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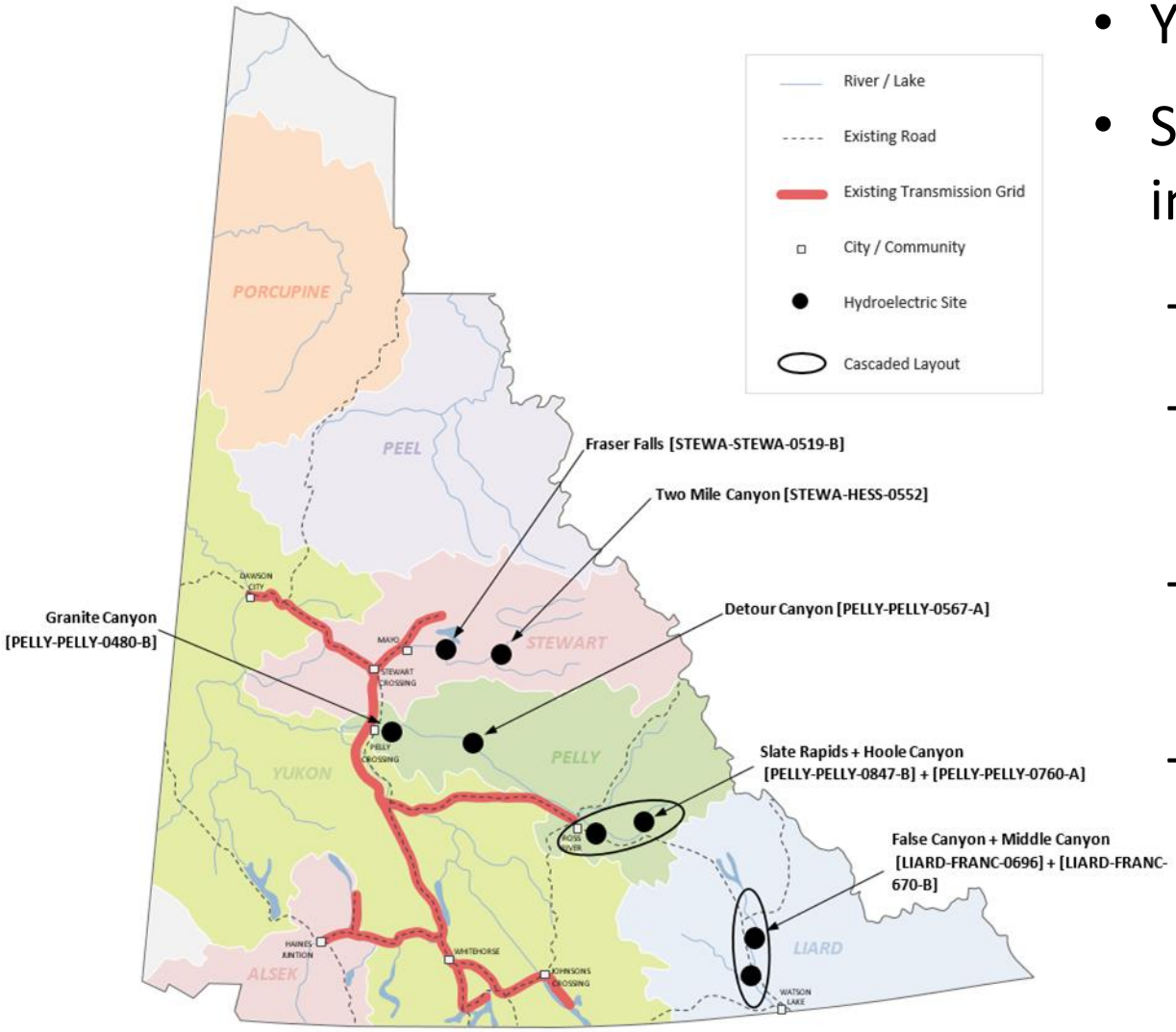
Next Generation Hydroelectric & Transmission Viability Study: Next Generation Hydro Projects Costs

