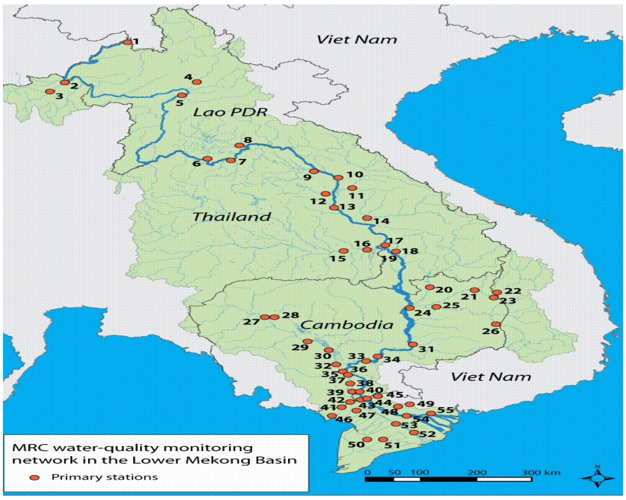
2014 Mekong Water Quality Monitoring in Thailand Report



Thailand National Mekong Committee

Department of Water Resources

Ministry of Natural Resources and Environment

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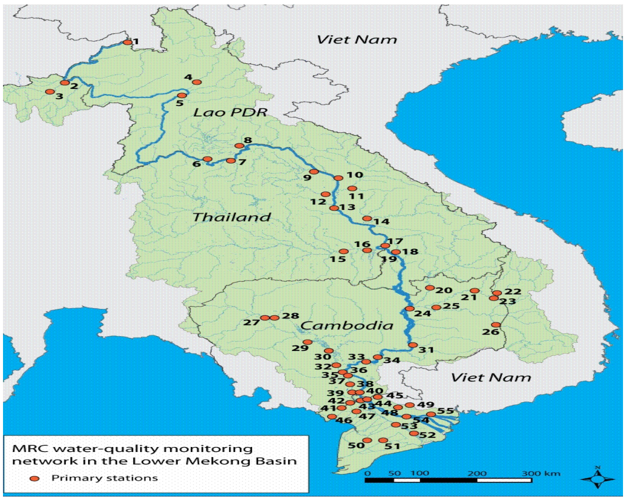

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Chapter 1
Introduction

1.1 The Mekong River Basin

The Mekong River is the longest river in South East Asia, the twelfth longest and the tenth largest discharge in the world (Dai and Trenberth, 2002). It has originated on the Tibetan Plateau and flows southward through China, Myanmar, the Lao PDR, Thailand, Cambodia and Viet Nam, where it discharges into the South China Sea. The catchment of the river, which covers an area of 795,000 km^2, is functionally divided into two basins; the Upper Mekong Basin, at where the Lanchang River flows southwards through China, and the Lower Mekong Basin, which includes parts of the Lao PDR, Thailand, Cambodia and Viet Nam. The river forms the border between the Lao PDR and Myanmar in the transition zone between the upper and lower basins. The Mekong River Basin Diagnostic Study (MRC, 1997) and the State of the Basin Report (MRC, 2003) provide further information on the basin, its water-related resources, and its inhabitants.

The hydrology of the Mekong system is dominated by the annual monsoon cycle, such that the discharge during the wet season (from June to November) may be up to twenty times greater than during the dry season (December to May). Geography also plays an important role in the annual variation of discharge, as the contribution to the flow coming from the Upper Mekong Basin varies according to the season. For example, at Kratie (in Cambodia) the so-called ‘Yunnan Component’ compromises 40% of the dry season flow, but only 15% of the wet season flow (MRC, 2005). In contrast, 50% of the sediment discharged into the South China Sea from the Mekong comes from China (MRC, 2004).

The livelihoods of most of the 60 million people who live in the Lower Mekong Basin (LMB) depend to some extent on the water resources of the Mekong River. These livelihoods rely on the environmental health of the Mekong River and its tributaries remaining in good condition. Water quality is a key factor in determining environmental health. Under the guidance of the Mekong River Commission, the four lower riparian countries (the Lao PDR, Thailand, Cambodia and Viet Nam) have monitored the water quality of the LMB since 1985 (monitoring of the Cambodian component began in 1993).

The condition of the River, which at present has a good/acceptable water quality, must be maintained to promote the sustainable development of the Mekong River Basin. The purpose of MRC water quality monitoring programme are to provide timely data and/or information on the status and changes in water quality of the Mekong River Basin, which are used by relevant stakeholders. Water quality monitoring of the River also help to recognize changes in the condition of the river's environment in sufficient time to take remedial action.

Water Quality Monitoring Network at the Lower Mekong Basin is a complementary task to the Environmental Programme. It is funded by SIDA through the Mekong River Commission cooperated with each National Mekong Committee (NMC) of four countries: Cambodia, the Lao PDR, Thailand and Viet Nam. Water quality monitoring programme has initially implemented in the Lao PDR, Thailand and Viet Nam since 1985, then later in Cambodia since 1993. (MRCS, 2003)

The monitoring stations are divided into two types, primary and secondary station. Primary stations are located in the Mekong River for monitoring water quality of the transboundary flow or water quality problems of general characteristics basin wide to meet the Water Utilization Program (WUP) and Basin Development Plan (BDP) targets. Secondary stations are located in the Mekong River tributaries for monitoring water quality to resolve problems for country level or local level which mainly focus on national or local interest.

In 2013, the programme monitors 48 stations of Water Quality Monitoring Network (WQMN), which 22 are primary stations and 26 are secondary stations on the main steam and important tributaries of the Mekong River, respectively (Figure 1.1).

Figure 1.1 The primary water quality monitoring stations of the MRC-WQMN in 2014

1.2 Overview of the Mekong River and Tributaries in Thailand

The Lower Mekong Basin (LMB) has total area around 606,000 km^2, which about 188,645 km^2 is located in Thailand. The LMB is divided into 10 sub-areas (SA) based on the hydrological conditions and country territory. The Mekong Basin's part in Thailand includes SA-2T (covering Kok river and Mekong river basins in the North), SA-3T (covering Mekong River basin in the Northeast), SA-5T (covering Chi river and Mun river Basins), and SA-9T (covering Tonle Sap basin).

Chiang Rai Sub-area (SA-2T) covers a total area of 18,859 km^2; consist of Kok river and Ing river basins located in Chiang Rai and Phayao provinces, and Mekong River Basin (MRB) Part 1. The Mekong River meanders along the Thai-Lao territory. This SA covers areas of the three province, Chiang Mai province, Chiang Rai province; and Phayao province.

SA-2T is dominated by tropical monsoon or tropical savanna climate. The rainy season occurs during May-October, which is influenced by the southwest monsoon from the Andaman Sea as well as typhoons and depressions from the South China Sea. Rains scatter widely over the whole area with a peak in August. Winter lasts from October to February. The area is subject to the influence of the Northeast monsoon, which brings cold and dry weather from China, thus causing low temperatures over the area. The summer is between February and mid-May with maximum mean temperature in April,

Nong Khai/Songkhram Sub-area (SA-3T) the total area is 46,460 km^2. It is narrow and elongated shape along the Mekong River. Upland is the general topographical feature of this area, with elevation range between 100 and 200 m MSL. The catchment is bounded to the west and east by high ridges, which dip northwards and eastwards to the Mekong River. This SA extends over eight northeastern provinces in the Mekong River Basin, i.e. Udon Thani, Sakon Nakhon, Loei, Nong Bua Lamphu, Nong Khai, Nakhon Phnom, Mukdahan, and Amnat Charoen.

The climate of the Mekong River Basin 2 is primarily influenced by the Southwest and Northeast monsoons. It is also subjected to depressions from the South China Sea each year. Consequently, heavy rains are observed during the wet season. There are three seasons in the area, i.e. rainy season, summer, and winter.

Mun/Chi Sub-area (SA-5T) in Thailand's part is divided into 2 main river basins, namely, Chi and Mun river basins, covering a total area of 119,177 km^2. They are under the jurisdiction of 15 provinces, namely, Ubon Ratchathani, Nakhon Ratchasima, Chaiyaphum, Maha Sarakham, Loei, Yasothon, Khon Kaen, Kalasin, Roi Et, Si Sa Ket, Udon hani, Nong Bua Lamphu, Buri Ram, Surin, and Amnat Charoen. High ridges form the western boundary of the area, i.e. Phetchabun range with elevation of 1,400 m MSL. Chi River originates from these mountainous areas. PhuPhan range forms the northeastern boundary with elevation of about 600 m MSL,stretching from Udon Thani to Ubon Ratchathani. This range is the source of Lam Pao and Yang rivers. On the south are Banthat and Dong Rak mountain ranges with elevation of 300-1,350 m MSL, which are the sources of Mun River. The central part of the SA is a low ridge, dipping southwards to Mun River. The area near the confluence of Mun and Chi rivers is low-lying land.

The climate in SA-5T2 is divided into 2 river basins, namely, Chi and Mun, because this SA covers a very large area. The collected data were divided based on the boundaries of river basins in Thailand.

1.3 Objective of the report

This annual country report on Water Quality Data monitoring provides an overview of water quality parameters and the changes of key environmental stressors that may impact on the rivers aquatic life, human health and agricultural uses via water quality indices. It provides a summary of water quality monitoring data during the period from January to December of 2014. The data are taken from 8 sampling sites in the Mekong River and its tributaries flow through Thailand.

Chapter 2
Methodology

2.1 Sampling plan

2.1.1 Sampling station

In 2014, the sampling stations in Thailand cover 8 stations, which categorized as 3 primary stations along Mekong River and 5 secondary stations in 4 tributaries as shown in Figure 2.1 and detail in Table 2.1.

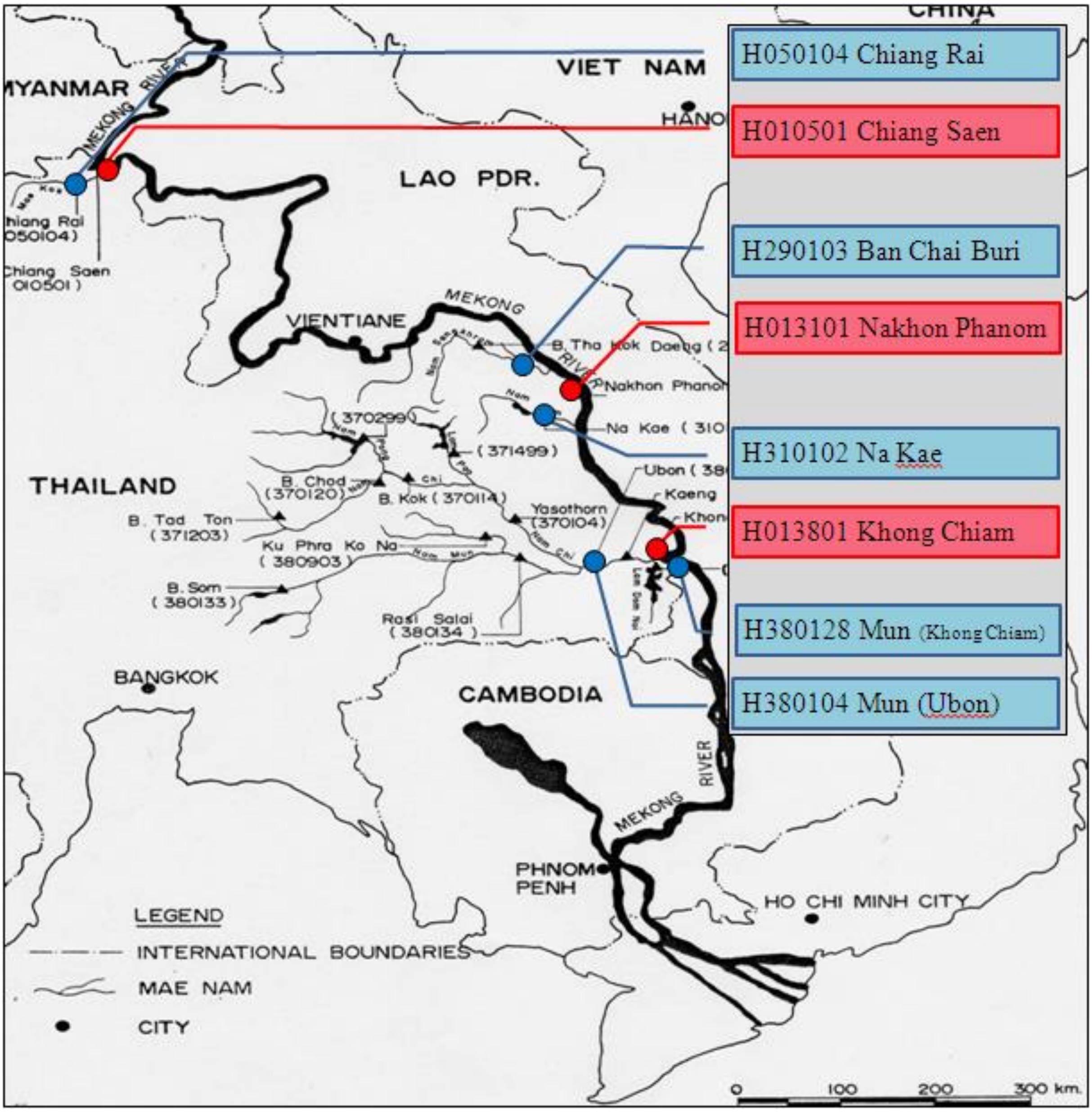

Figure 2.1 The MRC-WQMN sampling sites of Thailand in 2014

Table 2.1 List of the water quality sampling sites

Station Code	Station Name	Station Location		River Name
		Latitude (N)	Longitude (E)	
H010501	Chiang Saen	20° 16′ 03″	100° 05′ 27″	Mekong (mainstream)
H013101	Nakhon Phanom	17° 25′ 30″	104° 46′ 28″	Mekong (mainstream)
H013801	Khong Chiam	15° 19′ 32″	105° 29′ 37″	Mekong (mainstream)
H050104	Chiang Rai	19° 55′ 15″	99° 50′ 46″	Mae Kok
H290103	Ban Chai Buri	17° 38′ 38″	104° 27′ 42″	Nam Songkhram
H310102	Na Kae	16° 57′ 26″	104° 30′ 15″	Nam Kam
H380104	Ubon	15° 14′ 35″	104° 57′ 17″	Nam Mun
H380128	Mun	15° 18′ 13″	105° 29′ 20″	Nam Mun

2.1.2 Sampling techniques

The Mekong River and its tributaries are generally well mixed, therefore the monitoring involves sampling on monthly basis by means of a simple surface grab technique from the edge of the river in a location where it is apparent that water is free flowing and well mixed. Water sample are taken at 30-50 cm depth below the surface.

Water sampling, sample preservation and transportation had been performed following the Standard Methods for the Examination of Water and Wastewater 20th Edition 1060 Collection and Preservation of Sample (Clesceri *et al*., 1998) and acceptable method in the guideline of WQMN as previously agreed between the laboratories and the MRCs. After preserving, all water samples were quickly transported to the laboratory of Research and Water Quality Analysis Division at Nonthaburi Province.

2.1.3 Sampling frequency and duration

The water monitoring were conducted from January through December, one sampling event every months. Monitoring samples were started in January and completed in the December. Thus, each site was monitored a total of twelve times during the year. Each sampling event was taken approximately in the middle of the month between the date 13th and 18th of each month.

2.2 Parameters and analytical methods

List of monitoring parameters are categorized in 5 indicating grouped as follows with analytical methods presented in Table 2.2

(1) Basic parameters: Temperature, pH, EC, TSS
(2) Main ions: Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}, Alkalinity, SO_4^{2-}, Cl^{-}
(3) Nutrients: NH_4^{+}-N, $NO_{2\&3}^{-}$-N, Total-N, Total-P
(4) Organic matters: DO, COD
(5) Microbiology: Faecal coliform

Table 2.2 List of parameters and analytical methods

No.	Parameters	Unit	Method Use	Recommended Methods
1	Temperature	ºC	Electrometric	2550-Temp/SM
2	pH	-	Electrometric	4500-H+/SM
3	Conductivity (EC)	ms/m	Electrometric	2510-Ec/SM
4	TSS	mg/l	Dried at 103 – 105 ^{0}C	2540-D-TSS-SM
5	Ca^{2+}	meq/l	EDTA Titration	3500-Ca-B/SM
6	Mg^{2+}	meq/l	EDTA Titration	3500-Mg-B/SM
7	Na^{+}	meq/l	Ion Chromatography	3500-Na-B/SM
8	K^{+}	meq/l	Ion Chromatography	3500-K-B/SM
9	Alkalinity	meq/l	Titration	2320-A/SM
10	SO_4^{2-}	meq/l	Turbidity	4500- SO4 –E/SM
11	Cl^{-}	meq/l	Argentometric	4500-Cl/SM
12	$NO_{2\&3}^{-}$	mg/l	Cd reduction	4500-NO2-3/SM
13	Total-N	mg/l	Digestion with $K_2S_2O_8$	4500-N/SM
14	NH_4^{+}	mg/l	Indophenols blue	4500-NH4/SM
15	Total-P	mg/l	Digestion with $K_2S_2O_8$	4500-P/SM
16	DO	mg/l	Winkler	4500-O/SM
17	COD	mg/l	Permanganate Oxidation	-
18	Faecal Coliform	MPN in 100 ml	Multiple Tube	9221-Faecal Coliform group/SM

2.3 Data assessment methodology

2.3.1 Data reporting

Current status and trend of water quality are reported in terms of temporal variation and spatial variation. For current status, temporal variations at each station for each parameter were employed by box plot. Spatial variations in Mekong River and 4 tributaries at each year from 1985 to 2014 for each parameter were also employed by box plot. Changes in water quality for both temporal and spatial variations in 2014 and 2013 were tested by independent t-test, paired-sample t-test and analysis of variance.

