

OCT 4 – 6, 2015 • Queens University • Kingston, ON Canada
Challenges and Innovations in Tunnelling

Data management for probabilistic tunnel modelling

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Tunnelling Association of Canada
Association Canadienne Des Tunnels





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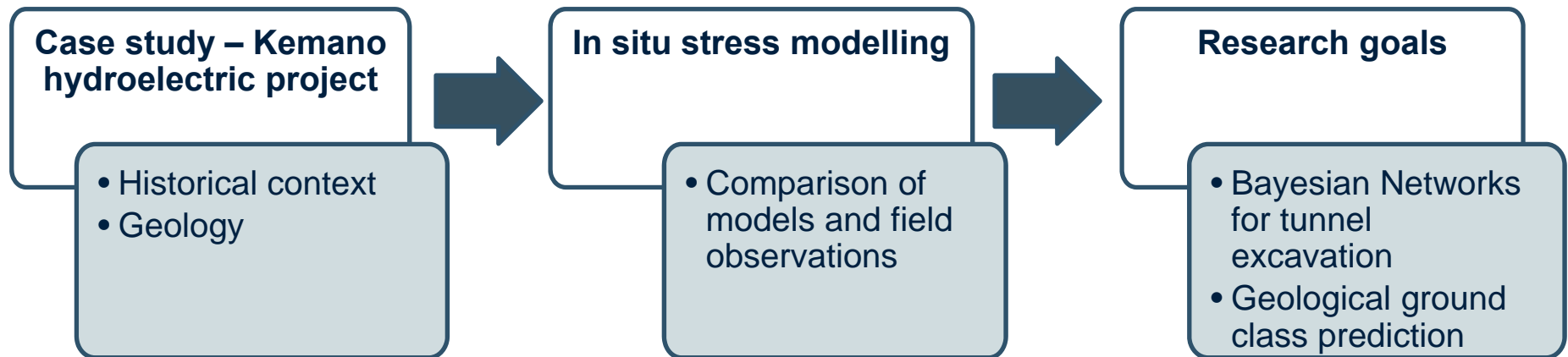
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Overview





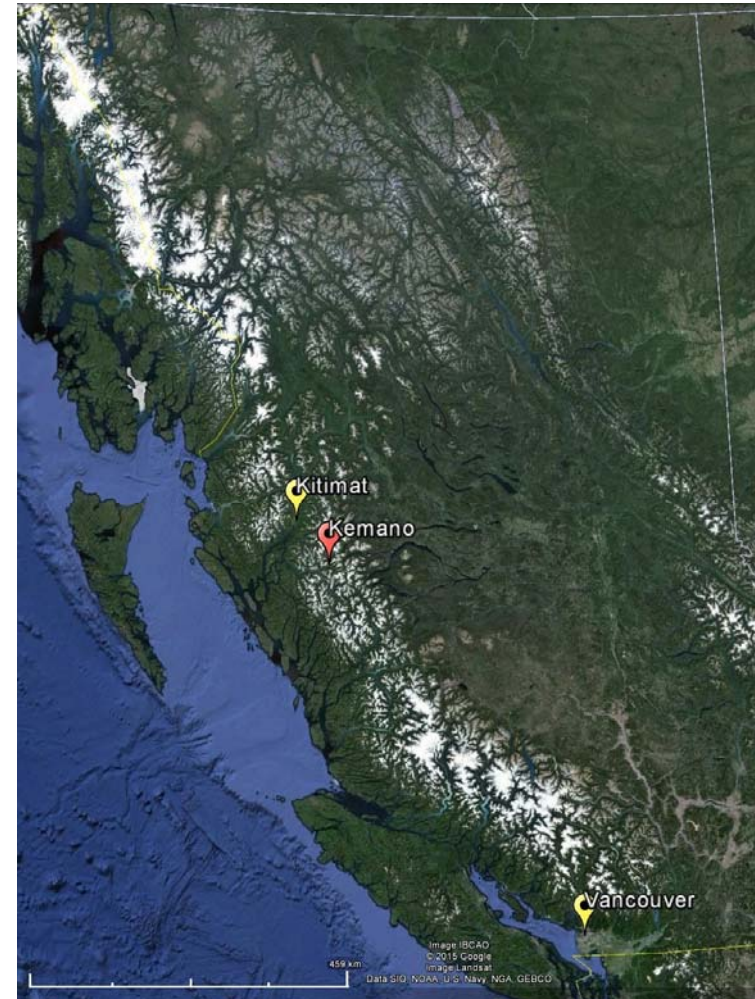
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Case Study – Kemano hydroelectric project

