



STANTEC CALGARY PRESENTS

CB MODELING

OR: HOW I LEARNED TO STOP WORRYING
AND LOVE THE FLOW-BY



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Intro



- This presentation will be a relatively nuanced presentation on the modeling of storm drains in Calgary. The Focus is entirely on how catch basins (CB)s are used in Calgary.
- Even if you're not from Calgary, I hope this will let you examine your own CB guidelines with a critical eye.

Agenda

- Catch Basin (CB) Basics
- Ponding CBs
- Mystery Factors
- Flow-by CBs
- Inlet Control Devices (ICDs)
- Take Aways
- Questions



Catch Basin (CB) Basics



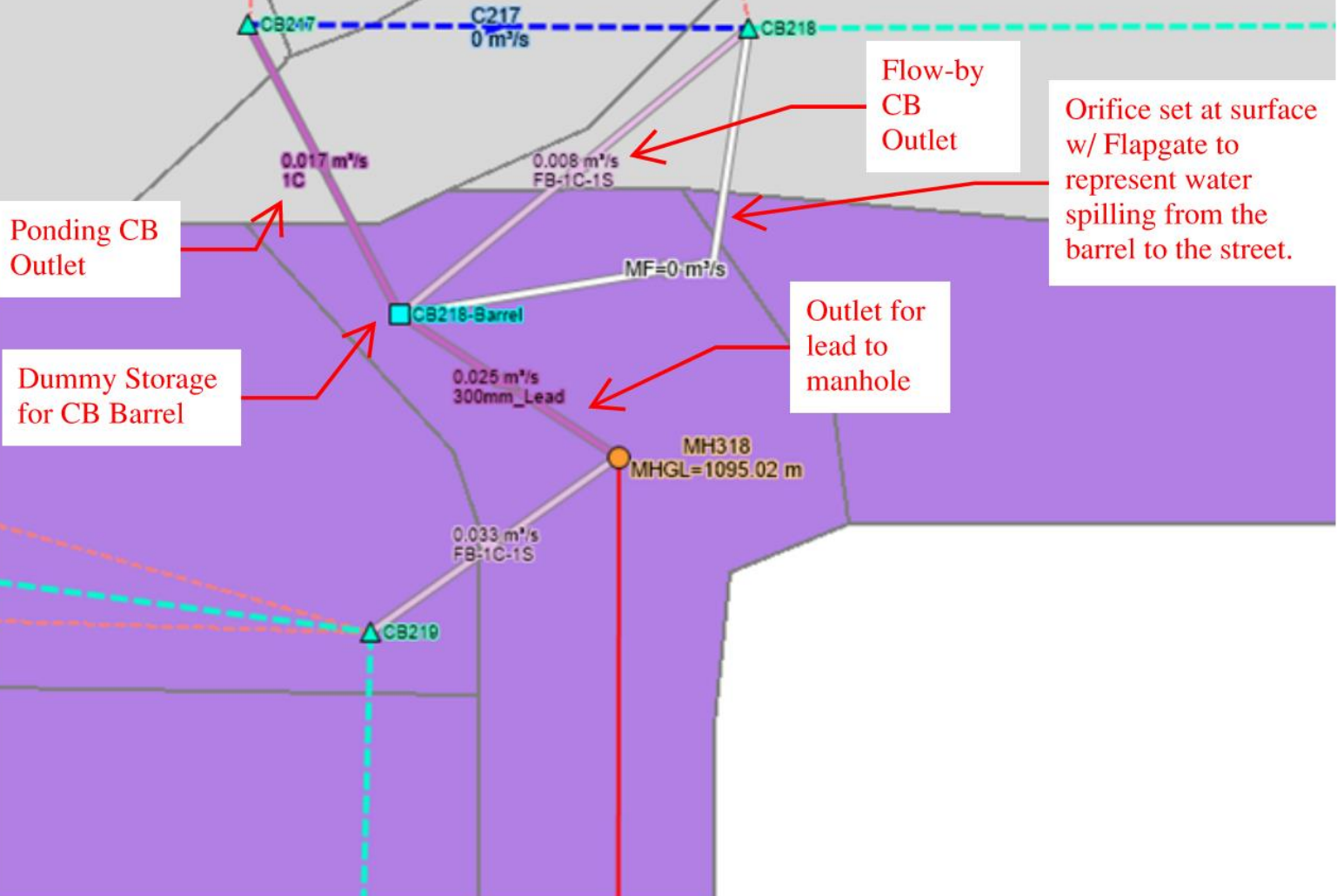
- Ponding CBs are set in a low-point.
- Flow-by CBs are set along a continuous grade.
- Interconnected CBs are when two CBs are connected via a lead before being connected to the storm sewer.
- CBs typically modeled with a storage node connected to MH by an outlet.
- CB curves are the relationship between depth/head of water above the CB, and capture rate.

