APPENDIX IV

OPINIONS RELATING TO ALL PHASES OF MINING OPERATIONS AND ESTIMATES OF TAILINGS PRODUCTION

TERRY MCNULTY, D. SC., P. E.

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL VALLEY REGION

CLEANUP AND ABATEMENT ORDER NO. R5-2014-XXXX

ATLANTIC RICHFIELD COMPANY
UNITED STATES DEPARTMENT OF AGRICULTURE,
UNITED STATES FOREST SERVICE

WALKER MINE TAILINGS
PLUMAS COUNTY

CLEANUP AND ABATEMENT ORDER NO. R5-2014-YYYY
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Opinions Relating to All Phases of Mining Operations and Estimates of Tailings Production

Terry McNulty, D. Sc., P. E.

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Opinions of Mineral Engineer Terry McNulty

I, Terry McNulty, D.Sc. P.E., am a fourth generation miner, with a Doctorate in Extractive Metallurgy and Professional Engineer registration in Metallurgical Engineering. I offer opinions in the case on the basis of my lifelong experience in the mining industry, my undergraduate and graduate education, and my 60-years of working with mining companies and around mines in North and South America and overseas.

1. Experience Growing Up in a Mining Family

I represent the fourth generation in my family to work in the mining industry. In April 1859, my paternal great grandfather was part of a group of prospectors that entered the Summit District north of where Leadville, CO is now located. The north boundary of the Climax waste dumps is McNulty Gulch. He later managed a turquoise mine near Cerrillos, NM for the Tiffany Company. His son, my paternal grandfather, began as a miner, but advanced to Mine Manager at Mineral Park, AZ. My maternal grandfather worked all of his life as a timberman, blacksmith, and underground miner in Arizona. My father and his two brothers were underground miners, but my father learned chemistry through the ICS and ultimately became a Chief Chemist.

As a youth, I lived with my parents in very remote prospecting and mining exploration camps in the interiors of Brazil and former British Guiana. I also lived in the mining and milling camps of Goldroad, AZ and Vanadium, NM. I began working as an apprentice assayer at Anaconda's uranium mining operation near Grants, New Mexico at age 15 and had the advantage of good summer/vacation jobs throughout my last 2 years of high school and all of undergraduate school. My entire professional life has been spent working for, or providing technical services to, the mining industry.

2. Education and Employment Related to Mining

I obtained a B. S (Chemical Engineering), an M. S.(Metallurgical Engineering), and a D. Sc. (Extractive Metallurgy) Degrees from Stanford University, Montana School of Mines, and Colorado School of Mines, respectively. (Refer to my CV at the end of this report.) I also studied geology, mineralogy, mining and processing practices. From 1954 through 1960, I worked as an intern in various mining industry operations. During 1961 to 1983, I was employed by various mining companies with responsibilities for process development, plant operations supervision, technical support, and general management, as detailed in my CV. As a mineral industry consultant for the last 26 years, I have been employed by scores of mining and processing entities throughout the U. S. and overseas. As a consultant I have provided consulting services in application of new technologies, process development, and productivity improvements to approximately 150 mines and processing plants worldwide. This has given me the opportunity to observe operations and management structures that have prevailed in many diverse corporate cultures. My CV also includes a list of my patents and publications

During my career with ACM, I worked in or visited many mines and concentrators and worked closely with mine geologists and exploration geologists. I was Concentrator Superintendent at a Canadian copper operation with responsibilities for plant operations, maintenance, and tailings disposal and all related decisions. I have served as a Manager of R&D and Technical Services, where my department and I provided a spectrum of services to all mining and processing operations and made appropriate recommendations to senior managers. In this role, we never gave orders to foremen, miners, equipment operators, or concentrator operators. We followed industry custom by supplying technical expertise and advice, but did not supervise. Please see my attached Curriculum Vitae for the story of my work in mining going back some 60 years.

3. Honors Received for My Work In Mining

As noted in the copy of my Curriculum Vitae (attached), during my career in mining, I have been honored to receive –

(a) Medal of Merit, American Mining Hall of Fame, 2010
(b) Election to National Academy of Engineering, 2005
(c) Richards Award for Distinction in Mineral Processing, AIME, 2003
(d) Distinguished Alumni Award, Montana Tech., 2002
(e) Henry Krumb Memorial Lecturer, AIME, 1989
(f) Distinguished Career Achievement Medal, Colorado School of Mines, 1989

4. Materials Considered

In preparation of my report and development of my opinions, I have reviewed ACM Sales Co. records, historical records produced by California Regional Board and the Prosecution Team exhibits, various historical and non-historical files from other sources, and Walker Mining Company annual reports.

