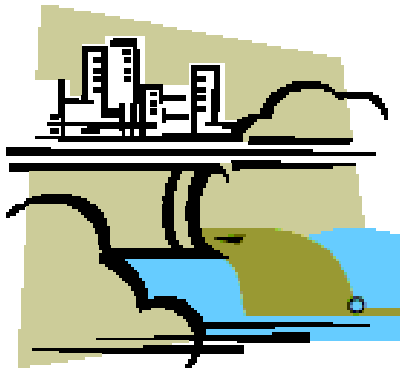
Integrated Management of Urban Sewer System under Wet-Weather

Lee, Ju Young

Korea Institute of Science and Technology (KIST)

Lee, Doo-Jin

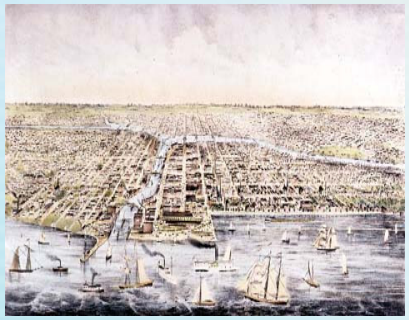
Korea Water Resources Corporation (Kwater)
Water & Wastewater Research Center

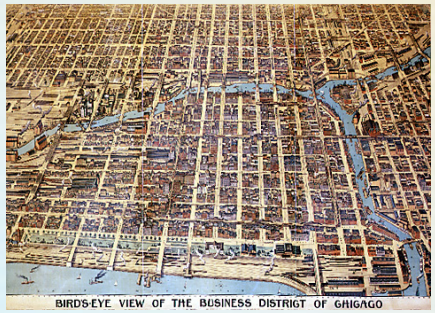


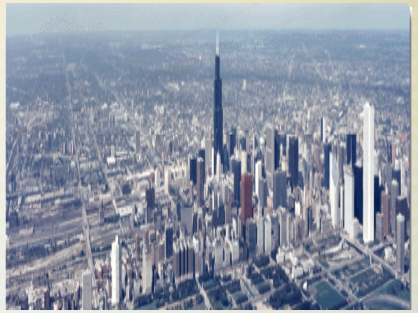
Contents

1. Introduction

Urban Sewer System







Urbanization → **Increase of impervious surface** → **Increase of Stormwater runoff** → **Receiving water deterioration**

While significant improvements have been achieved in controlling point source water pollution *As a result, stormwater management has become a national priority in the effort to further reduce water pollution(US EPA, 2000).*

How to manage the stormwater pollution ?

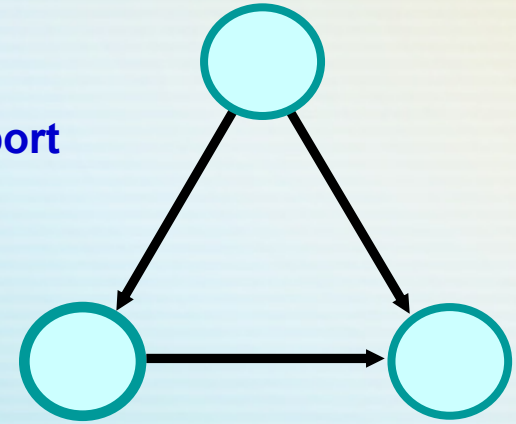
Sewer + Treatment plant = Integrated management

1. Introduction

Urban Sewer System

Sewer line

: collection, transport

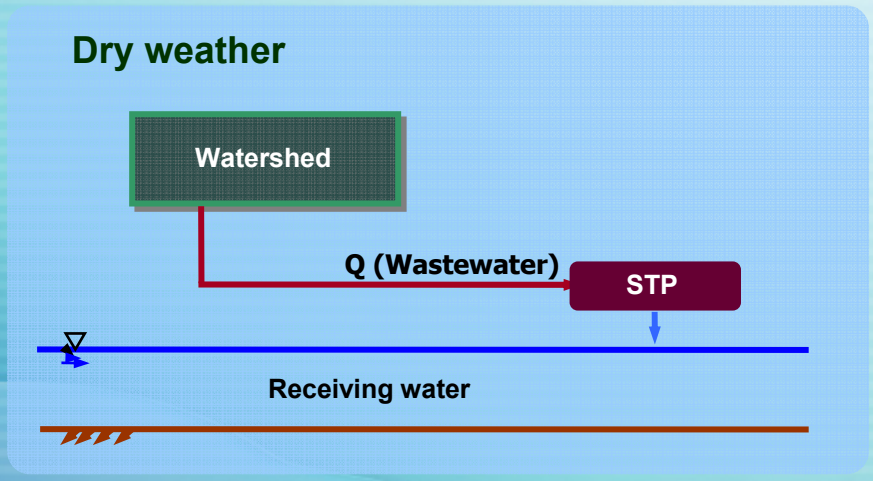


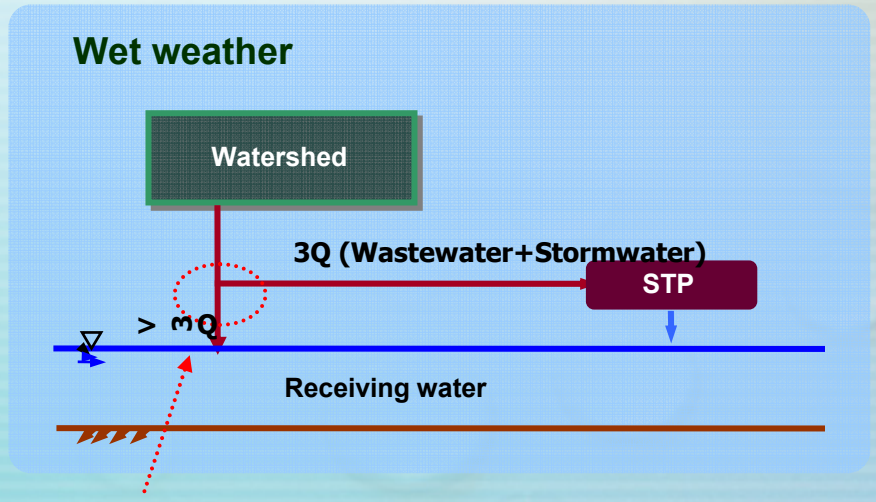
Sewage Treatment Plant(STP)

: treatment, discharge

Receiving water

: river, lake, coast



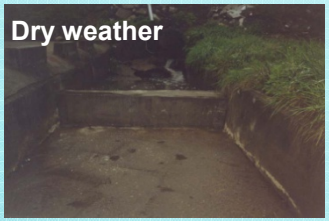


Overflow pollution can damage the quality of receiving water

2. Background

Wet Weather Flows in Urban Area

- **Stormwater :**
  That runs off the land into streams or other surface-water during or soon after heavy precipitation. It can carry pollutants from the air and land into receiving waters.
- **Combined Sewer Overflows(CSOs):**
  Discharges a mixture of stormwater and wastewater when the flow capacity of the sewer system is exceeded during rainstorms.
- **Sanitary Sewer Overflows (SSOs):**
  Discharges of raw sewage from municipal sanitary sewer systems. During floods SSOs can release untreated sewage into basements or out of manholes and onto city streets, playgrounds.



