Advantages of Integrated Surface Water/Groundwater Modelling for Low Impact Development

Chris Gabriel
Colin Hansen

Enviro Tech, Calgary

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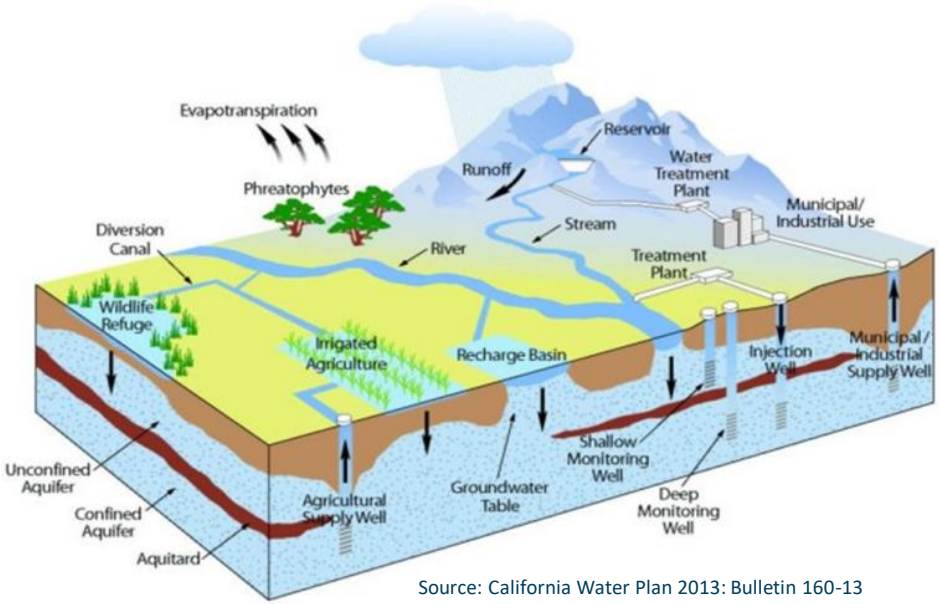
Agenda

- Integrated Modelling
- Stormwater Management
- Case Studies
  - Planning Level Evaluation
  - Development Level Evaluation
  - Detailed Design Level Evaluation



Source: California Water Plan 2013: Bulletin 160-13

"Nature laughs at the difficulties of integration" (Pierre Laplace)

"The health of our waters is the principal measure of how we live on the land" (Luna Leopold)

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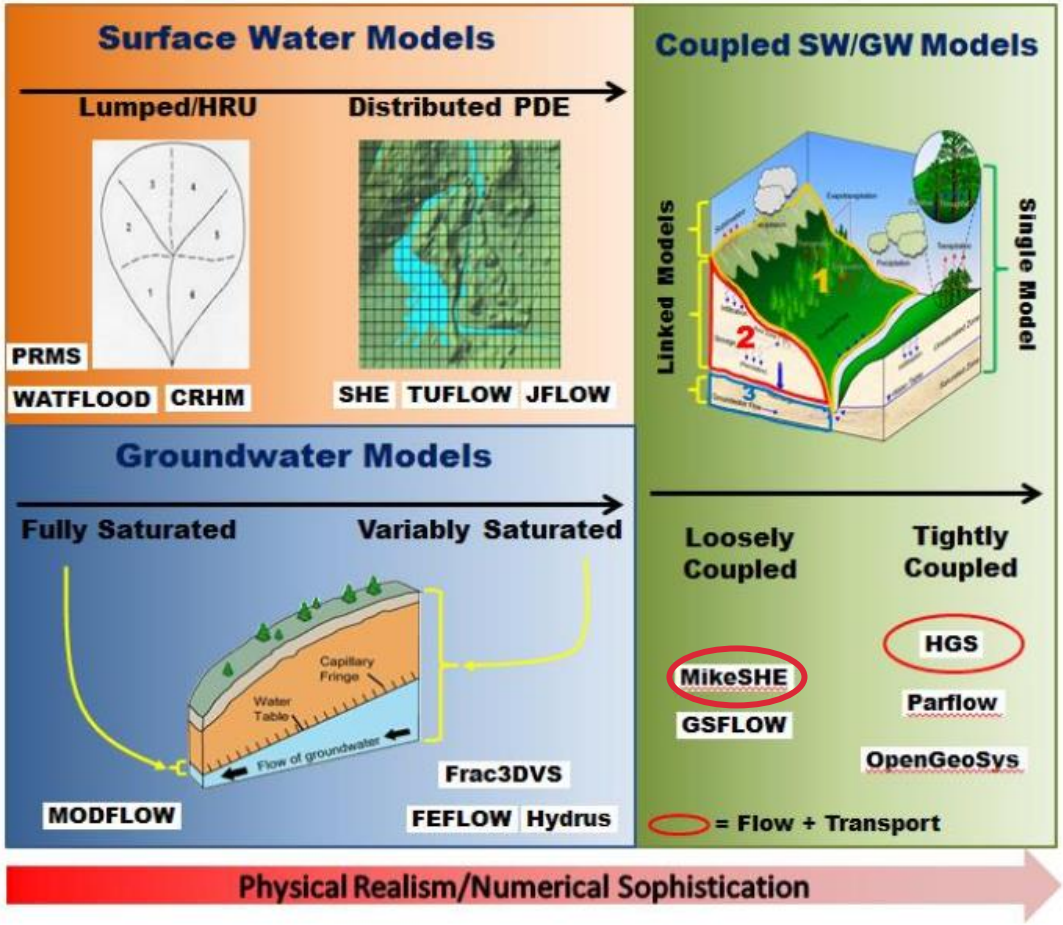
Modelling Approaches for Naturally Occurring Water



Source: Introduction to Integrated Hydrologic Modelling with HydroGeoSphere. Aquanty, 2022

Mostly use at Matrix

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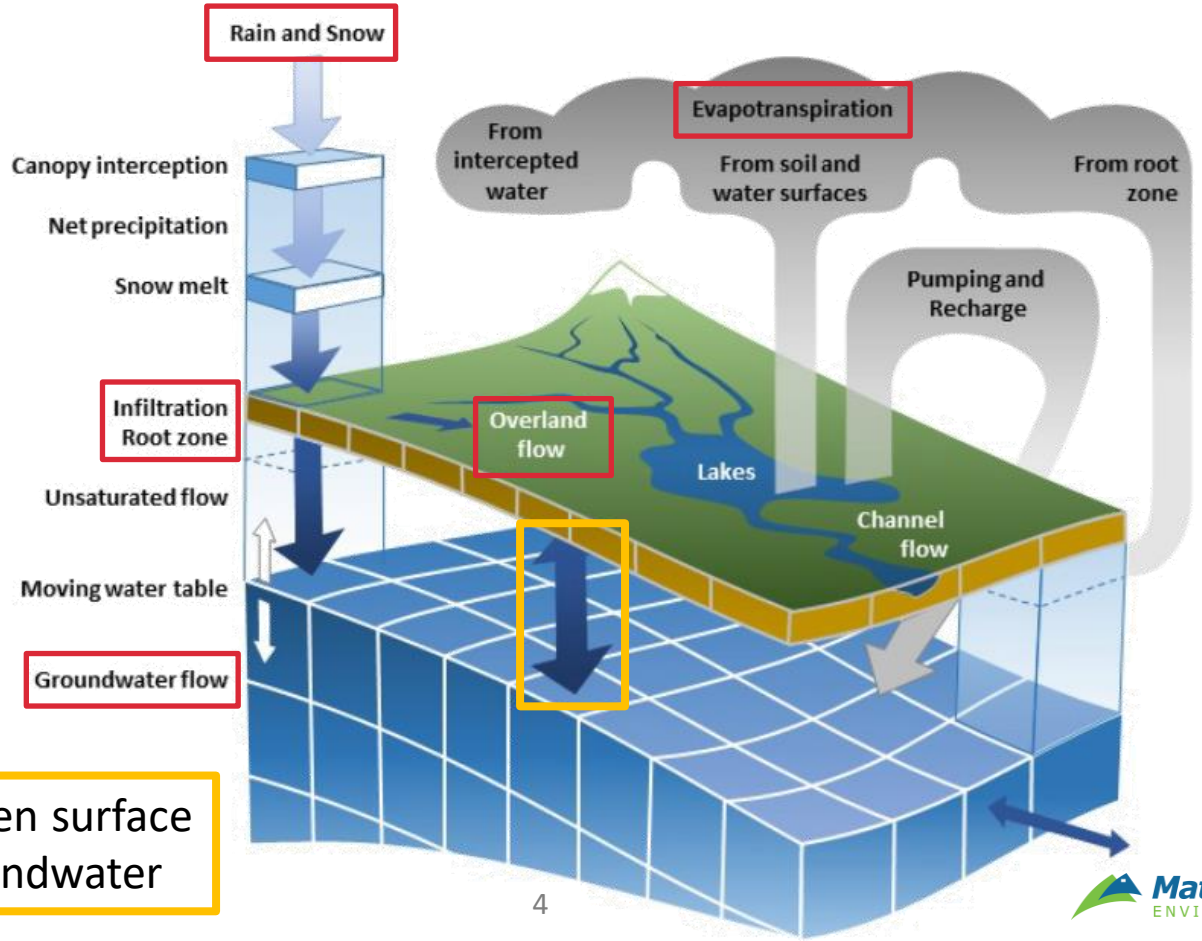
Integrated Surface Water/Groundwater Modelling

