# **Quick Start Lessons**

Building a Network and Performing a Steady-State Analysis

**Extended Period Simulation** 

Scenario Management

Reporting Results

Automated Fire Flow Analysis

Water Quality Analysis

Darwin Designer to Optimize the Setup of a Pipe Network

Darwin Designer to Optimize a Pipe Network

Scenario Energy Costs

Pressure Dependent Demands

Criticality and Segmentation

Flushing

## Building a Network and Performing a Steady-State Analysis

In constructing a distribution network for this lesson, you do not need to be concerned with assigning labels to pipes and nodes, because Bentley WaterCAD V8*i* will assign labels automatically. When creating a schematic drawing, pipe lengths are entered manually. In a scaled drawing, pipe lengths are automatically calculated from the position of the pipes' bends and start and stop nodes on the drawing pane.

In this network, the modeling of a reservoir connected to a pump simulates a connection to the main water distribution system. Simplifying the network in this way can approximate the pressures supplied to the system at the connection under a range of demands. This type of approximation is not always applicable, and care

should be taken when modeling a network in this way. It is more accurate to trace the network back to the source.

In this lesson, you will create and analyze the network shown below. You will use a scaled background drawing for most of the network; however, four of the pipes are not to scale and will have user-defined lengths.



### Step 1: Create a New Project File

1. From the welcome dialog, click Create New Project and an untitled project opens. Or click File > New to create a new project.



2. Click the Tools menu and select the Options command. Click the Units tab. Since you will be working in System International units, click the Reset Defaults button and select System International.



- 3. Verify that the Default Unit System for New Project is set to System International. If not, select from the menu.
- 4. Click the Drawing tab to make sure Drawing Mode is set to Scaled.

Options		×
Global Project Drawing Units Lab	eling ProjectWise	
Drawing Scale		
Drawing mode:	Scaled	•
Plot scale factor 1 cm =:	40.00 m	

- 5. Set the Plot Scale Factor 1 cm = 40 m.
- 6. Click OK.
- 7. Set up the project. Choose File > Project Properties and name the project Lesson 1—Steady State Analysis and click OK.

Project Properties	x
Title:	Lesson 1-Steady State Analysis
File Name:	C:\Program Files\Bentley\WaterGEMS\Lessons\MYLESSON1.
Engineer:	
Company:	
Date:	2/27/2006
Notes:	*
	▼ OK Cancel Help

8. Choose File > Save as. In the Save File As dialog box, browse to the My Documents/Bentley/WaterGEMS folder.

Save As					<u>? ×</u>
Save jn:	🔁 WaterGEMS		•	G 🕫 🖻	<b>.</b>
My Recent Documents					
Desktop					
My Documents					
My Computer					
My Network	File <u>n</u> ame:	MYLESSON1		•	Save
Places	Save as type:	WaterGEMS Project F	iles (*.wtg)	•	Cancel

9. Enter the file name MYLESSON1.WTG for your project, and click Save.

## Step 2: Lay out the Network

- 1. Select Pipe From the layout toolbar.
- 2. Move the cursor on the drawing pane and right click to select Reservoir from the menu or click if from the toolbar.
- 3. Click to place R-1.
- 4. Move the cursor to the location of pump P-1. Right-click and select Pump from the shortcut menu.



5. Click to place it.

- 6. Right click to select Junction from the menu and click to place J-1.
- 7. Click to place junctions J-2, J-3, and J-4.
- 8. Click on J-1 to finish.
- 9. Right-click and choose Done from the menu.



- 10. Create J-5.
  - a. Select the **Pipe** layout tool again.
  - b. Click junction J-3.
  - c. Move the cursor to the location of J-5, and click to insert the element.
  - d. Right-click and select Done.



11. Lay out junction **J-6** and the **PRV** by selecting the **Pipe** layout tool and placing the elements in their appropriate locations.

Be sure to lay out the pipes in numerical order (P-7 through P-9), so that their labels correspond to the labels in the diagram. Right-click and select **Done** from the menu to terminate the Pipe Layout command.

