Financial Responsibility Requirements under CERCLA § 108(b) for Classes of Facilities in the Hardrock Mining Industry Proposed Rule: Financial Responsibility Reductions

Technical Support Document

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U.S. Environmental Protection Agency

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Acronyms

Acronym		Definition
ACE	-	U.S. Army Corp of Engineers
ADEQ		Arizona Department of Environmental Quality
AMD	-	Acid Mine Drainage
APP		Aquifer Protection Program
ARD	-	Acid Rock Drainage Mine Influenced Water
BADCT		Best Available Demonstrated Control Technology
BLM		Bureau of Land Management
BMPs	-	Best Management Practices
CERCLA		Comprehensive Response, Compensation, and Liability Act of 1980
CQA/CQC		Construction Quality Assurance/Construction Quality Control
EPA	-	Environmental Protection Agency
FEMA		Federal Emergency Management Agency
GARD Guide	-	International Network for Acid Prevention's Global Acid Rock Drainage Guide
MIW	-	Mine Influence Water
MPE	-	Maximum Probable Earthquake
NMAC		New Mexico Administrative Code
NPDES		National Pollutant Discharge Elimination System
O&M		Operations and Maintenance
RCRA	-	Resource Conservation and Recovery Act
TOMS	-	Tailings Operations, Maintenance and Surveillance
TSFs	-	Tailings Storage Facilities
USFS	-	U.S. Forest Service
UUD		Unnecessary or Undue Degradation

Introduction and Background

The Environmental Protection Agency (EPA) is developing a proposed rule entitled "Financial Responsibility Requirements under CERCLA § 108(b) for Classes of Facilities in the Hardrock Mining Industry." That proposed rule would require owners and operators of hardrock mining facilities to demonstrate and to maintain financial responsibility consistent with the degree and duration of risk associated with the management of hazardous substances at their facilities.

Section 320.63 of the proposed rule includes a hardrock mining financial responsibility formula that owners and operators would use to determine a financial responsibility amount for their facilities.[1] The rule also proposes under § 320.63(c) to allow (but not require) owners or operators to reduce the response cost component of the financial responsibility formula by making an adequate demonstration that risk reducing regulatory requirements are in place. To qualify for the reductions, owners and operators would have to demonstrate that they meet specific minimum standards for various formula components, along with a general performance standard, and other requirements.

Section 320.63(c)(3) includes the proposed EPA is proposing specific minimum standards for the various categories of reductions. These are specified in § 320.66(c)(3). This portion of the proposed rule provides the criteria that owners or operators must meet for particular reductions. The performance standards in paragraph (c) describe objectives for reducing risk at facilities and include future engineering controls and practices that reduce the risk associated with the hazardous substances at the site. That paragraph provides reduction criteria for each component of the maximum financial responsibility formula – capital costs, interim O&M, short-term O&M, long-term O&M, water treatment, hazardous materials management, and surface water drainage. For capital costs, the paragraph provides reductions for each site-feature category – open pits, underground mines, waste rock, heap and dump leach, tailings impoundments and stacks, process ponds and reservoirs, and slag piles. Owners and operators that meet the criteria for a formula component would not have to calculate financial responsibility for that component. Because the natural resource damage component is calculated by a multiplier, this component would produce a correspondingly smaller amount, as the reductions are claimed.

Purpose of the Document

The objective of this document is to provide the rationale for the proposed "specific minimum standards" for the various categories of reductions described above.

The document is organized in the following manner. The next section describes the

[1] For a detailed discussion of the development of the financial responsibility formula, see the CERCLA § 108(b) Financial Responsibility for Hardrock Mining Facilities Background Document – Peer Review Draft (Background Document), located in the docket for this proposal (Docket No. EPA-HQ-SFUND-2015-0781).

methodology used to develop the specific minimum standards for the site-features. The sections that follow provide the rationale for the practices and performance criteria contained in the proposed specific minimum standards for each of the following 13 site-feature categories:

- Waste Rock Piles
- Open Pit Mines
- Underground Mines
- Heap and Dump Leach Piles
- Tailings Storage Facilities
- Process Ponds and Reservoirs
- Slag Piles
- Hazardous Materials Management
- Surface Water Drainage
- Short-term Operations & Maintenance
- Interim Operations & Maintenance
- Long-term Operations & Maintenance
- Water Treatment

Appendix A contains a summary table for most of the site-features of the releases and potential releases of hazardous substances and management practices used to prevent/address them.

Methodology

This section describes the methodology used to develop the proposed specific minimum standards for each of the site-features.

The methodological approach initially focused on the identification of potential sources and releases of Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) designated hazardous substances and general management practices used to control or prevent those potential sources and releases. It then focused on the identification of current/ modern hardrock mining "best management practices" (BMPs) For each feature, information was gathered on hardrock mining BMPs through a literature review spanning technical references, academic sources, government regulations, and government guidance documents.

Since the modern era of mining, circa 1980, the technical and regulatory approaches to hardrock mine design, operations, and reclamation and closure, have evolved significantly. Today, BMPs have been developed that can mitigate potential impacts from mining to meet EPA's goal "…that the engineering requirements will result in a minimum degree and duration of risk associated with the production, transportation, treatment, storage, or disposal, as applicable, of all hazardous substances present at that site feature."

The BMPs together with most of the proposed specific minimum standards have been incorporated into federal and state regulations and/or guidance. For instance the New Mexico Copper Rule adopted a comparably high level of specific performance standards, similar to that being proposed by EPA. The New Mexico Copper Rule is supported by the New Mexico Mining Association because "The rules must specify the measures to be taken to prevent water pollution and to monitor water quality. The purpose of the rules is to provide the copper mining industry with clearly defined requirements for preventing ground water and surface water pollution and to ensure consistent regulatory compliance rather than determining requirements on a case-by-case basis." Similarly, the Bureau of Land Management (BLM) has issued its 3809 Handbook and additional guidance that has, and as they are applied more broadly within the agency continues to, result in a much higher level of consistent regulatory process and compliance. The same can be said of similar efforts to provide measurable standards as evidenced in some other State and Federal regulations and guidance enacted over the past 30 or more years. Together, these are representative of a broad set of BMPs that have been identified and summarized in regulation and/or guidance.

EPA's rule is intended, in part, to provide incentives for practices that reduce Superfund risks. EPA recognizes that many existing closure and reclamation programs include requirements for such practices, and has considered, and in some cases incorporated, the risk reducing practices required by those programs in developing reduction criteria for the proposed rule. This approach would allow for reduction to the CERCLA § 108(b) financial responsibility amount where relevant best management practices are being implemented as a result of regulatory program requirements.

For each site-feature the sections are structured similarly and provide the following information and discussion.

- The proposed specific minimum standards.
- Potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases;
- For the standard or subsections of the standard;
  - Current BMPs
  - Rationale for Specific Minimum Standard

Because the proposed specific minimum standards for each feature are multi-part, the identification of the references and rationale are presented for each part rather than the standard as a whole. Also, because some of the proposed standards are redundant for some features, the previous sections are referenced instead of repeated. To accommodate this approach, the section for waste rock is presented first as this feature has the most common aspects that occur throughout the document.

1. Waste Rock Piles

This section describes the proposed specific minimum standard for Waste Rock Piles, potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases, and for subsections of the standard, current BMPs and the rationale for the specific minimum standard.

Specific Minimum Standard

To satisfy **the waste rock category** component in paragraph (b)(1)(iii):

(i) A plan to address public safety by prevention of public access by means of security fencing, or other effective methods.

(ii) If prevention/avoidance is relied on, a management plan that demonstrates geochemically active materials will effectively be avoided, and that includes provisions for sampling and monitoring documentation.

(iii) Requirements for concurrent or sequential reclamation of mined areas as they become available prior to final cessation of operations and closure.

(iv) Requirements to regrade surface during closure to a stable configuration that prevents ponding and promotes the conveyance of surface water off the unit, and that requires closure of all waste rock piles considered to be critical structures to be designed for a long-term static factor of safety of 1.5 or greater and all non-critical structures to be designed for a long-term static factor of safety of 1.3 or greater; and requires that the units being closed be designed for a factor of safety of 1.1 or greater under pseudostatic analysis.

(v) Requirements to provide for a stability analysis to be conducted for the unit as part of the original design, and as part of mine modifications during the active life of the mine.

(vi) A plan for the management of all stormwater and sediment generated during operations and during and following closure. The plan must include permanent stormwater conveyances, ditches, channels, and diversions, as necessary, designed to convey the peak flow and ponds and other collection devices. For existing units, the plan must provide for permanent stormwater conveyances, ditches, channels and diversions designed to convey the peak flow and ponds and other collection devices designed to store the volume generated during a 24-hour period by a 100-year return interval storm event. For units that become authorized to operate after the effective date of this rule, these plans must provide for controls designed to store the volume generated during a 24-hour period by a 200-year return interval storm event.

(vii) A plan for the minimization, prevention, or collection and treatment of discharges and/or seepage, based on site hydrology and water quality characterization information, that provides for a cover system of, at a minimum, a store and release earthen cover system with a thickness of at least 12 inches and, if necessary, additional source controls or capture and treatment at closure, all of which meet a minimum 200-yr life design criteria. If seepage water quality is not expected to meet applicable federal and state groundwater and surface water quality standards at the point of compliance, the plan must provide for:

(A) implementation of a containment system that immobilizes hazardous substances to meet applicable water quality standards (e.g., an engineered cover system designed to achieve, at a minimum, a 95 percent reduction in annual net-percolation based on the long-term average to reduce seepage discharges to meet applicable water quality standards;

(B) a capture and treatment system designed to achieve at least a 95 percent capture efficiency and meet applicable water quality standards; or combination of an engineered cover system and a capture and treatment system to achieve at least a 95 percent reduction in discharged load and meet applicable water quality standards at the point of compliance, or

(C) a solution containment system to assure seepage flows are collected, contained, conveyed, and treated to achieve at least a 95 percent reduction to meet applicable water quality standards.

Potential Sources and Releases and Management Practices

Potential sources and releases of CERCLA hazardous substances for waste rock, and management practices to address those potential sources and releases, are provided in Appendix A, Table A1. Waste Rock Piles.

Waste rock is a primary source of mine influenced water (MIW) including acid mine drainage (AMD) at hardrock mine sites. Source characterization is key to prevention and/or management of MIW/AMD during the entire mining life-cycle from exploration and development, during operations, reclamation, and post-closure. Management practices for mitigation of MIW/AMD include a variety of methods including avoidance, management of waste and disposal into engineered repositories, construction of engineered liners and covers, and methods such as submergence, neutralization and co-disposal with tailings. In addition to source controls, groundwater and surface water capture and treatment may also be used to mitigate MIW/AMD.

Waste rock is also subject to erosion leading to surface water sedimentation. This occurs during construction, operations and following reclamation. Following reclamation, stormwater controls are needed to address erosion to prevent exposure of encapsulated materials or damage to engineered structures. Management practices for stormwater control include the allowance for, and design of, stormwater control structures including slope breaks, conveyances, and holding/ sedimentation ponds.

Waste rock piles are subject to deformation or collapse as a result of mass wasting due to erosion and potentially due to other stability issues. Including geotechnical analysis in the design and operational monitoring are recommended to prevent mass instability. In the event instability is detected, a variety of engineering methods such as buttresses to counter movement or wick drains to reduce pore water pressure in foundations are commonly used.

Waste Rock Piles Subsection (i)

Proposed Specific Minimum Standard

(i) A plan to address public safety by prevention of public access by means of security fencing, or other effective methods.

Current BMPs

The need to address public safety is a widely recognized and standard BMP for both active mines and reclaimed mines. In a testimony before the Committee on Energy and Natural Resources, U.S. Senate the U.S. Government Accountability Office noted that "in 1997, BLM and the Forest Service each launched a national Abandoned Mine Lands Program to remedy the physical and environmental hazards at thousands of abandoned hardrock mines on the federal lands they manage. According to a September 2007 report by these two agencies, they had inventoried thousands of abandoned sites and, at many of them, had taken actions to clean up hazardous substances and mitigate safety hazards.[2] Furthermore, according to the BLM, approximately 25 fatalities related to abandoned mines occur each year in the U.S. The BLM uses "…fences, warning signs, and, most effectively, seals mine openings with bat gates, expanding foam, and backfill to prevent access and exposure to associated hazards, including falls into openings, rotten timbers, bats, toxic air, and forgotten explosives."[3]

At modern hardrock mine sites, BLM requires, "**Fencing, signing, or placing access restrictions** around mine openings may also be needed to **protect public safety**."[4] The U.S. Forest Service (USFS) does not have explicit requirements for public safety but does mention it with respect to reclamation standards and financial assurance in guidance.[5]

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[2] U.S. Government Accountability Office, HARDROCK MINING: Information on Abandoned Mines and Value of Coverage of Financial Assurances on BLM Land (Testimony Before the Committee on Energy and Natural Resources, U.S. Senate, March 12, 2008), GAO-08-574-T, p. 6.

[3] U.S. Department of the Interior, Bureau of Land Management and U.S. Forest Service, Abandoned Mine Lands: A Decade of Progress Reclaiming Hardrock Mines (Washington, DC: U.S. Government Printing Office, 2007), p. 21.

[4] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.13: Maintenance and Public Safety, p. 5-26.

[5] U.S. Forest Service, Training Guide for Reclamation Bond Estimation and Administration for Mineral Plans of Operation Authorized and Administered under 36 CFR 228A (April 2004), p. 12.

Arizona requires that reclamation plans include, "The **measures that will be taken to restrict public access** to pits, **adits, shafts** and other surface features that may be a hazard to **public safety**."[6] Nevada requires "…the Division shall require the operator to **take sufficient measures to ensure public safety**."[7]

Rationale

The requirement for measures to address public safety is a recognized BMP, as evidenced by its widespread inclusion in federal and state hardrock regulations. The proposed specific minimum standard for waste rock piles is consistent with those requirements.

Waste Rock Piles Subsection (ii)

Proposed Specific Minimum Standard

(ii) If prevention/avoidance is relied on, a management plan that demonstrates geochemically active materials will effectively be avoided, and that includes provisions for sampling and monitoring documentation.

Current BMPs

The International Network for Acid Prevention's Global Acid Rock Drainage Guide (GARD Guide) identifies avoidance as a best practice method to address ARD and MIW, noting that it can be achieved through integration of characterization and prediction with mine planning, design and waste management strategies. It also notes that "*Avoidance includes the decision not to extract a particularly reactive rock type that will be too difficult to manage in the future. This may require the development of mine designs that avoid or work around difficult rock types through alteration of mine access, inclines, stopes, and open pit designs*."[8]

Rationale

This proposed specific minimum standard is intended to provide an opportunity for mines that do not mine or produce as waste products materials that contain hazardous substances, to perform geochemical characterization to identify themselves. This would remove any requirements for mitigation related to water quality described in other sections.

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[6] ARS 27-971: Submission and contents of reclamation plan, 9(a).

[7] NRS-519A.230: Provisions of plan for reclamation; inclusion of pit lake in plan, 3.

[8] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.1: Avoidance.

Waste Rock Piles Subsection (iii)

Proposed Specific Minimum Standard

(iii) Requirements for concurrent or sequential reclamation of mined areas as they become available prior to final cessation of operations and closure.

Current BMPs

It has long been recognized that conducting concurrent or sequential reclamation is a mechanism that reduces liability to the regulators, public and mining company and ultimately is one of the best means to reduce the risk of release of release of hazardous substances.[9] This is particularly the case in areas with high potential for Acid Mine Drainage (AMD), where concurrent reclamation has shown to be an effective practice to reduce AMD risk by limiting the amount of time that pyritic minerals are exposed to oxygen rich environments.[10,11,12,13] Regulatory requirements that require concurrent reclamation are supported by these incentives.[14] In addition to reducing liabilities, concurrent reclamation also allows for the success of reclamation and any associated mitigation methods to be measured and perfected, prior to actual closure.

This is further supported by current federal and state regulations and other guidance specific to hardrock mining activities in the U.S.

BLM requires, "The operator must **initiate reclamation at the earliest economically and technically feasible time on those portions of the disturbed area that the operator will not disturb further**. Early initiation of reclamation will stabilize soil, control runoff, and otherwise prevent [unnecessary or undue degradation] (UUD). This concurrent reclamation standard means that the operator must reclaim parts of the operations even as activity is continuing in other portions of the project area. The intent is that operators not defer all the reclamation until the closure phase of the project. Waiting on some yet-to-occur technological breakthrough or change

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[9] C.A. McLean and L.W. Cope, ed., "Chapter 11: Placer or Alluvial Mining," in Mining Environmental Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining, ed. J.J. Marcus (London: Imperial College Press, 1997), p. 657.

[10] Oregon Department of Geology and Mineral Industries and Washington Department of Natural Resource, Best Management Practices for Reclaiming Surface Mines in Washington and Oregon, Open Fire Report 96-2/Open File Report O-96-2 (December 2000).

[11] Acid Drainage Technology Institute, *A Handbook of Technologies for Avoidance and Remediation of Acid Mine Drainage* (June 1, 1998); Acid Mine Drainage Technology Institute, *Prediction of Water Quality at Surface Coal Mines* (December 11, 2000).

[12] Mining entities have incorporated concurrent reclamation plans into their environmental performance standards. See, for example, information concerning Newmont Mining's plan at: http://sustainabilityreport.newmont.com/2014/environmental/environmental-closure.php#sthash.IDWMTezJ.dpuf

[13] ADTI (Acid Drainage Technology Initiative). 2000. *Prediction of Water Quality at Surface Coal Mines*. December 11. Available online at: http://www.osmre.gov/resources/library/ghm/predictH2O.pdf

[14] Alyson Warhurst and Maria Ligia Noronha, *Environmental Policy in Mining: Corporate Strategy and Planning* (CRC Press, 1999), p. 188.

in economic factors, such as metal prices, does not justify withholding areas from concurrent reclamation."[15] The USFS does not have explicit requirements for these activities but in guidance does identify concurrent reclamation as a mitigation method including for hydrological and water quality related concerns.[16]

Alaska requires "… the mining operation shall be **reclaimed** as contemporaneously as practicable with the mining operation to leave the site in a **stable condition**."[17] Nevada requires, "That reclamation activities, particularly those relating to the control of erosion, **must be conducted simultaneously with the mining operation to the extent practicable**, and otherwise must be initiated promptly upon the completion or abandonment of the mining operation in any area that will not be subject to further disturbance."[18] New Mexico requires that mine features "**be sited and constructed in a manner that facilitates, to the maximum extent practicable, contemporaneous reclamation** consistent with the closeout plan"[19] and "…require that all waste, waste management units, pits, heaps, pads and any other storage piles are **designed, sited and constructed in a manner that facilitates, to the maximum extent practicable, contemporaneous reclamation** and are consistent with the new mining operation's approved reclamation plan." New Mexico Energy and Natural Resources Department, Mining and Minerals Division's Closeout Plan Guidelines also recommend that consideration be given to concurrent reclamation.[20]

Rationale

The requirement for concurrent or sequential reclamation is a recognized BMP that reduces the risks and liabilities for the government, public and mine operator. This is evidenced by a number of technical references and its widespread inclusion in federal and state hardrock regulations. The proposed specific minimum standard for waste rock piles is consistent with those requirements.

Waste Rock Piles Subsection (iv-v)

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[15] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.2.5: Concurrent Reclamation, p. 5-5, -6.

[16] U.S. Forest Service, Training Guide for Reclamation Bond Estimation and Administration for Mineral Plans of Operation Authorized and Administered under 36 CFR 228A (April 2004), p. 40-41.

[17] AS Sec. 27.19.020: Reclamation Standard, in Alaska Department of Natural Resources: Division of Mining Land and Water, State of Alaska Mining Laws and Regulations (2014), p .IV-1.

[18] NRS-519A.230: Provisions of plan for reclamation, 1. (a).

[19] NMSA 69-36-7: Commission; duties, D. (3).

[20] New Mexico Energy Minerals, and Natural Resources Department, Mining and Minerals Division, Mining Act Reclamation Bureau, Closeout Plan Guidelines for Existing Mines (April 30, 1996), p. 3.

Proposed Specific Minimum Standard

(iv) Requirements to regrade surface during closure to a stable configuration that prevents ponding and promotes the conveyance of surface water off the unit, and that requires closure of all waste rock piles considered to be critical structures to be designed for a long-term static factor of safety of 1.5 or greater and all non-critical structures to be designed for a long-term static factor of safety of 1.3 or greater; and requires that the units being closed be designed for a factor of safety of 1.1 or greater under pseudostatic analysis.

(v) Requirements to provide for a stability analysis to be conducted for the unit as part of the original design, and as part of mine modifications during the active life of the mine.

Current BMPs

The need to address stability as it relates to both stormwater and other events that could cause mass instability is a BMP recognized by industry. According to Robertson and Shaw "…buildings, structures, workings, pit slopes, underground openings etc. must be stable and not move so as to eliminate any hazard to the public health and safety or material erosion to the terrestrial or aquatic receiving environment at concentrations that are harmful. Engineered structures must not deteriorate and fail."[21] In addition, the GARD Guide notes that "designs need to minimize the risk of severe erosion and structural stability of major containment facilities, especially after closure."[22]

This is further supported by current federal and state regulations and guidance specific to hardrock mining activities in the U.S.

According to Federal Emergency Management Agency (FEMA), "In general usage, the term '**critical facilities**' is used to describe **all manmade structures or other improvements that, because of their function, size, service area, or uniqueness, have the potential to cause serious bodily harm, extensive property damage, or disruption of vital socioeconomic activities if they are destroyed, damaged, or if their functionality is impaired**."[23]

The Department of Homeland Security[24] recognizes "16 critical infrastructure sectors whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security,

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[21] A. Robertson and S. Shaw, *Mine Closure* (Infomine E-book), p. 3.

[22] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.7.5: Streamflow Regulation.

[23] Federal Emergency Management Agency, Risk Management Series: Design Guide for Improving Critical Facility Safety from Flooding and High Winds (January 2007), p. 1-2.

[24] "Critical Infrastructure Sectors," Department of Homeland Security. Accessed at: https://www.dhs.gov/critical-infrastructure-sectors.

national economic security, national public health or safety, or any combination thereof." One of the sectors is the "Dams Sector" which comprises "…dam projects, navigation locks, levees, hurricane barriers, mine tailings impoundments, and other similar water retention and/or control facilities." Open pit mines, when they contain a pit lake, in most cases serve as water retention and/or control facilities, and therefore could be considered critical infrastructure under this sector.

The BLM requires, "The reclamation plan must also address erosion control through various means including, reshaping the disturbed area, **conveyance of runoff water**, and establishment of vegetation. **Reshaped or regraded** disturbance must achieve a **stable configuration**."[25]

BLM also requires, "Regraded **waste rock dumps** and heap leach piles must be reduced to a slope considerably less than the angle of repose in order to form a base that will support growth medium without slippage or excessive erosion and to support vegetation**. If a barrier-type reclamation cover is to be used that involves placement of a synthetic liner, the operator should determine the allowable steepness of the reclaimed slope through a geotechnical analysis to ensure the slope configuration will be stable**."[26] Additionally, "Reshaped or regraded disturbance must achieve a stable configuration. **The BLM should ask the operator to provide an engineering evaluation when slope stability is uncertain or a slope failure would result in significant environmental or safety impacts**"[27] and, "**Where the stability of the final proposed design is open to question, the operator will be required to provide an engineering analysis which clearly shows a stable slope design**."[28] The USFS does not have explicit requirements for stability but does mention it with respect to reclamation standards and financial assurance throughout guidance.[29]

Alaska requires "… the mining operation shall be **reclaimed** as contemporaneously as practicable with the mining operation to leave the site in a **stable condition**.[30]

[25] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.3.2.2: Erosion, Landslides and Runoff, p. 5-11.

[26] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.3.2.2: Erosion, Landslides and Runoff, p. 5-11.

[27] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.3.2.2: Erosion, Landslides, and Runoff p. 5-11.

[28] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.3.2.4: Reshaping, Soil Placement, and Revegetation, p. 5-12.

[29] U.S. Forest Service, Training Guide for Reclamation Bond Estimation and Administration for Mineral Plans of Operation Authorized and Administered under 36 CFR 228A (April 2004), p. 13 and Appendix C1 p. 6, 8, and 9.

[30] AS Sec. 27.19.020: Reclamation Standard, in Alaska Department of Natural Resources: Division of Mining Land and Water, State of Alaska Mining Laws and Regulations (2014), p. IV-1.

Arizona requires, "The proposed reclamation measures that are necessary to achieve the post-mining land use including information concerning: …(b) The measures that will be taken to address **erosion control and stability**."[31]

Nevada requires that the reclamation plan provide, "For the reclamation of all land disturbed by the exploration project or mining operation to a **stability comparable to that of adjacent areas**."[32]

New Mexico requires that "…the closeout plan specifies incremental work to be done within specific time frames that, if followed, will **reclaim the physical environment of the permit area to a condition that allows for the reestablishment of a self-sustaining ecosystem** on the permit area following closure, appropriate for the life zone of the surrounding areas unless conflicting with the approved post-mining land use New Mexico." New Mexico's Closeout Plan Guidelines contain details on the requirements and provide advice on surface grading, stormwater conveyance and stability.[33]

New Mexico also requires, "The permittee of a copper mine facility shall maintain and implement a plan for the **management of all stormwater and sediment** generated from the copper mine facility during reclamation and following closure.[34]"

The New Mexico copper mine regulations explicitly require, "At closure, tailing impoundment(s) not regulated by the office of the state engineer, leach stockpile(s) or **waste rock stockpile(s)** shall be constructed to promote the long-term stability of the structure. **Closure of all critical structures at a copper mine facility shall be designed for a long-term static factor of safety of 1.5 or greater and non-critical structures shall be designed for a long-term static factor of safety of 1.3 or greater. The units being closed shall also be designed for a factor of safety of 1.1 or greater under pseudostatic analysis. A stability analysis shall be conducted for the unit and shall include evaluation for static and seismic induced liquefaction**."[35] New Mexico provides the following definition, "Critical structure" means earthen or rock structures or embankments (such as an outslope of a rock stockpile), that are likely to cause an exceedance of applicable groundwater standards or undue risk to property in the event of a significant unexpected slope movement.[36]"

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[31] ARS 27-971: Submission and contents of reclamation plan, 9.

