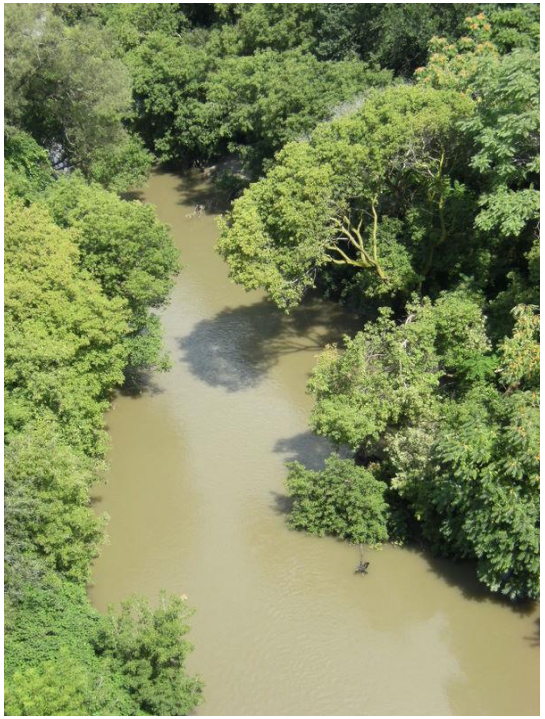
Modelling the Idiosyncrasies of the Don River Watershed

March 6, 2019

The Living City Foundation

Toronto and Region Conservation for The Living City

Don River Watershed Hydrology



Topics of Discussion

1. Acknowledgements
2. Objectives
3. Building the Model
4. Calibration/Verification
5. Peer Review
6. Conclusions and Recommendations

Acknowledgements

- AECOM project team: Brian Richert and Olivia Chung
- Municipal staff
- TRCA Hydrometrics and Flood Risk Management staff
- Staff and volunteers

Objectives of the Current Study

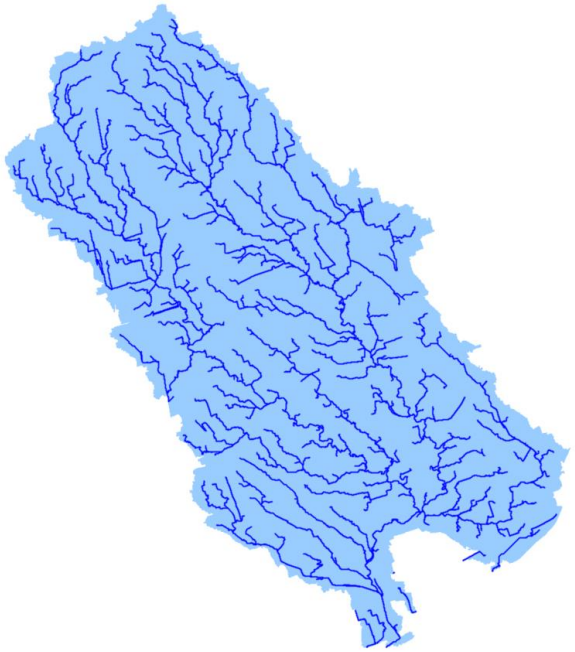
- Build a process-oriented hydrologic model of an urbanized watershed;
- Simulate watershed response of existing and future development scenarios (synthetic return period events and regulatory storm):
  - Update of the 2004 model work by Marshall, Macklin, Monaghan;
  - Apply conventional hydrologic modelling practices with refinements.

Methodology

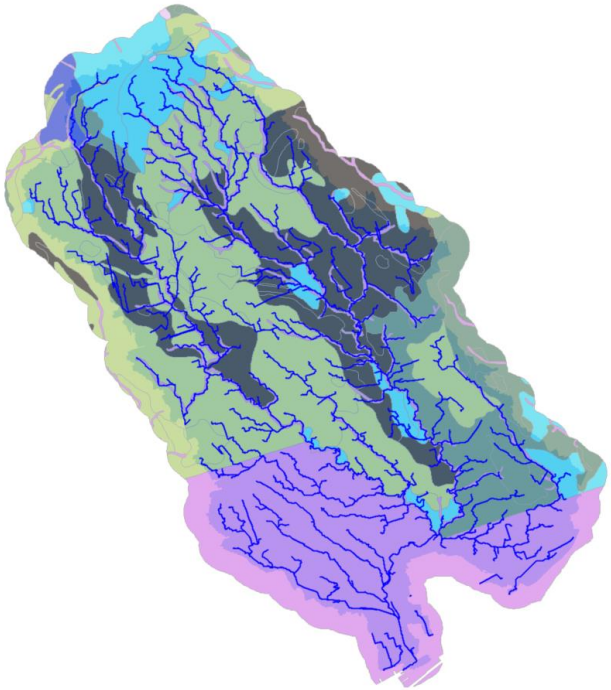
- Conventional approach:
  - Catchment and watercourse delineation based on DEM;
  - Soil maps and significant geological features;
  - Landuse mapping of existing development and those within the planning horizon;
  - Rainfall and streamflow gauge data.
- Refinements:
  - Review and inclusion of subwatershed model work;
  - Processing orthographic imagery for impervious cover;
  - Calibration based on sub-area routing and process-oriented infiltration approach.

LiDAR

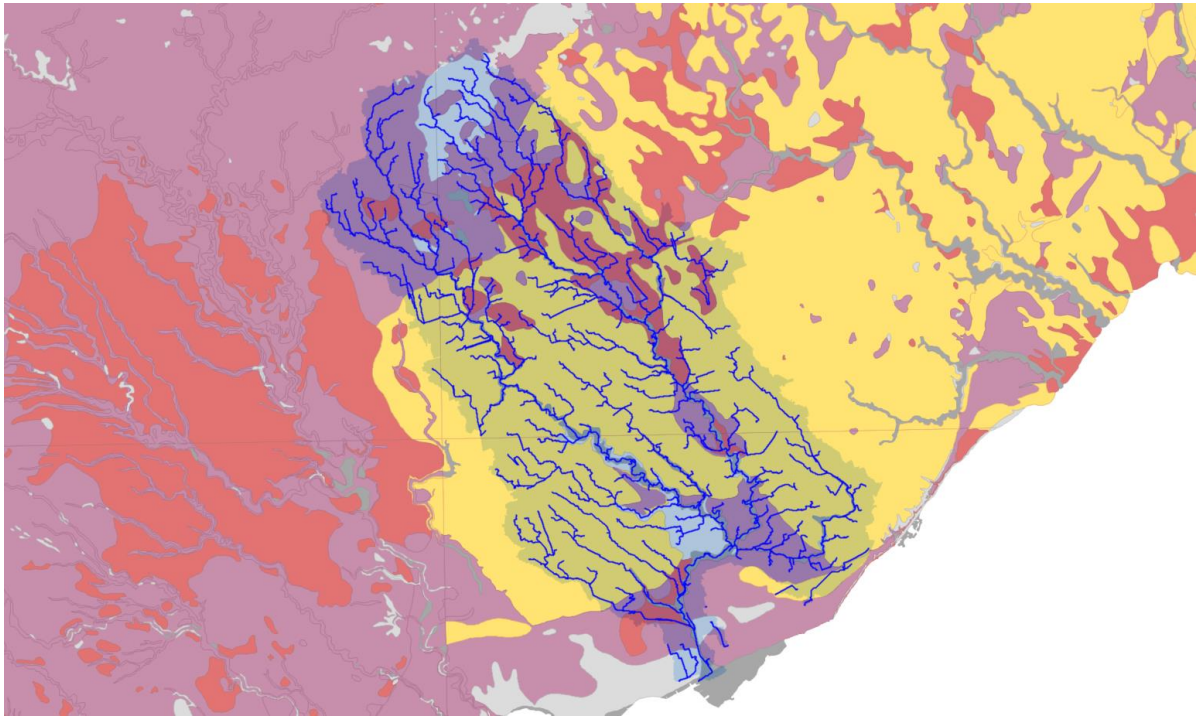
Catchments and Drainage Features



Soils



Soils (Supplemental)



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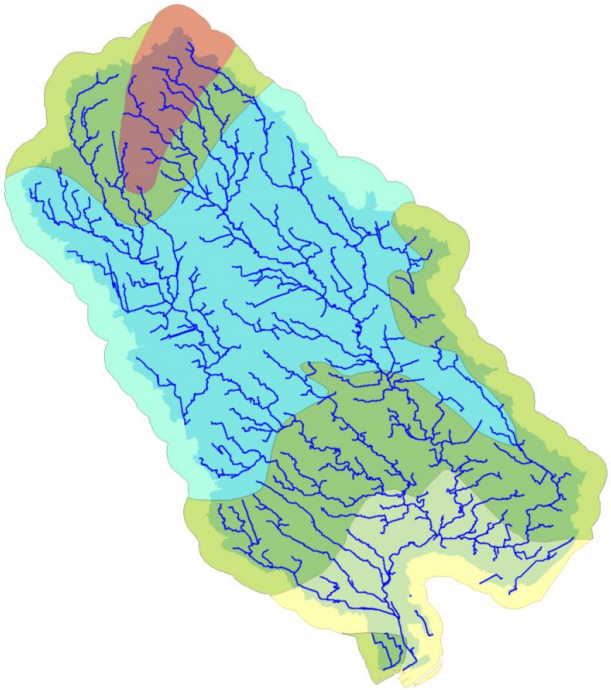
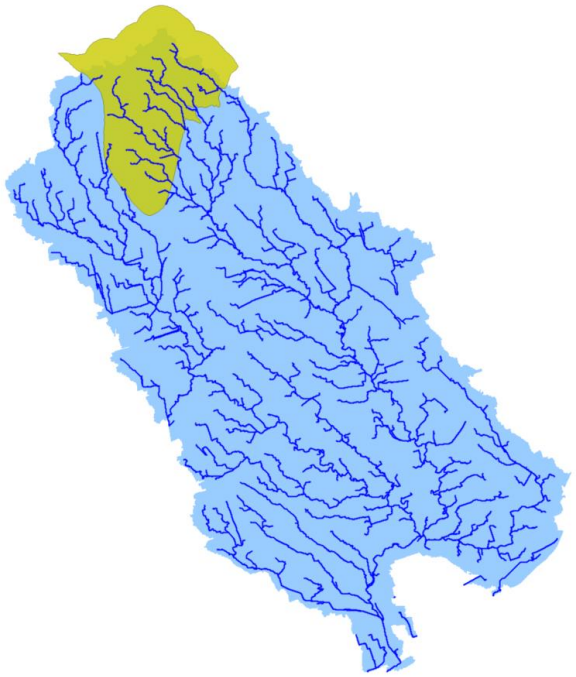
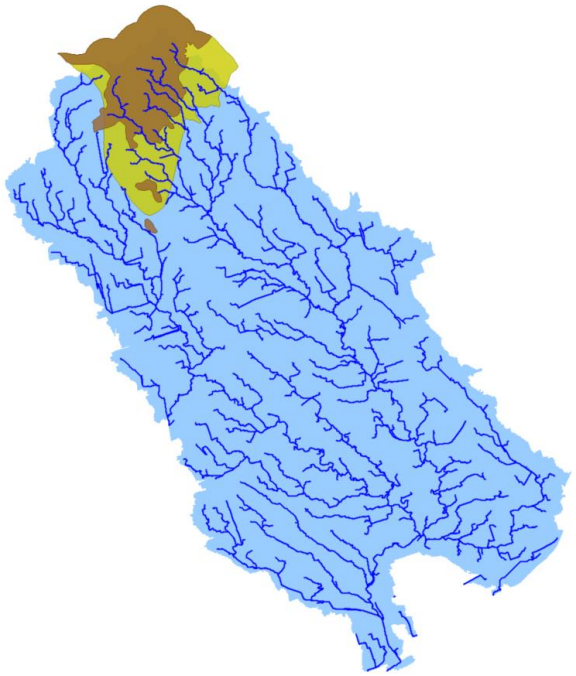