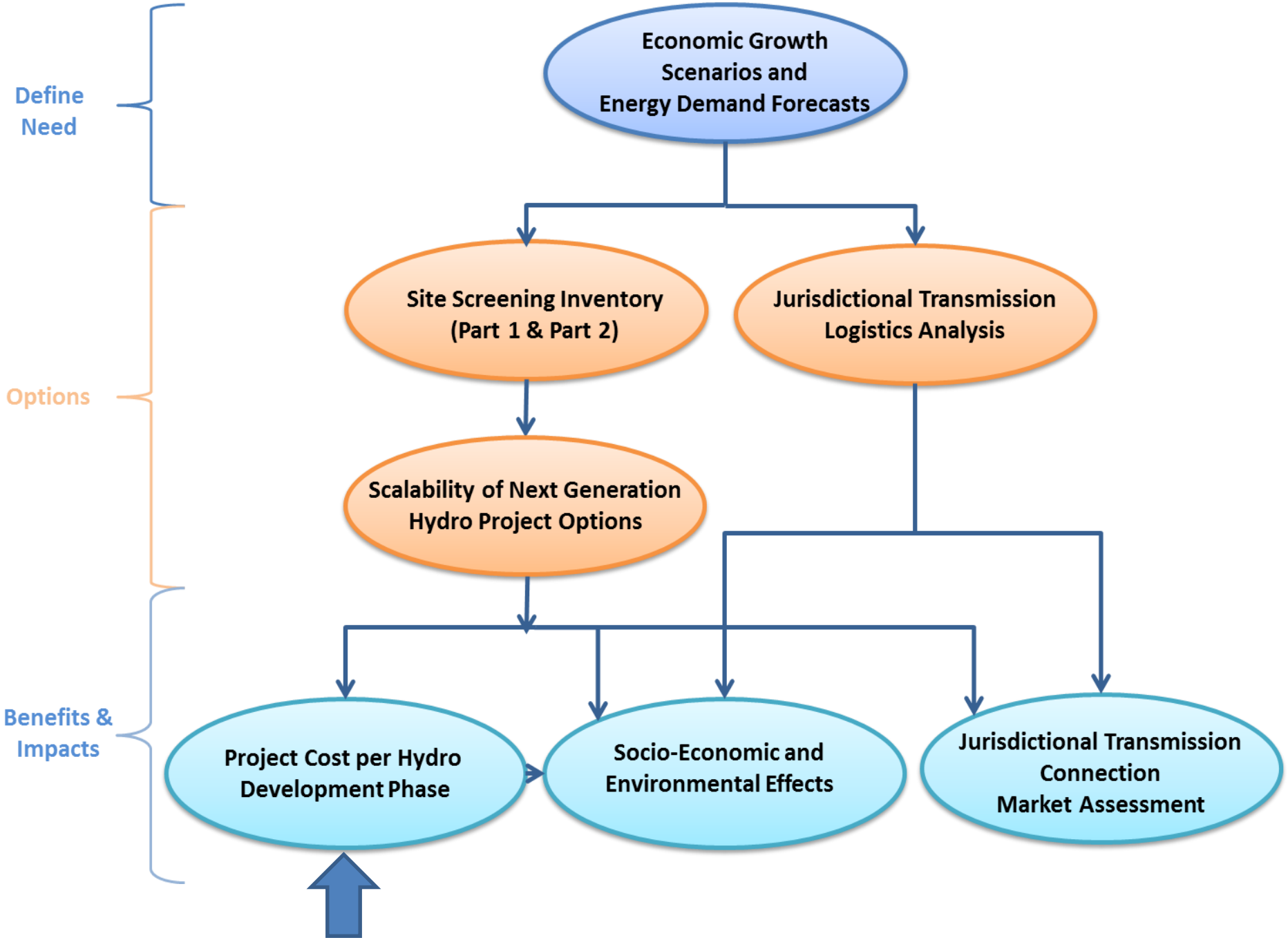
27 November 2015

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

Technical Papers



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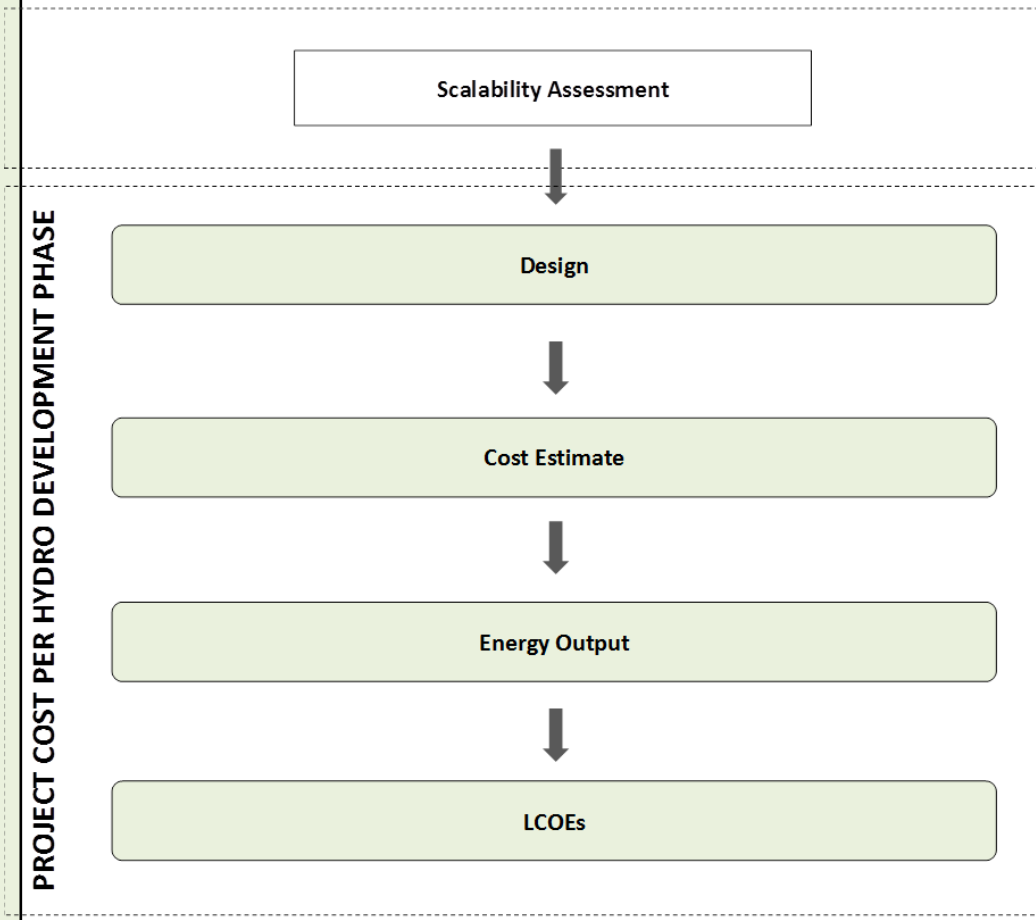
Next Generation Hydro Project Costs

Project Cost Report: Objective

OBJECTIVE: Assess the Scalability Shortlist projects in terms of:

1. ***Design & Build Out***
2. ***Cost***
3. ***Energy Output***
4. ***Levelized Cost of Energy (LCOE).***

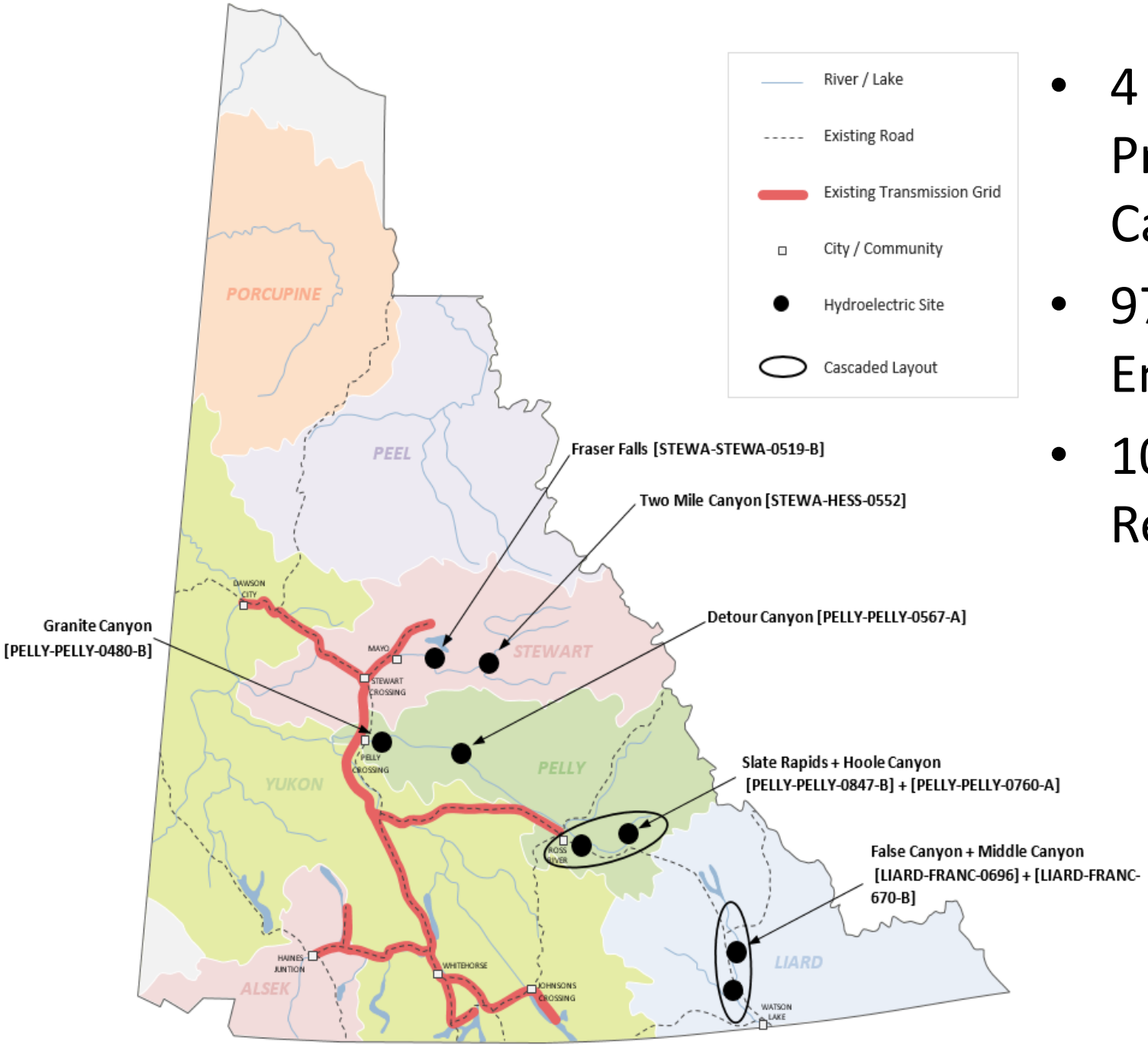


Notes:

- No perfect project

Scalability Assessment: Brief Recap

Scalability Shortlist



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

Scalability Build Out

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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

Design

Design: Project Site

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Design: Access and Camp Site

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Design: Reservoir Clearing

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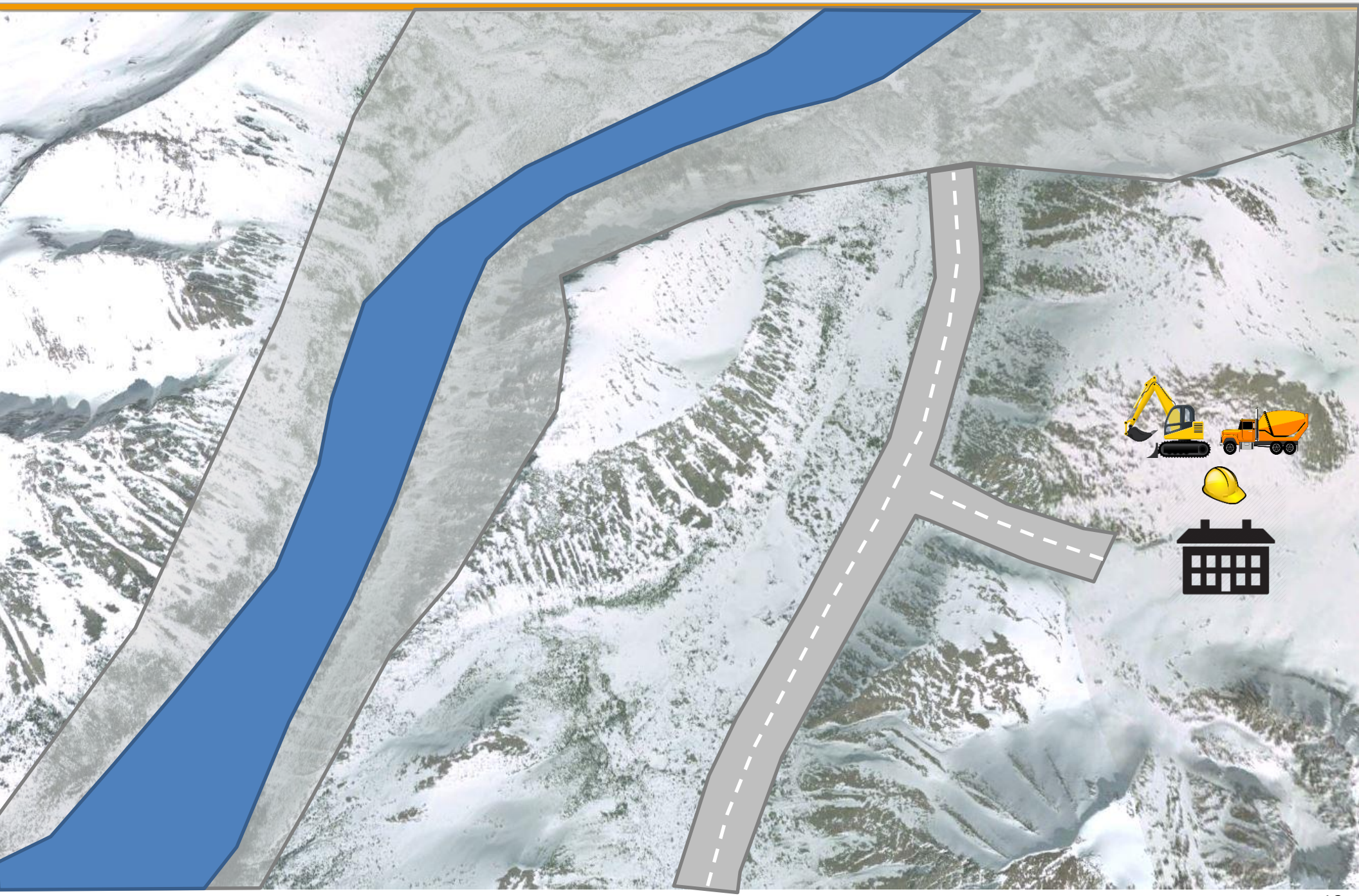