[32] NRS-519A.230: Provisions of plan for reclamation, 1.(c).

[33] New Mexico Energy Minerals, and Natural Resources Department, Mining and Minerals Division, Mining Act Reclamation Bureau, Closeout Plan Guidelines for Existing Mines (April 30, 1996).

[34] NMAC 20.6.7.33 E: Surface water management.

[35] NMAC 20.6.7.33: CLOSURE REQUIREMENTS FOR COPPER MINE FACILITIESB. Slope Stability.

[36] NMAC 20.6.7.7: DEFINITIONS: B. (16).

Rationale

EPA has determined that evaluating stability for critical structures is a necessary risk reduction measure that should be a specific minimum standard for waste rock piles. EPA chose the factors of safety, and the requirement for a stability analysis, as a conservative approach consistent with existing BMPs. The requirement for measures to address stability is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for waste rock piles is consistent with those requirements.

Additional support for the specific factor of safety recommendations is provided in Tailings Storage Facilities Sub-section (ii) and (vii).

Waste Rock Piles Subsection (vi)

Proposed Specific Minimum Standard

(vi) A plan for the management of all stormwater and sediment generated during operations and during and following closure. For existing units, the plan must provide for permanent stormwater conveyances, ditches, channels and diversions designed to convey the peak flow and ponds and other collection devices designed to store the volume generated during a 24-hour period by a 100-year return interval storm event. For unit that become authorized to operate after the effective date of this rule, the plan must provide for controls designed to store the volume generated during a 24-hour period by a 200-year return interval storm event.

Current BMPs

The proposed specific minimum standard is a recognized BMP. As noted by the GARD Guide, "Control of surface water can minimize flow through potentially acid generating materials and thereby reduce the volume of ARD. Surface water diversion may include upstream ditching or impervious channels to divert drainage around impacted areas. Drainage works must be sized based on catchment hydrology, including snowmelt and storm events, and will typically require ongoing maintenance (because of debris accumulating, sloughing, and animal activity) to ensure long-term performance."[37] And as further noted in the GARD Guide, "Stormwater management associated with extreme climatic events is often the most important issue for peak flow prediction, design of impoundment storage capacity, freeboard, spillways, flow concentrations, and diversion channels. Design inadequacies and failure of surface water management systems generally occur during extreme events so designs are based on storm return periods and hydrologic assessments. In many cases, it is better to use multi-staged designs based on

[37] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.5.3: Diversion.

operational flow rates supported with bypass spillways and diversion channels to handle extreme high-flow conditions. Criteria for bypass flow must be established based on risk, peak loadings, and downstream dispersion and dilution. Designs need to minimize the risk of severe erosion and structural stability of major containment facilities, especially after closure."[38]

At hardrock mine sites in the U.S. stormwater requirements are in most cases dictated by general stormwater post-construction standards that in most cases are incorporated as State and in some cases Federal National Pollutant Discharge Elimination System (NPDES) General Stormwater Permit requirements. EPA has summarized the Various state stormwater performance standards, which currently range from 2-year 24-hour events to 100-year 24 hour events.[39]

The ACE requires that fills within 100-Year Floodplains must comply with applicable FEMA approved state or local floodplain management requirements.[40] Executive Order 11988[41] was issued "as part of a national policy on resilience and risk reduction" consistent with the President's Climate Action Plan. The resulting Federal Flood Risk Management Standard defines one way of determining a floodplain as "(iii) the area subject to flooding by the 0.2 percent annual chance flood." Given that New Mexico's existing stormwater design criteria are antiquated with regard to climate change considerations, we recommend that the New Mexico Environmental Department recognize a 500-yr storm event standard.

This is further supported by current federal and state regulations and guidance specific to hardrock mining activities in the U.S.

As noted by BLM, "Diversion of run-on waters is especially important for reclaimed heaps or waste rock in order to avoid creating large additional volumes of contaminated leachate that then require special handling or treatment.[42] Water management plans include plans for management of all waters on the mine site, stormwater control, management of process solutions in leaching facilities, and the handling of any mine drainage including acid rock drainage (ARD) and pit lake waters. Key components include establishment of the design storm event, a determination of runoff from the design storm event, the location and sizing of runoff control structures (especially those control structures whose construction requires disturbance of public lands), the ability to contain leaching solutions during wet periods or extreme precipitation events, and

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[38] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.7.5: Streamflow Regulation

[39] U.S. Environmental Protection Agency, Office of Water, Office of Wastewater Management, Water Permits Division, Summary of State Post Construction Stormwater Standards (July 2016).

[40] U.S. Army Corps of Engineers, Nationwide Permits, Conditions, District Engineer's Decision, Further Information, and Definitions (with corrections) (September 2012), p. 30.

[41] "Executive Order 13690: Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input," in *Federal Register* Vol. 80, No. 23, February 4, 2014.

[42] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.3.2.3: Isolate, Remove, or Control Toxic Materials, p. 5-11.

contingency plans for the disposal or treatment of excess solutions.[43] Post-reclamation runoff or run-on control structures must be incorporated by the operator into the overall reclamation plan and built to accommodate flows from the design storm event. Inadequate consideration of the runoff area(s), control designs, or improper runoff management procedures, can cause cascading downgradient reclamation failures that may seriously affect the overall reclamation success.[44] The BLM Solid Minerals Reclamation Handbook recommends "that at a minimum, sediment ponds should be designed with excess capacity to retain the volume of water and sediment contributed from a 24 hour-10 year precipitation event, or to State standards where the state requirements are more stringent."[45]

New Mexico requires that, "The permittee of a copper mine facility shall maintain and implement a plan for the management of all stormwater and sediment generated from the copper mine facility during reclamation and following closure.[46] 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. A. Design storm event. Permanent storm water conveyances, ditches, channels and diversions required for closure of a discharging unit at a copper mine facility shall be designed to convey the peak flow generated by the 100-year return interval storm event. The appropriate design storm duration shall be selected based on the maximum peak flow generated using generally accepted flood routing methods. Sediment traps or small basins intended as best management practices may not be subject to this requirement, based on department approval.[47]"

Rationale

EPA has determined that stormwater management is a necessary risk reduction measure that should be a specific minimum standard for waste rock piles. EPA chose the 100-year return interval storm event for existing mines as a conservative approach consistent with existing BMPs. The 200-year interval storm event for new mines as a similarly conservative approach based on the consideration of climate change and other factors. The requirement for measures to address stormwater is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for waste rock piles is consistent with those requirements.

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[43] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 4.3.3.2.3: Water Management Plans, p. 4-16.

[44] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.3.2.2: Erosion, Landslides and Runoff, p. 5-11.

[45] U.S. Department of the Interior, Bureau of Land Management, Solid Minerals Reclamation Handbook H-3042-1, (Washington, DC: U.S. Government Printing Office, 1992), p. VIII-14.

[46] NMAC 20.6.7.33 E: Surface water management.

[47] NMAC 20.6.7.33: CLOSURE REQUIREMENTS FOR COPPER MINE FACILITIES.

Waste Rock Piles Subsection (vii)

Proposed Specific Minimum Standard

(vii) A plan for the minimization, prevention, or collection and treatment of discharges and/or seepage, based on site hydrology and water quality characterization information, that provides for a cover system of, at a minimum, a store and release earthen cover system with a thickness of at least 12 inches and, if necessary, additional source controls or capture and treatment at closure, all of which meet a minimum 200-yr life design criteria. If seepage water quality is not expected to meet applicable federal and state groundwater and surface water quality standards at the point of compliance, the plan must provide for:

(A) implementation of a containment system that immobilizes hazardous substances to meet applicable water quality standards (e.g., an engineered cover system designed to achieve, at a minimum, a 95 percent reduction in annual net-percolation based on the long-term average to reduce seepage discharges to meet applicable water quality standards;

(B) a capture and treatment system designed to achieve at least a 95 percent capture efficiency and meet applicable water quality standards; or combination of an engineered cover system and a capture and treatment system to achieve at least a 95 percent reduction in discharged load and meet applicable water quality standards at the point of compliance, or

(C) a solution containment system to assure seepage flows are collected, contained, conveyed, and treated to achieve at least a 95 percent reduction to meet applicable water quality standards.

Current BMPs

The GARD Guide "…deals with the prediction, prevention, and management of drainage produced from sulphide mineral oxidation" termed ARD or MIW, is an example of the numerous technical references that have been produced by industry recognizing the need to characterize, predict and mitigate MIW impacts." "The GARD Guide is intended as a state-of-practice summary of the best practices and technology to assist mine operators, excavators, and regulators." [48] Other examples of similar guidance have been produced by MEND,[49] the Society of Mining Engineers,[50] and EPA[51].

As noted by Logsdon with respect to mine facility design-life, "There is no industry standard for such a long-term performance of closed mine facilities, nor are there established regulatory criteria for rock piles."[52] He recommends, "Consideration of closure stage, closure risks, and engineering practice suggest that a **planning period of management of mine wastes should be nominally 200 years**. It should include a semi-quantitative assessment of whether or not major changes in performance are likely to occur between approximately 200 and 1,000 years."[53]

This is further supported by current federal and state regulations and guidance specific to hardrock mining activities in the U.S.BLM requires, "Proper disposal of mining wastes means that all such material **must be identified in advance, placed in locations to minimize the potential for environmental impact, and reclaimed in a manner that maximizes the long-term stability while eliminating or minimizing the formation and release of deleterious leachate**.[54]

During exploration, mining, or reclamation, the operator must manage all tailings, **rock dumps**, deleterious material or substances, and other waste produced from the operations **to prevent impacts that would violate applicable Federal or state laws**. The operator **must incorporate identification, handling, and placement of potentially acid-forming, toxic, or other deleterious materials into the operation procedures, facility design, reclamation,** and environmental monitoring programs **to minimize the formation and impacts of acidic, alkaline, metal-bearing, or other deleterious leachate**. Determining whether rock or overburden materials require special handling is based on a variety of tests (acid-base accounting, humidity cells, leachate extraction tests, whole rock analysis, etc.). While standard protocols are available for most tests, a final determination as to the acid generating character of the material requires evaluating the test results against site-specific environmental and

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[48] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 1.1: Introduction.

[49] William Price, "Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials," MEND Report 1.20.1 (December 2009).

[50] Virginia T. McLemore, ed., *Basics of Metal Mining Influenced Water (Management Technologies for Metal Mining Influenced Water)* (Littleton, CO: Society for Mining, Metallurgy, and Exploration, Inc., 2008).

[51] U.S. Environmental Protection Agency Region 10, EPA and Hardrock Mining: A Source Book for Industry in the Northwest and Alaska (Washington, DC: U.S. Government Publishing Office, 2003).

[52] Mark J. Logsdon, "What Does 'Perpetual' Management and Treatment Mean? Toward a Framework for Determining an Appropriate Period-of-Performance for Management of Reactive, Sulfide-Bearing Mine Wastes," presented at the International Mine Water Association 2013 Annual Conference, Golden, Colorado, August 6-9, 2013, p. 56.

[53] Mark J. Logsdon, "What Does 'Perpetual' Management and Treatment Mean? Toward a Framework for Determining an Appropriate Period-of-Performance for Management of Reactive, Sulfide-Bearing Mine Wastes," presented at the International Mine Water Association 2013 Annual Conference, Golden, Colorado, August 6-9, 2013, p. 57.

[54] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.2: Mining Wastes, p. 5-9.

mineralogical conditions under a specific mine plan. There are no established testing criteria to determine whether acid generation will or will not be an issue without also considering the site-specifics of the particular mine plan. For example, rock with a net acid generating potential greater than 20 could present no problem in a dry underground mine, but might require extensive special handling at an open pit mine in a wetter environment. Consult the BLM's Reclamation Handbook for an overview of the ARD issue and a list of references on ARD evaluation.[55]

The operator must **handle, place, or treat potentially acid-forming, toxic, or other deleterious materials in a manner that minimizes the likelihood of acid formation and toxic and other deleterious leachate generation. As a performance standard the operator must make a good faith effort to use all reasonably applicable technology to keep mine waste from generating leachate that could cause environmental impacts**. **The primary environmental controls that must be used are methods that will stop or minimize the formation of deleterious leachate.**

For potentially acid forming materials this standard could require that such materials be either:

- Mixed with acid-neutralizing materials or additives.
- Treated to stop or slow the acid generating reactions.
- Placed away from potential contact with surface or ground waters.
- Covered to limit or prevent the infiltration of precipitation.
- Some combination of the above.

Operators generating other mine wastes that could generate alkaline or metal-bearing leachate are required to apply similar source control measures to meet this performance standard.[56]"

The USFS does not have explicit requirements for characterization and mitigation, but does mention it with respect to reclamation standards and financial assurance throughout guidance.[57]

Alaska requires, "*A miner shall reclaim a mined area* **that has potential to generate ARD in a manner that prevents the generation of ARD or prevents the offsite discharge of ARD**."[58]

Arizona's Best Available Demonstrated Control Technology (BADCT) guidance suggests, "**A liner system may be an integral part of BADCT for a facility. Site characterization is**

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[55] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.11: Acid-Forming, Toxic, or Deleterious Materials Management, p. 5-21.

[56] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.11.1: Source Control, p. 5-21, -22.

[57] U.S. Forest Service, Training Guide for Reclamation Bond Estimation and Administration for Mineral Plans of Operation Authorized and Administered under 36 CFR 228A (April 2004), p. 13 and Appendix C1 p. 6, 9, and 39.

[58] 11 AAC 97.240: Acid rock drainage, in Alaska Department of Natural Resources: Division of Mining Land and Water, State of Alaska Mining Laws and Regulations (2014), p. IV-5.

necessary to evaluate the performance of the proposed facility both from a geotechnical and geohydrological perspective. The availability of borrow materials (e.g., low permeability materials which could be used for liner construction) and other site specific conditions, such as geologic containment, are important in developing a site specific BADCT design. The selection of liner materials should match with discharged material characteristics and impoundment design."[59]

New Mexico requires, "At closure, a permittee shall **install a cover system on waste rock piles**, leach stockpiles, tailing impoundments and other units **that have the potential to generate leachate and cause an exceedance of applicable standards** at monitoring well locations specified by 20.6.7.28 NMAC (New Mexico Administrative Code) using the following criteria, as appropriate.

(2) **Soil cover systems shall be designed to limit net-percolation by having the capacity to store within the fine fraction at least 95 percent of the long-term average winter (December, January and February) precipitation or at least 35% of the long-term average summer (June, July and August) precipitation, whichever is greater.** The water holding capacity of the cover system will be determined by multiplying the thickness of the cover times the incremental water holding capacity of the approved cover materials. Appropriate field or laboratory test results or published estimates of available water capacity shall be provided by the permittee to show that the proposed cover material meets this performance standard.[60] New Mexico has detailed material characterization and material handling plan requirements[61] and engineering design requirements for new waste rock piles including requirements for groundwater interceptor systems and additional controls such as a liner system."[62]

Rationale

EPA has determined that waste rock characterization and mitigation by various means is a necessary risk reduction measure that should be a specific minimum standard for waste rock piles. EPA chose the 200-year design life as a conservative approach consistent with existing BMPs, and the minimum 95% reduction in infiltration as a similarly conservative approach. The requirement to characterize and mitigate waste rock is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for waste rock piles is consistent with those requirements.

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[59] Arizona Department of Environmental Quality, Arizona Mining Guidance Manual: Best Available Demonstrated Control Technology - Aquifer Protection Program (2001), p. 1-36.

[60] NMAC 20.6.7.33 F: Cover system.

[61] NMAC 20.6.7.21: REQUIREMENTS FOR COPPER MINE WASTE ROCK STOCKPILES:

[62] NMAC 20.6.7.21: REQUIREMENTS FOR COPPER MINE WASTE ROCK STOCKPILES: B. Engineering design requirements for new waste rock stockpiles.

2. Open Pit Mines

This section describes the proposed specific minimum standard for Open Pit Mines, potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases, and for subsections of the standard, current BMPs and the rationale for the specific minimum standard.

Open Pit Mines Specific Minimum Standard

To satisfy **the open pit category** component in paragraph (b)(1)(i):

(i) Where ponding will occur, a plan to regrade the bottom surface during closure to a stable configuration that prevents ponding and promotes the conveyance of surface water off the unit, and that requires closure of all open pits where public access is not restricted, and that are considered to be critical structures to be designed for a long-term static factor of safety of 1.5 or greater and all non-critical structures to be designed for a long-term static factor of safety of 1.3 or greater; and requires that the units being closed be designed for a factor of safety of 1.1 or greater under pseudostatic analysis. The plan must also provide for a stability analysis to be conducted for the unit and include evaluation for static and seismic induced liquefaction.

(ii*)* A plan for the management of all stormwater and sediment generated during reclamation and following closure. The plan must include permanent stormwater conveyances, ditches, channels, and diversions, as necessary, designed to convey the peak flow and ponds and other collection devices, and must provide for controls designed to store the volume generated during a 24-hour period by a 200-year return interval storm event.

(iii) Where pit lake will form, or where meteoric water will percolate through the pit rock into groundwater below, and pit lake or any discharges will not meet water quality standards, a plan for the minimization, prevention, or collection and treatment of pit lakes, discharges, and/or seepage, based on site hydrology, water quality characterization information, and pit lake ecological risk assessment information. The plan must address and must provide for capture and treatment at closure consisting of a capture and treatment system that meets a minimum 200-yr life design criteria, and that is designed to either prevent pit lake formation or groundwater contamination exceeding applicable water quality standards to achieve at least a 95 percent capture efficiency of the affected groundwater, and to meet applicable water quality standards.

(iv) If prevention/avoidance is relied on, a management plan that demonstrates geochemically active materials will effectively be avoided, and that includes provisions for sampling and monitoring documentation.

Potential Sources and Releases and Management Practices

Potential sources and releases of CERCLA hazardous substances at open pit mines, and management practices to address those potential sources and releases, are provided in Appendix A, Table A2. Open Pit Mines and Underground Mines.

Open Pit Mines are primary sources of MIW, including AMD, at hardrock mine sites. Source characterization is key to prevention and/or management of MIW/AMD during the entire mining life-cycle from exploration and development, during operations, reclamation, and post-closure. Management practices for mitigation of MIW/AMD include a variety of methods including avoidance, backfilling, prevention of pit lake formation, hydrologic controls, and pit lake treatment. In addition to source controls, groundwater and surface water capture and treatment may also be used to mitigate MIW/AMD.

Open pits are also subject to erosion leading to surface water sedimentation. This is necessary both during construction, operations, and following reclamation. Following reclamation, stormwater controls are needed to address erosion to prevent exposure of encapsulated materials or damage to engineered structures. Management practices for stormwater control include the allowance for, and design of, stormwater control structures including slope breaks, conveyances and holding/ sedimentation ponds.

Open pit mines are subject to deformation or collapse as a result of mass wasting due to erosion and potentially due to other stability issues. Including geotechnical analysis in the design and operational monitoring is recommended to prevent mass instability. In the event instability is detected, a variety of engineering methods such as buttresses to counter movement can be utilized.

Open Pit Mines Subsection (i) (Part 1)

Proposed Specific Minimum Standard

(i) Where ponding will occur, a plan to regrade the bottom surface during closure to a stable configuration that prevents ponding and promotes the conveyance of surface water off the unit, and that requires closure of all open pits where public access is not restricted, and that are considered to be critical structures to be designed for a long-term static factor of safety of 1.5 or greater and all non-critical structures to be designed for a long-term static factor of safety of 1.3 or greater; and requires that the units being closed be designed for a factor of safety of 1.1 or greater under pseudostatic analysis. The plan must also provide for a stability analysis to be conducted for the unit and include evaluation for static and seismic induced liquefaction.

Current BMPs

See **Waste Rock Piles Subsection (iv-v)** for applicable BMPs.

Montana provides the following specific requirements for open pit stability:

> "(b) With regard to open pits and rock faces, the reclamation plan must provide sufficient measures for reclamation to a condition:
>
> > (i) of stability structurally competent to withstand geologic and climatic conditions without significant failure that would be a threat to public safety and the environment;"[63]

Rationale

EPA has determined that evaluating stability for critical structures is a necessary risk reduction measure that should be a specific minimum standard for open pit mines. EPA chose the factors of safety and the requirement for a stability analysis as a conservative approach consistent with existing BMPs. The requirement for measures to address stability is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for open pit mines is consistent with those requirements.

Open Pit Mines Subsection (ii)

Proposed Specific Minimum Standard

(ii) A plan for the management of all stormwater and sediment generated during reclamation and following closure. For existing units, the plan must provide for permanent stormwater conveyances, ditches, channels and diversions designed to convey the peak flow and ponds and other collection devices designed to store the volume generated during a 24-hour period by a 100-year return interval storm event. For unit that become authorized to operate after the effective date of this rule, the plan must provide for controls designed to store the volume generated during a 24-hour period by a 200-year return interval storm event.

Current BMPs

See **Waste Rock Piles Subsection (vi)** for applicable BMPs.

Rationale

EPA has determined that stormwater management is a necessary risk reduction measure that should be a specific minimum standard for open pit mines. EPA chose the 200-year interval storm event for both existing and new mines as a similarly conservative approach for based on the consideration of climate change and other factors. The requirement for measures to address

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[63] MCA 82-4-336: Reclamation plan and specific reclamation requirements, (9).

stormwater is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for open pit mines is consistent with those requirements.

Open Pit Mines Subsection (iii)

Proposed Specific Minimum Standard

(iii) Where pit lake will form, or where meteoric water will percolate through the pit rock into groundwater below, and pit lake or any discharges will not meet water quality standards, a plan for the minimization, prevention, or collection and treatment of pit lakes, discharges, and/or seepage, based on site hydrology, water quality characterization information, and pit lake ecological risk assessment information. The plan must address and must provide for capture and treatment at closure consisting of a capture and treatment system that meets a minimum 200-yr life design criteria, and that is designed to either prevent pit lake formation or groundwater contamination exceeding applicable water quality standards to achieve at least a 95 percent capture efficiency of the affected groundwater, and to meet applicable water quality standards.

Current BMPs

As noted by the GARD Guide, "Because pit lakes may potentially represent a long-term source of ARD that persists after mine closure, **prediction of the quality and environmental impacts of these lakes is a key part of the ARD management plan**."[64] The GARD Guide also notes that, "Salt budgets may also be critical at arid sites for pit lakes and surface impoundments where a negative water balance because of low precipitation and high evaporation can cause evapoconcentration or hyper saline conditions to develop with time."[65]

This is further supported by current federal and state regulations and guidance specific to hardrock mining activities in the U.S.

BLM requires that, "Reclamation plans for open pits must describe **the likely presence or absence of a pit lake and the anticipated water quality and quantity over time**, and include a description of post-closure safety controls around the pit."[66] BLM also requires that, "the operator must capture and treat acid drainage, or other undesirable effluent, to the applicable

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[64] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 4.2.2.1: Surface Mines

[65] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.7.6: Water Recycle and Reuse.

[66] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 4.3.3.3.3: Closure Plans for Mine Openings and Pit Backfilling Information, p. 4-21.

standard if source controls and migration controls do not prove effective.[67] BLM has also produced Ecological Risk Assessment Guidelines for Open Pit Mine Lakes in Nevada.[68] The USFS does not have explicit requirements for pit lakes.

The Arizona Aquifer Protection Program (APP) requires the following:

"A discharging facility at an open pit mining operation shall be deemed to satisfy the requirements of subsection B, paragraph 1 of this section if the director determines that both of the following conditions are satisfied:

1. **The mine pit creates a passive containment that is sufficient to capture the pollutants discharged and that is hydrologically isolated to the extent that it does not allow pollutant migration from the capture zone**. For purposes of this paragraph, "passive containment" means natural or engineered topographical, geological or hydrological control measures that can operate without continuous maintenance. Monitoring and inspections to confirm performance of the passive containment do not constitute maintenance.
2. **The discharging facility employs additional processes, operating methods or other alternatives to minimize discharge**."[69]

Nevada does not explicitly address pit lakes other than access requirements.[70] New Mexico addresses pit lakes as follows:

"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 or other activities at open pits 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 open pit hydrologic containment**. This is limited to contaminants associated with standard copper mining practices and found to be present within the open pit, or that can be generated from the natural materials present in the open pit through degradation, oxidation, decay or other expected process.

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[67] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.11.3: Capture and Treatment, p. 5-22, -23.

[68] U.S. Department of the Interior, Bureau of Land Management, Instruction Memorandum No. NV-2010-030, re: Ecological Risk Assessment Guidelines for Open Pit Mine Lakes in Nevada (2010).

