ESTIMATION OF DAM DISCHARGE FOR THE DOWN STREAM WATER QUALITY(*)

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1. INTRODUCTION

Concerns about the environmental values and uses of the Keum River flow are having a powerful effect on Dam operation rule for the downstream water quality. The Keum River begins as high quality water from the mountains of the Sobak. As it moves through the basin toward down stream the river and its tributaries pass through many urban and agricultural areas that the sources of pollutant loadings. The increase of population and development of industry were the major sources of water pollution of the river flow. Population and industry have been considered to be increased and developed. And the water quality problem is also considered to be serious for the future.

In order to improve the water quality, the reduction of the input pollutant loads of the river by the tools of conservation and working the treatment plants, and flushing or dilute the pollutants with the dam discharge. Especially the dam discharge is very efficient to improve the water quality in dry seasons.

The minimum required flows to meet the water quality standards of river were estimated for several important representative stations along the main stream. And the dam discharges to satisfy the minimum required flow were estimated for the several cases of flow rate. The water use in the basin are considered. The yearly water use is reviewed by referencing the water use survey report. Two periods will be set according to usage: agricultural irrigation use and non-irrigation use. Also the amount of the return flow must be considered in the

(*)Evaluation du débit des barrages pour la qualité de l'eau en aval.

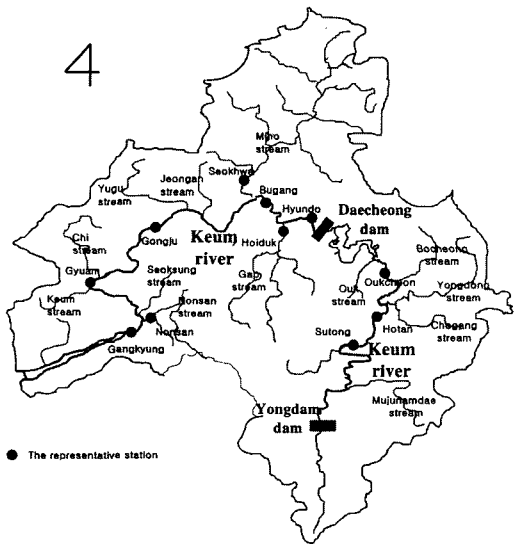


Fig1. Basin map of the Keum River
- Carte du bassin du fleuve Keum

establishment of discharge schemes for the water use.

The Keum River basin is located in the central-western part of Korean Peninsula. The Keum River basin has an area of 9,810.40 km^2, which ranks third after the Han river basin and the Nakdong river basin. The length of its mainstream is 395.90 km. (Chungcheong-namdo, 1993). Also, the basin has Daecheong Dam (4,143km^2, 1980 copmpleted) and Yongdam Dam (930km^2, 2001 completed) which function as water supply and flood protection dams(Fig.1).

2. ESTIMATION OF LOW FLOW

The low flow estimation and analysis were carried to get a regional low flow formula. Two methods can be applied when the regional analysis of low flow; one is a method by multiple regression analysis in which all the hydraulic components are considered, and the other is a method on the basis of the basin area(Riggs, 1989). In this research, the method on the basis of the basin area was adapted. This method has mainly been applied to the estimation of river basin flow rate and instream flow in Korea. The standards suggested in the 〈Method for Determining the Instream Flow〉(Ministry of Construction & Transportation, 1997) were referred.

In the analysis of the low flow, the target was the low flow before dam construction, when there was no artificial regulation of river flow. Therefore the data before Daecheong Dam construction were used. Frequency analysis for the low flow was carried for each stations to get the 2.33 year low flow($Q_{2.33}$) and 10 year low flow(Q_{10}). It was necessary to estimate the low flow rate for ungauged stations. Therefore a regional low flow formula was suggested accordance with the basin area, using the $Q_{2.33}$ and Q_{10} flow(Fig. 2). Table 1 shows the estimated low flow for each representative stations.