Source	BOD_5	TSS	TP	TKN
Untreated wastewater(in dry)	*88-251*	*118-287*	*1.3-15.7 (5.8)*	*11.4-61 (33)*
Wet weather SSOs	*6-413 (43)*	*10-348 (91)*		
CSOs	*3.9-696 (43)*	*1-4,420 (127)*	*0.1-20.8 (0.7)*	*0-82.1 (3.6)*
Stormwater	*0.4-370 (8.6)*	*0.5-4800 (58)*	*0.01-15.4 (0.27)*	*0.05-66.4 (1.4)*

2. Background

U.S.

- U.S.
- 1965~1989 : The Storm and Combined Sewer Pollution Control Research, Development and Demonstration Program(SCSP).
  - 1989 : National CSOs control Strategy
    - Six minimum measures for CSOs control.
  - 1992~1994 : CSOs Control Policy developed
  - 1994 : National CSOs Control Policy :
    - Nine Minimum Control
    - Long Term Control Plan(LTCP)

2. Background

Japan

- Japan
  - 1971 : Water Pollution Control Law
    - CSOs must be comply with the Water Pollution Control Law
  - 1982 : Tentative guideline and design manual for CSOs abatement
    - “The target level of CSOs abatement is to less than 5% of the annual load BOD”
    - Intercepting 2mm/hr of Storm water runoff
  - 1972~1992 : Planning and design guideline for wastewater facilities
    - To reduce annual pollutant loads discharged from CSS to the same or lower level as the pollutant loads from SSS

2. Background

Korea (Continued)

- KOREA
  - No regulation for CSOs and Stormwater management before 2005

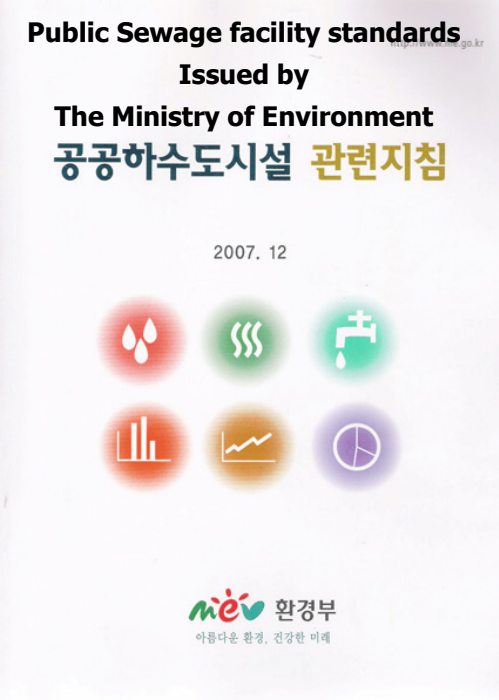
Plan for the reduction for urban runoff (facilities) (Recommend)

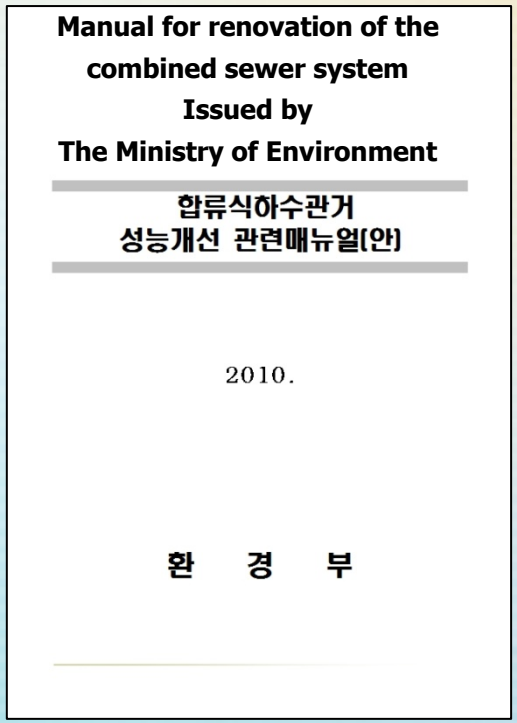
유지관리기법 (Operation and maintenance practices)	발생원억제 (Source control)
	오염원유출예방 (Pollution prevention)
	토지관리 (Land management)
	공공홍보 (Monitoring, Reporting and Public notification)
관거시스템개선 (Collection system controls)	관거분류화 (Sewer separation)
	관거퇴적물제어 (Sewer sediment solids control)
	협잡물제어 (Floatable control)
	우수토실개선 (Regulator adjustment)
	차집관거용량증대 (Interceptor capacity maximization)
	펌프장 개선
	실시간제어방법 (Monitoring and RTC)
저류시설 (Storage facilities)	지역내저류 (In-site storage)
	지역외저류 (Off-site storage)
처리기술 (Treatment technologies)	추가처리 (Supplemental treatment)
	처리장우천시하수처리 (Managing wet-weather flows in WWTPs)

2. Background

Korea

- KOREA





- CSOs monitoring & characteristics (Loads, Quantity & Quality, Frequency)
- Survey about regulator & interceptor
- Maintenance about regulator & interceptor
- Operation of equalization tank (first flush effect)

- Active CSOs control management
- CSO control using real-time monitoring and modeling
- Decentralized CSO control system
- Systemic monitor procedure
- Systemic operation procedure in WWTP

2. Research Theme

Contents and Flow of Study

Identification of Problem

Tool : Field trip



Evaluation of Characteristics in Urban runoff

- **Characteristics analysis of flow and WQ**
- **Analysis of pollution origin**
- **Relationship of affecting factors**

Part 1

Part 2

How to control runoff pollution

- **I/I reduction :** flow management
- **Sewer flushing :** Source control
- **Storage tank** : Construction alternative
- **Stochastic model: Worst case/Best case**

