Okotoks Bioretention Research:

The Effects of Plants and Media on the Performance

2018-09-21

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Bioretention Performance

To date, successes and challenges have been observed and documented

Successes include reliable peak flow reductions, overall runoff volume reductions, and consistently high (80-90 %) TSS removals

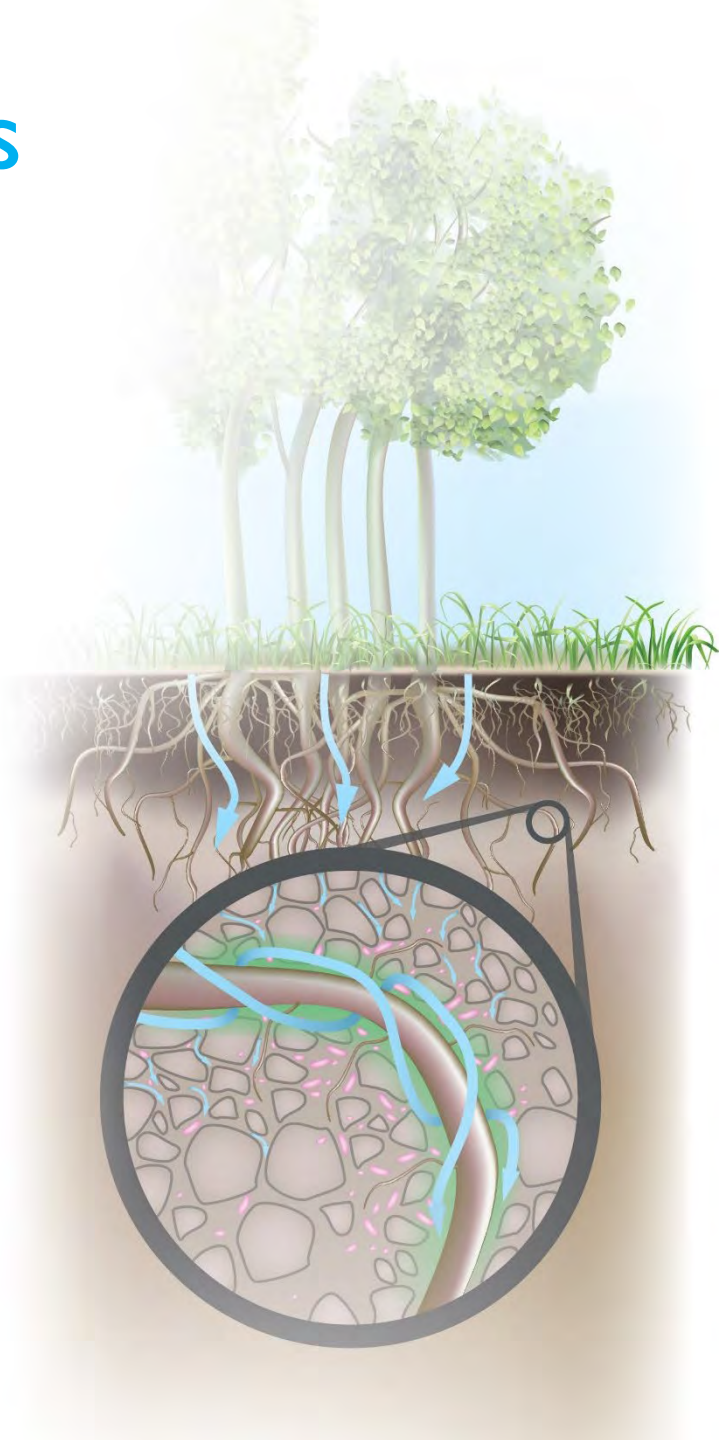
Challenges include highly variable nutrient removals, media clogging, vegetation failure, and unpredictable variation with time

Plants + Soil Interactions

Complex biogeochemical interactions

Crucial impacts on soil structure, microbial communities, retention or breakdown of water and contaminants

How would it impact bioretention performance?



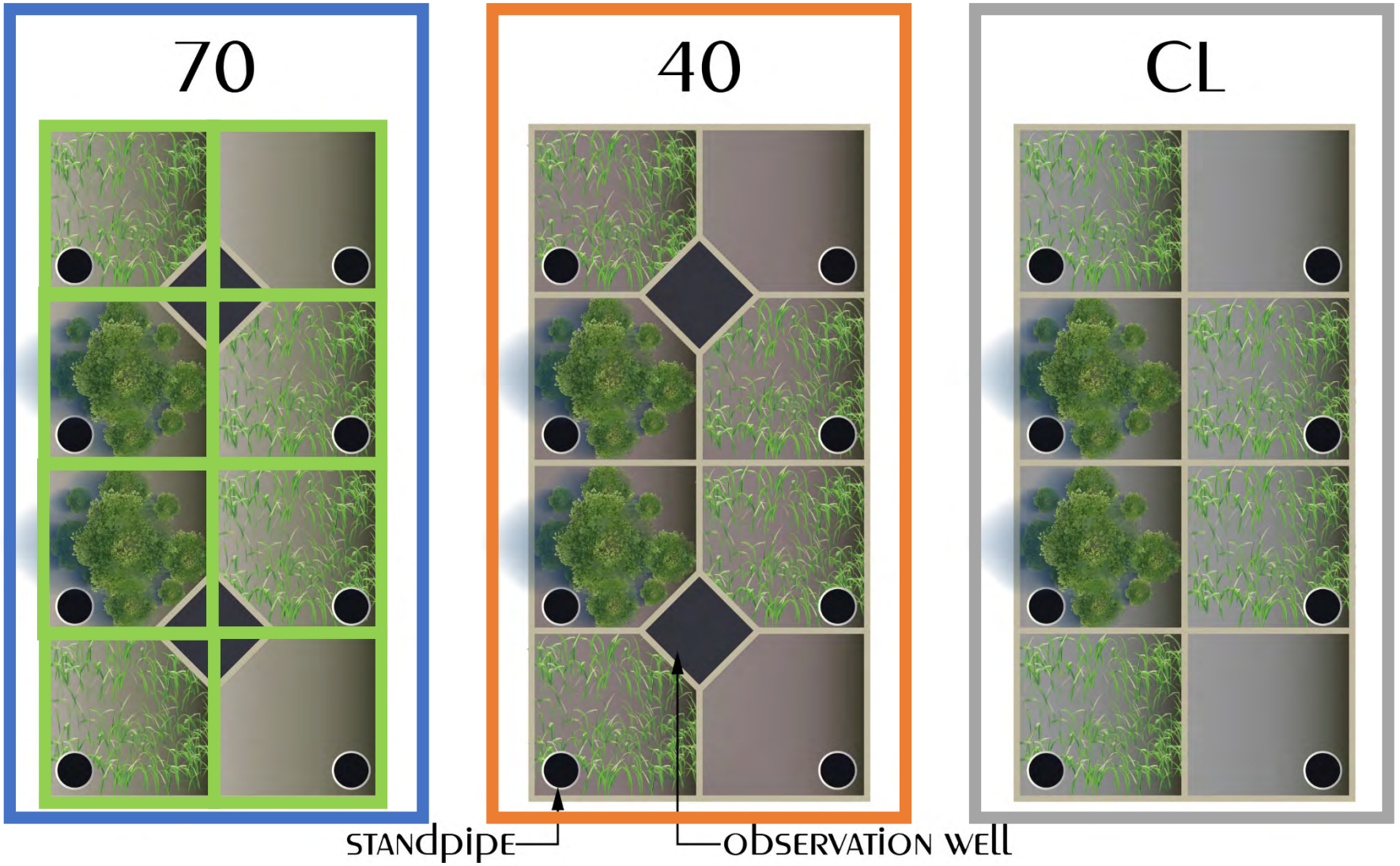
This Project's Objectives

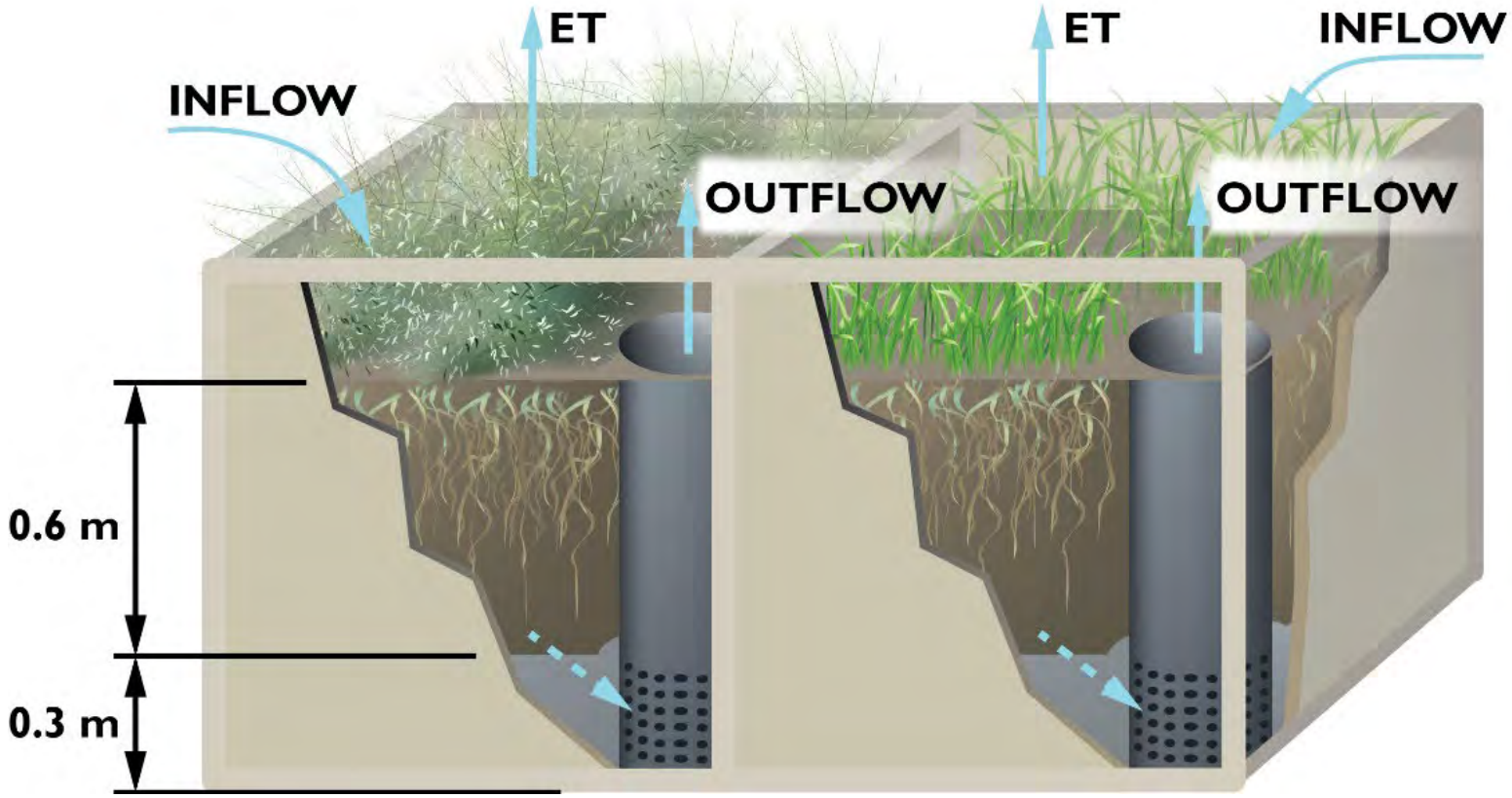
1) Investigate the effect of three different soil media and plant communities on water and nutrient retention and to analyze the impact of accumulating sediment

2) Quantify the effect of plant roots on the media.

3) Quantify the effect of plant transpiration on the bioretention performance.

