Bureau of Mining Regulation and Reclamation

GUIDANCE FOR PERMANENT CLOSURE OF UNDERGROUND MINE WORKINGS

Introduction

The purpose of this document is to provide guidance to mine operators on Nevada requirements for permanent closure of shafts, adits, vent raises, other underground mine workings, and all pollutant sources associated with or located within, when planning underground mine closure activities.

For example, if an underground mine has penetrated the water table, cessation of dewatering activities should result in the eventual return of groundwater approximately to pre-mining water table elevations, unless other approved water uses prevent a full rebound. This inundation of underground workings with groundwater could create the potential to degrade waters of the State of Nevada (WOTS) if appropriate permanent closure actions are not taken. Proper plugging of openings to underground mines (on the land surface) and removal, mitigation, or chemical stabilization of all pollutant sources are required to protect WOTS.

This document does not establish new statutory or regulatory requirements but describes closure planning and methods likely to satisfy the Nevada statutes and regulations applicable to underground mines currently operating in the state of Nevada and those that have operated on or since 1 September 1989. Each underground mine is unique and will require an individual closure plan. The methods described herein are not intended to be inclusive of all possible acceptable closure configurations. Though each underground mine closure is unique, this document and the statutory and regulatory requirements referred to herein are applicable to any underground mining facility operating in the state of Nevada on or since 1 September 1989.

Authority

It is the statutory responsibility of the Nevada Department of Conservation and Natural Resources (DCNR) – Division of Environmental Protection (NDEP) to administer and enforce the provisions of Nevada Revised Statutes (NRS) 445A.300 - 445A.730 (Nevada Water Pollution Control Law) and NRS 519A.010 - 519A.280 (Reclamation of Land Subject to Mining Operations or Exploration Projects), and associated regulations at Nevada Administrative Code (NAC) Chapters 445A and 519A, for the purposes of protecting WOTS and ensuring productive postmining land uses.

Per intradepartmental correspondence dated 11 January 2019, the State Engineer of the Nevada Division of Water Resources (NDWR) determined that, "*Mining and mine closure activities relating to vents, shafts, adits, tunnels, blast holes, shot holes, instrumentation boreholes, etc., that do not fall under the definition of water well and related drilling is not within the scope of authority of the Office of the State Engineer, and as such, is not regulated by the NDWR.*" This determination, combined with the provisions of NAC 445A.350 – 445A.447, inclusive (Regulations Governing Design, Construction, Operation and Closure of Mining Operations) and NAC 519A.010 - 519A.635, inclusive (Regulations Governing Reclamation of Land Subject to Mining Operations and Exploration Projects), establish NDEP's Bureau of Mining Regulation

and Reclamation (BMRR) as the agency responsible for oversight of closure and abandonment of underground mine workings to protect WOTS. This determination does not negate requirements that all water wells and related drilling boreholes, including exploration boreholes, must be plugged pursuant to NRS 534 and NAC 534.

Regarding abandonment of solid wastes in underground workings, NRS 444.630 defines the "…(placement of) any solid waste…upon any…public property other than property designated or set aside for such a purpose by the governing body thereof, or upon any private property…" as illegal. Additionally, NAC 445A.598 defines an open dump as "…an uncontrolled disposal site where solid waste is disposed of in a manner which does not comply with NRS 444.630, NAC 444.570 to 444.7499, inclusive, or any permit issued pursuant thereto." Based on these references, and per intradepartmental correspondence dated 3 September 2020, the Nevada Bureau of Sustainable Materials Management (BSMM) determined that any disposal of waste material and equipment in an unauthorized manner would be illegal. Further, specific to abandonment of solid wastes in underground mines, BSMM *"declines to apply the Class III waiver provision of NAC 444.731(3) to this manner of solid waste disposal."* This establishes BMRR as the agency responsible to review and authorize closure plans for, and to enforce requirements related to, removal and/or abandonment of solid wastes within underground mines.

General Requirements for Permanent Closure of Underground Workings and Associated Pollutant Sources

Per NRS 445A.415, WOTS "means all waters situated wholly or partly within or bordering upon this State…," including all groundwater and surface water. Pursuant to NAC 445A.424, mining facilities are prohibited from degrading WOTS beyond specified water quality limits (for groundwater: drinking water standards or natural background concentrations, whichever are higher).

All mining facilities are subject to requirements for closure. Facilities are defined at NAC 445A.359 as "all portions of a mining operation, including, but not limited to, the mine, waste rock piles, ore piles, beneficiation process components, processed ore disposal sites, and all associated buildings and structures. The term does not include any process component or non-process component which is not used for mining or mineral production, and has not been used in the past for mining or mineral production as part of an operation which is active as of 1 September 1989."

Permanent closure is defined at NAC 445A.367 as "the time in the life of a facility when activities for the final stabilization, removal or mitigation of [pollutant] sources are undertaken."

