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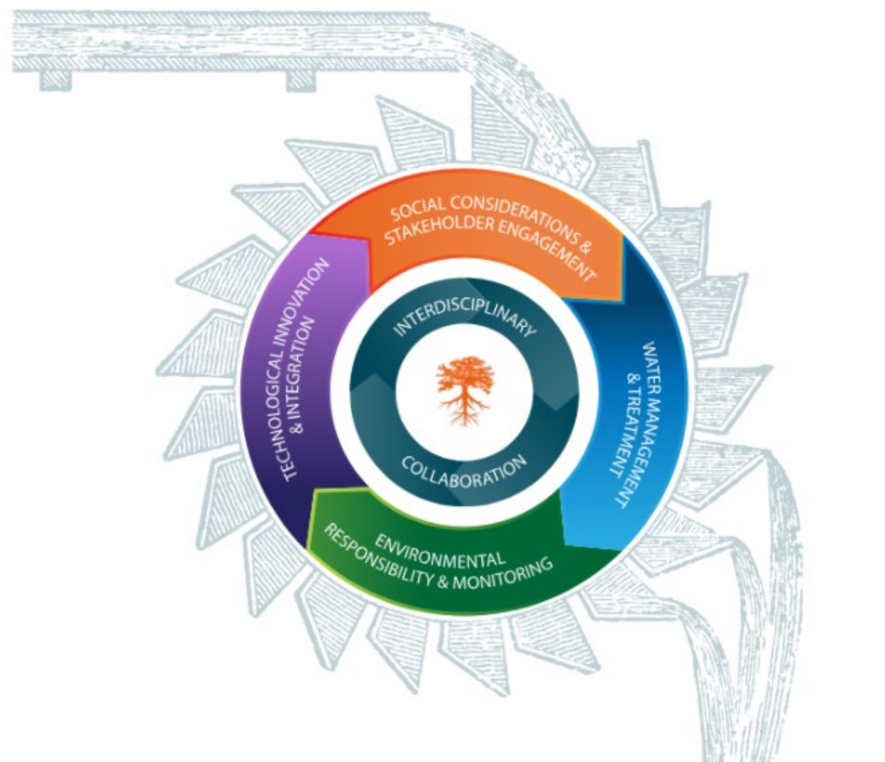
Water Effects with the Neo-Marvin Orebody - Emerging insights

4/5th Dec 2024 Communications Session



GWI water wheel framework

Global Water Initiative

CEEC THE FUTURE

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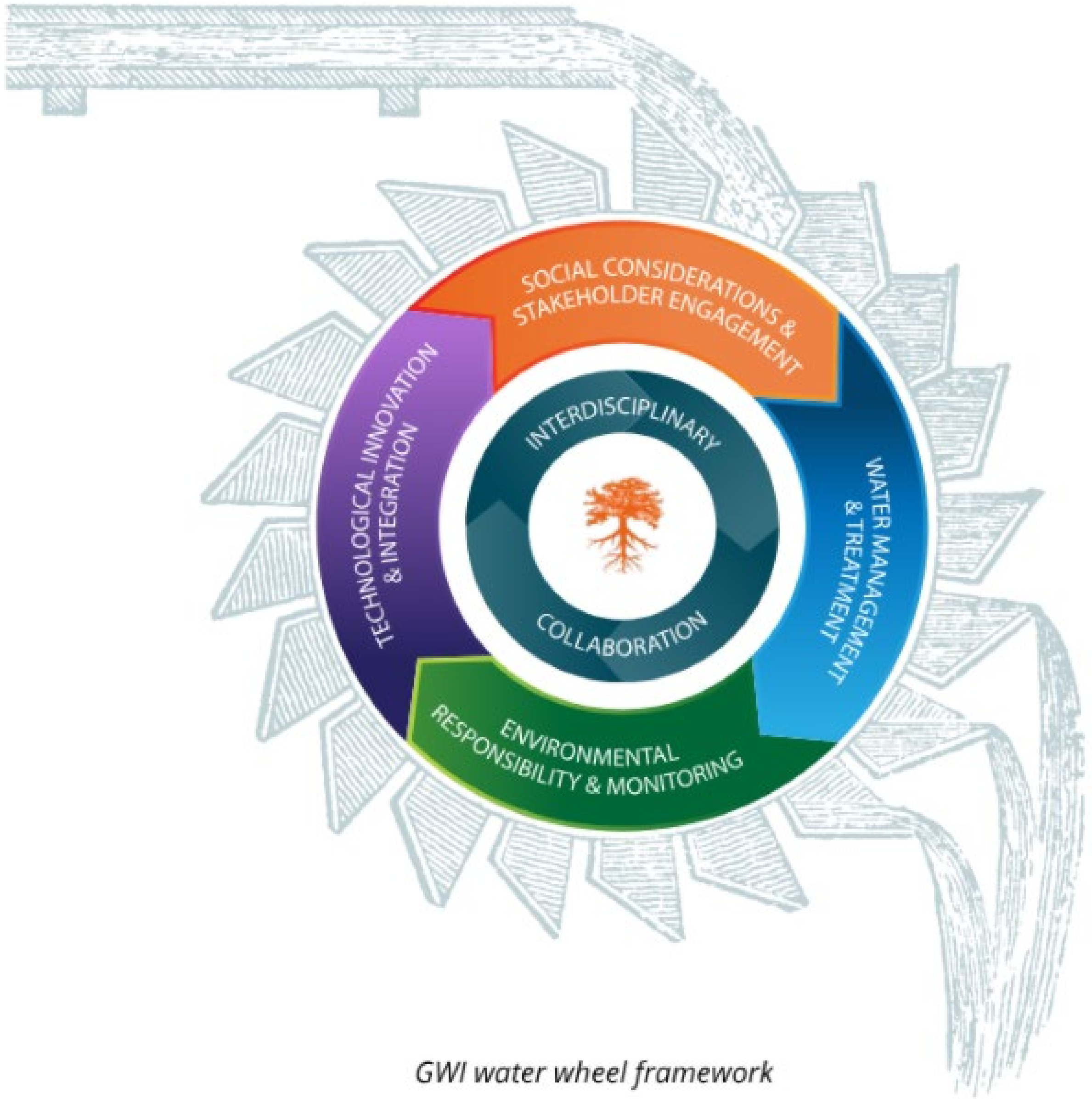
Context & Objectives

CEEC GWI Enterprise Optimisation Case Study



GWI water wheel framework

This case study seeks to:

- Combine the objectives of the GWI with the notion of Integrated Strategic Planning
- Promote comparisons between context-specific options for the preservation of water resources.

It is a preliminary meta-study exploring how to model water consumption, treatment & management, and link directly to:

- the LOM plan;
- the production scale; whilst,
- considering climatic & geological contexts.

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Highest Level Hypotheses

There is a link between hydrology and mine planning that is not accounted for in modelling in either discipline; it should be.

Material changes in water-related costs (infrastructure, treatment, source or cost-structure) will have an effect on the size, shape and scheduling of the orebody. (Second-order effects).

Material changes motivated by third-order issues (social, environmental) are nonetheless mitigated by such second-order effects.

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Agenda

Today is a communications session at the half-way point, describing the model build and early insights.

1. Introductions & Context
2. Neo Marvin Visualisation
3. The work so far
4. Second-order Effects explanation
5. The work contemplated in Jan/Feb 2025
6. Other work to consider
7. Discussion
8. Concluding remarks

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Your Study Team

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Craig Davies
Melbourne, VIC, Australia

Three years with Whittle Consulting, Geology and Maths, numerical modeling and programming expert.

Leigh Lawrence
Melbourne, VIC, Australia

Tech Services Specialist. Geologist and Research Scientist.

Philip Bangerter
Brisbane, QLD, Australia

Project manager with 40 years experience; Process Engineer, Sustainability Specialist, Study Manager.

Gerald Whittle
Melbourne, VIC, Australia

CEO. Peer review and Consultant support.

Neo-Marvin Model

Porphyry Cu–Au deposit

- Three mineralised rock types.
- Weathering profile – oxidised, transitional, fresh.
- Realistic distribution of elements.
- Not commercially sensitive.
- Built/Updated by Whittle Consulting.

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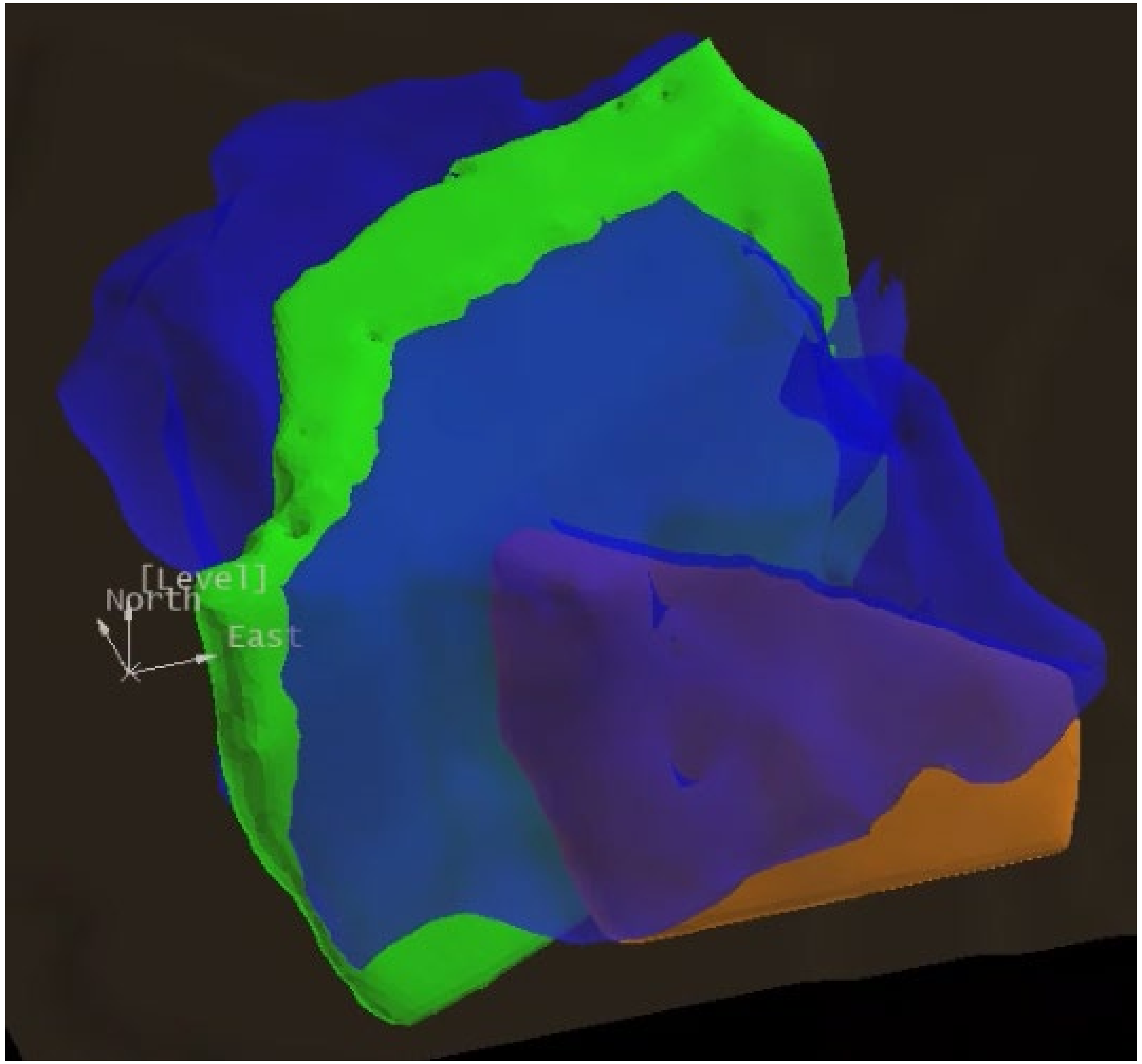
Neo-Marvin Visualisation



