SPRING ... 1987

THE LIMITATIONS OF WASSP

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Wallingford

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The limitations of WASSP are of several different forms:

1 the overall purpose of the programs
2 the size of system or length of storm
3 the way in which the mathematical equations are handled
4 how they should be used.

1) OVERALL PURPOSE

The Rational and Optimising methods cannot be used for simulating the behaviour of a system under real conditions; they are purely design programs. They are also unsuitable for designing systems downstream of significant detention storage.

The Hydrograph method cannot be used for systems with surcharge. It is also unable to model in detail storage upstream of tanks or tank sewers. The program is therefore best used only for design.

The rest of this paper refers mainly to the Simulation method which is the most widely used of the programs in the package.

2) PROGRAM SIZE

The limits on program size refer only to MicroWASSP; with the mainframe it is possible to redimension the arrays to allow larger systems or storms. The main limits are:

Number of nodes (i.e. pipes + outfalls)	300
Duration of simulation	480 minutes
Number of outfalls (main or subsidiary)	2
Number of tanks	15
Number of pumping stations	5
Number of gauge pipes	30
Number of input hydrographs	4

3) LIMITATIONS OF PROGRAM DESIGN

There are limitations inherent in the equations used in the model. These will be considered for each stage of the model.

4) HYDROLOGY

The basic limitation of the hydrology is that it is intended for urban sewered catchments in the UK (except for the overseas version of WASSP). For these catchments the events causing flooding are well represented by short intense summer storms falling on a relatively dry catchment. These are the conditions assumed for the synthetic storms.

The runoff is calculated using the percentage runoff equation. This is only valid if the rules given in the manual for defining catchment areas are followed. It is also only valid if the data lies within the range given in the manual. For example UCWI cannot exceed 300.

The calculation of the speed of runoff overland into the sewer system is calculated for small paved areas draining directly into the system. The maximum area is taken as 600 m2 per gully. This effectively means that there is assumed to be no delay or attenuation to the flow from its entering the gully to its reaching the first pipe which is included in the model. There is no allowance which can be made for this and it should be considered when choosing how large to make individual contributing areas.

5) FREE SURFACE FLOW

The fundamental assumption is that all flows are at normal depth. This means that under free surface flows no backwater effects can be taken into account be the program. Until a pipe becomes surcharged the levels at its downstream end are effectively invisible to the flows at the upstream end. This also means that imposed level hydrographs are ineffective until they become sufficiently high to cause surcharge in the outfall pipe.

Following from this restriction is that under free surface conditions the minimum pipe gradient is set at 1:10 000. It is therefore not possible to correctly model flat pipes or pipes with backfalls. This is because it is not possible to define a normal depth of flow for pipes with zero or negative gradients.

6) SURCHARGE FLOW

The main limitations on modelling flow in surcharge are due to the rapid fluctuations in flow which occur under these conditions. It is therefore necessary to use a short timestep in order to follow these fluctuations. The recommended value is 15 seconds, although this is partly influenced by the modelling of ancillaries which is mentioned below.

One aspect of the modelling of surcharge flows which causes confusion but is not really a limitation of the program is in the method of handling the storage in unsurcharged pipes upstream of a surcharged pipe. This storage is represented only as a level pool not as the true backwater curve.

7) ANCILLARIES

7.1) MODELLING OVERFLOWS

The on line tank is used to represent both on line storage and overflow structures. It has several limitations due to the interaction of flows.

The main limitations is that the diverted flow can never be in the reverse direction, i.e. into the overflow structure. This is not allowed even for transient flows which have no real significance. This can obviously only arise if the overflow feeds into another pipe. As reverse flows can in general only happen when the overflow pipe is surcharged they can often be avoided by inserting a short dummy pipe of large capacity immediately downstream of the overflow. This will prevent surcharge due to transient flows and give stable results.

A second limitation of the tank is that it is not possible to model a bifurcation where the continuation and overflow pipes are at very similar levels. This type of situation gives (both in reality and in the model) oscillations of flow which cannot be modelled correctly.

