Design of Water Transmission Line and Flood Protection Works for Al Kharj City

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Abstract

Al-Kharj City is one of the main cities of Riyadh region, located southeast of Riyadh. It is exposed to a massively decreasing groundwater level, and there is a life-threatening problem for them regarding the amount of water. There is also another problem that flood attack the city frequently. The project aims to design a water transmission line to deliver water from the capital to the city to overcome the water supply deficit. Then, study the water supply network for a pilot area of the city. Finally, study the surface hydrology of the city for flood protection work. The catchments, the Historical Intensity-Duration-Frequency (IDF) curve for different return periods, and calculate the peak runoff.

In the GP1 stage, the design of the gravity water transmission line has been carried out. The line connects the station located east of Riyadh at the highest point on Ramah Road to the city of Al-Kharj, with a length of 180 km. This water transmission line has a diameter ranging from 1100 mm to 1200 mm and works by gravity. The runoff calculations have been conducted for different return periods. The catchment areas of attacking wadies were calculated; the maximum catchment area is 1965.7 Km^2, the wadi length is 10,000 km, and the total flow equals 10855m^3/s for RP 50 years

The goals of GP2 are to carry out the water hammer analysis via Open Flows HAMMER and Allievi software for the relevant transmission lines selected in GP1 and investigate their suitable protection by using the pressure relief valve PRV and air vessels. Also, a pilot area has been selected to design water distribution networks in Alkharj City, including 79 main pipes and 56 junctions (under maximum hourly demand). conduction by adjusting the suitable pipe sizes the minimum is 150 mm according to the Saudi code

Objectives

Project is divided into multiple objectives across two phases, In the first phase(GP1) :

. Design of the transmission pipe to serve Al-Kharj city.

. Flood analysis for the city.

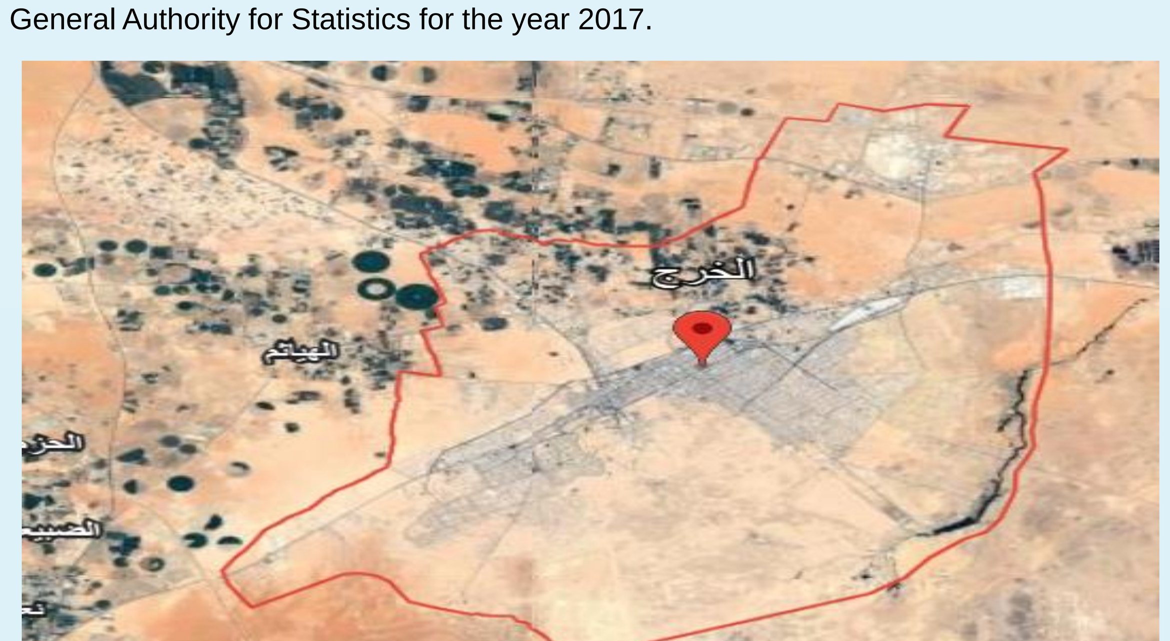
In the second phase(GP2), there were:

. Design the distribution network for Al-Kharj city.

. Unsteady work for transmission line (water hammer).