3.3.4.4.2 Ponding Conditions

Table 3-17: Capture Rating Data for City of Calgary Catchbasins under Ponding Conditions¹⁶

Ponding Depth (m)	Capture Rates (L/s)				
	K2 Inlet	Grated Top Manhole	K3 Inlet	C Inlet	Twin C Inlet
0	0.0	0.0	0.0	0.0	0.0
0.10	98.4	52.4	77.9	110.3	201.2
0.20	149.8	74.2	110.1	149.8	209.7
0.30	155.5	90.8	134.9	155.5	217.8
0.40	161.0	104.9	155.7	161.0	225.7
0.50	166.3	117.3	166.3	166.3	233.2

Interconnected CB Arrangement



CB GOLDEN RULE

THOU SHALL NOT
COMBINE PONDING
AND FLOW-BY CURVES

Basic CB calculations

CBs curves are calculated based on the following elements.

1. CB Ponding Condition. (Ponding or Flow-by)
2. CB type used.
3. CB barrel depth
4. Lead Elements
 - Lead size, Lead Slope, Lead Length, Lead roughness.
 - The same again for interconnected leads.
5. ICD (Inlet Control Device) size

CAPACITY RATINGS FOR CITY OF CALGARY CBs, PONDING CONDITIONS																						
Based: November 6, 2008 calculations																						
					Type Inlet	Open Area (Standard Specifications Sewer Construction 2016, City of Calgary 2016)																
Added Barrel Size (mm)	0	mm			K2 Grate	0.1664	m ²	1 K2 CB is 2 K2 Grates (Ref. Page 186)														
Cd Orifice =	0.6		Nominal Lead Size (mm)	250.0	C Grate	0.1706	m ²	0.1853 = Value used														
Cd Weir =	1.656		ID for Lead (m)	0.25146	C Side Front	0.124	m ²	0.103 for Two Piece C Side Inlet														
Wall Thickness, 250 mm PVC =	0.008	m	z for Lead (m)	1.213	C Side Bottom	0.159	m ²															
Wall Thickness, 300 mm PVC =	0.009	m	a (ICD Notch) (m)	0.03	GTMH	0.124793	m ²															
Wall Thickness, 375 mm PVC =		m	ICD	No ICD	K3	0.1706	m ²	0.1853 = Value used														
ID for 250 mm PVC Lead Pipe =	0.251	m	z = Depth of CB																			
ID for 300 mm PVC Lead Pipe =	0.299	m	ICD Size	0																		
ID for 375 mm PVC Lead Pipe =	0.366	m	CB1 Type	C																		
z for 250 PVC Lead =	1.213	m	# of CBs	1	Slope of Interconnected Lead Pipe:	0.020	m/m	Stre														
z for 300 PVC Lead =	1.212	m	CB1 Offset (m)	0.000	Length of Interconnected Lead Pipe:	0.0	m															
z for 375 PVC Lead =	1.209	m	CB1 Capture Type	Ponding	Nominal Int-Lead Size (mm)	250.0																
Slope of Lead Pipe =	0.020	m/m	CB2 Type	0.0	ID for Int-Lead (m)	0.25146																
Length of Lead Pipe (m)	15.0	m	# of Int-CBs	1	z for Int-Lead (m)	1.213																
Manning n =	0.011		CB2 Offset (m)	0.000	Int - Manning n =	0.011																
Ke For Lead Pipe Inlet =	0.5		CB2 Capture Type	Ponding	Ke For Int - Lead Pipe Inlet =	0.5																
Reduction Factor for Grated Inlet	0.5																					
Reduction Factor for Curb Inlet	0.8																					
			K2	C	GTMH	K3																
Depth	Inlet Control		Outlet Control	K2 Grate	C Grate	C Side	C Total	GTMH	K3 Grate	ICD	Ponding Depth (m)		CB Capture - Main	Interconnect CB Inlet Control	Interconnect CB Outlet Control	CB Capture - Interconnected	ΣCB Intake	Final				
(m)	H (m)	Q (m ³ /s)	Q (m ³ /s)	Q (m ³ /s)	Q (m ³ /s)	Q (m ³ /s)	Q (m ³ /s)	Q (m ³ /s)	Q (m ³ /s)	H (m)	Q (m ³ /s)	CB1	CB2	Q (m ³ /s)	H (m)	Q (m ³ /s)	Q (m ³ /s)	Q (m ³ /s)	Q (m ³ /s)	Depth (m)	Q (m ³ /s)	
0.00	1.088	0.138	0.144	0.000	0.000	0.000	0.000	0.0000	0.000	1.18	0.000	0.0000	0.0000	0.000	1.088	0.138	0.176	0.000	0.000	0.000	0.000	0.000
0.01	1.098	0.138	0.145	0.023	0.025	0.001	0.026	0.0166	0.025	1.19	0.000	0.0100	0.0100	0.026	1.098	0.138	0.177	0.000	0.026	0.010	0.026	0.026
0.02	1.108	0.139	0.146	0.034	0.035	0.003	0.038	0.0235	0.035	1.20	0.000	0.0200	0.0200	0.038	1.108	0.139	0.178	0.000	0.038	0.020	0.038	0.038
0.03	1.118	0.140	0.146	0.044	0.043	0.005	0.048	0.0287	0.043	1.21	0.000	0.0300	0.0300	0.048	1.118	0.140	0.179	0.000	0.048	0.030	0.048	0.048
0.04	1.128	0.140	0.147	0.052	0.049	0.008	0.057	0.0332	0.049	1.22	0.000	0.0400	0.0400	0.057	1.128	0.140	0.180	0.000	0.057	0.040	0.057	0.057

