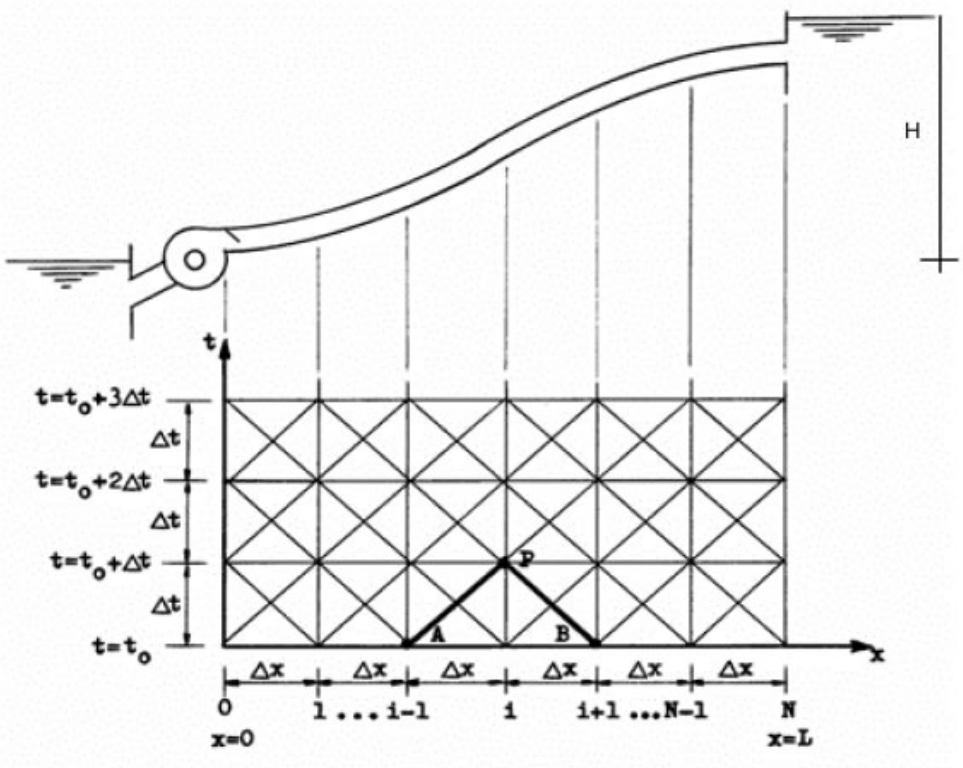
Pipe2000/Surge – Brief Tutorial

CES
Consulting Engineers
Salzgitter GmbH

Typical example: Waterhammer in a discharge pipeline provided for a pump and with a check valve located at the beginning of the pipeline.



Content

1. Data
2. Introduction of data in „**Surge**"
3. Result Analysis
4. Reducing the surge effects

1. Data

We will have only 3 nodes and 2 lines:

- Node: Reservoir
- Node: Pump
- Node: Tank
- Line: Reservoir-Pump
- Line: Pump-Tank

Node	Elevation [m]
Reservoir	0
Pump	0
Tank	70

Line	Nodes	Length [m]	Diameter [mm]
1	Reservoir-Pump	5	350
2	Pump-Reservoir	2500	300

Flow:

- Q= 33 l/s
- C=140 (Hazen-Williams)
- Assumed head loss =10 m

Pipe:

- PVC
- Wave speed = 350 m/s

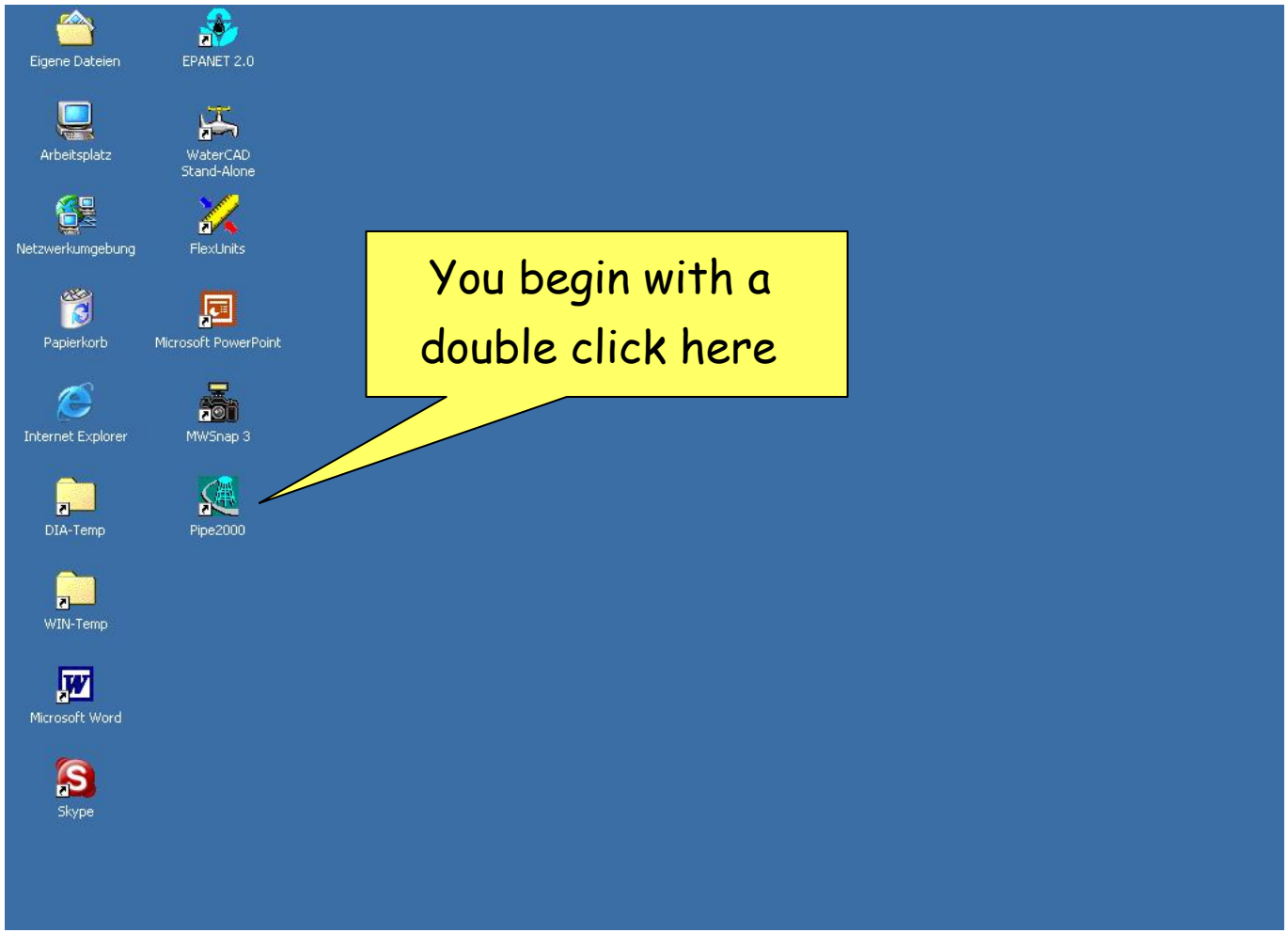
Reservoir:

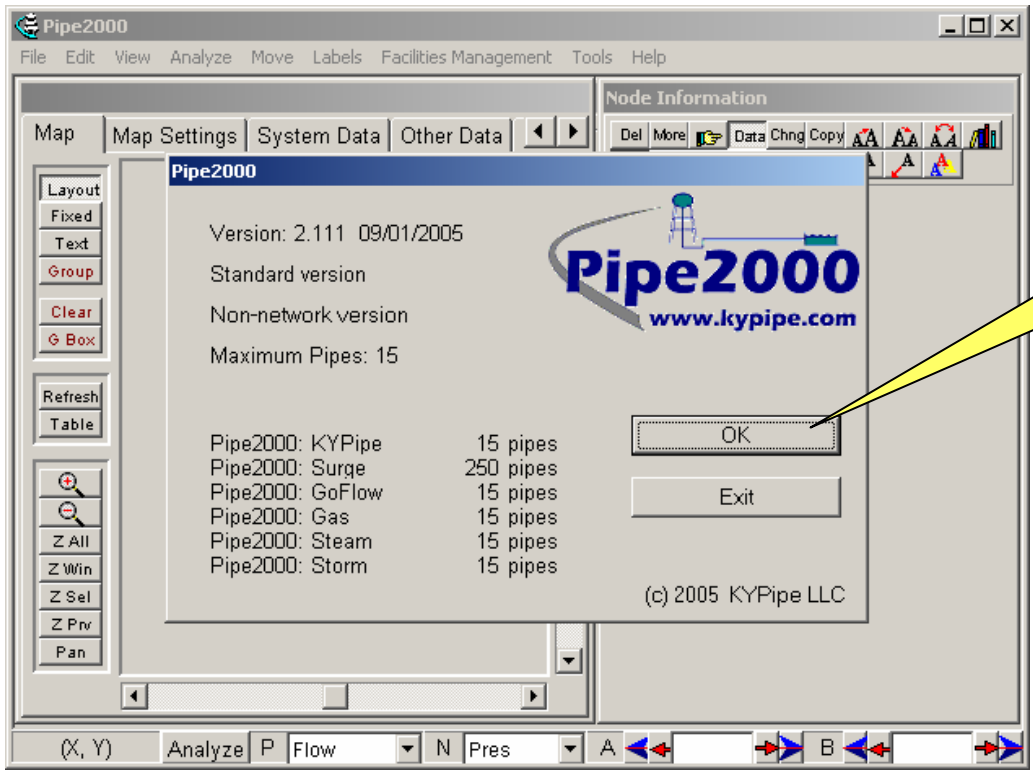
- Reservoir Level = 70 m

Pump:

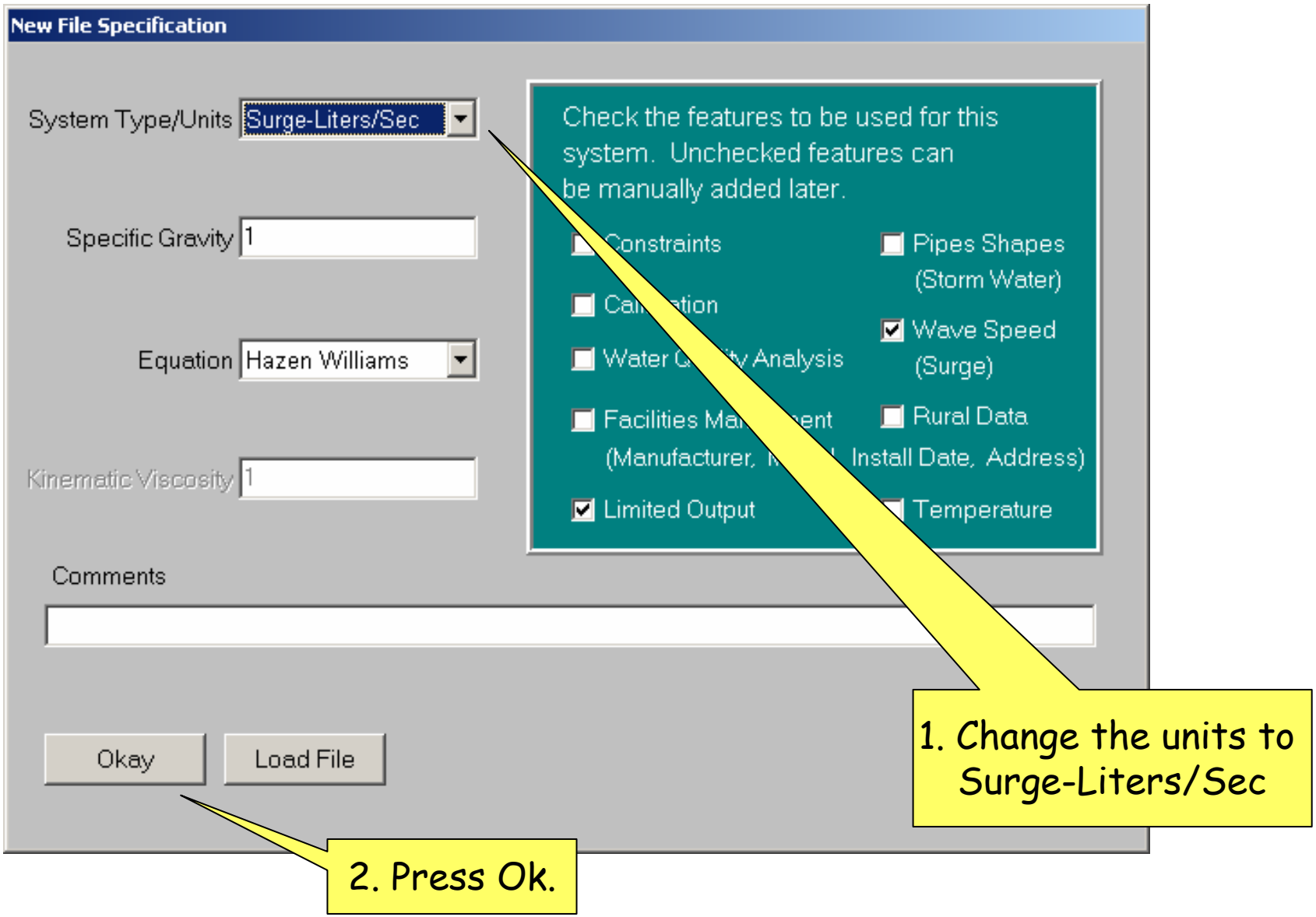
- Speed = 3500 rpm
- Rated head = 80 m
- Rated flow =33 l/s
- Inertia (pump+Motor) = 2 N.m2 (from manufacturer)

