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 12-001(R)**

WRITTEN TESTIMONY OF T. NEIL BLANDFORD

I. INTRODUCTION

My name is T. Neil Blandford. I hold a B.A. in Environmental Science from the University of Virginia; the course of study for this degree included geology, hydrology, meteorology and ecology. The majority of my course work focused on geology and hydrology. I also hold a M.S. degree in Hydrology from the New Mexico Institute of Mining and Technology. The course of study for this degree included multiple courses in ground water hydrology, contaminant transport in ground water, hydrogeochemistry and quantitative methods including the numerical simulation of ground water flow and solute transport.

I have been employed as a consulting hydrologist since 1987. I was employed for about 6 years at HydroGeoLogic, Inc. (HGL) in northern Virginia. At HGL I was responsible for the development and application of computer models of ground water flow and solute transport. I either led or worked with teams to develop models of ground water flow and solute transport for the U.S. Environmental Protection Agency (U.S. EPA) to assist with regulatory compliance and uncertainty analysis for landfills, surface impoundments, and the determination of wellhead protection areas for public water supply wells. While at HGL I also developed ground water flow and solute transport models to assess ground water resources and sea water intrusion across large portions of central Florida. Since 1994 I have been employed at Daniel B. Stephens & Associates, Inc. (DBS&A). At DBS&A I have conducted numerous site investigations and hydrogeologic studies, including computer modeling, to quantify ground water resources, assess impacts to ground water from various types of contaminant sources, and to design and implement appropriate remedial actions. Clients I have served while at DBS&A include the U.S. EPA, Indian tribes and pueblos, water districts, local governments, private companies or individuals, and multiple state agencies including the New Mexico Environment Department, the Mining and Minerals Division, and the Office of the State Engineer.

I have analyzed ground water flow and quality at mine sites for much of my career. I have been involved with or led studies to evaluate the effects of mine operations (copper, coal, uranium, phosphate and aggregate) on water resources in Arizona, New Mexico, Nevada, Texas and Florida. In New Mexico, I have been involved with the Chino, Cobre, Tyrone, Little Rock and Pecos mines and their associated facilities in various capacities, although the majority of my experience has been at the Tyrone Mine and the closed Pecos Mine and associated El Molino Mill site (the mine site and the mill site are about 12 miles apart). At the Tyrone Mine near Silver City I have been responsible for the design, placement and installation of dozens of monitor and ground water extraction wells; aquifer testing of multiple wells; the development and application of ground water flow and solute transport models to assess the effects of open pits and other mine facilities on ground water; development of comprehensive Stage 1 and Stage 2 Abatement Plan Proposals, and technical support and hydrogeologic investigations for all operational discharge permits, including the design and implementation of seepage collection systems. At the Pecos Mine/El Molino Mill sites near Pecos, I have been responsible for long-term ground water and surface water monitoring and reporting, development of a ground water flow and solute transport model for the reclaimed tailing, and the development of compliance monitoring plans for surface water and ground water.

A copy of my current Curriculum Vitae showing my professional training, certifications, professional affiliations, experience and publications is attached as Exhibit Blandford-1.

I am familiar with the Proposed Rule in this matter attached to the New Mexico Environment Department's (NMED) Petition and I participated in some stakeholder meetings that preceded its issuance. Namely, I participated in several meetings regarding the potential effects of tailing impoundments on ground water and the utility and efficacy of seepage collection systems. I also reviewed various draft portions of the Proposed Rule regarding ground water monitoring and open pits.

My direct testimony will focus on the portions of the Proposed Rule that apply to water quality monitoring at all mining facilities and operational and closure requirements for open pits. I also provide some discussion of seepage collection systems typically used to contain and remediate impacted ground water. My written testimony incorporates the language of the Proposed Rule from Attachment 1 to the NMED'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 Water Quality Control Commission (WQCC), the record is clear regarding the exact language to which my testimony applies.

II. WATER QUALITY MONITORING REQUIREMENTS (20.6.7.28 NMAC)

The water quality monitoring requirements for copper mines in the Proposed Rule are located at Section 20.6.7.28 NMAC, which begins as follows:

> **20.6.7.28 WATER QUALITY MONITORING REQUIREMENTS FOR ALL COPPER MINE FACILITIES.** The following water quality monitoring requirements apply to all copper mine facilities unless otherwise specified.

Monitor wells are used to monitor both ground water levels and ground water quality through time. According to the U.S. Army Corps of Engineers (1998, p. 5-1), a monitor well is:

> ... a device designed for the acquisition of groundwater samples that represent the chemical quality of the aquifer adjacent to the screened interval, unbiased by the well materials and installation process, and which provides access to measure the potentiometric surface for that screened interval.

Monitoring of ground water levels at multiple locations allows for the determination of ground water flow directions, areas of hydrologic containment, and other hydrogeologic conditions of interest, such as drawdown (declining water level) that may occur in response to dewatering an open pit. Monitoring for water quality allows for the detection of ground water impacts due to mine operations, determination of the extent of such impacts, determination of trends in water quality, and determination of the effectiveness of ground water abatement measures or corrective action that may be implemented if ground water concentrations exceed applicable standards due to discharge from a facility.

In the Proposed Rule, applicable standards are defined in Section 20.6.7.7.B(3) NMAC as

> (3) "Applicable standards" means either the standards set forth in 20.6.2.3103 NMAC including, when applicable, the existing concentration; the background concentration approved by the department; or, for an existing copper mine facility, any alternative abatement standard approved by the commission pursuant to 20.6.2.4000 NMAC through 20.6.2.4115 NMAC.

The applicable standard concept is necessary to determine if impacts to ground water have occurred due to a mine facility, and if so whether or not the level of impacts require implementation of a corrective action plan or abatement action. Ground water quality standards do not apply to ground water where the total dissolved solids concentration exceeds 10,000 parts per million. Section 20.6.2.3103 NMAC standards are maximum allowable concentrations in ground water to be measured at a place of withdrawal of water for present or reasonably foreseeable use ("place of withdrawal") to protect certain uses, as identified in Section 20.6.2.3103 NMAC. Therefore, if ground water at a "place of withdrawal" has a concentration for a given constituent that is less than the Section 20.6.2.3103 NMAC standard, discharge to ground water can increase the concentration of that constituent up to the standard, but not above. If the existing concentration of a given constituent in ground water prior to discharge already exceeds the Section 20.6.2.3103 NMAC standard, no additional degradation above the existing concentration is allowed (Subsection A of 20.6.2.3101 NMAC). If an abatement plan is required, then the WQCC's abatement rules specify the abatement standards and requirements, which work similar to the discussion above. *See* Section 20.6.2.4103 NMAC. The technical feasibility of achieving abatement standards can be considered by NMED under the abatement program. *See* Section 20.6.2.4103.E NMAC. If discharge to ground water has occurred and the permittee has submitted a Stage 2 Abatement Plan, the permittee may request that alternative abatement standards be approved by the WQCC. *See* Section 20.6.2.4103.F NMAC. If approved, the alternative abatement standards become the applicable standard rather than Section 20.6.2.3103 NMAC standards.

Background is defined at Section 20.6.6.7.B(7) of the Proposed Rule as

> (7) "Background" means the concentration of water contaminants naturally occurring from undisturbed geologic sources of water contaminants.

Background concentration of a constituent in ground water, therefore, is the concentration that would exist at a given location if mining never occurred. This definition is equivalent to the "existing concentration" applied in Section 20.6.2.3101.A NMAC for a mine site where mining activities have not affected the concentration value.

