Questions for Nevada Division of Environmental Protection, Bureau of Mining Regulation and Reclamation from the stakeholder group for the negotiated rulemaking of Idaho's Rules for Ore Processing by Cyanidation; August 27, 2019.

1. **What pre-application discussions and interactions occur between Nevada regulators and mining companies regarding a permit for processing operations? Where does a conceptual design fit into the Nevada permitting process?**

   We're fortunate in Nevada in that most of our permittees understand the Nevada mining regulation, closure, and reclamation programs and are familiar with what we typically require for an application submittal.

   Prior to submitting a permit application or modification, the prospective applicant must meet with BMRR staff to discuss location, operating plans, and general characteristics of the facility. This is required pursuant to Nevada Administrative Code (NAC) 445A.391.

   These pre-meetings (also referred to as "kick-off" meetings), are an integral part to the permitting process and this is where the three branches of BMRR, the permittee and their consultant(s) can discuss conceptual designs, data collection, scheduling, regulatory requirements, bonding implications, and closure prior to a formal submittal.

   The application, in addition to basic ownership and facility information, must include meteorological information, a complete description of the proposed activity, characterization of the ore, waste rock, and all potential receiving waters, and the production rate in tons of ore per year.

   The application must be accompanied by required supporting documents on the design, construction, operation, and closure of operations. Documentation of notice to the local board of county commissioners is also required. Issuance of a permit does not relieve the operator of the responsibility to secure the approval of any other State, Federal, or local agencies

   BMRR staff engineers and environmental scientists are assigned to a particular project based on its geographic location; their experience with a particular operation/process/environmental concerns; interest in a particular facility, process, or commodity; and/or case work load. It is not uncommon for us to have several meetings prior to the final document/application submittal. Depending on the complexity and completeness of the application, the technical review could take anywhere from several weeks to months before we issue an approval and for a new permit, renewal permit or a modification.

2. **(A) Please explain how Nevada's regulations allow for a performance-based approach to the design and construction of cyanidation facilities.**

   Nevada has several decades of experience permitting, monitoring, and regulating cyanide and acid leaching process facilities. Our regulation branch has responsibility for protecting waters of the State under the NAC 445A Water Pollution Control Regulations. The branch consists of the permitting and inspection sections. The permitting section is staffed by engineers that review and evaluate designs, data, and operating plans and issues permits to ensure that the quality of Nevada's water resources are not impacted by mining activity. The inspection section conducts *regular compliance inspections during the life of a mining facility to confirm that operations are in compliance with permit requirements.*

Our mining program framework was used as the basis in the development of the International Cyanide Management Code (www.cyanidecode.org) and the Global Acid Rock Drainage Guide (http://www.gardguide.com/images/5/5f/TheGlobalAcidRockDrainageGuide.pdf) prepared by the International Network for Acid Prevention (https://www.inap.com.au).

(B) Please identify the criteria for evaluating the performance of a particular design or construction method. Please provide examples of each type of facility containing process water, as applicable, that is permitted using a performance-based approach.

For heap leach pads (HLPs) and other non-impounding surfaces, BMRR requires that a minimal amount of hydraulic head (one foot) be maintained on a primary liner. When our regulations were first promulgated in the 1980s, clay was acceptable for liner construction because of its relative availability throughout the state and lower costs compared to the geosynthetics manufactured at the time. Although our regulations still allow the use of clays for containment construction, we have not approved a clay-lined HLP since the late-1980s. Clay experiences repeated wetting, swelling, and desiccation overtime, dramatically changing the overall permeability and hydraulic conductivity. This could create long-term closure and liability issues due to leaking process solution. That is why BMRR prefers to use the term "clay layer" instead of clay liner.

We strongly encourage (and prefer) our permittee's to place geosynthetic liner (usually HDPE or LLDPE) over a compacted engineered subbase because of its better performance, reliability, and life expectancy. We also require the placement of groundwater monitoring wells around HLPs and any other process components to demonstrate continued containment integrity. In addition, all process ponds must be double lined and have an interstitial leak detection (e.g., geonet) and collection system (sump) for any leaks from the primarily liner.

