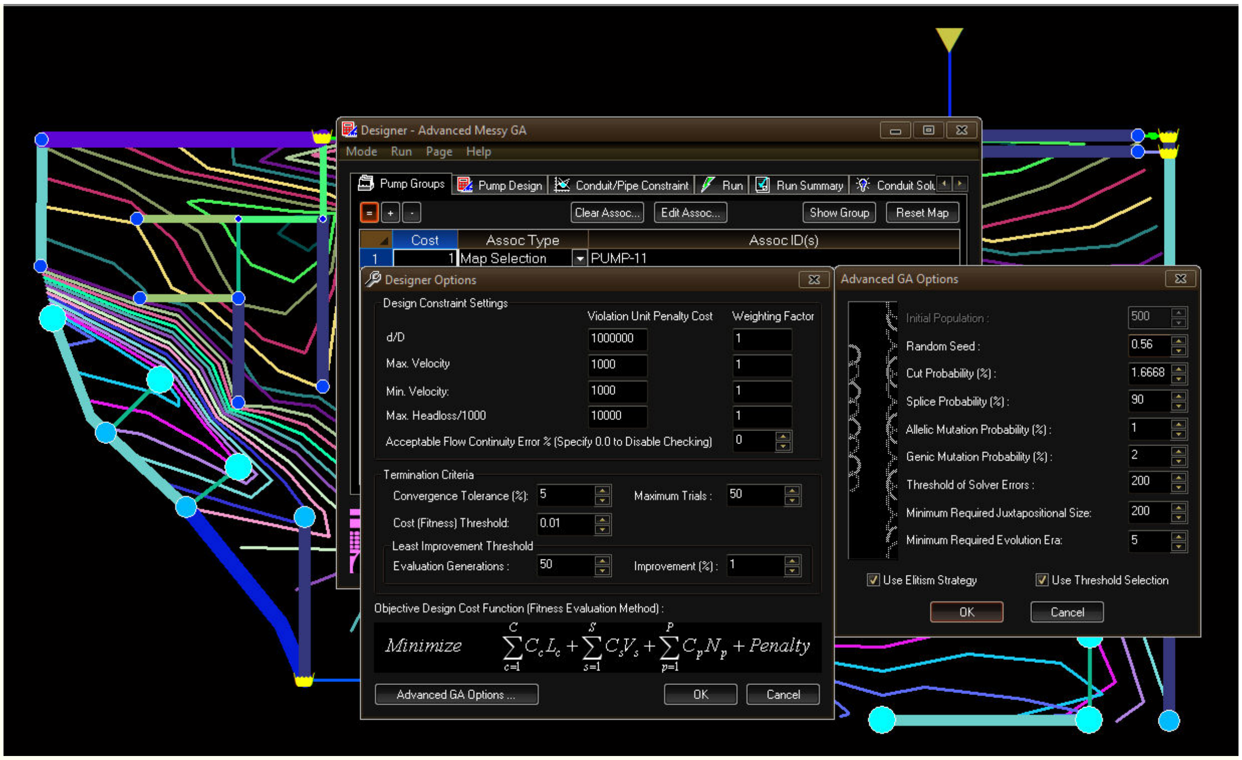
Introduction to Designer for InfoSWMM

InfoSWMM

Designer is used to optimize system performance at a low cost and is comprised of the components listed in the Group, Design, Constraints, Run Mode, Options and Solutions Table. For an overview of the Designer's capabilities, please click here. Designer is part of the comprehensive set of Addons in IInfoSWMM

Designer quickly determines the most cost-effective solution to flooding and pollution management by finding the precise combination of pipe slope and size, storage volume, pumping capacity and new piping that will best convey sewer flows without surcharging, overflows, flooding, and backups — at maximum cost savings. These comprehensive capabilities will greatly assist you in planning and designing reliable and efficient systems that meet regulations, minimize your capital investment, and promote healthier communities and a safer environment.

Groups	Design	Constraints and Penalties	Running the Designer	Options	Solutions
Conduit Groups	Conduit Design	Conduit Constraints	The Run Tab	General Options	Conduit Solution
Pump Groups	Pump Design	Conduit Penalty	Run Summary	Advanced GA Options	Pump Solution
Storage Groups	**Storage Design**	**User Guide Constraints**		Design Options	**Storage Solution**



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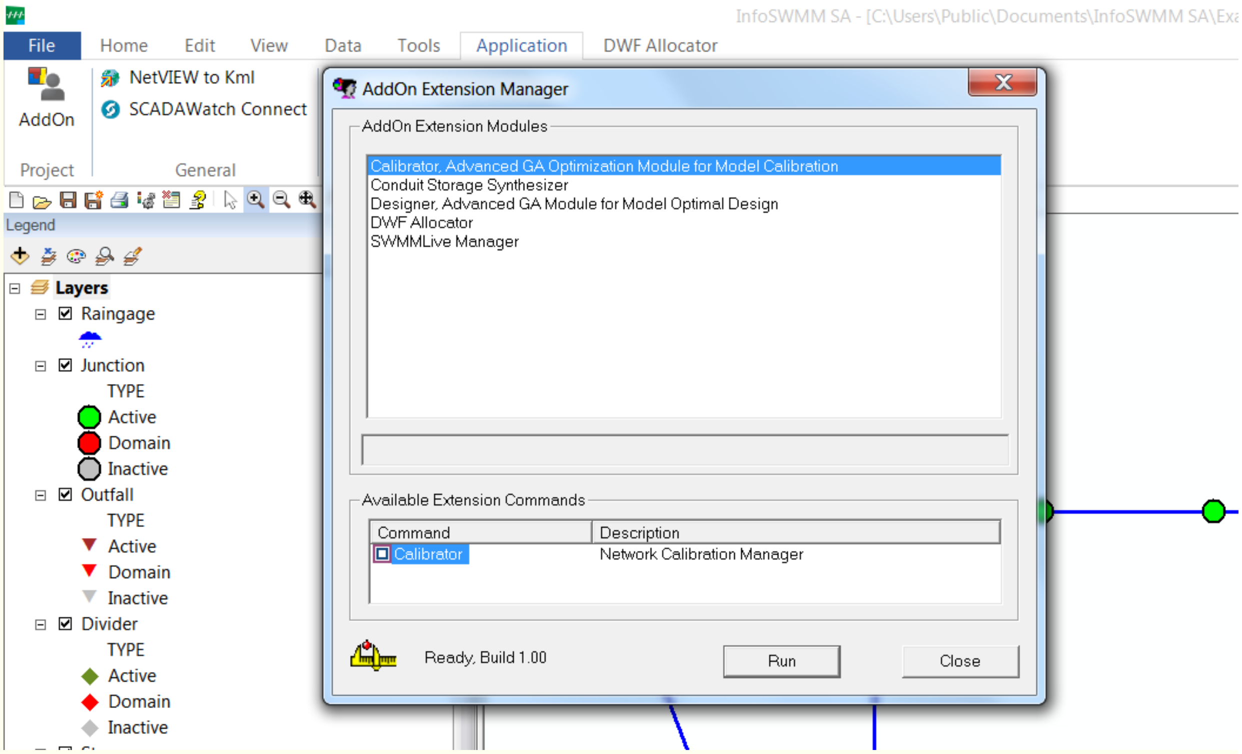
How to use Designer with InfoSWMM SA

You can call the Innovyze SWMM Designer from the InfoSWMM SA Ribbon



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About Designer

Control of sewer overflows is vital to reducing risks to public health and protecting the environment from water pollution. Sewer overflows are a leading cause of water pollution in the nation’s lakes, streams and inland bays. The untreated sewage from these overflows contains microbial pathogens, suspended solids, toxics, nutrients, trash, and other pollutants that deplete dissolved oxygen and can contaminate our waters, causing serious water quality problems and threatening drinking water supplies, fish and shellfish. This sewage can also back up into basements, causing property damage and creating threats to public health for those who come in contact with the untreated sewage.

With the growing expectations by the public for quality services, the U.S. Environmental Protection Agency under the authority of the Clean Water Act adopted by Congress has implemented pollution control programs and set wastewater standards for the industry. In order to meet these requirements, comprehensive modeling and analysis of these sewer systems becomes necessary for developing and evaluating sound cost-effective solutions for enhancing system integrity and performance to reliably convey sewer flows without surcharging, overflows, flooding, and backups.

Today, many wastewater utilities utilize hydraulic network simulation models to plan improvements and design better systems. These improvements are normally achieved through increasing conduit capacity, storage volume, and pumping capacity. Current practice involves a tedious trial-and-evaluation procedure that seldom leads to the most effective or most economical solutions for upgrading collection systems. This requires using the hydraulic collection system simulation model to evaluate the hydraulic performance of the existing collection system with different design alternatives (modifications) under a range of loading conditions. The design that meets the target hydraulic criteria for the lowest cost is then selected from among the alternative designs.

However, given the vast number of combinations of possible enhancements, it is unlikely that even the most experienced engineer will be able to determine the least-cost improvement alternative. This process is also not able to ensure that the final design could perform adequately under all possible loading conditions. The result of using the traditional trial-and-evaluation approach is often inefficient performance at greater cost.

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Designer offers a very sophisticated optimization capability representing a major step forward for collection system modeling. With this capability, you can rapidly formulate and assess various reliable and cost-effective improvement solutions, which previously required a tedious trial-and-error approach or were not practical to even attempt. I *Designer* leverages the power of advanced Genetic Algorithms optimization technology to automatically select the most cost-effective solution to flooding and pollution management, using a combination of pipe upsizing, storage, pumping and new piping to eliminate unwanted sewer overflows and achieve targeted system performance requirements. It is the ultimate tool to help engineers produce the best possible design and improvement alternatives with minimum effort and at significant cost savings. Performance criteria include maximum allowable depth to diameter ratio, minimum and maximum pipe velocities, and maximum head loss for force mains. These capabilities will greatly assist wastewater utilities in planning and designing reliable systems and optimizing their capital improvement programs — leading to healthier communities, cleaner beaches, and fish and shellfish that are safer to eat.

An invaluable and complete master planning, operations and decision support tool,InfoSWMM

Designer gives wastewater utilities the very best tool for performing the highly sophisticated urban stormwater runoff modeling they need to shape their stormwater runoff management plans and control sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs). It will help them pinpoint the most cost-effective way to remove all targeted flooding, keep their systems operating efficiently well into the future, and safeguard against adverse health and environmental effects – all in an extremely easy-to-use and fully interactive GIS environment.

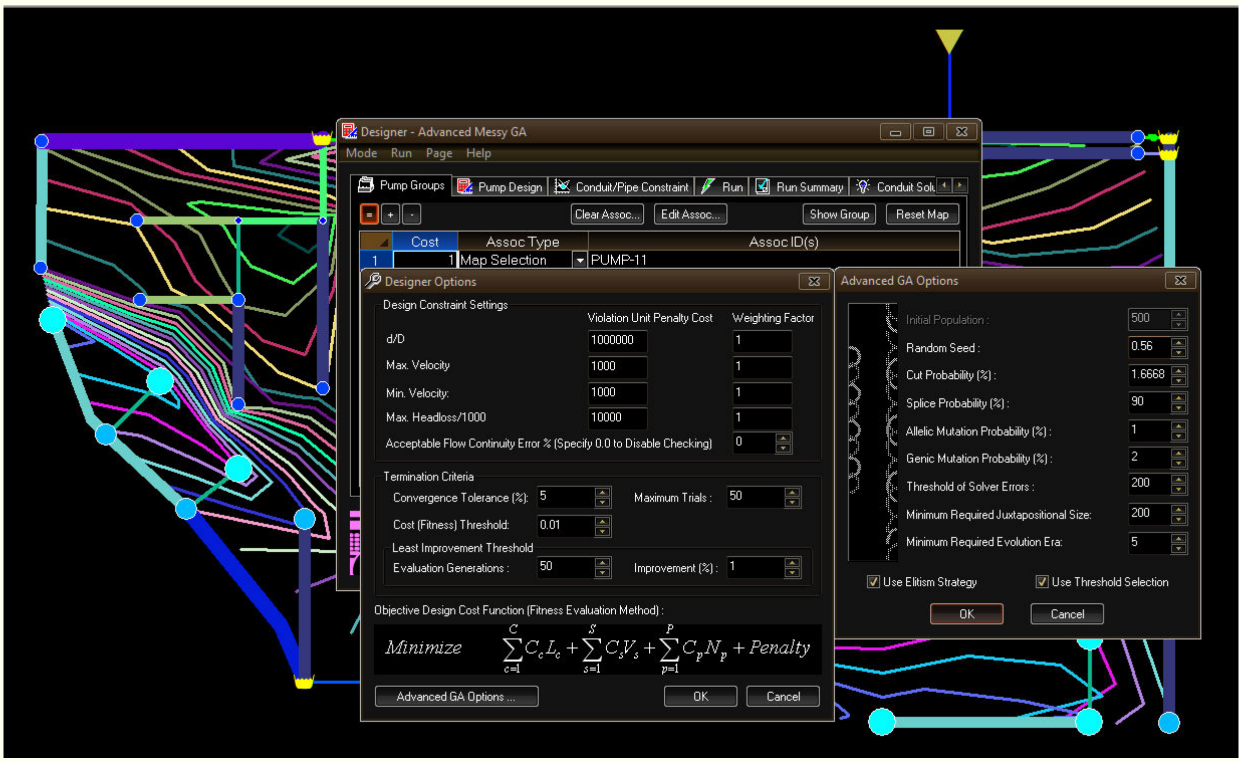
We are happy to bring you the state-of-the-art in collection system optimization technology to help you plan, design, construct and operate better systems.

Paul F. Boulos, Ph.D., BCEEM, Hon.D.WRE, Dist.D.NE, F.ASCE

President,

COO and Chief Technical Officer, Innovyze Inc.

January 30, 2019



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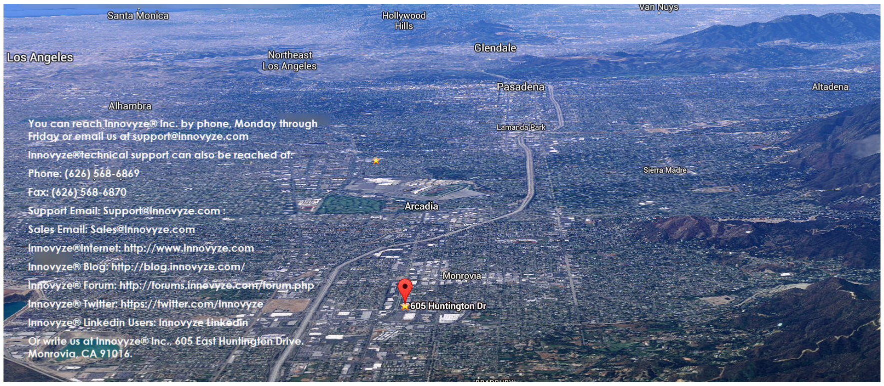

You can reach **Innovyze® Inc.** by phone, Monday through Friday or email us at support@innovyze.com

Innovyze®technical support can also be reached at:

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Fax: (626) 568-6870

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Or write us at **Innovyze® Inc., 605 East Huntington Drive. Monrovia, CA 91016.**

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- Your name
- Your company details
- Innovyze product name and version number
- Operating system on which the software is running
- The level of urgency of the problem
- A brief description of the enquiry, fault or problem

If you contact the support team by fax or e-mail, please include all this information. It will help us to deal with your request more quickly.

We will also seriously consider your suggestions for future versions of all Innovyze®Products.

For international support, please contact your local Innovyze®Inc. Certified agent.

We occasionally create interim updates that contain fixes and/or new features or send you an interim dll update.

Please Note: Do not forget to renew the Annual Maintenance Agreement (Subscription Program) to take full advantage of future enhancements, product upgrades and product updates.

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Call us at:

(available Monday through Friday)

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Technical Support (AUS):	**+61 (0)5506 5700**
FAX (US):	**(626) 568-6870**

Email us at:

Contact Type	Email
Technical Support Email:	**support@innovyze.com**
Sales Email:	**sales@innovyze.com**

Write us at:

Region	Address
Innovyze Inc (USA):	**605 East Huntington Drive, Suite 205** **Monrovia, CA 91016** **United States of America**
Innovyze Ltd (UK):	**Kestrel House** **Howbery Park** **Wallingford** **Oxfordshire, OX10 8BA** **United Kingdom**
Innovyze Pty Ltd (AUS):	**Suite 38, 75 Wharf St** **Tweed Heads** **NSW 2485** **Australia**

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- Your name
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If you contact Innovyze support team by fax or e-mail, please include all the above information. It will help us to deal with your request more quickly.

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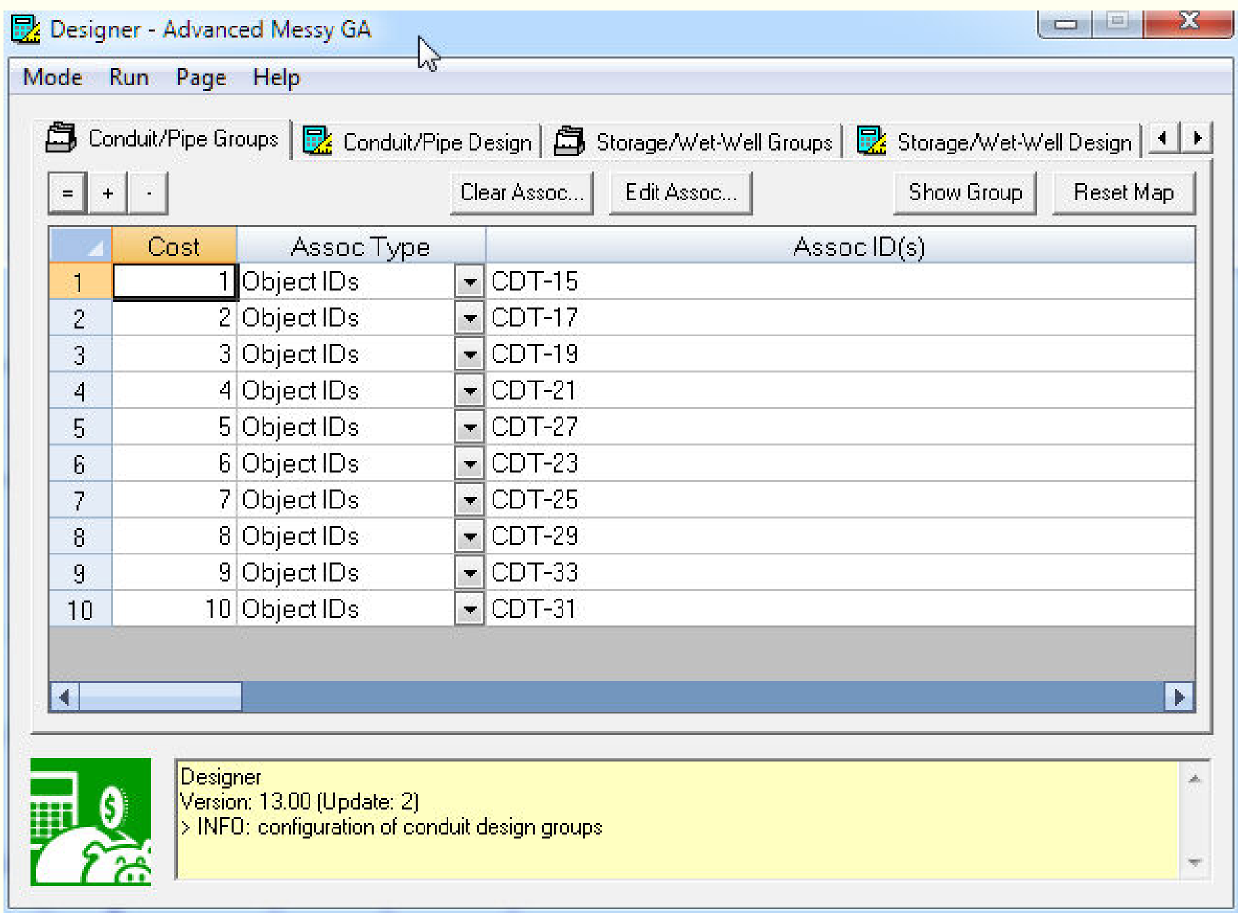
Conduit/Pipe Groups

The Conduit Groups tab defines the conduits grouped in each cost code.

From this tab, cost codes are associated with conduit ID's. The cost code also is associated with potential replacement conduit cross-section on the Conduit Design tab. After a Designer run, one optimal cross-section is selected for each cost code value. The optimal cross-section will be assigned to all conduits with the same cost code if the solution is applied.

Each conduit group can have only one cost code. Therefore, it is recommended that areas of similar costs are determined (e.g., conduits in an urban area with heavy traffic will normally have different costs than conduits in a rural area with no traffic and no paved roads) as one basis for selecting conduit groups. All conduits in that group will be replaced with the same cross section, so the hydraulic functionality must also be considered when creating groups.



Note -

Click on any portion of the dialog box above for information on any item.

<u>See Also</u>

[Pump Groups]

[Storage Groups]

[Conduit Design]

[Conduit Constraints]

[Conduit Penalty]

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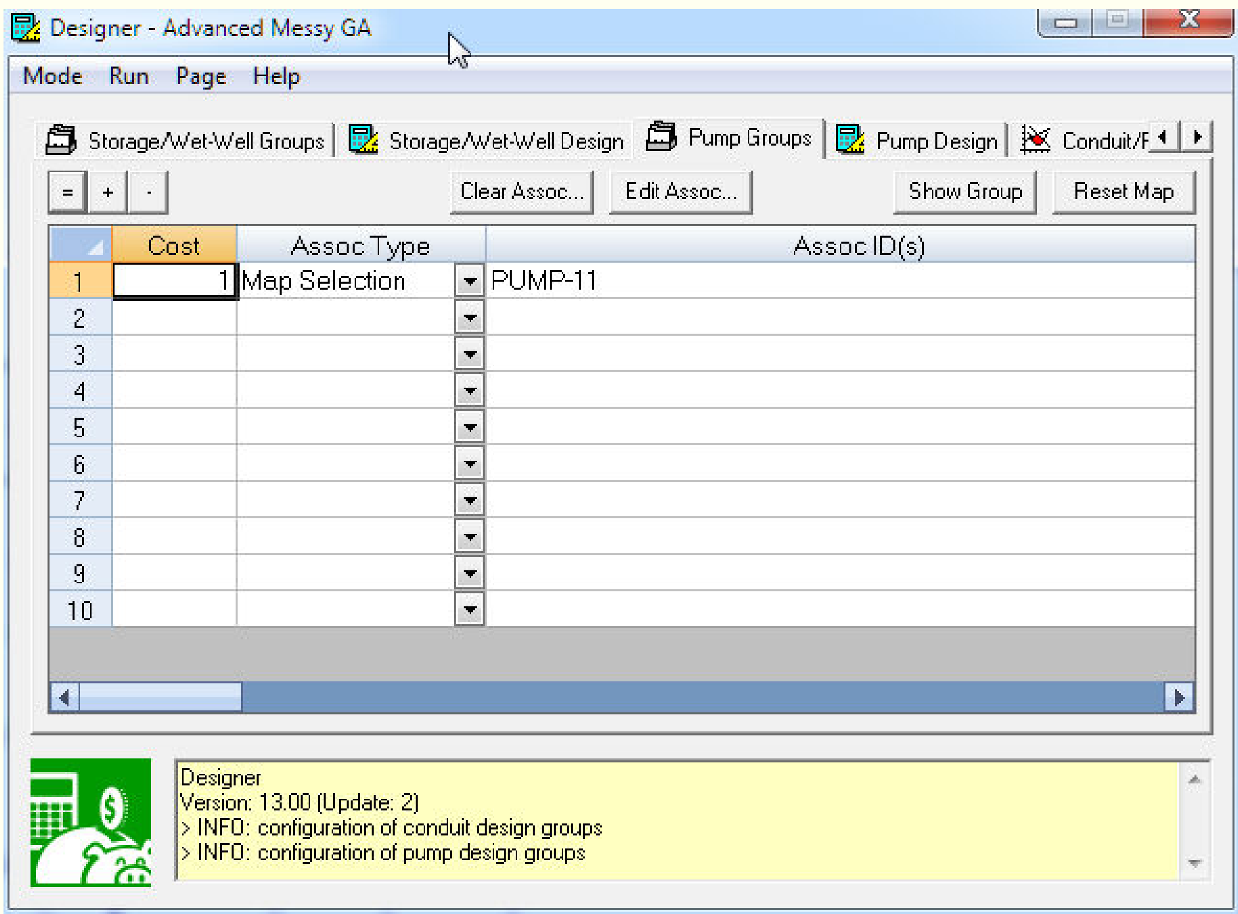
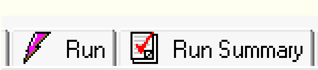
Pump Groups

The Pump Groups tab is used to define the Pumps grouped in each cost code. From this tab, cost codes are associated with pump ID's.

The cost code also is associated with potential replacement pump curves on the Pump Design tab. After a Designer run, one optimal curve is selected for each cost code value. The optimal curve will be assigned to all pumps with the same cost code if the solution is applied. Refer to the helpfile for more information on curves. Each pump group can have only one cost cod e. Pumps located at the same pumping station must be grouped with care (if not grouped together), so one pump does not shut off another.





Note -

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See Also

[Pump Groups]

[Storage Groups]

[Conduit Design]

[Conduit Constraints]

[Conduit Penalty]

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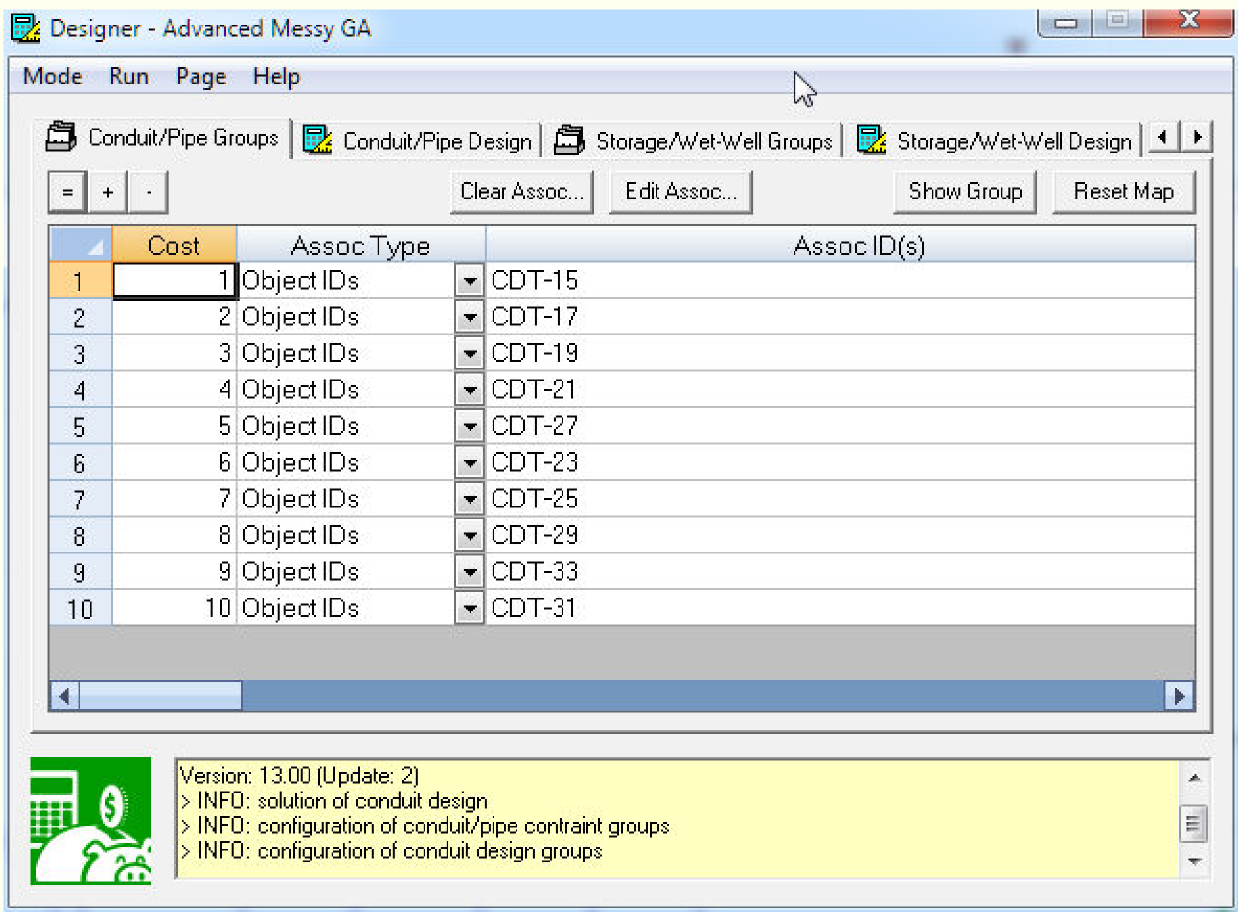
Storage Groups

The Storage Groups tab defines the storage facilities grouped in each cost code. From this tab, cost codes are associated with storage IDs.

The cost code also is associated with potential replacement storage geometries on the Storage Design tab. After a Designer run, one optimal geometry is selected for each cost code value. The optimal geometry will be assigned to all storages with the same cost code if the solution is applied. Refer to the InfoSWMM

helpfile for more information on storage geometries. Each storage group can have only one cost code. Therefore, it is recommended that if a system has a limited number of storage facilities (less than 10), each storage facility be in it own group.



Note -

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See Also

Pump Groups

Storage Groups

Conduit Design

Conduit Constraints

Conduit Penalty

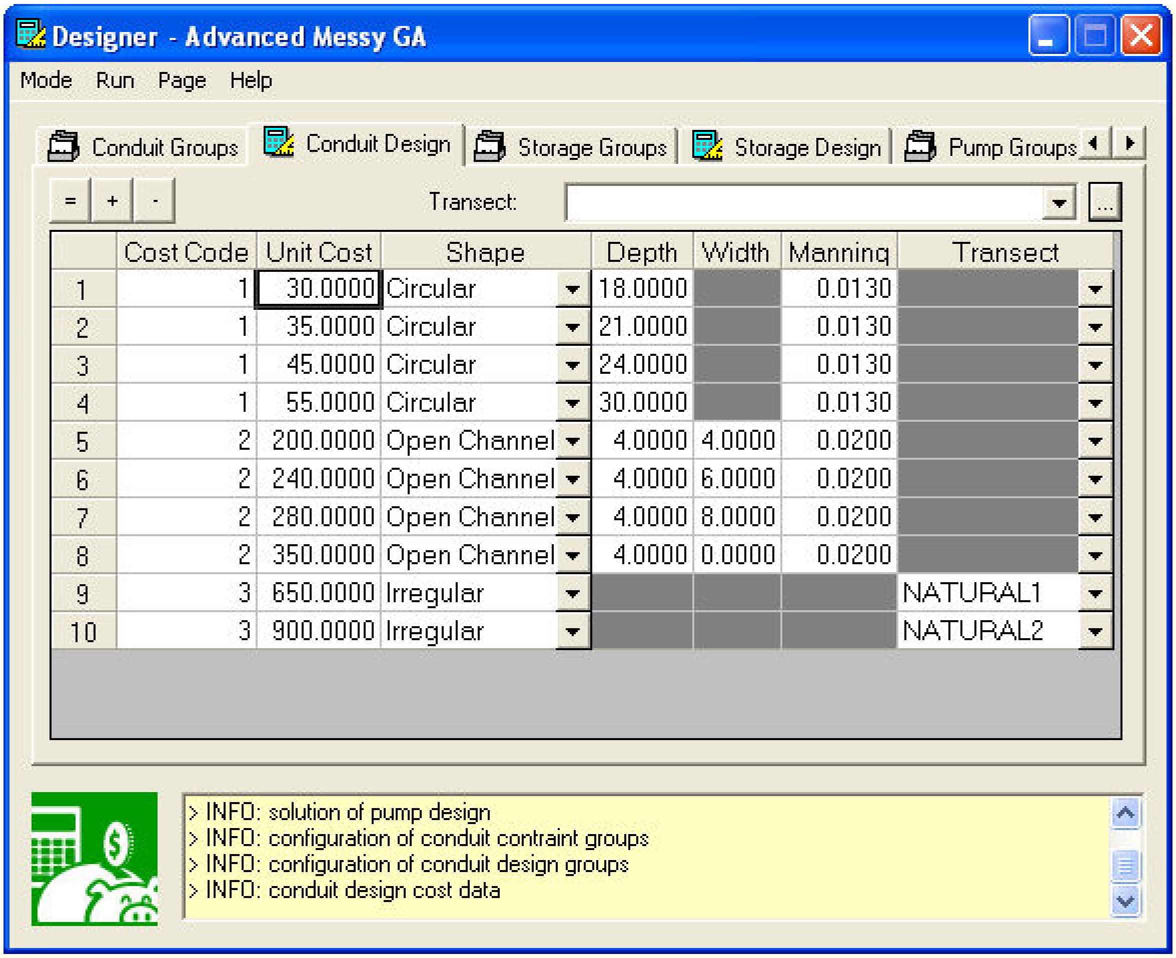
Conduit Design

The Conduit Design tab is used to define the replacement conduit cross-sections available for each cost code. Note that non-circular closed conduits must be specified with an equivalent circular section.

Under this tab, the cost per linear foot of each conduit cross-section (row) is defined. This value is used to calculate the costs during the optimization. The type of conduit cross-section for each row is specified as Circular, Open Channel, or Irregular. The shape of the improvement impacts the data that must be entered on the right side of the table.

For all closed conduits a diameter or equivalent diameter (depth) and manning coefficient must be specified. For regular shaped open channels, the depth, width, and manning coefficient need to be specified. The depth is defined as the height of the open channel. The width is defined as the bottom width. Note that the Designer uses the same side slopes for replacement channels. Thus, rectangular channels will be replaced with rectangular channels. For irregular shaped channels, the transect ID defining the cross-section geometry must be specified. Transects are created in the Operation tab of the Control Center under Hydraulics. Refer to the InfoSWMM

helpfile for more information on Transects.



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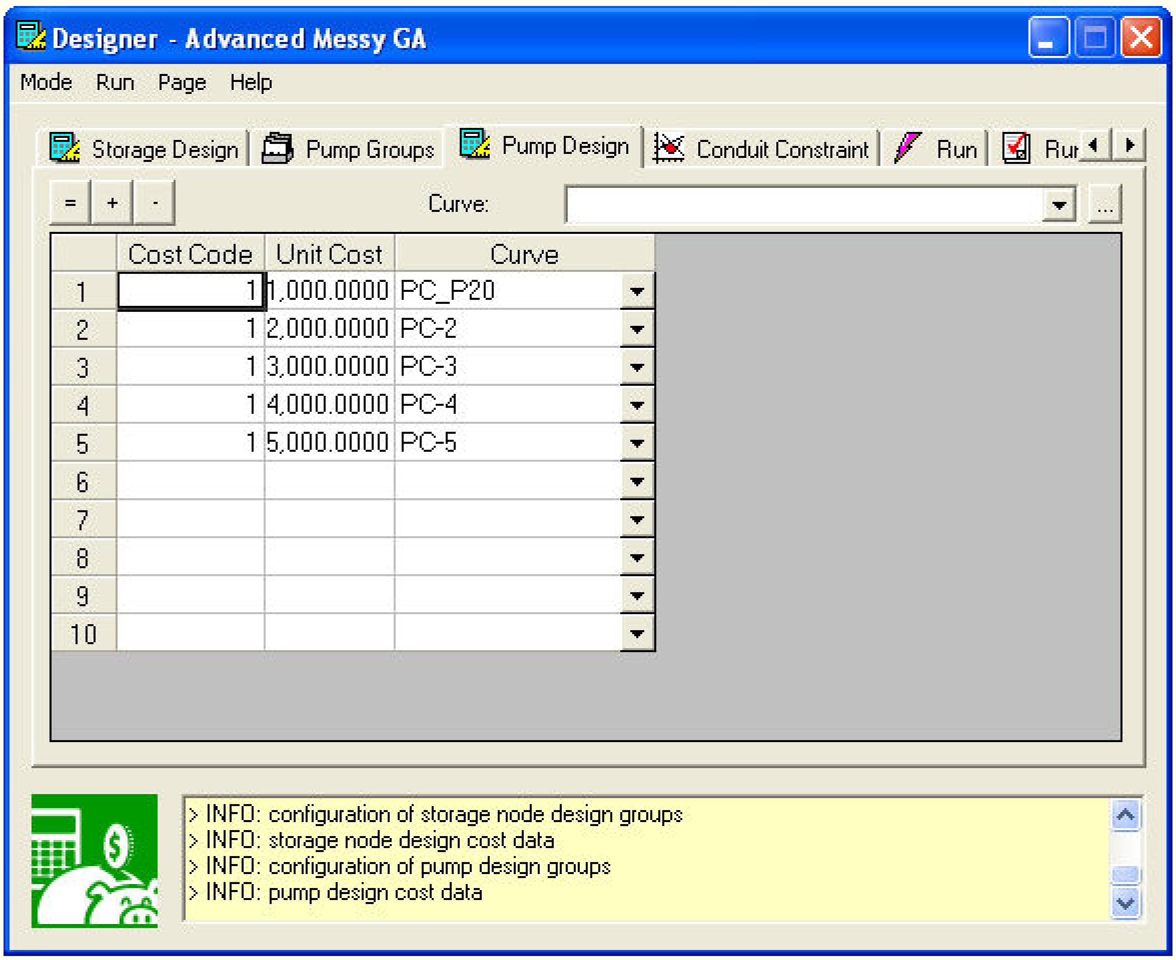
Pump Design

The Pump Design tab is used to define the replacement pump curves available for each cost code.

Under this tab, the cost of each pump curve is defined. This value is used to calculate the costs during the optimization. The pump curves can be created in the Operation tab of the Control Center under Curves. Refer to the InfoSWMM

helpfile for more information on pump curves.



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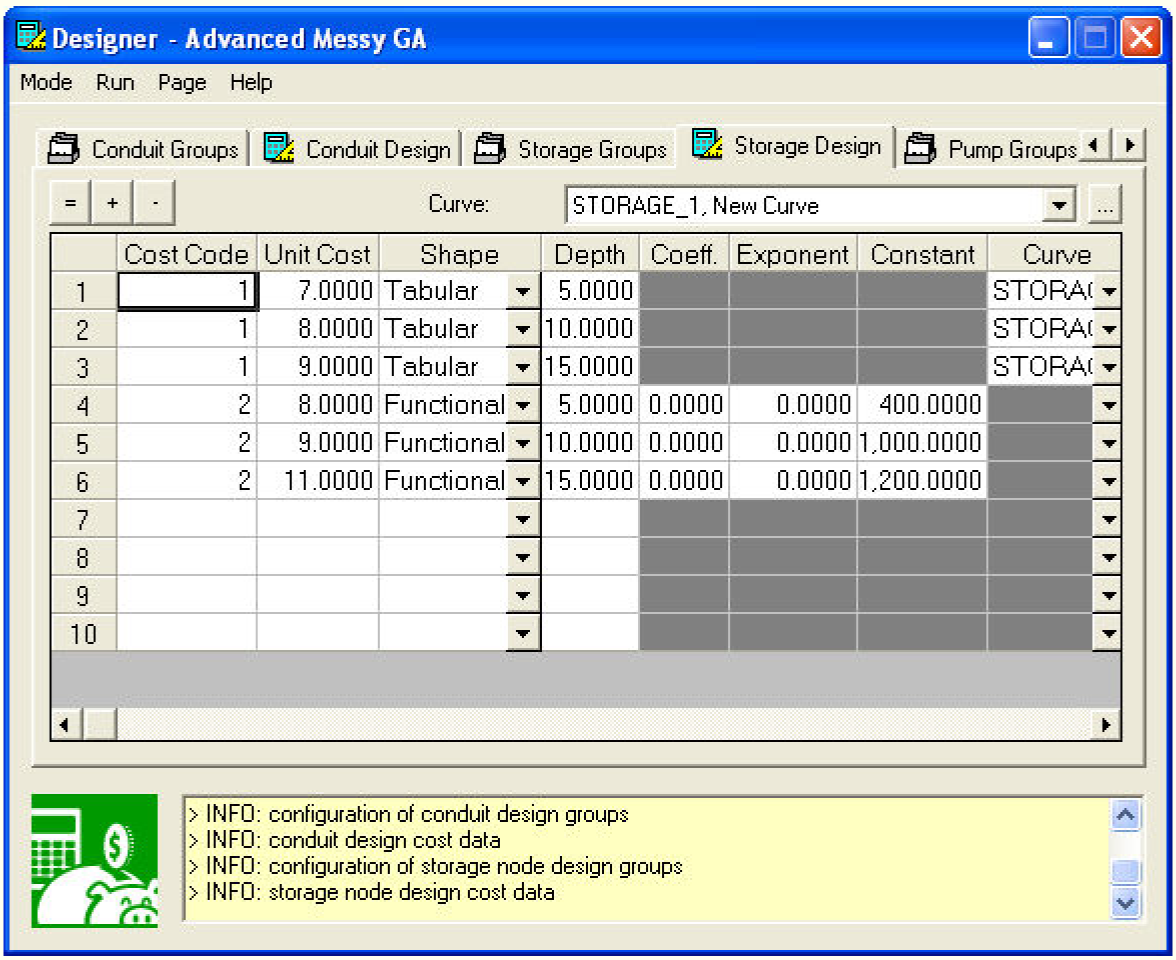
Storage Design

The Storage Design tab is used to define the replacement storage geometries available for each cost code.

Under this tab, the cost per gallon of each storage geometry (row) is defined. This value is used to calculate the costs during the optimization.

The shape can be defined as either tabular or functional. Tabular storages have a storage curve assigned to them. The storage curves are defined as depth verses area and can be created in the Operation tab of the Control Center under curves. Functional storage uses the power function (A = coeff. (Depth)^Exponent + constant) to describe how surface area varies with depth. The equation parameters are input to the right of the shape column. Refer to the InfoSWMM helpfile for more information on storage geometries.



