A COMPARISON OF WALLRUS-SIM VERSION 1.2 WITH WASSP-SIM

N.R.Orman - Water Research Centre November 1989

1.0 Introduction

WALLRUS was first released in August 1988 with version 1.1 following in February 1989. In April 1989 I presented a paper highlighting certain problems with the early versions of the WALLRUS Simulation program (WALLRUS-SIM). An improved version of WALLRUS, version 1.2 was released in September 1989. This paper is an assessment of this new version.

The assessment was carried out so that WRc could establish that WALLRUS-SIM was producing sensible results before using it in earnest.

2.0 Tests without backwater

A series of tests were carried out on a small part of a verified model of a flat catchment. In order to isolate any effects of the runoff model, input hydrographs only were used to route various flows through the model. The time of flow through the system was approximately 30 minutes. A flat catchment was selected as any differences in the programs are most noticeable in such conditions.

2.1 Pipe routing

Tests for an unsurcharged event showed very similar predictions of flow and depth for both programs, with the WALLRUS prediction about 10% slower and correspondingly more attenuated. The difference in peak depths was more marked with a variation of 15%. This has been found to be due to an error in the normal depth calculations in WASSP-SIM. Though the difference is large it is unlikely to be significant in comparison to the free surface backwater effects (which are ignored) and it is unlikely to affect flooding predictions since this should not occur in free surface flows. In this respect we can therefore consider the models as comparable, with any differences being attributable to problems with WASSP not WALLRUS.

Tests on a surcharged event showed a closer match between the results from the two programs with the peaks at the same time.

2.2 Ancillaries

Anyone who has done much modelling with WASSP will be aware that it is not the pipe routing that causes most problems but in the modelling of tanks and pumping stations. Tests were carried out on a number of configurations of tanks and with a pumping station.

The tests on the early versions of WALLRUS showed considerable problems with mathematical instability. Our tests on the latest version showed that with the high level overflow test and with the level bifurcation there were no such instability problems, and in these instances WALLRUS predicted very similar results to WASSP. On the low level overflow test, however the instability remained. The instability was indicated by a sawtooth effect on the overflow hydrograph, the volume balances on the tank were, however, very good. It is therefore possible that in certain circumstances such instability could be tolerated. Further investigation showed that this could be reduced by reducing the major timestep from 15 seconds to 5 seconds overflow, but with a corresponding threefold increase in run times. This instability was found not to be due to the level of the overflow but due to the overflow pipe becoming surcharged. When the overflow pipe was enlarged then the instability was solved.

Test with a simple pumping station showed similar results to WASSP-SIM.

3.0 Tests with Backwater

The same series of tests were carried out with the backwater flag set on every pipe in the sewer system data file.

3.1 Pipe Routing Tests with full backwater

Initially no dry weather flows were specified, however it became apparent that without an initial flow in a pipe the program was unable to initialise the system properly, this results in a very large and spurious peak at the start of the hydrograph. Users should therefore ensure that any pipe where the backwater flag is set should have a dry weather flow of about 3 l/s flowing through it. After this no further problems were experienced with this phenomenon.

The tests showed that for free surface flow with the backwater the routing time was about four minutes shorter than with WASSP but the hydrograph was much more attenuated. The hydrographs also exhibited a degree of instability. The slightly increased routing time is explained by the use of a critical depth on the outfall rather than the implicit normal depth assumption in WASSP and in WALLRUS without backwater.

Since no real comparison can be made with WASSP for backwater tests some comparisons were made with a Danish program called MOUSE. These showed that the results from WALLRUS and MOUSE were comparable.

The tests were repeated to see the effect of various level hydrographs on the outfall. The use of the level hydrograph above critical depth effectively solved the instability problem. The tests showed that the greater the level of the outfall level hydrograph the faster the routing time and the higher the peak. This is contrary to what would be generally expected.

3.2 Pipe routing tests with partial use of backwater.

Some tests were carried out with the backwater flag set on only some of the pipes. A number of these showed subsequent spurious peaks after the end of the storm. This seemed to be associated with the number of points where there was a transition between backwater and non-backwater calculations. Provided that a single group of pipes are set for backwater together then there were few problems. If a number of isolated pipes were set then problems seemed to occur.

3.3 Ancillaries

The earlier tests on ancillaries were repeated with backwater flags set on all pipes. The performance of the tanks was very similar to the non backwater tests. In the case of the low overflow with the surcharged overflow pipe the addition of the backwater flag seemed to slightly improve the instability.

Where a bifurcation takes place and the backwater flag is set then a dry weather flow must be included on the overflow pipe or there will be initialisation problems with the backwater routines as before. This is also a problem with some pumping stations where the pumps are initially all off.

4.0 Run times

The following comparisons were made of run time for a series of runs on a Compaq 386 with a 20MHz chip. Run times on other machines were generally altered in proportion to the clock speed of the chip.

It was found that WALLRUS without backwater is faster than WASSP.

There is an increase in run times from the use of backwater of just under 100% of the non backwater run time, but this is still only 60% increase on the WASSP run times.

The run times for the backwater option have been reduced by a factor of about 5 since the version 1.0. This makes the use of the backwater routines a practicable option.

5.0 Conclusions

In the areas where the two programs are directly comparable, WALLRUS-SIM generally produces similar results to WASSP-SIM. In the cases where the results differ WALLRUS appears to be giving the correct answers.

When the backwater options are used, direct comparisons cannot be made with WASSP-SIM. Comparison of the WALLRUS results with MOUSE using the diffusive wave method show similar results. This shows the limitations of WASSP-SIM in correctly simulating the routing of flow in free surface conditions when tidal restraints are applied to outfalls.

WALLRUS-SIM has problems coping with a large number of boundaries between backwater and non-backwater flow conditions. This can result in generation of extraneous volumes.

Although WALLRUS-SIM is a faster program, the run times are likely to increase in many cases because of the use of the use of shorter timesteps to overcome instability problems and the use of the backwater flag.

6.0 Recommendations

The latest version of WALLRUS-SIM now appears to be at a level where it can be used with confidence.

7.0 Acknowledgement

I would like to thank my colleagues at WRc and in particular Helen Day, for their assistance in carrying out this work.

2.2 WASSP/WALLRUS Comparison - N. Orman WRc

Brian McNicol - Wessex Water

On one of your comparison hydrographs, it seemed to show a continuous tail for the WALLRUS plot when numerous random backwater flags were set, producing about 15% extra volume. Is this a problem?

Ans: Yes, but you would not normally have numerous random backwater flags and so you should not encounter it.

Dr. R.K. Price - HRL

I would like to point out that if you need to set a backwater flag in a particular location, then the flags on all downstream pipes should be set also.