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VIA E-MAIL

Mr. Eric Evans
Planning Director
Malheur County
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Re: Response to written public testimony of 1000 Friends of Oregon and Oregon Natural Desert Association regarding the Grassy Mountain Gold Mine Application

Dear Eric:

This office represents Calico Resources USA Corp. ("Calico") in its application for a Conditional Use Permit ("CUP") and Sage Grouse Permit ("SGP") (together, the "Application") for an approximately 62-acre underground gold mine approximately 22 miles south of Vale, Oregon. The Planning Commission held its initial hearing on the Application on March 28, 2019. The previous afternoon, the Oregon Natural Desert Associations ("ONDA") and 1000 Friends of Oregon ("1000 Friends") (together, "ONDA") submitted a 21-page letter accompanied by 563 pages of exhibits, in opposition to the Application. At the hearing, an ONDA representative requested that the hearing be continued to the following month's Planning Commission meeting and Calico supported that request. This letter responds to ONDA's written testimony and is timely submitted prior to the close of the continued hearing on April 25, 2019. Please place this letter and its attachments before the Planning Commission for its consideration.

I. Summary

The following discussion addresses issues raised by ONDA as follows:

- <u>Scope of the Application.</u> The Application is for a mine on the Patent Parcel only and does not authorize processing activities on federal land. Therefore, the Commission should not apply the County's criteria to activities not proposed in the Application.

- Consistency with applicable goals and policies of the County's Comprehensive Plan. The Application is consistent with the applicable Goals and Policies because, among other reasons, it includes fencing to prevent disruption of surrounding grazing activities, will have a negligible impact on the supply of grazing lands in the County, and will include substantial water quality protection measures.

- Water quality considerations. The Patent Parcel is devoid of any identified surface water features or perennial drainages. The maximum depth of the mine is above the measured water table, and all water used in the mine, or that enters the mine, will be captured and reused prior to treatment and being placed in the Tailings Storage Facility ("TSF"). These actions will prevent infiltration of process water into groundwater. The TSF, process water ponds, and waste rock storage facility will be fully lined to prevent water seepage into groundwater, and capped to prevent water seepage as part of mine reclamation and closure.

- Acid mine drainage. Calico has determined that ore and waste rocks involved in the Project have the potential to generate acid. Consistent with state requirements, all materials with such potential will be treated with a strong base to prevent acid mine drainage prior to disposal.

- The Project's economic and social benefits. The project will create more than 100 new jobs with wages significantly higher than the County's median wage. Related economic multipliers are likely to be positive, and there is no evidence that these new jobs will cause a housing crisis.

- Fish and wildlife impacts. There are no County-designated critical habitats on the Patent Parcel or within the Project Area. The northern part of the access route, which is miles north of the Project Area, traverses deer winter range designated by the Oregon Department of Fish and Wildlife (ODFW), but such roadways already exist. The evidence in the record demonstrates that there are no sensitive species present on the Patent Parcel.

- Sage Grouse Rule requirements. A sage grouse mitigation plan is not required in order for the County to approve a Sage Grouse Permit.

- Financial guarantee. A complete financial guarantee ensuring proper mine reclamation is required by the Oregon Department of Geology and Mineral Industries ("DOGAMI") prior to issuance of a Consolidated Permit.

II. General Observations

There are two fundamental problems with ONDA's testimony. First, the majority of ONDA's comments concern aspects of the Project which are not part of the Application. The Application only proposes mining activities on the Patent Parcel because this is the only property within the Project Area over which the County has jurisdiction.

Second, ONDA asks the County to duplicate permitting processes already required at the state and federal level. Indeed, ONDA raises several issues concerning mine processing activities, all of which is to occur are off the Patent Parcel, and all of which are subject to a comprehensive state and federal permitting.

As explained in detail below, the Grassy Mountain Project requires a Consolidated Permit approved by DOGAMI. The Consolidated Permit process applies all relevant state regulations set forth in the Oregon Administrative Rules (OARs) and involves multiple state agencies. The permitting process is managed by an interagency Technical Review Team which has held several meetings over the past year to scope and review studies necessary for Calico to demonstrate compliance with applicable regulations. These meeting are open to the public and ONDA has been a frequent participant.

Applicable state regulations broadly address the following:

- Protection of water quality. OAR 340 division 43.
- Protection of air quality. OAR 340, divisions 216 and 245.
- Protection of wildlife habitat, including an objective of zero mortality and no loss of existing critical habitat. OAR 632-073-0120(40, 0125(1).
- Use of the Best Available Practicable and Necessary Technology. OAR 632-037-0118.
- Mine construction and operations. OAR 632-037-0118; 340-043-0120.

- Removal, reuse, and destruction of weak-acid dissociable (WAD) cyanide. OAR 340-043-0130.

- Mill tailings disposal. OAR 340-043-0130.

- Acid mine drainage. OAR 340-043-0080, 0130, 140.

- Mine closure. OAR 632-037-0130; 340-043-0120.

- Financial security. OAR 632-037-0135.

These regulations address every external impact of chemical process mining and apply irrespective of the County's Conditional Use criteria, which themselves do not address mining in significant detail.

ONDA's position is essentially that Calico must demonstrate how each of the above regulations are met before the County may approve a CUP for the mine on the Patent Parcel. That is simply wrong: there is nothing in the County's Comprehensive Plan ("Plan") or its land use regulations which require that.

However, the larger problem with ONDA's position is that it promotes a regulatory scheme that no mining applicant could ever satisfy, for the simple reason that a County Conditional Use approval is, according to DOGAMI, required before Calico can even submit plans addressing these state regulations.

There is no legal merit to ONDA's view of the relationship between state and local mining regulation. Unlike the various environmental performance standards addressed by state regulations, the essential matter for the County to determine is whether the Application satisfies the applicable Conditional Use criteria set forth in the Malheur County Code ("MCC"), which address the impact of a proposed use on surrounding uses and development.

The MCC's purpose statement for a Conditional Use is as follows:

> "A conditional use is a use of land expressly authorized if the general and specific criteria set forth in this chapter are met. The applicant for the conditional use must show that the use will not create problems that call for denial or special conditions. The use should be in character with existing development in the zone and approval may be

> conditioned with requirements which are intended to make the use and the facilities it requires an asset to the area." MCC 6-6-1.

Thus, the Conditional Use process allows the County to determine the effect of the Project on surrounding land uses and impose conditions to minimize any adverse effects. As explained in the Application, staff report, and below, the Commission can find that the Application satisfies all applicable criteria. There is nothing express or implied in those criteria that require a demonstration that the Project already complies with all applicable state regulations. However, as no mining activities will be permitted unless and until Calico obtains a Consolidated Permit and other federal approvals, the County can find that no mining will be allowed that violates applicable state environmental regulations.

III. Response to ONDA's Arguments

The following sections provide a summary of ONDA's arguments and Calico's response.

A. Scope of the Application

The entire mine Project Area, including the Patent Parcel and the surrounding mine processing area, is approximately 886 acres; 824 of which are federal. Approximately 540 acres will be fenced to enclose the mine, processing area, and TSF, and less than 266 acres are anticipated to be disturbed. Malheur County has jurisdiction over only the 62-acre Patent Parcel, which is surrounded by thousands of acres of federal BLM land and is separated from the nearest town, Vale, by over 12 miles of BLM land and several more miles of private land. Therefore, the CUP and SGP, if approved, would allow only mining on the Patent Parcel; it would neither allow nor prohibit any of the mine processing activities.

ONDA suggests "that the Planning Commission consider the likely range of environmental and social impacts from all aspects of the proposed mining operation" and implies that it must consider the land use impacts from activities on federal lands. ONDA provides no legal justification for such an approach, nor does it explain how the Conditional Use criteria would require it. The problem with ONDA's approach is that the Application does not propose, and the County's approval would not authorize, any of the processing activities proposed to be located on federal land.

However, this does not imply that adequate regulatory safeguards are not in place. All mine facilities, as well as the mine itself, require approval from DOGAMI, Oregon Department of Environmental Quality (DEQ), Oregon Water Resources Department (OWRD), Oregon Department of Fish & Wildlife (ODFW), and Oregon State Historic Preservation Office (SHPO), as well as other federal agencies.

DOGAMI in particular imposes very specific regulations on construction of the processing facility and TSF, and will not approve the Project unless the Project meets each requirement, which include:

> "(1) Chemical process mining including extraction, processing, and reclamation, must be undertaken in a manner that minimizes environmental damage through the use of the best available, practicable, and necessary technology to ensure compliance with environmental standards." OAR 632-037-0118(1).
>
> "(1) Mine facilities have been designed to handle the 100-year, 24-hour precipitation event, at a minimum." OAR 632-037-0120(1).
>
> "An interim vegetative cover of stockpiles of topsoil or overburden materials that will be used in reclamation shall be required to prevent erosion or fugitive dust release from the overburden storage or spoils area." OAR 632-037-0120(2).
>
> OAR 632-037-0125 Fish and Wildlife Standards
>
> "The Department shall require a mining operation to comply with protection standards for fish and wildlife consistent with policies of the Department of Fish and Wildlife, including:
>
> (1) Protective measures to maintain an objective of zero wildlife mortality.
>
> (2) All chemical processing solutions and associated wastewater must be covered or contained to preclude access by wildlife, or maintained in a condition that is not harmful to wildlife.
>
> (3) Onsite and offsite mitigation ensuring there is no overall net loss of habitat value.

> (4) No loss of existing critical habitat of any state or federally listed threatened or endangered fish or wildlife species.
>
> (5) Any other standard adopted by rule by the Department of Fish and Wildlife applicable to a mining operation."
>
> OAR 632-037-0130 Reclamation and Mine Closure Standards
>
> "The Department shall require a mining operation to comply with reclamation and mine closure standards utilizing the best available, practicable and necessary technology to ensure compliance with environmental standards. The reclamation and mine closure standards shall include but not be limited to the following:
>
> (1) Surface reclamation shall ensure environmental protection and the protection of human health and safety, as well as livestock, fish and wildlife.
>
> (2) Surface reclamation of a mining operation shall require certification by the Department of Fish and Wildlife and the Department of Agriculture that a self-sustaining ecosystem, comparable to undamaged ecosystems in the area, has been established in satisfaction of the permittee's habitat restoration obligations.
>
> (3) Post-closure monitoring shall be required by the Department to ensure compliance with decommissioning performance standards."

DOGAMI and DEQ's chemical mining regulations are included as **Exhibits 1** and **2** of this letter. Since early 2018, DOGAMI has convened a Technical Review Team (TRT) to determine how the regulations will be implemented and to guide Calico on information necessary to satisfy those regulations. ONDA has been a frequent participant in TRT meetings and is presumably aware of the studies Calico has already submitted to comply with the above regulations.

Finally, in order to obtain BLM's approval to conduct processing and tailings management activities, Calico must also comply with federal regulations under NEPA and the Endangered Species Act (ESA).

The County does not have detailed performance and engineering standards pertaining to mining; however, the County can find that the regulations identified above, along with federal NEPA and ESA reviews, will provide adequate protection of surrounding federal lands.

B. Adequacy of Information

ONDA goes on to argue that "the applicant must provide additional and more detailed information about the entire project" and that the "application is not complete because all pertinent issues have not been addressed." However, ONDA fails to explain what "additional and more detailed information" is required by the MMC. It fails to do so because the County's application requirements do not require more. In fact, the application requirements require five primary elements (MCC 6-6-5):

1. Pre-Application Conference. A pre-application conference between the County and Calico was held on July 31, 2018.

2. Application Form. The Application includes a completed application form.

3. Tax Assessment Map. A tax assessment map is included in the Application as Exhibit 7.

4. Plot Plan. A plot plan is included in the Application as Exhibit 2.

5. Comments of Other Agencies. The County received comments from the Vale Rangeland Fire Protection Association, Sheriff's Office, County Environmental Health Department, County Road Master and Engineer, and County Vector Control District. All of these letters indicate that it is feasible for the Project to meet each agency's standards.

MCC 6-6-8-4.A also requires that "[s]ubmitted plans and specifications shall contain sufficient information to allow the planning commission to set standards pertaining to:

1. Noise, dust, traffic and visual screening.

2. Setbacks from property lines.

3. Location of vehicular access points.

4. Fencing needs.

5. Prevention of the collection and stagnation of water at all stages of the operation.

6. Rehabilitation of the land upon termination of the operation."

In order to satisfy these requirements, Calico provided a site plan, over 100 pages of project details from its Preliminary Feasibility Study and Technical Report (Application Exhibit 1) and a 25-page summary of its draft operation and reclamation plans (Application Exhibit 3). Finally, although it is not required by the MCC, the Application includes an October 2018 Wildlife Resources Baseline Report (Application Exhibit 7).

Thus, the Commission can find that the Application includes all submittal items required by the MCC,[1] and all information reasonably required for the Commission to evaluate the Application's compliance with the applicable criteria.

C. Comprehensive Plan Goals and Policies

ONDA argues that the Project is not consistent with a number of County Plan goals and policies. These were addressed on pages 15–25 of the Application. For the reasons therein and below, the Commission can reject ONDA's testimony and find that the Project is consistent with all applicable Plan goals and policies.

1. Whether the Patent Parcel consists of "agricultural lands" is not in dispute.

The Patent Parcel is made up of mostly Type VII and Type VI soil, as explained in Application Exhibit 6. ONDA argues that "Class VI soil is not unsuitable for agriculture." That argument is irrelevant because the Patent Parcel, with its Exclusive Range Use ("ERU") zoning, is already designated by the Plan as "agricultural land," and the Application does not propose to change that.

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[1] Note that even if the Application failed to include one or more items normally required by the MCC, such an omission does not prevent the Commission from evaluating the Application's compliance with the criteria. *Hess v. City of Corvallis*, 70 Or LUBA 283 (2014).

Soil class is addressed in the County's plan in two policies:

> "1. Public and private land classified by the Natural Resources Conservation Service (formerly U.S. Department of Agriculture Soil Conservation Service) as being in Capability Classes I through VI, as well as High Value Farmland as defined by applicable Oregon Revised Statutes and Oregon Administrative Rules and any other lands determined to be necessary and required for farm use, are considered to be agricultural lands.
>
> 2. High Value Farmlands (ORS and OAR designated) shall be given the greatest protection. Lands classified by the Natural Resources Conservation Service, as Capability Classes I through VI shall be afforded the next highest protection with Class I having the highest protection and Class VI the least."

These two policies are legislative mandates for the County in making zoning decisions and do not supply applicable standards for granting a CUP. The NRCS has not characterized the soil on the Patent Parcel – it was identified through a third party study. There is also no question that the NRCS has not designated the Patent Parcel as "high-value farmland." Therefore, neither of the above policies directly apply to the Application.

2. The County can find that "normal farming and ranching activities will be allowed to exist and continue without interference from non-farm users of the land."

Policy 8 of Goal 3 requires that "normal farming and ranching activities will be allowed to exist and continue without interference from non-farm users of the land." There are no farming activities surrounding the Patent Parcel. Under BLM regulations, the area surrounding the Patent Parcel is open range, but is used for a variety of other activities, including recreation. The area within the proposed perimeter fence is located entirely within the Nyssa Grazing Allotment, which provides for 5,348 cattle animal unit months (AUMs). There is a total of 76,176 public land acres in that allotment, most of which are outside of the proposed fence (there are other state and private acres). **Exhibit 3**. The perimeter fence enclosure is anticipated to be approximately 540 acres. There are 14.4 acres per cattle AUM[2] in that allotment. Based on this, the entire Project could result in the displacement of approximately 0.7 percent of allotted cattle AUMs, while the mining activity on the Patent Parcel itself would result in displacement of .08 percent of allotted cattle AUMs in the allotment. This assumes the full authorized allotment is being utilized. Therefore, this is the worst-case scenario and would only last for the life of the mine.

The Application explains that the mining will be underground and cattle will be excluded from the Project Area, and therefore the proposed mine use will not adversely impact surrounding rangeland uses. Nearest cattle watering areas are located outside of the Patent Parcel and will not be displaced by the mine.

Land outside of the Patent Parcel may be dedicated to a future mine processing use pursuant to an approved mineral lease granted by the BLM, which authority is provided for in the federal 1872 Mining Law and the Federal Land Policy and Management Act. As explained above, ONDA has offered no legal authority for the proposition that the County must consider impacts on rangeland uses from anything other than the uses proposed in the Application. Even if the County did so, to the extent that Policy 8 could be read to prohibit use of BLM open range for mining processing uses, it is likely preempted by federal law.

However, there is no evidence in the record that the Project will conflict with cattle ranching activities occurring outside of the Project Area. The proposed fence will keep cattle from straying onto the Project Area and, as described in more detail below, Calico's dewatering and tailings management plan will ensure that groundwater is not contaminated. A map of existing livestock water sources is enclosed as **Exhibit 4**. Any existing watering troughs that may be within the planned fence will be relocated outside of the fence to ensure their continued availability to cattle, unless BLM or the grazing permittees request otherwise.

Finally, given that Project would displace, even under a worst case scenario, less than 1% of the cattle AUMs in the Nyssa Allotment, and would do so for a limited period prior to mine reclamation, the Commission can find that the Project as a

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[2] The Nyssa Grazing Allotment also provides for 534 sheep AUMs, which equate to sheep AUMs of approximately 144 acres. Thus, under the worst case scenario, the Project would displace less than 4 sheep AUMs, or 0.75 percent.

whole—and the mining activity occurring on the Patent Parcel—would have no significant effect on the capacity of rangelands in the County.

The Commission can find that the Application is consistent with the above policy for these reasons.

3. Coordination with state agencies.

ONDA argues that the County has failed to satisfy Policy 3 of Plan Goal 5, which requires the County to "cooperate with other government agencies in the enforcement of mining regulations." The Commission can find that this policy merely requires no more than what it says, which is that the County will cooperate with other agencies when they seek to enforce their mining regulations. This Application does not affect how other government agencies will enforce their mining regulations.

ONDA also argues that the County has not complied with two other policies. First, Policy 1 of Goal 5 provides that "the county will continue to cooperate with local, state and federal agencies to identify the location, quality and quantity of fish and wildlife habitat." As explained in the Application, this requirement is worded as a general policy and places no specific obligations on the County in reviewing a development application.

Second, Policy 4 provides that "the County will notify and consult with appropriate state agencies during review of development proposals that might affect surface or groundwater quality." Groundwater quality is regulated by the Oregon Department of Environmental Quality. DEQ is represented on the DOGAMI consolidated permit Technical Review Team ("TRT") by Larry Knudsen and other staff, as demonstrated on **Exhibit 5**. DEQ has been involved for a number of years in scoping and reviewing Calico's water quality studies and proposed strategy to ensure water quality. The Commission can find that the ongoing TRT provides adequate consultation with state agencies to satisfy the above policies.

4. Water quality information.

Policy 1 of Goal 11 states that the "County, in considering land use proposals, will ensure that the physical characteristics of land that affect sewage disposal, water supply, and water quality are carefully considered." Contrary to ONDA's assertion, this only requires information on the "physical characteristics of the land," which is clearly explained in Exhibit 1 of the Application.

However, to ensure that the Commission has the full range of available information regarding water quality management, we enclose Calico's Baseline Study Work Plan explaining how it analyzed water resources (**Exhibit 6**), Geochemical Report Summary and Report (**Exhibits 7** and **8**), and Draft Tailings Storage Facility (TSF) Design Summary and Report (**Exhibits 9** and **10**). Finally, Application Exhibit 1 at 77 explains the Project's dewatering plan.

In summary, these documents explain the following:

- The primary groundwater aquifer is below the lowest level of the mine, so direct groundwater intrusion from the mine to the aquifer is unlikely to occur.

- The mine will be dewatered (i.e. pumped) if any water enters it, returned to the surface, treated, and re-used in the processing plant.

- The TSF facility will include a complete liner system that is capable of preventing intrusion of tailing water into the ground water. In addition, the TSF will include a piped drainage system ("Tailings Underflow Collection System") to intercept as much water as possible before it contacts the liner.

- The TSF facility is designed so that it can handle at least a 500-year, 24-hour storm event with wave action without overflowing. Permanent and temporary stormwater diversions will collect and divert a majority of the stormwater around the facility to a natural drainage on the north side of the TSF.

- Water collected by the TSF's drainage system will be pumped to a reclaim pond, which itself will be double-lined to prevent leakage. Water from the pond will be treated and reused in the processing plant.

- All pipes will be laid above a secondary containment system (a lined trench) composed of impermeable membranes or concrete containment structures, as appropriate.

- At mine closure, the mine itself will be backfilled with gravel and other waste rock. All mine backfill that is acid generating will be treated with a strong base (typically lime) to neutralize the material, thereby preventing acid drainage.

- At mine closure, the TSF will be:
    - Pumped of all surface water and allowed to dry for 1-2 years.
    - Regraded and covered with gravel from non-acid generating mine waste or on-site borrow, covered with an impermeable geomembrane liner, 18 to 14 inches of growth medium, and seed mix for revegetation.
- The proposed temporary waste rock dump will have a similar underdrain collection system and liner. Any remaining waste dump material will be treated and placed in the TSF during mine closure.

The mine and facilities are designed as a closed system where any water that contacts acid-generating rocks or chemicals will be treated, contained, and recirculated through the operation. Water that is not treated and used in the processing will be intercepted before leaching into the groundwater table.

Finally, Calico will be required to comply with stringent state rules concerning the protection of groundwater, which are found in OAR 340-043, "Chemical Process Mining." These rules address and fully regulate, among other things, the control of surface water runoff (OAR 340-043-0090), disposal of mill tailings (OAR 340-043-0130), and land disposal of wastewater (OAR 340-043-0170). **Exhibit 2**.

Water quantity is regulated by the Oregon Water Resources Department (OWRD). As noted in the Staff Report, the Applicant has provided the County with water rights certificates, and these water rights are sufficient to meet Project needs. In any case, water quantity is regulated by OWRD and not by local governments. *Ashland Drilling, Inc. v. Jackson County*, 168 Or App 624 (2000).

For the above reasons, the Commission can find that the Application is consistent with Goal 11, Policy 1.

D. Specific Plan Applicability

As explained in the Application, there are no specific County plans applicable to the Property. While the Application is not for the mine processing area outside of the Patent Parcel, the Applicant is not aware of any County plans applicable to this area, and Staff have not identified any.

E. Viewpoints

According to USGS topographic data, the crest of the proposed mine is at 3,960 feet. Grassy Mountain itself, located directly to the east, has a maximum elevation of over 4,200 feet. Based on GIS analysis, the nearest occupied structures are due east from the Patent Parcel along the Owyhee River, at an elevation of approximately 2,360 feet. **Exhibit 11**. Based on the intervening elevation between this property and the Patent Parcel, as well as the distance of over 20 miles of the Parcel from Vale, the Commission can find that the Project will have no view impacts on occupied properties.

F. Services and Utilities

ONDA claims that the installation of power lines in the County and BLM right-of-way will "entail potentially significant impacts to wildlife and other resources and land uses." The power lines that will be constructed on public rights-of-way are not subject to a CUP requirement, and ONDA does not claim that they are. Per the proposed conditions of approval, Calico will abide by local and federal requirements pertaining to construction of electrical distribution lines within existing rights-of-way.

G. Social and Economic Effects

ONDA makes several arguments regarding the social and economic impact of the project. Each are addressed below. As an initial matter, none of the economic and social issues raised by ONDA are expressly identified in the criteria. Indeed, local governments "have considerable discretion in shaping the economic future of their community," *Walker v. City of Dayton*, 44 Or LUBA 766 (2003), and the Commission has substantial discretion in evaluating which sorts of economic and social impacts are desirable.

1. Economic impacts on the community.

ONDA first argues that mining is susceptible "to negative effects of 'boom and bust' economics," citing a 2002 economic study by Freudenburg and Wilson.

The Freudenburg and Wilson study is inapplicable this Application because it examines *mining dependent communities*, which it defines as communities with at least 20% of total income from mining. With only 24 employees in the mining industry in the County, or 0.38% of the workforce, the County is not a mining dependent county and will not be so while the mine is in production.[3]

With regard to "boom and bust" economics, Calico has never asserted that the jobs the Project will bring to the County will last in perpetuity. The Commission can nonetheless find that the jobs, taxes, and economic activity generated by the Project will provide a substantial boost to the local economy during the mines construction, operation, and post-closure phases, and will not create a "boom and bust" economy in the County.

ONDA also ignores a similarly-sized body of economic studies supporting the positive economic impacts from mining, particularly when considering its direct and indirect economic effects (i.e. multipliers). For example, Malheur County will benefit from not only direct jobs, as described in the Application, but also indirect jobs created by the project. A study from Maxwell Stamp PLC and the World Gold Council found that for every direct job created by mining projects, an additional 1.8 jobs in indirect jobs are created.[4] **Exhibit 12.** Numerous other studies, including those of other developed countries such as Sweden[5] and Australia[6], have emphasized that any analysis of local economic effects of mining requires a close look at local job multipliers.

2. Job creation and workforce partnerships.

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[3] American Community Survey 2016 dataset. https://datausa.io/profile/geo/malheur-county-or/#economy (retrieved on April 19, 2019).

[4] The Social and Economic Impacts of Gold Mining, March 2015. http://www.mining.com/wp-content/uploads/2015/06/The-social-and-economic-impacts-of-gold-mining-june2015.pdf (retrieved on April 17, 2019).

[5] Moritz, Thomas, et al. The Local Employment Impacts of Mining: An Econometric Analysis of Job Multipliers in Norther Sweden. 2017. The study found that every 100 mining jobs on Norrbotten County in Northern Sweden generates nearly 100 additional jobs in other sectors, a 1 to 1 multiplier, but noting that the multiplier depends on a number of factors.

[6] Fleming, David, et al. Local Job Multipliers of Mining. 2014. The study discusses that, because direct labor for mining is low compared to other industries, it is important to observe local job multipliers when attempting to calculate the local economic impact of mining activities.

ONDA next argues that "Malheur County does not have a mining work force" and that the Application's description is inadequate regarding workforce training opportunities.

Malheur County does not have to have a mining workforce in order to benefit from the project. As an initial point, broadly speaking, the Maxwell Stamp study found that over 90% of gold mining operation workforces in North America consist of local employees.[7] Indeed, not all of the jobs created by this Project will require pre-existing mining skillsets and many of the jobs only require transferable skills already found in Malheur County's manufacturing and industrial workforce. For those jobs that may require technical skills, the applicant has described anticipated workforce training and other local partnerships intended to offer partnership curriculum.

Even so, employees who move to the area for employment at the project still provide a benefit to Malheur County, as local businesses benefit from consumer spending out of direct and indirect labor income. These indirect benefits are part of the multiplier effect, as illustrated by a 2013 economic impact study in the state of Arizona.[8] Although Oregon currently has a limited metal mining presence of only 37 direct metal mining jobs statewide, there are 281 indirect or induced jobs from metal mining in the state, according to the National Mining Association.[9] This ratio shows the strong indirect impacts from mining jobs.

3. Wages and economic benefits.

ONDA argues that the wages estimated in the Application are speculative and are not likely to occur because they are above the national average for mining jobs. However, the average wage data from the Bureau of Labor Statistics is just that, an *average*. Because it is an average, various operators across the country offer wages both below and above the average. The applicant's preliminary feasibility study provides extensive information regarding the economics of the mine and how anticipated wages will be supported. As the employer that will be establishing its own wages, Calico is in the best position to describe the wages that will be offered

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[7] *Supra* note 2.
[8] L. William Seidman Research Institute at Arizona State University. October 2013. The Economic Impact of the Mining Industry on the State of Arizona. http://www.azmining.com/uploads/2012%20AZ%20Mining%20Economic%20Impact%20Study_1.pdf (retrieved April 2019).
[9] Oregon Fact Sheet. 2018. https://nma.org/wp-content/uploads/2018/12/or.pdf (retrieved April 17, 2019).

at the project. Finally, even if the wages at the mine were at the national average for all metal ore mining, this would still be significantly above the County average, as discussed in the Application. Thus, the Application contains information regarding wage and economic benefits that support a finding that the Application will improve the community's social and economic characteristics.

4. Potential impact to housing.

ONDA also argues that the Application fails to consider the impact of new workers moving to the area, particularly with regard to housing.

As an initial matter, the Planning Commission is required to consider the "stability of the community's social and economic characteristics." On its face, this general criteria does not mandate the consideration of housing supply.

Second, there is no basis to conclude that this single project will cause a housing crisis in Malheur County, for two reasons. First, it is anticipated to create in excess of 100 living-wage jobs, and there is no evidence in the record that those with these relatively higher-paying jobs will displace those in low-income housing. Second, to the extent that these jobs are taken by residents already in the region, there is unlikely to be any adverse impacts on housing supply.

Finally, ONDA discusses housing affordability challenges, but fails to consider that the family wage jobs created by the proposed use will assist local employees with being able to afford housing in Malheur County. As discussed in the Application, the average operational and post-closure/reclamation job is anticipated to pay $79,518, which is significantly greater than the median household income in the county of $37,112.[10] Individuals employed by the project will presumably constitute a market for higher market-rate housing, not displace those already in subsidized or below-market housing.

At bottom, the implication of ONDA's economic arguments are troubling because they appear to advocate a low- or no-growth alternative in the County, which no reasonable person could expect to improve the County's existing social and economic challenges.

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[10] U.S. Census Bureau, 2017 dataset.
https://www.census.gov/quickfacts/fact/table/malheurcountyoregon/afn120212 (retrieved April 17, 2019).

H. Fish and wildlife.

MCC 6-6-7.F provides that conditional uses may not "interfere with traditional fish and wildlife use of habitats determined to be critical or sensitive in the fish and wildlife habitat protection plan for Malheur County." ONDA argues that Calico has not "met its burden of showing that the proposal will not have a significant permanent adverse impact on fish or wildlife habitat." ONDA misstates the criterion and attempts to widen it beyond its plain terms: the question is not whether the Application will have a significant impact on fish and wildlife, it is whether it will affect habitats determined by the County to be <u>critical or sensitive</u> in its fish and wildlife protection plan.

As the Staff Report clearly explained, the County does not have a "Wildlife Protection Plan." Therefore, the Commission can find that the above criterion is inapplicable. Even if it did, the Application includes a Wildlife Report that identified no critical or sensitive habitats within the Patent Parcel.

ONDA's additional arguments regarding ODFW's designated big game winter range are irrelevant for two reasons. First, none of that range is identified on the Patent Parcel and in fact, none of that range is within the larger Project Area. Rather, the only designated winter range is located along the northern five-mile section of the access road, as explained in Calico's Wildlife Report. *See* Application Exhibit 7 at 40.

Second, the fact that existing access roadways traverse state-designated habitat areas is irrelevant to the question of whether the County may approve a CUP on the Patent Parcel. This is because the access roadways already exist and there is no rational basis to believe that the small amount of anticipated new truck traffic will have substantial impacts on wildlife—especially given that the project does not even generate enough trips, under a reasonable worst-case scenario, to require a traffic impact analysis.

ONDA goes on to argue that the Migratory Bird Treaty Act prohibits a take of avian species and that pygmy rabbits are designated by federal law as "habitat specialists." At most these are issues for consideration in Calico's federal Environmental Impact Statement, but they are certainly not issues regulated by the County's Plan, conditional use criteria or other land use regulations.

Finally, ONDA argues that the Application must address ODFWs mitigation policy set forth in OAR 635 division 415. It claims this is so because Policy 3 of Plan Goal 5 provides that "the Oregon Department of Fish and Wildlife's 'Fish and Wildlife Protection Plan' will be recognized as a guideline for planning decisions." The Application addressed this policy at page 20.

There are number of problems with ONDA's argument. First, there is nothing in the above policy that expressly requires the County to apply OAR 635 division 415. Second, the fact that ODFW's "Fish and Wildlife Protection Plan" (which Plan ODFW has abandoned and replaced) is a "guideline for planning decisions," does not mean that it or division 415 supply applicable criteria. Indeed, the Commission can find that this policy was intended to guide comprehensive planning decisions and is now inapplicable because ODFW has replaced its "Fish and Wildlife Protection Plan."

Finally, ODFW's rules are, by express statutory authority, for ODFW to implement and enforce. ORS 496.118(1)(c).[11] And, as explained above, ODFW applies its division 415 regulations to the entire Project as part of the state Consolidated Permit process (OAR 632-037-0125), and Calico will be required to provide "a fish and wildlife protection and mitigation plan developed according to standards adopted by the Department of Fish and Wildlife." OAR 632-037-0060(12).

ONDA offers no reason why the County must duplicate this effort. Given that mining activities may only begin if and when DOGAMI finds that all applicable ODFW standards are satisfied, and the only evidence in the record demonstrates that there are no threatened or endangered species, nor any sage grouse, on the Patent Parcel, the Commission can find that the Application can meet ODFW standards as they apply to the Patent Parcel.

I. Sage Grouse Rule permit.

The Sage Grouse Rule ("SGR") places the responsibility for determining habitat mitigation requirements on ODFW, even for projects under County jurisdiction. As explained in the Application and at the March 28 hearing, Calico will be required to provide a complete mitigation plan to ODFW for the entire Project

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[11] "Subject to policy direction by the State Fish and Wildlife Commission, the State Fish and Wildlife Director shall: (c) Administer and enforce the wildlife laws of the state."

Area in order to obtain a consolidated permit, making specific mitigation proposals for the Patent Parcel duplicative and unnecessary. ODFW and the Department of Land Conservation and Development (DLCD) agreed with this approach, and recommended the following condition, which Calico accepts:

> "To satisfy the requirements of approving a conflicting use within significant sage-grouse habitat, the applicant shall comply with OAR Chapter 660, Division 023 and OAR Chapter 635, Division 140. The applicant must coordinate with ODFW and apply the mitigation hierarchy of avoidance, minimization and compensatory mitigation to address direct and indirect impacts of the development to low-density habitat for sage-grouse. A compensatory mitigation plan shall be developed by the applicant and approved by the ODFW through DOGAMI's consolidated permit process (OAR Chapter 632, Division 37) and other applicable rules, including OAR Chapter 635, Division 420 and OAR Chapter 635, Division 415, prior to any construction or ground disturbing activities."

In essence, the above condition requires a holistic look at the impacts of the Project on sage grouse habitat and requires Calico to abide by mitigation requirements imposed by ODFW.

Despite this, ONDA promotes an erroneous theory that the Patent Parcel must be considered separately for purposes of sage grouse mitigation, and consequently makes a number of legally incorrect statements. These are addressed below:

> "The Wildlife Report uses an inapplicable procedure for characterizing sage-grouse habitat within the project area."

<u>Response</u>: This statement mischaracterizes the Wildlife Report. The Application applied the Sage Grouse rule precisely as ONDA would have it: it relied on ODFW's habitat maps and noted that the Patent Parcel includes some "Low-Density" sage-grouse habitat. The Wildlife Report does not seek to re-draw ODFW's habitat maps, but the report itself was required by ODFW as part Calico's obligation to carefully investigate the conditions within that mapped habitat.

> "Approximately half of the project area falls within low-density sage grouse habitat and will require in-kind, in-proximity mitigation as

> Category 2 habitat." "Nowhere in the application or the wildlife report does the applicant acknowledge [the Sage-Grouse Development Siting Tool] or specific mitigation techniques that would be required to approve the project."

Response: ONDA again misstates the law. Mitigation under the sage grouse rule is required by OAR 660-023-0115(9)(D) as follows: "to the extent that a proposed large-scale development will have direct or indirect impacts on a core area after application of the avoidance and minimization standards and criteria, above, the permit must be conditioned to fully offset the direct and indirect impacts of the development to any core area. [T]he required compensatory mitigation must comply with OAR chapter 635, division 140."

The plain language of the above rule requires mitigation only if a large-scale development will have direct or indirect impacts on a Core Area. There is no Core Area habitat on the Patent Parcel, and the enclosed ODFW map demonstrates that the nearest Core Area habitat is over five miles away from the boundary of the Project Area, and even farther from the Patent Parcel. **Exhibit 13**. For this reason, there is no reason to believe that the Project will impact that Core Area habitat.

Moreover, OAR 660-023-0115(9)(b) places the responsibility on reviewing and approving compensatory mitigation on ODFW, not the County.

For the above reasons, the Commission can find that Calico need not provide a habitat mitigation plan before the County can approve an SGP.

J. Specific criteria to evaluate suitability

The County's Specific Criteria to Evaluate Suitability provides that "submitted plans and specifications shall contain sufficient information to allow the planning commission to set standards" addressing a number of development considerations. MCC 6-6-8-4.

In considering the matters listed in MCC 6-6-8-4, the Commission need not find that the Application meets any specific criteria. Rather, the question before the Commission is two-fold: first, the Commission must decide whether specific standards regarding the listed development issues are necessary, and second, if it wishes to set such standards, the Commission must determine whether there is enough information in the record for the Commission to do so.

ONDA offers conclusory challenges to a number of these considerations but at no point does it argue that the Commission need impose any specific standards.

The factors are listed below:

1. **Noise, dust, traffic and visual screening.**

2. **Setbacks from property lines.**

3. **Location of vehicular access points.**

4. **Fencing needs.**

5. **Prevention of the collection and stagnation of water at all stages of the operation.**

As explained in the Application, there is no reason for the Commission to set specific standards addressing any of the above. This is so in no small part because of the sheer physical separation of the Patent Parcel and Project Area from any other developed areas. ONDA's contrary arguments require no further response.

6. **Rehabilitation of the land upon termination of the operation.**

ONDA argues that the Application is deficient because it includes only a preliminary reclamation plan. In so doing, ONDA misstates the criteria. There is no County criterion requiring a final reclamation plan; the County need only decide (1) whether it needs to set standards pertaining to "rehabilitation of the land upon termination of the operation," and (2) if so, whether it has enough information in the record to do so.

The Commission need not set specific reclamation requirements for the simple reason that DOGAMI, through its Consolidated Permit process, applies extremely detailed reclamation requirements. A complete copy of these regulations is included as **Exhibit 1**.

As to the second question, the primary reclamation approach is described in detail in the Application. In summary, this involves complete chemical treating of any acid-producing materials, backfilling the mine with materials that are either non-acid producing or have been treated with a strong base to ensure that they will not produce acid, covering the TSF with an impermeable geomembrane, removing all plant and equipment, and covering any disturbed areas of the site with growth medium (soil) and an appropriate seed mix. Additional detail on mine closure and reclamation is provided in **Exhibit 10**.

In essence, ONDA's argument is that the County must set its own standards for mine reclamation. While the criteria allow the County to do so, they do not require it to do so. Indeed, ONDA offers no principled reason why the County cannot rely on the comprehensive reclamation requirements imposed by DOGAMI and other state agencies, and BLM.

ONDA's argument is also largely focused on the Project Area in general and not on the Patent Parcel. For these reasons, the Commission can reject ONDA's arguments and find that (1) the project will be required to provide DOGAMI with a complete reclamation plan meeting all state standards, (2) that these standards are sufficient to protect the public health, wildlife, and livability of the County, and (3) that substantial evidence in the record demonstrates that it is feasible for Calico to meet these standards.

K. Effects of Chemical Processing and Acid Mine Drainage

ONDA argues that the Application fails to include information about the impacts of chemical processing. As an initial matter, the Commission can reject this argument because Calico does not apply for a CUP permit to conduct chemical processing; rather the Application is for an underground mine on the Patent Parcel. And, ONDA offers no evidence that rebuts or contradicts evidence already in the record establishing that the mine and the Project will not "force a significant change in accepted farm or forest practices" as required by ORS 215.296.

However, Calico understands that the Commission may be understandably interested in the chemical processes that will be utilized on federal land if and when the Project is approved by the state and BLM. This is why Exhibit 1 of the Application includes an explanation of how the proposed chemical mining process will work, and **Exhibit 14** to this letter provides additional detail. As explained therein, and unlike the "heap leach" mining that has gained a poor historic reputation, the mining process proposed for Grassy Mountain utilizes an entirely enclosed system whereby all chemical processes occur in sealed vessels, and all processing chemicals, including cyanides, are destroyed and/or neutralized before process tailings are deposited in the TSF. This is done via the INCO process explained in **Exhibit 15**. Under state law, WAD cyanide levels of the tailing are limited to 30 parts per million.[12] The INCO process has been proven for decades to reduce cyanide far below this level, as demonstrated by the case study in **Exhibit 16**.

Acid neutralization of all mining waste materials is required by state regulation.[13] Calico has studied the acid generating potential of mine waste, as explained in the enclosed summary of its Baseline Geochemical Characterization Study (**Exhibit 7**) and the full study text (**Exhibit 8**).

L. Financial Guarantee

The County's conditional use criteria do not require a financial guarantee to provide for mine closure and reclamation. However, state law does. OAR 632-037-0135(1) requires that "[a] reclamation bond or alternative security acceptable to the Department shall be posted before the start of any construction, excavation or other ground disturbing activity associated with mining operations, other than baseline data collection." The amount of the security is required to include the actual closure and reclamation costs and must account for environmental protection costs in the event of an incident. *Id*. DOGAMI will review the surety amount annually and determine whether it must be increased based on any changes in the costs of reclamation. *Id*. at (2).

As a public company, Calico is of a sufficient size and has sufficient assets to provide the required security. However, should the Commission feel it necessary to ensure adequate security is available, Calico recommends the following additional condition of approval: "The Applicant shall comply with OAR 632-

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[12] OAR 340-043-0130.

[13] "The permittee shall determine the acid-producing and metals-release potential of the wasterock, low-grade ore or other mined materials by acid/base accounting and other appropriate static and dynamic laboratory tests. If the mined materials are shown to be potentially acid forming, or capable of releasing toxic metals, the permittee shall submit a plan for correction and disposal for Department approval prior to permanently placing the materials." OAR 340-043-0140.

"(3) If acid formation can occur, basic materials shall be added to the tailings in the amount of three (3) times the acid formation potential or to give a net neutralization potential of at least 20 tons of $CaCO_3$ per 1,000 tons of tailings, whichever is greater, before placing tailings in the disposal facility." "(4) The disposal facility shall be provided with a leachate collection system above the liner suitable for monitoring, collecting and treating potential acid drainage." OAR 340-043-0130.

037-0135 prior to the start of any construction, excavation, or ground disturbing activities."

IV. Conclusion

For the above reasons, the Commission should reject ONDA's arguments and approve the Application.

Best regards,

Garrett H. Stephenson

Enclosures:

Exhibit 1 – OAR 632
Exhibit 2 – OAR 340
Exhibit 3 – Nyssa Allotment
Exhibit 4 – Nyssa Allotment Map
Exhibit 5 – TRT Meeting Summary
Exhibit 6 – Water Study Work Plan
Exhibit 7 – Geochemistry Summary
Exhibit 8 – Geochemical Report
Exhibit 9 – TSF Summary
Exhibit 10 – TSF Study
Exhibit 11 – OR Grassy Mountain Topo
Exhibit 12 – The Social Economic Impacts of Gold Mining
Exhibit 13 – Core Area Sage Grouse
Exhibit 14 – Processing Summary
Exhibit 15 – Cyanide Detox Summary
Exhibit 16 – Cyanide Detox

cc: Ms. Nancy Wolverson
Ms. Stephanie Williams
Mr. Carlo Buffone
Mr. Glen Van Treek
Mr. Brien Flanagan

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Department of Geology and Mineral Industries

Chapter 632

Division 37
CONSOLIDATED PERMITTING OF MINING OPERATIONS

632-037-0005
Purpose

(1) The purpose of these rules is to implement the consolidated permitting provisions of ORS 517.952 to 517.989, applicable to metal mines, except placer mines and operations using only gravity separation to process ore. These rules address:

(a) Implementation of a state consolidated permitting process for mining operations;

(b) Coordination of federal and state permitting processes as they relate to the consolidated permitting process; and

(c) Opportunities for public participation and comment throughout the state consolidated permitting process.

(2) It is the policy of the State of Oregon to protect the environmental, scenic, recreational, social, archaeological and historic resources of this state from unacceptable adverse impacts that may result from mining operations, while permitting operations that comply with the provisions set forth in ORS 517.952 to 517.989, and ensure the protection of the public health, safety, welfare and the environment.

(3) Applicants submitting a consolidated application to the Department should be aware that federal and local agencies may require the applicant to obtain additional permits and approvals prior to operation.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.750 - 517.995
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0010
Definitions

The definitions in ORS 517.952 are hereby incorporated as the definitions to be used in interpreting these rules, unless a term is specifically defined within these rules.

(1) "Affected Agency" includes permitting agencies, cooperating agencies and commenting agencies.

(2) "Available Technology" means technology that is obtainable and has been demonstrated to meet environmental standards at an existing mine or a demonstration project of similar size and scale, or is reasonably expected to meet or exceed environmental standards at the proposed mine.

(3) "Baseline Data" means information gathered to characterize the natural and cultural environments of a mining operation site before a mining operation begins.

(4) "Chemical Processing" means a processing method for extracting metal from metal bearing ores that uses chemicals to dissolve metals from ore.

(5) "Commenting Agency" means an agency that makes recommendations to the Department or to a permitting agency regarding permit conditions or whether to approve or deny a permit under the consolidated application process established under ORS 517.952 to 517.989. Commenting agencies may include but are not limited to the following agencies: Department of Economic Development, Emergency Management Division, Department of Energy, Department of Forestry, Health Division, Department of Land Conservation and Development, Department of Parks and Recreation, Public Utility Commission, Office of

the State Fire Marshal, and the Department of Transportation. Commenting agencies may also be permitting and cooperating agencies that wish to comment on a permit issued by another agency.

(6) "Consolidated Application" means the single application required under ORS 517.971.

(7) "Cooperating Agency" means an agency that has statutory responsibility related to a mining operation but that does not issue a permit for the mining operation. Cooperating agencies may include but are not limited to the following agencies: Department of Agriculture and Department of Fish and Wildlife.

(8) "Credible Accident" means an unplanned discharge of ore processing solutions, ore processing solution contaminated water, or chemicals from a mine facility into surface water, ground water, soil, overburden, or living resources in sufficient quantity to impair the pre-mine quality of the receiving water, soil, overburden, or living resources, or that would exceed the discharge limitations of the Department of Environmental Quality. A credible accident may also include but is not limited to the following types of accidents: fires, unplanned detonation of explosives, equipment failures, fuel spills and accidents resulting from human errors.

(9) "Department" means the Department of Geology and Mineral Industries.

(10) "Disturbed Area" means any area within a permit area boundary where surface or subsurface resources are impacted as a result of mining, processing or mine facilities.

(11) "Environmental Evaluation" means an analysis prepared under ORS 517.979 to address specific impacts of the mining operation, to allow affected agencies to develop permit conditions.

(12) "Environmental Standards" means standards established either by statute or rule that must be met by a mining operation.

(13) "Facilitating Agency" means the Department of Geology and Mineral Industries. The Department shall coordinate the activities of the affected agencies related to the consolidated application process established in ORS 517.952 to 517.989.

(14) “Gravity Separation” means the separation of mineral particles, with the aid of water or air, according to the differences in the specific gravities of the particles.

(15) “Master List” means a consolidated list of all interested persons compiled by the Department and each permitting and cooperating agency and maintained by the Department.

(16) "Mine Facilities" includes but is not limited to the following:

(a) Leach pads and vats;

(b) Recovery plants and/or mill;

(c) Process solution ponds and/or storage ponds;

(d) Impoundments and diversions;

(e) Tailing disposal facility;

(f) Haul roads;

(g) Open pits;

(h) Related buildings;

(i) Energy facilities at the mine site;

(j) Disposal areas for waste rock and other mining wastes; and

(k) Storage areas for subgrade ore.

(17) “Mining Operation” means a surface or underground mine that processes, produces, or reclaims metal ore using a method other than, or in addition to, gravity separation to process the ore.

(18) "Mitigation" means the reduction of adverse effects of a proposed mining operation by considering, in the following order:

(a) Avoiding the impact altogether by not taking a certain action or parts of an action;

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation;

(c) Rectifying the impact by repairing, rehabilitating or restoring the affected environment;

(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action by monitoring and taking appropriate corrective measures; or

(e) Compensating for the impact by replacing or providing comparable substitute resources or environments.

(19) "Necessary Technology" means technology that is required to ensure compliance with environmental standards.

(20) "Operating Permit" means a permit issued by the Department that allows for the mining and processing of metal-bearing ores and provides for reclamation.

(21) "Permit Area" means the geographical location of a mining operation and related development activities covered by an operating permit and is defined by boundaries acceptable to the Department submitted by the applicant on a map. The permit area shall include the reasonably foreseeable extent of the mine and will generally be a parcel or contiguous parcels of land available to the permittee for mining. Areas used for the storage or disposition of any product or waste material from the mining operation, even though separate from the area of extraction, shall be included in the permit area. The permit area may be redefined as the mining operation progresses, subject to the requirements of OAR 632-037-0120.

(22) "Permitting Agency" means an agency that has a separate permitting authority for a proposed mining operation. Permitting agencies may include but are not limited to the following agencies: Department of Environmental Quality; Department of Geology and Mineral Industries, Division of State Lands, and the Water Resources Department.

(23) "Person" means any individual, partnership, corporation, association, public interest organization, the State of Oregon or any political subdivision, board, agency or commission of the State of Oregon.

(24) "Practicable Technology" means available and necessary technology whose costs are not significantly disproportionate to the potential environmental benefits. A technology is not practicable if the cost is so high it renders a mining operation infeasible.

(25) "Processing" means separating metals from ore through a method other than gravity separation, including milling and the use of chemicals to dissolve metals from ore. As used in these rules, "processing" includes, but is not limited to; cyanide heap leach processing operations, cyanide vat processing operations, and froth floatation processing operations.

(26) "Processing Solutions" means those solutions that are used directly or indirectly to recover minerals.

(27) "Project Coordinating Committee" means the interagency governmental committee established in accordance with ORS 517.965.

(28) "Reclamation" means the employment in mining of procedures reasonably designed to minimize as much as practicable the disruption from the mining operation and to provide for the rehabilitation of any surface and subsurface resources through the use of plant cover, soil stability techniques, measures to protect the surface and subsurface water resources, including but not limited to domestic water use and agricultural water use, and other measures appropriate to the subsequent beneficial use of any land or water resource affected by a mining operation. Surface reclamation shall also provide for the protection of human health and safety, as well as that of livestock, fish, and wildlife; environmental protection; and the establishment of a self-sustaining ecosystem, comparable to undamaged ecosystems in the area of the mine.

(29) "Study Area" means those areas determined by the technical review team for which baseline data must be collected and an environmental evaluation and socioeconomic impact analysis must be developed.

(30) "Technical Review Team" means the interagency group established in accordance with ORS 517.967.

(31) "Undamaged Ecosystem" means an ecosystem that is comparable in utility and stability to the ecosystem surrounding the mine and/or the pre-mine ecosystem, and that retains the principal ecological characteristics reasonably expected to exist under local, climatic, geological, soil, hydrological and biological conditions.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.750 & 517.952
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0015
State and Federal Agency Coordination

(1) When a mining operation is proposed on federal land, the Department shall, when agreed to by the federal agency, enter into a memorandum of agreement with the federal agency that is designated as the lead agency for the proposed mine under the National Environmental Policy Act. The purpose of a memorandum of agreement shall be to coordinate the state consolidated application process established in ORS 517.952 to 517.989 with the federal application process to the fullest extent possible.

(2) The memorandum of agreement may:

(a) Provide for the selection of the same third party contractor, if any, to prepare the environmental evaluation and socioeconomic impact analysis required by ORS 517.952 to 517.989 and the environmental assessment or environmental impact statement required by the National Environmental Policy Act;

(b) Coordinate the timeliness for preparation and content of the environmental evaluation and the environmental assessment or environmental impact statement;

(c) Ensure that all data, information and documents prepared in satisfaction of the requirements of ORS 517.952 to 517.989 will also satisfy to the fullest extent possible the requirements of corresponding portions of the National Environmental Policy Act; and

(d) Ensure that the state and federal financial security requirements are coordinated to the fullest extent possible.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.952 & 517.965
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0020
Project Coordinating Committee

(1) Purpose. The purpose of a project coordinating committee shall be to share information and coordinate county, state and federal permitting requirements in order to avoid contradictory requirements, facilitate the exchange of ideas, promote interdisciplinary decision making, optimize communication and avoid duplicative effort. A project coordinating committee shall also review proposed permit modifications that are deemed significant by a permitting agency or a cooperating agency under OAR 632-037-0120 and determine those portions of ORS 517.952 to 517.989 and these rules with which the applicant must comply.

(2) Committee Members. The Department shall act as the facilitating agency for a project coordinating committee. Upon receipt of a notice of intent, the Department shall request the participation of a representative of each of the following:

(a) All permitting and cooperating agencies;

(b) Affected federal agencies;

(c) Local government agencies; and

(d) Any affected Indian tribe.

(3) Staff. Each permitting and cooperating agency shall designate an appropriate staff person(s) to participate on the project coordinating committee. Each agency shall assume responsibility for those sections of the consolidated application and environmental evaluation over which the agency has permitting authority or special expertise.

(4) Meetings. The project coordinating committee shall meet at appropriate times during the consolidated application process. Any member may request a meeting of the Committee. If a majority of members concur with the request, the Department shall facilitate a meeting. All meetings of the project coordinating committee shall be open to the public and each meeting shall include an opportunity for public comment on matters before the Committee.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.965
History:

DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0025

Technical Review Team

(1) Duties. The duties of the technical review team shall include but not be limited to the following:

(a) Provide an interagency and interdisciplinary review of technical permitting issues and serve in an advisory capacity to a project coordinating committee;

(b) Approve the methodology to be used in the collection of baseline data;

(c) Coordinate with the applicant the collection and verification of baseline data;

(d) Determine the study areas for a proposed mine;

(e) Identify any reasonable alternatives that were not analyzed by the applicant or contractor in a consolidated application and direct staff or a third party contractor to analyze such alternatives in accordance with the requirements of OAR 635-037-0045(5);

(f) Determine whether any part of a consolidated application, including an environmental evaluation, is complete;

(g) Determine whether a proposed mining operation complies with the standards established in ORS 517.952 to 517.989, these rules and the statutes and rules governing the issuance of all applicable permits set forth in ORS 517.952 to 517.989;

(h) Reconcile contradictory permit conditions;

(i) Advise an applicant of the application requirements relevant to a proposed mine; and

(j) Identify the characteristics reasonably expected to exist under local conditions under OAR 632-037-0010(24).

(2) Team Members. The Department shall act as the facilitating agency for the technical review team. Upon receipt of a notice of intent, the Department shall request the participation of a representative of each permitting and cooperating agency.

(3) Staff. Each permitting and cooperating agency shall designate an appropriate staff person(s) to participate on the technical review team. Each agency shall assume responsibility over those sections of the consolidated application and environmental evaluation over which the agency has permitting authority or special expertise. When special expertise resides in more than one agency, the agencies shall coordinate their activities to avoid duplication or contradiction.

(4) Meetings. The technical review team shall meet at those times necessary and appropriate to accomplish the purposes of ORS 517.952 to 517.989 and these rules. Any member may request a meeting of the team. If a majority of other members concur with the request, the Department shall facilitate a meeting.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.967
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0030

Public Notice Procedure

(1) Whenever public notice is required by ORS 517.952 to 517.989 or these rules, the Department shall:

(a) Mail a written notice to all permitting and cooperating agencies and affected federal and local agencies;

(b) Mail a written notice to each owner of property located within one-half mile of the perimeter of the proposed permit area of the mining operation. As used in this paragraph, "owner" means the owner of the title to real property or the contract purchaser of real property of record as shown on the last available complete tax assessment roll;

(c) Mail a written notice to persons on the master list;

(d) Mail a written notice to unpatented mineral claimants for claims that are filed with the county and are located within one-half mile of the perimeter of the proposed permit area of the mining operation; and

(e) Cause to be published a notice in at least one newspaper of general circulation in the state and in at least one local newspaper of general circulation in the county or counties in which the proposed mining permit area is located. A notice by publication shall be given at least once each week for two weeks immediately preceding an action by the Department or following an action by an applicant that requires public notice under ORS 517.952 to 517.989 or these rules. In the event that a local newspaper is not published on a weekly basis, the notice by publication shall be given in a manner that is consistent with the publishing schedule of a local newspaper.

(2) The notice provided pursuant to this section shall satisfy any notice requirement of an individual permitting or cooperating agency related to a permit included in the consolidated application process.

(3) A notice given pursuant to section (1) of this rule shall include:

(a) The name, address and telephone number of the Department and all permitting and cooperating agencies, and, if applicable, the local government responsible for land use approval, including a contact person for each agency when known;

(b) The name and address of the applicant;

(c) The location of the proposed mining operation;

(d) A description of the action or proposed action;

(e) The location or locations where interested persons may obtain further information and inspect and copy relevant forms and documents;

(f) A statement describing any opportunities and requirements for public comment and the date, time and location of any public meeting or hearing; and

(g) Any other information required by ORS 517.952 to 517.989 or these rules.

(4)(a) The Department shall establish a master list for each proposed mining operation. To establish a master list, the Department shall request from each permitting and cooperating agency a list of the names and addresses of persons who have expressed interest in a proposed mining operation;

(b) The Department may charge the addressee on the master mailing list a fee of $5 to defray the costs of maintaining the master list and mailing public notices to persons on the master list. Any person may be added to the master list by mailing or delivering a written request and, if required, the fee to the Department.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.959
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0035
Notice of Intent

(1) A prospective applicant shall file with the Department a notice of intent to submit a consolidated application. The notice shall include the following information:

(a) Name and location of the proposed mining operation, including a legal description of an area that fully encompasses the proposed boundary of the permit area and a general description of the proposed boundary of the permit area;

(b) Name, mailing address and phone number of the prospective applicant;

(c) The legal structure (e.g., corporation, partnership, individual) of the applicant as filed in the business registry with the Secretary of State and the legal address of the applicant.

(d) Brief description of the proposed mining operation.

(2) Within ten days of the filing of a notice of intent, the prospective applicant shall post a copy of the notice at each common access point and on four posts, one post at each of the four cardinal headings (north, south, east and west) along the proposed boundary of the permit area. For the purposes of this section, "common access points" shall include but not be limited to roads and trails as shown on such documents as state and county road maps and quadrangles prepared by the United States Geological Survey.

(3) Upon receipt of a notice of intent, the Department shall:

(a) Provide public notice in accordance with OAR 632-037-0030. The notice shall include the information contained in the notice of intent and information on how a person may be added to the master list;

(b) Activate a project coordinating committee for the proposed mining operation and coordinate the participation of committee members and the prospective applicant in the activities of the project coordinating committee;

(c) Activate a technical review team; and

(d) Inform the prospective applicant of the names and contact persons for all permitting and cooperating agencies that will be participating in the consolidated application process.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.958 & 517.961
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0040
Notice of Prospective Applicant's Readiness to Collect Baseline Data

(1) When a prospective applicant is ready to begin collecting baseline data for a proposed mining operation, the applicant shall notify the Department. The notice shall include a proposed baseline data collection work plan. A work plan by discipline shall include:

(a) Data collection methodologies by discipline;

(b) Area of study; and

(c) Timing and duration of baseline data collection and verification.

(2) Upon receipt of a notice of a prospective applicant's readiness to begin collecting baseline data, the Department shall provide public notice that the applicant is ready to begin collecting baseline data and identify the location(s) where additional information may be obtained or reviewed.

(3) Within 30 days after receiving a notice, the Department shall conduct two public information meetings. One public meeting shall be conducted in the population center closest to the proposed mining operation and one public meeting shall be conducted in a major population center for the state, as determined by the Department. If the major population center for the state is the same as the population center closest to the proposed mining operation, the Department may conduct only one public information meeting.

(4) The Department shall accept written comments from the public and affected agencies for 45 days after receiving the notice.

(5) The purposes of the public information meetings and public comment period in sections (3) and (4) of this rule shall be to:

(a) Identify issues raised by the proposed mining operation; and

(b) Receive information from the public, including information related to the collection of baseline data that is relevant to the characterization of the pre-mine environment and the evaluation of a consolidated application for a proposed mining operation in order to assist the Department and the permitting and cooperating agencies.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.958 & 517.969
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0045
Content

The applicant shall submit to the Department a consolidated application that includes but is not limited to the following sections:

(1) General Information;

(2) Existing Environment – Baseline Data;

(3) Operating Plan;

(4) Reclamation and Closure Plan;

(5) Alternatives Analysis.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.971
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0050
General Information

The General Information section of a consolidated application shall include but not be limited to the following:

(1) The name, mailing address and phone number of the applicant and a registered agent for the applicant.

(2) The name(s) and address(es) of all owners of the surface and mineral estate.

(3) The legal structure (e.g., corporation, partnership, individual) of the applicant as filed in the business registry with the Secretary of State and the legal address of the applicant.

