

LECTURE 8-A

INTRODUCTION TO EPANET



*CEEN 4800/6965 - Special Topics
Geographic Information Systems and Hydrologic & Hydraulic Modeling
Sam Shamsi, Ph.D., P.E.
Adjunct Professor
Department of Civil / Environmental & Chemical Engineering*

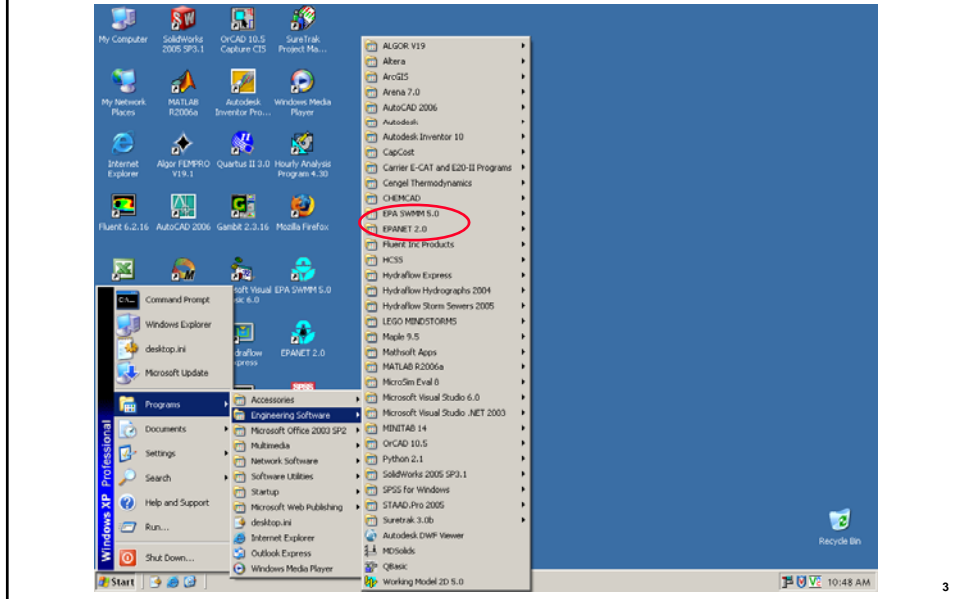
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OUTLINE

- ◆ Download instructions
- ◆ EPANET description
- ◆ EPANET capabilities
- ◆ EPANET applications
- ◆ User interface
- ◆ EPANET input data
- ◆ EPANET output results
- ◆ Tutorial
- ◆ Exercise
- ◆ Homework

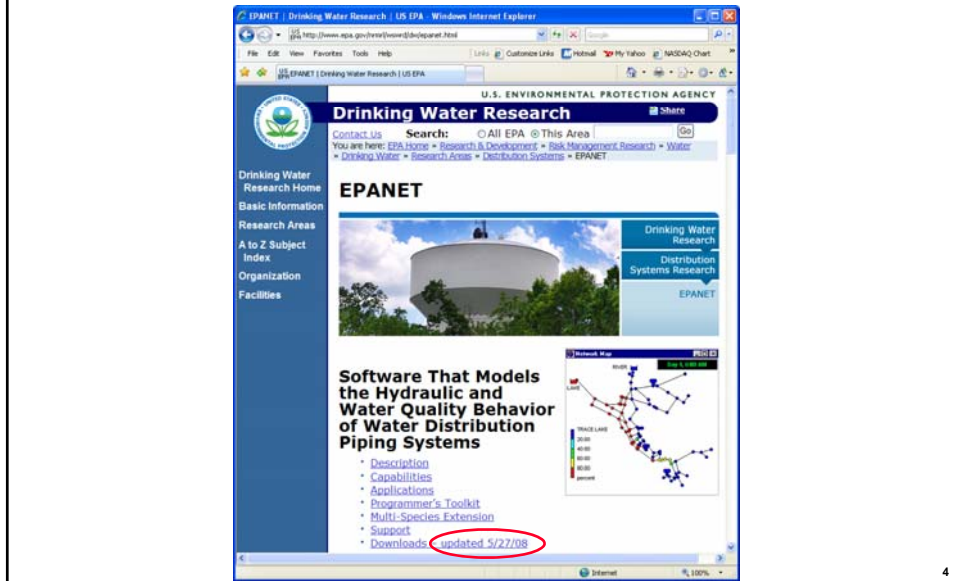
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EPANET IN COMPUTER LAB



