

Hydraulic Modeling in GIS: Time Series Results in Mapplet

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A single Enterprise GIS (EGIS) dataset may be used by different users in water/wastewater agencies. One such use, which has been getting more attention recently, is the use of GIS data to perform hydraulic modeling of the water distribution and sewer collection systems. Conversely, the time series data resulting from the modeling effort may be imported into the EGIS and made available to other users. The objective of this paper is to illustrate a workflow implemented by the Irvine Ranch Water District where EGIS data is used for hydraulic modeling, and the modeling results are made available to all the EGIS users through a Web-based viewer. Hydraulic modeling involves running the model over a time period. The results from such analysis could be viewed only in the modeling software, which the majority of the users do not have access to.

Introduction

The Irvine Ranch Water District uses Hydraulic Models for their Water Distribution system analysis, and design and Master Planning purposes. The District also has a well-developed enterprise GIS that is being used across all the departments in the District. This paper is a description of the workflow the District intends to use – in making the hydraulic modeling results applicable to multiple users and also update the hydraulic model when some one updates any data in the GIS that can affect the model.

Enterprise GIS is finding its way into more and more organizations as a unified and dynamic data management system. It does take some effort for any organization to build an enterprise GIS. But it is well worth the effort since the advantages offered by the system far outweigh the expenditure and effort invested in the long run. As more and more organizations opt for enterprise GIS, it will soon be an unspoken standard for managing spatial and temporal data.

For basics - Hydraulic modeling is the simulation of the Water Utility Network on the computer. It is used to simulate scenarios – existing, proposed, or emergency conditions in order to handle the day-to-day utility operations, Master planning, or Security.

A hydraulic model is similar to GIS in the following ways:

Both show the data spatially.

Both contain attribute data tied to the features.

The Work Flow – Updating the Model, and Presenting the Results.

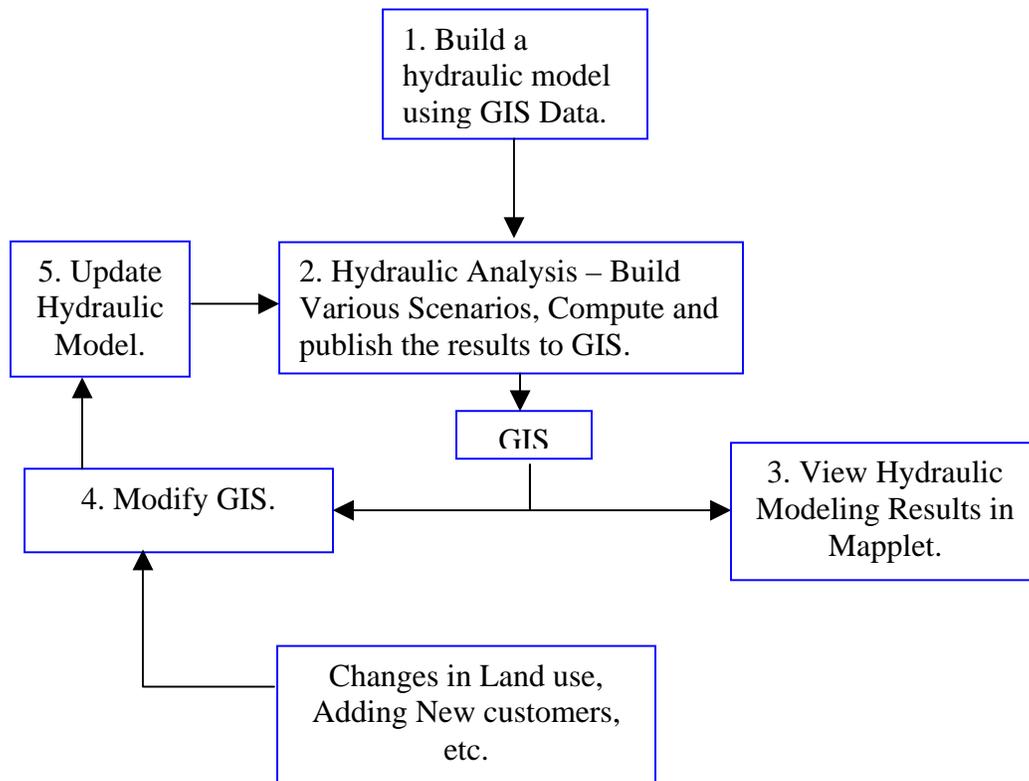
A workflow has been identified to make the hydraulic modeling results available via EGIS, while at the same time, updating the hydraulic model with any changes in the EGIS.

