STATE OF NEW MEXICO
BEFORE THE WATER QUALITY CONTROL COMMISSION

In the Matter of:	)	
PROPOSED AMENDMENT TO 20.6.2 NMAC (Copper Rule)	)	No. WQCC 12-01(R)

WRITTEN TESTIMONY OF LEWIS MUNK

I. BACKGROUND AND EXPERIENCE

I am a professional soil scientist with a strong background in vegetation ecology and geomorphology, I earned degrees in Soil and Water Science (BS) from the University of Arizona; Soils and Biometeorology (MS) from the Utah State University; and Soils and Biogeochemistry (Ph.D.) from the University of California-Davis. I have practiced in a professional capacity in various aspects of soil science, vegetation ecology, and geomorphology since 1978. My experience was obtained in the public, academic, and private sectors, with emphasis on natural and disturbed lands in the Western United States. I have worked on a broad range of mine reclamation related projects in New Mexico starting in 1989 with coal mine related investigations. I participated in the process of the development of the New Mexico Mining Act and Mining Act Rules in 1993 and 1994. I have been involved with the closure permitting and mine reclamation process at the Tyrone and Chino Mines since 1997. A current copy of my resume is attached as Exhibit Munk-1. My testimony below reflects my review of the range of scientific literature on these topics, my experience with natural ecosystems, closure

and reclamation of a variety of mines, particularly in New Mexico, my familiarity with various regulatory requirements and, importantly, my direct experience with closure and reclamation of copper mines in New Mexico and the data collected regarding that work.

II. INTRODUCTION

I am providing this direct written testimony on behalf of Freeport-McMoRan (Freeport) regarding the Environment Department's (Department) Proposed Copper Mine Rule. My written testimony incorporates the language of the Proposed Rule from Attachment 1 to the Environment Department's Petition in this matter, dated October 30, 2012 (Proposed Rule). This language is incorporated into my testimony for ease of reference, and so that if any changes to the Proposed Rule are considered by the Commission, the record is clear regarding the exact language to which my testimony applies. My direct testimony focuses on certain technical aspects of the Proposed Rule provisions relating to closure, particularly the cover and revegetation requirements. I also will discuss relevant studies and data collected at New Mexico copper mines regarding these points along with relevant scientific literature.

I participated in the Department's process to develop the Proposed Rule, particularly in the Technical Committee discussions related to the closure requirements. I participated in several conference calls and technical meetings that spanned about a 4 month period from May through August 2012. My involvement was focused on the practical and technical aspects of cover design and construction, and performance evaluations of the cover related to vegetation, erosion, and water relations.

My work for Freeport and its predecessor Phelps Dodge, involved soil and vegetation surveys, closure/closeout planning, development of vegetation success guidelines, cover design, reclamation design specifications, and vegetation and erosion monitoring at the Chino, Tyrone

and Cobre Mines. I led the team responsible for the design and implementation of the test plot programs. I have been involved with this project on a more or less continuous basis for 16 years.

In accordance with the respective mine closure permits issued by the Environment Department, particularly DP-1340 for Chino, DP-1341 for Tyrone, and DP-1403 for Cobre issued by the Department and the Mining Act permits issued by the Mining and Minerals Division (MMD), Freeport has constructed and monitored large scale reclamation test plots. Freeport has constructed 48 individual test plots at the Tyrone, Chino, and Cobre mines. The test plots were primarily intended to evaluate vegetation and water relations performance differences among different cover thicknesses; the potential for upward migration of acidity, the efficacy of fertilization, metal uptake and root habits of the plants; and the soil erosion response over time in relation to varying slope gradients and slope lengths. The test plots have site-specific meteorological stations, and most are instrumented with devices that measure soil water relations and quantitative vegetation and erosion studies are conducted on a periodic basis. The test plots are in various states of completion. In addition to the test plots, data has been obtained from the full-scale reclamation that has been completed, particularly at the Tyrone Mine.

III. DISCUSSION OF THE PROPOSED RULE

The first portion of the Proposed Rule I would like to discuss is the definition of "meteorological data" in Subsection W of Section 20.6.7.7. The collection of appropriate meteorological data is important for the development of a detailed closure plan appropriate for a particular mine site. There are sufficient meteorological records available for New Mexico in the areas where most New Mexico copper mines are located. Sufficient existing data typically is

available for use as the basis for a closure plan for a New Mexico copper mine. Additional site-specific data, however, may be needed to refine closure plans as a mine proceeds through development, operation and eventual closure. The Proposed Rule defines the meteorological data to be collected at a copper mine as follows:

> **W. Meteorological data.** An application shall include a plan to measure meteorological data at sites throughout the copper mine facility including precipitation, temperature, relative humidity, solar radiation, wind speed and wind direction.