Design: Diversion Tunnel

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Design: Opening of Diversion Tunnel

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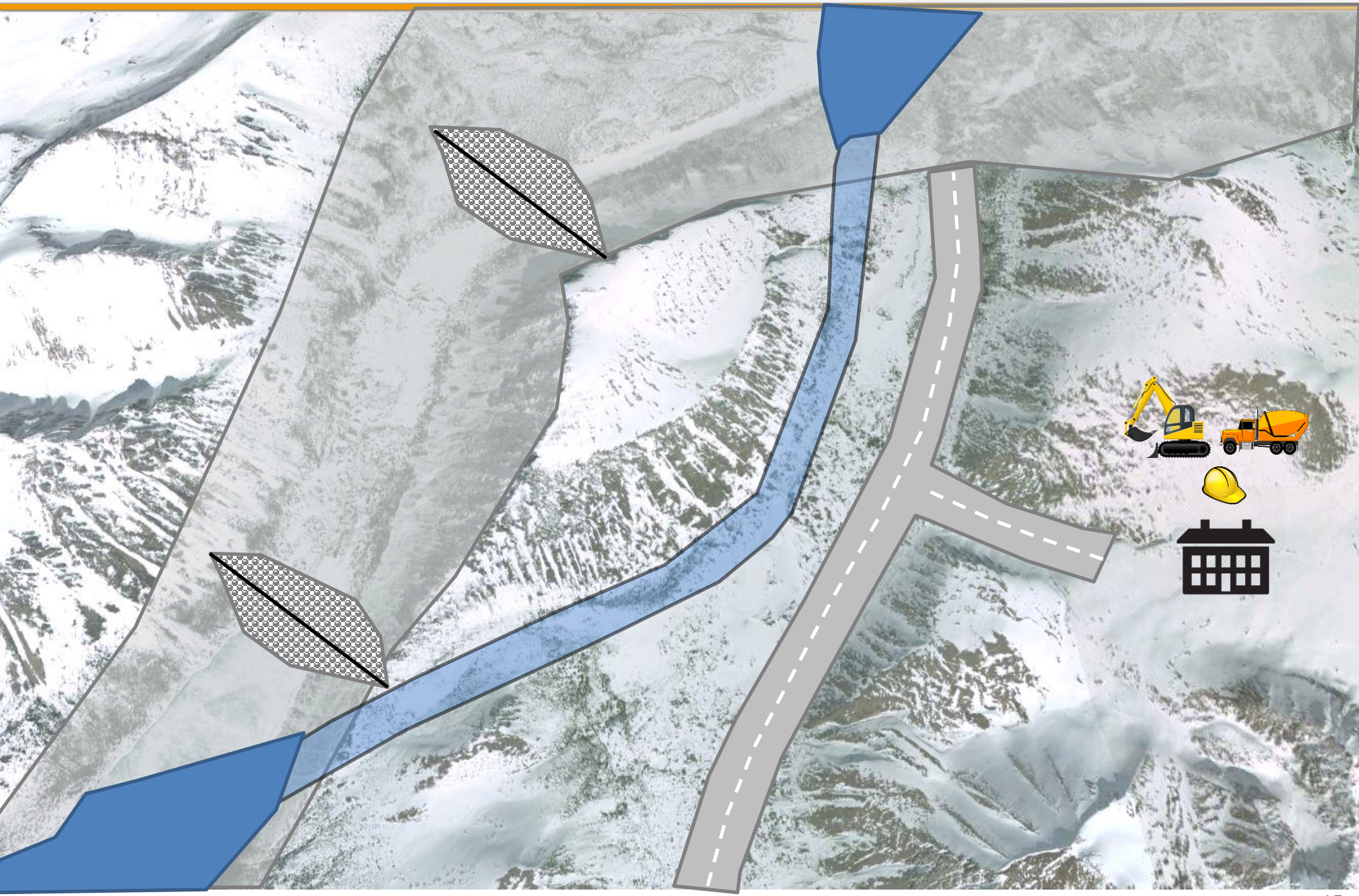
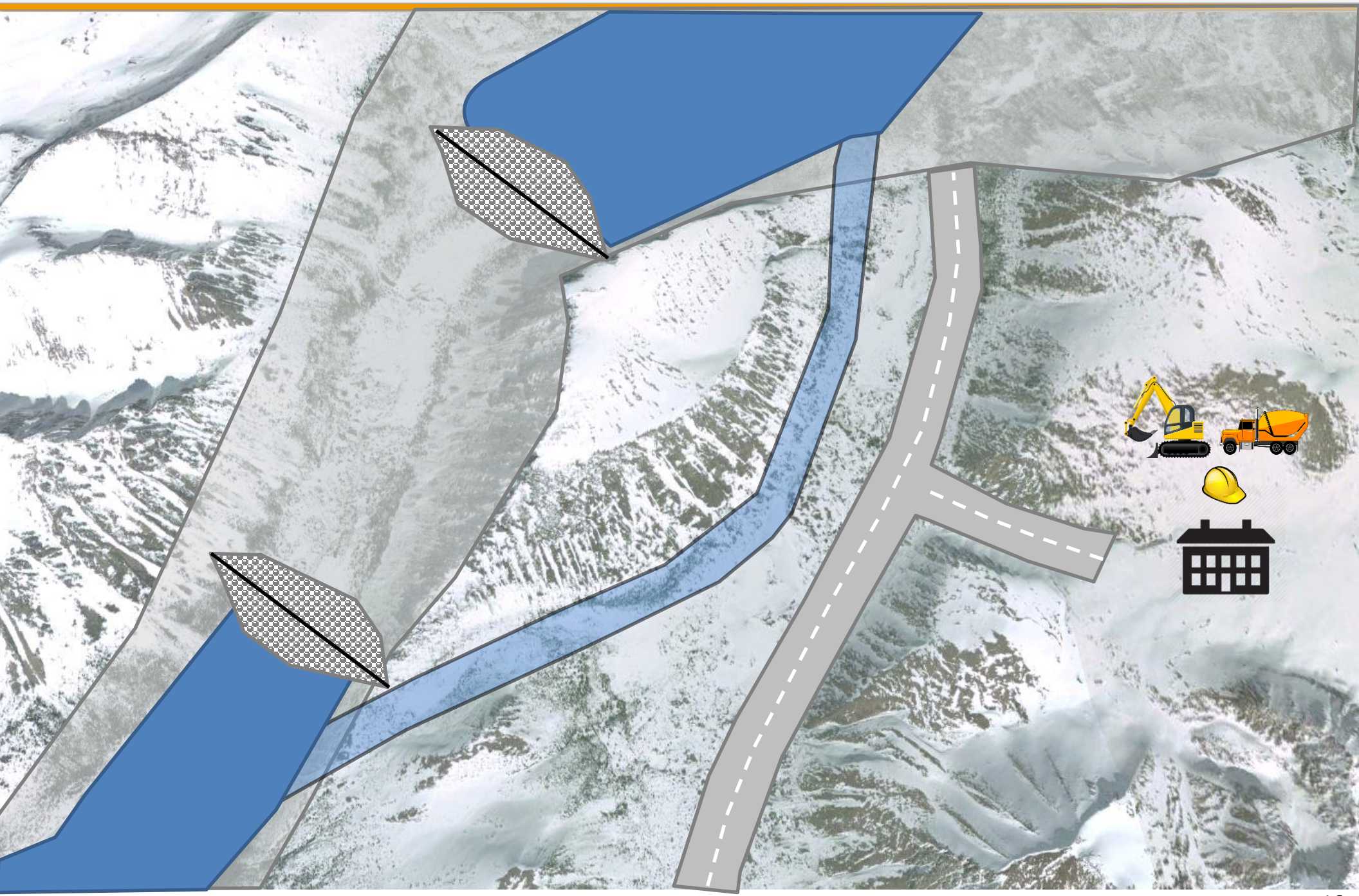
Design: Cofferdams (Low Flows)



Design: Cofferdam (High Flows)