Represents the complete water cycle



Feedback between surface water and groundwater

Source: DHI- MIKE SHE Manual

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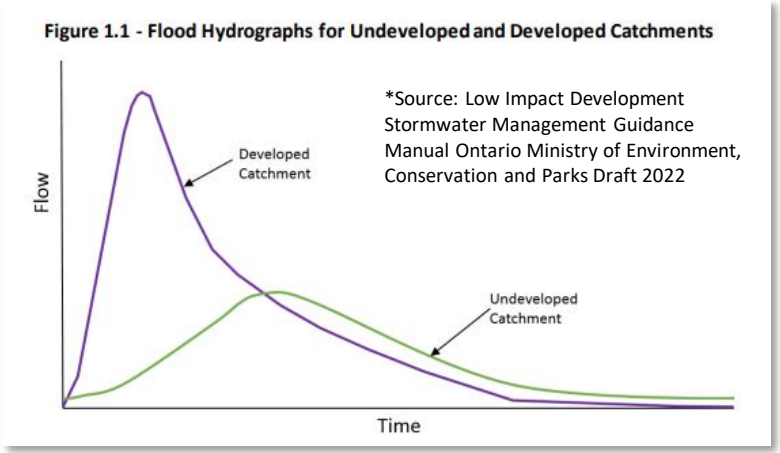
Stormwater Management (SWM)



Traditional SWM Approach

- Mitigation of flood and erosion risk
- Centralized end-of-pipe (SWM pond)
- Detention of a spectrum of rainfall events

Low Impact Development (LID) Approach

- Capture, retention, and infiltration of small *and* frequent events
- Distributed source control focus
- Goal: Maintain
  - Ecosystem-based water balance
  - SW/GW connection and function
  - Aquatic/fish/terrestrial habitat
  - Stream morphology

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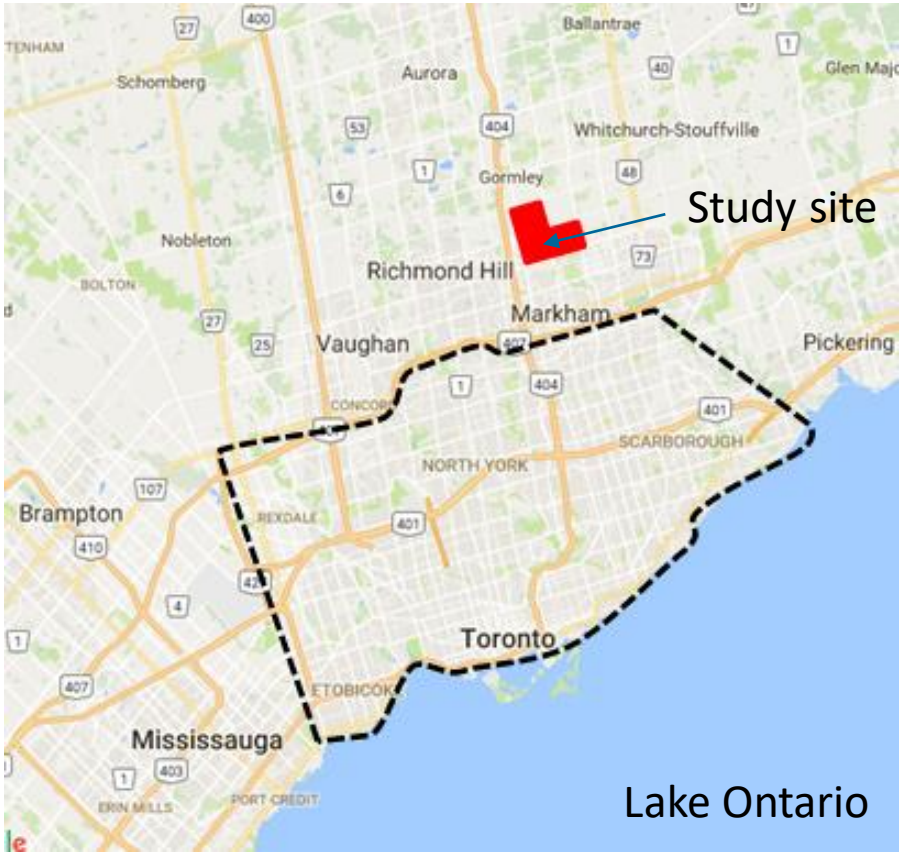
Case Study 1
Planning Level Evaluation

North Markham Future Urban Area Planning Study



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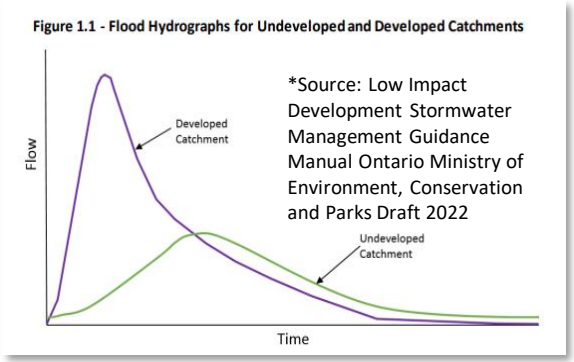
Planning Level
Stormwater Management Approach

- Design Criteria
  - Optimal runoff capture/source control volume
  - Optimal location and dimension of LID features
  - Control Runoff (erosion)
- Management Criteria
  - Maintain GW recharge
  - Maintain depth to GW
  - Maintain GW flow direction/gradients
  - Maintain GW discharge to surface water features
- Evaluate local and cumulative effects of proposed development



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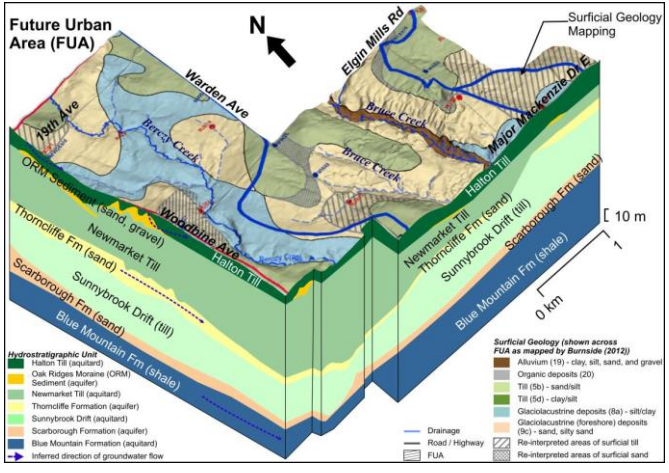
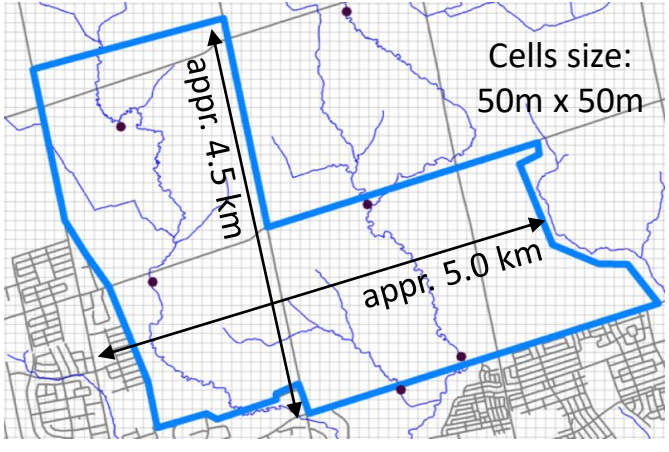
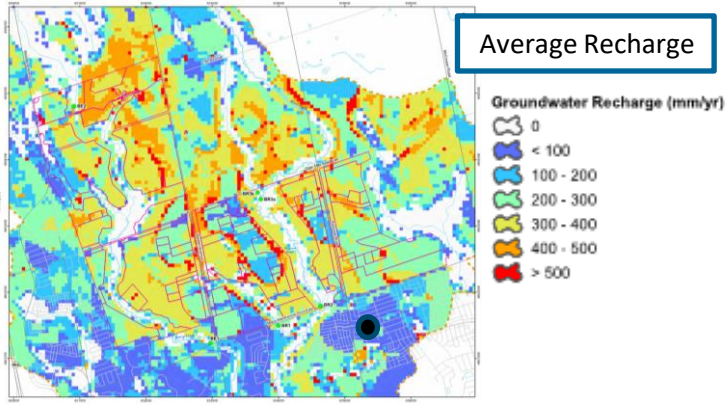
Model Development