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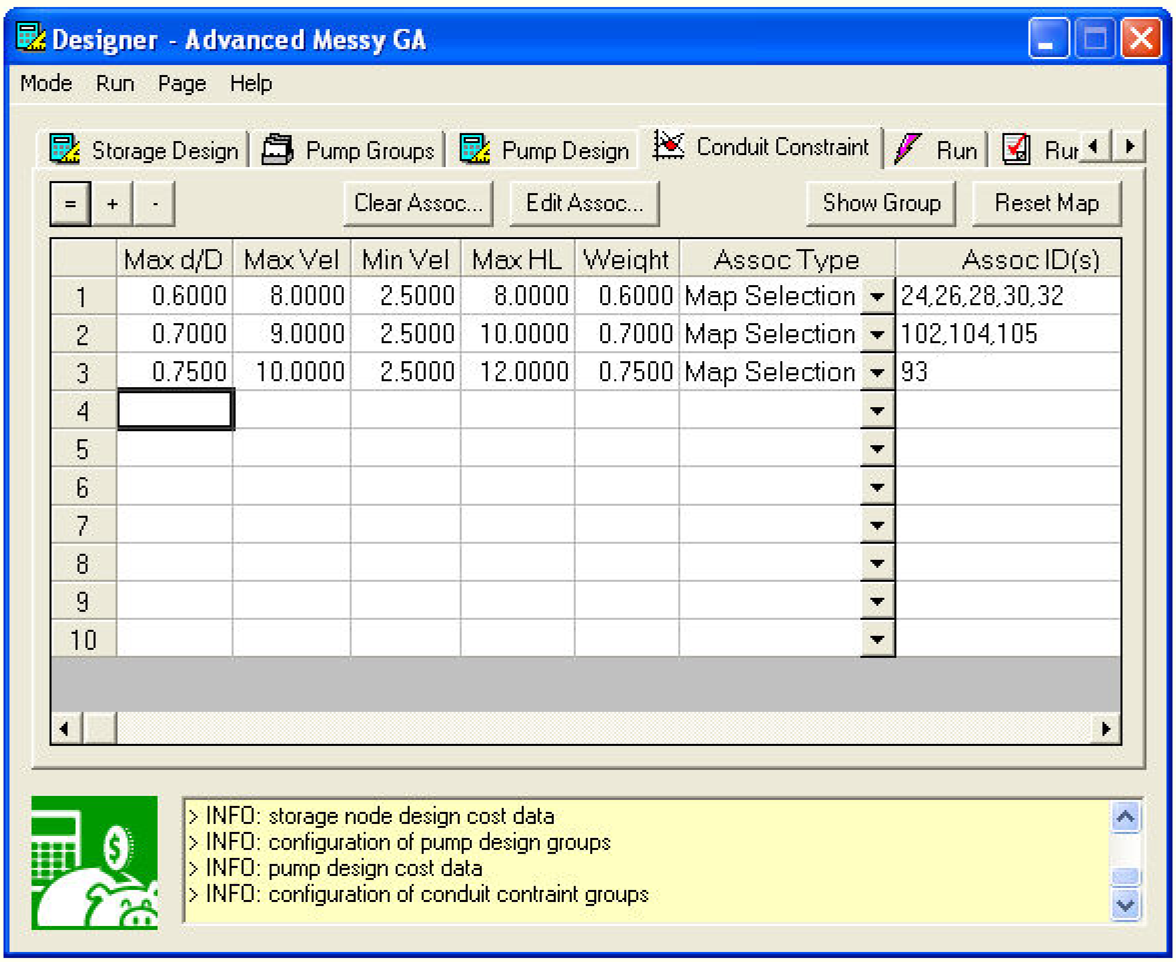
Conduit Constraints

The Conduit Constraints tab is used to define the hydraulic criteria that will be used to control the optimization. Costs are incurred when a solution violates any of the hydraulic criteria defined on this tab. The Designer attempts to minimize violations in order to keep the solution cost low. The penalty costs specified in the options

directly impacts the violations that will be seen in a solution.

Maximum depth over diameter, minimum and maximum velocity, and maximum headloss constraints can be specified for conduits. The constraints will be applied to the conduits IDs listed in the Associated ID column.



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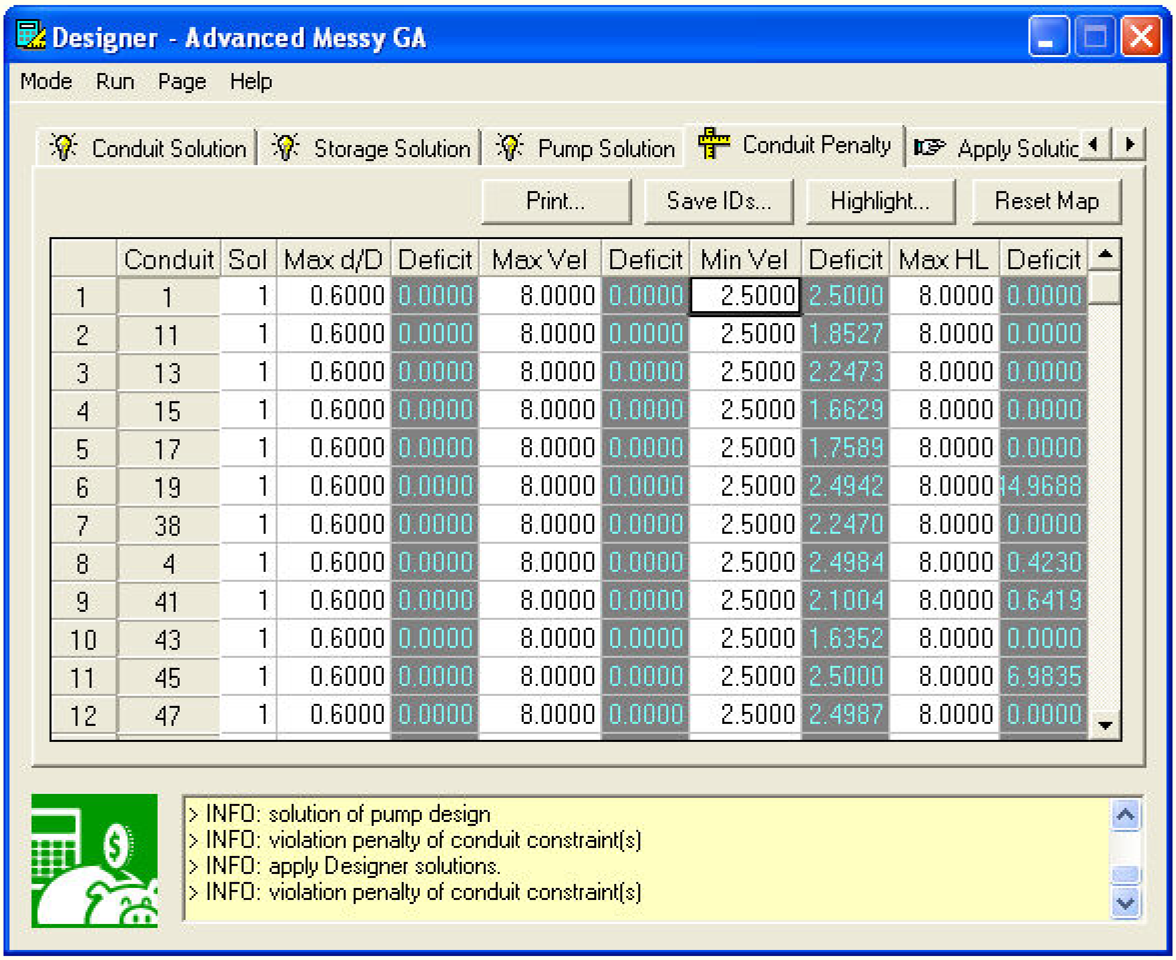
Conduit Penalty

The Conduit Penalty tab is used to detail violations (if any) of hydraulic constraints as specified on the conduit constraints tab.

The penalty costs specified in the options directly impacts the violations that appear in this report. This tab summarizes the design criteria and the deficit (the difference between the simulated result and the design criteria) for all conduits for each solution. The number of violations may be typically reduced by increasing the penalty costs in the options.



Note -

Click on any portion of the dialog box above for information on any item.

The column shown as Sol is actually Solution. The column is narrow for display.

See Also

Pump Groups

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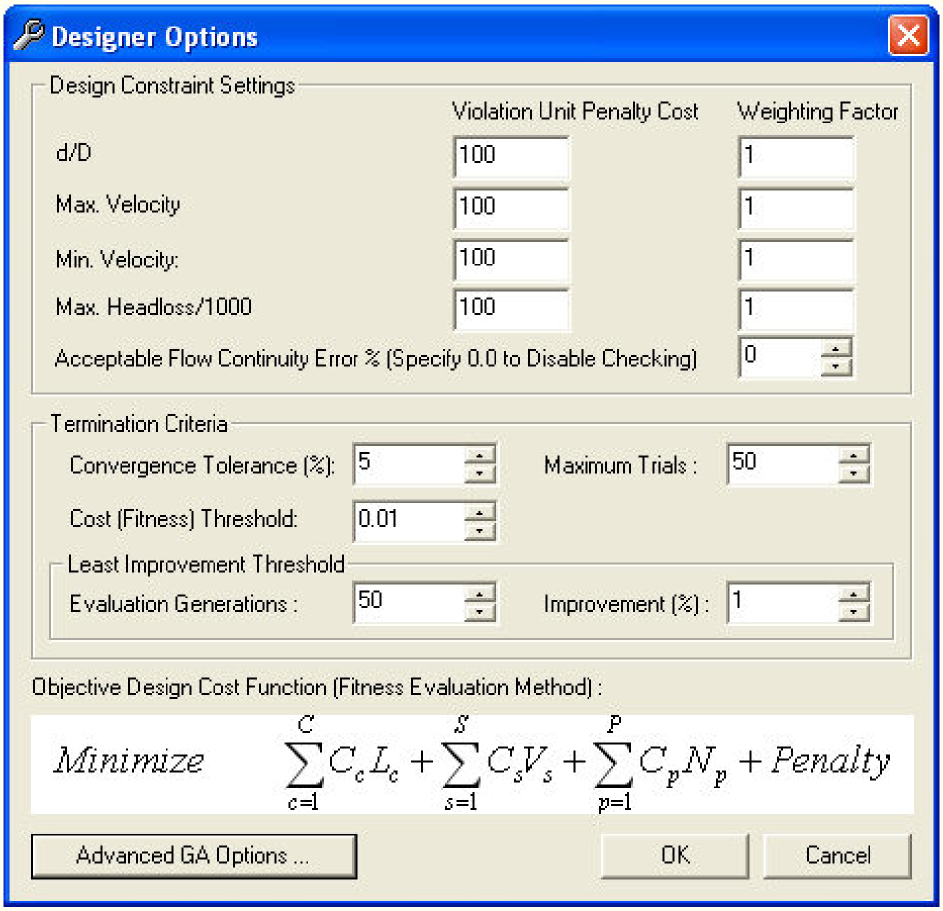
Options

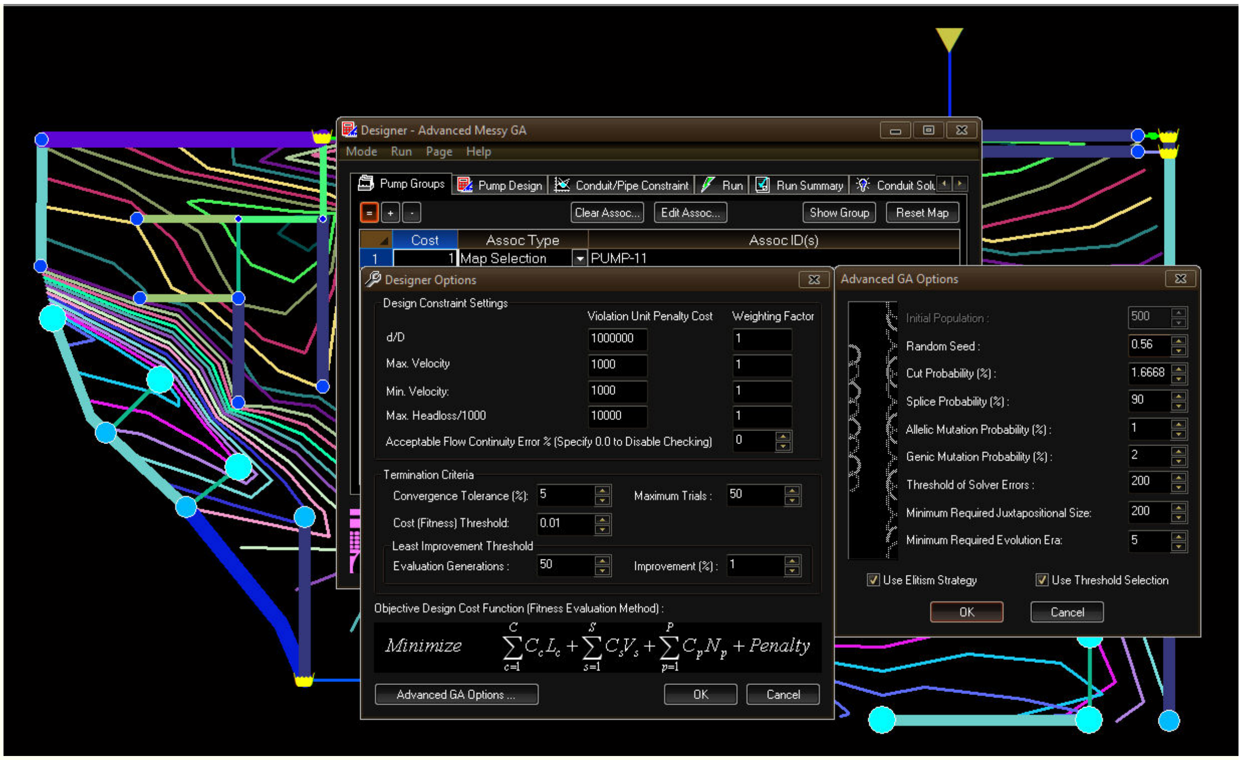
The Options dialog box controls optimization during a Designer run.

Within this dialog box, the user specifies the data units, penalty costs and weighting factors, convergence parameters, and advanced GA options.



See Also

Genetic Algorithm Overview



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Advanced GA Options

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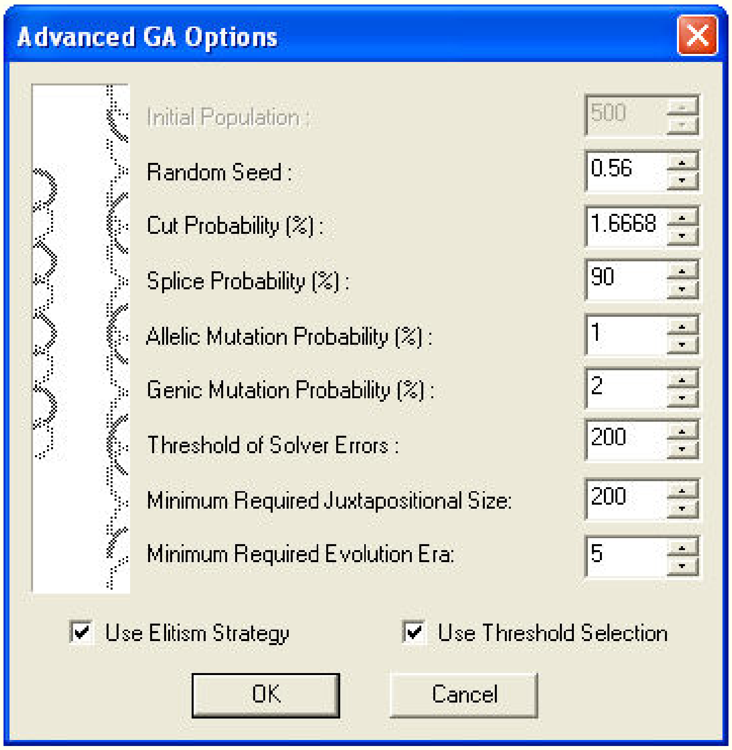
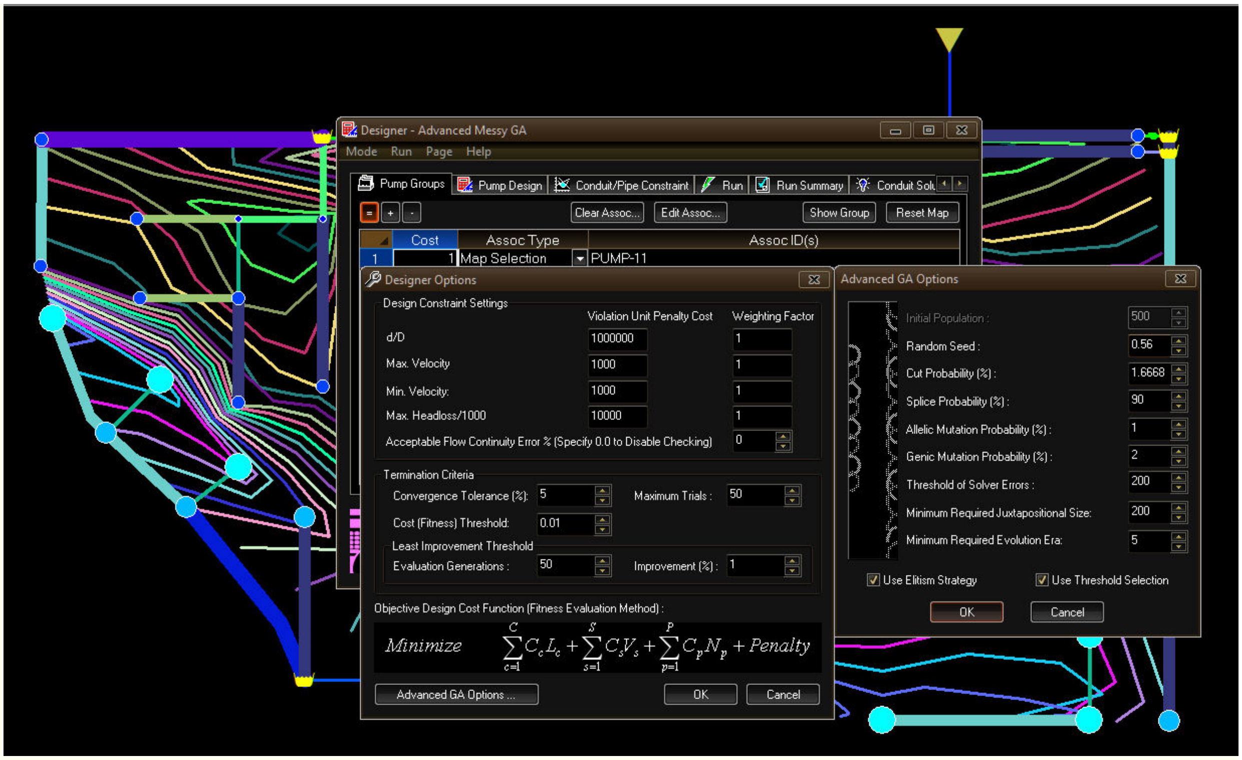
Advanced GA options dialog is used to edit the following options. Click any portion of the dialog for more information.



See Also

Genetic Algorithm Overview



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Run

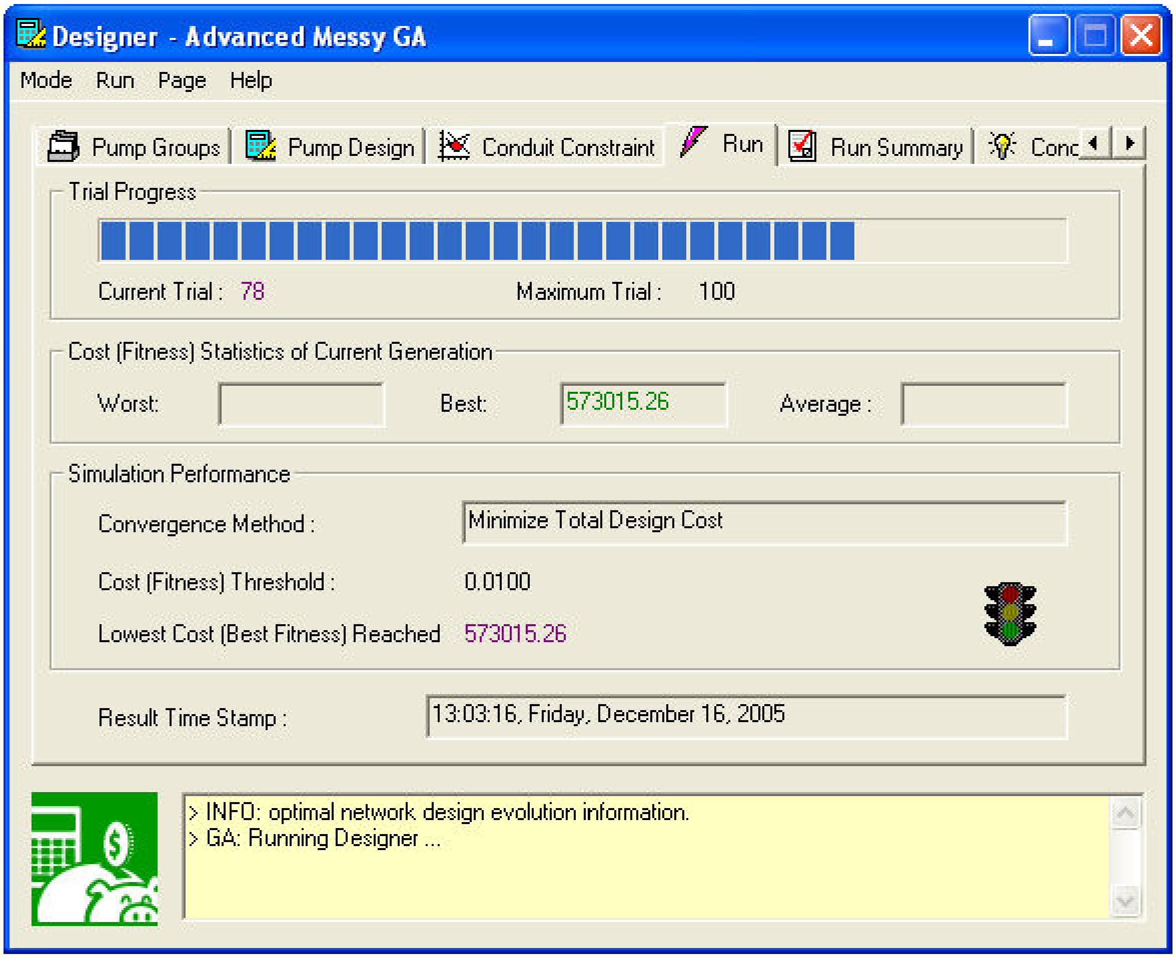
The Run tab is used to detail the optimization process. To start the optimization, choose 'Start' from the Run menu. To stop the optimization at any time, choose 'Stop' from the Run menu. The run can be stopped at any time, even before convergence or whether the maximum trial number has been reached, from the run drop down menu. Results can still be viewed if the optimization analysis is pre-maturely stopped.

Designer will search for the minimum cost solution. The penalty cost is used to avoid solutions that violate hydraulic constraints and thus guide the optimization procedure towards the desired solution space. Different values of the penalty cost will result in different design solutions and also affect the efficacy of the optimization calculation. Therefore, a number of trial design runs with different penalty costs are recommended for better exploring the solution space and narrowing in on the lowest cost solutions.

The Designer optimization uses the current scenario, enabled controls, and simulation options. Please note that running the Designer using Kinematic Wave routing is significantly faster than using Dynamic Wave routing.

Depending on the system's hydraulics, you may use Kinematic Wave routing to find optimized designs then test the solution using Dynamic Wave routing.

A running InfoSWMM model is required to perform a successful Designer optimization.



Note -

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See Also

[Options]

[Run Summary Graph]

[Run Summary Report]

[Run Summary Evolution Summary]

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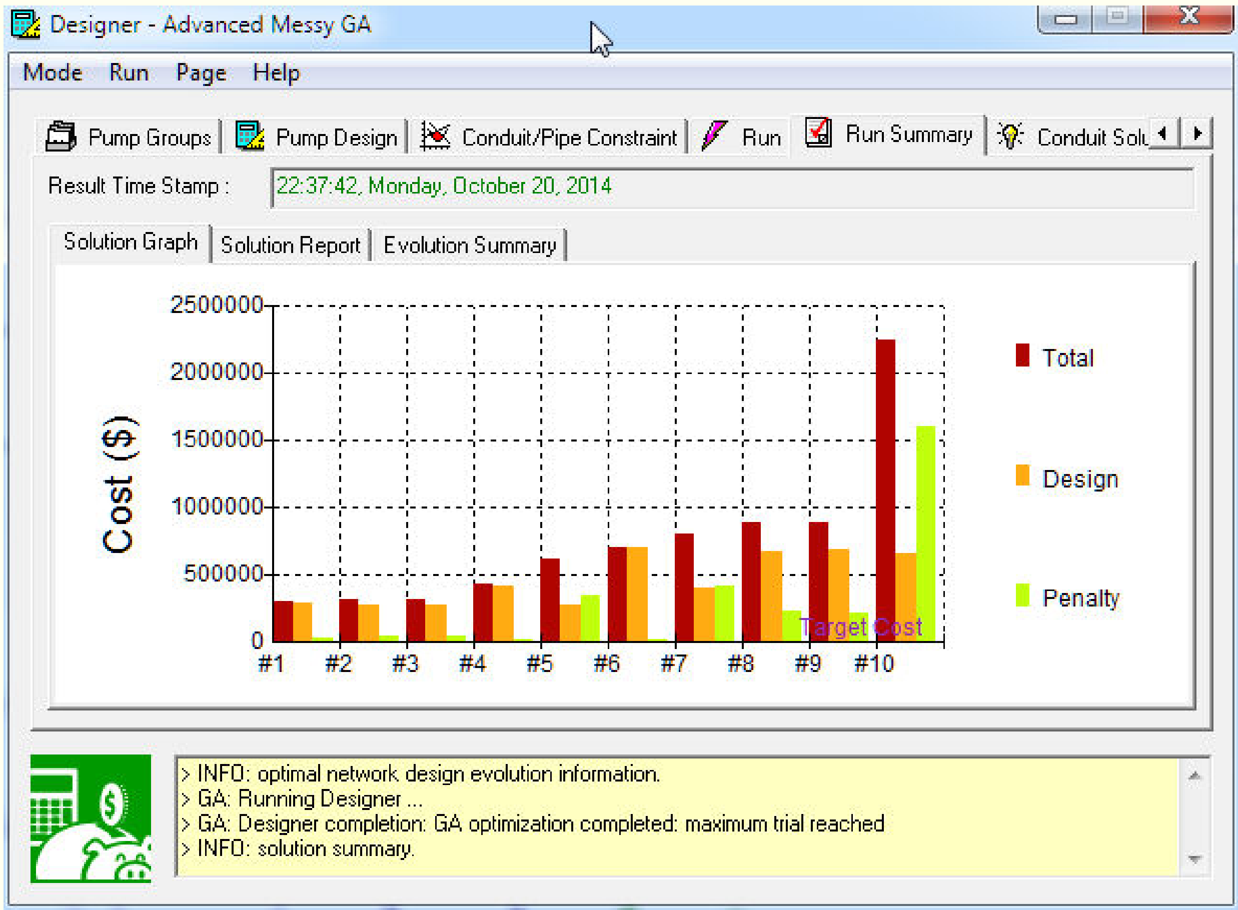
Run Summary - Graph

The Run Summary tab is used to detail the best solutions from the last optimization.

The Solution Graph displays a bar graph of the best (lowest total cost) solutions. The total cost, design cost, and penalty cost are detailed for each solution. A maximum of f 10 solutions will be presented on this graph.



Note -

Click on any portion of the dialog box above for information on any item.

See Also

[Running the Designer]

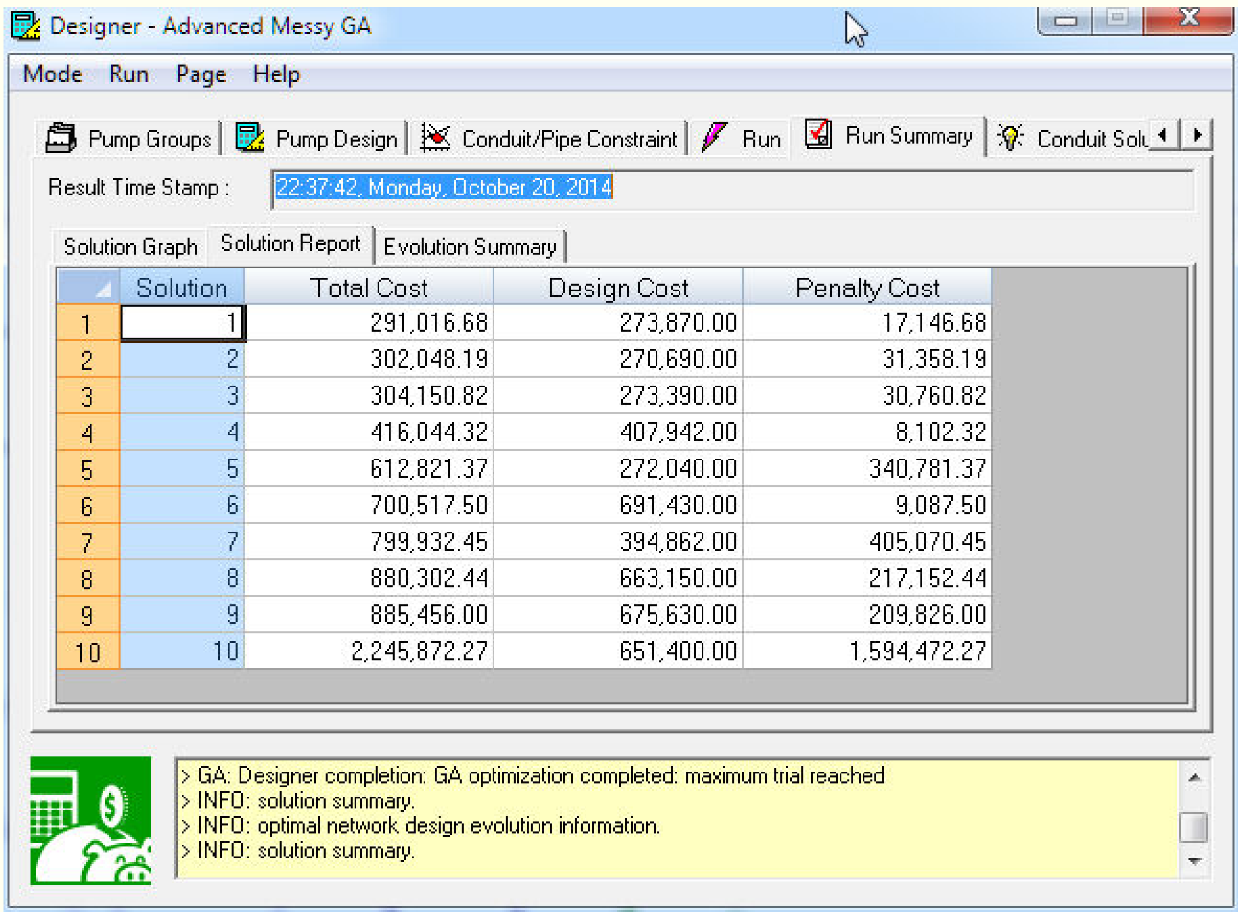
[Run Summary Report]

[Run Summary Evolution Summary]

Run Summary - Report

The Run Summary tab is used to detail the best solutions from the last optimization.

The Solution Report displays a chart of the best (lowest total cost) solutions. The total cost, design cost, and penalty cost are detailed for each solution. A maximum of 10 solutions will be presented on this report. Click any portion of the dialog for more information.



	Solution	Total Cost	Design Cost	Penalty Cost
1	1	291,016.68	273,870.00	17,146.68
2	2	302,048.19	270,690.00	31,358.19
3	3	304,150.82	273,390.00	30,760.82
4	4	416,044.32	407,942.00	8,102.32
5	5	612,821.37	272,040.00	340,781.37
6	6	700,517.50	691,430.00	9,087.50
7	7	799,932.45	394,862.00	405,070.45
8	8	880,302.44	663,150.00	217,152.44
9	9	885,456.00	675,630.00	209,826.00
10	10	2,245,872.27	651,400.00	1,594,472.27

Note -

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See Also

[Running the Designer]

[Run Summary Graph]

[Run Summary Evolution Summary]

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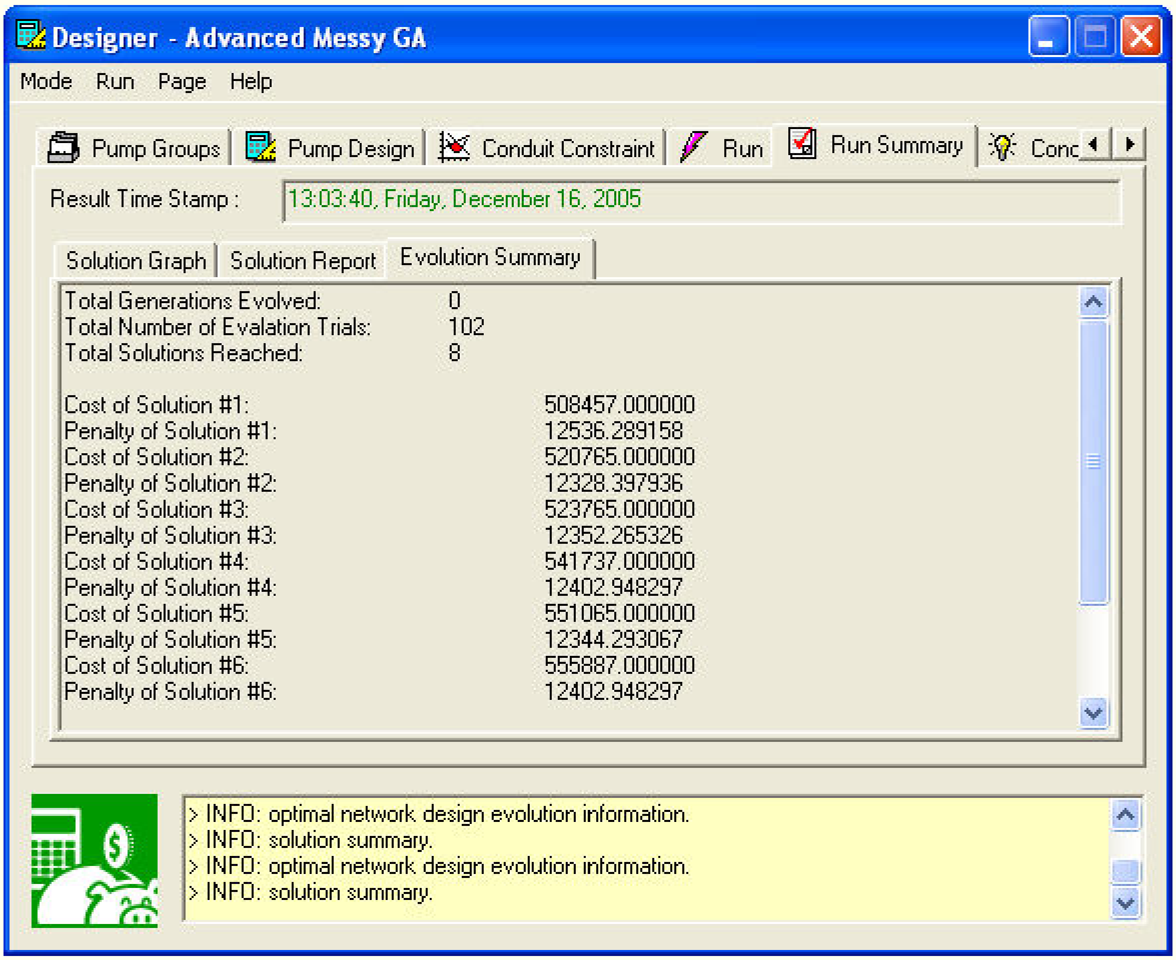
Evolution Summary

Run Summary - Evolution Summary

The Run Summary tab is used to detail the best solutions from the last optimization.

The Evolution Summary displays total and penalty costs for each solution.

A maximum of 10 solutions will be presented on this graph.



Note -

Click on any portion of the dialog box above for information on any item.

See Also

Running the Designer

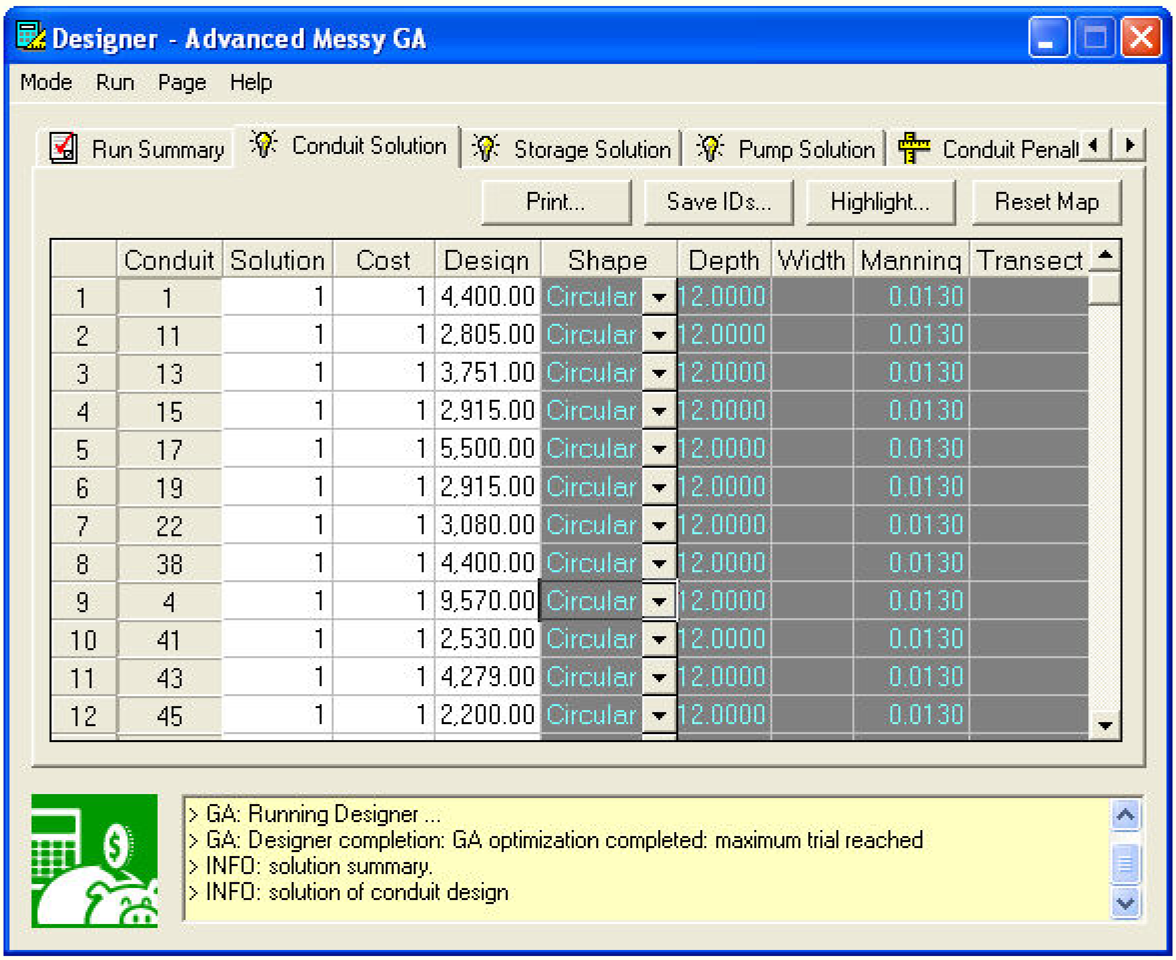
Run Summary Report

Run Summary Evolution Summary

Conduit Solution

The Conduit Solution tab details the optimal cross-sections as determined by the last Designer optimization run for all conduits listed on the [Conduit Group](#) tab.

This tab summarizes the design cost and parameters (depth for circular conduits, depth and width for open channels, curve for irregular channels, and manning roughness for all types of conduits) for all optimal solutions.



Note -

Click on any portion of the dialog box above for information on any item.

The columns shown as Cost and Design are actually Cost Code and Design Cost, respectively. The columns are narrow for display.

See Also

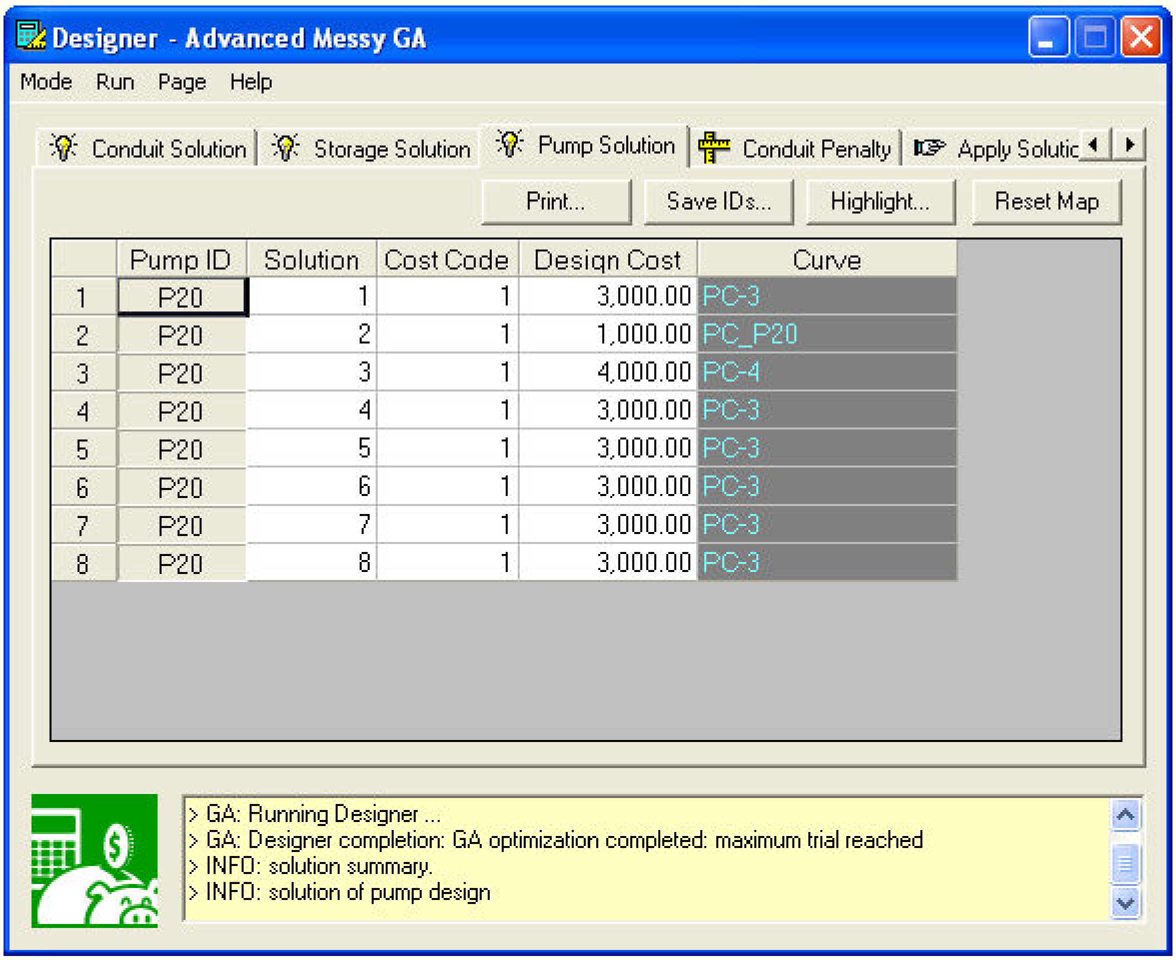
[Conduit Groups]

[Conduit Design]

[Conduit Penalty]

Pump Solution

The Pump Solution tab details the optimal curves as determined by the last Designer optimization run for all pumps listed on the Pump Group tab. This tab summarizes the design cost and optimal pump curve for the best solutions.



