IAFSM 2024 Annual Conference

The Nitty Gritty of Green Infrastructure Design

FLOSSMOOR

Welcoming. Beautiful. Connected.

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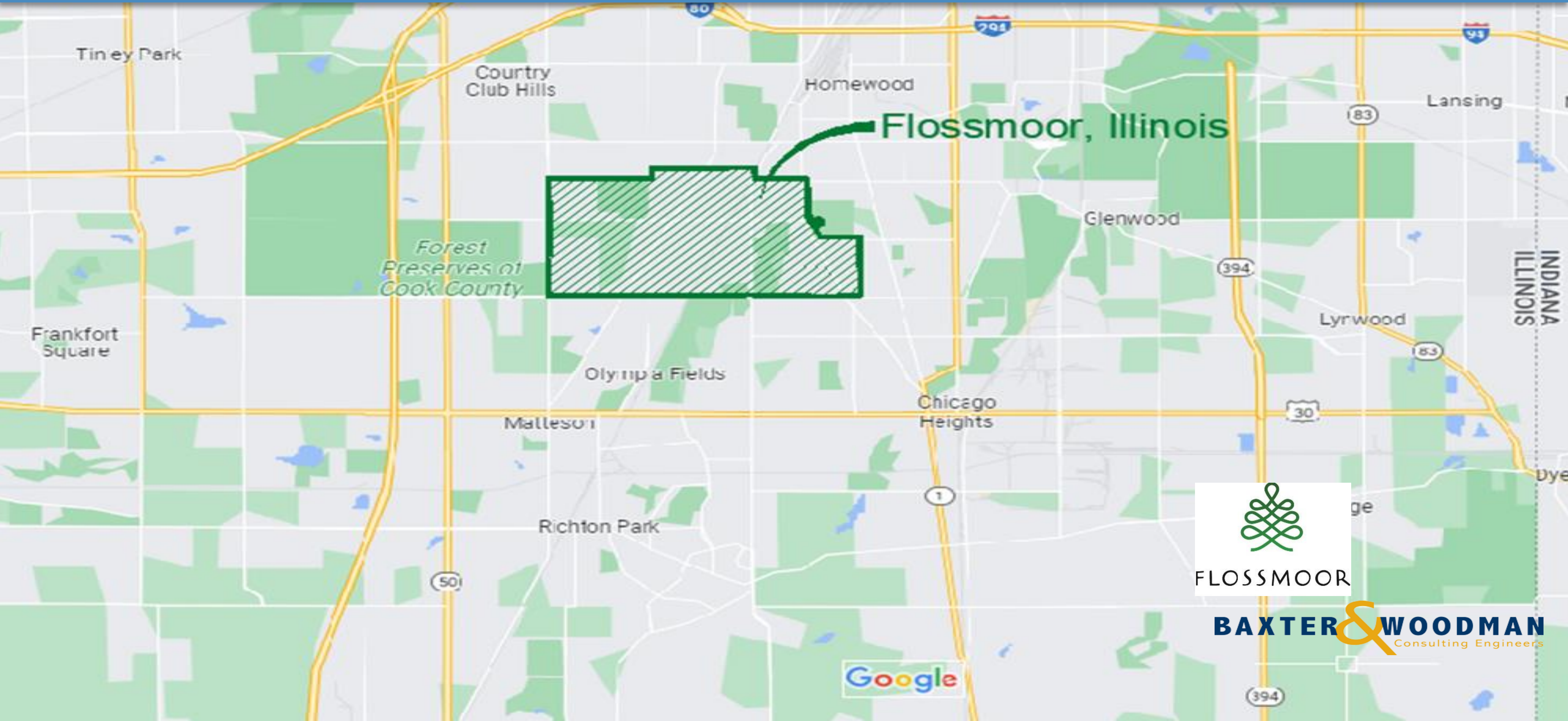
Consulting Engineers

March 11, 2024

Where is Flossmoor, Illinois?



History of Flossmoor

Flossmoor Train Station built in 1890 with the extension of the Illinois Central Railroad

Incorporated in 1924 with a population of 270

Developed as a summer home and golf destination for IC Railroad executives and the University of Chicago faculty

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Flossmoor Today

- Located 28 miles south of the City of Chicago in Southern Cook County
- Diverse population of 9,704 (2020 census)
- Area of 3.66 square miles
- Bedroom community

Flossmoor Road Viaduct Flooding

Viaduct flooding is top priority to Village for mitigation

Flooding has been an issue since its construction in early 1900s

Flossmoor Rd. Viaduct - 1951

Flossmoor Rd. Viaduct - 1928

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Flossmoor Road Viaduct Flooding - 2019

Berry Lane Flooding - 2019

Plan of Action

- Previous ACOE drainage studies focused on viaduct
- Baxter & Woodman completed a comprehensive study in 2020
- Determined two options for improvements

