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Presented by:

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Lake Simcoe Region conservation authority

Credit Valley Conservation – inspired by nature

City of Toronto
Crawford Lane LID Pilot

Presented by: Abe Mouaket, Ph.D., P. Eng., Transportation Services Division
Co-Presented by: Anisha Patel, Transportation Services Division

2024 Source to Stream Conference

TORONTO

Toronto's Future Weather

HOTTEST DAY

38.4º

celsius

2051-80

33.6º

1976-2005

HOT DAYS

55

above 30º

2051-80

12

1976-2005

ANNUAL PRECIPITATION

870

millimetres

2051-80

793

1976-2005

Source: Climate Atlas of Canada, Climate Change and Canada's Cities – Toronto, Ontario. Data assumes a high emission scenario (RCP8.5, CMIP5). March, 2019.

**mean values*

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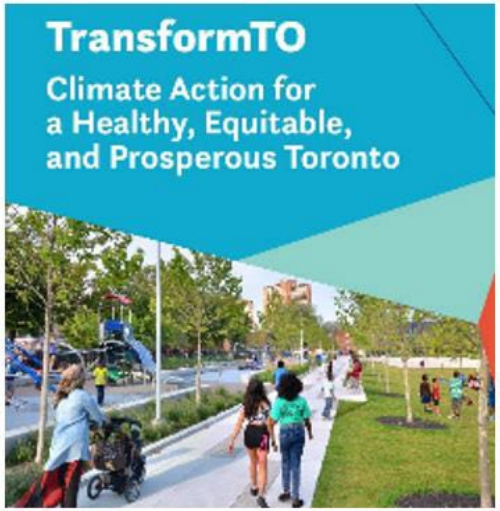
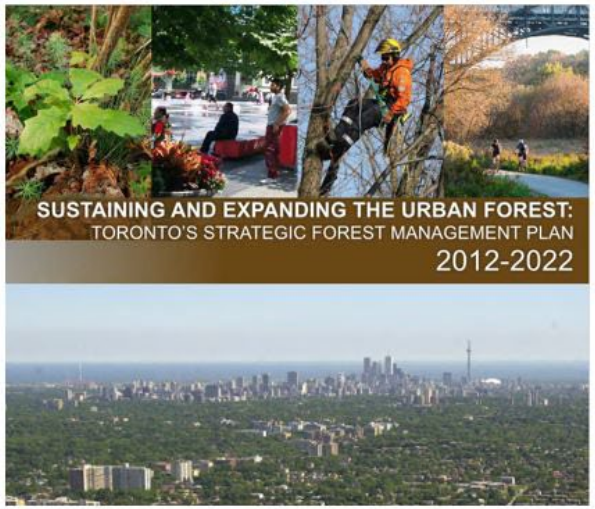
Policy Drivers





October 2 and 3, 2019: City Council declared a **climate emergency** for the purpose of naming, framing, and deepening our commitment to protecting our economy, our ecosystems and our community from climate change.

