Nordic Hydrology, 15, 1984, 297-306

Simulation of Water Resources Development Projects in the Nam Kam Basin, Thailand

Paper presented at the Nordic Hydrological Conference
(Nyborg, Denmark, August – 1984)

M. Dyhr Nielsen and Børge Storm

Danish Hydraulic Institute, Hørsholm, Denmark

The Nam Kam basin is located in north east Thailand, discharging into the Mekong river. At present, a hydropower project has been constructed in the basin, and Nong Han, a natural lake, is regulated for fish-production purposes. In addition, four potential reservoir sites for irrigation projects have been identified.

The water availability resulting from various combinations of project developments has been analyzed by a simulation model.

Rainfall-runoff-models were calibrated on typical subcatchments. Based on 30 years of rainfall data, a long time series of natural inflow to the various project sites was simulated. Water level variations in the reservoirs were simulated based on inflows, reservoir losses and releases. A plant-soilwater model was developed for simulation of irrigation requirements of rice paddy and upland crops.

For various cropping alternatives, the total irrigation water availability for the basin was determined under the assumption that shortages may occur in one out of five years. The simulations formed the basis for a water master plan of the basin.

For the Lower Nam Kam Project, a detailed simulation of the operation of a 14,000 ha pump irrigation project was carried out. Based on 30 years of simulated data for inflow and irrigation requirements, pumping needs and power consumption of 4 irrigation pump stations and a feeder pump station at Mekong was determined. The results formed part of the basis for the feasibility study of the project.

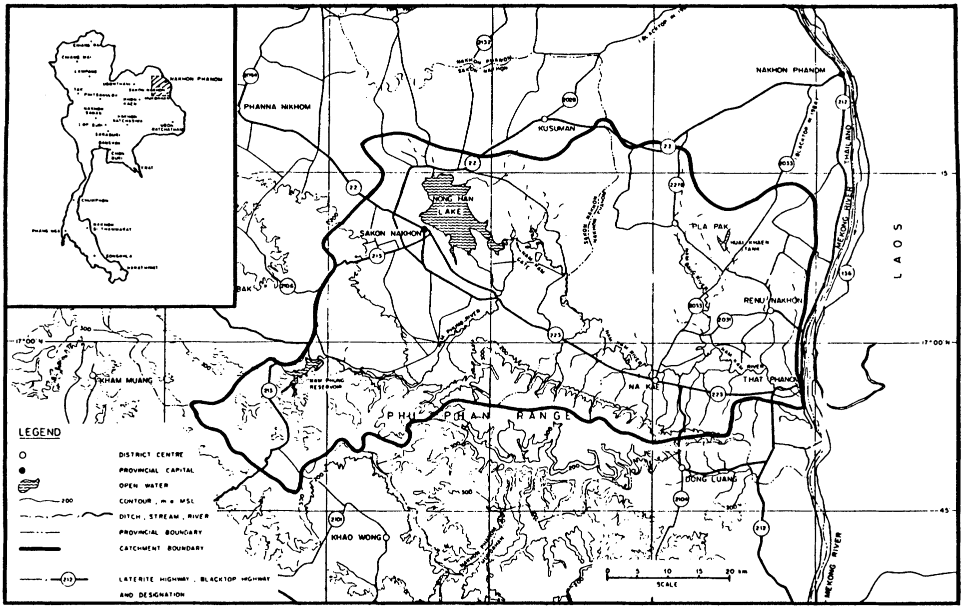

Fig. 1. The Nam Kam Basin.

The Nam Kam Basin

The Nam Kam basin is located in the north-eastern part of Thailand in the provinces of Sakhon Nakhon and Nakhon Phanom. It has a catchment area of 3,440 km^2 and enters the Mekong river at That Phanom.

The basin is located in the geological region named the Korat Plateau, formed by sedimentary mesozoic rocks. The southern boundary of the Nam Kam basin is formed by the Phu Phan Range, a low mountain range rising 300-500 m above the surrounding plains. North of the Phu Phans, the undisturbed Korat Plateau is forming a plain with flat or gently rolling topography. The major streams have cut valleys in the original surface, creating terraces at several levels around the streams.

