KEEPING THE BALANCE

Feature-based water balance in the planning process

SESSION 2: How does modelling inform development design?

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Environment Canada Environnement Canada

Toronto and Region Conservation Authority

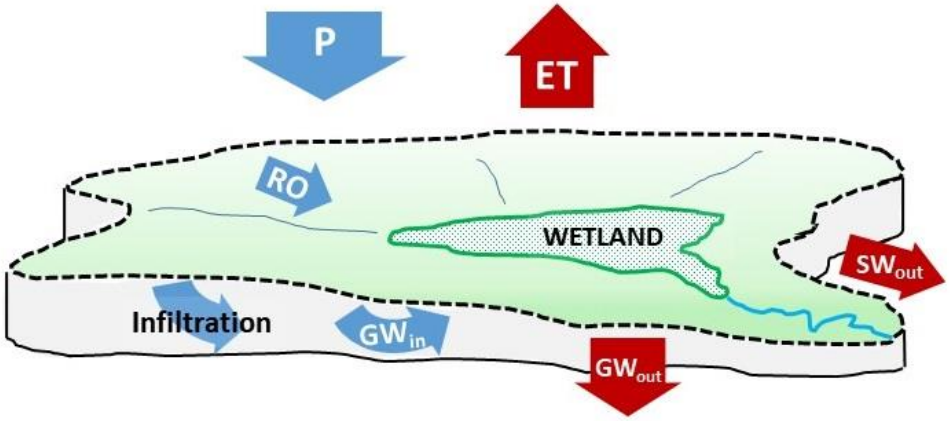
Session 3 objectives

Answer the following questions:

- What is a water balance model;
- Why a continuous hydrology model;
- What should you look for in a modeling team;
- How is modeling used to assess the need for, and design of, mitigation;
- How do I put together a Terms of Reference for a feature-based water balance;
- What's an example of mitigation design; and
- How do I know if a mitigation system is functioning properly?

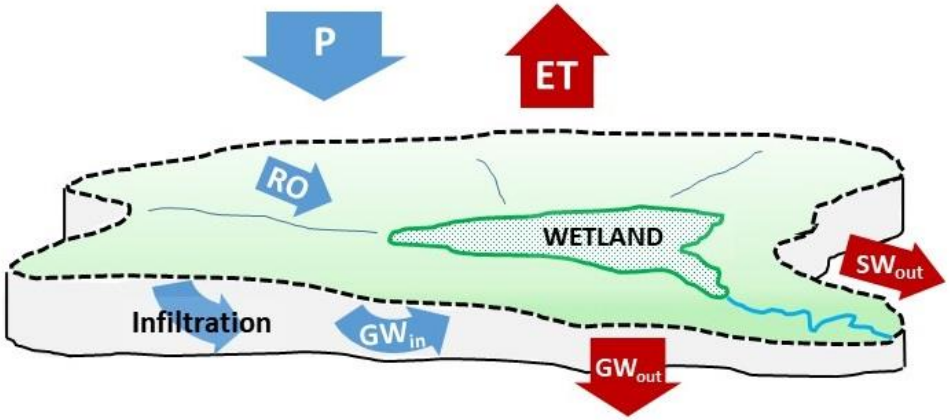
What is a water balance model?

- Tool to represent water budget inputs and outputs to and from an area (lake, stormwater pond, wetland)
- Used extensively in water resources engineering and hydrogeology
- Range from very simple to very complex and everything in between



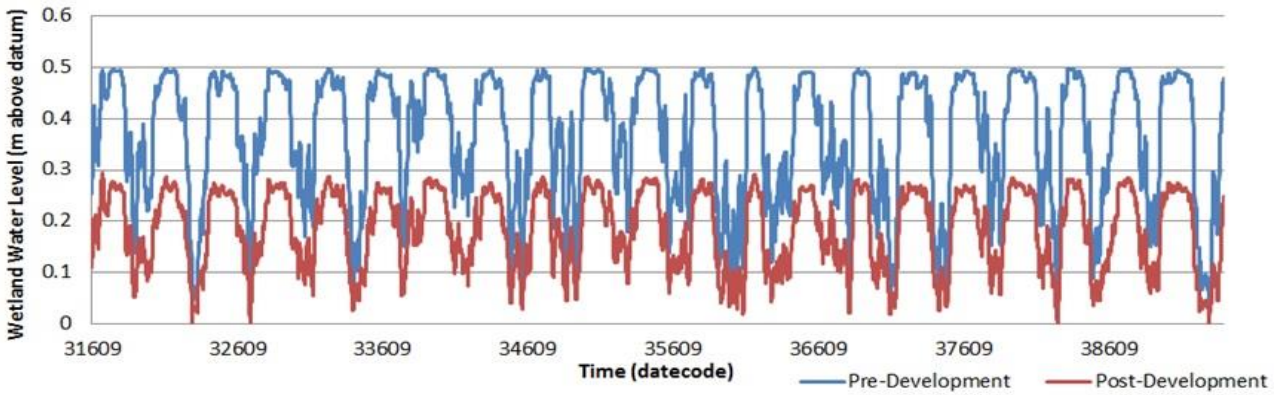
What is a water balance model?

- System of interacting equations → represent how rainfall, snowmelt, groundwater move through a drainage basin over time
- *Timestep* can vary → Annual / seasonal / monthly / weekly / daily / hourly / 15 mins
- All models represent surface water processes; representation of groundwater varies



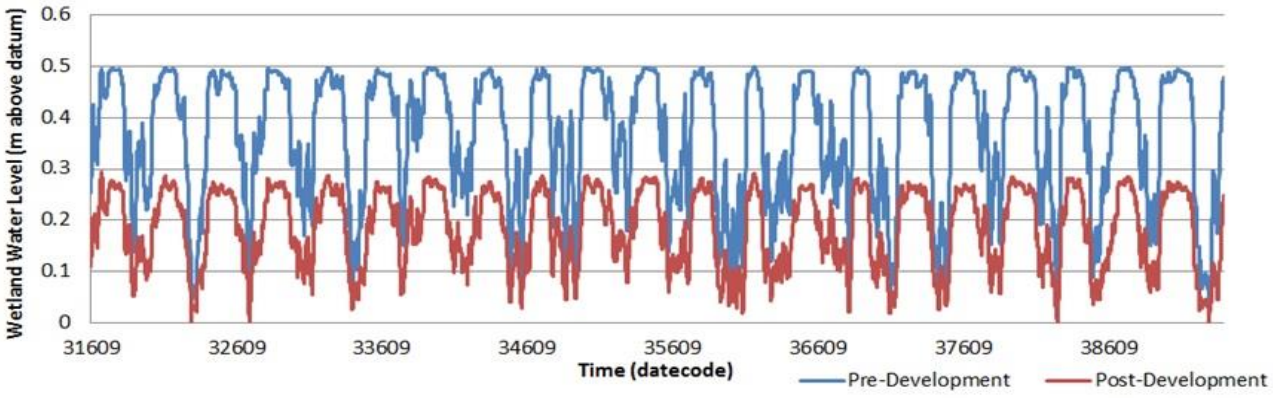
Why a continuous hydrology model?

