng dưới đây liệt kê phương pháp phân tích và giới hạn phát hiện của phương pháp phân tích sử dụng trong phòng thí nghiệm cho từng thông số kiểm soát chất lượng nước sông Sài Gòn – Đồng Nai (do đơn vị tư vấn cung cấp).

Table 4: Analytical methods

Parameter	Analytical method	Limit of detection	Note
pH, temperature, DO, conductivity, turbidity	YSI Multi-parameter analyzer		Measure in the field
pH	TCVN 6492:1999	2	Accredited by VILAS
Temperature			
Turbidity (NTU)	TCVN 6184:1996	0.2	
TSS (mg/l)	TCVN 6625:2000	0.5	
DO (mg/l)	TCVN 7324:2004	0.02	Accredited by VILAS
BOD_5 (20^oC) (mg/l)	TCVN6001-1:2008	2	Accredited by VILAS
COD (mg/l)	TCVN 4565:1988 hoặc SM 5220C	0.5	Accredited by VILAS
Ammonia (NH_4^+ as N) (mg/l)	SM4500NH_3 F. 2005	0.01	Accredited by VILAS
Phosphate (PO_4^{3-} as P) (mg/l)	TCVN6202:2008	0.005	Accredited by VILAS
Salinity (Cl^-) (g/l)	Đo máy	0.01	
Lead (Pb) (mg/l)	SMEWW 3113B	0.002	Accredited by VILAS
Cadmium (Cd) (mg/l)	SMEWW 3113B	0.002	Accredited by VILAS
Copper (Cu) (mg/l)	SMEWW 3113B	0.002	Accredited by VILAS
Chrome (Cr) (mg/l)	SMEWW 3113B	0.002	
Manganese (Mn) (mg/l)	SMEWW 3113B	0.05	
E. Coli (MPN/100ml)	SMEWW 9221	3	
Coliform (MPN/100ml)	SMEWW 9221	3	
Oil & grease (mg/l)	TCVN	0.005	

CHAPTER 5. THE DATA ANALYSIS APPROACH

5.1 Action levels to be applied

The water quality monitoring network of Saigon – Dong Nai river system is divided into two categories:

(1) Stations being monitored for water supply, consisting of 7 stations which water quality needs to meet Level A1 of QCVN 08:2008

- Ben Cui (Saigon river)
- Ben Suc (Saigon river)
- Thi Tinh (Thi Tinh river)
- Trung An (Saigon river)
- Hoa Phu (Saigon river)
- Phu Cuong (Saigon river)
- Hoa An (Dong Nai river)

(2) Stations being monitored for other purposes, consisting of the rest 17 stations which water quality needs to meet at least Level B1 in QCVN 08:2008

5.2 Summary for each determinant

Table 5: Kết quả tóm tắc cho các thông số chất lượng nước

Determinant	Type of value (min, max)	Action level		Required LoD	Actual LoD	Analytical method
		A1	B1			
pH	between	6-8.5	5.5-9		2	TCVN 6492:1999
Temperature	-					
Turbidity (NTU)	max				0.2	TCVN 6184:1996
TSS (mg/l)	max	20	50	4.0	0.5	TCVN 6625:2000
DO (mg/l)	min	6	4	1.2	0.02	TCVN 7324:2004
BOD_5 (20^oC) (mg/l)	max	4	15	0.8	**2**	TCVN6001-1:2008
COD (mg/l)	max	10	30	2.0	0.5	TCVN 4565:1988 or SM 5220C
Ammonia (NH_4^+ as N) (mg/l)	max	0.1	0.5	0.02	0.01	SM4500NH_3 F. 2005
Phosphate (PO_4^{3-} as P) (mg/l)	max	0.1	0.3	0.02	0.005	TCVN6202:2008
Salinity (Cl^-) (g/l)	max	250	600	50	0.01	Multi-parameter analyzer
Lead (Pb) (mg/l)	max	0.02	0.05	0.004	0.002	SMEWW 3113B
Cadmium (Cd) (mg/l)	max	0.005	0.01	0.001	**0.002**	SMEWW 3113B
Copper (Cu) (mg/l)	max	0.1	0.5	0.02	0.002	SMEWW 3113B
Chromium (Cr) (mg/l)	max				0.002	SMEWW 3113B

Manganese (*) (Mn) (mg/l)	max	0.2	0.5	0.04	**0.05**	SMEWW 3113B
E. Coli (MPN/100ml)	max	20	100	4	3	SMEWW 9221
Coliform (MPN/100ml)	max	2500	7500	500	3	SMEWW 9221
Oil & grease (mg/l)	max	0.01	0.1	0.002	0.005	TCVN

(*) According to TCXDVN 33:2006

5.3 Budget for monitoring activities

Table 9: Summary of budget allocated for monitoring activities in 201x

Activity	Description	Items	Budget (VND)
Surface water monitoring	Sampling, analysis, report writing, monitoring plan appraisal and monitoring results assessment	22 stations in Saigon – Dong Nai rivers + 10 stations in canal system	2,152,960,000
Hydrological monitoring	Measuring, report writing, monitoring plan appraisal and results assessment	15 hydrological stations	1,520,103,000
Groundwater monitoring	Sampling, analysis, report writing, monitoring plan appraisal and results assessment	15 stations with 40 wells	521,191,569
Coastal water monitoring	Sampling, analysis, report writing, monitoring plan appraisal and results assessment	9 stations	765,722,331
Grand total			**4,959,976,900**

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Nước thải sinh hoạt gây ô nhiễm sông Sài Gòn, http://www.sggp.org.vn/moitruongdothi/2012/6/291209/

ANNEX

Annex 1: Land use status of Ho Chi Minh city until 2010

Type of land	Area (ha)			Area and land owner						Compared to 2005	
	Total	%/total area	%/ group of land	Individual		Domestic owner		Foreign owner			
				Area	%	Area	%	Area	%	Increase	Decrease
WHOLE CITY	**209554.97**	**100**		**93302.79**	**44.52**	**114462.96**	**54.62**	**1789.22**	**0.86**		**0.02**
AGRICULTURAL LAND	***118171.66***	***56.39***	***100***	***75067.94***	***63.52***	***42951.69***	***36.35***	***152.02***	***0.13***		***5427.93***
Paddy field	27795.86	13.26	23.52	27493.72	98.91	302.14	1.09				8920.22
Grassland for animals	2228.14	1.06	1.89	1226.35	55.04	1001.79	44.96			694.31	
Annual plant	9959.25	4.75	8.43	7685.06	77.17	2274.19	22.83			1031.06	
Perennial plant	32285.30	15.4	27.32	28115.5	87.08	4140.28	12.82	29.53	0.01	1346.40	
Forest land	34114.23	16.28	28.87	5.96	0.02	34086.7	99.92	21.57	0.06	335.05	
Aquaculture land	9442.05	4.5	8	8894.42	94.2	547.63	5.8				322.31
Salt field	1943.37	0.92	1.64	1602.3	82.45	341.07	17.55			472.06	
Other agriculture land	403.46	0.19	0.34	45.09	11.19	257.46	63.81	100.92	25		64.29
NON-AGRICULTURAL LAND	***90747.82***	***43.3***	***100***	***17779.17***	***19.59***	***71331.45***	***78.6***	***1637.2***	***1.81***	***7055.79***	
Housing area	23552.89	11.24	25.95	16737.41	70.06	6389.74	27.13	425.74	2.81	3150.85	
Offices	439.89	0.21	0.48			431.64	98.12	8.25	1.88		416.57

Military land	2280.66	1.09	2.51			2280.66	100			413.31	
Security land	294.1	0.14	0.32			294.1	100			115.59	
Commercial land	11000.73	5.25	12.12	566.37	5.15	9877.73	89.79	556.63	5.06	1388.95	
Public land	18951.95	9.04	20.88	33.78	0.17	18292.74	96.58	625.43	3.25	977.44	
Religious land	410.42	0.2	0.45	9.77	2.38	400.65	97.62			9.43	
Cemetery	951.04	0.45	1.05	412.49	43.37	538.55	56.63			19.50	
River, stream and surface water use	32812.53	15.66	36.16	11.49	0.04	32779.88	99.9	21.15	0.06	1476.13	
Other type of non-agricultural land	53.62	0.03	0.06	7.86	14.66	45.76	85.34				78.84
UNUSED LAND	***635.50***	***0.31***	***100***	***455.68***	***71.7***	***179.82***	***28.3***				***1627.84***
Flat land	626.99	0.3	98.66	455.68	72.68	171.31	27.32				1630.95
Treeless rocky land	8.51	0.05	1.34			8.51	100			3.11	

[i] Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4. United States Environmental Protection Agency. Office of Environmental Information Washington, DC 20460. EPA/240/B-06/001 February 2006.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

SOCIALIST REPUBLIC OF VIET NAM

MINISTRY OF NATURAL RESOURCES & ENVIRONMENT

The Project
for
Strengthening Capacity of Water Environmental Management
in Vietnam

DQO Based Water Quality Monitoring Plan for

[Ba Ria-Vung Tau Province, Dinh river]

Table of contents

CHAPTER 1 INTRODUCTION

1.1 Introduction

Systematic water quality monitoring in Vietnam is a relatively new activity and the national strategy for monitoring was set out by the Ministry of Natural Resources and Environment (MONRE) through the publishing of Decision No. 16/2007/QD-TTg of January 29, 2007, Approving the General Planning on the National Network of Natural Resources and Environment Observation.

The Master Plan for the years up to 2020, approved by the Prime Minister together with his January 29 Decision, aims to build a comprehensive, advanced and modern national network of natural resource and environment observation stations, meeting the demand for basic information and data on the environment, water resources and hydrometeorology.

The network is also expected to assist effectively the treatment of environmental pollution, the forecast, warning, prevention and mitigation of damage caused by natural disasters, for the strong and sustainable national socio-economic development.

The specific objectives set for the years 2007-10 were to:

- Reorganize the management and administration apparatus and train more observers;
- Amend and make comprehensive observation regulations, processes and criteria;
- Consolidate and modernize, step by step, existing natural resource and environment observation stations; and
- Build and put into operation at least one-third of the proposed stations.

For the period 2011-15 period the objectives are to:

- Continue consolidating and modernizing existing observation stations;
- Build and put to operation at least half of the remaining stations; and
- Upgrade the natural resource and environment database.

For the final period, 2016-20, the objectives are to:

- Complete the building of, and put to efficient operation, all observation stations under the Plan;
- Raise the capability of observers, technicians and managers to satisfy the requirements of the national network of natural resource and environment stations.

The major tasks to be undertaken which will enable the implementation of the Master Plan include:

- To prepare and issue legal documents, econo-technical processes, regulations and norms related to the observation, collection, management and supply of information and data on natural resources and environment according to uniform standards to be applied nationwide;
- To promulgate more preferential policies to encourage persons engaged in natural resource and environment observation and survey, especially those working in deep-lying, remote, border and island areas;

- To standardize the profession of natural resources and environment observers;
- To step up scientific research, develop and apply advanced technologies, and enhance human resource training; and
- To expand and enhance international cooperation in the domain of natural resource and environment observation.

The implementation of the Master Plan will be effected by MONRE at the National level and the individual DONRE at the Provincial Level. At the National level the monitoring will focus on trans-national boundary water quality, and at provincial boundaries. At the provincial level the DONRE will focus on strategic locations within the province.

At the present time the details of the provincial Water Quality Monitoring Plans are prepared by a team of experts at the request of the Peoples' Committees. The plans are circulated for comment and revised and finally approved by the Peoples' Committees. The respective DONRE will subsequently implement the approved monitoring program.

1.2 Purpose of this document

The purpose of this document is to define the basis for the monitoring carried out at Provincial level by *Center of Environmental Monitoring and Analysis in BaRia-Vung Tau (CEMAB), BaRia-VungTau DONRE*. The document has been compiled as part of a training workshop to develop the capacity of the DONRE staff for the design and implementation of monitoring plans and programs. The workshop was part of the JICA funded Project for Strengthening Capacity of water Environmental Management in Vietnam carried out in 2011/2013. The document defines the environmental problems relating to water quality in the province, the purpose of the monitoring to be carried out, references all the methodologies to be used during the monitoring, the rational for selecting the contaminants to be measured and the reasons for the selected sampling stations. It also defines the statistical test to be used to interpret the data and what procedures will be used to handle concentrations which are below the Limit of Detection and how to identify rogue or outlier values.

By drawing all of the above information into one document it provides immediate access to all of the fundamental assumptions made at the planning stage and a reference to all of the technical procedures used during the monitoring process.

1.3 The DQO Process

The DQO Process is a series of logical steps that guides project managers or scientific staff in the planning of resource-effective collection of environmental data. It can be used to plan the compiling of existing data and the collection of data into the future as in the case of water quality monitoring

The process is flexible and iterative, and can be applied to both the decision-making process (e.g., compliance/non-compliance with a standard) and estimation (e.g., determining the mean concentration level of a contaminant in the environment).

The DQO process is described in full in Guidance on Systematic Planning Using the Data Quality Objectives Process EPA QA/G-4. In August 2011 the staff of the DONRE were given a 1-day introduction to the DQO process as part of the training program.

The DQO Process is used to establish performance and acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the

study. Use of the DQO Process leads to efficient and effective expenditure of resources; agreement between stakeholders on the type, quality, and quantity of data needed to meet the project goal; and the full documentation of actions taken during the development of the project.

CHAPTER 2 OBJECTIVES AND RESOURCES FOR MONITORING PROGRAM

2.1 Status of water quality in Dinh river basin

Importance of Dinh river system

Dinh river and rivers in the Dinh river system are of great socio-economic significance to Ba Ria – Vung Tau. These rivers are main surface water sources for daily, agricultural and industrial activities of the province. Da Den reservoir located on Dinh river provides a raw water source for key domestic water supply plants of the province namely Ho Da Den and Song Dinh drinking water treatment plants. In addition, other rivers such as Chau Pha river with Chau Pha reservoir and Da stream with Kim Long reservoir are major water sources for local inhabitants living in surrounding areas.

Status of water quality and pollution causes

According to the monitoring report of the Center of Environmental Monitoring and Analysis in Ba Ria-Vung Tau (CEMAB) in 2011, water quality in the Dinh river system should be taken into account. Reservoirs used as a domestic and agricultural water supply sources (including Da Den, Kim Long, and Chau Pha) show concentrations of NH_4^+, BOD, and COD at some certain time exceeding A2 level in QCVN 08:2008/BTNMT, which are usually found in dry season. The results indicate that these reservoirs have started to be polluted by domestic wastewater discharged from surrounding areas. Monitoring points from Cau Do dam toward downstream area witness a gradually increasing concentration of NH_4^+ exceeding B1 level (Cau Do dam and Long Huong bridge) or B2 level (from Co May bridge toward downstream area). At the monitoring point of Long Huong bridge, in addition to NH_4^+ pollution, the concentrations of BOD, COD, NO_2^-, and Fe are relatively high at some certain time despite their lower value than the B1 level. Water quality in Long Huong bridge area is obviously greatly affected by domestic wastewater sources in Ba Ria city area. Pollution at downstream points of Co May bridge and Phuoc Tinh fish port may result from seafood processing entities and shrimp ponds. In Cua Lap bridge area and Phuoc Tinh fish port, oil concentration is observed to exceed the QCVN (B2, QCVN 08:2008/BTNMT). The furthest area suffering from salt intrusion can be seen in Long Huong bridge where salinity is much higher than B1 level at some certain monitoring time.

Necessity of a monitoring plan

Regular monitoring results show that pollution in Dinh river has started and not yet been serious. However, regular monitoring for quality evaluation of domestic water supply sources is of great significance and necessity for timely control of water source quality trend, especially of pollution problems so as to provide warnings and orientations for water source protection.

2.2 Overall information on the monitoring plan

2.2.1 Objectives of the monitoring plan

The monitoring plan for Dinh river basin in Ba Ria-Vung Tau province is designed to reply to the questions in priority order as follows:

(i) Is water quality of rivers and lakes in Dinh river system suitable to the water use requirements specified in QCVN?

(ii) Are there longitudinal changes in river water quality and how is the change trend?

(iii) Do highly potential pollution sources in Dinh river basin exert impacts on the river water quality?

(iv) Does water quality temporally get worse (through years)?

(v) Do and how do meteorological factors and seasons affect water quality?

2.2.2 Type of monitoring and scope of the monitoring plan

(1) Type of Monitoring

Accroding to Circular 29/2011/TT-BTNMT, there are two types of monitoring including baseline environmental monitoring and impact environmental monitoring. As such, the type of monitoring employed in the Dinh river monitoring plan can be classified as an impact environmental monitoring.

Target population of the monitoring plan is surface water including river, stream and lake water.

(2) Spatial scope

The water monitoring plan for Dinh river system will be conducted in main Dinh river and its main tributaries and distributaries in Ba Ria – Vung Tau province.

(3) Deadline for the monitoring program

A monitoring plan lasts for a year. The starting date of the plan is 01st January and the plan ends on 31st December of a year. The plan implementation is summed up in the annual report to be submitted in the early time of the next year. Additionally, a brief report for each monitoring trip is required.

2.2.3 Composition of the monitoring planning team

A planning team comprises 5 key members of the Center of Environmental Monitoring and Analysis in Ba Ria-Vung Tau. List of members and their responsibilities are presented in Table 2.1.