(4) The proposed starting date and expected life of the proposed mining operation.

(5) The name and location of the proposed facility.

(6) The location of existing and proposed roads.

(7) Appropriate maps, aerial photographs, cross sections, plans, design drawings and documentation of appropriate scale may be required by the technical review team. The applicant may contact the technical review team for recommendations regarding scale and amount of detail required. The applicant may be required to submit extra copies of materials to be circulated to other agencies. Information that may typically be required on maps, aerial photographs or design drawings includes but is not limited to:

(a) Permit area lateral extent and proposed depth of excavation;

(b) Mine location;

(c) Waste rock, ore storage, subgrade ore or overburden stockpile locations;

(d) Processing facility locations;

(e) All other facility locations;

(f) Topsoil stockpile locations;

(g) Typical cross sections, including but not limited to, the pit, major facilities, cut and fill slopes and other disturbed areas;

(h) Plan views and profiles, including but not limited to, the pit, major facilities, cut and fill slopes and other disturbed areas;

(i) Existing watercourses and ponds;

(j) Interim watercourses and ponds;

(k) Reconstructed watercourse and ponds;

(l) Proposed post-mining topography;

(m) Property lines;

(n) General ore body location and area extent.

(8) Written evidence that the surface estate and mineral estate owners concur with the proposed reclamation plan and that they will allow the Department access to complete reclamation within the permit area if the permittee fails to comply with the approved reclamation plan. If the applicant can document a legal right to mine without the consent of the surface owner, and the applicant can ensure that the Department will have a right to enter upon the permit area to complete the reclamation within the permit area if the permittee fails to complete the approved reclamation plan, the Department may issue an operating permit. If the proposed mine is located on federal land, the requirement of this section can be satisfied by documentation from the federal government verifying that the land is open to mineral exploration and development.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.971
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0055
Existing Environment — Baseline Data

The Existing Environment — Baseline Data section of a consolidated application shall include but not be limited to the following:

(1) Baseline data that describes the environmental, socioeconomic, historical, and archaeological conditions of the study area, and the land use designations and special use designations in the study area. Such information shall include, but not be limited to, description of the following:

(a) Vegetation;

(b) Soil/overburden;

(c) Climate/air quality;

(d) Fish, fish habitat and aquatic biology;

(e) Wildlife and wildlife habitat;

(f) State or federally listed threatened or endangered species and habitat and state sensitive species and habitat;

(g) Surface and groundwater;

(h) Seismicity;

(i) Geology and geologic hazards;

(j) Mineralogy and chemistry;

(k) Noise;

(l) Existing land use and land use designations;

(m) Cultural/historical resources;

(n) Archaeological resources;

(o) Socioeconomic conditions;

(p) State scenic waterways designated under ORS 390.805 {to} 390.925 and federal wild, scenic or recreational rivers designated under 28 U.S.C. 1271 {to} 1287; and

(q) Identification of special natural areas designated by the state or federal government, including but not limited to the following:

(A) Areas designated as areas of critical environmental concern as defined by the Federal Land Policy and Management Act, 43 U.S.C. 1700 et seq.;

(B) Research natural areas as defined by the National Forest Management Act of 1976, Public Law 94-588 as amended;

(C) Outstanding natural areas as defined by 43 CFR 2070; and

(D) Areas designated by the Oregon Natural Heritage Plan established under ORS 273.576.

(2) The level of detail required in section (1) of this rule may vary depending upon the location, size, scope and type of mining operation. The applicant should consult with the Department and the technical review team to determine the level of detail necessary for the applicant's proposed mining operation;

(3) The Department and the technical review team shall coordinate with appropriate federal agencies that have similar baseline data requirements, to avoid duplication for the applicant.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.971
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0060
Operating Plan

The Operating Plan section of a consolidated application shall include but not be limited to the following:

(1) A detailed description of the proposed mining and ore processing methods.

(2) A general list of equipment required for the proposed operation.

(3) A general schedule of construction and operation starting with the beginning of construction and ending with the completion of mining.

(4) General design assumptions and plan profile, cross sections and capacities for mine facilities including but not limited to:

(a) Leach pads;

(b) Impoundments;

(c) Ponds;

(d) Stormwater and surface water diversion systems;

(e) Waste disposal systems;

(f) Stockpiles and dumps;

(g) Pits;

(h) Tailing disposal facilities; and

(i) Transportation and storage systems for hazardous chemicals.

(5) A process water budget analysis including but not limited to:

(a) Precipitation and evaporation data;

(b) Make-up water needs;

(c) Make-up water source;

(d) Procedures to dispose of precipitation and ground water in excess of designed capacities to include but not be limited to solution treatment facilities or proposed treatment, disposal or discharge strategies. This section should be coordinated with procedures for seasonal or temporary closure and decommissioning of the operation;

(e) Surface water runoff determination for the watershed containing the mining operation.

(6) Seasonal or temporary closure procedures if applicable including but not limited to:

(a) Target seasonal or temporary storage volumes;

(b) Total system storage capacity;

(c) Procedures to handle volumes of water in excess of seasonal or temporary storage capacities;

(d) Estimated schedule for closure; and

(e) Monitoring and reporting programs, including but not limited to:

(A) Surface and ground water monitoring systems within and outside of the permit area and reporting frequency;

(B) Water balance of the process system and leak detection systems and reporting frequency;

(C) Biological monitoring and reporting procedures and frequency; and

(D) Fish and wildlife injury and mortality monitoring and reporting frequency developed according to standards adopted by the Department of Fish and Wildlife.

(7) Operational monitoring and reporting programs, including but not limited to:

(a) Surface and ground water monitoring systems within and outside of the permit area and reporting frequency;

(b) Water balance of the process system and leak detection systems and reporting frequency;

(c) Biological monitoring and reporting procedures and frequency; and

(d) Fish and wildlife injury and mortality monitoring and reporting frequency developed according to standards adopted by the Department of Fish and Wildlife.

(8) Surface water management procedures to provide for protection against contamination of ground water and the off-site discharge of sediments into adjacent waterways.

(9) Plans for stable storage of the following:

(a) Overburden;

(b) Waste rock and low grade ore: The pre-dump topography, ground preparation, method of emplacement of dump material, height of lifts, total height and final slopes shall be described. The Department shall require design and review by a registered professional engineer or certified engineering geologist;

(c) Topsoil or suitable growth media maintained for use in revegetation;

(d) Mill tailings: Plans and specifications of all dams, impoundments or landfills proposed to be constructed for the purpose of storing or disposing of mill tailings, processing solutions or other materials consequent to the mining and milling operation may be required by the Department to be prepared by a registered professional engineer or certified engineering geologist. Procedures to prevent pollution of air, water and land shall be described. Details on how each tailings disposal facility will be reclaimed shall be submitted; and

(e) Mined ore: Plans and specifications prepared by a registered professional engineer or certified engineering geologist of all ore storage facilities may be required by the Department. Ore storage facilities may include but not be limited to reusable or permanent leach pads, stockpiles, storage bins and silos.

(10) A subsidence control plan for underground mines:

(a) An application for an underground mine operation must include an inventory that shows whether structures, renewable or nonrenewable resources, or water resources exist within the proposed permit area and adjacent area, and whether subsidence may in the professional judgment of the Department cause damage to, or diminution of reasonable foreseeable uses of the structures, renewable or nonrenewable resources, or water resources;

(b) If the Department finds, after reviewing the inventory, that no structure or renewable or nonrenewable resource exists and in the professional judgment of the Department no damage or diminution could be caused in the event of mine subsidence, the Department will not require further information under this subsection;

(c) If the Department finds, after reviewing the inventory, that any structure, renewable or nonrenewable resource, or water resources exists and that subsidence could in the professional judgment of the Department cause damage or diminution of value of subsequent land use, then the applicant shall submit a subsidence control plan that contains:

(A) A detailed description of all proposed methods of operation that may cause subsidence including the technique of ore removal and the extent, if any, to which planned and controlled subsidence is intended;

(B) A detailed description of the measures to be taken to mitigate or prevent damage caused by subsidence, or diminution of value of subsequent land use, including the anticipated effects of planned subsidence, if any, and measures to be taken to reduce the likelihood of subsidence;

(C) Measures to be taken on the surface to prevent damage or lessening of the value of subsequent land use;

(D) A detailed description of measures to be taken to determine the degree of damage or diminution of value of subsequent land use including measures such as the results of pre-subsidence surveys of all structures and surface features that might be damaged by subsidence and monitoring, if any, proposed to measure deformation near specified structures or features or otherwise as appropriate for the operations.

(11) A list of chemicals and the quantity of such chemicals to be used and procedures for the handling, storage and disposal of any chemicals, acid-forming materials or radioactive or hazardous material or wastes generated from or required for mining or processing at the proposed operation.

(12) A fish and wildlife protection and mitigation plan developed according to standards adopted by the Department of Fish and Wildlife.

(13) A plan for the transportation of toxic chemicals developed according to standards adopted by the State Fire Marshal.

(14) An employee safety training plan developed according to state and federal law.

(15) A spill prevention plan that includes but is not limited to initial response, safety, reporting procedures, notification to appropriate state and local agencies and a corrective action plan.

(16) Characterization and management plan for all wastes, including quantity and quality.

(17) Within 30 days after completion of construction, but before mine operation, a signed registered engineers' or certified engineering geologists' report, complete with accurate drawings and specifications depicting the actual construction shall be submitted to the Department. Specific provisions shall be made for inspections by the Department, other permitting agencies and cooperating agencies during construction and installation of any mine facilities.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.971
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0070
Reclamation and Closure Plan

The Reclamation and Closure Plan section of a consolidated application shall include but not be limited to the following provisions for the protection of public health, safety, and the environment:

(1) Procedures for the salvage, storage and replacement of topsoil or acceptable substitute.

(2) Provisions for recontouring, stabilization and topsoil replacement of all disturbed areas, where appropriate.

(3) Provisions for the revegetation of all disturbed areas consistent with the establishment of a self-sustaining ecosystem, comparable to undamaged ecosystems in the area of the mine. This shall include but not be limited to seedbed preparation, mulching, fertilizing, species selection, seeding planting rates and schedules. If applicable, the applicant shall include a plan for control of noxious weeds as identified by the Department of Agriculture.

(4) Characterization and management plan for all wastes, including quantity and quality.

(5) Provisions for specifying adequate setbacks from adjacent property boundaries and from surface waters or other resources when necessary to ensure compliance with environmental standards.

(6) Procedures for all impacted or reconstructed stream channels, riparian area vegetation and stream banks to be rehabilitated or restored so as to maximize water retention and to minimize bank erosion, channel scour, siltation, and increased water temperatures.

(7) Provisions for prevention of stagnant water may be required by the Department.

(8) Provisions for the establishment of required slopes, including reclaimed highwalls and in-water slopes.

(9) Provisions for visual screening of proposed operation if the permit area is visible from a public highway or residential area. Techniques for visual screening include but are not limited to vegetation, fencing or berms.

(10) Procedures for the removal or disposal of all equipment, refuse, structures and foundations from the permit area.

(11) Provisions to maintain access to utilities when a utility company right-of-way exists.

(12) Procedures or information for decommissioning mine facilities including but not limited to:

(a) Procedures for ore storage sites to meet decommissioning performance standards for protection of air quality, surface and ground water quantity and quality and living resources and to achieve reclamation requirements;

(b) Procedures for tailing disposal facility to meet decommissioning performance standards for long-term stability, protection of air quality, surface and ground water quantity and quality and living resources and to provide for attainment of reclamation objectives;

(c) Removal of all process chemicals;

(d) Appropriate isolation or removal of waste material; and

(e) Monitoring systems by which the success of the proposed reclamation and closure can be measured for bond release.

(13) An estimate of the total cost of reclamation consistent with the standards imposed under ORS 517.750 to 517.955.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.971
History:
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0075
Alternatives Analysis

(1) The alternatives analysis shall include an identification and analysis of the environmental impacts of the proposed mining operation and alternatives to avoid or minimize adverse impacts and/or enhance the quality of the human and natural environment.

(2) The alternatives analyzed by the applicant or contractor shall include, but not be limited to, the following:

(a) Alternative locations for mine facilities, including heap leach pads, roads, impoundments, ponds, ore storage areas and waste disposal areas;

(b) Alternative designs, processes (including chemical processes), operations and scheduling for mine facilities and operations, including heap leach pads, roads, impoundments, ponds, ore storage areas and waste disposal areas;

(c) Alternative water supply;

(d) Alternative power supply; and

(e) Alternative reclamation procedures.

(3) The alternatives analysis shall include sufficient detail in the description of each alternative so that affected agencies and the public may evaluate the comparative merits of each alternative.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.979
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0077
Additional Requirements

In addition to the requirements in OAR 632-037-0050 to 632-037-0075, the applicant shall submit all information required by either state law or the administrative rules of a permitting agency to determine whether to issue or deny each and all of the following permits that are applicable to the proposed operation:

(1) Fill and removal permits required under ORS 196.600 to 196.665 and 196.800 to 196.900.

(2) Permits to appropriate surface water or ground water under ORS 537.130 and 537.615, to store water under ORS 537.400 and impoundment structure approval under ORS 540.350 to 540.390.

(3) National Pollutant Discharge Elimination System permit under ORS 468.740.

(4) Water pollution control facility permit under ORS 468.740.

(5) Air contaminant discharge permit under ORS 468.310 to 468.330.

(6) Solid waste disposal permit under ORS 459.205.

(7) Permit for use of power driven machinery on forestland under ORS 477.625.

(8) Permit to clear right of way on forestland where clearing constitutes a fire hazard under ORS 477.685.

(9) Permit for placing explosives or harmful substances in waters of the state under ORS 509.140.

(10) Hazardous waste storage permit under ORS 466.005 to 466.385.

(11) Land use permit, if applicable consistent with the Department's state agency coordination agreement, including relevant sections of OAR chapter 632, division 001.

(12) Any other state permit required for the proposed mining operation.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.971 & 517.978
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0080
Notice to Proceed

(1) Within ten days after receiving a consolidated application, the Department shall provide a copy of the application to each affected local government, permitting agency, cooperating agency and federal agency. For the purposes of this section, "affected local government" shall mean those local city and county governments, school districts, people's utility districts, irrigation districts, and road districts, that are within the study area of the proposed mining operation. The Department shall also provide public notice of the receipt of a consolidated application. In addition, upon written request, a copy of the consolidated application shall be made available to any government that believes it will be impacted by the proposed mining operation.

(2) Within 90 days of receipt of a consolidated application, the Department, in conjunction with all permitting and cooperating agencies, shall determine whether the application is complete. A completeness determination shall include the verification of baseline data as accurate.

(3) Before determining whether or not the application is complete and after all members of the technical review team concur that the permitting and cooperating agencies are ready to begin preparing draft permits, the Department shall conduct a public hearing and accept written comments on whether the information contained in the consolidated application is complete and sufficient to allow the permitting agencies to determine whether to issue or deny a permit. The Department shall determine and provide public notice of the date and location of the hearing and the period allowed for written comment. Any person who believes an application is incomplete due to a lack of quantity or quality shall clearly identify the incomplete sections of the application and the reasons such sections are incomplete.

(4) If the permitting and cooperating agencies determine that the application is complete, the Department shall issue a Notice to Proceed with the permitting process and the preparation of draft permits. If the applicant is not required to submit additional information as suggested in oral or written comments that clearly identify the incomplete sections of the application and the reasons such sections are incomplete, the agencies shall prepare a written response explaining why the additional information is not being requested from the applicant.

(5) If the permitting and cooperating agencies determine that additional information is necessary, the Department shall notify the applicant in writing of the additional information that is required. Upon receipt of the additional information, the Department shall provide public notice and accept written comments for a period of 14 calendar days.

(6) After the issuance of a notice to proceed, if new information becomes available or is required by a permitting agency or cooperating agency to determine whether to issue or deny a permit or issue a permit with conditions, and the agencies determine that additional information is significant to the issuance or denial of a permit, the Department shall conduct an additional public hearing to determine whether the new information is complete within 14 days of receipt of the information. The permitting and cooperating agencies may continue to review an application while in the process of requesting additional information.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.977
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0085
Environmental Evaluation

(1) The purpose of an environmental evaluation shall be to address specific impacts of a mining operation in order to allow affected agencies to make decisions on whether to issue or deny a permit and develop permit conditions. It shall provide full and fair discussion of significant environmental impacts and shall inform decision makers and the public of reasonable alternatives that would avoid or minimize adverse impacts and/or enhance the quality of the human and natural environment. An environmental evaluation shall focus on significant environmental issues and alternatives.

(2) For the purposes of this rule, "impacts" include both direct and indirect impacts:

(a) "Direct impacts" are those impacts that are caused by the action and occur at the same time and place as the action;

(b) "Indirect impacts" are those impacts that are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable.

(3) The Department shall direct staff or hire a third party contractor to prepare an environmental evaluation. The applicant shall pay costs of hiring a third party contractor. The scope of the environmental evaluation shall be determined by the technical review team following consultation with the project coordinating committee.

(4) An environmental evaluation shall be completed by Department staff or a third party contractor at least 60 days before the issuance of any draft permits. Upon receipt of a complete environmental evaluation, the Department shall provide public notice in accordance with OAR 632-037-0030 stating that the environmental evaluation is complete and receive written comments for a period of 14 calendar days after the notice is given.

(5) A complete environmental evaluation shall include the following sections:

(a) Impact Analysis;

(b) Cumulative Impact Analysis;

(c) Alternatives Analyses.

(6) Impact Analysis. An impact analysis shall include but not be limited to the following:

(a) An analysis of the reasonably foreseeable causes and impacts of the proposed mine on the environment, including but not limited to air, water, soil, vegetation, wildlife and wildlife habitat, geology, cultural resources and visual resources; and

(b) An analysis of the causes and impacts of the following types of credible accidents, including the catastrophic consequences of such accidents even if the probability of occurrence is low, provided that the analysis is supported by credible scientific evidence and is not based on pure conjecture:

(A) Releases of contaminants into the environment as a result of the mine operation or closure;

(B) Precipitation events and other natural events such as earthquakes that exceed the design standards of the mine facilities;

(C) Human error;

(D) Fire;

(E) Unplanned detonation of explosives; and

(F) Equipment failures.

(7) Cumulative Impact Analysis. A cumulative impact analysis shall include an assessment of the total cumulative impact on the environment that results from the incremental impact of an action when added with other past, present and reasonably foreseeable future actions, regardless of the agency or persons that undertake the other action, or whether the actions are on private, state or federal land:

(a) A cumulative impact analysis shall include but is not limited to the following:

(A) An identification of those resources for which an impact could occur from the proposed mining operation that could potentially combine with the impacts of other past, present or reasonably foreseeable future actions to produce a cumulative impact;

(B) An identification of past, present and reasonably foreseeable future actions that may occur in the study area, including each of the following types of actions:

(i) Similar actions. Actions that, when viewed with other reasonably foreseeable or proposed actions, have similarities that provide a basis for evaluating their environmental consequences together, such as common timing or geography;

(ii) Connected actions. Actions that cannot or will not proceed unless other actions are taken previously or simultaneously, or that are interdependent parts of a larger action and rely on the larger action for their justification;

(iii) Separate actions. Actions that affect the same environmental resources, including air, vegetation, wildlife and wildlife habitat, soil, and water resources.

(C) An analysis, by resource category identified in paragraph (A) of this subsection, of the cumulative impacts of the proposed mining operation and each of the actions identified in paragraph (B) of this subsection.

(b) The extent of a cumulative impact analysis shall be determined by a technical review team. In making such a determination, the technical review team shall consider the following:

(A) The alternatives considered for the proposed mining operation;

(B) The type of environmental impacts that are evaluated in the environmental evaluation; and

(C) The physical dimension of the proposed mining operation.

(8) Alternatives Analysis:

(a) An alternatives analysis shall include a review and analysis of the following:

(A) All alternatives analyzed by the applicant or applicant's contractor in accordance with OAR 632-037-0045(6); and

(B) Any reasonable alternatives identified by the technical review team to ensure that all alternatives within the authority of each permitting or cooperating agency are reviewed and analyzed. The alternatives identified by the technical review team may include, but not be limited to, the following:

(i) Alternative locations for mine facilities, including heap leach pads, roads, impoundments, ponds, ore storage areas and waste disposal areas;

(ii) Alternative designs, processes (including chemical processes), operations and scheduling for mine facilities and operations, including heap leach pads, roads, impoundments, ponds, ore storage areas and waste disposal areas;

(iii) Alternative water supply;

(iv) Alternative power supply; and

(v) Alternative reclamation procedures.

(b) The review and analysis required under subsection (a) of this section shall:

(A) Explore and evaluate the environmental impacts of all reasonable alternatives, and include a brief discussion of reasons a particular alternative was eliminated by the applicant;

(B) Include sufficient detail in the description of each alternative so that affected agencies and the public may evaluate the comparative merits of each alternative; and

(C) Discuss the systematic procedure used to arrive at the preferred alternative, including the decision criteria used and the information considered.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.978
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0090
Socioeconomic Impact Analysis

(1) Concurrent with the development of an environmental evaluation, the Department shall direct staff or hire a third party contractor to prepare a socioeconomic impact analysis. The analysis shall include but not be limited to an identification of the major and reasonably foreseeable socioeconomic impacts on individuals and communities located in the vicinity of the proposed mine resulting from mine construction and operation. Such identification shall include the short and long term impacts on population, economics, infrastructure and fiscal structure. The Department shall make the analysis available to the public upon request.

(2) Upon completion of the socioeconomic impact analysis, the Department shall distribute a copy of the analysis to each local government within the vicinity of the proposed mine and affected agencies.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.980
History:
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0095
Permitting Agency Action on a Consolidated Application

(1) Within 225 days of the issuance of a Notice to Proceed and not sooner than 60 days after the submittal of a complete environmental evaluation, each permitting agency shall submit to the Department its draft permit and permit conditions or permit denial document.

(2) If a permitting agency includes in its draft permit a condition that is inconsistent with the environmental evaluation, the agency shall include with its draft permits a written explanation of the conditions setting forth the findings of the agency that

support the condition.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.978
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0100
Cooperating Agency Action on a Consolidated Application

(1) At least 30 days before the issuance of draft permits, each cooperating agency shall submit to the Department:

(a) Written concurrence or non-concurrence with the terms and conditions of the draft operating permit as such pertain to the statutory authority of each cooperating agency; and

(b) Permit conditions within the expertise and authority of the cooperating agency.

(2) The Department shall not issue a draft permit until each cooperating agency has concurred with the terms and conditions of the draft permit as such pertain to the statutory responsibility of each cooperating agency.

(3) The Department shall include permit conditions submitted by a cooperating agency as conditions on the Department's draft operating permit.

(4) If the Department finds that a proposed permit condition imposed by a cooperating agency creates a conflict between permits, the technical review team shall resolve the conflict.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.981
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0105
Consolidated Public Hearing; Final Permits

(1) Within 15 days of receiving all draft permits and the completion of its draft operating permit, the Department shall issue public notice of the date and location of a consolidated public hearing and period for written comment on all permits.

(2) A consolidated public hearing shall occur not sooner than 45 days and not later than 60 days after the Department issues a public notice under section (1) of this rule.

(3) At least seven days before the issuance of a final operating permit, each cooperating agency shall submit to the Department:

(a) Written concurrence or non-concurrence with the terms and conditions of the final operating permit as such pertain to the statutory authority of each cooperating agency; and

(b) Permit conditions within the expertise and authority of the cooperating agency.

(4) The Department shall not issue a permit until each cooperating agency has concurred with the terms and conditions of the permit as such pertain to the statutory responsibility of each cooperating agency.

(5) The Department shall include permit conditions submitted by a cooperating agency as conditions on the Department's final operating permit.

(6) If the Department finds that a proposed permit condition imposed by a cooperating agency creates a conflict between permits, the technical review team shall resolve the conflict.

(7) Based on information received at a consolidated public hearing and within 45 days of the hearing, or within the time period required by applicable federal law, whichever is sooner, each permitting agency shall approve, deny or modify the agency's permit with conditions necessary to ensure that the mining operation allowed under a permit complies with the applicable standards and requirements.

(8) Each other permitting agency shall notify the Department of the issuance of final permits. The Department shall provide public notice of the issuance of final permits.

(9) Notwithstanding any other provisions of law, the Department and any other permitting agency shall take final action to issue or deny a permit subject to the consolidated application process within one year after issuance of a notice to proceed. However, with the concurrence of the applicant, the processing of the application may be suspended for a period of time to allow the applicant to resolve issues having a bearing on, or necessary to any permitting agency's decision on whether to issue or deny a permit.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.981
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0110
Appeals; Consolidated Contested Case Hearing

(1) The applicant or any person who appeared before a permitting agency at the consolidated public hearing, either orally or in writing, may file with the State Geologist a written request for a consolidated contested case hearing. The request shall be filed within 30 days after the date the permit was granted or denied. The applicant or person requesting a consolidated contested case hearing shall state the reasons for requesting the hearing and the objections to the permitting agency's action in accordance with the Attorney General's Model Rules of Procedure.

(2) Upon receipt of a request under section (1) of this rule, the Department shall schedule a consolidated contested case hearing. The hearing shall be held not less than 60 days or more than 75 days after the notice of permit issuance or denial. The hearing shall be conducted in accordance with ORS Chapter 183 and the Attorney General's Model Rules of Procedure.

(3) Any permit granted by a permitting agency shall be suspended until completion of the administrative hearings process.

(4) If all permitting agencies are subject to ORS 183.635(1), DOGAMI may request that a single administrative law judge be appointed to preside over the consolidated contested case hearing. If more than one hearings officer is appointed, the Department shall appoint a chief hearings officer. The role of the chief hearings officer shall be to organize the proceedings.

(5) The hearings officer(s) shall prepare a proposed order for each contested permit.

(6) A party may file written exceptions to the proposed order with the appropriate permitting agency. If the permitting agency determines that additional information presented in a written exception was unavailable at the time of the consolidated contested case hearing and is significant to the adoption or modification of the proposed order, the agency shall remand the order to the appropriate hearings officer for further consideration.

(7) After receiving exceptions and hearing argument on the exceptions to the proposed order, the permitting agency may either adopt the proposed order or issue a new order.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.983
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0115
Judicial Review

(1) A petition for judicial review of a permitting agency's issuance or denial of a permit must be filed with the Supreme Court within 60 days following the date the permit is issued or denied following the entry of an order subsequent to a consolidated contested case hearing.

(2) Except as provided in section (3) of this rule, if the permit with prescribed conditions is approved, the filing of a petition for judicial review shall stay the permit during the pendency of judicial review for a period of up to six months from the date the petition is filed. The Supreme Court may extend the stay beyond the six-month period upon written request and a showing by the petitioner that the activities allowed under the permit could result in irreparable harm to the site.

(3) When only the applicant files a petition for judicial review, the six-month stay imposed under section (2) of this rule may be removed by the permitting agency upon the applicant's written request within 60 days after filing of the petition and upon a showing by the applicant that supports a finding by the permitting agency that proceeding with any or all activities under the permit will not result in irreparable harm to the site.

(4) In making findings under section (3) of this rule, the permitting agency may require an additional bond or alternative security to be filed with the Department as provided in ORS 517.987 and these rules. The bond or alternative security shall be in an amount the permitting agency determines necessary to ensure complete restoration of the site if the petitioner elects not to complete the project following judicial review. Agency denial of the request to remove the stay is subject to review by the Supreme Court under such rules as the Supreme Court may establish.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.983
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0118
Best Available Practicable and Necessary Technology

(1) Chemical process mining including extraction, processing, and reclamation, must be undertaken in a manner that minimizes environmental damage through the use of the best available, practicable, and necessary technology to ensure compliance with environmental standards.

(2) In determining the best available, practicable, and necessary technology for use in a mining operation, the technical review team shall apply in consultation with the applicant, the following process:

(a) The technical review team shall determine the necessary technologies if such technologies exist;

(b) The technical review team shall determine which, if any, of the necessary technologies is available;

(c) The technical review team shall determine which, if any, of the necessary and available technologies is practicable;

(d) The technical review team will review, determine, and rank the necessary, available and practicable technologies by their potential environmental benefits;

(e) The technical review team shall recommend to the Department, the technology that the technical review team has determined is the best available, necessary, and practicable technology to ensure compliance with environmental standards. The determination shall be made with reference to the policies expressed in ORS 517.953 and 517.956.

(3) The department will require the applicant to use the best available, practicable, and necessary technology to ensure compliance with the environmental standards. The determination must be made with reference to the policies expressed in ORS 517.953 and 517.956.

(4) If the technical review team or the Department is unable to identify a necessary technology that is available and practicable, the Department shall not issue an operating permit.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.956
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 4-1991, f. & cert. ef. 12-5-91

632-037-0120
Mine Operation Standards

The Department shall require a mining operation to comply with the following mine operation standards:

(1) Mine facilities have been designed to handle the 100-year, 24-hour precipitation event, at a minimum.

(2) An interim vegetative cover of stockpiles of topsoil or overburden materials that will be used in reclamation shall be required to prevent erosion or fugitive dust release from the overburden storage or spoils area.

(3) Any standard adopted by rule by any permitting or cooperating agency related to the operation of a mining operation.

(4) No loss of existing critical habitat of any state or federally listed threatened or endangered plant species, as determined by the Department of Agriculture.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.956
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0125
Fish and Wildlife Standards

The Department shall require a mining operation to comply with protection standards for fish and wildlife consistent with policies of the Department of Fish and Wildlife, including:

(1) Protective measures to maintain an objective of zero wildlife mortality.

(2) All chemical processing solutions and associated wastewater must be covered or contained to preclude access by wildlife, or maintained in a condition that is not harmful to wildlife.

(3) Onsite and offsite mitigation ensuring there is no overall net loss of habitat value.

(4) No loss of existing critical habitat of any state or federally listed threatened or endangered fish or wildlife species.

(5) Any other standard adopted by rule by the Department of Fish and Wildlife applicable to a mining operation.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.956 & 517.987
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0130
Reclamation and Mine Closure Standards

The Department shall require a mining operation to comply with reclamation and mine closure standards utilizing the best available, practicable and necessary technology to ensure compliance with environmental standards. The reclamation and mine closure standards shall include but not be limited to the following:

(1) Surface reclamation shall ensure environmental protection and the protection of human health and safety, as well as livestock, fish and wildlife.

(2) Surface reclamation of a mining operation shall require certification by the Department of Fish and Wildlife and the Department of Agriculture that a self-sustaining ecosystem, comparable to undamaged ecosystems in the area, has been established in satisfaction of the permittee's habitat restoration obligations.

(3) Post-closure monitoring shall be required by the Department to ensure compliance with decommissioning performance standards.

(4) Revegetation shall be considered successful if it is consistent with the establishment of a self-sustaining ecosystem, comparable to undamaged ecosystems in the area of the mine. Vegetation test plots and chemical/physical soil and subsoil analysis may be required to ensure establishment feasibility.

(5) Native species shall be established unless the use of non-native species is justified and approved by the technical review team.

(6) Seed mixes, fertilizer rates and other requirements will be derived from departmental experience and advice from sources such as the Oregon Department of Agriculture, U.S. Soil Conservation Service, Oregon State University Extension Service, the Oregon Department of Transportation, the Bureau of Land Management, the Forest Service, local soil conservation districts and private sector experts.

(7) All final slopes shall be stable, blend into adjacent terrain and be compatible with the establishment of a self-sustaining ecosystem, comparable to undamaged ecosystems in the area of the mine.

(8) Reclaimed highwalls shall not have slopes exceeding 1-1/2 horizontal to 1 vertical (1-1/2:1). The Department may grant exceptions for steeper slopes when the applicant can document that the slopes will be stable and if the steeper slopes:

(a) Blend into the adjacent terrain features;

(b) Existed prior to mining; or

(c) Are consistent with the establishment of a self-sustaining ecosystem, comparable to undamaged ecosystems in the area of the mine.

(9) Fill slopes shall be 2:1 or flatter unless steeper slopes are approved by the Department. Technical data supporting steeper slope stability may be required by the Department.

(10) In-water slopes to six feet below water level for permanent water impoundments when necessary shall be 3:1. Reasonable alternatives may be approved by the Department when they are consistent with the reclamation plan. For example, safety benches no more than two feet below water level and five-feet wide may be substituted for the slope requirement where the Department determines that sloping is not practical.

(11) Permanent structures may remain if they are part of the approved reclamation plan.

(12) Any standards adopted by rule by a permitting or cooperating agency related to reclamation or closure of a mining operation.

(13) Backfilling or partial backfilling of pits shall be required if the Department determines that:

(a) Backfilling is necessary to achieve the reclamation objectives set forth in ORS 517.952 to 517.989;

(b) Reclamation objectives, including but not limited to compliance with environmental standards, cannot be achieved through mitigation or other reclamation technologies; and

(c) Backfilling is the best available, practicable and necessary technology to ensure compliance with environmental standards.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.956, 517.971 & 517.987
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0135
Financial Security

(1) A reclamation bond or alternative security acceptable to the Department shall be posted before the start of any construction, excavation or other ground disturbing activity associated with mining operations, other than baseline data collection. "Alternative security" shall include certificates of deposit or irrevocable letters of credit issued by a federally-insured bank. The purpose of the financial security shall be to allow the Department to meet the requirements of the reclamation and closure plan and to provide protection of surface and subsurface resources. The amount of the financial security shall be calculated on the basis of the estimated actual cost of reclamation and closure and shall not be limited. The calculation shall also consider environmental protection costs based on the credible accident analysis and the factors listed in section (6) of this rule.

(2) The Department shall assess annually the overall cost of reclamation. If changes in the operation or modifications to a permit cause the cost of reclamation to exceed the amount of the financial security currently held by the state, the permittee shall post an additional security for the difference. All reclamation calculations shall be approved by the Department.

(3) The Department shall provide for incremental surety increases, with the level of surety required being consistent with the degree and forms of surface disturbance anticipated within a time period specified by the Department. When the actual surface area to be disturbed approaches the level expected by the Department, the permittee shall notify the Department sufficiently in advance of reaching the acreage limit specified to allow for a review of the surety requirements and posting of additional surety by the permittee prior to exceeding the acreage limit set by the Department.

(4) If reclamation costs will exceed the posted financial security and the operator does not increase the amount of the financial security, the department and other permitting agencies shall suspend all permits until the permittee posts the additional financial security.

(5) The Department may seek a lien against the assets of the permittee to cover the cost of reclamation if the financial security posted is insufficient. The amount of the lien shall be the amount of the costs incurred by the Department to complete reclamation. All current operating permits of the permittee shall be suspended and the Department shall deny immediately all pending applications of the permittee to conduct mining operations.

(6) The factors the Department shall consider in determining the amount of the security may include but are not limited to the following:

(a) The reclamation estimate submitted by the applicant as part of the consolidated application;

(b) The impact analysis, including the credible accident analysis;

(c) Supervision;

(d) Mobilization;

(e) Costs of equipment;

(f) Costs of labor;

(g) Removal or disposition of debris, junk, equipment, structures, foundations and unwanted chemicals;

(h) Reduction or stabilization of hazards such as in-water slopes, highwalls, and landslides or other mass failure;

(i) Disposition of oversize, rejects, scalpings and overburden;

(j) Backfilling, contouring or regrading and topsoil replacement;

(k) Draining, establishment of drainage and erosion control;

(l) Soil tests;

(m) Seedbed preparation, seeding, mulching, fertilizing, netting, tackifiers or other stabilizing agents;

(n) Tree and shrub planting;

(o) Fencing;

(p) Liability insurance;

(q) Long-term stabilization, control, containment or disposition of waste solids and liquids;

(r) Final engineering design;

(s) Costs of remedial measure identified to clean up releases of contaminants associated with mining, processing or beneficiation that are reasonably likely to cause a threat to public health, safety or the environment;

(t) The estimated cost of detoxification or disposal of ore processing solutions and solution contaminated ore so as to meet the standards for reclamation approved for the operation in the operating permit issued by the Department and the standards established in ORS 517.952 to 517.989 and these rules;

(u) The estimated cost of restoration of contaminated soil, surface and ground water or living resources within the standards established in ORS 517.952 to 517.989 and these rules should an accident occur at the site;

(v) The estimated cost of removal and/or disposal of chemicals used on site;

(w) The spill prevention plan;

(x) Estimated Department-contracted service expenses including but not limited to supervision, mobilization, labor and equipment needs of the department for decontamination and restoration should the Department be required to perform such restoration.

(7) Cost estimate information shall be derived from sources such as:

(a) Comparable costs from similar projects;

(b) Catalog prices;

(c) Guides and cost estimates obtained from appropriate government, public and private sources;

(d) Site test and monitoring data;

(e) Operator estimates; and

(f) Equipment handbooks.

(8) Using the reclamation estimate submitted in the consolidated application and the impact analysis as a guide, the Department shall distribute an initial determination of the amount of financial security necessary to implement the reclamation and closure plans and to protect human health and the environment to all permitting and cooperating agencies for review and comment. After considering the comments of such agencies, the Department shall set the amount of financial security and notify the applicant.

(9) The financial security acceptable to the Department shall be posted before the start of any construction, excavation or other ground disturbing activity associated with mining activities other than baseline data collection activities. No permit shall be issued or renewed until all financial security for a mining operation is on file with the Department. Bonds or other securities shall be maintained until operations have ceased, reclamation has been completed and all decommissioning performance standards have been met. Bonds shall be United States Treasury listed, provided by surety companies licensed to operate in Oregon and acceptable to the Department. A mining operation may not satisfy the financial security requirements through self-insurance.

(10) The Department may require financial security or an annuity for post-reclamation monitoring and care.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.987
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0140
Obtaining Financial Security Release

(1) Upon completion of full reclamation, the permittee shall submit to the Department a written request for the release of its financial security.

(2) If a permittee has conducted concurrent reclamation or partial reclamation following the cessation of mine operations, the request for release of financial security must include an estimate of the percentage of reclamation done to date and the corresponding percentage of reclamation funds that the permittee believes should be released. A bond release or reduction request must state in unambiguous terms all measures taken to reclaim the site and any problems or potential problems that may inhibit reclamation in accordance with permit requirements. The Department shall consider any such problems in determining the appropriate level of financial security to be maintained.

(3) Upon receipt of a request to release financial security, the Department shall:

(a) Issue a public notice in accordance with OAR 632-037-0030; and

(b) Distribute the request to each permitting and cooperating agency, members of the public who participated in any hearing or written comment period under these rules, and to any person who requests such notification.

(4) No sooner than 60 days after taking the actions required under section (3) of this rule, the Department shall conduct an informal public hearing to determine whether to allow the release or reduction of the financial security.

(5) The Department may require security or an annuity for post-reclamation monitoring and care to be paid before final release of the financial security. The Department shall determine the amount of the security or annuity and distribute the proposal to all permitting and cooperating agencies. After considering the comments of such agencies, the Department shall set the amount of the security or annuity and notify the permittee.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.987
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0145
Permit Modifications

(1) The permittee, the Department, or any other permitting or cooperating agency may request the modification of a permit issued under the consolidated application process at any time.

(2) If a permitting agency is requested to make a permit modification that the permitting agency or a cooperating agency finds is a significant permit modification, the agency shall notify the Department. The Department shall coordinate the organization of a project coordinating committee.

(3) The project coordinating committee shall review the proposed modification and determine the portions of ORS 517.952 to 517.989 and these rules with which the permittee must comply. The Committee shall limit its determination to those portions of the mine operation to be modified and shall be consistent with the public participation requirements set forth in ORS 517.952 to 517.989 and these rules.

(4) The permittee may continue to operate under its existing permit(s) pending completion of the permit modification process.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.984
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0150
Civil Penalties

(1) In addition to any other sanctions authorized by law, the Governing Board of the Department may impose a civil penalty as authorized by ORS 517.992

(2) The Department shall provide a written warning of its intent to impose a civil penalty at least 48 hours prior to imposing the penalty when there is no immediate danger to human health, safety or the environment. The warning may be personally served on the person incurring the penalty or may be sent by registered or certified mail. The warning must include:

(a) A reference to the particular sections of the statute, rule, order or permit involved; and

(b) A short and plain statement of the matters asserted or charged.

(3) A civil penalty imposed under this section is due and payable ten days after the order imposing the civil penalty becomes final by operation of law or on appeal. A person against whom a civil penalty is to be imposed shall be served with a notice in the form provided by ORS 183.415. Service of the notice shall be accomplished in the manner provided by ORS 183.415.

(4) The person to whom the notice provided for in section (3) of this rule is addressed shall have 20 days from the date of service of the notice in which to make written application for a hearing. If no application for a hearing is made, the agency may make a final order imposing the penalty.

(5) Any person who makes application as provided in section (4) of this rule is entitled to a hearing conducted pursuant to the applicable provisions of ORS 183.413 to 183.470.

(6) A civil penalty shall be assessed under this rule in accordance with the following schedule:

(a) Class 1. Potential threat to human health or safety: warning to $10,000;

(b) Class 2. Immediate threat to human health or safety: warning to $25,000;

(c) Class 3. Potential threat to the environment: warning to $10,000;

(d) Class 4. Immediate threat to the environment; warning to $25,000;

(e) Class 5. Failure to comply with laws, rules, Governing Board orders or permit conditions, with no threat to human health, safety or the environment: warning to $10,000;

(f) Class 6. Damage to health, safety or the environment: $1,000–$50,000;

(g) Failure to comply with prior warning or penalty (continued or repeat violation) within the following classes:

(A) Class 1: $200–$10,000;

(B) Class 2: $200–$50,000;

(C) Class 3: $200–$50,000;

(D) Class 4: $200–$50,000;

(E) Class 5: $200–$50,000;

(F) Class 6: $2,000–$50,000.

Statutory/Other Authority: ORS 517.750–517.995
Statutes/Other Implemented: ORS 517.992
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

632-037-0155
Fees

(1) Permit fees are established in ORS 517.973. Pursuant to ORS 517.793, a prospective applicant or applicant also must pay the Department and permitting and cooperating agencies for all expenses incurred relating to the processing and evaluation of the consolidated application process to the extent such expenses exceed the statutory fees. Recoverable expenses include, but are not limited to, the following:

(a) Baseline data methodology review;

(b) Baseline data verification;

(c) Public meetings, except any costs related to mailing notice to parties on the master list;

(d) Completeness determination of the consolidated application, including the environmental evaluation;

(e) Permit preparation, drafting and issuance;

(f) Environmental evaluation, preparation and review;

(g) Project administration; and

(h) Legal expenses.

(3) Subject to the requirements and limitations in ORS 517.973(4), the prospective applicant or applicant shall pay the expenses of the Department and each permitting and cooperating agency within 30 days after receiving an invoice itemizing the expenses.

(4) With the agreement of a permitting or cooperating agency, the applicant or prospective applicant may arrange for invoices to be sent by and payments made to the Department on behalf of the permitting or cooperating agency.

(5) The Department and prospective applicant or applicant may agree to procedures to resolve disputes regarding payment of expenses.

(6) Subject to section (5) above, if expenses are not paid within 30 days of receiving an invoice, the Department may suspend pre-application work or decline to issue a notice to proceed under ORS 517.977. If the notice to proceed has been issued and invoices are outstanding after 30 days, the Department may deny the application unless the applicant concurs with a suspension of the permitting process under ORS 517.986.

Statutory/Other Authority: ORS 517.750 - 517.995
Statutes/Other Implemented: ORS 517.973
History:
DGMI 1-2014, f. & cert. ef. 4-2-14
GMI 2-1991, f. & cert. ef. 10-11-91

Department of Environmental Quality

Chapter 340

Division 43
CHEMICAL MINING

340-043-0000
Purpose and Policies

(1) The purpose of these rules and guidelines is to prevent water pollution and protect the quality of the environment and public health in Oregon, consistent with the policies of ORS 468B.015 and 468B.020, by requiring application of all available and reasonable method for control of wastes and chemicals relative to design, construction, operation, and closure of mining operations which use cyanide or other toxic chemicals to extract metals or metal-bearing minerals from the ore and which produce wastes or wastewaters containing toxic materials.

(2) The following policies are established to provide further guidance regarding the level of environmental protection these rules are intended to achieve:

(a) Liner, leak detection and leak collection systems (systems) are necessary for heap leach pads, solution ponds, and tailings facilities to assure that any leak will be detected before toxic materials escape from the liner system and are released to the environment. For purposes of these rules, the environment is considered to begin at the bottom of the last liner. These systems shall assure that a leak is found, and that sufficient time is available to allow for the repair of the leak and cleanup of any leaked material before there is a release to the environment. Natural conditions, such as depth to groundwater or net rainfall, shall be considered as additional protection but not in lieu of the protection required by the engineered liner system;

(b) The toxicity of mill tailings and the potential for long-term cyanide and toxic metals release from mill tailings shall be reduced to the greatest degree practicable through removal, reuse, or destruction of chemical solutions prior to placement of tailings in the tailings disposal facility;

(c) The closure of heap leach pads and tailings disposal facilities shall prevent future release to the environment of residual potentially toxic chemicals contained in the facility.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468B.015, 468B.020, 468B.048 & 468B.155
History:
DEQ 39-2018, minor correction filed 04/02/2018, effective 04/02/2018
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0010
Definitions

Unless the context requires otherwise, as used in this Division:

(1) "Chemical Process Mine" means a mining and processing operation for metal-bearing ores that uses chemicals to dissolve metals from ores.

(2) "Department" means the Department of Environmental Quality.

(3) "Guidelines" means this body of rules contained in OAR 340-043-0080 through 340-043-0180.

(4) "Positive Exclusion of Wildlife" means the use of such devices as tanks, pipes, fences, netting, covers and heap-leach drip-irrigation emitters or covered emitters.

(5) "Tailings" means the spent ore resulting from the milling and chemical extraction process.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.030 & 517.952
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0020

Permit Required

(1) As required by ORS 468B.050, a person proposing to construct a new chemical mining operation, commencing to operate an existing non-permitted operation, or proposing to substantially modify or expand an existing operation shall first apply for, and receive, a permit from the Department. The permit may be an NPDES (National Pollutant Discharge Elimination System) permit if there is a point-source discharge to surface waters or a WPCF (Water Pollution Control Facility) permit if there is no discharge. Consideration may be given to site-specific conditions such as climate, proximity to water, and type of wastes to establish the final permit type and requirements for the facility.

(2) The permit application shall comply with the requirements of OAR 340, divisions 14 and 45 and be accompanied by a report that fully addresses the requirements of this Division.

(3) Prior to issuance of a permit for a chemical process mining activity under this Division, a determination of compliance with statewide planning goals and compatibility with local land use plans must be made. The Department shall determine compliance with Statewide Planning Goals and compatibility with acknowledged comprehensive plans and land use regulations in a manner consistent with its approved State Agency Coordination Program and the rules in OAR 340, division 18. In making these determinations, the Department shall consider and may rely on the findings and recommendations made by the project coordinating committee authorized by ORS 517.965 and by the Department of Geology and Mineral Industries pursuant to their State Agency Coordination Program and OAR 632, divisions 1 and 37.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 197.180, 468.065, 468B.050 & 517.965
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0025

Permit Conditions on Assumption of Liability

(1) This rule is necessary for the following reasons:

(a) ORS 468B.015 expresses an extremely strong state policy against pollution of the waters of the state; and

(b) ORS 468B.010 declares that the “water pollution laws of this state shall be liberally construed for the accomplishment of the purposes set forth in ORS 468B.015”; and

(c) ORS 468B.020 directs the Department to require the use of all available and reasonable methods necessary to achieve the purposes of ORS 468B.015; and

(d) Under ORS 468.065, the Department, in any permit it issues, is required to specify conditions for compliance with the rules and standards adopted by the Environmental Quality Commission pursuant to state law;

(e) Certain chemical process mines pose an unusual risk of substantial environmental harm;

(f) There is no significant operating history of chemical process mines in Oregon, and experience in other states demonstrates that, at least in some instances, chemical process mines have produced extraordinary environmental harm, and the permittees have escaped responsibility for such harm;

(g) It is inherent in the nature of chemical process mining that income from the mining activity will likely cease before the obligations and costs of the permittee, thereby creating a serious risk that pollution will not be abated unless adequate financial safeguards are required;

(h) The Reclamation Bond or alternative security required by ORS 517.987 and OAR 632-037-0135 for a chemical mining facility is intended to provide adequate resources to cover the costs of reclamation and a credible accident. The amount of security required is to be determined at the time permits are issued and adjusted as necessary during site operations. Lack of long-term experience with chemical mining activities makes it difficult to confidently estimate the full range of problems that could develop after chemical mining activities have ceased. This bond may not be adequate to address the full range of costs for protection and restoration of the environment if the permittee defaults;

(i) It is appropriate to take reasonable steps to assure continuing accountability from those who profit from chemical mining activities.

(2) Unless an exception is granted by the EQC pursuant to section (3) of this rule, and consistent with the provisions of section (4) of this rule, the Department shall require, prior to issuing or renewing a permit for a chemical mining facility, and as a condition of the permit, that those persons or entities who control the permittee assume liability for environmental injuries, remediation expenses, and penalties.

(3) The EQC may grant an exception to the requirements of section (2) of this rule upon entering a finding that a particular chemical process mine for which a permit is required does not pose a risk of substantial environmental harm. A finding under this section may be based upon one or more of the following factors which are deemed to relate to the risk of substantial environmental harm:

(a) Nature of the chemical mining process;

(b) Size and scope of the operations;

(c) Types of discharges;

(d) Sensitivity of the potentially affected environment;

(e) Difficulty and costs of implementing remediation measures;

(f) Potential for unintentional or unanticipated environmental injury and the potential magnitude of such injury; or

(g) Long-term operating history for the particular type of chemical process mine.

(4) If any of the securities of the permittee or of an entity assuming liability under section (2) of this rule are Publicly Traded, the investors of such Publicly Traded entity shall not be required to assume liability for environmental injuries, remediation expenses, and penalties. As used in this section, "Publicly Traded" means listed on the New York Stock Exchange or the American Stock Exchange or designated under the National Association of Securities Dealers Automated Quotations System, Inc., National Market System.

(5) As used in section (2) of this rule, "control" means the power to direct or exercise significant control over the management or policies of the permittee:

(a) The power to direct or exercise significant control arises principally from ownership, directly, indirectly or through intermediary entities, of the permittee;

(b) An important indicator of significant control arises from the ownership of or the power to vote ten percent (10%) or more of the securities of the permittee. Such ownership or voting rights may be either direct or indirect through intermediary entities;

(c) An important indicator that significant control exists arises if the entities share a significant number of common directors or officers;

(d) Individuals who hold status as officers, directors, employees, or agents of the permittee or intermediary entities shall not be deemed to fall under the definition of "control" for purposes of this rule solely as a result of such status;

(e) Commercial lending institutions operating within the scope of their normal business activities shall not be deemed to fall under the definition of "control" for purposes of this rule.

(6) The assumption of liability provided for in section (2) of this rule may, at the option of the persons or entities who control the permittee, be accomplished by joining with the permittee as a co-permittee or such other means as the Environmental Quality Commission, with advice of the Attorney General, may approve as being legally sufficient to protect the interests of the State of Oregon and its citizens.

(7) No permit for a chemical process mining activity shall be transferred without the prior written approval from the Department and full compliance with any applicable rules regarding permit transfer. Such approval may be granted by the Department when the transferee acquires a property interest in the permitted activity or agrees in writing to comply fully with all the terms and conditions of the permit and the applicable statutes and rules and demonstrates to DEQ's satisfaction the ability to fully comply.

(8) This rule shall apply to all permit applications either pending on or submitted after the effective date of this rule. This rule shall also apply to all transfers pending on or requested after the effective date of this rule and to all persons who control the associated transferee.

Statutory/Other Authority: ORS 468.020, 468B.010, 468B.015 & 468B.020
Statutes/Other Implemented: ORS 468.020, 468B.010, 468B.015, 468B.020, 468B.030 & 517.956
History:
DEQ 9-1994, f. & cert. ef. 4-27-94

340-043-0030
Permit Application

(1) The permit application shall fully describe the existing site and environmental conditions, with an analysis of how the proposed operation will affect the site and its environment. The application shall, at a minimum, contain the information specified for the DOGAMI (Department of Geology and Mineral Industries) consolidated application under ORS 517.971 (Section 13, Chapter 735, 1991 Oregon Laws). The Department will also use the information contained in NEPA (National Environmental Policy Act), EA (Environmental Assessment), or EIS (Environmental Impact Statement) documents, if they are required for the project, as partial fulfillment of the requirements of this section.

(2) The permit application shall, in addition to the information described in section (1) of this rule, include the following information, unless the information has been otherwise submitted:

(a) Climate/meteorology characterization, with supporting data;

(b) Soils characterization, with supporting data;

(c) Surface water hydrology study, with supporting data;

(d) Characterization of surface water and groundwater quality;

(e) Inventory of surface water and groundwater beneficial uses;

(f) Hydrogeologic characterization of groundwater, with supporting data;

(g) Geologic engineering, hazards and geo-technical study, with supporting data;

(h) Characterization of mine materials and wastes which include, for example, overburden, waste rock, stockpiled ore, leached ore and tailings. Characterization of mine materials and wastes shall include, but not be limited to the following:

(A) Chemical and mineral analysis related to toxicity;

(B) Determination of the potential for acid water formation;

(C) Determination of the potential for long-term leaching of toxic materials from the wastes:

(i) Characterization of wastewater (quantity and chemical and physical quality) produced by the operation;

(j) Assessment of the potential for acid-water formation from waste disposal facilities, low-grade ore stockpiles, waste rock piles and for surface water or groundwater accumulation in open pits that will remain after mining is ended.

(3) Data submitted by the permit applicant should be based on analysis of the actual materials, when possible, or may be based on estimates from knowledge of similar operations and professional judgment.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 517.790, 517.915 & 517.920
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0040
Plan and Specifications

(1) A person constructing or commencing to operate a chemical process mine or substantially modifying or expanding an existing chemical process mine shall first submit plans and specifications to the Department for construction, operation and maintenance

of the facilities intended for treatment, control and disposal of wastes.

(2) The plans shall address all applicable requirements of this Division and shall include, but not be limited to, the following:

(a) A description of the facilities to be constructed, including tanks, pipes and other storage and conveyance means for processing chemicals and solutions and wastewaters;

(b) A management plan for control of surface water;

(c) A management plan for treatment and disposal of excess wastewater, including provisions for reuse and wastewater minimization;

(d) A facility construction plan including, as applicable, the design of low-permeability soil barriers, the type of geosynthetics to be used and a description of their installation methods, the design of wastewater treatment facilities and processes, a quality assurance plan for applicable phases of construction and a listing of construction certification reports to be provided to the Department;

(e) A preliminary closure plan;

(f) A preliminary post-closure monitoring and maintenance plan;

(g) A spill containment and control plan.

(3) The Department shall approve the plans, in writing, before construction of the facilities may be started.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468B.055 & 517.971
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0050
Design, Construction, Operation and Closure Requirements

(1) All chemical process and waste disposal facilities and facilities for mixing, distribution, and application of chemicals associated with on-site mining operations; ore preparation and beneficiation facilities; and processed ore disposal facilities shall be designed, constructed, operated and closed in accordance with the guidelines contained in this Division.

(2) Alternative facilities and methods of control of wastes and potential pollutants may be approved by the Department if the permit applicant can demonstrate that the alternate facilities and methods will provide environmental protection that is fully equivalent or better than that achieved by the facilities specified in the guidelines in OAR 340-043-0070 to 340-043-0180. The burden of proof of fully equivalent protection lies with the permit applicant. Written approval of any alternative by the Department shall be evidence of acceptance as equivalent or better level of environmental protection.

(3) A groundwater monitoring plan shall be submitted to, and be approved by the Department. Monitoring wells shall be installed for detection of groundwater contamination as required by OAR 340, division 40, unless the Department concludes in writing that the hydrogeology of the site or other technical information indicates that an adverse impact on groundwater quality is not likely to occur.

(4) The Department may, in accordance with a written compliance schedule, grant reasonable time for existing facilities to comply with these rules.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468B.190, 517.956 & 517.971
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0060
Exemption from State Permit for Hazardous Waste Treatment or Disposal Facilities

(1) The state hazardous waste program requires a permit for the “treatment,” “storage” or “disposal” of any “hazardous waste” as identified or listed in OAR 340, division 101 from the Department, prior to the treatment and disposal of wastes. Permitting requirements can be found in OAR 340, division 105, Hazardous Waste Management.

(2) However, any operation permitted under this division, which would otherwise require the neutralization or treatment of hazardous waste and would require a permit pursuant to OAR 340, division 105, shall be exempt from the requirement to obtain such hazardous waste treatment permit.

(3) All mined materials disposed of under this Division shall pass Oregon's hazardous waste rule criteria or they will be considered a state hazardous waste and must be disposed of accordingly.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 466.020 & 468.020
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0070
Guidelines for the Design, Construction, Operation and Closure of Chemical Mining Operations: Purpose

(1) This Division establishes criteria for the design, construction, operation and closure of chemical mining operations and supplements the provisions of OAR 340-043-0000 through 340-043-0060. These criteria are intended to establish the minimum level of environmental protection that is necessary using a combination of performance standards and minimum design criteria. Approval of alternative facilities or methods to achieve an equivalent or better environmental result is allowed as defined in OAR 340-043-0050.

(2) Any disapproval of submitted plans or specifications, or imposition of requirements by the Department to improve existing facilities or their operation will be referenced when appropriate, to applicable guidelines or rules.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.020 & 468B.055
History:
DEQ 40-2018, minor correction filed 04/02/2018, effective 04/02/2018
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0080
Guidelines for the Design, Construction, Operation and Closure of Chemical Mining Operations: General Provisions

(1) Facilities permitted under either a WPCF or NPDES permit shall not discharge wastewater or process solutions to surface water, groundwater or soils, except as expressly allowed by the permit.

(2) Facilities subject to these rules shall not be sited in 100-year floodplains or wetlands. A buffer zone (a minimum of 200 feet wide) shall be established between waste disposal facilities and surface waters.

(3) All chemical conveyances (ditches, troughs, pipes, etc.) shall be equipped with secondary containment and leak detection means for preventing and detecting release of chemicals to surface water, groundwater or soils.

(4) Acid water accumulation in open pits resulting from the mining operation must be prevented by appropriate mining practices, by measures taken in the closure process, or be treated to control pH and toxicity, for the life of the pit.

(5) Construction of surface impoundment liner systems shall conform generally to the principles and practices described in EPA/600/2-88/052, Lining of Waste Containment and Other Impoundment Facilities, September 1988.

(6) The Department may require the permittee to hire a third-party contractor to perform the functions set forth below. Selection of the contractor shall be subject to Department approval:

(a) Review and evaluate the design and construction specifications of all mined-materials disposal facilities permitted under this Division for functional adequacy and conformance with Department requirements. The Department shall not approve construction of the disposal facilities until the design and construction specifications have been evaluated;

(b) Monitor the course of construction of all mined-materials facilities for compliance with the approved design and construction specifications. The third-party contractor shall regularly document the progress of construction and the Department shall require the permittee to take corrective action if construction does not satisfactorily conform to the approved design and construction specifications;

(c) Provide on-site inspections during ongoing operations, including but not limited to the loading of the heap, to assure protection of the integrity of the liner system and other environmental protection measures.

[Publications: Publications referenced are available from the agency.]

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.020 & 468B.055
History:
DEQ 41-2018, minor correction filed 04/02/2018, effective 04/02/2018
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0090

Guidelines for the Design, Construction, Operation and Closure of Chemical Mining Operations: Control of Surface Water Run-On and Run-Off

(1) Surface water run-on and run-off shall be controlled such that it will not endanger the facility or become contaminated by contact with process materials or loaded with sediment. The control systems shall be designed to accommodate a 100-year, 24-hour storm event, or any other defined climatic event that is more appropriate to the site, and be placed so as to allow for restoration of the natural drainage network, to the maximum extent practicable, upon facility closure.

(2) All mined materials shall be properly placed and protected from surface water and precipitation so as not to be eroded and contribute sediment to site stormwater run-off or to otherwise contaminate surface water.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.020
History:
DEQ 42-2018, minor correction filed 04/02/2018, effective 04/02/2018
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0100

Guidelines for the Design, Construction, Operation and Closure of Chemical Mining Operations: Physical Stability of Retaining Structures and Emplaced Mine Materials

(1) Permit applicants must demonstrate to the Department that the design of chemical processing facilities and waste disposal facilities is adequate to ensure the stability of all structural components of the facilities during operation, closure and post closure.

(2) Retaining structures, foundations and mine materials emplacements shall be designed by a qualified, registered professional and be constructed for long-term stability under anticipated loading and seismic conditions.

