The costs and benefits from utilizing fresh water for salinity intrusion for tangerine plantation in Bangmod area, Bangkok

Charit Tingsabadh and Wilawan Chaturongpalathipat[1]

Abstract: *Economic Evaluation of Salinity Control in the Chao Phraya River annual flow for salinity control accounts for just under 10% of the water allocation. Is this level optimal? The paper considers the case of salinity control for citrus orchards and production of potable water supply. The costs and benefits of salinity control are calculated and implications for water allocation are discussed.*

1 Introduction

1.1 Water problem in Thailand

Water is known to be vital in our life, mains used are in consumption and agriculture. It is also utilized in prevention of salinity intrusion, inland navigation and hydropower generation. Scarcity water, which is not only a national problem but also, extends the boundary to global problem. To use the water for every purpose has to consider in the utility that gets. Each purpose tries to maximize utility.

The agriculture is very important in the economic part of Thailand. The saline water is the major problem in agriculture part because the high salinity index of the water has direct impact on crop productivity. The salinity intrusion purpose is the third priority for water allocation. Especially in the dry season, the water is very scarce comparing to the other seasons. The plan of using water has to very concern about the utility and benefits that can get from that usage. Tangerine plantation is one of major part of economic plantation especially in the Bangmod area, Bangkok where is sensitive to saline water because it locates near the sea. The study of utilizing fresh water for salinity intrusion to maintain the Tangerine plantation has to consider about the opportunity costs of using for that purpose consisting of the maximum value of other purposes. In this study will concentrate on the opportunity costs by calculating the maximum value of domestic consumption purpose.

[1] Centre of Ecological Economics, Chulalongkorn University

1.2 Purpose of the study

To determine the costs and benefits of utilizing reserved fresh water for salinity Intrusion to maintain the Tangerine plantation in Bangmod area.

1.3 Scope of the study

In Bangmod area, where have soil characteristics and conditions that are suitable for Tangerine plantation and nowhere else can produce the good quality of Tangerine in Thailand. Now it confronts with the saline water, which affects the Tangerine productivity.

According to the water allocation planing by the Royal Irrigation Department, the water resources is allocated for 5 main purposes; Domestic consumption, Irrigated agriculture, Inland navigation, Salinity intrusion and Power generation. To use fresh water for salinity intrusion in the area of Tangerine plantation in Bangmod area, we have to concern about the opportunity costs that are forgone for other purposes as mentioned above.

To determine the cost, we will use the opportunity cost for domestic consumption by calculating the net profit of water, which represents the value of the water from the Metropolitan Waterworks Authority. The benefits of utilizing fresh water for salinity intrusion will be calculated in terms of the revenue from Tangerine productivity.

1.4 Method of study

1.4.1 Review previous literatures

1.4.2 Data collection

The salinity of the water from the Royal Irrigation Department (Water Operation Branch) from 1985 to 1995 (See Appendix 1).

The Tangerine productivity from the Ministry of Agriculture and Cooperatives from 1985 to 1995 (See Appendix 1).

The net profit of water which represents the opportunity cost of the water from Metropolitan Waterworks Authority from 1989 to 1998 (See Appendix 2).

1.4.3 Data analysis

The model from regression, used for this analysis is $Y = C(1)+C(2)*S_1+C(3)*S_1^2$

2 Review of literature

2.1 Tangerine productivity and salinity of water relationship

The water is one of the most important input for Tangerine plantation. The contamination of water is affected directly to their productivity such as the saline water will cause the water has high content of sodium salt measured by the salinity measurement. The salinity prevents their root system to absorb the water so their productivity is reduced when the level of salinity is higher their tolerance level. From now, there is no literature that shows the relationship between salinity and Tangerine productivity to find the optimum salinity level which tangerine can produce the maximum productivity and beyond this level, the productivity will be reduced by the effect of the high salinity level of the water.

2.2 Water used for salinity control

The Royal Irrigation Department, charged with responsibility to control the salinity in the river, has urged the Asian Institute of Technology to investigate the salinity conditions in the river under very low flow, and possibility revise the existing salinity intrusion model. This research was under the topic of "Salinity Intrusion during severe drought in the Chao Phraya River", December 1980.

