Photo credit: Ian Bryson

Systematic River Restoration Planning using Network Analysis, Optimisation, and GIS.

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SCHOOL FOR RESOURCE AND ENVIRONMENTAL STUDIES

FIPEX beta

NOVA SCOTIA POWER An Emera Company

Fisheries and Oceans Canada | Pêches et Océans Canada

Department of Fisheries and Oceans Maritimes

NSERC CRSNG

Motivations / Objectives

1. Where should we focus our efforts?
2. How can we assess trade-offs?
3. How can we use our budget wisely?

Problem Overview

Reasons why optimisation is not more prevalent?

- Expertise required
- Transparency
- Flexibility

Toolset Development

Optimisation Models → O'Hanley & Tomberlin, 2005
O'Hanley, 2011

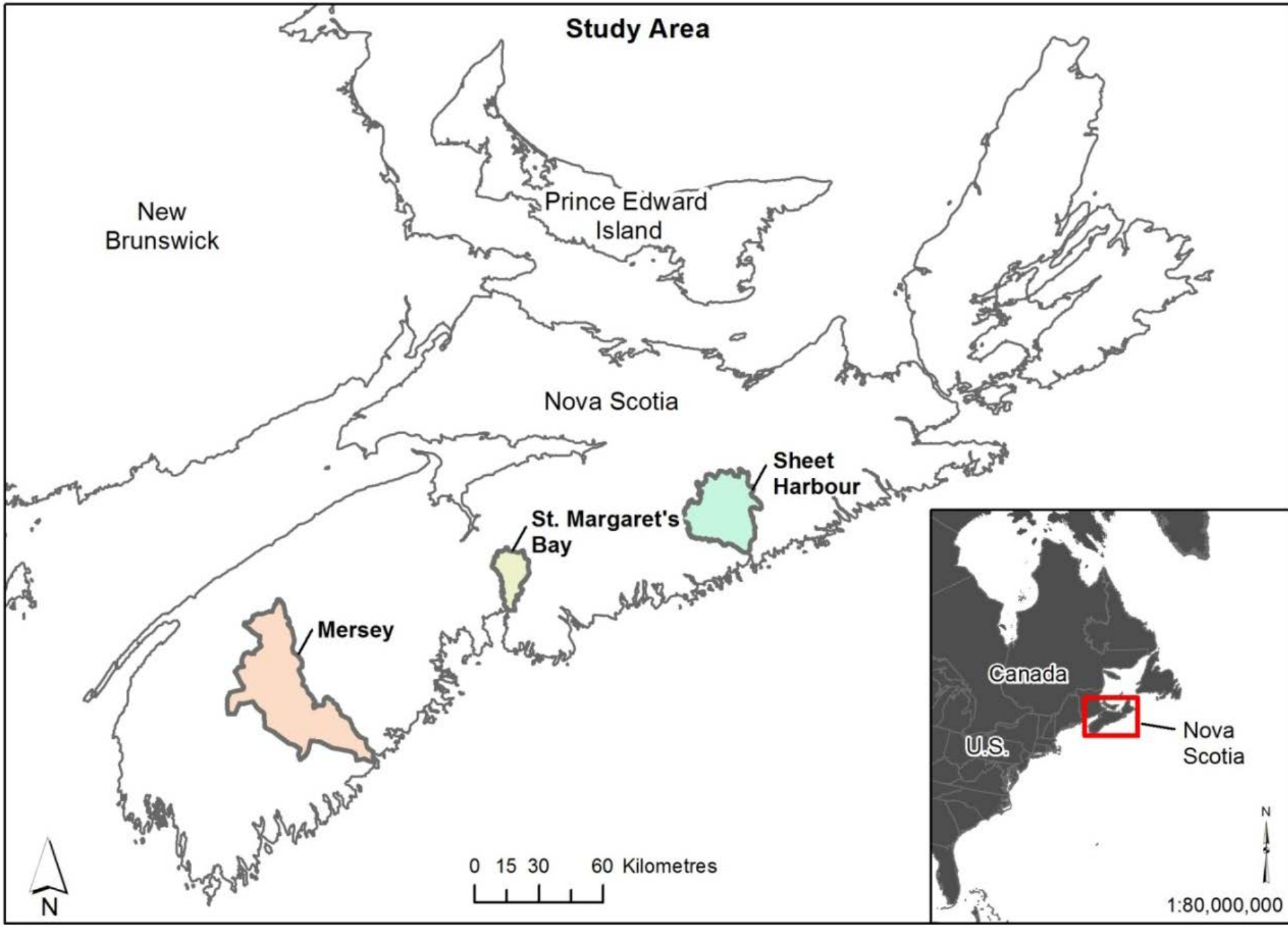
+

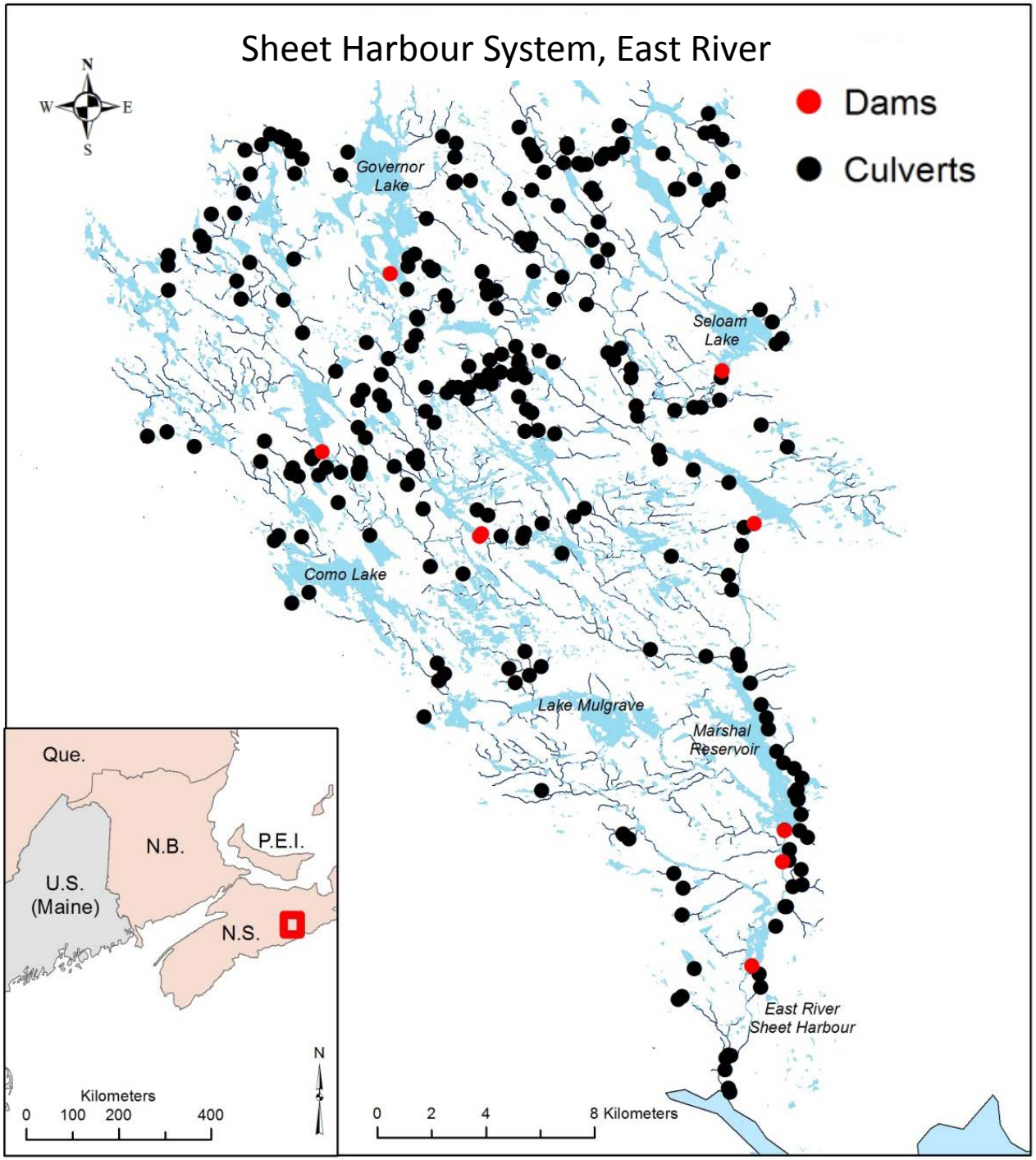
Network Analysis → 

The Fish Passage Extension (FIPEX; DFO, 2010)

+

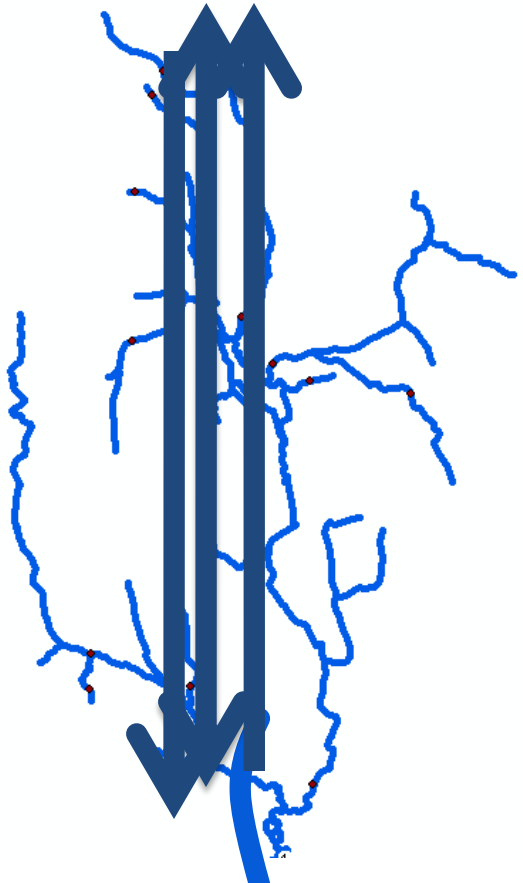
Systemic Connectivity Metrics → The Dendritic Connectivity Index (DCI; Cote et al., 2009)


Study Area
New Brunswick
Prince Edward Island
Nova Scotia
Sheet Harbour
St. Margaret's Bay
Mersey
N
0 15 30 60 Kilometres
Canada
U.S.
Nova Scotia
N
1:80,000,000