In the north-western part of the basin, the Nong Han Lake is created in a large depression. Originally a swamp in the dry season, a permanent lake is now established by operation of the Nam Kam Gate at the outlet.

The main inflow to Nong Han originates from the Nam Phung River, which drains a catchment in the Phu Pan range. Downstream of the Nam Kam Gate, the Nam Kam River follows a very meandering course through an alluvial plain towards the Mekong. Its main tributary, the Nam Bang River drains the north-eastern part of the catchment.

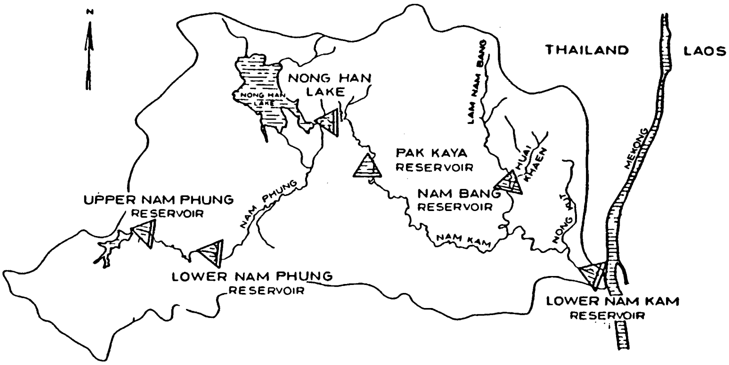

Fig. 2. Existing and potential reservoir sites.

The climate of the basin is characterized by two distinct monsoon seasons. The south-west monsoon carries substantial amounts of rainfall (1,400-1,600 mm/year) during the rainy season from May to October. The north-east monsoon of the dry season from November to April carries almost no precipitation, and it is not possible to raise crops during this period without irrigation.

In accordance with the seasonal variations in rainfall, the runoff regime is characterized by a flood season in July to September with large runoff. But due to a very low retention capacity of the basin, runoff becomes minimal in December-January, and most streams run dry from February till April.

The basin may be divided into two characteristic types of terrain:

- the Phu Phan foothills, characterized by steep slopes and covered by dense forest vegetation,
- the plains, characterized by small slopes covered with a mixture of paddy and uncultivated areas with low, open forest or bamboo and brushwood vegetation.

The hydrologic response of these two catchment types are quite different, and this difference has been accounted for in the hydrologic modelling.

Water Resources Projects in the Nam Kam Basin

The main purpose of water resources projects is provision of storage to cover water demand during the dry season. Fig. 2 shows the location of existing and potential future storage reservoirs in the basin.

Existing Projects

Upper Nam Phung Dam – The Upper Nam Phung Reservoir is used for storage for generation of hydropower. The reservoir is located on the Nam Phung and has a storage capacity of 155 mio. m^3. The average annual inflow is estimated at 67 mio. m^3. The power plant has a capacity of 3.15 MW.

Table 1 – Potential Projects in the Nam Kam Basin.

River	Name	Storage cap. mio m^3	Annual inflow mio. m^3
Nam Phung	Lower Nam Phung Res.	163	130
Nam Kam	Ban Pak Kaya Res.	51	520
Lam Nam Bang	Lam Nam Bang Res.	144	260
Nam Kam	Lower Nam Kam Res.	44	1,220

Nong Han Lake – The water level of the Nong Han Lake is controlled by the Nam Kam Gate. Releases are operated with the purpose of maximizing fish production in the lake. With the present operation, the storage volume of the lake amounts to 186 mio. m^3. The average annual inflow is 410 mio. m^3.

Potential Projects

Additional potential dam sites have been identified, ref. Table 1.

The main purpose of these reservoirs is to satisfy irrigation demand during the dry season. It has also been considered to change the present operation of Nong Han Lake, so that it will benefit irrigation demands downstream the Nam Kam Gate in the socalled Upper Nam Kam Project.

The Simulation Models

Hydrologic simulation models were developed to simulate the interaction between various development alternatives. Two main cases were considered:

- The overall water availability in the entire basin,
- Detailed simulation of the operation of the Lower Nam Kam Project.

