The CEDRA Corporation's

COMMAND OF THE MONTH

A monthly information bulletin February 2012

FEATURED COMMAND

Fire Flow Analysis using EPANET 2

Figure 1 - CEDRA-AVwater-Menus Toolbar

Application Description

ArcGIS® is used for many applications such as mapping, redistricting, tracking animal migration, monitoring tree health and much much more. Few folks are aware however, that water distribution modeling is also an application in which ArcGIS can be employed.

The CEDRA-AVwater software offers a set of tools which integrates ArcGIS with the U.S.A.E.P.A.'s EPANET 2 modeler. This software package enables engineers to perform water distribution analysis and water quality modeling from within the ArcMap environment.

This month's issue of Command of the Month discusses how a fire flow analysis can be performed using the CEDRA-AVwater software in conjunction with the EPANET 2 modeler.

It should be pointed out that water distribution agencies, worldwide, have the responsibility to supply water to fight fires, and to verify that this responsibility can be met. As such, the ability to perform a fire flow analysis is an essential function.

Basically, a fire flow analysis involves calculating how much flow is available at any hydrant or group of hydrants in a water distribution model, based upon pressure and flow constraints which are defined by local regulations. Fire flow analysis results are used in sizing a network. Larger pipes leads to larger costs. A proper fire flow analysis enables the engineer to balance system adequacy and cost.

The CEDRA Solution

Shown in Figures 1 and 2 are the menus and tools which comprise the CEDRA-AVwater software package. Shown in Figure 3 are the modeling commands which appear in the left-most drop-down of the CEDRA-AVwater-Menus toolbar. The [Execute] command is the specific command which performs an analysis.

> ***Command Of The Month bulletin***
>
> *This month's issue discusses how to perform a fire flow analysis using the EPANET 2 modeler from within the ArcMap environment.*

AVwater Model Overview

A CEDRA-AVwater water model consists of basically two layers and a series of tables. The layers are of point and line type and contain all of the nodes and pipes which comprise the water model.

Shown in Figure 4 is the default classification scheme for the CEDRA-AVwater node and pipe layers. This classification can be altered by the user, if so desired.

The tables, mentioned above, contain modeling information pertaining to the specific types of nodes and the overall model itself.

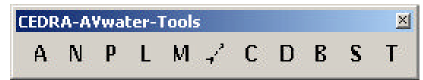

Figure 2
CEDRA-AVwater-Tools Toolbar

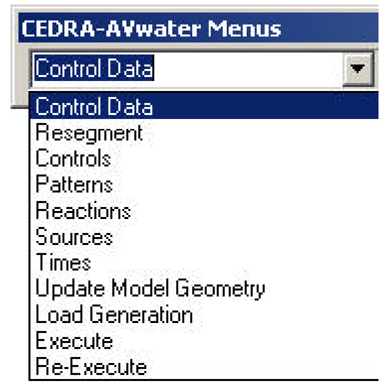

Figure 3
Modeling Commands ComboBox

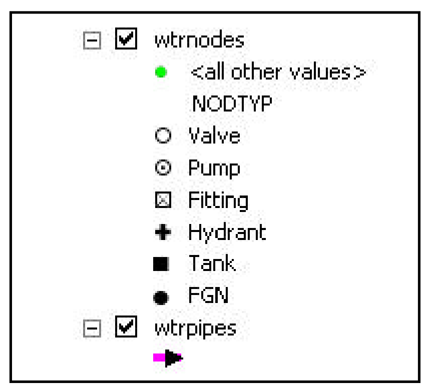

Figure 4
Modeling Commands ComboBox

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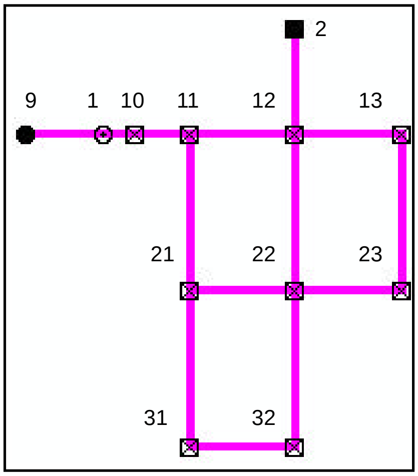

Figure 5
Sample Water Distribution Model

Attached to the nodes and pipes are a set of attributes used in performing steady-state, extended period simulations and water quality analyses. Note, this does not preclude the user from adding other attributes to the node and pipe layers.