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Upsized Conveyance Option

10-Year Design for Berry Lane, 100-Year Design for Viaduct

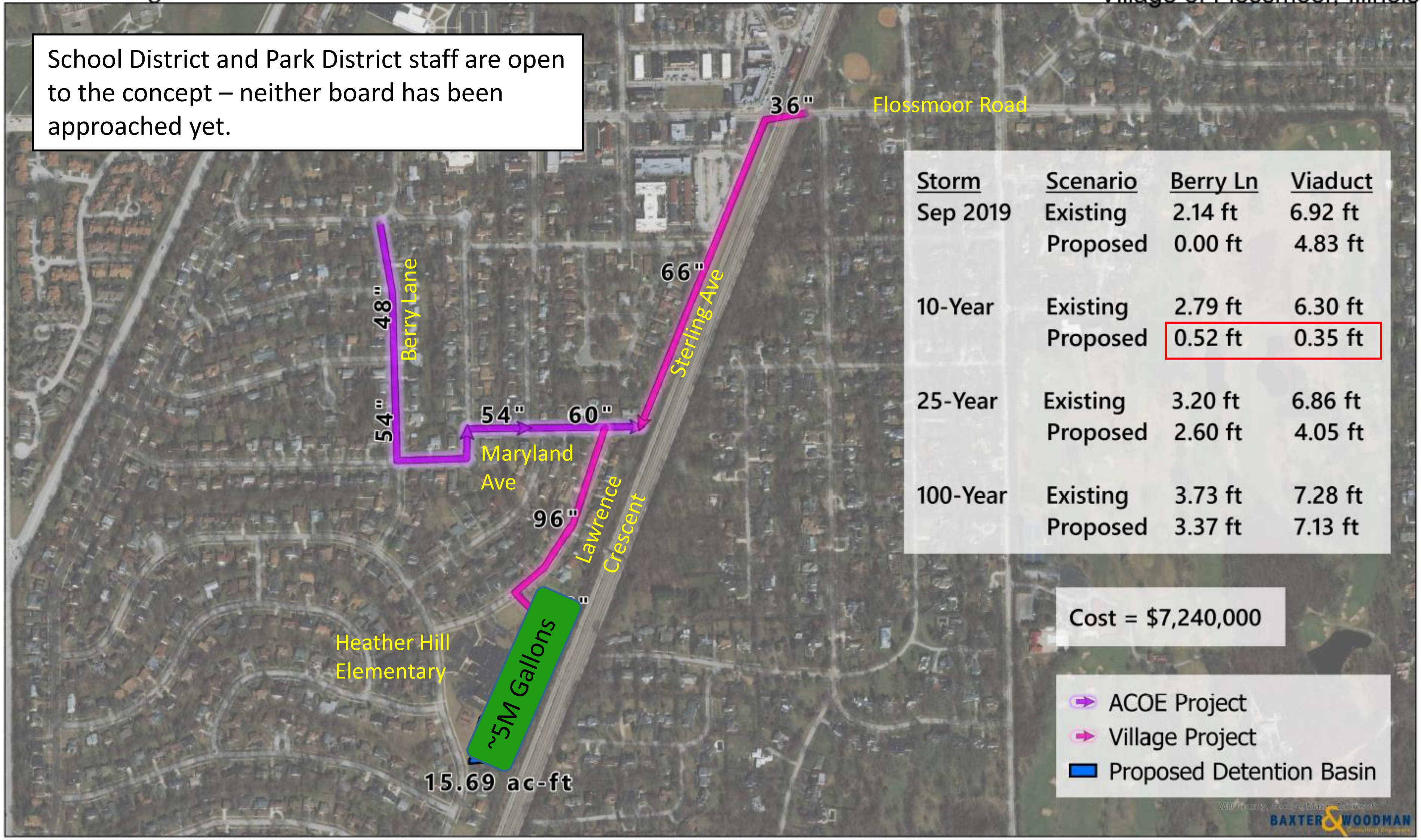
Village of Flossmoor, Illinois

Storm	Scenario	Berry Ln	Viaduct
Sep 2019	Existing	2.14 ft	6.92 ft
	Proposed	0.00 ft	0.00 ft
10-Year	Existing	2.79 ft	6.30 ft
	Proposed	0.33 ft	0.00 ft
25-Year	Existing	3.20 ft	6.86 ft
	Proposed	2.40 ft	0.00 ft
100-Year	Existing	3.73 ft	7.28 ft
	Proposed	3.27 ft	0.00 ft

Local Detention Option

10-Year Design

Village of Flossmoor, Illinois



School District and Park District staff are open to the concept – neither board has been approached yet.

Storm	Scenario	Berry Ln	Viaduct
Sep 2019	Existing	2.14 ft	6.92 ft
	Proposed	0.00 ft	4.83 ft
10-Year	Existing	2.79 ft	6.30 ft
	Proposed	0.52 ft	0.35 ft
25-Year	Existing	3.20 ft	6.86 ft
	Proposed	2.60 ft	4.05 ft
100-Year	Existing	3.73 ft	7.28 ft
	Proposed	3.37 ft	7.13 ft

Cost = $7,240,000

ACOE Project – Phase 1

- ACOE Project Defined Early
- Upstream Project Works!
- Add Permeable Pavers

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Funding

- G.O. Bond Referendum was approved by voters for $10 million for Street Rehabilitation and Flossmoor Road Viaduct Drainage Improvements
- ACOE Section 219 Funding
- MWRD Green Infrastructure Partnership
- IEPA Green Infrastructure Grant Opportunity

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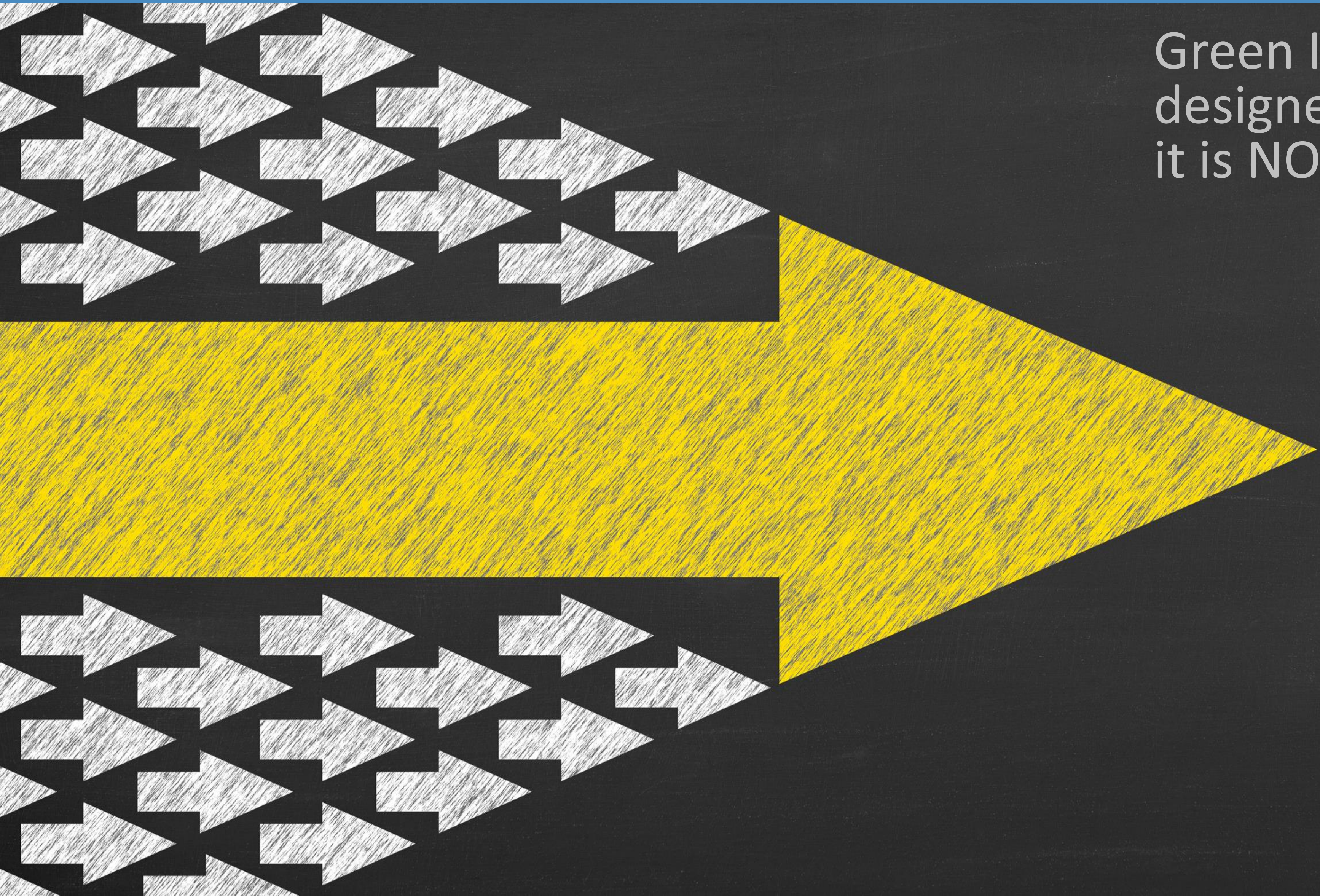
Comprehensive Design



Green Infrastructure must be designed as part of the system – it is NOT plug and play