- Located ~600 km north of Vancouver
- 8 turbines in powerhouse inside Mount DuBose
- 860 m of pressure head
- \$500 million of capital and 6,000 construction workers in 1950
- \$11 billion worth of infrastructure today



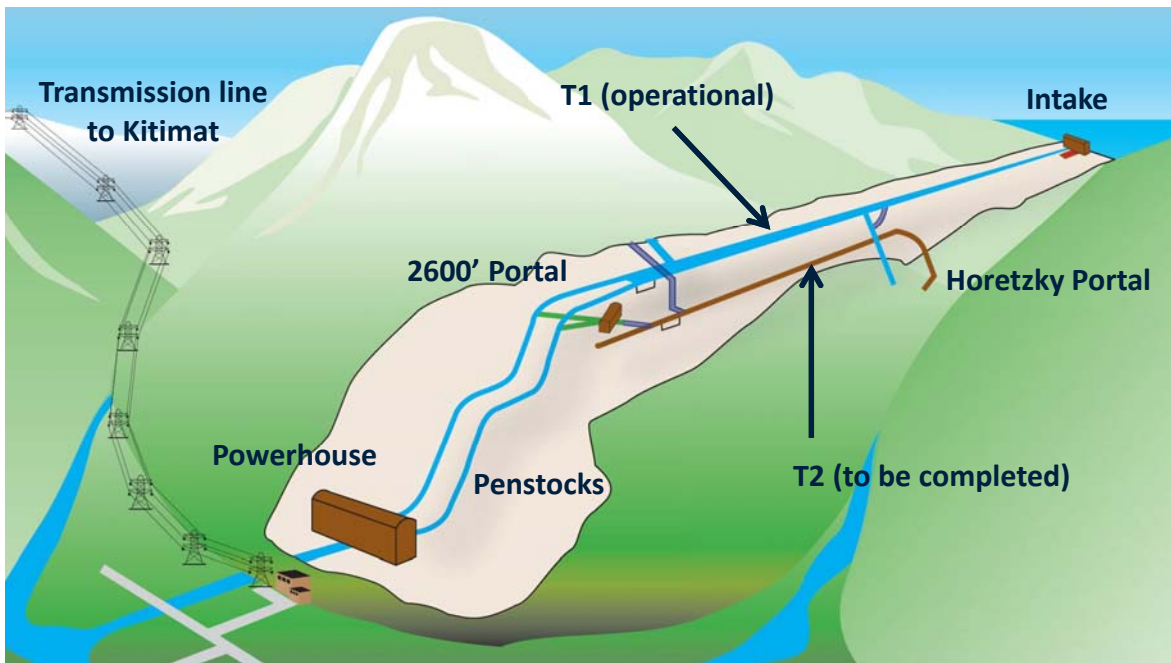


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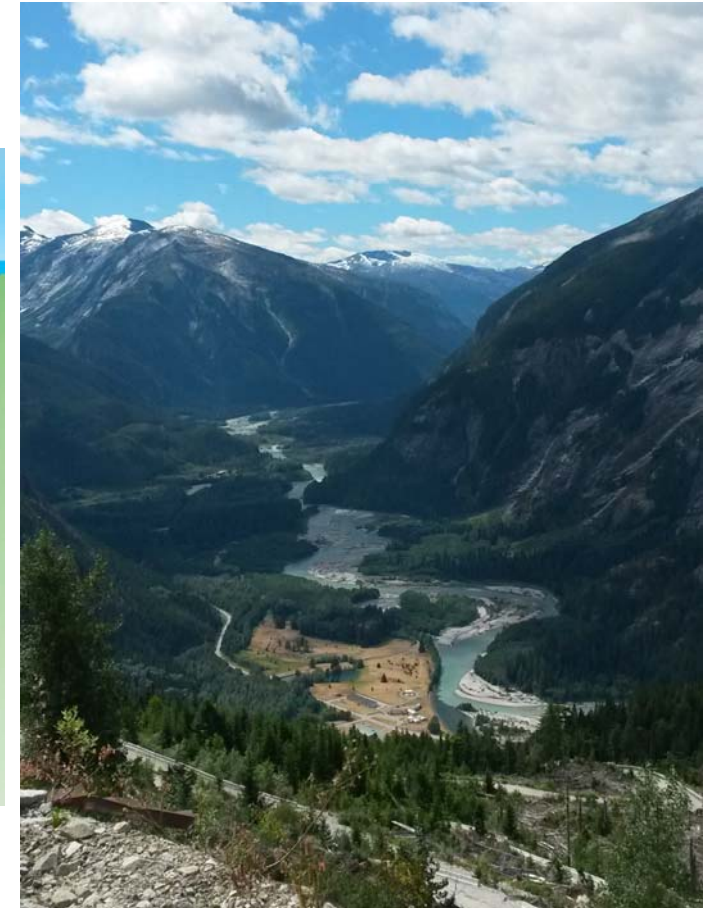