Proposed Rule Section 20.6.7.28.A NMAC provides:

> **A. Monitoring wells - location proposals.** An applicant for a new, renewed or modified discharge permit or permittee shall submit a plan for department approval identifying the proposed location of monitoring wells required pursuant to Subsection B of this Section, and shall include the following information.
>
> (1) The location of each monitoring well relative to the unit of the copper mine facility it is intended to monitor shall be indicated on the scaled map required by Subsection J of 20.6.7.11 NMAC
>
> (2) The ground water flow direction beneath the copper mine facility used to determine the monitoring well location(s), including supporting documentation used to determine ground water flow direction.

Subsection A requires that monitor well location proposals be provided by an applicant for new, renewed, or modified discharge permits. The location proposal must include the proposed monitor well locations relative to the facility that the well is intended to monitor, and the ground water flow direction. The determination of ground water flow direction is based on ground water levels beneath a given unit. Typically lines of equal ground water elevation are drawn based on observed data, and the direction of ground water flow is generally perpendicular to the ground water level elevation contours, or "downhill" relative to the ground water surface. *See* Exhibit Blandford-2.

A typical monitor well location proposal would include at least one figure or map that presents the location of the facility being monitored, the location of the proposed monitor wells, and a map of water levels and any other information used to determine the direction of ground water flow beneath the facility. The proposal would also likely include a brief description of why the proposed monitor well locations were selected, and a description of any extenuating circumstances that affected the selection of monitor well placement, such as safety concerns or access limitations. Information used to prepare the proposal would include a ground water contour map for the aquifer(s) of interest based on water level measurements or other information (*e.g.*, spring locations), and geologic information including rock type, geologic contacts and the location of faults or fracture zones, to the extent such information is available. The proposal may also include anticipated depth to water, total well depth, and top and bottom of screen, although actual depth to water and the final well depth and screen placement is commonly adjusted in the field based on actual conditions encountered. This last statement is particularly true of fractured rock settings.

The general approach and information required by Section 20.6.7.28.A NMAC essentially formalizes the approach already followed by the NMED regarding the siting and approval of monitor well locations. Currently, formal monitor well location proposals are not required, but much of the same information as would be required in a monitoring well location proposal is provided to, and considered by, NMED prior to their final approval of a proposed monitor well location.

Proposed Rule Section 20.6.7.28.B provides:

> **B. Monitoring wells - required locations.** A permittee shall monitor ground water quality around and downgradient of the perimeter of each open pit, leach stockpile, waste rock stockpile, tailings impoundment, process water impoundment, and impacted stormwater impoundment The department may require additional wells around the perimeter of mine units that are underlain by areas where ground water flow directions are uncertain, including fracture flow systems, and around copper mine units that have the potential to cause ground water mounding. The department may require additional monitoring wells at any other unit of a copper mine facility that has the potential to cause an exceedance of applicable standards as additional permit conditions in accordance with Subsection I of 20.6.7.10 NMAC. Monitoring wells shall be located pursuant to this Section to detect an exceedance(s) or a trend towards exceedance(s) of the ground water standards at the earliest possible occurrence, so that investigation of the extent of contamination and actions to address the source of contamination may be implemented as soon as possible.

Subsection B requires that monitor wells be used to monitor ground water quality "around and downgradient of the perimeter of each open pit, leach stockpile, waste rock stockpile, tailings impoundment, process water impoundment, and impacted stormwater impoundment." This requirement is appropriate because each of these types of mine units are generally of significant size and have the potential to impact ground water due to the seepage of process solutions or acid mine drainage. Often the majority of the land surface at a mature mine site would be encompassed by one or more of these types of mine units. The concept of monitor well placement downgradient of a mine facility is illustrated conceptually for a process water impoundment and a waste rock stockpile in Exhibits Blandford-3 and Blandford-4, respectively. These types of facilities will not necessarily impact ground water; the seepage indicated on the exhibits is for explanatory purposes only.

There are additional facilities (generally smaller in size) at mine sites that will not impact ground water or have only limited potential to impact ground water. Examples include repair shops and garages, warehouses, loading and unloading areas, fabrication shops, power stations and administrative offices. It is reasonable to exclude such facilities from the Proposed Rule because: 1) they pose minimal risk to ground water, and 2) NMED has the discretion to require additional monitoring wells "at any other unit of a copper mine facility that has the potential to cause an exceedance of applicable standards...." Therefore, if any units at the mine not listed in the Proposed Rule are of concern to NMED for good cause, the NMED can require ground water monitoring specific to that unit.

Proposed Rule Section 20.6.7.28.B(1) NMAC provides:

> (1) **Use of existing monitoring wells.** A monitoring well in existence before the effective date of the copper mine rule shall be deemed to be in an approved location for ground water monitoring purposes provided the following requirements are met.
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> (a) The monitoring well location was previously approved by the department; and,
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> (b) The monitoring well is constructed as previously approved by the department; or
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> (c) If the monitoring well and construction was not previously approved by the department, the applicant or permittee can demonstrate that the well meets the location and construction requirements of this section.
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> (d) A permittee may cease monitoring of an existing monitoring well if the monitoring well location is not required by the copper mine rule, an approved discharge permit or an approved abatement plan.

Subsection B, paragraph (1) allows for the use of existing monitoring wells if the monitoring well location and construction was previously approved by NMED, or if the applicant or permittee demonstrates that the well meets applicable location and construction requirements as listed in the Proposed Rule. These conditions are appropriate, since existing wells approved by NMED have been deemed to meet the specific purpose of required monitoring related to the existing discharge permit for which the monitor well is required. Furthermore, in the past, NMED has followed the same general principles of well construction and placement as documented in the Proposed Rule, including: 1) appropriate placement of monitor wells to detect potential impacts to ground water from a given facility, and 2) construction of monitor wells with limited screen lengths and other attributes so that water quality values indicative of potential impacts to ground water would be collected. There is no reason to reject the validity of the previous monitoring wells approved by NMED due to minor differences in well construction (*e.g.*, screen length) or some other reason.

If an existing well location or construction has not been approved by NMED, it is reasonable that the permittee or applicant have the opportunity to present information to NMED regarding the appropriateness of a given well for monitoring potential discharge to ground water from a given facility. If the NMED determines that an existing well will meet the intended purpose of ground water monitoring, utilization of the existing well will add to the consistency of the monitoring record (*i.e.*, a new well does not be drilled and sampled), and other issues are avoided, such determination of a suitable location to drill.

Proposed Rule Sections 20.6.7.28.B(2)&(3) NMAC provide:

> (2) **Ground water monitoring – leach stockpiles, waste rock stockpiles, tailings impoundments.** A permittee shall install a sufficient number of monitoring wells around and downgradient of the perimeter of each new leach stockpile, waste rock stockpile and tailings impoundment located outside of the open pit surface drainage area, including its leachate and solution capture and containment systems, to adequately monitor ground water that may be impacted by water contaminants from those units. Each monitoring well shall be installed as close as practicable to the proposed leach stockpile, waste rock stockpile or tailings impoundment, including its leachate and solution capture and containment systems, that is to be monitored considering the slope of the land surface, hydrogeological conditions, geologic controls, infrastructure, engineering design plans, depth to ground water, working distance and safety.
>
> (a) For a new copper mine facility, the monitoring well networks shall be installed before emplacement of ore, waste rock or discharge of tailings at an individual leach stockpile, waste rock stockpile or tailings impoundment.
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> (b) A permittee constructing a new leach stockpile, waste rock stockpile or tailings impoundment at an existing copper mine facility, or expanding the footprint of an existing leach stockpile, waste rock stockpile, or tailings impoundment, shall install the monitoring well networks required to monitor ground water around and downgradient of the leach stockpile, waste rock stockpile or tailings impoundment before emplacement of ore, waste rock or discharge of tailings unless an existing monitor well network adequately monitors water quality in the area of the new leach stockpile, waste rock stockpile or tailings impoundment.
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> (3) **Ground water monitoring – process water and impacted stormwater impoundments.** A minimum of two monitoring wells shall be located downgradient and within 75 feet (measured as horizontal map distance) or as close as practicable considering the slope of the land surface, hydrogeologic conditions, infrastructure, working distance and safety of each

new process water or impacted stormwater impoundment located outside of an open pit surface drainage area.

