B－32 **Evaluation of stormwater reservoir operation on CSO pollutant load reduction by model simulations during a whole year.**

Department of Urban Engineering, the University of Tokyo oH.K.P.K Jinadasa
Hiroaki Furumai
Fumiyuki Nakajima

1. Introduction

Essential features of combined sewer systems are that the sewer network is usually designed to carry 3~4 times designed dry weather flow to the treatment plant during wet weather periods, and that excess flow is directly discharged to public water bodies as combined sewer overflows (CSOs) at relatively strong rainfall events. Stormwater reservoirs have been widely used to store peak flows, to capture so-called first flush, and to reduce CSO pollutant loads. High cost and land limitation encountered in constructing large-scale structures in urban areas limit the size of the stormwater reservoirs. Therefore, it is important to find efficient reservoir operation methods to reduce CSO pollutant loads.

In this study, a model analysis of wet weather pollution was conducted for a combined sewer system with an additional main pipe and a stormwater reservoir. After calibrating the runoff model parameters in a distributed model, long-term simulations were carried out for a whole year period. Two stormwater reservoir operation scenarios were compared to investigate the effectiveness on reduction of CSO pollutant loads.

2. Methodology

2.1 Study catchment

An urban catchment with a combined sewer system to drain domestic wastewater and stormwater in a total area of 5.04km^2 was studied. The sewer system consists of three pumping stations, a storm water reservoir and a treatment plant as shown in **Fig.1**.

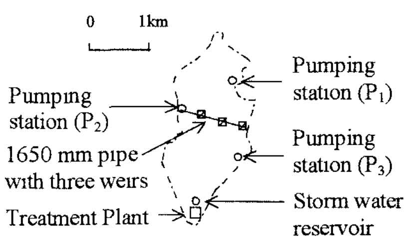

Fig.1: Study catchment

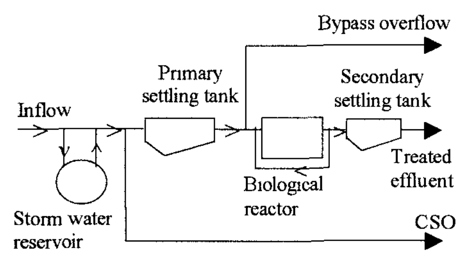

Fig.2: Water flow in treatment plant

During dry weather periods the average wastewater flow was 0.60m^3/s. The sewer system and the primary treatment unit were designed to carry and treat wastewater flow of 4.25m^3/s and the secondary treatment unit was designed to treat a flow of 1.00m^3/s. Therefore when the inflow to the treatment plant is greater than 4.25m^3/s, the excess is discharged as CSO. Once the inflow to the secondary treatment is greater than 1.00m^3/s, the excess flow bypasses the secondary treatment and is discharged to public water bodies as show in **Fig. 2**. The stormwater reservoir with a capacity of 12600m^3 is used to capture the first part of wet weather flow.

Rainfall events were defined based on minimum dry weather period of 6 hours using AMeDAS data. As 6-hour duration was sufficient enough to treat the captured stormwater in the reservoir, it was assumed that storm water reservoir was empty at the beginning of each rainfall event. Based on rainfall event data for seven years, year 2001 was selected as a representative year in terms of total rainfall height and number of events.

2.2 Distributed model tool

In this study, InfoWorks software was used to simulate runoff and suspended solid (SS) washoff in the catchment. The parameters for effective rainfall model are shown in **Table 1**, which were successfully calibrated for runoff in a previous study (Furumai et al.1999).

Table.1: Effective rainfall parameters

Surface type	Initial loss	Infiltration
Roof	0.3mm	-
Road	2.0mm	-
Pervious	6.0mm	10mm/hr

Table.2: Sediment particle parameters

Sediment type	Specific gravity	Particle size (mm)
Surface	1.7	0.04
Wastewater	1.4	0.04

Although the runoff model of InfoWorks has already been satisfactorily calibrated to represent the hydraulic behavior of urban catchments, the water quality model has not been calibrated properly. **Table2** shows the washoff parameter values related to the sediments used in the simulations. Three rainfall events having different characteristics as shown in **Table 3** were used to investigate the applicability of the parameters in **Table2**. Surface sediment build up factor of 13kg/ha, which was reported in a previous study (Furumai et al.1999) was used. Initial sediment conditions of the sewer network and the urban surface were defined according to the dry weather period.

Table. 3: Rainfall characteristics

Date	Rainfall (mm)	Duration (min)	Peak intensity (mm/hr)	Dry weather period (hrs)	Antecedent rainfall (mm)
Sep 29, 1994	34.5	805	18	17	5.5
Nov 18, 1994	28.5	650	12	18.5	3.0
Nov 30, 1993	14.0	610	7	221	24

2.3 Reservoir operation scenarios

Two scenarios of stormwater reservoir operations described below were compared to investigate the effectiveness on reduction of overflow suspended solid quantity. It was assumed that the primary sedimentation removed 60% of SS during wet weather periods.

Scenario 1: Starts to store stormwater when inflow exceeds the capacity of primary sedimentation ($4.25m^3/s$).

Scenario 2: Starts to store stormwater when inflow exceeds the capacity of secondary treatment unit ($1m^3/s$).