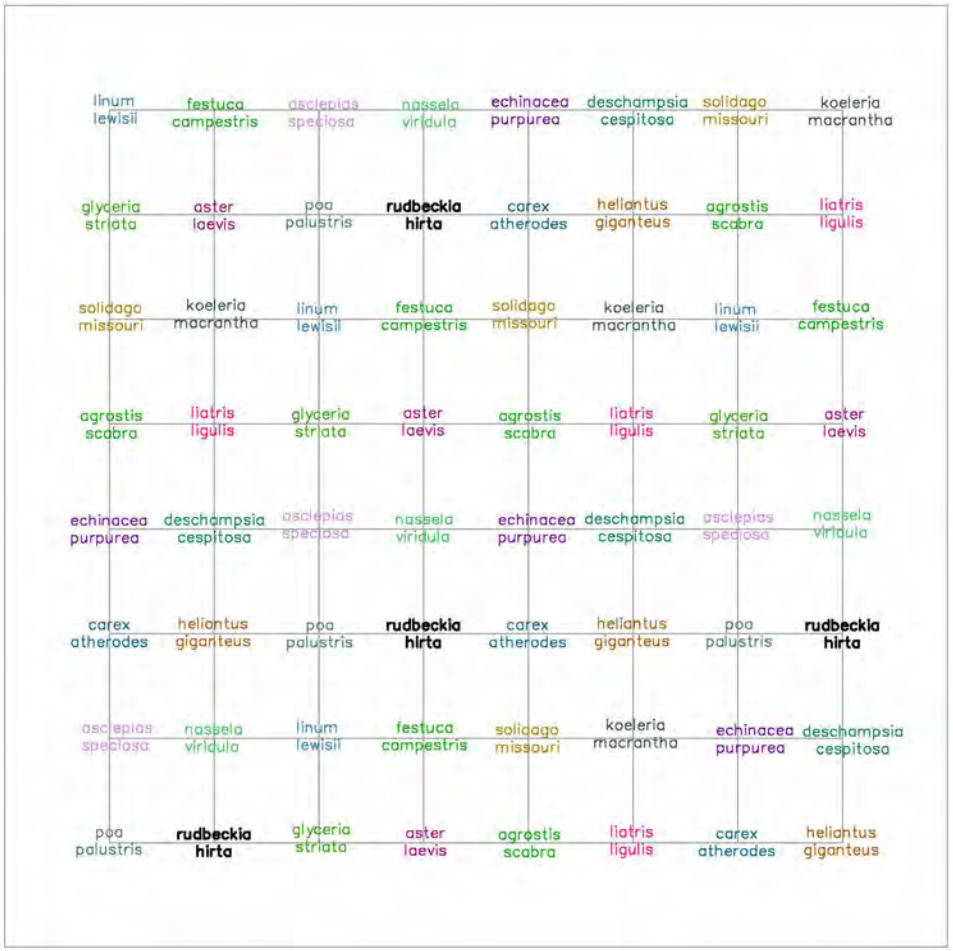
4) Develop an empirical tool/model to predict soil-plant impacts on bioretention performance.


70
40
CL
STANDPIPE
OBSERVATION WELL


ET
ET
INFLOW
INFLOW
OUTFLOW
OUTFLOW
0.6 m
0.3 m

Construction-2017

- Construction of bioretention cells completed by June 10th
- All beds were lined
- 300 mm of drainage layer placed (drainage rock, pea gravel, sand)
- 600 mm of media placed in 200 mm lifts



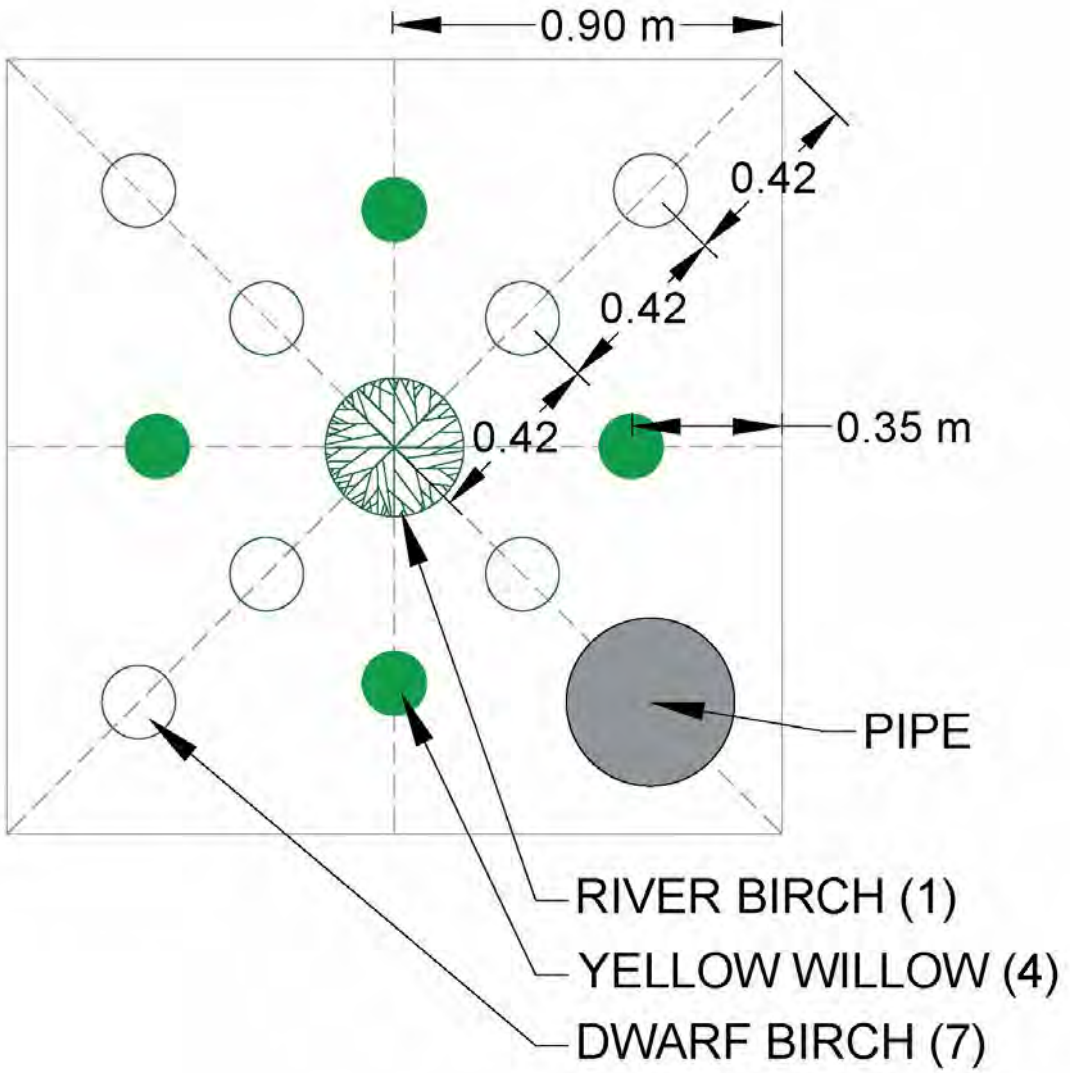
Forbs:

Blue flax
Showy milkweed
Purple coneflower
Missouri goldenrod
Smooth aster
Black-eyed Susan
Tall sunflower
Meadow blazingstar

Grasses:

Foothills fescue
Green Needle Grass
Tufted Hairgrass
June Grass
Fowl Manna Grass
Fowl Bluegrass
Awned Sedge
Rough Hair Grass


June 09, 2017


0.90 m
0.42
0.42
0.42
0.35 m
PIPE
RIVER BIRCH (1)
YELLOW WILLOW (4)
DWARF BIRCH (7)


June 20, 2017

July 11, 2017

July 04, 2018

2017 Preliminary Experiments

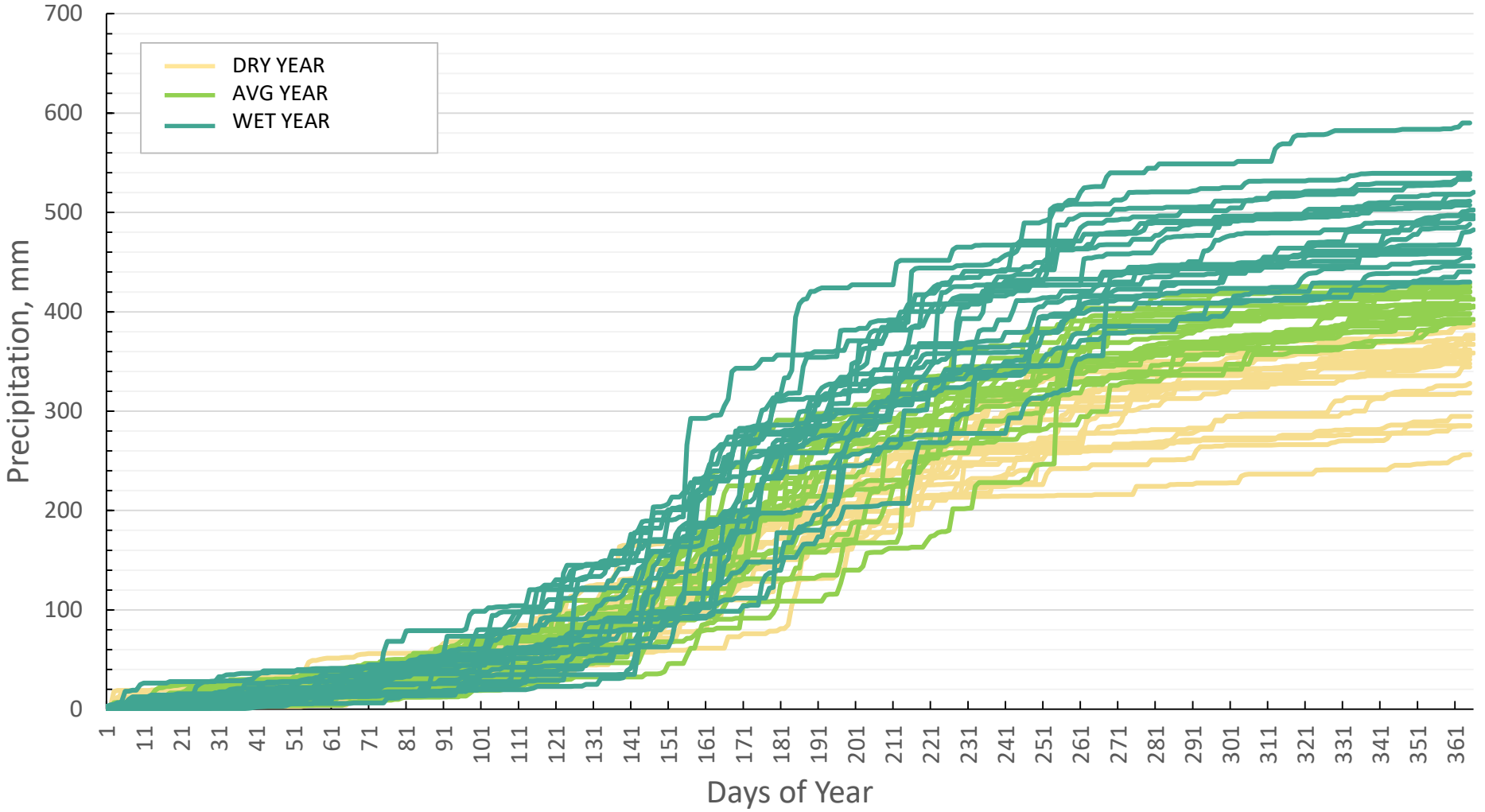
- Leaching
- 3 trial applications of raw water: Aug 22, Sep 06 and 29
- ~700 L of water w/o additives applied to each bed

- Potential issues
  - nutrient leaching
  - rapid infiltration
  - poor retention

2018 Field Research

- Collaboration with the City of Calgary and the ALIDP
- 25 simulated events of varying magnitude
- Goal to match seasonal precipitation/run-off typical for Calgary area

