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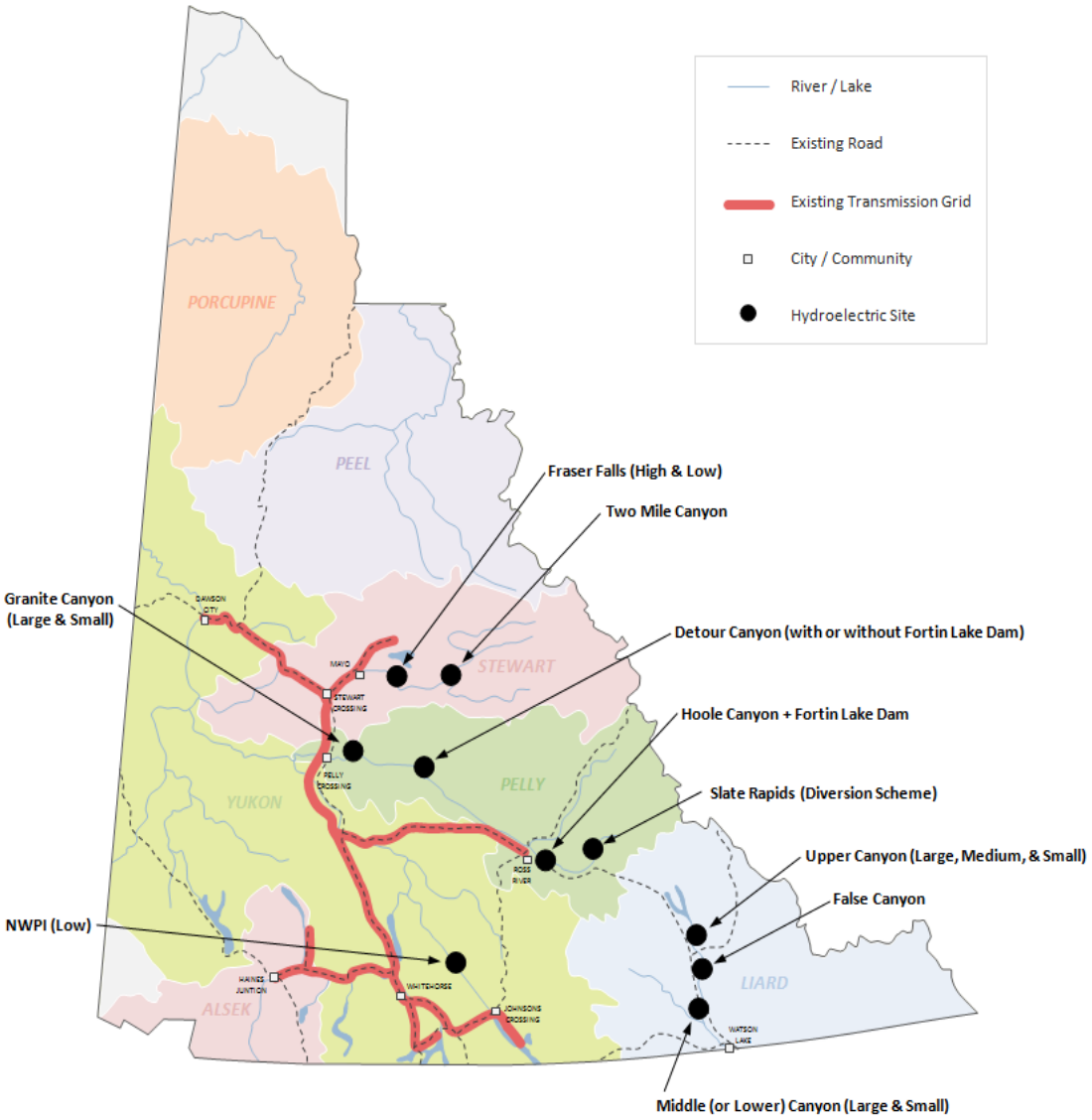
CONSULTING INC.

Next Generation Hydroelectric & Transmission Viability Study:

Scalability of Next Generation Hydro Projects

16 November 2015

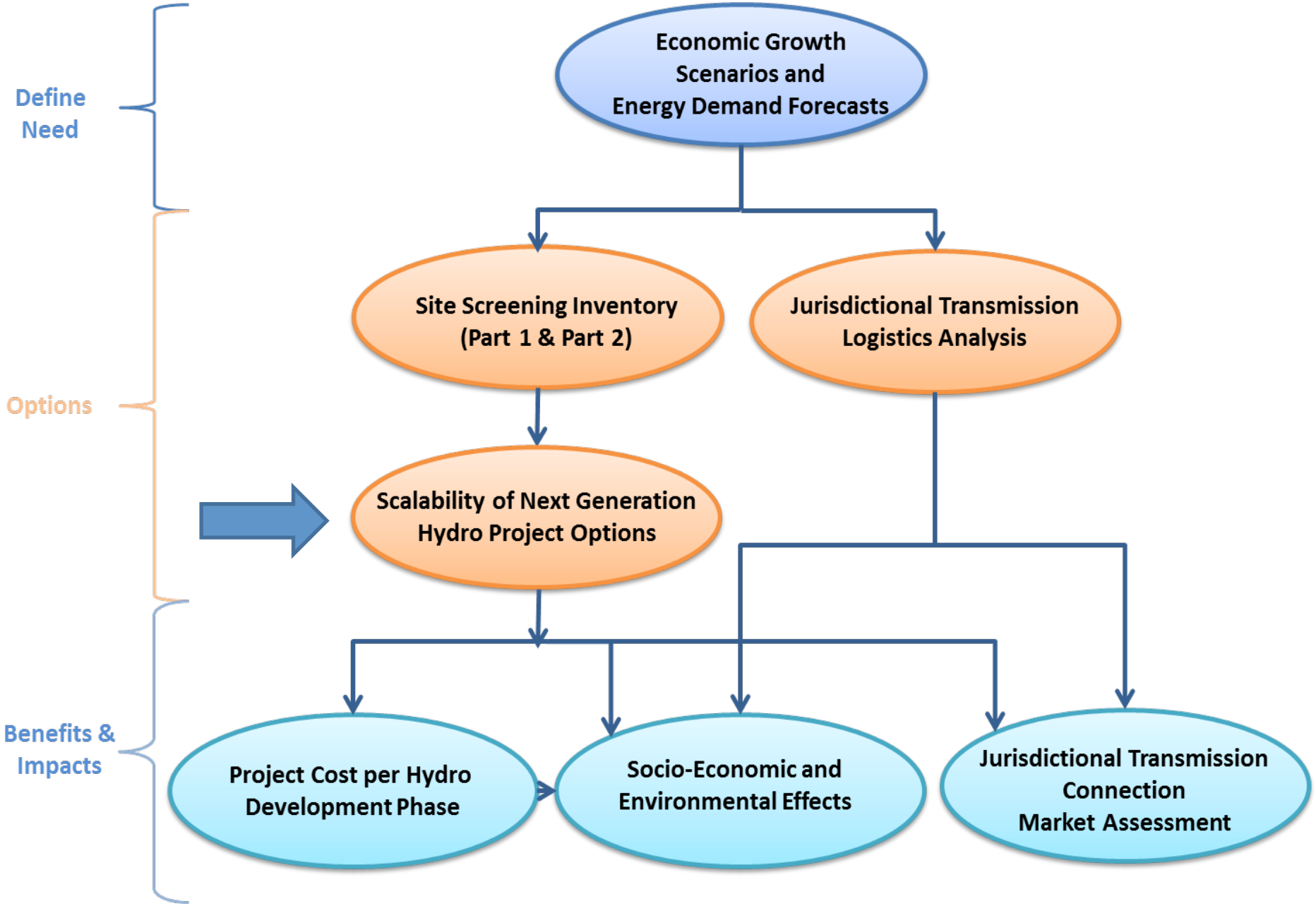
Yukon Energy Challenge



- Yukon is facing a difficult decision
- Some of the key challenges include:
  - Small islanded grid
  - Demand for winter energy and peaking capacity
  - Stakeholder and First Nation concerns
  - Balancing environmental, cultural and socio-economic impacts with technical & economic constraints

Approach & Methodology

Technical Papers



Scalability Assessment

Scalability Assessment: Objective

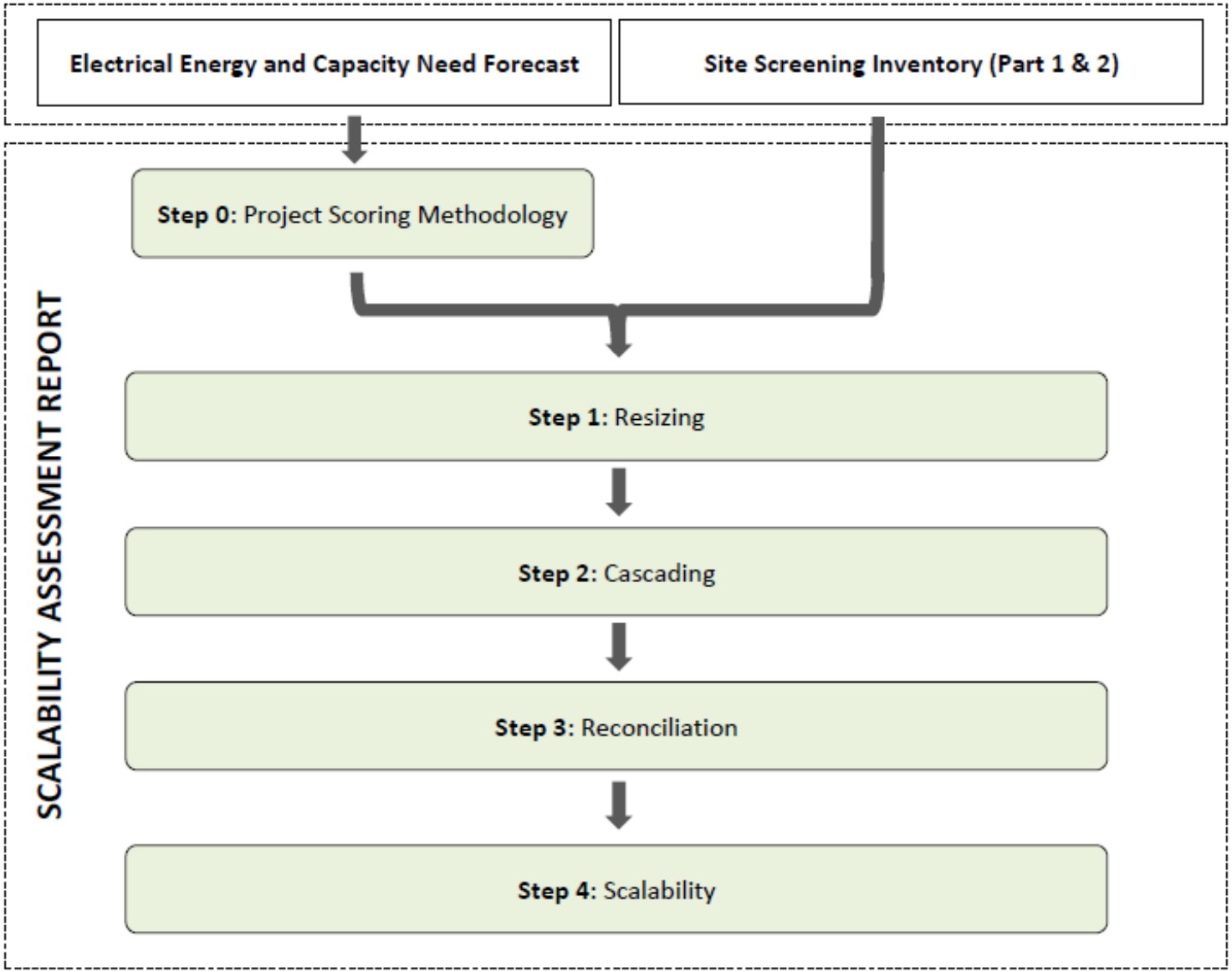
OBJECTIVE:

- ***Match the size and scale of potential hydroelectric projects to the Yukon's forecasted need for electrical energy and capacity while reducing potential impacts.***

Important:

- No perfect project
- First Step: Additional consideration required for design, construction, economics, environmental and socio-economic impacts