The input for a hydraulic model is a subset of the GIS data. But the output from the hydraulic model is not necessarily the required input into the GIS – adding all the attributes of the hydraulic model to the GIS requires that there is a change to the database. (Unless it has been already accounted for. Even otherwise, it just makes the database very bulky). This is not very desirable at a stage when the GIS is fully

developed. Additionally, only some information from the hydraulic modeling results may be useful to other users (outside the engineering department).

Due to the above reasons, we find it necessary to maintain the hydraulic model and the GIS separately, but at the same time, it is very important that the hydraulic model be updated as and when updates are made to the GIS.

The following figure illustrates the workflow in a nutshell:



1. Build a hydraulic model from the GIS:

A hydraulic model consists of the nodes and links of the water utility. A hydraulic model- how much ever skeletonized, must represent the real world / onsite scenario. The effort invested in building an EGIS can be leveraged- by using the EGIS to build the hydraulic model.

The differences between an EGIS and a hydraulic model must be considered however before one proceeds to build a hydraulic model from EGIS data.

The following are the differences between a typical GIS system and Hydraulic model for a Water Utility:

	GIS System for Water Utility	Hydraulic Model for Water Utility
1	Detail oriented - contains almost all the water facilities that actually exist in field along with abandoned / proposed features.	Contains only the elements that are of interest to the users of the model. The model will be very bulky with unnecessary detail if the number of facilities is same as GIS.
2	Serves a wide range of users with different levels of control over the data as per the requirement.	Usually limited to the Engineering department. On request from the other users, the Modeler can make the results of hydraulic model available.
3	Unified - single model throughout the Utility. If using an EGIS, the model could span over various departments.	Different versions of model could exist depending on the scenarios, intended use of the model, and different users.
4	Since GIS is very detailed, demands are assigned to different meters. The customer billing information is associated with each meter.	Demands for a certain area are assigned to a single node - usually based on land use. Usually individual customer connections are not accounted for - unless the Modeler specifically includes them.
5	GIS has the capability to link a feature to as-built drawings. This enables users to pull out the construction drawings with a click. Additionally, GIS can also handle information on repairs and maintenance.	The hydraulic model can handle some of the information, (in terms of attributes only – not linked drawings) but it is not really necessary. The repair information only matters if it is relevant when the results are to be viewed.
6	An EGIS system is dynamic. It is easily maintained / updated at various levels by different users.	The Hydraulic model can also be updated by many users – one after another, but it is highly recommended that a single person handle the updates of the system.

A typical GIS for a Water Utility will have more information than is necessary for a hydraulic model. A well-built GIS system can be easily translated to a hydraulic model. The modeler however needs to give some consideration as to which features and attributes will be brought in from the GIS into the model.

IRWD's Water model has been created using GIS shape files and was in the Cybernet version earlier. Presently, this model is converted to the WaterGEMS version. At this stage a link (unique identifier field acting as a primary key in the model) must be created and maintained between the EGIS and the model forever. It is okay to use an existing field like the feature identifier in the hydraulic model.

The use of GIS for creating this hydraulic model proved to be very advantageous. New developments are continuously being added to the model, after verifying the spatial and attribute accuracy using GIS. The existing Atlas Maps of the Water and Recycled systems are being referenced to add the new development data into the hydraulic model. All the edits to the hydraulic model – like for example – changing pipe diameters, adjusting pipe locations are being done in GIS. The hydraulic model is automatically updated by the link that WaterGEMS provides between GIS and the hydraulic model.

2. *Hydraulic analysis and output of the results to an enterprise geodatabase:*

Various scenarios are created in the hydraulic model as per the requirement of the users. The model is first analyzed for specific scenarios (like fire flow, peak hour demand, water quality analysis, etc.) and the results are published to feature datasets on the enterprise geodatabase. (Each scenario is output to a separate feature dataset.) The attributes that will be exported can be chosen at this stage, and also the units and projection information assigned. The time series results must however be exported out from the hydraulic model by the modeler. The output for the time-series results must be in dbf format. These results can be stored in any database for future reference, but it is preferable to store it in the same feature dataset as the results of a particular scenario.

3. *Making the Modeling Results Accessible to All Users:*

Once created from GIS, a hydraulic model only needs to be updated on a regular basis. The output from a hydraulic model (such as calculated demands, fire flows, calculated pressures) can be presented in form of maps, tables, reports and charts.

Hydraulic modeling results are useful to a number of users within and outside an organization. If the hydraulic modeling software alone is used for reporting purposes, it is difficult to make the results accessible to a number of users outside the Engineering Department. Bringing the results out from the hydraulic model to a common platform is very useful.

Apart from within the engineering department, there are a number of other users outside needing this information.