2.3.2 Group of parameter

(1) Basic parameters: Temperature, pH, EC, TSS
(2) Nutrients: NH_4^+-N, $NO_{2\&3}^-$-N, Total-N, Total-P
(3) Organic matters: DO, COD

2.3.3 Water quality indices

Another way for evaluation the water body adequacy and impact is considered by water quality index (WQI). The WQI is one of the most widely used of all existing water quality procedures. Water Quality indices were related to water quality in some physic-chemical properties.

Since the adoption of the Water Quality Indices in 2006, the MRC Member Countries have collaboratively adopted the Procedures for Water Quality (PWQ) with an objective of establishing “a cooperative framework for the maintenance of acceptable/good water quality to promote the sustainable development of the Mekong River Basin.” With the adoption of the PWQ, Member Countries have also developed the Technical Guidelines for Implementation of the Procedures for Water Quality (TGWQ), which consist of five chapters. Chapter 1 and Chapter 2 of the TGWQ, which focus on the protection of human health and the protection of aquatic life, respectively, were finalized by the Member Countries in 2010. These two chapters call for the Member Countries to commence the monitoring of a number of direct and indirect impact parameters on human health and aquatic life. The chapters also provide target values for each direct and indirect impact parameter to protect human health and aquatic life. In addition to the finalization of the chapters, some Member Countries have developed and updated target values for a number of water quality parameters for different type of water use (e.g. drinking water, protection of aquatic life, recreation and contact, industrial discharge, etc.).

The review of the MRC Water Quality Indices was initiated in 2013 taking into account requirements under Chapters 1 and 2 of the TGWQ and available water quality guidelines of the Member Countries. Following the review, the Member Countries have agreed to adopt the following water quality indices, as tools for interpreting the results of the MRC WQMN data, turning the complex data into information that can be understood by the public.

(1) Water Quality Index for the Protection of Aquatic Life (WQI_{al}).

(2) Water Quality Index for the Protection of Human Health with a focus on Human Acceptability (WQI_{ha}).

(3) Water Quality Index for Agricultural Use (WQI_{ag}) which is divided into 2 categories: (i) general irrigation and (ii) paddy rice.

Details of water quality indices and guideline values following Campbell (2014) are described in Appendix B.

2.1.2 QA/QC program

1) Collection, storage and preservation of samples

The program includes training course in sampling method, sample preservation techniques and site data collection to field technician at the Hydrological Center, Water Resources Regional Office. The 4 centers including Chiang Rai, Mukdaharn, Ubon Ratchatani and Khong Chiam are responsible for river water sampling on monthly basis. River water is sampled from the 30 cm under water surface and the midstream of water river body. Two types of water sample are collected as type A and B with the difference in preservation technique. Each type of sample is collected in two plastic bottles. One liter of water sample is collected in each bottle for most physical and chemical analyses. Only type B sample is preserved by adding 1.5 ml of concentrated sulfuric acid to pH less than 2. The sample used for Dissolved Oxygen measurement are taken in 2 BOD bottles and added with the oxygen fixing reagent at the sampling site. In addition, the collections of field blank and duplicate sample are generally assigned to all hydrological centers. The samples used for Fecal Coliform Bacteria analysis are separately collected in two 125-mL glass bottles. All of water samples are kept in cool box with control temperature less than 4 °C and immediately sent to Research and Water Quality Analysis Division.

2) Sample analysis

Because of biological activity, adsorption to the wall of container and change in sensitive parameters involving sample stability, all of samples are immediately analyzed to complete within 2 weeks in laboratory to reduce the elapsed time between sample collection and analysis. Two types of control charts commonly used in the laboratory are as X-chart and R-chart. The synthesized control samples of EC, pH, NH_4^+, $NO_{2\&3}^-$, Total-N, Total-P and COD are analyzed at the same time with sample analysis. The derived data was used as the values plotted in X-chart to determine the reliable of the analysis while the range of duplicate data obtained by measurement in Dissolved Oxygen, TSS and Fecal Coliform Bacteria analysis are used in R-chart. The checking correctness of analyses by ion-balance is applied to each water sample for which relatively complete analyses are made.

Chapter 3
Results and Discussions

3.1 Water quality parameters in Mekong River and tributaries

The water quality in Mekong River and tributaries in 2014 for Thailand were conducted at 3 primary sampling stations along Mekong River from Chiang Saen, Nakhon Phanom and Khong Chiam stations. The four tributary rivers consist of Kok River, Song Khram River, Kam River and Mun River, which alternating with primary stations, were conducted from 5 sampling stations. The water quality parameters analysis were displayed in this section with box-and-whisker plot. The plot informs the information of lower extreme, lower quartile, median, upper quartile and upper extreme, also outliner and extreme outlier.

The sequence of stations to display are sequenced by location to reach from Mekong River upstream to downstream. The upstream station before station in Thailand locates in the Lao PDR. The first station in Thailand is Chiang Rai station, which discharged in Mekong River with Chiang Saen station as downstream monitoring station. Next, Song Khram River discharges into Mekong River with Nakorn Phanom station as downstream monitoring station. Then, Kam River discharges into Mekong River with Khong Chiam as downstream monitoring station. Finally, Mun River discharges into Mekong River with downstream monitoring station locate in Pakse, the Lao PDR.

The water quality analysis data in the past from 1985 to present also showed yearly variation with box plot in Mekong River and 4 tributaries; Kok River, Song Khram River, Kam River and Mun River. The variations in average water quality parameter show the trend of changes both locations and time series.

Note that in Song Kram River and Mun River, the monitoring station between 1985 and 2003 and the monitoring station between 2004 to present had been located in difference location. However, the box plot of variation in average water quality parameter values of these two tributaries should be plotted based on data collecting year, thus the difference in sampling locations were neglect.

3.1.1 Basic parameters

1) pH

The average observed pH value at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 7.43, 7.47 and 7.55, respectively. These average pH values were around 1.05 higher than average pH values of the Mekong mainstream stations in 2013. These different were statistically significant both paired-sample t-test and independent-sample t-test with 95% confidence level, so pH values in Mekong River in this year were increase significantly after lower pH values were occurred for previous 3 years since 2011.

The average observed pH values at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 7.59, 7.55, 7.50, 7.39 and 7.42, respectively. The difference between average values in 2013 and 2014 with 95% confidence were statistical significance at all stations.

The box plot of pH values in Figure 3.1 show the variation in pH at individual station. The monitoring stations in Mekong River had similar pH variation to the tributaries. The overall average pH values in mainstream and tributaries represent by mean and median were equal to 7.68 and 7.51, respectively.

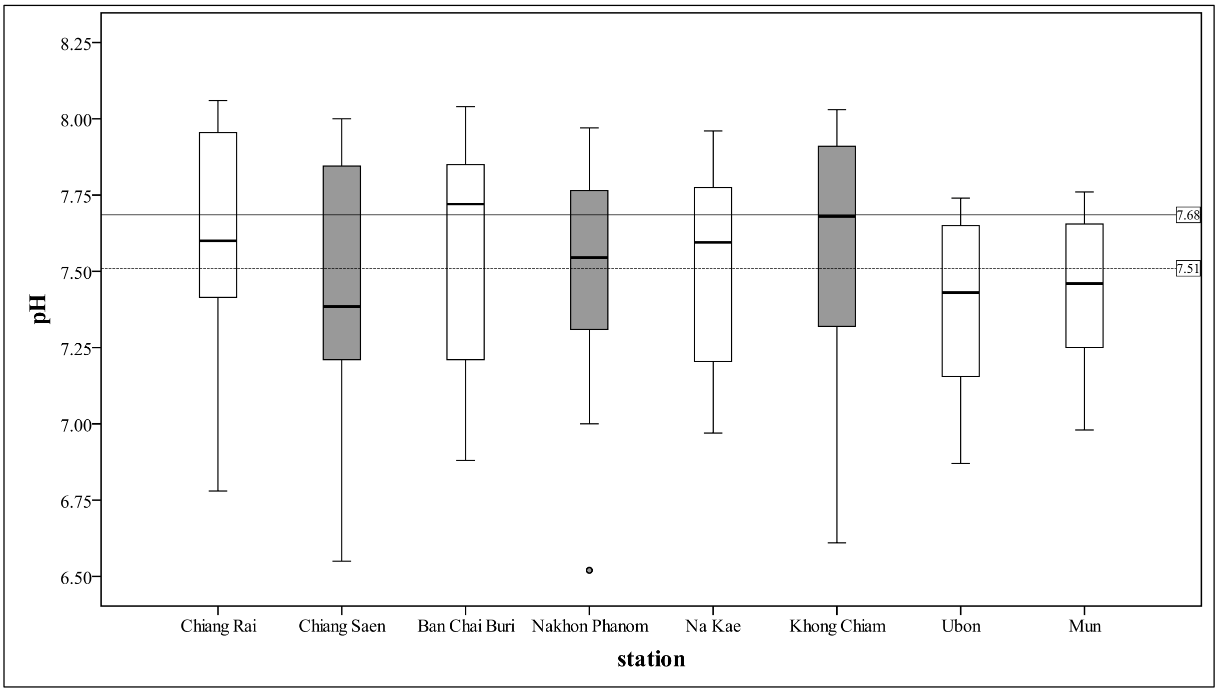

Figure 3.1 The observed pH at monitoring stations in 2014

The variation of pH values along Mekong mainstream and tributaries from 1985 to 2014 were compared in Figure 3.2. These plot figures out the Mekong mainstream had relatively low variation than Song Khram River and Mun River, which had the highest variation. Moreover, the change of median in pH at each year seems to be related in all streams. In 2012, Mekong River shows the lowest pH value since 1985 and others tributaries also have lower pH values than previous series years. In this year, the pH values were significantly increasing back to neutral pH scale after continually decreasing for 3 years since 2011. The pH values in tributaries also increasing to normal condition.

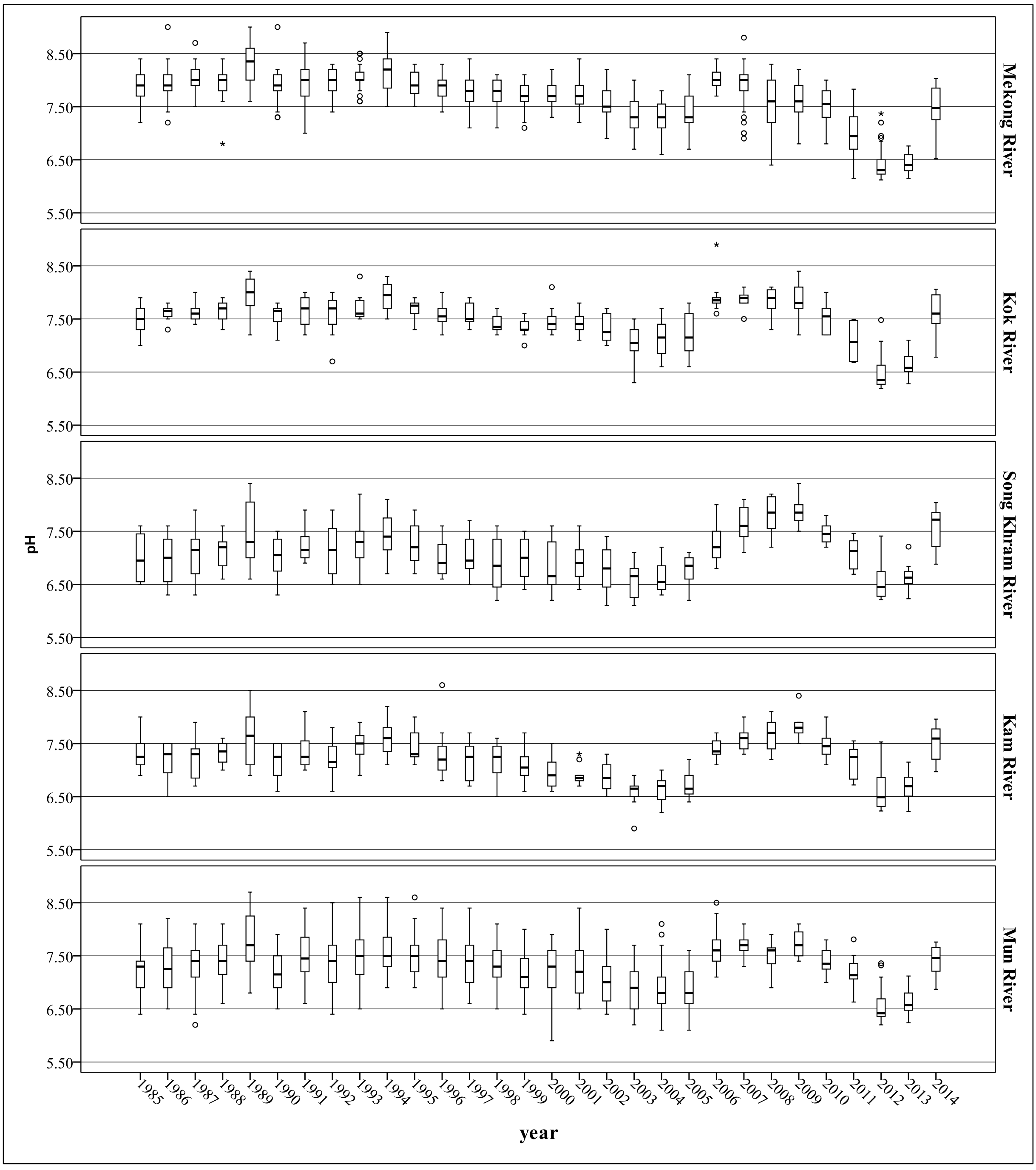

Figure 3.2 The variation of pH in Mekong River and tributaries from 1985 to 2014

2) Electrical conductivity (EC)

The average observed EC values at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 24.21, 21.03 and 19.71 mS/m, respectively. These average EC values were very few higher than the Mekong mainstream stations in 2013 just around 0.6 mS/m, and these were not statistically significant differences in EC values for overall and each station observed in 2013 with 95% confidence.

The average observed EC values at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 11.57, 27.87, 12.22, 25.76 and 14.48 mS/m, respectively. The difference between average values in 2013 and 2014 with 95% confidence were not statistical significance both all river and all stations. Variation of EC values for each station in Figure 3.3 shows overall mainstream and tributaries mean and median equal to 19.6 and 18.3 mS/m, respectively.

The EC value in Song Khram River at Ban Chai Buri was found extremely higher than others stations in momentary time period, especially in dry season (January to May). Song Khram river originate in Sakon Nakhon province and flow through the severely salt affected area in Ban Dung district of Udon Thani province, where has more than 30% widespread of rock salt farming area. In 2014, the high EC values in Song Khram River at Ban Chai Buri station were 39.20, 47.00, 31.40, 62.50 and 28.20 mS/m from January to May, respectively, and also show the highly concentration of chloride and sodium ion which mainly compound of rock salt (Table C3).

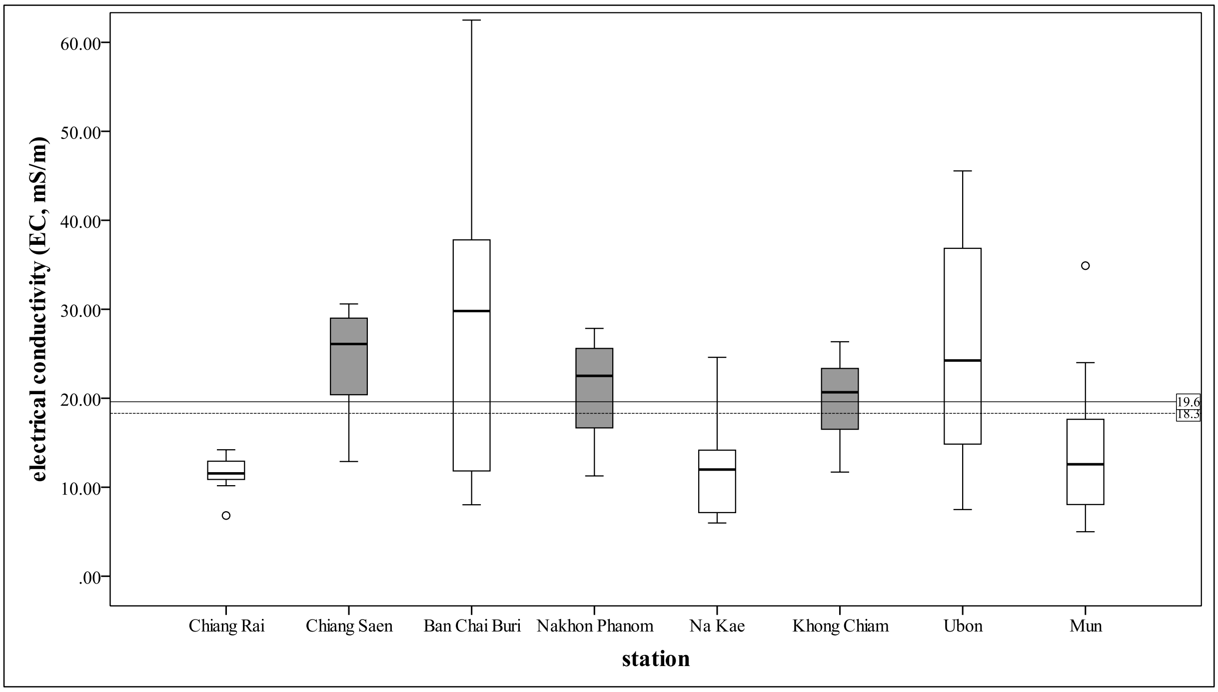

Figure 3.3 The observed EC at monitoring stations in 2014

The variation of EC values along Mekong River and tributaries from 1985 to 2014 were compared in Figure 3.4. These plot figures out the Mekong River, Kok River and Kam River (since 2001) had quite stable in EC values. While the EC values in Song Khram River showed the highly variation, because of this river had affected from salinized water discharge from rock salt farming in Ban Dung district, especially in dry season. However, the highest EC from Song Khram River seems not affecting the EC value in Mekong River all the record years since 1985.

