# A DECADE OF WATER QUALITY MONITORING IN THAILAND'S FOUR MAJOR RIVERS: THE RESULTS AND THE IMPLICATIONS FOR MANAGEMENT*[1]

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## ABSTRACT

Over the course of a decade, the Pollution Control Department (PCD) monitored the water quality in four major rivers (Chao Phraya, Thachin, Maeklong, and Bangpakong Rivers), that discharge into the Gulf of Thailand. The results indicated that the lower parts of the Chao Phraya and Thachin Rivers were degraded and that several major parameters exceeded the National Surface Water Quality Standards and Classification*. The major water quality problems were low dissolved oxygen (DO), high ammonia-nitrogen, high fecal coliform bacteria, high turbidity, and high organic matter (biochemical oxygen demand, BOD), respectively. The major sources of water pollution were communities, industry, and agriculture. However, the proportion each source contributed varied from river to river. For example, communities were the major sources of pollutants discharged into the lower part of the Chao Phraya River, whereas industry was the significant contributor of pollutants into the lower part of the Thachin River. The degradation of water quality in the major rivers has affected the water quality and natural resources in the Gulf of Thailand.

In the past, wastewater problems were managed within political boundaries. New approaches, such as basin management and maintaining the carrying capacity of receiving waters, have been adopted for controlling both point source and non-point source pollution in the Thachin River Basin as well as in other basins. Future decisions on water quality management should not solely focus on managing domestic wastewater, but should also include measures for controlling other urban and rural sources. Additionally, addressing nutrient loads from agricultural activities must be considered as integral to future planning strategies.

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*THE NATIONAL WATER QUALITY STANDARDS AND CLASSIFICATION
The National Environmental Board was notified of the National Standard of Surface Water Quality and Classification for Thailand's surface water in 1994. There are 5 classes that are considered for surface water quality and are used to support the receiving water based on major beneficial uses. There are as follow:
Class 1: Extra clean for conservation purposes
Class 2: Very clean. Used for (1) consumption, which requires ordinary water treatment processes (2) aquatic organism conservation (3) fisheries, and (4) recreation (for example, DO > 6 mg/l, BOD < 1.5 mg/l, and TCB < 5,000 MPN/100 ml)
Class 3: Medium clean. Used for (1) consumption but passing through ordinary treatment process and (2) agriculture (for example, DO > 4 mg/l, BOD < 2 mg/l, and TCB < 20,000 MPN/100 ml)
Class 4: Fairly clean. Used for (1) consumption but requires special treatment process and (2) industry (for example, DO > 2 mg/l, BOD < 4 mg/l)
Class 5: Water not classified in class 1-4. Used for navigation

## INTRODUCTION

Chao Phraya, Thachin, Bangpakong, and Maeklong comprise the four major rivers of Thailand's central basin. They serve over 20 million people in an area of 100,000 square kilometers. The geographic feature and land-use of the rivers are shown in Figure 1.