Site Infrastructure



Source: Hatch Ltd.

Reversal of the Nechako River by constructing Kenney Dam



View of camp from 2600' Portal



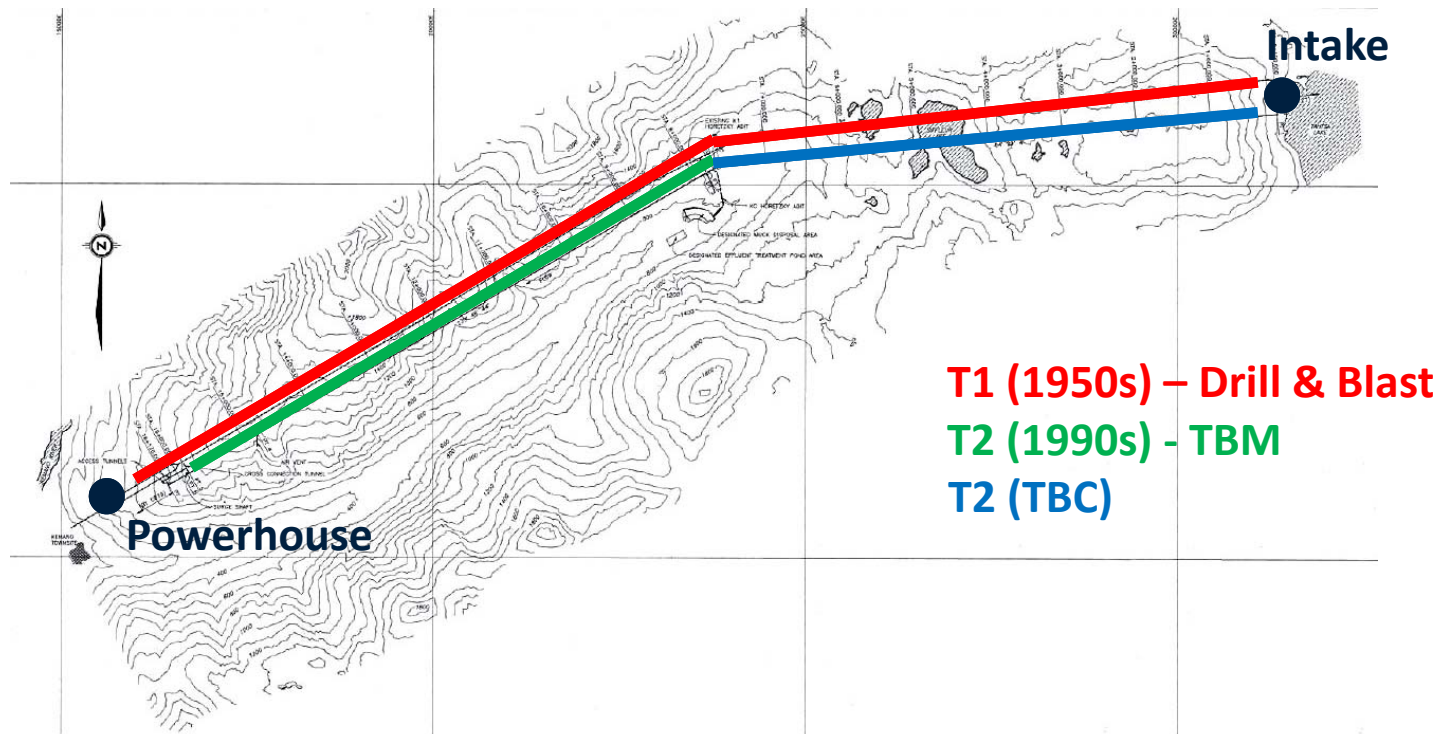
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Water Conveyance Tunnels

- Parallel, 16 km long tunnels



Source: Hatch Ltd.



