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ARCHITECTURE
ENGINEERING
CONSTRUCTION MANAGEMENT

Resolution Copper Project

Viability of In-Situ Leaching of the Resolution Copper Deposit

Superior, Arizona

Prepared For:

RESOLUTION COPPER

VIABILITY OF IN-SITU LEACHING OF THE RESOLUTION COPPER DEPOSIT

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EXECUTIVE SUMMARY

In response to Public Comments on the Resolution Copper Draft Environmental Impact Statement (DEIS), the USFS assigned an action item to evaluate the alternative with respect to the Resolution Copper Deposit (EIS-272 – Submittal of Memo on In-Situ Mining). In-situ leaching would replace the underground mine, surface-level mineral processing plant (concentrator), and tailing storage facility with facilities for in-situ acid injection, pregnant leach solution recovery, and a solvent extraction and electrowinning (SX/EW) plant. Cathode copper would be produced on-site in-lieu of copper concentrate. Due to the nature of the Resolution Copper deposit (ore mineralogy, depth, host rock hydrogeologic characteristics), in-situ mining is not reasonable, practicable or technically feasible for the large majority of the copper minerals that comprise the Resolution ore body. As such this method would not meet the purpose and need associated with the Resolution Copper Mine Plan of Operations analyzed in the DEIS.

Per the mineralogy of the Resolution Copper (RC) deposit, copper recovery would be approximately 15% or less of the total mineable deposit with in-situ mining. The Resolution Copper deposit has no copper oxide mineralization; the oxide mineralization would typically be well suited to leaching. Thus, the percentage is likely an optimistic approximation of what might be recoverable. The copper mineralization associated with the deposit is comprised of chalcopyrite and bornite, sulfide based-copper minerals, which are not readily leachable. Additionally, the recovery of molybdenum is expected to be minimal, as the bulk of the mineralization is molybdenite. Any fraction of molybdenum that does leach into solution would require separate processing unit operations at the surface, as the molybdenum would not be recovered with the cathode copper from the electrowinning facility.

In-situ leaching is typically employed with oxide deposits that are relatively close to the surface at depths of up to 2,000 feet. Given the depth of the RC deposit, at approximately 7,000ft below the surface, well drilling and the solution pumping systems would be outside typical design conditions.

Aside from the challenges of low availability of material amenable to leaching and the greater than typical depths of the deposit, the surrounding host rock and hydrogeologic characteristics of the rock do not allow for acceptance or recovery of leaching solution. The average saturated hydraulic conductivity of the rock is between 1e-6 and 1e-8 cm/sec, which falls in the range of an aquitard or aquiclude. Saturated hydraulic conductivities on the order of alluvial sand and gravels or highly fractured rock, as low as 1e-4 cm/sec, would allow pumping and recovery of fluids – several orders of magnitude different. The only possible method of creating such a large increase in hydraulic conductivity would be hydraulic fracturing across the entirety of the Resolution Copper deposit, which would be an unprecedented technical undertaking given the size and depth and existing hard rock conditions.

For the reasons mentioned above, in-situ leaching of the ore body is not a viable alternative for the RC deposit.

1 PURPOSE OF REPORT

1.1 DESCRIPTION OF STUDY OBJECTIVE

This study consists of an evaluation into the viability of in-situ leaching as an alternative mining method.

1.2 SCOPE OF INVESTIGATION

For the purposes of this study, in-situ leaching would replace the concentrator and tailing storage facility with a wellfield for acid injection into the orebody, pregnant leach solution recovery and a hydrometallurgical plant for production of cathode copper.

2 TECHNICAL ASPECTS

2.1 IN-SITU LEACHING

In-situ leaching initially involves the drilling of holes into the ore deposit. Explosive or hydraulic fracturing would need to be used for the Resolution Copper Deposit to create open pathways in the deposit for the leaching solution to penetrate. Leaching solution is pumped into the deposit where it makes contact with the ore. The solution bearing the dissolved ore content is then pumped to the surface and recovered through a solvent extraction and electrowinning plant to produce cathode copper. Figure 1 is a process overview of in-situ leaching.