I have reviewed this language and, in my opinion, this describes an appropriate set of meteorological data to be included for closure plan purposes. For clarification, at least one station should include the full range of capabilities indicated in the Proposed Rule. If additional stations exist at the mine they may not require the full list of instruments, with the main emphasis on collecting site-specific precipitation data.

The next portion of the rule language that I will comment on is Subsection C of Section 20.6.7.33, regarding surface regrading for closure. This subsection reads as follows:

> **C. Surface re-grading:** During closure of any tailing impoundment, waste rock pile or leach stockpile at a copper mine facility, the surface shall be re-graded to a stable configuration that minimizes ponding and promotes the conveyance of surface water off the facility. The operator may propose for department approval a grading plan that allows ponding as an appropriate part of closure provided additional ground water protection measures, such as synthetic liner systems, are included as part of the design.
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> (1) The top surfaces of all tailing impoundments at a copper mine facility shall be constructed to a minimum final grade of one-half of one percent (0.5%) after accounting for the estimated magnitude and location of large-scale settlement due to totaling consolidation or differential settlement. Prior to final re-grading activities, the permittee shall ensure that adequate drainage of the tailing impoundment has occurred to ensure that large-scale settlement following grading is minimized. The CQC and CQA plan shall provide the methods and procedures to ensure that the design and construction activities will be completed according to the approved final design and specifications, including design aspects related to potential future settlement.
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> (2) The top surfaces of all waste rock and leach stockpiles at a copper mine facility shall be constructed to a minimum final grade of one percent (1%).
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> (3) The outslopes of all tailing impoundments, waste rock and leach stockpiles at a copper mine facility shall be constructed to an interbench slope no steeper than three (3) horizontal to one (1) vertical (3H:1V). Alternative slope gradients may be allowed within an open pit surface drainage area, or if the permittee provides information showing that the cover performance objectives in Subsection F of this Section are met and the exception is approved by the department.

(a) At existing copper mine facilities, where re-grading of individual outslopes would intersect a highway, cultural resource, physical infrastructure or a surface water of the state, outslopes may be re-graded no steeper than 2.5:1 or as otherwise approved by the department in Paragraph (3) of this Subsection.

(b) At existing copper mine facilities, the waste rock and leach stockpile outslopes within an open pit surface drainage area are not required to be graded and covered.

(4) For design purposes, allowable uninterrupted slope lengths shall be calculated using a generally accepted erosion estimation method and shall be based on the final slope angle and cover material characteristics representative of the cover materials proposed for use at the site. The maximum uninterrupted slope lengths shall be no greater than 300 feet for 4.0:1, 200 feet for 3:1 slopes and 175 feet for 2.5:1 slopes. Alternative slope lengths may be allowed if the permittee provides information showing that the cover performance objectives specified in Subsection F of this Section will be achieved and the exception is approved by the department.

My testimony for the surface grading aspects of the Proposed Rule deals with post reclamation considerations associated with erosion and ponding. It is based on knowledge of the construction processes and subsequent conditions at Tyrone and Chino in association with the reclamation conducted at those facilities.

Tailing is finely crushed and milled ore that is generated through the copper concentration process. After removal of the copper concentrate, the tailing is typically delivered to the tailing dam by pipeline as a high water content slurry. The fine-grained nature of the tailing makes them highly susceptible to wind and water erosion. The tailing may or may not contain sulfide minerals that have the potential to form acidity. The tailing at Tyrone and Chino contain appreciable pyrite, whereas, the Cobre tailing do not. Because alkaline agents (lime) are used in the concentration process, the tailing is typically alkaline when it is placed. Acid conditions may occur in the sulfide containing tailing if the materials are allowed to oxidize. The high water content in the tailing limits oxygen diffusion and the rate of oxidation. Tailing in the interior and deep in the impoundments are typically unoxidized. The application of a soil cover with vegetation will moderate drying of the surficial tailing and reduce the potential for oxidation of the tailing and the generation of acid solutions.