- Larger scale, watershed to subwatershed (50m x 50m grid)
- Continuous in time simulation
- Focus on groundwater function

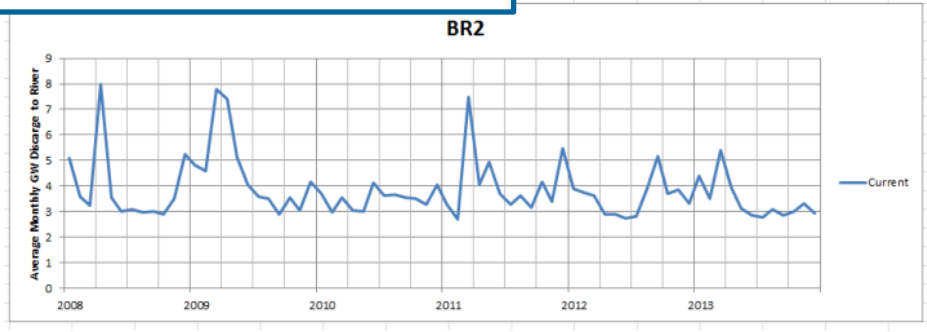




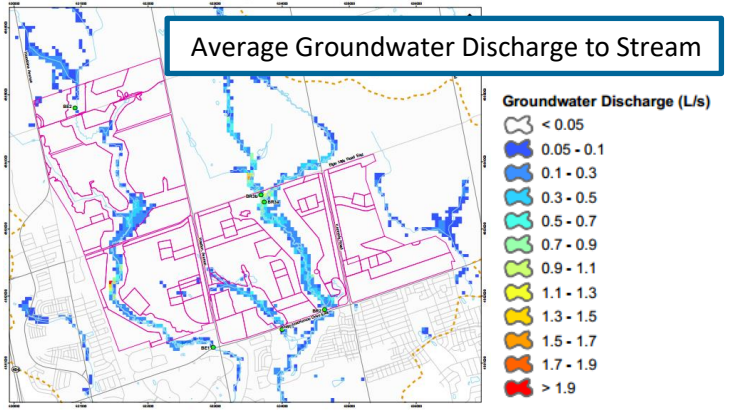
Existing Conditions Simulation: Spatial and Temporal Characterization



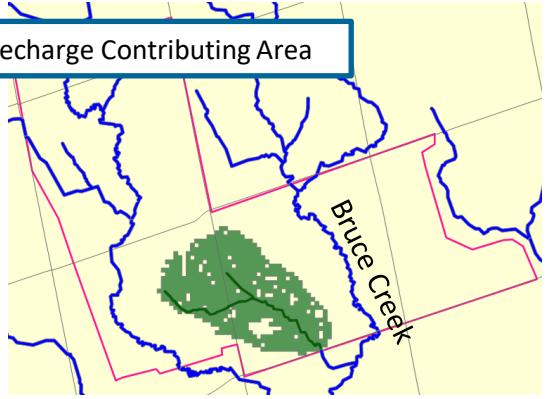
Average Recharge



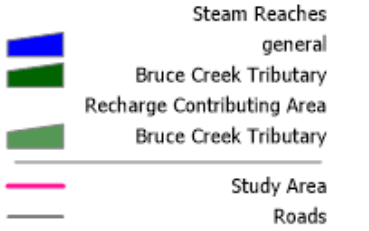
Monthly Groundwater Discharge to Stream



Average Groundwater Discharge to Stream



Recharge Contributing Area



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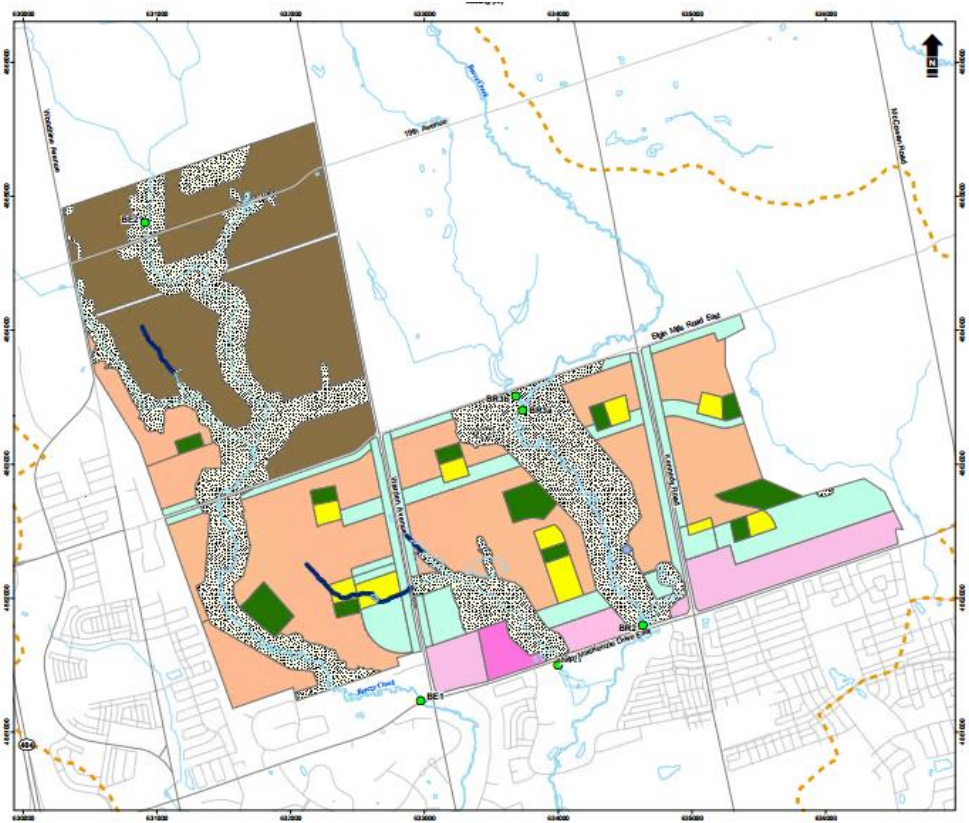
Proposed Future Land Use



