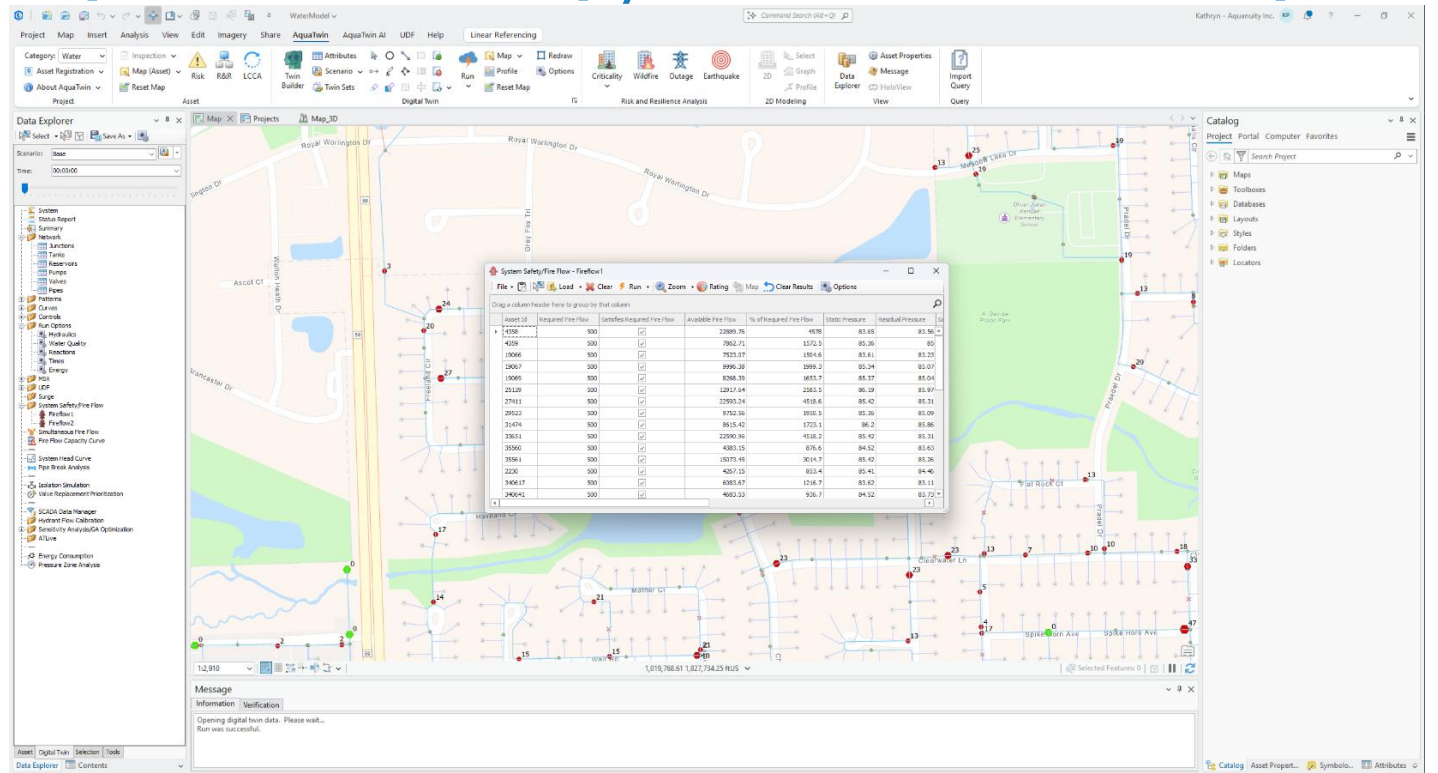


System Safety/Fire Flow Analysis

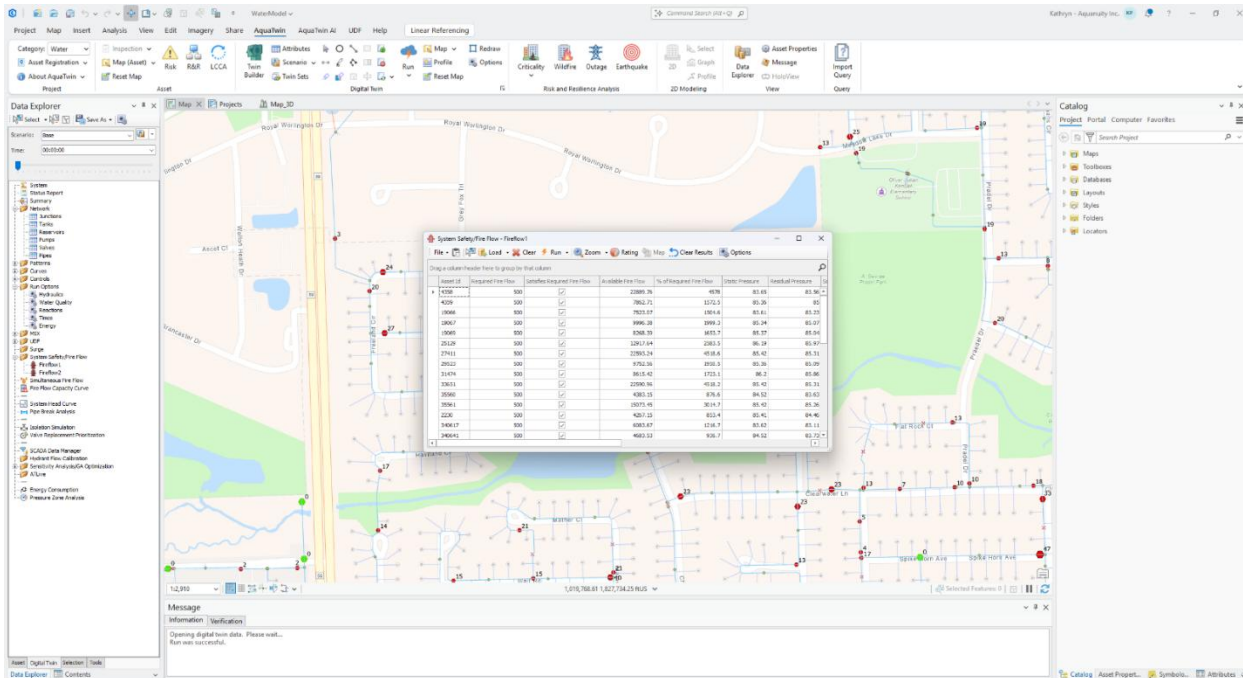


Digital Twin Safety Systems/Fire Flow Dialogue Box

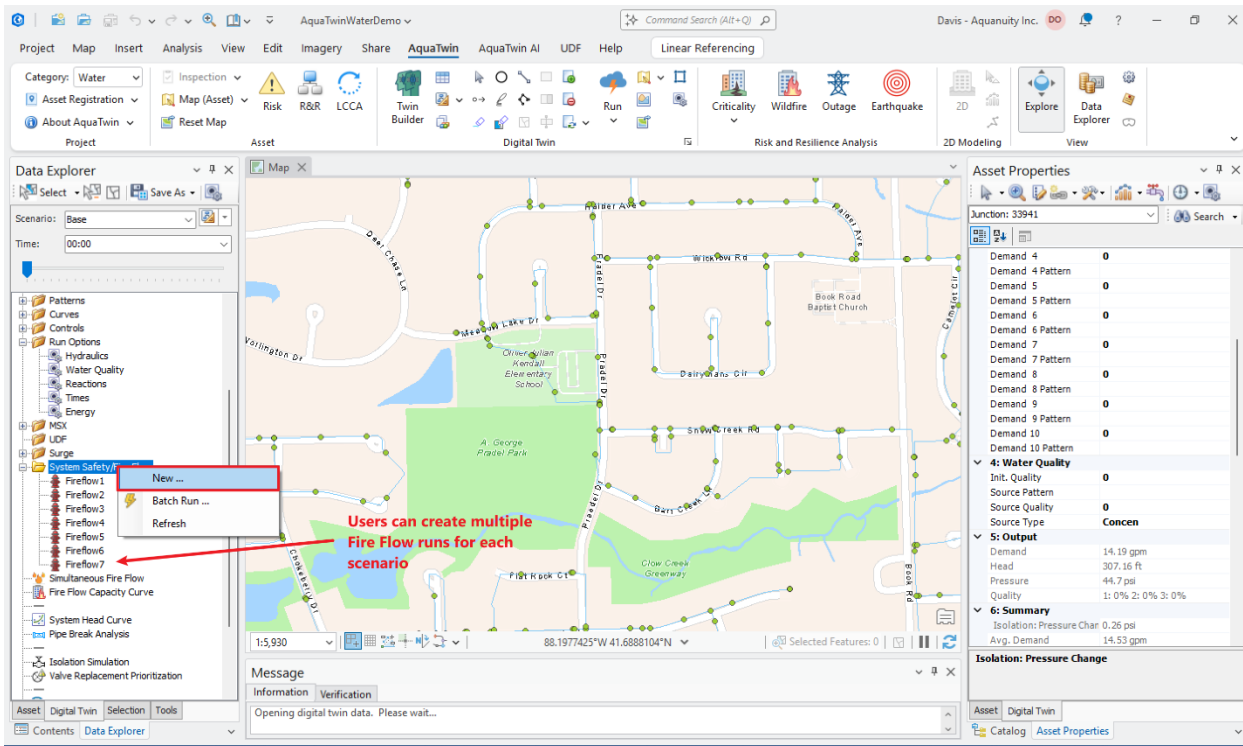
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Overview



To analyze available fire flows throughout the water system, there is a System Safety/Fire Flow Analysis wizard in the Digital Twin Tab of the Data Explorer. This tool can be used on Model Junctions or an external ArcGIS Hydrants Layer. A Steady State run can be performed to find the *Available and Maximum Fire Flow* at each node, or an Extended Fire Flow Analysis can be specified. To create a new Fire Flow Analysis Run, users can right click on the System Safety/Fire Flow folder and select “New”.