Table 2.1: List of members in planning team

Name	Position	Responsibilities	Contact
Le Tuan Kiet	Vice director, CEMAB	Team leader, final decision maker	0903 809 553 kietqtmtbrvt@yahoo.com
Nguyen Xuan Son	Deputy head, monitoring division	Vice team leader, in charge of general information collection	0989 227 220 xuanson0171@yahoo.com
Nguyen Thi Hang	Head, monitoring division	Member	
Le Thi Thanh Lieu	Head, analysis division	Member, in charge of information on analysis method	0909 652 072 lieuthanh3011@yahoo.com
Nguyen Thi Le Hang	Deputy head, analysis division	Member	

2.3 Resources for the monitoring plan

2.3.1 Budget for monitoring activities

The budget for monitoring activities in Dinh river basin is extracted from the budget for the general

monitoring plan for rivers and lakes in Ba Ria –Vung Tau province, which is determined in Decision 79/2009/QĐ-UBND of Ba Ria-Vung Tau Provincal People Comittee. Table 2.2 below lists brief estimation of budget breakdown for monitoring activities in Dinh river basin.

Table 2.2: Budget for monitoring activities of the monitoring plan in Dinh river basin

Monitoring activities	**Detail**	**Budget**
Sampling (6 times)	- Travelling means - Allowance for involved staff - Sample preservation cost	15,000,000
Sample analysis in CEMAB (6 times)	- Chemicals - Tools - Energy	135,000,000
Manpower involved in management & analysis (6 times)	- Management fee - Payment for analysis staff	27,000,000
External analysis (outsource) (6 times)	- Sample sending cost - Sample analysis cost	22,000,000
Total		**199,000,000**

2.3.2 Tasks and qualifications/background of monitoring staff

The monitoring plan for Dinh river basin is implemented by Centre of Environmental Monitoring & Analysis in Ba Ria- Vung Tau (CEMAB). Most of activities from monitoring plan making, sampling, analysis, and reporting are conducted by CEMAB. CEMAB's human resources used for the monitoring plan are listed in table 2.3.

Table 2.3: Tasks and background of CEMAB staff

Unit	**Full name**	**Position**	**Background**	**Task**
CEMAB	Le Tuan Kiet	Vice director	University degree, chemical engineering	General management
Monitoring	Nguyen Thi Hang	Head,monitoring division	University degree, biology	General management
	Nguyen Xuan Son	Deputy head,monitoring division	M.Sc.: natural resources & environment B.Sc.: environmental chemistry	Synthesizing & reporting
	Trinh Dinh Loi	Official	College degree, Silicate chemistry	Sampling, preparation of service report
	Le Van Cuong	Official	Vocational certificate, hydrometeorology	
	Le Tu Anh	Official	B.Sc, Seafood Processing technology	
	Truong Thi Le Phuong	Official	Vocational certificate on environment	
Analysis	Le Thi Thanh Lieu	Head, analysis division	B.Sc. on chemistry	As, Hg analysis
	Nguyen T Le Hang	Deputy head, analysis division	B.Sc. on environment	Microbial analysis
	Doan Thanh Hai	Official	M.Sc. on biology	Analysis of total oil;

Unit	Full name	Position	Background	Task
				mineral oil, T-Ca & Mg, H_2S
	Pham Ba Thien	Official	B.Sc. on analytical chemistry	Analysis of heavy metals (Cd, Pb,..), turbidity, pH
	Nguyen Thi Kim Loan	Official	B.Sc. on biology	Analysis of DO, Fe, $PO_4^{3-,}$ Cl^- (residual)
	Trinh Thi Thuc	Official	College degree on chemistry	Analysis of BOD, COD, permanganate
	Hoang Thi Hoa	Official	College degree on chemistry	Analysis of T-N, NH_4^+, SO_4^{2-}
	Nguyen Ngoc Anh	Official	College degree on environment	Analysis of color, TSS, NO_2^-, NO_3^-
	Nguyen Thi Luat	Official	College degree on chemistry	
Loc An station	Nguyen Vy Quang	Head of the station	B.Sc. on food chemistry	General management
	Nguyen Huu Phat	Official	College degree on environment	Sampling, analysis
	Cao Manh Cong	Official	College degree on environment	Sampling, analysis
	Do Thi Thanh Nga	Official	Vocational certificate on environment	Sampling, analysis

2.3.3 Commitments of CEMAB staff to other activities

In addition to the tasks above, CEMAB staff can join in other activities of DONRE or CEMAB:

- Provide training and participate in short-term and long-term training courses to enhance capacity for newcomers and update new methods –techniques (timing for these activities is equally distributed all the year round)
- Attend workshops and training courses held by VEA or VEA's monitoring center
- Attend mass organization activities (sports, environmental day event, green campaigns) held by DONRE (short time, limited number of staff)
- Activities of the Centre: visiting other units, travelling for tourism purpose, etc.…

2.3.4 Field and laboratory equipment

(1) Field equipment

Field equipment used for surface water sampling is fully equipped by CEMAB as listed in the table 2.4 below.

Table 2.4: Field equipment of CEMAB's

No	Items	Manufacturer/Origin/Model	Number	Specification
1	Field sampling tools	COLE PARMER (USA)	01	Max. length (2.5*2m)
2	ALPHA vertical water sampler	WILDCO (USA).	01	
3	ALPHA horizonal water sampler	WILDCO (USA)	01	
4	KEMMER bottom water sampler	WILDCO (USA)	02	
5	Closed Water Sampler	Sigma SD900	01	
6	EC meter	WTW (Germany), LF330	01	Electrical conductivity, salinity (TDS: 0-1999mg/l)
7	Multi-parameter meter	Horiba (Japan) U-52	01	temperature, pH, DO, salinity, conductivity, TDS, turbidity
8	Satellite positioning instrument	GARMIN (USA), GPS 12 XL	01	
9	KTS camera	Sony	01	4MB resolution
10	Velocity and cross flow area meter	SIGMA 950	01	
11	Ultrasonic flow meter	Cole-Parmer (USA), 32986-00	01	

(2) Laboratory equipment

List of laboratory equipment of CEMAB's is presented in detail in table 2.5.

Table 2.5: List of CEMAB's laboratory equipment

Equipment	Manufacturer/Origin/Model	Number	Specifications
F-AAS atomic absorption spectrometer	Perkin Elmer (USA)	01	Pb, Cd, Cr, Cu, Ni, Mn, Hg, Zn, K, Na, Ca, Mg, Fe Graphite furnace for low concentrations or high atomization temperature elements (Cd, Pb, Al, ...) Hydride vapor generation/cold vapor technique (cho As, Se, Hg...).
GC-XL Gas chromatograph equipment	Perkin Elmer (USA)	01	Automatic inject, dectector: ECD, FID
Spectrophotometer	Hach (USA), DR2010	01	400-900 nm
Spectrophotometer	Germany, DR2800	01	400-800 nm
UV-vis Spectrophotometer	Labomed (USA)		190-1100 nm
pH meter	Switzerland, S20	01	0-14
pH/ion meter (Floride measurement)	Horiba (Japan), LAQUA	01	
Disolved oxygen meter	Schott –Germany	01	
Oil content analyzer	OCMA 310	01	
Colony counter	Taiwan	01	

Equipment	**Manufacturer/Origin/Model**	**Number**	**Specifications**
Microscope	Labova	01	4 glass plates
Kejdahl distillation set	TT121A	01	
Acid vapor suction and neutralization	TUR	01	Absorption by concentrated Na_2CO_3 or NaOH
Vacuum instrument	Viet Nam	01	100-200 kPa
Rotary Evaporator	Bibby (England), RE300	01	20-190 rpm
Centrifuge	Germany, T30	01	
Soxhlet extraction equipment	Gerthadt (Germany)	01	25-425 ^oC
Solid phase extraction apparatus	Wheaton/Germany	01	
Automatic distillation system	VAP20	01	Cooling water 3 l/min, 1.3 bar
COD reactor	Hach (USA)	01	105-155 ^oC
BOD incubator	Aqualytic (Germany), AL654	01	2-50 ^oC
Incubator	Velp (Italy), FOC 225 E	01	0-50 ^oC
Incubator	Hach (USA), 205	01	0-50 ^oC
Incubator	Sanyo (Japan), MIR	01	30-70 ^oC
Incubator	Czechoslovakia, Incucell 111	01	5-100 ^oC
Dyring oven	Germany	01	120 ^oC
Dyring oven	Sheldom (USA), 1370GX	01	30-275 ^oC
Dyring oven	Memmert (Germany)	01	220 ^oC
Cooling cabinet	AUCMA	01	360 L
Cooling cabinet	AS (Italy), FRI 500V-GL	01	2-12 ^oC, 500 L
Cooling cabinet	Viet Nam, JW 470R	01	430 L
Furnace	Nabertherm (Germany), HTC	01	1400 ^oC, 3 L
Water bath	South Korea, WISE BATH	01	25-100 ^oC
Water bath	Memmert (Germany), WB14	01	30-95 ^oC
Cold water bath	Julabo (Germany), F12	01	-15 – 100 ^oC
Water distillation instrument	Aquatron A4000D	01	4 l/h
Water distillation instrument	Aquatron A8000	01	8 l/h
Super-clean water filtration system	Barnstead/Thermoly (USA), D7401	01	1.3 l/min
Ultrasonic cleaner	Branson (USA)	01	Frequency 40 kHz
Autoclave	Sturdy (Taiwan), SA 252F	01	1.5 atm, 120 ^oC
Autoclave	China, YX 280A	01	0.25 MPa, 138 ^oC
Magnetic stirrer	Hanna (Singapore), HI 8418	01	
Heating and Magnetic stirrer	Europe, ARE	01	50-370 ^oC, 50-1200 rpm
Technical balance	Mettler Toledo (Switzerland), ML1502E	01	0-1.52 kg; 0.01 g
Analytical balance	Ohause (Switzerland), E 12140	01	0-210 g; 0.0001 g
Refrigerator	Sanyo (Japan), SMR – 184 GY	01	177 L
Refrigerator	Lec (England), IST 56	01	217 L
Refrigerator	Sanyo (Japan)	01	522 L
Laminair	BioAir (Italy), AURA-VF48	01	Bulb > 100lux
Fume hood	Labconco (USA), Basic 47	01	

CHAPTER 3 NECESSARY INFORMATION FOR MONITORING PLAN DEVELOPMENT

3.1 Characteristics of Dinh river system

Dinh river and Dinh river system lie entirely in Ba Ria-Vung Tau. Dinh river starts from Cu Bi commune, Chau Duc district and runs in the north- south direction, generating a natural boundary between the two districts of Tan Thanh and Chau Duc. The upstream section of Dinh river is named as Soai river. After running about 15km, Dinh river is temporarily stopped/hindered, forming Da Den reservoir. Tributaries of Dinh river in the upstream area include Gia Hop river, and Da stream. In addition, Da Den reservoir also receives water from other streams such as Chich, Com, Nhat, and Lup. From Da Den reservoir, Dinh river continues running between the boundary of the two districts of Tan Thanh and Chau Duc, receiving more water from Son stream, Chau Pha river and Song Cau stream. Dinh river, then, flows through Ba Ria city and into Ganh Rai bay in Vung Tau city. In Ba Ria city, two dams are built on Dinh river, comprising Dinh river dam (at the boundary of Hoa Long commune and Phuoc Hung ward) and Cau Do dam (Phuoc Hung ward). In Phuoc Trung ward, Ba Ria city, Dinh river is divided into 3 branches. The middle branch is considered as Dinh river, running through Vung Tau city, and thereby, many sea ports are found along the river banks such as Cat Lo port. The right branch is called Mui Giui river, running through Long Son commune, Vung Tau city and also flow into Ganh Rai bay. The left branch is named as Cua Lap river, flowing into the East Sea and forming a boundary between Long Dien district and Vung Tau city. Dinh river, from the starting point to the sea, is about 54 km in length. Rivers/streams in the Dinh river system are listed in table 3.1 and visually presented in figures 3.1 and 3.2.

Table 3.1: Rivers/streams of Dinh river system in Ba Ria-Vung Tau province

Rivers/steams	Length (km)	Dams on rivers/streams	Characteristics
Dinh	54	Da Den Reservoir dam, Song Dinh dam, and Cau Do dam	River water is used for domestic water supply (upstream area of Da Den reservoir), agricultural activities (downstream area of Da Den reservoir), shrimp farming and salt making (downstream area of Long Huong bridge)
Tributaries			
Gia Hop river	14	*None*	Flowing into Dinh river in upstream area of Da Den reservoir
Da stream	11	Kim Long Reservoir dam	
Chich stream	10	*None*	Flowing into Da Den reservoir
Com stream	3		
Nhat stream	4		
Lup stream	12		
Chau Pha river	26	Nha Be Reservoir dam, Chau Pha Reservoir dam	Flowing into Dinh river in downstream area of Da Den reservoir
Son stream	12	*None*	
Song Cau stream	8	Ben Da Reservoir dam	

Rivers/steams	**Length (km)**	**Dams on rivers/streams**	**Characteristics**
Distributaries			
Cua Lap river	17	*None*	Flowing into the sea
Mui Giui river	12		

Dinh river is of special significance to Ba Ria-Vung Tau province. In Dinh river system, various man-made lakes are observed namely Da Den reservoir (Dinh river), Kim Long reservoir (Da stream), Chau Pha reservoir (Chau Pha river), Nha Be reservoir (Chau Pha river), and Ben Da reservoir (Song Cau stream). These reservoirs are water supply sources for not only agricultural activities but also for domestic water supply factories. List of reservoirs in Dinh river system is indicated in table 3.2 and visually presented in figures 3.1 and 3.2.

Table 3.2: Lakes in the Dinh river system of Ba Ria –Vung Tau province

Reservoirs	**Area (ha)**	**Functions**
Da Den	348	Domestic and agricultural water supply source
Kim Long	44	Domestic and agricultural water supply source
Chau Pha	123	Domestic and agricultural water supply source
Nha Be	7	Agricultural water supply source
Ben Da	6	Agricultural water supply source

Hydraulic structures of Dinh river system including river/stream system, location of dams and reservoirs are displayed in figures 3.1 and 3.2 below.

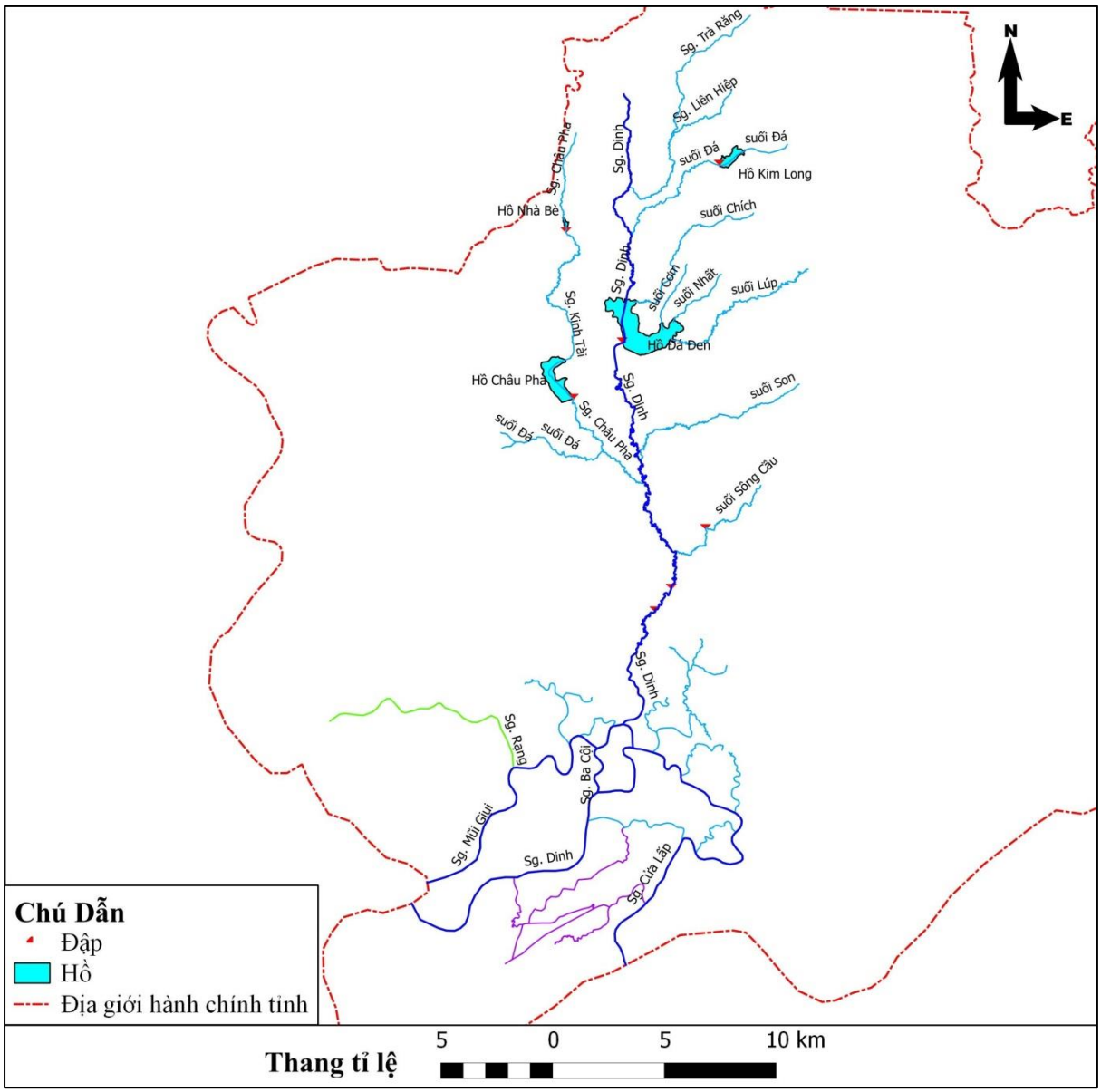

Fig. 3.1: Rivers and lakes in Dinh river basin in Ba Ria- Vung Tau province.