Note -

Click on any portion of the dialog box above for information on any item.

See Also

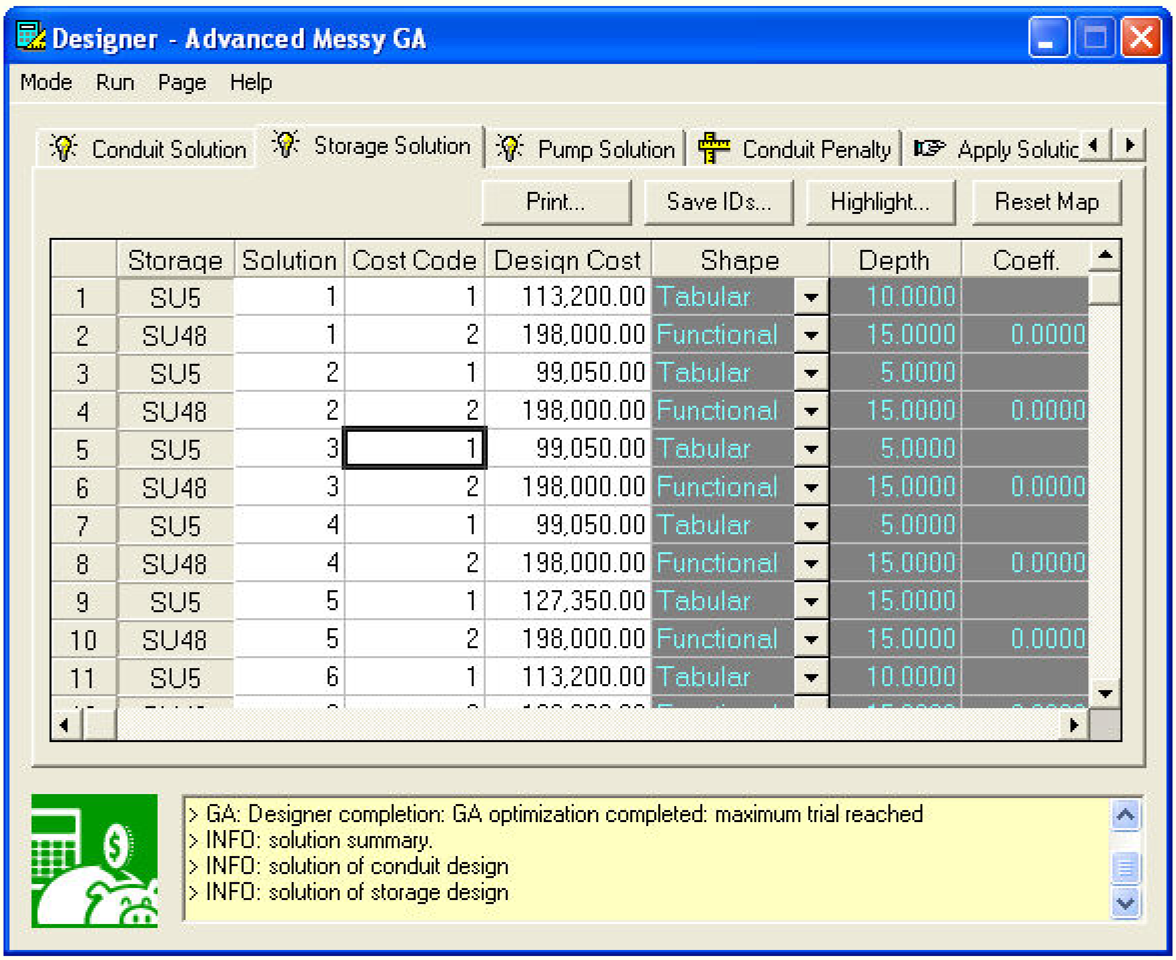
[Pump Groups]

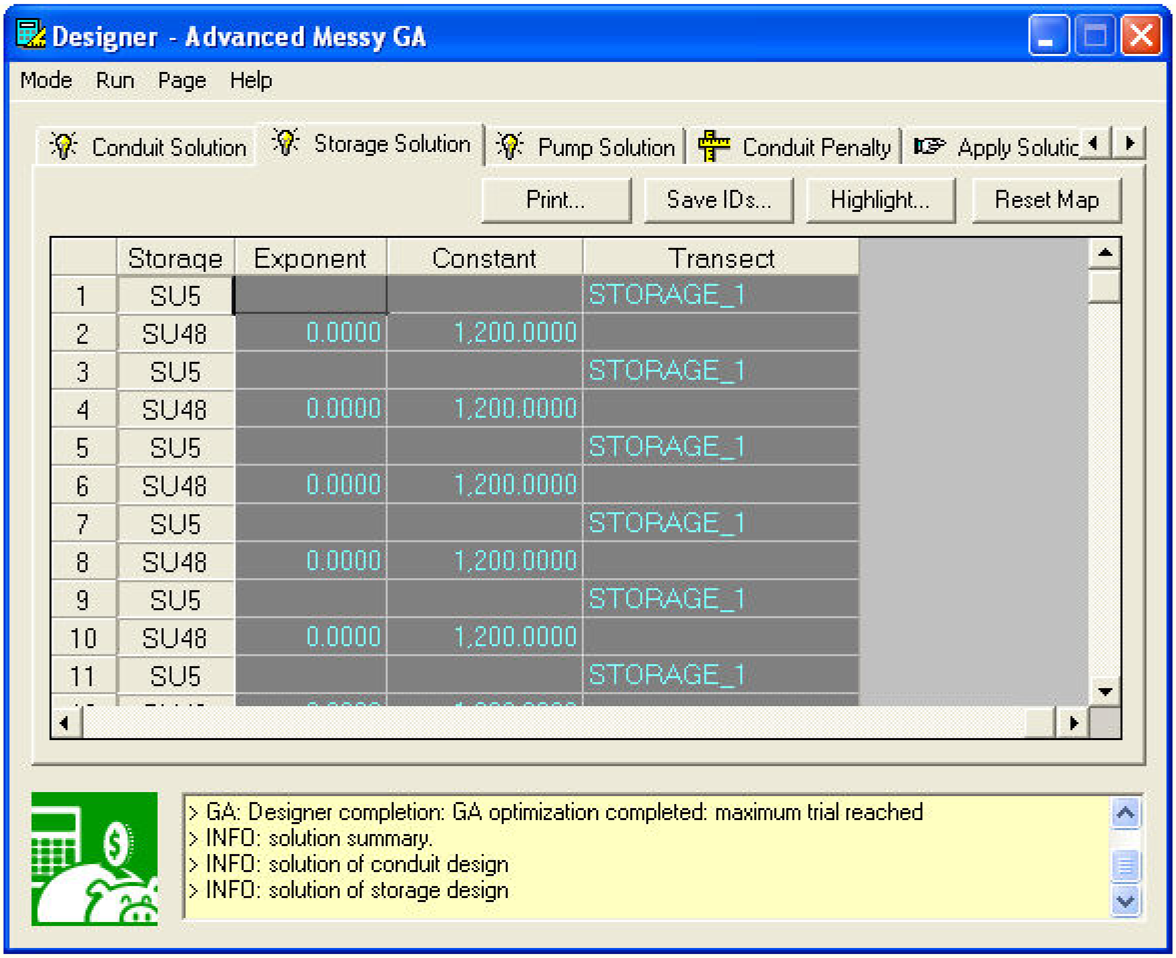
[Pump Design]

Storage Solution

The Storage Solution tab details the optimal geometries as determined by the last Designer optimization run for all storages listed on the Storage Group tab.

This tab summarizes the design cost and parameters (storage depth, area v. depth curve for tabular storage, and equation variables for functional storage) for all solutions.





Note -

Click on any portion of the dialog box above for information on any item.

See Also

[Storage Groups]

[Storage Design]

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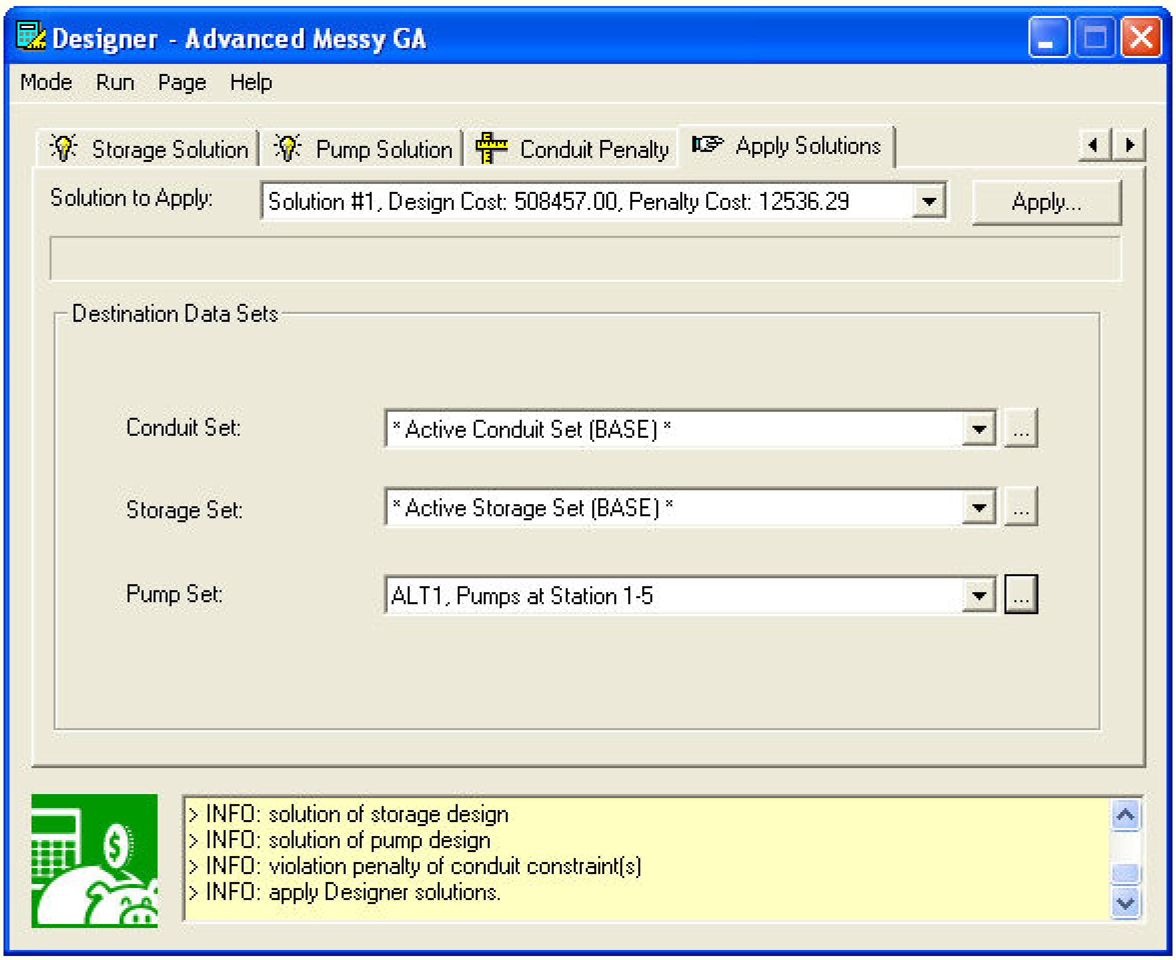
Apply Solutions

The Apply Solutions tab is used to export parameters obtained through the optimization process. The parameters may be exported to the dataset of any scenario. Please refer to the InfoSWMM

helpfile for more information on datasets and scenarios.

The apply solutions button is not available until after the Designer has run. Upon completion of a design run, optimized solutions can be exported and the datasets from the drop-down will be overwritten.



Note -

Click on any portion of the dialog box above for information on any item.

See Also

[Running the Designer]

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Introduction

Control of sewer overflows is vital to reducing risks to public health and protecting the environment from water pollution. Sewer overflows are a leading cause of water pollution in the nation’s lakes, streams and inland bays. The untreated sewage from these overflows contains microbial pathogens, suspended solids, toxics, nutrients, trash, and other pollutants that deplete dissolved oxygen and can contaminate our waters, causing serious water quality problems and threatening drinking water supplies, fish and shellfish. This sewage can also back up into basements, causing property damage and creating threats to public health for those who come in contact with the untreated sewage.

With the growing expectations by the public for quality services, the U.S. Environmental Protection Agency under the authority of the Clean Water Act adopted by Congress has implemented pollution control programs and set wastewater standards for the industry. In order to meet these requirements, comprehensive modeling and analysis of these sewer systems becomes necessary for developing and evaluating sound cost-effective solutions for enhancing system integrity and performance to reliably convey sewer flows without surcharging, overflows, flooding, and backups.

Today, many wastewater utilities utilize hydraulic network simulation models to plan improvements and design better systems. These improvements are normally achieved through increasing conduit capacity, storage volume, and pumping capacity. Current practice involves a tedious trial-and-evaluation procedure that seldom leads to the most effective or most economical solutions for upgrading collection systems. This requires using the hydraulic collection system simulation model to evaluate the hydraulic performance of the existing collection system with different design alternatives (modifications) under a range of loading conditions. The design that meets the target hydraulic criteria for the lowest cost is then selected from among the alternative designs.

However, given the vast number of combinations of possible enhancements, it is unlikely that even the most experienced engineer will be able to determine the least-cost improvement alternative. This process is also not able to ensure that the final design could perform adequately under all possible loading conditions. The result of using the traditional trial-and-evaluation approach is often inefficient performance at greater cost.

InfoSWMM

Designer offers a very sophisticated optimization capability representing a major step forward for collection system modeling. With this capability, you can rapidly formulate and assess various reliable and cost-effective improvement solutions, which previously required a tedious trial-and-error approach or were not practical to even attempt. InfoSWMM

Designer leverages

the power of advanced Genetic Algorithms optimization technology to automatically select the most cost-effective solution to flooding and pollution management, using a combination of pipe upsizing, storage, pumping and new piping to eliminate unwanted sewer overflows and achieve targeted system performance requirements. It is the ultimate tool to help engineers produce the best possible design and improvement alternatives with minimum effort and at significant cost savings. Performance criteria include maximum allowable depth to diameter ratio, minimum and maximum pipe velocities, and maximum head loss for force mains. These capabilities will greatly assist wastewater utilities in planning and designing reliable systems and optimizing their capital improvement programs — leading to healthier communities, cleaner beaches, and fish and shellfish that are safer to eat.

An invaluable and complete master

planning, operations and decision support tool, InfoSWMM

Designer gives

wastewater utilities the very best tool for performing the highly sophisticated urban stormwater runoff modeling they need to shape their stormwater runoff management plans and control sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs). It will help them pinpoint the most cost-effective way to remove all targeted flooding, keep their systems operating efficiently well into the future, and safeguard against adverse health and environmental effects – all in an extremely

easy-to-use and fully interactive GIS environment.

We are happy to bring you the state-of-the-art in collection system optimization technology to help you plan, design, construct and operate better systems.

Colby T. Manwaring, P.E.

Chief Executive Officer, Innovyze Inc.

Portland, Oregon USA January 30, 2019

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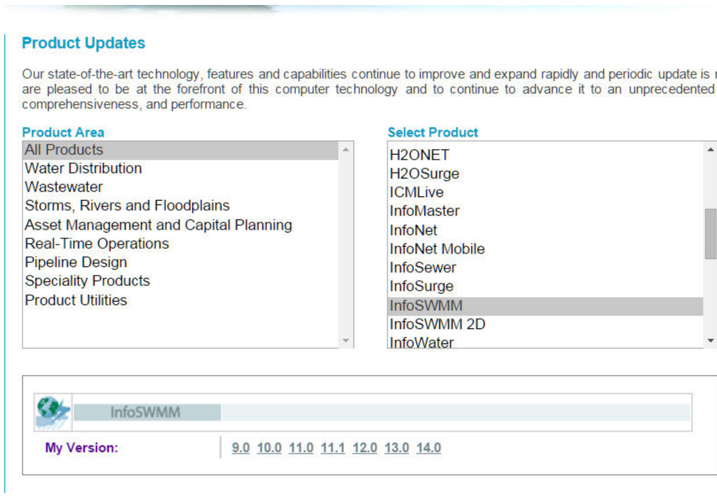
Installation Guide

System Requirements for InfoSWMM w ArcGIS, H2OMap SWMM does not need ArcGIS	
Compatible 32-bit OS:	Windows Server 2008 R2, Windows Server 2012 R2, Windows 7/8/8.1/10 pro or above
Compatible 64-bit OS:	Windows Server 2008 R2, Windows Server 2012 R2, Windows 7/8/8.1/10 pro or above
Compatible ArcGIS:	10.0, 10.1, 10.2 and 10.3 -10.4 (**Check your PC ability to run ArcGIS**)
Prerequisites:	**Microsoft Visual C++ 2008 Redistributable - x64 v9.0.30729.17**/**Microsoft Visual C++ 2008 Redistributable - x86 v9.0.30729.17**, **Microsoft Visual C++ 2010 Redistributable - x86 v10.0.40219.1**/**Microsoft Visual C++ 2010 Redistributable - x64 v10.0.40219.1** and **Windows Internet Explorer 7 or later**
Hardware Requirements:	CPU Speed: 2.2 GHz minimum or higher; Hyper-threading (HHT) or Multi-core recommended Processor: Intel Pentium 4, Intel Core Duo, or Xeon Processors; SSE2 (or greater) Memory/RAM: 2 GB or higher Screen Resolution: 1024 x 768 recommended or higher at Normal size (96dpi) Disk Space: 500 MB of free space to accommodate a full setup installation and additional disk space - keep as much free disk space available as possible. Its virtual memory system needs additional free disk space when working on large projects Video/Graphics Adapter: 64 MB RAM minimum, 256 MB RAM or higher recommended. NVIDIA, ATI and INTEL chipsets supported Networking Hardware: Simple TCP/IP, Network Card or Microsoft Loopback Adapter is required for the License Manager

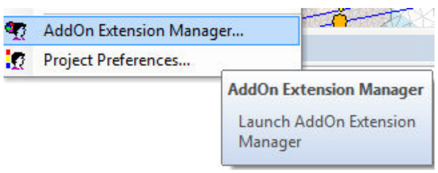
Installing Innovyze Software Add On's and Extensions

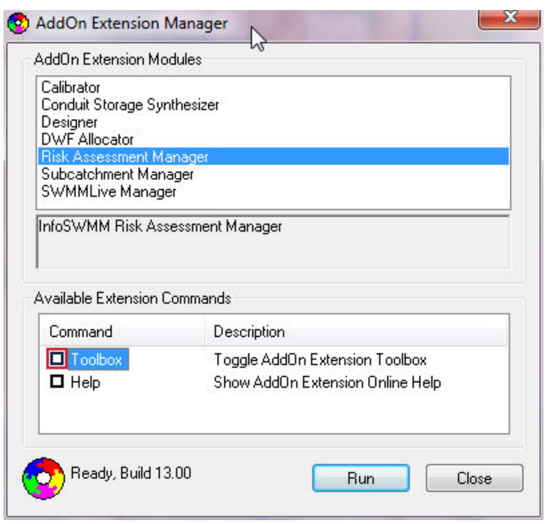
Innovyze programs can only be installed from our Internet website. To install this program or a single user, perform the following procedure:

- Turn on your computer and start Windows. Close any other applications that are currently running.
- Start your Internet Browser software and go to http://www.Innovyze.com. Once on Innovyze® Inc's homepage, please go to http://www.innovyze.com/updates/ Choose the *program* tab and click on the link. This will launch the File Download dialogue box.
- Choose the *SAVE THIS PROGRAM TO A Directory* option and follow the on-screen instructions. When saved on your hard drive run the Execute (*.exe) file from the folder that was downloaded and follow the on-screen instructions.



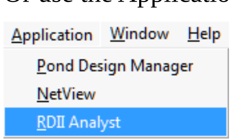
Upon successful installation of the program, the program is initialized from inside InfoSWMM by using the “AddOn Extension Manager” tool. From the Tool Menul, select an Add On as shown below.

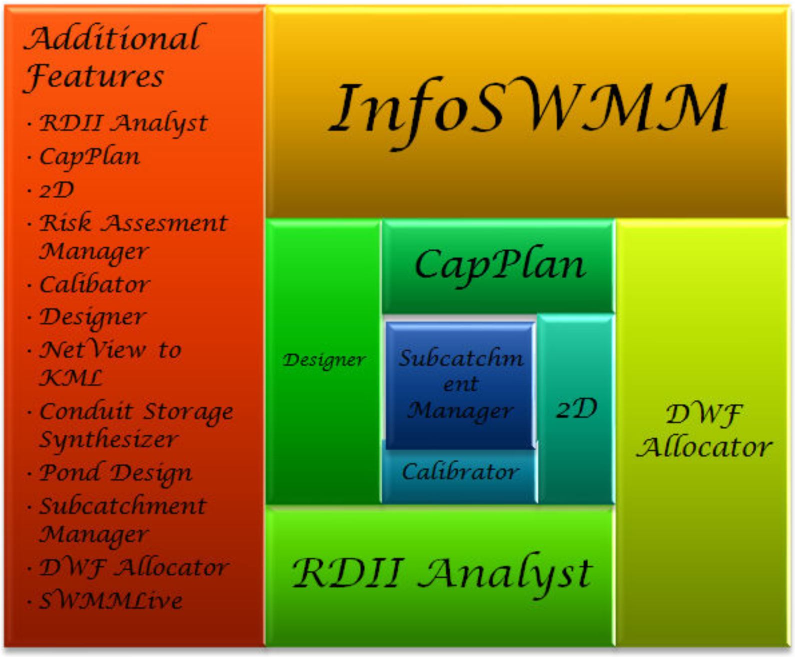




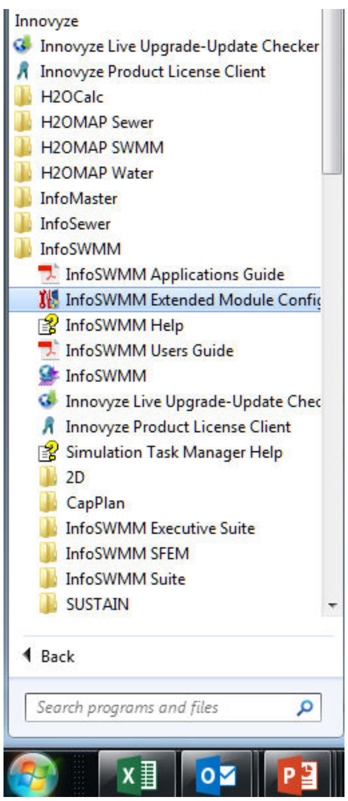
The selected run dialog appears, and it is now available for use. Section 2 discusses each icon and the menu shown below in detail. This program is part of the InfoSWMM Suite.

Or use the Application Window where there are additional AddOns for InfoSWMM





If you do not see the AddON's or Applications for the InfoSWMM Suite version of then you can use the InfoSWMMExtended Module Configuration from Windows Start.



Using the On Line Help

Innovyze provides on-line Help with extensive information about modeling features and capabilities. The documentation includes numerous topics, each including narrative descriptions, illustrations, and diagrams describing the features of each program.

The on-line Help offers the ability to search for a desired topic rapidly or to move between related topics in a fast, efficient manner. An extensive index is available allowing you to search on any number of words, phrases, or commands. Innovyze Help includes several major sections, each identified by a magenta book in the Help Contents. Each section contains numerous related topics.

StartingInnovyze Help

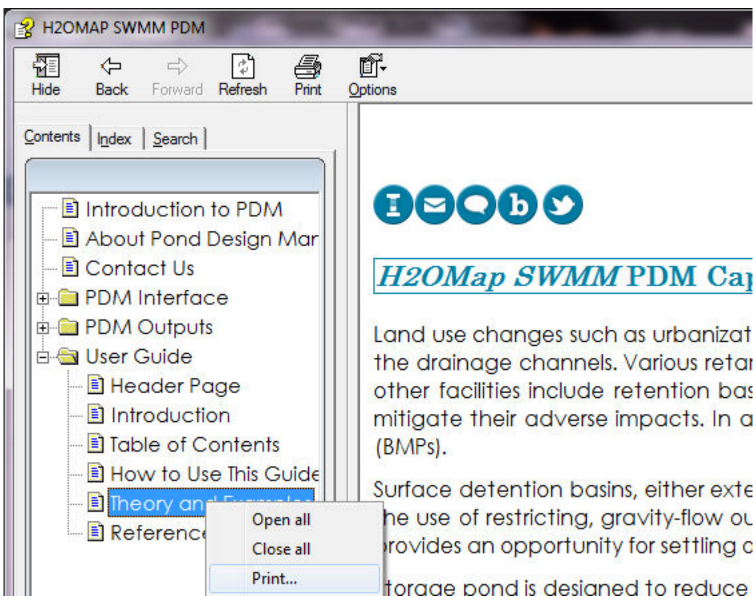
Innovyze Help is available by opening any Innovyze dialog box and pressing the F1 key. You may click on any portion of the dialog box in the help topic for more information.

Navigating the On Line Help

Use either Innovyze Help Contents or the Index to navigate to the desired topic. Choose the Help Topic button in the upper left-hand corner of the Help window to access the Help contents and index. Embedded in the text of each topic are numerous *links*, identified as underlined blue text, to related topics. Simply click on the desired link text with the mouse to move immediately to the related topic.

Printing the OnLine Help

You may print any Innovyze Help topics you desire. To do so, navigate to the desired Help topic and then choose the Print Topic command from the Help window File menu.



Instructions to Renew the CD and License Keys for the Innovyze (MWH Soft) Floating License Server

Below are instructions to renew the CD and License Keys for the Innovyze (MWH Soft) Floating License Server and the floating licenses to reflect the current expiration date.

1. Open the Innovyze (MWH Soft) Floating License Server.
2. Go to the **Help** -> **About** menu in the upper left corner.
3. Go to the Request License Key On-line for dropdown menu and select Renewal. Press the **Go** button. This will open our On-Line License Registration page.

4. Complete the requested information and press the **Submit** button. This should return to you a new CD Key and License Key.

5. Copy and paste the new keys into the appropriate boxes in the **About** dialog box.

6. Press the **Apply License Changes** button. A new Subscription Expiration Date should appear.

7. Close the **About** box and the Innovyze (MWH Soft) Floating License Server.

8. Download and run the update for the Innovyze (MWH Soft) Floating License Server from the attached link:

- [Innovyze Floating License Server 5.0 Update 020 (22.03 MB), 12/10/2015]

9. Open the Innovyze (MWH Soft) Floating License Server.

10. If your FLM is installed on a virtual server, go to the upper left corner and select **Action** -> **Register Virtual Environment …**

11. Select the License Administration tab.

12. Go to the Request License Key On-Line for dropdown menu and select **Renewal**. Press the **Go** button. This will open our On-Line License Registration page.

13. Complete the requested information and press the **Submit** button. This should return to you a new CD Key and License Key.

14. Copy and paste the new keys into the appropriate boxes in the License Administration tab.

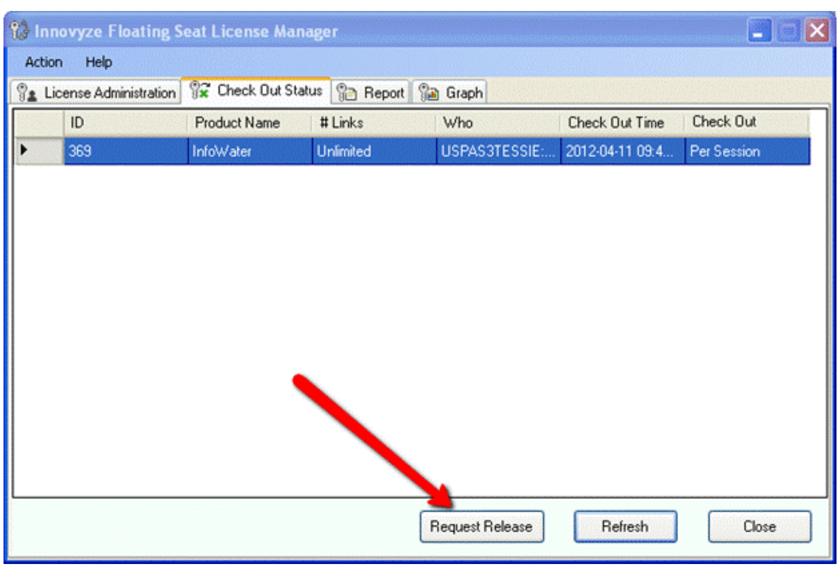
15. Press the **Apply** button. A new Expiration Date should appear.

Press the Close button

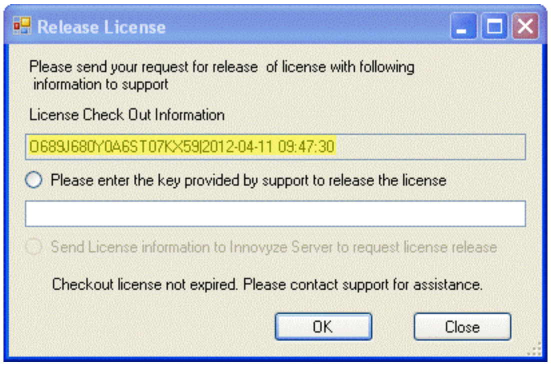
Please follow the instructions below to request a license release key for a floating license.

Please follow the instructions below to request a license release key for a floating license. Most likely this will need to be forwarded to someone who has access to the Innovyze Floating Seat License Manager on a server.

- Open the Innovyze Floating Seat License Manager and select the Check Out Status tab.
- Select the license to release and press the Request Release button.



Copy the License Check Out Information generated and paste into an email to support@innovyze.com



- We will return to you a code to enter in to the second field.
- Once both fields are populated in the Release License dialog box, press the OK button to release the license.

Technical Support On the Web and by Email

See the Help file Topic Contact Us for detailed Innovyze Technical Support information.

2.0 SWMM Designer Interface

Designer provides very sophisticated system optimization capabilities for reliable, cost-effective, and efficient design of collection systems.

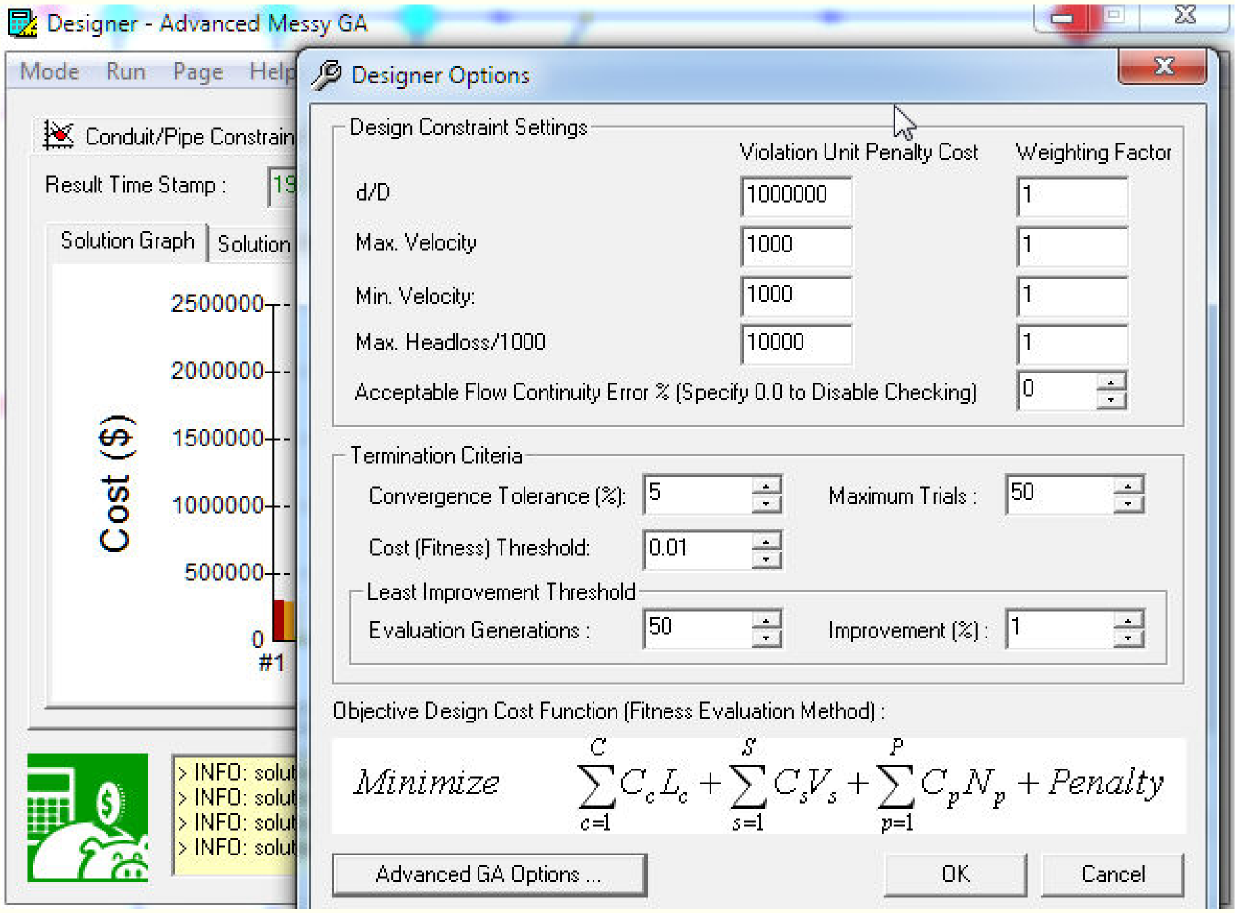
It casts the design conditions as an implicit nonlinear mathematical optimization problem. The optimization problem consists of determining the best combination of sewer, pump and storage sizes that produce the minimum cost while satisfying prescribed system design/hydraulic performance criteria.

Improvement unit costs (i.e. cost per length, pump cost, and/or cost per volume of storage) can be specified for each type of candidate improvement (construction of a new sewer, additional storage, and increased pumping capacity) alternatives. Any number of unit costs may be designated for each sewer size so that estimated costs based on urban versus rural areas, high traffic versus low traffic areas, and other pipe installation conditions can be accurately represented. The portion of the system to be optimized may also be specified. Any desired section of the collection system model can be selected for optimization including the entire system, any particular sub-division, a geographical area, or any area selected through a database query. A database query may be applicable when evaluating different improvement options for sanitary sewer versus storm sewer in a combined system.

Conduits, Storage, and Pumps selected for an optimization run are lumped into distinct "groups" for each type of facility based on the cost. Separate facility groups are then identified with the appropriate cost code and allowable improvement actions. Finally, target design/hydraulic performance constraints are specified such as maximum allowable depth to diameter ratio, maximum velocity, minimum velocity, and maximum head loss in a force main.

Following the completion of a *Designer* run, the best identified solution for the input parameters specified is presented. *Designer* output results include all recommended replacement sewers, additional or increased storage, and modified pumping capacity for increasing the hydraulic capacity of existing system. *Designer* allows for the automatic update of the InfoSWMM database tables with the recommended conduit diameters and new roughness values, the alternative storage volume, and modified pumping capacity that reflect the computed improvement solutions.

In addition, all recommendations can be automatically entered into a new user-defined database field in the existing pipe information table.



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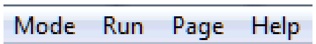
Menu Overview

Designer commands are logically organized into menu pillars (drop-down menus with multiple command choices).

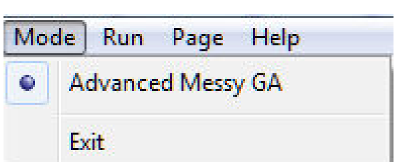


The following commands are available from the above menu bar of the *Designer* dialog box:

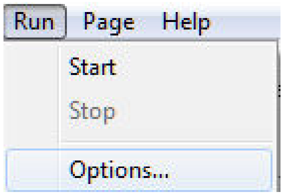
MODE: <u>The following commands are available from the Mode menu.</u>

Advanced Messy GA: Presently, the advanced messy Genetic Algorithm is the only optimization method available with the *Designer*. User specifications to the GA can be made under the Run menu described later in this section.

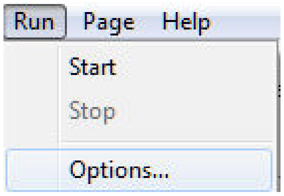
Exit: Exits the *Designer* dialog box and returns to InfoSWMM .



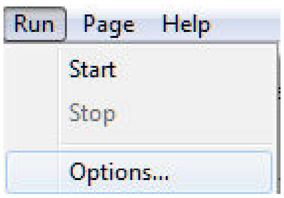
RUN: <u>The following commands are available from the Run menu:</u>



Start: Launches the optimization run based on the input parameters specified.

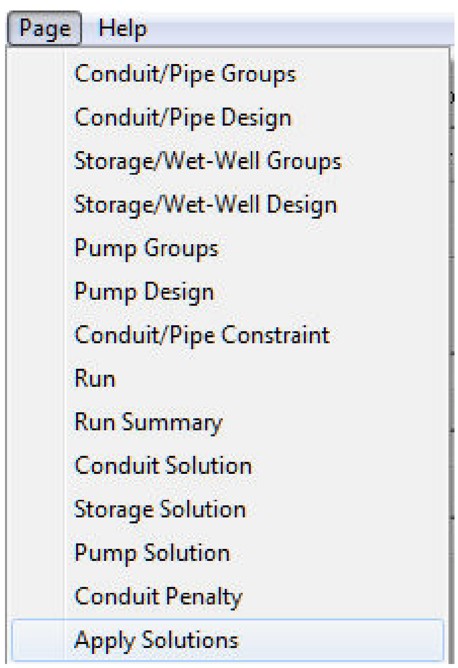


Stop: Interrupts the optimization run. Stops the optimization at any time and allows for the review of the optimization results.



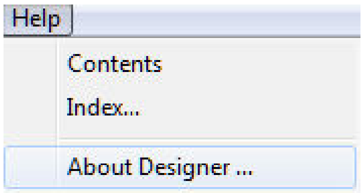
Options: Provides access to specify design constraint settings, termination criteria, and advanced GA options. Details on these options can be found in the on-line help.

<u>**PAGE:** The following commands are available from the Page menu.</u>

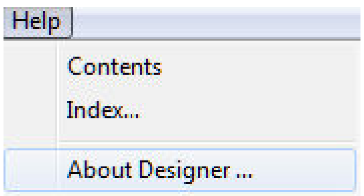


Navigate to different tabs within the *Designer* dialog box. Pages can also be accessed by clicking directly on the tab.

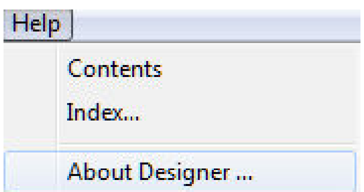
<u>**HELP:** The following commands are available from the *HELP* menu:</u>



Contents: Launches the Contents tab of the *Designer* On-line Help dialog box.

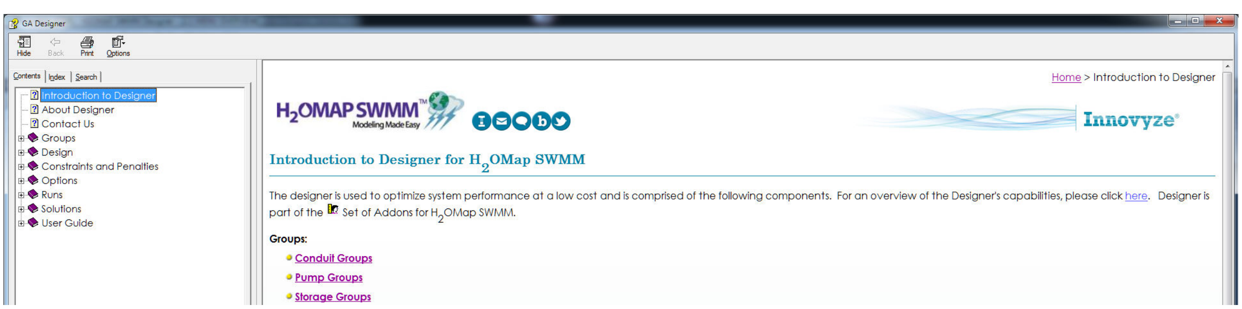


Index…: Launches the Index tab of the *Designer* On-line Help dialog box.



About *Designer*…: Launches the About *Designer* dialog box which summarizes the version properties and other information.

Press the F1 key to see documentation on the command or tool being used. For example, when the Options dialog box is open and the F1 key is pressed, the Options help topic appears on the screen while the Option dialog box is open. Additionally, click on any portion of the dialog box in the help topic for more information.