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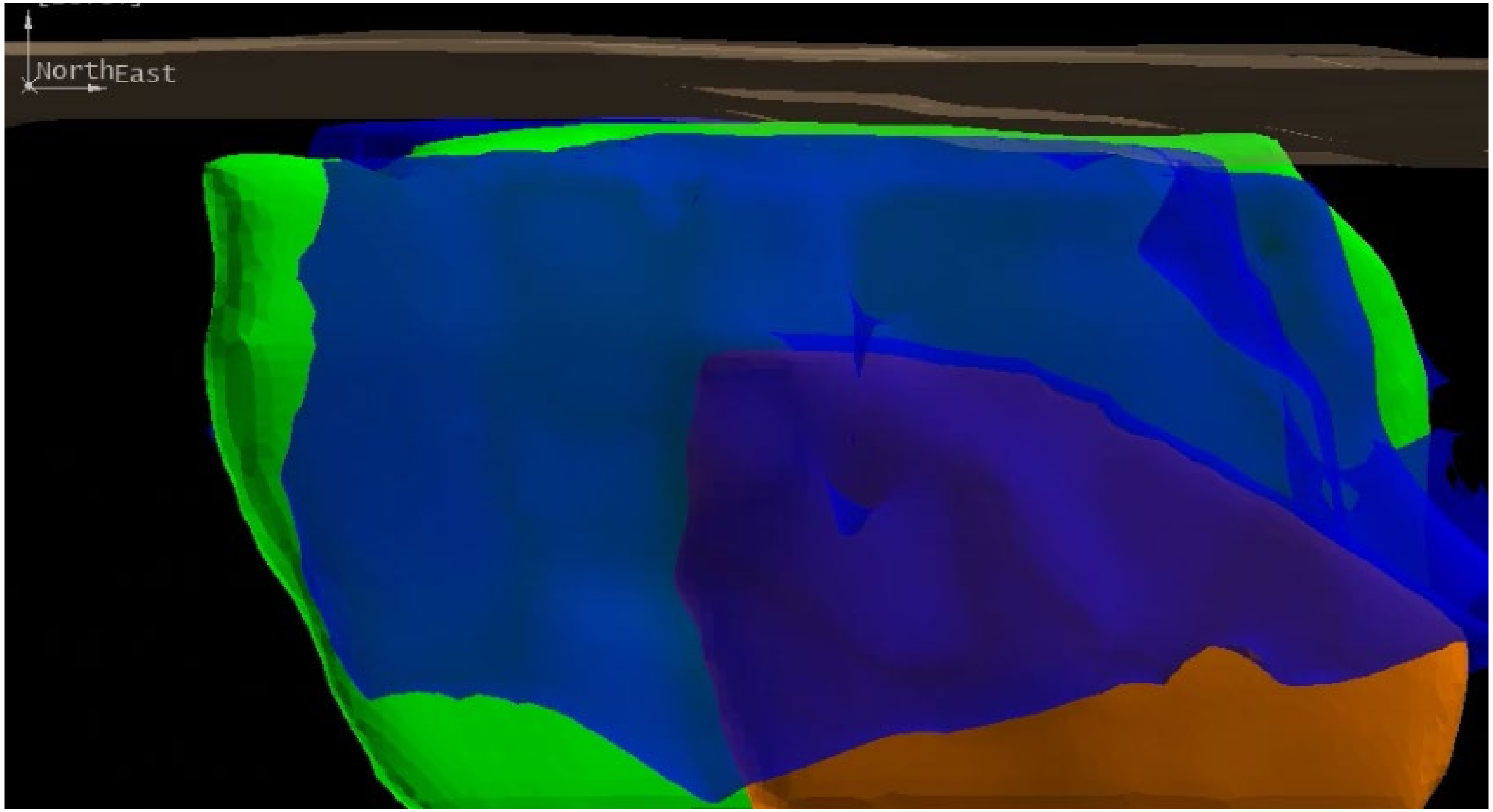
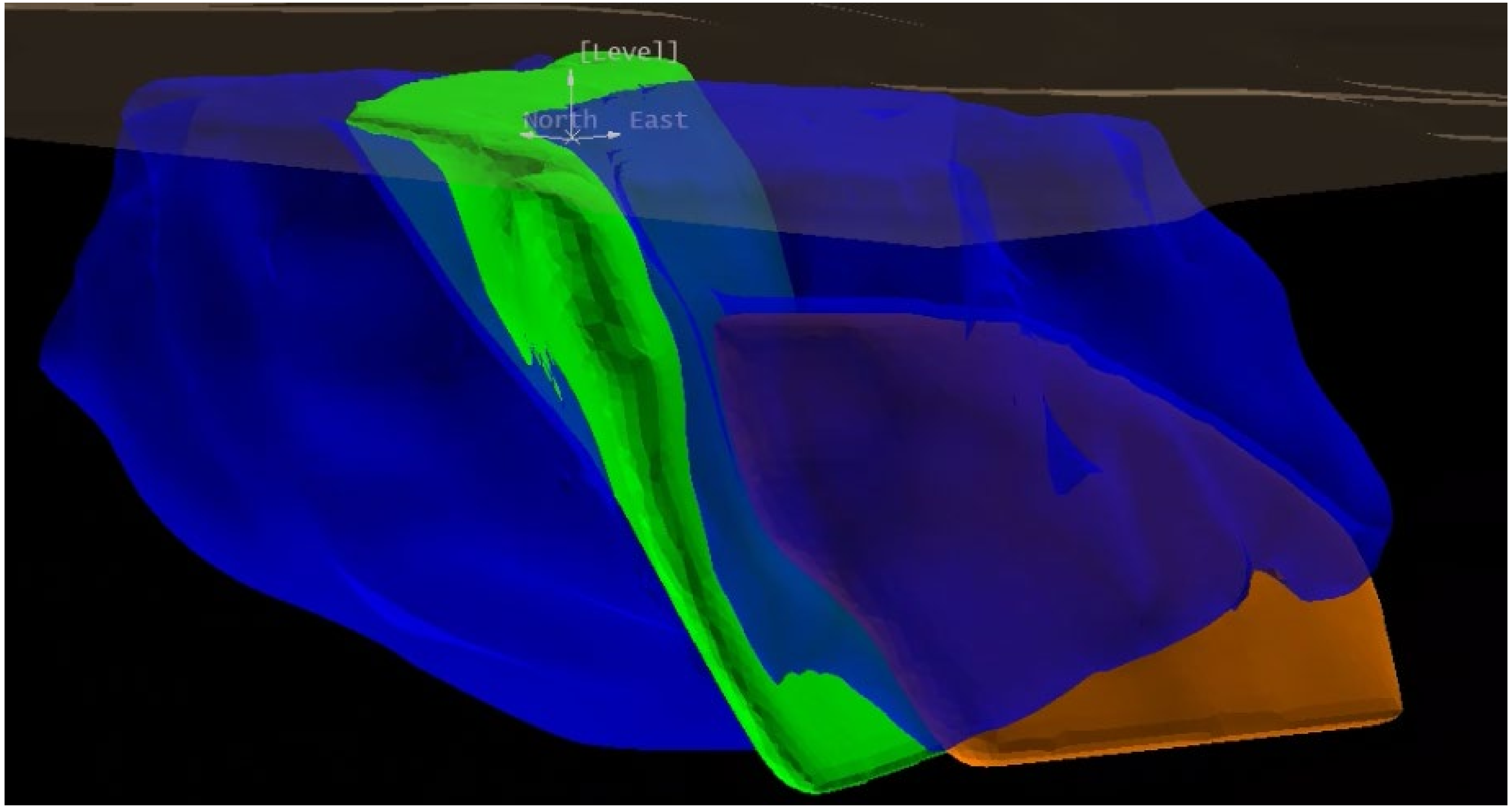
Neo-Marvin Visualisation