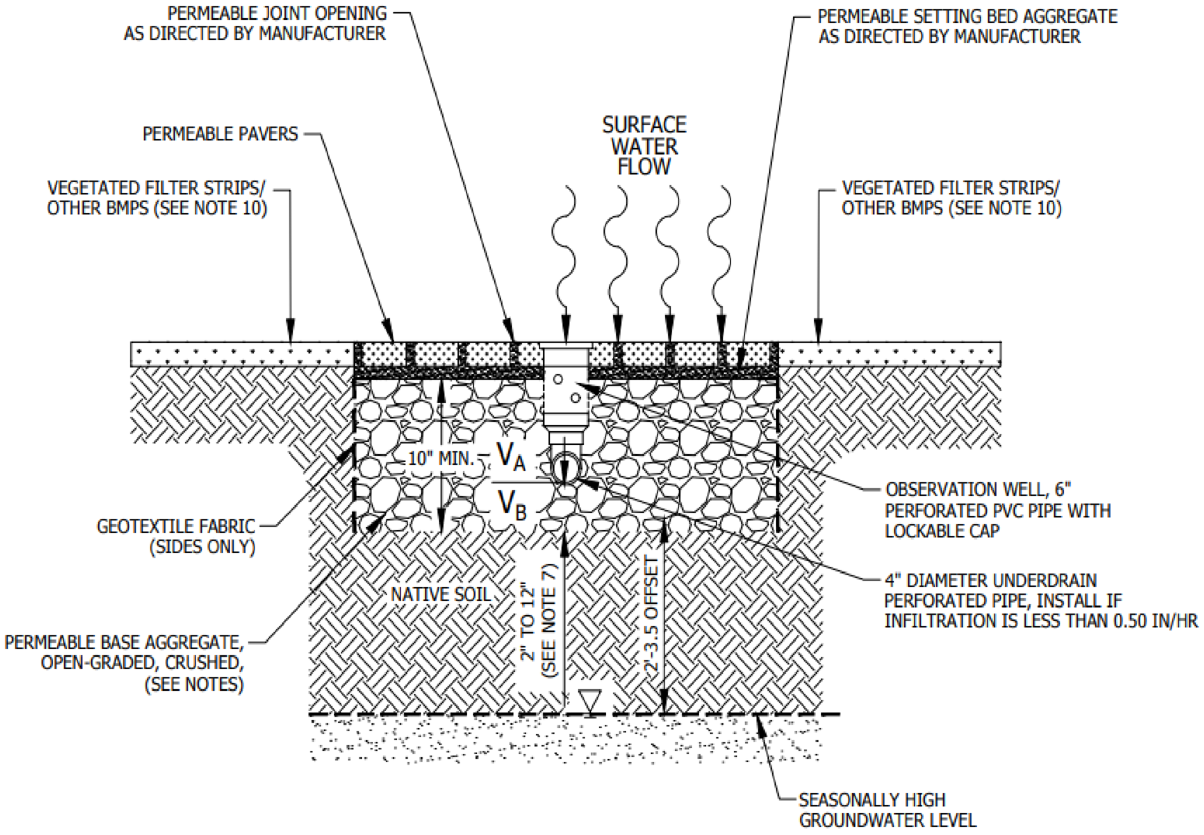
- Roadway System
- Stormwater System
- Environmental System

Advantages of Permeable Pavers

- Slows water, attenuates peak flow
  - Urban areas
  - Detention/infiltration
  - Water quality benefits
- Reduces outflow volume by increasing infiltration*
- Green infrastructure – advantageous for certain funding

Considering Context

Typical MWRD Detail



MWRD TGM, PERMEABLE PAVERS DETAIL, STD. DWG. NO. 9 (2018)

Not Plug and Play!

- Native Soils
- Hydrology/Hydraulics
- Terrain
- Outlet
- Neighborhood Practices

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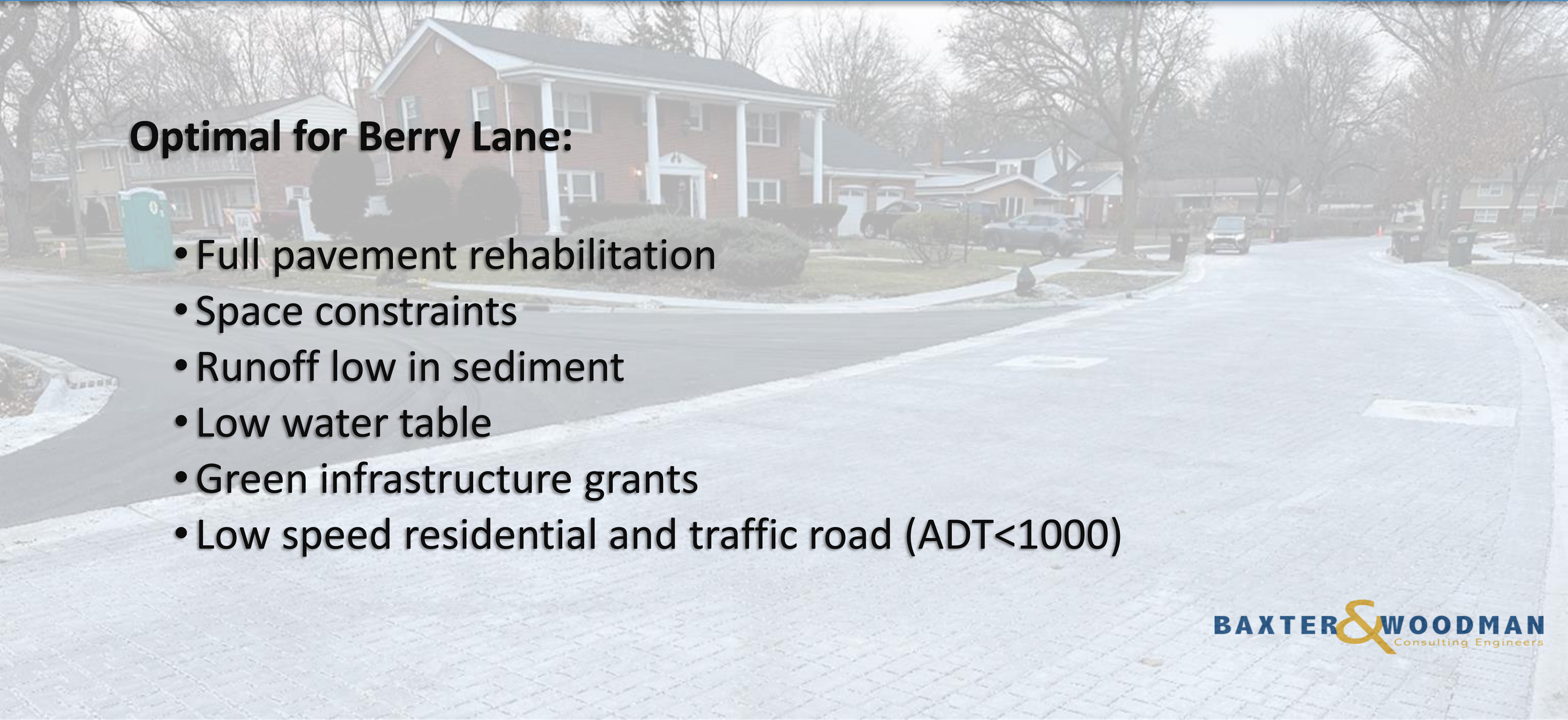
Model and Design for Environment & Situation



Optimal for Berry Lane:

- Full pavement rehabilitation
- Space constraints
- Runoff low in sediment
- Low water table
- Green infrastructure grants
- Low speed residential and traffic road (ADT<1000)