The model consists of 2 portions: the tidal dynamics portion and the salt balance portion. The tidal dynamic portion is described by 2 equations namely:

Continuity $\partial H/\partial t + \partial Q/\partial x - q = 0$ ……………………………….(1)

Momentum $Q/\partial t + (Q/A)q - (Q^2/A^2)\,\partial A/\partial x + gA\partial H/\partial x + g(n^2Q|Q|/AR^{4/3} = 0$…(2)

The salt balance portion is described by the equation:

$\partial(AS)/\partial t = \partial(QS)\,\partial x + \partial(EA\partial S/\partial x)/\partial x$ ……………………………………(3)

where:

A	=	cross-sectional area
B	=	surface width of channel
E	=	longitudinal dispersion coefficient
g	=	gravitational acceleration
H	=	water surface elevation or stage above mean sea level
n	=	manning roughness coefficient
Q	=	instantaneous discharge
q	=	lateral inflow per unit length of channel
R	=	hydraulic radius
S	=	cross-sectional averaged salinity
t	=	time
x	=	distance along the river

From the equation (1), (2) and (3), there are many factors that affects the salinity level. The result from the AIT study and the actual observation from Water Operation Branch (WOB), we found that the actual observation is not related to the AIT formulation because the salinity level of the water is depended on the amount of rainfall, the amount of discharged water, the current of the water, the water level due to the sea level (fluctuated water level during the day) and the distance from the sea to that point. So the estimation of the salinity level of the water by calculating the water level, discharged water and others is very complex.

2.3 Water policy

According to The Royal Irrigation Department, its duty is charged with the responsibility to allocated the water with set criterion from "Water Resources Planning and Management of the Chao Phraya River basin, Thailand [2]. The allocation criterion of water release for various purposes has been adopted as practical guideline on priority basis as follows:

[2] The World Bank assignment for presentation in the workshop on water resources management policies, held on June 25-28,1991 in Washington D.C. by Messrs B.Badhanaphuti, T.Klaikayai, S.Thanopanuwat of Royal Irrigation Department and N.Hungspreug, Thammasart University, Bangkok, Thailand

1. Top priority is given to the domestic consumption as it is considered essential for the living of the people .The water required for domestic use only accounted for about 7-8 percent of the total demand.
2. Water for irrigated agriculture to be made available during any dry spell or drought period in the early wet season in order to avoid damage to newly planted crops, and for dry season cropping. Water demand for irrigated agriculture is the highest among other users and equivalent to nearly 90 percent of the total demand.
3. Inland navigation. In some instance when the water level in certain stretches of waterways become low preventing passage of navigation of large shipment, it is then necessary to release extra water from the reservoir for a short period ot make passage of the navigation possible. Delay of large shipment could cause heavy damage to the concerned parties. During the low flow period, barge operators have also been requested to lower the carrying capacity of the barges to reduce water depth requested for passage of 2 meters draft.
4. Salinity intrusion. To prevent salinity intrusion into the Chao Phraya River near the river mouth causing damage to the fruit trees and orchards in the area surrounding Bangkok and to keep salt content below standard for production of potable water by the MWWA in the dry season, it is necessary to maintain the salinity at the Memorial bridge (48 kms from the river mouth) at not more than 2 ppt (part per thousand). During the low flow period, this problem has been well under control, but on the other hand, the water quality in the Chao Phraya River and canals around the city of Bangkok is below the allowable standard. This is a major problem has yet to be solved without further delay. To release additional water for water quality improvement, however, is not practical at present because the supply is still inadequate.
5. Hydropower generation. The hydropower plants normally operate for peak power generation in the evening to supplement the power generation from other power plants inter-connected to the national grid.