Neo-Marvin Visualisation



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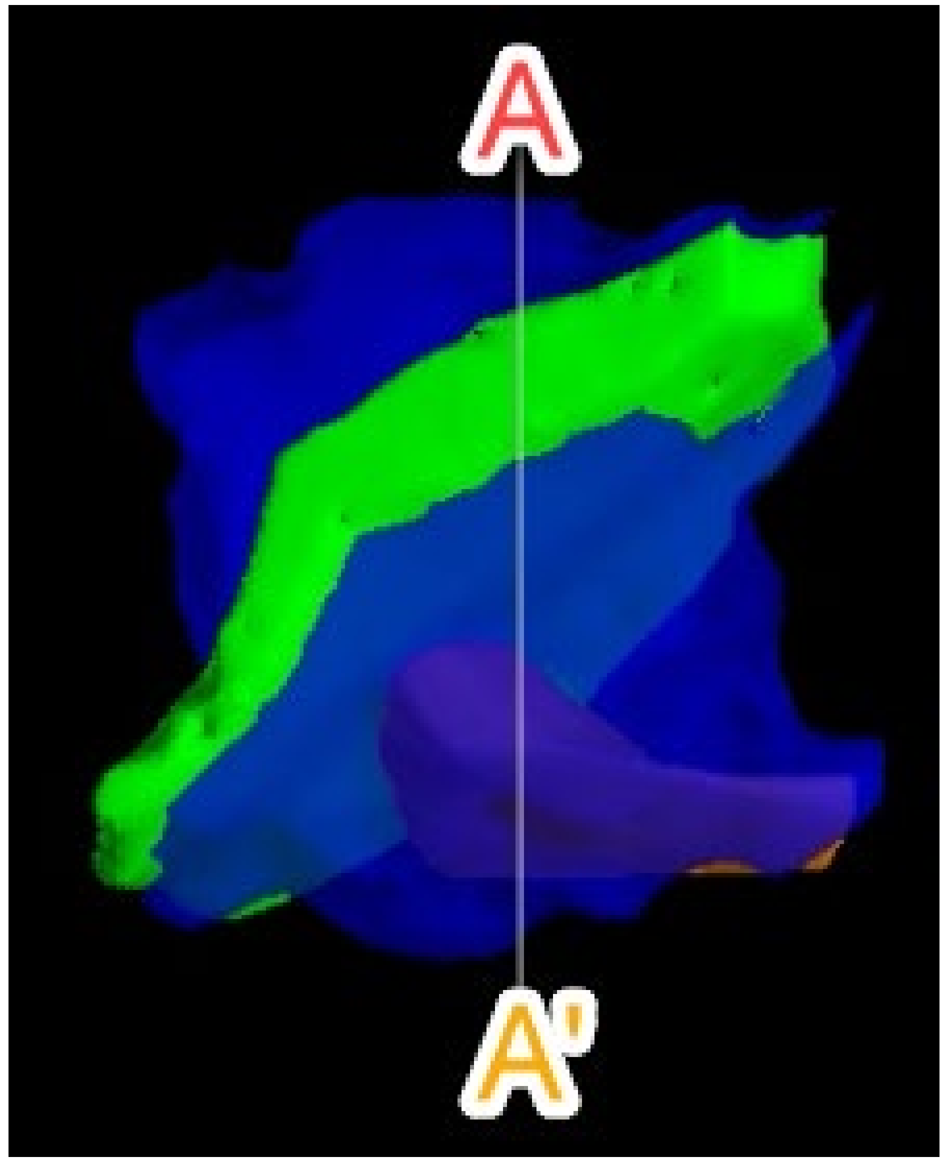
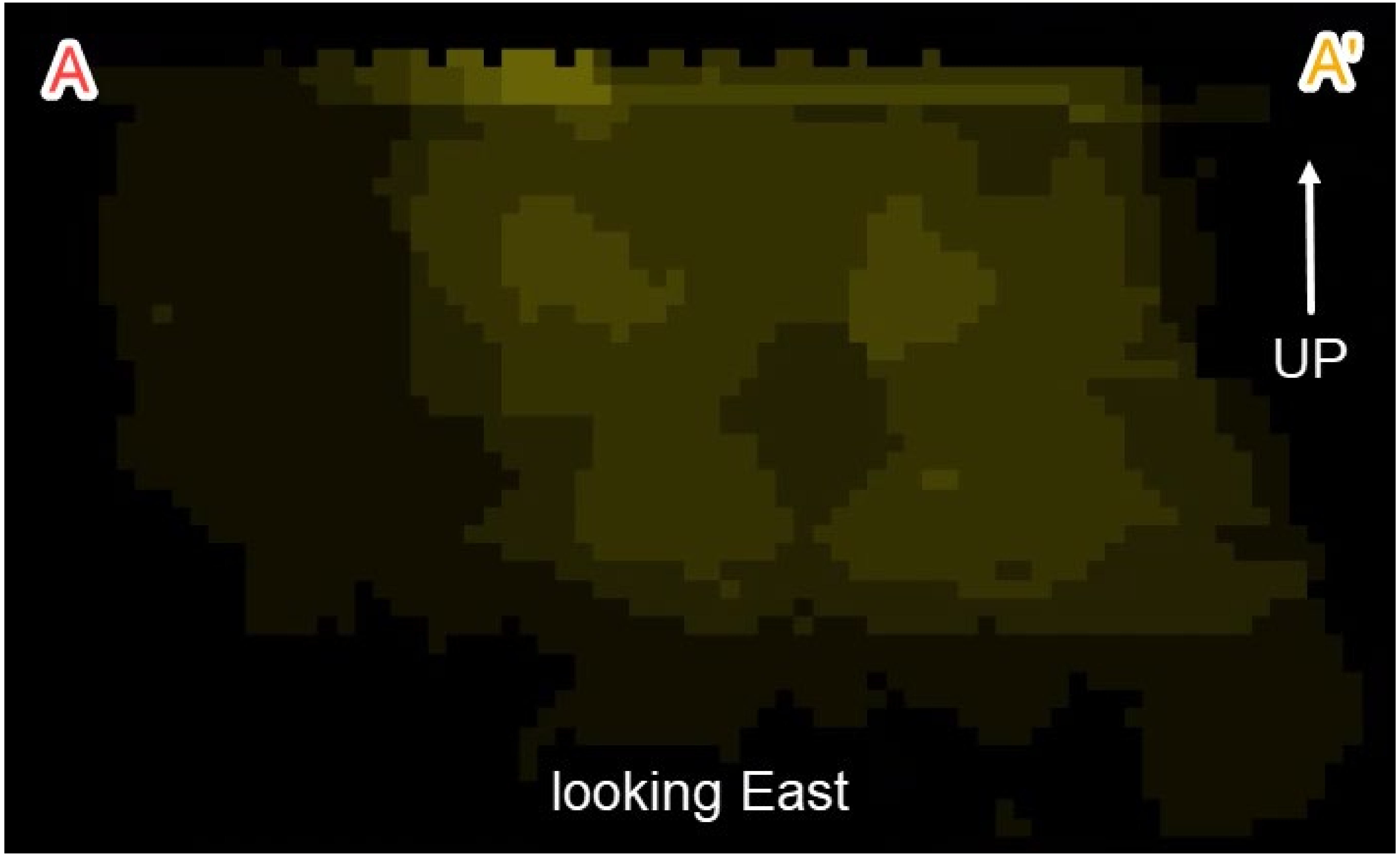
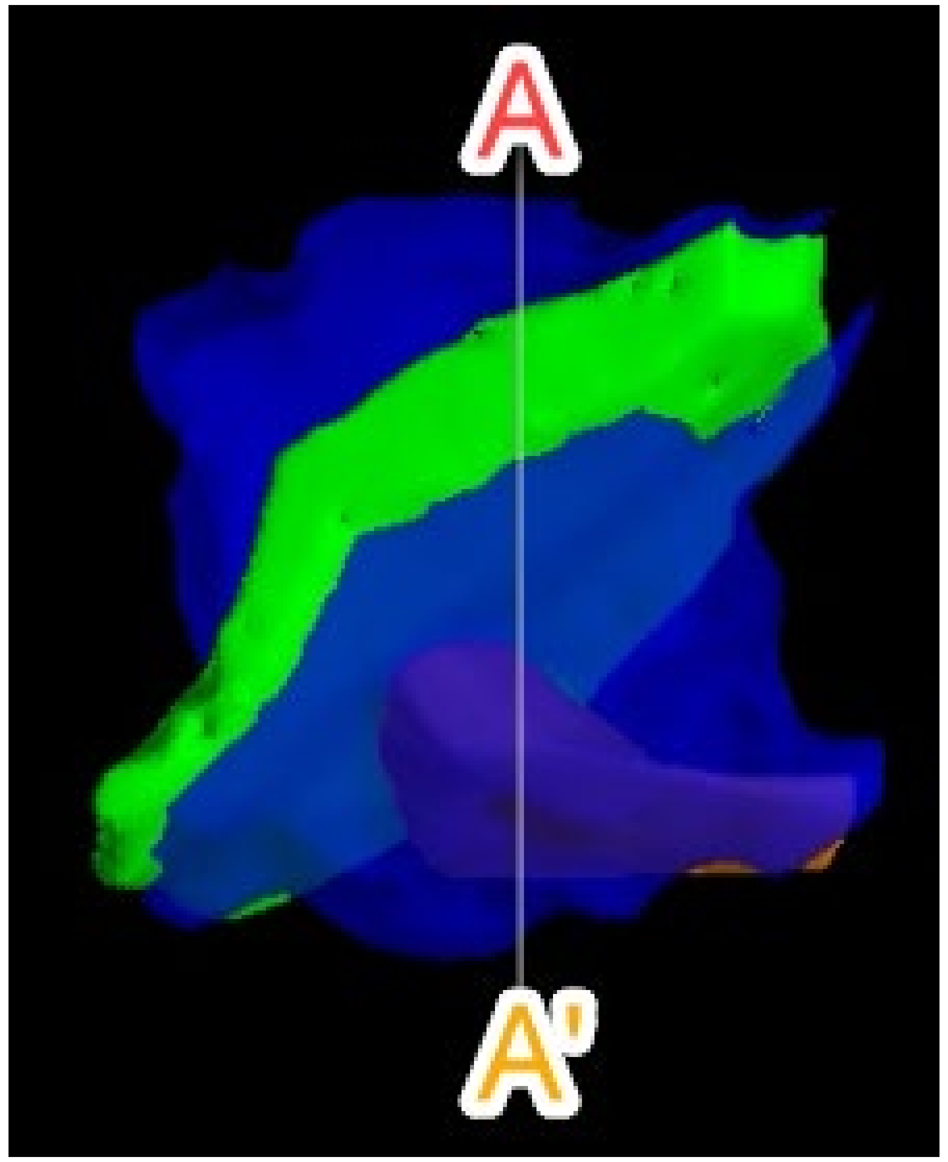
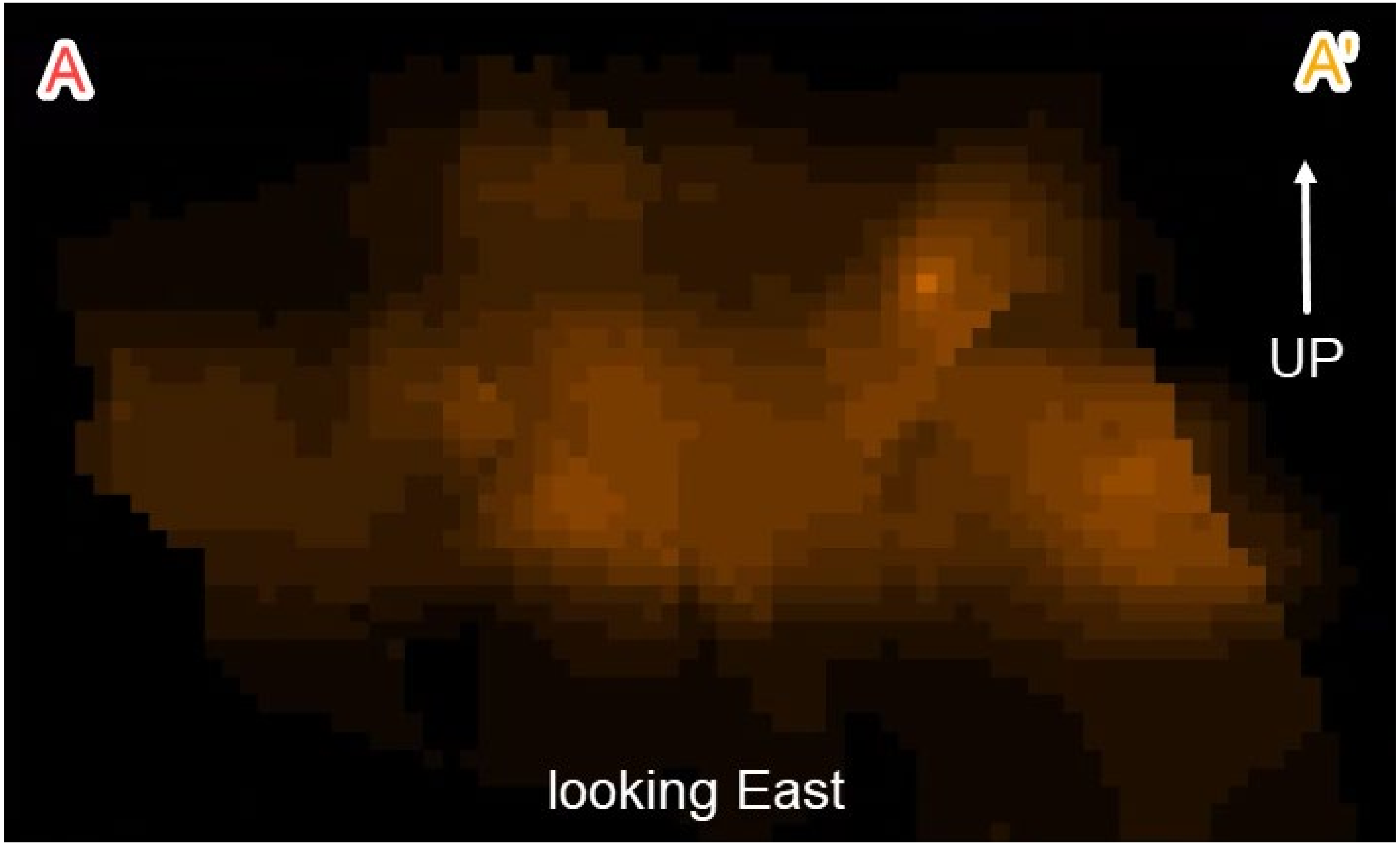
Neo-Marvin Visualisation - Au