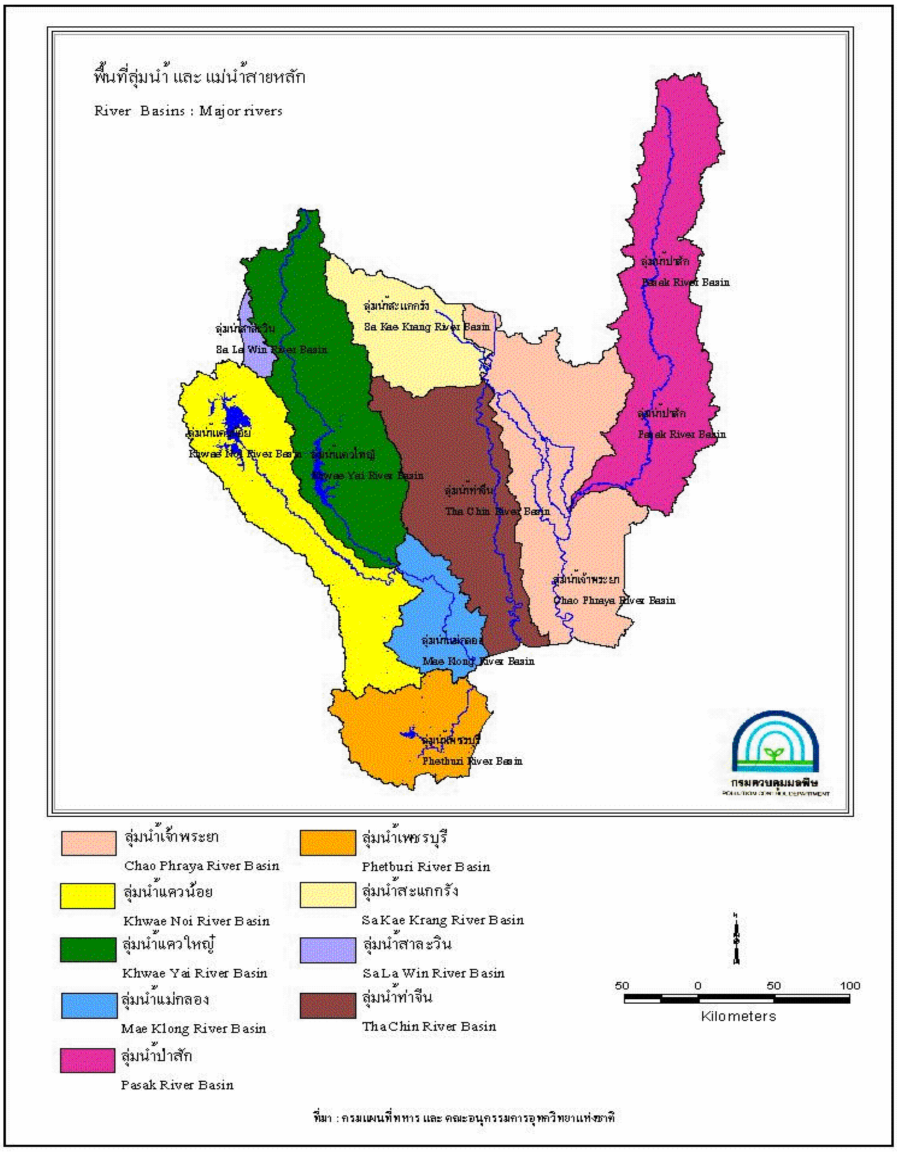


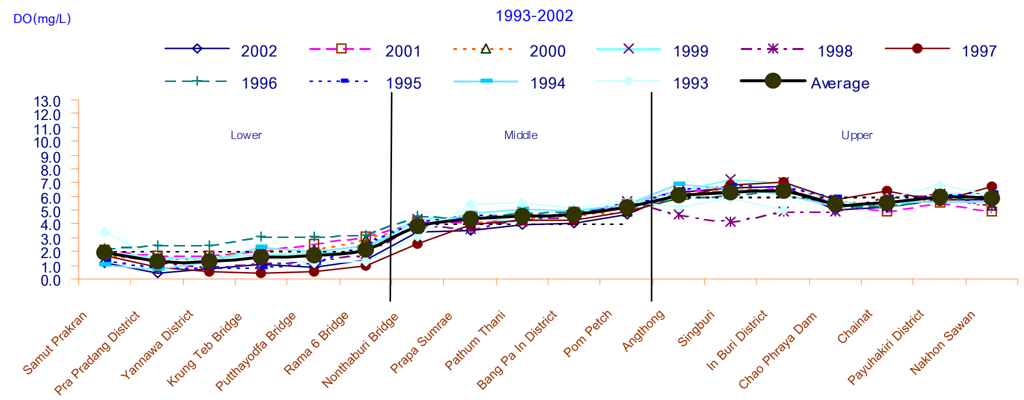

Figure 1. Geographical Features of the Four Major Rivers in Thailand

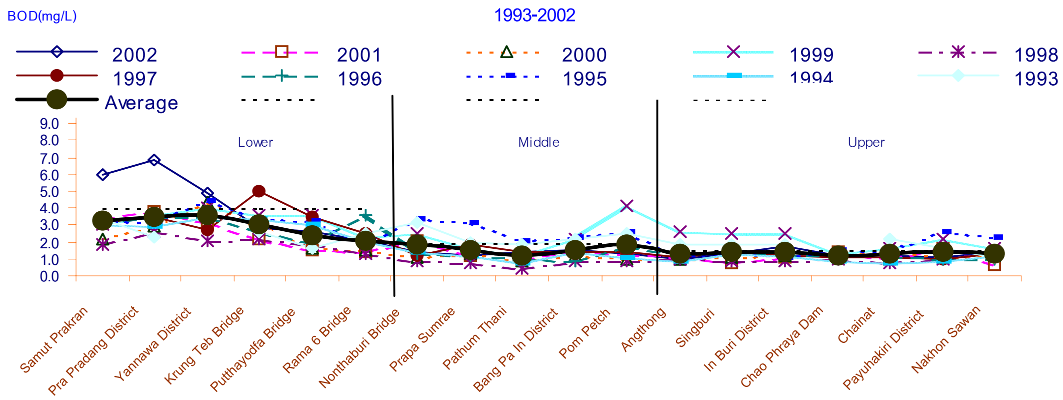
Traditionally, water quality, quantity, and pollution were managed separately. Water quantity management focused on maximizing irrigation distribution while disregarding water quality issue. Consequently, the incompatible management structures caused pollution and environmental degradation. The following are the results of water monitoring activities from 1993-2002.