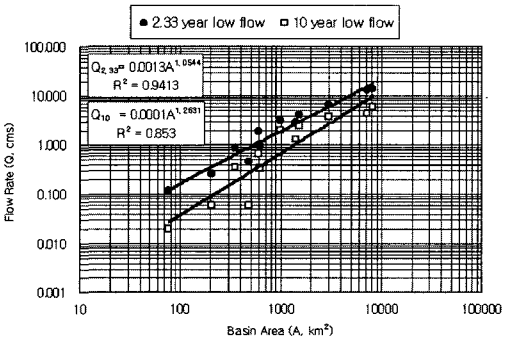


Fig 2 Specific low flow formulation
- Formulation spécifique du débit faible

Table 1. The Estimated Low Flow for Each Gauging Station
- Débit faible évalué pour chaque station de jaugeage

Basin		Number of Section	Sites	Q_{10}	$Q_{2.33}$
Upstream Of Daecheong Dam	Mainstream	I	Sutong	1.1	3.0
		II	Hotan	1.4	3.7
		III	Oukcheon	2.4	5.9
Downstream Of Daecheong Dam	Mainstream	IV	Hyundo	3.7	8.5
		V	Bugang	4.8	10.5
		VI	Gongju	7.4	15.1
		VII	Gyuam	8.9	17.5
		VIII	Gangkyung	10.3	19.9
	Kap stream	IX	Hoiduk	0.3	1.1
	Miho stream	X	Seokhwa	1.0	2.7
	Nonsan stream	XI	Nonsan	0.2	0.8

Q_{10} : 10 year low flow (cubic meters per second : cms)
$Q_{2.33}$: 2.33 year low flow (cubic meters per second : cms)

3. ESTIMATION OF MINIMUM REQUIRED FLOW AND DAM DISCHARGE

The current water quality status in the Keum River were surveyed with the water quality year book(The Ministry of Environment, 1991-1998). The water quality of Daecheong Dam upstream was 1-3 ㎎/ℓ of Biochemical Oxygen Demand (BOD). But the down stream of it was worse than 3 ㎎/ℓ of BOD.

The pollutant loads expected for the target years (1999, 2001, 2006, and 2011) to predict future water quality. Also using water quality models, we estimated the minimum required flow to satisfy the target water quality. The QUAL2E model(Brown and Barnwell, 1991) was used to estimate the minimum required flow to satisfy the target year water quality criteria for the case of irrigation and non-irrigation periods.

3.1 FIELD WORKS

The flow rate measurements and water quality analysis were carried 12 times from 1998 to 1999 for 26 stations to estimate delivery rate and calibrate, verify the reaction coefficient of the QUAL2E model. The water quality analysis items were pH, BOD,), NH3-N, NO2-N, NO3-N, PO4-P, Chloropyll-a, DO(Dissolved Oxygen), COD(Chemical Oxygen Demand), SS(Suspended Solid), TN(Total Nitrogen), TP(Total Phosphorus),

The Keum River Basin was divided to 27 sub-basins and 90 small-basins. And the sources of pollutants, population, livestock, land use, industrial waste, fishing and farming, were investigated. The pollutant loads of BOD, SS and TP at each sub-basin were estimated. The delivery pollution loads were estimated with discharge pollutant loads and delivery rates. The average delivery rates for BOD, SS and TN were 10.92%, 16.08%, 8.8% respectively.

3.2 MODEL COMPOSITION

The QUAL2E model was composed for the upstream of Daecheong Dam(from Yongdam Dam to Daecheong Dam) and down stream of Daecheong Dam respectively. For the main stem of upstream section was divided 9 reaches and the down stream of Daecheong Dam section divided 9 reaches too. The Gap stream, one of important tributaries of the Keum River, divide 3 reaches. The element in each channel reach was set to have a 1km interval. The schematic diagram of down stream section is Fig. 3.

The model calibration and verification were conducted with the measured data and National Water Quality Network data(Fig.4 and Fig.5). According to the calibration and verification result, the QUAL2E model were relatively accurate when compared to actual results.