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2.2 Design Setup and Configuration

Under the tabs of the *Designer* dialog box, design groups can be defined and configured to be used in the optimization analysis. In addition, the cost data and the defined. Finally, the user has the ability to define options controlling the optimization run such as the convergence criteria, and advanced GA options, system constraints can be:

margin-top: 0pt; margin-bottom: 4.5pt; font-weight: bold;">

Innovyze InfoSWMM Innovyze

Groups

Design Set-up and Configuration

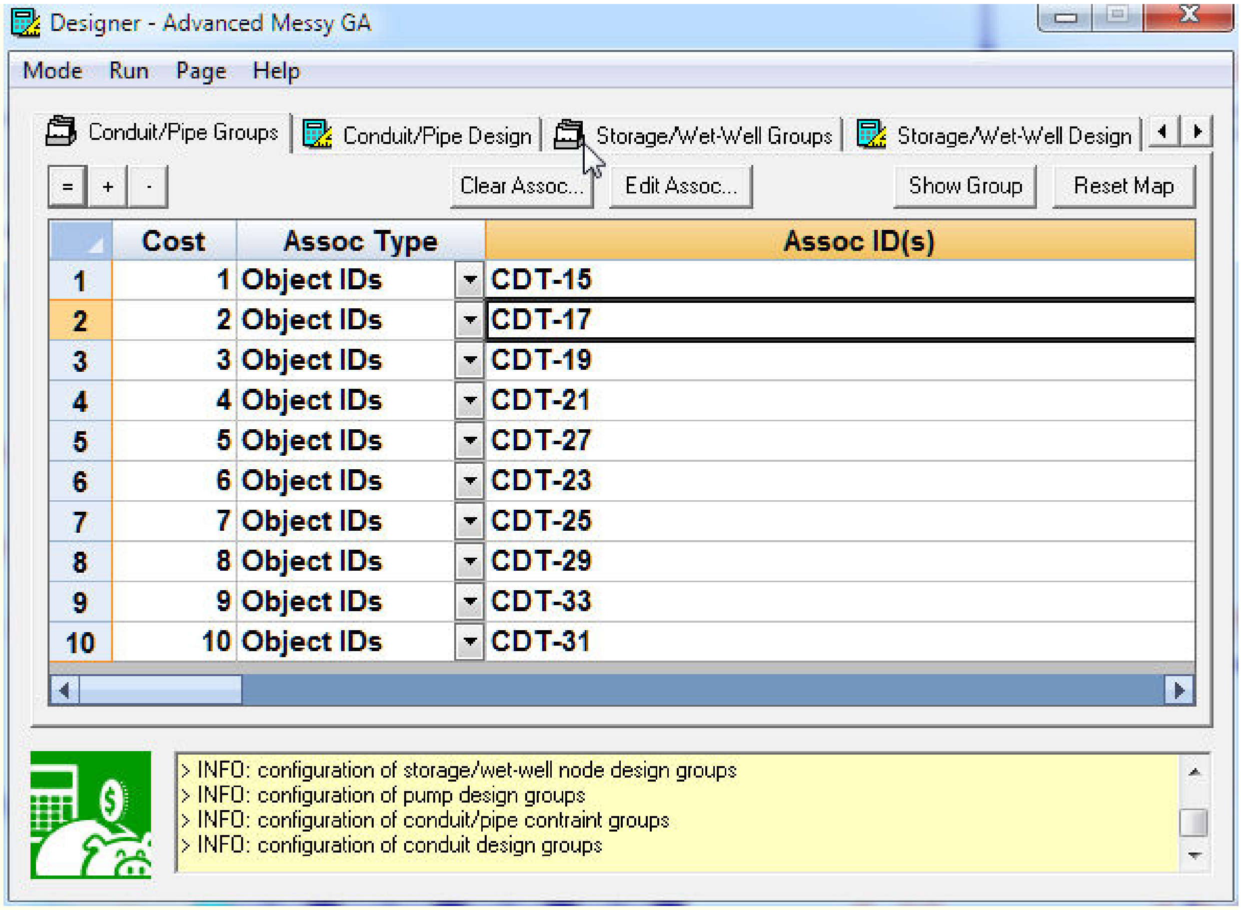
Under the tabs of the *Designer* dialog box, design groups can be defined and configured to be used in the optimization analysis. In addition, the cost data and the system constraints can be defined. Finally, the user has the ability to define options controlling the optimization run such as the convergence criteria, and advanced GA options.

The conduit, storage, and pump groups can be defined based on cost code and used in the optimization analysis. Each element can only belong to one group within a single data field column (e.g. conduit no. 10 cannot belong to both conduit group 1 and conduit group 2).

Unlimited cost codes can be created to evaluate different grouping options (various improvement alternatives). Only elements that are candidate for design or rehabilitation need to be associated with a cost code. Elements that do not belong to a particular group will remain unaffected (their condition unchanged) by the optimization process. Each type of group is described below.

Conduit Group:

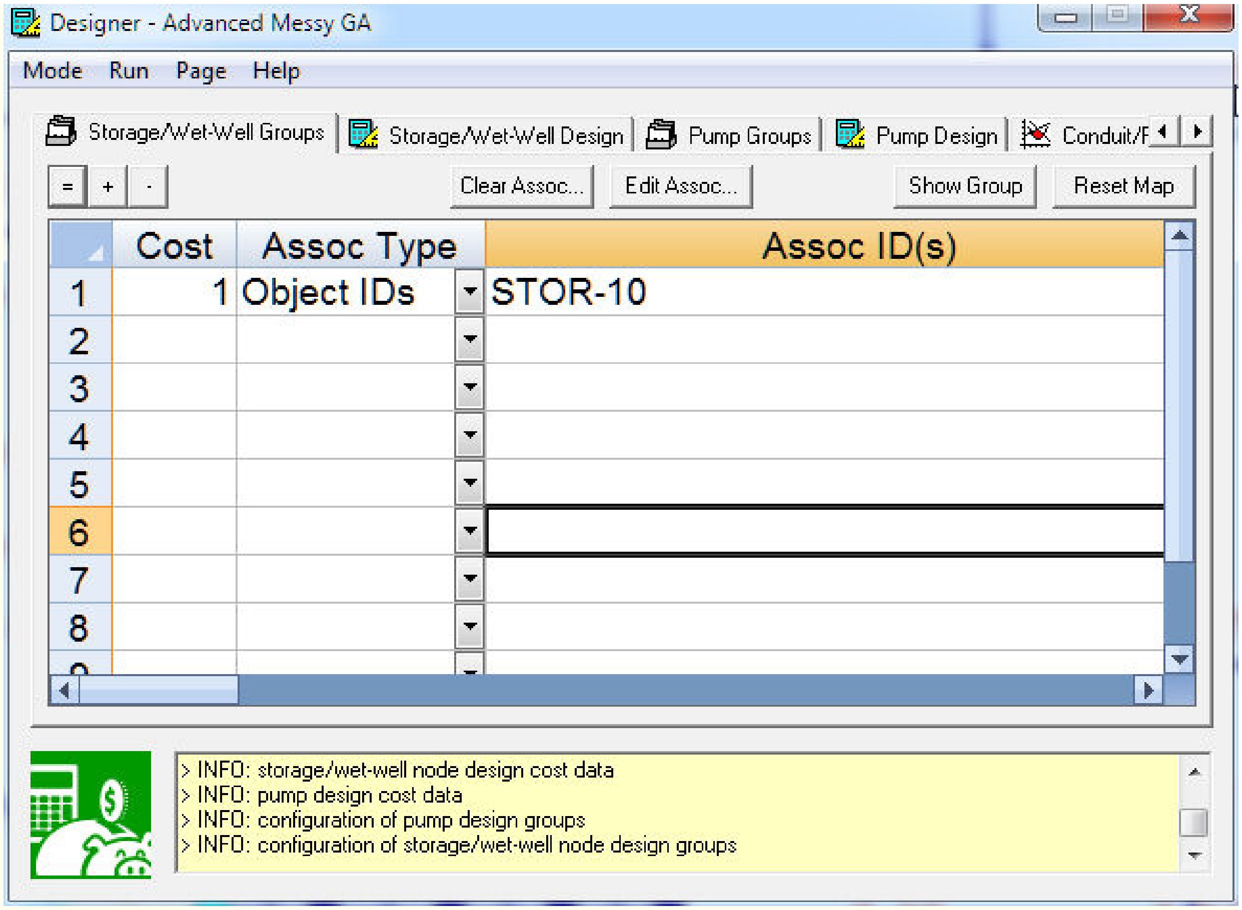
The Conduit Groups tab defines the conduits grouped in each cost code. From this tab, cost codes are associated with conduit ID's. The cost code also is associated with potential replacement conduit cross-section on the Conduit Design tab. After a *Designer* run, one optimal cross-section is selected for each cost code value. The optimal cross-section will be assigned to all conduits with the same cost code if the solution is applied.



Each conduit group can have only one cost code. Therefore, it is recommended that areas of similar costs are determined (e.g., conduits in an urban area with heavy traffic will normally have different costs than conduits in a rural area with no traffic and no paved roads) as one basis for selecting conduit groups. All conduits in that group will be replaced with the same cross-section, so the hydraulic functionality must also be considered when creating groups.

Storage Group:

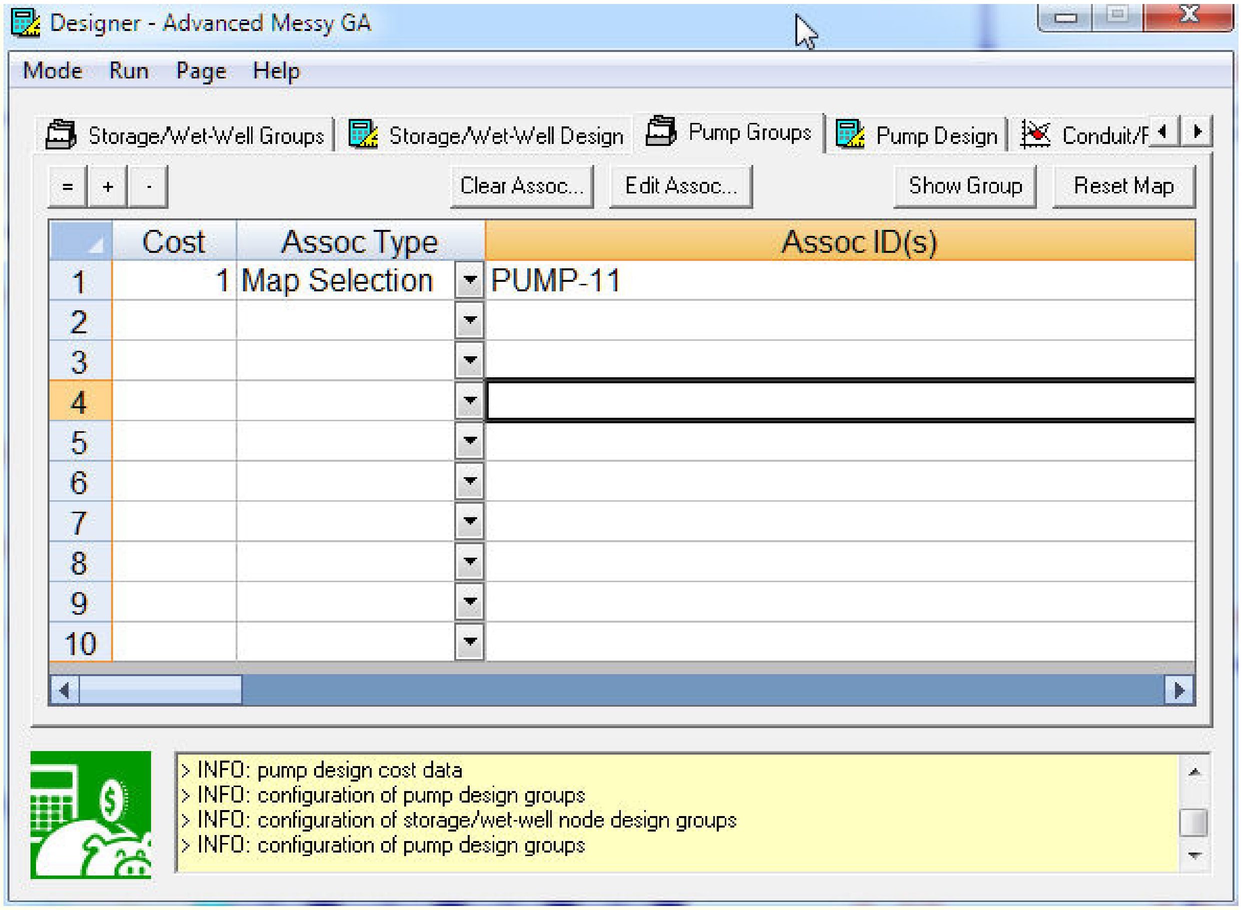
The Storage Groups tab defines the storage facilities grouped in each cost code. From this tab, cost codes are associated with storage ID’s. The cost code also is associated with potential replacement storage geometries on the Storage Design tab. After a *Designer* run, one optimal geometry is selected for each cost code value. The optimal geometry will be assigned to all storages with the same cost code if the solution is applied.



Each storage group can have only one cost code. Therefore, it is recommended that if a system has a limited number of storage facilities (less than 10), each storage facility be in it own group.

Pump Group:

The Pump Groups tab is used to define the Pumps grouped in each cost code. From this tab, cost codes are associated with pump ID’s. The cost code also is associated with potential replacement pump curves on the Pump Design tab. After a *Designer* run, one optimal curve is selected for each cost code value. The optimal curve will be assigned to all pumps with the same cost code if the solution is applied.



Each pump group can have only one cost code. Pumps located at the same pumping station must be grouped with care (if not grouped together), so one pump does not shut off another.

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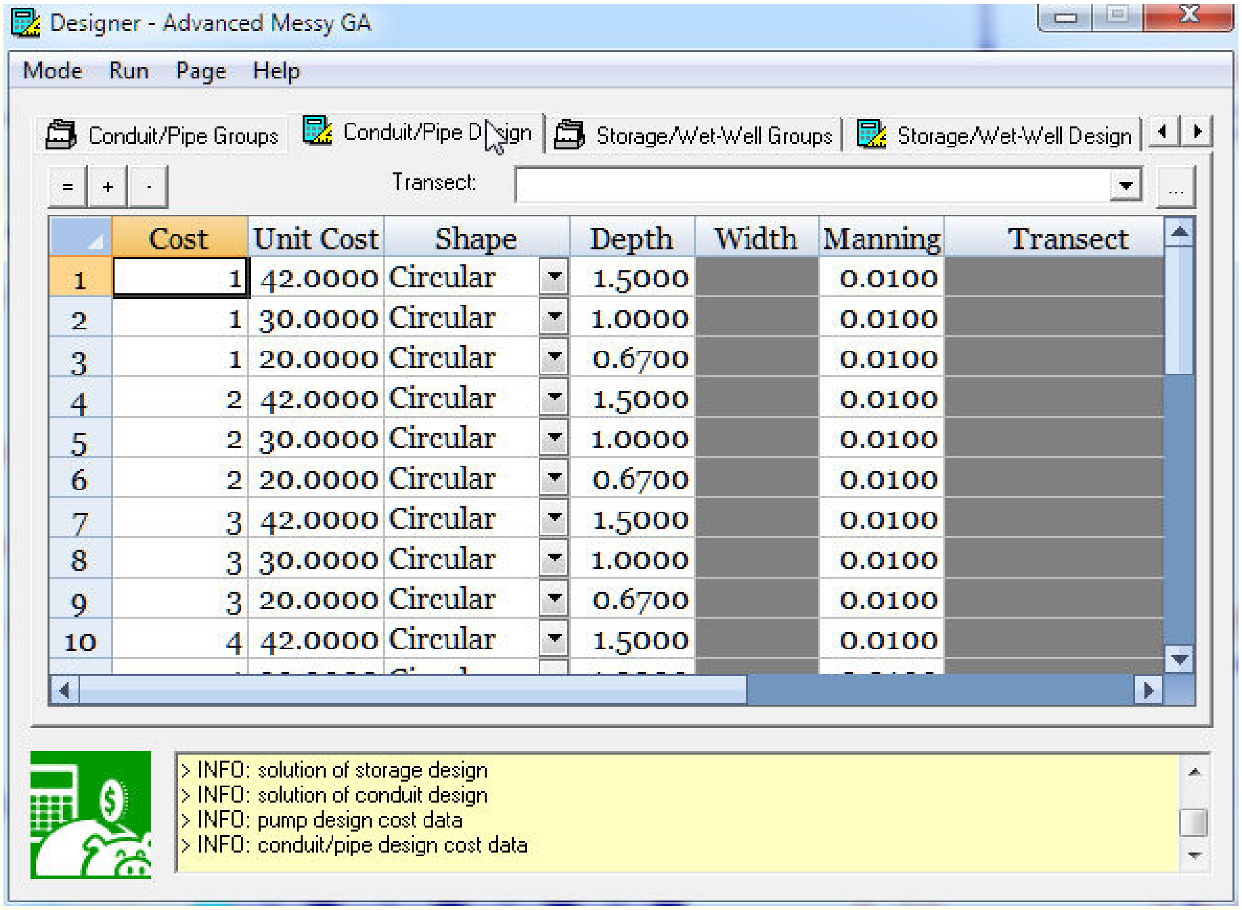
Design

The design tabs are used to specify and define the replacement parameters and unit costs available for each cost code.

Conduit Design:

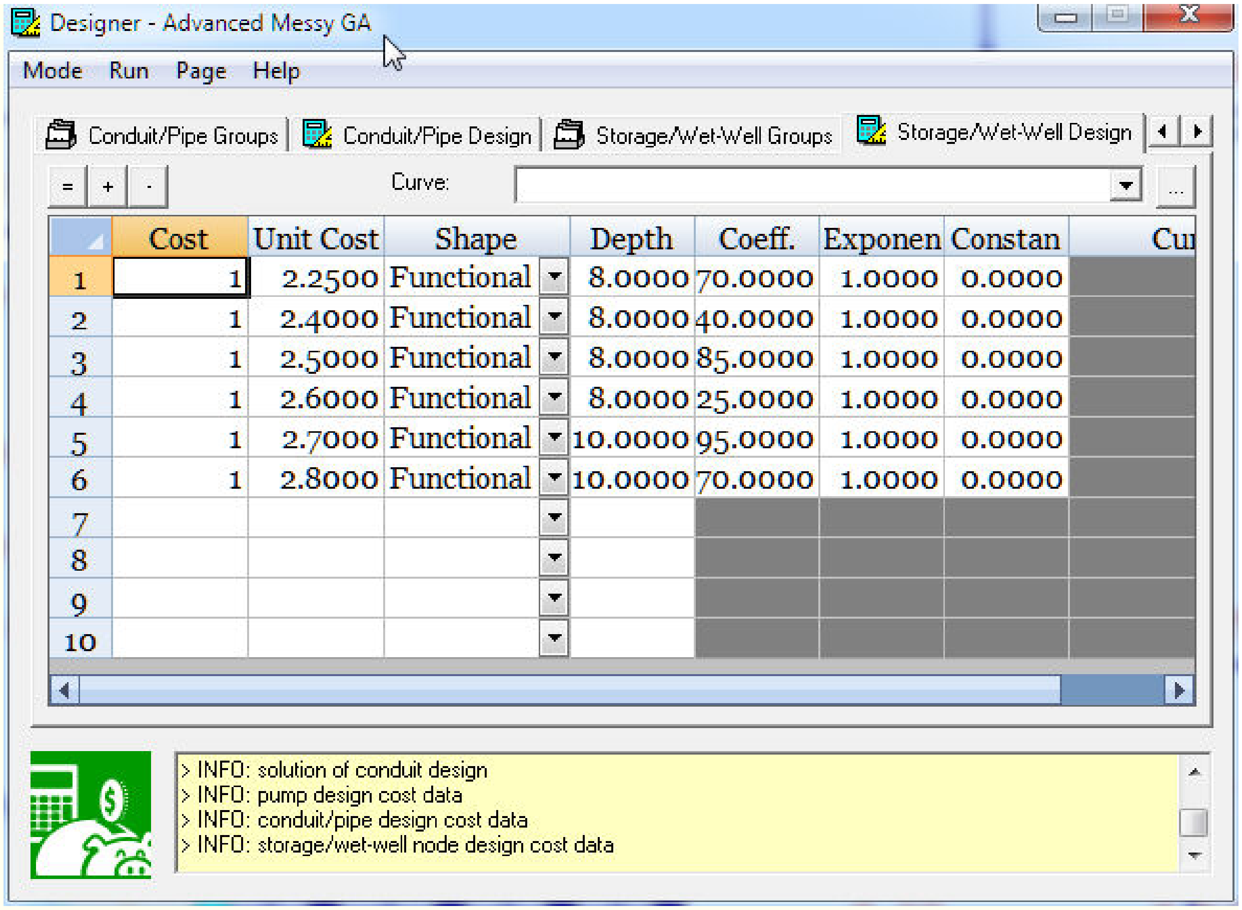
The Conduit Design tab is used to define the replacement conduit cross-sections available for each cost code. Note that non-circular closed conduits must be specified with an equivalent circular section.

Under this tab, the cost per linear foot of each conduit cross-section (row) is defined. This value is used to calculate the costs during the optimization. The type of conduit cross-section for each row is specified as Circular, Open Channel, or Irregular. The shape of the improvement impacts the data that must be entered on the right side of the table. For all closed conduits a diameter or equivalent diameter (depth) and manning coefficient must be specified. For regular shaped open channels, the depth, width, and manning coefficient need to be specified. The depth is defined as the height of the open channel. The width is defined as the bottom width. Note that the *Designer* uses the same side slopes for replacement channels. Thus, rectangular channels will be replaced with rectangular channels. For irregular shaped channels, the transect ID defining the cross-section geometry must be specified. Transects are created in the Operation tab of the Control Center under Hydraulics.



Storage Design:

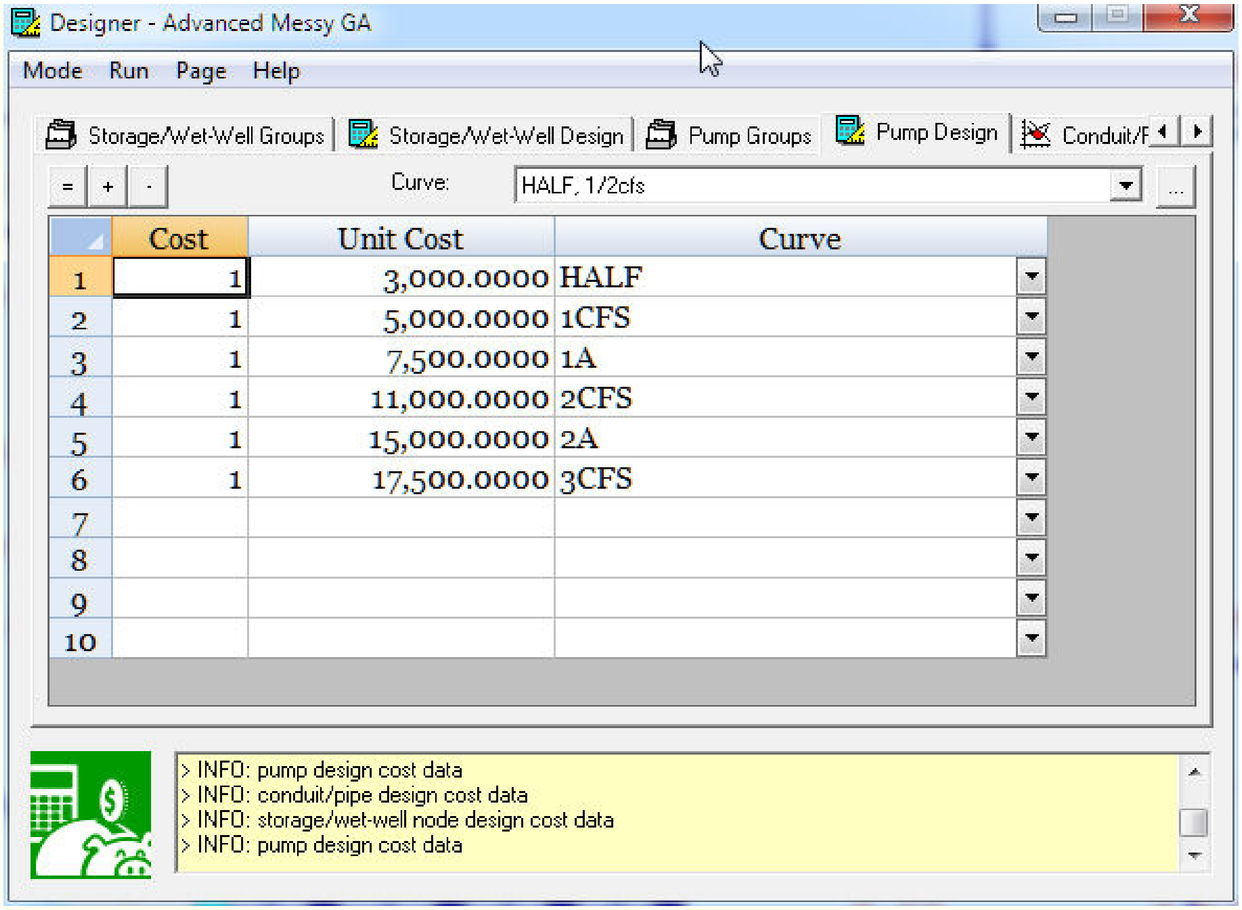
The Storage Design tab is used to define the replacement storage geometries available for each cost code.



Under this tab, the cost per gallon of each storage geometry (row) is defined. This value is used to calculate the costs during the optimization. The shape can be defined as either tabular or functional. Tabular storages have a storage curve assigned to them. The storage curves are defined as depth verses area and can be created in the Operation tab of the Control Center under curves. Functional storage uses the power function (A = coeff.(Depth)^Exponent + constant) to describe how surface area varies with depth. The equation parameters are input to the right of the shape column.

Pump Design:

The Pump Design tab is used to define the replacement pump curves available for each cost code.



Under this tab, the cost of each pump curve is defined. This value is used to calculate the costs during the optimization. The pump curves can be created in the Operation tab of the Control Center under Curves.

More

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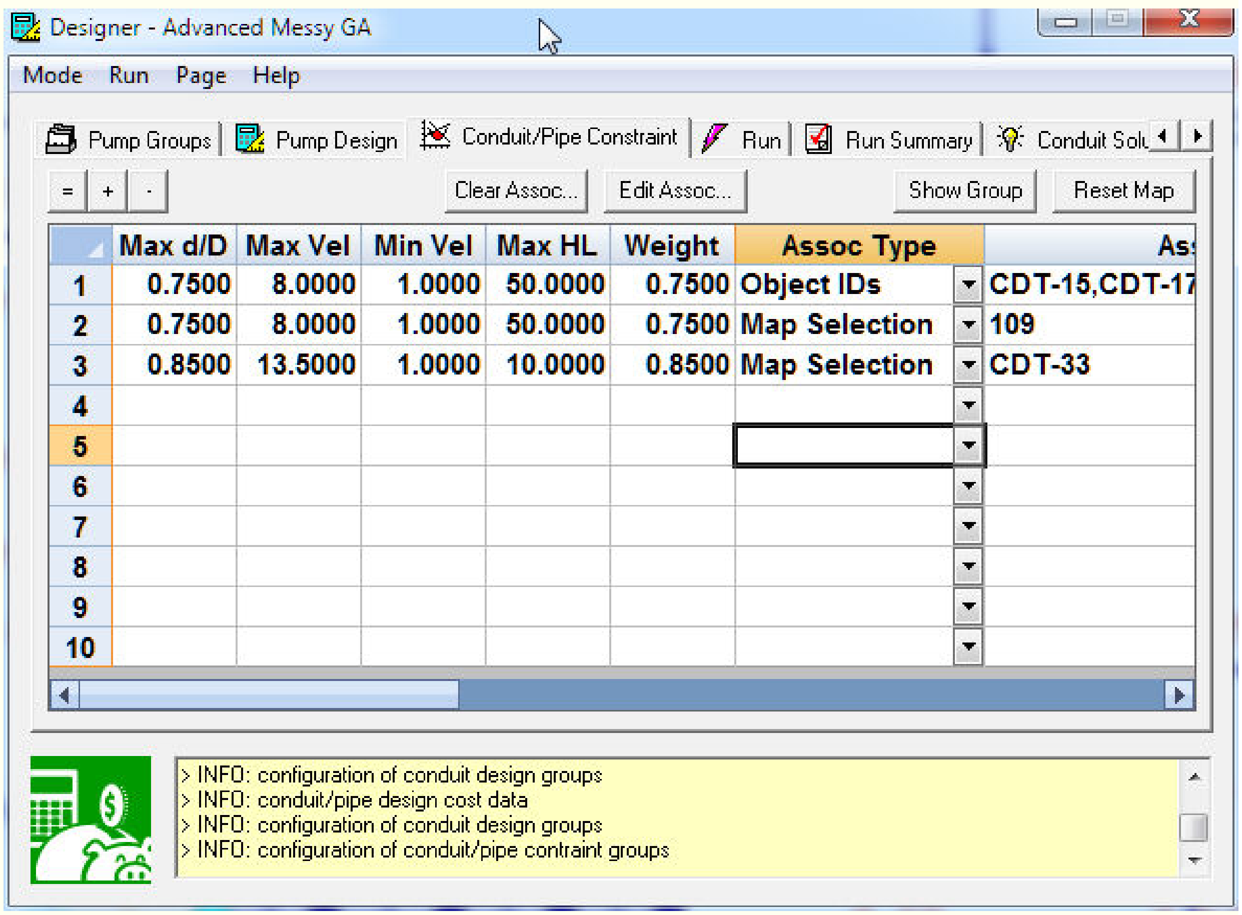
Constraints

The Conduit Constraints tab is used to define the hydraulic criteria that will be used to control the optimization.

Costs are incurred when a solution violates any of the hydraulic criteria defined on this tab. The *Designer* attempts to minimize violations in order to keep the solution cost low. The penalty costs, specified under Options of the Run menu, directly impact the violations that will be seen in a solution.

Maximum depth over diameter, minimum and maximum velocity, and maximum headloss constraints can be specified for conduits. The constraints will be applied to the conduits IDs listed in the Associated ID column.



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Run

To run the *Designer*, select start from the pull down run menu.

The program automatically goes to the run tab. The Run tab is used to detail the optimization process. From this dialog box, the worst, best, and average cost solutions are presented. Also shown are the convergence method, fitness threshold, and lowest cost solution. The run can be stopped at any time, even before convergence or whether the maximum trial number has been reached, from the run drop down menu. Results can still be viewed if the optimization analysis is pre-maturely stopped.

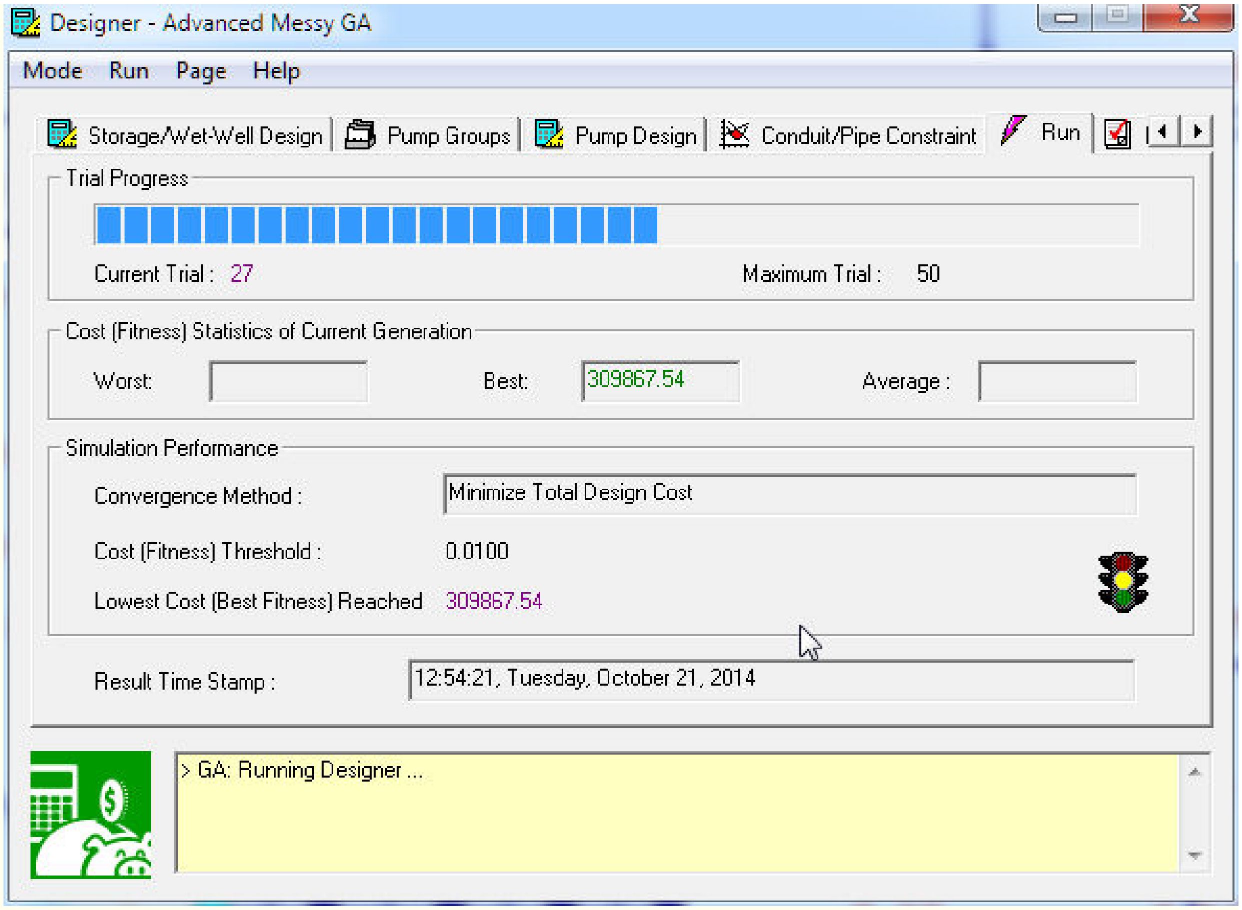
Designer will search for the minimum cost solution. The penalty cost is used to avoid solutions that violate hydraulic constraints and thus guide the optimization procedure towards the desired solution space.

Different values of the penalty cost will result in different design solutions and also affect the efficacy of the optimization calculation. Therefore, a number of trial design runs with different penalty costs are recommended for better exploring the solution space and narrowing in on the lowest cost solutions.

The *Designer* optimization uses the current scenario, enabled controls, and simulation options. Please note that running the *Designer* using Kinematic Wave routing is significantly faster than using Dynamic Wave routing. Depending on the system's hydraulics, you may use Kinematic Wave routing to find optimized designs then test the resulting solution using Dynamic Wave routing. A running InfoSWMM

model

is required to perform a successful *Designer* optimization.



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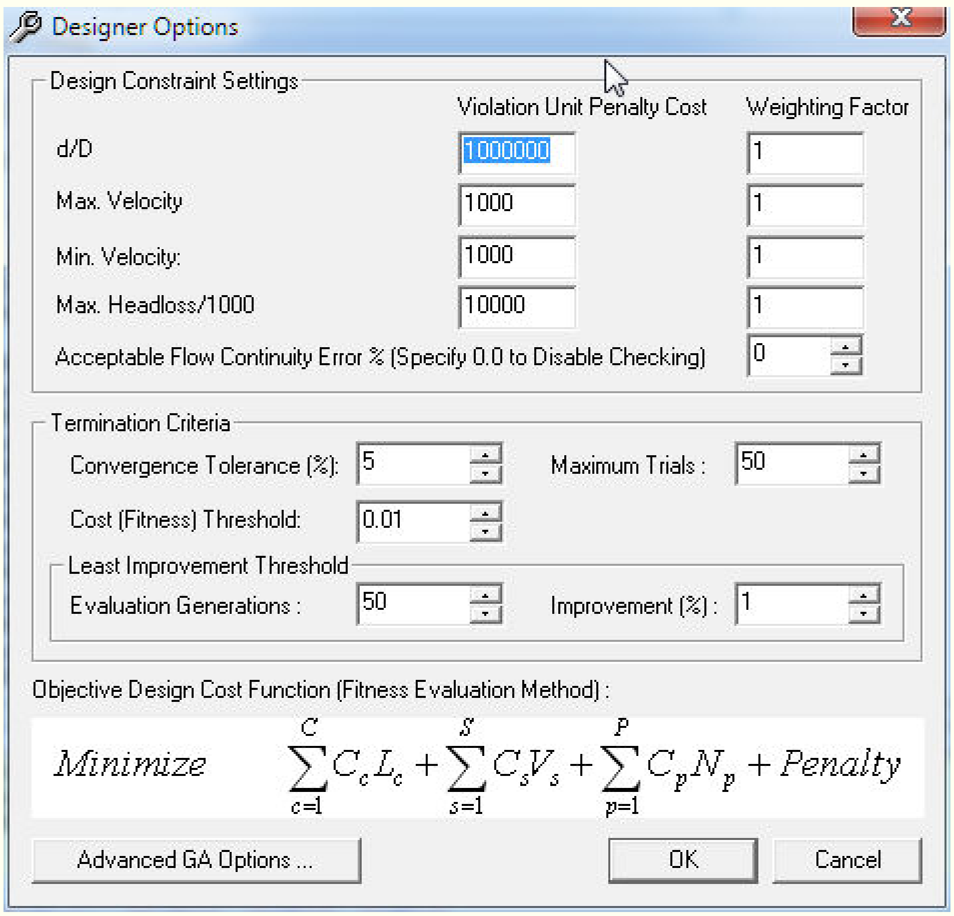
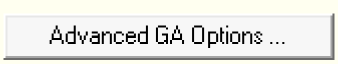
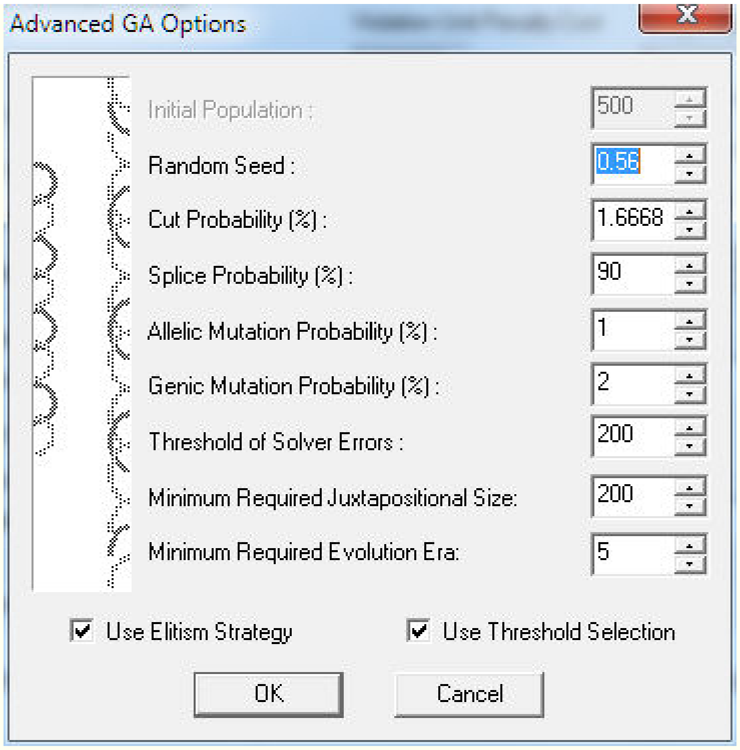
Designer Options

The optimization options can be set from the options dialog box on the run drop down menu. Within this dialog box, the penalty cost data and weighting factors, convergence parameters, and thresholds are set. Advanced GA Options are also accessed through the dialog on the next page.





Launches the dialog box shown below. Advanced GA parameters improve convergence and accuracy.



NOTE: *Refer to Section 4 – Methodology for additional information on the calculation of the objective function.*

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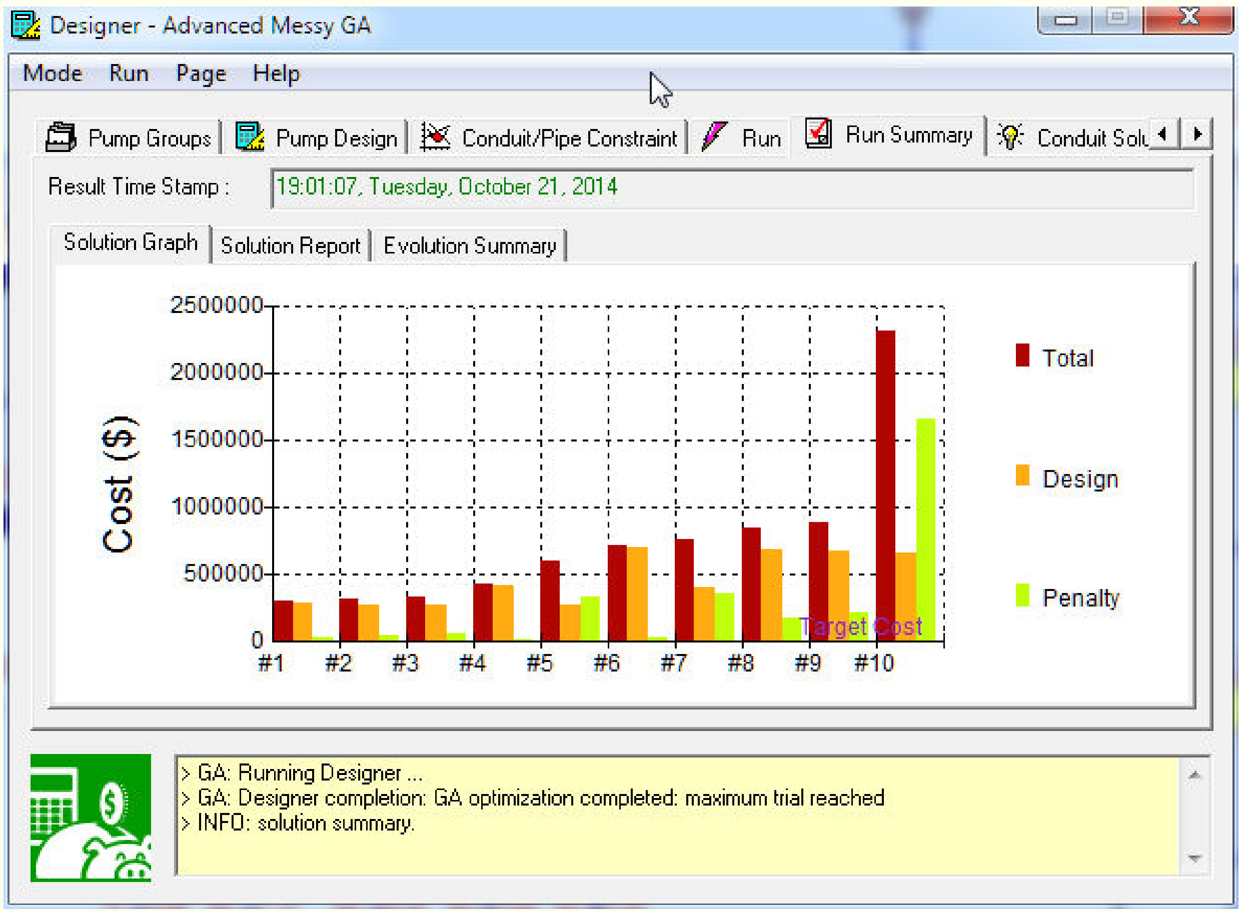
Run Summary

The Run Summary tab is used to detail the best solutions from the last optimization. The solutions are presented graphically and tabular, as well as summarized by evolution.