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Drill and Blast Excavation (T1)





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Geological Conditions (D/S T2)



Source: Hatch Ltd.

Coast Intrusions - Granodiorite and diorite



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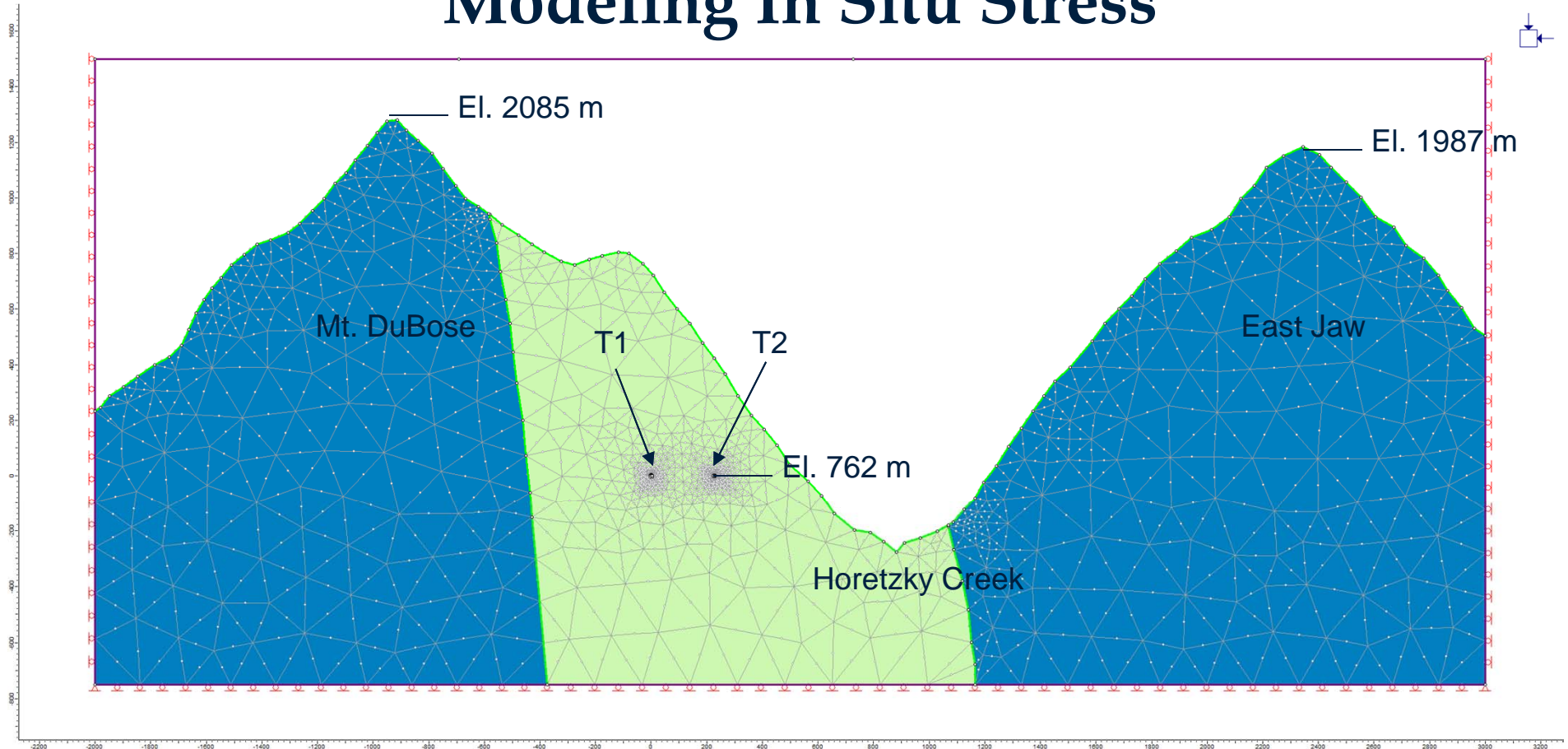
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