- Simulation over longer time period needed to explore how changes in land use and drainage may affect water levels under full range of natural conditions expected;
  - Need to understand impacts during the spring freshet, when some wetlands receive the majority of their runoff over a long period of time, and summer storm events, which tend to be flashier and result in more instantaneous impacts to water levels, but less on overall volume contributions.



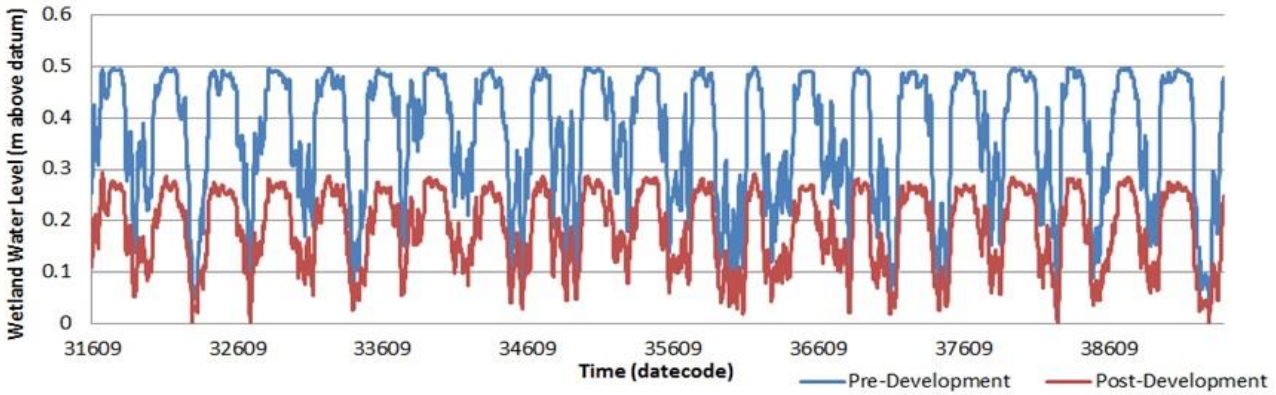
Why a continuous hydrology model?

- Much more detailed representation of hydrology → more robust decision making around potential impacts and corresponding mitigation measures
- But ONLY IF model is well conceptualized, calibrated, validated



Why a continuous hydrology model?

- TRCA has evaluated the capability of models for water balance (HEC-HMS, SWMM, Visual OttHymo, HSPF, MIKE-SHE)
- General modeling procedures and report expectations outlined in TRCA *Wetland Water Balance Modeling Guidance Document*
- Recommendations on applications of different models made in appendix of case studies



What areas of expertise should the modeling team have?

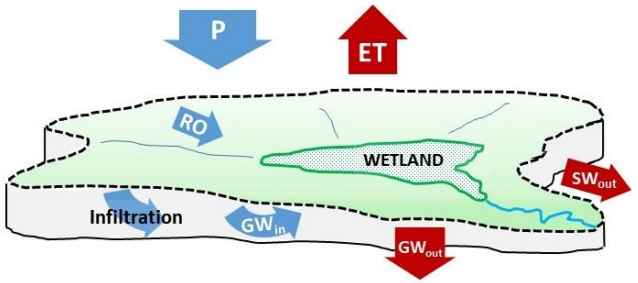
- Truly a team approach to preparing a feature based water balance model, including:
  - Ecologist: Characterize wetland and provide input on species and wetland tolerances;
  - Hydrogeologist: Wetland groundwater inputs (if available), inflow rates, and seasonal groundwater rates;
    - If the wetland is primarily groundwater fed, then the hydrogeologist will lead the modelling exercise with inputs from other team members.

What areas of expertise should the modeling team have?

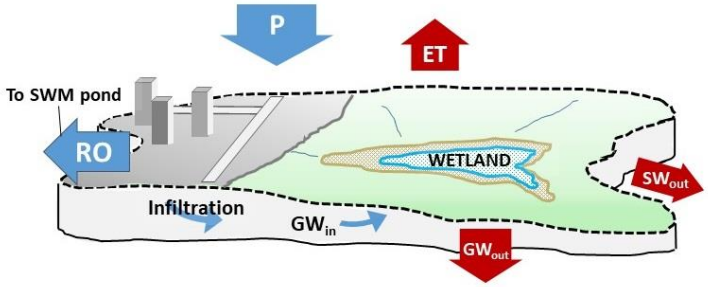
- Water Resources Engineer: Determine surface water inputs, inflow rates and volume, and response to rainfall events and snowmelt;
  - If the wetland is primarily surface water fed or a combination of surface and groundwater, then the Water Resources Engineer will lead the model development.
- Municipal Engineer: Provide input on mitigation practices; and
- Planner: Provide coordination between landowners, consulting teams and approval agencies while ensuring practices applicable to planning stage.

How is modeling used to assess the need for, and design of, mitigation?

Pre-development



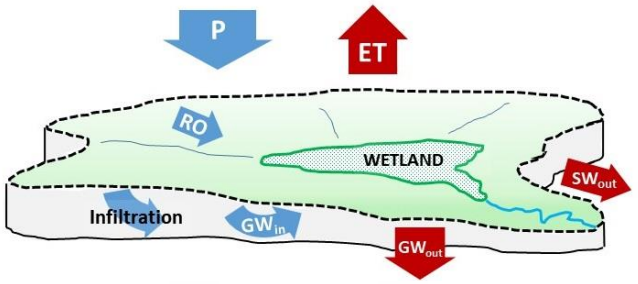
Post-development



How is modeling used to assess the need for, and design of, mitigation?

1. Pre-development baseline data collected:
   a) Wetland Characterization, including how is the wetland fed;
   b) 3-years of surface water and groundwater monitoring information, including water levels, inflow and outflow, groundwater levels, groundwater input, and precipitation gauging;
   c) Ecological information on surrounding species.

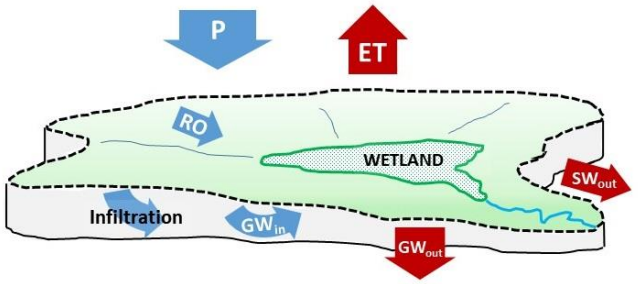
Pre-development

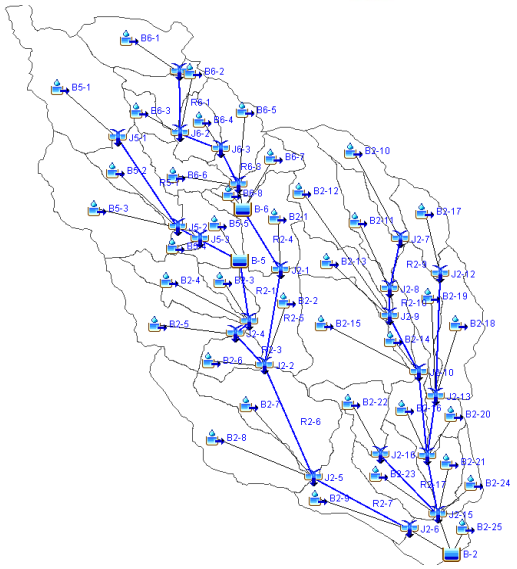


How is modeling used to assess the need for, and design of, mitigation?