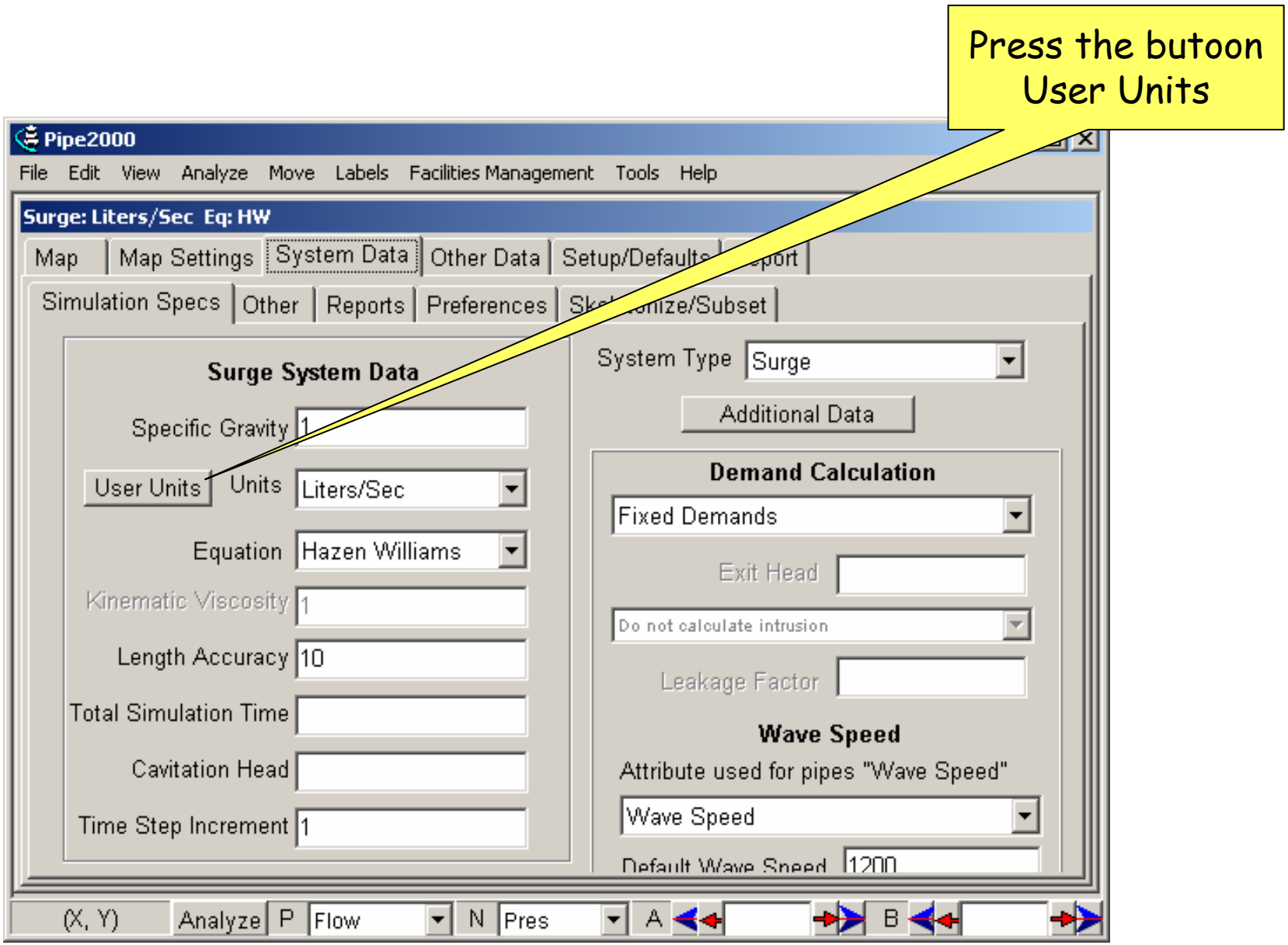
2. Introduction of data in Surge



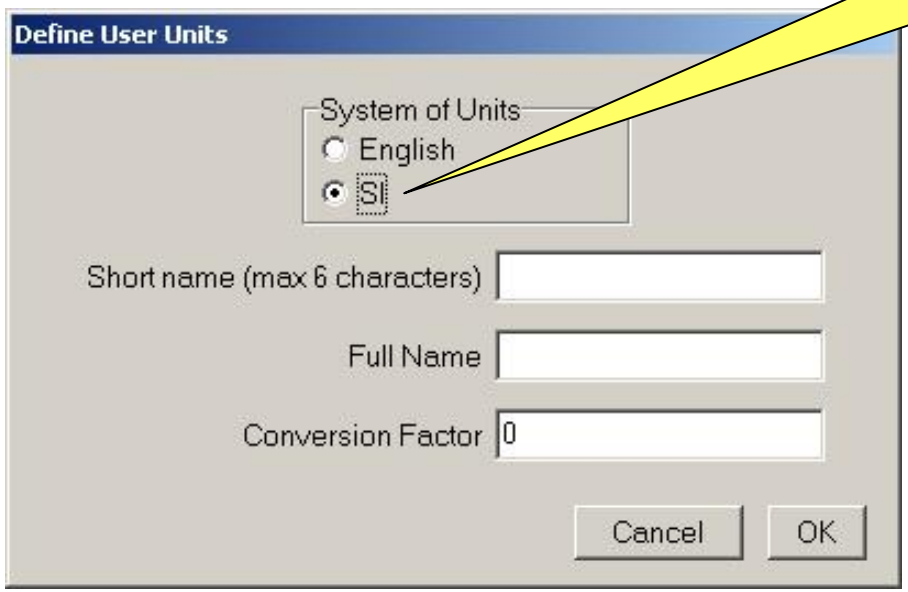


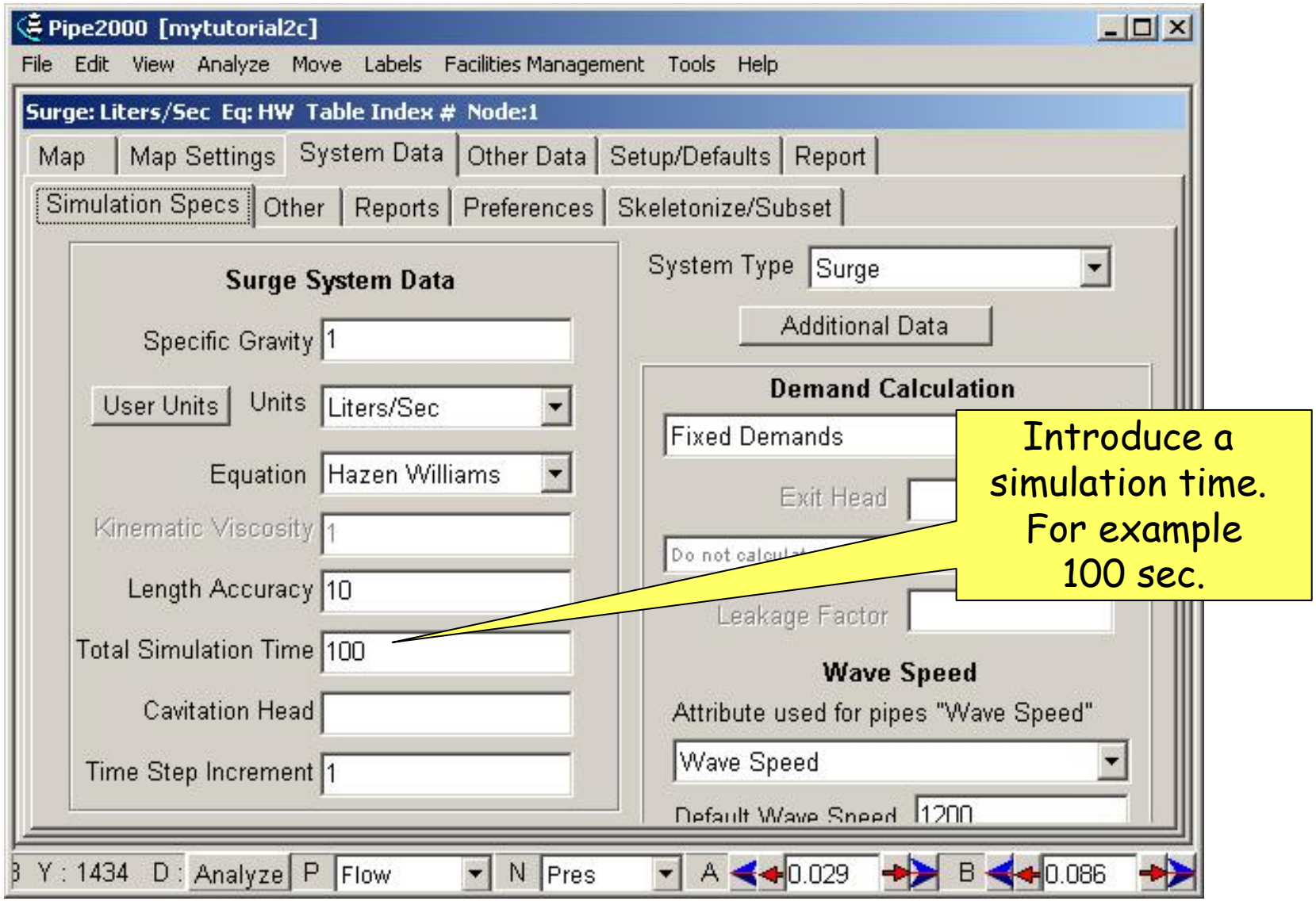
Press Ok to begin

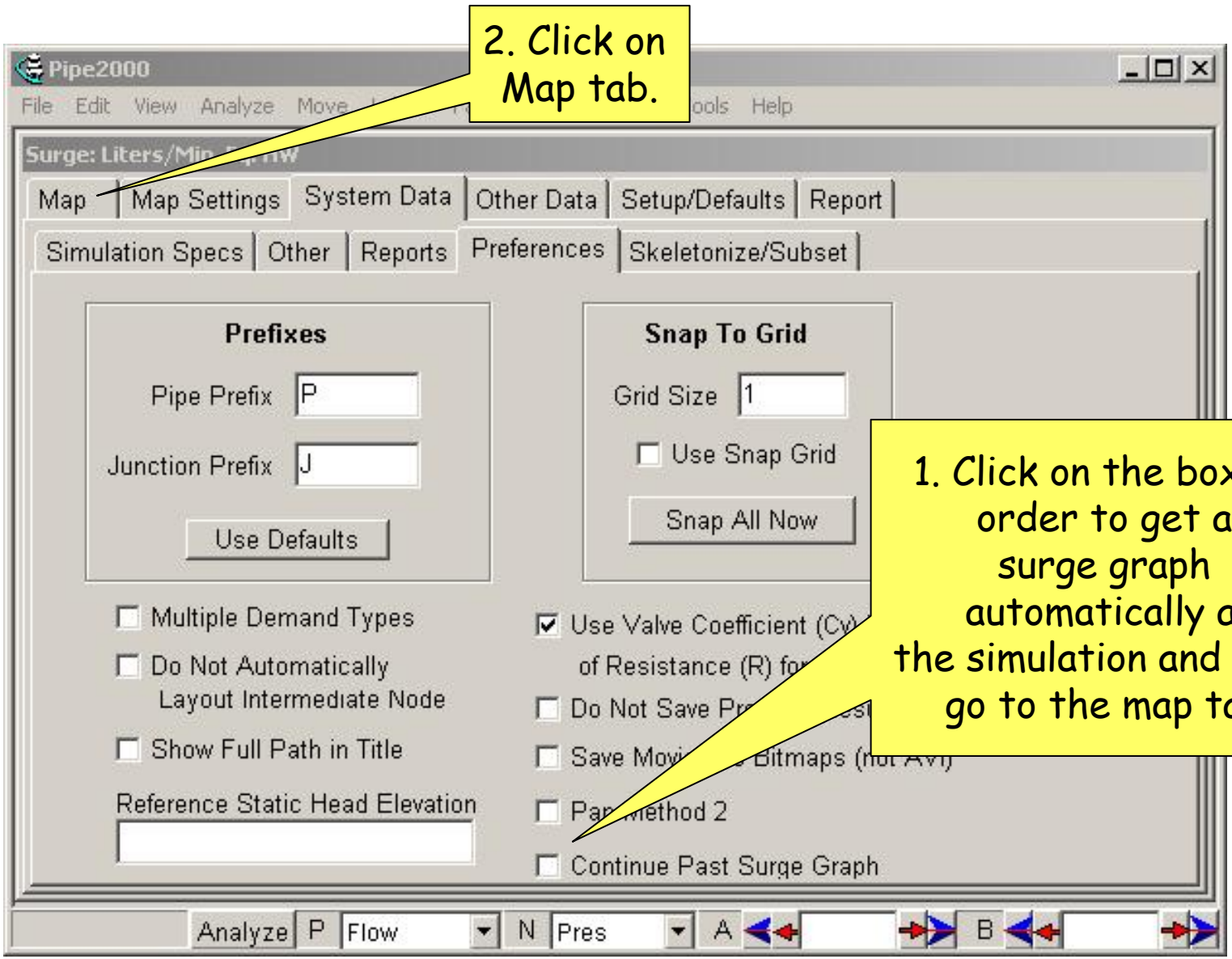

New File Specification
System Type/Units
Surge-Liters/Sec
Specific Gravity
1
Equation
Hazen Williams
Kinematic Viscosity
1
Check the features to be used for this system. Unchecked features can be manually added later.
Constraints
Pipes Shapes (Storm Water)
Wave Speed (Surge)
Rural Data
Limited Output
Temperature
Comments
Okay
Load File
1. Change the units to Surge-Liters/Sec
2. Press Ok.


Press the butoon
User Units
Pipe2000
File Edit View Analyze Move Labels Facilities Management Tools Help
Surge: Liters/Sec Eq: HW
Map Map Settings System Data Other Data Setup/Defaults
Simulation Specs Other Reports Preferences
Surge System Data
Specific Gravity 1
User Units Units Liters/Sec
Equation Hazen Williams
Kinematic Viscosity 1
Length Accuracy 10
Total Simulation Time
Cavitation Head
Time Step Increment 1
System Type Surge
Additional Data
Demand Calculation
Fixed Demands
Exit Head
Do not calculate intrusion
Leakage Factor
Wave Speed
Attribute used for pipes "Wave Speed"
Wave Speed
Default Wave Speed 1200
(X, Y) Analyze P Flow N Pres A B

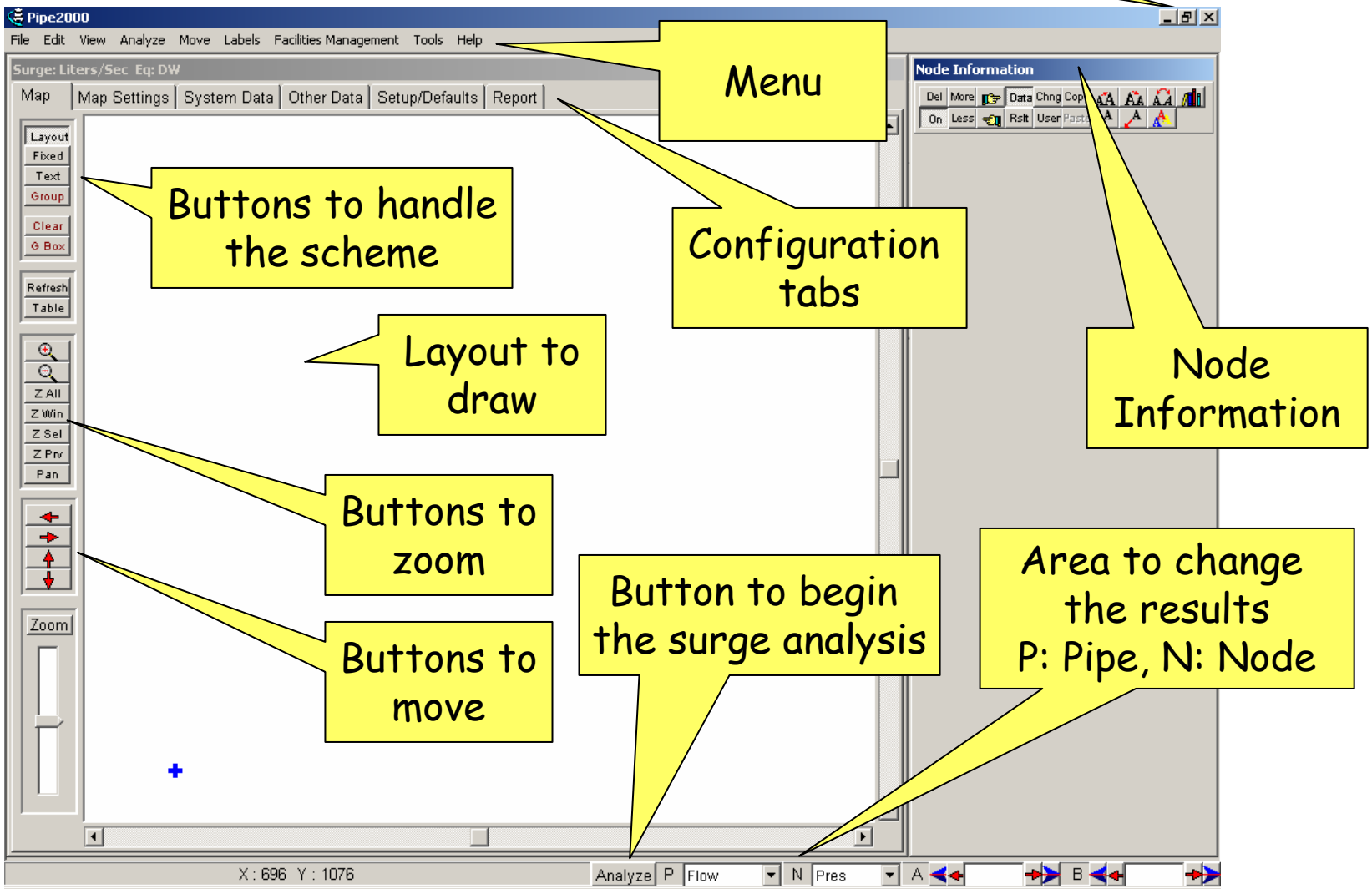
Now, change the System of Units, and later click Ok!