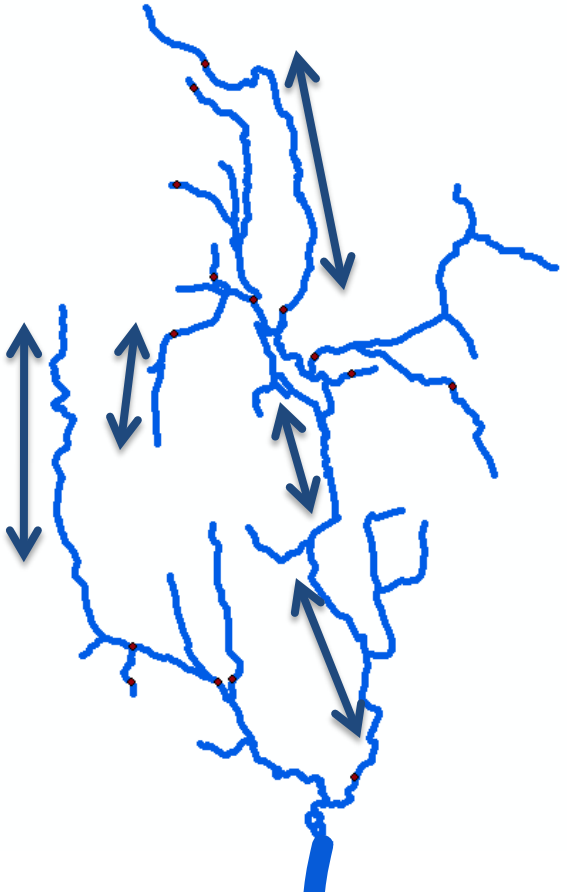

Sheet Harbour System, East River
N
W
E
S
Dams
Culverts
Governor Lake
Seloam Lake
Como Lake
Lake Mulgrave
Marshal Reservoir
East River Sheet Harbour
Que.
N.B.
P.E.I.
U.S. (Maine)
N.S.
Kilometers
0 100 200 400
N
0 2 4 8 Kilometers