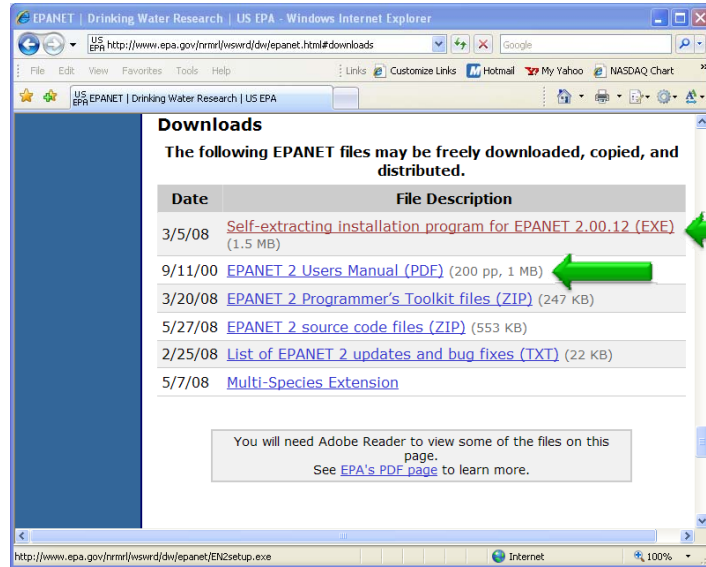
EPANET DOWNLOAD

<http://www.epa.gov/ORD/NRMRL/wswrd/epanet.html>



EPANET DOWNLOAD

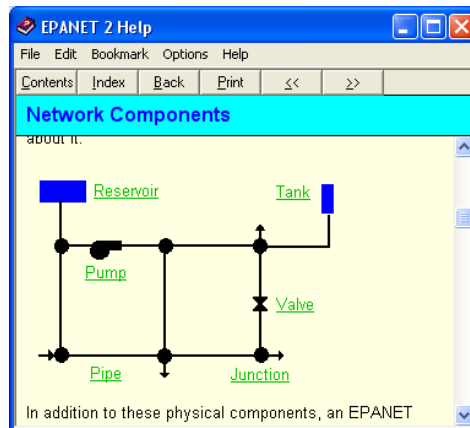
<http://www.epa.gov/ORD/NRMRL/wswrd/epanet.html#Downloads>



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DESCRIPTION

- ◆ EPANET models flow rate, pressure, and water quality (contaminant concentration) in a water distribution system.
- ◆ The modeled network can consist of:
 - ◆ Nodes:
 - ◆ pipe junctions
 - ◆ storage tanks, and
 - ◆ reservoirs.
 - ◆ Links:
 - ◆ pipes
 - ◆ pumps
 - ◆ valves
 - ◆ EPANET demo



Shortcut to Net1.net.lnk

C:\Documents and Settings\sshamsi\My Documents\2008\YSUGIS08\Lectures\10-EPANET\EPANET\AGNETDemo1\Net1.net

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DESCRIPTION

- ◆ **EPANET models:**
 - ◆ flow of water in pipes,
 - ◆ pressure at junctions,
 - ◆ height of water in tanks,
 - ◆ concentration of a chemical,
 - ◆ water age, and
 - ◆ source tracing (trace the source of a contaminant)

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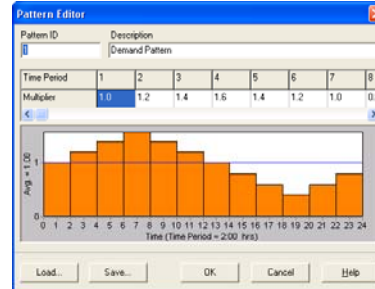
CAPABILITIES

- ◆ Extended period hydraulic analysis
- ◆ Can model systems of any size
- ◆ Computes friction head loss using one of the following equations
 - ◆ Hazen-Williams,
 - ◆ Darcy-Weisbach, or
 - ◆ Chezy-Manning
- ◆ Allows minor head losses for bends, fittings, etc.
- ◆ Models constant or variable speed pumps
- ◆ Computes pumping energy and cost

