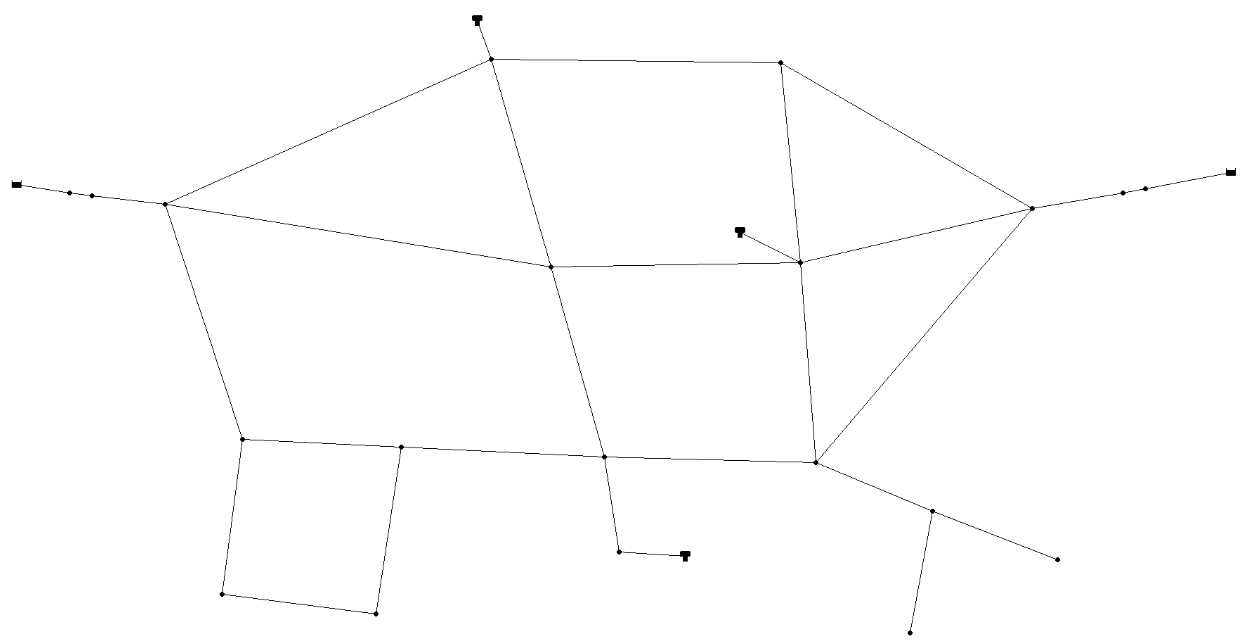
SYSTEM ID: KYPIPE Example 8

NARRATIVE DESCRIPTION

The KYPIPE Example 8 system is a simple, hypothetical network used to familiarize people with the KYPIPE software. The system has an average demand of 15.5 MGD. The network was used by Wood (1980) as a proof of concept system for his algorithm that would become KYPIPE. A general schematic of the system is shown below. The system had two reservoirs, each followed by a pump station. Additionally, there are three tanks within the system.

NETWORK SCHEMATIC:



HISTORY OF THE NETWORK FILE

The network was first published by Wood (1980) and later became an example for the KYPIPE User Manual. The original citation and abstract are listed below.

ORIGINAL REFERENCE:

Wood, D. J. (1980). *Computer Analysis of Flow in Pipe Networks Including Extended Period Simulations.* University of Kentucky Office of Engineering Continuing Education.