1. Pre-development baseline data collected.
2. Baseline data informs conceptual model:
   a) Based on surface water and groundwater information, choose an appropriate model for the wetland;
   b) Begin building model to mimic wetland hydroperiod and determine initial water budget; and
   c) Modelling can occur in parallel with monitoring data collection.

Pre-development

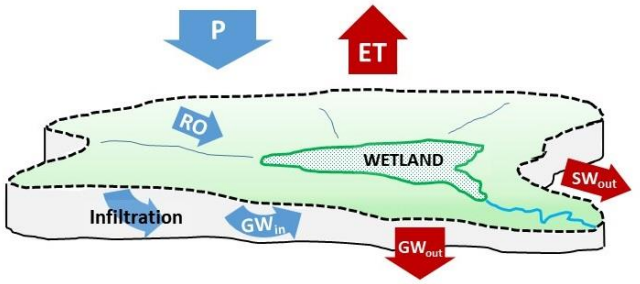




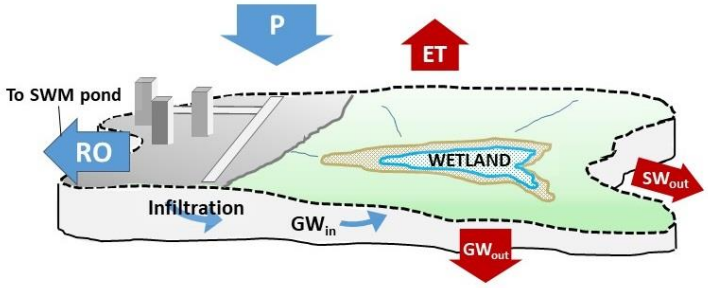
How is modeling used to assess the need for, and design of, mitigation?

1. Pre-development baseline data collected
2. Baseline data informs conceptual model
3. Baseline data used to calibrate + validate continuous model (pre-development condition, long term run)
4. Use calibrated model to simulate post-development land use + drainage without mitigation practices

Pre-development



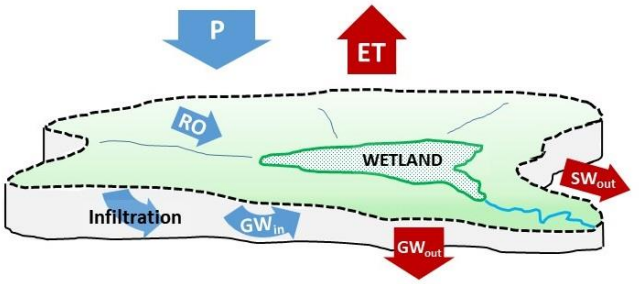
Post-development



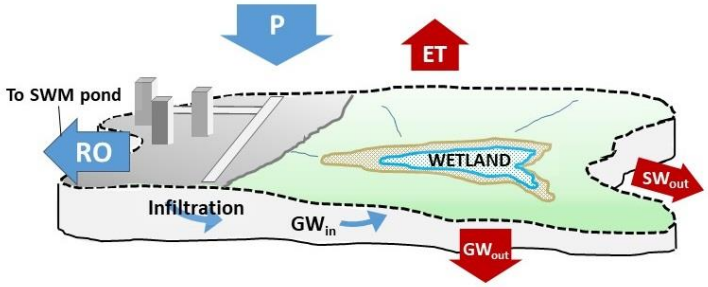
How is modeling used to assess the need for, and design of, mitigation?

5. Compare pre- to post-development hydroperiod:
   a) Determine changes in runoff volume and timing to wetland, and potential water level changes within wetland;
   b) Provide summary tables of the weekly, monthly, and annual water budget results and annual hydrographs for comparison; and
   c) Consult with ecologist on understanding the impacts of these changes on the wetland.

Pre-development

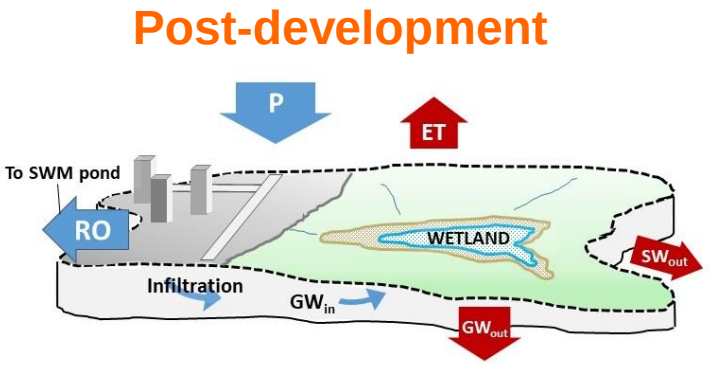


Post-development



How is modeling used to assess the need for, and design of, mitigation?

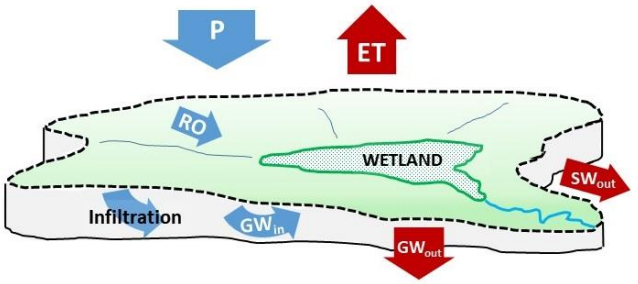
5. Compare pre- to post-development hydroperiod
6. Determine whether mitigation is required based on projected pre- to post- differences:
    a) If needed, set preliminary design targets based on differences between pre- and post-development runoff volumes and timing.



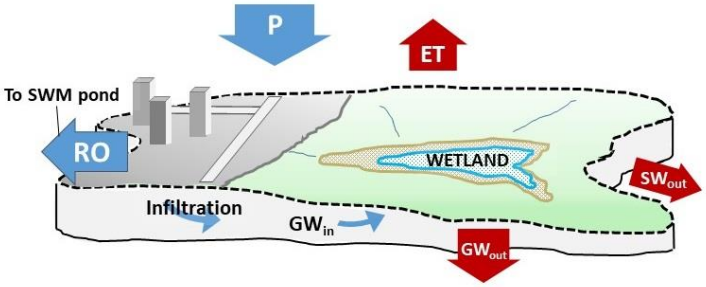
How is modeling used to assess the need for, and design of, mitigation?

5. Compare pre- to post-development hydroperiod
6. Determine whether mitigation is required based on projected pre- to post- differences
7. Evaluate potential mitigation measures and design alternatives
    a) Recommend meeting with CA and municipal staff to determine which alternatives will work best AND will be accepted by municipal engineering and maintenance staff.

