Upper Thames River Stream Flow Statistics Update

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Outline

- Background/Historical Context
- Hydrology
- Frequency Analyses
    - Flow Naturalization
- Results
    - Maximum Mean Daily (MMD)
    - Maximum Instantaneous Discharge (MID)
    - Ten Day Annual Maximum Runoff Volumes
- Attenuation of Flood Peaks through Reservoirs
- Summary/Conclusions

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Background/Historical Context

- Frequency of flows important for determining flooding regulation limits
- Last major review of watershed stats 1984 via Glengowan report
- Many more hydrometric stations and years of data since 1984

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Hydrology

- “Statistical analysis in hydrology consists of estimating future frequency or probability of hydrologic events based on information contained in hydrologic records”

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Hydrology

- 20 active Environment Canada maintained hydrometric stations
- 9 discontinued hydrometric stations
- 23 hydrometric stations with 20+ years of data
- 18 stations with 50+ years of data
- 6 stations with 75+ years data
- First two stations established in 1915

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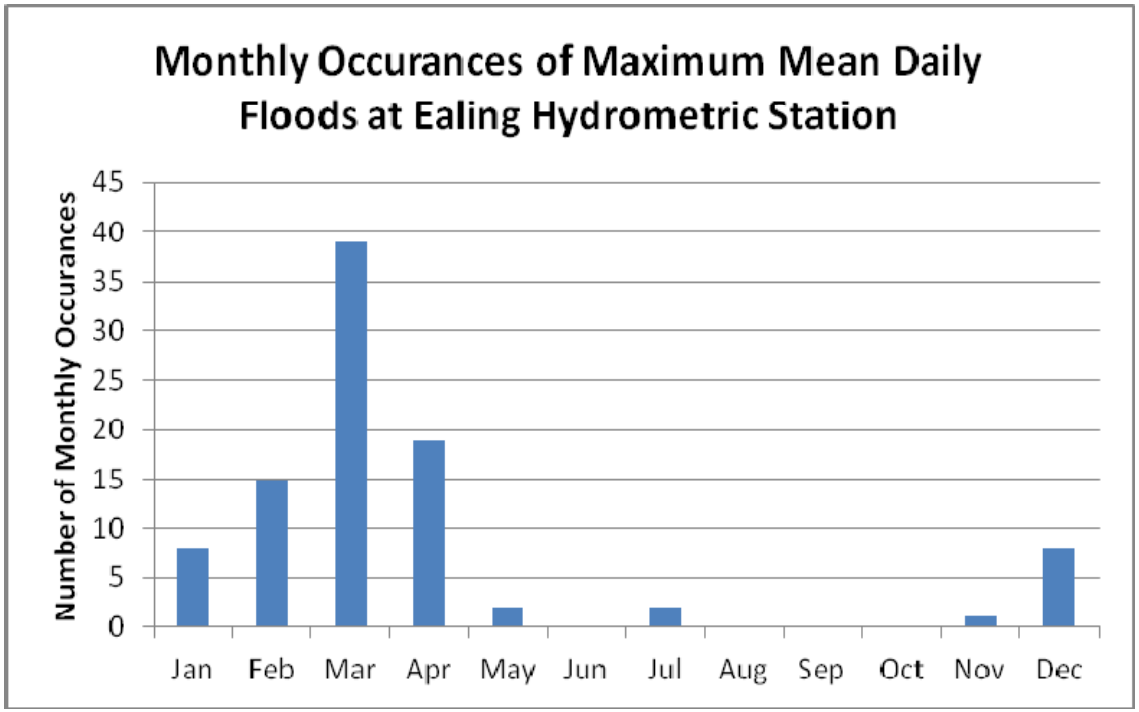
Hydrology

- Most major flood events in the Thames River basin occur in the winter months
- Only 5 – 10% of MMD flood events occur in non winter months



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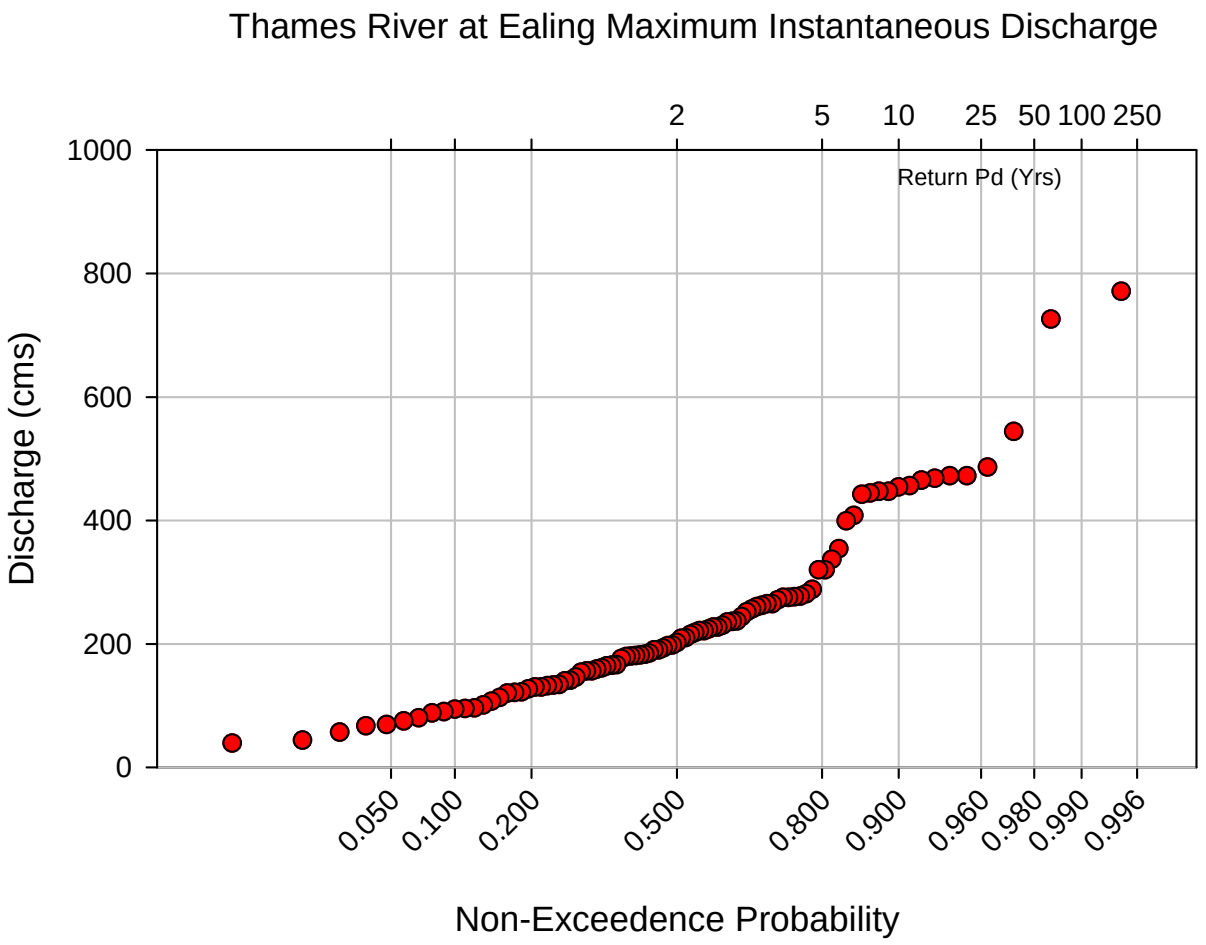
Frequency Analysis

- “Plotting position” provides empirical probability estimates
- Maximum annual (winter/spring) values sorted from highest to lowest value and plotted with probability estimated as:
  P = (k-0.5)/(n-1)



