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Mining and Geological Consultants

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January 11, 2023
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New York State Department of Environmental
Conservation
Bureau of Resource Management & Development
Division of Mineral Resources
625 Broadway, Third Floor
Albany, NY 12233-6500

Attention: Thomas R. Rigley
Bureau of Resource
Management & Development

Subject: Planned S3 Submain Sump
Cayuga Mine, Cargill, Inc.
Seneca and Tompkins Counties, New York

Dear Mr. Rigley:

As requested by you on January 6, 2023, this letter provides the professional opinion of John T. Boyd Company (BOYD) regarding the construction of the planned S3 Submain Sump.

Dr. Vincent Scovazzo, Executive Consultant – Geotechnical, of BOYD reviewed several documents provided by Cargill, Inc. concerning ground control matters for the planned sump.

Conclusion

Based on review of the supplied documents, it is the opinion of BOYD that installation of the sump will not cause global instability of the mine, the S3 Submain, or E 5 panel.

The following identifies and discusses the documents reviewed:

RESPEC June 30, 2021 A

This Respec 2021 letter¹ generally reviews some of the hazards associated with underground brine storage with particular emphases on the two storage sites being

¹ Belzer, Brett E., 2021, Conceptual Review of Containment Methods for Evaluation of Brine Storage on the 6-Level in Abandoned Workings, ReSpec, letter to Zoe Scopa, Cargill Salt, June 30.

considered; South 3 Mains and U54 through U60 panels. The effects on the panel, its closure rates, and rock mass strain/stress were not addressed in the letter, nor were the mine wide effects of introducing water into the mine.

RESPEC June 30, 2021 B

This presentation² addressed global stability, modes of failure, conversion rates, and hydraulic potential for a brine filling operation in the South 3 Submain. Respec noted that close-to-saturated brine storage would not result in instability of the South 3 Submain.

Kenney Geotechnical October 4, 2021

Laboratory report³ for test results on salt blocks using ASTM standard D3080, a procedure addressing the shear strength of soil. Kenny Geotechnical notes "Testing performed on rock salt block samples provided by Cargill. Sample wrapped in plastic prior to testing. Small block cut from three different blocks. Sample saturated in brine solution for 24 hours before testing."

Kenney Geotechnical October 5, 2021

Laboratory report⁴ for test results on salt blocks using ASTM standard D5607, a procedure addressing the shear strength of rock. Kenny Geotechnical notes "Testing performed on rock salt block samples provided by Cargill. Sample wrapped in plastic prior to testing. Application of seating load (approx. 22 psi). Shear Plane was approximately 10 to 15 degrees from Horizontal. Shear Plane crushed during testing."

Agapito, March 11, 2022

This draft report⁵ of Agapito considers the stability of E5 Panel and adjacent S3 Mains if the panel is flooded. It appears this report was finalized on April 2022. At Cargill's request, input data for the FLAC3D model was the same or similar as the Respec Model. BOYD did not receive the Respec report that addressed their model, however, the model was discussed by Respec in their letter¹ and presentation². Agapito's results were presented in map and graph forms for stress, safety factor, and closure. No results were presented regarding the effects on the lake bottom or for layers above elevation -883 ft.

The results of the Agapito draft report support the Respec analysis.

² Respec, 2021, S3 Brine Storage Update, ReSpec, Power Point presentation, Cargill Salt, June 17, June 30.

³ Kenney Geotechnical Engineering Services, PLLC, 2021, Direct Shear of Rock, Project Number 2021-146, October 3.

⁴ Kenney Geotechnical Engineering Services, PLLC, 2021, Direct Shear of Soil, Project Number 2021-146, October 4

⁵Agapito Associates, Inc. 2022, DRAFT FLAC3D Analysis of Flooded Panels Stability E5 Panel off the S3 Submain, Cayuga Mine, report number 1043-1, prepared for Cargill, Inc., March 11

Agapito, April 12, 2022

This report⁶ of Agapito is consistent with the draft report⁵. In this report Agapito notes “The immediate roof over the panel is a claystone that is somewhat water sensitive; therefore, it is expected that the roof will tend to deteriorate over the entries in time after the panels are flooded. Agapito proposed, and Cargill approved, a criterion for roof deterioration based on the stress state and flexural strength of the claystone, allowing for likely effects of roof deterioration on pillar and panel stability to be included in the analysis.”

- “A total of 50 years of creep was included. The E5 Panel was developed approximately 12 years ago, and Cargill estimates that it will take 8 additional years for the water stored in the S3 Submains to reach the roof of the E5 Panel. At this point, flooding will continue updip for 10 years, with the head at the E5 roof increasing from 0 pounds per square inch (psi) to 20 psi in that time (the panels are isolated hydraulically from the overlying strata and Cayuga Lake).”
- “The precise behavior of the claystone roof when exposed to water is unknown, but it is hypothesized that the current mining state has caused relaxation of the roof over the entries, meaning that portions of the roof are in tension or relatively low compression, and that these portions of the roof are especially susceptible to deterioration and failure as the panel is flooded.”
- “The final criterion adopted was to delete claystone roof elements and all elements below them to the roofline when the vertical tensile stress in the element was 240 psi or greater.”
- Agapito “... understand that the closest aquifer is about 1,200 ft above the No. 6 Salt, so the figures indicate that the potential for paths between the aquifer and the mine workings is low.”