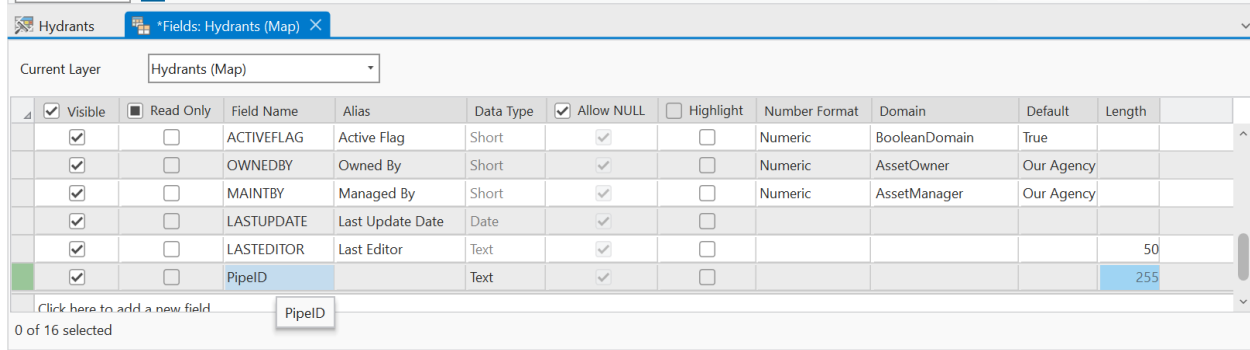


Available and Maximum Fire Flow Analysis

Prerequisites

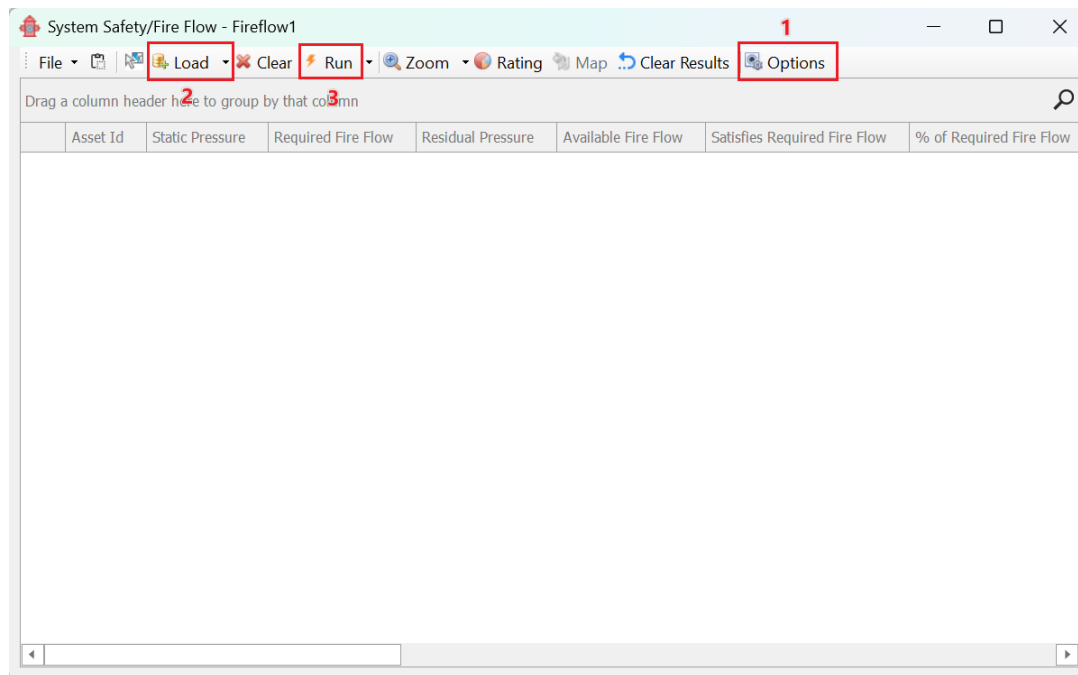
To analyze Available and/or Maximum fire flows, a model must have:

1. A stable hydraulic run on the Active Scenario
2. A Hydrants Feature layer (if utilizing) with a blank/ <null> PipeID Field for associating with the model pipes.



3. Optional: A Table or Feature Layer containing required fire flows by model Junction ID to IMPORT or a polygon layer with Land Usage to ALLOCATE to the required fire flow to junctions/hydrants.
4. Optional: A [Saved Selection](#) with Pipes and Junctions of interest.

Steps for Available and/or Maximum Fire Flow Analysis:



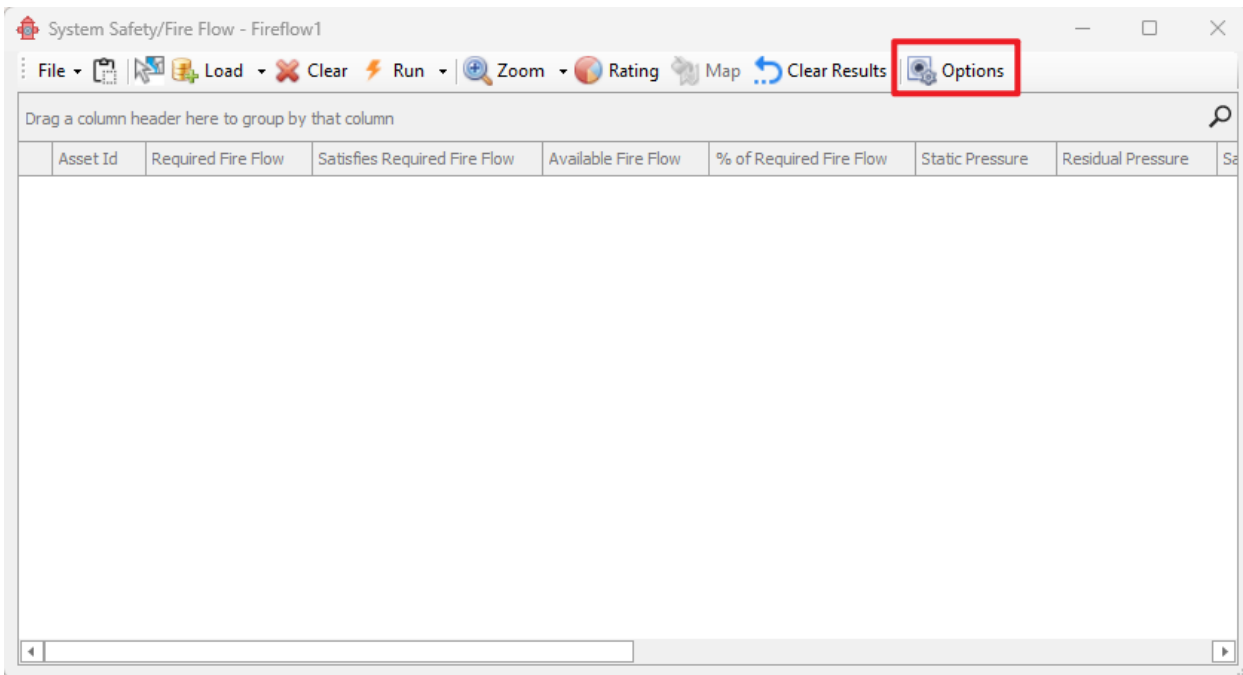
First, the user must specify the settings/parameters in the Options dialogue box.

1. The user will Load the appropriate nodes to be analyzed and Allocate the Required Fire Flow for each node. This can be done with an active ArcGIS selection or AquaTwin Saved Selection. If no selection or Saved Selection is specified, the analysis will be run on every model Junction.

1. User will specify the required fire flows manually, or automatically by clicking the arrow next to Load and Importing from a table or feature layer OR Allocate required fire flows from a land use polygon feature layer.
 2. Any changes to the Advanced Options in Step 1 may require re-allocation in Step 2.
2. The Fire Flow analysis can now be Run.

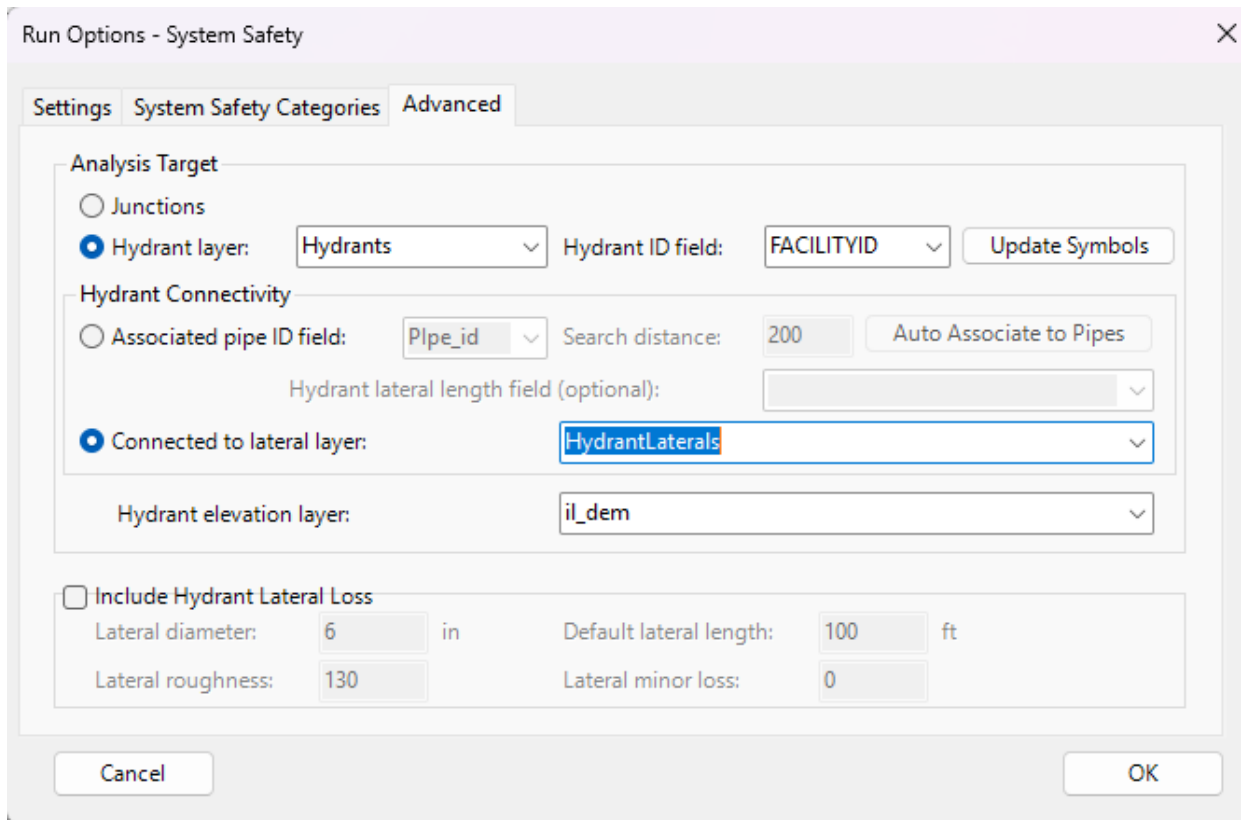
Step 1: Options and Setup

Upon setting up a new System Safety/Fire Flow Scenario from the Digital Twin Tab in the Data Explorer, a blank table appears.



Advanced Options:

Clicking Options and navigating to the Advanced tab shows the following dialogue box:



The image shows a software dialog box titled "Run Options - System Safety" with a close button (X) in the top right corner. It has three tabs: "Settings", "System Safety Categories", and "Advanced", with "Advanced" being the active tab. The dialog is divided into several sections. The "Analysis Target" section has two radio buttons: "Junctions" (unselected) and "Hydrant layer:" (selected). Next to "Hydrant layer:" is a dropdown menu showing "Hydrants". To the right is "Hydrant ID field:" with a dropdown showing "FACILITYID" and an "Update Symbols" button. The "Hydrant Connectivity" section has two radio buttons: "Associated pipe ID field:" (unselected) and "Connected to lateral layer:" (selected). Next to "Associated pipe ID field:" is a dropdown showing "Pipe_id", followed by "Search distance:" with a text box containing "200" and an "Auto Associate to Pipes" button. Below this is "Hydrant lateral length field (optional):" with a dropdown menu. Next to "Connected to lateral layer:" is a dropdown menu showing "HydrantLaterals". Below the connectivity section is "Hydrant elevation layer:" with a dropdown showing "il_dem". At the bottom, there is a checkbox labeled "Include Hydrant Lateral Loss". Below this checkbox are four input fields: "Lateral diameter:" with a text box containing "6" and the unit "in", "Default lateral length:" with a text box containing "100" and the unit "ft", "Lateral roughness:" with a text box containing "130", and "Lateral minor loss:" with a text box containing "0". At the very bottom are "Cancel" and "OK" buttons.

Analysis Target:

User can specify that Junctions are the target layer for the analysis, or specify an external Hydrant Layer and Hydrant ID field. Clicking "Update Symbols" will add symbology to the Hydrant layer to indicate it is being used in AquaTwin.

Hydrant Connectivity:

Associated Pipe ID Field: Hydrant ID field and Pipe ID field will need to be selected before specifying a Search distance. (Pipe ID Field can be <null> values and should be added as a field prior to running the fire flow tool). Clicking "Auto Associate to Pipes" will run a background spatial join process to assign each hydrant to the closest pipe. Users may also specify a Hydrant Lateral Length field (if applicable).