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Streets as Opportunities

¼
land coverage

5,400km
streets

7,945km
sidewalks

322km
laneways

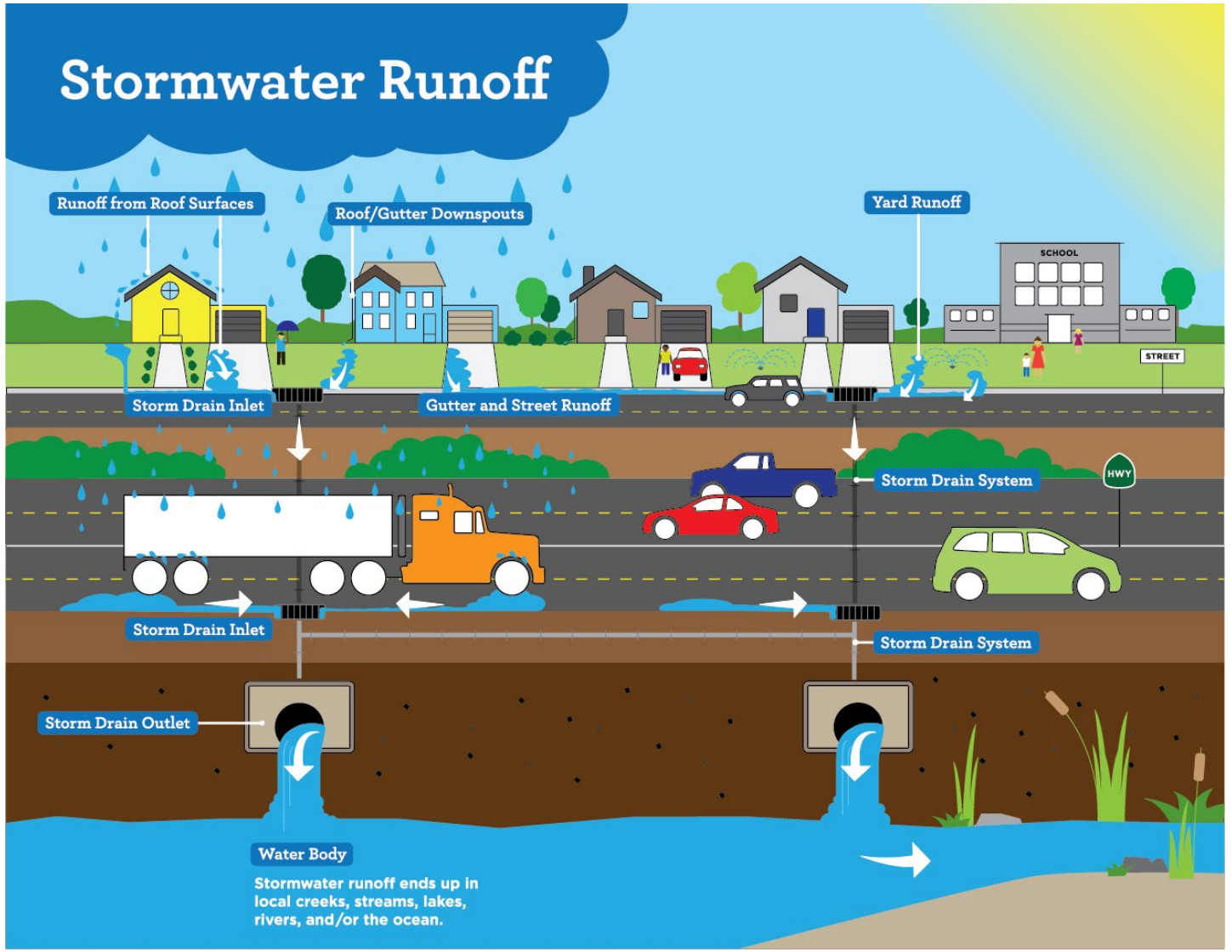

Image courtesy of protecteverydrop.com

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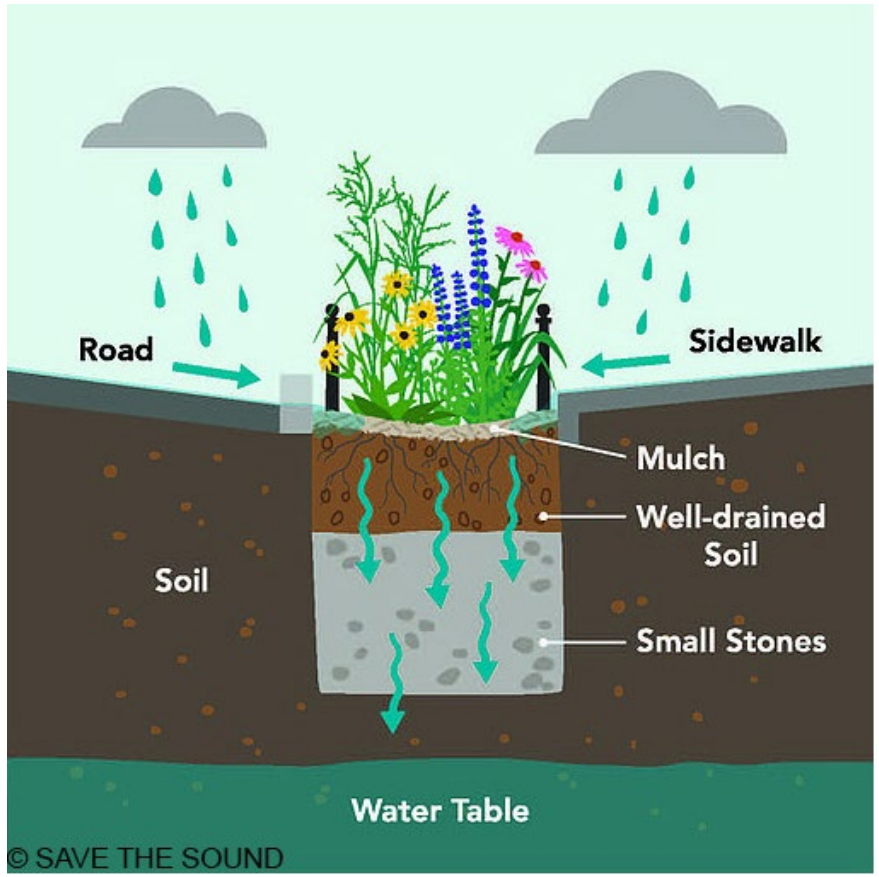
What are Green Streets?

A road or street that incorporates **green infrastructure**, which includes natural and human-made elements

Green Streets are designed to capture rainwater at its source, where it falls while providing co-benefits.



Green Infrastructure: Bioswale
Location: Byng Avenue, Etobicoke

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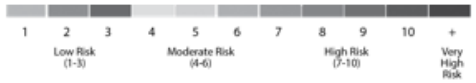
(Co)Benefits of Green Streets

Managing stormwater runoff to enhance water quality, to reduce erosion in receiving water bodies, and to enhance urban resilience.

Provide opportunities to enhance biodiversity

Mitigating urban heat island effect

Enhancing the extent and longevity of the urban forest



Enhancing air quality

Promoting infiltration

Conserving / generating energy

Beauty

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Implementation & Co-Benefits

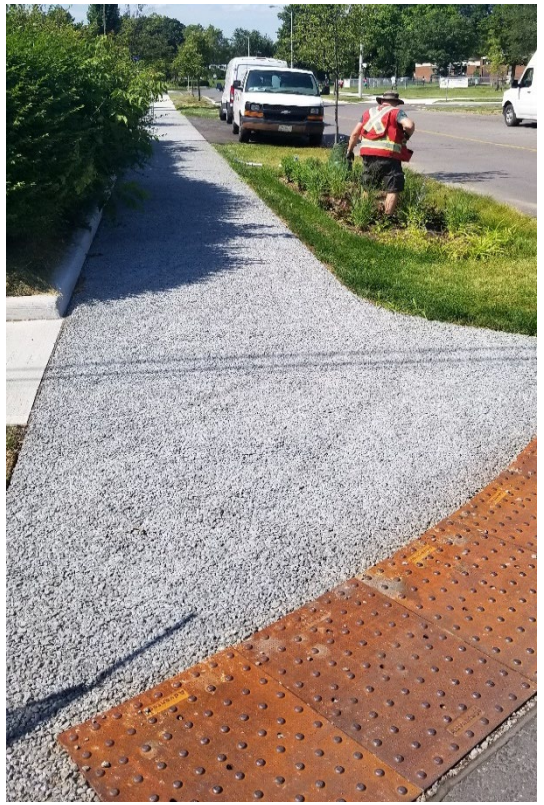
SWM Tree Trench
Canopy Cover

Stormwater Treen Trench: Six Points

Green Gutter
Cycle Lane Barrier

Green Gutter: Murray Ross Pkwy

Permeable Concrete
Infiltration



Permeable Concrete: Byng Ave

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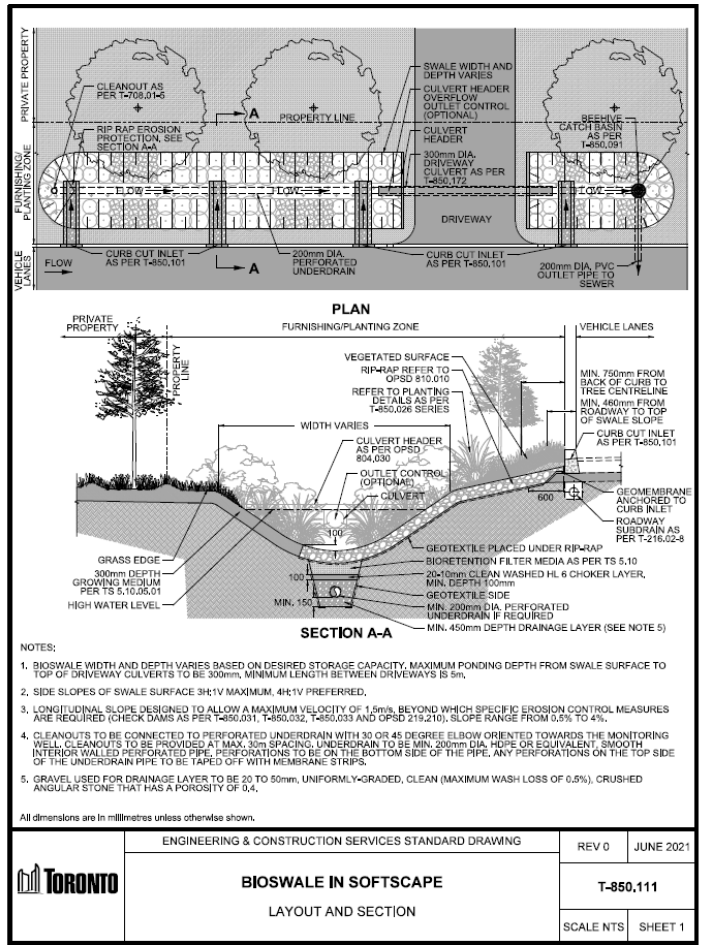
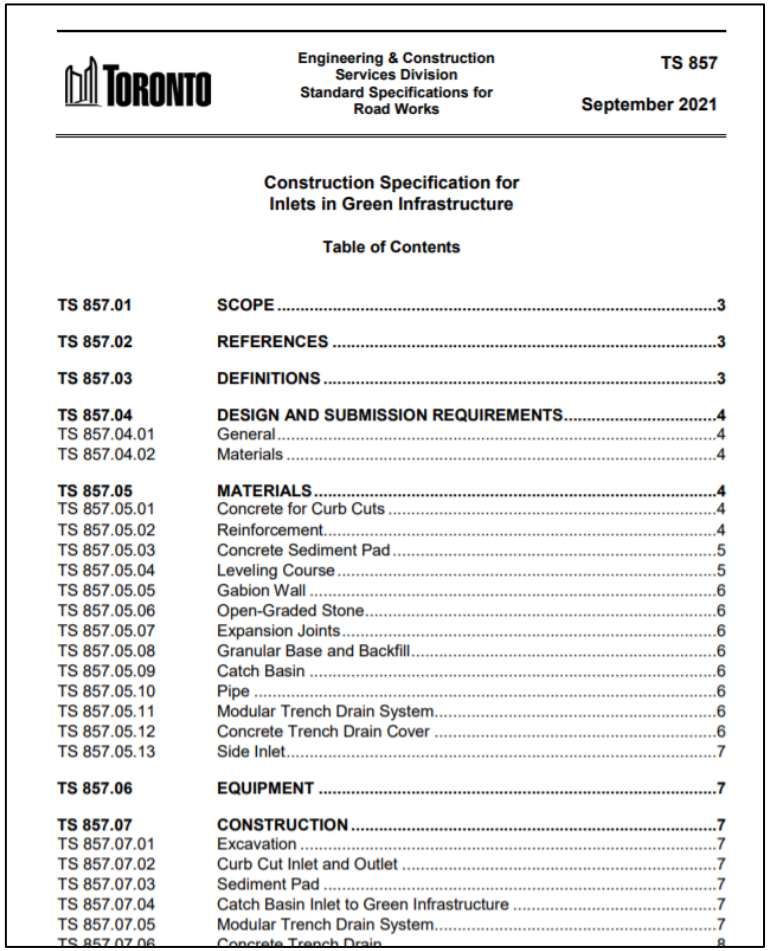
Details & Specifications





