Sustainable Urban Drainage Systems (SUDS)

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Paper 2: Latest Design Tools and Software – Practical Application

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1. What is SUDS/Source Control?

SUDS or Sustainable Urban Drainage Systems is the course of much debate. The word sustainable may be interpreted in many ways as to what it actually refers to. For the purpose of this paper on design aspects, we will concentrate on Source Control. This is an easier term to consider since any storm water, which lands on the catchment and is harnessed or attenuated near to where it lands is effectively Source Control. It is precisely that we are controlling the storm water close to its source.

2. Traditional Methods of Source Control

Source Control Techniques are as old as intelligent man itself. From our earliest civilisation, we have sought to harness rainwater originally as a means of supply. Of course, over the centuries storm water has been seen as a waste and with public health systems the modern technique has been to try to get rid of it as soon as possible. As stated earlier there is nothing new about Source Control Techniques and for generations upon generations, we have constructed ditches, filter basins and ponds. In an engineering or building context, they have been more specific to projects. In many engineers eyes when we speak of SUDS or Source Control we are only talking about House Soakaways and Infiltration Trenches (French Drains). These have received a bad press in certain regions, which can be unjustified as in some cases the method has usually been poorly constructed, inappropriate for its use or badly maintained. It is not the scope of this paper to discuss these issues and there are many professionals following who will continue with this aspect of the debate. In traditional methods of source control, the main feature was to dispose of the water to a suitable strata capable of receiving water through infiltration.

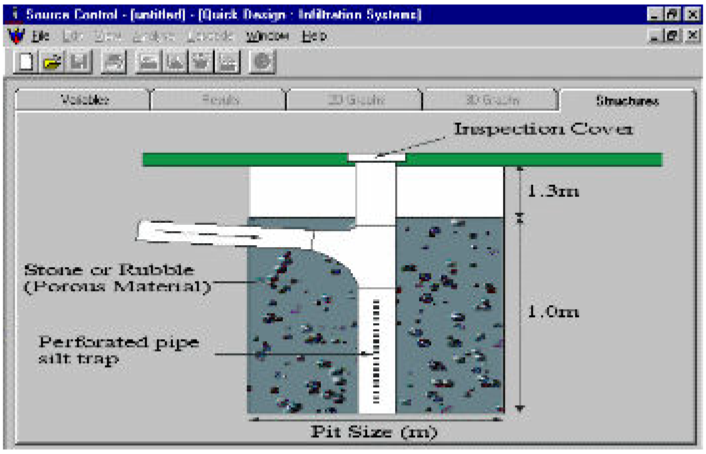


Fig (i) House Soakaways (Typical)

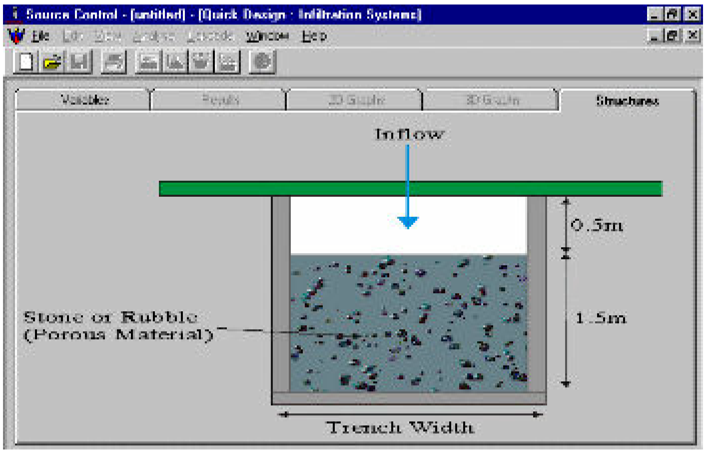


Fig (ii) Infiltration Trench (Typical)