Design: Dam Start

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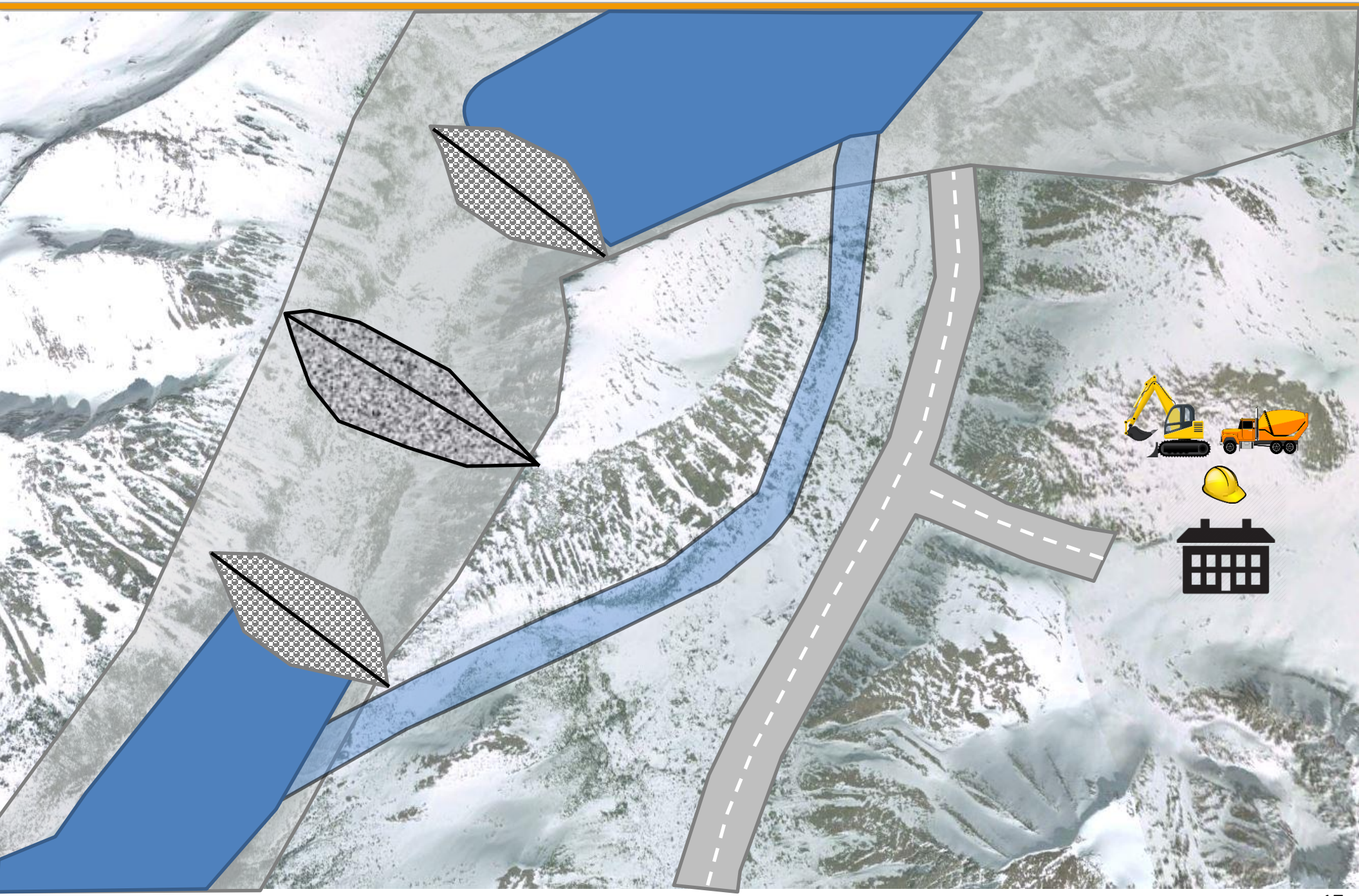

Design: Intake + Penstock + Powerhouse

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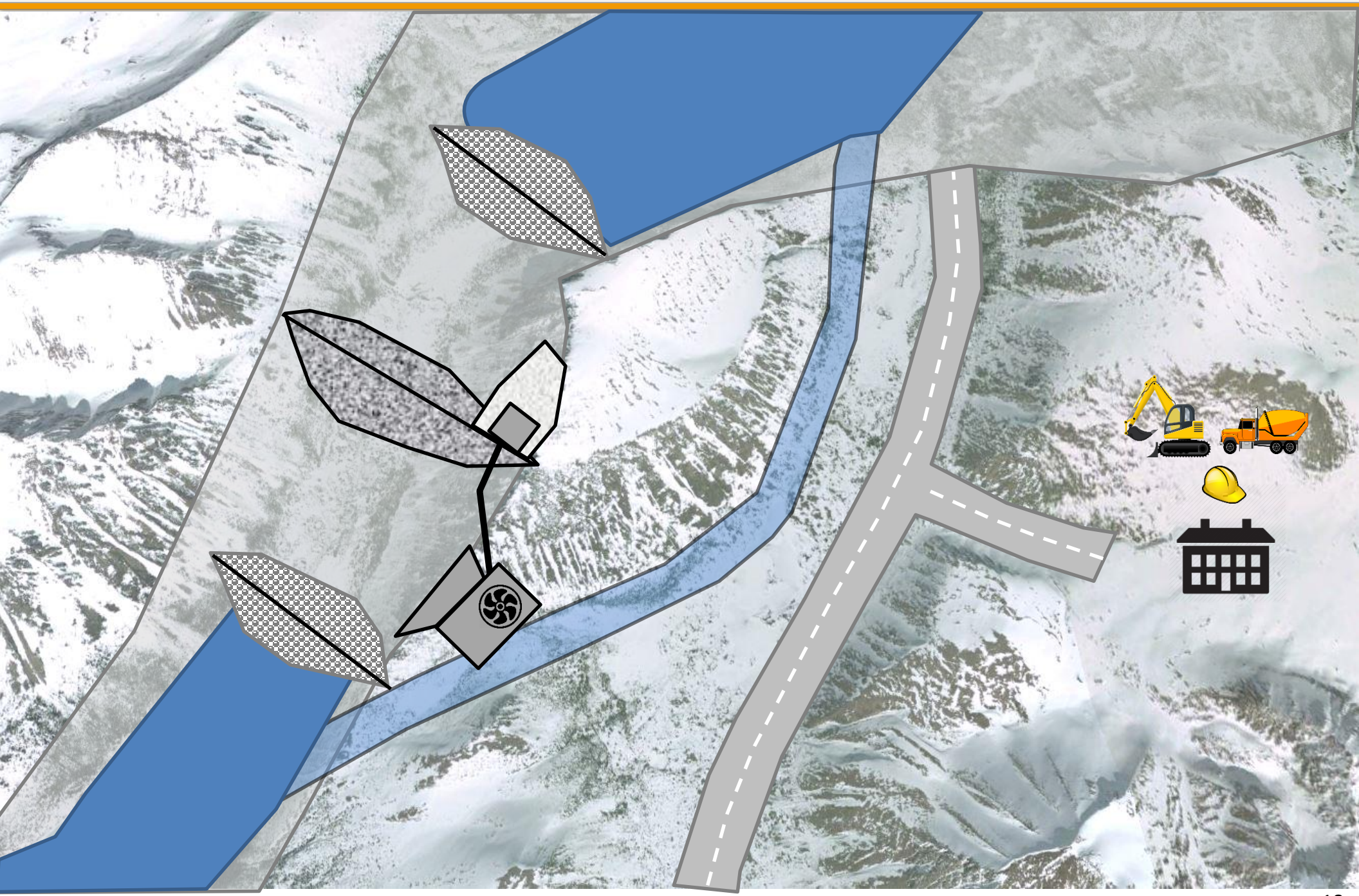