(3) Temporary structures and materials emplacements may, with written approval from the Department, be constructed to a lesser standard if it can be shown that they pose no, or minimal, threat to public safety or the environment.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.020
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0110

Guidelines for the Design, Construction, Operation and Closure of Chemical Mining Operations: Protection of Wildlife

(1) Wildlife shall be positively excluded from contact with chemical processing solutions and wastewaters containing chemicals.

(2) The Department may waive the positive exclusion requirement if the Oregon Department of Fish and Wildlife (ODF&W) certifies to the Department that the project is designed such that it will adequately protect wildlife.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.020 & 498.046
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0120

Guidelines for the Design, Construction, Operation and Closure of Chemical Mining Operations: Guidelines for Design, Construction, and Operation of Heap-Leach Facilities

(1) This section applies to heap-leach facilities using dedicated, or expanding, pads. Heap-leach facilities using on-off, reusable pads may require variations from these rules; they shall be approved on a case-by-case basis by the Department.

(2) The heap-leach facility (pad and associated ponds, pipes and tanks) shall be sized to prevent flooding of any of its components.

(3) Table 1 of this Division establishes minimum capacity-sizing criteria for the leach-pad and ponds. The pad and ponds may be designed to act separately or in conjunction with each other to obtain the required storage volumes. Other design criteria may be used, with Department approval, if local conditions warrant. The best available climatic data shall be used to confirm the critical design storm event and estimate the liquid levels in the system over a full seasonal cycle. The liquid mass balance may include provision for evaporation.

(4) The heap leach pad liner system shall be designed, constructed, and operated to meet the following criteria:

(a) A primary liner consisting, at a minimum, of a continuous flexible-membrane of suitable synthetic material shall be provided. This liner shall function together with the process chemical collection system installed immediately above this liner (see section (8) of this rule) to remove process chemicals from the heap;

(b) A leak detection system shall be installed immediately below the primary liner for the purpose of detecting loss of process solutions by leakage through the primary liner. The leak detection system shall be capable of detecting leakage through the primary liner of 400 gallons/day-acre within ten weeks of leak initiation. The leak detection system shall consist of appropriately sized collection piping placed within a minimum thickness of 12 inches of permeable material (minimum permeability of 10-2 cm/sec) that is capable of withstanding the anticipated weight of the heap without loss of function;

(c) A secondary liner shall be placed below the leak detection system to provide assurance that any leakage through the primary liner during the operation of the heap and following closure of the heap is not released to the environment. The secondary liner shall be of a composite design with a continuous flexible-membrane of suitable synthetic material in direct contact with an engineered, stable, low permeability soil/clay bottom liner (maximum permeability of 10-7 cm/sec) with a minimum thickness of 36 inches;

(d) Each liner system component described in subsections (4)(a)–(c) of this rule addresses a specific need and purpose with respect to environmental protection. For purposes of evaluating alternative facilities and methods of control under OAR 340-043-0050(2), an alternative may be approved if the level of environmental protection intended by each separate liner system component is achieved either within the individual component or on a cross component basis.

(5) The processing chemical pond liner system shall be designed, constructed, and operated to meet the following criteria:

(a) A primary liner consisting, at a minimum, of a continuous flexible-membrane of suitable synthetic material shall be provided. This liner shall provide for positive containment of processing chemical solutions;

(b) A leak detection system shall be installed immediately below the primary liner for the purpose of detecting loss of process chemical solutions by leakage through the primary liner. The leak detection system shall be capable of detecting leakage through the primary liner of 400 gallons/day-acre within ten weeks of leak initiation. The leak detection system shall consist of appropriately sized collection piping placed within a layer of permeable material (minimum permeability of 10-2 cm/sec);

(c) A secondary liner shall be placed below the leak detection system to provide assurance that any leakage through the primary liner during the use of the pond is not released to the environment. The secondary liner shall be of a composite design with a continuous flexible-membrane of suitable synthetic material in direct contact with an engineered, stable, low permeability soil/clay bottom liner (maximum permeability of 10-7 cm/sec) with a minimum thickness of 36 inches;

(d) Each liner system component described in subsections (5)(a)–(c) of this rule addresses a specific need and purpose with respect to environmental protection. For purposes of evaluating alternative facilities and methods of control under OAR 340-043-0050(2), an alternative may be approved if the level of environmental protection intended by each separate liner system component is achieved either within the individual component or on a cross component basis.

(6) Emergency ponds may be constructed as an alternative to larger pregnant and barren ponds. The emergency pond may be constructed to a lesser standard, with the limitation that it is to be used only infrequently and for short periods of time. The Department will specify reporting and use limitations for the ponds in the permit. A between-liner leak detection system is not required for the emergency pond.

(7) The emergency pond liner shall be of composite construction consisting of:

(a) An engineered, stable, low permeability soil/clay bottom liner (maximum permeability of 10-6 cm/sec) with a minimum thickness of 12 inches; and

(b) A single flexible-membrane synthetic top liner of suitable material.

(8) The heap-leach pad shall be provided with a process chemical collection system above the upper-most liner that will prevent an accumulation of process chemical within the heap greater than 24 inches in depth.

(9) The permittee shall prepare a written operating plan for safe temporary shutdown of the heap-leach facility and train employees in its implementation.

(10) The permittee shall respond to leakage collected by the heap-leach and processing-chemical storage pond leak-collection systems according to the process defined in Table 2.

(11) The permittee shall determine the acid-generating potential of the spent ore by acid/base accounting and other appropriate static and dynamic laboratory tests. If the spent ore is shown to be potentially acid generating under the conditions expected in the heap at closure, the permittee shall submit a plan for acid correction for Department approval prior to loading the heap.

[ED. NOTE: Tables referenced are available from the agency.]

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.020 & 468B.160
History:
DEQ 43-2018, minor correction filed 04/02/2018, effective 04/02/2018
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0130

Guidelines for the Design, Construction, Operation and Closure of Chemical Mining Operations: Guidelines for Disposal of Mill Tailings

(1) Mill tailings shall be treated by cyanide removal, reuse, or destruction prior to disposal to reduce the amount of cyanide introduced into the tailings pond to the lowest practicable level. The permittee shall conduct laboratory column tests on mill tailings to determine the lowest practicable concentration to which the WAD cyanide (weak-acid dissociable cyanide as measured by ASTM Method D2036-82 C) can be reduced. In no event, shall the permitted WAD cyanide concentration in the liquid fraction of the tailings be greater than 30 ppm.

(2) The permittee shall determine the potential for acid-water formation from the tailings by means of acid-base accounting and other suitable laboratory static and dynamic tests. If acid formation can occur, basic materials shall be added to the tailings in the amount of three (3) times the acid formation potential or to give a net neutralization potential of at least 20 tons of $CaCO_3$ per 1,000 tons of tailings, whichever is greater, before placing tailings in the disposal facility.

(3) The disposal facility shall be lined with a composite double liner consisting of a flexible-membrane synthetic top liner in tight contact with an engineered, stable, soil/clay bottom liner (maximum coefficient of permeability of 10-7 cm/sec) having a minimum thickness of 36 inches. Construction of the liner shall generally follow the principles and practices contained in EPA/600/2-88/052, Lining of Waste Containment and Other Impoundment Facilities, September, 1988.

(4) The disposal facility shall be provided with a leachate collection system above the liner suitable for monitoring, collecting and treating potential acid drainage.

[Publications: Publications referenced are available from the agency.]

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.020 & 468B.160
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0140

Guidelines for the Design, Construction, Operation and Closure of Chemical Mining Operations: Guidelines for Disposal or Storage of Wasterock, Low-Grade Ore and Other Mined Materials

The permittee shall determine the acid-producing and metals-release potential of the wasterock, low-grade ore or other mined materials by acid/base accounting and other appropriate static and dynamic laboratory tests. If the mined materials are shown to be potentially acid forming, or capable of releasing toxic metals, the permittee shall submit a plan for correction and disposal for Department approval prior to permanently placing the materials.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.020
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0150

Guidelines for the Design, Construction, Operation and Closure of Chemical Mining Operations: Guidelines for Heap-Leach and Tailings Disposal Facility Closure

(1) The waste disposal facilities shall be closed under these rules in conjunction with the reclamation requirements of DOGAMI (Oregon Department of Geology and Mineral Industries).

(2) An updated closure plan and post-closure monitoring and maintenance plan shall be submitted to the Department by the permittee at least 180 days prior to beginning closure operations or making any substantial changes to the operation. The closure plan must be compatible with DOGAMI's reclamation plan and may be part of it.

(3) Chemical conveyances (ditches, troughs, pipes, etc.) not necessary for post-closure monitoring shall be removed. The secondary containment systems shall be checked before closure for process-chemical contamination, and contaminated soil or other materials, if any, shall be removed to an acceptable disposal facility.

(4) Closure of the heap-leach facility:

(a) The heap shall be detoxified over a suitable period of time prior to closure, using rinse/rest cycles of rinsing and chemical oxidation, if necessary. The WAD cyanide concentration in the rinsate shall be no greater than 0.2 ppm;

(b) Following detoxification as defined in subsection (a) of this section, the heap shall be closed in place on the pad by covering the heap with a cover designed to prevent water and air infiltration. The cover should consist, at a minimum, of a low-permeability layer and suitable drainage and soil layers to prevent erosion and damage by animals and to sustain vegetation growth, in accordance with DOGAMI's reclamation rules;

(c) The ponds associated with the heap shall be closed by folding in the synthetic liners and filling and contouring the pits with inert material. Residual sludge may be disposed of in one of the on-site waste disposal facilities, provided it meets the criteria for such wastes in these guidelines. The process chemical collection system of the heap shall be maintained in operative condition so that it can be used to monitor the amount and quality of infiltrated water, if any, draining from the heap.

(5) The tailings disposal facility shall be closed by covering with a composite cover designed to prevent water and air infiltration and be environmentally stable for an indefinite period of time. Maximum effort shall be made to isolate the tailings from the environment. Construction of the cover shall generally follow the principles and practices contained in EPA/530-SW-89-047. Technical Guidance Document — Final Covers on Hazardous Waste Landfills and Surface Impoundments.

[Publications: Publications referenced are available from the agency.]

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.020 & 517.770
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0160

Guidelines for the Design, Construction, Operation and Closure of Chemical Mining Operations: Post-Closure Monitoring

(1) The Department may continue its permit in force for thirty (30) years after closure of the operation and will include permit requirements for periodic monitoring to determine if release of pollutants is occurring.

(2) Monitoring data will be reviewed regularly by the Department to determine the effectiveness of closure of the disposal facilities. The Department will consult with DOGAMI on release of security funds that would otherwise be needed to correct problems resulting from ineffective closure.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.020, 468B.050 & 517.760

History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0170

Guidelines for the Design, Construction, Operation and Closure of Chemical Mining Operations: Land Disposal of Wastewater

(1) To qualify for land disposal of excess wastewater, the permit applicant shall demonstrate to the Department that the process has been designed to minimize the amount of excess wastewater that is produced, through use of water-efficient processes, wastewater treatment and reuse, and reduction by natural evaporation. Excess wastewater that must be released shall be treated and disposed of to land under the conditions specified in the permit.

(2) A disposal plan shall be submitted as part of the permit application that, at a minimum, includes:

(a) Wastewater quantity and quality characterization;

(b) Soils characterization and suitability analysis;

(c) Drainage and run-off characteristics of the site relative to land application of wastewater;

(d) Proximity of the disposal site to groundwater and surface water and potential impact;

(e) Wastewater application schedule and water balance;

(f) Disposal site assimilative capacity determination;

(g) Soils, surface water and groundwater monitoring plan;

(h) Potential impact on wildlife or sensitive plant species.

(3) The Department will evaluate the disposal plan and set site-specific permit conditions for the wastewater discharge.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.020, 468B.030 & 468B.160
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

340-043-0180

Guidelines for the Design, Construction, Operation and Closure of Chemical Mining Operations: Guidelines for Open-Pit Closure

(1) Open pits that will be left as a result of the mining operation shall be assessed prior to, and following, mining operations for the potential to contaminate water to the extent that it might not meet water-quality standards due to buildup of acid or toxic metals.

(2) If the Department finds that the potential for water accumulation in the pit(s) exists, the permit applicant shall submit a closure plan for the pit that will address contamination prevention and possible remedial treatment of the water. The closure plan shall, at a minimum, examine the following alternatives:

(a) Avoidance, during mining, of acid-generating materials that can be left in place, rather than being exposed to oxidation and weathering;

(b) Removal from the pit and disposal, during or after the mining operation, of residual acid-generating materials that would otherwise be left exposed to oxidation and weathering;

(c) Protective capping in-situ of residual acid-generating materials;

(d) Treatment methods for correcting acidity and toxicity of accumulated water;

(e) Installation of an impermeable liner under ponded water to prevent groundwater contamination;

(f) Backfilling of the pit(s) to the level necessary to, in conjunction with other appropriate control measures, prevent oxidation of residual acid-generating materials.

Statutory/Other Authority: ORS 468.020
Statutes/Other Implemented: ORS 468.020, 468B.030 & 468B.160
History:
DEQ 23-1992, f. & cert. ef. 9-8-92

NYSSA ALLOTMENT MANAGEMENT PLAN
(10403)

INTRODUCTION

Nyssa Allotment is located approximately 20 miles south of Vale and 10 miles west of Adrian, Oregon (figure 1). The topography consists of rolling hills and rocky rim-land with watersheds flowing north to Malheur River, east to Owyhee River, and south to Dry Creek. Boundaries of the allotment are defined by Dry Creek to the south, Owyhee River to the east and a common boundary with Freezeout Allotment to the north and west. Vegetation is dominated by cool season sagebrush/bunchgrass communities. Portions of six pastures have been seeded to crested wheatgrass to stabilize soils and restore forage productivity to poor condition rangelands.

All allotments within Harper Basin Management Unit (0400) were classified as "I" category allotments for management in the Southern Malheur Rangeland Program Summary (RPS) . Nyssa Allotment remains classified as an "I" allotment. Livestock grazing authorization within Harper Basin Management Unit was set at 38,539 AUMs within the RPS. By agreement, Harper Basin Management Unit was divided to form separate allotments in 1984. Livestock grazing authorization within Nyssa Allotment was set at 5882 AUMs by that agreement. No grazing authorization is currently held in suspension. Preference to graze livestock within the community allotment is shared by the following operators:

Operator		Authorized Active Use	Season
Gary Cleaver		2191 AUMs cattle	4/1 to 10/31
Christian and Ann Bennight		1120 AUMs cattle	4/1 to 10/31
Jeff Hess		1617 AUMs cattle	4/1 to 10/31
Vernon and Velma Widmer		350 AUMs cattle	4/1 to 10/31
Adah Schweitzer		70 AUMs cattle	custodial
Frank Shirts		534 AUMs sheep	4/1 to 5/3
	Total	5882 AUMs	

Permitted use for all cattle operators is between 4/1 and 10/31 annually while permitted use for the one sheep operator is 4/1 to 5/3.

The 76,955 acre community allotment is currently divided into nine pastures and a number of small enclosures as follow:

Pasture	BLM	Other Federal	Private	Total
North Mud Spring	5,067	0	255	5,322
South Mud Spring	3,057	0	0	3,057
North Rock Creek	7,992	160	0	8,152
South Rock Creek	6,496	821	1	7,318
Sagebrush	12,175	0	0	12,175
Rye Field Seeding	3,752	0	0	3,752
Grassy Seeding	2,971	0	0	2,971
Grassy Mountain	25,551	4,733	85	30,369
FFR	992	0	182	1,174
Ryefield Res Ex	4	0	0	4
Mud Spring Res Ex	3	0	0	3
North Grassy Mountain Res Enclosure	12	0	0	12
Rock Creek Riparian Stream Enclosure (Owyhee River Corridor)	258	2,130	256	2,644
Sagebrush Res Ex	2	0	0	2
Total	68,332	7,844	779	76,955

Shortly after division of the Harper Basin Management Unit in 1984, an allotment management plan (AMP) was developed and implemented for Nyssa Allotment. Grazing by cattle was divided into two overlapping areas-of-use. Neither sheep grazing authorization held by Frank Shirts nor the cattle grazing authorization held by Adah Schweizer were addressed in that AMP. As a result of two pasture divisions since 1984 and completion of an allotment evaluation in 1989, a revised grazing schedule was implemented in 1989. A second evaluation was completed in 1994 with recommendations to once again revise the grazing to better address multiple-use management and sustaining of resources within upland and riparian vegetation communities as well as other identified values. Livestock operators expressed a desire to redefine the boundaries of each area-of-use without overlap in pastures. This could serve as an initial step toward division of the large community allotment into two smaller community allotments.

The Owyhee River below the Dam was found administratively suitable with a tentative recreational river designation as a part of the National Wild and Scenic Rivers System (NWSR) within the Draft Southeastern Oregon Resource Management Plan dated October 1998. Outstanding Remarkable Values (ORVs) for which it may be recommended for inclusion in the NWSR System are scenery, recreation, geology, fish, wildlife, and special status plants.

OBJECTIVES

Guidance from the Northern Malheur Management Framework Plan and the Southern Malheur Rangeland Program Summary requires that livestock grazing systems be determined based on the ecological condition of the pastures within the allotment, riparian considerations and wildlife habitat requirements as follow:

> Native range pastures are to be managed for general eco-site condition improvement. The long term objective (more than 15 years) is to attain late (good) or climax (excellent) condition on the majority of the area in pastures that are in middle (fair) condition and middle condition in pastures that are now in early (poor) condition.
>
> Crested wheatgrass seedings will be grazed closely, with a maximum utilization level of 65 percent of the current years growth.

Specific resource management objectives within Nyssa Allotment are as follow:

North Mud Spring Seeding Pasture
- Present Condition: Late (Seeding: Good)
- Land Use Plan Objective:
  - -Maintain late ecological condition (Maintain seeding condition and productivity).
- AMP Objectives:
  - -Maintain the late ecological condition of native portions of North Mud Spring pasture. Trend in ecological condition will be measured through change in recorded cover and dominance of native perennial bunchgrass species, primarily bluebunch wheatgrass.
  - -Maintain the good condition classification of seeded portion of North Mud Spring pasture as measured through the recorded change in cover and dominance of crested wheatgrass.

South Mud Spring Seeding Pasture
- Present Condition: Late (Seeding: Good)
- Land Use Plan Objective:
  - -Maintain late ecological condition (Maintain seeding condition and productivity.)
- AMP Objectives:
  - -Maintain the late ecological condition of native portions of South Mud Spring pasture. Trend in ecological condition will be measured through change in

recorded cover and dominance of native perennial bunch grass species, primarily blue bunch wheatgrass.
-Maintain the good condition classification of the seeded portion of South Mud Spring pasture as measured through the recorded change in cover and dominance of crested wheatgrass.

Sagebrush Pasture

Present Condition: Middle

Land Use Plan Objective:

-Improve to late ecological condition.

AMP Objectives:

-Improve the ecological condition of upland plant communities within Sagebrush pasture from middle to late within 15 years. Trend toward change in ecological condition will be measured through a change in the cover and dominance of native perennial bunch grass species (primarily blue bunch wheatgrass) and change in shrub cover recorded at approximate five year intervals.

North Rock Creek Pasture

Present Condition: Early

Land Use Plan Objective:

-Improve to middle ecological condition.

AMP Objectives:

-Improve the ecological condition of upland plant communities within North Rock Creek pasture from early to middle within 15 years. Trend toward change in ecological condition will be measured through a change in the cover and dominance of native perennial bunch grass species (primarily bluebunch wheatgrass) and change in shrub cover recorded at approximate five year intervals.

-In accordance with the Bureau's Wetland and Riparian Initiative for the 1990's, improve the condition of riparian vegetation communities adjacent to Rock Creek to functioning condition [1] within 5 years.

South Rock Creek Pasture

Present Condition: Early

Land Use Plan Objective:

-Improve to middle ecological condition.

AMP Objectives:

- Improve the ecological condition of upland plant communities within South Rock Creek pasture from early middle within 15 years. Trend toward change in ecological condition will be measured through a change in the cover and dominance of native perennial bunch grass species (primarily blue bunch wheatgrass) and change in shrub cover recorded at approximate five year intervals.

- Improve the health and vigor of significant riparian communities associated with moist springs and small tributaries of Owyhee River.

Grassy Mountain Pasture

Present Condition: Late

Land Use Plan Objective:

-Maintain late ecological condition.

AMP Objectives:

- Maintain the ecological condition of upland plant communities within Grassy Mountain pasture in late ecological condition. Trend toward change in ecological condition will be measured through a change in the cover and dominance of native perennial bunch grass species (primarily blue bunch wheatgrass) and change in shrub cover recorded at approximate five year intervals.

Grassy Seeding (Cherry Creek Pasture)

Present Condition: Late (Seeding: Good)

Land Use Plan Objective:

- Maintain late ecological condition (Maintain seeding condition and productivity.)

AMP Objectives:

- Maintain the late ecological condition of native portions of Grassy Seeding pasture. Trend in ecological condition will be measured through change in recorded cover and dominance of native perennial bunch grass species, primarily blue bunch wheatgrass.
- Maintain the good condition classification of the seeded portion of Grassy Seeding pasture as measured through the recorded change in cover and dominance of crested wheatgrass.

Ryefield Seeding Pasture

Present Condition: Late (Seeding: Good)

Land Use Plan Objective:

-Maintain late ecological condition (Maintain seeding condition and productivity.)

AMP Objectives:

-Maintain the late ecological condition of native portions of Ryefield Seeding pasture. Trend in ecological condition will be measured through change in recorded cover and dominance of native perennial bunch grass species, primarily blue bunch wheatgrass.

-Maintain the good condition classification of the seeded portion of Ryefield Seeding pasture as measured through the recorded change in cover and dominance of crested wheatgrass.

Rock Creek Riparian Stream Enclosure (Owhyee River)

Present Condition: Early (uplands)
Land Use plan Objective:
-Improve to middle ecological condition
Amp Objectives:
-Improve the ecological condition of upland plant communities within Rock Creek Stream Riparian enclosure from early to middle within 15 years. Trend toward change in ecological condition will be measured through a change in the cover and dominance of native perennial bunch grass species (primarily bluebunch wheatgrass) and change in shrub cover recorded at approximate five year intervals.
-In accordance with the Bureau's Wetland and Riparian Initiative for the 1990's, improve the condition of riparian vegetation communities adjacent to the Owyhee River to functioning condition within 5 years. Improve and maintain riparian vegetation communities through livestock exclusion except for spring and fall cattle trailing between base property and the public land grazing allotments.
-Manage public land uses within the corridor adjacent to Owyhee River below the Dam to protect and enhance the outstanding remarkable values for which this river was found administratively suitable for potential designation by Congress as a part of the National Wild and Scenic Rivers System.

Fenced Federal Range (Adah Schweitzer custodial pasture)
Present Condition: unknown
Land Use Plan Objective:
-Improve ecological condition
AMP Objective:
-Manage as custodial public lands with enclosed private lands. Livestock management actions will be consistent with improving the ecological condition of upland vegetation communities.

Mud Springs Enclosures
Present Condition: unknown
Land Use Plan Objective:
-Improve riparian habitat

AMP Objectives:
- Improve and maintain riparian vegetation communities associated with Mud Spring and Mud Spring Reservoir through livestock exclusion.

Sagebrush Reservoir Enclosure
Present Condition: unknown
Land Use Plan Objective:
-Improve riparian habitat
AMP Objectives:

Improve and maintain riparian vegetation communities associated with Sagebrush Reservoir through livestock exclusion.

Ryefield Reservoir Enclosure
Present Condition: unknown
Land Use Plan Objective:
-Improve riparian habitat
AMP Objectives:
-Improve and maintain riparian vegetation communities associated with Ryefield Reservoir through livestock exclusion.

KEY SPECIES AND PHENOLOGY

Grazing schedules will be established based on the requirements for growth and maintenance of vigor of key vegetation species and other valued resources. The key species for native upland plant communities is blue bunch wheatgrass. The key species for the seeded portions of pastures is crested wheatgrass. Approximate phenological dates for blue bunch wheatgrass development in Nyssa Allotment are as follow:

Begin growth	3/15 to4/1
Six inch leaf growth	4/15 to5/1
Flowering	5/15 to7/1
Seed set	7/1 to7/15
Seed dissemination	7/15 to8/1

Approximate phenological dates for crested wheatgrass development in Nyssa Allotment are one to two weeks earlier than those identified for blue bunch wheatgrass.

PLANNED GRAZING USE

The Southern Malheur RPS identified some tools intended to facilitate meeting land use plan objectives. In addition to the intensity of grazing, livestock impacts to upland vegetation communities are dependent on the frequency of use during critical periods of the growth cycle. Periodic year-long rest or deferment of grazing during the growing season (4/1 to 7/15) is required to improve and maintain the vigor of native upland bunchgrass/sagebrush communities. Successful grazing of upland pastures will allow periodic deferment during active plant growth and prior to seed set. The degree of localized defoliation and physical impacts to upland vegetation communities during scheduled livestock use is directly related to the intensity of livestock management provided by the livestock operator. The deferred rotation grazing schedules for grazed pastures of Nyssa Allotment identified in the RPS were intended to meet objectives to improve or maintain vegetation community health and vigor as well as sustain most resource values. Additionally, the RPS set maximum allowable utilization limits of 50 percent on native range and from 50 to 65 percent on seeded range as tools intended to maintain vegetation community health and vigor.

Allotment evaluations completed in 1989 and 1994 identified a need to better define the scheduled grazing use in Nyssa Allotment to potentially meet land use plan objectives. Two areas-of-use will be maintained in Nyssa Allotment to support active grazing authorizations of cattle operators. A similar two year deferred rotation grazing schedule will be implemented in each area-of-use. Pastures used in the southern area-of-use by Gary Cleaver will include South Rock Creek, Grassy Seeding, Ryefield Seeding and Grassy Mountain. Gary Cleaver will use Rock Creek Riparian Pasture (Owyhee River corridor) annually in the spring and again in the fall to trail cattle between private land and public land in Nyssa, Black Jack, and Lower Owyhee allotments. The Owyhee River below the Dam has been found administratively suitable for designation as a part of the National Wild and Scenic Rivers System (NWSRS), with a tentative recreational river classification. To better ensure that outstanding remarkable values of the river corridor are protected and enhanced, trailing of any group of cattle will be limited to one day within the river corridor, be restricted to the road and adjacent areas disturbed during road construction and maintenance, be stipulated to avoid livestock access to grounds and developed facilities at Snively Hot Spring and Lower Owyhee Watchable Wildlife Areas, and be stipulated to avoid cattle access to sandy benches adjacent to Owyhee River and other identified habitats suitable for supporting special status plant species.

Pastures used in the northern area-of-use by Christian Bennight, Jeff Hess, Vernon Widmer and Gerald Williams will include North Rock Creek, North Mud Spring, South Mud Spring and Sagebrush.

A two year deferred rotation grazing schedule will be implemented as identified on the following page. Maximum allowable utilization limits of 50 percent in native vegetation communities and 65 percent in non-native seeded vegetation communities set in the Southern Malheur RPS will not be exceeded with livestock use.

Southern Area-of-Use Grazing Schedule

Pasture	Year 1 ('99,'01, ..)	Year 2 ('00,'02, ..)
South Rock Creek	4/1 - 4/30	4/1 - 4/30
Rye Field Seeding	5/1 - 7/15	9/15 - 10/31
Grassy Mountain	7/16 - 9/31	6/16 - 9/15
Grassy Seeding	10/1 - 10/31	5/1 - 6/15

Rock Creek Riparian (Owyhee River corridor) spring and fall trailing

Northern Area-of-Use Grazing Schedule

Pasture	Year 1 ('99,'01, ..)	Year 2 ('00,'02, ..)
North Rock Creek	4/1 - 4/30	4/1 - 4/30
North Mud Spring Seeding	5/1 - 7/15	9/16 - 10/31
South Mud Spring seeding	9/16 - 10/31	5/1 - 7/15
Sagebrush	7/16 - 9/15	7/16 - 9/15

Adah Schweitzer's authorized active grazing will be maintained in the Schweitzer Custodial Pasture as has occurred in recent years. Sheep grazing will occur in native pastures of the allotment as identified in turnout statements issued annually prior to the grazing season. A primary consideration in the management of sheep, which are herded daily, is to avoid repeat grazing of any site. Terms and conditions will include the requirement that camps be moved at least every five days and sheep be bedded in no location more than once per grazing season.

GRAZING SCHEDULE RATIONALE

The above grazing schedule limits use of pastures containing significant riparian communities (North and South Rock Creek) to early spring only. Cattle are more likely to distribute use away from riparian communities and into green upland communities during April use than during other periods of the grazing season. With use of riparian communities limited to spring only, channel stabilizing vegetation will not be impacted by livestock use during mid-summer, a period when the majority of growth occurs and cattle tend to concentrate in these communities for water, shade and forage. Residual herbaceous and woody riparian vegetation will remain on site to dissipate hydraulic energy of peak stream flows during mid-summer storms and spring run-off. Within these two pastures with early seral upland conditions, limiting the majority of use to early-spring only will encourage grazing within cheatgrass dominated communities. Soil moisture should remain in most years after 5/1 to allow regrowth of native bunchgrass species, maintaining their vigor and health.

Use of seeded pastures will be deferred until after seed set in alternate years allowing healthy crested wheatgrass communities to maintain vigor. Native bunchgrass communities within seeded pastures, primarily Grassy Seeding, are in late seral condition and are also expected to maintain health and vigor with deferment of use until after seed set in alternate years. Sagebrush and Grassy Mountain pastures will be grazed after seed set in all years and are expected to improve in vigor and productivity.

Livestock trailing through Rock Creek Riparian Pasture (the Owyhee River corridor) in the spring and fall to move cattle between private land and public land in Nyssa, Blackjack, and Lower Owyhee allotments will limit impacts to riparian resources and outstanding remarkable values for which Owyhee River below the Dam was found administratively suitable for inclusion in the NWSRS.

GRAZING SCHEDULE FLEXIBILITY

Turn out of cattle onto public land of Nyssa Allotment will occur no earlier than April 1 to minimize soil compaction from concentrated trampling. Sheep turn out may be as early as March 20 in years with early herbaceous growth and range readiness provided conscientious livestock management occurs. The first move of cattle within the allotment from riparian pastures to spring use seeded pastures will be completed prior to May 1 to ensure maintenance of health and vigor of riparian and upland native vegetation. The above grazing schedule includes flexibility to make moves to subsequently scheduled pastures at any time after July 15 due to livestock management needs or public land resource needs. Move dates that vary more than 7 days from the defined schedule should be coordinated with BLM range staff in a timely manner. No more than one pasture within each area of use will be used at one time. By written application, cattle use may extend to November 30, resulting from reduced livestock numbers during the active growing season (5/1 to 7/15) and provided active authorized use is not exceeded. Similarly, sheep use may begin as early as 3/20 based on range-readiness as determined by BLM and may extended to 5/30 provided active authorized use is not exceeded. The maximum allowable utilization levels set in the RPS will be maintained at 50 percent on native vegetation communities and 65 percent on non-native seeded vegetation communities unless more restrictive limits are determined to be necessary to meet management objectives.

RANGE IMPROVEMENTS

The permittees authorized to graze livestock within Nyssa Allotment have maintenance responsibility for all rangeland improvements with the exception of land treatments involving vegetation manipulation and designated enclosures constructed for purposes other than livestock management. Periodic damage to fences caused by snow loading, wildlife, livestock, normal weathering and seasonal high stream flows require frequent inspection and repair by the permittees to prevent unscheduled livestock moves between this allotment and adjoining private and federal lands. Gates left open by users of the public land continue to provide livestock access to and from the allotment during periods when livestock are present. Livestock management remains the responsibility of the permitted livestock operators. Existing rangeland improvements within Nyssa Allotment are listed as follow:

Project	Number	Twsp	Rng	Sec
Lone Willow Spring	0059	21S	44E	24
Shell Bark Spring	0066	21S	44E	13
Lowe Spring	0070	21S	44E	28
Lowe Spring Tank	0089	21S	44E	28
Owyhee Cattle Assn Drift Fence	0101	20S	45E	15
Elbow Drift Fence	0198	23S	43E	13
Lowe Reservoir	0285	21S	44E	28
Grassy Reservoir	0286	22S	43E	12
Cow Skull Spring	0440	22S	45E	5
Schweizer Reservoir	0445	22S	44E	8
Grassy Spring #1	0458	22S	44E	17
Grassy Mtn Reservoir	0459	22S	44E	5
Oxbow Reservoir	0677	22S	44E	21
Mendiola Spring	0678	22S	44E	1
Holy Land Cattleguard	0726	21S	44E	11
Owyhee Siphon Drift Fence	0956	21S	44E	14
Twin Spring Reservoir	0962	22S	43E	35
Chalk Spring	1041	20S	45E	21
Up Cow Hollow Cattleguard	1115	21S	44E	3
Shell Rock Cattleguard	1204	21S	45E	6
Twin Springs	1226	22S	43E	35
Sagebrush Spring	1236	21S	44E	34
North Grassy Mtn Reservoir	1265	22S	44E	3
O T Spring	1396	21S	44E	35
Deer Butte Spring	1486	21S	45E	20
Leaky Reservoir	1494	20S	45E	18
Chalk Reservoir	1495	20S	40E	18

Mud Reservoir	1496	20S	45E	29
North Reservoir	1497	20S	45E	32
Rock Creek Reservoir	1498	21S	45E	6
Darkey Reservoir	1499	21S	44E	11
Yellow Jacket Reservoir	1500	21S	44E	1
Ryefield Seeding	1530	21S	44E	28
Rock Spring Cattleguard	1535	21S	45E	4
Ryefield Fence	1613	22S	43E	12
Red Rim Cattleguard	1644	21S	44E	32
Lowe Spring Cattleguard	1645	21S	44E	28
O T Cattleguard	1646	21S	44E	33
McKnight Mtn Cattleguard	1647	22S	43E	12
Ox Yoke Spring	1745	22S	44E	33
Mud Spring	1834	20S	45E	29
Mud Spring Wildlife Fence	1839	20S	45E	29
Frog Pond Cattleguard	1863	22S	43E	35
Sourdough Cattleguard #1	1887	23S	43E	1
Darkey Rock Creek Division Fence	1912	20S	44E	33
Rock Creek Reservoir	1998	20S	45E	33
Fletcher Reservoir	1999	20S	45E	28
Fletcher Gulch Reservoir	2000	20S	45E	27
Shellrock Butte Division Fence	2085	21S	44E	26
Lowe Cattleguard	2113	21S	44E	24
Deer Butte Cattleguard	2114	21S	45E	7
Frog Pond Spring	2161	22S	43E	35
Oxbow Spring	2162	22S	44E	28
Grassy Mtn Division Fence	2164	21S	44E	25
Whiskey Spring	2168	22S	44E	31
Haystack Butte BC	3681	21S	45E	4
Keg Spring	3770	22S	44E	24
Shack Spring	3771	22S	44E	24
Schweizer Spring	3803	20S	45E	17

Ryefield Reservoir	3869	22S	43E	1
Sourdough Basin Division Fence	4250	23S	44E	18
Government Corral Spring Pipeline	4295	21S	44E	34
Rimtop Spring	4517	20S	44E	33
Dam Spring	4518	21S	45E	18
Mud Spring Pipeline	4522	20S	45E	30
Haystack Butte Spring	4525	21S	45E	19
Rock Creek Canyon Spring	4569	21S	45E	5
Ryefield Res Fence	4609	22S	43E	1
Grassy Mtn Seeding	4657	21S	44E	35
Ridgeline Fence	4691	20S	45E	17
Grassy Mtn Seeding Fence	4693	22S	44E	4
Owyhee Ridge Windmill	4702	22S	44E	8
Oxbow Basin Windmill	4703	22S	44E	33
Ridgeline Fence Cattleguard	4707	20S	45E	18
Sagebrush Reservoir	4726	21S	44E	27
Sagebrush Res Fence	4727	21S	44E	27
Owyhee Ridge Well Pipeline	4731	22S	44E	8
Double Mtn Well	4962	21S	44E	3
Sagebrush Burn	5453	21S	44E	22
Oxbow Watergap Fence	5522	23S	43E	1
Rock Springs Watergap	5523	21S	45E	4
Rock Creek Division Fence	5529	21S	45E	30
Rock Creek Division Cattleguard	5530	21S	45E	30
Mud Spring Seeding Cattleguard	5531	20S	45E	29
Mud Spring Seeding Division Fence	5532	20S	45E	30
Ryefield Spring	5533	22S	44E	8
Grassy Mtn Spring	5603	22S	44E	16
Angel Cattleguard	5774	22S	45E	8
Rock Creek Riparian Fence	5773	21S	45E	8

The following pipelines are proposed to improve livestock distribution:
Double Mountain Well Pipeline
Twin Springs Pipeline

BILLING PROCEDURES

This Allotment Management Plan is the annual authorization to graze livestock within Nyssa Allotment. No billing or receipt will be issued prior to use. The operators will annually receive a grazing application (form 4130-3a) prior to the scheduled grazing season. The application will be the operator's opportunity to change the basic scheduled livestock grazing for the upcoming year or apply for non-use. All applications, changed or unchanged, must be signed and returned to the Vale District Office prior to the operators earliest scheduled turnout date. The signed application will be the operator's annual authorization to graze livestock upon public lands within Nyssa allotment.

After the fact billing will be based on the operator's reported actual use. The operator's actual use record must be received by the Vale District BLM within 15 days of the end of scheduled grazing for the season. A billing notice based on those data provided will be issued within 15 days of receipt of the actual use record. Payment of grazing fees must be made within 15 days of the due date of any billing notice to avoid late fee assessment in accordance with 43 CFR 4130.7-1.

MONITORING / EVALUATION

Allotment evaluation within this "I' category allotment will be scheduled approximately every five years or as needed to determine progress toward meeting identified management objectives. Changes in authorized grazing use within Nyssa Allotment may be made periodically as supported by monitoring over time in accordance with procedures identified in regulation (43 CFR 4110.3 and 43 CFR 4180) . BLM will conduct the following monitoring studies in the allotment to provide data for periodic evaluations:

Utilization

Utilization data will be gathered annually on the key forage species in each grazed pasture after livestock have been removed. The Key Forage Plant Method will be used and appropriate records maintained to calculate average annual carrying capacity. Utilization limits set in the RPS will not be exceeded in any year and may be adjusted as the result of monitoring to ensure management objectives will be met.

Actual Use

Accurate actual use records by pasture will be kept by the operator on forms furnished by BLM. These records will be submitted to BLM within 15 days of the close of the authorized grazing season. Data will be used for the computation of billings and to calculate average annual carrying capacity.

Climate
The Owyhee Dam NOAA weather station will be the source of climate data used in allotment evaluations. A forage crop index will be calculated annually using the regression relationship between crop year precipitation and herbaceous production published by the Oregon Agricultural Experiment Station (Station Publication 659).

Ecological Condition
The present ecological condition class of upland vegetation communities in each pasture was determined in 1980 by using an inventory based on range site classification and was presented in the Southern Malheur Grazing Management program EIS. For native pastures, the condition class designated is the ecological condition class representing the majority of the pasture. The condition of pastures seeded to introduced non-native species such as crested wheatgrass does not fit an ecological classification. In order to determine if a pasture has met a condition class management objective when management of the allotment is evaluated, the condition class for each range site in the pasture will have to be redetermined using appropriate methodology.

Riparian system function will be determined according to accepted BLM standards as outlined in TR 1737-9 1993.

Trend
Upland trend data will be gathered from permanently established line intercept studies, photographed 3X3 trend plots, carrying capacity calculated from actual use and utilization data, and professional judgement in each pasture. Measurement of trend toward meeting ecological condition classification objectives will be assessed based on the assumption that an increase in the dominance and cover of late seral native bunch grass species, primarily bluebunch wheatgrass, will indicate improvement in ecological condition. Similarly, recorded change in crested wheatgrass dominance and cover will indicate trend toward condition change in seedings. These data will indicate whether observed change is toward or away from ecological condition objectives.

Riparian management pastures and enclosures will be monitored using low level color infra-red imagery, ground photographic plots, and\or water quality samples. Data derived from these studies will be used to determine riparian site trend and function.

S&G Assessments

Periodical assessments of rangeland health will be completed to assure that management actions are consistent with Standards for Rangeland Health and Guidelines for Livestock Management for Public Lands in Oregon and Washington (June 1997). Grazing permits are subject to modification as necessary to achieve compliance with these standards and guidelines (43 CFR 4180).

AGREEMENT

We, the undersigned do hereby agree to and accept the Nyssa Allotment Management Plan. We understand that the grazing privileges authorized in this document are subject to the provisions of the Code of Federal Regulations (CFR 4100) which defines regulations for the orderly administration of grazing use on the public lands. It is also agreed that the terms and conditions of this agreement shall be incorporated into grazing permits to make use within Nyssa Allotment, and shall be binding upon the permittee, heirs, executors, administrators, successors in interest or assigns.

Christian Bennight
Christian and Ann Bennight — Date: 3-1-99

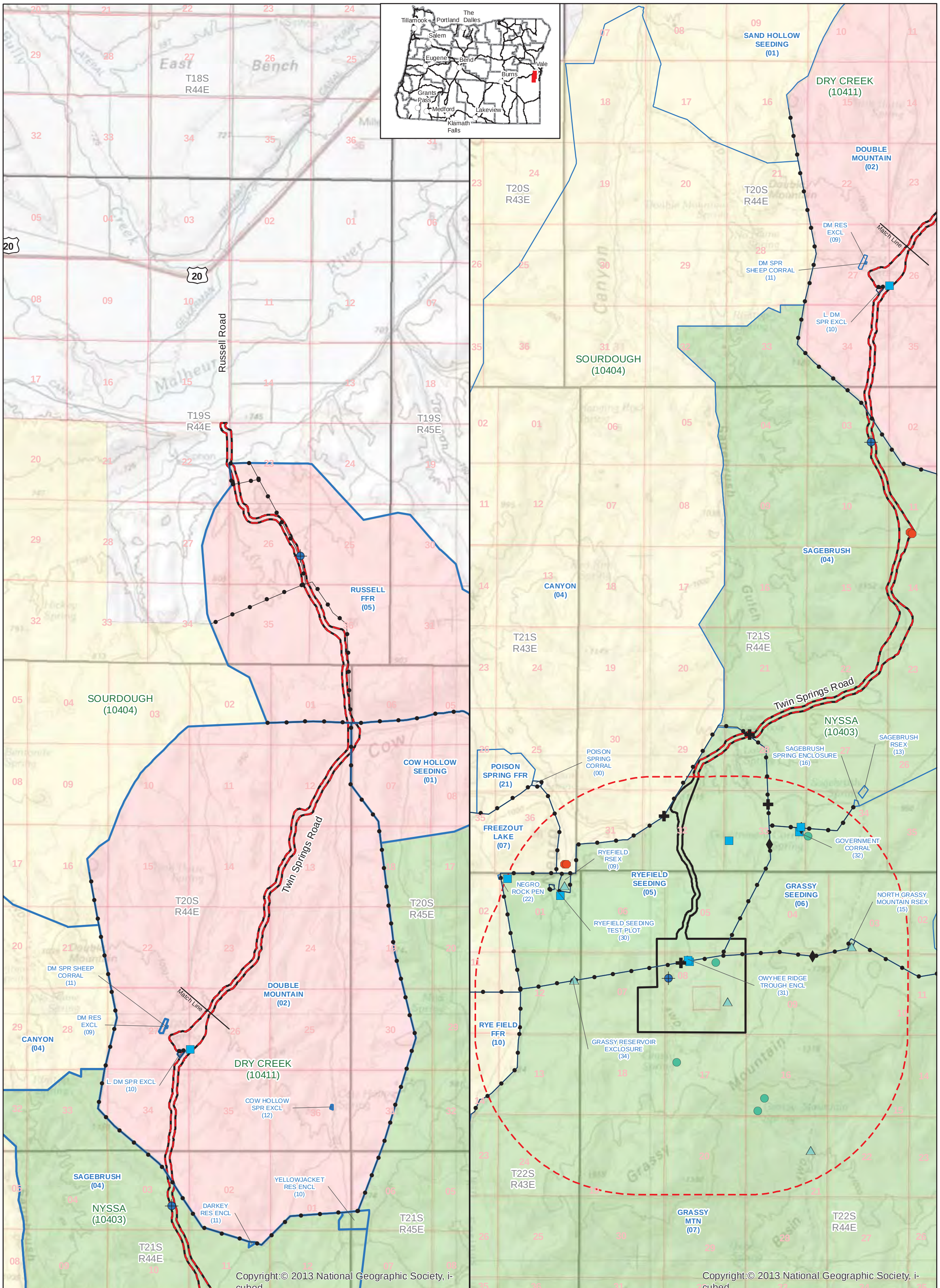
Jeffrey J. Hess
Jeff Hess — Date: 3-1-99

Verna Velma Widmer
Vernon and Velma Widmer — Date: 3-1 99

Gary Cleaver
Gary Cleaver — Date: 3-1-99

Frank Shirts
Frank Shirts — Date: 4/4-99

Roy L. Masinton
Roy L. Masinton
Field Office Manager
Malheur Resource Area — Date: 4/9/99



Explanation

- Permit Area
- Grazing Management Study Area
- BLM Pasture

BLM Grazing Allotments
- Dry Creek (10411)
- Nyssa (10403)
- Sourdough (10404)

Rangeland Improvements
- Cattleguard
- Fence-Gate
- Sign
- Reservoir - Includes ponds
- Spring Development
- Trough
- Well - Water
- Fence

0 2,000 4,000 6,000 8,000 10,000 Feet
0 1 2 Miles

Projection: UTM Zone 11 North, NAD83, meters

CALICO RESOURCES USA CORP.

GRASSY MOUNTAIN MINE PROJECT

BLM Grazing Allotments and Pastures in the Study Area

Figure 4

Date: 12/19/2017 Drawn By: JDB
Project No: 3672
Base Map: USGS 100K quad: Vale
File Name: 3672G_GrassyMtn_BL_GM_Fig04_Allotments.mxd

Exhibit 4
Page 1 of 1

Calico Technical Review Team
Salem, Oregon – and by phone
February 5, 2018
Meeting Summary

Attendance:

- Randy Jones, DOGAMI
- Karen Colvin, DOGAMI
- Bob Brinkmann, DOGAMI
- Larry Knudsen, DEQ
- Jim Billings, DEQ
- Doug Welch, DEQ
- John Dadoly, DEQ
- Ken Lucas, DEQ
- Bill Mason, DEQ
- Matt Diederich, SHPO
- Phil Marcy, WRD
- Phil Milburn, ODFW
- Tom Segal, ODFW
- Nancy Wolverson, Calico/Paramount
- Rich DeLong, EM Strategies
- Adam Bonin, Cardno
- Chris Lewis, TetraTech
- Kelly Fuller, Western Watersheds Project
- Larry Meyer, Argus Observer
- Matt Vaughn
- Janet Gillaspie, Environmental Strategies

The group introduced themselves. Randy Jones, DOGAMI, chaired the meeting.

Review of Agenda and Additional Items to Add

Jones asked the group for additional items to add to the agenda; no items were added.

TRT Vice-Chair Election

Randy Jones said he served as the vice chair of the TRT when Gary Lynch, DOGAMI, was the project lead. Since Jones has moved over to DOGAMI and given the number of permits under DEQ's control, it is logical for DEQ to serve as the vice chair, and Larry Knudsen is currently the lead for DEQ. Jones asked for feedback from the TRT on appointing Knudsen as the TRT vice chair.

Jones asked for unanimous consent and hearing no objections, Knudsen will serve as the TRT vice chair.

Status of Pending Calico Baseline Data Review Topics
Jones reminded the TRT that the baseline data methodologies were approved by the TRT on 12/7/17 for all topics except wetlands and noise.

On noise, Calico is working on a response to the DOGAMI contractor issues. On wetlands, DeLong indicated that a response would be filed in the next few weeks.

Calico Submittal of Baseline Data Reports to DOGAMI and TRT Review Process
Jones reported that the baseline data reports for these baseline data methodologies have been received:

- Visual resources
- Grazing
- Recreation
- Air Quality
- Land use
- Transportation
- Vegetation
- Aquatic resources
- Geochemistry

The TRT has 3 weeks for review of the baseline data. Jones indicated that the TRT is currently working on the baseline data reviews.

This is a rolling set of 3-week review periods, said Jones. The review to ensure the data is consistent with the accepted methodologies is important, he said.

Jones asked the TRT to ensure they have blocked adequate time to review the reports when they are received. Contact the DOGAMI project staff or Janet Gillaspie if TRT members have questions or need additional information.

The TRT should expect additional, more frequent meetings as the Consolidated Application is received.

Nancy Wolverson added that the older versions of the reports have generally been reviewed by TRT members. She continued by explaining that the reports have the same headings and format as the earlier reports. The first portion of each report describes how this report is different than the earlier report. Where data from earlier reports is used, that is included as an appendix, she said.

DeLong indicated that there will be several additional reports this week, including socioeconomics and environmental justice.

Jones reported that the final geochemistry report has been submitted – a large, detailed report written by SRK. It will be initially reviewed by the TRT

Geochemistry Subcommittee and then will be evaluated by a full discussion of the TRT members.

Jones reminded the TRT that meetings are scheduled for the first Monday of each month; the next meeting is March 5, 2018.

Calico TRT Tailings Facility Design Subcommittee – Key Recommendations
The Tailings Facility Design Subcommittee met in January to review the conceptual design and technical review report and develop a recommendation to the full TRT. A technical review was completed by Tetra Tech, under contract to Cardno. The technical review memo and inventory of issues were distributed prior to the meeting.

An inventory of topics for additional consideration in the conceptual design has been developed for review and improvement by TRT members.

Jones asked members of the Tailings Facility Subcommittee to offer any additional thoughts or suggestions; none were received.

Technical Review of Calico Grassy Mountain Conceptual Tailings Storage Facility Design
Adam Bonin with Cardno introduced Chris Lewis with Tetra Tech, an expert in tailings facility design.

Lewis used a *PowerPoint* presentation to review the technical memo. A copy of the presentation is available from the DOGAMI office.

In his review, Lewis described:

- Background technical information
- Regulatory framework
- Long term accepted standards of practice for slurry impoundment facilities across industries including metal mining and coal extraction
- Long term environmental productively issues, along and reclamation and closure issues

Tetra Tech concluded:

- The basics of the design meets the Oregon regulatory structure
- Composite liner and leachate collection system conforms to standards of practice in the industry
- Closure practices were not detailed and additional information is needed
- A leak detection system is not included between the first and second liner system

DeLong asked if a leak detection system was required by the Oregon regulations; Lewis indicated no, but there has been additional discussion.

Larry Knudsen, DEQ, added that the guidelines do not require leak detection, but the beginning of the rules (see OAR 340-043-000 – Purpose and Policies) would require leak detection. This is not a guideline, but a requirement. Knudsen concluded that leak detection would be required for the tailings impoundment facility.

Jones said that leak detection in the basin liner and overall protection of the environment was discussed at the Tailings Facility Design Subcommittee meeting.

Lewis continued that leak detection between liners is not common in the mining industry. For many mines, the leachate collection system is considered adequately robust to protect the environment.

Jones continued by discussing the leak detection issues and issues such as timing, response, fate, and transport. There are many questions related to leak detection, both short term (life of mine) and long term (up to 100 years and beyond). These are all issues to be tackled by the Tailings Facility Design Subcommittee and the TRT.

Lewis indicated there are technical issues related to incorporating leak detection systems, but the tailings design experts can tackle those issues in continuing to design the system.

Additional review of the Water Resources Department (WRD) Division 20 'low hazard' ranking should be further explored, especially the impacts of failure. In general, the TetraTech review concluded:

- The proposed conceptual design is reasonably anticipated to meet the minimum requirements of Oregon DEQ's chemical mining rules, including liner specifications.
- Additional information on facility closure will be needed to determine if closure activities are consistent with Oregon regulations
- The WRD Dam Safety hazard potential classification for the impoundment should be carefully examined
- The resiliency of the design and the reliance on pumping for the supernatant pool and underdrain reclaim pond should be examined
- Additional geotechnical information is needed
- Less rigid and more crack resistant backfill should be examined for pipe transitions and connections.
- Additional criteria for evaluating the liner, in addition to the DEQ standard related to hydraulic conductivity, should be considered

This inventory is focused on engineering issues, not cyanide or other environmental issues, said Lewis.

Jones reported that the additional geotechnical investigation has been collected at the site, and Calico is still reviewing that data. A complete, final report will be provided to the TRT.

Jones continued to describe the overall tailings facility design and the tailings facility construction process. He recalled a comment by Golder, that the facility should be considered a ringed structure with beaches of tailings material being built over time.

He recalled that the DEQ standards, in Division 43, are based on standard practices of the mid-1980s, and newer technology should be considered to meet with *'best, available practicable and necessary technology'* (see OAR 632-037-0188).

DeLong added that the tailings facility is not full of water, it is designed to contain the solids with a small amount of water that are recycled through the mill processing. The Oregon Water Resources Department dam safety regulations are focused on retaining water AND the dam height.

Jones added that the tailings cyanide concentrations and tailings material chemistry are also unknown areas. Metals leaching from the tailings needs to be evaluated, along with the potential for acid leaching.

Matt Diederich with SHPO asked about the DEQ standards for 36 inches of clay – on top of the ground or dug out of the ground, he questioned; cultural resources might be exposed if it is dug out on site. DeLong answered that the geotechnical investigations are still ongoing, but in general, it would be both earthwork to smooth the topography with some material removal, and then native material must be augmented. Lewis added that the conceptual design does not use a 36-inch liner, but a geomembrane improved version.

Jim Billings with DEQ added that there will be standing leachate in the tailings facility – standing water for most of the 10-year life of the mine. The leak detection system appears to not be fully understood, he said. The Resource Conservation and Recovery Act (RCRA) subtitle C and D regulations for leachate detection and collection are applicable. DEQ is thinking along RCRA Subtitle C plan, rather than a Subtitle D plan.

Janet Gillaspie, Environmental Strategies, suggested that DOGAMI send a letter back to Calico regarding the conceptual standards, requesting additional information, and requesting a revised conceptual design prior to submittal of the consolidated application. She highlighted that the cultural resources issues should be added to the inventory.

Bob Brinkmann with DOGAMI stressed that knowing the chemical composition of the tailings is critical. There are many DEQ regulations that need to be addressed, he said.

Larry Knudsen with DEQ added that when the regulations were written in 1992, the issue was would Oregon allow chemical process mining - and the answer was 'yes', but in the Oregon method. Generally, overall policy statements are set, and then specific regulatory requirements are followed by guidelines. Knowing what is done in other states or best-in-class industry wide or RCRA standards is useful, but applying our Oregon specific information is needed, he said.

The sooner the TRT has an understanding of the tailings facility design is important, he said. The baseline data collection is informing the process, but the TRT needs to consider the additional information necessary to support the permits. This additional information is important to inform the Consolidated Application, he concluded.

Jones asked the Oregon Department of Fish and Wildlife (ODFW) about the fish and wildlife issues that need to be addressed. Phil Milburn from ODFW indicated that slurry water as 'wastewater' must be covered or be maintained to not be a threat to wildlife. The rules are straight-forward, he said.

Jones thanked Chris Lewis for his work for the TRT. Jones asked if there was consensus for requesting a revised, conceptual tailings facility design concept for review from the TRT.

The TRT took a break.

Chemistry of Cyanide
Dr. Adam Bonin with Cardno gave a *PowerPoint* presentation on the chemistry of cyanide. A copy of the presentation is available from the DOGAMI office.

He discussed:

- Basic cyanide chemistry
  - Triple bonded, negatively-charged ion
- Nature and common uses
  - Found in nature in
    - Bacteria, fungi, and algae
    - Spinach, bamboo shoots, almonds, lima beans, fruit pits, cassava, and tapioca
  - Cigarette smoke and vehicle exhaust,
  - Common uses include in pesticides, pharmaceuticals, steel production, and others
  - Mining contributes about 10% of the total global cyanide use
- Cyanide in Gold Mining
  - Ore is crushed and ground; free gold is gravity- separated
  - Cyanidation/leaching process uses a dilute sodium cyanide to dissolve the gold; high pH is needed to prevent hydrogen cyanide (HCN) formation

        - Activated carbon or zinc is then added to the slurry to extract gold
    - Detoxification process
- Residual cyanide after gold mining
    - Other metals will be complexed with the gold
    - International Cyanide Management Code (ICMC) has an interim benchmark of 50 mg/l of Weak-Acid Dissociable (WAD) cyanide; does not protect aquatic receptors. The allowable Oregon standard is 30 mg/l WAD
    - WAD cyanides are stable in typical tailings storage facility
        - Monitoring elements must include HCN, WAD, and total cyanide
        - Disassociation of cyanide and metals can still occur
    - Hydrogen cyanide
        - Toxic but not persistent
        - Volatilization can be increased by shallow, large surface area tailings facility's, aeration and mixing, maintain a pH between 8.0 – 9.2
        - Natural degradation
    - Fate and Transport
        - Cyanide not persistent
            - Volatilization
            - Biodegradation
            - Oxidation
            - Hydrolysis
            - Absorption
        - Common by products
            - Ammonia and carbon dioxide
            - Nitrogen and carbon dioxide
            - Oxidation
            - Thiocyanate, when combined with sulfur
        - Cyanide in soil
            - Biodegradation and volatilization
            - Less mobile in clays
        - Cyanide in air
            - HCN gas with slow degradation
        - Cyanide in surface waters
            - Volatilization
        - Cyanide in Groundwater
            - May persist
    - Toxicity and risk
        - Human Health Risk
            - Receptor categories including workers, inspectors, agency personnel, trespassers
            - Free cyanide is most toxic

            - Exposure routes include ingestion, inhalation, absorption
            - Acute toxicity due to hypoxia
            - EPA Maximum Contaminant Level (MCL) is 0.2 mg/l (drinking water related)
        - Ecological Risk
            - Free cyanides most toxic
            - Aquatic organisms are most sensitive, especially fish
            - Birds that feed on flesh are most sensitive (raptors, due to low pH of stomach) – ingestion of water or contaminated flesh
            - Mammals sensitive to acute exposure
    - Risk Reduction Strategies
        - Reduce cyanide discharge concentration to below 50 mg/l WAD
            - Mine waste treatment
            - Supernatant ponds with a capacity to dilute high influx
        - Proper Personal Protective Equipment
        - Production of hypersaline tailings slurry and supernatant
            - Salt discourages ingestion
            - Decreases HCN solubility
            - Thickening the tailings
        - Wildlife deterrents
            - Fencing, netting, mitigation sites that are more desirable offsite

Jones asked about cyanide transfer in the supernatant pool. Brinkmann asked how cyanide concentrations might naturally degrade in the tailings facility due to volatilization and other natural processes.

What are the fugitive air cyanide emissions from the tailings facility, asked Jones. Bonin responded that there is a chance of cyanide, but residual metal concentrations in the dust are likely a larger risk, both during operation and after closure. Maintaining moist conditions during and after operations is critical, said Bonin.

DeLong mentioned that the International Cyanide Management Code is a voluntary organization that sets 'cradle-to-grave' standards for the use of cyanide. Almost all the precious metal mines in the Western US are members of the International Cyanide Management Code.

Calico would like to engage the TRT members on cyanide issues and that will be most useful post Feasibility Study with specifics.

Additional presentations are needed on:

- Calico-specific information on processing and tailings composition briefings

- Transportation of cyanide – primary cyanide distributor to focus on transport from Oregon border

This issue should be coordinated with the National Environmental Policy Act (NEPA) process.

Briefing on Activities at Grassy Mountain
Nancy Wolverson from Calico provided an update on current and ongoing activities at Grassy Mountain. She indicated there are no activities on site other than the quarterly water resources monitoring.

The well drilling has been stopped for now and will be restarted in the spring. The two upgradient wells (upgradient and downgradient) need to be completed. Knudsen asked if the delay was weather related; generally, yes, said Wolverson. All Calico activities are focused on the Pre-Feasibility Study completion. There will be additional work after the Pre-Feasibility Study to complete the Consolidated Application.

Diederich asked about consultation with BLM and the Tribes and the overall NEPA process. DeLong indicated the draft Plan of Operations has been filed with BLM and BLM has provided comments. Some of the questions BLM has asked are related to completing the Pre-Feasibility Study.

Jones reported that he was meeting with the BLM later this week with a focus on coordination with the NEPA process and he was reaching out to the Burns Paiute Tribe.

Brinkmann asked about the additional drilling. Wolverson indicated that the resource holes have been drilled and 2 out of the 5 monitoring wells have been installed. All the information will be compiled into the final report for the drilling program.

Jones asked Wolverson about the results of the geochemistry investigations to be incorporated. Wolverson said the revised tailings conceptual design should be filed with the State after the Pre-Feasibility Study is completed.