Part 3

How to operate STP

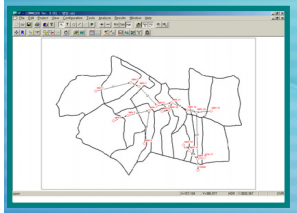
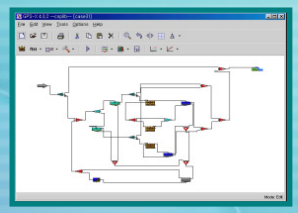
- **Evaluation of operation alternatives**

Alt.1 : 2nd treatment increases(1Q→3Q)

Alt.2 : Treatment of bypass flow

Application of Alternatives

Tool : Simulation model (SWMM, ASM)

Integrated management of urban sewer system under wet weather

2. Research Theme

Study area

- **Location: the City of Gwangju, Geonggi do**
- **Typical conditions of WWTP**

Capacity (m^3/d)	Population (person)	Type of sewer system	Watershed area (ha)	Process
25,000	62,079	Combined sewer system	552	Activated Sludge process

- **Operation conditions of WWTP**

Item	Value		
Capacity(m^3/d)	25,000		
Area(ha)	552.5		
1st clarifier		**1 line**	**2 line**
Surface area(m^2)	778	∅16m × H3m	∅15.5m × H3m
Total volume(m^3)	2,338	603.18m^3 × 2set	566.07m^3 × 2set
Retention time(h)	2.8	2.6	3.02
Aeration tank		**1 line**	**2 line**
Tatal volume(m^3)	5,220	W9m × L27m × H3m 729m^3 × 4set	W8m × L24m × H3m 576m^3 × 4set
Hydraulic Retention time(h)	6	6	6
Mixed liquid suspended solid(mg/L)	1,764		
Solid Retention Time(d)	13		
Dissolved Oxygen(mg/L)	1.2		
pH	6.8		
Temperature(°C)	12.8		
Air flow rate(m^3/h)	23,000		
2nd clarifier		**1 line**	**2 line**
Surface area(m^2)	988	∅18.5m × H3m	∅17m × H3m
Total volume(m^3)	2,974	806.4m^3 × 2set	680.94m^3 × 2set
Retention time(h)	3.5	3.5	3.6
Others			
Recyle MLSS(mg/L)	4,076		
Recycle ratio(%)	39.3		
Dewater sludge cake(m^3/d)	16.4		
T-COD in supernatant(mg/L)	21,000		
The ratio of contain water in sludge cake(%)	80		

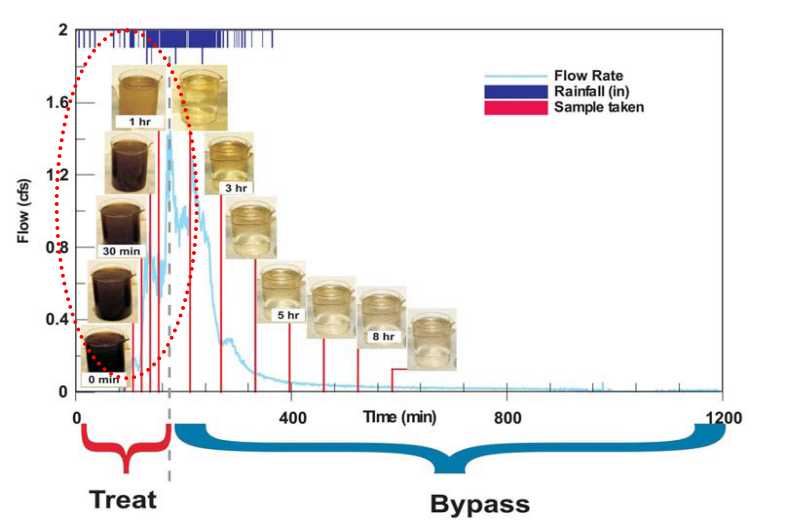
- **Total conduit length 18km**
- **Impervious layer 87%**
- **24 subarea, 58 conduit(link), 59 M/H**

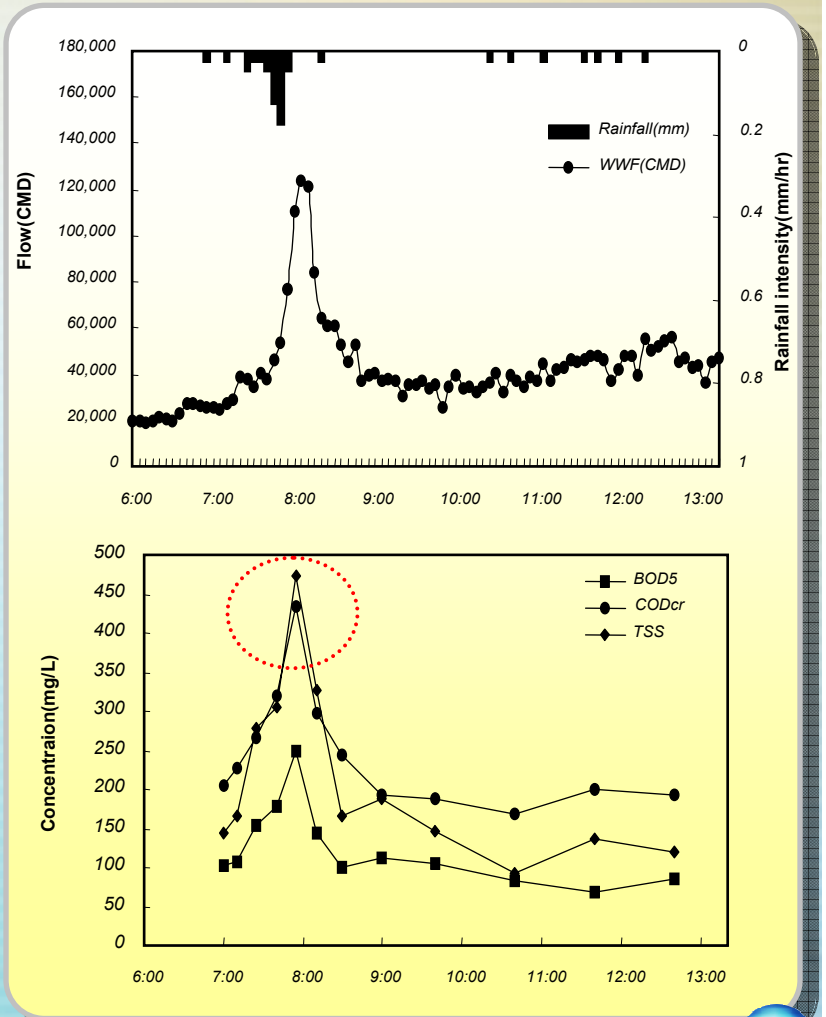
3. Results & Discussion

Characteristics of Urban Runoff （Part1)

First flush effect

In the beginning of a rainstorm,
It carries with high concentrations of pollutants that have accumulated during dry weather between storms.





