



Establishing Innovative Watershed-Scale Criteria for Flood Control in the Rouge River Watershed

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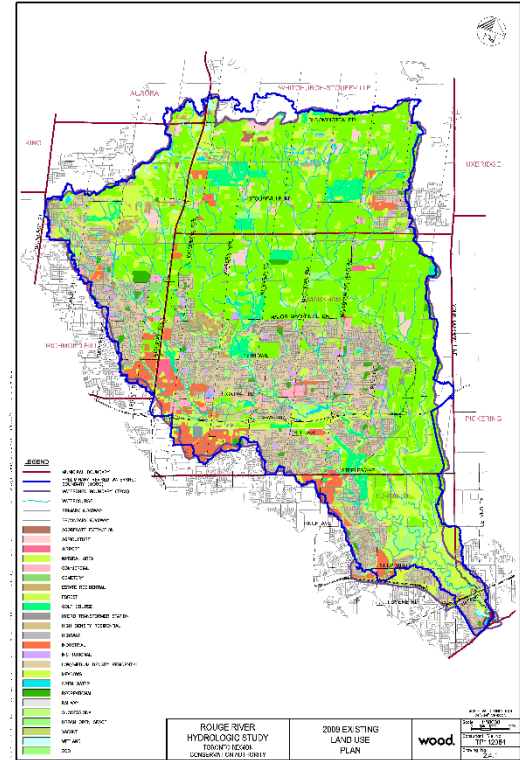
Presentation Outline

1. Introduction and Study Context
2. Hydrologic Model Development
 - 2.1 *Model Selection, Discretization and Parameterization*
 - 2.2 *Model Calibration and Design Storm Selection*
3. Impact Assessment
 - 3.1 *Future Land Use Conditions*
 - 3.2 *Hydrologic Assessment*
4. Stormwater Management Plan
 - 4.1 *End-of-Pipe Only*
 - 4.2 *End-of-Pipe with LID BMPs*
5. Conclusions



1. Introduction and Study Context

- Rouge River Watershed:
 - In TRCA jurisdiction
 - Measures some 336 km²
 - 65% +/- is in a non-urban condition



1. Introduction and Study Context

- Rouge River Watershed Hydrology Study conducted to:
 - *Update the watershed hydrologic modelling (from 2000);*
 - *Calibrate and validate the updated model;*
 - *Estimate peak flows for 2 to 350-year design storms and the Regional Storm;*
 - *Develop flood (quantity) control criteria for proposed future development lands (based on approved Official Plans).*



2. Hydrologic Model Development

2.1 Model Selection, Discretization and Parameterization

- PCSWMM selected as the preferred modelling platform
 - Fully compatible with GIS software.
 - Widely used across North America.
 - Analytical core of the PCSWMM platform (EPA SWMM) supported by the MNRF for Regulatory Floodline Mapping.
 - EPA SWMM hydrologic model fully supported by the US EPA and freely available.
 - EPA SWMM hydrologic model can apply the Green & Ampt methodology, applied by other accepted hydrologic models for modelling *non-urban* subwatersheds.



2. Hydrologic Model Development

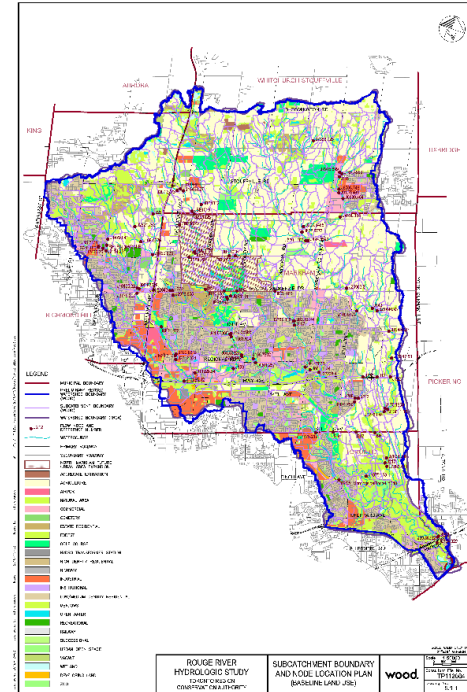
2.1 Model Selection, Discretization and Parameterization

- Subcatchment boundaries delineated using current DEM and analysis tools within ArcGIS™ and refined based upon available information (confirmatory)
- Hydraulic elements representing the open watercourses generated from DEM
- Storage-discharge relationships representing stormwater management facilities incorporated into the model based upon existing design reports; where not available, surrogate techniques applied