Water Allocation in the Entire Basin

The overall allocation of the surface water resources of the basin was determined based on simulations of the runoff distribution of the basin. The Water Allocation Model (WAM) consisted of two submodels:

- a rainfall-runoff model to simulate 30 years of daily runoff at the project sites,
- a reservoir operation model to simulate storage changes, reservoir loses, flood-spills and irrigation releases.

Rainfall-Runoff Modelling – A traditional lumped rainfall-runoff model NAM (Nielsen and Hansen 1973) was calibrated on runoff observations representing respetively the Phu Phan foothills and the plains, ref. Fig. 3.

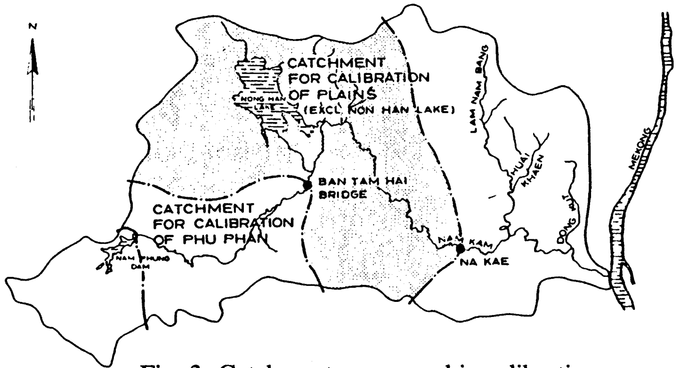

Fig. 3. Catchment areas used in calibration.

A result of a simulation of the Phu Phan catchment is shown in Fig. 4.

In most years, the deviation between simulated and observed annual runoff was below 10 per cent.

The model parameters revealed that the storage capacity in the root zone is significantly larger in the Phu Phans than in the paddy-plains. Furthermore, a

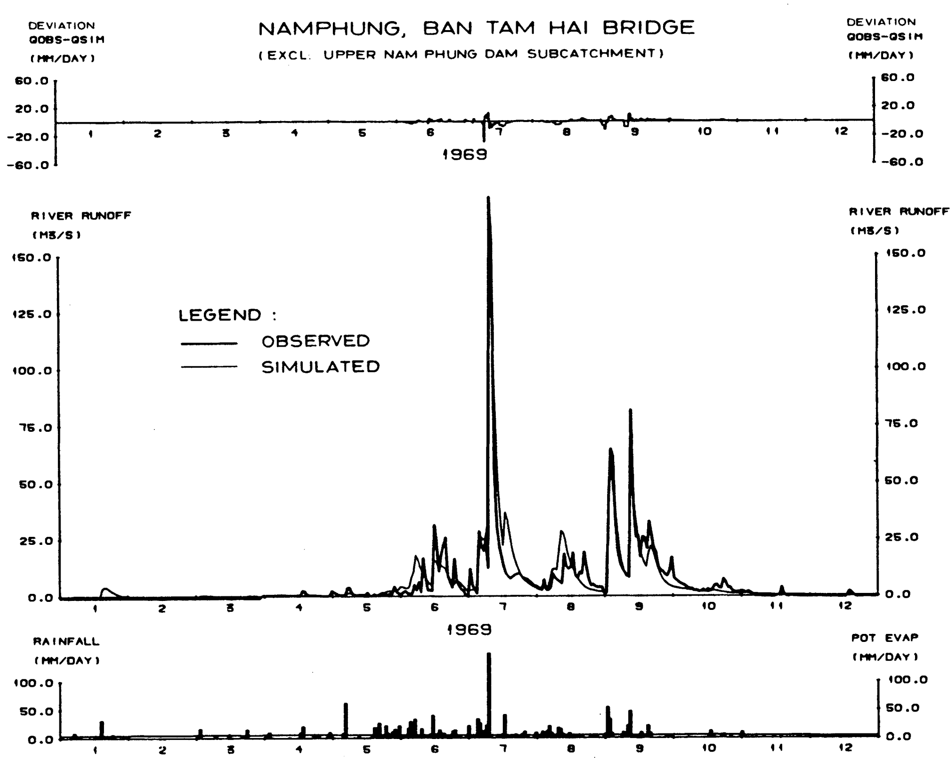

Fig. 4. Nam simulation of Phu Phan Catchment.