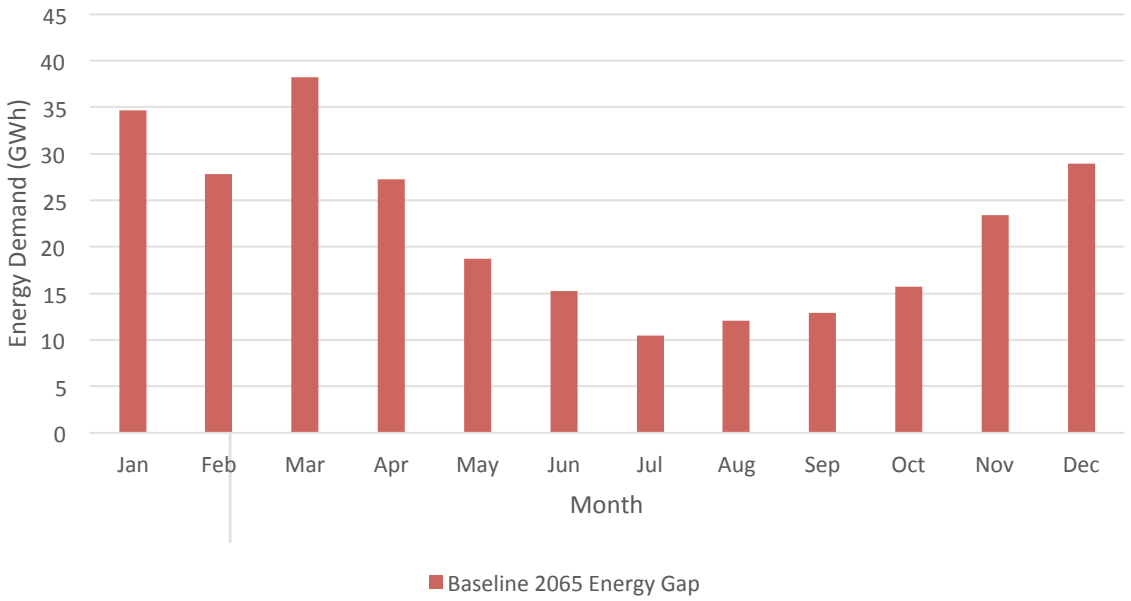
Scalability Assessment: Methodology



Electrical Energy and Capacity Need Forecast (2035 to 2065): Brief Recap

Gap Analysis: Findings

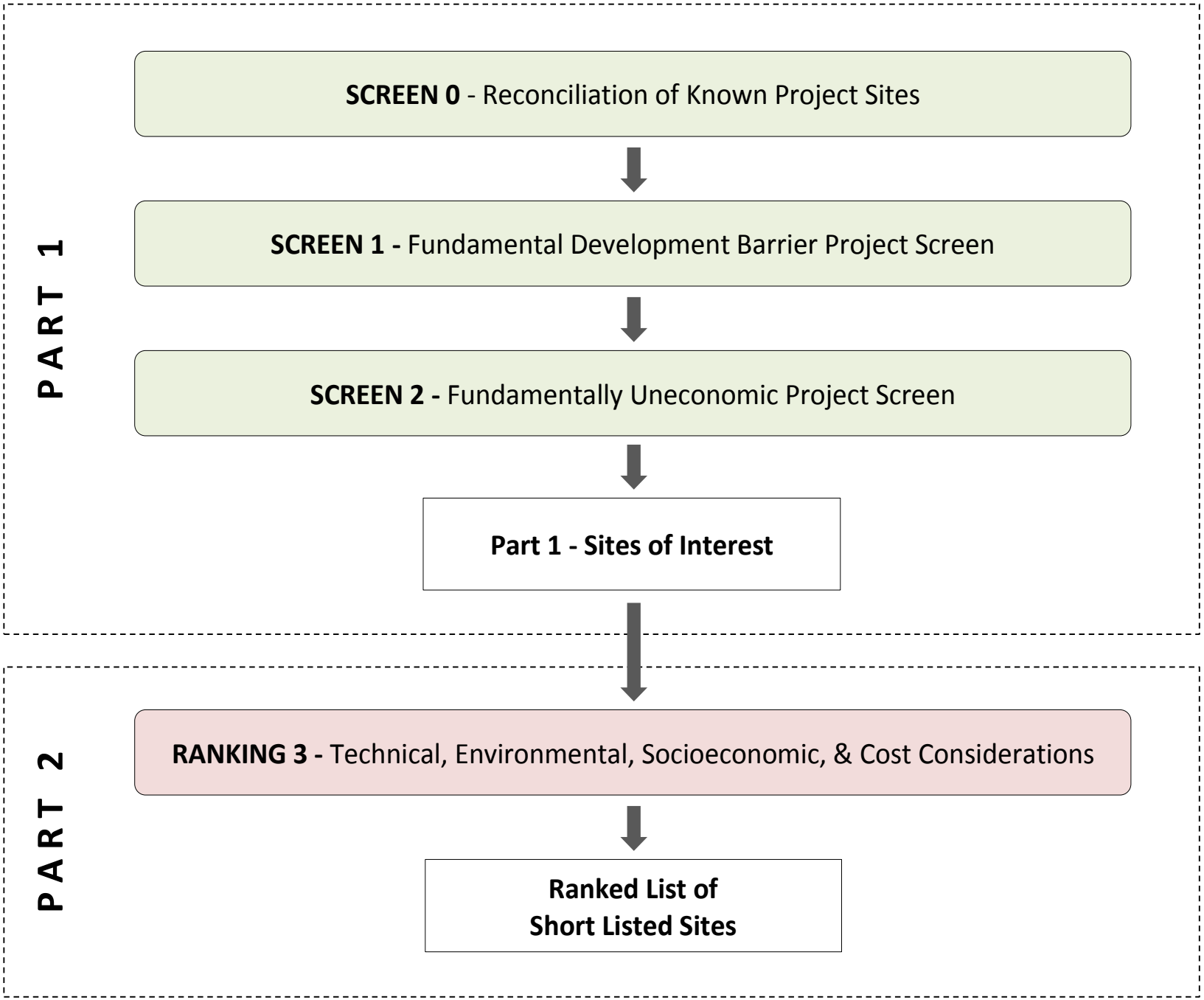
	2035	2045	2055	2065
Low Case Scenario	11 MW 54 GWh	17 MW 85 GWh	24 MW 118 GWh	31 MW 154 GWh
Baseline Case Scenario	21 MW 103 GWh	31 MW 157 GWh	42 MW 211 GWh	53 MW 265 GWh
High Case Scenario	36 MW 180 GWh	62 MW 311 GWh	95 MW 476 GWh	136 MW 682 GWh



Scalability Assessment:
1) Projects sized to meet the Baseline 2065 Gap
2) Projects build out to meet progressively the Baseline demand from 2035 to 2065

Site Screening Inventory (Part 1&2): Brief Recap

Site Screening Inventory



Site Screening Inventory (Part 1&2): Recap

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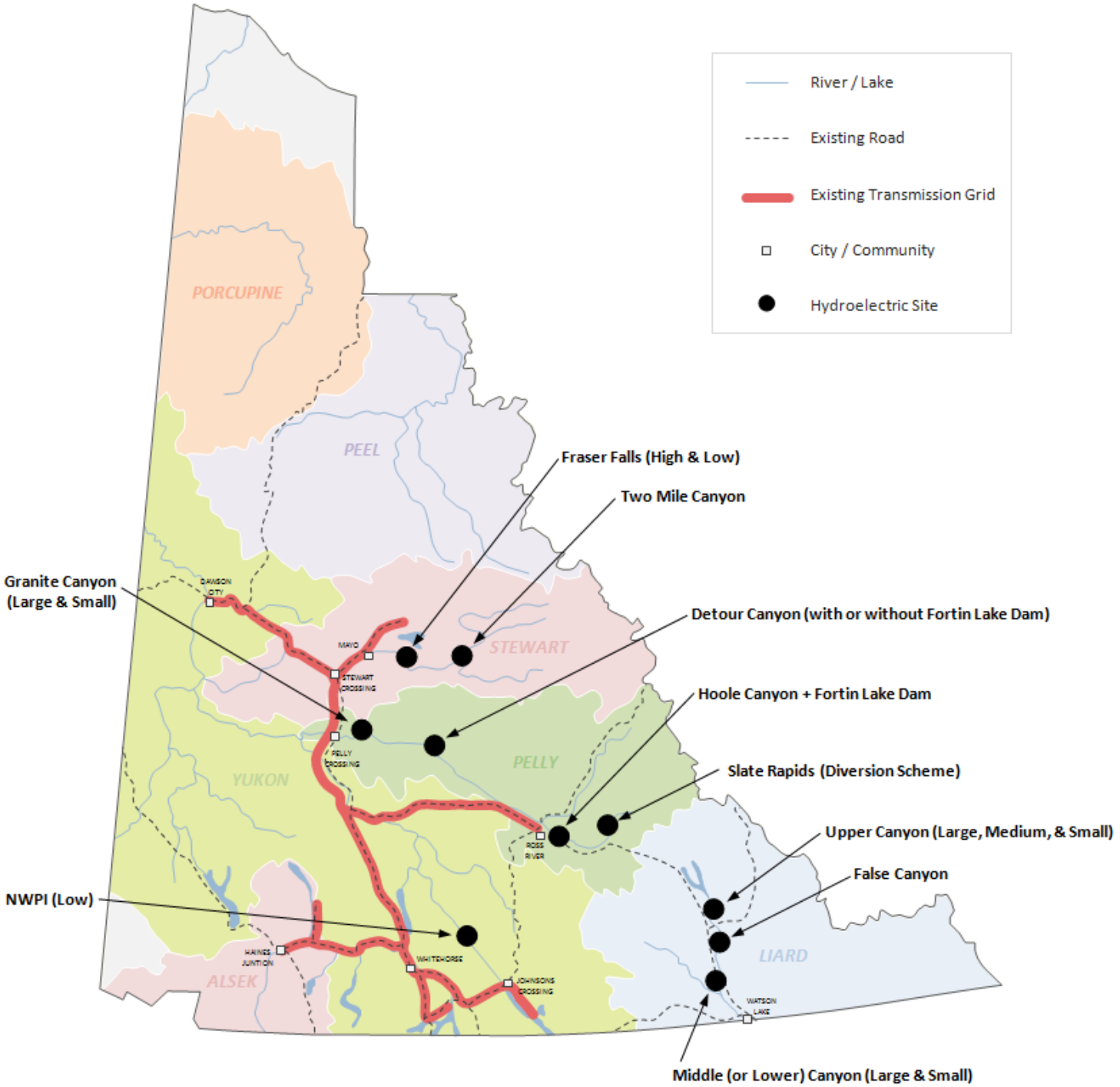
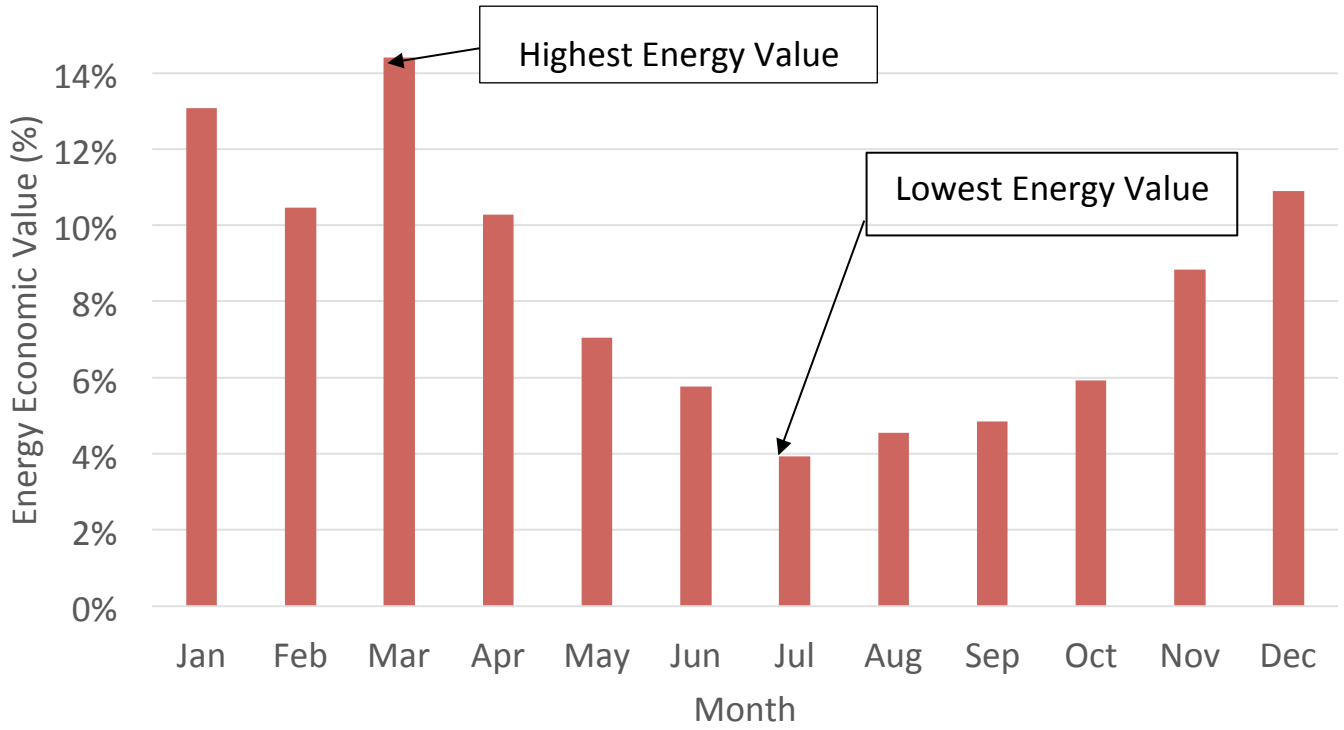
Part	Description	Refinement
1	Screen 0: Reconciliation of Known Project Sites	200+ → 108
	Screen 1: Fundamental Development Barrier Project Screen	108 → 47
	Screen 2: Fundamentally Uneconomic Project Screen	47 → 16
2	Ranking 3: Initial Project Ranking & Variation Consolidation	16 → 10

