Contents

1 Introduction

This is a manual for the tradesman to design a guttering system for a roof. You will be given the option to provide

(1) The roof area.

(2) The type and geometry of the gutters.

(3) The type and geometry of the downpipe

(4) The rain rate.

The program will then calculate:

(1) The downpipe flow rate necessary to clear the roof of water for a given rain rate and downpipe geometry.
(2) The likely speed, at the downpipe start orifice, of the flowing water, dependent upon the gutter inclination.

(3) The rate at which the gutter must clear water depending upon the rain rate and gutter geometry. This is the rate at which water must enter the downpipe.

The model employed is that of a single gutter and downpipe combination clearing a section of roof of water. For a large roof area you should be able to use the program to determine an optimum number of downpipes and sections of gutter. Do this by splitting the roof into multiple sections if necessary.

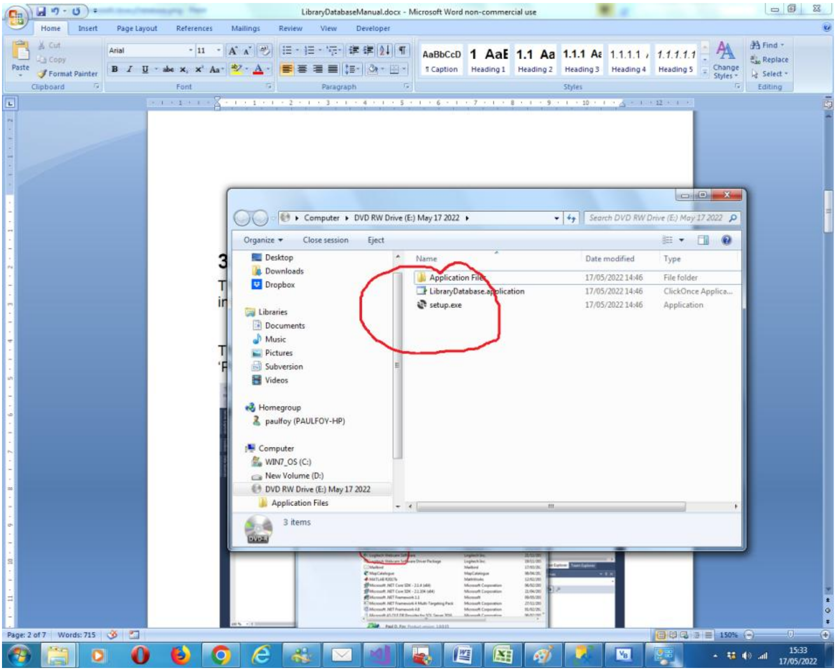
2 Pre-requisites.

1. A PC running Windows 7 or above.

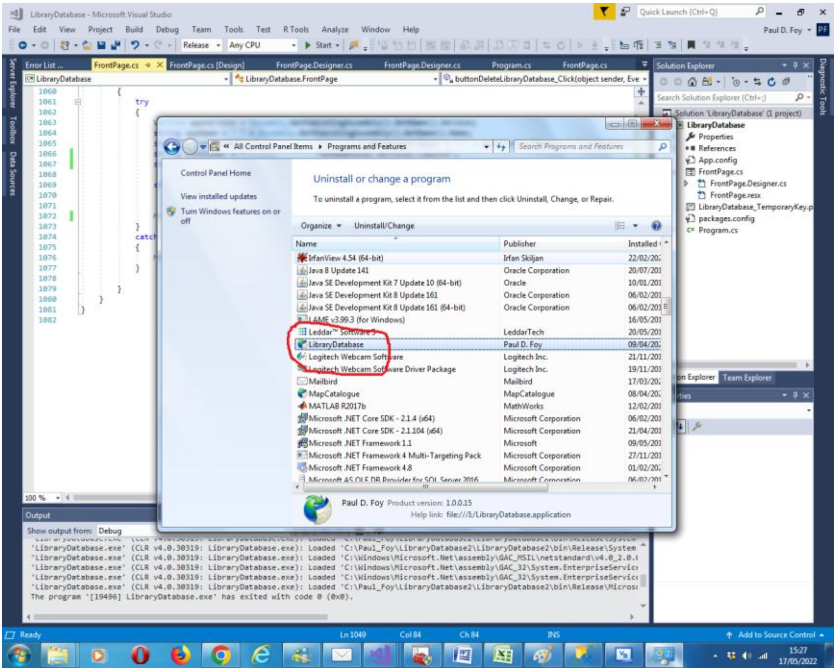
2. A USB stick or optical drive containing the program setup files, together with this manual (available online).

