Hydrological assessment for mini hydropower potential at Sungai Pahang @ Temerloh

L M Sidek, A Z A Zaki, Z Mustaffa, M I H Ibrahim, Z C Muda, S Thiruchelvam and H Basri
1 Centre for Sustainable Technology and Environment, College of Engineering, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, 43000 Kajang, Selangor, Malaysia
2 ZHL Engineers Sdn Bhd, No 16A, 2nd Floor, Jalan Diplomatik 2/1 Presint Diplomatik 15, 62502 Putrajaya
E-mail: lariyah@uniten.edu.my

Abstract. Sg Pahang at Temerloh was considered for assessment of hydropower potential using hydrological analysis method and hydrological model. The available data related to topography, soil, land use, weather and discharge pertaining to the study catchment were used to characterize the catchment. The characterization was required for water resources hence hydropower assessment. The hydrology of the study catchment was simulated through the model. This hydrological study is required due to the proposed mini hydroelectric power plant at Pulau Temerloh. It is essential to evaluate the existing river flow characteristic and to model the environmental flow assessment of the river. Two rainfall stations, JPS Temerloh and Pintu Kawalan Paya Kertam Station are selected to develop the Rainfall Intensity Duration frequency (RIDF) Curve to determine the rainfall intensity of the area. Daily river flow were recorded at Sg Pahang at Temerloh and Sg Pahang at Lubok Paku were used to develop the Flow Duration Curve (FDC) to study the characteristic of Sungai Pahang flow. The 7 days low flow with 10 years return period (7Q10 low flow) was obtained using both Gumbel Method and Log Pearson Type III Method. The results from FDC shows that 50% percentage of time the Sg Pahang @ Temerloh is exceeded over a historical period is 400 m$^3$/s and 50% percentage of time the Sg Pahang @ Lubok Paku is exceeded over a historical period is 650 m$^3$/s. The required environmental flow are set to be 7Q10 low flow which is 64.215 m$^3$/s for Sg Pahang at Temerloh and 79.24 m$^3$/s for Sg Pahang at Lubok Paku. The results show the water resources are abundant and hence boost the mini hydropower potentiality at Sg Pahang.

1. Introduction
Hydropower is a clean, renewable and reliable energy source that serves national environmental and energy policy objectives. It is one of the most important renewable sources for production of electric power due to several obvious reasons. It is renewable in nature, unlike wind, supply variability within shorter time period is less and most importantly green house gas (GHG) emission is least. It is derived from the falling water, either from rivers and streams flowing downhill along the river course due to force of gravity. Harnessing the kinetic energy from the flowing water for driving turbine generates hydropower [1].

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This study was conducted as requirement prior to construction of Mini Hydroelectric Power Plant at Pulau Temerloh, Pahang. The planning plays important role in the growth and development of hydropower. The amount of achievable hydropower at any given site is a function of turbine head and the corresponding flow rate. Thus, harnessing hydroenergy requires assessment of the water resource which depends upon the natural processes occurring locally and also the terrain characteristics. Accurate and reliable assessment of water resources leads to successful planning. One of the factors that must be considered when planning the construction of mini hydroelectric power plant is the amount of flow needed to make sure full hydropower electric can be supplied at all time with the consideration to the minimum river flow needed to sustain the ecosystem of aquatic life. In this sense, the study of the flow characteristic of the Sg Pahang is essential especially during dry time where water level is at its minimum. Hydrological methodology relies mostly on the past recorded data of river flow. The flow duration curve provides information about the percentage of time or days that a particular stream flow was exceeded over some historical period. It has long been used as a way of summarizing catchments hydrologic responses, but more recently these curves have been used to validate the output of hydrologic models and compare the observed and modeled hydrologic responses.

Apart from analysis of Flow Duration Curve, low flow analysis was conducted using 7Q10 or 7 days low flow with 10 years return period. This analysis are required for protecting or regulate water quality, serves as general indicator of prevalent drought conditions which is normally cover large area and finding total maximum daily load to assess aquatic life protection. The low flow analysis is able to find minimum quantity of stream flow that are necessary to protect habitat during drought situation, to be considered as the worst case scenario in water quality and lastly to compare the impact of climate change and irrigation on low surface stream flow [2].

2. Methodology
For the purpose of this study, there are several data that must be obtained, which includes the historical rainfall data, historical stream flow data, annual 7 days low flow and the water quality data of Sungai Pahang. Two rainfall stations and two stream flow stations were selected for this study.