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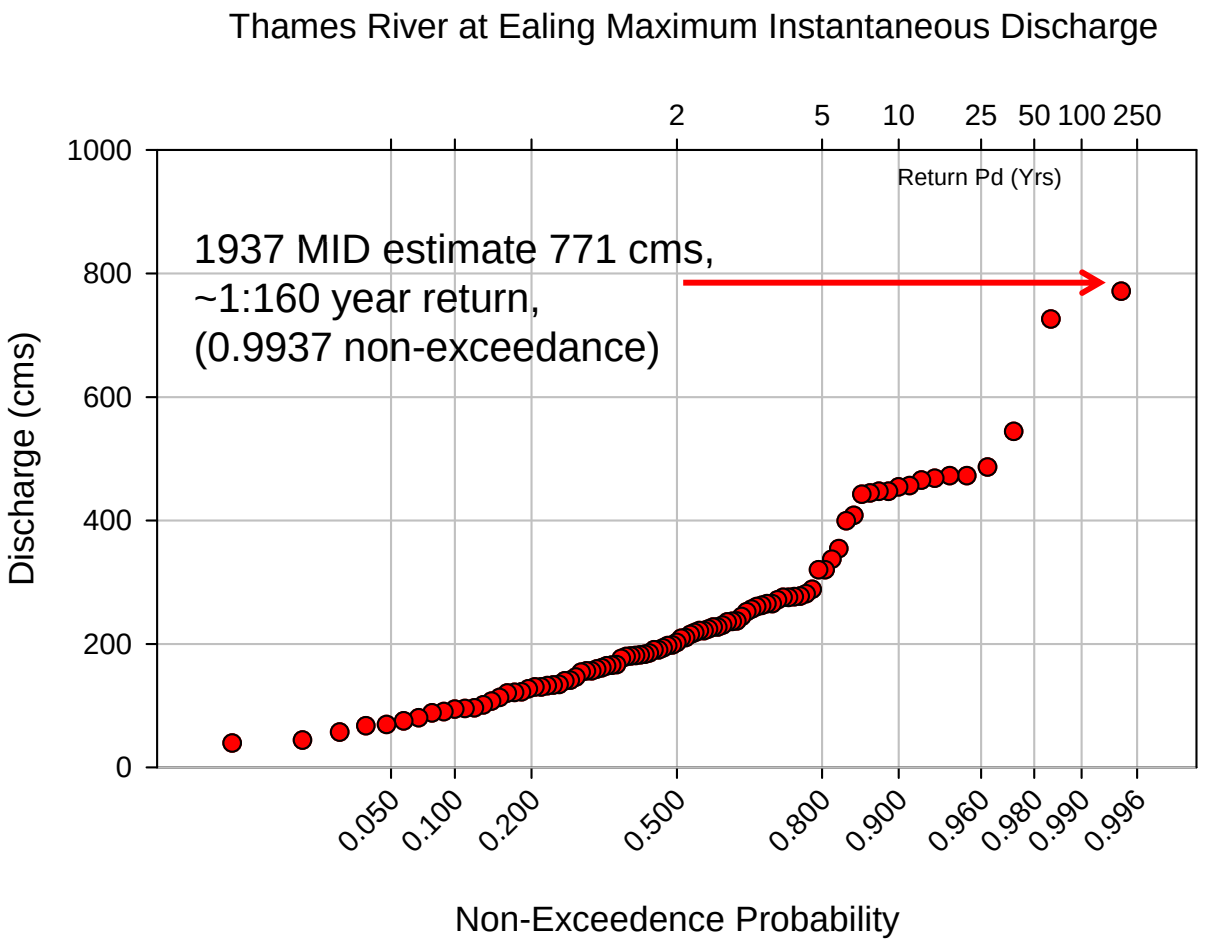
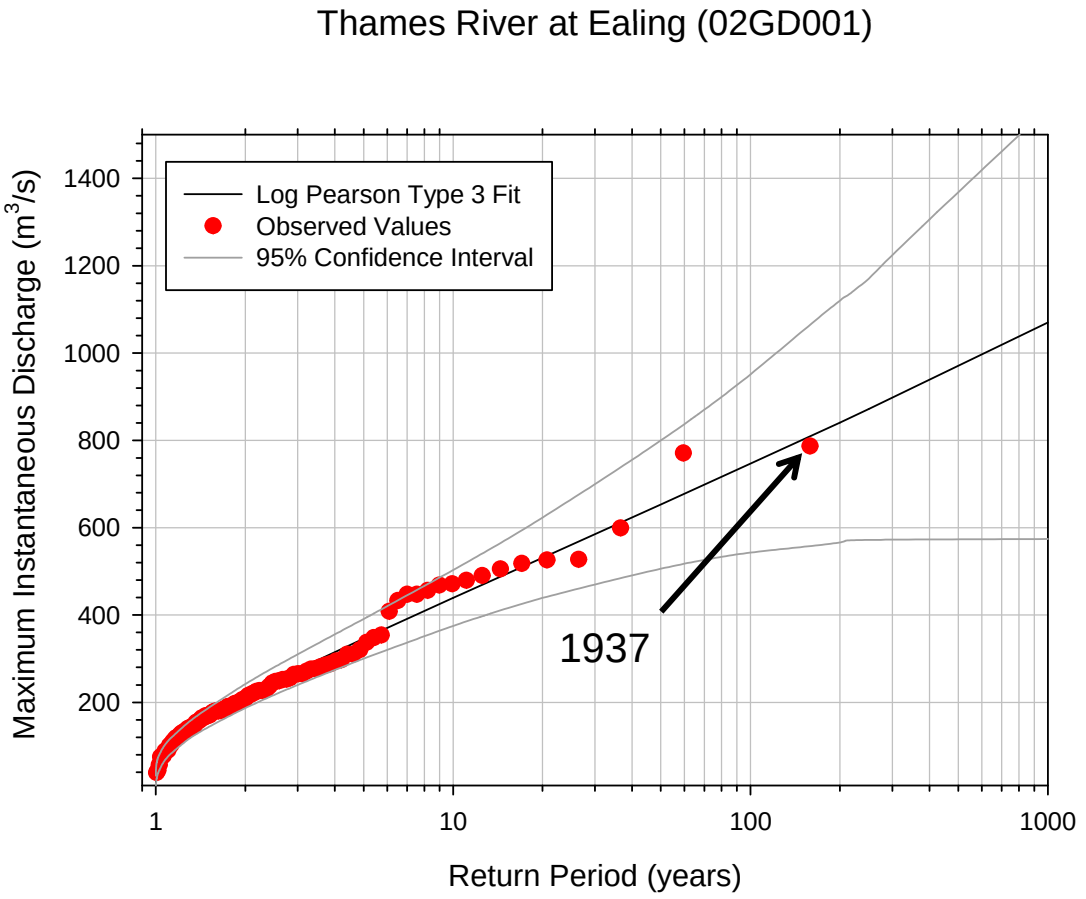