Water allocation planning in 1999 (January – June,1999)

Available water resources around 3,900 million cubic meters, which has to be managed for many activities during 6 months (dry spell). The water is allocated for these activities around 3,600 million cubic meters as follows:

Activities	Water allocated (million cubic meters)
Consumption (22 provinces)	700 (19.44%)
Agriculture encouraging	1,900 (52.78%)
Inland navigation	0
For Metropolitan Waterworks Authority	650 (18.06%)
Salinity intrusion	350 (9.72%)

3 Data analysis

3.1 Tangerine productivity and salinity level

The model represented the relationship between Tangerine productivity and salinity level is shown by the following model:

$$Y = C(1)+C(2)*S_1+C(3)*S_1^2$$

Where: Y = Tangerine productivity (kgs/rai/year)
S_1 = Salinity index of the water (g/l)
C = coefficient

From the regression result, the value of coefficient are

C(1)=2668.194, C(2)=195.0508, C(3)=-14.42594.

	Coefficient	Std.Error	t-Statistic	Prob.
C(1)	2668.194	295.9676	9.015155	0.0000
C(2)	195.0508	235.9956	0.826502	0.4325
C(3)	-14.452594	21.85292	-0.660955	0.5272

R-squared	0.117405	Mean dependent var	2905.727
Adjusted R-squared	-0.103244	S.D. dependent var	533.4889
S.E. of regression	560.3524	Akaike info criterion	12.88413
Sum squared resid	2511958	Schwarz criterion	12.99265
Log likelihood	-83.47105	F-statistic	0.532088
Durbin-Watson stat	2.181950	Prob (F-statistic)	0.606802

Observed year	Actual	Fitted	Residual
1985	3000.00	2958.06	41.9394
1986	3000.00	2879.77	120.2290
1987	2800.00	2823.45	-23.4539
1988	2350.00	3141.24	-791.2360
1989	3200.00	2926.26	273.7430
1990	3200.00	2889.67	310.3260
1991	3200.00	2789.62	410.3820
1992	3460.00	3307.80	152.2040
1993	3076.00	3100.28	-24.2855
1994	1542.00	2560.83	-1018.8300
1995	3135.00	2586.02	548.9810

In 1988 and 1994, the result from regression shows difference between the model and the actual data. The reason is in both 2 years, the available water in the dam was less amount comparing to other years. Therefore in those years, the Tangerine productivity was not related to the salinity level.

The relationship between Tangerine productivity and salinity level is shown in Appendix 3. The optimum salinity level can be determined by differential the model

$$Y = 2668.194+195.0508*S_1-14.42594*S_1^2$$

which is $dY/dS = 195.0508-2(14.42594)* S_1 = 0$

so the optimum salinity level ($S_{optimum}$) is 6.76 g/l.

As The Royal Irrigation Department set up the level of salinity index at 2 g/l to maintain the crop productivity but for the Tangerine , it can endure the salinity up to 6.76 g/l.

3.2 Water requirement for salinity control

The optimum salinity level is 6.76 g/l (for Tangerine productivity) comparing to the standard from RID which is 2 g/l. Water used for salinity control will reduce from the water allocation plan from RID which is 350 million cubic meters.

To determine the amount of water required for salinity control is compared to the ratio of salinity level from RID (2 g/l) and optimum salinity level (6.76 g/l) which is represented by:
The ration of Soptimum/SRID = 6.76/2 = 3.38
where Soptimum = Optimum salinity level (g/l)
SRID = Salinity level (g/l) from RID

Since the model represented the relationship between the amount of water and salinity control is very complex, we will estimate the amount of water for salinity control by relating to the ration between the salinity level from RID and optimum salinity level for Tangerine. So the water used for salinity control at 6.76 g/l is less than the water allocation plan by 3.38 times.

The water used for salinity control at 6.76 g/l is 350 million m^3/3.38 = 103.55 million m^3
The water used reduces from plan equals to 350 – 103.55 = 246.45 million m^3

3.3 Cost-Benefit of salinity control

3.3.1 The cost of water for salinity control at 6.76 g/l.

= opportunity costs of water * 103.55 million m^3
= 1.87 Baht/m^3 * 103.55 million m^3
= 193.64 million Baht

3.3.2 The benefits from reducing the water used for salinity control at 6.76 g/l

= opportunity costs of water * 246.45 million m3
= 1.87 Baht/m3 * 246.45 million m3
= 460.86 million Baht