Pre-development



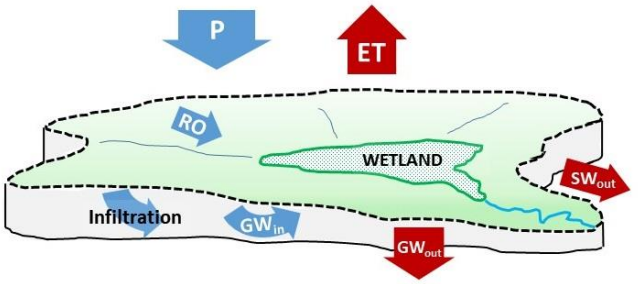
Post-development



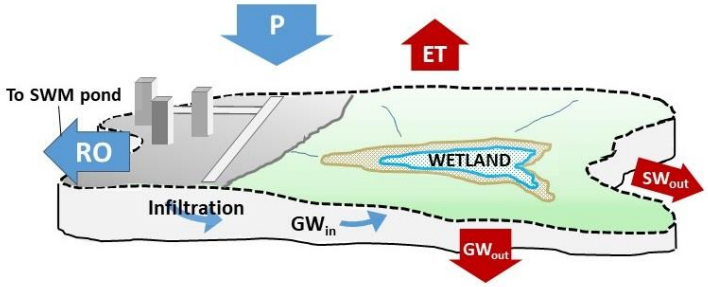
How is modeling used to assess the need for, and design of, mitigation?

5. Compare pre- to post-development hydroperiod
6. Determine whether mitigation is required based on projected pre- to post- differences
7. Evaluate potential mitigation measures and design alternatives
8. Continue revising mitigation measures until post-development difference is acceptable

Pre-development

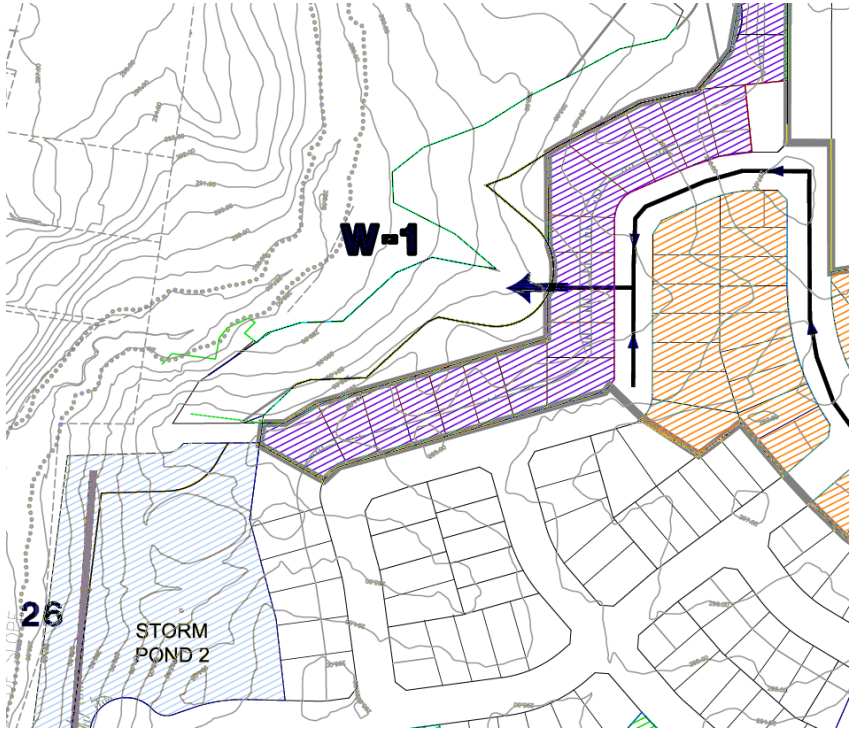


Post-development

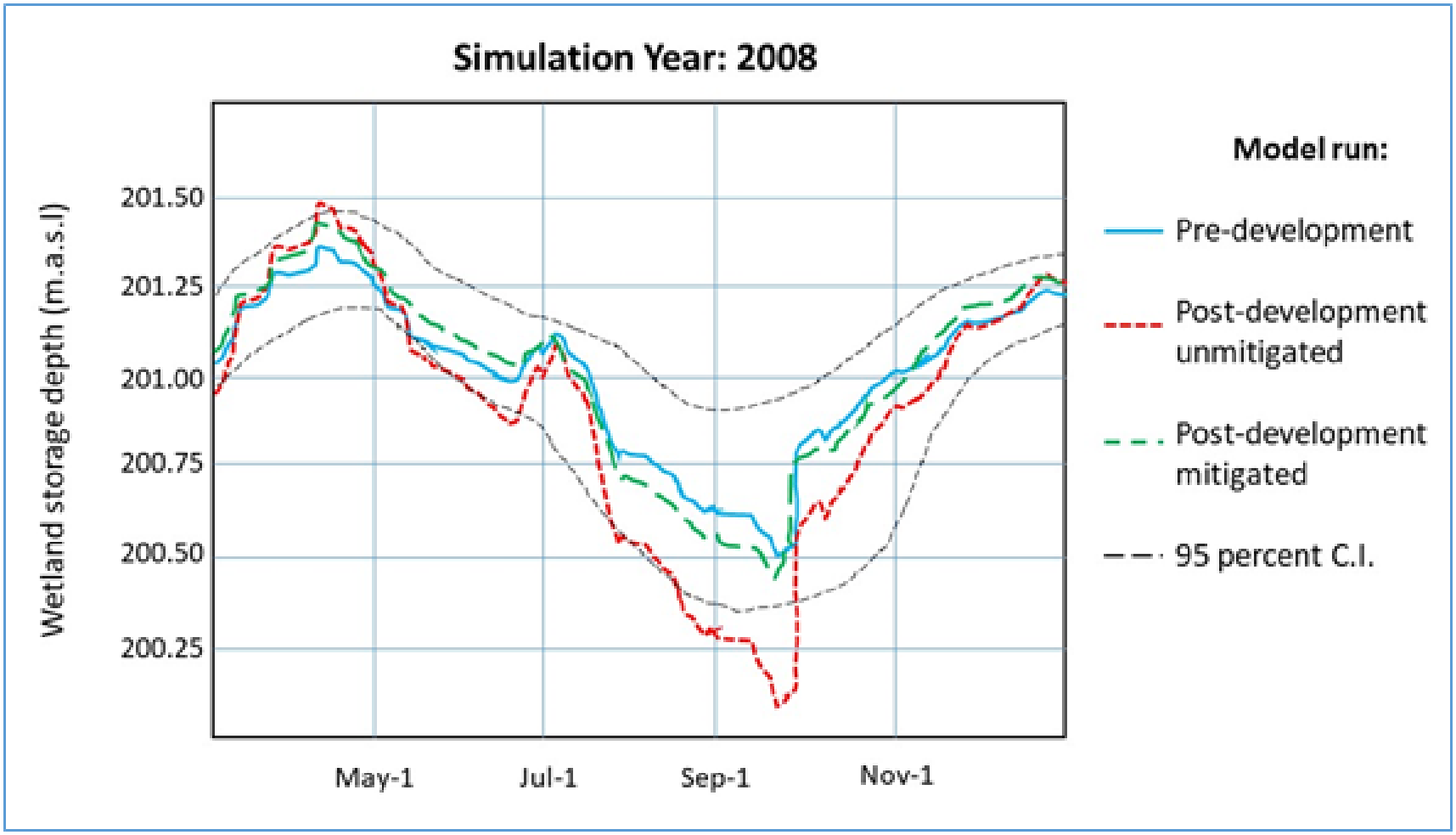


How is modeling used to assess the need for, and design of, mitigation?