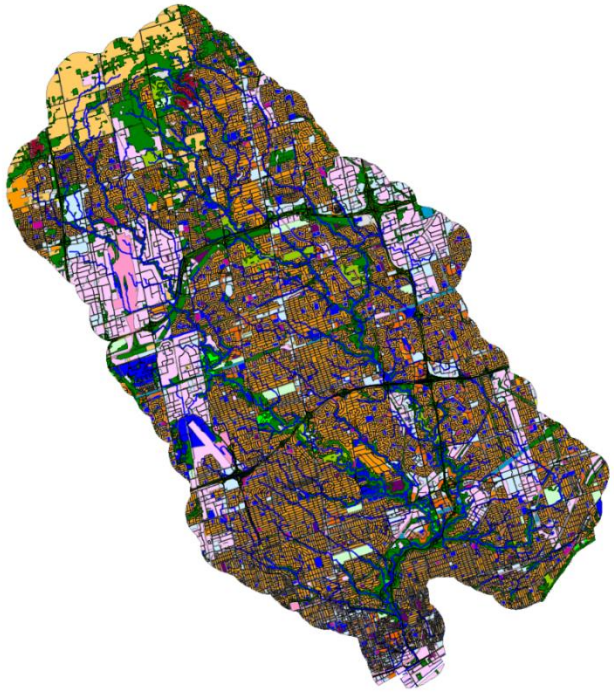
Geological Features



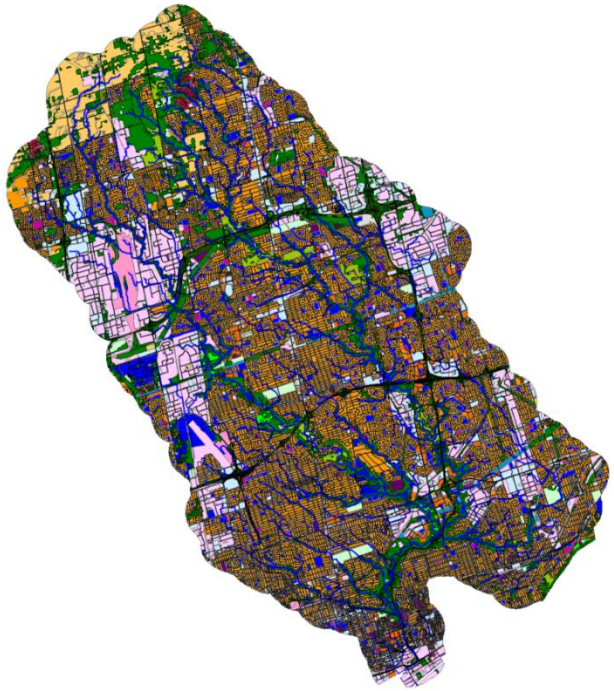
Geological Features



Existing Development



Future Official Plan



Imperviousness Measurement

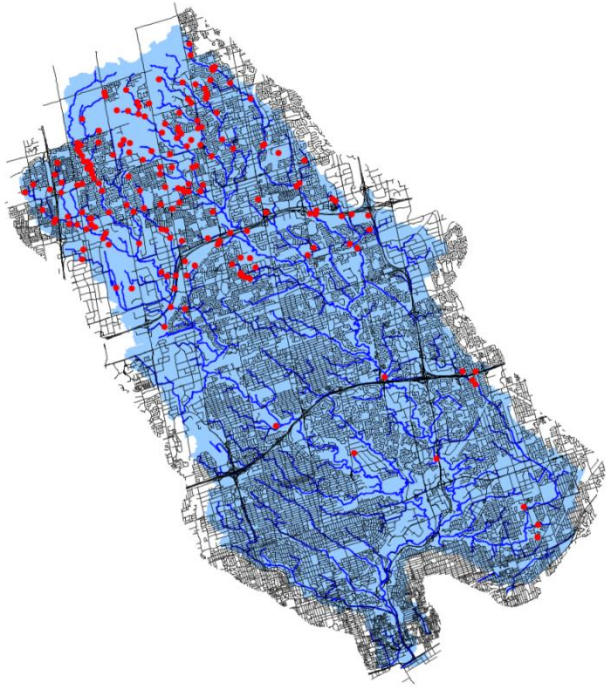
- Typical practice is to assign catchment imperviousness based on GIS landuse mapping and a look-up table (e.g. TRCA standard);
- There is spatial variation (e.g. municipal landuse-imperviousness definitions) and temporal variation (e.g. changes in definitions across time);
- Assume that measurement of absolute imperviousness will capture spatial and temporal variation in the Don Watershed during the period of calibration/validation events.

Imperviousness Measurement

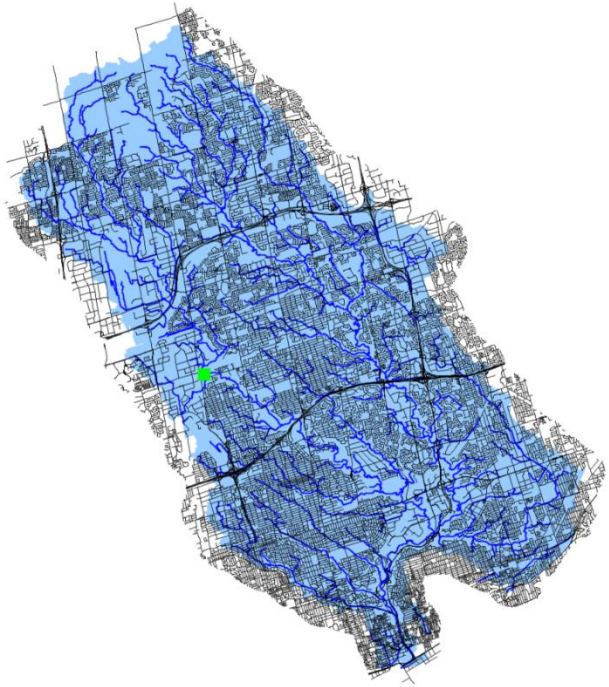
Imperviousness Measurement

Imperviousness Measurement

SWM Ponds



G Ross Lord Dam



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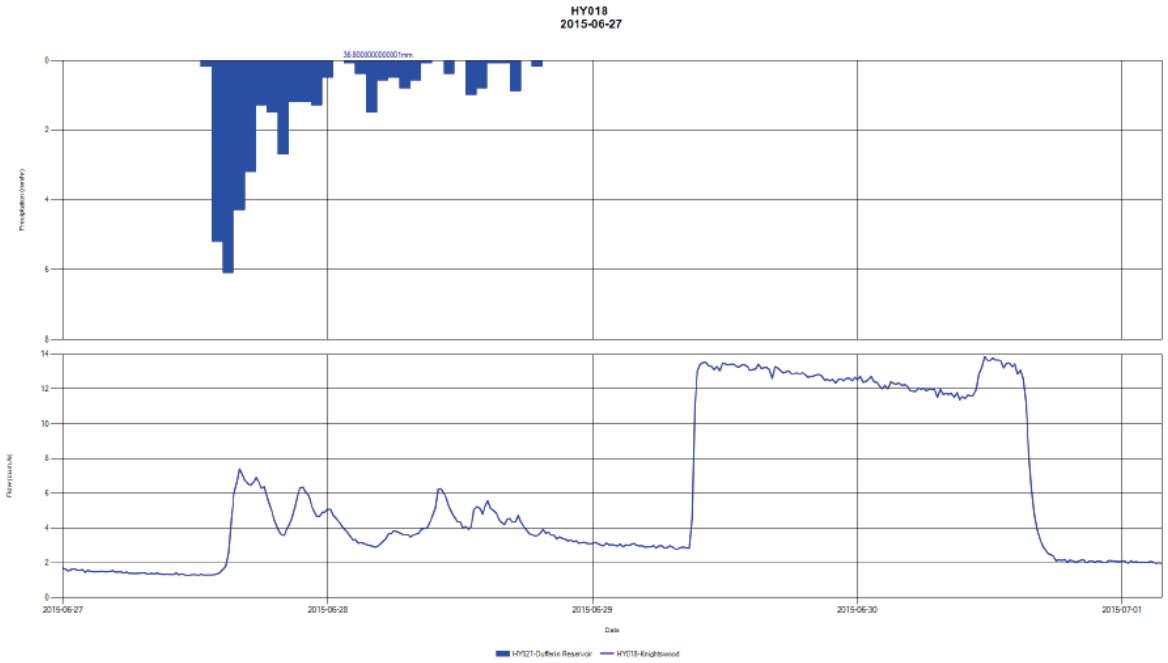

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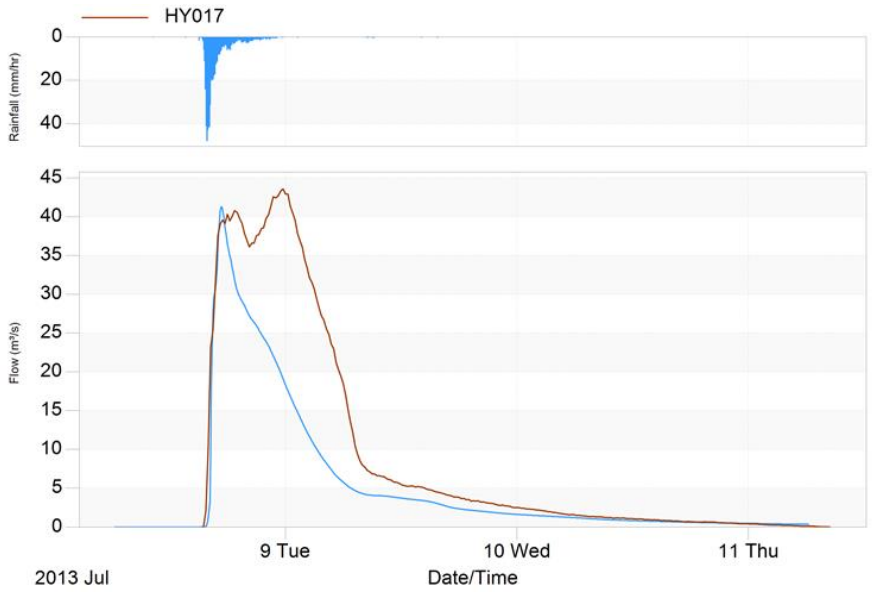
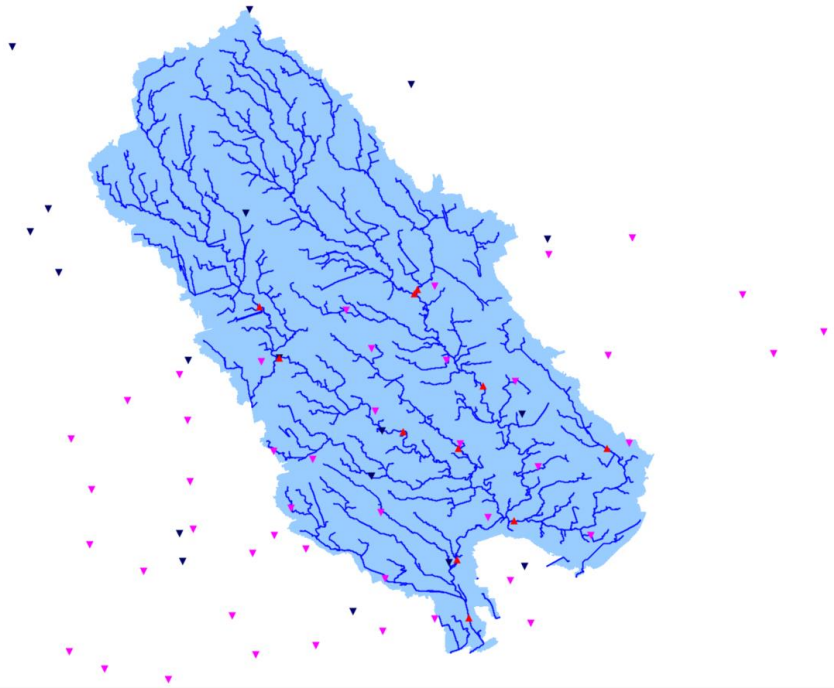
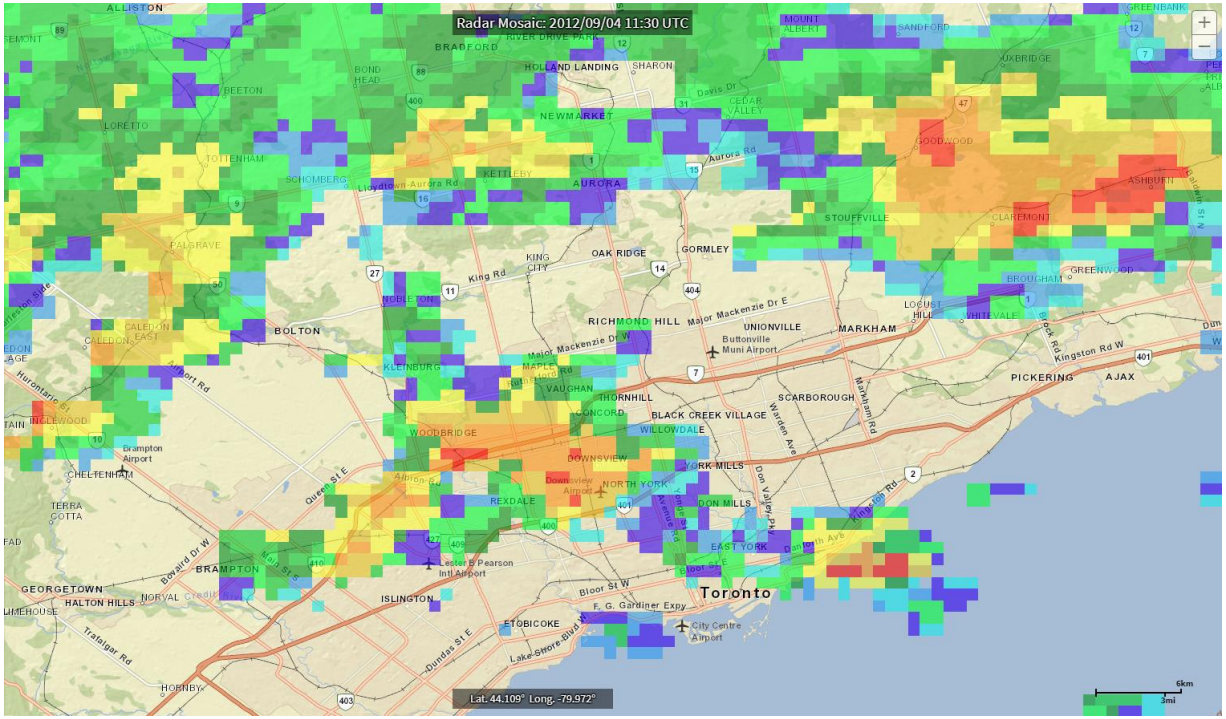