Adversely impacting the Water Ecosystem by high concentrated pollution during short time.

3. Results & Discussion

Characteristics of Urban Runoff

Origin of Runoff Pollution

a) Street

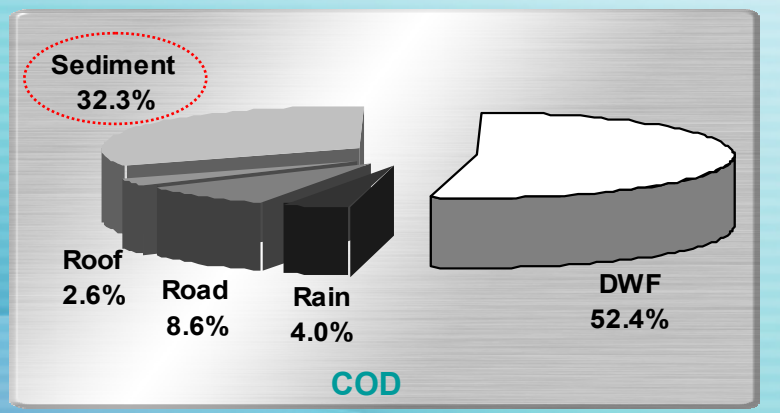
b) Road

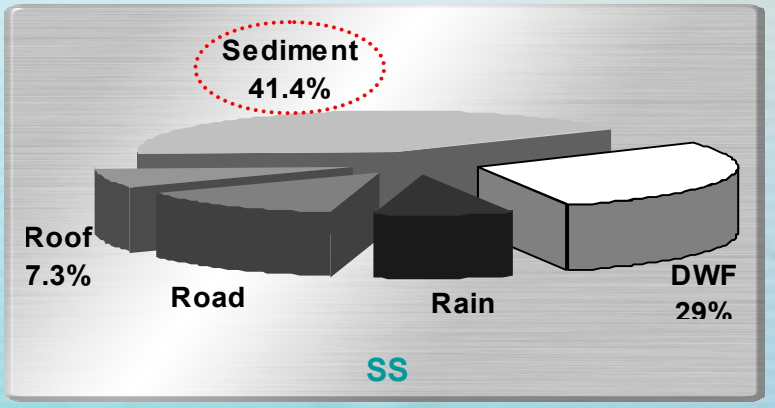
c) Roof

d) Outfall

Discharge into the receiving water

Total outfall pollution
= base wastewater + atmosphere washing(rain) + roof runoff + road runoff + sewer sediment

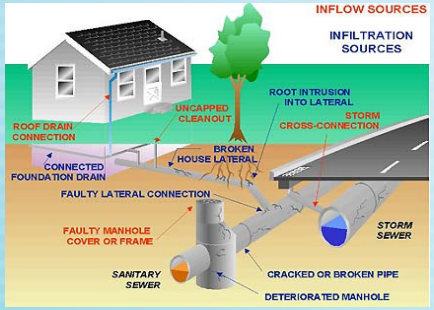




Accumulated sediment in sewer is the main pollution origin

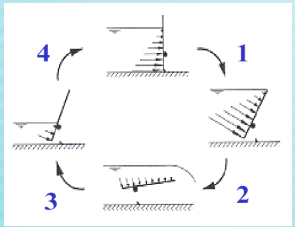
3. Results & Discussion

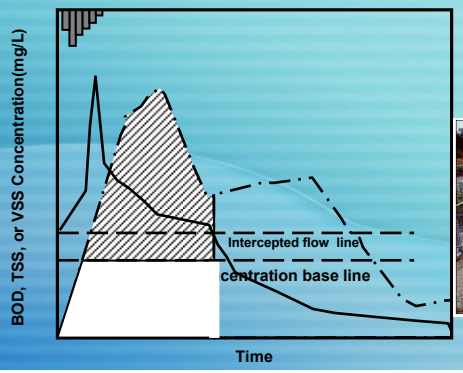
How to Control Runoff Pollution (Part 2)