Calgary Annual Ppt 1960-2016

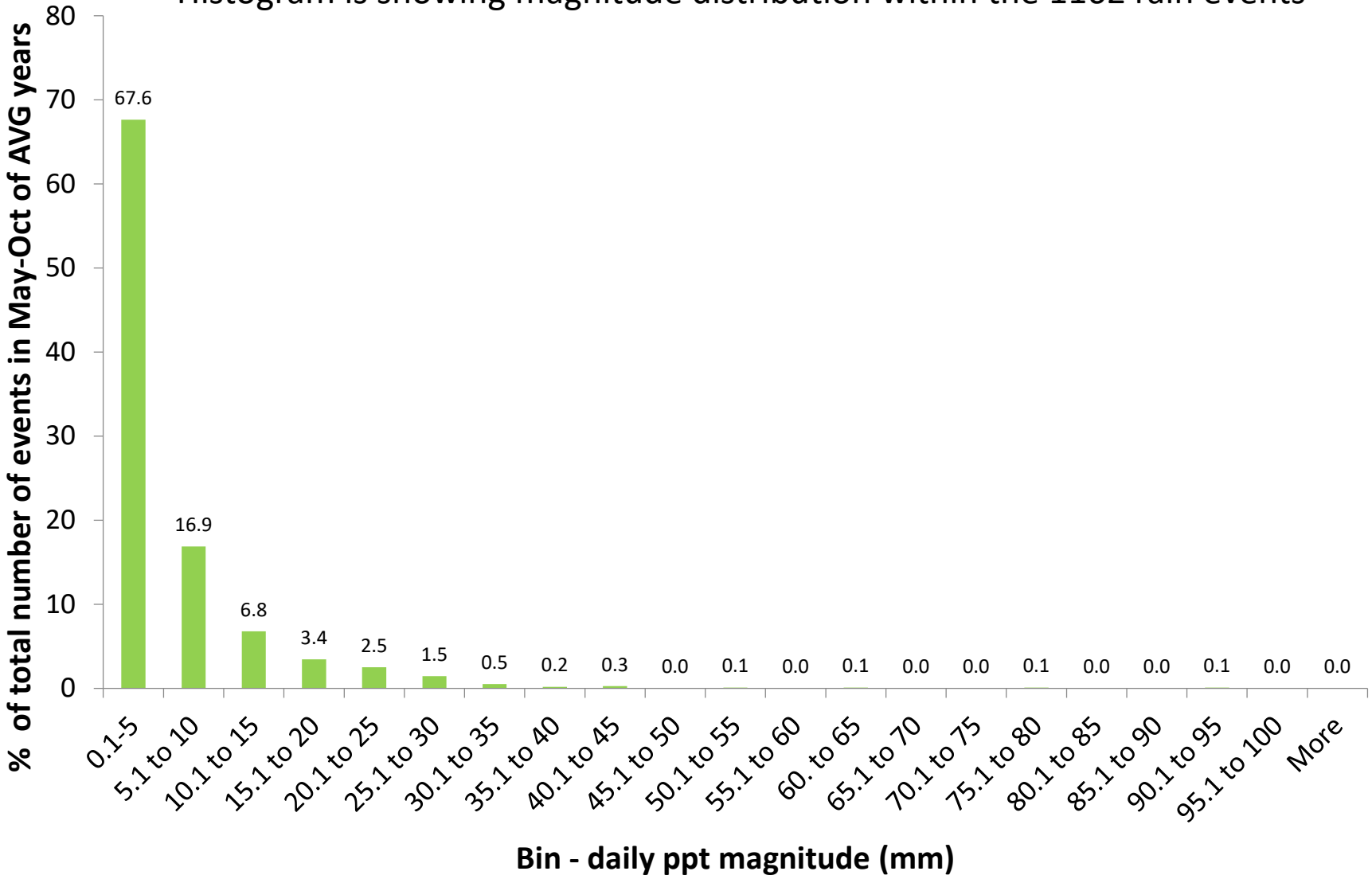


DRY YEAR	
TOTAL	**343.2**
JAN	12.2
FEB	9.3
MAR	17.3
APR	23.2
MAY	44.6
JUN	64.0
JUL	51.5
AUG	49.7
SEP	31.0
OCT	16.3
NOV	10.4
DEC	13.6

AVG YEAR	
TOTAL	**407.3**
JAN	11.5
FEB	10.1
MAR	13.7
APR	22.2
MAY	53.7
JUN	89.1
JUL	71.1
AUG	49.2
SEP	45.6
OCT	15.5
NOV	14.4
DEC	11.1

WET YEAR	
TOTAL	**495.4**
JAN	11.6
FEB	11.0
MAR	15.3
APR	34.0
MAY	69.4
JUN	115.5
JUL	81.7
AUG	60.4
SEP	50.2
OCT	18.1
NOV	14.2
DEC	14.2

Focus on May to Oct (~ growing season) of AVG years
3490 days total, 2328 rain-free 1162 rain events
Histogram is showing magnitude distribution within the 1162 rain events



- Run majority as small events, find a combination that can achieve seasonal target

- Up to 30 total events
- (at least 50% as small, e.g. 5 mm, events)
- 15 small events
- 5 medium events (e.g. 10 mm)
- 5 water quality events (15 mm)
- 3 large events (e.g. 25 mm)

- 28 events a season, total is 275 mm

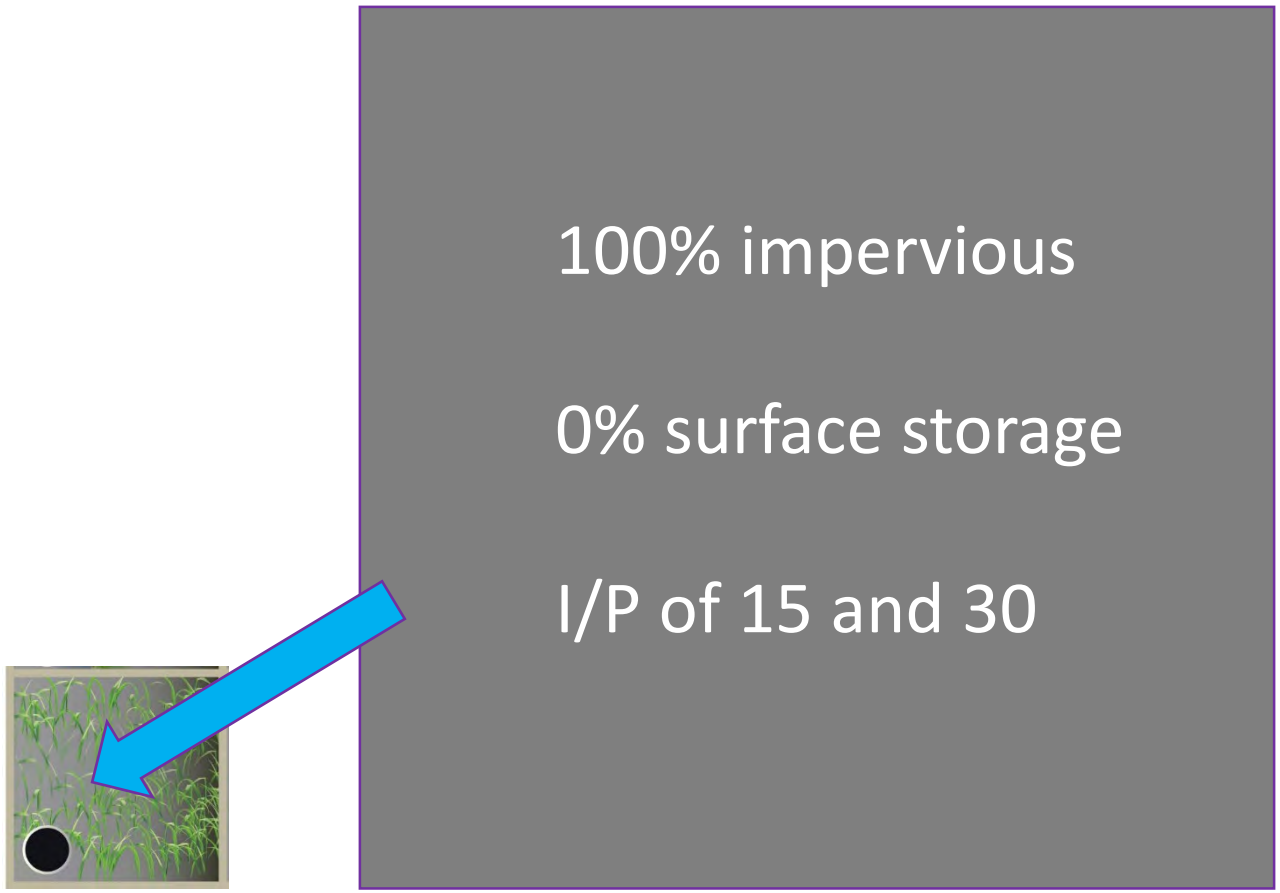
- Another adjustment - 1 mm reduction to account for events that would not generate run-off

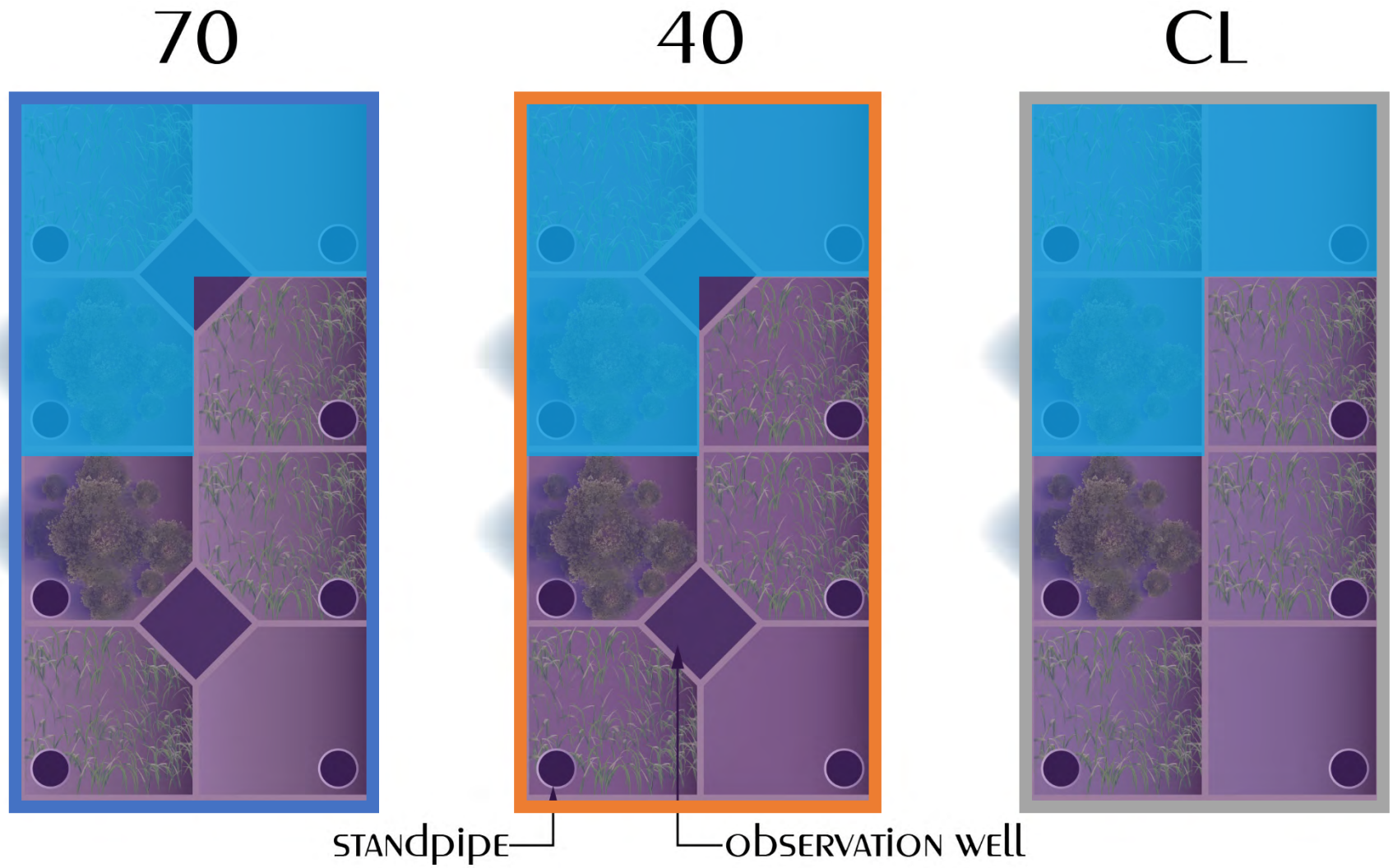
- Final application regime:

- 15 events at 4 mm
- 5 events at 9 mm
- 5 events at 14 mm
- 3 events at 24 mm

- 28 events a season, total is 247 mm

Contributing Area

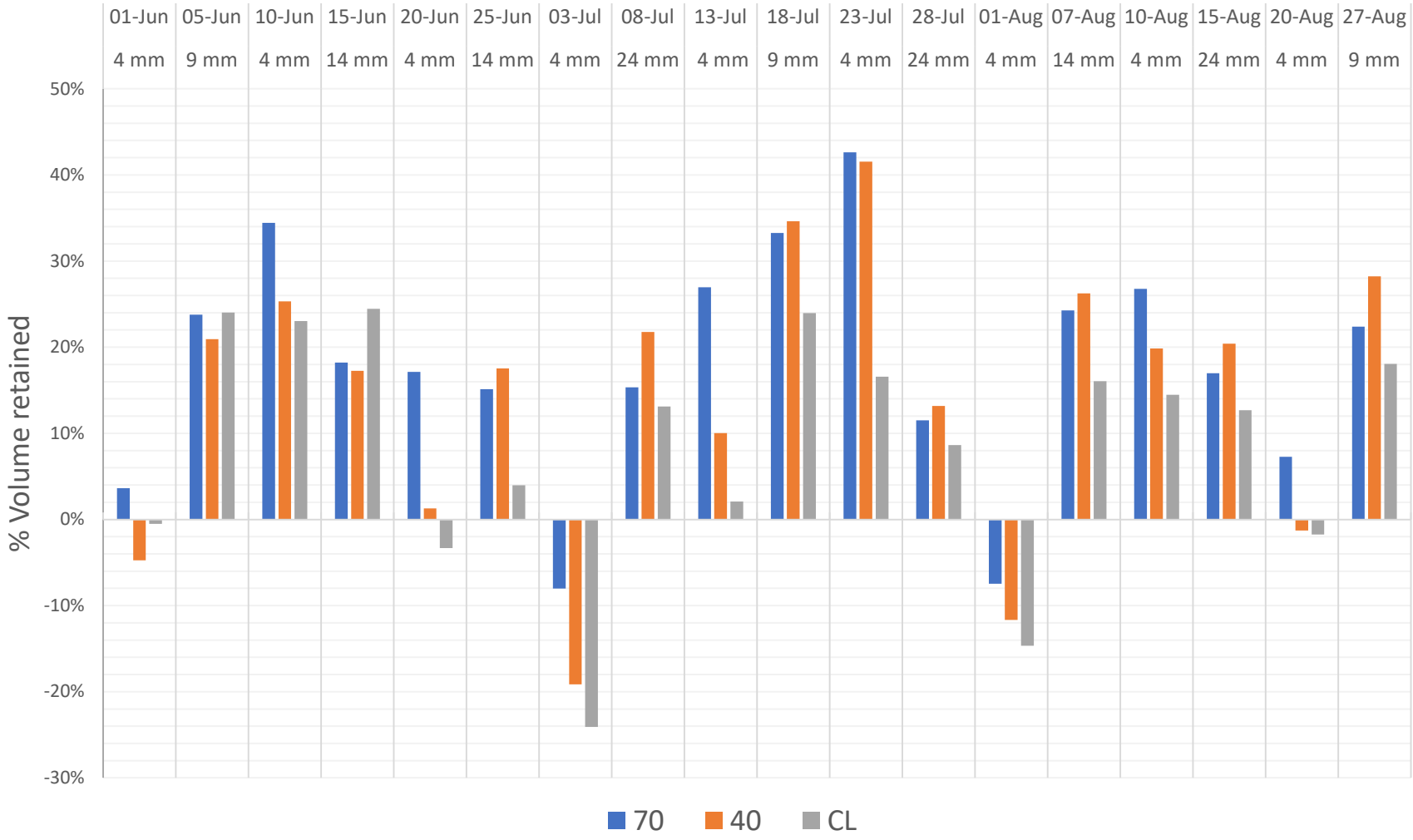



70
40
CL
standpipe
observation well

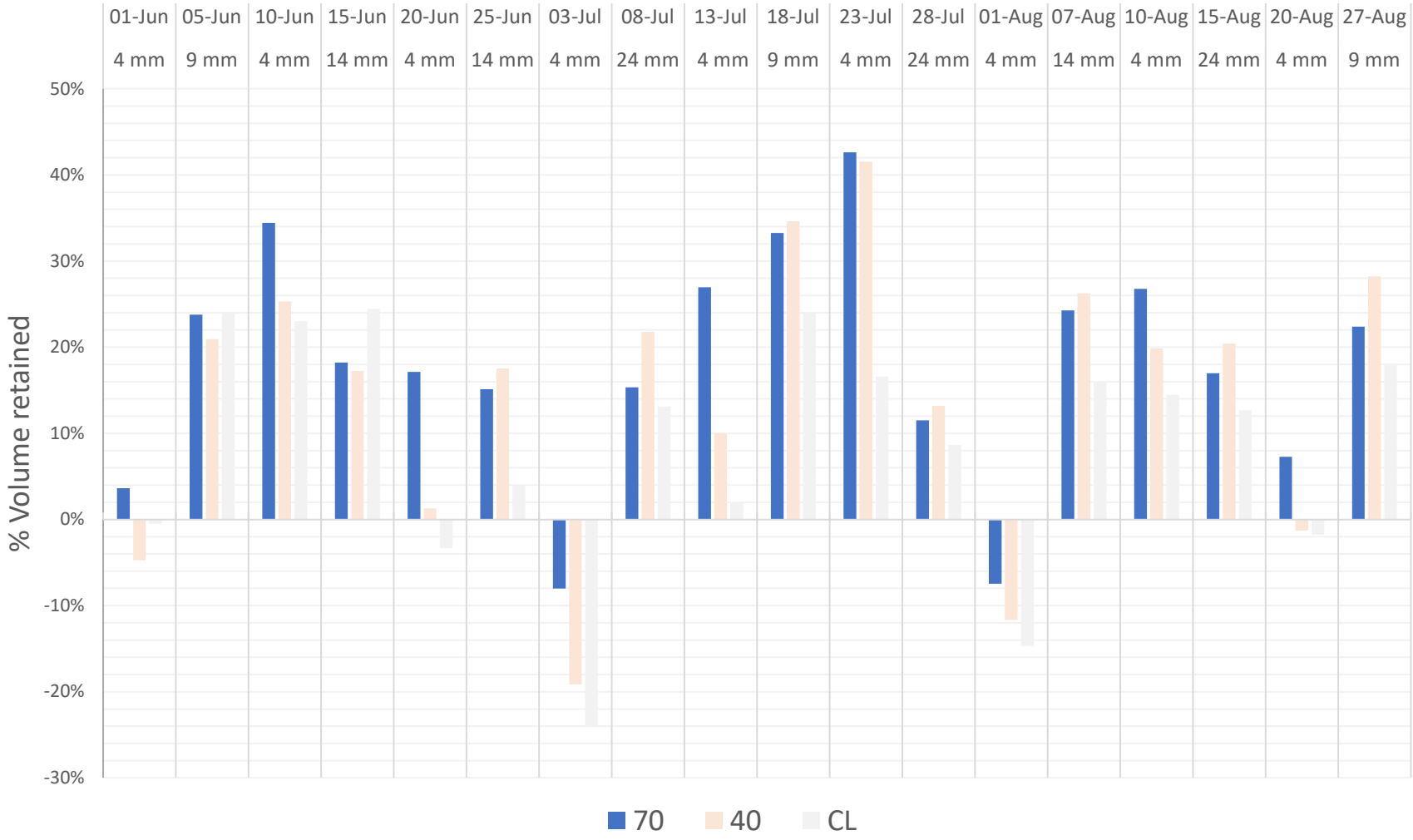
2018 June- Aug Preliminary Results

- Seasonal vs event-specific performance
- Hydrologic – volume retention, infiltration
- Water quality – RP, TP, Nitrate, TN, TOC