2. Hydrologic Model Development

2.1 Model Selection, Discretization and Parameterization

- PCSWMM model includes:
 - 840 subcatchments (average size 40 ha)
 - 1,336 hydraulic elements for open watercourses
 - 151 elements representing stormwater management facilities



2. Hydrologic Model Development

2.1 Model Selection, Discretization and Parameterization

Soil Properties

Challenges:

- Dominant soils type, based on surficial geology, is diamicton
- Diamicton is a general reference to glacial deposition, encompassing a variety of soil types
- Uniform parameterization of diamicton soils failed to yield acceptable calibration results

Solutions:

- TRCA database included attributes which characterized diamicton soils texture, however no literature data were available for these textures
- Base soils parameterization established by determining corresponding parameterization for loamy soils



2. Hydrologic Model Development

Soil Properties

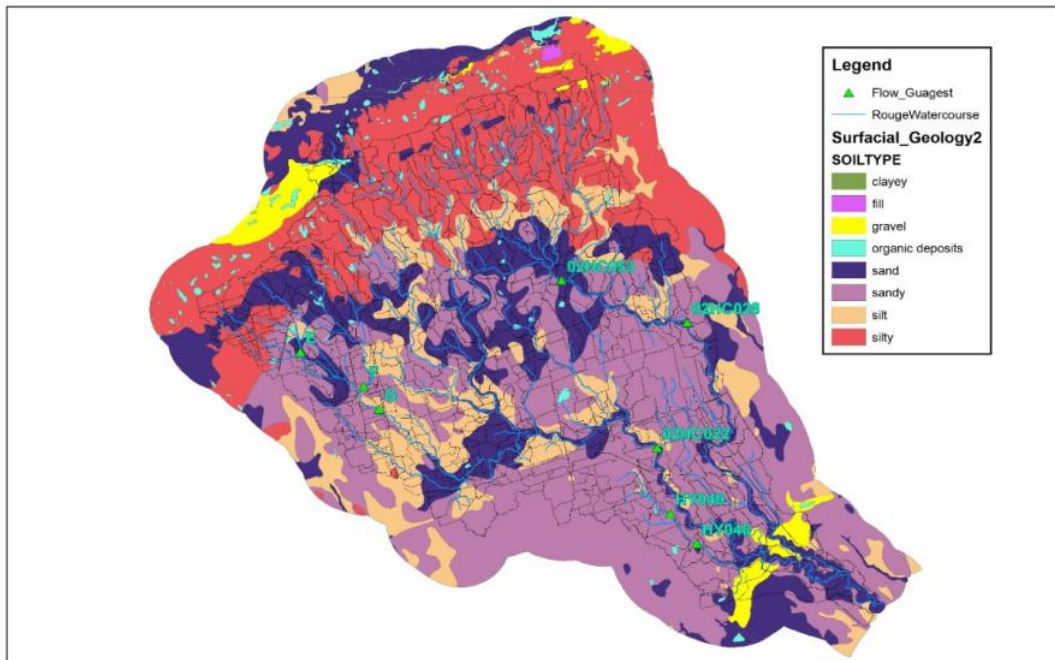


Table 2.4.2 Green and Ampt Infiltration Parameters			
Soil Type	Conductivity (mm/hr)	Suction Head (mm)	Initial Moisture Deficit (fraction)
Recommended Green-Ampt Parameters as per CHI, 2010			
Sand	120.4	49.02	0.024
Loamy Sand	29.97	60.96	0.047
Sandy Loam	10.92	109.98	0.085
Loam	3.3	88.9	0.116
Silt Loam	6.6	169.93	0.135
Sandy Clay Loam	1.52	219.96	0.136
Clay Loam	1.02	210.06	0.187
Silty Clay Loam	1.02	270	0.21
Sandy Clay	0.51	240.03	0.221
Silty Clay	0.51	290.07	0.251
Clay	0.25	320.04	0.265
Initial Green-Ampt Parameters for Soils As Identified in TRCA Database			
clayey	1.02	270	0.21
gravel	120.4	49.02	0.024
organic deposits	6.6	169.93	0.135
sand	29.97	60.96	0.047
sandy	1.52	219.96	0.136
silt	6.6	169.93	0.135
silty	6.6	169.93	0.135

2. Hydrologic Model Development

2.1 Model Selection, Discretization and Parameterization

Rural Land Use

Challenge:

- Initial parameterization of rural subcatchments generated zero or near-zero runoff response for formative storm events (i.e. 100 year and Regional Storm event) for certain subcatchments

Solution:

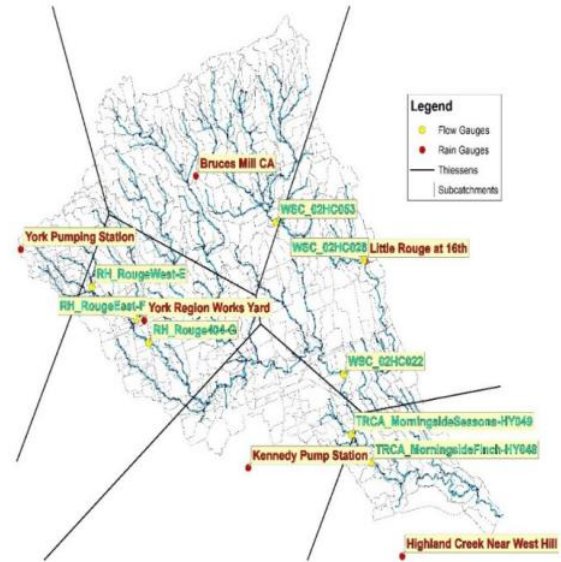
- Subcatchment imperviousness was identified as key parameter influencing runoff response for rural subcatchments
- Rural subcatchment imperviousness was established as 10% for Little Rouge Subwatershed and 5% for remainder of watershed reflecting farmsteads, roadways, and other compacted soil areas



2. Hydrologic Model Development

2.2 Model Calibration and Design Storm Selection

- The base PCSWMM model calibrated using rainfall and flow data local to the Rouge River Watershed
 - 6 rainfall gauges
 - 4 flow gauges
- Local calibration and parameterization used to establish soil parameters for:
 - West Rouge River Watershed
 - Little Rouge River Watershed



2. Hydrologic Model Development

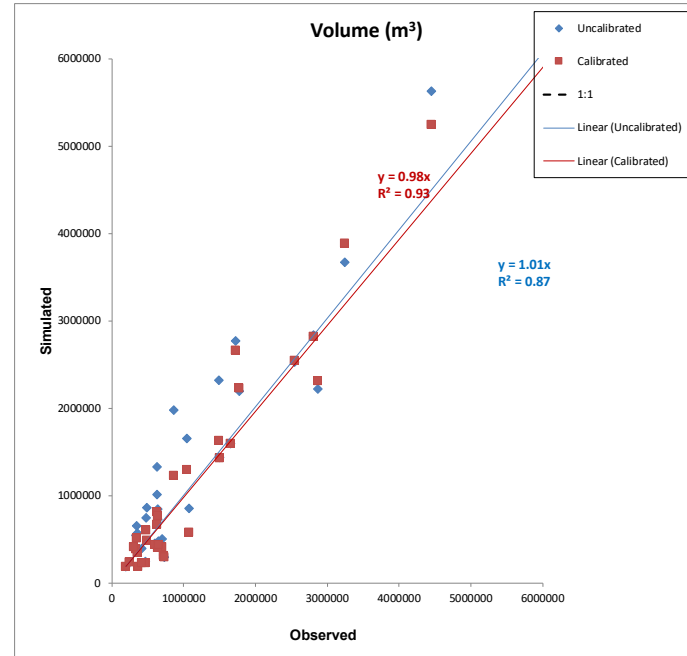
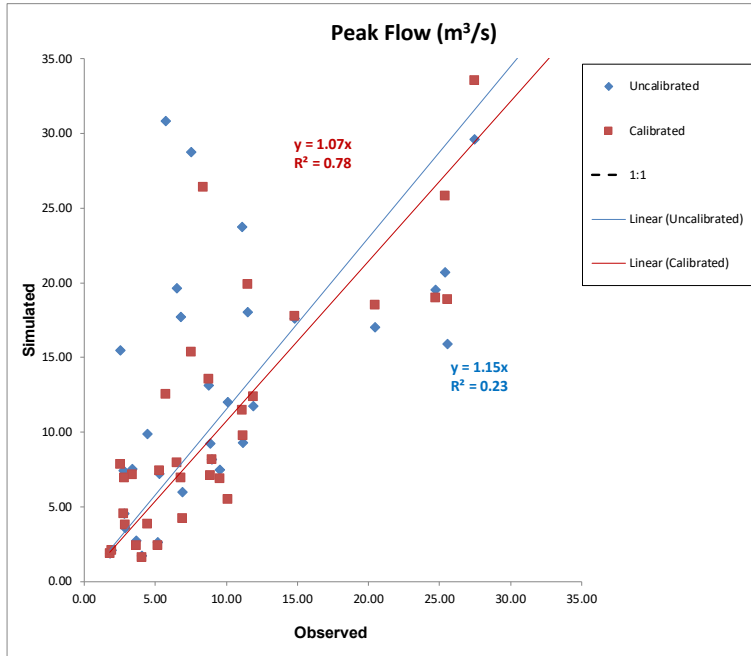
2.2 Model Calibration and Design Storm Selection