3 Installation/Removal

The program is installed by inserting the supplied stick or disc into the PC and running the ‘setup.exe’ program on it.



The program can be removed from the PC, by using the ‘Program & Features’ menu from within Control Panel.



LibraryDatabase - Microsoft Visual Studio
Uninstall or change a program
To uninstall a program, select it from the list and then click Uninstall, Change, or Repair.
LibraryDatabase
Paul D. Foy

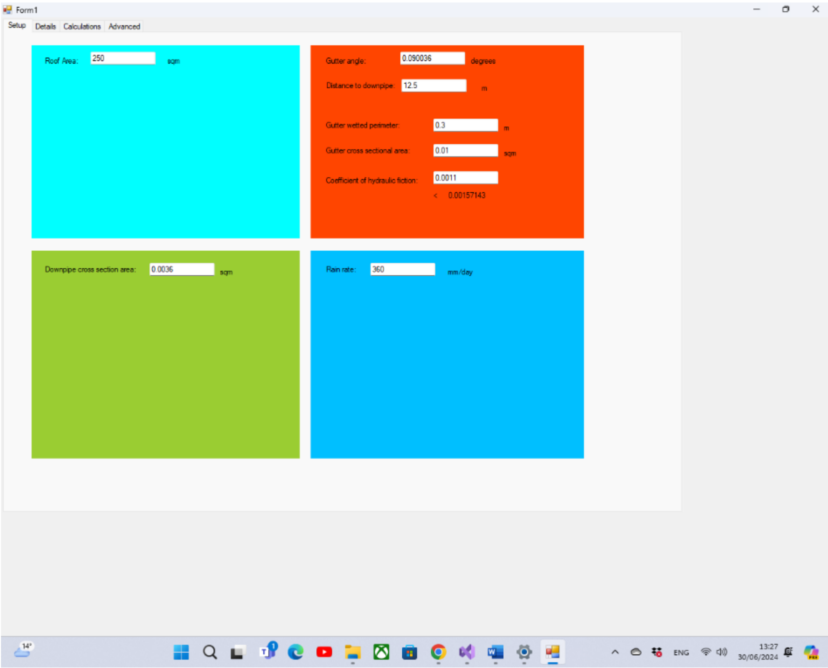
4 Quick Start Guide

1. Setup the rain rate and the roof area (tabs 1 and 2)
2. Describe the gutter (tabs 1 and 2)
3. Calculate the flow rate of the gutter to clear (green button, tab 3).
4. Calculate Mannings flow rate (tab 4).
5. Adjust the angle of the gutter so that the values calculated in steps 3 and 4 are roughly equal.
6. Using the inclination of step 5, and the flow rate of step 3 or 4 (and an estimate for the coefficient of friction), use the left-hand panel of tab 4 to calculate the distance to downpipe consistent with these values (and the kinetic model of the blue button, tab 3). This should be less than the distance to downpipe of tab 1, of which the serving roof area of the model is based. Otherwise the system can't clear this amount of roof.

5 Use

The application has 4 tabs:

5.1 Setup



The tab has 4 panels corresponding to the 4 pieces of essential information which must be provided to configure the system. You should provide these parameters manually if you do not want to rely on the calculated values and the model of geometry assumed by the second Details tab.

Top left: The roof area in square meters.

