GWINNETT-ARCHYDRO: SETTING THE FOUNDATION FOR INTEGRATED WATER RESOURCES DECISION SUPPORT

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ABSTRACT: Gwinnett County is one of the largest counties in the Metropolitan North Georgia Water Planning District (MNGWPD). Its burgeoning population and growing industry have spurred great interest in cataloging, understanding the workings of, and ensuring the stability of the county's water resources. This paper will describe the development of Gwinnett-ArcHydro, an information solution comprising an enhanced version of the ArcHydro database schema (Maidment et. al) that catalogs small-basin scale hydrologic, hydraulic, dam breach, and water quality models into the traditional ArcHydro edge/junction stream network. Several goals were identified early on in the development process including: 1) catalog all flood-mapping related models in a regional GIS database that enables ongoing modeling of all of the county's river systems; 2) ensure sustainability, adaptability, and expandability of the database design and tools to incorporate new water control structures, new models, and even new study arenas; 3) make all database designs, tools for database population and maintenance, and user interfaces public domain; and 4) integrate the most commonly used tools for hydraulic and hydrologic analysis into the solution. This paper will outline the reasoning for these goals and the solution developed to address them.
KEY TERMS: ArcHydro, Gwinnett, Decision Support, Model Maintenance, Model Inventory

INTRODUCTION

Gwinnett County is one of the largest counties in the Metropolitan North Georgia Water Planning District (MNGWPD). Its burgeoning population and growing industry have spurred great interest in cataloging, understanding the workings of, and ensuring the stability of the county's water resources. Over the past several years, and motivated by its goal to establish a comprehensive set of flood insurance studies, Gwinnett County's department of public utilities (GCDPU) has commissioned hydraulic and hydrologic (H&H) studies of all of its watersheds and has produced a collection of non-georeferenced Hec-RAS, Hec-GEORAS, and Hec-HMS models. These models have been stored in directory structures and have been difficult to access, visualize, and maintain as a result. The aim of the current project was to create a publicly accessible, GIS-based, solution that conveniently catalogs the models and provides a centralized visualization of the model results for decision support.

This paper will first present the project goals in terms of information solution requirements. An information solution consisting of 1) an enhanced version of the ArcHydro database schema, 2) an integrated system of public domain tools for H&H modeling, and 3) a custom set of tools for database management, visualization, and decision support is presented. Finally, the solution's future development prospects are described in the context of the county's water resources management and decision support needs.

Figure 1: Location Map and Hydrography of Gwinnett County, GA.

PROJECT GOALS

From the seemingly simple goal of providing a user-friendly and publicly accessible way to work with a large collection of models, a more rigorous set of requirements was built. It was recognized early on that these requirements were a necessary part of the project scoping process because they would ensure that the implicit constraints related to making the software publicly accessible and GIS-based would be met. The requirements are listed below:

1. The database will operate on a **large basin scale** – there will be one database each for Chattahoochee, Ocmulgee, and Oconee basins (see figure 1).
2. The database will house and facilitate maintenance of **H&H models** including GCDPU's existing H&H models, which will be converted to HEC-HMS v2.2.2 or HEC-RAS v. 3.1.3. To accommodate the introduction of new models from the development community, a variety of model formats will be facilitated.
3. The database will provide **basin-scale display** of the ArcHydro stream network, hydraulic model cross sections, watershed boundaries, floodplains, floodways, and other data normally associated with GIS-based HEC-RAS and HEC-HMS models.
4. The database will house the model data and results for **dam-breach studies**. The storage and visualization of these models will be similar to that of the hydraulic models identified in requirement 2 as the dam-breach analysis is also conducted with HEC-RAS. Additional information concerning property ownership, dam study priority, and other data relevant to the modeling methods for dam breach studies will also be stored.
5. The database will house results of **water quality data** and the models used to generate them. The database will be capable of providing basin-scale displays of water quality data important for decision making such as red-line streams and TSS benefit, among other parameters.
6. Any **tools** used/built to populate, maintain, or visualize the database must be **public domain**.
7. A solution for building a **web portal** for a) accessing the inventory of H&H and other models, and b) submitting new H&H studies will be constructed.
8. A one to two day workshop to illustrate the design and usage of the information solution will be conducted at the end of the project.