The tailing ponds are typically configured to have coarser (sand) embankments that grade to low areas on the interior of the pond with finer sediments (slimes). Most tailing dams are constructed and operated to collect the excess water from the slurry that is liberated as the tailing sedimentation process ensues. This decant water is collected and reused in mine operations. The slope gradients on the top surface are typically low gradient and represent the natural flow surface for the materials. The operational slope gradients on the top surfaces are conducive to promoting positive drainage.

One of the goals for the Proposed Rules was to establish a minimum gradient for the top surfaces of the tailing dams, which may represent extremely large, low gradients facilities. The overall objective of the grading requirement is to minimize ponding. Even modest changes in the slope gradient of these facilities (*i.e*, from 0.5 to 1.0%) would require massive earth moving efforts. Engineers calculate the gross settlement of the tailing and this information is incorporated into the design. However, predicting the location of small settlement features is impossible.

The proposed 0.5% gradient is a reasonable practical minimum to minimize ponding. Small depressions occur on the reclaimed tailing dams at Tyrone in areas with slope gradients in the 0.5 to 1.0+ % range. The depressions are localized and relatively minor in overall extent. In the worst case, these areas occupy less than 1% of the top surface areas of the reclaimed facilities. These areas developed in response to localized and unpredictable settlement and post-cover-placement grading anomalies.

The original cover design was selected because we anticipated the possibility that localized settlement could occur. Mitigation of significant settlement features can be achieved through a maintenance process without impacting the overall cover function. Because of the

nature of the cover, mitigation involves simply adding cover materials to bring the area back to a positive drainage condition. I believe that this mitigation should be performed after a sufficient period of time has passed to ensure the consolidation process is more or less complete. The post-closure monitoring provisions in the Proposed Rule allow for identification and mitigation of these features, if they occur.

The slopes of most existing tailing dams in New Mexico are constructed at gradients of 3:1 or flatter (upstream construction method), although other types of dams with steeper slopes could be constructed in the future (e.g., centerline or dry stack). Appropriate reclamation of these types of facilities may not be fully anticipated in the Proposed Rule, except where provisions for alternate designs are considered. Limits for the slope gradients of the pond embankments are regulated by the Office of the Sate Engineer with respect to gross stability considerations. Because of the physical nature of the tailing, application of an erosion resistant cover is critical for preventing redistribution of the tailing by wind and water.

The slopes of waste and leach stockpiles are typically placed with gradients near the angle of repose (1.5H:1V). This configuration is necessary for leach stockpiles to maximize the leach surface. Reducing the slope gradient from angle of repose to 2.5:1 or 3:1 typically increases the foot print of the stockpile and/or the amount of area characterized by slopes compared to top surfaces. Under normal reclamation circumstances, slope reduction in necessary to facilitate cover placement using standard construction equipment and to reduce the potential for erosion. Slope gradient and slope length affects the potential erosion rates all other things being equal. Rates of erosion typically increase as either the slope gradient or slope length increases. Tyrone and Chino have demonstrated that 2.5:1 slopes can be successfully

constructed and reclaimed using standard construction equipment. Studies at Tyrone and Chino have demonstrated that reducing slope length compensates for increased slope gradients.

As a general practice, requiring maximum gradients of 3:1 is reasonable for large scale surface mining operations for both the stockpiles and tailing facilities. However, using specialized equipment or under special circumstances slopes steeper than 2.5:1 or 3:1 can be constructed and successfully reclaimed. It is my opinion that the rules should allow flexibility for steeper slopes in situations where the no environmental benefits are obtained by requiring the slope reduction. For example, earthen rock dams composed of inert materials that impound tailing should be considered for a steep slope exclusion. This situation would not be unlike earthen water control dams that exist throughout New Mexico. Other situations may occur where extremely short slopes exist and the additional costs for specialized equipment or treatment are warranted.

The slope lengths specified in the Proposed Rule are reasonable maximums for the corresponding slope gradients for closure design purposes recognizing that site specific factors may necessitate shorter slope lengths. The nature of the cover materials, climate conditions, and vegetation strongly influence the ultimate design. However, in my experience, and based on the experience at Tyrone, Chino and Cobre, the Proposed Rule minimum specifications for slopes are appropriate for closure and reclamation of copper mines in New Mexico, given the range of soils, climate conditions, and native vegetation found in known or potential areas where copper mines might be established. They also allow for design of closure and reclamation plans that generally will be acceptable for compliance with the Mining Act and Mining Act Rules.