Solution Graph: The Solution Graph, as shown below, displays a bar graph of the best (lowest total cost) solutions.



The total cost, design cost, and penalty cost are detailed for each solution. A maximum of 10 solutions will be presented on this graph.

Solution Report: The Solution Report displays the same results as the Solution Graph in a tabular format as shown below.

Solution Graph | Solution Report | Evolution Summary

	Solution	Total Cost	Design Cost	Penalty Cost
1	1	294,661.72	273,870.00	20,791.72
2	2	309,867.54	273,390.00	36,477.54
3	3	320,149.74	270,690.00	49,459.74
4	4	422,563.63	407,942.00	14,621.63
5	5	600,031.62	272,040.00	327,991.62
6	6	711,887.40	691,430.00	20,457.40
7	7	746,199.36	394,862.00	351,337.36
8	8	834,415.63	675,630.00	158,785.63
9	9	879,136.03	663,150.00	215,986.03
10	10	2,311,109.65	651,400.00	1,659,709.65

These results can be cut and pasted into Excel or other word Windows compliant software.

Evolution Summary: The Evolution Summary displays total and penalty costs for each solution and summarizes the total generations evolved, number of evolution trials, and total solutions reached.

Solution Graph | Solution Report | Evolution Summary

Total Generations Evolved:	0
Total Number of Evolution Trials:	52
Total Solutions Reached:	10
Cost of Solution #1:	273870.000000
Penalty of Solution #1:	20791.724473
Cost of Solution #2:	273390.000000
Penalty of Solution #2:	36477.535166
Cost of Solution #3:	270690.000000
Penalty of Solution #3:	49459.742709
Cost of Solution #4:	407942.000000
Penalty of Solution #4:	14621.625577
Cost of Solution #5:	272040.000000
Penalty of Solution #5:	327991.620957
Cost of Solution #6:	691430.000000
Penalty of Solution #6:	20457.401253
Cost of Solution #7:	394862.000000

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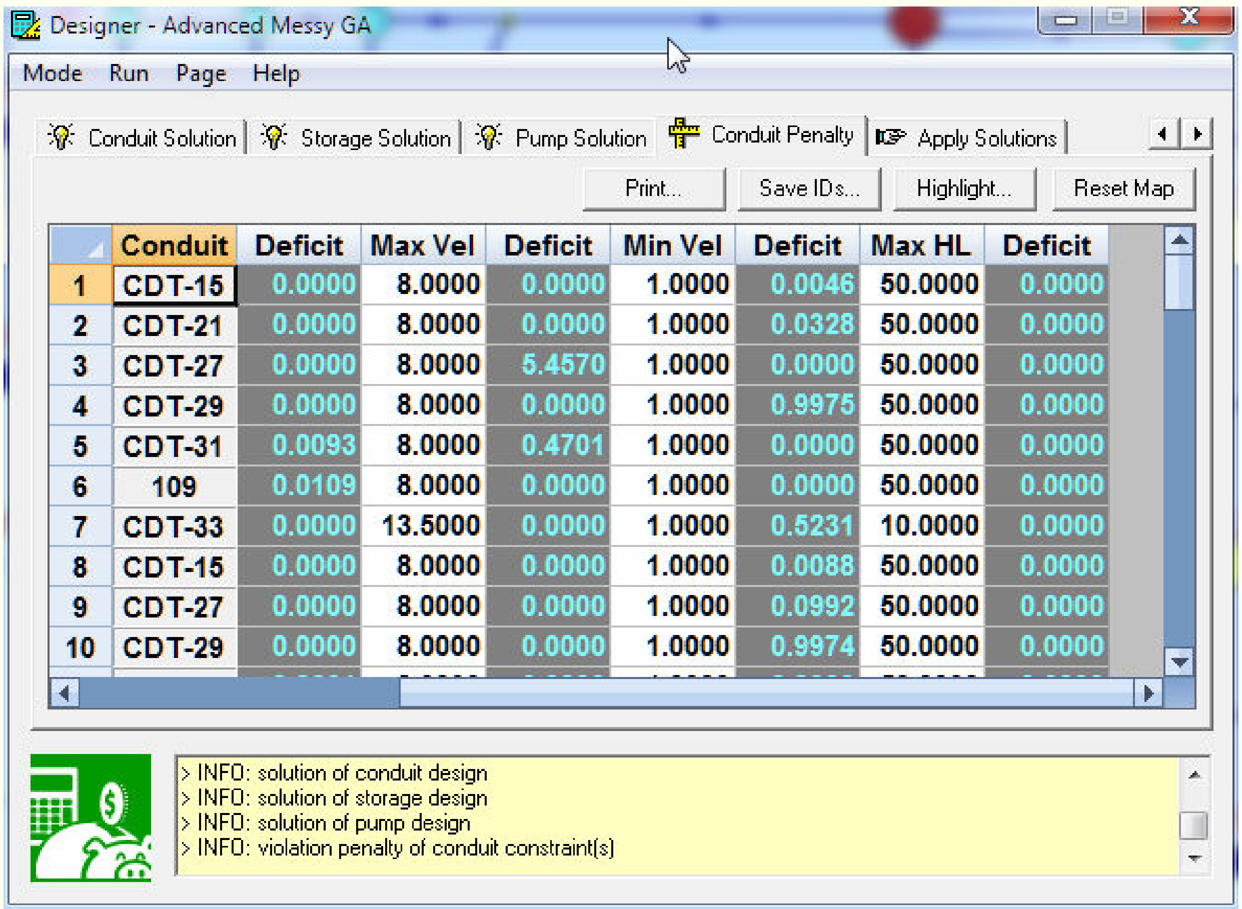
Conduit Penalty

The Conduit Penalty tab is used to detail violations (if any) of hydraulic constraints as specified on the conduit constraints tab. The penalty costs specified in the options directly impacts the violations that appear in this report. This tab summarizes the design criteria and the deficit (the difference between the simulated result and the design criteria) for all conduits for each solution. The number of violations may be typically reduced by increasing the penalty costs in the options.



	Conduit	Deficit	Max Vel	Deficit	Min Vel	Deficit	Max HL	Deficit
1	CDT-15	0.0000	8.0000	0.0000	1.0000	0.0046	50.0000	0.0000
2	CDT-21	0.0000	8.0000	0.0000	1.0000	0.0328	50.0000	0.0000
3	CDT-27	0.0000	8.0000	5.4570	1.0000	0.0000	50.0000	0.0000
4	CDT-29	0.0000	8.0000	0.0000	1.0000	0.9975	50.0000	0.0000
5	CDT-31	0.0093	8.0000	0.4701	1.0000	0.0000	50.0000	0.0000
6	109	0.0109	8.0000	0.0000	1.0000	0.0000	50.0000	0.0000
7	CDT-33	0.0000	13.5000	0.0000	1.0000	0.5231	10.0000	0.0000
8	CDT-15	0.0000	8.0000	0.0000	1.0000	0.0088	50.0000	0.0000
9	CDT-27	0.0000	8.0000	0.0000	1.0000	0.0992	50.0000	0.0000
10	CDT-29	0.0000	8.0000	0.0000	1.0000	0.9974	50.0000	0.0000

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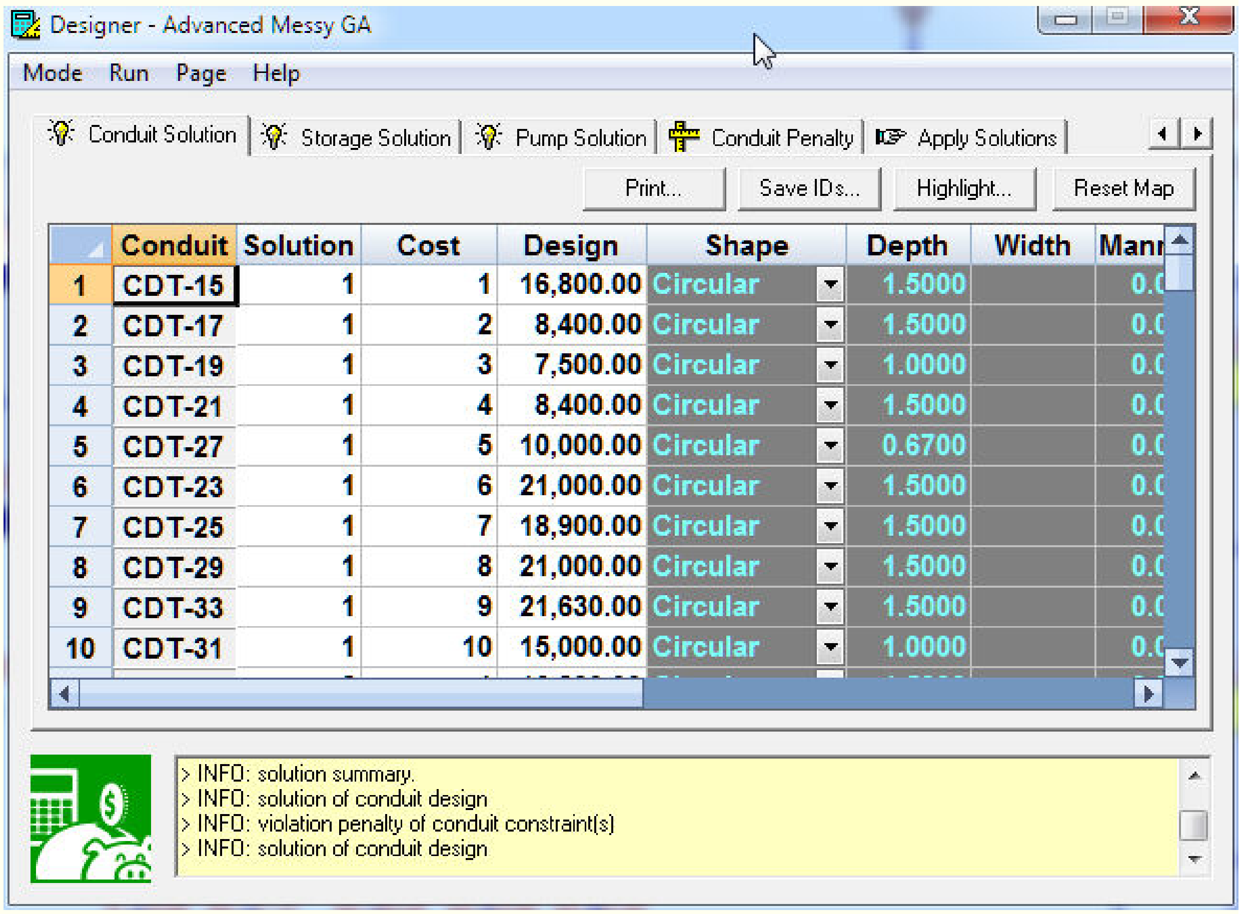
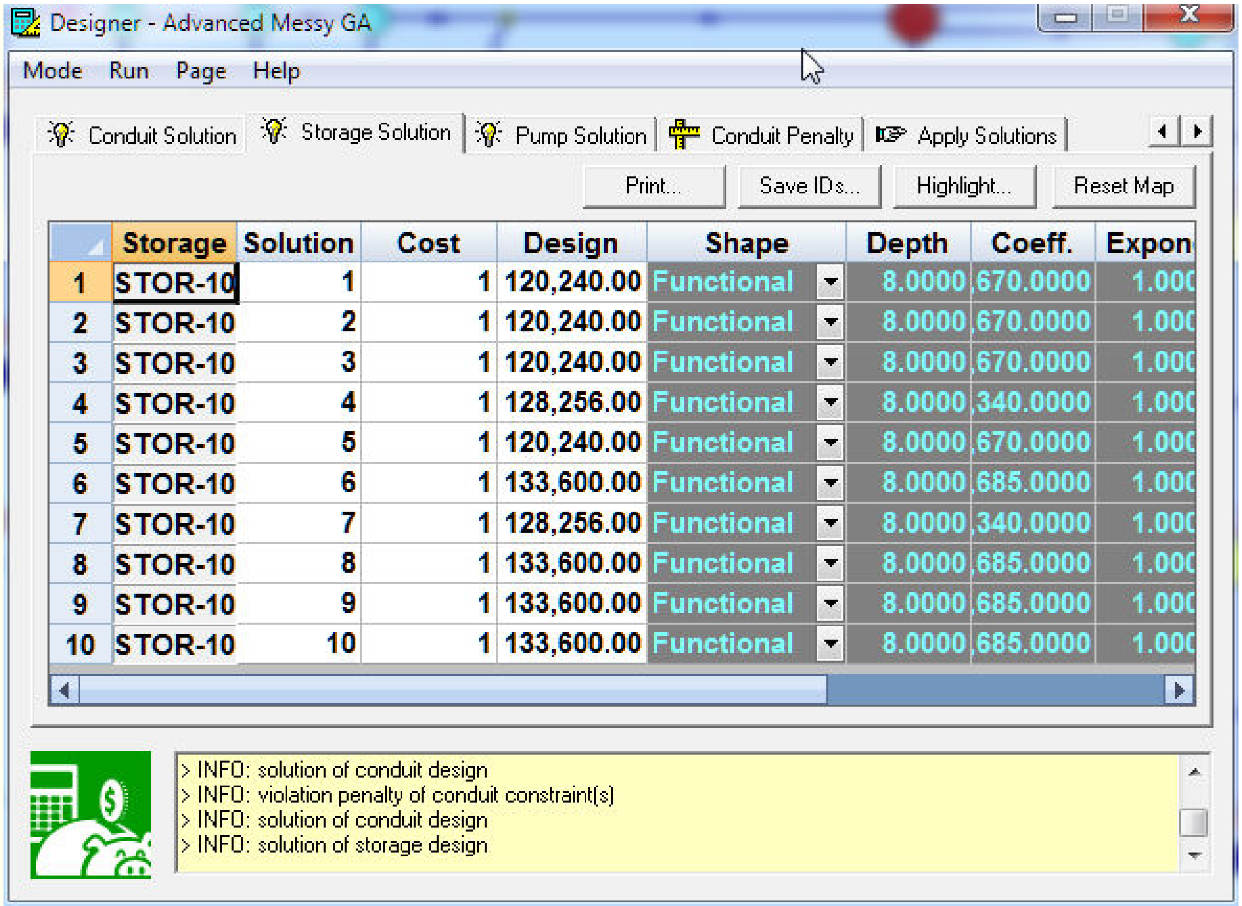
Solutions

The solution tabs detail the optimal solutions for conduits, storage and pumps by feature ID.

Conduit Solution: The Conduit Solution tab details the optimal cross-sections as determined by the last *Designer* optimization run for all conduits listed on the Conduit Group tab. This tab summarizes the design cost and parameters (depth for circular conduits, depth and width for open channels, curve for irregular channels, and manning roughness for all types of conduits) for all optimal solutions.

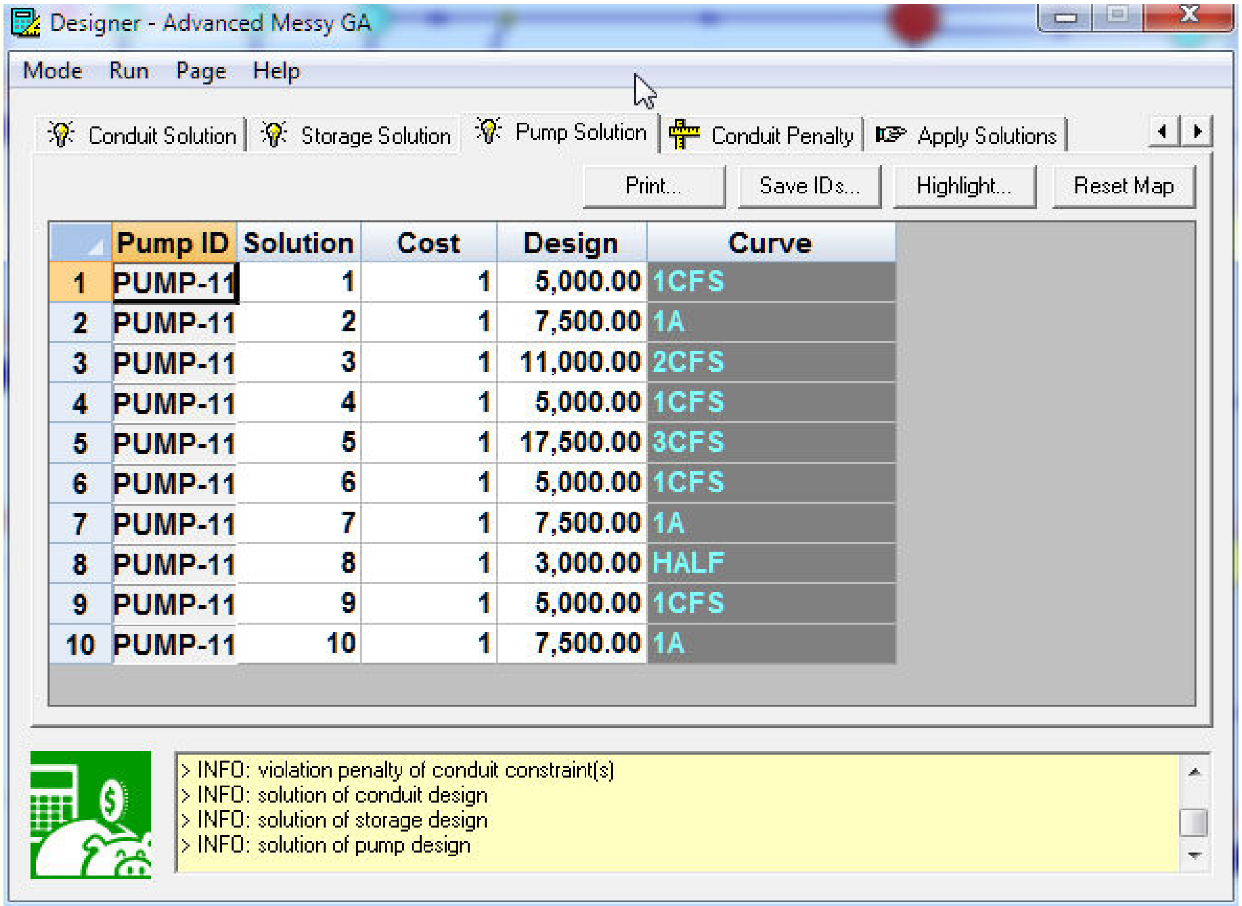


Storage Solution: The Storage Solution tab details the optimal geometries as determined by the last *Designer* optimization run for all storages listed on the Storage Group tab.



This tab summarizes the design cost and parameters (storage depth, area vs. depth curve for tabular storage, and equation variables for functional storage) for all solutions.

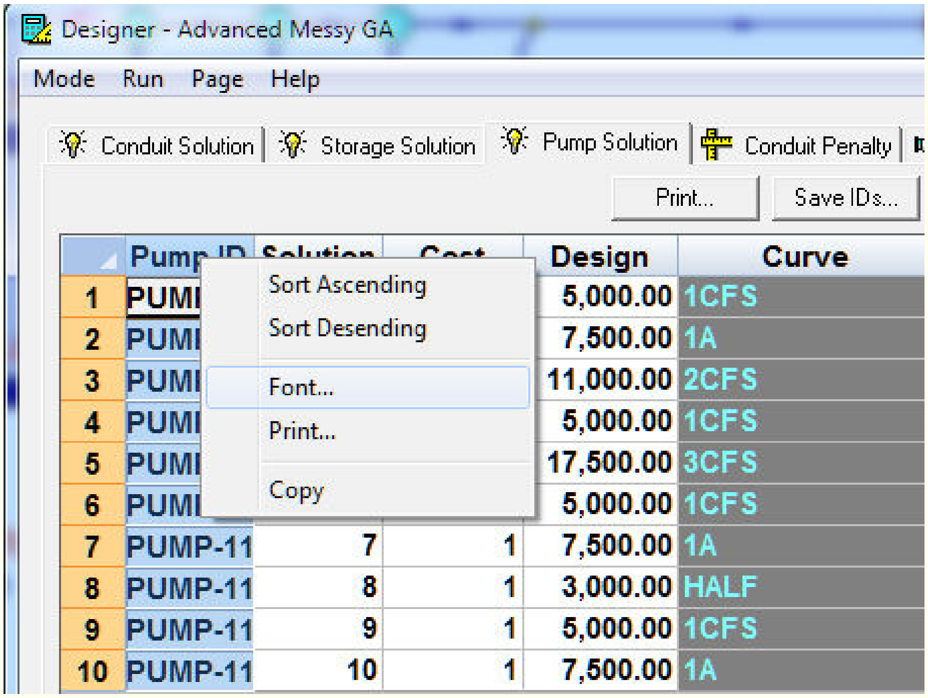
Pump Solution: The Pump Solution tab details the optimal curves as determined by the last *Designer* optimization run for all pumps listed on the Pump Group tab.



This tab summarizes the design cost and optimal pump curve for the best solutions.

[How to Change the Font]

How to change the font of all your tables


Designer - Advanced Messy GA
Mode Run Page Help
Conduit Solution
Storage Solution
Pump Solution
Conduit Penalty
Print...
Save IDs...
Pump ID
Solution
Cost
Design
Curve
Sort Ascending
Sort Desending
Font...
Print...
Copy
1 PUMI 5,000.00 1CFS
2 PUMI 7,500.00 1A
3 PUMI 11,000.00 2CFS
4 PUMI 5,000.00 1CFS
5 PUMI 17,500.00 3CFS
6 PUMI 5,000.00 1CFS
7 PUMP-11 7 1 7,500.00 1A
8 PUMP-11 8 1 3,000.00 HALF
9 PUMP-11 9 1 5,000.00 1CFS
10 PUMP-11 10 1 7,500.00 1A

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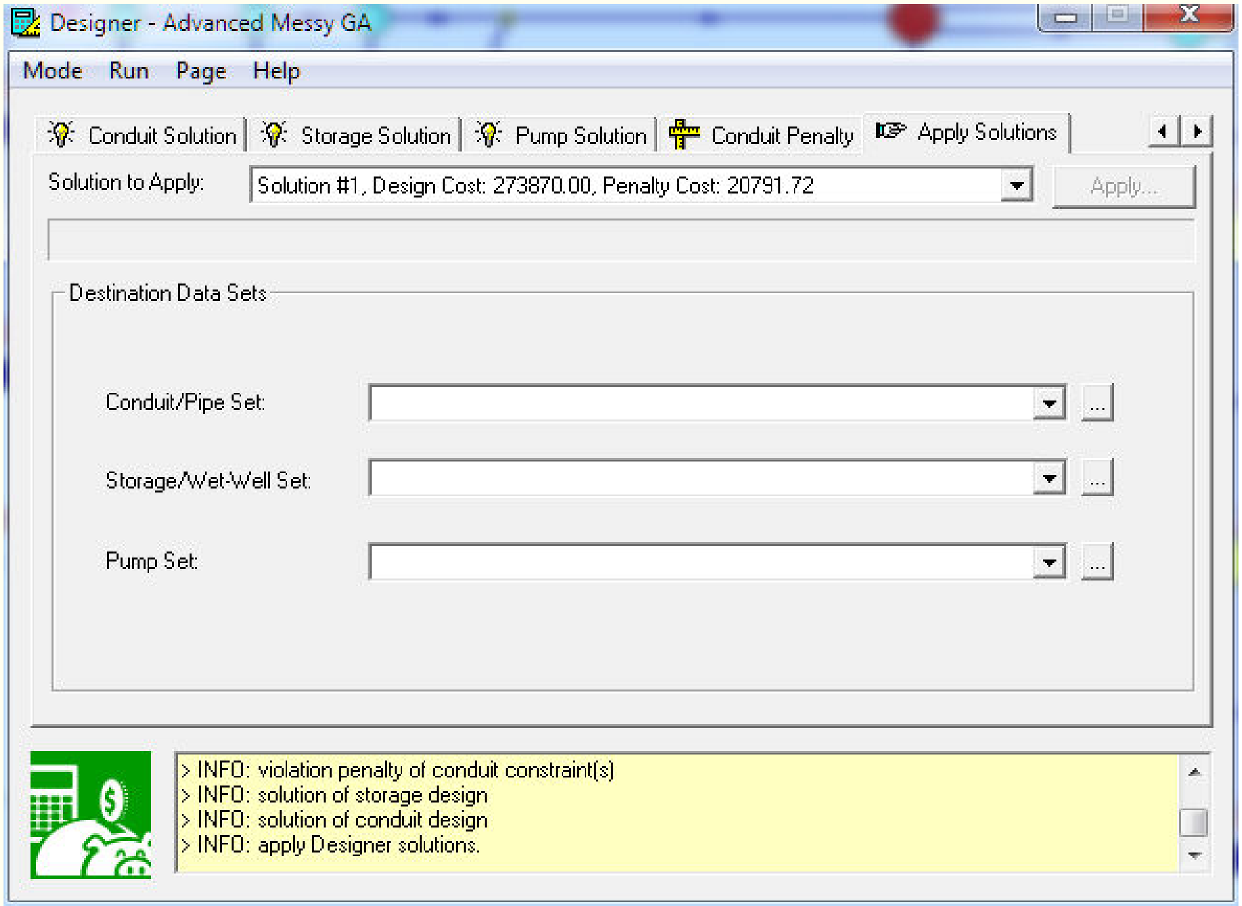
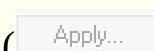
Apply Solutions

The following dialog box appears when Apply Solutions tab is selected.



The Apply Solutions tab is used to export parameters obtained through the optimization process. The parameters may be exported to the dataset of any scenario. Please refer to the InfoSWMM

user guide for more information on datasets and scenarios.

The apply solutions button (

) is not available until after the *Designer* has run. Upon completion of a design run, optimized solutions can be exported and the datasets from the drop-down will be overwritten.

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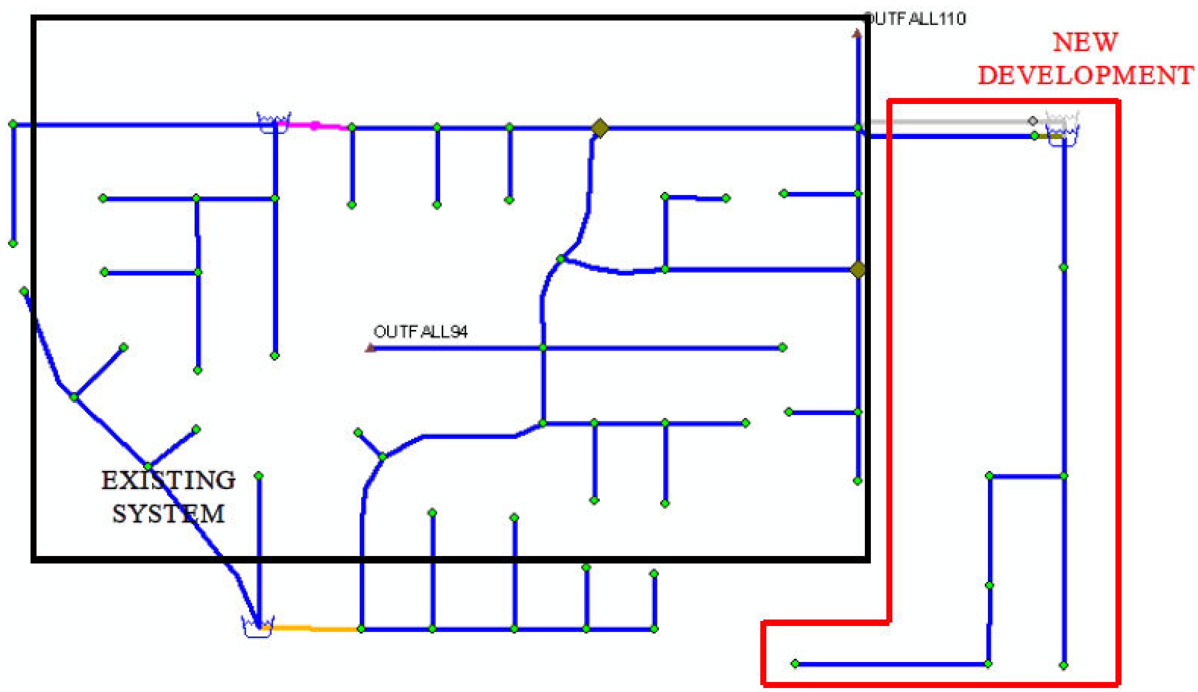
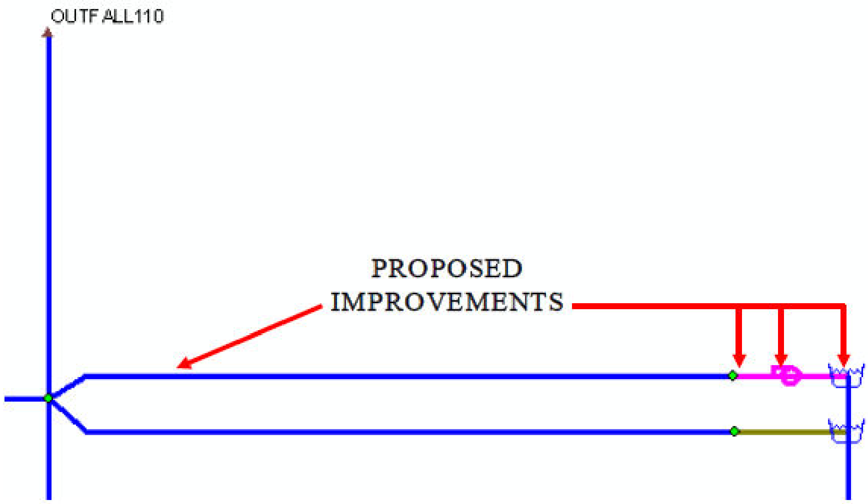
Introduction to Example One

This project modified in this tutorial illustrates how *Designer* calculates sewer conduit size, storage volume, and pump size to meet specified design criteria at the minimum cost.

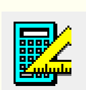
The model schematic is shown on the next page. The model contains two wastewater treatment plants (outfall110 and outfall94), the existing system, the new development, and the proposed improvements (to prevent exceeding the maximum capacity of the treatment plant). The existing system data is populated with existing data. The new development is populated with the proposed design data. The proposed improvements will be input and populated during this tutorial. The objective is to cost-effectively size the new development sewer and proposed improvements for the given conditions and design criteria.

NOTE: *The decision variables for this problem are the proposed pipe diameters, storage sizes, and pump curves. This will result in a solution space containing more than a billion possible designs.*



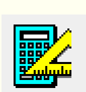


During this first tutorial, you will be guided through the following steps:



1. Opening

the project and designer.



2. Review

existing results.

3. Review

results of new development without improvements.

4. Creating

conduit groups and design.

5. Creating

storage groups and design.

6. Creating

pump groups and design.

7. Creating

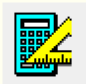
design constraints.

8. Choosing

design options.

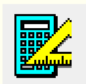
9. Performing

a design run.



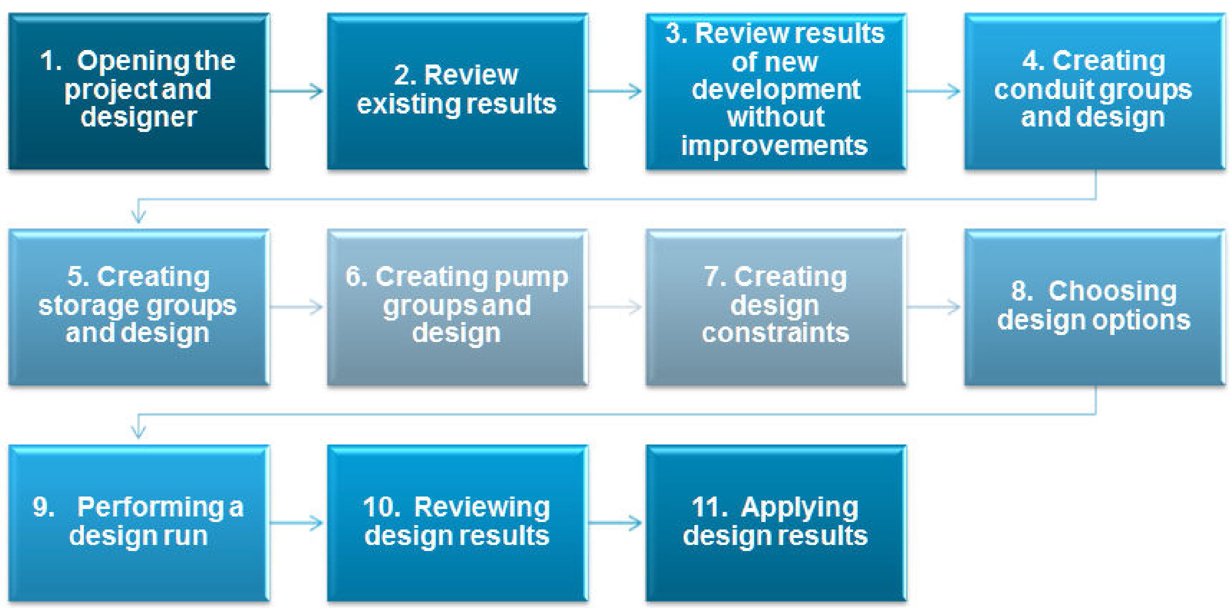
10. Reviewing

design results.



11. Applying

design results.



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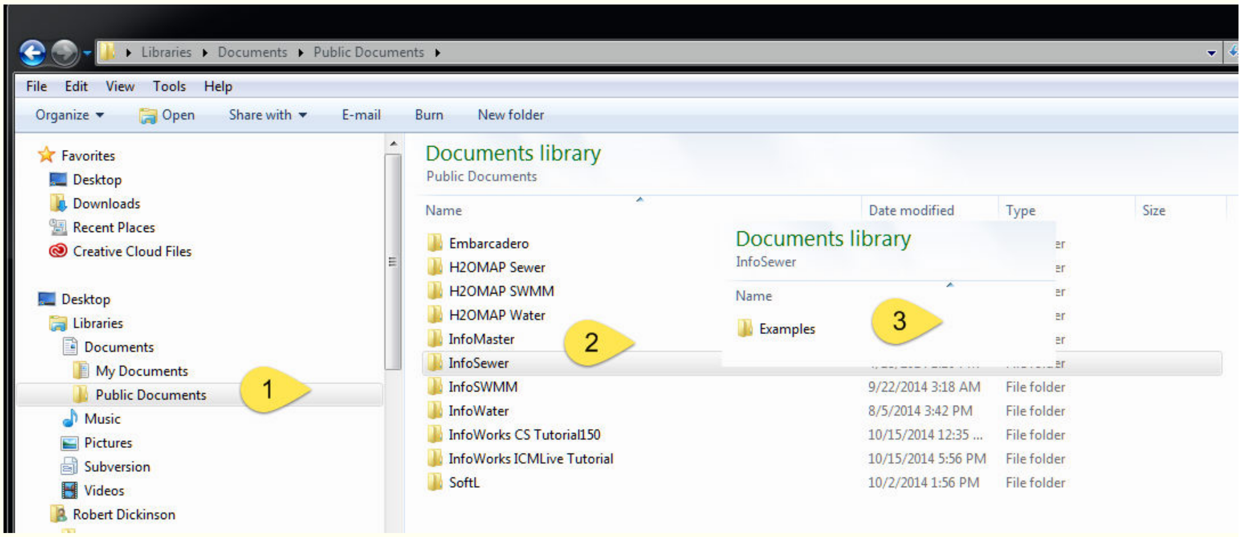
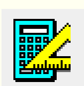
Step 1: Open the Designer Sample Project

The first step is to load the “**Designer_Sample”** project.

All of the @innovzye sample files are in the Public Documents/

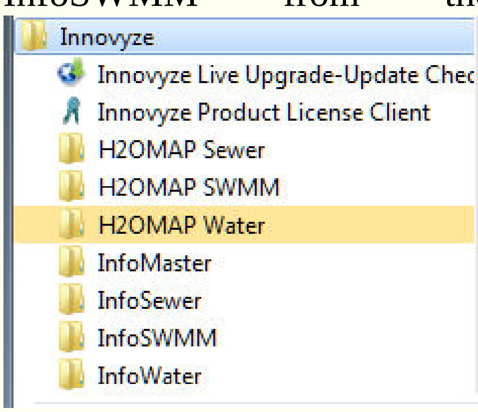
Name of Software / Examples folder

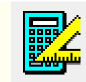




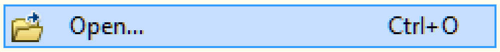
1. Start InfoSWMM by clicking the Desktop Shortcut (

) or by choosing InfoSWMM from the Innovyze List of Programs



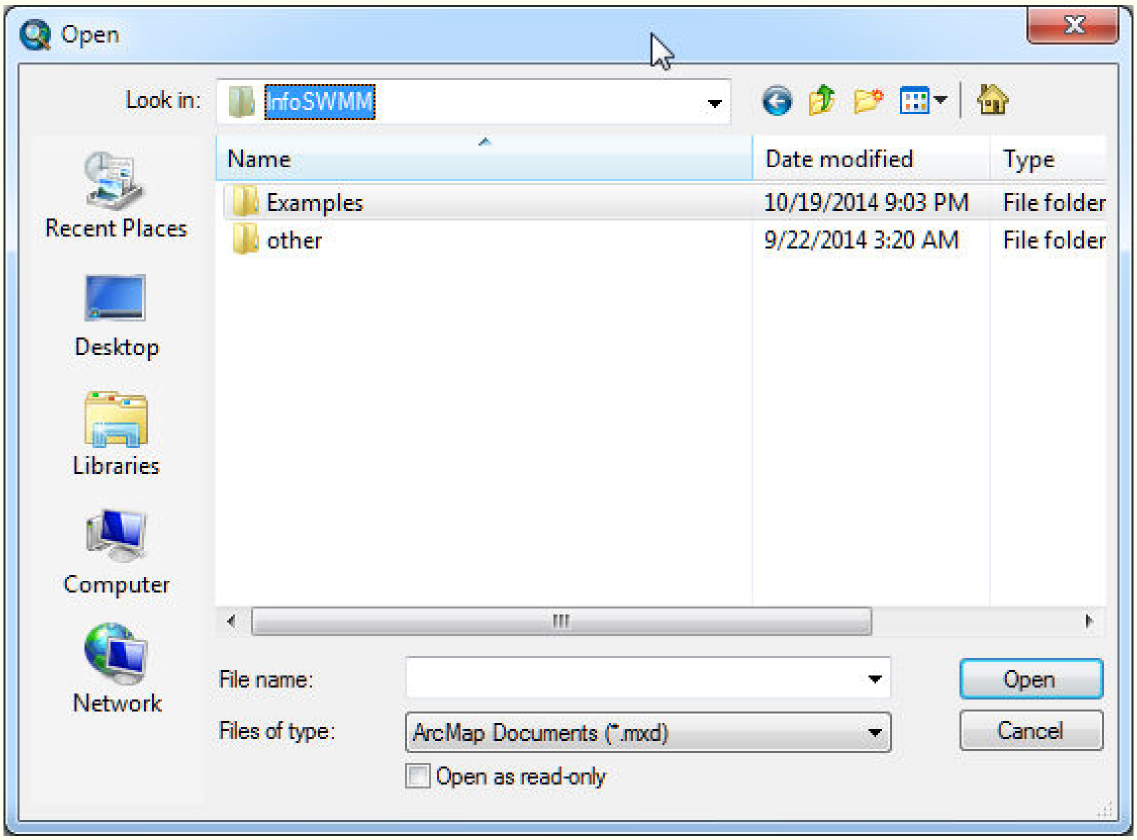
C:\Users\Public\Documents\InfoSWMM\SampleDesignSol.mxd 

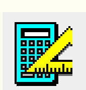
2. Select

the 

option in the ArcMAP dialog box and click 

.

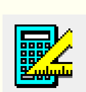




3. Browse

to C:\Users\Public\Documents\InfoSWMM\Examples and open SampleDesignSol.mxd

(the path may be different for custom installations)



4. Initialize

InfoSWMM (press).

5. Before

continuing, save the “**Designer_Sample**”

project to a new project. If you wish to restart the tutorial, the original project will be available.

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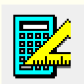
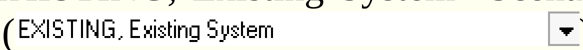
Step 2: Review the Existing Results

To understand the existing system, review the existing system results. This requires running the program for the existing facility only.