- Lost catchment runoff volume often replaced using roof or lot runoff
- Roof drainage collector systems, foundation drains, sized using insights from model
- Important to control rate of runoff release to wetland, usually with a Low-Impact Development facility

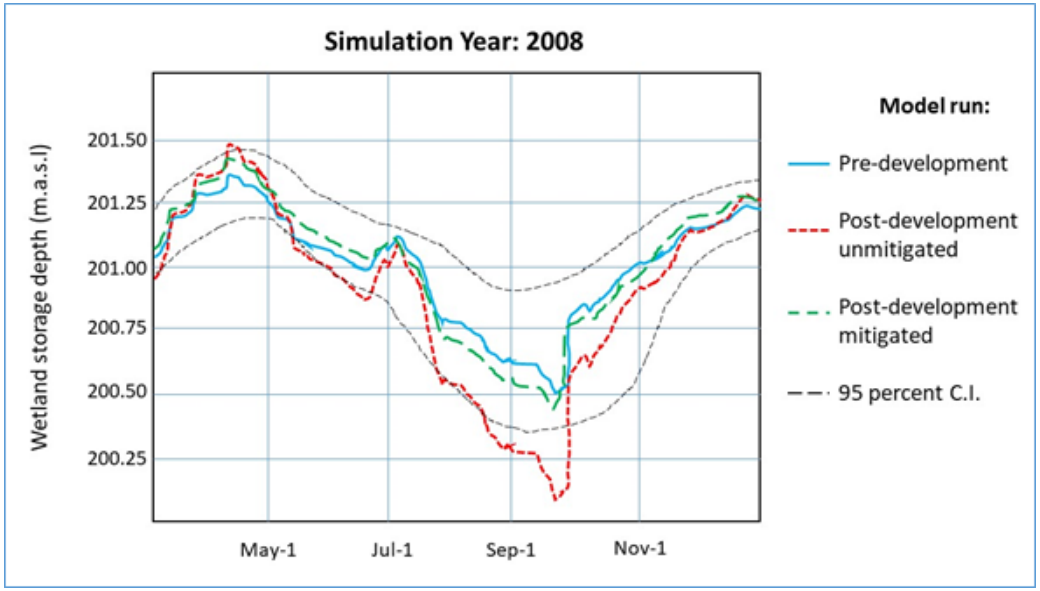


What do we look for in reviewing model output?



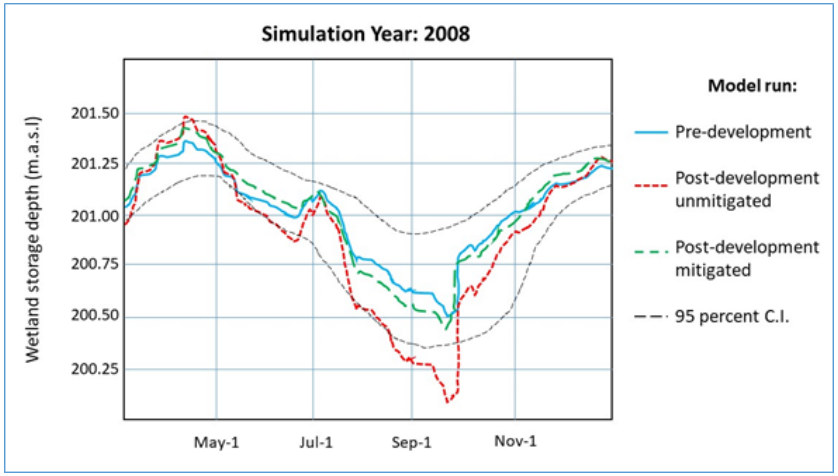
What do we look for in reviewing model output?

- Graphical review (such as the example hydrograph)
  - Prefer to see annual hydrographs on a single plot for easiest review;
  - Hydrographs also allow for quick review of the proposed response to storm events and an understanding of the timing impacts of the proposed mitigation.



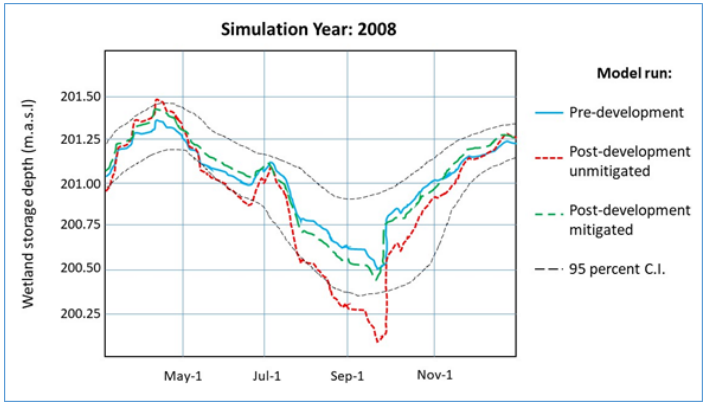
What do we look for in reviewing model output?

- Graphical review (such as the example hydrograph)
  - Will also provide an understanding to the impacts to the water levels within the wetland during the year.
  - This should be reviewed in detail with an ecologist to confirm any potential impacts to the wetland species, and if the changes in water levels are acceptable.
- Discuss all findings related to this in the final report.



What do we look for in reviewing model output?

- Tabular results of the water budget:
  - Model should be set up to easily create weekly, monthly, and annual summaries of the water budget information;
  - Tables can be provided to summarize this information for easy comparison;
  - Reviewers can quickly compare information for crucial periods, including spring freshet runoff volumes and summer storm event volumes and timing response.
- Again, review with the ecologist and discuss all findings related to this in the final report.



How is modeling used to assess the need for, and design of, mitigation?

- If modeling is done using poor quality data or faulty assumptions, issues can result
- Need to include municipal Maintenance and Ops staff in early discussions to understand what mitigation practices they are willing to take on.
    - Always remember: any public lands mitigation practices will be assumed by municipalities.

What needs to be included in a Terms of Reference?

- Assuming wetland has been classified and primary input determined...
- Monitoring:
  - BE SPECIFIC: number of years, types of monitors, number of gauges, locations, etc.
  - Typically, request 3-years of monitoring, including water level loggers recording the response within the wetland to a rain event (surface levels, deep and shallow piezometres for groundwater levels),
    - If possible, monitor specific inflow and outflow rates, but not always available/feasible.
    - Don't forget rain gauge, as the nearest rain gauge may be several kilometres away and won't accurately capture rain event the wetland loggers captured

What needs to be included in a Terms of Reference?

- Existing Conditions Modelling:
  - Outline how key subwatershed information is determined, including drainage boundaries, soils classification;
  - Outline how wetland will be modelled, including preparation of stage/storage/discharge information, preferably based on surveyed information.
  - Outline how calibration and validation will be performed;
    - Specify if only certain parametres will be adjusted, and to what tolerance levels, etc.
    - Specify when to "stop" calibrating;
    - How to present calibration results.

What needs to be included in a Terms of Reference?