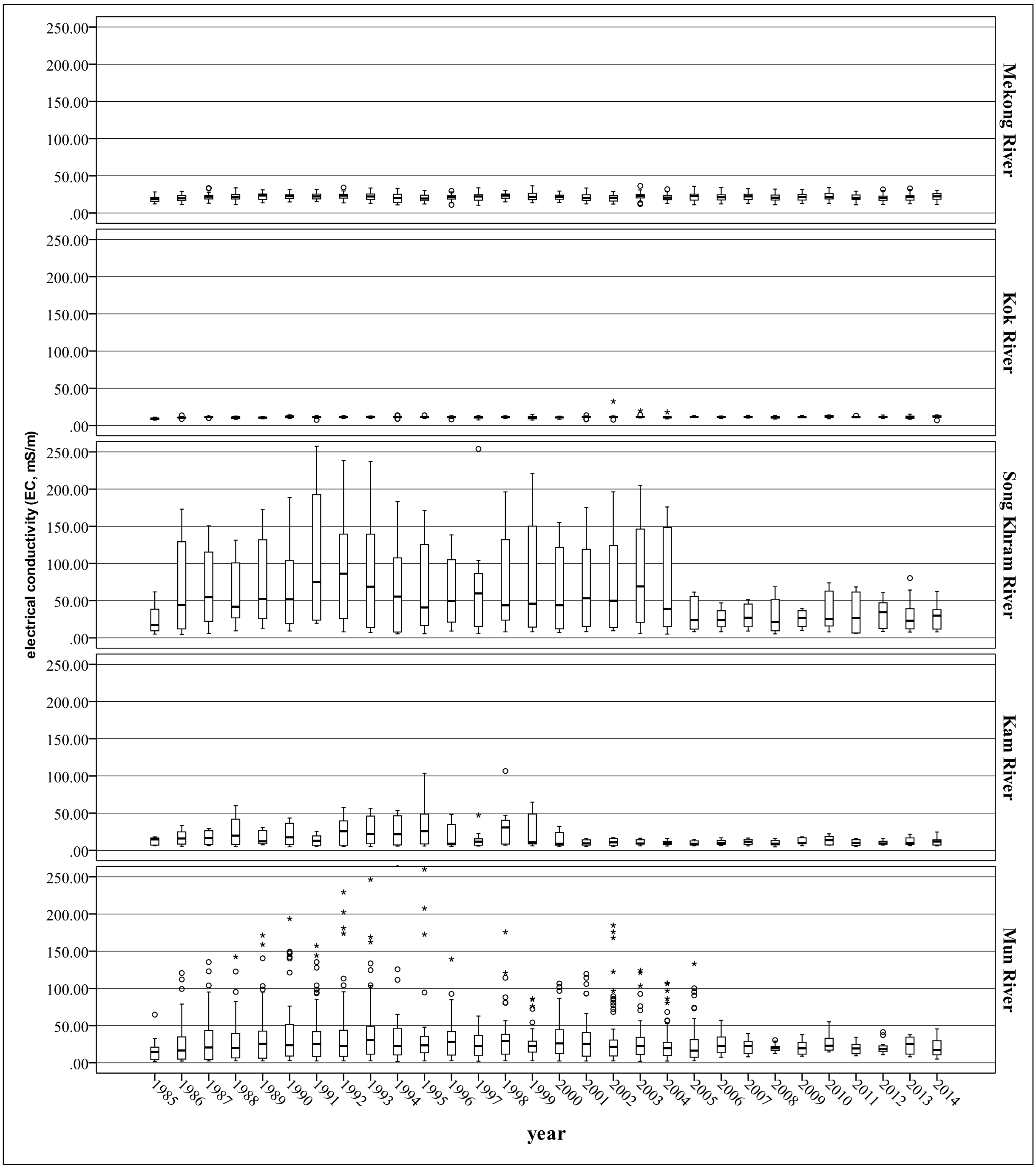

Figure 3.4 The variation of EC in Mekong River and tributaries from 1985 to 2014

3) Total Suspended Solids (TSS)

The average observed TSS concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 92, 83 and 74 mg/l, respectively. These average TSS concentrations were lower than average TSS concentrations of Mekong mainstream stations in 2013 around 22 mg/l, but these were not statistically significant differences in TSS concentrations for overall mainstream and each station observed in 2013 with 95% confidence.

The average observed TSS concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 119, 19, 12, 21 and 14 mg/l, respectively. The difference between average concentrations in 2013 and 2014 with 95% confidence were not statistical significance at all monitoring stations.

The box plot of TSS concentrations (Figure 3.5) shows the variation of TSS at individual station. The monitoring stations in Mekong River had very relative high TSS variation and median than the tributaries, except Kok River (Chiang Rai sampling station) that also had more variation. However, the median at Chiang Saen station also lower than Chiang Rai station, so the tributaries should not be effected the TSS concentration in Mekong River. The overall average TSS values in mainstream and tributaries represent by mean and median were equal to 54.1 and 22.7 mg/l, respectively.

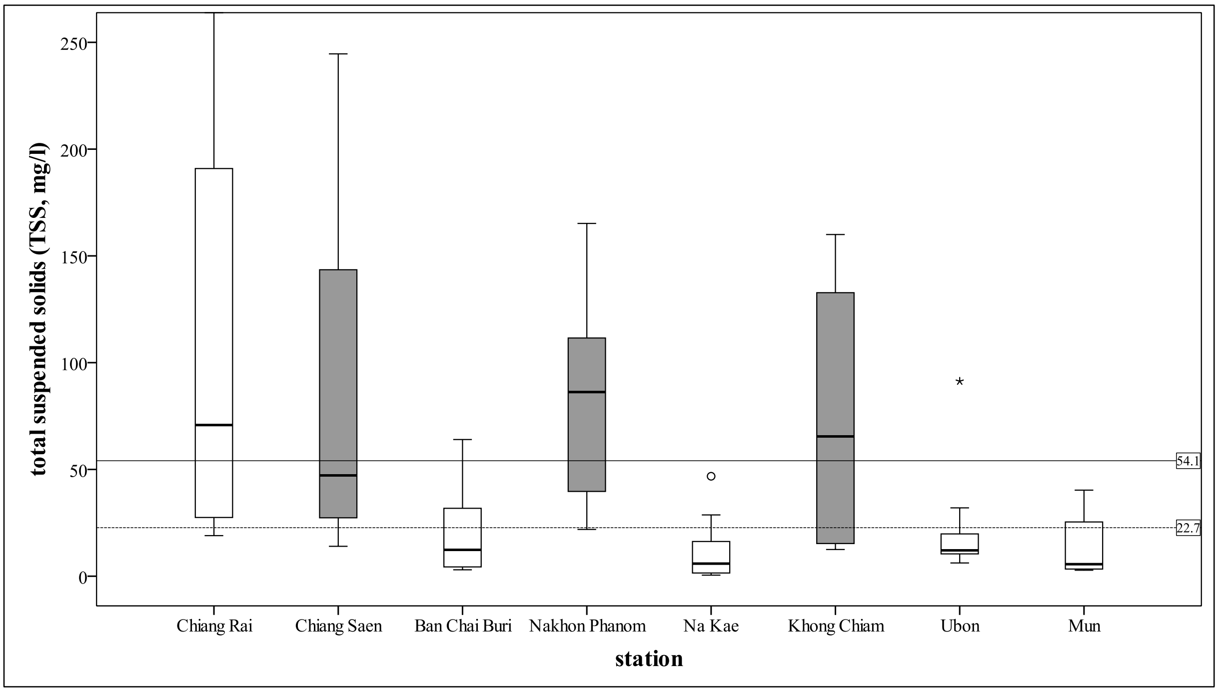

Figure 3.5 The observed TSS at monitoring stations in 2014

The variation of TSS concentrations along Mekong River and tributaries from 1985 to 2014 were compared in Figure 3.6. These plot figures out the Mekong River and Kok River had highly variation in TSS concentrations; especially Mekong River also had much extreme concentration frequently. While the TSS values in the three rest tributaries show the stable with very low concentration and variation.

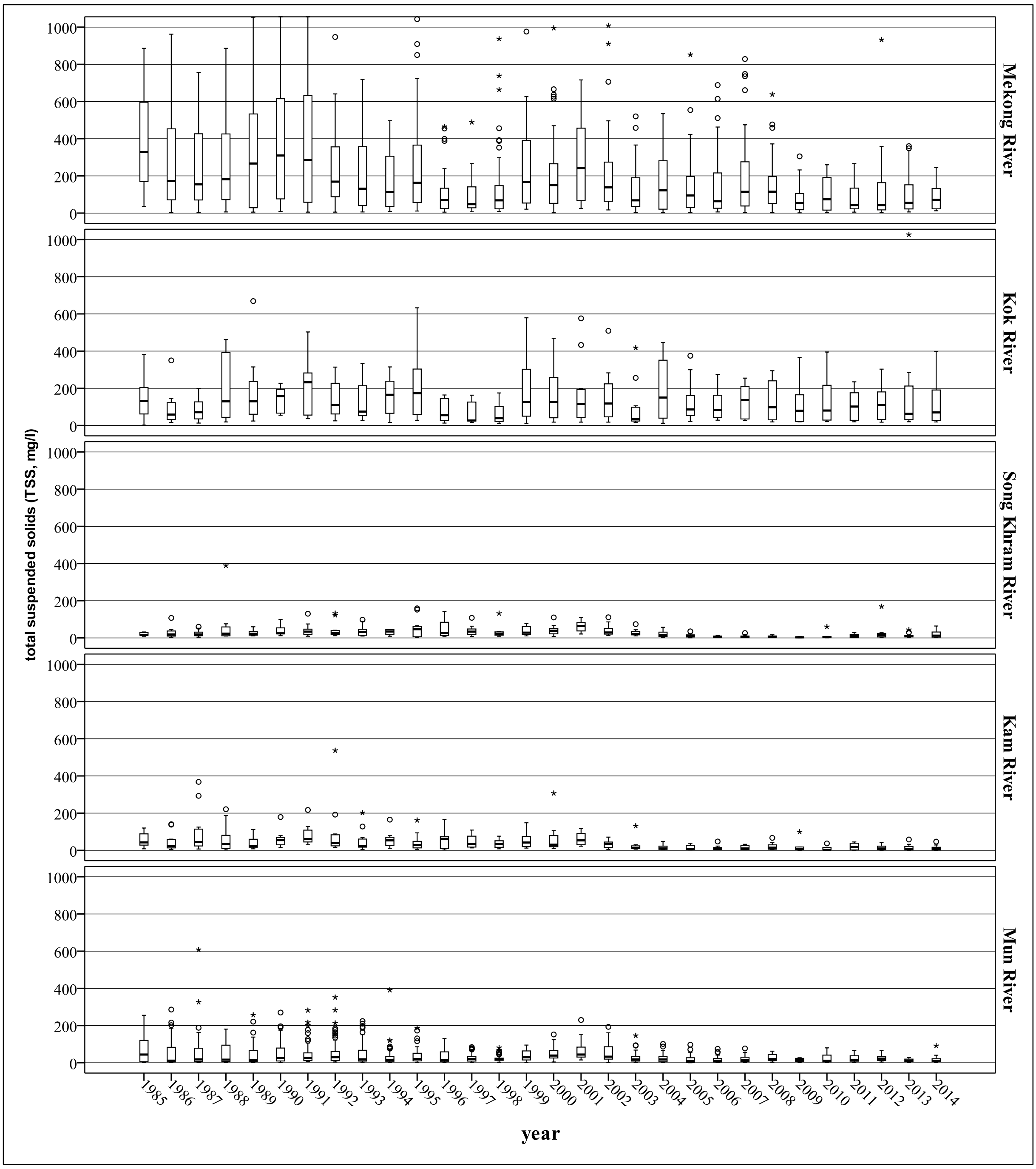

Figure 3.6 The variation of TSS in Mekong River and tributaries from 1985 to 2014

3.1.2 Nutrient

1) Ammonium nitrogen (NH_4^+-N)

The average observed NH_4^+-N concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 0.026, 0.035 and 0.029 mg/l, respectively. These average NH_4^+-N concentrations were significantly lower than average NH_4^+-N concentrations of all Mekong mainstream stations in 2013 around 0.036 mg/l, but these were not statistically significant differences in NH_4^+-N concentrations for each stations observed in 2013 with 95% confidence.

The average observed NH_4^+-N concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 0.045, 0.084, 0.046, 0.081 and 0.032 mg/l, respectively. The difference between average concentrations in 2013 and 2014 with 95% confidence were not statistical significance at all stations.

The box plot of NH_4^+-N concentrations (Figure 3.7) shows the variation of NH_4^+-N at individual station. The monitoring stations in Mekong River had quite stable in variation range and median, although the NH_4^+-N discharge from Mun River at Ubon station had higher concentration. The overall average NH_4^+-N values in mainstream and tributaries represent by mean and median were equal to 0.046 and 0.034 mg/l, respectively.

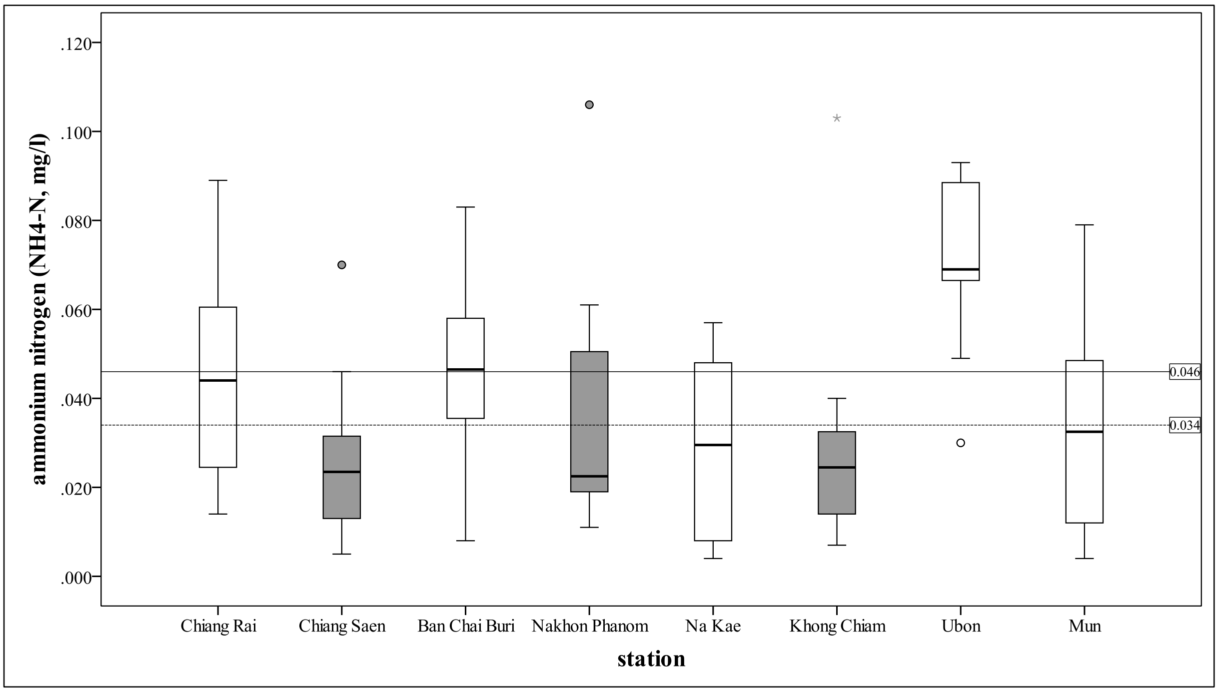

Figure 3.7 The observed NH_4^+-N at monitoring stations in 2014

The variation of NH_4^+-N concentrations along Mekong River and tributaries from 1985 to 2014 were compared in Figure 3.8. These plot figures out the Mekong River and all four tributaries had much variation in NH_4^+-N concentrations with correlated in variation. In 2014, Mekong River and all tributaries seem to have lower variation and mean concentration compare to the past 3 years.