## CHAO PHRAYA RIVER

The Chao Phraya River is considered the lifeblood of Thailand. The 379 kilometer-long river supports 13 million people and is used in a variety of ways, including drinking water, irrigation, and as the primary water source for the Thachin River. As a confluent of the Ping, Wang, Yom, and Nan Rivers; the Chao Phraya River water quality is greatly affected by upstream activities. For example, in 1995, 2001, and 2002, upstream flooding resulted in high sedimentation rates and significant changes in water turbidity. In normal to low water levels, domestic, agricultural, and industrial discharges are greater than the river's capacity for self-purification. During 1993 to 2002, domestic, agricultural, and industrial discharges contributed 70 percent, 25 percent, and 5 percent to the waste load, respectively. In the Samut Prakarn Province Industrial Area, industry contributed over 70 percent to the total waste load.

In summary, the majority of waste discharged to the Chao Phraya River is organic waste and fecal coliform bacteria from domestic sources. Water quality is degrading with a slow restoration potential. Dissolved Oxygen (DO) is below the national standard* in the lower part of the river. Existing wastewater treatment plants (WWTP) cover only limited areas. For example, in 2002, Bangkok only had a capacity to treat 20 percent of its wastewater. In order to improve the Chao Phraya River's water quality, construction of new wastewater treatment plants are suggested. Moreover, community involvements, through means such as water conservation and waste minimization programs in Pathum Thani and Nonthaburi, are essential.



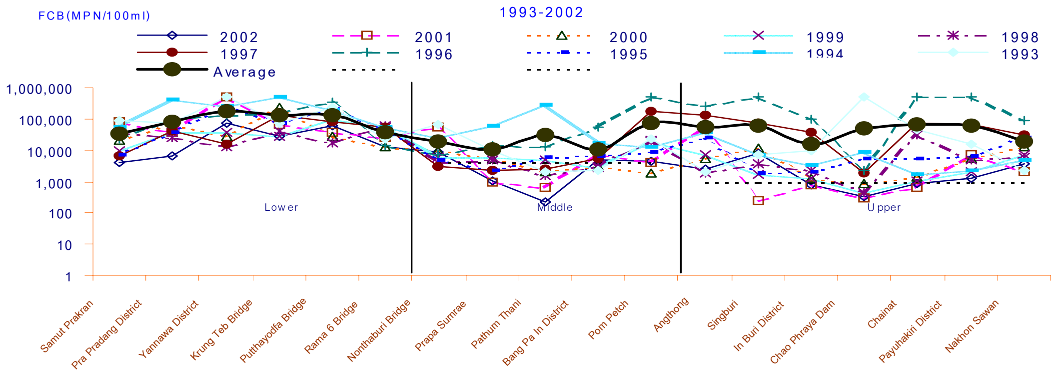



Figure 2. Chao Phraya River Water Quality 1993-2002

**THACHIN RIVER**

The 320 kilometer-long Thachin River is a tributary of the Chao Phraya River and the Maeklong River. Seventy-six percent of the Thachin River Basin is used for agriculture. In general, community, industry, and agriculture contribute 30 percent, 33 percent, and 47 percent to the waste load, respectively. Pig farms are the major source of pollution in Nakhon Pathom Province while industry is a major source of pollution in Samut Sakhon Province. From 2000 to 2002, the Thachin River was ranked the most polluted river in the country. Communities and effluent from pig farms in Nakhon Chaisri District, Nakhon Pathom Province were significant contributors to deteriorating water quality in the lower part of the basin. DO was below the national standard* of 2.0 mg/l and occasionally below 1 mg/l. Many canals became sewer lines and experienced rapid growth of water hyacinth.

From April to May of 2000, over 16,000 hectares of rice fields were unexpectedly flooded generating over 100 million cubic meters of wastewater. The discharge polluted a reach of the river over 150 kilometers long with an estimated capital loss of millions of bahts. The cost of the ecological damage was not included.

As shown in figure 3, the water quality in the Thachin River is declining. Prior to 2000, the problem-solving process in the Thachin Basin was proceeding more slowly than in the Chao Phraya Basin. However, the crisis in 2000 presented an opportunity for collaboration among four provinces within the basin: Chainat, Supanburi, Nakhon Pathom, and Samut Sakhon. PCD and relevant agencies envision the Thachin River meeting the national water quality standards* within the next 10 years.

In 2002, the Royal Irrigation Department proposed two watergates at Banglane District in Nakhon Pathom and Samut Sakhon Provinces for flooding control. However, the locals opposed the project in the public hearing, as it needs more study, especially in regards to the potential environmental impacts, before a tangible solution can be reached. The approach should also consider all stakeholders and other possible alternatives.

