2.12 Thailand

1 | Country Information

Table 2.12.1 Basic indicators

Land Area (km²)		510,890 (2016)
Total Population		69.625 million (2019)
GDP (current USD)		543.65 billion (2019)
GDP per capita (current USD)		7,260 (2019)
Average Precipitation (mm/year)		1,718.1 (2016)*
Total Renewable Water Resources (km³)		438.7 (2017)**
Total Annual Freshwater Withdrawals (billion m³)		57.3 (2014)
Annual Freshwater Withdrawals by Sector	Agriculture	90% (2014)
	Industry	5% (2014)
	Municipal (including domestic)	5% (2014)

(Source: World Bank 2020, *Thai Meteorological Department 2016, **World Data Atlas 2017)

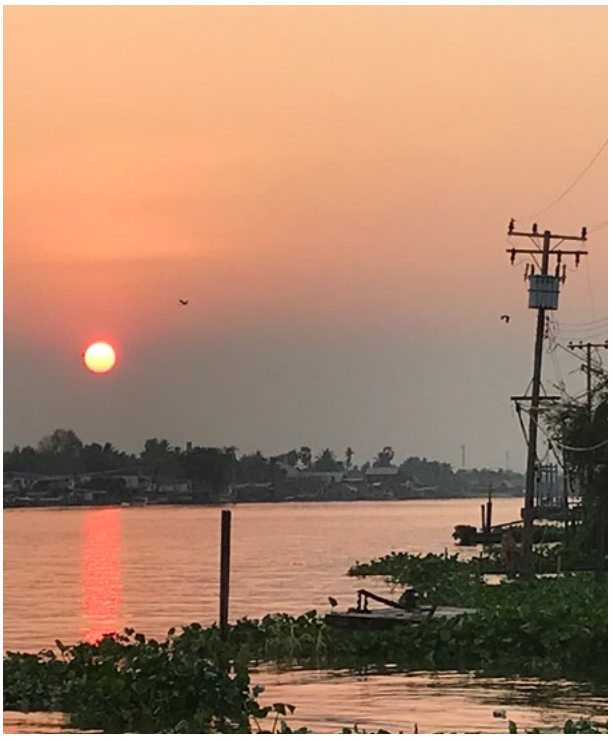

Figure 2.12.1 Chao Phraya River in Thailand

2 | State of Water Resources

Based on geographical characteristics, Thailand can be divided into 25 river basins. The total volume of water from rainfall in all river basins is estimated at more than 800,000 million m³, of which 75% is lost through evaporation, evapotranspiration and infiltration, and the remaining 25% constitutes the runoff that flows into the rivers and streams. The available water quantity is about 3,300 m³/capita/year (Office of National Water Resources Committee 2000).

According to ADB (2013), Thailand has abundant water resources with an estimated 126 billion cubic meters (m³)/annum exploitable, considerably more than the reported national demand for water of 50–56 billion/m³/annum (excluding navigation and ecosystem requirements). Of these water resources, groundwater is important as it supplies 20% of public water supply and 75% of domestic water. The groundwater system is mainly recharged by rainfall of about 40,000 million m³ and seepage from rivers. It was estimated from previous hydrological balance studies that about 12.5 to 18% of rainfall reaches aquifers. Both the government and the private sector have undertaken more than 200,000 groundwater well projects with a total capacity of about 7.55 million m³/day (information from the WEPA focal person in 2012).

3 | State of Ambient Water Quality

3.1 Surface Water

According to the 2019 water quality monitoring results published by the Pollution Control Department of Thailand in 2020, of the 65 major water sources across the country, in terms of water quality, 2% were found to be very good (excellent), 34% were good, 46% were fair, and 18% were poor. The 'very good' water source was the Upper Tapi River. Surface water quality in the northern, central, north-eastern, and eastern regions was worse than in the previous year, and water quality in the central region was worse than other regions. When compared to the surface water classification criteria, only three sources, representing 5% of water sources, met the water quality. The majority of water sources over the past decade (2010–2019) tended to be stable, with water quality ranging from fair to good.

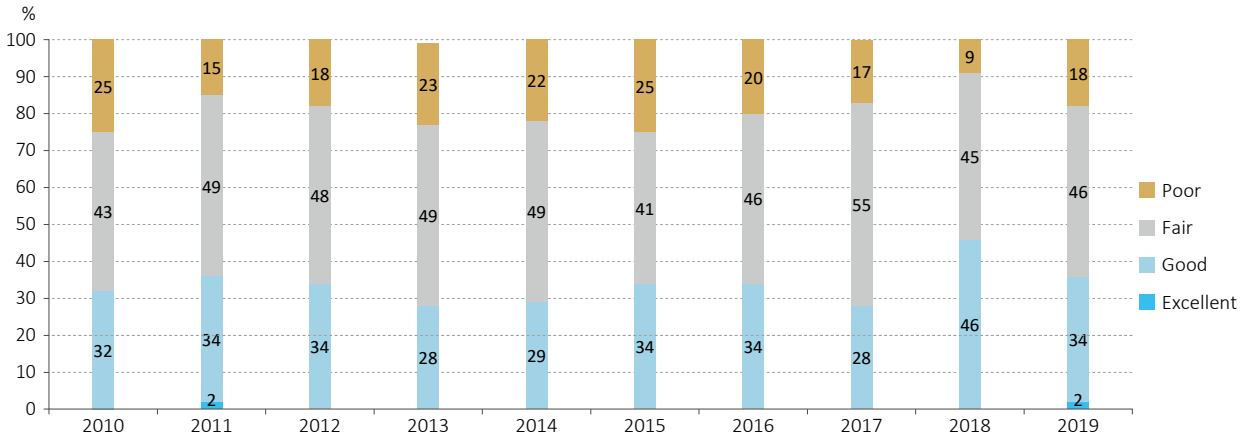

Figure 2.12.2 State of surface water quality across the country during 2010–2019 (Source: PCD 2020)

From the analysis of surface water quality data, it was found that main parameters such as DO, BOD, Total Coliform Bacteria (TCB), Faecal Coliform Bacteria (FCB), Ammonia-Nitrogen (NH_3-N) and Heavy Metals (HMs), did not meet the required standard for surface water sources classification during 2010–2019. More specifically, the percentage of heavy metal values that exceeded the surface water source classification ranges from 0.2–1.5%; meanwhile, for BOD and DO values, they range from 19–36% and 19–31%, respectively, with a slight downward trend.