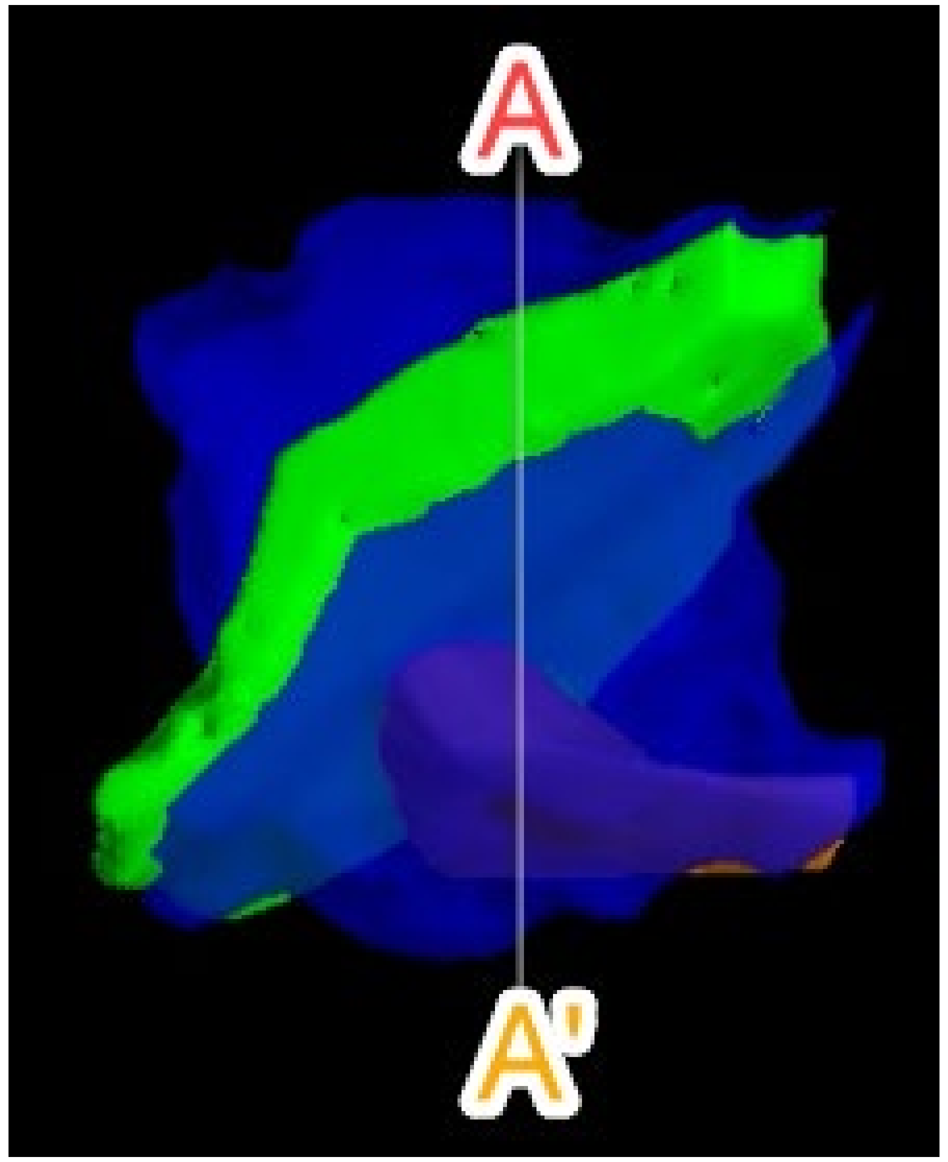


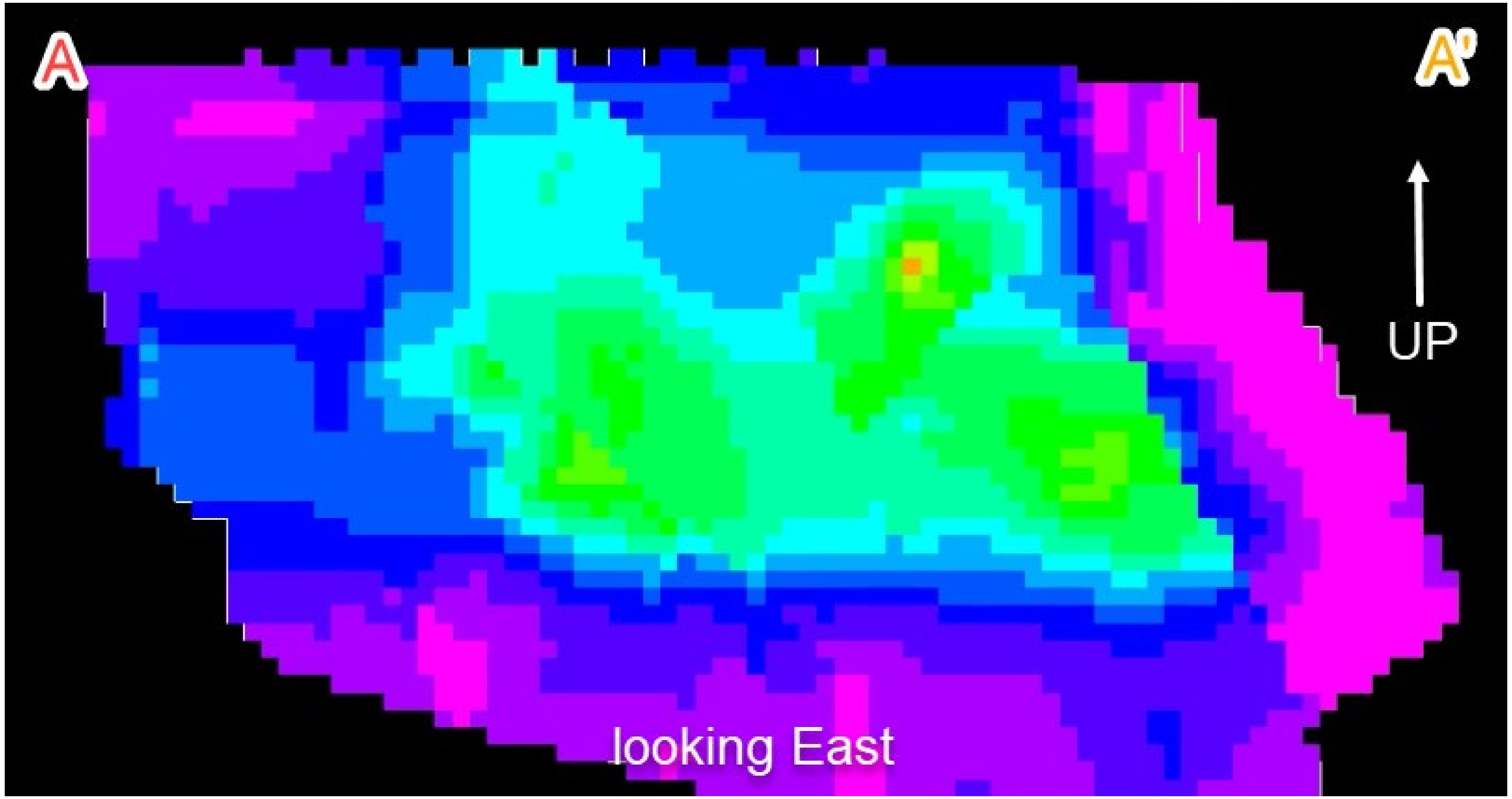
Neo-Marvin Visualisation - Cu





Neo-Marvin Visualisation - Revenue





Narratives for Chilean Desert Archetype

<u>Local water is unavailable or restricted for a New Project located in an arid and mountainous location (e.g. Chile)</u>

Pumping from the Coast	Water Supply	Tailings Practices
Altitude Distance	Continental Seawater Desalination	Thickening Filtration HDS

← Work to-date

Inputs Validation	2nd-Order Effects	Next Contemplated
Refinements to assumptions (External)	Mining Pit-shape	Simulated Moly Pre-concentration Cu Price

