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# Dam Pre-Release Strategy for TNB Dams in Sg Perak Hydroelectric Scheme

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**Keywords**

*Pre-release*
*Sg Perak*
*dam safety*
*TNB*
*Hydroelectric dam*

**Abstract**

The dam related disaster caused thousands of people's lives and billions of property damages in the world. In Malaysia, one case study of dam failure in Sungai Perak may result in the death of more than 10,000 and RM 1.25 Billion of property damages. The loss of life and property damages is mostly happened due to the lack of timely release of the water. In this research, we proposed a pre-release strategy for all TNB dams in Sg Perak Hydroelectric scheme. The pre-release of the reservoir water will prevent the floods in the nearby area of the dams. Two pilot case study is being shown and proved that applying pre-release strategy ensure the safety of the dams.



## 1. INTRODUCTION

Dam-reservoir systems play a crucial role for providing multiple services for the society, including water supply, irrigation, flood protection and hydropower generation worldwide, and East Asia is not an exception [1]–[3]. Hydropower production is a cleaner, renewable energy source, and it is one form of powering developing countries. In addition, dams contribute to achieve the established Sustainable Development Goals (SDGs), adopted by all United Nations Member States in 2015, providing resources and services to reduce poverty, improve health and well-being, and boosting economic growth, among others.

The most important part of a hydropower-generating dam is problem formulation which means representing all aspects of the reservoir/environmental process in mathematical expressions. The accuracy of the mathematical formulation is empathetic, and the parameters/variables involved in this formulation should be chosen with great care. However, every TNB owned dams are different and have their objectives, chased to gain by their operational method. As the inflow pattern is changing by adopting corrected PMF, an optimum "pre-release" from the dam could prepare the dam to sustain and minimize the flood hazards. Pre-release is the strategic release of water to actively manage the water level in a dam before forecast rainfall. The pre-release concept is introduced to a flood control dam. In this methodology, we would like to describe the "pre-release" strategy for Sg. Perak Hydroelectric Scheme. Pre-release has been practised by many countries [4]–[7]. In Melbourne Water, Australia, there are 16 dams and the authority continually observes the stability of the dams. They initiate reserved discharges of water from its dams when it is believed compulsory for dam safety purposes. Other members in South Gippsland Water, Australia delineate the operating rules and relevant measures related to the pre-release and extra discharge of dams during heavy rainfall events. On the other hand, Goulburn-Murray Water, Australia ensures that the pre-release would not cause any human-made flooding and there is no previous flooding downstream that would be impacted by the pre-release unprepared. In Orange-Fish-Sundays River Basin, South Africa, the authority minimizes the water loss and ensure that the irrigation demands were fulfilled. They use MIKE II software for model and simulation and propose multiple objectives of the simulation-optimization. However, none of them is the hydroelectric dam.

Figure 1 shows the schematic illustration of the dam cross-section. The basic concept of pre-release is based on controlling the dam level between minimum water level and maximum water level. Equation 1 shows the proposed scheme for the volume of water that needs to be discharged.

$$V_d = V_s - (Q_u + Q_r \tag{1}$$

where $V_d$ is the volume of water need to be discharged, $V_s$ is the new storage volume and $Q_u$ and $Q_r$ is the forecast inflow from upper dam and runoff respectively. It is vital to ensure that the water level in the dam is maintained at least the minimum required level so as not to affect the operational requirement of the electricity generation.

In this paper, a concept is proposed to identify the optimized dam pre-release strategy that can be implemented at four reservoirs of Sg. Perak Hydroelectric Scheme. The

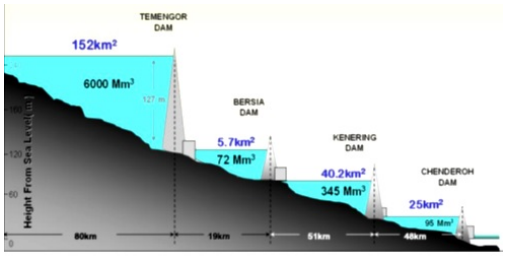


**Figure 1.** Advisable DAM Operations in Sg Perak Hydroelectric Scheme

research will develop and implement the dam pre-release strategy for reservoirs in Sg. Perak and will revise and simulate the sufficient triggering level for Temengor and Kenyir Dam and the time of evacuation for the Emergency Action Plan (EAP) efficiency. On this process, the concept will eventually help to establish the new dam pre-release management system as non-structural alternatives in maintaining and monitoring the water level of TNB dams.

