MAGNET4WATER ConduitNET SAMPLE PROJECT 1

Problem Description[1]

A small (but quickly growing community) relies on groundwater to meet its water needs. But over pumping of the aquifer is causing deeper, highly mineralized groundwater to migrate to the shallow subsurface, contaminating the local supply. The community has decided to switch to surface water supply and needs to build a drinking water distribution system that must satisfy certain requirements.

The community's Development Company provided a preliminary design of the distribution system, but the community would like an external review of the design before proceeding with construction. You have been hired analyze the hydraulic feasibility of the preliminary design, particularly with respect to minimum pressure and flow velocity requirements: pressure at all junctions with non-zero demand should exceed the minimum allowable pressure of 15 psi but be less than 165 psi (note: *all* junctions should have positive pressure). Velocity in the pipes should exceed 1 ft/s but be less than 8 ft/s.

Analyze the flow dynamics (pressures, velocity, flow, and head loss), with a particular focus on how pressures changes, where head loss is most significant, and how the design can be optimized.

Technical Details

The proposed distribution system is *gravity-fed*: water is released from nearby reservoir (10 miles away) situated at a higher elevation (131m) to the system of 24 junctions and 25 pipes (see Figure 1). The preliminary design includes specifications for each pipe's length, diameter and roughness, as well as the elevation and base water demand at each junction (see Tables 1 and 2). An expected 24-hour water demand pattern is also provided (Table 3)

To aid in your feasibility analysis, use MAGNET4WATER ConduitNET[2] - Pipe and Conduit System Analysis Network Platform - to model the flow dynamics (velocity, head, pressure) across the proposed distribution system. If the preliminary design is not feasible, suggest and analyze ways in which the system could be modified the satisfy the requirements. See "ConduitNET– Hints / Additional Instructions" below.

Deliverable

Please summarize your findings in a clear, well-organized Memo. Please limit the Memo to two page (single-space) and submit supporting documentation and technical details as an attachment or Appendix.

Your Appendix should include detailed model information to support the conclusions and recommendations made in your memo. In particular, your Appendix should include the following information:

1. Project Motivation and Objective

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[1] Based loosely on the system described in: Kurniati, E. and Susilawati, T., 2021, April. *Analysis of clean water distribution systems using EPANET 2.0 (Case study of Uma Sima Village, Sumbawa Regency)*. In IOP Conference Series: Earth and Environmental Science (Vol. 708, No. 1, p. 012105). IOP Publishing.

[2] MAGNET4WATER ConduitNET utilizes the EPANET open source code developed by the US Environmental Protection Agency (EPA) to compute the flow dynamics in a pressurized pipe system like the one described in this project.

2. Preliminary Design. Provide a summary of the preliminary design in the form of tables and pipe network maps. Describe the flow dynamics in the pipe network based on the initial design. Do the dynamics make sense (e.g., pressure distribution across the network and over time)? Explain why the initial design is insufficient and use tables and graphs to demonstrate this insufficiency. In particular, use 3D Plot to show pressure and velocity distribution throughout the network and to identify potential issues. Use time series to plot simulated pressures and velocities over time at problematic nodes / links .
3. Improved / modified design. Provide a summary of your improved design. Describe the flow dynamics in the pipe network based on the modified design. Explain how you achieve the design objectives. This summary can be in the form of tables or graphics or both. There is more than one way to achieve the design objectives, explain why your improved design makes sense.

Your Appendix needs to be professional. Please type up your appendix in WORD. There is no length limit on the appendix.

ConduitNET– Hints / Additional Instructions

Quick Tutorial

If you have not already completed the ConduitNET *Quick Tutorial*, please do so before proceeding. The *Quick Tutorial* explains step-by-step how to add network objects, assign attributes, run the model, and visualize / analyze the results. To access the *Quick Tutorial*:

1. Navigate to MAGNET4WATER ConduitNET: https://www.magnet4water.org/conduitnet/
2. In the header Menu bar, go to: Tutorial > Quick Tutorial

Model Setup

After completing the *Quick Tutorial*, begin this project by constructing the water distribution network using the provided specifications. Carefully input the node and link attributes using the information provided in Tables 1 and 2. Note that unit conversions are required before inputting into ConduitNET. Double-check that your inputs are correct (better yet, have a different project partner / teammate check for you!).

