CARBON CIRCUIT MODELLING – THEORY AND APPLICATION

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WHEN YOU NEED TO BE SURE

SGS

OUTLINE

- Introduction
- Background
- Opportunities and Value
- Methodology
- Inputs/Outputs
- Results (Case Studies)

INTRODUCTION

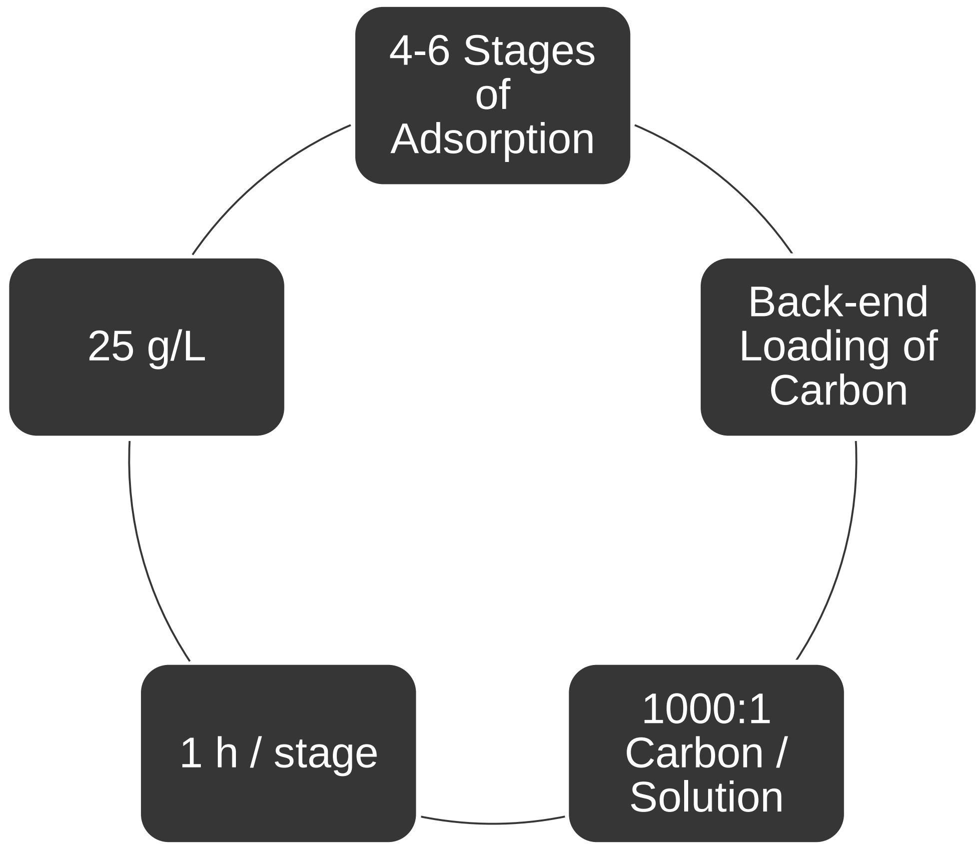
The SGS carbon-in-pulp (CIP) / carbon-in-leach (CIL) modelling package is used to:

- Estimate the performance of a full-scale CIP and CIL plant.
- Derive the optimum design criteria based on the results of small scale experiments.

Powerful design tool that uses results from standard leach and adsorption tests (bottle roll tests) to generate kinetic data that are fitted to leaching and carbon adsorption equations.

BACKGROUND

- Early CIP plants were built using “rules of thumb” design criteria with minimal theoretical basis



OPPORTUNITIES

Existing Plants – Lower Opex and Losses

- Increase/decrease carbon concentration (g/L)
- Increase/decrease carbon advance rate (t/day)
- Better elution / regeneration

New Plants – Minimize Costs

- Optimize pulp density for leach/adsorption kinetics
- Optimize number and size of tanks
- Optimize carbon inventory
- Optimize carbon advance rate. Higher gold loadings (>1000:1) lower elution costs