As defined per updated, but not yet codified regulations, effective 30 August 2018 "Mitigate" or "mitigation" includes, without limitation:

1. Avoiding the potential degradation of waters of the State by taking or not taking a certain action or parts of an action;
2. Minimizing the degradation or potential degradation of waters of the State by limiting the degree or magnitude of an action or its implementation;

3. Reducing or eliminating the degradation or potential for degradation of waters of the State by taking corrective action as defined in NAC 445A.2262; or
4. Reducing or eliminating the degradation or potential for degradation of waters of the State over time through preservation and maintenance over the life of the action."

NAC 445A.398 states that the operating plans for a facility must include a tentative plan for permanent closure (TPPC). Per updated, but not yet codified regulations, effective 30 August 2018 and 26 August 2020, the TPPC must include the conceptual procedures, methods, and schedule for stabilizing all pollutant sources at a mining facility, must contain enough detail to support the cost estimate for reclamation per NAC 519.360, and must be kept up to date throughout the mine life cycle as plans, operations, and site conditions change.

NAC 445A.429 provides requirements for permanent closure of mine pits and underground workings, including: "The holder of the permit must institute appropriate procedures to ensure that all mined areas do not release contaminants that have the potential to degrade waters of the State," and "Underground mines must, to the extent practicable, be left in a manner which minimizes the inflow and outflow of water through the openings to the mine on the surface of the land."

NAC 445A.446 specifies when permanent closure of a mining facility or an individual pollutant source at a mining facility must be initiated including: "For an underground mine, and any source therein, which has the potential to degrade waters of the State, before the elimination of safe access to the mine" and when permanent closure is complete, the length of time the post-closure monitoring period must last after permanent closure (up to 30 years, but commonly less).

NAC 445A.447 states, "Plans for permanent closure are required for all [pollutant] sources at a facility," and "A final plan for permanent closure of any source which has been identified as a process component must be submitted to the Department at least two years before the anticipated permanent closure of that process component."

NAC 519A.044 defines mine-impacted waters as any contaminated water resulting from a mining operation, including, without limitation, an underground mine and requiring stabilization, management, control, or treatment to prevent or mitigate the degradation of WOTS.

Finally, NAC 519A.345.10 states that the Division may, if appropriate, require an operator of a mining operation to reclaim underground mines by sealing shafts, adits, portals and tunnels to prevent access and to implement measures to stabilize, manage, control, or treat mine-impacted waters.

Permanent closure of underground workings must, to the extent safe and practicable, prevent cross-contamination between different groundwater aquifers if the aquifer chemistry is such that the mixing would cause degradation of an aquifer per NAC 445A.424. This will be evaluated on a site-by-site basis and may result in the need to install one or more seals or backfill/plugged zones to isolate certain zones above or below the predicted groundwater rebound elevation as necessary within the underground workings. These seals or backfill/plugged zones act to isolate aquifers to either preclude sulfide oxidation or formation of acidic or metalliferous evaporative mineral precipitates (EMPs) by restricting airflow, or to chemically isolate zones where these and/or any

other contaminants in the underground workings are not practicable to remove. Alternatively, other actions may be acceptable if they remove, mitigate, or chemically stabilize contaminants and reduce or eliminate the potential for degradation of WOTS.

All closed mine openings shall have a monument placed to establish location of the closed feature. The location shall be recorded in meters and decimals of meters, using the Nevada Coordinate System of 1983 in accordance with the requirements of Chapter 327 of NRS.

For all mine facilities, the owner and operator are responsible for contacting other federal, state, and local agencies to determine any other applicable requirements related to mine closure, and for communicating such requirements in the mine closure plans. For example, the Nevada Division of Wildlife (NDOW) or the Bureau of Land Management (BLM) may require installation of a bat gate instead of a surface seal.

Specific Requirements for Permanent Closure of Underground Mine Workings and Associated Pollutant Sources

Tentative and Final Plans for Permanent Closure (TPPCs and FPPCs)

For general requirements applicable to all TPPCs and FPPCs, please refer to the BMRR guidance documents, "Guidance for Preparing Tentative Plans for Permanent Closure" and "Preparation Requirements and Guidelines for Permanent Closure Plans and Final Closure Reports" at Mining Closure Guidance, Policies, References, and Requirements. Specific TPPC requirements for underground mines are not addressed in this guidance. As a mine commences operation and nears closure, the TPPC will become more specific to the site conditions. Operators are encouraged to develop the TPPC such that when the time comes, the FPPC may largely rely on information already contained within the TPPC. FPPCs for underground workings and associated pollutant sources must include:

1. Geologic maps and analytical data describing the structure, lithology, mineralogy, alteration, geochemistry, and hydrology in the area of the underground mine workings being proposed for closure;
2. Mine history summary including mine plan with a map of underground workings that includes locations and dimensions of all service/supply boreholes (e.g., for oils, fuel, water, ventilation, escape), EMPs (as applicable), etc.;
3. Condition of access into mine workings including potential risks to life and property associated with the mine;
4. Discussion of the known potential for surface elevation changes due to subsidence, water table variations, and/or collapse of workings;
5. Potential for water to flow into or out of each mine opening to the land surface;
6. Presence or evidence of acid rock drainage (ARD), and potential for generation of ARD;
7. Listing of potential underground pollutant sources including locations and descriptions of:
    a. Supply and chemical storage areas and their contents;
    b. Equipment, infrastructure, and containment areas (e.g., truck wash sumps, maintenance shops and sumps, fueling stations, tank farms, petroleum pipes, contact water sumps,

petroleum release locations, cement plants, tailings paste fill plants and pipes, major electrical components, etc.);

8. Proposed actions to remediate each potential pollutant source (e.g., removal, mitigation, or chemical stabilization) or a demonstration/rationale that the source does not have the potential to degrade WOTS. As applicable, include how and where any associated waste materials will be properly disposed;
9. If the operator proposes to abandon any materials in place, a description of the materials and justification for their abandonment based on legitimate safety and/or logistical concerns. For example, it may be necessary to abandon structural materials required for safe access, ventilation system components for workers performing closure activities, and steel structures that are unsafe to dismantle. Abandonment will be approved only upon presentation of sufficient justification. All materials that are deemed acceptable for abandonment must be approved, in writing, prior to abandonment;
10. If underground mine operations penetrate the water table: The volume, location, solubility, mineralogy, and analytical data for EMPs or any other contaminants introduced or concentrated by the mining operation that are proposed to remain during closure at or beneath the predicted ultimate elevation of groundwater rebound;
11. If underground mine operations penetrate the water table and there is potential for acid generation or acidic EMPs: The approximate volume and locations of shotcrete or other neutralizing materials that have been applied and are proposed to remain during closure under the predicted ultimate elevation of groundwater rebound;
12. If BMRR determines that there is a significant potential for degradation of WOTS (e.g., acid generation, acidic or metalliferous EMP, etc.), a hydrogeochemical predictive model may be required to determine potential impacts to groundwater quality for different mitigation scenarios;
13. Per NAC 445A.429, engineered designs stamped by a Nevada-licensed professional engineer, as applicable, for proposed surface plugs/seals and/or other components to minimize the inflow and outflow of water through all adit or shaft openings to the land surface. As noted below, a surface seal or barrier is required by the BMRR Reclamation Branch even if there is no potential to degrade WOTS;
14. Engineered designs, stamped by a Nevada-licensed professional engineer, for proposed underground sealing and/or plugging actions and locations, if necessary, to reduce or eliminate the potential for degradation of WOTS from: a) pollutant sources, b) cross-contamination of groundwater aquifers, or c) EMPs or other contaminants introduced or concentrated by the mining operation; and
15. Details of any other proposed actions to reduce or eliminate the potential to degrade WOTS.

FPPCs must be submitted to BMRR for review and approval. Once approved by BMRR, the permanent closure activities may commence per an approved or agreed upon schedule.

Final Closure Reports

Within 30 days after completion of approved permanent closure actions, the Permittee must submit a Final Closure Report, including as-built information, daily logs, photographs and quality

assurance/quality control data. For more information on Final Closure Reports, please refer to the BMRR guidance document, "Preparation Requirements and Guidelines for Permanent Closure Plans and Final Closure Reports" at Mining Closure Guidance, Policies, References, and Requirements.

Decommissioning of Underground Workings

Upon cessation of underground production activities, all equipment that can safely and practicably be removed from the underground shall be removed and brought to the surface, including but not limited to the following:

- Mobile equipment;
- Electrical equipment, control gear, substations and transformers, wire, cable, etc.;
- Ventilation equipment, including fans, adapters, and starters;
- Pumps, hoses, flow meters and stage tanks;
- Miscellaneous hand tools and apparatus;
- Communication equipment, emergency facilities, safety and first-aid supplies;
- Sanitary facilities;
- Explosives;
- Unused ground support materials;
- Cement batch plant;
- Emergency escape elevator system, if applicable, and;
- Other miscellaneous operating supplies.

All tanks, pipes, and sumps containing hydrocarbons, or any other fluids, shall be flushed or emptied prior to removal or abandonment in the underground workings.

All power and water services shall be disconnected in accordance with applicable procedures and standards such that they do not pose electrical and/or other related safety hazards. Where practicable, cabling containing copper is to be brought to surface.

Abandonment of items will be evaluated on a site-specific basis. Abandonment will be allowed only upon presentation of sufficient justification related to safety and/or logistical concerns, as presented by the Permittee in the FPPC and approved by the Division. All materials that are deemed acceptable for abandonment must be approved, in writing, prior to abandonment.

Permanent Closure Methods for Underground Mine Workings that Do Not Penetrate the Groundwater Table

If groundwater is not encountered in the underground workings, the Division presumes that groundwater is present at 1 foot beneath the total depth, unless hydrologic characterization indicates otherwise. Generally, underground workings may be demonstrated not to penetrate the water table if hydrologic characterization shows that groundwater is not predicted to recover within 25 feet of any portion thereof.

