USDA Forest Service
Tonto National Forest
Arizona

March 24, 2019

Process Memorandum to File

DRAFT Review of Stakeholder Analysis of Alternative Mining Techniques

Disclaimer: This document is deliberative and is prepared by the third-party contractor in compliance with the national environmental policy act and other laws, regulations, and policies to document ongoing process and analysis steps. This document does not take the place of any line officer's decision space related to this project.

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Revision History

- February 26, 2019. Initial draft created.
- March 24, 2019. Revisions made based on Dr. Kliche's final memorandum.

Purpose of Process Memorandum

On December 18, 2018, the Tonto National Forest held one in a series of recurring meetings with a group of stakeholders concerned with the Resolution Copper project and the ongoing National Environmental Policy Act (NEPA) analysis. During several previous meetings, the stakeholders expressed the view that an alternative mining technique other than block-caving could be financially feasible for Resolution Copper. The stakeholders specifically pointed to cut-and-fill mining, which if feasible could have benefits of both preventing subsidence and reducing the amount of tailings storage required for the project. The stakeholders also indicated that they possessed a technical analysis that supported this view. After the December 18 meeting, they provided a copy of a document purported to be the technical analysis demonstrating the financial feasibility of cut-and-fill mining. The analysis reportedly was conducted by Dr. David Chambers, an environmental planner associated with the Center for Science in Public Participation.

The document provided is a single-page Excel spreadsheet, reproduced in its entirety as Attachment 1. No additional documentation or narrative was provided. However, the spreadsheet is relatively simple and the approach contained therein was readily understood by the NEPA team. In the spreadsheet, the Net Present Value (NPV) was calculated for five different scenarios:

- Block-cave mining, lower range of per-ton mining cost, entire deposit at 1.5% grade
- Block-cave mining, higher range of per-ton mining cost, entire deposit at 1.5% grade
- Cut-and-fill mining, lower range of per-ton mining cost, entire deposit at 1.5% grade
- Cut-and-fill mining, higher range of per-ton mining cost, entire deposit at 1.5% grade
- Cut-and-fill mining, higher range of per-ton mining costs, focusing on a smaller amount of material at 3% grade

No explanations were provided to support the many assumptions required to do the calculations. The results of the calculation—if taken at face value—show that not only are cut-and-fill scenarios financially feasible, but the final cut-and-fill mining scenario would result in a greater NPV than the block-cave mining scenarios. Or in other words, that Resolution Copper could make more profit while preventing subsidence and reducing the need for tailings storage.

The Tonto National Forest had already conducted an analysis of the feasibility of alternative mining techniques, but given the potential benefits and the claims from the stakeholders, the NEPA team undertook a critical evaluation of the spreadsheet. Ultimately, the Tonto National Forest determined that:

- The spreadsheet attempts to answer a question that is not pertinent to the decision space of the Forest Supervisor;
- The analysis provided is insufficiently documented to be relied upon, and the parameters used are arbitrary, without any stated rationale;
- Setting aside the above concerns, the analysis provided is an inappropriately simplistic approach for assessing the feasibility of a mine plan of operation;

- When viewed strictly in a technical light, several key assumptions used in the analysis are not reasonable when compared to objective facts, specifically the capital investment cost assumed (all scenarios), the per-ton mining costs assumed (cut-and-fill scenarios), and the reduced amount of ore assumed to represent the 3% grade (final cut-and-fill scenario).

Technical aspects of the calculation were evaluated for the Tonto National Forest by Dr. Charles Kliche. Dr. Kliche is the author of the previous assessment conducted by the NEPA team during alternatives development, which concluded that other alternative mining techniques like cut-and-fill are not technically feasible. Dr. Kliche's technical assessment of the Chambers spreadsheet is included as Attachment 2.

The purpose of this memo is to provide detailed rationale for the determinations expressed above.

Analysis is not Pertinent to the Decision Space

Forest Service Authority

The analysis provided to the Forest Service attempts to answer the question: is a different mining technique financially feasible? This is fundamentally the wrong question to be asked, and the resulting answer is not pertinent to the decision space the Forest Supervisor has for the Resolution Copper project.

The Forest Supervisor has the authority to require changes to the mine plan of operation in order to minimize effects on National Forest System surface resources, but this authority is not absolute. When assessing how far this authority can be extended to modify a plan of operation, Forest Service mineral regulations do not rely on financial criteria. Rather than dollars or profit, the bar set for the Forest Supervisor is one of reasonableness.

Please see Attachment 3 for a detailed discussion of the legal underpinnings of the Forest Service ability to regulate or require changes to mine plans of operation. The basic standard when considering whether an alternative mining technique could be required by the Forest Service can be generally summarized as follows:

- The requirement cannot endanger or materially interfere with mining operations;
- The requirement must be reasonable;
- The requirement may not result in operations being so unreasonably circumscribed as to amount to a prohibition;
- The requirement may not impermissibly encroach on legitimate uses incident to mining.

Further Considerations

When evaluating new information provided by the public during the NEPA process, whether during scoping or afterwards, it is often a mistake to take information or comments too literally. The process is better served when the NEPA team considers not only the specific content of the comment, but also asks: even if this specific comment or information is flawed, is the comment pointing to an issue that is not adequately evaluated or considered?

Viewed in this more forgiving light, by providing this analysis to the Forest Service the stakeholders may have intended this analysis not strictly as a decision point based solely on financials, but rather as a suggestive piece of evidence that alternative mining techniques are worth further consideration. However, even if the submittal is taken in this less literal sense, the analysis fails to provide new information to inform the process.

There is no need to convince the Forest Service to assess alternative mining techniques; the NEPA team already made such an assessment a cornerstone of the alternatives development process. During alternatives development, the Forest Service analyzed the technical and financial implications of alternative mining techniques (see SWCA 2017[1], Kliche 2017[2], and Appendix B of the DEIS).

Even if the calculation had been conceived and executed properly, nothing in the spreadsheet challenges Dr. Kliche's previous evaluation of the technical feasibility of cut-and-fill mining specifically with the Resolution ore deposit, or the analysis of the trade-offs that would be required to focus solely on higher grade ore. The spreadsheet speaks to financial feasibility, but Dr. Kliche did not attempt to investigate financial feasibility, which isn't directly pertinent to the Forest Service decision. Dr. Kliche's analysis rather demonstrated the implications of using an alternative mining technique, which were then considered by the Tonto National Forest in the context of Forest Service regulations. Those implications still stand and are not contradicted by the spreadsheet provided.