Frequency analysis

- Log Pearson Type 3 Probability Distribution is fit to data



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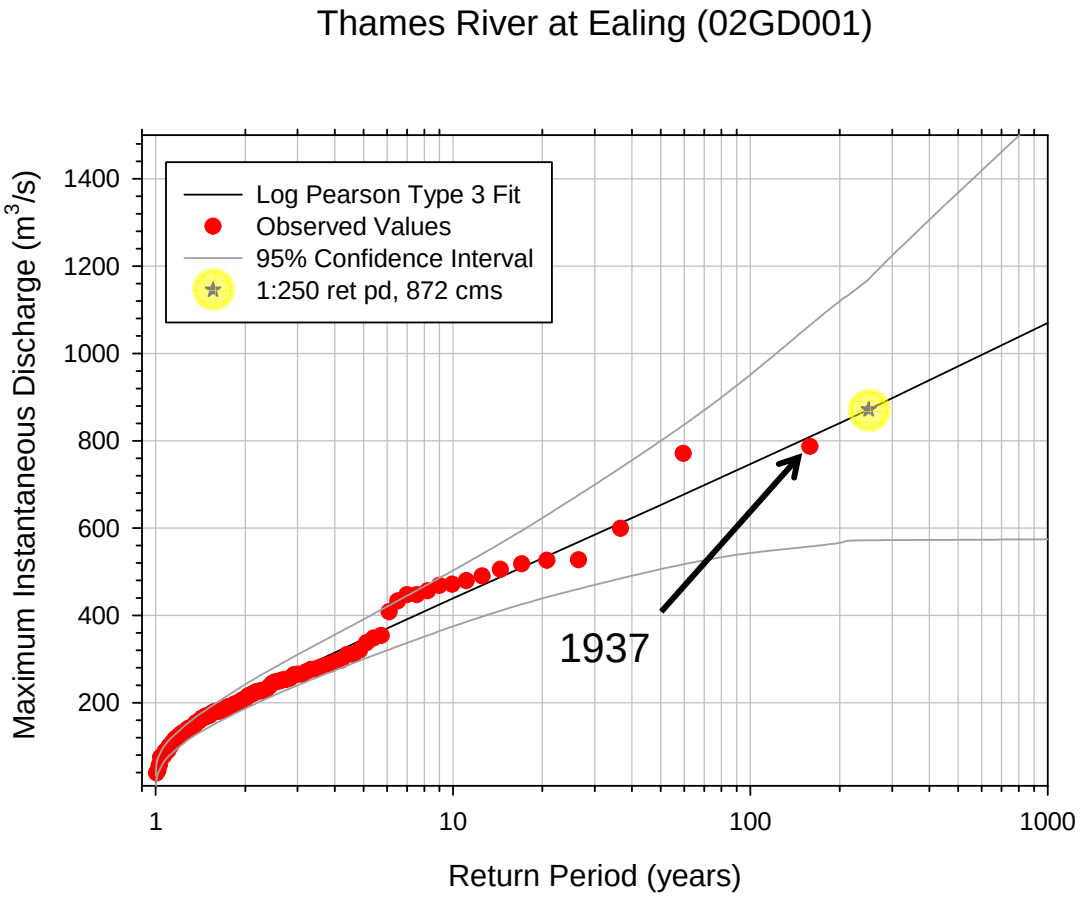
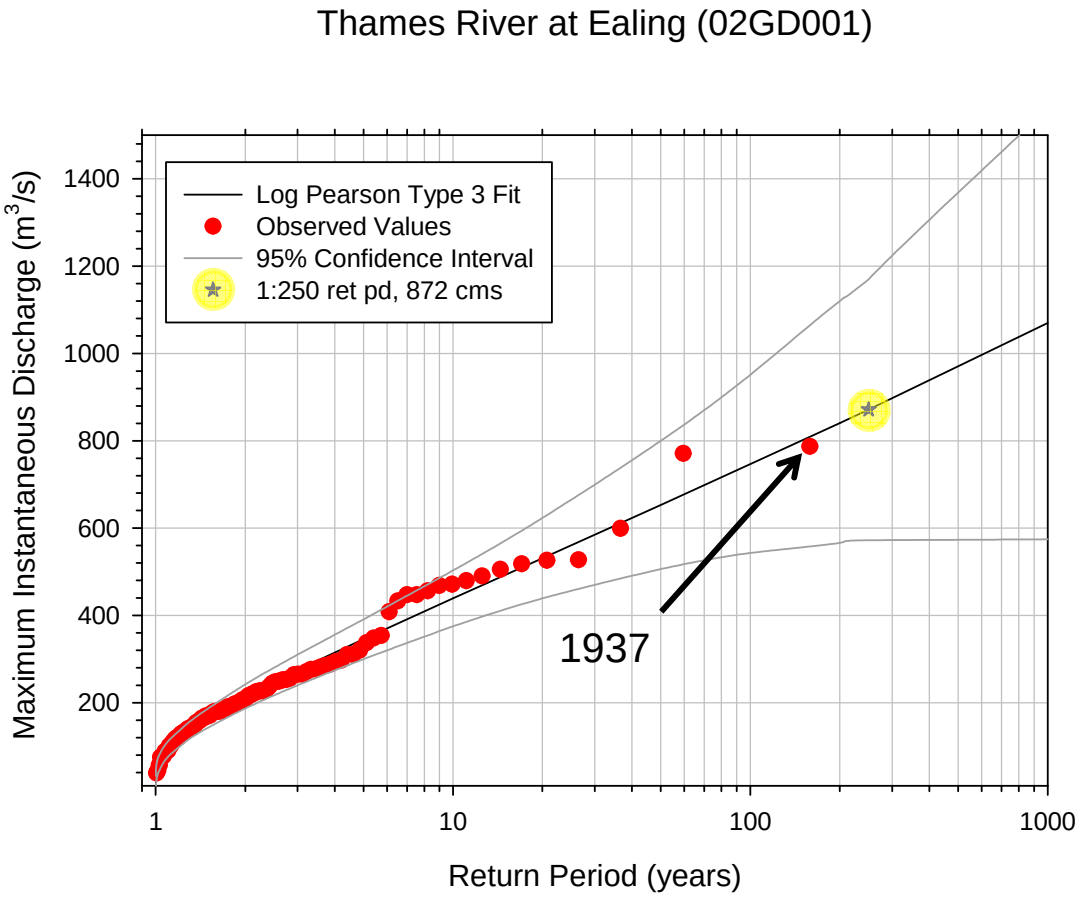


Frequency analysis

- Log Pearson Type 3 Probability Distribution is fit to data
- Frequency analysis undertaken at 19 hydrometric stations with 20 or more years of data



Flow Naturalization

- Reservoirs change the nature of hydrology, and we are interested in natural conditions
- 3 large reservoirs to be naturalized before statistics can be evaluated: Fanshawe, Wildwood and Pittock reservoirs
- Accomplished by area transforming upstream flows, or by “back routing”

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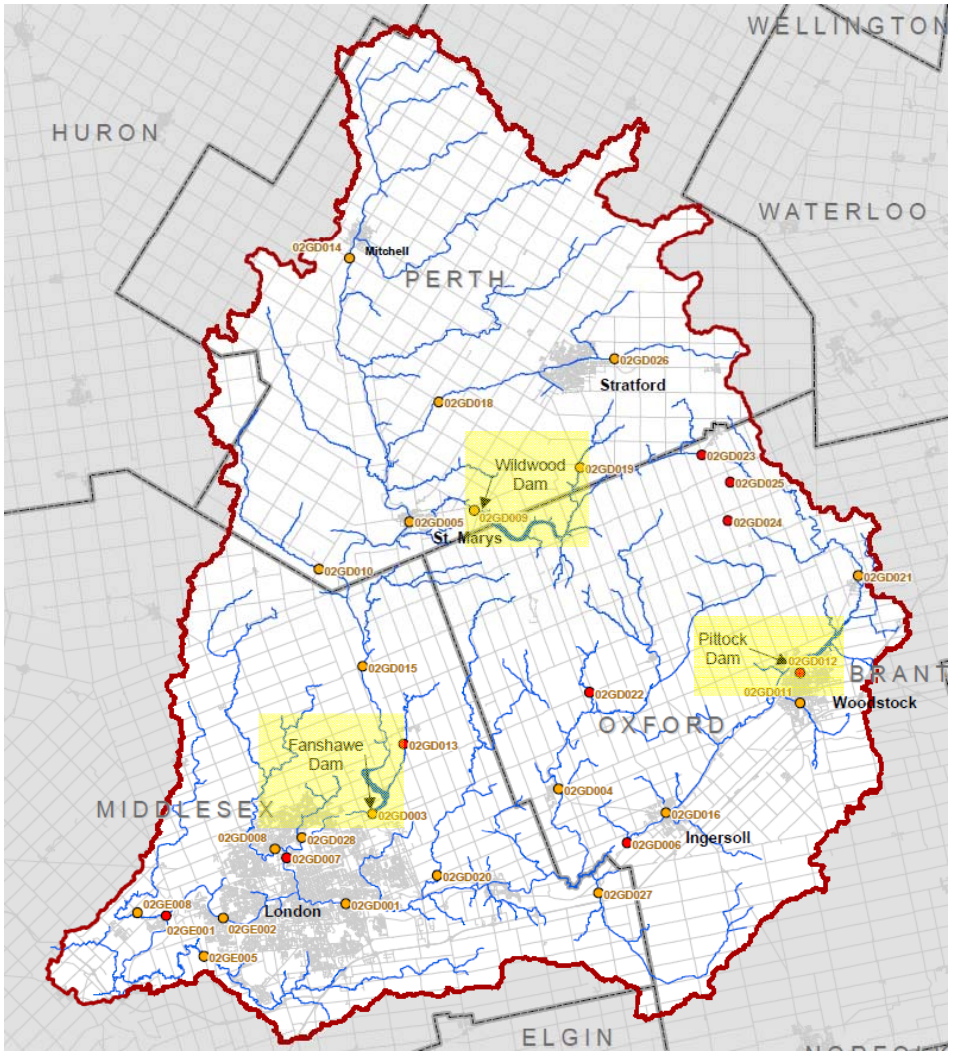
Flow Naturalization