- Proposed Conditions Modelling:
  - Specify proposed conditions modelling without mitigation practices first, to establish an understanding of impacts;
  - Specify to what degree volume and hydroperiod timing will mitigation strategy need to meet pre-development water budget, or when this will be determined;
- Post Construction Works:
  - Specify monitoring type and length,
  - Require an Adaptive Management Plan, including contingency plans, etc.

What needs to be included in a Terms of Reference?

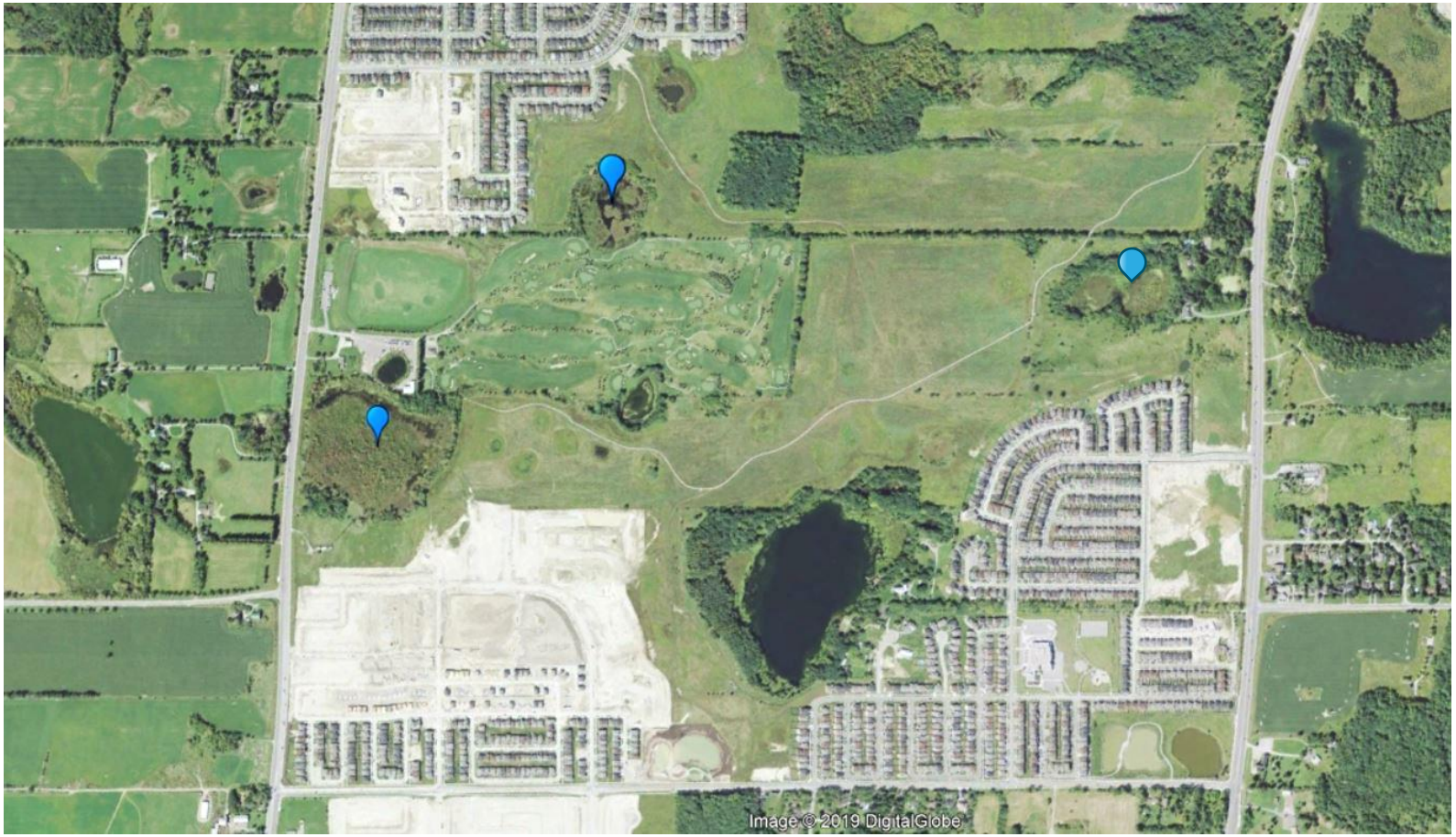
- Reporting:
  - Specify when reports, memos, or technical documents will be produced and submitted to review agencies;
    - Recommend a technical memo related to pre-development information, calibration and validation;
    - Recommend another technical memo related to mitigation requirements.
    - Requirements to go into final reports, including design targets
  - Meetings:
    - Number of meetings, when to meet, in order to ensure modelling exercise stays on track.