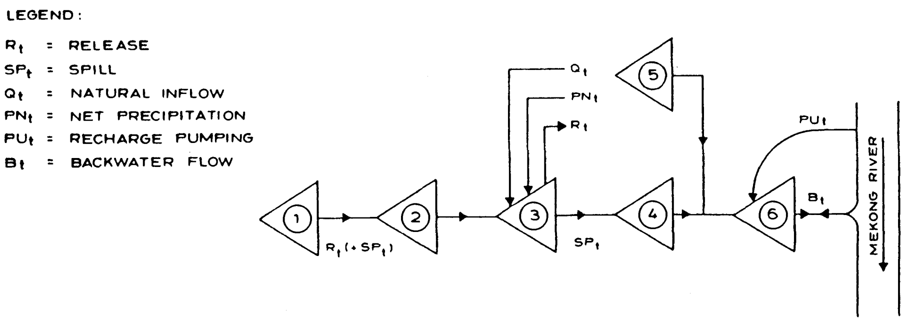

Fig. 5. Schematic illustration of reservoir system.

lower amount of surface runoff is experienced from the Phu Phans than from the plains, i.e. the plains react quicker to intensive rainfall.

The model parameters were assumed constant within each basin type but runoff simulations were performed for subbasins using the rainfall data in the subbasin. A test on newly collected data in the Lam Nam Bang supported the reliability of this approach.

Reservoir Modelling – A schematic illustration of the reservoir system is given in Fig. 5.

For each reservoir, variations in storage is calculated by a water balance over 10 days

$$S_t = S_{t-1} + Q_t + PN_t - R_t - SP_t + SPU_t$$

where

S_t – storage in reservoir after period t
Q_t – natural inflow, computed by NAM
PN_t – net rainfall on the reservoir
SP_t – spill from reservoir where the water level exceeds the maximum level of the reservoir
SPU_t – spill from upstream reservoirs
R_t – release for irrigation

The release R_t from a reservoir can be computed in two different ways. Either as a *specified* total yearly release, without consideration to the potential extreme water levels of the reservoir, or as an *optimized* yearly release. In the latter case, the optimization is subjected to a criterion of the maximum number of years, within the simulation period, during which the water level falls below a lower critical level, i.e. the reservoir falls below the outlet.

The total annual release is distributed over the year according to the seasonal variation in irrigation demand.

Table 2 – Annual net release (mio. m^3) from reservoirs in the Nam Kam Basin.

	Alternative				
	A	B	C	D	E
Lower Nam Phung Dam	120	–	–	–	120
Nong Han Lake	125	185	185	185	125
Ban Pak Kaya Res.	55	55	–	–	–
Lam Nam Bang Res.	140	140	140	–	–
Lower Nam Kam Res.	55	55	55	60	60
Total	495	435	380	245	305

The optimal release for a failure rate of say 1 out of 5 years (20 per cent) is determined by gradually increasing the release until 6 failures during the 30 year simulation period are experienced.

The annual net release from various alternatives is shown in Table 2.

It can be seen that with total development (alt. A) a total of 495 mio. m^3 may be released for irrigation. Omission of the Lower Nam Phung Dam (alt. B) increases the release from Nong Han Lake with 60 mio. m^3. Construction of dams at Ban Pak Kaya and in Lam Nam Bang (alt. B and C versus alt. D) has only a minor influence on the release from the Lower Nam Kam Reservoir. Alternative E corresponds to the final recommendation of the water master plan: development of Lower Nam Phung and Upper and Lower Nam Kam.

Simulation of Irrigation Withdrawal from Lower Nam Kam Reservoir

A schematic drawing of the Lower Nam Kam Project is given in Fig. 6.