- Model calibration applied criteria based on Wastewater Planning Users Group (WaPUG) Modelling Code of Practice (2002) for closed conduit models:
 - *Simulated volume is within +20% to -10% of the measured volume*
 - *Simulated peak flow is within +25% to -15% of the measured value*
 - *The observed and modelled hydrographs meet the criteria for two (2) out of three (3) events*
- Visual inspection of simulated and observed hydrographs used for shape and timing



2. Hydrologic Model Development

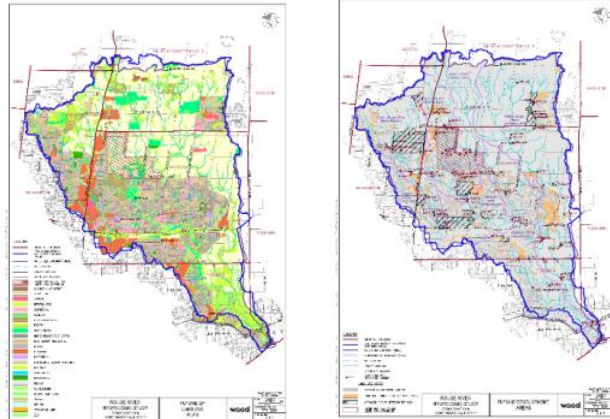
2.2 Model Calibration and Design Storm Selection



3. Impact Assessment

3.1 Future Land Use Conditions

- Future land use conditions based upon the Municipal Official Plans for the member municipalities within the Watershed (five municipalities)
- Subcatchment impervious coverages adjusted to represent areas of future development; impervious values based on trends from current studies



3. Impact Assessment

3.2 Impact Assessment

- In the absence of quantity controls, return period and Regional Storm event peak flows would be anticipated to increase throughout the Watershed primarily within, and proximate to, the future development areas
- Increases in peak flows during more frequent events at all locations downstream of future development areas, with some reductions in peak flows during less frequent events due to shifts in hydrograph timing



3. Impact Assessment

3.2 Impact Assessment

Table 6.3.2: Percent Difference In Simulated Instantaneous Peak Flows – Future Uncontrolled Land Use Conditions Compared to Baseline Land Use Conditions

Name/ Subwatershed	Return Period (Years)							Regional
	2	5	10	25	50	100	350	
Little Rouge River Subwatershed								
J167.4563	56%	54%	52%	51%	53%	56%	47%	65%
J115	50%	43%	43%	40%	38%	38%	25%	37%
J6765.748	75%	74%	70%	66%	67%	60%	39%	27%
J91.75469	14%	12%	12%	11%	10%	9%	5%	5%
J5830.464	5%	2%	2%	4%	5%	6%	27%	24%
J4490.154	35%	26%	27%	29%	27%	26%	23%	14%
J494.5593	34%	23%	35%	26%	30%	40%	13%	12%
J7386.725	0%	0%	0%	0%	0%	0%	0%	0%
J207.3486	3%	2%	2%	1%	1%	1%	-1%	0%
J672.9773	5%	3%	2%	2%	1%	1%	-2%	0%
J320.1186	25%	15%	23%	18%	17%	24%	10%	8%
J25903.3	23%	31%	17%	13%	12%	12%	5%	3%
J149	17%	21%	20%	14%	10%	11%	4%	3%
J21490.93	14%	20%	20%	13%	10%	10%	3%	3%
J19448.27	14%	25%	19%	12%	10%	10%	3%	3%
J17247.58	14%	22%	19%	12%	10%	10%	3%	3%
J122	14%	22%	20%	12%	10%	10%	3%	3%
J13011.35	14%	20%	17%	14%	10%	11%	3%	3%
J121	122%	124%	124%	124%	123%	122%	118%	85%
J170.1953	96%	90%	85%	83%	83%	81%	76%	52%
J12763.44	39%	17%	16%	13%	9%	10%	2%	-1%