Yonge West Development, Richmond Hill

2002 – Pre-development

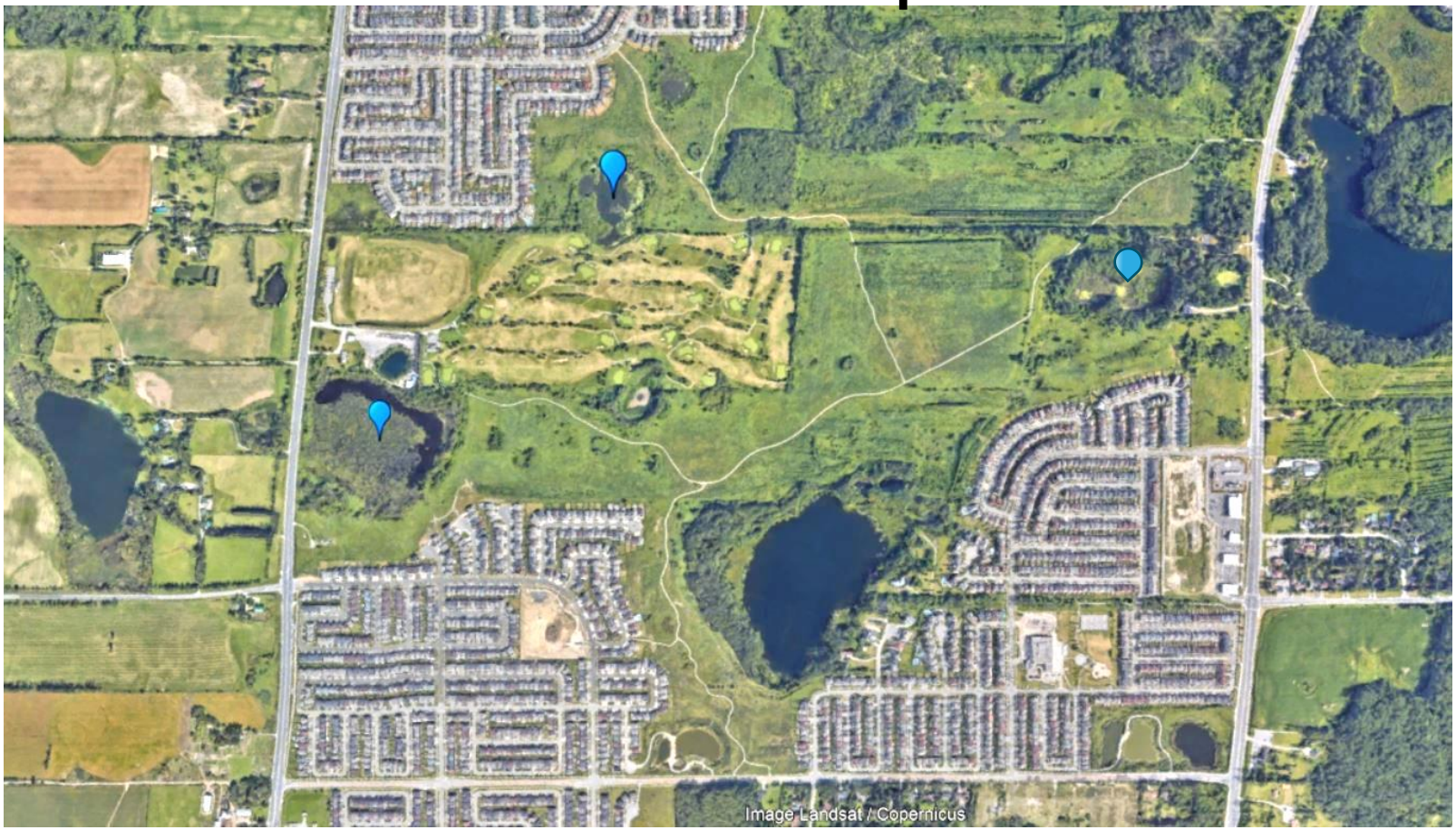
Yonge West Development, Richmond Hill

2009 – Construction

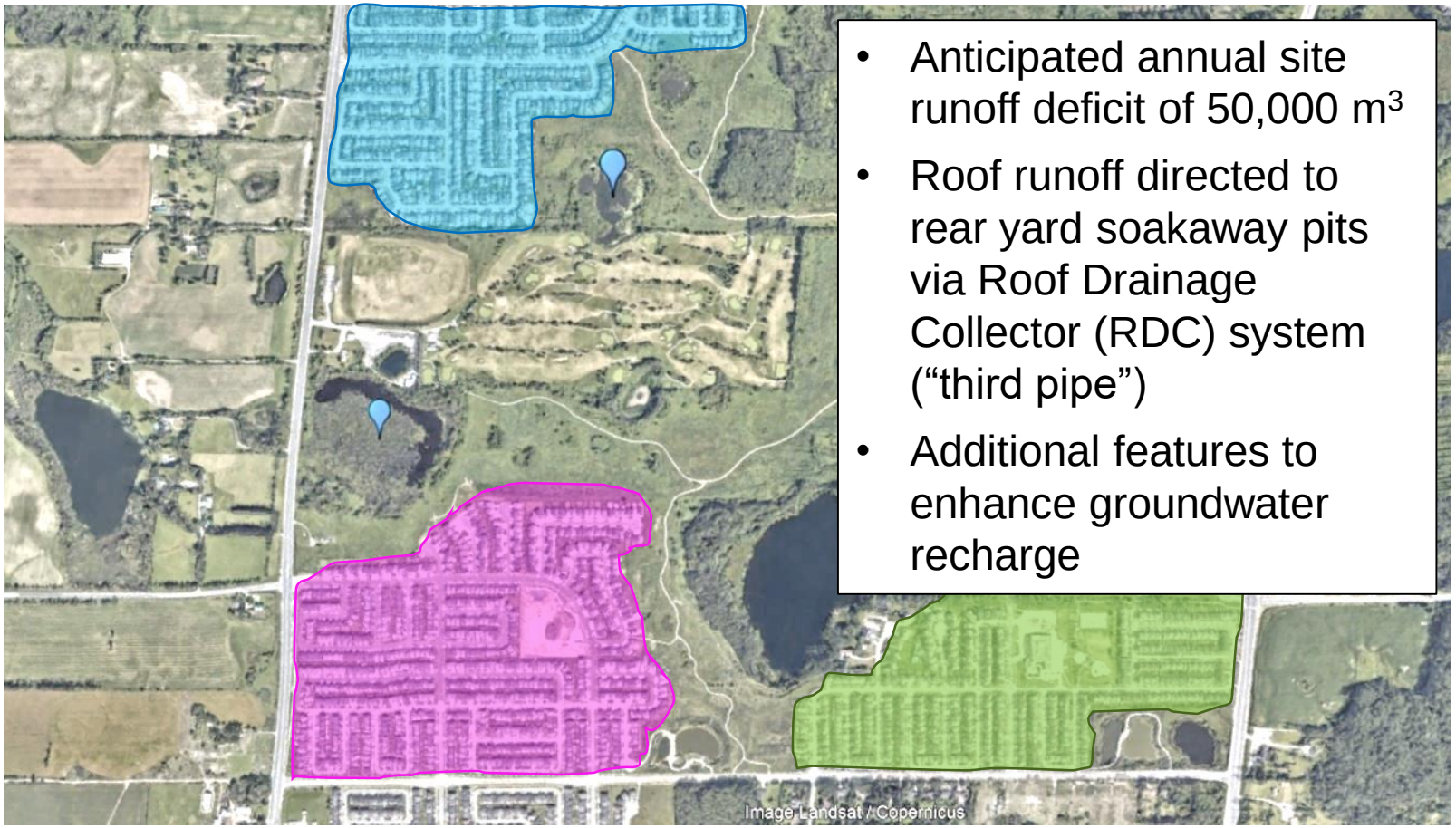


Yonge West Development, Richmond Hill

2018 – Post-development

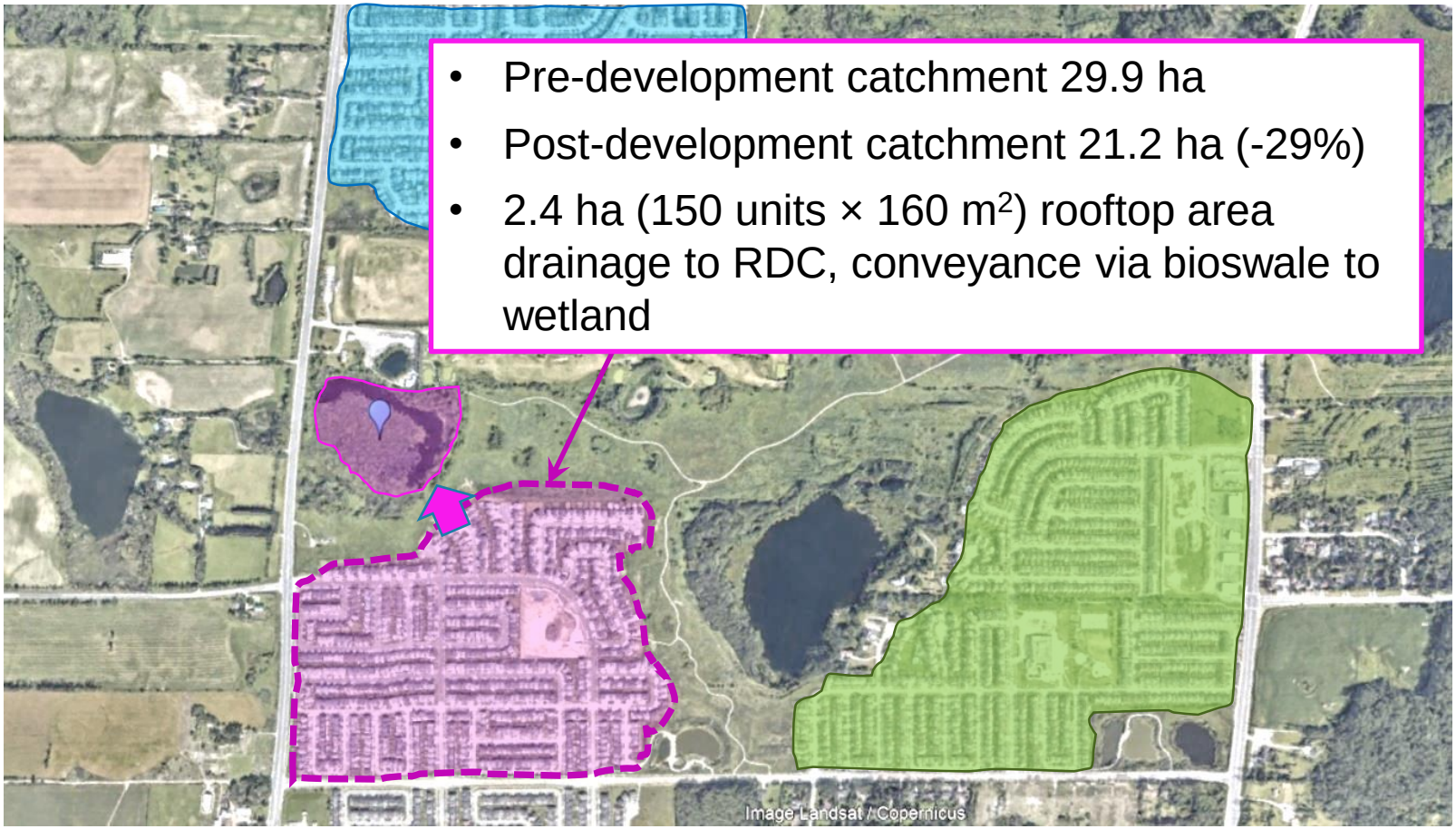


Yonge West Development, Richmond Hill



- Anticipated annual site runoff deficit of 50,000 m^3
- Roof runoff directed to rear yard soakaway pits via Roof Drainage Collector (RDC) system (“third pipe”)
- Additional features to enhance groundwater recharge

Yonge West Development, Richmond Hill



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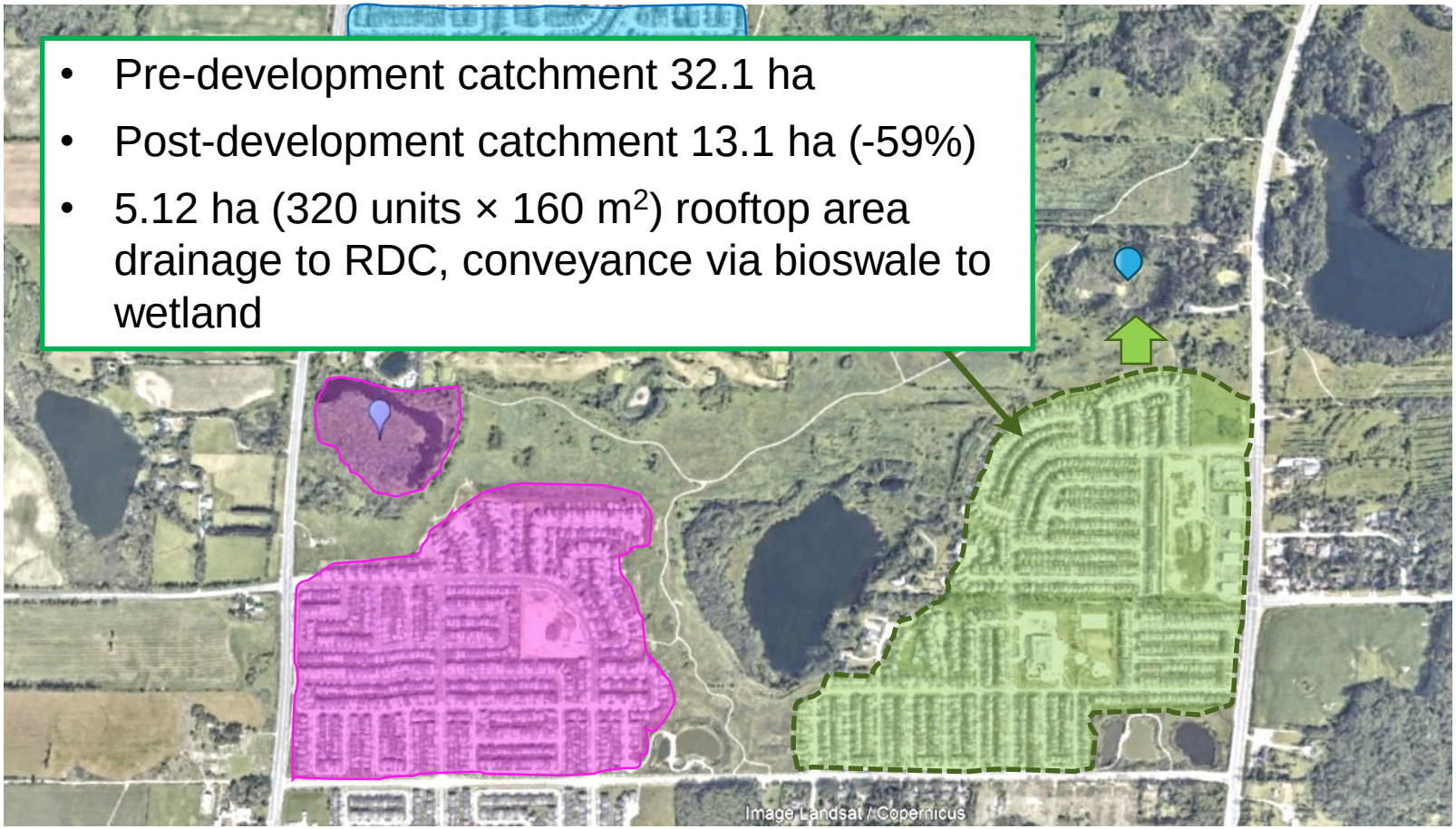

How do I know if a mitigation system is functioning properly?

- Post Construction Monitoring
  - Try for several years of monitoring post substantial buildout;
  - Require report prepared comparing post construction annual hydrograph of water levels compared to pre-development;
  - Any refinements will have to come from Adaptive Management Plan as prepared during design stage

Questions?

KEEPING THE BALANCE

Feature-based water balance in the planning process

Breakout Exercise #2 – Water balance discussion

June 20, 2019

Environment Canada Environnement Canada

Toronto and Region Conservation Authority

Breakout exercise #2 instructions

- Participants have **25 minutes** to discuss a set of 5 questions as a group, drawing on their professional experience and knowledge.
- Groups will be called on to report back on their answers. Facilitators will be on hand should any of the questions be unclear; note that questions are open-ended.
- Please answer questions on sheet in bullet points or short form to record discussion (Sheets will be collected at the end of the workshop).