It has always been known that 15 seconds timestep gives the best results with tank structures, and we strongly recommend that no other timestep be used.

7.2) MODELLING STORAGE TANKS

If storage is modelled as an on line tank then the limitations are as for the overflow structures. When using an off line tank however further limitations apply. The return flow from an off line tank is discharged into the pipe immediately downstream of the on line tank, but only when this pipe is not surcharged. This can lead to an effective bypassing of the flow control.

7.3) PUMPING STATIONS

There are two main limitations at pumping stations. The overflow must go to waste, not into another pipe. Surface flooding cannot be allowed to occur. This should be prevented by giving an artificially high water level if necessary.

8) MODELLING LIMITATIONS

In this section I include the things which WASSP can represent but which many users do not include in theire models. The first of these is the use of a wide range of storm durations covering all of those likely to be critical for flooding. Where detention storage is included longer durations must be considered. For design durations in excess of 6 hours the behaviour in winter conditions should also be considered.

The other two problems concern the storage in the model. The inclusion of storage in the system is covered in a later paper, but when looking at surface flooding, it is also necessary to realistically model the area over which this can occur.

WALLINGFORD PROCEDURE USERS GROUP (WaPUG)

NORTHERN SPRING MEETING - 30 APRIL 1987

Mr J H Wyborne, Director of Highways and Engineering Services for Leeds City Council, welcomed delegates to Bodington Hall, University of Leeds. He stated his belief that there was great benefit to be gained from sharing experiences with other users and that WaPUG provided this forum. He considered his view was reflected by the increasing numbers attending meetings and by the full range of users represented.

SESSION 1 : PRESENTATION OF REQUESTED PAPERS AND DISCUSSION PERIOD

Session Chairman Dr D J Balmforth, Sheffield Polytechnic

(a) Limitations of WASSP
- M Osborne, Hydraulics Research Ltd

The limitations of WASSP are of several different forms:

1. the overall purpose of the programs
2. the size of system or length of storm
3. the way in which the mathematical equations are handled
4. how they should be used.

This paper refers mainly to the Simulation method which is the most widely used of the programs in the package.

There are limits on program size in MicroWASSP; with the mainframe it is possible to redimension the arrays to allow larger systems or storms.

There are limitations inherent in the equations used in the model.

Runoff is calculated using the percentage runoff equation. This is only valid if the rules given in the manual for defining catchment areas are followed. It is also only valid if the data lies within the range given in the manual. For example UCWI cannot exceed 300.

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The fundamental assumption is that all flows are at normal depth. This means that under free surface flows no backwater effects can be taken into account by the program.

Following from this restriction is that under free surface conditions the minimum pipe gradient is set at 1:10 000. It is therefore not possible to correclty model flat pipes or pipes with backfalls.

One aspect of the modelling of surcharge flows which causes confusion but is not really a limitation of the program is in the method of handling the storage in unsurcharged pipes upstream of a surcharged pipe. This storage is represented only as a level pool not as the true backwater curve.

The main limitation is that the diverted flow can never in the reverse direction, i.e. into the overflow structure. This is not allowed even for transient flows which have no real significance.

A second limitation of the tank is that it is not possible to model a bifurcation where the continuation and overflow pipes are at very similar levels. This type of situation gives (both in reality and in the model) oscillations of flow which cannot be modelled correctly. It has always been known that 15 seconds timestep gives the best results with tank structures, and we strongly recommend that no other timestep be used.

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In this section I include the things which WASSP can represent but which many users do not include in their models. The first of these is the use of a wide range of storm durations covering all of those likely to be critical for flooding. Where detention storage is included longer durations must be considered. For design durations in excess of 6 hours the behaviour in winter conditions should also be considered.

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Discussion:-

Mr Trayner, Ronald Leach and Associates

Are there not occasions when it is advisable to specify 0% flooded area?