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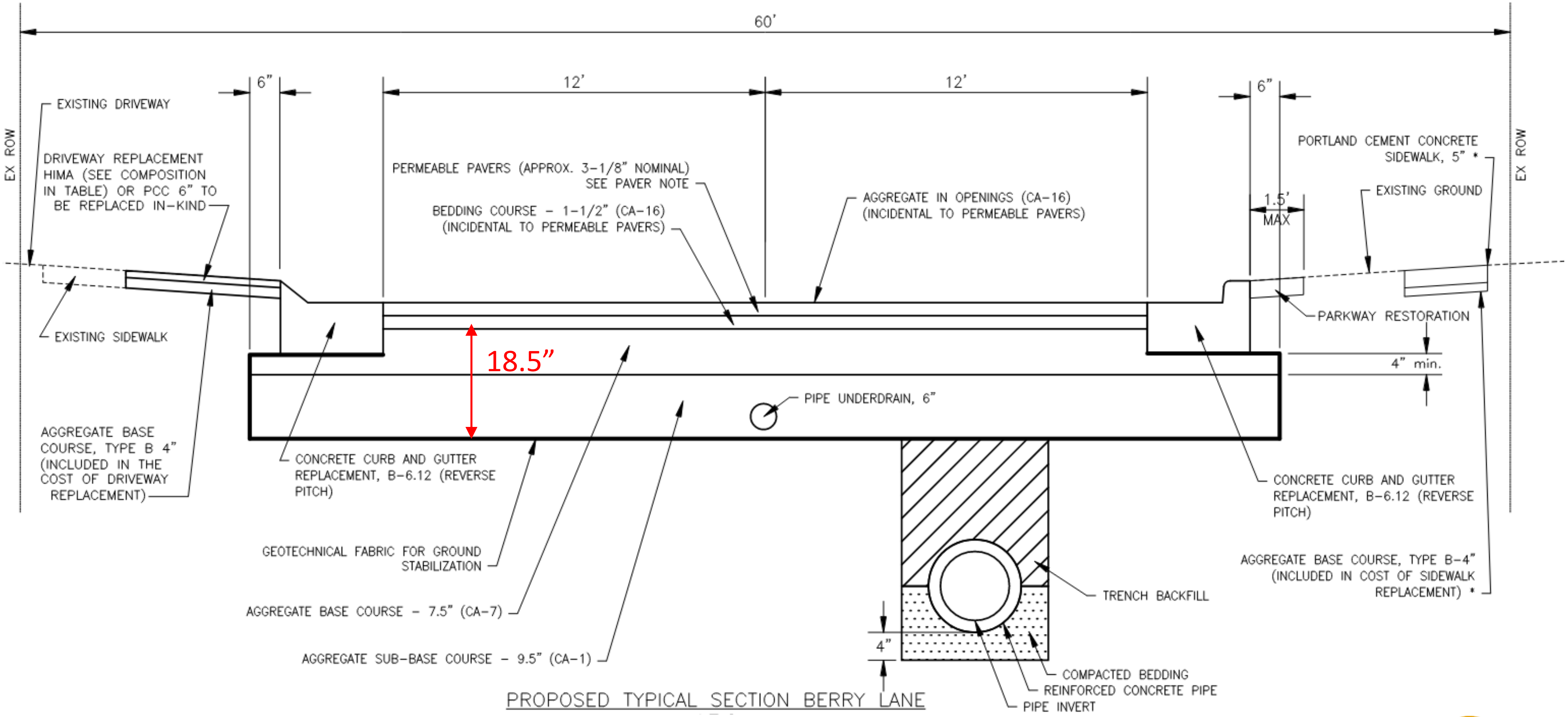
Berry Lane Example - Full Width Permeable Pavers



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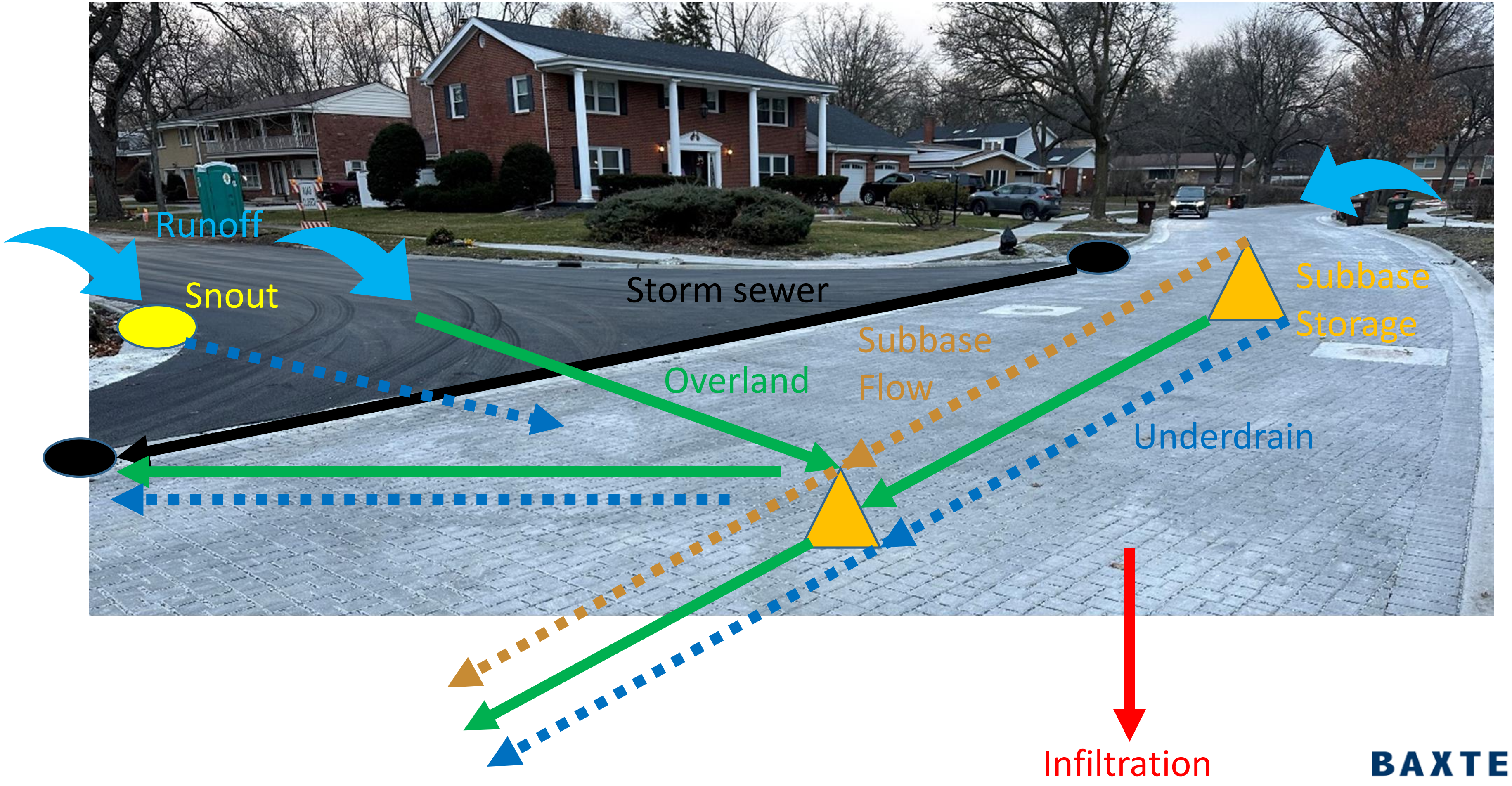
Modeling – Nitty Gritty