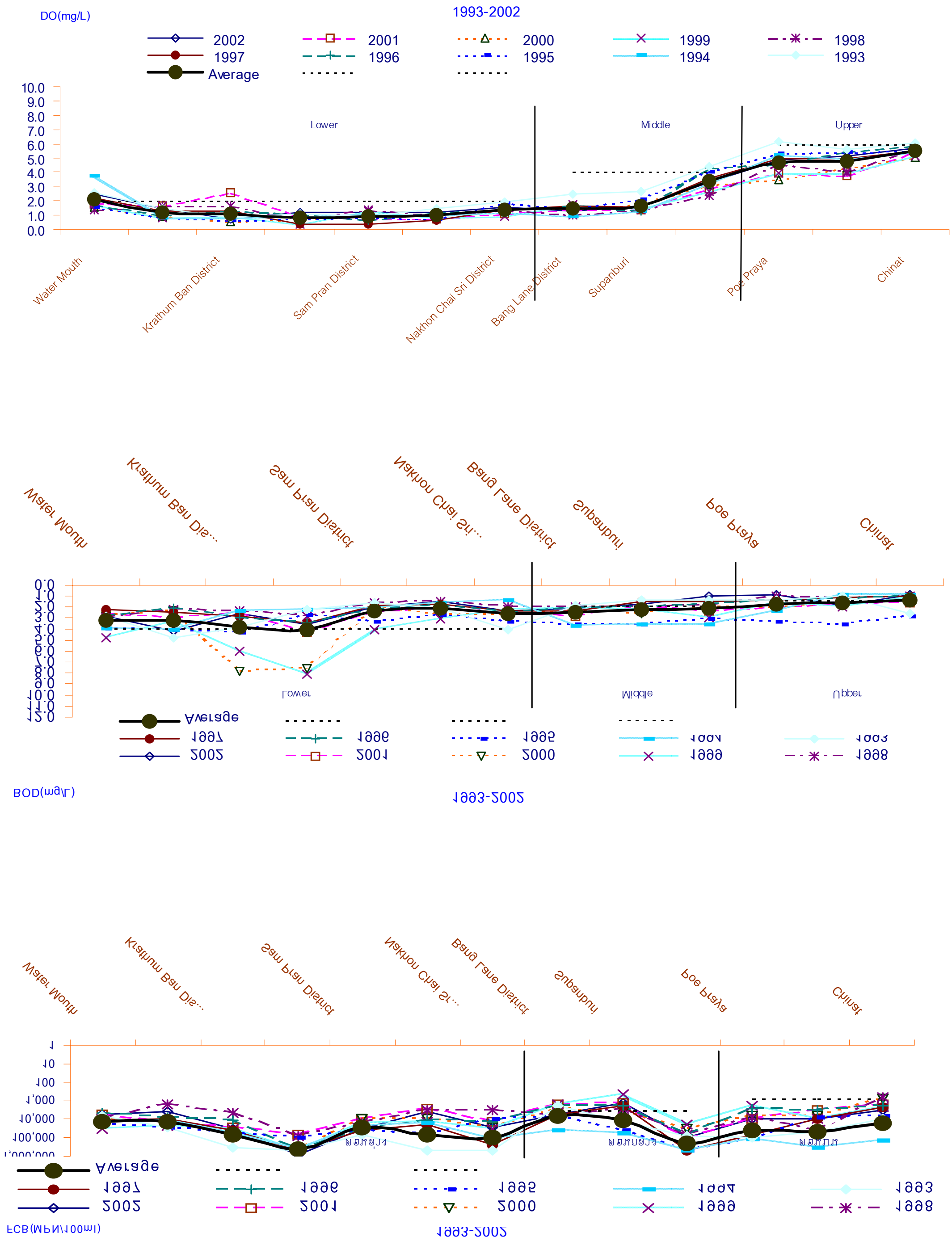
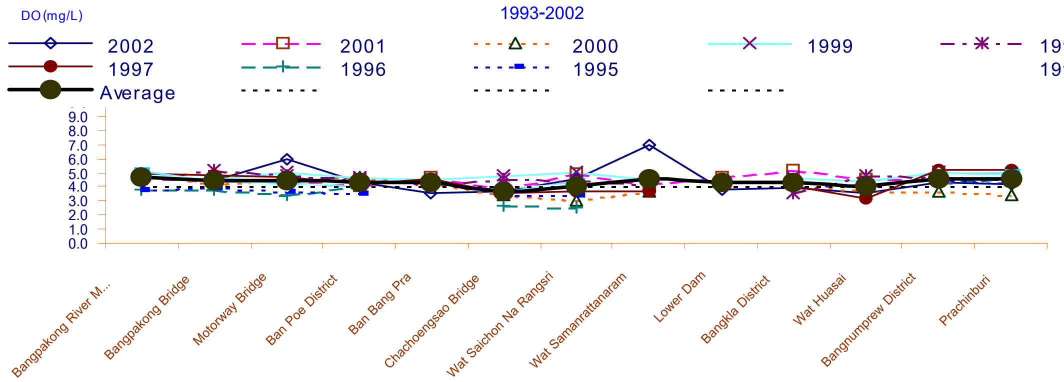