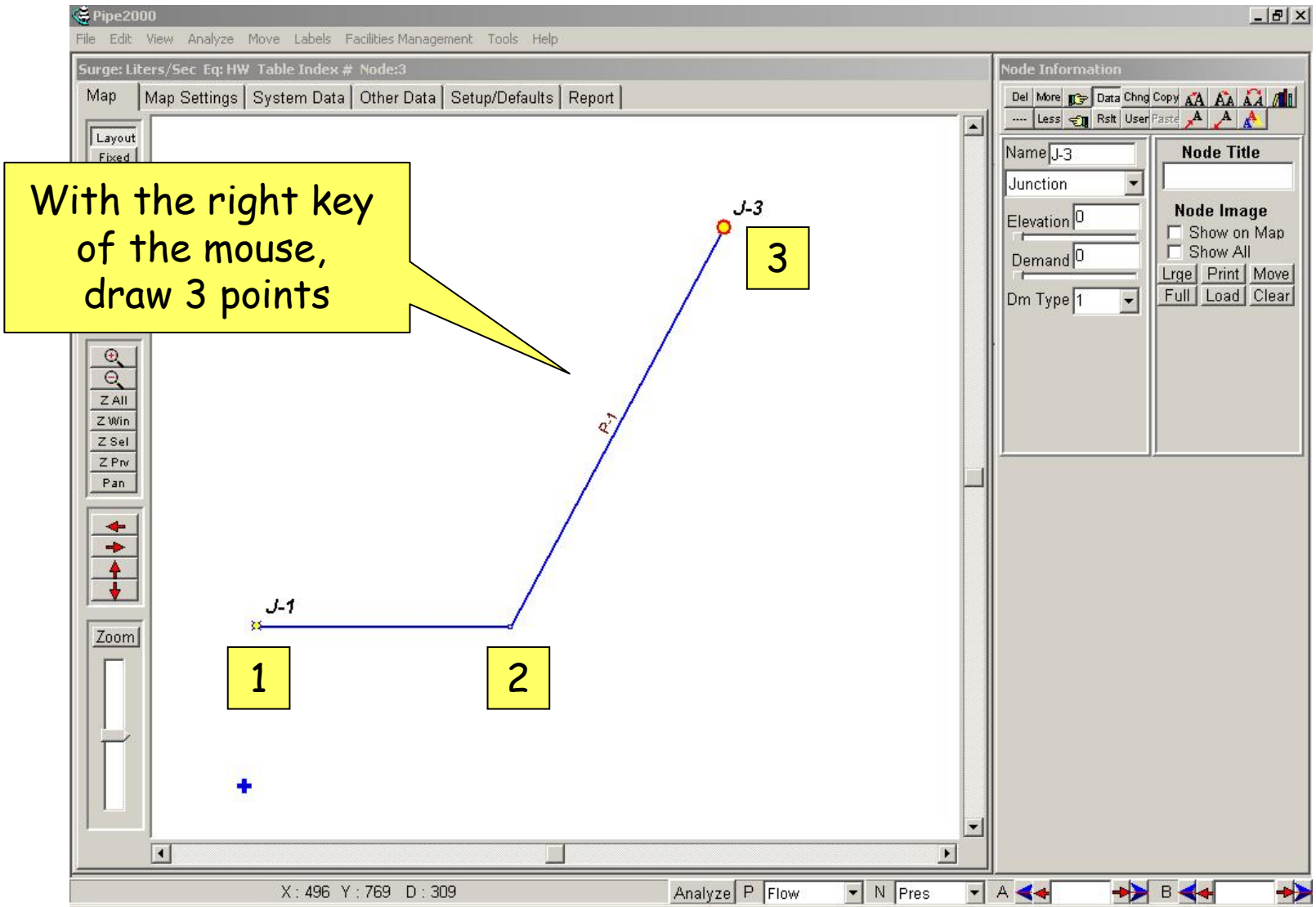


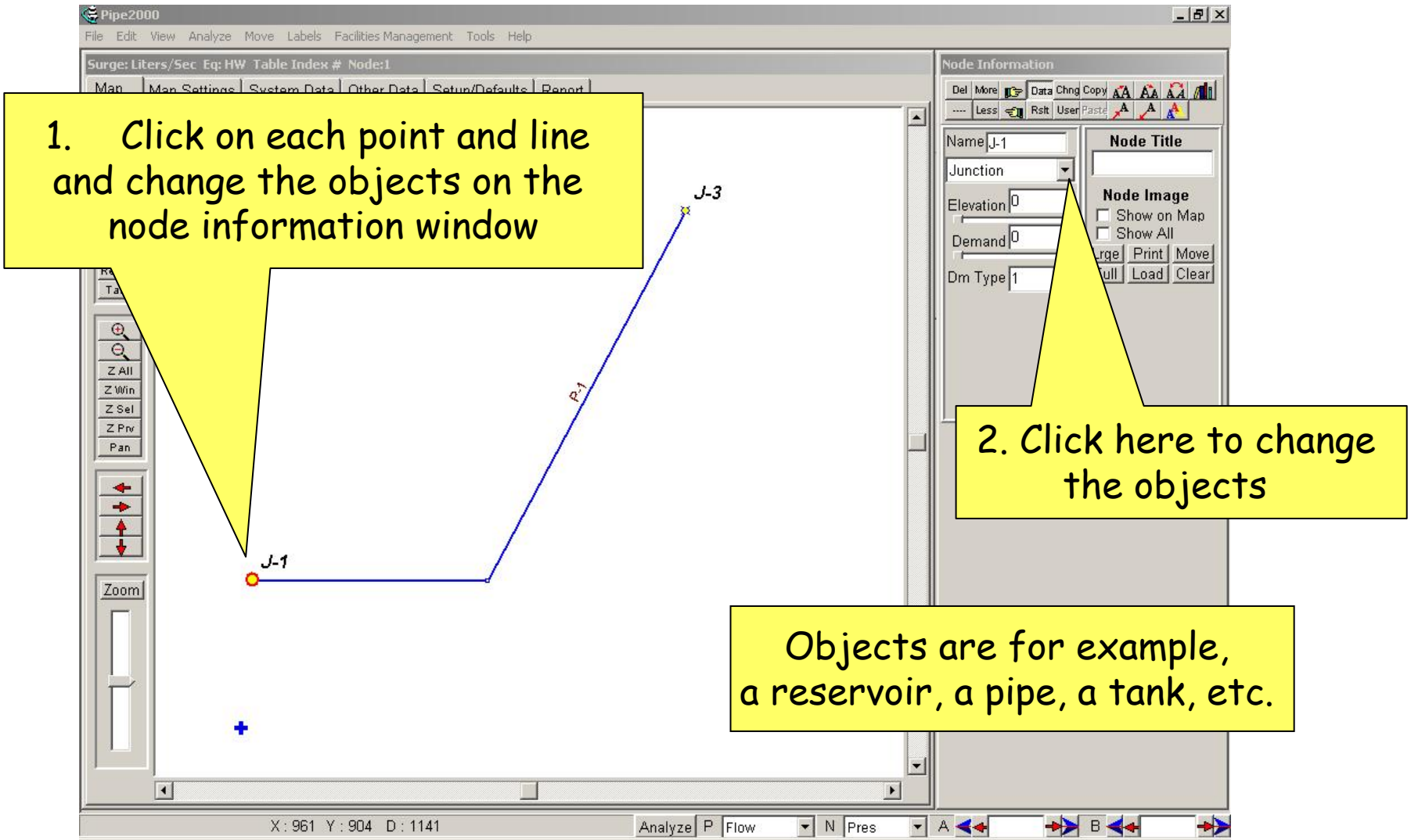

Pipe2000 [mytutorial2c]
File Edit View Analyze Move Labels Facilities Management Tools Help
Surge: Liters/Sec Eq: HW Table Index # Node:1
Map Map Settings System Data Other Data Setup/Defaults Report
Simulation Specs Other Reports Preferences Skeletonize/Subset
Surge System Data
Specific Gravity 1
User Units Units Liters/Sec
Equation Hazen Williams
Kinematic Viscosity 1
Length Accuracy 10
Total Simulation Time 100
Cavitation Head
Time Step Increment 1
System Type Surge
Additional Data
Demand Calculation
Fixed Demands
Exit Head
Leakage Factor
Wave Speed
Attribute used for pipes "Wave Speed"
Wave Speed
Default Wave Speed 1200
Y : 1434 D : Analyze P Flow N Pres A 0.029 B 0.086
Introduce a simulation time. For example 100 sec.


2. Click on Map tab.
Pipe2000
File Edit View Analyze Move
Surge: Liters/Min
Map
Map Settings
System Data
Other Data
Setup/Defaults
Report
Simulation Specs
Other
Reports
Preferences
Skeletonize/Subset
Prefixes
Pipe Prefix
P
Junction Prefix
J
Use Defaults
Snap To Grid
Grid Size
1
Use Snap Grid
Snap All Now
Multiple Demand Types
Do Not Automatically Layout Intermediate Node
Show Full Path in Title
Reference Static Head Elevation
Use Valve Coefficient (Cv)
of Resistance (R) for
Do Not Save Pr
Save Movi
Bitmaps (not AVI)
Par
Method 2
Continue Past Surge Graph
Analyze
P
Flow
N
Pres
A
B
1. Click on the box, in order to get a surge graph automatically at the simulation and next go to the map tab.

Enlarge the window and you will see the complete work area for **Surge**

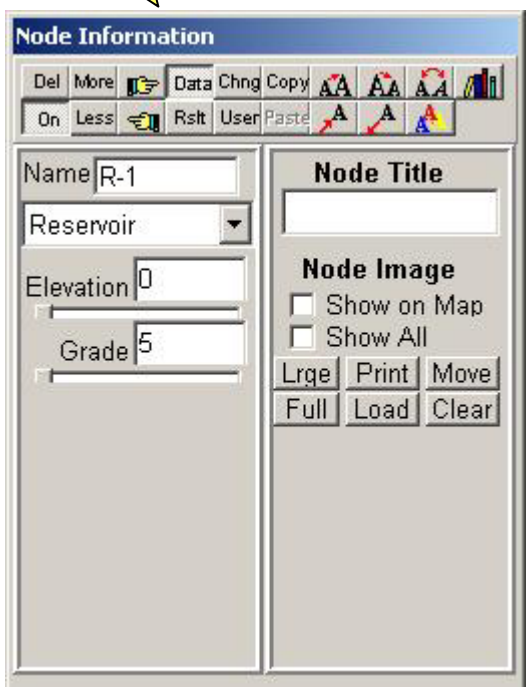



With the right key of the mouse, draw 3 points
Pipe2000
File Edit View Analyze Move Labels Facilities Management Tools Help
Surge: Liters/Sec Eq: HW Table Index # Node:3
Map Map Settings System Data Other Data Setup/Defaults Report
Layout
Fixed
Z All
Z Win
Z Sel
Z Prv
Pan
Zoom
J-3
3
P-1
J-1
1
2
Node Information
Del More Data Chng Copy
Less Rslt User Paste
Name J-3
Junction
Elevation 0
Demand 0
Dm Type 1
Node Title
Node Image
Show on Map
Show All
Lrge Print Move
Full Load Clear
X : 496 Y : 769 D : 309
Analyze P Flow N Pres A B


1. Click on each point and line and change the objects on the node information window
2. Click here to change the objects
Objects are for example, a reservoir, a pipe, a tank, etc.
Pipe2000
File Edit View Analyze Move Labels Facilities Management Tools Help
Node Information
Name J-1
Junction
Elevation 0
Demand 0
Dm Type 1
Node Title
Node Image
Show on Map
Show All
Print
Move
Load
Clear
J-1
J-3
P-1
Zoom
X : 961 Y : 904 D : 1141
Analyze
Flow
Pres

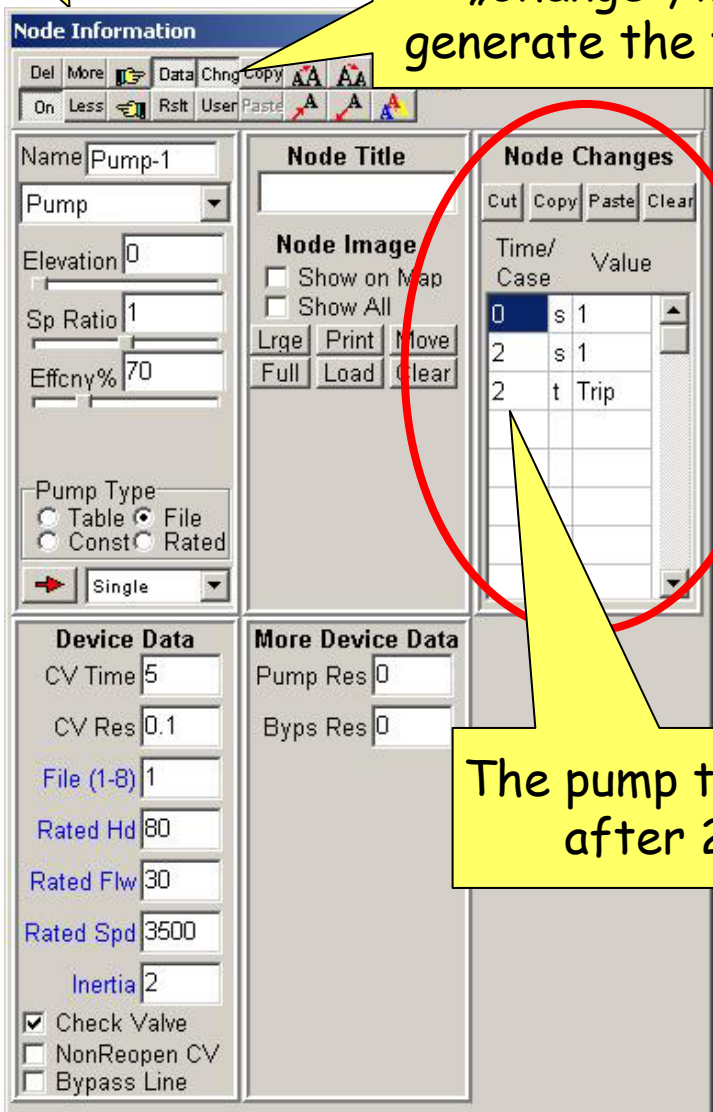
By beginning on the left side on the layout, we introduce the data for the nodes and lines.

Node 1: Reservoir



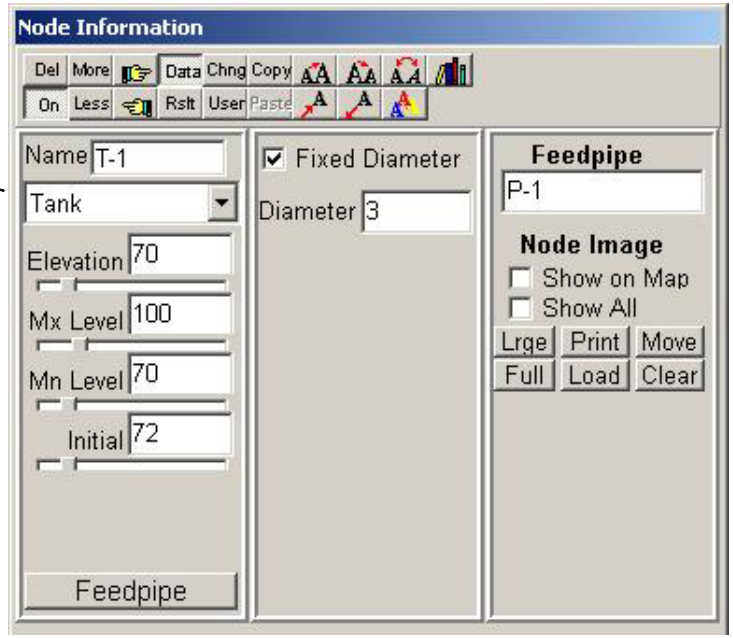
Node 2 : Pump

By means of the button „Change", we will generate the transient

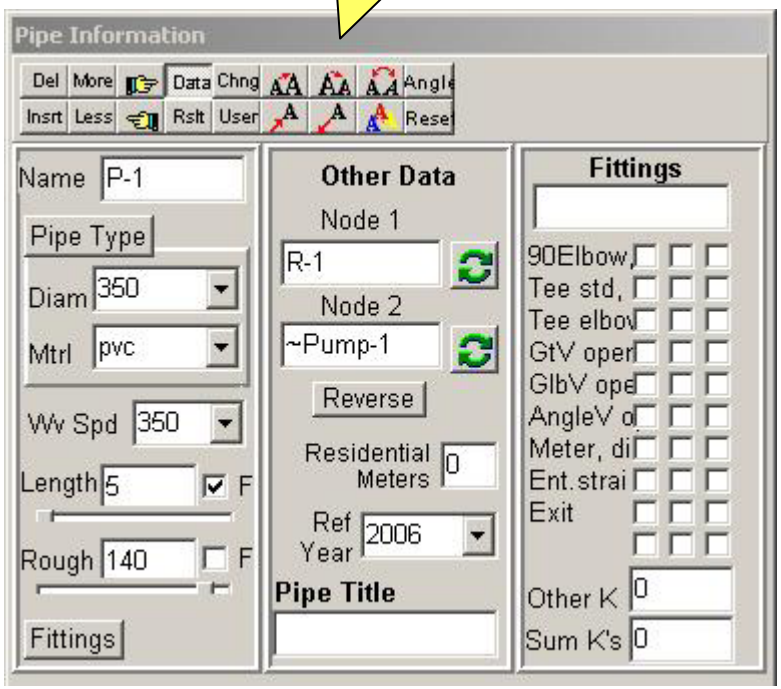


The pump trip occurs after 2 sec.