Set up the model to perform a 24-hour analysis (Total Duration: 24:00) with a 1-hour time step (Hydraulic Time Step: 1:00) and a 6-hour pattern time step (Pattern Time Step: 6:00). Use the Pattern Editor to create the demand pattern presented in Table 3.

Run Analysis and visualize / analyze the results. Is there sufficient pressure at all nodes and at different times? Are there any negative pressures (i.e., the hydraulic grade line is lower than the pipe elevation)???

Design Optimization

You should consider adding a pump at to your network somewhere downstream from the reservoir. The pump lift required and potentially pipe sizes are what you need to experiment on to ensure that the pressures and velocities in all pipes - at all times - are in the required range.

You can add a pump anywhere, but it makes most sense hydraulically if you add it at locations before negative pressures occur. See the diagram (Figure 2) at the end of the project description for guidance on adding a pump to the existing network (while maintaining network topology).

You must link your pump to a pump curve (pump lift vs flow) that characterize the pump performance. You must define a pump curve. If you only provide one "operational" point on the pump curve (e.g., design flow of 700GPM, pump head or lift needed of 100ft), the software automatically makes a pump curve by adding two extra points (assuming that the pump lift decreases with quadratically with increasing flow). In particular, the software assumes i) the pump lift increases by a third (33%) if the flow reduces to zero; and ii) the pump lift reduces to zero if flow exceeds 2 times the design flow. The pump automatically shuts off if the flow in the network falls outside the operational range designed by the curve.

The design flow can be computed by adding the max demand at all nodes.

After drawing the pump and creating the pump curve, Run Analysis again. Analyze the new results to determine if the pressure in all nodes, for all time-steps, is sufficient or not. A properly placed pump should alleviate insufficient pressure issues (if any) in the distribution network.

Once node pressures are within the acceptable range, carefully check the velocities in all pipes and at different times. If velocities in one or more pipes is not acceptable for one or more time-steps, modify the pipe characteristics (e.g., diameter and/or roughness) and re-run the model, analyze the results, and so on. Continue adjusting input parameters until all velocities (for all pipes, at all times) are within the acceptable range.

Key Reminders.

Carefully check your model inputs and make sure:

1. Your reservoir total head is from the project statement, NOT the DEFAULT
2. Your base demands at the nodes are from the project, NOT the DEFAULT
3. Your nodal elevations where demand occurs are from the project statement, Not the DEFAULT.
4. Your demand PATTERN used (demand multipliers at different times during the 24 hour simulation time) is from the project, NOT the DEFAULT
5. Your pipe diameters, lengths, and roughness are from the project, NOT the DEFAULT

Please note that a pump link is a special "NO LENGTH" link. When you add a pump, you should insert a link, not just replace an existing link with a pump link. (Again, see the diagram (Figure 2) at the end of the project description for guidance on adding a pump to the existing network).

Please make full use of the ConduitNET's reporting capabilities in assessing your design performance. Use "3D Plot" (under Report) to visualize the overall network dynamics and the "time series plot" to visualize the dynamics at particular nodes / in particular pipes.