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Modeling In Situ Stress



-  Hazelton group (metasedimentary)
-  Horetzky dyke (diorite intrusion)



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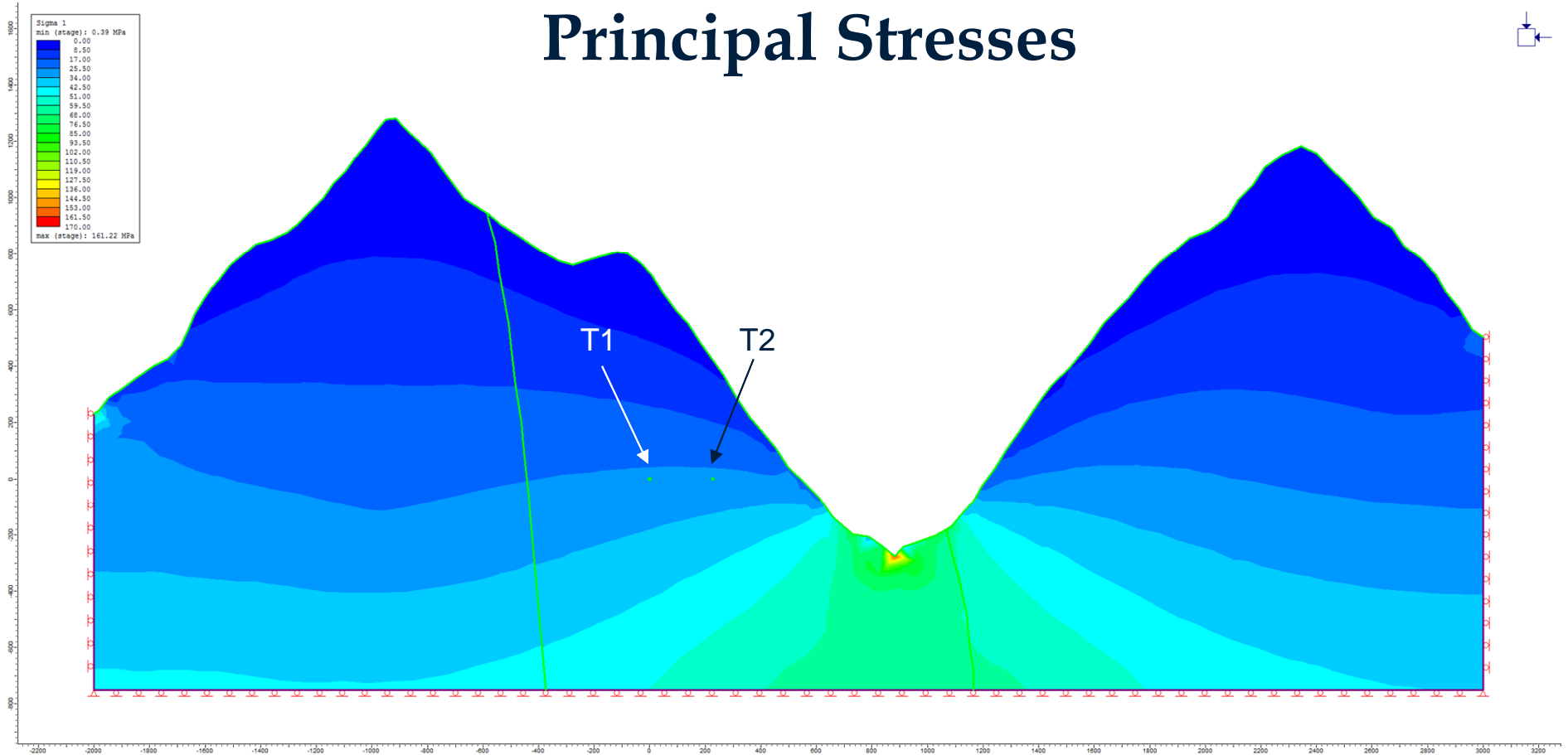
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Principal Stresses



	Principal		Tangential		K ratio
	σ_1 (MPa)	σ_3 (MPa)	σ_{max} (MPa)	σ_{min} (MPa)	
T1	27.0	10.9	70.2	5.6	2.5
T2	27.5	6.6	76.0	-7.7	4.2