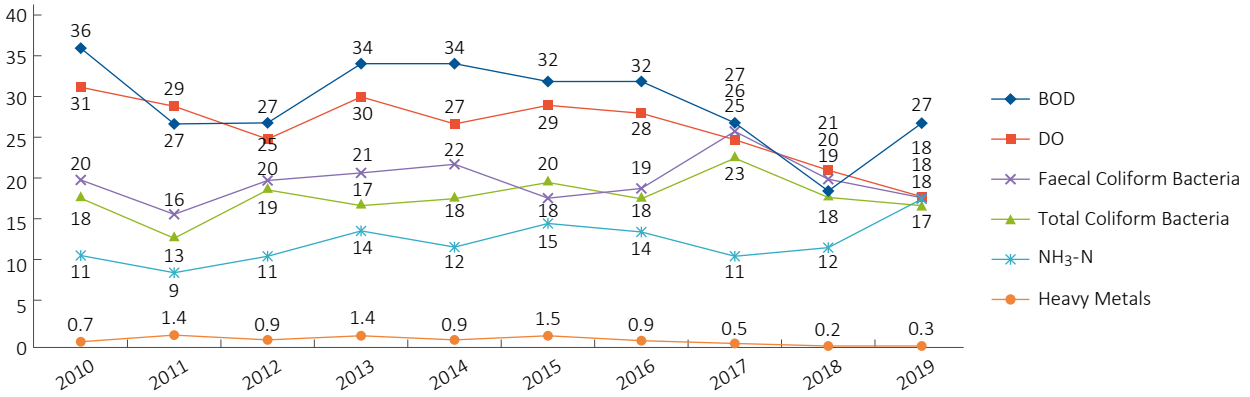

Figure 2.12.3 Percentage of parameters that do not meet the surface water sources classification during 2010–2019 (Source: PCD 2020)

When assessed using the water quality index, that the water sources of highest quality were 1) the upper Tapi River, 2) the Kwai Noi and Kok River, 3) the upper Phetchaburi River, 4) the Lee and Kwai Yai Rivers, and 5) the Tradd River. The most deteriorated water sources were 1) the lower Ram Tahong River, 2) the lower Chao Phraya River, 3) the lower Tha Chin River and the upper Panglad River, 4) the lower Rayong River and the Lopburi River, and 5) the Sakae Klang River. The causes of poor water quality were municipal wastewater, industrial sewage, and agricultural and livestock runoff discharging into major water sources, as well as inefficient wastewater treatment systems and inadequate wastewater collection and treatment (PCD 2020).

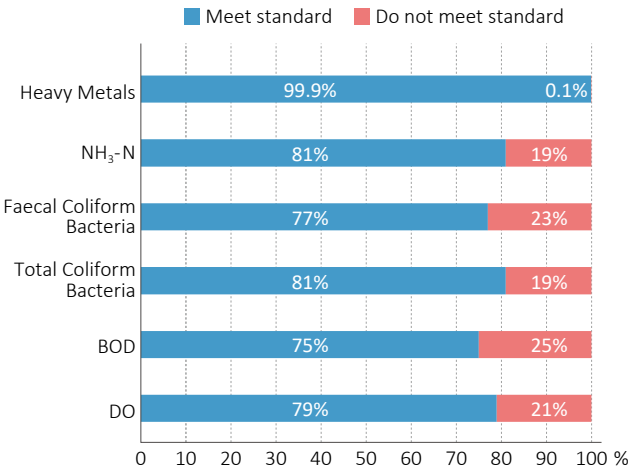

Figure 2.12.4 Results of surface water quality monitoring in the Central region compared to the surface water quality standard - Class 3 (Source: PCD 2020)

Over the past 11 years (2009–2019), the water quality of most water sources was fair. None have been found to be of very poor quality since 2009, and water sources in general are undergoing a transformation towards good water quality. Sources that have consistently retained 'good' status are Upper Tapi, Khwae Noi, and Lum Chee. Conversely, some sources tend to be of consistently poor quality, requiring close monitoring and problem solving, which are the Lower Chao Phraya, Lower Tha Chin, Lop Buri and Lower Lumtakong.

For the purposes of water quality monitoring and evaluation, water samples are collected four times a year, and analysed in accordance with surface water quality standards issued under the Enhancement and Conservation of Natural Environmental Quality Act 1992. The 23 parameters analysed include temperature, Acidity/Alkalinity (pH), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Coliform Bacteria (TCB), Faecal Coliform Bacteria (FCB), Nitrate-Nitrogen (NO_3^--N), Ammonia-Nitrogen (NH_3-N), heavy metal group such as Copper (Cu), Nickel (Ni), Manganese (Mn), Zinc (Zn), Cadmium (Cd), Chromium (Cr), Lead (Pb), Mercury (Hg), Arsenic (As), and chlorinated pesticides such as DDT, Alpha-BHC, Dieldrin, Aldrin, Endrin, and Heptachlor Epoxide (PCD 2014).

3.2 Coastal Water

According to the Thailand State of Pollution Report 2019, the coastal water quality is generally fair to good. While tourist beaches have excellent coastal water quality, some coastal areas are consistently defined as poor, especially in the Inner Gulf of Thailand.