[69] Arizona Department of Environmental Quality, Arizona Mining Guidance Manual: Best Available Demonstrated Control Technology - Aquifer Protection Program (2001), 1.2.5 Passive Containment, p. 1-35.

[70] NRS-519A.230:Provisions of plan for reclamation; inclusion of pit lake in plan, 3.

(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 monitoring well locations specified by 20.6.7.28 NMAC, then the open pit shall be considered a flow-through pit.** In a flow-through pit system the open pit water quality must meet ground water standards of 20.6.2.3103 NMAC or the open pit must be pumped in order to maintain an area of open pit hydrologic containment."[71]

Rationale

The requirement for pit lake prediction and mitigation, as a part of hardrock mine reclamation and closure, is a recognized BMP as evidenced by its inclusion in the technical references and federal and state regulations and guidance. EPA's proposed specific minimum standard for open pit mines is consistent with those requirements and recommendations.

Open Pit Mines Subsection (iv)

Proposed Specific Minimum Standard

(iv) If prevention/avoidance is relied on, a management plan that demonstrates geochemically active materials will effectively be avoided, and that includes provisions for sampling and monitoring documentation.

Current BMPs

See **Waste Rock Piles Subsection (ii)** for applicable BMPs.

Rationale

This proposed specific minimum standard is intended to provide an opportunity for mines that do not mine or produce as waste products materials that contain hazardous substances, to perform geochemical characterization to identify themselves. This would remove any requirements for mitigation related to water quality described in other sections.

Open Pit Mines - Other Information Considered

Open Pit Backfilling

EPA did not include backfilling as a requirement.

BLM addresses backfilling with the following requirements:

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[71] NMAC 20.6.7.33 D: Open pits.

“Mine pit backfilling may be part of the reclamation plan proposed by the operator or required by the BLM as a condition of approval. Pit backfilling is one aspect of the reclamation plan where the operator must provide the BLM with specific information so the BLM can determine the appropriate amount of backfilling, if any, required. The operator is required to provide information and analysis on pit backfilling that details economic, environmental, and safety factors. This includes information on the anticipated backfilling costs, character of the potential backfill material, stability of highwalls or backfill material, size and quality of potential pit lakes, and safety issues that may be associated with backfilling. An operator statement of “pit backfilling is not feasible” without providing supporting technical, environmental, or economic data does not meet the Plan content requirement. While there is no set formula for how to consider information provided by the operator on the feasibility of pit backfilling, the BLM must weigh the costs, impacts, and difficulties of pit backfilling with the anticipated environmental and safety benefits on a case-by-case basis in order to determine the appropriate amount of pit backfilling, if any, needed to meet the performance standards.[72]”

New Mexico addresses backfilling in its regulations by stating: “(3) include backfilling or partial backfilling only when necessary to achieve reclamation objectives that cannot be accomplished through other mitigation measures.”[73]

The GARD Guide recognizes mine backfilling as a MIW mitigation measure, and acknowledges that it “…might be preferred in some situations, but this method of disposal usually only becomes available after or well into the mine operating phase.”[74]

Discussion

EPA did not include backfilling as a specific minimum standard because it is highly site-specific and not always consistent with BMPs. However, EPA does intend that any reclamation and closure plans that do incorporate backfilling to accomplish reclamation, as mitigation or to meet water quality standards, be evaluated for “worst case” (e.g. early closure) circumstances, and adequate financial assurance be incorporated in the estimate to allow for the anticipated pit backfilling necessary at that time.

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[72] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 4.3.3.3.3: Closure Plans for Mine Openings and Pit Backfilling Information, p. 4-21; see also Section 5.3.3.2.5: Mine Pit Backfilling.

[73] NMSA 69-36-7: Commission; duties, H.

[74] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.7: Selection and Evaluation of Alternatives.

3. Underground Mines

This section describes the proposed specific minimum standard for Underground Mines, potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases, and for subsections of the standard, current BMPs and the rationale for the specific minimum standard.

Underground Mines Specific Minimum Standard

To satisfy **the underground mine category** component in paragraph (b)(1)(ii):

(i) A plan to address public safety by prevention of public access by means of security fencing, or other effective methods.

(ii) A plan for the minimization, prevention or collection and treatment of discharges and or seepage based on site hydrology and water quality characterization information that provides for necessary additional source controls and/or capture and treatment at closure, all of which meet a minimum 200-year life design criteria, and includes:

(A) Requirements for installation of a bulkhead or other device to restrict unwanted access

(B) If seepage and/or discharge water quality is not expected to meet applicable water quality standards then requirements for a capture and treatment system designed to achieve at least a 95 percent capture efficiency and to meet applicable water quality standards, and

(C) If there will be pressurized plug as a permanent feature controlling a discharge from underground mine workings at moderate to high heads (100-1,000+ kPa), a requirement to maintain the plug as a permanent feature.

(iii) If prevention/avoidance is relied on, a management plan that demonstrates geochemically active materials will effectively be avoided, and that includes provisions for sampling and monitoring documentation.

Potential Sources and Releases and Management Practices

Potential sources and releases of CERCLA hazardous substances at underground mines, and management practices to address those potential sources and releases, are provided in Appendix A, Table A2. Open Pit Mines and Underground Mines.

Underground Mines are primary sources of MIW, including AMD, at hardrock mine sites. Source characterization is key to prevention and/or management of MIW/AMD during the entire mining life-cycle from exploration and development, during operations, reclamation, and post-closure. Management practices for mitigation of MIW/AMD include a variety of methods including avoidance, backfilling, grouting, flooding, seals, hydrologic controls, and discharge capture and treatment.

Subsidence at underground mines can similarly lead to stability issues and hydrologic impacts.

Underground Mines Subsection (i)

Proposed Specific Minimum Standard

(i) A plan to address public safety by prevention of public access by means of security fencing, or other effective methods.

Current BMPs

See **Waste Rock Piles Subsection (i)** for applicable BMPs.

Alaska requires that, "*A miner shall stabilize and* ***properly seal the openings of all shafts, adits, tunnels, and air vents to underground mine workings*** *after mine closure* ***to ensure protection of the public****, wildlife, and the environment.*"[75]

Rationale

The requirement for measures to address public safety is a recognized BMP, as evidenced by its widespread inclusion in federal and state hardrock regulations. The proposed specific minimum standard for underground mines is consistent with those requirements.

Underground Mines Subsection (ii) (Part 1)

Proposed Specific Minimum Standard

(ii) A plan for the minimization, prevention or collection and treatment of discharges and or seepage based on site hydrology and water quality characterization information that provides for necessary additional source controls and/or capture and treatment at closure, all of which meet a minimum 200-year life design criteria,

Current BMPs

See **Waste Rock Piles Subsection (vii)** for applicable BMPs.

Rationale

EPA has determined that characterization and mitigation by various means is a necessary risk reduction measure that should be a specific minimum standard for underground mines. EPA

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[75] 11 AAC 97.220: Underground mines, in Acid rock drainage, in Alaska Department of Natural Resources: Division of Mining Land and Water, State of Alaska Mining Laws and Regulations (2014), p. IV-5.

chose the 200-year design life as a conservative approach consistent with existing BMPs. The requirement to characterize and mitigate underground mines is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for underground mines is consistent with those requirements.

Underground Mines Subsection (ii) (Part A)

Proposed Specific Minimum Standard

(ii) …and includes: (A) If seepage and/or discharge water quality is not expected to meet applicable water quality standards then requirements for a capture and treatment system designed to achieve at least a 95 percent capture efficiency and to meet applicable water quality standards…

Current BMPs

See **Waste Rock Piles Subsection (vii)** for applicable BMPs.

Rationale

EPA has determined that characterization and mitigation by various means is a necessary risk reduction measure that should be a specific minimum standard for underground mines. EPA chose the 200-year design life as a conservative approach consistent with existing BMPs. The requirement to characterize and mitigate underground mines is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for underground mines is consistent with those requirements.

Underground Mines Subsection (ii) (Part B)

Proposed Specific Minimum Standard

(ii) …and includes: (B) If there will be a pressurized bulkhead or plug as a permanent feature controlling a discharge from underground mine workings at moderate to high heads (100-1,000+ kPa), a requirement to maintain the plug as a permanent feature.

Current BMPs

As noted by the U.S Bureau of Reclamation in their report on the Gold King Mine incident:

"Although the coal mine bulkheads are subject to regulation under the Surface Mining Control and Reclamation Act, no comprehensive program exists to deal with the long-term care and maintenance of the hard-rock mine facilities. Many design documents and some State permit approvals describe these bulkheads as facilities requiring little to no maintenance. Although they will last for many years, they have a finite life and require monitoring and maintenance. Although bulkhead failures are likely to lead to environmental contamination, a blowout caused by the failure of a mine bulkhead at the Marcopper mine in the Philippines resulted in the death of livestock and evacuation of approximately 1,200 people. The designs and monitoring and maintenance requirements for all mines having hydraulic bulkheads are important documents that should be added to the National Mine Map Repository. The potential consequences of a bulkhead failure should be evaluated. If the likely consequences of failure are potentially severe, then inundation maps, emergency action plans, and provisions for monitoring should be developed or enhanced for those facilities as necessary."[76]

According to Lang[77] and common to mining and tunneling industry vernacular, for the purpose of addressing hydrology four types of structures are used in closing underground workings: dams, fill fences, bulkheads and plugs. Dams are generally used to store water during mine operations and are low head, free to overflow and temporary. Fill fences are typically used for retaining backfill in mines and are low head (<100 kPa), free draining and/or overflowing and temporary. Bulkheads are typically used to retain backfill and to seal off water under moderate head (100-1,000 kPa) conditions and are free draining and/or overflowing and temporary. In is important to note that in all three cases the maximum design loading conditions are temporary and only expected to occur during the operational life of the mine during which times normal operations and maintenance would be routinely performed as required to maintain design conditions. Upon closure, it would be anticipated that these structures could be abandoned in most cases, however, on a site-specific basis some dams, fill fences and bulkheads could represent a hazard in terms of backing up water and backfill material (e.g. tailings, waste rock, accumulated sediment) that could result in significant discharges, that could require mitigation such as breaching, maintenance and periodic replacement.

Tunnel plugs are used to impound water and tailings and prevent them from discharging from underground workings at moderate to high heads (100-1,000+ kPa). Plugs are considered permanent features and are typically designed with a minimum 100-yr design life but may have a service life of 1,000+ years. They are typically designed to be permanent structures and not require maintenance or monitoring. However, they are susceptible to various failure modes and require adherence to conservative design criteria and quality assurance controls, as well as location of suitable sites within the underground mine for plug installation.

BLM requires, "Information on closure of all mine openings is required, whether the opening is an open pit, an adit, a portal, or a shaft associated with an underground operation. The plans must include information on where the closures would be constructed, the nature of the material or devices used to achieve closure, and a **description of any long-term care or maintenance**

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[76] U.S. Department of the Interior, Bureau of Reclamation, Technical Evaluation of the Gold King Mine Incident, San Juan County, Colorado (October 2015), p. 74-75.

[77] Brennan Lang, "Permanent Sealing of Tunnels to Retain Tailings or Acid Rock Drainage," presented at the International Mine Water Association 1999 Congress, Sevilla Spain, p. 647-655.

requirements associated with closure of the opening. Information required for closure of underground operations includes items such as gate or **bulkhead design**, backfill placement and amendments, **and provisions to control hydrostatic pressure**."[78]

No other specific performance standards addressing bulkheads or plugs or their permanence as features was identified in the federal or state regulations or guidance.

Rationale

The requirement for measures to address pressurized bulkheads or plugs at underground mines is a recognized BMP as suggested by the technical references, the U.S. Bureau of Reclamation and the BLM. Also, as noted, no comprehensive program exists to deal with the long-term care and maintenance of the hard-rock mine facilities that require bulkheads or other similarly intended devices. EPA's proposed specific minimum standard for underground mines fills a gap in existing federal and state regulations and is needed to reduce the risk from underground mine facilities.

Underground Mines Subsection (iii)

Proposed Specific Minimum Standard

(iii) If prevention/avoidance is relied on, a management plan that demonstrates geochemically active materials will effectively be avoided, and that includes provisions for sampling and monitoring documentation.

Current BMPs

See **Waste Rock Piles Subsection (ii)** for applicable BMPs.

Rationale

This proposed specific minimum standard is intended to provide an opportunity for mines that do not mine or produce as waste products materials that contain hazardous substances, to perform geochemical characterization to identify themselves. This would remove any requirements for mitigation related to water quality described in other sections.

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[78] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 4.3.3.3.3: Closure Plans for Mine Openings and Pit Backfilling Information, p. 4-20.

4. Heap and Dump Leach Piles

This section describes the proposed specific minimum standard for Heap and Dump Leach Piles, potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases, and for subsections of the standard, current BMPs and the rationale for the specific minimum standard.

Heap and Dump Leach Piles Specific Minimum Standard

To satisfy **the heap and dump leach category** component in paragraph (b)(1)(v), and the tailings facility category component in paragraph (a)(1)(v):

(i) A plan to address public safety by prevention of public access by means of security fencing, or other effective methods.

(ii) A plan to regrade surface during closure to a stable configuration that prevents ponding and promotes the conveyance of surface water off the unit, and that requires closure of all heap leach and dump leach piles considered to be critical structures to be designed for a long-term static factor of safety of 1.5 or greater and all non-critical structures to be designed for a long-term static factor of safety of 1.3 or greater; and requires that the units being closed be designed for a factor of safety of 1.1 or greater under pseudostatic analysis. The plan must also provide for a stability analysis to be conducted for the unit and include evaluation for static and seismic induced liquefaction.

(iii*)* A plan for the management of all stormwater and sediment generated during reclamation and following closure. The plan must include permanent stormwater conveyances, ditches, channels, and diversions, as necessary, designed to convey the peak flow and ponds and other collection devices. For existing units, the plan must provide for controls to be designed to store the volume generated during a 24-hour period by a 100-year return interval storm event; for units that become authorized to operate after the effective date of this rule, the plan must provide for controls designed to store the volume generated during a 24-hour period by a 200-year return interval storm event.

(iv) A plan for the minimization, prevention, or collection and treatment of discharges and/or seepage, based on site hydrology and water quality characterization information, that provides for a cover system of, at a minimum, a store and release earthen cover system with a thickness of at least 12 inches and, if necessary, additional source controls or capture and treatment at closure, all of which meet a minimum 200-yr life design criteria. If seepage water quality is not expected to meet applicable water quality standards, the plan must provide for:

(A) implementation of an engineered cover system designed to achieve at least a 95 percent reduction in annual net-percolation based on the long-term average and reduce seepage discharges to meet applicable water quality standards;

(B) a capture and treatment system designed to achieve at least a 95 percent capture efficiency and meet applicable water quality standards; or combination of an engineered cover system and a capture and treatment system to achieve at least a 95 percent reduction in discharged load and meet applicable water quality standards, or

(C) a solution containment system to assure seepage flows are collected, contained, conveyed, and treated to achieve at least a percent reduction to meet applicable water quality standards.

(v) (For heap leach) A liner designed to minimize/eliminate releases from the unit based on site specific conditions.

Potential Sources and Releases and Management Practices

Potential sources and releases of CERCLA hazardous substances from heap and dump leach piles and management practices to address those potential sources and releases, are provided in Appendix A, Table A3. Cyanide Leaching and Table A4. Acid Leaching.

Leach solution from heap and dump leaching that is discharged as a result of accidents, spills, liner and other containment punctures and breaches, together with spent leach piles, is a primary source of MIW containing cyanide and leached metals from hardrock mine sites. Engineered liner systems using liners and leachate collection systems have effectively been used, together with rinsing and/or collection and treatment of leach draindown solutions. Leach piles may also be long-term sources of MIW, including AMD, at hardrock mine sites. Source characterization is key to prevention and/or management of MIW/AMD during the entire mining life-cycle from exploration and development, during operations, reclamation, and post-closure. Management practices for mitigation of MIW/AMD include a variety of methods including avoidance, source controls and capture and treatment.

Mercury releases can be an issue associated with cyanide heap leach facilities. Radon radiation may be an issue associated with acid leach facilities.

Heap and Dump Leach Piles Subsection (i)

Proposed Specific Minimum Standard

(i) A plan to address public safety by prevention of public access by means of security fencing, or other effective methods.

Current BMPs

See **Waste Rock Piles Subsection (i)** for applicable BMPs.

Rationale

The requirement for measures to address public safety is a recognized BMP, as evidenced by its widespread inclusion in federal and state hardrock regulations. The proposed specific minimum standard for heap and dump leach piles is consistent with those requirements.

Heap and Dump Leach Piles Subsection (ii)

Proposed Specific Minimum Standard

(ii) Requirements to regrade surface during closure to a stable configuration that prevents ponding and promotes the conveyance of surface water off the unit, and that requires closure of all waste rock piles considered to be critical structures to be designed for a long-term static factor of safety of 1.5 or greater and all non-critical structures to be designed for a long-term static factor of safety of 1.3 or greater; and requires that the units being closed be designed for a factor of safety of 1.1 or greater under pseudostatic analysis.

Current BMPs

See **Waste Rock Piles Subsection (iv-v)** for applicable BMPs.

Arizona provides the following specific requirements for heap leach stability:

> "Potential geologic hazards should be considered present if conditions prone to the following occur at the proposed facility location:
>
> - Excessive or differential subsidence;
> - Collapsing soils;
> - Landslides;
> - Strong seismic shaking;
> - Other potential ground instability.
>
> If present, conditions prone to these hazards must be documented for consideration in facility design. Geologic hazards will not preclude the use of Prescriptive BADCT provided that such hazards do not have a significant potential to impact the effectiveness of the Prescriptive BADCT design (considering mitigating engineering measures, if any).[79]
>
> The heap shall be evaluated and designed to provide stability of the heap under static and potential seismic loading conditions. Shear strengths should be based on site-specific

[79] Arizona Department of Environmental Quality, Arizona Mining Guidance Manual: Best Available Demonstrated Control Technology - Aquifer Protection Program (2001), 2.4.1.3 Geologic Hazards, p. 2-32.

material evaluations and not on published values. Stability evaluations should be conducted for ultimate pile heights, intermediate construction stages, and maximum anticipated phreatic surfaces that may be critical with regard to stability. Static stability analyses should indicate a factor of safety of at least 1.3. Seismic evaluations should be based on the Maximum Probable Earthquake (MPE). The MPE is the largest earthquake with a 100-year return interval. The MPE should be evaluated considering all known active faults within a distance of 200 kilometers. Seismic stability analyses may include pseudostatic and deformation analysis methods, as further discussed in Appendix E. When deformation analyses are required, the displacement predicted shall be within the following limits unless engineering evaluations are provided to demonstrate that larger displacements will not jeopardize containment integrity:

- Deformations not affecting geomembranes shall be less than or equal to 1 foot.
- Deformations affecting geomembranes shall be less than or equal to 6 inches."

80,,

Rationale

EPA has determined that evaluating stability for critical structures is a necessary risk reduction measure that should be a specific minimum standard for heap and dump leach piles. EPA chose the factors of safety and the requirement for a stability analysis as a conservative approach consistent with existing BMPs. The requirement for measures to address stability is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for heap and dump leach piles is consistent with those requirements.

Heap and Dump Leach Piles Subsection (iii)

Proposed Specific Minimum Standard

(iii) A plan for the management of all stormwater and sediment generated during operations and during and following closure. For existing units, the plan must provide for permanent stormwater conveyances, ditches, channels and diversions designed to convey the peak flow and ponds and other collection devices designed to store the volume generated during a 24-hour period by a 100-year return interval storm event. For unit that become authorized to operate after the effective date of this rule, the plan must provide for controls designed to store the volume generated during a 24-hour period by a 200-year return interval storm event.

[80] Arizona Department of Environmental Quality, Arizona Mining Guidance Manual: Best Available Demonstrated Control Technology - Aquifer Protection Program (2001), 2.4.2.5 Stability Design, p. 2-35, 36. Note that "Appendix E" refers to an appendix to the cited document.

Current BMPs

See **Waste Rock Piles Subsection (vi)** for applicable BMPs.

Arizona provides the following specific requirements for heap leach stormwater controls:

> "The control of surface water is a design factor for the Prescriptive BADCT process. Surface water run-on from upstream watershed areas should be diverted around heap leach facilities. The minimum design storm is the 100-year, 24-hour storm event unless another regulatory program requires a larger design storm or other hydrologic criteria, or due to potential threat to human life (Appendix E).
>
> Erosion of diversion structures should be controlled by placing rip-rap at ditch entrances, exits and other erosion sensitive points. Alternative acceptable methods of erosion control include suitable channel geometry, soil cementation, limiting watershed areas (e.g., through the use of additional diversion trenches and dikes), slope down-drain pipes, energy dissipaters (e.g., gabions, rip-rap), retention basins to attenuate peak flows, etc. If facilities are proposed within the 100-year flood plain, drainage controls must in addition to the above, be designed to protect the facilities from damage or flooding for 100-year peak streamflows.
>
> Lakes, wetlands, springs and other surface waters must be identified in order to safely design the facility (minimize run-on) and minimize any unnecessary discharge to surface waters. Knowing the location of surface waters also will inform the applicant if other agencies must be contacted (see Appendix F).[81]"

Rationale

EPA has determined that stormwater management is a necessary risk reduction measure that should be a specific minimum standard for heap and dump leach piles. EPA chose the 100-year return interval storm event for existing mines as a conservative approach consistent with existing BMPs. EPA chose the 200-year interval storm event for new mines as a similarly conservative approach based on the consideration of climate change and other factors. The requirement for measures to address stormwater is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for heap and dump leach piles is consistent with those requirements.

[81] Arizona Department of Environmental Quality, Arizona Mining Guidance Manual: Best Available Demonstrated Control Technology - Aquifer Protection Program (2001), 2.4.1.2 Surface Water Control, p. 2-32. Note that "Appendix E" and "Appendix F" refer to appendices to the cited document.

Heap Leach Piles Subsection (iv)

Proposed Specific Minimum Standard

(iv) A plan for the minimization, prevention, or collection and treatment of discharges and/or seepage, based on site hydrology and water quality characterization information, that provides for a cover system of, at a minimum, a store and release earthen cover system with a thickness of at least 12 inches and, if necessary, additional source controls or capture and treatment at closure, all of which meet a minimum 200-yr life design criteria. If seepage water quality is not expected to meet applicable federal and state groundwater and surface water quality standards at the point of compliance, the plan must provide for:

(A) implementation of an engineered cover system designed to achieve at least a 95 percent reduction in annual net-percolation based on the long-term average and reduce seepage discharges to meet applicable water quality standards;

(B) a capture and treatment system designed to achieve at least a 95 percent capture efficiency and meet applicable water quality standards; or combination of an engineered cover system and a capture and treatment system to achieve at least a 95 percent reduction in discharged load and meet applicable water quality standards, or

(C) a solution containment system to assure seepage flows are collected, contained, conveyed, and treated to achieve at least a percent reduction to meet applicable water quality standards.

Current BMPs

See **Waste Rock Piles Subsection (vii)** for applicable BMPs.

Arizona provides the following specific requirements for heap leach piles:

"A closure/post-closure strategy must be drafted and submitted to [Arizona Department of Environmental Quality] (ADEQ) for preliminary approval as part of the APP application. The applicant must still comply with the requirements of Arizona Administrative Code R18-9-A209(B) prior to formal closure. The closure strategy shall eliminate, to the greatest extent practicable, any reasonable probability of further discharge from the facility and of exceeding Aquifer Water Quality Standards at the applicable point of compliance. Closure will include: characterization and neutralization or rinsing (see Section 3.2.5 for further information) of all spent ore or waste residues; elimination of free liquids; recontouring of heaps as necessary to eliminate ponding; and, if necessary, to prevent the formation of leachate that may adversely impact aquifer water quality after closure, capping with a low permeability layer. Measures to provide long-term physical stability of the Heap Leach Pad are part of BADCT to the extent that they may affect aquifer loading. Measures in addition to those discussed above may be necessary to stabilize the Heap Leach Pad to be resistant to water and wind erosion. Such erosion can affect the physical stability in the long-term or lead to sediment transport that can discharge pollutants to the aquifer by indirect surface water pathways to groundwater. Physical stabilization measures that will normally be an integral part of Prescriptive BADCT include:"

- "Drainage controls upgradient of Heap Leach Pads will normally be left in place at the time of closure to protect the Heap Leach Pad from washout.
- The Heap Leach Pad surface can be stabilized with vegetation or by leaving durable rock on the pile slopes.[82]"

Alaska requires "After neutralization of heaps, pads, ponds, and other such facilities has been approved by the appropriate regulatory authority (the EPA or the Department of Environmental Conservation), a miner shall reclaim the site of a heap leach operation to the standards of AS 27.19 and this chapter.[83]"

Rationale

EPA has determined that characterization and mitigation by various means is a necessary risk reduction measure that should be a specific minimum standard for heap and dump leach piles. EPA chose the 200-year design life as a conservative approach consistent with existing BMPs. The requirement to characterize and mitigate heap and dump leach piles is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for heap and dump leach piles is consistent with those requirements.

Heap and Dump Leach Piles Subsection (v)

Proposed Specific Minimum Standard

(v) A liner designed to minimize/eliminate releases from the unit based on site specific conditions.

Current BMPs

According to EPA, "Process solutions have the ability to degrade surface and ground waters should they escape from leach pads and solution storage and conveyance systems. For most

[82] Arizona Department of Environmental Quality, Arizona Mining Guidance Manual: Best Available Demonstrated Control Technology - Aquifer Protection Program (2001), 2.4.4 Closure/Post-Closure Criteria, p. 2-38.