- Land Development and Planning.
- Customer Billing.
- Security Department (Homeland Security)
- Departments handling emergencies – like fire.
- Public Health

The field personnel in the Engineering department also need additional information available at hand – some times just the paper map will not give all the information that is required for a job on-site. A good map with versatile symbology can only show a limited amount of attribute data to the users.

Hydraulic Modeling software can export the results to GIS format (like shapefiles, geodatabase). Even though the results are available in GIS, not all the users may be able to access them due to lack of expertise or infrastructure.

A common interface to present the hydraulic analysis results over a wide range of audience within an organization is necessary. It must meet the following requirements:

1. Simplicity in usage.
2. Security.
3. Portability.
4. Ability to present Time-Series data / related data.
5. Searchable.
6. Ability to add comments on the data.
7. Produce maps on the fly.

Mapplet.Net from DCSE is .NET GIS Enterprise application that enables users to view GIS data without actually running GIS software or having GIS expertise directly on the user end. It allows an enterprise to leverage its investment in the Geographical Information System (GIS). Mapplet.NET enables users across the enterprise to gain access to data (including time series data) and documents from a spatial perspective.

Since it is a web application, the expertise required on user-end is minimal – with a little training or no training, a user can view the hydraulic analysis results on this interface.

It is secure – since it requires login, and also, the user must be connected to the network of the organization. On the user end Mapplet does not allow any edits to the data and the data is hence secure.

Thus the ability to edit the data is only with the Admin or the modeler.

Mapplet can be easily used on a tablet pc where a field personnel can go to a particular location using the Map on Mapplet, refer to attribute data, close a valve, and make a note of the same on Mapplet using which the hydraulic model can be later updated.

Temporal data exported from the hydraulic model can be presented via Mapplet. Similarly, any other data - like the as-built drawings for a pump station, etc. can be linked to the features and presented via Mapplet.

The attribute data in Mapplet can be made searchable. Additionally, there is a facility to implement geocoding services. A user can simply input the street intersection to zoom to that location.

Of course, there is a facility in Mapplet to automatically generate a map of any part of the hydraulic model with a scale and the North Arrow.

The Mapplet administrator is responsible for all the data uploads, and symbology. It is recommended however that the modeler also be involved in the initial phase, where the symbology is being set, just so that the analysis results are communicated clearly to the intended audience.

Since hydraulic modeling results are in an enterprise geodatabase, multiple users can access these results via Mapplet. There is a one-time effort involved in setting up the Mapplet. The first step is to prepare an MXD using the hydraulic model results in the EGDB. Proper symbology must be chosen in order to show the results as per necessity. This depends on the scale of the model, the application of the results, and the intended audience. If necessary, the results of multiple scenarios can be included in a single Map document, and also, any scenario comparisons can be done via GIS analysis tools in ArcMap. The results of such comparisons can also be published to the EGDB, and included in Mapplet.

The next step is to make these results accessible via Mapplet. The Mapplet Admin uploads the MXD to the server and once this is done, and the Mapplet

is set up, the users can access the modeling results from Mapplet interface. Time series results will also be linked up by the admin into the Mapplet.

4. Users update the enterprise geodatabase:

Users of the enterprise geodatabase can update the geodatabase as and when necessary. Some of the changes may be applicable to the hydraulic model – like changes in pipe attributes, locations, etc. All the changes made to the EGDB must be logged and the modeler can review them whenever it is necessary to obtain the most current information or on a weekly basis.

5. Updating the Hydraulic Model:

If the modeler finds any changes that could affect the hydraulic model – then these changes must be reflected in the hydraulic model also.

The history of the EGDB can be tracked in order to find out whether any new features have been added, or existing features in the hydraulic model are modified. If any relevant changes are made to the EGIS, the modeler may import data pertaining only to the changed features using database synchronization in WaterGEMS.

This is achieved by synchronizing the geodatabase to the hydraulic model, and update the hydraulic model. And since the hydraulic model has been updated, we need to get to step 2 again since the results will change as per the changes to the model.

Problems Encountered:

The above workflow is simple in description, but it involves its own complexities created by the ArcSDE and the ArcIMS software. There are number of workarounds necessary so that the data is not locked by sde for editing, while it is being viewed on Mapplet at the same time.

Another complexity is the accessibility of results. The results exported out from the hydraulic modeling into GIS are always a single snapshot of time. The time-series data must be exported out separately from within the modeling software. (Method varies depending on the software and the modeler will know it the best).

The workflow has scope for more automation, which needs to be taken advantage of.

Conclusions:

The workflow for developing, and maintaining a hydraulic model using EGIS leverages the investment in EGIS. With Mapplet.Net’s capabilities, even temporal data can be presented to a wide range of users with minimal resources. As technology advances, we can expect that the workflow will be more unified with minimal manual effort.

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References

The Mapplet User Guide

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