(a) For a new copper mine facility, monitoring wells shall be installed before discharging to an individual process water or impacted stormwater impoundment at the copper mine facility.

(b) A permittee constructing a new process water or impacted stormwater impoundment at an existing copper mine facility shall install the monitoring well(s) required to monitor ground water downgradient of the impoundment before discharging process water to the impoundment, before collecting impacted stormwater in the impoundment unless an existing monitor well network adequately monitors water quality in the area of the new process water or impacted stormwater impoundment.

Subsection B, paragraphs (2) and (3) state that monitor wells must be located downgradient but as close as practical to new facilities considering factors such as slope of the land surface, hydrogeologic conditions, geologic controls, infrastructure, engineering design plans, depth to ground water, working distance, and safety. These considerations regarding monitor well placement are appropriate and necessary at copper mines. Examples include:

- Land Surface - A flat or nearly flat surface is a requirement to conduct drilling using conventional drill rigs typically used in the environmental industry. Surfaces that slope too steeply can require extensive excavation, re-grading, and unwarranted disturbance and maintenance.

- Hydrogeologic Conditions, Geologic Controls, and Depth to Ground Water - Items such as these should be considered in the decision of where to place a monitor well because they can affect the migration of impacted ground water. As noted above, the purpose of a monitor well is to detect and monitor discharges to ground water if they occur. Therefore, placement of a monitor well should be selected such that it is most likely to fulfill its intended purpose. For example, if there is a fault or other geologic condition that may influence the pathway for potential contaminant migration, that feature should be considered in the selection of an appropriate monitor well location.

- Infrastructure, Working Distance, and Safety - Utility clearances and one-calls are standard operating practice for any type of earth excavation, including drilling. For safety purposes, protection of property, and avoidance of undue disruption of services, monitor wells should not be drilled adjacent to underground utilities if it can be avoided. Overhead utilities (*e.g.,* power lines) pose a significant safety hazard, not only during drilling but during well maintenance and other activities that may have to be conducted. Other types of infrastructure, such as roads and buildings, may obviously place additional limitations on potential monitor well locations.

- Engineering Design Plans - Consideration of engineering design plans can be a very important component of monitor well site selection. For example, a monitor well constructed in the path of future haul road, within the future outline of a stockpile toe, or within areas of future excavation will have to be plugged and abandoned or may be accidentally destroyed. Consideration of engineering design plans relative to proposed monitor well locations will assist with 1) maintaining consistency and longevity of monitoring locations, 2) avoiding the expense of well replacement, and 3) decreasing the possibly of accidental well destruction.

In addition, the general requirement that monitor wells be placed "as close as practicable to the proposed leach stockpile, waste rock stockpile or tailings impoundment, including its leachate and solution capture and containment systems" is consistent with typical professional practice and well locations approved by NMED under existing discharge permits.

Proposed Rule section 20.6.7.28.B(4) NMAC provides:

> (4) **Ground water monitoring – open pit.** A permittee shall install a sufficient number of monitoring wells around the perimeter of an open pit to adequately monitor ground water quality and the hydrologic gradient around the pit.
>
> (a) For a new open pit, an applicant or permittee shall submit a monitor well network installation plan to the department for approval. The plan shall include proposed locations of monitoring wells and a statement of the reasons for selection of the monitoring well locations.

Subsection B, paragraph (4) requires that a sufficient number of monitor wells be installed around an open pit to adequately monitor ground water quality and the hydrologic gradient around the pit. The purpose of this requirement is to monitor ground water conditions in the vicinity of the pit. An open pit at a copper mine may or may not be deep enough to reach ground water. Either type of pit, however, can be a source of discharge to ground water. The source of the discharge is precipitation that falls on or runs on to the pit walls and benches. When this occurs, the precipitation water may react with the exposed rock surfaces and become impacted by multiple constituents. This impacted water may infiltrate into the pit walls and benches, and eventually reach ground water below the pit, where it may affect ground water quality. For a pit that has not reached ground water, impacted storm-water runoff can collect at the bottom of the pit where infiltration to ground water may also occur.

For an open pit that is deep enough to reach the water table, ground water that enters the pit must be removed (pumped out) for mining to occur in that pit. In this case, ground water will flow toward the open pit from all directions. Water levels obtained from observation wells around the pit, along with observed water levels within the pit itself, will allow for the determination of the direction of ground water flow and the area of hydrologic containment associated with the pit. *See* Exhibit Blandford-5. The effects of open pits on ground water flow are discussed in greater detail in Section III of my testimony.

The planning and placement of monitor wells to meet the Subsection B, paragraph (4) requirements is one example where the consideration of engineering design plans will be critical. The appropriate placement of monitor wells around an open pit will need to account for pit extent and the placement of adjacent stockpiles and other mine facilities. Even with careful planning, it is probable that some monitor wells will need to be plugged and abandoned and replaced at alternative locations at various times during the life of the mine.

Proposed Rule Sections 20.6.7.28.B(5)&(6) NMAC provide:

> (5) **Ground water monitoring – upgradient of each potential contaminant source.** A minimum of one monitoring well shall be located upgradient of each new leach stockpile, waste rock stockpile, tailings impoundment, and process water and impacted stormwater impoundment at a copper mine facility to establish upgradient ground water quality conditions not likely to be affected by each contamination source that is being monitored. If an applicant or permittee has obtained sufficient background data from monitoring wells at a copper mine facility to establish upgradient conditions, the department may waive the requirement for additional upgradient wells.
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> (a) For a new copper mine facility, upgradient source monitoring wells shall be installed before emplacement of ore, waste rock or discharge of tailings or other water contaminants at an individual leach stockpile, waste rock stockpile, tailings impoundment or other impoundment.
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> (b) A permittee constructing a new leach stockpile, waste rock stockpile, tailings impoundment or other impoundment at an existing copper mine facility shall install the monitoring well(s) required to monitor ground water quality upgradient of a leach stockpile, waste

rock stockpile, tailings impoundment or other impoundment before emplacement of ore, waste rock or discharging of tailings or water contaminants into the individual source required to be monitored unless an existing monitor well network adequately monitors water quality upgradient of the area of the new leach stockpile, waste rock stockpile, tailings impoundment, process water impoundment or impacted stormwater impoundment.

(6) **Ground water monitoring – upgradient of the copper mine facility.** A sufficient number of monitoring wells shall be located upgradient of all potential ground water contamination sources at a copper mine facility to establish upgradient ground water quality conditions that are not affected by any potential contamination sources at the copper mine facility.

(a) For a new copper mine facility, upgradient monitoring wells shall be installed before emplacement of ore, waste rock or discharge of tailings or other water contaminants at an individual leach stockpile, waste rock stockpile, tailings impoundment or other impoundment.

