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Jörg Höttges

FH Aachen Univ. of Applied Sciences, Germany

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Optional Cover Page Acknowledgements

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QKan - Management of drainage system data with QGIS

Jörg Höttges^{a,*}

^a*Lehrgebiet für Wasserwirtschaft und Bauinformatik, FH Aachen University of Applied Sciences 52066 Aachen, Bayernallee 9, Deutschland*

Abstract: Based on QGIS a database structure and a set of plugins have been developed to improve the workflow for the hydraulic design of urban drainage systems for consulting engineers. The main goal is pre- and postprocessing of the drainage system data in combination with various commercial hydraulic simulation software packages. The plugins provide import and export functionalities, simulation result viewing and generation of longitudinal cross sections in a CAD program. All modules make intensive use of SQL based spatial functions instead of functions implemented in QGIS, because of their stability, higher flexibility and speed due to the indexing functionality. On the other hand the database structure is kept simple to make it possible for engineers as a typical user to work directly with the data in the database.

*Corresponding author
Email address: hoettges@fh-aachen.de (Jörg Höttges)

1. Introduction

Since the release of version 2 of QGIS consulting engineers, water boards and public authorities in the Germany and Switzerland started to use QGIS due to its usability and the absence of license restrictions. With the upcoming of open data, which was slightly delayed in Germany for legal reasons, application of GIS is accelerated significantly. QGIS has become very useful for application development, because it offers all functionality that is necessary for consulting engineers working in the wide area of water management.

Whereas drainage system data is hold in database-driven network information systems operated by public authorities (cities, water boards) being the legal owner of the sewage systems, a lot of work has to be done to prepare the data for hydraulic simulation of stormwater runoff. For this purpose temporal modifications of the data are necessary, which unfortunately are not supported by the software systems used by the authorities. Hence the data has to be exported and to be modified in the simulation software package afterwards. For many years the developers of the simulation software packages have created their own user interface for this task, whereas during the last years they shifted to a GIS based user interface. One of the main reasons was the necessity of spatial analysis functions, e.g. for the collection of the fraction of pervious and impervious sub-areas.

In contrast to the commercial GIS based applications and also to other QGIS based application modules like the swiss QGEP project (Fischer 2015), the author of this paper gathered the experience that the best way of working for consulting engineers is to have an open database structure which can be modified to satisfy individual needs in contrast to a closed system with fixed and predefined workflows. Consultant engineers in Germany usually work for various authorities, which means they have to be more flexible and adapt to various data structures and sometimes also use different simulation software packages. On the other hand, it can be very useful to establish an engineering team workflow partially independent from the chosen simulation software. This has been an important design criteria for the QKan plugins.

2. Database Structure

QKan uses a SpatiaLite database. As an alternative a POSTGIS database will be implemented with an option for the user to choose between the two. It is very efficient to handle the table data via SQL statements (Figure 1) using the QGIS DB Manager or the spatialite-gui tool (Furieri 2017). Therefore the database omits the declaration of referential integrity using additional primary and foreign keys, but uses direct references between label attributes in the base table and the parent table instead. The disadvantage of lower performance and the abandonment of a verification of uniqueness is compensated by the fact that SQL statements prove to be much simpler and thus enable an easier approach to the user. Usually the uniqueness of labels is reviewed by the engineer during the export process to the simulation software.

3. Geo Functions Database-Driven

The author has come to the decision that using the SQL based spatial functions provided with the database should be preferred against using the QGIS based spatial functions from the API, although these are clearly provided in the QGIS menu bar and the toolbox and seem easier to use. Practical experience indicates that using the database functions yields more

homogeneous software code and leverages the use of database indexing. Combination of data from multiple tables is much easier using SQL than writing explicit software code. Figure 1 demonstrates an SQL statement for connecting subcatchment areas to the pipe laying within the area:

```
UPDATE subcatchments
SET pipename =
( SELECT subcatchname
  FROM pipes
 WHERE within(centroid(subcatchments.geom),pipes.geom) )
```

Figure 1: SQL statement for connecting pipes and subcatchments by location.

From the engineering point of view SQL encourages consulting engineers with a certain knowledge in programming languages to directly manipulate data using the SQL window in QGIS. Once a collection of approved SQL statements has been collected in a team of engineers it is easy to adapt an SQL statement to a similar use case. Spatial SQL commands are strongly standardized and can be used in combination with ordinary SQL statements, which after a certain training period leads to a very high productivity and flexibility.