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CAPABILITIES

- ◆ Models various types of valves including:
 - ◆ Shutoff valves
 - ◆ Check valves
 - ◆ Pressure regulating valves
 - ◆ Flow control valves
- ◆ Models storage tanks of any shape (i.e., diameter can vary with height)
- ◆ Allows multiple demand categories at nodes, each with its own pattern of time variation



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APPLICATIONS

- ◆ Plan and improve a system's hydraulic performance
- ◆ Pipe, pump and valve placement and sizing
- ◆ Fire flow analysis
- ◆ Maintain and improve the quality of water delivered to consumers
- ◆ Study disinfectant loss and by-product formation
- ◆ Evaluate alternative strategies for improving water quality such as:
 - ◆ Altering source utilization within multi-source systems,
 - ◆ Modifying pumping and tank filling/emptying schedules to reduce water age,
 - ◆ Utilizing booster disinfection stations at key locations to maintain target residuals

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USER INTERFACE

- ◆ Provides a visual network editor that simplifies the process of building piping network models and editing their properties.
- ◆ Various data reporting and visualization tools are used to assist in interpreting the results of a network analysis. These include:
 - ◆ Graphical views (time series plots, profile plots, contour plots, etc.),
 - ◆ Tabular views, and
 - ◆ Special reports (e.g., energy usage).

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USER INTERFACE

The screenshot displays the IPANET 2 software interface. The window title is "IPANET 2 - Net1.net". The interface includes a menu bar (File, Edit, View, Project, Report, Window, Help) and a standard toolbar. A "MAP TOOLBAR" is also visible. The main area shows a "Network Map" with a "Source", "Pump", and "Tank" connected by pipes. The simulation time is "Day 1, 12:00 AM".

Labels on the left side of the screenshot:

- INPUT FILE NAME
- STANDARD TOOLBAR
- MAP AND DATA BROWSER
- SIMULATION TIME

Labels within the software interface:

- MENU BAR
- MAP TOOLBAR
- Browser (Data, Map)
- Nodes: Pressure (25.00, 50.00, 75.00, 100.00)
- Links: Unit Headloss (0.00, 0.05, 0.08, 0.10)
- Unit Headloss (0.00, 0.05, 0.08, 0.10)
- MAP LEGEND
- NETWORK MAP
- SIMULATION TIME

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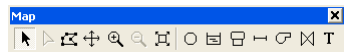
STANDARD TOOLBAR

The screenshot shows the EPANET 2 Help window with the 'Standard Toolbar' section highlighted. The list of functions includes:

- Opens a new project
- Opens an existing project
- Saves the current project
- Prints the currently active window
- Copies selection to clipboard or to file
- Deletes currently selected item
- Finds a specific item on the map
- Runs a simulation
- Runs a visual query on the map
- Creates a new graph view of results
- Creates a new table view of results
- Modifies options for the currently active view

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MAP TOOLBAR



The screenshot shows the EPANET 2 Help window with the 'Map Toolbar' section highlighted. The list of functions includes:

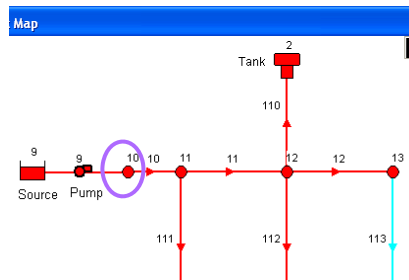
- Selects an object on the map
- Selects link vertex points
- Selects a region of the map
- Pans across the map
- Zooms in on the map
- Zooms out on the map
- Draws the map at full extent
- Adds a junction to the map
- Adds a reservoir to the map
- Adds a tank to the map
- Adds a pipe to the map
- Adds a pump to the map
- Adds a valve to the map
- Adds a Label to the map

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EPANET INPUT

◆ Junctions

- ◆ Coordinates (can import from GIS)
- ◆ Elevation
- ◆ Demand (gallons per minute)
- ◆ Initial quality