3.3.3 The benefits in terms of maximum productivity from salinity control at the optimum salinity level.

The productivity at the optimum salinity level is calculated by:

2668.194 + 195.0508*Soptimum – 14.42594*Soptimum2 = Y

2668.194 + 195.0508(6.76) – 14.42594*(6.76)2 = 3327.5066

The maximum productivity equals to 3327.5066 kgs/rai/year. The current market price of Tangerine is around 30 Baht/kg. The benefits from controlling salinity level at 6.76 g/l is

= 3327.5066 kgs/rai/year * 30 Baht/kg = 99825.20 Baht/rai/year.

4 Discussion and result

The cost of water allocated for salinity control can be determined by the opportunity cost of water which is forgone for other purposes such as for domestic consumption. The Metropolitan Waterworks Authority has responsibility for domestic consumption, therefore the opportunity cost of the water is the net profit.

To consider the current situation, the average salinity level of the water of April,1999 is 2.73 g/l (See Appendix 6). The amount of water used to control the salinity level at 6.76 g/l which maximizes the Tangerine productivity. The RID allocated the water for salinity intrusion can control the salinity level to be at 2.73 g/l.

The ratio between the optimum salinity level and the current situation equals to 6.76/2.73 = 2.47. Therefore the amount of water for salinity control is less than their plan by 2.47 times which is 350/2.47 = 141.70 million m^3 and the water used reduces from plan equal to 350 – 141.70 = 208.30 million m^3

4.1 The cost of water for salinity control at 6.76 g/l.

= opportunity cost of water * 141.70 million m3
= 1.87 Baht/ m3 * 141.70 million m3
= 264.98 million m3

4.2 The benefit from reducing the water used for salinity control at 6.76 g/l.

= opportunity cost of water * 208.30 million m3
= 1.87 Baht/ m3 * 208.30 million m3
= 389.52 million m3

But in this study, we can not calculate the amount of water controlled the salinity level of the water correctly because of the complexity of the relationship among the nature such as the maximum and minimum water level of the Chao Phraya River, the distance between the sea and the studied location. So the research to find the exact relationship between the amount of water for salinity control have to be studied more in the future.

5 Conclusion

This paper studies about the impact of saline water on Tangerine productivity and the costs and benefits of utilizing fresh water for salinity intrusion. The factors that effect on the Tangerine productivity are salinity level of the water, rainfall, the discharged water, the distance from the sea to that point (Bangmod area). The relationship between Tangerine productivity and salinity index of the water can be represented by the regression model by the equation of $Y = C(1)+C(2)*S_1+C(3)*S_1^2$

The optimum salinity level is 6.76 g/l which is different from the level from The RID ; 2g/l. From this point, we can reduce the amount of water for salinity intrusion from 350 million cubic meters to 103.55 million cubic meters which is different in the amount of 246.45 million cubic meters. For this different amount of water, we can allocate to other purposes such as for domestic consumption. The value of costs and benefits are summarized in the below table:

	Type of cost	Unit
1	Cost of allocated water for salinity intrusion (103.55 million cubic meters)	193.64 million Baht
	Type of benefit	Unit
1	Reduce the allocated water from RID water allocation plan	460.86 million Baht
2	Tangerine productivity	99825.20 Baht/rai/ye (in Bangkok)

Appendix 1: Table 1: The salinity index (g/l) from 1985 to 1995

Year	Salinity index (g/l)
1985	0.59
1986	0.41
1987	0.34
1988	2.38
1989	1.31
1990	1.34
1991	1.02
1992	6.10
1993	10.74
1994	0.49
1995	0.83

TABLE2: TANGERINE PRODUCTIVITY (KGS/RAI/YEAR) FROM 1985 TO 1995

Year	TangerineProductivity (kgs/rai/year)
1985	3,000
1986	3,000
1987	2,800
1988	2,350
1989	3,200
1990	3,200
1991	3,200
1992	3,460
1993	3,076
1994	1,542
1995	3,135