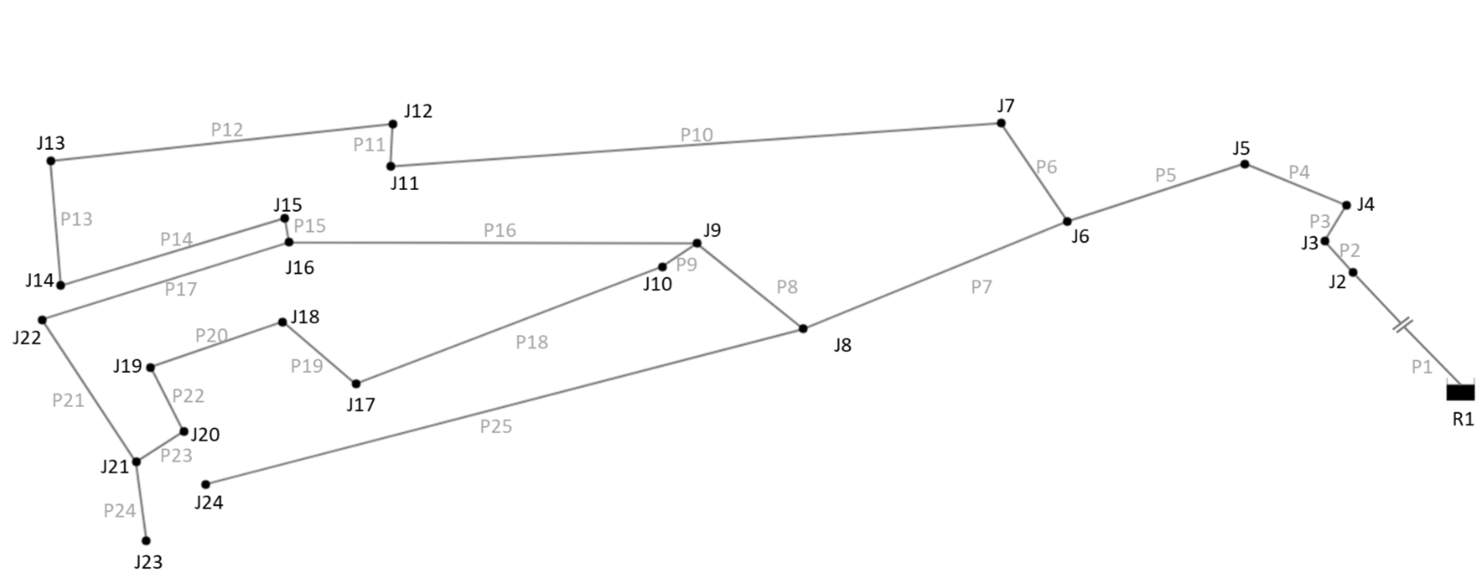

Figure 1: Proposed water distribution network.

Table 1: Characteristics of the junctions in the preliminary design. (Note that the expected unit of elevation in MAGNET Pipe Network Analysis is feet; for demand, expected unit is GPM. A conversion prior to direct input is needed.)

ID	Elevation (m)	Base Demand (LPS)
J2	94	0
J3	94	0
J4	99	0
J5	93	0
J6	103	2.48
J7	76	2.1
J8	27	0.592
J9	27	3.225
J10	27	0.412
J11	71	2.1
J12	71	2.1
J13	70	2.1
J14	27	2.82
J15	27	5.785
J16	27	3.225
J17	25	0.145
J18	25	0.145
J19	25	0.145
J20	25	0.145
J21	25	3.58

J22	27	5.38
J23	25	5.38
J24	25	0.5

Table 2: Characteristics of pipes in the preliminary design (Note that the expected unit of pipe length in MAGNET Pipe Network Analysis is feet; for diameter, expected unit is inches. A conversion prior to direct input is needed.)

Pipe ID	Length (m)	Diameter (mm)	Roughness (C-factor)
P1	16093	300	120
P2	25	300	120
P3	150	300	120
P4	250	300	120
P5	280	150	120
P6	136	150	120
P7	650	150	120
P8	330	150	120
P9	171	150	120
P10	2500	150	120
P11	366	150	120
P12	1387	150	120
P13	620	100	120
P14	1334.5	75	120
P15	63	100	120
P16	2200	150	120
P17	1334.5	100	120
P18	1217	150	120
P19	321	150	120
P20	556	150	120
P21	623	50	120
P22	213	150	120
P23	146	150	120
P24	150	150	120
P25	630	50	120

Table 3: Demand pattern for 24-hour period (four 6-hr time periods).