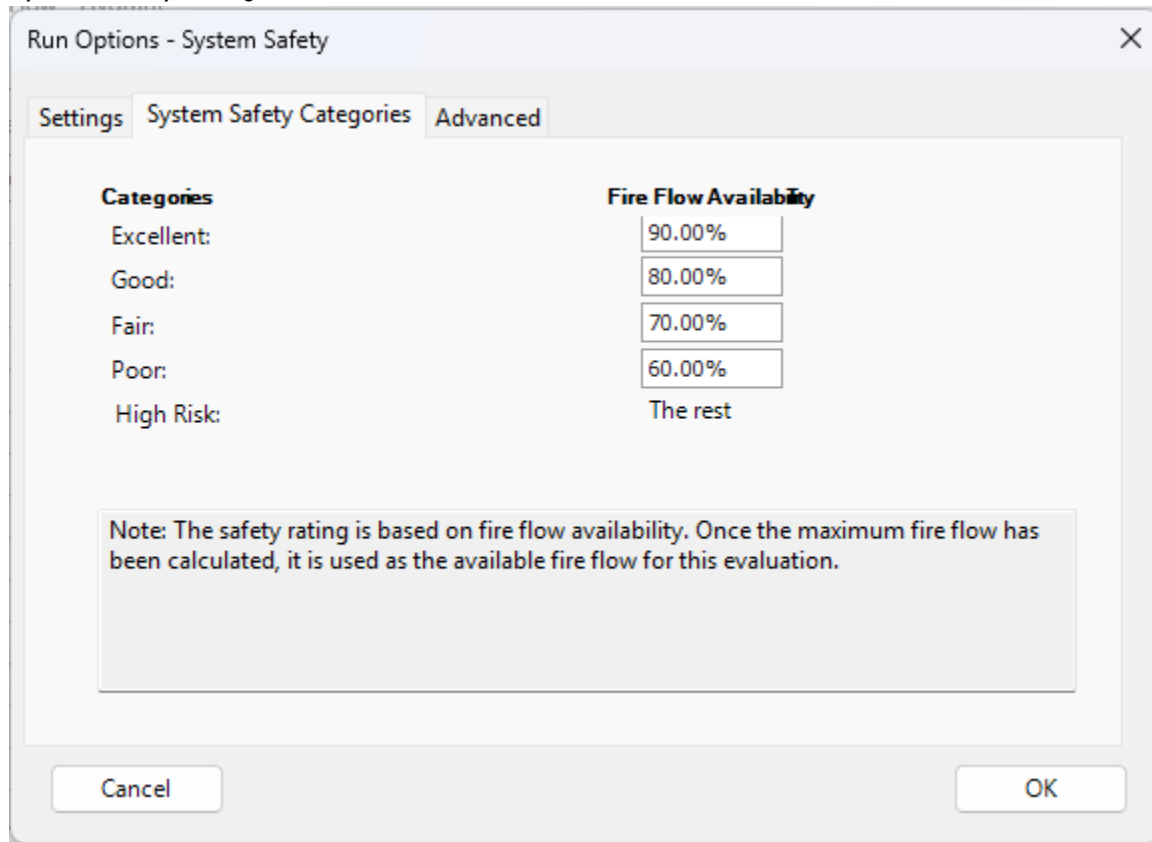
Connected to lateral Layer: User can specify an external Hydrant Lateral Layer which will establish connectivity (via background spatial join) between the Hydrant and the model Pipe layer during analysis.

Hydrant Elevation Layer: An elevation layer can be selected to provide better accuracy for hydrant pressures.

Include Hydrant Lateral Losses:

Hydrant Lateral Losses can be added to either a Junction run or a Hydrant layer run. Note that the defined default lateral length only applies if you are not using an external Hydrant layer or lateral layer. If you are using an external Hydrant layer and/or lateral layer, the lateral length will be automatically calculated if the lateral length is empty (not defined). Users may also specify a Hydrant Lateral Length field (if applicable).

System Safety Categories:



The image shows a software dialog box titled "Run Options - System Safety". It has three tabs: "Settings", "System Safety Categories" (which is selected), and "Advanced". The "System Safety Categories" tab contains a table with two columns: "Categories" and "Fire Flow Availability". The table lists five categories: "Excellent:", "Good:", "Fair:", "Poor:", and "High Risk:", each with a corresponding percentage or description in the "Fire Flow Availability" column. Below the table is a note explaining that the safety rating is based on fire flow availability. At the bottom of the dialog are "Cancel" and "OK" buttons.

Categories	Fire Flow Availability
Excellent:	90.00%
Good:	80.00%
Fair:	70.00%
Poor:	60.00%
High Risk:	The rest

Note: The safety rating is based on fire flow availability. Once the maximum fire flow has been calculated, it is used as the available fire flow for this evaluation.

In the same Run Options dialogue box under the System Safety Categories tab, percentage of required fire flow can be categorized from Excellent to High Risk according to user input.

Note: if the maximum fire flow option is selected then the system safety categories will represent the maximum fire flows and not the available fire flows.

Settings:

Run Options - System Safety

Settings System Safety Categories Advanced

Default fire flow demand: 500 gpm EPS Time: 00:00:00

☐ Extended fire flow duration: 1 hour(s) ☐ Report min. residual pressure

Options

☒ Compute residual pressure

☒ Compute available fire flow @ minimum pressure: 20 psi

☒ Compute maximum fire flow

☒ Minimum pressure: 20 psi Limiting velocity: 7 ft/s

☐ Maximum velocity: 7 ft/s Limiting pressure: 20 psi

☒ Dual constraints

☒ Apply to junctions/pipes within Saved Selection: FF

Cancel OK

Calculate residual pressure: If checked, model will calculate the residual pressure of each node/hydrant in the analysis at the Required Fire Flow Demand.

Compute available fire flow: If checked, model will compute the fire flow available @ minimum pressure specified.

Compute maximum fire flow: If checked, model will compute the maximum fire flow available when confining the entire fire flow area (either a Saved Selection "Apply to junctions/pipes within Saved Selection" or the entire model) to either a minimum node pressure, or a maximum pipe velocity specified by the user or both, using Dual constraints.

- Minimum Pressure:** If a minimum pressure is specified, users can set a Limiting velocity for pipes and results will indicate when pipes exceed this velocity.
 - Note: The Limiting velocity is for reporting only. The maximum fire flow calculated for the target minimum pressure may not meet the limiting velocity specified for the selected set of pipes.
 - To meet the Limiting Velocity and the Minimum Pressure, rerun the Maximum Fire Flow using *Dual Constraints*
- Maximum Velocity:** If a Maximum velocity is specified, users can set a Limiting pressure for nodes and results will indicate when nodes exceed this pressure.
 - Note: The Limiting pressure is for reporting only. The maximum fire flow calculated for the target maximum velocity may not meet the limiting pressure specified for the selected set of nodes.
 - To meet the Limiting Pressure and the Maximum Velocity, rerun the Maximum Fire Flow using *Dual Constraints*
- Dual Constraints:** If checked, the Fire Flow analysis will return a Maximum FF which meets BOTH the Minimum Pressure and the Maximum Velocity as specified by the user.

Saved Selection: Maximum fire flow settings can be applied to a relevant Saved Selection (such as a pressure zone).