Results – Connectivity Type

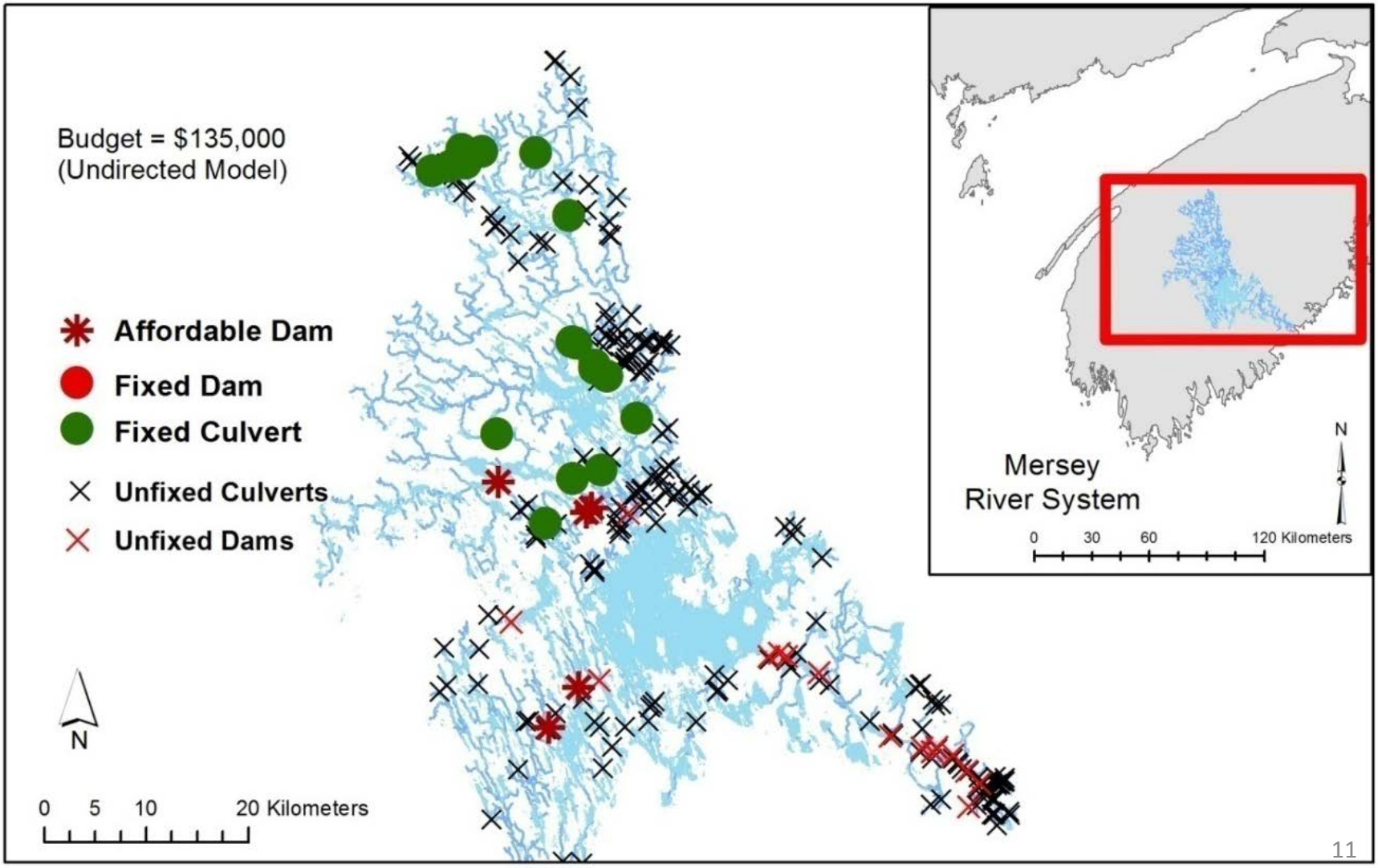
"Directed" Connectivity



"Undirected" Connectivity



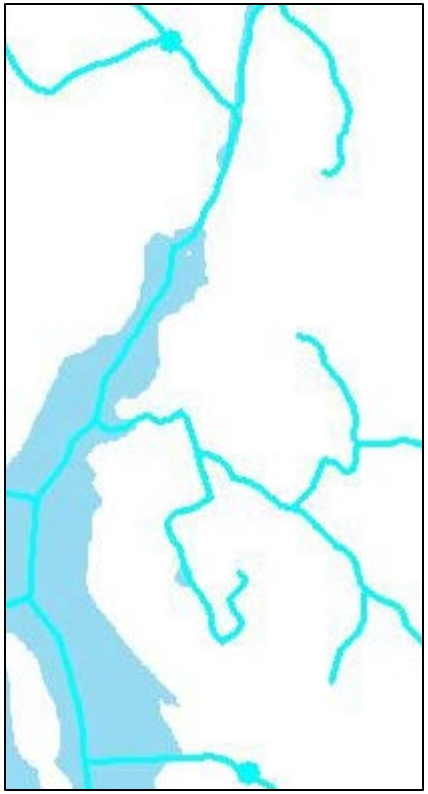
Results – Culverts Vs. Dams



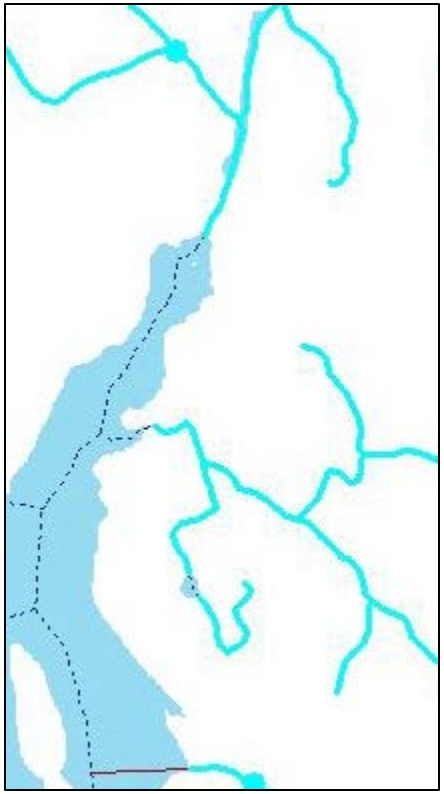
Results – Quantification Method

Four Treatments

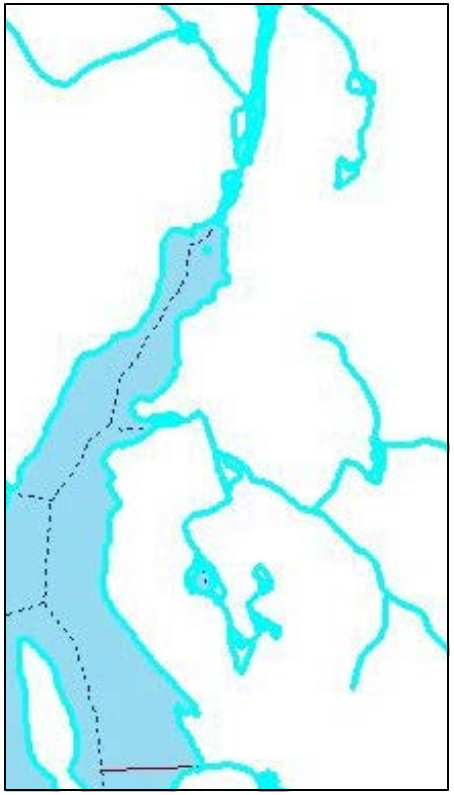