3. **How is Section 445A.438 applied given that the other sections specific to different types of processing facility components already specify liner requirements? What types and thicknesses of synthetic liners are required or approved by Nevada? Under what conditions and for which types of processing facilities are synthetic liners required? How do geosynthetic clay liners and compacted clay liners fit into liner requirements?**

NAC 445A.438 states the following:

1. *When placed on native materials, soil liners must have a minimum thickness of 12 inches and be compacted in lifts which are no more than 6 inches thick. Except when used in tailing impoundments, a soil liner must have a permeability of not more than that exhibited by 12 inches of 1x10-7 cm/sec material.*
2. *Synthetic liners must be rated as having a resistance to the passage of process fluids equal to a coefficient of permeability of 1x10-11 cm/sec.*
3. *The Department shall review for completeness the applicant's evaluation of the following design parameters, where applicable, for a liner:*
   (a) The type of foundation, slope and stability;
   (b) The over liner protection and provisions for hydraulic relief;

(c) The load and means of applying load;
(d) The compatibility of a liner with process solutions;
(e) The complexity of the leak detection and recovery systems;
(f) The depth from the surface to all groundwater; and
(g) The liner's ability to remain functionally competent until permanent closure has been completed.

As stated above, although our regulations still allow the use of clay (soil) layers for primary liners, we have limited this use to specific applications (e.g., waster rock facilities, fresh water and sediment ponds), where characterization data has demonstrated to our satisfaction there will be no potential for degradation to waters-of-the-state (WOS).

We strongly encourage (and prefer) the placement of the geosynthetic liners over a compacted engineered subbase by our permittees, due to their long-term performance and properties. Two types of geosynthetic we have found to perform acceptably are High-Density Polyethylene (HDPE) and Linear Low-Density Polyethylene (LLDPE):

HDPE	*60-mil or greater for secondary liners* *60-mil or greater for primary liners (80-mil preferred)*
LLDPE	*60-mil or greater for secondary liners* *60-mil or greater for primary liners (80-mil preferred)*

In addition, all process ponds must be double lined and have an interstitial leak detection and collection system for any leaks from the primarily liner. We are also seeing an increase in a recent innovation called "drain liner" which replaces the commonly used geonet with a combination liner and leak detection layer.

We have also determined that the following geosynthetic liners do not perform well in Nevada's dry, arid climate due to either poor UV resistance, chemical resistance, and/or strength:

CSPER	*Scrim Reinforced Chlorosulfonated Polyethylene (also referred to as Hypalon)*
EPDM	*Ethylene Propylene Diene Monomer (also referred to as modified natural rubber)*
FPP	*Firestone Polypropylene Rubber*
PVC	*Polyvinyl Chloride*
EIA	*Ethylene Interpolymer Alloy (also referred to Chemically-Reinforced Polyethylene or CRP)*

While GCL is often promoted as having combined the best performance characteristics of both geosynthetics and clay, BMRR limits its application to sites where engineered clay sub-layers are either impractical or cost prohibitive. GCL installation is also problematic in that the amount of GCL overlap and bentonite for proper seem sealing varies by installation crew and manufacturer recommendations. We are aware of instances where the GCL has actually pulled apart due to repeated wetting and drying, resulting in expensive repairs, operational issues premature closure of the process component by BMRR.

4. **(A) In evaluating containment permeability equivalence under NAC 445A-437.01, how often are synthetic liners approved by Nevada?**

   As stated previously, we strongly encourage (and prefer) the placement of the geosynthetic liners over a compacted engineered subbase by our permittees, due to their long-term performance and superior properties. All HLP and pond construction utilizes geosynthetic liners with either a leak detection, collection, and recovery system or an enhanced groundwater monitoring network. We have permitted over 300 geosynthetic-lined HLPs, ponds, and conveyance channels since the inception of the mining program in 1989 and are confident in their performance.

   Most tailings impoundments (currently around 50) that are lined with geosynthetics, however there are still a handful of active impoundments (less than 10) that were constructed with clay/soil. Several of these are approaching their design capacities and tailings deposition is expected to cease within the next few years.

   (B) Does Nevada accept manufacturer representations on permeability of liners when approving an equivalent containment design?

   Yes we do. In addition, we require pursuant to NAC 450.439 a strict Quality Assurance/Quality Control (QA/QC) program be implemented for any liner installation and we will not allow any deposition of solids, slurries, or fluids until we thoroughly review before we approve any As-built designs, reports and the QA/QC documentation. Although this close attention to detail during the review process is time consuming, industry understands that it is a necessary part of the process and that they must consider the review process into their overall planning and scheduling.