Site Screening Inventory (Part 1&2): Results



Step 0: Project Scoring Methodology

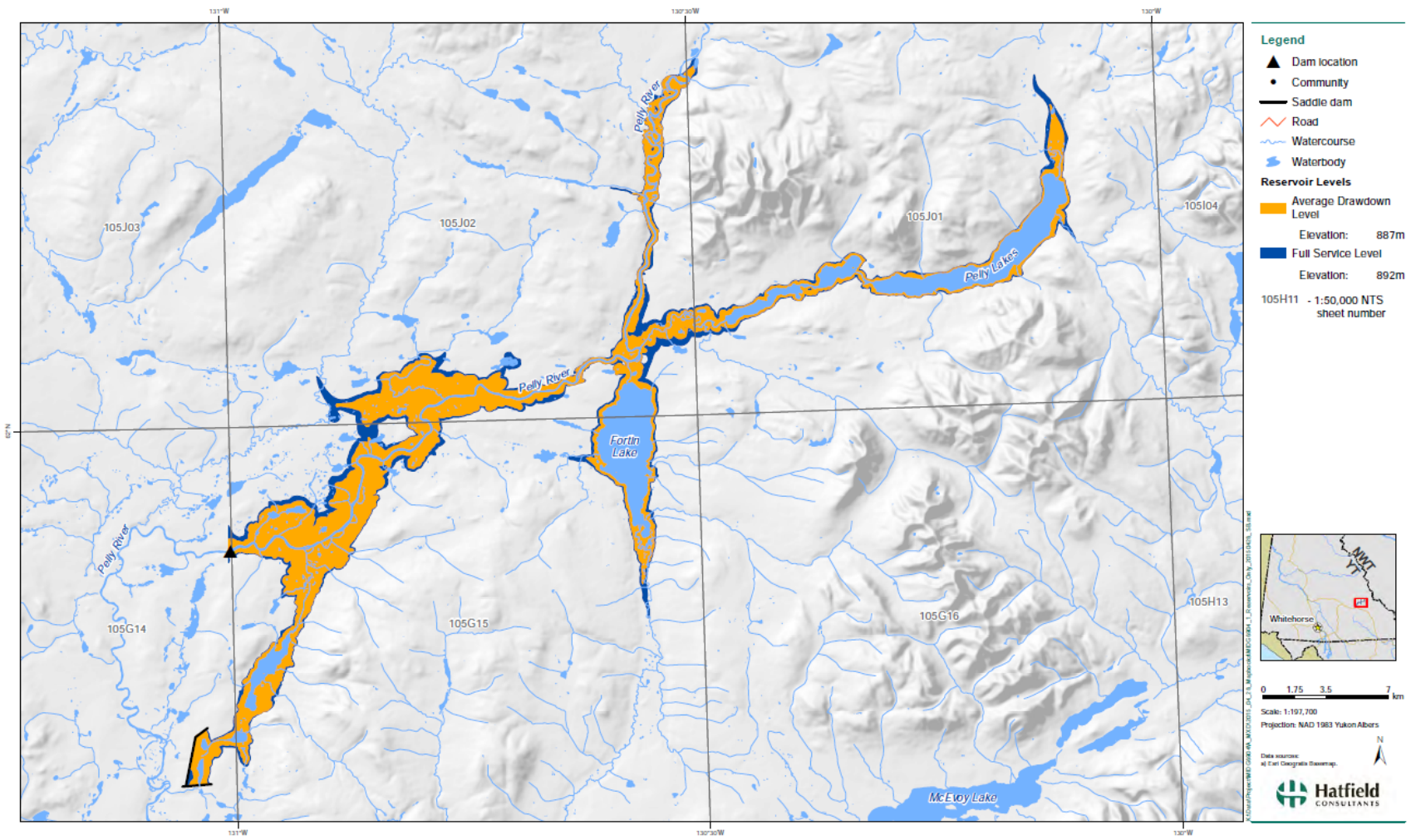
Step 0: Gap Closure and Energy Value



Month	Energy Value (%)
Jan	13.1%
Feb	10.5%
Mar	14.4%
Apr	10.3%
May	7.1%
Jun	5.8%
Jul	3.9%
Aug	4.6%
Sep	4.8%
Oct	5.9%
Nov	8.8%
Dec	10.9%

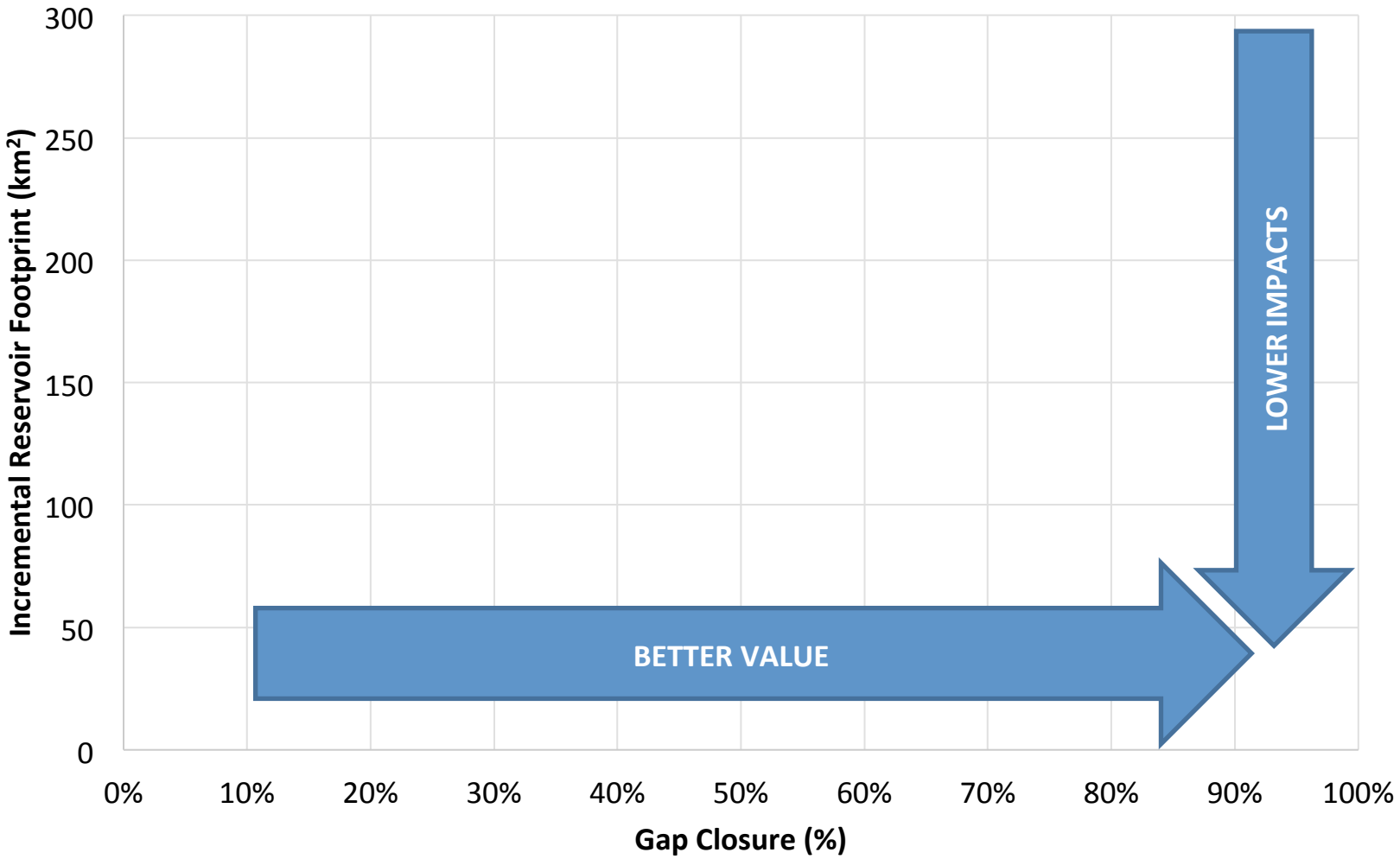
- Winter energy is more valuable
- Excess energy has no value
- Gap Closure Target >= 95%

Step 0: Incremental Reservoir Footprint



- Existing lake areas accounted separately
- Drawdown limited: Target 3m, Maximum 10m

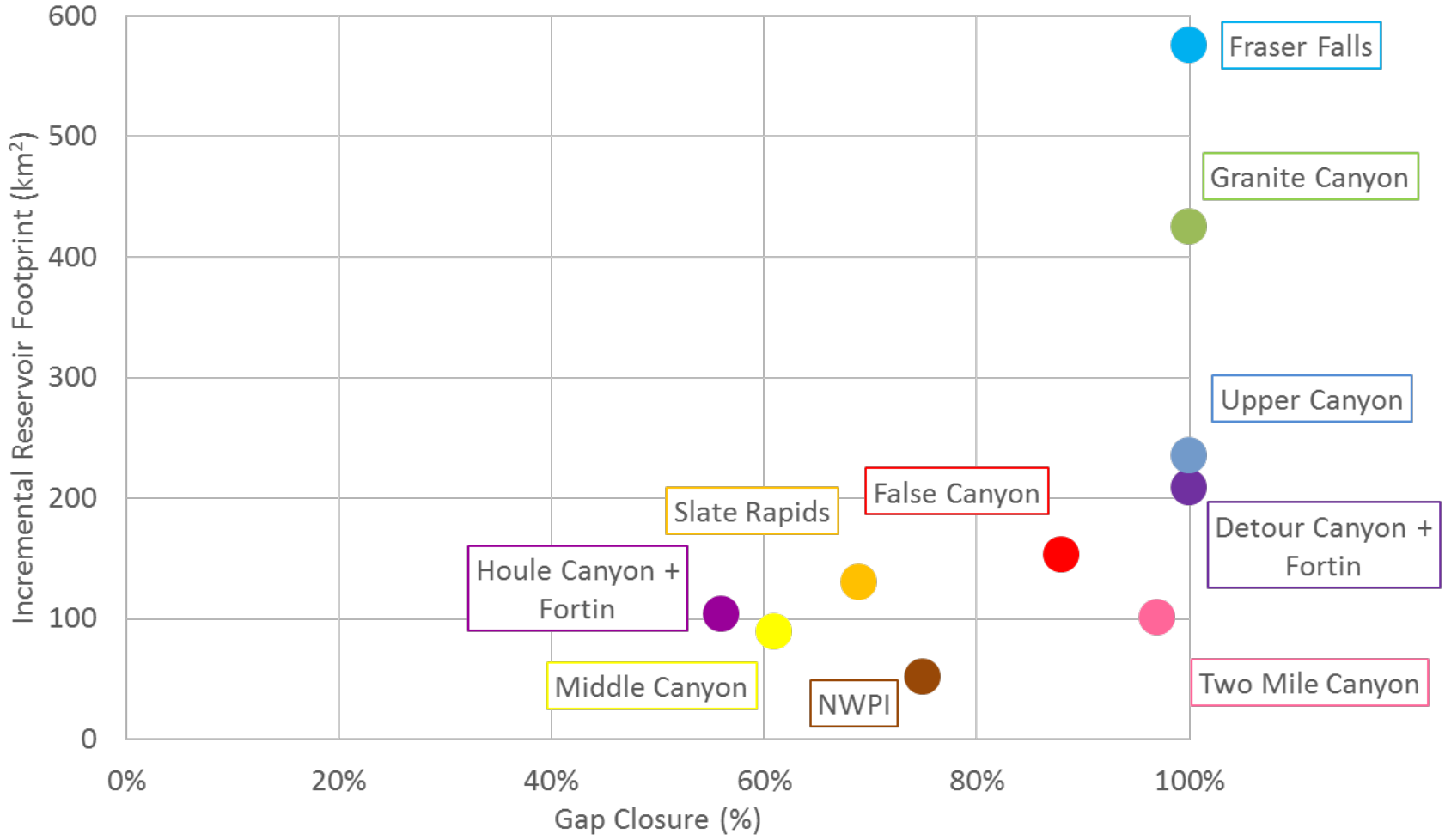
Step 0: Reservoir Footprint vs. Gap Closure