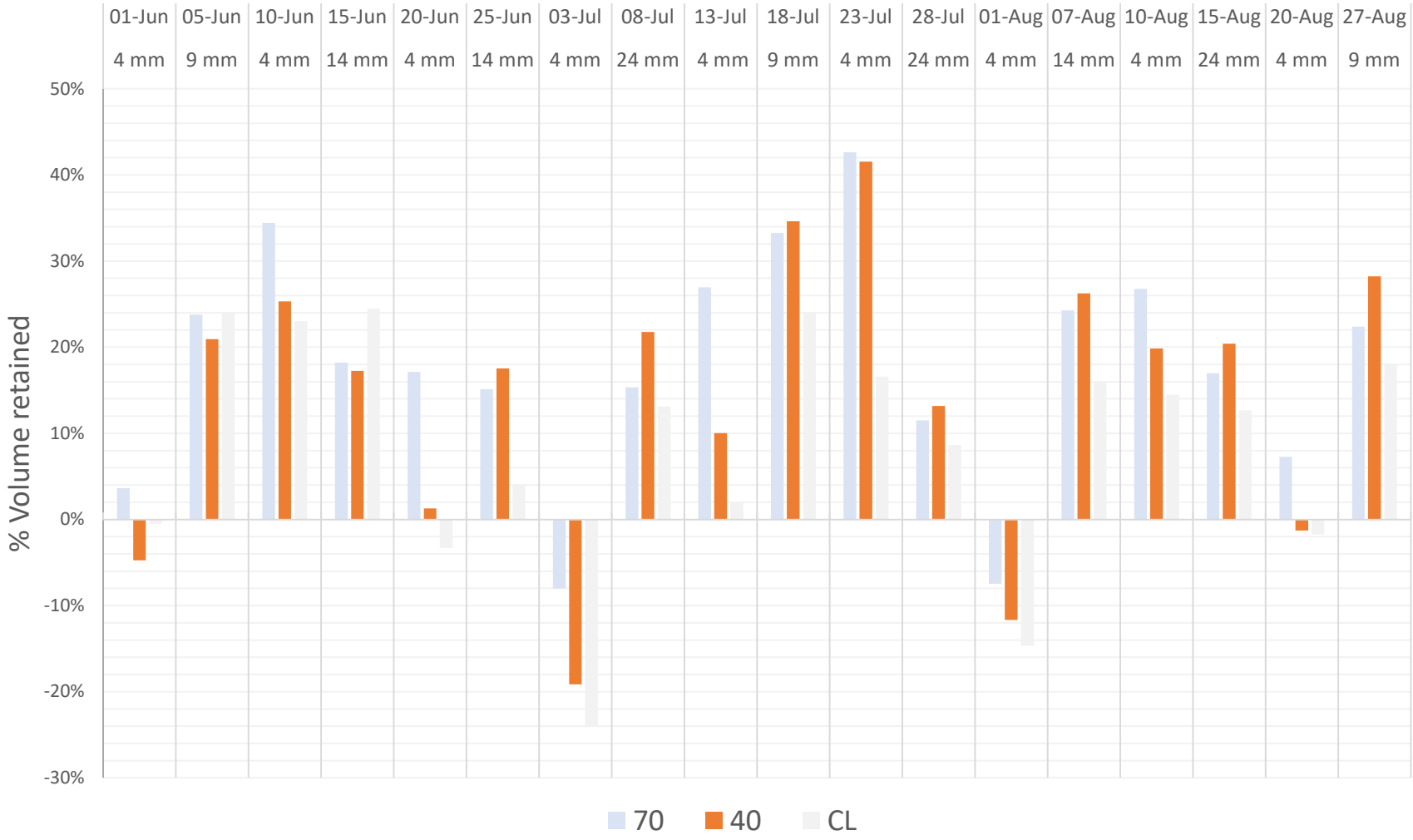
Volume retention – seasonal variation



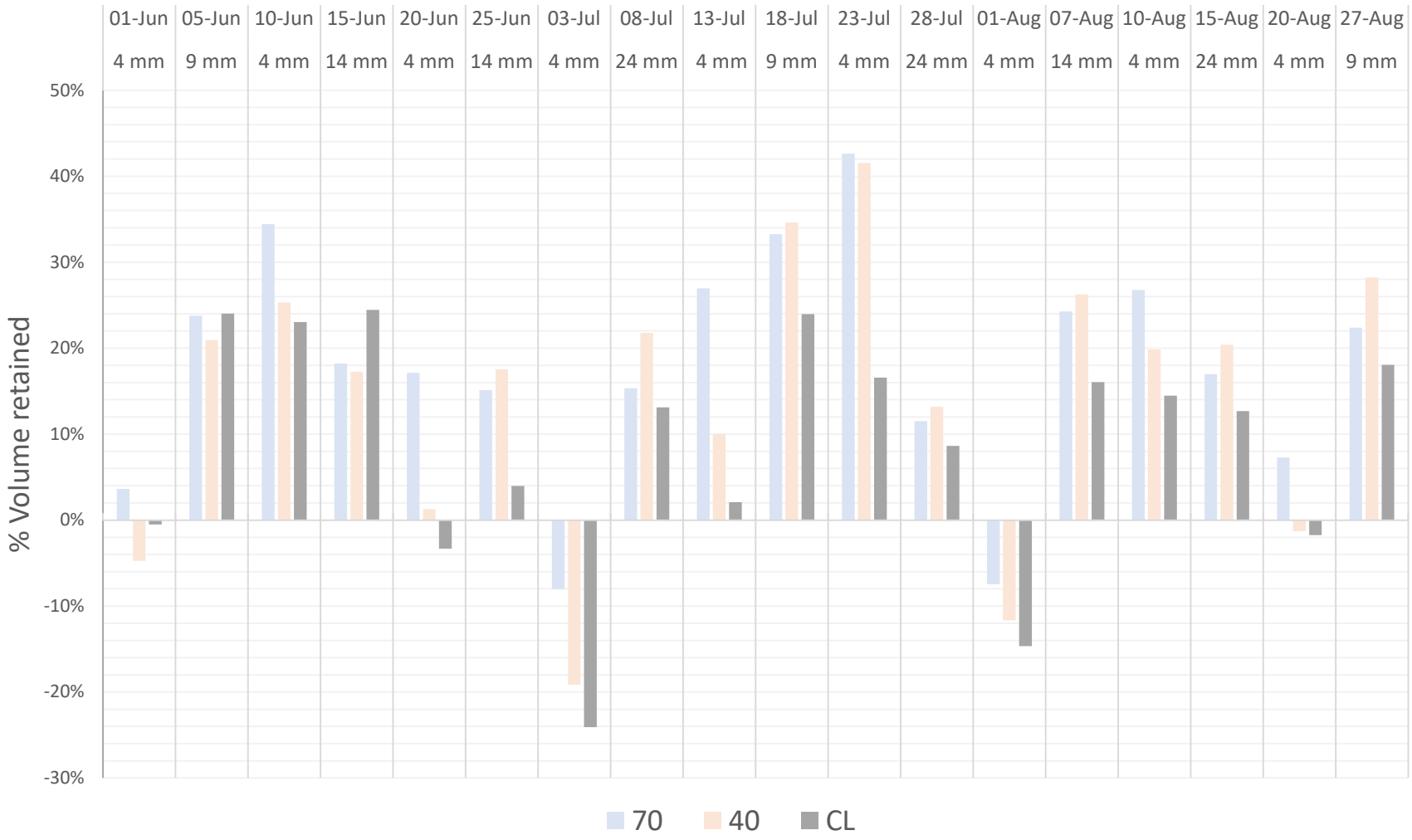
Volume retention – seasonal variation



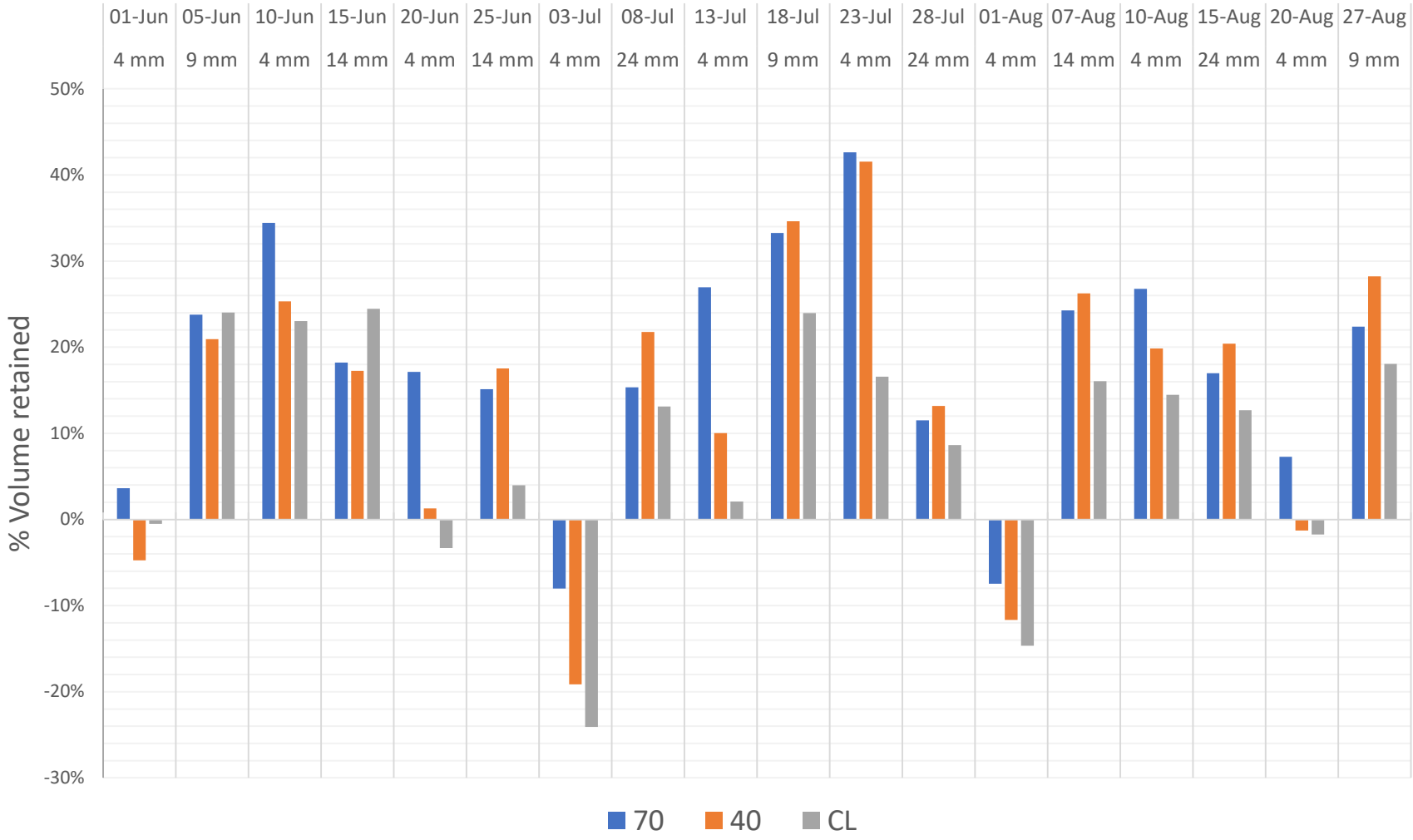
Volume retention – seasonal variation



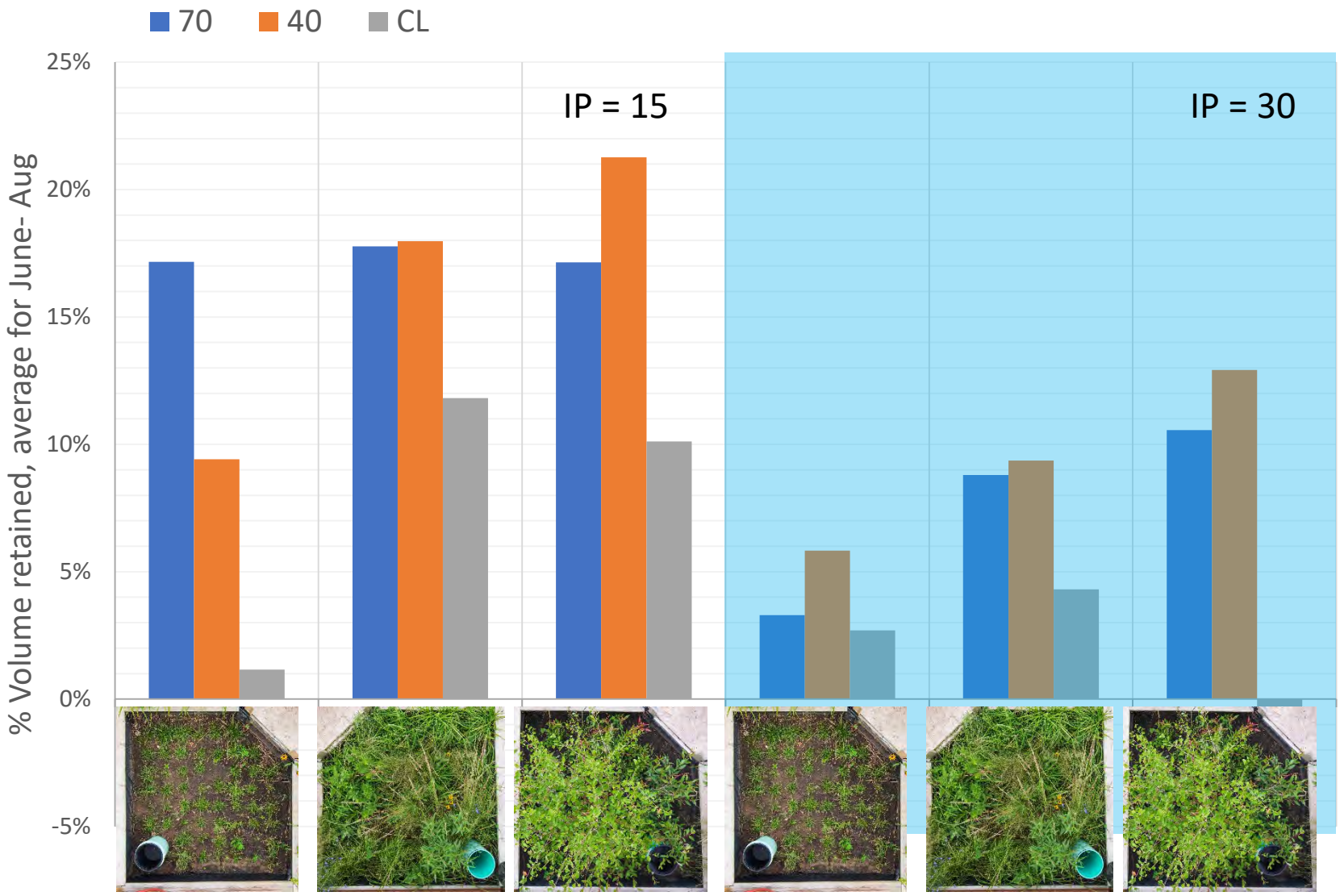
Volume retention – seasonal variation



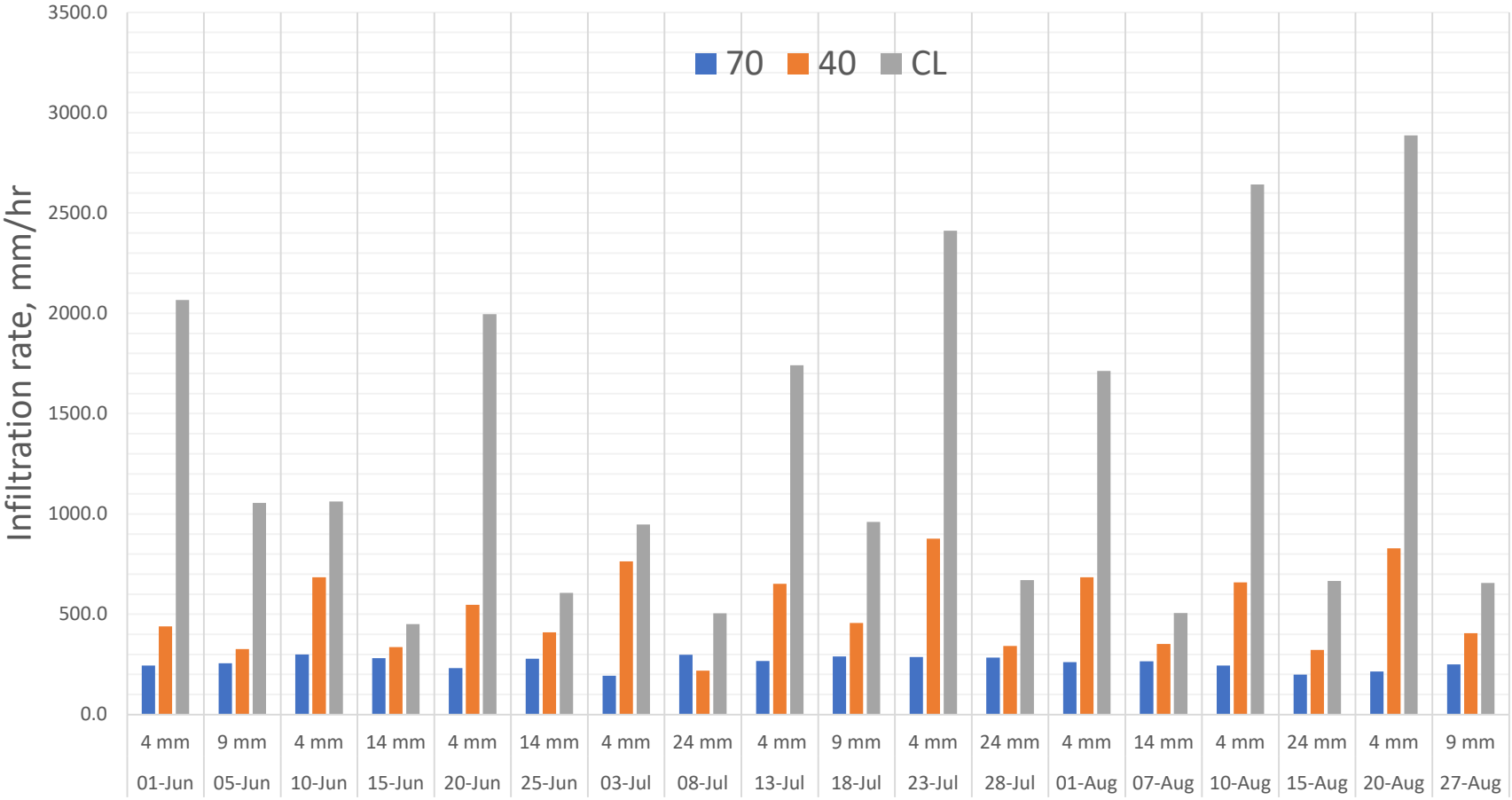
Volume retention – seasonal variation



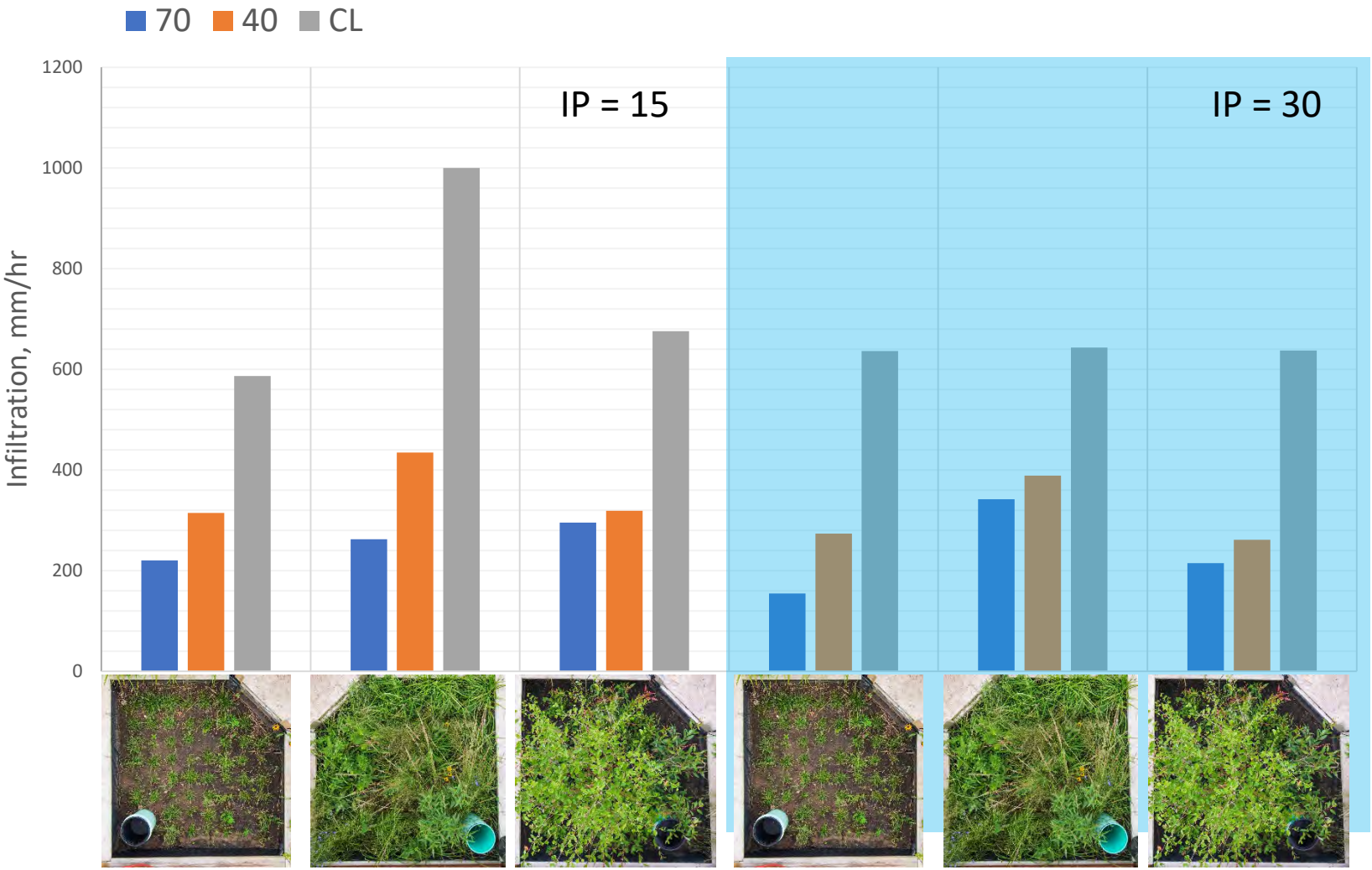