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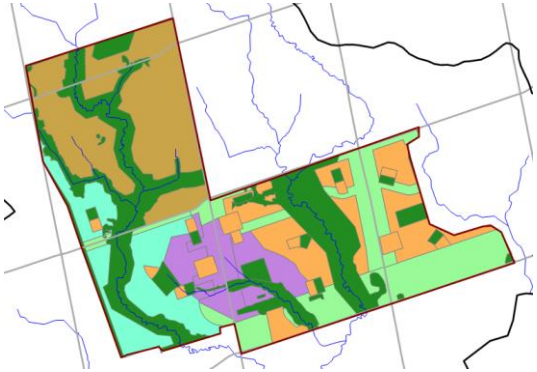
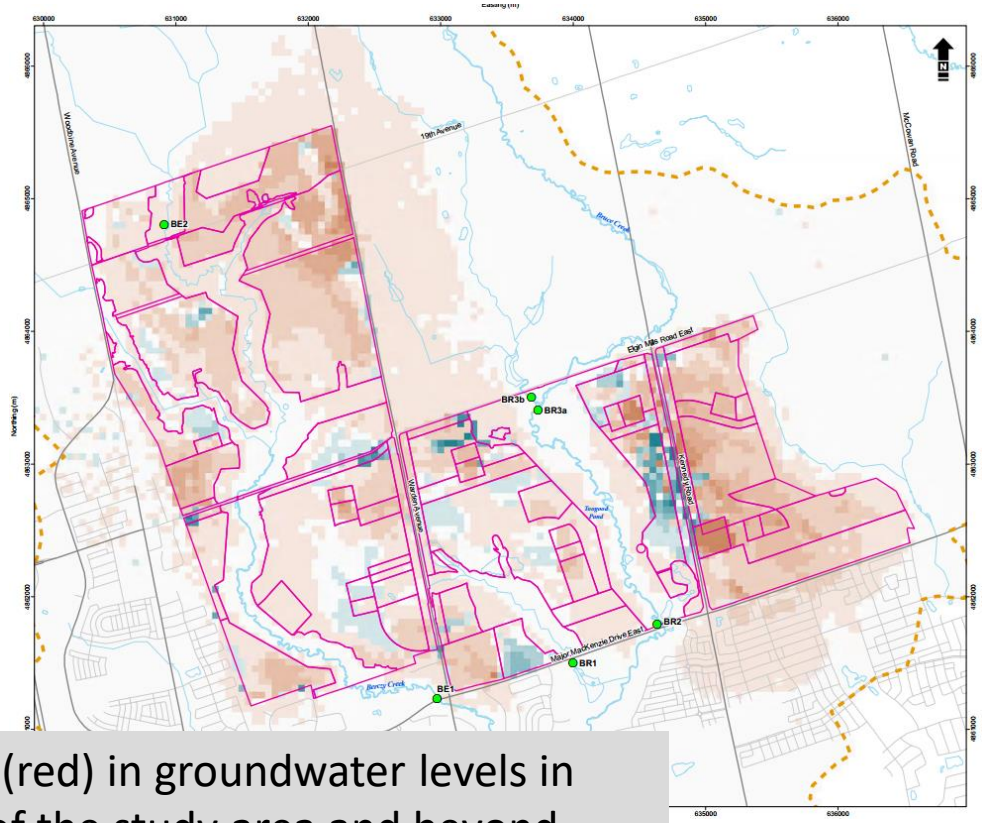
Establishing LID Requirements

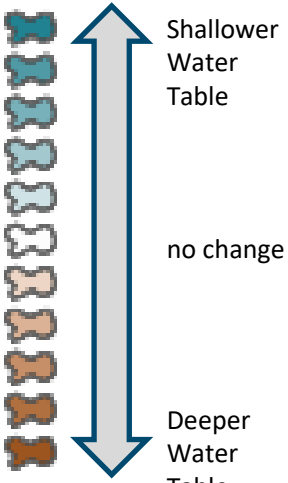
- LID Capture of 0-10 mm/imp. ha applied evenly within development

- LID Capture of 2-10 mm per imp. ha spatially variable by land use



Change in Depth to Water Table – No LID BMPs





Lowering (red) in groundwater levels in majority of the study area and beyond

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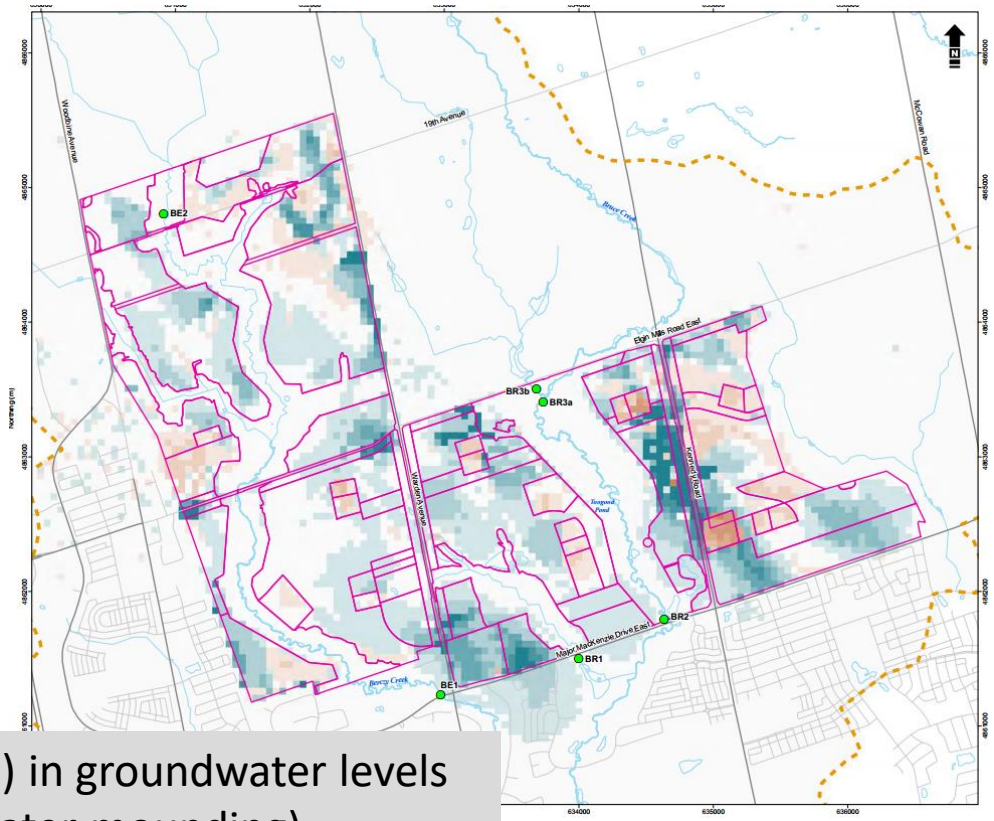
Change in Depth to Water Table - 10 mm Capture



Rise (blue) in groundwater levels (groundwater mounding)

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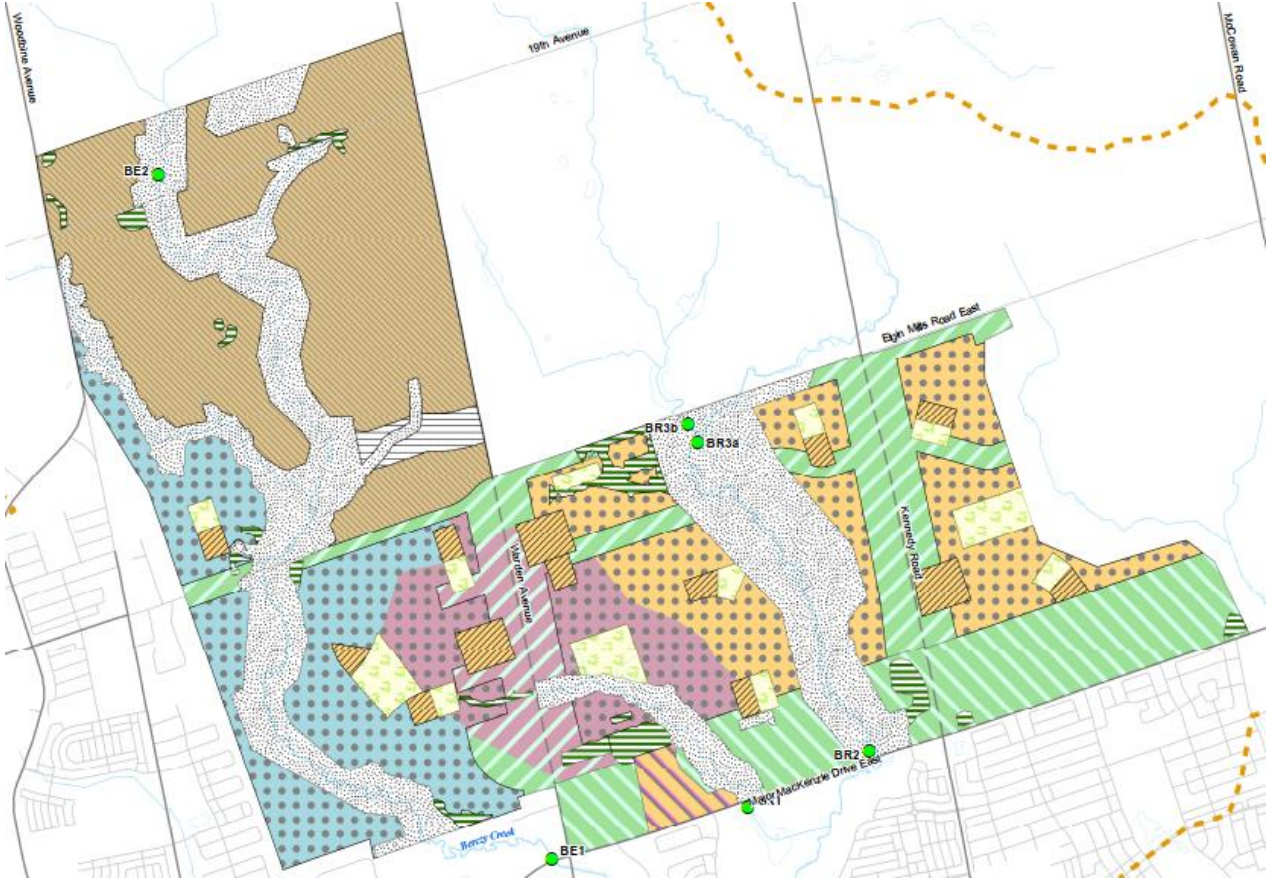
Planning Study Outcomes: Spatially Variable Capture