Drainage Curves

From these factors, the following flow rates are determined:

- CB capture rate at surface
- Lead inlet and outlet flow capacities.
- ICD flow capacity.
- Flow capacities assume the CB barrel is filled with water. While this is not accurate. Given the extremely small volume of a CB barrel, it is a useful approximation for any storm event worth modeling.
- For any given depth, the smallest of the four calculated values is taken as the capture rate for that CB.



Calgary Drainage Curves

- Drainage Curves are given in the City of Calgary – Water Resources – Stormwater management & Design Manual
- Source is Stantec Consulting circa 1996.

3.3.4.4.2 Ponding Conditions

Table 3-17: Capture Rating Data for City of Calgary Catchbasins under Ponding Conditions¹⁶

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3.3.4.4.1 Flow-by Conditions

Table 3-16: Capture Rating Data for City of Calgary Catchbasins under Flow-by Conditions¹⁵

K2 CB		K3 CB		C CB	
Street Flow (L/s)	Capture (L/s)	Street Flow (L/s)	Capture (L/s)	Street Flow (L/s)	Capture (L/s)
0	0.00	0	0.0	0	0.0
8	8.00	6	6.0	9	9.0
15	10.6	10	7.6	15	12.7
25	12.8	25	10.8	25	16.5
50	15.7	50	15.5	50	23.0
75	18.2	75	19.6	75	28.2
100	24.4	100	23.5	100	32.8
200	39.6	200	35.2	200	48.0
300	48.4	300	42.2	300	61.1
500	59.6	500	51.0	500	79.3
1000	74.7	1000	63.0	1000	104.0



Ponding CB Calcs

- Bottom Openings use Orifice Equation
- Side Openings use Weir Equation
- Total Combined Open area is used.
- Reduction Factors are applied.
 - Likely a clogging factor, but actual reason can only be inferred.

Problems with Ponding CB Calcs

- Outdated Information
- Assumed Orifice Flows for all ponding flow conditions,
 - Weir flow may be more appropriate for low flows
- Lack of Proper Sourcing resulting in Mysterious Reduction Factors



The Case of the Mystery Factors

- The Reduction Facts have no proper sourcing
 - Almost certainly Clogging Factors
- They are not “Factors of Safety” they are “Factors of Wrongness”
- With Storm Drainage, less Capture is not always safer than more capture.



Why the Mystery?

The Calgary CB calcs are older than I am.

Reduction factors probably based on "Capacities of Catch basin Inlets - Based on Use in Alberta" (Dave Wilson, Sept 1983, p.22)

This Dave Wilson references these values to "Urban Storm Drainage Criteria Manual, 1969" (No Author or Publisher given).

Denver did put out a manual by that name in 1969.