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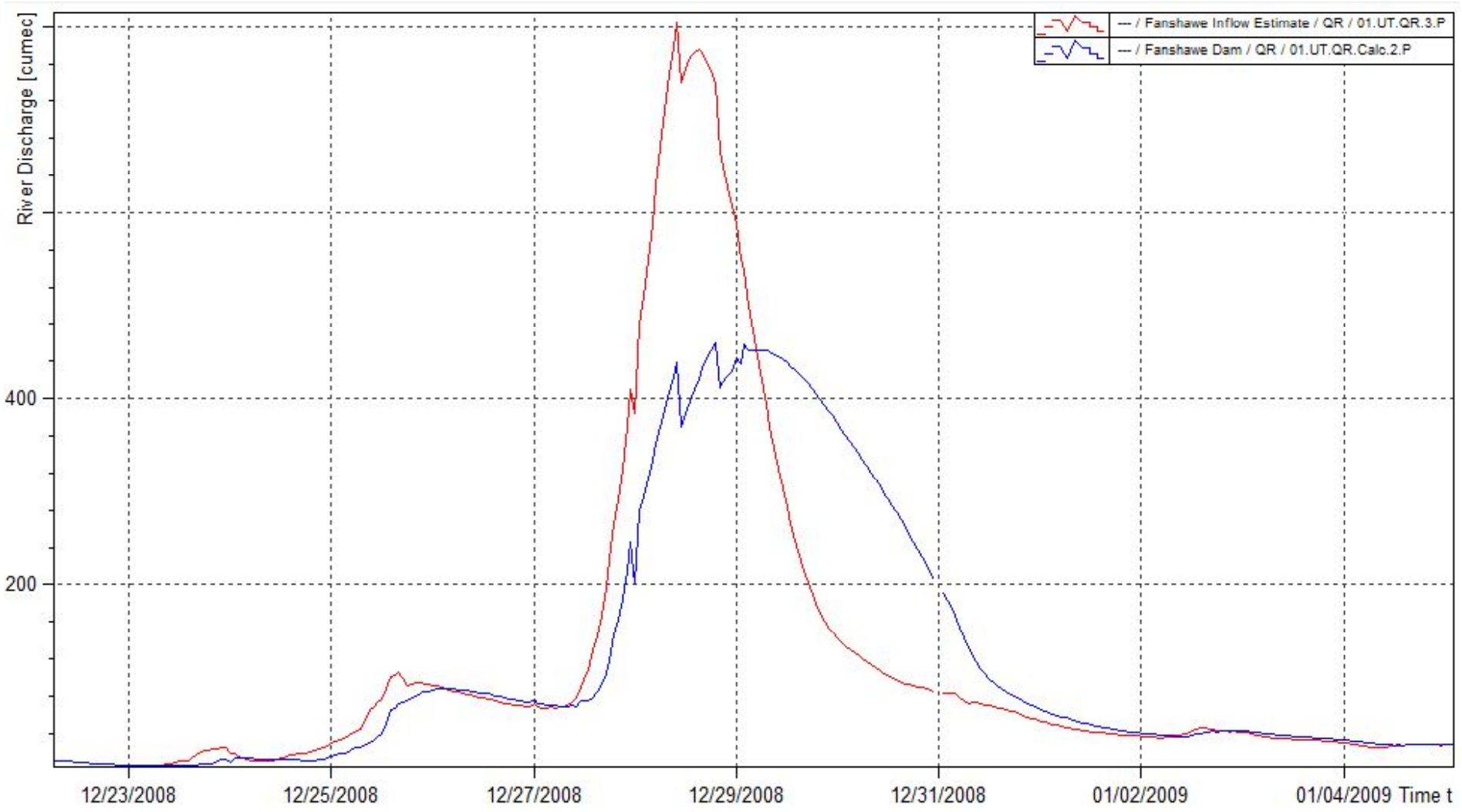

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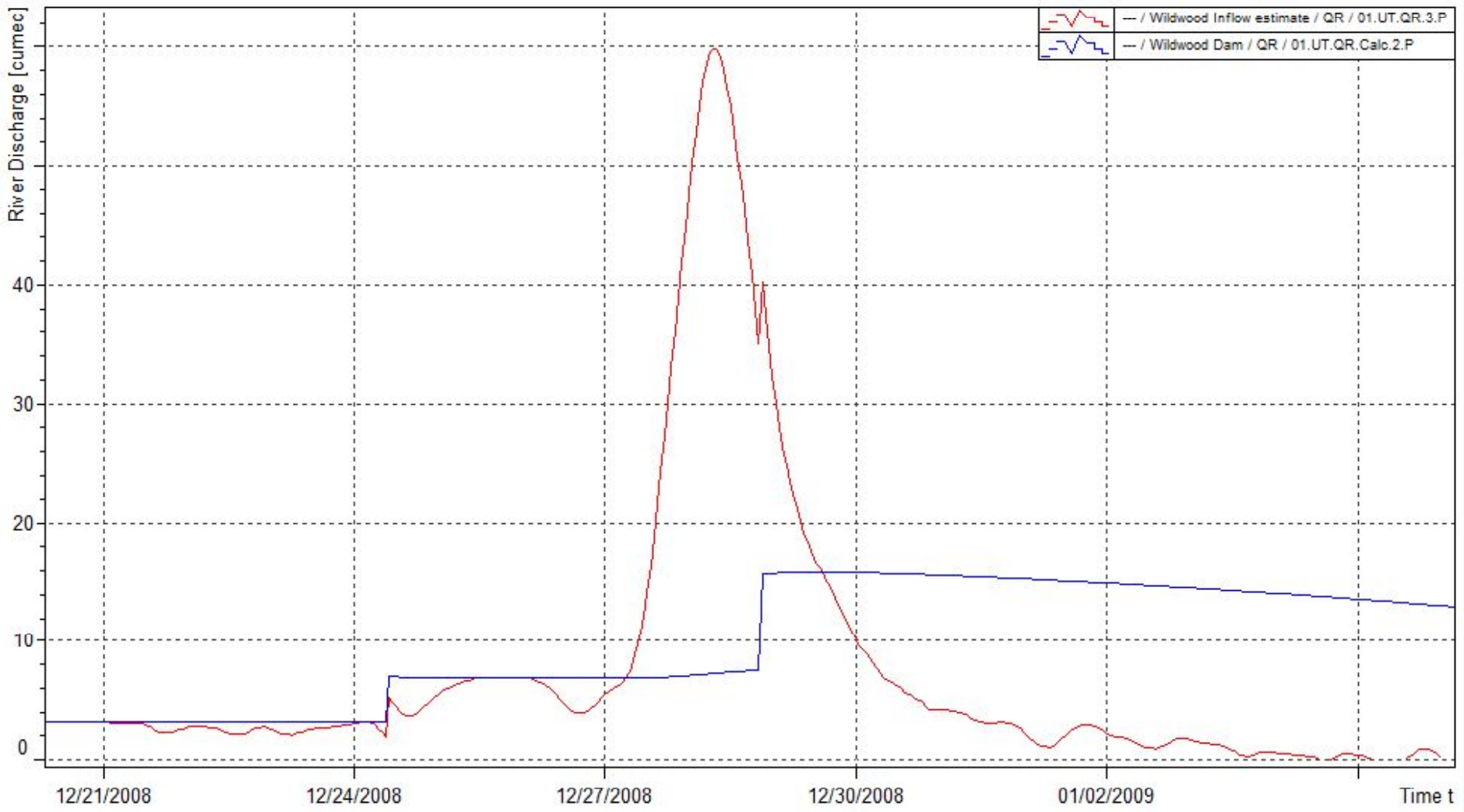
Flow Naturalization



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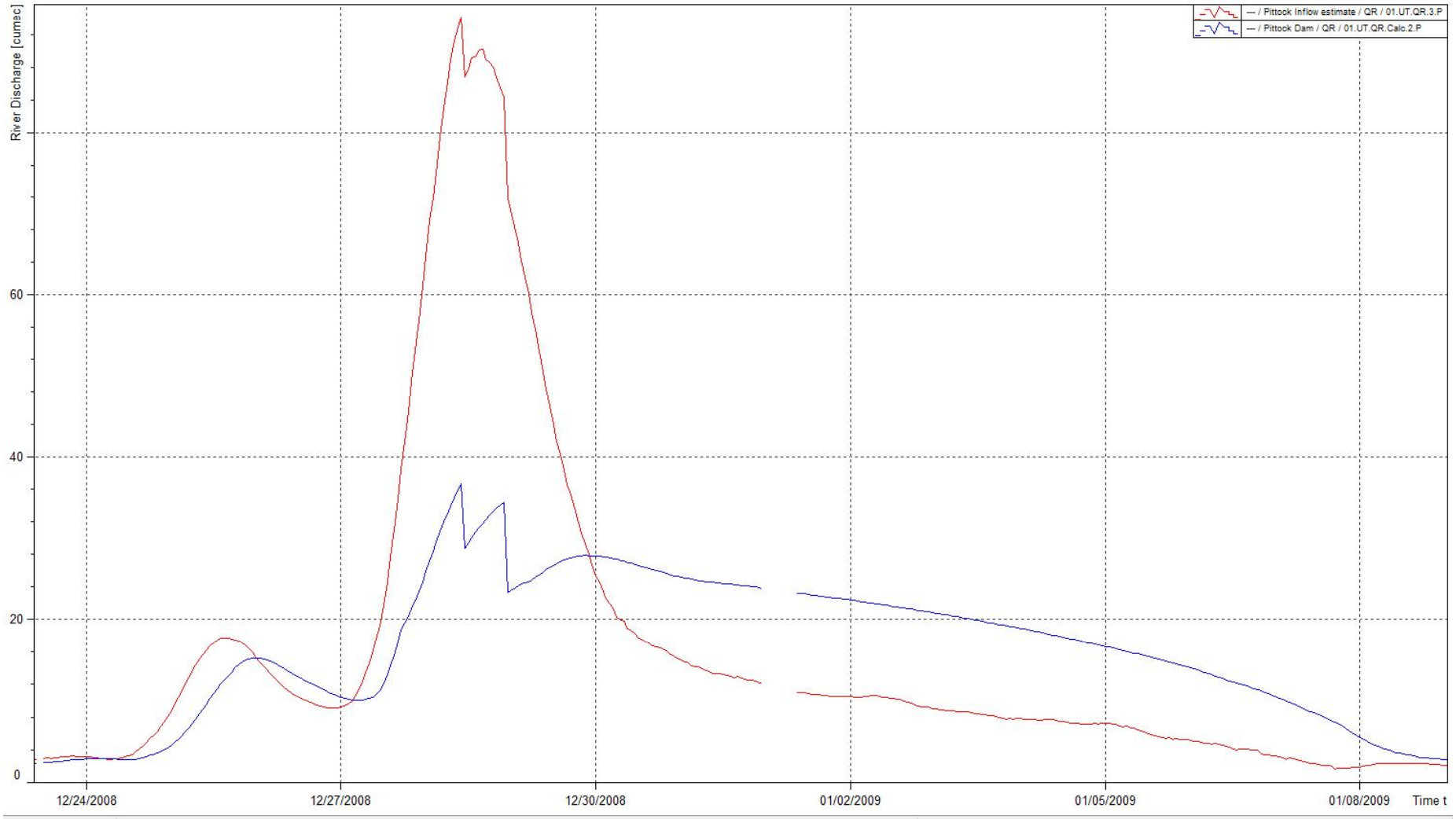
Flow Naturalization



