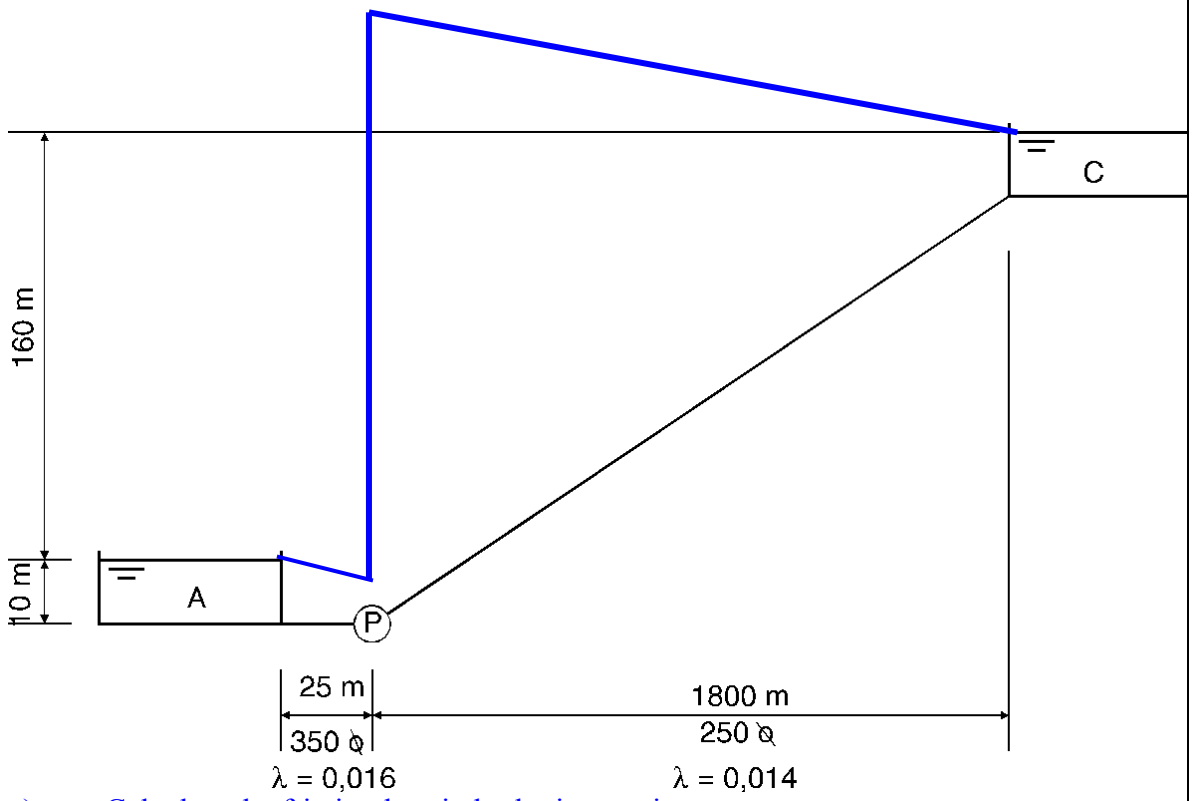
SOLUTIONS
PUMP STATION DESIGN COURSE
DAY 2

CONTINUING PROFESSIONAL DEVELOPMENT RESULTS SHEET

PUMP STATION DESIGN PRACTICAL 3
Question 1 **As sketched at course.**

PUMP STATION DESIGN
PRACTICAL 3

Question 2



a) Calculate the friction loss in both pipe sections:

$$h_{f1} = \frac{\lambda_1 L_1 V_1^2}{2gD_1} = \frac{(0{,}016)(25)\left(\frac{0{,}098}{\pi\left(\frac{0{,}35}{2}\right)^2}\right)^2}{2(9{,}81)(0{,}35)} = 0{,}0604 \text{ m}$$

$$h_{f2} = \frac{\lambda_2 L_2 V_2^2}{2gD_2} = \frac{(0{,}014)(1800)\left(\frac{0{,}098}{\pi\left(\frac{0{,}25}{2}\right)^2}\right)^2}{2(9{,}81)(0{,}25)} = 20{,}477 \text{ m}$$

Thus:
$V_1 = 1{,}02$ m/s
$V_2 = 2{,}0$ m/s

The pressure head downstream of the pump is 160 + 20,477 + (10 – 0,0604) = 190,417 m
For a bypass to be activated the pressure needs to drop to a level lower than 10 m. The downstream pressure would then be less than the upstream pressure and the bypass will start to discharge water from up- to downstream to balance the two sides.

