

# IMPROVING THE USABILITY AND FUNCTIONALITY OF A SOFTWARE TOOL FOR ASSISTING IN THE DESIGN OF EFFECTIVE QUARRY-WATER MANAGEMENT STRUCTURES

## 1. Introduction

One of the main outputs from an earlier MIST project (MA/2/1/003) '*Practical hydrological assessments in and around aggregate quarries*' completed by GWP Consultants ("GWP") was a program, PondSizer, written to calculate the sizes of attenuation ponds and settlement lagoons. PondSizer was intended to be a tool for assisting in the design of such structures that make it possible for the rate and quality of discharged quarry water to meet regulatory requirements. However, we recognised that non-specialists could not easily use PondSizer and in this project we have sought to address this by creating a more user-friendly interface with on-screen support as well as provide some additional functionality. It is hoped that this software tool will become widely used by those with an interest in the environmental impacts of quarries, including quarry operators and managers, consultants, regulatory bodies, and other environmental organisations; but particularly by those with responsibility for designing management systems for quarry water. The relevance of this software was recognised by Aggregate Industries, which has collaborated as an industrial partner.

Commercial software packages are available that are designed to perform many types of calculations for drainage applications and some of these are able to calculate the sizes of attenuation ponds. However their cost (hundreds of pounds) is a disincentive to using them, certainly for small enterprises that are only likely to want to size ponds very occasionally. PondSizer is freely available and it is hoped that this will encourage its widespread use. Training in its background and use and support will be provided by GWP on a commercial basis. If as hoped this tool becomes widely used there should be consequent beneficial outcomes for the aquatic environment as a result of improved pond and lagoon design.

## 2. Methodology

### 2.1 Work plan

Creating the application involved the standard elements of software development viz. breaking the project down into modules, translation of the modules into efficient algorithms, coding of the algorithms, debugging and optimisation of the code, testing of the code, linking of the modules, and deploying the product. The key tasks of the work plan originally identified were:

- i. developing the application software;
- ii. initial deployment and testing of the software tool;
- iii. correcting any software 'bugs' and incorporating any improvements arising from the testing and review process;
- iv. dissemination of the of the software.

### 2.2 Use of third party software

PondSizer requires data from the Flood Estimation Handbook (FEH) CD ROM (Institute of Hydrology, 1999; Centre for Ecology and Hydrology, 2006), to generate rainfall distributions. Users of PondSizer therefore require a licensed copy of the FEH CD-ROM to generate the rainfall growth curve parameters or be provided lawfully with these data from a third party. PondSizer also requires parameter values for short duration storms from the Flood Studies Report (FSR; NERC 1975) which for durations less than one hour is more accurate than the FEH. However these FSR data can be calculated using algorithms given in the FSR,

which does not require a licence. Notwithstanding this, other electronic digital data, specifically Winter Rainfall Acceptance Potential (WRAP) data and the boundaries of the UK Hydrometric Areas and Regions, derived from the maps within the FSR, do require payment of a licence fee. It was intended that GWP would provide those users without a copy of the FEH with the relevant rainfall distribution data, and that a means of providing the FSR data would be developed that is not dependent upon using licensed electronic digital data.

### **3. Implementation of the work plan**

#### *3.1 Development of the software*

The main core of PondSizer performs all of the calculations to generate the appropriate rainfall figures for a given location and calculates the dimensions of the attenuation ponds, settlement lagoons and sumps as required. It is written in the FORTRAN 90 programming language. For this project we linked this code to a Graphical User Interface (GUI) 'front end' program that makes it possible for the user to interact with the application *via* a Windows environment. To do this, new FORTRAN code was written to allow interaction with the GUI and the GUI code itself was written in Visual Basic for Applications (VBA). The FORTRAN code was developed using the Microsoft Visual Studio Development Environment, whereas the VBA code was developed within the MS Access database structure. This made it possible to create a sophisticated GUI without the need to invest in the software development that would normally be required and which would not have been possible within the budget of this project. Figure 1 shows a screen dump of the PondSizer GUI.