5. Compensation

I am being compensated by Atlantic Richfield Company at a uniform hourly rate of $300 for consulting and testimony.

6. Statement of My Opinions

On the basis of my lifelong experience with mines, my undergraduate and graduate training in mine-related disciplines, and my 60-year work experience in the mines and mining industry, together with my review of voluminous documents produced in this case, including materials in the Anaconda collection at the University of Wyoming, I have developed the following opinions:

1. All mines are different because of location, geology, nature of target minerals, extractive resource economics and the individual and corporate personalities of the companies which operate and consult with respect to each mine.

2. Yet mining generally occurs in six phases: (a) exploration and development of ore reserves, (b) mine development, (c) ore extraction, (d) concentrating, (e) product shipment, and (f) waste disposal.

3. In reviewing the documents available relating to the Walker Mine, I see no evidence that Anaconda Copper Mining Company ("ACM") or International Smelting and Refining Company ("IS&R") sought to have, or in fact had, any influence over WMC's ore extraction, concentrating, product (concentrate) shipment, or waste disposal.

   (a) Mine development work was performed by WMC's own staff. ACM and IS&R guided and made recommendations concerning prospecting and mine development, and at times required WMC to seek approval before commencing underground activities about prospecting and reserve development, but all underground prospecting work, including core drilling was undertaken by WMC.
   (b) Geologists on the WMC staff received the recommendations from IS&R / ACM geologists and supported mine development with WMC's own staff.

(c) Day-to-day, mining geologists on WMC's staff also supported mining and ore extraction.
(d) Processing ore through the concentrator was undertaken by WMC.
(e) Handling and shipment of concentrate was undertaken by WMC.
(f) Construction and maintenance of the tailings ponds and the disposal of concentrator waste ("tailings") was undertaken by WMC.
(g) Neither AMC, nor IS&R, had any control over WMC concerning the Walker Mine's waste disposal activities.
(h) These spheres of influence in mining operations at the Walker Mine were generally consistent with what I have observed in the other mines I have visited, studied, and/or worked in.

7. Bases for My Opinions

A. Basis for Opinions Concerning Prospecting, Exploration, and Development

In most mining operations, underground mining (referred to above as ore extraction) is guided on a daily basis by geological engineers, usually referred to as mine geologists, and the responsibilities of the mine geologist are described in the following sections of my report. On the other hand, identification and definition of a mineralized zone that can be added to the mines reserve inventory is based on prospecting by a specialist called an exploration geologist. Exploration geologists are key personnel in the first of the six phases of mining (referred to above as exploration and development of ore reserves).

Underground mining and mineral concentration are universally the same as to general features, although each mine is different with regard to the physical and chemical characteristics of the ore, accessory minerals, and host rock. The common features are as follows:

(1) Exploration and Reserve Development

Prospecting by diamond drilling and extraction of core samples is done from "stations", often excavated into one side of a main drift or haulage tunnel. With the exception of the volume of rock removed to create the station, typically a room no more than ten feet on each side and 6-8 feet high, little material has to be blasted and moved.

(2) Mine Development (to Gain Access to Ore)

Often, vertical shafts are sunk from the ground surface, and they usually begin at exposed mineralization, called an "outcrop" on the surface. Additionally, or alternatively, horizontal openings (drifts or crosscuts), inclines or declines, or raises or winzes are driven from a haulage tunnel to a location near or in mineralization. Ideally, these openings are made in ore, but they sometimes must be made in waste. They are advanced by drilling small-diameter holes, loading the holes with cylindrical "sticks" of explosive, arming the explosives with detonators ("caps") and breaking the rock into fragments of manageable size.

(3) Ore Extraction (breaking and removing ore from the mine workings)

Diamond drilling guides short-range definition of the geometry and grade of a mineralized section of rock, often a vein structure, by providing the mine geologist with the information needed to assist the mine foreman with planning of shift-to-shift work.

Production drilling, using the same equipment ("jacklegs" and "stopers") used in mine development makes hole that can be loaded and blasted.

Mucking, originally done by men with hand shovels, was by the 1930s, almost entirely done with the aid of small front-end loaders called "mucking machines". The broken rock ("muck) was loaded into small rail cars, typically with a capacity of 0.5-5 tons.

Tramming was the act of hauling loaded cars to a location on the surface, typically just outside the portal of the haulage tunnel.

