PUMPING STATION MONITORING AS PART OF A SHORT TERM FLOW SURVEY

R. Henderson*, A. Bedi** & N. Beaven*

* Wessex Water, Lower Bristol Road, Bath
** Software & Training Limited, 71 Crombey Street, Swindon

WaPUG Spring Meeting, 11 May 1994

INTRODUCTION

Pumping stations are an integral part of many, if not most, sewerage systems. Their operation and performance is, however, not always addressed as part of a Drainage Area Study and this is often due to difficulties in monitoring flows to the station with sufficient accuracy and reliability.

Many Water Companies and their Agency Councils have installed permanent telemetry facilities at their strategic pumping stations and the data from such systems can be very useful in determining pump operation as part of a wider flow survey investigation. Most telemetry systems are, however, designed to meet real-time operational needs, hence flow data collection, interpretation and archiving is an additional objective which may be incompatible with the primary aim of the system. Typically the output will be a sequence of switch on - off times for each pump, with data more than (say) one week old being overwritten on the data archiving system - not very satisfactory for the drainage engineer.

IDENTIFICATION OF NEEDS

Pump logging using "current clamps" has been practised for a number of years and is often undertaken as part of a flow survey. Again, this provides valuable data on pump status but there are three main problems:

i) How to interpret the switch on-off data (and relate it to flows measured elsewhere in the system).
ii) How to manage and archive the pumping station data in an integrated format with other data from the flow survey.
iii) How to integrate pumping station flow data with the WALLRUS model (for verification).

Over the years a number of relatively simple "ad-hoc" methods have been developed by engineers to convert switch on-off times to flow rates, often using spreadsheets. These do not address problems ii) and iii) above and may be inadequate to provide reliable flow interpretations for many circumstances.

The need to develop a reliable system for pumping station monitoring was identified within the Wessex region largely as a result of difficulties encountered in measuring flows in rural sewerage systems draining to pumping stations. The main problems identified include:

- inaccurate flow measurement in small sewers,
- low flow velocities due to backing up from the station,
- silt deposition in the vicinity of the station,
- inflow pipes to a station are often difficult sites for monitoring due to bends, junctions and a variable hydraulic regime,
- monitoring multiple inflow pipes increases survey costs.

Wessex Water use the PC-based SSAS (Sewer Survey Analysis Software) system for processing and management of all conventional depth-velocity flow survey data and therefore requested that STL (as developers of SSAS) upgrade the software to accommodate the pumping station monitoring requirement.

PUMPING STATION SOFTWARE REQUIREMENTS

The main attributes required of the enhanced SSAS software included:

- computed pumping station flows should be handled and presented in the same way as conventional flow survey data within SSAS (including standard format for input to WALLRUS),
- it should accommodate:-
    - virtually all pumping station configurations,
    - up to 9 operational pumps,
    - variable speed pumps,
- graphical and tabular output may be selected for any period,
- key statistics to be produced for any period and for each or all of the pumps, including:-
    - total volume pumped,
    - peak pumping rate,
    - pump run times (in minutes or as a percentage of the period),
- it should compute flows corresponding to:-
    - instantaneous pump outputs, and
    - inflows averaged over any selected time interval (1 to 60 minutes).

The software comprises four modules which are additional to the existing SSAS package for depth-velocity flow survey analysis. These modules are used for checking, analysing and maintaining the pump station data for the entire survey.

APPLICATIONS

The software is equally applicable to short-term flow monitoring applications (e.g.as part of a conventional sewer flow survey) or over a longer period (e.g. to assess seasonal variation of infiltration rates to upstream sewers in the catchment).

Two contrasting applications are to be described in the presentation of this paper:-

1) Castle Combe Infiltration Survey

This survey was carried out to identify the extent and sources of severe winter infiltration to sewers serving a rural village (pop 450) draining to a pumping station. Prolonged high flows have previously caused surcharging and flooding of property downstream of the rising main discharge point. Depth-velocity measurement plus monitoring of the station (alternating duty pumps plus storm pump) indicated that infiltration worsened progressively during winter, with infiltration rates of up to seven times the mean foul flow being observed. Main sources of infiltration were subsequently pinpointed by a combination of flow measurement and site work. Results from depth-velocity monitoring alone would have been inadequate due to erratic data caused by a combination of clear flows and small diameter pipes.

Figures 1 and 2 show pump activity and averaged flows derived from the survey and clearly illustrate the progressive increase in base flows following wet weather.