Alkharj City

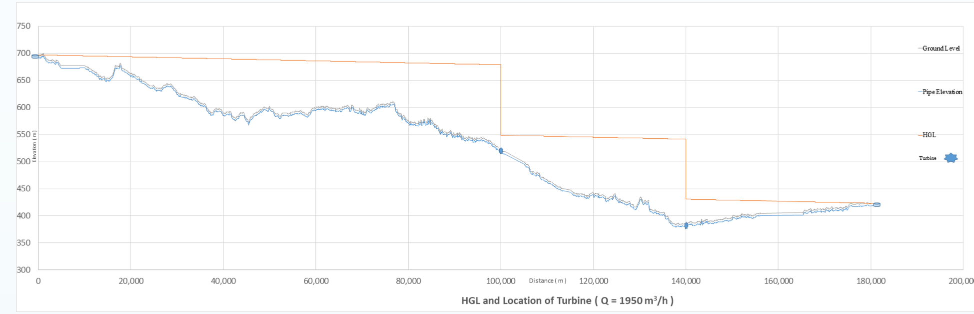
Al-Kharj Governorate is one of the important governorates in the Kingdom of Saudi Arabia affiliated with the Riyadh region. It is located in the southeast of the capital, Riyadh. Its area is 19,790 square kilometers , and its population is 332,243 people, according to the statistics of the General Authority for Statistics for the year 2017.

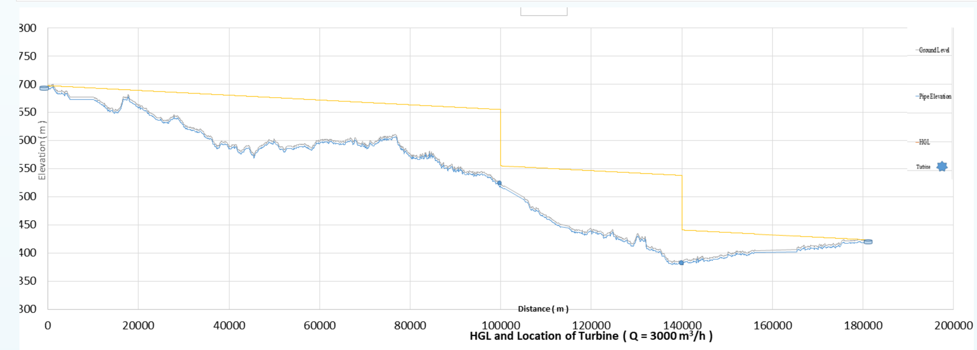


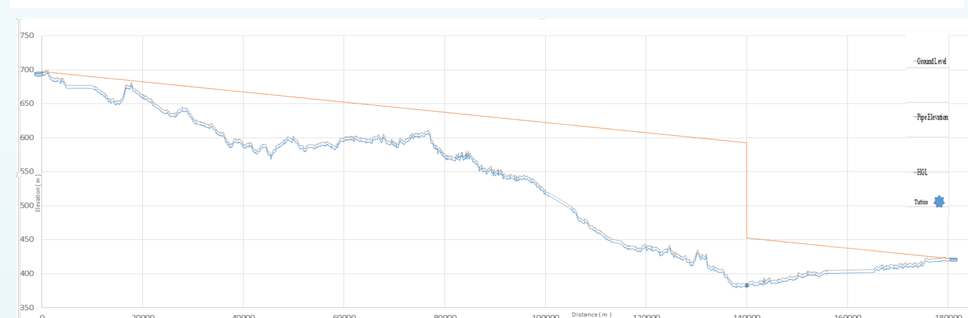
Al-Kharj City.