Analysis is Insufficiently Documented

When conducting an environmental analysis, the Forest Service is guided by both NEPA and the Administrative Procedures Act (APA). Under NEPA implementing regulations, a certain level of documentation and rationale is required:

> "**Methodology and scientific accuracy**. Agencies shall insure the professional integrity, including scientific integrity, of the discussions and analyses in environmental impact statements. *They shall identify any methodologies used and shall make explicit reference by footnote to the scientific and other sources relied upon for conclusions in the statement*. An agency may place discussion of methodology in an appendix" (40 C.F.R. § 1502.24, emphasis added)

Similarly, the APA directs that when reviewing agency decisions:

> "The reviewing court shall…2) hold unlawful and set aside agency action, findings, and conclusions found to be—(A) *arbitrary, capricious*, an abuse of discretion, or otherwise not in accordance with law;" (5 U.S.C. § 706, emphasis added)

Given this legal direction, the Forest Service strives to document the rationale for any significant choices or decisions made during a NEPA analysis, including key assumptions used in a technical

[1] DRAFT Alternatives Evaluation Report

[2] Dr. Kliche's previous evaluation of alternative mining techniques

analyses. This documentation is included in either the EIS itself or in the project record. In this case, because no narrative has been provided with the spreadsheet, while it is easy enough for the Forest Service to understand what choices were made to achieve the calculations in the spreadsheet, it is impossible to understand why those choices were made. This is insufficient to support the NEPA analysis.

Technical Evaluation

Concerns with Overall Approach

The complete critique of the Chambers spreadsheet by Dr. Charles Kliche is included as Attachment 2.

A fundamental concern with the overall approach is that—specific assumptions aside--it is too simplistic to reflect the true economics of a mining project. As Dr. Kliche points out, there are standardized methods for performing cash flow evaluations for mining projects, and at least seven parameters typically included in a cash flow analysis are ignored or missing from the Chambers calculation—all of which are costs that would tend to reduce NPV. Dr. Kliche also points out that some basic considerations fundamental to a mining project have been ignored, such as a percent reduction in recovered copper to account for mill recovery.

Concerns with Specific Assumptions Used

Several specific concerns with technical assumptions used are worth noting:

- The capital cost used by Chambers ($1.25 billion) is underestimated by about a factor of 10 ($11.4 billion, see Elliot D. Pollack & Company 2011, p. 1).
- The per-ton mining cost for cut-and-fill used by Chambers ($35/ton) is underestimated by about a factor of two ($68/ton, see Kliche 2017, Table 2)
- The amount of ore recoverable at 3% grade used by Chambers (868 million tons) is substantially overestimated, potentially by several orders of magnitude. Average grade is not known precisely, however the analysis based on actual grade maps provided by Resolution Copper indicate this amount would almost certainly be lower (386 million tons based on the 2% shell; 7.5 million tons based on the 3% shell) (see Kliche 2017, Figure 28).

Conclusions

Based on the analysis of the spreadsheet contained in this process memo, the Tonto National Forest determined that:

- When viewed strictly in a technical light, several key assumptions used in the analysis are not reasonable when compared to objective sources, specifically the capital investment cost assumed (all scenarios), the per-ton mining costs assumed (cut-and-fill scenarios), and the reduced amount of ore assumed to represent the 3% grade (final cut-and-fill scenario).
- Further, the assumptions used in the spreadsheet lack all documentation, explanation, and rationale.

- The overall approach ignores standard protocols for cash flow evaluation and specific aspects that are unique to mining projects, such as mill recovery.
- Even if the spreadsheet had presented a valid technical approach, the spreadsheet attempts to answer a question that is not pertinent to the decision space of the Forest Supervisor. When deciding whether to modify a mine plan of operation, the bar for the Forest Supervisor is one of “reasonableness”, not one of economics.
- The spreadsheet does not provide new information that contradicts the analysis of technical feasibility and trade-offs for alternative mining techniques performed during the alternatives development process, which informed the Forest Service determination that those alternative mining techniques were not reasonable to impose on Resolution Copper.

Literature Cited

Elliot D. Pollack & Company 2011. Resolution Copper Company, Economic and Fiscal Impact Report, Superior, Arizona. September 2011.

Kliche, C. 2017. Technical Memorandum for Alternative Mining Methods, Resolution Copper Mining, LLC, Superior, AZ. November 1, 2017.

SWCA Environmental Consultants. 2017. Resolution Copper Project and Land Exchange Environmental Impact Statement DRAFT Alternatives Evaluation Report. Prepared for U.S. Forest Service. Phoenix, Arizona: SWCA Environmental Consultants. November.

Attachment 1 – Full Spreadsheet Provided by Stakeholders Assessing Economic Feasibility of Alternative Mining Techniques

Caving Case - Lowest Cost		Year	1	2	3	4	5	6	7	8	9	10	11	12	13
		Copper Price/lb	-	-	-	-	-	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00
Copper Grade	1.50%	Tons per day	0	0	0	0	0	50,000	65,000	85,000	110,000	110,000	110,000	110,000	110,000
Mining cost/ton*	$5	Revenue ($1000s)	$0	$0	$0	$0	$0	$1,620,000	$2,106,000	$2,754,000	$3,564,000	$3,564,000	$3,564,000	$3,564,000	$3,564,000
Cost of capital	7.5%	Costs ($1000s)	($250,000)	($250,000)	($250,000)	($250,000)	($250,000)	($90,000)	($117,000)	($153,000)	($198,000)	($198,000)	($198,000)	($198,000)	($198,000)
NPV ($1000s)	$24,230,766	Net	($250,000)	($250,000)	($250,000)	($250,000)	($250,000)	$1,530,000	$1,989,000	$2,601,000	$3,366,000	$3,366,000	$3,366,000	$3,366,000	$3,366,000

Caving Case - Highest Cost		Year	1	2	3	4	5	6	7	8	9	10	11	12	13
		Copper Price/lb	-	-	-	-	-	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00
Copper Grade	1.50%	Tons per day	0	0	0	0	0	50,000	65,000	85,000	110,000	110,000	110,000	110,000	110,000
Mining cost/ton*	$20	Revenue ($1000s)	$0	$0	$0	$0	$0	$1,620,000	$2,106,000	$2,754,000	$3,564,000	$3,564,000	$3,564,000	$3,564,000	$3,564,000
Cost of capital	7.5%	Costs ($1000s)	($250,000)	($250,000)	($250,000)	($250,000)	($250,000)	($360,000)	($468,000)	($612,000)	($792,000)	($792,000)	($792,000)	($792,000)	($792,000)
NPV ($1000s)	$19,776,253	Net	($250,000)	($250,000)	($250,000)	($250,000)	($250,000)	$1,260,000	$1,638,000	$2,142,000	$2,772,000	$2,772,000	$2,772,000	$2,772,000	$2,772,000