2) Ashton Avenue, Bristol

This survey was carried out primarily to test the modified SSAS software at a large and relatively complex pumping station comprising five DWF pumps which operate in a range of pre-set combinations. The upstream catchment comprises a substantial area of south Bristol and peak flows of up to 1600 l/s were observed. Measurement of dry weather flow by conventional depth-velocity means in the very large and flat trunk sewers upstream was problematical due to relatively low flow velocities and depths (particularly at night). Pumping station monitoring provided an alternative and relatively accurate means of flow measurement.

Figure 3 shows pump activity and computed flows for both dry weather and storm conditions.

A database stores details of:

- pump station configurations
- pump rates
- pump combinations
- pump on/off telemetry
- drop test results.

MONITORING METHODOLOGY

The recommended monitoring arrangement requires the logging of:

- current to each operational pump (using current clamps),
- sewage depth in the wet-well (using a conventional pressure transducer)

at an interval of one minute or less. Sewage depth in the wet-well is required in order to determine the rate of rise and fall in level when pumps are off or on respectively.

Installation of the monitoring equipment should take only a few minutes and normally requires no modification to the pump control system or disruption to the station.

In order to determine the characteristics of the pumps it is necessary to carry out "drop tests" over the normal operating range of the pumps. This should be done for each pump individually and for all combinations which would be expected over the survey period. Practice has suggested that drop tests should be carried out both on installation and on removal of monitoring equipment in order to identify any change in pump performance over the period (due to partial blockage for example).

Clearly the drop tests are crucial to the accuracy of the final results and care must be taken to define the cross-sectional area of the wet-well over the entire range of depth. In the absence of drop tests, use may be made of pump manufacturer's curves, data from previous tests or 'standard' calibration curves; these are not generally recommended however.

Pump activity and sewage depth data are generally downloaded on a weekly basis and transferred to SSAS. Drop test results are entered to SSAS from observer site sheets or may be downloaded directly (where drop test depths have been logged). Regression analysis is used to evaluate flow rates for each pump combination over the operating range which actually occurred during the survey.

SSAS calculates pump station flows and produces graphical plots and tabular data to show:

- flow rates and total volume pumped during storm events
- diurnal patterns and hourly average flows during dry weather days
- comparison with other sites in the flow survey.