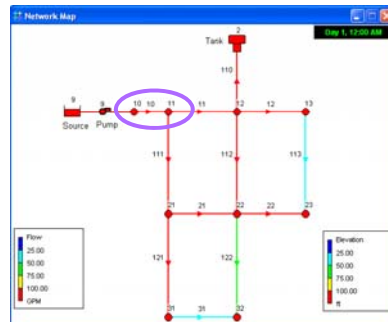
| Property | Value |
|-------------------|---------|
| *Junction ID | 10 |
| X-Coordinate | 20.00 |
| Y-Coordinate | 70.00 |
| Description | |
| Tag | |
| *Elevation | 710 |
| Base Demand | 0 |
| Demand Pattern | |
| Demand Categories | 1 |
| Emitter Coeff. | |
| Initial Quality | 0.5 |
| Source Quality | |
| Actual Demand | 0.00 |
| Total Head | 1004.35 |
| Pressure | 127.54 |
| Quality | 0.50 |

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EPANET INPUT

◆ Pipes

- ◆ Length
- ◆ Diameter
- ◆ Roughness coefficient (Hazen-Williams C factor)

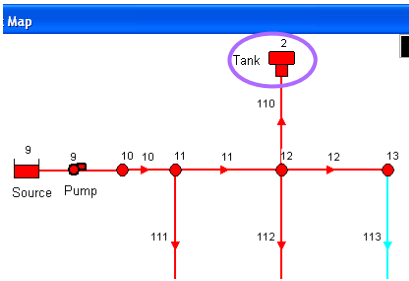


| Property | Value |
|-----------------|---------|
| *Pipe ID | 10 |
| *Start Node | 10 |
| *End Node | 11 |
| Description | |
| Tag | |
| *Length | 10530 |
| *Diameter | 18 |
| *Roughness | 100 |
| Loss Coeff. | 0 |
| Initial Status | Open |
| Bulk Coeff. | |
| Wall Coeff. | |
| Flow | 1866.18 |
| Velocity | 2.35 |
| Unit Headloss | 1.82 |
| Friction Factor | 0.032 |
| Reaction Rate | 0.00 |
| Quality | 0.50 |
| Status | Open |

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EPANET INPUT

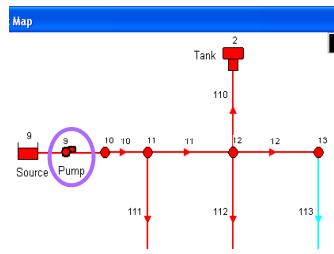
- ◆ Tanks data
 - ◆ Coordinates (can import from GIS)
 - ◆ Elevation
 - ◆ Levels
 - ◆ Initial
 - ◆ Minimum
 - ◆ Maximum
 - ◆ Diameter
 - ◆ Volume



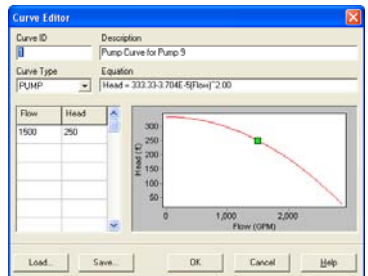
| Property | Value |
|-----------------|--------|
| *Tank ID | 2 |
| X-Coordinate | 50.00 |
| Y-Coordinate | 90.00 |
| Description | |
| Tag | |
| *Elevation | 850 |
| *Initial Level | 120 |
| *Minimum Level | 100 |
| *Maximum Level | 150 |
| *Diameter | 50.5 |
| Minimum Volume | 0 |
| Volume Curve | |
| Mixing Model | Mixed |
| Mixing Fraction | |
| Reaction Coeff. | |
| Initial Quality | 1.0 |
| Source Quality | |
| Net Inflow | 766.18 |
| Elevation | 970.00 |
| Pressure | 52.00 |
| Quality | 1.00 |

EPANET INPUT

- ◆ Pumps data
 - ◆ Start node
 - ◆ End node
 - ◆ Pump curve
 - ◆ Initial status (open, close)
- ◆ Valves data