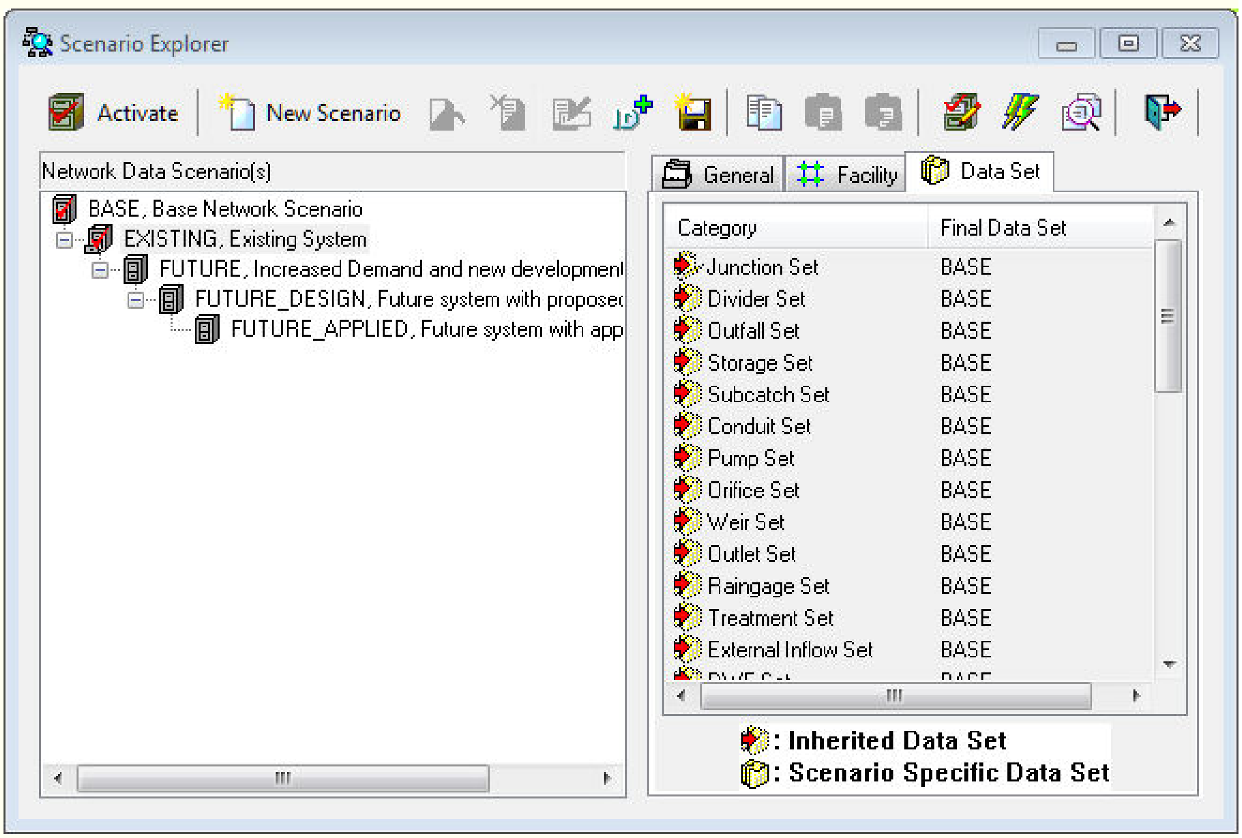


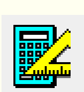
1. Activate

the "EXISTING, Existing System" Scenario using the scenario drop-down menu (

).

1. The existing system will be shown as active, while the new development and the proposed improvements are grayed out.





2. Open

the Run Manager (press).

3. Run

the simulation (Press in the Run Manager).

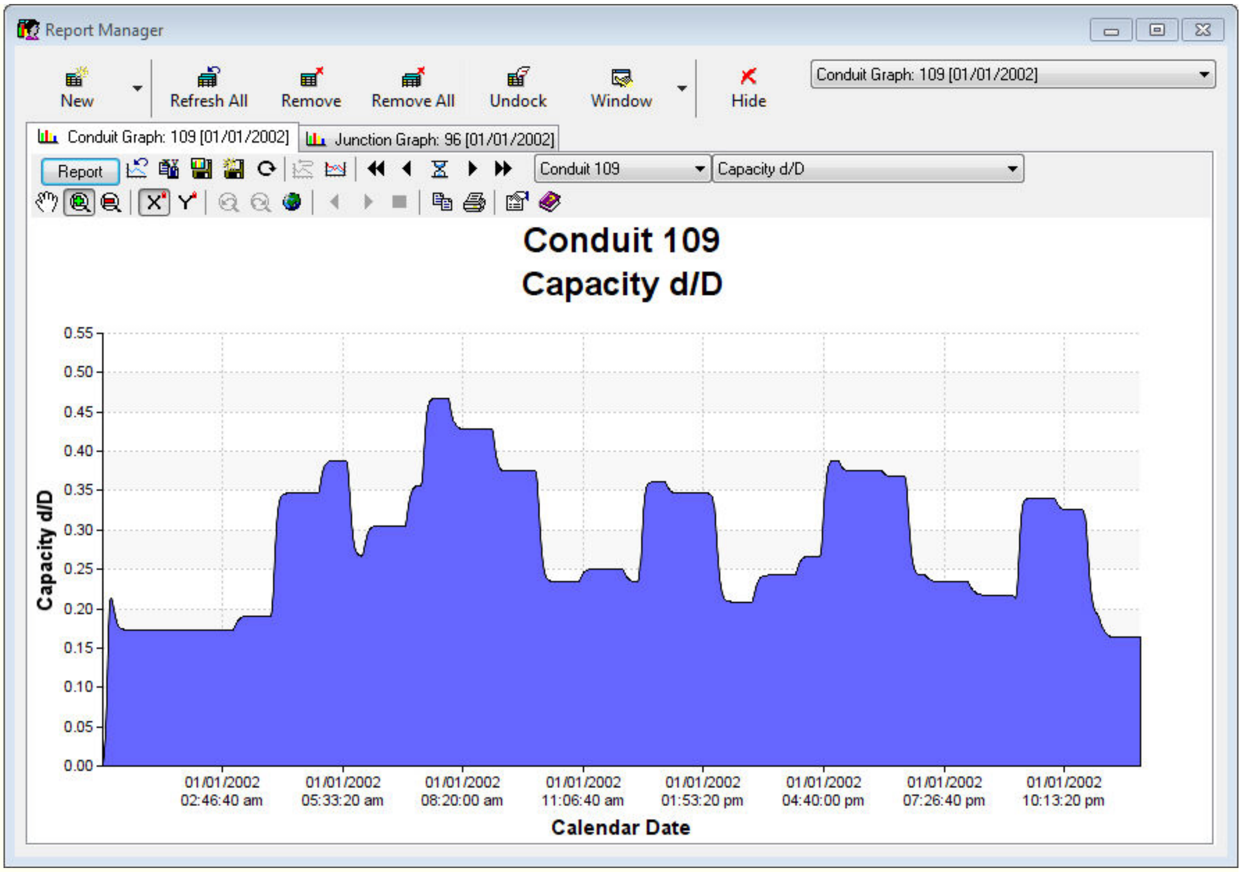
1. The traffic light in the upper left corner will register green indicating a successful run.

4. Click .

5. Select ( ) the northern outfall conduit (Conduit 109).

6. Create a graph of the conduit (Press from the attribute browser)

7. Choose Conduit 109 d/D to see the available remaining capacity.



NOTE: *For this example, assume that 80% capacity of the outfall pipe represents the maximum capacity of the WWTP. Thus 80% capacity of this conduit cannot be exceeded, nor can the diameter of this conduit be increased during the design analysis.*

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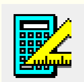
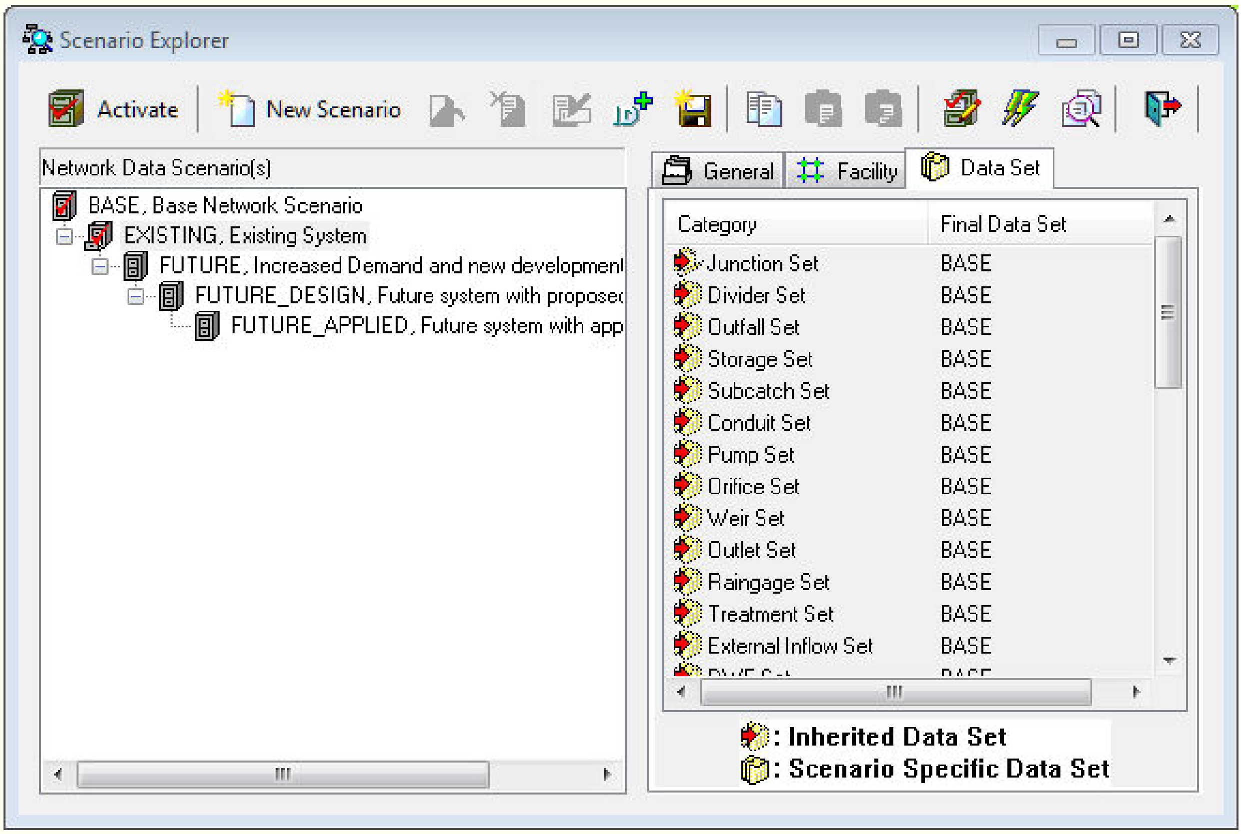
Step 3: Review New Development Results

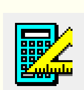
Review the results of the Future system to better understand what happens in the system when the proposed develop is added with no additional improvements (that is, to determine if the system exceeds its capacity).



1. Activate

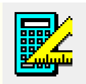
the “FUTURE, Increased Demand and no Improvements” Scenario using the scenario drop down menu (
).





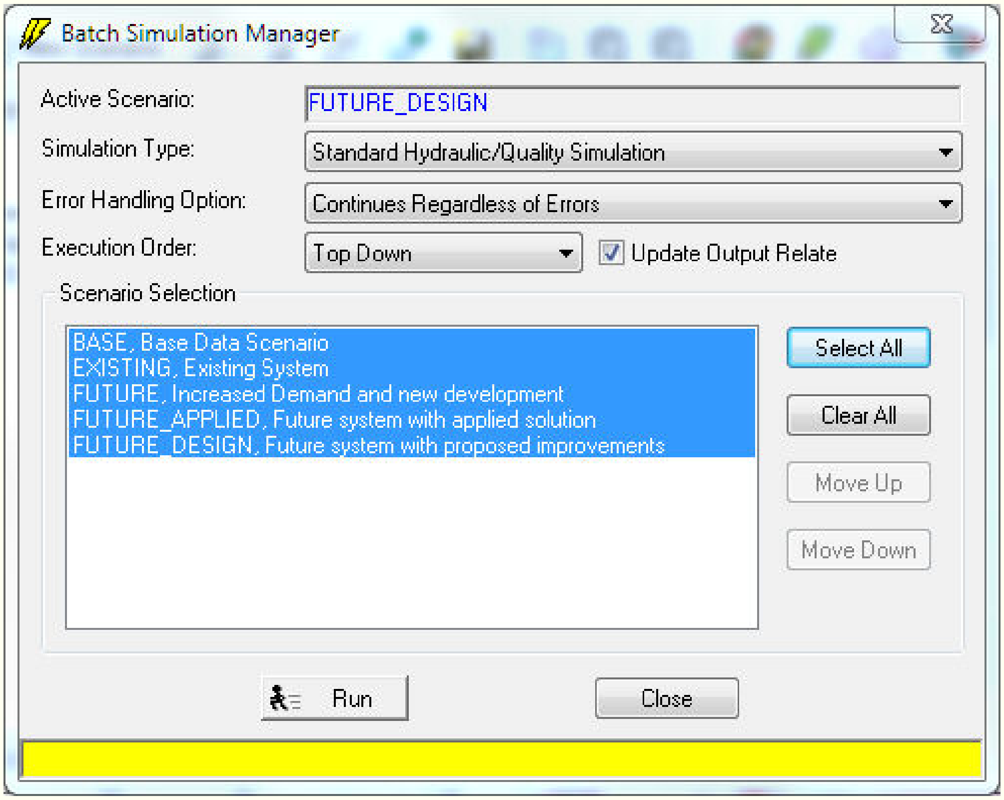
The future system, including the new development, will be shown as active.

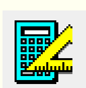
The proposed improvements are still grayed out.



2. Open

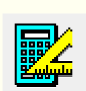
the Batch Simulation Dialog (InfoSWMM >> Tools >> Batch Simulation).



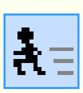


3. Highlight

the “EXISTING” and “FUTURE” scenarios.



4. Press

 to run the simulation.

The Message Board will show the results and times of the run

MESSAGE: Standard Hydraulic/Quality Simulation of scenario 'BASE' failed at 09:38:52, Wednesday, January 20, 2016.

MESSAGE: Standard Hydraulic/Quality Simulation of scenario 'EXISTING' succeeded at 09:38:55, Wednesday, January 20, 2016.

MESSAGE: Standard Hydraulic/Quality Simulation of scenario 'FUTURE' succeeded at 09:38:58, Wednesday, January 20, 2016.

MESSAGE: Standard Hydraulic/Quality Simulation of scenario 'FUTURE_APPLIED' succeeded at 09:39:01, Wednesday, January 20, 2016.

MESSAGE: Standard Hydraulic/Quality Simulation of scenario 'FUTURE_DESIGN' succeeded at 09:39:05, Wednesday, January 20, 2016.

5. View

the results for the outfall conduits before and after the new development.

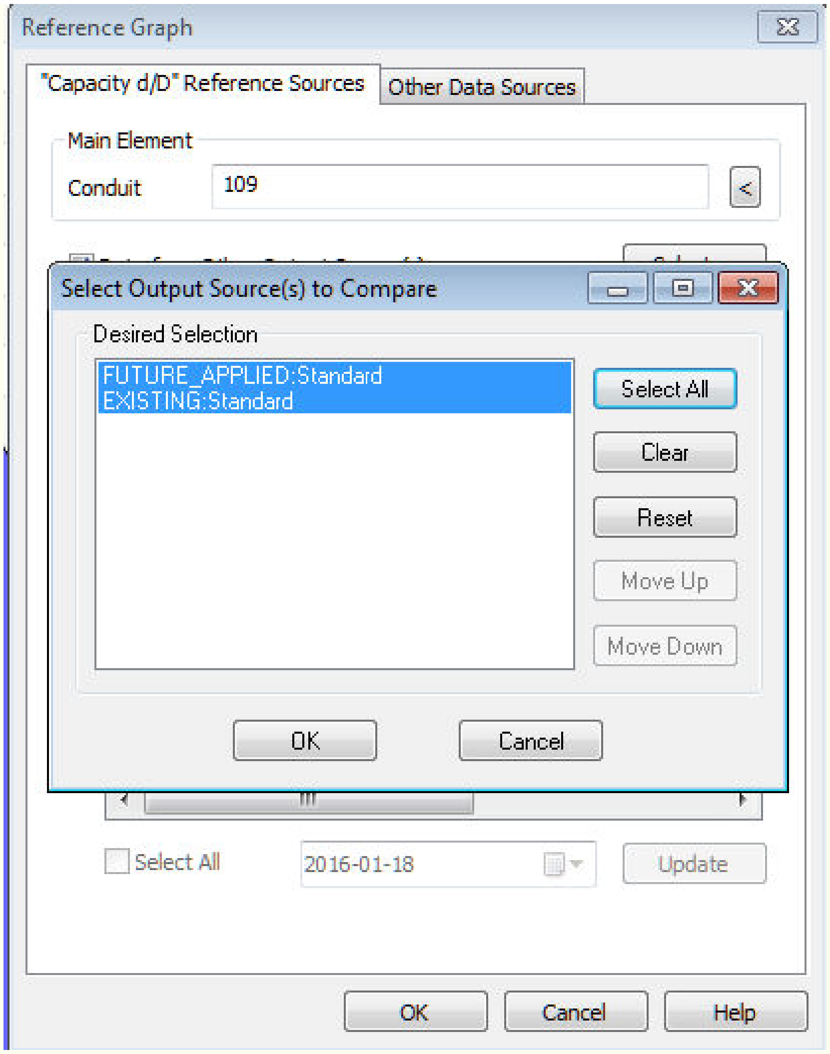
6. Select Conduit 109 ( ).

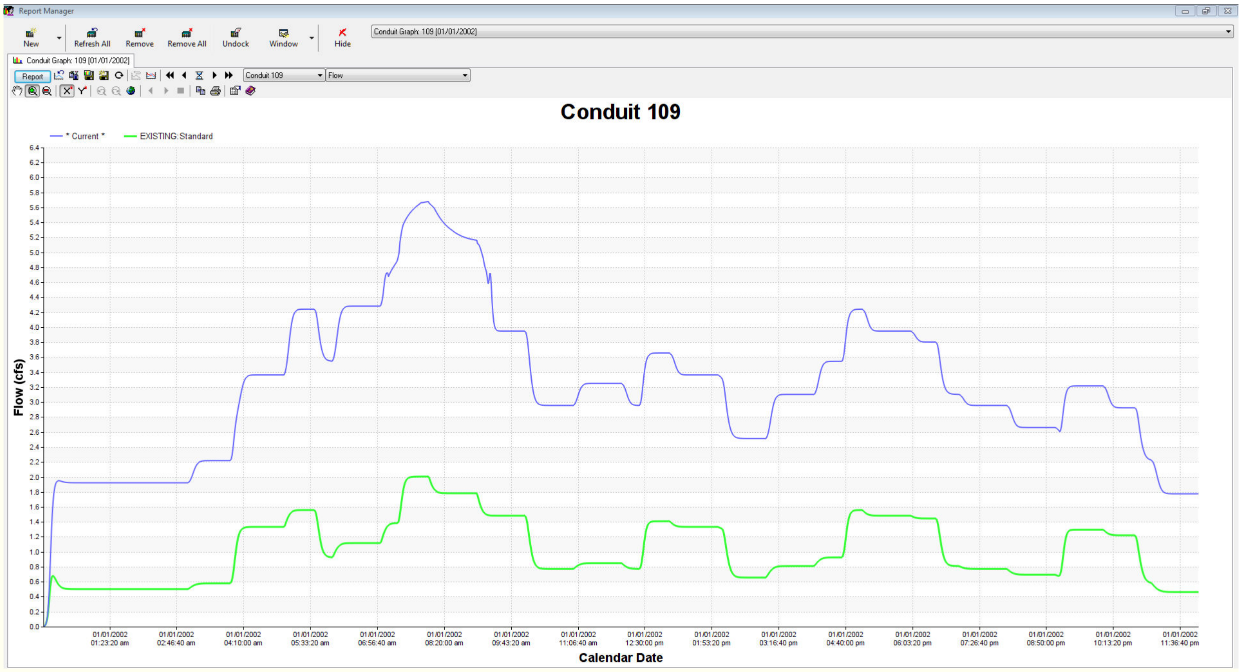
7. Create a graph of the conduit (Press from the attribute browser).

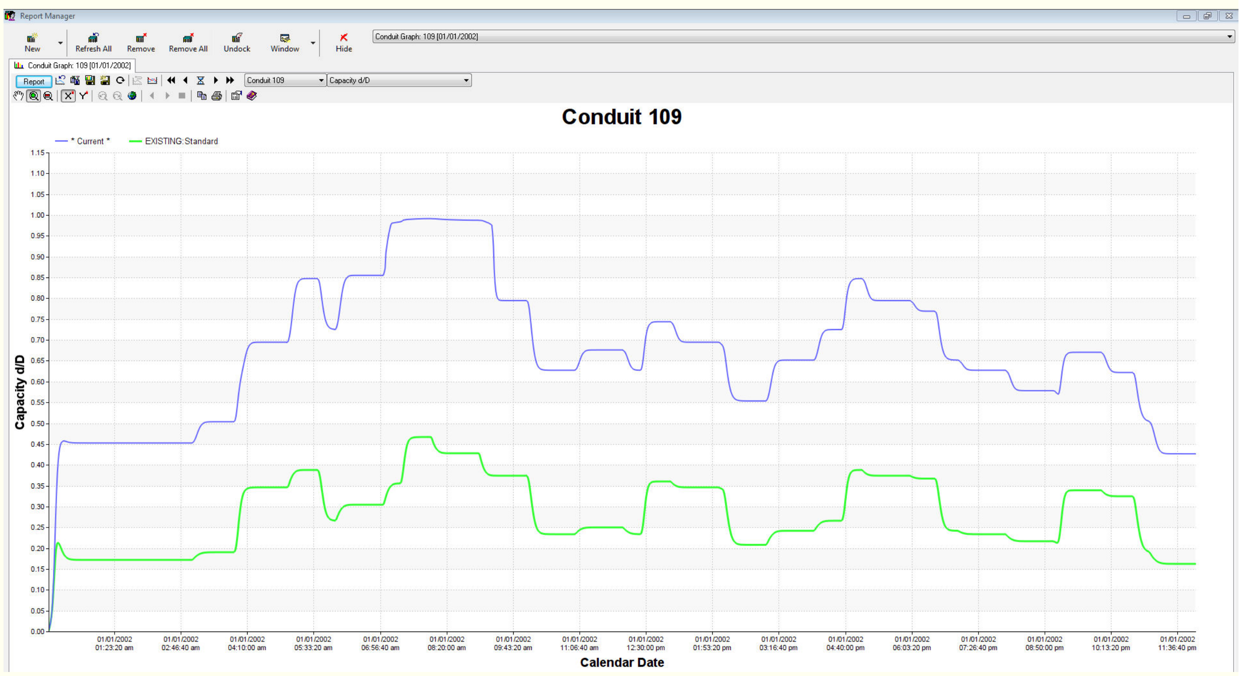
8. Choose Conduit 109 d/D.

9. Press , select "EXISTING"

from Flow Reference Sources, then press OK.


Reference Graph
"Capacity d/D" Reference Sources
Other Data Sources
Main Element
Conduit
109
Select Output Source(s) to Compare
Desired Selection
FUTURE_APPLIED:Standard
EXISTING:Standard
Select All
Clear
Reset
Move Up
Move Down
OK
Cancel
Select All
2016-01-18
Update
OK
Cancel
Help





NOTE: *The new improvements exceed 80% capacity in the outfall conduit. All conduits in the new improvement were set to 2' to ensure this would detail what would happen if no storage was provided. In addition to designing pumping and storage, the proposed conduits will be sized during the optimization as well. A real-time control is employed for the future* *improvements to ensure that the weir will close if the outfall conduit exceeds 75% capacity. The pump also has a real-time control.*

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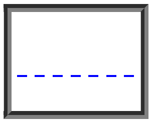
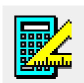
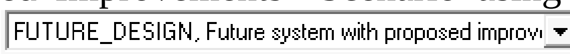


Step 4: Create Conduit Groups and Design

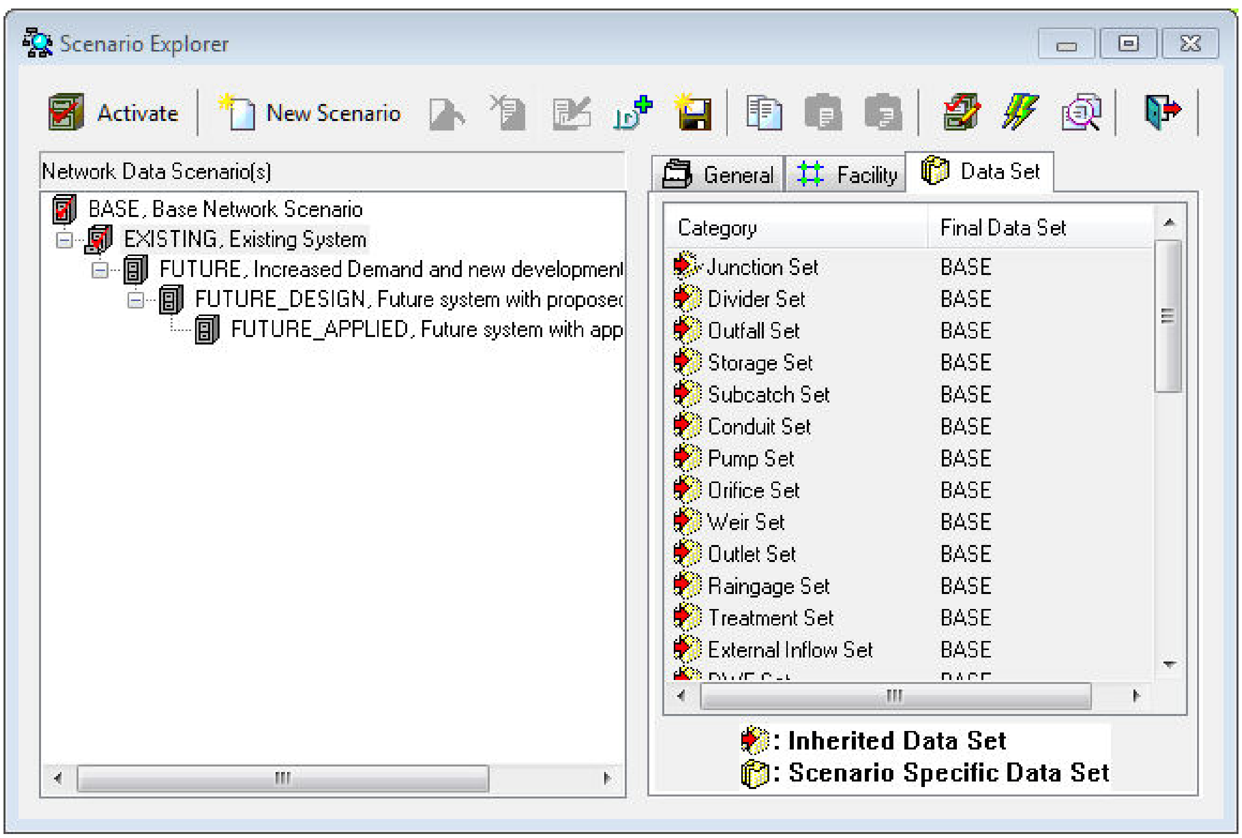
The first step in the design process is to define the conduits whose flow exceeds its capacity to a cost code (or improvement) group. Conduits should be grouped together based on similar characteristics (e.g., material, age, location and diameter) and associated improvement costs. It is assumed that all pipes within a group will **<u>globally</u>** possess the same final diameter.

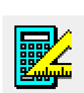
For this example, you will create eight conduit cost codes, one group for each conduit in the new development.

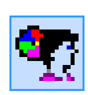


1. Activate the “FUTURE_DESIGN, Future System with Proposed Improvements” Scenario using the scenario drop-down menu (

).





2. Open AddOn Extension Manager 

3. Highlight Designer and click Run.

4. Click on the Conduit/Pipe Groups tab and enter the following information:

Object IDs CDT-15

Object IDs CDT-17

Object IDs CDT-19

Object IDs CDT-21

Object IDs CDT-27

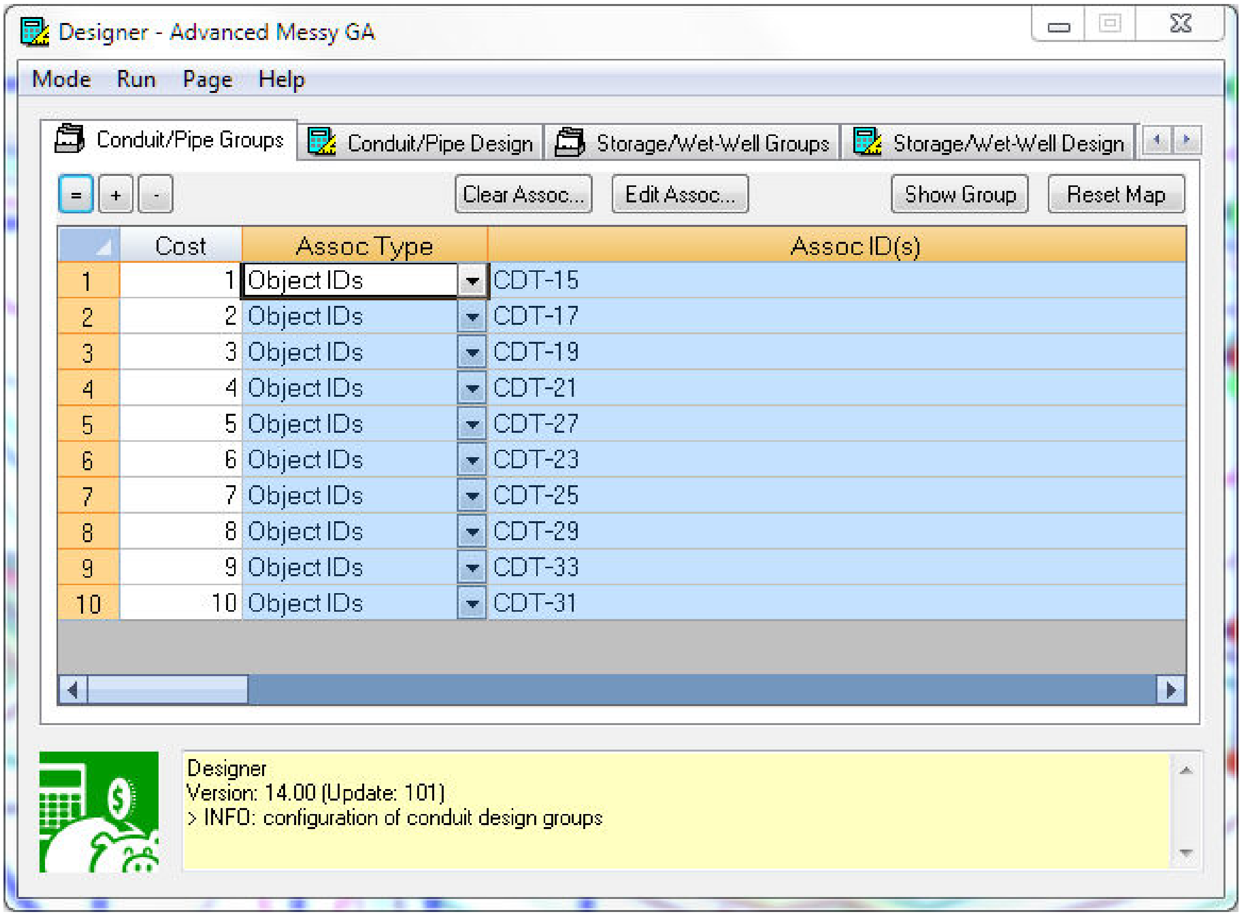
Object IDs CDT-23

Object IDs CDT-25

Object IDs CDT-29

Object IDs CDT-33

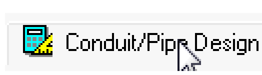
Object IDs CDT-31



5. Select the 

tab.

NOTE: *This tab limits the Designer's choices for improvement options. For this example, each conduit group (i.e. each cost code) which represents only one conduit will be given three diameter options: 8", 12" and 18". The unit cost for each diameter is $20/lf, $30/lf, and $42/lf.*

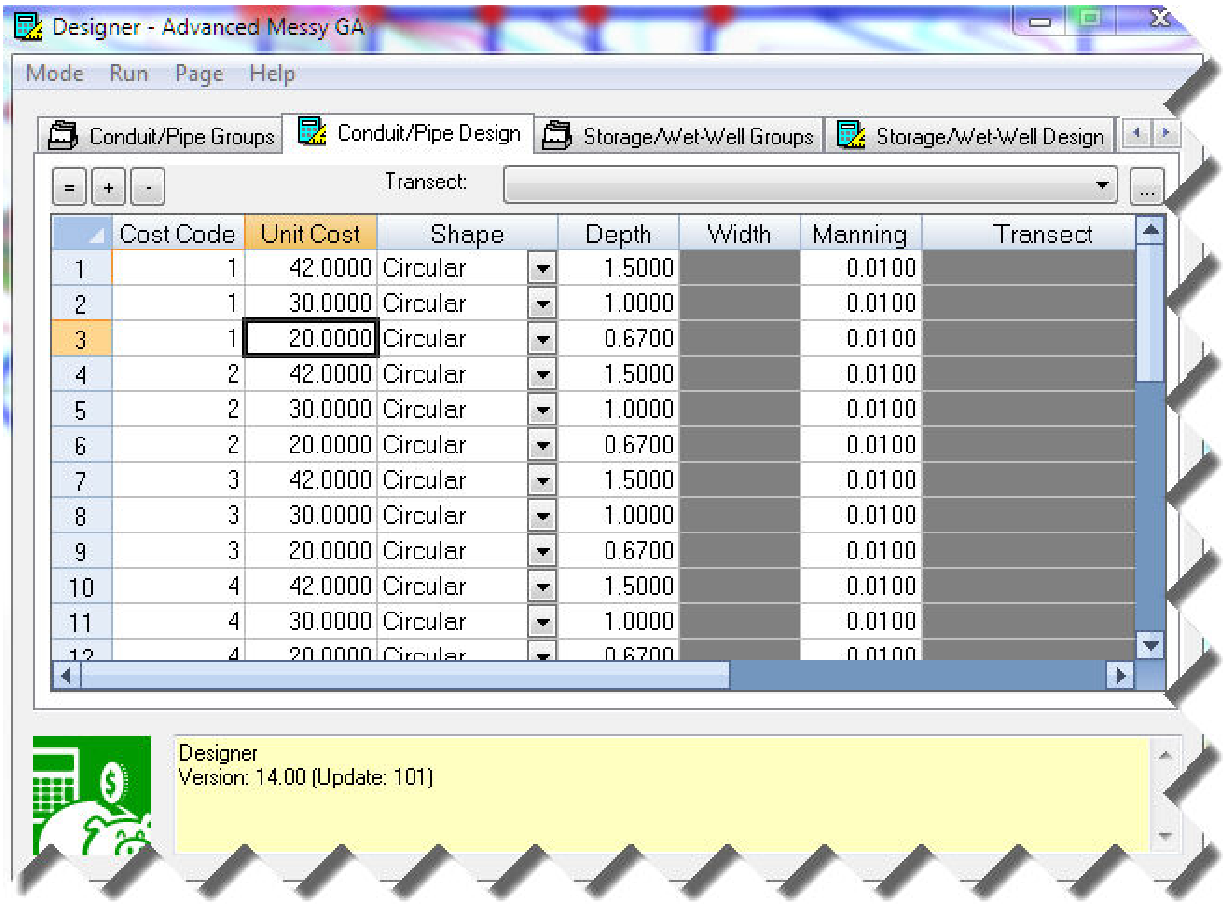
6. Populate the 

tab with the following information for each cost code (1-10):

7. 30 Rows will be required (Press

to set).

8. Duplicate information may be copied and pasted for solutions 2-10.



1 42.0000 Circular 1.5000 0.0100

1 30.0000 Circular 1.0000 0.0100

1 20.0000 Circular 0.6700 0.0100

2 42.0000 Circular 1.5000 0.0100

2 30.0000 Circular 1.0000 0.0100

2 20.0000 Circular 0.6700 0.0100

3 42.0000 Circular 1.5000 0.0100

3 30.0000 Circular 1.0000 0.0100

3 20.0000 Circular 0.6700 0.0100

4 42.0000 Circular 1.5000 0.0100

4 30.0000 Circular 1.0000 0.0100

4 20.0000 Circular 0.6700 0.0100

5 42.0000 Circular 1.5000 0.0100

5 30.0000 Circular 1.0000 0.0100

5 20.0000 Circular 0.6700 0.0100

6 42.0000 Circular 1.5000 0.0100

6 30.0000 Circular 1.0000 0.0100

6 20.0000 Circular 0.6700 0.0100

7 42.0000 Circular 1.5000 0.0100

7 30.0000 Circular 1.0000 0.0100

7 20.0000 Circular 0.6700 0.0100

8 42.0000 Circular 1.5000 0.0100

8 30.0000 Circular 1.0000 0.0100

8 20.0000 Circular 0.6700 0.0100

9 42.0000 Circular 1.5000 0.0100

9 30.0000 Circular 1.0000 0.0100

9 20.0000 Circular 0.6700 0.0100

10 42.0000 Circular 1.5000 0.0100

10 30.0000 Circular 1.0000 0.0100

10 20.0000 Circular 0.6700 0.0100

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Step 5: Create Storage Groups and Design

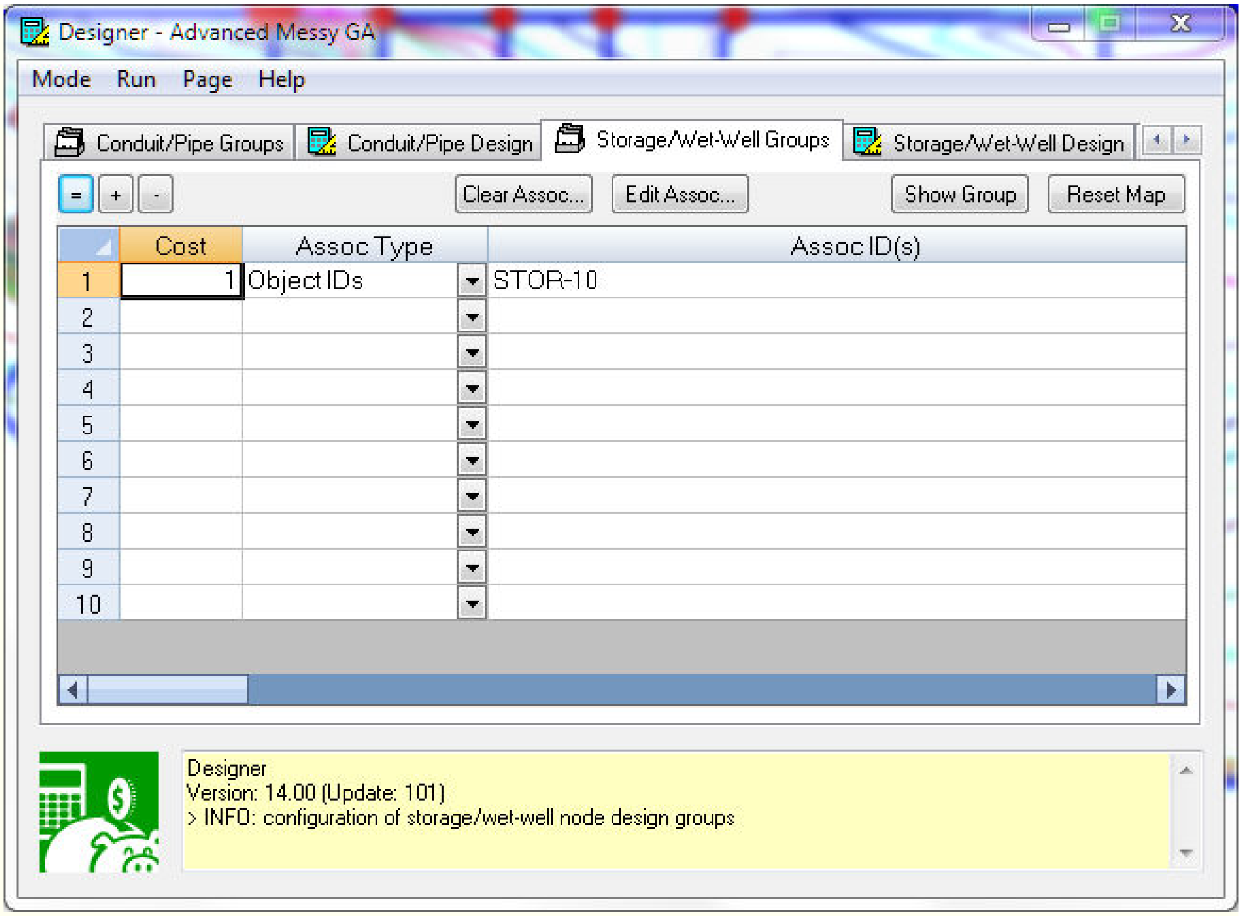
The next step in the design process is to define possible storage alternatives to detain flow until there is available capacity in the outlet conduit. Storage facilities should be grouped together based on similar characteristics (e.g., size, location, etc.) and associated improvement costs. It is assumed that all storage facilities within a group will **globally**

possess the same characteristics.

> **NOTE:** *For this example, it is assumed that the WWTP can not be expanded. Therefore storage and pumping will be a necessary improvement. This is the purpose of the Future_Design scenario. The storage and pump to be optimized were digitized in this scenario. Thus, the designer will need to be run on top of this scenario.*

For this example, you will create one storage cost code for the one proposed storage location with 6 alternative storage volumes.