Shown in Figure 5 is a sample water distribution model. This model could have been created from within the CEDRA-AVwater software using the **A**, **N** and **P** tools in the CEDRA-AVwater-Tools toolbar or it could have been imported using the [**Import Points**] command in the CEDRA-AVcad-Menus toolbar. The [**Update Model Geometry**] command shown in Figure 3 can be used to convert ArcMap point and line feature layers into CEDRA-AVwater node and pipe layers. As such, there are a few different ways a CEDRA-AVwater model can be established.

Fire Flow Analysis Overview

CEDRA-AVwater supports two different types of fire flow analysis. The first is to determine the maximum available pressure (the demand case), while the second determines the maximum available flow (the required pressure head case).

Fire Flow loads are stored as attributes in the node layer. The FIRFLO attribute is used to store the load when it is desired to compute the maximum available pressure, while the RPRESS field contains the load value when the maximum available flow is to be computed.

The **L** tool in the CEDRA-AVwater-Tools toolbar can be used to assign the fire flow load. Alternatively, native ArcMap functionality can be used as well.

Note that the fields FIRFLO and RPRESS are used in this discussion. It should be pointed out that the user is able to create other fields containing different values and have those fields used in the analysis. In so doing, the user is able to define various load scenarios by creating different fields for the various loading scenarios.

When a fire flow analysis is performed, it is referred to as a run. In a single fire flow run a maximum of 30 nodes can be assigned a fire flow load. This would simulate 30 fires occurring at the same time. There is no limit to the number of fire flow runs that can be executed.

The table called FireFlowData is used to store the number of fire flow runs and what nodes are loaded for each fire flow run. The FireFlowData table is created by the [Execute] command when the user specifies that a fire flow analysis is to be performed.

Figure 6
Report File Specification Dialog Box

Fire Flow Analysis Operation

To perform a fire flow analysis, the following should be performed.

➤ **1** **Scroll** down in the **{Modeling Commands}** menu combo box, and **select** the **[Execute]** menu command (see Figure 3) to display the report file specification dialog box shown in Figure 6.

➤ **2** **Select** the **Browse** button to display the typical Windows file navigation dialog box shown in Figure 7. **Navigate** to the appropriate location and either **pick or enter** the name of the report file to be created followed by **clicking** the **Save** button. If an existing file has been specified, confirmation will be asked as to if the existing file is to be overwritten. In this case, click the Yes or No button. Once the name of the report file has been established, the dialog box