Goal: High gap closure (>95%) with lower Incremental Reservoir Footprint

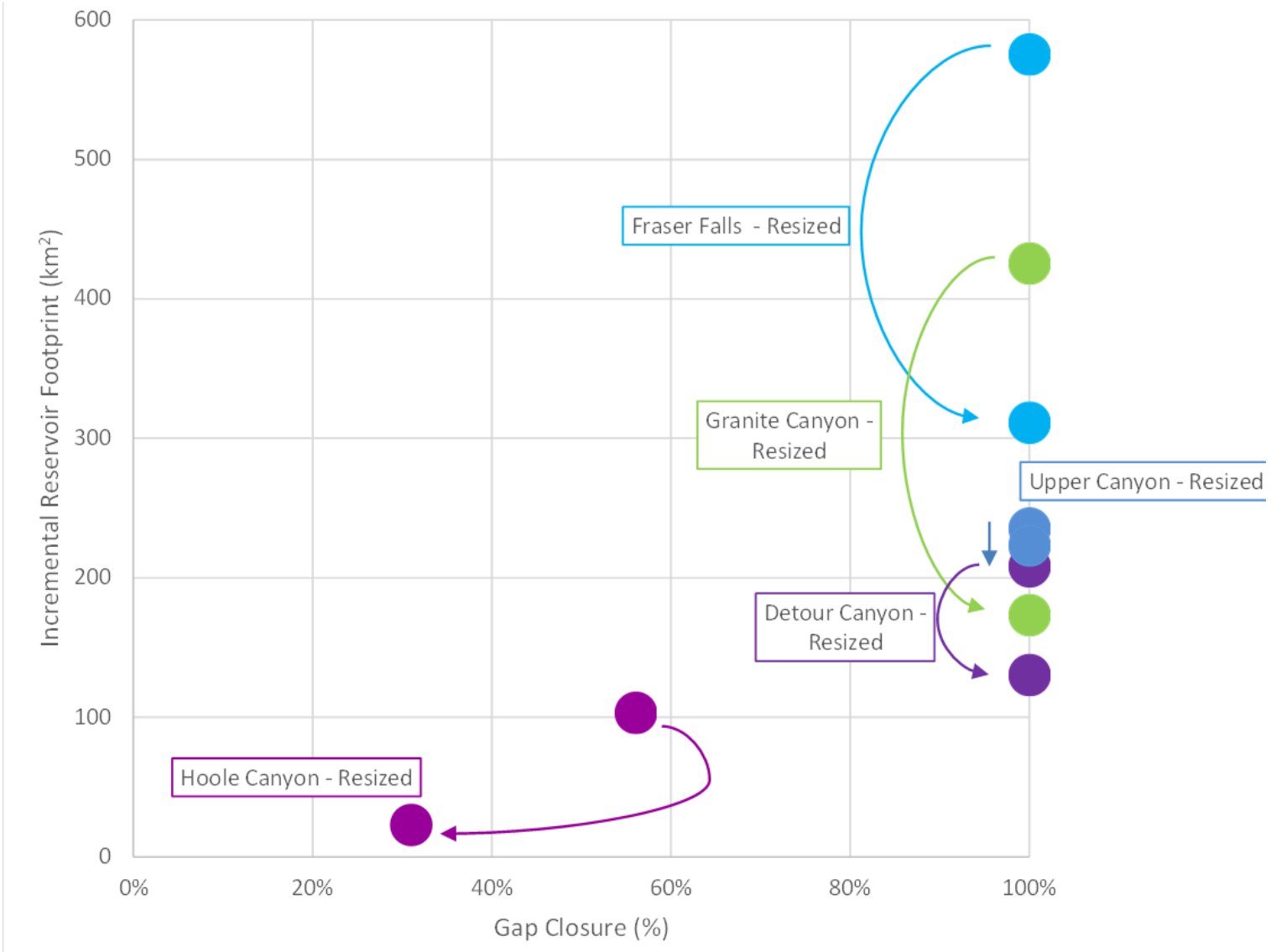
Step 1: Resizing

Step 1: Original Project Designs



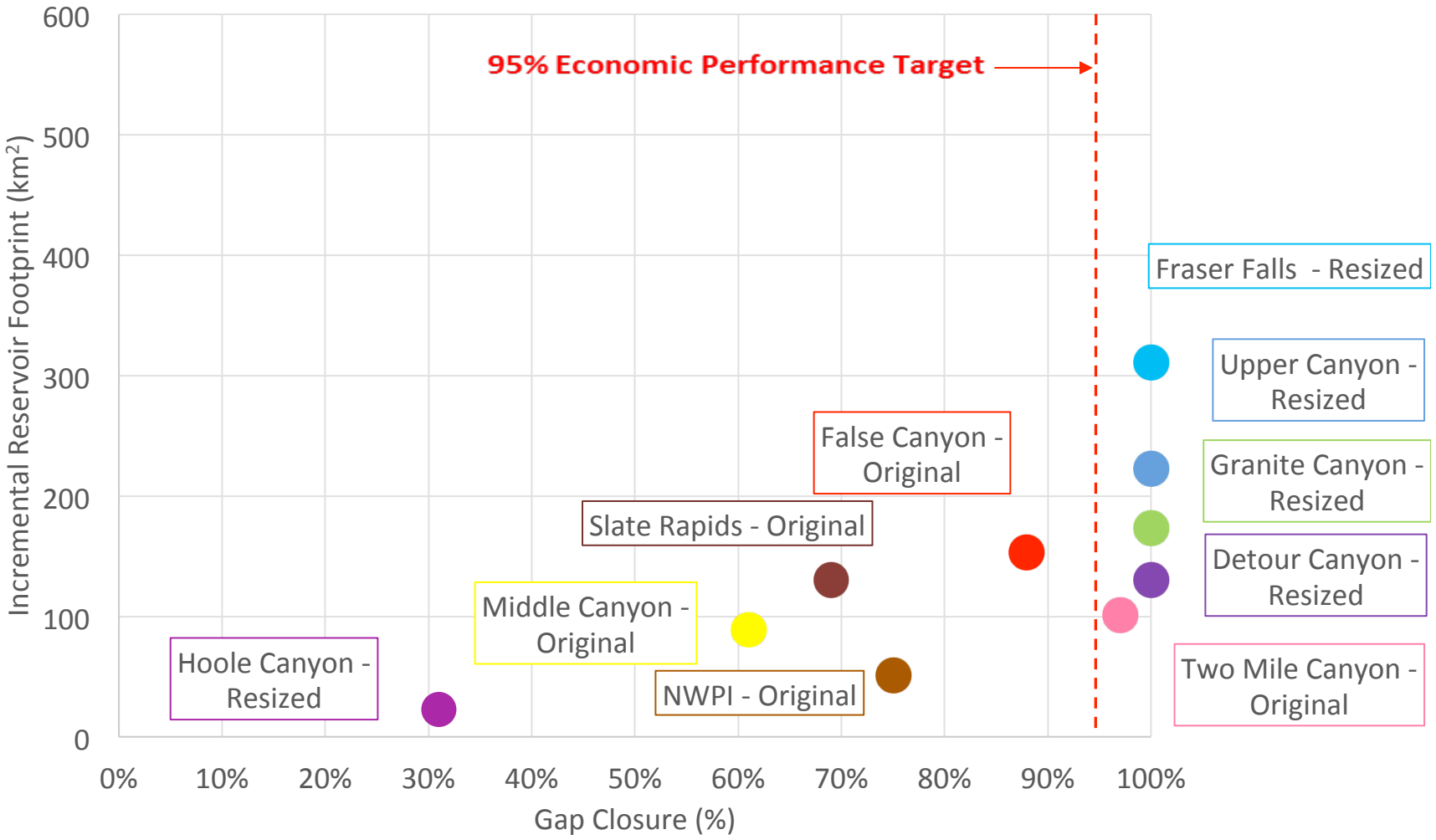
- Some historic projects sized too large for Yukon need (e.g. Fraser Falls, Granite Canyon)

Step 1: Resizing



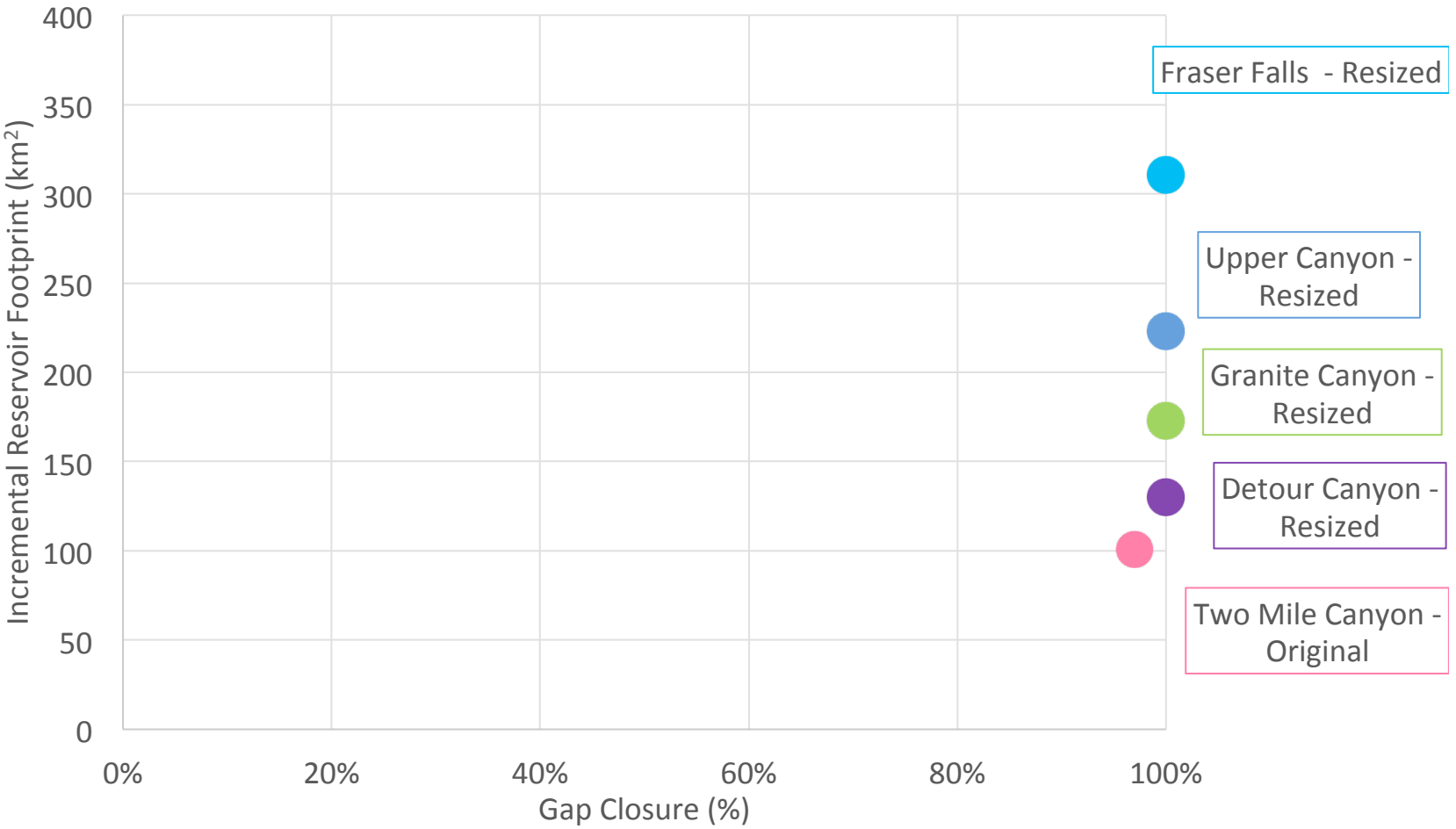
- Resize to meet at least 95% Gap Closure
- Fortin Lake - Not effective source of water storage