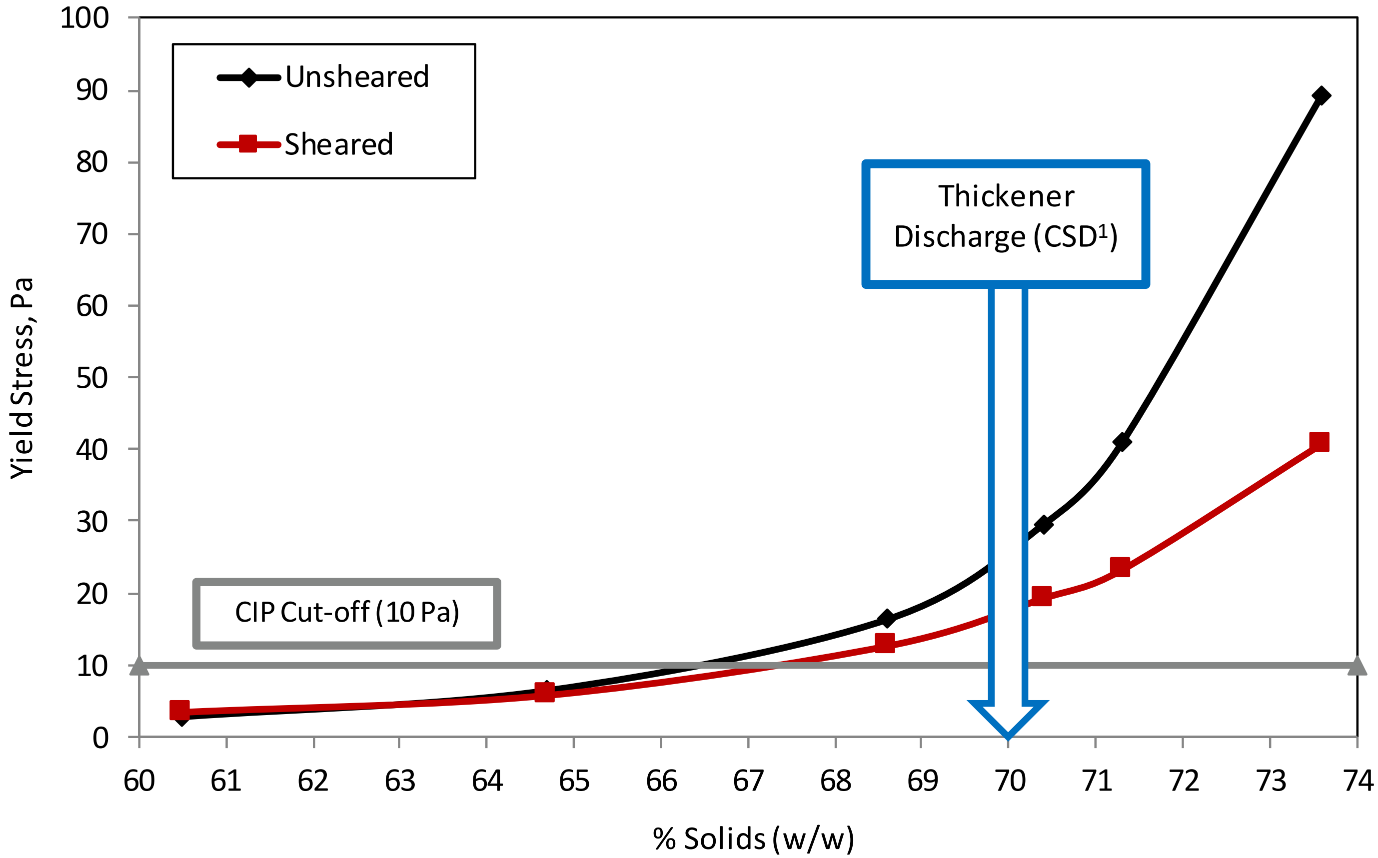
VALUE OF THE CIP/CIL MODEL

- Can mimic the performance of an existing plant and evaluate the consequences of making changes.

- Can generate data for trade-off studies for a new plant, from which an economic optimum design can be derived.