If no part of the underground workings penetrates the pre-mining water table and there is no potential for degradation of WOTS, nor potential for water to flow into or out of any of the surface

mine openings, a surface seal or barrier, at a minimum, is still required per NAC 519A.345 Section 10, for public safety and/or wildlife purposes. Consult with the BMRR Reclamation Branch and the federal land management agency, if any, to determine design requirements.

Permanent Closure Methods for Underground Mine Workings that Do Penetrate the Groundwater Table

All openings to the land surface (e.g., shafts, vent raises, adits, escape ways, declines, boreholes for piping and wiring, etc.) of an underground mine that penetrate the pre-mining water table elevation must be plugged and sealed to minimize the potential for degradation of WOTS per NAC 445A.424 and to minimize the inflow or outflow of water through the surface openings per NAC 445A.429. Additional plugs and seals may also be required deeper in the workings at or below the predicted groundwater rebound elevation, as noted above, in cases of ARD potential, acidic or metalliferous EMPs, or other factors that create the potential for degradation of WOTS.

Plugging and Sealing Vertical Workings

Concrete (or similar) Lined Shaft – General – The following is an example of a closure design that could be approved for plugging and sealing vertical underground workings such as shafts, vent raises, or escape raises. See Figures 1 and 2. This is an example only; the operator may propose an alternative design intended to achieve the same goal of protecting WOTS.

- Prior to cessation of dewatering activities, all infrastructure within the shaft or raise that would impede plugging and water-tight seals, or that could leave an open conduit to groundwater (e.g., stairways and landings with fine grating, skips and cables, ventilation ducts, piping, conduit, etc.), will be removed.
- Inert or non-potentially acid-generating (non-PAG) sand or other fine aggregate fill material is poured down the shaft or raise to fill from the bottom of the shaft/raise to not less than 25 feet below the predicted ultimate groundwater rebound elevation. The fill must be fine-grained enough to prevent bridging or voids around any remaining infrastructure, and the volume of fill must be carefully determined taking into account the extra amount that will spill into the adjacent workings at depth.
- A minimum 15-foot thickness of concrete grout is placed from the top of the fill to 10 feet below the predicted groundwater rebound elevation. (Concrete grout, cement grout, neat cement or bentonite grout are all acceptable 'plugging' materials.)
- A minimum 50-foot thickness of bentonite (grout or chips) is then placed on top of the concrete grout to 40 feet above the predicted groundwater rebound elevation.
- The remainder of the shaft/raise is filled with sand, fine aggregate, select alluvium, or screened non-PAG waste rock to 20 feet below the surface, taking into account extra volume that will spill into any adjacent workings. Adjacent workings may also be plugged, e.g., rock/cemented backfill or bulkhead, to minimize the volume required to fill the workings.
- The top 20 feet is plugged with cement grout and capped with a concrete surface seal. The concrete cap shall extend a minimum of one-half the diameter of the shaft.

An abandonment log must be completed to document the closure process.