Wolverson described the Pre-Feasibility Study. She indicated that Calico will issue a press release that the Pre-Feasibility Study is completed. There is then a 45-day period for Calico to complete its report. Calico will likely take the complete 45 days to finalize its report.

Jones provided a heads-up that State Agency partners should start preparing for gathering a detailed budget proposal for the 24-month period after a Consolidated Permit Application is received. State agency staff will have a few months from now to prepare those budget estimates. DOGAMI will be providing budget templates and direction to the TRT partner agencies for completing this budget estimate.

TRT members were asked if there were additional items to discuss – there were none…

TO DO Inventory

The 'to do' inventory developed during the meeting included:

- DOGAMI will craft a response to Calico on the tailings facility conceptual design
- Distribute information to the TRT on the International Cyanide Management Codes
- Forecast additional cyanide briefings for TRT discussion
- Summarize existing baseline data submittals, links to data, reviewing agencies, and deadlines and provide to TRT
- Set Calico Project Coordinating Committee (PCC) meeting in Ontario – could be late March
- Set Geochemistry Subcommittee meeting; forecast full TRT discussion

Janet Gillaspie
Environmental Strategies
2/6/18

Environmental Baseline Study Work Plans

Grassy Mountain Project

CALICO RESOURCES

September 22, 2017

Prepared by
EM Strategies, Inc.
1650 Meadow Wood Lane
Reno, Nevada 89502
775-826-8822

Environmental Baseline Study Work Plans

Grassy Mountain Project

Malheur County, Oregon

May 17, 2017

Revised September 22, 2017

Prepared for
Calico Resources USA Corp.

Prepared by

EM Strategies, Inc.
1650 Meadow Wood Lane
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EM STRATEGIES

3.3 Surface Water

SURFACE WATER ENVIRONMENTAL BASELINE WORK PLAN
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
SEPTEMBER 2017

3.3.1 Purposes and Objectives

The purpose of this surface water baseline study is to describe appropriate methodology needed to characterize existing surface water resources at the Grassy Mountain Project mine site. The overall water resources characterization includes surface water, hydrogeology and hydrochemistry of the project area in the vicinity of the mine and mill, in order to meet Oregon Department of Geology and Mineral Industries (DOGAMI) requirements: Division 37 Chemical Process Mining, Oregon Administrative Rule (OAR) 632-037-0055, Existing Environment-Baseline Data, and Oregon Department of Environmental Quality (ODEQ) requirements of Division 43 Chemical Mining, OAR 340-043-0000 through OAR 340-043-0160. An important aspect of the environmental baseline program will be characterizing existing surface water quality and quantity. This information will be used in future evaluations to determine potential impacts on local surface water quality. Note that spring baseline monitoring is described in the ground water baseline study work plan.

The water quality monitoring program will be periodically re-assessed to consider future exploration, mining programs and monitoring needs. An example would be changes in potential mining facilities sitings, like the processing plant, and related needs to modify the monitoring stations. A second example would be if site investigations demonstrate any effects on surface water are highly unlikely due to the lack of this resource at the proposed development sites. In this situation, Calico would advise DOGAMI and ODEQ of proposed changes to the plan and formally seek approval of those changes. All procedures and protocols described in this work plan and approved by the technical review team (TRT) would be applied to any proposed revisions or modifications in order to meet the requirements of Division 37 and Division 43.

The purposes of this surface water resources baseline study are as follows:

- Characterize the pre-project surface water resources baseline conditions.
- Meet the requirements of the Oregon Division 37 Chemical Process Mining rules and related Consolidated Application and Permit Review Standards for Chemical Process Mining.
- Meet related ODEQ Division 43 Chemical Mining and related regulations outlined in 340-043-0000 through 340-043-0160.
- Meet related Oregon Department of Fish and Wildlife (ODFW) Division 420, Chemical Process Mining consolidated application and permit review standards, including 635-420-0010, Wildlife Protection Plan, and 635-420-0030, Wildlife Mitigation Plan.
- The results of the monitoring programs will be reviewed by the regulatory and management agencies and the Grassy Mountain professional staff on a regular periodic basis.

A detailed discussion of characterization and measurement of surface water hydrology and ground water hydrogeology will be required to satisfy the Division 37 permitting process, and any related National Environmental Policy Act (NEPA) analysis that may be needed. The objectives of this surface water resources baseline study are as follows:

- Accurately characterize the local surface water resources, both quality and quantity, and the pre-project "environmental baseline."
- Monitor the effects of exploration and mining-level operations impacts on these important resources.
- Ensure that the data collected is of known and acceptable quality.

- Ensure that project-specific methods and procedures are implemented.
- Determine if there are naturally occurring variables or trends, or project-related influences on local water quality.
- Collect data to be used in permit applications and environmental reviews of the proposed Grassy Mountain Project.
- Develop a database that will be used to further establish long-term reclamation and closure needs.

3.3.2 Project Study Area

3.3.2.1 Project Area

The Grassy Mountain Project area (Permit Area) is located in Malheur County, Oregon, approximately 22 miles south-southwest of Vale (**Figure 1)**, and consists of two parcels: the Mine and Process Area, and the Access Road Area (**Figure 2**).

The Mine and Process Area parcel is located on three patented lode mining claims and unpatented lode mining claims that cover an estimated 886 acres. These patented and unpatented lode mining claims are part of a larger land position that includes 419 unpatented lode mining claims and nine mill site claims on lands administered by the BLM (**Figure 2**). All proposed mining would occur on the patented claims. The Mine and Process Area is located in all or portions of Sections 5-8, Township 22 South, Range 44 East (Willamette Meridian).

The Access Road Area parcel is located on public land managed by the BLM, and private land controlled by others (**Figure 2**). A majority of the access road is a Malheur County Road named Twin Springs Road. The access road extends north from the Mine and Process Area to Russell Road, a paved Malheur County Road. The Access Road Area parcel is located in portions of: Section 5, Township 22 South, Range 44 East; Sections 3, 10, 11, 14, 21- 23, 28, 29, and 32, Township 21 South, Range 44 East; Sections 1, 12-14, 23, 26, 27, and 34, Township 20 South, Range 44 East; and Sections 23, 26, 35, and 36, Township 19 South, Range 44 East (Willamette Meridian). The width of the Access Road Area is 300 feet (150 feet on either side of the access road centerline). This width is used to accommodate possible minor widening or re-routing, and a potential power line adjacent to the access road. There are several areas shown that are significantly wider than 300 feet on the Permit Area Map (**Figure 2**), which are areas where the final alignment has not yet been determined. The final engineering of the road will be consistent throughout, and within the Permit Area shown on **Figure 2**.

The approximate acreages of the two parcels described above are as follows:

Mine and Process Area:	886 acres
Access Road Area:	876 acres
Total Permit Area:	**1,762 acres**

Anticipated Project Disturbance (excluding access road): 400 acres

3.3.2.2 Water Resources Study Area

The water resources study area is shown in **Figure 8, Water Resources Study Area and Permit Area and Figure 9, Water Resources Study Area**. The main study area boundary includes a background sampling site on Dry Creek Arm of Owyhee Lake, where Dry Creek and Twin Springs Creek enter the reservoir. This site was selected to assess any potential surface water runoff impacts of the project on Owyhee Lake, although no impacts are anticipated since the lake is considered to be in a separate watershed than the project. In addition to this location, the study area also includes two separate, non-contiguous, areas on the Owyhee River/Lake. One location is on the Owyhee River, four miles downstream of Owyhee Dam, and the other location is upstream of the dam and project area on the Owyhee River/Lake at Leslie Gulch.

Although we anticipate no potential for impacts to Owyhee River/Lake from the proposed project, these two areas were added to allow background water quality sampling from the Owyhee River/Lake.

3.3.2.3 Regional Hydrologic Setting

The project area is rolling hill terrain. Negro Rock Canyon to the west of the main project area and the Owyhee River Canyon to the southeast provide more relief in topography. The highest elevation is about 4,800 feet above mean sea level (msl) along the west flank of Grassy Mountain. Elevation decreases to the north (about 3,250 feet above msl at Negro Rock Canyon). Elevation falls to about 2,400 feet above msl at the Malheur River (ABC 1992).

The Owyhee River is the largest surface water in the region. The U.S. Bureau of Reclamation supplies about 500,000 acre-feet of water to a little over 118,000 acres along the west side of the Snake River. Negro Rock Canyon drainage contains an intermittent stream that only flows in response to snowmelt or heavy precipitation. There are no known stream gaging records within the Negro Rock Canyon basin. There are published stream gaging records for the Owyhee River, Malheur River, and the north fork of the Malheur River. Several reservoirs in the Malheur River Basin also report water surface elevation (USGS 2001).

There are no jurisdictional floodplains within the study area.

3.3.2.4 Climate

The Grassy Mountain climate is typical of a cold desert environment. Annual precipitation is 10.3 inches. Pan evaporation exceeds 40 inches in a normal year. These estimates represent 30-year average values for precipitation and evaporation. Most of the precipitation falls in the winter as snow. Winds are predominantly from the south and west (Air Sciences 1990). Climate data for Vale, Oregon, which is the closest nearby site of reference, is listed in **Table 3**. Annual precipitation reported for the Negro Rock Canyon basin is 9.8 inches (ABC 1992).

Table 3. Vale, Oregon, Historic Average Climate, Temperature-Precipitation[1]

	Jan	Feb	Mar	Apr	May	Jun
Average high in °F	35	44	57	66	75	84
Average low in °F	18	24	30	35	44	51
Average precip in inches	1.22	0.94	0.98	0.87	1.06	0.75
	July	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Average high in °F	93	92	80	66	48	37
Average low in °F	56	53	42	33	26	18
Average precip in inches	0.47	0.39	0.51	0.63	1.1	1.34

[1]NOAA, 2011.

The average annual high temperature is 64.8 degrees Fahrenheit (°F). The average annual low temperature is 35.8°F (NOAA 2011).

The mean wind speed at the site is 7.6 miles per hour (mi/hr). Wind speeds are normally fairly light. About 3.3 percent of the 2-year-period monitored in 1989 through 1990 recorded wind speeds of greater than 18 mi/hr (Air Sciences 1991).

The annual average runoff within the Negro Rock Canyon basin is estimated to range from 1.3 to 1.5 inches per year, with peak runoff rates ranging from 5 to 15 cubic feet per second (cfs) per square mile (ABC 1992). Peak runoff in Negro Rock Canyon basin may be an order of magnitude greater due to the effect of isolated, infrequent thunderstorms.

The 100-year, 24-hour storm has been reported to be 2.2 inches (ABC 1992). This storm event is generally used for designing drainage facilities, although the 1-hour duration can be a more useful metric for small drainages such as those in the project area. The 100-year, 1-hour storm has been reported to be 1.0 inch (ABC 1992).

Supplemental climatological data to be used in the water resources hydrological evaluation for the Grassy Mountain Project is being collected at the site as part of the air quality resources work plan. Meteorological data to be collected will include:

- Precipitation and evaporation
- Relative humidity
- Temperature
- Delta temperature
- Wind direction
- Wind speed
- Barometric pressure
- Solar radiation
- PM_{25} and PM_{10}

Climatological data collected on site will be used to verify the accuracy of reported storm and runoff values and produce updated storm design criteria and flood flow predictions.

3.3.2.5 Watershed Boundaries

The two surface watersheds that could be impacted by surface runoff from Grassy Mountain Gold Project surface facilities are Negro Rock Canyon, which could receive runoff from processing facilities, and Sagebrush Gulch (a tributary to Negro Rock Canyon, which could potentially receive runoff from mine facilities). It is assumed that project facilities will not extend south from the Bishop Well into the Dry Creek drainage.

These watershed delineations will be investigated in the field as part of the overall baseline work and modified as needed to reflect the results of the field work.

3.3.3 Regulatory Framework

The primary regulatory requirements for the surface water baseline study are DOGAMI regulations described in the Division 37 Chemical Process Mining rule (OAR 632-037-0055). ODEQ also enforces the related requirements of the Division 43 Chemical Mining rule (OAR 340-043-0000 to -00180). The Oregon Department of State Lands (DSL) has jurisdiction over some surface waters, including rivers, intermittent and perennial streams, lakes, reservoirs, and ponds (OAR 141-085-0515). Streams and waterways will be characterized and reported under the wetland baseline study. These waters will be characterized using SDAM for Oregon.

All sampling and analytical methods used to meet the monitoring requirements will be done in accordance with the following:

- The latest edition of “Guidelines Establishing Test Procedures for the Analysis of Pollutants” (40 Code of Federal Regulations [CFR] 136).
- DOGAMI requirements of Division 37 Chemical Process Mining Rules, ODEQ Division 43 Chemical Mining Rules, and related ODFW Consolidated Application and Permit Review Standards for Chemical Process Mining (Division 420).

The following current sources are also referenced:

- American Public Health Association, Standard Methods for the Examination of Water and Waste Waters.

- American Society for Testing and Materials (ASTM) Standards, Part 31, Water, Atmospheric Analysis.
- U.S. Environmental Protection Agency (USEPA), Methods for Chemical Analysis of Water and Wastes.
- ODEQ, *Water Monitoring and Assessment Mode of Operations Manual*, March 2009.
- ODEQ, *Field Sampling Reference Guide*, January 2010.
- ODEQ, *Quality Manual*, May 2011.

3.3.4 Study Methodology

3.3.4.1 Literature Review

The following documents and previous monitoring studies will be reviewed to determine the validity of the reports and data:

- ACZ collected water quality samples at the Grassy Mountain site from nine surface water stations in 1993. ACZ also collected streambed sediment samples from the site. ACZ also photographed and surveyed springs and seeps flowing in the project area in that same year.
- In 1992 and 1993, Adrian Brown Consultants, Inc. (ABC) evaluated physical resources at the Grassy Mountain site, including surface water hydrology and quality. This study also addressed water rights at the site.
- SPF Water Engineering, LLC (SPF). 2015. *Grassy Mountain Gold Project Water Resources Baseline Study 2013 Annual Sampling Report.*
- SRK prepared a surface water and ground water report in 1989 for the originally proposed surface mine and heap leach operation.
- In 1988, Western Technologies, Inc. (WTI) examined surface water hydrology and water quality at the Grassy Mountain gold mine site. This involved a seasonal hydrological flow analysis, surface water quality, and water rights.
- *Water Resources Technical Memorandum* developed for Atlas Precious Metals, Inc. (Atlas) as part of the *Grassy Mountain Project Environmental Impact Statement* (ABC 1992). The memorandum describes the geology and geochemistry of the project site, monitoring and production wells completed at the time, historical ground and surface water quality data, results of ground water modeling, and discusses the potential impacts of mining on ground and surface water resources.
- *Draft 2011 Hydrologic Testing Program Interpretive Report*, Rocky Mountain Environmental Corporation (RMEC).
- Initial baseline environmental studies conducted by Atlas, which included surface and ground water quality monitoring and a compilation of data collected from springs and wells in the area.
- WTI oversaw the installation of three monitoring wells (GW-1, GW-2, and GW-3) and one production well (Prod-1) on the site in 1988. The location of GW-2 is currently unknown and there is uncertainty over whether or not the WTI GW-3 is the same as the GW-3 where monitoring occurred in 2011 by RMEC. WTI collected water quality samples from the four wells, the BLM Owyhee Ridge Well, and from four surface water locations in 1989.
- In 1989 and 1990, SRK Consulting, Inc. (SRK) oversaw the installation of monitoring well GW-4 and the production wells (PW-1 and PW-4). Water quality samples were collected from these wells and test pumping was performed on the production wells. SRK presented the results to Atlas from SRK in a 1989 report.
- Quarterly reports by SPF Water Engineering, LLC from 2013 to 2017.

Once the environmental baseline study work plans for the Grassy Mountain Project have been approved, Calico will finalize all internal consultant selections for the various resource categories. At that point, extensive review of prior environmental studies will commence.

Calico will use the following validation/verification criteria to determine the applicability and competency of the previous environmental baseline data and studies:

- Are data and/or reports relevant to the characterization of the pre-mine environment (OAR 632-037-0040)?
- Have environmental conditions for this particular resource category changed substantially from the period during which previous data was collected?
- Do these data fall within the accuracies of currently accepted environmental criteria and standards?
- Were the methodologies used to collect the data appropriate at the time?
- Are these previously collected baseline data useful in making quantitative determinations of direct and indirect impacts that could result if the proposed project is implemented?
- Will these data be useful to agencies in making individual decisions to issue or deny a permit(s)?

Assuming a majority of the six criteria are met, the data may be used for comparative and qualitative purposes to indicate changes and/or trends that may have occurred since the early 1990s. In most cases, it is acknowledged that recent technologies and improvements in analytical procedures, quality control programs, and field procedures and methodologies have substantially improved during the past 20 years. Nevertheless, where applicable and agreed upon, these data and/or reports would be evaluated and used as appropriate.

3.3.4.2 Field Studies

3.3.4.2.1 Surface Water Quality Monitoring Sites

Calico Resources would conduct pre-project baseline monitoring at the Grassy Mountain site, as appropriate. The mine site and mill site do not have perennial surface waters in their vicinity. The area is a net evaporation condition (46.16 inches evaporation; 9.83 inches precipitation). On a larger scale, the Owyhee River, Twin Springs Creek, and Negro Rock Canyon will be sampled strictly to establish pre-project “background conditions.”

This work plan proposes water quality sampling from three sites located on the Owyhee Lake/River, identified on **Figure 9**. One is south of the proposed processing area, at Dry Creek Arm on Owyhee Lake where Dry Creek and Twin Springs Creek enter the reservoir. Two other background sites are located at the upper end of the reservoir at Leslie Gulch and 4 miles downstream of the Owyhee Dam (see **Figure 9**). The downstream site has been used by ODEQ for water quality sampling in the past (Station 11048).

In addition to the three sites on Owyhee Lake/River, background sampling will also be conducted at Twin Springs Creek above the confluence with Dry Creek when flow is present during the bi-annual visit (spring and fall). This site is shown on **Figure 9**. Negro Rock Canyon Creek will also be sampled for background data at a location at the northern boundary of the water resources study area when flow is present during the bi-annual visit. This site is shown on **Figure 9**.

Additional surface water quality monitoring sites may be added at selected upgradient and downgradient sites where exploration activities are planned, if surface water is present. Certain of these sites may also be sampled as part of the background environmental data collection effort during ultimate facilities construction and operation. The results of data collection may reveal the need to add or remove surface water monitoring sites to provide additional baseline water quality and flow data that the existing sites cannot adequately provide in both the mining and the process areas. The baseline work plan should be viewed as a flexible, working guide that can be revised as needed to meet baseline reporting requirements and to adequately assess potential impacts to water resources.

3.3.4.2.2 Sampling Schedule and Procedure

"Trend" monitoring implies that measurements will be made at regular time intervals in order to determine the long-term trend of a particular water quality parameter. Additionally, sampling must occur at a frequency to account for seasonal flow regimes (high, medium and low flow conditions). It is currently anticipated that bi-annual background monitoring of surface water will be conducted, in the spring and the fall.

Standard hydrologic field procedures and methodologies will be used to ensure accurate and reliable data collection. Sampling procedures will adhere to the following guidelines: *Field Sampling Reference Guide* (ODEQ 2010), *Water Monitoring and Assessment Mode of Operations Manual* (ODEQ 2009), and guidelines established in the *Environmental Baseline Study Work Plans, Grassy Mountain Project* (EM Strategies 2017).

Standardized log sheets for surface water sampling will be used for recording sampling data. These sheets list the locations being sampled and allow sampling personnel to record weather conditions and other relevant information during the sampling. See Appendix E for the *Grassy Mountain Gold Project Water Resources Baseline Study Winter 2013 Monitoring Plan* and a copy of the sampling form and Streamflow Duration Assessment Method (SDAM) form. All personnel conducting field work will receive adequate training on operation of equipment and sampling protocols to ensure accurate and reliable data collection.

Quality assurance and quality control (QA/QC) are an important component of the monitoring program. The QA/QC protocols described in the ODEQ *Water Monitoring and Assessment Mode of Operations Manual* (ODEQ 2009), the ODEQ *Quality Manual* (ODEQ 2011), and the *Environmental Baseline Study Work Plans, Grassy Mountain Project* (EM Strategies 2017) will be followed. Specific QA/QC details are described in Section 3.3.4.2.6.

Surface water quality sampling will include the following tasks:

1. Identify specific sampling locations for future reference. Surface water sampling sites will be marked with a handheld global positioning system (GPS) unit.
2. Digital photographs of each site will be taken to adequately document location and sampling conditions.
3. Conduct surface water monitoring at approved locations. Currently, "background" water quality sampling is scheduled at three sites. One site is located on the Owyhee River, a second site in Negro Rock Canyon, and a third site on Twin Springs Creek.
4. Measure (either directly or using gaging records) surface water flow at the time of data collection (see Section 3.3.4.2.3). The Oregon Department of State Lands (DSL) SDAM will be used to determine if a stream is perennial, intermittent, or ephemeral.
5. Conduct field measurements for certain water quality parameters (see Section 3.3.4.2.4).
6. Conduct water quality sampling according to approved sample collection procedures (see Section 3.3.4.2.5).
7. Perform field QA/QC (see Section 3.3.4.2.6).
8. Verify data results and transmittal of samples (Chain of Custody, see Section 3.3.4.2.5).
9. Report results.

3.3.4.2.3 Flow Measurements

For all surface water monitoring locations, flow will be estimated or measured at the time of data collection.

Stream flow measurements will be as follows:

1. For sites with channels that can be waded, flow will be measured using an accepted U.S. Geological Survey (USGS) field measurement method.

2. For sites that cannot be waded and with available stream gaging records, these records will be used to measure flow at the time of data collection.

For the Owyhee River background sampling, stream gaging records will be used.

3.3.4.2.4 Field Water Quality Parameters and Analysis

Surface water conditions will be considered steady state and only one set of field parameters (pH, alkalinity, electrical conductivity, specific conductance, dissolved oxygen) will be collected. Field measurements will be taken concurrently with water quality sampling.

The sensors for the pH meter, conductivity meter, and dissolved oxygen meter will be placed directly in the surface water for data collection. Readings will be recorded once the measurements have stabilized. Equipment calibration will be performed prior to the sampling event and checked again on the morning of each sampling day. Field personnel will be required to review an “instruction manual” prior to using the equipment.

The following equipment (or equal) is anticipated for field water quality data collection:

1. The pH (S.U.) will be measured using a YSI EcoSense Model pH100 meter. A 2-point calibration will be performed using pH 4, 7, or 10 standard solutions.
2. Specific conductance (SC, microsiemens per centimeter [µS/cm] at 25 degrees Celsius [ºC]) will be measured using an YSI EcoSense Model EC300 meter.
3. Electrical conductivity (EC, µS/cm) will be measured using a YSI EcoSense Model EC300 meter.
4. Temperature (°C) will be measured using the YSI Model EC300 meter.
5. Dissolved oxygen (DO) (milligrams per liter [mg/L]) will be measured using an OxyGuard Handy Polaris 2 Portable DO meter. This DO meter automatically compensates for temperature and barometric pressure, and has an automatic calibration with stability check. The calibration of the instrument will be checked on a daily basis to ensure that the meter is operating within the acceptable range.

3.3.4.2.5 Laboratory Parameters and Analysis

Table 4 lists the constituents that will be sampled from each surface water site for analysis at the laboratory, including the proposed laboratory testing method. For metals, samples for both total and dissolved metals will be collected. These are identified in **Table 4**. For the other parameters, only total samples will be collected. **Table 4** also lists the testing method detection and reporting limit. The preservatives used by the laboratory and the recommended holding times for each testing method are summarized in **Table 5**.

Table 4. List of Water Quality Analytes and Testing Methods

Parameter	Laboratory Method of Analyses	Detection Limit	Reporting Limit	Sample Type
Aluminum, Al	USEPA 200.7	0.03 mg/L	0.15 mg/L	total and dissolved
Total Arsenic	USEPA 200.8	0.0002 mg/L	0.001 mg/L	total and dissolved
Inorganic Arsenic	As speciation by HPLC ICP/MS	0.5 ug/L	0.5 ug/L	total and dissolved
Barium, Ba	USEPA 200.7	0.003 mg/L	0.015 mg/L	total and dissolved
Cadmium Low	USEPA 200.8	0.0001 mg/L	0.0005 mg/L	total and dissolved
Calcium, Ca	USEPA 200.7	0.2 mg/L	1 mg/L	total and dissolved
Chromium Low	USEPA 200.8	0.0005 mg/L	0.002 mg/L	total and dissolved
Copper Low	USEPA 200.8	0.0005 mg/L	0.0025 mg/L	total and dissolved
Iron, Fe	USEPA 200.7	0.02 mg/L	0.05 mg/L	total and dissolved
Lead Low	USEPA 200.8	0.0001 mg/L	0.0005 mg/L	total and dissolved
Magnesium, Mg	USEPA 200.7	0.2 mg/L	1 mg/L	total and dissolved
Manganese Low	USEPA 200.8	0.0005 mg/L	0.0025 mg/L	total and dissolved
Mercury, Hg (Low Level)	1631E	0.2 ng/L	0.5 ng/L	total and dissolved
Nickel Low	USEPA 200.8	0.0006 mg/L	0.003 mg/L	total and dissolved
Potassium, K	USEPA 200.7	0.3 mg/L	1.5 mg/L	total and dissolved
Selenium Low	USEPA 200.8	0.0001 mg/L	0.00025 mg/L	total and dissolved
Silver Low	USEPA 200.8	0.00005 mg/L	0.00025 mg/L	total and dissolved
Sodium, Na	USEPA 200.7	0.3 mg/L	1.5 mg/L	total and dissolved
Zinc, Zn	USEPA 200.7	0.01 mg/L	0.05 mg/L	total and dissolved
Antimony	USEPA 200.8	0.0004 mg/L	0.002 mg/L	total and dissolved
Beryllium	USEPA 200.8	0.00005 mg/L	0.00025 mg/L	total and dissolved
Bismuth	USEPA 200.7	0.04 mg/L	0.2 mg/L	total and dissolved
Boron	USEPA 200.8	0.0005 mg/L	0.001 mg/L	total and dissolved
Cobalt	USEPA 200.8	0.00005 mg/L	0.00025 mg/L	total and dissolved
Gallium	USEPA 200.7	0.1 mg/L	0.5 mg/L	total and dissolved
Lithium	USEPA 200.7	0.02 mg/L	0.1 mg/L	total and dissolved
Molybdenum	USEPA 200.8	0.0005 mg/L	0.0025 mg/L	total and dissolved
Scandium	USEPA 200.7	0.1 mg/L	0.5 mg/L	total and dissolved
Strontium	USEPA 200.7	0.01 mg/L	0.05 mg/L	total and dissolved
Thallium	USEPA 200.8	0.0001 mg/L	0.0005 mg/L	total and dissolved
Tin	USEPA 200.8	0.0004 mg/L	0.002 mg/L	total and dissolved
Titanium	USEPA 200.7	0.005 mg/L	0.025 mg/L	total and dissolved
Vanadium	USEPA 200.8	0.0002 mg/L	0.001 mg/L	total and dissolved
Nitrate (as N)	USEPA 353.2	0.02 mg/L	0.1 mg/L	total
Ammonia Direct (as N)	USEPA 350.1	0.05 mg/L	0.5 mg/L	total
Nitrite (as N)	USEPA 353.2	0.01 mg/L	0.05 mg/L	total
Alkalinity	SM 2320B	2 mg/L	20 mg/L	total
Bicarbonate	SM 2320	2 mg/L	20 mg/L	total
Carbonate	SM 2320	2 mg/L	20 mg/L	total

Table 4. List of Water Quality Analytes and Testing Methods

Parameter	Laboratory Method of Analyses	Detection Limit	Reporting Limit	Sample Type
Chloride, Cl	USEPA 300.0	0.5 mg/L	2.5 mg/L	total
Conductivity	SM 2510B	1 umhos/cm	10 umhos/cm	total
Cyanide, Total	USEPA 335.4	0.003 mg/L	0.01 mg/L	total
Cyanide, Weak Acid Digestion	SM 4500	0.003 mg/L	0.01 mg/L	total
Fluoride, F	USEPA 300.0	0.1 mg/L	0.5 mg/L	total
Hardness	SM 2340 B	calc	calc	total
pH	SM 4500-H B	0.1 C	0.1 C	total
Sulfate, SO4	USEPA 300.0	0.5 mg/L	2.5 mg/L	total
Total Dissolved Solids	SM 2540C	10 mg/L	20 mg/L	total
Total Suspended Solids	SM 2540D	5 mg/L	20 mg/L	total
Total Phosphorus	USEPA 365.1	0.01 mg/L	0.05 mg/L	total

Table 5. List of Water Quality Analytes, Hold Times, and Preservatives

Parameter	Laboratory Method of Analyses	Hold Time	Preservative	Bottle Type
Aluminum, Al	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Total Arsenic	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Inorganic Arsenic	HPLC ICP/MS	28 Days	EDTA-HAc	125 mL amber HDPE
Barium, Ba	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Cadmium Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Calcium, Ca	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Chromium Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Copper Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Iron, Fe	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Lead Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Magnesium, Mg	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Manganese Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Mercury, Hg (Low Level)	1631E	90 Days	5mL HCl	250 mL borosilicate glass
Nickel Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Potassium, K	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Selenium Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Silver Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Sodium, Na	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Zinc, Zn	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Antimony	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Beryllium	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Bismuth	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Boron	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Cobalt	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Gallium	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Lithium	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Molybdenum	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Scandium	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Strontium	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Thallium	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Tin	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Titanium	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Vanadium	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Nitrate (as N)	USEPA 353.2, Revision 2.0	28 Days	H2SO4	250 mL HDPE
Ammonia Direct (as N)	USEPA 350.1	28 Days	None	250 mL HDPE
Nitrite (as N)	USEPA 353.2, Revision 2.0	28 Days	H2SO4	250 mL HDPE
Alkalinity	SM 2320B	14 Days	None	500 mL HDPE
Bicarbonate	SM 2320	14 Days	None	500 mL HDPE

Table 5. List of Water Quality Analytes, Hold Times, and Preservatives

Parameter	Laboratory Method of Analyses	Hold Time	Preservative	Bottle Type
Carbonate	SM 2320	14 Days	None	500 mL HDPE
Chloride, Cl	USEPA 300.0	28 Days	None	250 mL HDPE
Conductivity	SM 2510B	28 Days	None	500 mL HDPE
Cyanide, Total	USEPA 335.4	14 Days	5 mL 10N NaOH	500 mL HDPE
Cyanide, WAD	SM 4500	14 Days	5 mL 10N NaOH	500 mL HDPE
Fluoride, F	USEPA 300.0	28 Days	None	250 mL HDPE
Hardness	SM 2340 B	NA	NA	NA
pH	SM 4500-H B	*	None	500 mL HDPE
Sulfate, SO4	USEPA 300.0	28 Days	None	250 mL HDPE
Total Dissolved Solids	SM 2540C	7 Days	None	500 mL HDPE
Total Suspended Solids	SM 2540D	7 Days	None	500 mL HDPE
Total Phosphorus	USEPA 365.1	28 Days	2mL 25% H2SO4	250 mL HDPE

*Perform in field within 15 minutes of sample collection. Laboratory analyses of pH are considered estimated.

BLM has recommended the following additional analytes be added to the list:

- antimony
- beryllium
- bismuth
- boron
- cobalt
- fluoride
- gallium
- lithium
- molybdenum
- scandium
- strontium
- thallium
- tin
- titanium
- vanadium

Calico has added these constituents. All of the analytes in the table above will be evaluated against current Oregon water quality standards and compared with known trace element chemistry of the area. Initial sampling analytes will be more extensive and possibly paired down based on sampling results and approved protocols.

For non-filtered samples (non-metals), water quality samples will be collected for analysis at the laboratory directly from each surface water site by the hand grab method, as described in the *Water Monitoring and Assessment Mode of Operations Manual* (ODEQ 2009). Surface water conditions will be considered steady state and samples will be collected immediately following field water quality measurements.

For filtered samples (metals), a water sample will be collected from the surface water in a clean container. All of the filtered samples at a site will be collected in the same container. A peristaltic pump (Geotech Geopump with easy-load pump head) and associated tubing will be used to transfer the water sample from the container, through a disposable high-capacity field filter with 0.45 µm membrane, and into the appropriate sample bottle obtained from the laboratory. The procedure will follow the "in-line peristaltic pump filtration from a container" method described in the *Water Monitoring and Assessment Mode of Operations Manual* (ODEQ 2009). Filtration equipment, including tubing, collection container, and filter, will only be used at a single site and then discarded.

The USEPA Method 1669 is the recommended procedure for collecting water quality samples for trace metals at USEPA Water Quality Criteria Levels. The sample collection procedures described above and in the ODEQ *Water Monitoring and Assessment Mode of Operations Manual* (ODEQ 2009) will be followed. These procedures may differ from the exact requirements of USEPA Method 1669, but the collection and analysis of blank samples as described in Section 3.3.4.2.6 will be used to verify the accuracy of sampling procedures.

The laboratory that will be used for sample analysis will be an Oregon Environmental Laboratory Accreditation Program (ORELAP) accredited out-of-state lab for inorganic chemistry and physical properties in water. Initially, SPF anticipates using ACZ Laboratories in Colorado for this service. This laboratory is accredited by National Environmental Laboratory Accreditation Program (NELAP) for water analysis. The proposed analytical methods are appropriate to meet ODEQ reporting and detection limits.

Samples will be collected in bottles supplied by an accredited laboratory. The laboratory will prepare the bottles with the appropriate preservative as required by the testing method. Samples will be taken by field engineers wearing latex gloves discarded after each use. Care will be taken to prevent the sample bottles and other sampling equipment from contacting the ground or other potential sources of contamination.

Appropriate preservatives and approved holding times and methods will be used. Equipment blanks will be collected at a minimum frequency of ten percent.

Following collection, sample bottles will be properly labeled with the surface water location, date, time, and other pertinent information. The sample bottles will be immediately packed in a cooler with ice packs. Samples will be hand delivered or mailed to the laboratory within specified hold times with proper chain of custody documentation.

At the conclusion of each monitoring event, the field technician will review field data sheets to ensure completion of all appropriate data. Upon determination that the data sheet is complete, the technician will initial the sheet to verify its completion.

3.3.4.2.6 Quality Assurance/Quality Control

Equipment blanks will be collected from the peristaltic pumping apparatus used for spring/surface water sampling at a ten percent sampling frequency. Collection of the equipment blank use the following procedure:

(1) Fill a clean container with deionized water.
(2) Install a new piece of Tygon tubing in the peristaltic pump head.
(3) Place the inlet end of the tubing into the container.
(4) Install a new 0.45 µm filter on the other end of the tubing.
(5) Start the pump and collect equipment blank samples in sample bottles.

The equipment blank will be analyzed for all the analytes listed in **Table 4**.

Collection of transfer blanks will be at a ten percent sampling frequency. Collection of the transfer blank will involve pouring a sample of deionized water from its original transport container directly to sample bottles. The transfer blank will be analyzed for all the analytes listed in **Table 4**.

The equipment and transfer blank analytical results will be compared with laboratory quality control limits. If the blanks fail the quality control limits, then target limits will be estimated for the sampling event.

Results will be presented in the sampling event monitoring report and any questionable sample results will be flagged. Corrective actions will be identified and implemented prior to the next sampling event.

Quality Assurance Plan. Field and laboratory quality assurance planning will be documented in detail in a quality assurance plan prepared by Calico, in compliance with the permit requirements, and the contract laboratory's quality assurance manual. This section summarizes many of the key elements of these quality assurance plans as they relate to surface water and ground water monitoring at the Calico Grassy Mountain Project.

- **Data Quality Objectives** – Data quality objectives (DQOs) include both quantitative and qualitative objectives, which define usable data for meeting the requirements of this program. DQOs define the quality of services provided by the laboratory and are used in the quality assurance review of the field and laboratory data. Review of the QC data against the DQOs determines if the data are full, usable, considered estimates, or rejected as unusable.
    1. **Quantitative DQOs** – The quantitative DQOs for the quality assurance plan include reporting limits, precision, accuracy and completeness.
        a) **Reporting Limits.** Reporting limits are determined by laboratory-provided or method-specified minimum levels, or by quantification levels specified by permit.
        b) **Precision.** Precision is the ability to replicate the measurement. It is expressed as relative percent difference (RPD).
        c) **Accuracy**. Accuracy is the closeness of the measurement to the true level of the variable. Accuracy is expressed as percent recovery (%R), usually 85-115 percent. The %R is normally determined by the use of known traceable laboratory control standards in the preparation and analysis of laboratory matrix spike samples.
        d) **Completeness.** Completeness is a measure of how many planned measurements for each constituent actually result in valid data. It is expressed as a percentage of the total number of samples collected under correct, normal conditions, usually 90 percent.
    2. **Qualitative DQOs** – The qualitative DQOs are representativeness and comparability.
        a) **Representativeness**. Representativeness is a measure of how well the sample represents the environmental conditions.
        b) **Comparability**. Comparability is a measure of how well data from different sources can be compared to each other.
- **Field Quality Assurance** - This component describes those QA/QC features that are required in the field, and are considered of the highest priority, because field personnel often change over the sampling program and the life of the project.
    1. **Sampling Personnel Training** – Personnel collecting field data and water quality samples will be Calico's staff or selected independent contractors/consultants. In either case, the personnel must have the following training:
        a) How to find and safely approach the sampling sites, including seasonal hazards.
        b) How to calibrate and operate field instruments, take specified field measurements, and follow proper sampling protocols.
        c) How to collect samples, including those for the analysis of mercury using USEPA Method 1631.
        d) How to fill out field data sheets and review for completeness and possible errors.
    2. **Maintenance and Calibration Field Instruments** – Procedures for maintaining and calibrating field instruments used to measure temperature dissolved oxygen, pH, and conductivity are discussed earlier. The quality objectives for the field parameters used for

monitoring require that all measurements are made with calibrated field instruments. Instruments are calibrated or calibrations are checked against known standards at scheduled times. Records of all such calibrations and checks will be maintained at the site.

3. **Collection of Field Quality Control Samples** – Field quality control samples consist of duplicates and blanks.

4. **Chain-of-Custody Forms** – During each sampling event, documentation consisting of a chain-of-custody form will be completed and copies included with the samples during shipment to the analytical laboratory. Chain-of-custody forms are used to document the possession history of the samples from the time collected in the field, throughout shipment, and during receipt by the analytical laboratory. Sample custody while at the project site will be maintained by

    a) keeping the samples in sight of the sampler; for example, in the sample backpack while sampling;

    b) keeping the samples refrigerated with ice or blue ice while in the field;

    c) sealing the samples in a cooler with blue ice and sealed with signed and dated custody seals.

    During shipment to the laboratory, custody will be maintained by sealing the samples and the chain-of-custody form inside a cooler with signed and dated custody seals. Once samples have arrived at the laboratory, they will be considered under custody within the laboratory environment. Upon receipt of the cooler at the laboratory, the sample custodian has the responsibility to note the conditions of the custody seals. If they are broken before receipt, note will be made by the sample custodian on the chain-of-custody form and that form will become part of the sample's permanent record.

5. **Field Data Documentation** – Field data are recorded on field data sheets. Field data sheets are designed to minimize errors in recording, to verify instrument calibration, to document the time samples were collected, and to note any unusual conditions or deviation from standard procedures. Either notebook logs or individual log forms will accompany field-monitoring equipment. These records are maintained in the environmental filing system. Included in the field data sheets are the following:

    - Sample date, time and exact place of monitoring
    - Weather observations
    - Field measurements such as dissolved oxygen, pH, conductivity, and temperature
    - Stream gauge readings
    - Sampling personnel
    - Samples collected
    - Unusual conditions

- **Laboratory Quality Assurance Plan** – This element of the overall QA/QC plan is equally important in meeting quality objectives. Once the contract laboratory is selected, this approach will be "final meshed" with the contract laboratory's plan.

1. The analytical laboratory conducts analytical testing according to well-documented standard operating procedures (SOPs). Laboratory operations are regulated by a written, comprehensive quality assurance plan that is based on controlling, monitoring and documenting every aspect of operation.

2. The following laboratory quality control samples will be prepared and evaluated in accordance with the analytical laboratories quality assurance plan.

    a) **Laboratory Quality Control Samples** - Laboratory duplicate samples to evaluate analytical precision will be prepared and analyzed.

b) **Matrix Spikes** – Laboratory matrix spikes to be evaluated for analytical accuracy will be prepared and analyzed.

c) **Laboratory Control Standards** – Calibration standards are analyzed and calibration curves developed for all applicable methods.

d) **Method Blanks and Instrument Blanks** – Method blanks are used to verify that contamination from laboratory reagents and glassware is not present.

- **Quality Assurance Review** – It is important that the data production and validation is fully described in the quality assurance review process.

1. Reduction of laboratory measurements and laboratory reporting of analytical parameters will be in accordance with the procedures specified for each analytical method (e.g., perform laboratory calculations in accordance with method specific procedures).
2. Data review and validation entails an examination of the field and laboratory quality control data and the raw data to verify that the laboratory was operating within control limits, the analytical results are correctly transcribed from the instrument read-outs.
3. Upon receipt of the data from the laboratory, each data package will be reviewed for the following:
    - Sample holding times
    - Instrumentation calibration
    - Review of calibration and preparation blanks
    - Interference checks
    - Laboratory quality control samples
    - Specific sample results
    - Field and other quality control sample results

3.3.5 Timing and Duration of Baseline Data Collection and Verification

SPF Water Engineering (SPF) anticipates that baseline data collection will be conducted on the schedule outlined in the Field Studies section of this work plan, with a minimum baseline data collection period of one year.

Although existing data have been collected during previous investigations, Calico understands that these data may not be accepted for inclusion in the baseline dataset if data collection methods were not in accordance with approved work plan methods, or were not properly documented. Calico will review existing data for applicability and, if acceptable, propose for inclusion in the dataset.

3.3.6 Further Anticipated Studies

No additional surface water studies are anticipated. If additional information is determined to be necessary, it will be collected using approved methodologies, gathered from documented sources, and coordinated with appropriate agencies.

This work plan is intended to be adaptable so that monitoring sample sites can be added or eliminated as appropriate and sampling schedules, parameters, and methods can be modified as needed. Additional studies and changes to the work plan will undergo review and approval by the TRT.

3.3.7 Baseline Characterization

The baseline characterization report for surface water will include:

- Introduction
- Regulatory environment

- Surface water study area
- Sampling events
- Sampling sites
- Data collection methods
  - Description of sampling sites
  - Surface water quality data collection method
  - Surface water quality QA/QC
- Results and analyses
  - Surface water quality analysis
  - QA/QC
- List of preparers

3.3.8 Bibliography

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Western Technologies, Inc. (WTI). 1988. WTI supervised the drilling and installation of three monitoring wells (GW-1-GM, GW-2-GM and GM-3-GM and completion of GM-Prod-1. The WTI work included logging of drill cuttings and recordation of lithologies.

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3.3.9 Contacts

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3.4 Ground Water

GROUND WATER ENVIRONMENTAL BASELINE WORK PLAN
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
SEPTEMBER 2017

3.4.1 Purposes and Objectives

The ground water resources baseline study will characterize existing hydrogeology and hydrochemistry at the Grassy Mountain Project mine site.

The purpose of this work plan is to establish appropriate baseline data collection methodology.

- The work plan includes project-specific monitoring methods and procedures.
- The work plan defines the study area
- The work plan is flexible and adaptive, so that monitoring can be expanded, terminated, or otherwise adjusted as needed to best meet the objectives of the ground water resources baseline study.
- A primary purpose of the work plan is to ensure that the data collected are of known and acceptable quality, and that project-specific methods and procedures are implemented.
- The monitoring program will be periodically re-assessed to consider future exploration and mining programs. An example would be changes in the proposed location of potential mining facilities, like the processing plant, and related needs to modify the associated monitoring stations.
- An important aspect of the baseline program will be characterizing existing water quality and quantity to use in future evaluations to determine whether the project could adversely affect water quality and quantity. The information will also be used to evaluate water supply potential for the project area.

The objectives of the ground water resources baseline study are as follows:

- Meet Oregon Department of Geology and Mineral Industries (DOGAMI) Division 37 Chemical Process Mining Rules (Oregon Administrative Rule (OAR) 632-037-0055, (Existing Environment-Baseline Data), and related Oregon Department of Environmental Quality (ODEQ) Division 43 Chemical Mining Rules, and related Oregon Department of Fish and Wildlife (ODFW) Consolidated Application and Permit Review Standards for Chemical Process Mining (Division 420).
- Develop a conceptual model of the nature and interaction of the various water-bearing units and aquitards in relation to relevant geologic structures. The conceptual model should identify which water-bearing units are hydraulically connected (i.e., the same aquifer) and whether each aquifer is unconfined, semi-confined, or confined.
- Develop a monitoring well network capable of monitoring ground water quality and ground water level changes in each aquifer potentially affected by mining operations.
- Accurately characterize the study area ground water resources, both quality and quantity, and the pre-project “environmental baseline.” This includes springs in the vicinity of Grassy Mountain.
- Determine if there are naturally occurring variables or trends, or project-related influences on local water quality.
- Provide data to be used in permit applications and environmental reviews of the proposed Grassy Mountain Project.
- Determine if potential environmental changes could result from project implementation

- Develop a database that will (1) be used in future monitoring of the effects of exploration and mining-level operations, and (2) will help establish long-term reclamation and closure needs.

The results of the baseline monitoring program and ground water resources baseline study will be reviewed by the regulatory and management agencies and the Grassy Mountain professional staff. If environmental changes are judged to be significant and adverse as a result of the mining operations, appropriate mitigation, reporting, and remedial measures will be implemented by Calico Resources USA Corp. (Calico). Specific details of these mitigation requirements would be negotiated between Calico, the State of Oregon, and/or other involved and responsible regulatory agencies.

3.4.2 Project Study Area

3.4.2.1 Project Area

The Grassy Mountain Project area (Permit Area) is located in Malheur County, Oregon, approximately 22 miles south-southwest of Vale (**Figure 1)**, and consists of two parcels: the Mine and Process Area, and the Access Road Area (**Figure 2**).

The Mine and Process Area parcel is located on three patented lode mining claims and unpatented lode mining claims that cover an estimated 886 acres. These patented and unpatented lode mining claims are part of a larger land position that includes 419 unpatented lode mining claims and nine mill site claims on lands administered by the BLM (**Figure 2**). All proposed mining would occur on the patented claims. The Mine and Process Area is located in all or portions of Sections 5-8, Township 22 South, Range 44 East (Willamette Meridian).

The Access Road Area parcel is located on public land managed by the BLM, and private land controlled by others (**Figure 2**). A majority of the access road is a Malheur County Road named Twin Springs Road. The access road extends north from the Mine and Process Area to Russell Road, a paved Malheur County Road. The Access Road Area parcel is located in portions of: Section 5, Township 22 South, Range 44 East; Sections 3, 10, 11, 14, 21- 23, 28, 29, and 32, Township 21 South, Range 44 East; Sections 1, 12-14, 23, 26, 27, and 34, Township 20 South, Range 44 East; and Sections 23, 26, 35, and 36, Township 19 South, Range 44 East (Willamette Meridian). The width of the Access Road Area is 300 feet (150 feet on either side of the access road centerline). This width is used to accommodate possible minor widening or re-routing, and a potential power line adjacent to the access road. There are several areas shown that are significantly wider than 300 feet on the Permit Area Map (**Figure 2**), which are areas where the final alignment has not yet been determined. The final engineering of the road will be consistent throughout, and within the Permit Area shown on **Figure 2**.

The approximate acreages of the two parcels described above are as follows:

Mine and Process Area:	886 acres
Access Road Area:	876 acres
Total Permit Area:	**1,762 acres**

Anticipated Project Disturbance (excluding access road): 400 acres

The Permit Area is rolling hill terrain. Negro Rock Canyon to the west of the main Permit Area and the Owyhee River Canyon to the southeast provide more relief in topography. The highest elevation is about 4,800 feet above mean sea level (msl) along the west flank of Grassy Mountain. Elevation decreases to the north (about 3,250 feet above msl at Negro Rock Canyon). Elevation falls to about 2,400 feet above msl at the Malheur River (ABC 1992).

The regional ground water system that includes the Permit Area is bordered roughly by the Sourdough Mountain upland area to the west of Grassy Mountain, the Malheur River to the north and west, and the Owyhee Reservoir and Owyhee River, and the Snake River to the south and east. Ground water studies by

Adrian Brown Consultants, Inc. (ABC 1992) and J.M. Montgomery, Consulting Engineers, Inc. (JMM 1991) further identified the following hydrostratigraphic units within the Permit Area:

- Local discontinuous water-bearing zones within the Grassy Mountain formation;
- Less permeable fine-grained sedimentary rocks (clay, clayey and tuffaceous siltstones, and indurated siltstone predominantly overlying and underlying the sandstone and conglomerate unites), acting as aquitards beneath the Permit Area; and
- Sandstone and conglomerate units that are inconsistent water-bearing units.

Water-bearing units are scattered and have restricted areal extent across the site. These units range from roughly 25 to 420 or more feet below ground surface (bgs). Ground water flow in the shallowest, unconfined water bearing zones generally follows the topography, with the flow direction in deeper, confined water-bearing zones likely disrupted by faults and other structures in the study area. Grassy Mountain appears to be a hydrologic divide between the Owyhee River and Negro Rock Canyon. Recharge to the regional system is by infiltration of incident precipitation and runoff.

3.4.2.2 Water Resources Study Area

The water resources study area is shown on **Figure 8, Water Resources Study Area and Permit Area and Figure 9, Water Resources Study Area**. The study area for water resources is defined as that area where the Grassy Mountain Project may potentially impact water resources, including surface water, ground water, and springs. Specifically, water resource conditions are described as (1) surface water flow and quality; (2) ground water levels, quantity, and quality; and (3) spring flow and quality.

Initially, an area of impact developed by Adrian Brown Consultants, Inc. (ABC 1992) was considered for defining the water resources study area. ABC completed a finite element ground water model for a previous Grassy Mountain project. Model predictions were used to identify the outermost edge of the drawdown cone based on average sustained production flow rates of 575 gallons per minute (gpm) over a 10-year pumping duration from seven water supply wells (Prod-1, PW-1, PW-4, Rye Field, 89-1, 89-2, and 89-5). The water use estimate was based on the development of a large-scale, 851-acre, surface mine, heap leach operation, and other related facilities. ABC referred to the area of predicted drawdown as “the maximum area of impact.”

The maximum area of impact described by ABC was ultimately rejected for the following reasons:

1. The project type and scope have changed to involve a small underground mine and mill. Average ground water pumping rates for the currently proposed project are anticipated to range from approximately 150 to 300 gpm. Therefore, the 575-gpm average water use assumed by ABC for modeling drawdown is not representative of currently anticipated water demands. Consequently, the area of impact predicted by that modeling is greater than the area of impact that will occur from pumping for the currently proposed project.
2. The ABC area of impact relies solely on anticipated drawdown effects, without taking into account watershed boundaries.

Due to the reasons described above, a slightly different approach was taken to define the proposed water resources study area for the Calico Grassy Mountain Project. This approach uses the following criteria:

1. The study area will extend a minimum two-mile radius from potential ground water production facilities. It is anticipated that ground water production facilities could include the Bishop Well, PW-4, future wells in the Negro Rock Canyon watershed northwest of the mine, dewatering wells surrounding the deposit, or the underground mining workings.
    a. The two-mile radii reflects a smaller radii of impact than assumed by ABC due to anticipated average future pumping rates by Calico that are 25 to 50 percent of the pumping rate assumed by ABC.

   b. The approximate two-mile radius from the mine workings was used to help define the southeastern boundary.
   c. The most northerly extent of the study area is approximately two miles north of well PW-4.
   d. The southern boundary was further extended to approximately seven miles south of the Bishop Well to encompass three springs (Twin Spring North, Twin Spring South, and Whiskey Spring) and a background surface water sampling site on Dry Creek Arm of Owyhee Lake. The springs have been historically sampled during past sampling efforts and are going to be sampled as part of the water resources baseline study.
2. The two surface watersheds that could be impacted by surface runoff from the Grassy Mountain Gold Project surface facilities were included. These watersheds consist of Negro Rock Canyon, which could receive runoff from processing facilities, and Sagebrush Gulch (a tributary to Negro Rock Canyon, which could potentially receive runoff from mine facilities. It is assumed that project facilities will not extend south from the Bishop Well into the Dry Creek drainage. The watershed delineation approach was used to better define the eastern and western edges of the study area.
3. An additional area further than two miles northwest of project facilities was also included, reflecting the anticipated northwesterly ground water flow direction from project facilities. This allows inclusion of more distant springs to the north and west.
4. The study area boundary is defined by section lines. Section lines provide definable boundaries, whereas watershed boundaries can be subject to interpretation given the complex topography in the project vicinity.

It is believed that this approach can accurately identify all water resources (ground water, surface water, springs) that could potentially be impacted by the currently-anticipated project. From a surface water perspective, any impacts from the project can be expected to occur within the same watershed. From a ground water perspective, the study area includes a reasonable maximum radius of influence around potential pumping wells, plus a larger area down-gradient of the project facilities and pumping wells, so that potential down-gradient water resources can be fully defined.

As stated under criterion one above, the study area will extend a minimum two-mile radius from potential ground water production facilities. If the future production wells are constructed at locations that are less than two miles from the proposed study area boundary, then the boundary will be expanded to maintain the two-mile radius from the production wells. The water resources study area boundary should be viewed as dynamic and will be modified as needed to adequately assess potential impacts to water resources.

The main study area boundary near the project includes a background sampling site on Dry Creek Arm of Owyhee Lake, where Dry Creek and Twin Springs Creek enter the reservoir. This site was selected to assess any potential surface water runoff impacts of the project on Owyhee Lake, although no impacts are anticipated since the lake is considered to be in a separate watershed than the project. In addition to this location, the study area also includes two separate, non-contiguous, areas on the Owyhee River/Lake. One location is on the Owyhee River, four miles downstream of Owyhee Dam, and the other location is upstream of the dam and Permit Area on the Owyhee River/Lake at Leslie Gulch. Although we anticipate no potential for impacts to Owyhee River/Lake from the proposed project, these two areas were added to allow background water quality sampling from the Owyhee River/Lake.

3.4.3 Regulatory Framework

The primary regulatory requirements for this component of the ground water baseline study work plan are DOGAMI regulations described in Division 37, Chemical Process Mining rule (OAR 632-037-0055). ODEQ also enforces the related requirements of the Division 43 Chemical Mining rule (OAR 430-043-0000). All sampling and analytical methods used to meet the monitoring requirements will be done in accordance with the following:

- The latest edition of "Guidelines Establishing Test Procedures for the Analysis of Pollutants" (40 Code of Federal Regulations [CFR] 136).
- DOGAMI Division 37 Chemical Process Mining Rules, ODEQ Division 43 Chemical Mining Rules, and related Consolidated Application and Permit Review Standards for Chemical Process Mining (Division 420).

The following current sources are also referenced:

- American Public Health Association, Standard Methods for the Examination of Water and Waste Waters
- American Society for Testing and Materials (ASTM) Standards, Part 31, Water, Atmospheric Analysis
- U.S. Environmental Protection Agency (USEPA), Methods for Chemical Analysis of Water and Wastes
- ODEQ, *Water Monitoring and Assessment Mode of Operations Manual*, March 2009.
- ODEQ, *Field Sampling Reference Guide*, January 2010.
- ODEQ, *Quality Manual*, May 2011.

3.4.4 Study Methodology

3.4.4.1 Literature Review

- Adrian Brown Consultants, Inc. (ABC). 1992, *Water Resources Technical Memorandum* for Atlas as part of the *Grassy Mountain Project Environmental Impact Statement*.
- Atlas Precious Metals, Inc. (Atlas). 1989. *Groundwater and Surface Water Hydrology Report*, Atlas Grassy Mountain Project.
- Atlas Precious Metals, Inc. (Atlas). 1990. *Initial Baseline Environmental Studies*: groundwater, surface water, seeps and springs.
- Calico Resources USA Corp. 2016. *Drill Program Work Plan Grassy Mountain Project, Malheur County, Oregon, October 4, 2016.*
- Rocky Mountain Environmental Corporation (RMEC). 2012. *Draft 2011 Hydrologic Testing Program Interpretive Report*.
- SPF Water Engineering (SPF). 2012. *Grassy Mountain Gold Project Groundwater Monitoring Report, May 2012 Sample Period, July 24, 2012 Draft*.
- SPF Water Engineering, LLC (SPF). 2015. *Grassy Mountain Gold Project Water Resources Baseline Study 2013 Annual Sampling Report.*
- SPF Water Engineering (SPF). 2016. *Work Plan for Grassy Mountain Monitor Wells, August 31, 2016*.
- SPF Water Engineering (SPF). 2016. *Preliminary Groundwater Conceptual Model at Grassy Mountain, November 16, 2016.*

Other monitoring efforts performed at the site, and which will be reviewed as applicable, include the following:

- Initial baseline environmental studies conducted by Atlas Precious Metals, Inc. (Atlas), which included surface and ground water quality monitoring and a compilation of data collected from springs and wells in the area.
- Western Technologies, Inc. (WTI) oversaw the installation of three monitoring wells (GW-1, GW-2, and GW-3) and one production well (Prod-1) on the site in 1988. The location of GW-2 is currently unknown and there is uncertainty over whether or not the WTI GW-3 is the same as the GW-3, where monitoring occurred in 2011 by RMEC. WTI collected water quality samples from the four wells, the BLM Owyhee Ridge Well, and from three surface water locations in 1989.

- In 1989 and 1990, SRK oversaw the installation of monitoring well GW-4 and the production wells (PW-1 and PW-4). Water quality samples were collected from these wells and test pumping was performed on the production wells. Results were presented to Atlas in a 1989 report.
- In 1991, JMM collected data in support of a ground water supply study for the then proposed Grassy Mountain Gold Project. The work included construction of three monitoring wells (GW-3A, GW-5, and GW-6), construction of one piezometer (GW-3B), measurement of ground water levels and spring flow rates, and conducting pumping tests on three wells.
- In 1992, ABC prepared a *Water Resources Technical Memorandum* for Atlas as part of the Grassy Mountain Project environmental impact statement (EIS). The memorandum describes the geology and geochemistry of the project site, monitoring and production wells completed at the time, historical ground water and surface water quality data, results of ground water modeling, and discusses the potential impacts of mining on ground water and surface water resources.
- In June 1993, ACZ Inc. collected ground water data from several springs and wells (GW-1, GW-6, BLM, Prod-1, 57-1, and 89-2). In September 1993, 12 new test and monitoring wells were installed, with work documented by Hydro-Geo Consultants, Inc. Water quality samples were also collected from these new wells. Hydro-Geo Consultants, Inc. also participated in rising head permeability testing of seven of the new wells, slug tests of four of the new wells, and pumping tests of two of the new wells. Results of this testing are currently unavailable.

3.4.4.2 Field Studies

3.4.4.2.1 Monitoring Wells

Twelve wells proposed for water level measurement and water quality sampling for the baseline monitoring effort are identified in **Table 6**, along with construction details, and illustrated on **Figure 10, Monitoring Wells and Springs,** and **Figure 11, Monitoring Wells**. The well name from Calico historical records, well logs, and the associated well tag number from the Oregon Water Resources Department (OWRD) are identified in **Table 6**. This table also includes completion depth, screened interval, and well casing diameter.

All twelve monitoring wells proposed for the baseline monitoring effort were sampled in late May/early June 2012 (SPF 2012). During that sampling event, these wells were located by global positioning system (GPS) using a Garmin GPS unit (Etrex Vista HCX). The Universal Transverse Mercator (UTM) coordinates (Zone 11N, NAD 83) are provided in **Table 7**.

The twelve wells identified in **Table 6** and **Figure 10** were selected for water level and water quality baseline monitoring based on a November 2011 evaluation of the construction, condition, productivity, and water quality of 15 monitoring wells as described in *Draft 2011 Hydrologic Testing Program Interpretive Report* by the Rocky Mountain Environmental Corporation *(*RMEC). Based on that evaluation, RMEC identified 11 wells as suitable for baseline monitoring. In addition to these wells, the Bishop Well is also included as a baseline monitoring location due to its proximity to the proposed mine processing area.

Static water levels were measured in these 12 wells in late May/early June 2012 by SPF (SPF 2012). SPF also measured ground elevation of each monitoring well using a handheld Garmin GPS unit (Etrex Vista HCX). These elevations are not survey-grade quality and vertical errors associated with a standard-grade GPS are generally considered to be +/- 10 to 20 meters. There are future plans to survey all of the monitoring wells to achieve more accurate well elevations. Using the measured ground elevation and static water levels, the ground water surface elevation in each well can be calculated. The ground elevation, static water level, and ground water elevation for each of the 12 monitoring wells is summarized in **Table 8**.