Step 1: Resizing



Several standalone project do not meet performance target

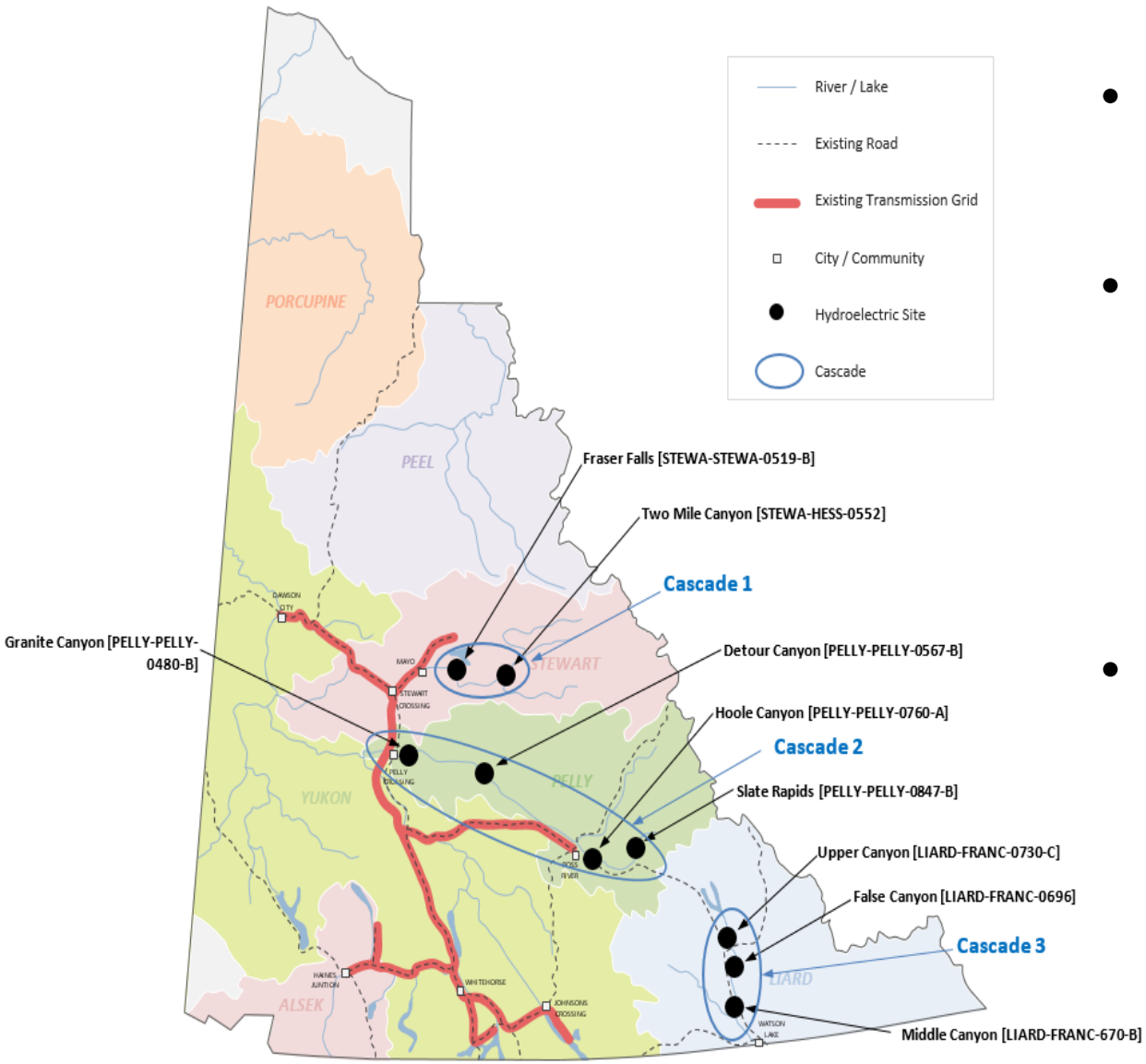
Step 1: Resizing Results



- 5 Standalone Projects
- 97% to 100% Gap Closure
- 101 km^2 to 311 km^2 Incremental Reservoir Footprint

Step 2: Cascading

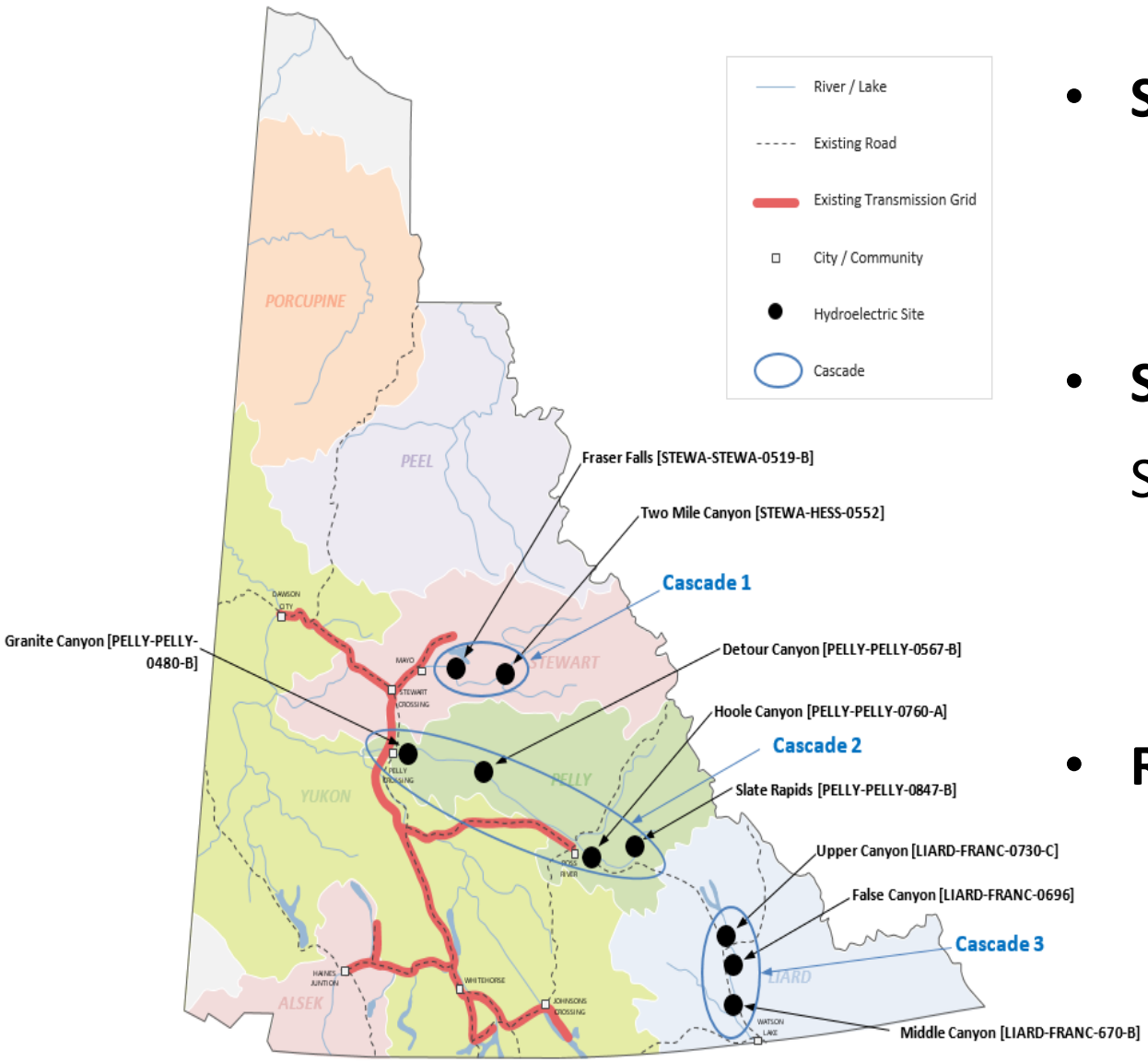
Step 2: Cascades



- **Cascade 1**: Two Mile Canyon → Fraser Falls
- **Cascade 2**: Slate Rapids → Hoole Canyon → Detour Canyon → Granite Canyon
- **Cascade 3**: Upper Canyon → False Canyon → Middle Canyon

- Note: NWPI does not belong to a cascade

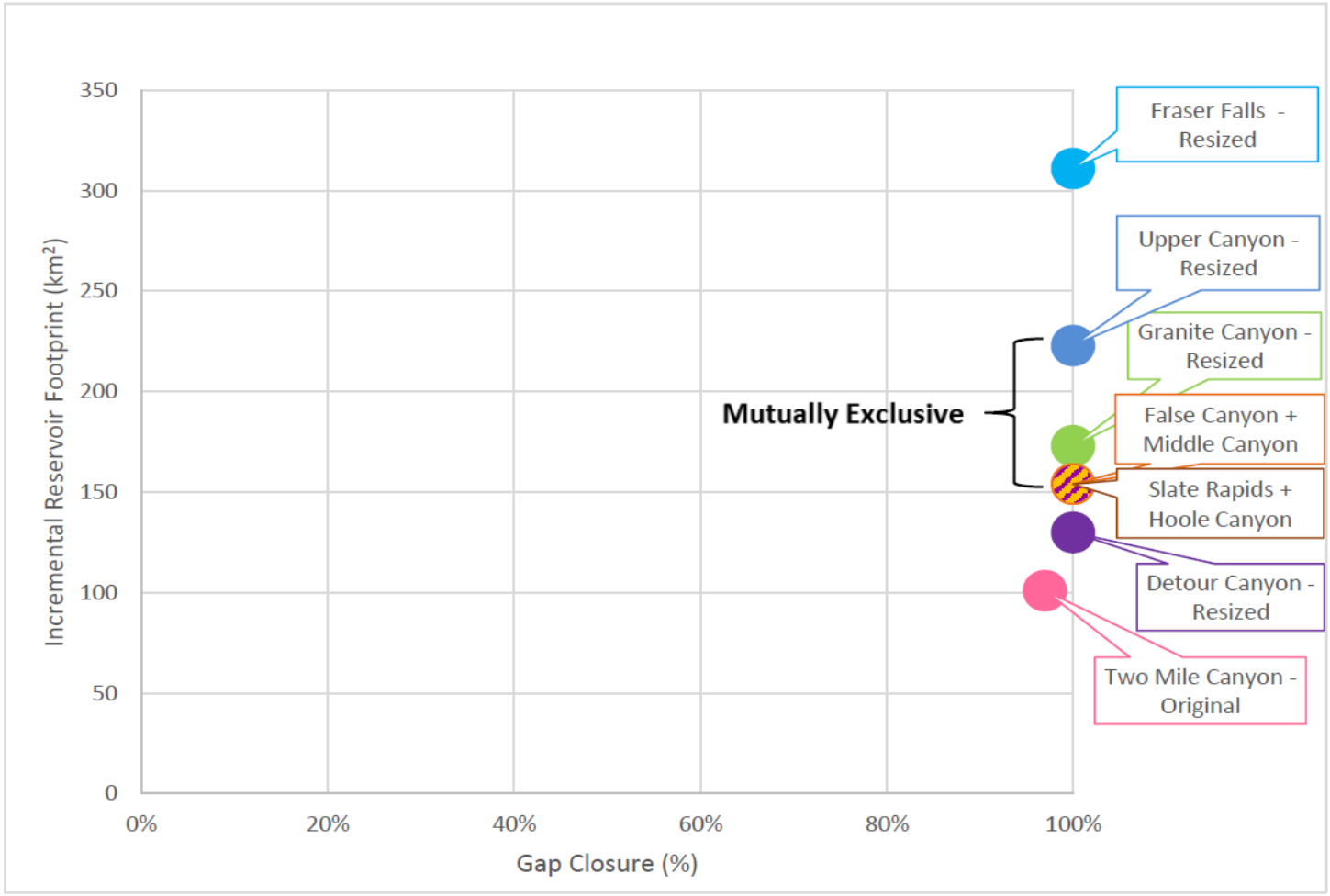
Step 2: Cascade Screen



- **Screen #1**: Mutually Exclusive
  - Overlapping Reservoirs
- **Screen #2**: Performant Standalone Project
  - Standalone Project 95%+ gap closure
- **Result:**
  - Upper Canyon + Middle Canyon ROR
  - Slate Rapids + Hoole Canyon ROR