We also modified PondSizer to allow the greenfield runoff rate to be calculated. This is the rate of peak surface flows from an undeveloped area; it is often required for assessing flood risk and environmental impacts of new developments and for designing Sustainable Drainage Systems. It is dependent upon catchment area, rainfall rate and soil characteristics. The calculation of the greenfield rate in PondSizer follows the methodology given in the Institute of Hydrology Report 124 as recommended in the 'SUDS Interim Code of Practice'. This method uses a regression equation relating the annual peak flow to various catchment characteristics including the Winter Rainfall Acceptance Potential (WRAP) as defined and mapped across the UK in the Flood Studies Report (FSR). In addition, determination of flood peaks for other return periods requires appropriate flood-peak growth factors which are categorised in the FSR by UK Hydrometric Region.

The components of the PondSizer code were tested thoroughly; both separately and with the FORTRAN and VBA components fully integrated as a working trial version before it was sent out for evaluation and testing to members of the testing panel.

It was recognised that few users will have access to the FSR, particularly since the Flood Estimation Handbook has largely superseded it. Alternative methods of determining the WRAP values and Hydrometric Region were therefore incorporated into PondSizer. A Help screen lists WRAP values according to soil characteristics that the user can identify for their specific site. This has the additional advantage of removing the uncertainties involved in using large-scale maps for assigning the parameter. To assist users in selecting the appropriate Hydrometric Regions, the URL of a map of hydrometric areas (<http://www.dundee.ac.uk/geography/cbhe/map.htm>) is given in a Help screen. The program calculates the relevant Hydrometric Region on the basis of the Hydrometric Area the user inputs.

#### *3.2 Licensing issues concerning the FEH CD-ROM and the FSR*

It was recognised that the need to own a copy of FEH (which currently costs £875 for a three-year licence) is a deterrent to some potential users of PondSizer who would not consider its purchase for a one-off use. We had expected that GWP would be allowed to supply users with one-off data for their site from GWP's licensed copy of the FEH CD-ROM, possibly for a small payment to the Centre for Ecology and Hydrology Wallingford (CEH). However we discovered after purchasing an upgrade to version 2 of the FEH CD-ROM that supplying any data from the CD-ROM to third parties is specifically prohibited under the terms of the version 2 licence. It was expected that it would be possible to come to an agreement with CEH so that GWP could supply site-specific data to users for a small royalty payment to CEH. Negotiating this became a new task within the work plan.

We have spent significant time and effort during the course of the project in trying to resolve the licensing issue. The situation is complicated because the data are the intellectual property of various public bodies including the Met Office, the Environment Agency, as well as CEH. A licensing solution would require the permission of each of these bodies together with an agreement acceptable to all parties on a licence fee to cover the royalties on the data. This issue has not been resolved because of the inability of CEH to address the matter within the lifetime of this project as a result of their very limited staff resources. To try to advance the process we wrote to the manager of the ALSF programme at Defra informing him of the position and asking if he might explore the possibility of an agreement between the relevant government departments to make the data freely available for this project. Unfortunately Defra was unable to help.

The licensing situation is unresolved and potential users of PondSizer who do not have a copy of the FEH CD-ROM are not able to use PondSizer. However we shall continue to attempt to come to an agreement and it is hoped that this will be sooner rather than later in the light of new staff appointments being made at CEH Wallingford.

### *3.3 Initial deployment and testing*

At the start of the project potential testers (including Aggregate Industries) were identified, contacted, and invited to take part in the software trial. Email invitations were sent out to a variety of potential end users, including quarry and landfill designers and operators, the Environment Agency, and environmental and engineering consultants, to join the panel so that a range of perspectives on the tool would be obtained. A PondSizer web page (<http://www.gwp.uk.com/pondsizer.htm>) was created that described the application and provided a form so that interested parties could register to be on the testing panel. We created this web page in time for display at the Hillhead exhibition where it was displayed on a laptop PC. This publicity did attract a few volunteers. Ultimately six volunteers were enlisted on the testing panel; not as many as we would have liked but enough to be useful.