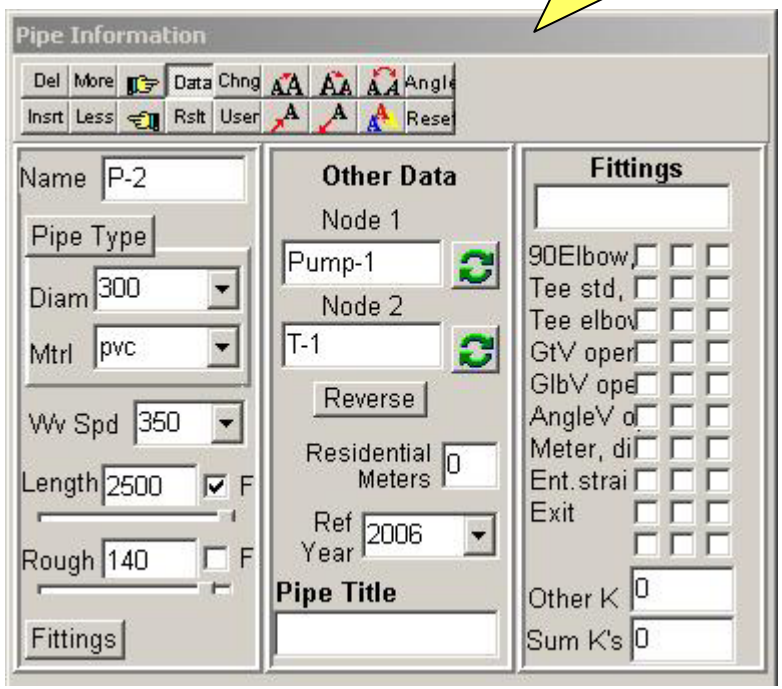
Node 3: Tank



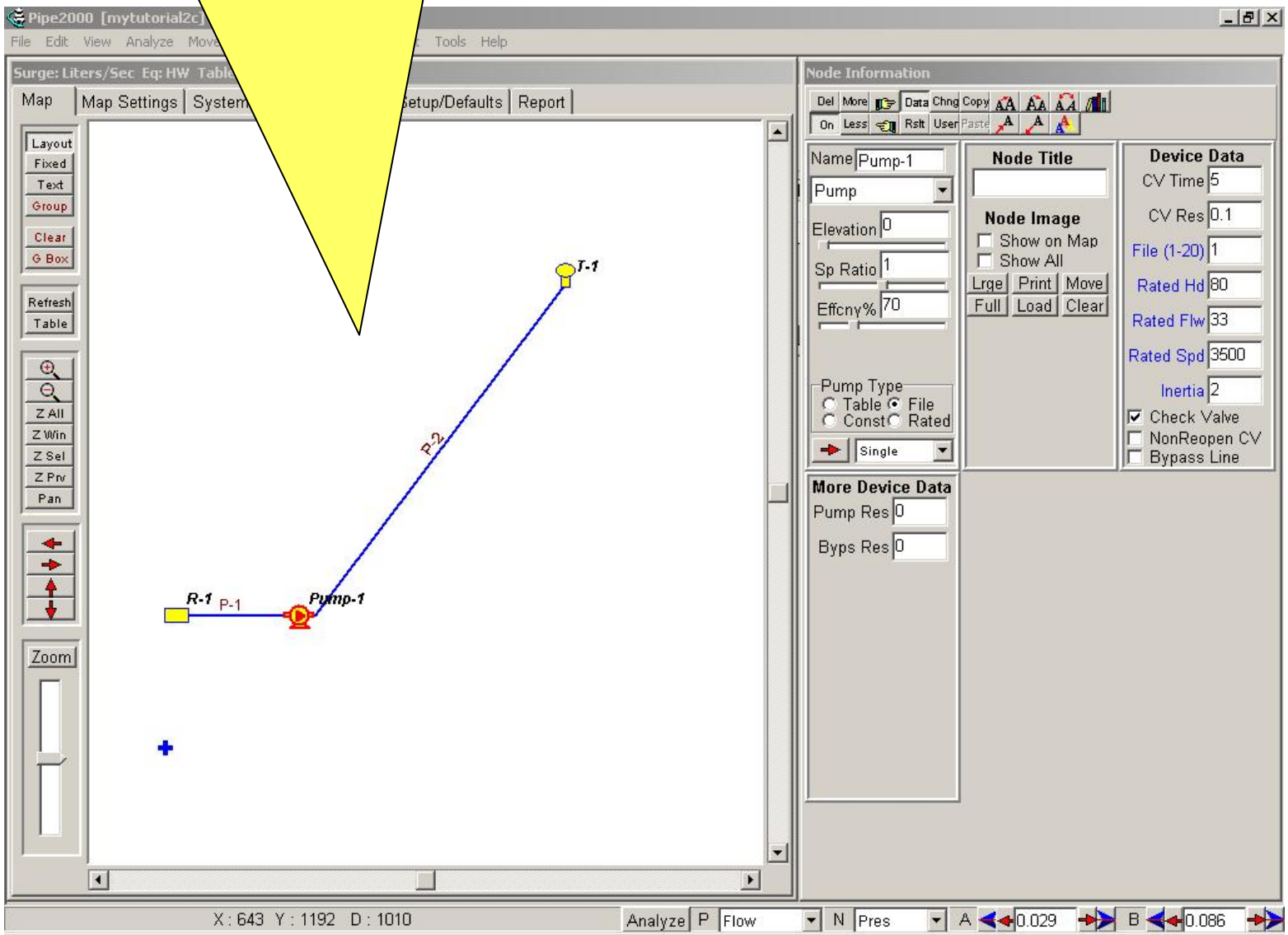
Line 1: Suction Pipe



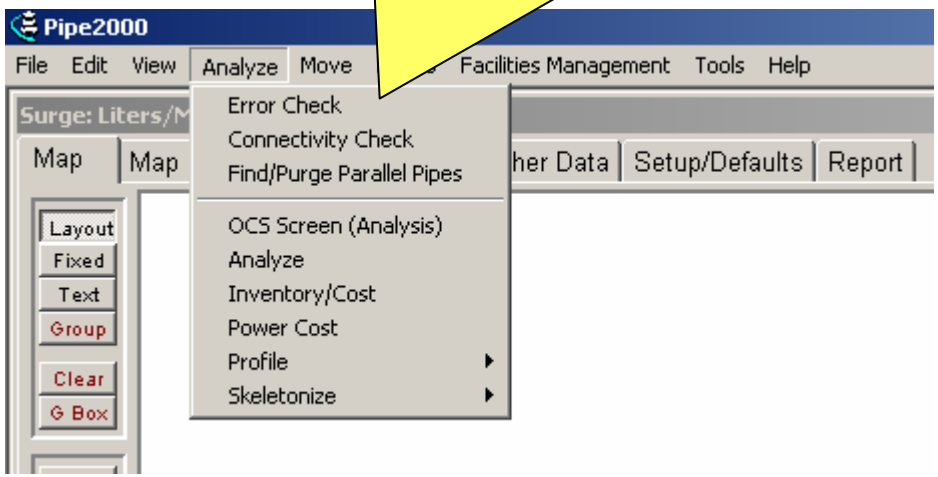
Line 2: Discharge Pipe



We have finished our pipeline scheme and now can begin with the surge simulation



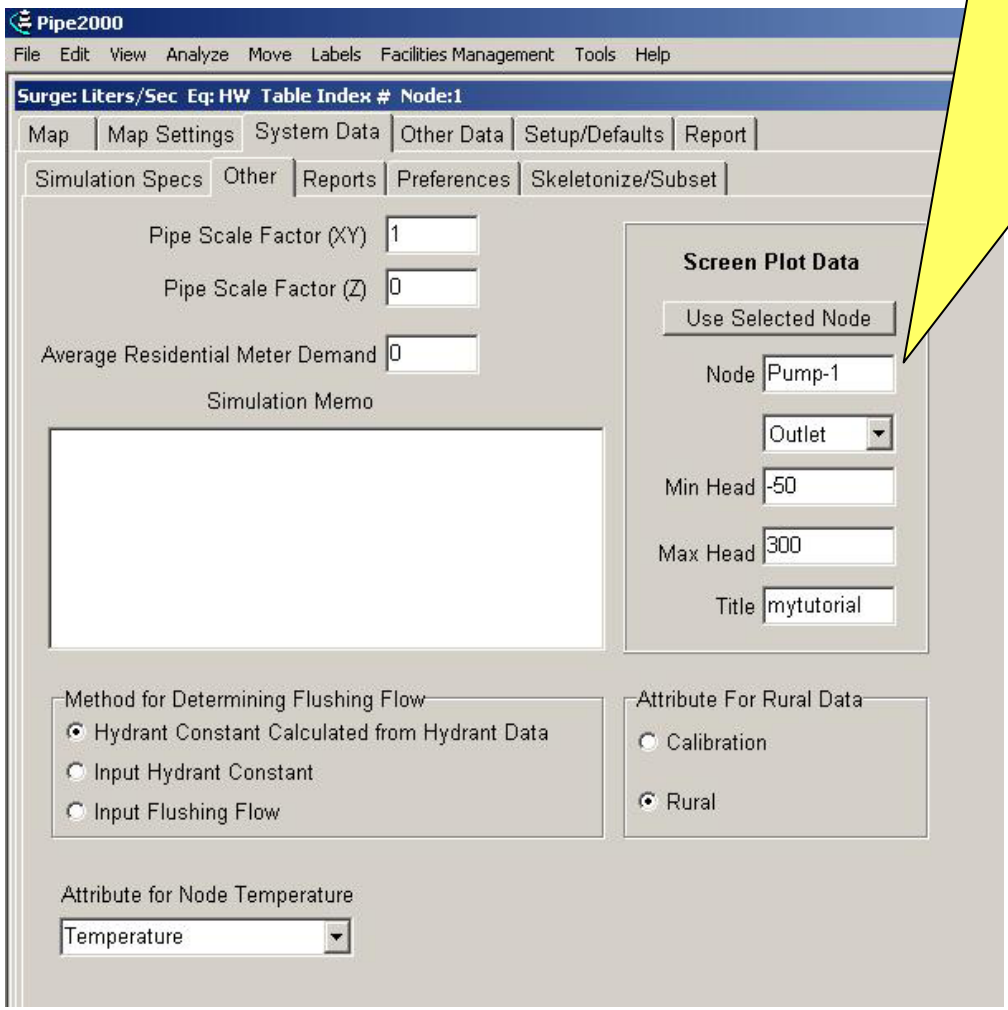
1. In order to begin with the simulation, we have to go to Analyze on the Menu and at first we proceed to make a error check.

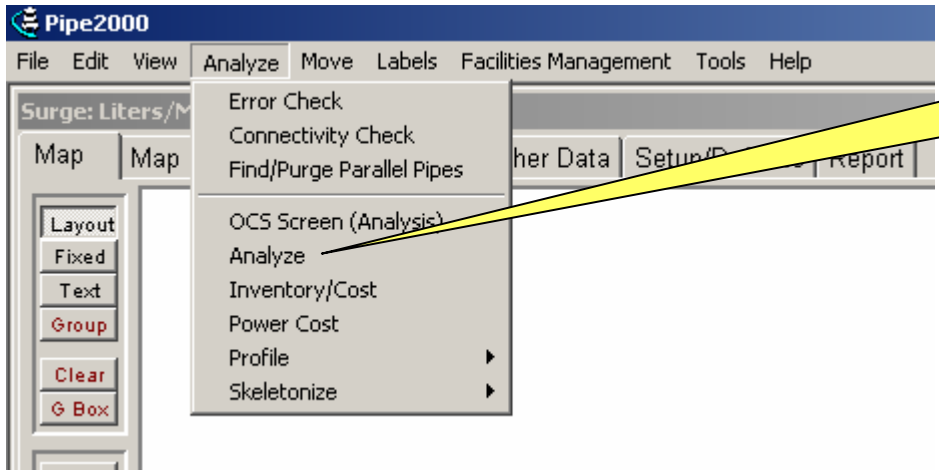


2. As we have not selected a node to plot the results, you receive the following Message (click Ok):

3. You receive also the following message (click Ok)

Next we introduce the node to plot the results. We go to System Data / Other and introduce the node information.

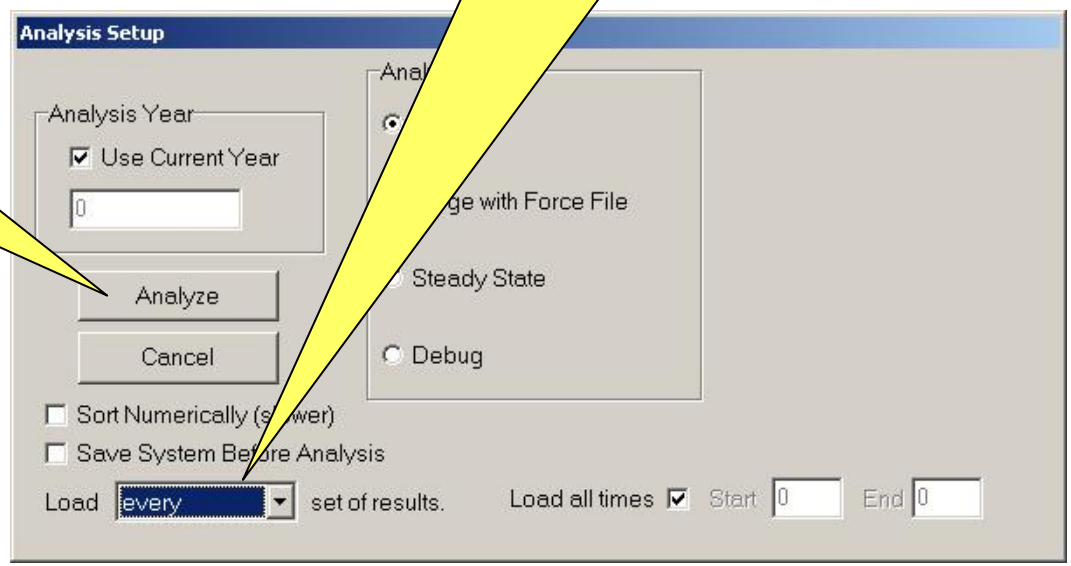




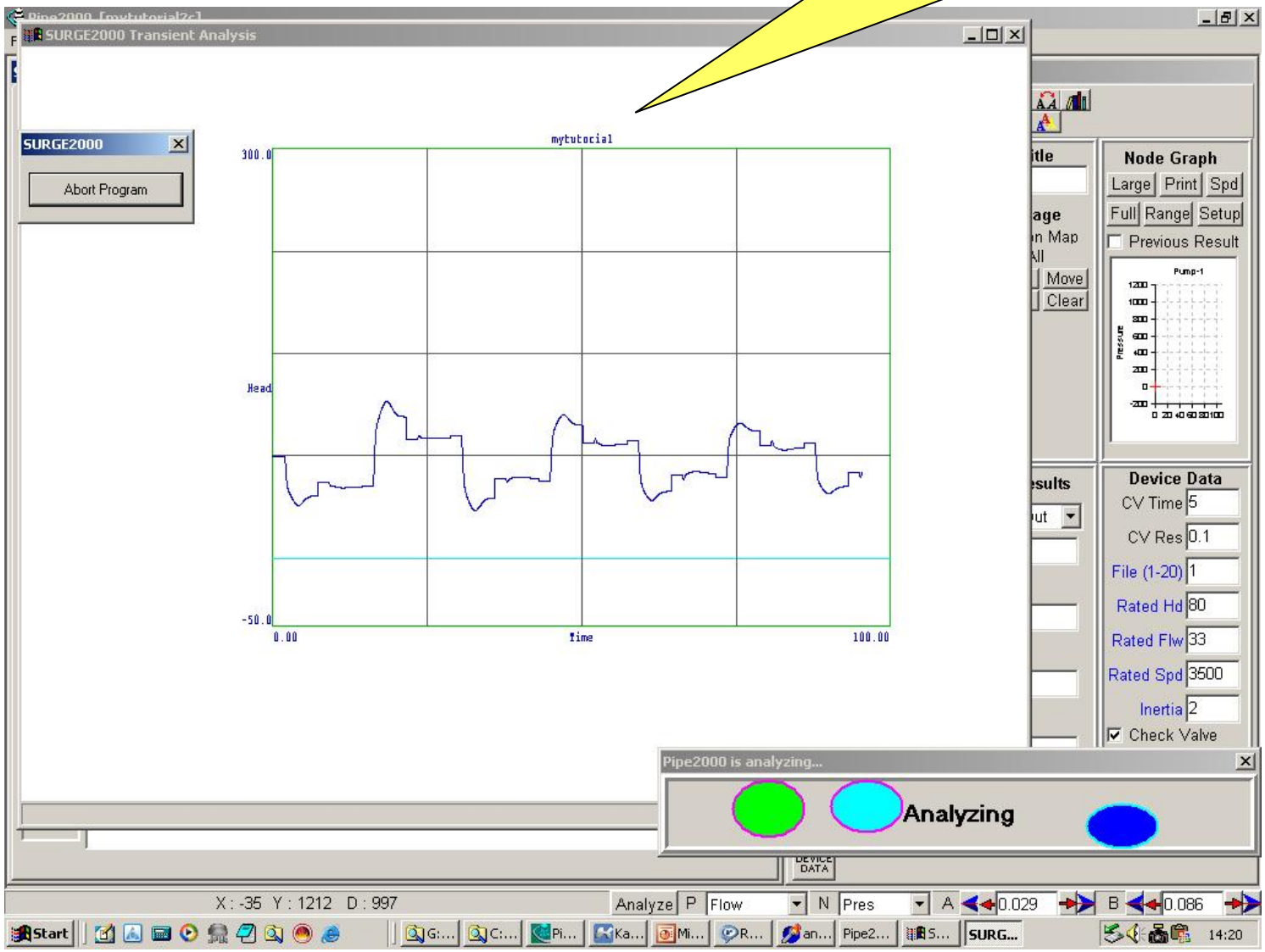
1. Now we click on Analyze !

