A Tale of Two Methods

The arguments for and against using the RTK method and the graphical method for estimating sanitary sewer inflow and infiltration rates
Authors

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What is I&I

• Inflow and Infiltration (I&I)

• **Infiltration:** The water entering a sewer system from the ground through such means as defective pies, pipe joints, connections, or manhole walls.

• **Inflows:** The water discharged to a sanitary system, including service connections, from such sources as roof leaders, foundation drains, manhole covers, interconnections from the storm sewers, combined sewers and catch basins, or surface runoff.
What is I&I

• Typically Separated into Two Segments

• **Groundwater Infiltration (GWI):** Infiltration resulting from flow of groundwater into the system; results of components of the sewer system located below the water table

• **Rainfall Derived Inflow and Infiltration (RDI&I):** Rainfall flows entering the system via Inflow and Infiltration
Sources of I&I

- **Infiltration:**
  - Cracks, holes, defects, joint failures, or joint separation in the sanitary sewers or manholes
  - High groundwater table
  - Other

- **Inflow:**
  - Roof and foundation drains connected to the sanitary laterals
  - Cross-connections from the storm drainage system
  - Faulty manhole covers or frames
  - Uncapped cleanouts
  - Other
Impact of I&I

- **Larger Infrastructure**: Increases peak flow rates
- **Increased Treatment Requirements**: Increases total sewage volume
- **Damage to Property and Environment**: Increase risk of sewer overflow
- **Increased Costs**
Impact of I&I
How to Quantify I&I

- GWI - Consistent easier to quantify
- RDI&I – Variable more difficult to quantify
- Two (2) common methods used to quantify RDI&I
  - Unit Hydrograph RTK Method (Tri-Triangular Method)
  - Graphical Method (Envelop Method)
RTK Method

- Unit hydrograph represented by three triangles
  - Slow Response
    - groundwater or slow infiltration
  - Medium Response
    - infiltration with medium time response
  - Fast Response:
    - direct inflow and rapid infiltration
- Unit hydrograph represents RDI&I into the sewer
- Not all three triangles are required

Also known as the Tri-Triangular Method
RTK Method

- Up to nine (9) parameters required
- RTK represents the three components of the triangles
  - R: Fraction of excess rainfall volume
  - T: Time to peak
  - K: Recession constant
- Values vary depending on the size and characteristics of the sewersheds
- Typical ‘T’ and ‘K’ values are provided below

<table>
<thead>
<tr>
<th></th>
<th>Fast</th>
<th>Medium</th>
<th>Slow</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>R1</td>
<td>R2</td>
<td>R3</td>
</tr>
<tr>
<td>T</td>
<td>&lt;2 hours</td>
<td>4 - 8 hours</td>
<td>10 - 24 hours</td>
</tr>
<tr>
<td>K</td>
<td>2 - 3</td>
<td>2 - 4</td>
<td>2 - 4</td>
</tr>
</tbody>
</table>
RTK Method

• External factors affecting shape
  – Size configuration of the sewershed
  – Surface abstraction
  – Infiltration

• Internal factors affecting shape
  – Physical condition of the system
  – Age, material, diameter, etc.
  – System configuration

• Flow monitoring requirements
  – Significant storm event require to calibrate parameters
  – Requires rainfall IDF curves

• Peak RDI&I quantified by modeling system response to design Hyetograph
Graphical Method

- Scatter plot of each storm event
  - peak RDI&I against total rainfall
- Extrapolation to 5-year and 25-year rainfall total
- Upper bound – saturated soil conditions
- Lower bound – unsaturated soil conditions
- Flow monitoring requirements
  - Multiple significant storms required to reduce extrapolation error and increase confidence interval
  - Requires rainfall IDF curves

Also known as the I&I Envelope Method
Graphical Method

• Different graphs must be produced for the different storm durations
  – 1 Hour, 2 Hour, 6 Hour, 12 Hour, 24 Hour, etc.
Advantages of RTK Method