RHEOLOGY TESTWORK

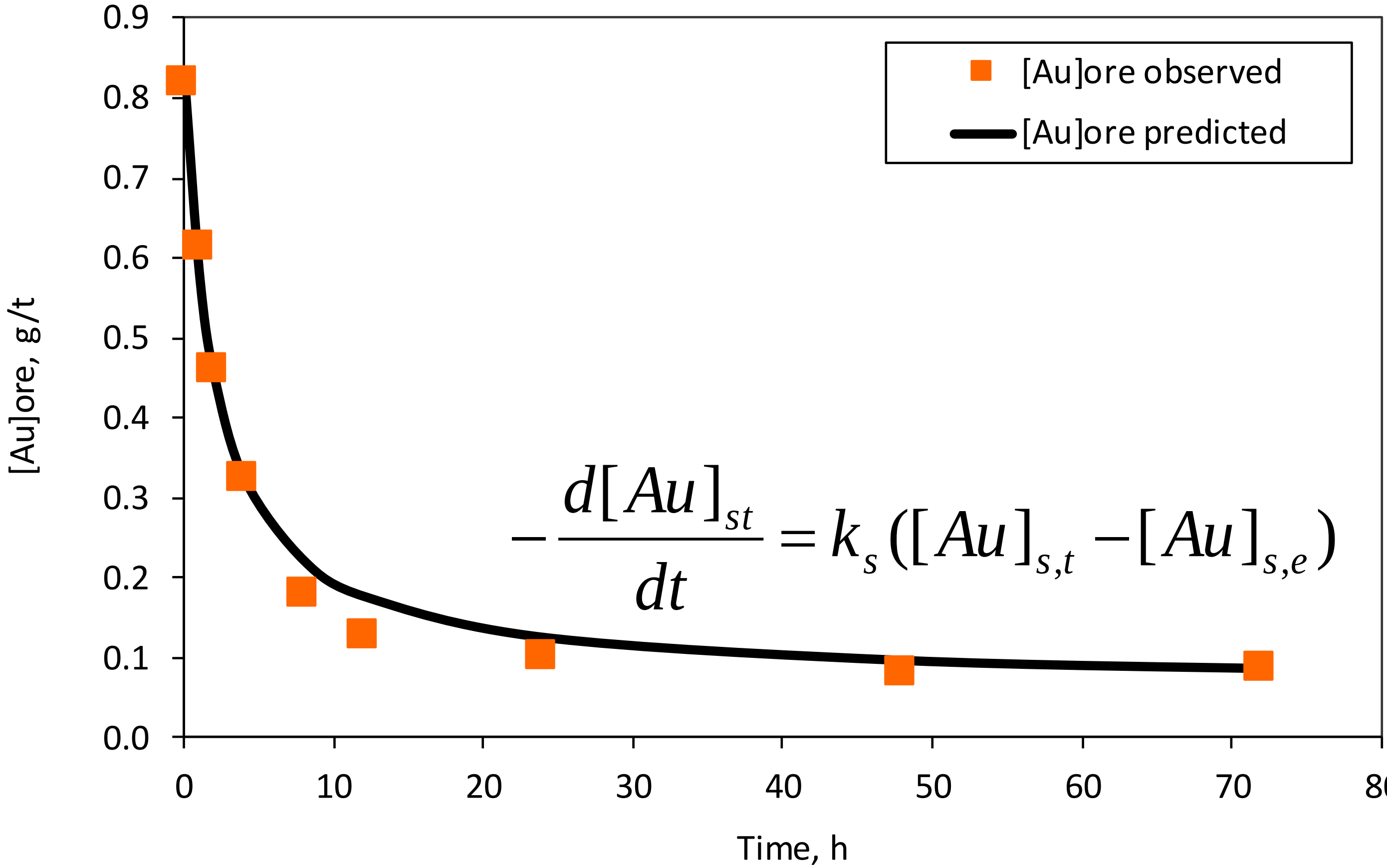
- Determine optimum pulp density and test the effect of pulp density on yield stress



[1] The Critical Solids Density (CSD) value is predictive of the maximum underflow solids density achievable in a commercial thickener and of the underflow solids density and pumpability ranges achievable in practice and with reasonable friction pressure losses for an economically feasible operation.

