# Assessment of Reservoir Lifetime after Sediment Flushing - A Case Study of Wlingi Reservoir, Indonesia -

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## INTRODUCTION

Sedimentation is one of the main problem of reservoirs in Brantas basin. Wlingi reservoir, built in 1977 has a catchment area of 2,890 km$^2$ of southern slope of Mt. Kelud. After the eruption of Mt. Kelud in 1990, the reservoir has been suffering from sediment inflows of volcanic materials about 1.3 x 10$^6$ m$^3$/year. Meanwhile, the useful life gets reduced by about 60%. To restore its original effective storage (5.2 x 10$^6$ m$^3$), the authority (Jasa Tirta-1) has regularly been conducting sediment removal by dredging and flushing with releasing sediment through the spillway gates. This study explores how to asses the reservoir lifetime due to flushing as well as to determine the next flushing period.

## DATA AND METHOD

The recent resevoir bathymetry data was collected through echo-sounding survey (Figure 1) before and after flushing event (2015-2016). The GIS technique was used to analyse the flushed sediment. The useful life may be computed by determining the number of years required for each incremental loss of reservoir capacity using the relation between trap efficiency of reservoir versus capacity-inflow ratio.

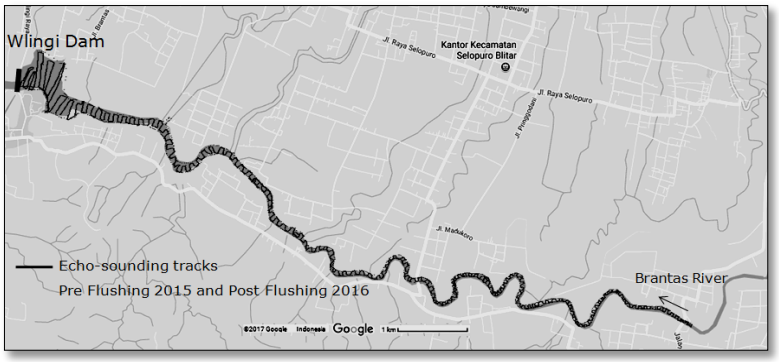


**Figure 1**. Scatter of echo-sounding data of pre and post flushing, 2016

## RESULT

In Figure 2, result from the bathymetry analysis, the volume of flushed sediment was about 1.02 x 10$^6$ m$^3$ during a single flushing event and the depth of eroded sediment varied up to 3 meter.