Seasonal average volume retention



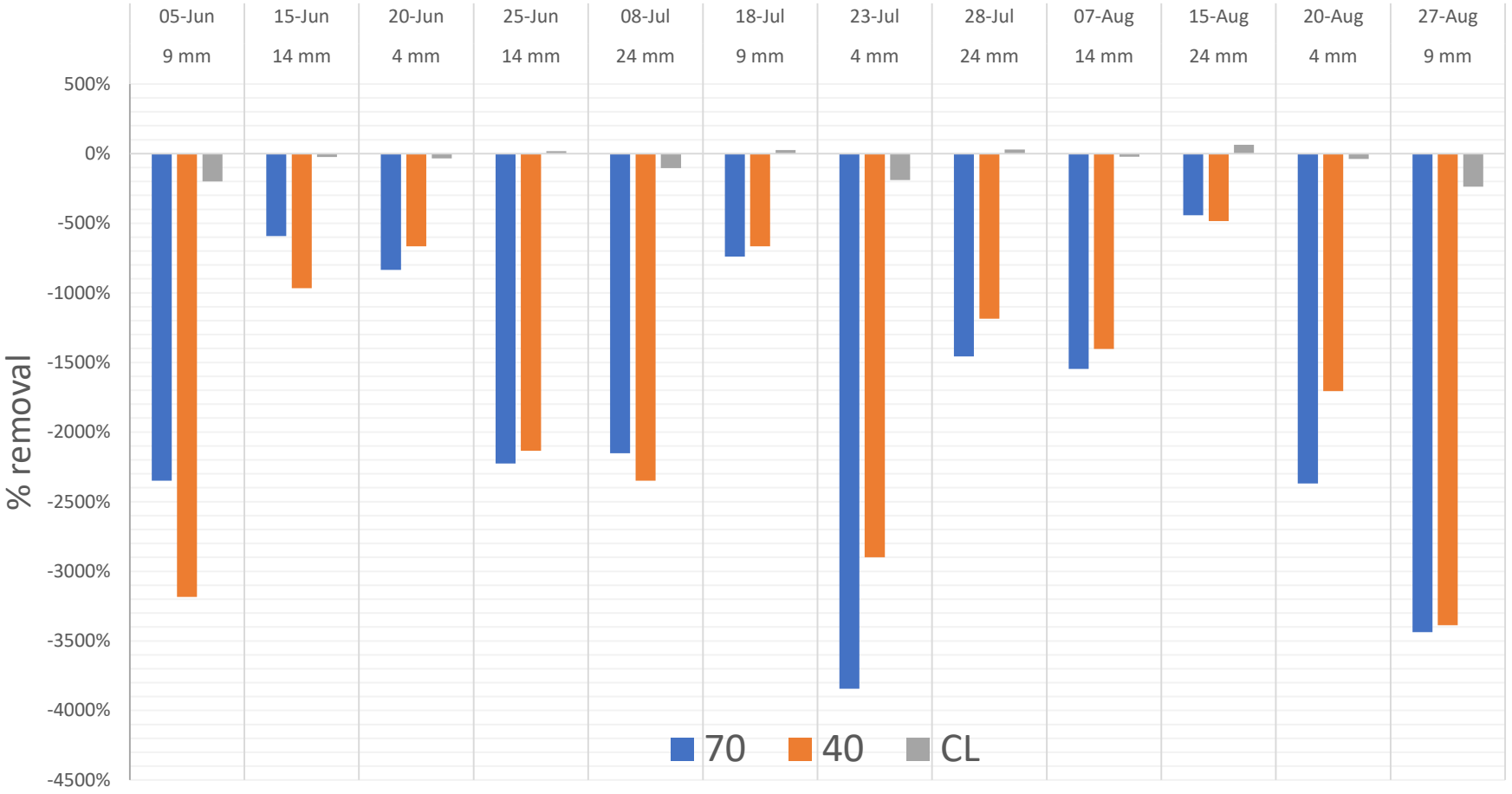
Infiltration– seasonal variation



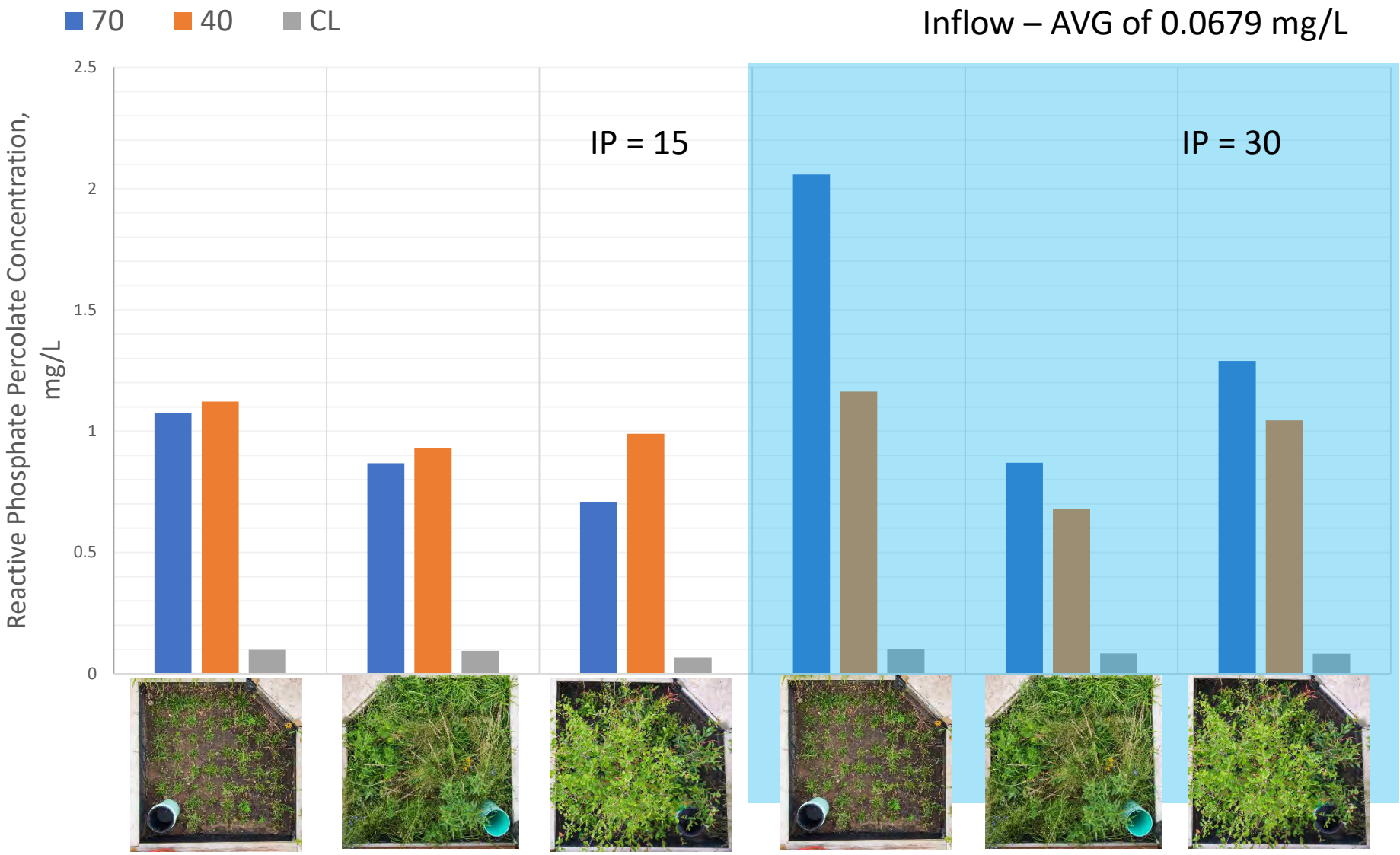
Seasonal average infiltration



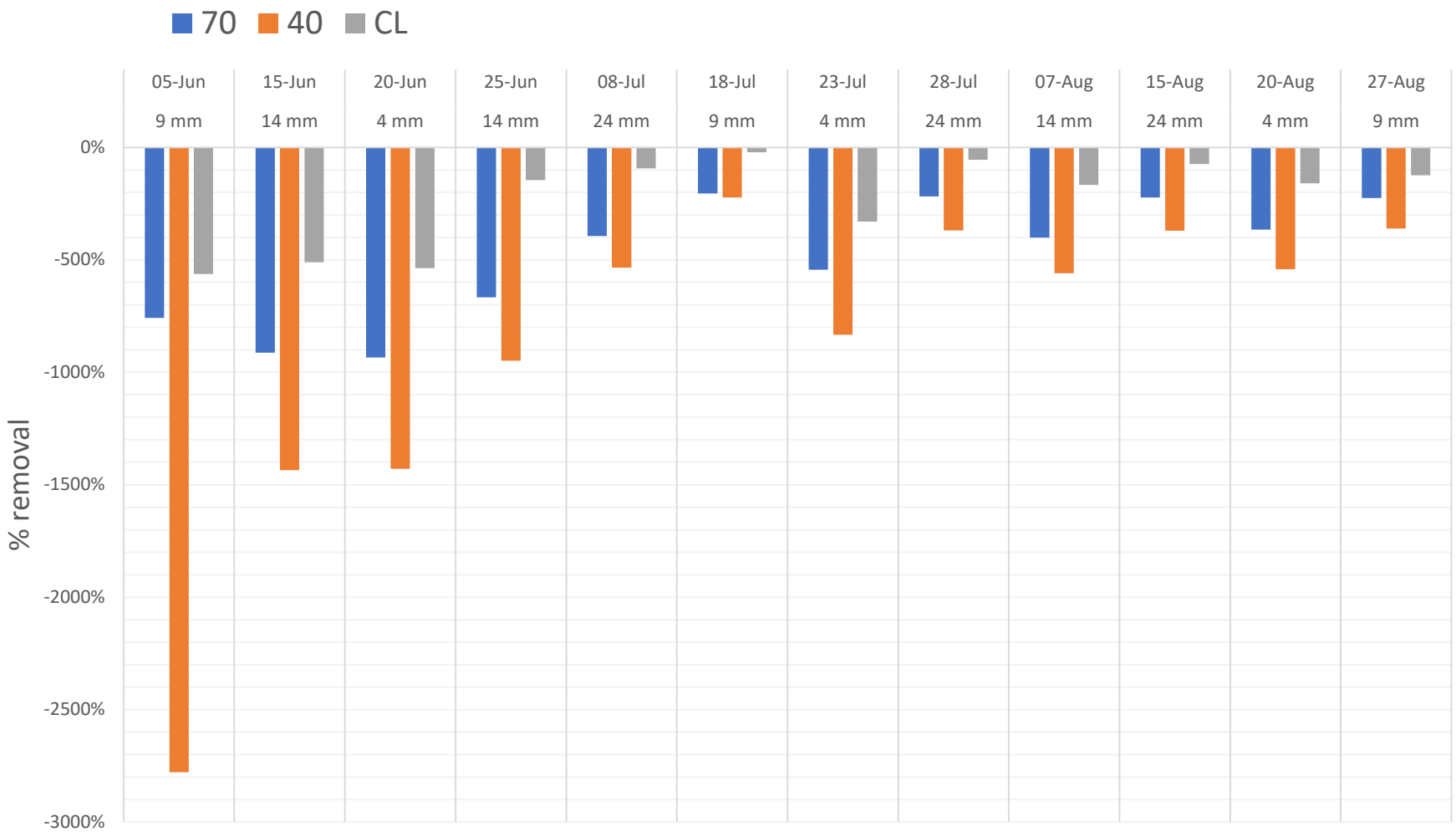
Reactive P – seasonal variation



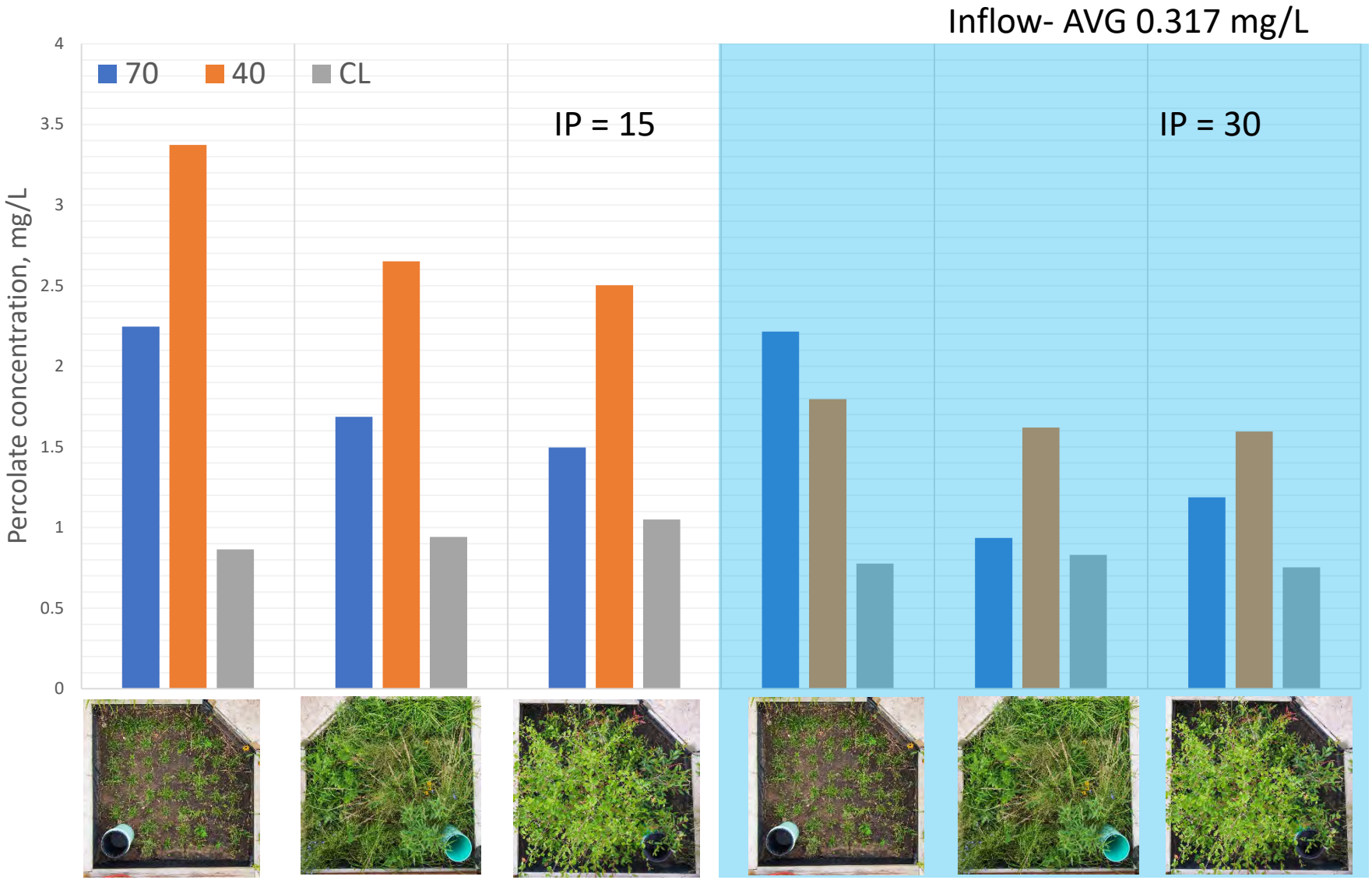
Reactive P – seasonal average



Nitrate – seasonal variation



Nitrate – seasonal average



Next steps

- Complete data collection for the 2018 growing season
- Soil moisture data