The lower part of the Nam Kam is converted to a reservoir by construction of a barrage near the confluence with Mekong river. Irrigation water is pumped from the reservoir to the command areas through four pump stations. The reservoir can be recharged from the Mekong through an 11 m^3/s pump station.

In order to obtain a realistic assessment of the irrigation demand, a Field Water Balance model was used to identify water deficiencies and the associated irrigation need. The model was a modified version of a model presented by Hoskin et al. (1981).

The structure of the model is illustrated in Fig. 7.

Based on measured rainfall and evaporation data for the area, 10-day values of irrigation demands were simulated for a 30-year period. Provision was made for land preparation of rice paddy, and to simulate the gradual increase in planted area, a special staggering procedure was applied to transfer the in-field values to values related to the entire command area.

Return flows from the irrigated areas were added to the reservoir content. The return flow was estimated at 58 per cent of the total gross water requirement and

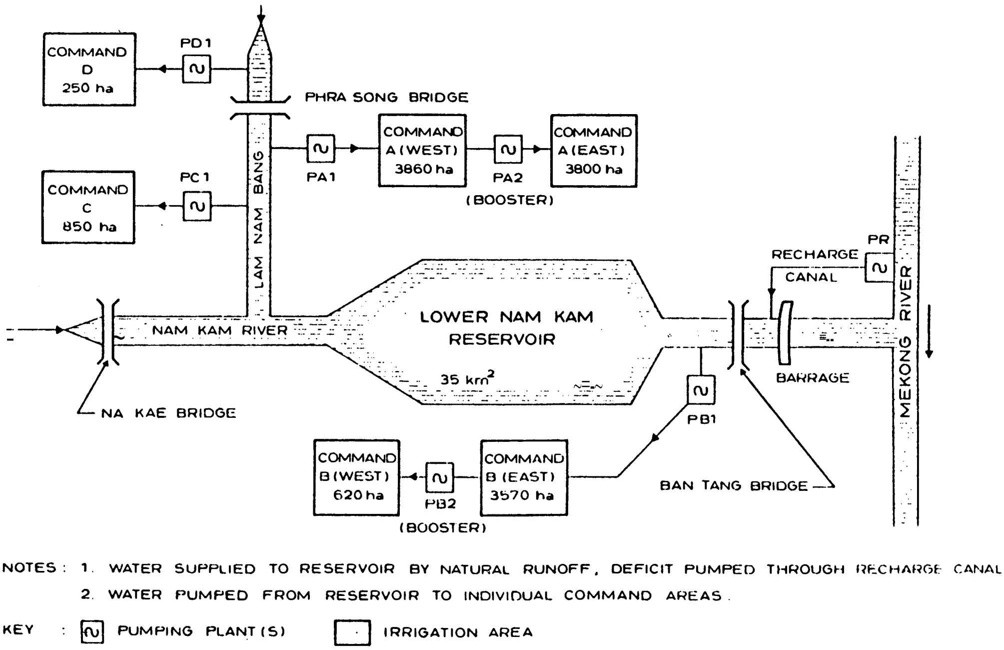

Fig. 6. Lower Nam Kam irrigation project.

contributes significantly to the water balance of the reservoir during the dry season.

Pumping from the Mekong was started when the reservoir level reached the minimum level.

The simulated water balance for the reservoir for the period 1952-81 is shown in

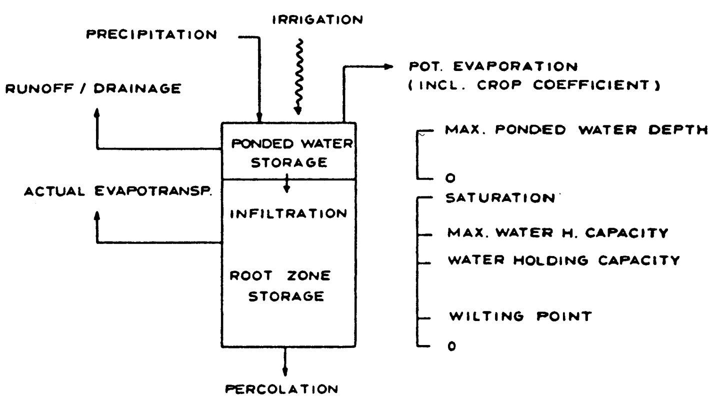

Fig. 7. Model structure of field water balance.

