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EXISTING RULES FOR OPERATION OF SRINAGARIND AND KHAO LAEM RESERVOIRS AND THEIR EFFECTS ON WATER MANAGEMENT OF MAE KLONG IRRIGATION SYSTEM

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Abstract

The existing rules for operation of Srinagarind and Khao Laem reservoirs and of Vajiralongkorn diversion dam were studied. The actual daily and weekly reservoir releases and Vajiralongkorn diversion were analyzed using the daily data of 1994-1997. The combined weekly reservoir releases satisfied the Vajiralongkorn diversion requirements. The release characteristics of Srinagarind, Tha Thung Na and Khao Laem showed the similar variation pattern during the irrigation week (Thursday to Wednesday). The releases decreased considerably on Saturday and Sunday. The water level upstream of Vajiralongkorn diversion dam was effected, particularly in dry season, in such a way that it was declined from FSL of 22.50 m (MSL) during Sunday to Tuesday. Generally during the peak irrigation water requirements in dry season and the beginning of wet season, the water level upstream of Vajiralongkorn sometimes dropped below 22.20 m (MSL). This effected the water delivery operation of GMKIP canals. Consequently the tail-end canal water level dropped to the level that water could not flow to the Romijn Weir type offtake structures. One way to solve this proldem is to use Tha Thung Na to reduce the release fluctuation. The other way is to increase the active storage of Vajiralongkorn by temporary setting the FSL at 22.70 m (MSL), 0.20 m above the existing rule, during Wednesday to Saturday to reduce the effect of reservoir release fluctuation.

Keywords: water management, Mae Klong irrrigation, Srinagarind, Khao Laem

1. INTRODUCTION

Mae Klong river has the total basin area of 30,106 square kilometers. It consists of 2 main tributaries namely Khwae Yai and Khwae Noi. In 1963, Mae Klong River Basin Development Plan was formulated. The plan is divided into 4 stages (RID, ____) :

Stage I: Construction of Vajiralongkorn Diversion Dam and distribution system over the area of 1,000,000 rai on the lower left bank of Mae Klong during 1964-1975

Stage II: Construction of Srinagarind Storage Dam and Tha Thung Na Regulating Dam on Khwae Yai and distribution system on the upper left bank and the right bank of Mae Klong over the area of 1,600,000 rai during 1970-1989. However, the construction of distribution system on some part of the upper left bank is delayed and continued in stage III

Stage III: Construction of Khao Laem Storage Dam on Khwae Noi during 1979-1984. Bang Laen irrigation project on the upper left bank which could not be completed in stage II, are continued in this stage. It is planned that the construction of Banglane project be completed by year 2,000

Stage IV: Construction of Nam Chon Storage Dam on the Upper Khwae Yai. The study for this plan was started in 1970. However the plan was suspended because of the objection on environmental impact of the dam.

The Electricity Generating Authority of Thailand (EGAT) is responsible for construction and operation of Srinagarind, Khao Laem and Tha Thung Na dams. The Royal Irrigation Department (RID) is responsible for construction and operation of Vajiralongkorn diversion dam and distribution systems which is known as "**The Greater Mae Klong Irrigation Project (GMKIP)**". Map of dams and irrigation systems is shown in Figure 1. The details of the dams and the irrigation projects are shown in Table 1 and 2 respectively.

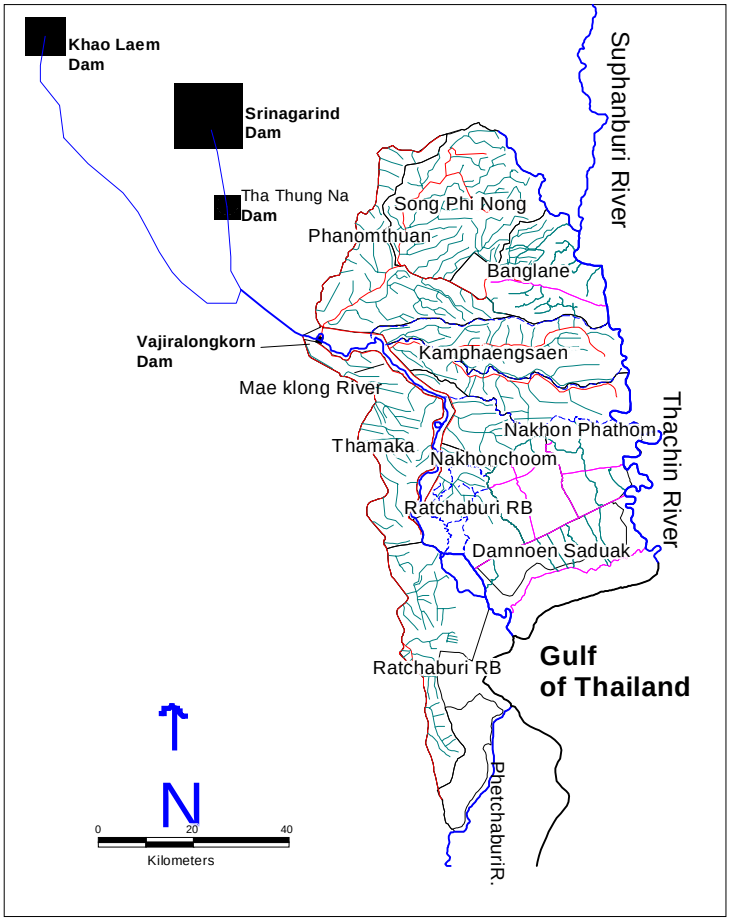

Figure 1 Map of Dams and Irrigation Projects in Mae Klong River Basin
(Kasetsart University-ORSTOM,1996)

The main purposes of Mae Klong River Basin Development Plan are as follows (EGAT,1996) :

(1) to supply water for Greater Mae Klong Irrigation Project in both wet and dry seasons (approximately 3 million rai at full development stage)
(2) to mitigate flood hazards in the plain of Mae Klong river
(3) to control salinity intrusion in estuary and coastal canals, and to increase domestic water supply (a minimum of 50 cms be released to downstream reach)

(4) to generate hydro-electric power, the present installed generating capacity is 1,058 MW which can generate the electricity of 1,810 million units annually on the average, and
(5) to help relief the water shortage problem in the lower Chao Phraya and Bangkok Metropolitan areas (a maximum of 45 cms can be diverted to Bangkok).

After the construction of Vajiralongkorn diversion dam, the irrigation water distribution system has been constructing with the increasing rate of 100,000 rai per year. It is expected to reach 3.0 million rai at the full development stage (AIT, 1994).

Besides, Department of Energy Development and Promotion (DEDP) has developed many small scale electrical pumping irrigation projects along Khwae Yai, Khwae Noi and Lam Pachee (a tributary of Khwae Noi). Each project can irrigate 500-3,000 rai. Now more than 50 pumping projects were completed with the total irrigable area of 69,000 rai (DEDP, 1998).

Table 1 General Data of Dams in Mae Klong River

Dam		Vajiralongkorn	Srinagarind	Tha Thung Na	Khao Laem
Type of Dam		Diversion	Storage	Regulating	Storage
Year of Completion		1970	1980	1982	1984
Storage Capacity (mcm.)	Total	~50	17,745	54.8	8,860
	Effective	-	7,470	28.8	5,848
Water Level (m,MSL)	Normal	22.5	180.0	59.7	155.0
	Minimum	-	159	55.5	135.0
Annual Inflow (mcm/yr)		-	4,457	-	5,161
Electricity Generating Capacity (MW)		-	720	38	300
Generated Electricity (million kw-hr/yr)		-	1,185	165	460

Table 2 General Data of Irrigation Sub-Projects in The Greater Mae Klong Irrigation Project

Irrigation Sub-Project	Irrigation Area (rai)	Remark
1. Kamphaengsaen	252,800	Lower Left Bank
2. Nakhon Pathom	364,200	"
3. Nakhonchoom	265,870	"
4. Ratchaburi Left Bank	258,000	"
5. Damnoen Saduak	208,100	"
6. Phanomthuan	332,300	Upper Left Bank
7. Song Phi Nong	364,100	"
8. Banglane (1)	316,350	"
9. Thamaka	295,600	Right Bank
10. Ratchaburi Right Bank	314,600	"
Total	2,971,920	

(1) Only 114,800 rai has been completed..

The study in 1994 indicated that the average annual releases from the two major reservoirs (Srinagarind and Khao Laem) were 3,807 mcm (the pumped back volume from Tha Thung Na is deducted) and 4,166 mcm respectively. The water level records in both reservoirs showed that they were mostly kept well within the upper and lower rule curves and thus two reservoirs had never faced serious water shortage in the past. Therefore, the total annual release of 7,973 mcm was supposed to meet all the downstream requirements. These included the 5,241 mcm of irrigation water requirement of Greater Mae Klong Irrigation Project of approximately 3.0 million rai and of DEDP pumping irrigation projects, at least 1,557 mcm for salinity control at the mouth of Damnoen Saduak canal less than 2 gm/liter and the domestic requirement downstream of Vajiralongkorn dam (or equivalent to 50 cms) and 1020 mcm for transbasin diversion to Tha Chin river (AIT, 1994).