[83] 11 AAC 97.230. Heap leach operations, in Acid rock drainage, in Alaska Department of Natural Resources: Division of Mining Land and Water, State of Alaska Mining Laws and Regulations (2014), p. IV-5.

facilities, solution containment is achieved through the use of impermeable liners beneath leach pads, sumps, and pregnant and barren solution ponds, and dual-wall piping."[84]

As noted by the GARD Guide, "There are a multitude of low-permeability materials, ranging from synthetic to geosynthetic to natural, that can be utilized in liner systems. There are also a multitude of liner system designs that can be applied. The combination of the design and the materials will determine the leakage rate of the liner system."

BLM requires, "The operator must have a low-permeability liner or containment system designed and constructed that will minimize the release of leaching solutions to the environment. The operator must monitor to detect potential releases of contaminants from heaps, process ponds, tailings impoundments, and other structures and remediate environmental impacts if leakage occurs.

While a large volume of technical material (see BLM Solid Minerals Reclamation Handbook, H-3042-1)[85] has been written on how to design, build, and operate leaching facilities or tailings impoundments, this performance standard emphasizes some basic requirements.

The operator must construct such facilities with a low permeability liner or containment system. The standard is met when the release of leaching solutions to the environment has been minimized using the best available technology.

The operator must monitor for the release of leaching solutions. Such monitoring can be accomplished by placing monitoring devices beneath or between the heap, pond, or tailing impoundment liner system or by adjacent monitoring wells or lysimeters. Environmental impacts caused by the leakage or seepage of process or waste solutions must be remediated in order to satisfy this performance standard.[86]"

Arizona provides extensive guidance on the following:

- "Design, Construction and Operations Criteria
- Solution and Waste Characterization
- Site Preparation
- Liner Specifications
- Quality Assurance/Quality Control Program.[87]"

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[84] U.S. Environmental Protection Agency Region 10, EPA and Hardrock Mining: A Source Book for Industry in the Northwest and Alaska (Washington, DC: U.S. Government Publishing Office, 2003), p. F-26.

[85] U.S. Department of the Interior, Bureau of Land Management, Solid Minerals Reclamation Handbook H-3042-1, (Washington, DC: U.S. Government Printing Office, 1992).

[86] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.12.2: Liners and Leak Prevention, p. 5-24.

[87] Arizona Department of Environmental Quality, Arizona Mining Guidance Manual: Best Available Demonstrated Control Technology - Aquifer Protection Program (2001), 2.4 HEAP LEACH PADS, p. 32-35

In New Mexico, "At a minimum, the following requirements shall be met in designing leach stockpiles at copper mine facilities unless the applicant or permittee can demonstrate that an alternate design will provide an equal or greater level of containment.

(1) New leach stockpiles. New leach stockpiles shall meet the following requirements.

(a) Liner system. A new leach stockpile shall be placed on an engineered liner system consisting of a subgrade and compacted earthen liner overlain by a synthetic liner which is overlain by a solution collection system designed to transmit process fluids out of the leach stockpile. The liner system shall be approved by the department prior to installation and shall be installed in accordance with a department approved Construction Quality Assurance/Construction Quality Control (CQA/CQC) plan pursuant to Paragraph (1) of Subsection C of 20.6.7.17 NMAC.

(b) Liner system subgrade and earthen liner. A liner system earthen liner shall be prepared and placed upon a stable subgrade. The prepared earthen liner shall consist of a minimum of 12 inches of soil that has a minimum re-compacted in-place coefficient of permeability of 1x10-6 cm/sec. The top surface of the earthen liner shall be smooth and free of sharp rocks or any other material that could penetrate the overlying synthetic liner.

(c) A synthetic liner for a leach stockpile shall provide the same or greater level of containment, including permeability, as a 60 mil HDPE geomembrane liner system. The liner system's tensile strength, tear and puncture resistance and resistance to degradation by ultraviolet light shall be compatible with design loads, exposures and conditions. A licensed New Mexico professional engineer with experience in liner system construction and installation shall identify the basis for the geomembrane composition and specific liner based upon:

(i) the type, slope and stability of the subgrade;

(ii) the overliner protection and provisions for hydraulic relief within the liner system;

(iii) the load and the means of applying the load on the liner system;

(iv) the compatibility of the liner material with process solutions applied to the leach stockpile and temperature extremes of the location at which it will be installed; and

(v) the liner's ability to remain functional for five years after the implementation.

(d) Solution collection system. A solution collection system shall be constructed in an overliner protection and drainage system. The solution collection system shall be designed to remain functional for five years after the operational life of the leach stockpile. The overliner protection shall be designed and constructed to protect the synthetic liner from damage during loading and minimize the potential for penetration of the synthetic liner. A sloped collection system shall be designed that will transmit fluids out of the drainage layer of the leach stockpile. The collection system shall be designed to maintain a hydraulic head of less than the thickness of the drainage layer but the drainage layer shall not exceed five feet in thickness. Any penetration of the liner by the collection system through which a pipe or other fixture protrudes shall be constructed in accordance with the liner manufacturer's requirements. Liner penetrations shall be detailed in the construction plans and as-built drawings.

(e) Solution containment systems. PLS flows exiting the leach stockpile shall be collected, contained and conveyed to a process water impoundment(s) or tank(s) using pipelines or lined conveyance systems.

(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 maximize 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. [88]"

Rationale

EPA has determined that a liner designed to minimize/eliminate releases from the unit based on site specific conditions is a necessary risk reduction measure that should be a specific minimum standard for heap and dump leach piles. The requirement for a liner designed to minimize/ eliminate releases from the unit based on site specific conditions is a recognized BMP for heap leach piles, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for a liner is consistent with those requirements for heap leach piles.

[88] NMAC 20.6.7.20: REQUIREMENTS FOR LEACH STOCKPILES AND SX/EW PLANTS: A. Engineering design requirements.

5. Tailings Storage Facilities

This section describes the proposed specific minimum standard for Tailings Storage Facilities, potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases, and for subsections of the standard, current BMPs and the rationale for the specific minimum standard.

Tailings Storage Facilities Specific Minimum Standard

To satisfy **the tailings category** component in paragraph (b)(1)(v):

(i) A plan to address public safety by prevention of public access by means of security fencing, or other effective methods.

(ii) A plan to regrade surface during closure to a stable configuration that prevents ponding and promotes the conveyance of surface water off the unit, and that requires closure of all tailings impoundments and stacks considered to be critical structures to be designed for a long-term static factor of safety of 1.5 or greater and all non-critical structures to be designed for a long-term static factor of safety of 1.3 or greater; and requires that the units being closed be designed for a factor of safety of 1.1 or greater under pseudostatic analysis. The plan must also provide for a stability analysis to be conducted for the unit and include evaluation for static and seismic induced liquefaction.

(iii*)* A plan for the management of all stormwater and sediment generated during reclamation and following closure. The plan must include permanent stormwater conveyances, ditches, channels, and diversions, as necessary, designed to convey the peak flow and ponds and other collection devices. For existing units, the plan must provide for controls to be designed to store the volume generated during a 24-hour period by a 100-year return interval storm event; for units that become authorized to operate after the effective date of this rule, the plan must provide for controls designed to store the volume generated during a 24-hour period by a 200-year return interval storm event.

(iv) A plan for the minimization, prevention, or collection and treatment of discharges and/or seepage, based on site hydrology and water quality characterization information, that provides for a cover system of, at a minimum, a store and release earthen cover system with a thickness of at least 12 inches and, if necessary, additional source controls or capture and treatment at closure, all of which meet a minimum 200-yr life design criteria. If seepage water quality is not expected to meet applicable water quality standards, the plan must provide for:

   (A) implementation of an engineered cover system designed to achieve at least a 95 percent reduction in annual net-percolation based on the long-term average and reduce seepage discharges to meet applicable water quality standards;

(B) a capture and treatment system designed to achieve at least a 95 percent capture efficiency and meet applicable water quality standards; or combination of an engineered cover system and a capture and treatment system to achieve at least a 95 percent reduction in discharged load and meet applicable water quality standards, or

(C) a solution containment system to assure seepage flows are collected, contained, conveyed, and treated to achieve at least a percent reduction to meet applicable water quality standards.

(v) A liner designed to minimize/eliminate releases from the unit based on site specific conditions.

(vi) If prevention/avoidance is relied on, a management plan that demonstrates geochemically active materials will effectively be avoided, and that includes provisions for sampling and monitoring documentation.

(vii) If a wet tailings impoundment is present:

(A) a requirement to develop and implement a Tailings Operations, Maintenance and Surveillance (TOMS) manual, or similar plan, that defines and describes roles and responsibilities of personnel assigned to the facility; procedures and processes for managing change; the key components of the facility; procedures required to operate, monitor the performance of, and maintain a facility to ensure that it functions in accordance with its design, meets regulatory and corporate policy obligations, and links to emergency planning and response; downstream notification; and, requirements for analysis and documentation of the performance of the facility.

(B) Annual tailings inspection reports by a qualified engineer, and an inspection report by an independent qualified engineer at least every five years.

(6) To satisfy the process pond and reservoir category component in paragraph (b)(1)(vi):

(i) A plan to address public safety by prevention of public access by means of security fencing, or other effective methods.

(ii) A plan for the design and operation of such ponds and reservoirs to ensure they have adequate freeboard and are designed to prevent discharges of hazardous substances.

(iii) A liner and collection system designed to minimize/eliminate releases from the unit based on site specific conditions.

(iv) A requirement that sludge and the sub-base below the liner be sampled and addressed in a manner that is protective of human health and the environment as part of closure.

Potential Sources and Releases and Management Practices

Potential sources and releases of CERCLA hazardous substances from cyanide and acid leaching associated with tailings facilities, and management practices, are provided in Appendix A, Table A3. Cyanide Heap Leaching and Table A4. Acid Dump Leaching. Additional potential sources and releases of CERCLA hazardous substances from tailings facilities, and management practices, are provided in Appendix A, Table A5. Tailings Storage Facilities.

Tailings containing leach solution from cyanide and acid leaching that is accidentally discharged as a result of accidents, spills, liner and other containment punctures and breaches, together with closed tailings facilities, is a primary source of MIW containing cyanide and leached metals from hardrock mine sites.. Tailings may also be long-term sources of MIW, including AMD, at hardrock mine sites. Source characterization is key to prevention and/or management of MIW/AMD during the entire mining life-cycle from exploration and development, during operations, reclamation, and post-closure. Management practices for mitigation of MIW/AMD include a variety of methods including avoidance, source controls and capture and treatment.

Mercury releases can be an issue associated with cyanide leach tailings. Radon radiation may be an issue associated with acid leach tailings.

Tailings Storage Facilities Subsection (i)

Proposed Specific Minimum Standard

(i) A plan to address public safety by prevention of public access by means of security fencing, or other effective methods.

Current BMPs

See **Waste Rock Piles Subsection (i)** for applicable BMPs.

Rationale

The requirement for measures to address public safety is a recognized BMP, as evidenced by its widespread inclusion in federal and state hardrock regulations. The proposed specific minimum standard for tailings storage facilities is consistent with those requirements.

Tailings Storage Facilities Subsection (ii)

Proposed Specific Minimum Standard

(ii) Requirements to regrade surface during closure to a stable configuration that prevents ponding and promotes the conveyance of surface water off the unit, and that requires closure of all waste rock piles considered to be critical structures to be designed for a long-term static factor of safety of 1.5 or greater and all non-critical structures to be designed for a long-term static factor of safety of 1.3 or greater; and requires that the units being closed be designed for a factor of safety of 1.1 or greater under pseudostatic analysis. The plan must also provide for a stability analysis to be conducted for the unit and include evaluation for static and seismic induced liquefaction.

Current BMPs

See **Waste Rock Piles Subsection (iv-v)** for applicable BMPs.

Following the catastrophic Mount Polley mine tailings breach in August 2014, the Canadian province of British Columbia developed and recently (August 2016) released new British Columbia Health, Safety and Reclamation Code Mine Tailings Part 10 Revisions (BC Revisions) and guidance[89] to address the recommendations of the Independent Expert Engineering Investigation and Review Panel's, Report on Mount Polley Tailings Storage Facility Breach.[90] The recommendations contained in the report made by the highly regarded Panel were intended to address the measures necessary to minimize the risk from existing mine tailings storage facilities (TSFs) and to ensure "zero risk" of similar failures at future TSFs.

Similar U.S. regulations and guidance have not been updated or revised to reflect the Panel recommendations except in the case of the State of Montana as noted herein, although in some state's State Engineer's and other offices responsible for dam safety provide similar regulations and guidance.

The Panel recommendations are grouped into the following seven areas:

1. Implement Best Available Practices and Best Available Technologies using a phased approach,
2. Improve corporate governance,
3. Expand corporate design commitments,
4. Enhance validation of safety and regulation of all phases of a TSF,
5. Strengthen current regulatory operations,
6. Improve professional practice, and
7. Improve dam safety guidelines

Appendix B, Table B1 summarizes the Panel Recommendations, British Columbia regulatory revisions, Montana's Metal Mine Reclamation Act tailings provisions enacted in 2015, and the

[89] British Columbia, Guidance Document: Health, Safety and Reclamation Code for Mines in British Columbia (July 2016).

[90] "Mount Polley Independent Expert Investigation and Review Report," Mount Polley Review Panel. Available at: https://www.mountpolleyreviewpanel.ca/.

existing regulations for the New Mexico Office of the State Engineer, which typify current state regulations addressing mine TSFs.

Rationale

EPA has determined that evaluating stability for critical structures is a necessary risk reduction measure that should be a specific minimum standard for tailings storage facilities. EPA chose the factors of safety and the requirement for a stability analysis as a conservative approach consistent with existing BMPs. The requirement for measures to address stability is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for tailings storage facilities is consistent with those requirements.

Tailings Storage Facilities Subsection (iii)

Proposed Specific Minimum Standard

(iii) A plan for the management of all stormwater and sediment generated during operations and during and following closure. For existing units, the plan must provide for permanent stormwater conveyances, ditches, channels and diversions designed to convey the peak flow and ponds and other collection devices designed to store the volume generated during a 24-hour period by a 100-year return interval storm event. For unit that become authorized to operate after the effective date of this rule, the plan must provide for controls designed to store the volume generated during a 24-hour period by a 200-year return interval storm event.

Current BMPs

See **Waste Rock Piles Subsection (vi)** for applicable BMPs.

Also, see **Appendix B, Table B1.**

Rationale

EPA has determined that stormwater management is a necessary risk reduction measure that should be a specific minimum standard for tailings storage facilities. EPA chose the 100-year return interval storm event for existing mines as a conservative approach consistent with existing BMPs. EPA chose the 200-year interval storm event for new mines as a similarly conservative approach based on the consideration of climate change and other factors. The requirement for measures to address stormwater is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for tailings storage facilities is consistent with those requirements.

Tailings Storage Facilities Subsection (iv) (Part 1)

Proposed Specific Minimum Standard

(vii) A plan for the minimization, prevention, or collection and treatment of discharges and/or seepage, based on site hydrology and water quality characterization information, that provides for a cover system of, at a minimum, a store and release earthen cover system with a thickness of at least 12 inches and, if necessary, additional source controls or capture and treatment at closure, all of which meet a minimum 200-yr life design criteria. If seepage water quality is not expected to meet applicable federal and state groundwater and surface water quality standards at the point of compliance, the plan must provide for:

(A) implementation of an engineered cover system designed to achieve at least a 95 percent reduction in annual net-percolation based on the long-term average and reduce seepage discharges to meet applicable water quality standards;

(B) a capture and treatment system designed to achieve at least a 95 percent capture efficiency and meet applicable water quality standards; or combination of an engineered cover system and a capture and treatment system to achieve at least a 95 percent reduction in discharged load and meet applicable water quality standards, or

(C) a solution containment system to assure seepage flows are collected, contained, conveyed, and treated to achieve at least a percent reduction to meet applicable water quality standards.

Current BMPs

See **Waste Rock Piles Subsection (vii)** for applicable BMPs.

New Mexico requires:

"(4) New tailings impoundments. Tailings impoundments shall be designed according to the following requirements.

(a) Stormwater run-on shall be diverted and/or contained to minimize contact between stormwater run-on and the tailing material.

(b) Seepage from the sides of a tailing impoundment shall be captured and contained through the construction of headwalls, impoundments and diversion structures as applicable.

(c) Ground water impacted by the tailing impoundment in excess of applicable standards shall be captured and contained through the construction of interceptor systems designed in accordance with Subparagraph (d) of Paragraph (4) of Subsection A of 20.6.7.22 NMAC.

(d) The applicant shall submit design plans signed and sealed by a licensed New Mexico professional engineer along with a design report that includes the following.

(i) The annual volumes and daily maximum design rates of tailings or other discharge approved by the department to be deposited in the impoundment.

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

(iii) The geology of the site.

(iv) The design footprint of the tailing impoundment.

(v) The design of tailing seepage collection systems, to be proposed based on consideration of site-specific conditions.

(vi) The design of stormwater diversion structures to minimize contact between stormwater run-on and the tailing material. The design shall consider the amount, intensity, duration and frequency of precipitation; watershed characteristics including the area, topography, geomorphology, soils and vegetation of the watershed; and run-off characteristics of the watershed including the peak rate, volumes and time distribution of run-off events.

(vii) An aquifer evaluation to determine the potential nature and extent of impacts on ground water from the tailings impoundment based on the proposed tailings impoundment design. The aquifer evaluation shall include a complete description of aquifer characteristics and hydrogeologic controls on movement of tailing drainage and ground water impacted by the tailings impoundment.

(viii) A design report for a proposed interceptor system for containment and capture of ground water impacted by the tailings impoundment based on the aquifer evaluation required in Subparagraph (d) of Paragraph (4) of Subsection A of this section. The design report shall include, at a minimum construction drawings and interceptor system performance information, recommended equipment including pumps and meters, recommended pump settings and pumping rates, methods for data collection, and a demonstration that the permittee has adequate water rights to operate the system as designed. The design report shall include a demonstration that interceptor system design will capture ground water impacted by the tailings impoundment such that applicable standards will not be exceeded at monitoring well locations specified by 20.6.7.28

NMAC. The interceptor system shall be designed to maximize capture of impacted ground water and minimize the extent of ground water impacted by the tailings impoundment.

(ix) Within 120 days of seepage collection and interceptor well system construction, or liner system installation a final report shall be submitted to the department that includes complete as-built drawings and a summary of how the items in Subparagraph (a) thru Subparagraph (d) of Paragraph (4) of Subsection A of 20.6.7.22 NMAC were incorporated into the design.

(e) If the department determines that the proposed tailings impoundment, seepage collection and interceptor systems when constructed and operated in accordance with the design plan specified in this paragraph would cause ground water to exceed applicable standards at monitoring well locations specified by 20.6.7.28 NMAC, the department shall require additional controls, which may include but are not limited to, a liner system as additional conditions in accordance with Subsection I of 20.6.7.10 NMAC.

(5) New dry stack tailing piles. New dry stack tailings piles shall comply with the material characterization, engineering design, construction, and operational requirements of 20.6.7.21 NMAC, as applicable.[91]"

Rationale

EPA has determined that characterization and mitigation by various means is a necessary risk reduction measure that should be a specific minimum standard for tailings storage facilities. EPA chose the 200-year design life as a conservative approach consistent with existing BMPs. The requirement to characterize and mitigate tailings storage facilities is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for tailings storage facilities is consistent with those requirements.

Tailings Storage Facilities Subsection (v)

Proposed Specific Minimum Standard

(v) A liner designed to minimize/eliminate releases from the unit based on site specific conditions.

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[91] NMAC 20.6.7.22: REQUIREMENTS FOR COPPER CRUSHING, MILLING, CONCENTRATOR, SMELTING AND TAILINGS IMPOUNDMENT UNITS:

Current BMPs

See **Heap and Dump Leach Piles Subsection (v)** for application of BMPs.

Rationale

EPA has determined that a liner designed to minimize/eliminate releases from the unit based on site specific conditions is a necessary risk reduction measure that should be a specific minimum standard for tailings storage facilities. The requirement for a liner designed to minimize/ eliminate releases from the unit based on site specific conditions is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for a liner is consistent with those requirements.

Tailings Storage Facilities Subsection (vi)

Proposed Specific Minimum Standard

(vi) If prevention/avoidance is relied on, a management plan that demonstrates geochemically active materials will effectively be avoided, and that includes provisions for sampling and monitoring documentation.

Current BMPs

Waste Rock Piles Subsection (ii) for applicable BMPs.

Rationale

This proposed specific minimum standard is intended to provide an opportunity for mines that do not mine or produce as waste products materials that contain hazardous substances, to perform geochemical characterization to identify themselves. This would remove any requirements for mitigation related to water quality described in other sections. Mines that use cyanide or acid leaching or other hazardous substances that are contained in the tailings storage facility would be exempt from claiming compliance with this standard.

Tailings Storage Facilities Subsection (vii)

Proposed Specific Minimum Standard

(vii) If a wet tailings impoundment is present:

(A) a requirement to develop and implement a TOMS manual, or similar plan, that defines and describes roles and responsibilities of personnel assigned to the facility; procedures and processes for managing change; the key components of the facility; procedures required to operate, monitor the performance of, and maintain a facility to ensure that it functions in accordance with its design, meets regulatory and corporate policy obligations, and links to emergency planning and response; downstream notification; and, requirements for analysis and documentation of the performance of the facility.

(B) Annual tailings inspection reports by a qualified engineer, and an inspection report by an independent qualified engineer at least every five years.

Current BMPs

See **Tailings Storage Facilities Subsection (ii)** for BMPs.

Appendix B Table B1 summarizes the Panel Recommendations, British Columbia regulatory revisions, MMRA tailings provisions enacted in 2015, and the existing regulations for the New Mexico Office of the State Engineer, which typify current state regulations addressing mine TSFs.

New Mexico requires:

"C. Operational Requirements.

(1) Tailings impoundment operating requirements. A permittee operating a tailings impoundment shall operate the impoundment pursuant to the following requirements.

(a) The tailings impoundment shall remain within the area identified in the approved design.

(b) The perimeter of the tailings impoundment and any associated solution collection systems shall be inspected monthly.

(c) Any evidence of instability in the tailings impoundment that could potentially result in a dam failure and an unauthorized discharge shall be reported to the department as soon as possible, but not later than 24 hours after discovery.

(d) Any leaks or spills outside the tailings impoundment and any associated containment system shall be recorded and reported pursuant to 20.6.2.1203 NMAC.

(e) If seeps occur, they shall be monitored on a monthly basis and an estimate of the seep flow rate shall be made. Monthly records of the seep inspections and flow rates shall be maintained and included in the site monitoring reports.

(f) The monthly volume of tailings placed in the impoundment shall be recorded, maintained, and included in the site monitoring reports.

(g) Tailings deposition rates shall not exceed the maximum rates approved in the discharge permit.

(h) The daily tailings deposition and associated solution system collection rate shall be determined using flow meters installed in accordance with Paragraph (5) of Subsection C of 20.6.7.17 NMAC.

(i) The average daily rate and monthly volume of tailings deposited and solution collected shall be recorded, maintained, and included in the site monitoring reports.

(j) The placement of tailings and effluent shall be in accordance with an operating plan that describes the following:

- (i) the sequencing of tailings deposition on an annual basis;
- (ii) measures to manage the surface impoundment area to maintain adequate freeboard;
- (iii) operation of seepage collection systems;
- (iv) operation of interceptor systems;
- (v) operation of systems to return water to the concentrator or other locations as appropriate; and
- (vi) any other water management features.

(k) If an interceptor system to maintain capture of ground water impacted by a tailings impoundment exists on the effective date of the Copper Rule, the permittee shall submit an interceptor system monitoring and evaluation report pursuant to 20.6.7.29 NMAC.[92]"

Rationale

EPA has determined that a TOMS Manual and independent engineering inspection, designed to minimize/eliminate releases from tailings storage facilities based on site specific conditions, is a necessary risk reduction measure that should be a specific minimum standard for tailings storage facilities. The requirement for TOMS Manual and independent engineering inspection to minimize/ eliminate releases from the unit based on site specific conditions is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for a TOMS Manual and independent engineering inspection is consistent with those requirements.

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[92] NMAC 20.6.7.22: REQUIREMENTS FOR COPPER CRUSHING, MILLING, CONCENTRATOR, SMELTING AND TAILINGS IMPOUNDMENT UNITS:

6. Process Ponds and Reservoirs

This section describes the proposed specific minimum standard for Process Ponds and Reservoirs, potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases, and for subsections of the standard, current BMPs and the rationale for the specific minimum standard.

Process Ponds and Reservoirs Specific Minimum Standard

To satisfy **the process pond and reservoir category** component in paragraph (b)(1)(vi):

(i) A plan to address public safety by prevention of public access by means of security fencing, or other effective methods.

(ii) A plan for the design and operation of such ponds and reservoirs to ensure they have adequate freeboard and are designed to prevent discharges of hazardous substances.

(iii) A liner and collection system designed to minimize/eliminate releases from the unit based on site specific conditions.

(iv) A requirement that sludge and the sub-base below the liner be sampled and addressed in a manner that is protective of human health and the environment as part of closure.

