1. One acre is a square with sides of length of 208.71 feet. How many square feet in an acre?

2. 1 inch is $\approx 25.4$ millimeters. What is the diameter of a six-inch pipe, in millimeters?

3. 1 meter is $\approx 3.28$ feet. There are 5280 feet in a mile. How many meters in one mile?

4. One hectare is a square with sides of length 100 meters. How many acres in one hectare?


Figure 1: Photograph of ancient storm drain

5. Figure 1 is a photograph of a
   (a) Water use system
   (b) Water control system
   (c) Environmental restoration system
   (d) Wässerbërger system

6. Figure 2 is a portion of an engineering drawing of a gravity-flow wastewater conduit.

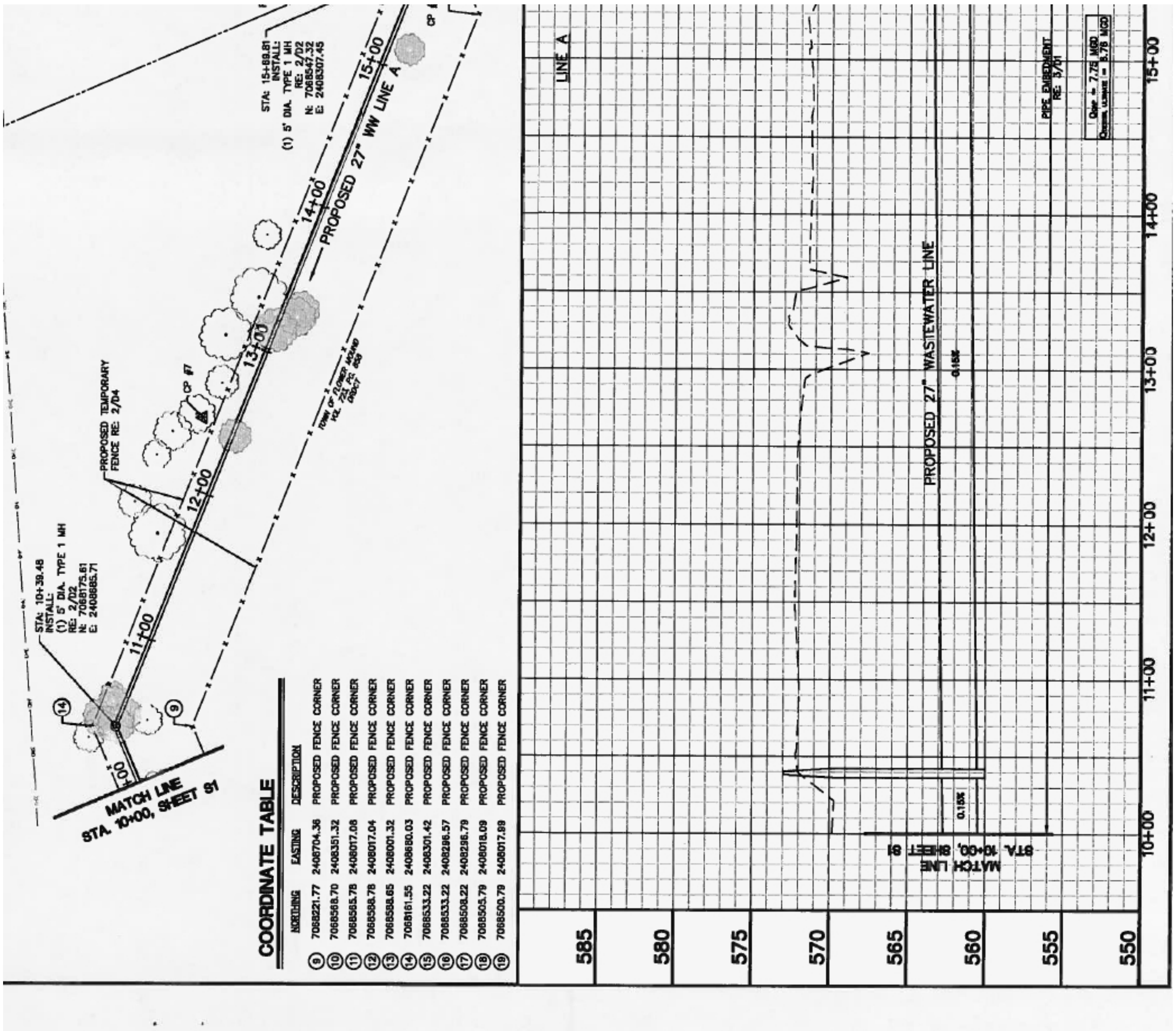

Figure 2: Engineering drawing of sanitary sewer system (display is rotated)

(a) What object is located at station 10+38.48?

(b) What is the invert elevation of the pipe at station 13+00?

(c) What is the diameter of the pipe in inches?

(d) What direction is sewage intended to flow?