← Scope to Feb 2025

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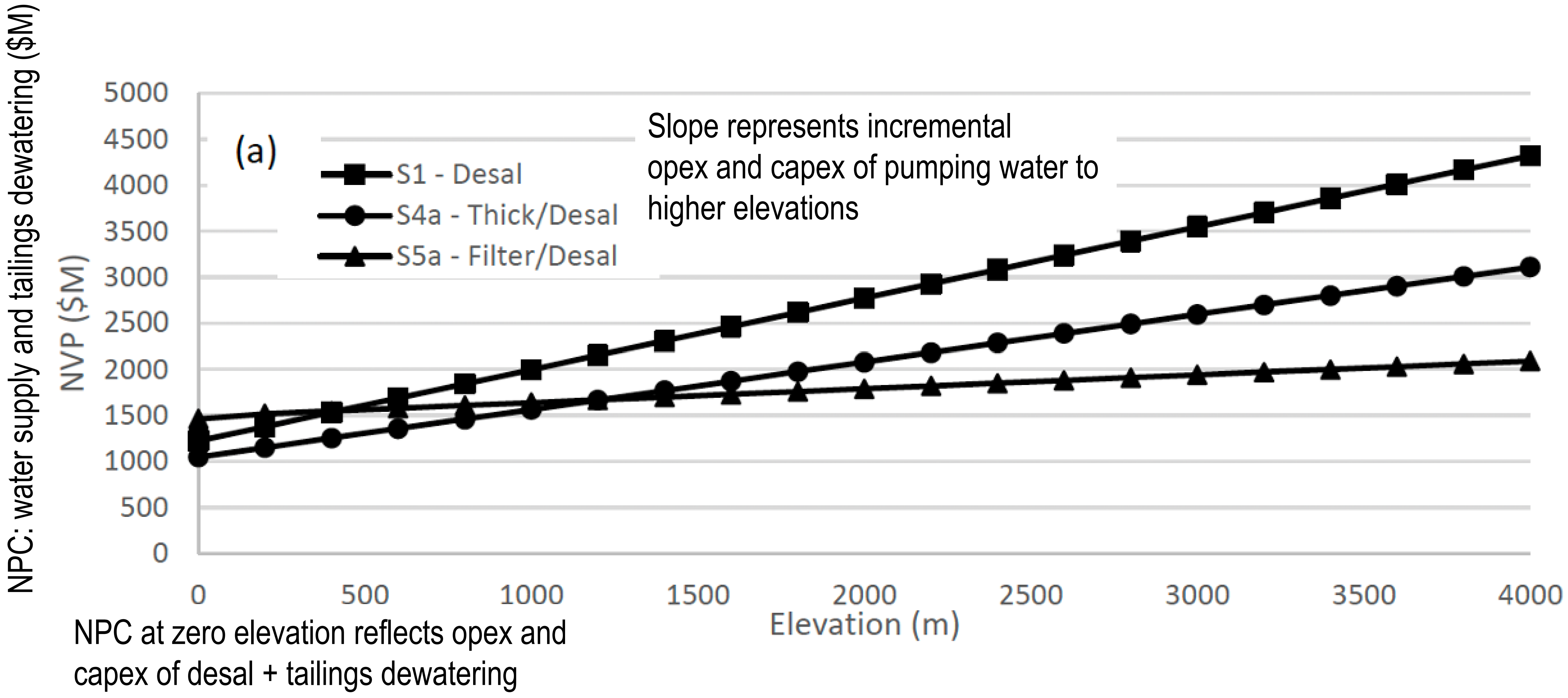
Comparison to Aitken et al and Pyle et al

Building off work of others on water supply and tailings dewatering, two key papers:

- Aitken et al, 2017
- Net Present Costs of water supply and tailings dewatering alternatives - Chilean Cu example

- Pyle et al, 2019
- Focus on throughput and cost drivers for pressure filtration, e.g. fines content in tailings



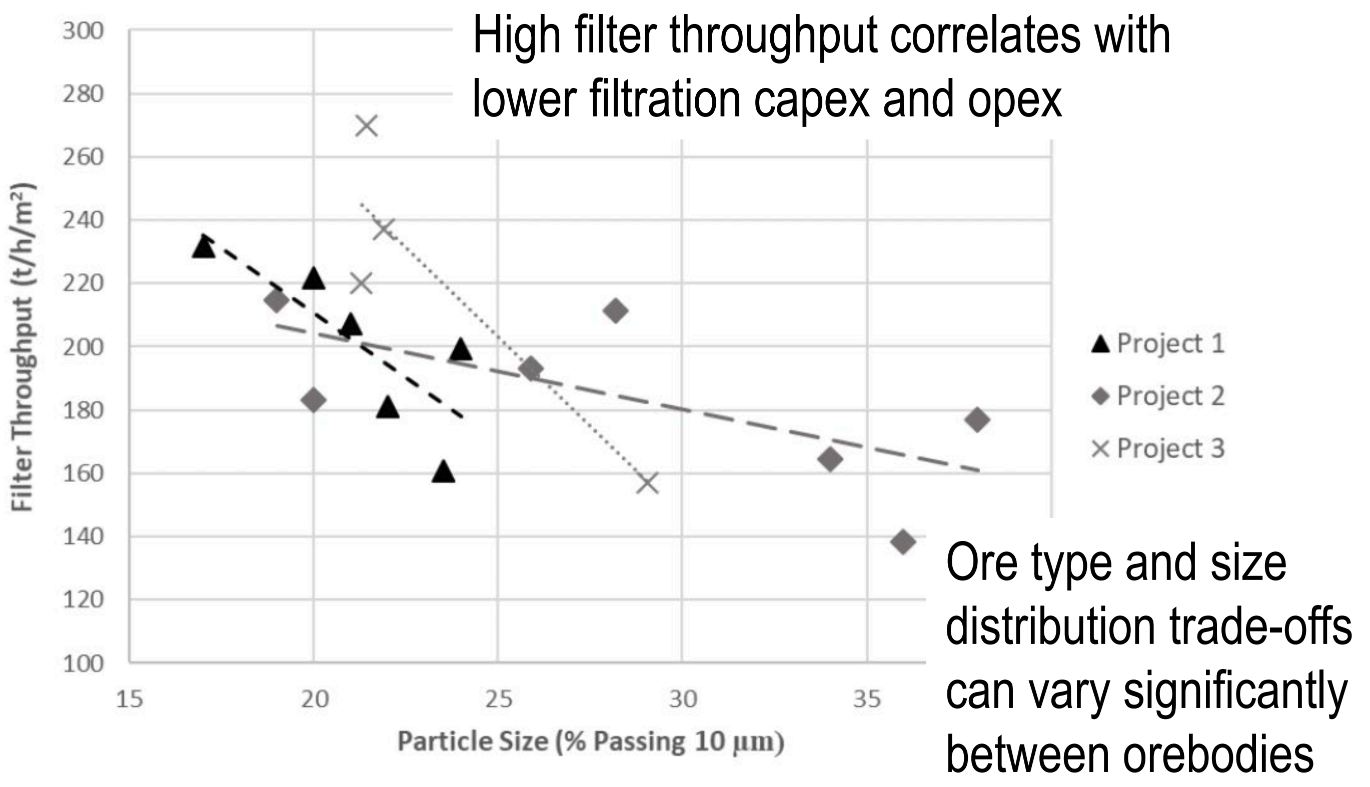


Figure 1 Impact of particle size on tailings filter throughputs

Douglas Aitken, Alex Godoy-Faúndez, Marcelo Vergara, Fernando Concha and Neil McIntyre (2017). Addressing decreasing water availability for the mining industry using cost-benefit analysis. XVI World Water Congress, Cancun, Mexico, IWRA.

Matthew Pyle, Richard Whittering and Greg Lane (2019). Economic Drivers for High-Capacity Tailings Pressure Filtration. Tailings 2019, Santiago, Chile, Gecamin.

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Inputs

Discrete

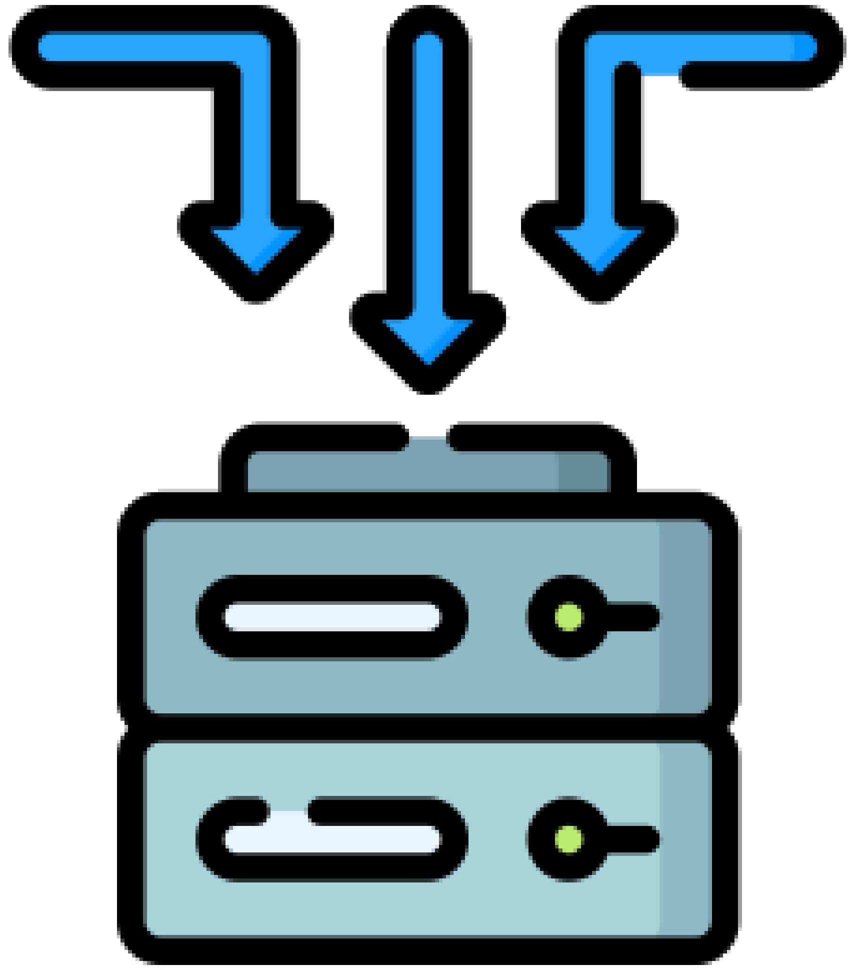
Water Source

Tailings Paradigm

Continuous

Elevation

Distance to Coast



Fixed

Mining costs, processing costs, metal price, power price, grindsize, recovery, mass pull, et. al.

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Scenarios

Local continental groundwater.

Pumping water from the coast.

Desalination?

		Tailings Technology			
		Thickened Low Reclaim	Thickened High Reclaim	Paste Thickened	Stacked Filtered
Water Source	Fresh Groundwater	Base Case (F_T1)			
	Desalinated Seawater	D_T1	D_T2	D_T3	D_T4
	Raw Seawater	S_T1	S_T2	S_T3	S_T4

Inputs

GWI1 - CEEC Water Case Study Business Model

Water assumptions

		v003	Fresh groundwater	Desalinated seawater	Raw Seawater
Density	t/m3	v003	0.997	0.997	1.024
Viscosity	Pa.s	v003	0.0008891	0.0008891	0.0009020
Cu Recovery delta	0-100%	v003	-	-	1.00%
Au Recovery delta	0-100%	v003	-	-	1.00%
Treatment Power	kWh/m3	v004	-	3.00	0.10
Power Price	USD/kWh	v003	0.12	0.12	0.12
Capex	MUSD per (l/s)	v003	0.02	1.00	0.05

Tailings assumptions

			Thickened low reclaim	Thickened high reclaim	Paste thickened	Stacked Filtered
Tailings thickener Feed	% Solids	v003	33.0%	33.0%	33.0%	33.0%
Tailings thickener UnderFlow	% Solids	v003	50.0%	52.0%	64.0%	52.0%
TSF consolidated	% Solids	v003	74.0%	74.0%	75.0%	85.0%
Evaporation losses	% Water	v003	40.0%	30.0%	25.0%	0.0%
Uncaptured seepage	% Water	v003	15.0%	5.0%	2.0%	0.0%
Tailings Filter cake moisture	% water	v003	50.0%	48.0%	36.0%	15.0%
Dewatering power	kWh/t tails	v003	0.20	0.20	0.20	0.30
Dewatering opex excl. Power	USD/t tails	v003	0.10	0.12	0.20	2.00
Dewatering capex estimate	USD/tpa tails	v003	2.00	2.50	3.00	15.00