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Engineering & Construction Services Division
Standard Specifications for Road Works

TS 857
September 2021

Construction Specification for Inlets in Green Infrastructure

Table of Contents

Documents developed to date:

- **80** Standard Drawings
- **8** Construction Specifications
- **3** Guidelines:
  - Design Criteria Guideline
  - Lifecycle Activities Guideline
  - Public Notification & Engagement

In progress:

- Retrofit Design Options
- Construction Specification for Retrofit Construction Around Existing Trees (TS 182)
- Additional Green Infrastructure Standards

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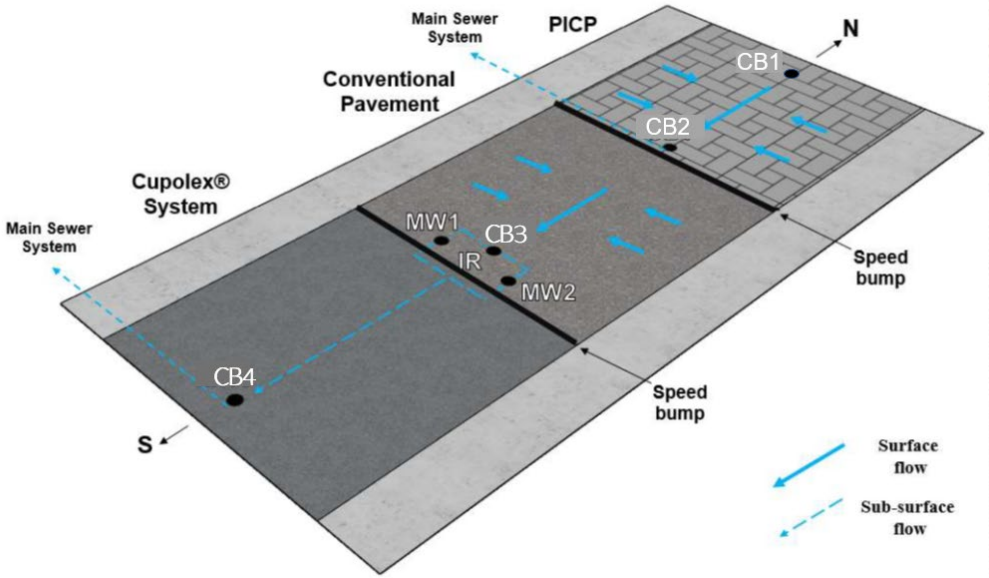
Innovations and Testing

Laneway Punctures



Cupolex® & Precast Interlocking Concrete Pavers

Soil Cell Evaluation

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The Challenge

- During heavy rainstorms, storm sewers tend to over-flood during the storm peaks
- As part of Green Street Program, TS wanted to explore available technologies that can help mitigate impacts on the sewer network
- Two technologies were identified for testing:
  - Cupolex® Concrete Systems (Cupolex)
  - Porous Interlocking Concrete Pavers (PICP)

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Cupolex®

Porous Interlocking Concrete Pavers (PICP)

Test-Site Selection Criteria

- **Testing site: ready for rehabilitation**
- **The test: should cause least disruption and least repair cost**
- **The test: well-designed to generate the required information**

- **Crawford Lane met the above determinants**

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The Pilot: Location and Layout

253 m long ➔ 3 sections, each about 84 m long

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The Actors

- Transportation Services and Engineering & Construction Services Engineers

- Pontarolo Engineering (distributer of Cupolex®)
- Dufferin Construction (PICP manufacturers)
- Burnside Engineering (Drainage Experts)

- The Water Institute (TMU, formerly Ryerson U) For Monitoring

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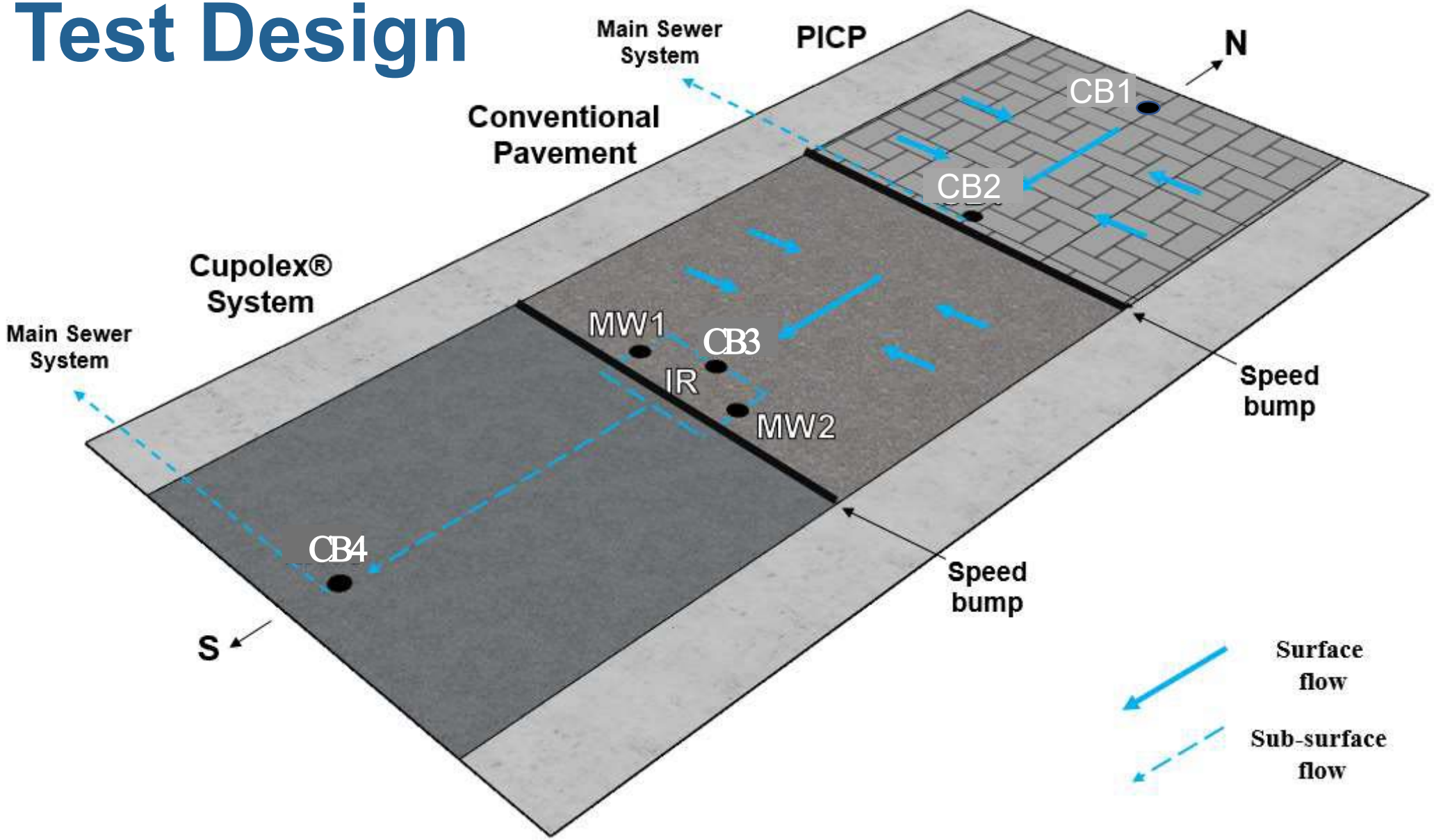
The Test Design



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Qrain (Calculated)

