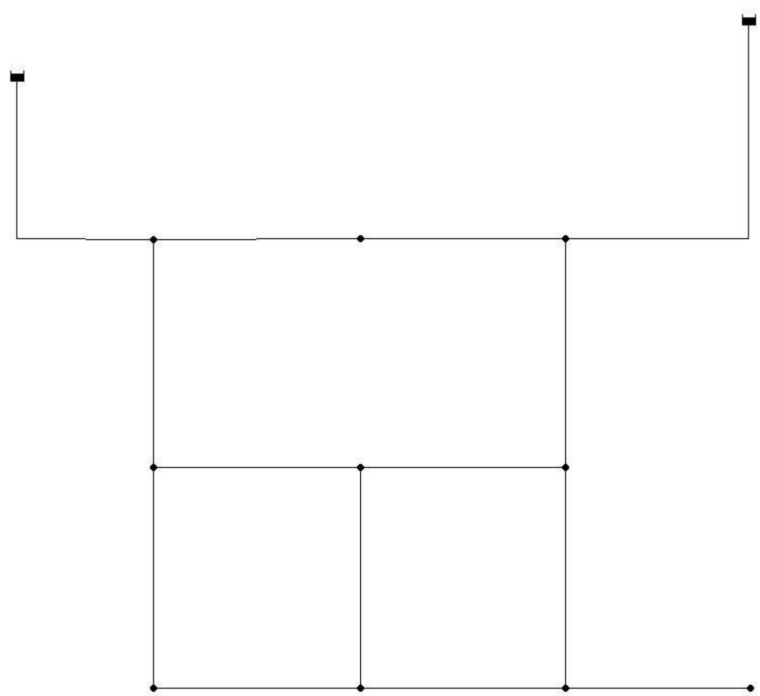
SYSTEM ID: Fourteen Pipe System

NARRATIVE DESCRIPTION

The Fourteen Pipe systems is a simple example system with an average demand of 140 LPS. The network was initially used by Gessler & Walski (1985) for optimization of pipe sizes. A general schematic of the system is shown below. The system has two sources (represented by the square reservoirs in the schematic).

NETWORK SCHEMATIC:



HISTORY OF THE NETWORK FILE

The network was first published by Gessler & Walski (1985) during a study on design optimization. The original citation and abstract are listed below.

ORIGINAL REFERENCE:

Gessler, J. and Walski, T.M. (1985) *Water distribution system optimization*, US Army corps of engineers waterways experimentation station, Technical Report TR EL-85-11, Vicksburg, Miss.

ABSTRACT: This report describes the development of a computer program WADISO (Water Distribution Systems Optimization) which can be used to optimally size pipes in water distribution systems and select optimal pipes for cleaning and lining. The program can also be used as a steady-state simulation program to calculate flows and pressures in pipe networks.

The simulation portion of the program uses the node method with sparse matrix techniques to reduce computations. The optimization portion uses a bounded enumeration technique, based on minimizing the sum of pipe installation, pipe cleaning and lining, and present sizes are considered. The program can handle virtually any typical water distribution system and includes pumps, pressure reducing valves, multiple pressure zones, and check valves. To use the optimization, the user must also specify the costs as a function of pipe diameter (or use default costs in the program), minimum pressures, up to five water use loadings, a list of which pipes are to be sized, and a range of sizes to be considered.

The program user's guide is included as an appendix to the report. Other appendices address how to access the program, how to obtain detailed documentation, the nature of pipe sizing, existing literature on pipe optimization, and a discussion of the relationship of pipe sizing and water distribution performance criteria.

ADDITIONAL CITATIONS:

The original publication of Gessler & Walski (1985) and by inference the Fourteen Pipe system have been cited by 78 additional authors. These may be accessed by moving your cursor over the following link while simultaneously depressing the CTRL key on your keyboard: 46 Citations.