Backfill Case - Lowest Cost		Year	1	2	3	4	5	6	7	8	9	10	11	12	13
		Copper Price/lb	-	-	-	-	-	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00
Copper Grade	1.50%	Tons per day	0	0	0	0	0	50,000	65,000	85,000	110,000	110,000	110,000	110,000	110,000
Mining cost/ton*	$12	Revenue ($1000s)	$0	$0	$0	$0	$0	$1,620,000	$2,106,000	$2,754,000	$3,564,000	$3,564,000	$3,564,000	$3,564,000	$3,564,000
Cost of capital	7.5%	Costs ($1000s)	($250,000)	($250,000)	($250,000)	($275,000)	($275,000)	($216,000)	($280,800)	($367,200)	($475,200)	($475,200)	($475,200)	($475,200)	($475,200)
NPV ($1000s)	$22,115,859	Net	($250,000)	($250,000)	($250,000)	($275,000)	($275,000)	$1,404,000	$1,825,200	$2,386,800	$3,088,800	$3,088,800	$3,088,800	$3,088,800	$3,088,800

↑ Higher capital costs for additional equipment to achieve equal production rates.

Backfill Case - Highest Cost		Year	1	2	3	4	5	6	7	8	9	10	11	12	13
		Copper Price/lb	-	-	-	-	-	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00
Copper Grade	1.50%	Tons per day	0	0	0	0	0	50,000	65,000	85,000	110,000	110,000	110,000	110,000	110,000
Mining cost/ton*	$35	Revenue ($1000s)	$0	$0	$0	$0	$0	$1,620,000	$2,106,000	$2,754,000	$3,564,000	$3,564,000	$3,564,000	$3,564,000	$3,564,000
Cost of capital	7.5%	Costs ($1000s)	($250,000)	($250,000)	($250,000)	($275,000)	($275,000)	($630,000)	($819,000)	($1,071,000)	($1,386,000)	($1,386,000)	($1,386,000)	($1,386,000)	($1,386,000)
NPV ($1000s)	$15,285,607	Net	($250,000)	($250,000)	($250,000)	($275,000)	($275,000)	$990,000	$1,287,000	$1,683,000	$2,178,000	$2,178,000	$2,178,000	$2,178,000	$2,178,000

Backfill Case[1]		Year	1	2	3	4	5	6	7	8	9	10	11	12	13
		Copper Price/lb	-	-	-	-	-	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00
Copper Grade	3.00%	Tons per day	0	0	0	0	0	37,500	48,750	63,750	82,500	82,500	82,500	82,500	82,500
Mining cost/ton*	$35	Revenue ($1000s)	$0	$0	$0	$0	$0	$2,430,000	$3,159,000	$4,131,000	$5,346,000	$5,346,000	$5,346,000	$5,346,000	$5,346,000
Cost of capital	7.5%	Costs ($1000s)	($250,000)	($250,000)	($250,000)	($275,000)	($275,000)	($472,500)	($614,250)	($803,250)	($1,039,500)	($1,039,500)	($1,039,500)	($1,039,500)	($1,039,500)
NPV ($1000s)	$31,247,609	Net	($250,000)	($250,000)	($250,000)	($275,000)	($275,000)	$1,957,500	$2,544,750	$3,327,750	$4,306,500	$4,306,500	$4,306,500	$4,306,500	$4,306,500

[1] *Assume High Cost, Higher Grade, and only 75% of tonage mined.*

by Dave Chambers, CSP2, 2/14/05 - updated with 2018 copper prices
Mining Cost per Ton from Introductory Mining Engineering, Hartman, 2002, p. 561

Attachment 2 – Technical Review of Chambers Spreadsheet by Dr. Charles Kliche

MEMORANDUM

TO: Resolution Copper Project Record
Attn: Chris Garrett, SWCA Project Manager

FROM: Charles A. Kliche, P.E., PhD

DATE: February 13, 2019 (Final Rev: March 24, 2019)

RE: **Memorandum regarding spreadsheet analysis of mining economics: "Dave Chambers, CSP2, 2/14/05 - updated with 2018 copper prices"**

I have been looking through the "Chambers mining economics - updated 2018" spreadsheet for a while now. It's not exactly obvious by looking at the spreadsheet what Mr. Chambers' assumptions were. He, it seems, has provided no narrative.

The spreadsheet seems to contain 5 Net Present Value (NPV) of cash flows (CF) over time (n = 35) for 5 different options (1 CF for each option), namely (in **bold** are the differences between the baseline case [Caving Case - Lowest Cost] and the others):

1. Caving Case - Lowest Cost (n = 35; i = 7.5%; avg Cu grade = 1.5%; Cu price = $3.00 per lb; mining cost = $5/ton; total tons mined = 1,141,200,000 over the 35 years)
2. Caving Case - Highest Cost (n = 35; i = 7.5%; avg Cu grade = 1.5%; Cu price = $3.00 per lb; **mining cost = $20/ton**; total tons mined = 1,141,200,000 over the 35 years)
3. Backfill Case - Lowest Cost (n = 35; i = 7.5%; avg Cu grade = 1.5%; Cu price = $3.00 per lb; **mining cost = $12/ton**; total tons mined = 1,141,200,000 over the 35 years)
4. Backfill Case - Highest Cost (n = 35; i = 7.5%; avg Cu grade = 1.5%; Cu price = $3.00 per lb; **mining cost = $35/ton**; total tons mined = 1,141,200,000 over the 35 years)
5. Backfill Case with assumptions of: high cost, higher grade, and only 75% of tonnage mined (n = 35; i = 7.5%; **avg Cu grade = 3.0%**; Cu price = $3.00 per lb; **mining cost = $35/ton**; **total tons mined = 867,787,500** [75% of tonnage] over the 35 years)

Chambers computed his CF per year as such:

Total mining revenue = (tons mined /day · 360 days/year · 2000 lb/ton · $3.00/lb · % Cu grade/100) - (tons mined/day · 360 days/year · mining cost $/ton)

He then discounted the yearly CF to the present by i = 7.5% per year for n = 35 years. If that CF, discounted to the present (t = 0) is greater than zero (which it was), then the project is viable, according to engineering economic theory[3, 4].