CB1 ➔ Sewer

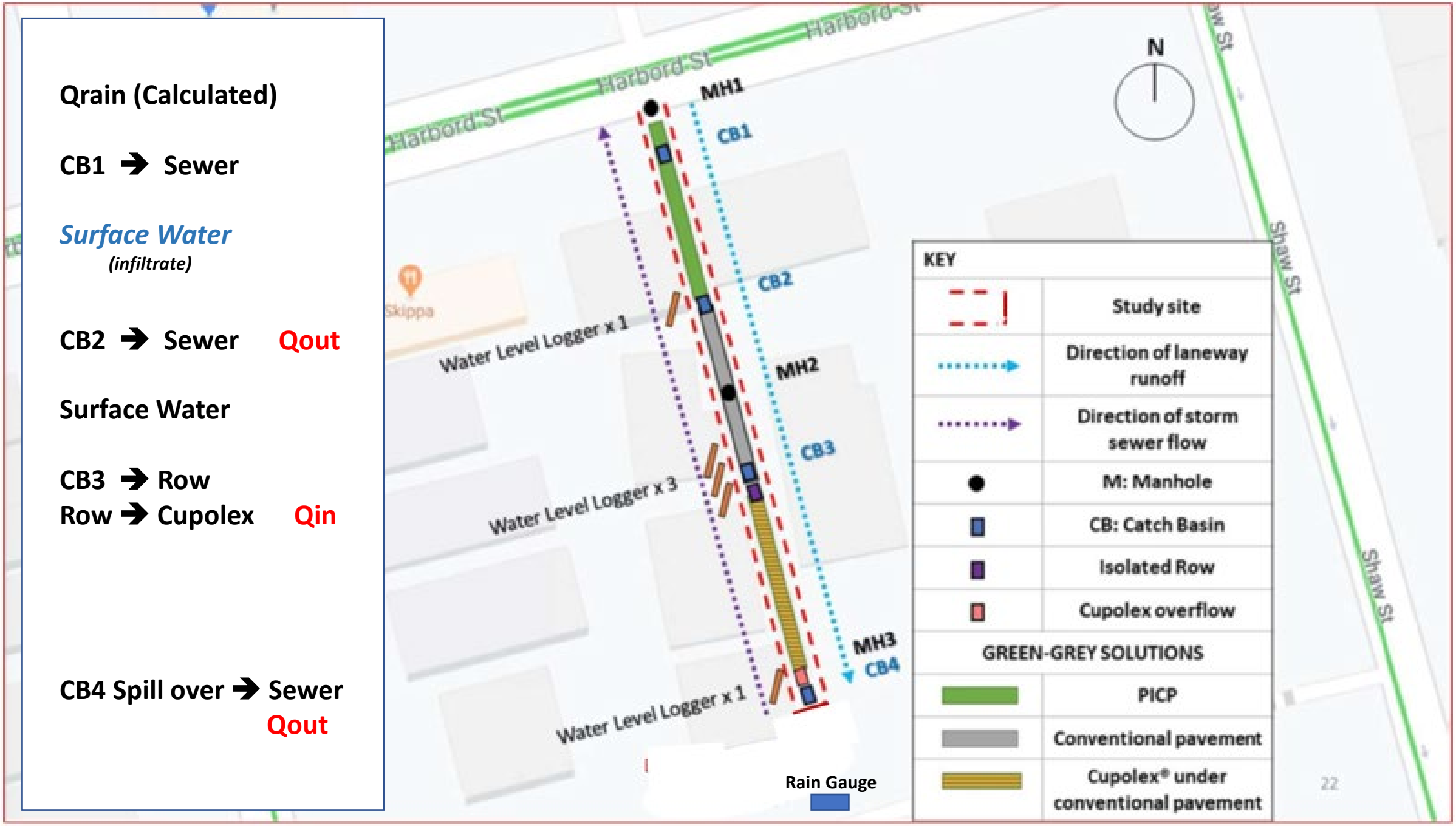
Surface Water
(infiltrate)

CB2 ➔ Sewer **Qout**

Surface Water

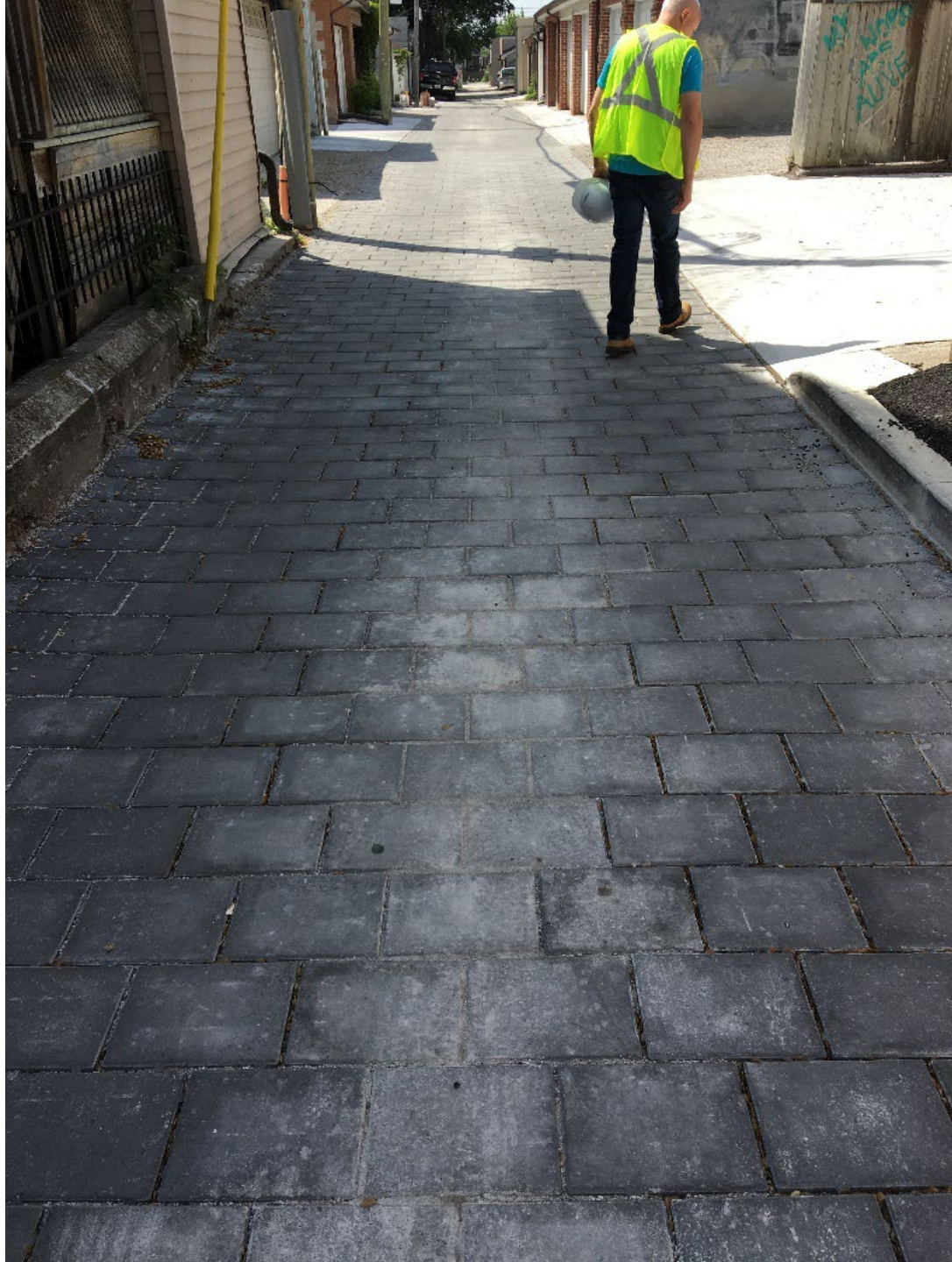
CB3 ➔ Row
Row ➔ Cupolex **Qin**

CB4 Spill over ➔ Sewer
Qout



Crawford Lane Pilot

Looking South from Harbord St.