Hydropower generation is a determining factor for releases from the 2 reservoirs during dry season, because this requirement is greater than the total downstream requirement (AIT, 1994). The actual irrigation diversion at Vajiralongkorn dam during 1972-1990 increased according to the increase of the cultivation area in both wet and dry seasons. It reached the maximum of 5,206 mcm/yr in 1989. Although there was irrigation requirements of DEDP pumping project, it is negligible comparing to those of Greater Mae Klong Irrigation Project. The study of EGAT pointed out that the actual irrigation diversion was highly linear correlated to the irrigated area particularly in dry season (r^2 = 0.76-0.96). Oftenly, the requested reservoir release was higher than the actual diversion. EGAT then estimated the irrigation diversion requirements of Mae Klong Irrigation Project from the cultivated area. The estimate was 6,363 mcm/yr, or 2,150 mcm for wet season and 4,210 mcm for dry season according to the estimated cultivation area of 2.69 million rai in wet season and 2.40 million rai in dry season (EGAT, 1992).

The main objective of this study is to analyze the effect of Srinagarind and Khao Laem reservoir operations on water management of Mae Klong Irrigation Project.

2. MATERIALS AND METHODS

The following daily data of 1994-1997 is used in this study :

(1) the daily releases of Srinagarind, Khao Laem and Tha Thung Na from EGAT,
(2) the daily diversion, downstream release and water level upstream of Vajiralongkorn diversion dam from RID Regional Office 10, and
(3) the daily water level record at the selected water control structures of Thamaka and Song Phi Nong irrigation sub-projects of GMKIP.

The methods for the study are as follows :

(1) to study the existing rules for operation of Srinagarind, Khao Laem and Tha Thung Na reservoirs and theirs influences on the operation of Vajiralongkorn diversion dam,
(2) to determine the daily reservoir release characteristics and their implications to the water level variation at Vajiralongkorn dam and GMKIP canals,
(3) to analyze the reservoir releases in comparison to the actual diversion at Vajiralongkorn dam on daily and weekly basis, using the data of 1994-1997, in order to identify some operational problems and improvement.

3. EXISTING RULES FOR OPERATION OF SRINAGARIND AND KHAO LAEM RESERVOIRS AND VAJIRALONGKORN DIVERSION DAM

3.1 OPERATION OF SRINAGARIND AND KHAO LAEM RESERVOIRS

EGAT is the agency responsible for operation of Srinagarind and Khao Laem Reservoirs which are the main water sources of Mae Klong River Basin.

Srinagarind and Khao Laem Reservoirs have the total storage capacity of 17,745 and 8,864 mcm respectively. At 25 km downstream of Srinagarind, there is Tha Thung Na regulating dam. Its functions are to create a downstream temporary storage for Srinagarind reversible turbines (2 units at 180 MW each) for pumping back water to the reservoir during the electricity surplus period at night and to control the release to Mae Klong river via Khwae Yai.

Srinagarind, Khao Laem and Tha Thung Na are operated to meet the water requirements for irrigation in GMKIP, domestic water supply, controlling the water quality in the tail reach of Mae Klong and Tha Chin rivers while the generated hydro-electricity is maximized. In general, the main water uses in Mae Klong River Basin are :

(1) the irrigation water requirements of GMKIP over the approximated area of 3 million rai and about 69,000 rai of DEDP irrigation pumping project area,
(2) the 50 cms minimum release from Vajiralongkorn diversion dam for domestic use and salinity control,
(3) the 30-60 cms transbasin diversion to Tha Chin during dry season, and
(4) the 0-45 cms diversion to Bangkok Metropolitan Water Works Authority.

In order to meet all the purposes, there is a good coordination between RID and EGAT in formulation of a short term (annual) operation plan for the reservoirs. The initial hydropower production plan is first prepared by EGAT according to the known storage volumes in Srinagarind and Khao Laem reservoirs in September. This plan may be adjusted periodically. In December, the total dry season cultivation area is determined from the available storages in Srinagarind and Khao Laem at the beginning of December and the expected inflow to the reservoirs. In the average to medium dry year, approximately 1.4 million rai of dry season upland crops and perenial crops (or 0.84 million rai of paddy equivalent area) can be cultivated if the combined effective storage in the two reservoirs is equal to 3,100 mcm. While in the dry year, the same dry season cultivation area can only be irrigated when the combined effective storage exceeds 4,100 mcm. If the effective storage is higher than the mentioned amount, more dry season paddy area can be irrigated accordingly. The maximum of dry season area is 1.84 million rai of dry season paddy equivalent area (EGAT, 1992).

The classification of expected inflow to Srinagarind and Khao Leam is divided into 5 levels namely wet, medium wet, average, medium dry and dry according to the combined annual inflow of 13,203, 10,671, 9,244, 7,390 and 6,011 mcm respectively (EGAT, 1992).

On weekly basis, GMKIP requests the weekly irrigation water requirements plus other requirements at Vajiralongkorn dam to EGAT. EGAT, then, usually releases the requested amount to GMKIP, if the storages in the 2 reservoirs are above the lower rule curve. Although the weekly release volume in mcm is generally greater or equal to the requested amount, the release sometimes is not matching Vajiralongkorn diversion rate because of the daily and hourly release fluctuation. The irrigation and other requirements at Vajiralongkorn are usually uniform during a week according to the existing rule for operation of Vajiralongkorn dam. Besides, Vajiralongkorn dam has no active storage to absorb the surplus or deficit.

For long term operation, the operating rule curves of Srinagarind and Khao Laem were developed as shown in Figure 2 and 3 respectively. The storage in the two reservoirs should be controlled within the same storage rule curve level to balance the release operation and to improve the hydropower production benefits.

3.2 OPERATION OF VAJIRALONGKORN DIVERSION DAM

Vajiralongkorn diversion dam is the headwork of GMKIP. Three main functions of the dam are:

(1) to control the water level at upstream of the dam at 22.50 m (MSL) so that the gravity irrigation in GMKIP can be practices, and
(2) to control the downstream release for domestic water supply and salinity control, and
(3) to deliver 60 cms to Tha Chin River during dry season.

Generally, the dam regulators are adjusted every 3 hours (at 24:00, 3:00, 6:00,....., 21:00) to control upstream water level at 22.50 m (MSL) for irrigation purposes while the minimum of 50 cms downstream release for 2 gm/liter salinity control is maintained. By this principle of dam operation, the downstream release amount depends on the Vajiralongkorn inflow and the amount of water diverted to GMKIP via 1R, 2R on the right bank, Feeder Canal on the left bank and Jorrakhe Sarmpun transbasin diversion canal to Tha Chin River. Feeder Canal delivers water to LMC (left main canal), 1L and 2L in order to distribute water to the upper and lower left bank irrigation systems. LMC also delivers water to Thasarn-Bangpla diversion canal, another transbasin diversion canal to Tha Chin River. The main irrigation and transbasin diversion canals of GMKIP are shown in Figure 4.

In normal operation, RID operates Vajiralonkorn dam to satisfy all the requirements as much as possible. However when the inflow is not sufficient, the transbasin diversion to Tha Chin River via Thasarn-Bangpla and Jorrakhe Sarmpum may be reduced to 30 cms. If it is still not sufficient, the downstream release is reduced to 30 cms. If the water shortage still exists, O&M division of RID Regional Office 10 informs the 9 irrigation sub-projects of the water shortage crisis where the critical water allocation and deliver practices must be adopted.

In order to avoid the water shortage situation, O&M division of RID Regional Office 10 determines the weekly water requirements of Vajiralongkorn dam one week in advance using the computer program name WASAM (Water Allocation Scheduling and Monitoring). Irrigation week of GMKIP is the period between Thursday to next Wednesday. Approximately 330-500 cms of discharge is required. RID Regional Office 10 informs the required discharge to O&M division of RID in Bangkok to coordinate with EGAT in order for Srinagarind and Khao Laem Reservoirs to release the required amount. It is anticipated that the travelling time is approximately 20 and 50 hours for Srinagarind and Khao Laem reservoirs, respectively.

In operation of Vajiralongkorn dam and GMKIP, there are some operational problems. As mentioned earlier, the main sources of water supply to Vajiralongkorn dam comes from Srinagarind and Khao Laem reservoirs. Although the reservoir release volume meet the GMKIP water requirements on weekly basis, the discharge (in cms) to Vajiralongkorn is not uniform according to the daily hydropower production plan of the reservoirs. This results in hourly and daily variation of water level upstream of Vajiralongkorn diversion dam which has little or no active storage as shown in Table 3.