Of note:

- Chambers started the mining revenue flow at year 6;
- His pre-mining capital cost investment (normally referenced as C_o) occurred in years 1 - 5. For Options 1 & 2, the total pre-mining capital investment is $1.25Bn; for Options 3 - 5, the

total pre-mining capital investments is $1.30Bn. **According to Resolution Copper, the pre-mining capital investment is closer to $11.4Bn[1]**;

- Chambers used a 360 day year;
- Chambers neglected the mill recovery of around 90%[2] in calculating total revenue;
- Chambers neglected any mining dilution;
- Neglected in the CF calculation were royalties, Federal income taxes, state income taxes, other state, local and Federal taxes, and any yearly capital expenditures, including development.

A typical yearly CF calculation for a mining venture takes the form[3] [4]:

Calculation	Component
	Revenue
Less:	Royalties (usually taken NSR)
Equal:	Gross Income From Mining
Less:	Operating Costs
Equal:	Net Operating Income
Less:	Depreciation and Amortization Allowance
Equal:	Net Income After Depreciation and Amortization
Less:	Depletion Allowance (15% of Gross Income From Mining)
Equal:	Net Taxable Income
Less:	State Income Tax (AZ = 4.9%)
Equal:	Net Federal Taxable Income
Less:	Federal Income Tax (eg: 28%)
Equal:	Net Profit After Taxes
Add:	Depreciation and Amortization Allowances
Add:	Depletion Allowance
Equal:	Operation Cash Flow
Less:	Capital Expenditures
Less:	Working Capital
Equal	**Net Annual Cash Flow**

[1] Pollock, Elliot D. & Company, "Resolution Copper Company Economic and Fiscal Impact Report Superior, Arizona", September 2011, page 1.
[2] Resolution Copper Mining, "General Plan of Operations Resolution Copper Mining, vol 1", Rev 2: January 12, 2016, page 112.
[3] Gentry, D.W. & T. J. O'Neil (1984), Mine Investment Analysis, SME of AIME, New York.
[4] Stermole, F.J. & J.M. Stermole (2012), Economic Evaluation and Investment Decision Methods, Investment Evaluations Corp., Lakewood, CO.

NOTE: CF elements shaded in grey are missing from Chambers' analyses.

Some questions arise on some of the numbers (assumptions) Mr. Chambers used, specifically:

- Where did the 7.5% rate come from at which the project CF was evaluated?

  Is this rate a calculated WACC[5] (Weighted Average Cost of Capital) for the venture, or a wild guess?

- The $3.00 per pound copper might be optimistic. It's been around $2.75 recently[6] with price around $1.00 per pound from 1974 to 2004. There are a lot of drivers in copper prices, one of which is the Chinese economy. Is it going to stay hot? It's cold right now.

Copper Prices - 45 Year Historical Chart

Interactive chart of historical daily COMEX copper prices back to 1971. The price shown is in U.S. Dollars per pound.
The current price of copper as of February 01, 2019 is **$2.77** per pound.

[5] Quirin, G.D. (1967), The Capital Expenditure Decision, Ch5 "Costs of Capital from Specific Sources," and Ch6 "Costs of Capital to the Firm." Richard D. Irwin, Inc.
[6] https://www.macrotrends.net/1476/copper-prices-historical-chart-data

- The mining cost for each of Chambers' cases is unrealistically low. That is, is processing cost included in this cost? Are other costs associated with the proposed backfilling also included?

  Is their "Mining Cost" total cost? Ie: Mining + transportation + processing + G&A + taxes + ….? For example, while the range of block caving costs used by Chambers ($5-$20/ton) matches reasonably well with other sources ($9/ton, see Kliche[7] 2017 Table 2), the range of cut-and-fill costs ($12-$35/ton) is remarkably low compared with other sources ($68/ton, see Kliche[7] 2017 Table 2)."

- How could the Backfill Case "Low Cost Per Ton" value be lower than the normal block caving "High Cost Per Ton" value?

- Interesting: Running the numbers again using an initial investment of $11.4Bn and a selling price of copper of $2.50 per pound, the implied ROR of the "Caving - Lowest Cost" is 20% (23.7% for $3 Cu). All the other options, then, have a Negative NPV at 20%.... **Except:** the "Backfill Case with *Assume High Cost, Higher Grade, and only 75% of tonnage mined"*, which still has a $2.195Bn NPV. **WOW!!**

  Why is the "Backfill Case with *Assume High Cost, Higher Grade, and only 75% of tonnage mined"* still highly profitable? Because: The copper grade of only 3%, average, is unrealistic; the tons available at the higher grade is unrealistically high; the mining cost is unrealistically low; and the capital costs are impossible to estimate without a detailed mine plan being developed.

  For example, the Chambers spreadsheet assumes a tonnage of 868 million tons at 3% copper grade, representing 75% of the ore body planned to be mined in the GPO. A more realistic idea of tonnage can be gathered from analysis conducted on the actual grade distributions obtained from Resolution (see Kliche[7] 2017). An estimate of tonnage within the 2% shell is 386 million tons (representing 34% of the ore body planned to be mined in the GPO) and an estimate of tonnage within the 3% shell is 7.5 million tons (representing less than 1% of the ore body planned to be mined in the GPO).

- NOTE: Ores mined from the Magma Mine deposit averaged 5.69% Cu from 1915 to the end of 1964[8]. Ore tons mined per year during the period from 1950 - 1964 ranged from 276,000 to 464,000[5]; and copper production ranged from 26,000,000 lb to 49,600,000 lb[5].

  The tonnage mined at Magma during 1950 - 1964 equated to approximately 1000 tpd. According to Table 2 of Kliche[7], 2017, the operating cost for a cut-and-fill mining operation producing at 1000 tpd is approximately $68 per tonne, or about $62 per st (short ton).