   During the 30 years of our program, we have found that although the best designs and materials may be utilized in the construction of a particular HLP, pond or tailings impoundment, it's really all about the execution and implementation of the designs and the placement and installation of the selected materials. The QA/QC review by staff allows for the identification and correction of problems or concerns and prevent degradation to WOS.

5. **(A) In determining whether an alternative level of containment may be required under 445A-437.02.a, one of the criteria applied is the "characteristics of the material deposited".**

   "Enhanced level of containment" would probably a better word choice, however, "Alternate level of containment" in this case refers to the placement of a thicker geosynthetic liner; placement of a double geosynthetic liner with an interstitial leak detection, collection, and recovery system; a highly-compacted sub-base layer with significantly reduced hydraulic conductivity; an enhanced monitoring network, or any or all of these.

   "Characteristics of material deposited" in this case refers to the potential to degrade WOS as determined by recognized analytical procedures intended to replicate the effect of climate and precipitation on a particular material (tailings, waste rock, etc.) in a laboratory setting at a much rapid pace. The required level of containment would be dependent on the comparison of the analytical results to background water quality or prevailing reference standards as well as other factors such as the depth to groundwater.

(B) Are there certain materials, like cyanide, mercury, arsenic etc., deposited in a tailings impoundment that automatically require alternative containment?

Based on our years of experience, we have found that our permittees tend to utilize tailings impoundments in a variety of roles. Depending on the type of containment, the impoundments might also serve as permanent depository for process upsets, contaminated soils due to a chemical release or spill in addition to tailings. As stated above, the required level of containment would be dependent on the comparison of the analytical results to background water quality or prevailing reference standards as well as other factors such as the depth to groundwater. The chemical reagents and metals identified in your question would be of concern to us, and we would most likely require appropriate containment based on their potential to degrade.

(C) What type of analysis does Nevada undertake in determining whether certain material deposited in an impoundment requires alternative containment? Are there threshold concentrations of materials deposited in an impoundment that require alternative containment? What level of containment does Nevada require for tailings impoundments that contain process water containing greater than 0.2, 1.0, 10, and 50 mg/L WAD cyanide? Please give some examples of alternative containment designs required under the Rule, with a brief explanation why such alternative containment was required.

We rely on materials characterization tests to determine the level of containment necessary. A guidance document is attached to the E-mail response. The constituent threshold we utilize is relatively simple: Is there potential to degrade WOS? We utilize either background water quality data if available or our Profile I reference values (based on the drinking water standards) for this determination. In addition, depth to groundwater and proximity of surface water also play a big role in our determination. We also consider environmental sensitivity.

Remember as a public agency we have to be defensible in our decisions. As a result, we tend to err on the side of caution and default to higher level of containment.

6. **(A) Same general questions regarding the criteria requiring alternative containment under 445A-437.02.d related to the "extent of and methods used for recycling or detoxifying liquids". Are there threshold concentration levels for liquids which are placed in an impoundment that require alternative containment?**

   Referring back to our responses to Question 5, the required level of containment would be dependent based on the comparison of the analytical results to the background water quality or prevailing reference standards as well as other factors such as the depth to groundwater.

   (B) What cyanide destruction processes, if any, are required prior to discharge to the tailings impoundment?

   Several "off-the-shelf" "weak acid-dissociable" (WAD) cyanide destruction process exist and are effective. These include

- *Chlorination*
- *Hydrogen Peroxide*
- *SO2/Air (Inco Process)*
- *Ferrous Sulfate Complexation*
- *Ozonation*
- *Caro's Acid*

More of our permittees are voluntarily implementing the International Cyanide Management Code at their mining and process facilities to reduce the amount and concentration of (WAD) cyanide discharged into tailings impoundments. Of those listed above, the three most common are SO_2/air, H_2O_2 and Caro's acid (H_2SO_4 and H_2O_2). Chlorination and ozonation, although effective, aren't commonly used in Nevada due to their expense. We're not aware of any site using ferrous sulfate complexation on a large scale.

The three commonly used processes will oxidize WAD cyanide species to cyanate and eventually hydrolize to carbonate and ammonia. The Caro's acid system kinetics are relatively fast and this system and has been shown to further oxidize cyanate under acidic conditions. The potential of these processes to oxidize other species generated during the cyanidation of complex ores, such as thiocyanate and thiosulfate, can have an impact on the tailings discharged into the impoundment. Caro's acid will oxidize thiocyanate, while Caro's acid and H_2O_2 individually will rapidly oxidize thiosulfate. When thiosulfate and thiocyanate are both present, the consumption of Caro's acid and H_2O_2 are significantly higher when compared to the amounts necessary to oxidize WAD cyanide.