3.3 ESTIMATION OF MINIMUM REQUIRED FLOW FOR EACH CHANNEL REACH

The Ministry of Environment(MOE) published the target water quality for each channel reach. According to the MOE, the target water quality for the section of Yongdam Dam to Daecheong Dam is class Ⅰ (less than 1 ㎎/ℓ based on BOD concentration), the down stream of Daecheong Dam is class Ⅰ-Ⅱ (less than 3 ㎎/ℓ), the Gap stream section is class Ⅱ-Ⅳ (less than 8 ㎎/ℓ). In the establishment of minimum required flow, the major water use was considered as dividing the target into the irrigation and non-irrigation seasons. The flow rates for the main stream was regarded as 2.33 year low flow and that was regarded two cases as 10 year low flow and 2.33 year low flow for the tributaries. When the result of the simulation does not meet the target water quality, the inflow from the upstream will be increased. The flow rate of the representative stations which satisfies the target water quality is the minimum required flow for the channel reach. The minimum required flow were estimated for irrigation and non-irrigation seasons.

The dam discharge considered two cases. One is that the water quality of dam outflow is target quality and the other is that the quality of dam discharge is current water quality status. The dam discharges to satisfy the flow rate of minimum required flow at the certain station also estimated for each cases of irrigation and non-irrigation season and current water quality and target water quality respectively. Table 2 and Table 3 shows the estimated minimum required flows and dam discharges for the case of all the tributary reaches have 2.33 year low flow and 10 year low flow for irrigation and non-irrigation period

In the non-irrigation seasons, the discharges of Yongdam Dam for 2006 and 2011 are estimated 20.7 and 26.2 cms respectively under the assumption of the flow rate condition is 2.33 year low flow. And those of Daecheong Dam are estimated 37.2 and 47 cms respectively.

For the upstream of Daecheong Dam(Okcheon station), the amount of discharges for water quality conservation in irrigation seasons are much more than those of non-irrigation seasons. However in the down stream of Daecheong dam, estimated Daecheong Dam discharges during the irrigation seasons are less than those of non-irrigation seasons. There are large cities with populations and industrial areas in the down