TRCA Gauges

Municipal Gauges



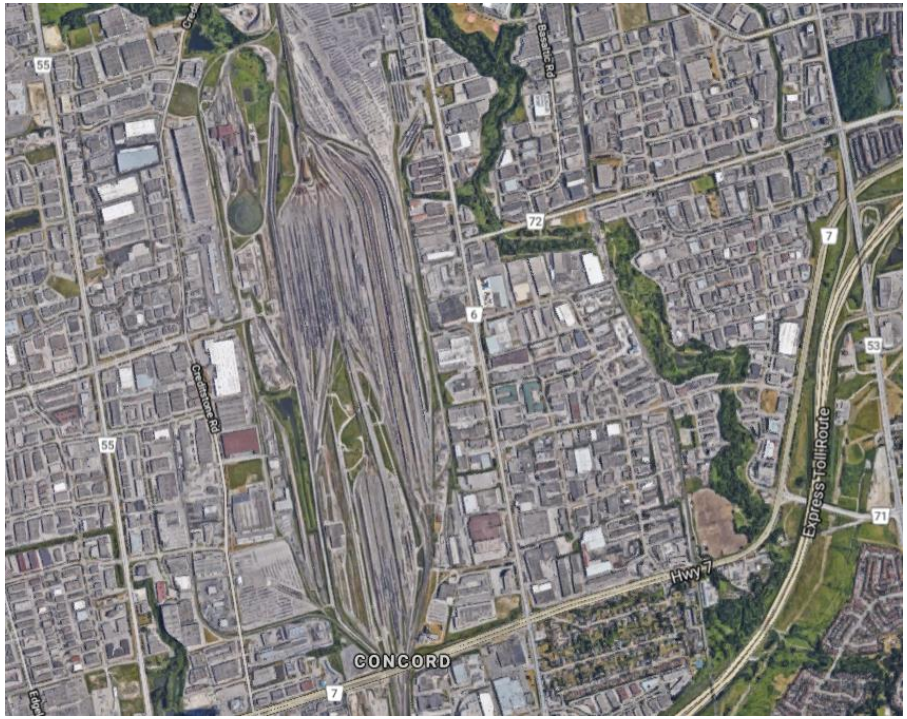
Radar Information



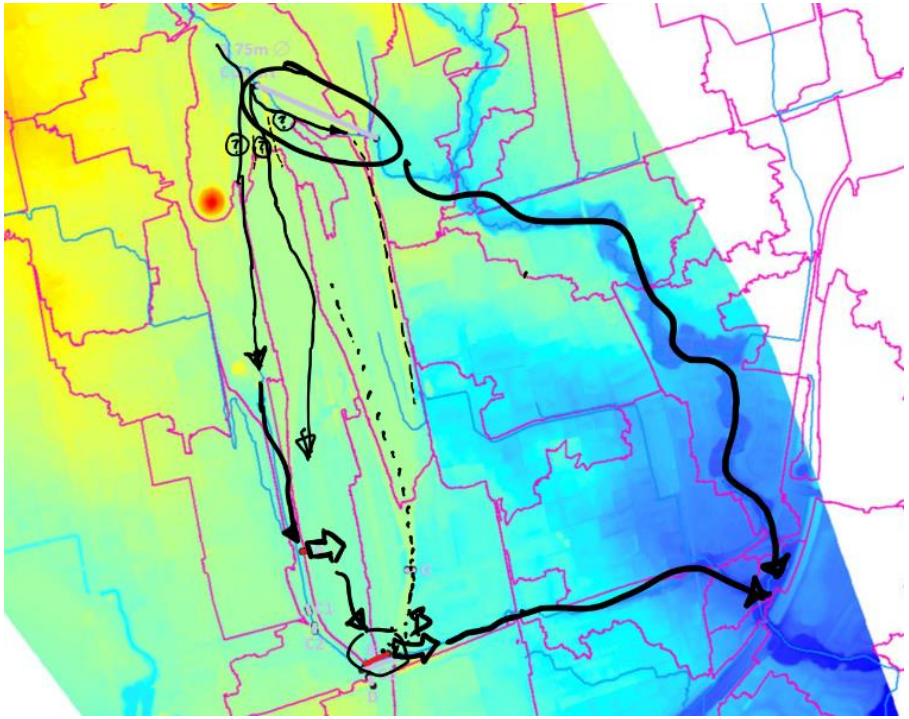
Continuity

- CNR MacMillan rail yard (2006) and auto compound (2009) studies by MMM Group;
- Fisherville Creek (R.J. Burnside, 2011);
- Mud Creek (GHD, 2013);
- Don Mills Ditch (Cole, 2011; City of Markham, ca. 2016).

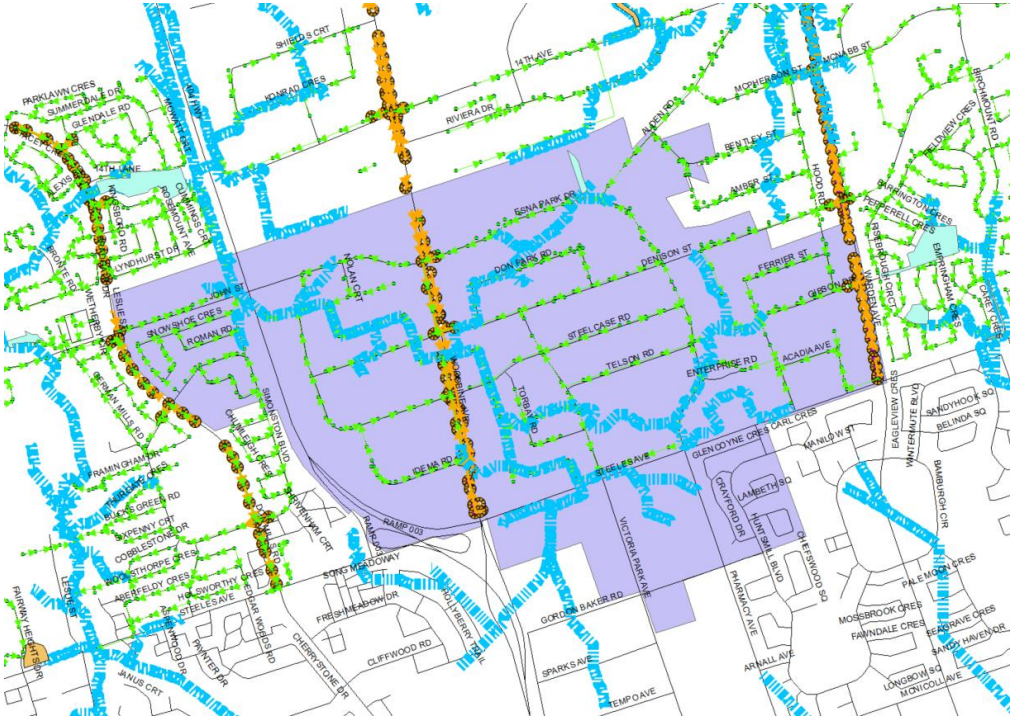
CNR MacMillan Rail Yard



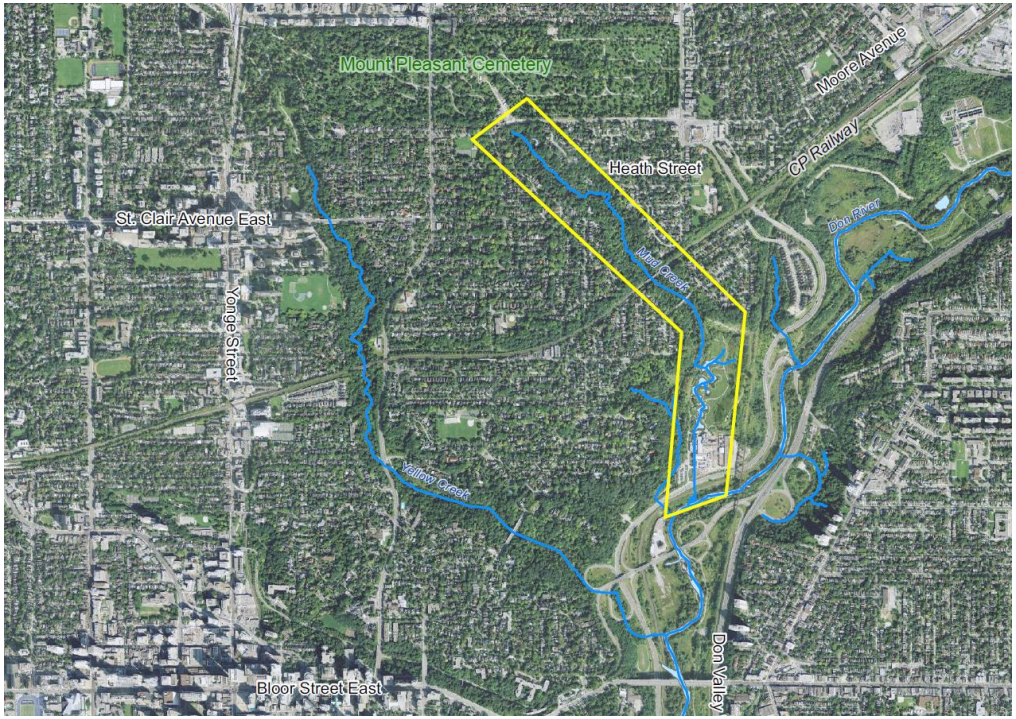
CNR MacMillan Rail Yard



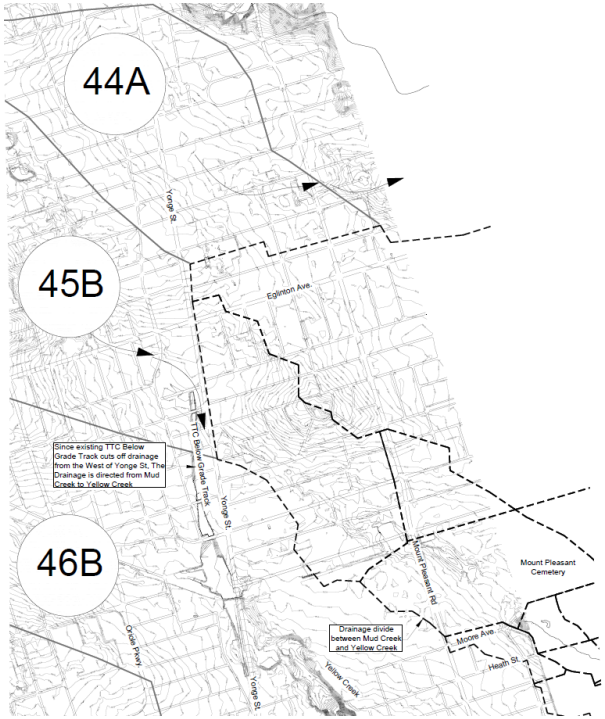
Don Mills Ditch



Mud Creek


Mount Pleasant Cemetery
Moore Avenue
CP Railway
Heath Street
St. Clair Avenue East
Don River
Mud Creek
Yonge Street
Vallein creek
Don Valley
Bloor Street East