1. Length



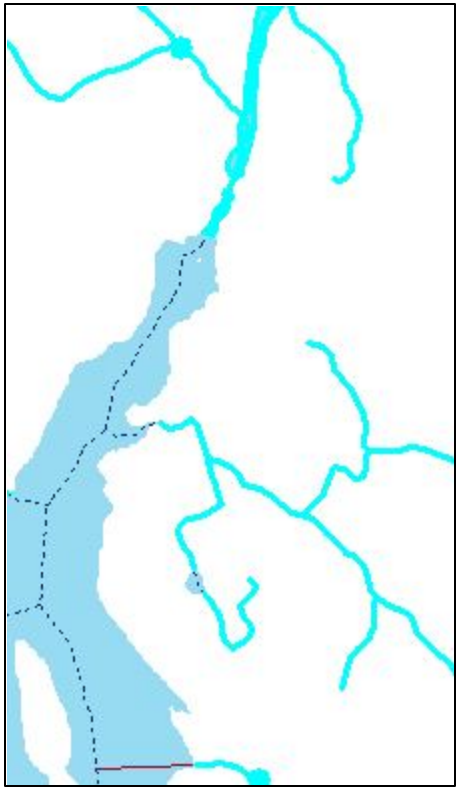
2. Length No Stillwater



3. Area

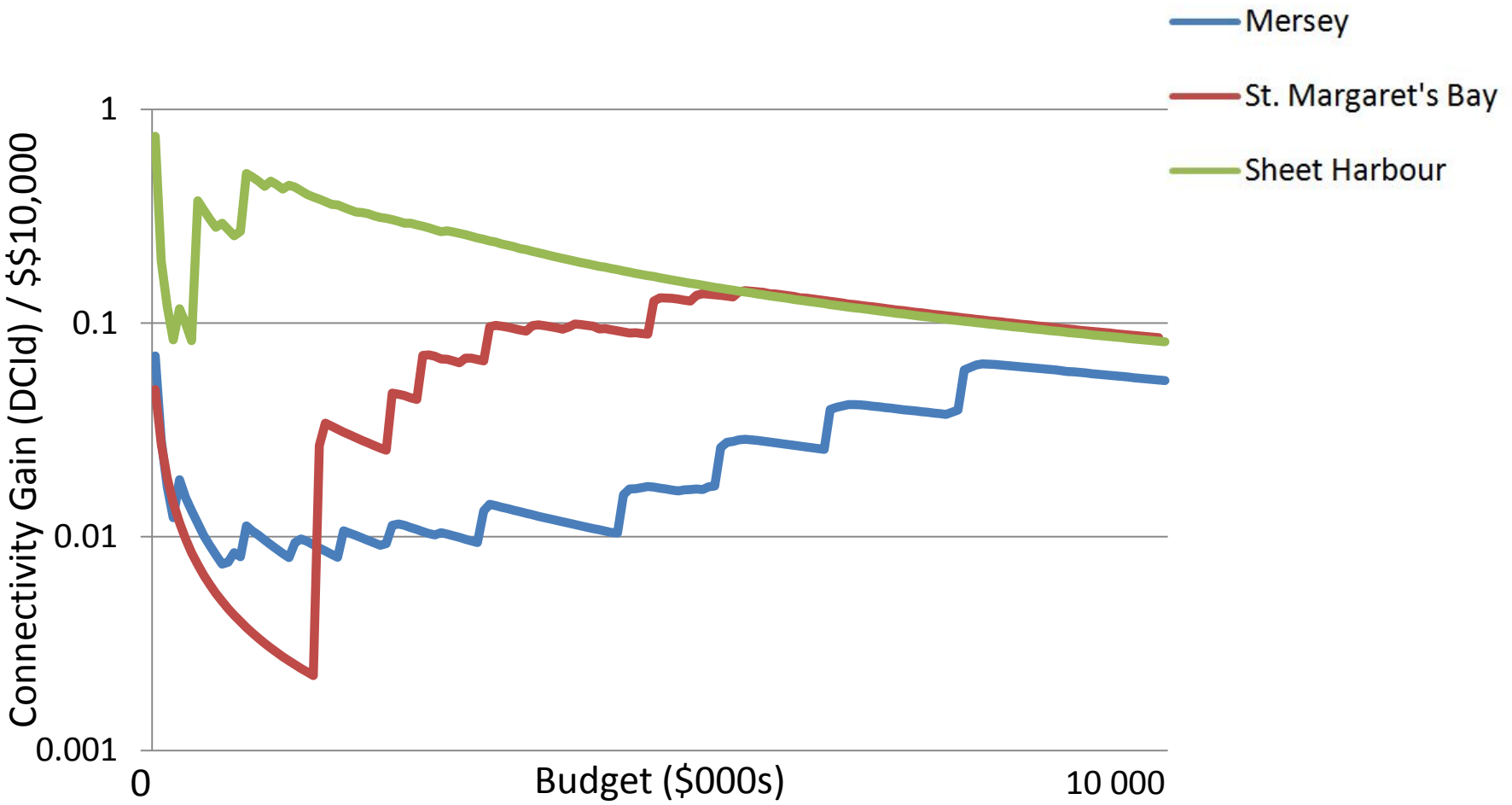


4. Area No Stillwater



Bright Blue Highlighted = Included

Results – Optimisation



Results – Toolset

FIPEX Toolset for ArcGIS (free product of Fisheries & Oceans, Canada) with optimisation integrated (free, open source)