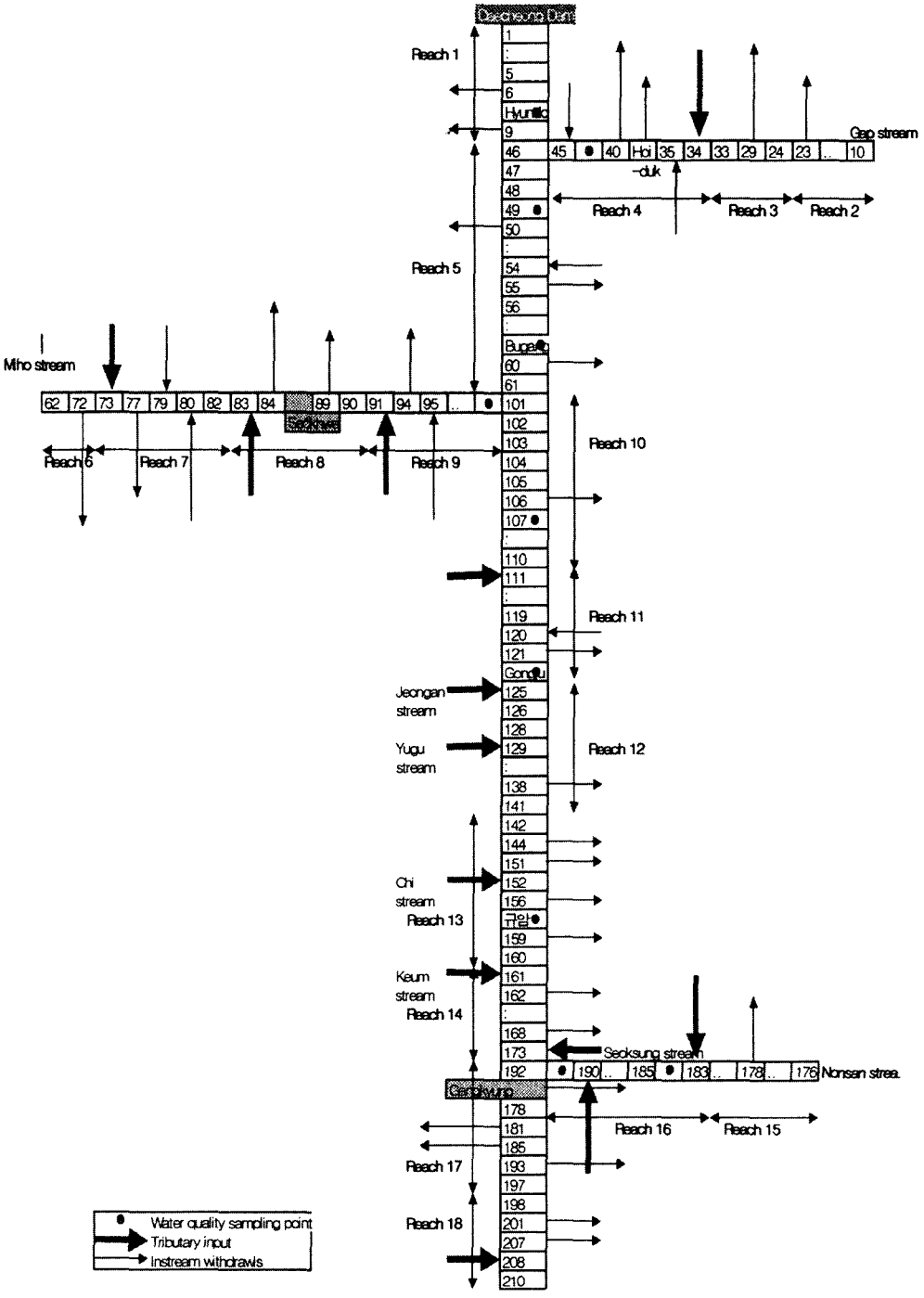


Fig 3. The Schematic Diagram of Model Composition (Down Stream of Daecheong Dam)
- Diagramme schématique de l'organisation du modèle (en aval du barrage de Daecheong)