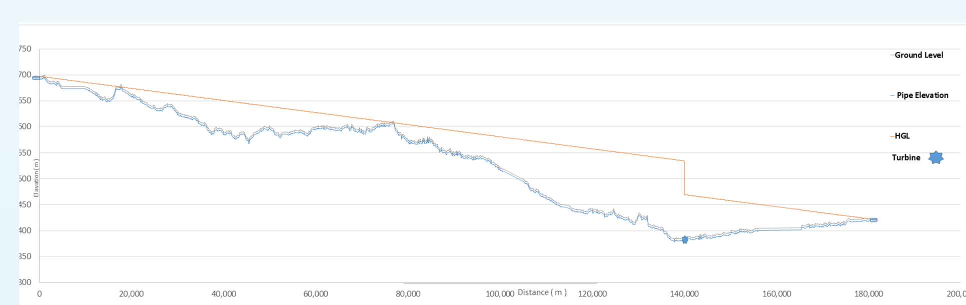
Pipe Transmission Lines

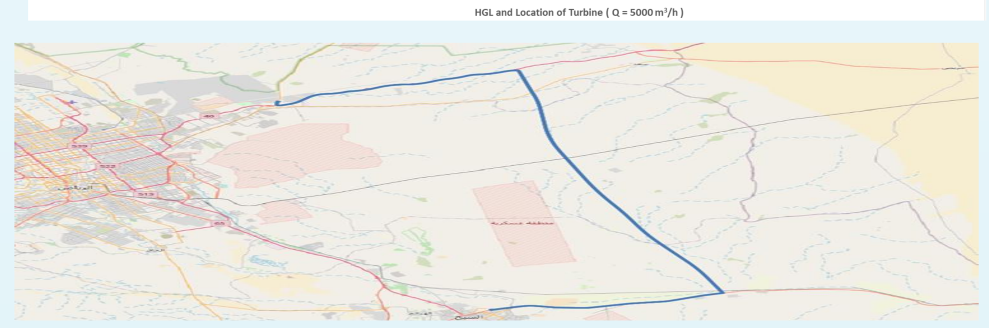
In the design of the water transmission pipeline, multiple solutions were considered, and the pipeline was examined for various flow rates. Moreover, turbines were employed to mitigate high pressures.



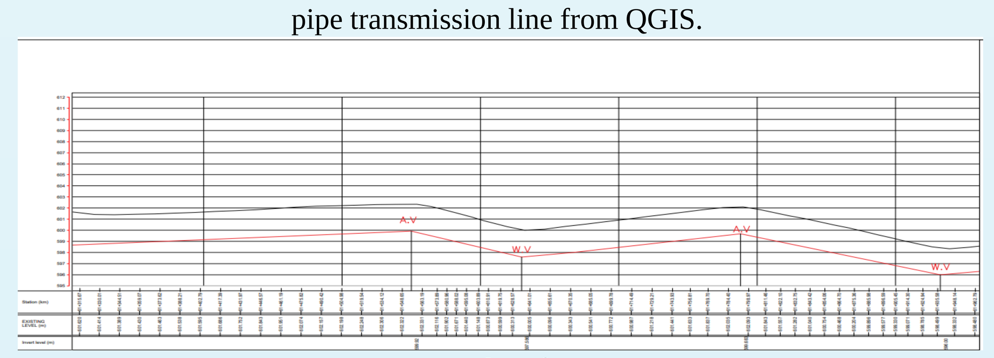








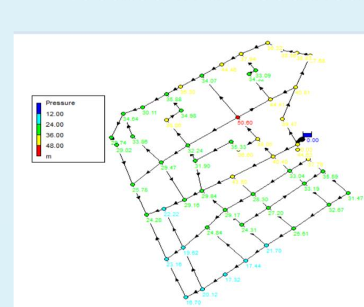
pipe transmission line from QGIS.



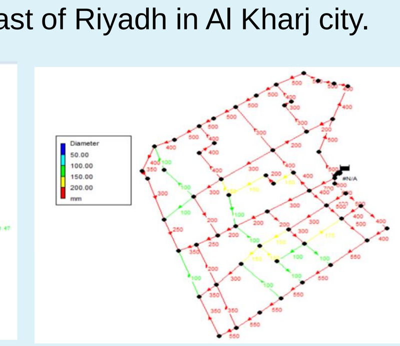
pipe transmission line from AUTOCAD.

Distribution Network

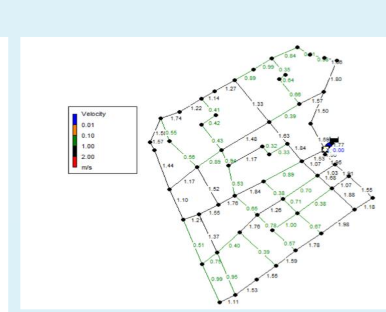
This project includes a basic study of the water distribution system with a brief description of all its components. In this design project, the looped network system was taken into consideration to distribute water to the residential area located in the southeast of Riyadh in Al Kharj city.



Pressure



Diameter



Velocity

Water Hammer Analysis

Hydraulic shock (water hammer; fluid hammer) is a pressure surge or wave caused when a fluid in motion, usually a liquid (but sometimes also a gas) is forced to stop or change direction suddenly, a momentum change.