(4) Concentrating (milling and treatment of ore)

Concentrating of the desired minerals such as copper sulfide grains is almost always carried out on the surface, although a few concentrating plants have been located inside underground mines. The ore is crushed and ground in successive stages by various types equipment to reduce the maximum particle dimension to a few hundredths of an inch or less. At this size distribution, and it varies with local mineralization, the desired mineral grains have been "liberated" from the country rock and are small enough to be readily suspended by mechanical agitation of a mud ""slurry" that usually consists of three parts water to one part ore by weight.

The concentrate, typically representing only a small fraction of the ore weight, but containing over 90 percent of the desired mineral originally present in the ore, is filtered to remove most of the water, the filtrate is returned to the grinding mills, and the concentrate is ready for shipment.

(5) Product Shipment

Unless there is a smelter adjacent to the concentrator, the concentrates must be shipped. In order to minimize the cost of shipping water, it is customary to thicken the concentrate slurry, then filter it to a point where is contains only about 8-12 percent moisture. Both the thickener overflow water and the filtrate are recycled.

Shipment of the concentrate to a smelter was once done in mule-drawn wagons, but truck and rail transportation became the industry standard by the late-1920s.

(6) Waste Disposal

The economics of mining are such that a careful distinction is made regarding waste rock even before it has been drilled and blasted. If it can be left in-place without impairing access to ore, it will be. If it must be moved, it will be left underground as backfill if possible. If waste rock must be trammed to the surface, it will be placed in a dump located so as to minimize transportation cost. Outside the mine workings, the waste (tailings) created during concentration usually has no value, so it is accumulated for disposal on the mine property. However, the water contained in the tailings has value and is often reclaimed from the settled tailings for reuse.

At the Walker mine, all of the foregoing operations were carried out, but there were local variations that suited copper sulfide ("chalcopyrite") mineralization associated with iron ("pyrite" and "magnetite") in quartz vein rock. The vein was essentially a tilted tablet over 500 feet deep, 15 to 50 feet thick and about two miles long. The vein was not continuously mineralized; instead, there were five distinct orebodies that were separated by hundreds up to several thousand feet along the vein. Some extended nearly to the surface, while two were deeper below-surface. The vein walls ("country rock") were very hard, homogeneous, and devoid of sulfide mineralization. It was therefore possible to remove ore selectively with minimum dilution by barren waste rock.

Mine development at Walker began with shafts, and the ore was initially hoisted to the surface ("shaft collar") and loaded into tram cars suspended from a cable running in a continuous loop. The mile-long tramway descended approximately 900 feet to the concentrator feed bins and crushers. There was a personnel camp near the shaft and another near the concentrator. Draft animals and wagons originally hauled concentrates to a rail siding, but a 9-mile overhead tramway to the railroad was constructed in 1919 and 1920. During 1920 and 1921, the 700 level haulage tunnel was driven 3,000 feet northward from a portal near the concentrator to intersect the vein. Electric trolley locomotives and cars with 2.75 ton capacity were used to tram ore[1].

Concentration was always accomplished by the selective flotation process. The ore was reduced in a series of jaw and roll crushers to a top size if 0.375-inch, then ground in rotating cylindrical ball mills to a top size of about 0.01-inch with half of the particles finer than 0.003-inch. Although the ore initially contained as much as 10 percent copper, the ore "grade" had declined to less than 2 percent copper by 1926[2].

The concentrates were thickened and filtered before being conveyed by a 9-mile tram way to a rail loading station for transportation to the IS&R smelter at Tooele, UT.

"Development" is a term which was used by WMC in the same two ways as the term was generally used throughout the mining industry and described above. In extensive correspondence between WMC geologists and IS&R and ACM geologists who provided advice on "development", the term was used to mean development of future reserves. In this context, the goal of development was not to open up access for extraction of ore, but to create a path through the country rock adjacent to the vein. If mineralized rock was produced in development, it would have been removed and processed. In my opinion, the volume of waste created by reserve development through mineralized rock (if any) would have been negligible, compared with tailings wastes generated from WMC's ore extraction.

Generally, in this first of the six phases of mining, the exploration geologist is looking to the future with the objective of ensuring that the mine's life will be sufficient, not only to pay back major investments like a new and larger concentrator, but also to maximize shareholders' return on their earlier investments. At WMC's Walker Mine, exploration geologist Reno Sales, who had developed the science of underground exploration in Butte, and Paul Billingsley, provided guidance on matters relating to exploration on behalf of ACM and IS&R

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[1] *Anaconda's Walker Mine and Mill,* Engineering and Mining Journal, Vol.117, No. 18, May 3, 1924, pages 725-730. (Ex. 36.)