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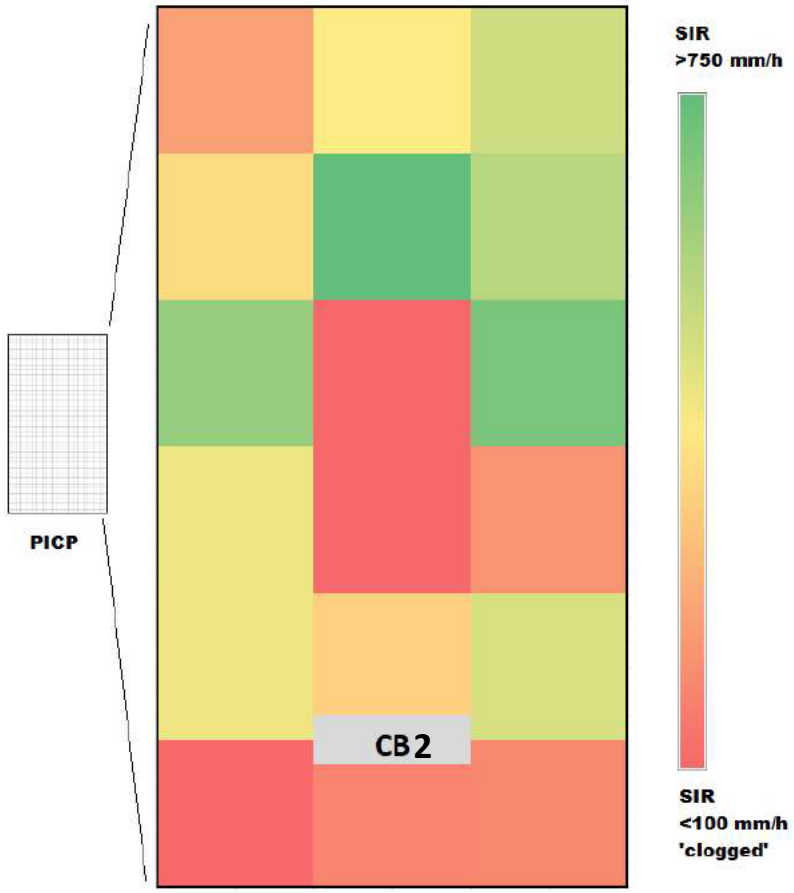


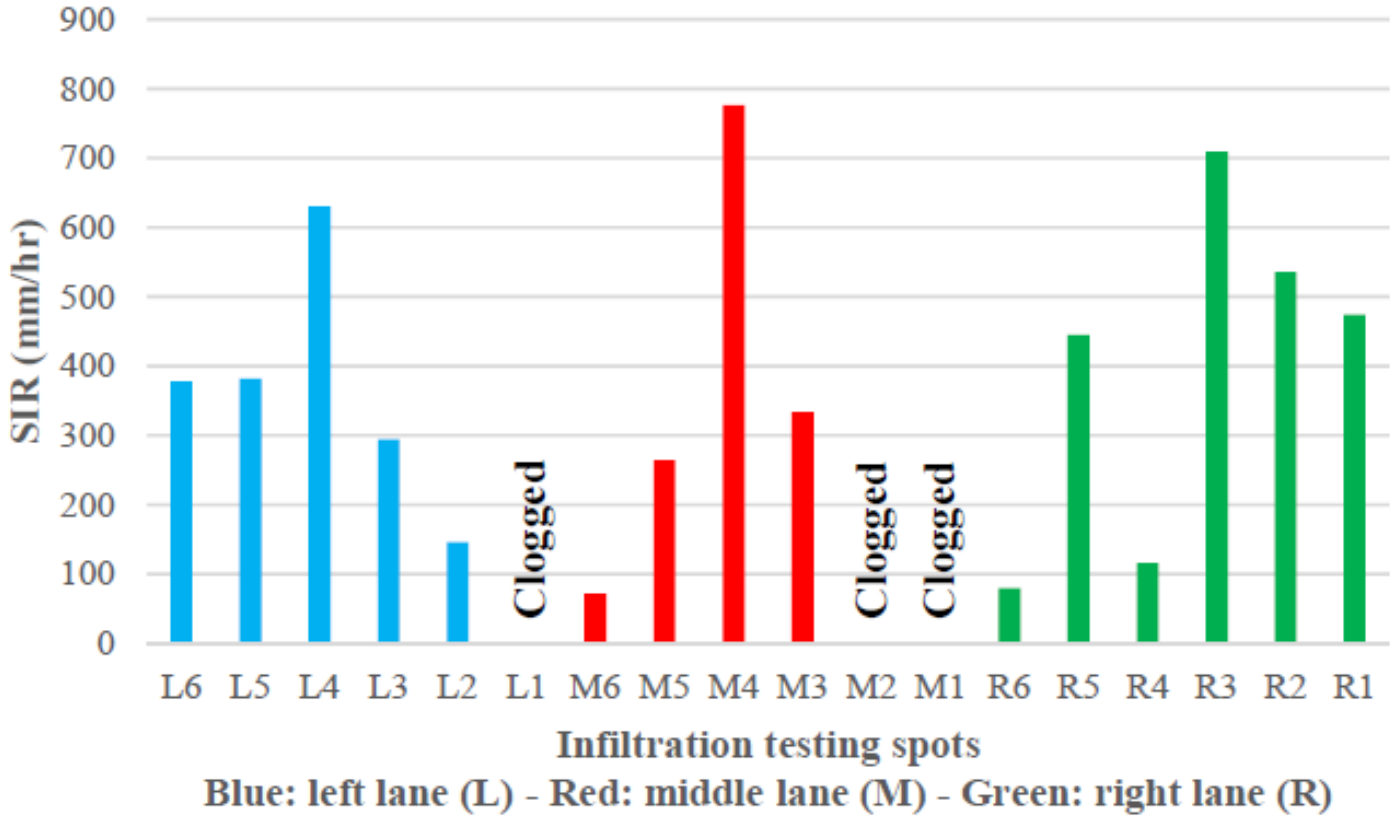
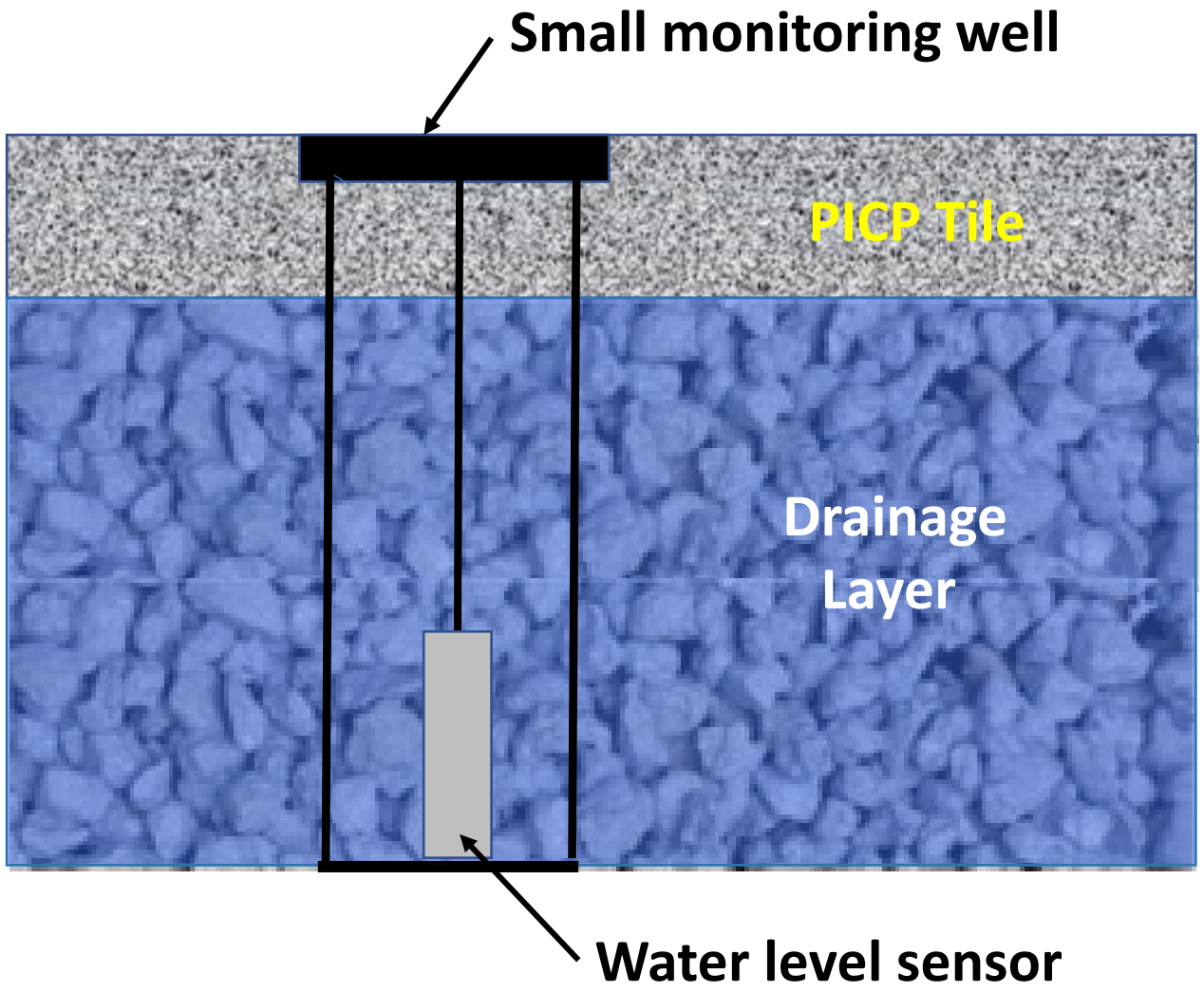