Potential Sources and Releases and Management Practices

Potential sources and releases of CERCLA hazardous substances from process ponds and reservoirs associated with cyanide and acid leaching, and management practices, are provided in Appendix A, Table A3. Cyanide Leaching and Table A4. Acid Leaching.

Process ponds and reservoirs containing leach solution from cyanide and acid leaching that is accidentally discharged as a result of accidents, spills, liner and other containment punctures and breaches, together with spent leach piles, is a primary source of MIW containing cyanide and leached metals from hardrock mine sites. Engineered liner systems using redundant liners and leak collection systems have effectively been used together with proper disposal of pond sludge and residues to mitigate MIW..

Process Ponds and Reservoirs Subsection (i)

Proposed Specific Minimum Standard

(i) A plan to address public safety by prevention of public access by means of security fencing, or other effective methods.

Current BMPs

See **Waste Rock Piles Subsection (i)** for applicable BMPs.

Rationale

The requirement for measures to address public safety is a recognized BMP, as evidenced by its widespread inclusion in federal and state hardrock regulations. The proposed specific minimum standard for process ponds and reservoirs is consistent with those requirements.

Process Ponds and Reservoirs Subsection (ii)

Proposed Specific Minimum Standard

(ii) A plan for the design and operation of such ponds and reservoirs to ensure they have adequate freeboard and are designed to prevent discharges of hazardous substances.

Current BMPs

This standard is supported by current federal and state requirements and other relevant guidance in the U.S., including, for example: FEMA's guidelines for inflow design floods for dams[93]; and US DOI freeboard criteria.[94]

In addition, BLM requires:

> "The operator must design, construct, and operate cyanide or other leaching facilities and impoundments to contain precipitation from the local 100-year, 24-hour storm event in addition to the maximum process solution inventory. The containment must include allowances for snowmelt events and draindown from heaps during power outages in the design.
>
> The 100-year, 24-hour storm event is a site-specific standard. Obtaining precipitation data for the project area, or extrapolating the design event based on existing data, is a critical step in establishing the design criteria at the project locale in order to meet this performance standard.
>
> The facility layout must route upgradient run-on waters around or under the process or wastewater facility so the precipitation does not enter the containment system during the design storm event. Ideally, the only water entering the system would be from direct precipitation. Modeling of precipitation, evaporation, water loss, and the addition of make-up water should be conducted to determine the amount of storage available throughout the anticipated life of the mine facility.[95]

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[93] FEMA (Federal Emergency Management Agency). 2013. *Selecting and Accommodating Inflow Design Floods for Dams*. FEMA P-94. August.

[94] US DOI (Department of the Interior). 1981. *ACER Technical Memorandum No. 2: Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams*. December.

[95] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.12.3: Containment Requirements, p. 5-24.

Post-reclamation diversion ditches or drains are constructed up gradient to prevent surface run-on from entering cyanide facilities. The structures should be designed to divert at least the anticipated run-on from the 100-year, 24-hour storm event or spring snowmelt. ·For facilities located in extremely sensitive areas it may be necessary to size diversion structures capable of handling the maximum probable flood event.[96]"

Arizona has guidance related to process ponds and reservoirs for:

- Site Characterization
- Surface Water Control
- Geologic Hazards.[97]

See also Arizona BADCT guidance Section 2.3 PROCESS SOLUTION PONDS.

New Mexico requires:

"(2) Impoundment capacity. Impoundments shall meet the following design capacities. Capacity requirements may be satisfied by a single impoundment or by the collective capacity of multiple interconnected impoundments and any interconnected tanks.

(a) Capacity requirements for impoundments that contain leach solutions. Process water systems that impound leach solutions shall be designed for adequate overflow capacity for upset conditions such as power outages, pump or conveyance disruptions and significant precipitation events. Any impoundment that collects leach solutions and is routinely at capacity shall be designed to maintain a minimum of two feet of freeboard during normal operating conditions while conveying the maximum design process flows. The appropriate overflow capacity design shall consider system redundancies such as backup power systems and pumps. The overflow capacity shall be designed to contain the maximum design flows for the collection system for the maximum period of time that is required for maintenance activities or restoration to normal operating conditions while maintaining two feet of freeboard. If the collection system receives direct precipitation run-off with little or no flow attenuation in the upgradient leach stockpile collection system, the overflow capacity shall be sized to contain the runoff from a 100 year, 24 hour storm event in addition to the upset condition capacity. For process water impoundments located within the open pit surface drainage area, the open pit bottom may

[96] U.S. Department of the Interior, Bureau of Land Management, Solid Minerals Reclamation Handbook H-3042-1, (Washington, DC: U.S. Government Printing Office, 1992), p. VIII-40.

[97] Arizona Department of Environmental Quality, Arizona Mining Guidance Manual: Best Available Demonstrated Control Technology - Aquifer Protection Program (2001), 2.2.1 Siting Criteria, p. 2-5, -6.

be utilized for a portion of the permitted impoundment capacity. Impoundments constructed on a leach stockpile such that any overflow would discharge to and be contained by the approved leach stockpile system are not subject to this capacity requirement.

(b) Other process water impoundment capacity requirements. Process water impoundments intended to manage or dispose of process water, other than leach solutions, shall be designed for adequate overflow capacity for upset conditions such as power outages, pump or conveyance disruptions and significant precipitation events. Any impoundment that collects such process water and is routinely at capacity shall be designed to maintain a minimum of two feet of freeboard during normal operating conditions while conveying. the maximum design process flows. The appropriate overflow capacity design shall consider system redundancies such as backup power systems and pumps. The overflow capacity shall be designed to contain the maximum design flows for the collection system for the maximum period of time that is required for maintenance activities or restoration to normal operating conditions while maintaining two feet of freeboard. For process water impoundments located within the open pit surface drainage area, the open pit bottom may be utilized for a portion of the permitted impoundment capacity. Impoundments constructed on a leach stockpile such that any overflow would discharge to and be contained by the approved leach stockpile system are not subject to this capacity requirement.

(c) Combination process water/impacted stormwater impoundment capacity requirements. Impoundments, other than impoundments for the containment of leach solutions, intended to dispose of a combination of process water and impacted stormwater shall be designed to contain, at a minimum, the volume described in Subparagraph (b) of Paragraph 2 of this subsection and the volume of stormwater runoff and direct precipitation generated from the receiving surface area resulting from a 100 year return interval storm event while preserving two feet of freeboard. For combination process water/impacted stormwater impoundments located within the open pit surface drainage area, the open pit bottom may be utilized for a portion of the impoundment capacity.[98]"

[98] NMAC 20.6.7.17: GENERAL ENGINEERING AND SURVEYING REQUIREMENTS:

Rationale

EPA has determined that a design and operation of process ponds and reservoirs to ensure they have adequate freeboard, and are designed to prevent discharges of hazardous substances to minimize/eliminate releases from process ponds and reservoirs based on site specific conditions, is a necessary risk reduction measure that should be a specific minimum standard for process ponds and reservoirs. The requirement for design and operation of process ponds and reservoirs to ensure they have adequate freeboard and are designed to prevent discharges of hazardous substances to minimize/ eliminate releases from the unit based on site specific conditions is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for design and operation of process ponds and reservoirs to ensure they have adequate freeboard and are designed to prevent discharges of hazardous substances is consistent with those requirements.

Process Ponds and Reservoirs Subsection (iii)

Proposed Specific Minimum Standard

(iii) A liner and collection system designed to minimize/eliminate releases from the unit based on site specific conditions.

Current BMPs

See **Section 6.7.1 Heap and Dump Leach Piles Subsection (v)** for application of BMPs.

Rationale

EPA has determined that a liner designed to minimize/eliminate releases from process ponds and reservoirs based on site specific conditions is a necessary risk reduction measure that should be a specific minimum standard for process ponds and reservoirs. The requirement for a liner designed to minimize/ eliminate releases from the unit based on site specific conditions is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for a liner is consistent with those requirements.

Process Ponds and Reservoirs Subsection (iii)

Proposed Specific Minimum Standard

(iv) A requirement that sludge and the sub-base below the liner be sampled and addressed in a manner that is protective of human health and the environment as part of closure.

Current BMPs

BLM requires, "The reclamation plan must address how the operator will deal with potentially toxic materials. Such material may be isolated from mobilizing agents such as air and water, removed to an alternate location where isolation or treatment can be achieved, or controlled through a variety of treatment or mitigating measures. Isolation includes measures such as covering or burying to prevent materials from becoming windborne or to limit contact with precipitation. Isolation also includes prevention of run-on waters from entering the toxic material, mobilizing contaminants, and causing a release to the environment.[99]

All operators must comply with applicable federal and state water quality standards, including the Federal Water Pollution Control Act, as amended.[100]"

Arizona guidance recommends:

> "Any residues or sludges remaining following discharge must be analyzed for applicable waste listing prior to disposal at an approved site. The following are example elements of a closure strategy (A.R.S. 49-243.A.8) for a Prescriptive BADCT Non-Storm Water Pond:
>
> - Excavated Ponds
>   - Removal and appropriate disposal of solid residue on the liner.
>   - Inspection of synthetic liner for evidence of holes, tears or defective seams that could have leaked.
>   - If there is no evidence of past leakage, the synthetic liner can be folded in place and covered by filling the excavation or removed for appropriate disposal elsewhere.
>   - Where inspection reveals presence of one or more holes or tears or defective seams, the synthetic liner is to be removed, and the underlying surface inspected for visual signs of impact. The ADEQ may require sampling and analysis of the underlying material to determine whether it poses a threat to groundwater quality.
>   - If required, conduct soil remediation to prevent groundwater impact.
>   - After the residual soil conditions are approved by ADEQ, the synthetic liner material can be placed back into the excavation or be removed for appropriate disposal elsewhere, and the excavation backfilled.

[99] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.3.2.3: Isolate, Remove, or Control Toxic Materials, p. 5-11.

[100] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.5: Water Quality, p. 5-15.

- The filled area will be graded to drain surface run-off and minimize precipitation infiltration.
- Capping of the pond area with a low permeability cover may also be part of a closure strategy if it will achieve further discharge reduction that maintains compliance with Arizona Water Quality Standards at the point of compliance.

Bermed Ponds

- Closure as for excavated ponds with the following exception: the synthetic liner will not be buried within the pond area and must be appropriately disposed of elsewhere.[101]"

See also AZ BADCT Section 2.3 PROCESS SOLUTION PONDS.

New Mexico requires:

"I. Impoundments. The permittee shall close all reservoirs and impoundments in a manner that ensures that the requirements of the Water Quality Act, commission rules and the discharge permit are met. Closure activities shall meet the following requirements:

(1) Fluids from reservoirs and impoundments shall be drained and appropriately disposed of.

(2) Sediments in the reservoir or impoundment shall be characterized and abated or appropriately disposed of in a manner that will not cause an exceedance of applicable standards.

(3) Materials underlying the reservoir or impoundment shall be characterized to determine if releases of water contaminants have occurred.

(4) Where characterization results show materials remaining within or beneath any reservoir or other impoundment that are not naturally occurring to be a source or potential source of ground water contamination outside the open pit surface drainage area, the reservoir or impoundment, shall be covered and re-vegetated pursuant to this section.

(5) Based on the characterization conducted pursuant to Paragraph (4) of this subsection, further characterization of ground water beneath and adjacent to the reservoir or impoundment may be required to determine if abatement is necessary.

(6) Reservoirs and impoundments located outside the open pit surface drainage area shall be closed in a manner that creates positive drainage

[101] Arizona Department of Environmental Quality, Arizona Mining Guidance Manual: Best Available Demonstrated Control Technology - Aquifer Protection Program (2001), 2.2.4 Closure/Post-Closure Criteria, p. 2-10, -11.

> away from the impoundments, unless needed during closure and post closure for storm water retention or seepage interception, post-closure water management and treatment, or unless otherwise approved by the department. Post-closure reservoirs or impoundments to be used for the collection of non-impacted storm water and located over areas where residual wastes, vadose zone contamination or ground water contamination remains shall be synthetically lined pursuant to the design and construction criteria of Paragraph (4) of Subsection D of 20.6.7.17 NMAC. [102]"

Rationale

EPA has determined that sludge and the sub-base below the liner be sampled and addressed in a manner that is protective of human health and the environment as part of closure to minimize/ eliminate releases from process ponds and reservoirs based on site specific conditions. The requirement for sludge and the sub-base below the liner be sampled and addressed in a manner that is protective of human health and the environment as part of closure to minimize/eliminate releases from the unit based on site specific conditions is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for a liner is consistent with those requirements.

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[102] NMAC 20.6.7.33 E: Surface water management.

7. Slag Piles

This section describes the proposed specific minimum standard for Slag Piles, potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases, current BMPs, and the rationale for the specific minimum standard.

Slag Piles Specific Minimum Standard

To **satisfy the slag pile category** component in paragraph (b)(1)(iv):

(i) A plan to address public safety by prevention of public access by means of security fencing, or other effective methods.

(ii) If prevention/avoidance is relied on, a management plan that demonstrates geochemically active materials will effectively be avoided, and that includes provisions for sampling and monitoring documentation.

(iii) Requirements for concurrent or sequential reclamation of mined areas as they become available prior to final cessation of operations and closure.

(iv) Requirements to regrade surface during closure to a stable configuration that prevents ponding and promotes the conveyance of surface water off the unit, and that requires closure of all waste rock piles considered to be critical structures to be designed for a long-term static factor of safety of 1.5 or greater and all non-critical structures to be designed for a long-term static factor of safety of 1.3 or greater; and requires that the units being closed be designed for a factor of safety of 1.1 or greater under pseudostatic analysis.

(v) Requirements to provide for a stability analysis to be conducted for the unit as part of the original design, and as part of mine modifications during the active life of the mine.

(vi) A plan for the management of all stormwater and sediment generated during operations and during and following closure. For existing units, the plan must provide for permanent stormwater conveyances, ditches, channels and diversions designed to convey the peak flow and ponds and other collection devices designed to store the volume generated during a 24-hour period by a 100-year return interval storm event. For unit that become authorized to operate after the effective date of this rule, these plans must provide for controls designed to store the volume generated during a 24-hour period by a 200-year return interval storm event.

(vii) A plan for the minimization, prevention, or collection and treatment of discharges and/or seepage, based on site hydrology and water quality characterization information, that provides for a cover system of, at a minimum, a store and release earthen cover system with a thickness of at least 12 inches and, if necessary, additional source controls or capture and treatment at closure, all of which meet a minimum 200-yr life design criteria. If seepage water quality is not expected to meet applicable federal and state groundwater and surface water quality standards at the point of compliance, the plan must provide for:

(A) implementation of a containment system that immobilizes hazardous substances to meet applicable water quality standards (e.g., an engineered cover system designed to achieve, at a minimum, a 95 percent reduction in annual net-percolation based on the long-term average to reduce seepage discharges to meet applicable water quality standards;

(B) a capture and treatment system designed to achieve at least a 95 percent capture efficiency and meet applicable water quality standards; or combination of an engineered cover system and a capture and treatment system to achieve at least a 95 percent reduction in discharged load and meet applicable water quality standards at the point of compliance, or

(C) a solution containment system to assure seepage flows are collected, contained, conveyed, and treated to achieve at least a 95 percent reduction to meet applicable water quality standards.

Potential Sources and Releases and Management Practices

Potential sources and releases of CERCLA hazardous substances for slag piles are provided in Appendix A, Table A6. Slag Piles.

Slag Piles can be a primary source of MIW at hardrock mine sites.[103] Management practices for mitigation of MIW from slag piles include a variety of methods similar to those for waste rock including avoidance, management of waste and disposal into engineered repositories, construction of engineered liners and covers, and methods such as recycling back to the mining facility.[104] In addition to source controls, groundwater and surface water capture and treatment may also be used to mitigate MIW. It is notable that a high percentage of smelters that produced slag in the U.S. have become CERCLA sites.

Current BMPs

No technical references for slag mitigation was identified in the literature. However, most cleanups that have been proposed or performed used soil or engineered covers and/or groundwater and surface water capture and treatment.

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[103] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 4.3.2.3: Testing Program Overview

[104] "Stillwater Mining Company Reports First Quarter 2016 Results," Stillwater Mining Company. Available at: http://investorrelations.stillwatermining.com/phoenix.zhtml?c=99837&p=irol-newsArticle&ID=2166021.

Most States do not include smelting activities as part of their hardrock mining reclamation and closure requirements. The exception is New Mexico which specifically requires the following for slag piles:

"(3) New smelting units. New smelting units shall be designed to contain and manage on impermeable surfaces all materials, including associated slag and flue dust, containing water contaminants that have the potential to migrate to ground water and cause an exceedance of applicable standards.[105]

(2) Smelting units. A permittee operating a smelting unit shall operate pursuant to the following requirements.

  (a) The smelting unit shall remain within the area identified in the discharge permit.

  (b) Slag and flue dust generated as a result of smelting activities shall be characterized, managed, and properly stored and disposed of.

  (c) Any leaks or spills outside the containment systems of the smelter unit shall be recorded and reported pursuant to 20.6.2.1203 NMAC.[106]"

Rationale

EPA has determined that mitigation by various means similar to that of waste rock is a necessary risk reduction measure that should be a specific minimum standard for slag piles. The requirement for slag piles to minimize/ eliminate releases from the unit based on site specific conditions is a recognized BMP, as evidenced by its application at CERCLA sites. The proposed specific minimum standard for mitigation of slag piles is consistent with those requirements.

Slag Piles Subsections (All)

See **Waste Rock Piles Subsections (i - vii)** for applicable BMPs.

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[105] NMAC 20.6.7.22: REQUIREMENTS FOR COPPER CRUSHING, MILLING, CONCENTRATOR, SMELTING AND TAILINGS IMPOUNDMENT UNITS: A. Engineering design requirements.

[106] NMAC 20.6.7.22: REQUIREMENTS FOR COPPER CRUSHING, MILLING, CONCENTRATOR, SMELTING AND TAILINGS IMPOUNDMENT UNITS: C. Operational Requirements.

8. Hazardous Materials Management

This section describes the proposed specific minimum standard for Hazardous Materials Management, potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases, current BMPs, and the rationale for the specific minimum standard.

Hazardous Materials Management Specific Minimum Standard

To satisfy **the solid and hazardous waste disposal** component in paragraph (b)(1)(viii):

(i) Requirements for disposal of all solid and hazardous wastes in a manner that is protective of human health and the environment and that is compliance with all applicable federal, state, and local requirements.

(ii) Requirements for contaminated soil disposal in a manner that is protective of human health and the environment and that is in compliance with all applicable federal, state, and local requirements.

(iii) Requirements to decontaminate buildings and structures to remove and safely dispose of hazardous substances.

Potential Sources and Releases and Management Practices

This requirement applies to all hazardous materials that are not beneficiation wastes excluded by the Bevill Exemption.[107] At most mine sites disposal of these types of materials is addressed by requirements established by the Resource Conservation and Recovery Act (RCRA). Aspects such as contaminated soil disposal and building decontamination are not addressed by RCRA requirements.

Hazardous materials can be a source of MIW at hardrock mine sites.[108] Management practices for mitigation of MIW from hazardous materials include a variety of methods similar to those for waste rock including avoidance, management of waste and disposal into engineered repositories, construction of engineered liners and covers, and methods such as recycling back to the mining facility.

Current BMPs

The BLM requires that, "It may also be necessary to have certain materials removed from the site for treatment and disposal. Lab wastes and sludge from process ponds are two examples of

[107] Van E. Housman, "The Scope of the Bevill Exclusion for Mining Wastes," *Environmental Law Reporter* 24:10657 (1994).

[108] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 4.3.2.3: Testing Program Overview.

materials that may not be suitable for onsite disposal. Certain tests are available to determine if the material requires special handling or disposal.[109] All operators must comply with applicable federal and state standards for the disposal and treatment of solid wastes, including regulations issued pursuant to the Solid Waste Disposal Act as amended by RCRA.[110] All operators must comply with applicable federal and state water quality standards, including the Federal Water Pollution Control Act, as amended."[111]

The USFS does not have explicit requirements for hazardous materials management, but does mention it with respect to reclamation tasks and financial assurance throughout guidance.[112]

Alaska's reclamation requirements note that "(d) This chapter **does not apply** to:

(1) **fuel spills, chemical neutralization, detoxification, or clean-up of hazardous substances used in mineral processing facilities associated with mining operations**."

Rationale

The requirement for measures to address hazardous materials management is a recognized BMP. However, most States assume that it will be prevented by RCRA requirements or otherwise excluded from reclamation and closure plan requirements, because it is not an anticipated task. However, it is notable that both the BLM and USFS recognize it as a part of hardrock mine reclamation and closure tasks. EPA's proposed specific minimum standard for hazardous materials management fills a gap in existing State regulations and is needed to reduce the risk from hazardous materials not otherwise addressed in reclamation and closure requirements.

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[109] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.3.2.3: Isolate, Remove, or Control Toxic Materials, p. 5-12.

[110] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.6: Solid Waste, p. 5-16.

[111] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.5: Water Quality, p. 5-15.

[112] U.S. Forest Service, Training Guide for Reclamation Bond Estimation and Administration for Mineral Plans of Operation Authorized and Administered under 36 CFR 228A (April 2004), p. 16, 26, 29, and 33.

9. Surface Water Drainage

This section describes the proposed specific minimum standard for Surface Water Drainage, potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases, current BMPs, and the rationale for the specific minimum standard.

Surface Water Drainage Specific Minimum Standard

To satisfy the **drainage category component in paragraph** (b)(1)(ix), For existing units, the plan must provide for permanent stormwater conveyances, ditches, channels and diversions designed to convey the peak flow and ponds and other collection devices designed to store the volume generated during a 24-hour period by a 100-year return interval storm event. For units that become authorized to operate after the effective date of this rule, the plan must provide for controls designed to store the volume generated during a 24-hour period by a 200-year return interval storm event.

Current BMPs

See **Waste Rock Piles Subsection (vi).**

Rationale

EPA has determined that surface water drainage is a necessary risk reduction measure that should be a specific minimum standard for tailings storage facilities. EPA chose the 100-year return interval storm event for existing mines as a conservative approach consistent with existing BMPs. EPA chose the 200-year interval storm event for new mines as a similarly conservative approach based on the consideration of climate change and other factors. The requirement for measures to address surface water drainage is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for surface water drainage is consistent with those requirements.

10. Short-term O&M

This section describes the proposed specific minimum standard for Short-term O&M, potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases, current BMPs and the rationale for the specific minimum standard.

Short-term O&M Specific Minimum Standard

To satisfy **the short-term O&M category component** in paragraph (b)(1)(x):

(i) A for groundwater and surface water monitoring to assure that monitoring wells are located to detect an exceedance(s) or trends towards exceedance(s) of the applicable standards, and are detected 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. The plan must be currently in effect and must cover a period of at least five years.

(ii) A plan for inspection and monitoring of erosion and revegetation to ensure reclamation success.

(iii) A plan for routine maintenance and repairs to roads, stormwater conveyances and collection devices and revegetation maintenance (e.g. weed controls) and repairs (e.g. areas of revegetation failure).

Potential Sources and Releases and Management Practices

Potential sources and releases of CERCLA hazardous substances and management practices from hardrock mine site-features have been described in previous sections. In order to monitor the effectiveness of the management practices applied, groundwater and surface monitoring are required. In addition, maintenance of features such as source control measures including reclamation covers and vegetation, stormwater conveyances and ponds, and site access are required to ensure the success of the measures applied to mitigate MIW.

Current BMPs

The GARD Guide notes, **"Effective maintenance and monitoring programs must follow selection and implementation of any technical method for prevention or mitigation. Monitoring demonstrates achievement of objectives and maintenance ensures engineering integrity of the design."**[113]

[113] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.9: Maintenance and Monitoring Considerations.

The BLM notes that, “Sometimes reclamation-related activities must continue long after the majority of reclamation work has been completed. Fencing may need to be maintained, signs replaced, water treatment systems operated or maintained, reclaimed slopes repaired, etc. The duration of such activity may be months, years, decades, or in the case of water treatment, the end date may be indefinite. The reclamation plan must clearly identify these post-closure activities and the operator’s commitment to performing the required work over the necessary time period.[114] The BLM also requires Components of reclamation include, where applicable: Providing for post-mining monitoring, maintenance, or treatment.[115]”

The USFS has specific requirements for monitoring in Section 2844 - RECLAMATION MONITORING:

> “Regional Foresters and Forest Supervisors shall determine those sites that need monitoring to assess the condition and environmental quality of reclaimed sites following release of bonds or other financial guarantees. Base monitoring priorities on the degree of risk to human health and safety or on long-term environmental effects. Reclaimed sites or structures that might require monitoring include, but are not limited to, revegetated areas, large waste embankments, tailing dams and impoundments, french-drains, stream diversions, dam structures on permanent water impoundments, and water treatment facilities”

The USFS also addresses long-term operation, maintenance and monitoring with respect to reclamation standards and financial assurance in guidance.[116]

Arizona requires information on reclamation that includes, “The measures that will be taken to address erosion control and stability” and “The measures that will be taken to address revegetation, conservation and the care and monitoring of revegetated areas as provided in this chapter.”[117]

Nevada similarly requires that reclamation plans describe, “The monitoring and maintenance of the reclaimed land that will be performed by the operator.”[118]

New Mexico has detailed requirements:

> “During closure the permittee shall continue monitoring pursuant to 20.6.7.28 and 20.6.7.29 NMAC. The permittee may propose and the department may approve

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[114] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 4.3.3.3.10: Post-Closure Management Plans, p. 4-24.