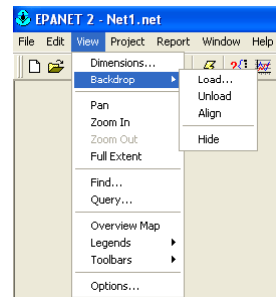
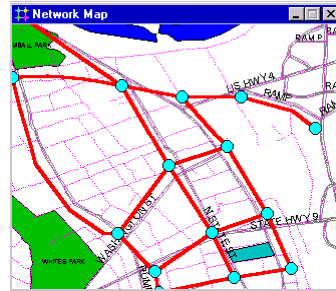


| Property | Value |
|----------------|---------|
| *Pump ID | 9 |
| *Start Node | 9 |
| *End Node | 10 |
| Description | |
| Tag | |
| Pump Curve | 1 |
| Power | |
| Speed | |
| Pattern | |
| Initial Status | Open |
| Effic. Curve | |
| Energy Price | |
| Price Pattern | |
| Flow | 1866.18 |
| Headloss | -204.35 |
| Quality | 0.75 |
| Status | Open |



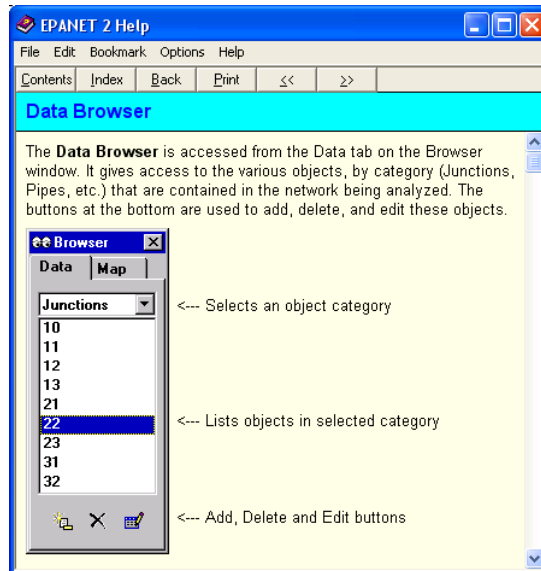
BACKDROP MAP

- ◆ EPANET can display a backdrop map behind the pipe network map.
 - ◆ street map,
 - ◆ utility map,
 - ◆ topographic map
- ◆ Simplifies the process of adding pipes to the network (heads up digitization)
- ◆ Windows enhanced metafile (wmf and emf) or bitmap (bmp)
 - ◆ Most CAD and GIS programs have the ability to save their drawings and maps as metafiles.
- ◆ Selecting View >> Backdrop from the Menu Bar will display a sub-menu with the following commands:
 - ◆ Load (loads a backdrop map file into the project)
 - ◆ Unload (unloads the backdrop map from the project)
 - ◆ Align (aligns the pipe network with the backdrop)
 - ◆ Show/Hide (toggles the display of the backdrop on and off)



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DATA BROWSER



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EPANET OUTPUT

- ◆ Junctions (nodes)
 - ◆ Pressure
 - ◆ Quality (e.g., residual chlorine concentration)
- ◆ Pipes (links)
 - ◆ Flow (gallons per minute)
 - ◆ Velocity (ft per second)
 - ◆ Head loss (ft)
- ◆ Tanks: inflow, level, quality
- ◆ Pump: flow rate

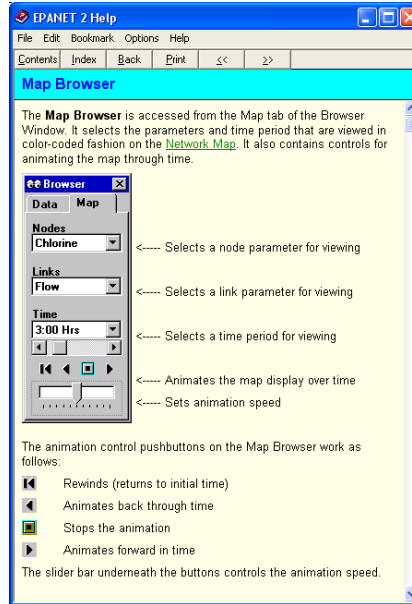
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TABULAR RESULTS