Figure 15: SIRs for the selected PICP spots

Measuring water infiltration through PICP



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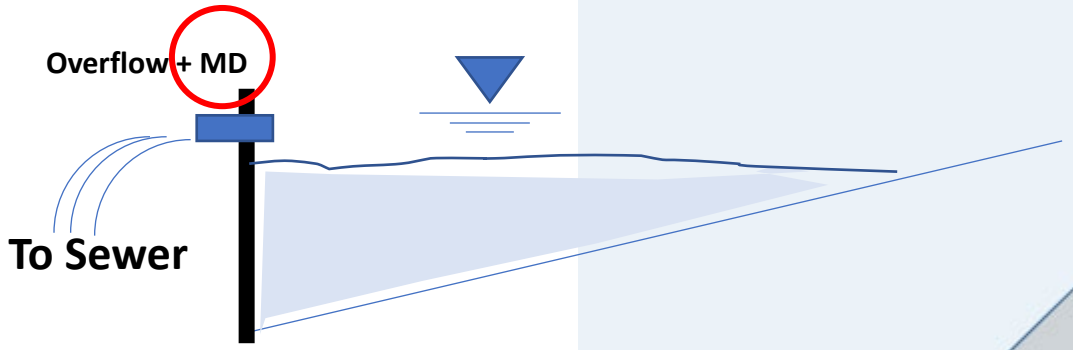
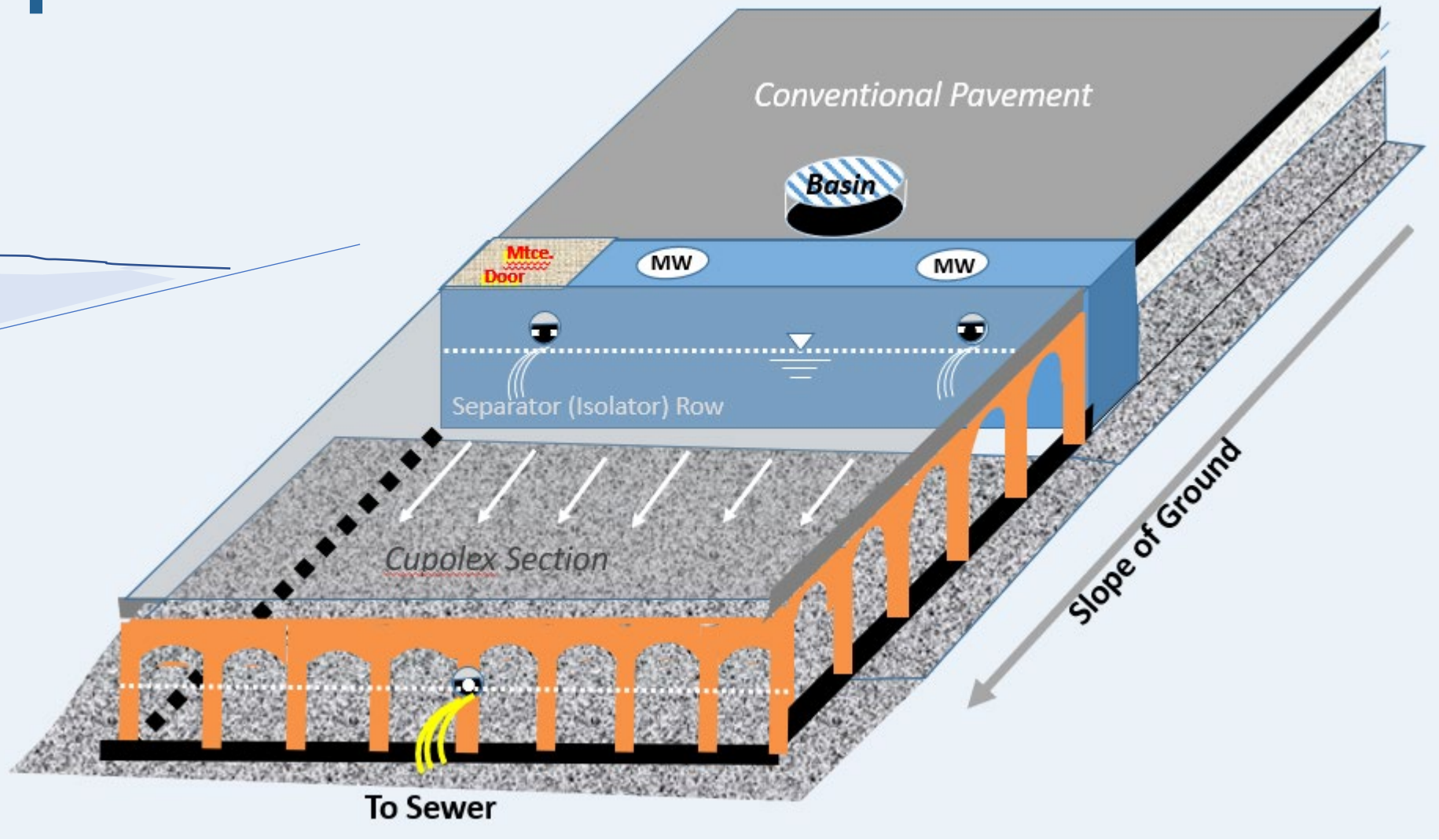
Isolator (Separator) Row Detailed Operation





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Sample Equipment Used in Monitoring