Have not been able to yet obtain the original 1969 version. Newer versions have reduction factors, but they are different and used differently. And are themselves improperly sourced. (No reference to Guo 2000a)

(◡ ◡) ◡ — —

Suggested Revisions for Calgary Ponding CBs

Compute Low Flows	Compute Weir Flow and Orifice Flow separately
Revise and Source	Revise and source reduction factors.
Consider Clogging	Consider policy on Clogging Factors for CBs.
Update	Update C-CB calculations to reflect the "C" type CB rather than the "K1"

Flow-bys

- Nobody likes Flow-bys. At best, they are a necessary evil.
- Flow-bys will (almost) never capture all the passing flow
- In Calgary, Flow-By curves are given as “Overland Flow Rate vs. Capture Rate”
- Issues with sourcing original calculations

3.3.4.4.1 Flow-by Conditions

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8	8.00	6	6.0	9	9.0
15	10.6	10	7.6	15	12.7
25	12.8	25	10.8	25	16.5
50	15.7	50	15.5	50	23.0
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100	24.4	100	23.5	100	32.8
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300	48.4	300	42.2	300	61.1
500	59.6	500	51.0	500	79.3
1000	74.7	1000	63.0	1000	104.0



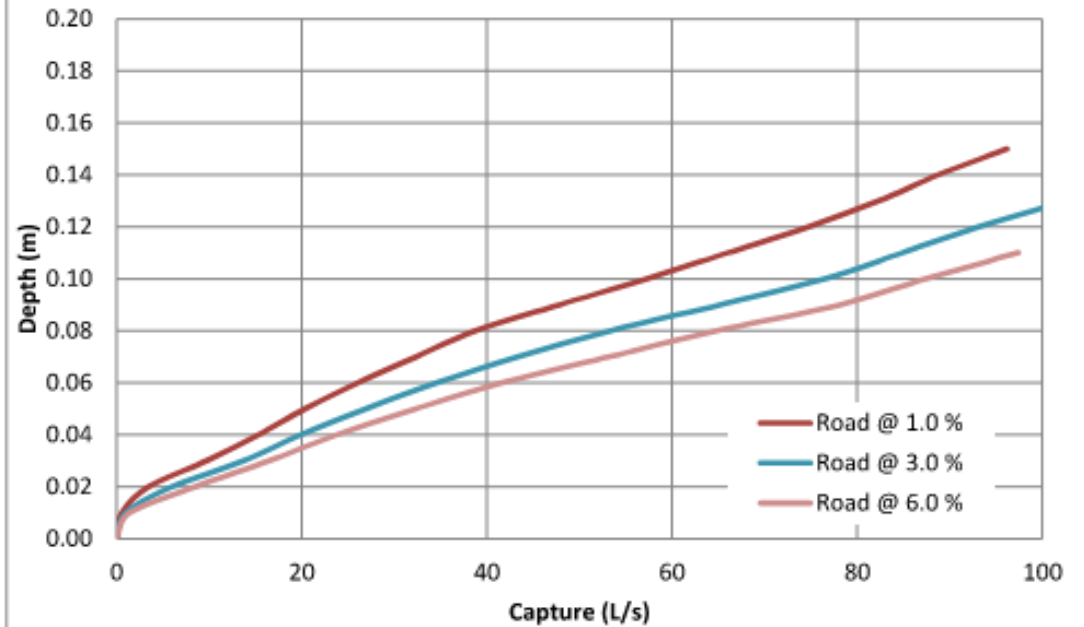
1-Sided vs. 2-Sided vs. Super Elevated Flows

- The same flow rate will produce different flow depths depending on different flow path cross sections.
- Usually, a CB only captures flow coming down a single side of the street.
- An exception for modeling purposes is interconnected CBs. Since the outlet curve models the connection between the surface and the sewer, it only cares how many sides of the street total are captured, from the main lead's perspective. An interconnected CB set up with CBs on both sides of the street can use 2 Sided Flows.
- A Super Elevated street Cross-Section might be a bit different than a 1-sided Street Cross-Section

The Problem With Slopes

- One of the issues with the conversion of “Flow Rate v. Capture” to “Depth v. Capture” is that it results in Capture rate increasing as Slope increases.
- Doesn't make sense with either theory, or empirical testing.
- A CB on a perfectly flat grade will capture for more water than a CB on a wall next to a waterfall.