AVAILABLE INFORMATION

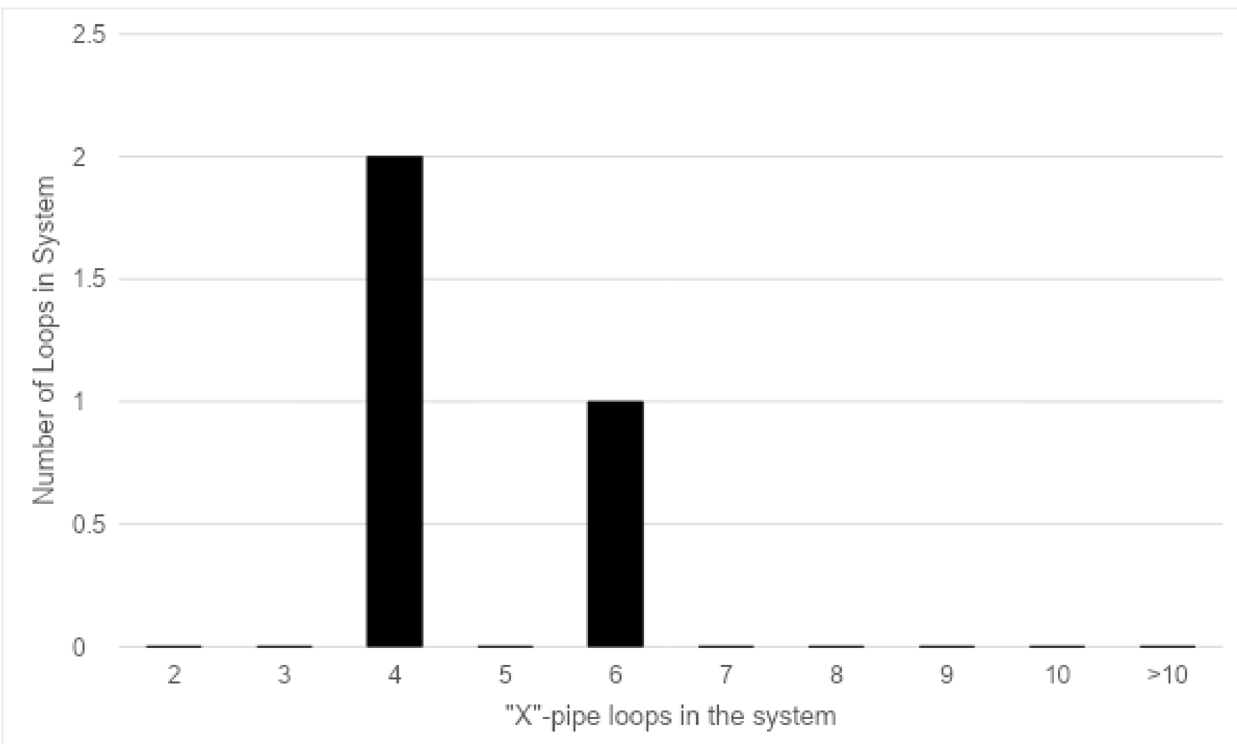
Physical attributes	Yes
Schematic diagram	Yes
Network geometry data	Yes
GIS data file	No
Background map	No
Elevation data	Yes
Pipe data	Yes
Pipe material	No
Pipe age	No
Pipe pressure class	No
Nominal or actual diameters	Nominal
Pump data	N.A.
Useful horsepower	
Pump operating curves	
Tank data	N.A.
Elevation data	
Stage storage curves	
Water quality information	
Valve data	N.A.
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 Fourteen Pipe system is provided below. Using this information, Hoagland et al., classified this system as being a GRIDDED system.