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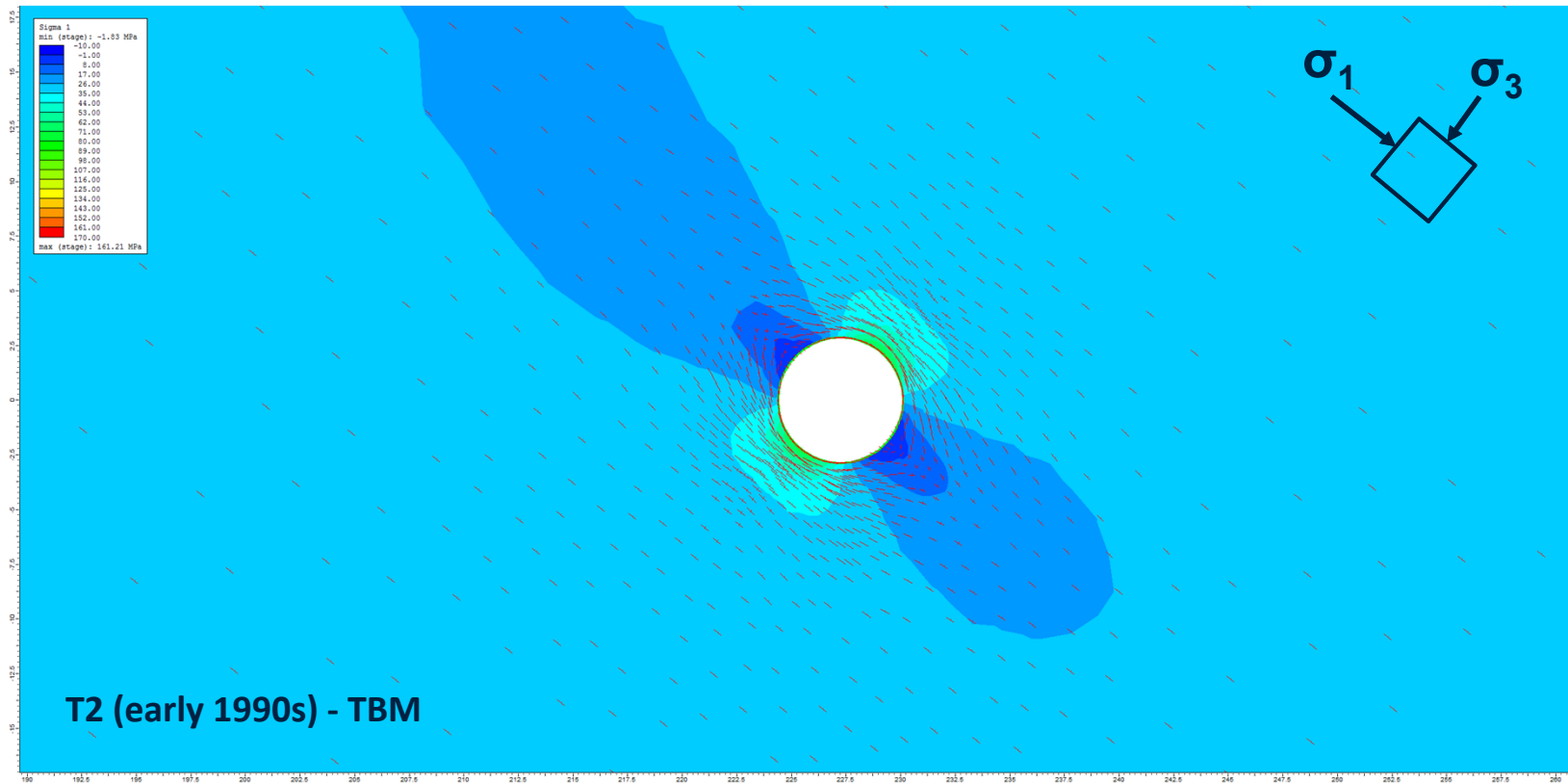
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Major Principal Stress Orientations





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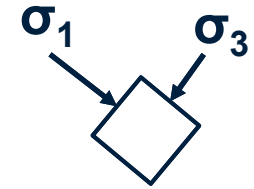
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Field Observations