  - analyze if antecedent moisture variation can explain the performance
  - analyze losses between events, estimate ET
- Weather station data
  - analyze how natural precipitation impacts the performance
- Investigate which factors have the greatest impact on the performance

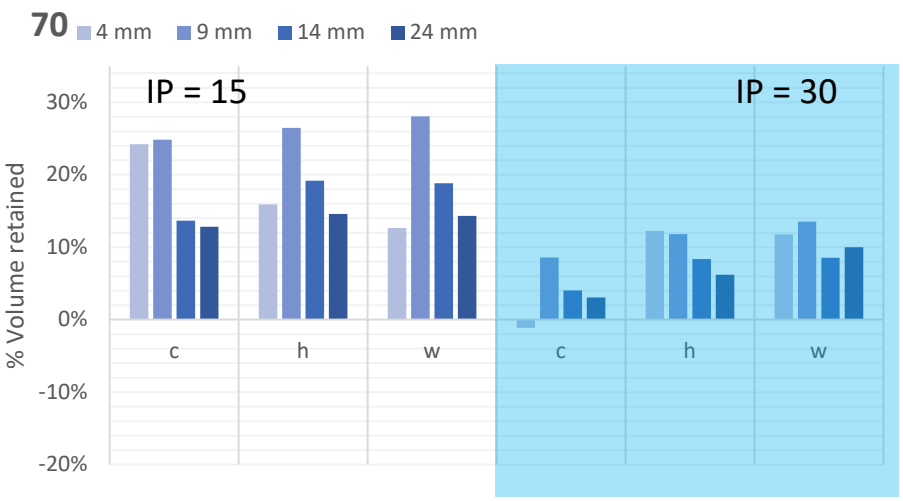
Special Thanks:

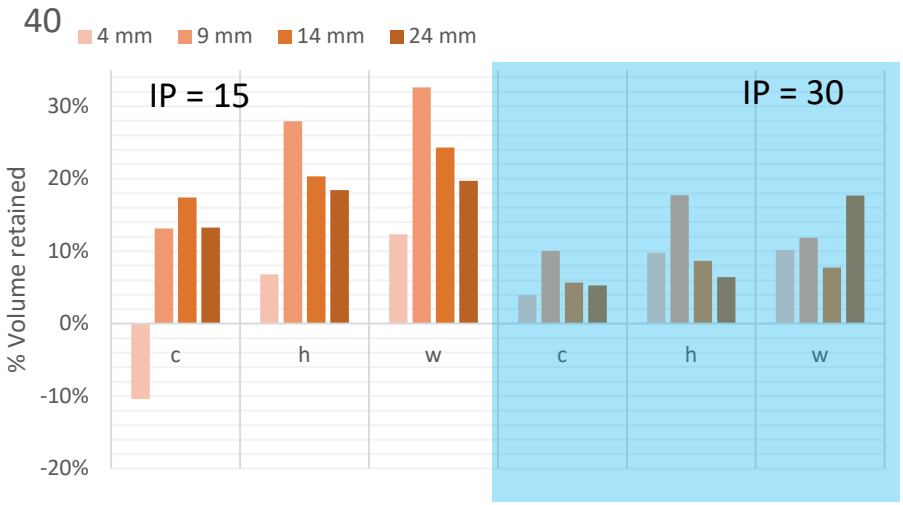
- Richard Nadori
- Mike(Xing) Li

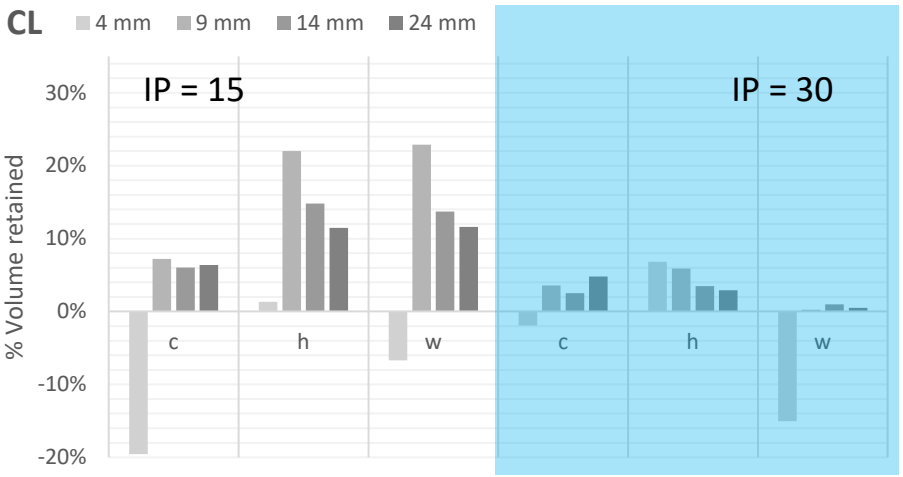
Thank you!