thefishpassageextension.net

Communicating Restoration Planning

Importance of…

- Systemic Connectivity
- Adequate Data
- Budget Selection
- Prioritisation Method

Thank You!

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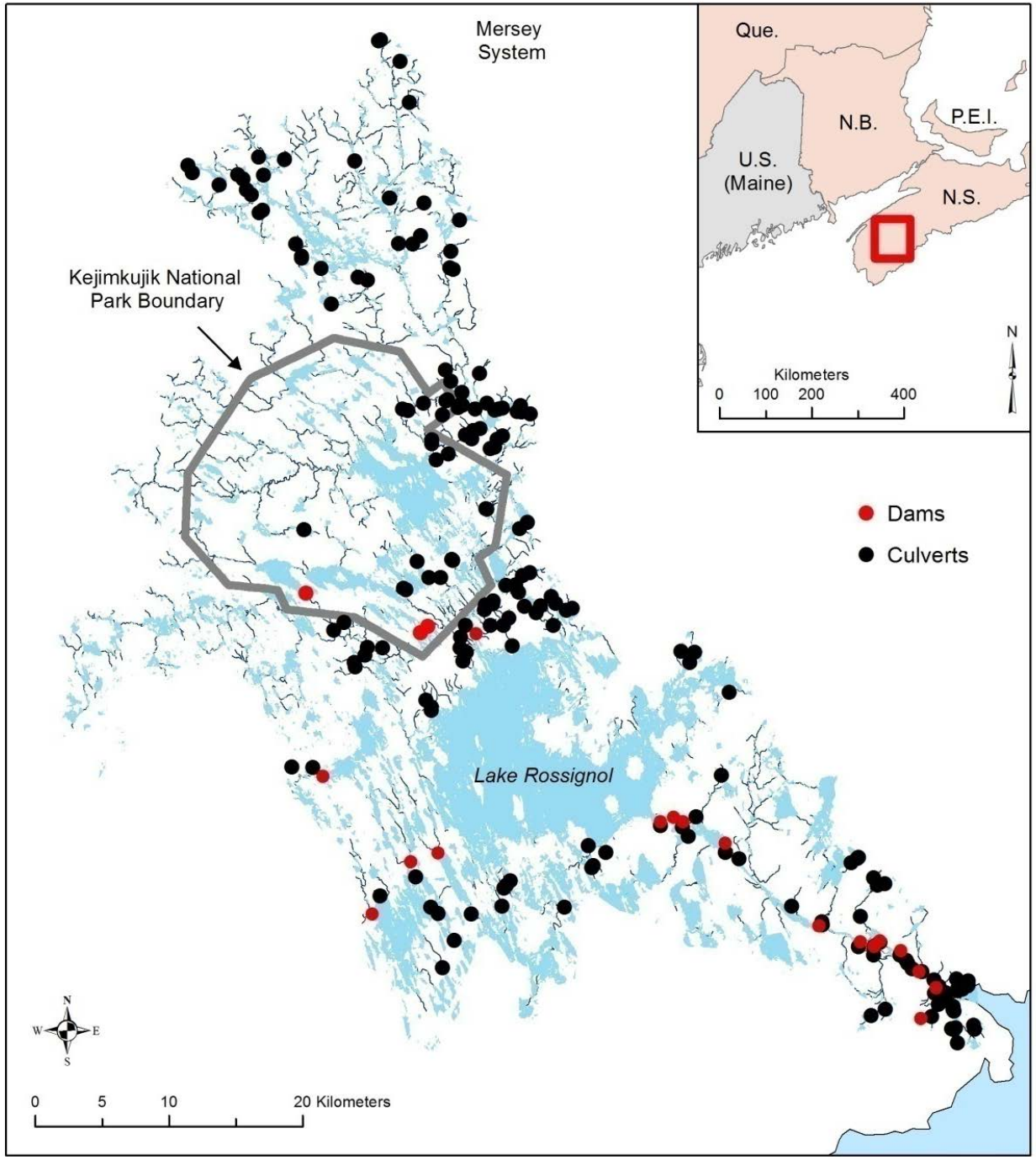
Chris Brooks