Capture per Impervious Hectare (mm)

- 0
- 2
- 3
- 4
- 6
- 10

Future Landuse

- Ecological Linkage
- Greenway
- Greenway Under Study
- Community Centre
- Employment
- Mixed Use Regional Corridor (MUR)
- Mixed Use Neighbourhood Corridor (MUN)
- Residential
- School - Elementary School, Secondary School
- Park - Community Park, Neighbourhood Park

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Planning Study Outcomes

- Area Specific Management Plan
- Catchment Level Targets and Objectives
- Mitigation of cumulative impacts at the watershed scale
- Maintenance of groundwater function
- Tool for additional planning
  - Climate change resilience
  - Development Level Conceptual Testing

Case Study 2
Development Level Evaluation
Site-Specific Conceptual Testing

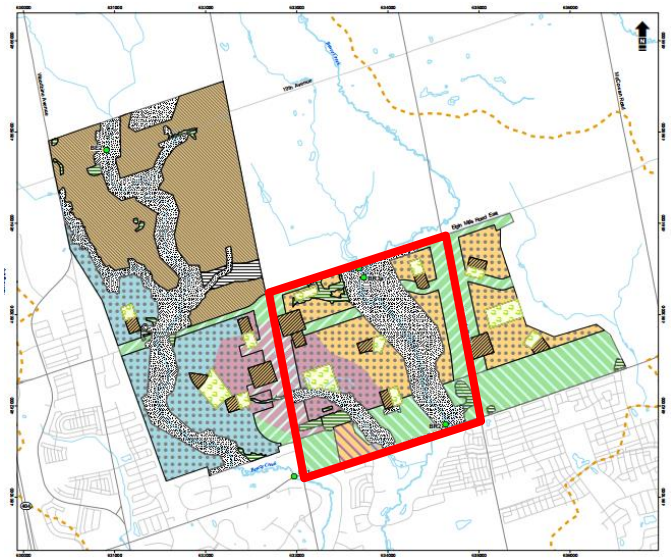
Source and End-of-Pipe Controls

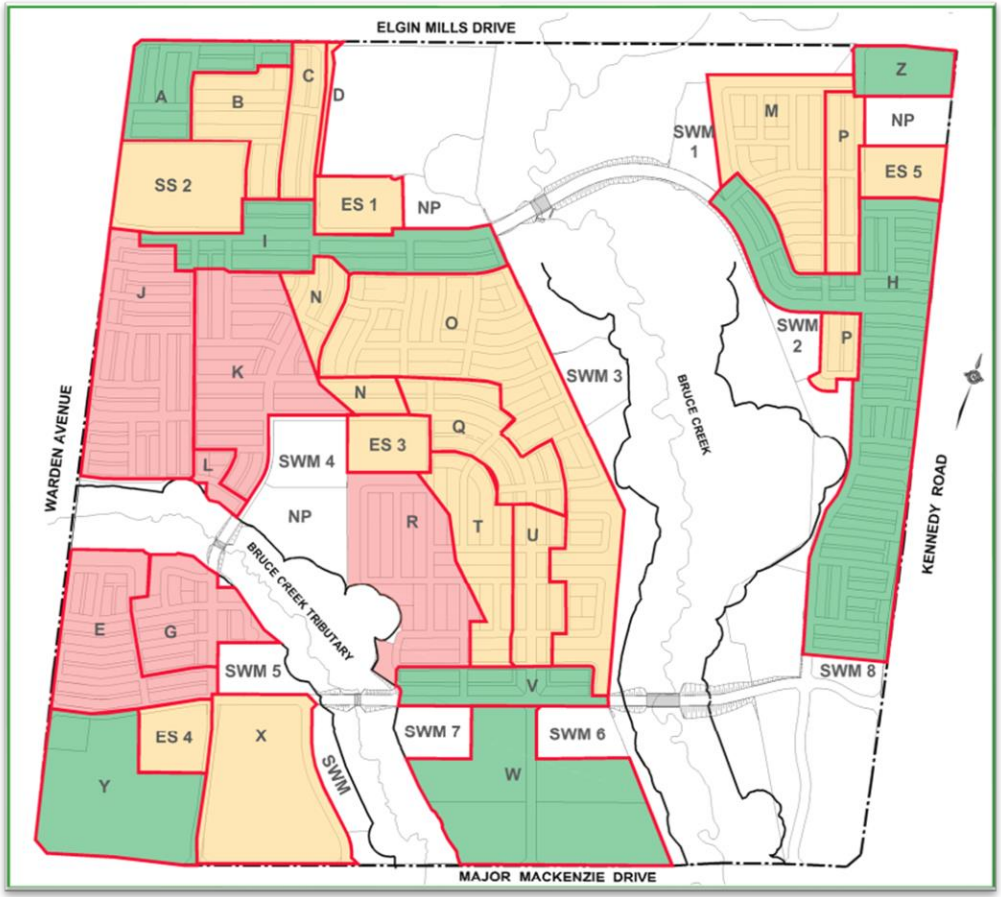
Source Control Volumes Derived from Planning Study

LEGEND

Capture per impervious Hectare

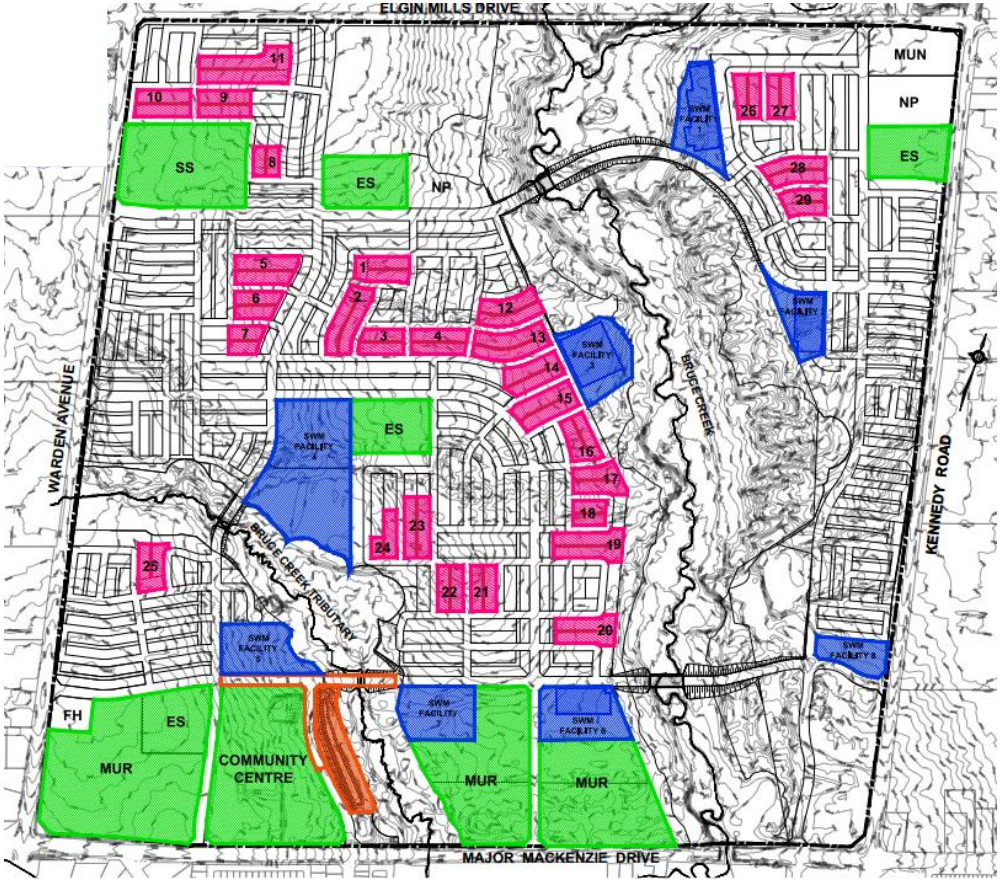
- 4mm
- 3mm
- 2mm





Developers Proposed Mix of Source Control LID and End of Pipe Facilities

Location of proposed
- Distributed LID features:
  Rear Lot Infiltration Galleries
- Centralized SWM facilities
  (with infiltration capacity):
  Underground Storage Tanks