3. Results and discussions

3.1 Quality model calibration

Washoff parameter values related to the sediments, which are shown in **Table 2**, were found to satisfactorily represent the washoff behavior of the catchment. **Fig3(a)**, **Fig3(b)** and **Fig3(c)** shows the simulated pollutographs of Sep 29, Nov 18 and Nov 30 rainfall events. Even though the simulated pollutographs show a little difference from the measured data, the results are satisfactory for discussing the efficiency of stormwater reservoir operations.

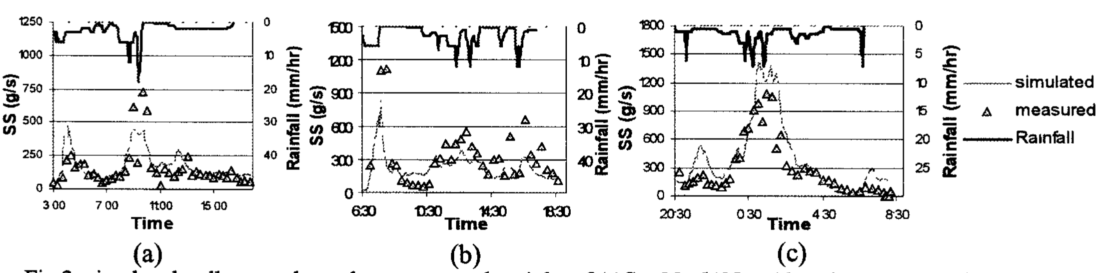

Fig 3: simulated pollutographs at the treatment plant inlet of (a)Sep29, (b)Nov 18 and (c)Nov 30 rainfall events

3.2 Comparison of two scenarios

Scenario 2 gave 24% and 16% lower annual bypass overflow volume and total overflow volume while 56% increase of CSO volume. In these calculations only the overflow at the treatment plant was considered because CSO at pumping stations were not affected by the reservoir operation. **Fig.4** shows the changes of overflow SS mass in CSO and bypass flow in each event due to the change of reservoir operation from scenario 1 to scenario 2. **Fig.5** shows the SS mass in CSO and bypass flow in both scenarios. Even though SS in CSO was 3.5 times as great as in scenario1, scenario 2 gave 34% lower SS in bypass and 16% lower total overflow SS than scenario1. Total overflow SS was reduced due to the increase of the reservoir operation frequency. Among the total of 92 rainfall events, reservoir was operated 82 times in which 49 times reservoir is full in scenario 2 where it was 29 and 12 times in scenario 1. Therefore in scenario2, the reservoir was effectively utilized to store stormwater so that almost 3.5 times stormwater and four times SS was stored compared to scenario1 as shown in **Fig.6**.

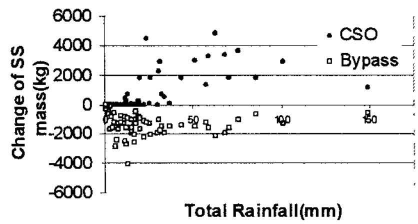

Fig.4: Change of SS mass in each type of overflow

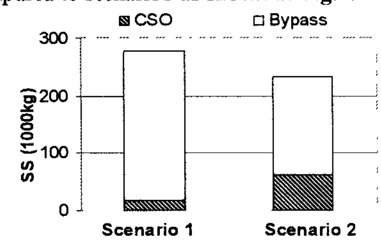

Fig. 5 Overflow SS mass

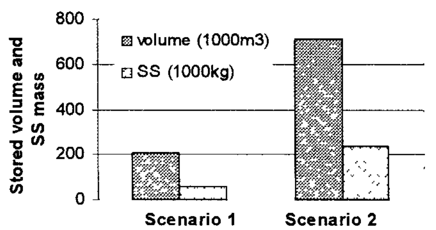

Fig.6: Stored water volume and SS in each scenario

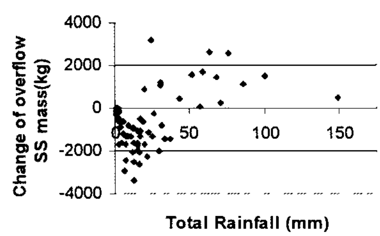

Fig.7: Change of total SS mass with rainfall height

Fig 7 shows the change of total SS mass in each event due to the reservoir operation change from scenario 1 to scenario2. Scenario2 gave lower total overflow SS mass in comparatively small and moderate rainfall events because bypass overflow could be reduced without increasing the CSO in small rainfall events and first flush could be stored in moderate rainfall events. Scenario 2 gave higher SS overflow mass in strong rainfall events because of the increase of CSO volume.

4. Conclusion

After calibrating, an urban distributed model was applied to an urban catchment having a combined sewer system with a stormwater reservoir. The SS washoff behavior in whole year 2001 was simulated and two scenarios of stormwater reservoir operation were compared to investigate the effectiveness on reduction of pollutant loads. It was found that both total annual overflow volume and total overflow SS mass at the treatment plant could be reduced by 16% due to the change of reservoir operation method. By the improved operation method (scenario2), the reservoir could store four times SS than in the present operation method (scenario1). Effects of reservoir operation on overflow SS mass depend on the characteristics of rainfall event. Scenario 2 was found to be effective for small and moderate rainfall events.

5. References

Furumai, H.,Hijioka, Y., and Ichikawa, A. Evaluation of storage ability of an additional main pipe in inundation control for suspended solids loads from CSO using a distributed model, Proceedings of Eighth international conference on urban storm drainage, Sydney, Australia, 1999, pp 1262-1270