Muskrat Falls Reservoir and the Canadian Reservoirs Comparison Matrix

St. John's Nfld., June 28

AZIMUTH

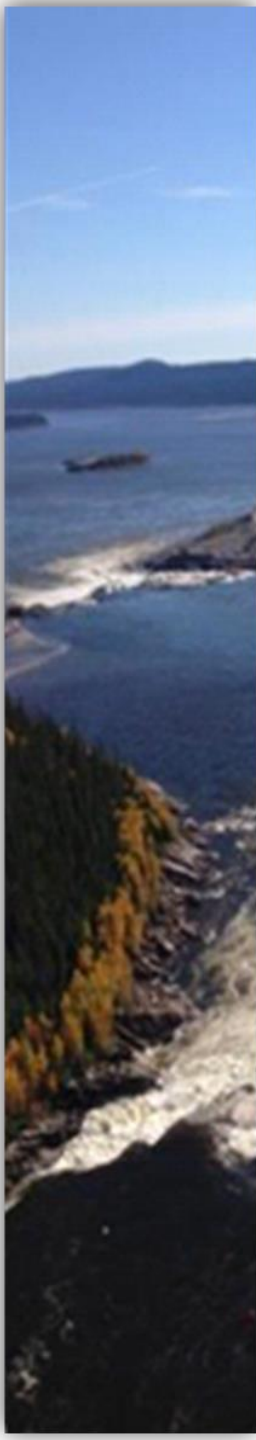# Canadian Reservoirs Comparison Matrix

- The CRCM compiled for Site C Clean Energy Project, BC

- Extensive literature review of empirical data from 14 Canadian reservoirs – built or advanced planning

- There are a number of physical, chemical and ecological parameters positively correlated with the magnitude and duration of increase of MeHg in fish in new reservoirs

  i. Physical – latitude, amount of flooding relative to original area, water residence time, temperature

  ii. Chemical – pH, soil carbon quality, baseline Hg/MeHg

  iii. Ecological – Food chain complexity, productivity
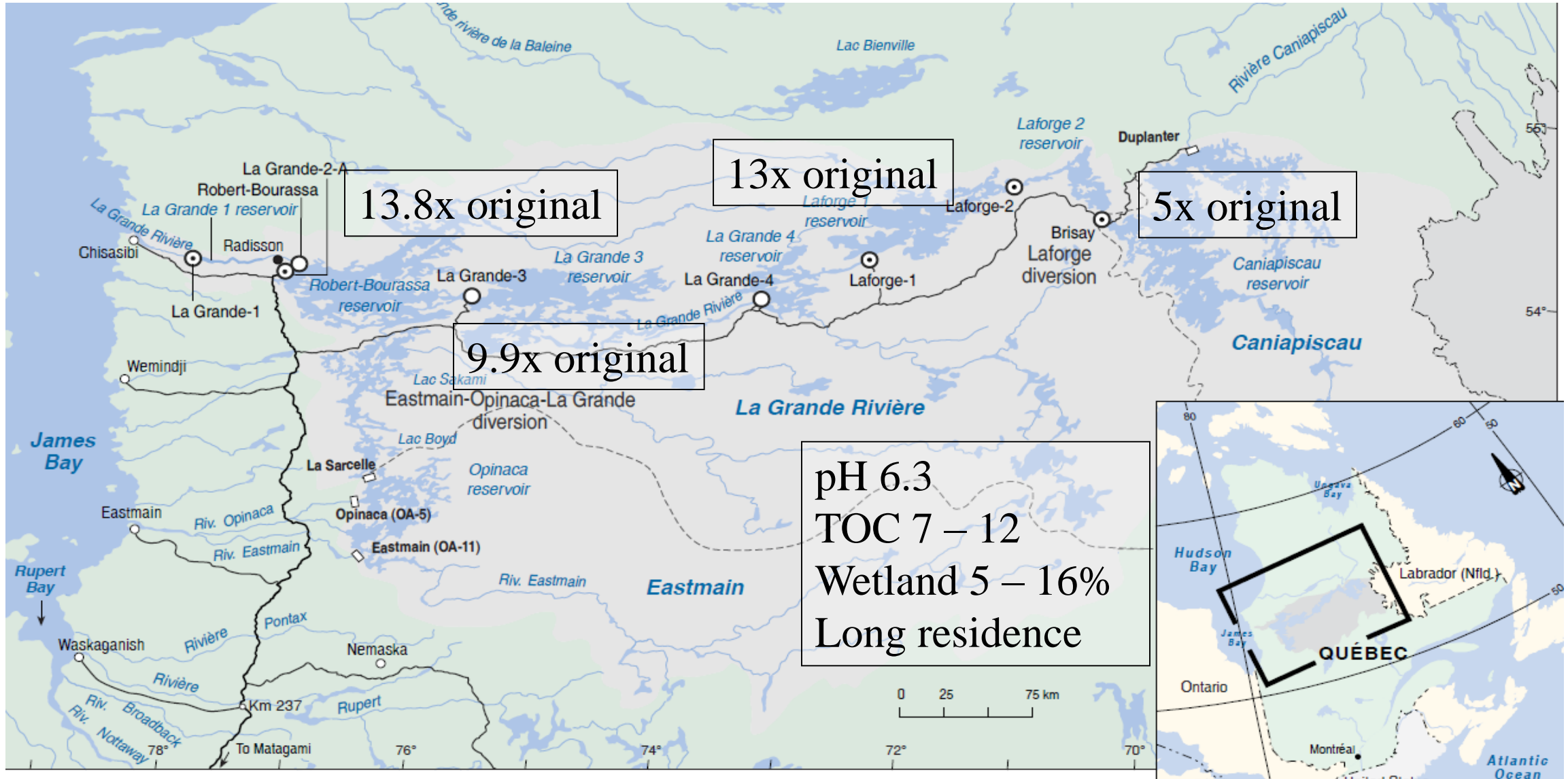
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CRCM – Key Parameters