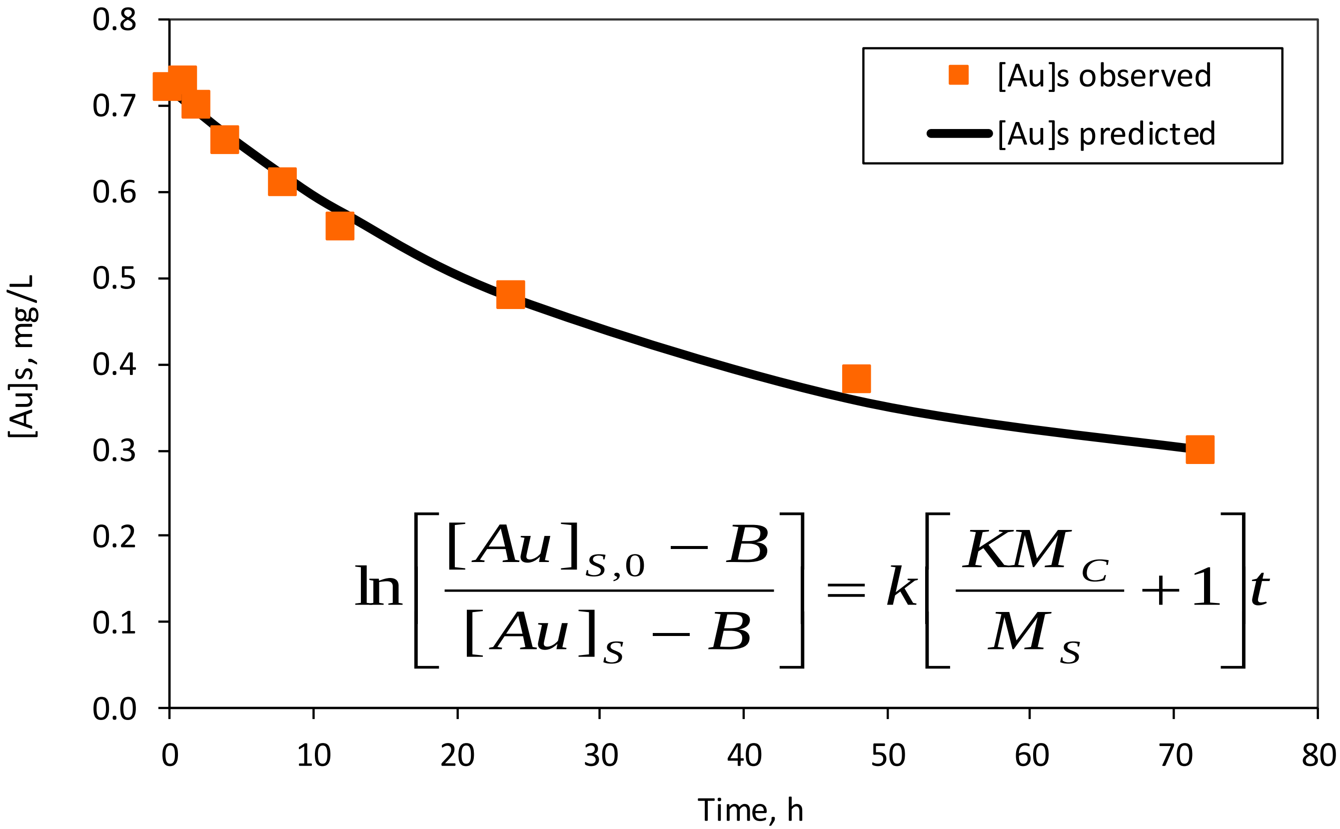
LEACH KINETICS

- Measure leach kinetics at selected pulp density in small scale batch test. Fit rate data to rate equation and generate constant, k_s.