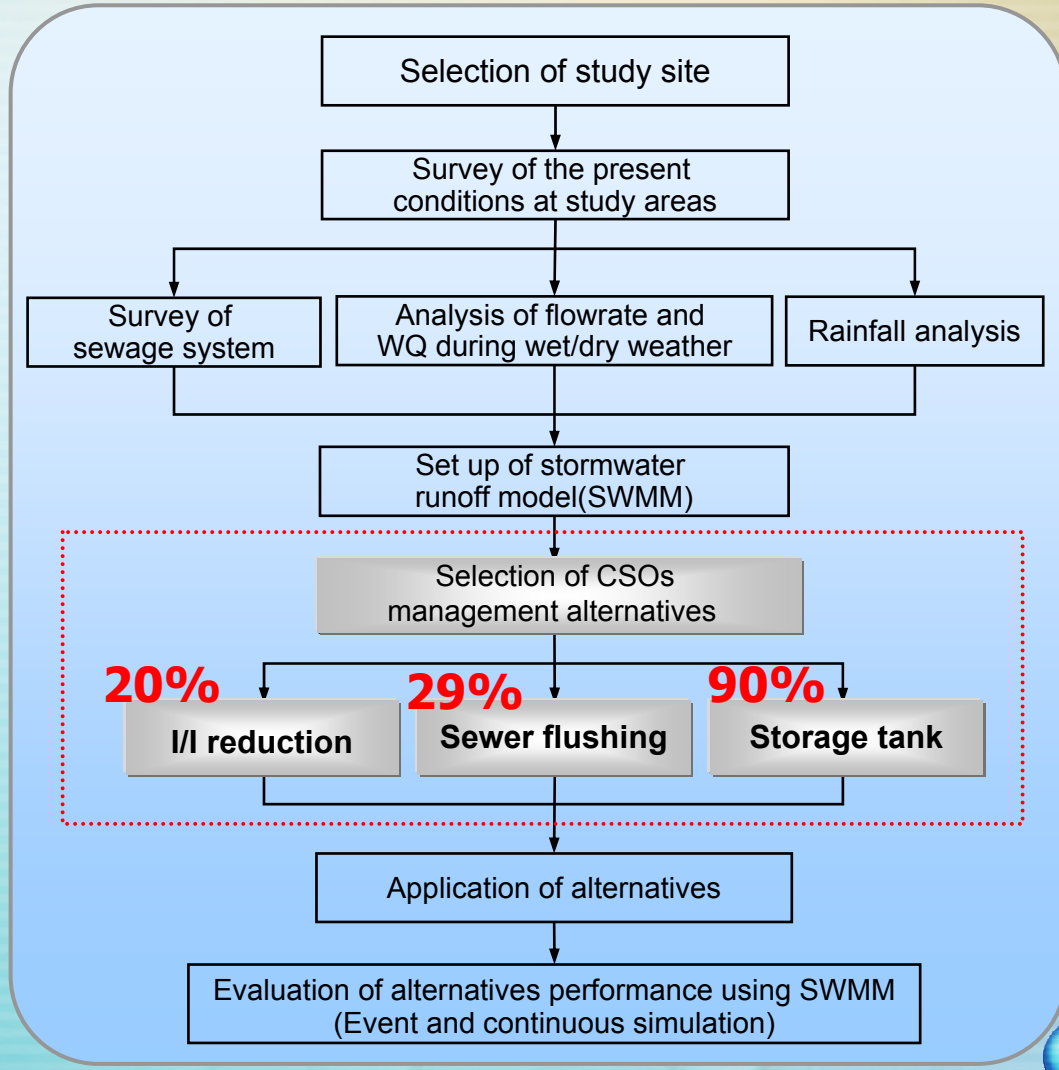
I/I reduction

Sewer flushing





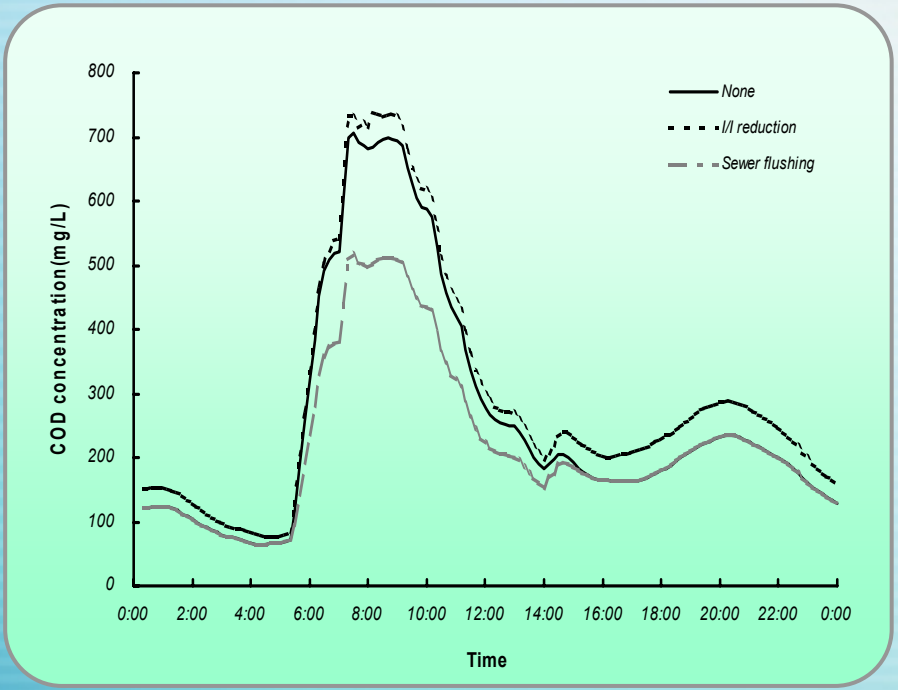
Storage tank

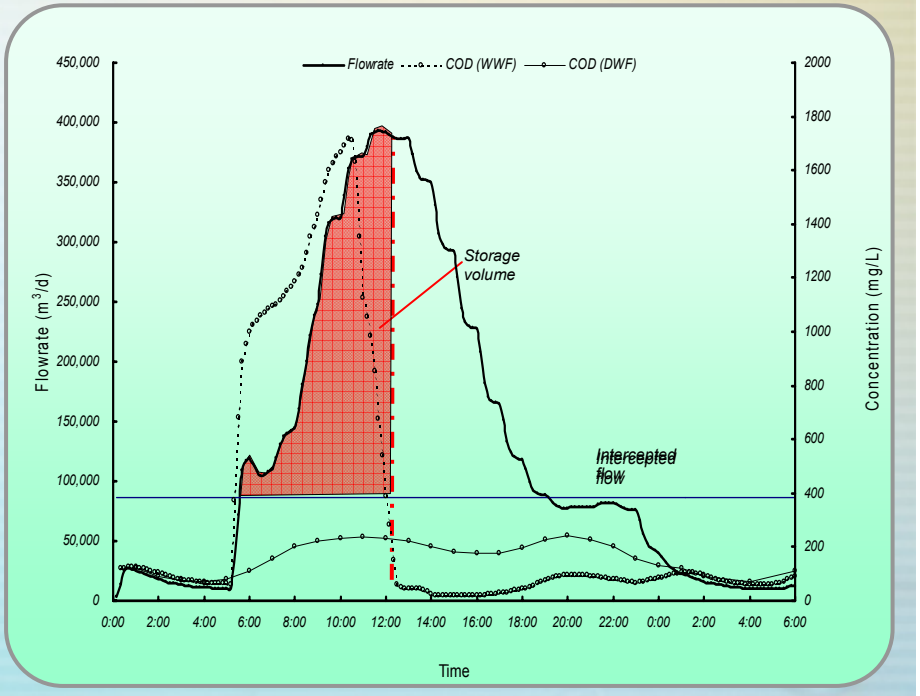


3. Results & Discussion

How to Control Runoff Pollution

Efficiency of pollution removal





- Removal efficiency was simulated as I/I reduction 20%, and Sewer flushing 26% by return period 1years storm
- Storage tank was designed by concept of first flush capture, Runoff pollution was reduced by 90% with storing 40% volume

3. Results & Discussion

How to Operate STP during Rainfall (Part3)