Rear Lot Infiltration Gallery (RLCB)

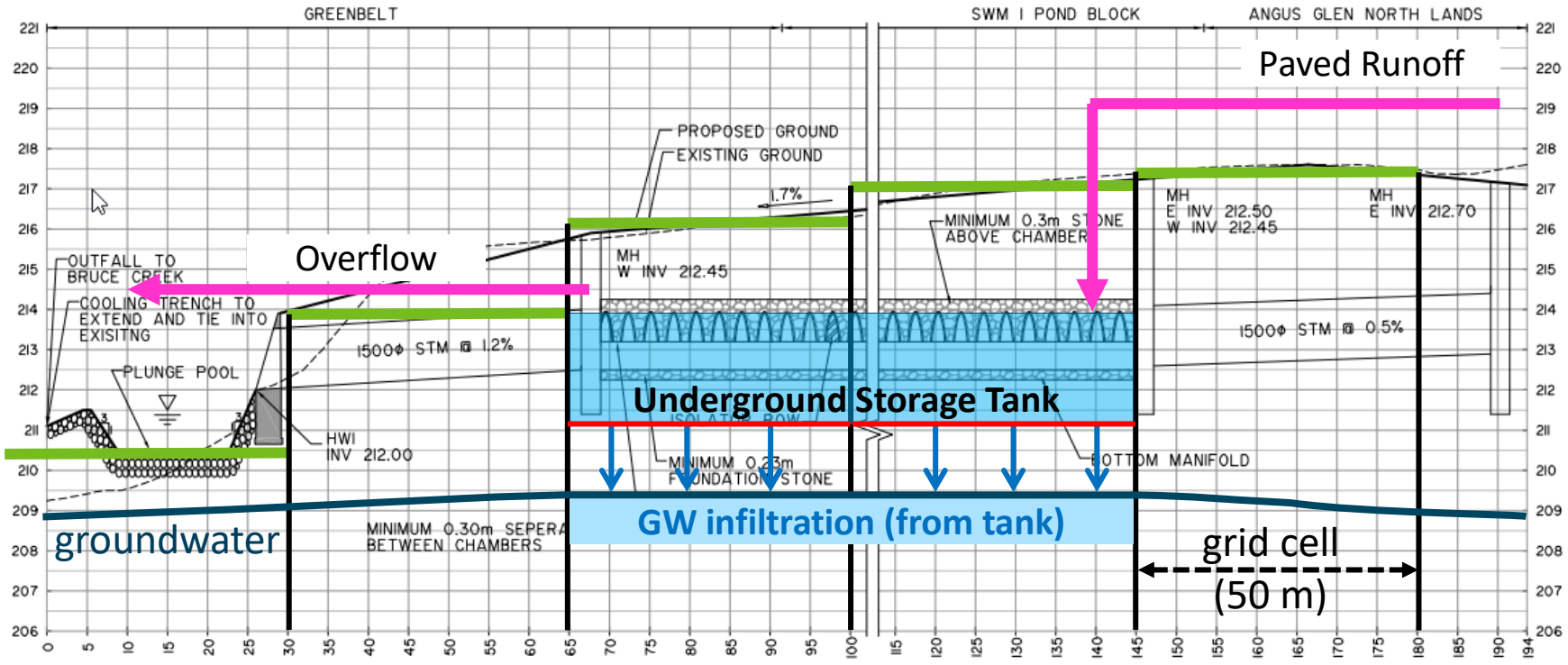
Lots Contributing to Rear Lot Infiltration (RLCB)

Stormwater Management Facility

Stormwater Management Facility with Designated Infiltration

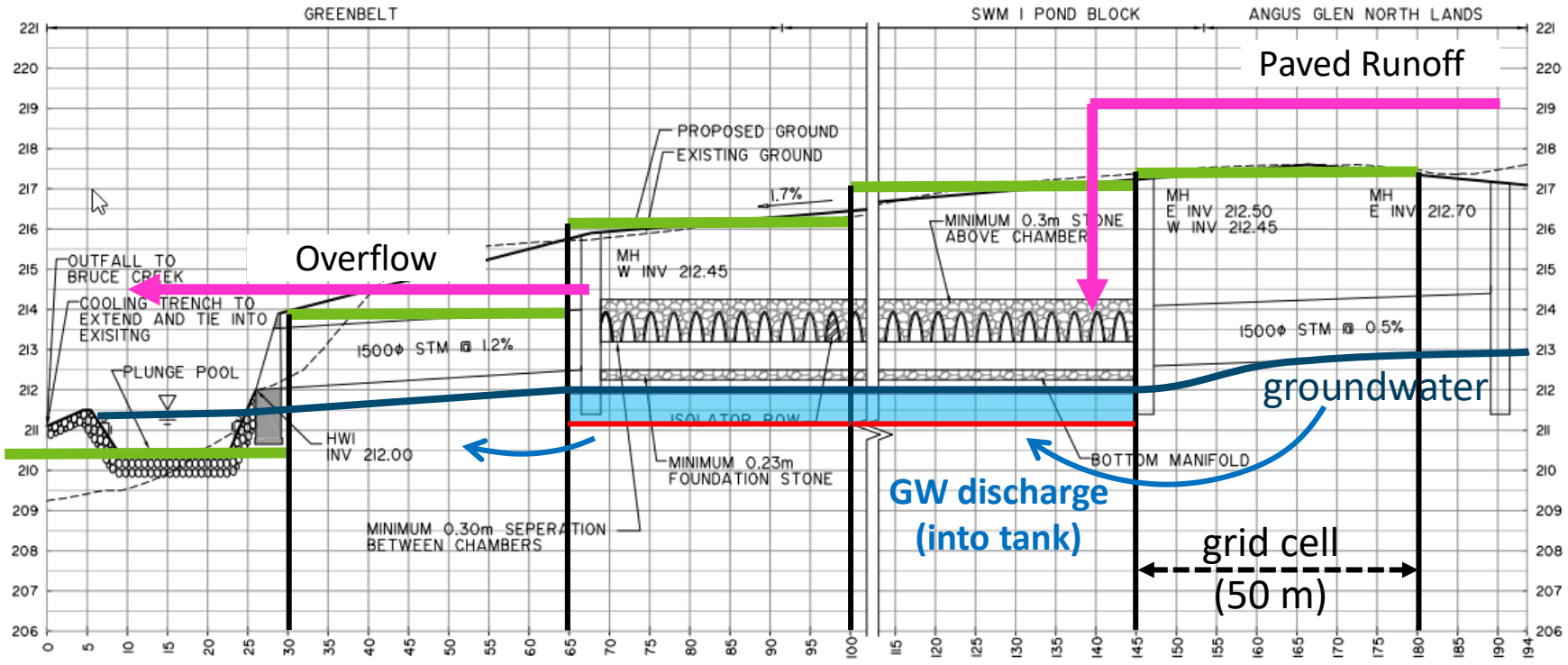
On-Site Control (details unknown at time of study)