Table 3 – Water Balance for Lower Nam Kam Reservoir, mio. m^3.

Year	Inflow	Net Rain	Irrig. Demand	Return Flow	Spill to Mekong	Pumping from Mekong
52	922	1	149	86	892	10
53	751	2	164	95	706	22
54	1266	0	138	80	1220	12
55	108	–10	227	131	27	24
56	1041	1	166	96	991	18
57	642	–3	156	90	589	18
58	445	–7	163	95	395	22
59	320	–7	166	96	253	19
60	1399	7	141	82	1366	10
61	1866	11	146	85	1819	4
62	1611	7	161	93	1557	4
63	1373	5	182	106	1318	17
64	1270	3	130	75	1211	0
65	1172	1	146	85	1113	0
66	916	0	166	96	873	21
67	405	–10	168	97	355	30
68	435	–12	177	103	372	21
69	1176	2	150	87	1133	18
70	2057	9	134	78	2022	12
71	1559	3	132	77	1510	3
72	554	–5	168	97	502	23
73	539	–2	158	92	493	21
74	1938	3	158	92	1875	3
75	1614	10	148	86	1572	7
76	486	–3	173	100	426	16
77	484	–4	172	100	422	14
78	1340	4	152	88	1299	19
79	1728	13	169	98	1689	18
80	1242	–3	165	96	1179	9
81	1330	9	150	97	1294	18

Table 3. It has been assumed that a potential net release of 185 mio. m^3 from the Nong Han has been consumed by upstream projects.

The seasonal distribution of the pumping is illustrated in Table 4.

It is noticed that the average assumed pumping from the Mekong amounts to 14.5 mio. m^3, and that pumping is only necessary during the months of February through April. It appears, that only about 8 per cent of the potential releases from Nong Han may be used to replace the pumping from Mekong.

Table 4 – Simulated Pumping from the Mekong and the Reservoir.

Month	Mekong Pump Station		Total Pumping from Reservoir	
	Average	20% exceed.	Average	20% exceed.
1	0.00	0.00	20.90	21.40
2	2.54	5.00	26.90	29.50
3	10.06	17.66	25.00	29.70
4	1.86	4.96	8.20	13.30
5	0.00	0.00	0.20	0.40
6	0.00	0.00	2.20	5.20
7	0.00	0.00	6.30	15.00
8	0.00	0.00	6.10	12.50
9	0.00	0.00	9.00	20.80
10	0.00	0.00	27.20	37.60
11	0.00	0.00	15.10	15.40
12	0.00	0.00	12.00	12.10
Total	14.46	27.62	159.10	212.90

Acknowledgement

The work presented was part of a feasibility study for the Lower Nam Kam Irrigation Project, carried out for the Department of Technical and Economic Cooperation and Royal Irrigation Department, Thailand. The feasibility study was performed by GITEC CONSULT GmbH, Düsseldorf, Federal Republic of Germany in association with Danish Hydraulic Institute, Copenhagen, Denmark and National Engineering Consultants Co., Ltd., Bangkok, Thailand. The assistance by and discussions with staff of the involved parties is acknowledged.

References

GITEC/DHI/NECCO (1984) Lower Nam Kam Irrigation Project. Feasibility Report, Annex A, Climate and Hydrology, Bangkok, Thailand.

Hoskin, R.J., et al. (1981) Assessment of Rainfed Agriculture in North East Thailand. Asian Institute of Technology, Bangkok, Thailand.

Nielsen, S.A., and Hansen, E. (1973) Numerical Simulation of the Rainfall Runoff Process on a daily basis. *Nordic Hydrology, Vol. 4,* pp. 171-190.

Mekong Secretariate, 1980: Comprehensive Development of the Nam Kam Basin, Bangkok, Thailand.

Received: 1 October, 1984

Address: Danish Hydraulic Institute,
5 Agern Allé,
DK-2970 Hørsholm, Denmark.