4. Stormwater Management Plan

4.1 End-of-Pipe Only

- Historic practice within Ontario uses end-of-pipe facilities to control post-development flows to pre-development levels for flood protection
- Commonly assumed that end-of-pipe SWM for all new development will achieve “post-to-pre” control
- For Rouge model storage elements representing future end-of-pipe facilities incorporated into the PCSWMM model to establish sizing criteria for peak flow control
- Release rates from the end-of-pipe facilities determined using unitary rates for the pervious and impervious areas
- Storage volumes adjusted until post-to-pre control achieved at points of interest



4. Stormwater Management Plan

4.1 End-of-Pipe Only

- Concluded that peak flows could not be controlled solely by the application of end-of-pipe facilities (i.e. post-to-pre control not achieved, regardless of how much storage was provided) due to timing and volume effects
- Greatest relative (i.e. percent) increases occurred for more frequent events (i.e. 2 year and 5 year)
- Results consistent with findings from other watershed-based studies (i.e. Credit River Flow Management Study; North Markham FUA Subwatershed Study) which concluded that residual increases were due to timing of peak flows and increase in runoff volume from future development



4. Stormwater Management Plan

4.2 End-of-Pipe with LID BMPs

- Low Impact Development Best Management Practices (LID BMPs) required to reduce runoff volumes and achieve stormwater peak flow control
- Use of LID BMPs is consistent with contemporary stormwater management practices which primarily incorporate technologies and practices to promote infiltration and/or intercept storm runoff for reuse



4. Stormwater Management Plan

4.2 End-of-Pipe with LID BMPs

Key Questions:

1. *“How much” runoff capture is required?*
2. *How to determine site-specific LID BMP sizing using catchment-scale discretization/resolution of modelling?*



4. Stormwater Management Plan

4.2 End-of-Pipe with LID BMPs

- LID BMPs represented in the model by depression storage within the pervious portion of the subcatchment
- Model sensitivity to depression storage is analogous to hydrologic sensitivity to implementing LID BMPs for volume control:
 - *Interception of runoff*
 - *Retention on-site (impervious depression storage)*
 - *Detention and infiltration on-site (pervious depression storage)*



4. Stormwater Management Plan

4.2 End-of-Pipe with LID BMPs

- Subcatchment routing modified to route the subcatchment runoff from future impervious surfaces across the pervious portion of the subcatchment, proportionate to the future development in the subcatchment
- Adjustment in depression storage for the pervious portion of the subcatchment weighted according to the proportion of future development in the subcatchment



4. Stormwater Management Plan

4.2 End-of-Pipe with LID BMPs

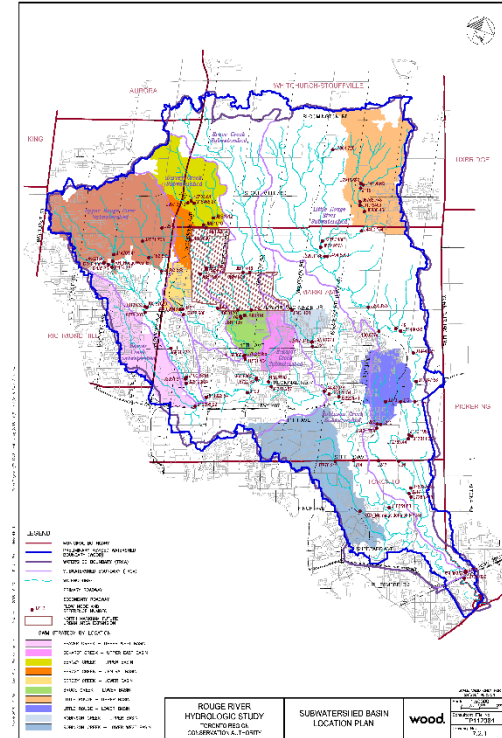
- Use of runoff capture (LID BMPs) alone without end-of-pipe control provided significant improvement to post-to-pre control, however insufficient to provide full post-to-pre control (particularly for less frequent and more formative events)
- Optimized use of LID BMPs and end-of-pipe facilities required, to achieve post-to-pre control



4. Stormwater Management Plan

4.2 End-of-Pipe with LID BMPs

- LID BMP capture of 20 mm/impervious hectare for future development within the Robinson Creek Subwatershed
- 15 mm/impervious hectare for future development within the remainder of the Rouge River Watershed