7. Equation 1 is the Hazen-Williams discharge model for U.S. Customary units.

$$Q = 1.318\ A\ C_h\ R^{0.63}\ S^{0.54} \tag{1}$$

where;

$Q$ is the discharge in $ft^3/sec$;
$A$ is the cross section area of pipe in $ft^2$ ($A = \frac{\pi D^2}{4}$; $D$ is the pipe diameter.);
$C_h$ is the Hazen-Williams friction coefficient (depends on pipe roughness);
$R$ is the hydraulic radius in $ft$; and
$S$ is the slope of the energy grade line ($\frac{h_f}{L}$); $L$ is the length of pipe.

(a) Rearrange the equation in terms of head loss ($h_f = \dots$).

(b) Estimate the head loss in a 12,000 foot length of 6-foot diameter, enamel coated steel pipe that carries carries $60^{o}$F water at a discharge of 295 cubic-feet per second (cfs), using the Hazen-Williams head loss model. Use a Hazen-Williams loss coefficient of $C_h = 150$.

8. Equation 2 is an explicit formula (based on the Darcy-Weisbach head loss model and the Colebrook-White frictional loss equation)for estimating discharge from head loss and material properties.

$$Q = -2.22D^{5/2} \times \sqrt{gh_f/L} \times [log_{10}(\frac{k_s}{3.7D} + \frac{1.78\nu}{D^{3/2}\sqrt{gh_f/L}})] \qquad (2)$$

where;

$Q$ is the discharge in $L^3/T$;
$D$ is the pipe diameter;
$h_f$ is the head loss in the pipe;
$g$ is the gravitational acceleration constant;
$L$ is the length of pipe;
$k_s$ is the pipe roughness height;
$\nu$ is the kinematic viscosity of liquid in the pipe;

Water at $50^o$F has kinematic viscosity of $1.45 \times 10^{-5}\ ft^2/s$. The sand roughness of ductile iron is $8.5 \times 10^{-4}\ ft$.

Determine:

(a) Depth of a column of water if the pressure at the bottom of the column is 21 psi?

(b) Estimate the discharge in the 3.2 mile long, 24-inch diameter, ductile iron pipeline connecting points A and B depicted in Figure 3. Point A is 28 feet higher in elevation than point B. The pressure at point B is 21 pounds per square-inch (psi) greater than the pressure at point A.

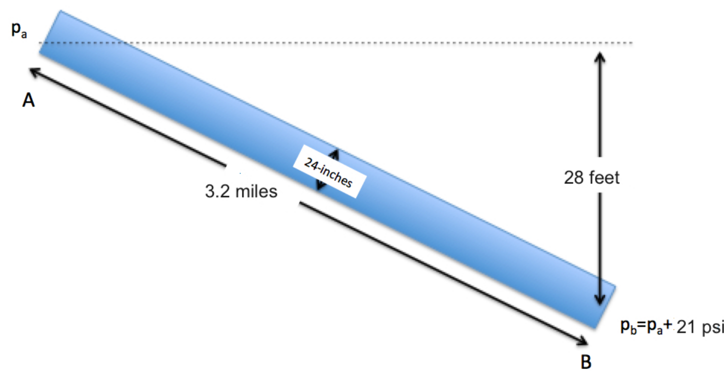


Figure 3: Pipeline Schematic

9. Figure 4 is an aerial image of a parallel pipeline system in California.

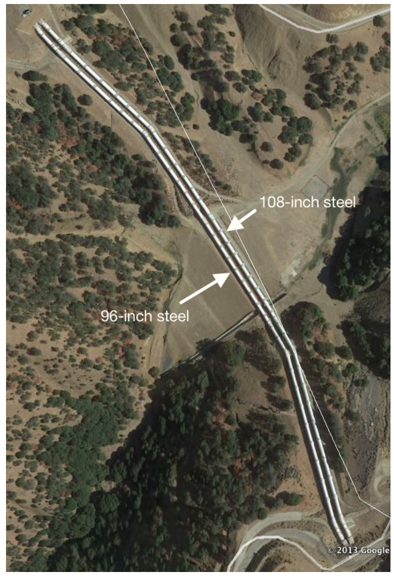


Figure 4: Parallel Pipeline System

The left pipeline is a 96-inch diameter steel pipe, whereas the right pipeline is a 108-inch diameter steel pipe. Water at $50^{o}$F has kinematic viscosity of $1.45 \times 10^{-5}\ ft^2/s$. The sand roughness of ductile iron is $1.64 \times 10^{-4}\ ft$. If the head difference for the one-mile long pipelines between the thrust blocks is 100 feet, determine the discharge in each pipe in cubic-feet-per-second.