3. New Methods of Source Control

The latest techniques of Source Control have considered issues far greater than purely the disposal of storm water. The fact that we are now considering much wider issues has much to do with the concerted efforts of authorities such as SEPA (Scottish Environment Protection Agency) and individuals such as Professor Chris Pratt of Coventry University. The representative for development of these procedures at the Environment Agency is Mr Prosper Paul and a great deal has been achieved in a comparatively short time. Whilst the methods of source control discussed earlier, still have a role to play in future design we have to pay particular attention to good construction practice, to ensure they provide us with a long and maintenance friendly operational life. The way in which we design source control elements can be categorised into three distinct ways: -

1. Infiltration structures that return all of the water to the ground.
2. Source control elements, which attenuate, flow rates but return nothing to the ground.
3. A combination of both infiltration to the ground and a proportion of water, using a controlled outflow or by an overflow, returning to a positive drainage system. Within any site we can potentially use any combination of the above.

Porous pavements are becoming an increasingly popular method of storage of water and as an infiltration system. They are comparatively low cost since they are often used where normal hard-standing such as car-parking would have to be implemented anyway. There are numerous surfacings available such as block paving, grass-crete blocks, formpave etc.

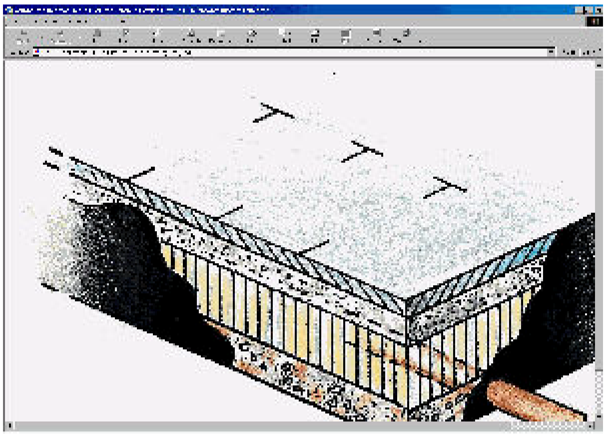


Fig (iii) Porous Car Parks

A major player in the development of all types of attenuation controls and storage techniques are Hydro International of Clevedon. Their use of their Hydrobrake flow control is widely accepted and the adoption of their Stormcell blocks for construction of underground tanks is growing. These blocks have the advantage of being light and easy to place.

Fig (iv) Stormcell

Fig (v) Garastor

A developer who has embraced the techniques of Source Control and embarked on many sites taking advantage of the benefits are Bryant Homes. They have developed a technique and a control whereby they can store much of the roof water from a housing site below the ground slabs of garages or specially constructed voids in the gardens of houses. This specification uses a custom control called the Garastor which provides not only a flow control but also claims to trap leaves and the like to prevent blockage. It also includes an overflow structure. We are advised that the technique and control has already received NHBC certification and has been constructed on a number of sites already.

4. When can we use Source Control?

The simple answer to this question is anywhere and everywhere (depending on the type). The effects of using Source Control either by utilising infiltration techniques, or not, has the benefit of reducing flows downstream by controlling storm water close to where it lands. This has a knock-on effect of requiring smaller storm water drainage systems or in the case of a permeable conveyance system smaller trenches or swales. As the water can be retained higher up the system the net effect is to further reduce the storage requirements in tanks or ponds downstream and hence potentially reduce cost. You will note that no mention has been made of any benefit to be achieved in a pollution sense. Filtration systems have been shown to provide a significant benefit in helping to reduce pollution levels in storm water. Again this is not within the scope of this paper and its discussion will be left to others.