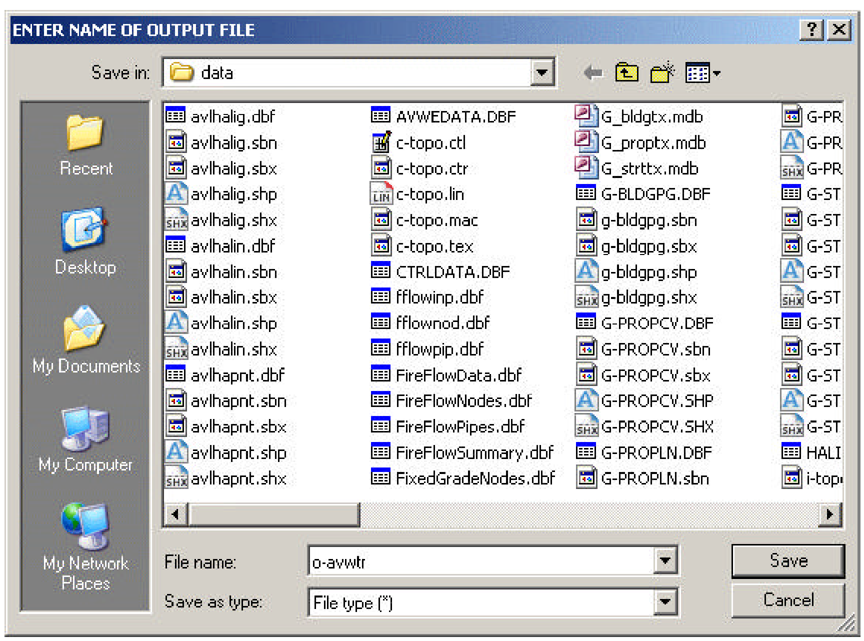

Figure 7 - File Navigation Dialog Box

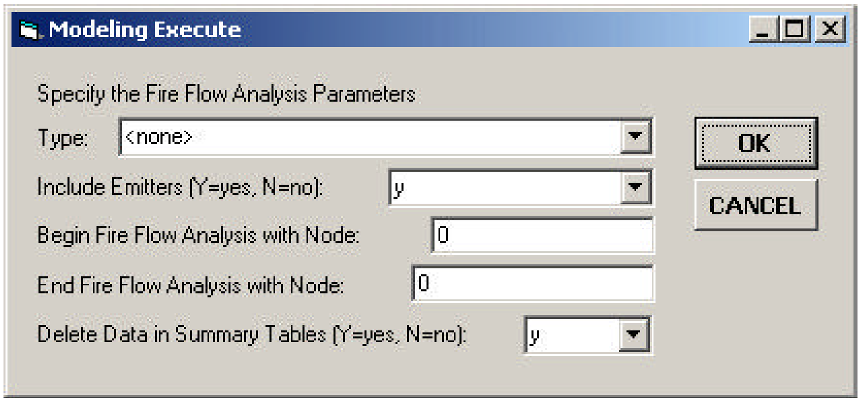

Figure 8 - Fire Flow Analysis Parameters

Figure 9
Fire Flow Analysis Types

Figure 10
Modify FireFlowData Table Query

shown in Figure 8 will be displayed.

➤ 3 **Scroll** down in the *Type:* data field, and **select** the desired type of fire flow analysis to be performed. Shown in Figure 9 are the available fire flow analysis types. If no fire flow analysis is to be performed, select the <none> option and proceed to Step 8.

➤ 4 **Scroll** down in the *Include Emitters:* data field, and **select** the option indicating if Emitters are to be included in the analysis.

➤ 5 **Enter** in the *Begin Fire Flow Analysis with Node:* data field, the node number of the starting fire flow run.

➤ 6 **Enter** in the *End Fire Flow Analysis with Node:* data field, the node number of the ending fire flow run.

➤ 7 **Scroll** down in the *Delete Data in Summary Tables:* data field, and **select** the option indicating if the existing data in the FireFlowNodes, FireFlowPipes and FireFlowSummary tables are to be deleted and replaced with new data.

➤ 8 **Click** at the **OK** button to continue,
or
click at the **Cancel** button to abort the command.

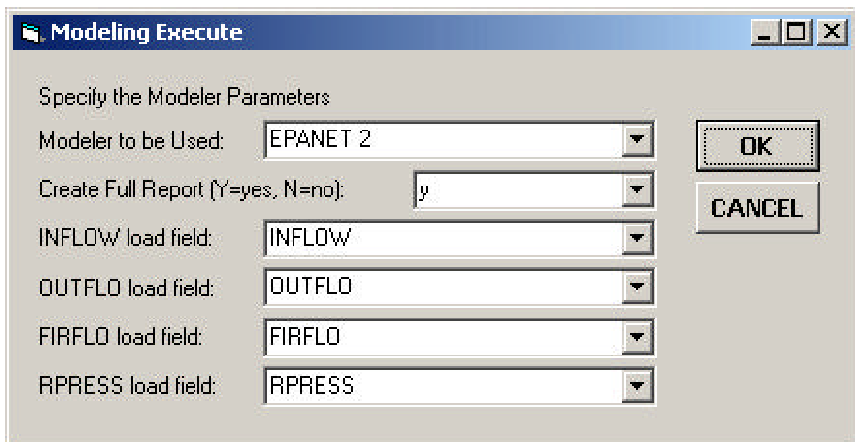

Figure 11 - General Analysis Parameters

➤ 9 If this is the first time a fire flow analysis has been performed or if no fire flow analysis is to be performed, skip to Step 10, otherwise, **click** at the **Yes** button shown in Figure 10 to replace the data stored in the FireFlowData table with new data,
or
click at the **No** button to use the data presently stored in the FireFlowData table.

➤ 10 **Scroll** down in the *Modeler to be Used:* data field shown in Figure 11, and **select** the desired modeler to be used in the analysis. The EPANET and EPANET 2 modelers are supported.

➤ 11 **Scroll** down in the *Create Full Report:* data field, and **select** the appropriate option indicating if a full report file is to be created or not.

➤ 12 **Scroll** down in the *INFLOW* data field, and **select** the name of the field that contains the inflow load values.

➤ 13 **Scroll** down in the *OUTFLO* data field, and **select** the name of the field that contains the outflow load values.

➤ 14 **Scroll** down in the *FIRFLO* data field, and **select** the name of the field that contains the fire flow demand values. This field is used when maximum available pressure is to be computed.