12. Insert the tank, T-1, using the **Pipe** layout tool. Pipe **P-10** should connect the tank to the network if you laid out the elements in the correct order.



13. Save the network by clicking Save

### Step 3: Enter and modify data

- **Dialog Boxes**—You can use the Select tool and double-click an element to bring up its Properties editor.
- FlexTables—You can click FlexTables to bring up dynamic tables that allow you to edit and display the model data in a tabular format. You can edit the data as you would in a spreadsheet.
- User Data Extensions—The User Data Extensions feature (Tools menu > User Data Extensions) allows you to import and export element data directly from XML files.
- Alternative Editors—Alternatives are used to enter data for different "What If?" situations used in Scenario Management.

### **Entering Data through the Properties Editor**

To access an element's property editor, double-click the element.

1. Open the **Reservoir Editor** for reservoir R-1.

(Show All>	<b>T</b>
≝ 2↓ ©	
ID	28
Label	R-1
Notes	
GISHDs	<lollection: uitems=""></lollection:>
Hyperlinks	<lollection: ultems=""></lollection:>
	67.20
∧ (III) ∑ (m)	-07.50
Active Topology	-2.34
Is Active?	True
3 Operational	1140
Controls	<collection></collection>
Physical	
Elevation (m)	0.00
Zone	<none></none>
Hydraulic Grade Pattern	Fixed
Transient (Physical)	
Elevation (Inlet/Outlet Invert	) 0.00
3 Water Quality	
Age (Initial) (hours)	0.000
Concentration (Initial) (mg/L)	0.0
Is Constituent Source?	False
Trace (Initial) (%)	0.0
Hudraulia Grada (m)	0124)
Flow (Out pet) (L/s)	(NZA)
Flow (In net) (I /s)	(N/A)
Has Calculation Messages N	
- Results (Transient)	
Head (Maximum, Transient)	L (NZA)
Head (Minimum, Transient)	(I. (N/A)
Pressure (Maximum, Transie	e (N/A)
Pressure (Minimum, Transie	r (N/A)
Air Volume (Maximum, Tran	s (N/A)
Vapor Volume (Maximum, T	r (N/A)
3 Results (Water Quality)	
Age (Calculated) (hours)	(N/A)

- 2. Enter the Elevation as 198 (m).
- 3. Set Zone to Connection Zone.
  - a. Click the Zone menu and select the Edit Zones command, which will open the Zone Manager.



c. Enter a label for the new pressure zone called Connection Zone.



- d. Click Close.
- e. Select the zone you just created from the Zone menu.
- 4. Click tank T-1 in the drawing to highlight it and enter the following: Elevation (Base) = 200 m
  Elevation (Minimum) = 220 m
  Elevation (Initial) = 225 m
  Elevation (Maximum) = 226 m
  Diameter = 8 m

#### Section = Circular

Set the Zone to Zone 1 (You will need to create Zone-1 in the Zone Manager as described above.)

Pr	operties - Tank - T-1 (48)		×
F	-1	👤 🔎 🕜 🛛 100% 🔄	•
<	Show All>	<b>.</b>	X
•			
	General		
-		48	F
	Label	T.1	
	Notes		
	GIS-IDs	<collection: ()="" items=""></collection:>	
	Hyperlinks	<collection: 0="" items=""></collection:>	
Ξ	(Geometry)		
	Xím)	338.60	
	Y(m)	302.81	
=	Active Topology		
	Is Active?	True	
=	Demand		
	Demand Collection	<collection: 0="" items=""></collection:>	
	Unit Demand Collection	<collection: 0="" items=""></collection:>	
Ξ	Operating Range		
	Operating Range Type	Elevation	
	Elevation (Base) (m)	200.00	
	Elevation (Minimum) (m)	220.00	
	Elevation (Initial) (m)	225.00	
	Elevation (Maximum) (m)	226.00	
	Use High Alarm?	False	
	Use Low Alarm?	False	
Ξ	Operational		
	Controls	<collection></collection>	
Ξ	Physical		
	Elevation (m)	0.00	
	Zone	Zone - 1	
	Volume (Inactive) (ML)	0.00	
	Installation Year	0	
	Section	Circular	
	Diameter (m)	8.00	
	Volume Full (Calculated) (ML	(N/A)	
	Has Separate Inlet?	False	
Ξ	Transient (Reporting)		
	Report Period (Transient)	0	
Ξ	Water Quality		
	Age (Initial) (hours)	0.000	-