INFORMATION SOLUTION

Following the requirements, an information solution was developed. The solution is shown in figure 2. The solution consists of two database tiers and a set of tools for operating on them. The upper or decision tier houses the basin scale ArcHydro network and the information from the various models that is deemed necessary for decision support. Each segment of the HydroEdge feature class is associated with one-to-many models that model the hydrofeature's characteristics.

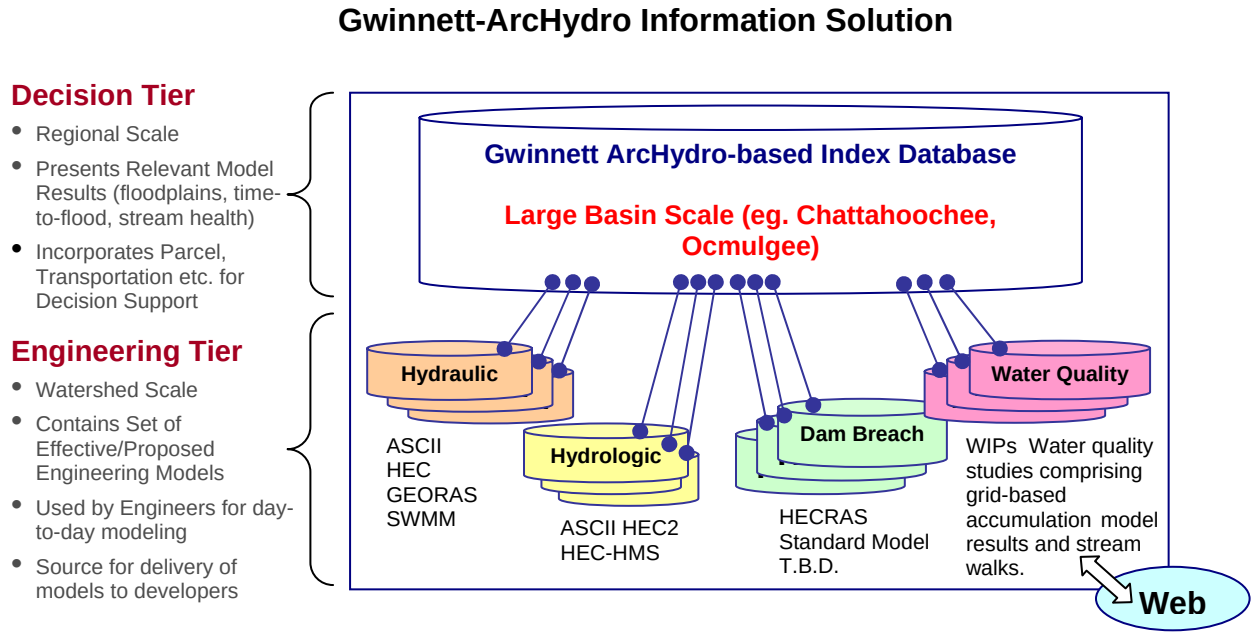

Figure 2: Gwinnett ArcHydro Information Solution

The lower or engineering tier houses the various models that are cataloged in the decision tier. To accommodate the need for GIS-based data, each of the models is stored as a couplet of both a geodatabase of model input and output information and the associated model files.

The geodatabase in this couplet is referred to as an Interface Data Model (IDM).

Gwinnett-ArcHydro

The basis of the decision tier is the Gwinnett-ArcHydro database. The schema for this database is an enhanced version of the traditional ArcHydro schema, where a ModelInfo table has been added, plus relationship classes linking the ModelInfo table's records to various ArcHydro features (HydroEdge, Basins, etc.) By adding this simple mechanism of relating hydro features in the decision tier database with models through the ModelInfo table, any kind of model can be cataloged. Non-georeferenced models, such as flood insurance studies for which there is only a HecRAS project are an example. More exotic models can also be cataloged such as water quality, socio-economic and adaptive water sources management models.