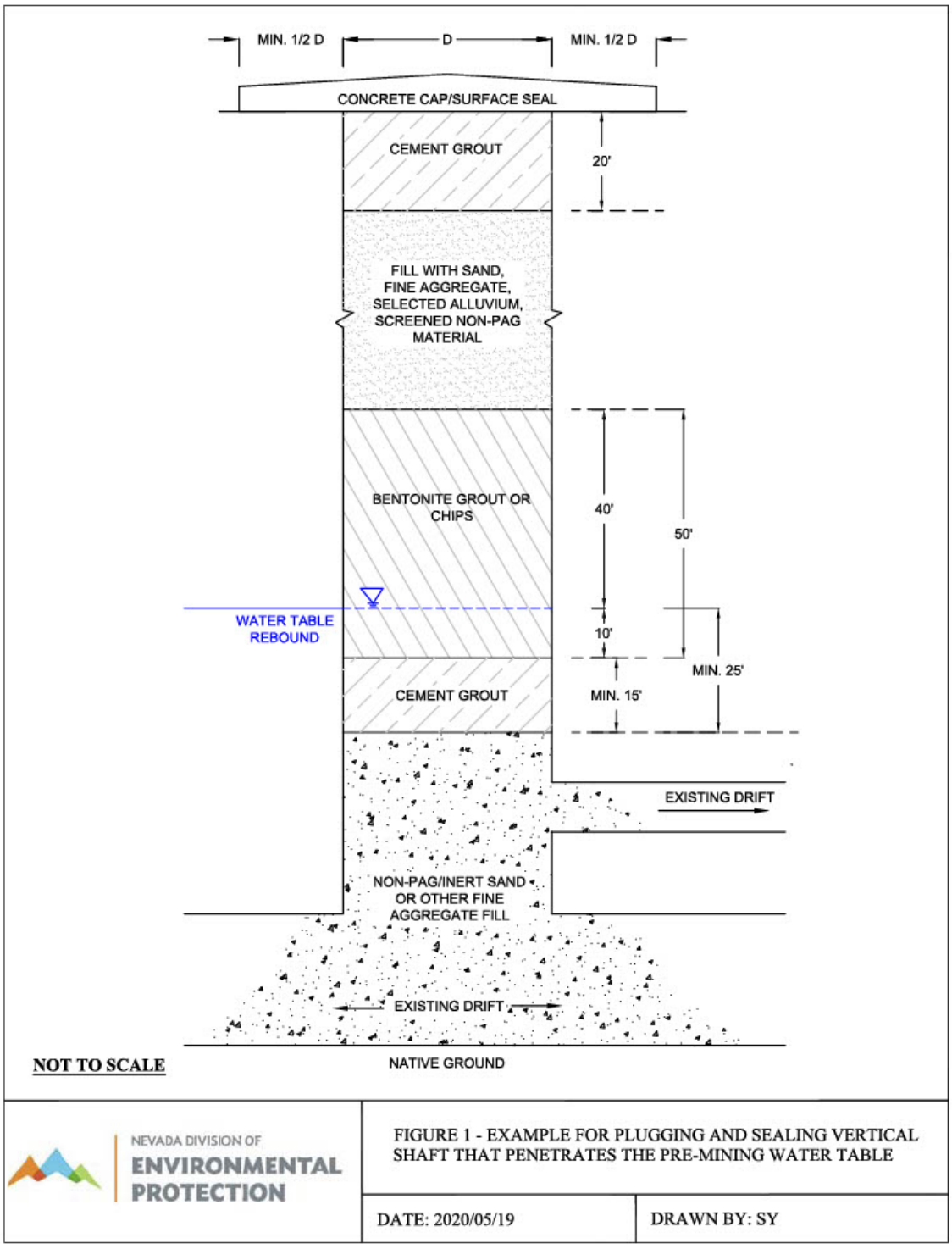

Figure 1 – Example for plugging and sealing vertical shaft that penetrates the pre-mining water table. All figures are conceptual in nature; site-specific engineered designs are required.

