

**REVISED**

**PLANNED S3 SUBMAIN SUMP**

**CAYUGA MINE, CARGILL, INC.**

Seneca and Tompkins Counties, New York

Prepared For

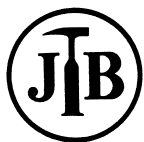
**NEW YORK STATE DEPARTMENT  
OF ENVIRONMENTAL CONSERVATION**

By

**John T. Boyd Company**

Mining and Geological Consultants

Pittsburgh, Pennsylvania



Report No. 2499.008

AUGUST 2023



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August 2, 2023  
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Thomas R. Rigley  
New York State Department of Environmental Conservation  
Bureau of Resource Management & Development  
Division of Mineral Resources  
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**Subject: Revised**  
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. On July 20, 2023, it was requested that the January 11, 2023, letter be revised based on information learned during the mine visit and meeting held on July 12, 2023. The principal change is the understanding that the initial discharge location would not be at the end of the E-5 Panel but at the end of the S-6 Main<sup>1</sup>. S-3 is actively being used as a sump but plans are to expand its use by increasing the flow rate.

Also learned at the meeting is that construction of the system is complete and it will saturate the brine up to approximately 24%–25% salt before pumping to the sump.

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

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<sup>1</sup> JMT of New York, Inc., 2023, Modification Application for Permit to Mine, Cargill, Inc., Cayuga Salt Mine, MLF # 70052, Prepared for: Cargill, Inc., Project No. 20-01312N-003, June.

## **Conclusion**

Based on a 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 E5 panel. The following identifies and discusses the documents reviewed:

### **RESPEC June 30, 2021 A**

This 2021 Respec letter<sup>2</sup> generally reviews some of the hazards associated with underground brine storage with particular emphases on the two storage sites being 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 presentation<sup>3</sup> 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 report<sup>4</sup> for test results on salt blocks using ASTM standard D3080, a procedure addressing the shear strength of the 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 report<sup>5</sup> 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 (approximately 22 psi). Shear Plane was approximately 10 degrees to 15 degrees from Horizontal. Shear Plane crushed during testing."

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<sup>2</sup> 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.

<sup>3</sup> Respec, 2021, S3 Brine Storage Update, ReSpec, Power Point presentation, Cargill Salt, June 17, June 30.

<sup>4</sup> Kenney Geotechnical Engineering Services, PLLC, 2021, Direct Shear of Rock, Project Number 2021-146, October 3.

<sup>5</sup> Kenney Geotechnical Engineering Services, PLLC, 2021, Direct Shear of Soil, Project Number 2021-146, October 4

### **Agapito, March 11, 2022**

This draft report<sup>6</sup> of Agapito considers the stability of the E5 Panel and adjacent S3 Mains if the panel is flooded. It appears this report was finalized in April 2022. At Cargill's request, input data for the FLAC3D model was the same or similar to the Respec Model. BOYD did not receive the Respec report that addressed their model; however, the model was discussed by Respec in their letter<sup>1</sup> and presentation<sup>2</sup>. 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.

### **Agapito, April 12, 2022**

This report<sup>7</sup> of Agapito is consistent with the draft report<sup>5</sup>. 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 up dip 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."

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<sup>6</sup>Agapito 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

<sup>7</sup> 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 "... 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."

#### **Agapito December 8, 2022**

This letter<sup>8</sup> is an addendum to Agapito's 2022 report<sup>6</sup>. 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 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 memorandum<sup>9</sup> 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

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<sup>8</sup> 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.

<sup>9</sup> Scopa, Zoe, 2022, Cayuga Mine –S3 Water Storage Memo, Cargill, Inc. Memorandum to Vincent Scovazzo, John T. Boyd Company, December 16.

be the Number 1 shaft (averages 28 gpm), the No. 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 emailed<sup>10</sup> BOYD concerning S3 Sump. Cargill noted; “After reviewing draft results from Respec we did not believe their modelling 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

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<sup>10</sup> Scopa, Zoe, 2023, S3 Water Storage at Cayuga, email to Vincent A. Scovazzo, January 9.

the implications of flooding the S3 workings and we believe their report is the best representation of our long-term water storage plan”.

### **Cargill July 21, 2023**

At BOYD’s request, Cargill<sup>11</sup> noted: “1. The brine making system construction is complete, but we still have programming to do before it could be fully operational. 2. The furthest south electronic station is 2750’ away from the initial discharge point. Beyond that there are 8 active manually read convergence rods and 21 installed but inactive manual convergence rods between that station and the end of the panel. We should have power to the electronic stations in S3 soon.”

### **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 E5 panel.

Of interest is the global stability of the S3 Main, but the studies presented here were for the E5 panel. However, the S3 Main is stronger than the E 5 panel because.

	<u>S3 Main dimensions</u>	<u>E 5 panel dimensions</u>
E 5 panel is wider	390 ft	490 ft
S3 Main has larger pillars	16 ft × 19 ft	13 ft × 19 ft
These pillars support the same roof area	43 ft × 61 ft	43 ft × 61 ft

Panel width includes stress relief rooms.

Therefore, the results of the Agapito and Respec studies for the E5 panel can safely be applied to the S3 Main.

Cargill has noted that they will continue monitoring for closure and humidity in the U12 Panel. They also note that Cargill’s closest electronic station is 2,750 ft away from the S-3 discharge point, and there are eight active manually read convergence rods to the north.

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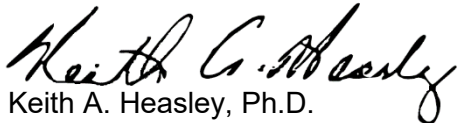
<sup>11</sup> Scopa, Zoe, 2023, RE: A few questions, email to Vincent A. Scovazzo, July 21.

BOYD does not recommend further monitoring for global stability determination. Note that powering of the electronic stations will result in near continuous monitoring of the S-3 Main.

Respectfully submitted,

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By:



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