Observations and data from the Tyrone test plots revealed that grading issues related to the slope shape, runon control, integration with the water control features and material

characteristics strongly affect erosion rates. At Tyrone, higher rates of erosion occurred on 4:1 slopes than 2.5:1 or 3:1 slopes because of the interplay of the factors. Thus, the criteria in the Proposed Rule provide acceptable bounds recognizing that site-specific material conditions still need to be considered in the closure planning process.

The primary focus of my testimony is the closure subsection regarding cover system requirements, as found in Subsection F of Section 20.6.7.33. Cover systems constructed of locally available earthen materials have been identified as a closure element for long-term protection of ground water quality following mine closure. These same cover systems must also have attributes that allow compliance with the Mining Act reclamation requirements, which seek to achieve different objectives such as attaining a post-mining land use and a "self-sustaining ecosystem." While the cover system requirements of the Proposed Rules focus on the features needed for protection of ground water quality, they generally complement the elements needed for compliance with the Mining Act. However, it should be noted that there are some instances these requirements compete or are to some degree mutually exclusive from a performance perspective. Thus, the cover design must be balanced to provide optimized performance considering the site-specific factors such as the materials available for reclamation and other components of the overall closure design.

Detailed provisions regarding cover systems also are included in the Proposed Rule because the Environment Department is required to provide a determination that a closeout or reclamation plan required under the Mining Act is designed to achieve applicable water quality standards. It is important for a mine operator and its consultants to know and understand the expectations and requirements of the Water Quality Act for greater certainty that the Department will issue this determination for a proposed closure plan, particularly cover systems, which

represent one of the major costs for reclamation. The Proposed Rule requirements for cover system design and performance are found in Section 20.6.7.33, Subsection F, quoted below:

> **F. Cover system:** At closure, a permittee shall install a cover system on waste rock piles, leach stockpiles, tailing impoundments and other facilities that have the potential to generate leachate and cause an exceedance of applicable standards at a designated monitoring well location using the following criteria, as appropriate. Any soil cover systems installed before the effective date of the copper mine rule are not subject to the requirements of the copper mine rule unless the department determines that an exceedance of applicable standards has occurred or is likely to occur as a result of the existing installed cover system, and that modification of the cover will prevent further impacts to ground water. Any cover system installed at an existing copper mine facility after the effective date of the copper mine rule shall be a store and release earthen cover system with a thickness of 36 inches and shall be constructed in accordance with the applicable requirements of Paragraphs 1 through 3 of this Subsection. For leach and waste rock stockpiles inside the open pit surface drainage area of an existing copper mine facility a 36-inch cover is only required on the top surfaces.
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> (1) The cover system shall be constructed of 36 inches of earthen materials that are capable of sustaining plant growth without continuous augmentation and have erosion resistant characteristics. Erosion rates shall be equal to or less than stable slopes in the surrounding environment after the vegetation has reached near-equilibrium cover levels. Erosion will be estimated using generally acceptable methods.
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> (2) Soil cover systems shall be designed to limit net-percolation by having the capacity to store within the fine fraction at least 95 percent of the long-term average winter (December, January and February) precipitation or at least 35 percent of the long-term average summer (June, July and August) precipitation, whichever is greater. The water holding capacity of the cover system will be determined by multiplying the thickness of the cover times the incremental water holding capacity of the approved cover materials. Appropriate field or laboratory test results or published estimates of available water capacity shall be provided by the permittee to show that the proposed cover material meets this performance standard.
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> (3) Cover thickness or other design criteria may be reduced or modified if:
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> (a) the cover system is installed over a lined facility and the design and function of the liner system will complement the cover system, or the permittee proposes a composite, layered or an alternate cover system with an equal or greater level of ground water protection described in Paragraphs (1) and (2) of this Section, or
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> (b) a demonstration is made that an alternate proposed cover system will ensure that an exceedance of applicable standards will not occur in ground water. Such a demonstration shall include:
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> (i) a comprehensive modeling study to estimate the quantity of net-percolation through a cover system that will not result in an exceedance of applicable standards in ground water;
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> (ii) a plan for performance monitoring of the cover system, including ground water monitoring; and
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> (iii) an agreement by the permittee to pay for the cost of a third party review of the modeling study and performance monitoring plan.
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> (4) A CQA/CQC plan shall be submitted for department review as part of the final cover design. The plan shall identify a licensed New Mexico professional engineer as the designated CQA officer and include his or her supervision of the CQA plan and shall identify the methods proposed to ensure that the closure construction will be completed in accordance with the design and specifications. Following the completion of the work, the CQA officer shall

prepare a final CQA report. The final CQA report shall provide a detailed description of the installation methods and procedures and document that the work was conducted as designed.