| Node ID | Elevation ft | Base Demand GPM | Initial Quality mg/L | Demand GPM | Head ft | Pressure psi | Chlorine mg/L |
|---------|-----------------|--------------------|-------------------------|---------------|------------|-----------------|------------------|
| Junc 10 | 710 | 0 | 0.5 | 0.00 | 1002.29 | 126.65 | 0.50 |
| Junc 11 | 710 | 300 | 0.5 | 300.00 | 982.89 | 118.24 | 0.50 |
| Junc 12 | 700 | 150 | 0.5 | 150.00 | 970.05 | 117.01 | 0.50 |
| Junc 13 | 695 | 100 | 0.5 | 100.00 | 968.75 | 118.61 | 0.50 |
| Junc 21 | 700 | 150 | 0.5 | 150.00 | 970.69 | 117.29 | 0.50 |
| Junc 22 | 695 | 200 | 0.5 | 200.00 | 968.82 | 118.65 | 0.50 |
| Junc 23 | 690 | 150 | 0.5 | 150.00 | 968.43 | 120.64 | 0.50 |
| Junc 31 | 700 | 100 | 0.5 | 100.00 | 966.67 | 115.55 | 0.50 |
| Junc 32 | 710 | 100 | 0.5 | 100.00 | 965.16 | 110.56 | 0.50 |
| Resvr 9 | 800 | #N/A | 1.0 | -1881.03 | 800.00 | 0.00 | 1.00 |
| Tank 2 | 850 | #N/A | 1.0 | 631.03 | 970.00 | 52.00 | 1.00 |

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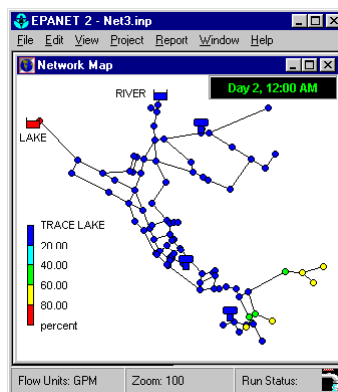
MAP BROWSER



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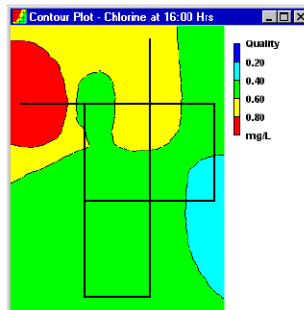
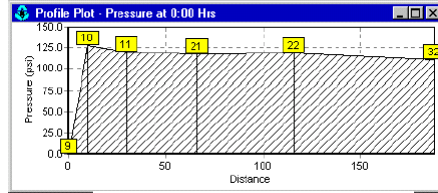
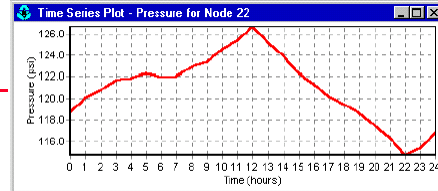
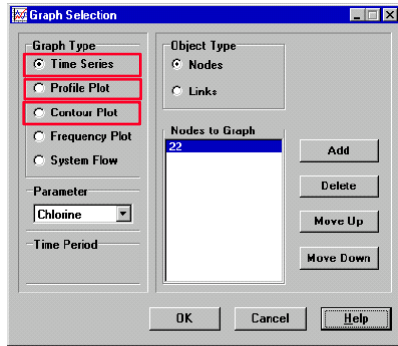
ANIMATED MAP RESULTS

EPANET's water quality analyzer
Track the percent of flow from a given
node reaching all other nodes over time



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GRAPHICAL RESULTS



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GRAPHS

EPANET 2 Help

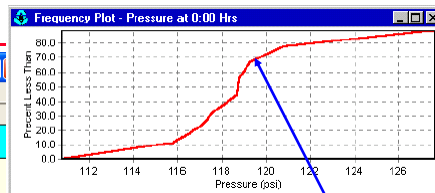
File Edit Bookmark Options Help

Contents Index Back Print << >>

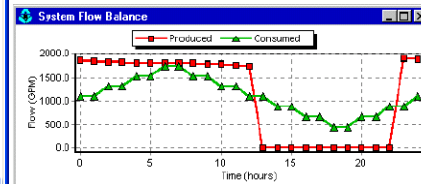
Types of Graphs

The following types of graphs can be used to view values for a selected parameter:

| Type of Graph | Description | Applies To |
|------------------|--|--|
| Time Series Plot | Plots value versus time | Specific nodes or links over all time periods |
| Profile Plot | Plots value versus distance | A list of nodes at a specific time |
| Contour Plot | Shows regions of the map where values fall within specific intervals | All nodes at a specific time |
| Frequency Plot | Plots value versus fraction of objects not exceeding the value | All nodes or links at a specific time |
| System Flow | Plots total system production and consumption versus time | Water demand for all nodes over all time periods |