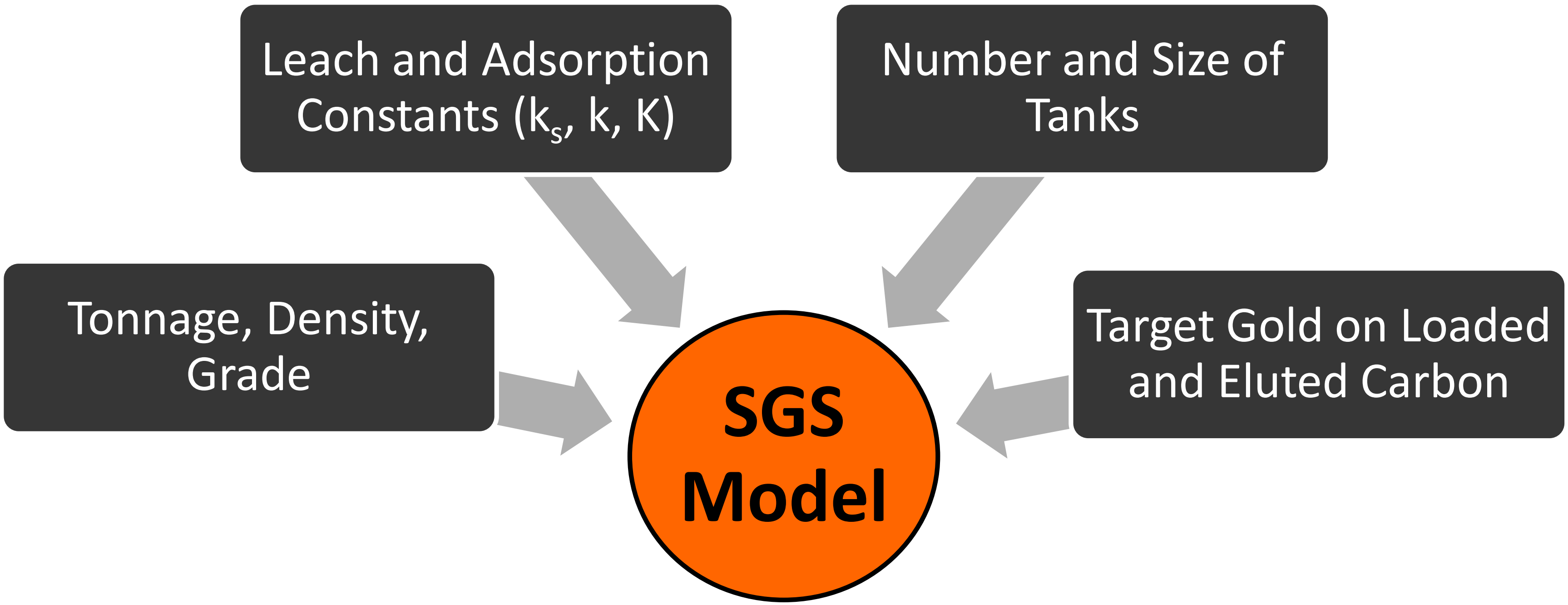
ADSORPTION KINETICS

- Measure kinetics of gold cyanide adsorption on carbon at selected pulp density in small scale batch test. Fit adsorption data to adsorption equation and generate constants k and K.



$$\ln\left[\frac{[Au]_{S,0} - B}{[Au]_S - B}\right] = k\left[\frac{KM_C}{M_S} + 1\right]t$$

