SYSTEM ID: KY 6

NARRATIVE DESCRIPTION

The KY 6 system is based on a real-world water distribution system in Kentucky. It serves 2,850 customers and sells water for $7.38 to $8.12 per 1,000 gallons. The system has an average demand of 1.56 MGD. The network was used by Jolly et al. (2014) as part of a classification study. A general schematic of the system is shown below. The system has two reservoirs, two pumps, three elevated storage tanks, and 58.5 miles of pipe. Water loss within the system is estimated to be 19%.

NETWORK SCHEMATIC:

HISTORY OF THE NETWORK FILE

The KY 6 system was originally created by Matthew Jolly and Amanda Lothes in 2012 as part of an article "Research Database of Water Distribution System Models" which was published in 2014 in the *Journal of Water Resources Planning & Management*. It was updated by Stacy Schal in 2013 and updated again by Steven Hoagland in 2014.

ORIGINAL REFERENCE:

Jolly, M. D., Lothes, A. D., Bryson, L. S., & Ormsbee, L. (2014). Research Database of Water Distribution System Models. *Journal of Water Resources Planning and Management,* 410-416. 10.1061/(ASCE)WR.1943-5452.0000352

ABSTRACT: Since the 1960s, researchers have continued to develop new methodologies and algorithms in support of the planning, design, and management of water distribution systems. While initial research focused on modeling the hydraulics of such systems, the 1980s gave rise to additional research focused on water quality issues. More recent research has expanded into issues of system reliability and resilience, energy management, and sensor and chlorine booster station placement. In most cases, researchers have relied on either hypothetical water distribution systems or a handful of actual systems for use as benchmark test systems. Some of the more widely used actual systems include the New York tunnel system and the Hanoi water distribution system. This paper describes the development of a database of several water distribution systems synthesized from a statewide database of systems originally developed by the Kentucky Infrastructure Authority. The developed models include both small and medium networks, as well a range of system characteristics (i.e.,system configuration-grid, looped, and branched systems-and system components-number of tanks, pump stations, and supply sources). The development of the database is described, as well as how to gain access to the developed models. All models have been developed to support use by water distribution system modeling software.

ADDITIONAL CITATIONS:

The original publication of Jolly et. al. (2014) and by inference the KY 6 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: 78 Citations