## 2. METHODOLOGY

The general optimization procedure consists of both statistical and hydrological measures to assess the performance of the model. The simulation will be done by feeding the historical inflow data to the system. The concept of the pre-release is given in the following diagram-

As depicted in Figure 2, the pre-release of the reservoir will be estimated from two considerations- Inflow from any pre-released water of the current reservoir and the natural flow due to rain and overland flow from surroundings. Depending on the revised PMF, the model will suggest an optimum release that should able to balance the storage constraints and the downstream scenarios. The model will also simulate the consequences of the pre-release water and will provide a clear understanding to minimize flood hazards due to a pre-release decision.

The objectives of the model can be derived from the following considerations-

- Maximizing: Hydropower generation
  - Subjected to the release amount ($R$) and the capacity to the water flow to the turbine is shown in Equation (2).

$$R_{max} < R_{turbine} < R_{max}, \quad R \in \text{power generation} \tag{2}$$

- Minimizing: water deficit
  - Subjected to the current storage capacity ($S$) and required amount at the downstream is described in Equation (3).

$$S_{max} < S_{reservoir} < S_{min} \tag{3}$$

- Minimizing: Flood risk
  - Subjected to the current storage capacity and probable maximum flood

To find out the overall best-suited optimization technique in the reservoir operation, two different types of reservoir data were examined as a Pilot Case study. Firstly, we created the release curves for a simple and comparatively small single reservoir – Klang Gates Dam (KGD) located in Malaysia. Secondly, Aswan High Dam (AHD) of Egypt is chosen for the case study, which is complex in terms of operation and relatively larger than KGD incapacity [8], [9]. The Monthly inflow states and water demands of both these dams are shown in Table 1.

The characteristics of the pre-release strategy on those dams imply that by applying pre-release in Sg. Perak Hydroelectric Scheme, this research will identify the logical expressions concerning the decision to release water. For example, for the high and medium inflow categories, the release curves will prove that can meet the demand line for low storage amounts, as there is adequate water available to release from the inflow. However, if the storage capacity increases, the suggested releases will be more likely to meet the demand. Finally, for extreme storage conditions, the research will suggest that more than demand is released to keep the storage levels in safe ranges. Consequently, for the lower inflow situation, the pre-release strategy will show that the reservoir is unable to produce adequate water for demand, and the water shortage may happen. In this paper, some constraints and parameters of this pre-release strategy are discussed.

## 3. RESULTS AND DISCUSSION

In Perak, there are four cascading hydroelectric dams, as shown in Figure 1, comprise of Temengor Dam, Bersia Dam, Kenering Dam and Chenderoh dam. It is naturally expected that TNB's procedure for releasing water is based on electricity demand; as their primary service is providing electricity for industrials and also domestic uses. Thus, for a hydroelectric dam, among the vital criteria that need to be considered in optimizing this concept are the dam level and dam discharge. For the hydroelectric dam, these two parameters are crucial because every drop of water that the dam releases is crucial for their operation. The dam cannot merely discharge water without proper planning ahead. Figure 3 shows the basic concept of how the pre-release would work.

The overall process is shown in Figure 4. The process for the general pre-release strategy is as follows:

1. Based on the Inflow data, reservoir routing needs to be done using traditional numerical methods. However, needs to check the accuracy with the existing flow record before application. Based on the reservoir routing the outflow is measured, which is the inflow to the dam as well.
2. For cascading reservoirs such as in Sg Perak Hydroelectric scheme, we need to add on the pre-release strategy that includes:
   a. Preparing the downstream dams to receive water from upstream