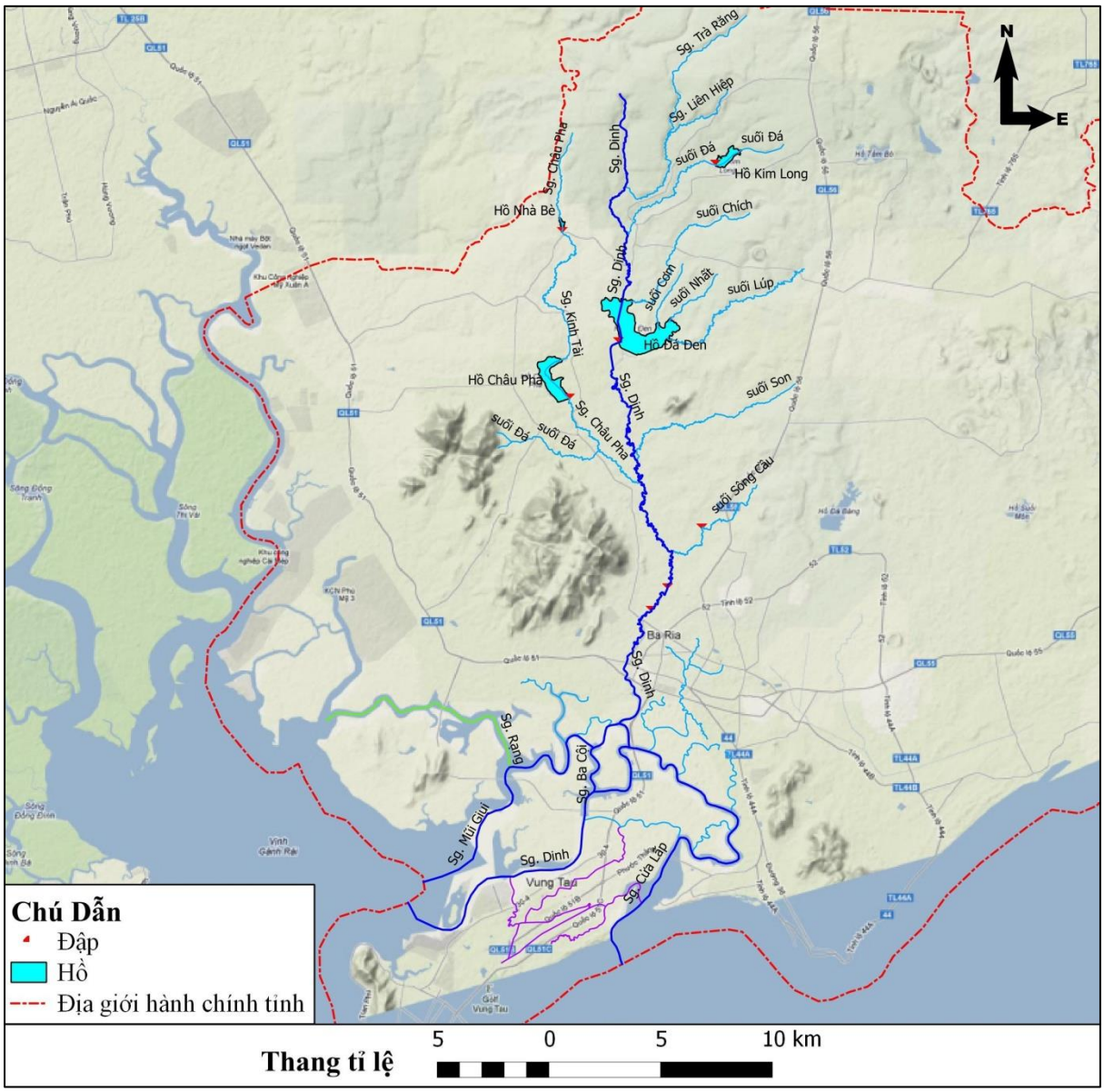

Fig. 3.2: Rivers and lakes in Dinh river basin in Ba Ria- Vung Tau province on topographic map.

3.2 Land use categories

(1) Land use classification

According to Resolution of the Government No 06/2007/NQ-CP dated 29th January 2007 upon revision of land use planning till 2010 and 5-year land use plan (2006-2010) in Ba Ria – Vung Tau province, land use status of Ba Ria – Vung Tau province can be seen in the table below.

Table 3.3: Land use planning for Ba Ria - Vung Tau province till 2010.

No	Land categories	Area (ha)	Percentage (%)
	TOTAL NATURAL AREA	**198,865**	**100.00**
1	**AGRICULTURAL LAND**	**142,377**	**71.59**
1.1	Land for agricultural production	101,251	
1.1.1	Land for annual crops	29,397	
	rice cultivation land	15,940	
1.1.2	Land for perennial crops	71,854	
1.2	Forestry land	33,561	
1.2.1	Land for production forest	6,030	
1.2.2	Land for protection forest	10,676	
1.2.3	Land for special use forest	16,855	
1.3	Aquaculture land	6,317	
1.4	Salt pans	1,171	
1.5	Other agricultural land	77	
2	**NON-AGRICULTURE LAND**	**55,417**	**27.87**
2.1	Residential land	6,380	
2.1.1	Residential land in urban area	3,694	
2.1.2	Residential land in rural area	2,686	
2.2	Land for special use	34,243	
2.2.1	Land for govermental office and public service	328	
2.2.2	Land for national defence & security	9,673	
2.2.2.1	National defence land	7,867	
2.2.2.2	Security land	1,806	
2.2.3	Non-agricultural production and bussiness land	11,256	
2.2.3.1	Industrial park land	6,214	
2.2.3.2	Non-agricultural production and bussiness land	4,197	
2.2.3.3	Mineral exploitation land	208	
2.2.3.4	Land for construction materials	637	
2.2.4	Land used for public purposes	12,986	
2.2.4.1	Transportation land	9,195	
2.2.4.2	Land for irrigation structure	1,284	
2.2.4.3	Land for energy and communication transfer	208	
2.2.4.4	Cultural works land	874	
2.2.4.5	Land for health care/medical sector	80	
2.2.4.6	Land for education & training	677	
2.2.4.7	Sport land	244	
2.2.4.8	Market land	97	
2.2.4.9	Historical, cultural relics land	149	
2.2.4.10	Land for waste disposal & treatment	178	
2.3	Land for religous beliefs	356	
2.4	Cemetery land	474	
2.5	Rivers, streams and specially used water surface	13.539	
2.6	Other non-agricultural land	425	
3	**UNUSED LAND**	**1,071**	**0.54**

(2) Land use classification in Dinh river basin

Based on satellite image data sources extracted from Google Earth for the period of 2003-2010, land in Dinh river basin is categorized according to different use purposes and can be seen in figures 3.3 – 3.6 below. Land categories are grouped as follows: (1) residential land in rural areas, (2) residential land in urban areas, (3) non-agricultural production land, (4) sea ports, (5) aquaculture & salt making land, (6) rice & subsidiary crop land, (7) perennial crop land, (8) forest land, (9) unused land, and (10) lakes, ponds land.

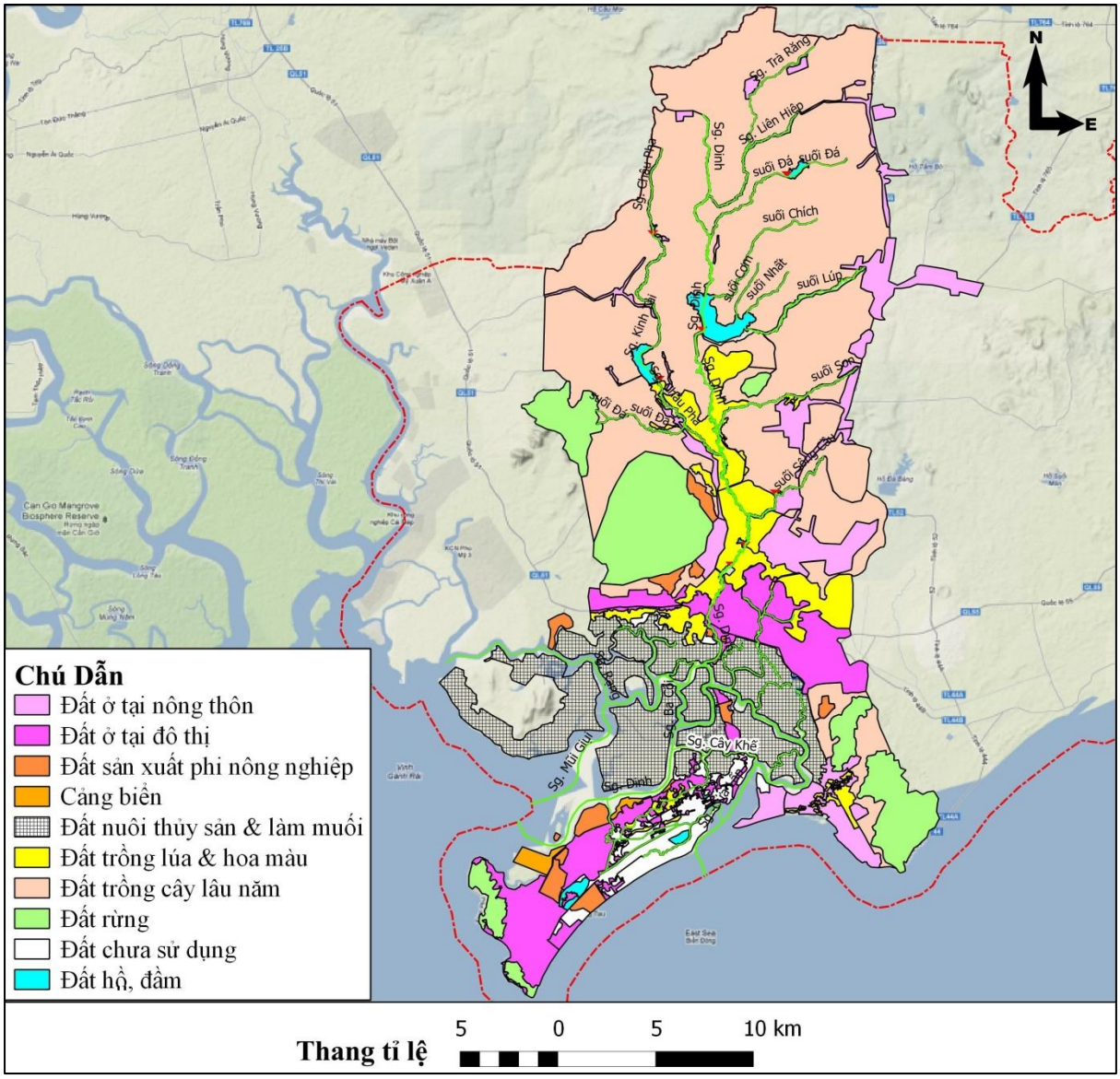

Fig. 3.3: Land use classification in Dinh river basin.

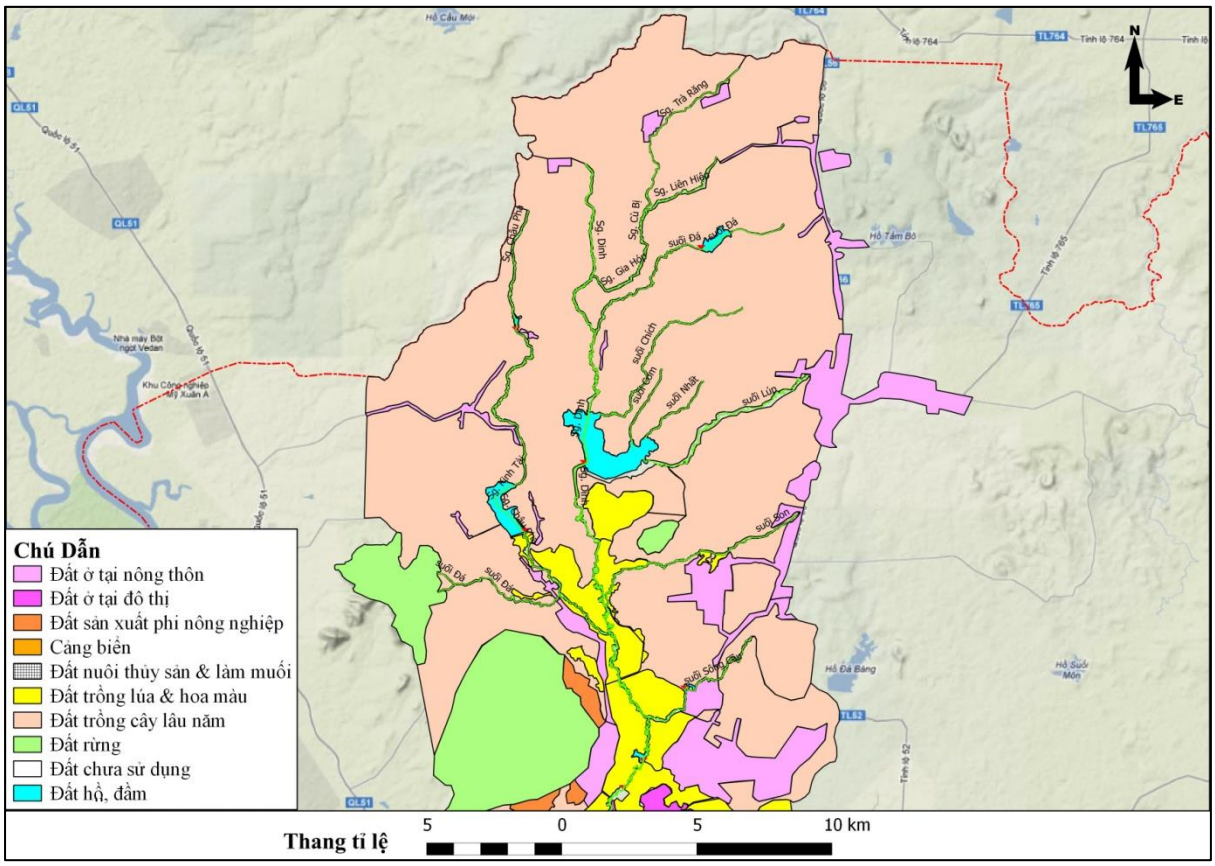

Fig. 3.4: Land use classification in upstream area of Song Dinh dam.

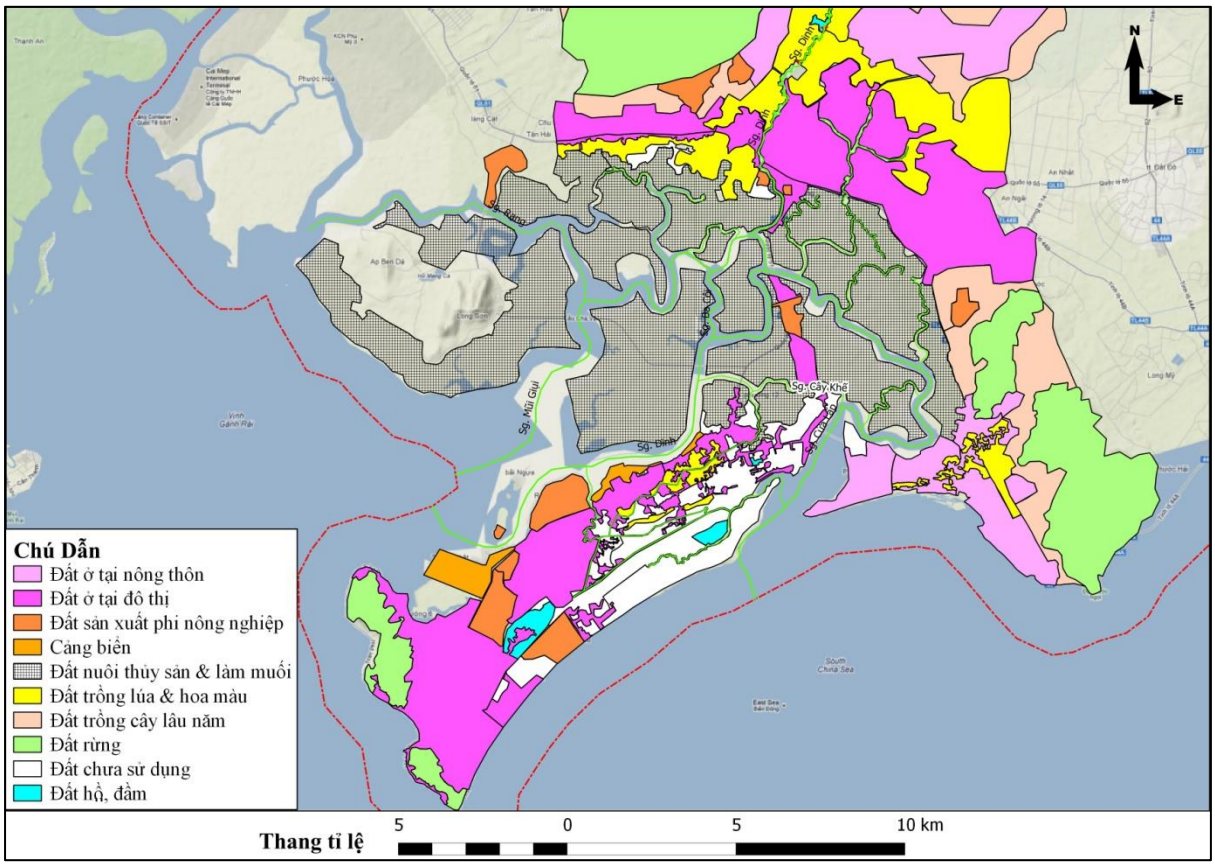

Fig. 3.5: Land use classification in downstream area of Song Dinh dam.

