Twin Metals Minnesota:

Stockpile Facility Analysis using Dynamic Simulation

MOSIMTEC™

TWIN METALS MINNESOTA

OVERVIEW

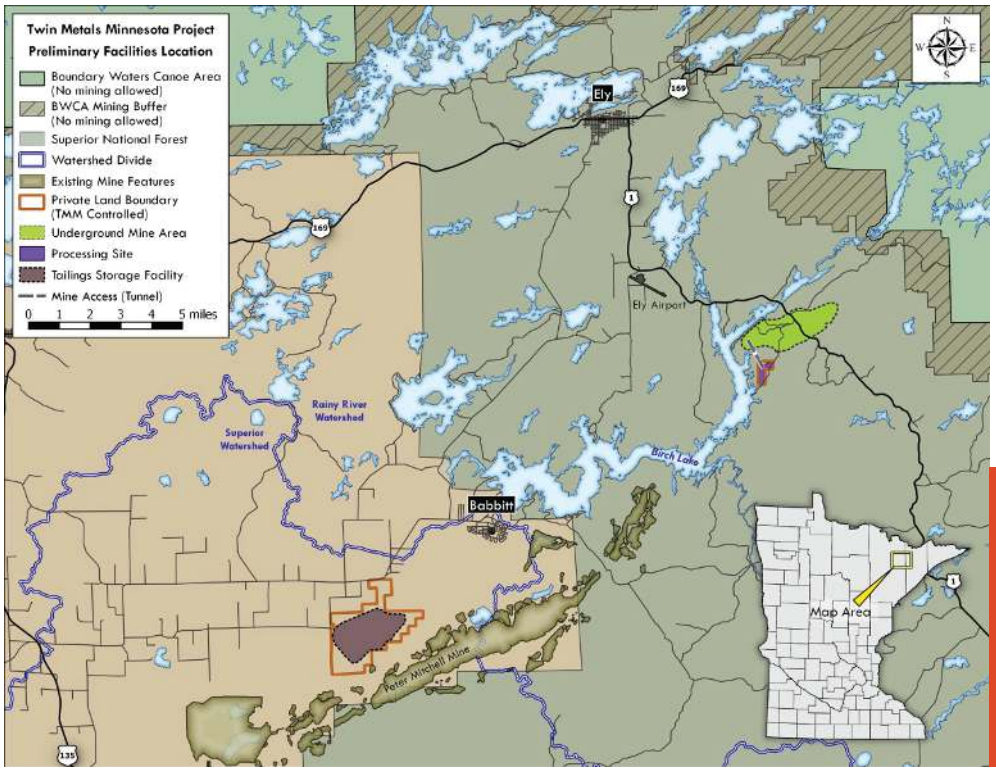
MOSIMTEC LLC (MOSIMTEC) built a simulator for Twin Metals Minnesota LLC (TMM) to help solve questions surrounding the company's stockpile design.

TMM is a Minnesota mining company focused on designing, constructing and operating an underground copper, nickel, platinum, palladium, gold and silver mining project in the Iron Range region of Minnesota. TMM is a wholly owned subsidiary of Antofagasta plc of Santiago, Chile, one of the top 10 copper producers in the world.

MOSIMTEC assists clients to make better decisions through the application of advanced decision support tools. MOSIMTEC leverages modern advancements in modeling and simulation science and technology to solve complex issues for clients across various industries.

MOSIMTEC and TMM have previously worked together to develop simulation models of specific underground actions for use in supporting engineering studies, including stope production and material handling. This new simulation focuses on stockpile facility sizing for TMM's underground mining project prefeasibility study. For mining projects, having a large Coarse Ore Stockpile (COS) is a benefit to the operation and provides flexibility to overcome typical operating issues such as shut downs. The COS also decouples the mine and the mill, allowing each component to operate efficiently in their own shift work time.

Although operators prefer to have a large COS, the TMM project is working to reduce project footprint and infrastructure height as much as possible, whilst maintaining target production throughput. Hence, MOSIMTEC created a simulation of the ore flow system from crushers underground to the COS on the surface. The simulation model also includes a Temporary Rock Storage Facility (TRSF) and the mill processing unit. The simulation was used in order to help with the design criteria for the stockpile facilities and the underground conveyor capacity.



TMM Preliminary Facilities Location.