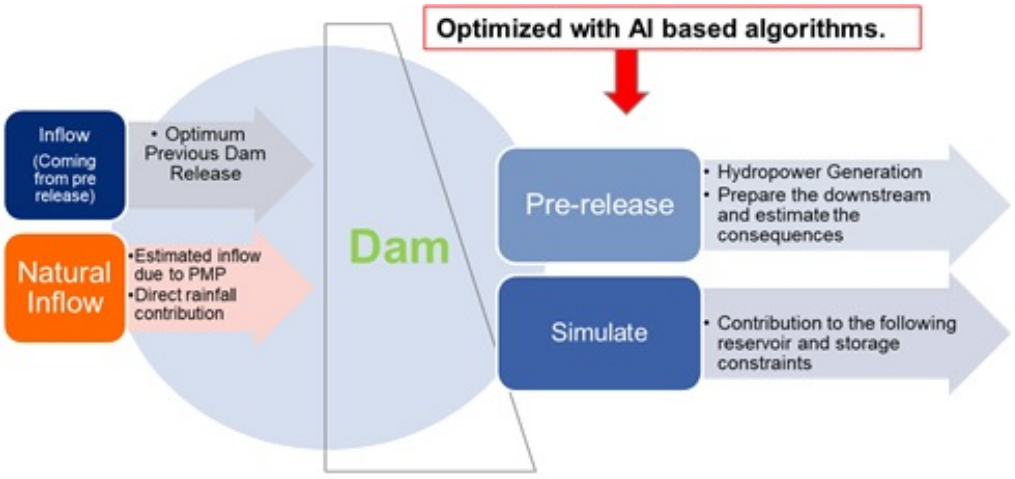


**Figure 2.** Pre-release concept

**Table 1.** Monthly inflow states and water demands

| | Case study 1: KGD (in MG) | | | | Case study 2: AHD (in BCM) | | | |
|---|---|---|---|---|---|---|---|---|
| | High | Medium | Low | Demand | High | Medium | Low | Demand |
| January | 1,506.89 | 760.85 | 123.12 | 1,298.64 | 4.8 | 3.15 | 1.9 | 3.5 |
| February | 1,901.08 | 1,024.49 | 259.34 | 1,083.09 | 3.7 | 1.95 | 0.8 | 3.8 |
| March | 2,831.7 | 1,646.31 | 923.24 | 1,152.45 | 3.5 | 1.7 | 0.55 | 4.4 |
| April | 2,919.74 | 1,959.92 | 764.88 | 1,173 | 2.7 | 1.15 | 0.3 | 4.1 |
| May | 2,974.2 | 1,786.87 | 938.31 | 1,198.73 | 2.5 | 1.35 | 0.65 | 5.1 |
| June | 2,825.69 | 1,355.22 | 447.97 | 1,271.73 | 2.8 | 1.65 | 0.9 | 6.3 |
| July | 2,717.32 | 1,618.95 | 645.61 | 1,258.14 | 7.7 | 4.75 | 2.8 | 6.8 |
| August | 2,948.26 | 1,644.53 | 816.78 | 1,206.41 | 27.5 | 20.4 | 15.05 | 5.9 |
| September | 3,368.12 | 1,859.86 | 631.15 | 1,160.05 | 31 | 24.05 | 18.55 | 4.5 |
| October | 3,545.83 | 2,316.13 | 654.35 | 1,204.14 | 21.2 | 15.6 | 11.3 | 3.9 |
| November | 3,838.47 | 2,342.89 | 1,021.79 | 1,213.09 | 10.9 | 7.3 | 4.75 | 3.8 |
| December | 2,699.3 | 1,455.7 | 340.69 | 1,290.59 | 6.5 | 4.3 | 2.7 | 3.7 |

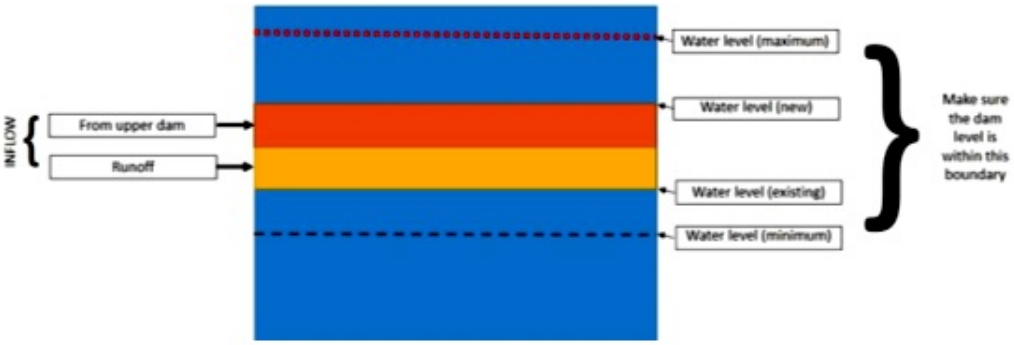


**Figure 3.** Conceptual Framework of Pre-Release

b. Optimized the release and continuity check.
c. Establish the relation between the reservoir.

3. The volume of water to be pre-released need to establish the strategy such as
   a. Maximize the hydropower release, which can be done using Artificial Intelligence methods.
   b. Flood protection enhancement
   c. Optimized hydropower generation as well as reservoir operation.