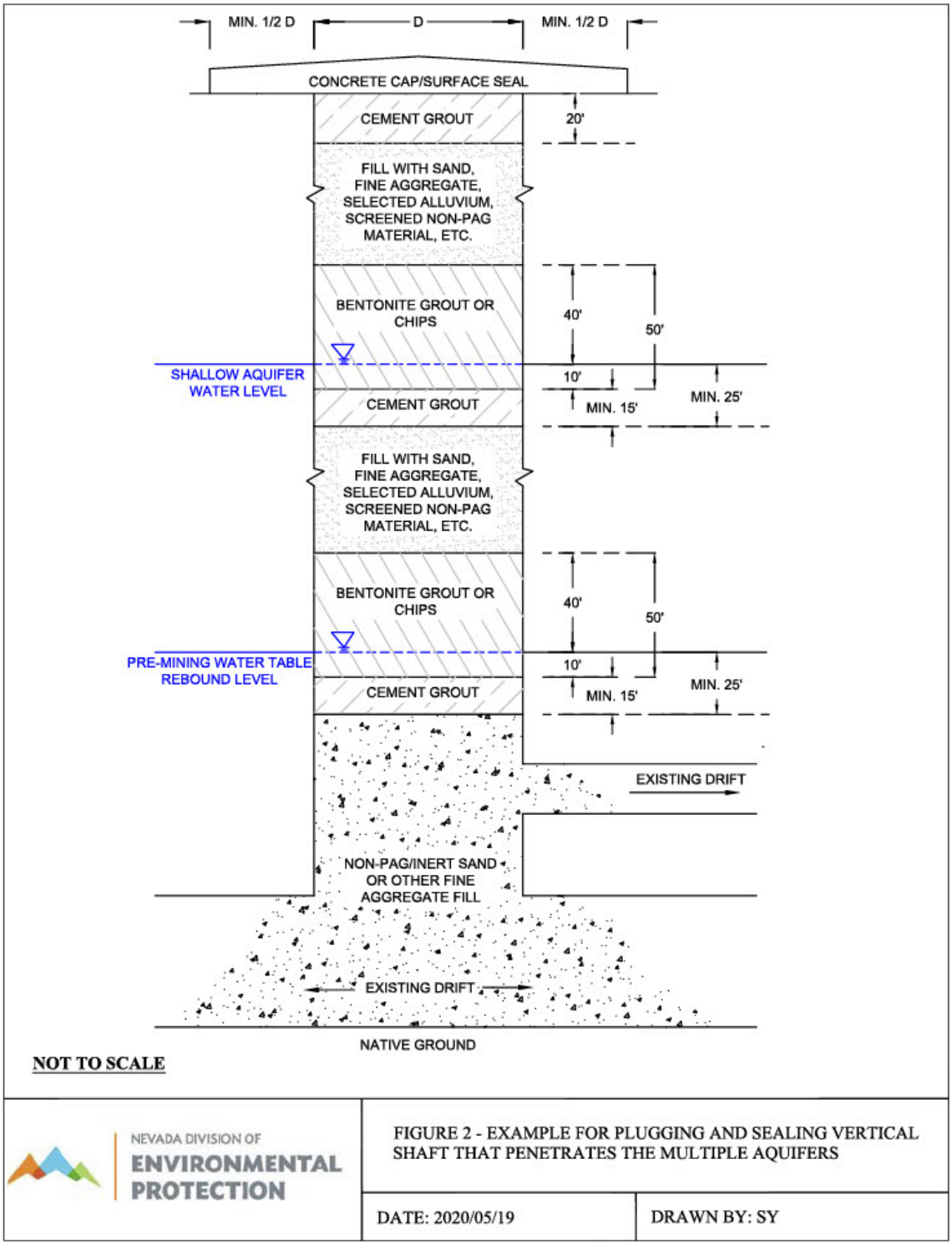

Figure 2 – Example for plugging and sealing vertical shaft that penetrates multiple aquifers. All figures are conceptual in nature; site-specific engineered designs are required.

Plugging and Sealing Non-Vertical Workings

Non-vertical surface openings (e.g., adits, declines, etc.) may be sealed with a steel or concrete cover that attaches to a concrete collar. The entrance area immediately behind the portal must be backfilled with rock or concrete as a further deterrent against entry. If groundwater is predicted to rebound to an elevation near or above the portal, the surface seal must be engineered to withstand the potential pressure exerted on the seal from groundwater.

Closure of Adits and Declines

- Plug with rock fill, cemented, or paste backfill, as appropriate given site-specific geophysical conditions. See Figure 3.
- If a potential exists for water to discharge from an adit, the backfill plug (bulkhead) must also be pressure grouted (e.g., Rosebud Underground Mine Portal Closure Report, 2001). See Figures 4 and 5.
- Backfill material shall be non-PAG. If non-PAG material is not available, the use of lime-amended PAG backfill may be acceptable given characterization showing no potential to impact WOTS.
- In certain instances, the Division may allow use of polyurethane foam (PUF) or polyurea silicate (PUS), or a mix thereof with inert waste rock, interlaced with heavy gauge wire. Once backfilling is complete, a growth medium cover shall be placed, and vegetation shall be established. The final surface must be reshaped to simulate surrounding topography while ensuring that the surface is free draining. Reclamation may require sacrificial erosion protection measures on the surface while vegetation is being established.

Closure of Declines that Penetrate the Water Table

Closure of portions of the decline may entail isolating the intersection zone(s) by construction of an engineered permanent airtight/watertight bulkhead (e.g., Storm bulkhead design [201603 BGMI Storm Bulkhead As-built Report]). If multiple aquifers exist, bulkheads may be required above and below to isolate the various aquifers and prevent mixing.

