

Example 4A-10_3: Pressure Flow Problem 1

Determine if the existing storm sewer pipe can be used in the new storm sewer design.

Given:

Discharge, $Q = 40 \text{ ft}^3/\text{s}$.

Pipe dimensions:

$L = 300 \text{ ft}$.

Diameter = 24 inches.

Slope = 1.0%.

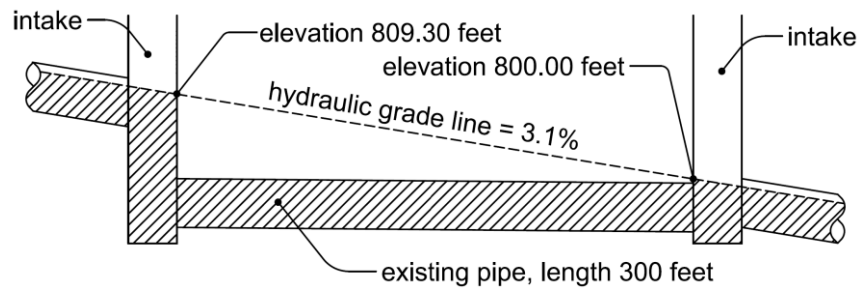


Figure 1: Existing storm sewer pipe.

Solution:

1. Check the velocity assuming no pressure in the existing pipe:

$$V = \left(\frac{K_c}{n} \right) \left(\frac{D}{4} \right)^{0.67} \sqrt{S} = \left(\frac{1.49}{0.013} \right) \left(\frac{2}{4} \right)^{0.67} \sqrt{0.01} = 7.20 \text{ ft/s}.$$

The velocity is acceptable.

2. Check the capacity:

$$Q = VA = V \times \left[\pi \frac{D^2}{4} \right] = 7.20 \times \left[\pi \frac{2^2}{4} \right] = 22.6 \text{ ft}^3/\text{s}.$$

The capacity of 22.6 ft³/s is below the new storm sewer design discharge of 40 ft³/s. Check the capacity under pressure flow.

3. Use the required capacity ($Q = 40 \text{ ft}^3/\text{s}$) to determine the needed hydraulic gradient:

$$40 = V \times \left[\pi \frac{2^2}{4} \right], \text{ so } V = \frac{40 \times 4}{\pi \times 2^2} = 12.73 \text{ ft/s, which is less than the 15 ft/s maximum.}$$

$$12.73 = \left(\frac{1.49}{0.013} \right) \left(\frac{2}{4} \right)^{0.67} \sqrt{S}, \text{ so } S = \left(\left(\frac{12.73 \times 0.013}{1.49} \right)^{1.5} \left(\frac{4}{2} \right) \right)^{0.67} = 3.1\%$$

4. Calculate the elevation required to create the needed hydraulic gradient:
- From Figure 1 above, the elevation in the downstream intake will be below the top of the existing pipe. Use 800.00 feet as the downstream elevation.
 - Determine the upstream elevation required to carry 40 ft³/s:
rise = length of existing pipe × hydraulic gradient = $300 \times 0.031 = 9.30$ feet.
upstream elevation = downstream elevation + rise = $800.00 + 9.30 = 809.30$ feet.
- If the elevation is above the form grade, the existing pipe will not work and will need to be replaced.