2. We change the box to „every“

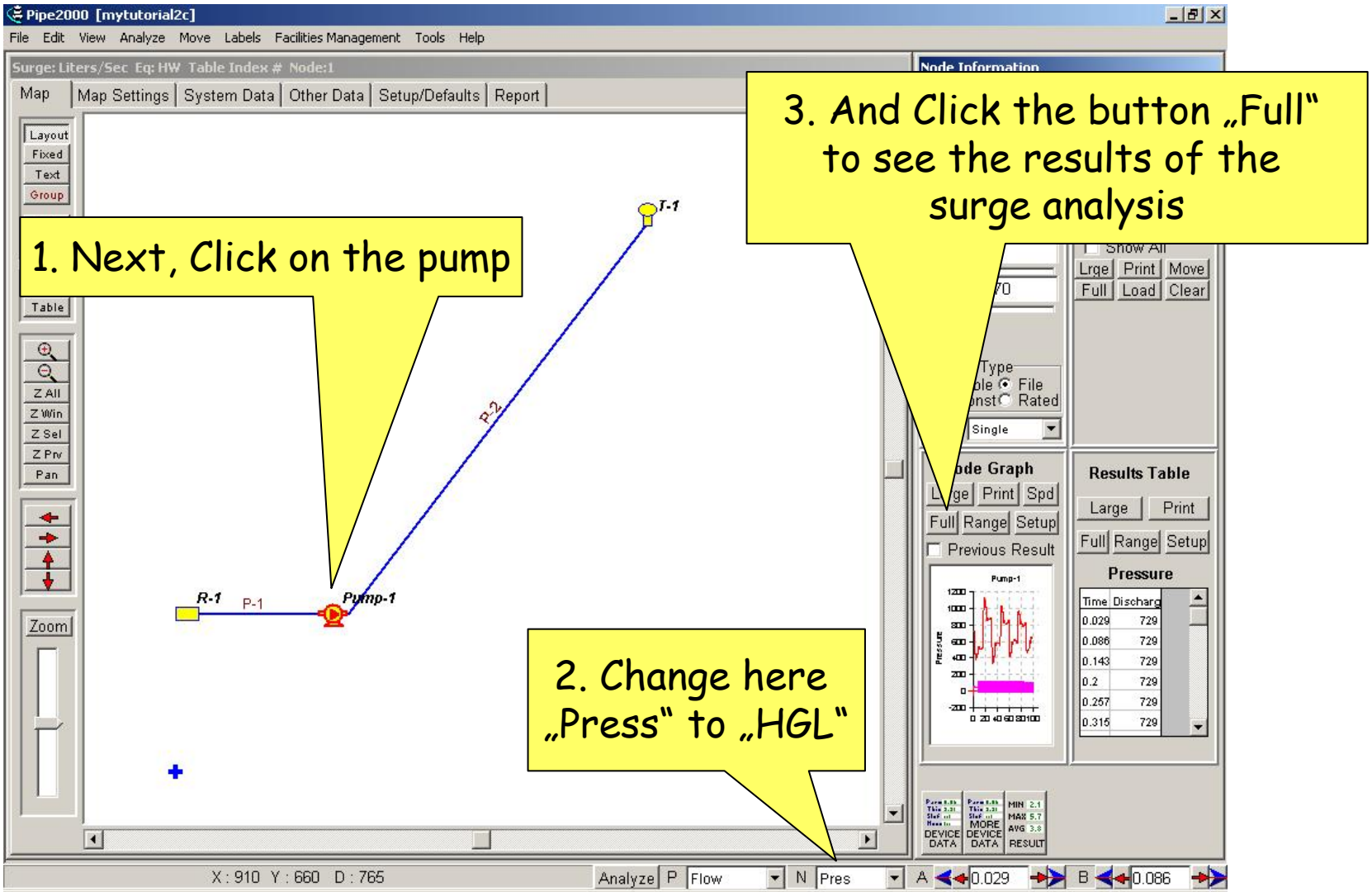
3. And press the button **Analyze**

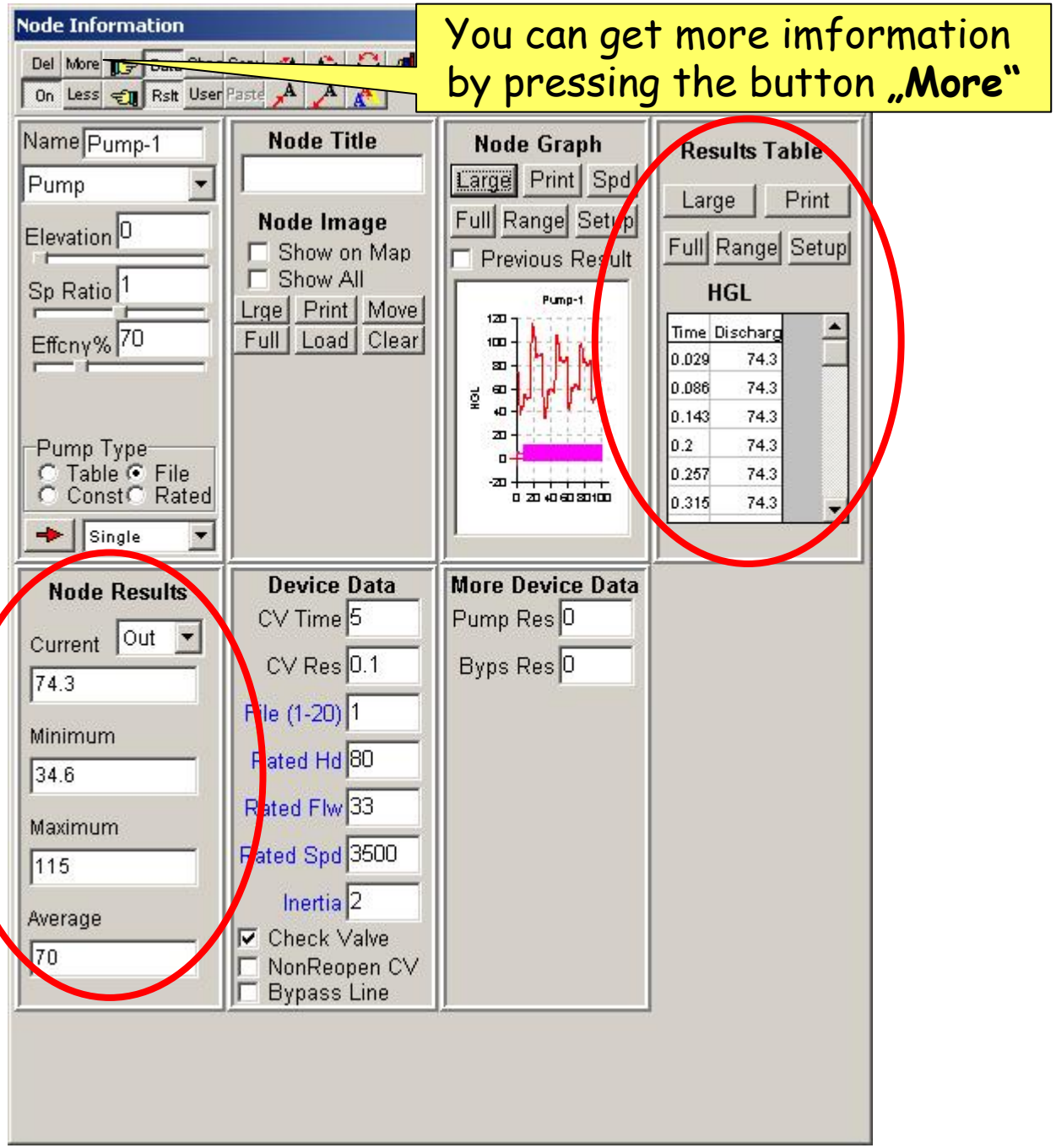


After pressing the button **„Analyze"** you get the following window

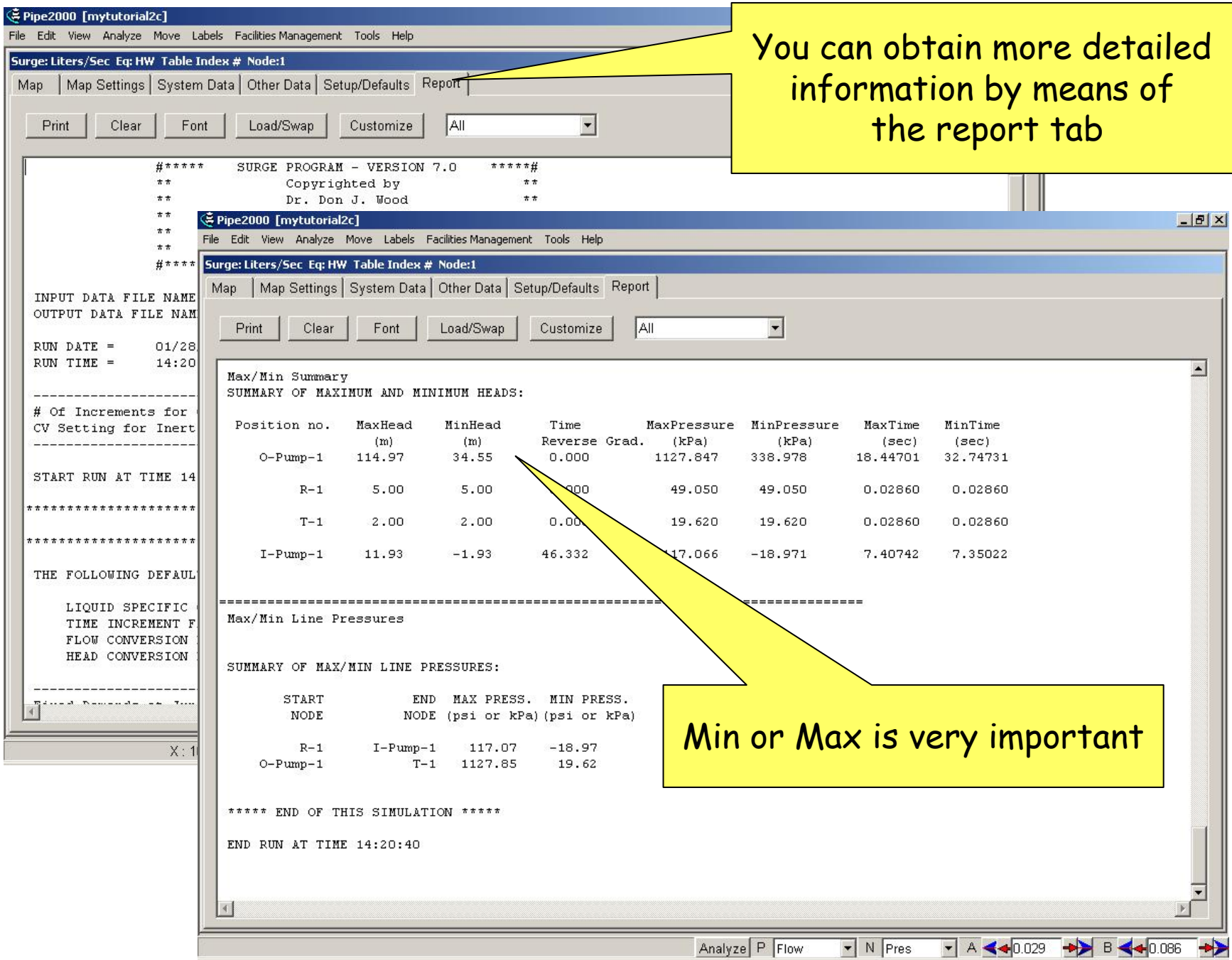


3. Results

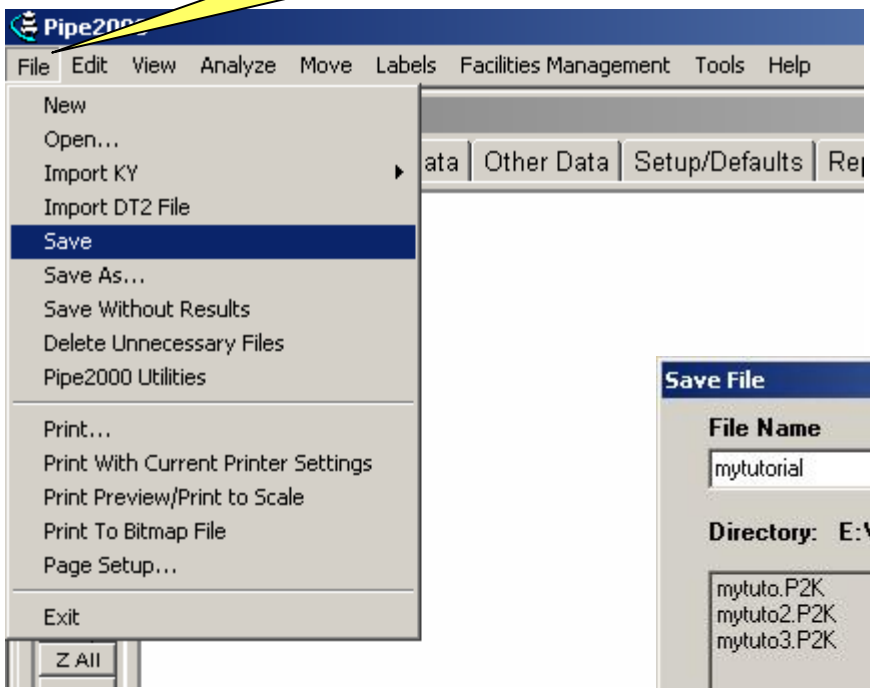

Pipe2000 [mytutorial2c]
File Edit View Analyze Move Labels Facilities Management Tools Help
Surge: Liters/Sec Eq: HW Table Index # Node:1
Map Map Settings System Data Other Data Setup/Defaults Report
Layout Fixed Text Group Table Z All Z Win Z Sel Z Prv Pan Zoom
T-1
P-2
R-1
P-1
Pump-1
1. Next, Click on the pump
3. And Click the button „Full" to see the results of the surge analysis
2. Change here „Press" to „HGL"
Node Information
Lrge Print Move
Full Load Clear
Single
Full Range Setup
Previous Result
Results Table
Large Print
Full Range Setup
Pressure
Time Discharg
0.029 729
0.086 729
0.143 729
0.2 729
0.257 729
0.315 729
DEVICE DATA
MORE DEVICE DATA
RESULT
X : 910 Y : 660 D : 765
Analyze P Flow N Pres A 0.029 B 0.086


Node Information
Del
More
On
Less
Rslt
User
Paste
You can get more imformation by pressing the button „More“
Name
Pump-1
Pump
Elevation
0
Sp Ratio
1
Effcny%
70
Pump Type
Table
File
Const
Rated
Single
Node Title
Node Image
Show on Map
Show All
Lrge
Print
Move
Full
Load
Clear
Node Graph
Large
Print
Spd
Full
Range
Setup
Previous Result
Pump-1
HGL
Results Table
Large
Print
Full
Range
Setup
HGL
Time
Discharg
0.029
74.3
0.086
74.3
0.143
74.3
0.2
74.3
0.257
74.3
0.315
74.3
Node Results
Current
Out
74.3
Minimum
34.6
Maximum
115
Average
70
Device Data
CV Time
5
CV Res
0.1
File (1-20)
1
Rated Hd
80
Rated Flw
33
Rated Spd
3500
Inertia
2
Check Valve
NonReopen CV
Bypass Line
More Device Data
Pump Res
0
Byps Res
0

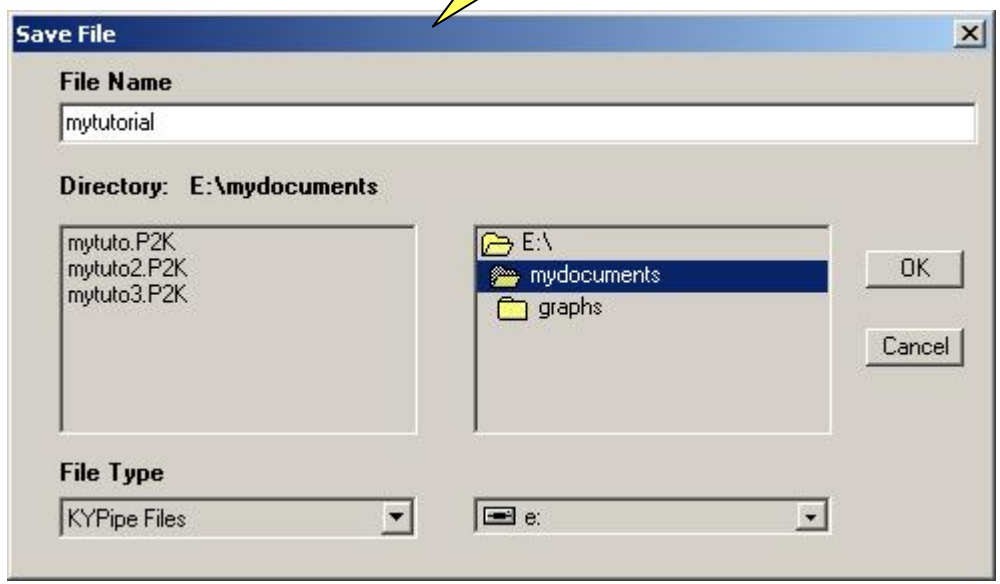

Finally, you have here the results for the node that we selected (Pump). One curve is for the discharge and one curve is for the suction.
Pipe2000 [mytutorial2b2]
File Edit View Analyze Move Labels
Node Information
Node Graph
Default Scale
Small Print Spd
Y min 10
Y max 50
arg Range Setup
Y div 4
Previous Result
Pump-1
HGL
120
100
80
60
40
20
0
-20
0
20
40
60
80
100
Discharge
Suction
Analyze P Flow N HGL
HGL Axis [m]
Time Axis [s]


Pipe2000 [mytutorial2c]
File Edit View Analyze Move Labels Facilities Management Tools Help
Surge: Liters/Sec Eq: HW Table Index # Node:1
Map Map Settings System Data Other Data Setup/Defaults Report
Print Clear Font Load/Swap Customize All
#***** SURGE PROGRAM - VERSION 7.0 *****#
** Copyrighted by **
** Dr. Don J. Wood **
INPUT DATA FILE NAME
OUTPUT DATA FILE NAM
RUN DATE = 01/28
RUN TIME = 14:20
Of Increments for
CV Setting for Inert
START RUN AT TIME 14
THE FOLLOWING DEFAUL
LIQUID SPECIFIC
TIME INCREMENT F
FLOW CONVERSION
HEAD CONVERSION
Pipe2000 [mytutorial2c]
File Edit View Analyze Move Labels Facilities Management Tools Help
Surge: Liters/Sec Eq: HW Table Index # Node:1
Map Map Settings System Data Other Data Setup/Defaults Report
Print Clear Font Load/Swap Customize All
Max/Min Summary
SUMMARY OF MAXIMUM AND MINIMUM HEADS:
Position no. MaxHead (m) MinHead (m) Time Reverse Grad. MaxPressure (kPa) MinPressure (kPa) MaxTime (sec) MinTime (sec)
O-Pump-1 114.97 34.55 0.000 1127.847 338.978 18.44701 32.74731
R-1 5.00 5.00 000 49.050 49.050 0.02860 0.02860
T-1 2.00 2.00 0.00 19.620 19.620 0.02860 0.02860
I-Pump-1 11.93 -1.93 46.332 17.066 -18.971 7.40742 7.35022
Max/Min Line Pressures
SUMMARY OF MAX/MIN LINE PRESSURES:
START NODE END NODE MAX PRESS. (psi or kPa) MIN PRESS. (psi or kPa)
R-1 I-Pump-1 117.07 -18.97
O-Pump-1 T-1 1127.85 19.62
***** END OF THIS SIMULATION *****
END RUN AT TIME 14:20:40
Analyze P Flow N Pres A 0.029 B 0.086
You can obtain more detailed information by means of the report tab
Min or Max is very important