APPENDIX 2: THE OPERATION COSTS OF WATER FOR WATER CONSUMPTION AND BENEFITS

TABLE 3: STATISTICAL DATA OF THE LAST DECADE

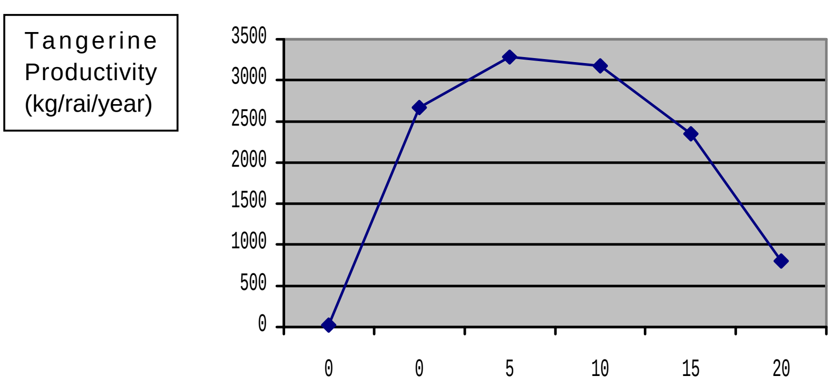
Descrip-tion	Unit	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Water Production	Mill. Cu.m.	934.3	1049.3	1109.2	1175.5	1224.9	1234.3	1405.2	1549.4	1632.8	1552.2
Water Sale	Mill. u.m.	628.2	718.7	781.3	823.4	836.1	816.1	870.3	911.2	944.8	914.8
Percent Sale	%	67.2	68.5	70.5	70.1	68.3	66.1	61.9	58.8	57.9	58.8
Customers	%	866673	949411	1027623	1090995	1139299	1194161	1241380	1289168	1341838	1369728
Employees	Number	5837	5732	5656	5618	5635	5742	5736	5684	5581	5432
Effective rate	Number	6.12	6.23	6.30	6.02	7.17	7.14	7.18	7.22	8.35	9.37
Cost per Unit sold	Baht/cu.m	5.34	5.19	5.23	5.19	5.38	5.84	7.08	7.33	7.55	8.96
Total Revenues	Mill. Baht	4531.5	5411.7	6128.5	6108.9	7051.2	7062.3	7516.8	7888.9	9037.3	9577.5
Total Expenses	Mill. Baht	3581.1	3976.0	4286.4	4439.2	4637.5	4931.3	6410.3	6936.2	7454.4	7513.5
Net Profit	Mill. Baht	950.4	1435.7	1842.1	1669.7	2413.7	2131.0	1106.5	952.7	1582.9	1182.7
Total Assets	Mill. Baht	19399.3	19846.5	21924.7	23748.4	26076.8	30800.0	33604.8	35999.2	40636.6	44280.4

TABLE 4: THE NET PROFIT (BAHT/CUBIC METER) AND AVERAGE VALUE FROM 1985 TO 1995

Year	Net profit (Baht/m3)
1989	1.51
1990	2.00
1991	2.36
1992	2.03
1993	2.89
1994	2.61
1995	1.27
1996	1.05
1997	1.68
1998	1.29
Average	1.87

The opportunity cost of using fresh water for salinity intrusion is 1.87 Baht per m^3

APPENDIX 3: THE RELATIONSHIP BETWEEN TANGERINE PRODUCTIVITY AND SALINITY LEVEL



Appendix4: Comparing table of water situation in large water reservoirs of The Royal Irrigation Department