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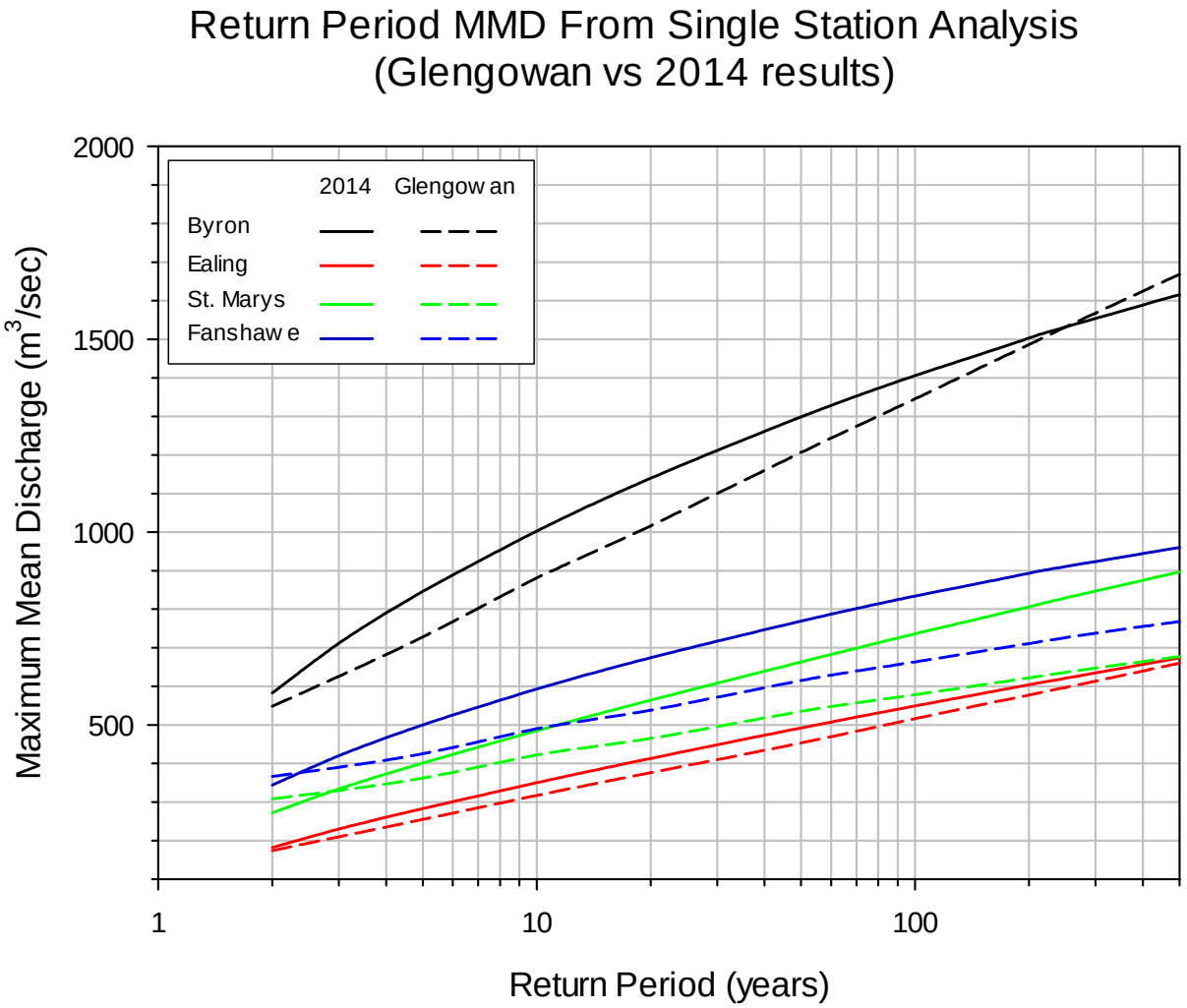
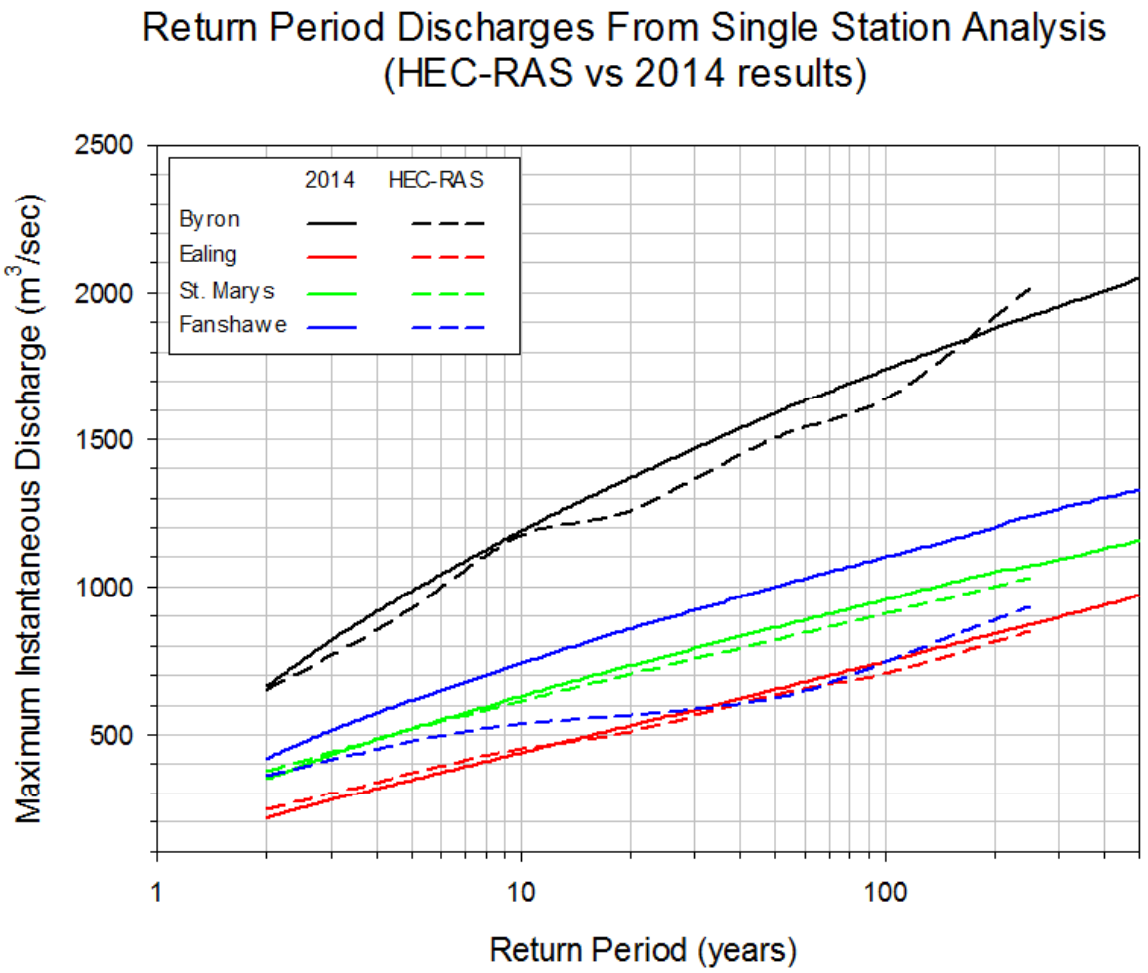
Results (MMD)