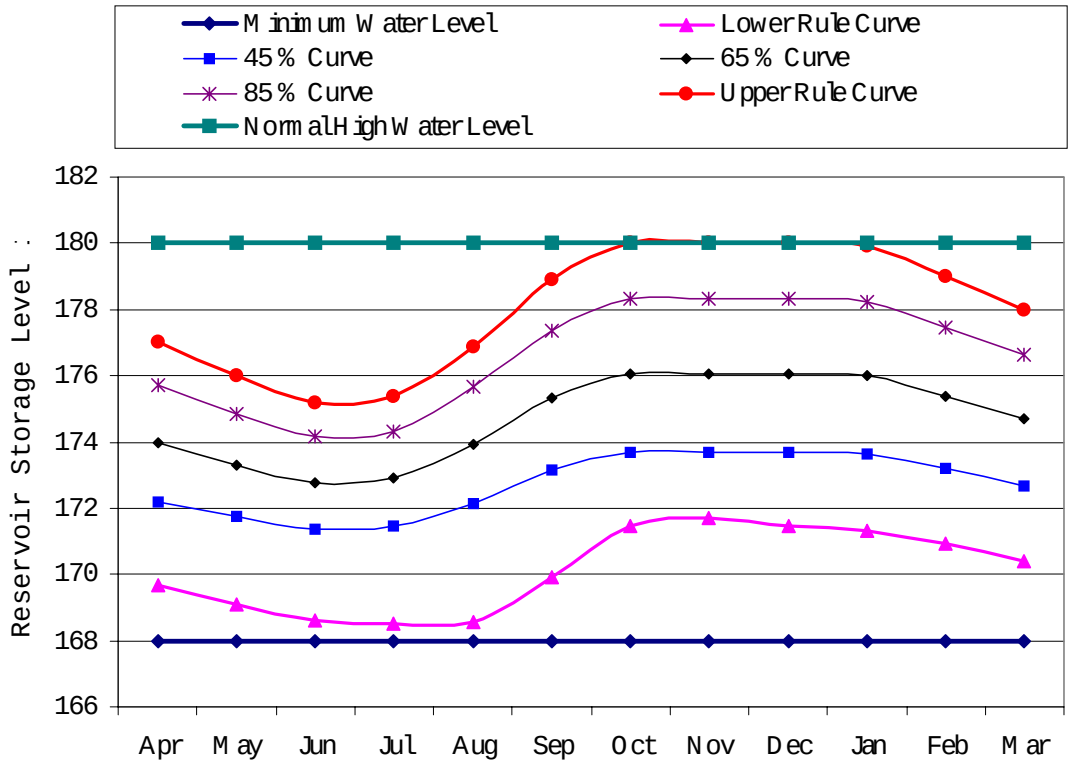

Figure 2 Srinagarind Reservoir Operating Rule Curves (EGAT, 1992)

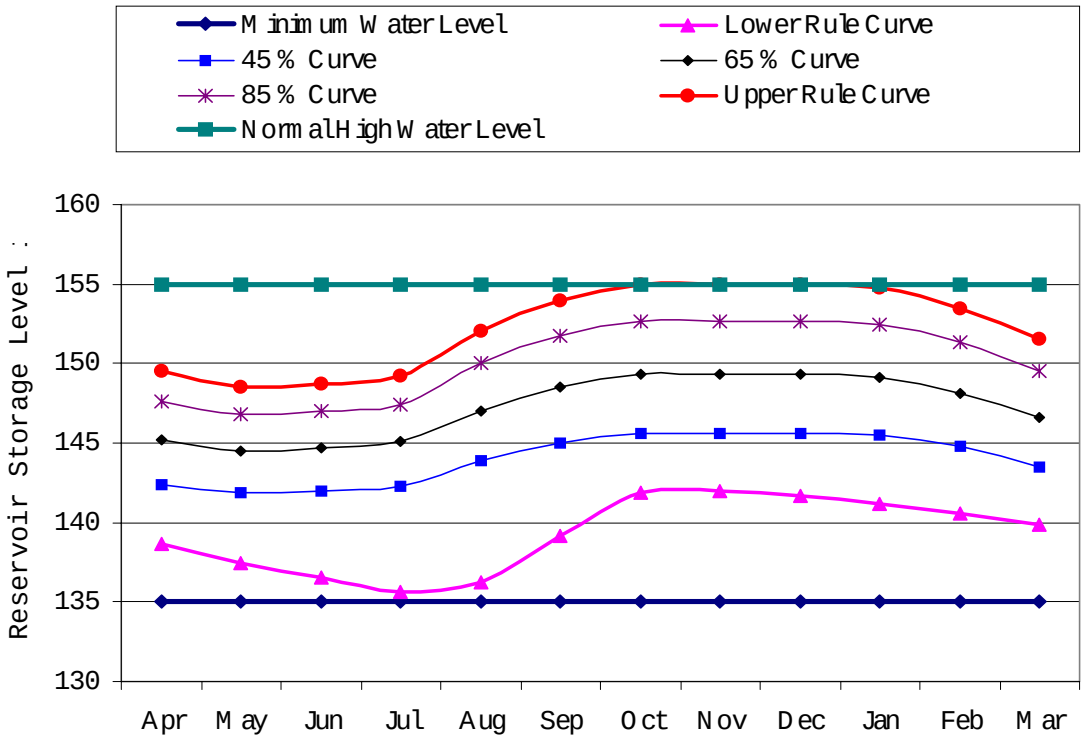

Figure 3 Khao Laem Reservoir Operating Rule Curve (EGAT, 1992)

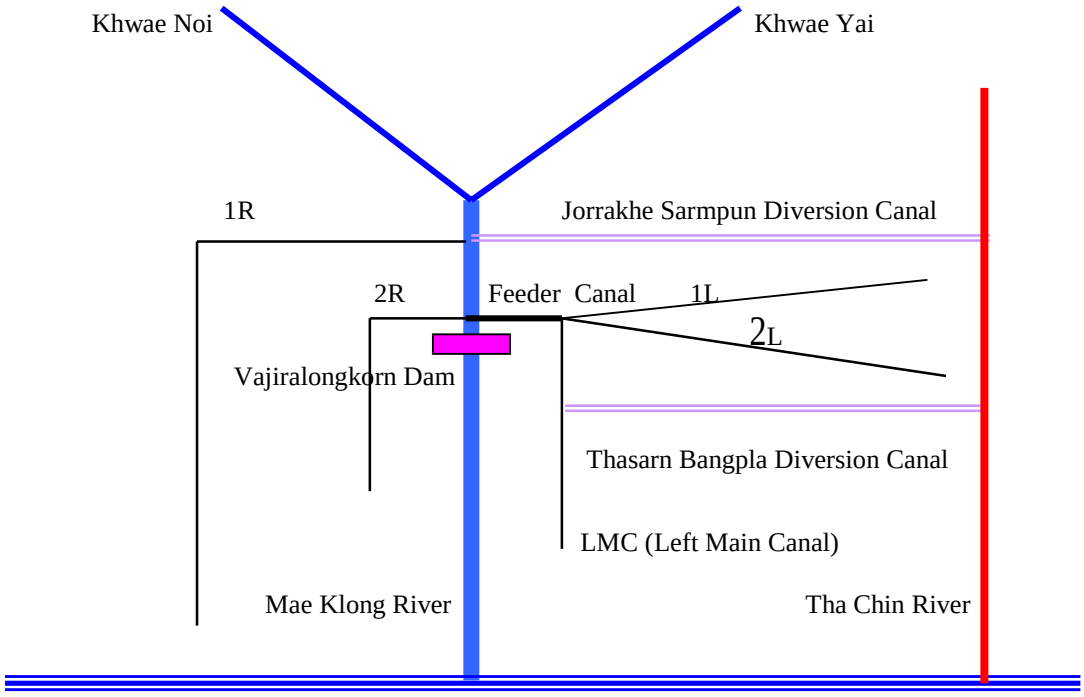

Figure 4 Main Irrigation Canals and Transbasin Diversion Canals of GMKIP

Table 3 General Periods of Low and High Water Levels at Vajiralongkorn Dam.

Period of	Hour	Day
Low Water Level High Water Level	0 : 00 – 14 : 00 14 : 00 – 0 : 00	Sunday – Tuesday Wednesday - Saturday

The variation of discharge to Vajiralongkorn dam has some effect on the operation of irrigation canal of GMKIP. Whenever, the water level upstream of Vajiralongkorn dam drops below +22.20 m (MSL) (or 0.30 m below the full supply level of 22.50 m), the water delivery to irrigation canals are effected, particularly 1R canal. This canal is more than 120 km long and supplies water to 2 irrigation sub-projects including Thamaka and Ratchaburi Right Bank irrigation projects. The water level in the middle and tail reaches of those canals drop below the full supply level (FSL) because the upstream control concept is practiced in GMKIP. One disadvantage of this concept is wherever water shortage takes place, it effects the tail end first. This further effects the distribution of water to field ditches because many of the offtake structures in GMKIP are Romijn Weir (adjustable overflow weir). Although Romijn Weir is a very good flow control structure, it is very sensitive to the variation of water level in main and lateral canals. If the water in the canal drops below the crest of diaphram wall of Romijn Weir, it cannot flow to the field ditches. The diaphram wall of many Romijn Weirs was destroyed by farmers so that the water can flow to their field ditches during the low water level period.