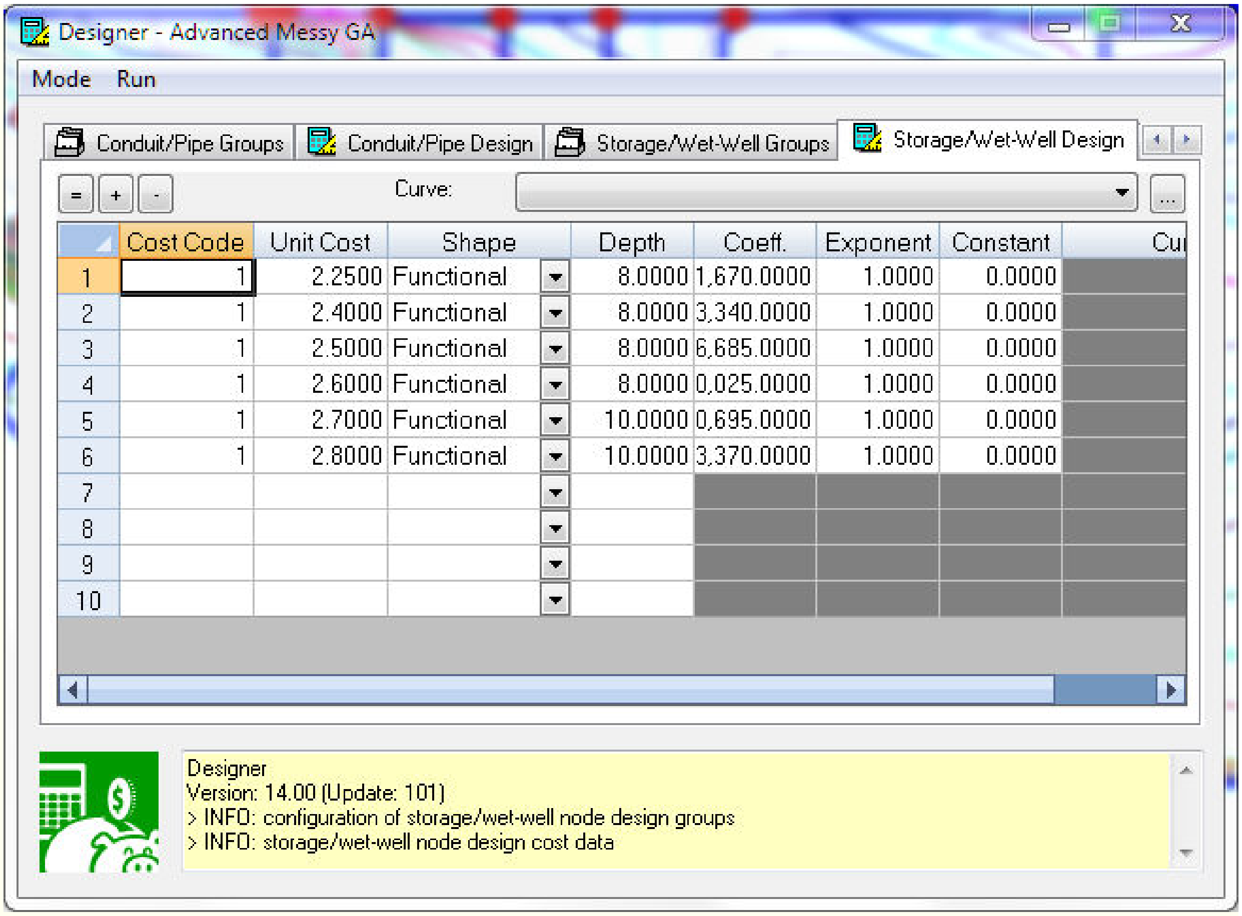
1. Click on the Storage/Wet-Well Groups tab and enter the following information:



2. Select the Storage/Wet-Well Design tab.

NOTE: *This tab also limits the Designer's choices for improvement options. For this example, the storage group (i.e. cost code) will be given six storage options, 0.1 MG, 0.2 MG, 0.4 MG, 0.6 MG, 0.8 MG, and 1.0 MG. The unit cost varies according to the footprint size and maximum depth.*

3. Populate the Storage/Wet-Well Design tab with the following information:



1 2.2500 Functional 8.0000 1,670.0000 1.0000

0.0000

1 2.4000 Functional 8.0000 3,340.0000 1.0000

0.0000

1 2.5000 Functional 8.0000 6,685.0000 1.0000

0.0000

1 2.6000 Functional 8.0000 10,025.0000 1.0000

0.0000

1 2.7000 Functional 10.0000 10,695.0000

1.0000 0.0000

1 2.8000 Functional 10.0000 13,370.0000

1.0000 0.0000

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Step 6: Create Pump Groups and Design

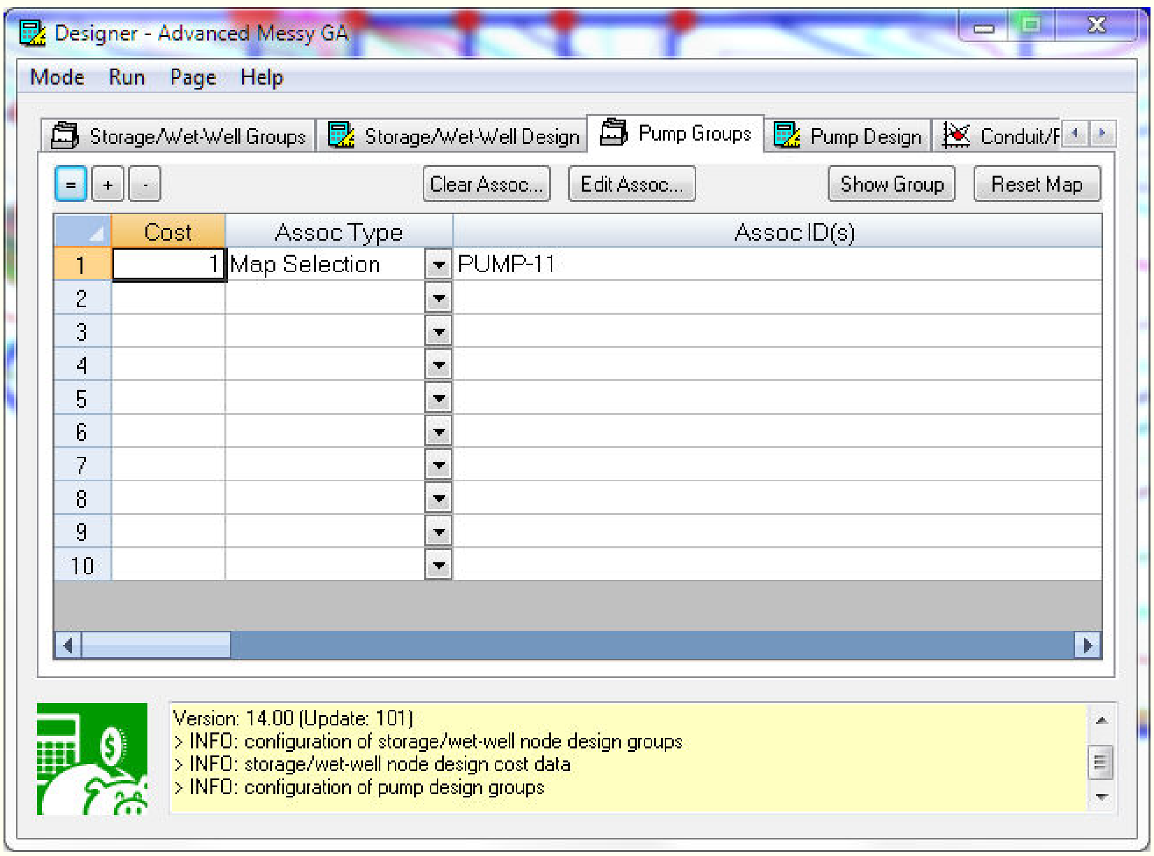
The final step in the design process is to define possible pumping alternatives to pump from the storage into the outfall conduit. Pumps should be grouped together based on similar characteristics (e.g., type, service area size, location, etc.) and associated improvement costs. All pumps within a group will **globally** possess the same pump curve.

For this example, you will create one pump cost code for the one proposed pump with 4 alternative pump curves.

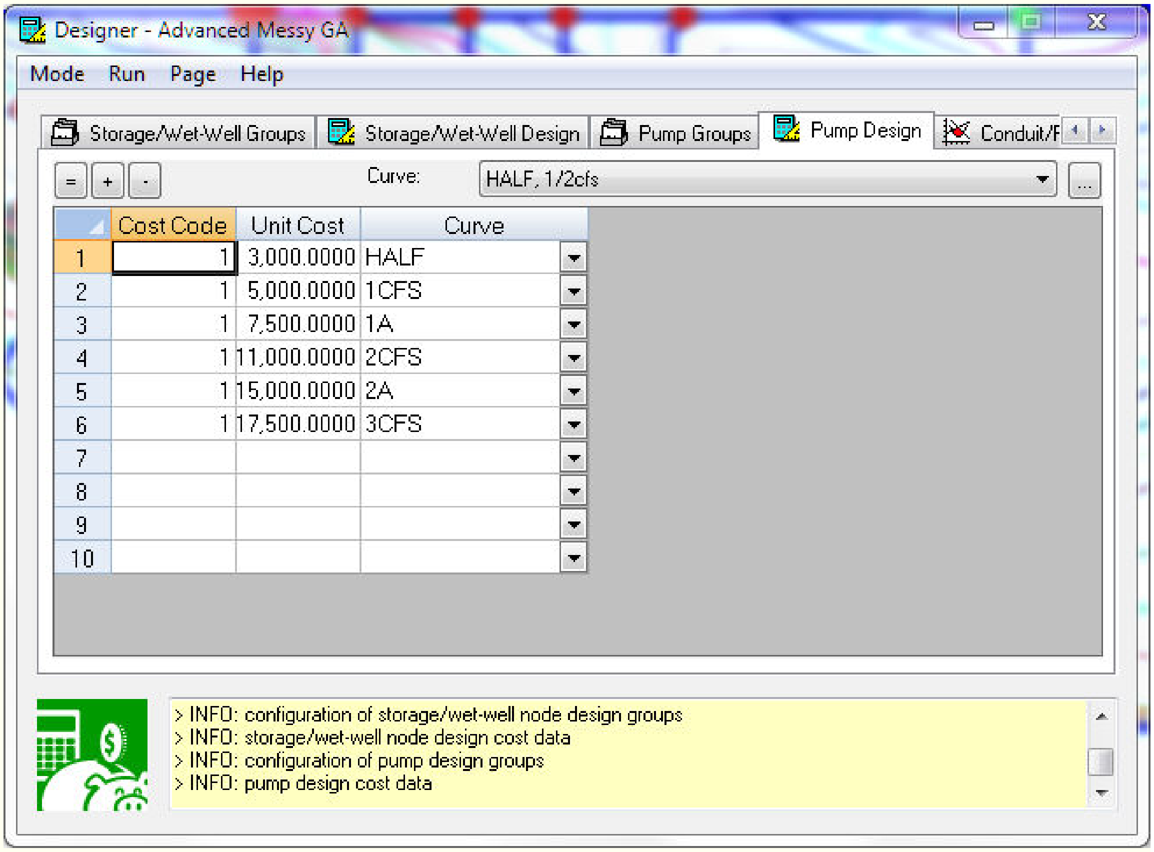
1. Click on the Pump Groups tab and enter the following information:

a. Double-click

in the Assoc ID(s) cell to enable map selection.



2. Select the Pump Design tab and populate with the following information.



1 5,000.0000 1CFS

1 7,500.0000 1A

1 11,000.0000 2CFS

1 15,000.0000 2A

1 17,500.0000 3CFS

NOTE: *These curves have already been created. For additional information on creating pump curves, reference the InfoSWMM*

User Guide and On-line Help menu.

Each curve can be viewed by pressing ... .

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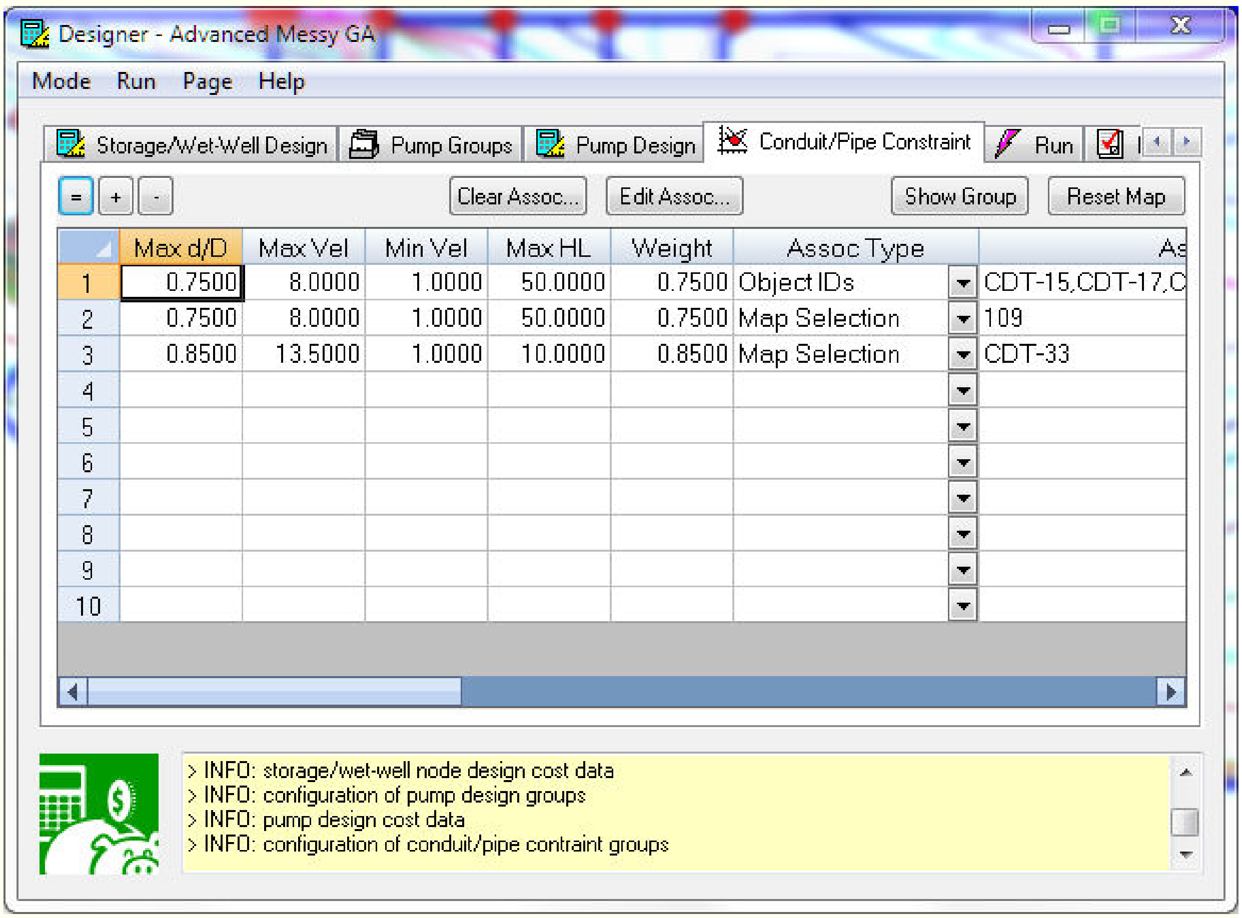
Step 7: Create Design Constraints

Now that the design options have been set, design constraints need to be defined. Constraints consist of maximum allowable depth over diameter ratio (d/D), maximum and minimum velocity, and maximum headloss (applicable for forcemains) and can vary for individual conduits. However, a conduit can be associated with only one set of constraints.

Select the Conduit/Pipe Constraint tab.

Populate the table with the following information:



0.7500 8.0000 1.0000 50.0000 0.7500 Object

IDs CDT-15,CDT-17,CDT-19,CDT-21,CDT-23,CDT-25,CDT-27,CDT-29,CDT-31

0.7500 8.0000 1.0000 50.0000 0.7500 Map

Selection 109

0.8500 13.5000 1.0000 10.0000 0.8500 Map

Selection CDT-33

The Assoc ID(s) in row 1 should include the following: CDT-15, CDT-17, CDT-19, CDT-21, CDT-23, CDT-25, CDT-27, CDT-29, and CDT-31. Conduit 109

is in its' own group so it can be given a higher weight. Any violation in this conduit will result in a penalty cost being added to the objective function. The weight indicates that the penalty cost for a constraint violation in this conduit will be 500 times greater than a violation in any of the other conduits. Conduit CDT-33 is in its' own group so a unique headloss constraint may be assigned as this conduit is downstream of the pump.

NOTE: *Right-clicking anywhere in the table allows the user to access additional commands, including copy and paste.*

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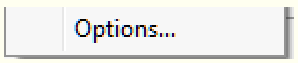
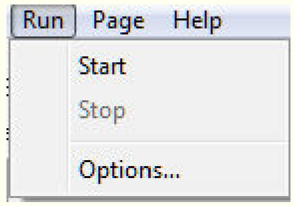
Step 8: Design Options

Prior to running the optimization, design constraint settings (penalty costs), termination criteria, and advanced GA Options should be checked and/or modified.

Click the 

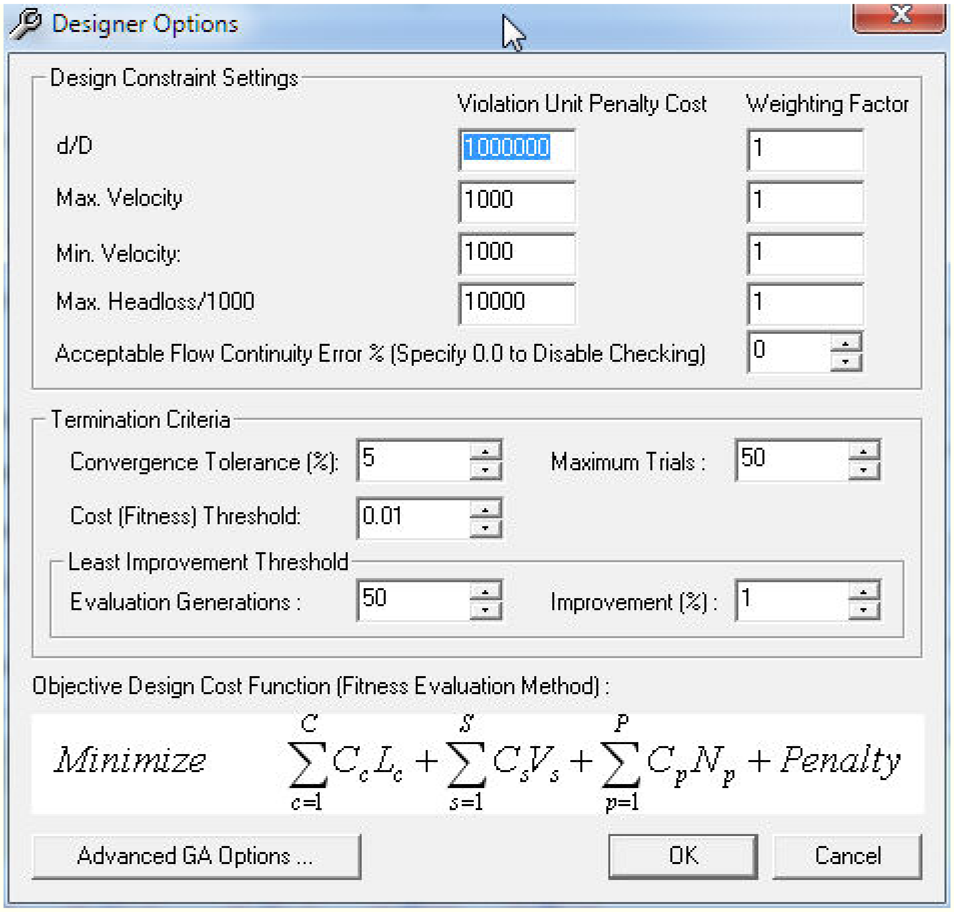
tab.

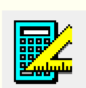
Select 

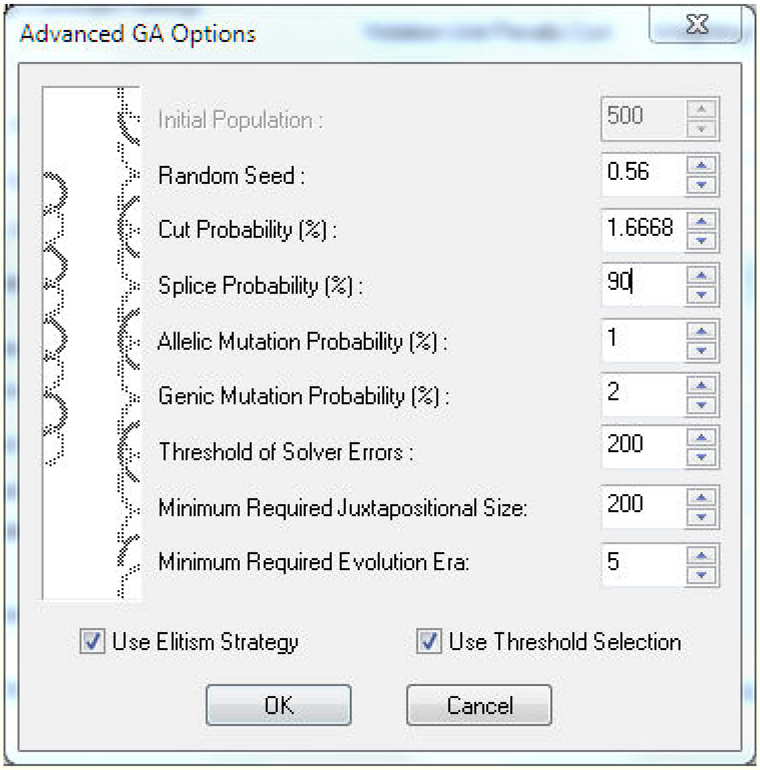
from the 

menu.

Set the Violation Unit Penalty Cost and Maximum Trials as shown below:



 Press Advanced GA Options ... and verify defaults settings have not changed.



NOTE: *It is recommended that unless there is reason to modify settings, default values in the Advanced GA dialog should not be changed.*

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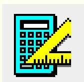
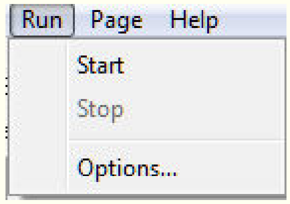
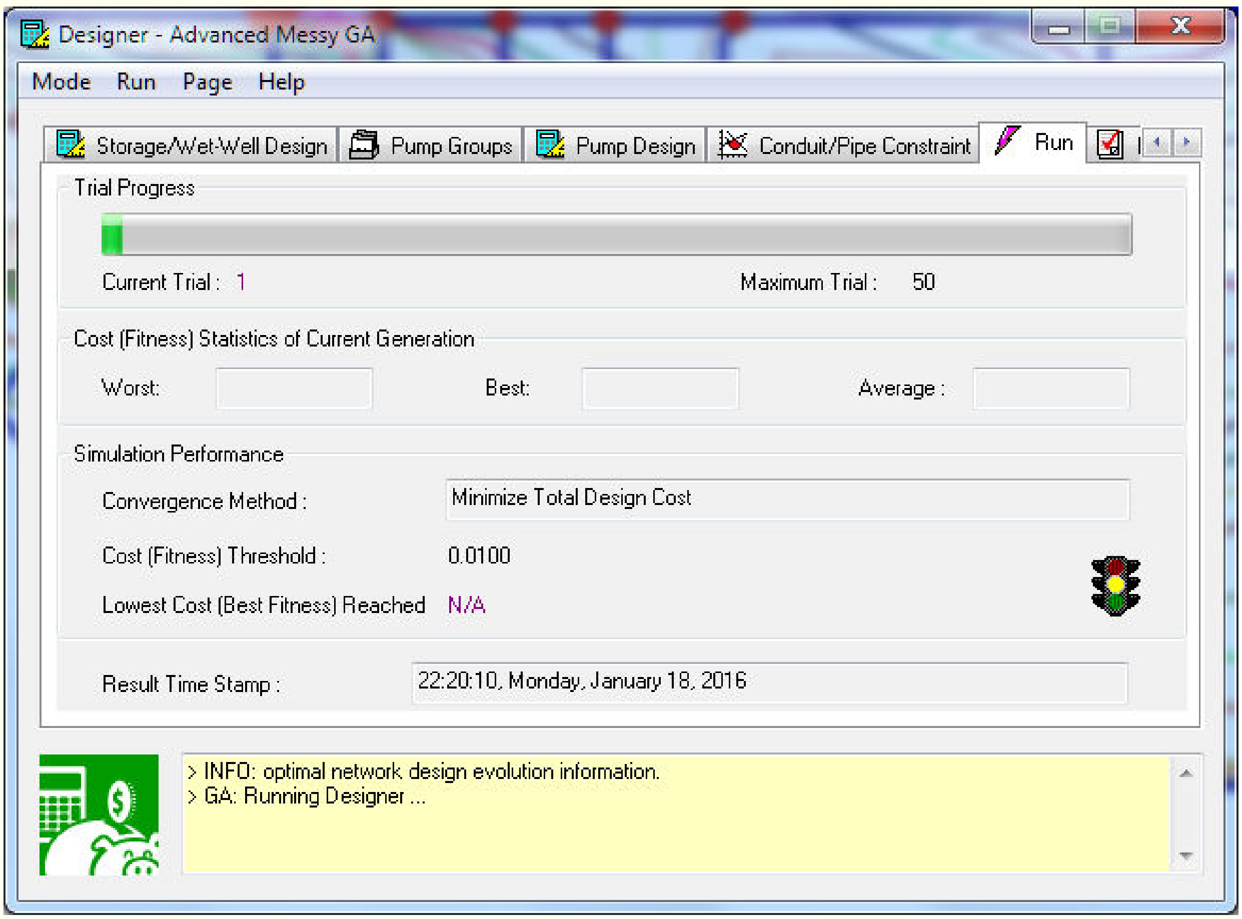
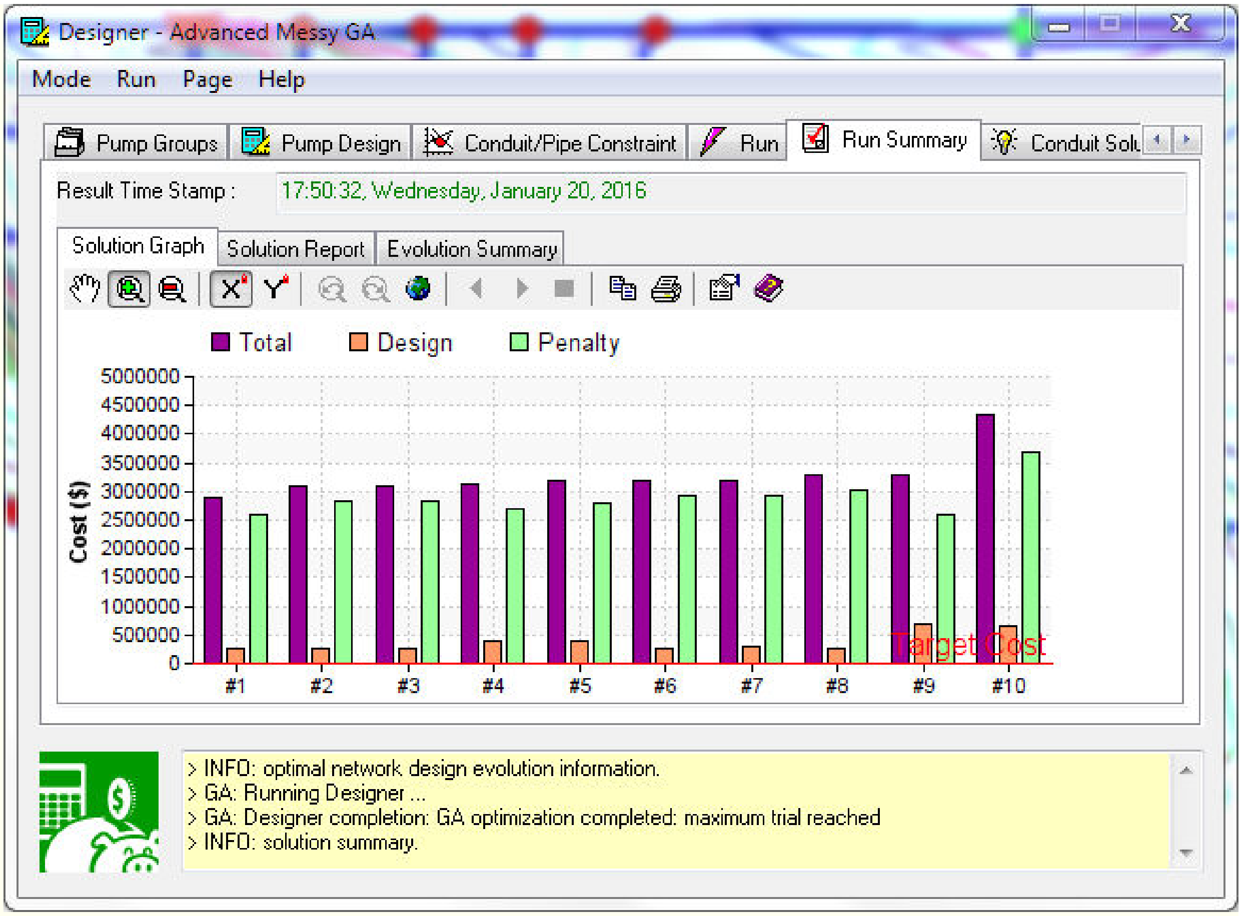
Step 9: Perform Design Run

At this point, the Designer optimization may be performed. Watch the run dialog as the simulation proceeds.

 1. Select "Run" from the 

menu.





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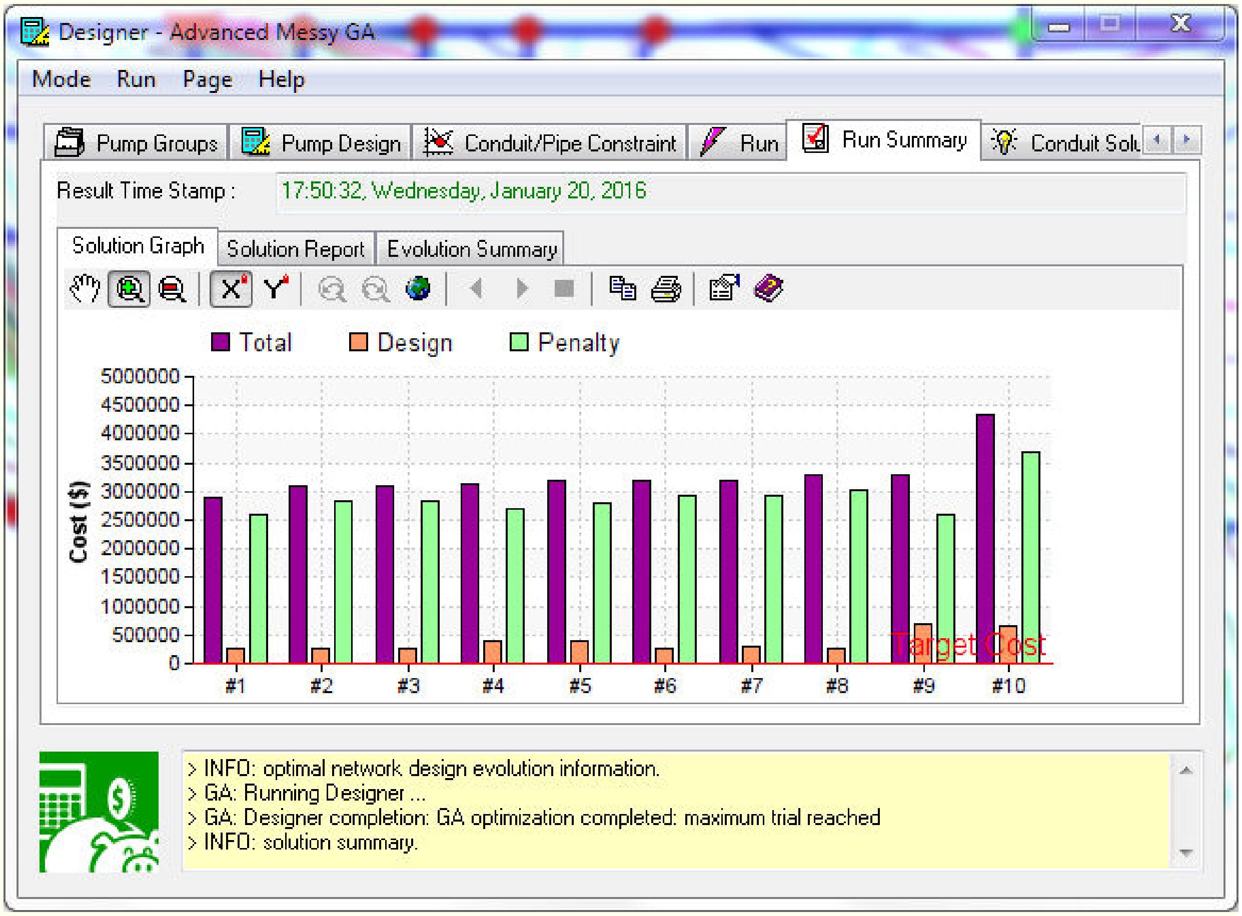
Step 10: Review Model Results

1. Review results from the Run Summary tab.

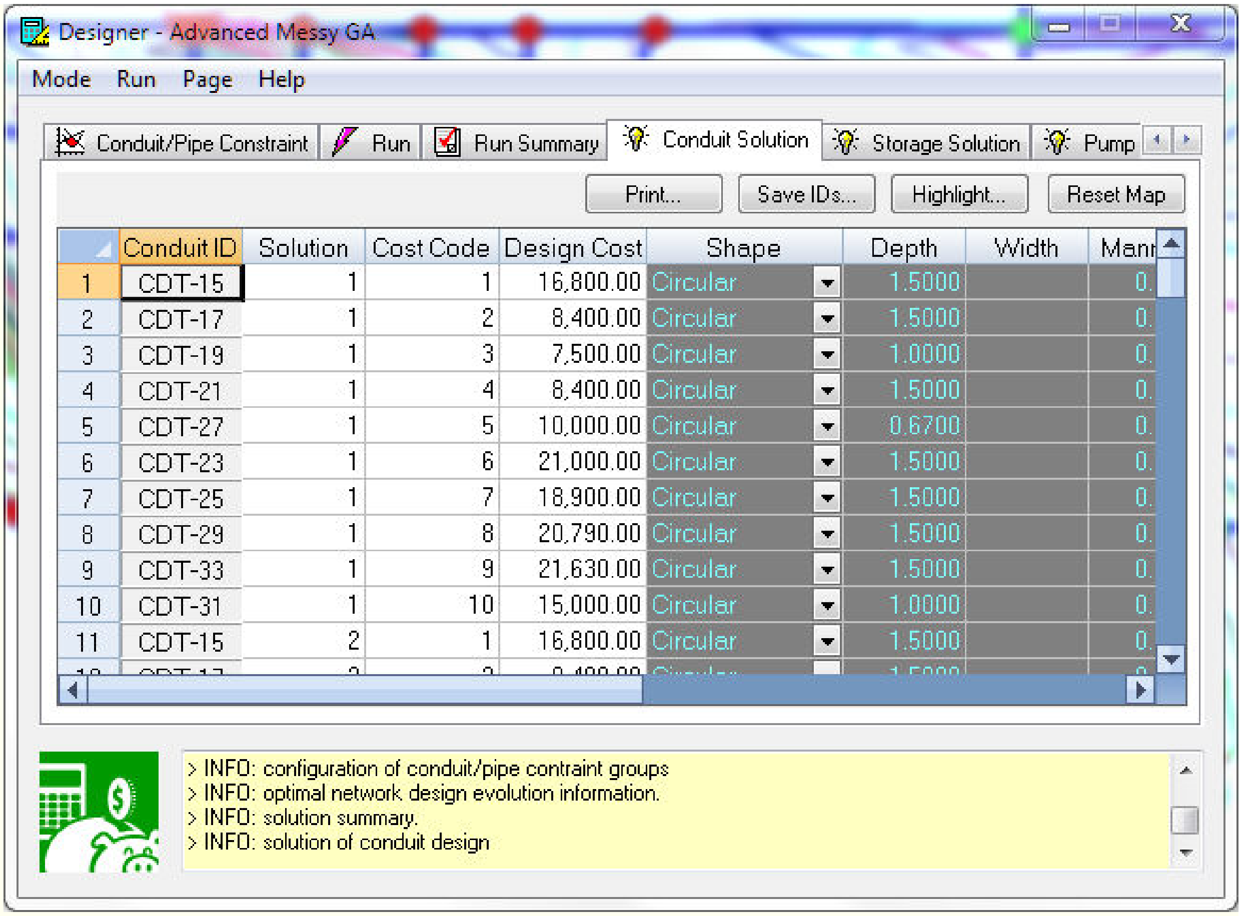
   a. Notice that the lowest cost solution may have higher penalty costs than other solutions. For this example, solution #3 appears to be the best option as it does not violate many constraints while maintaining a relatively low design cost.