  According to *Volume 1 – Administrative Information Aquifer Protection Permit Application Resolution Copper Mining Limited West Plant Site, Superior Mine Superior, Arizona*[9]:

  > "Mining of the Magma Vein, a quartz-sulfide ore body, occurred from the late 1800s through the 1940s at the West Plant Site and was followed by the discovery and

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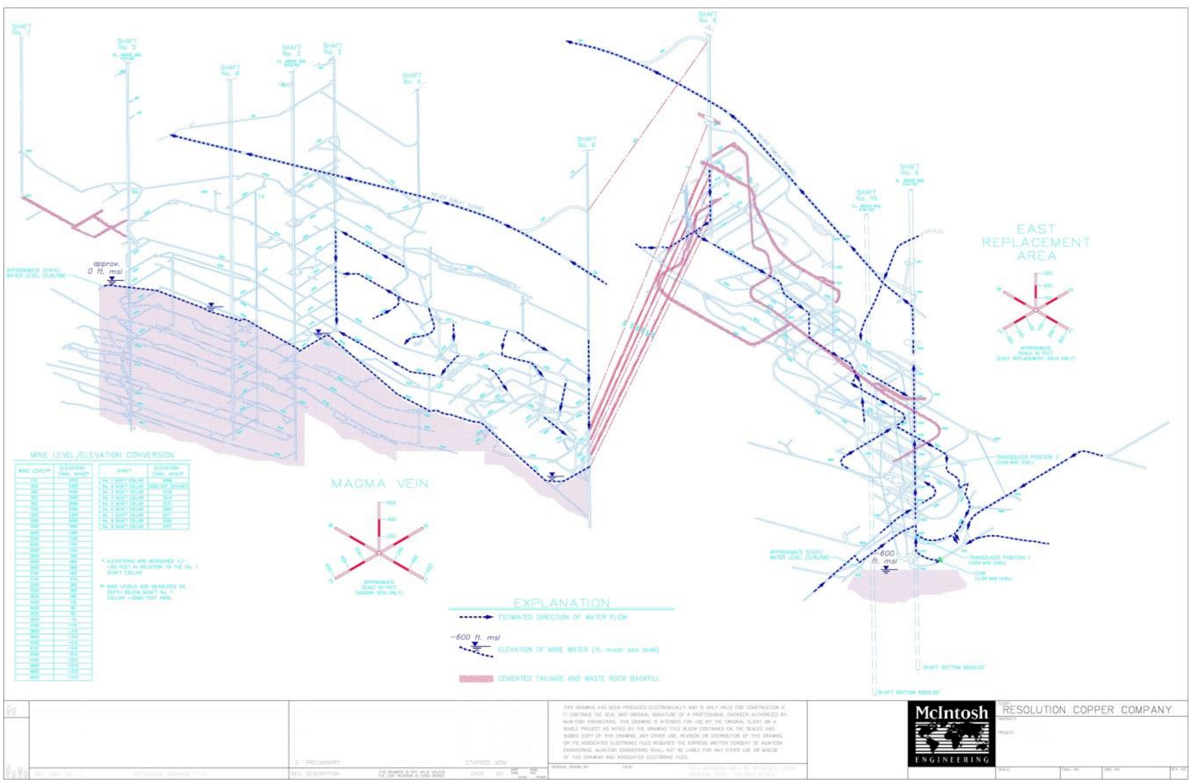
[7] Kliche, C.A., "Draft Technical Memorandum for Alternative Mining Methods, Resolution Copper Mining, LLC, Superior, AZ", Table 2, July 7, 2017
[8] Ridge John D., ed. Ore Deposits in the United States 1933/1967, vol II, "Geology of the Magma Mine Area, Arizona," AIME, 1968.
[9] Courtesy of Ms. Victoria Peacey, 3/30/17.

mining of a carbonate replacement ore body to the east. Underground mining activities conducted from the late 1800s through mid-1996 produced approximately 26 million tons of ore at the mine, out of which approximately 20 million tons were tailings. About 6 to 7 million tons of the tailings reported to the underground workings as structural support and the remainder reported to the tailings facilities at the West Plant Site.

Less than 50% of the Magma Mine was backfilled with tailings in the cut-and-fill mining process (shaded portion on figure below shows the backfilling)[10].

The final figure[9] shows the surface distribution of the tailings from The Magma Mine adjacent to the city of Superior.



- The most interesting aspect of Chambers' "analysis" is the three backfilling cases (#3. Backfill Case - Lowest Cost; #4. Backfill Case - Highest Cost; and #5. Backfill Case with assumptions of: high cost, higher grade, and only 75% of tonnage mined).

  Specifically, it appears that, in all three backfill cases in the Chambers analysis, the backfilling is to be concurrent with the mining. Yet, in 2 of the backfill cases, (#3 and #4) 100% of the tonnage which is proposed to be mined by caving is also assumed to be mined by the method employing the backfilling. The indication, therefore, is that caving will also be used as the mining method

[10] Courtesy of Ms. Victoria Peacey, 3/25/17.

for #s 3 & 4, and the filling will be concurrent with the mining (there is no capital or operating cost at the end of mining to indicate backfilling occurs after mining).

Something that most definitely was overlooked in the Chambers analysis is that broken rock swells (bulks) from its in situ volume as much as 20 - 60%, with a good average being 30 - 35%.

So, say one caves and extracts a given in situ volume of rock (say 1,000,000 yd^3) with some in situ material overlying that extracted material which is allowed to cave and bulk into the extracted volume (a very elementary theory of block caving), then the actual subsidence crater formed by the caved material overlying the extracted material will have a volume less than the volume extracted by some swell factor (ie < the 1,000,000 yd^3 by up to 30 or 35%).

Additionally, the ore rock going to and through the mill is reduced in size by various methods (called "comminution") in order to get it to sand and sub-sand (clay-like) particle size so more surface area is exposed and allow the chemical used to bond to and remove the copper and molybdenum efficiently by the extraction method being employed (flotation).

These small sand-sized or clay-sized particles, barren of the Cu and Mo after extraction, also bulk as the rock is being reduced in size. This swelling, or bulking, may be around 8 - 15%, with a good average being about 12%. This material, called "tailings" goes out the back door of the mill and is normally either placed in a containment area (tailings basin) or, in the case of certain underground stoping methods, placed back into the mined out cavity (cut-and-fill underground mining), or both, since there is usually excess material beyond what is required for backfilling underground.

Because no narrative is provided with the Chambers spreadsheet, certain assumptions have to be made in this critique, including about how the backfilling would be achieved. So, if the thought of Chambers is that the tailings be placed back into the subsidence crater, then numerous problems will entail:

1) There will be excess material beyond the volume of the crater requiring a storage facility (tailings basin) for the remainder.

2) Will the tailings be stacked, dried and conveyed or trucked back to the subsidence crater? If so, this will entail some sort of loading apparatus (reclaimer) plus conveyor system and radial stacker; or loader(s) plus trucks plus dozers plus other heavy equipment.