4. RESULTS AND DISCUSSION

4.1. DAILY RESERVOIR RELEASE CHARACTERISTICS AND THEIR IMPLICATIONS TO WATER LEVEL VARIATION AT VAJIRALONGKORN DAM AND GMKIP CANALS

The daily release of Srinagarind, Tha Thung Na and Khao Laem reservoirs during 1994-1997 were analyzed to identify the reservoir release characteristics of the GMKIP irrigation week (Thursday-Wednesday). The example of Khao Laem reservoir release in both wet and dry season of 1994 is shown in Figure 5. The release varies from day to day within the irrigation week and varies from week to week. The average release from Thursday to Wednesday indicated that the reservoir release is decreased on Saturday to reach the minimum on Sunday. The average Sunday release in dry season is less than half of the weekly average release. The release characteristics of Khao Laem reservoir shows the same pattern on both wet and dry season. The average release characteristics of Srinagarind, Tha Thung Na and Khao Laem reservoirs during 1994-1997 are shown in Figure 6. The average release patterns of Thursday to Wednesday of the 3 reservoirs are similar. That is the release starts decreasing on Saturday and reaching the minimum on Sunday. The release starts increasing on Monday and reaches the weekly peak on Wednesday or Thursday.

This daily release variation may not be a flavorable condition for operation of Vajiralongkorn diversion dam and GMKIP because Vajiralongkorn dam has very small active storage or is negligible comparing to the daily irrigation water requirements of GMKIP, particularly on the peak day. It is estimated roughly that from the 50 mcm storage capacity of Vajiralongkorn dam, the active storage is only a few mcm. The peak daily water requirements of Vajiralongkorn dam usually exceed 30 mcm. Thus, whenever the total reservoir release is less than the water requirements at Vajiralongkorn, the water storage of Vajiralongkorn is decreased. The water level upstream of Vajiralongkorn will drop below the 22.50 m (MSL) full supply level. The water level upstream of Vajiralongkorn dam in dry season 1994-1997 was plotted in Figure 7. It shows that at the beginning of the irrigation week, the water level upstream of Vajiralongkorn dam is maintained at 22.50 m (MSL). The water level is beginning to drop from FSL on Sunday and reaches the minimum around Tuesday. However, on the average, the water level upstream of Vajiralongkorn is well maintained at or near FSL even on Tuesday. This indicates that although the reservoir release varies from day to day, it is not much effect the operation of Vajiralongkorn dam on the average according to the analysis of 1994-1997 situations. However in some week, particularly during the peak irrigation water requirement week, the water level upstream of Vajiralongkorn dam cannot be maintained within the acceptable limit of FSL as indicated by week 8-10 and week 17-20. The general dry and wet season of GMKIP is given between week 6-22 and week 29-48 respectively. The result is the flow through head regulators of 1R, 2R, Feeder Canal and Jorrakhe Sarmpum diversion canal reduced. Since the upstream flow control system is practiced in GMKIP, the upper reach of the canal will not be much effected. The shortage is usually propagated to the middle and the tail reaches.

The study of canal water level at the 2 selected cross regulators in GMKIP is shown in Figure 8. The cross regulator of 1R at km 64.800 belongs to Thamaka irrigation project, the most upstream project on the right bank. This regulator is located about the middle reach of 1R canal to maitain water level for Thamaka lateral canals and to regulate the flow for Ratchaburi Right Bank irrigation project. The 5L-2L cross regulator at km 26.401 is located almost on the tail reach of Song Phi Nong irrigation project on the upper left bank, about 50 km from Vajiralongkorn diversion dam. It is important to note that Song Phi Nong project recieves irrigation water from Phanomthuan project. The daily water level plot in dry season 1994 indicated that Song Phi Nong regulator had some difficulties to maitain water level at FSL of 8.35 m(MSL). The canal water levels dropped more than 0.30 m below FSL in many weeks.

The situation of Thamak regulator was better. There were only 4 weeks that the FSL of 13.55 m(MSL) could not be maitained during Tuesday, Wednesday and Thursday. The water level fluctuated up and down during irrigation week. There was one remarkable drop in water level on week 13. This happened on both Thamaka and Song Phi Nong regulators. The water level characteristics during irrigation week in both dry and wet seasons of 1994-1997 were plotted ing Figure 8. This confirms that the tail reach of 5L-2L of Song Phi Nong project faces the water delivery and distribution problems more than the middle reach of Thamaka 1R canal. Although it cannot conclude that this problem is the direct effect of the operation of Vajiralongkorn, Tha Thung Na, Srinagarind and Khao Laem. It might be only the conflicting use of the upstream and downstream irrigation users. However, the fluctuation of water supply to irrigation project can also cause this kind of problems.

4.2 COMPARISION OF ACTUAL RESERVOIR RELEASES AND GMKIP DIVERSION

In the pervious session, the analysis showed that the daily variation of reservoir release causes the variation of water level upstream of Vajiralongkorn dam. However, it fluctuates within the acceptable range and may effect the water delivery and distribution.

The daily and weekly releases from Khao Laem and Tha Thung Na during 1994-1997 were compared to the daily and weekly Vajiralongkorn diversions as shown in Figure 9. The weekly plot indicated that the releases were usually greater than the actual diversions during 1994-1997. This confirms that, in general, the reservoir releases satisfy the diversion requirements of GMKIP and of the downstream reach of Mae Klong, a minimum of 50 cms (4.32 mcm/day) in normal operation or 30 cms (2.592 mcm/day) in critical period. Only a few weeks in 1994 and one or two weeks in 1995-1997 when the weekly releases were less than the actual diversions plus 50 cms. This situation was taken place during the late week in dry season and at the beginning week of wet season. In wet season, it was noticed that the reservoir releases were much greater than the water requirements of Vajiralongkorn.

The daily plot, in Figure 9, indicated that the reservoir releases were often less than the daily actual diversions, particularly during dry season because of the low releases during Saturday and Sunday. The insufficient releases consequently resulted in the decreasing water level upstream of Vajiralongkorn as indicated by daily water level plot. There were many times that the water level upstream of Vajiralongkorn dropped below 22.20 m (MSL) and effected the operation of GMKIP canals, except in 1997.

The analysis is not taken into account of the side flow between Khao Laem, Tha Thung Na and Vajiralongkorn since this side flow is small comparing to the reservoir releases. Only 1.06-3.9 mcm/day during dry season (EGAT, 1992). Besides the reservoir releases are also used by DEDP pumping irrigation project and the domestic water supply system of Kanchanaburi province. Thus the inflow to Vajiralongkorn dam in dry season is not much different from the reservoir releases.

As mentioned earlier that Vajiralongkorn has very few mcm active storage it can absorb only a small difference between the daily reservoir releases and GMKIP diversion. One way to solve this problem is the release policy of Tha Thung Na may be revised, particularly on Saturday and Sunday to maintain uniform releases during the irrigation week.

"*Ohi dam and Kottu, Miyata irrigation projects on Kiso River in Japan is a good example of success in solving conflict between irrigation and hydropower sectors. After Ohi dam was completed in 1924 and Daido electric power company was in charge of operation. The irrigation associations suffered from a fluctuation of river flow induced by the reservoir operation according to the pattern of the electricity demand in a day. The water right in Japan prescribed only the maximum flow rate for hydropower generation, but not the minimum value*

which would assure the stable diversion for the irrigation projects. Finally the power company constructed a regulating reservoir called Imawatari, downstream of Ohi dam to maintain a constant release for irrigation projects (Satoh et al., 1979) "

The other way is Vajiralongkorn dam must increase the active storage by establishing a temporary water level above 22.50 m (MSL) during the period of high reservoir releases (Wednesday - Saturday) to relief the effect on operation of GMKIP canals during the period of low reservoir releases (Sunday - Tuesday). It is estimated roughly that the new temporary FSL of 22.70 m(MSL) upstream of Vajiralongkorn may be possible. If RID Regional Office 10 changes the operation rule of Vajiralongkorn as suggested, it can absorb the daily deficit of 8-10 mcm without effecting the GMKIP canal operation.

Table 4 shows the frequency of different daily different deficit during 1994-1997. The daily deficit is calculated from the combined Khao Laem and Tha Thung Na daily releases minus Vajiralongkorn diversion plus 50 cms minimum requirements for salinity control and domcitic uses. It indicates that the daily deficit exceeding 12 mcm/day is 9-14 days per year. Thus if the recommended temporary setting of FSL of 22.70 m (MSL) is acceptable, it may reduce degree of the problems.

Table 4 Frequency of Daily Deficit at Vajiralongkorn due to Low Reservoir Releases during the Weekend

Daily Deficit Volume (mcm)	Frequency (days)			
	1994	1995	1996	1997
> 0	98	63	60	46
> 2	84	52	53	39
> 4	64	45	39	31
> 6	47	39	30	24
> 8	32	26	21	17
> 10	23	17	14	13
> 12	14	13	9	9

5. CONCLUSIONS

The analysis of the existing rule for operation of Srinagarind, Khao Laemm and Tha Thung Na indicated that the reservoir releases meet the diversion requirements of Vajiralongkorn dam on weekly basis. The daily release characteristics show the variation during the irrigation week (Thursday-Wednesday). The releases drop considerably on Saturday and Sunday, particularly on Sunday when the releases reach the minimum. This daily release variation results in frequent insufficient supply to Vajiralongkorn during Sunday to Tuesday particularly during the peak irrigation water requirements period. The water level upstream of Vajiralongkorn dam cannot be maintained at the design full supply level of 22.50 m (MSL). Whenever the water level upstream of Vajiralongkorn drops below 22.20 m (MSL), it effects the water delivery operation of GMKIP canal system. The water level in the tail reach of the canal droped to the level that the Romijn Weir type offtake structures is not functioning. Two alternatives to this problem is recommended. One is to use Tha Thung Na regulating reservoir to maintain the constant release. The other is to increase the active storage of Vajiralongkorn dam by temporary setting the FSL at 22.70 m (MSL) during Wednesday to Thursday.