Subsections B, paragraphs (5) and (6) require the installation of upgradient monitor wells at the identified new mine facilities to establish ground water quality unaffected by the potential contamination sources. The purpose of upgradient wells is to provide the required information to distinguish effects on ground water quality due to potential discharge from the new mine facility as opposed to existing constituent concentrations in ground water. This is accomplished by sampling ground water before it flows beneath a permitted facility, where it may become impacted by discharge from the facility. *See* Exhibits Blandford-3 and Blandford-4. A second purpose of upgradient monitoring that could be applicable at some sites is the establishment of background constituent concentrations that may exceed Section 20.6.2.3103 NMAC standards. If certain constituents exceed Section 20.6.2.3103 NMAC standards naturally or due to upgradient sources, then the elevated value should be the numerical standard considered for regulatory purposes as noted in Subsection B of 20.6.2.4101 NMAC. Determination of an appropriate background standard is best done using wells that monitor water quality unaffected by the mining activity subject to the permit or application.

Proposed Rule Section 20.6.7.28.C-E NMAC provides:

C. **Monitoring wells - identification tags.** A permittee shall clearly identify all monitoring wells required by the copper mine rule with a permanent well identification tag that contains well identification nomenclature specified in a discharge permit.

D. **Monitoring wells - construction and completion.** A permittee shall construct monitoring wells pursuant to 19.27.4 NMAC and the following requirements unless the department approves of an alternate monitoring well construction and completion design based upon site-specific hydrogeological conditions. . . .

E. **Monitoring wells - office of the state engineer requirements.** A permittee shall obtain any well permits required by the office of the state engineer prior to well drilling.

Subsections C through E provide detailed requirements for monitor well identification, construction, completion, and permitting. These sections of the Proposed Rule cover items such as drilling methods, well casing and screen materials, casing joint connections, filter pack, annular seals, wellhead completion and protection, and the requirement that a well permit must be obtained from the New Mexico Office of the State Engineer prior to drilling. These sections of the Proposed Rule are reasonable and consistent with the purpose of a monitor well as presented at the introduction to my testimony. The detailed requirements presented in Subsection D, which are not listed above, are consistent with the general approaches outlined in numerous monitor well guidance documents, including ASTM (2004), U.S. EPA (2008), the U.S. Army Corps of Engineers (1998) and multiple guides compiled by environmental agencies in other states. These referenced guidance documents are attached as Exhibits Blandford-6 through 8.

Subsection D also allows NMED to approve "alternate monitoring well construction and completion design based upon site-specific hydrogeological conditions." This flexibility is essential to allow for alternate approaches to monitor well completion based on a variety of complex conditions that can be encountered at a mine site. For example, in low-yield fractured rocks commonly encountered at copper mines, determination of the water-table location during drilling can be difficult, and at some locations a screen length greater than twenty feet may be required to avoid completing a dry well screened above the water table that cannot be sampled.

Proposed Rule Section 20.6.7.28.G NMAC provides:

> **G. Ground water sampling and reporting - routine.** A permittee shall collect ground water samples quarterly, or a reduced frequency approved by the department pursuant to Subsection H of this Section, from all monitoring wells specified in a discharge permit and required by Subsection A of this Section and 20.6.7.30 NMAC and any other location specified in the discharge permit or record and report any reason for being unable to collect a sample. A permittee shall also collect water samples quarterly from all springs and seeps on a copper mine facility that flow during the quarter. Samples shall be analyzed for dissolved concentrations of arsenic, cadmium, chromium, fluoride, lead, selenium, uranium, chloride, copper, iron, manganese, sulfate, total dissolved solids, zinc, pH, aluminum, cobalt, nickel, alkalinity-bicarbonate, alkalinity-carbonate, calcium, magnesium, sodium, and potassium, pursuant to Subsection B of 20.6.7.29 NMAC. A permittee shall submit to the department in the semi-annual monitoring reports the depth to ground water, the field parameter measurements, the parameter stabilization log (if applicable), the analytical results (including the laboratory quality assurance and quality control summary report) and a map showing the location and number of each well in relation to the contamination source it is intended to monitor.

Subsection G details routine ground water sampling and reporting requirements, which include quarterly sampling for 24 analytes at each monitor well specified in a discharge permit. The list of analytes is similar to the list already sampled at copper mines in New Mexico, and consists of constituents that might be expected to occur or become elevated in ground water if seepage from copper ore mining or processing activities (*i.e.*, either acid mine drainage or seepage of process solutions, such as pregnant leach solution) were to reach ground water. Exhibit Blandford-9 provides a general overview of potential source minerals for each of the listed analytes. Monitoring of the listed analytes, therefore, allows for the detection if impacts to ground water from a given facility, tracking of concentration trends, and confirmation that, if impacts to ground water have occurred, implemented abatement or corrective action plans are effective.

It is my opinion, however, based on my professional knowledge and training and more than 15 years of experience reviewing water quality data at the Tyrone Mine and the Pecos Mine/El Molino Mill sites, that Subsection G should be amended by granting permittees and the NMED flexibility regarding the list of constituents in ground water that must be sampled at monitor wells, as well as the sampling frequency. Additional flexibility is appropriate beyond that provided in Proposed Rule Section 20.6.7.28.H NMAC, which allows for a reduction in sampling analytes only for constituents that are not detected or are below standards for 8 consecutive quarters. A number of existing discharge permits require ground water sampling at monitor wells for a reduced list of constituents and at a frequency less than quarterly. Often some wells in a discharge permit might only be sampled for field parameters (electrical conductivity [EC], temperature and pH) rather than a full list of constituents, such as the 24 listed in Subsection G. EC is collected because it can be used to provide an accurate estimate of total dissolved solids (TDS) in the water, but it does not provide concentration values for individual constituents, such as sulfate.

For example, discharge permit DP-286 at the Tyrone Mine requires ground water sampling for field parameters only on a quarterly basis at 12 perched zone monitor wells that monitor leach stockpile seepage. Only field parameters are collected for 70 wells out of a total of 103 regional aquifer monitor wells, and of the 33 regional aquifer monitor wells that are sampled for the full list of constituents similar to that listed in Subsection G, 21 wells are sampled on a semi-annual basis rather than quarterly. *See* Exhibit Blandford-10, Discharge Permit DP-286 Renewal and Modification, February, 2010.

Sampling for field parameters only is an appropriate monitoring approach. When ground water is impacted due to copper mining, whether due to seepage from acid rock drainage or seepage of mine process solutions (*e.g.* pregnant leach solution), TDS concentrations, which represent all dissolved constituents in the groundwater, will become elevated as concentrations of constituents such as sulfate and metals in groundwater increase. As previously mentioned, EC values directly correlate with TDS concentration, so TDS may be accurately monitored using EC. Therefore, monitoring for TDS through measurement of the field parameter EC provides an efficient yet protective approach for monitoring ground water impacts and the effects of remedial actions.

In addition, rather than requiring the "one size fits all" approach based on a standard list of metals that must be sampled for in ground water, a more efficient and equally protective approach would be to tailor lists of required constituents by mine or discharge permit if requested by the permittee and approved by the NMED. Where ground water is impacted by metals it is rare that only one metal is elevated in concentration, but rather if one metal is elevated typically other metals are elevated also. This phenomenon reflects the interaction of ground water with rocks and sediments. As native or impacted ground water flows through an aquifer at a mine site, the water dissolves minerals in the rocks, releasing metals and sulfate into groundwater. Pyrite, an iron sulfide mineral common at mine sites, contains iron as well as other metals such as copper, nickel, cobalt, zinc, arsenic and selenium. When pyrite is dissolved in water, iron and these other soluble metals are released along with sulfate. So as pyrite dissolves, iron concentrations increase in conjunction with the other associated metals. The concentrations of each metal will reflect their initial concentration in the pyrite and their chemical nature. Based on the physical and chemical behavior of metals in natural systems and observed concentrations in ground water at the Tyrone Mine, metals may be lumped into groups that reflect their mobility in ground water. For example, the eight metals manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), cadmium (Cd) and aluminum (Al) exhibit this behavior and may be lumped into two groups. The groups are 1) Mn, Fe, Co and Ni, and 2) Cu, Zn, Cd and Al. Within each of these groups of metals, the concentration of one metal tends to be highly correlated to the concentrations of the others in the group. These groupings reflect the physical nature and chemical behavior of these metals at Tyrone, and possibly other sites. Consequently, sampling for a reduced list of metals, such as one or two selected from each group, would be sufficient to reasonably infer the concentrations of the others, and specifically whether or not they likely exceed applicable standards.