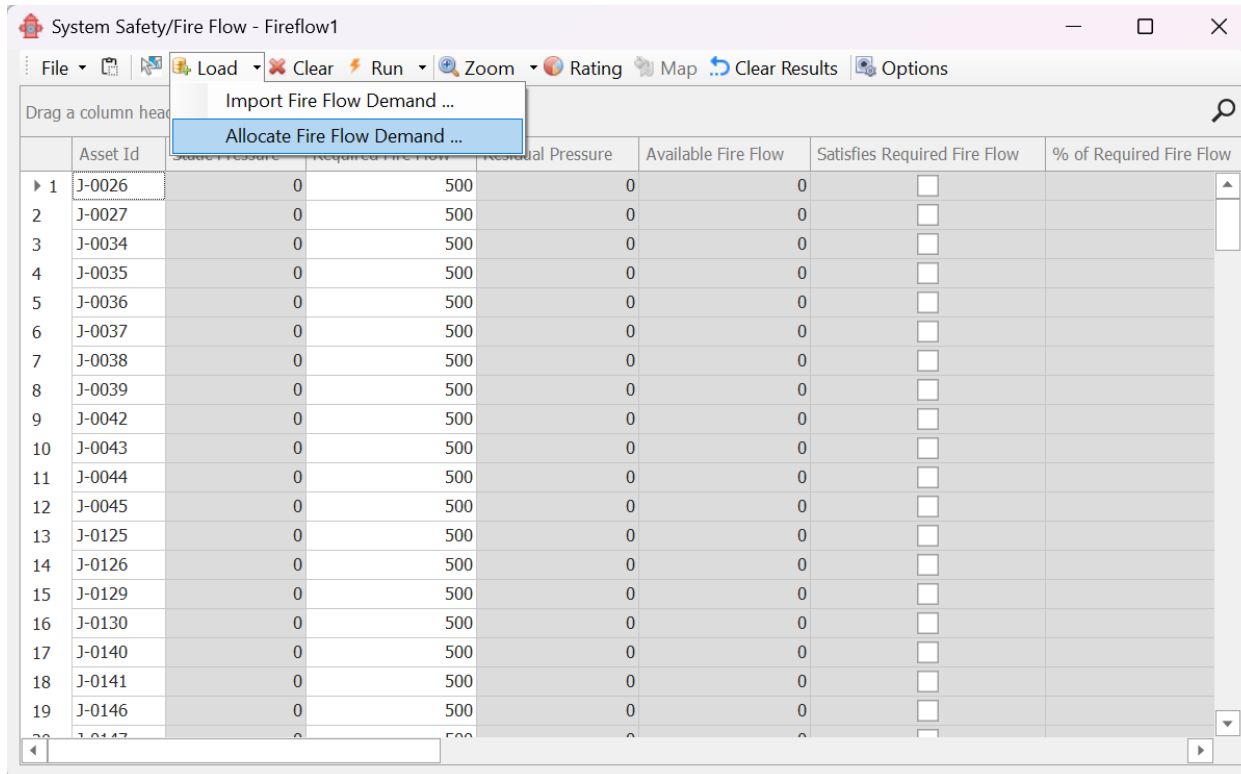
Step 2: Load Nodes and Allocate/Import Fire Flow Demands

Loading Nodes/Hydrants

To load the appropriate Junctions or Hydrants to be included in the Fire Flow Analysis, click on the Select button () in the System Safety/Fire Flow dialogue box. From there, draw a box around the Nodes you'd like to add, double click a Saved Selection or Query (only is using Junctions), or perform an ArcGIS "Select By Attributes", "Select by Location", or any other ArcGIS selection tool. Users may also pre-select appropriate Junctions or Hydrants before opening the System

Safety/Fire Flow tool. After selecting the appropriate Nodes, click the Load button ( Load) to load them into the tool.

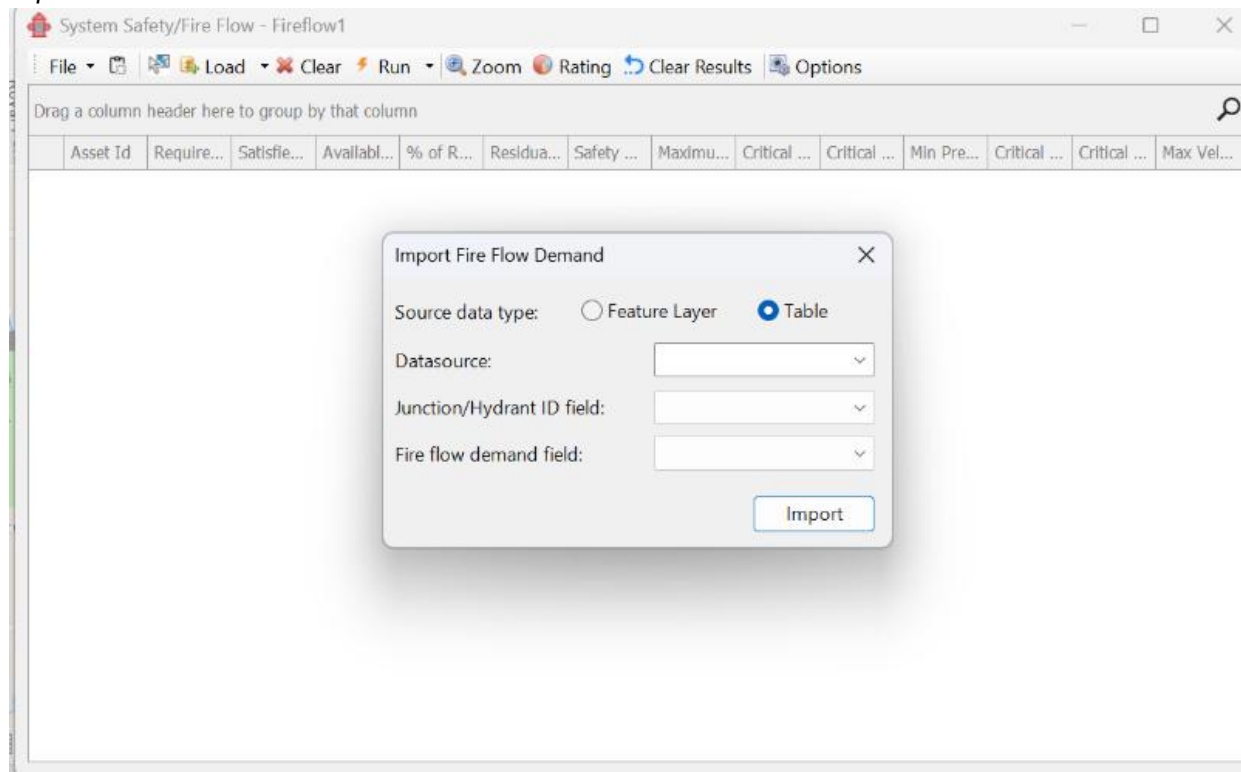
Allocate or Load Fire Flow Demands



	Asset Id	Static Pressure	Required Fire Flow	Residual Pressure	Available Fire Flow	Satisfies Required Fire Flow	% of Required Fire Flow
1	J-0026	0	500	0	0	☐	
2	J-0027	0	500	0	0	☐	
3	J-0034	0	500	0	0	☐	
4	J-0035	0	500	0	0	☐	
5	J-0036	0	500	0	0	☐	
6	J-0037	0	500	0	0	☐	
7	J-0038	0	500	0	0	☐	
8	J-0039	0	500	0	0	☐	
9	J-0042	0	500	0	0	☐	
10	J-0043	0	500	0	0	☐	
11	J-0044	0	500	0	0	☐	
12	J-0045	0	500	0	0	☐	
13	J-0125	0	500	0	0	☐	
14	J-0126	0	500	0	0	☐	
15	J-0129	0	500	0	0	☐	
16	J-0130	0	500	0	0	☐	
17	J-0140	0	500	0	0	☐	
18	J-0141	0	500	0	0	☐	
19	J-0146	0	500	0	0	☐	
20	J-0147	0	500	0	0	☐	

Required Fire Flow Demands can be manually allocated per Junction/Hydrant by typing into the table. Specifying a Default Fire Flow Demand in the Options --> Settings will set every Node to that Required Fire Flow Demand whenever Nodes are Loaded. Required Fire Flow Demand can also be automatically *Imported* or *Allocated* with an external GIS Table or Polygon Layer.