A Public Domain Integrated Solution

The requirement that the solution be public domain meant that a single-package, proprietary solution that housed a database of the various models and the linking stream network was not feasible. Instead, existing public domain tools were integrated into the solution. As mentioned above, ArcHydro and the ArcHydro tools were used to construct the decision tier databases. For hydraulic modeling (both flood insurance studies and dam breach studies), HecRAS and HecGEORAS were used. The HecGEORAS 4.1 IDM was used as the IDM in the engineering tier. For Hydrologic modeling, HecHMS and HecGEOHMS were used. The HecGEOHMS IDM will be used as the engineering tier IDM in this case. To tie the solution together and provide the tools for linking the two tiers, a custom set of tools was developed called Gwinnett-ArcHydro tools that will be public domain.

Gwinnett-ArcHydro Tools

To accomplish the goal of user-friendliness, a set of custom tools called Gwinnett-ArcHydro Tools was developed. The tools are installed as an extension in ArcMAP, work with an ArcView license for the broadest public accessibility, and are anchored by a single dockable window that contains Set-up, Models, and GeoReports tabs. Figure 3 shows the Gwinnett-ArcHydro Tools window. To use the tools, the user 1) associates the tool with a Gwinnett-ArcHydro database, 2) associates hydrofeatures in the decision tier with models through selecting hydrofeatures and then selecting Add or Remove Model, and 3) updates the decision tier with results from the models and creates gis-based reports or GeoReports from the model information.

The concept that dictated the use of a dockable window (instead of the normal toolbar) was one directly tied to user-friendliness. The goal of the dockable window is to contain all the controls the user will need in a single location. In the Models tab, for instance, is a toolbar that contains Select, Add Model, Remove Model, Update Model Information, and View Model buttons. These are all of the tools that the user will need to operate the system and therefore all of the tools that are presented to the user. The dockable window also explains in good detail what exactly the tool does. By centralizing the entire control panel within a single location, the user can quickly begin to use the tools to produce results.

Decision Driven Upward Data Migration and GeoReports

Though a catalog of models is a very useful database, the intent of the information solution is that this catalog is the foundation for a decision support system. As such, the Gwinnett ArcHydro tools also migrates the result data deemed necessary for decision support from the engineering tier to the decision tier. Information such as floodplains, hydrographs, and river reach health index, is copied from the IDMs and made as attributes of the Gwinnett-ArcHydro features. Just what information is upward-migrated is decided by the decision makers.

Once the information is migrated, the user can create GeoReports, which provide a county-wide picture of the information the models are providing. For example, one GeoReport is the Flood Insurance Study Model inventory, as shown in figure 4. When the user creates this report, each river in the system is colored according to the type of model that is modeling it. Dark blue river segments mean the most up-to-date model is being used (eg. HecGEORAS 4.1); light blue means an older model has been used (eg. non-georeferenced HecRAS 3.0); red lines mean that no model exists. In a single look, the decision maker can thus assess the extent to which the county has been modeled and make decisions on which areas to focus on for modeling in the future. Another example of a GeoReport is the RedLine Stream report, which colors each river segment according to its health index, an index created through watershed assessments commissioned by the county. Red line streams are those of the poorest health. A countywide view of stream health can thus be generated very quickly.