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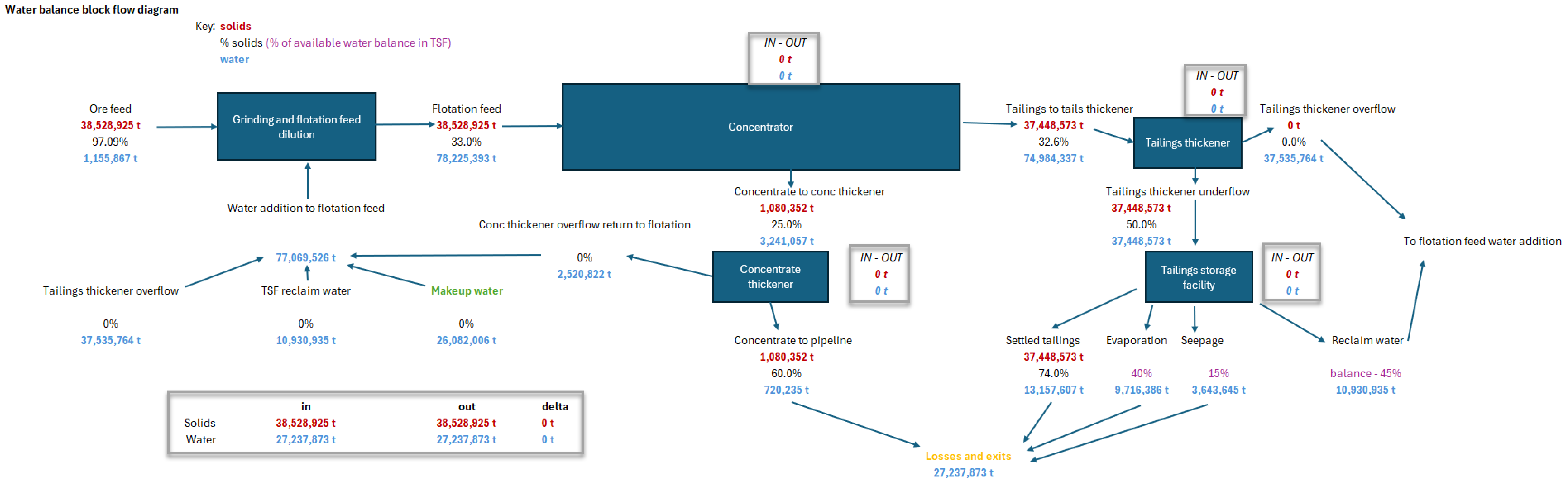
Inputs



	in	out	delta
Solids	38,528,925 t	38,528,925 t	0 t
Water	27,237,873 t	27,237,873 t	0 t

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Measuring success?

Mine is financially viable

NPV_{10}

CAPEX

NPV_{10}/ CAPEX > 100%

Water intensity?

Community impact?

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Outputs

CEEC GWI1, Prober Run 005_F_T1_L1

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Integrated Strategic Planning for the Mining Industry

LOM NPV:	4,044	US$M	Water Type:	Fresh groundwater	Mined Material:	1,406.5	Mt	MakeUp Water	25.10	Mtpa	Water supply OPEX	169.7	MUSD
Mine Life:	20.4	Years	Tailing Paradigm:	Thickened low reclaim	Ore Processed:	709.5	Mt	Tailings Volume	510.03	M m³	Water treat OPEX	0.0	MUSD
Comp. LOM NPV		US$M	Location:	650masl 80km	Discarded Mineralised:	216.5	Mt	Slurry Density	1.86	t/m³	Tail Dewater OPEX	86.9	MUSD
Comp. Delta		%			Peak Stockpiled:	118.7	Mt	SG of Dry Tailings	1.37	t/m³	Water supply CAPEX	0.0	MUSD
					Cu Produced:	2,047.9	Kt				Water treat CAPEX	26.3	MUSD
					Au Produced:	4.11	M TrOz	Water Intensity	0.67	m³/Ore t	TSF dewater CAPEX	108.8	MUSD
					As Produced:	34.5	Kt	..for Cu produced	231.51	m³/Cu t	TOTAL Capex	2,152.8	MUSD

Fresh groundwater - Thickened low reclaim - 650masl 80km
static grindsize and concentrate grade

RUN 005_F_T1_L1 DASHBOARD

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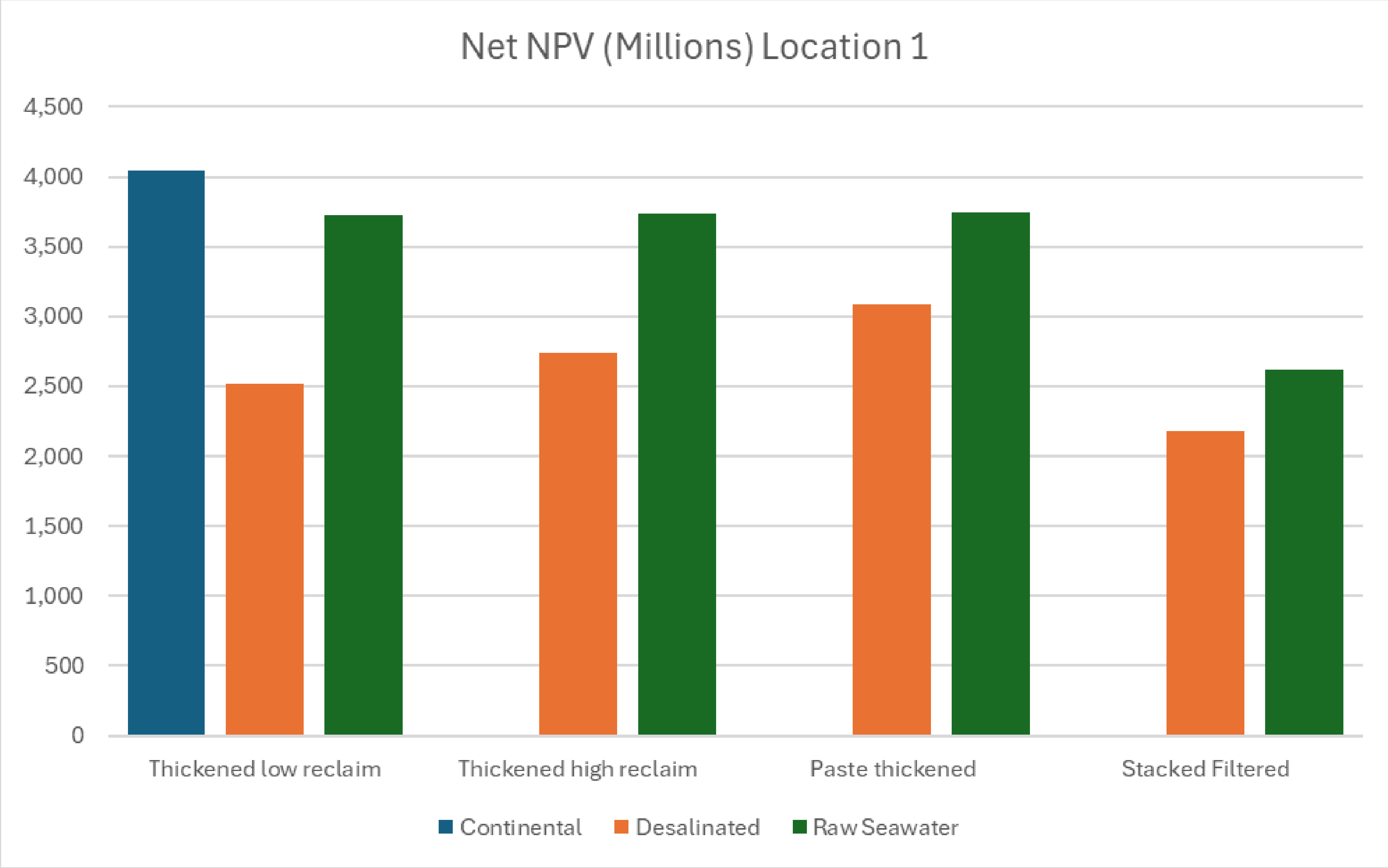
Outputs – 650masl 80km

Net NPV	CAPEX	NPV/CAPEX	Water Type:	Tailing Paradigm:	Water Supply OPEX	Water Treatment OPEX	Tails Dewater OPEX	Water Supply CAPEX	Water Treatment CAPEX	TSF Dewatering CAPEX	Water intensity Ore	Water intensity Cu
MUSD	*MUSD*	*0-100%*			*MUSD*	*MUSD*	*MUSD*	*MUSD*	*MUSD*	*MUSD*	*m^3 / ore t*	*m^3 / Cu t*
4,043.9	2,152.8	188%	Fresh groundwater	Thickened low reclaim	169.7	0.0	86.9	0.0	26.3	108.8	0.67	231.5
2,516.6	3,578.3	70%	Desalinated seawater	Thickened low reclaim	238.7	167.3	84.9	240.0	1,211.6	108.9	0.67	226.0
2,736.5	3,390.9	81%	Desalinated seawater	Thickened high reclaim	177.2	124.2	98.6	240.0	997.1	136.1	0.50	167.9
3,090.5	3,075.8	100%	Desalinated seawater	Paste thickened	90.8	63.6	153.3	240.0	654.6	163.4	0.25	86.0
2,180.9	3,519.6	62%	Desalinated seawater	Stacked Filtered	46.4	32.5	1,393.8	240.0	445.4	816.5	0.13	43.9
3,728.1	2,432.6	153%	Raw Seawater	Thickened low reclaim	236.2	5.4	84.9	240.0	65.9	108.9	0.67	226.0
3,734.3	2,443.8	153%	Raw Seawater	Thickened high reclaim	175.4	4.0	98.6	240.0	50.0	136.1	0.50	167.8
3,742.8	2,448.5	153%	Raw Seawater	Paste thickened	89.8	2.1	153.3	240.0	27.3	163.4	0.25	86.0
2,623.2	3,090.0	85%	Raw Seawater	Stacked Filtered	45.9	1.1	1,393.8	240.0	15.8	816.5	0.13	43.9