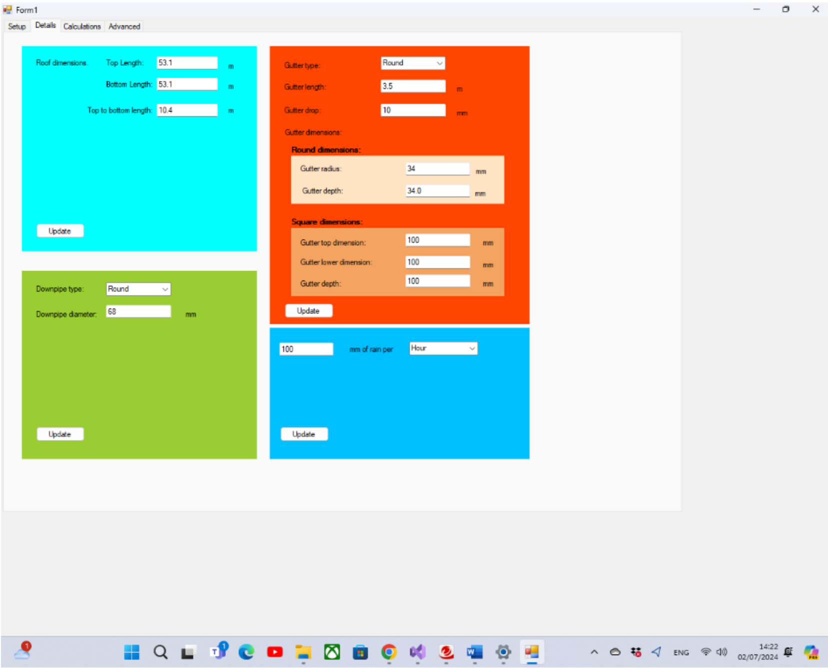
Top right: The gutter inclination in degrees. A distance to the downpipe orifice. This is the furthest distance that the slope will afford. The gutter cross-sectional area in square metres. The (wetted) inside perimeter of the gutter. So for a square gutter, for example, this would be 3 diameters long. A coefficient of hydraulic friction. This is a scaling factor used to reduce the theoretical tendency (because of friction) of water to flow down an open pipe. It must be less than the static coefficient of friction (shown below). If it is equal to this value, then the water is in equilibrium in the pipe and there is no flow (the gutter is blocked!). I suggest starting off with a value of 0.0011. The coefficient of static friction is the tangent of the gutter inclination angle.

Bottom left: The downpipe cross sectional area in square meters.

Bottom right: The rain rate in millimetres per day.

Clearly two of these panels (1 and 4) have a critical effect on the rate at which water *must be* cleared. 2 and 3 influences the rate at which water *can be* cleared.

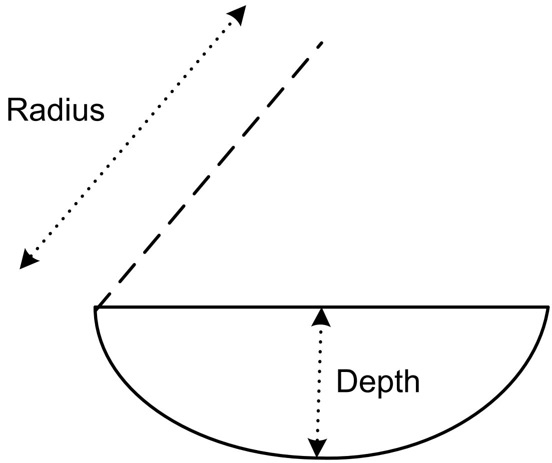
5.2 Details



This tab allows you to provide more details to configure the system more precisely. Upon updating, the calculated parameters are used to update the Setup screen. The panels in this screen correspond to their positions in the Setup screen.

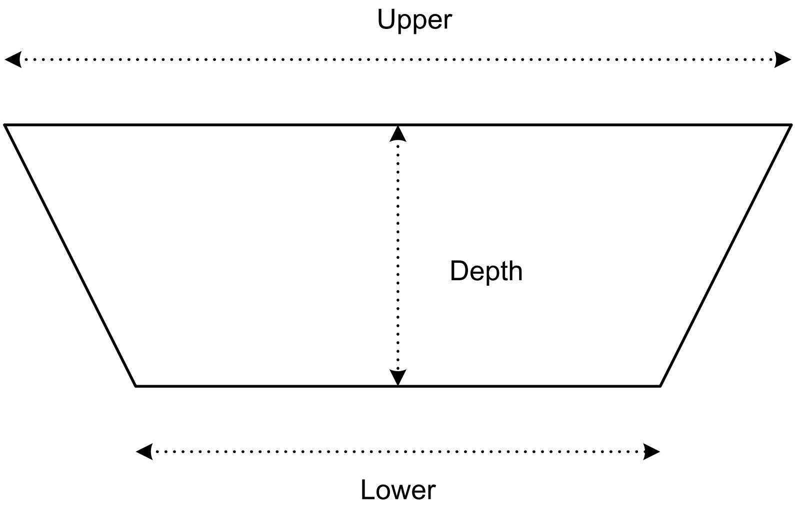
Top Left: Provide the roof section dimensions. The model is that of a trapezoid which may have different top and bottom heights. The height of the trapezoid is the top to bottom length.

