Module 6, Operational Water Management, Real-time control of water systems
Assignment PID controllers, by Leonardo Alfonso

Objective: To apply the principles of PID controllers in a water system and identify the effects of each PID term.
Mark: This assignment corresponds to the 30% of the assignments part of OWM.
Submission type and deadline: Upload your report in PDF format via eCampusxl no later than Friday 20 March at 18:00.
Questions: Check dates and times in the slides of the first session.

Description:

Consider a reservoir with an area of 10.0 km^2 that is fed by a river, with a given input discharge Q_{inp} that changes in time. The reservoir serves various users with different requirements, who agreed (after a long consultation process) on having a water level setpoint of 3.5m. They are willing to allow for some fluctuation, as long as the water level is within the drought (3.2m) and flood (4.5m) levels (Figure 1).

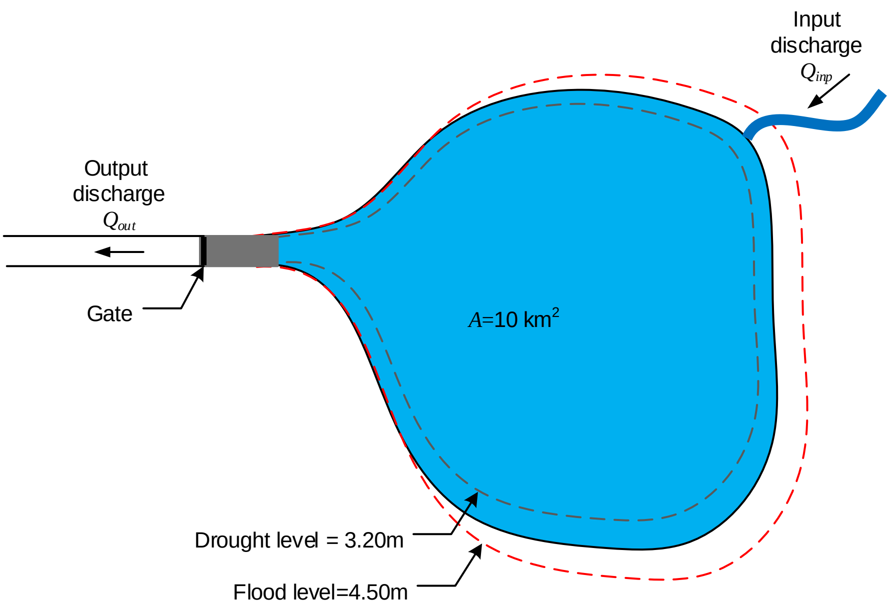


Figure 1. Plan view of the reservoir

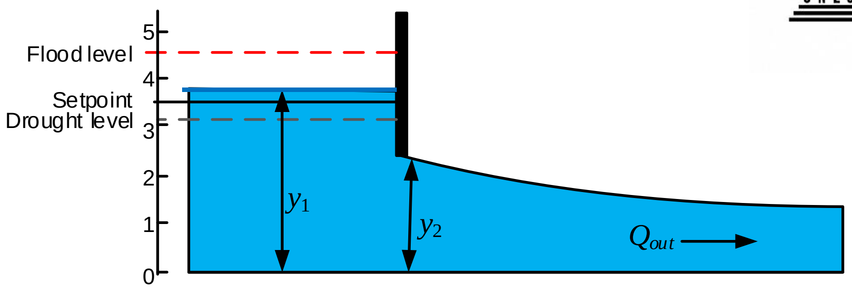
The water level in the reservoir can be controlled by a sluice gate (Figure 2) that gives an output discharge Q_{out} in m^3/s given by:

$$Q_{out} = y_2 * W * Cd * \sqrt{2 * g * y_1}$$

Where y_1 is the water level in the reservoir (m); y_2 is the gate opening with respect to the gate bed (m); W is the width of the gate (W = 3m), g=9.81 m/s^2, and Cd *is* the discharge coefficient, given by:

$$Cd = \frac{Cc}{\sqrt{1 + Cc\frac{y_2}{y_1}}}, \quad with\ Cc \ = \ 0.61$$

The gate can be opened from 2.0m to 4.0m. Assume the gate is never submerged, so the Q_{out} equation is always valid.



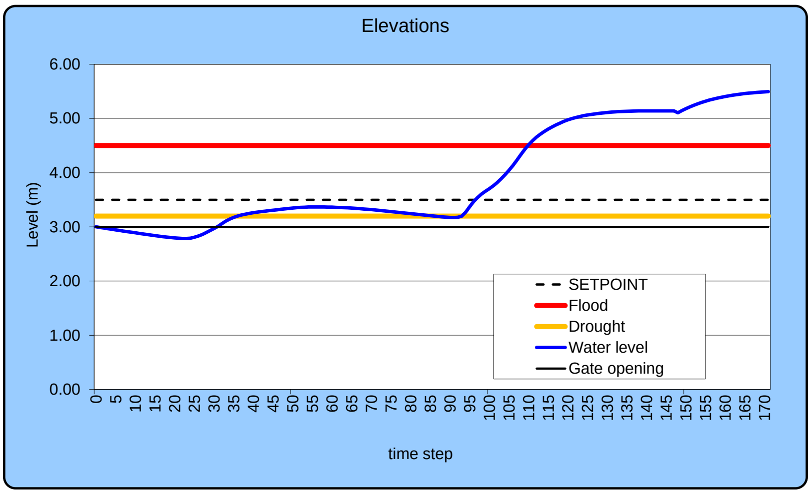
$2.0m < y_2 < 4.0m$

Figure 2. Gate profile

Steps

1. Download the Excel file Qinp.xlsx, available in eCampusxl, and use it as the input discharge Q_{inp}. These flow records were taken every 2 hours, so *dt* = 7200s.
2. Modify the PID spreadsheet you completed in class for the case of a weir control, adding convenient variables and names related to this problem. The water balance expression is still valid for the reservoir. However, the expression for the output discharge Q_{out} must be changed, as this is a different hydraulic structure. Use the one described above.
3. Mind that when the water level in the reservoir is too high, the controller output *u* should **increment** y_2 in order to bring it closer to the setpoint. However, take care of the limits of the gate opening by adding conditionals where required.
4. Assume that at *t*=0: a) the gate level is 3.0m; b) the water in the reservoir is 3.0m.
5. Assume also that, when the water level is lower than the gate, Qout can be estimated using the Manning equation (use S=0.001, n = 0.015).

Hint: Graph 1 should look similar to the following for the case of having the gate fixed at 3.0m for all time steps:



Report to submit via eCampus (Turnitin)

Please submit a report (5 page max, excluding cover) that includes the following:

1. Graph 1: y_1 (water levels) vs *t*, for each controller (P, PI and PID)
2. Graph 2: y_2 (gate opening) vs *t* for each controller (P, PI and PID)
3. Graph 3: Q_{inp} and Q_{out} vs *t* for the PI controller only
4. Comment briefly each graph, analysing the effect of each PID term.
5. What values of K and Ti would you recommend for the PI controller?
6. What further changes in the system would you recommend to improve its performance?

Structure of the document is free, but: 1) avoid long introductory text, 2) clearly indicate the 6 sections above.