Below are helpful links for detailed information:

https://www.sgs.pt/~/media/Global/Documents/Flyers%20and%20Leaflets/SGS-MIN-WA017-Cyanide-Destruction-EN-11.pdf

https://www.911metallurgist.com/blog/cyanide-destruction-methods

7. How does the size and volume of a tailings impoundment dictate whether Nevada will require alternative containment under 445A-437.02?

Although it is stated in the above regulation that size and volume can be utilized to determine alternative containment requirements, however an impoundment could be of such a large size and volume that the placement of a geosynthetic liner could be cost prohibitive. In this case BMRR would consider the installation of a less robust liner system with an expanded groundwater monitoring network. On the other hand, a relatively small impoundment intended for the deposition of tailings which have been previously characterized and have demonstrated an extremely high potential to degrade WOS would strongly encourage the installation of a single geosynthetic liner (on a prepared and engineered subgrade) and if practical, a double-lined with a leak detection, collection, and recovery system.

8. **(A) How does minimization of hydraulic head on liner, and determination of its sufficiency, work in practice under 445A-437.02c?**

   By minimizing hydraulic head, the potential for leakage by the liner system is also minimized regardless of material (clay, geosynthetics, geosynthetic clay layer, bitumen, etc.).

   (B) What are the hydraulic relief requirements for a tailings impoundment containment system?

   Standard accepted engineering practice is to utilize a maximum 1-foot head above any liner surface. To accommodate this, tailings impoundments are designed with an underdrain collection and conveyance system placed above the liner. The collection system is a network of perforated pipe placed within a layer of drain gravel. Solution collected is conveyed to lined ponds and can be evaporated or in some instances returned to the process circuit or tailings impoundment. Tailings impoundments are managed such that the amount of supernatant solution collected on the surface is minimized and that amount of beach is maximized to facilitate evaporation and maintain impoundment integrity and structural stability. Discharge to tailings impoundments is performed by a series of spigots strategically placed within the internal embankment and operated in a manner to optimize discharge and minimize the amount of supernatant added.

9. **(A) What would be the specific requirements for a tailings impoundment containing cyanidation process water?**

   In addition to NAC 445A.437, the concentration of WAD cyanide would have to be less than 0.50 mg/L (this is a wildlife standard versus 0.20 mg/L the drinking water standard) and no potential for degradation of WOS by any residual contaminants.

   (**B) How do the physical and chemical characteristics of the impounded materials and process water affect the design approach?**

   Two of the major physical aspects we consider is the particle size of the solid tailings and percent solution and solids of the tailings slurry. The smaller the particle size, higher the entrained moisture content in the slurry, consequently more water in the supernatant that will have to be managed. The goal is to minimize the volume of the supernatant solution where possible.

   Chemical characterization would demonstrate what constituents could be problematic-our concern is the potential liberation of heavy metal

   (C) What are typical designs approved by Nevada for tailings impoundments that contain process water containing cyanide?

   - *Avoid valley fill designs when and where possible;*
   - *Strongly recommend the placement of dry-stack tailings (i.e., tailings with a bulk of their moisture content removed prior to discharge via filtering).*

- *Strongly recommend Geosynthetic liner system, 60-mil or greater. Depending on the material characteristics, depth to groundwater and proximity to surface water, a double-lined and leak detected system might be necessary.*
- *Upstream, downstream or any combination of both for impoundment embankment construction;*
- *Freeboard of at least 3 to 5 feet to accommodate wave run up (this is more of an issue for ponds);*
- *Piezometers placed in embankments to determine presence of fluids in the embankment;*
- *Internal collection and recovery system for solution drainage from the impoundment;*
- *Installation of a monitoring well network; and*
- *Submittal of a tailings operation and management plan for agency review. This plan would indicate how tailings are discharged and deposited as well as the response plan for a system upset.*

10. (A) What would be the specific requirements for a pond containing cyanidation process water?

Per NAC 445A.435, ponds must be double-lined (preferably with geosynthetic liner as the primary and secondary liners) and a system for leak detection, collection, and recovery. In addition, storm water diversion structures to divert run-off away from the ponds might also be required, depending on the site. Depending on the concentration of cyanide in the ponds (WAD CN > 0.50 mg/L), birdballs or netting would be required by the Nevada Department of Wildlife along with fencing to prohibit access.