5. How do we assess the effectiveness of Infiltration Methods compared to conventional storage techniques?

From this point the Micro Drainage Software Win*Des* will be used to illustrate the decision making process. Every site is different but essentially, there are usually three defining characteristics: - 1. The maximum permitted discharge from the site. 2. The total impermeable area of the site 3. The ground strata that is available for infiltration techniques. As an example, consider a site approximately 10 hectares in impermeable area with a permitted discharge of 20 l/s, an allowance for infiltration techniques will be made if it is a viable method. We first run the Quick Storage Estimate

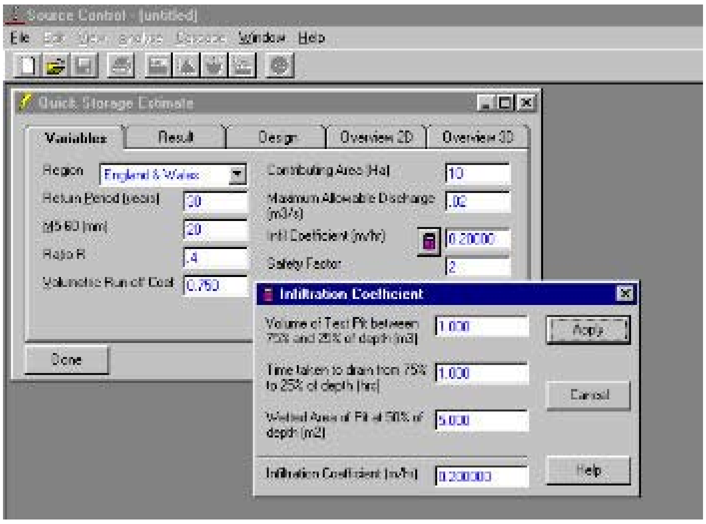
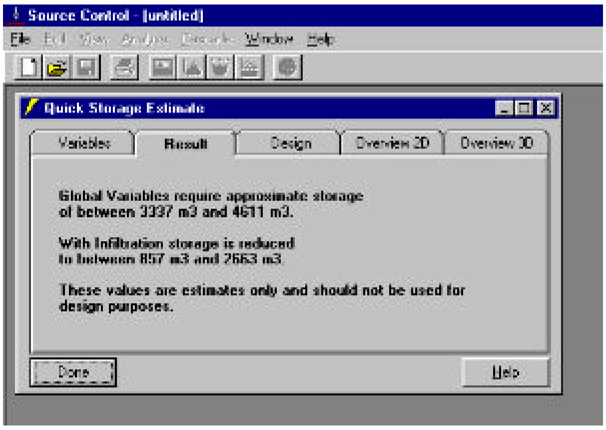


Fig. (vi) Q.S.E.



As you can see if storage structures without infiltration are used the volume of storage will be 3337 m^3 to 4611 m^3. If infiltration systems are used then the volume of storage reduces to 857 m^3 to 2663m^3. (The variation in storage is dependent on the type of structures constructed and the flow controls used.) A saving of approximately 2000 m^3. Storage can be as expensive as £500/m^3 then a potential saving of £1M could be available on a project of this type.