70% nodes have pressure less than 120 psi



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EPANET TUTORIAL

- ◆ Great way to practice and learn
- ◆ Build a network from scratch
- ◆ Chapter 2, Page 13 of the Users Manual

CHAPTER 2 - QUICK START TUTORIAL

This chapter provides a tutorial on how to use EPANET. If you are not familiar with the components that comprise a water distribution system and how these are represented in pipe network models you might want to review the first two sections of Chapter 3 first.

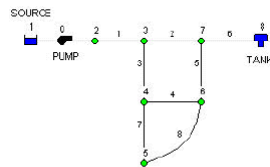
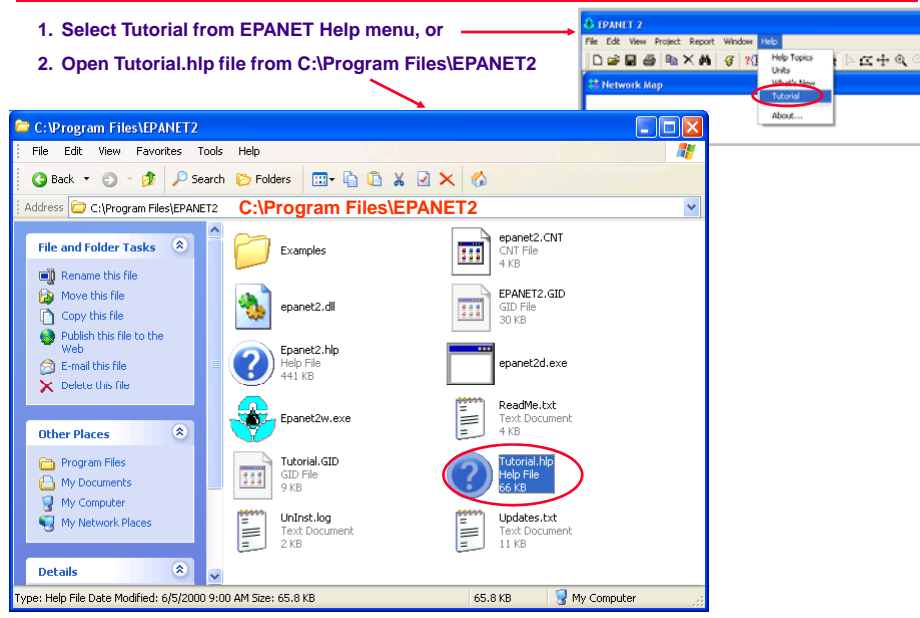


Figure 2.1 Example Pipe Network

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EPANET TUTORIAL

1. Select Tutorial from EPANET Help menu, or
2. Open Tutorial.hlp file from C:\Program Files\EPANET2



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EPANET TUTORIAL

EPANET 2 Tutorial

File Edit Bookmark Options Help

<< >>

EPANET TUTORIAL

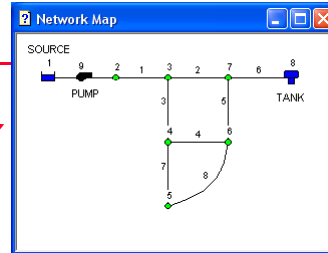
This tutorial provides an introduction on using EPANET to analyze the hydraulic and water quality behavior of piping networks. The topics to be covered include:

- ▶ Project Setup
- ▶ Constructing a Network Model
- ▶ Setting the Properties of Network Objects
- ▶ Saving and Opening Projects
- ▶ Running a Single Period Analysis
- ▶ Running an Extended Period Simulation
- ▶ Running a Water Quality Simulation

Click here to begin...