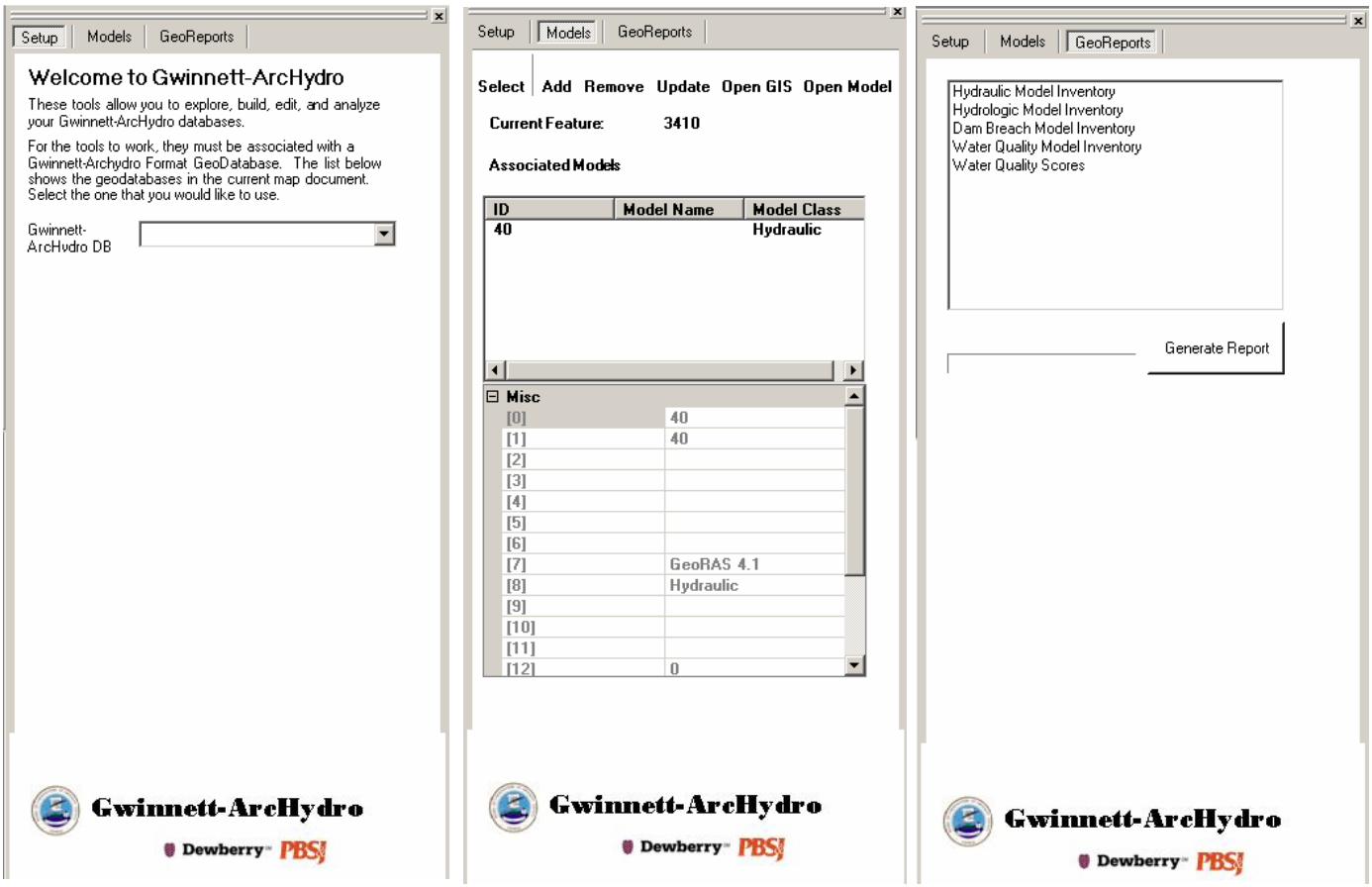

Figure 3: Gwinnett ArcHydro Tools; Left: Setup Tab, Middle: Model Inventory Tab, Right: GeoReports Tab

FUTURE DEVELOPMENT

Gwinnett County is one of the fastest growing counties in the fastest growing city in civilization (Nygren, 2005). As such, the Gwinnett-ArcHydro information solution must be cognizant of the future needs of the county. Once the solution has been implemented in the county it will represent a good foundational system for adding models of various disciplines and thereby provide a more and more accurate picture of the nature and character of the county's water and natural resources. Other avenues for future development are also planned. Some of them are:

- The models that are cataloged, though integrated in the decision tier, are not integrated in the engineering sense. A more integrated solution can be devised that will seek to model the landscape – both natural and man-made – and will thus contain all of the data necessary to create engineering models and to support decisions. This solution brings about difficulties in importing and exporting new information, but it provides a more cohesive representation of reality and will thereby enhance the information used for decision support. A similar approach has been taken in the San Antonio River Authority's Regional Watershed Modeling System (RWMS).
- With a more realistic data model of the watershed, regional analysis can be conducted. Examples are:
    - Estimates of the impact of regulatory water supply decision on long-term or short-term water levels can be made.
- The models are used by the community for various activities. For example, developers use the effective flood insurance studies as the basis for their development hydraulic models in the permitting process. The information solution can be ported to the web to provide a source for these base models.
- The Stormwater department at GCDPU handles queries concerning property and its proximity to 100-year floodplains for insurance reasons. The decision tier can provide a streamlined method for answering these queries.