M Osborne

Entering flooded areas is dependent on the individual situation, e.g. it would be incorrect to enter a flooded area on a steeply sloping catchment, it would also be inadvisable not to enter a flooded area where ponding could occur. As a general rule many users ignore the flooding facility and produce unsatisfactory results.

Mr McDonald, Ronald Leach and Associates

Can the small level difference between continuation and overflow be defined when using on-line tanks to model bifurcations.

M Osborne

Generally a minimum of 1/4 to 1/3 pipe depth, however always check results for oscillations.

J Turner, Leeds City Council

Does the regression equation for P R not allow for 100% paved areas.

M Osborne

The equation holds true for PIMP of 20% - 70% however if pervious areas are excluded PIMP becomes 100% which is outside the range of the data set. See WaPUG User Note No.5 which deals with this topic in particular relation to separate or partially separate systems.

J Benn, Hydraulic Analysis Ltd

Are there any developments in the modelling of free surface backwater effects.

M Osborne

It is hoped in the future to include a facility where the user will be able to select certain pipes in the system where free surface backwater effects should be modelled. The use of this facility would however increase running times.

An alternative programme (SPIDA) will model the effect in all pipes, this too suffers from long run times.

D Balmforth, Sheffield Polytechnic

Large tanks in WASSP tend to generate errors. Why is this and can it be overcome by using a series of small tanks.

M Osborne

For tanks of large plan areas even large inflows produce negligible increases in depth and oscillations can become a problem. The orifice coefficient should be considered with care. Use of small tanks in series may cause more problems than it solves due to the interconnecting dummy pipes. Solutions should be tested on a trial and error basis.

Mr Reed, Sir William Halcrow

There are problems limiting discharge downstream of an on-line/off-line tank configuration.

M Osborne

To overcome this problem a dummy pipe should be inserted for the continuation from the on-line tank. This pipe should be such that it represents the throttling effect of the orifice. The bypass loop that may be set up via the on-line to off-line tank and to the continuation pipe is then overcome since the off-line tank will not discharge until there is spare capacity in the continuation from the on-line tank.

M Killen, Lincoln City Council

Problems experienced modelling partially separate systems and infiltration.

M Osborne

Read User Note No.5 by A.Eadon for advice on modelling partially separate systems. Modelling infiltration is a problem as ideally it would require an input hydrograph to each pipe. If it occurs across the system try increasing the DWF by the average infiltration value.

P Deakin, Northumbrian Water

Experienced a problem where large pervious areas drained to the system via land drains. This caused modelling problems on long duration storms. Two methods were tried to overcome this.

1. Alter the hydrograph to simulate additional flow entering the system.
2. Add in an additional area connected via a very long pipe.

M Osborne

Method 1. is not recommended as it is forcing the model.
Method 2. may be alright but still seems dubious.

G Pettigrew, Sir William Halcrow

Raised several problems encountered in recent verification exercises. When representing tidal effects by using a level hydrograph, water was generated where junction records returned loops to the system. Also unable to satisfactorily model a dipping weir overflow which had several different characteristics in operation, some success was achieved but there was instability in modelling depth.

M Osborne

WASSP can become unstable when modelling looped systems. Efforts should be made to reduce loops to a minimum. Depth becomes unstable at the transition to surcharge due to the additional headloss which occurs in practice due to the formation of a vortex.

D Balmforth

With respect to the dipping weir problem it should also be noted that in WASSP the discharge over a weir is controlled by the downstream conditions as happens in practice for high side weirs. However discharge over low side weirs in practice are controlled by the upstream conditions and therefore this may give additional problems.

J Blanksby, Oldham MBC

Showed overheads off fits modelling low side weirs and how these could be improved using a correction method suggested by D Balmforth. However to obtain the correct discharge over the weir its height had to be increased which can cause flooding upstream.

D Balmforth

The continuation pipe may be artificially increased in size to overcome the flooding. When the method of dealing with low side weir overflows is perfected it will be released.