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EPANET TUTORIAL



SEE NEXT SLIDE

EPANET TUTORIAL

<< >> View Network Quit

Example Network

In this tutorial we will analyze the simple distribution network shown below. It consists of a source reservoir (e.g., a treatment plant clearwell) from which water is pumped into a two-loop pipe network. There is also a pipe leading to a storage tank that floats on the system.

SOURCE

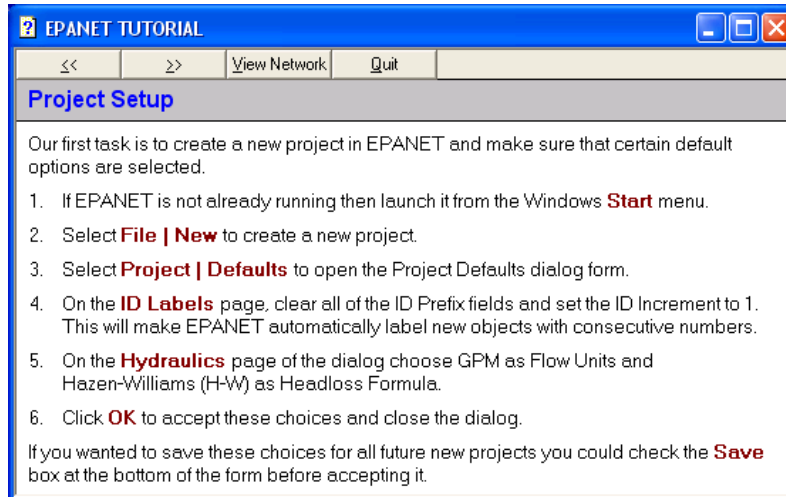
PUMP

TANK

Click the **View Network** button above to refer to this drawing at any time. Use the >> button to move to the next topic and the << button to return to the previous topic.

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EPANET TUTORIAL



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EPANET EXAMPLES

- ◆ EPANET comes with three example pipe networks to help one become familiar with the program.
- ◆ The example input files are installed in the "Examples" folder underneath the EPANET 2 installation directory
 - ◆ C:\Program Files\EPANET2\Examples
- ◆ Examples include:
 - ◆ net1.net: a simple pipe network modeling chlorine decay
 - ◆ net2.net: an example of a tracer study utilizing calibration data
 - ◆ net2-FL.dat: calibration data used with net2.net
 - ◆ net3.net: a larger network model illustrating source tracing
- ◆ View the Project Summary for example description (select Project >> Summary from the main menu)

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HOMEWORK 6: EPANET EXERCISE

- ◆ EPANET Example 1: net1.net
- ◆ A simple example of modeling chlorine decay

The screenshot shows the EPANET 2.0 interface. The main window displays a network diagram with a source, a pump, and a tank. A 'Project Summary' dialog box is open, showing the following details:

| Statistics | |
|----------------------|-----|
| Number of Junctions | 9 |
| Number of Reservoirs | 1 |
| Number of Tanks | 1 |
| Number of Pipes | 12 |
| Number of Pumps | 1 |
| Number of Valves | 0 |
| Flow Units | GPM |

HOMEWORK 6: EPANET EXERCISE



- ◆ Download and print the exercise from the Course Web site (HW5.pdf)
- ◆ It has 20 steps.
- ◆ Exercise has questions that should be answered.
- ◆ Answer the exercise questions
- ◆ Submit the exercise with answers

HOMEWORK NO. 5: EPANET EXERCISE

CEEN 4800/6965 - Special Topics
Geographic Information Systems and Hydrologic & Hydraulic Modeling

- ◆ Launch EPANET software from Start → All Programs → EPANET 2.0
- ◆ From File menu select Open. Navigate to C:\Program Files\EPANET2\Examples folder if necessary. Select the EPANET input file Net1.inp and click open.

The 'Open a Project' dialog box shows the 'Look in' field set to 'Examples'. The file list contains 'Net1.net', 'Net2.net', and 'Net3.net'. The 'File name' field is set to 'Net1.net'. The 'Files of type' dropdown is set to 'Network files (*.NET)'. The 'Open' button is highlighted.