At this level you can save your file. Go to menu „File“

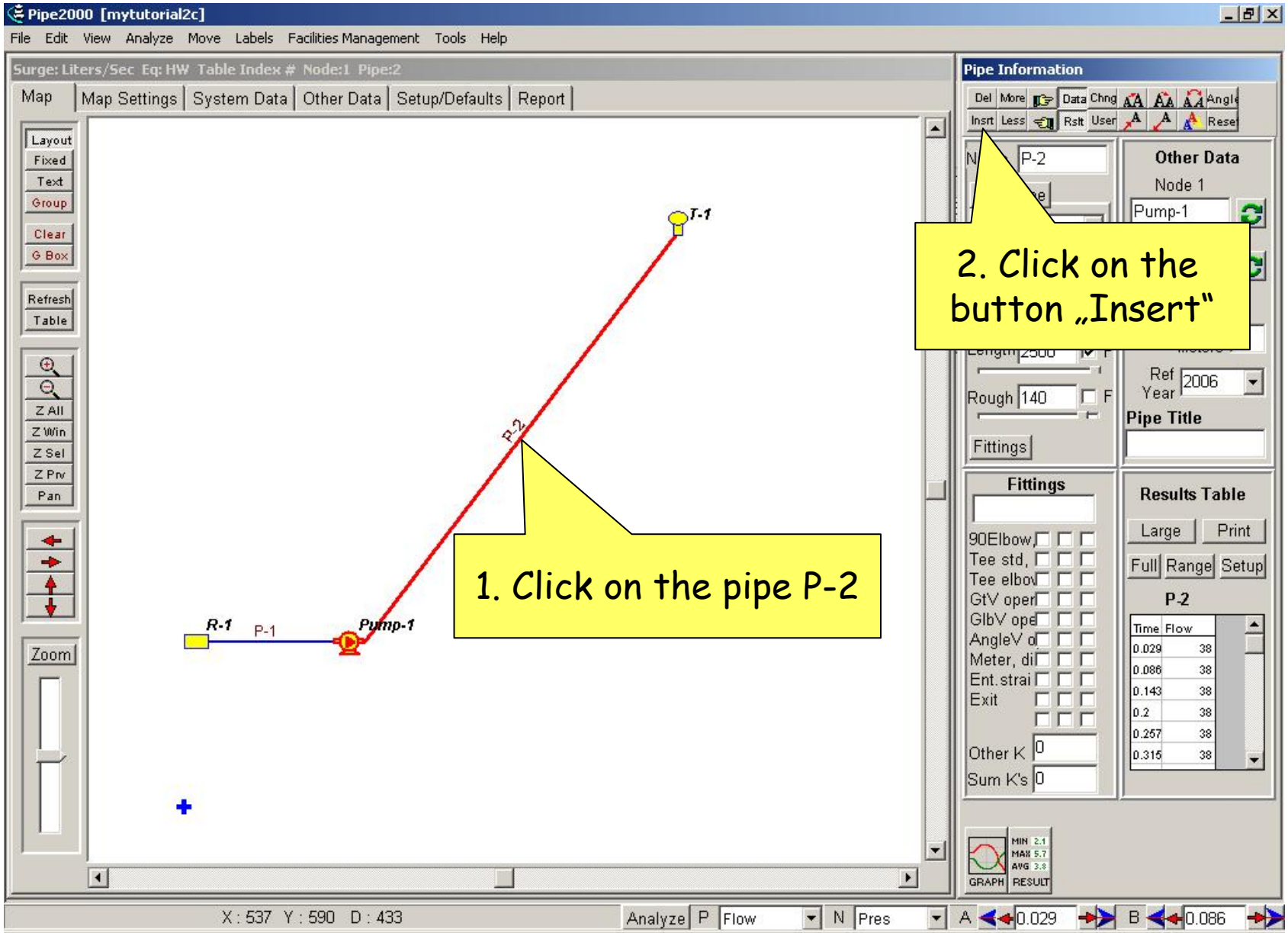


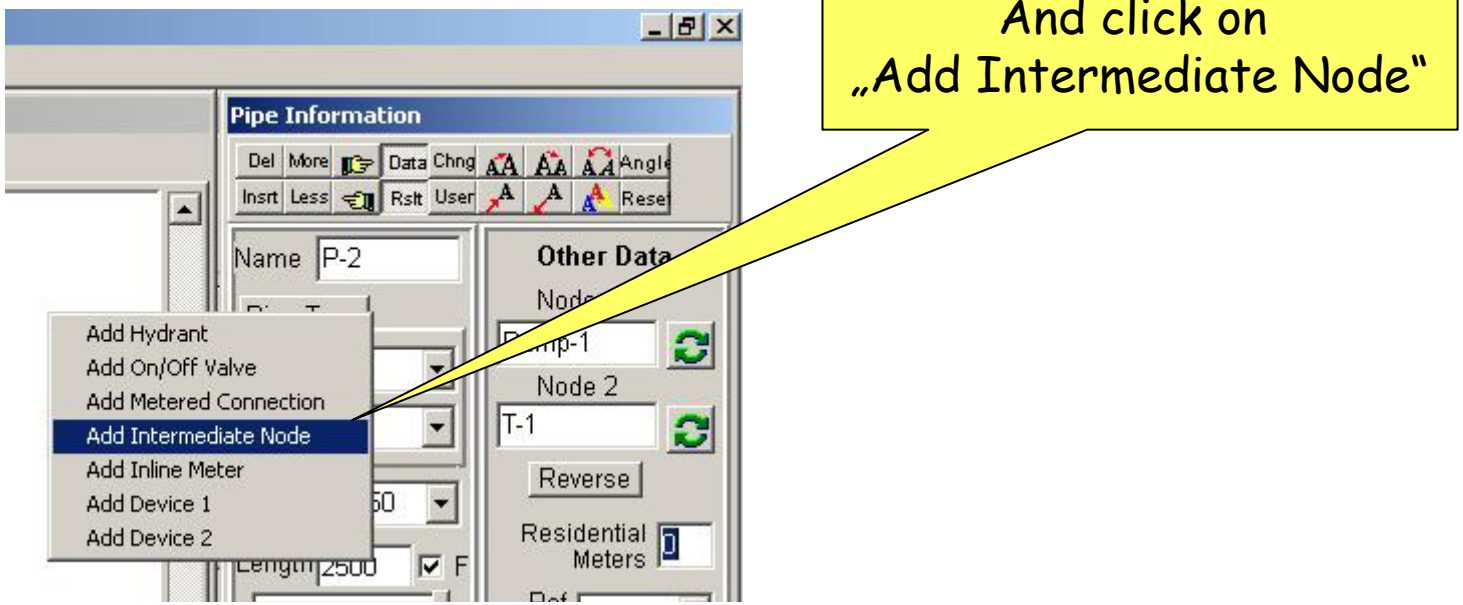
Introduce file name and next press Ok.

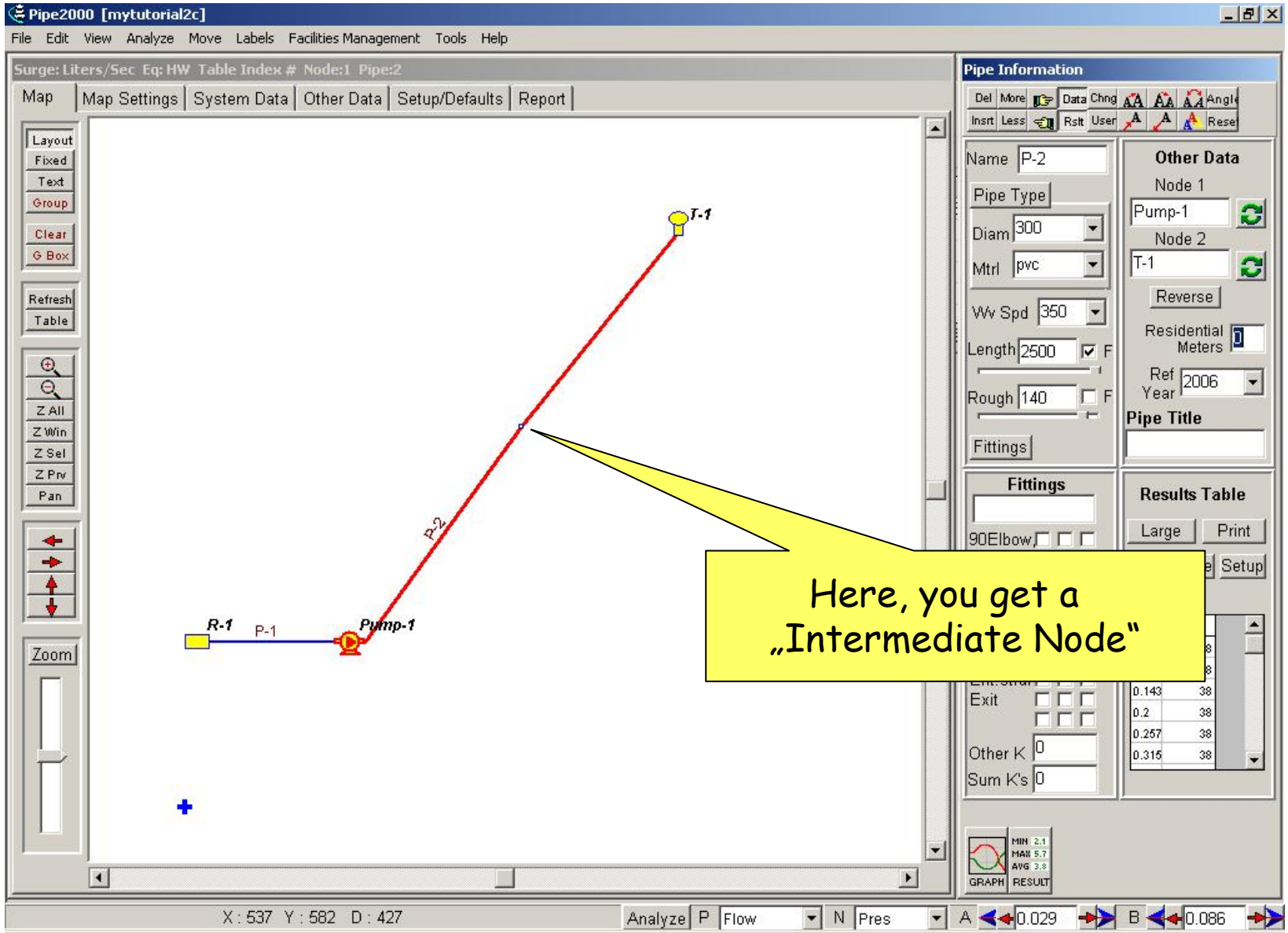


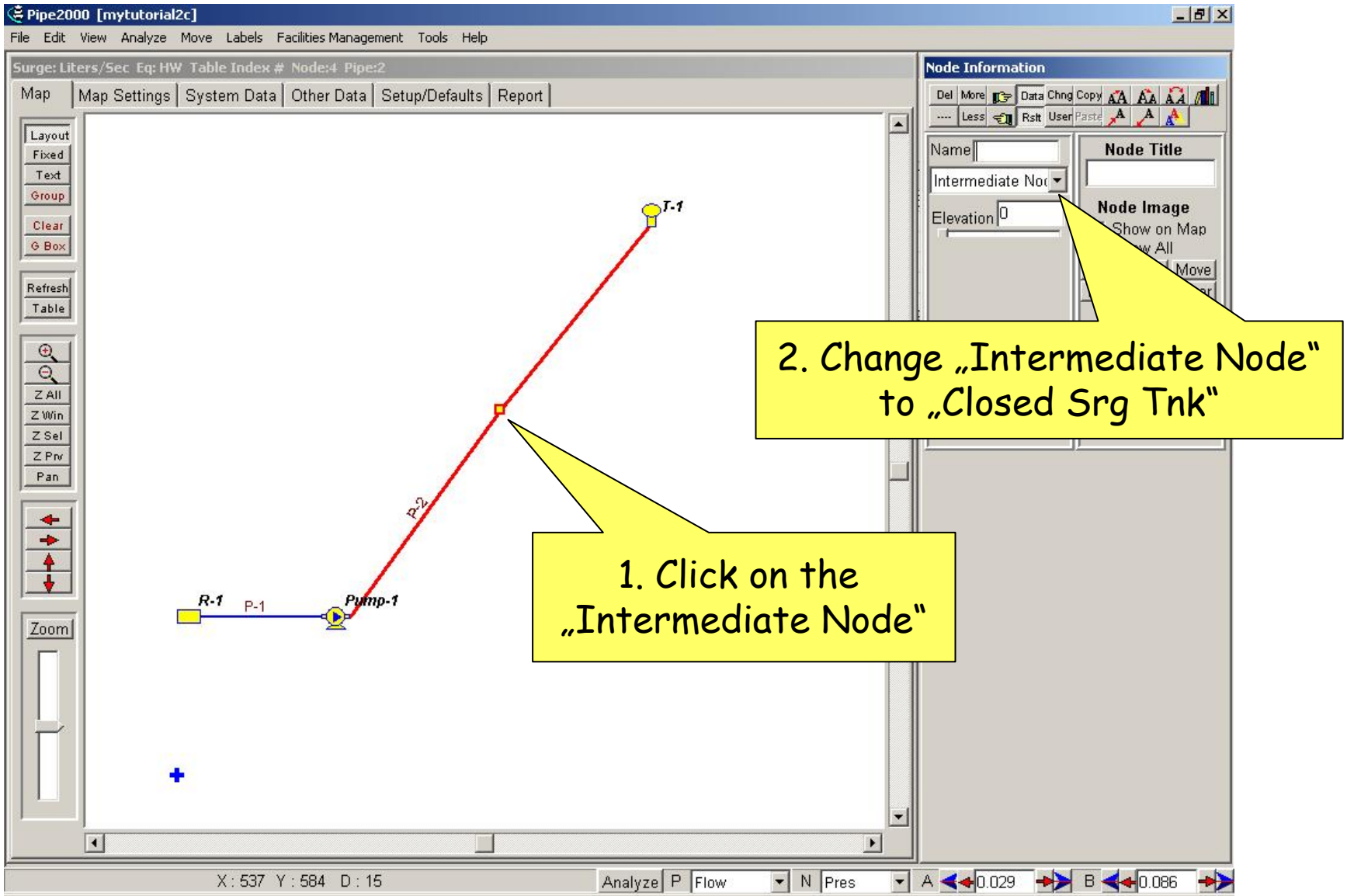
4. Reducing the surge effects

Reducing the Surge effects!

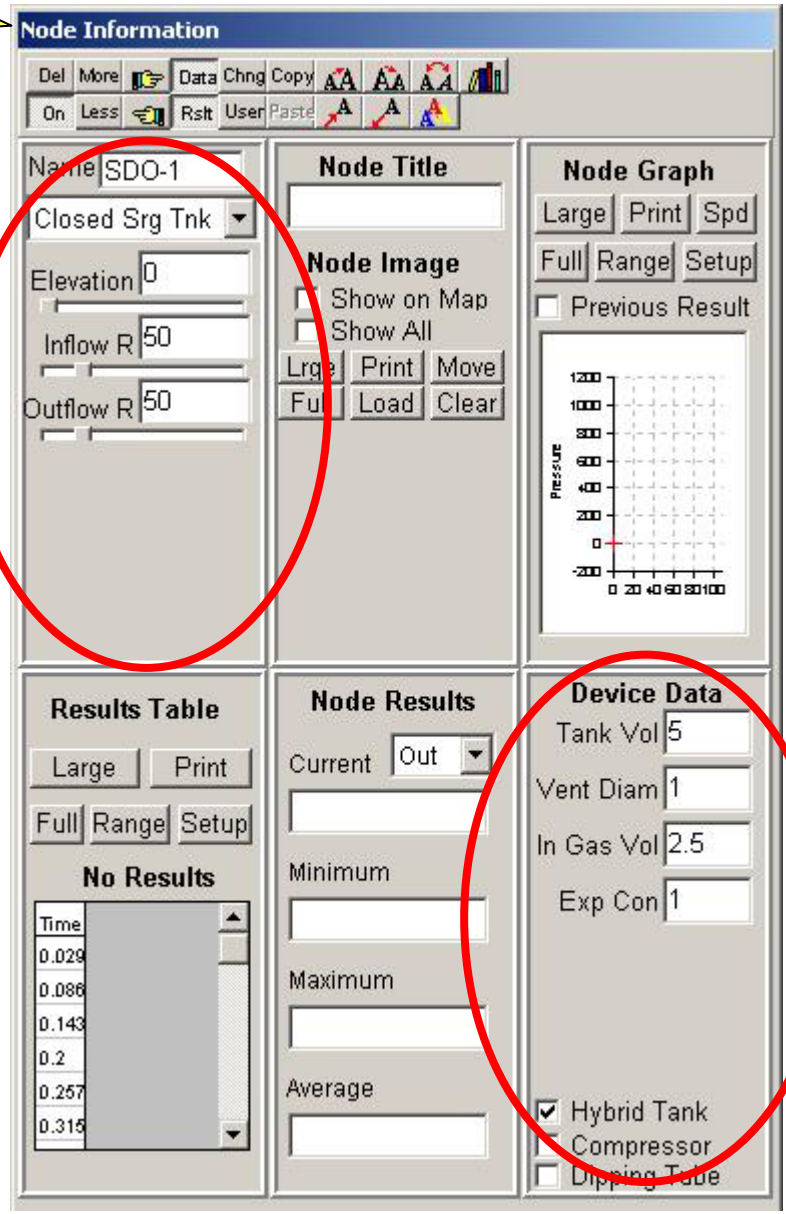

Pipe2000 [mytutorial2c]
File Edit View Analyze Move Labels Facilities Management Tools Help
Surge: Liters/Sec Eq: HW Table Index # Node:1 Pipe:2
Map Map Settings System Data Other Data Setup/Defaults Report
Layout Fixed Text Group Clear G Box
Refresh Table
Z All Z Win Z Sel Z Prv Pan
Zoom
T-1
P-2
R-1
P-1
Pump-1
1. Click on the pipe P-2
Pipe Information
Del More Data Chng Insrt Less Rslt User Reset
P-2
Other Data
Node 1
Pump-1
2. Click on the button „Insert“
Ref Year 2006
Rough 140
Pipe Title
Fittings
Fittings
90Elbow,
Tee std,
Tee elbo
GtV oper
GlbV ope
AngleV o
Meter, di
Ent. strai
Exit
Other K 0
Sum K's 0
Results Table
Large Print
Full Range Setup
P-2
Time Flow
0.029 38
0.086 38
0.143 38
0.2 38
0.257 38
0.315 38
GRAPH RESULT
X : 537 Y : 590 D : 433
Analyze P Flow N Pres A 0.029 B 0.086