Calculate the pressure drop due to the power failure:

$$\Delta h = \frac{-c\rho\rho_0}{\rho g} = \frac{(980)(1000)(2{,}0)}{(1000)(9{,}81)} = -199{,}8 \text{ m}$$

This means that the pressure will drop to a lower level on the downstream side and thus a bypass situated at the pump will be activated i.e. it will open.

b) I would put it at the pump. Since the pressure drop at the pump will result in a negative pressure on the delivery side an air valve (vacuum function) would work there (instead of bypass).

If the pressure drop was less than 160 + 20,477 = 180,477 m then the position on the line should be determined where the gradient will intersect the profile and place the air valve at this location to prevent the vacuum from forming.

PUMP STATION DESIGN
PRACTICAL 3

Question 3

Two options have been analysed:
Option 1: 6 % interest rate and 0 % escalation
Option 2: 6% interest rate and 5 % escalation

Option 1:

Assumptions:	Assume values are end of year values		
	Off-peak rate	0.15	R/kW
	Standard	0.25	R/kW
	Peak	0.33	R/kW

Description	Alternative 1	Alternative 2	Units
Capital cost	R 1,200,000.00	R 1,700,000.00	
Additional investment	R 250,000.00	R 0.00	
Pumping head	185	155	m
Pumping time	12	15	hours/day
Flow rate	30	24	l/s
System efficiency	70	71	%
Power	77.78	51.40	kW
Hours off peak	12	14	
Hours standard	0	1	
Hours peak	0	0	
Escalation	0	0	%
Interest rate	6	6	%
Maintenance	2.5	2.5	%

Year	Energy	Maintenance	Energy	Maintenance
1	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
2	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
3	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
4	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
5	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
6	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
7	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
8	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
9	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
10	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
11	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
12	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
13	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
14	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
15	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
16	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
17	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
18	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
19	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
20	R 51,100.99	R 30,000.00	R 42,211.32	R 42,500.00
NPV Year 0	**R 586,124.34**	**R 344,097.64**	**R 484,160.57**	**R 487,471.65**

Total NPV	**R 2,380,221.97**	**R 2,671,632.22**

Option 2:

Assumptions:	Assume values are end of year values		
	Off-peak rate	0.15	R/kW
	Standard	0.25	R/kW
	Peak	0.33	R/kW

Description	Alternative 1	Alternative 2	Units
Capital cost	R 1,200,000.00	R 1,700,000.00	
Additional investment	R 250,000.00	R 0.00	
Pumping head	185	155	m
Pumping time	12	15	hours/day
Flow rate	30	24	l/s
System efficiency	70	71	%
Power	77.78	51.40	kW
Hours off peak	12	14	
Hours standard	0	1	
Hours peak	0	0	
Escalation	5	5	%
Interest rate	6	6	%
Maintenance	2.5	2.5	%

Year	Energy	Maintenance	Energy	Maintenance
1	R 53,656.04	R 31,500.00	R 44,321.89	R 44,625.00
2	R 56,338.84	R 33,075.00	R 46,537.99	R 46,856.25
3	R 59,155.78	R 34,728.75	R 48,864.88	R 49,199.06
4	R 62,113.57	R 36,465.19	R 51,308.13	R 51,659.02
5	R 65,219.25	R 38,288.45	R 53,873.54	R 54,241.97
6	R 68,480.21	R 40,202.87	R 56,567.21	R 56,954.06
7	R 71,904.23	R 42,213.01	R 59,395.57	R 59,801.77
8	R 75,499.44	R 44,323.66	R 62,365.35	R 62,791.86
9	R 79,274.41	R 46,539.85	R 65,483.62	R 65,931.45
10	R 83,238.13	R 48,866.84	R 68,757.80	R 69,228.02
11	R 87,400.04	R 51,310.18	R 72,195.69	R 72,689.42
12	R 91,770.04	R 53,875.69	R 75,805.47	R 76,323.89
13	R 96,358.54	R 56,569.47	R 79,595.75	R 80,140.09
14	R 101,176.47	R 59,397.95	R 83,575.54	R 84,147.09
15	R 106,235.29	R 62,367.85	R 87,754.31	R 88,354.45
16	R 111,547.05	R 65,486.24	R 92,142.03	R 92,772.17
17	R 117,124.41	R 68,760.55	R 96,749.13	R 97,410.78
18	R 122,980.63	R 72,198.58	R 101,586.59	R 102,281.32
19	R 129,129.66	R 75,808.51	R 106,665.92	R 107,395.38
20	R 135,586.14	R 79,598.93	R 111,999.21	R 112,765.15
NPV Year 0	**R 926,582.05**	**R 543,971.09**	**R 765,391.34**	**R 770,625.71**

Total NPV	**R 2,920,553.13**	**R 3,236,017.04**

Alternative 1 remains the better alternative of the two analysed based on its NPV which is the lowest