Modelling of Leaky End-of-Pipe Facility



Representation in Model
with underground infiltration tank

Modelling of Leaky End-of-Pipe Facility



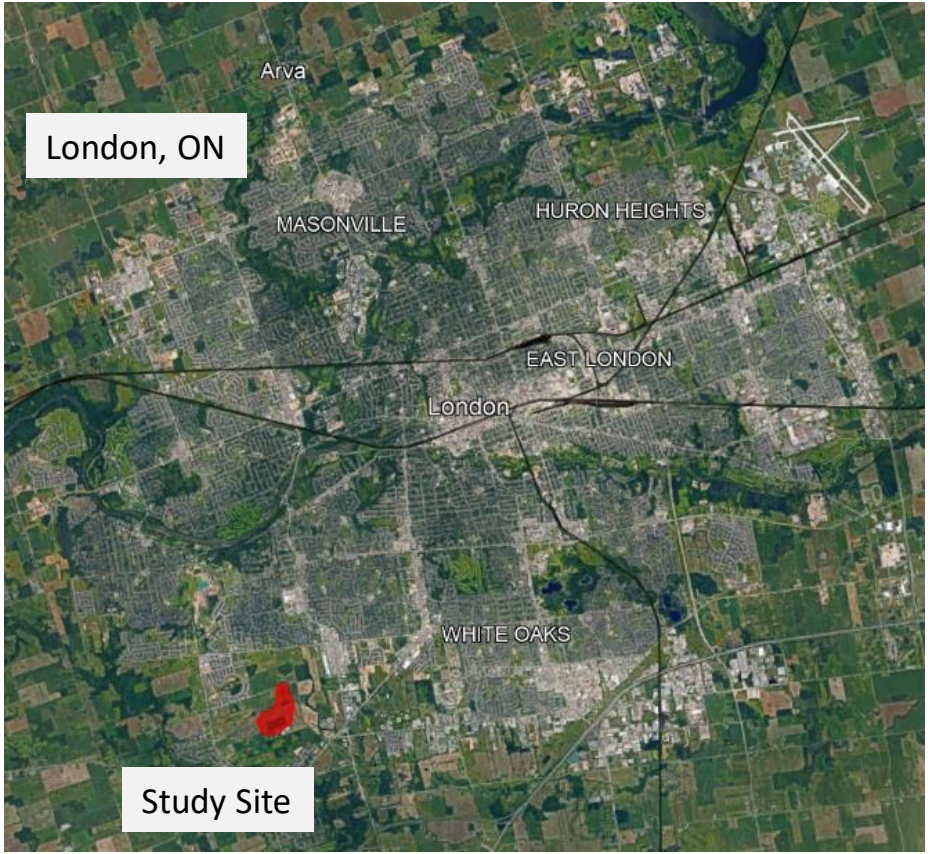
Representation in Model
with underground infiltration tank

Conceptual Design Testing Outcomes

- Successfully tested developers' proposed site-specific conceptual design
- Confirmed that site-specific design can maintain management objectives including ecological function
- Provided feed back to help
  - Optimize final design and location
  - Optimize performance monitoring plan

Case Study 3
Detailed Design Support

W3 Farms Subdivision Woodland Patch 10069



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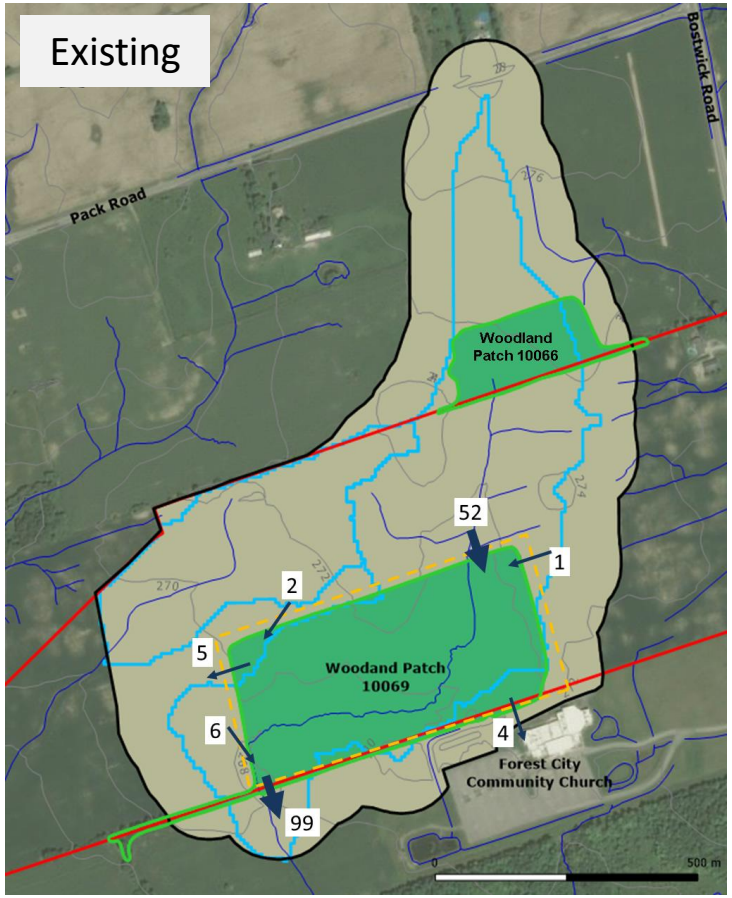
Subdivision Development Application

- Local scale catchment-based study (5m x 5m grid)
- Woodland SW or GW supported?
- Focus on Surface Water function: runoff to Woodland
- Goal: maintain runoff contribution and hydroperiod of the Woodland
- Rerouting of surface runoff



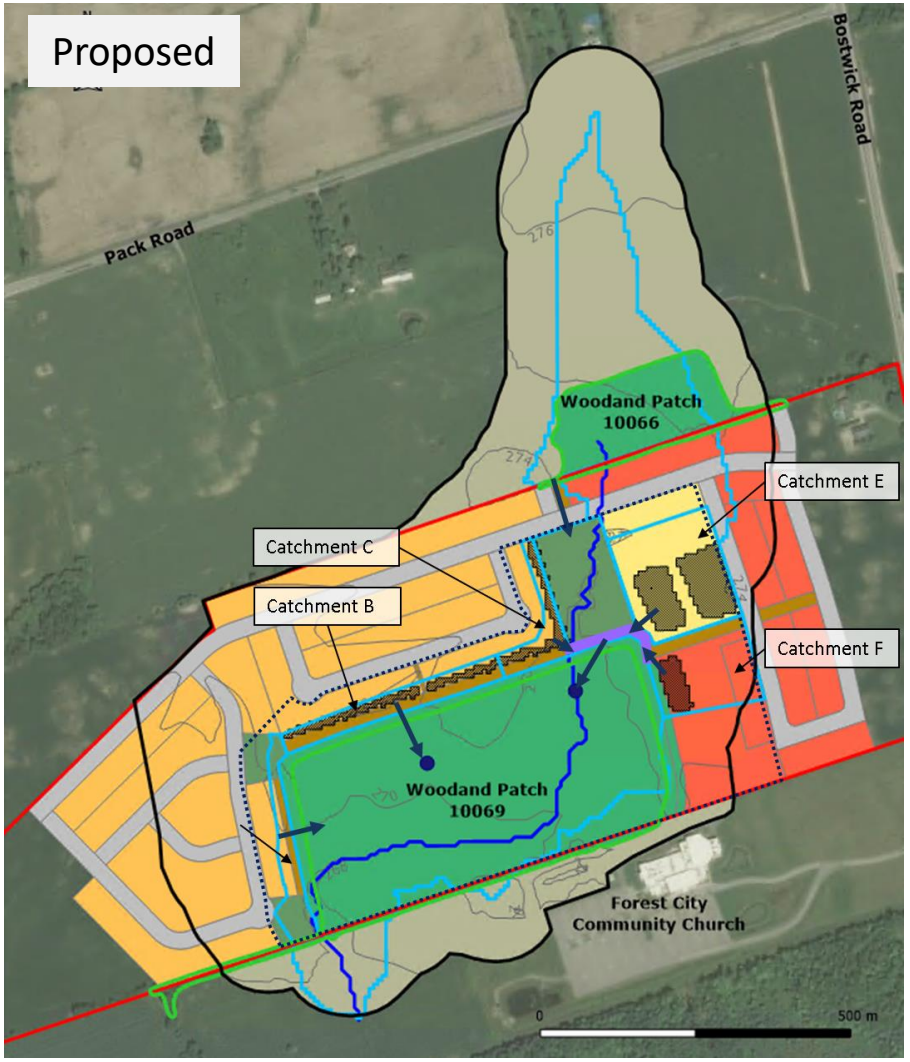
Future Conditions Model

Routing of Surface Runoff (examples):