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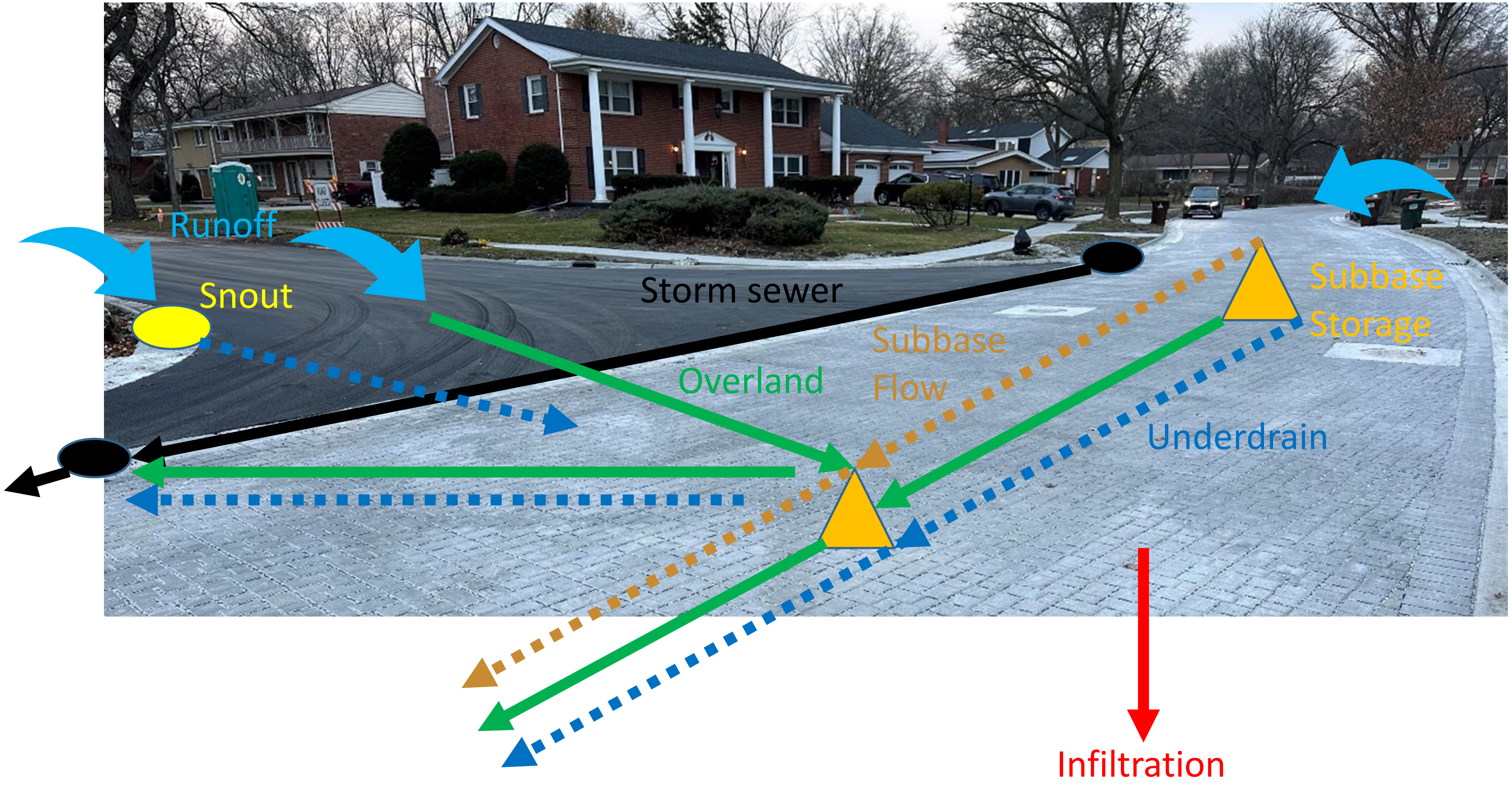
Model Setup

- Nodes
  - Inlets
  - Paver Sections
  - Manholes
- Links
  - Overland flow paths
  - Underdrains
  - Subbase flow
  - Infiltration
  - Stormwater Pipes



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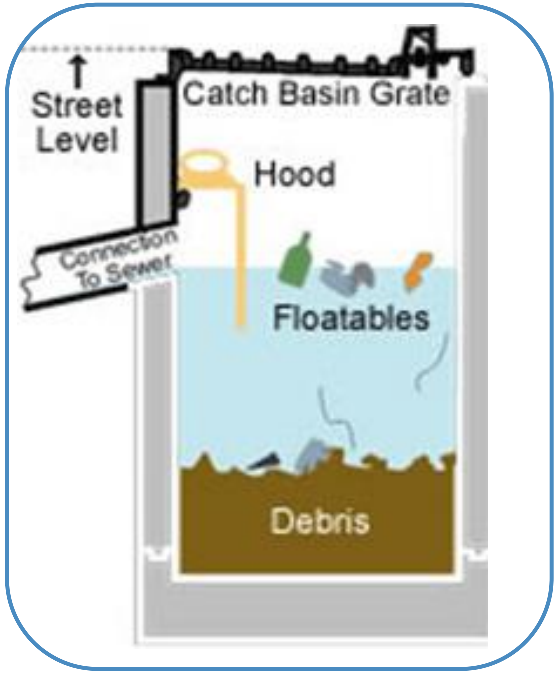
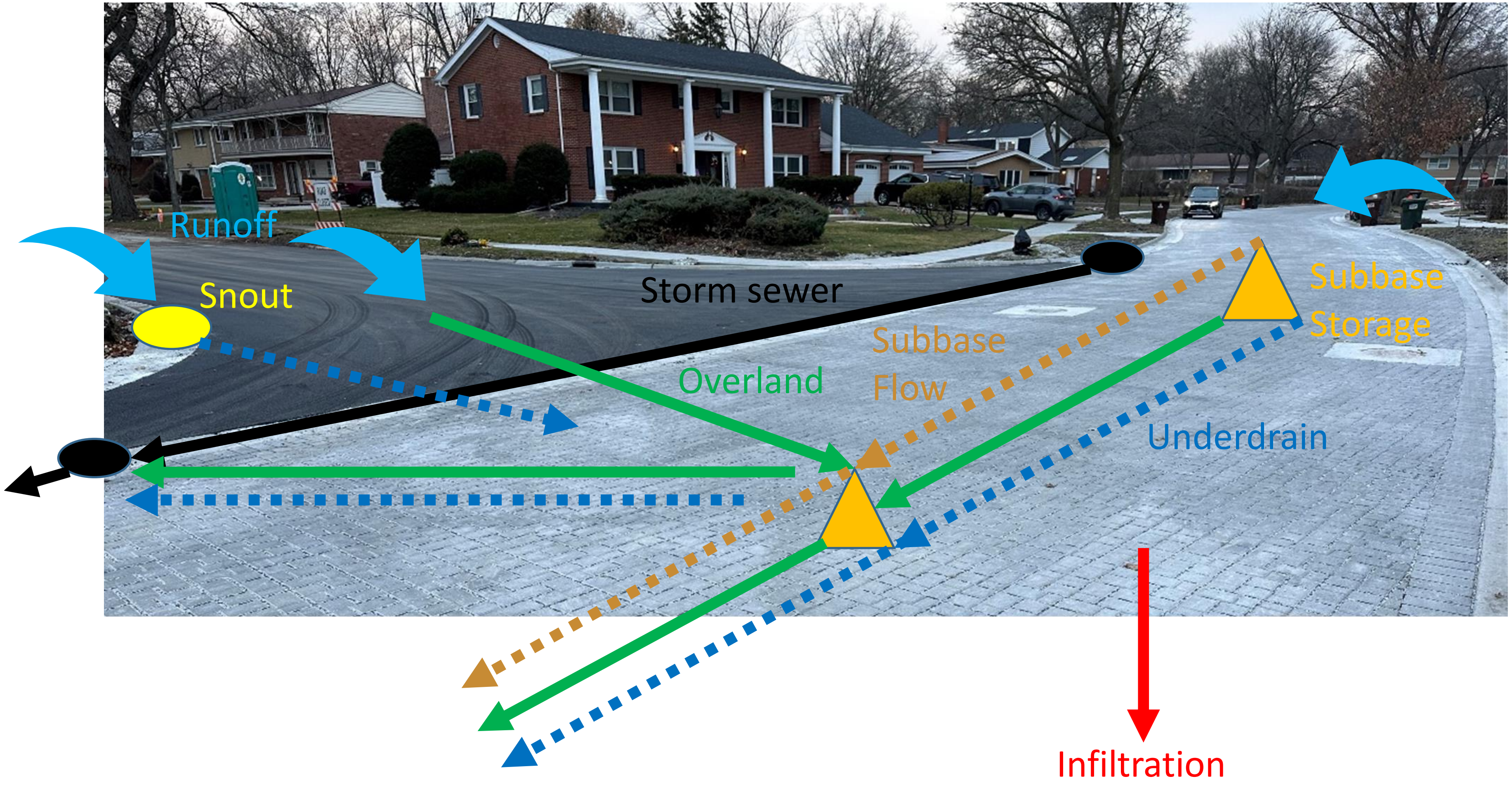
Interception of Off-Site Flows