[2] Walker Mining Company Annual Report for 1926. (Ex. 52.)

to Walker Mining Company's geologists for their consideration, and at times required WMC's staff geologists to obtain their approval to proceed.

At times, the correspondence shows Reno Sales expressed frustration that his geological direction and advice related to development of ore reserves was not being followed. While it is clear that his opinions were respected, it is also clear that local variables may have influenced acceptance. (Exs. 115, 39, 47.)

Although WCM's mine geologists, like Seth Droubay, were very competent, they likely did not possess the interest, training, or expertise to serve as exploration geologists. In any case, their day-to-day job was to direct the second phase of mining (ore extraction). If Sales and Billingsley had not been available, WCM would have had to pay for a geological exploration consultant, but it is very unlikely that they could have found any as competent as the ones made available to them by their IS&R and ACM.

Of all the documents reviewed in this case, none present any evidence that exploration geologists (active in the first phase of mining) or any other representative of IS&R or ACM had any direction, supervision or control, over the disposal of mining wastes produced by the Walker Mine operations.

B. Basis for Opinions Concerning Ore Extraction Operations

Whereas the art and science of prospecting, exploration, and resource development is essentially strategic and long- range, the practice of operating a mining and processing complex (that is, the activities constituting the later five phases – mine development, ore extraction, concentrating, product shipment and waste disposal) is purely tactical. Generally, in the mining industry, there are daily, weekly, and monthly production targets, and every attempt is made to plan for periodic and very brief maintenance and repair shutdown, but most decisions are reactionary and based either on brief conversations between supervisors and subordinates at the beginning or end of a shift or are made on-the-run during the shift. The information on which these decisions are based may range from changes in ore characteristics underground to a change in equipment availability to substitution for an ill or injured worker.

I will address organizational structure and personnel classifications and responsibilities in the following sections of this report, but want to preface those comments with clarification of jurisdictional considerations regarding the creation and management of wastes.

(1) Mining Phase Three – Ore Extraction

Extraction of the copper ore from the Walker Mine was driven by economics that govern the so-called cutoff grade (COG), the copper concentration below which downstream processing would cost more than the recovered value. At Walker, the cutoff grade varied with the market price, but likely followed an industry standard of 0.5% copper, or 10 pounds of copper per ton of ore. Any rock containing less that the COG was likely designated "waste rock". If the waste rock came from the ore vein and contained some copper mineralization, WMC would have treated it as a mineral asset, not waste. This asset was probably hauled ("trammed") to a dump outside the 700 level tunnel's portal and stockpiled for future processing in response to favorable copper price. However, the host ("country") rock that bounded the vein on both sides of the Walker Mine contained no copper. If it was drilled and blasted to provide access to a mineralized zone that could be stope-mined,[3] waste rock would likely have been used to backfill the stope to minimize future unintended caving or to provide a working platform. The expense of tramming waste rock from underground would only have been authorized by WMC management if there were no cheaper or better destination.

The mining method used in the Walker Mine was a technique called "shrinkage stoping" and it basically involved driving access workings into a steeply tipped nearly tabular quartz vein over 500 feet high, two miles long, and 15-50 feet thick. This vein structure contained five orebodies, the South, Central, North, 712, and Piute (or Paiute). The shrinkage stoping technique is described in an E&MJ article[4] and a summary in The Mines Handbook[5]

Mining was occurring in tandem with ore reserve development in different parts of the mine, e.g., above the 700 level, while WMC was prospecting below or in other ore bodies. (Exs. 65, 81, 64, 60.) I estimate that waste rock trammed from the underground amounted to less than 5 percent of the total mass or volume of material (ore plus waste rock) removed from the Walker Mine. This type of information was presented in weekly reports from the Mine Manager to the President of WMC. In the report dated March 13, 1937 from L. F. Bayer to J. R.

[3] In shrinkage stoping, ore is mined out in successive inclined (or vertical) slices, working upward from a haulage level. After each slice is blasted, enough broken ore is drawn down from below to provide a working space between the top of the broken ore and the top ("back") of the stope.

[4] "Anaconda's Walker Mine and Mill," Engineering and Mining Journal, Vol. 117, pages 725-730, May 3, 1924. (Ex. 36.)

[5] "Walker Mining Company," The Mines Handbook, pages 685-687, 1931. (Ex. 69.)