The Optimization model can be generalized as follows.

*Objective function:* Hydropower operations aim to maximize total hydroelectric generation by making the best use of hydro resources over a specific scheduling duration. The Objective function can be equivalently expressed using Equation (4).

$$\begin{cases} F = \max \sum_{t=1}^{n} \sum_{i=i}^{4} N_{i,t} \Delta t \\ N_{i,t} = \sigma H_{i,t} R_{i,t} \end{cases} \quad (4)$$

where $F$ denotes hydropower generation of hydro units over a scheduling period $n$; $m$ is the total number of cascaded

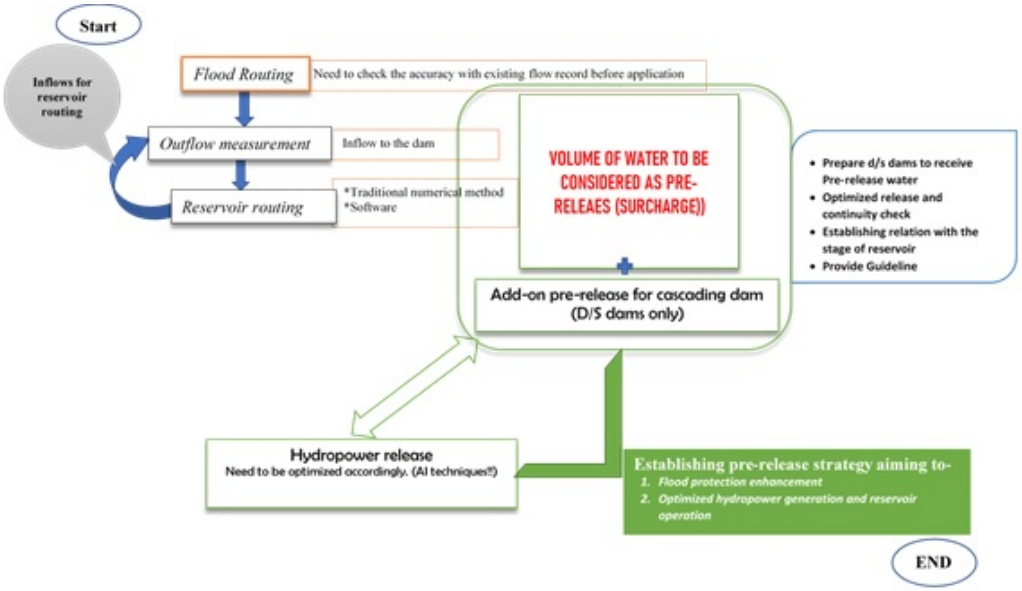


**Figure 4.** The pre-release process flow

hydropower plants under consideration; $N_{i,t}$ is the power corresponding to plant $i$ during period $t$, which is the decision variable of the model; $\Delta t$ is the short time interval; $H_{i,t}$ is the hydraulic head of plant $i$ during period $t$; $R_{i,t}$ is the release passing turbines of the hydropower plant $i$ during period $t$; $\sigma$ represents the power coefficient.

*Constraints:* Power constraints of stations are expressed using Equation (5).

$$N_{i,tmin} \leq N_{i,t} \geq N_{i,tmax} \quad i = 1 \text{ to } 4 \tag{5}$$

where $N_{i,tmin}$ and $N_{i,tmax}$ are the upper limits and lower limits of power for plant $i$ during period $t$ respectively.

This research aims to propose a pre-release strategy for all TNB dams in Sg Perak Hydroelectric project. Therefore, to prove the concept, two pilot case studies are shown in this paper. The concept for implementing the pre-release strategy for hydropower dams in Sg Perak is critical to ensure the dam safety as well as to protect the community near the TNB dams.

## 4. CONCLUSION

In this proposed research project, the application of a pre-release strategy for dam safety management will be done. An optimize dam pre-release strategy for all reservoirs in Sg. Perak Hydroelectric Scheme will be implemented to determine the triggering levels and flood arrival time for Sg Perak Hydroelectric scheme. The revised triggering level will help on developing the flood hazard maps based on 100 and 1000-year ARIs and triggering levels for EAP. The research will integrate all information on the dam in a secure and smart data management platform owned by TNB. Finally, this research will boost the innovation in not only through models, engineering solutions and technologies but also in terms of policies and efficient and effective decision-making.

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