- Direct runoff onto permeable pavers

- Side street flow
  - Inlet Pretreatment
  - Enter storage directly





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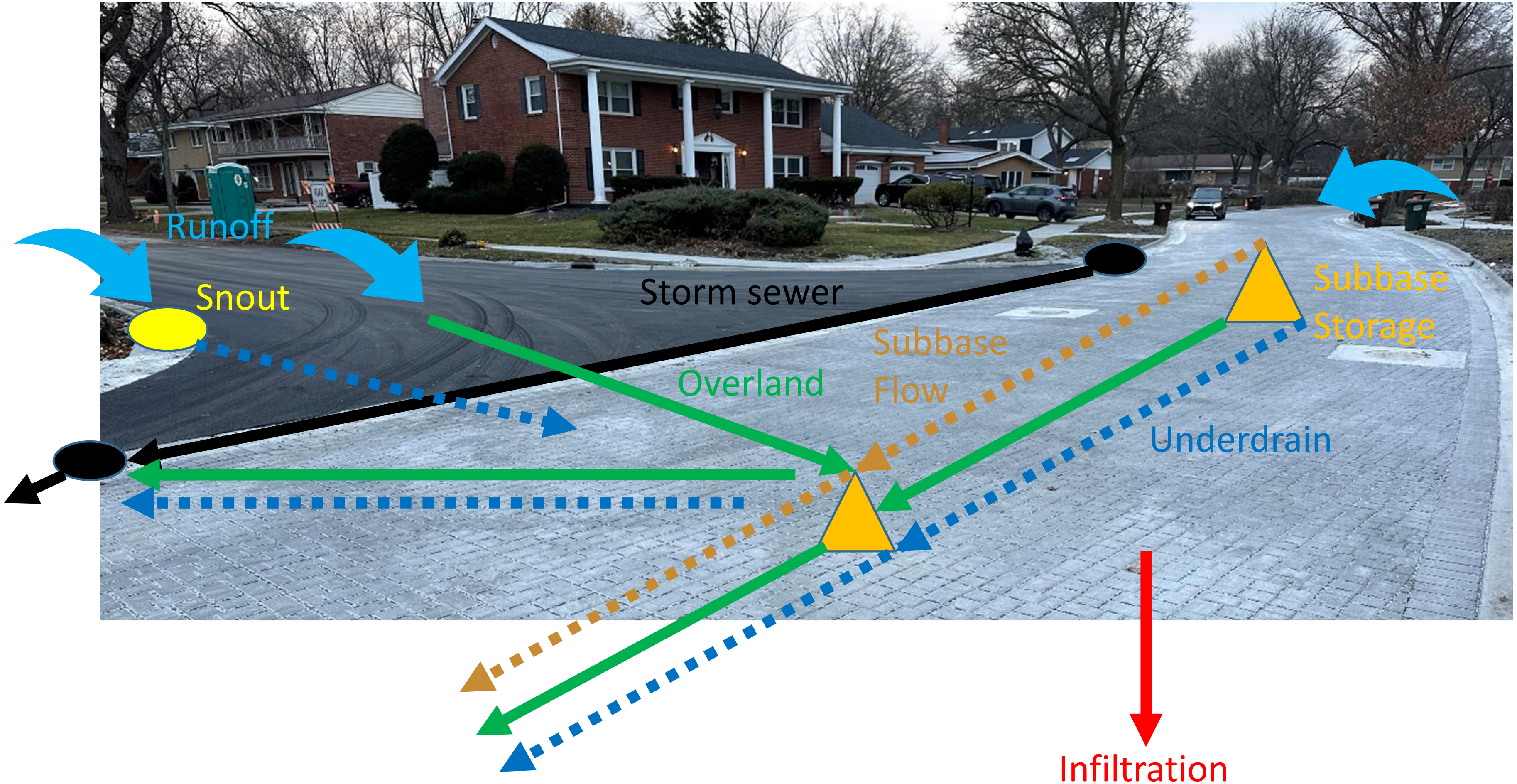
Lateral Flow through Subbase

- slow compared to pipe and overland flow
- Underdrains
  - Decrease drawdown time
- Subbase flow represented as conduit
  - Calibrate pipe size and Manning's n to flow calculated with Darcy's equation