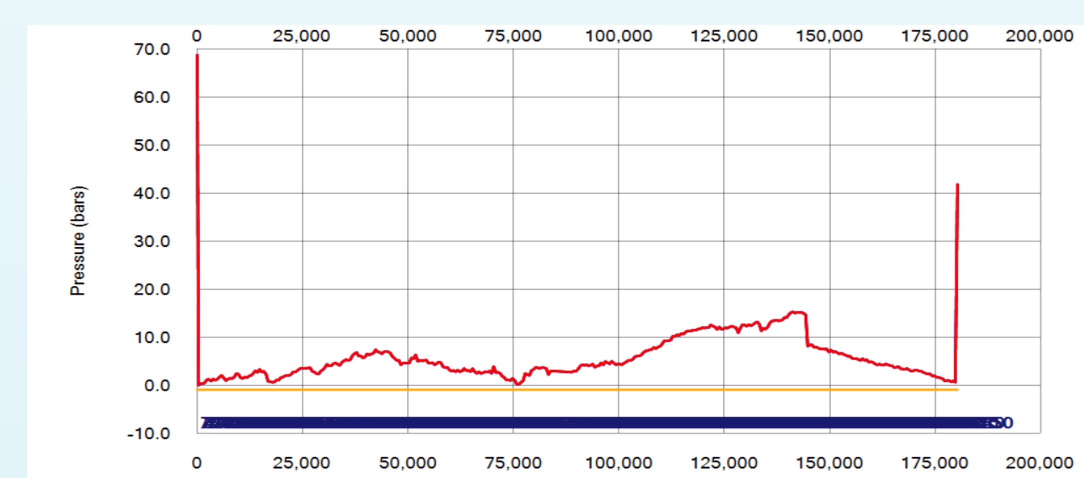
A. USING ALLIEVI:

pipe transmission line from Allievi (first 50 km)

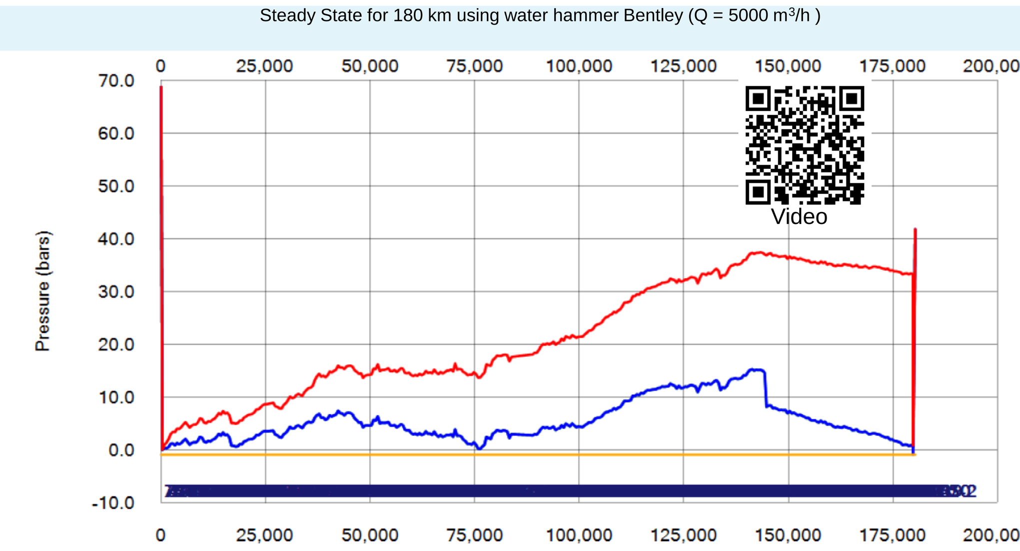
Max and Min Pressure Envelops of Water Hammer using Allievi Due to valve closure (Tc = 16 sec) (without Protection) for first 50 km

Max and Min Pressure Envelops of Water Hammer using Allievi Due to valve closure (Tc = 16 sec) (with PRV and Air Vessel Protection) for first 50 km