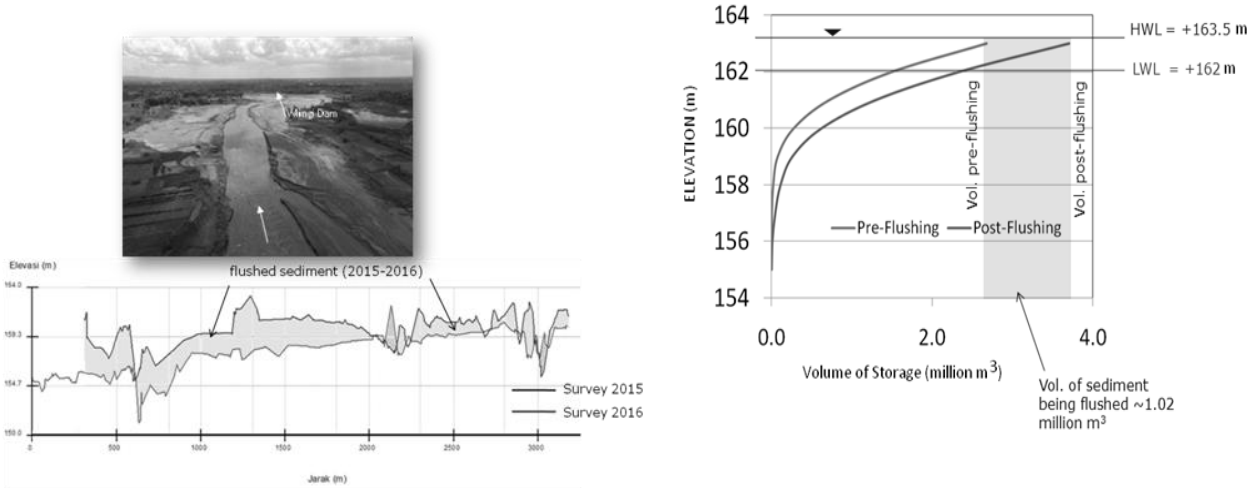


**Figure 2**. Longitudional profile of pre and post flushing event, 2016

By assuming the constant inflow of sediment then it takes 2.78 years to fullfill its dead storage (Table 1). It can be thus concluded that the next flushing event should be carried out every 2 years.

**Tab. 1** Estimation of reservoir lifetime after flushing

| No | Capacity ($10^6$ m$^3$) | $\Delta_C$ ($10^6$ m$^3$) | Cum ($10^6$ | C/I - | Trap Efficiency (%) Brune's | Average | Vol. ($10^6$ m$^3$) | Period (year) | Cumulative (year) | Type of Storage |
|---|---|---|---|---|---|---|---|---|---|---|
| [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | |
| 1 | 3.70 | 0.00 | 0.00 | 0.0010 | 98.69 | | | | | |
| 2 | 3.45 | 0.25 | 0.25 | 0.0009 | 98.69 | 98.69 | 1.00666 | 0.248 | 0.248 | Efective |
| 3 | 3.20 | 0.25 | 0.50 | 0.0009 | 98.69 | 98.69 | 1.00664 | 0.248 | 0.497 | |
| 4 | 2.95 | 0.25 | 0.75 | 0.0008 | 98.69 | 98.69 | 1.00664 | 0.248 | 0.745 | |
| 5 | 2.70 | 0.25 | 1.00 | 0.0007 | 98.69 | 98.69 | 1.00664 | 0.248 | 0.993 | |
| 6 | 2.45 | 0.25 | 1.25 | 0.0007 | 98.69 | 98.69 | 1.00664 | 0.248 | 1.242 | |
| 7 | 2.35 | 0.10 | 1.35 | 0.0006 | 98.69 | 98.69 | 1.00664 | 0.099 | 1.341 | Dead |
| 8 | 1.75 | 0.60 | 1.95 | 0.0005 | 98.69 | 98.69 | 1.00664 | 0.596 | 1.937 | |
| 9 | 1.15 | 0.60 | 2.55 | 0.0003 | 98.69 | 98.69 | 1.00664 | 0.596 | 2.533 | |
| 10 | 0.55 | 0.60 | 3.15 | 0.0002 | 98.69 | 98.69 | 1.00664 | 0.596 | 3.129 | |
| 11 | 0.05 | 0.50 | 3.65 | 0.0000 | 0.00 | 49.35 | 0.50332 | 0.993 | 4.123 | |

Lifetime 2.78 year

Note :

[1] = No.
[2] = Reservoir capacity ( C )
[3] = Reduced in capacity (trial)
[4] = $(3)_n+(3)_{n+1}$
[5] = Capacity Inflow Ratio = C/I = [3]/[4]
[6] = Modified Brune Trap Efficiency
[7] = $((6)_n+(6)_{n+1})/2$
[8] = [7]*Qs/100
[9] = [8]/[3]
[10] = (9)n+(9)n+1

Initial Gross capacity, HWL = 3.70 Million m$^3$
Dead Storage Capacity, LWL = 2.34 Million m$^3$
Annual Inflow discharge, I = 3,647 Million m$^3$
Annual Sediment Inflow, Qs = 1.02 Million m$^3$

## CONCLUSIONS

Flushing and excavation practices are now being considered as an effective way to remove part of the sediment build-up in Wlingi reservoir. Here, we have estimated the volume of flushed sediments in Wlingi reservoir. Sediment flushing in Wlingi reservoir could significantly recover its capacity and prolong the lifetime for about 2.78 year. Result of this study suggests that sediment flushing should be practically implemented on Wlingi reservoir every two years.

**Keywords**: sediment flushing, reservoir lifetime, deposition, distribution