[115] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.3: Performance of Reclamation, p. 5-9, -10.

[116] U.S. Forest Service, Training Guide for Reclamation Bond Estimation and Administration for Mineral Plans of Operation Authorized and Administered under 36 CFR 228A (April 2004), p. 23.

[117] ARS 27-971: Submission and contents of reclamation plan, 9.(b) and (c).

[118] NRS 519A.220: Applicant to complete checklist for permit; contents. 1.(i).

modifications to the required monitoring to reflect changes in conditions during closure, including abandonment of monitoring wells.[119]

For each unit closed at a copper mine facility, the closure period shall cease, and the post-closure period shall commence, following the permittee's submission and department approval of a final CQA/CQC report that includes as-built drawings and a closure report documenting completion of regrading, covering, seeding, and construction of any other elements required for closure of a unit. The post-closure period for a copper mine facility or unit shall begin when the final CQA report is approved and only monitoring, inspections, maintenance, or operation of a closure water treatment and management plan remain to be conducted. During the post-closure period, a permittee shall conduct post-closure monitoring, inspection, reporting, maintenance, and implementation of contingency actions as specified by this section. The post-closure period shall end for a unit of a copper mine facility upon the completion of post-closure monitoring, inspection and maintenance for the unit as required by this section. The post-closure period shall cease when all monitoring, inspections, maintenance, and operation of the water management and treatment plan required under this section may cease. For units of a copper mine facility subject to an abatement plan, monitoring, inspection, reporting, and operation of abatement systems shall be conducted in accordance with the approved abatement plan rather than this section.

A. Interceptor system inspections. A permittee shall perform quarterly inspections and annual evaluations of all interceptor systems and perform maintenance as necessary to ensure that the systems are performing as designed and are functioning in a manner that is protective of ground water quality. The inspection results and any maintenance performed by the permittee on interception systems shall be reported pursuant to Subsection D of this section.

B. Water quality monitoring and reporting. A permittee shall perform water quality monitoring and reporting during the post-closure period pursuant to 20.6.7.28 and 20.6.7.29 NMAC, as applicable and modified by this section. Ground water elevation contour maps required pursuant to Subsection L of 20.6.27 NMAC shall be submitted annually during the post-closure period. A permittee may request to reduce the frequency of or cease sampling a water quality monitoring location if the water contaminants in a monitoring well have been below the applicable standards for eight consecutive quarters, provided an adequate monitoring well network remains. If sampling of a monitoring well ceases in accordance with this subsection, the monitoring well shall be abandoned in accordance with applicable requirements unless the permittee requests and the department approves the monitoring well to remain in place for an alternative use or future monitoring.

[119] NMAC 20.6.7.33 L: Closure monitoring and maintenance.

C. Reclamation monitoring, maintenance, and inspections.

(1) Vegetation. To ensure that vegetated covers required by the copper mine rule or the approved discharge permit are protective of water quality, a permittee shall perform post-closure monitoring of vegetation pursuant to schedules and monitoring requirements approved by the mining and minerals division. Any proposed changes to the closure or post-closure vegetation monitoring plan to meet Mining Act requirements shall be submitted to the department to ensure monitoring is protective of water quality. The permittee shall provide the department with a copy of monitoring results for vegetated covers, including photographic documentation as required by the mining and minerals division. At such time as the mining and minerals division vegetation success requirements under the Mining Act have been met, the permittee shall provide a final report to the department and vegetation monitoring may cease.

(2) Erosion, subsidence, slope instability, ponding, and other features. The permittee shall visually inspect closed discharge permit areas where a cover was installed for signs of excessive erosion, subsidence features, slope instability, ponding, development of fissures, or any other feature that may compromise the functional integrity of the cover system or drainage channels. Drainage channels, diversion structures, retention ponds, and auxiliary erosion control features shall be inspected in accordance with professionally recognized standards (e.g., U.S. department of agriculture natural resources conservation service standards). The inspections shall be conducted monthly for the first year following submission of the final CQA/CQC report for the unit, and quarterly thereafter until the end of post-closure monitoring, provided the department may approve a schedule allowing less-frequent monitoring. Discharge permit areas where covers were installed shall also be inspected for evidence of excessive erosion within 24 hours, or the next business day, following storm events of one inch or greater as measured at the nearest rain gauge on the copper mine facility. The permittee shall report and take corrective action pursuant to 20.6.2.7.30 NMAC regarding signs of excessive erosion, subsidence features, slope instability, ponding, development of fissures, or any other feature that may compromise the functional integrity of the cover system or drainage channels. Monitoring and inspection results shall be reported as required by Subsection D of this section.

(3) Entry. A permittee shall inspect and maintain the fencing or other management systems required by the discharge permit to prevent access

by wildlife and unauthorized members of the public to an open pit, reservoir, impoundment or any sump that contains water that may present a hazard to public health or wildlife.

(4) Cover maintenance. A permittee shall perform maintenance on all areas where a cover system was installed as required by the copper mine rule, including associated drainage channels and diversion structures if their performance may affect cover system function. Based on monitoring of vegetation and erosion required by Paragraphs (1) and (2) of this subsection, a permittee shall provide recommendations for maintenance work in semiannual monitoring reports described in Subsection D of this section, including a schedule for completion of work.

(5) Other inspection and maintenance. A permittee shall routinely inspect and maintain all structures, units, and equipment the failure of which may impact ground water quality. Water collected that exceeds the ground water quality standards in Section 20.6.2.3103 NMAC shall be stored, conveyed, treated and discharged requirements. The inspection results shall be reported as required in Subsection D of this section. Inspections and maintenance shall include but are not limited to:

(a) storm water retention reservoir(s);

(b) water treatment plant(s);

(c) pumps and pipelines to deliver water to water treatment plant(s); and

(d) seepage collection ponds.[120]"

Rationale

EPA has determined that short-term O&M is a necessary risk reduction measure that should be a specific minimum standard. The requirement for measures to address short-term O&M is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for short-term O&M is consistent with those requirements.

[120] NMAC 20.6.7.35: POST-CLOSURE REQUIREMENTS:

11. Interim O&M

This section describes the proposed specific minimum standard for Interim O&M, potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases, current BMPs and the rationale for the specific minimum standard.

Interim O&M Specific Minimum Standard

To satisfy the **interim O&M category component** in paragraph (b)(1)(xi):

(i) A plan for the purpose of interim emergency water management to provide information on how process water systems, interceptor wells, seepage collection systems and storm water management systems are operated and maintained to prevent discharges in the event the regulator assumes management of the mine facility. The plan must include process water flow charts showing electrical system requirements, pump operations, seepage collection and interceptor well operations and applicable operation and maintenance requirements. The plan must be updated as major process water system changes occur that would affect the interim emergency water management plan.

(ii) A conceptual engineering document that describes the processes and methods that are expected to be used to reduce the quantities of process water in storage and circulation inventory at the end of mine production until all process solutions are eliminated and steady-state discharge is reached, in preparation for long-term water management or treatment. The document must include:

(A) a description and list of the current or proposed process water management units and inventories of process water,

(B) a description of the modifications to the process water management system required to create an efficient process water reduction system,

(C) the operation and maintenance requirements for the system with material take-offs of sufficient detail to prepare an engineering-level cost estimate,

(D) an estimate of the required water reduction period based on the water reduction calculations provided in the plan to be used for planning and operation and maintenance cost calculations.

Potential Sources and Releases and Management Practices

Potential sources and releases of CERCLA hazardous substances and management practices from hardrock mine site-features have been described in previous sections. In the event of unexpected mine closure interim O&M is required to maintain the condition of the site until operations resume or reclamation and closure tasks can be initiated. This includes maintenance of process solutions and other site features as necessary to mitigate the potential for discharge of MIW.

Current BMPs

The technical literature does not address interim operations and maintenance. This is primarily because it is not an event that is typically planned for by the mining industry, particularly that of bankruptcy forcing pre-mature mine closure.

BLM requires:

> "All Plans of Operations must contain an interim management plan. These plans establish actions required during periods of temporary or seasonal closure under 43 CFR 3809.424 to avoid causing UUD. There are six items that must be covered by the interim management plan:
>
> - Measures to stabilize excavations and workings.
> - Measures to isolate or control toxic or deleterious materials.
> - Provisions for the storage or removal of equipment, supplies, and structures.
> - Measures to maintain the project area in a safe and clean condition.
> - Plans for monitoring site conditions during periods of non-operation.
> - Schedule of anticipated periods of temporary closure.
>
> Operators may have prepared or other government agencies may have required a "care and maintenance" plan, which is the mining industry equivalent to an interim management plan. Such a plan may be accepted by the BLM if it contains the content required at 43 CFR 3809.401(b)(5).[121]
>
> Measures for removal, stabilization, control, and reclamation of waste products from water treatment systems must be integrated in the operating and reclamation plans. Disposal and reclamation of waste product must achieve long-term stability in the post-reclamation environment and in conformance with applicable state and Federal environmental standards.[122]
>
> In order for reclamation to be considered complete, operators must have detoxified leaching solutions and spent ore heaps to the applicable regulatory criteria and manage tailings or other process waste to minimize impacts to the environment from contact with toxic materials or leachate. Often there is a state standard that determines the detoxification

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121 U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 4.3.3.5: Interim Management Plans, p. 4-27.

122 U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.11.3: Capture and Treatment, p. 5-22, -23.

requirement. The detoxification criterion should be established during the Plan of Operations approval process. If no standards have been developed in advance for the project, then detoxification must reduce cyanide content to levels where discharge would be in compliance with the applicable water quality standards.

Acceptable practices to detoxify solutions and materials include natural degradation, freshwater rinsing, chemical treatment, biological degradation, or equally successful alternatives methods. While active treatment of cyanide using reagents such as hydrogen peroxide or hypochlorite are effective, consideration should be given to the potentially deleterious by-products when compared to natural degradation. Upon completion of reclamation, all materials and discharges must meet applicable effluent standards.[123]"

The USFS also addresses interim operation and maintenance with respect to reclamation standards and financial assurance in guidance.[124]

New Mexico requires:

> "An applicant or permittee shall develop and submit to the department an interim emergency fluid management plan. The purpose of the interim emergency water management plan is to provide information to the department on how process water systems, interceptor wells, seepage collection systems and storm water management systems are operated and maintained to prevent discharges in the event the department assumes management of the copper mine facility. An applicant or permittee shall include in the plan process water flow charts showing electrical system requirements, pump operations, seepage collection and interceptor well operations and applicable operation and maintenance requirements. The interim process water management plan shall be updated as major process water system changes occur that would affect the interim emergency water management plan. The interim emergency water management plan shall be maintained on site and be available for department review. The plan shall be submitted within180 days of discharge permit renewal for an existing copper mine facility and no less than 60 days prior to discharge at a new copper mine facility.[125]
>
> The closure plan shall include a process solution reduction plan for the copper mine facility. The process solution reduction plan shall be a conceptual engineering document that describes the processes and methods that are expected to be used at a copper mine facility to reduce the quantities of process water in storage and circulation inventory at the end of copper production in preparation for long-term water management or treatment. The plan shall describe and list the current or proposed process water

[123] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.12.5: Solution Detoxification, p. 5-25, -26.

[124] U.S. Forest Service, Training Guide for Reclamation Bond Estimation and Administration for Mineral Plans of Operation Authorized and Administered under 36 CFR 228A (April 2004), p. 13.

[125] NMAC 20.6.7.30 K: Interim Emergency Water Management.

management units and inventories of process water. The plan shall describe the modifications to the process water management system required to create an efficient process water reduction system and the operation and maintenance requirements for the system with material take-offs of sufficient detail to prepare an engineering-level cost estimate equivalent to the cost estimate to be provided with the closure plan. The plan shall provide an estimate of the required water reduction period based on the water reduction calculations provided in the plan to be used for planning and operation and maintenance cost calculations.[126]"

Rationale

EPA has determined that interim O&M is a necessary risk reduction measure that should be a specific minimum standard. The requirement for measures to address interim O&M is a recognized BMP, as evidenced by its widespread inclusion in federal and state hardrock regulations and guidance. The proposed specific minimum standard for interim O&M is consistent with those requirements.

[126] NMAC 20.6.7.33 G: Process solution reduction plans.

12. Long-term O&M

This section describes the proposed specific minimum standard for Long-term O&M, potential sources and releases of CERCLA hazardous substances and management practices to address those potential sources and releases, current BMPs and the rationale for the specific minimum standard.

Long-term O&M Specific Minimum Standard

To satisfy the **long-term O&M category component** in paragraph (b)(1)(xii):

(1) A plan for groundwater and surface water monitoring to assure that additional monitoring wells are located to detect an exceedance(s) or trends towards exceedance(s) of the applicable standards and that they are detected 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. The plan must be currently in effect, and must cover a period of at least 200 years.

(2) A plan for inspection and monitoring of mass stability, erosion and revegetation certified by a professional engineer to ensure reclamation success.

(3) A plan for routine maintenance and repairs to roads, stormwater conveyances and collection devices, cover systems, and revegetation maintenance (e.g. weed controls) and repairs (e.g. areas of revegetation failure) and monitoring wells.

Potential Sources and Releases and Management Practices

Potential sources and releases of CERCLA hazardous substances and management practices from hardrock mine site-features have been described in previous sections. In order to monitor the effectiveness of the management practices applied, groundwater and surface monitoring are required. In addition, maintenance of features such as source control measures including reclamation covers and vegetation, stormwater conveyances and ponds, and site access are required to ensure the success of the measures applied to mitigate MIW.

Current BMPs

See **Section 12 Short-term O&M.**

Rationale

EPA has determined that long-term O&M is a necessary risk reduction measure that should be a specific minimum standard. The requirement for measures to address long-term O&M is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for long-term O&M is consistent with those requirements.

13. Water Treatment

This section describes the proposed specific minimum standard for Water Treatment to address potential releases of CERCLA hazardous substances and management practices to address potential sources and releases, current BMPs, and the rationale for the specific minimum standard.

Water Treatment Specific Minimum Standard

To satisfy **the water treatment category component** in paragraph (b)(1)(xiii):

(i) A plan for closure water management and water treatment consisting of a conceptual engineering document that describes the processes and methods that are expected to be used for long-term management or treatment of seepage and includes an analysis of the expected operational life of each long-term water management or water treatment system, including collection/interceptor systems, until each system is no longer needed to protect water quality and applicable standards are met. The plan must describe whether active or passive treatment is proposed and include all operations and maintenance activities required to support all collection and treatment systems. The plan must describe the long-term water management and water treatment systems with sufficient detail, including locations of key components, expected operational life, material take-offs, and capital, operational and maintenance costs to prepare an engineering-level cost estimate. The plan must be currently in effect and must cover a period of at least 200 years.

(ii) A plan for disposal of wastes produced from water treatment that is protective of human health and the environment and meets applicable federal, state, and local requirements.

Potential Sources and Releases and Management Practices

Potential sources and releases of CERCLA hazardous substances and management practices from hardrock mine site-features have been described in previous sections. This category, water treatment, is required in order to manage (operate and maintain) those features where groundwater and/or surface water capture and treatment are necessary to reduce the risk of release of hazardous substances.

Current BMPs

According to the GARD Guide, **"Mine drainage diversion, collection and conveyance systems are critical components of any treatment project."**[127] **"A wide spectrum of drainage treatment technologies has been developed, proven, and applied to many different**

[127] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 7.4: Drainage Sources, Collection and Management.

applications."[128] "The design life of post-closure treatment facilities should be based on geochemical model predictions of the long-term mine drainage flow and quality."[129]

BLM requires:

> "The operator must capture and treat acid drainage, or other undesirable effluent, to the applicable standard if source controls and migration controls do not prove effective. The performance standard recognizes that when it is not possible to prevent the formation or migration of leachate or effluent, the operator must capture and treat it to meet the applicable water quality standard. While complete capture of seepage is not always possible, the treated discharge, when mixed with the un-captured leachate, must meet the applicable effluent limit at the point of compliance.
>
> Long-term, or post-mining, effluent capture and treatment are not acceptable substitutes for source and migration control; and the operator may rely on them only after all reasonable source and migration control methods have been employed. While capture and treatment can be highly effective at limiting environmental impacts, in order to meet this performance standard, the operator must first apply source and migration control measures to the mining and reclamation plans in order to minimize treatment needs. Operating plans that propose to "treat water if necessary" must include source control measures to satisfy this performance standard.
>
> Water treatment systems can include active, passive, or semi-passive approaches. In addition to requiring approval during the Plan of Operations review process, water treatment systems must comply with any separate authorizations from the state or Federal permitting authority and require an NPDES permit where discharging to surface water. Water treatment systems must be operated and maintained in compliance with all state or other Federal standards.
>
> All treatment systems generate some waste product, whether it is sludge, liquid concentrate, or solid waste residue. Measures for removal, stabilization, control, and reclamation of waste products from water treatment systems must be integrated in the operating and reclamation plans. Disposal and reclamation of waste product must achieve long-term stability in the post-reclamation environment and in conformance with applicable state and Federal environmental standards.[130]
>
> The reclamation plan must address how the operator will deal with potentially toxic materials. Such material may be isolated from mobilizing agents such as air and water,

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[128] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 7.5: Mine Drainage Treatment Technologies.

[129] The International Network for Acid Prevention, Global Acid Rock Drainage Guide (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 7.8: Treatment in the Context of Mine Closure and Post Closure.

[130] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.11.3: Capture and Treatment, p. 5-22, -23.

removed to an alternate location where isolation or treatment can be achieved, or controlled through a variety of treatment or mitigating measures.

> Isolation includes measures such as covering or burying to prevent materials from becoming windborne or to limit contact with precipitation. Isolation also includes prevention of run-on waters from entering the toxic material, mobilizing contaminants, and causing a release to the environment.[131]

> All operators must comply with applicable federal and state water quality standards, including the Federal Water Pollution Control Act, as amended.[132]"

The USFS addresses water treatment with respect to reclamation standards and financial assurance in guidance.[133]

Arizona BADCT guidance notes that, "Interception and treatment of leachate is a long-term commitment which must be very carefully evaluated before it is implemented."[134]

New Mexico requires:

> "The applicant or permittee shall submit a closure water management and water treatment plan. The closure water management and water treatment plan shall consist of a conceptual engineering document that describes the processes and methods that are expected to be used at a copper mine facility for long-term management or treatment of process water. The plan shall include an analysis of the expected operational life of each long-term water management or water treatment system, including interceptor systems, until each system is no longer needed to protect ground water quality and applicable standards are met. The plan shall describe the long-term water management and water treatment systems with sufficient detail, including locations of key components, expected operational life, material take-offs, and capital, operational and maintenance costs to prepare an engineering-level cost estimate. The plans shall provide sufficient detail to estimate capital and operating costs to provide the basis for financial assurance for these activities.[135]"

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[131] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.3.2.3: Isolate, Remove, or Control Toxic Materials, p. 5-11.

[132] U.S. Department of the Interior, Bureau of Land Management, Surface Management Handbook H-3809-1 (Washington, DC: U.S. Government Printing Office, 2012), Section 5.3.5: Water Quality, p. 5-15.

[133] U.S. Forest Service, Training Guide for Reclamation Bond Estimation and Administration for Mineral Plans of Operation Authorized and Administered under 36 CFR 228A (April 2004), p. 16.

[134] Arizona Department of Environmental Quality, Arizona Mining Guidance Manual: Best Available Demonstrated Control Technology - Aquifer Protection Program (2001), p. 3-16 and 33.

[135] NMAC 20.6.7.33 H: Closure water management and water treatment plan.

Rationale

EPA has determined that water treatment is a necessary risk reduction measure that should be a specific minimum standard. The requirement for measures to address water treatment is a recognized BMP, as evidenced by its widespread inclusion in technical references and federal and state hardrock regulations and guidance. The proposed specific minimum standard for water treatment is consistent with those requirements.

Appendix A. Summary Tables for Each Site-feature of the Releases and Potential Releases of Hazardous Substances and BMPs used to prevent/address them.

Table A1. Waste Rock Piles

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
MIW/AMD	Rock drainage can occur with a wide variety of mineralogical, hydrological, and chemical factors in place, although there are multiple standard test procedures used to predict the character of waste rock.[136] MIW generally may contain residual process chemicals or mobilized contaminants, with high acidity further mobilizing potentially hazardous trace elements. AMD involves the oxidation of metal sulfide minerals, often in the host rock of metal mining commodities. Extraction exposes the rock to air and water thus increasing its acid-generating potential. Upon exposure, a number of factors determine the rate, severity, and mobility of acid generation: the kind of sulfide mineral present, amount of water exposure, amount of oxygen exposure, presence of ferric iron, bacteria to catalyze oxidation reaction, and generated heat.[137] The sizes of waste rocks in a pile or dump can vary, from fine particles to boulders. Although a part of a waste rock pile predominantly made up of large rocks has increased air flow and lower permeability, smaller particles generate more acid because more of their surface area is exposed to oxygen, which leads to increased oxidization of constituent sulfides.[138] AMD has a considerable lag time from the first deposition of waste material to the observation of acidic discharge, making it an ongoing and potentially perpetual source of hazardous contamination at a mine site.[139]	Pre-operational analysis of the acid generating potential of waste rock is essential to determine whether the operation is feasible or how to neutralize any acid produced.[140] Potentially acid-generating waste rock may be saturated during disposal, or co-disposed with tailings and/or overburden to neutralize acidity. Co-disposal restricts access to oxygen of potentially acid generating material. Co-disposal material may also be alkaline-generating, thereby neutralizing acid-generating potential of waste rock. Co-disposal may involve the dumping of reactive waste rock into a saturated tailings impoundment or introducing waste rock to tailings before they undergo the filtration process to become paste tailings, creating "paste rock."[141] Co-disposal can also involve the layering of potentially acid generating layers with neutralizing layers (or vice versa) to minimize the transportation of acidic or basic discharge.[142] Potentially acid or alkaline generating waste rock piles or dumps may also be encapsulated by non-acid generating or neutralizing materials to act as a physical and chemical barrier to prevent rock drainage. Consideration of the hydrology and topography of the dump or pile site is necessary for effective encapsulation.[143]

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[136] U.S. Environmental Protection Agency, *Technical Report: Acid Mine Drainage Prediction* (Washington, DC: U.S. Government Printing Office, 1994), p. 1.

[137] U.S. Environmental Protection Agency, *Technical Report: Acid Mine Drainage Prediction* (Washington, DC: U.S. Government Printing Office, 1994), p. 4-6.

[138] D.J.A. Van Zyl and J.N. Johnson, "Systems Design for Site Specific Environmental Protection," in *Mining Environmental Handbook: Effects on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997), p. 451.

[139] U.S. Environmental Protection Agency, *Technical Report: Acid Mine Drainage Prediction* (Washington, DC: U.S. Government Printing Office, 1994), p. 2.

[140] U.S. Environmental Protection Agency, *Technical Report: Acid Mine Drainage Prediction* (Washington, DC: U.S. Government Printing Office, 1994), p. 9-10; The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 5.0.

[141] International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.3.7.

[142] U.S. Environmental Protection Agency, *Technical Report: Acid Mine Drainage Prediction* (Washington, DC: U.S. Government Printing Office, 1994), p. 7.

[143] International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.3.5.

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
Erosion	Many factors can contribute to the erosion of the waste rock dump site. Most commonly, erosion is caused by hydrological weathering from precipitation and runoff or the geochemical nature of the waste rock material itself. Erosion can result in sudden deformation and collapse and/or the release of hazardous material into the environment.[144]	The operator must characterize the erosion potential of waste rock material before the start of operations to determine the optimal manner of deposition. A concave pile design mimics the natural path of erosion and mitigates the impact of an erosive event. Material with low erosion potential can cap higher erosion potential material.[145] That cap can be applied continuously as the disposal is constructed. To prevent water from entering the waste rock disposal and contributing to erosion, an operator can dig ditches around the disposal to divert water.[146] Consistent slope and water monitoring are also necessary to prevent erosion, with the potential addition of water treatment depending on the chemical content of the water.[147]
Deformation or Collapse	Waste rock piles can reach heights of up to five hundred meters. Those structures can fail for a variety of reasons, either due to significant precipitation, erosion, seismic activity, or fundamental structural instability. When failure occurs, waste rock escapes the bounds of the facility and any hazardous substances present in the waste rock can enter the local environment. Furthermore, even geochemically benign waste rock ejected from a waste rock pile as a result of sudden failure can cause significant physical harm to the local environment.[148]	Pre-operational planning and analysis to account for and avoid topographical and geological factors that could contribute to failure mitigates the possibility of release in the operational and post-closure phases.[149] Simple monitoring and visual inspection, if performed consistently and thoroughly, is essential to lessen the risk of deformation or collapse.[150] Additionally, an automated wireline extensometer can monitor the physical stability of a dump or pile remotely by recording the changes in tension of a line

[144] Marc Orman, Rich Peevers, and Kristin Sample, "Chapter 8.11: Waste Piles and Dumps," in *SME Mining Engineering Handbook*, ed. Peter Darling (Englewood, CO: Society for Mining, Metallurgy, and Exploration, Inc., 2011), Volume 1, p. 675-676.

[145] Marc Orman, Rich Peevers, and Kristin Sample, "Chapter 8.11: Waste Piles and Dumps," in *SME Mining Engineering Handbook*, ed. Peter Darling (Englewood, CO: Society for Mining, Metallurgy, and Exploration, Inc., 2011), Volume 1, p. 675-676.