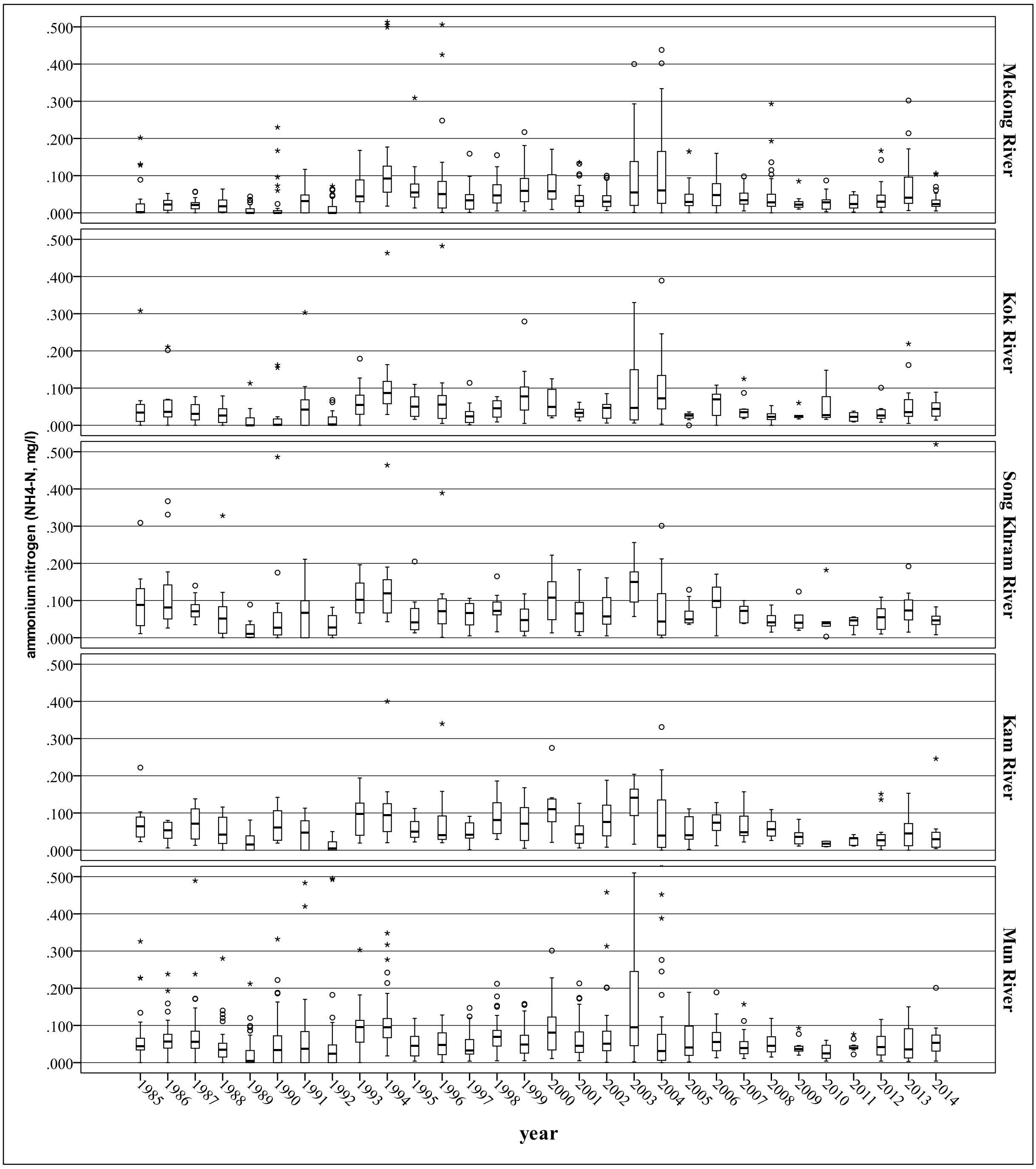

Figure 3.8 The variation of NH_4^+-N in Mekong River and tributaries from 1985 to 2014

2) Nitrite and nitrate nitrogen ($NO^-_{2\&3}$-N)

The average observed $NO^-_{2\&3}$-N concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 0.350, 0.261 and 0.244 mg/l, respectively. These average $NO^-_{2\&3}$-N concentrations were very few higher than average $NO^-_{2\&3}$-N concentrations of all Mekong mainstream stations in 2013 around 0.003 mg/l, but these were not statistically significant differences in $NO^-_{2\&3}$-N concentrations for each stations observed in 2013 with 95% confidence.

The average observed $NO^-_{2\&3}$-N concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 0.190, 0.129, 0.055, 0.159 and 0.128 mg/l, respectively. The difference between average concentrations in 2013 and 2014 with 95% confidence were statistical significance only at overall stations in Mun River tributaries (Ubon and Mun station), which shown increasing in concentration around 0.047 mg/l.

The box plot of $NO^-_{2\&3}$-N concentrations (Figure 3.9) shows the variation of $NO^-_{2\&3}$-N at individual station. The monitoring stations in Mekong River at Chiang Saen, Nakhon Phanom and Khong Chiam had pretty high variation range with high concentration, although the $NO^-_{2\&3}$-N discharge from tributaries had the same variation but lower in median. The overall average of $NO^-_{2\&3}$-N values in mainstream and tributaries represent by mean and median were equal to 0.248 and 0.203 mg/l, respectively.

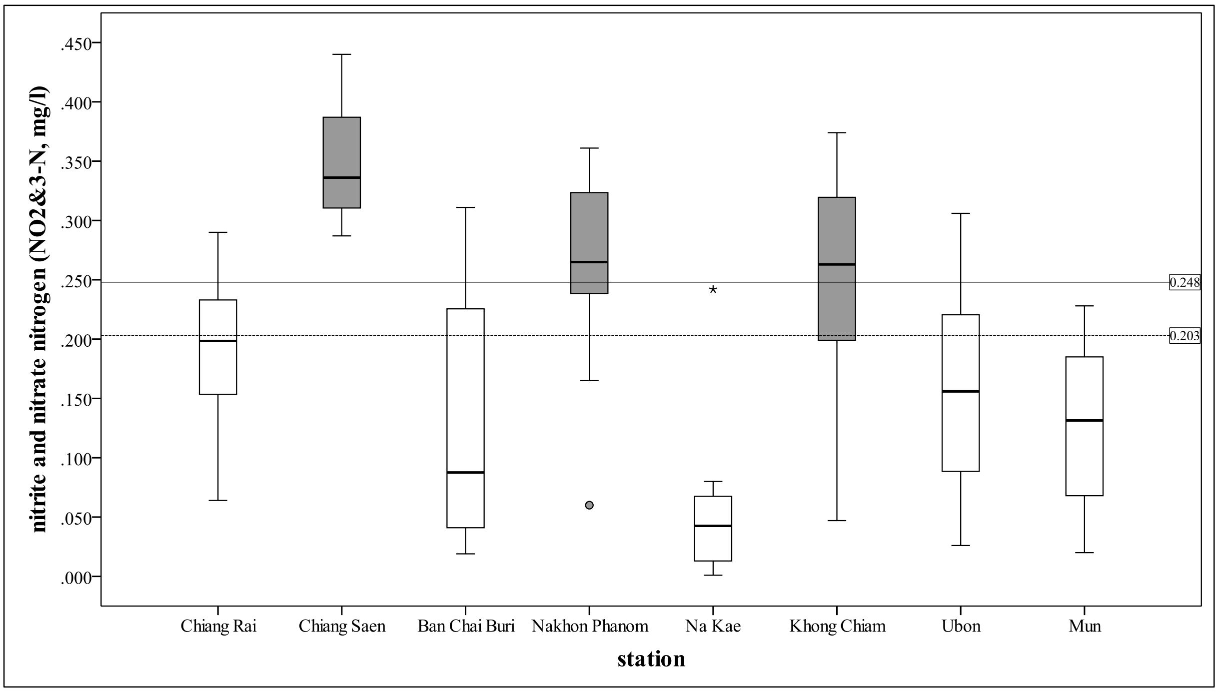

Figure 3.9 The observed $NO^-_{2\&3}$-N at monitoring stations in 2014

The variation of $NO_{2\&3}^{-}$-N concentrations along Mekong River and tributaries from 1985 to 2014 were compared in Figure 3.10. These plot figures out the Mekong River had quite stable variation range since 1985, and median of $NO_{2\&3}^{-}$-N seems to decrease since 2004. In the tributaries, these show the same result in smooth increasing of median since 2004, except Kam Rivers had sharp change. Please note that Song Khram River and Mun River had been moving to new station location since 2004, so median and variation may be much different. Mun River is only tributaries which increasing in concentration in this year.

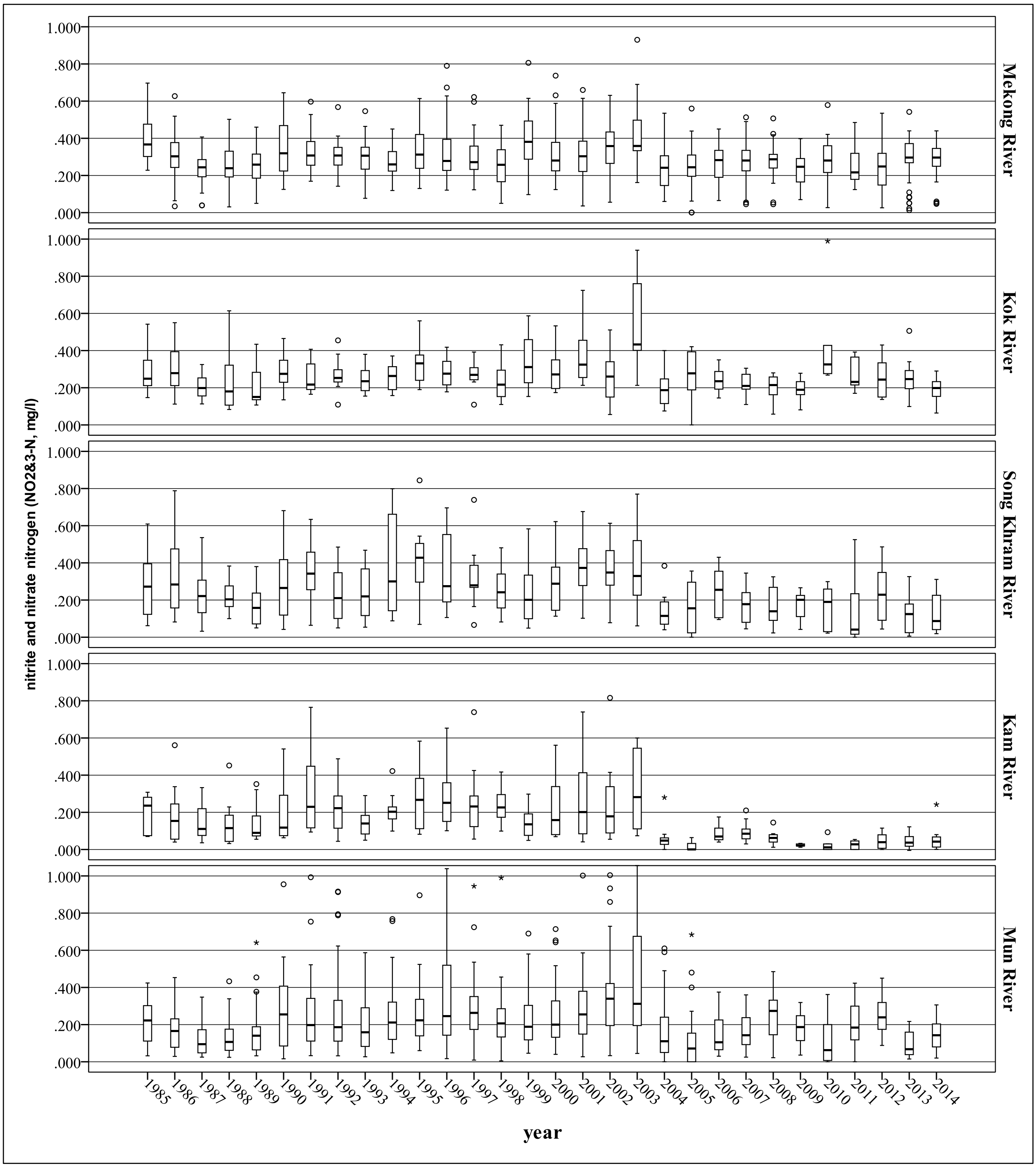

Figure 3.10 The variation of $NO_{2\&3}^{-}$-N in Mekong River and tributaries from 1985 to 2014

3) Total nitrogen (Total-N)

The average observed Total-N concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 0.517, 0.489 and 0.406 mg/l, respectively. These average Total-N concentrations were little higher than average Total-N concentrations of all mainstream stations in 2013 around 0.011 mg/l, but these still were not statistically significant differences in Total-N concentrations for all and each station observed in 2013 with 95% confidence.

The average observed Total-N concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 0.553, 0.527, 0.323, 0.588 and 0.406 mg/l, respectively. The difference between average concentrations in 2013 and 2014 with 95% confidence were not statistical significance at all stations.

The box plot of Total-N concentrations (Figure 3.11) shows the variation of Total-N at individual station. The all monitoring stations in Mekong River and tributary had the same high variation range with difference median concentrations. The median of Total-N in Mekong River had higher than in tributary, which discharge into upstream of monitoring station in Mekong River. The overall average of Total-N values in mainstream and tributaries represent by mean and median were equal to 0.476 and 0.430 mg/l, respectively.

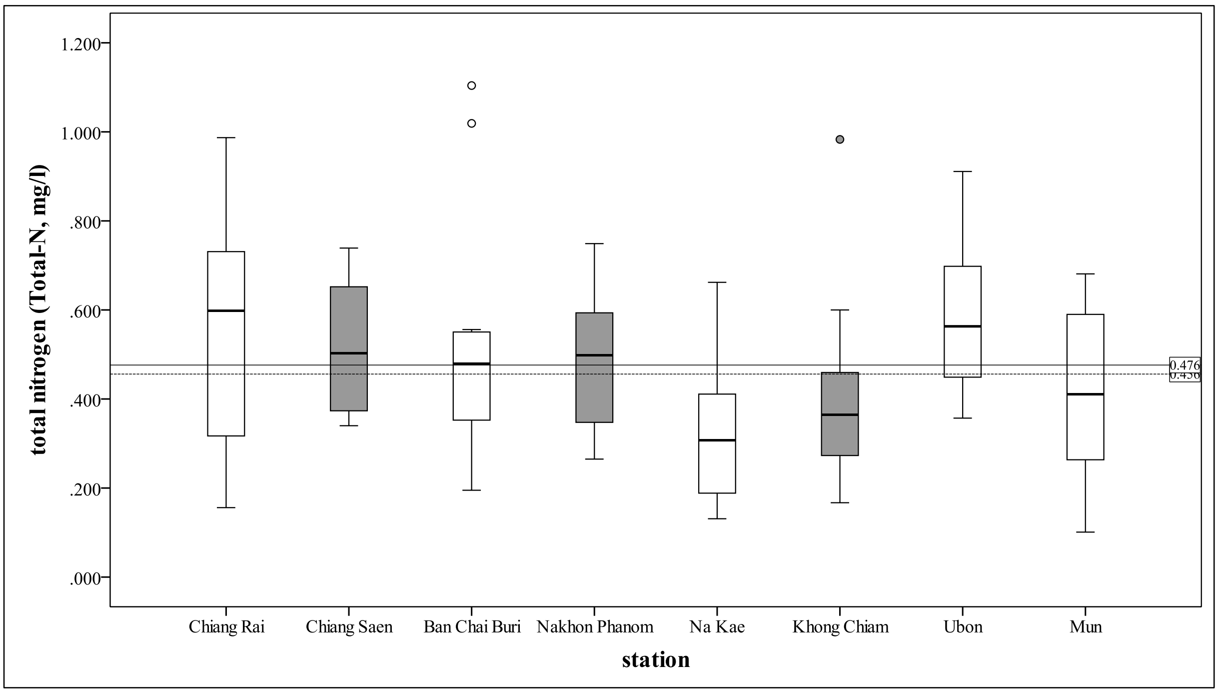

Figure 3.11 The observed Total-N at monitoring stations in 2014

The variation of Total-N concentrations along Mekong River and tributaries from 1985 to 2014 were compared in Figure 3.12. These plot figures out the Mekong River and all tributaries had the same pattern of variation range, and each stream had not much median concentration variation.