- Some stations very similar to past analyses (ie South Branch flow at Ealing)
- North branch flows are significantly higher with updated analysis



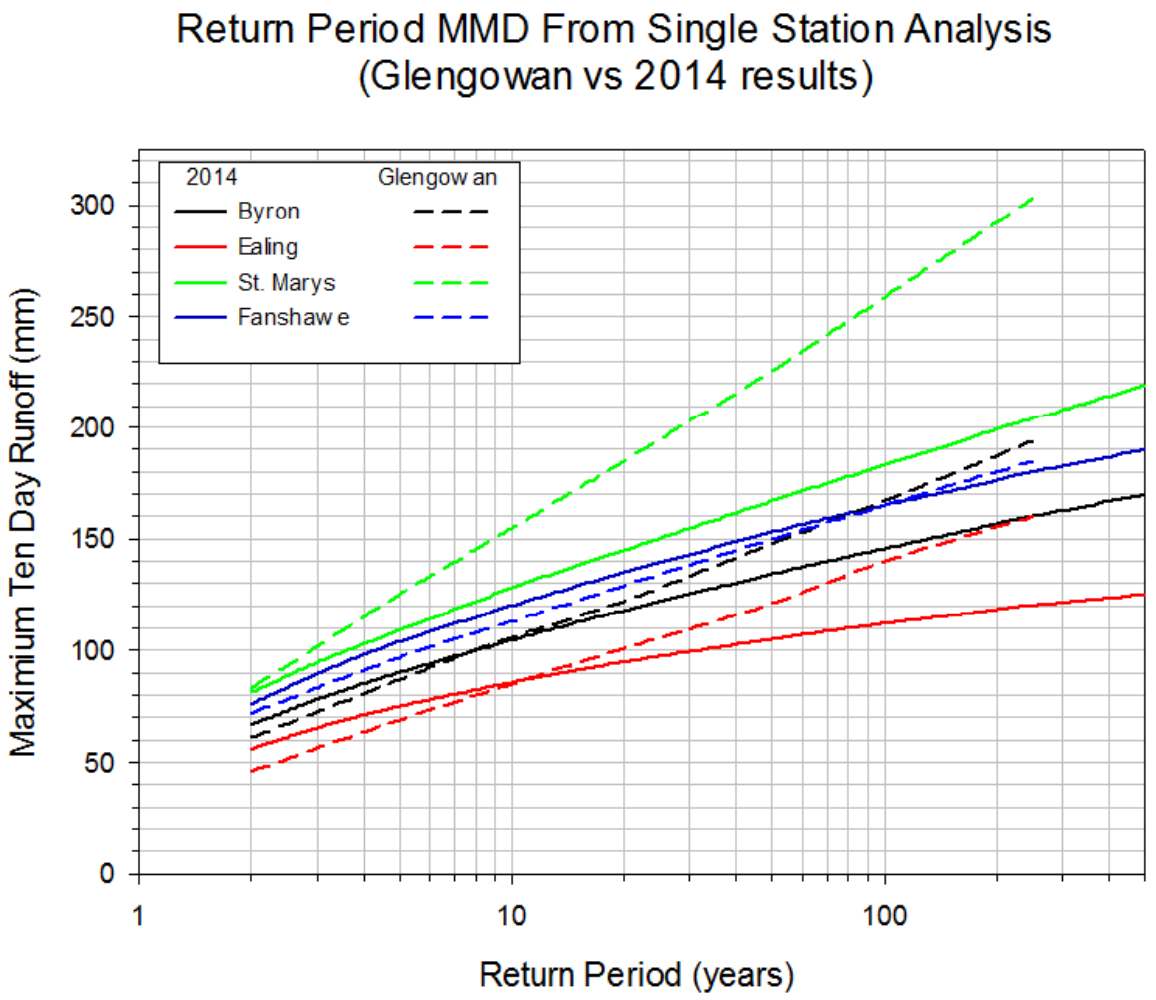
Results (MID)

- Comparison of 2014 results with values used in current HEC –RAS models for flood plain mapping
- Byron, Ealing St. Marys very similar. Fanshawe Dam values great in 2014 study



Results (Ten Day Runoff)

- Generally a reduction in 10 day runoff at lower frequencies
- Big disparity on North Thames river at St. Marys



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Reservoir Effects

- “Dams can reduce flood risk downstream, but they do not eliminate the risk. The purpose of a dam is to protect existing development, but not to free up additional land and allow for new development.”
- Still of interest to determine downstream attenuated frequency flows.
- Natural frequency design hydrographs are used as input to reservoirs, which are then routed downstream to determine the attenuated frequency.
- Useful in design of other aspects of a flood control system (ie flood walls, channels etc)

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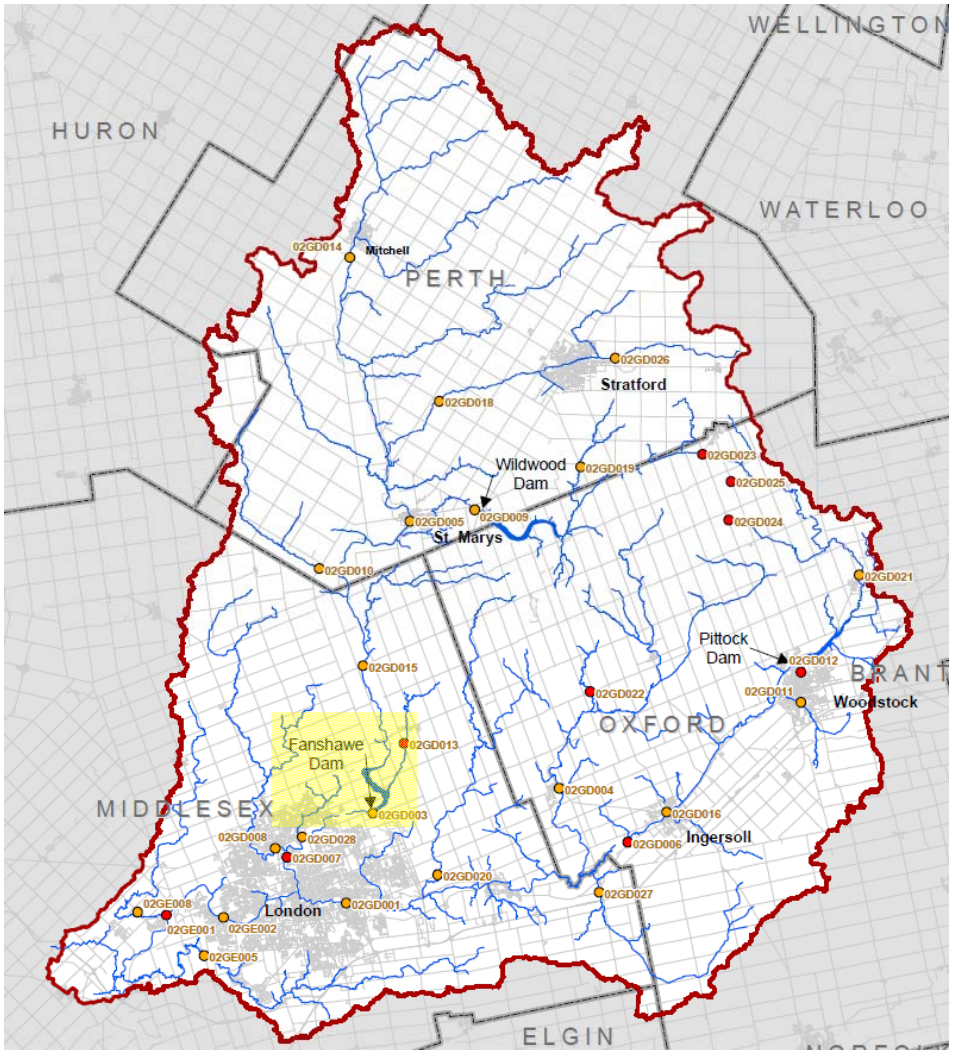
Reservoir Effects

- Fanshawe Reservoir:
  - North Thames River
  - 1450 km^2
  - 25 mm runoff storage