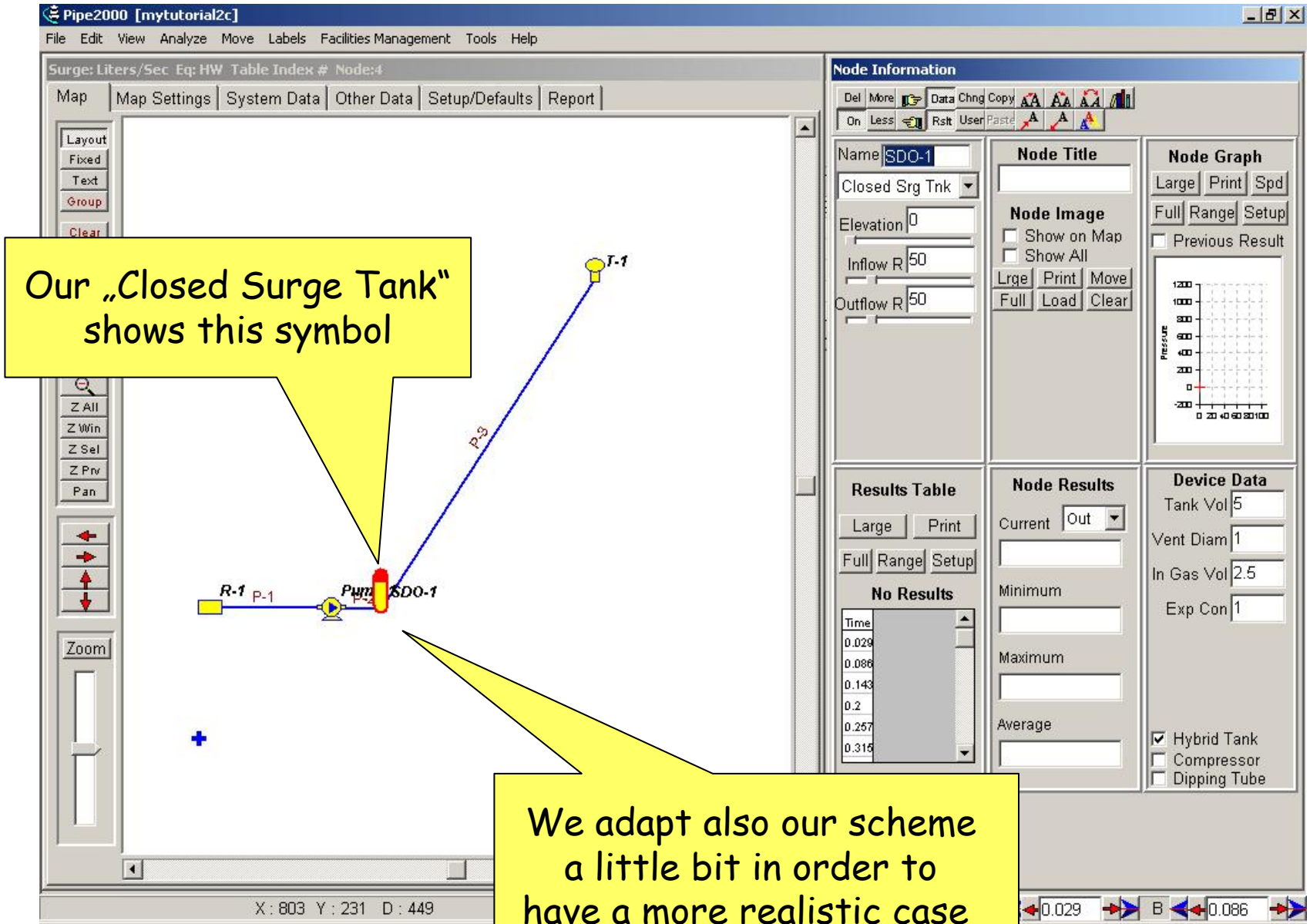

And click on
„Add Intermediate Node“
Pipe Information
Del
More
Data
Chng
Insrt
Less
Rslt
User
Name
P-2
Other Data
Node 2
T-1
Reverse
Residential Meters
Add Hydrant
Add On/Off Valve
Add Metered Connection
Add Intermediate Node
Add Inline Meter
Add Device 1
Add Device 2

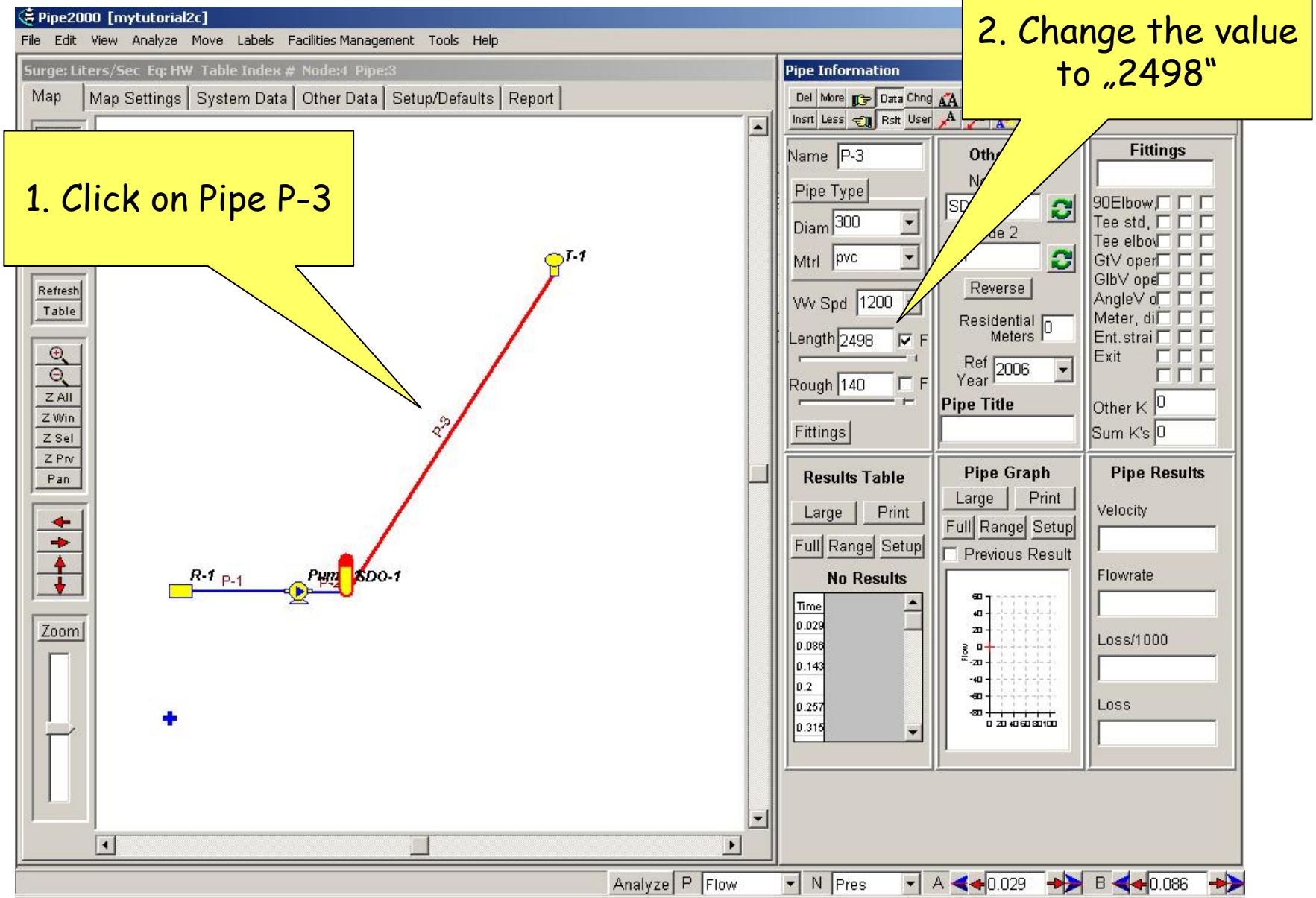

Pipe2000 [mytutorial2c]
File Edit View Analyze Move Labels Facilities Management Tools Help
Surge: Liters/Sec Eq: HW Table Index # Node:1 Pipe:2
Map Map Settings System Data Other Data Setup/Defaults Report
Layout Fixed Text Group Clear G Box
Refresh Table
Z All Z Win Z Sel Z Prv Pan
Zoom
T-1
P-2
R-1
P-1
Pump-1
Here, you get a „Intermediate Node“
Pipe Information
Del More Data Chng Angle
Insrt Less Rslt User Reset
Name P-2
Pipe Type
Diam 300
Mtrl pvc
Wv Spd 350
Length 2500 F
Rough 140 F
Fittings
Other Data
Node 1
Pump-1
Node 2
T-1
Reverse
Residential Meters 0
Ref Year 2006
Pipe Title
Fittings
90Elbow
Exit
Other K 0
Sum K's 0
Results Table
Large Print
Setup
0.143 38
0.2 38
0.257 38
0.315 38
MIN 2.1
MAX 5.7
AVG 3.8
GRAPH RESULT
X : 537 Y : 582 D : 427
Analyze P Flow N Pres A 0.029 B 0.086

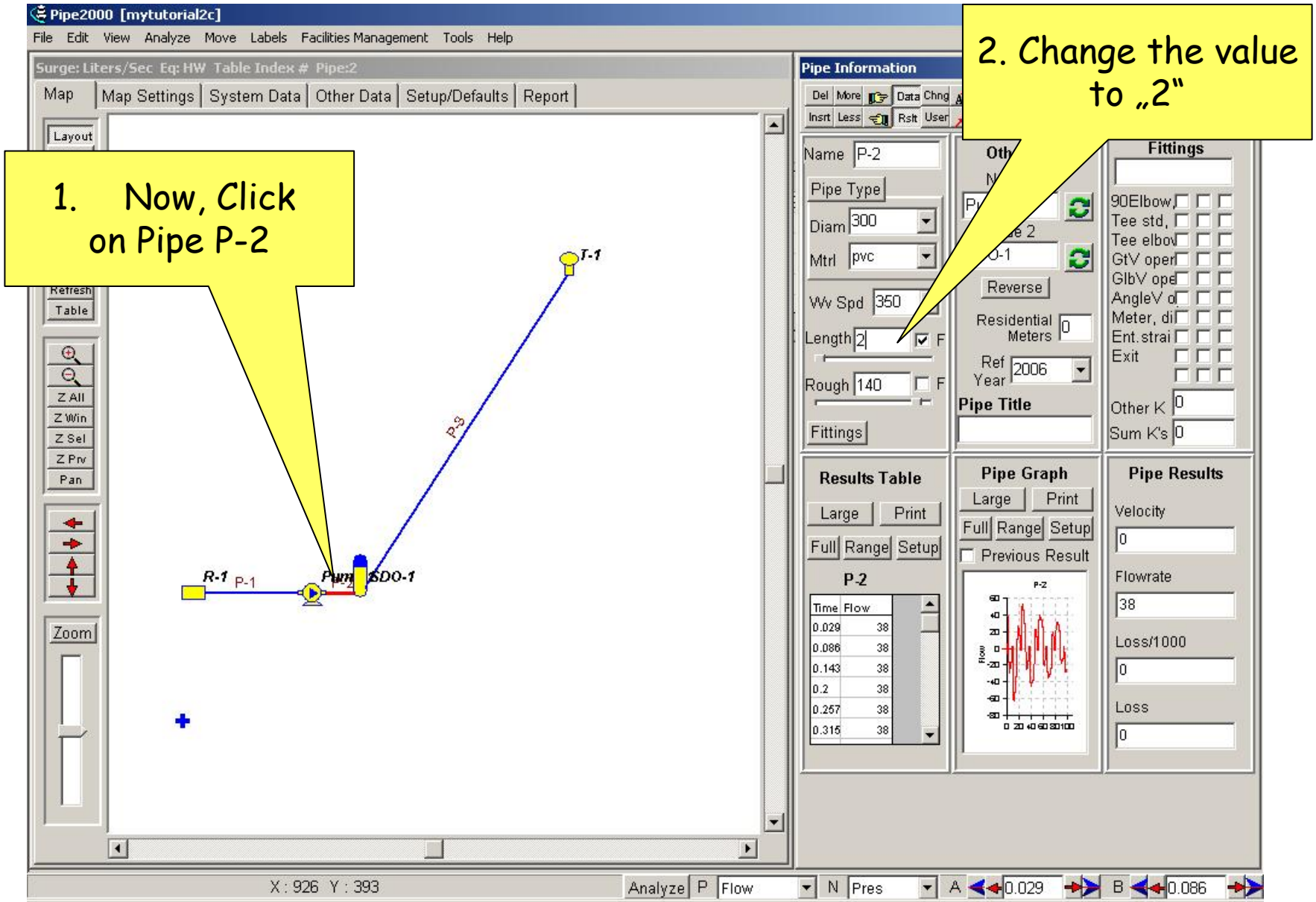

Pipe2000 [mytutorial2c]
File Edit View Analyze Move Labels Facilities Management Tools Help
Surge: Liters/Sec Eq: HW Table Index # Node:4 Pipe:2
Map Map Settings System Data Other Data Setup/Defaults Report
Layout Fixed Text Group Clear G Box
Refresh Table
Z All Z Win Z Sel Z Prv Pan
Zoom
T-1
P-2
R-1
P-1
Pump-1
Node Information
Del More Data Chng Copy
Less Rslt User Paste
Name
Intermediate Noc
Elevation 0
Node Title
Node Image
Show on Map
Move
2. Change „Intermediate Node“ to „Closed Srg Tnk“
1. Click on the „Intermediate Node“
X : 537 Y : 584 D : 15
Analyze P Flow N Pres A 0.029 B 0.086

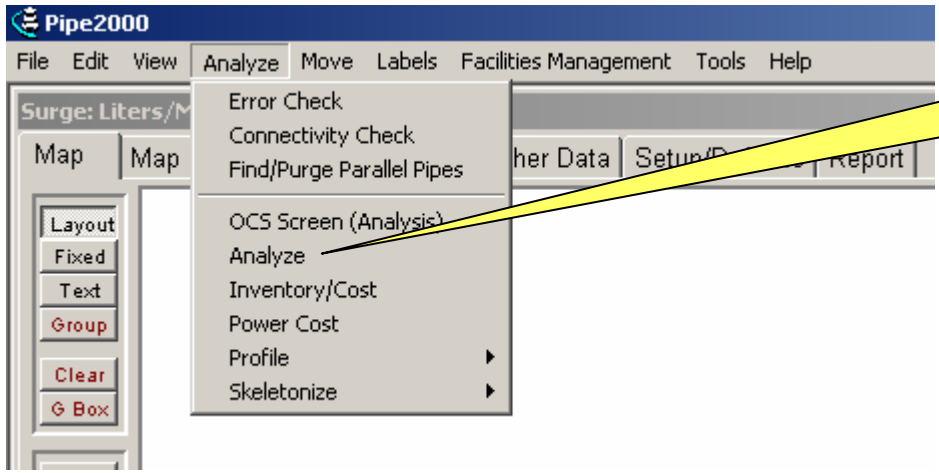
The node information for „Closed Srg Tnk“ must to have values as shown here




Pipe2000 [mytutorial2c]
File Edit View Analyze Move Labels Facilities Management Tools Help
Surge: Liters/Sec Eq: HW Table Index # Node:4
Map Map Settings System Data Other Data Setup/Defaults Report
Node Information
Our „Closed Surge Tank" shows this symbol
We adapt also our scheme a little bit in order to have a more realistic case
T-1
P-3
R-1
P-1
SDO-1
X : 803 Y : 231 D : 449

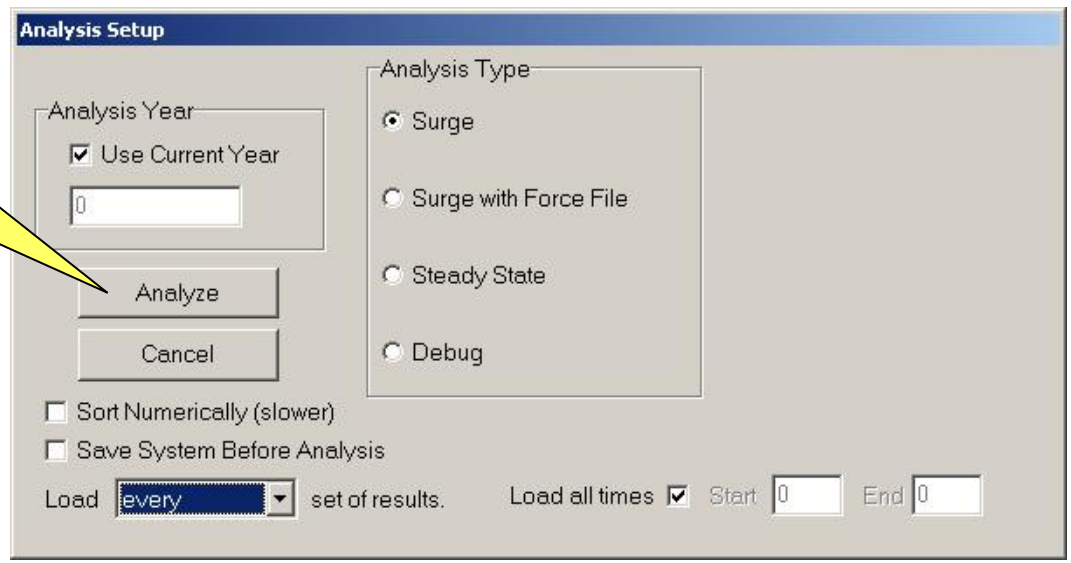

1. Click on Pipe P-3
2. Change the value to „2498“
Pipe2000 [mytutorial2c]
File Edit View Analyze Move Labels Facilities Management Tools Help
Map Map Settings System Data Other Data Setup/Defaults Report
Pipe Information
Name P-3
Pipe Type
Diam 300
Mtrl pvc
Wv Spd 1200
Length 2498
Rough 140
Fittings
Reverse
Residential Meters 0
Ref Year 2006
Pipe Title
Other K 0
Sum K's 0
Results Table
Large Print
Full Range Setup
No Results
Pipe Graph
Large Print
Full Range Setup
Previous Result
Pipe Results
Velocity
Flowrate
Loss/1000
Loss
Refresh Table
Z All Z Win Z Sel Z Prv Pan
Zoom
T-1
P-3
R-1
P-1
SDO-1
Analyze P Flow N Pres A 0.029 B 0.086

