Using System Analysis Methodology To Enhance Efficiency Of Best Management Practices For Capturing Stormwater—Case Study; District Of Columbia

Mohammadreza Jabehdari, LeeRoy Bronner, Ph.D.

Morgan State University
Department of Industrial and System Engineering
Agenda

- Background
- Objective
- Method
  - System Development Life Cycle (SDLC)
    - Conceptual Model
    - Use Case Model
    - Object-Oriented Model – Problem Solution
- Conclusion
- References
Sanitary Sewer Overflow (SSO):
untreated sewage is discharged from a sanitary sewer into the environment prior to reaching sewage treatment facilities.

Combined Sewer Overflow (CSO):
To avoid flood, regulators are designed to let the excess flow, which is a mixture of stormwater and sanitary wastes, be discharged directly into the rivers and creeks.
Background

Location of the SSOs:

![Location Map](image1.png)

SSOs increasing trend since 2013:

![Graph](image2.png)
The environment and scope of the project:
System Development Life Cycle (SDLC)

- Problem Definition
- High-Level System Diagram
- JAD Session
- System Engineer
- Users Stakeholders

- Problem Description
- Conceptual Model
- Use Case Model
- Analysis Model (OOAD)
- Design Model
- Implementation Model
- Test Model
- System Evaluation

- Artifacts of Analysis
- Class Diagram
- Object Diagram
- Sequence Diagram
- Activity Diagram
- State Diagram

Iterate on Analysis
Continuous User Involvement
Iterate on Evaluation

Artifact Diagrams Used Throughout Solution Process
Problem Definition

- Stormwater runoff pollutes river
- Usable water is wasted by allowing to become stormwater
Rain → Stormwater

Combined sewer system → Waste water treatment plant

Stormwater → May overflow River or City

River

City

Drinking water treatment plant

Residential & industrial usage
Conceptual Model

Precipitation

Impervious area

Well-designed network of BMPs
- Store water
- Green space
- Infiltrate
- Delay to sewer system

No CSO

CSO

Drinking water

Residential user

Sewer

Industrial user

Combined Sewer system

Waste water

Stormwater

Separate Sewer system

City

Non-potable Water

CSO - Store water
CSO - Green space
CSO - Infiltrate
CSO - Delay to sewer system

Non-effective BMPs

Can go non-effective BMPs

Stormwater
Users

- City
- Contractor
- Managers
- Researcher
Use case diagram

**Stormwater management**

**Policy**

- Prepare standard operation method and checklists to evaluate contractors

**Stormwater BMP**

- Simulate the amount of runoff for each node
- Determine appropriate BMP based on the local potential
- Strategically design network of BMPs
- Construct BMPs

**Sewer system**

- Adapt the sewer system drains with designed BMPs
Use case diagram - Water transfer infrastructure

Enterprise Architect software:

- A graphical tool
- Helps teams build robust and maintainable systems
## Use Case Scenarios

### Stormwater management

**Stormwater BMP**

**Strategically design network of BMPs:**

1. Manager gives **mission** to city by new policies to capture stormwater.
2. City ask researcher for a comprehensive **plan** to capture stormwater.
3. Researcher **simulate** the amount of runoff stream for each sewer drain.
4. Researcher determine the best **type of BMPs** for each location based on the physical limits and runoff reduction.
5. Researcher prepare documents of required **capacity of BMPs** for given reliability.
6. City approves the **requirements**.
7. Researcher design strategical **network of BMPs**.
8. Researcher prepare type, location, size and material of the BMPs for the City to give it to the contractors.
9. Contractor **builds BMPs** using documents.
10. City **controls** and approves.
**Network of BMPs**

Hirschman et al. 2008.
Sewer system network

Using models:

- Probability of precipitation
- Probability of runoff for each nodes
- Highest capacity determine by the highest precipitation
- Desire reliability determine the required capacity for BMPs.
There are some BMPs in this area but not adequate.
How Network of BMPs cover the area:
Nodes of the network

class Network of BMPs - Picture

BMP1
- Location: int
- Type: SW
- Capacity: 40 int
- Capture the water(): char
- Provide water(): char

BMP2
- Location: int
- Type: WS
- Capacity: 20 int
- Capture the water(): char
- Provide water(): char

BMP3
- Location: int
- Type: SW
- Capacity: 20 int
- Capture the water(): char
- Provide water(): char

BMP4
- Location: int
- Type: SW
- Capacity: 20 int
- Capture the water(): char
- Provide water(): char

BMP5
- Location: int
- Type: SW
- Capacity: 15 int
- Capture the water(): char
- Provide water(): char

BMP6
- Location: int
- Type: WS
- Capacity: 20 int
- Capture the water(): char
- Provide water(): char

BMP7
- Location: int
- Type: SW
- Capacity: 40 int
- Capture the water(): char
- Provide water(): char

BMP8
- Location: int
- Type: WS
- Capacity: 20 int
- Capture the water(): char
- Provide water(): char

BMP9
- Location: int
- Type: WS
- Capacity: 20 int
- Capture the water(): char
- Provide water(): char
Sequence diagram - Create new design for Road construction

1. Manager gives the city mission to capture the stormwater ()
2. City asks researcher to prepare documents and requirements ()
3. Researcher prepares documents ()
4. City uses document to enact policy ()
5. City gives call for new policies to the manager ()
6. Makes contract and gives the documents ()
7. Contractor builds the BMPs based on the document and policy ()
8. City controls and approves the BMPs if they meet the requirements ()
Manager gives the city mission to capture the stormwater

City asks researcher for a comprehensive plan to capture stormwater

Researcher simulates the amount of runoff stream for each sewer drain

Researcher determines the best type of BMPs for each location based on the physical limits and runoff reduction

Researcher prepares documents of required capacity of BMPs for given reliability

Researcher designs strategic network of BMPs

Researcher prepares type, location, size and material of the BMPs for the City to give it to the contractors

Contractor builds BMPs using documents

Final control

Conclusion and future research

- Systems engineering is broadly concerned with the planning and management. Incorporating this system with water management, can lead to the systematic solutions:
  - Determine responsibilities of all stakeholders or users.
  - Activity plan which is ready to be used by project managers for each specific section.
  - Detail oriented with holistic view.
Thank you for your attention!

Question?

Email: mojab1@morgan.edu

Morgan State University
Department of Industrial and System Engineering
1. District of Colombia, Water and Sewer Authority
5. McGraw-Hill, Boston, Massachusetts, 2005