In 2019, the coastal water quality monitoring results showed that 2% of samples were of very good quality, 59% were of good quality, 34% were fair, 3% were poor, and 2% very poor. Coastal water quality over the past 10 years has tended to improve since 2016 and remained stable through 2019. 'Very good' coastal waters were Koh Lann, Phrao Bay (Samet Island), Ban Son Bay, and Koh Phangan; however, the Gulf of Thailand at the mouths of the Bang Pakong, Chao Phraya, and Tha Chin rivers continued to have poor to very poor water quality. There were 26 red tide events (over four times the amount in the previous year), presumably caused by factors such as municipal wastewater discharge, industrial and agricultural drainage, oil spills from drilling, oil transport, navigation, and rapid phytoplankton production (PCD 2020).

The trend of coastal water quality in the period of 2010–2019 also showed that, in general, most of the coastal water quality has been at a fair to good level, the percentage of coastal water locations with poor and very poor quality have reduced, and the percentage of coastal water locations with fair and good quality has increased, especially after 2015.

Coastal water samples have been collected twice a year and evaluated using the Marine Water Quality Index (MWQI). This tool was developed by the Pollution Control Department for assessing marine water quality in a range of 0–100 (0–25: very poor; 25–50: poor; 50–80: fair; 80–90: good; 90–100: excellent). The MWQI is calculated from the coastal water quality data across eight parameters: Dissolved Oxygen (DO), Total Coliform Bacteria (TCB), Phosphate - Phosphorus (PO_4^{3-}-P), Nitrate - Nitrogen (NO_3^--N), Temperature (Temp.), Suspended Solids (SS), Acidity - Alkalinity (pH) and Ammonia - Nitrogen (NH_3-N). However, if levels of pesticides and toxic elements such as Mercury (Hg), Cadmium (Cd), Total Chromium (Total Cr), Chromium Hexavalent (Cr^{6+}), Lead (Pb), Copper (Cu), Cyanide (CN^-) and PCBs are found to exceed the Marine Water Quality Standards, the MWQI is recorded as "0" by default (PCD 2017). In general, the main parameters indicating coastal water quality problems are bacteria (Total Coliform Bacteria, Faecal Coliform Bacteria and Enterococci), as well as chemical contaminants, i.e., phosphates (phosphorus)

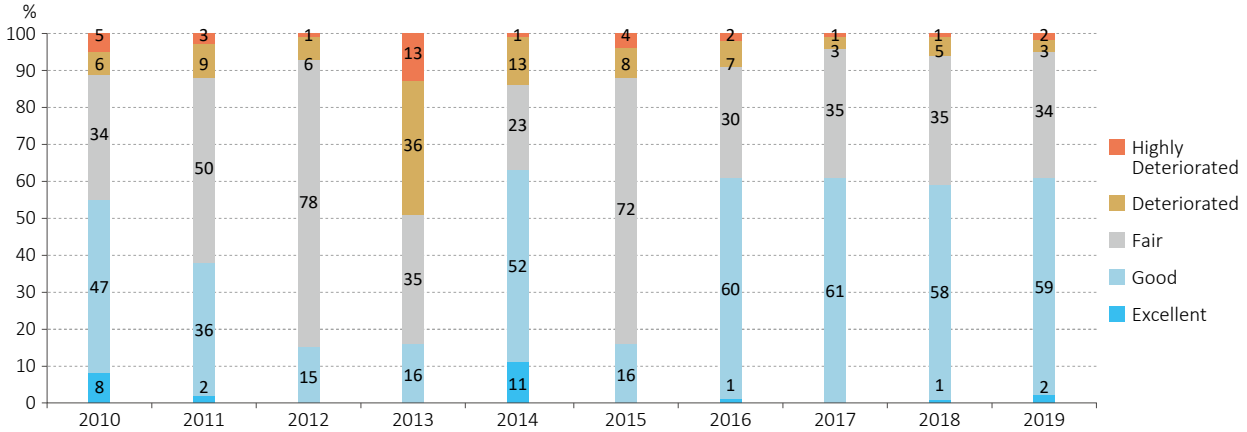

Figure 2.12.5 State of coastal water quality across the country over 2010–2019 (Source: PCD 2020)

and nitrates (nitrogen), mostly from communal and tourist areas, and agricultural and industrial activities. Areas where water quality was found to be of poor to very poor quality are areas of the Inner Gulf of Thailand and estuaries of the Bang Pakong River, the Chao Phraya River, the Tha Chin River, and the Mae Klong River (PCD 2015, PCD 2017).

3.3 Groundwater

In 2019, groundwater quality and groundwater level changes were monitored from 1,162 observation wells at 2,098 sites distributed across 27 basins/watersheds. The results showed that groundwater was generally of good quality and within the standard, according to the Groundwater Act B.E.2520. However, in some areas, concentrations of iron and manganese exceeded the standard due to geographical or hydrological conditions. Also, in the Gulf of Thailand and areas along Lake Songkhla, the salinity level of groundwater has increased. Heavy Metals (HMs) and volatile organic compounds (VOCs) exceeding the required standard for groundwater have been detected in samples at some waste disposal sites, industrial waste disposal sites, and industrial parks (PCD 2020). Therefore, groundwater use needs to be carefully monitored for possible contamination.