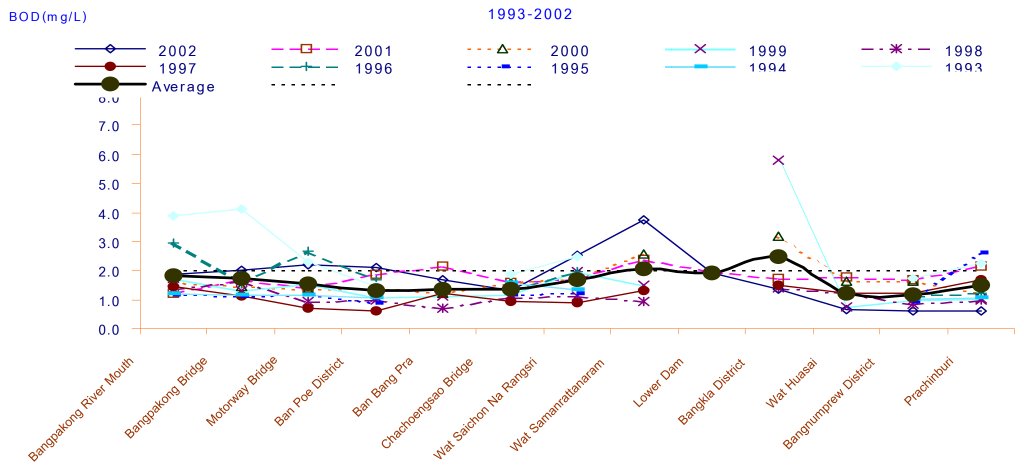

Figure 3. Thachin River Water Quality 1993-2002

## BANGPAKONG RIVER

The Bangpakong River is a confluent of the Prachin Buri and Nakhon Nayok Rivers. The 122 kilometer-long river serves as a water supply for drinking water, agriculture, aquaculture, and industry. Saline water advancement often occurs through out the river and extends up to the Prachin Buri and Nakhon Nayok Rivers. The majority of the waste discharged into the river is organic and is generated by communities, industry, pig farms, and aquaculture. In general, the Bangpakong River is categorized in class 3* of water quality standards with DO not less than 4 mg/l and BOD not exceeding 2 mg/l. Water quality is often contaminated by fecal coliform bacteria in excess of the standard (4,000 MPN/100 ml) (See Figure 4).

In 1996, the Bangpakong Dam Project was established in Muang District in Chachoangsoa Province (7 km from the river mouth) to hold back freshwater upstream for a variety of purposes. The project was completed in 1999 but the test run in 2000 caused wastewater, primarily from pig farms and aquaculture, to accumulate in the river and its tributaries above the dam. It also led to landslides and the collapse of buildings on the bank downstream. As a result, in 2002, the government raised the budget for the study of adverse effects, problem-solving, and the construction of wastewater treatment (WWT) systems for pig farms. However, the problem still persists during the high-sea-level season due to wastewater from shrimp farms upstream of the dam. A concrete solution is needed.