Design: Switchyard and Transmission Line

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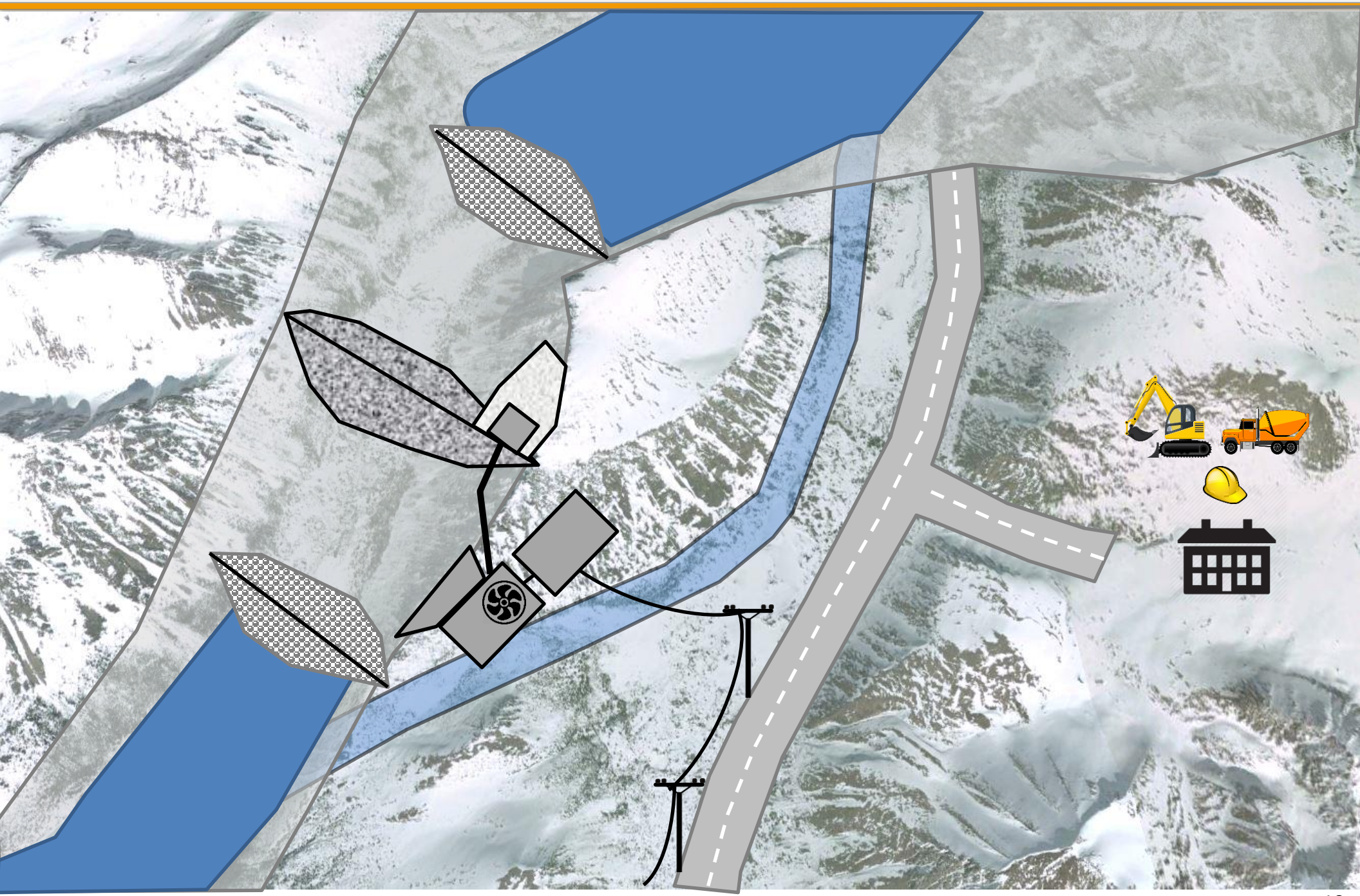

Design: Full Dam and Spillway

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Design: Fish Passage

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Design: Remove Diversion & Operate

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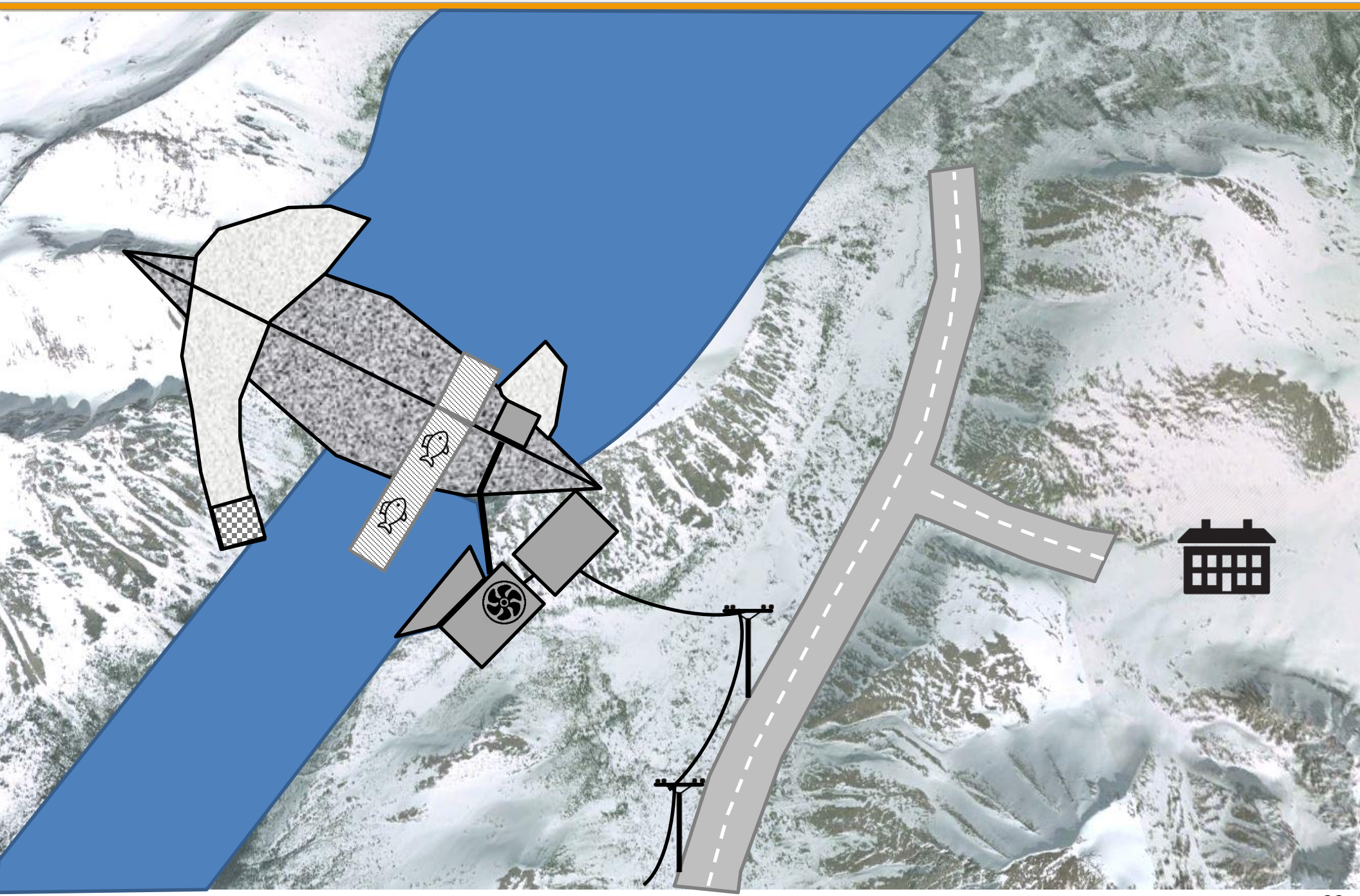
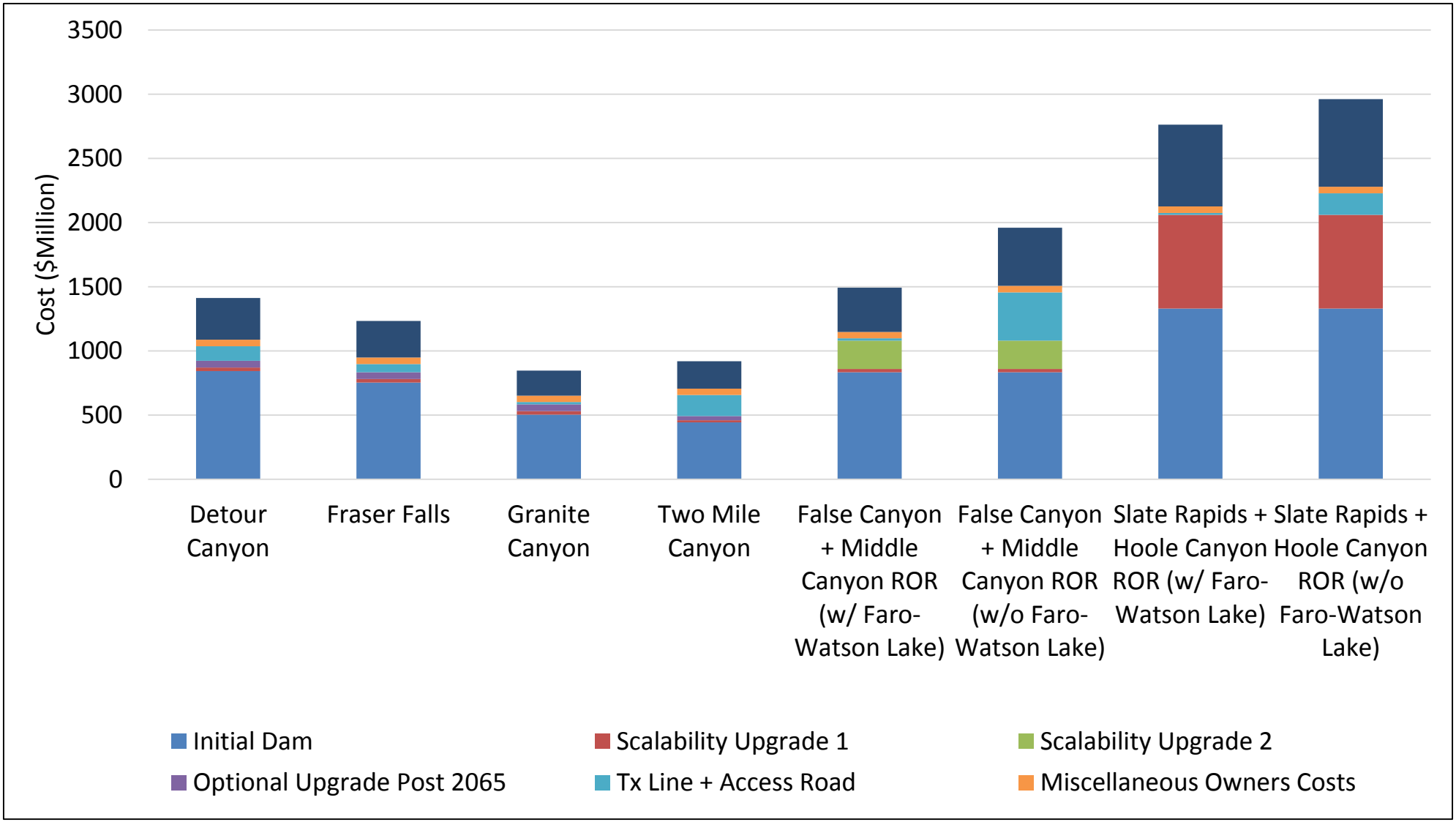