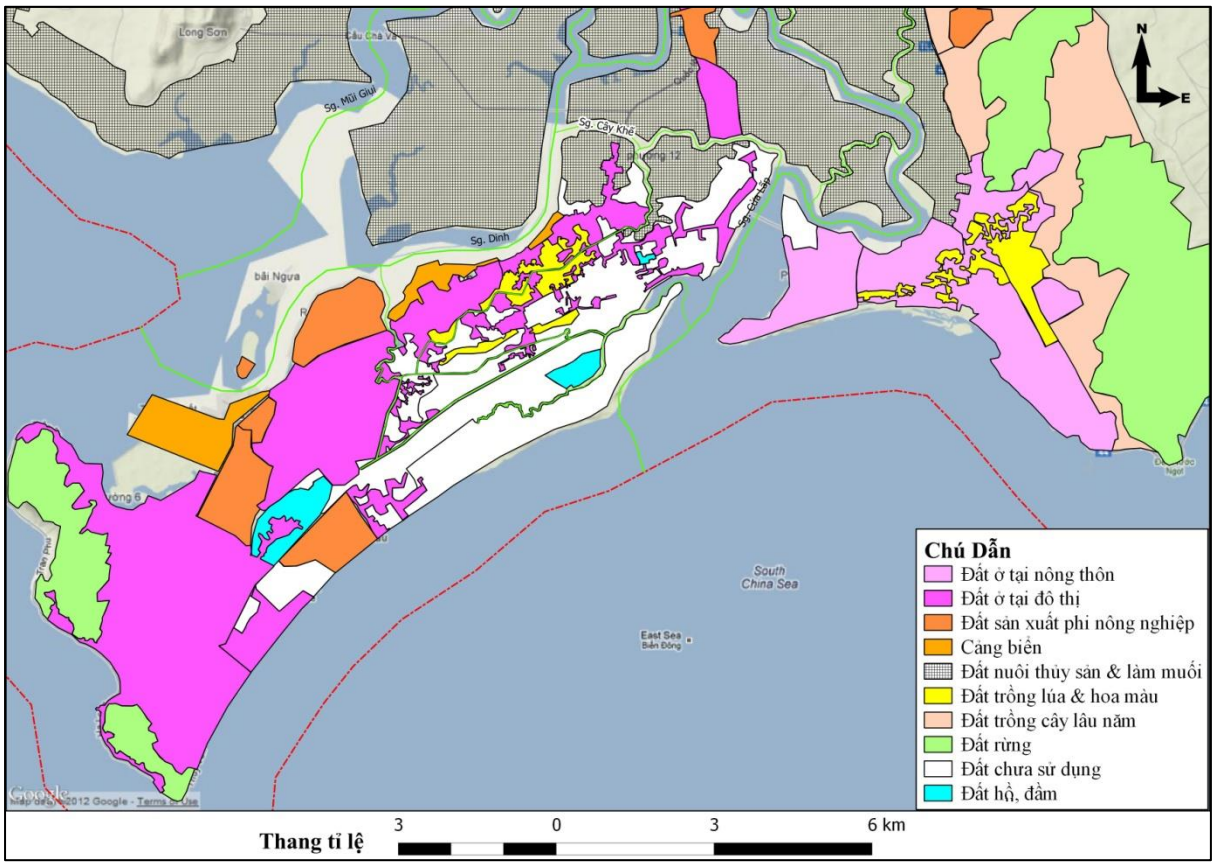

Fig. 3.6: Land use classification in Vung Tau city.

(3) Land use planning till 2020

In addition to the above mentioned present land uses, oriented partitioning of land use planning till 2015 in Ba Ria – Vung Tau province approved by Prime Minister in Decision 15/2007/QĐ-TTg, presented in figure 3.7 below.

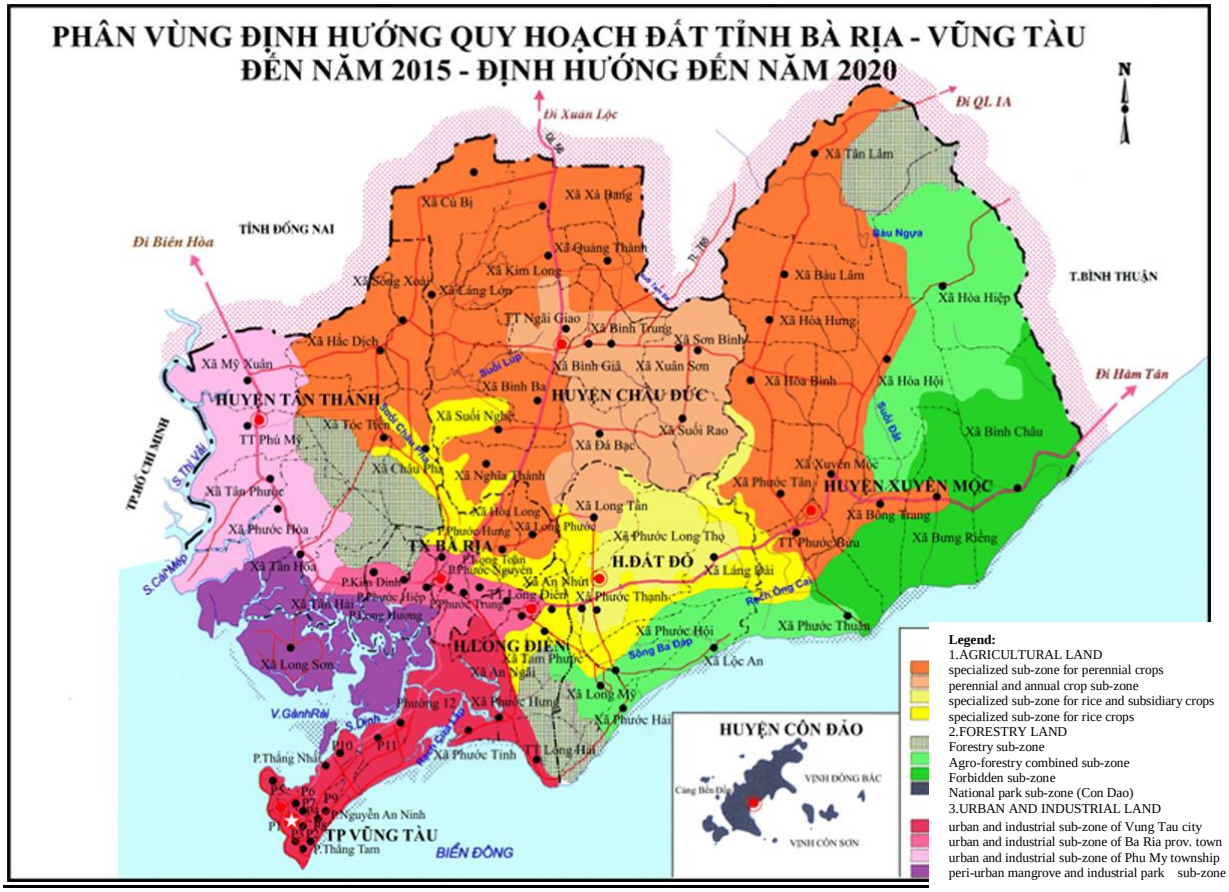

Fig. 3.7: Oriented partitioning of land use planning for Ba Ria- Vung Tau province till 2015 – orientations till 2020.

3.3 Location of intake points

3.3.1 Intake points for domestic water factories

Intake points from Dinh river system supply water for domestic water factories listed in table 3.4. Da Den reservoir supply water for two Da Den reservoir and Dinh river water supply factories with a total capacity of 150,000 m^3/day – major domestic water supply source for Ba Ria and Vung Tau cities. Additionally, water of Kim Long and Chau Pha reservoirs can also be used for domestic water factories.

Table 3.4: List of water intake points from Dinh river system for domestic water factories

No	Intake points	Location	Water sources	Domestic water factories
1	Kim Long reservoir	Kim Long commune, Chau Duc district	Kim Long reservoir	Ngai Giao water supply factory (4000 m^3/day)
2	Da Den reservoir	in Song Xoai commune, Tan Thanh district & Lang Lon, Binh Ba, Suoi Nghe communes in Chau Duc district	Da Den reservoir	Water supply factories of Da Den reservoir (120,000 m^3/day) and Dinh river (30,000 m^3/day)
3	Chau Pha reservoir	Chau Pha commune, Tan Thanh district	Chau Pha reservoir	Chau Pha water supply factory

3.3.2 Intake points for agricultural activities

In addition to water supply for domestic/daily activity purposes, Dinh river and other rivers in Dinh river system provide water for agricultural activities. Water intake points for agricultural activities are seen in table 3.5.

Table 3.5: List of water intake points from Dinh river system for agricultural activities

No	Intake points	Locations	Water source	Note
1	Canal gate 1	Nghia Thanh commune, Chau Duc district	Dinh river	
2	Canal gate 2	Chau Pha commune, Tan Thanh district	Dinh river	
3	Canal gate 3	Hoa Long commune, Ba Ria provincial town	Dinh river	
4	Canal gate 4	Tan Hung commune, Ba Ria provincial town	Dinh river	Water intake from Song Dinh dam
5	Canal gate 5	Phuoc Hung ward, Ba Ria provincial town	Dinh river	Water intake from Song Dinh dam

Specific locations of water intake points for domestic water factories and agricultural activities are described in figure 3.8 below.

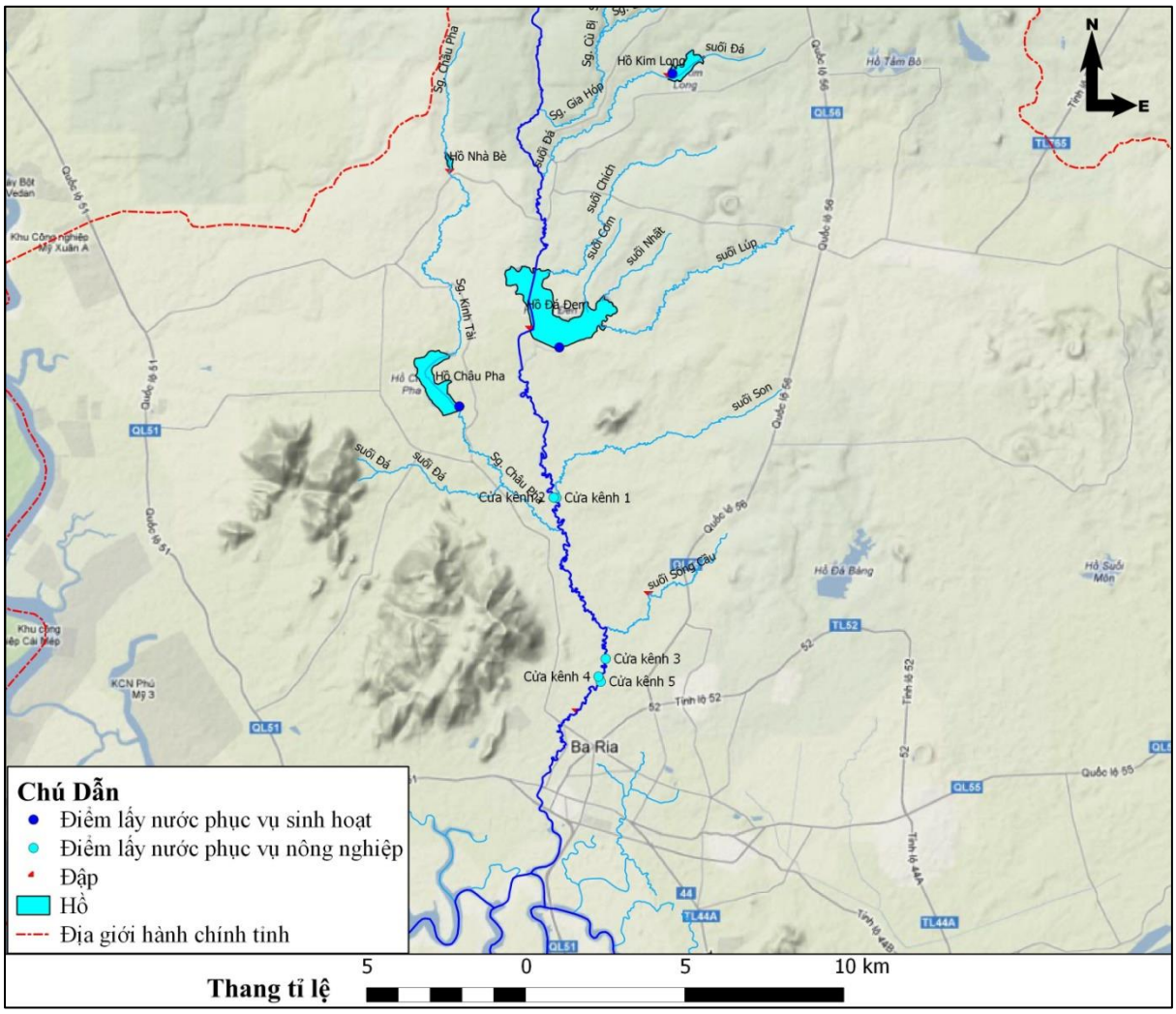

Fig. 3.8: Location of water intake points along Dinh river in Ba Ria- Vung Tau province.

3.4 Sensitive areas

Sensitive receiving areas in Dinh river system are mainly shrimp ponds, on-river cage fishing farms and salt pans in downstream area of Co May bridge. Table 3.6 below provides a list of receiving points and relatively general location of these points.

Table 3.6: List of sensitive points

Receiving points	Location	Scope/capacity	QCVN application
Shrimp ponds	• Ba Ria city: Phuoc Trung, Long Huong, Kim Dinh wards • Vung Tau city: ward No 12 and Long Son commune • Long Dien district: Long Dien township & An Ngai commune	*No information*	QCVN 10:2008/BTNMT, aquaculture area
Salt pans	• Ba Ria city: Long Toan and Phuoc Trung wards, • Vung Tau city: Ward No 12 & Long Son commune • Long Dien district: Long Dien township and An Ngai commune	1200 ha, output 80,000 ton/year	*Not determined*
On-river cage fishing farms	Dinh river in Long Son commune	*No information*	QCVN 10:2008/BTNMT, aquaculture area
*: Based on monitoring data in 2010 from CEMAB, Dinh river water in downstream area of Long Huong bridge has salinity > 5 ppt and then must be considered as coastal water. Applied regulation for water quality in the area, therefore, must be QCVN 10:2008/BTNMT for coastal water.			

3.5 Location of pollution sources

Entities and their operation types possibly causing river/stream water pollution in Dinh river basin are listed in table 3.7.

Table 3.7: List of potential pollution sources in Dinh river basin

No	Types	Pollution sources	Location/description	Impacts	Main pollutants
1	Dump site	Toc Tien dump site	Toc Tien commune, Tan Thanh (planning area of 100 ha, but presently only 14 hectares are being used)	Possibly exerting impacts on groundwater	Heavy metals, ammonium, coliform
2	Mineral mining	Quarrying area in Chau Pha commune	Chau Pha commune, Tan Thanh district	*No information*	TSS
3		Kim Dinh stone quarrying and crushing area	Kim Dinh ward, Ba Ria city		TSS
4	Livestock raising	Hung Viet pig farm	Long Tam ward, Ba Ria city		ammonium, coliform, sulfide
5		Ba Ria chicken hatchery	Phuoc Hung ward, Ba Ria city		ammonium, coliform, sulfide
6	Agricultural processing	Cashew nut processing entity	Phuoc Hung ward, Ba Ria city		Phenol

No	Types	Pollution sources	Location/description	Impacts	Main pollutants
7	Seafood processing: 178 entities, 250 thousand tonnes of finished products /year	Tan Hai seafood processing cluster	Tan Hai commune, Tan Thanh district (Tan Thanh district includes 22 entities, mainly found in Tan Hai commune)	Having impacts on aquaculture area, Rang river	ammonium, plant oil & animal fat, residual chlorine,coliform
8		Some seafood processing entities in Ba Ria city	Phuoc Trung ward, Ba Ria city (Ba Ria city has 7 entities)	*No information*	ammonium, plant oil & animal fat, residual chlorine,coliform
9		Phuoc Co seafood processing cluster	Ward No 12, Vung Tau city (Vung Tau city with 59 entities, mainly found in Ward No 12 (33 entities))	Pollution in Cay Khe river, adversely affecting aquaculture area and salt pans	ammonium, plant oil & animal fat, residual chlorine,coliform
		Long Dien : 68 entities	*No information*	adversely affecting aquaculture area and salt pans	ammonium, plant oil & animal fat, residual chlorine,coliform
10	Power plant	Ba Ria thermal power plant	Long Huong ward, Ba Ria city	*No information*	Temperature
11	Petroleum & ship building	Dinh Co gas treatment plant	An Ngai commune, Long Dien district		Mineral oil& grease
12		Nam Con Son plant	An Ngai commune, Long Dien district		Mineral oil& grease
13		Vung Tau Petroleum Service & Shipbuilding Company	Ward No 11, Vung Tau city		Mineral oil& grease
14		Cu Lao Tau petroleum warehouse	Cu Lao Tau, Thang Nhat ward, Vung Tau city		Mineral oil& grease
15		Storage Company No 4	Thang Nhat ward, Vung Tau city		Mineral oil& grease
16		Petroleum exploitation enterprise	Phường Thắng Nhất, thành phố Vũng Tàu		Mineral oil& grease
17		Vietsopetro service -joint venture enterprise	Thang Nhat ward, Vung Tau city		*No information*
18		Petroleum service port limited company	Thang Nhat ward, Vung Tau city		Mineral oil& grease
19		Sao Mai-Ben Dinh petroleum	Thang Nhat ward, Vung Tau city (112 ha)		Mineral oil& grease