# Total Pipes:	14
# Branch Pipes:	3
Ratio (Branch Pipes / Total Pipes):	0.21



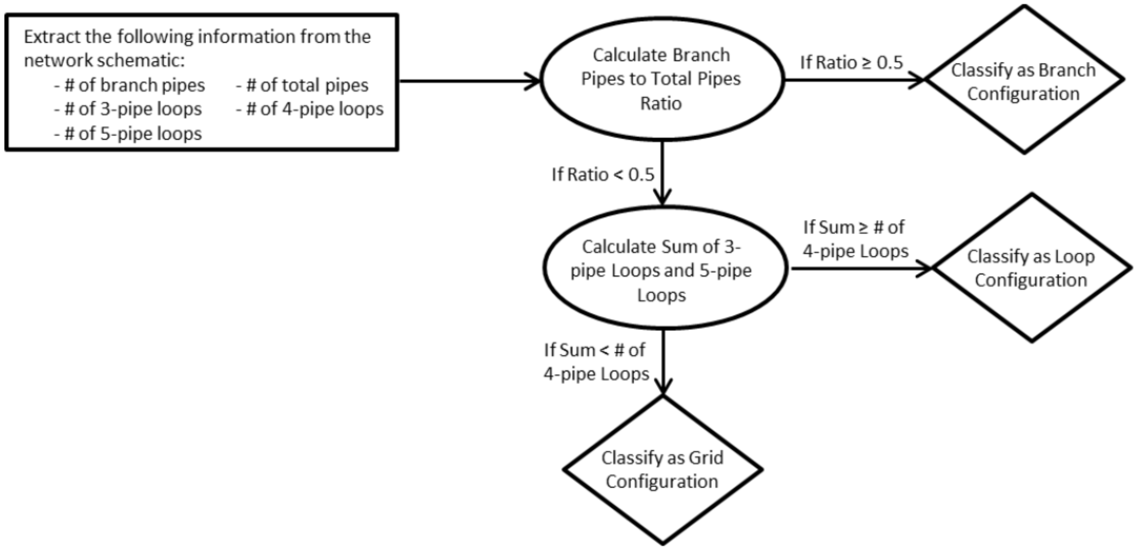


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

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	14
Pipes	14
Nodes	12
Average Diameter	190
Reduced Nodes	7
Reduced Edges	9
Branched Edges	3
Branched Index	0.3
Meshed Connectedness	0.2
Reduced Meshed Connectedness	0.33
Loop Density	0.2
Average Node Degree	2.3
Hwang & Lansey Classification	Distribution Dense-Grid

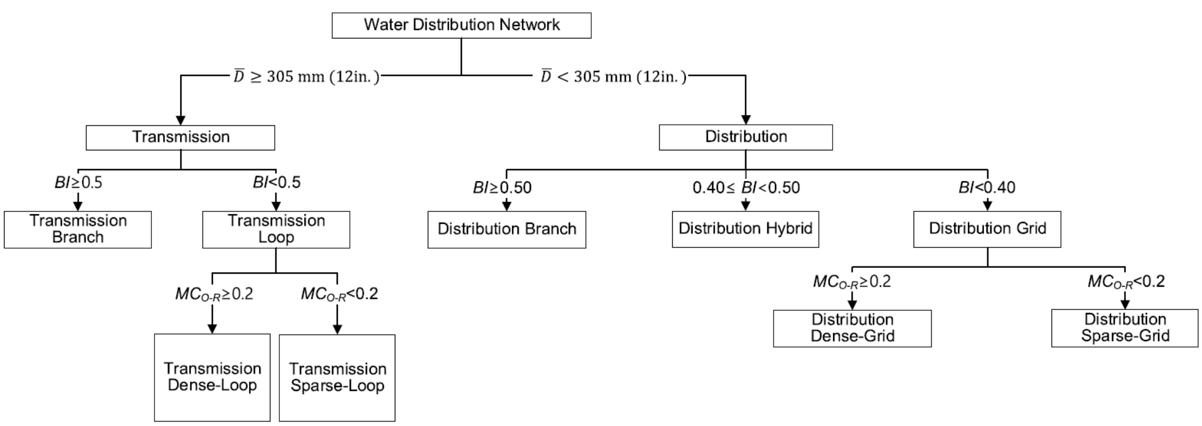


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)

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	0
Pumps	0
Water Sources	2

NETWORK CHARACTERISTICS:

# Total Pipes:	14
# Branch Pipes:	3
Ratio (Branch Pipes / Total Pipes):	0.21
# Junctions	10
# Reservoirs	2
# Tanks	0
# Regulating Valves	Unknown
# Isolation Values	Unknown
# Hydrants	Unknown
Elevation Data	YES

PIPE DATA:

Diameter (mm)	Length (m)
102	1609
203	3218
254	12873
305	8045
356	4828

PUMP DATA:

Pump Horsepower	NO
Pump Curves:	NO

DATA FILE ATTRIBUTES:

ATTRIBUTE		UNITS
Pipe Length & Diameter	X	Meters & Millimeters
Pipe Age		
Node Elevation	X	Meters
Node Demand	X	LPS
Valves		
Hydrants		
Tank Levels		
Tank Volume		
PRVs		
WTP		
WTP Capacity		
Pump Data		