Table 6. Grassy Mountain Water Quality Monitoring Wells and Construction Details

Calico Well ID	OWRD Well Tag Number	Alternate Name	Well Const. Depth (ft)	Screened Interval (ft)	Well Casing Diameter (in)
GW-1	107469	47-1	155.5	135.5-155.5	4
GW-4	107460		370	280-350	4
Prod 1	107457		425	145-255 325-355 380-420	4
PW-1	109353		550	320-340 400-420	6
PW-4	109351		375	280-300 340-360	6
BLM	109398	Owyhee Ridge	175	159-166	6
59760	107462	Middle Sweizer, TW-1	203	163-203	6
59761	109400	Lower Sweizer, MW-2	118	97-117	4
59763	109356	TW-4	323	293-323	6
59766	107468	MWS-8	45	25-45	4
59772	109352	Upper Sweizer, MWS-13	207	146-206	4
Bishop Well	None	Rye Field	482	135-145	12

Table 7. GPS Coordinates for Grassy Mountain Monitoring Wells

Calico Well ID	OWRD Well Tag Number	Northing (UTM 11N, NAD83)	Easting (UTM 11N, NAD 83)
GW-1	107469	4835644	471460
GW-4	107460	4838740	470557
Prod 1	107457	4837684	470904
PW-1	109353	4835627	471431
PW-4	109351	4838778	470535
BLM	109398	4835898	470406
59760	107462	4835250	471497
59761	109400	4835286	471532
59763	109356	4835105	469094
59766	107468	4836380	469927
59772	109352	4835229	471504
Bishop Well	None	4833564	466562

Table 8. Grassy Mountain Monitoring Well Ground Water Elevations

Calico Well ID	OWRD Well Tag Number	May/June 2012 Static WL (ft bgl)	Ground Elevation (ft)[1]	May/June Ground Water Elevation (ft bgl)
GW-1	107469	51.98	3,715	3,663
GW-4	107460	80.93	3,347	3,266
rod 1	107457	Flowing	3,447	NA
PW-1	109353	51.96	3,709	3,657
PW-4	109351	77.27	3,343	3,266
BLM	109398	156.30	3,584	3,428
59760	107462	86.11	3,779	3,693
59761	109400	86.45	3,761	3,675
59763	109356	277.63	3,519	3,241
59766	107468	24.06	3,462	3,438
59772	109352	92.53	3,796	3,703
Bishop Well	None	105.43	3,400	3,295

1 - Ground Elevation from SPF (2012) using Garmin Etrex Vista HCX

In addition to the 12 wells proposed for water level and water quality monitoring, seven monitoring wells are proposed for quarterly baseline water level measurements. These wells and their construction details are listed in **Table 9**, and are also shown on **Figure 10** and **Figure 11**. **Table 9** includes OWRD well tag number, completion depth, screened interval, and well casing diameter. OWRD has located these wells using a hand-held GPS, and reported the locations as latitude and longitude. The latitude and longitude as reported by OWRD and the converted UTM coordinates (Zone 11N, NAD 83) for these wells are provided in **Table 10**.

SPF did not measure static water levels in these seven wells during the May/June 2012 sampling event. Static water levels have been measured in these wells during previous monitoring efforts and these are reported in **Table 11**, along with reported surface elevation, ground water elevation, and the source of the data. During the winter 2013 sampling event, well locations and elevations were identified using a handheld Garmin GPS unit (Etrex Vista HCX). All of the monitoring wells will be surveyed to achieve more accurate well elevations.

Table 9. Grassy Mountain Water Level Monitoring Wells and Construction Details

Calico Well ID	OWRD Well Tag Number	Alternate Name	Well Const. Depth (ft)	Screened Interval (ft)	Well Casing Diameter (in)
GW-2	109357	47-2	325	290-320	4
GW-3	107467	47-3	350	320-350	4
GW-6	109368		340	300-340	2
89-2	109360		425	386-406	unknown
59762	109371	MW-3	700	550-660	4
59764	107466	MW-5	305	279-299	4
26-092-915	109354		915	228-268	2

Table 10. GPS Coordinates for Grassy Mountain Water Level Monitoring Wells

Calico Well ID	OWRD Well Tag Number	Latitude[1]	Longitude[1]	Northing (UTM 11N, NAD83)[2]	Easting (UTM 11N, NAD 83)[2]
GW-2	109357	43.659110	-117.367150	470396	4834077
GW-3	107467	43.672780	-117.365150	470563	4835595
GW-6	109368	43.672880	-117.392810	468334	4835616
89-2	109360	43.683350	-117.397060	467997	4836780
59762	109371	43.673890	-117.359760	470999	4835716
59764	107466	43.668270	-117.384100	469034	4835101
26-092-915	109354	43.672440	-117.355860	471312	4835554

1 - Latitude and longitude reported by OWRD

2 - Northing and Easting converted from latitude and longitude

Table 11. Grassy Mountain Water Level Monitoring Well Ground Water Elevations

Calico Well ID	OWRD Well Tag Number	Reported Static WL (ft bgl)	Ground Elevation (ft)	Ground Water Elevation (ft bgl)	Source
GW-2	109357	164	3,822	3,658	JMM 1991
GW-3	107467	230	3,626	3,396	JMM 1991
GW-6	109368	138	3,365	3,227	JMM 1991
89-2	109360	59	3,300	3,241	JMM 1991
59762	109371	600	3,718	3,118	Hydro-Geo 1993
59764	107466	271	3,519	3,248	Hydro-Geo 1993
26-092-915	109354	56	3,704	3,648	JMM 1991

These seven wells were selected for quarterly water level monitoring to provide additional baseline water level data and to better define ground water flow within the water resources study area. These wells were not selected for water quality monitoring because either the well has been reported as unsuitable for water quality sampling (RMEC 2012, JMM 1991), the well has not been evaluated for condition in the last 20 years, or the well is considered to be redundant to a well that is being sampled (constructed similarly with similar water levels and located in close proximity to a well that will be sampled).

In addition to the wells proposed for monitoring, there are also two wells known to be dry; these are 59765 (MW-6, OWRD well tag number 109355) and GW-3A. There are also two flowing wells identified on the topographic map in Section 27 of T21S, R43E. One of these wells is called Darky Rock Well and the other is called Flowing Well in ABC (1992). These wells will be visited, photographs taken, and flow measured semi-annually (spring and fall). These wells are shown on **Figure 10**.

Three monitoring wells will be used for continuous baseline water level measurements using water level pressure transducers, which were installed during the 2013 sampling event.

At least one well in the mill area will also be equipped with a transducer to characterize water levels in the mill site vicinity. Additional transducers may also be installed in one or more wells completed in the aquifers developed as water sources.

Measuring water levels at a higher frequency will provide a more complete description of seasonal ground water level trends. The wells selected for continuous water level measurements have different completion depths, ground water elevations, and are located around the project site in an attempt to collect water level data from different water-bearing zones and at various locations throughout the study area. The wells proposed for continuous water level monitoring are listed in **Table 12** and **Figure 10**. Well GW-2 is currently proposed for continuous water level measurements, but SPF has not visited this well to confirm location, condition, and access. If GW-2 cannot be used, then well 59763 will be used.

Table 12. Grassy Mountain Wells Proposed for Continuous Water Level Monitoring

Calico Well ID	OWRD Well Tag Number	Well Const. Depth (ft)	Screened Interval (ft)	Ground Water Elevation (ft bgl)
GW-1	107469	155.5	135.5-155.5	3,663
GW-4	107460	370	280-350	3,266
GW-2	109357	325	290-320	3,658
OR				
59763	109356	323	293-323	3,241
Well in Mill Area	---	---	---	---

The results of data collection may reveal the need to add or remove monitoring wells to provide additional baseline ground water quality or ground water level data that the existing wells cannot adequately provide in both the mining and the process areas. The baseline work plan should be viewed as a flexible, working guide that can be revised as needed to meet baseline reporting requirements and to adequately assess potential impacts to water resources.

The goal of the water quantity and quality investigations in the mining area are to identify all water bearing zones that could potentially be affected by the mine and their hydraulic characteristics (such as flow direction, yield, interconnectedness and the like). Likewise, in the process area, ground water data will need to be collected in the vicinity of process or disposal areas to characterize the vulnerability of the shallowest laterally extensive water-bearing zone, and to provide data pertinent to process and disposal area engineering designs. An initial plan for ground water characterization near the ore body and processing area is described in Section 3.4.4.3.2. Additional data will be collected in the aquifers developed as the source of water for the mine site.

3.4.4.2.2 Springs

There are numerous springs located within the water resources study area. This ground water baseline study work plan proposes quarterly visits to 11 springs, with water-quality sampling and flow measurement if there is observed flow. These springs are listed in **Table 13**, along with the May/June 2012 measured flow rate, and the UTM coordinates (Zone 11N, NAD 83). These springs are also shown on **Figure 10**.

During the May/June 2012 sampling event conducted by SPF, seven of these springs had measurable flow and a location suitable for collecting samples. These springs were also located by GPS using a Garmin GPS unit (Etrex Vista HCX). Three of the springs appeared to be dry, and another spring (Poison Spring) did not have a defined source and location appropriate for sampling. At Poison Spring, water quality sampling will occur during future sampling events if a suitable location can be identified.

Table 13. Grassy Mountain GPS Coordinates and Flow for Baseline/Background Springs

Spring	Northing (UTM 11N, NAD83)	Easting (UTM 11N, NAD 83)	Flow Rate (gpm)
Baseline Study Springs			
Government Corral Spring	4838649	472953	1.3
Sagebrush Spring	4839227	474047	1.9
Grassy Spring Stock Tank	4836114	470717	0.2
Twin Spring North	4829624	466218	1.7
Twin Spring South	4829253	466389	9.4
Sourdough Spring Upper	4833121	463632	0.4
Whiskey Spring	4829321	469195	0.9
Sourdough Spring Lower	4834094	470470	Dry
Grassy Spring*	4840108	471660	Dry
Lowe Spring*	4839604	467781	Dry
Poison Spring*	4839604	467781	No Measurement
Background Springs**			
Bull Spring*	4833030	472642	No Data Available
Grassy Mountain Spring*	4833030	472642	No Data Available
Oxbow Spring*	4830340	472202	0.36 (12-15-90)
Oxyoke Spring*	4829509	472161	0.33 (12-15-90)
Unnamed spring in Section 13 T22S, R44E*	4833096	477302	No Data Available
West Whiskey Spring*	4839057	464143	0.50 (No Date Reported)
Wildcat Spring*	4839039	465444	0.45 (12-9-90)
Unnamed spring in Section 19, T21S, R44E*	4841682	469488	No Data Available

*Northing and Easting taken from topographic map. These springs will be located by GPS when visited.

**Flow rates for the background springs are the most recent as reported by ABC 1992, with the sample date noted in parentheses.

In addition to the 11 baseline springs listed in **Table 13** that will be visited quarterly and sampled if flow is present, a reconnaissance inventory of spring sites in the study area and background area will be performed. This reconnaissance inventory will include an examination of aerial photography and topographic maps and field verification work to provide a complete inventory of all springs in the study area and background area. After completing the spring inventory, all known springs within the study and background areas will be visited semi-annually in the spring and fall to provide background flow data. These springs will be visited, photographs taken, and flow measured if flow is observed. Currently, there are believed to be eight more springs that will be part of the semi-annual investigation. These are Bull Spring, Grassy Mountain Spring, Oxbow Spring, Oxyoke Spring, unnamed spring in section 13, T22S, R44E, West Whiskey Spring, Wildcat Spring, and an unnamed spring in section 19, T21S, R44E. These springs are identified in **Table** 13 as background springs and shown on **Figure 10**.

Only springs with a minimum flow of approximately ¼ liter per minute that can be adequately captured for sampling will be sampled. Flow less than ¼ liter per minute that is considered unsuitable for collecting samples. Similarly, diffuse flow that cannot be captured and measured will not be sampled.

The springs proposed for quarterly water quality and flow monitoring in this ground water baseline study work plan are considered to adequately characterize baseline ground water conditions in the study area. However, the results of future data collection, including the complete inventory and resulting semi-annual investigation, may reveal the need to add or remove springs to provide additional baseline spring quality or flow data. The baseline work plan should be viewed as a flexible, working guide that can be revised as needed to meet baseline reporting requirements and to adequately assess potential impacts to water resources.

3.4.4.2.3 Sampling Schedule

"Trend" monitoring implies that measurements will be made regular time intervals in order to determine the long-term trend of a particular water-quality parameter. Additionally, sampling must occur at a frequency to account for seasonal spring-flow and ground water water-level variations.

Calico will conduct quarterly ground water monitoring, with sampling events planned for the mid-point of each quarter. The schedule may vary due to poor weather and limited access to the site. However, a minimum of three weeks will separate each sampling event. Due to the relative flexibility of the schedule, it is very unlikely that a quarterly sampling event will be completely missed. See Appendix E for the *Grassy Mountain Gold Project Water Resources Baseline Study Winter 2013 Monitoring Plan*.

During each sampling event, water quality and water levels will be collected from the wells identified in **Table 6**, water levels will be measured in the wells identified in **Table 9**, and water quality and flow will be measured in the springs identified in **Table 13**. Continuous water level data will be collected from the wells identified in **Table 12**. All springs in the study area (other than the 11 that will be visited quarterly) and the 2 flowing wells in Section 27 of T21S, R43E, will be visited semi-annually (spring, fall) for flow measurements and photo documentation.

3.4.4.2.4 Sampling Procedure

Standard hydrologic field procedures and methodologies will be used to ensure accurate and reliable data collection. Sampling procedures will follow the *Field Sampling Reference Guide* (ODEQ 2010), the *Water Monitoring and Assessment Mode of Operations Manual* (ODEQ 2009), and the guidelines established in the *Environmental Baseline Study Work Plans, Grassy Mountain Project* (EM Strategies 2017).

A monitoring plan will be developed for each specific sampling event, identifying the specific wells, springs, and surface water sites that will be visited during that event. The plan will describe the specific type of monitoring (i.e., water-quality sampling, water-level measurements, flow measurements) that will be conducted at each site. The monitoring plan for the winter 2013 sampling event is included as Appendix E.

Standardized log sheets for ground water/spring sampling will be used for recording sampling data. These sheets list the locations being sampled and allow sampling personnel to record weather conditions and other relevant information during the sampling. All personnel conducting field work will receive adequate training on operation of equipment and sampling protocols to ensure accurate and reliable data collection. A copy of the log sheets is included with the *Grassy Mountain Gold Project Water Resources Baseline Study Winter 2013 Monitoring Plan* included as Appendix E.

Quality assurance and quality control (QA/QC) are important components of the monitoring program, and the QA/QC protocols described in the *Water Monitoring and Assessment Mode of Operations Manual* (ODEQ 2009), the ODEQ *Quality Manual* (ODEQ 2011), and the *Environmental Baseline Study Work Plans, Grassy Mountain Project* (EM Strategies 2017) will be followed. Specific QA/QC details are described in Section 3.4.4.2.11.

Ground water quality sampling will include the following tasks:

1. Identify ground water and spring monitoring locations (see 3.4.4.2.1 and 3.4.4.2.2).

2. Identify specific sampling location for future reference. Sampling sites will be marked with a handheld GPS unit.
3. Digital photographs of each well and spring will be taken to adequately document location and sampling conditions.
4. Measure static water levels of each well (see Section 3.4.4.2.5).
5. Install continuous water level transducers and perform quarterly calibration and data download (see Section 3.4.4.2.5).
6. Measure spring flow at the time of data collection (see Section 3.4.4.2.6).
7. Install dedicated pumps in wells for purging and sample collection (see Section 3.4.4.2.7).
8. Initiate purge pumping prior to sample collection (see Section 0).
9. Conduct field measurements for certain water quality parameters (see Section 3.4.4.2.10).
10. Conduct water quality sampling according to approved sample collection procedures (see Section 3.4.4.2.11).
11. Perform field QA/QC (see Section 3.4.4.2.11).
12. Verification of data results and transmittal of samples (chain of custody, see Section 3.4.4.2.11).
13. Report results (see Section 3.4.4.2.12).

3.4.4.2.5 Well Static Water Level

The static water level of each well will be measured prior to purge pumping using an electric-line well sounder relative to the top of the outer well casing, as described *Draft 2011 Hydrologic Testing Program Interpretive Report*. The measurement point on each well casing shall be marked for consistency. If the well cap is not vented, then measurements will be taken after the static water level has had adequate time to reach equilibrium.

A data collection form has been developed for recording important field data. Static water level will be recorded on the data collection form along with the well name, OWRD well tag number (if present), date, time, height of outer well casing relative to ground surface, measurement point (MP) description, well condition, and other relevant information. For the well condition assessment, the well casing(s) and concrete pad (if present) will be visually examined for damage. The area around the well will be examined for standing water. These measurements and observations will occur prior to the start of purge pumping.

The electric line well sounder unit used for each measurement shall be identified. Calibration information for each well sounder used shall be provided with the measurement report. Both raw and adjusted (based on calibration) measurements shall be provided. SPF currently uses a Waterline electric-line well sounder that is calibrated annually (at a minimum) with a steel tape.

The well designated as Prod-1 has artesian flow, and is allowed to flow continuously for stockwater use. Accurate measurement of static water level would require that the well be shut in for an extended period (days or weeks) to allow the water level to equilibrate. Rather than shut the well in, the well can best be monitored similar to a spring, with artesian flow rate measured at the time of each sampling event.

To continuously record water levels, water-level and barometric-pressure transducers will be installed in three monitoring wells (GW-1, GW-4, GW-2 or 59763). Solinst Levelogger Edge (Model 3001) pressure transducers will be installed in each monitoring well to continuously record water level and temperature data. A single Solinst Barologger (Model 3001) will be installed in GW-1 (a centrally located monitoring well) to compensate water level observations for fluctuations in atmospheric pressure. Equipment accuracy of the Solinst Levelogger Edge is listed at 0.05 percent over the full-scale length of 10 meters.

At each monitoring well, the Levelogger will be suspended via a stainless steel cable attached to an I-bolt affixed to the top of the well casing. The Levelogger will be placed approximately 4 meters (13 feet) below the static ground water surface. At the centrally located monitoring well (GW-1), the Barologger will be attached to a 1-meter section of stainless steel cable affixed to the I-bolt to ensure it is above the water table. Prior to installation, the Leveloggers and Barologger will be set up for recording data using standard manufacturer software. All Levelogger pressure transducers will be set to record water level (or barometric pressure for the Barologger) at 30-minute intervals.

At the time of installation of the Levelogger, a calibrated electric-line sounder will be used to manually measure the depth to water relative to the top of the well casing. Manual water level measurements will occur at the wells where transducers are installed on a quarterly basis. The manually recorded depth to water, along with barometric data, will be used to generate a calibrated time series of ground water elevation. Levelogger data retrieval will coincide with manual observations of ground water level on a quarterly basis to allow for recalibration of each quarterly data set. SPF uses a Waterline electric-line sounder that is calibrated annually with a steel tape.

3.4.4.2.6 Spring Flow Measurement

The flow from each spring will be measured using a container of known volume and a stopwatch. When possible, flow measurements will be accomplished without altering the spring or disturbing the area around the spring. In some instances, temporary piping will be used to collect flow into a measureable stream. A general description of the spring and any associated stock tanks or ponds will be recorded along with photographic documentation.

3.4.4.2.7 Dedicated Pump Installation

Permanent, dedicated pumps will be installed in the eight monitoring wells that do not already have pumps installed and where water quality samples will be collected. The Bishop Well and wells PW-1 (109353), Prod-1 (107457), and 59760 (107462, Middle Sweizer, or TW-1) already have permanent pumps. The new pumps were installed prior to the winter 2013 sampling event.

A 3-inch submersible pump manufactured by Grundfos will be installed in each of the eight wells. The pumps are constructed of stainless steel and synthetic materials. The pumps do not contain mercury. Pumps were selected for each well based on well capacity and available drawdown, so that the time required to purge each well can be minimized. The pumps will be set on 1.25-inch diameter Schedule 80 PVC drop pipe with stainless steel couplers. The pump to be installed in each of the eight wells is listed in **Table 14**, along with motor horsepower, design criteria, drop pipe diameter, and setting depth. This information will be recorded on the data collection form during each sampling event. Each pump will be powered by a portable generator with a 240V, 30 amp breaker. A hole will be drilled in each pump check valve to allow water to slowly drain from the drop pipe to prevent freezing.

Table 14. Grassy Mountain Monitoring Well Dedicated Pumps

Well No.	Well Casing Diameter [in]	Constructed Well Depth [ft]	Design Pumping Rate [gpm]	Drop Pipe Diam [in]	Setting Depth Below Casing [ft]	TDH [ft]	Recom Grundfos Pump	Motor HP
GW-1	4	156	20	1.25	105	98	22SQ-120	0.75
GW-4	4	370	30	1.25	126	133	22SQ-220	1.5
PW-4	6	375	30	1.25	147	144	22SQ-220	1.5
BLM	6	175	5	1.25	168	170	5SQ-180	0.5
59761	4	118	10	1.25	105	99	10SQ-110	0.5
59763	6	323	3	1.25	322	302	5SQ-230	0.75
59766	4	45	3	1.25	42	36	5SQ-90	0.5
59772	4	207	26	1.25	126	133	22SQ-160	0.75

At the time of pump installation, the following additional equipment will also be installed:

- A sanitary well seal installed on the top of the well casing inside the outer protective surface casing. The well seal (Baker cast iron well seal or equal) will have double holes and access port. One hole will be used for drop pipe penetration, one hole will be used for accessing the sounding tube, and the access port will be used for access to the pump motor electrical cable. The access port will provide venting for the well, and additional venting will be provided by cutting slots in the sounding tube above the static water level.
- A stainless-steel tee installed on top of the well seal, with the bottom vertical leg supporting the pump drop pipe by a threaded connection, the top vertical leg capped but available for connection to the field water-quality testing/flow bypass manifold, and the horizontal leg fitted with a stainless steel ball valve and barbed fitting available for connection to temporary Tygon tubing for water-quality sampling.
- 1-inch Schedule 40 PVC sounding tube, placed from the top of the casing to the top of the pump and strapped to the drop pipe at each joint with stainless steel straps. The sounding tube shall be accessed at the surface through the well seal.

Prior to installation of the permanent pumps, one of the pumps will be set on one piece of PVC drop pipe and lowered into a 30-gallon container of deionized water. A stainless-steel tee, ball valve, and barbed fitting will be installed on top of the drop pipe. A piece of Tygon tubing will be connected to the barbed fitting. All equipment will be decontaminated using deionized water. The pump will be turned on, and deionized water will be pumped through the pump, drop pipe, tee, ball valve, barbed fitting, and tubing. An equipment blank will be collected from this pumped deionized water and submitted to the laboratory for analysis of all the analytes listed in **Table 15**. A transfer/equipment blank will also be collected directly from the 30-gallon container of deionized water to determine if the deionized water is contaminated prior to pumping through the equipment.

Collection of the pumping system equipment blank will be used to evaluate the effectiveness of the decontamination procedure and to assess any potential contamination resulting from the pump and associated equipment. It is anticipated that analytical results from the equipment blank will be received and evaluated prior to installation of the pumps in the monitoring wells. If the laboratory analyses indicate the presence of any of the analytes outside acceptable laboratory accuracy control limits, then corrective action will be taken, which may include decontaminating the pumping equipment again and collecting another equipment blank.

All pumps, drop pipe, and other equipment will be decontaminated and rinsed with deionized water prior to installation in the monitoring wells.

3.4.4.2.8 Field Water-quality Testing Manifold

To allow for measurement of field water quality parameters directly from the pump discharge, a testing manifold will be connected to the top vertical leg of the stainless steel tee installed above the well seal in each monitoring well. This testing manifold (see **Photo 1)** will also provide an outlet for bypass and purge flows from the pump. Discharge manifold piping and valves in contact with water samples are constructed of inert PVC.

The testing manifold provides a flush line for purge flows and a connection to a field water quality sampling port and multi-probe flow container. A third leg originally intended to provide a connection to a water quality sampling port with filter will no longer be used. When purging the well prior to sample collection, the stainless steel ball valve located on the horizontal leg of the tee will be closed and the PVC ball valve on the manifold flush line will be opened. When field water quality parameters are to be measured, the PVC ball valve on the manifold field water-quality line will be opened to direct flow to the multi-probe flow container.

The 0.45-micrometer (μm) filter has a maximum pressure rating of 23 pounds per square inch (psi), so the PVC ball valve on the main testing manifold line can be opened as needed to prevent excessive pressure through the filter.

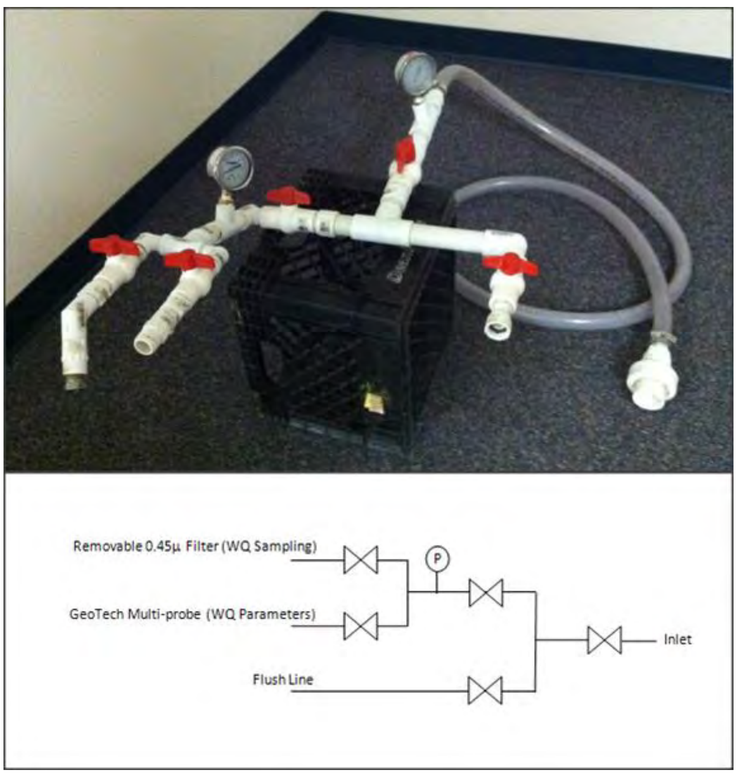

Photo 1. Discharge testing manifold photograph and diagram

3.4.4.2.9 Purge Pumping

Each monitoring well will be pumped to purge a minimum of three casing volumes of water from the well, standard practice to remove stagnant water prior to ground water sample collection. Purge water will be discharged to waste at the well site through the field water quality testing manifold.

During pumping, the pumping rate will be measured using a 5-gallon bucket and stopwatch. Pumping volume will be calculated from the pumping rate and pumping duration. Pumping rate and volume will recorded on the field data collection form. Additionally, field water quality parameters will be measured and recorded on the data collection form. The appearance and odor of the purged water will be noted.

After a minimum of three casing volumes have been pumped, and once field water quality parameters have stabilized, water-quality samples can be collected. The anticipated time required for purging each well can be calculated based on the design pumping rate of the pump that will be installed and the casing volume of each well. This information is presented in a summary table of monitoring well construction and purge pumping calculations included with the monitoring plan in Appendix E. Note that because Prod-1 continuously flows by artesian pressure, this well will not be purged and samples will be collected directly from the artesian flow.

3.4.4.2.10 Field Water Quality Parameters and Analysis

Purge water will be discharged from the pump into the testing manifold and part of the flow will be diverted through the Geotech multiprobe flow container. This flow container allows for continuous measurement of field parameters (pH, temperature, electrical conductivity, specific conductance) without aeration of the sample. Field parameters will be monitored during purging to ensure parameters are stable prior to sampling. Parameters will be considered stable when consecutive measurements taken a maximum of one casing volume apart meet the following conditions: temperature within 1 degree Celsius, pH within 0.3 standard pH units, and specific conductance measurements within 10 percent of each other (ODEQ 2009). Dissolved oxygen will be measured in a separate purge water container (clean plastic bucket). At least two measurements of field water quality data will be recorded on the data collection form.

The testing manifold and flow container will only be used for measuring field water quality parameters; water collected for laboratory analyses will not pass through the manifold but will instead be diverted through the horizontal leg of the stainless steel tee at the well head. Therefore, decontamination and collection of equipment blanks from the testing manifold is not considered necessary.

Only springs with a minimum flow of approximately ¼ liter per minute will be sampled. Any flow less than that is considered unsuitable for collecting samples. For those springs that flow continuously, conditions will be considered steady state and only one set of stabilized field parameters (pH, electrical conductivity, specific conductance, dissolved oxygen) will be collected. For those springs that are normally valved off, the isolation valve will be opened and the spring will be allowed to flow for a minimum of 15 minutes prior to field water quality measurements.

Spring flow will be collected in a 5-gallon plastic bucket (or smaller plastic container for low-flow rate springs), pre-rinsed with water from that spring. Flow measurements will be accomplished without altering the spring or disturbing the area around the spring. The sensors for the pH meter, conductivity meter, and dissolved oxygen meter will be rinsed with spring water and placed in the sample bucket. Readings will be recorded once the measurements have stabilized. The same meters will be used as for ground water sampling.

Equipment calibration will be performed prior to the sampling event and checked again on the morning of each sampling day. Field personnel will be required to review an “instruction manual” prior to using the equipment.

The field equipment (or equal) that will be used for measuring field water quality parameters is listed below, along with the equipment calibration procedure. Personnel performing equipment calibration will be adequately trained, and results of calibration will be recorded on the calibration form included with the monitoring plan in Appendix E.

1. The pH (S.U.) will be measured using a YSI EcoSense Model pH100 meter. A 2-point calibration will be performed using pH 4, 7, or 10 standard solutions.
2. Specific Conductance (SC, μS/cm @ 25°C) will be measured using a YSI EcoSense Model EC300 meter.

3. Electrical Conductivity (EC, µS/cm) will be measured using a YSI EcoSense Model EC300 meter.
4. Temperature (°C) will be measured using the YSI Model EC300 meter.
5. Dissolved Oxygen (mg/L) will be measured using an OxyGuard Handy Polaris 2 Portable DO meter. This DO meter automatically compensates for temperature and barometric pressure, and has an automatic calibration with stability check. The calibration of the instrument will be checked on a daily basis to ensure that the meter is operating within the acceptable range.

3.4.4.2.11 Sample Collection for Laboratory Analysis

Ground water quality samples will be collected from monitoring wells for analysis at the laboratory after a minimum of three casing volumes have been purged and the field water-quality parameters have stabilized as evidenced by the conditions described above. The constituents that will be sampled from each well for analysis at the laboratory are listed in **Table 15**. **Table 15** also includes the laboratory testing method, the laboratory detection limit, and the reporting limit. The laboratory that will be used for sample analysis will be an Oregon Environmental Laboratory Accreditation Program (ORELAP) accredited out-of-state lab for inorganic chemistry and physical properties in water. Initially, SPF anticipates using ACZ Laboratories in Colorado for this service.

For metals, samples for both total and dissolved metals will be collected. These are identified in **Table 15**. For the other parameters, only total samples will be collected. The preservatives used by the laboratory and the recommended holding times for each testing method are summarized in **Table 16**.

This list of constituents is quite extensive and some may be removed from the list after a number of sampling events demonstrate that the constituent is not of concern.

Water quality samples from wells will be collected using permanent dedicated pumps installed in each monitoring well. The pump will be installed on drop-pipe below the cast iron well seal, and a stainless steel tee will be installed above the well seal with a threaded connection to the drop-pipe. On the horizontal leg of the tee, a stainless steel ball valve and barbed fitting will be installed in each well. A piece of disposable Tygon tubing will be connected to the barbed fitting for collecting water quality samples. This tubing will only be used once and then discarded.

For collection of samples to be analyzed for dissolved metals, samples will be filtered in the field using a disposable high-capacity field filter with 0.45-µm membrane (Geotech dispos-a-filter with Versapor membrane) connected directly to the disposable Tygon tubing. Pressure to the filter will be maintained below the filter maximum pressure rating of 23 psi. The filter and tubing will be discarded after use at a single monitoring well.

Collection of samples from continuously flowing artesian wells will be conducted in the same manner as spring water samples (described below).

Table 15. List of Water Quality Analytes and Testing Methods

Parameter	Laboratory Method of Analyses	Detection Limit	Reporting Limit	Sample Type
Aluminum, Al	USEPA 200.7	0.03 mg/L	0.15 mg/L	total and dissolved
Total Arsenic	USEPA 200.8	0.0002 mg/L	0.001 mg/L	total and dissolved
Inorganic Arsenic	As speciation by HPLC ICP/MS	0.5 ug/L	0.5 ug/L	total and dissolved
Barium, Ba	USEPA 200.7	0.003 mg/L	0.015 mg/L	total and dissolved
Cadmium Low	USEPA 200.8	0.0001 mg/L	0.0005 mg/L	total and dissolved
Calcium, Ca	USEPA 200.7	0.2 mg/L	1 mg/L	total and dissolved
Chromium Low	USEPA 200.8	0.0005 mg/L	0.002 mg/L	total and dissolved
Copper Low	USEPA 200.8	0.0005 mg/L	0.0025 mg/L	total and dissolved
Iron, Fe	USEPA 200.7	0.02 mg/L	0.05 mg/L	total and dissolved
Lead Low	USEPA 200.8	0.0001 mg/L	0.0005 mg/L	total and dissolved
Magnesium, Mg	USEPA 200.7	0.2 mg/L	1 mg/L	total and dissolved
Manganese Low	USEPA 200.8	0.0005 mg/L	0.0025 mg/L	total and dissolved
Mercury, Hg (Low Level)	1631E	0.2 ng/L	0.5 ng/L	total and dissolved
Nickel Low	USEPA 200.8	0.0006 mg/L	0.003 mg/L	total and dissolved
Potassium, K	USEPA 200.7	0.3 mg/L	1.5 mg/L	total and dissolved
Selenium Low	USEPA 200.8	0.0001 mg/L	0.00025 mg/L	total and dissolved
Silver Low	USEPA 200.8	0.00005 mg/L	0.00025 mg/L	total and dissolved
Sodium, Na	USEPA 200.7	0.3 mg/L	1.5 mg/L	total and dissolved
Zinc, Zn	USEPA 200.7	0.01 mg/L	0.05 mg/L	total and dissolved
Antimony	USEPA 200.8	0.0004 mg/L	0.002 mg/L	total and dissolved
Beryllium	USEPA 200.8	0.00005 mg/L	0.00025 mg/L	total and dissolved
Bismuth	USEPA 200.7	0.04 mg/L	0.2 mg/L	total and dissolved
Boron	USEPA 200.8	0.0005 mg/L	0.001 mg/L	total and dissolved
Cobalt	USEPA 200.8	0.00005 mg/L	0.00025 mg/L	total and dissolved
Gallium	USEPA 200.7	0.1 mg/L	0.5 mg/L	total and dissolved
Lithium	USEPA 200.7	0.02 mg/L	0.1 mg/L	total and dissolved
Molybdenum	USEPA 200.8	0.0005 mg/L	0.0025 mg/L	total and dissolved
Scandium	USEPA 200.7	0.1 mg/L	0.5 mg/L	total and dissolved
Strontium	USEPA 200.7	0.01 mg/L	0.05 mg/L	total and dissolved
Thallium	USEPA 200.8	0.0001 mg/L	0.0005 mg/L	total and dissolved
Tin	USEPA 200.8	0.0004 mg/L	0.002 mg/L	total and dissolved
Titanium	USEPA 200.7	0.005 mg/L	0.025 mg/L	total and dissolved
Vanadium	USEPA 200.8	0.0002 mg/L	0.001 mg/L	total and dissolved
Nitrate (as N)	USEPA 353.2	0.02 mg/L	0.1 mg/L	total
Ammonia Direct (as N)	USEPA 350.1	0.05 mg/L	0.5 mg/L	total
Nitrite (as N)	USEPA 353.2	0.01 mg/L	0.05 mg/L	total
Alkalinity	SM 2320B	2 mg/L	20 mg/L	total
Bicarbonate	SM 2320	2 mg/L	20 mg/L	total

Table 15. List of Water Quality Analytes and Testing Methods

Parameter	Laboratory Method of Analyses	Detection Limit	Reporting Limit	Sample Type
Carbonate	SM 2320	2 mg/L	20 mg/L	total
Chloride, Cl	USEPA 300.0	0.5 mg/L	2.5 mg/L	total
Conductivity	SM 2510B	1 umhos/cm	10 umhos/cm	total
Cyanide, Total	USEPA 335.4	0.003 mg/L	0.01 mg/L	total
Cyanide, Weak Acid Digestion	SM 4500	0.003 mg/L	0.01 mg/L	total
Fluoride, F	USEPA 300.0	0.1 mg/L	0.5 mg/L	total
Hardness	SM 2340 B	calc	calc	total
pH	SM 4500-H B	0.1 C	0.1 C	total
Sulfate, SO4	USEPA 300.0	0.5 mg/L	2.5 mg/L	total
Total Dissolved Solids	SM 2540C	10 mg/L	20 mg/L	total
Total Suspended Solids	SM 2540D	5 mg/L	20 mg/L	total
Total Phosphorus	USEPA 365.1	0.01 mg/L	0.05 mg/L	total

Table 16. List of Water Quality Analytes, Hold Times, and Preservatives

Parameter	Laboratory Method of Analyses	Hold Time	Preservative	Bottle Type
Aluminum, Al	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Total Arsenic	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Inorganic Arsenic	HPLC ICP/MS	28 Days	EDTA-HAc	125 mL amber HDPE
Barium, Ba	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Cadmium Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Calcium, Ca	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Chromium Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Copper Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Iron, Fe	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Lead Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Magnesium, Mg	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Manganese Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Mercury, Hg (Low Level)	1631E	90 Days	5mL HCl	250 mL borosilicate glass
Nickel Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Potassium, K	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Selenium Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Silver Low	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Sodium, Na	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Zinc, Zn	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Antimony	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Beryllium	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Bismuth	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE

Table 16. List of Water Quality Analytes, Hold Times, and Preservatives

Parameter	Laboratory Method of Analyses	Hold Time	Preservative	Bottle Type
Boron	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Cobalt	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Gallium	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Lithium	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Molybdenum	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Scandium	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Strontium	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Thallium	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Tin	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Titanium	USEPA 200.7	6 Months	2mL 50% HNO3	250 mL HDPE
Vanadium	USEPA 200.8	6 Months	2mL 50% HNO3	250 mL HDPE
Nitrate (as N)	USEPA 353.2, Revision 2.0	28 Days	H2SO4	250 mL HDPE
Ammonia Direct (as N)	USEPA 350.1	28 Days	None	250 mL HDPE
Nitrite (as N)	USEPA 353.2, Revision 2.0	28 Days	H2SO4	250 mL HDPE
Alkalinity	SM 2320B	14 Days	None	500 mL HDPE
Bicarbonate	SM 2320	14 Days	None	500 mL HDPE
Carbonate	SM 2320	14 Days	None	500 mL HDPE
Chloride, Cl	USEPA 300.0	28 Days	None	250 mL HDPE
Conductivity	SM 2510B	28 Days	None	500 mL HDPE
Cyanide, Total	USEPA 335.4	14 Days	5 mL 10N NaOH	500 mL HDPE
Cyanide, WAD	SM 4500	14 Days	5 mL 10N NaOH	500 mL HDPE
Fluoride, F	USEPA 300.0	28 Days	None	250 mL HDPE
Hardness	SM 2340 B	NA	NA	NA
pH	SM 4500-H B	*	None	500 mL HDPE
Sulfate, SO4	USEPA 300.0	28 Days	None	250 mL HDPE
Total Dissolved Solids	SM 2540C	7 Days	None	500 mL HDPE
Total Suspended Solids	SM 2540D	7 Days	None	500 mL HDPE
Total Phosphorus	USEPA 365.1	28 Days	2mL 25% H2SO4	250 mL HDPE

*Perform in field within 15 minutes of sample collection. Laboratory analyses of pH are considered estimated.

Water quality samples from springs will be analyzed for the same constituents as for samples collected from monitoring wells. **Table 16** lists the constituents that will be sampled from each spring for analysis at the laboratory, including the proposed laboratory testing method. For metals, samples for both total and dissolved metals will be collected. For the other parameters, only total samples will be collected. Water quality samples will be collected without altering the spring or disturbing the area around the spring.

For non-filtered samples (non-metals), water quality samples will be collected for analysis at the laboratory directly from each spring by placing sample bottles directly under the spring discharge pipe (if present), or dipped directly from the spring water surface (if a pipe is not present). For those springs that flow continuously, conditions will be considered steady state and sampled will be collected immediately following field water quality measurements. For those springs that are normally valved-off, the isolation valve will be opened and the spring will be allowed to flow for a minimum of 15 minutes prior to sample collection.

All of the filtered samples at a site will be collected in the same clean container. A peristaltic pump (Geotech Geopump with easy-load pump head) and associated Tygon tubing will be used to transfer the water sample from the container, through a disposable high-capacity field filter with 0.45-μm membrane, and into the appropriate sample bottle obtained from the laboratory. The procedure will follow the "in-line peristaltic pump filtration from a container" method described in the *Water Monitoring and Assessment Mode of Operations Manual* (ODEQ 2009). Filtration equipment, including tubing, collection container, and filter, will only be used at a single site and then discarded. A site-specific testing plan for each spring is included with the monitoring plan in Appendix E.

The USEPA Method 1669 is the recommended procedure for collecting water quality samples for trace metals at USEPA Water Quality Criteria Levels. The sample collection procedures described above and in the ODEQ *Water Monitoring and Assessment Mode of Operations Manual* (ODEQ 2009) will be followed. These procedures may differ from the exact requirements of USEPA Method 1669, but the collection and analysis of blank samples as described in Section 3.4.4.2.12 will be used to verify the accuracy of sampling procedures.

The laboratory that will be used for water quality sample analysis will be accredited by National Environmental Laboratory Accreditation Program (NELAP) for water analysis. The proposed analytical methods are appropriate to meet ODEQ reporting and detection limits.

Samples will be collected in bottles supplied by the accredited laboratory. The laboratory will prepare the bottles with the appropriate preservative as required by the testing method. Samples will be taken by field engineers wearing latex gloves discarded after each use. Care will be taken to prevent the sample bottles and other sampling equipment from contacting the sampling source (i.e., supply pipe), ground, or other potential sources of contamination.

Following collection, sample bottles will be properly labeled with the sampling location, date, time, and other pertinent information. The sample bottles will be immediately packed in a cooler with ice packs. Samples will be mailed to the laboratory within specified hold times with proper chain-of-custody documentation.

At the conclusion of each monitoring event, the field technician will review field data sheets to ensure completion of all appropriate data. Upon determination that the data sheet is complete, the technician will initial the sheet to verify its completion.

Following receipt of all laboratory data, the monitoring event shall be reported in a monitoring event memo or report. This document shall include all event data (field measurements, photographs, laboratory data, QA/QC, etc.). The report shall be available in electronic and hard copy formats, and shall be stamped by a registered Oregon geologist. Data shall be incorporated into a baseline water resource monitoring data base.

3.4.4.2.12 Quality Assurance/Quality Control

Prior to installation of the permanent pumps, an equipment blank will be collected from one of the pumping systems (pump, piece of drop pipe, tee, valve, tubing, and filter) by pumping deionized water through the system. All equipment will be decontaminated using deionized water prior to collection of the equipment blank. The equipment blank will be used to evaluate the effectiveness of the decontamination procedure and to assess any potential contamination resulting directly from the pump and associated equipment. This equipment blank is considered to be representative of all the pumping equipment installed in the wells. If this blank indicates adequate decontamination procedures, then no additional equipment blanks will be collected from the monitoring wells.

Equipment blanks will be collected from the peristaltic pumping apparatus at a 10 percent sampling frequency. A total of between 7 and 11 springs, depending upon whether flow is observed at the spring, plus well Prod-1 will be sampled. Therefore, one equipment blank will be collected from the pumping apparatus. Collection of the equipment blank will follow this procedure: (1) a clean container will be filled with deionized water, (2) a new piece of Tygon tubing will be installed in the peristaltic pump head, (3) the inlet end of the tubing will be placed into the container, (4) a new 0.45-µm filter will be installed on the other end of the tubing, and (5) the pump will be started and equipment blank samples will be collected in sample bottles. The equipment blank will be analyzed for all of the analytes listed in **Table 15**.

Water quality samples for non-filtered samples will be collected directly from each spring by placing sample bottles directly under the spring discharge pipe or the water surface of the spring. Therefore, collection of transfer blanks at a 10 percent sampling frequency is appropriate. One transfer blank will be collected at a randomly selected spring. Collection of the transfer blank will involve pouring a sample of deionized water from its original transport container directly to sample bottles. The transfer blank will be analyzed for all the analytes listed in **Table 15**.

The equipment and transfer blank analytical results will be compared with laboratory quality control limits. If the blanks fail the quality control limits, then target limits will be estimated for the sampling event. Results will be presented in the sampling event monitoring report and any questionable sample results will be flagged. Corrective actions will be identified and implemented prior to the next sampling event.

Field duplicate samples will be collected at a 10 percent sampling frequency for quality assurance purposes and is used to measure precision between samples. A total of 12 wells will be sampled and between seven and one springs, so two field duplicate will be collected from one monitoring well and one spring selected at random. This duplicate sample will be identified as such and analyzed for all the analytes listed in **Table** 15. The laboratory's duplicate precision control limit will be used to evaluate field duplicate samples. The primary sample and duplicate samples will be compared based on the precision control limits, and any discrepancies noted. Results of the duplicate sample analyses will be presented in the sampling event monitoring report and any questionable sample results will be flagged.

In addition to field QA/QC, the laboratory will complete blank, spike, and duplicate sample tests in accordance with ISO 17025 and ISO 9001 standards. Results will be presented in the sampling event monitoring report.

3.4.4.3 Plan for Future Testing

3.4.4.3.1 Plan for Testing of Future Water Supply Wells

There are four identified water supply wells within one mile of the proposed permit boundary. These are the BLM Well, PW-1, PW-4, and Prod-1. Construction details for these wells are provided in **Table 6**, and ground water elevations based on static water level measurements made in May/June 2012 and approximate ground elevations are provided in **Table 8**. A map showing these wells, the permit boundary, and the one-mile radius is included as **Figure 12, Water Supply Wells**. In addition to the four wells identified above, an additional well (PW-4) is located more than 1 mile from the permit boundary.

The existing onsite wells, PW-1, PW-4, and Prod-1, have all been test-pumped in the past as described in JMM 1991 and SRK 1989. This testing occurred in 1989 and 1991. Aquifer testing was performed with the objective of characterizing the hydrogeology and for assessing water supply potential. Additional testing of these wells is not considered necessary at this time because of this historical testing.

It is anticipated that additional wells will need to be constructed and tested to meet water demands for mining, processing, and hauling operations. Water supply for the processing area may be met in part by piping water from dewatering/production wells located near the mine site. The project's anticipated peak water use is currently estimated to be approximately 350 gpm, average water use will likely range from 150 to 300 gpm. Given the relatively low yield of existing onsite water supply wells, two or more new wells may be needed to meet project water demands. At this point in time in the project development, a general description of potential locations for water supply wells, potential construction details, and an outline for a testing program can be made. A more concrete plan for water supply development can be put forth once site infrastructure and mining plans are better defined. Therefore, it is possible that the general description provided below may change as the project moves forward.

Once the two new wells are completed, the first production well will be test pumped at the design capacity of the well. Flow will be measured using a flow meter or other acceptable means. Water level drawdown will be measured using an electric-line well sounder with measurements occurring throughout the test. The second new well and the other existing wells be used as monitoring wells. Additionally, other wells in the vicinity (one to two miles) would be used as monitoring wells, such as well 89-2 in Negro Rock Canyon.

Drawdown will be measured in the monitoring wells to assess the drawdown response of pumping the production well. It is anticipated that water levels will be measured manually with an electric-line well sounder. A pressure transducer may also be installed in a monitoring well for continuous water level measurements. The pumping test would be planned for several days. If an adequate water supply cannot be developed from the existing water supply wells and the two new wells, additional exploration drilling will be conducted to develop the remaining project water supply. Plans for testing of additional test production wells will be similar to the testing proposed for new wells.

3.4.4.3.2 Plan for Additional Ground Water Characterization and Monitoring Well Construction

This section describes an initial plan for ground water characterization near the ore body and in the processing area as well as the general content of a more detailed plan. Because the project is in the early stage of planning, it is not possible to identify the exact locations of all future monitoring wells, definitively describe how they will be constructed, and the specific details of the testing program. Incorporating the results of the initial characterization, a more detailed plan for ground water characterization will be developed as the project progresses and site infrastructure and mining plans are better defined.

The initial characterization will include two steps:

1. A thorough examination of past work to determine what may be useful for ground water characterization, as well as to identify data gaps where additional information is needed, and
2. Development of a report describing the conceptual model of the site. The conceptual model will identify the nature and interaction of the various water-bearing units and aquitards in relation to relevant geologic structures, which water-bearing units are hydraulically connected (i.e., the same aquifer) and whether each aquifer is unconfined, semi-confined, or confined.

The detailed characterization plan will use the site conceptual model to propose additional ground water characterization work sufficient to fill existing data gaps. The detailed ground water characterization work plan will be submitted for review prior to completion of the Oregon Division 37 Chemical Process Mining Consolidated Permit Application.

Additional characterization work near the ore body will include at least one exploration borehole near the ore body drilled to a depth below the ore body; a depth of 1,000 feet is initially proposed. The boring will be drilled using a “drill a while then wait a while” method to minimize the potential for drilling past water-bearing zones. All water-bearing zones encountered by the borehole will be noted by the observing geologist. Well cuttings will be collected, examined in the field for moisture content, and inventoried and a geophysical log may be performed to provide additional information on the formation. If the borehole encounters ground water, the hole may be completed as a 6-inch well with a screen interval targeting the deepest water-producing zone. Filter pack would be placed around the screens and the well would be sealed to the surface. This well may be used as a future dewatering/water supply well for the mine. Well construction will comply with OWRD guidelines and requirements.

Based on the results of the first exploration borehole, additional wells may be needed to adequately characterize the water quantity and quality of all potentially affected water-bearing zones near the ore body. These additional wells would be constructed to target additional water-bearing zones encountered by the first hole. These wells would likely be shallower than the first well and completed as monitoring wells with minimum 4-inch PVC casing and screen. Filter pack would be placed around the screens and the well would be sealed to the surface.

In the proposed ore processing area, the Bishop well has been test pumped, and water-quality samples have been collected in the past. This data is useful for a preliminary description of ground water-quality and aquifer characteristics, but additional data are needed with the objective of characterizing the water quality and water quantity of the uppermost regional water-bearing zone. The ore processing area is a promising location for water supply development, as described in Section 3.4.4.3.2. Additional ground water quality characterization in the ore processing area may be accomplished by collecting ground water quality samples during test pumping of the proposed test production wells described in Section 3.4.4.3.2. Future sampling can be conducted using a temporary or permanent pump.

Near the ore body, there are numerous (approximately 200) exploration holes. There are records of total depth, collar elevation, depth to water, and an estimate of flow when water was encountered. A map of these holes has been located, but what is not known is if any of these holes are still open and their locations relative to recent mining plans. If any are holes are determined to be open, piezometers may be installed to provide additional hydraulic data for ground water characterization.

In 1993, test pumping and rising head permeability tests were performed on several wells understood to be located near the ore body. Wells included in this testing were 59760 (also referred to as middle Sweizer or TW-1), 59761 (also referred to as lower Sweizer or MW-2) and MW-3. A more thorough examination of these tests and associated results will occur to determine if this previous work as well as other work already performed on site to determine whether ground water in the vicinity of the ore body has been fully characterized. Previous work will be used to the extent possible to assess potential impacts from mining on ground water-quality and quantity, and to quantify ground water inflows into the mine.

After a thorough examination of previous hydrogeological studies, additional wells will be installed in the vicinity of the ore body for ground water characterization. Wells would be sited in a location near the ore body but outside the active mining area so the wells can be used for the life of the mine. Exact locations for the wells can be determined once site facilities and mine workings are better defined.

Ground water quality samples can be collected from these wells using temporary or permanent pumps, with sampling and analysis procedures consistent with baseline study work plan procedures. Additionally, these wells may be used to determine hydraulic head, gradient, and conductivity information (by slug-testing or test pumping) in the area of the ore body. Long-term test pumping of one or more of these wells would be conducted to better define hydraulic parameters in the near vicinity of the deposit. Test-pumping may provide useful information to estimate ground water flow into the mine workings during operations. It is anticipated that new and existing wells in the vicinity would be used as monitoring wells.

3.4.4.3.3 Plan for Designating an Upgradient Monitoring Well

Ground water elevation contours generated from ground water levels measured during May/June 2012 indicate ground water generally flows in a westerly to northwesterly direction in the area of the project facilities. This is a general observation and does not account for localized conditions such as aquitards, aquicludes, or perched aquifers. It also does not account for the boundary effects of faults in the area.

These results are generally consistent with previous studies, including RMEC 2011and ABC 1992. JMM (1991) concluded that potentiometric data from the study area indicates that Grassy Mountain is a hydrologic divide between the Owyhee River and the Negro Rock Canyon.

SPF will continue to collect ground water level measurements during future quarterly sampling events and, once a site conceptual model is approved, develop ground water contour maps for each aquifer to further define the flow of ground water in the area of the mine. A survey of well head elevations will be completed to provide more accurate ground water elevations.

There are several existing monitoring wells that may be located upgradient (located easterly to southeasterly) of the mine site. These existing wells may serve as upgradient ground water quality monitoring sites. These wells are 59772 (upper Sweizer, MWS-13, OWRD Tag #109352), 59760 (middle Sweizer, TW-1, OWRD Tag #107462), 59761 (lower Sweizer, MW-2, OWRD Tag #109400), and GW-2 (OWRD Tag #109357). These wells are shown on **Figure 10** and available information on these wells is summarized in **Table 17**.

Table 17. Construction and Water Level Information for Monitoring Wells

Calico Well ID	OWRD Well Tag Number	Well Const. Depth (ft)	May/June 2012 Static WL (ft bgl)	Well Casing Diameter (in)
GW-2	109357	325	Not Measured	4
59760	107462	203	86.11	6
59761	109400	117	86.45	4
59772	109352	207	92.53	4

Wells 59760, 59761, and 59772 were sampled (water level, water quality) during May/June 2012. These wells are also proposed for future quarterly baseline monitoring. GW-2 was not visited in May 2012 and at this time is not included in the list of wells that will sampled in the future. However, GW-2 may be a useful monitoring location because it is deeper than the other upgradient wells (total depth of 325 feet). This well is proposed for water level monitoring, and if conditions are acceptable will be used for continuous water level monitoring. Samples collected from GW-2 in 1989 by Western Technologies (WTI) as described in JMM 1991 were generally turbid and produced questionable water quality data. GW-2 was subsequently redeveloped, and found to contain significant drilling fluid. It appears that GW-2 was successfully redeveloped, and samples were collected by JMM in 1991.

None of the existing up-gradient wells reach to the total anticipated depth of the mine workings (approximately 1,000 feet). To better describe ground water quality upgradient and from depths at or below the ore body, a deep monitoring well will be needed. Construction of this well would serve two main purposes: (1) provide a ground water monitoring location upgradient of the mine and (2) be used to characterize ground water in the vicinity of the ore body.

As described in Section 3.4.4.3.2, at least one well will be constructed near the ore body and located to serve the life of the mine. The first exploration borehole would be drilled to a depth below the ore body. If the borehole encounters ground water, the hole may be completed as a 6-inch well with screens targeting the deepest water-producing zone. This well could then be sampled to provide upgradient ground water quality information. Ultimately this well could be used as a future dewatering/water supply well for the mine. Based on the results of the first exploration borehole, additional wells will be constructed to adequately characterize the water quantity and quality of all potentially affected water-bearing zones near the ore body.

3.4.5 Timing and Duration of Baseline Data Collection and Verification

It is anticipated that baseline data collection will be conducted on the schedule outlined in Section 3.4.4.2.3, with a minimum baseline data collection period of one year.

Although existing data have been collected during previous investigations as described in Section 3.4.4.1, Calico understands that these data may not be accepted for inclusion in the baseline data set if data collection methods not in accordance with approved work plan methods or were not properly document. Existing data will be reviewed by Calico for applicability and, if acceptable, proposed for inclusion in the data set. Calico understands that existing data may not be accepted.

SUMMARY INFORMATION REGARDING ACID MINE DRAINAGE AT THE PROPOSED GRASSY MOUNTAIN MINE

The following information is excerpted from the Geochemistry Baseline Report (SRK, 2018) which has been submitted to the TRT for review. Following TRT review, additional test work has been initiated, which will be included in the final Geochemistry Baseline Report, to be submitted as part of the Consolidated Permit Application. These excerpts are from a document that is public information, having been discussed in public meetings related to DOGAMI's Division 37 Pre-Application process for the Consolidated Permit Application. The information included in this summary is meant to highlight the purpose of the tests, the results and the ongoing tests. It is not meant to be a stand along document for the geochemistry of the proposed Grassy Mountain Mine. Calico recommends interested parties request the full document.

A brief list of the issues in this summary of the Geochemistry Baseline Report, as they relate to the proposed Grassy Mountain Mine, are:

- Most of the rocks that will be mined at Grassy have the potential for producing acid.
  - Testing has been conducted to determine the Net Acid Generation (NAG) of the ore, waste and tailings types
  - Additional testing has been conducted to determine the amount of lime needed to neutralize each rock type to comply with the Oregon regulations (Chemical Mining Rules, OAR 340-043 and Division 37 Chemical Process Mining, Oregon Administrative Rule (OAR) 623-037-0055 and OAR 632-037- 0085)
  - All material that will be put on the Tailings Site Facility or backfilled into the mine will be neutralized to at least the levels required by the regulations stated above
  - Prior to neutralization, acid generating material will be in full containment (see Tailings Design Report summary)
- Tests have also been conducted (or are in progress) to determine the NAG on the borrow material that will be backfilled into the mine and used for construction purposes.
  - These tests are still in progress, but no acid generating borrow material will be used for mine backfill, unless it is neutralized in compliance with Oregon regulations (as stated above)

Purpose and Scope

SRK Consulting U.S., Inc. ("SRK") has completed a baseline geochemical characterization study for the Grassy Mountain Project, Oregon on behalf of Calico Resources USA Corp. ("Calico").

The Grassy Mountain Project consists of an underground gold resource located in Malheur County, Oregon, about 22 miles south-southwest of Vale, Oregon in an area where no previous mining activity has occurred. Processing will be by conventional mill and containment of tailings in an engineered tailings impoundment.

The purpose of the baseline geochemical characterization program is to provide a prediction of the potential geochemical reactivity and chemical stability of mine waste that will be produced by the proposed Grassy Mountain underground gold mine. The results of the geochemical characterization program will assist in determining the potential for acid rock drainage and metal leaching associated with the project. Data produced during this study can be used in the project design process and as an operational tool for identifying material types that require special handling during operations.
The characterization work undertaken for the Grassy Mountain project meets the following regulatory requirements:

- Oregon Department of Geology and Mineral Industries (DOGAMI) Division 37 Chemical Process Mining, Oregon Administrative Rule (OAR) 623-037-0055 and OAR 632-037- 0085(Environmental Evaluation); and
- Applicable Oregon Department of Environmental Quality (ODEQ) Division 43 Chemical Mining Rules, OAR 340-043, which address process mining.

In addition, the geochemical characterization program was designed to follow guidelines set forth in the Bureau of Land Management Instruction Memorandum NV-2013-046, Nevada Bureau of Land Management Rock Characterization Resources and Water Analysis Guidance for Mining Activities (BLM, 2013).

In March 2013, SRK developed the *Final Revised Geochemistry Environmental Baseline Work Plan for the Grassy Mountain Project* (March 2013) pursuant to Oregon Revised Statute (ORS) 517.967 using criteria and/or guidelines and information provided by the technical review team (TRT) assembled for the project. This work plan was reviewed and approved by the TRT and contains a description of the baseline data requirements for the various resource categories including geochemical characterization of mine waste. As described in the approved baseline work plan, a detailed work plan with more information on sample selection, laboratory procedures and key criteria for decision-making throughout the process would be prepared and submitted for agency review and approval.