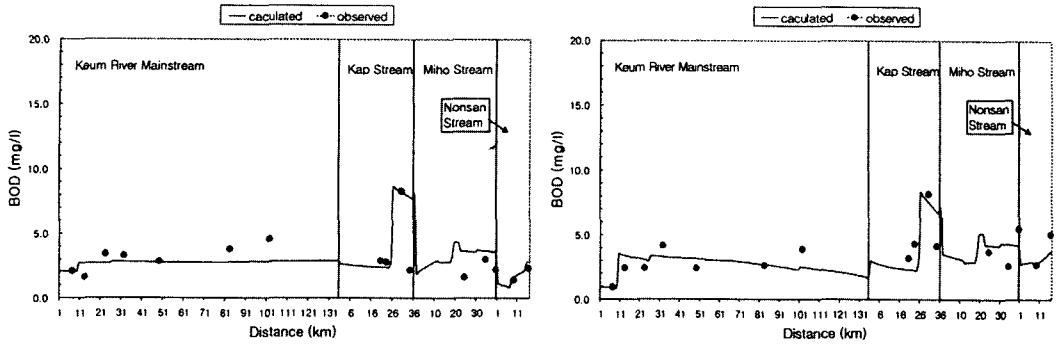


Fig 4. QUAL2E Model Calibration - Calibration par le modèle QUAL2E

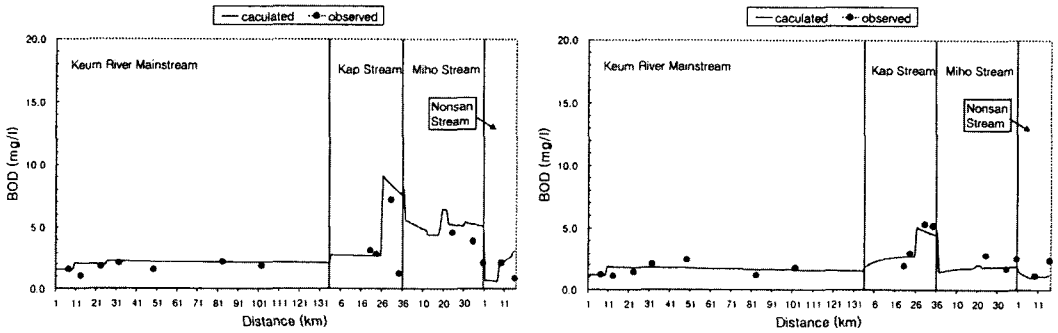


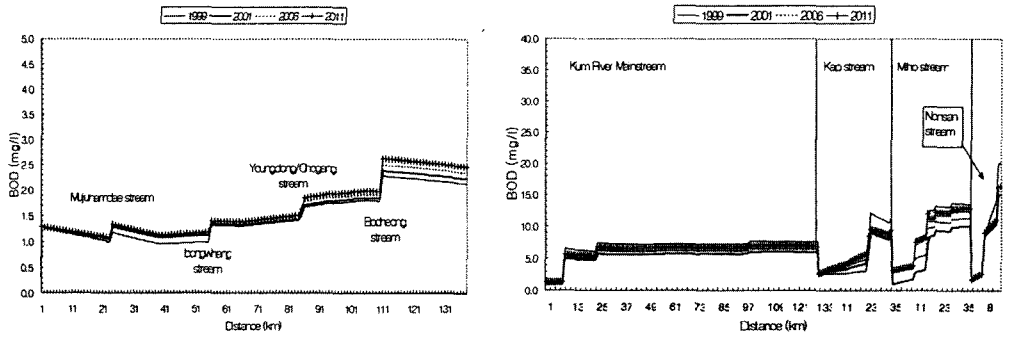
Fig 5. QUAL2E Model Verification - Vèrification du modèle QUAL2E

Table 2. Minimum Required Flow and Dam Discharge(Irrigation Season)
- Débit minimum requis et debit du barrage (en saison d'irrigation)

		Head Water	Target year	1999			2001			2006			2011		
			Station	Dam Dis. (cms)	BOD (mg/l)	station flow rate (cms)	Dam Dis.	BOD (mg/l)	station flow rate (cms)	Dam Dis. (cms)	BOD (mg/l)	station flow rate (cms)	Dam Dis. (cms)	BOD (mg/l)	station flow rate (cms)
Q10 for the tributaries	Ⅲ	Yongdam Dam	Okcheon	36.3	1.0	34.3	39.3	1.0	37.3	42.2	1.0	40.3	46.2	1.0	44.2
	Ⅵ	Daecheong Dam	Gongju	35.8	3.0	37.9	26.7	3.0	28.8	27.7	3.0	29.8	34.1	3.0	36.3
	Ⅶ	Daecheong Dam	Gyuam	39.4	3.0	35.9	30.2	3.0	26.7	31.5	3.0	28.1	37.8	3.0	34.4
Q2.33 for the tributaries	Ⅲ	Yongdam Dam	Okcheon	18.5	1.0	19.6	20.7	1.0	21.8	23.0	1.0	24.0	26.2	1.0	27.2
	Ⅵ	Daecheong Dam	Gongju	36.9	3.0	40.8	26.9	3.0	30.8	28.0	2.9	32.1	34.7	3.0	38.7
	Ⅶ	Daecheong Dam	Gyuam	37.2	3.0	37.0	27.5	3.0	27.4	28.7	3.0	28.6	35.0	3.0	35.0

Table 3 Minimum Required Flow and Dam Discharge(Non-irrigation Season)
- Débit minimum requis et débit du barrage (en saison de non-irrigation)