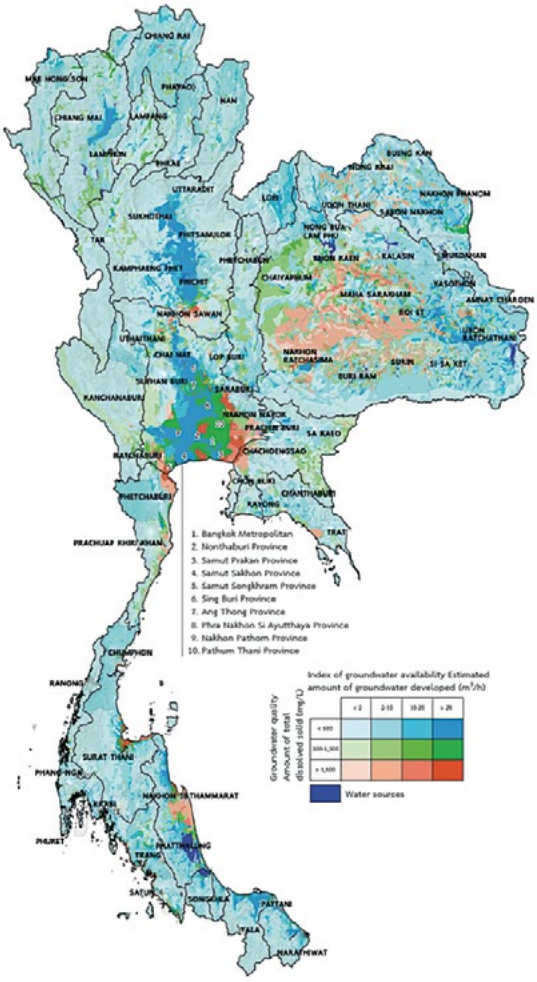

Figure 2.12.6 State of groundwater quality in Thailand
(Source: Department of Groundwater Resources 2019, PCD 2020)

4 | State of Wastewater Treatment

Rapid population growth and the lack of proper collection, treatment, and management of domestic wastewater are the main causes of water quality degradation in surface and coastal waters. In 2019, the total population increased from 66.41 million (2018) to 69.63 million, and numbers of foreign tourists entering the country increased from 25.83 million (2018) to 26.56 million (PCD 2020). Consequently, the total amount of generated wastewater has also increased. Meanwhile, wastewater is discharged into water resources from various sources, including local businesses, factories, and agricultural activities, often exceeding the carrying capacity of the concerned water source, especially in some important river basin areas, major waterways, and tourist destinations. Activities such as related to industry, ports, tourist attractions, and aquaculture are also increasing each year.

Although both surface and groundwater pollution derive from various sources, the main sources of water pollution can be divided into three types: domestic wastewater with a total generated amount of about 9.7 million m³/day, industrial wastewater with a total volume of 17.8 million m³/day, and agricultural wastewater with a discharged volume of 4.9 million m³/day (only for pig farms and aquaculture operation) (Chaiyo 2019).

Domestic wastewater

Every day it is estimated that 9.7 million cubic meters of domestic wastewater is generated across the country, which is managed by 105 centralised municipal wastewater treatment plants operated by local government agencies and wastewater management authorities. Currently, 95 treatment plants are in operation, with a treatment capacity of 2.6 million cubic meters per day (27% of total wastewater volume). In big cities like Bangkok, ratios of treated wastewater are higher, estimated at 45% (PCD 2020). The main reason for the low ratios of treated domestic wastewater across the country is the lack of budget to cover investment as well as operation and maintenance system expenditure at the local administrative organization level. The treatment technology used for wastewater mainly comprises stabilization ponds, aerated lagoons, and activated sludge systems.

Houses and all other buildings are required to install

wastewater treatment systems for primary treatment to reduce the contamination of wastewater before it is discharged into water sources.

Large buildings such as hotels, condominiums, hospitals, department stores, markets, restaurants, schools, dormitories and office buildings are required to install wastewater treatment systems and treat wastewater according to standards. Monitoring and law enforcement are regularly implemented to manage wastewater treatment, especially in important river basin areas, major canals, and attractive beaches. Survey results revealed that 62% of large buildings are in compliance with the law (PCD 2020).

Industrial wastewater

Industries discharge processed wastes including by-products from industrial operations as wastewater. At present, many industries are located in areas of high population density or within residential areas in cities. Across the country there are more than 120,000 industrial establishments of various sizes in 77 provinces, carrying out a wide range of activities, located within the Inner Gulf. Meanwhile, there are approximately 87,000 small or community factories in Thailand, contributing 6% of the BOD load in main rivers (Wangcharoenrung 2017). The total amount of generated industrial wastewater was estimated at 17.8 million m^3/day (Chaiyo 2019). Laws and regulations are being strictly enforced for small/community, medium-sized and large factories, industrial plants and industrial estates, which were all required to have wastewater systems complying with the effluent standards set by the Government of Thailand.

General standards for controlling effluent from industry, industrial parks, industrial zones and specific standards for producing fresh water from seawater reverse osmosis plants, leather mills, pulp and paper mills have been issued.

Many industries, such as dyeing, textiles, pulp and paper, tea, coffee and beverage industries, small and medium-sized enterprises (SMEs), have transferred to using clean technologies to reduce waste, water and raw material use, energy, greenhouse gas and CO_2 emissions, and have achieved effluent standards in both production processes and discharge lines. During 2011–2018, about 34,000 plants were certified as green industrial plants.

Industries that generate large volumes of wastewater are obliged to install equipment and tools to measure Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) parameters, and report such to local authorities via computer networks to ensure their treated wastewater meets the standards.

Agricultural wastewater

Agricultural activities such as the use of chemical fertilizers, pesticides and animal wastes from livestock farms (e.g., pig farms) all produce wastewater. A large portion of the fertilizer used for rice paddy fields is washed away by irrigation water and flows into rivers, estuaries, or other bodies of water, which causes eutrophication and encourages water hyacinth growth. This unwanted plant grows very quickly, and smothers major areas of water bodies.