Process and Methods

Measurement

Evaluation of input flow and water quality in WWTP during dry and wet weather

Simulation

Selection of alternative

Alternative Ⅰ

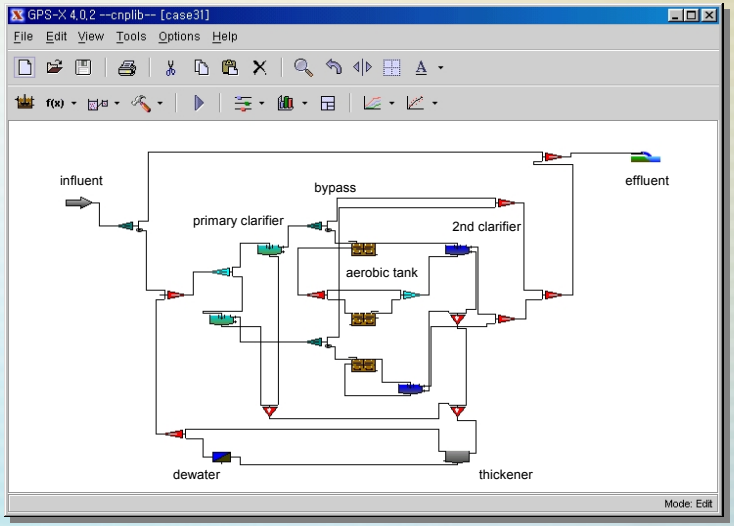
Increasing 2nd treatment flow

Alternative Ⅱ

Bypass with treatment

Establishment of optimal alternative

Activated Sludge Model Set up



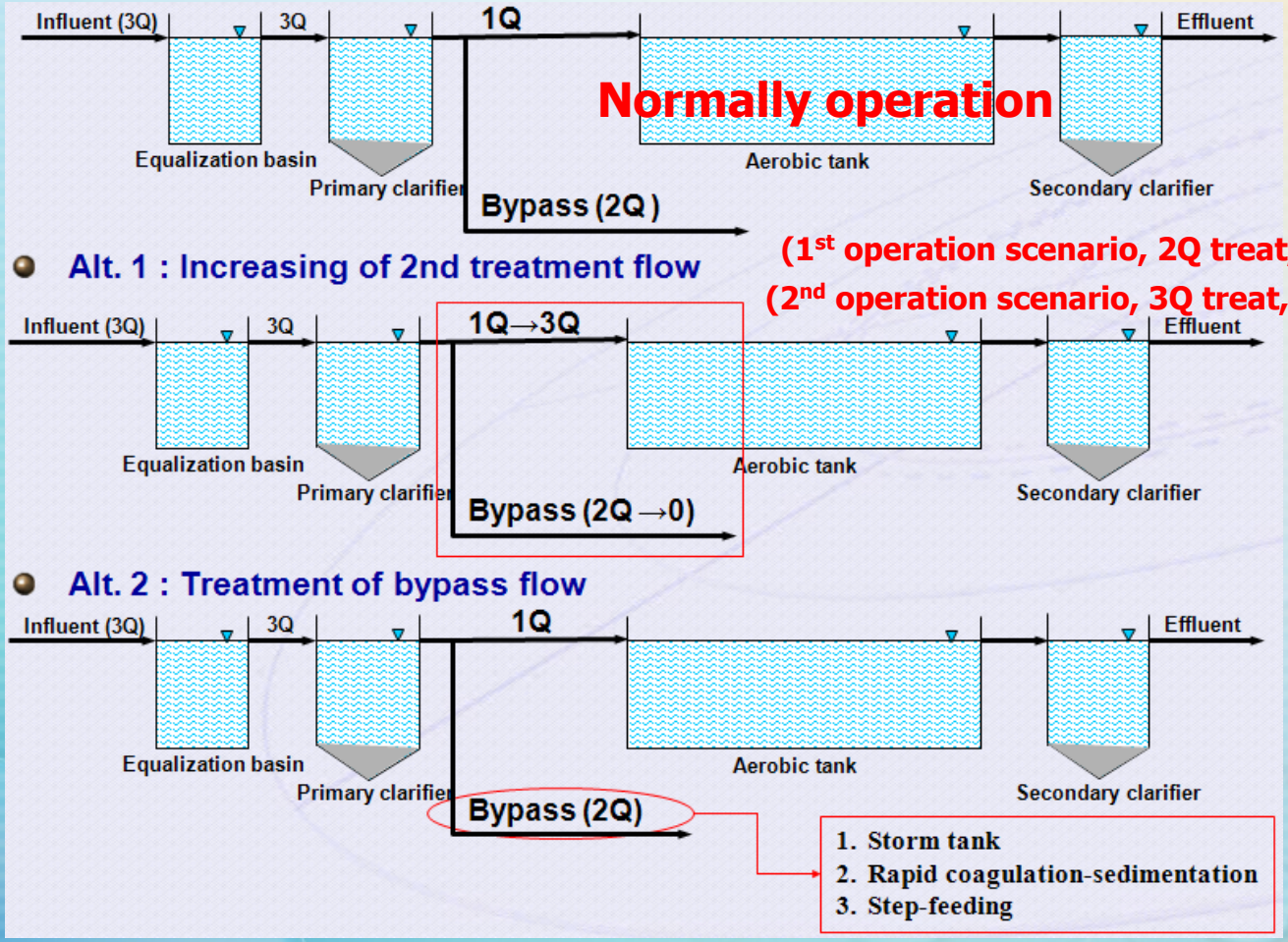
- 2nd treatment flow was increased from 1Q to 3Q

