Technical Memorandum

ITASCA Consulting Group, Inc.

Date: May 2, 2018

To: Victoria Peacey, Resolution Copper Mining LLC

From: Matthew Pierce and Tryana Garza-Cruz

Re: Answers to Questions Raised in March 16, 2018
Review of Itasca Analysis of Resolution Subsidence

Ref: 2-4208-04:18TM15

In 2017, Itasca conducted geomechanical studies of cave growth and subsidence potential for Resolution Copper Mining. The results of these studies are documented in a report titled "Assessment of Surface Subsidence Associated with Caving — Resolution Copper Mine Plan of Operations." A subsidence impact model was run to support the mine plan of operations, which was submitted to the United States Forest Service (USFS) in November 2013 to initiate the comprehensive environmental review under the National Environmental Policy Act (NEPA) with the completion of an Environmental Impact Statement (EIS). The main purpose of the study was to evaluate the potential ground collapse and surface deformations associated with caving at Resolution Copper for the EIS based on a production schedule of approximately 135,000 short tons per day (120,000 metric tonnes per day). The analyses were conducted with *FLAC3D*. This technical memo addresses three specific questions raised by reviewers of the subsidence analysis in a March 2018 meeting. These questions are outlined and answered below.

Q1: What was the minimum zone size used to represent faults implicitly within the *FLAC3D* model?

A1: The minimum zone size used to represent faults in the *FLAC3D* model is 20 m. The fault is represented as a feature 2-3 zones wide to resolve shear deformations correctly when the fault crosses the hexahedral model mesh at an angle. Thus, the fault is represented as a feature 40-60 m wide in the area of interest. This is considered reasonable given the scale of the caving footprint (~1300 m x 1400 m).

Q2: What is the volume of caved rock remaining in the ground at the end of mine life?

A2: The volume of caved rock remaining at the end mine life is predicted to be approximately 4.5 billion cubic meters.

Q3: What is the potential for residual subsidence after production from the panel cave has ceased?

A3: Most measurements of residual mining-induced subsidence are associated with underground coal mining. The duration of reported residual subsidence movements above longwall coal mines is relatively short, typically between a few weeks to 5 years. Singh (2003) reports that the magnitude of residual subsidence rarely exceeds about 10% of the total subsidence. If we apply this to the Resolution case, this would represent an additional residual subsidence of approximately 24-34 m for a crater depth range of 240-340 m predicted from the model sensitivity analysis of subsidence.

Subsidence monitoring of man-made rockfill piles also provides some evidence for the phenomenon of residual subsidence. A review of the literature carried out by Naderian and Williams (1997) indicated a range of measured settlements under dry conditions between 0.3% and 7% of the rockfill height, with further 1% to 4% settlement on groundwater recovery. The wide range in reported values is due to the fact that residual subsidence of man-made rockfill piles varies significantly with mineralogy, degree of compaction (porosity), fragment strength, pile shape, and the fact that there is often minimal opportunity for arching during residual settlement. Typical settlement (normalized relative to the initial fill thickness) versus time (after the end of backfilling) plots for waste-rock backfilling of open pits in the Midlands coalfields of England (Williams, 2001) are shown in Figure 1. Considering the conservative case of uncompacted rockfill, it would suggest residual subsidence at Resolution of approximately 25-30 m occurring over several years after production stops. This is consistent with the estimate of 24-34 m obtained above from comparison against longwall coal mining case studies.

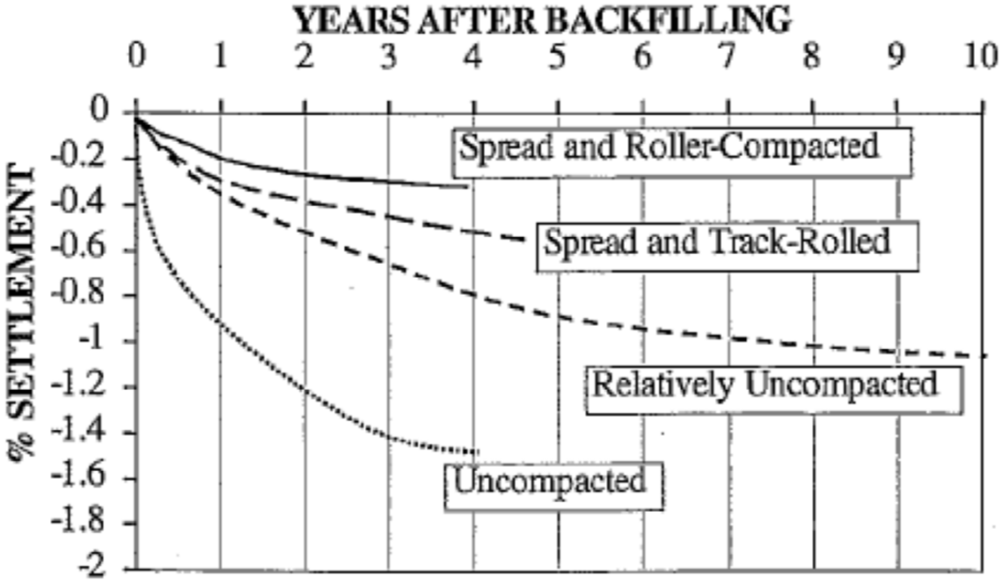

Figure 1 Mine waste-rock backfill settlement versus time (Williams, 2001).

REFERENCES

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