The information provided in this section of my testimony is provided only to illustrate the point that permittees, subject to approval by the NMED, should be granted additional flexibility through the Proposed Rule to propose alternative sampling regimens (including both the constituents sampled and the frequency of sampling) for a given site or discharge permit.

Proposed Rule Section 20.6.7.28.H NMAC provides:

> **H. Ground water sampling and reporting – reduction of sampling analytes routine.** A permittee may request to reduce the sampling frequency of individual water quality analytes specified in Subsection G of this Section if the analyte has either not been detected in ground water from a particular monitoring well or is below the applicable standard for eight consecutive quarters. In such a case, the permittee may reduce the sampling frequency for a particular analyte from a quarterly basis to a frequency of once every five years and shall submit the results of the sampling to the department in the subsequent semi-annual monitoring reports following the collection of the sample.

Subsection H allows a permittee to request a reduction in the sampling frequency of individual analytes if the analyte has "either not been detected in ground water from a particular monitoring well or is below the applicable standard for eight consecutive quarters." This condition allows for the reasonable and appropriate measure whereby a permittee is not required to spend time and resources sampling for, reporting on, and keeping track of analytes that do not occur in ground water at a given location, or occur in ground water only at levels consistently below the applicable ground water quality standard.

The minimum two-year time period (eight consecutive quarters) is consistent with other portions of Title 20 NMAC. For example, eight consecutive quarters of monitoring data are required to provide the basis to demonstrate a statistically valid decrease in constituent concentrations (Section 26.2.4101.E - Technical Infeasibility), and to consider ground water or surface water abatement complete (Section 20.6.2.4103.D). Eight consecutive quarters (two years and multiple seasons) of consistent quarterly data is a sufficient period of time for the NMED to determine if a reduction in sampling frequency of a given constituent is warranted at a copper mine. This point can be demonstrated using historical ground water sampling results at existing operational mines, such as Tyrone and Chino. Exhibit Blandford-11 illustrates the observed copper concentrations for two monitor wells at the Tyrone Mine for the period 2000 through 2012; one well is upgradient of potential sources of ground water contamination and one well is downgradient of potential sources of ground water contamination. As indicated in the exhibit, observed copper concentrations have either been non-detect or below the Section 20.6.2.3103 NMAC standard for periods of time far greater than two years, and there is no indication (*e.g.*, trends in observed concentrations) that this condition will change. At these wells, continued sampling for copper does not serve a useful role in protecting ground water resources. Numerous other constituents and monitor wells could have been selected to illustrate this same point.

The Proposed Rule also addresses specific contingency requirements based upon ground water monitoring or to replace monitoring wells that need to be relocated or are not functioning as intended. These contingency requirements establish certain requirement responses, including confirmatory sampling, investigations, developing corrective action plans, NMED review and approval of corrective action plans, and schedules to implement corrective actions. In some instances, NMED also may require an abatement plan under the WQCC's existing abatement rules. These requirements read as follows:

> **20.6.7.30 CONTINGENCY REQUIREMENTS FOR COPPER MINE FACILITIES:**
>
> **A. Exceedance of ground water standards - all monitoring wells except impoundment monitoring wells.** If monitoring of a water contaminant source other than an impoundment indicates that applicable standards are exceeded, or the extent or magnitude of existing ground water contamination is significantly increasing, the permittee shall collect a confirmatory sample from the monitoring location(s) within 15 days to confirm the initial sampling results, unless the permittee elects to accept the initial sampling results as an accurate measurement of water quality. Within 30 days of the confirmation of the exceedance of applicable standards or significant increases in existing contamination, the permittee shall take the following actions. The department may approve a longer time period not to exceed 90 days for good cause shown.

(1) A corrective action plan shall be submitted to the department for approval. The corrective action plan shall describe any repairs made or proposed to address the cause of the exceedance or increase and shall propose source control measures and a schedule for implementation. The department shall approve or disapprove the corrective action plan within 60 days of receipt. Following the department's approval of the corrective action plan, the permittee shall initiate implementation of the plan according to the approved schedule. If the department does not approve the corrective action plan, the department shall notify the permittee of the deficiencies by certified mail. The permittee shall submit a revised corrective action plan to the department within 60 days of the date of postal notice of the notice of deficiency. The department shall approve or disapprove the revised corrective action plan within 60 days of receipt.

(2) The permittee may be required to submit to the department for approval an abatement plan, which includes a site investigation to define the source, nature and extent of contamination; a proposed abatement option, and a schedule for its implementation. The site investigation and abatement option shall be consistent with the requirements and provisions of Sections 20.6.2.4101, 20.6.2.4103, 20.6.2.4106, 20.6.2.4107, 20.6.2.4108 and 20.6.2.4112 NMAC.

(3) A corrective action plan or abatement plan approved or submitted prior to the date of the copper mine rule that shall satisfy the requirements of this Subsection provided that any substantial change in monitoring results after the effective date of the copper mine rule may require additional corrective action under this Subsection or modification of a previously approved or submitted corrective action plan or abatement plan.

B. Exceedance of ground water standards - impoundment monitoring well. If monitoring from a monitoring well(s) intended to monitor an impoundment indicates that applicable water standards are exceeded, or the extent or magnitude of existing ground water contamination is significantly increasing, the permittee shall collect a confirmatory sample from the monitoring location(s) within 15 days to confirm the initial sampling results unless the permittee elects to accept the initial sampling results as an accurate measurement of water quality. Within 30 days of the confirmation of the exceedance of applicable standards or significant increases in existing contamination, the permittee shall take the following actions. The department may approve a longer time period not to exceed 90 days for good cause shown.

(1) A corrective action plan shall be submitted to the department for approval. The corrective action plan shall describe any repairs or changes in practices made or proposed to address the cause of the exceedance or increase and shall propose source control measures and a schedule for implementation. The department shall approve or disapprove the corrective action plan within 60 days of receipt. If the corrective action plan proposes actions to correct deficiencies with the liner, the proposed actions shall include repair or replacement of the existing liner, or construction and lining of a new impoundment. If liner repair is practicable, repairs shall be made pursuant to 20.6.7.17 NMAC or using a material that is equivalent to the existing liner with respect to material thickness and composition. Repairs shall be completed in accordance with the approved schedule. If liner repair is not practicable, the corrective action plan shall propose reconstruction and relining of the impoundment pursuant to 20.6.7.17 NMAC or construction and lining of a new impoundment pursuant to 20.6.7.17 NMAC. Reconstruction or construction plans and specifications for the impoundment shall be completed pursuant to 20.6.7.17 NMAC and submitted with the corrective action plan along with a schedule for implementation. If a new impoundment is constructed the existing impoundment shall be closed pursuant to 20.6.7.33 NMAC.

(2) Following the department's approval of the corrective action plan, the permittee shall initiate implementation of the plan according to the approved schedule. If the department does not approve the corrective action plan, the department shall notify the permittee of the deficiencies by certified mail. The permittee shall submit a revised corrective action plan to the department within 60 days of the date of postal notice of the notice of deficiency. The department shall approve or disapprove the revised corrective action plan within 60 days of receipt.