Water pumping power required ~2.6 kWh per m^3

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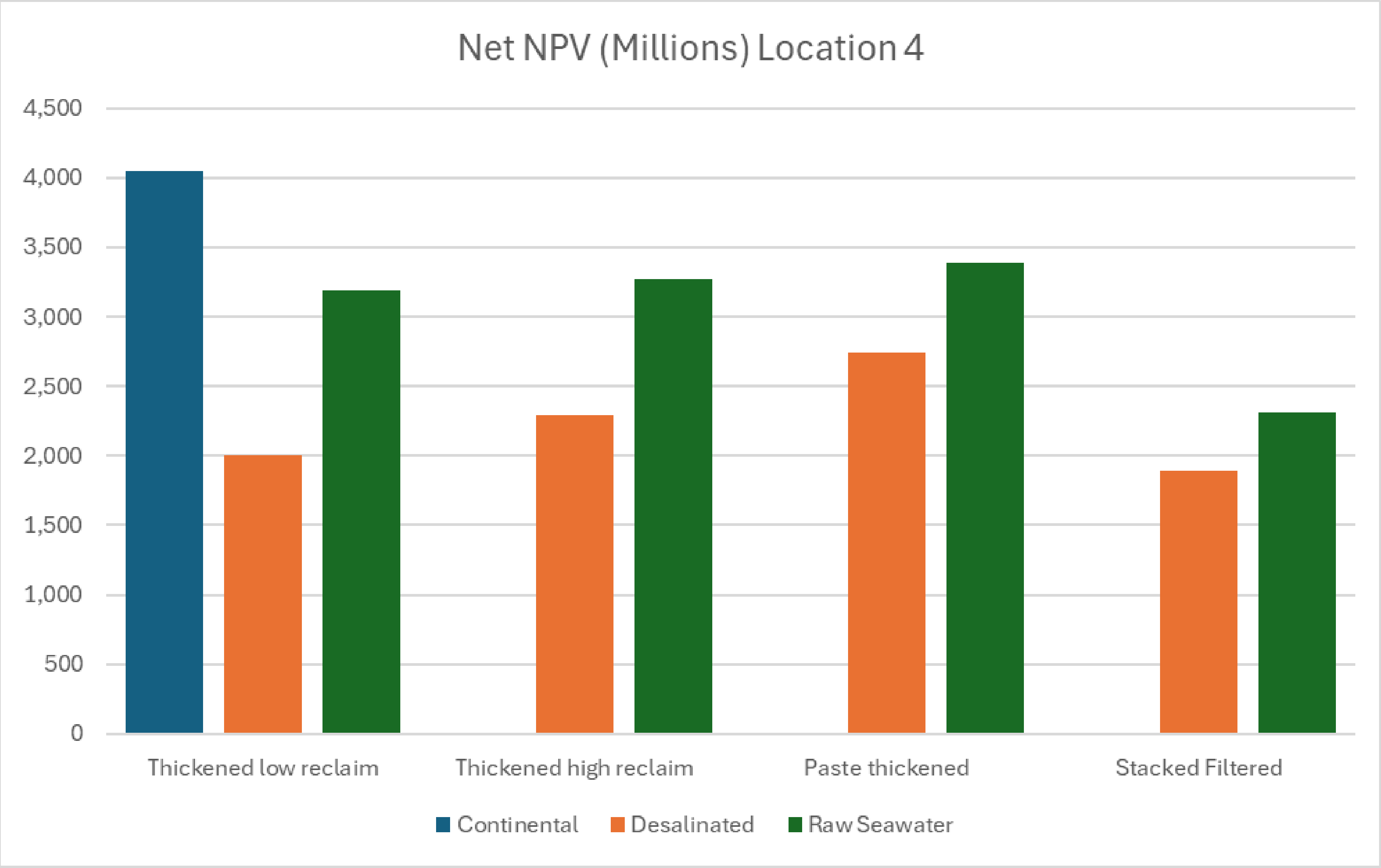
Outputs – 4400masl 165km

Net NPV	CAPEX	NPV/CAPEX	Water Type:	Tailing Paradigm:	Water Supply OPEX	Water Treatment OPEX	Tails Dewater OPEX	Water Supply CAPEX	Water Treatment CAPEX	TSF Dewatering CAPEX	Water intensity Ore	Water intensity Cu
MUSD	*MUSD*	*0-100%*			*MUSD*	*MUSD*	*MUSD*	*MUSD*	*MUSD*	*MUSD*	*m^3 / ore t*	*m^3 / Cu t*
4,044.0	2,152.8	188%	Fresh groundwater	Thickened low reclaim	169.6	0.0	86.8	0.0	26.3	108.8	0.67	231.3
1,999.8	3,804.2	53%	Desalinated seawater	Thickened low reclaim	989.4	170.1	86.3	495.0	1,182.6	108.8	0.67	230.1
2,293.4	3,622.8	63%	Desalinated seawater	Thickened high reclaim	735.6	126.5	100.4	495.0	974.0	136.1	0.50	171.1
2,745.1	3,315.8	83%	Desalinated seawater	Paste thickened	377.1	64.8	156.3	495.0	639.8	163.2	0.25	87.7
1,895.6	3,762.3	50%	Desalinated seawater	Stacked Filtered	191.6	32.9	1,411.9	495.0	433.4	816.2	0.13	44.5
3,184.8	2,685.3	119%	Raw Seawater	Thickened low reclaim	987.8	5.5	86.4	495.0	63.8	108.8	0.67	230.3
3,267.9	2,697.2	121%	Raw Seawater	Thickened high reclaim	733.8	4.1	100.4	495.0	48.3	136.1	0.50	171.1
3,389.5	2,702.4	125%	Raw Seawater	Paste thickened	372.8	2.1	154.9	495.0	26.3	163.4	0.25	86.9
2,315.4	3,344.0	69%	Raw Seawater	Stacked Filtered	191.1	1.1	1,412.2	495.0	15.2	816.0	0.13	44.5



Water pumping power required ~15.8 kWh per m^3

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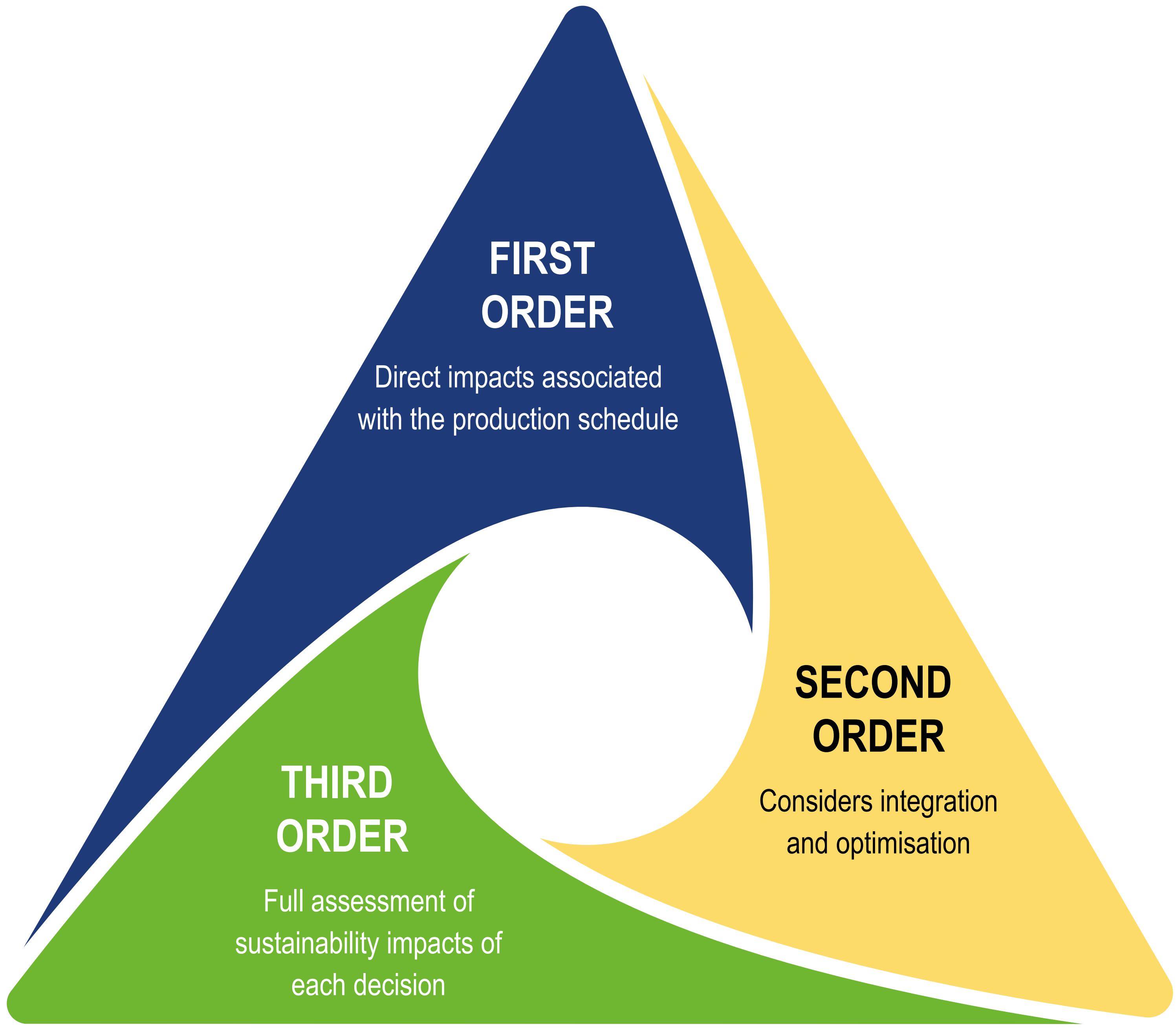
Outputs

Row Labels	Thickened low reclaim	Thickened high reclaim	Paste thickened	Stacked Filtered
650masl 80km				
Fresh groundwater	188%			
Desalinated seawater	70%	81%	100%	62%
Raw Seawater	153%	153%	153%	85%
4400masl 165km				
Fresh groundwater	188%			
Desalinated seawater	57%	69%	89%	50%
Raw Seawater	126%	129%	135%	74%

Dynamic Influences of Optimisation on Water

How does optimisation play a role?