An essential functionality is the possibility for the consulting engineer to work efficiently with the table data within the database. QGIS supports editing of table data with the easy-to-use QT Designer, which enables engineers to create straightforward forms including combo boxes displaying data from reference tables (Figure 2).

Figure 2: Pipe data editing form created with QT Designer.

4. Import and Export Functionality

There are three variants for exchanging data between a hydraulic simulation software and the QKan database. Some software programs offer a facility to copy paste the data, but it is useful primarily for small modifications by pasting the data into a text editor or a spreadsheet software (e.g. EXCEL). The second variant utilizes interchange formats defined by technical

organizations or the software developer, which often implies a restriction on the extent of information. The third variant is the possibility of a direct access to the files or the database utilized by the simulation software.

4.1. Simulation software HYSTEM-EXTRAN

In Germany a widespread software (HYSTEM-EXTRAN, Institut für technisch-wissenschaftliche Hydrologie GmbH, Hannover, Germany) for hydrodynamic simulation of rainfall runoff and primarily originated from SWMM (EPA 2015), uses a Firebird database, which is accessible via Python requiring installation of the Firebird Server and the firebirdsql Python module. An import and an export plugin have been created (Höttges and Molitor 2016, Höttges 2017) covering all necessary drainage system data (pipes, nodes, pumps, weirs, pipe cross section data, catchment data, etc.) except rainfall data and simulation parameter files. The latter must be provided by the user by preparation of an empty database file created using the simulation software. Thus, the export module nearly allows an export-and-run-workflow because all data preparation, inspection and spatial data composition can be conducted using QKan/QGIS.

The QKan import plugin creates a SpatiaLite database and an appropriate project file (see below) from a Firebird database file containing the drainage system data. As an interesting secondary effect an authority responsible for the drainage system can visualize the results of a simulation project carried out by e.g. an engineering office without installation of the simulation software (Figure 3+4). This enables an engineering office to very easily exchange preliminary results to the customer throughout the design process and transfer the final results after completion of the project.

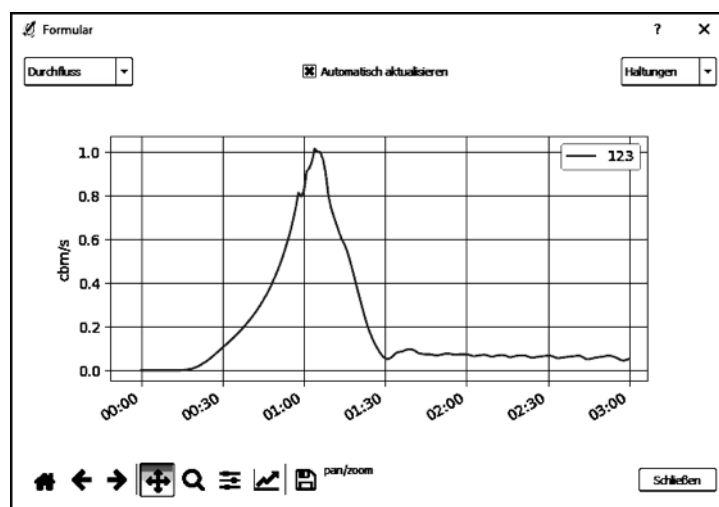


Figure 3: Discharge hydrograph.

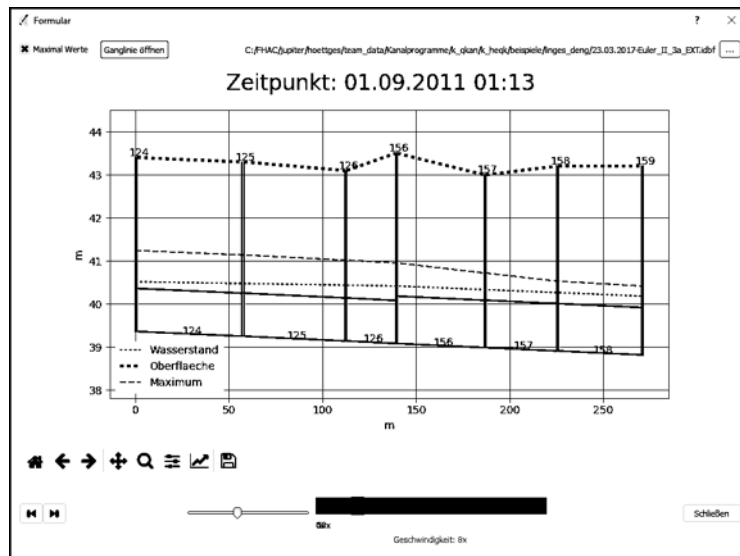


Figure 4: Longitudinal cross section with animation of water level.

