ENE422: Applied Hydraulics, Project – 1.
Full Points=100
Due Date: 3/25/2025 by 11:59 PM (D2L Dropbox). Assigned on 2/20/2025

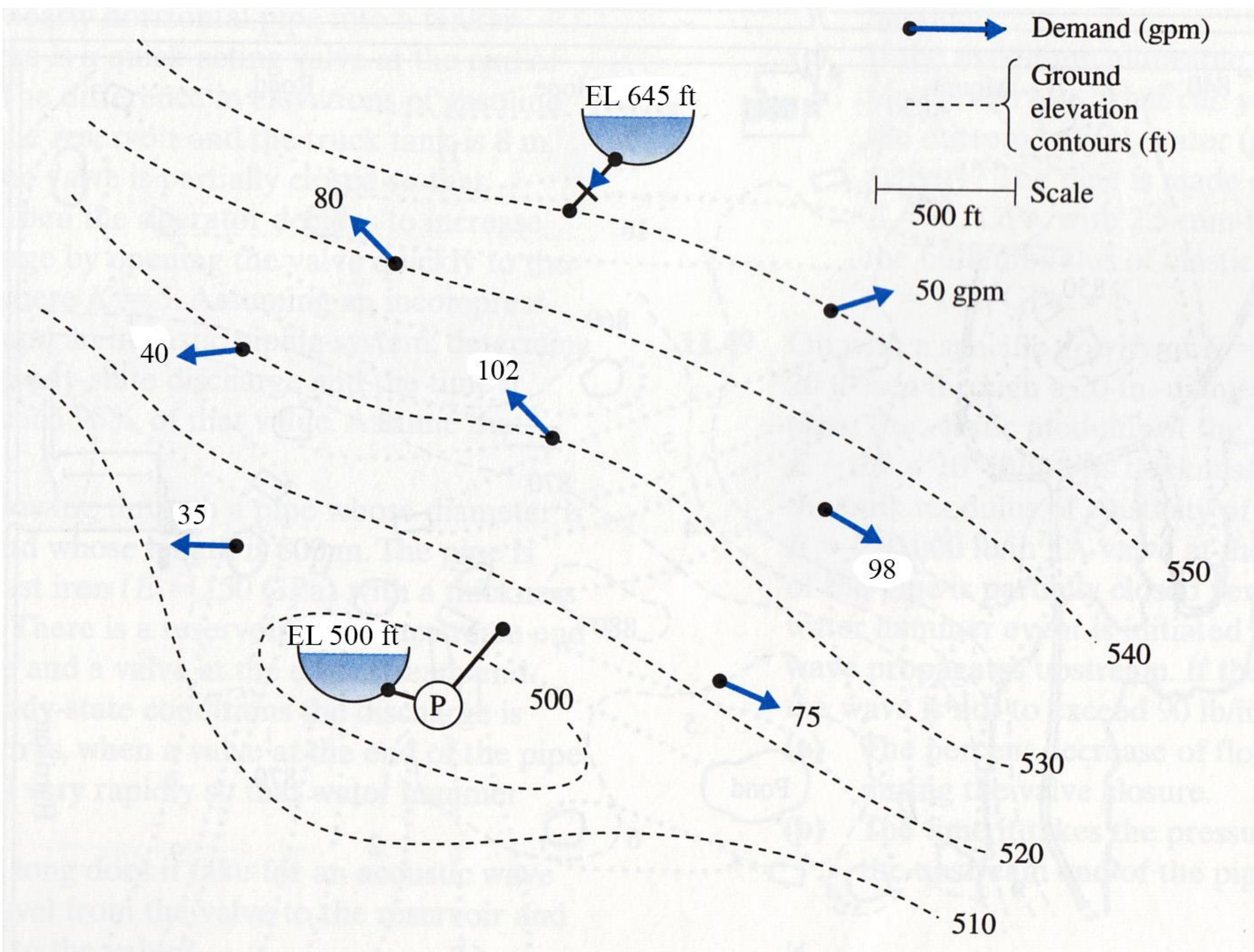
For the general problem statement given below, you have been tasked to design a pipe network system for a proposed industrial complex and examine the following **three scenarios**:

***a) Fire demand with no broken pipes***
***b) Normal demand with no broken pipes and***
***c) Normal demand with one broken pipe***.

Follow the directions included below but if the information for any of the scenarios contradicts the problem statement, follow the guidelines under each scenario (a, b or c).

## Problem Statement:

Water demands for a proposed industrial complex are shown in the Figure below. Design an appropriate network and determine the appropriate useful power for a pump to meet the demand needs.



## Design Criteria:

1. The lower reservoir supplies water to the system. The upper reservoir is used only during emergencies such as fire, line breaks and so on; under normal operation, there is no flow into or out of it.
2. Under normal operation, pressures in the network should be maintained between **80 and 120 psi**.
3. Two gate valves are to be placed in each line (one at each end) to isolate the line in case of a break or for needed maintenance.
4. For analysis of the "pipe break" condition: All demands must be met in case of a single line break with a minimum allowable pressure of **20 psi**.
5. Pipes are cast iron, with the following standard diameters available: **4,6,8,12,16,20,24,30,36,42 and 48 inches**. Pipes can be placed anywhere within the region.
6. Fire demand should be **3400 gpm** at **any one node** in the system at a time, and the maximum velocity should not exceed **6 fps**. The minimum allowable pressure during fire demand is **20 psi**.
7. Maximum allowable age for the water in the system is **2 days**.
8. Don't have unnecessary pipes – minimize the total number of pipes.
9. Your network should have a sufficient number of pipes to supply water to all nodes even if any of the pipes breaks. Note that the upper reservoir is available if there is a pipe break. Do not specifically draw valves in any line. To shut down a line for analysis simply close the line in the property editor window.