Step 3: Reconciliation

Step 3: Step 1 & 2 Reconciliation



- 5 Standalone Projects + 2 Cascaded Projects
- 2 Mutually Exclusive Projects (Upper Canyon and False Canyon)
- 97% to 100% Gap Closure
- 101 km^2 to 311 km^2 Incremental Reservoir Footprint

Step 3: Scalability Shortlist

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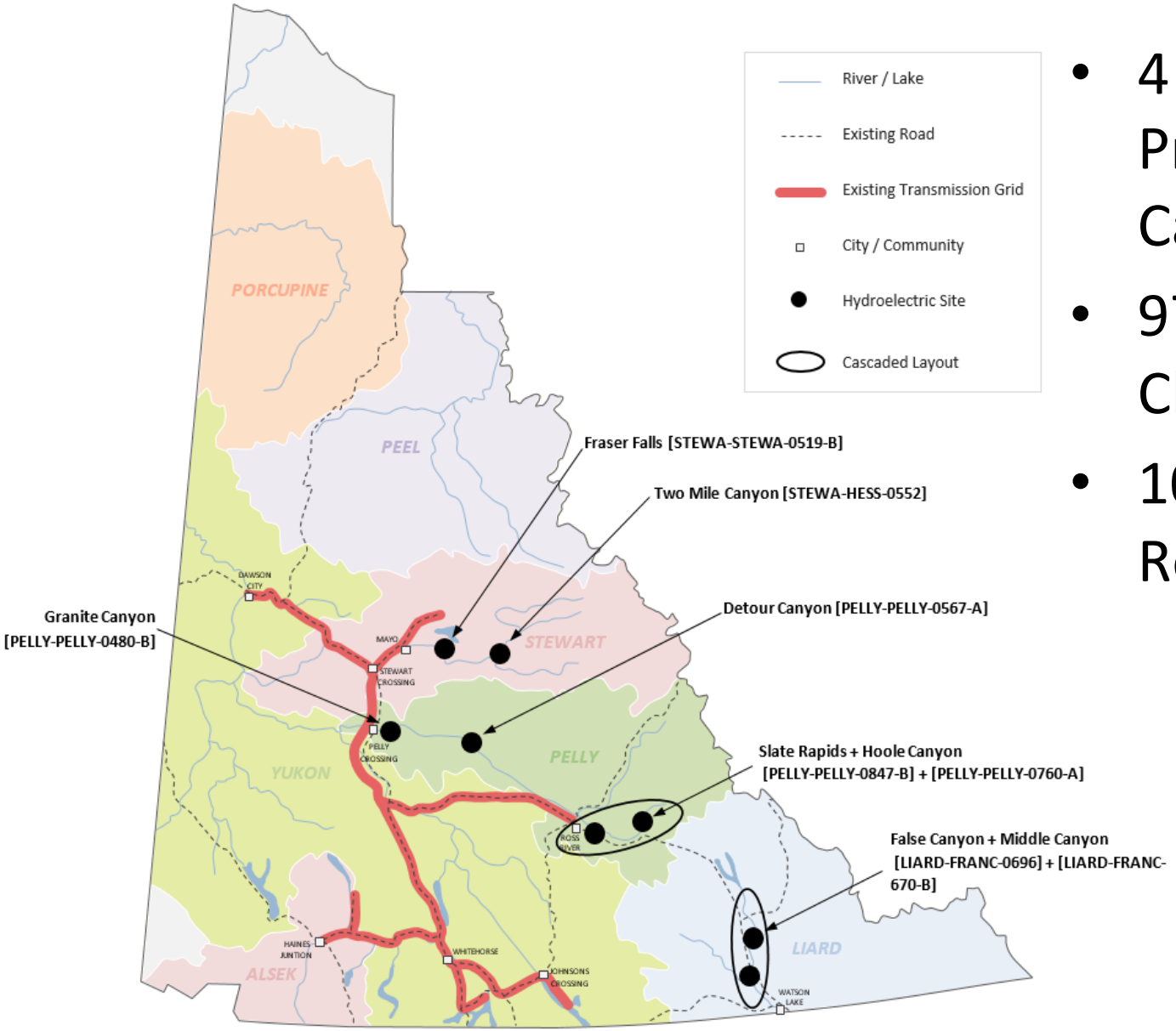
Site Name	Existing Lake Area	Incremental Reservoir Footprint	Total Reservoir Footprint	Gap Closure
Detour Canyon	0 km^2	130 km^2	130 km^2	100%
Fraser Falls	0 km^2	311 km^2	311 km^2	100%
Granite Canyon	0 km^2	173 km^2	173 km^2	100%
Two Mile Canyon	0 km^2	101 km^2	101 km^2	97%
False Canyon + Middle Canyon ROR	109 km^2	154 km^2	263 km^2	100%
Slate Rapids + Hoole Canyon ROR	37 km^2	154 km^2	191 km^2	100%

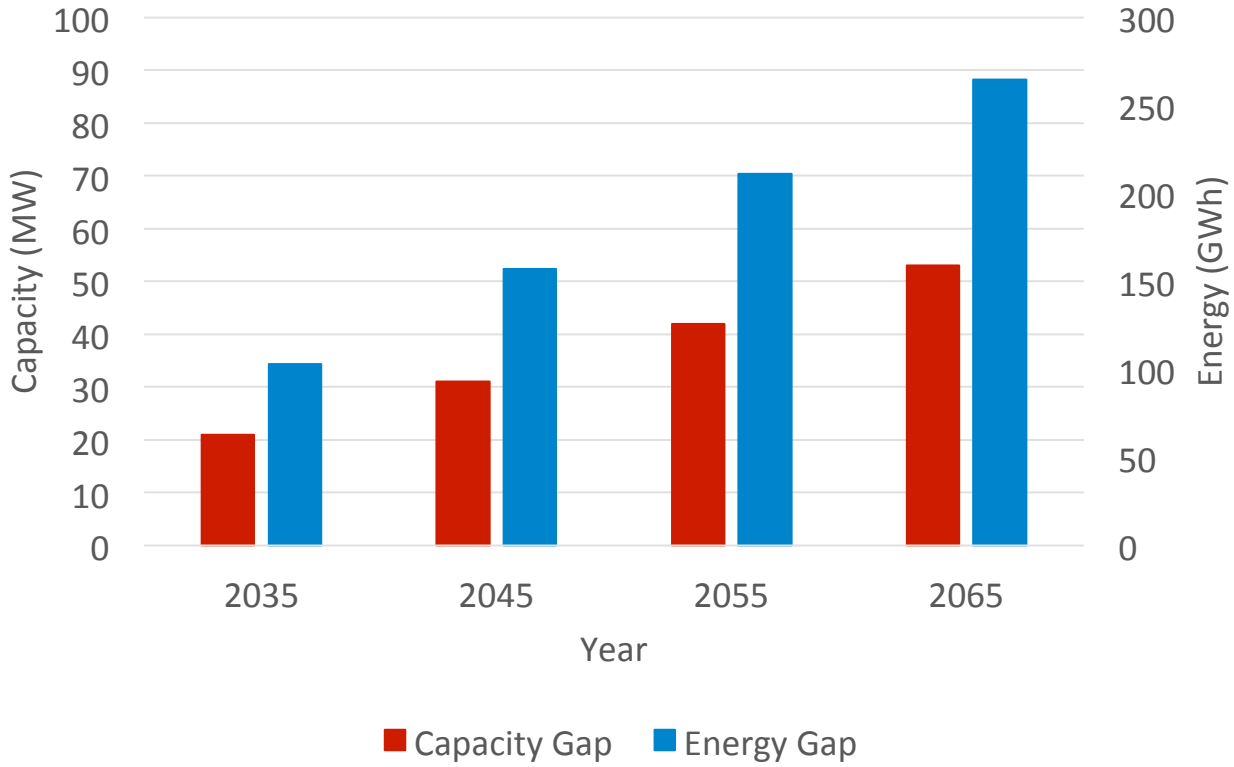
Step 3: Scalability Shortlist



- 4 Standalone Projects + 2 Cascaded Projects
- 97% to 100% Gap Closure
- 101 km^2 to 311 km^2 Reservoir Footprint