In January 2016 a revised Work Plan (*Geochemistry Baseline Study: Preliminary Results and Work Plan for the Grassy Mountain Project)* was submitted to the Oregon Department of Geology and Mineral Industries (DOGAMI) and Oregon Department of Environmental Quality (ODEQ) to provide a plan for additional sample collection; this report also provided description of the geochemical characterization study methodology and a summary of the data available to date. The Environmental Baseline Study Work

Plans were updated at the request of DOGAMI in September 2017. The updated Work Plans were approved in January 2017.

The following activities have been completed as part of the current geochemical characterization program:

- Review of site geology and identification of the primary material types.
- Collection of drill core samples representative of waste rock and ore.
- Collection of test residues from metallurgical testing that are representative of tailings material associated with the project.
- Static and kinetic laboratory testing of selected waste rock, ore and tailings samples.
- The two main considerations of this baseline environmental geochemical characterization are:

- Acid generation due to oxidation of sulfide minerals, which can potentially lead to development of Acid Rock Drainage (ARD).
- Potential for leaching of metals (e.g., manganese) and salts (e.g., sulfate).

The processes of acid generation and leaching can operate independently, although the development of acidic conditions enhances the leachability of many metals. To address this, an extensive characterization program has been completed for the Grassy Mountain Project to define the geochemical characteristics of the waste rock and ore as in terms of their potential to generate acid and generate low quality leachate.

Table 3-1 provides a list of the mine facilities that will require geochemical characterization, location and duration of the facility, and the types of geochemical data required. Characterization of the amended tailings and cemented rock backfill is not included in this program.

The design of the geochemical characterization program has been developed based on the geology of the site and the mine plan information that has been described in the CUP, and includes the following steps:

- Refinement of the current conceptual geochemical model for each mine facility including understanding of the geological materials involved and the conceptual management approach.
- Design of the sampling approach for each component.
- Selection of suitable test procedures to assess potential impacts.

Samples have been collected as part of a comprehensive program designed to examine the range of conditions that could occur. Tested materials include exploration core (as available), surface samples and test residues from metallurgical testing. The characterization studies were conducted in a manner that provides a conservative estimate of the composition of waste rock and ore, in order to provide information necessary to determine the potential environmental impacts in the environmental evaluation phase of the Division 37 permit process.

The geochemical baseline study is designed to follow guidelines set forth in the Bureau of Land Management Instruction Memorandum NV-2010-014, Nevada Bureau of Land Management Rock Characterization Resources and Water Analysis Guidance for Mining Activities (BLM, 2013). In addition, the program follows the guidance provided in the Global Acid Rock Drainage (GARD) Guide (INAP, 2009), the industry best practices for characterization to support evaluation of potential future impacts to water resources and design of appropriate mitigation strategies.

Leachate chemistry will be compared to Oregon Groundwater Quality Guidelines (OGWQG, OAR 340-40-020) to provide a context in which to understand and interpret the data.

Table 3-1: Program Design

Source	Description	Location	Duration	Composition	Sample Types	Geochemical Data Needs				
						Static	Mineralogy	Erionite Mineralogy	MWMP	HCT
Waste rock dump	Waste rock dump	Mine area (surface)	Permanent	Non-PAG and PAG waste rock	Core	X	X	X	X	X
Ore stockpile	Ore stockpiled near mill	Plant site	LOM	Underground ore	Core	X	X	X	X	--
Underground workings	Exposed rock in workings	Mine area (underground)	Permanent	Waste rock and ore	Core	X	X	X	X	X
Tailings	Dry stack tailings	Plant site	Permanent	Low pyrite tailings	Metallurgical testwork	X	X	--	X	X
Underground backfill[1]	Cemented backfill	Mine area (underground)	Permanent	Cemented waste rock	Core/cement	X	--	--	X	X
Access and haul roads[1]	Surface development (cut/fill)	Various	Permanent	Alluvium/bedrock	Surface samples	X	--	--	X	--
Topsoil stockpiles[1]	Surface development (Pre-strip)	Various	LOM	Soil for reclamation	Surface samples	X	--	--	X	--
Borrow material[1]	Borrow materials for construction	Various	Permanent	Non-PAG waste rock	Core	X	--	--	X	--

[1] Characterization of this material source is not included in this study and will be provided under separate cover.

Waste Rock and Ore

SRK collected a total of 105 samples for geochemical characterization testing as part of the current evaluation of the Grassy Mountain project. This included 68 samples collected from exploration drill core and 36 pulp samples representative of development rock (ore and waste rock). In addition, one sample of tailings material collected from the metallurgical testwork program was included in the characterization program. Sample collection activities are described in the following sections.

Sample selection is a fundamental step in the waste rock/ore characterization program and requires careful consideration. Guidelines applied to determine sampling adequacy are provided by the USEPA (1994), by the British Columbia AMD Task Force (BCATF, 1989) and Canada's Mine Environment Neutral Drainage (MEND) Program (Price, 2009). However, professional judgment and sound geological knowledge of a deposit are even more significant factors in the number and types of samples selected, as opposed to a strict numerical adherence to the guidelines (INAP, 2009).

The MEND Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (Price, 2009) provides suggested initial sampling frequency based on tonnage of units mined. Based on the current mine plan, approximately 2 Mt of waste rock will be generated during mining. Between 26 and 80 samples is an appropriate number of samples for the baseline characterization program. However, sample selection should be based on best judgment and an understanding of the variability of the deposit geology.

To characterize the Acid Rock Drainage and Metal Leaching (ARD/ML) potential for the Grassy Mountain Project, a weighted approach was taken to assess the geochemical variability of geologic materials that will be encountered during mining. The approach included the collection of an appropriate number of samples based on the relative importance or mass of the lithological unit with respect to the total mass in the deposit. As stated in the GARD Guide, material types that comprise less than five percent of the waste rock typically require fewer samples since they are less likely to have a considerable influence on the geochemical nature of the dump facility (INAP, 2009).
Selection of representative sample intervals was completed with the aid of the Leapfrog Software package which enables 3D visualization of imported drill hole data. This can then be viewed in relation to the proposed underground workings and ore body. Sample intervals were selected from the exploration drill holes to develop a dataset that is as lithologically and as spatially representative of the deposit as possible with the information and drill core available for sampling.

SRK personnel visited the project site in January 2015 in order to collect representative samples of waste rock/ore from drill core being stored at the Vale core shed. During the sample program, SRK collected a total of 68 samples from core holes. The selected sample intervals range from about 10 to 20 feet in length depending upon the geology and gold grade. For each sample interval, approximately 8 to10 kg of sample material was selected from existing core boxes, placed in sample bags, and labeled with the drill hole number, and the interval. In all cases, the material type collected within each interval is identical. In addition to the core samples, 36 pulp samples were selected to characterize the waste rock within the decline area where limited core material was available.

The resulting dataset is lithologically representative of the deposit to the extent possible based on the scope of the exploration program and materials available. This shows good lithological representation of samples, with a bias towards material types that will ultimately comprise a greater proportion of development rock. The mudstone unit occurs at the base of the deposit and although only a very small amount of this material type will be mined as part of the current mine plan, it has been included in the geochemical characterization study for completeness. At the time of sample collection, none of the drill holes for which sample material was available intercepted the basalt and tuff units. Therefore, no samples of basalt or tuff have been collected to date. However, these units comprise less than one percent of the material that will be mined. If basalt or tuff is encountered in future exploration drilling programs, samples of these rock types will be collected for testing.

The dataset is spatially representative of the deposit to the extent possible based on the location of the drill holes and core/pulp material available. The spatial distribution of sample intervals in relation to the proposed underground decline and ore shells shows generally good spatial representation. However, a few gaps still exist due to a lack of drilling in some areas. Additional images showing sample distribution are provided in Appendix A. Even though GMC-014 is located outside the underground development, core samples were collected from this hole for similar material types due to limited core material available for the decline area.

Multi-element data and total sulfur data was not available for the exploration dataset; therefore, a statistical evaluation of the dataset cannot be made. However, Calico has developed a comprehensive geologic model of the deposit resulting in good geologic control of the sample selection. Based on the geologic interpretation, the geologic units are fairly continuous with consistent oxidation throughout the deposit. Furthermore, the geologic units that will be encountered in the northern portion of the deposit are geologically the same as the units in the other portions of the deposit and no new rock types will be encountered in this area. Therefore, the current dataset is lithologically representative of the deposit and is considered adequate for the baseline characterization program. However, some spatial gaps will need to be addressed in the future when drilling is conducted in these areas. Prior to initiation of mining in these areas Calico will develop and implement a sampling and testing program to verify and confirm the rock units in these areas are geochemically similar to the waste rock material included in the baseline geochemical characterization program. Sampling and testing methods will be consistent with the baseline geochemical characterization program to ensure comparable results.
Samples were submitted to McClelland Laboratories (Sparks, Nevada) for sample preparation and geochemical characterization testing.

Tailings Sample

A sample of tailings material from the metallurgical testing conducted at Resource Development Inc. was also analyzed. The metallurgical test was conducted on a sample collected from core that consisted of a range of lithologies and gold grades (i.e., average ore grade and composition). Due to the consistent nature of the geology of the deposit and the fact that the deposit has been oxidized, major shifts in the ore (and tailings) geochemistry is not anticipated. The tailings sample was collected after Inco cyanide destruction using sodium bisulfite as a SO2 source. Calico is planning on including the Inco cyanide destruction in their process circuit, therefore this sample is considered representative of the final tailing product.

Solution representative of process solution entrained in the tailings after cyanide destruction was not available from the metallurgical test for analysis. However, based on the proposed tailings disposal methods, the amount of solution that will be entrained in the tailings is anticipated to be low (less than 10%). Therefore, the proposed tailings characterization without solution chemistry is considered adequate for the baseline characterization program. A metallurgical test program is currently underway and Calico plans on collecting samples representative of tailings material as well as samples of entrained solution for analysis including pH, major ions, metals, weak-acid dissociable cyanide, total cyanide and including thiocyanate.

Acid Base Accounting

Acid Base Accounting provides an industry-recognized assessment of the acid generation or acid neutralization potential of rock materials. The ABA method used for the characterization of the Grassy Mountain samples is the modified Sobek ABA method (Sobek, 1978), which includes both laboratory analysis and empirical calculations based on acid generating potential (AP) and neutralizing potential (NP). An estimate of acid generation is made by assuming complete reaction between all minerals with acid generating potential and all of the minerals with neutralizing potential (essentially dissolution of carbonate minerals and to very limited extent silicate minerals as the latter have very slow reaction kinetics; Bowell et al., 2000).

The AP values were calculated from sulfide sulfur concentrations and reported as CaCO3 equivalents per 1,000 tons of rock. The modified Sobek method determines the sulfide sulfur and sulfate sulfur content by measuring the amount of nitric acid-extractable sulfur and the amount of hot water-extractable sulfur. According to this method, the AP is established by determining three sulfur content numbers including:

- Total Sulfur – determined from analysis of an untreated sample using a LECO furnace. The result is a measure of all sulfur forms in the sample.
- Non-Extractable Sulfur – determined from digestion of a sample with nitric acid followed by filtration and then LECO analysis. Nitric acid removes sulfate and sulfide minerals and the only remaining minerals are insoluble sulfate minerals such as barite.
- Non-Sulfate Sulfur – determined from digestion with hot water followed by filtration and then LECO analysis. The hot water extraction leaches

sulfate minerals (e.g., gypsum) from the sample leaving behind sulfide sulfur and non-extractable sulfur forms.

Sulfide sulfur is the difference between the non-sulfate sulfur (i.e., sulfide sulfur plus non- extractable sulfur) and non-extractable sulfur. The AP is calculated by multiplying the sulfide sulfur concentration by 31.25. In the case where sulfide sulfur was below the laboratory detection limit, the laboratory detection limit (i.e., 0.01 wt%) was used to calculate AP.

The NP values were determined using the modified Sobek protocol that includes a digestion to expel any CO2 followed by a back titration with NaOH to a pH of 8.3. Neutralizing potential is calculated as CaCO3 equivalents per 1,000 tons of rock. Total Inorganic Carbon (TIC) was also analyzed in order to provide a second measure of neutralization potential; however the Sobek NP values were used for the purpose of the data evaluation. For those samples with NP below the laboratory detection limit, the NP is assumed to be the detection limit (i.e., 0.3 kg CaCO3 eq/ton) or the ABA calculations.

The balance between the acid generating mineral phases and acid neutralizing mineral phases is referred to as the net neutralization potential (NNP), which is equal to the difference between NP and AP. The NNP allows classification of the samples as potentially acid consuming or acid producing. A positive value of NNP indicates the sample neutralizes more acid than is produced during oxidation. A negative NNP value indicates there are more acid producing constituents than acid neutralizing constituents. Material that would be considered to have a high potential for acid neutralization produces a net neutralizing potential of greater than 20 kg CaCO3 eq/ton. Acid Base Accounting data is also described using the neutralization potential ratio, which is calculated by dividing the NP by the AP (i.e., NP:AP, also referred to as NPR).

The Nevada BLM Water Resource Data and Analysis Guide for Mining Activities (BLM, 2008) establishes the following guidelines for the evaluation of ABA test results:

- NP:AP (NPR) values greater than 3 and NNP values greater than 20 kg CaCO3 eq/ton are not acid generating and do not require further testing.
- NP:AP (NPR) values less than 3 and/or NNP values less than 20 kg CaCO3 eq/ton have uncertain potential and require further evaluation using kinetic test methods.

Net Acid Generation

Static Net Acid Generation (NAG) testwork was carried out in order to determine the maximum potential for acid generation from the samples. The static NAG test differs from the ABA test in that it provides a direct empirical estimate of the overall sample reactivity, including any acid generated by semi-soluble sulfate minerals as well as potentially acid-generating sulfide minerals. Depending upon the site mineralogy and geology, the NAG test can provide a better estimate of field acid generation than the more widely-used ABA method, which defines acid potential based solely on sulfide content. NAG testing was carried out by SVL laboratories in accordance with the method described by Miller et al. (1997) and Miller (1998). The method involves intensive oxidation of the sample using hydrogen peroxide (H2O2), which accelerates the dissolution of sulfide minerals and has the net result that acid production and neutralization can be measured directly. Leachate was then titrated with sodium hydroxide in two stages (pH 4.5 and to pH 7) to determine the NAG value, calculated as follows:

$$NAG = (VInit / X)\ (49 * VNaOH * M) / W$$

Where:
NAG = net acid generation (kg H2SO4 eq/ton);
VInit = volume of initial hydrogen peroxide solution (mL); X = volume used to determine NAG by titration (mL); VNaOH = volume of NaOH used in titration (mL);
M = concentration of NaOH used in titration (moles/liter); and W = weight of sample reacted (g).

The guidelines used for assessing the acid generation potential based on NAG results are summarized in Table 4-5. Samples with NAG pH values greater than pH 4.5 are predicted to be non-potentially acid generating (non-PAG). Net acid generation is only measured for samples with NAG pH values less than pH 4.5. NAG results greater than one kg H2SO4 eq/ton indicate the sample will generate some acidity in excess of available alkalinity and is potentially acid generating (PAG). However, by convention, any NAG value below 10 kg H2SO4 eq/ton of material has a limited potential for acid generation and the results are considered inconclusive because a blank hydrogen peroxide solution (the reagent in the NAG test) can generate a NAG artifact value up to 10 kg H2SO4 eq/ton.

Table 4-5: Acid Generation Criteria for NAG Results

Acid Generation Capacity		Final NAG pH (s.u.)	Static NAG (kg H_2SO_4 eq/ton)
Potentially Acid Generating (PAG)	High Capacity	< 4.5	>20
	Low to Moderate Capacity	< 4.5	1-20
Non-Potential Acid Generating		≥ 4.5	<1

Conclusions

SRK Consulting (US) Inc. (SRK) has completed a mine waste characterization program for Calico as part of the planning and impact assessment for the Grassy Mountain Project. Geochemical testing of mine waste materials provides a basis for assessment of the potential for ARD/ML prediction of contact water quality, and evaluation of options for design, construction, and closure of the mine facilities. The characterization effort focused on the assessment of development rock (waste rock and ore) geochemistry and evaluation of tailings material from mineral beneficiation.

The following sections provide a summary of the results of the geochemical characterization study for waste rock and ore and mill tailings associated with the Grassy Mountain Project.

Waste Rock and Ore

The Grassy Mountain underground waste rock shows variable geochemical behavior and each material type has a wide range of sulfide content and predicted acid generation from the static test results. Overall, the waste rock has very limited acid neutralizing capacity due to the low inorganic carbon content and as such the predicted acid generating potential is strongly related to sulfide content. The characterization results for the ore grade material are comparable to the waste rock material.

Based on the ABA and NAG results, six out of the 104 waste rock and ore samples contain greater than 0.5% sulfide sulfur indicating a higher potential for acid generation. The remaining samples have an uncertain potential for acid generation with NNP values between -20 and 20 kg CaCO3 eq/ton. The NAG results are consistent with the ABA data and show samples with sulfide sulfur greater than 0.5 wt% are predicted to have a higher capacity for acid generation with NAG values greater than 20 kg H2SO4 eq/ton. Samples with sulfide sulfur content between 0.05 and 0.5 wt% show a low to moderate potential for acid generation with NAG values between 1 and 20 kg H2SO4 eq/ton.

Based on the MWMP test, the majority of the samples have neutral to alkaline paste pH values (pH 6 - 8) indicating minimal readily soluble acid sulfate salts from prior oxidation of the core material. The exceptions are a few samples of mudstone and siltstone with the highest sulfide sulfur content that generated acidic leachate. Constituents above OGWQG under the low pH conditions include sulfate, arsenic, cadmium, chromium, copper, fluoride, iron, manganese, selenium and zinc. For samples with neutral pH (i.e., pH >7) all constituents were below the OGWQG.

Eight of the ten humidity cell tests generated acidic leachate throughout the test and indicate that samples with an uncertain potential for acid generation from the ABA will generate acid under long term weathering conditions. The only two samples that maintained neutral conditions during the HCT program consisted of sinter material. All other material types are considered to be acid generating including the sandstone, siltstone and mudstone. A comparison of the HCT leachate chemistry to OGWQG indicates the mudstone (HC-3 and HC-4) had the greatest number of parameters that exceeded guidelines and the sinter cells (HC-8 and HC-9) had the least. Most cells that developed acidic conditions leached copper, iron, manganese, arsenic and sulfate at concentrations greater than the guidelines, indicating these elements are mobile under acidic pH conditions. Other constituents that were leached above OGWQG during the first few weeks of the test include cadmium, chromium, copper, fluoride, lead, selenium, silver and zinc.

Tailings

The tailings sample contains a small amount of sulfide (0.09%) and shows an uncertain potential for acid generation-based ABA testing with NPR values between 1 and 3 and NNP values between -20 and 20 kg CaCO3 eq/ton. NAG results indicate that the tailings sample has a low potential for acid generation. Despite the addition of lime, the neutralization capacity of the tailings sample is low due to the cyanide destruction process that was used. The Inco process uses sodium bisulfite as a SO2 source, which lowers the pH. Even though lime was added to control pH during this process, the addition of sodium bisulfite during the testing was enough to offset any neutralizing capacity from the lime that was added. However, the process applied at the field scale will not be as efficient and there could be more neutralization capacity remaining in the final tailings material that is produced onsite in comparison to the tailings from the metallurgical testing.

The tailings material generated acid during the HCT program and showed a similar range of metal release to that observed for the waste rock cells. Total cyanide in the tailings cell was measured below the detection limit each week after week 16 and WAD cyanide was measured below the detection limit after week two.

Additional Testing

The geochemical evaluation of materials that will be generated during construction and operation of the Grassy Mountain is being conducted under a separate program. This characterization program is in progress and includes the following:

- Tailings material amended with lime to meet Oregon regulation standards
- Cemented rock fill that will be used to support the underground workings
- Cut and fill material generated during haul road and access road construction
- Borrow sources that may be used for construction material
- The results of this characterization program will be provided to DOGAMI and BLM under separate cover.

Baseline Geochemical Characterization Report

Grassy Mountain Project

Calico Resources USA Corporation

Report Prepared for

Oregon Department of Geology and Mineral Industries

Report Prepared by

srk consulting

SRK Consulting (U.S.), Inc.
SRK Project Number 506800.02
January 2018

Baseline Geochemical Characterization Report

Grassy Mountain Project

Calico Resources USA Corporation

Oregon Department of Geology and Mineral Industries

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January 2018

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1 Introduction

1.1 Purpose and Scope

SRK Consulting U.S., Inc. (“SRK”) has completed a baseline geochemical characterization study for the Grassy Mountain Project, Oregon on behalf of Calico Resources USA Corp. (“Calico”). The Grassy Mountain Project consists of an underground gold resource located in Malheur County, Oregon, about 22 miles south-southwest of Vale, Oregon in an area where no previous mining activity has occurred. Processing will be by conventional mill and containment of tailings in an engineered tailings impoundment.

The purpose of the baseline geochemical characterization program is to provide a prediction of the potential geochemical reactivity and chemical stability of mine waste that will be produced by the proposed Grassy Mountain underground gold mine. The results of the geochemical characterization program will assist in determining the potential for acid rock drainage and metal leaching associated with the project. Data produced during this study can be used in the project design process and as an operational tool for identifying material types that require special handling during operations.

The characterization work undertaken for the Grassy Mountain project meets the following regulatory requirements:

- Oregon Department of Geology and Mineral Industries (DOGAMI) Division 37 Chemical Process Mining, Oregon Administrative Rule (OAR) 623-037-0055 and OAR 632-037-0085(Environmental Evaluation); and
- Applicable Oregon Department of Environmental Quality (ODEQ) Division 43 Chemical Mining Rules, OAR 340-043, which address process mining.

In addition, the geochemical characterization program was designed to follow guidelines set forth in the Bureau of Land Management Instruction Memorandum NV-2013-046, Nevada Bureau of Land Management Rock Characterization Resources and Water Analysis Guidance for Mining Activities (BLM, 2013).

In March 2013, SRK developed the *Final Revised Geochemistry Environmental Baseline Work Plan for the Grassy Mountain Project* (March 2013) pursuant to Oregon Revised Statute (ORS) 517.967 using criteria and/or guidelines and information provided by the technical review team (TRT) assembled for the project. This work plan was reviewed and approved by the TRT and contains a description of the baseline data requirements for the various resource categories including geochemical characterization of mine waste. As described in the approved baseline work plan, a detailed work plan with more information on sample selection, laboratory procedures and key criteria for decision-making throughout the process would be prepared and submitted for agency review and approval.

In January 2016 a revised Work Plan (*Geochemistry Baseline Study: Preliminary Results and Work Plan for the Grassy Mountain Project)* was submitted to the Oregon Department of Geology and Mineral Industries (DOGAMI) and Oregon Department of Environmental Quality (ODEQ) to provide a plan for additional sample collection; this report also provided description of the geochemical characterization study methodology and a summary of the data available to date.

The following activities have been completed as part of the current geochemical characterization program:

- Review of site geology and identification of the primary material types.
- Collection of drill core samples representative of waste rock and ore.
- Collection of test residues from metallurgical testing that are representative of tailings material associated with the project.
- Static and kinetic laboratory testing of selected waste rock, ore and tailings samples.

The two main considerations of this baseline environmental geochemical characterization are:

- Acid generation due to oxidation of sulfide minerals, which can potentially lead to development of Acid Rock Drainage (ARD).
- Potential for leaching of metals (e.g., manganese) and salts (e.g., sulfate).

The processes of acid generation and leaching can operate independently, although the development of acidic conditions enhances the leachability of many metals. To address this, an extensive characterization program has been completed for the Grassy Mountain Project to define the geochemical characteristics of the waste rock and ore as in terms of their potential to generate acid and generate low quality leachate.

1.2 Background

Calico proposes to construct, operate, reclaim, and close an underground mining and precious metal milling operation known as the Grassy Mountain Mine Project (Project). The Project area is comprised of approximately 981 acres, of which 919 acres are public land administered by the Bureau of Land Management. Approximately 62 acres within the Project area are private land controlled by Calico (Figure 1-1). In general, the proposed mining and precious metal processing operations under this Plan will consist of underground mine and ore processing facilities, including a conventional mill and tailings storage facility, and waste rock storage areas, as well as other support facilities. The Project will include the following major components:

- One underground mine;
- One waste rock storage area;
- One carbon-in-leach processing plant;
- Three borrow pit areas;
- One tailings storage facility;
- Run-of-mine (ROM) ore stockpile;
- One reclaim pond;
- A water supply well field and pipeline, associated water delivery pipelines, and power;
- A power substation and distribution system;
- Access and haul roads;
- Ancillary facilities that include the following: haul, secondary, and exploration roads; truck workshop; warehouse; storm water diversions; sediment control basins; reagent and fuel storage; storage and laydown yards; explosive magazines; fresh water storage; monitoring

wells; meteorological station, an administration/security building; borrow areas; landfill; growth media stockpiles; and solid and hazardous waste management facilities to manage wastes; and

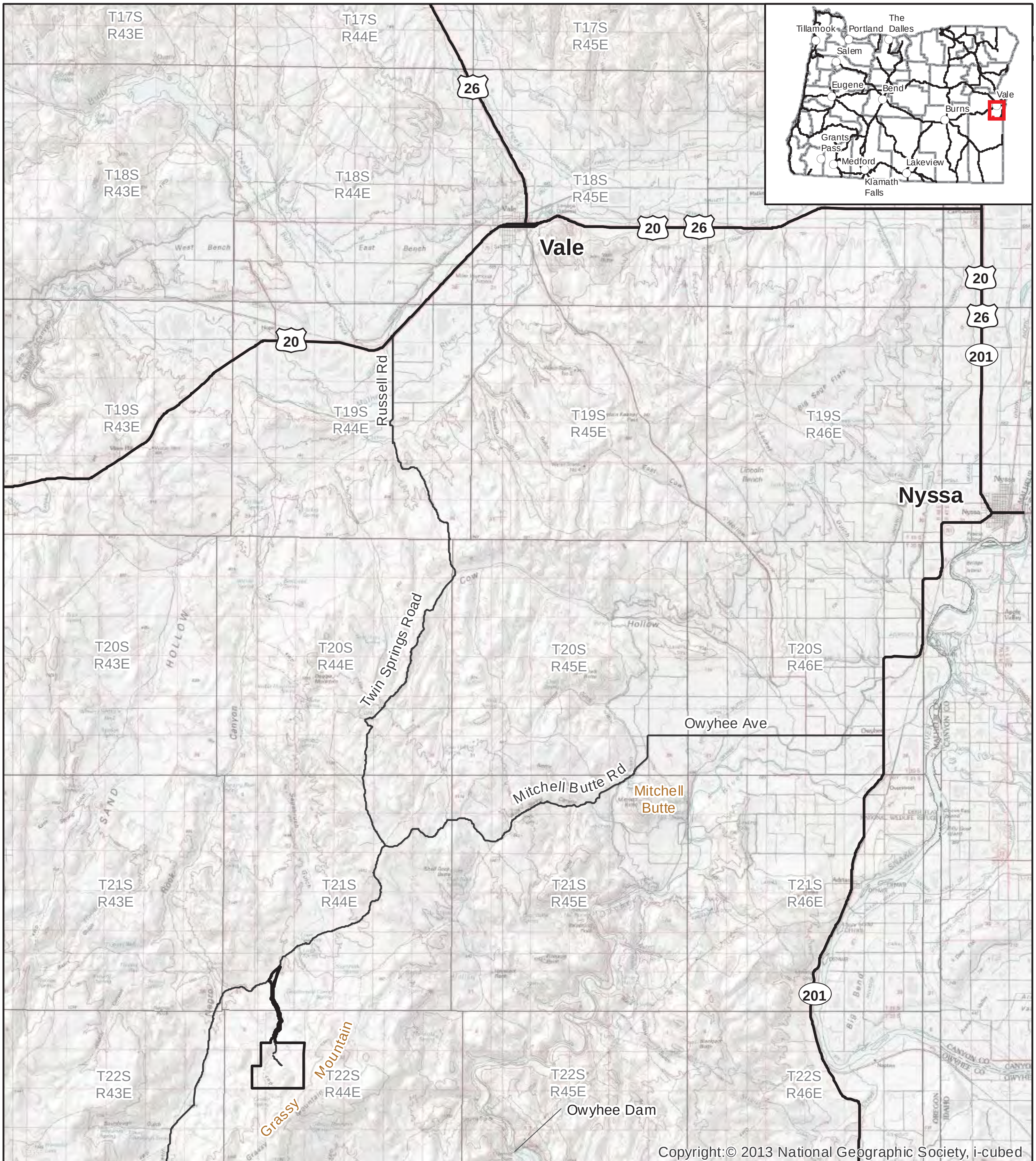
- Reclamation and closure, including the development of an evaporation (E) cell for potential long-term discharge from the tailings storage facility (TSF).

Calico proposes to mine approximately 3.0 million tons of mill-grade ore and 0.2 million tons of waste rock (total of 3.2 million tons). The material (both ore and waste) will be extracted from the underground mine using conventional underground mining techniques of drilling, blasting, mucking, loading, and hauling. Calico will use hydraulic loaders to load the ore and waste into the haul trucks. The haul trucks will transport the waste rock to the waste rock disposal areas near the tailings facility, and transport the ore to the ROM stockpile adjacent to the crushing and milling facilities. The ore will be leached in a carbon-in-leach processing plant to recover the precious metals into a “pregnant” leach solution. The pregnant solution will then be processed for metal recovery and further off-site refining. Exploration activities, expected to disturb up to 10 acres, will occur within the Project Area. The acreage of proposed surface disturbance associated with the Project as a whole is approximately 265.8 aces.

1.3 Project Study Area Description

As shown in Figure 1-1, the Grassy Mountain project is located in Malheur County, Oregon, about 22 miles south-southwest of the City of Vale. The project study area, shown in Figure 1-2, encompasses portions of Section 32, Township 21 South, Range 44 East, and Sections 5, 7 and 8, Township 22 South, Range 44 East, Willamette Base and Meridian.

The project is accessed via Highway 20, west from Vale, to Russell Road. The site is approximately 25 to 30 miles up Russell Road and Twin Springs Road.



Explanation

Project Area

Existing Road

Projection: UTM Zone 11 North, NAD83, meters

0 2 4 Miles

N

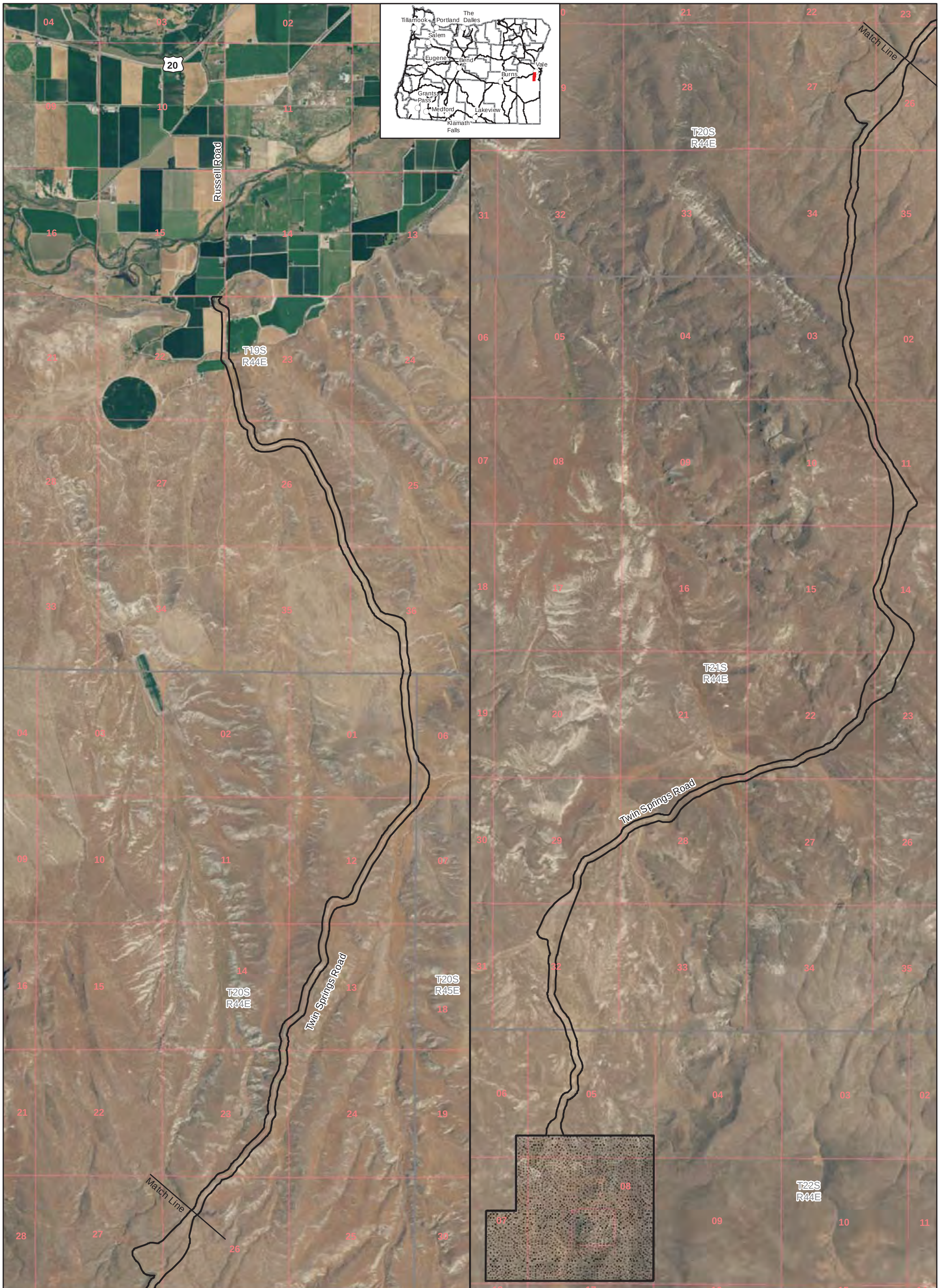
CALICO RESOURCES USA CORP.

GRASSY MOUNTAIN PROJECT

Figure 1-1: Project Location

Date:	07/27/2017	Drawn By:	GSL
Revised:		Project No.:	3672
Base Map:	USGS 100K quads: Boise, Brogan, Vale, Weiser		
File Name:	3671GX_GrassyMtn_Fig1_Location.mxd		

EM STRATEGIES



Explanation

Permit Area

Geochemistry Study Area

Projection: UTM Zone 11 North, NAD83, meters

0 1 2 Miles

N

CALICO RESOURCES USA CORP.

GRASSY MOUNTAIN PROJECT

Figure 1-2: Permit Area and Geochemistry Study Area

Date: 12/21/2017 Drawn By: JDB/GSL
Project No.: 3672

2 Site Conditions

2.1 Topographic Setting and Climate

The Grassy Mountain property is located in the semi-arid plateau region of eastern Oregon. The local landscape is typical of a high mountain desert environment and range land. Terrain is gentle to moderate throughout most of the project study area, with elevations ranging from 3,330 to 4,300 feet above mean sea level (amsl).

Seasonal mean temperatures are typical of the western United States, with mostly sunny winter and summer skies and little overcast. Local weather data indicate a mean annual temperature of 52°F, with daily temperatures ranging from an extreme low of -20°F in the winter to extreme highs of 100°F and higher in the summer. Annual precipitation is about 9.8 inches, roughly half of which falls as snow between November and March. Winter and wet weather occasionally limit access to the project site, but operations may generally be carried out year round.

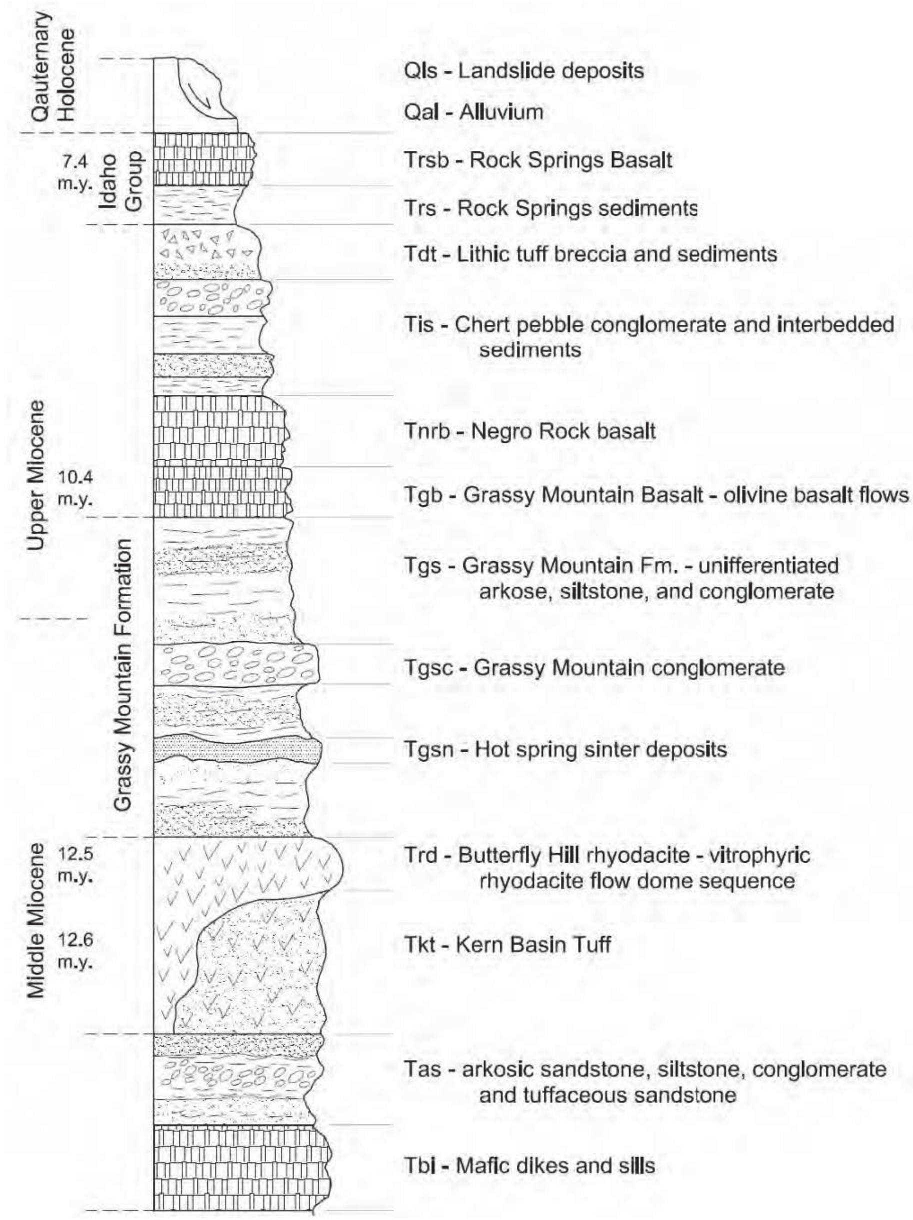
2.2 Geology

The following description of regional and project geology is from the *Geology and Soils Baseline Study for the Grassy Mountain Project* (McGinnis, 2014).

2.2.1 Regional Geology

Grassy Mountain is the largest of twelve recognized epithermal hot spring precious metal deposits of the Lake Owyhee volcanic field. The Lake Owyhee volcanic field occurs at the intersection of three tectonic provinces: the buried cratonic margin, the northern Basin and Range, and the Snake River Plain. During the mid-Miocene, large volume, peralkaline, caldera volcanism occurred in response to large, silicic magma chambers emplaced in the shallow crust throughout the region. The volcanic field includes several caldera-sourced ash-flow sheets and rhyolite tuff cones that were deposited about 15 million years ago (Ma).

At about 15 Ma, subsidence of the Lake Owyhee volcanic field triggered a change in volcanic eruption style, resulting in small volume, basalt-rhyolite deposits of limited extent. Volcanism during the mid to late Miocene is evidenced by small volume, metaluminous, high-silica rhyolite domes and flows, and small volume basalt flows and mafic vent complexes in north- and northwest-trending Basin and Range-type fracture zones and ring structures related to resurgent calderas. Regional subsidence facilitated the formation of through-going fluvial systems, and large volumes of fluvial sediments, sourced from the exhumed Idaho Batholith to the east, were deposited in conjunction with volcanism and hot spring activity during the waning stages of volcanic field development. The resulting regional stratigraphic section is a thick sequence of mid-Miocene volcanic rocks and coeval-to-Pliocene age non-marine lacustrine, volcaniclastic, and fluvial sedimentary rocks. For the purpose of geologic mapping at the project study area, a stratigraphic column is shown in Figure 2-1. Table 2-1 describes the stratigraphic column in more detail including the geologic units mapped within the project study area, the unit's age and lithologic description, and provides the map symbols used to cross reference with the geologic units shown on the project study area geology map (Figure 2-2 and Figure 2-3).



Source: Calico Resources, 2014

Figure 2-1: Grassy Mountain Stratigraphic Column

Table 2-1: Stratigraphic Column Descriptions

Map Symbol	Rock Unit	Age (Millions of years before present in parenthesis)	Description
Qal	Alluvium	Pleistocene and Holocene	Unconsolidated and generally poorly sorted deposits of gravel, sand and silt accumulated along modern streams, drainages and flood plains
Qls	Landslide Deposits	Pleistocene and Holocene	Landslide and slump deposits of unconsolidated and unstratified soil and angular rock fragments formed as the result of bedrock failure. Includes large slump and debris flows composed of blocks of capping basalt on the flanks of Grassy Mountain and Sourdough Basin.
Trsb	Rock Spring Basalt	Upper Miocene (7.4 m.y.)	Snake River type olivine basalt flows and interbedded deposits of Tuffaceous siltstone and sandstone. Unit is made up of approximately equal amounts of volcanic flows and interflow sedimentary rocks. Trsb flows range from 2 to 20 feet thick. Entire unit of basalt with sedimentary interbeds reaches maximum thickness of 400 feet east of Shell Rock Butte.
Trs	Rock Spring Basalt - tuffaceous siltstone and sandstone	Upper Miocene	Sandstone and tuffaceous siltstone interbedded with unit Trsb are mapped separately where well exposed. Upper beds are mainly tuffaceous siltstones and include some bentonitic clays.
Tdt	Lithic tuff breccias	Upper Miocene	Mafic clast lithic tuff, airfall tuffs and overlying reworked tuffaceous silt and sandstones. Breccia clasts include yellow inflated pumice and basaltic scoria. Distinguished from Tkt by absence of banded rhyolite clasts and absence of biotite and hornblende phenocrysts that are present in Tkt. Unit is approximately 80 feet thick in western portion of map. Unconformably overlies Tis and is conformably overlain by Trsb.
Tis	Interbedded conglomerate and siltstone	Upper Miocene	Chert pebble conglomerate and interbedded diatomaceous siltstone. Mainly tuffaceous and arkosic sandstone and siltstone with interbedded conglomerate. Locally becomes finer grained upward into pale, white and yellow claystones and interbedded diatomaceous siltstones. Presumed base of Tis near Grassy Mountain Reservoir contains black chert-pebble and granite-clast conglomerate. Erosional contact with underlying unit Tgs marked by rounded boulders of olivine basalt unit tgb. Unit is approximately 400 feet thick in mapped area.
Tnrb	Negro Rock Basalt	Upper Miocene	Dark brownish gray, locally flow banded basalt. Dikes, plugs and sills are common. Typically higher Fe/Mg ratios and much lower chromium content than Tgb or Trsb.
Tgb	Grassy Mtn Basalt	Upper Miocene (10.4 m.y.)	Flow on flow sequence of olivine basalts capping the summit of Grassy Mountain; includes somewhat younger intra-canyon flows forming benches on the south side of Grassy Mountain. Locally includes overlying stream gravels containing chert pebbles and large rounded basalt clasts. Maximum thickness of 200 feet; individual flows up to 40 feet thick.

Map Symbol	Rock Unit	Age (Millions of years before present in parenthesis)	Description
Tgs	Grassy Mtn Formation-undifferentiated	Upper and Middle Miocene	Arkosic sandstones and channel-fill granite clast conglomerates. Mainly white to tan arkosic sandstones. Includes Tgsc, channel fill conglomerates with abundant granite and rhyolite clasts in the upper part of the unit. Uppermost conglomerates locally contain rounded obsidian clasts and rare black chert clasts. Unit Tgs generally becomes finer grained upward and includes white bentonitic clays near the top of the section which, where overlain by unit Tgb often generate large landslide masses. Hot spring activity contemporaneous with the deposition of the arkoses is indicated by sinter beds Tgsn, and sinter boulders containing silicified reeds and wood near the Grassy Mountain gold deposit. Unit Tgs is the host for both the Grassy Mountain and Crabgrass gold deposits.
Tgsc	Grassy Mtn Formation-Conglomerate		Conglomerates occurring in the upper portion of Tgs - mapped individually where possible
Tgsn	Grassy Mtn Formation-Sinter		Hot spring sinter deposits within Tgs - mapped individually where possible
Trd	Butterfly Hill Rhyodacite	Middle Miocene (12.5 m.y.)	Rhyodacite flow dome complex.
Tkt	Kern Basin Tuff	Middle Miocene	Mainly non-welded fine-grained, white to pale-yellow lithic tuff contain basalt, banded rhyolite, and white pumice clasts with biotite, hornblende, quartz and plagioclase crystals. Includes thinly bedded airfall tuffs at the base of the unit and overlying thin lenses of interbedded tuffaceous and arkosic sandstone and granite-clast conglomerate. Locally includes chaotically bedded airfall tuff with slump structures and massive surge deposits of matrix-supported lithic tuff composed of rhyolite and pumice clasts. Pumice clasts in the lithic tuff deposits increase in abundance and size toward the top of the unit. Unconformably overlies unit Tas.
Tas	Arkosic and tuffaceous sandstone	Middle Miocene	Arkosic and tuffaceous sandstone, siltstone and conglomerate. Mainly white to tan arkosic sandstone with minor amounts of granite-clast conglomerate. Includes 20 feet thick massive beds of coarse matrix supported, granite-clast conglomerate near the exposed base of the unit.
Tbi	Mafic dikes and sills	Middle Miocene	Mafic dikes and sills. Younger sequence includes irregularly shaped sills and dikes that intrude units Tas, Tkt and Tgs along both flanks of Grassy Mountain. Dikes and sills are olivine basalts believed to be feeders to units Tbg and Trsb. Dike cut through lowermost flows of unit Trsb north of Grassy Mountain near Willow Spring.

Source: Source: Calico Resources, 2014

2.2.2 Project Geology

Bedrock outcrops in the project study area are typically composed of olivine-rich basalt and siltstones, sandstones, and conglomerates of the late Miocene Grassy Mountain Formation.

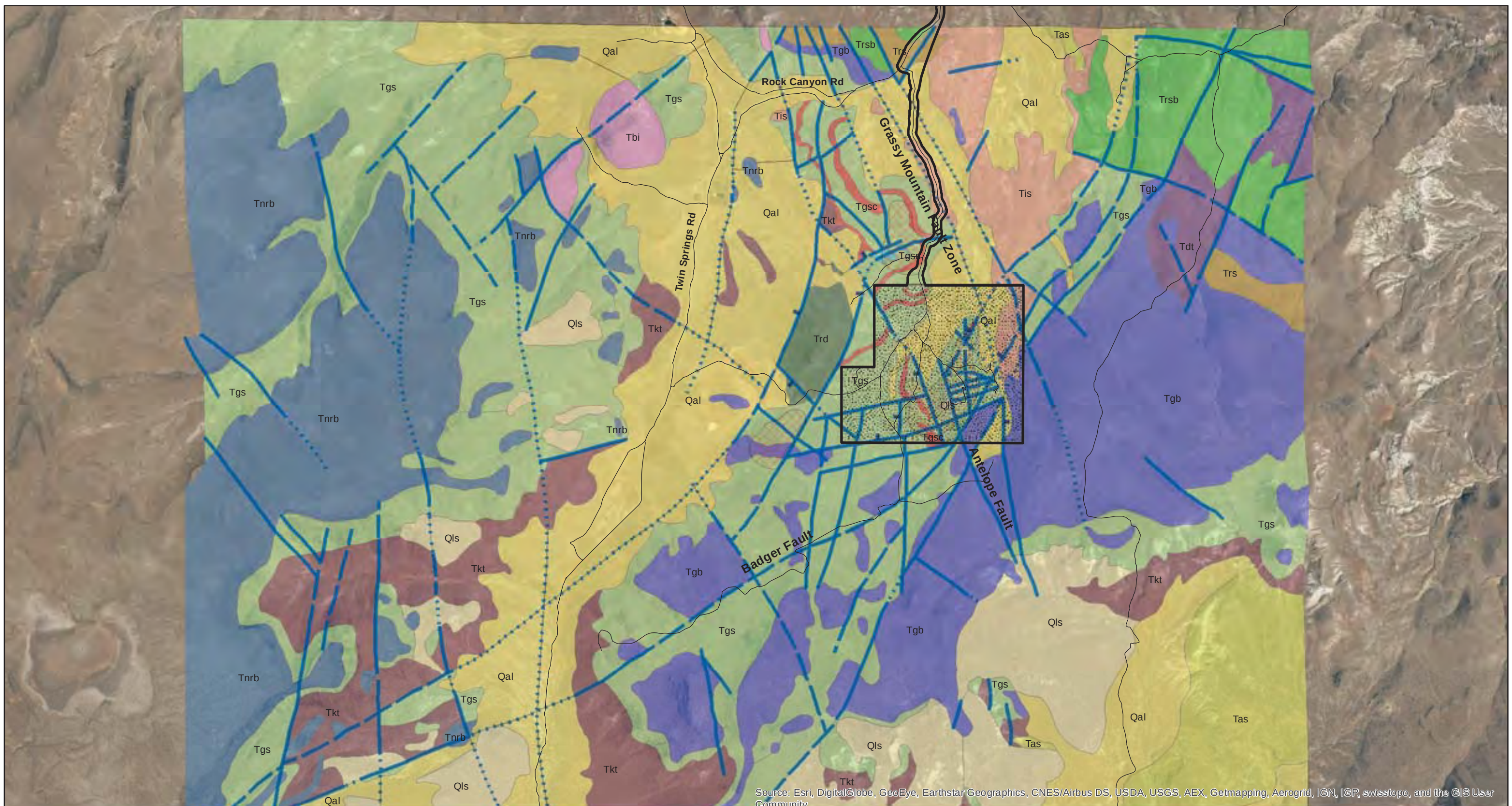
These rocks are locally covered with relatively thin, unconsolidated alluvial and colluvial deposits. Erosion-resistant basalts cap local topographic highs. Arkosic sandstones have been encountered at the surface and at depth, but have not been correlated across the project study area, in part due to lateral discontinuity associated with sedimentary facies changes and structural offset. The project study area geology is shown in Figure 2-2 and Figure 2-3.

Surface and drill-defined stratigraphy within the project study area reveals complex facies that were produced during the waning stages of deposition of the Lake Owyhee volcanic field. The oldest units encountered are the flow-on-flow Blackjack and Owyhee Basalts (14.3 to 13.6 Ma).

These basalts are overlain by arkosic sandstone, tuffaceous sandstone, and conglomerates of the Deer Butte Formation. The basal unit to the overlying Grassy Mountain Formation is the Kern Basin Tuff, a nonwelded, pumiceous, crystal tuff that displays cross beds and local surge structures. Clast size, thickness of individual ash units, and bedding structures suggest a source in the Grassy Mountain area. The Kern Basin Tuff ranges in thickness from 300 feet on the south bluffs of Grassy Mountain, to 1,500 feet in a drill hole beneath the project study area.

The Kern Basin Tuff is overlain by a series of fluvial, lacustrine, and tuffaceous sediments. Most of the sedimentary units in the project study area are silicified and strongly indurated. These sedimentary units include granitic clast conglomerate, arkosic sandstone, fine grained sandstone, siltstone, and tuffaceous siltstone/mudstone. The sedimentary facies of the Grassy Mountain Formation range from 300 to over 1,000 feet thick, and provide the host rocks of the Grassy Mountain mineral resource.

Several siliceous terraces are interbedded with the silicified sediments of the Grassy Mountain Formation. Terrace construction was apparently episodic and intermittently inundated by fluvial/lacustrine sediments and ash, resulting in an interbedded sequence of siltstone, tuffaceous siltstone, sandstone, conglomerate, and sinter terrace deposits. Load casts, flame textures, convolute lamination and other soft-sediment deformation textures are common in both the sinter beds and sedimentary facies. The amount and size of the sinter clasts in the sedimentary rocks reflect relative proximity to a terrace. Proximal deposits are angular, inhomogeneous, clast supported breccias of sandstone, siltstone, and sinter with indistinct clast boundaries in a sulfidic mud-textured matrix.



Explanation

Permit Area	Qal: Alluvium	Tgsn: Grassy Mtn Formation - Sinter
Geochemistry Study Area	Qls: Landslide deposits	Tis: Interbedded conglomerate and siltstone
Fault, Location Certain	Tas: Arkosic and tuffaceous sandstone	Tkt: Kern Basin Tuff
Fault, Location Inferred	Tbi: Mafic dikes and sills	Tnrb: Negro Rock Basalt
Fault, Concealed	Tdt: Lithic tuff breccias	Trd: Butterfly Hill Rhyodacite
Alteration	Tgb: Grassy Mtn Basalt	Trs: Rock Spring Basalt - tuffaceous siltstone and sandstone
Road	Tgs: Grassy Mtn Formation - undifferentiated	Trsb: Rock Spring Basalt
	Tgsc: Grassy Mtn Formation - Conglomerate	

0 2,000 4,000 Feet

N

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GRASSY MOUNTAIN PROJECT

Figure 2-2: Regional Geology

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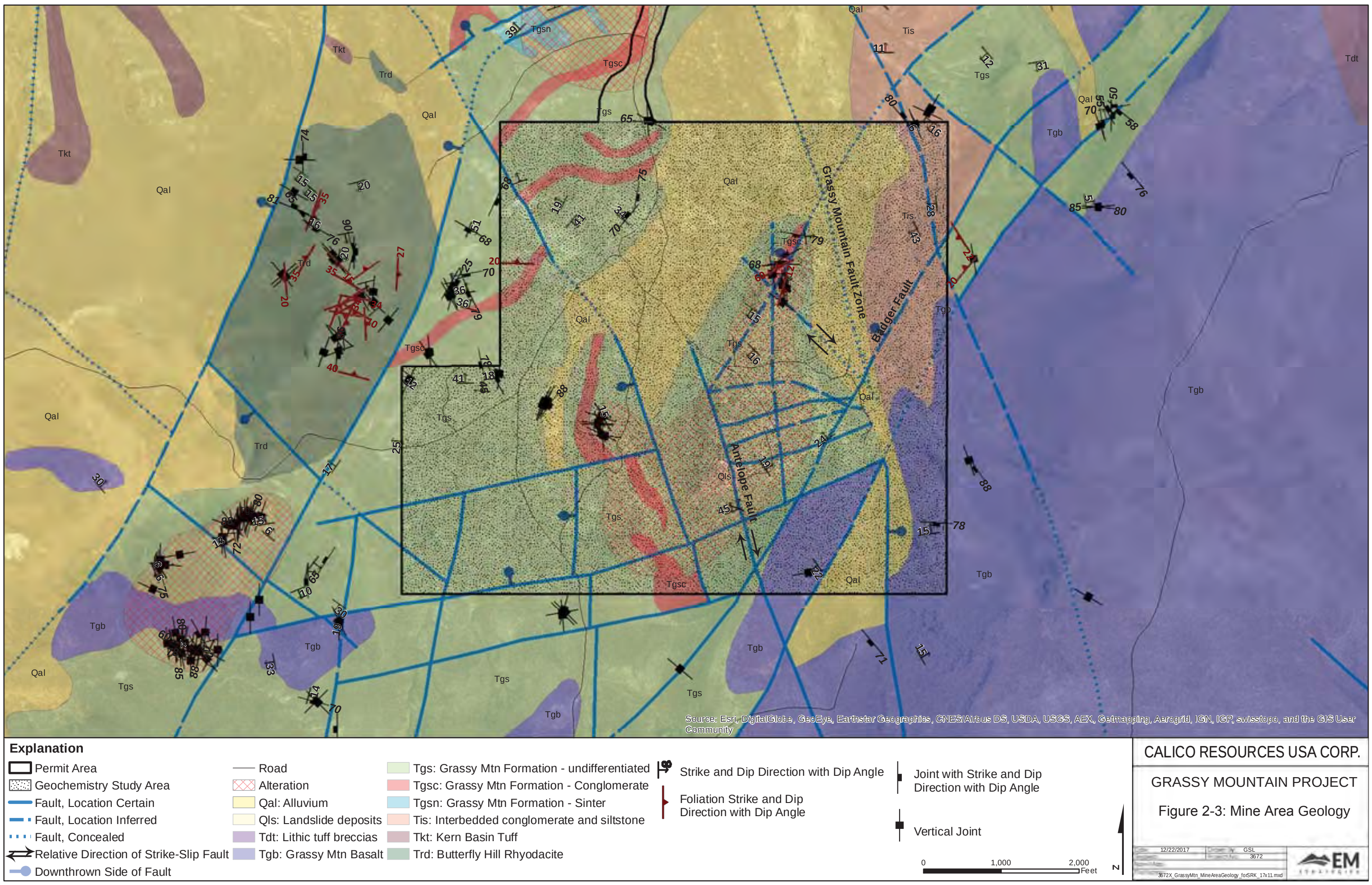
Grassy Mountain Fault Zone
Badger Fault
Antelope Fault
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
Explanation
Permit Area
Geochemistry Study Area
Fault, Location Certain
Fault, Location Inferred
Fault, Concealed
Relative Direction of Strike-Slip Fault
Downthrown Side of Fault
Road
Alteration
Qal: Alluvium
Qls: Landslide deposits
Tdt: Lithic tuff breccias
Tgb: Grassy Mtn Basalt
Tgs: Grassy Mtn Formation - undifferentiated
Tgsc: Grassy Mtn Formation - Conglomerate
Tgsn: Grassy Mtn Formation - Sinter
Tis: Interbedded conglomerate and siltstone
Tkt: Kern Basin Tuff
Trd: Butterfly Hill Rhyodacite
Strike and Dip Direction with Dip Angle
Foliation Strike and Dip Direction with Dip Angle
Joint with Strike and Dip Direction with Dip Angle
Vertical Joint
0
1,000
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GRASSY MOUNTAIN PROJECT
Figure 2-3: Mine Area Geology
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2.3 Water Resources

2.3.1 Surface Water and Springs

The project area is rolling hill terrain. Negro Rock Canyon to the north west of the project area and the Owyhee River Canyon to the southeast provide more relief in topography. The highest elevation is about 4,800 feet amsl along the west flank of Grassy Mountain. Elevation decreases to the north (about 3,250 feet amsl at Negro Rock Canyon). Elevation falls to about 2,300 feet amsl at the Malheur River 18 miles to the north and to 2340 feet amsl at the Owyhee River 5 miles to the west.

There are two watersheds that could be impacted by surface runoff from Grassy Mountain Gold Project surface facilities; Negro Rock Canyon, which could receive runoff from processing facilities; and Sagebrush Gulch (a tributary to Negro Rock Canyon, which could potentially receive runoff from mine facilities). Project facilities will not extend south into the Dry Creek drainage (an Owyhee River tributary).

All the drainages in the vicinity of the project boundary are ephemeral or intermittent. Several springs exist within the project area. Many of the springs appear to represent discharge of groundwater from deep aquifers while others represent discharge of groundwater from local shallow perched water-bearing zones. Some of the springs are dry during most of the year and are active only during the spring and early summer.

The Owyhee River is the largest surface water body in the region. The U.S. Bureau of Reclamation supplies about 500,000 acre-feet of water from the river basin to irrigate approximately 118,000 acres along the west side of the Snake River in the vicinity of Adrian, Nyssa, and Ontario. Negro Rock Canyon drainage contains an intermittent stream that only flows in response to snowmelt or heavy precipitation. There are no known stream gaging records within the Negro Rock Canyon basin. There are published stream gaging records for the Owyhee River, Malheur River, and the north fork of the Malheur River. Owyhee Reservoir and several reservoirs in the Malheur River Basin also report water surface elevations (USGS, 2001).

There are no jurisdictional wetlands or floodplains within the study area.

2.3.2 Groundwater

The regional groundwater system that includes the project study area is bordered by the Sourdough Mountain upland area to the west of Grassy Mountain, the Malheur River to the north and west, and the Owyhee Reservoir and Owyhee River, and the Snake River to the south and east. Groundwater studies by Adrian Brown Consultants, Inc. (ABC, 1992) and J.M. Montgomery, Consulting Engineers, Inc. (JMM, 1991) further identified the following hydrostratigraphic units within the project study area:

- Local discontinuous water-bearing zones within the Grassy Mountain formation.
- Less permeable fine-grained sedimentary rocks (clay, clayey and tuffaceous siltstones, and indurated siltstone predominantly overlying and underlying the sandstone and conglomerate unites), acting as aquitards beneath the project study area.
- Sandstone and conglomerate units that are inconsistent water-bearing units.