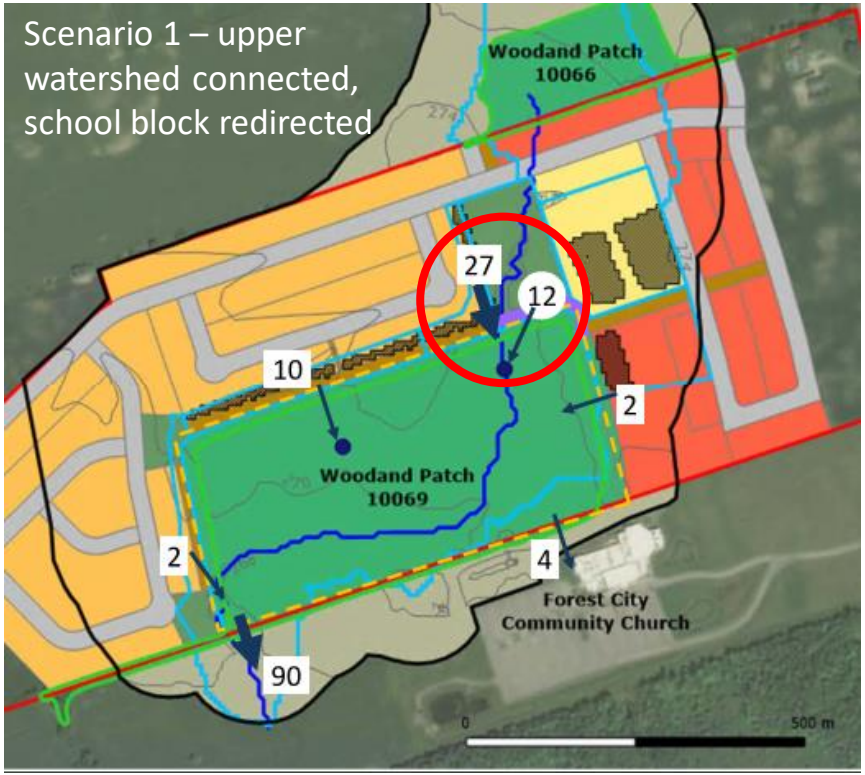
- B: rear lots + roof → woodland
- C: rear lots → woodland; roofs → LID
- E: impervious → sewers (1) **OR** LID (2)
- F: roof → LID

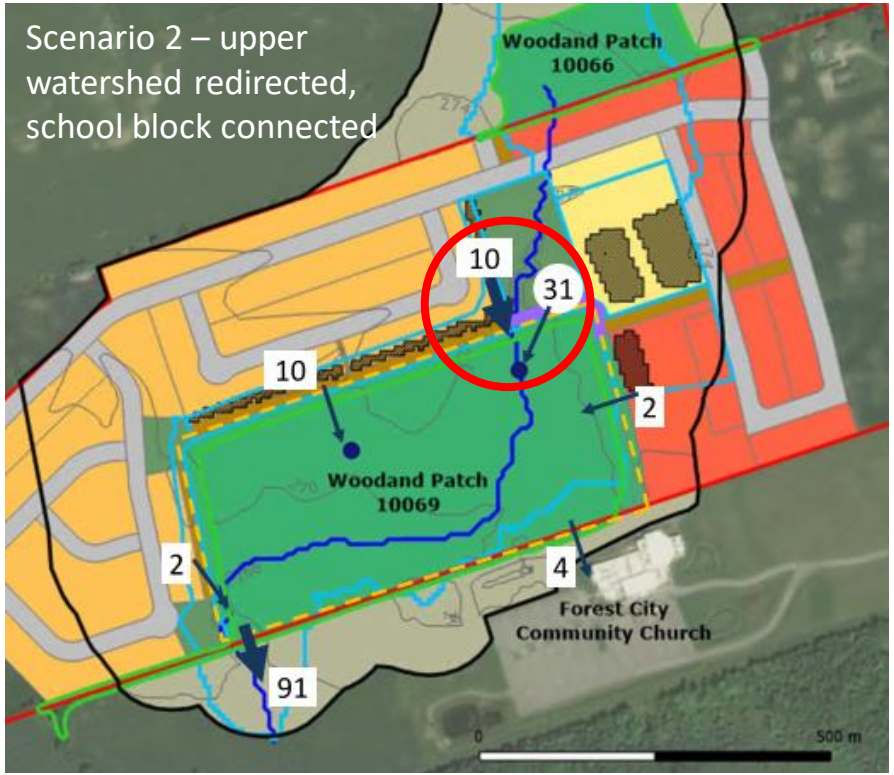
Proposed Future Landuse

Elementary School
Single Family Homes
Medium Density
Road
Walkway
Park
Woodland
Agriculture



Future Conditions Water Budget





6 LID Contribution (m^3/day)

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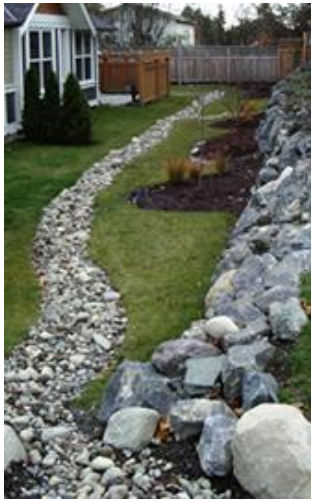
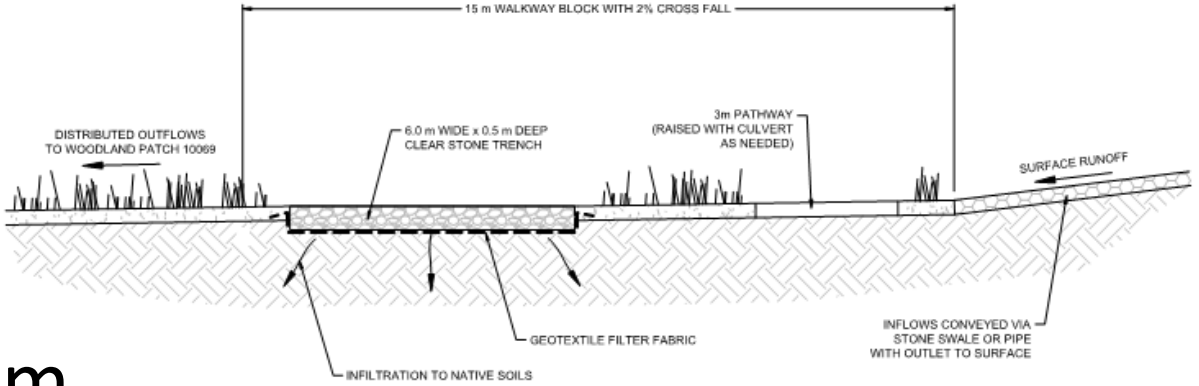
LID Design



- Stone bioswale for conveyance
- LID Stone Trench 160 m X 6m x 0.5m



LID STONE TRENCH CONCEPTUAL DESIGN DETAIL

NOT TO SCALE

Source: STEP gallery

Outcomes and Suggestions

- Model was able to replicate expected water balance, observed downward gradients and seasonal groundwater response
- Proposed Development with LID design should maintain the water balance and hydroperiod of the Woodland close to existing conditions
- Continued monitoring of Woodland to adjust design if needed

Advantages of Integrated Modelling over Traditional SWM Modelling

- More physical representation of flow process
- Topography driven runoff - model determines direction of flow
- Spatial distribution of inputs/outputs
- Flexibility in spatial and temporal discretization
- Direct feedback between surface water and groundwater processes
- Explicit representation of groundwater
- Incorporate “external sources” (regional groundwater inflows)
- Understanding for a broad set of questions/application

Integrated Modelling: Other Application

- Spill Response Support
- Pipeline Risk Assessment
- Remediation Alternatives
- Freshet-driven Groundwater Flooding
- Irrigation Impacts (Agricultural Sustainability)
- Climate Change Impact Assessment

Contact Us

Chris S. Gabriel, Dipl.-Ing., M.Sc.
Senior Environmental Consultant
cgabriel@matrix-solutions.com
226.314.1940

Colin R. Hansen, M. Eng., P.Eng.
Senior Civil Engineer
chansen@matrix-solutions.com
403.237.0606

matrix-solutions.com

Thanks to Our Project Partners

wood.

- Ron Scheckenberger, Aaron Farrell, Steve Chipps
- Stormwater and Surface Water

- Bill Blackport
- Hydrogeology

- Cam Portt
- Aquatics/ Fisheries

- Steve Hill
- Terrestrial

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