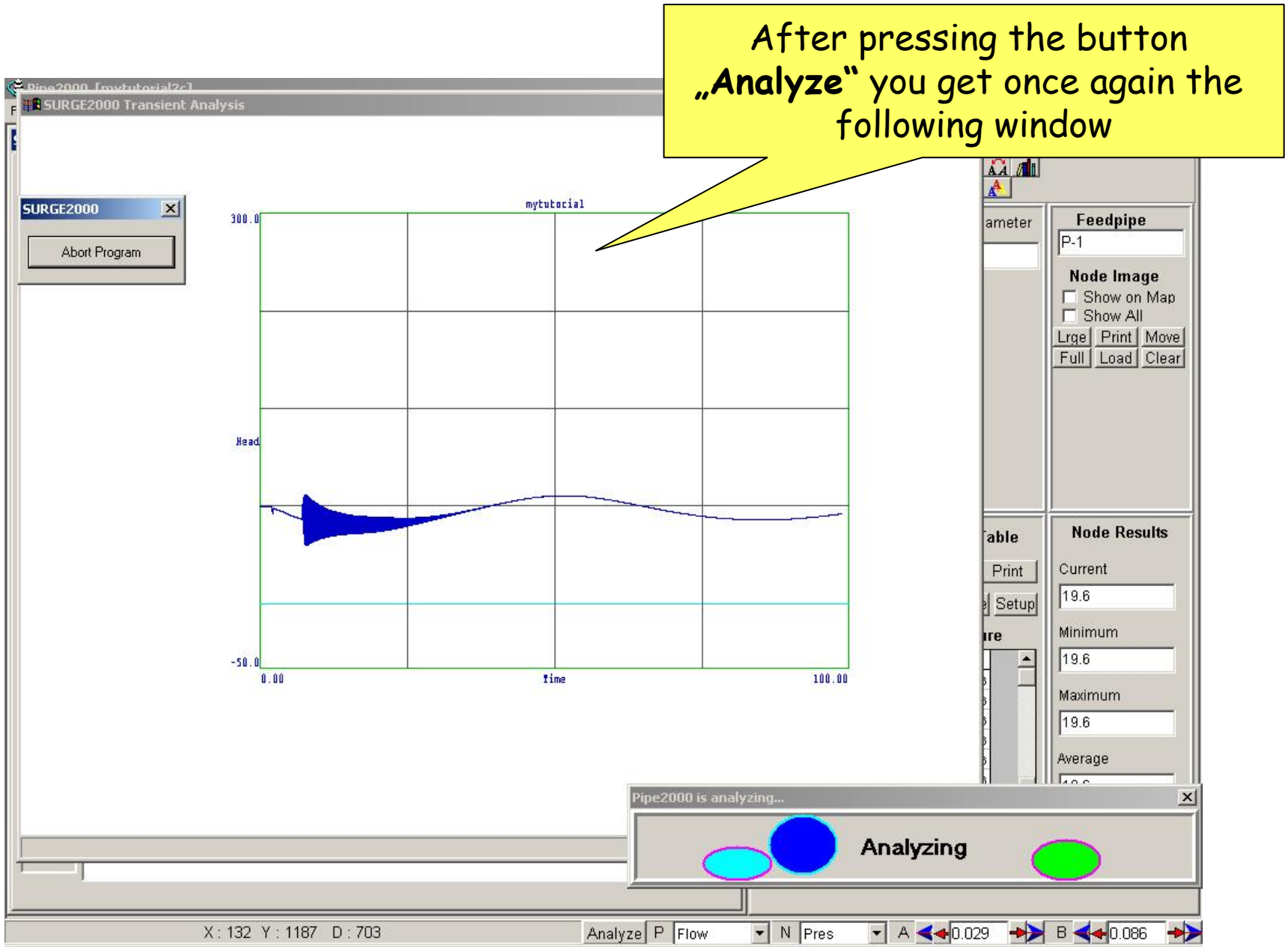

Pipe2000 [mytutorial2c]
File Edit View Analyze Move Labels Facilities Management Tools Help
Surge: Liters/Sec Eq: HW Table Index # Pipe:2
Map Map Settings System Data Other Data Setup/Defaults Report
Layout
Refresh Table
Z All Z Win Z Sel Z Prv Pan
Zoom
1. Now, Click on Pipe P-2
2. Change the value to „2“
T-1
P-3
R-1
P-1
Pump
SDO-1
Pipe Information
Del More Data Chng
Insrt Less Rslt User
Name P-2
Pipe Type
Diam 300
Mtrl pvc
Wv Spd 350
Length 2
Rough 140
Fittings
Reverse
Residential Meters 0
Ref Year 2006
Pipe Title
Fittings
90Elbow
Tee std,
Tee elbo
GtV oper
GlbV ope
AngleV o
Meter, di
Ent.strai
Exit
Other K 0
Sum K's 0
Results Table
Large Print
Full Range Setup
P-2
Time Flow
0.029 38
0.086 38
0.143 38
0.2 38
0.257 38
0.315 38
Pipe Graph
Large Print
Full Range Setup
Previous Result
Pipe Results
Velocity 0
Flowrate 38
Loss/1000 0
Loss 0
X : 926 Y : 393
Analyze P Flow N Pres A 0.029 B 0.086

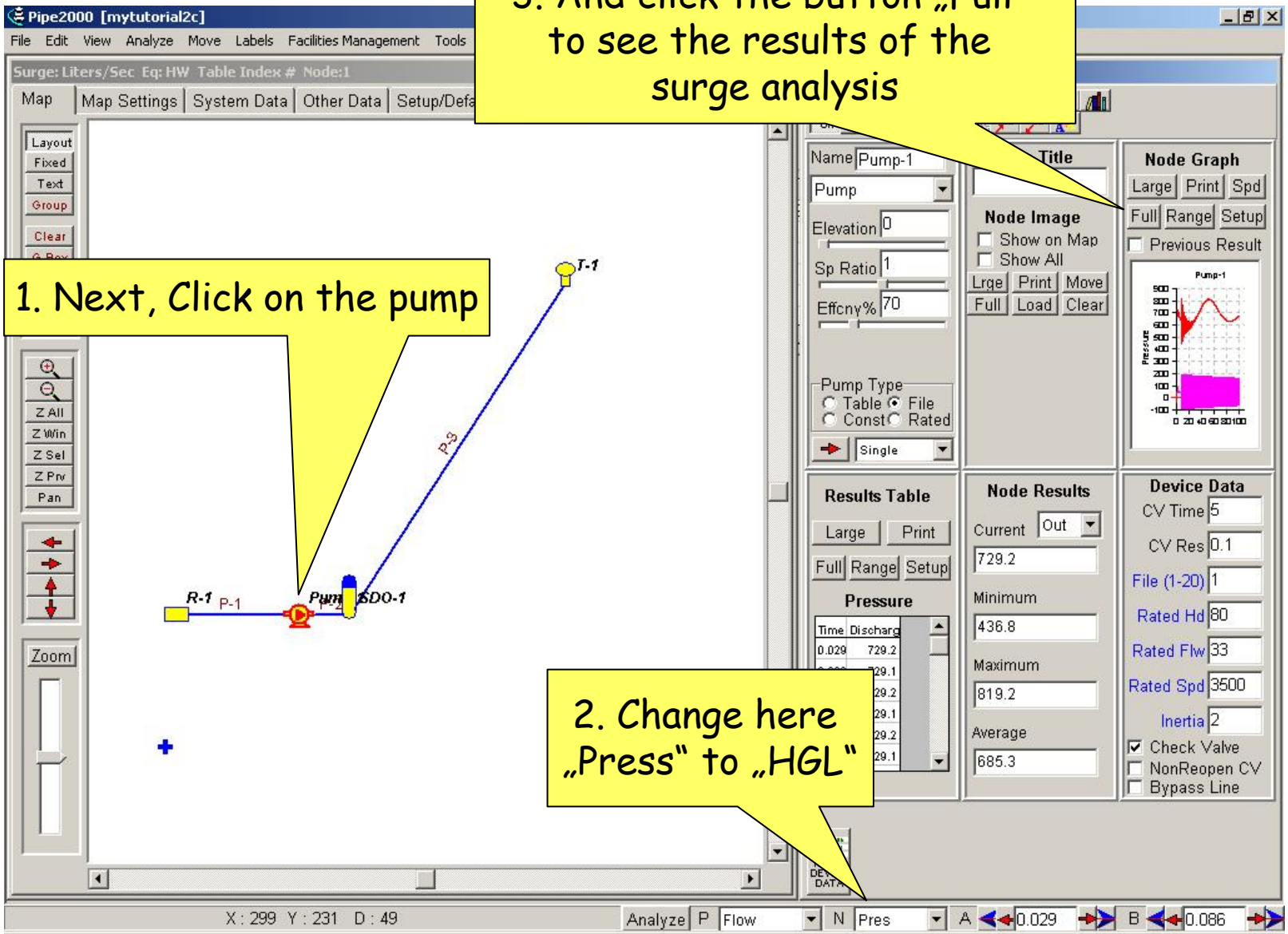


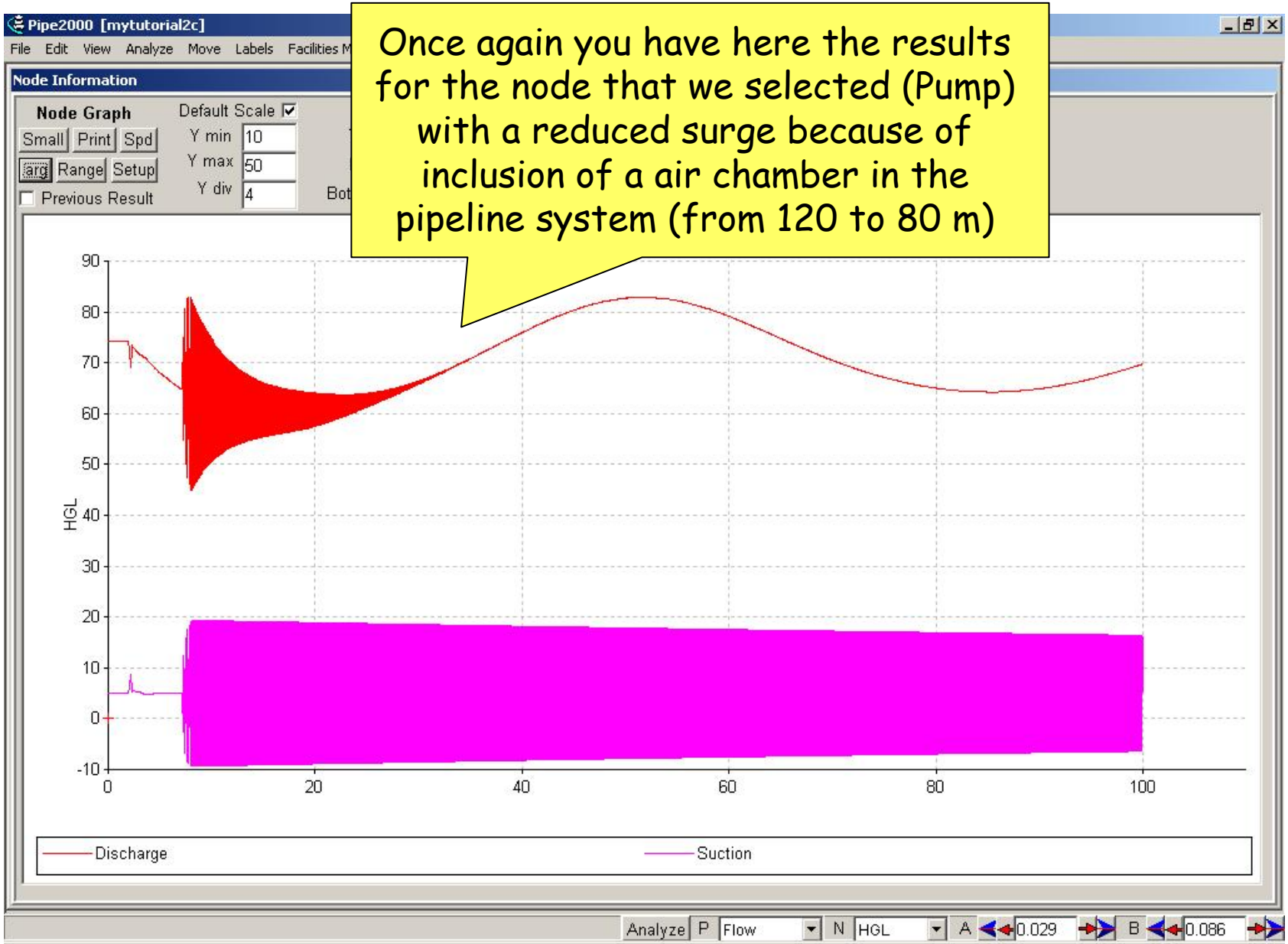
1. Now we click on Analyze !

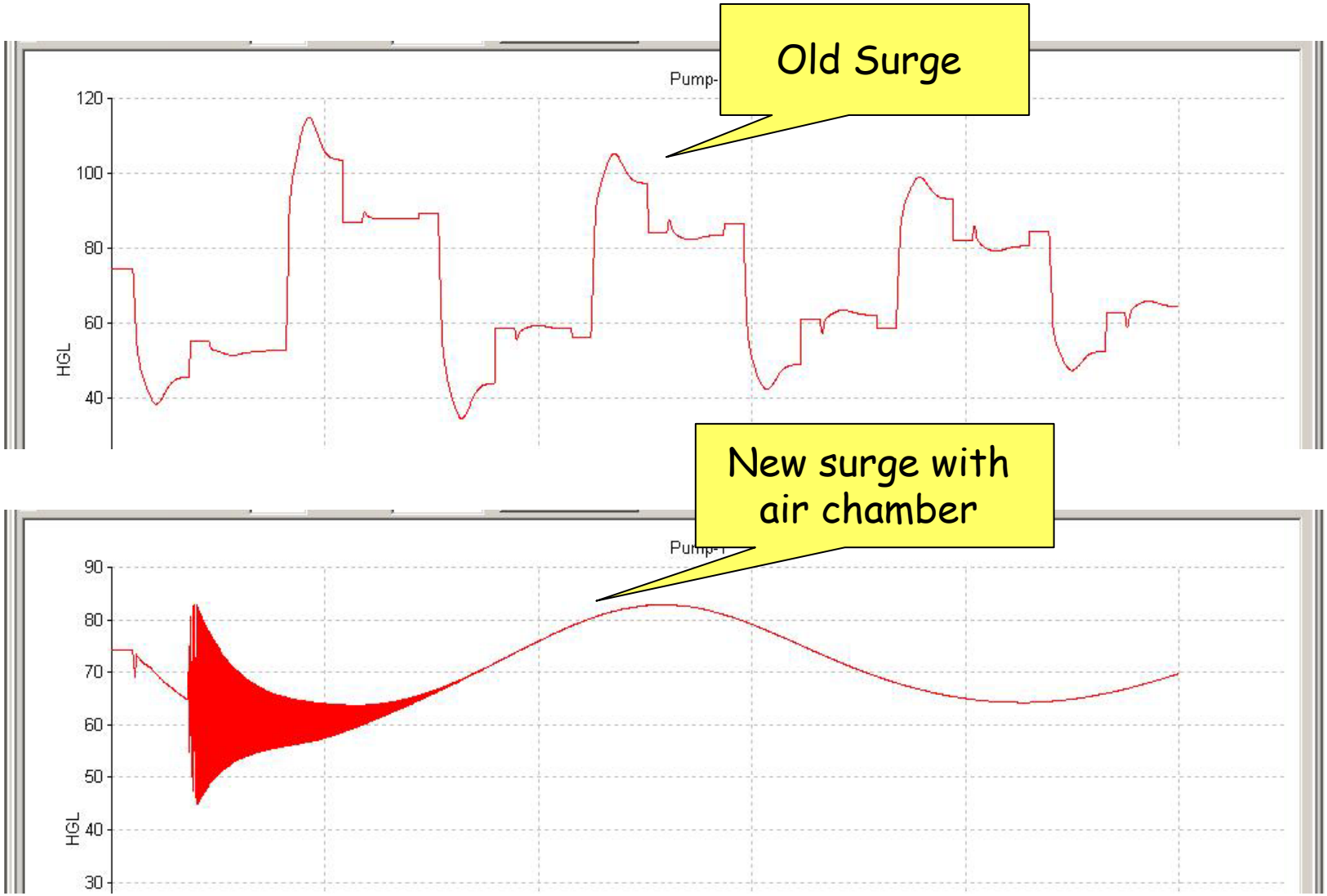
3. And press the button **Analyze**




After pressing the button „Analyze" you get once again the following window
SURGE2000 Transient Analysis
SURGE2000
Abort Program
mytutorial
300.0
Head
-50.0
0.00
Time
100.00
Feedpipe
P-1
Node Image
Show on Map
Show All
Lrge
Print
Move
Full
Load
Clear
Node Results
Current
19.6
Minimum
19.6
Maximum
19.6
Average
Print
Setup
Pipe2000 is analyzing...
Analyzing
X : 132 Y : 1187 D : 703
Analyze
P
Flow
N
Pres
A
0.029
B
0.086


3. And click the button „Full“ to see the results of the surge analysis
1. Next, Click on the pump
2. Change here „Press“ to „HGL“
Pipe2000 [mytutorial2c]
File Edit View Analyze Move Labels Facilities Management Tools
Surge: Liters/Sec Eq: HW Table Index # Node:1
Map
Map Settings
System Data
Other Data
Setup/Defa
Layout
Fixed
Text
Group
Clear
Z All
Z Win
Z Sel
Z Prv
Pan
Zoom
R-1
P-1
P-3
T-1
SDO-1
Name Pump-1
Pump
Elevation 0
Sp Ratio 1
Effcny% 70
Pump Type
Table File
Const Rated
Single
Title
Node Image
Show on Map
Show All
Lrge Print Move
Full Load Clear
Node Graph
Large Print Spd
Full Range Setup
Previous Result
Pump-1
Pressure
Results Table
Large Print
Full Range Setup
Pressure
Time Discharg
0.029 729.2
Node Results
Current Out
729.2
Minimum
436.8
Maximum
819.2
Average
685.3
Device Data
CV Time 5
CV Res 0.1
File (1-20) 1
Rated Hd 80
Rated Flw 33
Rated Spd 3500
Inertia 2
Check Valve
NonReopen CV
Bypass Line
X : 299 Y : 231 D : 49
Analyze P Flow N Pres A 0.029 B 0.086


Pipe2000 [mytutorial2c]
File Edit View Analyze Move Labels Facilities
Node Information
Node Graph
Default Scale
Small Print Spd
Y min 10
Y max 50
Y div 4
arg Range Setup
Previous Result
Once again you have here the results for the node that we selected (Pump) with a reduced surge because of inclusion of a air chamber in the pipeline system (from 120 to 80 m)
HGL
90
80
70
60
50
40
30
20
10
0
-10
0
20
40
60
80
100
Discharge
Suction
Analyze P Flow N HGL A 0.029 B 0.086


Old Surge
Pump-
120
100
80
60
40
HGL
New surge with
air chamber
90
80
70
60
50
40
30
HGL

That is all folks!

By Dr.-Ing. Over Díaz
Jan 2006
Germany

CES
Consulting Engineers
Salzgitter GmbH