The initial deployment of the test version of PondSizer planned for September 2007 was significantly delayed until December 2007 because of the FEH licensing issues. The intention had been to supply testers who did not have their own copy of the FEH CD-ROM with the necessary data from GWP's copy. At first we deferred developing and issuing the software and spent time trying to resolve the licensing issue. When it became apparent that a quick solution was not possible we resumed work on the programming and addressed the problem of providing FEH CD-ROM data to the testers. Instead of supplying testers with genuine data for their sites we generated dummy data that met the formatting requirements and would not infringe licensing restrictions. Although this enabled testers to evaluate the operation and capabilities of the trial version of PondSizer it prevented testers without a FEH licence from using it for sizing ponds at real sites, which reduced the inducement for them contribute to the project to test the tool

### *3.4 Correction and modification*

Although six people agreed to test the application, feedback was only received from three of them. Two of these reported that they were unable to use the PondSizer as they did not have copies of Microsoft Access on their computers. Feedback from the remaining tester together with internal testing within GWP provided valuable information that allowed us to correct a couple of bugs, and to make improvements to the operation of the software, specifically:

- a timing bar has now been added that gives reassurance to the user that calculations are proceeding during long calculation runs;
- the means of saving and recalling previous run setups has been redesigned

### *3.5 Dissemination of the application*

For testing purposes the trial version of PondSizer was distributed to the testing panel using a zipped package of files attached to an email. The files in this package were as tabulated in Table 1.:

**Table 1 The files included in the PondSizer installation package**

<b>file</b>	<b>description</b>
<i>FEH_Demo.csv</i>	Dummy data in FEH (v2) format
<i>PondSizer2.exe</i>	Pondsizer executable
<i>Pondsizer_2003.mde</i>	Database GUI Access 2003 version
<i>Pondsizer_97.mde</i>	Database GUI Access 97 version
<i>pondsizer.ico</i>	Icon file
<i>PSoutput.doc</i>	Description of PondSizer output
<i>ReadMeFirst.txt</i>	Instruction and information file
<i>salflibc.dll</i>	DLL required by PondSizer2.exe

Two versions of the Microsoft Access data base files were provided making it possible for users with different versions of Access to be able to run the program. GWP has the software necessary to provide royalty-free stand alone database files for users without Access.

To ensure its widest uptake, it is possible for anyone to download PondSizer from the GWP website at [www.gwp.uk.com/research.html](http://www.gwp.uk.com/research.html). Two versions are available to ensure compatibility with Versions 1 and 2 of the FEH CD-ROM. However, until the licensing issue has been resolved GWP is not able to supply the necessary data files for users without their own copy of the FEH CD-ROM.

As with any piece of software it is to be expected that there will be future versions produced to correct any remaining bugs, to disseminate upgrades to the functionality or to provide modifications that may be desirable in the light of new environmental legislation. An example of the latter might be a requirement for the greenfield runoff to be calculated in a different way.

#### **4. PondSizer - a summary**

The PondSizer GUI allows the user to select the desired type of calculation (e.g. pond or sump sizing, run-off calculations, *etc.*) and facilitates the selection by relatively inexperienced users of appropriate data and parameter values needed for those calculations. This is achieved using drop-down menus, buttons and forms with prompts, and lists of suggested parameter values. The user is prevented from selecting incompatible values. Dynamic Help screens also provide guidance to the user.

The following description of PondSizer is provided in the *PSoutput.doc* file included in the zipped release package.

PondSizer calculates the dimensions of attenuation ponds and settlement lagoons linked by a single pipe containing a throttle plate with a single circular orifice, or sumps with pumped outflow, for prescribed design rainfall events which have the option for climate change enhancement. Additionally the user may choose to calculate just the runoff or the greenfield runoff, as specified by the 'Interim code of practice for SUDS' and frequently required by the Environment Agency, or both. The user is able to specify the return period in years (mean annual probability) storm durations and profiles, climate change enhancement factors, surface (soil) types and runoff model, range of throttle plate orifice diameters or pump rates (for sumps), and other variables that are described in the dynamic help feature.

Output appears in three files in the same directory as the executable file:

##### *pondsize\_data.dat*

This file contains the dimensions of an attenuation pond (or sump) and settlement lagoon for every combination of return period, storm duration and throttle plate diameter (or pump rate). On occasions when the combination of rainfall events and soil permeability do not result in any predicted runoff from the catchment there will be no output record produced.