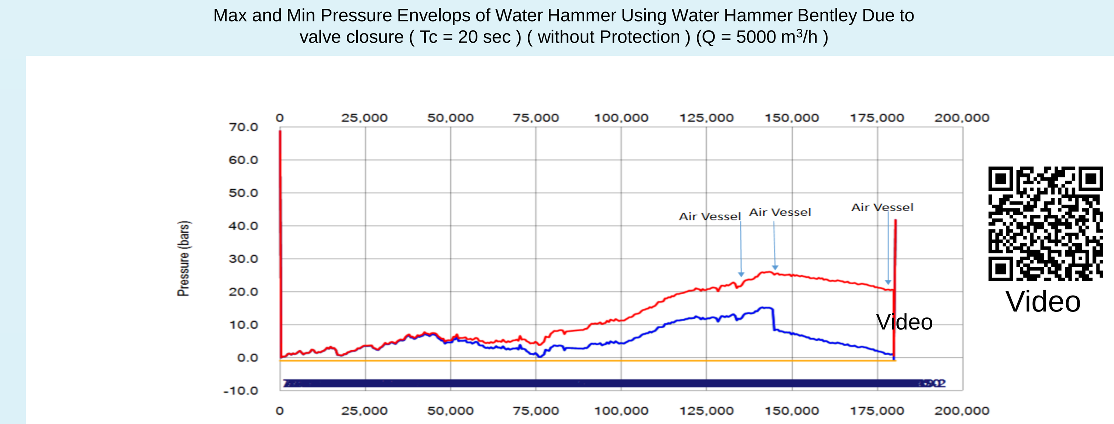
B. USING WATER HAMMER BENTLEY :



Steady State for 180 km using water hammer Bentley (Q = 5000 m^3/h)



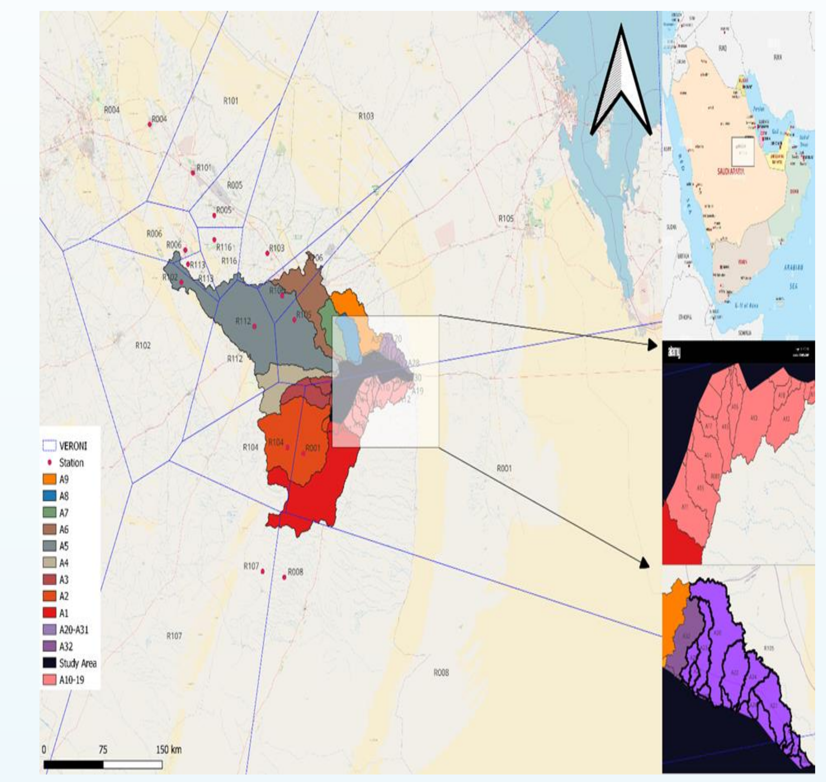
Max and Min Pressure Envelops of Water Hammer Using Water Hammer Bentley Due to valve closure (Tc = 20 sec) (without Protection) (Q = 5000 m^3/h)



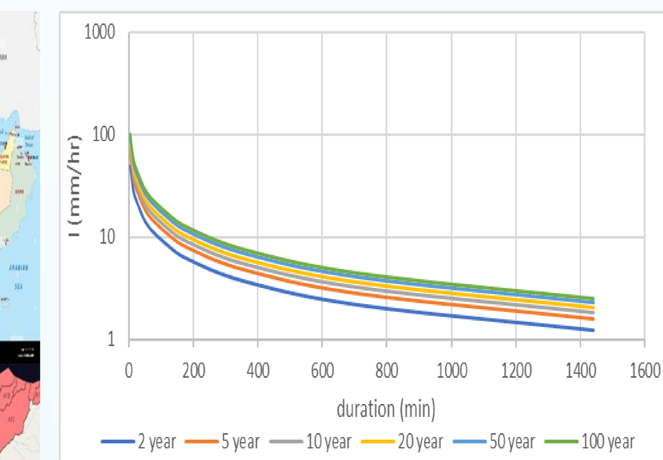
Max and Min Pressure Envelops of Water Hammer using Water Hammer Bentley Due to valve closure (Tc = 20 sec) (with Air Vessel Protection) for 180,000 km (Q = 5000 m^3/h)

Flood Protection Works

Hydrological and Runoff analysis is the process of evaluating the risks associated with flooding in a particular area. It typically involves gathering and analyzing data on the potential causes and impacts of flooding, such as rainfall patterns, soil types, topography, and land use.