FIRST ORDER
Effects concerned with assembling capital and operating costs and calculating a net-present-cost for these

SECOND ORDER
Effects concerned with the orebody as an integrated whole and its optimisation

THIRD ORDER
Effects concerned with environmental and community value or impact

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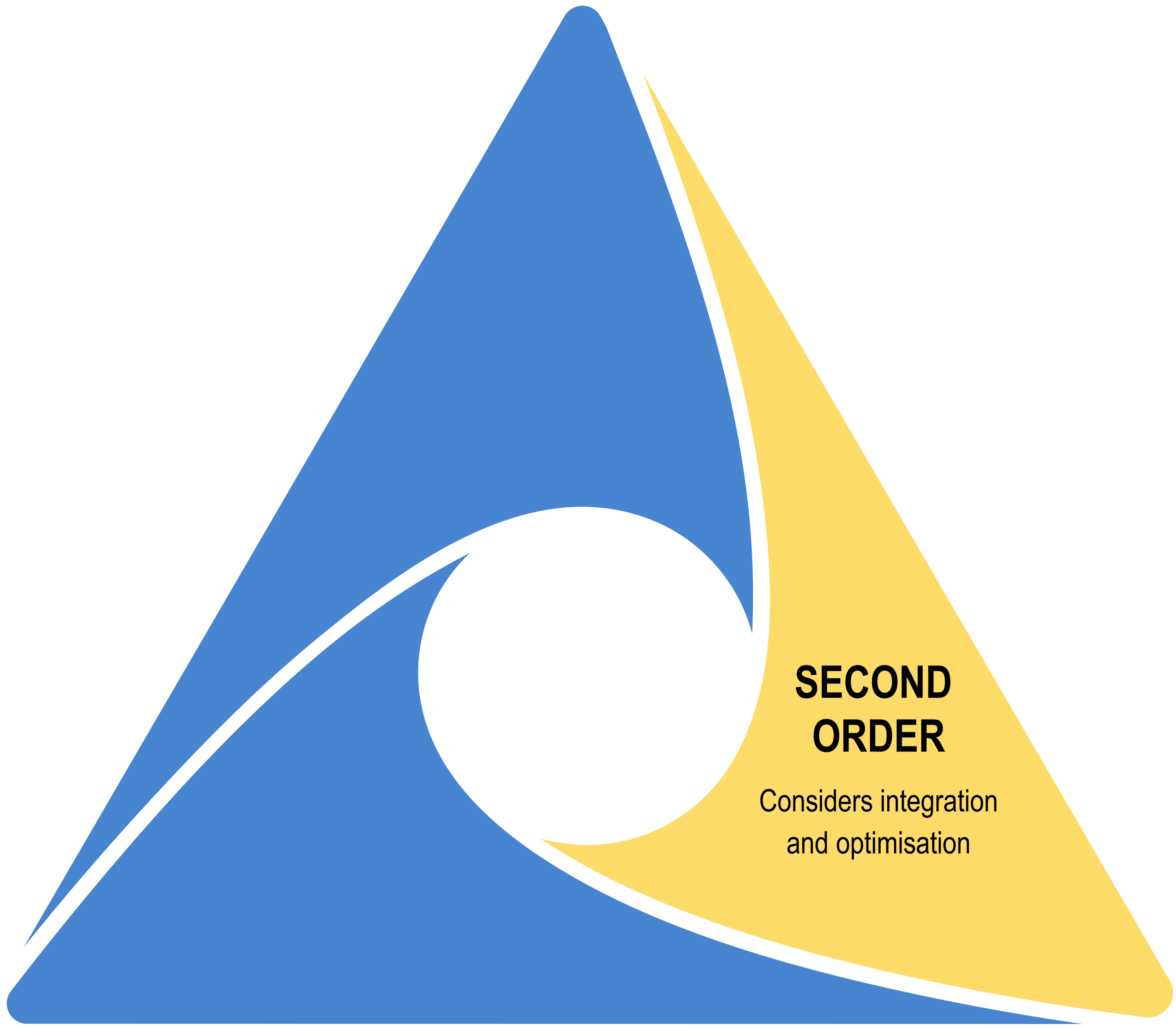
Dynamic Influences of Optimisation on Water

How does optimisation play a role?



It is the dynamic interaction of these three orders that concerns the case-study.

Initial questions are:

1. In what way does water consumption or treatment volume behave when LOM planning and optimisation takes place?
2. In what contexts does this matter and which aspects are material?
3. Is there a way to predict the 2nd-order effects of emergent water-related technologies or design methodologies; do any substantially alter the economics beyond the 1st-order considerations?

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Narratives for Chilean Desert Archetype

<u>Local water is unavailable or restricted for a New Project located in an arid and mountainous location (e.g. Chile)</u>

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← Work to-date

Inputs Validation	2nd-Order Effects	Next Contemplated
Refinements to assumptions (External)	Mining Pit-shape	Simulated Moly Pre-concentration Cu Price

← Scope to Feb 2025

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New Scope Ideas

Existing Operation

Depleted Orebody
Looming Restrictions

Options Analysis

- Close (or C&M)
- Scale Back
- Change Supply
- Change Tails de-water
- Flowsheet or Technol Options

Current Model

Processing (GTR)
PAG vs NAG
New Climatic Loc.

Link to Hydrology Models

River Diversion;
Pit Boundaries;
Lake Interactions;
Pit-dewatering etc

New Versions of Marvin

What Commodity?

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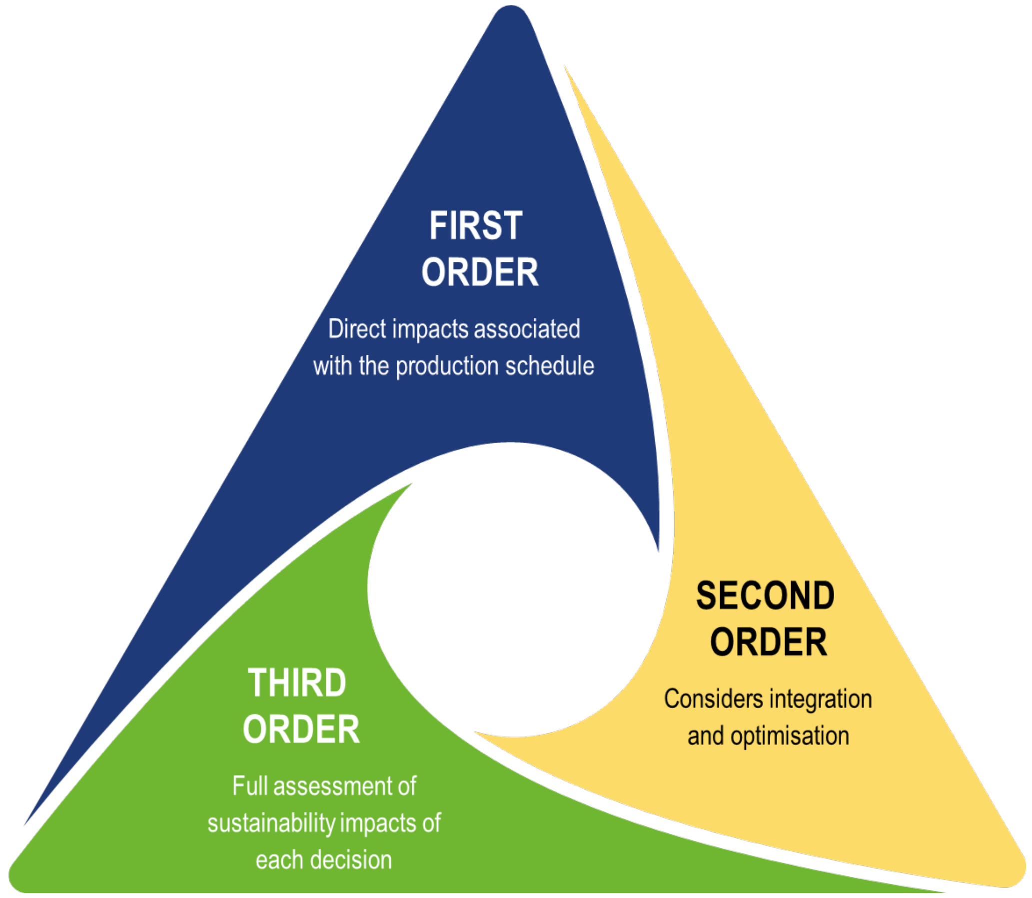
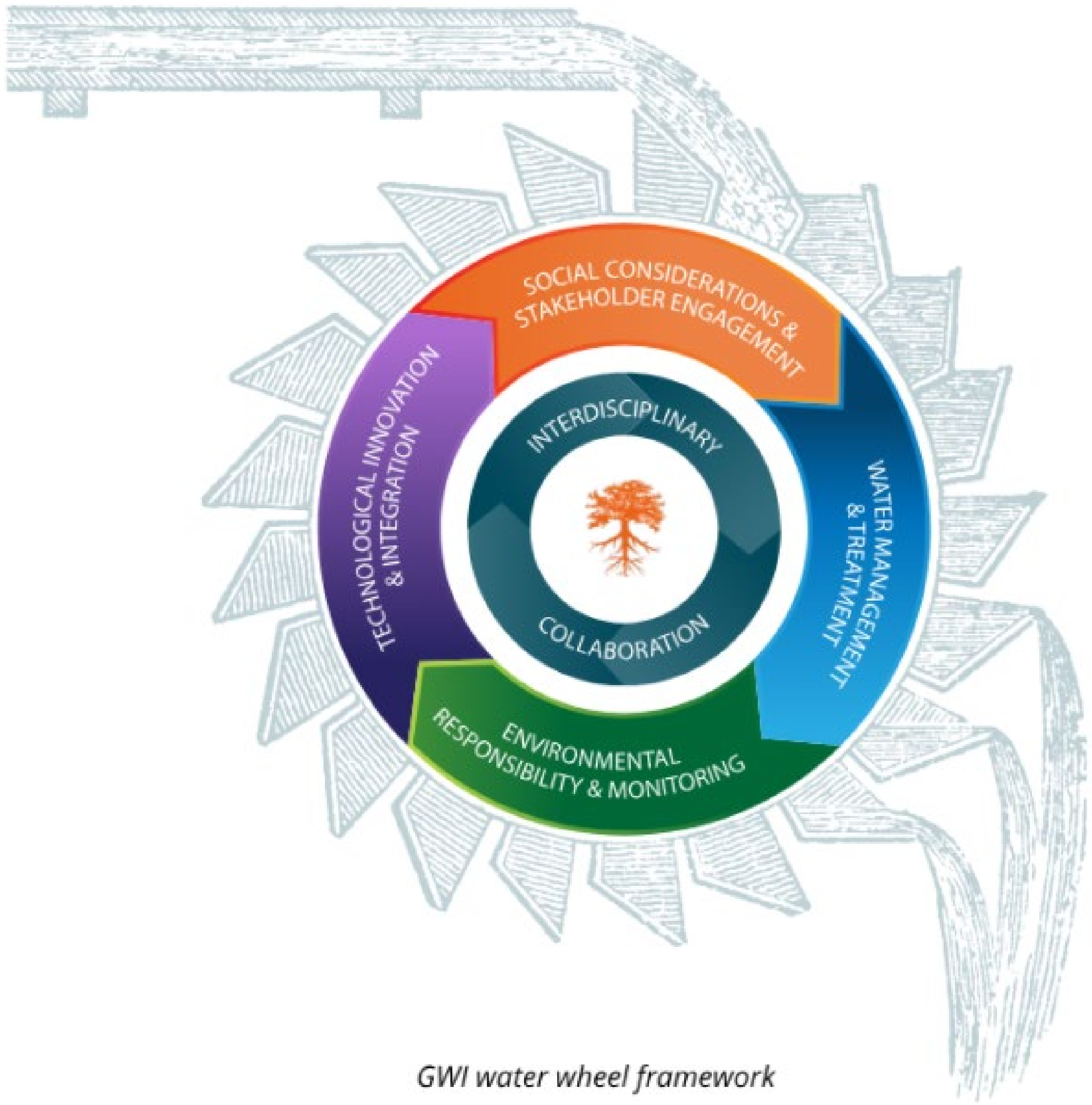
Discussion & Questions

Results so far

Early 2025 Scope

New Scope Ideas





GWI water wheel framework

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Thanks

Thanks to CEEC Sponsors & Partners of GWI

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WEIR

UBC

SMI Sustainable Minerals Institute

Grantham Foundation for the Protection of the Environment

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