While the groundwater system appears to be regionally continuous, individual water bearing units are scattered and have restricted areal extent across the site. These units range from roughly 25 to 420 or more feet below ground surface (bgs). Groundwater flow in the shallowest, unconfined water bearing zones generally follows the topography. Flow in deeper, confined water-bearing zones is likely disrupted by faults and other structures in the study area. Grassy Mountain appears to be a hydrologic divide between the Owhyee River and Negro Rock Canyon.

Recharge to the regional system is by infiltration of incident precipitation and runoff. The general direction of groundwater flow in 2013 (SPF) was to the northwest, which was consistent with previous studies. Figure 2-4 shows the 2013 groundwater contours.

Estimates of the transmissivity of the aquifers vary from 175 to 2,800 gallons per day per foot (gpd/ft) (JMM, 1991). Aquifer testing suggests that the transmissivity decreased to the south, with low permeability near areas where the sedimentary rocks become silicified and more indurated. The hydrothermal alteration and silicification at Grassy Mountain may have locally affected the hydraulic properties of sedimentary rocks within the area and caused permeabilities in the vicinity of the ore deposit to be significantly reduced relative to permeabilities north and west of the mine.

Geologic and hydrogeologic information from the site indicates that water-bearing zones are generally confined by layers of fine-grained sedimentary rocks. Low permeabilities are also expected in siltstone and claystone materials at depth (JMM, 1991). The fine-grained sediments will retard downward migration of surface contaminants to potential deeper water-bearing units. The potential for faults to act as contaminant transport pathways has been examined. Aquifer test data indicate that the faults probably restrict lateral groundwater flow, acting as negative hydraulic boundaries. According to JMM (1991) this information, together with the evidence that low-permeability sediments dominate the subsurface for at least 100 feet in the vicinity of the proposed mine and process facilities (which would have lower permeabilities along fault zones) indicates that faults in the area have little potential to act as contaminant transport pathways.

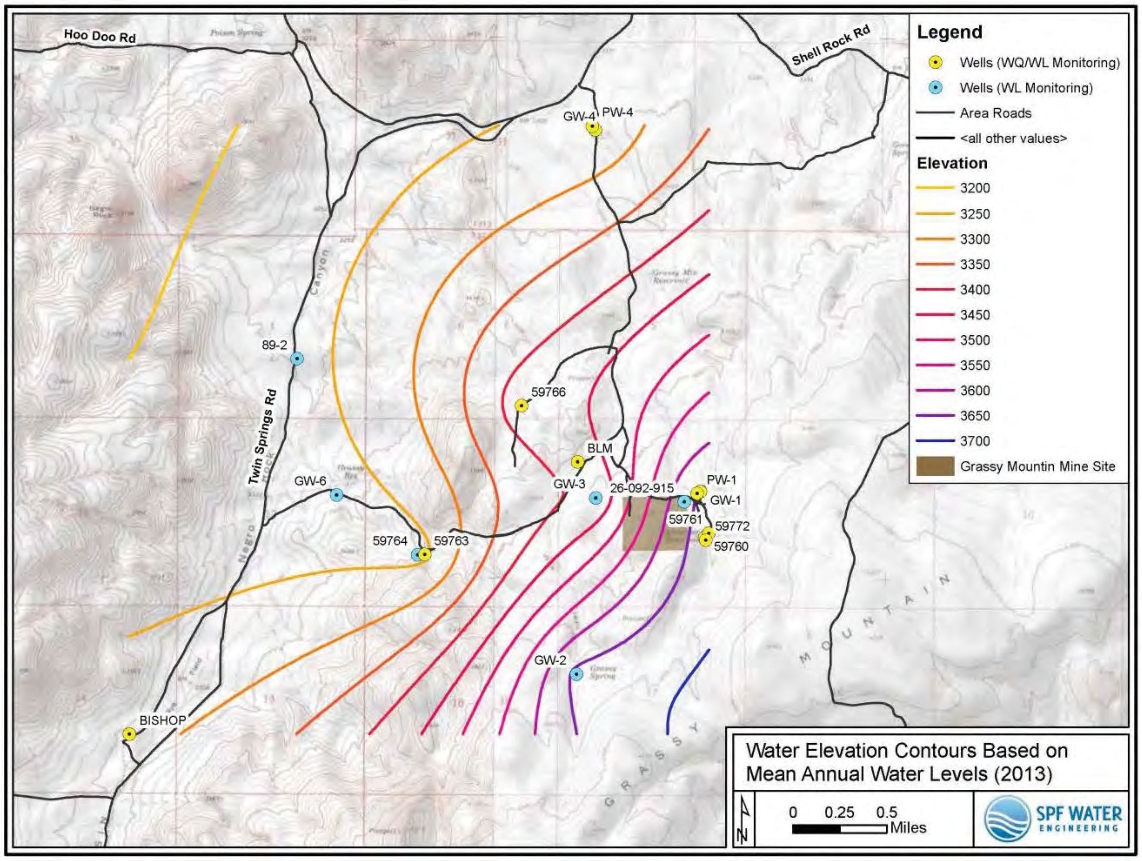


Figure 2-4: Groundwater Contour Map (2013)

3 Mine Plan, Conceptual Model and Program Design

SRK has developed a conceptual geochemical model based on the deposit geology combined with the proposed mining and processing methods. This conceptual model provides the basis for the scope and methodology of the geochemistry baseline study and defines the approach for sample selection, laboratory procedures and key criteria for decision-making throughout the process.

The Grassy Mountain Project consists of an underground gold resource located in Malheur County, Oregon, about 22 miles south-southwest of Vale, Oregon in an area where no previous mining activity has taken place. The Grassy Mountain Project is an epithermal gold deposit that was formed by epithermal hot spring activity. The boiling water produced brecciation, alteration of county rock, and precipitation of precious metals with only trace amounts of base metals as sulfide minerals. Alteration occurred mainly by silicification with the precious metals commonly occurring in quartz adularia-sericite veinlets. Silica is almost always the most abundant gangue mineral. Pyrite and other iron sulfides are the most common sulfide phases. Arsenic, mercury, and antimony sulfides may also be present, but are subordinate to pyrite. From geologic logging of drill core, it appears that the sulfide ore body has been partially oxidized by groundwater. Within the oxidized zone, sulfides may be wholly or partially replaced by oxides, hydroxides, sulfates, or carbonates. There are limited carbonate minerals present within the deposit.

The Grassy Mountain Project will be developed as an underground mine with an expected operational mine life of 8 to 10 years. Ore and waste rock will be excavated using conventional drill and blast techniques. Waste rock will be generated from road (and other) construction as well as during excavation of the underground decline. Waste rock will be placed in mined out areas or placed in above ground waste rock dumps. Ore will be deposited onto a temporary coarse ore stockpile at the site prior to being transferred to the process area.

The Grassy Mountain Project process circuit includes crushing and grinding the ore, gravity separation, cyanide leaching (CIL) thickened tailings, electrowinning recovery, cyanide detoxification, and a Knelson concentrator sewer to separate the free milling gold. The rougher concentrate is then pumped to the CIL circuit where the tailings are thickened and sodium cyanide, lime, and oxygen are added. This chemical reaction dissolves or leaches the precious metals into solution in a series of agitated tanks. It will be a “zero discharge” operation. The final step in processing is to treat the remaining tailings to remove any residual reagents or chemicals, and to neutralize any residual cyanide.

The operation would employ an industry standard tailings management technology that will stabilize the tailings deposited in the management facility.

The design of the geochemical characterization program has been developed based on the geology of the site and the mine plan information and includes the following steps:

1. Refinement of the current conceptual geochemical model for each mine facility including understanding of the geological materials involved and the conceptual management approach.
2. Design of the sampling approach for each component.

3. Selection of suitable test procedures to assess potential impacts.

Table 3-1 provides a list of the mine facilities that will require geochemical characterization, location and duration of the facility, and the types of geochemical data required. Characterization of the amended tailings and cemented rock backfill is not included in this program.

Samples have been collected as part of a comprehensive program designed to examine the range of conditions that could occur. Tested materials include exploration core (as available), surface samples and test residues from metallurgical testing. The characterization studies were conducted in a manner that provides a conservative estimates of the composition of waste rock and ore, in order to provide information necessary to determine the potential environmental impacts in the environmental evaluation phase of the Division 37 permit process.

The geochemical baseline study is designed to follow guidelines set forth in the Bureau of Land Management Instruction Memorandum NV-2010-014, Nevada Bureau of Land Management Rock Characterization Resources and Water Analysis Guidance for Mining Activities (BLM, 2013). In addition, the program follows the guidance provided in the Global Acid Rock Drainage (GARD) Guide (INAP, 2009), the industry best practices for characterization to support evaluation of potential future impacts to water resources and design of appropriate mitigation strategies. Leachate chemistry will be compared to Oregon Groundwater Quality Guidelines (OGWQG, OAR 340-40-020) to provide a context in which to understand and interpret the data (Table 3-2).

Table 3-1: Program Design

Source	Description	Location	Duration	Composition	Sample Types	Geochemical Data Needs				
						Static	Mineralogy	Erionite Mineralogy	MWMP	HCT
Waste rock dump	Waste rock dump	Mine area (surface)	Permanent	Non-PAG and PAG waste rock	Core	X	X	X	X	X
Ore stockpile	Ore stockpiled near mill	Plant site	LOM	Underground ore	Core	X	X	X	X	--
Underground workings	Exposed rock in workings	Mine area (underground)	Permanent	Waste rock and ore	Core	X	X	X	X	X
Tailings	Dry stack tailings	Plant site	Permanent	Low pyrite tailings	Metallurgical testwork	X	X	--	X	X
Underground backfill[1]	Cemented backfill	Mine area (underground)	Permanent	Cemented waste rock	Core/cement	X	--	--	X	X
Access and haul roads[1]	Surface development (cut/fill)	Various	Permanent	Alluvium/bedrock	Surface samples	X	--	--	X	--
Topsoil stockpiles[1]	Surface development (Pre-strip)	Various	LOM	Soil for reclamation	Surface samples	X	--	--	X	--
Borrow material[1]	Borrow materials for construction	Various	Permanent	Non-PAG waste rock	Core	X	--	--	X	--

[1] Characterization of this material source is not included in this study and will be provided under separate cover.

Table 3-2: Oregon Groundwater Quality Guidelines (OAR 340-40-020)

Parameter	Units	Reference Level[1]	Guidance Level[1]
Arsenic	mg/L	0.05	-
Barium	mg/L	1	-
Cadmium	mg/L	0.01	-
Chloride	mg/L	-	250
Chromium	mg/L	0.05	-
Copper	mg/L	-	1
Fluoride	mg/L	4	-
Iron	mg/L	-	0.3
Lead	mg/L	0.05	-
Manganese	mg/L	-	0.05
Mercury	mg/L	0.002	-
Nitrate	mg/L as N	10	-
pH	s.u.	-	6.5 - 8.5
Selenium	mg/L	0.01	-
Silver	mg/L	0.05	-
Sulfate	mg/L	-	250
Total Dissolved Solids (TDS)	mg/L	-	500
Zinc	mg/L	-	5

[1] All reference and guideline levels are for total (unfiltered) concentrations.

4 Characterization Program Methodology

4.1 Material Type Delineation

Underground development rock will consist of waste rock and ore materials that can be classified and tested according to material type, and the number of samples selected for geochemical testing is typically based on the relative percentage of each material type predicted to be mined from the geologic model.

The term ‘material type’ typically denotes a unique combination of lithology, alteration and oxidation state. However, because silicic alteration is pervasive in the Grassy Mountain deposit and the deposit is mostly oxidized, material types were delineated solely on lithology. Based on this assumption, a total of eight material types have been identified. These are summarized in Table 4-1 along with an estimate of the percent of each material type that will be mined based on the geologic block model. The characterization program included samples of waste and ore grade rock from the underground development, with a focus on waste grade material.

Table 4-1: Grassy Mountain Material Types

Material Type	Approximate Proportion of Development Rock – Ore/Waste (%)
Siltstone	54
Sandstone	26
Sinter	11
Mud/clay	5
Breccia	<1
Mudstone	<1
Tuff	<1
Basalt	<1

Source: Calico (personal comm.)

4.2 Sample Collection

4.2.1 Waste Rock and Ore

SRK collected a total of 105 samples for geochemical characterization testing as part of the current evaluation of the Grassy Mountain project. This included 68 samples collected from exploration drill core and 36 pulp samples representative of development rock (ore and waste rock). In addition, one sample of tailings material collected from the metallurgical testwork program was included in the characterization program. Sample collection activities are described in the following sections.

Sample selection is a fundamental step in the waste rock/ore characterization program and requires careful consideration. Guidelines applied to determine sampling adequacy are provided by the USEPA (1994), by the British Columbia AMD Task Force (BCATF, 1989) and Canada’s Mine Environment Neutral Drainage (MEND) Program (Price, 2009). However, professional judgment and sound geological knowledge of a deposit are even more significant factors in the number and types of samples selected, as opposed to a strict numerical adherence to the guidelines (INAP, 2009).

The MEND Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials (Price, 2009) provides suggested initial sampling frequency based on tonnage of units mined (Table 4-2). Based on the current mine plan, approximately 2 Mt of waste rock will be generated during mining (Table 4-2). According to Table 8.2, between 26 and 80 samples is an appropriate number of samples for the baseline characterization program. However, sample selection should be based on best judgment and an understanding of the variability of the deposit geology.

Table 4-2: MEND Table 8.2 - Sample Frequency

Tonnage (metric tons)	Number of Samples
<10,000	3
<100,000	8
<1,000,000	26
<10,000,000	80

To characterize the Acid Rock Drainage and Metal Leaching (ARD/ML) potential for the Grassy Mountain Project, a weighted approach was taken to assess the geochemical variability of geologic materials that will be encountered during mining. The approach included the collection of an appropriate number of samples based on the relative importance or mass of the lithological unit with respect to the total mass in the deposit. As stated in the GARD Guide, material types that comprise less than five percent of the waste rock typically require fewer samples since they are less likely to have a considerable influence on the geochemical nature of the dump facility (INAP, 2009).

Selection of representative sample intervals was completed with the aid of the Leapfrog Software package which enables 3D visualization of imported drill hole data. This can then be viewed in relation to the proposed underground workings and ore body. Sample intervals were selected from the exploration drill holes to develop a dataset that is as lithologically and as spatially representative of the deposit as possible with the information and drill core available for sampling.

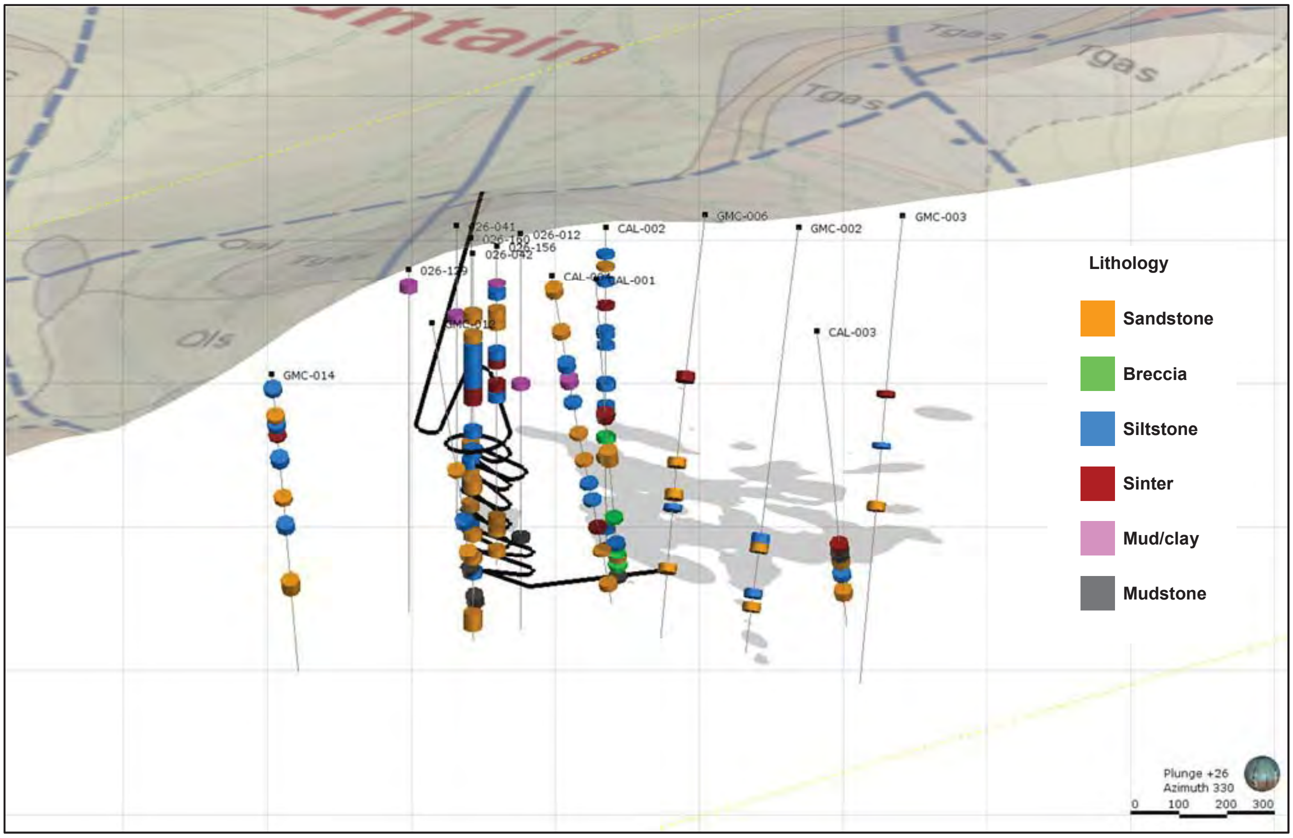
SRK personnel visited the project site in January 2015 in order to collect representative samples of waste rock/ore from drill core being stored at the Vale core shed. During the sample program, SRK collected a total of 68 samples from core holes. The selected sample intervals range from about 10 to 20 feet in length depending upon the geology and gold grade. For each sample interval, approximately 8 to10 kg of sample material was selected from existing core boxes, placed in sample bags, and labeled with the drill hole number, and the interval. In all cases, the material type collected within each interval is identical. In addition to the core samples, 36 pulp samples were selected to characterize the waste rock within the decline area where limited core material was available.

The resulting dataset is lithologically representative of the deposit to the extent possible based on the scope of the exploration program and materials available. Table 4-3 shows the distribution of samples in relation to the proportion of each material type predicted to be mined. This shows good lithological representation of samples, with a bias towards material types that will ultimately comprise a greater proportion of development rock. The mudstone unit occurs at the base of the deposit and although only a very small amount of this material type will be mined as part of the current mine plan, it has been included in the geochemical characterization study for completeness. At the time of sample collection, none of the drill holes for which sample material was available intercepted the basalt and tuff units. Therefore, no samples of basalt or tuff have been collected to date. However, these units comprise less than one percent of the material that will be mined. If basalt or tuff is encountered in future exploration drilling programs, samples of these rock types will be collected for testing.

The dataset is spatially representative of the deposit to the extent possible based on the location of the drill holes and core/pulp material available. The spatial distribution of sample intervals is shown in relation to the proposed underground decline and ore shells in Figure 4-1, which shows generally good spatial representation. However, a few gaps still exist due to a lack of drilling in some areas. Additional images showing sample distribution are provided in Appendix A. Even though GMC-014 is located outside the underground development, core samples were collected from this hole for similar material types due to limited core material available for the decline area.

Multi-element data and total sulfur data was not available for the exploration dataset; therefore a statistical evaluation of the dataset cannot be made. However, Calico has developed a comprehensive geologic model of the deposit resulting in good geologic control of the sample selection. Based on the geologic interpretation, the geologic units are fairly continuous with consistent oxidation throughout the deposit. Furthermore, the geologic units that will be encountered in the northern portion of the deposit are geologically the same as the units in the other portions of the deposit and no new rock types will be encountered in this area. Therefore, the current dataset is lithologically representative of the deposit and is considered adequate for the baseline characterization program. However, some spatial gaps will need to be addressed in the future when drilling is conducted in these areas. Prior to initiation of mining in these areas Calico will develop and implement a sampling and testing program to verify and confirm the rock units in these areas are geochemically similar to the waste rock material included in the baseline geochemical characterization program. Sampling and testing methods will be consistent with the baseline geochemical characterization program to ensure comparable results.

Samples were submitted to McClelland Laboratories (Sparks, Nevada) for sample preparation and geochemical characterization testing (as specified in Section 4.4, below). The number of samples submitted for geochemical testing is provided (per material type) in Table 4-3.



Source: HDR\402200.010_Calico_Grassy_Mountain\020_Project Data\Leapfrog Files\LeapfrogModel-Geo

Figure 4-1: Spatial Distribution of Samples in Relation to Underground Workings

Table 4-3: Sample Collection and Testing Matrix

Material Type	Proportion of Development Rock - Ore/Waste (%)	Number of samples submitted for testing				
		Core		Pulps		Total
		Waste	Ore	Waste	Ore	
Siltstone	54	13	9	10	1	33
Sandstone	26	19	5	14	2	40
Sinter	11	6	1	4	0	11
Mud/clay	5	1	0	3	1	5
Breccia	<1	1	6	0	0	7
Mudstone	<1	6	1	0	1	8
Tuff	<1	0	0	0	0	0
Basalt	<1	0	0	0	0	0
Tailings	N/A	N/A	N/A	N/A	N/A	1
TOTAL	**100**	**46**	**22**	**31**	**5**	**105**

Source: Grassy Mountain Static Test Database Rev14

4.2.2 Tailings Sample

A sample of tailings material from the metallurgical testing conducted at Resource Development Inc. was also analyzed. The metallurgical test was conducted on a sample collected from core that consisted of a range of lithologies and gold grades (i.e., average ore grade and composition). Due to the consistent nature of the geology of the deposit and the fact that the deposit has been oxidized, major shifts in the ore (and tailings) geochemistry is not anticipated. The tailings sample was collected after Inco cyanide destruction using sodium bisulfite as a SO_2 source. Calico is planning on including the Inco cyanide destruction in their process circuit, therefore this sample is considered representative of the final tailing product.

Solution representative of process solution entrained in the tailings after cyanide destruction was not available from the metallurgical test for analysis. However, based on the proposed tailings disposal methods, the amount of solution that will be entrained in the tailings is anticipated to be low (less than 10%). Therefore, the proposed tailings characterization without solution chemistry is considered adequate for the baseline characterization program. A metallurgical test program is currently underway and Calico plans on collecting samples representative of tailings material as well as samples of entrained solution for analysis including pH, major ions, metals, weak-acid dissociable cyanide, total cyanide and including thiocyanate.

4.2.3 Erionite Sampling and Analysis

Additional sample collection and testing was completed to determine the presence of erionite, a fibrous zeolite and known carcinogen, in the geologic materials that will be encountered during mining and construction activities associated with the Grassy Mountain Project. This sampling was conducted according to the February 2015 Erionite Sampling and Analysis Plan (Erionite SAP) to address comments received from the Oregon Department of Geology and Mineral Industries (DOGAMI) and Oregon Department of Agriculture (ODA) January 26, 2015.

As described in the Erionite SAP, a subset of samples from the baseline geochemical characterization study was selected for mineralogical analysis to determine if erionite is present within the geologic materials that will be encountered during mining and construction. Samples selected for mineralogical analysis focused on those lithologies that have a potential to contain erionite including siltstones/mudstones of the Grassy Mountain Formation and the Butterfly Hill rhyodacite. Erionite is not likely to occur with the sinter units, arkosic sandstone and sandstone units of the Grassy Mountain Formation or soil/alluvium. In addition, the Kern Tuff and Negro Rock basalt will not be encountered during construction activities within the process area. Therefore, samples of these lithologies were not included in this program.

Samples were selected in order to provide a sample set that is spatially representative of the geologic material that will be encountered during mining/construction. Samples selected for mineralogical analysis were also submitted for the mineralogical testwork described in the following section.

Samples were shipped to McClelland Laboratories (MLI) for sample preparation. For each sample selected for testing, two splits were generated. One 100 gram split was generated and pulverized for XRD analysis and a separate 100 gram split of each sample was generated and set aside for SEM and optical mineralogy as required.

In accordance with recommendations on testing from DOGOMI and ODA, samples selected for mineralogy were shipped to SRK (UK) where they underwent x-ray diffraction (XRD) testing at the School of Earth & Ocean Sciences Cardiff University for identification of erionite. For erionite determination, the accumulated 2θ values obtained by XRD were compared to those reported in the JCPDS determination database for erionite. In cases where the initial XRD analysis indicated that zeolite minerals were absent, no further testing was conducted. Those samples for which XRD testing identified the presence of erionite or other fibrous zeolite minerals, were submitted for optical mineralogy and scanning electron microscope (SEM) to confirm the presence of erionite.

The SEM analysis was consistent with U.S. Geological survey publication Denver Microbeam laboratory Administrative Report 14012007 (Lowers, H.A., and Meeker, G.P., 2007). Using SEM, each sample was examined for the distinctive needle-shaped crystals of erionite. Needle-shaped grains that were found were documented with a digitally captured SEM image.

In order to ensure quality control, all elemental analysis was conducted after daily calibration of the spectrometers to pure metal standards, compounds and natural minerals for definitive elements. In addition, a reference sample of erionite from Oregon, was sent to the analytical lab for test sample comparisons. Results of the mineralogical analysis were accompanied by the lab’s statement of qualifications which included: a written quality assurance/quality control (QA/QC) program with procedures; instrumentation summary; list of personnel and qualifications; all accreditations and licenses; and a summary of related work experience.

4.3 Quality Control

The Global Acid Rock Drainage (GARD) Guide (INAP, 2009) recommends a rigorous QA/QC program for geochemical characterization and recommends that data be validated.

Laboratories selected for this characterization program are certified with the State of Oregon and State of Nevada for the proposed testing and operate internal QA/QC procedures to ensure adequate data quality. This included the analysis of certified reference materials in addition to laboratory control samples, matrix spikes, standards, method blanks, and instrument blanks. However, SRK also applied a number of QA/QC checks on the MWMP and HCT data, including the calculation of ion balances to determine the balance of cations and anions in the generated solutions. A comparison of pH measurements from both McClelland and WetLab was also be carried out to assess data quality.

4.4 Geochemical Testwork Methods

The static and kinetic testing methods selected for the Grassy Mountain Project were designed to address the bulk geochemical characteristics of the waste rock and tailings samples, and to assess the potential of the waste rock to generate acid or release metals in drainage. “Static testing” is a general term describing those analytical methods applied to characterize acid generation potential and metal leaching characteristics of material at the time of testing and does not account for temporal changes that may occur in the material as chemical weathering proceeds. Static tests provide a balance of acid generating and acid consuming reactions at an end point and also may be used to determine the potential magnitude of leaching metals from a given material.

Static testing is distinguished from "kinetic tests", which evaluate the rate of sulfide oxidation and metal release over time. Static testing provides a conservative approximation of acid generation and trace metal release potential, which is used to determine where more comprehensive kinetic testing is warranted. Based on the results of the static test work, materials that exhibit uncertain or highly variable geochemical behavior may require further characterization using kinetic test methods to determine the rates and character of longer-term leaching.

The static testing methods selected for this project were designed to address the bulk geochemical characteristics of waste rock, ore and tailings samples and include the following:

- Multi-element analysis using aqua regia digest and ICP analysis to determine total metal and metalloid chemistry for 48 elements (ALS Chemex Method ME-MS41).
- Acid Base Accounting (ABA) using the modified Sobek method (Sobek, 1978) with sulfur speciation by hot water, hydrochloric acid, and nitric acid extraction.
- Total Inorganic Carbon Analysis (TIC) by Leco.
- Net Acid Generating (NAG) test that reports the final NAG pH and final NAG value after a two-stage hydrogen peroxide digest.

These test methods and the criteria commonly used in the evaluation of the resulting data set are described in the following sections. Samples were submitted to McClelland Laboratories (MLI) in Sparks, Nevada for sample preparation and MWMP extraction. The MWMP extracts were then sent to ACZ Laboratories in Steamboat Springs Colorado for chemical analysis.

4.4.1 Multi-Element Analysis

A multi-element analysis of the waste rock and tailings samples was completed through ALS Chemex, Reno, to provide an upper limit of available metals for leaching from the samples. The analysis involved aqua regia digestion followed by analysis by ICP-OES and ICP-MS for a full suite of metals and metalloids. This included determination of major elements (e.g. aluminum, calcium, magnesium, sodium, potassium, iron, sulfur) and trace elements (e.g., arsenic, antimony, mercury, zinc, copper, cadmium and lead). The results of the multi-element analysis were analyzed using the Geochemical Abundance Index (GAI) (Förstner et al., 1993), which compares the concentration of an element in a given sample to its average crustal abundance. GAI values are particularly useful in determining the relative enrichment of elements based on lithology and may be used to identify elements enriched above average crustal concentrations. GAI values are calculated as follows:

$$GAI = \log_2 [C/(1.5*S)]$$

Where *C* is the concentration of an element as determined from the multi-element assay and *S* is the average crustal abundance of the element of interest (Mason, 1966). Materials were then assigned a GAI value between zero and six based on the degree of enrichment (Table 4-4), with a GAI value greater than three indicating significant enrichment. These elements therefore have potential to be leached in sufficient concentration to have an environmental impact.

Table 4-4: Interpretation of GAI values

GAI Value	Interpretation
0	< 3 times average crustal concentrations
1	3 to 6 times average crustal concentrations
2	6 to 12 times average crustal concentrations
3	12 to 24 times average crustal concentrations
4	24 to 48 times average crustal concentrations
5	48 to 96 times average crustal concentrations
6	>96 times average crustal concentrations

4.4.2 Acid Base Accounting

Acid Base Accounting provides an industry-recognized assessment of the acid generation or acid neutralization potential of rock materials. The ABA method used for the characterization of the Grassy Mountain samples is the modified Sobek ABA method (Sobek, 1978), which includes both laboratory analysis and empirical calculations based on acid generating potential (AP) and neutralizing potential (NP). An estimate of acid generation is made by assuming complete reaction between all minerals with acid generating potential and all of the minerals with neutralizing potential (essentially dissolution of carbonate minerals and to very limited extent silicate minerals as the latter have very slow reaction kinetics; Bowell et al., 2000).

The AP values were calculated from sulfide sulfur concentrations and reported as $CaCO_3$ equivalents per 1,000 tons of rock. The modified Sobek method determines the sulfide sulfur and sulfate sulfur content by measuring the amount of nitric acid-extractable sulfur and the amount of hot water-extractable sulfur. According to this method, the AP is established by determining three sulfur content numbers including:

- Total Sulfur – determined from analysis of an untreated sample using a LECO furnace. The result is a measure of all sulfur forms in the sample.
- Non-Extractable Sulfur – determined from digestion of a sample with nitric acid followed by filtration and then LECO analysis. Nitric acid removes sulfate and sulfide minerals and the only remaining minerals are insoluble sulfate minerals such as barite.
- Non-Sulfate Sulfur – determined from digestion with hot water followed by filtration and then LECO analysis. The hot water extraction leaches sulfate minerals (e.g., gypsum) from the sample leaving behind sulfide sulfur and non-extractable sulfur forms.

Sulfide sulfur is the difference between the non-sulfate sulfur (i.e., sulfide sulfur plus non-extractable sulfur) and non-extractable sulfur. The AP is calculated by multiplying the sulfide sulfur concentration by 31.25. In the case where sulfide sulfur was below the laboratory detection limit, the laboratory detection limit (i.e., 0.01 wt%) was used to calculate AP.

The NP values were determined using the modified Sobek protocol that includes a digestion to expel any CO_2 followed by a back titration with NaOH to a pH of 8.3. Neutralizing potential is calculated as $CaCO_3$ equivalents per 1,000 tons of rock. Total Inorganic Carbon (TIC) was also analyzed in order to provide a second measure of neutralization potential; however the Sobek NP values were used for the purpose of the data evaluation. For those samples with NP below the laboratory detection limit, the NP is assumed to be the detection limit (i.e., 0.3 kg $CaCO_3$ eq/ton) for the ABA calculations.

The balance between the acid generating mineral phases and acid neutralizing mineral phases is referred to as the net neutralization potential (NNP), which is equal to the difference between NP and AP. The NNP allows classification of the samples as potentially acid consuming or acid producing. A positive value of NNP indicates the sample neutralizes more acid than is produced during oxidation. A negative NNP value indicates there are more acid producing constituents than acid neutralizing constituents. Material that would be considered to have a high potential for acid neutralization produces a net neutralizing potential of greater than 20 kg $CaCO_3$ eq/ton. Acid Base Accounting data is also described using the neutralization potential ratio, which is calculated by dividing the NP by the AP (i.e., NP:AP, also referred to as NPR).

The Nevada BLM Water Resource Data and Analysis Guide for Mining Activities (BLM, 2008) establishes the following guidelines for the evaluation of ABA test results:

- NP:AP (NPR) values greater than 3 and NNP values greater than 20 kg $CaCO_3$ eq/ton are not acid generating and do not require further testing.
- NP:AP (NPR) values less than 3 and/or NNP values less than 20 kg $CaCO_3$ eq/ton have uncertain potential and require further evaluation using kinetic test methods.

4.4.3 Net Acid Generation

Static Net Acid Generation (NAG) testwork was carried out in order to determine the maximum potential for acid generation from the samples. The static NAG test differs from the ABA test in that it provides a direct empirical estimate of the overall sample reactivity, including any acid generated by semi-soluble sulfate minerals as well as potentially acid-generating sulfide minerals. Depending upon the site mineralogy and geology, the NAG test can provide a better estimate of field acid generation than the more widely-used ABA method, which defines acid potential based solely on sulfide content.

NAG testing was carried out by SVL laboratories in accordance with the method described by Miller et al. (1997) and Miller (1998). The method involves intensive oxidation of the sample using hydrogen peroxide (H_2O_2), which accelerates the dissolution of sulfide minerals and has the net result that acid production and neutralization can be measured directly. Leachate was then titrated with sodium hydroxide in two stages (pH 4.5 and to pH 7) to determine the NAG value, calculated as follows:

$$NAG = (V_{Init} / X)\ (49 * V_{NaOH} * M) / W$$

Where:
NAG = net acid generation (kg H_2SO_4 eq/ton);
V_{Init} = volume of initial hydrogen peroxide solution (mL);
X = volume used to determine NAG by titration (mL);
V_{NaOH} = volume of NaOH used in titration (mL);
M = concentration of NaOH used in titration (moles/liter); and
W = weight of sample reacted (g).

The guidelines used for assessing the acid generation potential based on NAG results are summarized in Table 4-5. Samples with NAG pH values greater than pH 4.5 are predicted to be non-potentially acid generating (non-PAG). Net acid generation is only measured for samples with NAG pH values less than pH 4.5. NAG results greater than one kg H_2SO_4 eq/ton indicate the sample will generate some acidity in excess of available alkalinity and is potentially acid generating (PAG). However, by convention, any NAG value below 10 kg H_2SO_4 eq/ton of material has a limited potential for acid generation and the results are considered inconclusive because a blank hydrogen peroxide solution (the reagent in the NAG test) can generate a NAG artifact value up to 10 kg H_2SO_4 eq/ton.

Table 4-5: Acid Generation Criteria for NAG Results

Acid Generation Capacity		Final NAG pH (s.u.)	Static NAG (kg H_2SO_4 eq/ton)
Potentially Acid Generating (PAG)	High Capacity	< 4.5	>20
	Low to Moderate Capacity	< 4.5	1-20
Non-Potential Acid Generating		≥ 4.5	<1

4.4.4 Short Term Leach Tests (MWMP)

Short term leach testing was conducted on representative samples of ore, waste rock and tailings for the Grassy Mountain project as described in the following sections. The samples submitted for MWMP testing are summarized in Table 4-6 and illustrated in the scatter plots presented in Figure 4-2 through Figure 4-8. These graphs show the distribution of the samples submitted for MWMP and HCT testing in relation to the entire dataset.

The MWMP test was conducted at McClelland Laboratories according to standard test method ASTM E-2242-13 that involves a 24-hour, single pass column leach using a 1:1 distilled water:rock ratio. The resulting leachate was submitted to ACZ Laboratories for major and trace element analysis for the full suite of parameters in Table 4 of Baseline Work Plans, with the requested revisions from DOGAMI as summarized in Table 4-7 below.

The MWMP test was developed to simulate the leaching of mine waste materials by meteoric water under typical low precipitation environmental field conditions. The results of the MWMP test can be used to identify the presence of leachable metals and readily soluble salts stored in the material, as well as provide an indication of their availability for dissolution and mobility. In addition to the leachable metals, the MWMP test also provides an assessment of the potential for acid release during dissolution of soluble acid salts (Ficklin et al., 1992). The final pH of the MWMP extract is representative of short-term leachate that could be produced from waste rock with readily soluble acid-producing salts under field conditions.

Leachate chemistry data collected during the MWMP test have been compared to the OGWQG (OAR 340-40-020) to determine which constituents could potentially be leached at concentrations above these values. However, due to differences in the liquid to solid ratio used in the test compared to typical site conditions, the MWMP test results only provide a qualitative estimate of elemental concentrations in the resulting leachates and are not considered conclusive or to represent actual predictions of water quality.

Ore Material

MWMP testing was completed on a subset of samples representative of ore that will be temporarily stockpiled onsite prior to processing. Six ore samples were selected for MWMP testing to represent the 50^{th} and 90^{th} percentile of sulfide sulfur for the main ore lithologies (i.e., sandstone, siltstone and breccia).

Waste Rock

SRK selected fourteen core samples representative of waste rock (i.e., waste rock and ore) for MWMP testing. The MWMP sample set is lithologically representative of the deposit and the number of MWMP samples selected for each material type was based on the relative importance or mass of the lithological unit with respect to the total mass in the deposit. Nine of these samples were also tested in the kinetic test program. These samples include two samples per material type including one that represents the median/mean sulfide sulfur content (50^{th} percentile) and one that represents the 95^{th} percentile sulfide content. Only one sample from the interbedded mud/clay unit (which will comprise 5 percent of the total development rock) was selected since it was the only available core sample for this material type. This sample represents the 75^{th} percentile of sulfide sulfur for this material type.

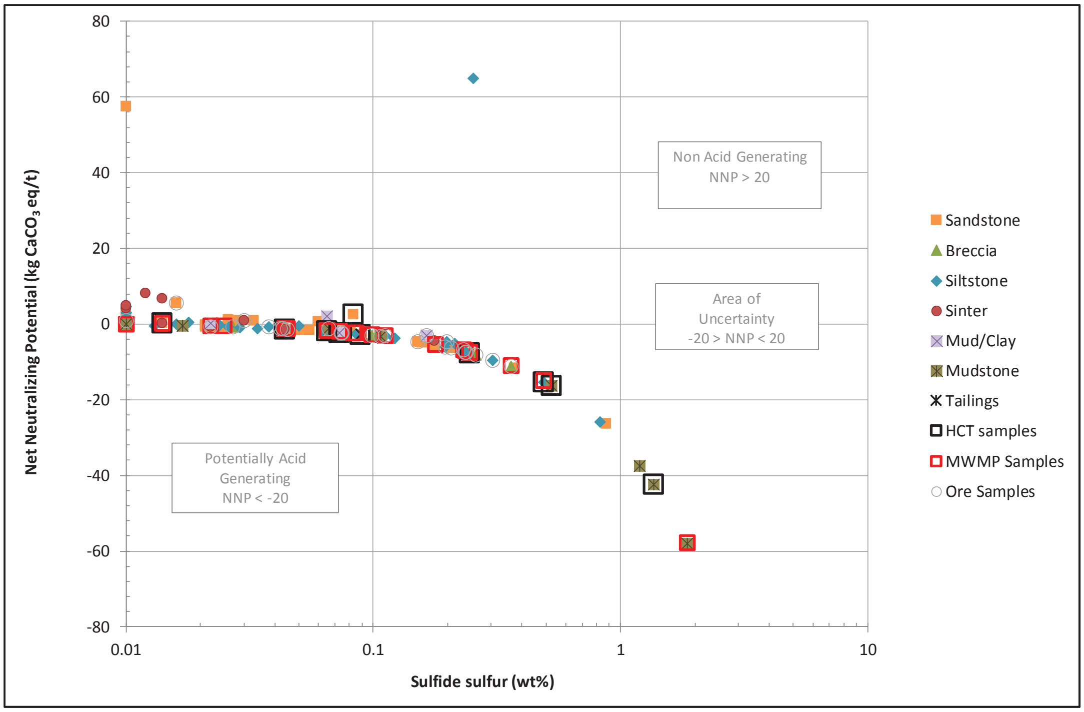
SRK selected 5 additional core samples that represent the 95^{th} and 75^{th} percentile sulfate content for the main material types (i.e., sandstone, siltstone and sinter). Because these samples were selected to determine the potential for sulfate phases present within the samples to generate acid, they were not been included in the kinetic testing program described below. Key graphs are presented in Figure 4-2 through Figure 4-8.

Material types that comprise an insignificant percent of the development rock include breccia and mudstone. Samples of breccia were not selected for MWMP or kinetic testing (as described in Section 4.5.2) since this material type is not likely to have a considerable influence on the geochemical nature of the waste rock facility. Although the mudstone from the base of the deposit will comprise an insignificant amount of the development rock, two samples of this material type were selected for MWMP testing due to the higher potential for acid generation observed for this material type as well as the potential for this material type to be exposed in the underground workings since it defines the lowest extent of the deposit. The samples of mudstone selected for MWMP testing represent the 50^{th} and 95^{th} percentile of sulfide sulfur for this lithologic unit.

Short term leach tests such as the MWMP are best applied to oxidized samples that contain soluble weathering products available for leaching rather than fresh core material. Therefore, the core samples representative of waste rock may under predict the potential for metal leaching that could occur under site conditions. Furthermore, the solubility of trace elements in leachate is commonly pH dependent and the MWMP test does not account for future changes in pH conditions that could occur as this material is exposed to site conditions. In order to address the uncertainties and limitations of the MWMP test, kinetic testing is required for waste rock characterization.

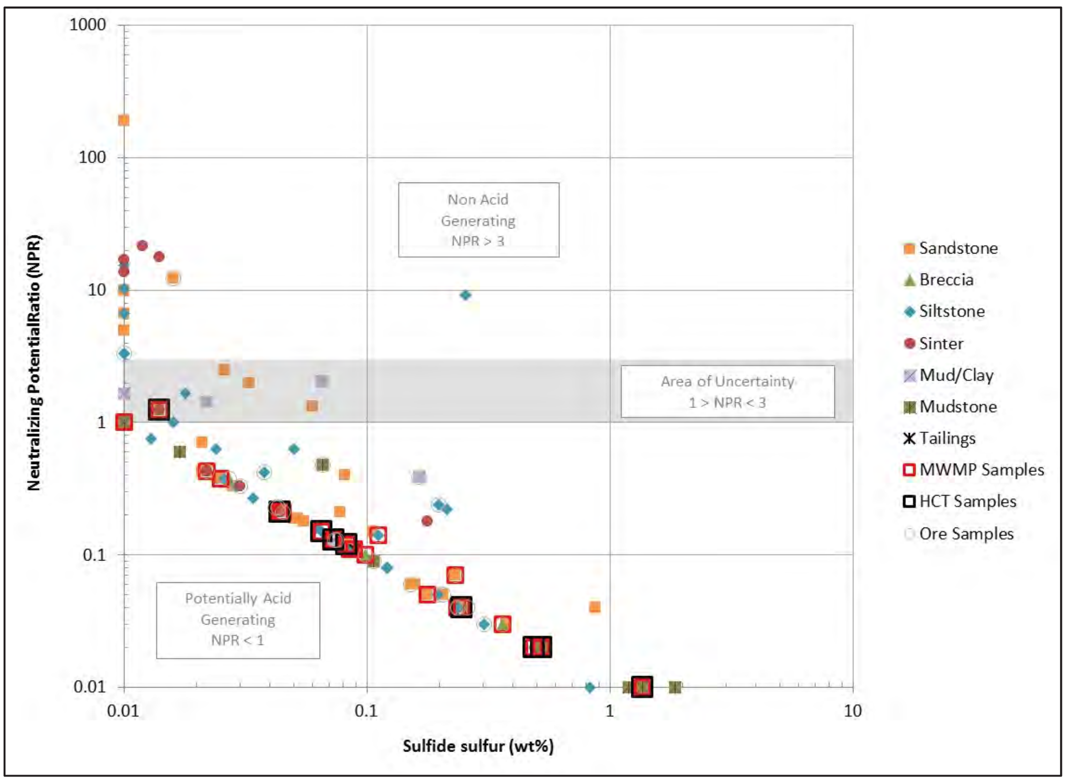
Tailings Material

Due to the fine grained nature of the tailings material, the bottle roll extraction variant of the MWMP was completed for the tailings sample from the metallurgical test program (NDEP, 2015).



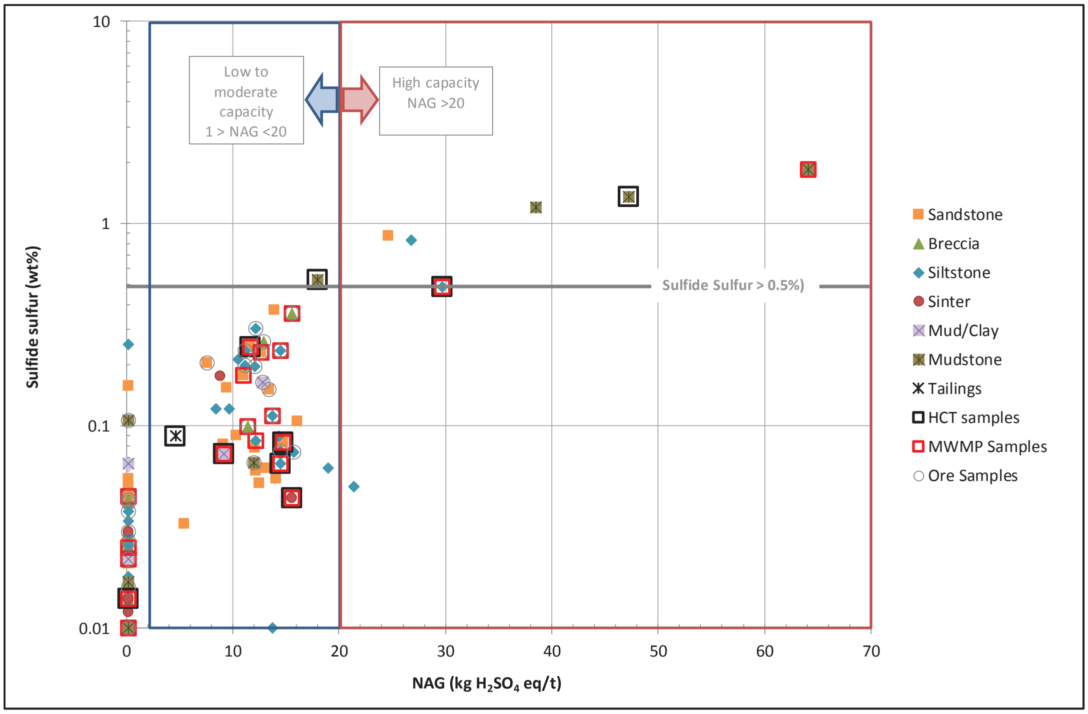
Source: Grassy Mountain Static Test Database Rev14

Figure 4-2: Sulfide Sulfur vs. NNP showing MWMP/HCT Samples



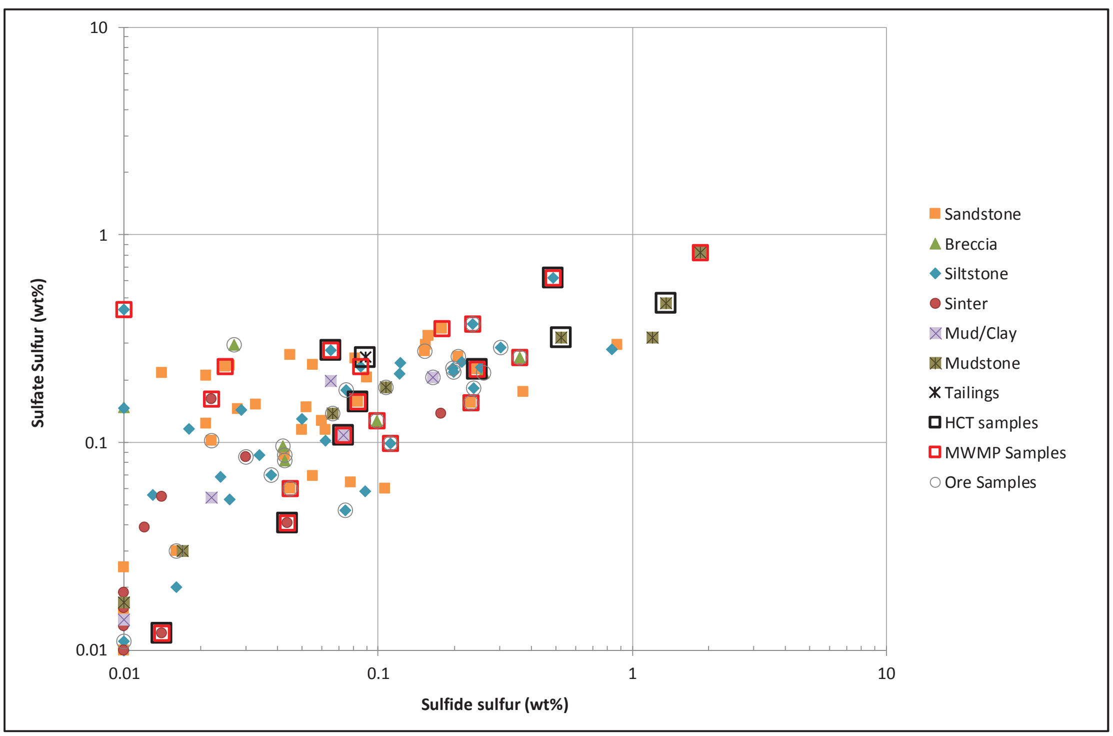
Source: Grassy Mountain Static Test Database Rev14

Figure 4-3: Sulfide Sulfur vs. NPR showing MWMP/HCT Samples



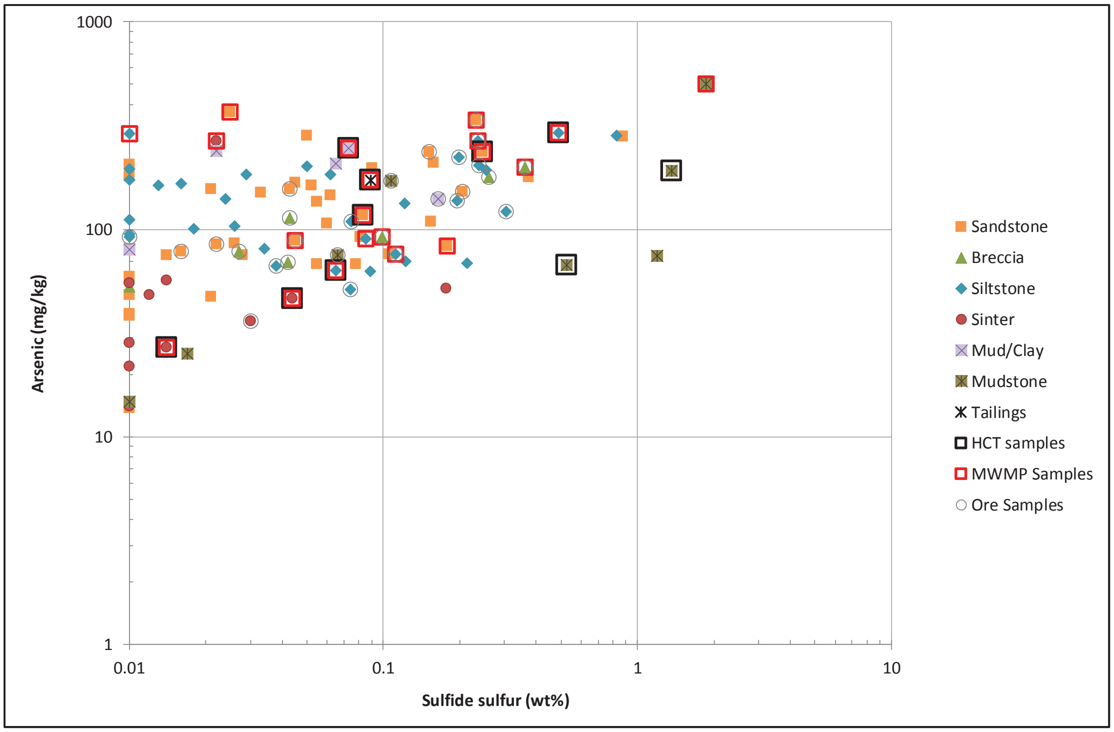
Source: Grassy Mountain Static Test Database Rev14

Figure 4-4: Sulfide Sulfur vs. NAG showing MWMP/HCT Samples



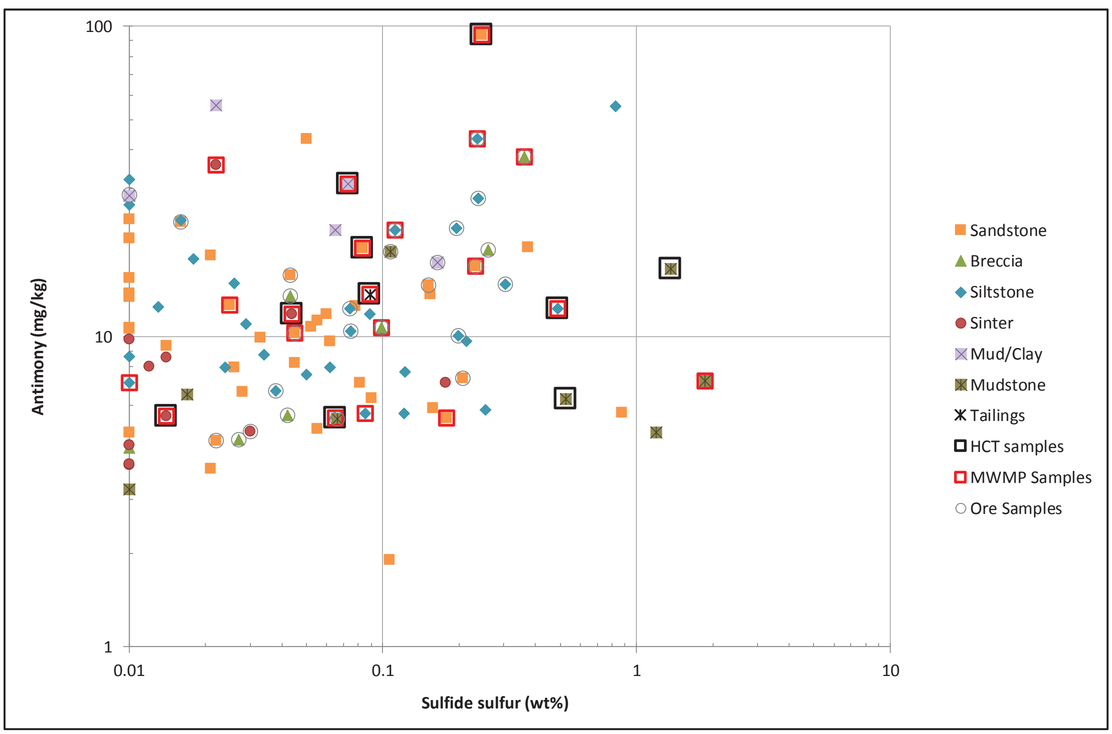
Source: Grassy Mountain Static Test Database Rev14

Figure 4-5: Sulfide Sulfur vs. Sulfate Sulfur showing MWMP/HCT Samples



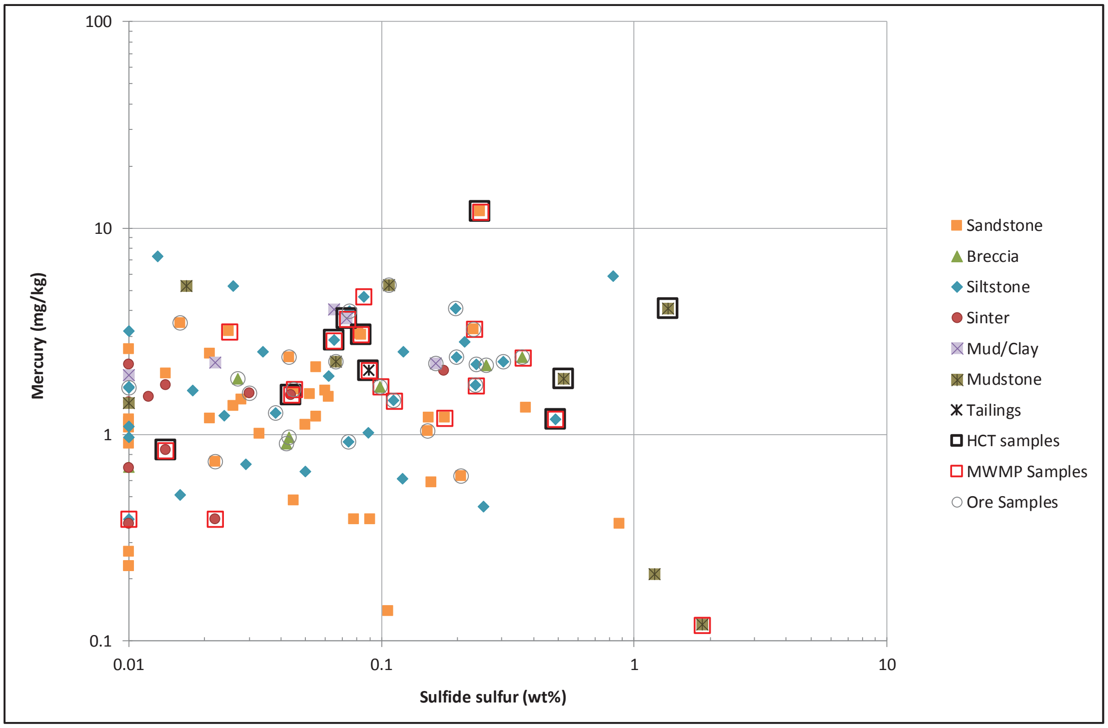
Source: Grassy Mountain Static Test Database Rev14

Figure 4-6: Sulfide Sulfur vs. Total Arsenic showing MWMP/HCT Samples



Source: Grassy Mountain Static Test Database Rev14

Figure 4-7: Sulfide Sulfur vs. Total Antimony showing MWMP/HCT Samples



Source: Grassy Mountain Static Test Database Rev14

Figure 4-8: Sulfide Sulfur vs. Total Mercury showing MWMP/HCT Samples

Table 4-6: Samples Submitted for MWMP Testing

Sample Type	Sample ID	From	To	Lithology	Paste pH	Sulfate Sulfur	Sulfide Sulfur	NNP	NPR	NAG pH	Total NAG	Sample Selection Rational
Ore	GMC-006	593	613	Sandstone	7	0.06	0.045	-1.1	0.21	4.7	0	50th percentile sulfide S
	CAL-001	487	505.4	Sandstone	5.4	0.16	0.23	-6.8	0.07	3.1	13	95th percentile sulfide S
	CAL-002	480	496	Siltstone	6.9	0.13	0.099	-2.8	0.1	3.3	11	50th percentile sulfide S
	CAL-002	430	438.2	Siltstone	6.6	0.26	0.36	-11	0.03	2.7	16	95th percentile sulfide S
	CAL-002	235	255	Breccia	6.7	0.099	0.11	-3	0.14	2.7	14	50th percentile sulfide S
	GMC-003	485	495	Breccia	6.1	0.37	0.24	-7.1	0.04	2.5	15	95th percentile sulfide S
Waste	CAL-002	86	95	Sandstone	6.4	0.23	0.25	-7.4	0.04	2.4	12	95th percentile sulfide S
	CAL-004	860	875	Sandstone	7.7	0.16	0.083	-2.3	0.12	3.1	15	50th percentile sulfide S
	CAL-004	445	455	Sandstone	5.9	0.23	0.025	-0.5	0.38	5.6	0	75th percentile sulfate S, 25th percentile sulfide S
	GMC-012	780	800	Sandstone	6.5	0.35	0.18	-5.3	0.05	2.7	11	95th percentile sulfate S, 75th percentile sulfide S
	CAL-001	750	762	Siltstone	6.6	0.28	0.065	-1.7	0.15	3.7	15	50th percentile sulfide S
	GMC-014	167	184	Siltstone	3.3	0.62	0.49	-15	0.02	2.7	30	95th percentile sulfide S
	CAL-002	697	706	Siltstone	7.2	0.23	0.085	-2.4	0.11	3.5	12	75th percentile sulfate, 50th percentile sulfide S
	GMC-014	44	59	Siltstone	5.9	0.44	0.01	0	1.0	5.4	0	95th percentile sulfate, 25th percentile sulfide S
	CAL-001	380	400	Sinter	7.7	0.012	0.014	0.1	1.3	5.5	0	50th percentile sulfide S
	CAL-002	177	187	Sinter	6.9	0.041	0.044	-1.1	0.21	4	16	95th percentile sulfide S
	GMC-014	208	215	Sinter	6.3	0.16	0.022	-0.4	0.43	5.1	0	95th percentile sulfate, 70th percentile sulfide S
	GMC-012	919	946	Mudstone	3	0.82	1.86	-57.8	0.01	2.24	64	95th percentile sulfide S
	CAL-004	295	315	Mud/clay	5.4	0.11	0.073	-2	0.13	3.2	9.2	75th percentile sulfide S (only available core sample - HCT)
Tailings	Calico Leach Res. After CN Destruct.			Tailings	6.8	0.26	0.089	-2.5	0.11	3.2	4.6	95th percentile sulfide S

Criteria for AP Predictions:

ABA Criteria	PAG	NNP<-20 or NPR<1
	Low PAG	NP between -20 and +20 or NPR between 1 and 3
	Non-PAG	NNP>20 or NPR >3
NAG Criteria	PAG	NAG>20
	Low to Moderate PAG	NAG between 1 and 20
	Non-PAG	NAG<1

Source: Grassy Mountain Static Test Database Rev14

PAG = Potentially Acid Generating, Low PAG = Uncertain Potential/Lower Capacity, Non-PAG = Non-Acid Generating

Table 4-7: List of Analytes for Leach Tests

Parameter	Laboratory Method	Detection Limit	Reporting Limit	Fraction[2]
Alkalinity	SM 2320B	2 mg/L	20 mg/L	dissolved
Bicarbonate	SM 2320	2 mg/L	20 mg/L	dissolved
Carbonate	SM 2320	2 mg/L	20 mg/L	dissolved
Aluminum	EPA 200.7	0.03 mg/L	0.15 mg/L	dissolved
Ammonia Direct as N	EPA 350.1	0.05 mg/L	0.5 mg/L	dissolved
Antimony	EPA 200.8	0.0004 mg/L	0.002 mg/L	dissolved
Arsenic	EPA 200.8	0.0002 mg/L	0.001 mg/L	dissolved
Barium	EPA 200.7	0.003 mg/L	0.015 mg/L	dissolved
Beryllium	EPA 200.8	0.00005 mg/L	0.00025 mg/L	dissolved
Bismuth	EPA 200.7	0.04 mg/L	0.2 mg/L	dissolved
Boron	EPA 200.8	0.0005 mg/L	0.001 mg/L	dissolved
Cadmium	EPA 200.8	0.001 mg/L	0.0005 mg/L	dissolved
Calcium	EPA 200.7	0.2 mg/L	1 mg/L	dissolved
Chloride	EPA 300.0	0.5 mg/L	2.5 mg/L	dissolved
Chromium	EPA 200.8	0.0005 mg/L	0.002 mg/L	dissolved
Cobalt	EPA 200.8	0.00005 mg/L	0.00025 mg/L	dissolved
Conductivity	SM 2510B	1 umhos/cm	10 umhos/cm	dissolved
Copper	EPA 200.8	0.0005 mg/L	0.0025 mg/L	dissolved
Cyanide, Total	EPA 335.4	0.003 mg/L	0.01 mg/L	dissolved
Cyanide, Weak Acid Digestion	SM 4500	0.003 mg/L	0.01 mg/L	dissolved
Fluoride	EPA 300.0	0.1 mg/L	0.5 mg/L	dissolved
Gallium	EPA 200.7	0.1 mg/L	0.5 mg/L	dissolved
Hardness	SM 2340B	calc	calc	dissolved
Iron	EPA 200.7	0.02 mg/L	0.05 mg/L	dissolved
Lead	EPA 200.8	0.0001 mg/L	0.0005 mg/L	dissolved
Lithium	EPA 200.7	0.02 mg/L	0.1 mg/L	dissolved
Magnesium	EPA 200.7	0.2 mg/L	1 mg/L	dissolved
Manganese	EPA 200.8	0.0005 mg/L	0.0025 mg/L	dissolved
Mercury[3]	EPA 200.8	0.0001 mg/L	0.0001 mg/L	dissolved
Molybdenum	EPA 200.8	0.0005 mg/L	0.0025 mg/L	dissolved
Nickel	EPA 200.8	0.0006 mg/L	0.003 mg/L	dissolved
Nitrate+Nitrite as N	EPA 353.2	0.02 mg/L	0.1 mg/L	dissolved
pH (s.u.)	SM 4500-H B	0.1 C	0.1 C	dissolved
Phosphorus	EPA 365.1	0.01 mg/L	0.05 mg/L	dissolved
Potassium	EPA 200.7	0.3 mg/L	1.5 mg/L	dissolved
Scandium	EPA 200.7	0.1 mg/L	0.5 mg/L	dissolved
Selenium	EPA 200.8	0.0001 mg/L	0.00025 mg/L	dissolved
Silver	EPA 200.8	0.00005 mg/L	0.00025 mg/L	dissolved
Sodium	EPA 200.7	0.3 mg/L	1.5 mg/L	dissolved
Strontium	EPA 200.7	0.01 mg/L	0.05 mg/L	dissolved
Sulfate	EPA 300.0	0.5 mg/L	2.5 mg/L	dissolved
Thallium	EPA 200.8	0.0001 mg/L	0.0005 mg/L	dissolved
Tin	EPA 200.8	0.0004 mg/L	0.002 mg/L	dissolved
Titanium	EPA 200.7	0.005 mg/L	0.025 mg/L	dissolved
Total Dissolved Solids	SM 2540C	10 mg/L	20 mg/L	dissolved
Uranium	EPA 200.8	0.0001 mg/L	0.0005 mg/L	dissolved
Vanadium	EPA 200.8	0.0002 mg/L	0.001 mg/L	dissolved
Zinc	EPA 200.7	0.01 mg/L	0.05 mg/L	dissolved

[1] WAD cyanide and total cyanide will be analyzed for the tailings sample only.