ABBREVIATIONS

DEDP = Department of Energy Development and Promotion
EGAT = Electricity Generating Authority of Thailand
FSL = Full Supply Level
mcm = million cubic meter
MSL = Mean Sea Level
RID = Royal Irrigation Department

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REFERENCES

Asian Institute of Technology (1994), Study of Potential Development of Water Resources in Mae Klong River Basin, Volume II : Main Report, Bangkok, Thailand.

Department of Energy Development and Promotion (1998), Project Document, Electrical Irrigation Pumping Service Center, Energy Development and Promotion Regional Office 1. Kanchanaburi, Thailand, 12 p.

Electricity Generating Authority of Thailand (1996), Mae Klong River Basin Development (in Thai), Public Relation Division, Bangkok, Thailand, 24 p.

Electricity Generating Authority of Thailand (1992), Criteria for Water Release from Reservoirs in Mae Klong River Basin, Research Report No. 60-59, Bangkok, Thailand, 133 p.

Kasetsart University - ORSTOM (1996), Identification of Agricultural and Irrigation Patterns in the Central Plain of Thailand : Prospects for Agricultural Resaerch and Development, DORAS Project, Bangkok, Thailand, 220 p.

Royal Irrigation Department (____). Mae Klong Irrigation Project, Bangkok, Thailand, 15 p.

Satoh,M and et al.(1979), Kiso River, in " History of Irrigation and Drainage in Japan" (in Japanese), edited by Japaneses Society of Irrigation, Drainage and Reclamation Engineering, Japan, p.1405-1458.

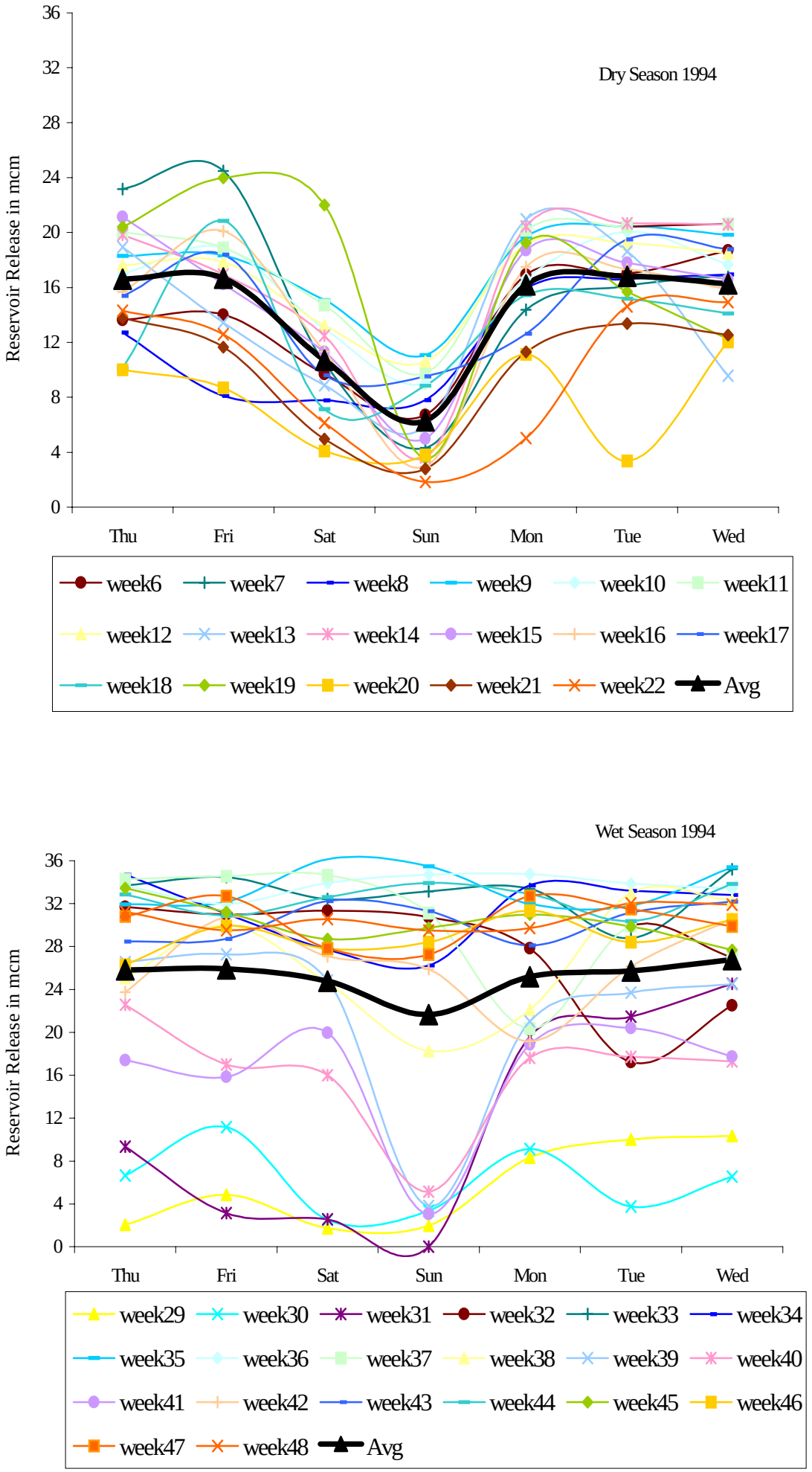


Figure 5 Khao Laem Reservoir Release Characteristics in Dry and Wet Season 1994

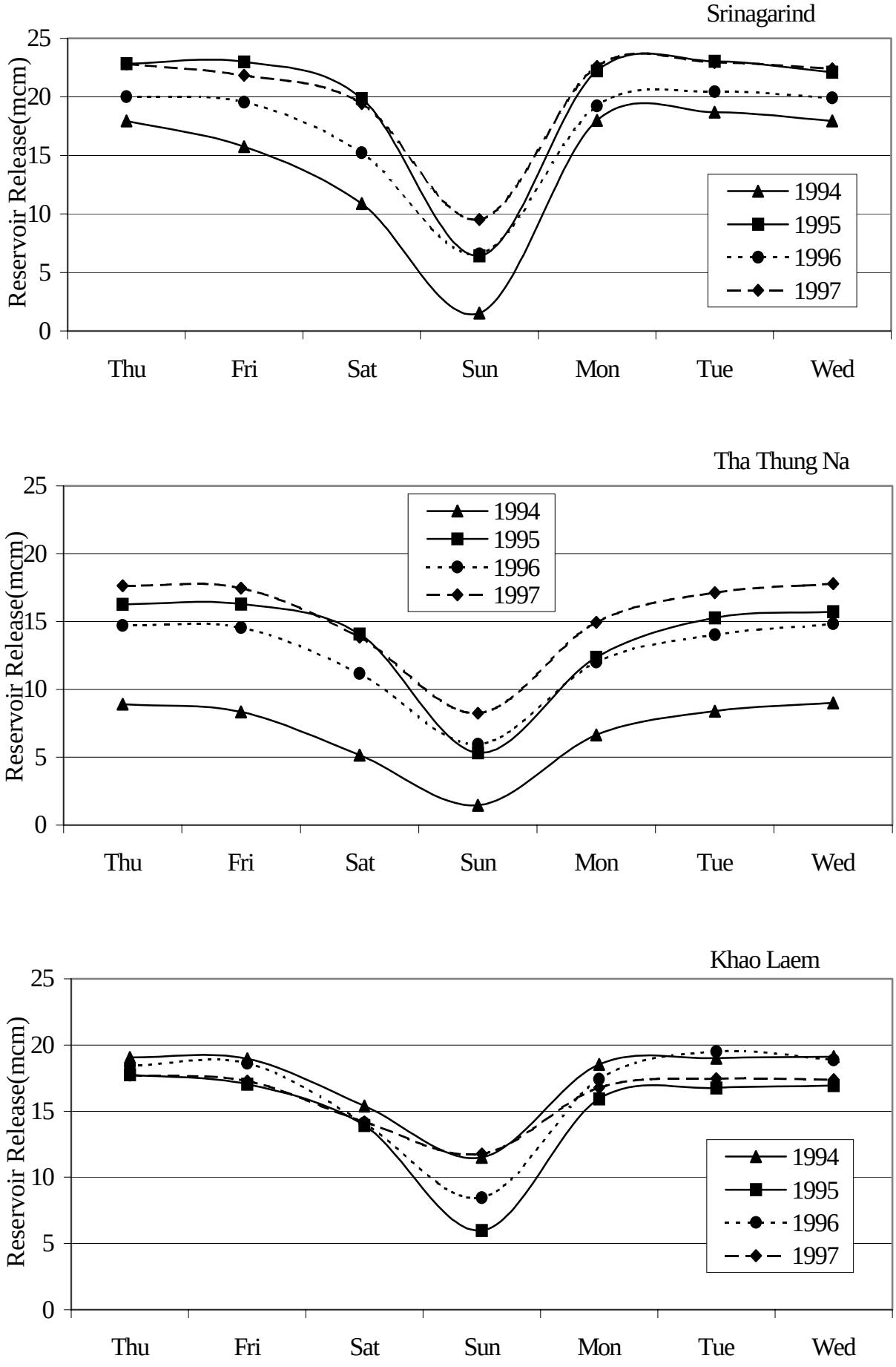


Figure 6 Release Characteristics of Srinagarind, Tha Thung Na and Khao Laem Reservoirs during 1994 - 1997

