Operation with a reservoir

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Part. 1

Objective and input data

The objective of this exercise is to calculate the hydraulic and operational regimes for 4 different scenarios :

- A wet hydrological year ($Q_m = 16,6$ m^3.s^{-1})
- A mean hydrological year ($Q_m = 13,3$ m^3.s^{-1})
- A dry hydrological year ($Q_m = 10,04$ m^3.s^{-1})
- A maximum operation in a wet hydrological year ($Q_m = 16,6$ m^3.s^{-1})

Where Q_m is the mean river flow.

For the calculations, we work with the following data:

- $Q = 71$ m^3.s^{-1}, our personal rated discharge;
- $\Delta t = 3600$ s, one hour computational time step;
- $E_{op} = 524,75$ m.asl, the operational reservoir elevation.

Calculation sheet

Hour of the day	Time from	to	V_d [m3]	V_i [m3]	Balance [m3]	Cummulative [m3]	Reservoir level [m.asl]	Volume [1000 m3]	Denivelation [m]
1	00:00	01:00							
2	01:00	02:00							
3	02:00	03:00							
4	03:00	04:00							
5	04:00	05:00							
6	05:00	06:00							
7	06:00	07:00							

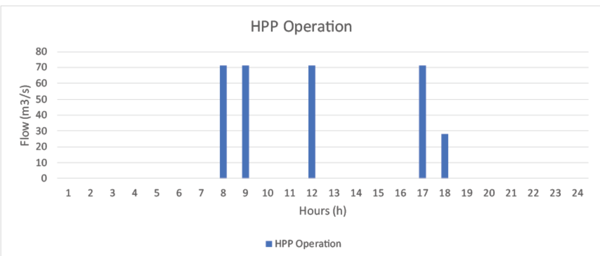
Operation with the HPP		
Hour	Mean year	Flow
1		
2		
3		
4		
5		
6		
7		

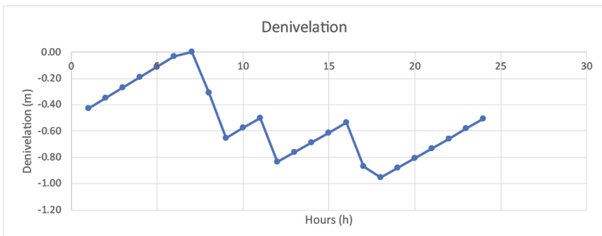
<u>Here is the explanation of our calculations :</u>

- $V_d = Q_m.\Delta t$, the intake of the reservoir [m^3];
- $V_i = f.\Delta t$, the outtake from the reservoir [m^3], f being the operational flow [m^3.s^{-1}];
- $Balance = V_d - V_i$ [m^3];
- $E_{res} = 501,8595 + 0,007054 * V_{res} - 9,04456 * 10^{-}7 * V_{res}^2 + 4,84154 * 10^{-}11 * V_{res}^3$, the reservoir level [m.n.m];
- $$V_{res} = 5414521,34504851 - 21286,7185857706 * E_{res} + 20,8148557973526 * E_{res}^2 + 0,00022032983939908 * E_{res}^3$$, the reservoir volume [m^3];
- $Denivelation(h) = E_{res}(h) - E_{op}$, the denivelation from the operation level of the reservoir.