[146] Dirk Van Zyl, "Mine waste disposal," in *Geotechnical Practice for Waste Disposal*, ed. D.E. Daniel (Medford, MA: Springer Science and Business Media, 2012), p. 271.

[147] Marc Orman, Rich Peevers, and Kristin Sample, "Chapter 8.11: Waste Piles and Dumps," in *SME Mining Engineering Handbook*, ed. Peter Darling (Englewood, CO: Society for Mining, Metallurgy, and Exploration, Inc., 2011), Volume 1, p. 675-676.

[148] D.J.A. Van Zyl and J.N. Johnson, "Systems Design for Site Specific Environmental Protection," in *Mining Environmental Handbook: Effects on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997), p. 463.

[149] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.1 ("*GARD Guide*").

[150] D.J.A. Van Zyl and J.N. Johnson, "Systems Design for Site Specific Environmental Protection," in *Mining Environmental Handbook: Effects on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997), p. 463.

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
		anchored in the waste rock.[151] Foundation pore water pressure analysis and foundation strains are more sophisticated mitigation methods.[152] The construction of dumps as a series of wrap-arounds so as to form a flat face minimizes the slope-related failure potential and facilitates reclamation.[153]

[151] D.J.A. Van Zyl and J.N. Johnson, "Systems Design for Site Specific Environmental Protection," in *Mining Environmental Handbook: Effects on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997), p. 452.

[152] D.J.A. Van Zyl and J.N. Johnson, "Systems Design for Site Specific Environmental Protection," in *Mining Environmental Handbook: Effects on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997), p. 463.

[153] D.J.A. Van Zyl and J.N. Johnson, "Systems Design for Site Specific Environmental Protection," in *Mining Environmental Handbook: Effects on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997), p. 462.

Table A2. Open Pit Mines and Underground Mines

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
Mine drainage – open-pit mines	Open-pit mine highwalls are prone to high rates of erosion and mass wasting. The exposed rock on the pit walls and the overburden may result in AMD or other MIW, often forming "pit lakes". Similar to underground mines, MIW can have environmentally significant concentrations of metals, other contaminants, and sediments, elevated temperatures, and altered pH.	Passive mitigation methods: [154] • Revegetation • Pit backfill to reduce exposure to air and water. For example, burying waste rock or using overburden material as backfill can reduce acid generation substantially, under proper geologic conditions. • Prevention of pit lake formation (e.g., drainage and treatment systems) • Diversion channels and ditches prevent AMD by intercepting and conveying runoff from undisturbed areas around active mining sites. [155] • Natural or constructed hydrological systems, including wetlands, limestone drains, water covers, and naturally occurring geochemical or biological processes • Bioremediation processes treating mine wastewater using natural acidophilic microbes.[156] Active: • Treatment of mining wastewater and separation of solids[157,158] • Pit lake pump/treatment/neutralization
Mine drainage – underground mines	Water flowing through underground mines can cause releases of mine water through mining openings.[159] Contact with exposed rock in mine shafts can transport contaminants and negatively impact soil and water quality. Mine water can have environmentally significant	Grouting and other methods have been shown to be highly effective at reducing drainage from underground mines during operations.[164] Flooding can significantly block the flow of oxygen and prevent acid generation; however, soluble products can result in unacceptable water quality.[165]

[154] R. Verburg, "Chapter 16.5: Mitigating Acid Rock Drainage," in *SME Mining Engineering Handbook*, ed. Peter Darling (Englewood, CO: Society for Mining, Metallurgy, and Exploration, Inc., 2011), Volume 2.

[155] G. Hilson and B. Murck, "Progress toward pollution prevention and waste minimization in the North American gold mining industry," *Journal of Cleaner Production* 9 (2001), p. 405-415.

[156] D.B. Johnson, "Acidophilic Microbial Communities: Candidate for Bioremediation of Acidic Mine Effluents," *International Biodeterioration & Biodegradation* 35:13 (1995), p. 41-58; T. Umita, "Biological mine drainage treatment." *Resources, Conservation and Recycling* 16 (1996), p.179-188; and United Nations. *1995 Industrial Commodity Statistics Yearbook - Production Statistics (1986-95)* (New York: United Nations, 1997).

[157] United Nations Environment Programme, United Nations Industrial Development Organization, and the World Bank Group, *Pollution Prevention and Abatement Handbook, Airborne Particulate Matter: Pollution Prevention and Control* (Washington DC: 1998), p. 235-239.

[158] G. Hilson,. "Barriers to Implementing Cleaner Technologies and Cleaner Production (CP) Practices in the Mining Industry: A Case Study of the Americas," *Minerals Engineering* 13:7 (2000), p. 699-717.

[159] U.S. Environmental Protection Agency, DRAFT: *Mining Environmental Impact Statement Technical Report* (Washington, DC: U.S. Government Printing Office, 2013), p. 31.

[164] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.5.5.

[165] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.5.4.

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
	concentrations of metals and solids, elevated temperatures, and altered pH, depending on the nature of the ore body and local geochemical conditions. In addition, mine water can acidify over time as sulfide minerals are exposed to water and air, resulting in AMD. AMD, and MIW more generally, can cause significant threats to surface water and groundwater resources during active mining and for decades after operations cease.[160] For example, in 1993, the U.S. Forest Service (USFS) estimated that AMD impacted between five and ten thousand miles of domestic streams and rivers.[161] The need for costly water treatment can persist for decades after a mine has closed.[162] Depending on the hydrology of the site, the drainage may be discharged to groundwater or surface water. Acidic drainage also increases the leaching and mobility of some metals and trace elements.[163]	Seals can be used to create flooded conditions, however, if considerable hydraulic head is created rigorous engineering design is required.[166] Where discharges from underground mines result in unacceptable water quality conditions the mine discharge may be allowed to discharge naturally (e.g. out the mine portal) where it is captured and treated, or the discharge may be prevented by pumping the underground mine and maintaining the level. This technique is also used where underground mine discharges to groundwater require mitigation.[167] In the event the mine drainage requires treatment prior to discharge, either during operations or post-closure, a variety of active, passive and in situ mine drainage treatment techniques are potentially applicable.[168]

[160] F.K. Allgaier, ed., "Chapter 5: Environmental Effects of Mining," in *Mining Environmental Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997).

[161] U.S. Environmental Protection Agency, Office of Compliance, *Sector Notebook Project: Profile of the Metal Mining Industry* (Washington, DC: U.S. Government Publishing Office, 1995).

[162] U.S. Environmental Protection Agency, Office of Compliance, *Sector Notebook Project: Profile of the Metal Mining Industry* (Washington, DC: U.S. Government Publishing Office, 1995).

[163] U.S. Environmental Protection Agency, Office of Solid Waste, Special Waste Branch, *Technical Resource Document: Extraction and Beneficiation of Ores and Minerals* EPA 530-R-94-013, Volume 2: Gold (Washington, DC: U.S. Government Printing Office, 1994). Accessed December, 2015, at: https://archive.epa.gov/epawaste/nonhaz/industrial/special/web/pdf/iron.pdf.

[166] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.5.5.

[167] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 7.4, 4.2.2.2.

[168] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 7.5.

Table A3. Cyanide Leaching

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
Solution from tanks or heap leach piles	Cyanide leaching uses one or combination of the following process chemicals: sodium cyanide, potassium cyanide, sodium hydroxide, nitric acid, and lime, as well as other process chemicals. Process chemicals may be discharged accidentally from drums, tanks and other storage containers during operations and post-closure if not properly disposed. Leaks may also occur from the leaching system itself, such as from heap leach pad liner punctures. Valley-fill heap leach designs create a high risk of solution leakage and storage issues, because of the high fluid pressures associated with tailings dams.[169] Cyanide solution without leached minerals, as well as process water recovered from tailings and heap leach facilities, is recycled back to the agitated tank cyanide leaching process. In addition to cyanide, the leach solutions accumulate metal impurities. Discharges of leach solutions may occur as a result of leakage of ponds, tanks, and piping during operations and may also be responsible for long-term post-closure seepage containing cyanide and metals.[170]	There are a multitude of liner systems and designs that can be applied. The combination of the design and the materials will determine the leakage rate of the liner system.[171] Liner systems can be designed and constructed with leak detection alarm systems and fluid recovery systems. Leak collection systems can be constructed between primary and secondary synthetic liners to collect and remove fluids from leaks, minimizing the pressure on the secondary liner. Fluid collection pipes can transmit fluid away from drainage layers.
Leach tailings	Following cyanidation processing, the spent ore or tailings is discharged to a tailings storage facility (impoundment). These wastes are typically treated to reduce the cyanide concentration, but may contain residual cyanide and cyanide complexes. They may also contain metals present in the ore body.[172] The waste impoundment may be unlined or lined, and in either case might incorporate a collection or pumpback system for recovery of escaped tailings solution. See Section 2.C. for further discussion of tailings management.	During mine design, targeted extraction techniques such as selective mining and avoidance could be used to minimize mining of ore resulting in leach tailings that could result in MIW.[173] As part of the leach tailings disposal facility design engineered barriers such as a liner can be utilized to collect seepage from tailings resulting in reduced seepage management requirements.[174] Another technique is production of paste or dry dewatered leach tailings to reduce potential for MIW.[175]

[169] Daniel Kappes, "Precious Metal Heap Leach Design and Practice," in *Mineral Processing Plant Design, Practice, and Control Proceedings*, ed. Andrew L. Mular (Englewood, CO: Society for Mining, Metallurgy, and Exploration, 2002).

[170] Daniel Kappes, "Precious Metal Heap Leach Design and Practice," in *Mineral Processing Plant Design, Practice, and Control Proceedings*, ed. Andrew L. Mular (Englewood, CO: Society for Mining, Metallurgy, and Exploration, 2002).

[171] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.6.1.

[172] Bernd Lottermoser, *Mine Wastes: Characterization, Treatment and Environmental Impacts*, 3rd Edition (Medford, MA: Springer Science and Business Media, 2010).

[173] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.1.

[174] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.6.1.

[175] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.8.

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
		During operations special handling techniques such the addition of alkaline materials or amendments can be used to reduce potential for AMD from leach tailings.[176] At closure leach tailings areas can be reclaimed using dry and wet covers to lessen or minimize discharges of MIW. [177]
Mine drainage	Water percolating through uncovered or otherwise exposed tailings or heap leach piles may react with sulfide minerals, creating acid drainage and other MIW. Depending on the hydrology of the site, the drainage may be discharged to groundwater or surface water. A variety of factors affect the rate of MIW generation from tailings including the water level within the pile, exposure to oxygen, and the presence of bacteria. Tailings and ore piles are susceptible to acid generation because of the increased surface area exposure of minerals not extracted by the cyanide leaching process. Both surface water discharges and seepage to groundwater from tailings impoundments may contain MIW which also increases the leaching and mobility of metals.[178] Nevada contains most of the current U.S. gold operations.[179] A 2003 USGS study of hydrological and geological conditions of northern Nevada found that mines in Nevada are much less likely than those in other states to discharge acid waters to local waterways because of low precipitation, the isolated nature of local waterways, composition of ores, and prevalence of soils containing neutralizing lime.[180] Risks from seasonal precipitation still exist, however, and there are several documented instances of AMD contamination from currently operating Nevada gold mines.[181]	In the event the mine drainage requires treatment prior to discharge, either during operations or post-closure, a variety of active, passive and in situ mine drainage treatment techniques are potentially applicable.[182]

[176] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.4.2.

[177] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.3.2.

[178] U.S. Environmental Protection Agency, Office of Solid Waste, Special Waste Branch, *Technical Resource Document: Extraction and Beneficiation of Ores and Minerals* EPA 530-r-94-013, Volume 2: Gold (Washington, DC: U.S. Government Printing Office, 1994).

[179] U.S. Environmental Protection Agency, Office of Solid Waste, Special Waste Branch, *Technical Document: Acid Mine Drainage Prediction* EPA 530-R-94-036 (Washington, DC: U.S. Government Printing Office, 1994). Accessed August 13, 2015, at: https://www.epa.gov/sites/production/files/2015-09/documents/amd.pdf

[180] J.T. Nash, *Overview of Mine Drainage Geochemistry at Historical Mines, Humboldt River Basin and Adjacent Mining Areas, Nevada*, USGS Bulletin 2210-E (Washington, DC: U.S. Government Printing Office, 2003). Accessed August 13, 2015, at: http://pubs.usgs.gov/bul/b2210-e/B2210E508V6.pdf

[181] Ronald Eisler, Biogeochemical, Health, and Ecotoxicological Perspectives on Gold and Gold Mining (Boca Raton: CRC Press, 2010).

[182] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 7.5.

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
Mercury releases	Gold ore processing and production facilities are the seventh largest source of mercury air emissions in the United States.[183] Mercury commonly occurs in gold-bearing ore and is a relatively volatile element. As such, it can escape to the atmosphere, particularly from thermal processes. Mercury releases can occur as a result of various cyanidation steps. [184,185] They include preliminary roasting and autoclaving, carbon regeneration, electrowinning, mercury distillation and recovery, and doré furnace smelting. Atmospheric mercury emissions can also volatilize from heaps and tailings facilities resulting in a discharge.[186]	As part of mine design targeted extraction techniques such as selective mining and avoidance could be used to minimize mining of waste rock that could result in mercury releases.[187] Releases can be reduced using a hypochlorite injection system and by improving process and control equipment efficiency.[188]
Land application disposal	Cyanide solution is sometimes applied to soil for disposal, in anticipation that exposure to air will neutralize the solution. Land application of spent cyanide solutions during operations, rinsing, and post-closure seepage treatment activities, however, may introduce cyanide into the environment that does not degrade and persists in the long-term.	In theory, cyanide may be attenuated in soils through treatment methods, including precipitation, biodegradation, and oxidation. Cyanide may persist long-term, though, despite these mechanisms.[189]

[183] "Fact Sheet: Final Rule to Reduce Mercury Emissions from Gold Mine Ore Processing and Production Sources," U.S. Environmental Protection Agency, updated 2010. Accessed February 13, 2015, at http://www.epa.gov/ttn/atw/area/gold_mines_fs_121610.pdf; and EPA. 2010. National Emission Standards for Hazardous Air Pollutants: Gold Mine Ore Processing and Production Area Source Category; and Addition to Source Category List for Standards. 40 CFR Part 63 Subpart EEEEEEE. 76 FR 9450.

[184] Glenn Miller, "Byproduct Mercury Production in Modern Precious Metals Mines in Nevada," presented at EPA Region 8: 2007 Stakeholder Panel for Managing Domestic Stocks of Commodity-Grade Mercury, July 24-25, 2007. Accessed August 13, 2015, at: https://archive.epa.gov/mercury/archive/web/pdf/byproductmercuryproductioninmodernpreciousmetalsminesinnevada.pdf

[185] Greg Jones and Glenn Miller "Mercury and Modern Gold Mining in Nevada," Final Report to EPA Region 9, October 24, 2005. Accessed January 13, 2015, at http://www.chem.unep.ch/mercury/Trade%20information/NRDC-NEVADABYPRODUCTRECOVERYREPORT.pdf.

[186] Glenn Miller, "Environmental Technologies in the Mining Industry," presented April 12, 2011. Accessed August 13, 2015, at: http://dels.nationalacademies.org/resources/static-assets/besr/miscellaneous/Miller.pdf

[187] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.1.

[188] "Nevada Voluntary Mercury Reduction Program (VMRP), Questions and Answers," Nevada Division of Environmental Protection, updated May 2005, accessed August 13, 2015, at https://ndep.nv.gov/mercury/docs/voluntar_mercury_q&a05.pdf.

[189] Glenn Miller, "Environmental Technologies in the Mining Industry," presented April 12, 2011.

Table A4. Acid Leaching

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
Solution from tanks or leach piles	Process chemicals such as sulfuric acid that are used in acid leach and SX/EW may be discharged from drums, tanks and other storage containers during operations and post-closure if not properly disposed. Leaks may also occur from the leaching system itself, such as from heap leach pad liner punctures. Valley-fill heap leach designs create a high risk of solution leakage and storage issues because of the high fluid pressures.[190] Discharges of leach solutions may occur as a result of leakage of ponds, tanks, and piping during operations and may also be responsible for long-term post-closure seepage containing acidic effluents and toxic metals.[191,192]	Liner systems can be designed and constructed with leak detection alarm systems and fluid recovery systems. Typically, a minimum of one synthetic membrane is used in combination with a compacted earthen liner. Additional measures, such as using two synthetic liners, can be applied when significant pressure creates cause for concern. Leak collection systems can be constructed between primary and secondary synthetic liners to collect and remove fluids from leaks, minimizing the pressure on the secondary liner. Fluid collection pipes can transmit fluid away from drainage layers. Detailed hydrologic characterization of heap and dump sites before construction and ongoing monitoring are additional proactive management steps that mitigate the possibility of a harmful release.
Leach tailings	Following acid leach operations, the spent ore or tailings is discharged to a tailings storage facility (impoundment). These wastes may be highly acidic and may also contain metals present in the ore body.[193] The waste impoundment may be unlined or lined, and in either case might incorporate a collection or pumpback system for recovery of escaped tailings solution.	During mine design, targeted extraction techniques such as selective mining and avoidance could be used to minimize mining of ore resulting in leach tailings that could result in MIW.[194] As part of the leach tailings disposal facility design, engineered barriers such as a liner can be utilized to collect seepage from tailings resulting in reduced seepage management requirements.[195] Another technique is production of paste or dry dewatered leach tailings to reduce potential for MIW.[196] During operations special handling techniques such as the addition of alkaline materials or

[190] Daniel Kappes, "Precious Metal Heap Leach Design and Practice," in *Mineral Processing Plant Design, Practice, and Control Proceedings*, ed. Andrew L. Mular (Englewood, CO: Society for Mining, Metallurgy, and Exploration, 2002).

[191] Daniel Kappes, "Precious Metal Heap Leach Design and Practice," in *Mineral Processing Plant Design, Practice, and Control Proceedings*, ed. Andrew L. Mular (Englewood, CO: Society for Mining, Metallurgy, and Exploration, 2002).

[192] U.S. Congress, Office of Technology Assessment, "Chapter 8, Environmental Aspects of Copper Production," in *Copper: Technology and Competitiveness* (Washington, DC: U.S. Government Printing Office, 1988).

[193] Bernd Lottermoser, *Mine Wastes: Characterization, Treatment and Environmental Impacts*, 3rd Edition (Medford, MA: Springer Science and Business Media, 2010).

[194] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.1.

[195] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.6.1.

[196] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.8.

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
		amendments can be used to reduce potential for AMD from leach tailings.[197] At closure leach tailings areas can be reclaimed using dry and wet covers to lessen or minimize discharges of MIW.[198]
Mine drainage	Water percolating through uncovered or otherwise exposed tailings or leach piles may react with sulfide compounds, creating acid drainage. Depending on the hydrology of the site, the acid drainage may be discharged to groundwater or surface water. A variety of factors affect the rate of acid drainage generation from tailings, including the water level within the pile, exposure to oxygen, and the presence of bacteria. Tailings and ore piles are susceptible to acid generation because of the increased surface area exposure of minerals not extracted by the leaching process. Both surface water discharges and seepage from tailings impoundments may contain acid drainage which also increases the leaching and mobility of metals.[199]	In the event the mine drainage requires treatment prior to discharge, either during operations or post-closure, a variety of active, passive and in situ mine drainage treatment techniques are potentially applicable.[200]

[197] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.4.2.

[198] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.3.2.

[199] U.S. Environmental Protection Agency, Office of Solid Waste, Special Waste Branch, *Technical Resource Document: Extraction and Beneficiation of Ores and Minerals* EPA 530-r-94-013, Volume 2: Gold (Washington, DC: U.S. Government Printing Office, 1994).

[200] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 7.5.

Table A5. Tailings Storage Facilities

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
Embankment Failure	Embankment failure occurs when the structures bounding an impoundment are compromised due to structural instability, rotational sliding, seismic events and liquefaction (weakening of soil through shaking), or erosion from tailings that corrode impoundment walls. Embankment failure results in the release of tailings into local environment and, if located near a watershed, dispersal of tailings downstream.[201]	• Thorough geotechnical site characterization prior to construction.[202] • Monitor embankment stability.[203] • Add to embankment when necessary to contain tailings. • Include impervious core in embankment design.[204] • Use downstream embankment design.[205] • Construct embankment out of materials that resist liquefaction.[206] • Install liner in impoundment above tailings line to prevent corrosion.
Mine Drainage and Seepage	MIW (e.g., acid, alkaline, or neutral mine drainage), runoff originating from exposed tailings, is also a distinct risk. Water percolating through uncovered or otherwise exposed disposal facilities may contain residual process chemicals or mobilized contaminants. While residual chemicals are usually recycled with tailings water, trace elements from the ore are housed in the tailings and represent longer-term sources of possible	• Installing an appropriate liner system that can incorporate leak detection and drainage systems.[210] • As part of mine design targeted extraction techniques such as selective mining and avoidance could be used to minimize mining of ore resulting in leach tailings that could result in MIW.[211]

[201] U.S. Environmental Protection Agency, *Technical Report: Design and Evaluation of Tailings Dams* EPA530-R-94-038 (Washington, DC: U.S. Government Printing Office, 1994), p.36-38; and D.J.A. Van Zyl and J.N. Johnson, eds., "Chapter 8: Systems Design for Site Specific Environmental Protection," in *Mining Environmental Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997), p. 440-441.

[202] U.S. Environmental Protection Agency, *Technical Report: Design and Evaluation of Tailings Dams* EPA530-R-94-038 (Washington, DC: U.S. Government Printing Office, 1994), p. 18-21.

[203] U.S. Environmental Protection Agency, *Technical Report: Design and Evaluation of Tailings Dams* EPA530-R-94-038 (Washington, DC: U.S. Government Printing Office, 1994), p. 38; and D.J.A. Van Zyl and J.N. Johnson, eds., "Chapter 8: Systems Design for Site Specific Environmental Protection," in *Mining Environmental Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997), p. 442.

[204] D.J.A. Van Zyl and J.N. Johnson, eds., "Chapter 8: Systems Design for Site Specific Environmental Protection," in *Mining Environmental Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997), p. 435.

[205] U.S. Environmental Protection Agency, *Technical Report: Design and Evaluation of Tailings Dams* EPA530-R-94-038 (Washington, DC: U.S. Government Printing Office, 1994), p. 24, 26-28; and D.J.A. Van Zyl and J.N. Johnson, eds., "Chapter 8: Systems Design for Site Specific Environmental Protection," in *Mining Environmental Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997), p. 435.

[206] U.S. Environmental Protection Agency, *Technical Report: Design and Evaluation of Tailings Dams* EPA530-R-94-038 (Washington, DC: U.S. Government Printing Office, 1994), p. 38; and D.J.A. Van Zyl and J.N. Johnson, eds., "Chapter 8: Systems Design for Site Specific Environmental Protection," in *Mining Environmental Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997), p.440-441.

[210] U.S. Environmental Protection Agency, *Technical Report: Design and Evaluation of Tailings Dams* EPA530-R-94-038 (Washington, DC: U.S. Government Printing Office, 1994), p. 45-48.

[211] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.1.

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
	contamination.[207] Further, drainage may react with sulfide minerals, creating acid drainage (which further mobilizes contaminants). [208] A variety of factors affect the rate of acid drainage generation from tailings including the water level within the pile, exposure to oxygen, and the presence of bacteria. Seepage involves the tailings breaching the storage facility and traveling into the groundwater or surface water. Although most commonly experienced with slurry tailings, seepage can also occur with thickened tailings, especially when exposed to precipitation. Breach can happen as a result of storage facility failure or through runoff that passes through the facility and carries tailings material with it. Seepage can occur in lined impoundments when the liner fails.[209] Further, impoundment failure via mine drainage or seepage and	• Production of paste or dry dewatered leach tailings to reduce potential for MIW.[212] • During operations special handling techniques such the addition of alkaline materials or amendments can be used to reduce potential for AMD from leach tailings.[213] • At closure leach tailings areas can be reclaimed using dry and wet covers to lessen or minimize discharges of MIW.[214]
Pipe Failure	Slurry tailings are piped from the processing facility to the impoundments. If the pipe fails at any point in the transportation process it discharges tailings to the local environment.[215]	• Monitor pipe stability regularly. • Install leak detection systems.[216]
Untreated Discharge	At processing facilities that do not reclaim water from tailings ponds, wastewater is sometimes treated and released into local waterways. If treatment fails, tailings water with constituent hazardous substances can be released.	• Install monitor for effluent discharge system.[217] • Capture using various hydrogeologic controls (e.g., cutoff wells, grout curtains, seepage

[207] See D.J.A. Van Zyl and J.N. Johnson, eds., "Chapter 8: Systems Design for Site Specific Environmental Protection," in *Mining Environmental Handbook: Effects of Mining on the Environment and American Environmental Controls on Mining*, ed. J.J. Marcus (London: Imperial College Press, 1997), p. 438 for recycling of supernatant with tailings water through decanting.

[208] U.S. Environmental Protection Agency, Office of Solid Waste, Special Waste Branch, *Technical Resource Document: Extraction and Beneficiation of Ores and Minerals* EPA 530-r-94-013, Volume 2: Gold (Washington, DC: U.S. Government Printing Office, 1994).

[209] U.S. Environmental Protection Agency, *Technical Report: Design and Evaluation of Tailings Dams* EPA530-R-94-038 (Washington, DC: U.S. Government Printing Office, 1994), p. 43-44.

[212] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.8.