Cost

Cost: Project Costs



Cost: Project Costs

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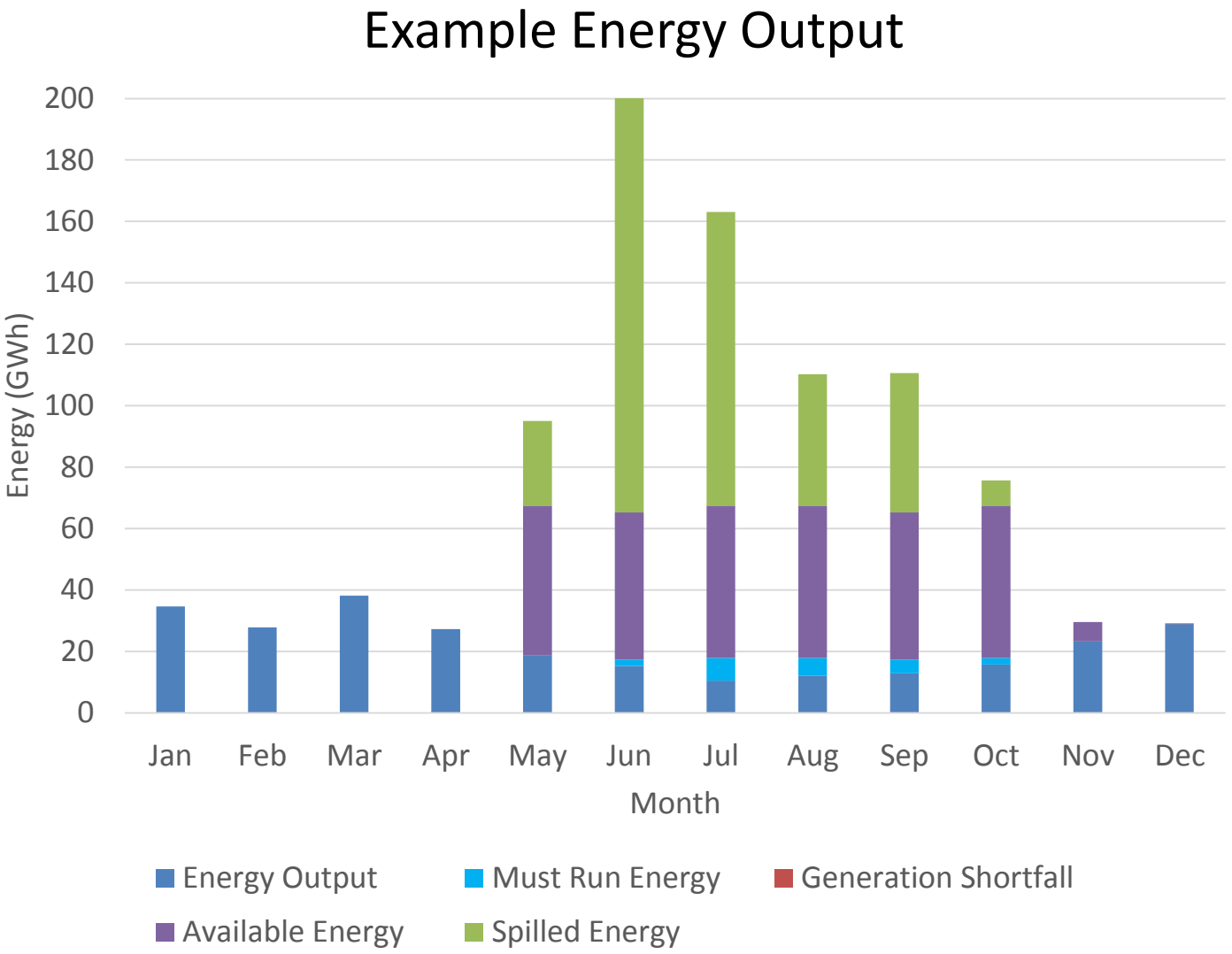
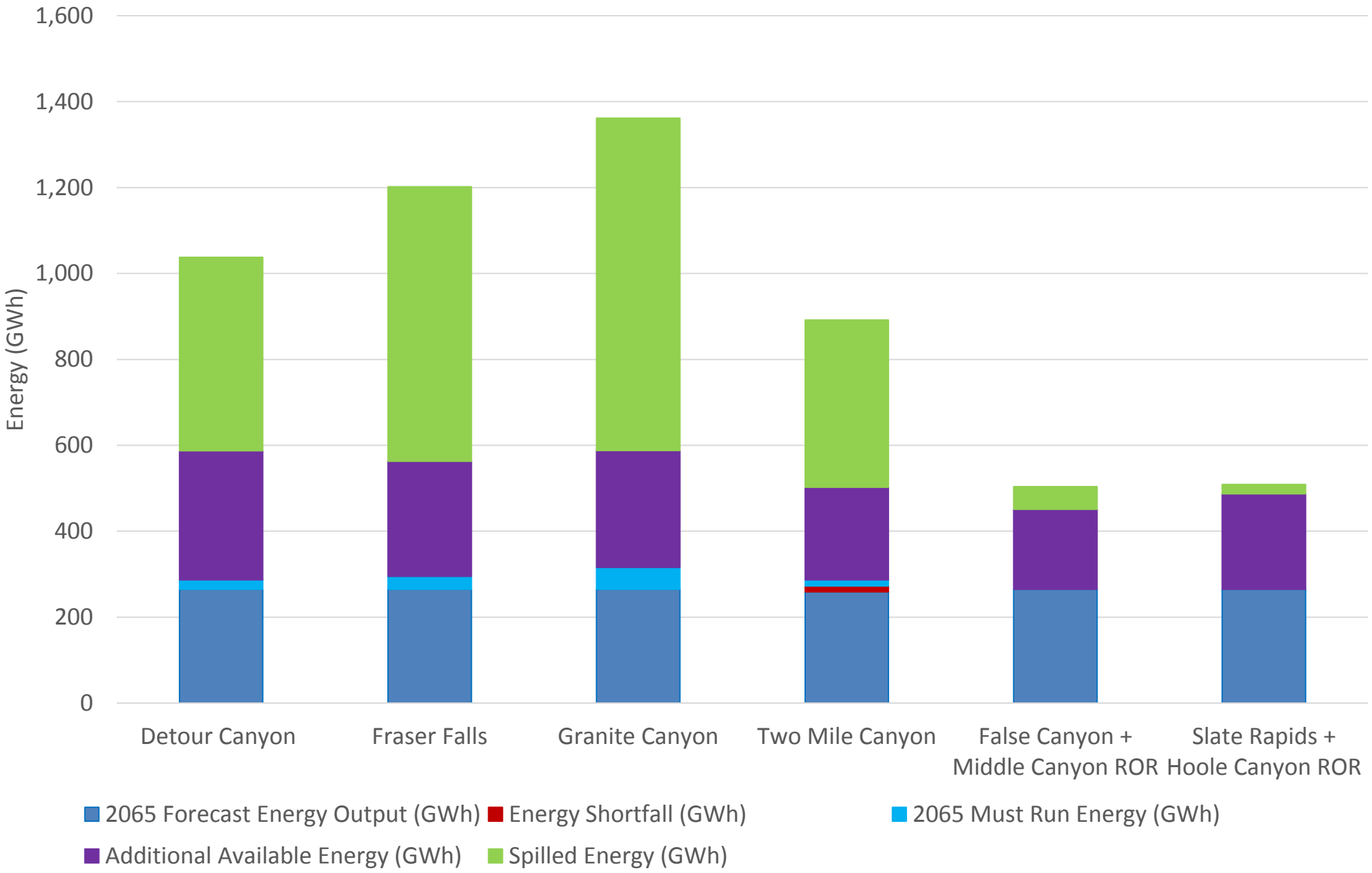
Project	Initial Dam	Scalability Upgrade 1	Scalability Upgrade 2	Post 2065	Tx Line + Road	Capital Cost
Detour Canyon	843	27	N/A	53	114	1413
Fraser Falls	753	27	N/A	54	64	1233
Granite Canyon	503	27	N/A	53	19	847
Two Mile Canyon	444	16	N/A	32	164	919
False + Middle ROR (w/ Faro-Watson Lake)	833	27	220	N/A	18	1493
False + Middle ROR (w/o Faro-Watson)	833	27	220	N/A	377	1959
Slate Rapids + Hoole ROR (w/ Faro-Watson)	1330	730	N/A	N/A	16	2764
Slate Rapids + Hoole ROR (w/o Faro-Watson)	1330	730	N/A	N/A	169	2962