Top Right: Gutter type: *Round*, or *Square-line* are possible. The model of Round is that of a semi-circle with a cut parallel to the diameter – this gives the depth, from the bottom apex to the cut, making a channel with circular underside.



Thus the depth cannot be greater than the radius.

The model of Square-line is a trapezoid with upper and lower length and a depth.



The *gutter inclination* (angle of slope) is provided by providing the *length* and *drop*. For example a drop of 10mm and a length of 3.5m corresponds to an angle of nearly 1/350 degrees. Industry standard angles vary from 1/350 to 1/700 degrees. You will find that it is a critical parameter in the system and must be matched to the distance to downpipe orifice.

Bottom Left: *Downpipe type*: Round, or Square. The downpipe diameter is either the diameter of the semi-circle (Round) or the length of the square side (Square).

Bottom Right: The number of millimetres of rain in the given time (Minute, Hour, Day, Week, Month, Year). Typical very extreme (very unusual) values in the UK might be 100mm per hour (the average UK rainfall is about 1000-1500mm per year).

Values in the tropics do reach this extreme value more regularly.

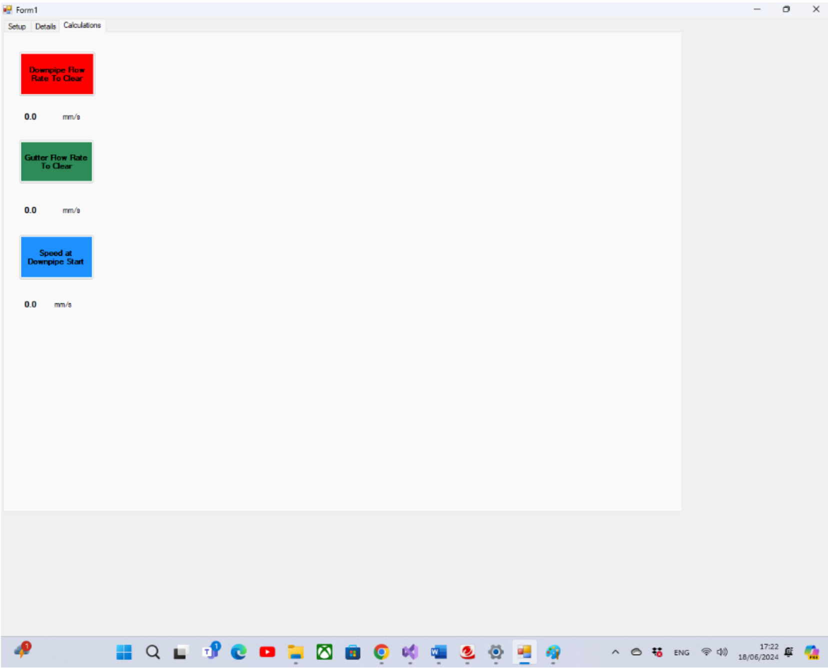
For example suppose we have a rectangular section of roof, and we are evaluating using one downpipe:

If the downpipe is at one end the distance to downpipe is the length of the roof and the area is the total area of roof. The gutter must be inclined to this one downpipe uniformly. See Figure 1 in this case.

If we are placing the downpipe in the centre the distance to downpipe is half the roof length and the roof area is half the total area of roof for the green button only, because two gutters are clearing the roof area in this case. The two lengths of gutter must be inclined separately to the downpipe. See Figure 2 or Figure 3 in this case.