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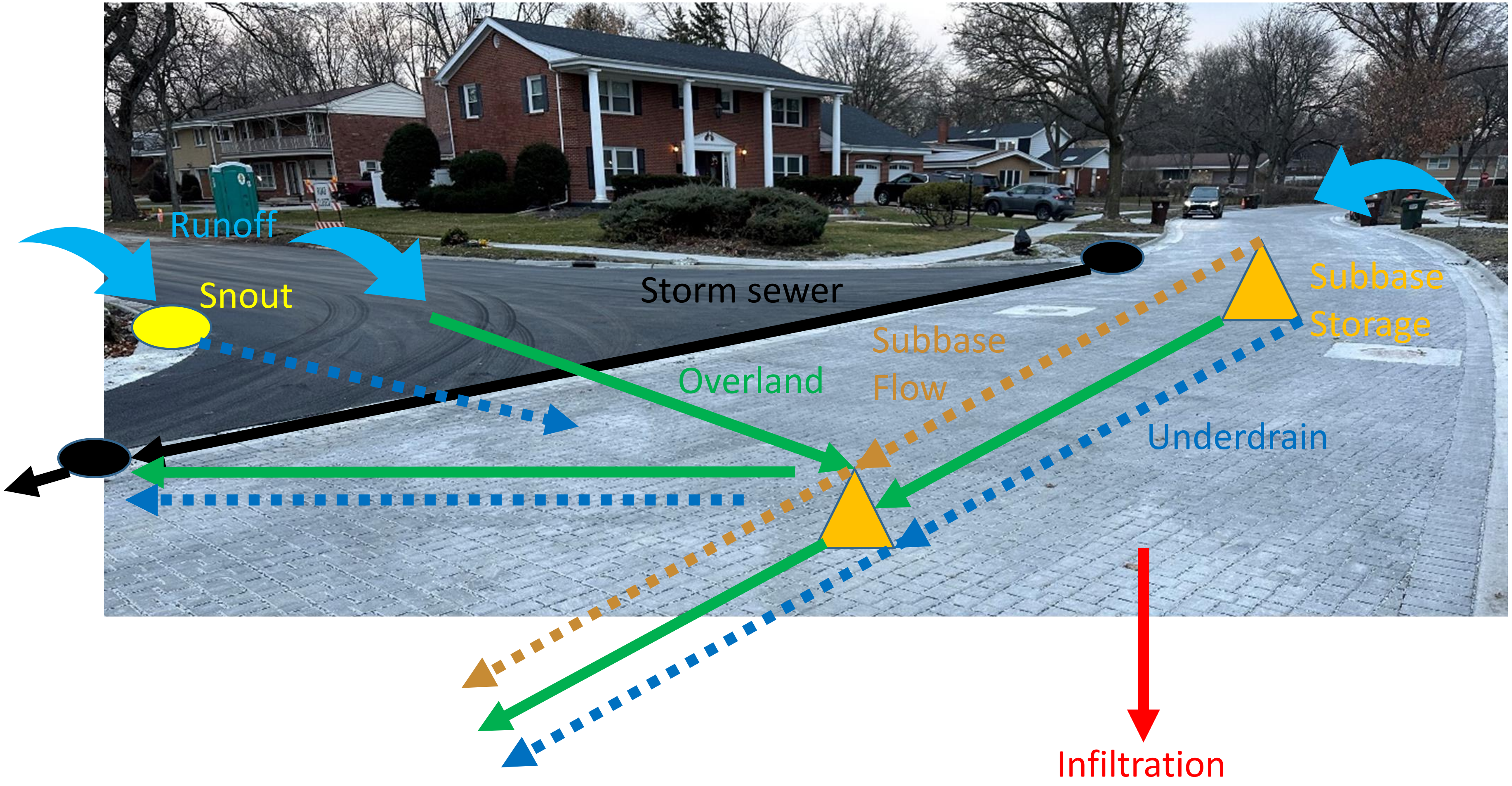
Overflow to Trunk Sewer

- Once subbase is fully saturated
- Overland flow connection between storage nodes and storm sewer
- Inlet capacity
  - Rating curve
  - Lower flow into storm sewer system at low ponding depths allows water to get into paver subbase



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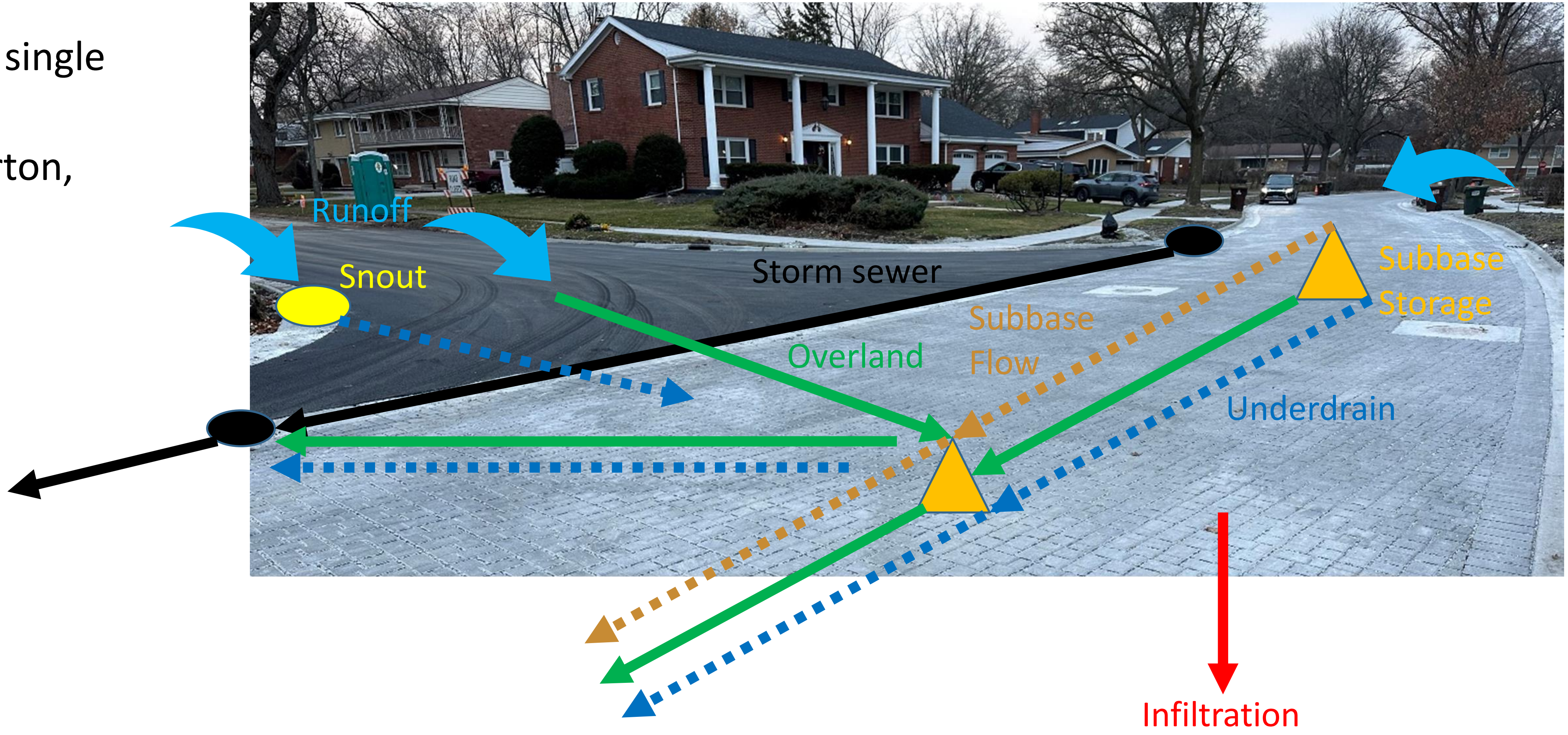
Infiltration

- Likely negligible for single storm event
- Calculated with Horton, Green-Ampt, etc.