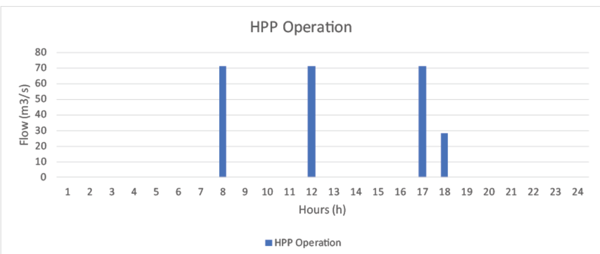
Results

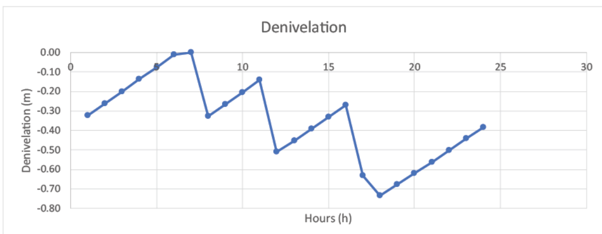
Mean year



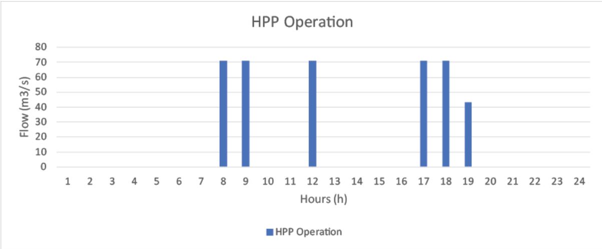


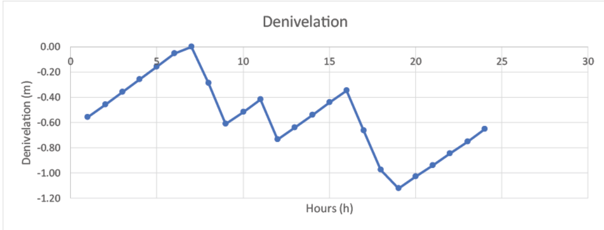
Dry year



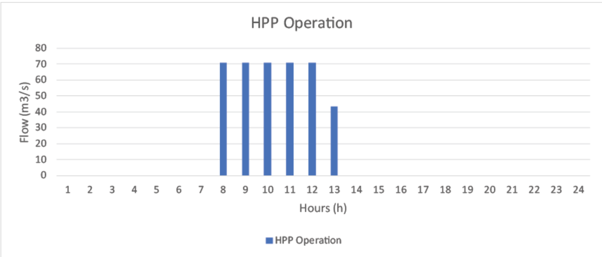


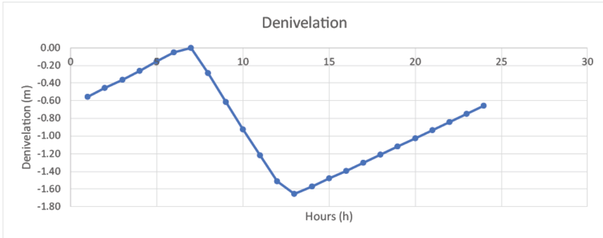
Wet year





Maximum operation in a wet year





We can conclude that we have similar behaviour in form for the first three scenarios. However, we observe very different variations, the dry year being much more volatile, then the wet year and finally the mean year. Except for the maximum operation in a wet year scenario where we observe an equal variation concentrated on a single peak in the middle of the day.

Part. 2, tailwater reservoir operation

On this part we are now looking to create the daily operation diagram for the wet, dry and mean scenario. As we are taking water from the river we need to compensate this loss to not affect that much the ecosystem.

Our input data are :

- $H_{dam} = 71$ m, the height of the dam;
- $Q = 71$ m^3.s^{-1}, the discharge;
- $\Delta t = 3600$ s, the calculation time step;
- $ht_{min} = 524,75 - H_{dam} - 3,5 = 450,25$ m, the minimum level of the tail water.

Calculation sheet

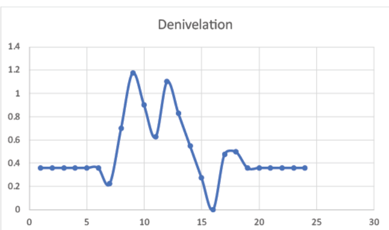
Hour	Time		Vodt	Vdot	Balance	Comulative	Level	Total volume	Denivelation
	from	to	[m3]	[m3]	[m3]	[m3]	[m asl]	[1000 m3]	[m]
1	00:00	01:00	0	0	0	0	450.6093613	1678.550474	0.359361258
2	01:00	02:00	0	0	0	0	450.6093613	1678.550474	0.359361258
3	02:00	03:00	0	0	0	0	450.6093613	1678.550474	0.359361258
4	03:00	04:00	0	0	0	0	450.6093613	1678.550474	0.359361258
5	04:00	05:00	0	0	0	0	450.6093613	1678.550474	0.359361258
6	05:00	06:00	0	0	0	0	450.6093613	1678.550474	0.359361258
7	06:00	07:00	-46800	0	-46800	-46800	450.4719584	1631.750474	0.221958425
8	07:00	08:00	-93600	255600	162000	115200	450.9475836	1793.750474	0.697583618
9	08:00	09:00	-93600	255600	162000	277200	451.4232088	1955.750474	1.173208812
10	09:00	10:00	-93600	0	-93600	183600	451.1484031	1862.150474	0.898403145
11	10:00	11:00	-93600	0	-93600	90000	450.8735975	1768.550474	0.623597477
12	11:00	12:00	-93600	255600	162000	252000	451.3492227	1930.550474	1.099222671
13	12:00	13:00	-93600	0	-93600	158400	451.074417	1836.950474	0.824417003
14	13:00	14:00	-93600	0	-93600	64800	450.7996113	1743.350474	0.549611336
15	14:00	15:00	-93600	0	-93600	-28800	450.5248057	1649.750474	0.274805668
16	15:00	16:00	-93600	0	-93600	-122400	450.25	1556.150474	0
17	16:00	17:00	-93600	255600	162000	39600	450.7256252	1718.150474	0.475625195
18	17:00	18:00	-93600	100800	7200	46800	450.7467641	1725.350474	0.496764092
19	18:00	19:00	-46800	0	-46800	0	450.6093613	1678.550474	0.359361258
20	19:00	20:00	0	0	0	0	450.6093613	1678.550474	0.359361258
21	20:00	21:00	0	0	0	0	450.6093613	1678.550474	0.359361258
22	21:00	22:00	0	0	0	0	450.6093613	1678.550474	0.359361258
23	22:00	23:00	0	0	0	0	450.6093613	1678.550474	0.359361258
24	23:00	00:00	0	0	0	0	450.6093613	1678.550474	0.359361258

Our calculus are :

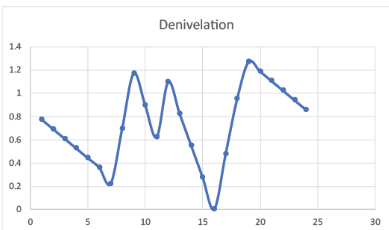
- $V_{odt} = -\Delta t.\, f_{out}$, the outtake from the tail race, f_{out} being the outflow from the tailrace;
- $V_{dot} = -V_i$, the intake of the reservoir;
- When the cumulative of the balance is at its minimum we set :
  - the water level to ht_{min};
  - the total volume equal to $340,604329.(ht_{min} - H_{dam} - 73) - 151119,74$;
  - the denivelation to 0.
- For before and after the minimum point we use the following formulas :
  - $level(h) = 0,00293595798661 * V_{total} + 516,681207587491 - H_{dam}$;
  - $V_{total}(h) = V_{total}(h+1) - \frac{Balance(h+1)}{1000}$, before the minimum;
  - $V_{total}(h) = V_{total}(h-1) - \frac{Balance(h-1)}{1000}$, after the minimum.

Results

Mean year



Wet year



Dry year