5. Project File Template

Project files are a crucial point in all geographical information systems, because they hold all kind of graphical interpretation (layer style, thematic mapping, labeling, subject-specific symbols, etc.). They are enhanced continuously and are valuable as a template for future projects (Figure 5). In the case of sewage system data, point symbols show the type of drainage system nodes, line thickness represents the diameter of the pipes, line styles symbolize nodes connections by pumps and weirs. Furthermore, the import plugin analyses drainage system nodes on special criteria as peak points, sink points, start nodes or singular nodes to enhance the inspection of the data quality. All these definitions are stored in the project file.

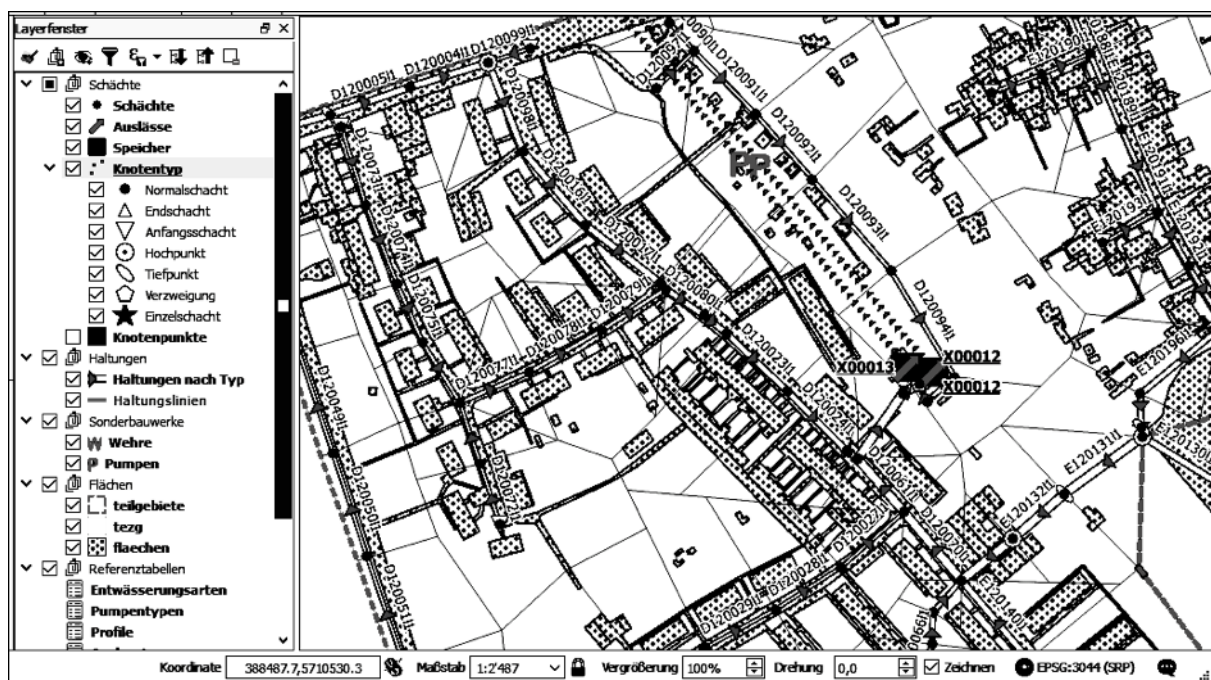


Figure 5: Sewage system plan after data import and customization of the template project file.

A template project file `project.qgs` is provided in the QGIS plugins folder. After completion of the data import the import plugin copies the template project file and treats it with an XML parser. Database path, coordinate reference system and display extent are adapted to the actual project, whereupon the project file is loaded into QGIS. The user can modify the project file and, if desired, use it as a new template by copying it to the template folder.

Furthermore, the user can establish his own set of templates. During the import it is possible to choose any other template project file as long as it includes layers connected to a QKan database. Additional layers remain unaffected.

The project file also contains the maps configured in the print composer, which is a very powerful tool for the consultant engineer for preparing printed layout plans. Very often title block templates exist, which have been designed with a CAD software. An efficient way to including such a file into a QGIS site plan is the free graphics software inkscape which imports Drawing Interchange File Format (DXF) and writes the Scalable Vector Graphics (SVG) format.

6. Further Development

The QKan project is still under development. The next plugins will enable data in- and export to the simulation software DYNA/Kanal++ (Tandler 2013). Additionally, a plugin for creating longitudinal sections in a CAD program will be realized with a direct link between the plugin and the CAD program.

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