Import Fire Flow Demand



Either a Feature Layer or a Table loaded into ArcGIS Pro containing a Hydrant or Junction ID field and corresponding Fire Flow Demand for that Hydrant or Junction. In the case of Hydrants, this can be a date field within the Hydrants Point Layer.

Allocate Fire Flow Demand

Using a Polygon Feature Layer with Land Use information, the user can specify required Fire Flow Demands based on land usage for each polygon (usually a Parcel layer).

Allocate Fire Flow Demand

Land use info. datasource: Parcel

Land use code field: LANDUSEDESC

Search distance: 200

Load

Clear

Delete

Allocate

Drag a column header here to group by that column

	Category Name	Demand	Comment
▶	Single Family	1000	
	Eating/Drinking Establishments	2000	
	Park	1000	
	Multi-Family	1500	
	Warehouse/Distribution	1800	
	Commercial Trade	2500	
	Manufacturing	2500	

Land use info Datasource: Feature Layer with Land usage for model

Land use code field: Field where land use classification is stored.

Search Distance: Search radius (in map units) for allocating demands of junctions/hydrants

Load: Loads all categories within the specified “Land use code field”

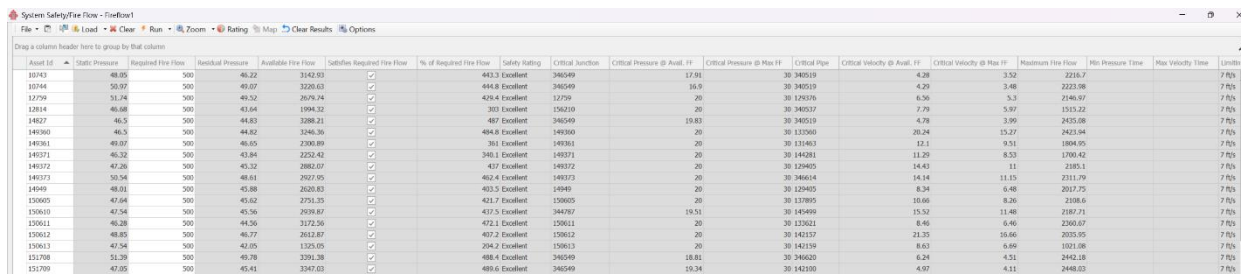
Clear: Clears all categories and demands

Delete: Deletes selected Category Name

Allocate: Allocates the written Fire Flow Demands to the Token Analysis nodes specified in Advanced Options.

Step 3: Run/View Results

Once run Options are set and required demands are Loaded, the Fire Flow Analysis is ready to Run. Results are available to be viewed in a table, as below. User may Zoom to the selected junction/hydrant by clicking Zoom.



Asset ID	Static Pressure	Required Fire Flow	Residual Pressure	Available Fire Flow	Satisfies Required Fire Flow	% of Required Fire Flow	Safety Rating	Critical Junction	Critical Pressure @ Avail. FF	Critical Pressure @ Max FF	Critical Pipe	Critical Velocity @ Avail. FF	Critical Velocity @ Max FF	Maximum Fire Flow	Min Pressure Time	Max Velocity Time	Limiting Value
10143	48.05	500	46.22	3142.03	✓	443.3	Excellent	346049	17.91	30	346019	4.28	3.52	2216.7			7.7%
10144	50.97	500	49.07	3226.03	✓	444.8	Excellent	346049	16.5	30	346019	4.29	3.48	2222.98			7.7%
12759	51.34	500	49.52	2679.24	✓	429.4	Excellent	12759	20	30	129216	6.56	5.3	2146.97			7.7%
12814	46.68	500	43.64	1994.32	✓	303	Excellent	156210	20	30	346037	7.79	5.87	1515.22			7.7%
14827	46.5	500	44.83	3288.21	✓	487	Excellent	346049	19.83	30	346019	4.78	3.89	2435.08			7.7%
14890	46.5	500	44.82	3246.36	✓	486.8	Excellent	149380	20	30	133960	20.24	15.27	2423.94			7.7%
149361	49.07	500	46.05	2306.89	✓	361	Excellent	149361	20	30	131463	12.1	9.51	1884.95			7.7%
149371	46.32	500	43.84	2252.42	✓	346.1	Excellent	149371	20	30	144281	11.29	8.53	1760.42			7.7%
149372	47.26	500	45.32	2882.07	✓	437	Excellent	149372	20	30	129405	14.43	11	2195.1			7.7%
149373	50.54	500	48.61	2927.05	✓	461.4	Excellent	149373	20	30	346014	14.14	11.35	2311.79			7.7%
14949	48.01	500	45.88	2620.83	✓	403.5	Excellent	14949	20	30	129405	8.34	6.48	2017.75			7.7%
150605	47.64	500	45.62	2751.35	✓	421.7	Excellent	150605	20	30	137895	10.66	8.26	2188.6			7.7%
150610	47.54	500	45.56	2679.87	✓	417.5	Excellent	104497	19.51	30	149499	15.52	11.48	2187.71			7.7%
150611	46.28	500	44.56	3172.56	✓	472.1	Excellent	150611	20	30	135621	6.46	6.46	2260.67			7.7%
150612	48.85	500	46.77	2612.87	✓	407.2	Excellent	150612	20	30	142157	21.35	16.66	2035.95			7.7%
150613	47.54	500	42.05	1325.05	✓	294.2	Excellent	150613	20	30	142159	6.63	6.69	1021.08			7.7%
151708	51.39	500	49.78	3291.38	✓	486.4	Excellent	346049	18.81	30	346020	6.24	4.52	2442.18			7.7%
151709	47.05	500	45.41	3347.03	✓	489.6	Excellent	346049	19.34	30	142180	6.07	4.11	2448.83			7.7%

Available and Maximum Fire Flow Analyses Outputs

Asset ID: ID of Junction or Hydrant

Static Pressure: The pressure calculated for the system demand at the fire flow simulation timestep

Residual Pressure: The pressure calculated for the Required Fire Flow at the Junction or Hydrant

Required Fire Flow: Required Fire Flow demand as imported or allocated.

Available Fire Flow: Fire Flow available at the specified minimum pressure at the specified junction

Satisfies Required Fire Flow: Indicates whether the Available FF meets the Required FF

% of Required Fire Flow: The % of the Required FF met by the Available FF. (If Max FF Option is checked, this will be based on Max FF.)

Safety Rating: Classification of % of Required FF based on user input rating

Critical Junction: The Junction with the lowest pressure at *Available Fire Flow* among the monitoring Junctions

Critical Pressure @ Avail. FF: The Critical Junction pressure for the *Available Fire Flow*

Critical Pressure @ Max. FF: The Critical Junction pressure for the *Maximum Fire Flow* (only populates if Max FF option is checked)

Critical Pipe: The Pipe with the highest velocity at *Available Fire Flow* among the monitoring Pipes

Critical Velocity @ Avail. FF: The Critical Pipe velocity for the *Available Fire Flow*

Critical Velocity @ Max. FF: The Critical Pipe velocity for the *Maximum Fire Flow* (only populates if Max FF option is checked)

Maximum Fire Flow: Maximum FF while satisfying either a minimum pressure or a max pipe velocity