The selection criteria of the hydrological stations are to have more than 20 years of historical data. The historical rainfall data will be used to develop Intensity Duration Frequency (IDF) Curve. An IDF Curve is a tool that characterizes an area’s design rainfall intensity. A Flow Duration Curve (FDC) will be developed using the stream flow historical data. FDC is a plot that shows the percentage of time that flow in a stream is likely to equal or exceed some specified value of interest. Meanwhile, low flow analysis will be conducted using analytical method i.e. Gumbel’s Method and Log Pearson Type III Method and graphical method using Plotting position method.

3. Results and Discussions
The IDF curve for rainfall station located at JPS Temerloh and Pintu Kawalan Paya Kertam was developed for 2, 5, 10, 20, 50 and 100 years ARI as shown in Figure 1. A similar trend was observed, where the rainfall intensity is decreased over time at both stations. Therefore, it can conclude that heavy storm only hit a short time, but minimal storm can go on for long periods. Apart from that, another observation that can can deduced from the IDF curve is that frequency and intensity are related, as rarer rainfall events (greater ARI) tend to have higher rainfall intensity for a given duration.

Flow Duration Curve (FDC) provides information on water availability in the river. The median flow (Q50) is the discharges which is equalled or exceed 50% of the time. The part of the curve with flow below the median flow represents low-flow conditions. The flow duration curves that are constructed for Sg Pahang at Temerloh and Sg Pahang at Lubok Paku will be used to show the percentage of time that flow in the river is likely to equal or exceed some specified value of interest.
The daily river flow value was analysed from as early as 1963 up to 2011 and the maximum flow, $Q$ (m$^3$/s) recorded was 6563.4 m$^3$/s while minimum flow was 19.0 m$^3$/s and mean flow is 542.8 m$^3$/s. A flow duration curve for Sungai Pahang at Temerloh is shown in Figure 2.

Table 1 tabulated the 7-days low flow estimates for Sg Pahang at Temerloh and Sg Pahang at Lubok Paku respectively using both Gumbel Method and Log Pearson Type III Method. The average low flow values are obtained by taking the average from Gumbel Graph Plotting and Log Pearson Type III Graph Plotting.

For this study, the 7 day low flow for 10 years return period (7Q10) is used as design criteria to define the environmental low flow condition of the Sg Pahang. Therefore, the values of 7Q10 low flow to be adopted in the environmental low flow assessment for Sg Pahang at Temerloh is 64.2 m$^3$/s while for Sg Pahang at Lubok Paku is 79.2 m$^3$/s.
Water quality data for Sg Pahang which includes parameters such as Dissolve Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), pH, NH₃NL and Pb are obtained from the Department of Environmental, Malaysia. Table 2 shows the DO, BOD, COD and TSS concentration for Sg Pahang at Temerloh and Sg Pahang at Lubok Paku respectively. Result shows that DO, BOD and COD are classified as Class II according to Interim National Water Quality Standard (INWQS). TSS and pH on the other hand, are categorized as Class III and Class I respectively. The estimated loading was computed by multiplying the value of DO, BOD, COD and TSS with the 7Q10 low flow as shown in Table 2.

| Value (mg/L) | Sg. Pahang at Temerloh | Sg. Pahang at Lubok Paku |
|-------------|------------------------|-------------------------|
| DO          | 6.74                   | 6.72                    |
| BOD         | 2                      | 3                       |
| COD         | 13                     | 16                      |
| TSS         | 105                    | 141                     |
| 7Q10 Low Flow (m³/s) | 64.215              | 79.24                   |
| Estimated Loading (mg/s) | 432,809             | 532,492                 |

Table 2. Environmental Flow Assessments based on DO, BOD, COD and TSS under 7Q10 Low Flow for Sg Pahang at Temerloh and Lubok Paku

4. Conclusions
Traditionally the water resources assessment is made using historically observed discharged data at outlet of the catchment. In the present study, the available hydrological data were analysed using various hydrological method to assess water resources and hence hydropower potentiality. The developments of the Flow Duration Curves have enabled the study of flow characteristic of Sungai Pahang both at Temerloh area and Lubok Paku area. In the environmental flow assessment, the 7Q10 low flow value of 64.215 m³/s was chosen as the recommended environmental flow for Sungai Pahang at Temerloh. This low flow value is set as the standard where the river flow must not be lower than this value for the benefits of those who very much depend of the river such as the aquatic life. The result of the hydrological study in Sg Pahang is anticipated to boost the current initiative of mini hydropower production in this region considering untapped vast water resources of Sg Pahang.

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