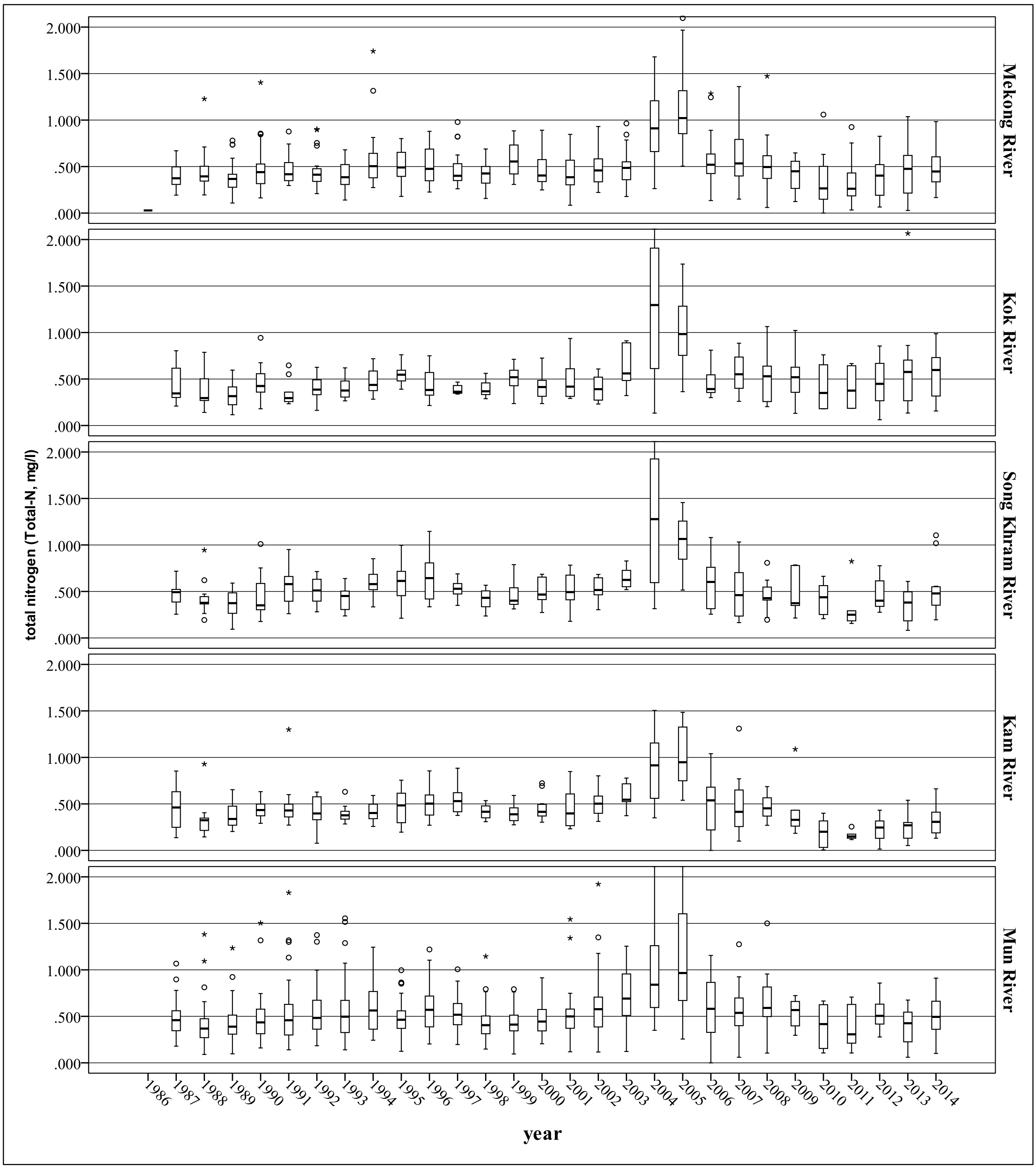

Figure 3.12 The variation of Total-N in Mekong River and tributaries from 1985 to 2014

4) Total phosphorus (Total-P)

The average observed Total-P concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 0.084, 0.081 and 0.069 mg/l, respectively. These average Total-P concentrations were statistically significant lower than average Total-P concentrations of overall mainstreams station in 2013 around 0.049 mg/l. For each station in mainstreams, total-P concentration was also lower than in 2013 significantly.

The average observed Total-P concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 0.156, 0.056, 0.057, 0.060 and 0.044 mg/l, respectively. The difference between average concentrations in 2013 and 2014 with 95% confidence were not statistical significant at all stations..

The box plot of Total-P concentrations (Figure 3.13) shows the variation of Total-N at individual station. The all monitoring stations in Mekong River and Kok River had the high variation of Total-P concentrations, and the median of Total-P in Kok River was highest. The others tributaries had low variation and median in Total-P. The overall average of Total-P values in mainstream and tributaries represent by mean and median were equal to 0.076 and 0.057 mg/l, respectively.

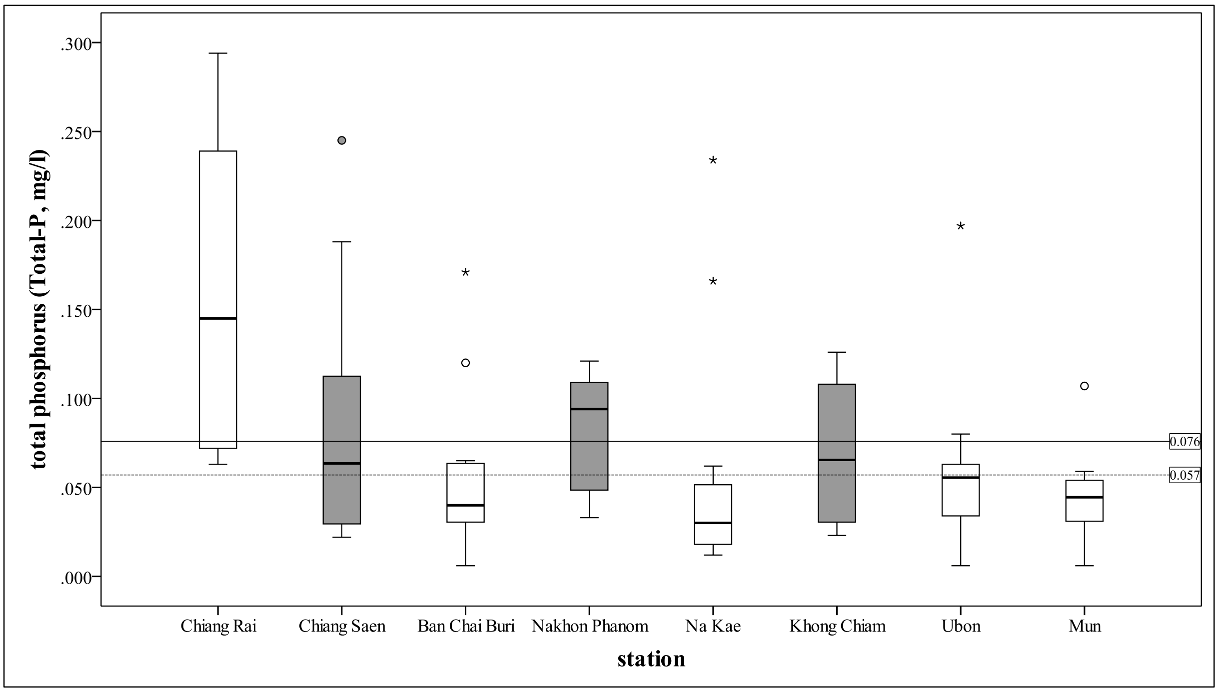

Figure 3.13 The observed Total-P at monitoring stations in 2014

The variation of Total-P concentrations along Mekong River and tributaries from 1985 to 2014 were compared in Figure 3.14. These plot figures out the Mekong River and Kok River had highly variation in Total-P concentrations, especially Kok River. While Total-P concentrations in the three rest tributaries show the stable with very low concentration and variation. These patterns had the same distribution compare to TSS concentration as Figures 3.6, two parameters should had the relationship in some reason.

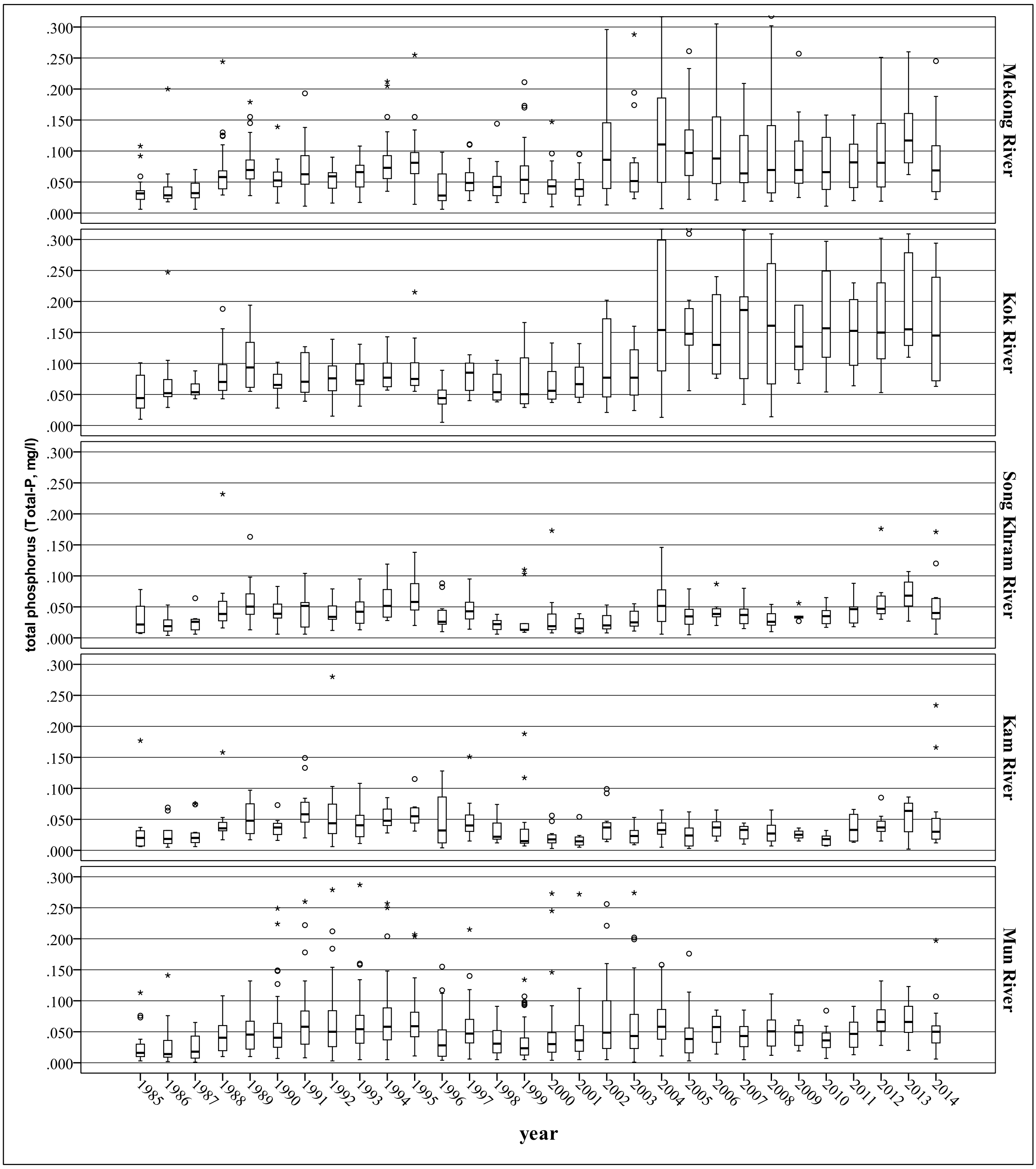

Figure 3.14 The variation of Total-P in Mekong River and tributaries from 1985 to 2014

3.1.3 Organic matters

1) Dissolved Oxygen (DO)

The average observed DO concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 8.99, 7.29 and 7.06 mg/l, respectively. These average DO concentrations were lower than average DO concentrations of all mainstream stations in 2013 around 0.19 mg/l, but these were not statistically significant differences in DO concentrations for both overall mainstream and each station observed in 2013 with 95% confidence.

The average observed DO concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 7.74, 6.21, 6.40, 6.20 and 6.08 mg/l, respectively. The difference between average concentrations in 2013 and 2014 with 95% confidence were not statistical significance at all stations.

The box plot of DO concentrations (Figure 3.15) shows the variation of DO at individual station. The all monitoring stations in Mekong River had the similar variation range in the same compare to tributaries, and also higher median than all upstream tributaries. The overall average of DO values in mainstream and tributaries represent by mean and median were equal to 7.00 mg/l.

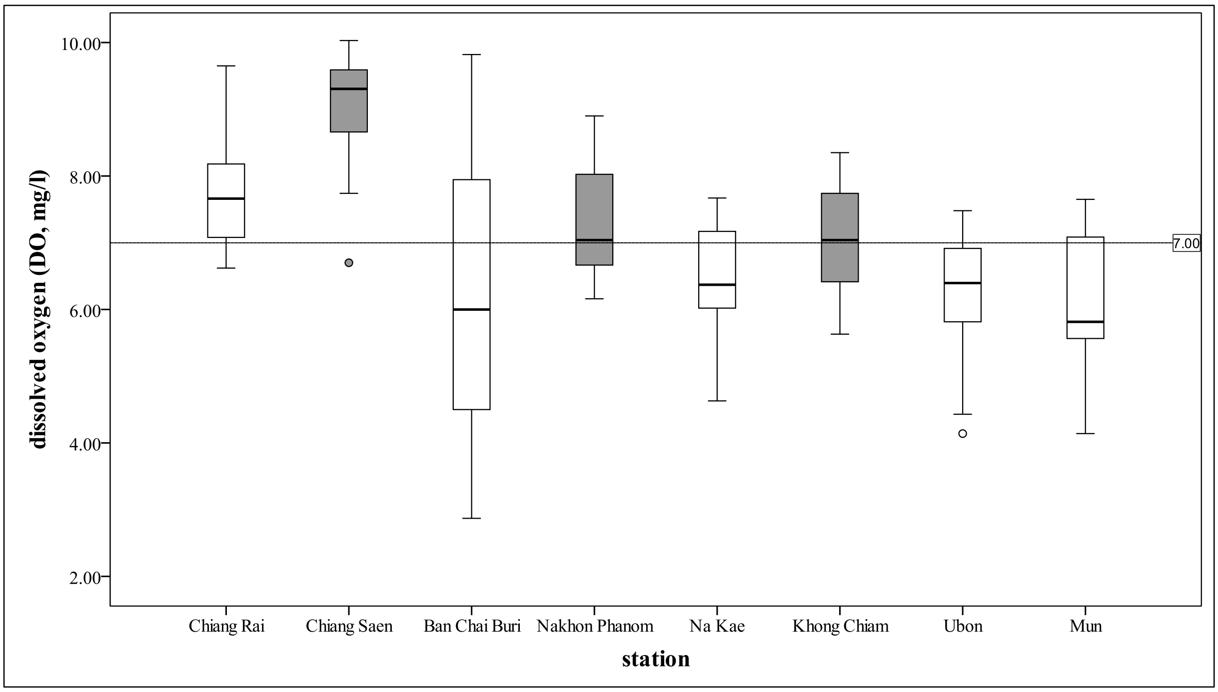

Figure 3.15 The observed DO at monitoring stations in 2014

The variation of DO concentrations along Mekong River and tributaries from 1985 to 2014 were compared in Figure 3.16. These plot figures out the Mekong River and all tributaries had the same pattern of variation range, and each stream had not much median concentration variation.

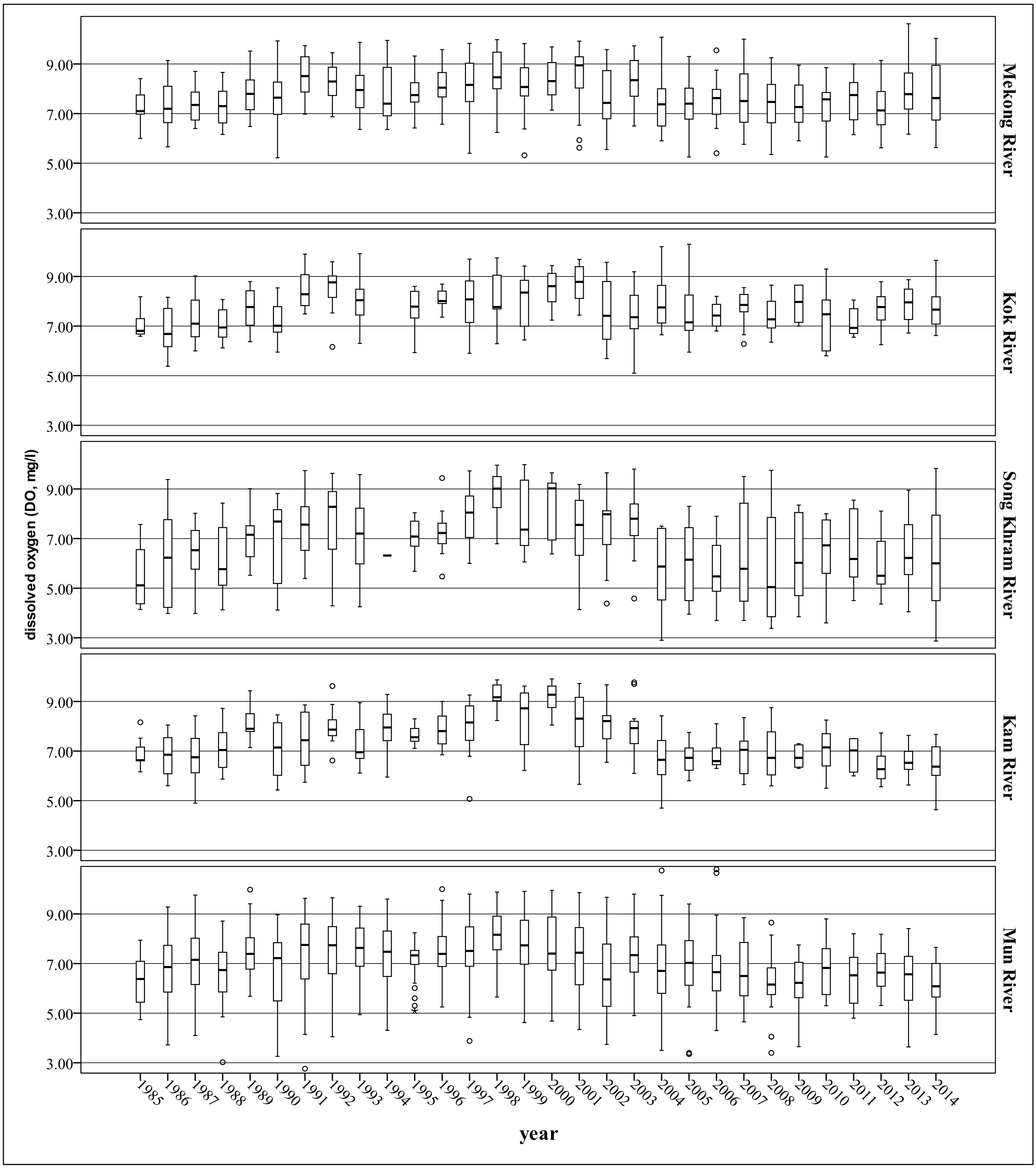

Figure 3.16 The variation of DO in Mekong River and tributaries from 1985 to 2014

2) Chemical Oxygen Demand (COD)

The average observed COD concentrations at Chiang Saen, Nakhon Phanom and Khong Chiam monitoring stations were 2.86, 3.75 and 2.88 mg/l, respectively. These average COD concentrations were little higher than average COD concentrations of same station in 2013 around 0.02 mg/l, but these were not statistically significant differences in COD concentrations for overall and each station observed in 2013 with 95% confidence.