Covers are an important component of the reclamation at Freeport properties. Freeport's performance objectives for covers are establishment of a self-sustaining ecosystem, control of fugitive dust, protection of the wastes from erosion and off-site sedimentation, and reduction of drainage of water into the wastes. Key design criteria related to the cover system are its ability to infiltrate and store water, physically support vegetation, and resist wind and water erosion to the extent practicable.

Tyrone and Chino identified the need for cover design studies in the development of their respective closure/closeout plans in 1997. Following discussions with the NMED and MMD during the spring of 1998, Tyrone and Chino prepared and submitted cover design work plans for regulatory review. Based upon agency comments, revised work plans were submitted and work was initiated on the cover design studies in early November 1998.

In 1999, implementation of this work led to the development of Cover Design Study Status Reports for Chino and Tyrone, which presented the results of material characterizations, soil water balance simulations, and technical reviews of various types of cover systems. Based on this work and subsequent collaboration with the NMED and MMD, a capacitive (store and release) type cover was selected as the most appropriate for use on these facilities. Test plot work plans were required as part of Discharge and Mining Act permits. Following approval of the work plans in 2004 (NMED) and 2006 (MMD), test plots were constructed at Tyrone tailing dams and stockpiles and the Chino stockpiles.

The Subsection F, paragraphs (1) and (2) in the Proposed Rule for cover are consistent with DP-1340 and DP-1341, if recent changes to those permits are included. For instance, DP-

1340 originally required a 2-foot thick at the tailing facilities, but Freeport agreed to and has constructed 3-foot thick covers. At Tyrone, the DP-27 Settlement Agreement required a 2-foot cover on the tailing facilities. The cover thickness at the Tyrone tailing facilities ranges from 2 to more than 10 feet thick. Otherwise, the permits require covers that are at least 3-feet thick on all stockpile areas, except the slopes within the open pit surface drainage area.

Test plots were required as conditions of DP-1340, DP-1341, DP-1403, and DP-27 Settlement Agreement. Tailing test plots were constructed at Tyrone and Cobre. Stockpile test plots were constructed at Tyrone, Chino, and Cobre. After 7 years of monitoring at Tyrone, the tailing and stockpile test plots are nearly complete. These test plots were intended to evaluate the performance differences between 1.5-, 2-, 3-, and 4-foot thick covers at the tailing facility, and 2-, 3-, and 4-foot covers on the stockpile facilities. At the stockpile test plots, different slope gradients were evaluated including 2:1, 2.5:1 and 3:1 slopes.

The primary evaluation metrics were related to constructability, plant performance, erosion, and soil-climate drainage relationships. Covers were successfully constructed on 2.5:1, 3:1, and 4:1 slopes using conventional equipment. Covers were placed on a 2:1 slope gradient test plots, but required special efforts and techniques that would be difficult to accomplish on a broad scale.