   Or, will the tailings be pumped back in slurry form? Then some sort of pumping plant, thickeners, etc will be needed at the tailings containment site, plus a network of pipes.

   In either case, if this operation is concurrent with the mining, then they would be dumping wet or dry tailings on top of the people and equipment working below. The water, in the wet pumping case, will percolate to the working levels and have to be pumped out. Additionally, the water may be contaminated due to exposure to sulfide materials and will need to be treated before release into the environment.

   Also, if the tailings are dumped back as the mine is being operated, mixing of the tailings and the ore being withdrawn may occur, resulting in some or significant dilution.

3) If the proposal is to pick up the tailings at the end of the mining and place them into the subsidence crater, then this would pose an additional exorbitant cost of rehandle on the company.

Now, for the case of option #5, the Backfill Case with assumptions of: high cost, higher grade, and only 75% of tonnage mined:

1) Is this some kind of proposal to only mine the higher grade material via block caving (resulting in the guesstimated 75% of tonnage)?

Did Chambers look at the grade distributions to see if this is even possible?

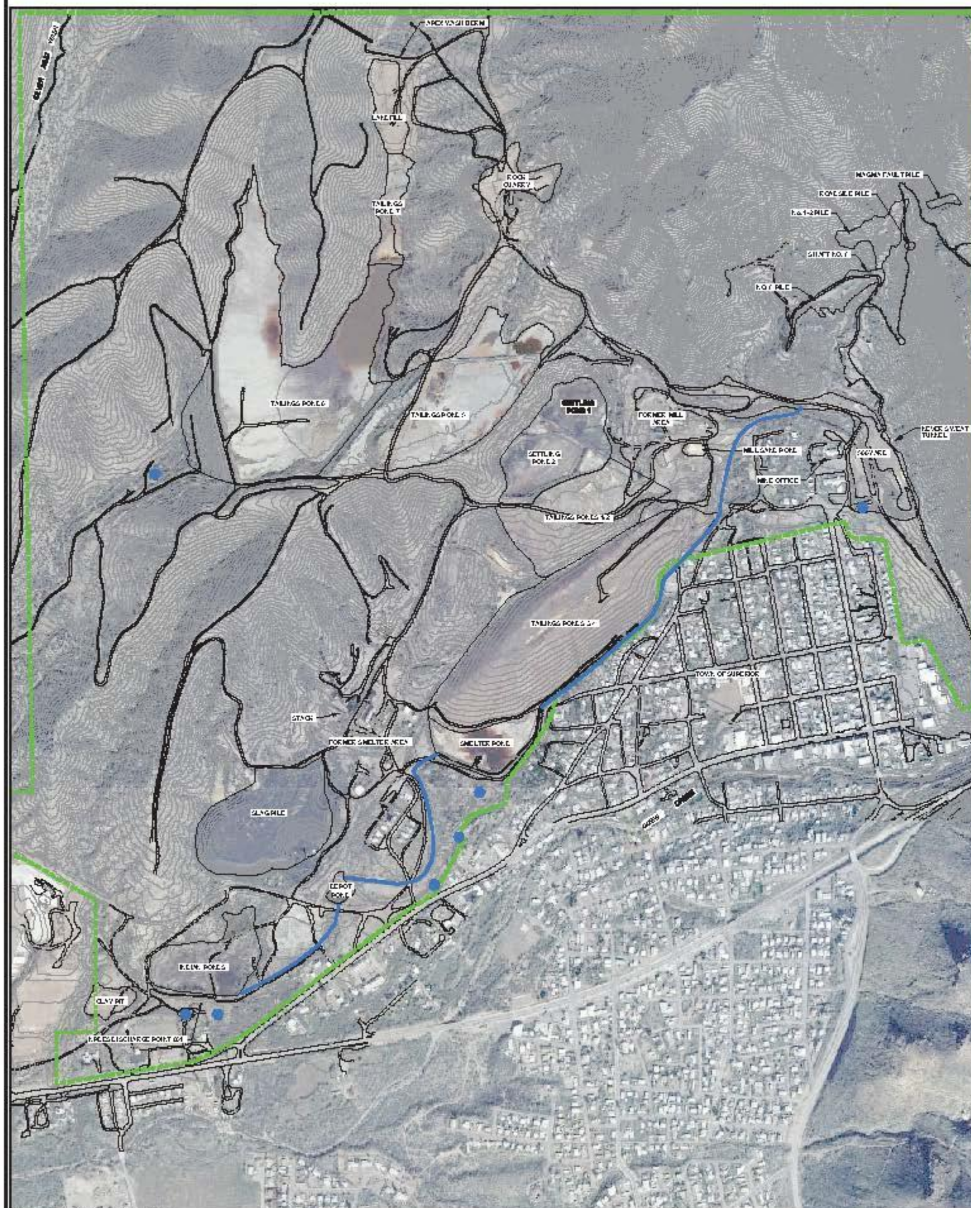
2) Where did the 3% average grade come from?

3) Where did the 75% of tonnage come from? Is Chambers privy to some sort of tonnage v (average or cut-off) grade relationship for the Resolution ore body?

4) Is the proposal here to mine the high grade areas within the Resolution deposit by some sort of cut-and-fill stoping method and backfill tailings into the voids created?

   If so, then 75% of the ore deposit being available for this method is way, way high.

   And 3% average grade is low.



EXPLANATION

APPROXIMATE PROPERTY BOUNDARY

Figure 1-2

SITE MAP
WEST PLANT SITE
RESOLUTION COPPER MINING LIMITED
SUPERIOR, ARIZONA

Concluding Remarks

1) The three backfilling options (#3. Backfill Case - Lowest Cost; #4. Backfill Case - Highest Cost; and #5. Backfill Case with assumptions of: high cost, higher grade, and only 75% of tonnage mined), as presented by Mr. Chambers, are unrealistic for any number of reasons.

2) The PV calculations, as presented by Mr. Chambers, are unrealistic due to bad assumptions and missing elements of each yearly CF calculation.

3) Even if backfilling of the subsidence crater with tailings is deemed a viable part of the mining/reclamation sequence, a tailings basin is going to be necessary. The size of said tailings basin may be as large, or smaller, than the one proposed by the proponents, depending on how and when the tailings would be returned to the crater.