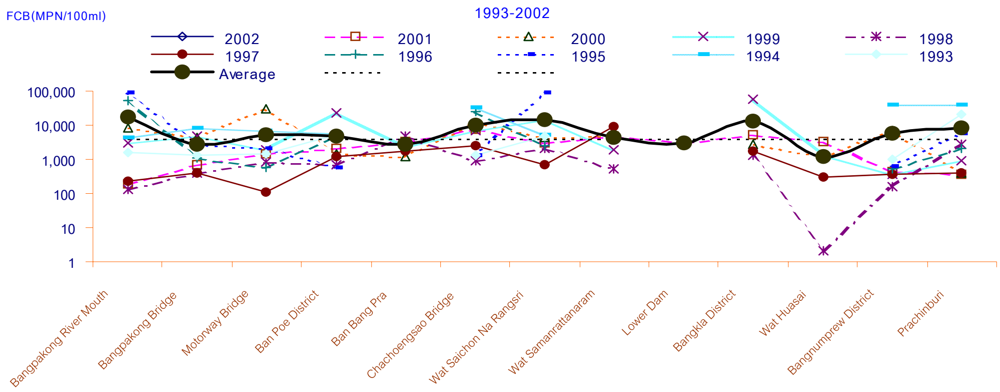


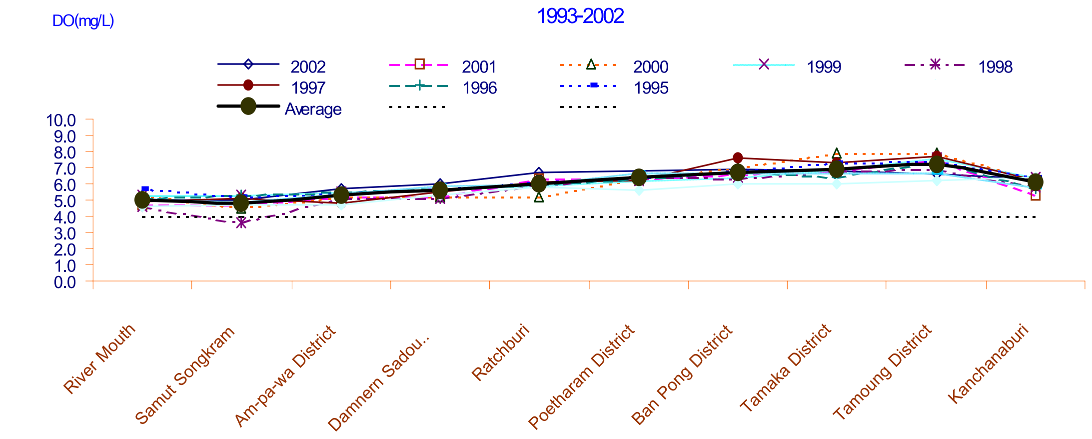

Figure 4. Bangpakong River Water Quality 1993-2002

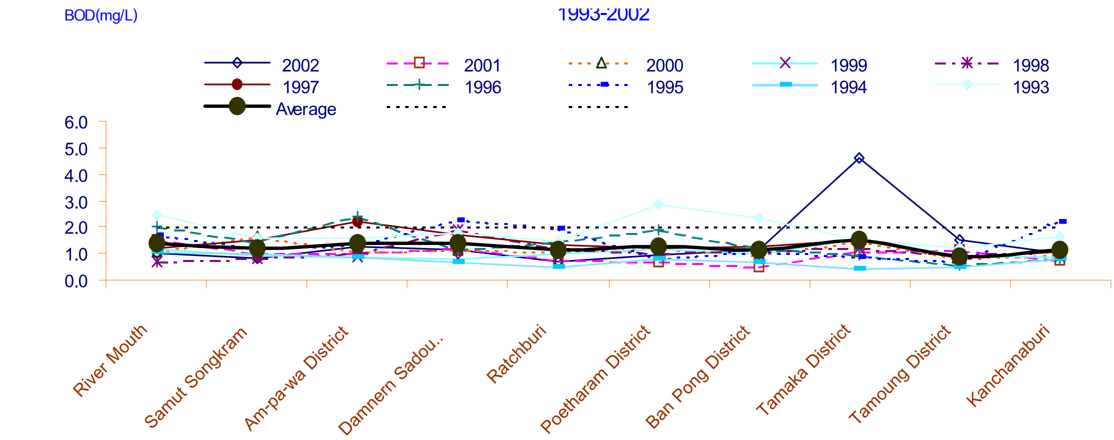
## MAEKLONG RIVER

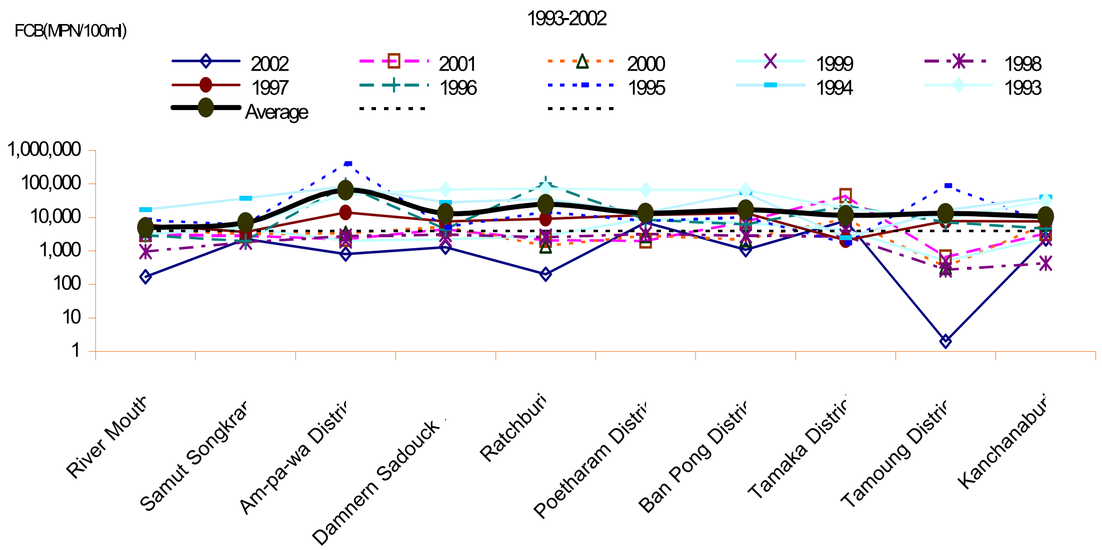
The 140 kilometer-long Maeklong River is a confluent of the Khwae Noi and Khwae Yai Rivers originating in the luscious forests of Thailand's west mountain range. After an incident in 1977 when effluent from a sugar cane plant led to eutrophication and fish kills, a WWTP was constructed which led to dramatic improvements in water quality. In the past 10 years, the Maeklong River water quality has been categorized as class 3* of the national water quality standards with DO not less than 4 mg/L, BOD not exceeding 2 mg/L, and fecal coliform bacteria less than 4,000 MPN/100mL. During the dry season, fecal coliform bacteria contamination is high in the population dense municipalities such as Samut Songkram, Ratchaburi, and Kanchanaburi. A decade of Maeklong River Water Quality is shown in Figure 5.