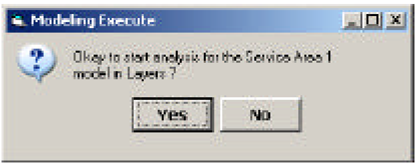

Figure 12
Begin Analysis Query

➤ **15** **Scroll** down in the *RPRESS* data field, and **select** the name of the field that contains the required pressure head values. This field is used when maximum available flow is to be computed.

➤ **16** **Click** at the **OK** button to continue,
or
click at the **Cancel** button to abort the command.

➤ **17** **Click** at the **Yes** button shown in Figure 12 to begin the analysis,
or
click at the **No** button to abort the command.

Having clicked at the *Yes* button, the command begins the process of executing the specified type of analysis. Depending upon the type of analysis to be performed, this can take a few seconds or several hours. Note, a fire flow analysis involving several thousand nodes can take several hours to complete.

Once the analysis has been completed, the query shown in Figure 13 will appear.

➤ **18** **Click** at the **Yes** button to view the report file using the Notepad program,
or
click at the **No** button to skip the viewing of the report file, thereby terminating the command.

As stated previously, the FireFlowData table contains the number of fire flow runs that are to be executed. Shown in Figure 14 is a sample FireFlowData table containing three records, which indicates that a maximum of three fire flow runs will be performed. The

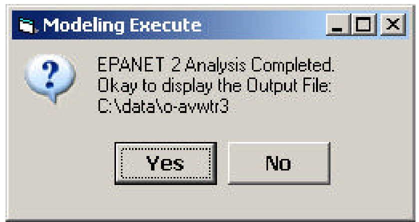

Figure 13
View Report File Query

FIRFLO_RUN field is used to contain the fire flow run number.

On each record a maximum of 30 node numbers may appear. The table shown in Figure 14 only contains node numbers under the NODE_1 field. This indicates that each fire flow run has only one node with a fire flow load assigned to it. If it is desired to process multiple nodes for a fire flow run, native ArcMap table editing functionality can be used to enter the appropriate node numbers. The first 0 node number in a fire flow run record terminates the definition of nodes with fire flow loads.

The results of a fire flow analysis are stored in the following tables:

FireFlowNodes
FireFlowPipes
FireFlowSummary

Shown in Figures 15, 16 and 17 are examples of the above mentioned tables.

The FireFlowNodes table contains the node's demand, grade line and pressure results under the DEMAND, GRADLN and PRESSR fields, respectively. The **_X** extension appears for each of the result fields. **X** denotes the fire flow run number.

The FireFlowPipes table contains the pipe's flow rate, velocity and head loss results under the FLOWRT, VELOCT and HL_1000 fields, respectively. The **_X** extension appears for each of the result fields. **X** denotes the fire flow run number.

The FireFlowSummary table contains for each fire flow run, the nodes with a fire flow run and the resultant node's demand, grade line and pressure for the run. In Figure 14, nodes 7, 62 and 69 appear under the NODE_1 field. These are nodes which have been assigned a fire flow load. In Figure 17, the same node numbers appear under the NODENO field. To the right of the node number value are the node's demand, grade line and pressure values for the fire flow run.

Notes

1. The [Import Points] command within the CEDRA-AVcad-Menus toolbar enables the user to import an existing EPANET model. Two files, which carry the .inp and .map extensions, are required in order to import an existing EPANET model.

2. When responding to the *Begin Fire Flow Analysis with Node:* and the *End Fire Flow Analysis with Node: parameters*, shown in Figure 8, the command scans the NODE_1 field in the FireFlowData table, see Figure 14, to determine the location in the table for extracting data.

3. When the FireFlowData table, see Figure 14, is built by the command, the command scans the node layer for nonzero values for the fields specified for the FIRFLO and RPRESS parameters, see Figure 11. Those nodes which have a nonzero value for either the FIRFLO or RPRESS fields will have a record added to the table with the node's node number value appearing in the NODE_1 field.

4. The EPANET option in the *Modeler to be Used:* data field refers to Version 1.1c of the U.S.A.E.P.A EPANET program. The EPANET 2 option refers to Version 2.00.12.