- Weight-of-Evidence, <u>empirical approach</u> to determine where the MeHg increase in fish will fall across the spectrum of what has been observed across Canada
  - \>3x baseline Hg in fish
  - <3x baseline Hg in fish
- This approach relies on empirical data gathered over 30 years
  - ➤7 Manitoba reservoirs
  - ➤5 Quebec reservoirs
  - ➤Williston Reservoir, Gull and Muskrat
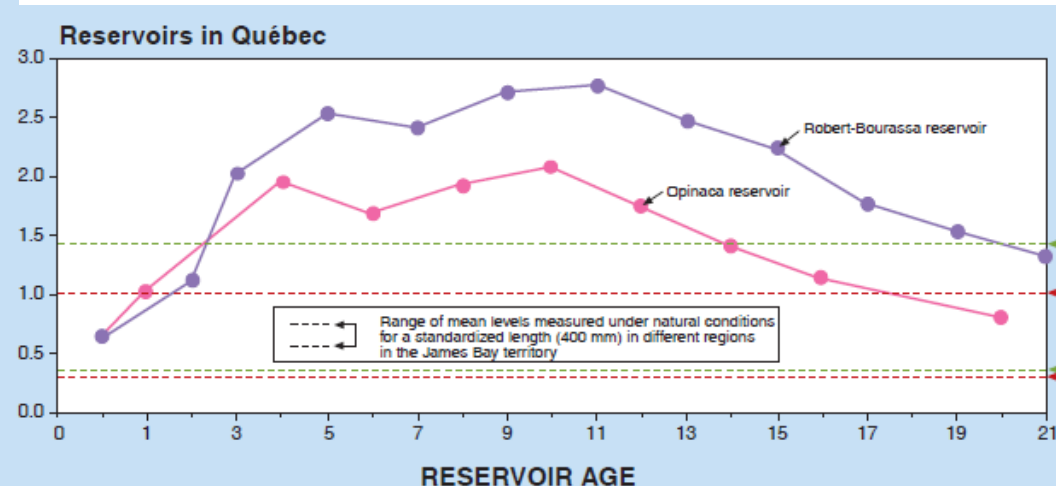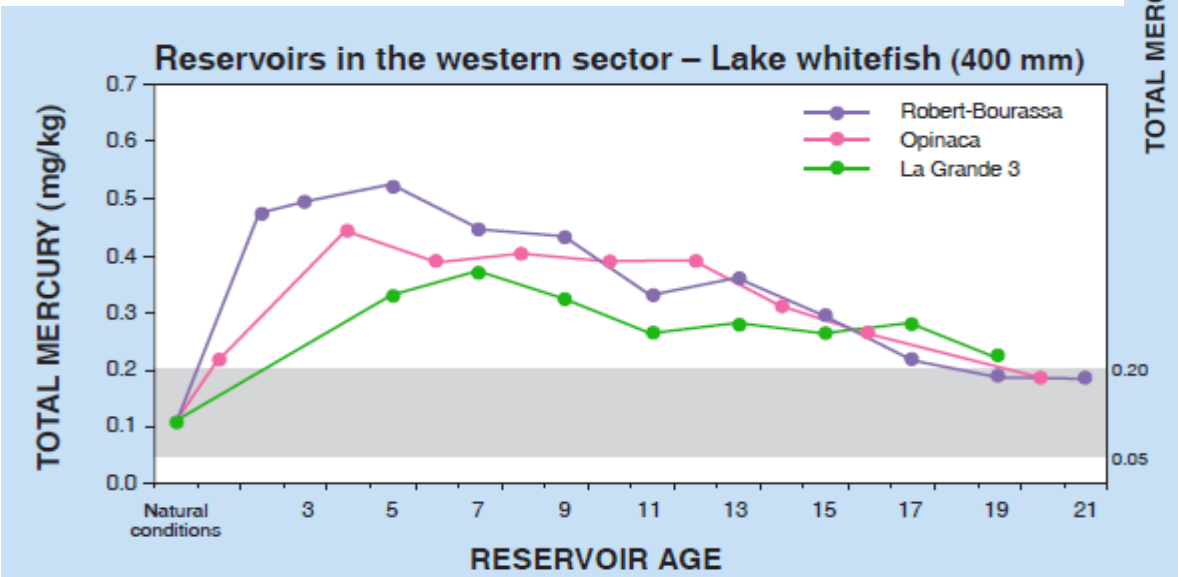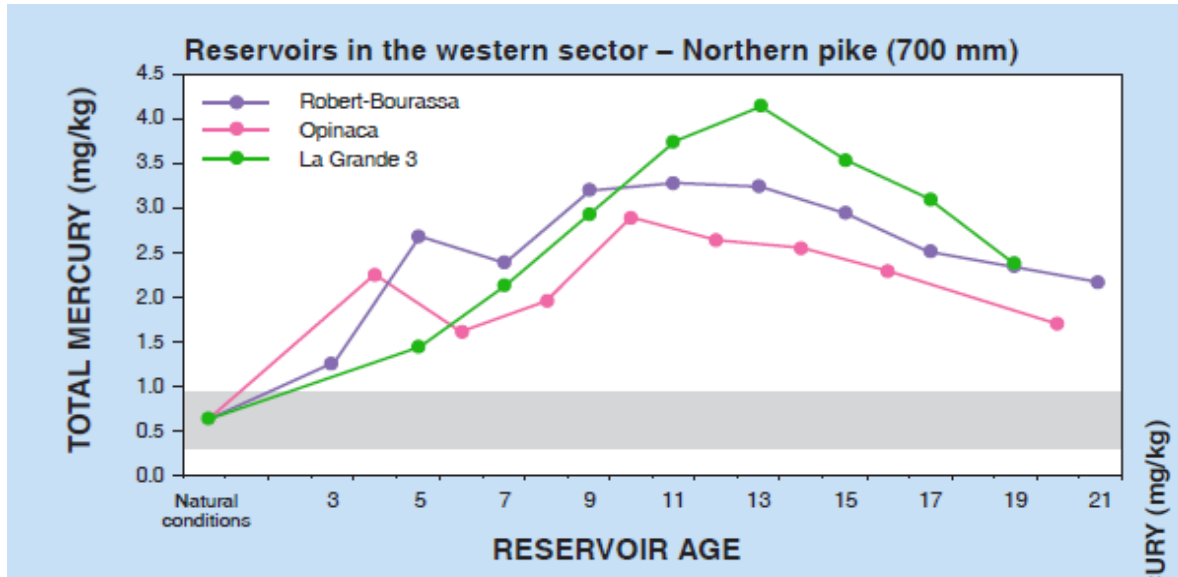
CRCM – Key Parameters