- Estimate impact of different drought scenarios.
- Estimate flooding impacts of predicted storms
- Observe detailed results of past decisions based on historic measured data such as SCADA or historic gauge data.

These are just a few of the future developments possible with the information solution. The important concept is that the information solution acts as the foundation for future development and the process will be one of evolution, not complete change.

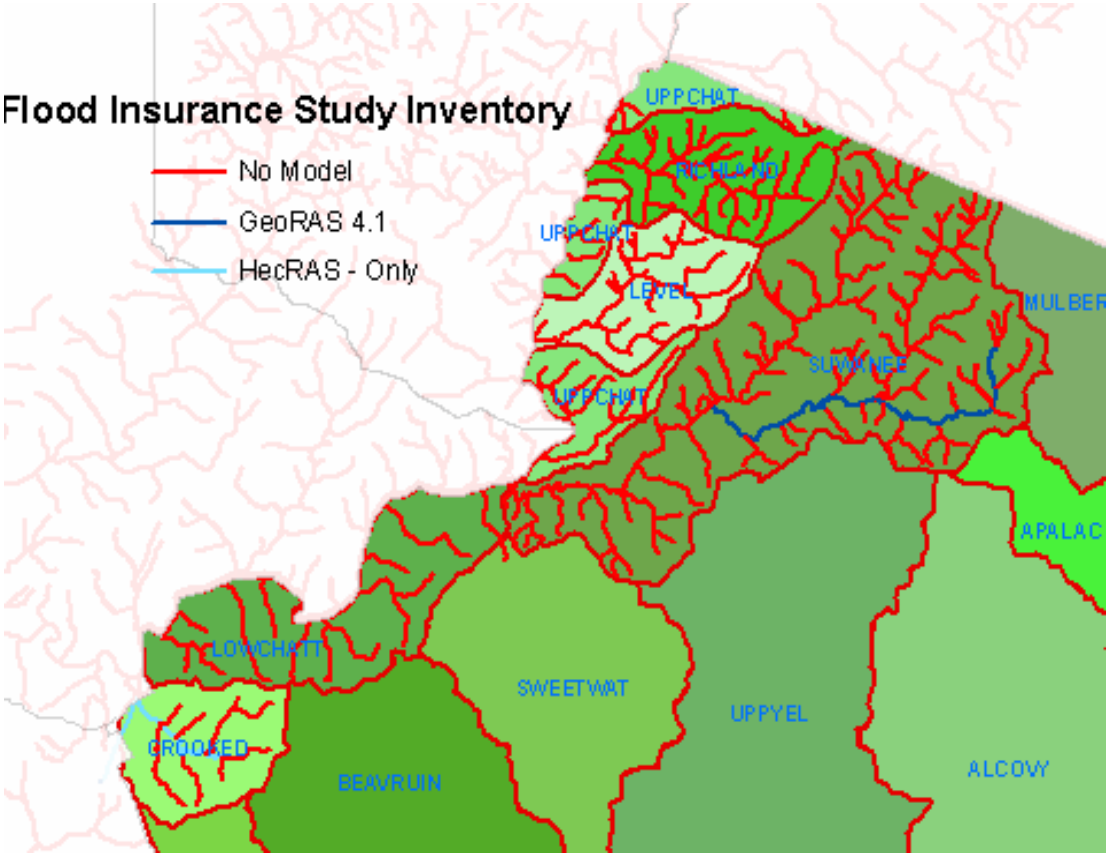

Figure 4: A Flood Insurance Study Inventory GeoReport

CONCLUSIONS

The Gwinnett-ArcHydro information solution provides a publicly accessible, user-friendly way for GCDPU to catalog and maintain its collection of models from many disciplines. By integrating public domain software and creating custom tools aimed at supporting day-to-day operations and regional planning and decision making, the solution will enhance the county's capabilities to support its users and its general population.

ACKNOWLEDGEMENTS

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