Energy

Energy: Energy Types



Energy: Projects Energy Output

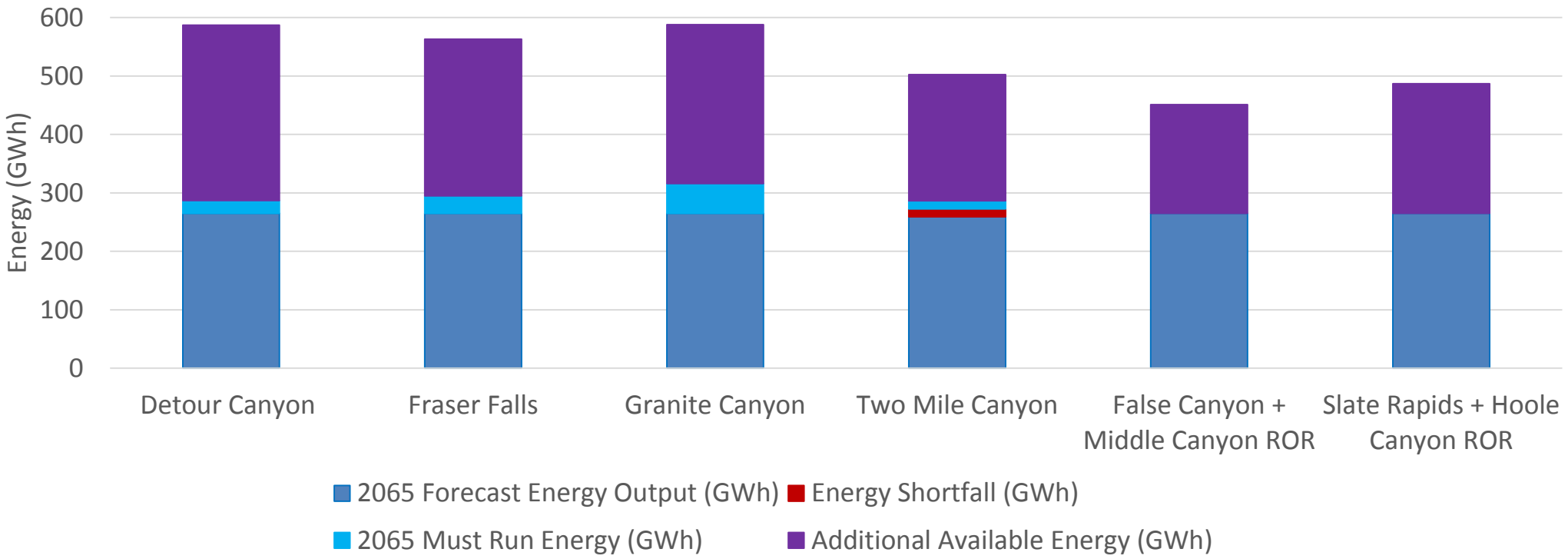


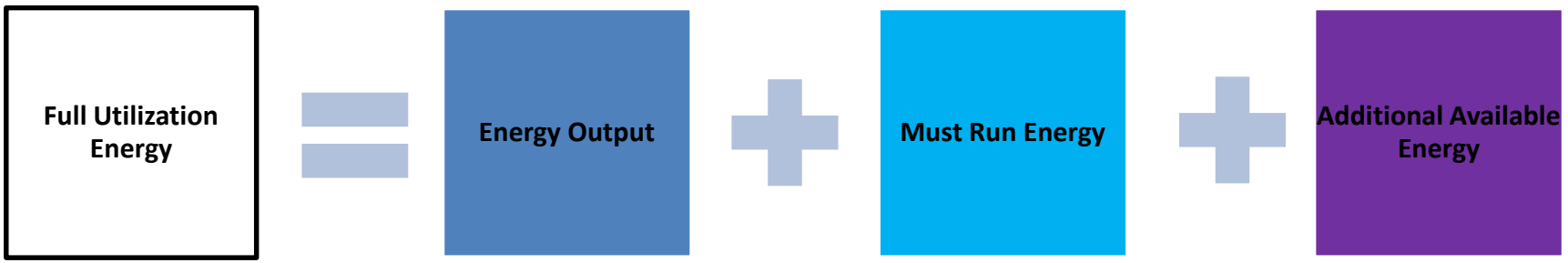
Energy: Projects Energy Output

Project	2065 Installed Capacity (MW)	2065 Forecast Energy Output (GWh)	2065 Must Run Energy (GWh)	Post 2065 Additional Available Energy (GWh)	Max Potential Energy Output (GWh)
Detour Canyon	60	265	22	300	587
Fraser Falls	57	265	30	268	563
Granite Canyon	57	265	51	272	588
Two Mile Canyon	54	259	14	216	489
False + Middle Canyon ROR	78	265	0	186	451
Slate Rapids + Hoole ROR	107	265	0	222	487

Levelized Cost of Energy (LCOE)

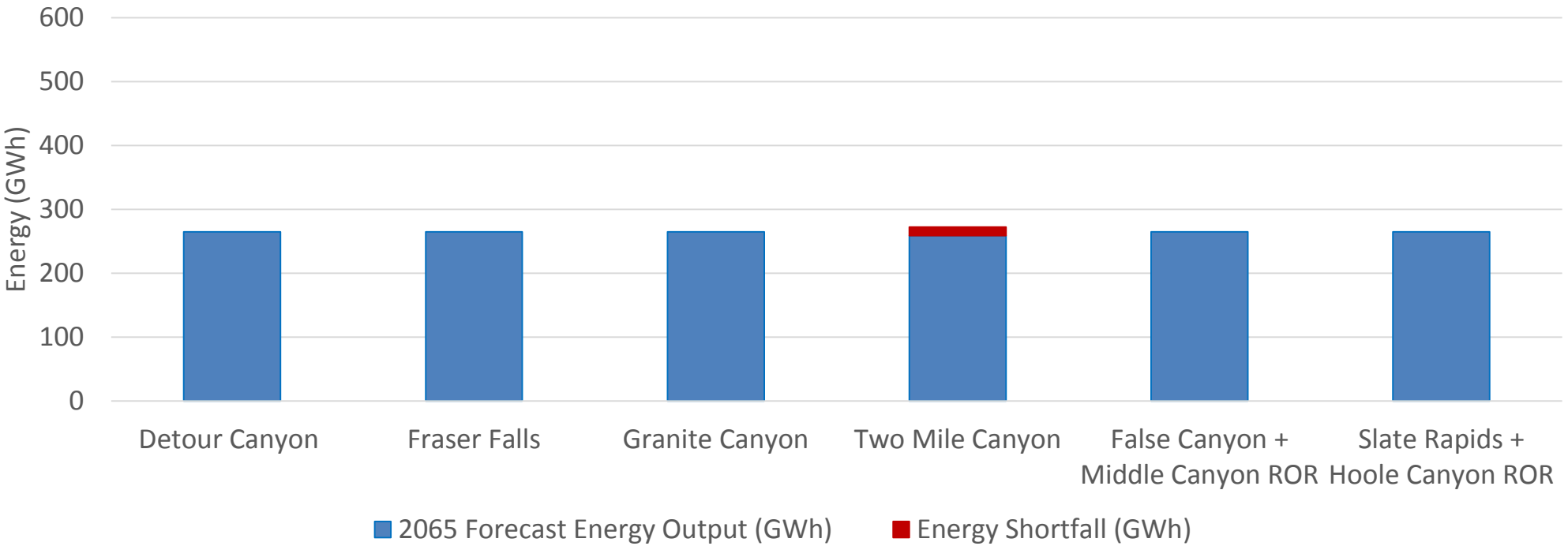
LCOE: Full Utilization LCOE

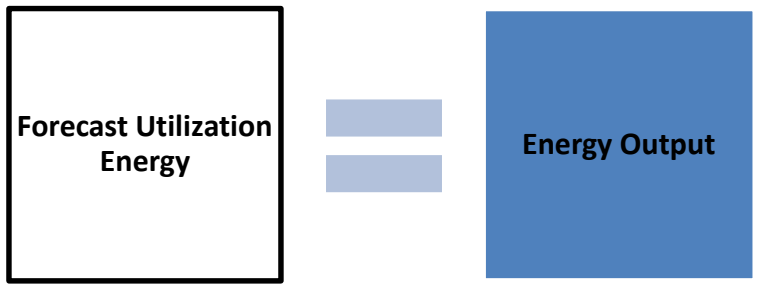




$$Full\ Utilization\ LCOE = \frac{Total\ Present\ Value\ of\ Costs}{Total\ Present\ Value\ of\ \textbf{Full Utilization Energy}}$$