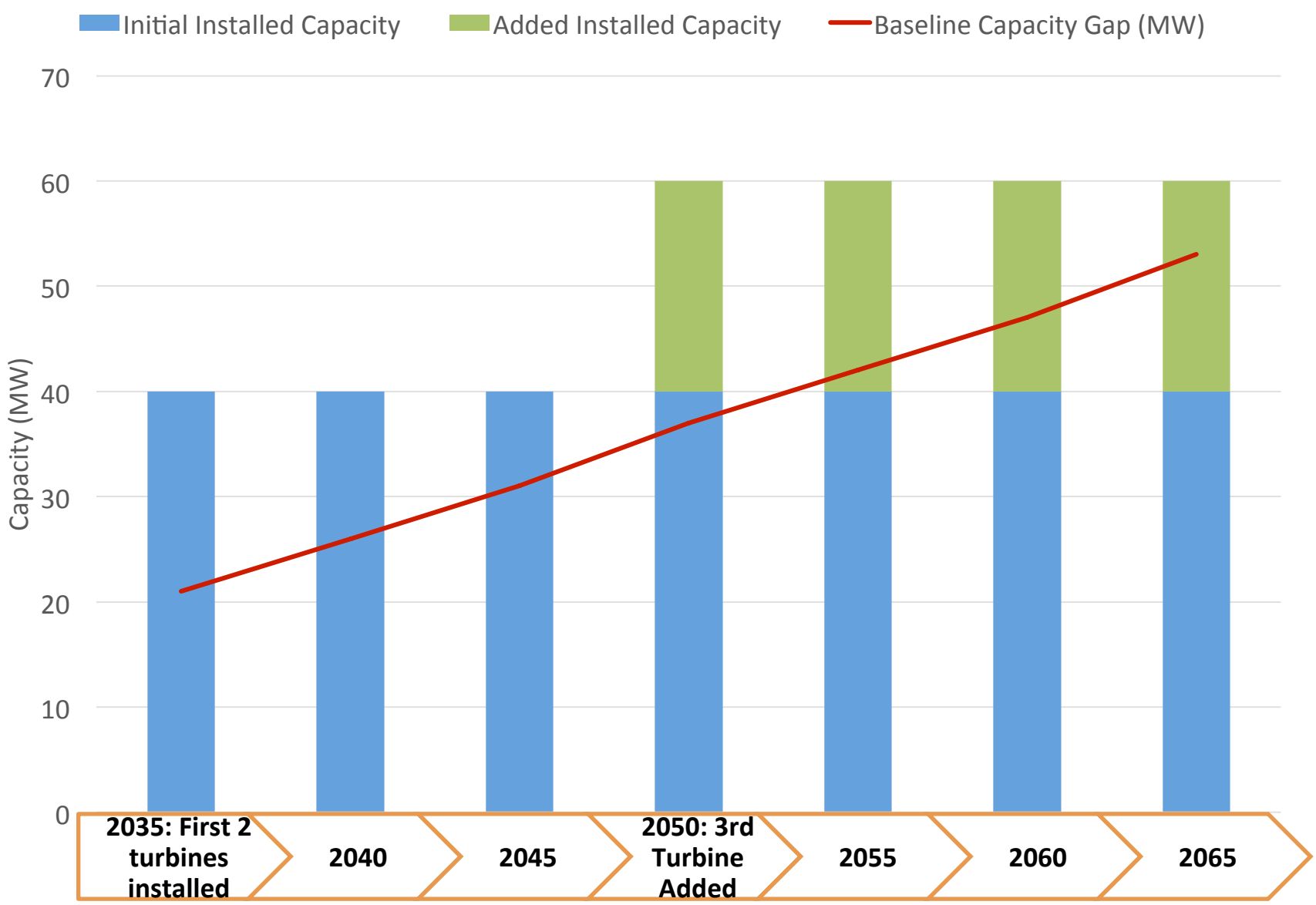
Step 4: Scalability

Step 4: Scalability Buildout Advantage

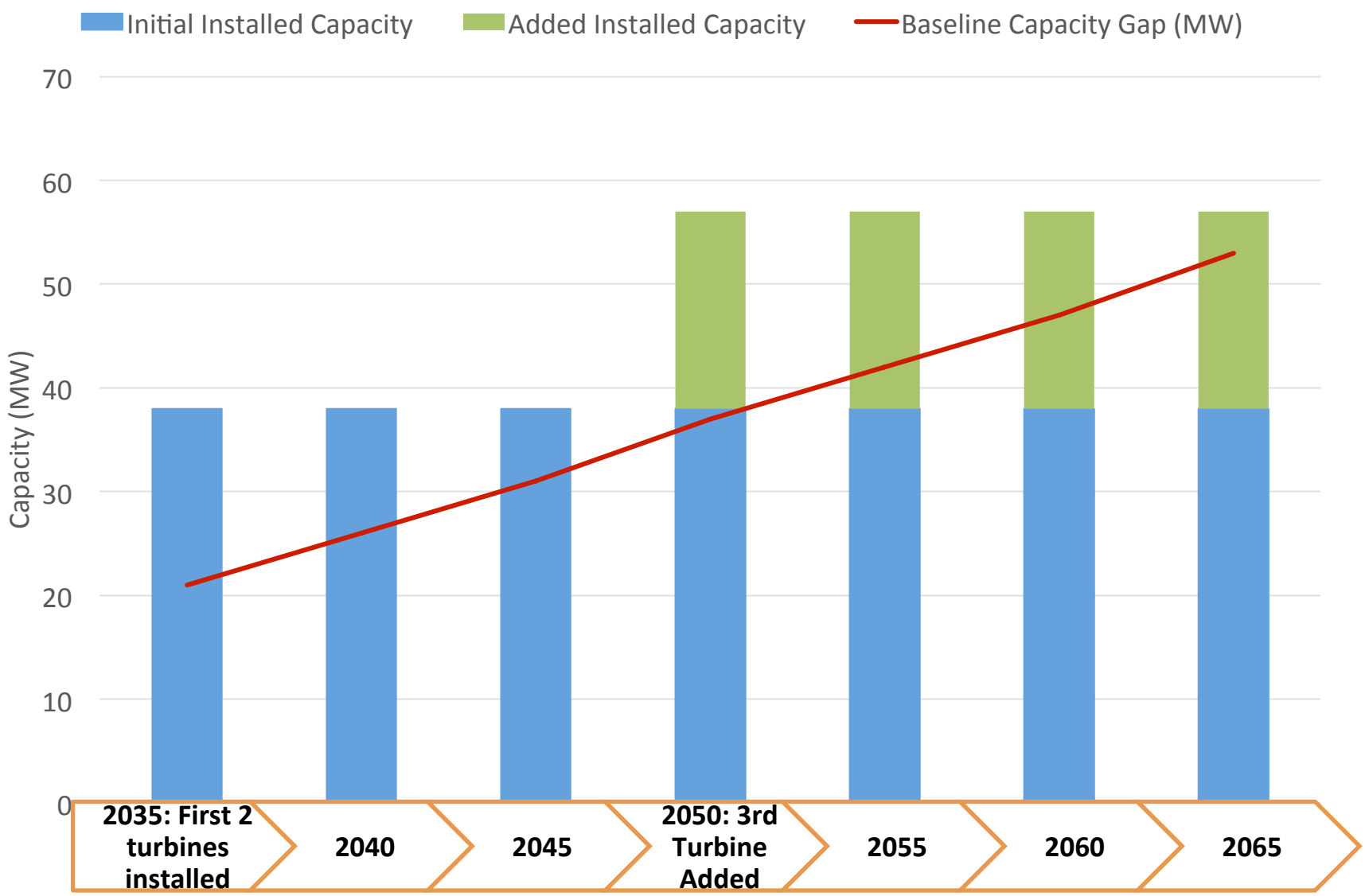


1) Better matching between project generation and the Yukon's energy and capacity needs with less risk of under-utilized generation assets,
2) Defers capital outlays, thus reducing the cost to electricity ratepayers,
3) Reduced operation and maintenance costs, thus reducing the cost to electricity ratepayers.

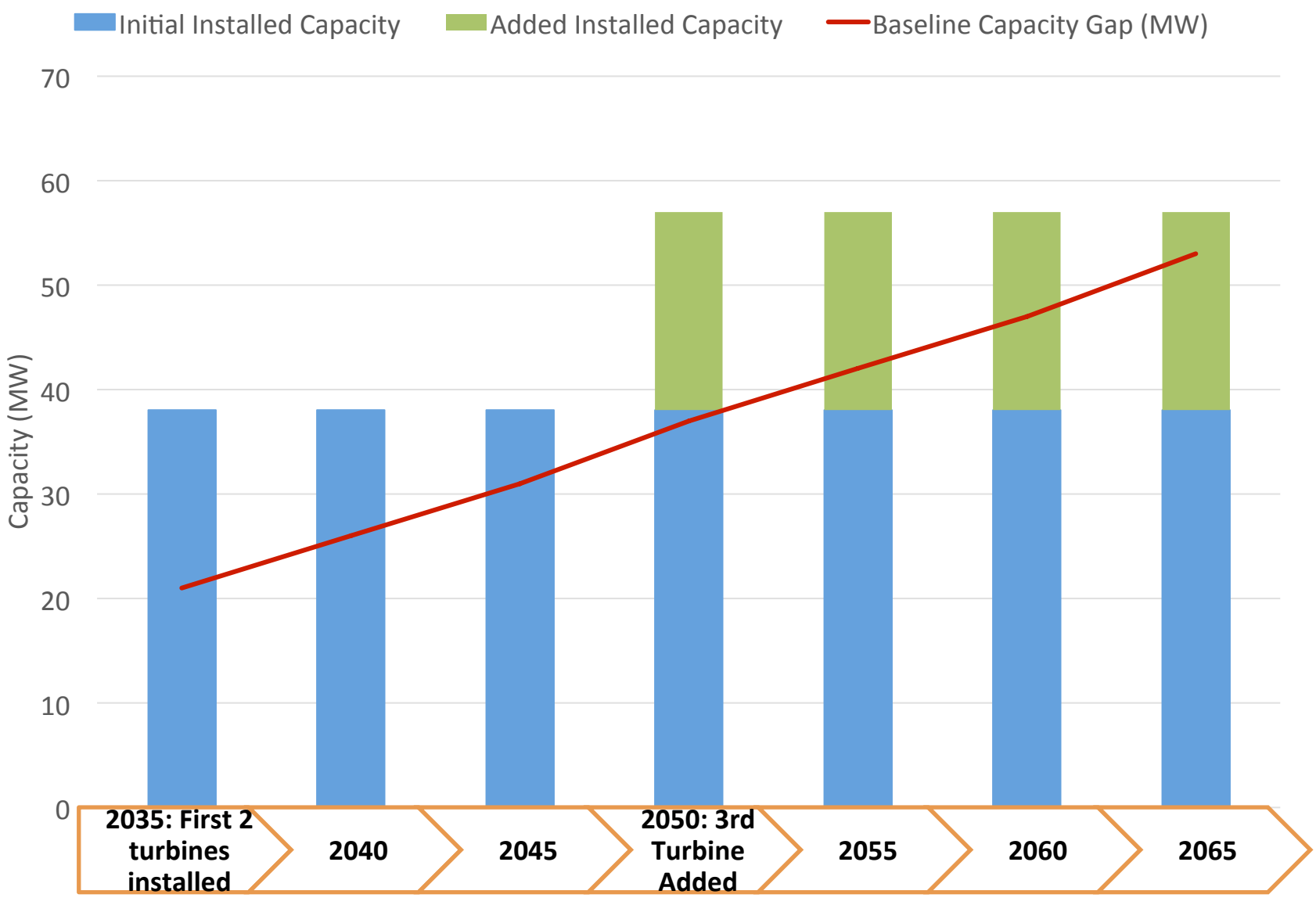
Step 4: Detour Canyon Scalability Buildout