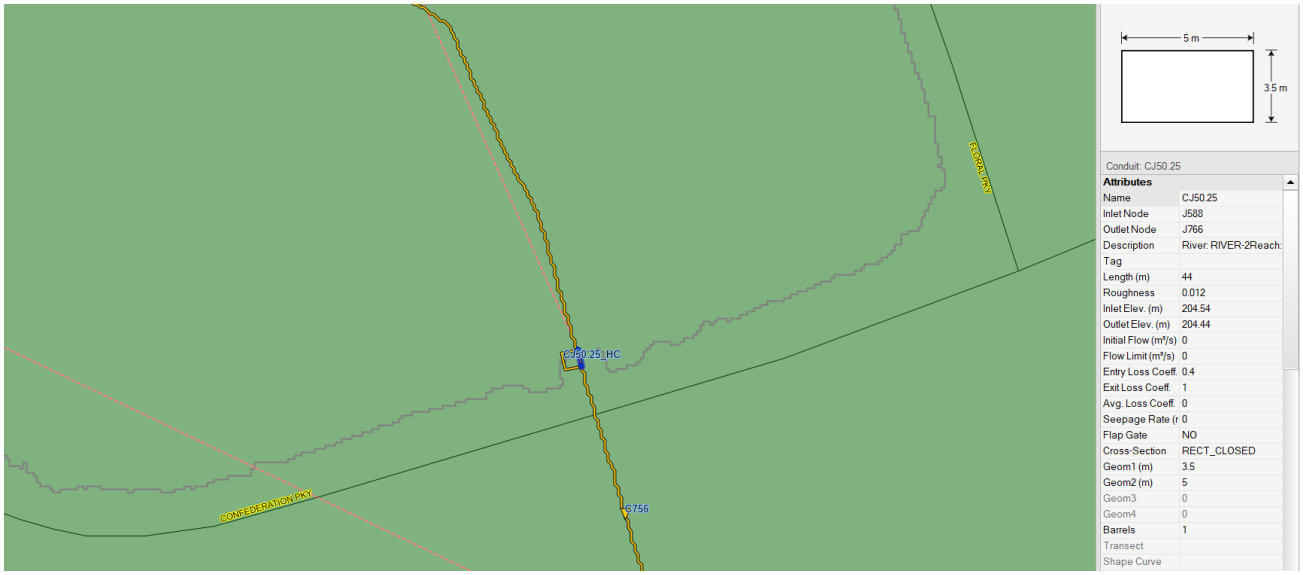
Mud Creek


44A
45B
46B
Yonge St.
Eglinton Ave.
TTC below grade Track
Since existing TTC Below Grade Track cuts off drainage from the West of Yonge St. The Drainage is directed from Mud Creek to Yellow Creek
Yonge St.
Mount Pleasant Rd.
Mount Pleasant Cemetery
Drainage divide between Mud Creek and Yellow Creek
Moore Ave.
Heath St.
Orcas Pkwy
Yonge St.
Yellow Creek

Conveyance Elements

- Used TRCA HEC-RAS modelling to identify and code significant crossings, as well as create representative channel cross-sections;
- Where overland flow paths were not well-defined, generic urban or rural drainage features were applied.

Conveyance Elements



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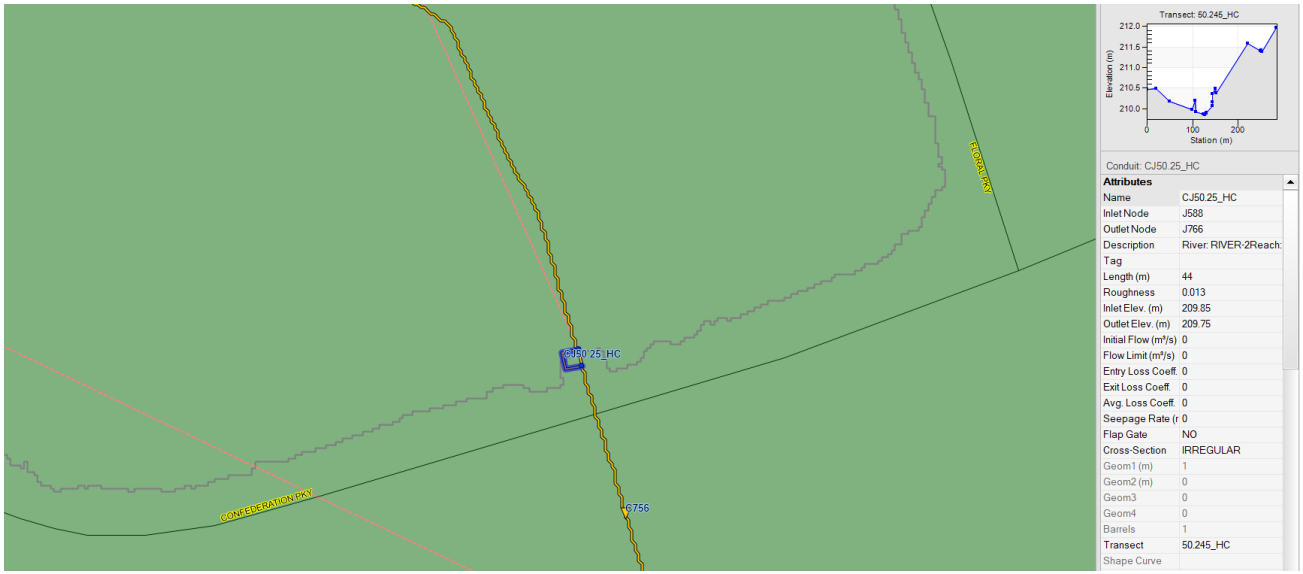

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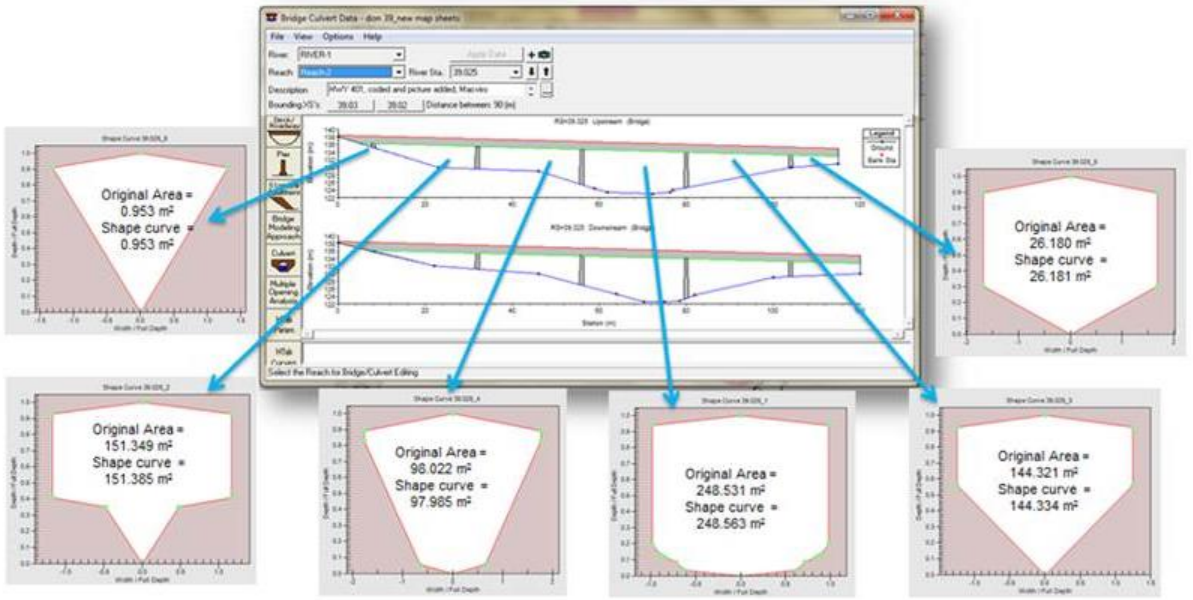
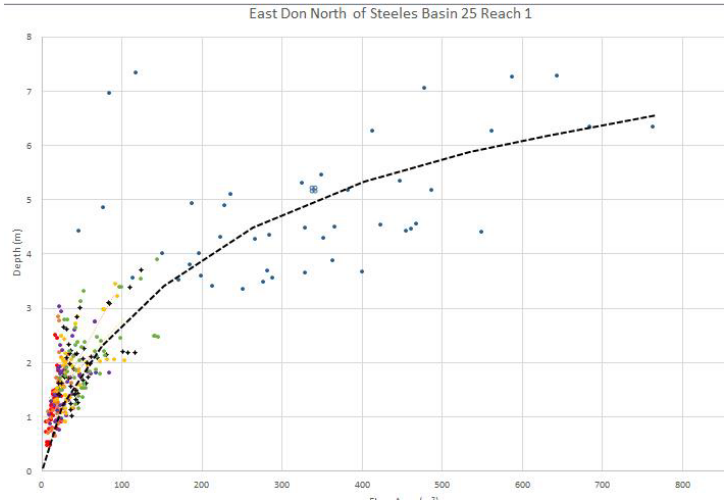


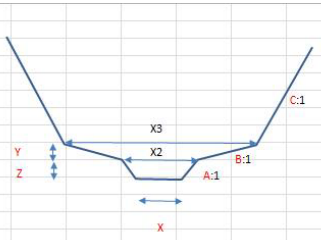
Conveyance Elements

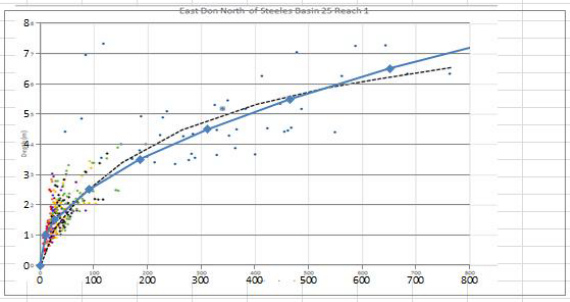


Conveyance Elements

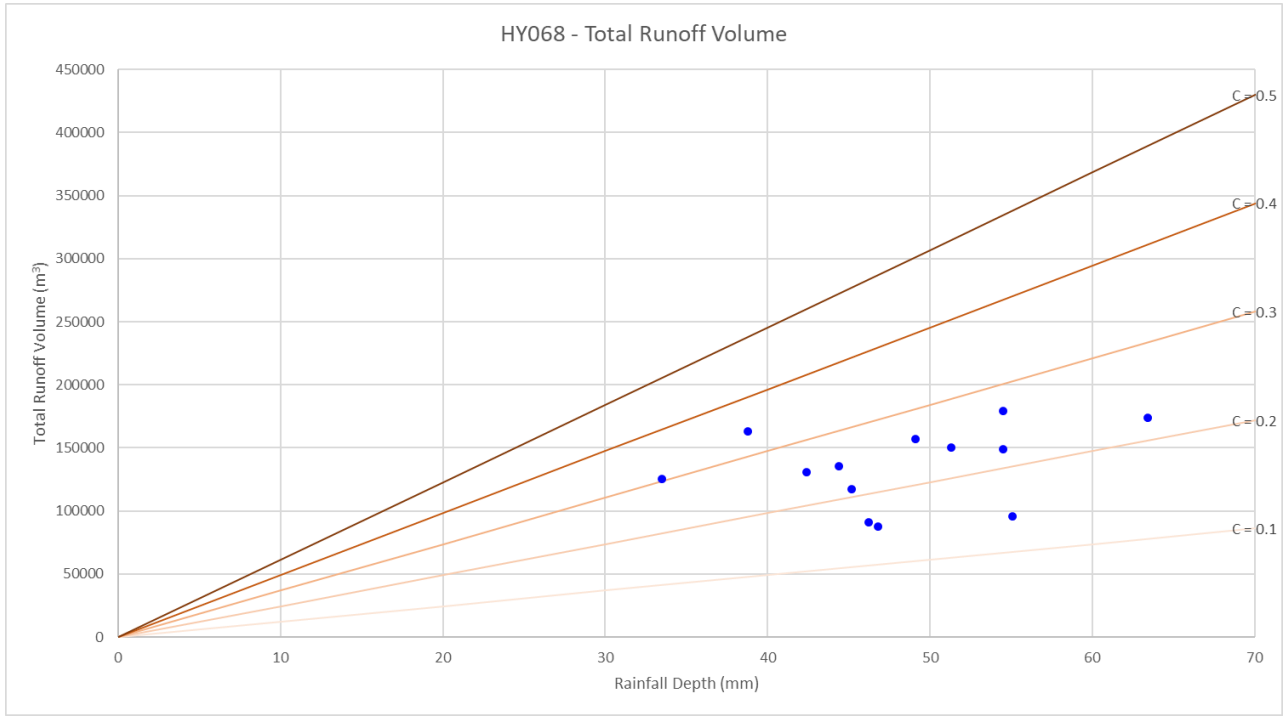
X	5		X2	15
Y	0.5		X3	50
Z	1			
A	5			
B	35			
C	15			

Depth	Top Width	Area
0	0	0
1	15	10
1.5	50	26.25
2.5	80	91.25
3.5	110	186.25
4.5	140	311.25
5.5	170	466.25
6.5	200	651.25
7.5	230	866.25