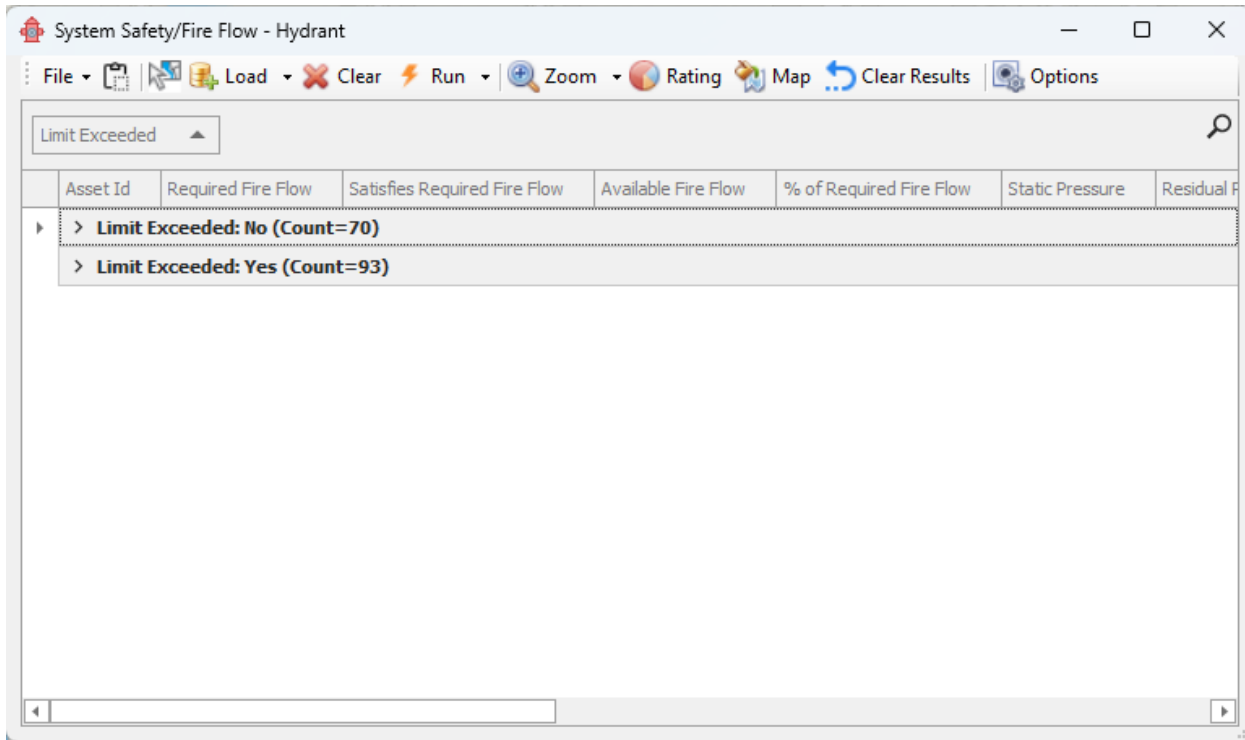
Min Pressure Time: Time when the critical junction has reached the minimum pressure (only available for the Extended FF)

Max Velocity Time: Time when the critical pipe has reached maximum velocity (only available for the Extended FF)

Limiting Value: Either displays the Limiting Velocity in ft/s (m/s in Metric Units) or the Limiting Pressure in PSI (m in Metric Units)

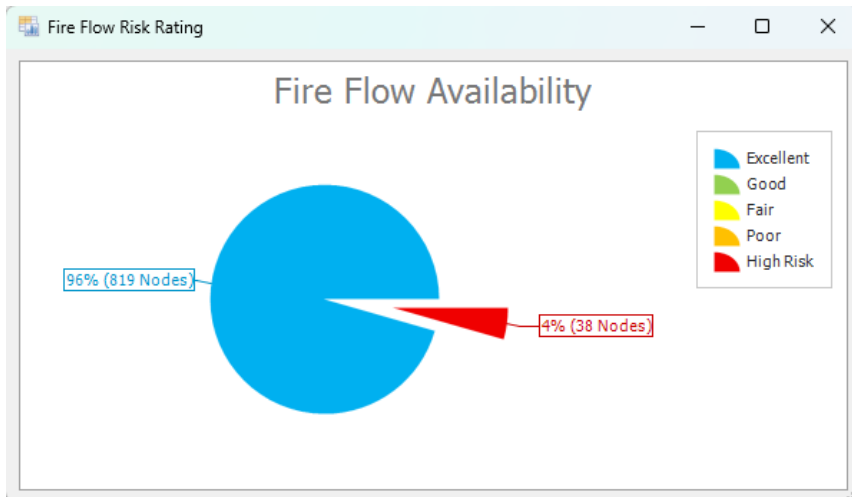
Limit Exceeded: Will indicate 'Yes' if Limiting velocity or Limiting Pressure is exceeded for the run, otherwise indicates 'no'

As with all AquaTwin tables, the user can create pivot tables by dragging a column name to the top of the table:

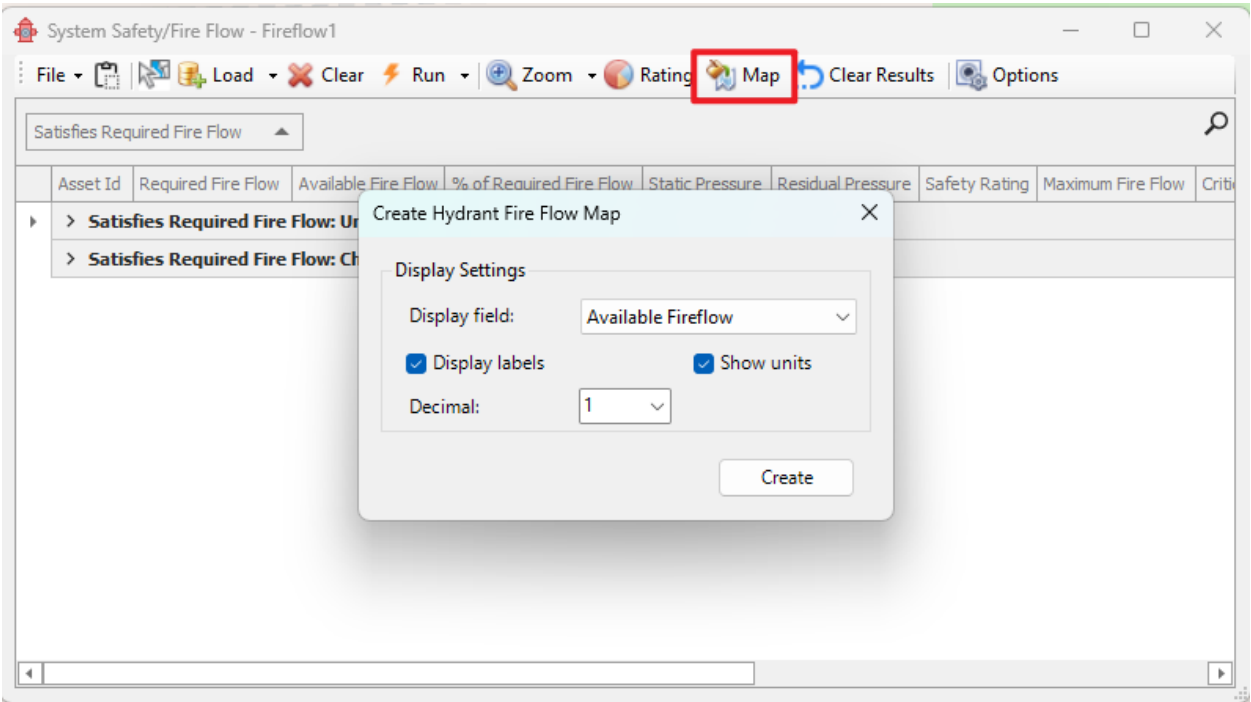


Asset Id	Required Fire Flow	Satisfies Required Fire Flow	Available Fire Flow	% of Required Fire Flow	Static Pressure	Residual P
> Limit Exceeded: No (Count=70)						
> Limit Exceeded: Yes (Count=93)						

The user can produce a Fire Flow Risk Rating pie chart by clicking Rating:



If an external Hydrant layer was used for the fire flow analysis, a map display can be created by clicking Map:



Extended Fire Flow Analysis

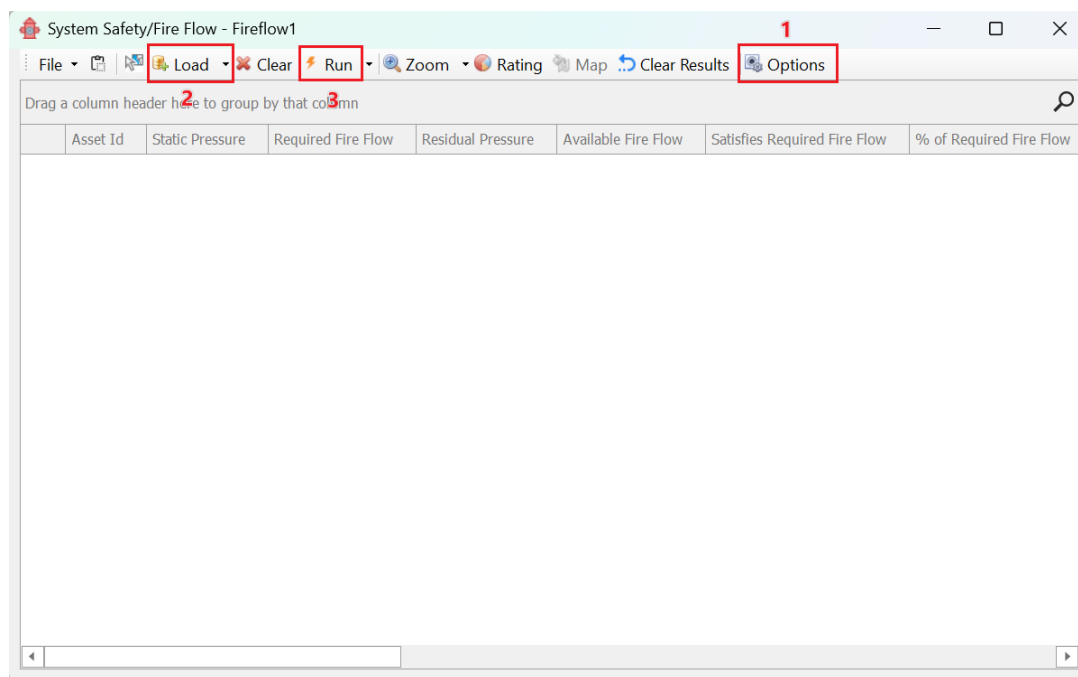
Prerequisites

To analyze Extended Fire Flow Duration, a model must have:

1. A stable EPS run on the Active Scenario
2. A Hydrants Feature layer (if utilizing) with a blank/ <null> PipeID Field for associating with the model pipes.

☒	☐	Field Name	Alias	Data Type	☒	☐	Number Format	Domain	Default	Length
☒	☐	ACTIVEFLAG	Active Flag	Short	☒	☐	Numeric	BooleanDomain	True	
☒	☐	OWNEDBY	Owned By	Short	☒	☐	Numeric	AssetOwner	Our Agency	
☒	☐	MAINTBY	Managed By	Short	☒	☐	Numeric	AssetManager	Our Agency	
☒	☐	LASTUPDATE	Last Update Date	Date	☒	☐				
☒	☐	LASTEDITOR	Last Editor	Text	☒	☐				50
☒	☐	PipeID		Text	☒	☐				255

Steps for Extended Fire Flow Analysis:



1. First, the user must specify the settings/parameters in the Options dialogue box.
2. The user will Load the appropriate nodes to be analyzed and Allocate the Required Fire Flow for each node. This can be done with an active ArcGIS selection or AquaTwin Saved Selection. If no selection or Saved Selection is specified, the analysis will be run on every model Junction.
 1. User will specify the required fire flows manually, or automatically by clicking the arrow next to Load and Importing from a table or feature layer OR Allocate required fire flows from a land use polygon feature layer.
 2. Any changes to the Advanced Options in Step 1 may require re-allocation in Step 2.

3. The Fire Flow analysis can now be Run.

Step 1: Extended Fire Flow Options/Settings

Advanced Options:

Like Available and Maximum Fire Flow analyses above, the Extended Fire Flow analysis can be run on a selection of model Junctions or a selection of Hydrants in an external GIS Layer. See

Advanced Options: above for setup using a Hydrants Layer.

Settings:

To Run an Extended Fire Flow, user must check "Extended fire flow duration" in the Settings, as shown below:

Run Options - System Safety

Settings System Safety Categories Advanced

Default fire flow demand: 500 gpm EPS Time: 00:00:00

☒ Extended fire flow duration: 2 hour(s) ☒ Report min. residual pressure

Options

☒ Compute residual pressure

☒ Compute available fire flow @ minimum pressure: 20 psi

☐ Compute maximum fire flow

☒ Minimum pressure: 20 psi Limiting velocity: 7 ft/s

☐ Maximum velocity: 7 ft/s Limiting pressure: 20 psi

☐ Dual constraints

☒ Apply to junctions/pipes within Saved Selection:

FF

Cancel OK

Default fire flow demand: The default Required Fire Flow Demand for all Junctions if not otherwise specified

EPS Time: The time of day for the run can be specified, such as the time of the peak hour.

Extended Fire Flow duration: Checking this box will perform an Extended Period Simulation (EPS) Fire Flow analysis that maintains the fire flow demand for the extended fire flow duration specified. For example, users may want to keep the fire flow demand for say 2 hours extended fire flow duration. The report will display the residual pressure at the end of the extended fire flow duration.

Report min. residual pressure: If checked, the report will display the Critical Junction and its corresponding minimum pressure, as well as the Critical Pipe and its corresponding maximum velocity in the system during the EPS run. The report will also show the time the minimum pressure and the maximum velocity occurred.

Step 2: Load Nodes and Allocate/Import Fire Flow Demands

Follow Step 2: Load Nodes and Allocate/Import Fire Flow Demands, above

Step 3: Run/View Results

Once run Options are set and required demands are Loaded, the Extended Fire Flow Analysis is ready to Run. Results are available to be viewed in a table, as below. User may Zoom to the selected junction/hydrant by clicking Zoom.

Extended Fire Flow Analysis Outputs

	Asset Id	Static Pressure	Required Fire Flow	Residual Pressure	Critical Junction	Critical Pressure	Critical Pipe	Critical Velocity	Min Pressure Time	Max Velocity Time
1	J-1390	85.03	500	81.48	J240	49.4	P102	13.35	01:13:20	00:00:00
2	J-0812	85.03	500	81.64	J240	49.4	P102	13.35	01:13:20	00:00:00
3	J-0813	84.6	500	81.41	J240	49.4	P102	13.35	01:13:20	00:00:00
4	J-1061	84.65	500	81.36	J240	49.4	P102	13.36	01:13:20	00:00:00
5	J-1244	84.79	500	81.4	J240	49.4	P102	13.36	01:13:20	00:00:00

Asset ID: ID of monitoring node (Junction or Hydrant)

Static Pressure: The static pressure calculated at the monitoring node (Junction or Hydrant) without any fire flow demand **at the end** of the Extended fire flow duration.

Residual Pressure: The pressure calculated for the Required Fire Flow at the monitoring node (Junction or Hydrant) **at the end** of the Extended fire flow duration.

Critical Junction: The Junction with the lowest pressure in the system during the *Extended Fire Flow*. (only populates if Report min. residual pressure is checked)

Critical Pressure: The Critical Junction pressure during the *Extended Fire Flow*. (only populates if Report min. residual pressure is checked)

Critical Pipe: The Pipe with the highest velocity in the system during the *Extended Fire Flow* (only populates if Report min. residual pressure is checked)

Critical Velocity: The Critical Pipe velocity during the *Extended Fire Flow*. (only populates if Report min. residual pressure is checked)

Min Pressure Time: Time when the Critical Junction has reached the minimum pressure. (only populates if Report min. residual pressure is checked)

Max Velocity Time: Time when the Critical Pipe has reached maximum velocity. (only populates if Report min. residual pressure is checked)