Prior to 2002, the major source of bacteria contamination was the illegal discharging of domestic wastewater from over 600 raft houses in Kanchanaburi. Since 2002, waste from the raft houses has been collected and treated at the central WWTP in Kanchanaburi Province. Mid-way through 2002, the illegal discharge of high salt and organic contamination from small industries caused fish kills in the fish farms downstream of Ratchaburi Municipality and led to a capital loss of millions of bahts. However flushing substantial amounts of fresh water from upstream quickly resolved the problem.

The above example shows the integrated relationship between managing water quality and managing water quantity. Local community involvement in the Maeklong River, such as the river conservation clubs in many provinces (eg. Kanchanaburi, Ratchburi, and Samut Songkarm), also helps authorities prevent water pollution, protect the environment, and increase public awareness.


DO(mg/L)
1993-2002
2002
2001
2000
1999
1998
1997
1996
1995
Average
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
River Mouth
Samut Songkram
Am-pa-wa District
Damnern Sadou..
Ratchburi
Poetharam District
Ban Pong District
Tamaka District
Tamoung District
Kanchanaburi


BOD(mg/L)
1993-2002
2002
2001
2000
1999
1998
1997
1996
1995
1994
1993
Average
6.0
5.0
4.0
3.0
2.0
1.0
0.0
River Mouth
Samut Songkram
Am-pa-wa District
Damnern Sadou..
Ratchburi
Poetharam District
Ban Pong District
Tamaka District
Tamoung District
Kanchanaburi


FCB(MPN/100ml)
1993-2002
2002
2001
2000
1999
1998
1997
1996
1995
1994
1993
Average
1,000,000
100,000
10,000
1,000
100
10
1
River Mouth
Samut Songkram
Am-pa-wa District
Damnern Sadouck
Ratchburi
Poetharam District
Ban Pong District
Tamaka District
Tamoung District
Kanchanaburi

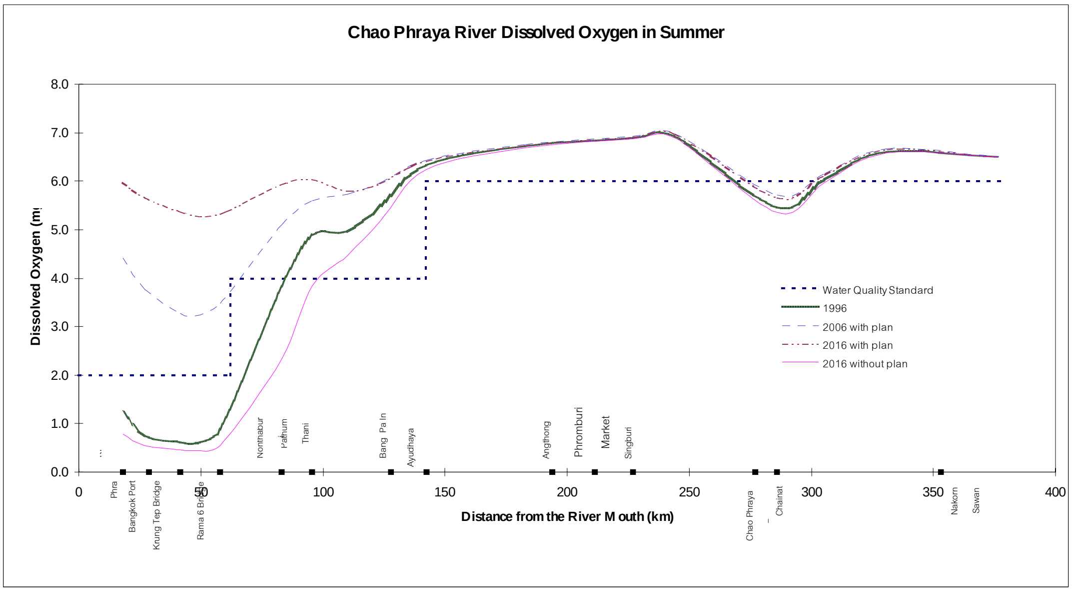
## EVALUATION OF THE CARRYING CAPACITY OF RECEIVING WATER BODIES

The Pollution Control Department utilizes mathematical models as a tool to forecast water quality and to present various management scenarios to decision-makers. The carrying capacity of the various rivers was determined on the basis of pollution variation and loading. Industrial, economic, and agricultural expansion rates were taken into account as well as municipal WWTP expansion, WWT technology, and water quality variation. The outcomes were considered both with and without implementation plans.