4) [11]On August 3, 1977, the 95th Congress passed Public Law 95-87—The Surface Mining Control and Reclamation Act of 1977. The focus of the law was coal; but Section 709 called for a study of surface mining for minerals other than coal to determine whether existing and developing technology for mining minerals other than coal can be used to achieve the requirements of the Act, and to discuss alternative regulatory mechanisms to control mining. The Act directed the Council on Environmental Quality (CEQ) to contract with the National Academy of Sciences, other agencies, or private groups, as appropriate, to conduct the study. In response to a request from the Council, the Board on Mineral and Energy Resources of the Academy's Commission on Natural Resources formed the Committee on Surface Mining and Reclamation (COSMAR).

   Specifics of SEC 709 of the Act:

   "STUDY OF RECLAMATION STANDARDS FOR SURFACE MINING OF OTHER MINERALS

   > SEC. 709. (a) The Chairman of the Council on Environmental Quality is directed to contract to such extent or in such amounts as are provided in appropriation Acts with the National Academy of Sciences-National Academy of Engineering, other Government agencies or private groups as appropriate, for an in-depth study of current and developing technology for surface and open pit mining and reclamation for minerals other than coal designed to assist in the establishment of effective and reasonable regulation of surface and open pit mining and reclamation for minerals other than coal. The study shall—
   >
   > (1) assess the degree to which the requirements of this Act can be met by such technology and the costs involved;
   >
   > (2) identify areas where the requirements of this Act cannot be met by current and developing technology;

[11] "Surface Mining of Non-Coal Minerals, A Study of Mineral Mining from the Perspective of the Surface Mining Control and Reclamation Act of 1977;" A report prepared by the Committee on Surface Mining and Reclamation - Board on Mineral and Energy Resources, Commission on Natural Resources, National Research Council; National Academy of Sciences, Washington, DC, 1979.

(3) in those instances, describe requirements most comparable to those of this Act which could be met, the costs involved, and the differences in reclamation results between these requirements and those of this Act; and

(4) discuss alternative regulatory mechanisms designed to insure the achievement of the most beneficial postmining land use for areas affected by surface and open pit mining.

(b) The study together with specific legislative recommendations shall be submitted to the President and the Congress no later than…."

Findings of the COSMAR group include:

(1) that the degree to which the requirements of the Act can be met by existing or developing technology ranges from readily achievable to impractical depending on specific requirements and on the location and nature of the mineral deposit and method of mining and processing; when existing or projected data made it possible, compliance costs were ascertained or estimated;

(2) that there are areas where the requirements of the Act cannot be met because of technological or economic limitations;

And:

Return to Original Contour

"The Act requires that the land be restored to approximately its original contour. This provision is generally not technically feasible for non-coal minerals, or has limited value because it is impractical, inappropriate, or economically unsound (Section 5.2.2)….

…. Further, to restore the original contour where massive ore bodies have been mined by the open-pit method would incur costs roughly equal to the original costs of mining. Although technically possible, such backfilling of a large open pit would be of uncertain environmental and social benefit, and it would be economically impractical to mine some deposits under the current cost structure."

…..

"Backfilling, provided that depletion of the mineral deposit makes it at all possible, is a costly requirement of 204 the Act if applied to some open pit operations (Sec. 515(b)(3)), as discussed below. Even if an adjacent pit is available for dumping, or if the nature of the mineral deposit is such that the pit can be advantageously dug in an elongate form, thus allowing for backfilling on one face while the pit advances on the opposite face (Banks and Franciscotti 1976), backfilling nonetheless requires rehandling of the material initially excavated. For this material, the cost of handling is at least doubled. In the case of mineral deposits that are reached only at depths of several hundred feet, this cost would be very large.

…..

Rather than backfill large open pits, placement of the rock waste and tailings conceivably can be managed in ways that would build a new landscape suitable for anticipated postmining uses. Such a concept has been presented for handling rock waste and tailings in the Sahuarita copper district (Matter and others 1974) and is consistent with certain provisions in the Act that provide flexibility in planning for postmining land use, for example, the requirements for mountain-top mining (Sec. 515(c)). Surface disposal of some solid waste is usually necessary in any case because the mined material expands during mining and processing, thus filling a volume greater than the original pit."

…..

"Changing economics often dictate that portions of ore bodies left behind in the past because they were uneconomic become economically available at some future time. One reason for this may be increased demand due to economic growth as supplies are diminished through depletion of the highest quality, most easily available deposits. Another reason is the development of new mining or metallurgical technology that improves the efficiency of recovery or diminishes production costs. Reopening of old mines may also be the result of the demand for by-products or changes in the price of by-products that can make the abandoned deposit economic once again.

If the lower grade materials left behind are buried due to the backfilling requirements in PL 95-87, the cost of recovering them in the future may be so high that they become entirely lost as a domestic resource."

…..

"…backfilling to original contour would require doubling the cost of loading and hauling, the largest components of mining costs."

<u>Bottom Line</u>: the backfilling requirements of SMCRA should not be applied to the large open pit mines and similar types of excavations, such as block caving subsidence craters, associated with hardrock mining.

5) You can't just say: "We'll mine 75% of the ore at a bit higher grade and put the tailings back into the excavation at a somewhat higher, arbitrary cost."

It just does not work that way. In order to determine if something like cut-and-fill stoping is a viable alternative to block caving, a detailed mine plan and economic feasibility analysis is required so one could do an economic and financial comparison of Alternative C&F vs Alternative BC.

Cut-and-fill (and other stoping methods) has a much higher mining cost than does block caving. On the other hand, block caving has a much higher capital cost. However, it's **<u>Operating Cost</u>** upon which the cut-off-grade is based and <u>not</u> capital cost (see Kliche[7] 2017). The increase in cut-off-grade due to an increase in operating cost makes significantly <u>less</u> ore available at some average grade above the cut-off-grade. This tonnage and grade relationship has been shown to be an <u>exponential</u> relationship (that is, as the cut-off-grade goes up, the tons of ore available goes down by some power function [see Kliche[7] 2017]).

Also, just because an alternative has a positive NPV or favorable ROI does not make it the BEST alternative for the investor(s).

Attachment 3 – Summary of Legal Underpinnings of Forest Service Ability to Regulate Mining Operations

The General Mining Act of 1872

The law most commonly cited with respect to the jurisdiction of the Forest Service to regulate mining projects is the Mining Act of 1872. In reality, citing the Mining Act of 1872 is shorthand for a more complex (and recent) suite of laws that govern Forest Service authority with respect to mining.