(3) The permittee may be required to submit to the department for approval an abatement plan, which includes a site investigation to define the source, nature and extent of contamination; a proposed abatement option, and a schedule for its implementation. The site investigation and abatement option shall be consistent with the requirements and provisions of Sections 20.6.2.4101, 20.6.2.4103, 20.6.2.4106, 20.6.2.4107, 20.6.2.4108 and 20.6.2.4112 NMAC.

(4) A corrective action plan or abatement plan approved or submitted prior to the date of the copper mine rule that shall satisfy the requirements of this subsection provided that any substantial change in monitoring results after the effective date of the copper mine rule may require additional corrective action under this Subsection or modification of a previously approved or submitted corrective action plan or abatement plan.

C. **Monitoring well replacement.** If information available to the department indicates that a monitoring well(s) required by 20.6.7.28 NMAC is not located downgradient of or does not adequately monitor the contamination source it is intended to monitor, is not completed pursuant to 20.6.7.28 NMAC, or contains insufficient water to effectively monitor ground water quality, a permittee shall install a replacement monitoring well(s). The replacement monitoring well(s) shall be installed within 120 days of the date of postal notice of notification from the department and a survey of the replacement monitoring well(s) shall be performed within 150 days of the date of postal notice of notification from the department. The replacement monitoring well(s) shall be located, installed, completed, surveyed and sampled pursuant to 20.6.7.28 NMAC. The permittee shall develop a monitoring well completion report pursuant to Subsection K of 20.6.7.28 NMAC and submit it to the department within 180 days of the date of postal notice of notification from the department. The department may approve longer time periods for good cause shown.

The contingency provisions in the Proposed Rule quoted above specify reasonable response actions and a reasonable process to address the circumstances described in the Proposed Rule provisions. In my experience, they also are consistent with the contingency and corrective action process described in the existing WQCC regulations, section 20.6.2.1203 NMAC, and the conditions contained in existing discharge permits issued for copper mines.

III. REQUIREMENTS FOR OPEN PITS (OPERATIONAL) (20.6.7.24 NMAC) AND (CLOSURE) (20.6.7.33 NMAC)

The operational requirements for open pits in the Proposed Rule are located at Section 20.6.7.24 NMAC, which states:

20.6.7.24. REQUIREMENTS FOR OPEN PITS

A. **Operational requirements.** A permittee operating an open pit shall operate the open pit pursuant to the following requirements, as applicable.

(1) The open pit shall remain within the area identified in the discharge permit.

(2) Stormwater shall be diverted outward and away from the perimeter of the open pit and, to the extent practicable, shall not be directed into the open pit.

(3) Water generated from within the perimeter of the open pit and pit dewatering activities shall be managed according to a mine operation water management plan. The water management plan shall be submitted to the department for approval in a discharge permit application for a new copper mine facility or in an application for a discharge permit renewal.

(4) During operation of an open pit, the standards of 20.6.2.3103 NMAC do not apply within the area of hydrologic containment.

The closure requirements for open pits are located in the Proposed Rule at Section 20.6.7.33 NMAC, which provides:

> **20.6.7.33** **CLOSURE REQUIREMENTS FOR COPPER MINE FACILITIES:** An applicant or permittee shall submit a closure plan for all portions of a copper mine facility covered by a discharge permit that addresses the following requirements.
>
> **D.** **Open pits.** The applicant or permittee shall provide detailed information and a closure plan for open pits that demonstrates how the following criteria will be addressed through water management and/or other activities at these facilities to minimize the potential to cause an exceedance of applicable water quality standards:
>
> (1) Open pits in which the evaporation from the surface of an open pit water body is predicted to exceed the water inflow shall be considered to be a hydrologic evaporative sink. If an open pit is determined to be a hydrologic evaporative sink, the standards of 20.6.2.3103 NMAC do not apply within the area of hydrologic containment.
>
> (2) After closure, if water within an open pit is predicted to flow from the open pit into ground water and the discharge from an open pit may cause an exceedance of applicable standards at a designated monitoring well location, then the open pit shall be considered a flow-through pit and the open pit water quality must meet ground water standards of 20.6.2.3103 NMAC or be managed to mitigate exceedances of applicable standards outside the area of hydrologic containment.

Since these two sections of the Proposed Rule are similar to one another in that required actions are in part dependent on the area of hydrologic containment, they are both addressed here.

An open pit at a copper mine may or may not be deep enough to reach ground water. Even a pit that does intersect ground water will be above the water table during initial periods of excavation, which can be significant in duration. *See* Exhibit Blandford-5. Once an open pit is excavated deep enough to reach the water table, ground water will flow into the pit bottom. The ground water that flows into the excavation needs to be removed in order for mining to continue. Removal of the ground water from the pit bottom will create a cone of depression in the water table adjacent to the open pit, similar to that which occurs adjacent to a pumping well (of course the pit bottom is much larger in diameter than a pumping well). *See* Exhibit Blandford-5. In some cases, a mine will operate extraction wells around an open pit to eliminate or reduce the amount of ground water inflow that actually occurs at the pit. How the water extracted from the pit will be utilized would be part of the water management plan required by the Proposed Rule.

Once ground water extraction occurs at an open pit, there is a portion of the adjacent aquifer that contributes ground water flow to the pit. This volume of adjacent aquifer that contains water that will eventually flow to the open pit can be delineated based on observed water levels and other hydrogeologic observations at a mine site. In the Proposed Rule, this zone of aquifer is referred to as the area of hydrologic containment. Specifically, the area of hydrologic containment is defined at Section 20.6.7.7.B(5) NMAC as:

> (5) "Area of hydrologic containment" means the area containing ground water underlying or adjacent to an open pit that drains to the open pit and is removed by evaporation and/or pumping and is interior to the department approved monitoring well network installed around the perimeter of an open pit pursuant to Paragraph (4) of Subsection B of 20.6.7.28 NMAC.

The area of hydrologic containment is illustrated schematically in Exhibit Blandford- 12.

Section 20.6.7.24.A(4) states that, during operation of an open pit, the standards of Section 20.6.2.3103 NMAC do not apply to ground water within the area of hydrologic containment. The reason for this is evident from the definition of the area of hydrologic containment and the exhibits. Ground water within the area of hydrologic containment, whether impacted by mine operations or not, will flow to, and be extracted at, the pit. The disposition of this ground water, therefore, is known, and it will be utilized and managed in accordance with an NMED approved water management plan. Water extracted at open pits is most commonly utilized as part of the mine operational water requirements, such as replenishment of the leach circuit.

Section 20.6.7.33.D addresses requirements for open pits after closure. After closure, water that enters an open pit does not have to be pumped due to mining operations, because active mining is completed. Once pumping of the pit is stopped, the only loss of water from the pit will be due to evaporation of the water that seeps into or runs onto the pit bottom. *See* Exhibit Blandford-13. For some open pits, the amount of evaporation that occurs from the lake or pit bottom surface can equal or exceed the amount of water that flows to the pit bottom from both runoff and ground water inflow. In effect, evaporation of water that collects in the pit bottom is sufficient to maintain an area of hydrologic containment after closure. This type of pit is called a hydrologic evaporative sink in the Proposed Rule. For an open pit that is a hydrologic evaporative sink, the standards of Section 20.6.3.3103 NMAC do not apply within the area of hydrologic containment because ground water within the area of hydrologic containment will be contained indefinitely at the pit location through natural processes.