4. Stormwater Management Plan

4.2 End-of-Pipe with LID BMPs

Table 7.2.2: Storm Water Management Facility Sizing Criteria – Unitary Storage (m³/impervious ha)

Subwatershed Basin	Return Period (Years)					
	2 Year	5 Year	10 Year	25 Year	50 Year	Regional/ 100 Year
Eckardt Creek - Upper East Basin	250	350	450	550	650	750
Beaver Creek - Upper West Basin	750	800	850	900	950	1000
Berczy Creek - Upper Basin	1000	1050	1100	1200	1600	1800
Berczy Creek - Central Basin	1000	1050	1100	1200	1600	1800
Berczy Creek - Lower Basin	1000	1050	1100	1200	1600	1800
Bruce Creek - Lower Basin	750	800	850	900	950	1200
Little Rouge - Upper Basin	750	800	850	900	950	1000
Little Rouge - Lower Basin	100	150	200	750	850	1200
Robinson Creek - Lower West Basin	350	400	500	600	900	1000
Robinson Creek - Upper Basin	1000	1050	1600	1700	1800	1900
Upper Rouge - Upper Basin	350	400	475	1200	1300	1400



3. Impact Assessment

3.2 Impact Assessment

Table 6.3.2: Percent Difference In Simulated Instantaneous Peak Flows – Future Uncontrolled Land Use Conditions Compared to Baseline Land Use Conditions

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J494.5593	34%	23%	35%	26%	30%	40%	13%	12%
J7386.725	0%	0%	0%	0%	0%	0%	0%	0%
J207.3486	3%	2%	2%	1%	1%	1%	-1%	0%
J672.9773	5%	3%	2%	2%	1%	1%	-2%	0%
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J12763.44	39%	17%	16%	13%	9%	10%	2%	-1%



4. Stormwater Management Plan

4.2 End-of-Pipe with LID BMPs

Table 7.3.2: Percent Difference in Simulated Instantaneous Peak Flows – Future Land Use Conditions with Recommended Stormwater Management Compared to Baseline Land Use Conditions

Watershed/Subwatershed	Return Period (Years)							Regional
	2	5	10	25	50	100	350	
Little Rouge River Subwatershed								
J167.4563	-27%	-20%	-20%	-24%	-18%	-16%	-27%	0%
J115	-23%	-24%	-23%	-18%	-14%	-13%	-12%	0%
J6765.748	-15%	-15%	-16%	-17%	-16%	-14%	-15%	0%
J91.75469	-4%	-4%	-4%	-3%	-3%	-2%	0%	0%
J5830.464	-1%	-3%	-3%	-2%	1%	-2%	-4%	0%
J4490.154	-4%	-4%	-4%	-3%	-2%	-2%	-2%	0%
J494.5593	-4%	-4%	-4%	-4%	-3%	-1%	-4%	0%
J7386.725	0%	0%	0%	0%	0%	0%	0%	0%
J207.3486	0%	0%	0%	0%	0%	0%	0%	0%
J672.9773	0%	0%	0%	0%	0%	0%	0%	0%
J320.1186	-3%	-3%	-3%	-3%	-3%	-2%	-3%	0%
J25903.3	-7%	-7%	-4%	-3%	-3%	-2%	-2%	0%
J149	-4%	-5%	-5%	-3%	-3%	-2%	-2%	0%
J21490.93	2%	-4%	-5%	-3%	-3%	-2%	-2%	0%
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J13011.35	2%	2%	-4%	-4%	-3%	-2%	-2%	0%
J121	-41%	-31%	-27%	-23%	-19%	-16%	-36%	-6%
J170.1953	-25%	-15%	-11%	-7%	-3%	-2%	-18%	-2%



5. Conclusions

1. Model Selection

- PCSWMM (USEPA SWMM) suitable for runoff simulation in mixed land use (rural/urban) Rouge River Watershed

2. Soils

- Surrogate techniques to establish soil properties for complex soil conditions (diamicton) are available and appropriate



5. Conclusions

3. Impact Management

- Conventional end-of-pipe techniques are inadequate to address peak flow increases for the Rouge River Watershed due to timing and volume effects

4. Source (Volume) Controls

- Appropriately sized LID BMPs, analysed and assessed using PCSWMM model, achieve no net increase (in peak flows) for Rouge River Watershed



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