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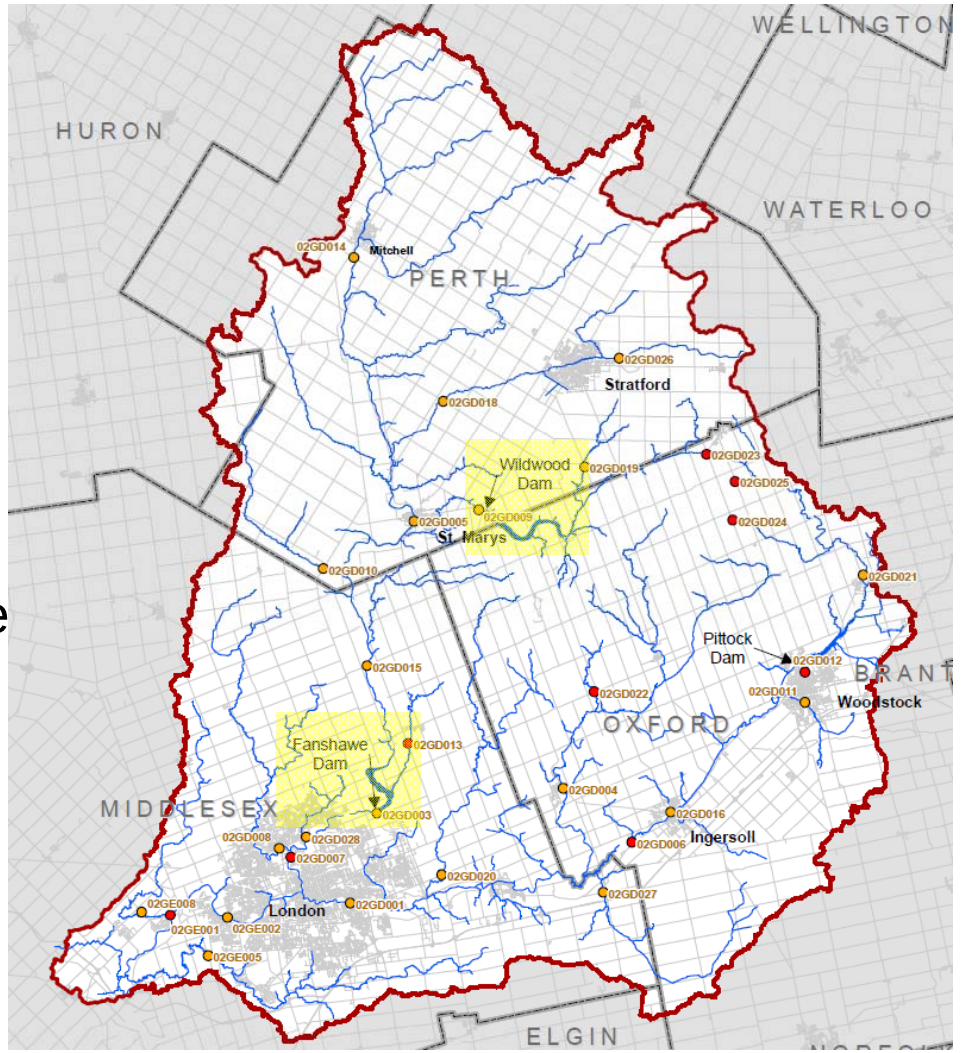
Reservoir Effects

- Fanshawe Reservoir:
  - North Thames River
  - 1450 km^2
  - 25 mm runoff storage
- Wildwood Reservoir
  - Trout Creek
  - 140 km^2
  - 140 mm runoff storage



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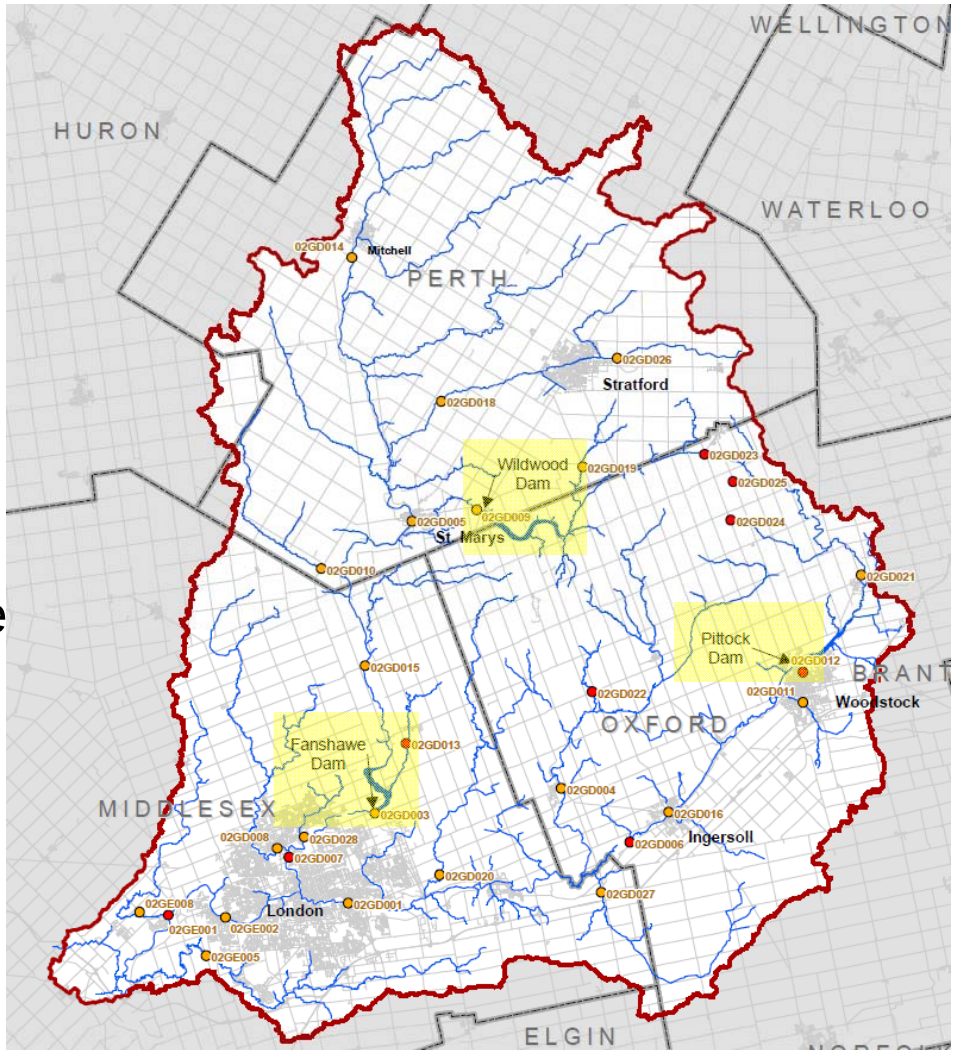
Reservoir Effects

- Fanshawe Reservoir:
  - North Thames River
  - 1450 km^2
  - 25 mm runoff storage
- Wildwood Reservoir
  - Trout Creek
  - 140 km^2
  - 140 mm runoff storage
- Pittock reservoir
  - Thames River
  - 245 km^2
  - 70 mm runoff storage