- Better representation of sources of RDI&I
- Can model the dynamic response of the sewer system to rainfall events
  - Quantify total RDI&I volume
  - Quantify storage or capture requirements of sewer overflows (CSO)
Disadvantages of RTK Method

- Requires a computer model
- No unique answer
  - Up to nine (9) parameters to calibrate
  - Different modelers produce different calibration parameters
  - Potential for variable peak RDI&I flows results (from same flow data)
- Calibrated unit hydrograph may not be logically correct
- Accuracy dependent on large storm events
Advantages of Graphical Method

• Extrapolation Method (no calibration requirement)

• Only requires data graphing tools (e.g. XLS)

• Easy to compare results between studies

• Popular method in BC
Disadvantages of Graphical Method

- Requires extended periods of field data
- Accuracy dependent on large storm events
- Only gives a representation of peak flows
- Assume a linear relationship between rainfall/peak flow
- Does not distinguish RDI&I source contributions (Inflow or Infiltration)
Case Study: North Road (Coquitlam, BC) Sanitary Sewer System

- Background Information

<table>
<thead>
<tr>
<th>Component</th>
<th>Total</th>
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<tbody>
<tr>
<td>Manholes</td>
<td>344</td>
</tr>
<tr>
<td>Total pipe length</td>
<td>22 km</td>
</tr>
<tr>
<td>Total catchment area</td>
<td>185 ha</td>
</tr>
</tbody>
</table>
Case Study: North Road (Coquitlam, BC) Sanitary Sewer System

• Project Work Plan
  – Build model and calibrate model
  – Calibrate RTK parameters
  – Determine I&I rates via Envelope Method
  – Model future scenarios and determine deficient pipes
  – Determine capacity-based upgrades
Case Study: I&I Results
Case Study: I&I Results

5 Year 24 Hour RDI&I Envelope for Calibration Site 1

- 11.7 L/s
- Linear (Observed Storm Event)
- Linear (Saturated Condition)

Observed Storm Event

5 Year
Case Study: I&I Results

• RTK Method Challenges
  – Limited flow monitoring period
  – Small catchment for calibration
  – Must apply calibrated values to entire catchment
  – Must extrapolate small measured rain event to larger design event

• Graphical Method Challenges
  – Limited flow monitoring period
  – Small catchment for calibration
  – Must apply calculated I&I rate to entire catchment
  – Must extrapolate small measured rain event to larger design event

<table>
<thead>
<tr>
<th>Storm Event</th>
<th>Graphical Method</th>
<th>RTK Method</th>
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<tr>
<td>5-Year 24-Hour</td>
<td>44,400 L/ha/day</td>
<td>44,900 L/ha/day</td>
</tr>
<tr>
<td>25-Year 1-Hour</td>
<td>80,100 L/ha/day</td>
<td>79,300 L/ha/day</td>
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Case Study: Impact on Peak Flows

Similar results for sewers downstream of flow monitor

Variable results for sewers upstream of the flow monitor. Function of catchment discretization

RTK flows higher with increased catchment discretization. GM flows higher with decreased catchment discretization
When to Use?

• **RTK Method**
  - Require total RDI&I volume
  - Wish to identify RDI&I source contributions (Inflow vs. Infiltration)

• **Graphical Method**
  - Only require peak flow

• **Both**
  - Use to measure relative change in I&I flow (I&I reduction program)
  - Used for existing system capacity analysis
Conclusion and Recommendation

• Both methods have their advantages and disadvantages

• Both:
  – Require flow monitoring data
  – Extrapolate small measured rain events to larger design events

• Major differences:
  – RTK – Volumetric
  – Graphical – Peak Flow
Useful Links

• RTK Method
  – Sanitary Sewer Overflow Analysis and Planning (SSOAP) Toolbox
    www.epa.gov/nrmrl/wswrd/wq/models/ssoap/
Questions and Answers

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