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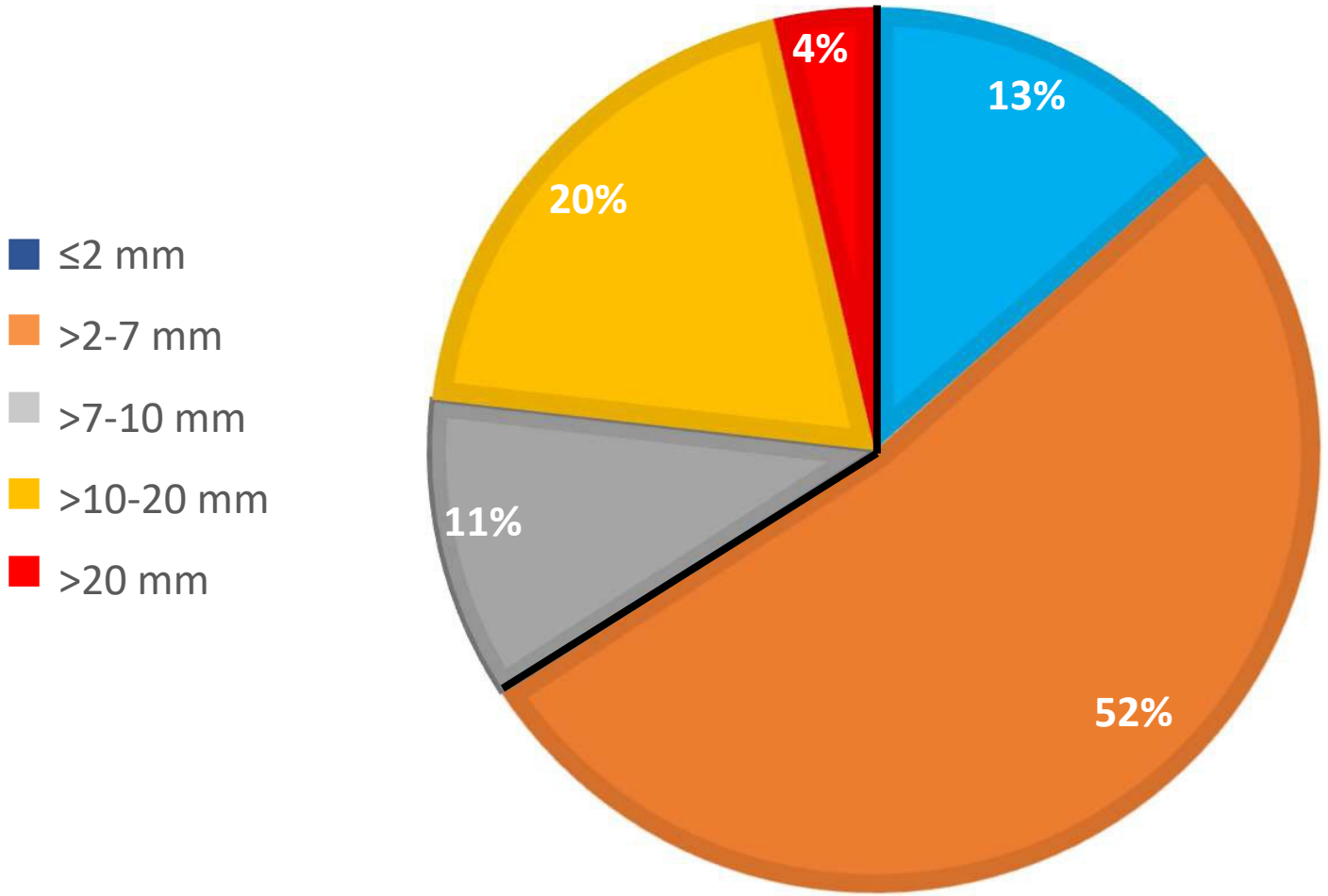
Data Collection

Date	Start Time (hh:mm)	Duration (min)	Total Rainfall Depth (mm)	Average Rainfall Intensity (mm/hr)	5-min Peak Rainfall Intensity (mm/hr)	Antecedent Dry Period (ADP) (d:hh:mm)
May 28, 2020	13:04	304	6.6	12.0	2.4	N/A
June 2, 2020	21:48	16	10	35.3	16.8	5:08:44
June 5, 2020	14:17	42	9.2	19.7	12.0	2:16:29
June 10, 2020	21:59	170	10.6	21.2	21.6	0:16:22
July 8, 2020	14:40	66	14	17.1	7.2	27:16:40
July 16, 2020	20:13	40	5	13.0	4.8	5:05:14
July 19, 2020	13:06	32	11.6	13.9	19.2	2:16:52
July 22, 2020	15:37	37	5	13.0	4.8	3:02:31
August 2, 2020	9:28	31	12.6	33.8	16.8	10:17:51
August 3, 2020	16:41	32	19.4	35.3	16.8	1:07:13
August 4, 2020	18:17	49	4.6	14.5	7.2	1:01:36
August 26, 2020	23:19	85	3.6	12.7	4.8	9:23:19

Classification of events based on rainfall depth



65% ≤ 7 mm

35% > 7 mm

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October 26, 2021	00:17	913	8.2	12.0	2.4	0:23:41
October 29, 2021	17:37	379	7.4	12.0	2.4	4:17:20

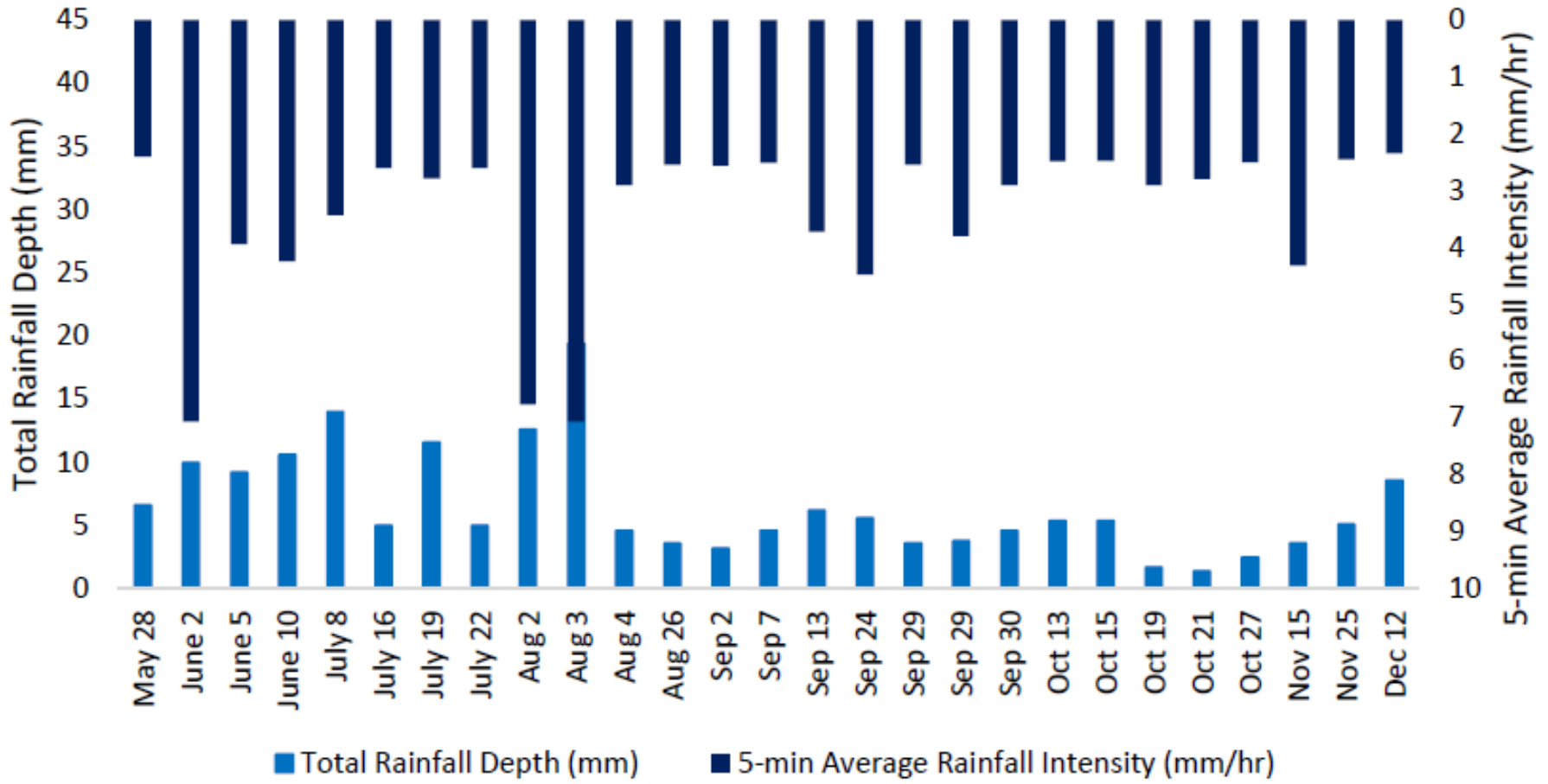

Figure 5: Total depth and 5-min average intensity for the recorded rainfall events in 2020

PICP

Over the monitoring period, field observations and inspections indicated the deteriorating surface conditions of the PICP.