If we have a more complex situation where the downpipe is not proposed to be situated centrally or at an end it is best if two roof sections are modelled. The first two scenarios are however the best design. The distance to downpipe will be different in each case and the speed at downpipe (blue button) also different (depending upon separate gutter inclination). However the latter could be made the same by appropriate choice of gutter inclination in each case (this would be good design). The total area of the roof has got to be used for the red button (downpipe flow rate) as this downpipe drains all the roof. However the area of separate roof sections must be used for the green button (gutter flow rate) as each gutter is acting independently to clear its roof area in this case.

5.3 Calculations



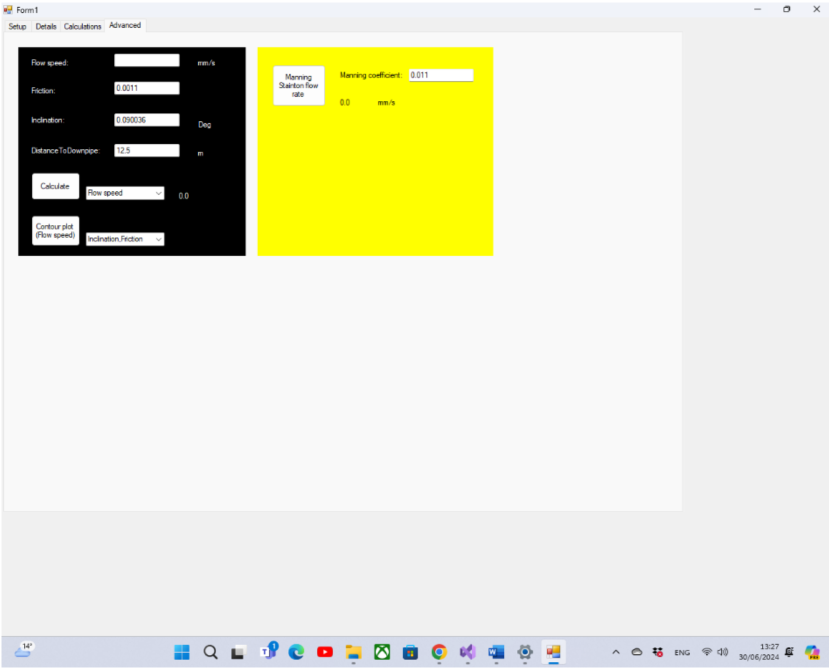
There are 3 buttons calculating critical parameters of the system:

Red button: The downpipe flow rate necessary to clear water given the rain rate, collecting area of roof and cross-sectional area of downpipe. This value can be high without due concern as the downpipe is usually vertical.

Green button: This calculates the rate at which it is necessary for the gutter to clear water from the roof. That is the rate at which it must enter the downpipe. It is naturally larger for gutters of a smaller cross section. The flow rate for the gutter will usually be twice that of the downpipe since it has half the cross-sectional area.

Blue button: The speed that is likely to be obtained at the start of downpipe orifice, given the inclination of the gutter, friction, and an assumed furthest distance to the orifice. The kinetic equation of motion, as a simplistic model, is used for this button. Good design would ensure this is greater than the green button flow rate, so that it is possible to get up to the speed necessary to clear from a standing start but not too much greater (else the water will tend to shoot past!). If this value is less than green button flow rate, then the system will tend to be overwhelmed (say in a storm). It is unlikely that a UK system will be able to be designed that can handle rain values typical of a storm (or in the tropics) – say 100mm an hour.

5.4 Advanced



Use this screen in a practical situation.

Left hand panel:

If one measures the flow rate at the downpipe orifice, then knowing the furthest distance to orifice and the gutter inclination an estimate of friction can be obtained. This can then be fed back into the model. Alternatively knowing any 3 parameters the fourth can be determined. For example having calculated the flow rate to clear, (the green button, a value independent of the inclination of the gutter) and given the coefficient of friction, a design value for the inclination of the gutter can be calculated. This can be used to provide the gutter drop for a given distance to downpipe (alternatively the gutter drop per unit distance of gutter length). These are the function of the **Calculate** button.

The **Contour plot (flow speed)** allows a graph of contours of flow speed of either friction against furthest distance to the orifice or friction against gutter angle. Knowing the angle or distance the eye can very quickly scan to estimate friction from rough measurements of the flow rate (or indeed from rough measurements of angle or distance).