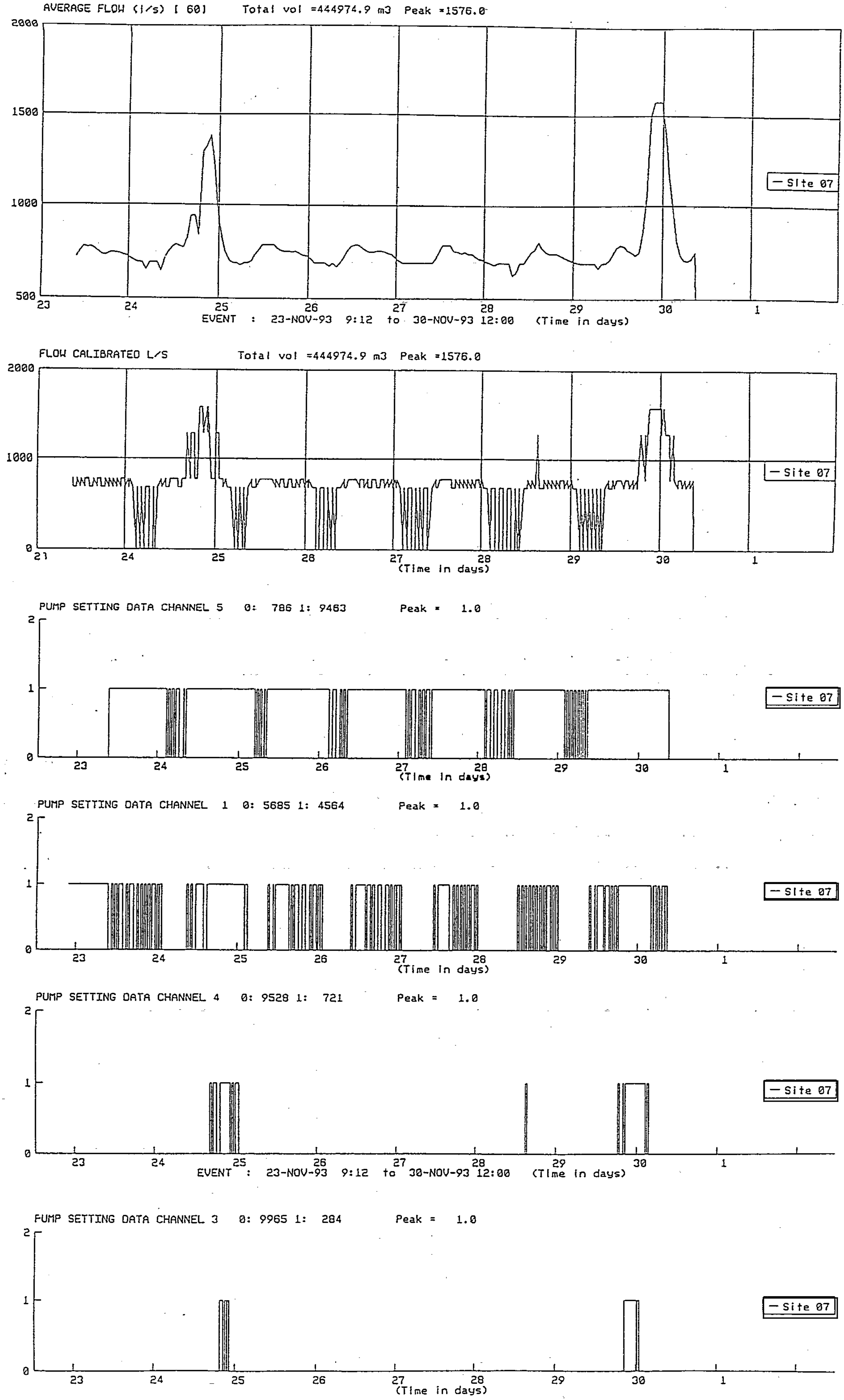

Figure 3.   Pump Activity and Computed Flows at Ashton Avenue P.S., Bristol

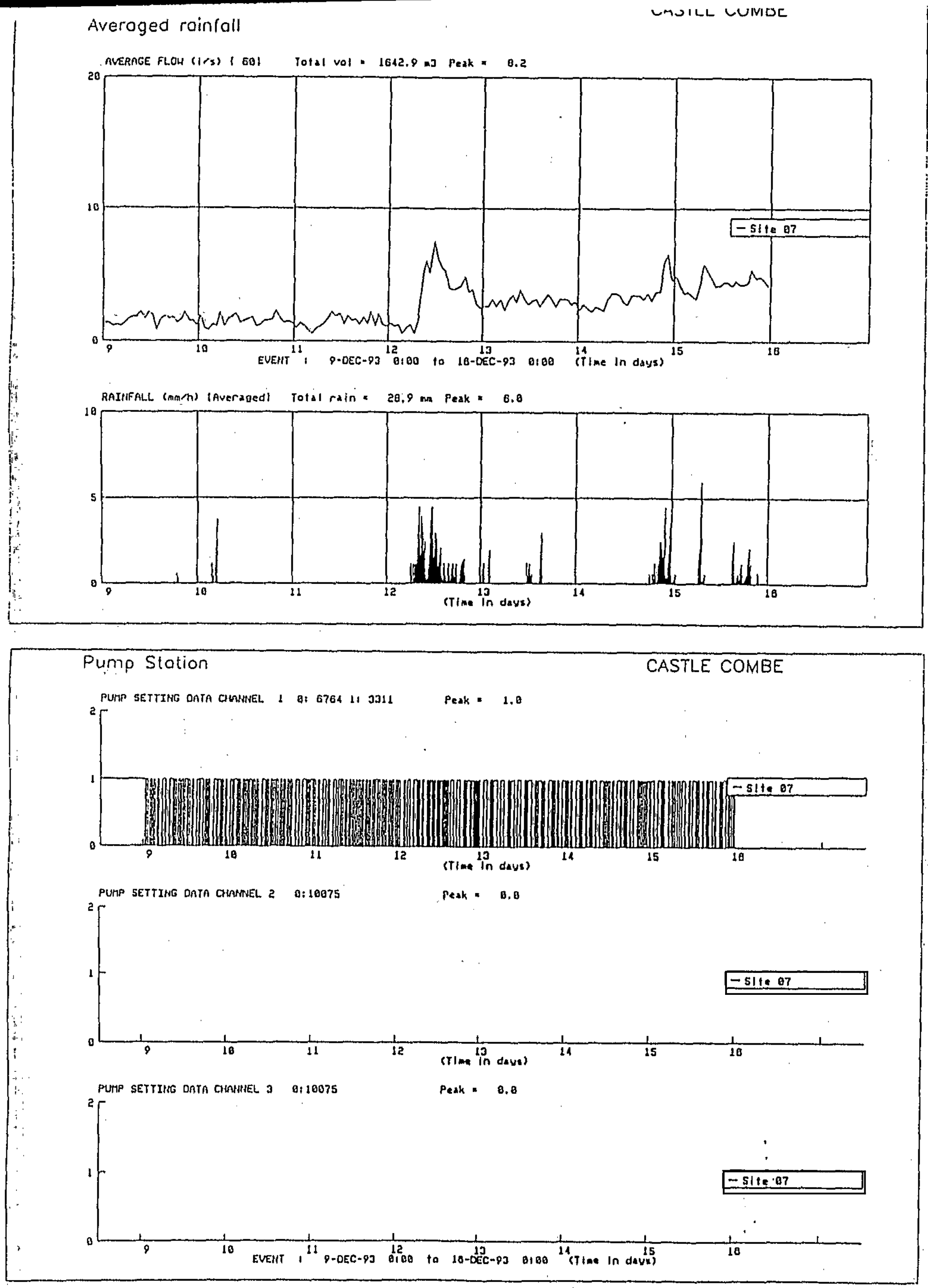

Figure 1.