ABSTRACT: KYPIPE has been developed to calculate steady state flows and pressures for pipe distribution systems. The program can be applied to any liquid but does not generally apply to gas flow unless the assumption of constant density is acceptable. The program is written to accommodate any piping configuration and various hydraulic components such as pumps, valves (including check valves and regulating valves), any component or fitting which produces significant head loss (such as elbows, orifices, etc.), flow meters and storage tanks. Computations can be carried out using both English and SI units. KYPIPE is also capable of carrying out an extended period simulation (EPS) considering storage tank levels which vary over the simulation period. Storage tanks may have any shape and have upper and lower surface levels which define the range of operation of the tanks. Lines leading to storage tanks will close if the liquid surface levels reach these limits (altitude valve). As a feature of the extended period simulation the open-closed status of designated pipes may be controlled by the hydraulic grade line at a specified location in the network (pressure switch). This feature will allow, for example, bringing a booster pump online if the pressure at a specified location drops below a specified switching value. This pump will operate until the pressure is increased above a **second** specified value. The same feature can be employed to use the water level in a storage tank to control a pump.

ADDITIONAL REFERENCES:

Wood, D. J. (1981). *Algorithms for Pipe Network Analysis and their Reliability*. University of Kentucky Water Resources Research Institute Lexington, KY.

ADDITIONAL CITATIONS:

The original publication of Wood (1980) and by inference the KYPIPE Example 8 system have been cited by 31 additional authors. These may be accessed by moving your cursor over the following link while simultaneously depressing the CTRL key on your keyboard: 31 Citations. The additional publication by Wood (1981) has been cited by 11 additional authors which may be accessed here: 11 Citations

AVAILABLE INFORMATION

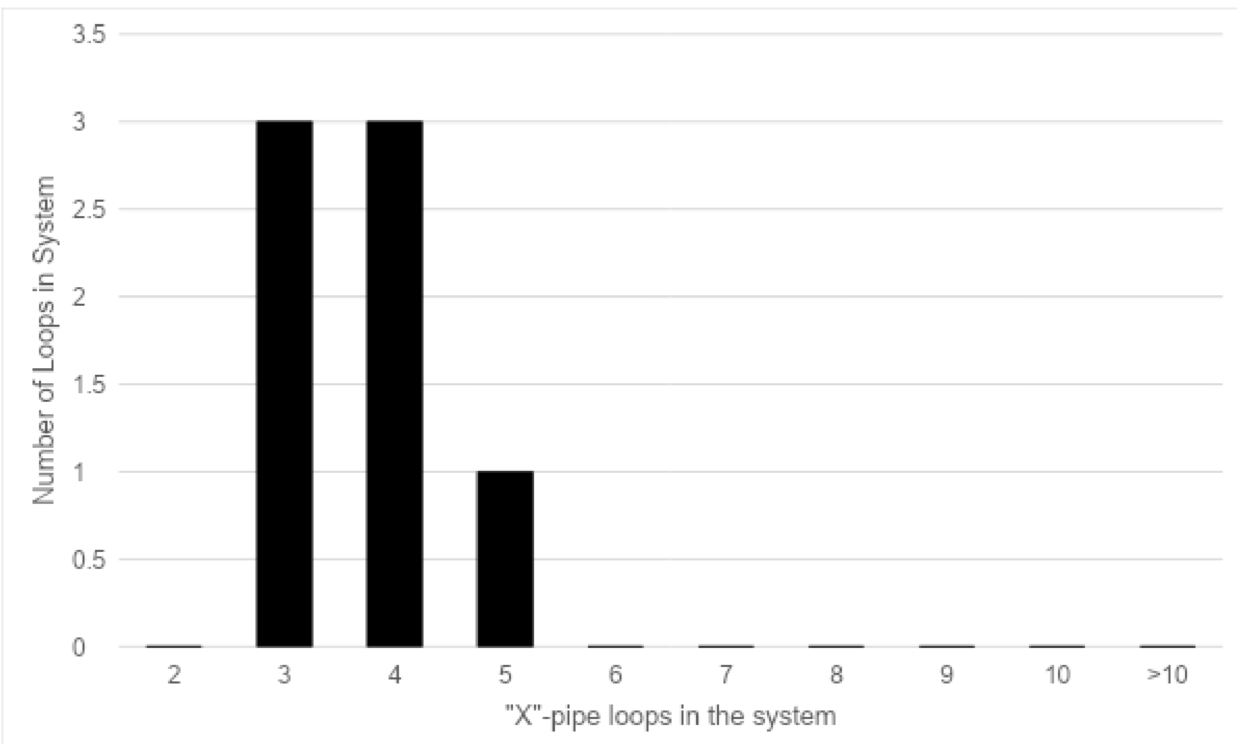
Physical attributes	Yes
Schematic diagram	Yes
Network geometry data	Yes
GIS data file	No
Background map	No
Elevation data	Yes
Pipe data	Yes
Pipe material	No
Pipe age	No
Pipe pressure class	No
Nominal or actual diameters	Actual
Pump data	Yes
Useful horsepower	No
Pump operating curves	Yes
Tank data	Yes
Elevation data	Yes
Stage storage curves	No
Water quality information	No
Valve data	NA
PRV/FCV data	
Isolation valve data	
Hydrant data	
Demand data	Yes
Total system demand	Yes
Nodal demand data	Yes
Temporal data demands	No
System leakage	No
Hydraulic data	No
Hydraulically calibrated model	
Field hydraulic calibration data	
Water quality data	No
Disinfection method	
Chlorine residual data	
Booster station data	
Fluoride/Chloride field data	
Water quality calibrated model	
Operational data	No
SCADA datasets	
Operational rules	