- **The wash-off of the aggregates and**
- **The accumulation of sediments were observed**.

Ontario's CVC LID Manual (2018) recommends **routine maintenance tasks, including surface sweeping, at least once or twice a year.** Sweeping helps in preventing clogging, a major limitation for permeable pavements.

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WEEDS


DEBRI

The Cupolex® Section

Sedimentation Survey:

- April 15, 2022, (**after 3 years**)
- using a **standard disc and rod method**
- accumulated sedimentation in CB2 and the isolator row.

Method

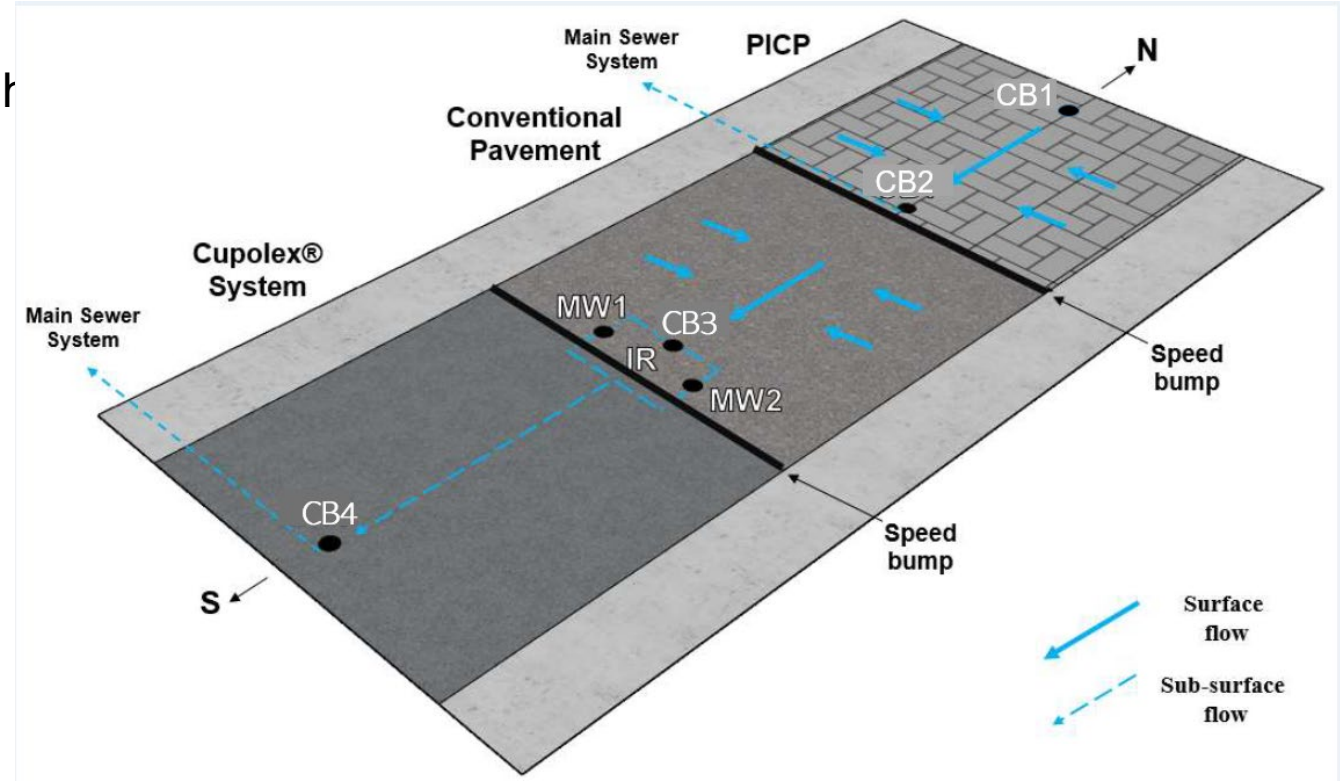
- The disc and rod were lowered until they gently h
  the bottom level.
- **Different measurements were taken** in each
  monitoring well to account for spatial variability.

Average sediment depth was:

CB2 ➔ 83.5 mm Catch-basin

MW1 ➔ 39 mm
MW2 ➔ 61.4 mm } Separator Row

Accumulation **after three years.**



Conclusions of the Analysis

- Surface infiltration measurements at the PICP section revealed a median infiltration rate of 336 mm/hr, 168 mm/hr, and 459 mm/hr for the left, middle, and right lanes.
- The tests indicated that the PICP was still operating after two years of construction,
- Although the infiltration rates were lower than the recommended standards. It is concluded that Cupolex® is a more effective stormwater conveyance system to mitigate increased surface runoff than the PICP, especially when the native soil is relatively impermeable.

Study Findings and Observations

- **The sizing of the Cupolex® is a crucial design element. While some design factors are easily determined (e.g., historical rainfall records), others could be relatively tricky (e.g., contributing drainage areas)**
- **The outlet of the Cupolex® system should always be coupled with an emergency overflow. In shorter antecedent dry periods, inflows in the Cupolex may build up before getting a chance to infiltrate.**
- **For design purposes, Cupolex® can be considered an infiltration-based device, similar to other infiltration LID facilities. Therefore, an underdrain may be required if the native soil is highly impermeable.**
- **Maintenance needs are lower for Cupolex® than PICP, whose surface is exposed to traffic and land-use conditions. However, the selection should also consider the life cycle costs for both systems.**
- **Cupolex® cells cannot be cleaned as they are embedded within the pavement. Thus, the isolator row is strongly recommended to allow for sediment settlement.**

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Where do we go from here?

- From practice viewpoint, 3 important questions:
  1. Does the technology achieve the objective?
  2. Does it impact road performance?
  3. Is it cost-effective?
- Today, I reported on Q.1 ➔ Yes it does [Cupolex > PICP]

- On Q.2 -- Cupolex,
  The Asset Management Unit monitors pavement performance;
  In short term (2 yrs) – random hair cracking; light ravelling on 4 panels
  ➔ Problem: Concrete mix, not structural

- PICP, serious deterioration in a number of spots: rocking, dislodging, erosion

Q.2 Physical Performance

1. **Cupolex concrete pavement** is holding reasonably well except for
   - light to medium ravelling for at least four to five panels.
   - There are also meandering cracks some follow the grid line and some are random.
   - There are also the traditional cracks at the maintenance hole covers.

2. **Conventional section** generally is fine. There are corner cracks on two adjacent panels. That corner must have lost its support.

3. **PICP pavement** condition was disappointing, although City maintenance have cleaned it recently. I did not see much debris in the cracks but there are many other problems, and some affected areas are fairly sizeable. Here are the observed distresses:
   a. The seams between the tiles has expanded to 1” in some cases.
   b. Some tiles have lost their support and are rocking.
   c. Some tiles have a differential settlement of 1” or greater.
   d. One or two tiles have cracked in the middle

Separation

Erosion of filtering sand

Mud replacement

<u>Bottom Line</u>:

Heavy on Maintenance

Where do we go from here?

- From practice viewpoint, 3 important questions:
  1. Does the technology achieve the objective?
  2. Does it impact road performance?
  3. Is it cost-effective?

- Does it impact road performance?

- **On Q.3, cost-effectiveness, we may have to do some different monitoring that will give us a better profile to carry out LCC of these technologies**

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Thank you!

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