- Storm tank
- Rapid coagulation-sedimentation
- Step-feeding

3. Results & Discussion

How to Operate STP during Rainfall

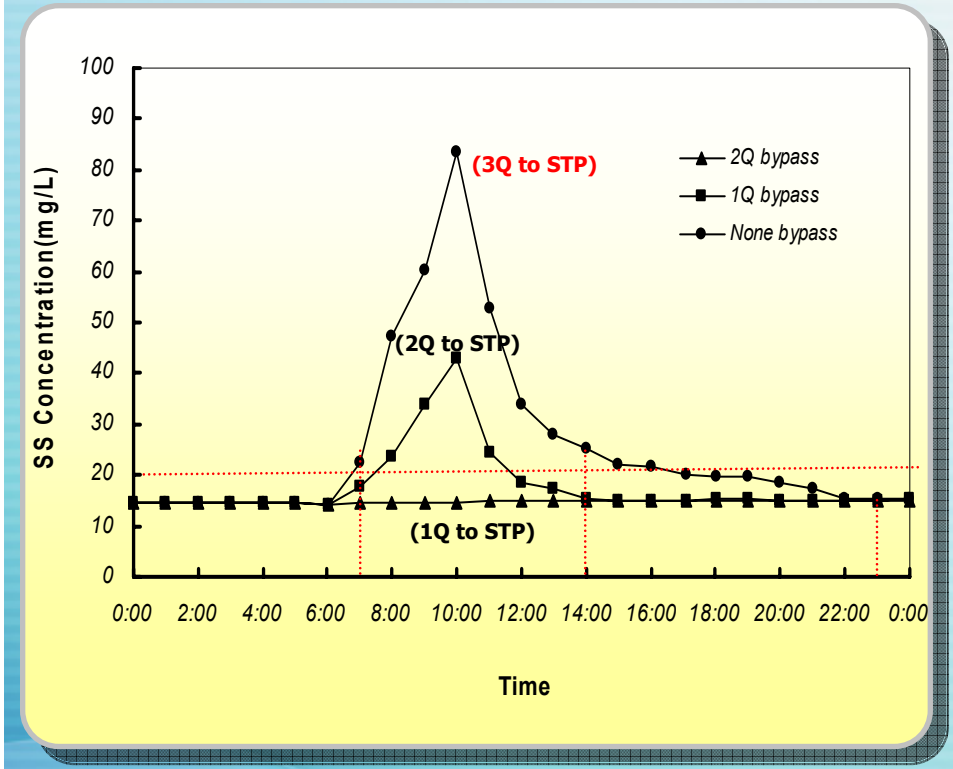
Process and Methods

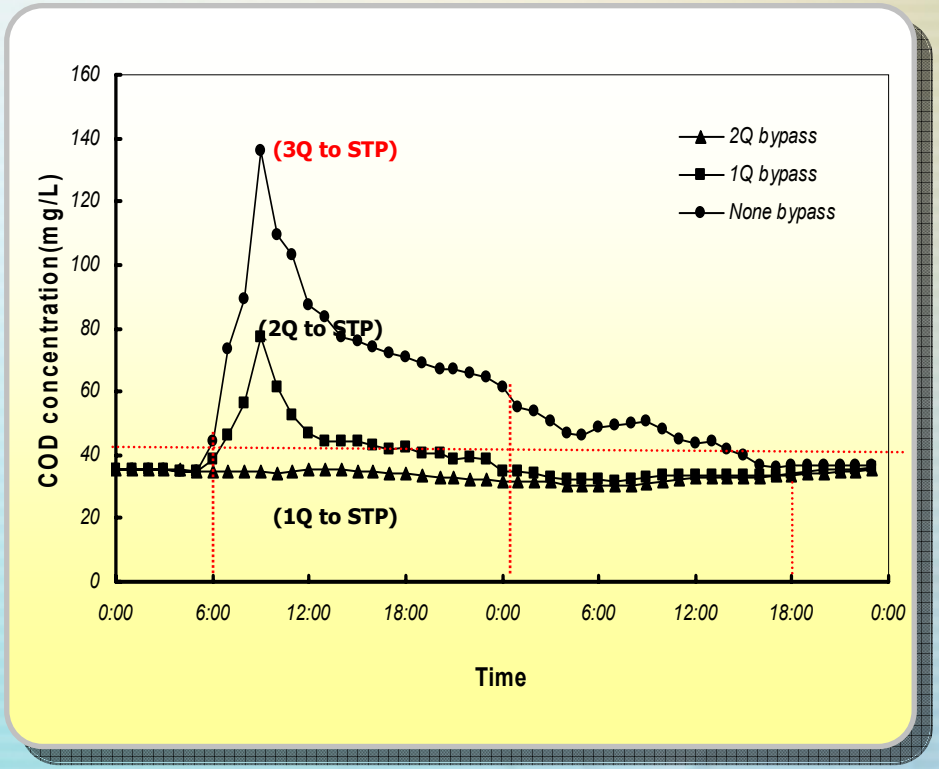


3. Results & Discussion

How to Operate STP during Rainfall

Result of Increasing 2nd treatment flow(Alt.1)





2nd treatment flow was increased(1Q → 3Q),
Effluent WQ was deteriorated, due to increase of hydraulic load exceeds design capacity

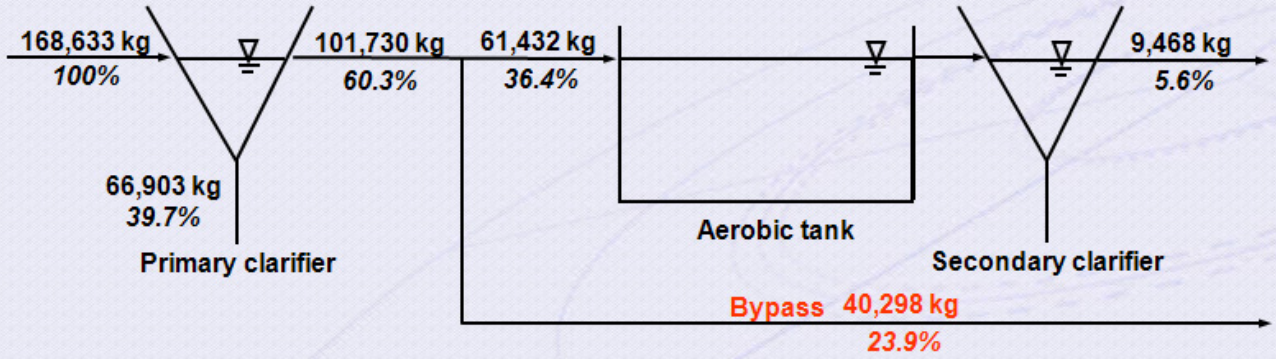
3. Results & Discussion

How to Operate STP during Rainfall

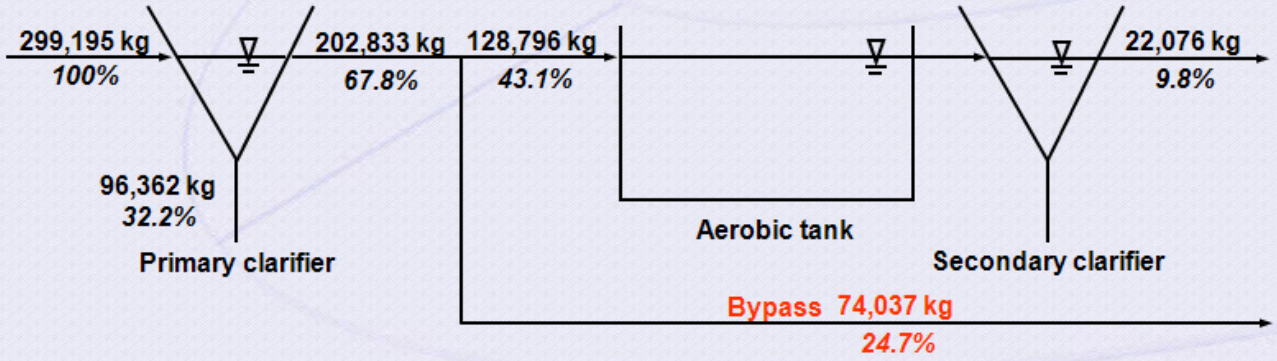
Result of Increasing 2nd treatment flow(Alt.1)