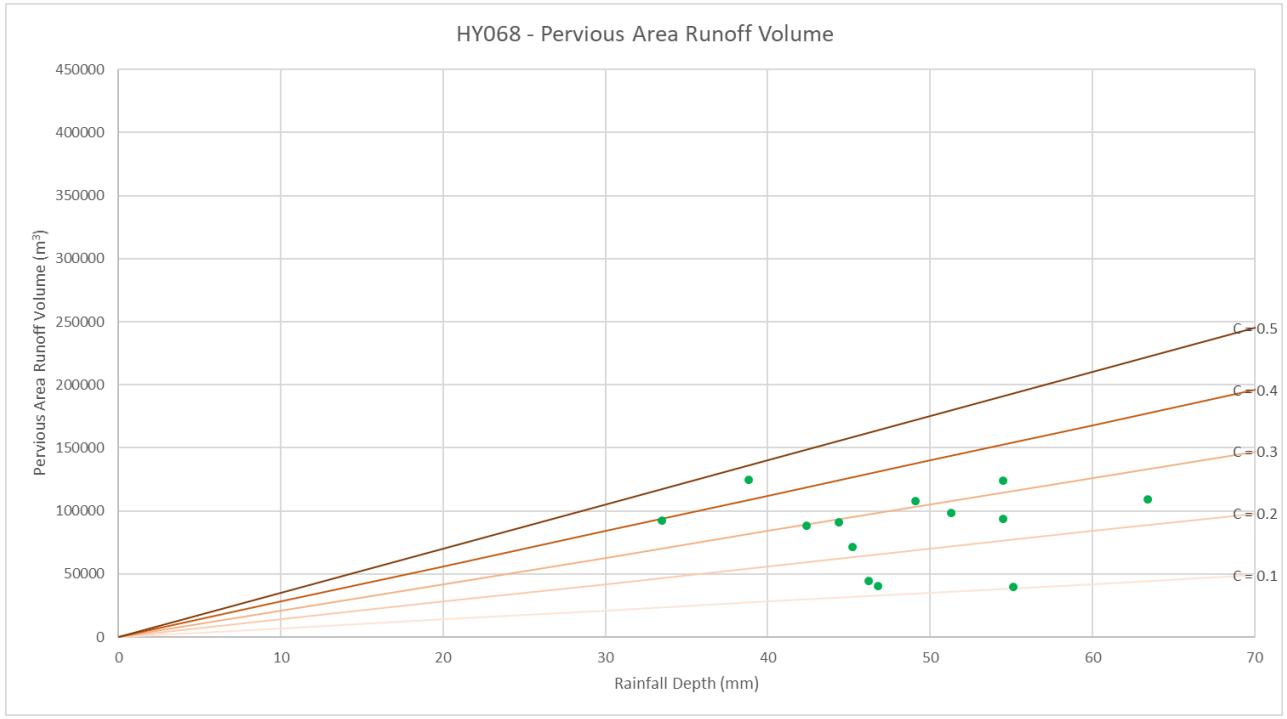
Calibration



Legend

- Observed Event

Calibration



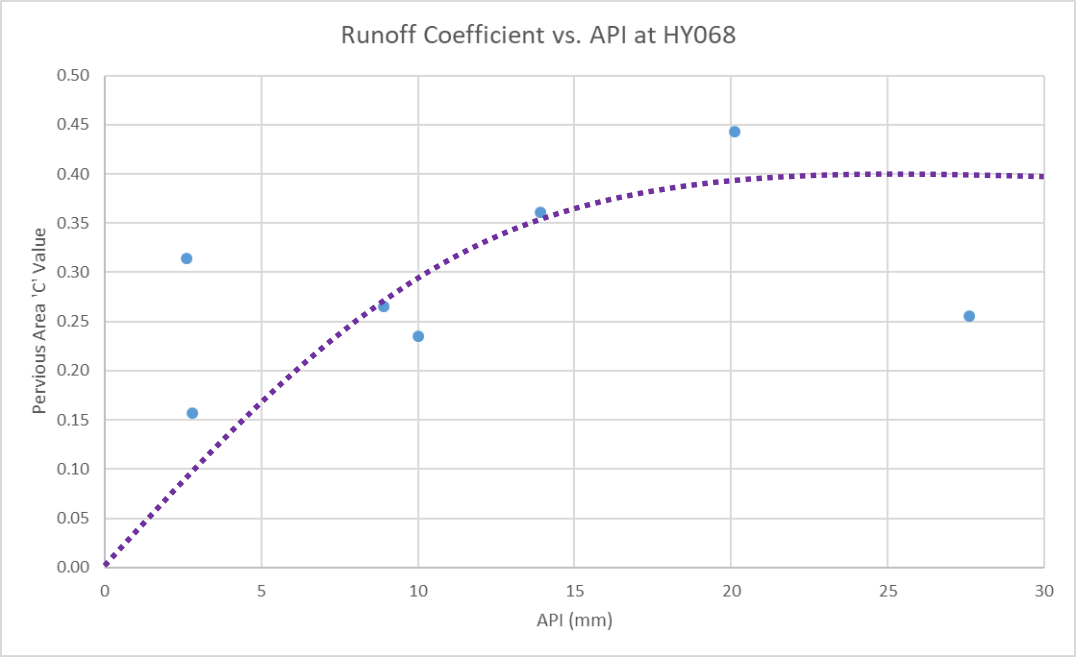
Legend

- Observed Event (Pervious Fraction)

Calibration

Event	Depth (mm)	Average API (mm)
7/8/2013	44.4	27.6
7/31/2013	45.2	10.0
9/20/2013	42.4	2.6
7/27/2014	46.2	2.8
9/10/2014	33.5	13.9
6/27/2015	38.8	20.1
10/28/2015	63.4	8.9

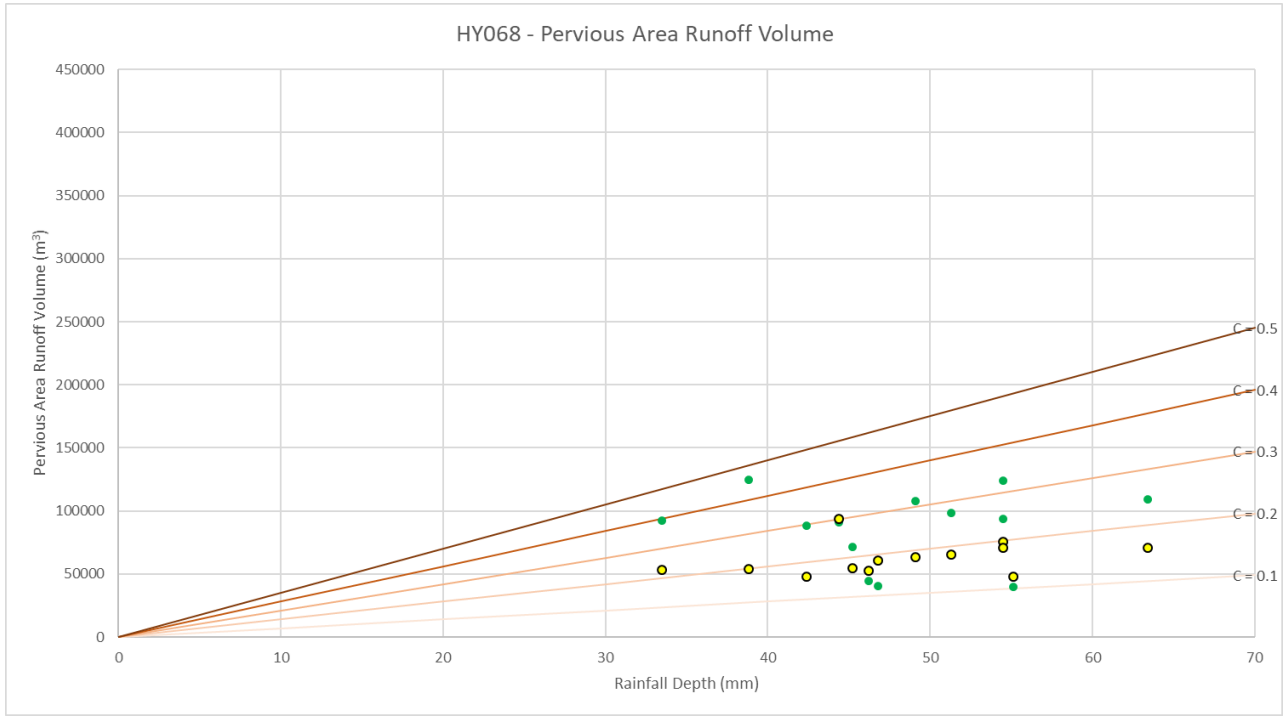
Calibration



Legend

- Calibration Event

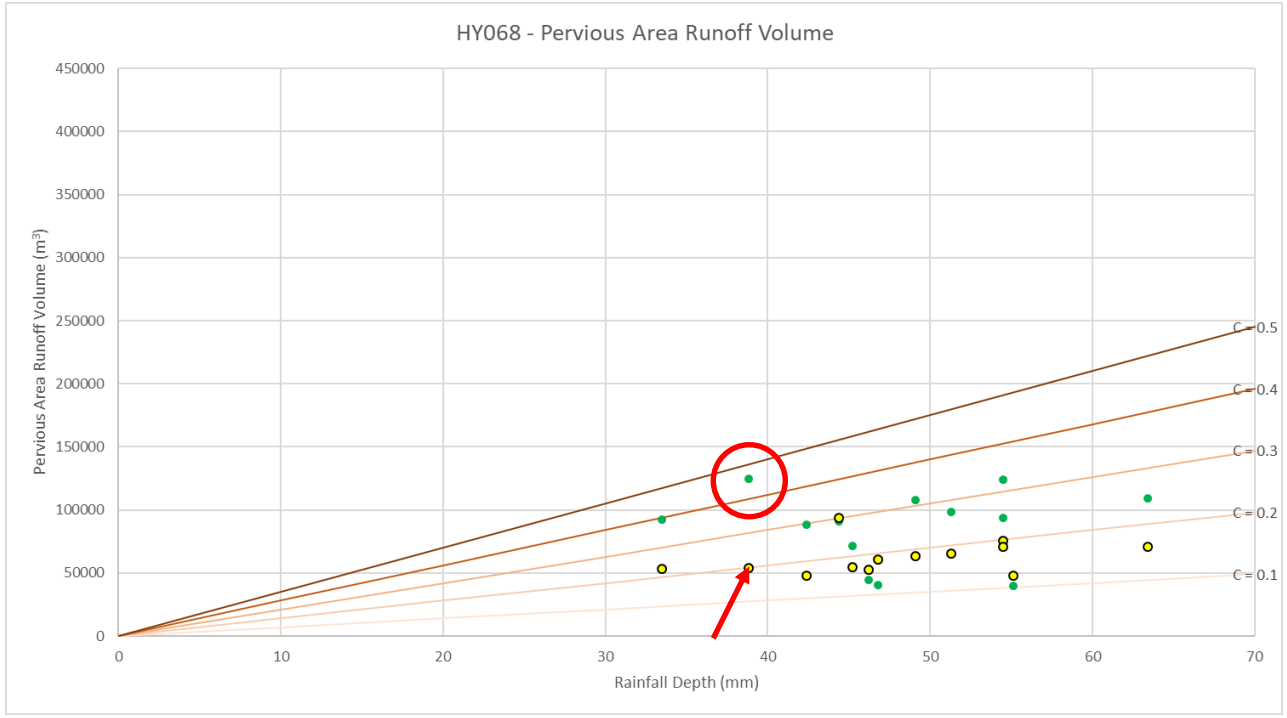
Calibration



Legend

- Observed Event (Pervious Fraction)
- Model Result (Pervious Fraction)