- 5. Click pump PMP-1 in the drawing to highlight it.
  - a. Enter 193 (m) for the Elevation.
  - b. Click in the Pump Definition field and click on Edit Pump Definitions from the drop-down list to open the Pump Definitions manager.

Pump Definitions		×
🗋 🗙 陷 🗊 🗎 🗢 -	Head Efficiency Motor Transient Library No	otes
Label	Pump Definition Type:	<b>T</b>
	Pump Power: 0.0	kW
	No Results to Graph	6
		ose Help
		11

- c. Click New 🔟 to create a new pump definition.
- d. Leave the default setting of Standard (3 Point) in the Pump Definition Type menu.
- e. Right click on the Flow column and select the Units and Formatting

command.

f. In the Set Field Options box set the Units to L/min.

/alue:	1 L/min	OK
		Cancel
Init	L/min	<u>H</u> elp
isplay Precision:	0	
ormat:	Number	

- g. Click OK.
- h. Enter the following information:

	Flow (L/min)	Head (m)
Shutoff:	0.00	30.00
Design:	3,800.00	27.40
Max. Operating:	7,500.00	24.80



i. Highlight **Pump Definition - 1** and click the **Rename** button. Change the name to **PMP-1**.

- j. Click Close.
- k. In the Properties editor, select **PMP-1** from the **Pump Definition** menu.
- Highlight valve PRV-1 in the drawing. Enter in the following data: Status (Initial) = Active Setting Type= Pressure Pressure Setting (Initial)= 390 kPa Elevation =165 m

Diameter (Valve) = 150 mm Create Zone-2 and set the valve's Zone field to Zone-2.

-		
<	show All>	
•	2↓   ⊂	
Ξ	<general></general>	<u> </u>
	ID	45
	Label	PRV-1
	Notes	
	GIS-IDs	<collection: 0="" items=""></collection:>
	Hyperlinks	<collection: 0="" items=""></collection:>
	Downstream Pipe	P-9
Ξ	<geometry></geometry>	
	X (m)	57.65
	Y (m)	239.88
Ξ	Active Topology	
	Is Active?	True
Ξ	Initial Settings	
	Status (Initial)	Active
	Setting Type	Pressure
	Pressure Setting (Initial) (kPa)	390.0
Ξ	Operational	
	Controls	<collection></collection>
E	Physical	
	Elevation (m)	165.00
	Installation Year	0
	Zone	<none></none>
	Diameter (Valve) (mm)	150.0
	Specify Local Minor Loss?	True
	Minor Loss Coefficient (Local)	0.000
	Pattern (Valve Settings)	Fixed
	Valve Type	Butterfly
Ξ	Transient (Operational)	
	Operating Rule	Fixed
Ξ	Water Quality	
	Age (Initial) (hours)	0.000
	Concentration (Initial) (mg/L)	0.0
	Trace (Initial) (%)	0.0
Ξ	Results	
	Flow (L/min)	(N/A)
	Velocity (m/s)	(N/A)
	Headloss (m)	(N/A) 👻

7. Enter the following data for each of the junctions. Leave all other fields set to their default values.

Junction	Elevation (m)	Zone	Demand (I/min)
J-1	184	Zone-1	38
J-2	185	Zone-1	31
J-3	184	Zone-1	34
J-4	183	Zone-1	38
J-5	185.5	Zone-1	350
J-6	165	Zone-2	356

In order to add the demand, click the ellipsis in the Demand Collection field to open the Demand box, click New, and type in the value for Flow (L/min).