The average observed COD concentrations at Chiang Rai, Ban Chai Buri, Na Kae, Ubon and Mun stations were 6.00, 3.78, 3.94, 5.46 and 4.72 mg/l, respectively. The difference between average concentrations in 2014 with 95% confidence were statistical significance at overall stations in Mun River with higher value than 2013 around 0.72 mg/l.

The box plot of COD concentrations (Figure 3.17) shows the variation of COD at individual station. The all monitoring stations in Mekong River had the pretty high variation range in the same compare to tributaries, but lower median than all tributaries. The overall average of COD values in mainstream and tributaries represent by mean and median were equal to 4.18 and 4.08 mg/l, respectively.

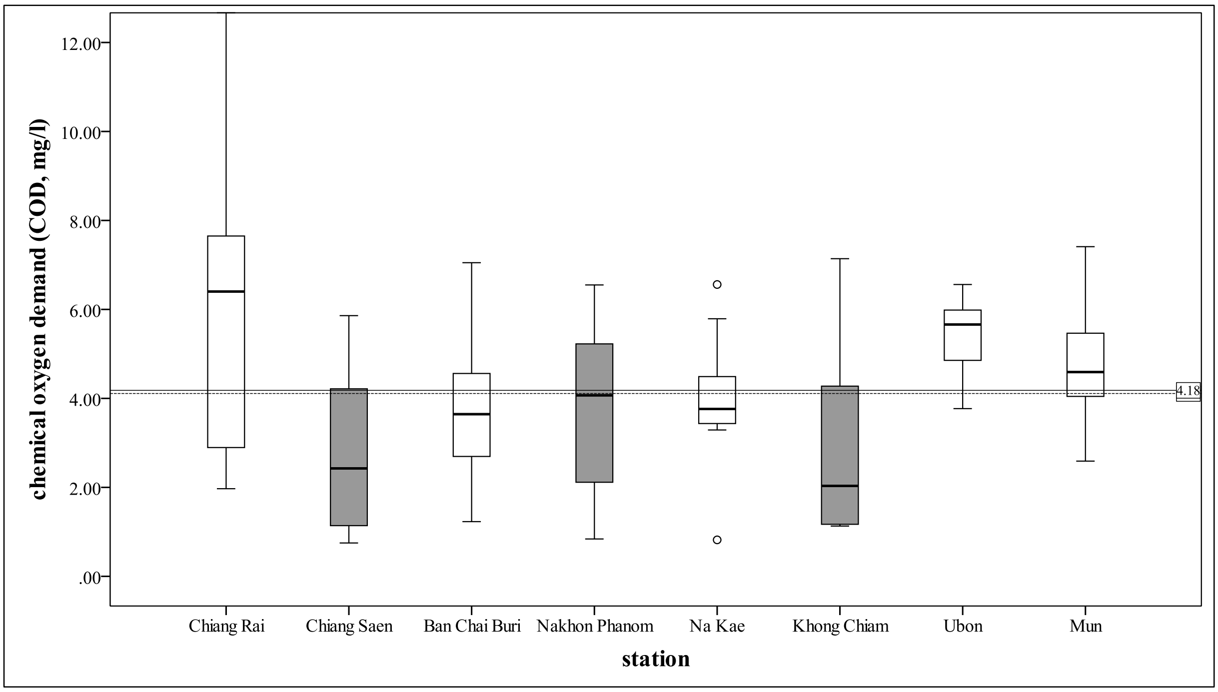

Figure 3.17 The observed COD at monitoring stations in 2014

The variation of COD concentrations along Mekong River and tributaries from 1985 to 2014 were compared in Figure 3.18. These plot figures out the Mekong River and all tributaries had the same pattern of variation range, and each stream had not much median concentration variation.

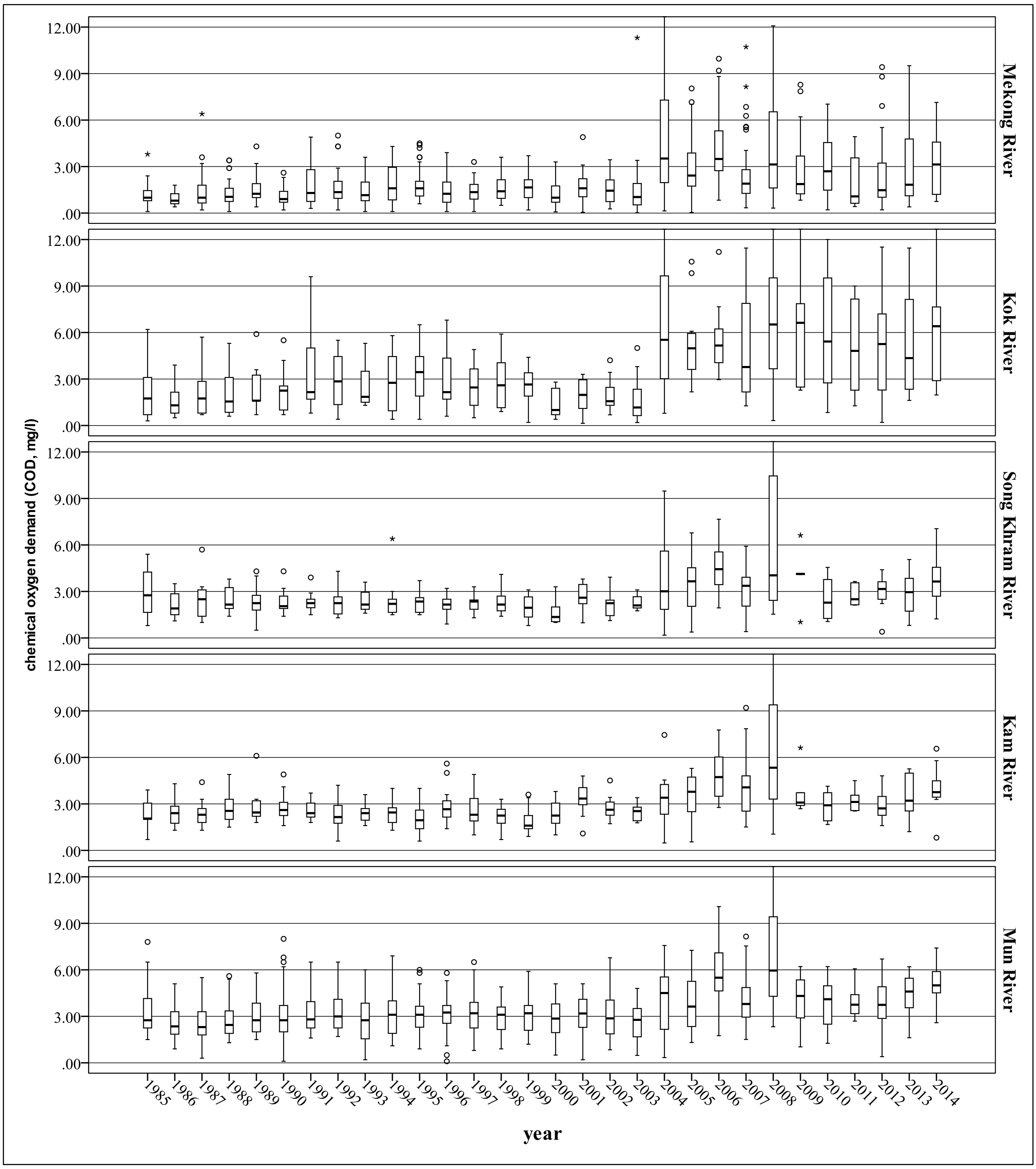

Figure 3.18 The variation of COD in Mekong River and tributaries from 1985 to 2014

3.2 Water Quality Indices (WQI)

Water Quality Index for Protection of Aquatic Life (WQI_{al}), Protection of Human Health with focusing on human acceptability (WQI_{ha}) and Agricultural Uses (WQI_{ag}) in 2014 were determined following the revised Water Quality Indices methodology (Campbell, 2014) as applied in Appendix B. In this revised WQIs, guideline values to developed WQIs are picking from the Procedures for Water Quality approved in 2013

Table 3.1 Water Quality Indices scores for Mekong River and tributaries in 2013 and 2014

Stations	Protection of aquatic life		Protection of human health		Agricultural use	
	2013	2014	2013	2014	2013	2014
Chaing Rai	8.61	9.17	89.2	88.3	Good	Good
Chiang Saen	9.17	9.58	89.7	90.2	Good	Good
Ban Chai Buri	9.72	9.17	90.3	80.6	Fair	Good
Nakhon Phanom	9.31	10.00	90.0	89.8	Good	Good
Na Kae	10.00	9.44	90.1	90.2	Good	Good
Khong Chiam	9.58	10.00	90.2	90.2	Good	Good
Ubon	9.86	9.58	89.2	88.4	Good	Good
Mun	9.58	9.86	80.3	89.8	Good	Good
Overall avg.	9.48	9.60	88.7	88.5	Fair	Good
Mainstream avg.	9.35	9.86	90.0	90.1	Good	Good
Tributaries avg.	9.56	9.44	87.8	87.5	Fair	Good

Remark Classify as following

Protection of aquatic life	Protection of human health	Agricultural use
High quality	Excellence quality	None restriction
Good quality	Good quality	Some restriction
Moderate quality	Moderate quality	Severe restriction
Poor quality	Poor quality	
Very poor quality	Very poor quality	

As illustrated in Table 3.1, the Water Quality Index for Protection of Aquatic Life in year 2014 at 8 monitoring stations ranged from 9.17 to 10.00, which indicated as high quality (all use are protected with a virtual absence of treat or impairment with no uses ever interrupted) at all station, except Chiang Rai Ban Chai Buri and Na Kae indicated as good quality (All use are protected with only a minor degree of treat or impairment with no uses ever interrupted.). Even though the lowest index score (9.17) was found in Kok River at Chiang Rai station and Song Kram River at Ban Chai Buri station, the water quality was still good quality for aquatic living organisms.

Water Quality Index for Protection of Aquatic Life for overall monitoring station was equal to 9.60 which indicated as high quality, as same as overall monitoring station in main stream that indicated in the high quality category with equal to 9.86 score. Instead of WQI_{al} in tributaries was equal to 9.44 which indicated as good quality. However, WQI_{al} in any case show the water quality in Mekong River mainstream and tributaries have been suitable for aquatic living niche.

The Water Quality Index for Protection of Human Health with focusing on human acceptability were ranged from 80.6 to 90.2 which indicated as good quality (Conditions rarely depart from desirable levels) at all monitoring stations. The lowest index was monitored in Song Khram River at Ban Chai Buri station. The Ban Chai Buri station is also the same station with lowest index for Protection of Aquatic Life. This stations might get closer to sometime depart from desirable levels In overall, the Water Quality Index for Protection of Human Health on monitoring station was equal to 88.5 which indicated as good quality, as same as overall monitoring station in main stream that indicated in the good quality category with equal to 90.1 score. Including WQI_{ha} in tributaries was equal to 87.5 which also indicated as good quality. However, WQI_{ha} in any case show the water quality in Mekong River mainstream and tributaries have been rarely depart from desirable levels, so human health would be acceptable protected .

Water Quality Index for Agricultural Uses were classified in 2 categories depend on purpose. Only electrical conductivity was used to determine the quality index, the guideline to defined parameter scores in assessing index for agricultural uses range shown while the electrical conductivity were lower than 70 mS/m, the water quality was most suitable for all types of agricultural. In year 2014, the maximum electrical conductivity value was 62.50 mS/m at Ban Chai Buri station in May, although this momentary extreme solely, the general irrigation and paddy field irrigation use water quality indices at all stations were determined in good quality for all station as show in Table 3.1. Mekong River and tributaries can be used for all agricultural purpose without restriction.

Chapter 4
Conclusions and Recommendations

4.1 Conclusions

The water parameter related to water quality indices were conducted and analysis in year 2014. These parameters consist of pH, EC, TSS, NH_4^+-N, $NO_{2\&3}^-$-N, Total-N, Total-P, DO and COD. Almost parameters compared with data conducted and analysis in year 2013 were little different without statistical significant. In the other hand, the water quality parameters were not clearly change in predictable trend, except the pH parameters. In this year, the pH values were significantly increasing back to neutral pH scale after continually decreasing for 3 years since 2011.

The high concentrations of nutrients (NH_4^+-N, Total-P) and organic matters indication (COD) were still observed in the Kok River, Songkram River and Mun River. These high concentration amounts were agricultural runoff with fertilizers, intensively fish cage culture and domestic sewage discharge from the localized urban via the tributaries. These have not been too much affected the water quality in the Mekong River. These conditions are probably the result of dilution due to the inflow of Mekong River. Thus, lower concentrations of these contents were found in Mekong River downstream of individual tributary discharge. However, the water quality indices along Mekong river main stream getting better than previous year, it seems reasonable to conclude that the Mekong River self-purification had reduced.

In addition, the assessment of water quality index from data records at the Water Quality Monitoring Network (WQMN) of Mekong River Thailand in 2014 also provides a useful picture to quantify the major sources of pollution which affected the quality of the Mekong River and its tributaries. Three water quality indices (WQIs) were applied. The WQI_{al} is ranged as high quality and good quality for the Protection of Aquatic Life in the Mekong River and tributaries. With regard to the water quality index for Protection of Human Health, water quality all and each station were good quality class. The stations in Song Khram River was the relative lower index values. However, the water quality in Mekong River mainstream and tributaries have been accepted for protection human health.

Water quality index for agriculture uses (WQI_{ag}), for all subcategories consist of general irrigation and paddy rice irrigation in Mekong River mainstream and tributaries have been suitable for all agricultural purposes.

4.2 Recommendations

Composite samples obtained by combining portions of multiple grab samples of river water at specific spot should be introduced by specialist to provide more representative of water body. The capacity building program in the topic of collection of samples, sample storage and preservation must be arranged by the Environmental Program to harmonize the field technicians in sample handling. The guideline of method validation for current methodology uses should be proposed as an important issue for quality assurance to obtain reliable and comparable water quality data among the countries of Mekong Basin.