By itself, the General Mining Act of 1872 (codified in 30 U.S.C. § 22 *et seq*) establishes the principle that federal lands are open for a person to claim and develop mineral resources. However, National Forest reserves did not exist in 1872 and would not exist until the Creative Act or Forest Reserve Act of 1891. The Forest Reserve Act of 1891 does not explicitly speak to mining but briefly establishes the presidential authority for reserving forested lands for public use.

The Organic Act of 1897 and Transfer Act of 1905

The Organic Act of 1897 (codified at 16 U.S.C. § 478 *et seq*) is the first act that establishes the principles by which National Forest reserves are to be managed. The second paragraph of the Organic Act of 1897 identifies the special consideration that mineral development receives within National Forests:

> "Nor shall anything in such sections prohibit any person from entering upon such national forests for all proper and lawful purposes, including that of prospecting, locating, and developing the mineral resources thereof. Such persons must comply with the rules and regulations covering such national forests." (16 U.S.C. § 478)

The Organic Act further determines that:

> "…any mineral lands in any national forest which have been or which may be shown to be such, and subject to entry under the existing mining laws of the United States and the rules and regulations applying thereto, shall continue to be subject to such location and entry, notwithstanding any provisions contained…in this title." (16 U.S.C. § 482)

Responsibility for management of Forest reserve lands was transferred from Interior to Agriculture in the Transfer Act of 1905, but the administration of mining laws was explicitly kept with Interior:

> "The Secretary of the Department of Agriculture shall execute or cause to be executed all laws affecting public lands reserved under the provisions of section 471 of this title, or sections supplemental to and amendatory thereof, after such lands have been so reserved, excepting such laws as affect the surveying, prospecting, locating, appropriating, entering, relinquishing, reconveying, certifying, or patenting of any of such lands." (16 U.S.C. § 472)

The Transfer Act of 1905 also established the Forest Service itself and established the role the Forest Service would serve in managing National Forest reserves:

> "The Secretary of Agriculture shall make provisions for the protection against destruction by fire and depredations upon the public forests and national forests which may have been set aside or which may be hereafter set aside under the provisions of section 471 of this title, and which may be continued; and he may make such rules and regulations and establish such service as will insure the objects of such reservations, namely, to regulate their occupancy and use and to preserve the forests thereon from destruction;" (16 U.S.C. § 551)

Between the Organic Act and the Transfer Act, the basic dual mandate was established that governs how the Forest Service must approach mineral exploration and development. National Forests are to remain open for mineral development (16 U.S.C. § 478) but the Forest Service can promulgate rules to regulate occupancy and use to preserve forest resources (16 U.S.C. § 551).

More Recent Multiple-Use Laws

In 1955, Congress passed the Surface Resources and Multiple Use Act—often known as the Multiple Use Act—governing federal activities on lands containing unpatented mining claims. This Act established the framework that mining-claim holders may not use their claims to exclude others from accessing the public lands and prohibits the use of any unpatented mining claim "for any purposes other than prospecting, mining or processing operations and uses reasonably incident thereto." (30 U.S.C. § 612(a))

However, the Multiple Use Act also once again gives special protection to mining uses:

> "Any such mining claim shall also be subject, prior to issuance of patent therefor, to the right of the United States, its permittees, and licensees, to use so much of the surface thereof as may be necessary for such purposes or for access to adjacent land: Provided, however, That any use of the surface of any such mining claim by the United States, its permittees or licensees, *shall be such as not to endanger or materially interfere with prospecting, mining or processing operations or uses reasonably incident thereto*" (30 U.S.C. § 612(b), emphasis added)

In 1960, the Multiple-Use Sustained Yield Act was passed to "authorize and direct that the national forests be managed under principles of multiple use and to produce a sustained yield of products and services, and for other purposes. This Act does not provide any guidance for managing mineral development, but as with previous laws, mineral development is given specific protection in the first paragraph: "Nothing herein shall be construed so as to affect the use of administration of the mineral resources of national forest lands." (16 U.S.C. § 528)

Based on the overall body of law (not just the Mining Act of 1872), rules have been promulgated by the Forest Service to regulate locatable mineral activity; these rules are found in 36 C.F.R. Part 228, Subpart A. These rules prohibit any person from conducting mining operations that will likely cause significant disturbance of National Forest System surface resources without a plan of operations approved by the Forest Service (36 C.F.R. §§ 228.4, 228.5), and also put forth specific requirements for environmental protection (36 C.F.R. § 228.8). This includes the requirement that "All operations shall be conducted so as, where feasible, to minimize adverse environmental impacts on National Forest surface resources," (36 C.F.R. § 228.8) Part of the evaluation of the mine plan of operation is to "analyze the proposal, considering the economics of the operation along with the other factors in determining the reasonableness of the requirements for surface resource protection" (36 C.F.R. § 228.5)

How far can the Forest Service go to regulate mining?

The Forest Service legal mandate is to regulate—but not prohibit—mining activities within National Forest System lands in order to minimize impacts to National Forest surface resources. The pertinent question is how far can the Forest Service go to minimize impacts to Forest surface resources? The fundamental restriction is that regulations cannot "endanger or materially interfere" with mining operations, and the regulations themselves call for "reasonableness".

Case law provides some additional interpretation, including:

> "While prospecting, locating, and developing of mineral resources in the national forests *may not be prohibited nor so unreasonably circumscribed as to amount to a prohibition*, the Secretary may adopt reasonable rules and regulations *which do not impermissibly encroach* upon the right to the use and enjoyment of placer claims for mining purposes." *United States v. Weiss*, 642 F.2d at 299 (emphasis added)
>
> "…the Forest Service may regulate use of National Forest lands by holders of unpatented mining claims, . . . but *only to the extent that the regulations are 'reasonable' and do not impermissibly encroach* on legitimate uses incident to mining and mill site claims." *United States v. Shumway*, 199 F.3d 1093, 1106–07 (9th Cir. 1999) (emphasis added)

While the economics of the operation is indeed one of the factors to be considered under 36 C.F.R. 228.5, the basic standard when considering whether an alternative mining technique could be required by the Forest Service can be generally summarized as follows:

- The requirement cannot endanger or materially interfere with mining operations;
- The requirement must be reasonable;
- The requirement may not result in operations being so unreasonably circumscribed as to amount to a prohibition;
- The requirement may not impermissibly encroach on legitimate uses incident to mining.

While a legitimate analysis of the economics of the operation may form part of the Forest Service consideration when seeking to modify a plan of operation, the bar the Forest Service must meet is one of "reasonableness", not one of economics.