A Taylor, WRC

Why should medium intensity storms (6-15 mm/hr) produce good verification fits whereas high intensity storms (30 mm/hr) give poor fits.

M Osborne

3 possible reasons:

1. Capacity of gullies is limited therefore all flow does not enter the system when WASSP assumes it does.
2. Overflows which may change in characteristic with high flows, or high level overflows, are present which would not normally operate.
3. Problems related to modelling storage.

M Osborne

Requested comments or problems associated with on and off-line tanks.

G Pettigrew, Sir William Halcrow

Experienced problems where off-line tanks discharged further downstream or to a different system. There is no facility for this in WASSP.

A Ryan, Wyre BC

Problems with large tanks generating water but used tank sewers to overcome the problem.

J Blanksby, Oldham MBC

Large tanks with downstream storage suffer from problems associated with surge. WASSP does not model this satisfactorily.

N Read, Sir William Halcrow

It would be desirable to have the option to return flow from the off-line tank back into the on-line tank.

D Balmforth, Sheffield Polytechnic

It would also be desirable to have the option to return flow from the off-line tank to a designated pipe downstream.

D Williams, WRC

There are limitations in modelling pumping stations. What plans exist to improve this situation.

M Osborne

Problem for HR is which improvements are most urgent or important. A new programme (WALRUS) will allow the user to run interactive and pause the programme at any point in order to activate pumps. Does anyone have a specific problem with pumping stations.

J Cooper, Babtie Shaw and Morton

The general configuration of the wet well is limiting.

WALLINGFORD PROCEDURE USERS GROUP (WAPUG)

15 MAY, 1987, LONDON

Dr. David Balmforth opened the meeting and welcomed delegates to the second 1987 Spring meeting at the Institution of Civil Engineers, Great George Street.

SESSION 1: PRESENTATION OF REQUESTED PAPERS AND DISCUSSION PERIOD

Chairman - Dr. D.J. Balmorth, Sheffield Polytechnic

(a) Limitations of WASSP

M. Osborne, Hydraulics Research Limited

See Leeds Meeting for Synopsis

Before commencing his paper Martin took the opportunity to introduce Mr. Andrew Brown who is the first line of contact for WASSP problems at H.R.

Discussion:

P. Boyle, Slough B.C.

Experienced problems with the programme when using dummy pipes of no length as a control.

M. Osborne

See Leeds Meeting Synopsis

WASSP will not model short pipes accurately, lengths below 10m should be avoided.

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Lennard, Howard Humphries

Has any research been carried out which may cast doubts on the PR equation.

M.Osborne

No, the equation generally performs well though there are some problems associated with less urbanised catchments such as slow run-off from pervious areas. This is however due to be rectified.

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Dr. Wright, Applied Research and Project Management Services.

How can you model flooding in WASSP.

M. Osborne

3 methods available

(i) Flood volumes are lost from the system

(ii) The manhole can be sealed, in effect it is giving infinite height

(iii) A flooded area can be specified - however the programme assumes a flat base and vertical sides.

Dr. Wright

Is it possible to model the flood area as a conical tank.

M. Osborne

Not at present, though it is feasible.

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W. Earp, Leicester C.C.

What are the limitations on level difference when trying to model bifucations.

M. Osborne

The limit is catchment sensitive but generally difference should be greater than 1/4 to 1/3 above. You will probably have to experiment.

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T. Webster, Severn Trent W.A.

Having problems modelling two tanks either side of a syphon. No satisfactory results have been obtained yet. Results have looked sensible on level 0 output but level 2 shows averaging of servere oscillations has taken place.

M. Osborne

The tank model is susceptible to instability and the syphon will add to the problem. Do not model the syphon as it is, instead model it as an equivalent straight pipe with an increased headloss.

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Mr. Melhuish, Grove Consultants

What is the extent of the error if 100% impermeable is used in HYD or SIM.

M. Osborne

Difficult to quantify as it depends on the catchment characteristics. The run-off would be overpredicted, the more permeable the soil type the greater the overprediction.