MODEL INPUTS / OUTPUTS



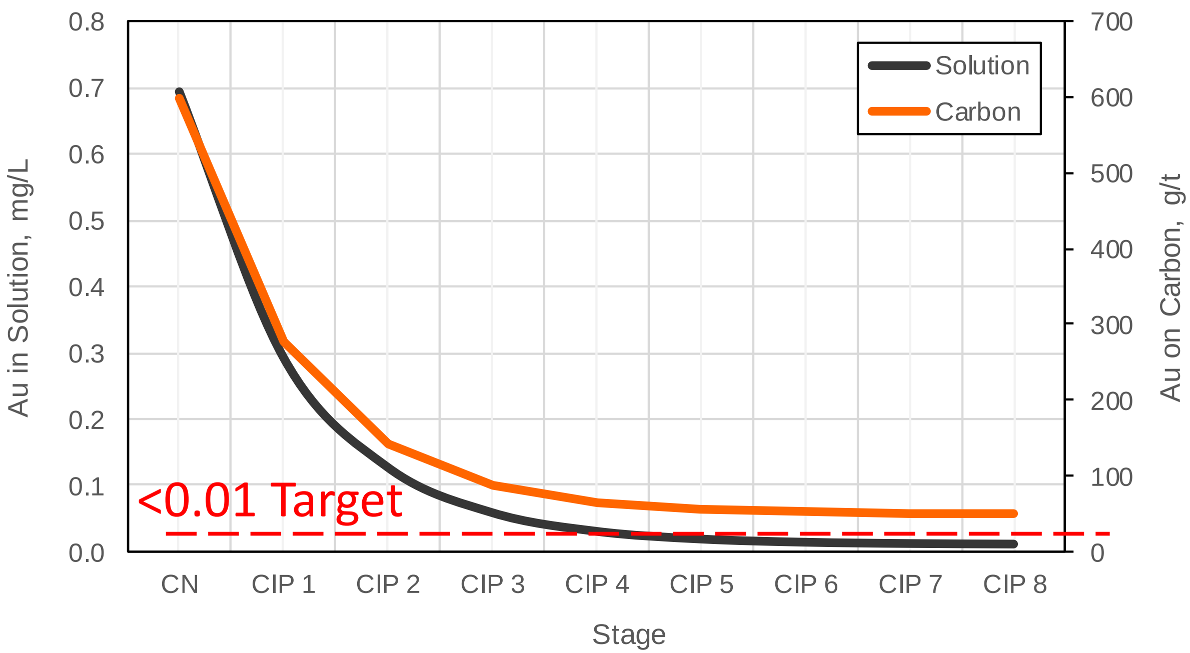
Concentration Profiles (gold in solution, in the ore, on the carbon)

Carbon Concentration (g/L)

Carbon Advance Rate to Elution / Regeneration

Gold Lock-up in the Plant

OUTPUT PROFILE



CASE STUDY #1 – CIP VS. CIL

- Russia – 100 t/h, gravity/leach plant, 50% solids, 0.82 g/t (after gravity), ~83% leach extraction after 24 hours, kK value of 52.

	CIP	CIL
Circuit Configuration	3 x 1080 m^3 (24h of CN) 8 x 120 m^3 (7h of CIP)	6 x ~700 m^3 (31h total)
Carbon Concentration	30 g/L	15 g/L
Carbon Loading	1142 g/t	1130 g/t
Carbon Transfer	1.5 t/day carbon transfer	
Carbon Inventory / Stage	3.6 t	10.1 t
Carbon Inventory (all)	29 t	61 t
Gold Lock-up on Carbon	10 kg	35 kg
Adsorption Efficiency	98.2%	93.6%
Overall Gold Recovery	**83.3%**	**80.8%**
Barren Solution Losses	**0.01 mg/L**	**0.03 mg/L**

CASE STUDY #2 – CIL CIRCUIT

- CIL Plant (Alamos Gold, Young-Davidson Mine) treating combined flotation concentrate / tailing
  - 5 CIL (conc only) + **3 CIL (combined conc/tail)**
  - Gold in barren solution = 0.044 mg/L
- Testwork → Plant carbon (49 g/t) and multiple densities (50-65% solids)
- Modelling: variables examined → Increased carbon concentration, number of stages and carbon flowrate

Parameter	OLD	NEW
Circuit Configuration	3 x 2800 m^3	3 x 2800 m^3 2 x 800 m^3
Daily Carbon Transfer	5 t/day	7.5 t/day
Carbon Concentration	18 g/L	18 g/L
Adsorption Efficiency	~70%	~85%
Overall Gold Recovery	**~40%**	**~49%**
Barren Solution Losses	**0.044 mg/L**	**0.021 mg/L**

CASE STUDY #3 – PLANT CHANGES

- B2Gold Masbate Plant, Philippines (open pit, 1 g/t Au, ~76% Au O'All Recovery)
- FS Level test program and plant data used in optimization.
- Plant Changes were implemented in May 2016 and results from 2016-2017 confirmed the model predictions.
- Testwork gave B2Gold the confidence to move ahead with changes that essentially changed the CIL circuit into CIP circuit.
- Carbon was removed from plant, which significantly lowered the inventory of gold in the plant, with no impact on solution losses and lower gold losses to carbon fines.
- The leach circuit upgrade also resulted in an overall gold recovery increase of ~3%.