AVAILABLE INFORMATION

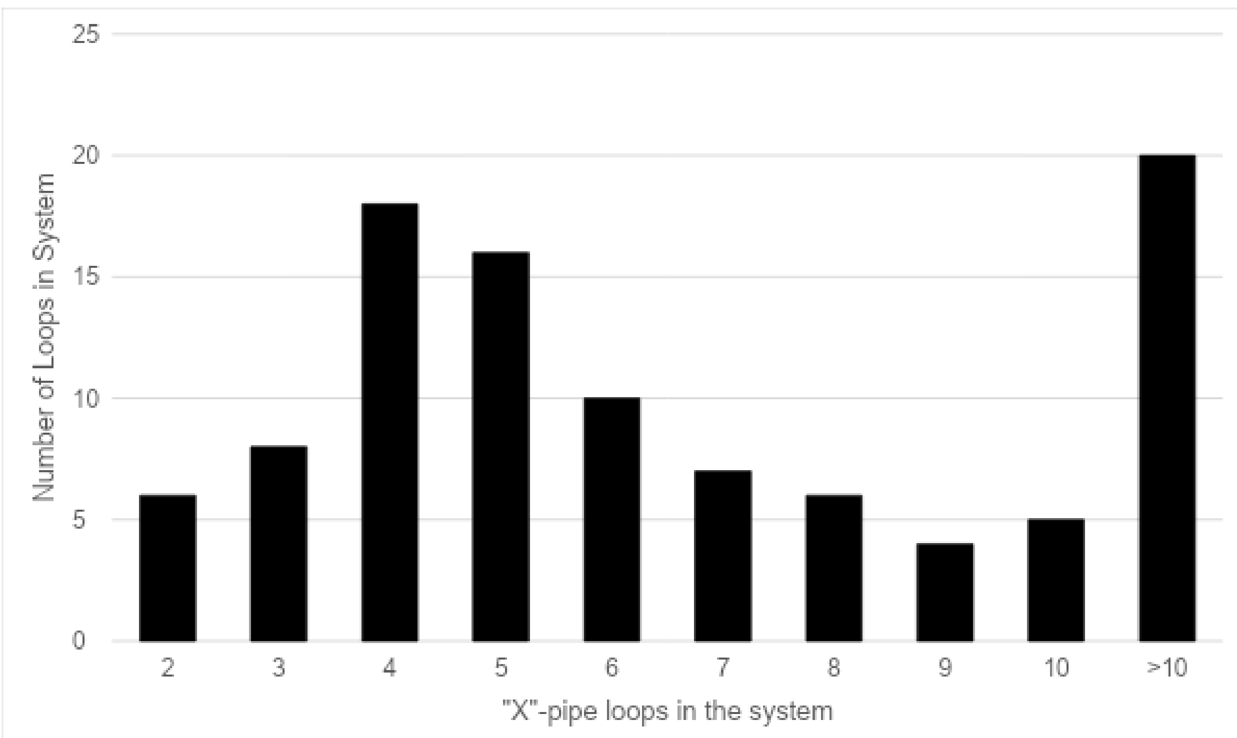
Physical attributes	Yes
Schematic diagram	Yes
Network geometry data	Yes
GIS data file	Yes
Background map	Yes
Elevation data	Yes
Pipe data	Yes
Pipe material	Yes
Pipe age	Yes
Pipe pressure class	No
Nominal or actual diameters	Nominal
Pump data	Yes
Useful horsepower	Yes
Pump operating curves	No
Tank data	Yes
Elevation data	Yes
Stage storage curves	No
Water quality information	No
Valve data	Yes
PRV/FCV data	Yes
Isolation valve data	No
Hydrant data	No
Demand data	Yes
Total system demand	Yes
Nodal demand data	Yes
Temporal data demands	Yes
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 KY 6 system is provided below. Using this information, Hoagland et al., classified this system as being a LOOPED system.

# Total Pipes:	644
# Branch Pipes:	204
Ratio (Branch Pipes / Total Pipes):	0.317



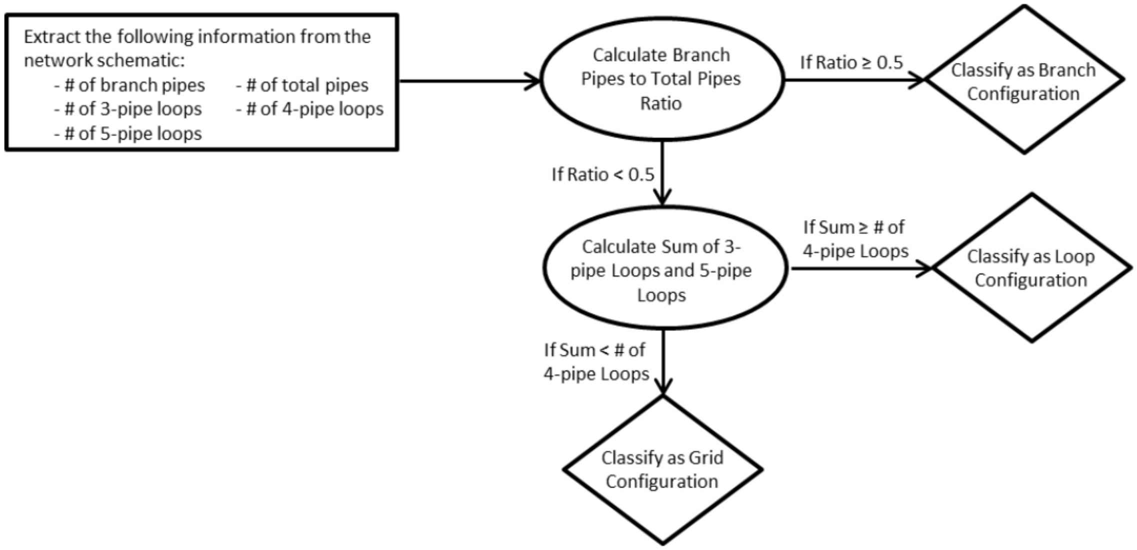


Figure 3.4. Classification Algorithm (Hoagland et al., 2015)