No	Types	Pollution sources	Location/description	Impacts	Main pollutants
		service unit			
20	Industrial park	Industrial –small scale industrial cluster of Ngai Giao township (30 ha): Meisheng Textile Ltd. Co.	Ngai Giao towship, Chau Duc district (spinning (18000 ton/year), textile (5000 ton/year), dying (600 ton/year))	According to the design: wastewater pipe system is 9.2 km long, running through Ngai Giao township, communes of Binh Ba & Suoi Nghe (Chau Duc) flowing into Dinh river. Final point of this pipe is Ri stream bridge – about 3 km from Da Den reservoir downstream. Actually: a part of wastewater enters a rainwater drainage system which flow into Lup stream.	Cr, Fe, Cu, residual chlorine, mineral oil& grease
21		Hong Lam industrial park	Kim Dinh ward, Ba Ria city	496 ha	*No information*
22		Dong Xuyen industrial park	Rach Dua ward, Vung Tau city	161 ha	
23	River and sea ports	Ha Loc port	Ward No 11, Vung Tau city	*No information*	Coliform, mineral oil& grease
24		Cat Lo fish port	Ward No 11, Vung Tau city		Coliform, mineral oil& grease
25		Con Dao ship-going port	Ward No 11, Vung Tau city		Coliform, mineral oil& grease
26		Cat Lo port	Ward No 11, Vung Tau city		Coliform, mineral oil& grease
27		Vietsopetro port	Thang Nhat ward, Vung Tau city		Coliform, mineral oil& grease
28		PTSC port	Thang Nhat ward, Vung Tau city		Coliform, mineral oil& grease
29		Phuoc Tinh fish port	Phuoc Tinh commune, Long Dien district		Coliform, mineral oil& grease
30	Hospitals	Ba Ria-Vung Tau	Phuoc Hung ward, Ba		Coliform, plant

No	Types	Pollution sources	Location/description	Impacts	Main pollutants
		hospital	Ria city		oil& animal fat, sulfide, ammonium
31		Ba Ria-Vung Tau hospital (new)	Long Tam ward, Ba Ria city		Coliform, plant oil& animal fat, sulfide, ammonium

At the 8th Aug 2012. meeting on the implementation of conclusions of Provincial Party Standing Committee on seafood processing zone planning in the province, the places for establishment of 3 seafood processing zones in the province were unanimously agreed, including : Ong Sam mound area (ward No 12, Vung Tau city) with a total area of about 340 ha, Loc An fish meal plant (Dat Do district) with a total area of 29 ha, and Theo Leo hamlet area, Binh Chua commune, (Xuyen Moc district) with a total area of 29 ha. The seafood processing zone planned to be in Ong Sam mound area will have around 60 entities from Vung Tau City and 20 entities in Tan Thanh distirct, 7 entities in Ba Ria provincial town and 50 entities in Long Dien district. The seafood processing zone planned to be in Loc An fish meal plant will have 8 processing entities of Dat Do district which is not under the planning and some processing entities in Long Dien district and Tan Thanh district (if necessary). The seafood processing zone in Theo Leo hamlet area will accommodate 11 processing entities of Xuyen Moc district. (Source: http://www.baria-vungtau.gov.vn/zW000000063/W000000063_000006FFE.asp)

Potential pollution sources in Dinh river basin are described in figure 3.9.

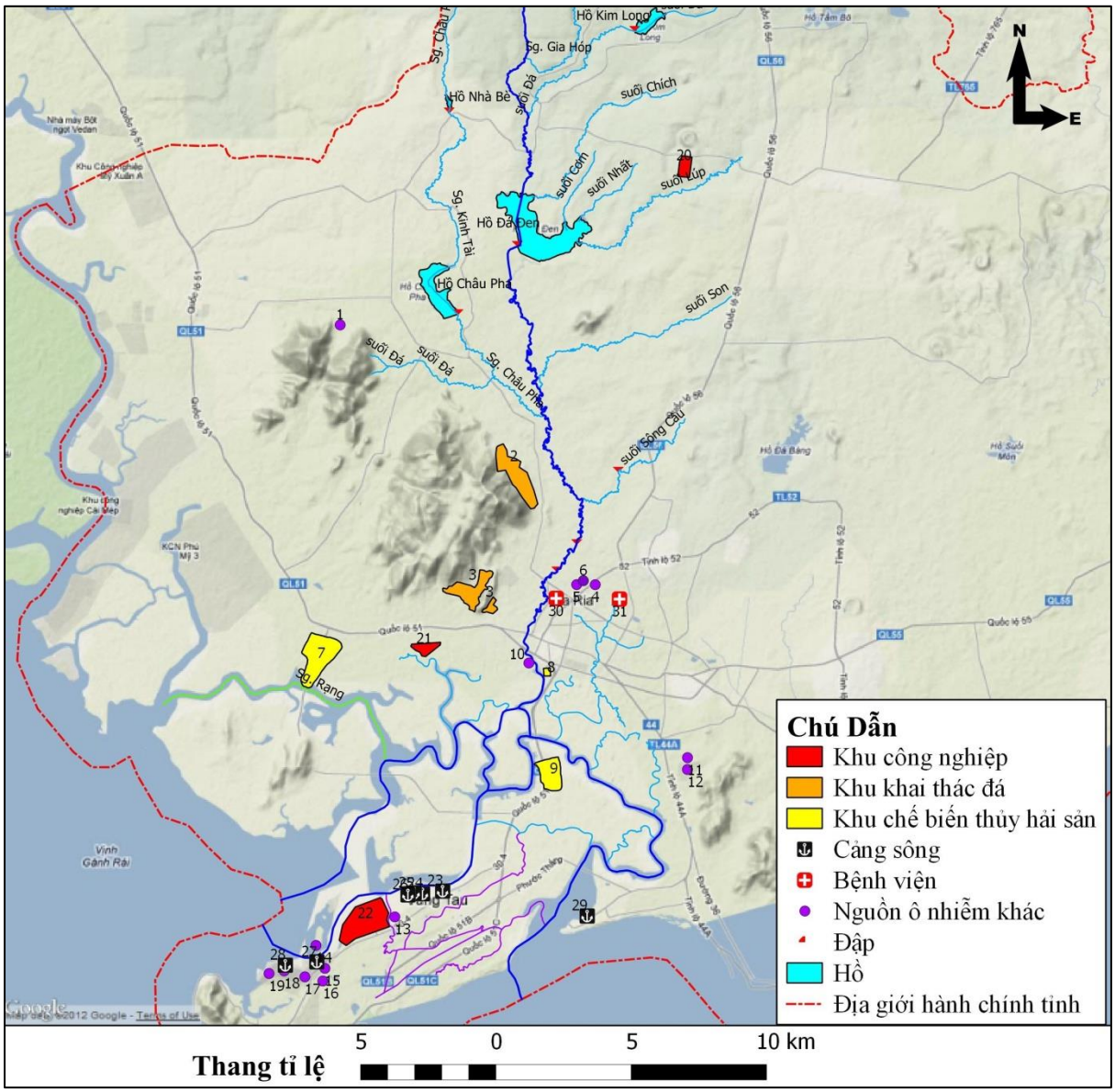

Fig. 3.9: Map of potential pollution sources in Dinh river basin, Ba Ria – Vung Tau province

3.6 Rainfall and other meteorological data

3.6.1 Location of meteorological stations

Table 3.8 shows independent rainfall stations and meteorological stations in Ba Ria – Vung Tau province.

Table 3.8: List of meteorological stations in Ba Ria – Vung Tau province

Stations	Location	Coordinates		Monitoring data	
		Latitude	Longitude	Rainfall	Meteorological data
Vung Tau	Ward VII, Vung Tau city	$10^0$22’	$107^0$05’	o	o
Con Dao	Con Dao township, Con Dao district	$8^0$41’	$106^0$36’	o	o
DK1-7	Huyen Tran flat, East Sea	$8^0$01’	$110^0$37’	o	o
Xuyen Moc	Phuoc Buu township, Xuyen Moc district	$10^0$32’	$107^0$24’	o	o
Chau Pha	Hamlet 6, Chau Pha commune, Tan Thanh district	$10^0$37'	$107^0$09'	o	
Binh Ba	Binh Ba, Chau Duc district	$10^0$38'	$107^0$13'	o	
Phuoc Hoa	Phuoc Hoa commune, Tan Thanh district	$10^0$31'	$107^0$03'	o	
Long Dien	Long Dien township, Long Dien district	$10^0$29'	$107^0$13'	o	
Kim Long	Kim Long commune, Chau Duc district	$10^0$43'	$107^0$14'	o	
Bau Lam	Group 3, Bau Lam commune, Xuyen Moc district	$10^0$40'	$107^0$26'	o	
Phuoc Nguyen	Phuoc Nguyen ward, Ba Ria city	*No information*		o	
Phuoc Long Tho	Phuoc Long Tho commune, Dat Do district			o	
Xuan Son	Xuan Son commune, Chau Duc district			o	
Lang Dai	Lang Dai commune, Xuyen Moc district	$10^0$32'	$107^0$22'	o	

Rainfall and meteorological stations are shown in figure 3.10.

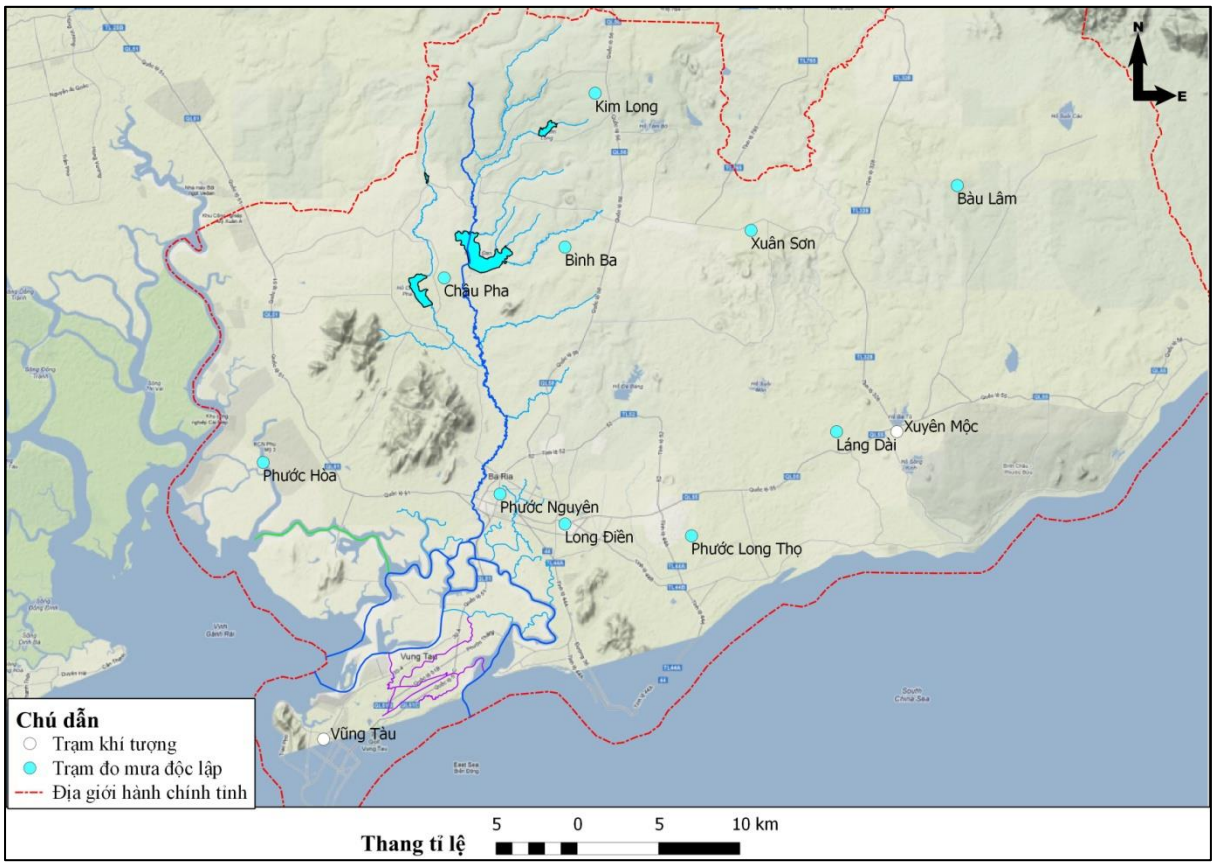

Fig. 3.10: Meteorological and rainfall stations in Ba Ria-Vung Tau province.

3.6.2 Climatic conditions in Ba Ria-Vung Tau province

Ba Ria-Vung Tau province is located in monsoonal tropical region with two distinct seasons. Rainy season starts from May to October with Southwest monsoon. Dry season lasts from November to April when Northeast monsoon occurs. Annual mean temperature is 27 ^{O}C, ranging from 24.8 ^{O}C (the lowest) to 28.6 ^{O}C (the highest). Sunny hours are as high as 2400 hours per year on average. Ba Ria - Vung Tau is located in the region not being hit by many storms and typhoons. (Source: http://www.baria-vungtau.gov.vn/)

Mean rainfall is 1500 mm per year. Rainfall chart in Vung Tau station through years can be seen in figure 3.11 below. Rainfall mainly focuses in rainy season months from May to October. In rainy season, rainfall is fairly evenly distributed between months and does not differ signigicantly; monthly mean rainfall is around 200 mm. Rainfall in dry months from November to April is relatively small. January, February and March witness much lower value < 5 mm/month; February mostly sees no rain (1 mm/month).

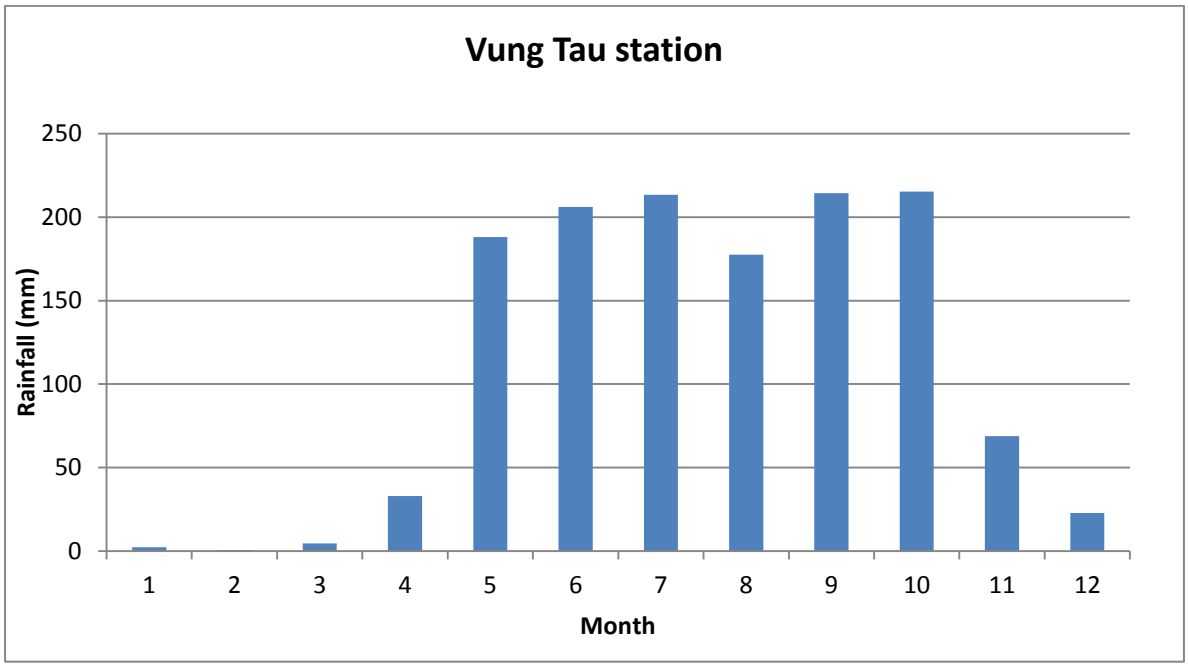

Fig. 3.11: Rainfall chart in Vung Tau station

3.7 River flow discharge

3.7.1 Hydrological and oceanographic stations

Hydrological and oceanographic stations in Ba Ria-Vung Tau province are listed in table 3.9 below.

Table 3.9: List of hydrological and oceanographic stations in Ba Ria-Vung Tau province

Station	Location	River/Sea	Latitude	Longitude	Parameter	Monitoring time
Hoa Hung	Hoa Long & Tan Hung communes, Ba Ria city	Dinh river	$10^{o}32'$	$107^{o}11'$	Water level	*No information*
Lang Dai	Lang Dai commune, Dat Do district	Ray river	$10^{o}33'$	$107^{o}20'$	Water level	
Vung Tau	Ward II, Vung Tau city	East Sea	$10^{0}20.41'$	$107^{0}4.26'$	Water level	1978 - 2008
Con Dao	Con Dao township, Con Dao district	East Sea	$8^{0}40'$	$106^{0}36'$	Water level	*No information*
DK1-7	Huyen Tran island flat, East Sea	East Sea	$8^{0}01'$	$110^{0}37'$	Water level	

Figure 3.11 delineates hydrological and oceanographic stations in Ba Ria-Vung Tau province.