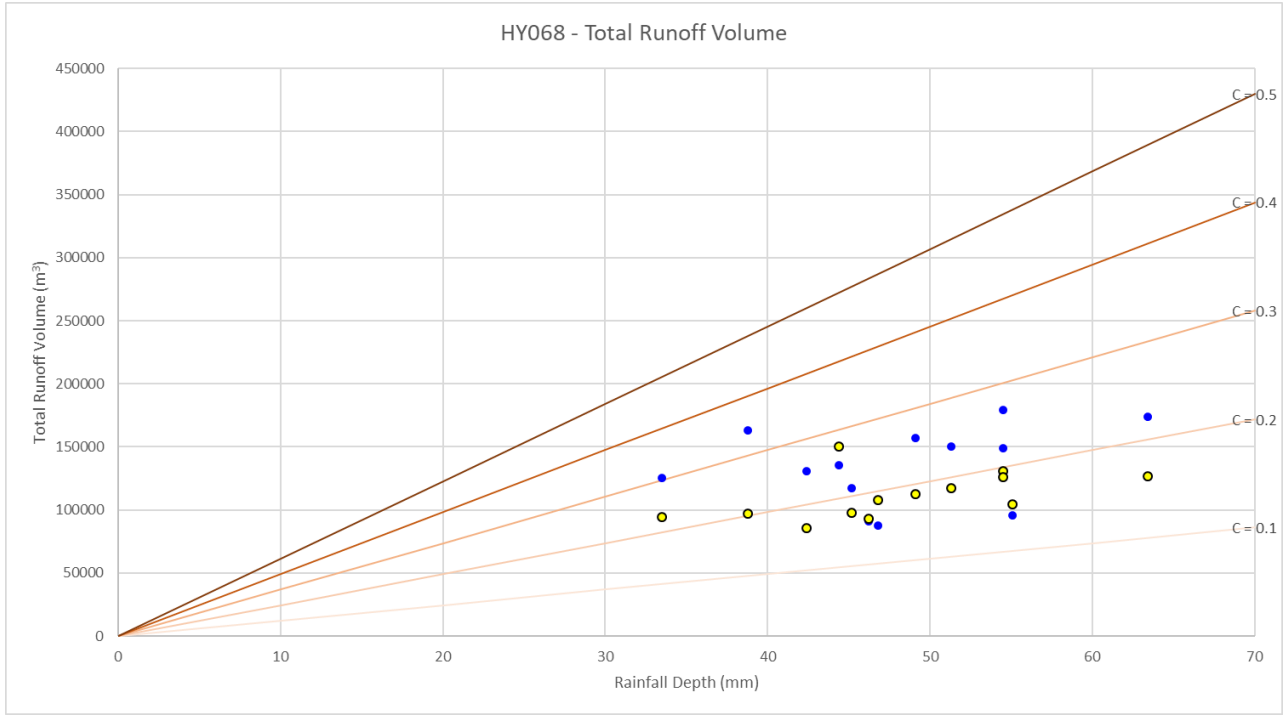
Calibration



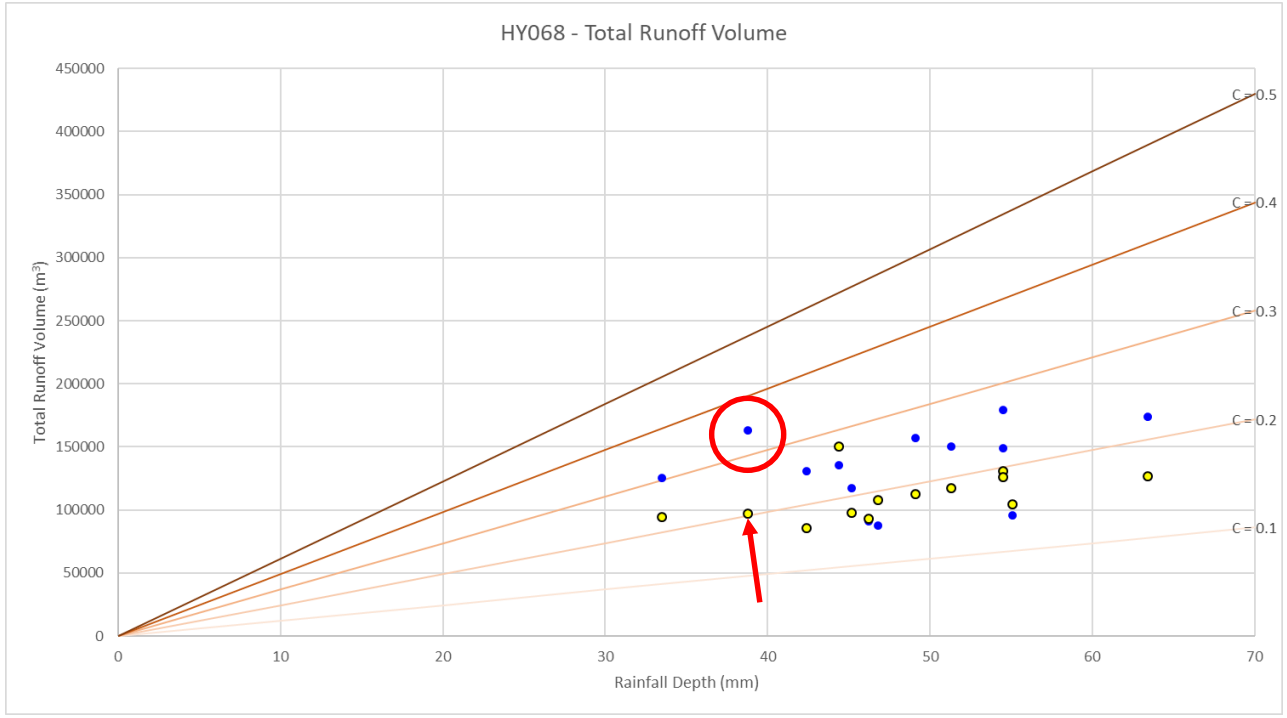
Legend

- Observed Event (Pervious Fraction)
- Model Result (Pervious Fraction)

Calibration



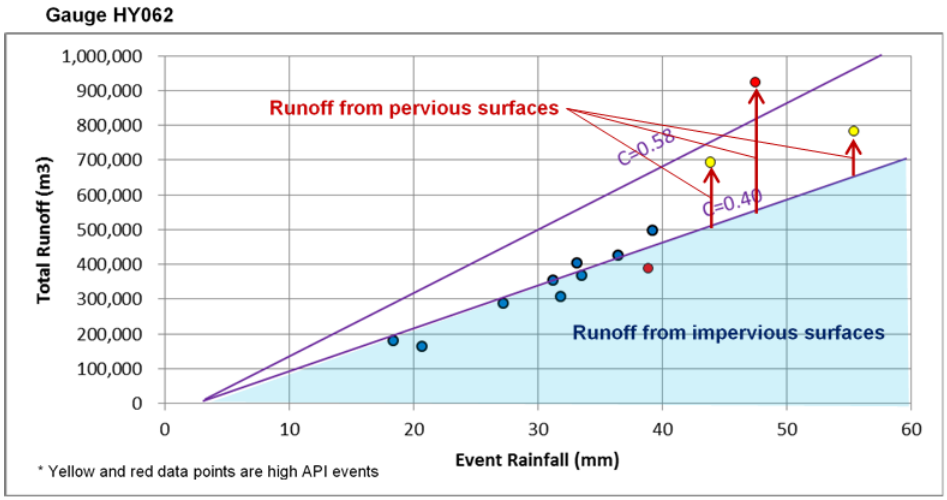
Calibration



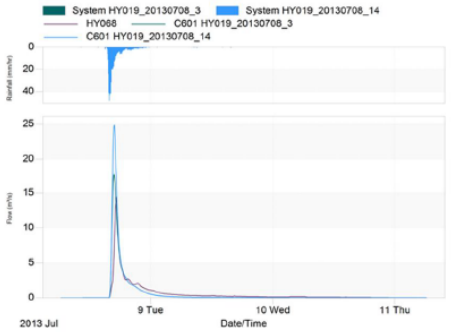
Legend

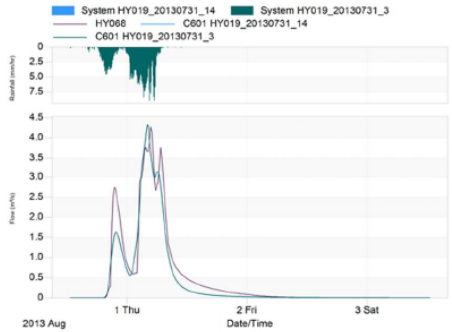
- Observed Event (Total)
- Model Result (Total)

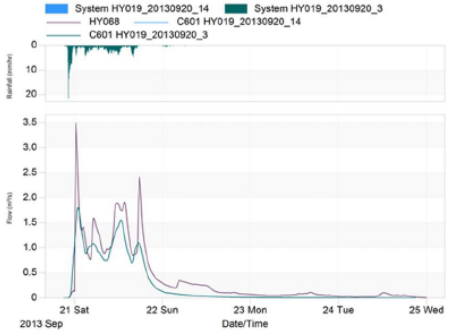
Calibration

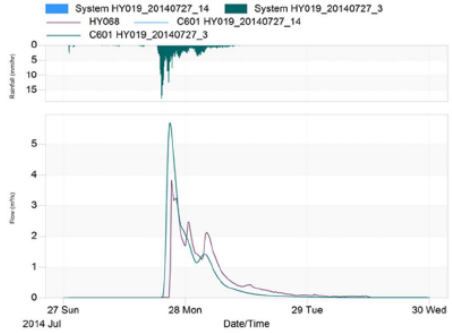


Calibration – HY068









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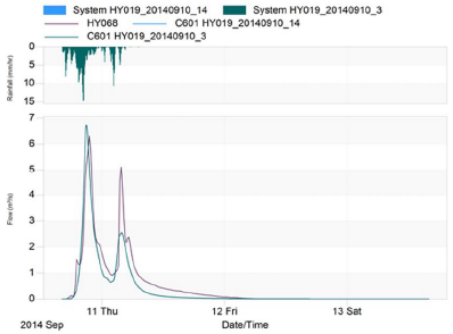
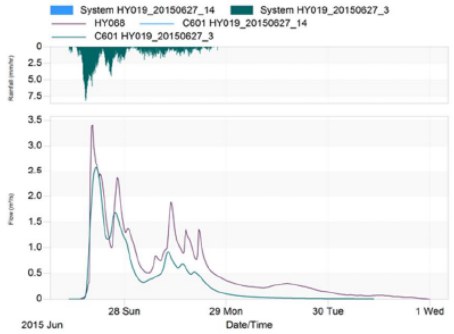
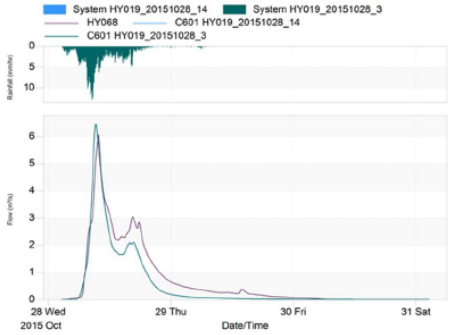
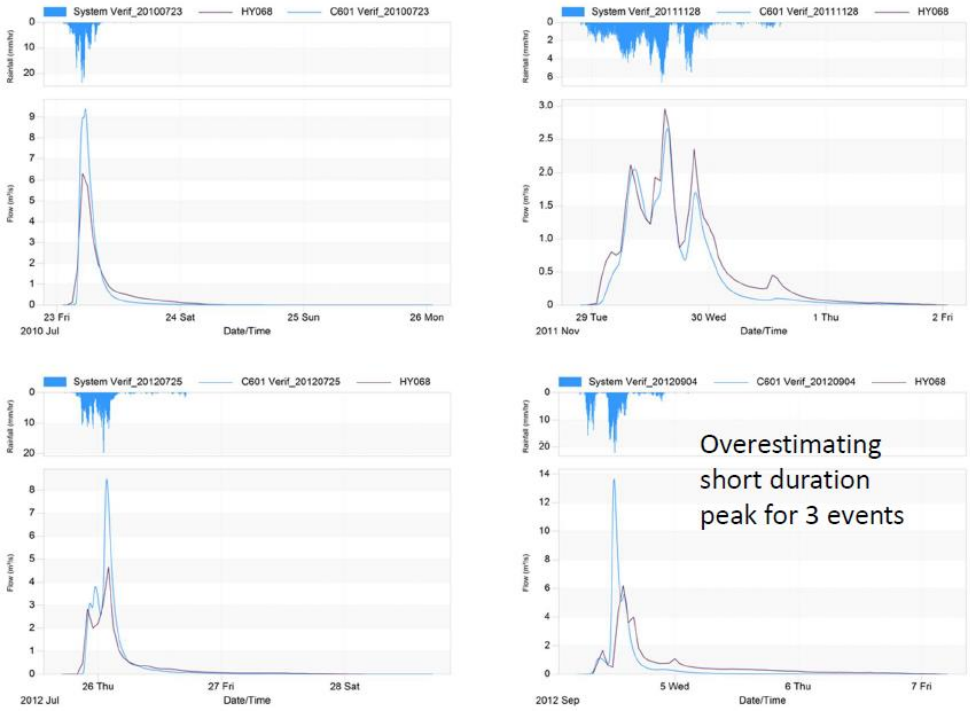






Verification – HY068



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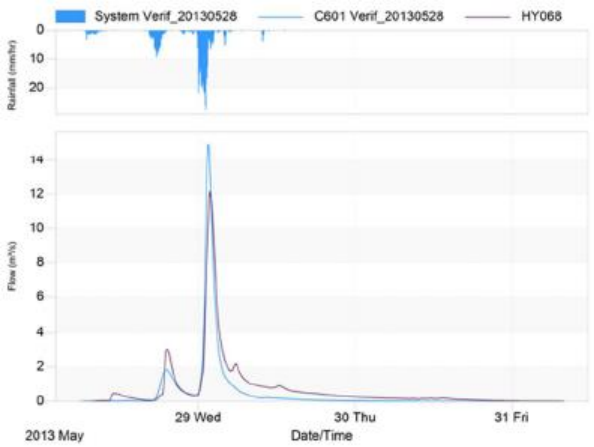