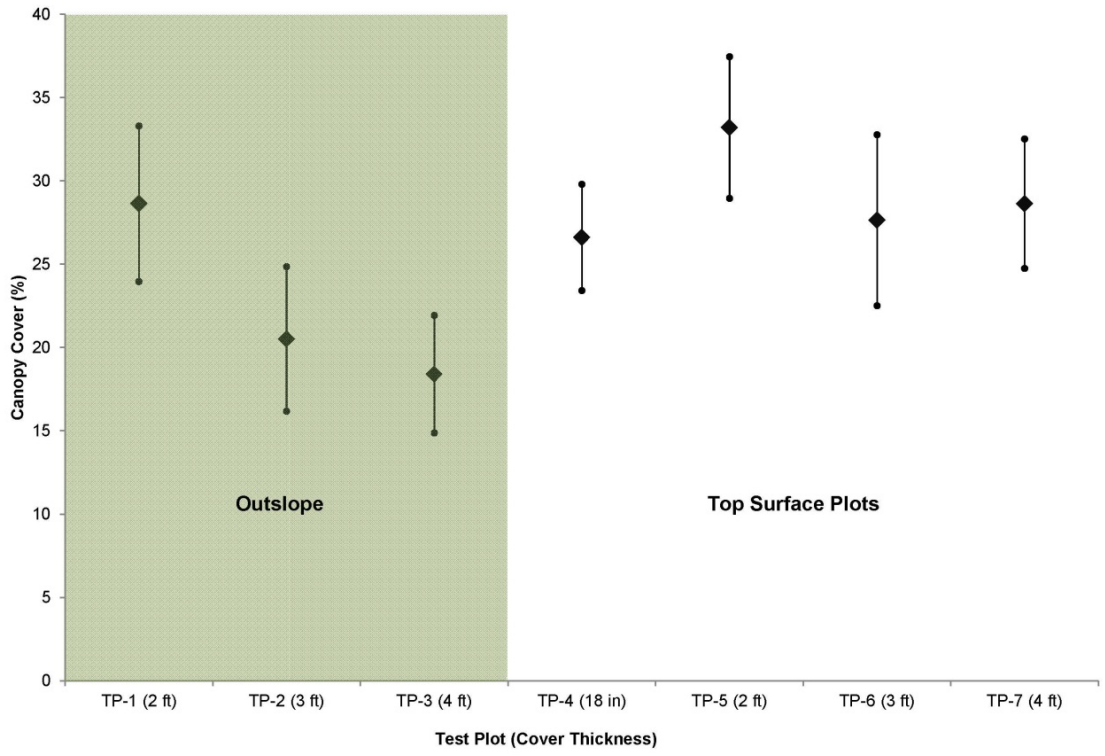
No definitive performance improvement has been observed for vegetation by increasing the cover thickness from 1.5- to 4-feet after seven years. Data from the vegetation monitoring conducted in 2012 at Dam 3X at Tyrone are shown in the graph below from the test plot annual report that has been provided to the Department and MMD. It should be noted that the 1.5 cover treatment was seeded a year later than the other test plots. These data reveal that increasing cover thickness has not resulted in a corresponding increase in vegetation canopy cover. The

vegetation cover is an important indicator of the water relations for the cover thickness treatments because increased water use and availability should be reflected in increased vegetation growth and canopy cover. The lack of evidence for an increase in vegetation canopy cover with increasing cover thickness suggests that additional water storage provided by the thicker soils is not being effectively exploited by the vegetation. The response of the vegetation at Dam 3X is consistent with the data from the No. 1 Stockpile test plots at Tyrone (data not shown).

January 2013

FIGURE 3-6
MEAN TOTAL CANOPY COVER MEASURED IN 2012 ON DAM 3X
(+/- 90% CONFIDENCE INTERVAL)

123-80012



3X_TABLE_FIGURE _3-2.xlsx/FIGURE 3-6

Similar to the vegetation response, no definitive performance improvement has been measured with respect to decreasing drainage with increasing cover thickness. In other words, drainage from the 2-foot cover treatments is equivalent or less than drainage from the corresponding 3- or 4-ft cover treatments.

The Proposed Rule for cover is intended to meet the performance requirements of the Mining Act. The Mining Act does not contain specific design requirements for covers, although it does contain guidance for the types of materials that might be used and suggests that covers less than 2-feet thick require additional analysis of the underlying wastes. In broad terms, the Mining Act requires that the covers are adequate to support performance criteria related to vegetation and erosion as dictated by the designated post-mining land use. The cover must be able to sustain vegetation, without continuous augmentation, at levels nearly consistent with the surrounding ecosystem. After vegetation establishment, erosion from the cover must be equivalent to that from the surrounding environment. Studies at Tyrone indicate that these performance criteria can be achieved by covers of similar water holding capacity to those in the Proposed Rule.

Erosion resistance is a commonly required cover attribute in most general guidance and rules, like the New Mexico landfill regulations for covers and EPA guidance (EXHIBIT MUNK-2). In the Proposed Rule, erosion resistance was defined relative to surrounding natural systems as demonstrated through analogue modeling. This approach is consistent with the Mining Act and adoption of the Proposed Rule by the WQCC would reduce redundancy and conflict between these overlapping regulatory programs. Currently, the most widely accepted method for assessing erosion at mine sites is the Revised Universal Soil Loss Equation (RUSLE). This

method is required and accepted by federal mine regulatory authorities, such as the Office of Surface Mining.