- Physical Parameters associated with >3x fish increase:
  - Total reservoir area – Large (>200 km^2)
  - Water residence time of > 30 d with high (> 5 m) annual drawdown
  - Ratio of original to flooded area is >3x

- Chemical Parameters
  - Slightly acidic water (pH <6.5)
  - Total and Dissolved Organic Carbon > 5 mg/L
  - Large store of labile carbon in soil, wetlands, peat, muskeg

- Ecological Parameters
  - Elevated MeHg in lower trophic levels
  - Long or complex food chain (zooplankton, benthos), high productivity

La Grande Complex, Quebec

13.8x original

13x original

5x original

9.9x original

pH 6.3
TOC 7 – 12
Wetland 5 – 16%
Long residence

5

Magnitude and Temporal Changes in Fish

Table 1. Summary table from Azimuth (2012) – Canadian Reservoirs Comparison Matrix – Site C.

Reservoir Characteristics	Low Magnitude Increase Reservoirs (Fish Mercury <3x Baseline)	High Magnitude Increase Reservoirs (Fish Mercury >3x Baseline)	Predicted Site C Result
Magnitude of Fish Mercury Increase above Baseline	Muskrat Falls, Gull Island (Nfld/Lab); Limestone, Long Spruce, Wuskwatim, Southern Indian Lake (MB) for some fish species	LG-1, LG-2, LG-3, Opinaca, Caniapiscau Quebec; Southern Indian Lake, MB (for some species) Williston, B.C.	
Physical Parameters			
Total Reservoir Area	Less than 200 km² ranging from 28 (Limestone) – 200 km² (Muskrat / Gull Island) for all reservoirs	Very large, with most exceeding 2,000 km² except Opinaca (1,040 km²), Williston (1,779 km²)	Site C predicted area = 93 km² and falls into LOW increase category
Original: Flooded Area	Less than 2 at Muskrat (1.5) and Gull (1.7) Nfld/Lab and Limestone (1.3), Long Spruce (1.9), and Wuskwatim, MB (1.5)	A ratio well in excess of 2 at LG1 (2.3), LG2 (13.8), LG3 (9.9), Opinaca (3.5), Caniapiscau (5), Williston (22), with a lower ratio at SIL (1.2)	Site C predicted ratio is 2.3 and would fall into the upper end of the LOW increase category; although similar to LG1, the influence of LG2 on Hg in LG1 fish was anomalous
Water Residence Time	In the order of days and typically less than one month in Muskrat (7d), Gull (26d), Limestone (5d), and Long Spruce (10 d)	Residence time much longer, typically greater than 5 months including LG2 (7m), LG3 (11m), Opinaca (3.8m), Caniapiscau (26m), and SIL (8m)	With a water residence time of 23 d, Site C falls into the LOW category