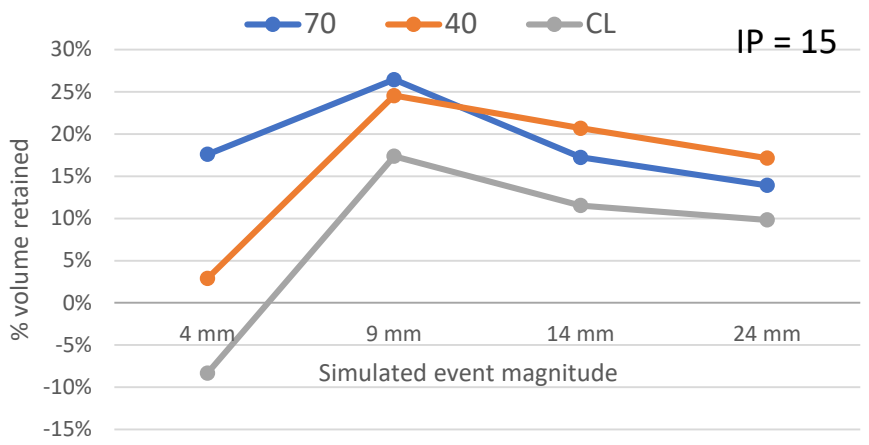

Okotoks Bioretention Research Facility
Environment and Climate Change Canada
Alberta Environment and Parks
source source
THE CITY OF CALGARY
Bow River BASIN Council
UNIVERSITY OF CALGARY
NSERC CRSNG
ALIDP Alberta Low Impact Development Partnership
MITACS
Friends of the Environment Foundation
Okotoks
Historic Past, Sustainable Future
University of Victoria
FORTIS ALBERTA

Magnitude-specific volume retention

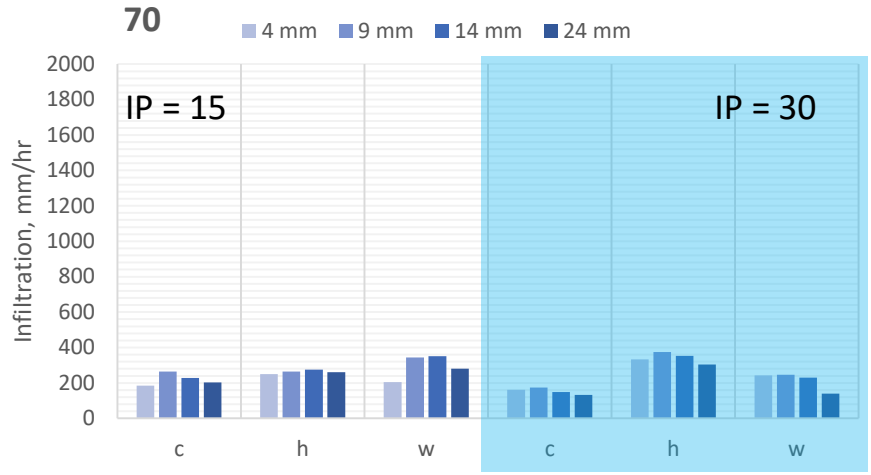


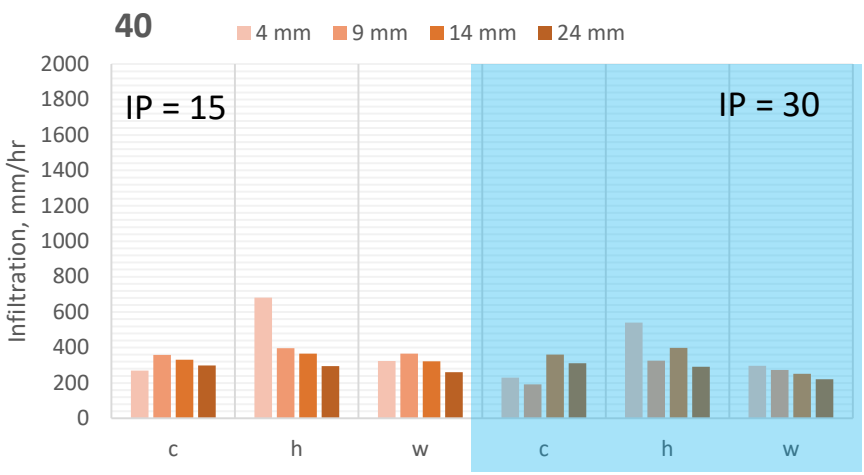


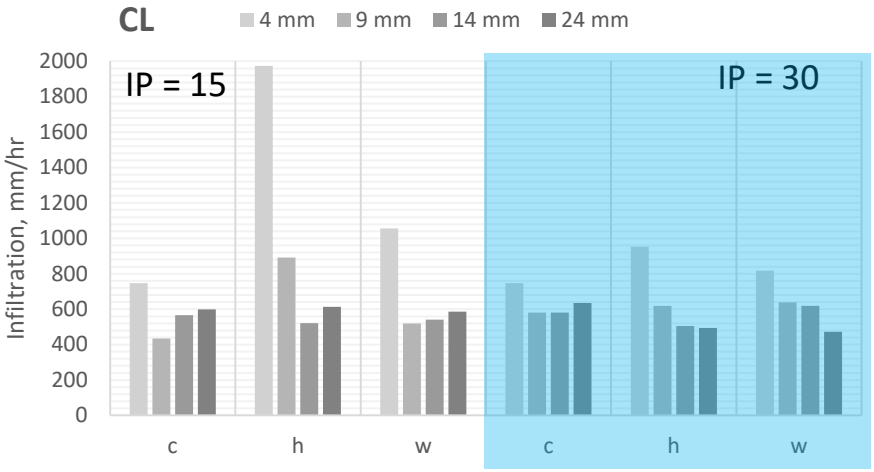


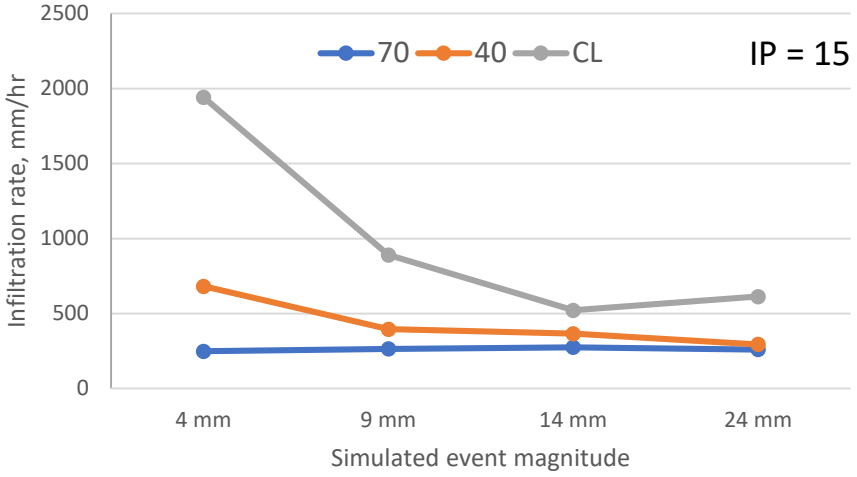


Magnitude-specific infiltration

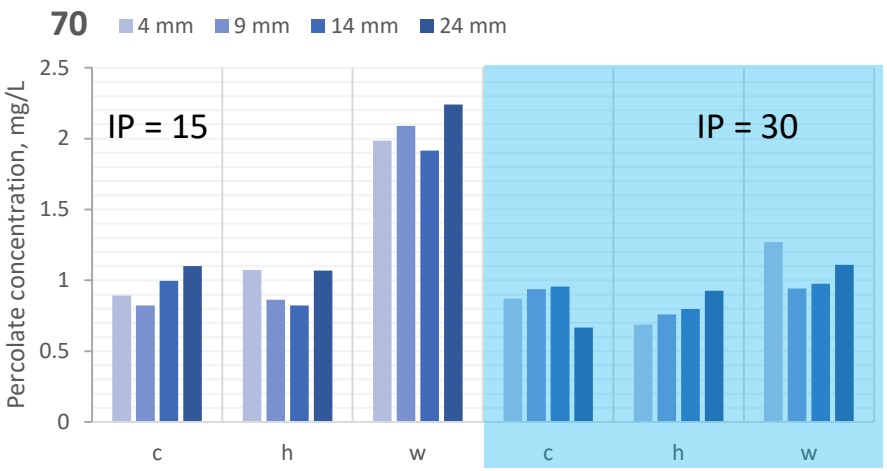


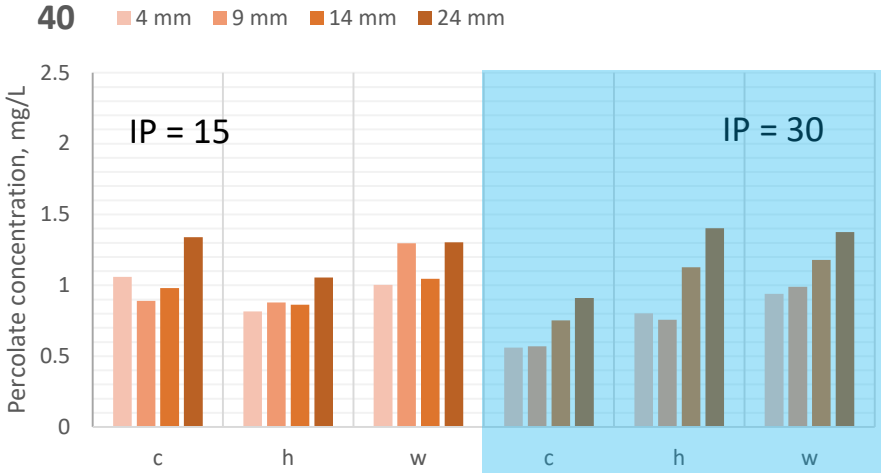


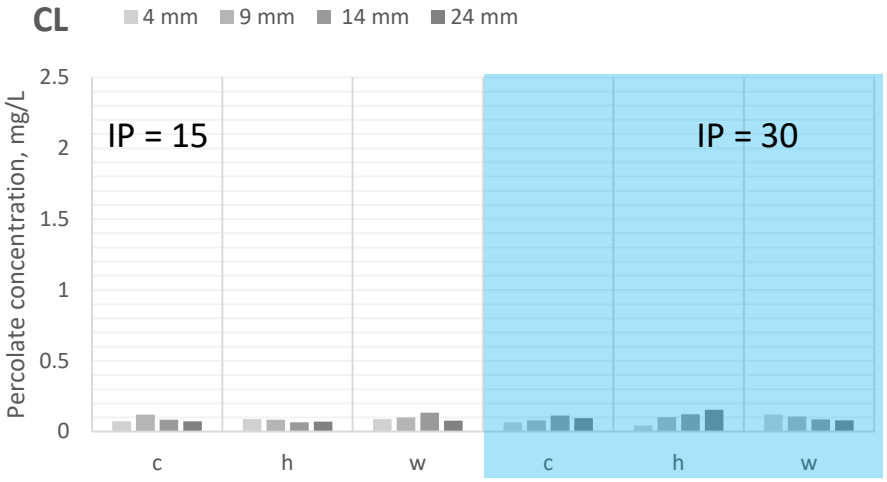


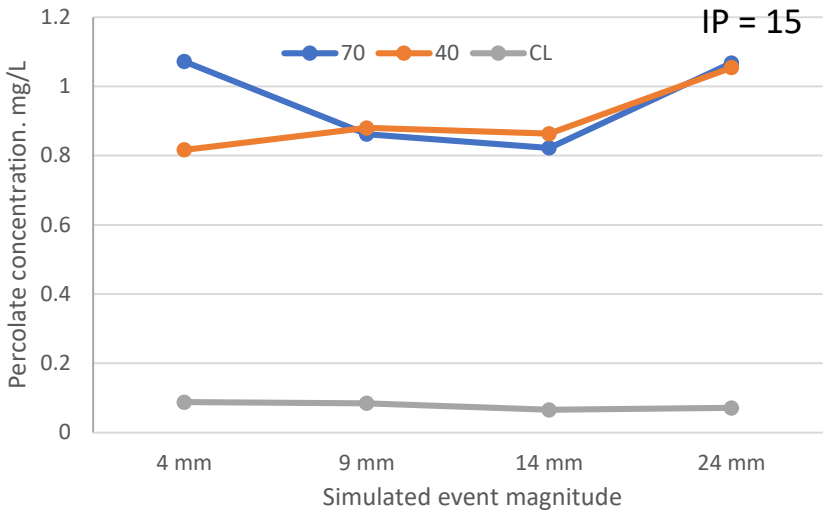


Reactive P – magnitude-specific









Nitrate – magnitude-specific