Region	Usable	Available Water That Can Be Used							
Reservoir	Volume (M m^3)	1997		1998			1999		
		(M m^3)	%availabl e volume	(M m^3)	%Availabl e Volume	(M m^3)	%Availabl e Volume	Drainage (M m^3/day)	Accumulated drainage (m m^3)
North									
Bhumibol	9662.00	7217.00	74.69	4504.00	46.62	1283.00	13.28	8.52	137.13
Sirikit	6660.00	4537.00	68.12	3360.00	50.45	2282.00	34.26	12.61	206.11
Mae Ngad	243.00	186.00	76.54	195.00	80.25	82.00	33.74	0.47	5.61
Kew Lom	108.00	101.00	93.52	95.00	87.96	65.00	60.19	0.98	8.71
Mae Kaung	249.00	134.00	53.82	75.00	30.12	17.00	6.83	0.00	0.36
Total North	16922.00	12175.00	71.95	8229.00	48.63	3729.00	22.04	22.58	357.92
Northern East									
Lam Paw	1345.00	1048.00	77.92	903.00	67.14	451.00	33.53	0.48	7.54
Lam Ta Kong	297.00	290.00	97.64	138.00	46.46	81.00	27.27	0.26	4.34
Lam Pra	109.00	109.00	100.00	31.00	28.44	29.00	26.61	0.29	0.26
Paeng	477.00	338.00	70.86	361.00	75.68	149.00	31.24	0.88	15.10
Nam Oun	1854.00	1510.00	81.45	516.00	27.83	581.00	31.34	2.21	40.90
Ubonrat	1135.00	843.00	74.27	882.00	77.71	606.00	53.39	1.97	8.81
Sirinthon	144.00	125.00	86.81	42.00	29.17	69.00	47.92	0.04	4.18
Chulaporn	108.00	101.00	93.52	78.00	72.22	6.00	5.56	0.00	0.00
Hauw Kaew	118.00	65.00	55.08	55.00	46.61	42.00	35.59	0.00	0.00
Lam Nangrong Moon Bon	134.00	129.00	96.27	70.00	52.24	12.00	8.96	0.03	0.53
Total Northern East	5721.00	4558.00	79.67	3076.00	53.77	2026.00	35.41	6.13	81.66
West									
Kang Krachan	643.00	633.00	98.44	592.00	92.07	173.00	26.91	0.00	1.73
Srinakarin	7480.00	6523.00	87.21	4570.00	61.10	2453.00	32.97	4.30	128.75
Koa Laem	5848.00	3873.00	66.23	4834.003	82.66	1157.00	19.78	6.49	121.25
Pranburi	385.00	384.00	99.74	65.00	94.81	95.00	24.68	0.26	0.26
Krasaew	200.00	203.00	101.50	43.00	21.50	147.00	73.50	0.02	1.98
TapSela	152.00	148.00	97.37	27.00	17.76	59.00	38.32	0.26	2.42
14708.00	11764.00	79.98	10431.00	70.92	4084.00	27.77	11.33	256.39	
East									
Bang Pra	102.00	89.00	87.25	48.00	47.06	42.00	41.18	0.13	1.83
Nong Koo	20.40	16.00	78.43	13.00	63.73	14.00	68.63	0.06	1.09
Mab Prochan	15.80	15.20	96.20	14.20	89.87	13.20	83.54	0.03	0.57
Dok Kray	69.50	65.00	93.53	65.00	93.53	61.00	87.77	0.23	3.35
Nong Plalai	151.20	141.50	93.58	127.50	84.33	144.50	95.57	0.22	4.24
Tatal East	358.90	326.70	91.03	267.70	74.59	274.70	76.54	0.67	11.08
South									
Rutchapropa	4287.00	2538.00	59.20	3006.00	70.12	2066.00	48.19	1.73	7.88
Bang Lang	1144.00	825.00	72.12	913.00	79.81	1063.00	92.92	4.76	40.25
Total South	5431.00	3363.00	61.92	3919.00	72.16	3129.00	57.61	6.49	48.13
Total Country	43140.90	32186.70	74.61	25922.70	60.09	13242.70	30.70	47.20	755.18