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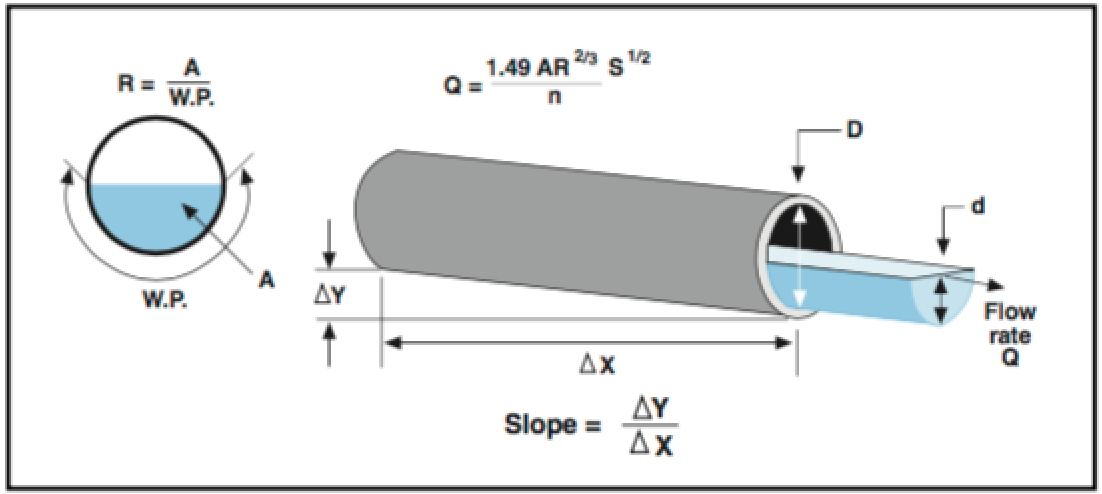
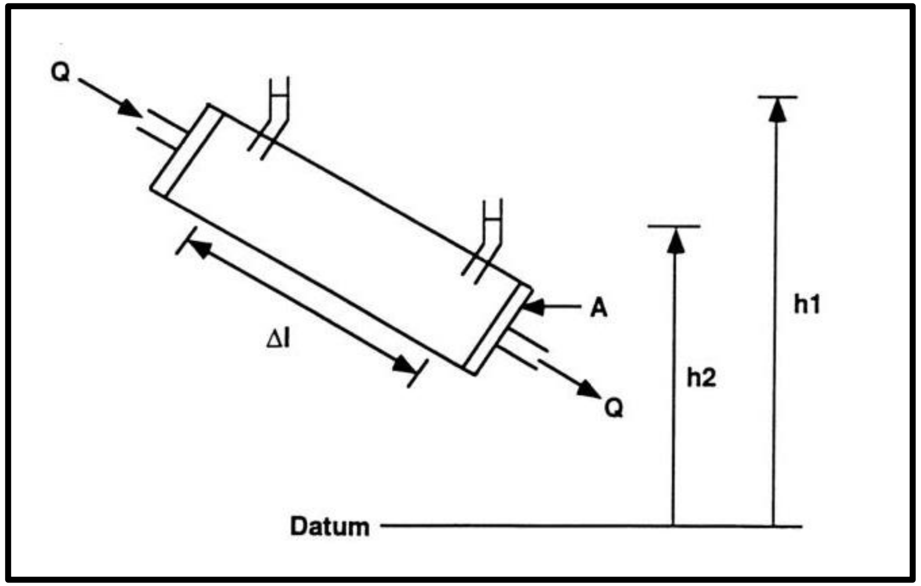
The Nitty Gritty



Manning Equation

$$Q = \frac{1.49}{n}\left(\frac{A_{Pipe}}{P}\right)^{\left(\frac{2}{3}\right)} S_0^{\left(\frac{1}{2}\right)} A_{Pipe}$$

S_0	= Pipe Slope
n	= Manning's n
A_{Pipe}	= Conduit Area
P	= Perimeter

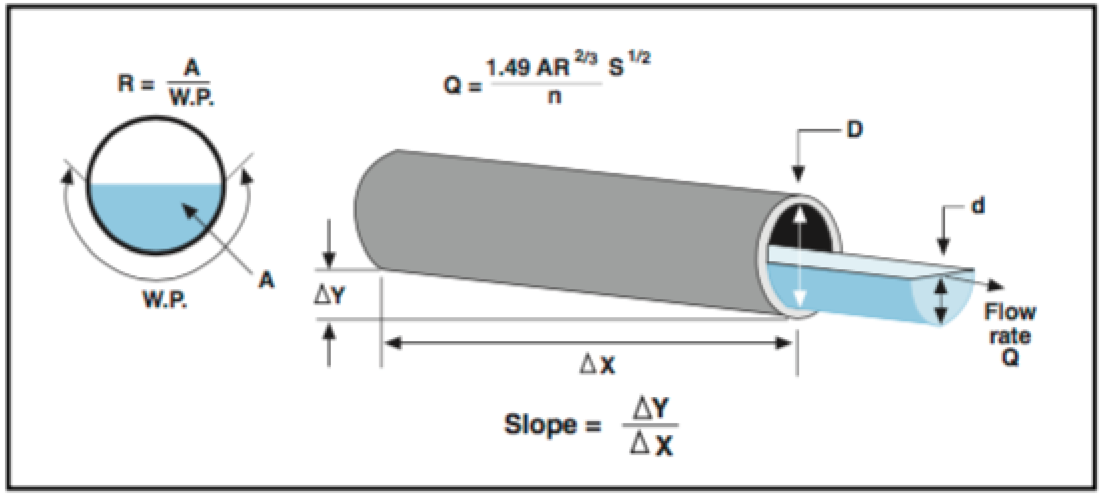


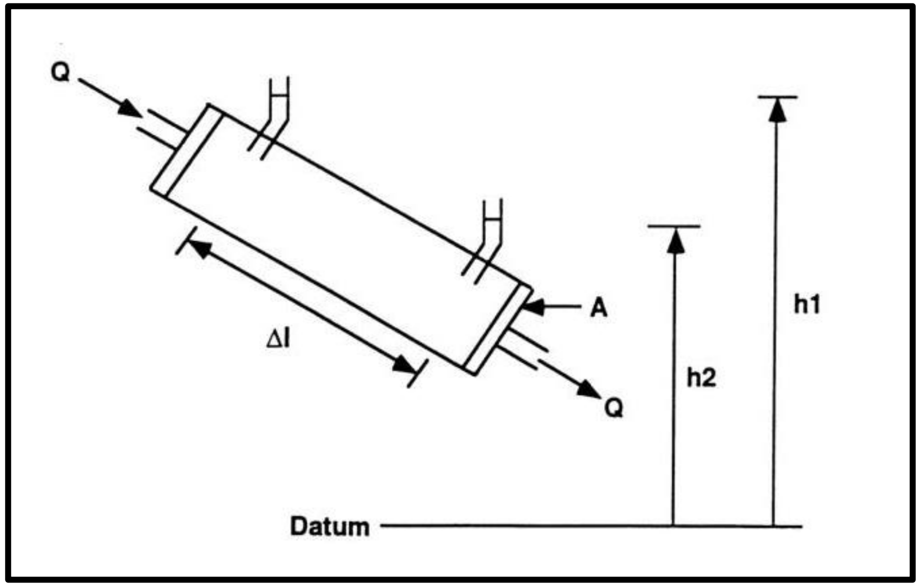
Darcy's Law

$$Q = K\frac{\Delta h_T}{L}A_D$$

K	= hydraulic conductivity
Δh_T	= Total change in head
L	= Segment Length
A_D	= Darcy Conduit Area

The Nitty Gritty





Manning Equation

$$Q = \frac{1.49}{n}\left(\frac{A_{Pipe}}{P}\right)^{\left(\frac{2}{3}\right)} S_0^{\left(\frac{1}{2}\right)} A_{Pipe}$$

S_0	= known
n	= unknown
A_{Pipe}	= unknown
P	= unknown

$$\frac{\left(\frac{A_{Pipe}}{P}\right)^{\left(\frac{2}{3}\right)}}{nA_{Pipe}} = K\frac{S_0^{\left(\frac{1}{2}\right)}}{1.49}A_D$$

Pipe size = calibration variable
n = calibration variable

Darcy's Law

$$Q = K\frac{\Delta h_T}{L}A_D$$

K	= known
Δh_T/L	= assumption (= S_0)
A_D	= known, actual XS area

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