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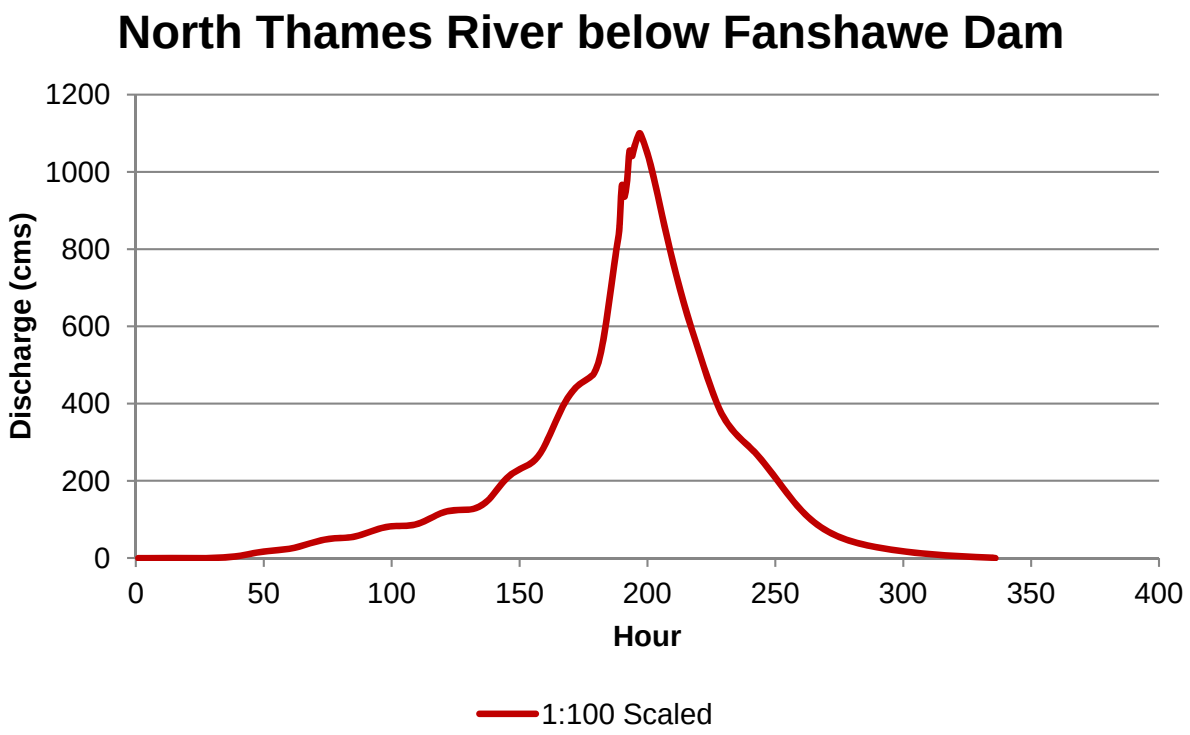
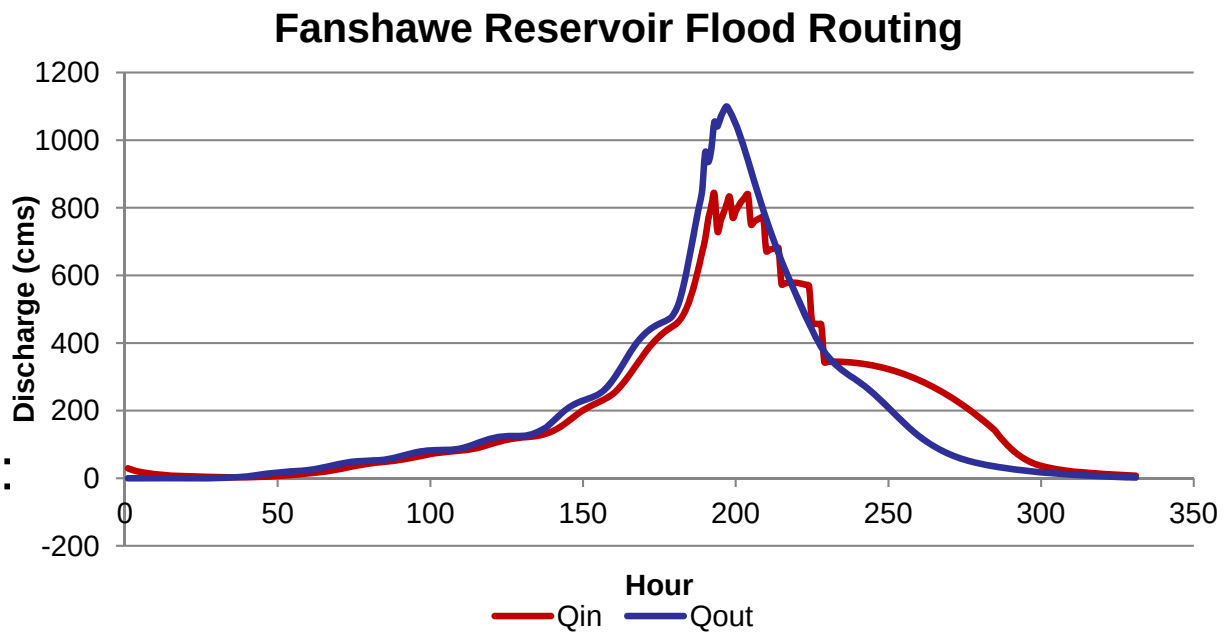
Reservoir effects

- Design hydrograph based on modelled hydrograph (to capture timing), ten day statistics to capture volume, and MID statistics to capture peak.



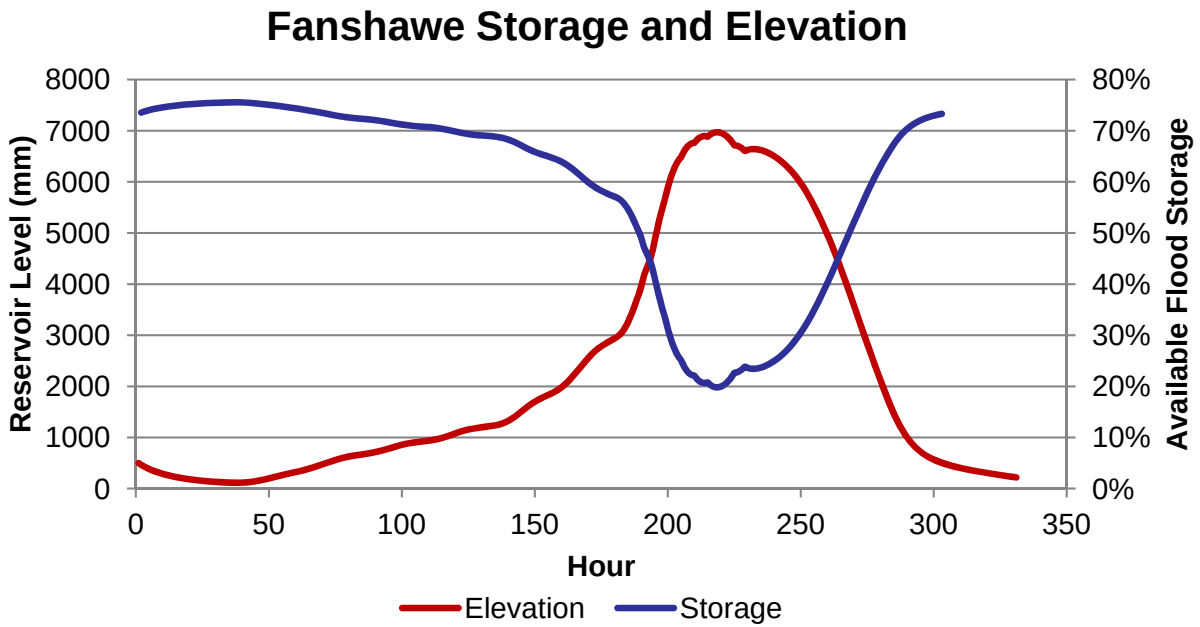
Reservoir effects

- Spreadsheet based routing routine uses knowledge of inflow, and the storage-elevation-discharge characteristics of the reservoir to analyze operation scenarios
- For 1:100 year inflow:
  - Qin 1100 cms,
  - Qout 820 cms



Reservoir effects

- Set maximum allowable reservoir elevation to 80% available storage use. (ie retain 20%)



Reservoir Effects

	Location		1:250 Discharge (m3/s)	1:100 Discharge (m3/s)
16% reduction →	Trout Creek at St. Marys	Unregulated	151	128
		Attenuated	124	116
2% reduction →	North Thames River at St. Marys	Unregulated	1070	956
		Attenuated	1063	935
38% reduction →	Thames River at Woodstock	Unregulated	245	210
		Attenuated	147	127
10% reduction →	Thames River at Ingersoll	Unregulated	288	259
		Attenuated	264	228
22% reduction →	Thames River below Fanshawe Dam	Unregulated	1240	1100
		Attenuated	960	842
26% reduction →	North Thames River at Medway Confluence	Unregulated	1455	1290
		Attenuated	1075	927
5% reduction →	Byron	Unregulated	1920	1740
		Attenuated	1885	1645

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Reservoir effects

- Process completed for each of the three major reservoirs, for a series of different return period inflows, with different points of interest investigated.
- Generally Fanshawe Dam can attenuate 25% of flood peaks immediately downstream, and this effect is lessened moving downstream and increasing drainage area.
- Pittock Reservoir is effective at reducing flooding in Ingersoll, but effects are very limited in London
- Wildwood reduces flooding on Trout creek, but little effect on North Thames River.

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Summary/Conclusions

- Statistics have changed since 1984 Glengowan hydrology study
- Thames River above forks not that different from past analyses (MID, MMD)
- North Thames River between Fanshawe and St. Marys increased
- North Thames River above St. Marys decreased
- Flood lines across the watershed should be re-evaluated using new statistics
- Ten Day runoff stats decreased
  - Possible this is from methodology of calculating the ten day values

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Summary/Conclusions

- North Thames River changed flows
  - Glengowan study dismissed St. Marys stats as they produced a larger discharge than the downstream natural Fanshawe flow
  - Used a linear relationship with the downstream station, Thorndale, as a surrogate. Thorndale many fewer years of data.
  - Present study, with more data, did not have the same issue
  - At headwaters, flows reduced at all return periods (~25%). Unclear where the data currently being used in models comes from.
- Hydrologic Models should be calibrated to the new 10-day runoff statistics and peak MID values found in the new study (Underway)
- Flood attenuation is investigated, but reduced flows should not be used to determine extend of downstream flood plain

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Questions?

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