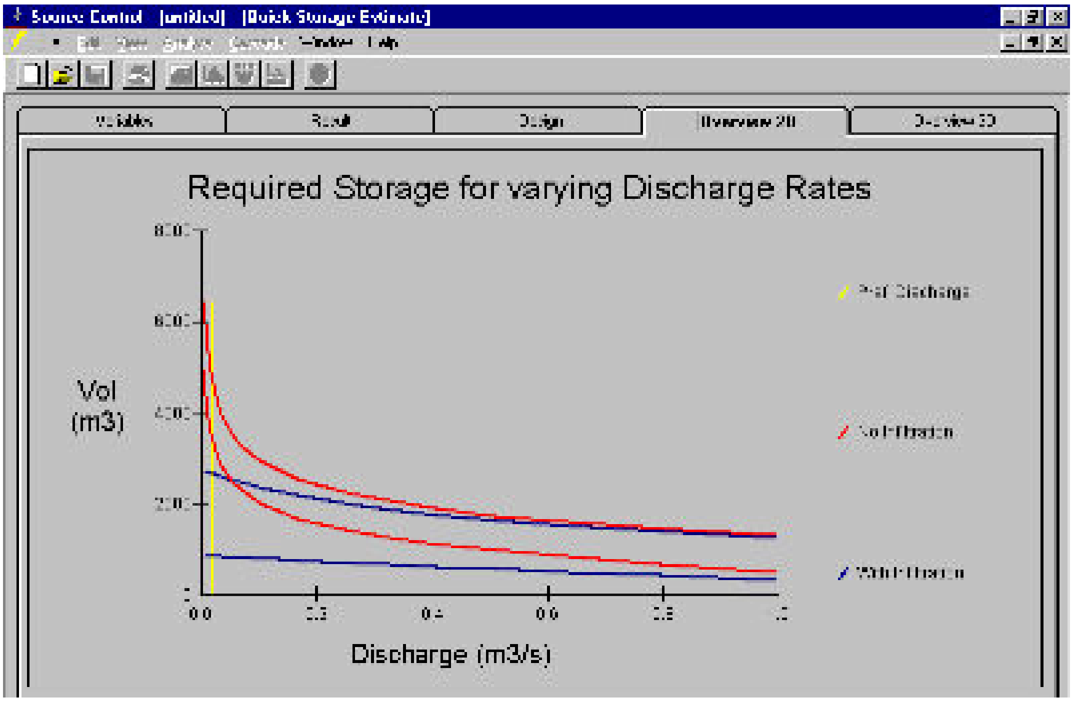


Fig (vi) Graphs

Looking at the graphs of volume against outflow indicates that when the discharges are low as in this case there are significant savings in storage volume to be made. Of course, as explained earlier not all sites are the same and in this case if the allowable discharge was closer to 200 l/s (0.2 cumecs) then the potential savings from using infiltration systems is reduced.

6. Deciding on which elements to use and how much we need

There are a large array of different techniques that can be used and it can sometimes be confusing when deciding which elements would be most appropriate for the project. But, like most engineering design there are usually a number of alternatives that could be considered for the design before embarking on a particular solution or solutions. What is unusual in the SUDS/Source Control arena is that the decision making process can involve issues which do not necessarily have an engineering input such as: - Legal Issues • Will the elements of the design be adoptable or unadoptable.* Who will own the completed works? House holder, Water Company, Highway Authority, Local Site Manager, Local Authority* Who will maintain the system:* What preference to design has the approving authority?Engineering issues are obviously important • Can the ground strata support infiltration?* Are there specific constraints e.g. if you need 600 soakaways and you have only 100 houses its going to be difficult to fit them in!Be prepared to present more than one proposal as a flexible approach is a usual requirement. Looking at our example (below) it shows that there are 4 ha roof drainage, 3 ha of car parking/hardstanding and 3 ha of normal road run-off.

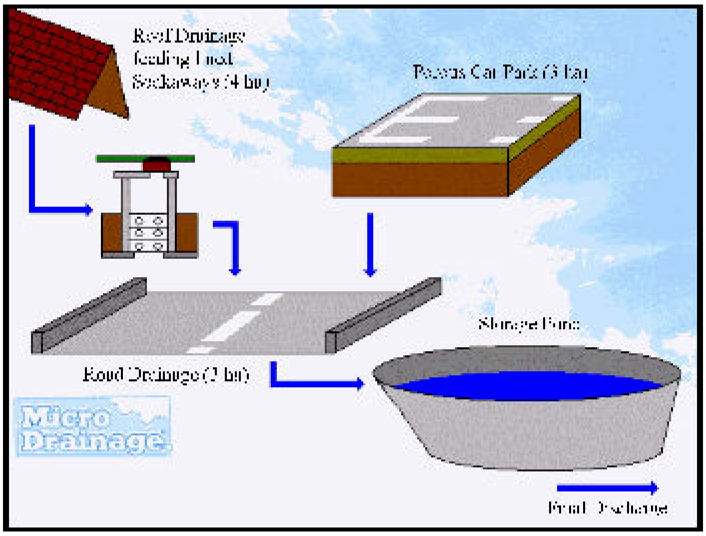


Fig (vii) Example of Run-Off

For the purpose of this example roof drainage will be routed through "lined soakaways", the car parking/hardstanding through "porous car parks" and the road drainage through a "storage pond". Using the "Quick Design Infiltration Systems" it can quickly be determined the number and size of all of these elements.