The difficulty lies in assessing the flow rate at downpipe orifice. I can think of the following 2 possible procedures:

(i) Either place a little float on the body of some water flowing down the gutter and time how quickly it takes to travel a length just before the orifice.

(ii) Feed (at right angles to the gutter), using a section of hosepipe of known cross section, water into the gutter. At the orifice end construct a collar so that the water is fed into a section of the same hose. Connect this hose to a plumber's water flow gauge meter such as 'Arctic Hayes U-flow water gauge'. Measure the flow rate here. Then (in the steady state condition) from the flow rate measurement and the cross-sectional area of the hose calculate the flow speed to use in this section.

Alternatively a contour plot for flow speed of inclination against distance to downpipe can be obtained. In this way, given an estimate of the flow rate to clear (green button) various scenarios for gutter inclination and downpipe siting can be explored by looking at the contour of the given flow rate.

Right hand panel:

The button **Manning Stainton flow rate** allows an estimate of the Manning flow rate through an open pipe, using the empirical equation, as suggested by the Irish engineer Robert Manning in 1890. The **Manning coefficient** is an empirical constant used in the formula. Tables for it are available for different materials of the conduit. I suggest 0.011 for guttering purposes (10 times the coefficient of hydraulic friction).

Good design would be to ensure that the Manning flow rate as calculated by this button (effectively the flow rate in an infinitely long pipe) is like the flow rate given by the green button. If the value given by the green button is much higher, than this flow rate to clear can never be achieved, indicating a poor design. The diameter of the gutter needs to be increased.

6 Theoretical Considerations

The situation can be thought of as a network with *sources* (the rain falling on roof sections) and *sinks* (the downpipes removing water), which are connected by *edges* (the gutters). Thus the application is aimed at modelling the simple situation of one source, one sink and one edge. See Figure 1 (source is blue, sink is yellow, edge is red).

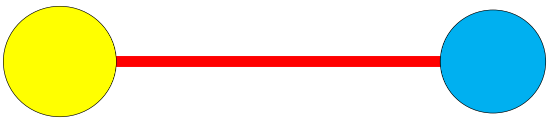


Figure 1 - Simple network.

When the single downpipe is in the middle of a rectangular roof, we can either model it as two sources (roof sections) and one sink with two edges (gutters) – see Figure 2.

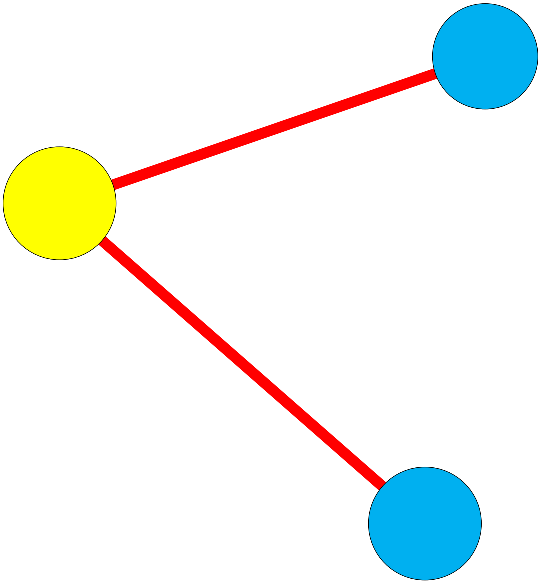


Figure 2 – A 2 source network.

Alternatively as (a multigraph) one source and sink with two edges (gutters) both going from the same source to sink – see Figure 3.

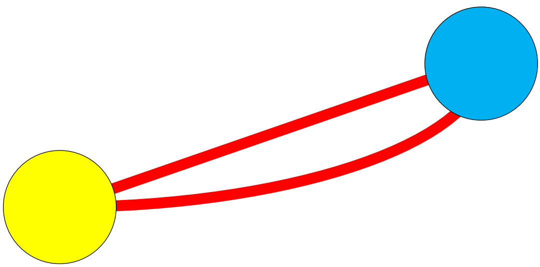


Figure 3 – A one source, 2 connection network.

The capacity of the edges are the cross-sectional areas of the gutters. The speed calculated is to meet the production of the source.

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