References

- Department of Fisheries and Oceans Canada [DFO] (2010) FIPEX Documentation.
- Kemp P. S. & O'Hanley J. (2010) Procedures for evaluating and prioritising the removal of fish passage barriers: a synthesis. *Fisheries Management and Ecology,* **17,** 297-322.
- O'Hanley J. (2011) Open rivers: Barrier removal planning and the restoration of free-flowing rivers. *Journal of Environmental Management,* **92,** 3112-3120.
- O'Hanley J. & Tomberlin D. (2005) Optimising the removal of small fish passage barriers. *Environmental Modeling & Assessment,* **10,** 85-98.

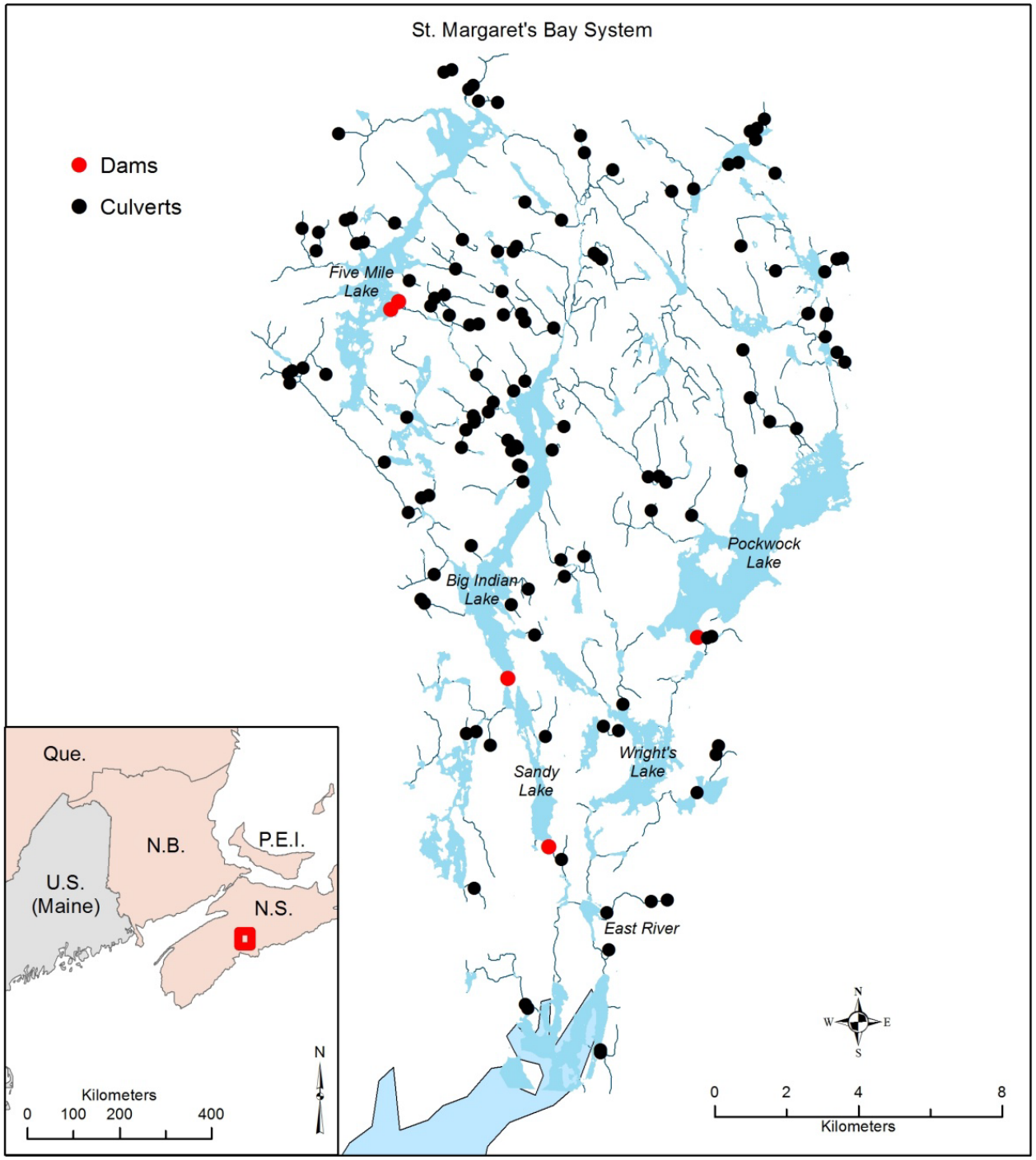


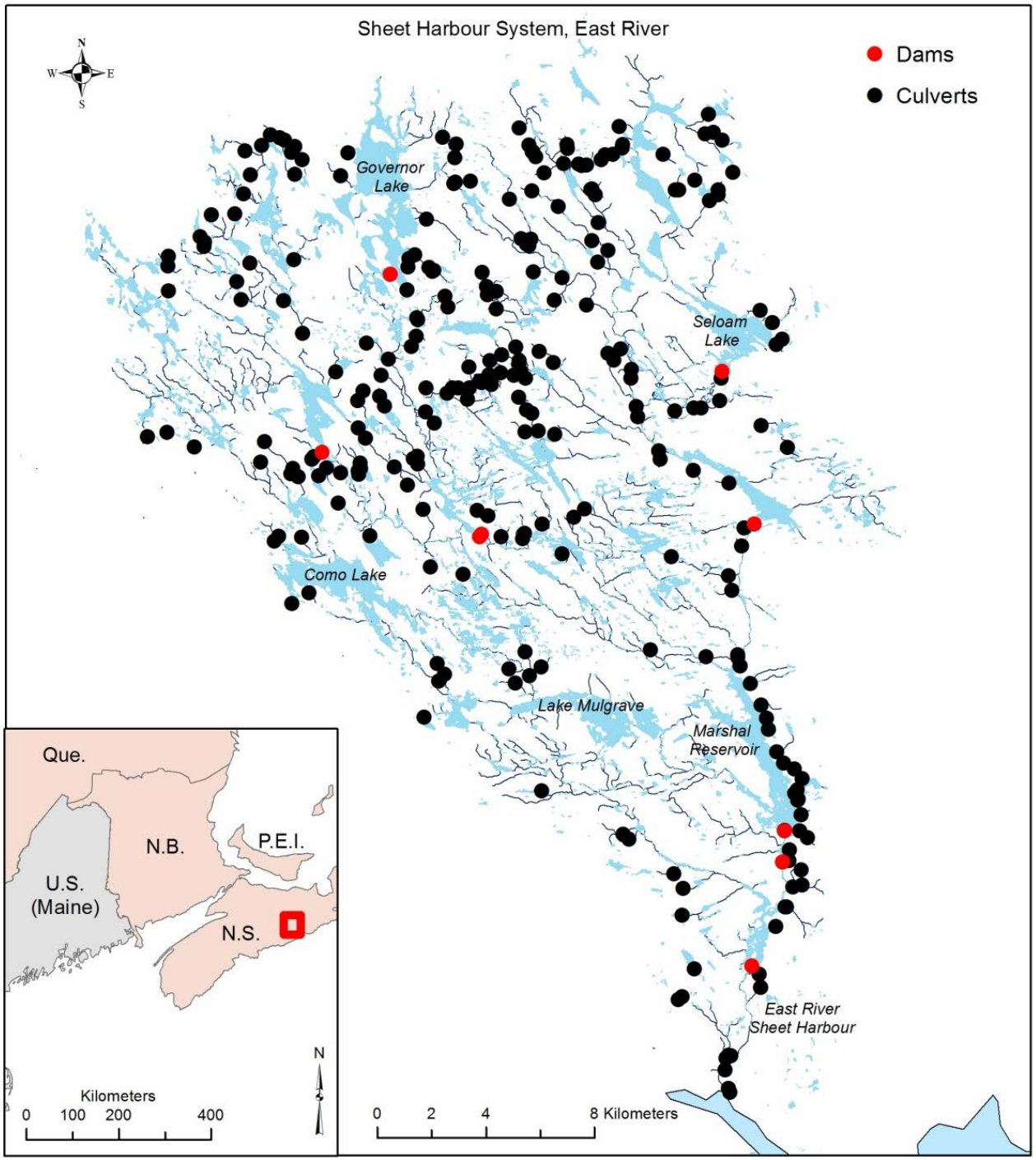
Mersey River

8 dams
181 culverts

St. Margaret's Bay River

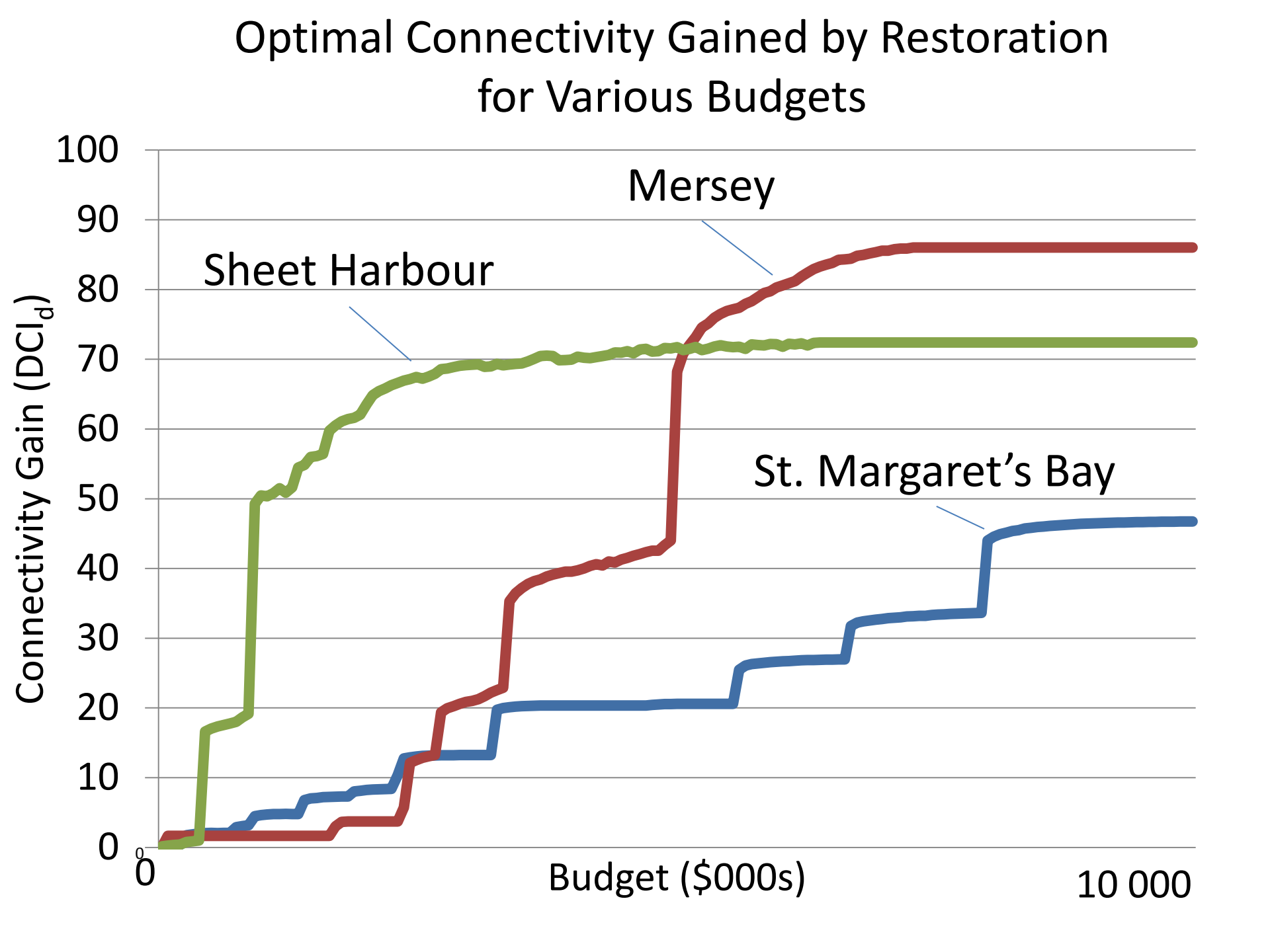