Standards for controlling water discharge from pig farms and aquaculture have been formulated, and monitoring systems are in place to ensure wastewater treatment plants operate within the standards. Farmers are assisted in managing wastewater efficiently and produce in an environmentally friendly manner. Currently, there are 18,118 aquaculture farms, which are GAP (Good Aquaculture Practice) certified (PCD 2020).

To both raise awareness and develop environmental management of pig farms, including of waste treatment and recycling in order to reduce the impact of odour and polluted water problems, a project named “Farm Rak Sing Waed Lom” (Environmentally Friendly Farm) was launched, aimed at farmers.

5 | Frameworks for Water Environmental Management

5.1 Legislation

The Constitution of Thailand (RTG 2017) stipulates that the Thai people have the duty to cooperate in and support the conservation and protection of the environment, natural resources, biodiversity, and cultural heritage (chapter IV, section 50-8). Meanwhile, the State has the responsibility to “conserve, protect, maintain, restore, manage, and utilize or arrange for utilization of natural resources, environment, and biodiversity to attain benefits in a balanced and sustainable manner and shall allow the people and communities in the concerned localities to participate in and benefit from the implementation herein described as required by the law” (chapter V, section 57-2). The Constitution also stipulates that the Thai people have a right to use the environment, but that they also have a duty to conserve and protect the environment.

Meanwhile, the Enhancement and Conservation of the National Environmental Quality Act (NEQA) of 1992 is the basic law for environmental conservation in the country and defines the authorities and responsibilities regarding environmental protection. Some key features of NEQA are as follows:

- Establishment of the Environmental Fund, from which resources will be drawn to solve environmental problems in priority areas.
- Formulation of a National Environmental Management Plan, executing duties of government agencies to implement the plan and for provinces to prepare action plans.
- Provision for the National Environmental Board (NEB) to declare Pollution Control Areas (PCAs) or Conservation and Environmentally Protected Areas when justified from an environmental point of view.
- Establishment of a multi-agency Pollution Control Committee for pollution control matters, including enactment of discharge standards.
- Recognition of the Polluter Pays Principle.

In terms of control and management of water quality issues in Thailand, the regulations can be grouped into three categories as follows:

- The application of the environmental impact assessment (EIA) to determine the impact and mitigation plan for development projects of various types and sizes such as dams with a storage volume of 100 million m^3 or more, irrigation projects of 12,800 ha or more, hotels or resorts with 80 rooms or more, thermal power plants with capacities of 10 MW or more, and mining projects of all scales.
- The establishment and application of effluent standards such as industrial effluent standards, domestic effluent standards, and effluent standards for pig farms and fish/shrimp farms.
- The ambient water quality standards and classification based on the state of water quality, socio-economic aspects and availability of treatment technologies.

An overview of the legislation related to water environmental management in Thailand is shown in Figure 2.12.7.

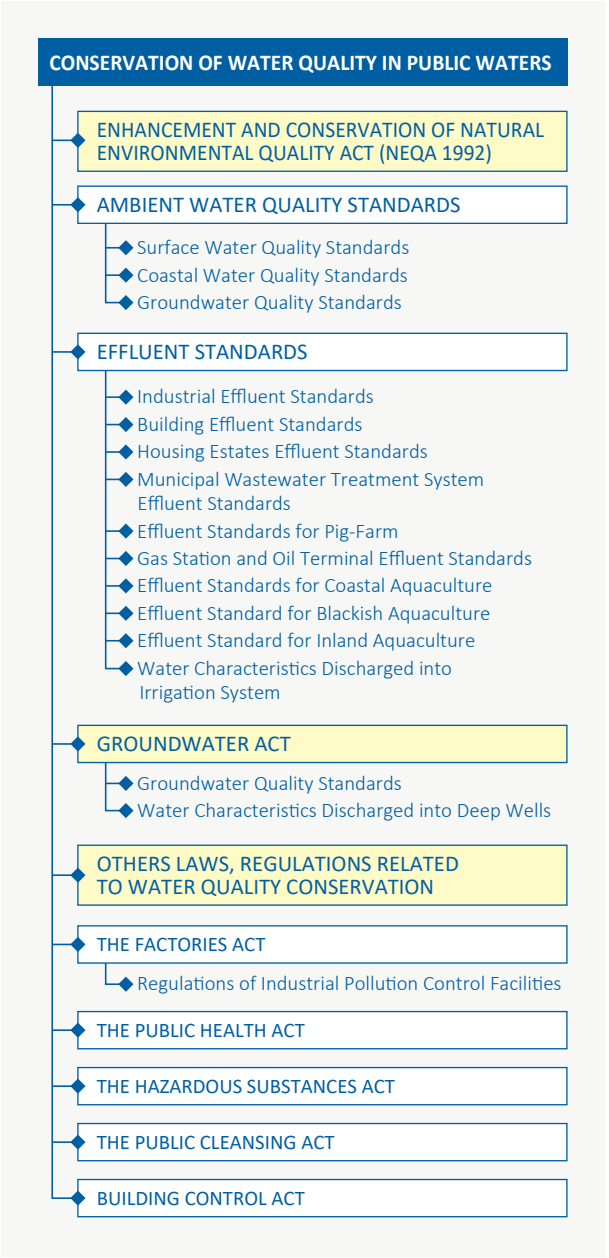

Figure 2.12.7 Legislative chart for water quality management

(Figure was prepared by IGES based on information from the official website of Thailand Pollution Control Department: http://www.pcd.go.th/about/en_ab_mission.html)

5.2 Institutional Arrangement

According to NEQA, PCD and the Office of Natural Resources and Environmental Policy and Planning (ONEP) under MoNRE are responsible for wastewater management through conducting national and regional water quality management planning as well as facilitating local authorities in their responsibilities for wastewater management. Under the EQA, the PCD establishes effluent standards for pollution control from point sources in order to meet ambient environmental quality standards.