- **Event(Aug 31,2009)**
  (Total rainfall depth 61 mm, duration 9 hr, peak rain intensity 19 mm/hr)

- **SS**



- **COD**

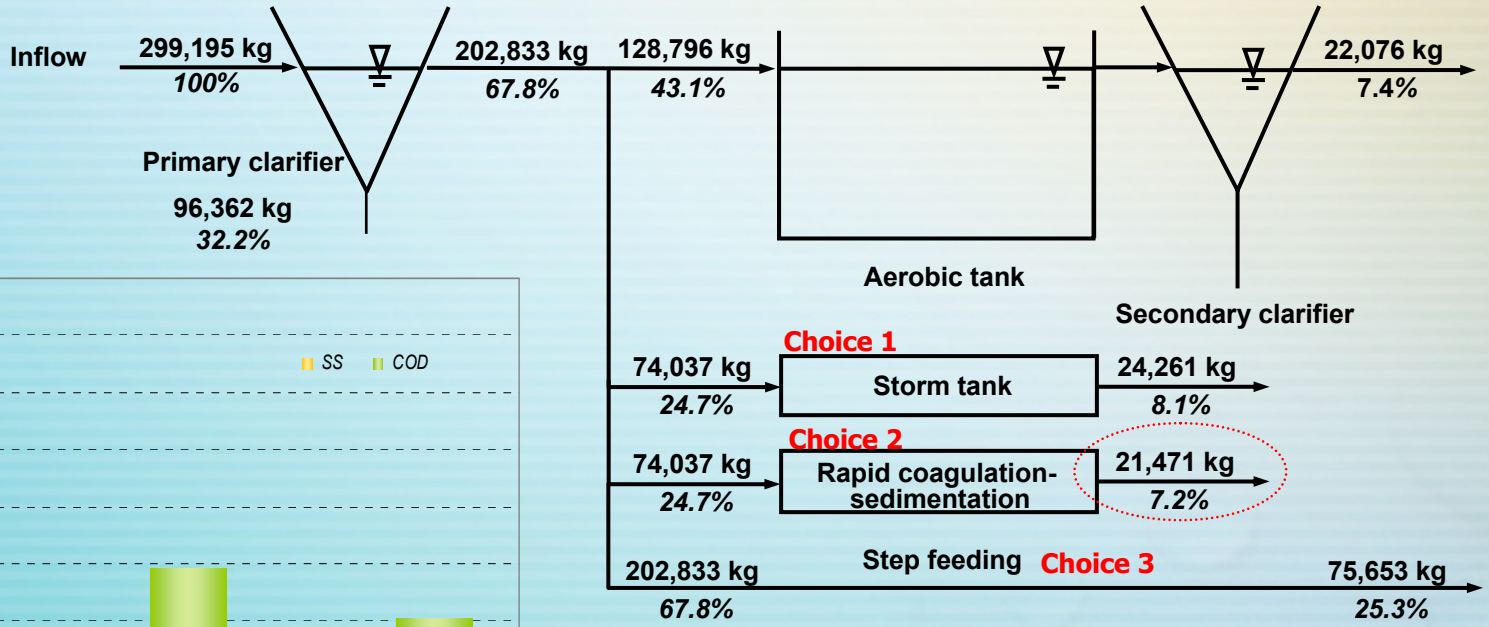


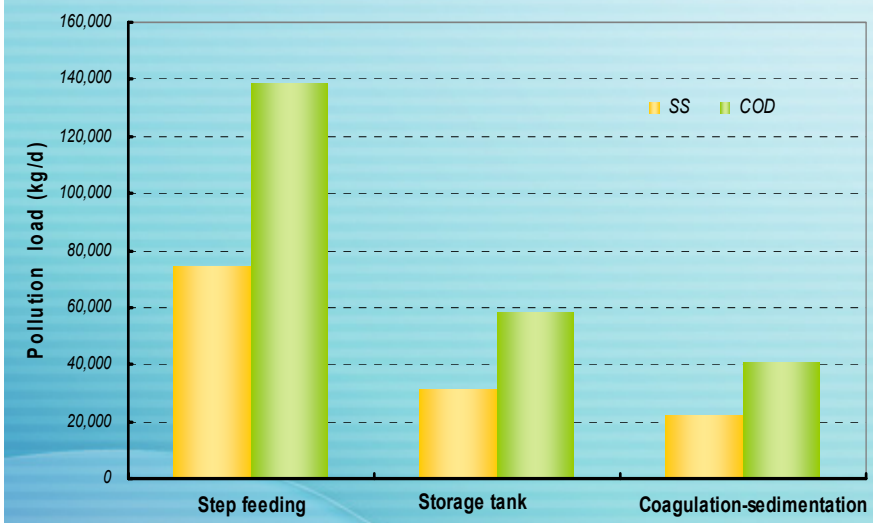
3. Results & Discussion

How to Operate STP during Rainfall

Result of bypass treatment (Alt.2)

Event
Aug 31,2009
COD





Rapid coagulation-sedimentation process is better than other combination

4. Conclusion

Characteristics of Runoff Pollution

-First flush : causes sudden increase of pollutants by washing out accumulated sediments

-Pollution origin : sediment in sewer(pollutants adsorbed to sediment particles)

-Excessive I/I : cause of increasing frequency and volume of CSO

How to Manage Overflows Pollution with SWMM simulation

-Effective reduction(5-25%) of CSOs pollution load by I/I reduction and sewer flushing

-Storage tank : Concept of first flush capture – store 1st 50% of flow, reduce pollution 90%

How to Operate STP with ASM simulation

-Serious pollution was discharged from bypass flow with operation rule regulation during wet weather (approximately, 25% of flow untreated)

Alternative I : Increasing 2nd treatment flow

- Deteriorate effluent WQ, because of increased hydraulic load to 2nd treatment process

Alternative 2: bypass flow treatment

- Rapid coagulation- sedimentation process, the highest removal efficiency

Thank you for your attention