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APPENDIX

Appendix A

Surface Water Quality Standards given by Thailand NEB

Table A1 Surface Water Quality Standards given by Thailand NEB

Parameter	Unit	Statistic	Sandard values for class ***				
			1	2	3	4	5
1. Odour, Colour, Taste	-	-	n	n	n	n	-
2. Temperature	°C	-	n	n	n	n	-
3. PH value	-	-	n	5-9	5-9	5-9	-
4. Dissolve oxygen	mg/l	P20	n	6	4	2	-
5. BOD (5 day,20 °C)	mg/l	P80	n	1.5	2.0	4.0	-
6. Coliform bacteria							
- Total coliform	MPN/100	P80		5,000	20,000	-	-
- Facial coliform	ml	P80					
7. NO_3-N	"	Max. allowance	n		5.0		-
8. NH_3-N	mg/l	"	n	:	0.5	:	-
9. Phenols	"	"	n	:	0.005	:	-
10. Cu	"	"	n	:	0.1	:	-
11. Ni	"	"	n	:	0.1	:	-
12. Mn	"	"	n	:	1.0	:	-
13. Zn	"	"	n	:	1.0	:	-
14. Cd	"	"	n	:	0.005*,0.05**	:	-
15. Cr (hexavalent)	"	"	n	:	0.05	:	-
16. Pb	"	"	n	:	0.05	:	-
17. Hg (total)	"	"	n	:	0.002	:	-
18. As	"	"	n	:	0.01	:	-
19. CN	"	"			0.005		
20. Radioactivity	"						
- Gross α	Becqurel/l	"	n	:	0.1	:	-
- Gross β	"	"	n	:	1.0	:	-
21. Pesticides (total)	mg/l	"	n	:	0.05	:	-
- DDT	µg/l	"	n	:	1.0	:	-
- α BHC	"	"	n	:	0.02	:	-
- Dieldrin	"	"	n	:	0.1	:	-
- Aldrin	"	"	n	:	0.1	:	-
- Heptachlor & Heptachlor epoxide	"	"	n	:	0.2	:	-
- Endrin	"	"	n		none		-

Note: P = Percentile value

N = Naturally

n' = Naturally but changing not more than 3 °C

* = When water hardness not more than 100 mg/l as $CaCO_3$

** = When water hardness not more than 100 mg/l as $CaCO_3$

*** = Water Classification

Classification: Objective/Condition & Beneficial usages

Class 1: Extra clean fresh surface water resources using for:

(1) conservation, not necessary pass through water treatment processes require only ordinary process for pathogenic destruction

(2) ecosystem conservation which basic living organisms can spread breeding naturally

Class 2: Very clean fresh surface water resources using for:

(1) consumption which require the ordinary water treatment process before uses

(2) aquatic organism conservation for living and assisting for fishery

(3) fishery

(4) recreation

Class 3: Medium clean fresh surface water resources using for:

(1) consumption but have to pass through an ordinary treatment process before uses

(2) agriculture

Class 4: Fairly clean fresh surface water resources using for:

(1) consumption but require special water treatment process before uses

(2) Industry

(3) other activities

Class 5: The resources which are not classified in class 1-4 and using navigation

Appendix B

Water Quality Indices and guideline values

1. Water Quality Index for Protection of Aquatic Life (WQI_{al})

Table B1 Parameters and guideline values used for assessing the Water Quality Index for Protection of Aquatic Life

Parameters	Symbol	Threshold	
		Value	Unit
pH	pH	6.0 – 9.0	-
Electrical conductivity	EC	< 150	mS/m
Ammonia	NH_3	0.1	mg/l
Dissolved oxygen	DO	> 5	mg/l
Nitrite and nitrate nitrogen	$NO^{-}_{2\&3}$-N	0.5	mg/l
Total Phosphorous	Total-P	0.13	mg/l

For the calculation of a WQI_{al} the following equation is used:

$$WQI_{al} = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n} p_{ij}}{M} X10$$

where p = score of index parameter j at day i

n = number of parameter indices

m = number of sampling day in each year

M = maximum possible score in each year

Table B2 Score used for classifying the Water Quality Index for Protection of Aquatic Life

Score	Class	Description
9.5 ≤ WQI ≤10	High Quality	All use are protected with a virtual absence of treat or impairment. No uses ever interrupted.
8 ≤ WQI < 9.5	Good Quality	All use are protected with only a minor degree of treat or impairment. No uses ever interrupted.

Table B2 Score used for classifying the Water Quality Index for Protection of Aquatic Life (cont.)

Score	Class	Description
6.5 ≤ WQI < 8	Moderate Quality	Most uses protected but a few threatened or impaired. A single use may be temporarily interrupted.
4.5 ≤ WQI < 6.5	Poor Quality	Most uses threatened or impaired. A several uses may be temporarily interrupted. condition often depart from natural or desirable levels.
WQI < 4.5	Very Poor Quality	Most uses threatened or impaired. An several uses may be temporarily interrupted. Condition usually depart from natural or desirable levels.

2. Water Quality Index for Protection of Human Health (WQI_{ha})

Table B3 Parameters and guideline values used for assessing the Water Quality Index for Protection of Human Health

Parameters	Symbol	Threshold	
		Value	Unit
pH	pH	6.0 – 9.0	-
Electrical conductivity	EC	< 150	mS/m
Ammonia	NH_3	0.5	mg/l
Dissolved oxygen	DO	4	mg/l
Nitrite and nitrate nitrogen	$NO^{-}_{2\&3}$-N	5	mg/l
Chemical oxygen demand	COD	5	mg/l

For the calculation of a WQI_{ha} the following equation is used:

$$WQI_{ha} = \frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}$$

where F_1 = the percentage of parameters which exceed the guidelines

$$F_1 = \left(\frac{number\ of\ failed\ parameters}{Total\ number\ of\ parameters}\right)$$

F_2 = the percentage of individual tests for each parameter that exceeded the guideline

$$F_2 = \left(\frac{number\ of\ failed\ tests}{Total\ number\ of\ tests}\right)$$

F_3 = the extent to which the failed test exceeds the target value

$$F_3 = \left(\frac{nse}{0.01nse + 0.01}\right)$$

nse = the sum of excursions

$$nse = \left(\frac{\sum excursion}{Total\ number\ of\ tests}\right)$$

$$excursion = \left(\frac{failed\ test\ value}{guideline\ value}\right) - 1$$

Table B4 Score used for classifying the Water Quality Index for Protection of Human Health

Rating Score	Class	Description
$95 \leq$ WQI ≤ 100	Excellent Quality	All measurements are within objectives virtually all of the time
$80 \leq$ WQI < 95	Good Quality	Conditions rarely depart from desirable levels
$65 \leq$ WQI < 80	Moderate Quality	Conditions sometimes depart from desirable level
$45 \leq$ WQI < 65	Poor Quality	Conditions often depart from desirable levels
WQI < 45	Very Poor Quality	Conditions usually depart from desirable levels

3. Water Quality Index for Agricultural Uses (WQI_{ag})

Two different subindices are used for general irrigation and paddy rice agriculture use. Only conductivity is used and is divided into three degree of consequence.

Table B5 Electrical conductivity guidelines and degree of consequence in assessing Water Quality Index for Agricultural Uses

Irrigation raw water	Unit	Good quality	Fair quality	Poor quality
General irrigation	mS/m	< 70	70 – 300	> 300
Paddy rice	mS/m	< 200	200 – 480	> 480

Remark: Good quality = 100% yield, Fair quality = 50-90% yield, Poor quality = < 50% yield

Appendix C

Water quality parameters analysis results

Table C1 Statistical characteristic descriptions of WQI related parameters in 2014

Station	Values	Parameters									
		Temperature (°C)	pH	EC (mS/m)	TSS (mg/l)	NH_4^+ (mg/l)	$NO_{2\&3}^-$ (mg/l)	Total-N (mg/l)	Total-P (mg/l)	DO (mg/l)	COD (mg/l)
H010501 Chiang Saen	Range	12.0	1.45	17.71	231	0.065	0.153	0.398	0.222	3.33	5.11
	Minimum	20.8	6.55	12.89	14	0.005	0.287	0.340	0.022	6.70	0.75
	Maximum	32.8	8.00	30.60	245	0.070	0.440	0.739	0.245	10.03	5.86
	Mean	24.1	7.43	24.21	92	0.026	0.350	0.517	0.084	8.99	2.86
	SD	3.2	0.41	5.86	81	0.017	0.048	0.138	0.068	0.92	1.78
H013101 Nakhon Phanom	Range	10.5	1.45	16.58	143	0.095	0.301	0.484	0.087	2.74	5.71
	Minimum	20.0	6.52	11.27	22	0.011	0.060	0.265	0.033	6.16	0.84
	Maximum	30.5	7.97	27.85	165	0.106	0.361	0.749	0.121	8.90	6.55
	Mean	27.3	7.47	21.03	83	0.035	0.261	0.489	0.081	7.29	3.75
	SD	2.9	0.39	5.47	47	0.026	0.081	0.145	0.032	0.83	1.77
H013801 Khong Chiam	Range	7.5	1.42	14.66	148	0.096	0.327	0.816	0.102	2.72	6.01
	Minimum	22.5	6.61	11.70	13	0.007	0.047	0.167	0.023	5.63	1.13
	Maximum	30.0	8.03	26.35	160	0.103	0.374	0.983	0.126	8.35	7.14
	Mean	27.3	7.55	19.71	74	0.029	0.244	0.406	0.069	7.06	2.88
	SD	2.1	0.41	4.42	58	0.024	0.102	0.210	0.040	0.83	1.93
H050104 Chiang Rai	Range	10.8	1.28	7.39	379	0.075	0.226	0.831	0.231	3.03	11.16
	Minimum	19.8	6.78	6.82	19	0.014	0.064	0.156	0.063	6.62	1.97
	Maximum	30.6	8.06	14.21	398	0.089	0.290	0.987	0.294	9.65	13.13
	Mean	25.6	7.59	11.57	119	0.045	0.190	0.553	0.156	7.74	6.06
	SD	2.9	0.36	1.83	113	0.023	0.063	0.264	0.081	0.81	3.37
H290103 Ban Chai Buri	Range	9.0	1.16	54.47	61	0.513	0.292	0.909	0.164	6.95	5.83
	Minimum	24.0	6.88	8.03	3	0.008	0.019	0.195	0.006	2.87	1.23
	Maximum	33.0	8.04	62.50	64	0.520	0.311	1.104	0.171	9.82	7.05
	Mean	29.0	7.55	27.87	19	0.084	0.129	0.527	0.056	6.21	3.78
	SD	2.0	0.36	16.29	18	0.133	0.101	0.262	0.044	2.06	1.71
H310102 Na Kae	Range	7.0	0.99	18.62	46	0.242	0.241	0.531	0.222	3.04	5.75
	Minimum	24.0	6.97	5.98	0	0.004	0.001	0.131	0.012	4.63	0.82
	Maximum	31.0	7.96	24.60	47	0.246	0.242	0.662	0.234	7.67	6.56
	Mean	28.1	7.50	12.22	12	0.046	0.055	0.323	0.057	6.40	3.94
	SD	2.6	0.32	5.23	13	0.063	0.062	0.154	0.067	0.92	1.35
H380104 Ubon	Range	8.5	0.87	38.06	85	0.171	0.280	0.554	0.191	3.34	2.80
	Minimum	24.0	6.87	7.49	6	0.030	0.026	0.357	0.006	4.14	3.77
	Maximum	32.5	7.74	45.55	91	0.201	0.306	0.911	0.197	7.48	6.56
	Mean	29.2	7.39	25.76	21	0.081	0.159	0.588	0.060	6.20	5.46
	SD	2.3	0.28	11.95	22	0.040	0.085	0.172	0.045	1.00	0.79
H380128 Mun	Range	7.0	0.78	29.90	38	0.075	0.208	0.580	0.102	3.51	4.83
	Minimum	24.5	6.98	5.00	3	0.004	0.020	0.101	0.006	4.14	2.59
	Maximum	31.5	7.76	34.90	40	0.079	0.228	0.681	0.107	7.65	7.41
	Mean	29.4	7.42	14.48	14	0.032	0.128	0.406	0.044	6.08	4.72
	SD	2.0	0.24	8.14	14	0.022	0.066	0.193	0.025	0.99	1.18

Table C2 Statistical tests in differencing of WQI related parameters between 2013 and 2014

test	parameters	Mekong								Kok		Song Khram		Kam		Mun					
		ALL		Chiang Saen		Nakhon Phanom		Khong Chiam		Chiang rai		Ban Chai Buri		Na Kae		ALL		Ubon		Mun	
		mean	p	mean	p	mean	p	mean	p	mean	p	mean	p	mean	p	mean	p	mean	p	mean	p
paired sample t-test	PH	1.05	.000	1.09	.000	1.03	.000	1.05	.000	0.95	.000	0.91	.000	0.80	.000	0.77	.000	0.78	.000	0.77	.000
	EC	0.60	.232	-0.27	.827	0.85	.202	1.22	.068	0.15	.773	-1.48	.818	-0.01	.996	-3.19	.130	-5.55	.123	-0.83	.722
	TSS	-22.10	.112	-28.86	.376	-14.87	.405	-22.58	.322	-56.68	.523	6.66	.123	-2.58	.611	4.80	.144	7.63	.216	1.96	.472
	NH_4^+	-0.036	.003	-0.044	.052	-0.028	.189	-0.038	.110	-0.016	.490	0.006	.876	-0.005	.829	0.005	.655	0.021	.332	-0.011	.293
	$NO_{2\&3}^-$	0.003	.857	-0.011	.657	0.016	.648	0.005	.897	-0.061	.092	0.007	.829	0.010	.642	0.047	.031	0.054	.132	0.040	.138
	Total-N	0.011	.817	-0.015	.847	0.073	.298	-0.024	.830	-0.066	.730	0.181	.075	0.079	.181	0.105	.053	0.149	.095	0.060	.361
	Total-P	-0.049	.000	-0.066	.005	-0.041	.002	-0.041	.004	-0.058	.225	-0.013	.300	0.003	.864	-0.017	.061	-0.014	.389	-0.021	.051
	DO	-0.19	.272	-0.06	.885	-0.08	.697	-0.44	.099	-0.13	.579	-0.19	.662	-0.19	.475	-0.20	.463	-0.46	.229	0.05	.896
	COD	0.02	.967	-0.65	.486	0.65	.355	0.05	.939	0.82	.339	0.94	.082	0.49	.293	0.72	.005	0.64	.051	0.80	.052
independent sample t-test	PH	1.05	.000	1.09	.000	1.03	.000	1.05	.000	0.95	.000	0.91	.000	0.80	.000	0.77	.000	0.78	.000	0.77	.000
	EC	0.60	.650	-0.27	.917	0.85	.686	1.22	.485	0.15	.856	-1.48	.861	-0.01	.997	-3.19	.346	-5.55	.217	-0.83	.799
	TSS	-22.11	.304	-28.87	.524	-14.79	.648	-22.68	.534	-56.72	.528	6.69	.317	-2.70	.677	4.81	.265	7.65	.283	1.97	.698
	NH_4^+	-0.036	.003	-0.044	.078	-0.028	.120	-0.038	.082	-0.016	.439	0.006	.885	-0.005	.846	0.005	.672	0.021	.285	-0.011	.399
	$NO_{2\&3}^-$	0.003	.899	-0.011	.689	0.016	.714	0.005	.922	-0.061	.111	0.007	.873	0.010	.653	0.047	.031	0.054	.116	0.040	.149
	Total-N	0.011	.831	-0.015	.874	0.073	.386	-0.024	.814	-0.066	.699	0.181	.066	0.079	.215	0.105	.079	0.149	.060	0.060	.468
	Total-P	-0.049	.000	-0.066	.031	-0.041	.021	-0.041	.042	-0.058	.219	-0.013	.388	0.003	.877	-0.017	.078	-0.014	.402	-0.021	.065
	DO	-0.19	.483	-0.06	.866	-0.08	.829	-0.44	.172	-0.13	.692	-0.19	.804	-0.19	.563	-0.20	.561	-0.46	.343	0.05	.915
	COD	0.02	.974	-0.65	.539	0.65	.477	0.05	.956	0.82	.558	0.94	.156	0.49	.411	0.72	.046	0.64	.099	0.80	.169