THE OPPORTUNITY

MOSIMTEC built a simulation-based tool which modeled the underground production to surface stockpile facility and applied the model to study the design criteria for the conveyor network and stockpile facility — with varying system component availability, production, and processing rates. All whilst taking into account TMM's own environmental standards.

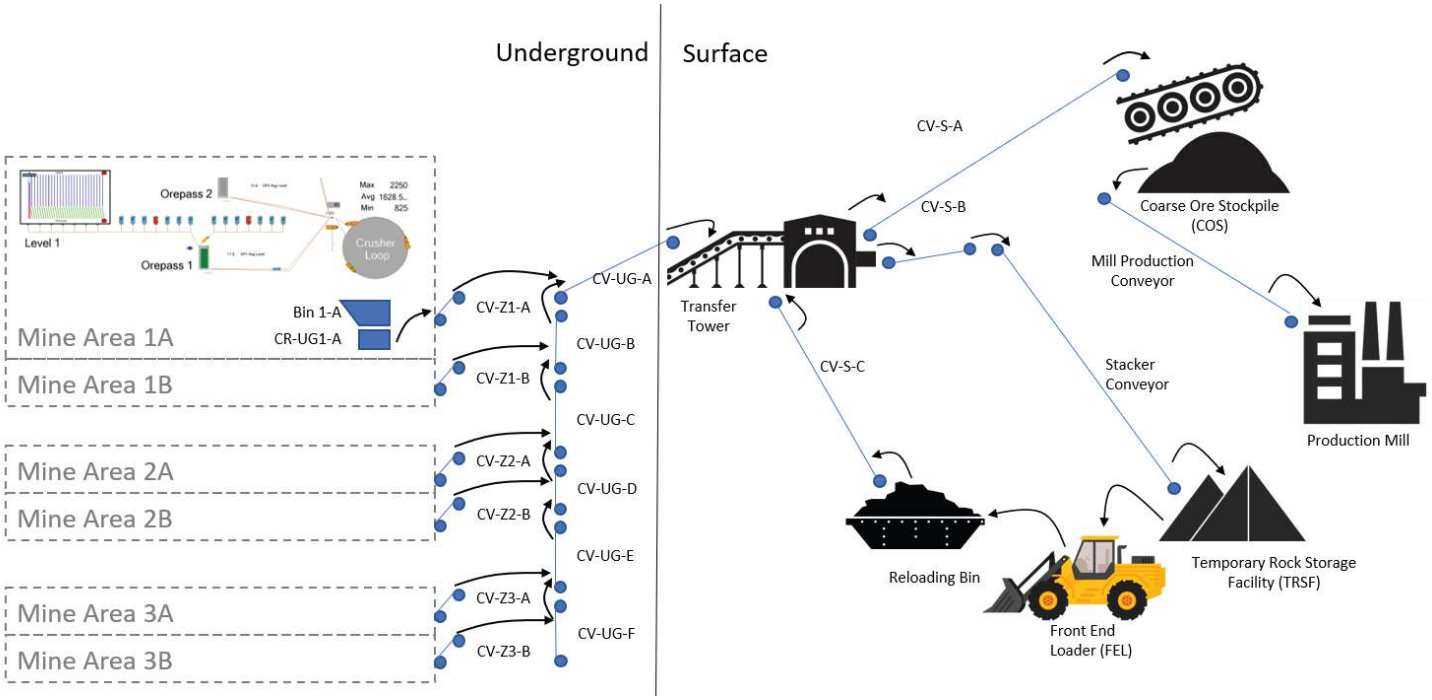
The analyisis has a target project throughput of 18,000 metric tons per day and considers a COS size with a capacity of 55,000 metric tons. MOSIMTEC was to see if this design was feasible with different:

- ✔ Active mining areas and a variable instantaneous underground production rate
- ✔ Conveyor reliability and availability rates
- ✔ Transfer rate from TRSF to COS, via Front-End Loader (FEL)
- ✔ Processing rate of the production Mill
- ✔ System downtimes and schedule shifts

SIMULATION MODEL DESCRIPTION

The scope of MOSIMTEC's model included underground mine areas (up to six defined), with up to three ore passes per mine area. Each mine area had handling equipment which transported the ore from ore passes to a mine area crusher & bin combination.