SYSTEM CLASSIFICATION:

PIPE/LOOP HISTOGRAM:

Hoagland et al. (2015) designed a network classification algorithm for use in classifying water distribution systems as either "branched," "looped," or "gridded" based on the observed frequency of network loops with different numbers of distinct pipe segments. The frequency distribution for the KYPIPE Example 8 system is provided below. Using this information, Hoagland et al., classified this system as being a LOOPED system.

# Total Pipes:	29
# Branch Pipes:	11
Ratio (Branch Pipes / Total Pipes):	0.38



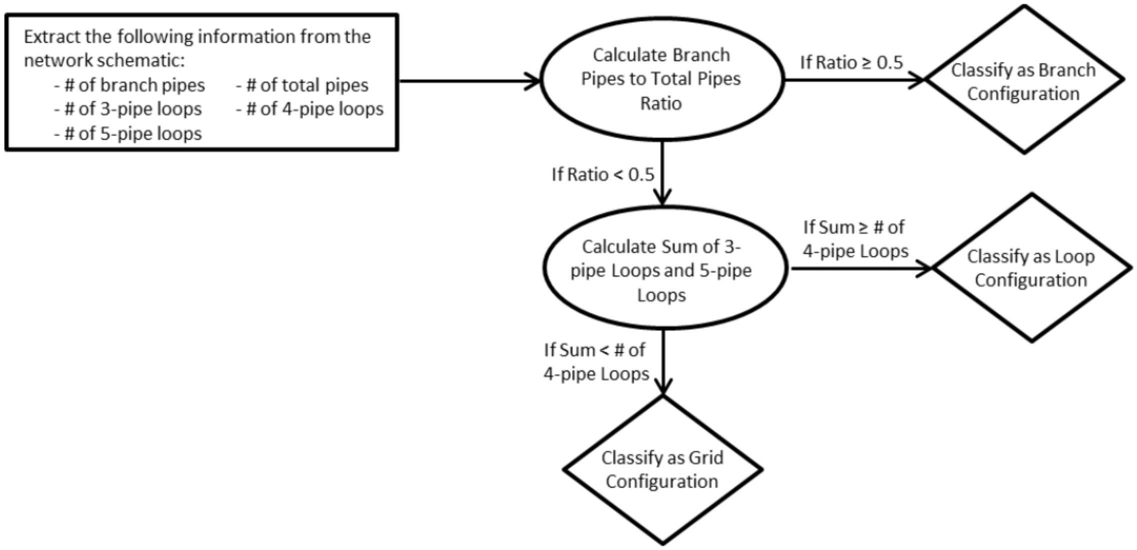


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

Hoagland, Steven & Schal, Stacey & Ormsbee, Lindell & Bryson, Lindsey. (2015). Classification of Water Distribution Systems for Research Applications. 696-702. 10.1061/9780784479162.064.