5.3 Ambient Water Quality Standards

Surface water quality standards

The first standard for ambient water quality was established in 1994, and comprised 28 items under five categories of water bodies, designated according

to water usage as shown in Table 2.12.2. The General Water Quality Index was established as an indicator to promote people's understanding of water quality, which was calculated with the values of eight parameters (pH, DO, BOD, TS, FCB, NO_3 , TP, SS). These standards are the national minimum standards.

Table 2.12.2 Surface water quality standard classification

Class	Description/Condition	Beneficial Use
Class 1	Natural water resources without wastewater from any activities	Water is safe for consumption, sanitized, and appropriate for propagation and ecosystem conservation.
Class 2	Very clean fresh surface water resources	Water resources for conservation, fishery, swimming, water recreation and consumption (with basic treatment).
Class 3	Medium clean fresh surface water resources	Water resources for agriculture and consumption (with general treatment).
Class 4	Fairly clean fresh surface water resources	Water resources for industrial work and consumption (with special treatment).
Class 5	Sources which are not classified into classes 1-4	Water resources for transportation.

(Source: PCD 2015)

Coastal water quality standards

The coastal water quality standards comprise 30 parameters designated in six classes, determined according to usage (six classifications). Different classifications are applied for the west coast of Phuket Island.

Groundwater quality standards

The parameters included in groundwater quality standards are divided into four groups: volatile organic compounds (15 parameters), heavy metals (10 parameters), pesticides (nine parameters) and others (four parameters).

Water quality monitoring framework

Under the EQA, the government conducts monitoring of the receiving water quality to maintain quality. The Water Quality Management Division under the Pollution Control Department - Ministry of Natural Resources and Environment (MONRE) is responsible for regular monitoring of both inland (surface and groundwater) and marine water. There are 368 general and 75 automatic monitoring stations across 48 main rivers and six standing surface water resources (lakes) within the country. Water quality samples from general monitoring stations are taken four times/year during the wet and dry seasons (Chaiyo 2020), and the methods used should follow the Standard Method for the Examination of Water and Wastewater (1998) (Yolthantham 2011). Monitoring results of ambient water quality, conducted by the Pollution Control Department, are summarized and made available to the public through online publications annually (e.g., Thailand State of Pollution Report).

5.4 Effluent Standards

Based on the NEQA (Section 32), a series of effluent standards have been set up as follows:

a. Industry

Industrial effluent standards

Standards are applied to factory Group II and III categories and all industrial estates under the Factory Act B.E. 2535 (1992). Standard values are designated for 15 parameters and 12 heavy metals. This standard has been used since 3 January 1996. The standard also provides some exemptions for certain industries such as related to chemicals, starch, and animal foods. Recently, a new Decree on Industrial Effluent Control Standard B.E. 2559 (2016) was announced by the Ministry of Natural Resources and Environment of Thailand, on 6 June 2016, to take effect from 6 June 2017. Under the new standard, no exemptions are permitted. The standard is comprised of two parts – a general effluent standard (consisting of 15 parameters and 16 heavy metals), and type-specific effluent standards.

Regarding effluent quality control, the Regulations of Industrial Pollution Control Facilities (1982) stipulates that specific industrial plants are obligated to have supervisors and machine operators responsible for pollution prevention. Such industrial plants include those using heavy metals in production processes and discharging wastewater in quantities above 50 m^3/day containing designated quantities of heavy metals.

b. Domestic and commercial

Building effluent standards

Effluents from each type of building, namely apartments, hotels, hospitals, schools and academic buildings, public

and private offices, department stores, fresh markets and restaurants, are regulated under these standards. Regulated parameters, depending on building size, include pH, BOD, suspended solids, sulfide, TKN, and fat, oil, and grease.

Housing estate effluent standards

These standards regulate effluent from housing estates, which are classified into two types: those with over 100 but less than 500 units, and those over 500 units. Regulated parameters include pH, BOD, suspended solids, settleable solids, total dissolved solids, sulfide, TKN and fat, oil, and grease.

Municipal wastewater treatment system effluent standards

This is a new standard, established in 2010, and contains six parameters, namely pH, BOD, SS, TN, TP and fat, oil, and grease.

Gas station effluent standards and oil terminal effluent standards

There are four parameters in these standards, namely pH, COD, SS, and fat, oil, and grease.

c. Agriculture

Effluent standards for pig farms

In consideration of the contribution of pig farms to water pollution such as in the Tha Chin River and Bang Pakong River, standards were established in 2001. Parameters designed by the standards include pH, BOD, COD, SS, and TKN and different values are applied to Type A (more than 600 livestock units) and Type B (60–600 livestock units).

d. Others

Effluent standards for coastal aquaculture and others

There are several effluent standards for aquaculture and others as follows:

- Effluent Standards for Brackish Aquaculture
- Effluent Standards for Inland Aquaculture
- Water Characteristics Discharged into Irrigation System
- Water Characteristics Discharged into Deep Wells

Effluent inspection procedures

Around 10 years ago, under the Environmental Army Project (2005–2007), over 25 universities across Thailand took part in a large-scale survey to support the inspection of about 120,000 factories in the country, which was aimed at building a wastewater database for better planning and management of industrial wastewater in the future. The data collected includes: (i) Contact address; (ii) GPS Coordinates; (iii) Photos of front door and effluent points; (iv) Boiler's exhaust opacity with Ringelmann Scale; (v) Effluent wastewater quality.

According to Wangcharoenrung (2017), under a survey carried out by the Environmental Army Project 10 years ago targeting factories, the results showed that compliance statistic was almost the same after 10 years. In addition, a number of challenges in monitoring have also been pointed out, including:

- Limited human resources: Approximately 120,000 factories in 77 provinces but only three inspection officers per province for Ministry of Industry and 40 officers for Pollution Control Department.
- Insufficient monitoring tools: lack of equipment and laboratory facilities for monitoring and analysis.
- Data exchanges between government agencies is not common thus much duplication exists.
- Lack of environmental awareness/honesty of factories; profit is considered paramount.