[213] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.4.2.

[214] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.3.2.

[215] U.S. Environmental Protection Agency, *Technical Report: Design and Evaluation of Tailings Dams* EPA530-R-94-038 (Washington, DC: U.S. Government Printing Office, 1994), p. 30.

[216] See best practices for seepage control. Pipe failure leads to seepage from the fail point. U.S. Environmental Protection Agency, *Technical Report: Design and Evaluation of Tailings Dams* EPA530-R-94-038 (Washington, DC: U.S. Government Printing Office, 1994), p. 45 and 48.

[217] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.3.2.

TYPE OF RELEASE	DESCRIPTION	MANAGEMENT PRACTICES
		controls).[218] In the event the mine drainage requires treatment prior to discharge, either during operations or post-closure, a variety of active, passive and in situ mine drainage treatment techniques are potentially applicable.[219]
Fugitive Dust	Fugitive dust can occur with both slurry tailings, when the tailings form a beach in the impoundment pond, or with thickened tailings. In high wind conditions fugitive dust can travel off-site, contaminating the local environment.[220]	• Manage tailings distribution to maximize surface moisture. • Spray tailings with water regularly. • Apply a dust suppressant on the tailings impoundment. • Crimp in straw to minimize erosion. • Monitor tailings impoundment daily.[221] • At closure, dry, wet, or vegetative covers can be used to lessen or minimize fugitive dust emissions.[222]

[218] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.5.1.

[219] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 7.5.

[220] See U.S. Environmental Protection Agency, *Technical Report: Design and Evaluation of Tailings Dams* EPA530-R-94-038 (Washington, DC: U.S. Government Printing Office, 1994), p. 2; for an example, see fugitive dust releases at the Climax Molybdenum Mine (MSHA ID 0502256), from U.S. Environmental Protection Agency, *Draft: Mining Waste Release and Environmental Effects Summary for the State of Colorado* (Washington, DC: U.S. Government Printing Office, 1994), cited in U.S. Environmental Protection Agency, Human Health Damages from Mining and Mineral Processing Wastes; Technical Background Document Supporting the Final Rule Applying Phase IV Land Disposal Restrictions to Newly Identified Mineral Processing Wastes, EPA530-R-99-O37 (April 1998).

[221] All of the above from "Morenci Facts from FCX: Tailings Dust Management at Morenci," Freeport-McMoRan Copper & Gold Company, updated May 2011. Accessed December 3, 2015, at: http://www.fcx.com/sd/pdf/morenci_tailings_dust_mgmt.pdf.

[222] The International Network for Acid Prevention, *Global Acid Rock Drainage Guide* (Santiago, Chile: International Network for Acid Prevention Operating Committee, 2009), 6.6.3.2; and Monica O. Mendez and Raina M. Meier, "Phytostabilization of Mine Tailings in Arid and Semiarid Environments – An Emerging Remediation Technology," *Environmental Health Perspectives* 116:3 (March 2008), p. 279.

Table A6. Slag Piles [223, 224]

METAL	PROCESS	MATERIAL INPUT	AIR EMISSIONS	LIQUID WASTE	OTHER WASTES
Copper	Copper smelting	Copper concentrate, siliceous flux	Sulfur dioxide, particulate matter containing arsenic, antimony, cadmium, lead, mercury and zinc	None	Acid plant blowdown slurry/sludge, slag containing iron sulfides, silica
Lead	Lead smelting	Lead sinter, coke	Sulfur dioxide, particulate matter containing cadmium and lead	Plant washdown wastewater, slag granulation water	Slag containing impurities such as zinc, iron, silica and lime, surface impoundment solids
Zinc	Zinc calcining	Zinc ore, coke	Sulfur dioxide, particulate matter containing zinc and lead	None	Acid plant blowdown slurry
Aluminum	Alumina calcination	Aluminum hydrate	Particulates and water vapor	None	None
	Primary electrolytic aluminum smelting	Alumina, carbon anodes, electrolytic cells, cryolite	Fluoride—both gaseous and particulates, carbon dioxide, sulfur dioxide, carbon monoxide, C2F6,CF4 and perfluorinated carbons (PFC)	None	Spent potliners
Iron	Iron smelting using a blast furnace	Iron ore or sinter, coke, limestone or dolomite	Sulfur dioxide, carbon monoxide	Coolant containing zinc, tar, and lime residue	Slag containing sulfur, magnesium, and/or silicon-based compounds

[223] Jeanne Mager Stellman, "Chapter 82 - Metal Processing and Metal Working Industry," *Encyclopaedia of Occupational Health and Safety*, (Geneva: International Labour Office/ ILO/ International Labour Organisation, 1998), Volume 4.

[224] U.S. Environmental Protection Agency, "Iron and Steel," in *Identification and Description of Mineral Processing Sectors and Waste Streams* (Washington, DC: U.S. Government Printing Office, 2012). Accessed November 5, 2015, at https://archive.epa.gov/epawaste/nonhaz/industrial/special/web/pdf/id4-hfa.pdf

Appendix B. Comparison of Mine Tailings BADCT and Regulations, Mt Polley Expert Panel, Montana SB409 Revisions, British Columbia Part 10 HSRC Revisions, New Mexico Office of State Engineer

Table B1. Comparison of Mine Tailings BADCT and Regulations

Mt Polley Expert Panel,[225] Montana SB409 Revisions,[226] British Columbia Part 10 HSRC Revisions,[227] New Mexico Office of State Engineer[228]

Mount Polley Expert Panel Recommendations (2014)	**Montana Metal Mine Reclamation Act Section 82-4 Revisions 7(SB 409) (2015)**	**British Columbia Health, Safety and Reclamation Code Part 10 Revisions (2016)**	**New Mexico Office of State Engineer Part 12 Dam Design, Construction and Dam Safety (2010)**
Implement Best Available Technologies (BAT) using a phased approach: • Existing TSFs. Rely on best practices for the remaining active life. • New TSFs. BAT (filtered tailings) should be actively encouraged for new tailings facilities at existing and proposed mines. • At closure. BAT principles (no surface water, unsaturated conditions, achieve dilatant conditions) should be applied to closure of active impoundments so that they are progressively removed from the inventory by attrition.	**82-4-303. Definitions.** (25) "Practicable" means available and capable of being implemented after taking into consideration cost, existing technology, and logistics in light of overall project purposes. **Section 5. Tailings Storage facility - design document - fee.** (2) The design document must contain: (e) an evaluation indicating that the proposed tailings storage facility will be designed, operated, monitored, and closed using the most applicable, appropriate, and current technologies and techniques practicable given site-specific conditions and concerns;	**Definitions.** “best available technology” means the site specific combination of technologies and techniques that most effectively reduce the physical, geochemical, ecological and social risks associated with tailings storage during all stages of operation and closure. **Application Requirements. 10.1.3** The application shall include the following unless otherwise authorized by the chief inspector: (f) an alternatives assessment for the proposed tailings storage facilities that assesses best available technology,	*Not addressed.*
Improve corporate governance: Corporations proposing to operate a TSF should be required to be a member of the Mining Association of Canada (MAC) or be obliged to commit to an equivalent program for tailings management, including the audit function.	**Section 5. Tailings Storage facility - design document - fee.** (2) The design document must contain: (x) a description of proposed risk management measures for each facility life-cycle stage, including construction, operation, and closure;	**Governance. 10.4.2** (1) The manager of a mine with one or more tailings storage facilities shall: (a) develop and maintain a Tailings Management System that considers the HSRC Guidance Document and includes regular system audits	**19.25.12.11 Design of a Dam:** G. Dam site security: Dams classified as high or significant hazard potential shall address security at dams to prevent unauthorized operation or access. If in the opinion of the state engineer, the failure of the dam will result in catastrophic consequences, a security and risk management program for the dam will be required. Elements of a security and risk management program are: (1) threat, vulnerability and risk assessments; (2) physical security plans; and (3) integration of security operational procedures.

[225] “Mount Polley Independent Expert Investigation and Review Report,” Mount Polley Review Panel. Available at: https://www.mountpolleyreviewpanel.ca/.

[226] Montana SB409 Revisions.

[227] British Columbia, Guidance Document: Health, Safety and Reclamation Code for Mines in British Columbia (July 2016).

[228] New Mexico Office of the State Engineer, Rules and Regulations Governing Dam Design, Construction, and Dam Safety (2010).

Table B1. Comparison of Mine Tailings BADCT and Regulations (continued)

Mt Polley Expert Panel, Montana SB409 Revisions, British Columbia Part 10 HSRC Revisions, New Mexico Office of State Engineer

Mount Polley Expert Panel Recommendations (2014)	Montana Metal Mine Reclamation Act Section 82-4 Revisions (SB 409) (2015)	British Columbia Health, Safety and Reclamation Code Part 10 Revisions (2016)	New Mexico Office of State Engineer Part 12 Dam Design, Construction & Dam Safety (2010)
Expand corporate design commitments: Future permit applications for a new TSF should be based on a bankable feasibility that would have considered all technical, environmental, social and economic aspects of the project in sufficient detail to support an investment decision, which might have an accuracy of +/- 10-15%. More explicitly it should contain the following: • A detailed evaluation of all potential failure modes and a management scheme for all residual risk • Detailed cost/benefit analyses of BAT tailings and closure options so that economic effects can be understood, recognizing that the results of the cost/benefit analyses should not supersede BAT safety considerations • A detailed declaration of Quantitative Performance Objectives (QPOs).	**Section 5. Tailings Storage facility - design document - fee.** (2) The design document must contain: (n) a dam breach analysis, a failure modes and effects analysis or other appropriate detailed risk assessment, and an observational method plan addressing residual risk; (t) a list of quantitative performance parameters for construction, operation, and closure of the tailings storage facility. The quantitative performance parameters may be expressed as minimums or maximums for embankment crest width, embankment slopes, beach width, operating pool volume, phreatic surface elevation in the embankment and foundation, pore pressures, or other parameters appropriate for the facility and location. (x) a description of proposed risk management measures for each facility life-cycle stage, including construction, operation, and closure;	**Application Requirements. 10.1.3** The application shall include the following unless otherwise authorized by the chief inspector: (d) a mine plan including: (vii) designs and details for tailings storage and a description of proposed quantifiable performance objectives, (e) a program for the environmental protection of land and watercourses during the construction and operational phases of the mining operation, including plans for (i) prediction, identification and management of physical, chemical, and other risks associated with tailings storage facilities and dams, (f) an alternatives assessment for the proposed tailings storage facilities that assesses best available technology,[229] **Governance. 10.4.2** (1) The manager of a mine with one or more tailings storage facilities shall: (d) review annually the tailings storage facility risk assessment to ensure that the quantifiable performance objectives and operating controls are current and manage the facility risks,	**19.25.12.18 Emergency Action Plan:** F. Inundation map: An inundation map delineating the areas that will be flooded as a result of dam failure. The inundation map shall be supported by a dam breach and flood routing analysis report. The dam breach and flood routing analysis shall evaluate the sunny day failure, failure at the high water line and any additional event deemed appropriate by the dam owner. If appropriate considering the consequences of dam failure, a simplified dam breach and flood routing analysis may be used with approval from the state engineer. If a dam is located downstream, failure scenarios with the downstream dam shall also be evaluated. Evaluation of the effects of flooding from dam failure shall extend at least to the location downstream where the consequences of dam failure does not pose a threat to life and evacuation or restricting access is not required. A professional engineer licensed in the state of New Mexico qualified in the design and construction of dams shall prepare this element. If available, shape files from geographic information system software of the inundation map shall be submitted. Inundation maps shall include the following information at critical locations downstream: (1) distance downstream from the dam; (2) arrival time of the leading edge of the flood wave; (3) peak flow depth, incremental rise and water surface elevation in feet; and (4) peak velocity in feet per second.

[229] BC HSRC for Mines Version 1.0, July 2016. The alternatives assessment for TSFs will consider BAT and will provide a comparative analysis of options considering the following sustainability factors: Environment; Society; Economics.

Table B1. Comparison of Mine Tailings BADCT and Regulations (continued)

Mt Polley Expert Panel, Montana SB409 Revisions, British Columbia Part 10 HSRC Revisions, New Mexico Office of State Engineer

Mount Polley Expert Panel Recommendations (2014)	**Montana Metal Mine Reclamation Act Section 82-4 Revisions (SB 409) (2015)**	**British Columbia Health, Safety and Reclamation Code Part 10 Revisions (2016)**	**New Mexico Office of State Engineer Part 12 Dam Design, Construction & Dam Safety (2010)**
Enhance validation of safety and regulation of all phases of a TSF: • Increase utilization of Independent Tailings Review Boards. • Utilize the concept of Quantitative Performance Objectives (QPOs) to improve regulator evaluation of ongoing facilities.	**Section 6. Independent review panel - selection - duties.** (1) An independent review panel shall review the design document required by [section 5]. (2) The operator or permit applicant shall select three independent review engineers to serve on the panel and shall submit those names to the department. The department may reject any proposed panelists. If the department rejects a proposed panelist, the operator or permit applicant shall continue to select independent review engineers as panelists until three panelists are approved by the department. (3) An independent review engineer may not be an employee of: (a) an operator or permit applicant; or (b) the design consultant, the engineer of record, or the constructor. (4) The operator or permit applicant shall contract with panel members, process invoices, and pay costs. (5) A representative of the department and a representative of the operator or permit applicant may participate on the panel, but they are not members of the panel and their participation is nonbinding on the review. (6) The engineer of record is not a member of the panel but shall participate in the panel review. (7) The operator or permit applicant shall provide each panel member with a hard copy and an electronic copy of the design document and other information requested by the panel. (8) The panel shall review the design document, underlying analysis, and assumptions for consistency with this part. The panel shall assess the practicable application of current technology in the proposed design. (9) The panel shall submit its review and any recommended modifications to the operator or permit applicant and the department. The panel's determination is conclusive. The report must be signed by each panel member. (10) The engineer of record shall modify the design document to address the recommendations of the panel and shall certify the completed design document. The operator or permit applicant shall submit the final design document to the department pursuant to [section 5]. (11) For an expansion of a tailings storage facility for which the original design document was approved by the department, the operator shall make a reasonable effort to retain the previous panel members. To replace a panel member, the process in subsection (2) must be followed.	**Governance. 10.4.2** (1) The manager of a mine with one or more tailings storage facilities shall: (c) establish an Independent Tailings Review Board, unless exempted by the chief inspector, (2) The composition of an Independent Tailings Review Board established under subsection (1) (c) shall be commensurate with the complexity of the tailings storage facility in consideration of the HSRC Guidance Document. (d) review annually the tailings storage facility risk assessment to ensure that the quantifiable performance objectives and operating controls are current and manage the facility risks, (3) The manager shall submit the terms of reference for the Independent Tailings Review Board including the qualifications of the board members to the chief inspector for approval. (4) The terms of reference for the Independent Tailings Review Board shall be developed or updated as required in consideration of the review under subsection (1) (d). **Annual Reporting. 10.4.4** The owner, agent or manager shall submit one or more annual reports in a summary form specified by the chief inspector or by the conditions of the permit by March 31 of the following year on the following: (c) a report of the activities of the Independent Tailings Review Board established under section 10.4.2 (1) (c) of this code that describes the following: (i) a summary of the reviews conducted that year, including the number of meetings and attendees; (ii) whether the work reviewed that year meets the Board's expectations of reasonably good practice; (iii) any conditions that compromise tailings storage facility integrity or occurrences of non-compliance with recommendations from the engineer of record; (iv) signed acknowledgement by the members of the Board, confirming that the report is a true and accurate representation of their reviews	*Not addressed.*

Table B1. Comparison of Mine Tailings BADCT and Regulations (continued)

Mt Polley Expert Panel, Montana SB409 Revisions, British Columbia Part 10 HSRC Revisions, New Mexico Office of State Engineer

Mount Polley Expert Panel Recommendations (2014)	**Montana Metal Mine Reclamation Act Section 82-4 Revisions (SB 409) (2015)**	**British Columbia Health, Safety and Reclamation Code Part 10 Revisions (2016)**	**New Mexico Office of State Engineer Part 12 Dam Design, Construction & Dam Safety (2010)**
Strengthen current regulatory operations: Utilize the recent inspections of TSFs in the province to ascertain whether they may be at risk due to the following potential failure modes and take appropriate actions: • Filter adequacy • Water balance adequacy • Undrained shear failure of silt and clay foundations	*No additional requirements for existing TSFs.*	Inspections required and completed. Final submissions received June 30, 2015. More information available at: http://www2.gov.bc.ca/gov/content/industry/mineralexploration-mining/dam-safety-inspections-2014	*No additional requirements for existing TSFs.*
Improve professional practice: Encourage the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) to develop guidelines that would lead to improved site characterization for tailings dams with respect to the geological, geomorphological, hydrogeological and possibly seismotectonic characteristics.	*No equivalent action has yet been performed by a professional organization located in the U.S.*	APEGBC developed and published Site Characterization for Dam Foundations in BC, August 2016. https://www.apeg.bc.ca/getmedia/34e1bb3f-cd39-450d-800e-614ac3850bc5/APEG_2016_Site-Characterization-for-Dam-Foundations_WEB_2.pdf.aspx	*No equivalent action has yet been performed by a professional organization located in the U.S.*

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Improve dam safety guidelines: Recognizing the limitations of the current Canadian Dam Association (CDA) guidelines incorporated as a statutory requirement, develop improved guidelines that are tailored to the conditions encountered with TSFs in British Columbia and that emphasize protecting public safety.	**Section 5. Tailings Storage facility - design document - fee.** (g) a demonstration through site investigation, laboratory testing, geotechnical analyses, and other appropriate means that the tailings, embankment, and foundation materials controlling slope stability are not susceptible to liquefaction or to significant strain-weakening under the anticipated static or cyclic loading conditions, to the extent that the amount of estimated deformation under the loading conditions would result in loss of containment; (h) for a new tailings storage facility, design factors of safety against slope instability not less than: (i) 1.5 for static loading under normal operating conditions, with appropriate use of undrained shear strength analysis for saturated, contractive materials; (ii) 1.3 for static loading under construction conditions if the independent review panel created pursuant to [section 6] agrees that site-specific conditions justify the reduced factor of safety and that the extent and duration of the reduced factor of safety are acceptable; and (iii) 1.2 for postearthquake, static loading conditions with appropriate use of undrained analysis and selection of shear strength parameters. Under these conditions, a postearthquake factor of safety less than 1.2 but greater than 1.0 may be accepted if the amount of estimated deformation does not result in loss of containment. (i) for a new tailings storage facility, an analysis showing that the seismic response of the tailings storage facility does not result in the uncontrolled release of impounded materials or other undesirable consequences when subject to the ground motion associated with the 1-in-10,000-year event, or the maximum credible earthquake, whichever is larger. Any numeric analysis of the seismic response must be calculated for the normal maximum loading condition with steady-state seepage. The analysis must include, without limitation, consideration of: (i) anticipated ground motion frequency content; (ii) fundamental period and dynamic response; (iii) potential liquefaction; (iv) loss of material strength; (v) settlement; (vi) ground displacement; (vii) deformation; and (viii) the potential for secondary failure modes. (j) if a pseudo-static stability analysis is performed to support the design, a justification for the use of the method with respect to the anticipated response to cyclic loading of the tailings facility structure and constituent materials. The calculations must be accompanied by a description of the assumptions used in deriving the seismic coefficient.	**10.1.8** (1) Seismic and flood design criteria for tailings storage facilities and dams shall be determined by the engineer of record based on the consequence classification determined under section 10.1.7 of this code in consideration of the HSRC Guidance Document, subject to the following criteria: (a) for tailings storage facilities that store water or saturated tailings, (i) the minimum seismic design criteria shall be a return period of 1 in 2475 years, (ii) the minimum flood design criteria shall be a return period1/3rd of the way between the 1 in 975-year event and the probable maximum flood, and (iii) a facility that stores the inflow design flood shall use a minimum design event duration of 72 hours; (b) for tailings storage facilities that cannot retain water or saturated tailings, (i) the minimum seismic design criteria shall be a return period of 1 in 975 years, and (ii) the water management design shall include an assessment of tailings facility erosion and surface water diversions as well as measures to prevent impounded tailings from becoming saturated that consider the consequence classification as determined under section 10.1.7 of this code. (2) The environmental design flood criteria shall be determined by a Professional Engineer in consultation with other qualified professionals. **10.1.9** For a tailings storage facility design that has an overall downstream slope steeper than 2H:1V, the manager shall submit justification by the engineer of record for the selected design slope and receive authorization by the chief inspector prior to construction. **10.1.10** For a tailings storage facility design that has a calculated static factor of safety of less than 1.5, the manager shall submit justification by the engineer of record for the selected factor of safety and receive authorization by the chief inspector prior to construction.	19.25.12.11 (12) Stability analysis. Cross-sectional design for dams shall be supported by slope stability analysis. For dams with aesthetic fill on the downstream slope, the stability of the downstream slope shall be evaluated with and without the aesthetic fill. Dams classified as low hazard potential with upstream slopes no steeper than 3 horizontal to 1 vertical, downstream slopes no steeper than 2 horizontal to 1 vertical and which are 25 feet or less in height will not require slope stability analysis. Stability analysis of the reservoir rim is required where slopes are steeper than 3 horizontal to 1 vertical. The analysis model shall adequately represent the geometry and zoning, shear strength parameters, material unit weights, pore pressure and seepage conditions, external loading and other relevant factors of the critical cross section or sections. Manual computations in the analysis will be accepted if judged to be sufficiently rigorous. Where appropriate, the analysis shall consider noncircular or block and wedge type failure surfaces as well as circular failures. All parameters and assumptions used in the analysis shall be summarized in a table and justified in the geotechnical investigation. A scale drawing, utilizing the same scale for vertical and horizontal dimensions, shall be provided for each cross-sectional model used in the analysis, with the critical failure surface(s) identified. Appropriate data sheets and computer program output computations from computerized analysis shall be provided. Dams shall be designed to provide the following minimum factors of safety from the stability analysis: (a) 1.5 for steady state long-term stability; (b) 1.5 for operational drawdown conditions; (c) 1.3 for rapid drawdown conditions; and (d) 1.3 for end of construction. (13) Seismic design and analysis. Dams and appurtenant structures classified as high or significant hazard potential shall be analyzed for seismic stability. Seismic analysis for water storage dams shall be based on full reservoir under steady state seepage conditions. Flood control dams with ungated outlets that satisfy Subparagraph (b) of Paragraph (7) of Subsection C of 19.25.12.11 NMAC without waiver shall be designed for earthquake loads under empty reservoir conditions and need not consider steady-state seepage. Dams sited on active faults shall obtain a waiver from the state engineer. To obtain a waiver the analysis shall show that the location of the dam is unavoidable and the dam must be designed to withstand anticipated fault movement without compromising its integrity. Appropriate data sheets and computer program output computations from computerized analysis shall be provided. The seismic analysis shall meet the minimum requirements described below. (a) A seismological investigation for the dam area and reservoir area shall be performed. This study may be part of the geological or geotechnical report for the structure, or may be a separate effort. The study shall determine and justify the appropriate seismic parameters to be used for design. The dam and appurtenant structures shall be capable of withstanding the operating basis earthquake with little to no damage and without interruption of function. The operating basis earthquake has a 50% probability of exceedance during the service life of the dam or appurtenant structures. In no case shall the service life be less than 100 years. The dam and appurtenant structures critical to the safety of the dam shall be capable of withstanding the design earthquake without failure. The seismic

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			parameters shall be based on the design earthquake requirements described below. (i) Dams classified as high hazard potential other than flood control structures shall be designed for the maximum credible earthquake or for a 1% probability of exceedance in 50 years (approximately 5000-year return frequency). (ii) Dams classified as significant hazard potential or high hazard potential dams whose sole purpose is for flood control shall be designed for a 2% probability of exceedance in 50 years (approximately 2500-year return frequency). (b) An analysis of materials in the foundation, reservoir area and proposed embankment shall be completed to determine the potential for liquefaction, earthquake-induced sliding, or other seismic sensitivity, which may be accomplished as part of the geotechnical investigation. (c) Pseudostatic analysis will be acceptable for the following cases: (i) the embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D 698, or at least 90% of the maximum modified Proctor density, ASTM D 1557; no materials prone to liquefaction are present in the foundation and peak ground acceleration is 0.20g or less; or (ii) the embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D 698, or at least 90% of the maximum modified Proctor density, ASTM D 1557; potentially submerged portions of the embankment except for internal drain elements are constructed of clayey material; the dam is constructed on clayey soil or bedrock foundation and peak ground acceleration is 0.35g or less; and (iii) all safety factor requirements in accordance with Subparagraphs (a) through (d) of Paragraph (12) of Subsection C of 19.25.12.11 NMAC are met; (iv) minimum freeboard requirements in accordance with Subparagraphs (a) through (e) of Paragraph (15) of Subsection C of 19.25.12.11 NMAC are met; and (v) the pseudostatic coefficient selected for analysis must be at least 50% of the predicted peak ground acceleration, but not less than 0.05g and the factor of safety under pseudostatic analysis shall be 1.1 or greater. In determining the factor of safety for pseudostatic analysis, a search for the critical failure surface shall be made. (d) For dams not satisfying the requirements for pseudostatic analysis, a deformation analysis is required. The resulting embankment must be capable of withstanding the design earthquake without breaching and with at least 3 feet of freeboard remaining after deformation. The analysis shall also assess the potential for internal erosion as a result of cracking during deformation.