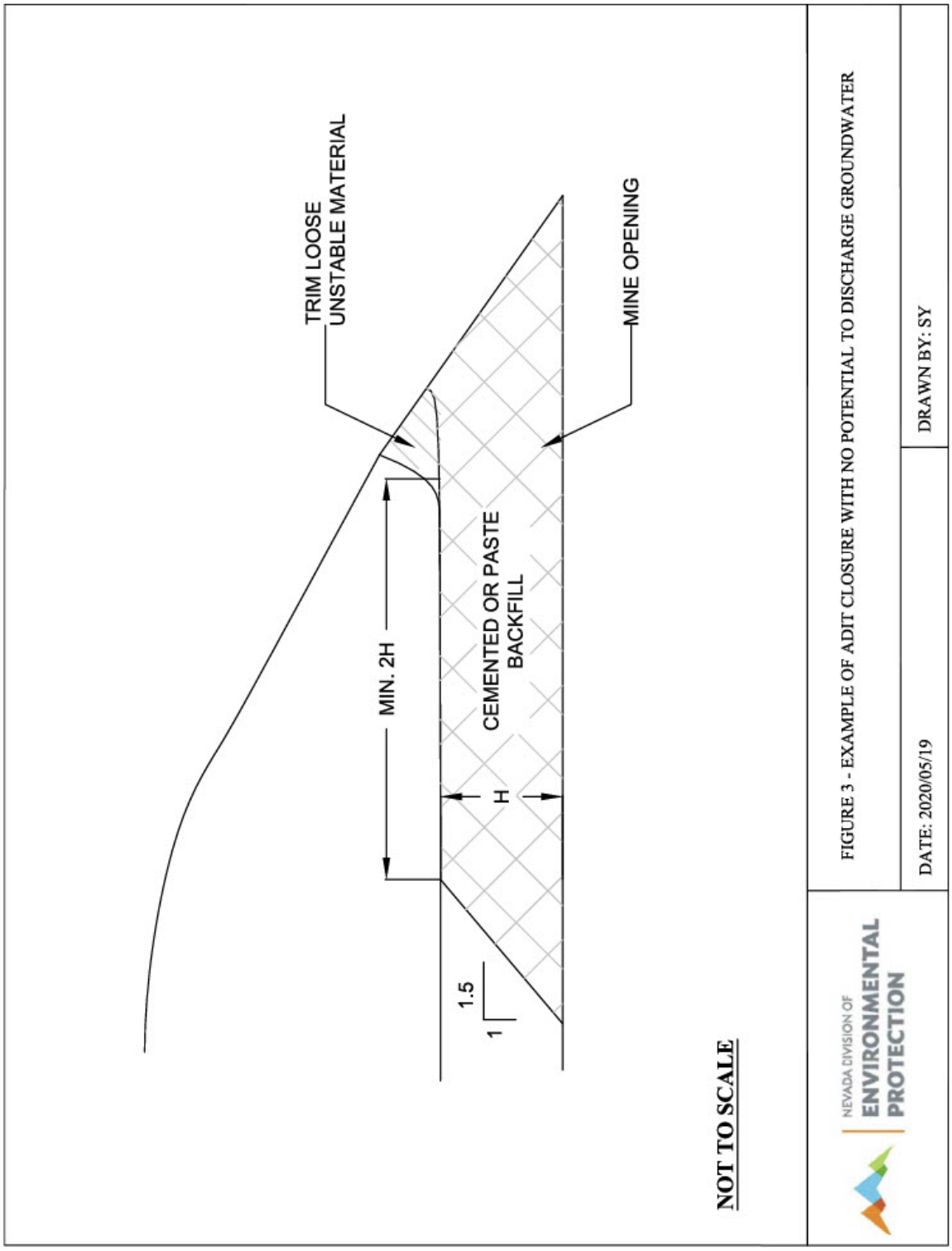

Figure 3 –Example of adit closure with no potential to discharge groundwater. All figures are conceptual in nature; site-specific engineered designs are required.