5. For a non-fire flow analysis a node's demand is computed using the following equations:

DEMAND = 0.0
DEMAND = DEMAND - INFLOW
DEMAND = DEMAND + OUTFLO

Attributes of FireFlowData

OID	FIRFLO_RUN	NODE_1	NODE_2	NODE_3	NODE_4	NODE_5	NODE_6	NODE_7	NODE_8	NODE_9	NODE_10
0	1	7	0	0	0	0	0	0	0	0	0
1	2	62	0	0	0	0	0	0	0	0	0
2	3	69	0	0	0	0	0	0	0	0	0

Record: 1 Show: All Selected Records (0 out of 3 Selected.) Options

Figure 14 - FireFlowData Table containing all Nodes with a Fire Flow Load for each Fire Flow Run

Attributes of FireFlowNodes

OID	NODENO	DEMAND_1	DEMAND_2	DEMAND_3	GRADLN_1	GRADLN_2	GRADLN_3	PRESSR_1	PRESSR_2	PRESSR_3
0	1	-1770.88	-2097.16	-1764.13	812.7	812.7	812.7	0	0	0
1	2	0	0	0	0	0	0	0	0	0
2	3	0	0	0	0	0	0	0	0	0
3	4	0	0	0	751.84	738.84	764.69	63.19	57.56	68.76
4	5	0	0	0	729.95	712.29	747.43	55.87	48.22	63.44
5	6	0	0	0	0	0	0	0	0	0

Record: 1 Show: All Selected Records (0 out of 107 Selected.) Options

Figure 15 - FireFlowNodes Table containing results for all Nodes analyzed in a Fire Flow Run

Attributes of FireFlowPipes

OID	PIPNUM	FLOWRT_1	FLOWRT_2	FLOWRT_3	VELOCT_1	VELOCT_2	VELOCT_3	HL1000_1	HL1000_2	HL1000_3
0	1	1048.24	1154.75	930.96	6.69	7.37	5.94	162.24	196.88	127.98
1	2	1048.24	1154.75	930.96	6.69	7.37	5.94	167.08	202.75	131.79
2	3	526.06	729.25	587.81	3.35	4.65	3.75	41.72	80.15	52.08
3	4	526.06	729.25	587.81	3.35	4.65	3.75	60.96	117.14	76.11
4	5	270.21	19.12	16.21	1.72	0.12	0.1	11.45	0.05	0.04
5	6	269.29	18.2	15.29	1.71	0.11	0.09	10.81	0.05	0.03

Record: 0 Show: All Selected Records (0 out of 64 Selected.) Options

Figure 16 - FireFlowPipes Table containing results for all Pipes analyzed in a Fire Flow Run

Attributes of FireFlowSummary

OID	FIRFLO_RUN	NODENO	DEMAND	GRADLN	PRESSR
0	1	7	750	717.05	44.65
1	2	62	2000	587.21	0.52
2	3	69	1000	675.73	39.75

Record: 0 Show: All Selected Records (0 out of 3 Selected.) Options

Figure 17 - FireFlowSummary Table containing results for each Node with a Fire Flow Load for each Fire Flow Run

As can be seen, the command uses both the INFLOW and OUTFLO values in computing a demand value. This approach offers the user greater functionality in assigning a demand value.

6. For a fire flow analysis where it is desired to calculate the maximum available pressure (the demand case), a node's demand is computed using the following equation:

   DEMAND = FIRFLO

   In this case the demand value is equal to the fire flow value.

7. For a fire flow analysis where it is desired to calculate the maximum available flow (the required pressure head case), a node's demand is computed using the following equation:

   DEMAND = 0.0
   DEMAND = DEMAND - INFLOW
   DEMAND = DEMAND + OUTFLO

   Additionally, the node's ground elevation value is computed using the following equations:

   ELEV = GRELVZ + RPRESS
   ELEV = ELEV - DROP

   Where RPRESS represents the required pressure head which is 2.3 times the pressure, which is expressed in PSI. GRELVZ and DROP are node attributes representing the ground elevation and drop values associated with the node.

   In this case the demand value is computed using the same equations as a non-fire flow analysis while the ground elevation is computed using the above equations. In a non-fire flow analysis, the ground elevation does not use the RPRESS value.

Summary

The ability to perform water distribution modeling within ArcGIS offers the engineer a powerful querying and mapping environment. In so doing additional data layers such as parcels, street centerlines can be superimposed upon the model. Furthermore, non-graphic information or tabular data, such as metering information, can be added and utilized in computing node demands.

As always, users who have a need for functionality that is not presently available in CEDRA software should feel free to forward these requests to CEDRA, as well as, any other comments or suggestions you may have.

If you have a request for Command Of The Month, feel free to phone, fax or e-mail your request to The CEDRA Corporation.