Problematic industries, which often fail to comply with the effluent standard are classified into three types (Wangcharoenrung 2017):

- High Risk Industry Group (1): Those with frequent accidents, such as in the petrochemical industry, ethanol industry, sugar industry and cold storage industry. Possible reasons: (i) lack of qualified/well-trained safety and environmental officers; (ii) lack of accident prevention training.
- High Pollution Industry Group (2): Those finding it challenging to comply with the effluent standard, such as the starch industry, textile, pulp and paper industry and leather tanning industry. Possible reasons: (i) one general effluent standard cannot fit all types of factories; (ii) only concentration-based standard exists; (iii) lack of knowledgeable persons for wastewater treatment plant operation.
- Low Capacity for Environmental Management Group: Those which do not treat wastewater, such as SMEs and community factories. The survey conducted in 2014 showed there are approximately 87,000 small and community factories, contributing 6% of the BOD load of main rivers in Thailand. Possible reasons: (i) factories lack funding and

knowhow for wastewater treatment; (ii) small site inspections are impossible or too challenging.

In 2016, statistics related to pollution complaints from various responsible offices showed that there were 10,422 complaints, a drop of 9% from the previous year. The types of pollution problems included air pollution (foul odours, dust and smoke), noise levels and vibration. However, most of the complaints received by the Public Service Center, Office of the Permanent Secretary, Prime Minister Office concerned municipal solid wastes, sewage wastes, and hazardous wastes (PCD 2016).

Effluent monitoring

The NEQA requires the owner or possessor of point sources of pollution designated under the act to monitor the quality of effluent and collect statistics and data, as well as submit notes and reports (Section 70 and 80). The types of effluent to be monitored are categorized into four groups: sewage-swine farms; land development, industrial estates and industrial zones, and Class A buildings (hotels, hospitals, condominiums, department stores, markets and restaurants). The point sources of water pollution were also monitored in three river basins: the Chao Phraya, Tha Chin, and Bang Pakong.

If the capability to treat or dispose of wastewater fails to meet applicable standards, the owner has a duty to make modifications or improvements to reach conformity with the pollution control official's directions. Fees, fines and civil liability and penal provisions are applied if violations are found or the owners refuse to comply. It is a promising trend that all sectors are willing to comply with the standards, and it can be advantageous for securing business agreements as well as lead to improved quality of the environmental and by extension quality of life.

Meanwhile, the Pollution Control Department has the authority as pollution control office under the National Environmental Quality Act B.E. 2535 (1992) to investigate wastewater effluent from various pollution sources. According to the PCD (2015) in 2015, 1,392 pollution sources consisting of industrial factories, industrial estates, certain types and sizes of buildings, gas service stations, swine farms, municipal wastewater treatment systems and allocated lands were under investigation, of which 404 sources did not meet the standards. While notification to officers in the Factory Act was required for industrial factory and industrial estate sources, administrative orders were issued to pollution contributors or possessors other than industrial factories and industrial estates to make changes, corrections, or improvements to their pollution treatment systems to meet the required standards within designated time durations.

5.5 Other Policies on Water Environmental Management

The Government of Thailand has, over time, invested over 83 billion THB in constructing centralized wastewater treatment facilities. As per Section 23 and Section 24 of the Decentralization Act, 1999, Provincial Administrative Organizations, Municipalities, Tamboon (sub-district) Administrative Organizations and the City of Pattaya may receive income from fees collected from users for the public services provided in order to operate and maintain the facilities (Bao et al. 2020).

Similarly, under the National Environmental Quality Improvement and Conservation Act of 1992, local governments may collect fees from service areas where centralized wastewater treatment facilities were built and operated as public works using government funds. On 4 December, 2006, the National Environmental Board (NEB) agreed to collect wastewater management fees based on the "Polluter Pays Principle" and the type of wastewater treatment system. According to a recent study, only around 17 local government agencies have adopted user fees for wastewater collection across the country (Bao et al. 2020). For various reasons, most local government agencies do not impose user fees or service charges for wastewater collection and treatment, which has resulted in insufficient funds to operate and maintain existing treatment plants.

Despite the many economic tools or instruments available, which have also been successfully applied in other countries, none have been successfully applied in Thailand. As a basic guiding rule, to effectively address the issues surrounding water pollution, the principle of 'polluters pay principal' should therefore be adopted nationwide. It should be noted that, based on the lessons learned from other ASEAN countries, economic instruments can be successfully implemented when combined with other measures, such as stricter environmental standards, guidelines on alternative technologies, and environmental awareness raising measures.

6 | Recent Developments in Water Environmental Management

The 12th National Economic and Social Development Plan

On 13 September 2016, the 12th National Economic

and Social Development Plan was approved by the Cabinet, which contains 10 strategies, two of which focus on pollution management: (1) a strategy on an "environmentally-friendly growth for sustainable development", and (2), strategy on "the development of the various regions, the cities, and economic areas, with the goal of conserving and restoring natural resources and the environment in order to sustain an environmentally-friendly growth and the people's good quality of life".

Pollution Management Plan for 2017–2021 period

Also occurring in September 2016 was the National Environmental Board's approval of the Pollution Management Plan for the 2017–2021 period, prepared by the Ministry of Natural Resources and the Environment (MONRE), which contains four strategies, two of which cover pollution management. One is a strategy for managing the quality of the environment in a good state, i.e., such that it is protected, rehabilitated and restored. The other focuses on increasing the efficiency of usage of natural resources in a worthy and sustainable manner, which can be used to gauge whether all stakeholders are aware of the value of natural resources, utilize them efficiently, as well as mitigate any potential environmental impact and thus enabling economic development on the bases of sustainable bio-resources.