Problem 3 (continued)

Figure 5 is a pipe network with the following properties:

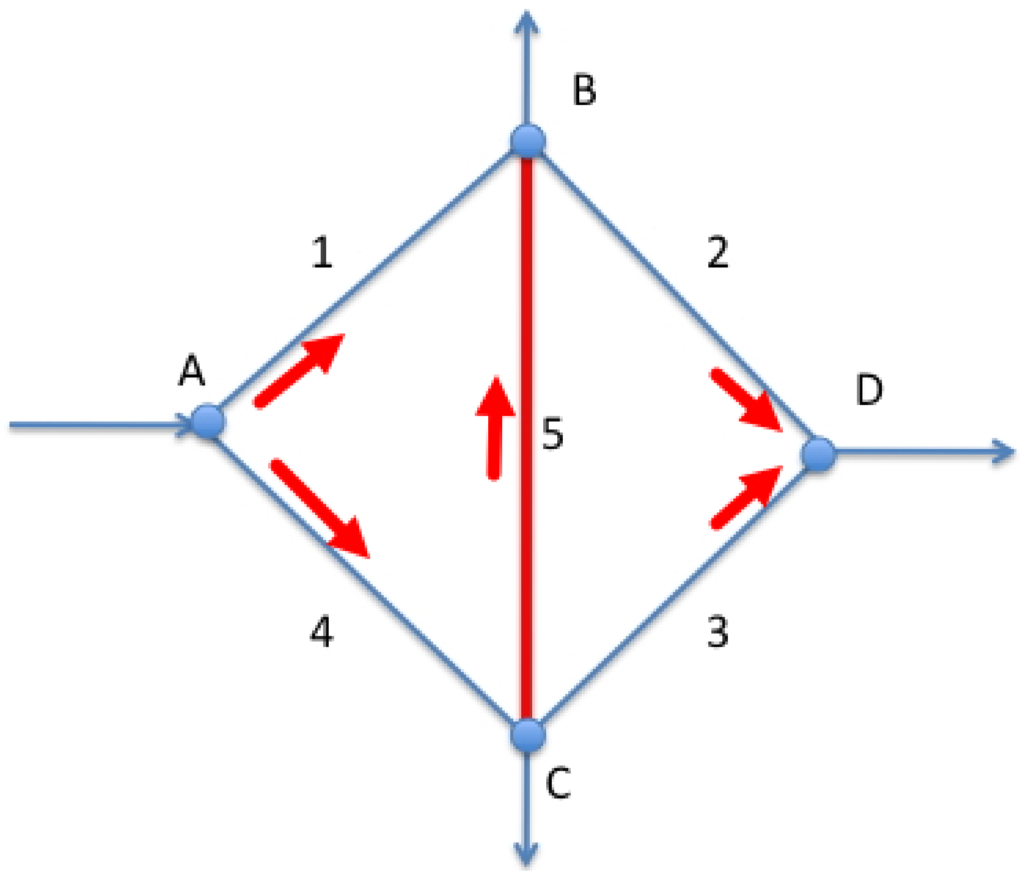


Figure 5: Pipe network

Table 1: Network properties for Figure 5

| Node | Demand (cfs) | Elevation(ft) |
|---|---|---|
| A | -0.60 | 0.00 |
| B | 0.15 | 0.00 |
| C | 0.15 | 0.00 |
| D | 0.30 | 0.00 |
| **Pipe** | **Length (ft)** | **Diameter (ft)** |
| 1 | 1000 | 3/12 |
| 2 | 1000 | 3/12 |
| 3 | 1000 | 3/12 |
| 4 | 1000 | 3/12 |
| 5 | 1400 | 3/12 |

10. Referring to Figure 5, the discharge in pipe 5 is closest to
    (A) 0.00 cfs, from Node B to Node C
    (B) 0.15 cfs, from Node C to Node B
    (C) 0.66 cfs, from Node C to Node B
    (D) 0.66 cfs, from Node B to Node C
11. Referring to Figure 5, if the demands at all nodes are those in Table 1, and pipe 2 is decreased to a diameter of 2/12, the discharge in pipe 5 is closest to
    (A) 0.00 cfs, from Node C to Node B
    (B) 0.15 cfs, from Node B to Node C
    (C) 0.30 cfs, from Node C to Node B
    (D) 0.60 cfs, from Node B to Node C
12. Referring to Figure 5, assuming the average friction factor is 0.018, the head loss, in feet, from Node A to Node C (when all pipes are the same diameter) is closest to
    (A) 12 feet
    (B) 25 feet
    (C) 50 feet
    (D) 75 feet
13. Referring to Figure 5, and Table 1 the flow distribution is:
    (A) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,0.15,0.15,0.30,0.00] CFS
    (B) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,0.15,0.15,0.30,0.30] CFS
    (C) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,0.15,0.15,0.00,0.50] CFS
    (D) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,-0.15,-0.15,0.30,-0.60] CFS
14. An EPANET model must have which of the following components to run
    (A) A pipe, a node, and a pump
    (B) A pipe, a node, and a valve
    (C) A pipe, a tank, and a pump
    (D) A pipe, a node, and a reservoir