Some open pits may not be a hydrologic evaporative sink after closure. It is possible that evaporation from the open pit water surface alone is sufficiently small relative to combined ground water and surface water inflow to the pit such that the water level in the pit can rise to a point where water can flow from the pit into adjacent ground water. This type of situation is called a flow-through pit in the Proposed Rule because ground water will flow into the pit from a portion of the adjacent aquifer, but pit water will also flow out of the pit into a different portion the adjacent aquifer. Ground water basically flows into the open pit from the upgradient direction, flows through the pit water body (where there will be some loss of water to evaporation), and exits the pit water body on the downgradient side. *See* Exhibit Blandford-13. For a flow-through pit, an area of hydrologic containment is not maintained indefinitely by natural processes. If a pit is expected to be a flow-through pit, and outflow from the pit may cause an exceedance of applicable standards at a designated monitoring well location, then the Proposed Rule requires that "the open pit water quality must meet the standards of Section 20.6.2.3103 NMAC or be managed to mitigate exceedances of applicable standards outside the area of hydrologic containment." One possible method of management to mitigate exceedances would be to continue pumping water from the pit after mine closure, thereby maintaining the area of hydrologic containment through the combined effects of evaporation and pumping. Other approaches may also be possible.

Either type of pit would affect the contents of the water management plan. For an evaporative hydrologic sink, water that flows to the pit would not need to be considered in the plan because the water is contained and lost through evaporation at the pit. For a flow-through pit, water that might be pumped from the pit would need to be considered in the plan. For example, water pumped from the pit might be treated to meet applicable standards prior to discharge.

Whether an open pit is expected to be a hydrologic evaporative sink or a flow-through pit after closure would be determined based on quantitative hydrogeologic calculations of an open-pit water balance, possibly utilizing numerical ground water flow modeling. Historical observations of pit dewatering volumes, water levels and other information collected during mine operation would be utilized in the computations.

Blandford Exhibits 14 through 17 illustrate the components of an open-pit water balance and some important terminology utilized in the Proposed Rule. Blandford Exhibit 14 illustrates outflow components for an open pit excavated below the water table. Namely, water is removed from the open pit through evaporation of water from the lake surface and possibly through pumping. Note that the amount of evaporation that occurs will be dependent on the area of the lake surface; as the water level in the pit lake rises, the area of water surface available for evaporation increases. Blandford Exhibit 15 illustrates the surface water inflow component to the open pit. Surface water inflow occurs due to precipitation events (snow or rainfall); precipitation that falls on the pit side of the surface drainage divide may enter the open pit as storm flow or snow melt. Blandford Exhibit 16 illustrates the primary source of water inflow to many open pits, which is ground water. As already discussed, ground water within the area of hydrologic containment, whether impacted or not, flows toward and will eventually reach the open pit.

Blandford Exhibit 17 illustrates all of the components of the pit water balance and conceptually illustrates another important concept used in the Proposed Rule relative to open pits, the open pit surface drainage area. The open pit surface drainage area is defined in the Proposed Rule in Section 20.6.7.7.B as:

> (42) "Open pit surface drainage area" means the area in which storm water drains into an open pit and cannot feasibly be diverted by gravity outside the pit perimeter, and the underlying ground water is hydrologically contained by pumping or evaporation of water from the pit bottom.

As illustrated in Exhibit Blandford-17, the open pit surface drainage area is the intersection of the surface drainage area associated with the open pit and the area that contributes ground water flow to the pit. The open pit surface drainage area is an important concept in the Proposed Rule because Proposed Rule Section 20.6.7.20.A(1)(f) NMAC provides:

> (f) **Alternate design.** An applicant may propose and the department may approve an alternative design for a leach stockpile located within an open pit surface drainage area provided that the stockpile and solution capture systems are designed to maximum leach solution

> capture considering the site-specific conditions of the open pit, underlying geology and hydrology, and leach solutions will not migrate outside of the open pit surface drainage area.

and Section 20.6.7.28.B(2) NMAC provides:

> (2) **Ground water monitoring – leach stockpiles, waste rock stockpiles, tailings impoundments.** A permittee shall install a sufficient number of monitoring wells around and downgradient of the perimeter of each new leach stockpile, waste rock stockpile and tailings impoundment located outside of the open pit surface drainage area, including its leachate and solution capture and containment systems, to adequately monitor ground water that may be impacted by water contaminants from those units. Each monitoring well shall be installed as close as practicable to the proposed leach stockpile, waste rock stockpile or tailings impoundment, including its leachate and solution capture and containment systems, that is to be monitored considering the slope of the land surface, hydrogeological conditions, geologic controls, infrastructure, engineering design plans, depth to ground water, working distance and safety.

and Section 20.6.7.33.F NMAC provides:

> **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.

Therefore, new leach stockpile facilities within the open pit surface drainage area may not require a liner (Section 20.6.7.20.A(1)(f) NMAC) or monitor wells (Section 20.6.7.28.B(2) NMAC), and at closure a cover system is only required for the top surfaces (not the side slopes) of leach and waste rock stockpiles within this zone (Section 20.6.7.33.F NMAC). Confirmation of predicted open pit hydrology, including the area of hydrologic containment and the open pit surface drainage area, would be conducted through post-closure monitoring.

Examples of a hydrologic evaporative sink and a flow-through pit can be drawn from existing mines in New Mexico. The Tyrone and Chino Mines are both large open-pit copper mines near Silver City. The largest and deepest open pit at the Tyrone Mine is the Main Pit. This pit, based on ground water model projections, is expected to be a flow-through pit if left to fill with water once mining ceases. Currently the Main Pit at Tyrone is pumped for mining and environmental purposes (discharge permit DP-166 requires pumping of the pit to maintain ground water flow toward the pit), and the pit is a hydraulic sink with ground water flow toward it from all directions. The Santa Rita Pit at Chino is expected to be an evaporative hydrologic sink in the future.

Under the Proposed Rule, since the Santa Rita Pit at Chino will be an evaporative hydrologic sink, and water within the pit and elsewhere within the area of hydrologic containment would not be subject to the ground water standards of Section 20.6.2.3103 NMAC. Conversely, since the Main Pit at Tyrone is expected to be a flow-through pit under closure conditions, the open-pit water quality would be subject to the ground water standards of Section 20.6.2.3103 NMAC, or alternatively the pit water would have to be managed in such a way as to mitigate exceedances of applicable standards outside the area of hydrologic containment, such as by continued pumping to maintain hydrologic containment, as required by existing Discharge Permit DP-1341.

IV. SEEPAGE COLLECTION SYSTEMS

If ground water at a mine site were to be impacted and containment of the impacted water is required, proven seepage collection methods can be employed. Typically, the impacted ground water would be extracted through one or more pumping wells as close to the source of impact as is feasible. The extraction well(s) form a cone of depression in the water table surface, and impacted water is drawn to and extracted at the pumping well(s). *See* Exhibit Blandford-18. The impacted water extracted at the well(s) is typically used for mine operations while the mine is active, or is treated to applicable standards prior to discharge during closure.