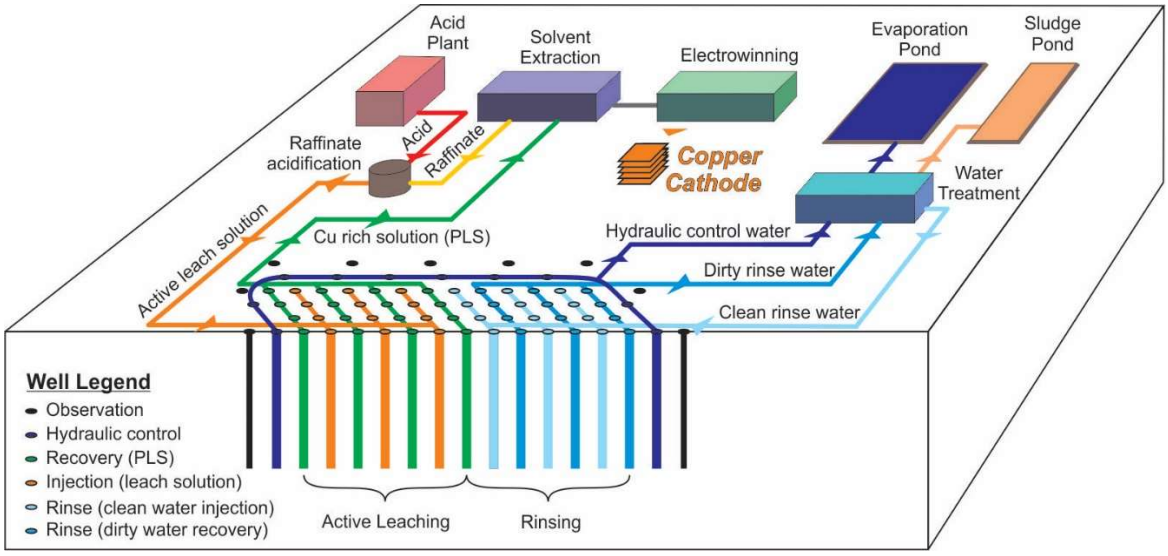

Figure 1 – In-Situ Leaching Process Overview

In-situ leaching allows the extraction of minerals from an ore body without the need for conventional or underground mining. This technology, however, has primarily been employed on fractured, oxide deposits at depths closer to the surface. For RC, an extensive network of injection and recovery wells would need to be installed across the entire surface of the Oak Flat area above and around the deposit.

The extremely low hydraulic conductivity associated with the host rock at depth (between 1e-6 and 1e-8 cm/sec), which falls in the range of an aquitard or aquiclude, make it nearly impossible to inject or recover leach solutions. Saturated hydraulic conductivities on the order of alluvial sand and gravels or highly fractured rock (as low as 1e-4 cm/sec) would allow pumping and recovery of fluids – several orders of magnitude different. The only possible method of creating such a large increase in hydraulic conductivity would be hydraulic fracturing across the entirety of the Resolution Copper deposit, down to a depth of 7,000 ft, which would be an unprecedented technical undertaking given the size and depth and existing rock conditions.

Injection and recovery wells would need to be drilled, have well casings and well screens installed (or perforation of the casing) to a depth of near 7,000 feet below the surface. This would be 3,400 feet deeper than the known deepest in-situ leaching wells, and a precedent in the industry, as these wells are typically around 2,000 feet in depth, with the deepest known around 3,600 feet in depth. Recovery wells would need to be the same depth or deeper than the injection wells. If submersible well pumps are used, they would have to produce 1000 to 2500 psi, depending on the static water level, and would require the flow to be small enough to keep the motor horsepower (HP) requirements adequately low to allow fitment of the motor in a reasonable sized well casing. This will translate to a larger number of

wells as compared to typical operating in-situ facilities. Also, the water temperature at the lower sections of the ore body is very high, which will cause problems for the well materials and systems.

Expected copper recovery would be approximately 15%, as the Resolution Copper deposit is mostly comprised of chalcopyrite and bornite ore and not copper oxide ore, which is readily leachable. The recovery of molybdenum is expected to be minimal since it occurs as molybdenite. If any minor amount of molybdenum does leach into solution, separate processing unit operations would be required at the surface, as the molybdenum would not be recovered with the cathode copper from the electrowinning facility.

3 CONCLUSIONS AND RECOMMENDATIONS

In-situ leaching of the ore body does not appear to be a viable alternative for the RC deposit. It is not reasonable, practicable, or technically feasible due to the non-leachable characteristics of the ore mineralogy, the depth of the ore body, and hydrogeologic characteristics of the host rock.

Victoria Boyne

From: ResolutionProjectRecord
Subject: FW: Action Item EIS-272
Attachments: In-Situ Mining Alternative Assessment.pdf

From: Peacey, Victoria (RC) <Victoria.Peacey@riotinto.com>
Sent: Tuesday, July 14, 2020 8:10 AM
To: Rasmussen, Mary C -FS <mary.rasmussen@usda.gov>
Cc: Donna Morey <dmorey@swca.com>; Chris Garrett <cgarrett@swca.com>
Subject: Action Item EIS-272

Hello Mary,

For your review and consideration and in response to Action Item EIS-272 (Submittal of memo on in-situ mining), please see the attached technical memorandum from M3.

Thanks,

Vicky Peacey
Senior Manager Permitting and Approvals

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