Agapito concludes;

- “The Agapito flooded model includes an alternative approach to simulate potential claystone roof deterioration. Using this alternative approach, the roof deteriorates in the flooded model over mine openings but is intact and stable over pillars.”
- “... the flooded model indicates that flooding the panels off the S3 Submain for water storage is not likely to give rise to global instability that could potentially cause rapid ejection of water from the panels and potential flooding of other mine areas.”
- “The results for the flooded model are very similar to the base model and show even slightly more stability due to the removal of roof weight and the slight confinement provided to the roof, pillars, and floor by the stored water.

⁶ Agapito Associates, Inc, 2022, Flac3D Stability Analysis of S3 Submains and E5 Panel, Cayuga Mine, report number 1043-01, prepared for: Cargill, Inc., April 12.

Agapito December 8, 2022

This letter⁷ is an addendum to Agapito's 2022 report⁶. Agapito concluded that;

- “The modeling results indicated a slight increase in global stability of the S3 mine workings after flooding. This is mainly attributed to the removal of roof weight during flooding and the slight confinement provided to the roof, pillars, and floor by the stored water.
- The modelling results also indicated that the mining induced stresses return to virgin stress conditions approximately 300 feet (ft) from the edge of the mine workings. This therefore suggests that any mining areas located greater than 300 ft from an adjacent stable mining area will not be subjected any significant stress surcharges.
- The mine has indicated that the extent of the stored water level will be limited to the midpoint between SW2 Mains and E3 Panel, an approximate distance of 1,500 ft from the nearest point of U12 Panel. AAI understands that the mine workings in S3 Submains dip away from U12 Panel.”

Cargill December 16, 2022

This memorandum⁸ notes that Cargill plans to move brine storage from the 4 Seam mine to the S3 mains and adjacent E3-E9 panels (sump). The brine source for this sump will be the Number 1 shaft (averages 28 gpm), the number 3 shaft, surface runoff concentrate, and U12 depressurizing boreholes. The total flow to the planned sump will be 30-35 gpm.

The brine is estimated to average 20 to 22% salt by weight, compared with 26.6% salt if fully saturated. Thus, some dissolving of the pillar in the sump was anticipated by Agapito by reducing the pillar dimensions by 1 ft in their analysis.

To lessen the pillar impact, Cargill is constructing a system that will bring the brine up to approximately 24-25% salt content before pumping to the sump. The system is to be finished in the fourth quarter of 2023

Cargill notes “The introduction of brine to the S3 panels will increase humidity in the area, but is not expected to cause adverse impacts significantly beyond the historical seasonal variations in convergence. Monitoring of humidity and its effects on convergence will continue as water is stored in the S3 workings.”

Cargill January 9, 2023

On January 9, 2023 Cargill emailed⁹ BOYD concerning S3 Sump. Cargill noted; “After reviewing draft results from Respec we did not believe their modelling

⁷ Stone, Ry, 2022, Comment on the Potential Geomechanical Impacts Associated with Flooding S3 Submains on the Neighboring U12 Panel, Agapito Associates, Inc., report number addendum to 1043-01, to Samrat Mohanty, Cargill Salt, December 8.

⁸ Scopa, Zoe, 2022, Cayuga Mine –S3 Water Storage Memo, Cargill, Inc. Memorandum to Vincent Scovazzo, John T. Boyd Company, December 16.

⁹ Scopa, Zoe, 2023, S3 Water Storage at Cayuga, email to Vincent A. Scovazzo, January 9.

approach was representative of our plan for water storage. At our request, Respec did not complete their investigation into the geomechanical implications of water storage in the S3 workings. Their preliminary simulation had an unrealistic assumption that the entirety of the 15' thick roof claystone layer across the 3-D model geometry lost 95% of its rock mass strength instantly at the onset of storage. Our view was that (a) the 95% loss in claystone strength assumption was arbitrary, especially in the absence of pertinent pre- and post-immersion claystone strength data, (b) the entire roof claystone layer thickness should not have been weakened instantly as such degradation is likely to be a progressive process from the roof line moving upwards, (c) the unexposed claystone zones away from the excavations and in the barriers should not have been weakened as such zones will never be in contact with the flood water making them unlikely to degrade. Subsequently, Agapito Associates proposed an alternate approach based on the tensile-stress states within the roof claystone in order to simulate the progressive degradation of the claystone when in contact with the flooded brine in S3 workings, which is outlined in their investigation report. Additionally, their investigation utilizes the direct shear strength parameters generated from lab testing of the roof claystone specimens. Agapito Associates performed the only complete geomechanical study on the implications of flooding the S3 workings and we believe their report is the best representation of our long term water storage plan”.

Findings

BOYD agrees with Cargill's critiques of Respec's approach, however, both Agapito and Respec noted that their analysis shows that the S3 Sump area will be globally stable. Based on this review of documents addressing S3 Sump area stability, BOYD opines that this sump will not cause global instability of the mine, the S3 Submain, or E 5 panel.

Cargill has noted that they will continue monitoring for closure and humidity in the U12 Panel. BOYD recommends the following tasks to further understand the effects of the S3 Sump on the U12 panel, the SW1 and S3 Submains, and to check on Agapito's model results:

- Monitor the U12 panel and the SW1 submain for both closure and humidity, and
- Install and monitor a minimum of 6 (six) closures station in the area of crosscuts O3 and P3 in the S3 submain.

BOYD suggests Cargill formalize a monitoring plan for review by the New York State Department of Environmental Conservation.

Respectfully submitted,

JOHN T. BOYD COMPANY

By:

A handwritten signature in black ink, appearing to read "V. Scovazzo", written over a light blue horizontal line.

Vincent Scovazzo, Ph.D.
Executive Consultant – Geotechnical

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