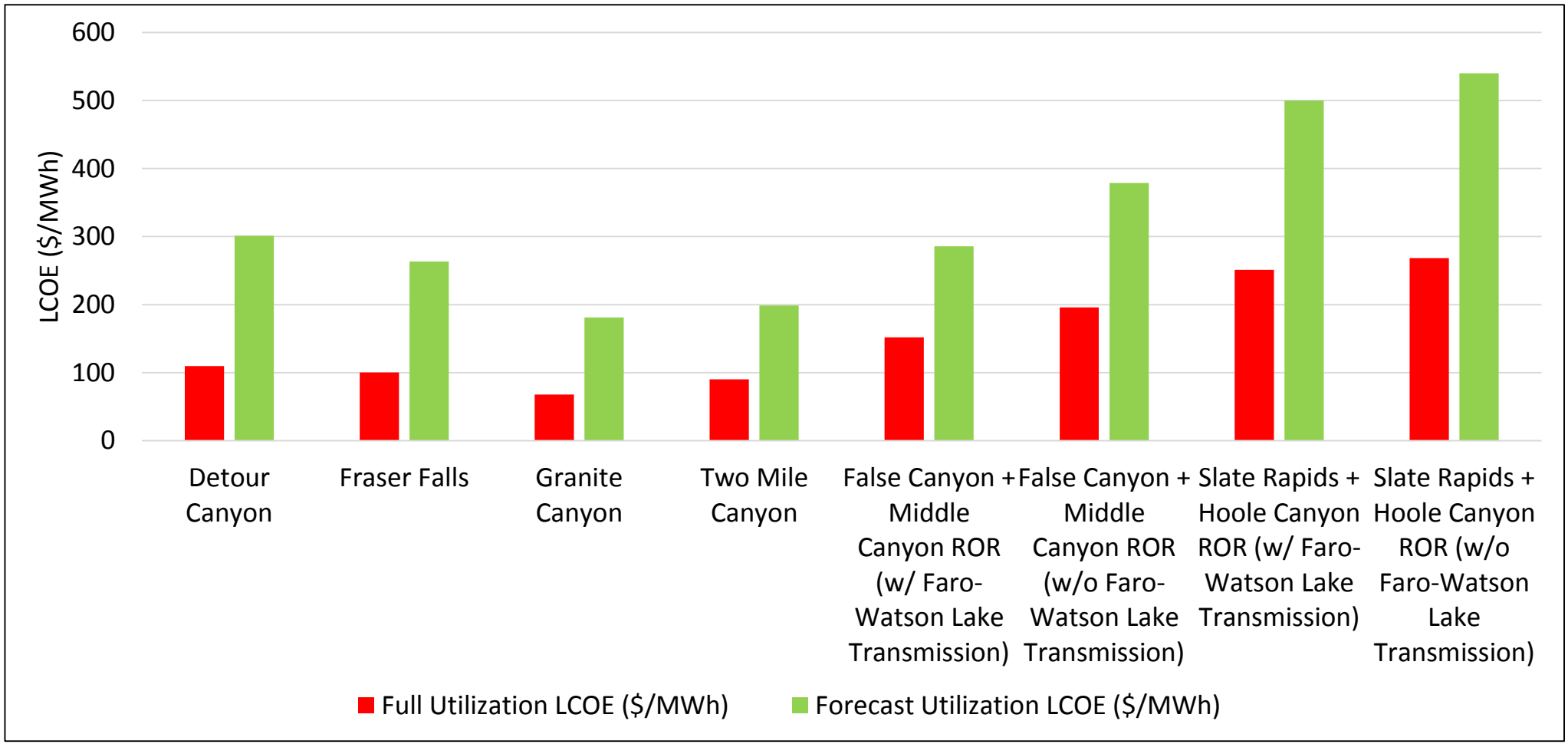
LCOE: Forecast Utilization LCOE





$$Forecast\ Utilization\ LCOE = \frac{Total\ Present\ Value\ of\ Costs}{Total\ Present\ Value\ of\ \textbf{Forecast Utilization Energy}}$$

LCOE: Projects LCOE



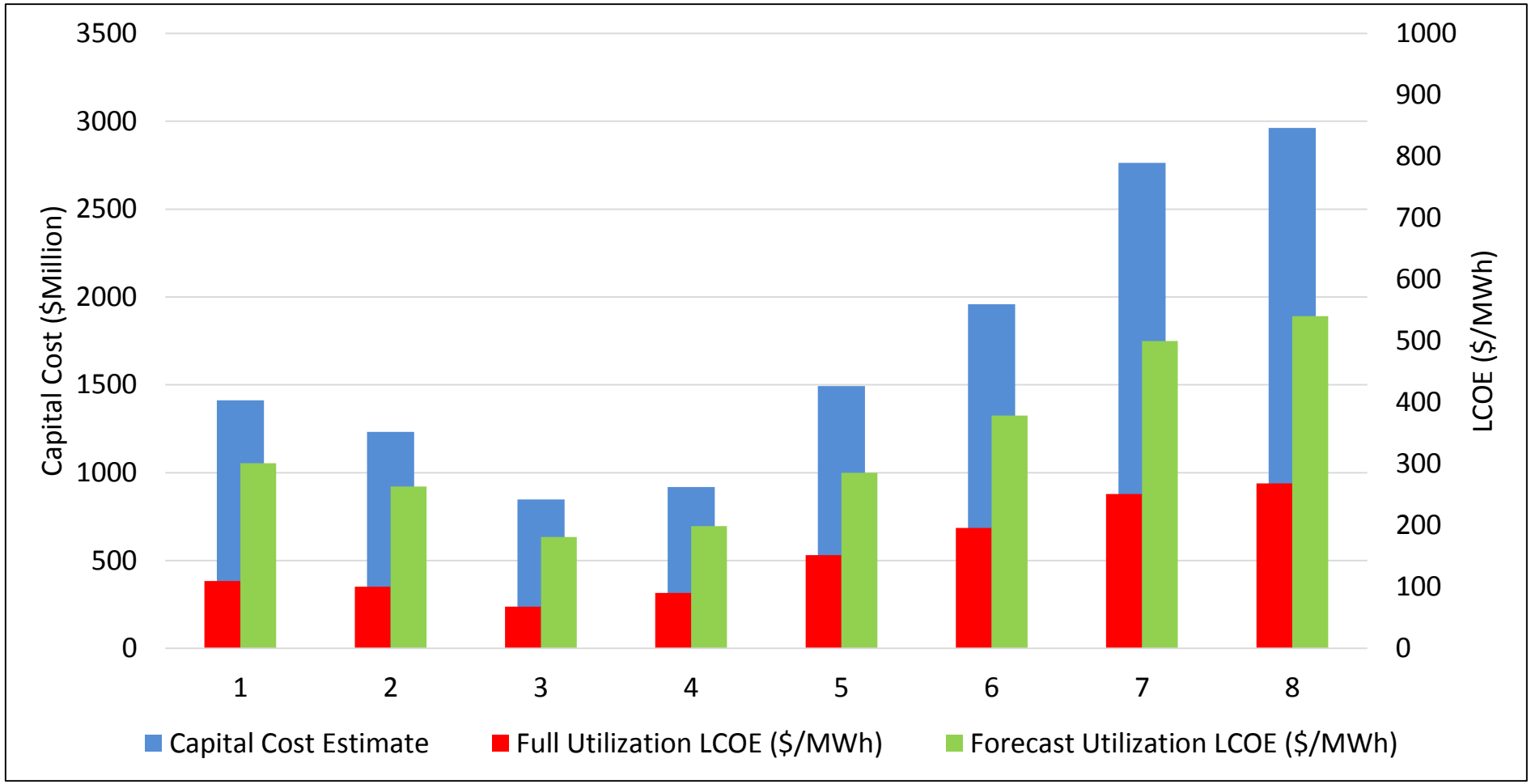
- Full Utilization LCOE ranges from $68/MWh to $269/MWh
- Forecast Utilization LCOE ranges from $181/MWh to $540/MWh

Energy: Projects LCOE

Project	Full Utilization LCOE ($/MWh)	Forecast Utilization LCOE ($/MWh)
Detour Canyon	110	301
Fraser Falls	100	263
Granite Canyon	68	181
Two Mile Canyon	90	199
False Canyon + Middle Canyon ROR (w/ Faro-Watson Lake)	152	286
False Canyon + Middle Canyon ROR (w/o Faro-Watson Lake)	196	379
Slate Rapids + Hoole Canyon ROR (w/ Faro-Watson Lake)	251	500
Slate Rapids + Hoole Canyon ROR (w/o Faro-Watson Lake)	269	540

Summary

Summary: Projects Cost and LCOE



- Slate Rapids + Hoole Canyon ROR has the highest LCOE ($269/MWh, $540/MWh)
- Granite Canyon has the lowest LCOE ($68/MWh, $181/MWh)

Thank You & Questions…

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