Summary for Physical Features at Site C from the CRCM
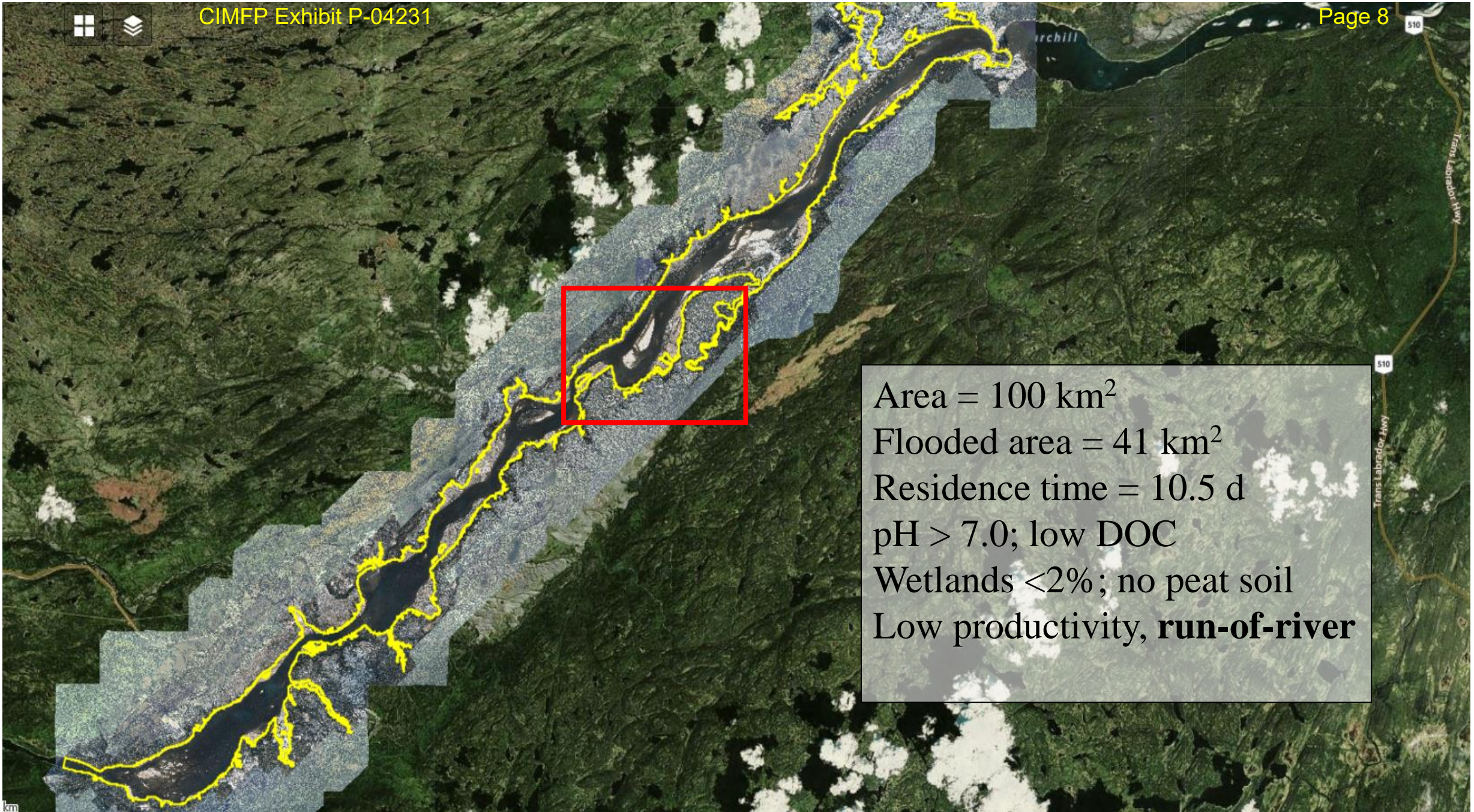
Area = 100 km^2
Flooded area = 41 km^2
Residence time = 10.5 d
pH > 7.0; low DOC
Wetlands <2%; no peat soil
Low productivity, **run-of-river**

Stream

Riparian

Gravel
Bar

Forest

Site C + Muskrat Falls Comparison

Parameter	Site C	MFR
Latitude (deg)	56°	53°
Area (km^2)	93	101
Mean Annual Discharge (m^3/s)	1230	1780
Flooded soils (km^2) and % organic	36 km^2 & 39 % organic soil	30 km^2 & 33% organic soil
Residence time (days)	23 d	10 d
Mean organic soil [Hg]	0.10 ppm	0.10 ppm
Mean organic soil depth (cm)	7.5 cm	8 cm
Mean organic soil TOC (%)	35	30

MeHg	Calder et al. + Azi	Calder et al.
Baseline (ng/L)	0.02	0.017 ng/L
Peak Value (ng/L) in water	0.04 ng/L or 2x	0.18 ng/L or ~10x
Peak Factor in Fish	<3x baseline	10x baseline

Site C + Muskrat Falls

- MFR does not conform to any physical, chemical or ecological feature to warrant a >3x increase category

- The physical, chemical and ecological features of Site C and MFR reservoirs are very similar; Both Harvard and Azimuth agree that Site C is a low Hg increase reservoir, yet no explanation for why MFR is the east coast evil twin

- Based on empirical weight-of-evidence there is no support or precedent for the magnitude of increase in fish [Hg] at MFR as promulgated by Harvard group.