Step 4: Fraser Falls Scalability Buildout



Step 4: Granite Canyon Scalability Buildout



Step 4: Two Mile Canyon Scalability Buildout

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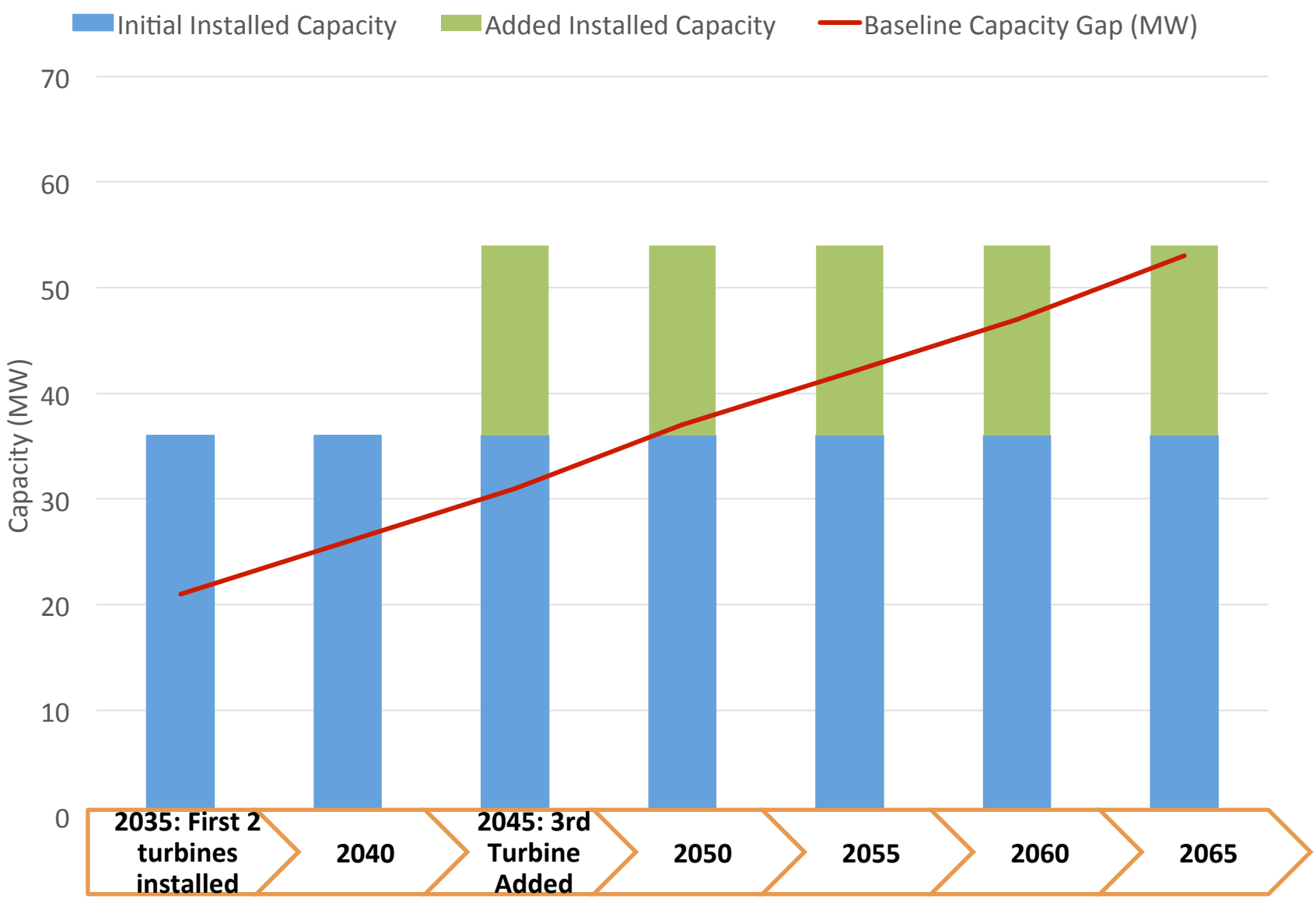
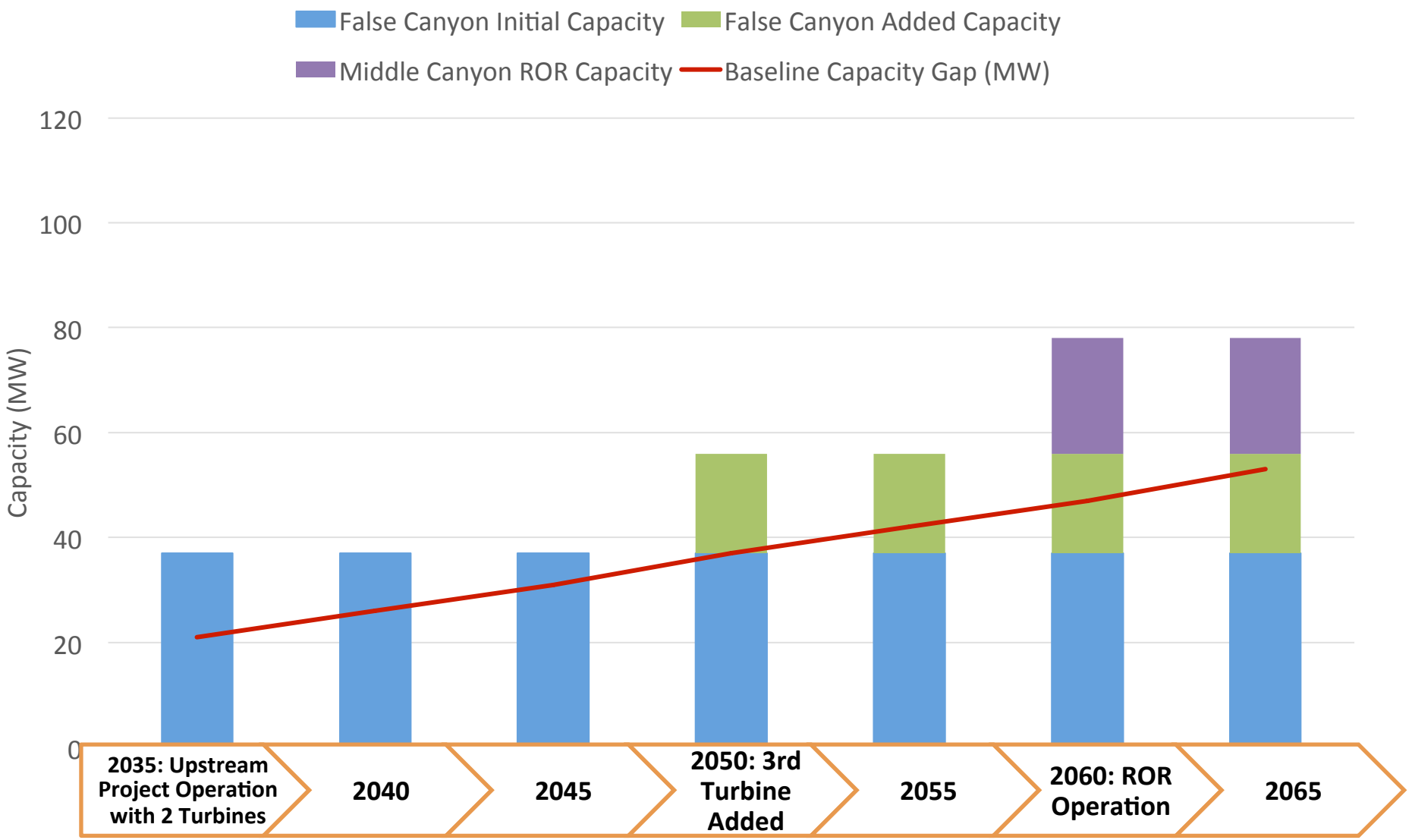
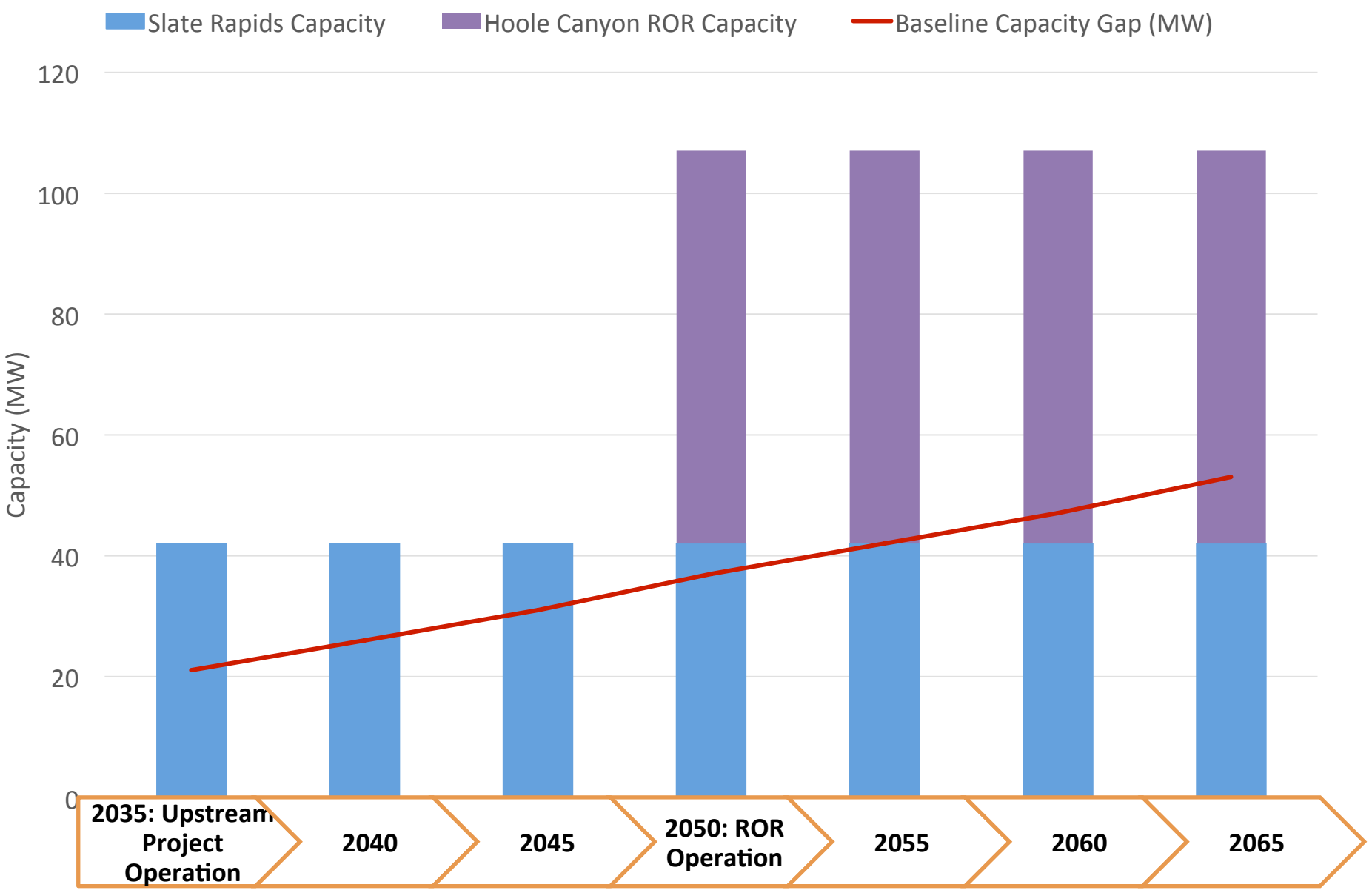


Step 4: False Canyon + Middle Canyon ROR Scalability Buildout



Step 4: Slate Rapids + Hoole Canyon ROR Scalability Buildout



Scalability

Project Name and Site ID	Build Out Timeline
Detour Canyon [PELLY-PELLY-0567-B]	2035: First 2 turbines installed → 2045 → 2050: 3rd Turbine Added → 2055 → 2060
Fraser Falls [STEWA-STEWA-0519-B]	2035: First 2 turbines installed → 2045 → 2050: 3rd Turbine Added → 2055 → 2060
Granite Canyon [PELLY-PELLY-0480-B]	2035: First 2 turbines installed → 2045 → 2050: 3rd Turbine Added → 2055 → 2060
Two Mile Canyon [STEWA-HESS -0552]	2035: First 2 turbines installed → 2045: 3rd Turbine Added → 2050 → 2055 → 2060
False Canyon + Middle Canyon ROR [LIARD-FRANC-0696 + LIARD-FRANC-0670-B]	2035: Upstream Project Operation with 2 Turbines → 2045 → 2050: 3rd Turbine Added → 2055 → 2060: ROR Operation
Slate Rapids + Hoole Canyon ROR [PELLY-PELLY-0847-B + PELLY-PELLY-0760-A]	2035: Upstream Project Operation with 2 Turbines → 2045 → 2050: ROR Operation → 2055 → 2060

Summary

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Shortlist Summary

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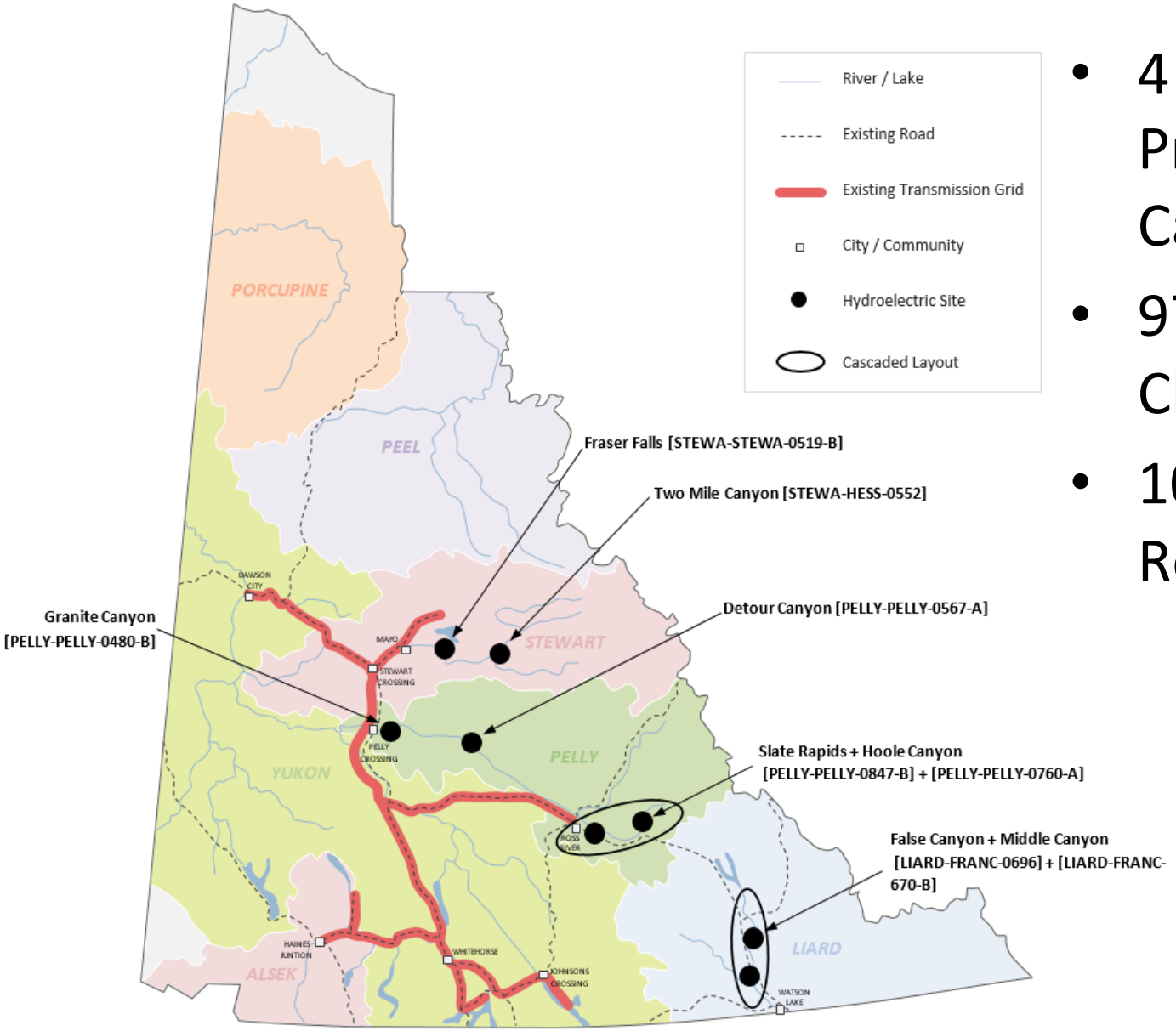

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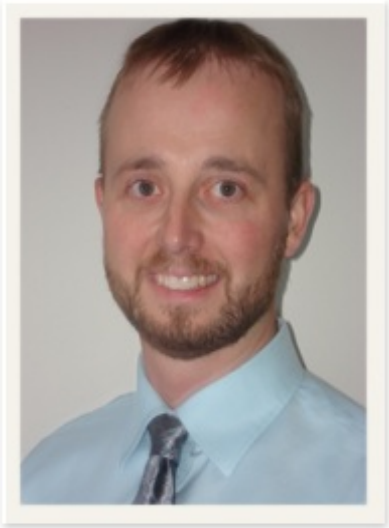
Thank You & Questions…



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