(B) What are typical designs approved by Nevada for ponds that contain process water containing cyanide?

These designs are site specific and are often dictated by the mining plan, plan of operation, economics and life of the project. Refer also to the response for 10A regarding design criteria.

11. (A) What would be the specific requirements for a leach pad containing cyanidation process water?

Per NAC 445.434, leach pads must be designed to be free flowing and promote horizontal flow. As stated previously, we strongly encourage our permittees to utilize HDPE or LLDPE for liners.

(B) What are typical designs approved by Nevada for leach pads that contain process water containing cyanide?

Pursuant to NAC 445A.435, all process ponds must be double-lined with geosynthetic liner and have an interstitial leak detection and collection system for any leaks from the primarily liner. We are also seeing an increase in a recent innovation called "drain liner" which replaces the commonly used geonet with a combination liner and leak detection layer.

12. (A) What failures in containment systems have occurred and what were the causes of those failures?

It's all about site preparation and installation! We rely on the daily logs, QA/QC documents, and field testing results along with on-site observations during construction, liner placement, and testing. I've attached our DRAFT guidance documents for QA/QC and As-built Reports and Specifications, Testing and Frequency to assist you. When we look at the entire QA/QC and As-built package, we look for the following:

- *Deviations from the approved design and explanation of the changes;*
- *Missing daily logs from the field engineer;*
- *Poor description of daily activities;*
- *Poor identification of liner placement, welds, seams, test patches;*
- *Excessive number of failed test welds for seams and patches (i.e., in excess of 0.5% of the total number of test welds);*
- *Insufficient overlap of liners (this is especially critical for GCL due to its repeated expansion and contraction);*
- *Insufficient compaction;*
- *Too many large rocks in the sub-layer (these need to be removed);*
- *For double-lined systems, has the leak detection, collection, and recovery sump been tested for integrity and functionality?*

With cell phones common in the work place, there is no reason to not have photographs of the construction activity included in the As-built report.

During one particular field inspection, we identified inadequate installation of liner in the key trench and the use of a sump for the disposal of empty paint cans. While this was a unique one-time incident, we can't stress the importance of actual site inspections during construction.

(B) How is potential damage to liners minimized during construction?

Here's what we have found based on our experience:

- *Avoid using off-spec liner (it's often available from vendors, however it's integrity will be always be suspect);*
- *Liner placement is performed by an experienced crew;*
- *Liner placement occurs under weather conditions as recommended by the manufacturer;*
- *Avoid if possible liner placement and welding during the winter months;*
- *Minimize the use of extrusion welds, wedge welding is preferred and performs better under load;*
- *Avoid the use of field constructed boots when piping needs to penetrate an embankment, a factory-manufactured boot has better performance characteristics; and*
- *Use HDPE and/or LLDPE liners for liner systems because of their proven performance.*

13. Does NDEP have any checklists or other guidance to help inform what additional information (and necessary level of detail) is required in support of a permit application, such as engineering calculations, modeling, laboratory testing results, and/or material specifications?

A DRAFT guidance document we are working on is attached to the E-mail response.

14. How many processing facilities are permitted in Nevada? *Of the 179 facilities currently permitted in Nevada, 61 use chemicals (primarily cyanide or acid) as part of their extraction process.*

    a. How many are leach pads or other non-impounding surfaces? *About 50 of these chemical facilities use heap leaching with the remainder using vat or tank leaching. It's not uncommon for a facility to have multiple HLPs operational at a given time.* How many of these are specifically for cyanidation processes? *Approximately 46 facilities use cyanide.*

    b. How many are process ponds? How many of these are specifically for cyanidation processes? *As a rule of thumb, for every HLP there is at least one pregnant pond and one barren pond associated with it. There are of course exceptions.*

    c. How many are vats, tanks or other containers? How many of these are specifically for cyanidation processes? *All but one of the 11 vat/tank leaching operations utilize cyanide.*

    d. How many are tailings impoundments? *There are about 45 active tailings impoundments in the state with multiple impoundments at facilities.* How many of these are specifically for cyanidation processes? *About 42 receive tailings from cyanide operations.*

15. Are datasets available for permitted facilities?

    Partially at this time. We are currently in the process of scanning our entire document library for electronic access.