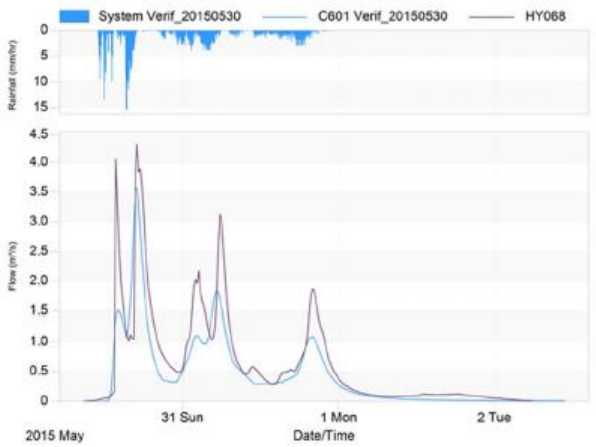

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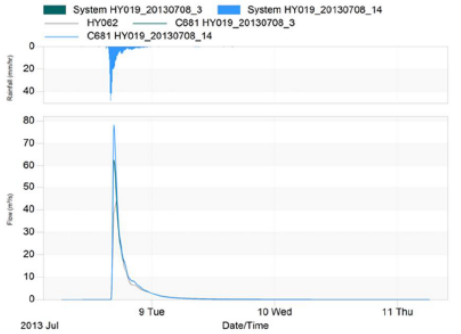

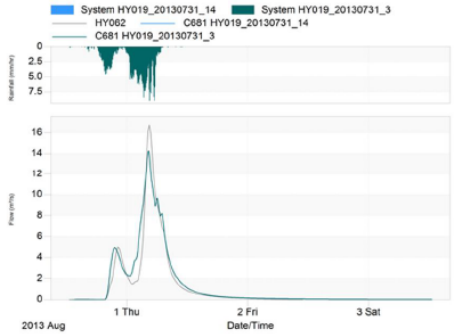

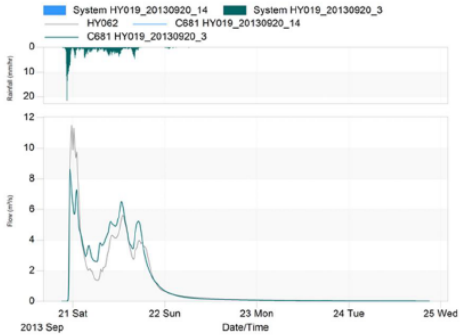

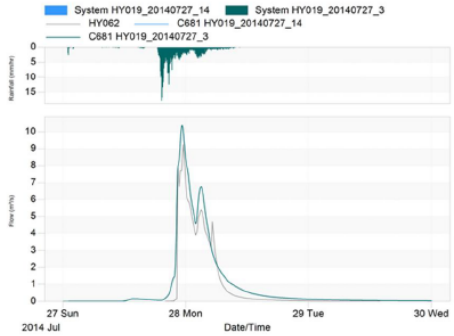

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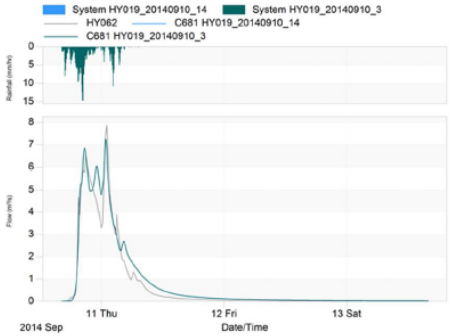

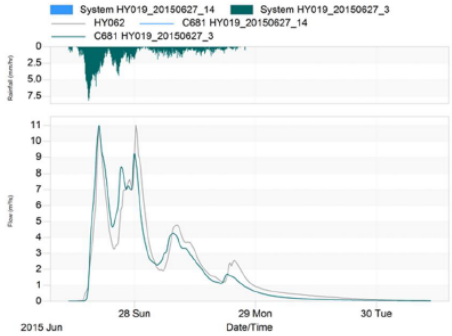

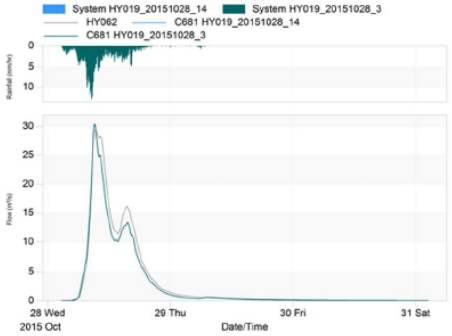

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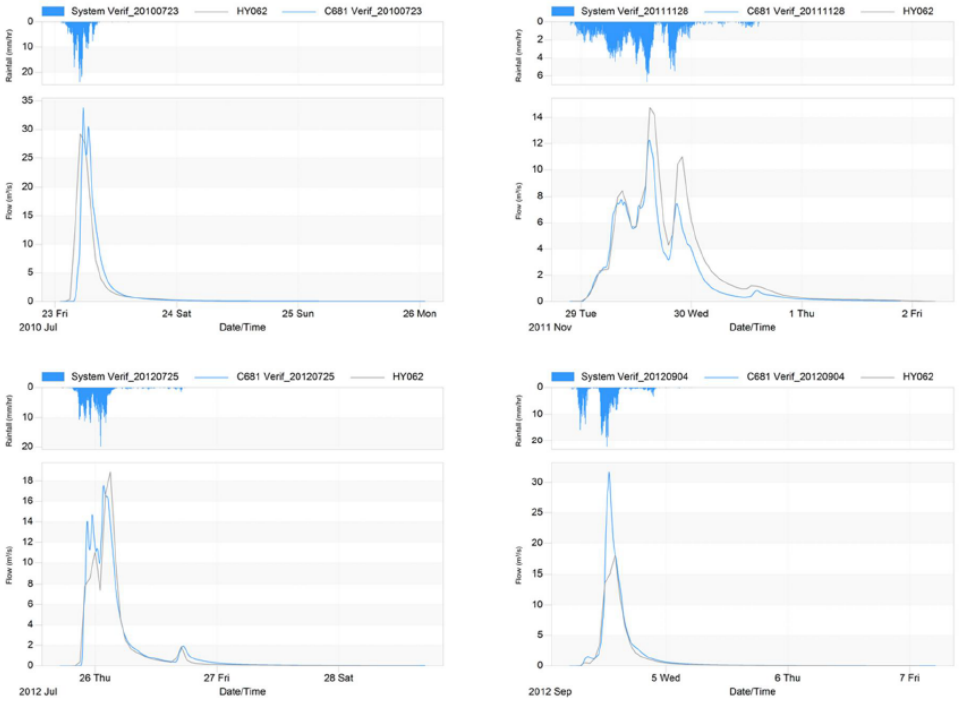
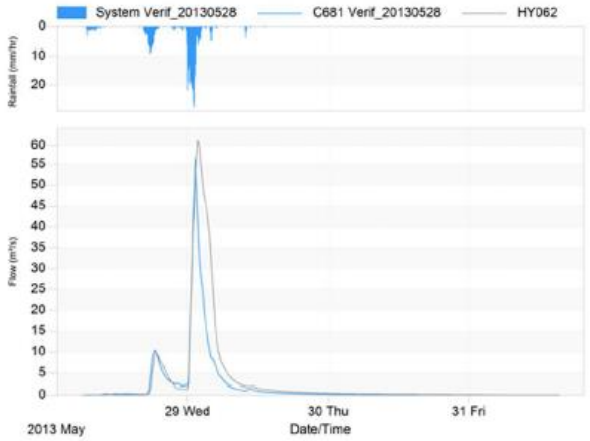
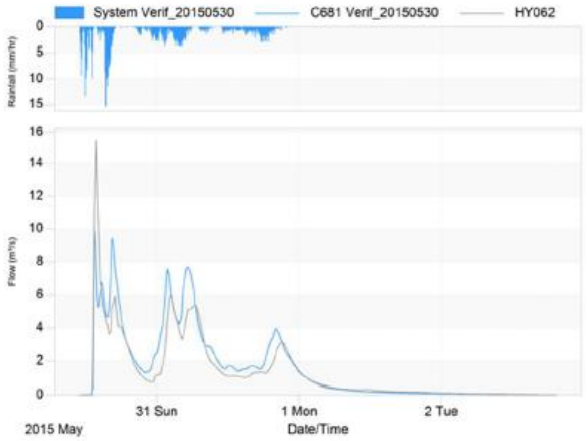
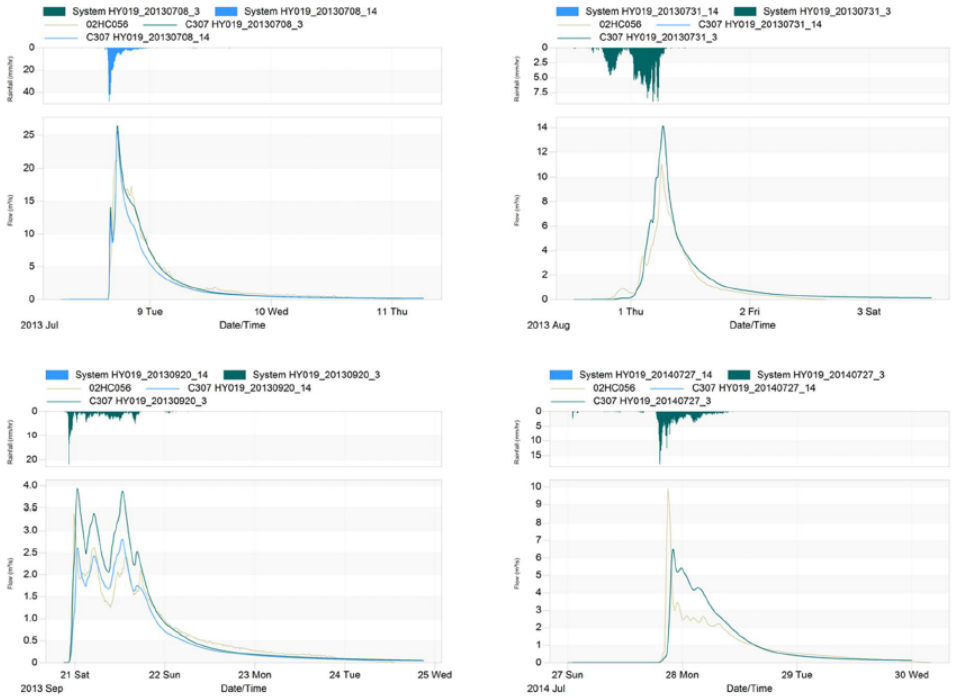


