Solution: (a) With the turbine, "1" is upstream:

$$\frac{p_1}{\rho g}+\frac{V_1^2}{2g}+z_1=\frac{p_2}{\rho g}+\frac{V_2^2}{2g}+z_2+h_f+h_t,$$

$$\text{or:}\quad 0+0+150=0+0+25+17=h_t$$

Solve for h_t = 108 ft. Convert Q = 15000 gal/min = **33.4** ft^3/s. Then the turbine power is

$$P=\gamma Qh_{turb}=(62.4)(33.4)(108)=225{,}000\ \frac{\text{ft}\cdot\text{lbf}}{\text{s}}\approx \mathbf{410\ hp}\quad \textit{Ans.}\ \text{(a)}$$

(b) For pump operation, point "2" is upstream:

$$\frac{p_2}{\rho g}+\frac{V_2^2}{2g}+z_2=\frac{p_1}{\rho g}+\frac{V_1^2}{2g}+z_1+h_f-h_p,$$

$$\text{or:}\quad 0+0+25=0+0+150+17-h_p$$

$$\text{Solve for}\quad h_p\approx 142\ \text{ft}$$

The pump power is $P_{pump}=\gamma Qh_p$ = (62.4)(33.4)(142) = 296000 ft·lbf/s = **540 hp**. *Ans.* (b)

3.136 Water at 20°C is delivered from one reservoir to another through a long 8-cm-diameter pipe. The lower reservoir has a surface elevation z_2 = 80 m. The friction loss in the pipe is correlated by the formula $h_{loss}\approx 17.5(V^2/2g)$, where V is the average velocity in the pipe. If the steady flow rate through the pipe is 500 gallons per minute, estimate the surface elevation of the higher reservoir.

Solution: We may apply Bernoulli here,

$$h_f=\frac{17.5V^2}{2g}=z_1-z_2$$

$$\frac{17.5}{2(9.81\ \text{m/s}^2)}\left[\frac{(500\ \text{gal/min})(3.785\ \text{m}^3/\text{gal})(\text{min}/60\,\text{s})}{\frac{\pi}{4}(0.08^2)}\right]^2=z_1-80\ \text{m}$$

$$\mathbf{z_1\approx 115\ m}\quad \textit{Ans.}$$