	Flow (Base) (L/min)	Pattern (Demand)
1	38.0	Fixed
*		

Specify user-defined lengths for pipes P-1, P-7, P-8, P-9 and P-10. a. Click pipe P-1 to open

the Pipe Editor.

b. Set **Has User Defined Length?** to **True**. Then, enter a value of **0.01 m** in the **Length (User Defined)** field.

Note that the default display precision will cause only "0" to be displayed. To change display precision, right click the column heading and select **Units and Formatting** to open the **Set Field Options** dialog; from here you can change the **Display Precision** to the desired value and click **OK**.

Since you are using the reservoir and pump to simulate the connection to the main distribution system, you want headloss through this pipe to be negligible. Therefore, the length is very small and the diameter will be large.

c. Enter **1000 mm** as the diameter of P-1.

] Physical	
Zone	<none></none>
Diameter (mm)	1,000.0
Material	Ductile Iron
Hazen-Williams C	130.0
Has User Defined Length?	True
Length (User Defined) (m)	0.01
Has Check Valve?	False
Specify Local Minor Loss?	True
Minor Loss Coefficient (Local)	0.000
Installation Year	0

- d. Change the lengths (but not the diameters) of pipes P-7 through P-10 using the following user-defined lengths: P7 = Length (User Defined): 400 m
  P8 = Length (User Defined): 500 m
  P0 = Length (User Defined): 21 m
  - P9 = Length (User Defined): 31 m
  - P-10 = Length (User Defined): 100 m
    - e. Close the Properties editor.

## **Step 4: Entering Data through FlexTables**

It is often more convenient to enter data for similar elements in tabular form, rather than to individually open the properties editor for an element, enter the data, and then select the next element. Using FlexTables, you can enter the data as you would enter data into a spreadsheet. **To use FlexTables** 

1. Click FlexTables	
FlexTables	×
→ × □   2 □ - 2 0	
Tables - Project	
Tables - Shared	
🔄 🖣 Tables - Predefined	
Fire Flow Node Table	
- III Pipe Table	
- Tim FCV Table	
- 🛗 GPV Table	
- 📶 Spot Elevation Table	
- Hvdropneumatic Tank Table	In choose View > FlexTab