20-Year Pollution Management Strategy

On 28 December 2016, the National Environmental Board gave its approval for the 20-Year Pollution Management Strategy prepared by MONRE, with goals in three phases: (i) Phase 1: in the first five years, improve the pollution management system; (ii) Phase 2: in years 10–15, produce and consume environmentally-friendly products on a daily-life basis; and (iii) Phase 3: within 20 years, gear the country towards becoming a low carbon and zero waste society.

Maintenance of the Cleanliness and Orderliness of the Country Act (No. 2) B.E. 2560 (2017)

Also taking place in 2016 was the Ministry of Interior's drafting of the Maintenance of the Cleanliness and Orderliness of the Country Act (No. 2) B.E. 2560 (2017), which was approved by the Cabinet on January 12th, 2016. It states that local administrative offices in each area are to be responsible for the collection and disposal of sewage waste and municipal solid waste. The Minister of Interior is to issue a ministerial regulation as follows: (i) set up a specific fee for sewage and municipal solid waste management, (ii) assign the responsibility and authority to Local Administrative Organizations concerning waste collection, transport and disposal, (iii) those who wish to conduct businesses around sewage and waste collection, transportation and disposal must apply for a license from the local administrator, (iv) the Department of Local Administration has the duty to propose, advise and support the Local Administrative Organizations to conduct plans for the Waste Management Project to be in-line with the provincial development plan, prepare a budget for local administrative organizations requiring budgetary support drawn from the National Budget, state the penalties under criminal law for those conducting unauthorized business operations around waste collection, transportation and disposal, as well as for those who infringe local laws. This Act was announced in the Royal Thai Government Gazette No. 134 Section 5A on 15 January B.E. 2560 (2017), and went into effect on 16 January B.E. 2560 (2017) (PCD 2016).

Strategy for Water Resource Management Act B.E. 2558–2569 (2015–2036)

MONRE in cooperation with Ministry of Agriculture and Cooperatives drafted the Strategy for Water Resource Management Act B.E. 2558–2569 (2015–2036) which was approved by the Cabinet on 7 May, 2015. The strategy set a policy framework for unified and integrated prevention of and solutions to water resource problems, including the scarcity of water, flooding and water quality issues. The vision of the strategy states that "Every single village has clean water for household consumption as well as for stable production. Damages from flooding are mitigated. Water quality meets the standard. Water resources are sustainably managed with balanced development and participation of all sectors". This Strategy consists of six sub-strategies, each focusing on a different target area: (i) Strategy for Water Management for Household Consumption, (ii) Strategy for Creation of the Stable Water Supply in Production Sector (both agricultural and industrial sectors), (iii) Strategy for Flooding Management, (iv) Strategy for Water Quality Management, (v) Strategy for Conservation and Mitigation of Impaired Watershed Forest and Prevention of Soil Erosion, and (vi), Strategy for Management.

7 | Challenges and Future Plans

The water environmental management in Thailand has historically been a priority for the country, especially since 1992. Legislative frameworks have since been developed and improved to promote implementation, and over the last 25 years, the overall picture of the

country's state of pollution shows some improvements, due to the cooperation of various stakeholders, including governmental and non-government actors. However, many issues still need to be addressed, such as the steady degradation of water quality in many cities and areas due to rapid development of communities, especially those living next to waterways, and impacts from agricultural and industrial activities. Many cities also still lack appropriate sewage collection and treatment systems.

Based on the current challenges and above discussion, it is recommended that the following measures be considered to further improve water quality and more effectively control water pollution in Thailand in the coming years:

- Effective implementation and enforcement of relevant laws and strategies on water pollution prevention and protection of water resources, including National Water Quality Management Plan under the 20-year Pollution Management Strategies, Strategy for Water Resource Management (2015–2036); 20-year Marine and Coastal Resources Management Master Plan (2017–2036), the National Water Quality Master Plan (2018–2037), and the 20-year Groundwater Resources Management Strategy (2017–2036).
- Effective application of economic measures in the pollution permitting system to reduce discharges to water sources and maintain acceptable water quality level.
- Establishing specific effluent standards, taking into account the sensitivity of the surrounding area and the assimilative capacity of the receiving water body.
- Regular monitoring of ambient water quality, investigation of water quality changes, and inventory of pollution sources, which play an important role in strategies for effective water quality protection and management.
- Use of less capital-intensive solutions, to avoid constructing costly centralized wastewater treatment plants and raise the ratio of wastewater treatment. Decentralized wastewater treatment systems can be integrated as an effective means to supplement centralized systems, due to their competitive advantages of cost, area availability and just-in-time nature, thereby improving wastewater management, especially in urban and peri-urban settings. There should be zoning of areas for different sanitation system schemes, i.e., on-site/decentralized/centralized or combinations thereof, considering various local factors such as population density and land availability.
- Development of appropriate guidelines and procedures for the collection of water protection fees, to ensure that the full cost of operating and maintaining the wastewater treatment system is recovered.
- Promotion of environmental awareness, by collecting wastewater treatment fees in the service areas of water quality management facilities so that the citizens benefitting from these facilities can participate in a holistic and sustainable solution to the problem, based on the polluter pays principle (PPP).
- Replication of knowledge dissemination and awareness programs on environmental measures across the country for all polluting sectors, especially agriculture and aquaculture. Environmentally friendly agricultural practices for farmers should be further strengthened to reduce the impact of environmental problems such as odours and wastewater.
- Creation (by government) of an enabling environment for private investment in the water and wastewater sector, ensuring good returns, while further encouraging private sector involvement in corporate social responsibility.