Verification – HY062

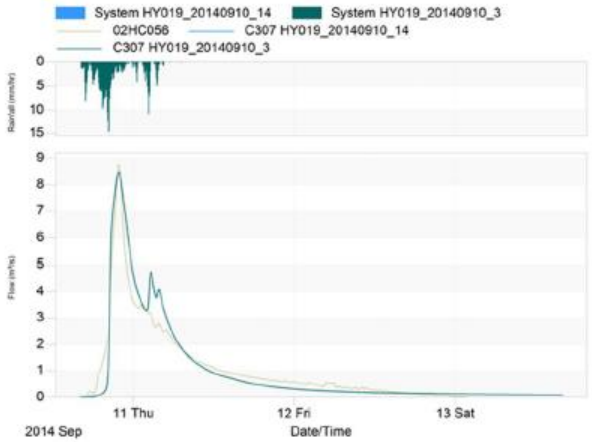


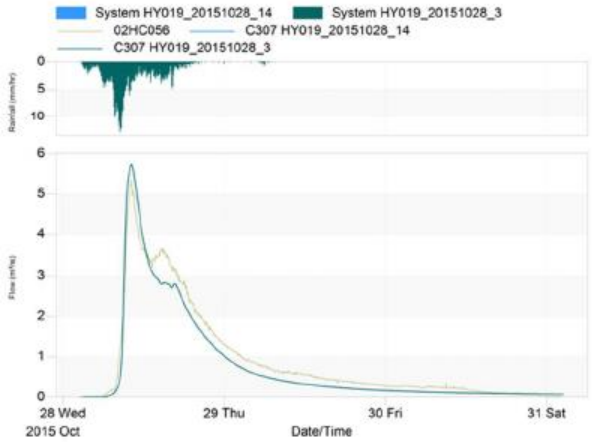


Calibration – 02HC056

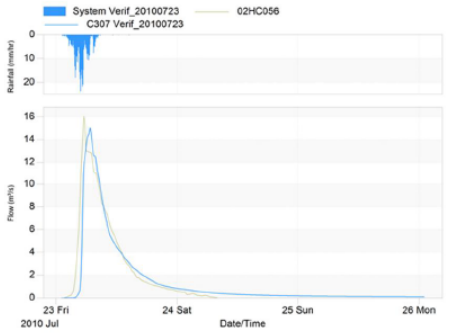


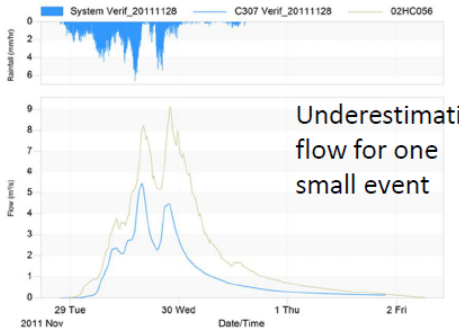
Calibration – 02HC056



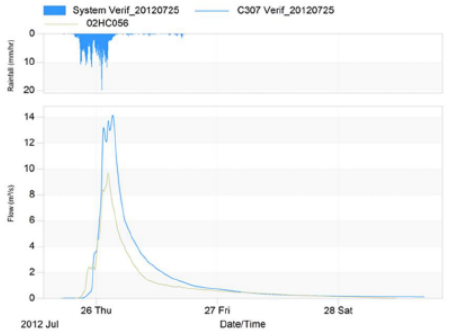


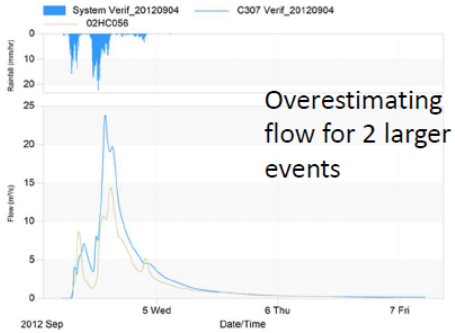
Verification – 02HC056





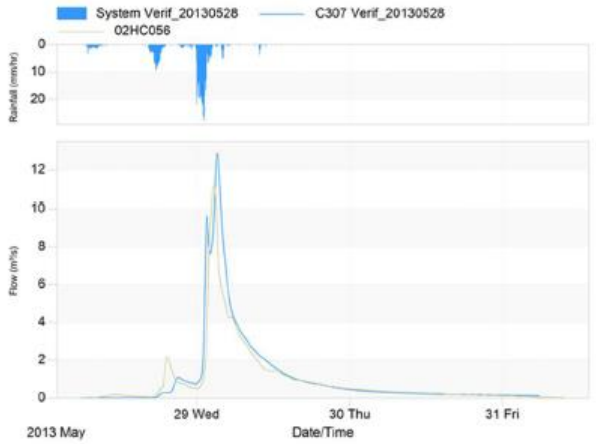
Underestimating flow for one small event

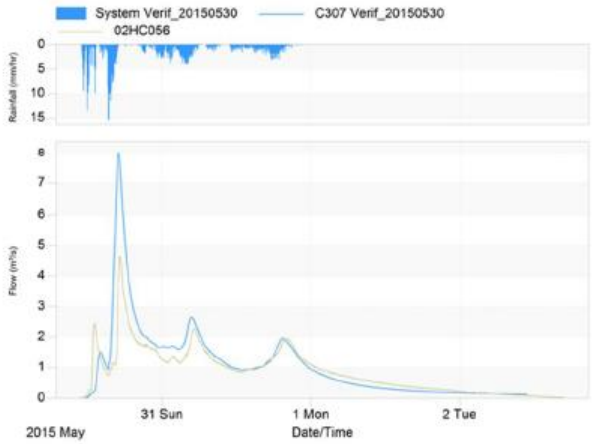




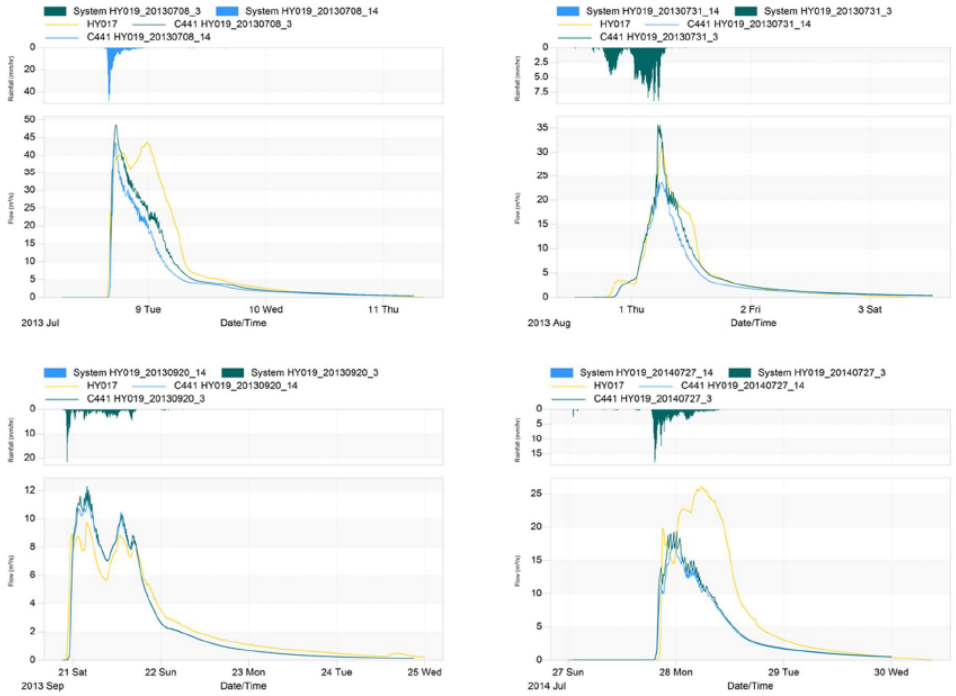
Overestimating flow for 2 larger events

Verification – 02HC056

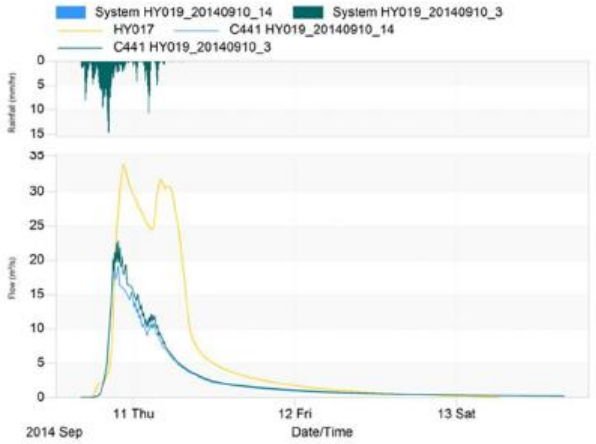




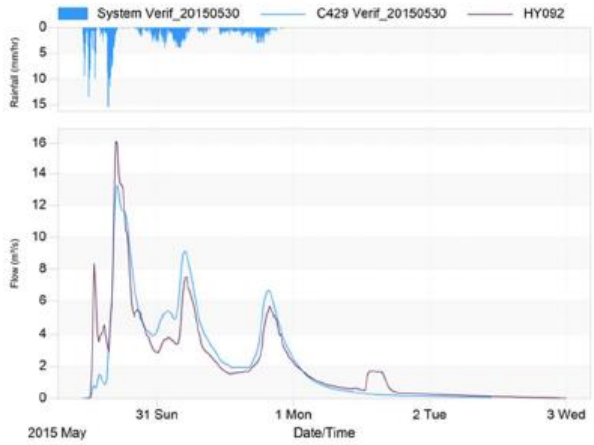
Calibration – HY017



Calibration – HY017



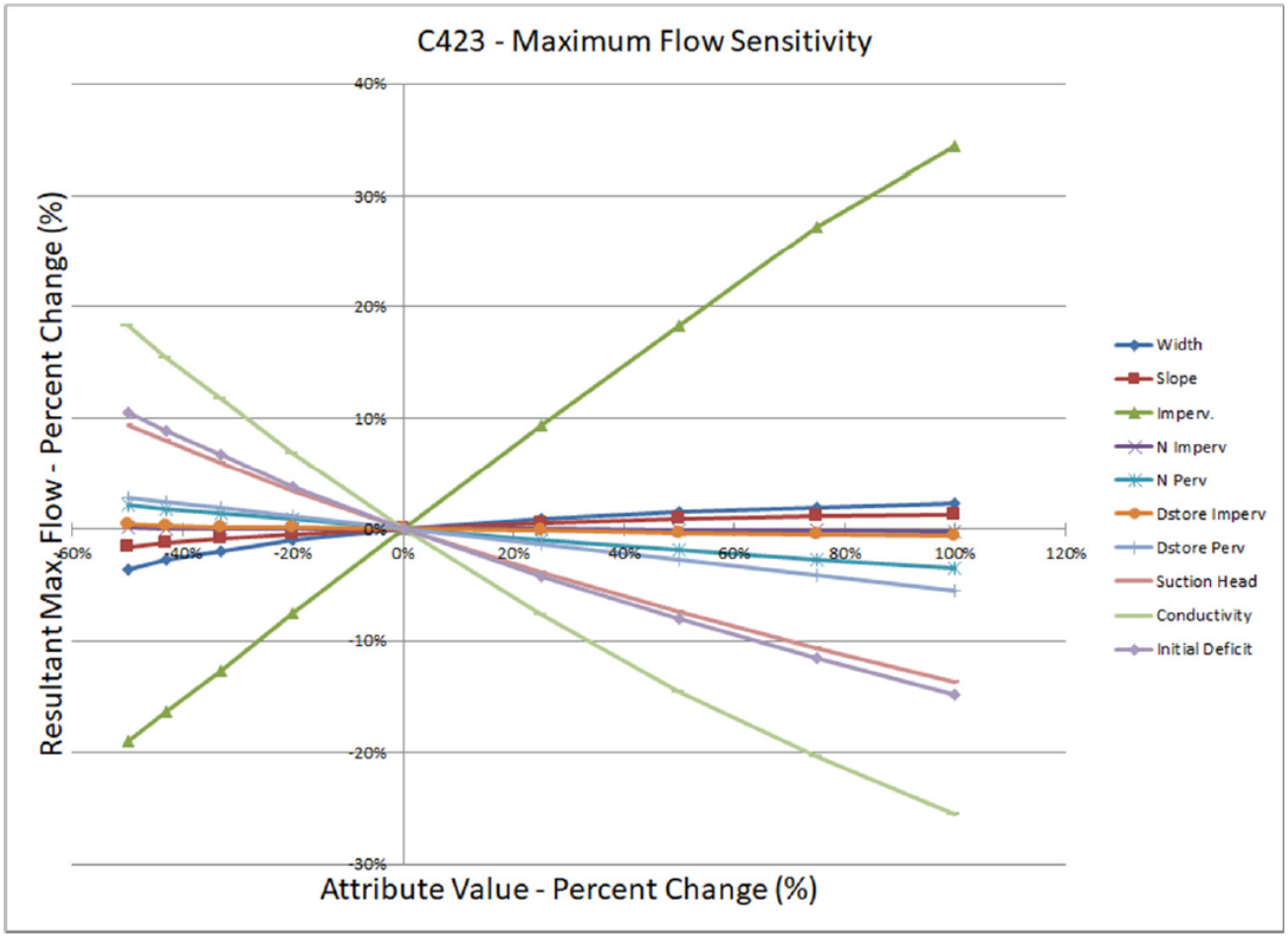
Verification – HY092



Peer Review

- Retained CHI in June of 2018;
- Model Setup:
  - Infiltration module, routing routine, time step selection.
- Hydrology:
  - Catchment delineation and parameterization;
  - Sensitivity analysis;
  - Rainfall QA/QC.
- Hydraulics:
  - Routing and storage.
- Comparison with previous (2004) model results.
- Largest uncertainty associated with infiltration parameterization.

Peer Review


C423 - Maximum Flow Sensitivity
Resultant Max. Flow - Percent Change (%)
Attribute Value - Percent Change (%)
40%
30%
20%
10%
0%
-10%
-20%
-30%
-60%
-40%
-20%
0%
20%
40%
60%
80%
100%
120%
Width
Slope
Imperv.
N Imperv
N Perv
Dstore Imperv
Dstore Perv
Suction Head
Conductivity
Initial Deficit

Conclusions

- A process-oriented hydrologic model of the Don River watershed has been built that predicts runoff response reasonably well;
- Accounting for factors that affect flow measurements, such as significant crossing structures and subarea routing, reduces exaggeration of model parameters;
- Separating directly connected impervious runoff volume from the total runoff volume allows for precise calibration of pervious area parameters, albeit with some exceptions;
- The certainty with which pervious surface runoff generation (i.e. the infiltration subroutine) can be calibrated decreases as the proportion of subarea routing to pervious areas increases.

Recommendations

- Identifying areas of significant subarea routing can help municipalities prioritize areas where SWM can be optimized, especially the conveyance portion of the “treatment train”;
- For a process-oriented hydrologic model, a dense gauge network is required to account for the spatial variability of rainfall; this project demonstrates how municipalities and other regulatory agencies can collectively provide the necessary gauge resolution;
- Continuing to update the API for each flow gauge will substantiate the relationship between IMD and runoff potential, making a case for how to manage green spaces at the subsurficial level of analysis;
- Field verification of watershed soil properties.

Model Build

Thanks for Listening

- Questions? Concerns?
- E-mail: who@trca.on.ca