Water and Sewer Systems

Around the world and in the United States, there is an increasing need to find fresh water sources to take care of the growing population. Creating new lakes in catchment areas and piping water to growing cities are continuous projects, made more difficult by erratic weather and drought conditions. One alternative has been to tap into ground water through a well system, although in many cities the ground water is brackish and must be processed through a desalination plant. These methods of increasing the fresh water supply to a local jurisdiction are costly. We must find newer and less expensive ways to supply clean drinking water to local populations.

An interstate waterway system, much like our interstate highway system, would be one method of solving the long-term water need in the United States. This type of system would help control flooding and drought conditions by moving surplus water to those who are in need.

The challenge of developing such a system is the economics of getting the water from the surplus area to the arid areas where water is in short supply. Some towns are in locations that must get their water from lakes and rivers that are quite far away. Town leaders have to weigh the cost of different sources of water, balancing the cost with other needs of the town. In Texas, for example, prolonged drought conditions have brought about restrictions in lawn and garden use of water and several towns are using or considering desalinated aquifer salt water to meet their needs. They are also looking at new sources of fresh water as well as recycling filtered water and processing and mixing it with raw water (natural water found in the environment, such as rainwater, ground water, and water from bodies like lakes and rivers).

Cost is a definitive factor for choosing the best method to meet future needs. When revenue is greater than cost (fixed cost plus variable cost), then the company providing the solution will make a profit. For a company to break even the revenue must be equal to cost.

Your team will be challenged to consider the most cost-effective methods of providing fresh water to a meet growing urban infrastructure need.

Assumptions and Givens

Agua Fria is a fictitious municipal water district servicing the town of Llano, Texas.

The formula for percentage change is $\frac{\text{new value-old value}}{\text{old value}}$ x100.

31. The town of Llano, TX has been experiencing a drought. The nearby Llano River usually flows at a rate of 123 cubic feet per second $\left[\frac{ft^3}{s}\right]$, but during the drought its flow has been averaging 2.8 $\frac{ft^3}{s}$. What is the percentage change in the flow rate of the river during the drought?

    a. −42.9%
    b. 87.2%
    c. 42.9%
    d. −97.7%
    e. −95.1%

Work it Out

Assumptions and Givens

Cubic feet x 7.48 = 1 gallon

32. Despite the drought, the Llano River still delivers water to the town's water treatment plant. If the river is flowing at a rate of 2.8 cubic feet per second $\left[\frac{ft^3}{s}\right]$, how many gallons of water does it deliver in 1 hour?

    a. 67,320.5 gallons
    b. 75,398.4 gallons
    c. 80,784.0 gallons
    d. 86,169.6 gallons
    e. 94,248.3 gallons

Work it Out

33. During times of drought, an electric pump is used 24 hours a day to draw water from various wells servicing Agua Fria to provide the town of Llano with enough water for its daily needs. The pump requires 18 kW of power to run, and the electric rate in Llano is $0.14/kWh. How much does it cost Agua Fria to use the pump if the drought lasts for 30 days?

Note: kWh = kW x hours.

a. $1,432.60

b. $1,519.30

c. $1,592.90

d. $1,655.40

e. $1,814.40

34. When Agua Fria uses the electric water pump during droughts it incurs an additional cost of $36,000/year. For the company to break even (revenues equal costs), it must charge households extra for the use of this well water. If there are 450 households in the town of Llano, what should Agua Fria charge each household per month?

a. $6.67

b. $15.01

c. $40.02

d. $53.36

e. $80.00

Assumptions and Givens

Volume of a cylinder = π x r^2 x h , h is the height and r is the radius.

35. The water that Agua Fria pumps from its wells is stored in a large concrete container in the shape of a cylinder. The radius of the container is 8 meters and it is 14 meters tall. What is the maximum volume of water that this container can hold?

a. 351.86 m^3

b. 1,105.40 m^3

c. 1,452.67 m^3

d. 2,814.87 m^3

e. 4,926.02 m^3

Work it Out

Assumptions and Givens

1 gallon = 3.79 liters

36. Because the water that Agua Fria draws from its wells is rather brackish (salty), a desalination system is used to remove the salt and produce fresh water. In the town of Llano, the well water has a salt concentration of 17 g/L. If the desalination system can process 5,000 gallons of water/day, how many kilograms (kg) of salt will be removed each day?

    a. 85.00 kg

    b. 322.15 kg

    c. 850.00 kg

    d. 3221.50 kg

    e. 8500.50 kg

Assumptions and Givens

1 acre = 43,560 square feet

37. During times of drought, limits are set on the amount of water that should be used for lawn and garden care every week. Residents are asked to use only 0.25 ft^3 of water for every square foot of lawn. If the average house has a lawn size of 0.55 acres, how many cubic feet of water can be used for lawn and garden care every week?

    a. 4,526.3 ft^3

    b. 5,256.6 ft^3

    c. 5,989.5 ft^3

    d. 6,289.1 ft^3

    e. 6,812.8 ft^3

Work it Out

Assumptions and Givens

The velocity of water moving through a pipe is v_{water} = flow rate/area , v_{water} is the velocity of the water (in ft/s), flow rate is in ft^3/s, and the area of the pipe is in ft^2.

38. To avoid problems with future local droughts, Agua Fria may become part of a regional water-sharing system. This system would—when needed—bring water from neighboring areas through a pipe with a diameter of 60 in. at a flow rate of 36 ft^3/s. At what velocity will this water be delivered through the pipe?

    a. 0.46 ft/s

    b. 0.55 ft/s

    c. 1.83 ft/s

    d. 2.29 ft/s

    e. 2.71 ft/s

39. During droughts, Agua Fria can either receive water through the regional water sharing system at a cost of $240/4,800 gallons, or pump and desalinate water from its own wells at a cost of $100/2,500 gallons. What is the difference in cost per gallon between these two methods?

    a. $0.01

    b. $0.02

    c. $0.03

    d. $0.04

    e. $0.05

Work it Out

40. Although Agua Fria can currently choose between the regional water-sharing system and its own wells, the aquifer that supplies its wells is disappearing. The aquifer currently has a volume of 1,550,000 gallons, and Agua Fria pumps 123,000 gallons/year from its wells. At this rate, and assuming that the aquifer is not replenished, how long will it be until Agua Fria is completely dependent on the regional water-sharing system for emergencies?

    a. 8.3 years

    b. 9.1 years

    c. 10.8 years

    d. 11.6 years

    e. 12.6 years

Work it Out