2. Double-click **Pipe Table**. Fields that are white can be edited, yellow fields can not.

30: P-1       30: P-1       99.35       R-1       PMP-1       1,000.0       Ductle Ir       130.0       0.000         34: P-2       34: P-2       115.95       PMP-1       J-1       152.4       Ductle Ir       130.0       0.000         36: P-3       36       P-3       195.95       J-1       J-2       152.4       Ductle Ir       130.0       0.000         36: P-4       38: P-4       243.96       J-2       J-3       152.4       Ductle Ir       130.0       0.000         40: P-5       40       P-5       195.30       J-3       J-4       152.4       Ductle Ir       130.0       0.000         40: P-5       40       P-5       195.30       J-3       J-4       152.4       Ductle Ir       130.0       0.000         41: P-6       41       P-6       243.32       J-4       J-1       152.4       Ductle Ir       130.0       0.000         43: P-7       43       P-7       88.24       J-3       F-5       152.4       Ductle Ir       130.0       0.000         43: P-7       46       P-8       76.52       J-6       PRV-1       152.4       Ductle Ir       130.0       0.000		ID	Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Has Check Valve?	Minor Los Coefficier (Local)
34: P-2         94         P-2         115.95         PMP-1         J-1         152.4         Ductile Ir         130.0         0.000           36: P-3         36         P-3         195.95         J-1         J-2         152.4         Ductile Ir         130.0         0.000           36: P-4         88         P-4         243.96         J-2         J-3         152.4         Ductile Ir         130.0         0.000           40: P-5         40         P-5         195.30         J-3         J-4         152.4         Ductile Ir         130.0         0.000           40: P-5         40         P-5         195.30         J-4         J-1         152.4         Ductile Ir         130.0         0.000           41: P-6         41         P-6         243.32         J-4         J-1         152.4         Ductile Ir         130.0         0.000           43: P-7         43         P-7         88.24         J-3         S-5         152.4         Ductile Ir         130.0         0.000           46: P-8         46         P-85.2         J-6         PRV-1         152.4         Ductile Ir         130.0         0.000           47: P-9         47	30: P-1	30	P-1	93.35	R-1	PMP-1	1,000.0	Ductile Ir	130.0		0.000
36: P-3         36: P-3         195.95         3-1         J-2         152.4         Ductle Ir         130.0         0.000           38: P-4         38< P-4	34: P-2	34	P-2	115.95	PMP-1	J-1	152.4	Ductile Ir	130.0		0.000
38: P-4         38: P-4         243.96         J-2         J-3         152.4 Ductile Ir         130.0         0.000           40: P-5         40         P-5         195.30         J-3         J-4         152.4 Ductile Ir         130.0         0.000           41: P-6         41         P-6         243.32         J-4         J-1         152.4 Ductile Ir         130.0         0.000           43: P-7         43         P-7         88.24         J-5         152.4 Ductile Ir         130.0         0.000           46: P-8         46         P-8         76.52         J-6         PRV-1         152.4 Ductile Ir         130.0         0.000           47: P-9         47         P-9         65.01         PRV-1         J-4         152.4 Ductile Ir         130.0         0.000           49: P-10         49         P-10         61.64         T-1         J-3         152.4 Ductile Ir         130.0         0.000	36: P-3	36	P-3	195.95	J-1	J-2	152.4	Ductile Ir	130.0		0.000
40: P-5         40         P-5         195.30         3-8         3-4         152.4         Ductie Ir         130.0         0.000           41: P-6         41         P-6         243.32         J-4         J-1         152.4         Ductie Ir         130.0         0.000           41: P-6         41         P-6         243.32         J-1         152.4         Ductie Ir         130.0         0.000           43: P-7         43         P-7         88.24         J-3         J-5         152.4         Ductie Ir         130.0         0.000           46: P-8         46         P-8         78.52         J-6         PRV-1         152.4         Ductie Ir         130.0         0.000           47: P-9         47         P-9         65.01         PRV-1         J-4         152.4         Ductie Ir         130.0         0.000           49: P-10         49         P-10         61.64         T-1         J-3         152.4         Ductie Ir         130.0         0.000	38: P-4	38	P-4	243.96	3-2	J-3	152.4	Ductile Ir	130.0		0.000
41: P-6         41         P-6         243.32         J-4         J-1         152.4         Ductile Ir         130.0         0.000           43: P-7         43         P-7         88.24         J-5         152.4         Ductile Ir         130.0         0.000           66: P-8         46         P-8         75.52         J-6         PRV-1         152.4         Ductile Ir         130.0         0.000           47: P-9         47         P-9         85.01         PRV-1         J-4         152.4         Ductile Ir         130.0         0.000           47: P-9         47         P-9         85.01         PRV-1         J-4         152.4         Ductile Ir         130.0         0.000           49: P-10         61.64         T-1         J-3         152.4         Ductile Ir         130.0         0.000	40: P-5	40	P-5	195.30	J-3	J-4	152.4	Ductile Ir	130.0		0.000
43: P-7         43: P-7         88:24         3-8         3-5         152.4         Ductile Ir         130.0         0.000           46: P-8         46: P-8         78:52         3-6         PRV-1         152.4         Ductile Ir         130.0         0.000           47: P-9         47         P-9         85:01         PRV-1         3-4         152.4         Ductile Ir         130.0         0.000           49: P-10         49         P-10         61:64         T-1         3-3         152.4         Ductile Ir         130.0         0.000	41: P-6	41	P-6	243.32	J-4	J-1	152.4	Ductile Ir	130.0		0.000
46: P-8         78.52         J-6         PRV-1         152.4         Ductile Ir         130.0         0.000           47: P-9         47         P-9         65.01         PRV-1         J-4         152.4         Ductile Ir         130.0         0.000           49: P-10         49         P-10         61.64         T-1         J-3         152.4         Ductile Ir         130.0         0.000	43: P-7	43	P-7	88.24	J-3	J-5	152.4	Ductile Ir	130.0		0.000
47: P-9         47: P-9         65.01         PRV-1         J-4         152.4         Ductile Ir         130.0         0         0.000           49: P-10         41.64         T-1         J-3         152.4         Ductile Ir         130.0         0         0.000	46: P-8	46	P-8	78.52	J-6	PRV-1	152.4	Ductile Ir	130.0		0.000
49: P-10 49 P-10 61.64 T-1 3-3 152.4 Ductile Ir 130.0 □ 0.000	47: P-9	47	P-9	85.01	PRV-1	J-4	152.4	Ductile Ir	130.0		0.000
	49: P-10	49	P-10	61.64	T-1	3-3	152.4	Ductile Ir	130.0		0.000