NETWORK STRUCTURE METRICS:

Building on the work of Hoagland et al., (2015), Hwang & Lansey (2017) created an expanded classification system that allows for further classification of a system as being either a transmission or distribution branched, looped, gridded, or hybrid system. Their algorithm streamlines the classification system by removing unnecessary nodes that do not contribute to the structure of the system while still retaining their use as intermediate points for demand data entry. A full description of the algorithm can be found in the cited reference.

Application of the Hwang and Lansey classification algorithm to the system yields the following statics and associated classification:

Parameter	**Value**
Edges	31
Pipes	29
Nodes	25
Average Diameter	12.1
Reduced Nodes	10
Reduced Edges	16
Branched Edges	13
Branched Index	0.5
Meshed Connectedness	0.2
Reduced Meshed Connectedness	0.47
Loop Density	0.1
Average Node Degree	2.5
Hwang & Lansey Classification	Transmission Dense-Loop

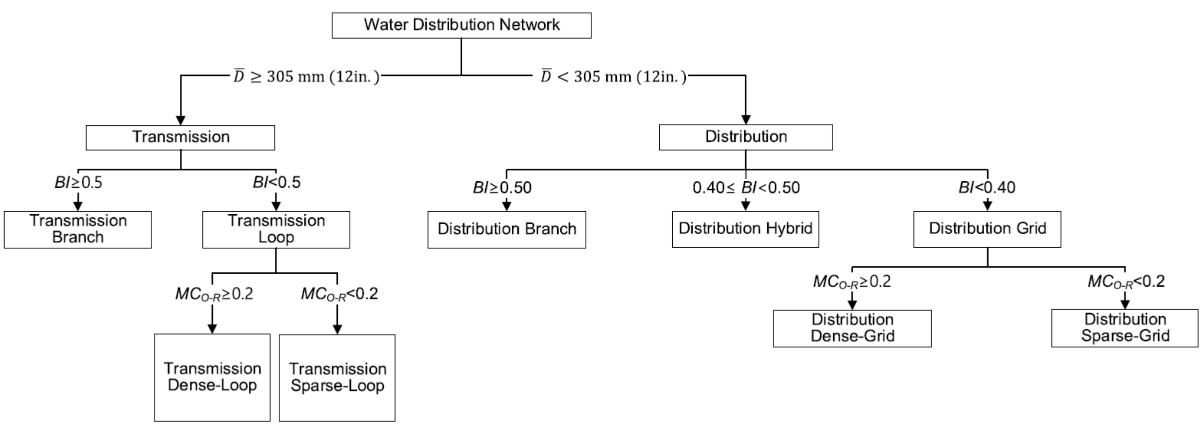


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)

Hwang H. & Lansey, K. (2015) "Water distribution system classification using system characteristics and graph theory metrics." *Journal of water resource planning and management* 143(12) https://doi.org/10.1061/(ASCE)WR.1943-5452.0000850

DETAILED DATA SUMMARIES

PHYSICAL ASSETS:

Asset Type:	# of Assets
Master Meters	0
Tanks	3
Pumps	2
Water Sources	2

NETWORK CHARACTERISTICS:

# Total Pipes:	29
# Junctions	16
# Reservoirs	2
# Tanks	3
# Regulating Valves	Unknown
# Isolation Values	Unknown
# Hydrants	Unknown
Elevation Data	YES

PIPE DATA:

Diameter (in)	Length (ft)
6	4750
8	8650
10	11500
12	20300
15	13900
16	7100
18	800
20	2000

PUMP DATA:

Pump Horsepower	NO
Pump Curves:	YES

DATA FILE ATTRIBUTES:

ATTRIBUTE		UNITS
Pipe Length & Diameter	X	Feet & inches
Pipe Age		
Node Elevation	X	Feet
Node Demand	X	MGD
Valves		
Hydrants		
Tank Levels		
Tank Volume		
PRVs		
WTP		
WTP Capacity		
Pump Data		