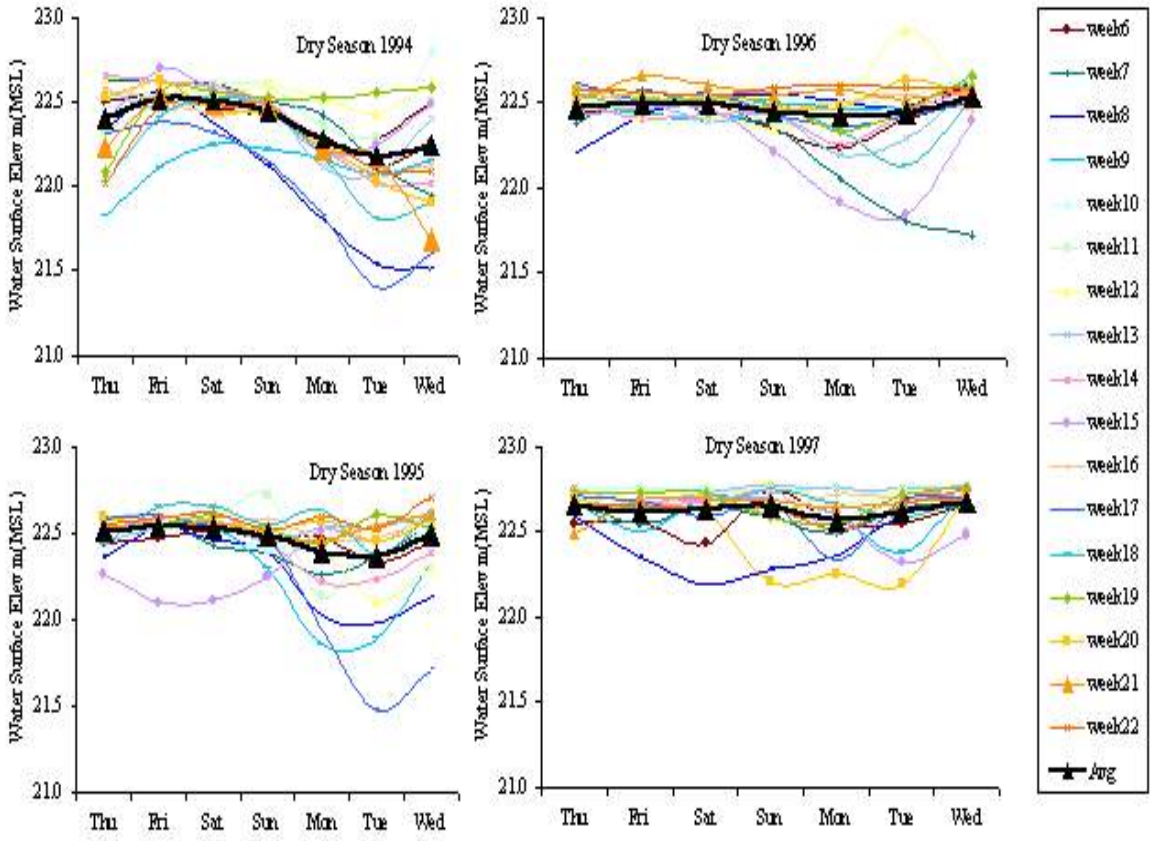
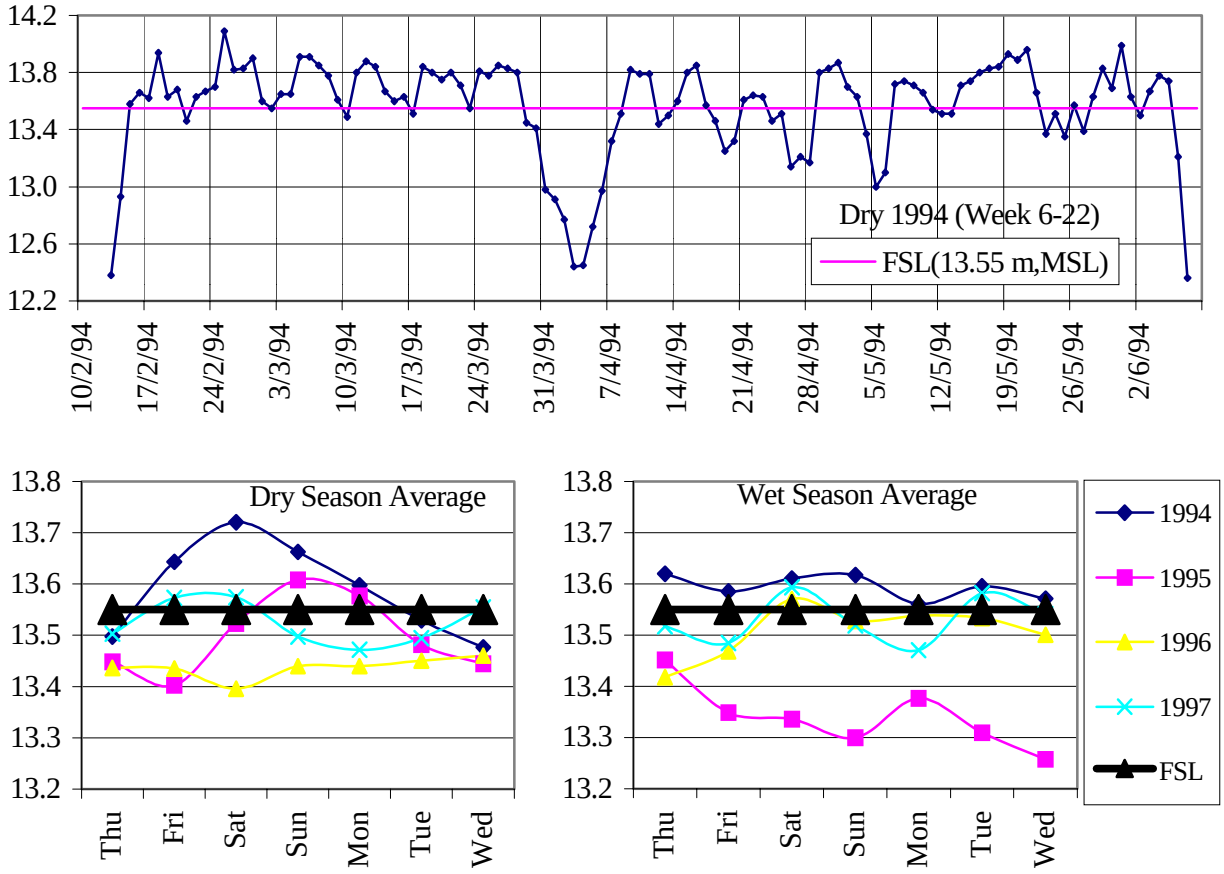


Figure 7 Water Level Characteristics Upstream of Vajiralongkorn Diversion Dam in Dry Season 1994-1997