The cover design recommendations developed for Tyrone and Chino were based on site-specific field studies of soils, vegetation, climate, and waste materials conducted over a period of several years. These field studies were augmented by specialized materials characterization, climatic analyses, and unsaturated flow modeling. The test plots and reclamation activities conducted at Tyrone since 2004 provide a demonstration of the effectiveness of the cover design and associated reclamation techniques.

The thickness and water storage capacity design limits in the Proposed Rule were developed recognizing that store and release covers will not provide complete preclusion of meteoric water from the waste under all circumstances of climate for the foreseeable future. The covers are intended to sustain vegetation, protect the wastes from wind and water redistribution, and limit drainage to the extent that potential groundwater impacts are mitigated through either natural attenuation processes or complementary control systems (e.g., interceptor wells, slurry walls, liners). The concept of sufficient and optimized, but not perfect, source control is consistent with the state of the science view of cover systems (EXHIBIT MUNK-2).

The proposed thickness limit (36 inches) conforms to previous permit requirements imposed by the Department. The threshold water storage capacity was determined based on field studies and long-term unsaturated flow modeling for covers in southwestern New Mexico. In collaboration with the Department, these storage values were then generalized to reflect peak seasonal precipitation regimes that may occur in different parts of New Mexico. Thus, the water storage requirements will vary depending on amount of precipitation in any given region and whether the climate is dominated by summer or winter precipitation regime. Normal or

long-term monthly average precipitation data are readily available from publically available sources for most parts of New Mexico. For the Silver City area, the threshold water storage capacity for the cover would be about 2.5 to 2.6 inches considering that the long-term summer precipitation is 7.25 inches and long-term winter precipitation is 2.70 inches.

Subsection F, paragraph (3) was proposed to allow the permittee to modify the cover design to address site-specific factors, while achieving the overall requirements of the Proposed Rule. This provision will allow the potential development and/or adoption of new technologies and innovations, without requiring an additional rule making process. A formalized peer review process is required to supplement the Department's assessment of any deviations from the Proposed Rule.

Overall, in my experience, and based on the studies and experience at the Tyrone and Chino mines, the Proposed Rule requirements for store and release covers and the minimum specifications for covers are appropriate for closure and reclamation of copper mines in New Mexico, based upon the range of soils, climate conditions, and native vegetation found in known or potential areas where copper mines might be established. They also allow for design of covers that generally will be acceptable for compliance with the Mining Act and Mining Act Rules.

The Proposed Rule requires a CQA/CQC plan for cover installation, which is important for documenting the methods to be employed and provides rationale for the selection of specific design details. This document and plans would present an integrated system of cover, grading, and water control structures. After closure of a facility, the CQA/CQC report is important for documenting the conditions of the reclamation at the time of completion.

The final portion of the Proposed Rule covered by my testimony covers the requirements for post-closure reclamation monitoring, maintenance and inspections, particularly as it relates to vegetation and covers. The proposed rule language is found in portions of Subsection C of Section 20.6.7.35 and reads as follows:

> **C. Reclamation monitoring, maintenance, and inspections.**
>
> (1) **Vegetation.** To ensure that vegetated covers required by the copper mine rule or the approved discharge permit are protective of water quality, a permittee shall perform post-closure monitoring of vegetation pursuant to schedules and monitoring requirements approved by the mining and minerals division. Any proposed changes to the closure or post-closure vegetation monitoring plan to meet Mining Act requirements shall be submitted to the department to ensure monitoring is protective of water quality. The permittee shall provide the department with a copy of monitoring results for vegetated covers, including photographic documentation as required by the mining and minerals division. At such time as the mining and minerals division vegetation success requirements under the Mining Act have been met, the permittee shall provide a final report to the department and vegetation monitoring may cease.
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> (2) **Erosion, subsidence, slope instability, ponding, and other features.** The permittee shall visually inspect closed discharge permit areas where a cover was installed for signs of excessive erosion, subsidence features, slope instability, ponding, development of fissures, or any other feature that may compromise the functional integrity of the cover system or drainage channels. Drainage channels, diversion structures, retention ponds, and auxiliary erosion control features shall be inspected in accordance with professionally recognized standards (e.g., U.S. department of agriculture natural resources conservation service standards). The inspections shall be conducted monthly for the first year following submission of the final CQA/CQC report for the unit, and quarterly thereafter until the end of post-closure monitoring, provided the department may approve a schedule allowing less-frequent monitoring. Discharge permit areas where covers were installed shall also be inspected for evidence of excessive erosion within 24 hours, or the next business day, following storm events of one inch or greater as measured at the nearest rain gauge on the copper mine facility. The permittee shall report and take corrective action pursuant to 20.6.2.7.30 NMAC regarding signs of excessive erosion, subsidence features, slope instability, ponding, development of fissures, or any other feature that may compromise the functional integrity of the cover system or drainage channels. Monitoring and inspection results shall be reported as required by Subsection D of this Section.
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> (4) **Cover maintenance.** A permittee shall perform maintenance on all areas where a cover system was installed as required by the copper mine rule, including associated drainage channels and diversion structures if their performance may affect cover system function. Based on monitoring of vegetation and erosion required by Paragraphs (1) and (2) of this Subsection, a permittee shall provide recommendations for maintenance work in semiannual monitoring reports described in Subsection D of this Section, including a schedule for completion of work.