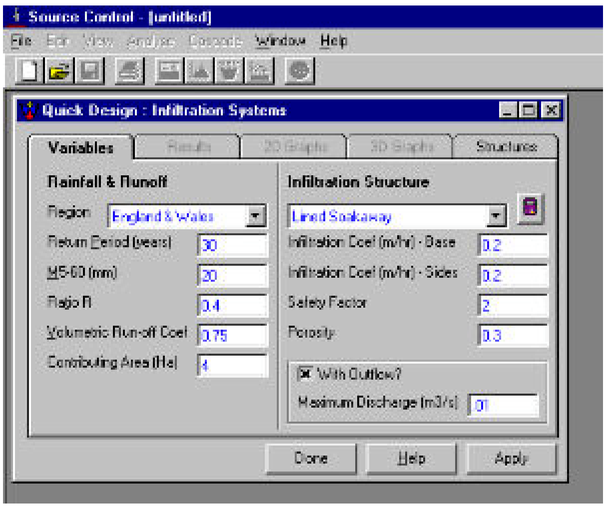
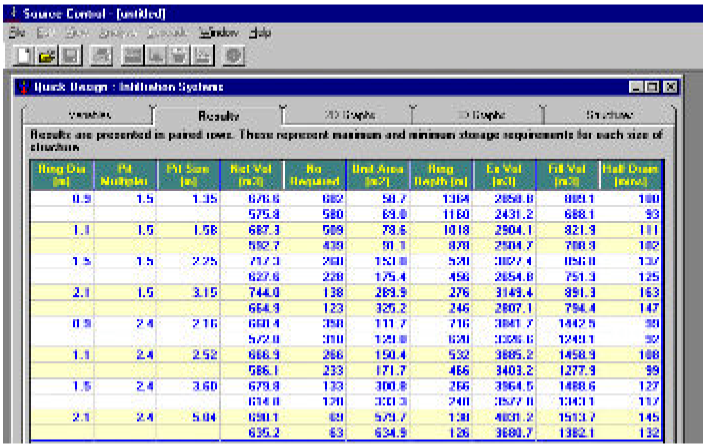


Fig (viii) Quick Design Infiltration Systems



Source Control - [untitled]

Quick Design : Infiltration Systems

Results are presented in paired rows. These represent maximum and minimum storage requirements for each size of structure