The Chao Phraya River Water Quality Management Plan provides a case study of applying the mathematical models. The Chao Phraya River has been categorized into 3 classes: class 2* in the upper reach, class 3* in the middle reach, and class 4* in the lower reach. Organic pollutant loads were calculated using population density, population growth, water consumption rates, and pollutant loads from both domestic and industrial sources.

Currently, water quality in the Chao Phraya River is declining and has the potential to become severely degraded. If population growth, industrial expansion, and non-point source pollution continue to increase unabated and without implementation of a WWT plan and best management practices for non-point source pollution, water quality in the year 2016 will severely decline (see Figure 6). Therefore, effective water quality management is essential. Since a majority of pollutants are from point sources, strengthening regulations pertaining to these sources would be beneficial at reducing the discharge of untreated effluent.

Maximizing wastewater collection and WWT efficiency are ways of restoring water quality. Primary treatment of wastewater without disinfection can decrease 75 percent of total coliform bacteria while secondary treatment can decrease the presence of total coliform bacteria by up to 95 percent. Moreover, municipal WWTP, in general, can treat BOD with 70-90 percent efficiency. By running a WWTP scenario, the model forecasts that we will be able to decrease up to 50-60 percent of BOD and over 85 percent of total coliform bacteria by 2006 and that water quality in the Lower Chao Phraya River will increase dramatically. By 2016, we will be able to maintain the upper reach of the Chao Phraya River in class 2*. In the lower reach of the Chao Phraya River, higher WWTP efficiency in Bangkok and the surrounding area will reduce total pollution loads by 60%.



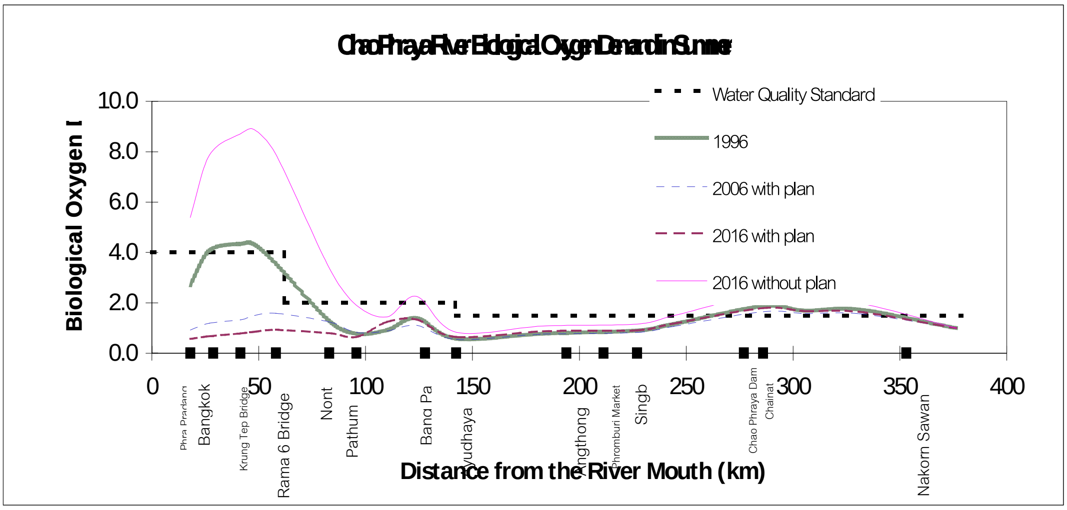




Figure 6. The Chao Phraya River Water Quality Model

## CONCLUSION

The water quality in the four major rivers was poor with the potential for severe degradation. The major waste load in the Chao Phraya River was from domestic sources. The environmental degradation situation was exacerbated in the Chao Phraya River and Lower Thachin River Basins due to water depletion. The Chao Phraya River WWTP Projects for Bangkok and Samut Prakan are in the design stages, however, they have been slowed down by public opposition. Agriculture was the major source of pollution in the upper Thachin River Basin while industry was the major source of pollution in the lower Thachin River Basin. There are several pollution control projects that are progressing slowly with strong community involvement. In the Bangpakong River Basin, which is suffering from significant amounts of organic pollutants, the Bangpakong Dam Project was launched to address the issue. On-going adjustments and public education are required to mitigate unexpected environmental impacts of the dam and to increase public acceptance. The Maeklong Water Quality is generally fair and is used as a water supply for Bangkok. However, there is still some public opposition on water diversion and sharing of the resources.

Although watershed management plans are being implemented slowly, water quality is improving. Integrated watershed management is an essential tool. Public education in water and related resource management is needed along with pollution load reduction. The issue of pollution, which has been affecting the quality of the rivers over the past decade, will be solved through the collaboration of central and local governments as well as the community.

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