		Head Water	Target year	1999			2001			2006			2011		
			Station	Dam Dis. (cms)	BOD (mg/l)	station flow rate (cms)	Dam Dis.	BOD (mg/l)	station flow rate (cms)	Dam Dis. (cms)	BOD (mg/l)	station flow rate (cms)	Dam Dis. (cms)	BOD (mg/l)	station flow rate (cms)
Q10 for the tributaries	Ⅲ	Yongdam Dam	Okcheon	34.2	1.0	35.2	37.2	1.0	38.3	40.3	1.0	41.3	44.2	1.0	45.2
	Ⅵ	Daecheong Dam	Gongju	56.9	3.0	67.4	40.7	3.0	51.2	42.8	3.0	53.4	53.4	3.0	63.9
	Ⅶ	Daecheong Dam	Gyuam	59.1	3.0	69.2	43.2	3.0	53.4	45.4	3.0	55.6	55.7	3.0	66.0
Q2.33 for the tributaries	Ⅲ	Yongdam Dam	Okcheon	16.2	1.0	20.3	18.5	1.0	22.5	20.7	1.0	24.8	24.0	1.0	28.0
	Ⅵ	Daecheong Dam	Gongju	51.0	3.0	65.2	35.2	3.0	49.4	37.2	2.9	51.5	46.9	3.0	61.2
	Ⅶ	Daecheong Dam	Gyuam	51.0	3.0	66.3	35.2	3.0	50.5	37.2	3.0	52.5	47.0	3.0	62.3



a) up stream of Daecheong Dam
En amont du barrage de Daecheong

b) down stream of Daecheong Dam
En aval du barrage de Daecheong

Fig 6. Simulated Result of the QUAL2E Model - Résultat simulé du modele QUAL2E

stream of Daecheong Dam, especially the Gap and the Miho stream basin. Therefore in the non-irrigation season, the tributary comes to main stream with high concentration of BOD is much more than the irrigation season, and the pollutant loading to the Keum River become higher.

4. CONCLUSION

The planning approach for the water quality management in this study, might seem that the dam discharge is available for the water quality control of down stream.

The minimum dam releases, by the means of

water quality conservation for the down stream of two multi purpose dams in the Keum River, were estimated for various situations. At Gongju, one of major station for water management in the Keum River, the minimum required flows for 2006 and 2011 were estimated 51.5 and 61.2 cms respectively for non-irrigation seasons. Therefore the accordant dam discharges are determined as 37.2, 46.9 cms.

As the result of this study, the estimated dam discharges should be index for dam regulated water quality conservation for the Keum River.

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Summary

In recent years the human impact on the environment becomes increasing life threatening, calls for the better management of resources. In field of water quality of river flow, the best way to conserve water quality is specific efforts to control the pollutant loadings and treat the loadings in the basin to reduce the discharge of pollutant loadings to river. But in general the water quality influenced by the dam discharge. Especially in dry season, it is more dominant way to improve the water quality which contaminated with the pollutant loadings from the basin.

The dam discharge amounts of the 2 dams in the Keum River that maintain the down stream water quality were estimated for the year of 1999, 2001, 2006, 2011, in case of irrigation and non-irrigation seasons. The pollutant loadings for the basin are estimated with the planning of treatment plants construction schedule for every sub-basins. The river flow rates were considered low flow as 2.33 year low flow and 10 year low flow. The QUAL2E model was used as a tool of simulation

Résumé

Ces dernierès années, l'impact des realisations humaines sur l'environnement est devenu une crainte croissante et appelle a une meilleure gestion des resources .

Dans le domaine de la qualité des cours d'eau, le meilleur moyen de conserver la qualité de l'eau de définir les moyens de contrôle des charges polluantes et de traiter ces charges dans le bassin afin de réduire le debit de charges polluantes dans les riviéres.

Mais en général, la qualité de l'eau est influencée par le débit des barrages. Spécialement pendant la saison séche, c'est le moyen prédominant pour améliorer la qualité de l'eau qui est contaminée par les charges polluantes du bassin.

Les quantités de débit des deux barrages du fleuve Keum, qui maintiennent la qualité de l'eau en aval, ont été evaluées pour les années 1999, 2001, 2006, 2001, dans le contexte d'une saison d'irrigation et d'une saison de non-irrigation.

Les charges polluantes du bassin sont évaluées avec le programme de mesures des traitements pour tous les bassins inférieurs.

La quantité du débit a été calculée pour des débits faible sur 2,33 ans et sur 10 ans. Le modéle QUAL2E a été utilisé comme outil de simulation.