(1) Thamaka Cross Regulator of 1R at Km 64.800



(2) Song Phi Nong Cross Regulator of 5L-2L at Km 26.401

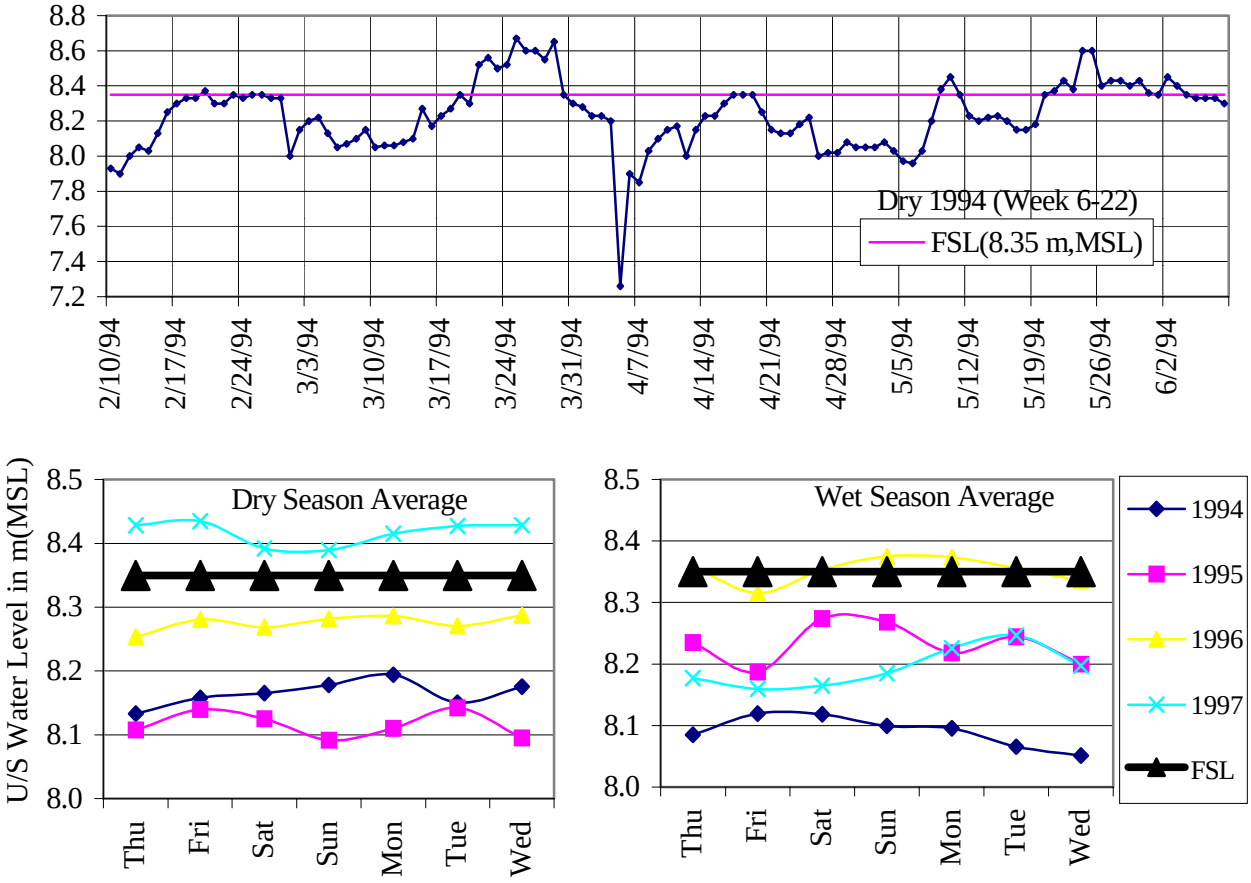


Figure 8 Water Level Characteristics Upstream of The Selected Cross Regulators in Thamaka and Song Phi Nong Irrigation Projects

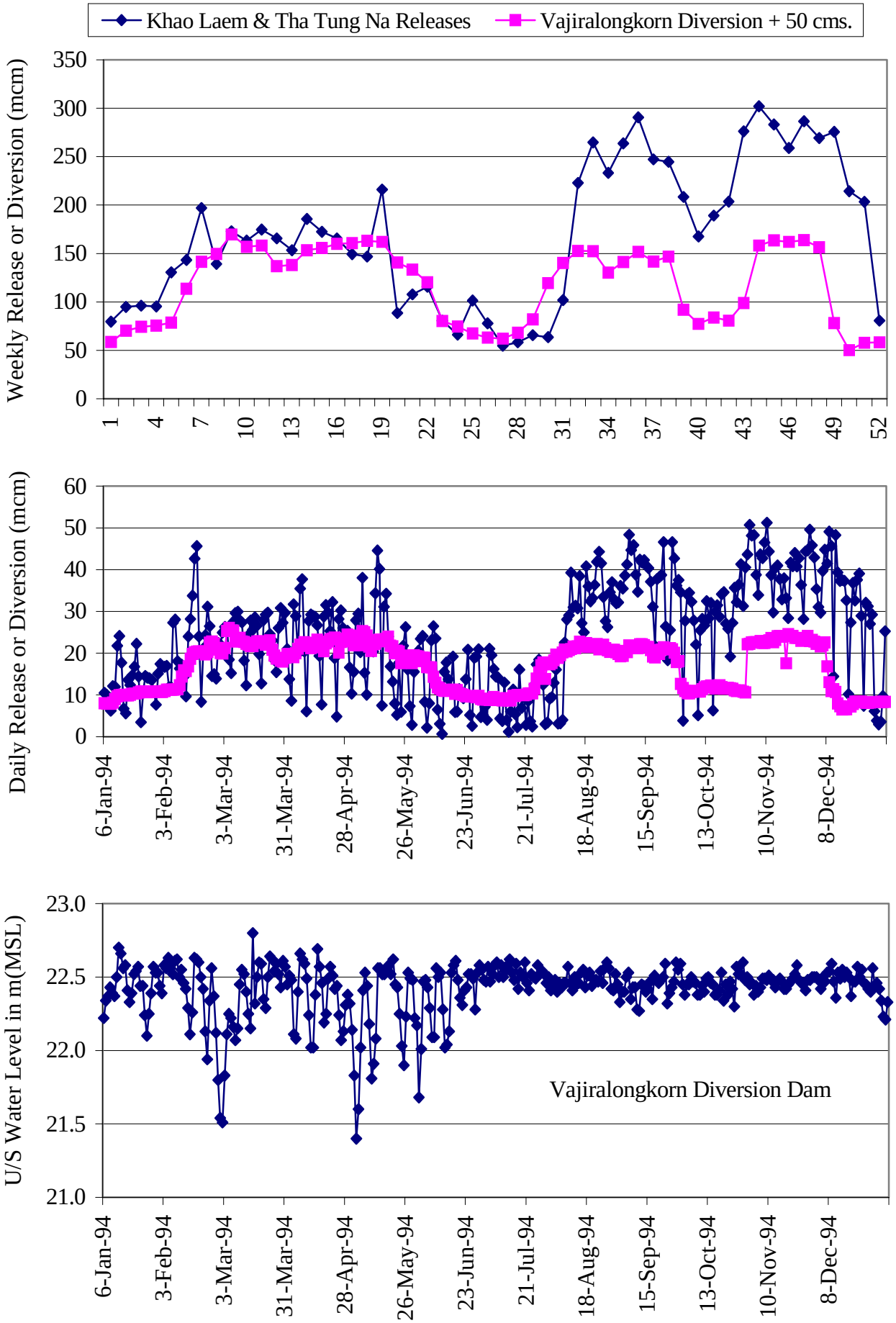


Figure 9(a) Comparison of Daily and Weekly Releases from Khao Laem and Tha Thung Na and Vajiralongkorn Diversion in 1994

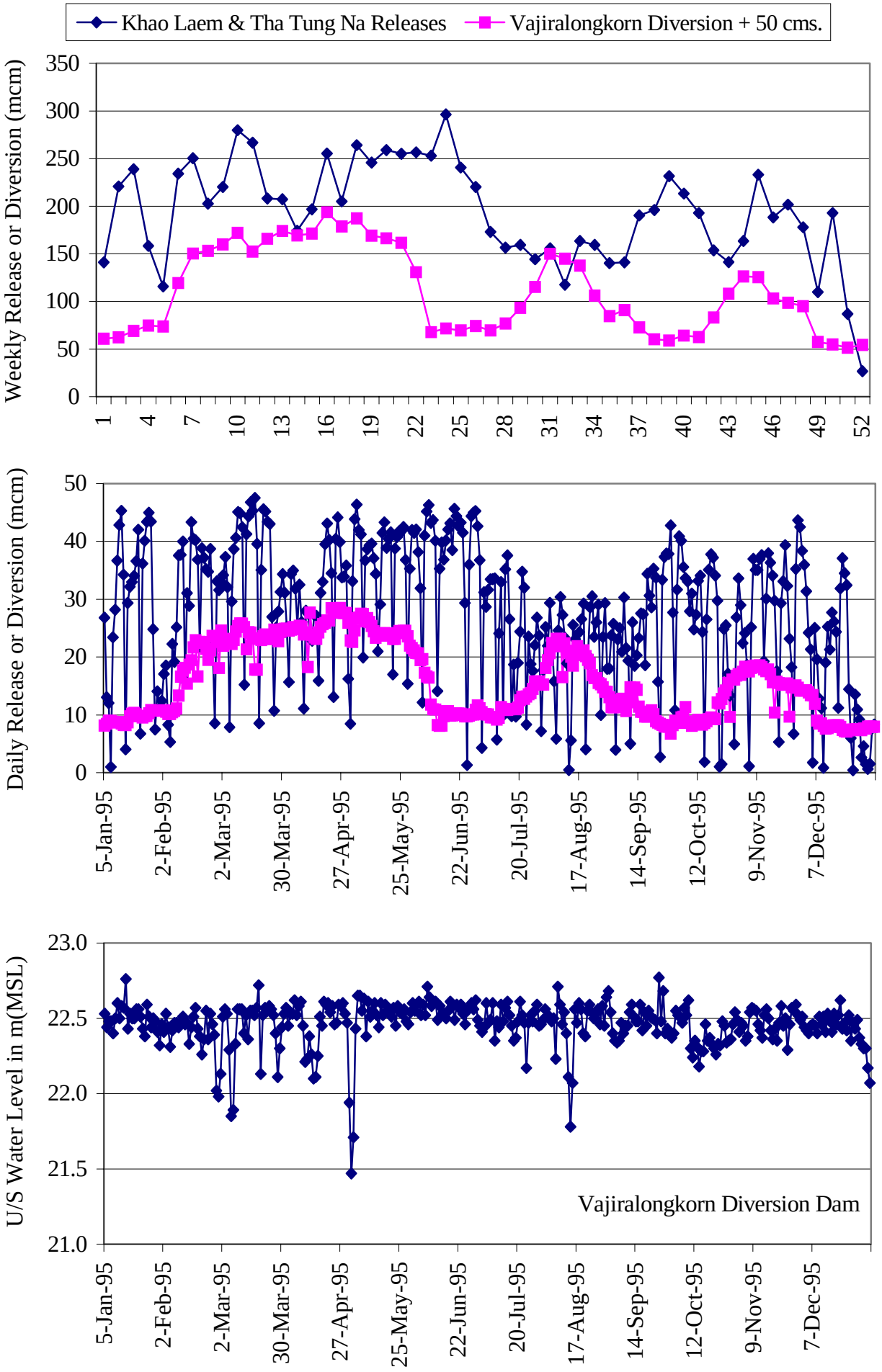


Figure 9(b) Comparison of Daily and Weekly Releases from Khao Laem and Tha Thung Na and Vajiralongkorn Diversion in 1995