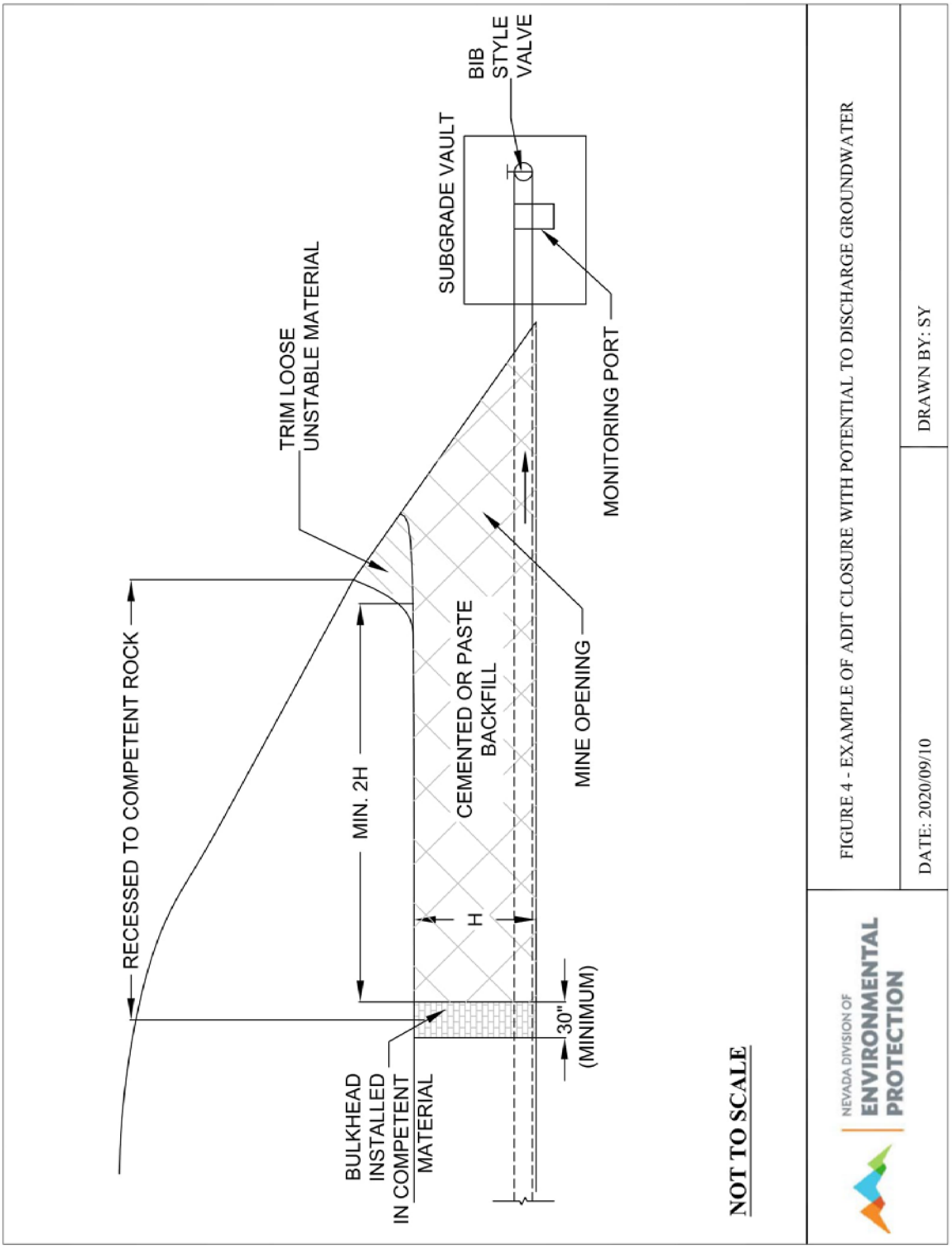

Figure 4 – Example of adit closure with low flow potential to discharge groundwater. All figures are conceptual in nature; site-specific engineered designs are required.

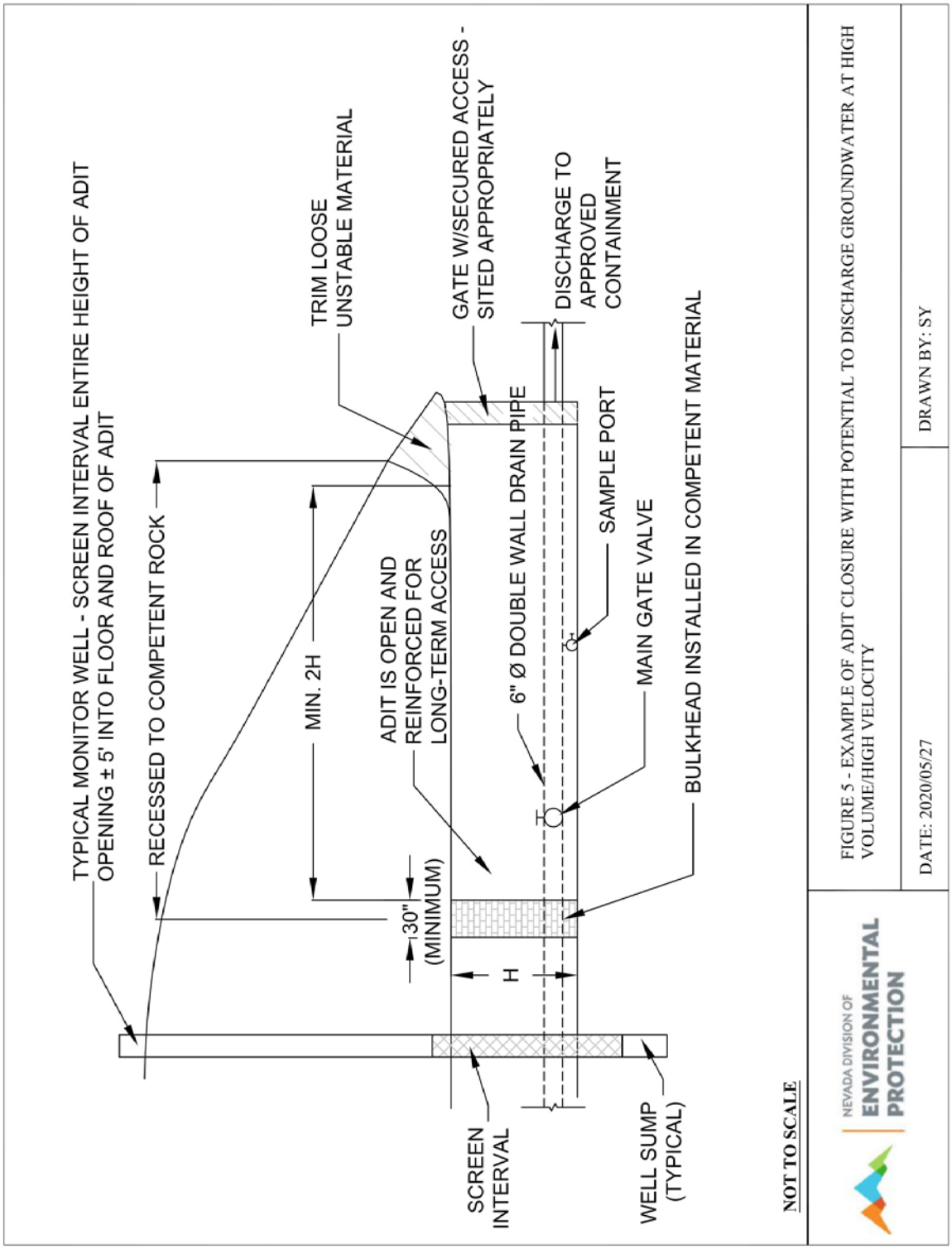

Figure 5 –Example of adit closure with high volume potential to discharge groundwater. All figures are conceptual in nature; site-specific engineered designs are required.

References:

Utah Natural Resources, “Oil, Gas, and Mining, Abandoned Mine Reclamation Program.”

Rosebud Mining Company, 2001, “Rosebud Underground Mine Portal Closure Report.”

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