The entries in the file (Figure 2) fall under the following abbreviated column heads:

R.P.	storm return period (years)
TPOD	throttle plate orifice diameter (mm)
DUR	storm duration (minutes)
IFLW_RT	rate of inflow (runoff) to pond (m <sup>3</sup> /h)
TOT.IFL	total storm inflow (m <sup>3</sup> )
TOT.AREA	total surface area (m <sup>2</sup> ) of the attenuation pond and settlement lagoon
SL_A	surface area (m <sup>2</sup> ) of the settlement lagoon
AP_A	surface area (m <sup>2</sup> ) of the attenuation pond
AP_VL	volume (m <sup>3</sup> ) of the attenuation pond
DPTH	depth of the attenuation pond (m)
MX_OFW	maximum rate of outflow (m <sup>3</sup> /h)
24H_OFW	total outflow in 24 hours (m <sup>3</sup> )
TFILL	time for the pond to fill (h)
TTMT	time for the pond to empty (h)
TTHMT	time for the pond to half empty (h)
RNFF_CO.	runoff coefficient for the storm (runoff/rainfall)

When PondSizer is used to size sumps the alternative abbreviations are used for the columns corresponding to the attenuation pond equivalents:

P.RATE	pump rate (m <sup>3</sup> /h) in place of TPOD
SMP AREA	surface area of the sump (m <sup>2</sup> ) in place of AP_A
SM.DPTH	depth of sump (m) in place of DEPTH
SM.VOL	sump volume (m <sup>3</sup> ) in place of AP_VL

### *pondsizes.dat*

This file (see Figure 3) is a summary file that contains a subset of the data given in pondsizer\_data.dat that corresponds to the largest total area of water for each return period and throttle plate orifice diameter. Fewer variables are given for each storm but there is one, the mean outflow rate that is not in the pondsizer\_data.dat data set. The abbreviations used in the headers are the same as for the pondsizer\_data.dat file. The file contains another set of data that are a subset of the subset that correspond to the smallest total surface area of water for each return period thereby specifying the throttle plate diameter required to minimise the space required for the pond and settlement lagoon. Finally there is another subset that specifies which storms give a runoff volume less than half the pond volume for ponds that will half empty in less time than a specified time. These data are useful for identifying ponds that, e.g. after a 100-year return-period storm have sufficient capacity within say 24 hours to contain the runoff from a 30-year return-period storm.

### *pondsize\_log.dat*

This file contains output from the model that is a record of the run. It informs when the model has automatically changed the depth to be consistent with new side lengths and the required storage volume. It also contains any error messages that may be generated.

### *Rainfalleeeeeee,nnnnnn.dat*

Rainfall files listing the rainfall for the range of specified storms, where eeeeeee,nnnnnn is the site national grid reference, are also output.

## 5. Outcomes

- PondSizer is now freely available for general use by those who own the FEH CD-ROM by downloading from the GWP website ([www.gwp.uk.com/research.html](http://www.gwp.uk.com/research.html)). Liaison with CEH will continue so that an arrangement is reached at the earliest opportunity to allow GWP to supply licensed data to those without the CD-ROM so that they too can use PondSizer. It provides a relatively intuitive tool for those familiar with Windows applications that will assist in the correct sizing of attenuation ponds, settlement lagoons and sumps as well as providing the facility for calculating the greenfield runoff rate that is often required in assessments of flood risk and environmental impact.
- As PondSizer becomes more widely used the results of the previous MIST project that produced the PondSizer software and the '*Handbook of methods for controlling surface waters in and around aggregate quarries*' will be more widely advertised.
- PondSizer will promote greater awareness of the potential hydrological impacts, and a greater understanding of the hydrological processes within quarries.
- All of the above will work towards reducing deleterious impacts on the water environment from quarry operations through the improved design of ponds and lagoons, and increased compliance with Environment Agency discharge consents.
- The project will also contribute to potential reductions in quarry operational costs, by eliminating flooding or at least reducing its occurrence.

## 6. References

Centre for Ecology and Hydrology, 2006 Flood Estimation Handbook CD-ROM version 2.0. C Centre for Ecology and Hydrology Wallingford. [www.ceh.ac.uk/feh](http://www.ceh.ac.uk/feh)

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NERC, 1975 Flood Studies Report (5 volumes), Natural Environment Research Council, London