## Report Format:

**You should** to submit a detailed design report **accompanied by an Executive Summary** that includes the name of design team member(s), name of the project, design objectives, summary of results, and comments or recommendations. The summary should be **no more than one page and should be placed after the cover sheet**.

The main body of the report should include the following **at the minimum**:

- One page introduction that includes the objective of the design, description of the industrial complex with the Figure, and details of design criteria.
- Details on pipe length, roughness height etc.
- Separate description, analysis, and discussion of each scenario, which should include tables showing node (e.g., pressure) and link properties (e.g., velocity, discharge, friction loss) from EPANET, Figures showing the node and link properties, and the details of the pump(s) used for that scenario.
- Critical situations that controlled your specific design: you should provide details of the reason behind the selection of pipe sizes, a specific pump, use of different pumps for different scenarios, use of multiple pumps etc.
- Description of how you determined the most demanding location (see scenario a below).
- Any additional information that was essential to complete your design/report can be included as appendix.

## <u>Scenarios</u>:

**(a)** ***<u>Analysis of Fire Demand</u>***: Assume that there are no broken pipes. Design the best network capable of supplying fire demand at any node (**<u>i.e., fire demand at only one node at one time</u>**) in the distribution region. Under this scenario, this system can make use of the upper reservoir and it could employ a different pump than that used for normal demand scenario at the lower reservoir, if necessary. **You need to justify the selection of a different pump in your report**, if you do so. This system should be tested for all possible locations of the fire demand (**again, fire demand at a single node at a time; repeat this for all nodes**). Submit only the analysis of conditions that proved to be the most demanding location (**i.e., the location where, if fire demand is placed, demands largest pipe diameter or biggest pump**) of the fire demand. Include the following:

a. Map 1 of the system: show node numbers, pipe numbers, flow directions, flow rates through the pipes and demands at the nodes.
b. Map 2 of the system: show node numbers, pipe numbers, unit head loss and nodal pressures.
c. Table of nodes: you make this table with the button on the top menu in EPANET. Once the table window opens, select nodes and go to the columns page in the window and check off the following information: elevation, base demand, initial quality, demand, head, pressure, age.
d. Table of links: select links in EPANET and on the column page check off the boxes to show: length, diameter, roughness, flow, velocity, unit head loss, friction factor, reaction rate, age and status.

**(b)** ***<u>Analysis of Normal Demand – No broken pipes</u>***: The same network as above except that all water must come from the lower reservoir and the **upper reservoir must be closed off**. You may employ a different pump for this solution than for the fire demand solution, if necessary (again, justification needed). Include (a), (b), (c), and (d), similar to that for scenario "a" above.

**(c)** ***<u>Analysis of Normal Demand – one broken pipe</u>***: This is the same network as above. No new pipes but you **should make use of the upper reservoir again**. **The broken pipe cannot be the main pipe to the system from any of the two reservoirs**. The system should be tested so that you have determined that it will perform satisfactorily (meet the 20 psi minimum pressure requirement) with any pipe in the system broken. Break each pipe at a time and repeat simulations, finally determining which case results in the most challenging scenario (e.g., in terms of maintaining velocity or pressure in the system). Submit only the analysis of conditions that proved to be the most challenging for the system. Include (a), (b), (c), and (d), similar to that for scenarios "a" above.

<u>Hints</u>:

1. Lay out a network with no more pipes than necessary. Do not directly insert valves into your network but include their effect with the minor loss coefficient for the pipe.
2. Solve the fire demand problem first. You can use the upper reservoir and you can use a

pump at the lower reservoir. This demand forces you to consider large diameter pipes to accommodate the demand. Keep your pipes small enough that the velocity in some parts of the system gets near but does not **exceed the maximum permissible velocity (see above)**. Keep all pipes of the same diameter since you need to be able to handle a demand anywhere. Check your system with the fire demand in all possible locations (where there are normal demands).

3. Next consider the normal demand. Use only the lower reservoir and size the pump needed to meet the pressure demands. Then look at the age of the water in your system. If it is too large you need to reduce the size of the pipes. Once the age looks ok, go back and check the fire demand. You may need to employ a larger pump now to compensate for the smaller diameter pipes.
4. Once everything is ok go on to check the pipe break situation. Remember that you can use both reservoirs and you could add other pumps but the fewer the better.

**<u>Additional Hints to Produce Maps/Figures on EPANET</u> (only for guidance—you can do your own exploration or watch online tutorials):**

1. In the map window of the Browser, set node = demand and link = flow
2. In the options menu set the following: node size = 5, link size = 3, notation – check off the first 4 items not the 5$^{th}$ and put the font size = 10; symbols – check all 5.
3. Adjust the colors in the legends. Right click on the legend then right click again on the color bar and select a new color. Set all of the segments of the color bar and then click OK to make the change on the map. Make sure you show the legend so that it is clear when plotted.
4. Once you run the solver you must go through the output on the map to get rid of the negative flows. To do this right click on any arrow where the flow is negative, select reverse. Do this for all negative flow arrows and re-run the solver. If you did this for all, there will be no negative flows. Now the continuity checks at the nodes should be easy.