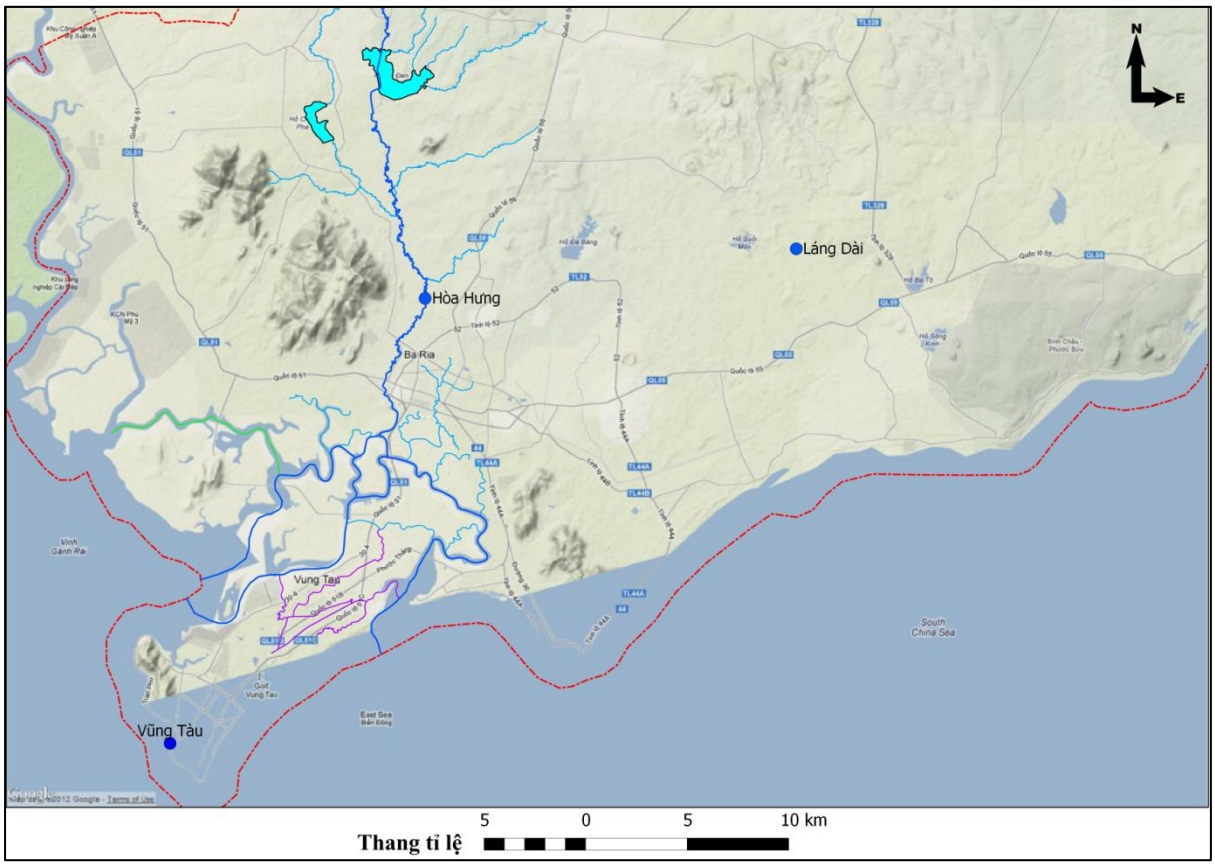

Fig. 3.11: Hydrological and oceanographic stations in Ba Ria-Vung Tau province.

3.7.2 Tidal pattern in Vung Tau

Vung Tau enjoys irregular semi-diurnal tidal regime with a tidal level of 3 - 4 m. Tidal pattern in Vung Tau station in January 2012 is illustrated in figure 3.12 (data source: Marine Technique Institute – Viet Nam Academy for Water Resources).

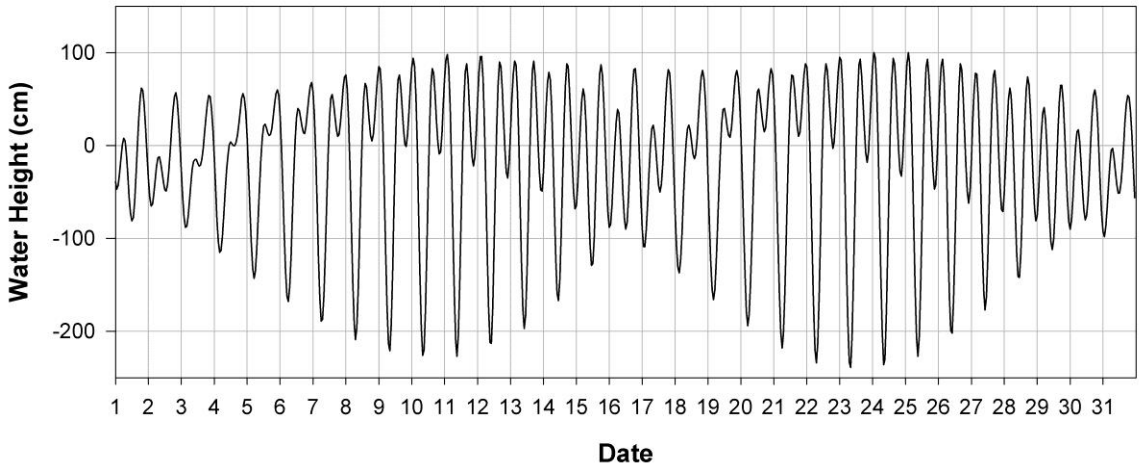

Fig. 3.12: Tidal pattern at Vung Tau station in January 2012.

CHAPTER 4 MONITORING PLAN

4.1 MONITORING NETWORK

4.1.1 Principles for selection of monitoring points

Monitoring points are selected to:

(i) Grasp water quality at water intake stations.

(ii) Grasp water quality along the river from the starting point to final point (in terms of hydraulic structure or administrative boundary)

(iii) Grasp river water quality in areas having high risk of pollution

(iv) Be or be close to hydrological and meteorological monitoring points.

To meet the above requirements, monitoring points should be placed as follows:

1) At the starting and ending points of a river/stream in the province

2) At the area of water intake stations

3) Before and after the confluence with other rivers/streams which possibly have great impacts on water quality.

4) Before and after discharge points or a polluted area through which the river runs.

5) At the location representative of river water quality in an area having only non-point pollution sources.

6) Being close to known hydrological and meteorological monitoring points.

Based on these principles and characteristics of Dinh river system in Ba Ria – Vung Tau province as presented above (characteristics of Dinh river system, location of dams, water intake stations, potential pollution sources, land use classification, hydrological stations …), 8 monitoring points have been placed in Dinh river, 2 monitoring points in Chau Pha river, 1 monitoring point in Mui Giui river and 3 monitoring points in Cua Lap river. Monitoring points are described in figure 4.1 below. Specific location and coordinates of each monitoring point as well as detailed description and monitoring purpose of each monitoring points are shown in table 4.1.

There are three new ones among the monitoring points. CP-2 point in Chau Pha river is supplemented to study impacts of Ong Keo river on water quality of Chau Pha river; Ong Keo river (Da stream) may be polluted by Toc Tien dump site in upstream area. MG-1 monitoring point in Mui Giui river is newly set up to understand water quality in Mui Giui river; this river water is likely to be affected by aquaculture activities in surrounding areas and has not yet ever been monitored. CL-1 monitoring point on Cua Lap canal is aimed to consider impacts of seafood processing plant in Ward 12, Vung Tau city on water quality of the canal.

4.1.2 Location of monitoring points

List of monitoring points in the monitoring plan for Dinh river water quality is presented in table 4.1.

Table 4.1: List of monitoring points in the monitoring plan for Dinh river water quality

No	River	Station code	Station name	Coordinates (VN-2000)		Location	Sampling location	Purposes	Note
				Latitude	Longitude				
1	Dinh	SD-1	Kim Long reservoir	10°41'43.10"N	107°12'01.74"E	Kim Long reservoir, Kim Long commune, Chau Duc district	Inside the reservoir, 15 m from the intake point for domestic water supply	To grasp quality of water supplied for water supply factories; To grasp water quality of the lake which is later released into Dinh river	Existing point
2		SD-2	Soai river bridge	10°39'19.64"N	107°09'55.98"E	Lang Lon commune, Chau Duc district	In the middle of Song Soai bridge across Dinh river, upstream of Dinh river, 2 km upstream of Da Den reservoir	This is a reference/baseline monitoring point – a basis for comparision of longitudal change of water quality	
3		SD-3	Da Den reservoir	10°37'11.68"N	107°10'10.69"E	Da Den reservoir, Chau Duc and Tan Thanh districts	Inside the reservoir, 15m from the intake point for domestic water supply	To grasp quality of water supplied for main domestic water supply factories of the province and for agricultural activities	
4		SD-4	Cau Do dam	10°31'09.14"N	107°10'27.78"E	Phuoc Hung ward, Ba Ria city	In the middle of the river, right before Cau Do dam (downstream of the dam, river water is influenced by tide)	To grasp water quality of the river before the water flows into Ba Ria city	
5		SD-5	Long Huong bridge	10°29'56.36"N	107°09'52.32"E	Long Huong ward, Ba Ria city	In the middle of Long Huong bridge (on CMT8 road, central area of Ba Ria city)	To grasp water quality of the river in Ba Ria city area and determine if the river water is affected by discharge sources in Ba Ria city or not	
6		SD-6	Co May bridge	10°27'54.26"N	107°10'02.04"E	Phuoc Trung ward, Ba Ria city	In the middle of Co May bridge, at the branching point of Dinh river being separated into two branches (Dinh and Cua Lap rivers)	To grasp water quality of the river before the river is branched	
7		SD-7	Confluence of Cay Khe & Dinh rivers	10°25'49.82"N	107°08'48.30"E	Ward 12, Vung Tau city	In the middle of the river, 700 m downstream of the confluence of Cay Khe and Dinh rivers, 1 km downstream of Go Gang bridge	To determine water quality of Dinh river after the river receives water from Cay Khe river	

8		SD-8	Cat Lo port	10°24'54.80"N	107°07'38.34"E	Ward 11, Vung Tau city	Con Dao ship –going port, located between Cat lo port and Cat Lo fish port, close to Dinh river mouth	To evaluate water quality of Dinh river near the river mouth and identify impacts of industrial zones and sea ports on water quality	
9	Chau Pha	CP-1	Chau Pha reservoir	10°36'14.42"N	107°08'25.62"E	Chau Pha reservoir, Chau Pha commune, Tan Thanh district	Inside the reservoir, 15 m from the intake point for domestic water supply	To grasp quality of water provided for water supply factories	
10		CP-2	Tan Le B	10°34'51.62"N	107°09'20.16"E	Tan Le B, Chau Pha commune, Tan Thanh district	In the middle of a small bridge over Chau Pha river, 300 m downstream of the confluence of Ong keo river (Da stream) and Chau Pha river	To grasp water quality of the Chau Pha river before the water flows into Dinh river and determine impacts of Ong Keo river on water quality of Chau Pha river	New point
11	Mui Giui	MG-1	Long Son	10°27'44.30"N	107°07'54.36"E	Long Son commune, Vung Tau city	In the middle of the river, 2 km upstream of the confluence of Mui Giui and Rang rivers	To grasp water quality of Mui Giui river close to the river mouth and impacts of shrimp farming in surrounding areas on river water quality	
12	Cua Lap	CL-1	An Ngai	10°26'15.56"N	107°12'32.04"E	An Ngai commune, Long Dien district	In the middle of the river, 400 m downstream of the confluence of Cua Ben and Cua Lap rivers	To check impacts of seafood processing activities in ward 12, Vung Tau city and shrimp farming on river water quality	
13		CL-2	Cua Lap bridge	10°25'20.24"N	107°10'59.94"E	Phuoc Tinh commune, Long Dien district	In the middle of Cua Lap bridge, 800 downstream of the junction of Cua Lap river and one branch of Cay Khe river	To grasp water quality of Cua Lap river, and check impacts of Seafood processing activities and domestic wastewater in surrounding areas.	Existing point
14		CL-3	Phuoc Tinh fish port	10°24'23.42"N	107°11'01.26"E	Phuoc Tinh commune, Long Dien district	Phuoc Tinh fish port, near Cua lap river mouth	To evaluate water quality of Cua Lap river near the river mouth, and check if the river water is impacted by surrounding industrial zones and ports	

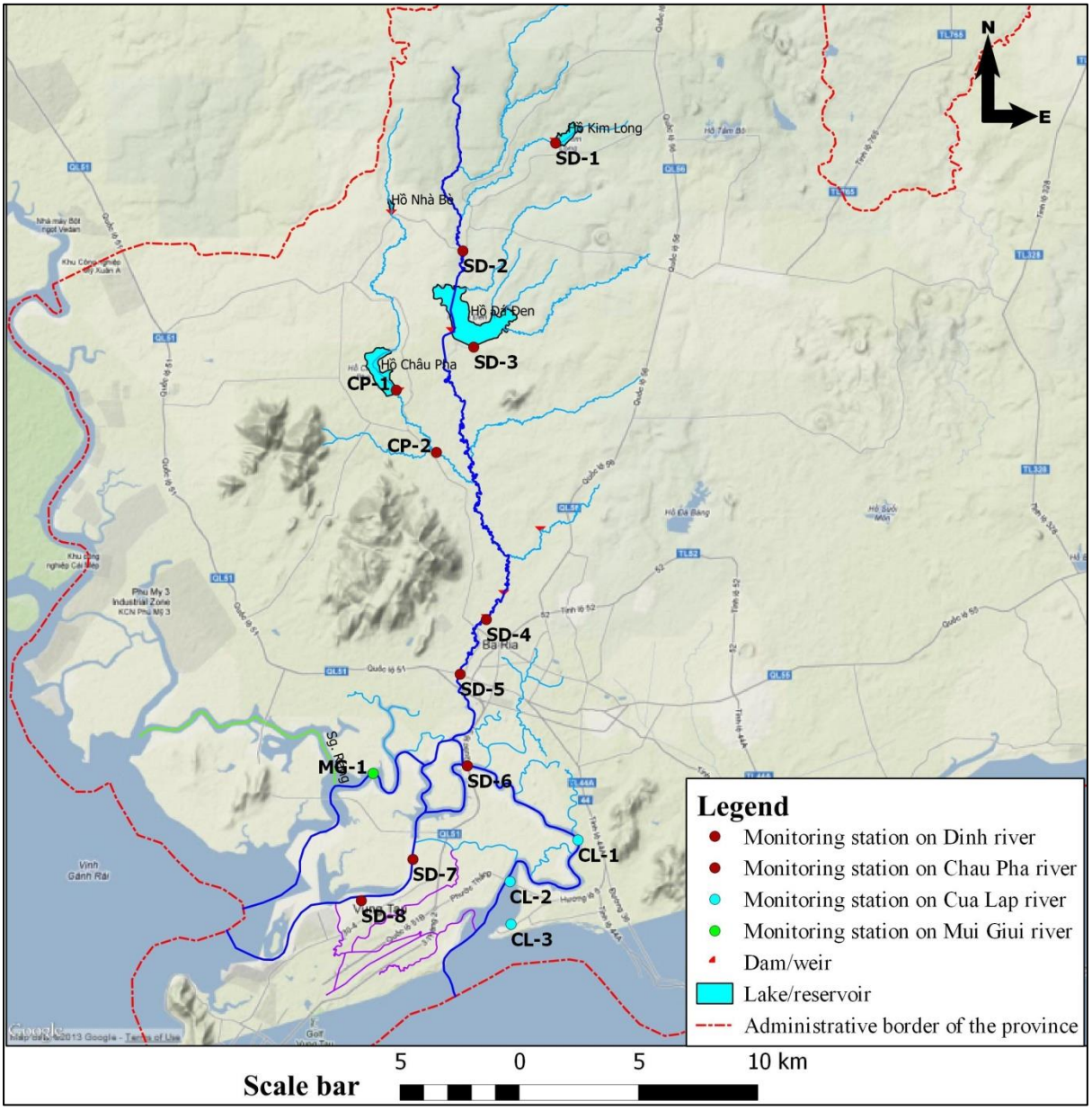

Fig. 4.1: Location of monitoring points of the monitoring plan for water quality in Dinh river

Location of monitoring points in a connection with water intake points, pollution sources, and sensitive receivers can be shown in Annexes from P-1 to P-3.

4.2 Monitoring parameters

Water quality parameters that need measuring along Dinh river to meet the requirements of water quality control (including 22 parameters) are listed in the table below.