Time Period	Multiplier
1	0.8
2	1.11
3	0.99
4	1.1

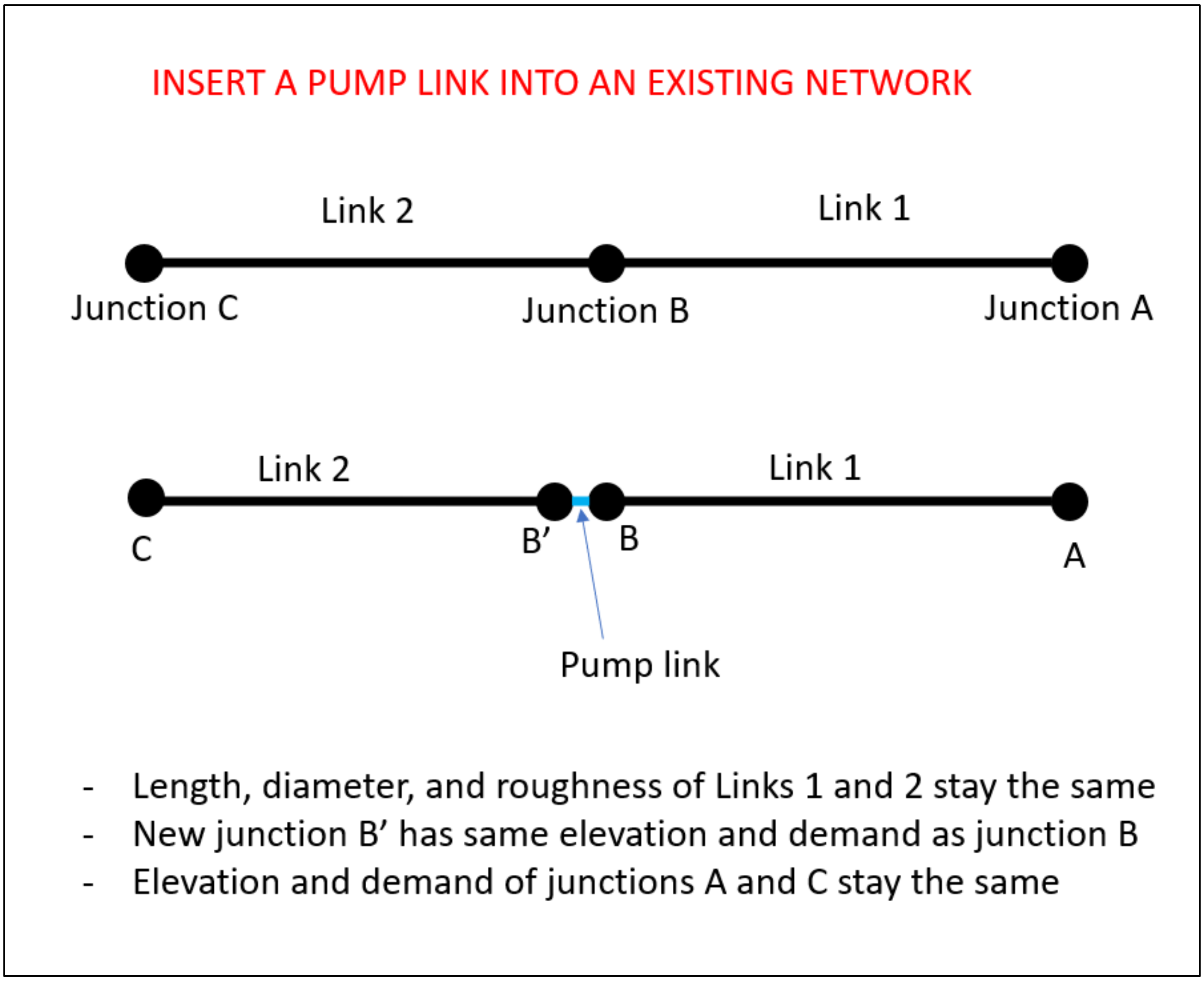

Figure 2: Guidance for inserting a pump link into an existing network (while maintaining overall network topology).