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Relation to Research

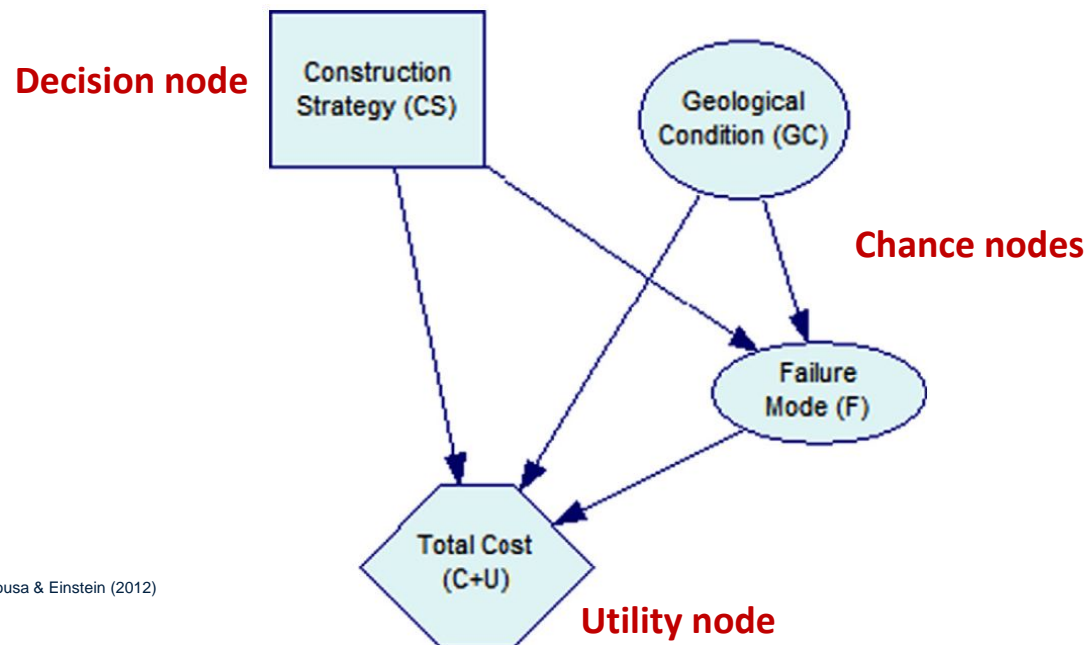
- Development, calibration and application of Bayesian Network
- Statistical analysis of ground class parameters along tunnel alignment to use as inputs