APPENDIX 5: THE PLAN OF UTILIZING RESERVED WATER FROM BHUMIPOL AND SIRIKIT DAM IN DRY SPELL DURING JANUARY TO JUNE

Water usage activities		1993	1994	1995	1996	1997	1998	1999
Available water on Jan1		5357	2048	12733	14582	12107	8200	3900
1.Domestic consumption		550	700	1100	1800	1650	1600	550
- Above Nakorn Sawan		250	300	500	900	800	800	150
- Chao Phraya Project		300	400	600	900	850	800	400
2.Dry spell agriculture		2100	500	3300	4950	4200	3400	2050
- Out of irrigation system								150
- In irrigation system		2100	500	3300	4950	4200	3400	1900
3.Navigation		300	0	300	400	300	300	0
4.Authority Waterworks		650	550	700	750	750	750	650
5.Salinity Intrusion		400	250	600	600	500	450	350
Total 1-5	Plan	4000	2000	6000	8500	7400	6500	3600
	Actual	4610	1894	7216	9643	8556	6656	-
6.Second crop-rice (rai)	Plan	1.50	0	2080	3.50	3.30	2.70	1.90
	Actual	1.96	1.77	3.19	4.15	4.06	3.79-	

APPENDIX 6: SALINITY CONDITION OF CHAO PHRAYA RIVER IN APRIL,1999

Date	Samrong	BangNa	PraKaNong	Krung Thep Bridge	Memorial Bride	RID Samsen	Nonthaburi	RID Pak Kret
1	22.82	16.85	15.80	9.06	7.55	3.63	1.64	0.45
2	20.71	15.80	12.90	8.08	5.25	2.58	1.40	0.47
3	19.30	14.95	12.35	7.30	4.35	1.87	1.27	-
4	18.81	13.25	11.40	6.80	4.05	1.64	1.16	-
5	17.90	11.75	10.38	6.20	3.78	1.56	1.01	0.36
6	16.99	11.30	9.06	5.10	3.30	1.46	0.93	-
7	16.15	9.72	7.45	4.25	3.08	1.33	0.88	0.22
8	15.98	8.30	6.40	4.05	2.93	1.27	0.83	0.18
9	14.74	7.30	6.25	3.10	2.48	1.21	0.78	0.19
10	14.39	6.55	5.63	2.53	1.93	1.01	0.46	-
11	13.65	6.25	4.35	2.00	1.40	0.93	0.38	-
12	12.50	5.80	3.83	1.74	1.06	0.53	0.28	0.15
13	12.90	8.70	5.25	2.25	1.21	0.73	0.30	-
14	16.50	12.90	10.23	5.10	1.33	0.93	0.32	-
15	11.00	9.72	6.03	2.48	0.83	0.46	0.22	-
16	10.23	7.15	3.20	1.56	0.40	0.19	0.15	0.11
17	9.65	6.55	2.68	1.46	0.32	0.16	0.14	-
18	9.06	6.03	2.30	1.27	0.19	0.15	0.12	-

Date	Samrong	BangNa	PraKaNong	Krung Thep Bridge	Memorial Bride	RID Samsen	Nonthaburi	RID Pak Kret
19	11.15	7.55	2.93	1.40	0.22	0.18	0.15	0.11
20	5.30	4.05	1.06	0.34	0.20	0.17	0.13	0.11
21	5.63	4.25	1.11	0.38	0.24	0.19	0.13	0.11
22	6.25	4.50	1.11	0.39	0.27	0.20	0.13	0.11
23	6.80	5.05	1.16	0.46	0.30	0.25	0.14	0.11
24	8.08	6.21	1.27	0.53	0.34	0.32	0.15	-
25	5.20	3.00	0.93	0.34	0.31	0.30	0.14	-
26	4.20	3.00	0.68	0.30	0.27	0.22	0.13	0.13
27	3.83	2.68	0.50	0.25	0.20	0.19	0.14	0.13
28	3.58	2.43	0.40	0.22	0.19	0.18	0.14	0.14
29	4.05	2.63	0.53	0.33	0.25	0.20	0.13	0.13

References

Frank Flatters, Theodore M,Horbulyk “Economic Perspectives on Water Conflicts in Thailand”, TDRI Quarterly Review Vol.10 No.3, 1995.

Asian Institute of Technology, Final Report “Salinity Intrusion in the Chao Phraya and Mae Klong Rivers” March 1978

The Royal Irrigation Department, “Water Resources Planning and Management of the Chao Phraya River Basin, Thailand, 1991.

The Royal Irrigation Department, Water Allocation Planning in 1999”.

Metropolitan Waterworks Authority, “Annual Report,1997”.