Section 20.6.7.22 NMAC of the Proposed Rule, Requirements for Copper Crushing, Milling, Concentrator, Smelting and Tailings Impoundment Facilities, lists requirements for seepage collection systems related to new tailing impoundments. Section 20.6.7.22.A(4) NMAC is as follows:

> (4) **New tailings impoundments.** Tailings impoundments shall be designed according to the following requirements.
>
> (a) The applicant shall submit design plans signed and sealed by a licensed New Mexico professional engineer along with a design report that describes how the following features were considered in developing the design plans:

(i) the annual volumes and daily maximum design rates of tailings and effluent to be deposited in the impoundment;

(ii) the topography of the site where the impoundment will be located;

(iii) hydrologic characteristics of the site, including depth to and quality of ground water;

(iv) the geology of the site;

(v) the design of drainage collection systems, to be proposed based on consideration of site-specific conditions and if drainage will be collected or will report at or above the ground surface;

(vi) the design of seepage collection systems, to be proposed based upon consideration of site-specific conditions where substantial seepage may report to ground water, including a design report that includes an aquifer evaluation to demonstrate that interceptor wells will be able to efficiently capture seepage such that applicable standards will not be exceeded at monitor well locations specified by 20.6.7.28 NMAC. The aquifer evaluation shall include a description of aquifer characteristics, hydrogeologic controls for seepage containment and capture, and an analysis of well spacing and capture rates. The interceptor well system shall be designed to maximize seepage capture and efficiency: and

(vii) a hydrologic analysis of drainage and seepage from the tailings impoundment based on the proposed design.

(b) If the permittee or the department determines that the proposed tailings impoundment, when operated in accordance with the design plan specified in Subparagraph (a) of this Paragraph, would result in discharges of seepage or leachate that would cause ground water to exceed applicable standards at a monitoring well located pursuant to 20.6.7.28 NMAC, the permittee may propose, or the department may require as an additional condition in accordance with Subsection I of 20.6.7.10 NMAC, additional controls, including but not limited to, a liner system.

(5) **New dry stack tailing piles.** New dry stack tailings piles located outside an open pit surface drainage area shall comply with the material characterization, engineering design, construction, and operational requirements of 20.6.7.21 NMAC, as applicable.

Depending on the site-specific conditions of the mining operation, it is possible to have seepage to groundwater beneath a tailing impoundment without exceeding applicable ground water standards at monitor wells. This was the case at the Tyrone Mine, which has six tailing impoundments (now reclaimed) north of the mine in the Mangas Valley. A seepage collection system was required at only one of the six Tyrone tailing impoundments, not due to seepage from the tailing itself, but due to seepage of impacted storm water from unlined impoundments at the toe of the tailing and/or because impacted water from the Main Pit at Tyrone was discharged on to the tailing for water management purposes. During the period of active tailing deposition at Tyrone, TDS and sulfate concentrations in ground water were elevated but did not exceed Section 20.6.2.3103 NMAC standards, with the exception of a limited zone that exceeded TDS and sulfate standards adjacent to the No. 2 tailing impoundment during the final year of active tailing deposition. *See* Exhibit Blandford-19. There are several local areas where Section

20.6.2.3103 NMAC standards were exceeded (and in some cases are still exceeded) for TDS and sulfate once active tailing deposition ceased. The source of these impacts was seepage from unlined storm-water impoundments (now reclaimed) constructed to contain runoff from the tailing. Under the Proposed Rule impoundments that collect impacted storm water would be lined. *See* Section 20.6.7.17 NMAC.

Other sites may not be like Tyrone, and a seepage collection system may be necessary at a new tailing impoundment because ground water standards at one or more monitor wells may be exceeded. Depending on the local hydrogeology, two types of seepage may typically occur. Perched zones of seepage may occur in the shallow subsurface above the regional water table. The perched zones often occur along natural drainages that extend beneath a facility. Perched seepage can be collected using shallow wells or gravel-filled trenches excavated through the alluvial material. Impacted water collected in the trenches is extracted through one or more pumping wells placed in each trench. *See* Exhibit Blandford-20.

Impacted seepage can also infiltrate to regional groundwater; this condition is illustrated schematically for a tailing impoundment in Exhibit Blandford-21. In this case, seepage can be collected using regional extraction wells, as illustrated schematically in Exhibits Blandford-21 and Blandford-22.

Section 20.6.7.22.A(4)(a)(vi) of the Proposed Rule requires that seepage collection systems be designed based on site-specific conditions such that applicable ground water standards will not be exceeded at monitor well locations specified by Section 20.6.7.28 NMAC. Design and operation of a seepage collection system is routinely accomplished by ground water professionals. For example, an active seepage collection system is operated at the Chino Mine at the toe of Tailing Pond 7. Reports regarding system performance are provided regularly to NMED. The system is actively managed, and adjustments to system operation are made as needed to maintain complete capture of impacted ground water beneath the tailing. Ground water pumped from the seepage collection system is re-cycled into the mining operation and reduces the demand from other ground water sources many miles away from the mine.

Design of a seepage collection system is based on the results of test drilling and monitor well installation, and subsequent aquifer testing. Aquifer testing provides information on the hydraulic properties of the aquifer (*i.e.*, hydraulic conductivity and storage coefficient) for which the seepage collection system will be designed, and on production-well characteristics (*i.e.*, how much drawdown occurs at the well for a given pumping rate). This information is used to determine the appropriate spacing between extraction wells and the pumping rate of each well. The collection systems are designed such that the zone of ground water that would be contained by each well individually overlaps one another; this approach ensures the complete capture of impacted water. *See* Exhibit Blandford-23.

Collection system efficiency is measured by the amount of impacted water extracted relative to the amount of clean water extracted at the seepage collection system; one goal in system design and operation is to maximize the former and minimize the latter. The amount of seepage anticipated can be calculated using mass-balance computations or seepage models, and changes in aquifer water levels are predicted and accounted for in the seepage collection system design.

The effectiveness of a seepage collection system is monitored through water level and water quality sampling at monitor wells and in some cases the pumping wells; some systems may be instrumented with transducers that transmit data directly to an office server, so that system performance can be monitored in real time. Monitoring requirements prescribed in the Proposed Rule to confirm the effectiveness of a tailing impoundment interceptor well system are provided in Section 20.6.7.22.C(1)(k) NMAC as follows:

> (k) If an interceptor well system to manage fluids that have migrated into ground water exists at a tailings impoundment, the permittee shall submit an interceptor well management plan that shall include:
>
> (1) well completion drawings and well performance information, recommended equipment including pumps and meters, recommended pump settings and pumping rates, and methods for data collection;
> (2) a monitoring plan detailing the monitoring system, metering requirements and recordkeeping, a water level monitoring program including methods and frequency of monitoring; and
> (3) an annual performance evaluation plan to evaluate the performance of individual wells, a review of the tailing facility water balance, evaluation of monitoring data to

determine capture efficiency, and recommendations for maintaining and improving capture efficiency.

Subsection C, paragraph (1) item (k) requires that the permittee submit to the NMED an interceptor well management plan that provides details of the seepage collection system operation and monitoring. This subsection also requires annual performance evaluations of well performance, capture efficiency, and a tailing facility water balance to confirm seepage collection system effectiveness.

V. CONCLUSION

In summary, the Proposed Rule provisions discussed above are consistent with current regulatory requirements, including monitoring requirements under existing discharge permits applicable to copper mining operations, and standard practices used by professionals to monitor the influence of copper mines on ground water quality and to assure containment of water contaminants so that they do not adversely impact surrounding ground water. This concludes my written direct testimony.

T. Neil Blandford

T. Neil Blandford

REFERENCES

American Society for Testing and materials (ASTM) Standard D5092-04, 2004. Standard Practice for Design and Installation of Ground Water Monitoring Wells. (Exhibit Blandford-6)

U.S. Environmental protection Agency (EPA), 2008. Design and Installation of Monitor Wells. U.S. EPA Region 4, Science and Ecosystem Support Division Guidance SESDGUID-101-R0. (Exhibit Blandford-7)

U.S. Army Corps of Engineers (1998). Monitoring Well Design, Installation, and Documentation at Hazardous, Toxic, and Radioactive Waste Sites. Engineer Manual (EM) 1110-1-4000. (Exhibit Blandford-8)