Table 4.2: Water quality parameters that need measuring in water quality monitoring plan for Dinh river

No	Type	Parameter	Selection reasons	Analysis method	Analysis unit

No	Type	Parameter	Selection reasons	Analysis method	Analysis unit
1	Physical	Temperature	Circular 29, Decision 879, a basis for estimating saturate DO.	Field measurement	CEMAB
2		Salinity	Basic parameter for water quality determination & salt intrusion level		
3		pH	Circular 29, Decision 879, basic parameter for determination of water quality & water properties.		
4		DO	Circular 29, Decision 879, important parameter for river health assessment and its impact on organism life		
5		Turbidity	Circular 29, Decision 879, basic parameter for determination of water quality & water properties.		
6		TSS		Weight method	
7	Nutritional	COD	Decision 879, for assessing river water quality in general and impacts of domestic, agricultural and industrial wastewater	Dichromate oxidation and spectrometry measurements	
8		BOD_5		DO is measured before and after 5 days of incubation	
9		NH_4^+	Regulated by Decision 879 for assessing impacts of wastewater from daily/domestic activities, agricultural, seafood and agro-produce processing industries	Titration	
10		NO_3^-	For assessing impacts of domestic wastewater and agricultural wastewater	spectrometry measurements	
11		NO_2^-			
12		PO_4^{3-}	Regulated by Decision 879 for assessing impacts of domestic wastewater and agricultural wastewater	Spectrometry using ammonium molybdate	
13	Iron	Fe	For assessing impacts of natural geological conditions, industries	Spectrometry using phenantrolin	
14	Toxic	Cd	For assessing impacts of industries on river water quality	Atomic absorption spectrometry	
15		Pb			
16		Zn			
17		CN^-		CN– ion selective electrode	
18		Phenol		Distillation & spectrometry measurements in aqueous solution	
19	Pesticide	Pesticide	For assessing impacts of pollution by cultivation activities	Liquid-liquid extraction, gas chromatography GC-ECD	Hai Dang Center for chromatography, Quatest 3
20	Oil	Total oil & grease	For assessing impacts of pollution resulting from waterway transportation and industrial activities	Weight method	CEMAB
21	Microbial	Fecal coliform	For assessing impacts of pollution by domestic wastewater and livestock raising wastewater	Multiple tube fermentation method	
22		Total Coliform	Regulated by Decision 879, this parameter is measured for assessing pollution by domestic and livestock raising wastewater		

Of the 22 water quality parameters mentioned above, there may be change in parameters selected for measurement, dependent on location and characteristics of each monitoring station (eg.: main pollutants that are likely to be found in each monitoring station based on waste sources in the area surrounding the station and land use classification). However, three basic types of parameters -physical, nutritional and microbial ones are usually measured at each monitoring station in accordance with Circular 29/2011/TT-BTNMT and Decision No 879/QĐ-TCMT. Table 4.3 covers parameters that need measuring at each monitoring station.

Table 4.3: List of parameters that need measuring at each monitoring station in Dinh river system

No	River	Station code	Station name	Types of parameters	Detail measurement parameters
1	Dinh	SD-1	Kim Long reservoir	Physical, nutrional, iron, microbial, pesticide	Temperature, salinity, pH, DO, turbidity, TSS, COD, BOD, NH_4^+, NO_3^-, NO_2^-, PO_4^{3-}, Fe, Fecal coliform, total coliform, pesticides.
2		SD-2	Soai river bridge		
3		SD-3	Da Den reservoir		
4		SD-4	Cau Do dam	Physical, nutrional, microbial	Temperature, salinity, pH, DO, turbidity, TSS, COD, BOD, NH_4^+, NO_3^-, NO_2^-, PO_4^{3-}, Fecal coliform, total coliform
5		SD-5	Long Huong bridge		
6		SD-6	Co May bridge		
7		SD-7	Confluence of Cay Khe river and Dinh river	Physical, nutrional, oil, microbial	Temperature, salinity, pH, DO, turbidity, TSS, COD, BOD, NH_4^+, NO_3^-, NO_2^-, PO_4^{3-}, oil&grease, Fecal coliform, total coliform
8		SD-8	Cat Lo port	Physical, nutrional, toxic, oil, microbial	Temperature, salinity, pH, DO, turbidity, TSS, COD, BOD, NH_4^+, NO_3^-, NO_2^-, PO_4^{3-}, Cd, Pb, Zn, CN^-, phenol, oil & grease, fecal coliform, total coliform
9	Chau Pha	CP-1	Chau Pha reservoir	Physical, nutrional, iron, microbial, pesticide	Temperature, salinity, pH, DO, turbidity, TSS, COD, BOD, NH_4^+, NO_3^-, NO_2^-, PO_4^{3-}, Fe, Fecal coliform, total coliform, pesticide
10		CP-2	Tan Le B		
11	Mui Giui	MG-1	Long Son	Physical, nutrional, oil, microbial	Temperature, salinity, pH, DO, turbidity, TSS, COD, BOD, NH_4^+, NO_3^-, NO_2^-, PO_4^{3-}, oil&grease, fecal coliform, total coliform
12	Cua Lap	CL-1	An Ngai		
13		CL-2	Cua Lap bridge		
14		CL-3	Phuoc Tinh fish port		

4.3 Monitoring time and frequency

4.3.1 Monitoring frequency

Monitoring frequency: 6 times/year

Sampling time: sampling time is February, April, June, August, October and December.

According to the guidance of Circular 29/2011/TT-BTNMT related to river flow regime, rainfall of Ba Ria- Vung Tau province, monitoring frequency of Dinh river is proposed to be 6 times/year, with 3 times of sampling in rainy season and 3 times of sampling in dry season. Sampling time is February, April, June, August, October and December; thus, in dry season, sampling is taken in December, February and April and in rainy season in June, August and October. Such proposed monitoring frequency and time could help monitor seasonal impacts on river water quality.

4.3.2 Temporal boundary

Sampling will be done during daytime from 8 a.m to 5 p.m.

Due to tidal impacts on water quality of monitoring points from SD-5 to SD-8 and from CL-1 to CL-3 as well as MG-1, sampling at these monitoring points should be undertaken at low tide to grasp quality of water which is least influenced by marine water.

4.3.3 Time frame for the monitoring plan

Environmental monitoring in 2013 is planned to be done in 6 periods of two months each, specifically as follows:

Table 4.4: Specific time frame of Dinh river monitoring plan

Month / Period	Jan. /2013	Feb./ 2013	Mar./ 2013	Apr. /2013	May/ 2013	Jun. /2013	Jul./ 2013	Aug. /2013	Sep./ 2013	Oct. /2013	Nov./ 2013	Dec. /2013	Jan./ 2014	Feb. /2014
I														
II														
III														
VI														
V														
VI														

: Preparation, monitoring and sampling.

: Aggregation and reporting.

: Aggregation and environmental reporting for 2013.

4.4 Practical constraints

Constraints of actual conditions possibly affecting the monitoring plan need to be checked before the implementation of the plan. Table 4.5 shows some constraints that may influence accessibility to sampling location.

Table 4.5: Constraints of actual conditions possibly influencing the monitoring plan

Type	Constraints	Description of Constraints	How to overcome
Internal	Human resources	New staff, lack of experience in sampling point description	Arranging both new and old staff to do the sampling
	Equipment	Sample containers not meeting the requirements Absence of quick measuring tool.	These should be included in equipment list to be procured
	Chemicals	*No information*	
External	Accessible to sampling location.	Accessibility to sampling points of MG-1, SD-7, and CL-1 should be checked prior to the sampling	Boats are recommended during the sampling at points of from SD-6 to SD-8 and from CL-1 to CL-3, and MG-1
	Travelling time	*No information*	

4.5 Sampling method

Sampling and sample preservation follows Vietnamese standards below:

- TCVN 6663-1:2011: water quality– sampling – guidance for sampling techniques
- TCVN 6663-3:2008: water quality– sampling – guidance for sampling, sample preservation and treatment.
- TCVN 6663-14:2000: water quality– sampling. Part 14 provides guidance for sampling quality assurance and water treatment.

Sampling of surface water (river, stream): sampling (following TCVN 6663-6-2008); sampling of lake water: following TCVN 5994-1995 and guidance of Circular 29/2011/TT-BTNMT- regulating technical procedures for surface water environment monitoring.

In addition to the five parameters directly measured in the field, 17 other parameters need to be measured in the laboratory. Therefore, these 17 parameters are required to be preserved and analyzed as in table 4.6.

Table 4.6: Summary of sampling methods for parameter determination

Parameter	Sampling bottle	Volume (mL)	Method of preservation	Preservation time
TSS	P & G	1000	2-5 ^{o}C	48 h
COD	P & G (used in case of low COD)	200	H_2SO_4 pH<2.2-5 ^{o}C	5 days
BOD_5	P & G (use of G bottle in case of low BOD_5)	1000	2-5 ^{o}C, dark	6 h

NH_4^+	P & G	1000	H_2SO_4 pH<2.2-5 ^oC	24 h
NO_3^-	P & BG	50	H_2SO_4 pH<2.2-5 ^oC	24 h
NO_2^-	P & G	50	2-5 ^oC	as soon as possible
PO_4^{3-}	BG & G	100	2-5 ^oC	as soon as possible
Fe	P & BG	100	H_2SO_4 pH <2.2-5 ^oC.	1 month
Cd, Pb, Zn	P & BG	250	Filtering after sampling, HNO_3 pH <2	1 month
CN^-	P or G	500	NaOH pH > 12.2–5 ^oC, dark	24 hours
Phenol	P or G, with PTFE lined cap	500	H_2SO_4 pH<2.2–5 ^oC	24 hours
Pesticide	G, with PTFE lined cap	1000	2–5 ^oC	7 days
Oil & grease	G, cleaned by extraction solvent	3000	HCl pH<2.2-5 ^oC, dark condition tối	24 h
Fecal Coliform	Sterilized glass bottles	150	2-5 ^oC	as soon as possible
Total Coliform	Sterilized glass bottles	150	2-5 ^oC	as soon as possible
P: Plastic, G: Glass, BG: Borosilicate glass				

4.6 Analysis method

4.6.1 Field measurement

There are five parameters measured right in the field, using quick measuring equipment as shown in table 4.7.

Table 4.7: Method of field measurement

No	Parameter	Method	Measuring equipment
1	pH	TCVN 6492: 2010	Multiparameter meter (Horiba U-52)
2	Temperature	APHA 2550B	
3	Turbidity	TCVN 6184: 2008	
4	DO	ISO 5418: 1990	
5	Salinity	APHA 2520 B, C, D	

4.6.2 Laboratory analysis

In addition to the parameters measured/tested in the field, the remaining are analyzed in the laboratory. Analysis methods are presented in the table below.

Table 4.8: Method of analysis in the laboratory

No	Parameter	Method	Equipment	Detection limit	
				Unit	Value
1	TSS	TCVN 6625: 2000	Drying oven (Memmert), Analytical balance (Ohause E 12140)	mg/l	2.0
2	COD	APHA 5220 D	COD reactor (Hach), incubator (Incucell 111), spectrophotometer (DR 2800)	mg/l	5.0

No	Parameter	Method	Equipment	Detection limit	
				Unit	Value
3	BOD_5	TCVN 6001-1: 2008	Dissolved oxygen meter (Schott), incubator (Velp FOC 225E & Hach 205)	mg/l	3.0
4	NH_4^+	TCVN 5988: 1995	Automatic distillation system (VAP20), titration	mg/l	0.2
5	NO_3^-	TCVN 6180: 1996	Spectrophotometer (DR 2800), Water bath (Wise bath)	mg/l	0.1
6	NO_2^-	TCVN 6178: 1996	Spectrophotometer (DR 2800)	mg/l	0.001
7	PO_4^{3-}	TCVN 6202: 2008		mg/l	0.005
8	Fe	TCVN 6177: 1996		mg/l	0.01
9	Cd	TCVN 6193: 1996	F-AAS atomic absorption spectrometer (Perkin-Elmer)	mg/l	0.025
10	Pb	TCVN 6193: 1996		mg/l	0.2
11	Zn	TCVN 6193: 1996		mg/l	0.025
12	CN^-	APHA 4500 CN^- C & F	CN^- ion selective electrode	mg/l	*No information*
13	Phenol	APHA 5530 D	Spectrophotometer (DR 2800)	mg/l	
14	Pesticide	APHA 6630 B: 2005	GC-ECD gas chromatography	ng/l	
15	Total oil & grease	TCVN 5070: 1995	Rotary evaporator (Bibby RE 300), Cold water bath (Julabo F12), analytical balance (Ohause E12140)	mg/l	0.3
16	Fecal Coliform	TCVN 6187-2: 1996	Incubator (Incucell 111), Laminair (BioAir, AURA-VF48), pH meter (S20)	MPN/100 ml	*No information*
17	Total Coliform	TCVN 6187-2: 1996			

Detection limits required for laboratory analysis methods are presented in section 5.3 of the following chapter.

4.7 Plan for taking quality control (QC) samples

A detailed QA project plan is not within the scope of this monitoring plan and therefore is prepared as a separate document which would be used in a tight relation with this monitoring plan. Herein, QC samples for field monitoring and laboratory analysis are described since the information is utilized for the calculation of total sample volume taken in each sampling period.

According to Circular 10/2007/TT-BTNMT on guiding the quality assurance (QA) and quality control (QC) in environmental monitoring and the 2nd draft of revised QA/QC circular published in 2012, QC samples for field and laboratory activities in Dinh river basin monitoring program were proposed as follows.

4.7.1 Field monitoring

For each parameter in each sampling period, QC samples for field monitoring must be prepared as follows.

- *Field blank sample*: Distilled water is taken by a sampler and then transferred to sampling bottles, preserved, transported, prepared, and analysed in laboratory as for real samples.
- *Field duplicate samples*: Two samples are taken at the same place and the same time; these samples are then preserved, transported, prepared, and analyses mutually.

Detail information of QC samples taken in the field sites is presented in Table 4.9.

Table 4.9: QC samples for field monitoring activities.

Type of sample	**Description**	**Dry season**		**Wet season**			**Dry season**
		1st period	**2nd period**	**3rd period**	**4th period**	**5th period**	**6th period**
Field blank sample	At SD-1 station, distilled water is taken by a sampler and then transferred to sampling bottles, preserved, transported, prepared, and analysed in laboratory as for real samples	1	1	1	1	1	1
Field duplicate samples*	Two samples are taken at the same place and the same time; these samples are then preserved, transported, prepared, and analyses mutually	SD-2 (river water)	SD-3 (lake water)	SD-7 (brackish water)	CP-1 (lake water)	SD-4 (river water)	CL-1 (brackish water)
*: Field duplicate samples are chosen so that all three types of surface water are taken during each season and the stations taken are distributed evenly on the river basin and on different river branches.							

4.7.2 Laboratory Analysis

For each parameter in each sampling period, QC samples for laboratory analysis must be prepared as follows. It is noted that these laboratory QC samples are not included calibration standards that are prepared for analysis of each parameter.

- *Instrument blank sample*: A sample of analyte-free reagents (water or solvent) will be directly inserted in the analytical equipment run.
- *Method blank sample*: A sample of analyte-free water that is carried throughout the entire preparation and analysis and contain all of the reagents in the same volumes as used in the processing of the samples.
- *Control standard sample*: A standard sample that has a concentration in the middle of the concentration range of the used calibration curve. They should be certified, purchased or independently prepared from a source other than the calibration standard.
- *Reagent water spike sample*: a sample of analyte-free water is spiked with the analyte of interest and prepared in the same way as the samples.
- *Laboratory duplicate samples*: are two aliquots of the same sample that are prepared and analyzed at the same time, but submitted and analyzed as separate samples.

Detail information of QC samples for laboratory analysis is presented in Table 4.10.

Table 4.10: QC samples for laboratory analysis activities.

Type of sample	Description	Dry season		Wet season			Dry season
		1st period	2nd period	3rd period	4th period	5th period	6th period
Instrument blank sample	Directly analyze a sample of analyte-free reagents (distilled water or solvent)	1	1	1	1	1	1
Method blank sample	A sample of analyte-free water is prepared and analyzed as real samples	1	1	1	1	1	1
Control standard sample	A certified standard sample has a concentration in the middle of the concentration range of the used calibration curve	1	1	1	1	1	1
Reagent water spike sample	A sample of analyte-free water is spiked with the analyte of interest and prepared in the same way as the samples	1	1	1	1	1	1
Laboratory duplicate samples*	are two aliquots of the same sample that are prepared and analyzed at the same time, but submitted and analyzed as separate samples	SD-7 (brackish water)	SD-4 (river water)	SD-2 (river water)	CL-1 (brackish water)	SD-3 (lake water)	CP-1 (lake water)
*: Laboratory duplicate samples are chosen so that all three types of surface water are analysed duplicated during each season and the stations taken are distributed evenly on the river basin and on different river branches. Moreover, in the same sampling period, the matrix type of field duplicate sample and laboratory duplicate sample must be different.							

4.8 Sampling units

Table 4.11 summarizes sampling units including sample volume for analysis and back-up sample for each parameter.

Table 4.11: Sampling information for each parameter in Dinh river monitoring plan

Parameter	Sample volume for analysis (mL)	Volume of back-up sample (mL)	Total volume (mL)
TSS	1000	1000	2000
COD	200	200	400
BOD_5	1000	1000	2000
NH_4^+	1000	1000	2000
NO_3^-	50	50	100
NO_2^-	50	50	100
PO_4^{3-}	100	100	200
Fe	100	100	200
Cd, Pb, Zn	250	250	500
CN^-	500	500	1000
Phenol	500	500	1000
Pesticide	1000	1000	2000
Oil & grease	3000	3000	6000
Fecal Coliform	150	150	300
Total Coliform	150	150	300
Total (mL)			**18,100**

Total sample volume taken at each station is 18.1 L. However, at stations where QC samples such as field duplicate samples or laboratory duplicate samples are needed, total sample volume taken must double the volume taken at the other stations. Total sample volume taken at different stations in each

sampling period is specified in Table 4.12.

Table 4.12: Total sample volume (L) taken at different sampling stations.