Figure 3 - Type 'C' Flowby Capture Rating:
9.5m Road





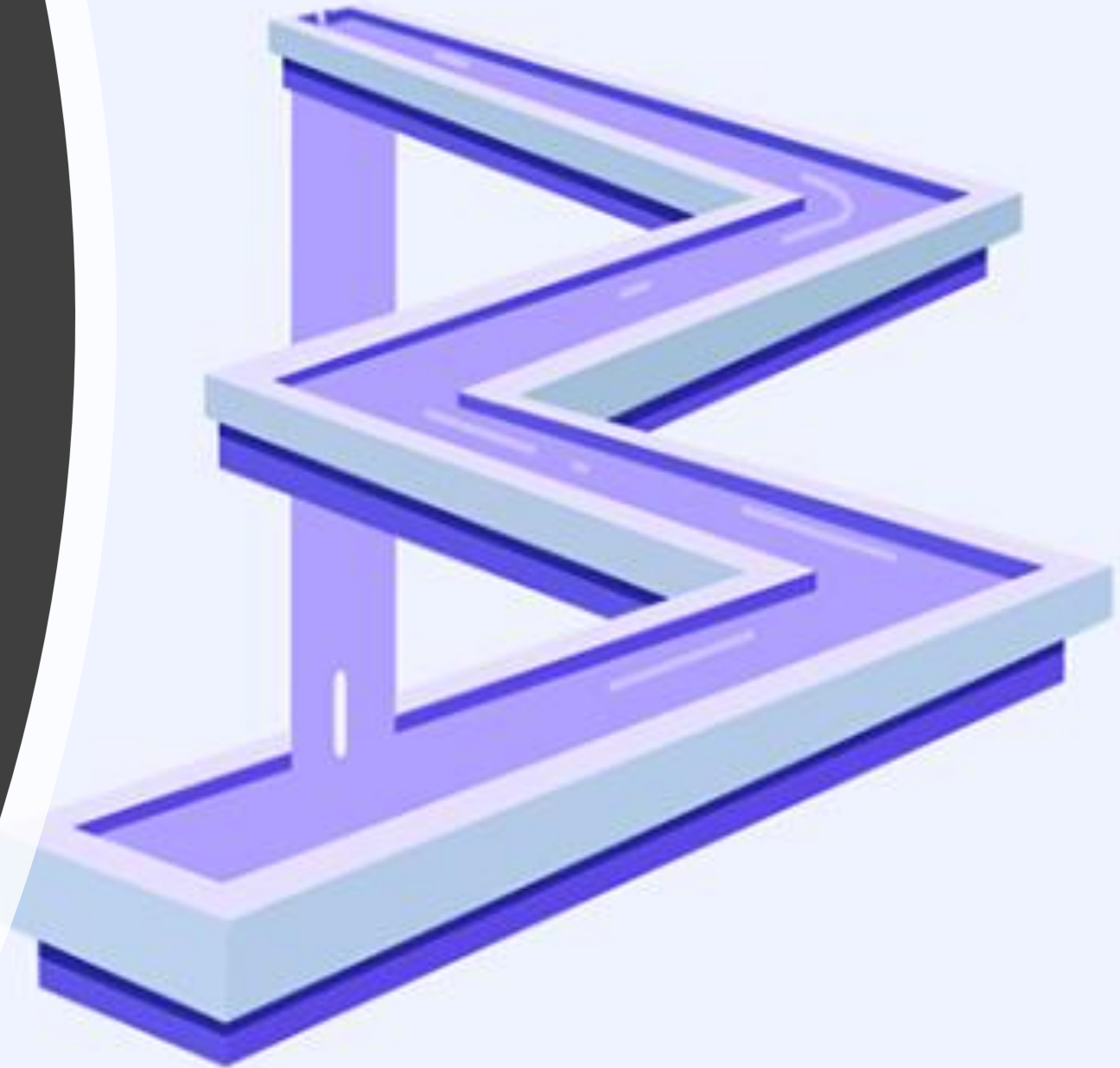
Inlet Control Devices (ICDs)

- ICDs are commonly used in Calgary
- This is due to Calgary's focus on using surface ponding.
- ICDs restrict flow into the CB's lead pipe.



ICD Quirks

- The guideline ICD curves in Calgary come from empirical testing, rather than mathematical modeling. (ICD Testing Results, Rev 1995=)
- Based on the empirical testing, the Calgary ICD curves assume some amount of flow goes around and behind the ICD plate, rather than through the ICD orifice.
- Sadly, Calgary R30s are not the key to perpetual motion, despite an apparent discharge coefficient > 1 .
- $Q(R30) \approx 20 \text{ L/s}$ $Q(R30 \text{ Bolted}) \approx 8 \text{ L/s}$