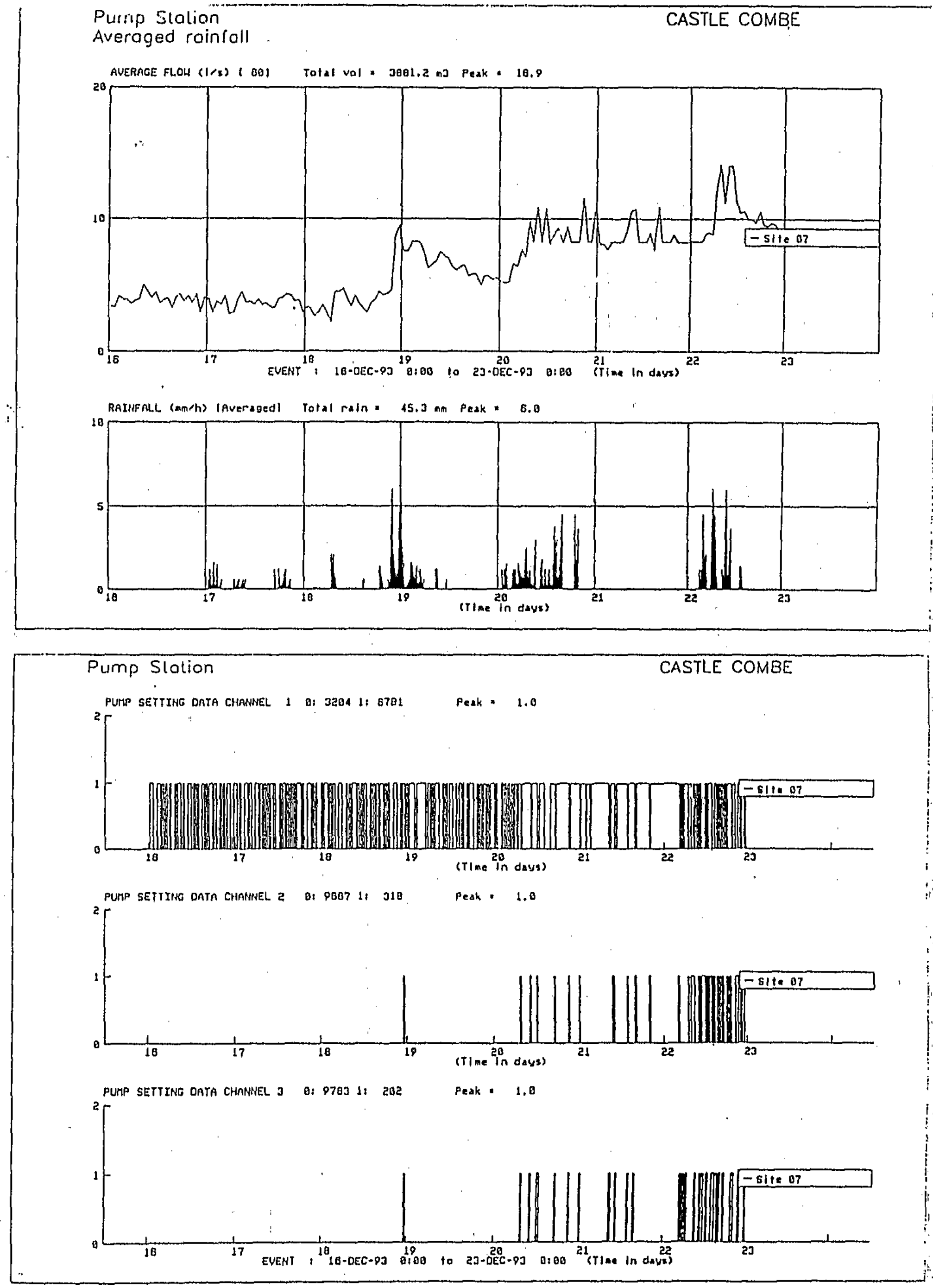

Figure 2.

Castle Combe Pumping Station Monitoring – Flow Response and Pump Activity, Illustrating Progressive Increase in Infiltration