9 dams
125 culverts



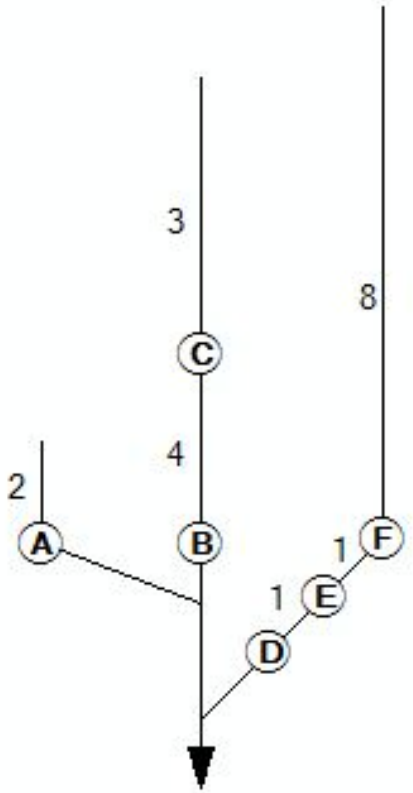


Sheet Harbour River

6 dams
250 culverts


Optimal Connectivity Gained by Restoration for Various Budgets
100
90
80
70
60
50
40
30
20
10
0
Connectivity Gain (DCI$_d$)
Mersey
Sheet Harbour
St. Margaret's Bay
0
Budget ($000s)
10 000

Problem Overview

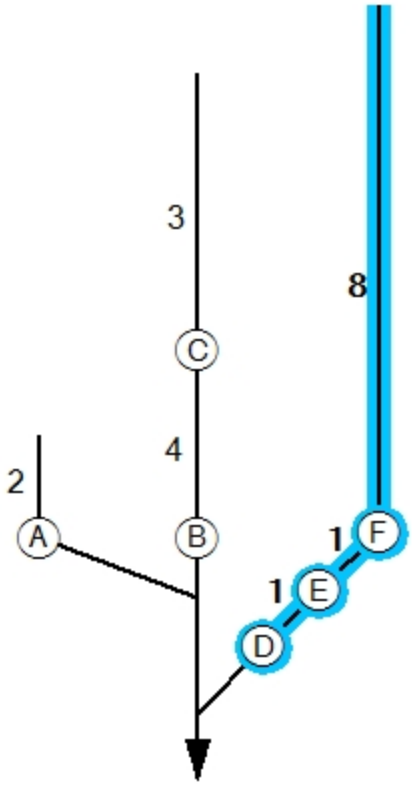


Challenge:
Maximise network reconnected to outflow

Assume:
- All barriers cost the same
- Budget is enough to 'remove' one barrier only

Problem Overview

Optimisation Method



Total Gain: 10
(Optimal)

RANK	BARR.	GAIN
1	**D,E,F**	**10**
2	A,B,C	9
3	B,C,D	8
4 *	B,C	7
5	A,B,D	7
6 *	A,B	6
7	B,E,D	6
8 *	B,D	5
9	A,B,D	5
10 *	B	4
11 *	B,E	4
12 *	B,F	4
13	A,D,E	4
14 *	A,D	3
15 *	A	2
16 *	A,F	2

Budget = 3