River	Station code	Station name	Dry season		Wet season			Dry season
			1st period	**2nd period**	**3rd period**	**4th period**	**5th period**	**6th period**
Dinh	SD-1	Kim Long reservoir	18,1	18,1	18,1	18,1	18,1	18,1
	SD-2	Soai river bridge	36,2*	18,1	36,2**	18,1	18,1	18,1
	SD-3	Da Den reservoir	18,1	36,2*	18,1	18,1	36,2**	18,1
	SD-4	Cau Do dam	18,1	36,2**	18,1	18,1	36,2*	18,1
	SD-5	Long Huong bridge	18,1	18,1	18,1	18,1	18,1	18,1
	SD-6	Co May bridge	18,1	18,1	18,1	18,1	18,1	18,1
	SD-7	Confluence of Cay Khe river and Dinh river	36,2**	18,1	36,2*	18,1	18,1	18,1
	SD-8	Cat Lo port	18,1	18,1	18,1	18,1	18,1	18,1
Chau Pha	CP-1	Chau Pha reservoir	18,1	18,1	18,1	36,2*	18,1	36,2**
	CP-2	Tan Le B	18,1	18,1	18,1	18,1	18,1	18,1
Mui Giui	MG-1	Long Son	18,1	18,1	18,1	18,1	18,1	18,1
Cua Lap	CL-1	An Ngai	18,1	18,1	18,1	36,2**	18,1	36,2*
	CL-2	Cua Lap bridge	18,1	18,1	18,1	18,1	18,1	18,1
	CL-3	Phuoc Tinh fish port	18,1	18,1	18,1	18,1	18,1	18,1

*****: Sample is taken separately twice; the sampling volume for one time is 18.1 L.

**: Sample is taken once with total volume of 36.2 L, then sample is divided into two equal aliquouts in laboratory.

CHAPTER 5 METHOD OF DATA ANALYSIS

5.1 Summarized results of each parameter

Result of water quality parameters is single value obtained from analysis of a unique sample in each sampling period.

The obtained value will be compared with QCVN using normal "greater than" or "less than" techniques to draw a conclusion on quality of river water in each sampling period.

5.2 Required standards for river water quality

According to Decision No 43/2011/QD-UBND of Ba Ria- Vung Tau Provincial People's Committee issued on 23th August 2011 regarding zonation of waste gas and wastewater discharge based on environmental QCVN in Ba Ria – Vung Tau, use purpose of rivers and streams in Dinh river system can be indirectly determined. Land use classification and corresponsing required standards to be met by water quality are shown in table 5.1 below.

Table 5.1: Required standards for river/stream and reservoir water quality in Dinh river system

River/stream	Use purposes	Applied QCVN 08:2008/BTNMT	Other applied QCVN
Dinh river (Xoai river) upstream of Da Den reservoir	Domestic water supply	A2	-
Gia Hop stream			
Tra Rang stream			
Da stream			
Com stream			
Chich stream			
Nhat stream			
Lup stream			
Dinh river (Ca river, downstream of Da Den reservoir)	In addition to domestic water supply purpose, the water is used for irrigation	B1	QCVN 39:2011/BTNMT
Chau Pha river (from Chau Pha reservoir to the upstream)	Domestic water supply	A2	-
Chau Pha river (from Chau Pha reservoir to the downstream)	In addition to domestic water supply purpose, the water is used for irrigation	B1	QCVN 39:2011/BTNMT (irrigation water)
Da stream			
Son stream			
Song Cau stream			
Cat stream			
Lung stream			
Dinh river (from Co May bridge to the upstream)			
Dinh river (from Co May bridge seaward)	In addition to domestic water supply purpose, the water is used for aquaculture purpose	*Not applicable*	Aquaculture area column (QCVN 10:2008/BTNMT, coastal water)
Ba Coi river			
Cay Khe river			
Cua Lap river			
Mui Giui river			
Dung Dan river			

River/stream	Use purposes	Applied QCVN 08:2008/BTNMT	Other applied QCVN
Da Den reservoir	Domestic water supply	A2	-
Chau Pha reservoir			
Kim Long reservoir			
Nha Be reservoir			
Ben Da reservoir	In addition to domestic water supply purpose, the water is used for irrigation	B1	QCVN 39:2011/BTNMT

In addition to the required standards for water quality applied to different sections of rivers/streams and reservoirs in Dinh river system mentioned above, the required standards applied to monitoring points in Dinh river monitoring plan are delineated in table 5.2. In case two QCVNs are employed, QCVN with stricter standards will be chosen.

Table 5.2: Required standards applied to each monitoring point

No	River	Station code	Station name	Required standards
1	Dinh	SD-1	Kim Long reservoir	A2 (QCVN 08:2008)
2		SD-2	Soai river bridge	
3		SD-3	Da Den reservoir	
4		SD-4	Cau Do dam	B1 (QCVN 08:2008) & QCVN 39:2011
5		SD-5	Long Huong bridge	
6		SD-6	Co May bridge	aquaculture area column (QCVN 10:2008)
7		SD-7	Confluecne of Cay Khe river & Dinh river	
8		SD-8	Cat lo port	
9	Chau Pha	CP-1	Chau Pha reservoir	A2 (QCVN 08:2008)
10		CP-2	Tan Le B	B1 (QCVN 08:2008) & QCVN 39:2011
11	Mui Giui	MG-1	Long Son	aquaculture area column (QCVN 10:2008)
12	Cua Lap	CL-1	An Ngai	
13		CL-2	Cua Lap bridge	
14		CL-3	Phuoc Tinh fish port	

5.3 Required detection limit

Required detection limit applied to the analysis method used in the above monitoring plan in section 4.6 should be 10-20% lower than the applied action level. Required detection limits are shown in table 5.3.

Table 5.3: Required detection limits (DL) of analysis methods applied in the laboratory

Parameter	Unit	QCVN 08:2008		QCVN 10:2008	QCVN 39:2011	Required DL	Actual DL of the analysis method	Analysis method (to achieve required DL)
		A2	B1	Aquaculture area				
Temperature	^oC	-	-	30	-			
pH	-	6-8.5	5.5-9	6.5-8.5	5.5-9			
DO	mg/l	≥ 5	≥ 4	≥ 5	≥ 2	0.2		
TSS	mg/l	30	50	50	-	3	2.0	
COD	mg/l	15	30	3*	-	1.5	**5.0**	
BOD_5	mg/l	6	15	-	-	0.6	**3.0**	
NH_4^+-N	mg/l	0.2	0.5	0.1	-	0.01	**0.2**	
NO_3^--N	mg/l	5	10	-	-	0.5	0.1	
NO_2^--N	mg/l	0.02	0.04	-	-	0.002	0.001	
PO_4^{3-}-P	mg/l	0.2	0.3	-	-	0.02	0.005	
Fe	mg/l	1.0	1.5	0.1	-	0.01	0.01	
Cd	mg/l	0.005	0.01	0.005	0.01	0.0005	**0.025**	
Pb	mg/l	0.02	0.05	0.05	0.05	0.002	**0.2**	
Zn	mg/l	1.0	1.5	0.05	2.0	0.005	**0.025**	
CN^-	mg/l	0.01	0.02	0.005	-	0.0005		
Phenol	mg/l	0.005	0.01	0.001	-	0.0001		
Pesticides								
Oil&grease	mg/l	0.02	0.1	nd	-	0.002	**0.3**	
Fecal Coliform	MPN/100 ml	50	100	-	200	5		
Total Coliform	MPN/100 ml	5000	7500	1000	-	100		
*: Use $KMnO_4$ method								

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APPENDICES

Location of monitoring stations in a connection with water intake stations and pollution sources along Dinh river

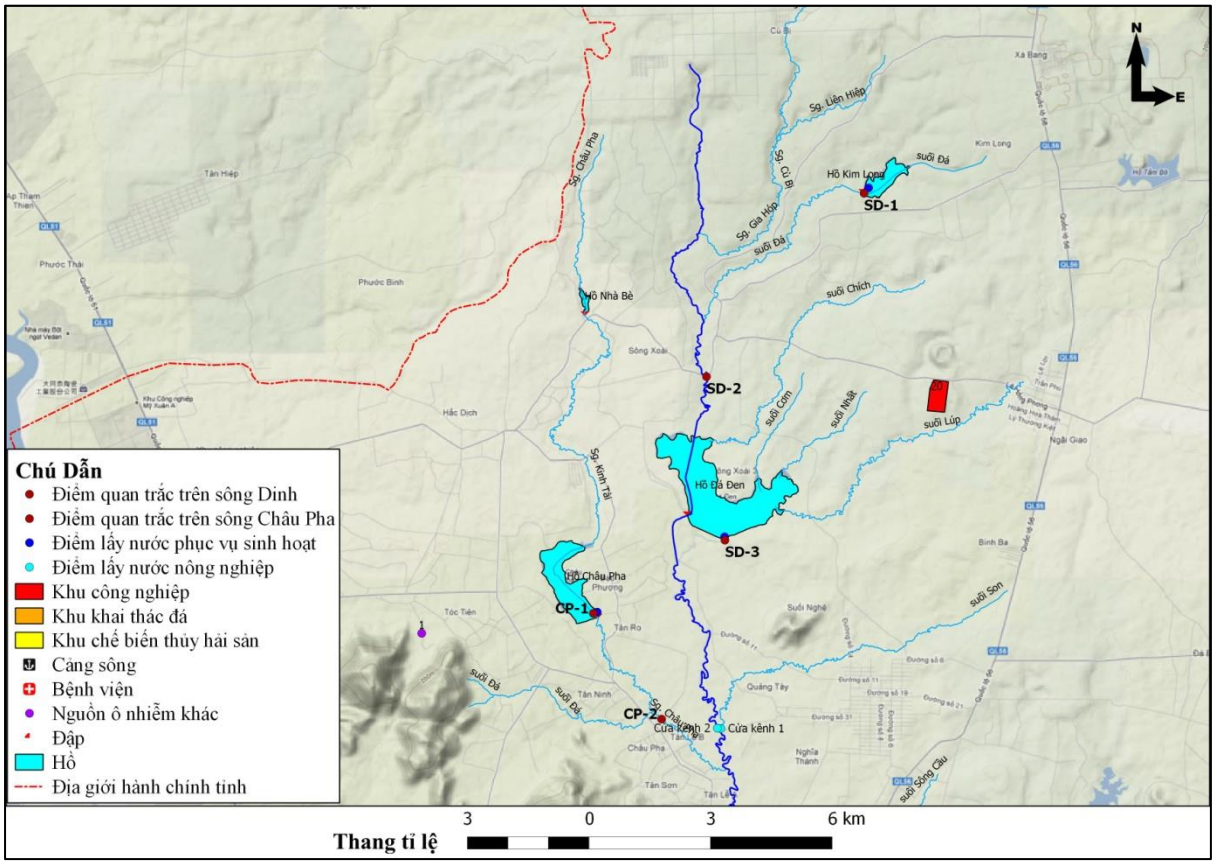

Fig. P-1: Monitoring points of from SD-1 to SD-3 in Dinh river and CP-1 and CP-2 in Chau Pha river

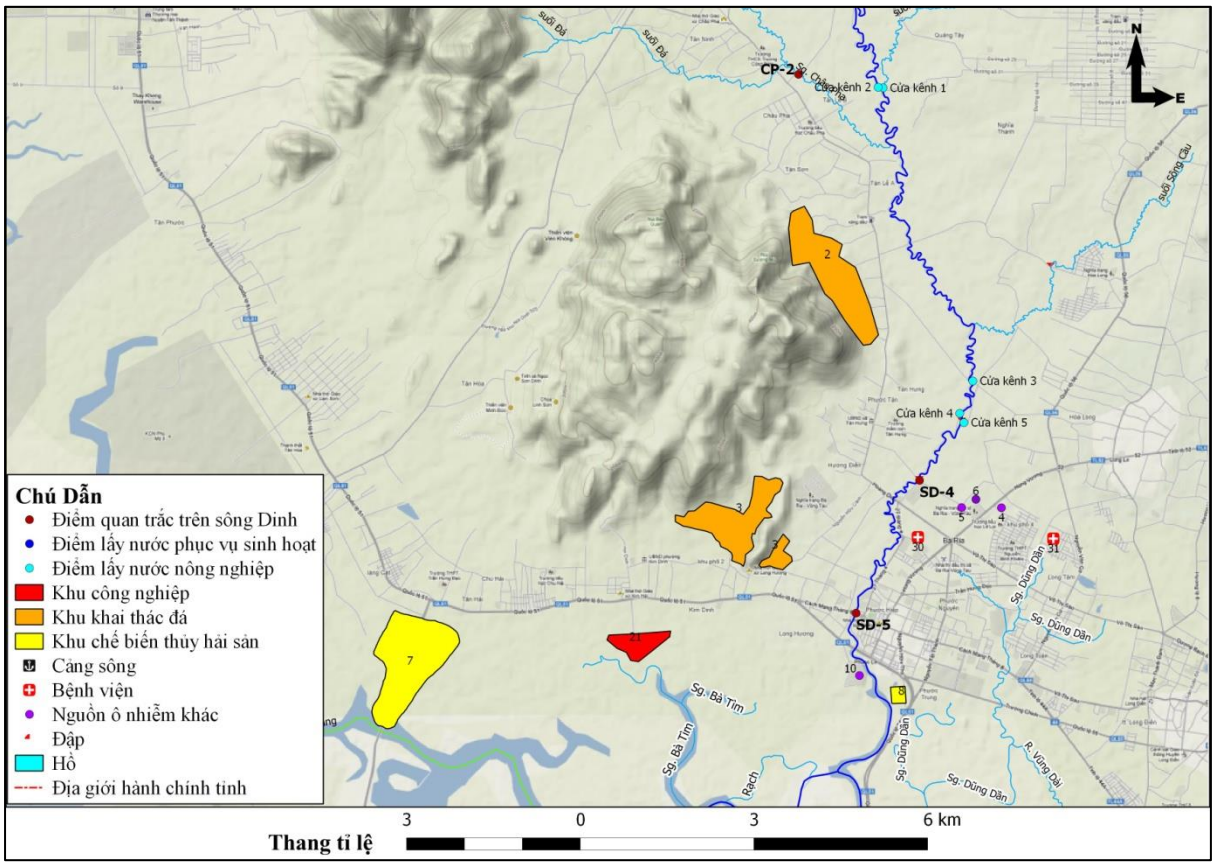

Fig. P-2: Location of monitoring points of SD-4 and SD-5 in Dinh river

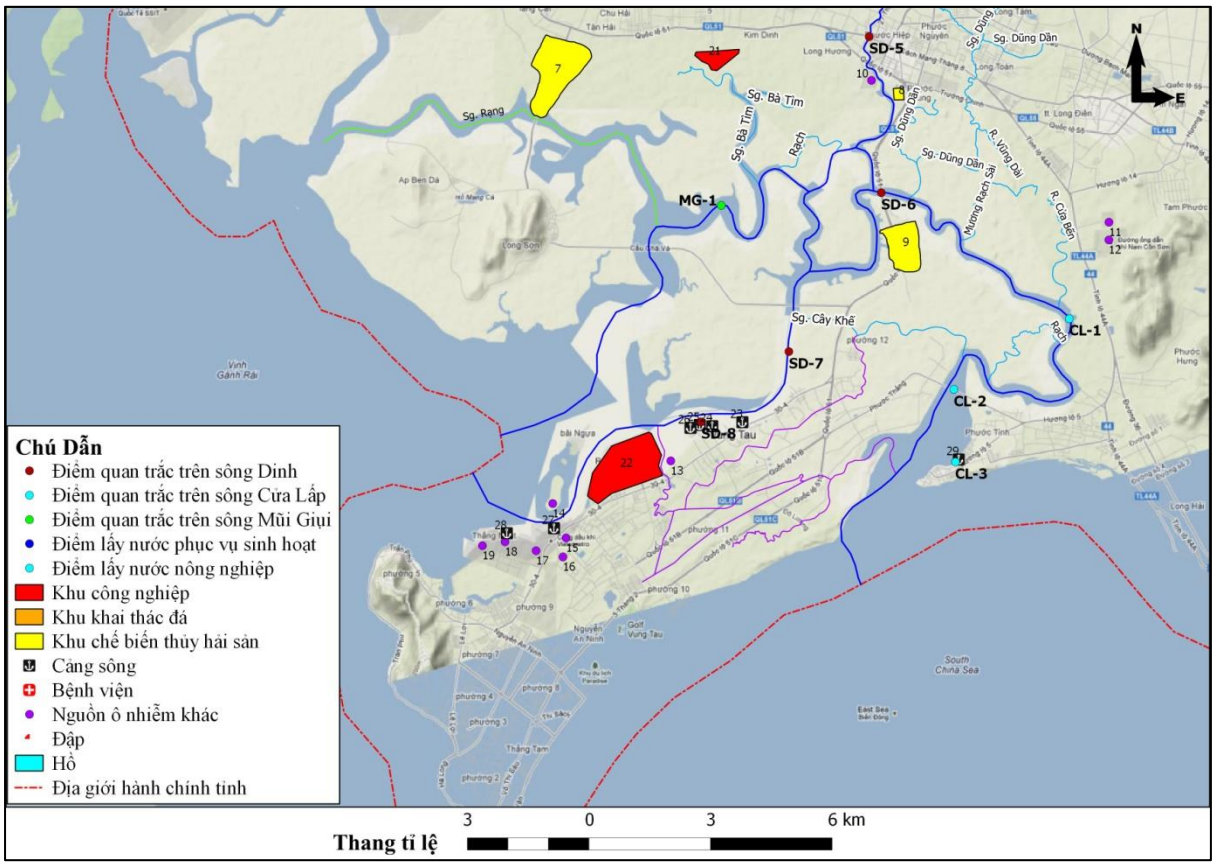

Fig. P-3: Location of monitoring points of from SD-6 to SD-8 in Dinh river and of from CL-1 to CL-3 in Cua Lap river and MG-1 in Mui Giui river