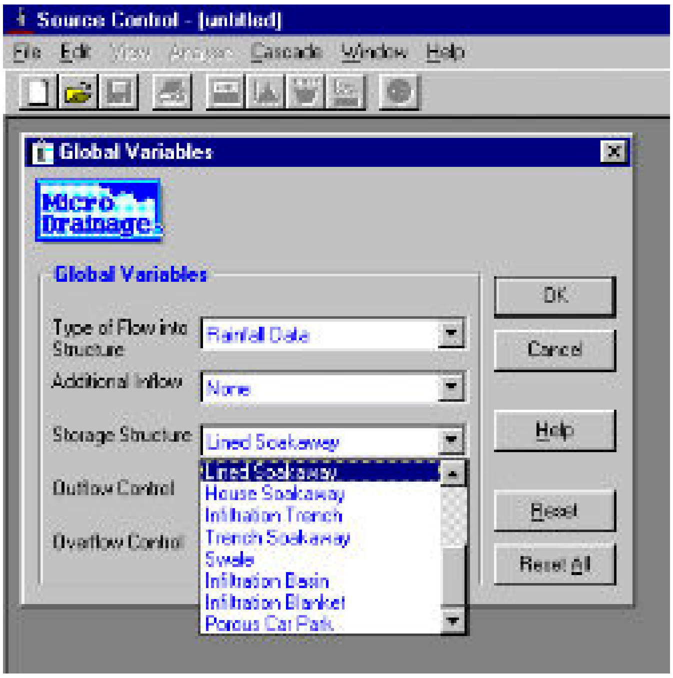
Ring Dia (m)	Pit Multiplier	Pit Size (m)	Net Vol (m3)	No Required	Unit Area (m2)	Ring Depth (m)	Ex Vol (m3)	Fill Vol (m3)	Half Drain (mins)
0.9	1.5	1.35	676.6	682	50.7	1364	2858.8	809.1	100
			575.8	580	69.0	1160	2431.2	688.1	93
1.1	1.5	1.58	687.3	509	78.6	1018	2904.1	821.9	111
			592.7	439	91.1	878	2504.7	708.9	102
1.5	1.5	2.25	717.3	260	150.0	520	3027.4	856.0	137
			627.6	228	175.4	456	2654.8	751.3	125
2.1	1.5	3.15	744.0	138	283.9	276	3149.4	891.3	163
			664.9	123	325.2	246	2807.1	794.4	147
0.9	2.4	2.16	660.4	358	111.7	716	3841.7	1442.5	98
			572.0	310	129.0	620	3326.6	1249.1	92
1.1	2.4	2.52	666.9	266	150.4	532	3885.2	1458.9	108
			586.1	233	171.7	466	3403.2	1277.9	99
1.5	2.4	3.60	679.8	133	300.8	266	3964.5	1488.6	127
			614.0	120	333.3	240	3577.0	1343.1	117
2.1	2.4	5.04	690.1	69	579.7	138	4031.2	1513.7	145
			635.2	63	634.9	126	3680.7	1382.1	132

Fig (ix) Result of Quick Design Infiltration Systems

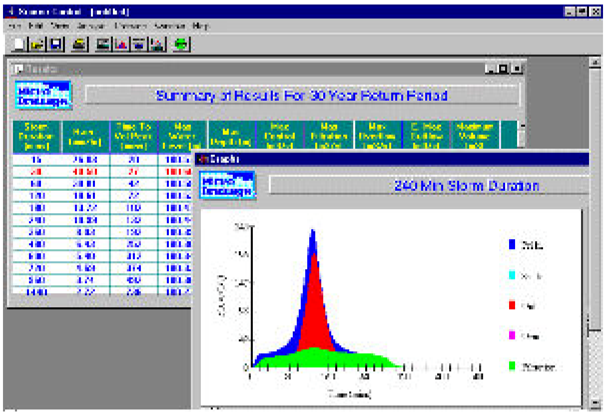
It can be seen from the above results that by choosing a 900 mm diameter ring size with an overall pit size of 1.35 m would require between 580 and 682 in total. If there are only, 130 houses on our site this is obviously not a viable alternative. On the other hand if 2.1 m diameter ring with overall pit size of 3.15 m is chosen the requirement would be between 123 and 138. Hence, having 130 houses would indicate that a design of this size would be appropriate. The outline requirement for Porous Paving would be determined in a similar manner the key variables being depth of filter media and surface area.

7. Designing the required elements

Win*Des* Source Control has the capability of designing all sorts of elements that can be used in SUDS.



The actual setting up of the data and running the program takes no longer than a couple of minutes. This will determine that our suggested designs are satisfactory, for the process. In the design of the lined soakaways and the porous car parking each set of elements has been designed with infiltration enabled but, an allowance of 10 l/s has been allowed to flow into the drainage system.



A storage pond has also been designed to take the 3 ha of road run-off and controlled to a limit of 20 l/s.