Vegetation is a key determinant of the performance of store and release covers. The uptake of water from the soil by plant roots (transpiration) increases the amount of water that can

be removed from a soil compared to evaporation alone. Transpiration is particularly important for removal of water at depth in the cover. Interception of rainfall by the vegetation canopy and subsequent evaporation reduces the amount of water that enters the soil. Vegetation cover and plant debris (litter) protect the soil surface from erosion. The fibrous root systems of plants help to further reduce the potential for erosion from overland flow.

The goal of the vegetation monitoring is demonstrate that vegetation is functioning at levels consistent with the fundamental constraints of the environment, which are usually related to the prevailing climate. The Mining Act requires that the vegetation achieve cover, density, diversity, and in some cases productively, requirements based on appropriate natural analogues. Because of the aridity and climatic variations in this region, the vegetation must be monitored for a period of no less than 12 years. The minimum monitoring period (12 years) in the Western US is longer than more humid Eastern regions (5 years) to ensure that the vegetation can withstand drought conditions. If the vegetation meets these success standards after this period of time it is assumed that the plant community can persist without intervention and termination of the monitoring is warranted. The Proposed Rule language is consistent with the goals and technical aspects of vegetation monitoring.

The dynamic interrelationship between erosion resistance, vegetation performance and drainage reduction is one area that requires optimization decisions for the cover. These decisions are further constrained by the kinds of materials available at the mine site that can be used as cover. The potential for erosion can be eliminated by constructing the cover from large rock fragments with little or no fine materials. However, this approach may prevent the establishment of an acceptable vegetation community and seriously reduce the potential for evapotranspiration. Thus, soil erosion will occur to some degree as it does on natural landscapes. Monitoring of

erosion during the vegetation monitoring period should allow identification of abnormally high soil erosion rates related to improper selection of the cover materials.

The cover design in the Proposed Rule anticipated that localized maintenance may be required in association with settlement or episodic storm events. The functional integrity of the cover is considered compromised if breaches in the cover associated with improper functioning water control structures expose or imminently threaten to expose waste materials. Localized settlement may result in the formation of depressions, fissures, or redirection of the grade. These kinds of processes may be slow to manifest or precipitated only by rare and extreme storm conditions.

The monitoring protocols in the Proposed Rule emulate the program that was developed over a period of years at Tyrone through collaboration with the Department and MMD. The frequency of monitoring is high (monthly) during the first year after seeding and less frequently thereafter. In my experience at Tyrone, critical design and/or construction imperfections were identified within the first few years following reclamation with the number of issues decreasing over time.

Few, if any, of the erosion features identified at Tyrone required immediate action. The erosion features would typically occur during the summer rains and were corrected once the ground conditions allowed access in the drier fall, winter, and spring months. A root cause analysis was typically employed to determine the type of corrective action to apply to avoid repeat events. This process allows the identification of preventive maintenance measures that can be applied where necessary.

IV. CONCLUSION

Based on my experience and credentials, and subject to the suggested changes noted above, I believe that the provisions in the Proposed Rule discussed above are consistent with permit requirements for copper mine closure imposed by the Department under the Water Quality Act and the existing Commission Regulations, and that the Proposed Rule requirements are technically appropriate for closure of copper mines in New Mexico. This concludes my direct written testimony.

Lewis P. Munk