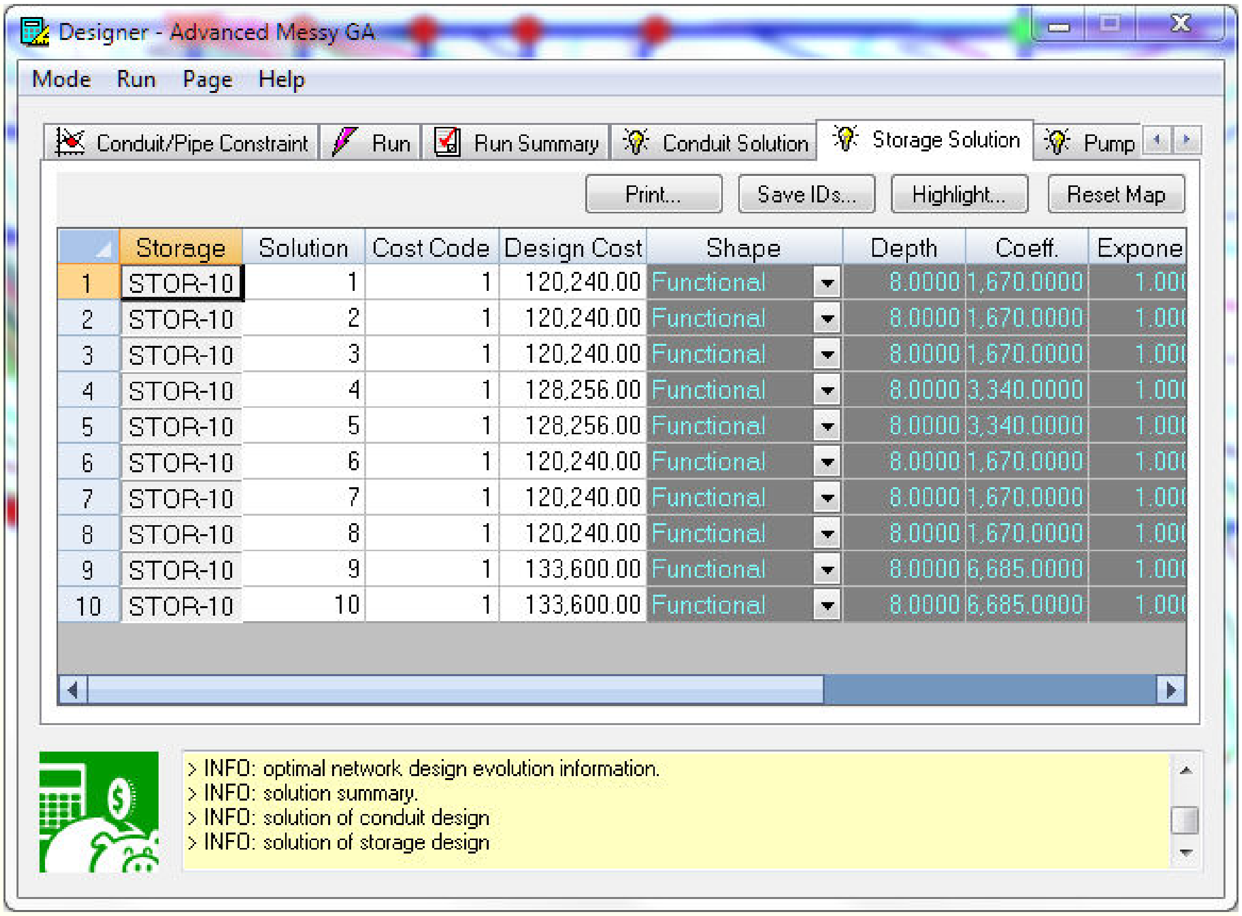


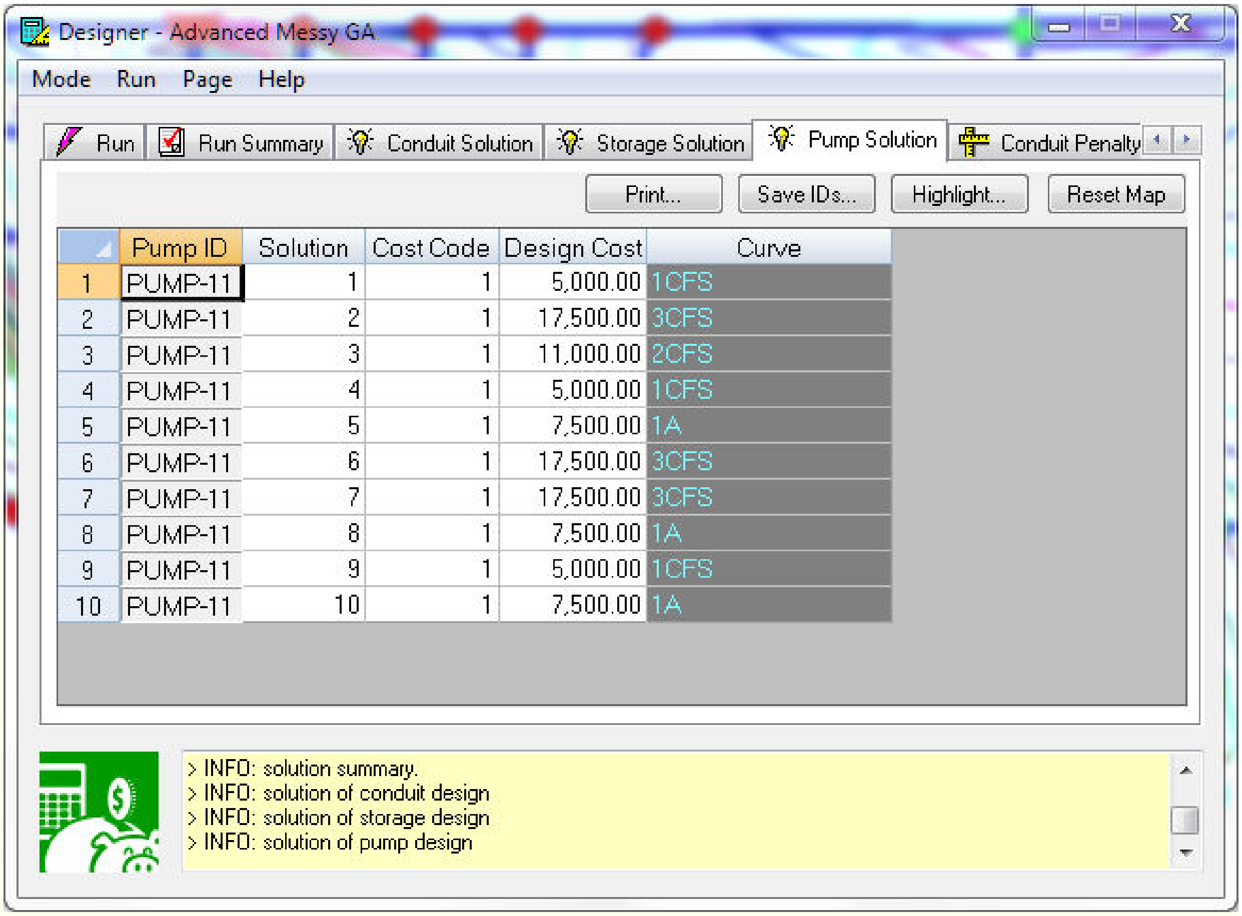
NOTE: *The designer saves at most 10 optimal solutions.*

2. For the detailed solutions, review the Conduit Solution tab, the Storage Solution tab, and the Pump Solution tab.

NOTE: *Since GA optimization is a stochastic search process, you may encounter local optimal solutions that differ from the global solution shown above. In case such a local solution is reached, simply rerun the design simulation to further explore the solution space to narrow the search towards the global solution.*


Designer - Advanced Messy GA
Mode Run Page Help
Conduit/Pipe Constraint
Run
Run Summary
Conduit Solution
Storage Solution
Pump
Print...
Save IDs...
Highlight...
Reset Map
Conduit ID | Solution | Cost Code | Design Cost | Shape | Depth | Width
1 CDT-15 1 1 16,800.00 Circular 1.5000
2 CDT-17 1 2 8,400.00 Circular 1.5000
3 CDT-19 1 3 7,500.00 Circular 1.0000
4 CDT-21 1 4 8,400.00 Circular 1.5000
5 CDT-27 1 5 10,000.00 Circular 0.6700
6 CDT-23 1 6 21,000.00 Circular 1.5000
7 CDT-25 1 7 18,900.00 Circular 1.5000
8 CDT-29 1 8 20,790.00 Circular 1.5000
9 CDT-33 1 9 21,630.00 Circular 1.5000
10 CDT-31 1 10 15,000.00 Circular 1.0000
11 CDT-15 2 1 16,800.00 Circular 1.5000
> INFO: configuration of conduit/pipe contraint groups
> INFO: optimal network design evolution information.
> INFO: solution summary.
> INFO: solution of conduit design


Designer - Advanced Messy GA
Mode Run Page Help
Conduit/Pipe Constraint
Run
Run Summary
Conduit Solution
Storage Solution
Pump
Print...
Save IDs...
Highlight...
Reset Map
Storage Solution Cost Code Design Cost Shape Depth Coeff. Expone
1 STOR-10 1 1 120,240.00 Functional 8.0000 1,670.0000 1.000
2 STOR-10 2 1 120,240.00 Functional 8.0000 1,670.0000 1.000
3 STOR-10 3 1 120,240.00 Functional 8.0000 1,670.0000 1.000
4 STOR-10 4 1 128,256.00 Functional 8.0000 3,340.0000 1.000
5 STOR-10 5 1 128,256.00 Functional 8.0000 3,340.0000 1.000
6 STOR-10 6 1 120,240.00 Functional 8.0000 1,670.0000 1.000
7 STOR-10 7 1 120,240.00 Functional 8.0000 1,670.0000 1.000
8 STOR-10 8 1 120,240.00 Functional 8.0000 1,670.0000 1.000
9 STOR-10 9 1 133,600.00 Functional 8.0000 6,685.0000 1.000
10 STOR-10 10 1 133,600.00 Functional 8.0000 6,685.0000 1.000
> INFO: optimal network design evolution information.
> INFO: solution summary.
> INFO: solution of conduit design
> INFO: solution of storage design



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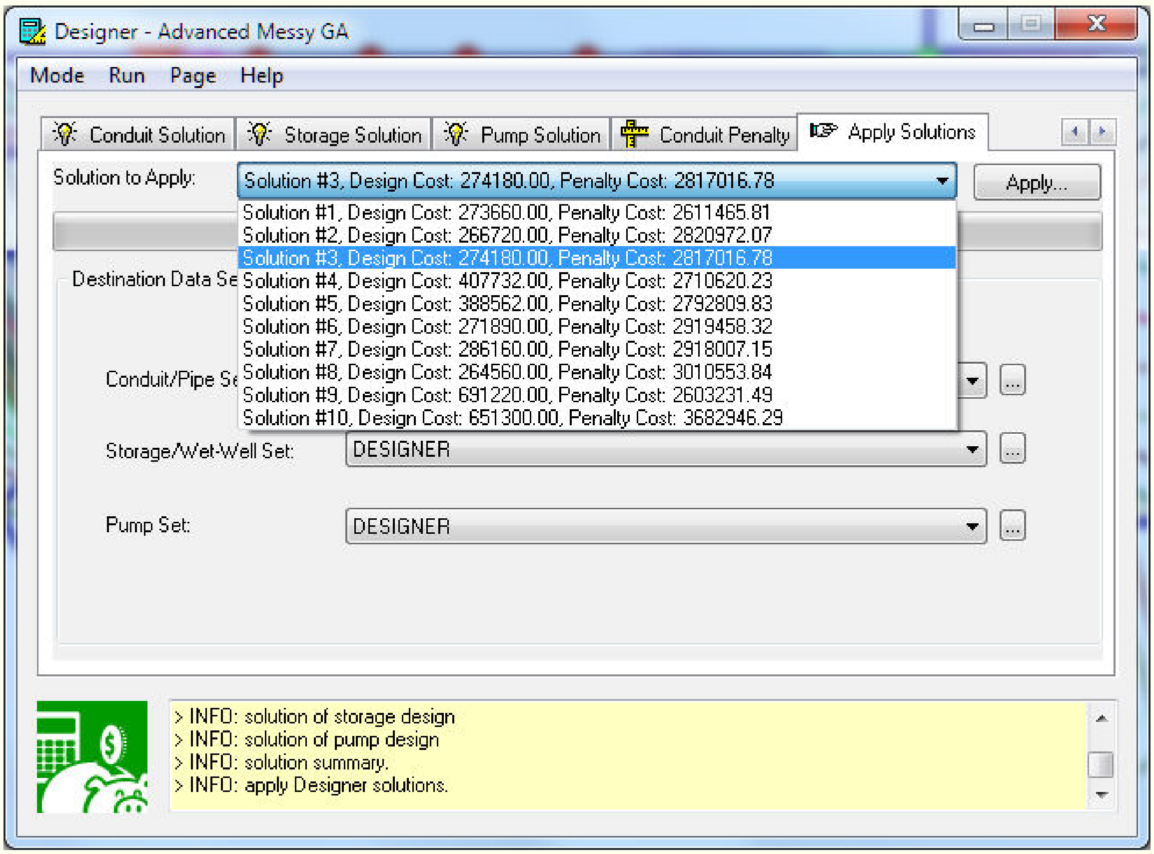
Step 11: Apply Design Solution

You can update the Modeling database table with the new sewer diameters, storage volume, and pumping capacity. To accomplish this, perform the following tasks:

1. Select the Apply Solutions tab.

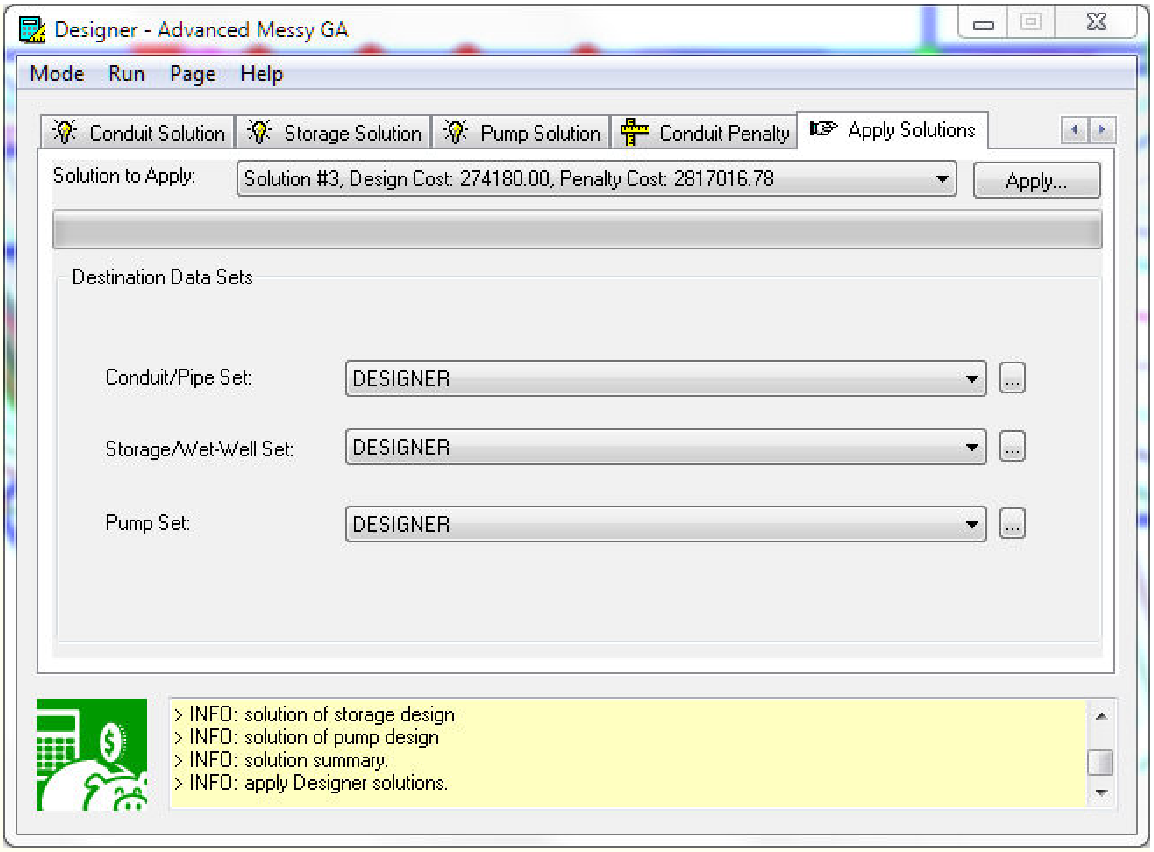
2. Choose solution #3 from the drop down menu.



NOTE: *For this example*

a scenario called Future_Applied was created for the final design. Data sets named “Designer” were created for this scenario. The selected optimal solution will be saved in these data sets.

3. Select the Designer data sets for each destination as shown.



4. Click Apply... .

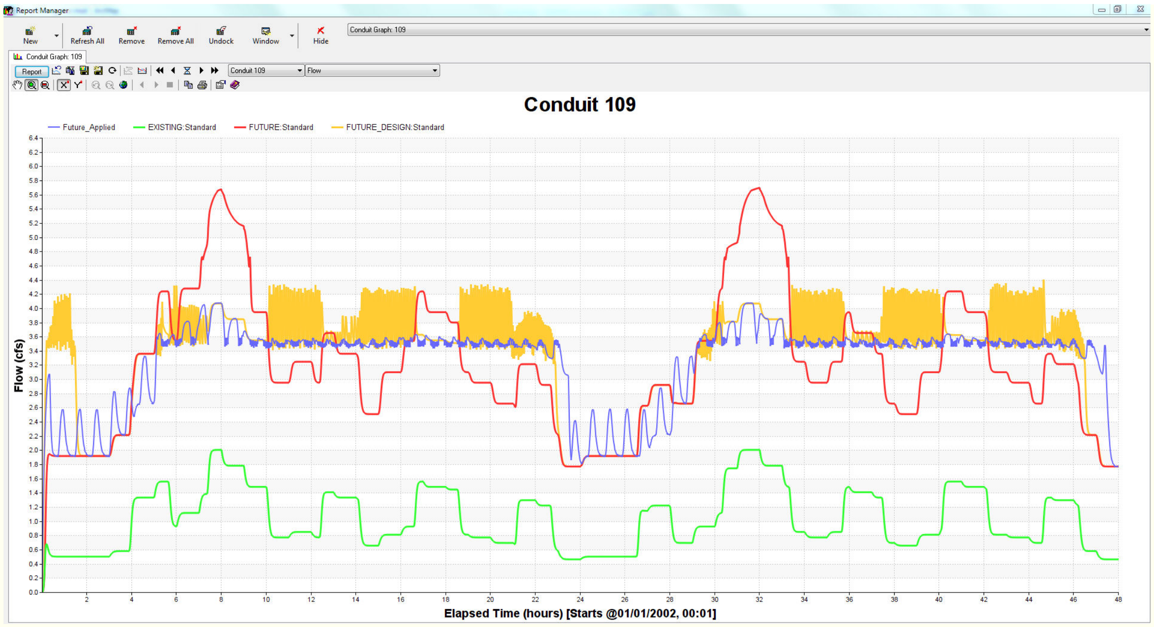
5. Exit ( ) the Designer.

6. Choose the scenario FUTURE_APPLIED, Future system with applied solution

7. Open the Run Manager ( ).

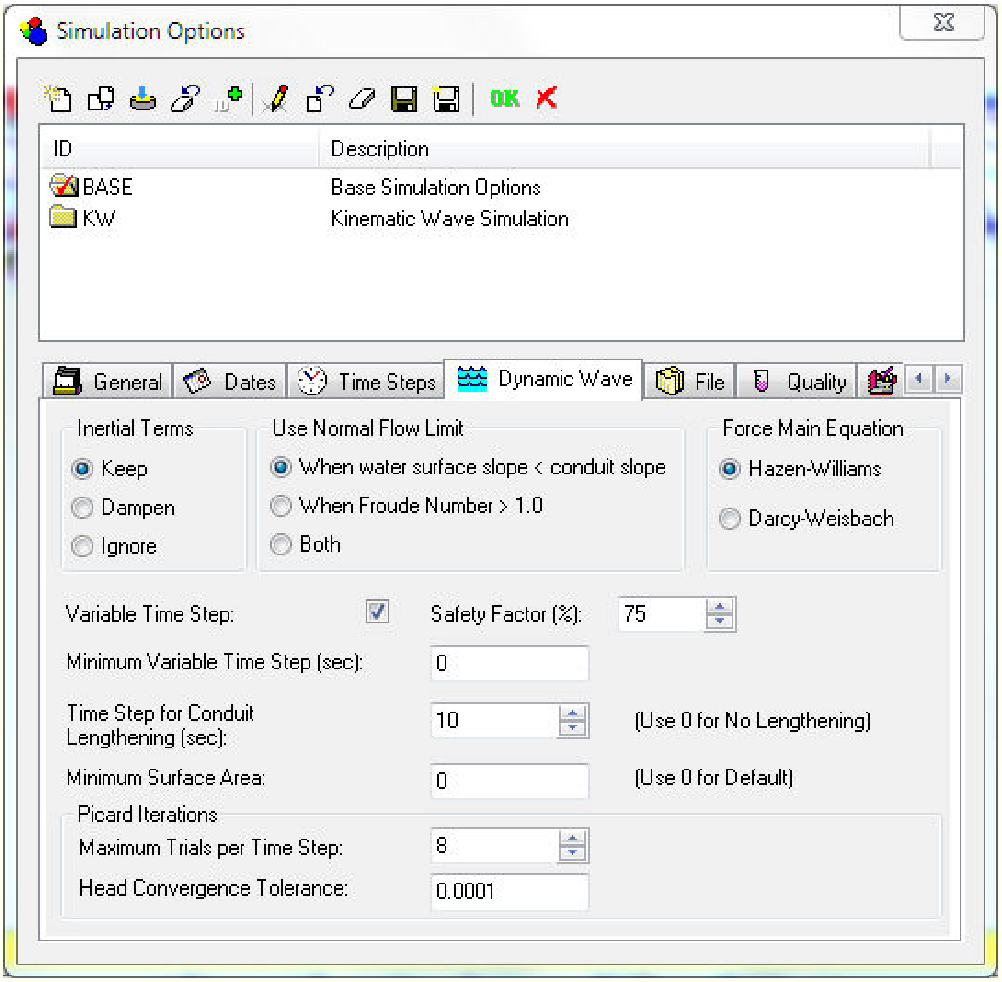
8. Run the Future_Applied scenario ( ).

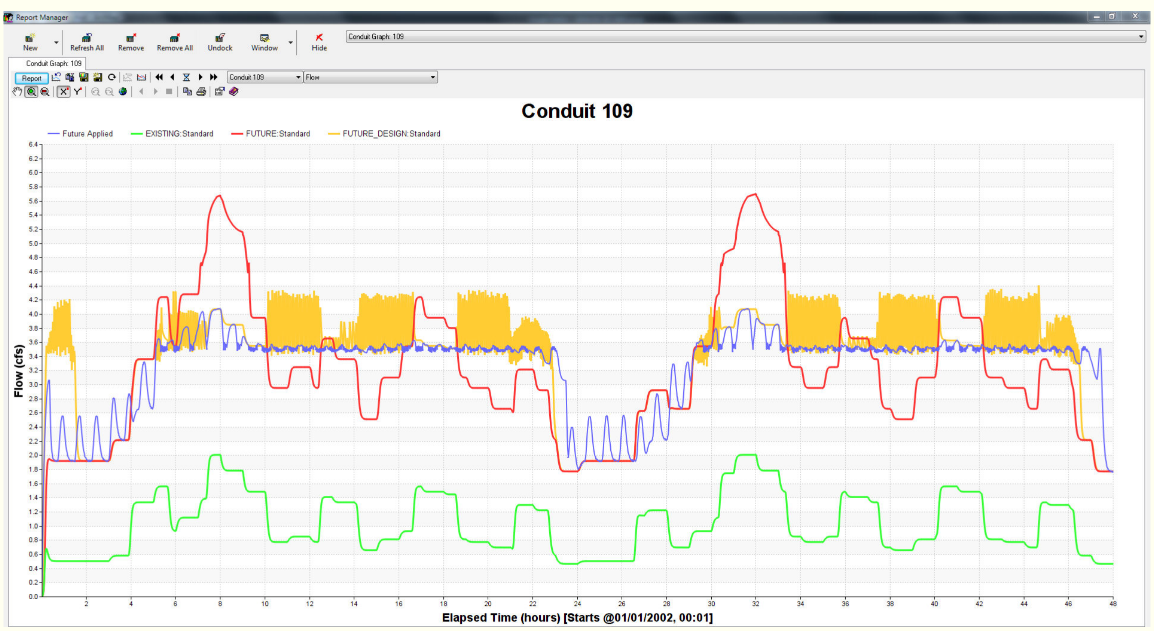
9. Review the results for Conduit 109.



Notice that the current run has a few unstable oscillations.

Change the number of Picard Iteration and the stopping tolerance.





NOTE: *Once the solution*

is applied the engineer should use sound engineering judgment. For example, the engineer may opt to increase the recommended diameter for a conduit in order to eliminate any bottlenecks.

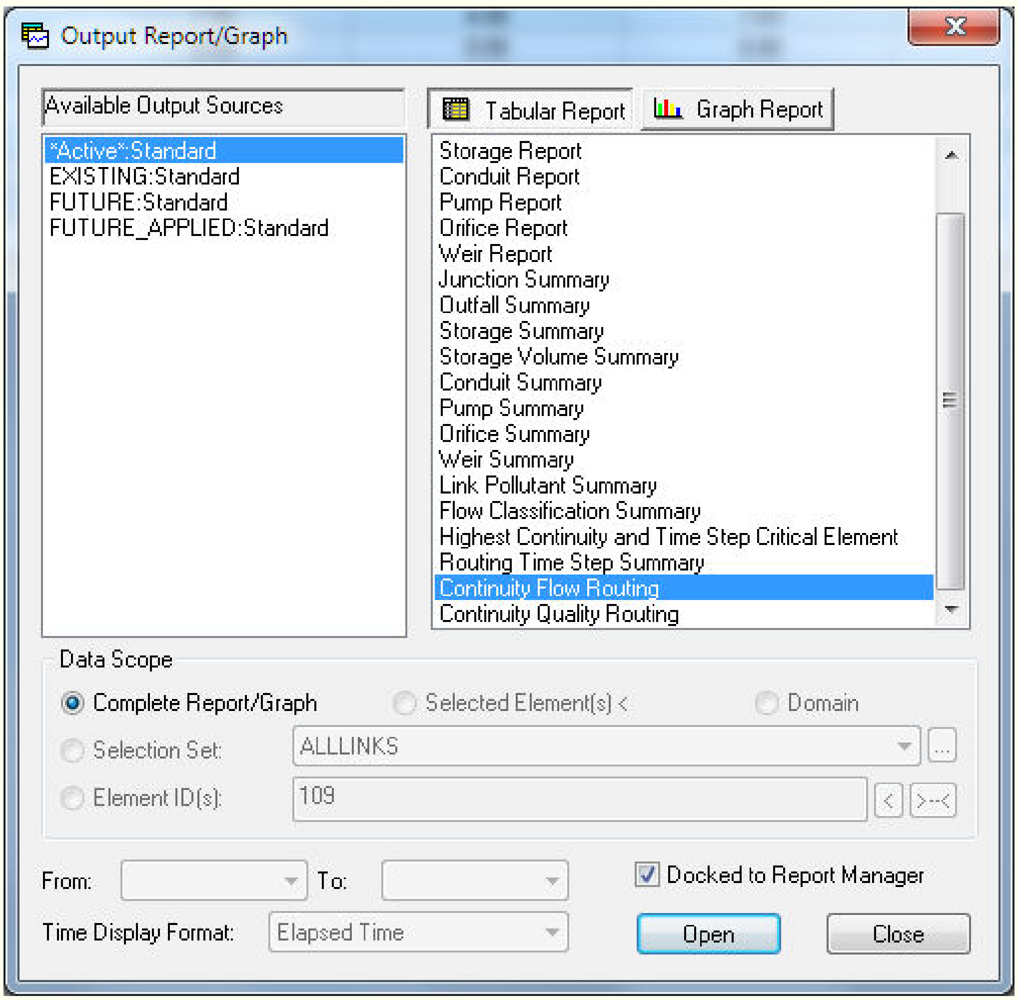
Bonus to SWMM Designer

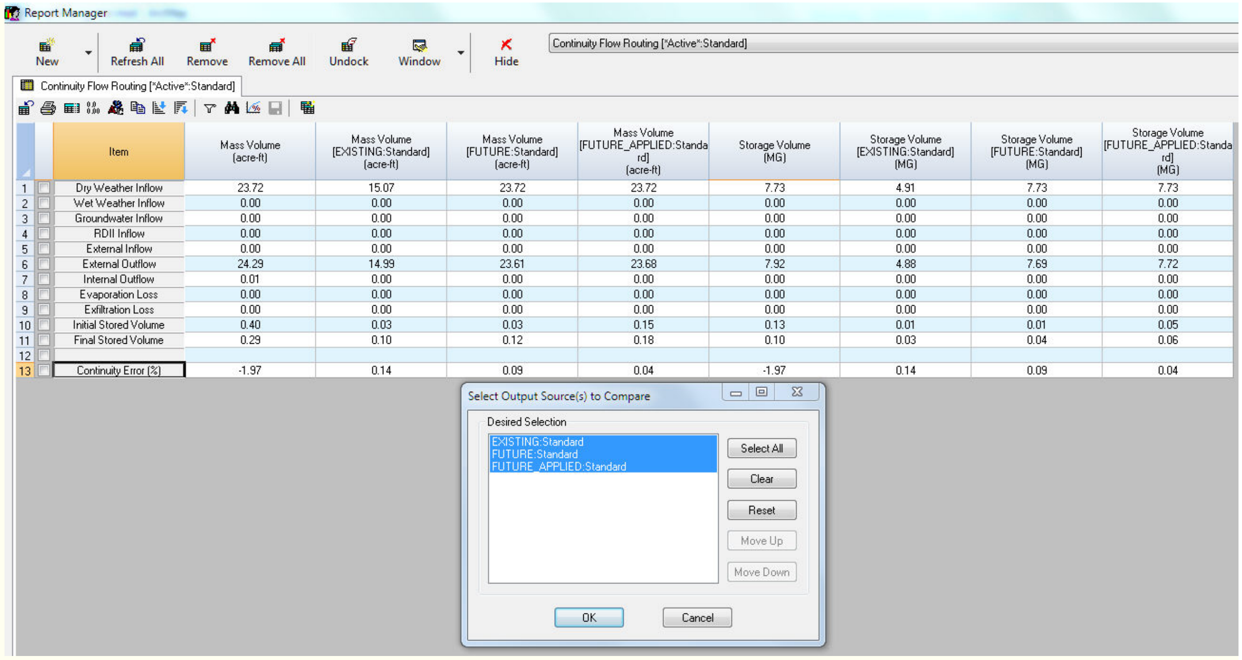
Try using various penalty costs and number of trials to determine if a lower cost solution can be found. New constraints may be added as well.

The designer is ready to run again, simply change the penalty costs and/or number of trials and run the simulation again (Steps 8-11). Solutions may be applied to unique scenarios and the results analyzed using the compare graph tool. Refer to the InfoSWMM

User Guide for help on creating and comparing scenarios.

Remember to always check the continuity error for flow routing in your output. You can also compare across all scenarios





	Item	Mass Volume (acre-ft)	Mass Volume [EXISTING:Standard] (acre-ft)	Mass Volume [FUTURE:Standard] (acre-ft)	Mass Volume [FUTURE_APPLIED:Standard] (acre-ft)	Storage Volume (MG)	Storage Volume [EXISTING:Standard] (MG)	Storage Volume [FUTURE:Standard] (MG)	Storage Volume [FUTURE_APPLIED:Standard] (MG)
1	Dry Weather Inflow	23.72	15.07	23.72	23.72	7.73	4.91	7.73	7.73
2	Wet Weather Inflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	Groundwater Inflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	RDII Inflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	External Inflow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	External Outflow	24.29	14.99	23.61	23.68	7.92	4.88	7.69	7.72
7	Internal Outflow	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	Evaporation Loss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	Exfiltration Loss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	Initial Stored Volume	0.40	0.03	0.03	0.15	0.13	0.01	0.01	0.05
11	Final Stored Volume	0.29	0.10	0.12	0.18	0.10	0.03	0.04	0.06
12									
13	Continuity Error (%)	-1.97	0.14	0.09	0.04	-1.97	0.14	0.09	0.04

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4.1.1 Objective Function

The objective (fitness) function of the collection system optimization problem is to minimize the design cost under a specified set of loading and operating conditions. The objective cost function can be mathematically expressed as:

Objective Cost Function:

$$Minimize \qquad \sum_{c=1}^{C} C_c L_c + \sum_{s=1}^{S} C_s V_s + \sum_{p=1}^{P} C_p + Penalty$$

where c, C_c and L_c used in the left-hand side term of the equation refer to conduits and represent conduit counter, replacement cost which is a function of conduit size, and length of the conduit, respectively. Likewise the s, C_s,

and V_s used in the middle term of the equation refer to storage node counter, cost per unit volume of storage and volume of the storage unit, respectively. The p and C_p

used in the last term of the equation refer to pump counter and cost associated with the pump, respectively.

The decision variables, which consist of conduit, storage and pump sizes, are automatically calculated to minimize the objective cost function while satisfying three different kinds of constraints: (1) A set of implicit system constraints; (2) a set of explicit bound constraints; and (3) a set of explicit variable constraints.

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4.1.2 Implicit System Constraints

The implicit constraints on the collection system are equality constraints defining the hydraulic equilibrium state of the system. They correspond to the St. Venant equations that are solved implicitly using InfoSWMM

. Each function call to the *InfoSWMM*

with a set of decision variables returns the simulated hydraulic equilibrium solution for flow velocities and heads.

4.1.3 Explicit Bound Constraints

The explicit bound constraints on the optimization problem represent system performance criteria and may include constraints on sewer flow velocity (*V*), depth to diameter ratio (d/D) and head loss (*HG*) in force mains for a given collection system loading and operating conditions.

1. Pipe Constraints:

A design solution is constrained by a minimum and maximum velocities and maximum depth to diameter ratio for pipes as well as maximum head losses for force mains given as:

$$V\,min_k \le V_k \le Vmax_k \qquad \forall k\,, \forall t$$

$$d\,/\,D_k \le d\,/\,Dmax_k \qquad \forall k\,, \forall t$$

$$HG_k \le HGmax_k \qquad \forall k\,, \forall t$$

where V_k is the flow velocity of conduit *k* at time *t, $Vmax_k$* represents the maximum allowable flow velocity for conduit *k*, $Vmin_k$ represents the minimum allowable flow velocity for conduit *k*, d/D_k

designates the depth too diameter ratio of conduit *k* at time *t*, $d/Dmax_k$ designates the maximum allowable depth to diameter ratio for conduit *k*, HG_k is the head loss for force main *k* at time *t* and $HGmax_k$ is the maximum allowable head loss for force main *k*. When a design solution does not satisfy an implicit bound constraint, a penalty method is used to handle the constraint violation.

3. Penalty Cost (PC):

A penalty cost is added to the objective function to penalize an infeasible solution (degrade its fitness) and force the search procedure towards the region of feasible solutions. The penalty cost function is defined as the divergence (distance) of the computed solution from the feasible region o

$$PC = \sum_{i=1}^{N} v_i \left| C_i(x) - C_i \right|$$

where N represents the number of constraints; v_i

represents a weighting factor associated to constraint C_i, $C_i(x)$ is the value of the i^{th} constraint and C_i

is the constraint limit.

It is expected that different values of the penalty costs will result in different solutions and also affect the efficacy of the optimization calculation. Therefore, a number of trial optimization runs with different penalty costs are recommended for better exploring the solution space and narrowing in on the lowest cost solutions. If a feasible solution (a solution that satisfies all the constraints) is not found, *Designer* will return the lowest-cost solution with the minimum constraint violation.

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4.1.4 Explicit Variable Constraints

The explicit variable constraints are used to set minimum (lower) and maximum (upper) limits on the sewer sizes and to specify the discrete (commercially available) diameter values for the new conduits. Conduits should be lumped together in separate logical design groups based on the known physical characteristics of the associated conduits such as size and location. As such all conduits within a group will possess an identical size.

For each conduit group, the sewer size is bound by an explicit inequality constraint as:

$$Dmin_n \le D_n \le Dmax_n \qquad \forall n, \forall D_n \in D^0 = \left\{ d_k^0, k = 1, \ldots K \right\}$$

where $Dmin_n$ designates the lower bound (the minimum value) of conduit sizes for conduit group n; $Dmax_n$ represents the upper bound (the maximum value) of conduit sizes for conduit group n; and D_n

is the conduit size for conduit group n and selected from a set of available conduit sizes of D^0.

Up to 100 distinct conduit groups can be defined with this version of the *Designer*. It should be noted that the choice of conduit groups greatly affect the optimization results as well as the convergence rate.

It is also expected that the computed solution for conduit sizes will be a near optimum solution and may not be the exact global minimum cost solution.

Similarly, pump curves are selected from the various pump curves specified.

Storage volumes are computed based on shape of storage, defined either as a mathematical function or in tabular form (head vs. area), and are bound by the minimum and maximum storage depths specified.

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4.2 Solution Methodology

To solve the sewer collection system optimization problem as formulated above, a dual-level solution methodology was employed by means of which the InfoSWMM (urban drainage system simulator) was directly embedded into the optimization model. Starting with an initial feasible set of design parameters, it is passed to theInfoSWMM

for

use in explicitly satisfying the implicit system constraints and in evaluating the implicit bound constraints. The collection system hydraulic solution (i.e., velocity and head) is then passed back to the optimization model for use in quantifying the objective function and any violations in the implicit bound constraints. This information is then utilized to produce an improved set of design parameters that automatically satisfy the explicit variable constraints and that seeks to minimize the objective function.

This iterative process is repeated until the best solution is found. The optimization model utilized is an efficient variation of genetic algorithms delivering reliable solutions in sub-quadratic time[1].

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4.3.1 Overview of Genetic Algorithms

Genetic algorithms (GAs) are stochastic numerical search procedures inspired by biological evolution, cross-breeding trial solutions and allowing only the fittest solutions to survive and propagate to successive generations.

They deal with a population of individual (candidate) solutions, which undergo constant changes by means of genetic operations of reproduction, crossover, and mutation. These solutions are ranked based on their fitness with respect to the objective function where the fit individuals are more likely to reproduce and propagate to the next generation. Based on their fitness values, individuals (parents) are selected for reproduction of the next generation by exchanging genetic information to form children (crossover). The parents are then removed and replaced in the population by the children to keep a stable population size. The result is a new generation with (normally) better fitness. Occasionally, mutation is introduced into the population to prevent the convergence to a local optimum and help generate unexpected directions in the solution space. The more GA's iterate, the better their chance to generate an optimal solution. After a number of generations, the population is expected to evolve artificially, and the (near) optimal solution will be reached. The measure of success is the convergence to a population with identical members. The global optimum solution however cannot be guaranteed since the convexity of the objective function cannot be proven (Boulos et al, 2006).

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4.3.2 Components of Genetic Algorithms

Standard genetic algorithms involve four basic functions: selection, crossover, mutation and elitism. Each function is briefly described below.

Selection - Individuals in a population are selected for reproduction according to their fitness values. In biology, fitness is the number of offspring that survive to reproduction. Given a population consisting of individuals identified by their chromosomes, selecting two chromosomes as parent to reproduce offspring is guided by a probability rule that the higher the fitness an individual has, the more likely the individual is selected. There are many selection methods available including weighted roulette wheel, sorting schemes, proportionate reproduction, and tournament selection.

Crossover - Selected parents reproduce the offspring by performing a crossover operation on the chromosomes (cut and splice pieces of one parent to those of another). In nature, crossover implies two parents exchange parts of their corresponding chromosomes. In genetic algorithms, crossover operation makes two strings swap their partial strings. Since more fit individuals have a higher probability of producing offspring than less fit ones, the new population will possess on average an improved fitness. The basic crossover is a one-point crossover. Two selected strings create two offspring strings by swapping the partial strings, which are cut by one randomly sampled breakpoint along the chromosome. The one-point crossover can be easily extended to k-point crossover. It randomly samples k breakpoints on chromosomes and then exchanges every second corresponding segments of two parent strings.

Mutation - Mutation is an insurance policy against lost bits.

It works on the level of string bits by randomly altering a bit value.

With small probability, it randomly selects one bit on a chromosome then inverts the bit from 0 to 1 or vice versa. The operation is designed to prevent GA from premature termination, namely converging to a solution too early.

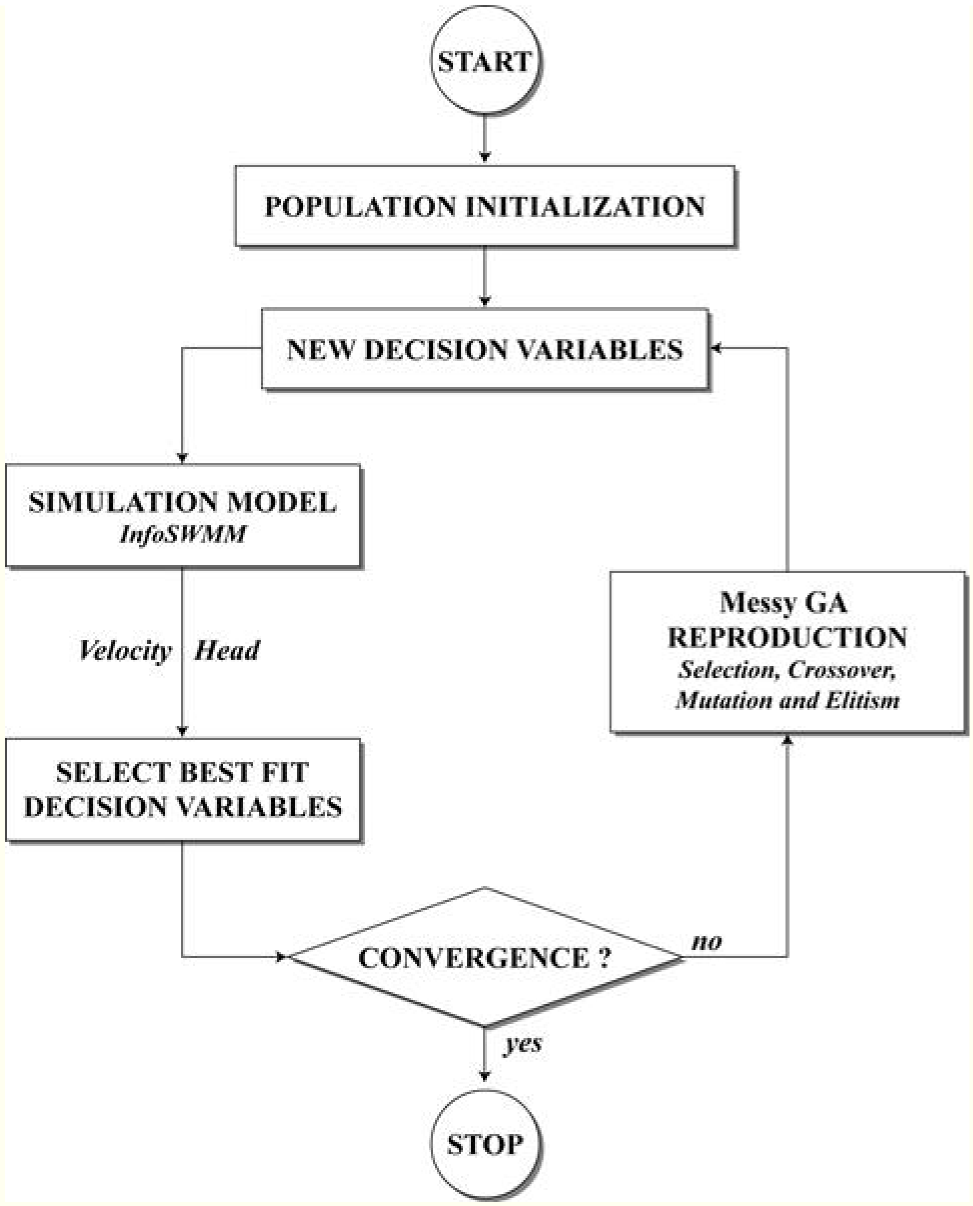
Elitism - The selection and crossover operators will tend to ensure that the best genetic material and the components of the fittest chromosomes will be carried forward to the next generation. However, the probabilistic nature of these operators implies that this will not always be the case. An elitist strategy is therefore required to ensure that the best genetic material will not be lost by chance. This is accomplished by always carrying forward the best chromosome from one generation to the next.

The flowchart below illustrates the sewer collection system optimization process.

Different GAs vary in the way they create the mating pool and the coding schemes, choose parents, generate children, or display their population dynamics, and several veraions have been proposed with varying levels of success (Goldberg, 1989; Boulos et al, 2000, 2001, 2006; Zheng et al, 2001). The fast messy GA (fmGA) implemented here is one of the most competent types of GA delivering reliable solutions in subquadratic time (Goldberg et al, 1989). It differs from other GA paradigms in solution representation, initialization, and reproduction.

The fmGA uses a flexible scheme of collection system design solution (gene) representation with strings of variable lengths. The length of strings varies from one string to another. It allows short strings (namely partial solutions) to be generated and evaluated during the GA optimization.

The short strings are considered to retain “building locks” or better fit partial strings that form the good solutions.



The fmGA proceeds in two phases of genetic operations. It starts with an initial population of full-length strings and follows by a filtering process including building blocks and reproduction. It identifies short strings of higher fitness by randomly deleting genes from the initial strings. The building block filtering process continues until the length of string is reduced to a prescribed order.

The identified short strings are used are used to form individual solutions.

An individual solution is produced by "cut" and "splice" operations, which are different from the standard GA crossover and mutation operations.

“Cut” divides the string into two strings, where as “splice” concatenates two strings to form one individual solution. Both genetic operations are designed to effectively exchange building blocks for composing the (near) optimal solution.

The fmGA combines the building block identification and reproduction phases into one artificial evolution process and continues over a number of outer iterations of solution initialization, filtering, and reproduction.

The iterations are continued until the (near) optimal solution is identified in a population.

4.4 References

- Boulos,

  P.F. et al. (2000). “Least Cost Design and Rehabilitation of Water Distribution Systems Using Genetic Algorithms.” In *Proceedings of the AWWA IMTech Conference*, April 16-19, Seattle, WA.

- Boulos, P.F.

  et al. (2001). “Optimal Operation of Water Distribution Systems Using Genetic Algorithms.” In *Proceedings of the AWWA Distribution System Symposium*, September 23-26, San Diego, CA.

- Boulos, P.F.,

  K.E. Lansey and B.W. Karney (2006). *Comprehensive Water Distribution Systems Analysis Handbook for Engineers and Planners*. Second Edition.

  MWH Soft Pub., Pasadena, CA.

- Nicklow, J.W.,

  P.F. Boulos and M.K. Muleta (2004). *Comprehensive Sewer Collection Systems Analysis Handbook for Engineers and Planners*. MWH Soft Pub., Pasadena, CA.

- Zheng,

  W, P.F. Boulos, C.H. Orr and J.J. Ro (2001). “Using Genetic Algorithms to Rehabilitate Water Distribution Systems.” *Journal AWWA*, 93(11), 74-85.

- Goldberg, D.E.

  (1989). *Genetic Algorithms in Search, Optimization and Machine Learning*. Addison Wesley, Reading, MA.

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Run Menu

The Run Menu is used to start or stop the Designer optimization (by pressing start or stop). The Designer options may also be accessed using this menu.

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