3. For each of the pipes, enter the diameter and the pipe material as follows:

Pipe	Material	Diameter (mm)
P-1	Ductile Iron	1000
P-2	Ductile Iron	150
P-3	Ductile Iron	150
P-4	PVC	150
P-5	Ductile Iron	150
P-6	Ductile Iron	150
P-7	PVC	150
P-8	Ductile Iron	150
P-9	Ductile Iron	150
P-10	Ductile Iron	150

4. In order to enter the material type, click the ellipsis to open the Engineering Libraries box. Click on Material Libraries > Material Libraries.xml and then click the appropriate material type and then click Select.



- 5. Notice that the C values for the pipes will be automatically assigned to preset values based on the material; however, these values could be modified if a different coefficient were required.
- 6. Leave the other data set to their default values. Click to exit the table when you are finished.

30: P-1	100								(Local)
	30	P-1	93.35	R-1	PMP-1	1,000.0	Ductile Ir	130.0	0.000
34: P-2	34	P-2	115.95	PMP-1	J-1	150.0	Ductile Ir	130.0	0.000
36: P-3	36	P-3	195.95	J-1	J-2	150.0	Ductile Ir	130.0	0.000
38: P-4	38	P-4	243.96	J-2	J-3	150.0	PVC	150.0	0.000
40: P-5	40	P-5	195.30	J-3	J-4	150.0	Ductile Ir	130.0	0.000
41: P-6	41	P-6	243.32	]-4	J-1	150.0	Ductile Ir	130.0	0.000
43: P-7	43	P-7	88.24	J-3	J-5	150.0	PVC	150.0	0.000
46: P-8	46	P-8	78.52	J-6	PRV-1	150.0	Ductile Ir	130.0	0.000
47: P-9	47	P-9	85.01	PRV-1	J-4	150.0	Ductile Ir	130.0	0.000
49: P-10	49	P-10	61.64	T-1	J-3	150.0	Ductile Ir	130.0	0.000

#### Step 5: Run a Steady-State Analysis

- 1. Click **b** to open the **Calculation Options** manager.
- 2. Double-click **Base Calculation Options** under the **Steady-State/EPS Solver** heading to open the **Properties** editor. Make sure that the **Time Analysis Type** is set to **Steady State**.

Calculation Times	
Simulation Start Date	1/1/2000
Time Analysis Type	Steady State
Use simple controls during ste	True
Is EPS Snapshot?	False
Start Time	12:00:00 AM

Close the Properties editor and the Calculation Options manager.

- 3. Click Compute 🗈 to analyze the model.
- 4. When calculations are completed, the Calculation Summary and User Notifications open.
- 5. A blue light is an informational message, a green light indicates no warnings or issues, a yellow light indicates warnings, and a red light indicates issues.
- 6. Click to close the Calculation Summary and User Notifications dialogs.
- 7. Click to Save 🔓 project.