8. Linking the elements together to assess the effectiveness of the design

The completion of the design of the individual elements determines the effectiveness of each part of the process. Bearing in mind that the lined soakaways and porous car parks have both been designed to allow 10 l/s back into the drainage system if the total of the outflow is only 20 l/s it would appear that we may have under designed our final pond which also has to accommodate the 3 ha of road run-off. This is where the Cascade aspect of the Source Control Program is so important.

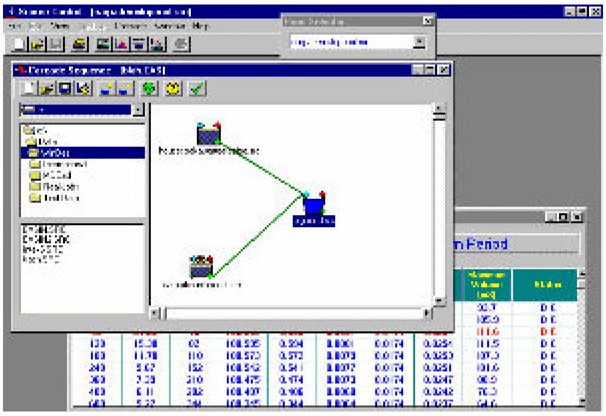
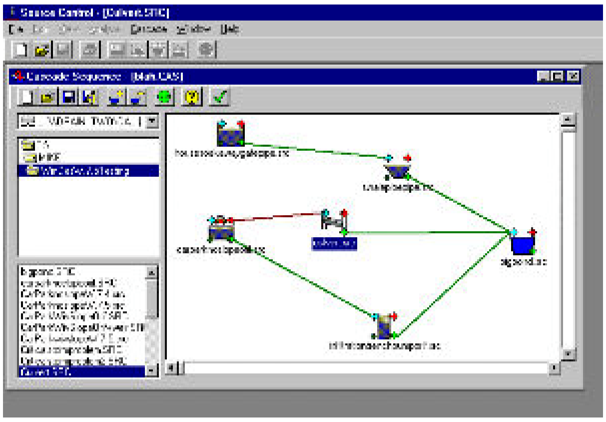


Fig. (x) Cascade

By simply linking the elements together (a maximum of 10,000 are allowed) in the graphics window the program will run every storm from 15 minutes to 7 days and indicate that the final pond actually only needs to have a volume of approximately 900 m^3. The reason for this is that each element is critical for different storm durations. The lined soakaways are critical for a 120 minute storm whilst the porous car park is critical for a 60 minute duration storm. The pond is critical for a much longer duration storm of 480 minutes. Hence, it can be shown that when our lined soakaways and porous car parks are at their peak, the pond is only approximately half full and can therefore accommodate the 10 l/s + 10 l/s = 20 l/s with ease. Equally when the pond is at its peak the lined soakaways and porous car-parks have drained to contribute very low flows. The introduction of this software is allowing us to consider the interaction of design elements where never before was it possible. The figure below shows how more complex scenarios can be easily prepared.



9. **Adding the elements to a network to assess the performance of a totally integrated solution.**

Provided that the elements have been well-designed in the first place adding them to a drainage network is more or less a simple rubber-stamping exercise. The "Win*Des* Simulation" software allows the user to "drop-in" the infiltration systems so that when the program is run on a drainage network the design can be proved to be satisfactory in a totally integrated system.

10. Benefits in using a well designed SUDS/Source Control System.

In conclusion the use of the software makes the application of SUDS/Source Control far easier than it has been before. The key features of using a well designed system are:- Infiltration systems decrease the quantity of water downstream and hence reduce the flow in storm water systems Infiltration Systems may be used when there is no convenient existing system to which connection can be made. Controlling storm water close to source reduces the hydrological input of urbanisation. Source Control can be used to replenish groundwater. Source Control can result in large reductions in the cost of storage. Infiltration Systems may reduce the risk of discharge from CSO's.

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