The model furthermore included auxiliary conveyors [CV-Z#-x] feeding onto the mainline conveyors [CV-UG-x] — which in turn fed to the surface transfer tower. Here, the ore was routed to either the COS or TRSF. The rehandling from the TRSF to the COS, by means of FEL and a rehandling conveyor to the transfer tower were additionally modeled. Finally, the mill production could be seen extracting from the COS.



Schematic illustration of the underground and surface operations at TMM as represented in the MOSIMTEC simulation model.

Both the COS and the TRSF had user-defined scales to determine how close to capacity each pile was. The scale can be seen in the adjacent diagram. There were important functions of TMM's process that was dependent on this scale, such that if the level of ore in the:

- ✔ COS exceeded the high mark, the mill would increase production to 105%, using designed turn-up capacity
- ✔ COS exceeded the high-high mark, the transfer tower rerouted the ore to the TRSF
- ✔ TRSF exceeded the low mark, the mill would further increase production to 115%
- ✔ COS returned below the high mark, the FEL would begin rehandling ore from the TRSF back to the COS. mill production, however, remained at 115% until the level in the TRSF fell below the low mark

Illustration of user defined stockpile level triggers.

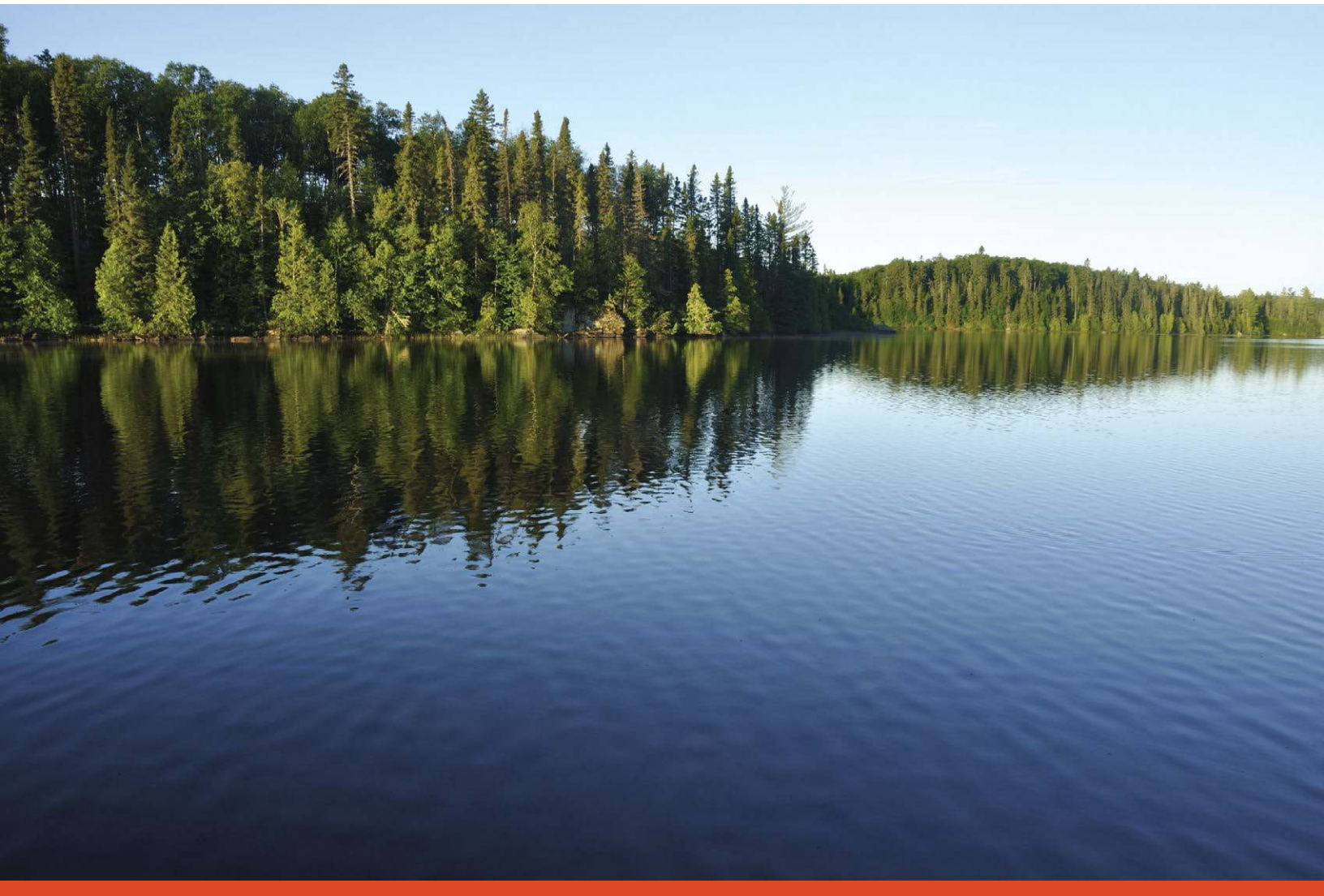
OUTPUTS & SCENARIOS

The data collected from the simulation model centred on:

- Time-delimited detailed observation log
- Component downtime (hours)
- Daily average & maximum stockpile levels (in metric tons)
- Daily underground production (in metric tons)

The scenarios ran varied in:

- FEL rehandling throughput rates — TRSF to COS
- The number of active mining areas — initial ramp-up and production in shallow areas of the deposit vs mining in lower ore zones at depth
- The availability of all conveyors by accounting for unplanned faults and scheduled maintenance



RESULTS

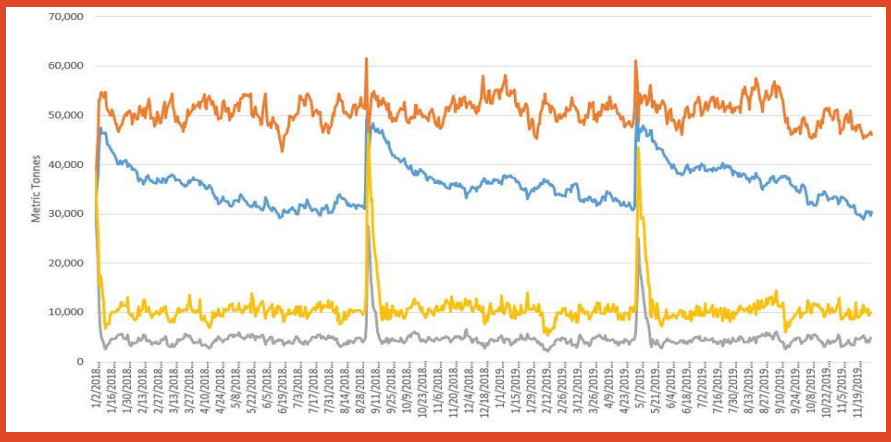
Through the model[1], MOSIMTEC concluded that the underground system and surface stockpile facility parameters used in the analysis was capable of producing sufficient material flow to maintain planned mill throughput.

MOSIMTEC found that:

- TRSF will always be a temporary stockpile and never be continuously utilised.
- ✔ The mine oreflow system can handle the desired mine output and is therefore sufficient for TMM's production process.
- ✔ The TRSF stockpile will not be a permanent stockpile reaching a capacity of between 40,000 to 50,000 metric tons, during a mill shutdown of 2 days, every 8 months.

"*The simulation analysis provides TMM the analytical results to confidently move ahead with its design,*" commented Glenn Barr, Director of Engineering at TMM. The simulation model supported a path forward that provides a design criteria that is technically defendable, environmentally conscious, and minimizes cost to save potentially millions of dollars in capital expenditure.

Sample simulation model output illustrating time delimited ore storage inventory.



[1]The experimentation included over 300 scenarios — each with 20 runs (margin of error being less than 10% of the Mean). Each scenario was run over a 100 and 150 week duration

AREAS OF FURTHER EXPLORATION

As time passes, the planned production process may evolve and differ from the current envisioned state. Hence, MOSIMTEC suggests to:

- Refine the model assumption and inputs as the actual system design evolves. There lies an opportunity to industrialize the model beyond Greenfield analysis.
- Perform additional analysis of equipment assignments. In the future an opportunity exists to optimize equipment specification, capital investment, and related deployment timing.
- Perform a detailed production stope buildout analysis. Essentially use the dynamic simulation to analyze the mine plan, with detailed representation of production stopes and related stope sequencing.

CONTACT US

MOSIMTEC™

297 Herndon Parkway, Suite 302, Herndon, VA 20170 USA

www.mosimtec.com

+1 (855) 677 3342

TWIN METALS MINNESOTA

280 St. Peter Street, Suite 705, St. Paul, MN 55102 USA

www.twin-metals.com

+1 (651) 842 6800