Table C3 Overall results from water quality parameters analysis in 2014

Station	Date	General				Main Ions (meq/l)							Nutrients (mg/l)				Organic matters		Faecal Coliform (MPN/100ml)
		Temperature (°C)	pH	EC (mS/m)	TSS (mg/l)	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	Alkalinity	SO_4^{2-}	Cl^{-}	NH_4^{+}	$NO_{2\&3}^{-}$	Total-N	Total-P	DO (mg/l)	COD (mg/l)	
H010501 Chiang Saen	13/01/2014	20.8	6.55	24.55	33	0.388	0.033	1.490	0.639	1.870	0.589	0.208	0.046	0.331	0.627	0.030	9.27	1.05	5,400
	17/02/2014	21.0	7.05	28.55	34	0.457	0.039	1.769	0.755	2.061	0.764	0.286	0.029	0.287	0.366	0.042	9.44	1.40	790
	17/03/2014	21.5	7.37	30.15	17	0.501	0.041	1.815	0.752	2.127	0.937	0.320	0.025	0.326	0.340	0.025	9.77	1.03	330
	17/04/2014	23.0	7.94	30.60	14	0.493	0.039	1.854	0.763	2.155	0.923	0.304	0.007	0.292	0.363	0.022	8.99	0.75	540
	14/05/2014	24.3	7.31	28.85	31	0.568	0.046	2.141	0.863	2.010	0.912	0.433	0.034	0.383	0.517	0.059	6.70	2.44	130
	16/06/2014	23.0	7.96	27.65	114	0.570	0.064	1.486	0.732	1.914	0.859	0.282	0.005	0.440	0.666	0.068	9.35	4.11	5,400
	15/07/2014	32.8	7.75	18.79	245	0.433	0.061	0.914	0.508	1.375	0.514	0.188	0.022	0.300	0.643	0.245	7.74	5.61	3,500
	18/08/2014	25.6	7.26	12.89	241	0.255	0.042	1.045	0.368	1.199	0.246	0.111	0.023	0.391	0.739	0.188	8.33	4.32	1,300
	18/09/2014	26.0	7.42	14.42	145	0.191	0.043	0.850	0.424	1.235	0.322	0.117	0.024	0.341	0.489	0.090	9.17	4.05	5,400
	14/10/2014	25.5	7.16	22.00	61	0.399	0.045	1.667	0.680	1.567	0.719	0.335	0.007	0.410	0.661	0.069	10.03	2.41	1,600
	17/11/2014	24.0	7.40	22.95	142	0.409	0.053	1.173	0.699	1.632	0.771	0.148	0.019	0.321	0.381	0.135	9.34	5.86	1,600
	15/12/2014	21.5	8.00	29.15	23	0.505	0.038	1.438	1.027	1.954	1.033	0.212	0.070	0.382	0.415	0.029	9.74	1.23	1,300
H013101 Nakhon Phanom	13/01/2014	20.0	6.52	24.50	53	0.384	0.035	1.414	0.558	0.967	1.336	0.234	0.106	0.322	0.749	0.049	8.11	0.84	1,300
	17/02/2014	24.5	7.00	23.35	50	0.387	0.033	1.494	0.561	1.842	0.429	0.234	0.022	0.254	0.363	0.059	7.94	6.55	270
	17/03/2014	27.0	7.61	27.85	29	0.487	0.038	1.669	0.676	2.039	0.796	0.308	0.023	0.060	0.265	0.038	8.90	2.38	140
	17/04/2014	29.0	7.97	25.35	23	0.409	0.039	1.549	0.596	1.913	0.619	0.238	0.026	0.254	0.310	0.033	7.45	1.07	240
	14/05/2014	30.0	7.81	26.20	95	0.531	0.040	1.970	0.741	1.917	0.710	0.431	0.053	0.294	0.569	0.087	7.00	3.60	1,600
	16/06/2014	29.0	7.72	20.80	91	0.427	0.031	1.200	0.501	1.524	0.506	0.269	0.061	0.361	0.658	0.107	6.92	3.79	1,700
	15/07/2014	28.5	7.46	14.16	108	0.402	0.033	0.722	0.306	1.041	0.247	0.282	0.018	0.165	0.610	0.111	6.59	5.29	2,200
	18/08/2014	29.0	7.38	11.27	165	0.296	0.029	0.882	0.266	0.981	0.136	0.306	0.020	0.233	0.520	0.120	6.23	5.16	2,200
	18/09/2014	30.5	7.59	12.10	158	0.254	0.035	0.652	0.317	1.032	0.134	0.208	0.020	0.276	0.442	0.101	6.16	4.35	1,300
	14/10/2014	29.0	7.24	19.18	115	0.521	0.044	1.408	0.464	1.306	0.375	0.672	0.014	0.350	0.577	0.103	6.74	4.53	920
	17/11/2014	27.0	7.50	21.70	81	0.463	0.053	1.076	0.537	1.632	0.484	0.228	0.048	0.325	0.476	0.121	7.08	5.55	1,100
	15/12/2014	24.0	7.89	25.85	22	0.466	0.032	1.385	0.817	1.861	0.689	0.212	0.011	0.244	0.332	0.048	8.36	1.85	1,100
H013801 Khong Chiam	13/01/2014	22.5	6.61	20.40	40	0.300	0.032	1.161	0.561	1.719	0.325	0.208	0.103	0.341	0.983	0.036	8.35	1.26	220
	17/02/2014	26.0	7.01	22.05	15	0.361	0.041	1.367	0.558	1.732	0.402	0.273	0.027	0.053	0.167	0.033	7.98	1.40	5
	17/03/2014	27.0	7.77	26.35	16	0.446	0.046	1.518	0.661	1.820	0.731	0.359	0.024	0.047	0.198	0.023	7.50	1.14	26
	17/04/2014	29.5	7.91	23.40	13	0.397	0.038	1.435	0.606	1.826	0.580	0.251	0.011	0.211	0.254	0.028	6.90	1.18	8
	14/05/2014	30.0	7.94	23.30	15	0.461	0.039	1.770	0.678	1.731	0.636	0.366	0.030	0.288	0.435	0.042	6.60	1.16	4
	16/06/2014	28.5	7.74	19.40	153	0.367	0.035	1.093	0.484	1.413	0.466	0.175	0.025	0.374	0.600	0.123	6.23	5.05	170
	15/07/2014	28.0	7.44	14.73	91	0.315	0.032	0.962	0.371	1.227	0.234	0.201	0.017	0.187	0.404	0.126	5.63	3.92	1,700
	18/08/2014	28.0	7.39	11.70	160	0.212	0.025	0.839	0.300	1.090	0.119	0.197	0.020	0.245	0.467	0.110	5.99	4.63	170
	18/09/2014	29.0	7.62	12.52	143	0.391	0.042	0.495	0.352	0.829	0.083	0.351	0.040	0.255	0.302	0.106	6.74	3.86	220
	14/10/2014	28.0	7.25	18.30	122	0.355	0.039	1.395	0.447	1.362	0.352	0.436	0.007	0.357	0.452	0.092	7.18	7.14	130
	17/11/2014	27.5	7.91	20.95	98	0.365	0.042	1.110	0.605	1.669	0.473	0.175	0.035	0.298	0.325	0.089	7.38	2.67	490
	15/12/2014	24.0	8.03	23.45	19	0.404	0.032	1.293	0.661	1.731	0.580	0.185	0.008	0.271	0.292	0.024	8.21	1.13	50

Table C3 Overall results from water quality parameters analysis in 2014 (Cont.)

Station	Date	General				Main Ions (meq/l)							Nutrients (mg/l)				Organic matters		Faecal Coliform (MPN/100ml)
		Temperature (°C)	pH	EC (mS/m)	TSS (mg/l)	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	Alkalinity	SO_4^{2-}	Cl^{-}	NH_4^{+}	$NO_{2\&3}^{-}$	Total-N	Total-P	DO (mg/l)	COD (mg/l)	
H050104 Chiang Rai	13/01/2014	19.8	6.78	11.04	33	0.221	0.055	0.592	0.306	1.139	0.055	0.052	0.089	0.170	0.987	0.107	8.20	2.93	3,500
	17/02/2014	23.0	7.17	10.96	22	0.252	0.057	0.588	0.280	1.140	0.061	0.026	0.014	0.104	0.156	0.063	8.13	2.86	4,500
	17/03/2014	23.5	7.68	13.06	20	0.364	0.064	0.583	0.291	1.184	0.086	0.154	0.058	0.064	0.384	0.070	7.45	1.97	1,700
	17/04/2014	28.0	7.96	14.21	19	0.289	0.070	0.772	0.353	1.496	0.071	0.053	0.017	0.151	0.318	0.074	6.90	2.46	1,600
	14/05/2014	30.6	7.97	12.62	70	0.341	0.094	0.786	0.350	1.266	0.072	0.093	0.053	0.209	0.629	0.175	9.65	7.41	300
	16/06/2014	27.8	7.64	13.23	133	0.362	0.124	0.655	0.352	1.152	0.094	0.107	0.077	0.290	0.795	0.237	6.62	7.26	1,700
	15/07/2014	27.6	7.51	10.79	398	0.253	0.106	0.535	0.249	1.041	0.082	0.054	0.056	0.278	0.963	0.294	8.46	13.13	930
	18/08/2014	28.4	7.46	6.82	239	0.187	0.062	0.438	0.214	0.799	0.044	0.028	0.035	0.194	0.667	0.250	7.26	7.89	1,600
	18/09/2014	26.8	7.56	10.17	167	0.170	0.062	0.500	0.342	1.032	0.034	0.052	0.034	0.156	0.595	0.180	6.88	6.63	1,700
	14/10/2014	24.4	7.37	12.79	215	0.217	0.065	0.448	0.510	1.082	0.036	0.046	0.063	0.231	0.601	0.241	7.33	10.76	1,600
	17/11/2014	24.3	8.06	11.69	72	0.269	0.074	0.578	0.268	1.075	0.049	0.054	0.028	0.235	0.316	0.115	7.87	6.17	1,400
	15/12/2014	23.5	7.95	11.42	37	0.265	0.058	0.544	0.311	1.117	0.047	0.026	0.021	0.203	0.231	0.064	8.16	3.29	30
H290103 Ban Chai Buri	13/01/2014	24.0	6.88	39.20	3	2.603	0.093	0.483	0.353	0.602	0.163	2.681	0.060	0.311	1.104	0.062	8.79	2.51	33
	17/02/2014	27.5	7.10	47.00	5	3.256	0.115	0.518	0.359	0.526	0.169	3.306	0.040	0.185	0.444	0.021	7.89	1.23	79
	17/03/2014	29.0	7.74	31.40	4	1.173	0.063	1.259	0.546	1.579	0.530	1.025	0.034	0.036	0.487	0.029	9.82	4.03	33
	17/04/2014	33.0	7.90	62.50	3	4.356	0.130	0.637	0.478	0.616	0.243	4.468	0.049	0.046	0.513	0.035	8.00	4.18	14
	14/05/2014	28.0	7.88	28.20	11	0.722	0.047	1.983	0.780	2.010	0.677	0.666	0.083	0.266	0.472	0.171	6.05	1.48	280
	16/06/2014	30.0	7.11	32.50	39	2.506	0.083	0.626	0.402	0.706	0.125	2.983	0.520	0.157	1.019	0.120	2.87	7.05	490
	15/07/2014	29.0	7.31	12.43	64	0.933	0.072	0.219	0.121	0.335	0.080	0.806	0.048	0.081	0.389	0.056	4.81	6.56	1,100
	18/08/2014	30.0	7.42	8.03	28	0.600	0.039	0.186	0.094	0.327	0.041	0.472	0.037	0.019	0.283	0.034	4.33	4.11	40
	18/09/2014	30.0	7.75	9.64	14	0.559	0.043	0.209	0.148	0.332	0.016	0.599	0.033	0.061	0.195	0.032	4.01	3.26	33
	14/10/2014	30.0	7.70	15.92	22	1.245	0.056	0.282	0.133	0.299	0.053	1.378	0.056	0.094	0.545	0.045	4.67	3.12	540
	17/11/2014	29.0	8.04	11.23	36	0.572	0.038	0.254	0.091	0.519	0.067	0.430	0.045	0.025	0.316	0.065	5.95	4.94	130
	15/12/2014	28.0	7.82	36.40	4	2.823	0.087	0.561	0.316	0.633	0.173	2.642	0.008	0.272	0.556	0.006	7.33	2.88	500
H310102 Na Kae	13/01/2014	24.0	6.97	11.51	1	0.528	0.028	0.353	0.270	0.602	0.055	0.521	0.015	0.006	0.519	0.012	7.67	3.77	13
	17/02/2014	24.5	7.30	18.73	4	1.020	0.039	0.506	0.184	0.702	0.157	0.963	0.008	0.004	0.131	0.018	6.97	0.82	210
	17/03/2014	28.0	7.80	14.84	2	0.684	0.039	0.457	0.186	0.746	0.135	0.590	0.008	0.043	0.178	0.014	7.16	3.41	140
	17/04/2014	31.0	7.75	12.45	1	0.580	0.039	0.377	0.221	0.660	0.074	0.555	0.004	0.001	0.280	0.021	7.40	3.75	170
	14/05/2014	30.0	7.65	13.49	0	0.755	0.048	0.191	0.186	0.633	0.090	0.547	0.037	0.042	0.367	0.234	6.10	4.66	21
	16/06/2014	31.0	7.05	12.95	14	0.660	0.059	0.407	0.330	0.781	0.077	0.537	0.246	0.029	0.662	0.062	4.63	5.79	70
	15/07/2014	29.0	7.11	7.10	47	0.345	0.042	0.223	0.151	0.483	0.049	0.269	0.045	0.061	0.455	0.166	6.25	6.56	940
	18/08/2014	31.0	7.30	5.98	29	0.269	0.030	0.312	0.111	0.508	0.035	0.222	0.044	0.053	0.335	0.034	5.94	4.32	140
	18/09/2014	27.0	7.59	7.20	17	0.229	0.024	0.332	0.169	0.479	0.017	0.260	0.057	0.080	0.238	0.018	6.21	3.46	140
	14/10/2014	30.0	7.60	6.61	5	0.244	0.032	0.398	0.129	0.410	0.013	0.425	0.008	0.074	0.199	0.034	6.49	3.52	11
	17/11/2014	28.0	7.96	24.60	7	1.902	0.076	0.324	0.247	0.408	0.105	1.828	0.051	0.242	0.360	0.026	4.82	3.91	11
	15/12/2014	24.0	7.86	11.23	16	0.554	0.029	0.446	0.153	0.633	0.053	0.449	0.022	0.020	0.151	0.041	7.18	3.29	23

Table C3 Overall results from water quality parameters analysis in 2014 (Cont.)

Station	Date	General				Main Ions (meq/l)							Nutrients (mg/l)				Organic matters		Faecal Coliform (MPN/100ml)
		Temperature (°C)	pH	EC (mS/m)	TSS (mg/l)	Na^+	K^+	Ca^{2+}	Mg^{2+}	Alkalinity	SO_4^{2-}	Cl^-	NH_4^+	$NO_{2\&3}^-$	Total-N	Total-P	DO (mg/l)	COD (mg/l)	
H380104 Ubon	13/01/2014	26.0	6.87	35.25	11	1.861	0.087	0.917	0.421	1.418	0.135	1.744	0.081	0.237	0.911	0.006	7.48	3.77	N/A
	17/02/2014	29.0	7.01	38.45	17	2.209	0.094	0.967	0.405	1.338	0.168	2.056	0.066	0.306	0.425	0.037	6.73	4.70	N/A
	17/03/2014	29.5	7.66	38.80	6	2.314	0.101	0.814	0.385	1.162	0.181	2.077	0.030	0.064	0.483	0.025	7.26	4.86	N/A
	17/04/2014	32.5	7.64	34.20	9	2.212	0.102	0.463	0.345	0.880	0.118	2.062	0.087	0.153	0.682	0.056	6.90	6.00	N/A
	14/05/2014	32.0	7.68	25.10	11	1.444	0.108	0.984	0.403	1.359	0.136	1.550	0.093	0.293	0.834	0.080	6.15	6.46	N/A
	16/06/2014	29.0	7.47	45.55	13	3.522	0.100	0.809	0.517	1.338	0.149	3.798	0.201	0.026	0.699	0.061	4.14	5.89	N/A
	15/07/2014	30.0	7.08	12.52	32	0.821	0.076	0.268	0.160	0.502	0.085	0.727	0.067	0.167	0.580	0.197	6.11	6.56	N/A
	18/08/2014	31.0	7.23	7.49	21	0.467	0.044	0.282	0.106	0.490	0.055	0.347	0.067	0.097	0.546	0.065	4.43	5.89	N/A
	18/09/2014	29.0	7.38	11.57	91	0.597	0.050	0.375	0.125	0.571	0.046	0.573	0.049	0.159	0.357	0.055	5.83	4.85	N/A
	14/10/2014	30.0	7.39	19.59	19	0.923	0.059	0.922	0.185	0.597	0.063	1.548	0.069	0.125	0.697	0.060	5.80	5.43	N/A
	17/11/2014	28.0	7.60	17.17	10	1.116	0.082	0.341	0.200	0.649	0.055	0.948	0.069	0.080	0.364	0.051	6.64	5.97	N/A
	15/12/2014	24.0	7.74	23.40	11	1.518	0.079	0.521	0.323	0.949	0.077	1.223	0.090	0.204	0.473	0.031	6.93	5.14	N/A
H380128 Mun	13/01/2014	24.5	6.98	18.39	4	0.993	0.058	0.421	0.249	0.731	0.053	0.963	0.033	0.228	0.681	0.006	7.09	3.77	23
	17/02/2014	30.0	7.32	8.56	3	0.390	0.035	0.261	0.104	0.482	0.050	0.286	0.014	0.020	0.101	0.029	7.65	4.50	8
	17/03/2014	29.5	7.76	5.00	3	0.235	0.030	0.130	0.229	0.351	0.046	0.231	0.004	0.056	0.122	0.010	7.40	2.59	11
	17/04/2014	31.0	7.65	10.71	4	0.494	0.050	0.384	0.134	0.572	0.067	0.449	0.014	0.041	0.288	0.035	5.17	3.54	33
	14/05/2014	31.5	7.66	34.90	3	2.535	0.103	0.392	0.395	1.042	0.155	1.900	0.032	0.215	0.644	0.059	5.65	4.66	8
	16/06/2014	31.0	7.45	24.00	8	1.337	0.109	0.815	0.330	1.338	0.136	1.247	0.010	0.167	0.637	0.045	5.65	5.79	40
	15/07/2014	30.0	7.10	7.55	28	0.451	0.050	0.177	0.208	0.483	0.066	0.322	0.079	0.118	0.543	0.107	5.48	7.41	490
	18/08/2014	31.5	7.19	6.58	38	0.394	0.039	0.241	0.096	0.472	0.045	0.277	0.057	0.121	0.456	0.057	4.14	5.58	40
	18/09/2014	29.5	7.31	10.76	40	0.554	0.050	0.322	0.174	0.516	0.043	0.521	0.040	0.203	0.365	0.051	5.68	4.65	11
	14/10/2014	29.0	7.48	16.88	23	0.800	0.056	0.959	0.178	0.672	0.050	1.249	0.047	0.143	0.504	0.049	6.05	4.53	17
	17/11/2014	29.0	7.47	14.41	7	0.912	0.078	0.294	0.253	0.593	0.048	0.772	0.050	0.080	0.239	0.044	5.95	5.35	110
	15/12/2014	26.5	7.72	15.99	4	0.960	0.060	0.361	0.266	0.670	0.070	0.752	0.006	0.142	0.292	0.033	7.08	4.32	80