Source: Google

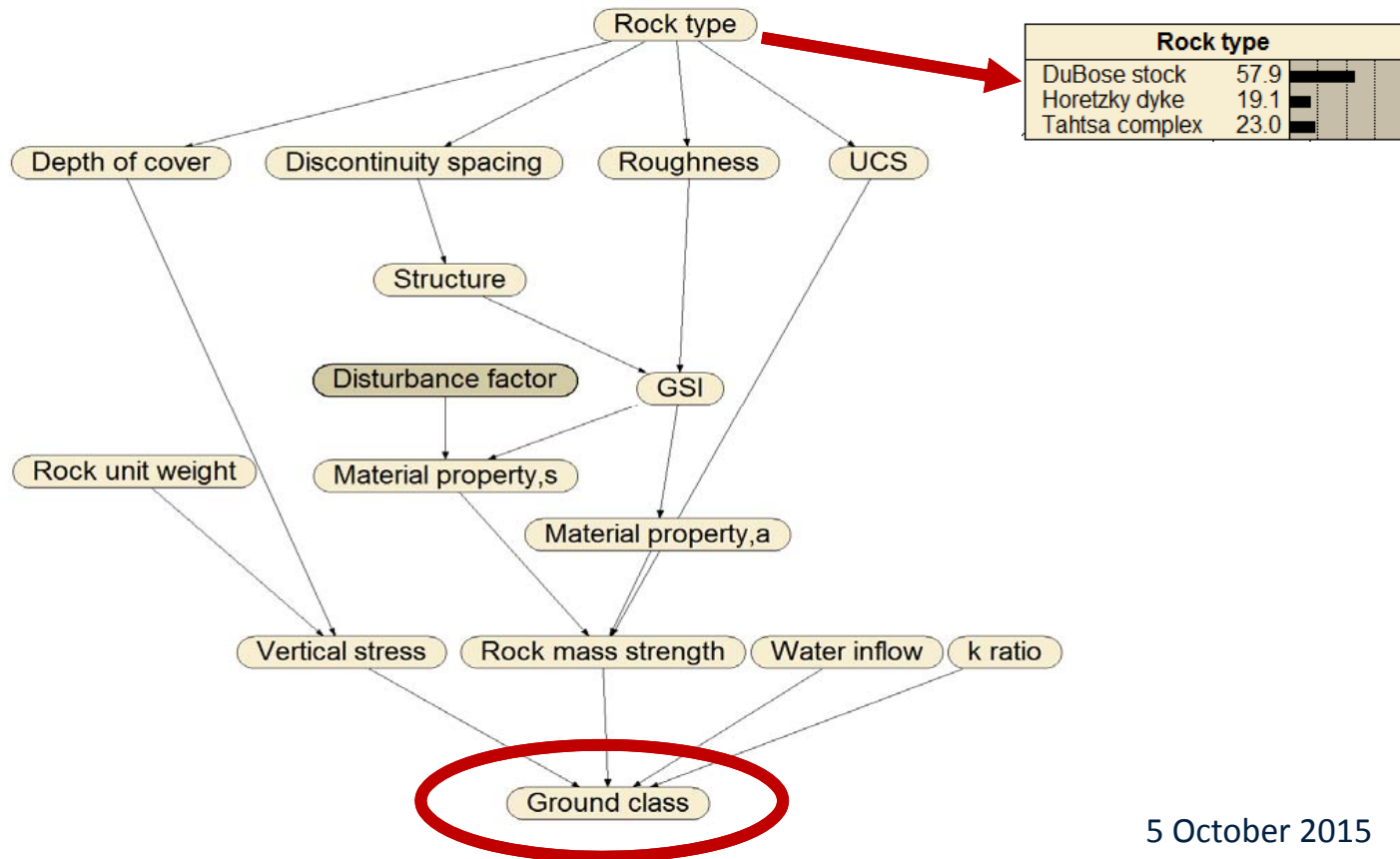
Bayesian Networks

- Probabilistic frameworks used to determine the conditional dependencies between random input variables
- Variables are discretized into “states”
- Evaluate these variable dependencies over iterations or time-steps (“Dynamic” Bayesian Network)



Geological and Ground Class Prediction using a DBN

- Predict the geological conditions at a particular slice of the tunnel, and then use this to predict conditions at the next slice





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Geological Conditions (D/S T2)



Source: Hatch Ltd.

Coast Intrusions - Granodiorite and diorite



Next Step: Ground Class → Support Class

Support Class	Dowels/Bolts	Shotcrete	Wire Welded Fabric	Other
I	Unsupported			
II	2.5m long, 25mm dia. grouted dowels, 1.5 m c/c 10 to 2 o'clock	75 mm minimum	-	-
III	2.5m long, 25mm dia. grouted dowels, 1.5 m c/c Springline to springline	75 mm minimum	4 in. squares or FRS	-
IV	2.5m long, 25mm dia. grouted dowels, 1 m c/c 5 to 7 o'clock	100 mm minimum	4 in. squares or FRS	Steel sets



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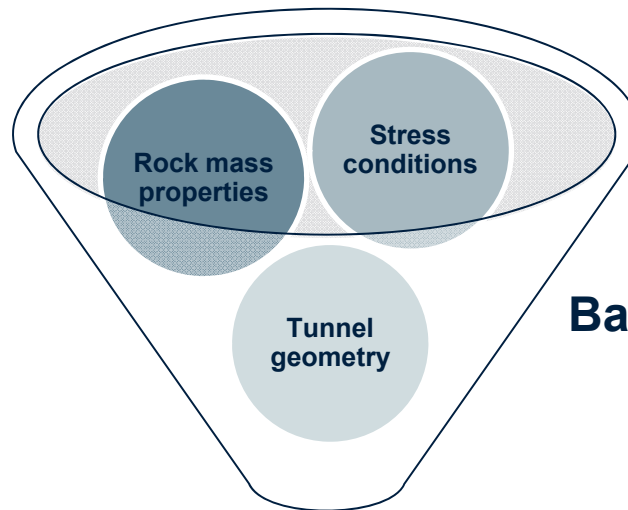


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Research Summary

Kemano case study



Bayesian Network



Ground Class

(as a function of tunnel chainage)



Support Class

(as a function of tunnel chainage)



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