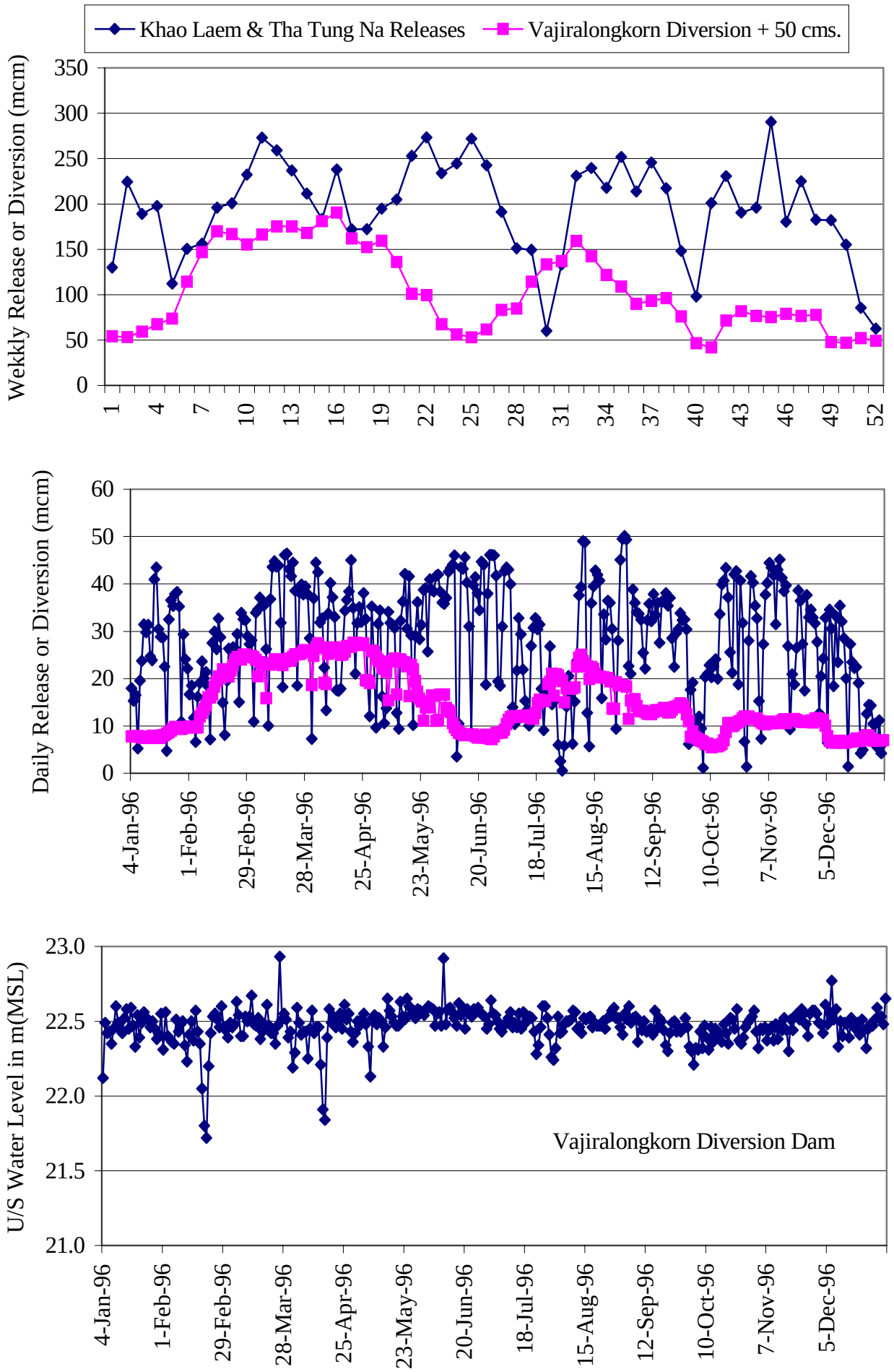


Figure 9(c) Comparison of Daily and Weekly Releases from Khao Laem and Tha Thung Na and Vajiralongkorn Diversion in 1996

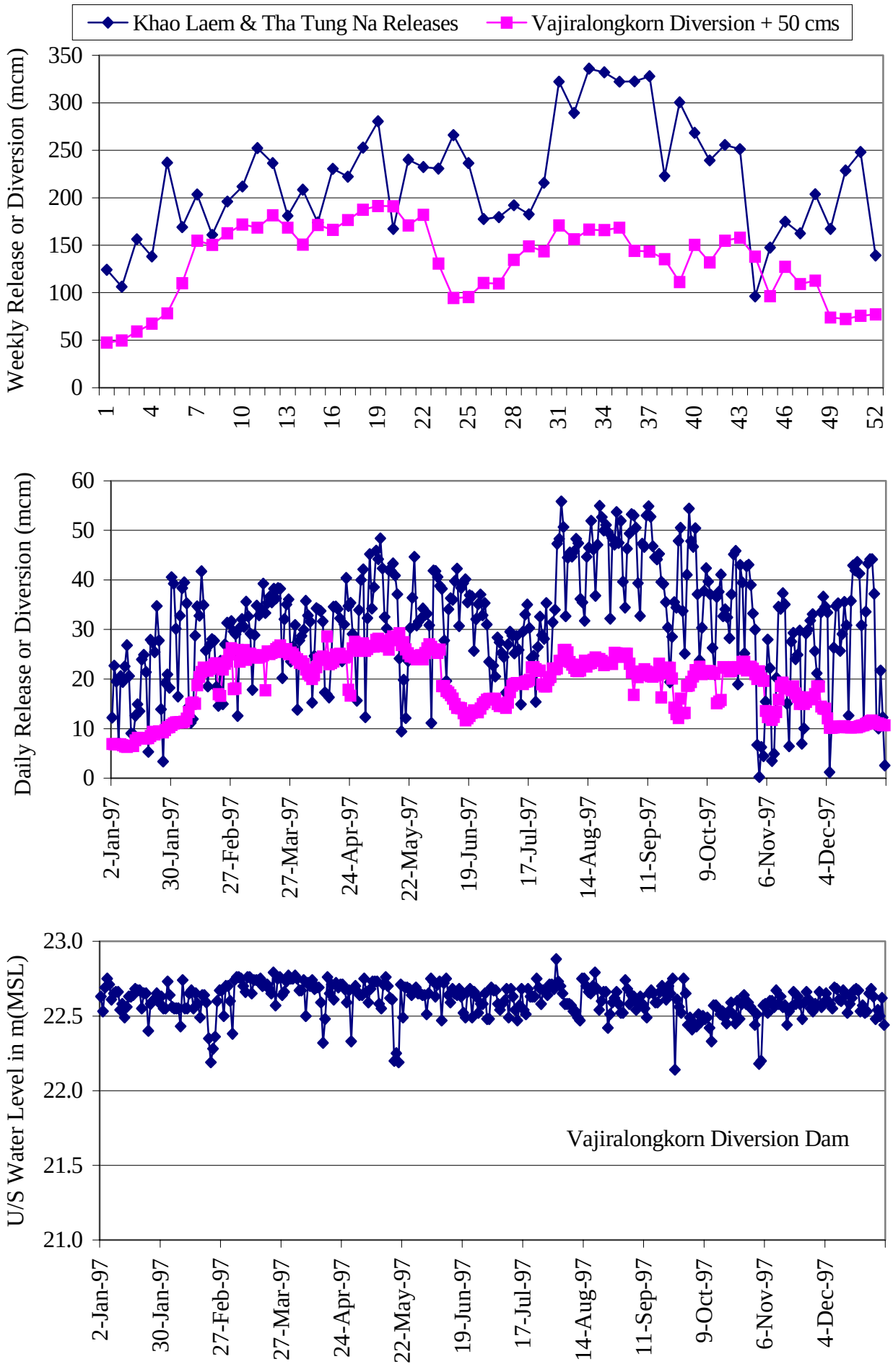


Figure 9(d) Comparison of Daily and Weekly Releases from Khao Laem and Tha Thung Na and Vajiralongkorn Diversion in 1997