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	647
Pipes	644
Nodes	548
Average Diameter	8
Reduced Nodes	244
Reduced Edges	343
Branched Edges	199
Branched Index	0.4
Meshed Connectedness	0.1
Reduced Meshed Connectedness	0.21
Link Density	0
Average Node Degree	2.4
Hwang & Lansey Classification	Distribution Dense-Grid

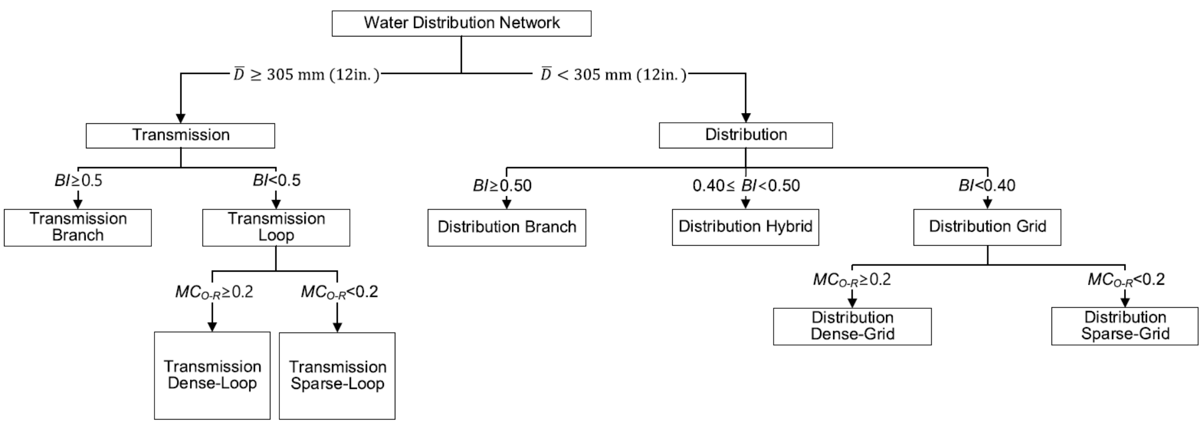


Figure 7. Water Distribution System Classification Flowchart (Hwang & Lansey, 2017)\

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	2
Tanks	3
Pumps	2
Water Sources	2

NETWORK CHARACTERISTICS:

# Total Pipes:	644
# Junctions	537
# Reservoirs	2
# Tanks	3
# Regulating Valves	1
# Isolation Values	Unknown
# Hydrants	Unknown
Elevation Data	YES

PIPE DATA:

Diameter (in)	Length (ft)
0.75	4,355
1	3,988
2	33,108
3	7,084
4	15,207
6	150,048
8	17,993
10	90,798
12	33,335
16	40,523
18	1,790

PUMP DATA:

Pump Horsepower	YES
Pump Curves:	NO

DEMAND STATISTICS:

Demographic Type	Population	Households
Directly Serviceable:	6,534	2,902
Indirectly Serviceable:	14,122	6,997
Total Serviceable:	20,656	9,899

Production Statistics	
Total Annual Volume Produced (MG):	730.311
Total Annual Volume Purchased (MG):	
Total Annual Volume Provided (MG):	730.311
Estimated Annual Water Loss:	19%

Water Costs	
Customer Type	Cost per 1000 gallons
Customers within the municipality	$7.38
Customers outside the municipality	$8.12

CUSTOMERS AND USAGE:

Customer Type	Customer Count	Average Demand (MG)
Wholesale:	1	171.077
Residential:	2,423	141.014
Commercial:	405	191.111
Institutional:		
Industrial:	21	85.300
Other:		
Total Customers:	2,850	
Flushing, Maintenance & Fire Protection:		
Total Water Usage:		588.502

DATA FILE ATTRIBUTES:

ATTRIBUTE		UNITS
Pipe Length & Diameter	X	Feet & inches
Pipe Age	X	Year Installed
Node Elevation	X	Feet
Node Demand	X	GPM
Valves		
Hydrants		
Tank Levels	X	Feet
Tank Volume	X	Cubic Feet
PRVs		
WTP		
WTP Capacity	X	GPD
Pump Data	X	HP