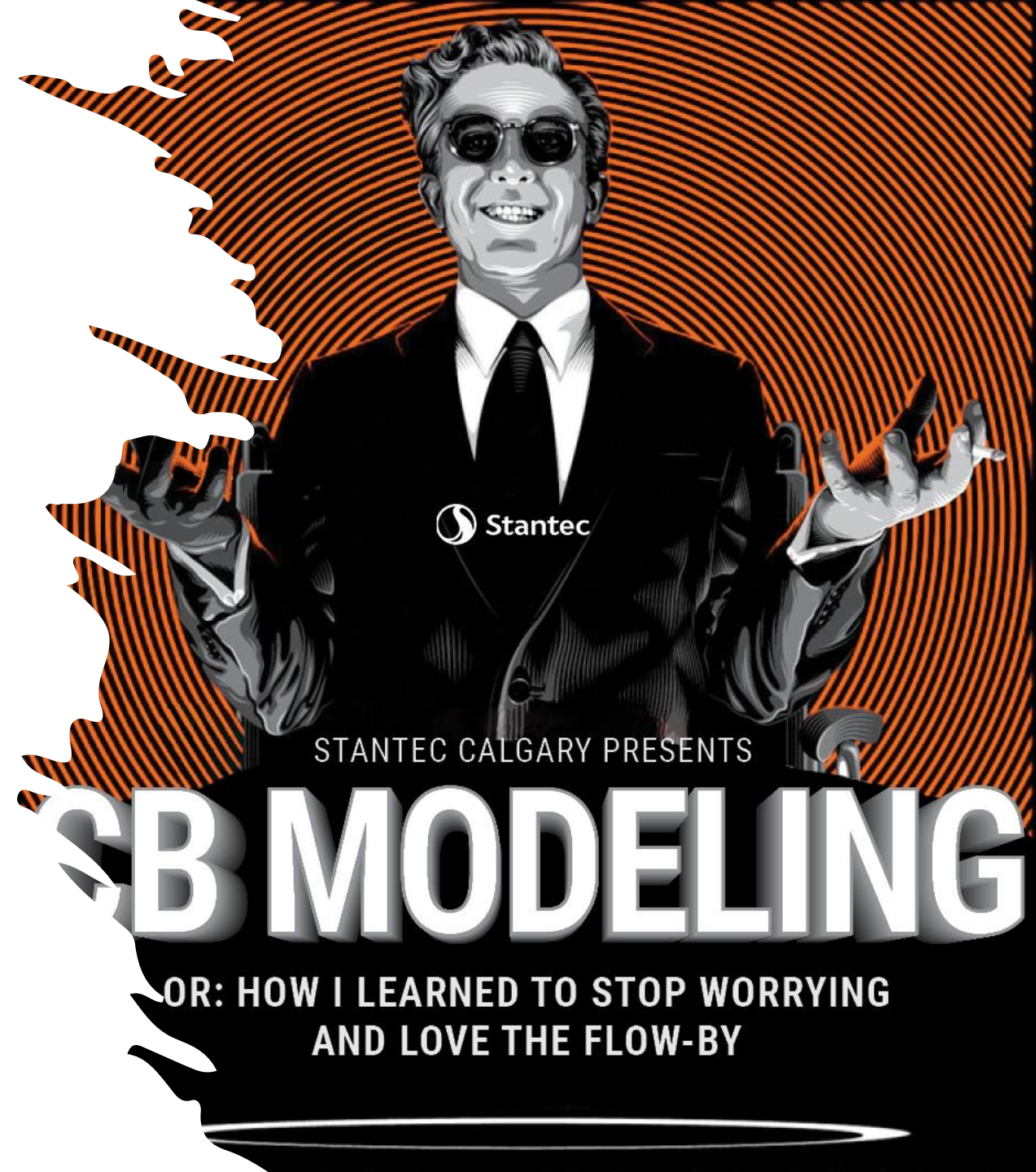


Take Aways

- There is a lot that goes into CB calculations.
- Being in the guidelines doesn't make it true or up to date.
- Sourcing is important.
- Trust but verify.

Sources

1. The City of Calgary; Standard Specifications Sewer Construction; 2016
2. The City of Calgary - Water Resources; Stormwater Management & Design Manual; September 2011
3. City of Calgary – Engineering & Environmental Services – Sewer Division; ICD Testing Results; Revised November 1995
4. Stantec Consulting Ltd. (formerly IMC Consulting Group); Application of DDSWMM with EXTRAN Linkage; September 1996.
5. Urban Drainage and Flood Control District, Denver, Colorado 80211; Urban Storm Drainage Criteria Manual" Volume 1 Management, Hydrology and Hydraulics; Updated January 2016



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