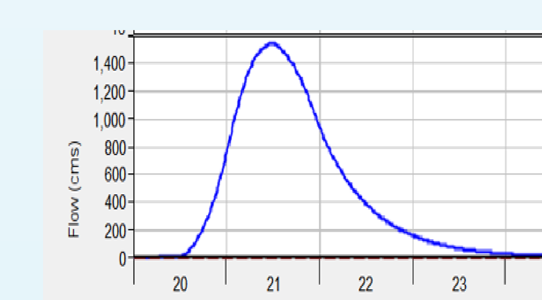


All basin attack Al-Kharj city and Rainfall Station.



IDF Curve for station.

from HEC-HMS for A1 basin



Hydrograph for A1 basin

Total rainfall depth for different sub-basins (RP = 50 years)

Name of basin	Area (km2)	Rainfall Depth (mm)	Name of basin	Area (km2)	Rainfall Depth (mm)
A1	5284.5	52.2	A17	163.484	39.0
A2	5111.6	58.4	A18	103.211	37.0
A3	1283.25	54.3	A19	51.113	33.0
A4	1876.4	59.8	A20	155.07	50.0
A5	9701.9	57.0	A21	80.01	42.0
A6	2465.4	54.4	A22	71.838	42.5
A7	992.95	53.0	A23	54.816	46.0
A8	812.75	52.0	A24	45.35	40.0
A9	1489.5	52.0	A25	21.346	38.0
A10	421.48	48.0	A26	30.678	35.0
A11	353.1	47.0	A27	9.9626	35.4
A12	272.84	45.0	A28	14.2187	35.1
A13	246.28	47.5	A29	10.3315	35.0
A14	229.94	47.2	A30	9.5691	34.9
A15	236.54	47.6	A31	7.853	35.3
A16	148.66	44.0	A32	66.425	43.0

Conclusions

- Current consumption is 1950 m^3/hr and future consumption is 4991 m^3/hr for a year 2030.
- Three different line path were studied and a comparison was made between them, and based on that study, the best path was chosen according to the social and economic constraints.
- Water transmission line works by gravity.
- Two turbines were placed on the line to reduce the pressure head, and if it reaches.
- Q=4000 m^3/hr the first turbine will be not necessary, but the second turbine will be needed.
- In the case of Q = 1950 m^3/hr, the energy generated from the turbine was used to generate electricity amounting to 1623 Kwatt with an annual income of 2,559,269 SR/yr. In the case of Q = 3000 m^3/hr, the annual income increased to 3,218,467 SR/yr, and in the case of 5000 m^3/hr the energy consumption decreased significantly, so the energy reached 1121 KWatt.
- Un-steady flow (Water hammer) was studied, the first 50 km was studied using the Allievi program, and the entire line was studied using the Bentley Hammer. In case the line was unprotected, the maximum pressure was 37.4 bar, and almost most of the line reached cavitation.
- Three air vessels were added to the system at specific locations along the pipeline: the first vessel at 179,950 km, the second at 140,000 km, and the third at 130,000 km. Each air vessel has a volume of 140 m^3. To reduce the maximum pressure to 26 bar and the minimum pressure to 0.1 bar.
- The water distribution network was studied over an pilot area of 7km^2. Diameters ranged from 150mm to 700mm and pressures from 1.5Bar to 5Bar. The cost of this section with a total length of 30km was calculated at a cost equal to 25,634,520SR.
- Total area for all Basins 31822.3 km^2, There are 32 basins flowing into Al-Kharj city.
- largest Basin is A5=9791.9 km^2, smallest basin is A31=7.85 km^2.
- Total flow rate for RP 50 years = 10855 m^3/s and for RP 20 years = 4328 m^3/s and for RP 10 years = 3306.3 m^3/s.

software used

Water Hammer, QGIS, HEC-SSP, HEC-HMS, EPANET, Allievi, AUTOCAD, GOOGLE EARTH PRO

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