[2] As part of the MWMP ASTM method, the column extract is filtered with a 0.45 μm filter. Extract analyses are therefore considered dissolved concentrations.

[3] HCT samples with mercury at concentrations below detection will be submitted every 8 weeks for low level mercury using Method 1631E (low level) to obtain a detection limit of 0.2 ng/L and 0.5 ng/L. MWMP extracts will be submitted for Method 1631E.

4.4.5 Long Term Leach Tests (HCT)

The objective of the static testing program was to allow rapid assessment of the acid generating and metal leaching characteristics of the main lithological units that will be exposed on site. However, these static tests do not consider the temporal variations that may occur in leachate chemistry as a result of long-term changes in oxidation, dissolution and desorption reaction rates. Because chemical weathering kinetics are known to strongly affect solute release over time, the results of static tests need to be confirmed using kinetic methods, particularly for samples which demonstrate an uncertain potential for acid generation on the basis of ABA and NAG testwork results.

Kinetic tests (e.g., humidity cell tests) evaluate temporal changes in leachate chemistry, through the sequential leaching of the rock weathered in a regular cycle of exposure to dry and wet air in a controlled laboratory environment. These cycles simulate and accelerate the chemical weathering rates observed under field conditions, using test conditions that are specifically designed to target oxidation of sulfide minerals. The goal of kinetic testing is to provide reaction rate data to support prediction of the leachate chemistry that would likely during through contact of meteoric water with waste rock.

The majority of the Grassy Mountain samples show uncertain acid generating characteristics according to BLM guidance (2008) from the ABA results and further testing is required to address the uncertainties of the ABA testing.

SRK selected a representative subset of nine waste rock samples from the static test database for kinetic testing. Details of these samples are provided in Table 4-8 and are illustrated in the scatter plots presented in Figure 4-2 through Figure 4-8. These graphs show the distribution of the samples selected for kinetic testing in relation to the entire dataset.

The steps taken to select samples for kinetic testing include:

- Identify the main material types that require characterization.
- Select two samples per material type including one that represents the median/mean sulfide sulfur content (50th percentile) and one that represents the 95th percentile sulfide content.
- Where more than one sample was available, the sample with the lowest neutralization potential (NP) was selected in order to characterize the effect of net acid generation.

One sample representing the 75th percentile of sulfide sulfur from the interbedded mud/clay unit (which will comprise 5 percent of the total development rock) was chosen since it was the only available core sample for this material type. In addition to the nine waste rock samples, the tailings sample has been selected for kinetic testing. Because the ore grade material will only be stockpiled onsite in the short term, no samples of ore grade material have been selected for kinetic testing.

The resulting HCT sample set is lithologically representative of the deposit and the number of kinetic test samples selected for each material type is based on the relative importance or mass of the lithological unit with respect to the total mass in the deposit. Material types that comprise an insignificant percent of the development rock include breccia and mudstone. Kinetic tests were also performed on the two samples of mudstone from the base of the deposit selected for MWMP testing.

Graphs of total arsenic, antimony and mercury versus sulfide sulfur are provided in Figure 4-6, Figure 4-7 and Figure 4-8 respectively. These graphs show the samples selected for kinetic testing are representative of the range of total concentrations of these constituents. Although antimony, arsenic and mercury concentrations were considered during the sample selection process, sulfide sulfur content is the main control on acid generation and was the key parameter used for sample selection.

Mineralogy on the test residues is not considered necessary since the results of the HCT program are conclusive and indicate the majority of the waste rock and ore material will generate acid and leach metals.

Table 4-8: Samples Submitted for Kinetic Testing

Sample ID	Lithology	Paste pH (s.u.)	Sulfide Sulfur (wt%)	NNP (kg $CaCO_3$ eq/t)	NPR	NAG pH (s.u.)	Total NAG (kg H_2SO_4 eq/t)	Sample Selection Rational
CAL-002 (86-95)	Sandstone	6.36	0.246	-7.7	0.04	2.37	11.7	95th percentile sulfide S
CAL-004 (860-875)	Sandstone	7.73	0.083	2.6	0.12	3.14	14.7	50th percentile sulfide S
CAL-003 (675-685)	Mudstone	3.76	1.36	-42.5	0.01	2.33	47.2	95th percentile sulfide S
GMC-012 (832-851)	Mudstone	3.78	0.526	-16.4	0.02	2.56	18	50th percentile sulfide S
CAL-004 (295-315)	Mud/clay	5.44	0.073	-2.3	0.13	3.2	9.2	75th percentile sulfide S (only available core sample)
CAL-001 (750-762)	Siltstone	6.57	0.065	-2.0	0.15	3.7	14.5	50th percentile sulfide S
GMC-014 (176-184)	Siltstone	3.29	0.488	-15.3	0.02	2.7	29.7	95th percentile sulfide S
CAL-001 (380-400)	Sinter	7.72	0.014	0.1	1.25	5.54	0	50th percentile sulfide S
CAL-002 (177-187)	Sinter	6.91	0.044	-1.4	0.21	3.96	15.6	95th percentile sulfide S
Calico Leach Res. After CN Destruct.	Tailings	6.80	0.089	-2.8	0.11	3.21	4.6	--

Criteria for AP Predictions:

ABA Criteria	PAG	NNP<-20 or NPR<1
	Low PAG	NP between -20 and +20 or NPR between 1 and 3
	Non-PAG	NNP>20 or NPR >3
NAG Criteria	PAG	NAG>20
	Low to Moderate PAG	NAG between 1 and 20
	Non-PAG	NAG<1

Source: Grassy Mountain HCT Database Rev02

PAG = Potentially Acid Generating, Low PAG = Uncertain Potential/Lower Capacity, Non-PAG = Non-Acid Generating

The kinetic testing method selected for this project is the standard humidity cell test procedure designed to simulate water-rock interactions in order to evaluate the rate of sulfide mineral oxidation and thereby predict acid generation and metals mobility (ASTM D-5744-13e1). Under ASTM methodology, the test typically runs for a minimum of 20 weeks and follows a seven-day cycle, unless uncertain chemistry requires that it be run longer to achieve steady state conditions. During the seven-day cycle, water is trickled over the rock for two days. Air that is humidified slightly above room temperature is introduced at the bottom of the column for two days of each cycle followed by two days of dry air. On the seventh day, the sample is rinsed with de-ionized water and the extracted solution is collected for analysis. Key parameters including; pH, alkalinity, acidity, electrical conductivity, calcium, magnesium, iron and sulfate were measured on a weekly basis by McClelland Laboratories. Major and trace element chemistry were measured on a weekly basis at McClelland Laboratories for the first four weeks of the test, after which the frequency of analysis was reduced to every fourth week. The HCT extracts were analyzed by

ACZ Laboratories for the same list of parameters as the MWMP extracts summarized in Table 4-7.

The ASTM procedure for humidity cell tests calls for a minimum test duration of 20 weeks (ASTM D-5744-13e1). However, there is no technical basis for this recommendation and based on SRK's experience, 20 weeks is typically insufficient to allow complete reaction of the sample material if sulfide-bearing materials are present. Essentially, there is no established criteria for the termination of kinetic tests, rather the point at which HCTs should be terminated is project specific and should be determined by the physical and chemical characteristics of the samples and the objectives of the test (Mills, 1998).

The HCTs were executed until the majority of the mineral reactions that can be predicted from mineralogy or static testing have been observed. This endpoint was assessed by monitoring the release rates of key constituents such as pH, sulfate, acidity, alkalinity and iron as well as dissolved metals and metalloids. It is common practice to terminate cells when the release rates for these parameters become relatively constant with time and there is no substantial change in the calculated release rate (INAP, 2009). In addition, the consumption of sulfide and neutralization potential within the cell was also evaluated throughout the test and was used to help define when a cell could be terminated.

The Grassy Mountain HCTs were operated for 87 weeks and were terminated following approval from DOGAMI and BLM. Following termination of the leach portion of the HCTs, the material within the cells was blended and split for termination testing. Termination testing included multi-element analysis, ABA and NAG on the test residues to define the mineralogical processes that occurred as the materials were exposed to oxygen and water.

Leachate chemistry data collected during the HCT test have been compared to the OGWQG (OAR 340-40-020) to determine which constituents could potentially be leached at concentrations above these values. However, due to differences in the liquid to solid ratio used in the test compared to typical site conditions, the HCT test results only provide a qualitative estimate of elemental concentrations in the resulting leachates and are not considered conclusive or to represent actual predictions of water quality.

5 Static Test Results

5.1 Multi-Element Analysis

Multi-element assay was completed on the underground development rock (waste rock and ore) and tailings samples to assess their bulk geochemical composition and identify any parameters elevated above average crustal concentrations. The results for key parameters related to ARD/ML are summarized in Table 5-1 and compared to average crustal concentrations using the Geochemical Abundance Index (GAI). Full results are provided in Appendix B.

Statistical analysis of the multi-element data indicates that many environmentally significant elements are below or close to their relative natural abundance in the samples. However, arsenic, antimony, gold, mercury, molybdenum, silver, sulfur and selenium are elevated in all material types. Elevated lead and tungsten are also found in the interbedded mud/clay material. This observation is consistent with the geochemistry of other epithermal gold deposits, with these elements being commonly associated with the gold mineralization (Rose, Hawkes and Webb, 1979). It is also consistent with the 43-101 report (Calico Resources, 2012), which notes anomalous arsenic, antimony and mercury in the trace element signature of the deposit.

Table 5-1: Summary of Multi-Element Assay Results (mg/kg)

Element	*Average crustal abundance (Mason, 1966)*	Sandstone (n = 40)*	Breccia (n = 7)*	Siltstone (n = 33)*	Sinter (n = 11)*	Mud/clay (n = 5)*	Mudstone (n = 8)*	Tailings (n = 1)*
Ag	*0.07*	2.16	5.69	2.77	2.10	0.70	2.53	7.54
Al	*81,300*	2,635	1,900	3,009	727	4,260	3,988	1,500
As	*2*	137	112	145	59	182	140	173
Au	*0.004*	0.39	2.83	0.45	1.40	0.42	0.28	1.20
B	*10*	<10	<10	<10	<10	<10	<10	<10
Ba	*425*	57.0	68.6	52.7	36.4	68.0	46.3	50.0
Ca	*36,300*	1,003	286	1,712	209	1,780	1,238	400
Cd	*0.2*	0.04	0.02	0.06	0.02	0.12	0.08	0.06
Co	*25*	1.66	1.01	2.46	1.41	2.84	4.49	1.40
Cr	*100*	87.7	128	106	178	58.0	46.8	31.0
Cu	*55*	9.25	11.2	11.4	8.9	20.3	15.5	92.7
Fe	*50,000*	8,885	7,271	10,579	10,464	14,800	11,513	14,000
Hg	*0.08*	1.67	1.52	2.21	1.30	2.81	2.56	2.05
K	*25,900*	1,828	1,957	1,691	555	1,620	2,288	1,300
Li	*20*	2.12	0.64	2.52	1.09	2.20	0.79	0.60
Mg	*20,900*	383	<100	370	118	660	300	<100
Mn	*950*	48.3	22.0	63.7	69.5	96.8	24.0	47.0
Mo	*1.5*	17.1	14.4	12.9	10.6	6.5	14.1	14.1
Na	*28,300*	223	129	179	<100	400	113	<100
Ni	*75*	9.08	8.97	11.6	25.2	8.72	9.23	7.50
P	*1,050*	136	64.3	185	46.4	196	158	120
Pb	*13*	13.3	4.77	14.5	7.18	59.4	23.4	10.2
S	*260*	2,280	2,886	2,803	782	1,720	8,863	3,400
Sb	*0.2*	14.2	13.7	16.1	9.42	30.9	8.61	13.7
Sc	*22*	0.38	0.30	0.59	0.19	1.10	0.55	0.40
Se	*0.05*	1.45	2.41	1.90	1.18	1.00	2.25	2.80
Sn	*2*	0.36	0.37	0.45	0.38	0.76	0.35	1.10
Tl	*0.5*	0.39	0.39	0.53	0.29	0.66	0.34	0.47
U	*1.8*	0.56	0.50	0.67	0.14	0.71	0.94	0.67
V	*135*	6.68	5.00	7.09	4.91	16.8	4.50	7.00
W	*1.5*	1.14	0.14	1.01	1.01	4.56	0.28	1.55
Zn	*70*	16.9	5.71	18.9	7.36	115	21.1	12.0

*	Average values in mg/kg per material type are presented
	Indicates less than 3 times average crustal abundance
	Indicates between 3 and 6 times average crustal abundance
	Indicates between 6 and 12 times average crustal abundance
	Indicates greater than 12 times average crustal abundance

Source: Grassy Mountain Static Test Database Rev14

5.2 Acid Base Accounting

Acid Base Accounting was performed in order to assess the balance of acid producing and acid neutralizing minerals in the underground development rock (waste rock and ore) and tailings samples. The results are summarized in Table 5-2 and are provided in full in Appendix B. Plots showing the acid generating characteristics of the samples are provided in Figure 5-1 through 5-5.

Table 5-2: Summary of Average Acid Base Accounting Results

Material Type	Paste pH	Total sulfur	Sulfide sulfur[1]	NP[2]	AP[3]	NNP[4]	NPR[5]
	s.u.	wt%	wt%	kg $CaCO_3$ eq/t			-
Sandstone (n = 40)	6.12	0.25	0.09	2.27	2.94	-0.60	6.21
Breccia (n = 7)	6.19	0.32	0.12	0.33	3.74	-3.63	0.38
Siltstone (n = 33)	4.78	0.30	0.12	2.95	3.85	-1.03	1.73
Sinter (n = 11)	6.80	0.08	0.03	2.54	0.99	1.65	6.76
Mud/clay (n = 5)	6.12	0.19	0.07	1.58	2.08	-0.50	1.13
Mudstone (n = 8)	3.74	0.95	0.64	0.39	20.1	-19.9	0.28
Tailings (n = 1)	6.80	0.35	0.09	0.30	2.80	-2.80	0.11

Source: Grassy Mountain Static Test Database Rev14

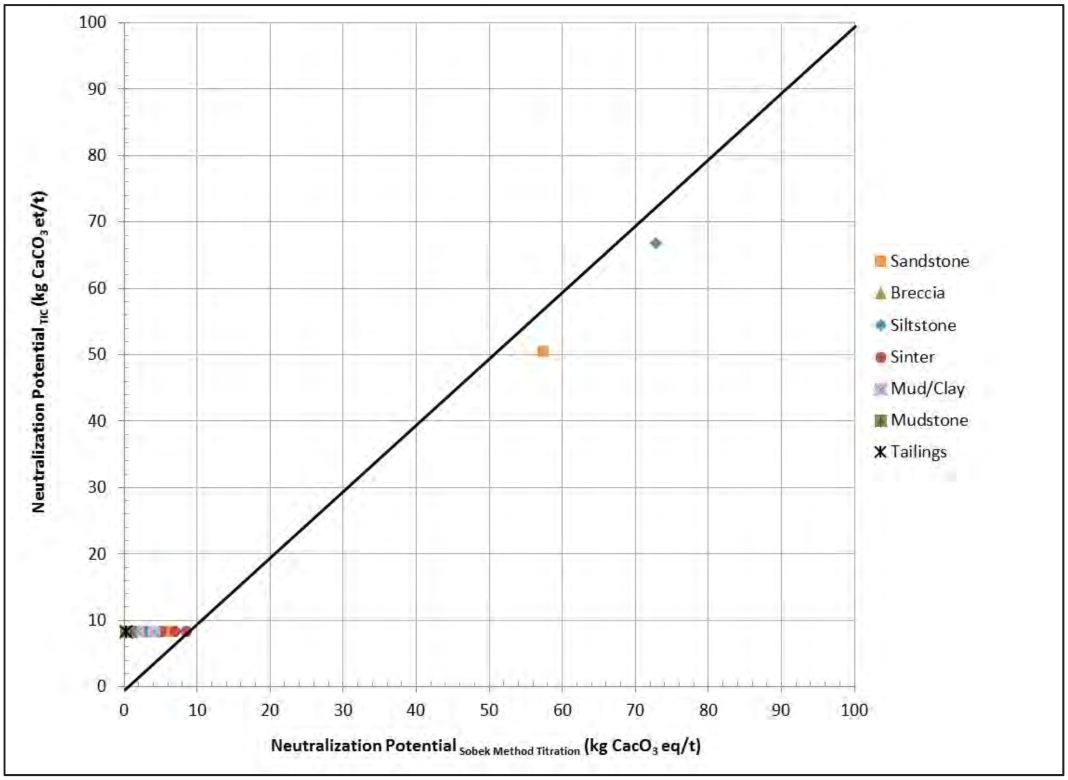
[1] Sulfide sulfur concentrations calculated from non-sulfate sulfur values determined by hot water extraction.
[2] Neutralization Potential (NP) determined from titration according to the modified Sobek method.
[3] Acidification Potential (AP) calculated from sulfide sulfur.
[4] Net Neutralization Potential (NNP) = NP-AP.
[5] Neutralization Potential Ratio (NPR) = NP/AP.

5.2.1 Determination of Neutralization Potential

The determination of NP is a critical part of material characterization and predicting the potential for ARD/ML. In some cases, laboratory titration methods, like those used in the modified Sobek method, can overestimate acid neutralization because silicates in the sample provide some neutralization capacity during titration. The procedures for determining NP involve addition of hydrochloric acid resulting in strongly acidic conditions which dissolves many common rock forming minerals (e.g., alumino-silicates) in addition to calcium carbonate. Therefore, the Sobek NP typically accounts for both carbonate and silicate minerals present. In reality, carbonate minerals provide the only source of buffering unless the acid generation rates are extremely slow because silicate minerals react slowly (Sverdrup, 1990). Direct determination of total inorganic carbonate (TIC) provides a second measure of NP and can help determine the influence of silicate dissolution on the Sobek NP.

The neutralization capacity of the Grassy Mountain waste rock and ore samples is low and NP values from the modified Sobek for all of the samples were fairly consistent, averaging 2.2 kg $CaCO_3$ eq/ton with a standard deviation of 9.0 kg $CaCO_3$ eq/ton resulting from two samples with NP values significantly greater than 10 kg $CaCO_3$ eq/ton The TIC results confirm the low NP of the material with inorganic carbon content below detection (<0.01%) for all but two of the samples. A comparison of the NP from the modified Sobek method to the NP calculated from the

TIC indicates that silicate dissolution does not contribute appreciably to the NP values reported by the Sobek method (Figure 5-1). The discussion of results in the following sections relates to NP determined by the modified Sobek method (i.e., titration).

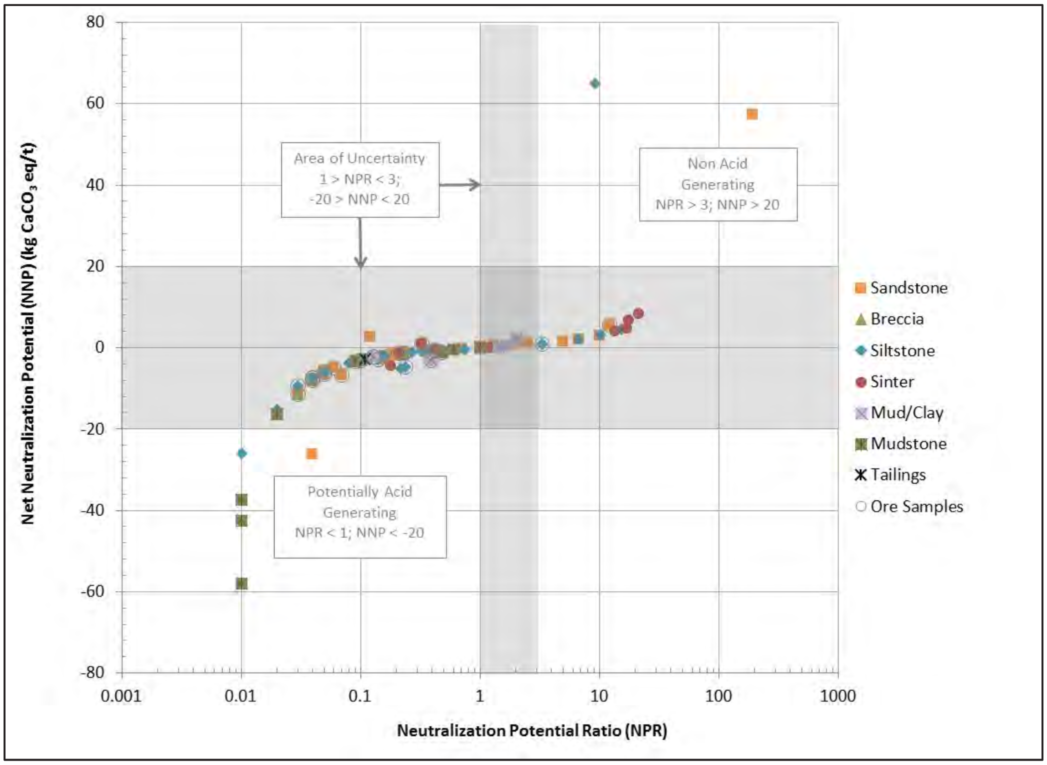


Source: Grassy Mountain Static Test Database Rev14

Figure 5-1: Comparison of Methods for Determination of Neutralization Potential

5.2.2 Acid Generation Potential based on BLM Criteria

The majority of samples tested (93%) show an uncertain potential for acid generation based on the BLM criteria (Figure 5-2). Only 2% of samples tested meet the BLM criteria and can be classified as non-acid forming materials based on a net neutralizing potential greater than 20 kg $CaCO_3$ eq/ton and greater than three-fold excess of neutralizing capacity. Five percent (5%) of samples tested are clearly acid forming materials based on NPR values less than 1 (i.e., no excess neutralizing capacity) and a net neutralization potential of less than -20 kg $CaCO_3$ eq/ton (Figure 5-2). Most of the samples that fall within the potentially acid forming category are samples of the mudstone from the base of the deposit which relates to the higher sulfide content of this material. In addition, one sample of siltstone and one sample of sandstone are also potentially acid forming.



Source: Grassy Mountain Static Test Database Rev14

Figure 5-2: Neutralization Potential Ratio vs. Net Neutralizing Potential

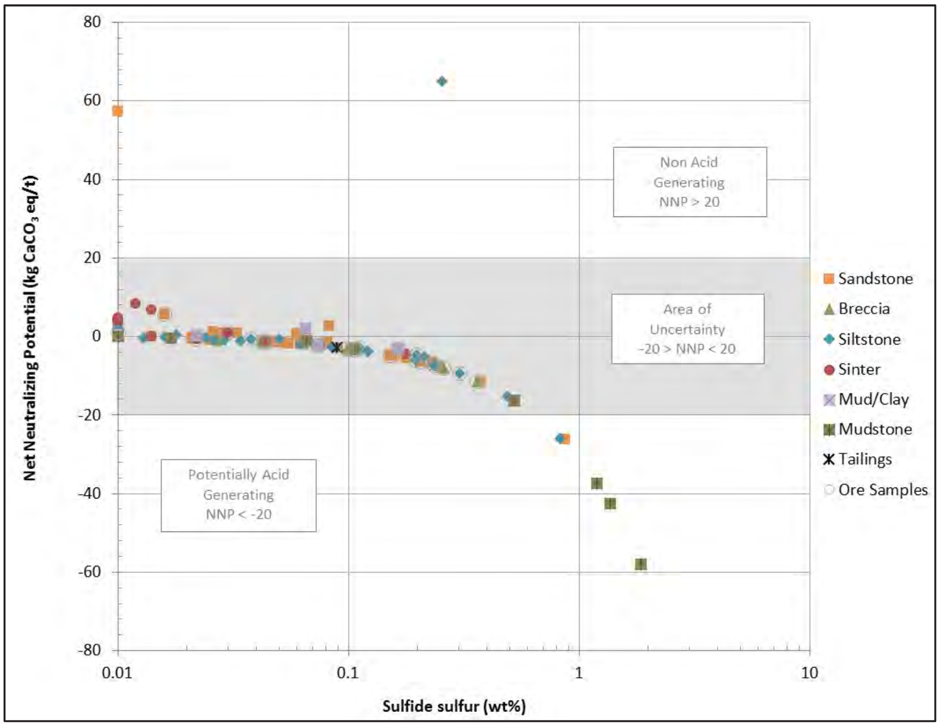
5.2.3 Control of Sulfide Sulfur on ARD Potential

The sulfide sulfur content of the Grassy Mountain waste rock samples varies from below analytical detection limits (<0.01 wt%) to a maximum of 1.86 wt% which equates to AP values ranging from 0.03 kg $CaCO_3$ eq/ton up to 58 kg $CaCO_3$ eq/ton.

As described above, the Grassy Mountain waste rock and ore materials have very limited acid neutralizing capacity due to the low TIC content. In the absence of NP, the acid generating potential of the materials is directly related to the sulfide content (Figure 5-3 and Figure 5-4). As shown in Figure 5-3, samples with a sulfide content greater than 0.5 wt% are acid generating with NNP values less than -20 kg $CaCO_3$ eq/ton. Figure 5-4 shows there is a near linear relationship between NPR and sulfide sulfur content and the potential for acid generation increases with increasing sulfide sulfur.

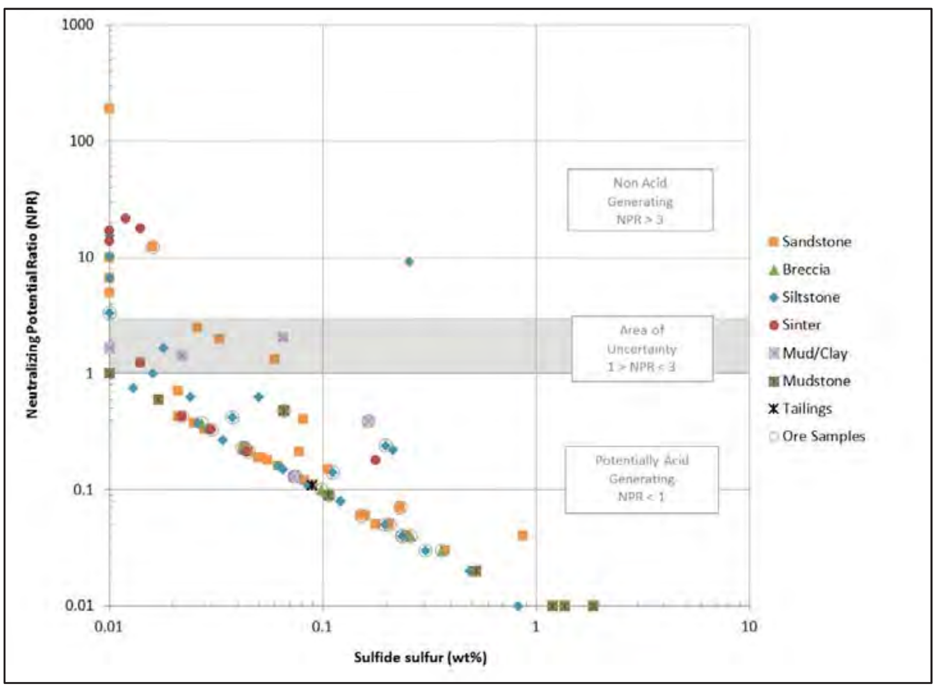
The presence of sulfide sulfur in higher concentrations increases the potential for the materials to produce acid where insufficient neutralizing potential is present. However, both the NPR and NNP criteria are less meaningful in the case where both NP and AP are low or near detection (i.e., inert from an ABA perspective) and the low NNP and NPR values may be misleading. In these cases, kinetic testing is important to better understand the actual acid generating potential of the materials.

For each waste rock material type, there is a wide range in sulfide content and predicted acid generation and there are no clear trends in acid generation by rock type. However, in general the sinter samples show a lower potential for acid formation and the mudstone samples show the greatest potential for acid formation. The sulfide sulfur results for the ore grade material are comparable to sulfide sulfur results for waste rock samples of the same lithology. Therefore, the ore grade material does not show a higher risk for ARD/ML in comparison to the waste rock material.



Source: Grassy Mountain Static Test Database Rev14

Figure 5-3: Sulfide Sulfur vs. Net Neutralizing Potential



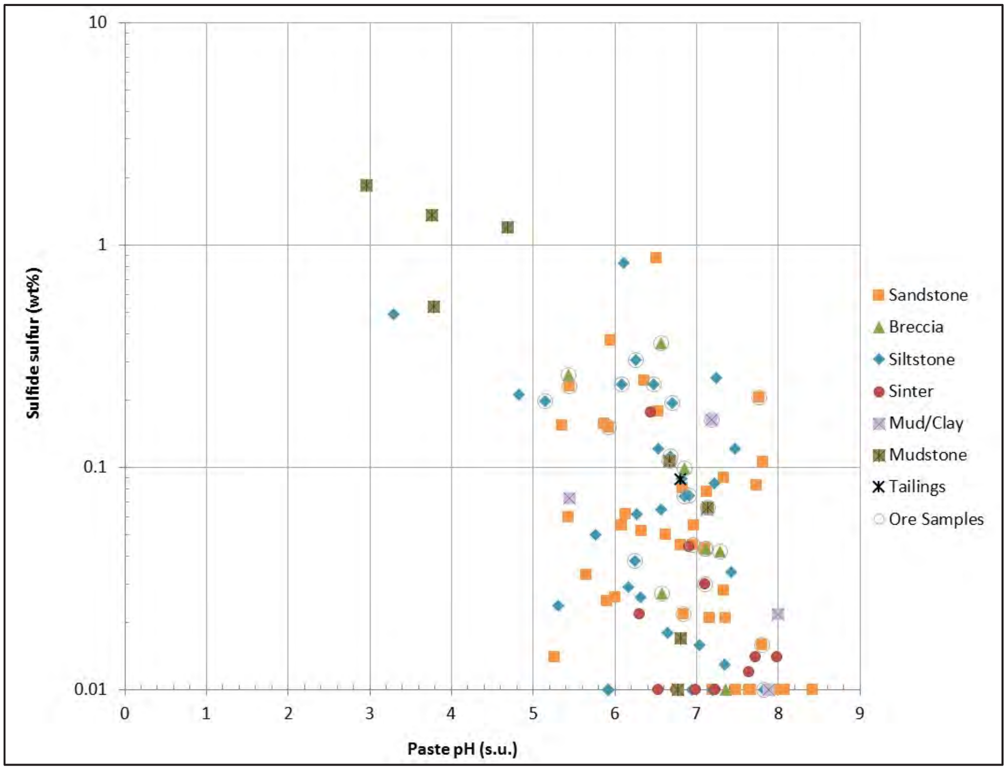
Source: Grassy Mountain Static Test Database Rev14

Figure 5-4: Sulfide Sulfur vs. Neutralization Potential Ratio

5.2.4 Paste pH Results

Measurements of paste pH from the ABA test provide an indication of the immediate reactivity of the samples. The results are plotted in Figure 5-5 and show that the majority of samples have neutral to alkaline paste pH values (pH 6 - 8) indicating minimal presence of readily soluble acid sulfate salts from prior oxidation. However, paste pH results cannot rule out the potential presence of acid-forming sulfate phases due to the short duration of the mixing times (10 minutes) and slow dissolution kinetics of some acid-forming sulfates (Price, 2009).

Only one sample of siltstone and a few samples of the mudstone produced more acidic paste pH values (pH 3-5). These samples also had the highest sulfide sulfur content.



Source: Grassy Mountain Static Test Database Rev14

Figure 5-5: Paste pH vs. Sulfide Sulfur

5.2.5 Acid Generating Potential of Tailings Sample

The tailings sample is characterized by a relatively low sulfide content of 0.09 wt%, but shows uncertain acid generating characteristics based on ABA results due to the low TIC content of the material. Despite the addition of lime, the neutralization capacity of the tailings sample is low due to the cyanide destruction process that was used. The Inco process uses sodium bisulfite as a SO_2 source, which lowers the pH. Even though lime was added to control pH during the metallurgical program, the addition of sodium bisulfite was enough to offset any neutralizing capacity from the lime that was added.

5.3 Net Acid Generation

Static NAG testing was undertaken on the development rock (waste rock and ore) and tailings samples to provide an empirical estimate of field acid generation. The results are summarized in Table 5-3 and are presented in Figure 5-6 and Figure 5-7. In general, a NAG pH less than 4.5 and a NAG value greater than 1 kg H_2SO_4 eq/ton are indicative of potentially acid forming characteristics.

Based on the NAG test results, seven out of the 104 waste rock samples (i.e., 7%) show higher capacity acid forming characteristics; 3 samples of siltstone, 3 samples of mudstone and one sample of sandstone. All but one of these samples show the highest potential for acid generation based on ABA testing. Forty-two samples (i.e. 40%) show a low to moderate capacity for acid generation.

Figure 5-7 and Figure 5-8 shows that the NAG results are consistent with the ABA results. In Figure 5-7 NAG pH is strongly controlled by the sulfide content, with higher sulfide materials generating more acidic NAG pH values. In general, waste materials containing greater than 0.5% sulfide show a greater potential for acid generation based on the NAG test results (Figure 5-8). Samples with NAG values between 1 and 20 kg H_2SO_4 eq/ton have a low to moderate capacity for acid generation and sulfide sulfur concentrations between 0.05 and 0.5 wt%. Kinetic testing is required to define the acid generation potential for samples in this range, particularly for samples with NAG values less than 10 kg H_2SO_4 eq/ton. By convention, any NAG value below 10 kg H_2SO_4 eq/ton of material are considered inconclusive because a blank hydrogen peroxide solution can generate a NAG artifact value up to 10 kg H_2SO_4 eq/ton.

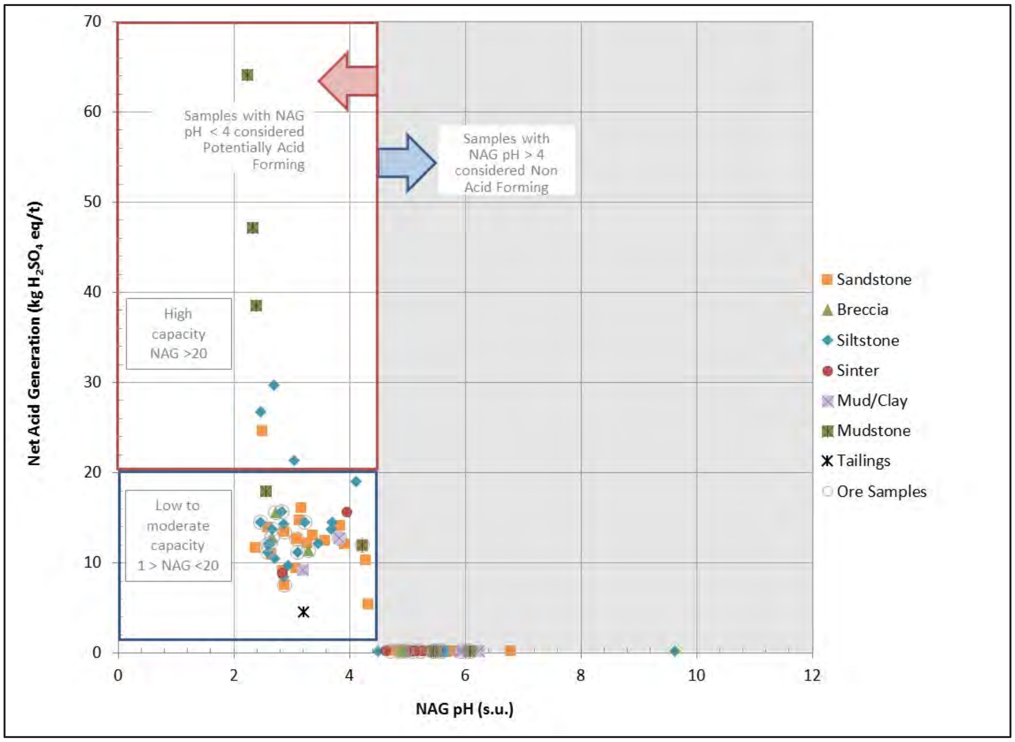
As with the ABA results, there is a wide range in predicted acid generation for each waste material type. However, in general, the sinter samples show a lower potential for acid formation and the mudstone samples from the base of the deposit show the greatest potential for acid formation.

Based on the NAG results the tailings sample has the potential for acid formation; however the capacity for acid generation is quite low. The acid generation potential of the tailings material can be attributed to the Inco cyanide destruction process that uses sodium bisulfite as a SO_2 source, which lowers the pH and consumes the neutralizing capacity from the lime that was added.

Table 5-3: Summary of Net Acid Generation Results

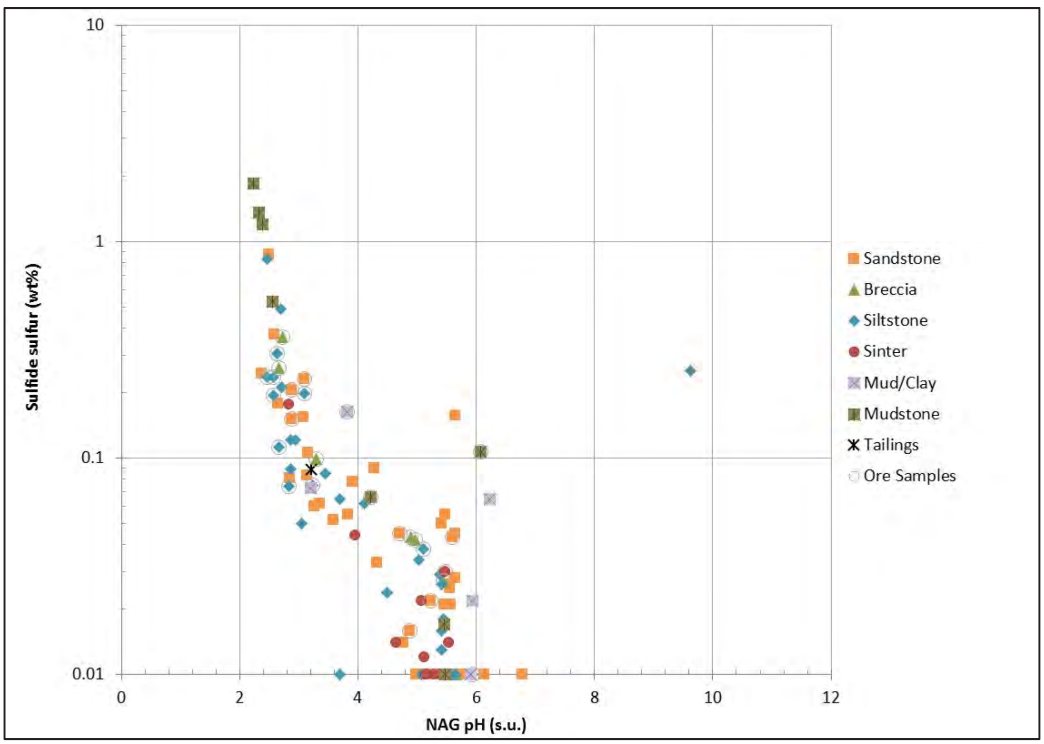
Material Type	NAG pH (s.u.)			Total NAG (kg H_2SO_4 eq/t)		
	Mean	Min.	Max	Mean	Min.	Max
Sandstone (n = 40)	4.47	2.37	6.78	5.71	0	24.6
Breccia (n = 7)	4.24	2.66	5.66	5.81	0	15.6
Siltstone (n = 33)	4.11	2.47	9.62	8.73	0	29.7
Sinter (n = 11)	4.90	2.84	5.54	2.38	0	15.6
Mud/clay (n = 5)	5.02	3.20	6.23	4.52	0	12.8
Mudstone (n = 8)	3.85	2.24	6.08	22.6	0	64.1
Tailings (n = 1)	3.21	-	-	4.60	-	-

Source: Grassy Mountain Static Test Database Rev14



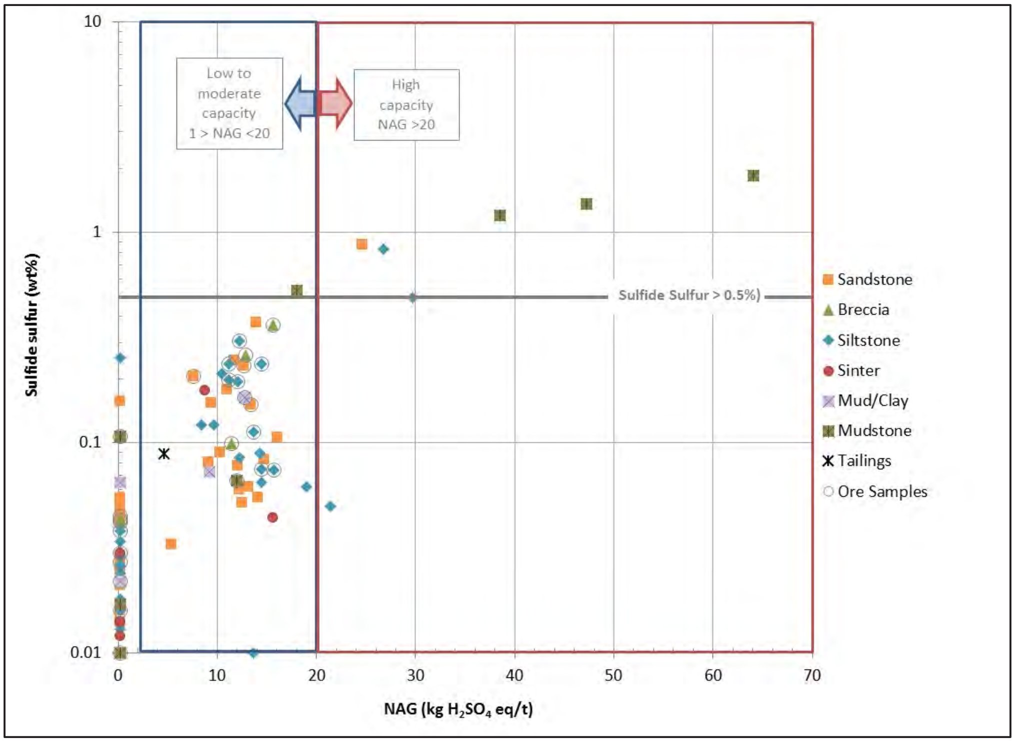
Source: Grassy Mountain Static Test Database Rev14

Figure 5-6: NAG pH vs. NAG



Source: Source: Grassy Mountain Static Test Database Rev14

Figure 5-7: NAG pH vs. Sulfide Sulfur



Source: Source: Grassy Mountain Static Test Database Rev14

Figure 5-8: NAG vs. Sulfide Sulfur

5.4 Erionite Analysis Results

A total of12 samples of waste rock and ore were submitted for XRD to determine if erionite is present in the Grassy Valley deposit. The samples submitted for this analysis represent the range of material types associated with the Grassy Mountain deposit. In addition the sample of tailings material was also submitted for XRD. Two standards containing erionite were also submitted and include 924635 and 924636.

The results of the XRD analysis are provided in Appendix C and summarized in Table 5-4. The results of this analysis show that erionite was not detected in any of the waste rock/ore samples or the tailings sample. The only samples that contained detectable levels of erionite were the two standards for erionite that contained erionite. Based on these results, additional analysis is not required.

Table 5-4: X-Ray Diffraction Results

Mineral Phase	Sinter		Sandstone			Siltstone			Mudstone			Breccia	Tailings		
	CAL 001 (380 - 400)	CAL 002 (177 - 187)	CAL 001 (487 - 505)	CAL 002 (86 - 95)	CAL 004 (860 - 875)	CAL 001 (750 - 762)	GMC 003 (485 - 495)	GMC 014 (176 - 184)	CAL 003 (675 - 685)	CAL 004 (295 - 315)	GMC 012 (832 - 851)	CAL 002 (430 - 438)	Calico Leached Res After CN Destruction	924635 (standard)	924636 (standard)
Quartz	98	98	84	89	80	75	89	82	50	88	66	72	75	27	57
Orthoclase	1	2	8	11	12	14	7					9	14	18	
Calcite	1														
Illite			8		8	11	4	7	42	6					
Albite										2		10			33
Muscovite											32	9	11		
Kaolinite									6						
Pyrite								2	2						
Magnetite										2					
Goethite										2					
Anorthoclase											2				
Rectorite								9							
Erionite														55	10

Note: Results presented as percentages of total mineral phases present.

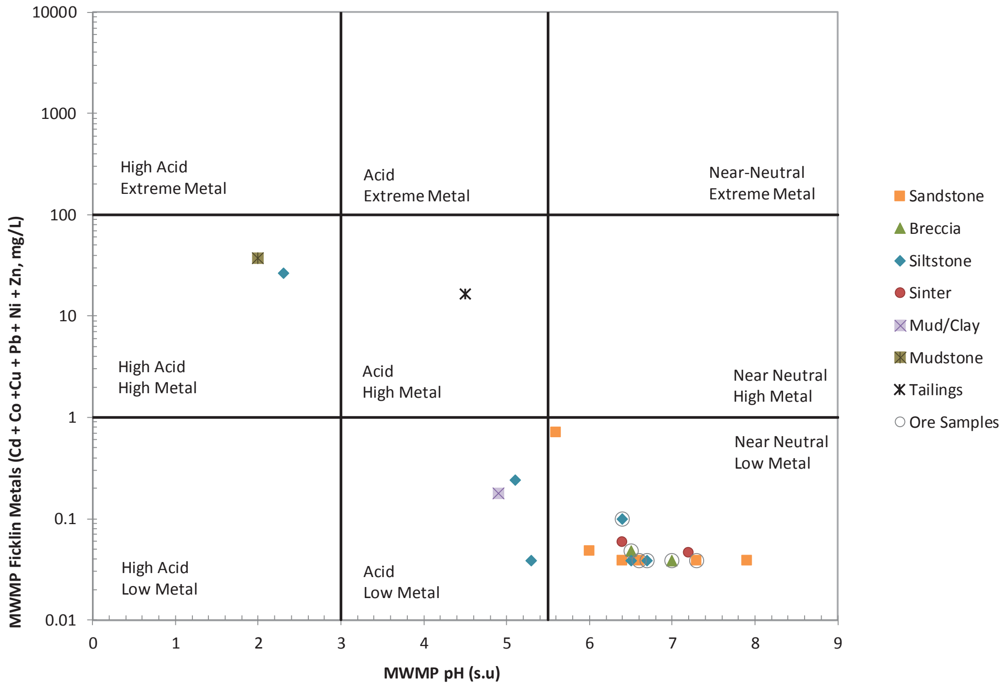
5.5 Meteoric Water Mobility Procedure

MWMP leach tests were conducted on a total of 13 waste rock samples, 6 ore samples and one sample of tailings material to provide an indication of short-term elemental mobility and metal(loid) release from the Grassy Mountain materials. Full results are presented in Appendix B.

The majority of the leachates generated during the MWMP tests of waste rock and ore were classified as “near-neutral, low-metal waters” based on pH values typically between 7 and 9 and total Ficklin metal release less than 1 mg/L (Figure 5-9). However, two samples of siltstone material and one sample of interbedded mud/clay were classified as “acid, low metal” and one sample each of mudstone and siltstone were classified as “high acid, high metal”. The tailings sample was classified as “acid, high-metal”. The higher release of acidity and metals from these samples therefore likely represents the flushing of soluble acidic sulfate weathering salts from the material surface.

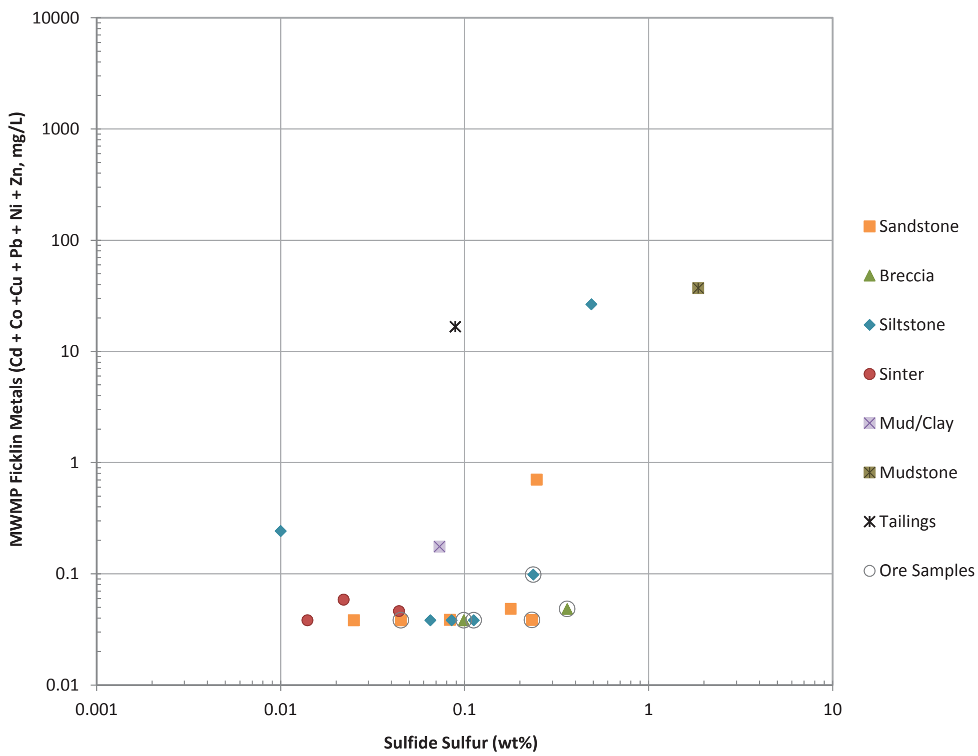
Samples were compared to the OGWQG (OAR 340-40-020) in Table 5-5. Under low pH conditions, the following parameters were found to exceed the most stringent OGWQG for one or more sample: pH, total dissolved solids (TDS), sulfate, arsenic, cadmium, chromium, copper, fluoride, iron, manganese, selenium and zinc. For samples with neutral pH (i.e., pH >7) all of the constituents were below the OGWQG.

One sample of siltstone waste rock (GMC-014 167-184) and one sample of mudstone (GMC-012 919-946) waste rock leached significantly higher concentrations of metal(loid)s in comparison to all other samples submitted for MWMP testing. Theses samples also have the highest sulfide sulfur concentrations (Figure 5-10). The highest concentration of arsenic was from the mudstone waste rock sample, GMC-012 (919-946) at 18.5 mg/L. Due to differences in the liquid to solid ratio used in the MWMP tests compared to typical site conditions, the test results only provide a qualitative estimate of elemental concentrations in the resulting leachates and are not considered conclusive or to represent actual predictions of water quality.



Source: Source: Grassy Mountain Static Test Database Rev14

Figure 5-9: Ficklin Metals MWMP vs MWMP pH



Source: Source: Grassy Mountain Static Test Database Rev14

Figure 5-10: Sulfide Sulfur versus Ficklin Metals MWMP

Table 5-5: Summary of MWMP Results

Parameter	Oregon Groundwater Quality Guidelines	Sandstone						Breccia		Siltstone						Sinter			Mudstone		Tailings
		Ore		Waste Rock				Ore		Ore		Waste Rock				Waste Rock			Waste Rock		
		GMC-006 (593-613)	CAL-001 (487-505.4)	CAL-004 (445-455)	GMC-012 (780-800)	CAL-002 (86-95)	CAL-004 (860-875)	CAL-002 (480-496)	CAL-002 (430-438.2)	CAL-002 (235-255)	GMC-003 (485-495)	GMC-014 (44-59)	CAL-001 (750-762)	CAL-002 (697-706)	GMC-014 (167-184)	CAL-001 (380-400)	GMC-014 (208-215)	CAL-002 (177-187)	CAL-004 (295-315)	GMC-012 (919-946)	Calico Leach Res. After CN Destruct.
pH, stu	*6.5-8.5*	7.30	6.60	6.40	6.00	5.60	7.90	7.00	6.50	6.70	6.40	5.10	5.30	6.50	2.30	9.40	6.40	7.20	4.90	2.00	4.50
TDS	*500*	24	20	130	<10	242	42	34	24	20	28	1,440	<10	<10	8,680	150	24	52	556	9,100	948
SO4	*250*	2.4	<1	48.7	2.4	139	10.8	4.6	2.2	3.8	5	732	5.5	1.1	5,360	35.1	8.4	26.8	329	5,060	606
As	*0.05*	0.010	0.0012	0.0039	0.00040	0.041	0.028	0.021	0.0048	0.0066	0.0027	0.030	0.0011	0.0025	16.7	0.18	0.0015	0.0084	0.051	18.5	0.0046
Ba	*1*	0.0070	0.016	<0.003	<0.003	0.064	0.10	0.0050	0.0050	0.0040	0.010	0.015	<0.003	<0.003	<0.02	0.026	<0.003	0.012	0.030	<0.02	0.045
Cd	*0.01*	<0.0001	<0.0001	<0.0001	<0.0001	0.00050	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.00080	<0.0001	<0.0001	0.053	<0.0001	<0.0001	<0.0001	0.00030	0.14	0.0030
Cl	*230*	0.60	0.70	4.50	0.70	5.20	1.00	0.90	0.80	0.80	<0.5	144	0.60	0.60	3.90	0.80	<0.5	1.40	15.4	2.10	1.60
Cr	*0.1*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.14	<0.01	<0.01	<0.01	<0.01	0.15	<0.01
Cu	*1*	<0.01	<0.01	<0.01	<0.01	0.020	<0.01	<0.01	<0.01	<0.01	0.020	<0.01	<0.01	<0.01	6.73	<0.01	0.020	<0.01	0.050	3.07	15.1
F	*4*	0.080	<0.05	0.12	<0.05	0.21	0.48	0.20	<0.05	<0.05	<0.05	0.36	0.060	0.060	11.0	0.33	0.050	0.23	0.56	<5	0.90
Fe	*0.3*	<0.02	<0.02	<0.02	0.090	11.1	0.22	0.030	0.040	<0.02	0.44	<0.02	0.13	<0.02	479	<0.02	<0.02	<0.02	0.73	773	1.24
Pb	*0.05*	<0.0001	0.00030	<0.0001	0.00040	0.00040	0.00050	<0.0001	0.00010	<0.0001	0.00020	0.0024	<0.0001	<0.0001	0.0096	0.00010	0.00040	0.00020	0.00040	0.0098	0.0028
Mn	*0.05*	0.0060	<0.005	0.032	<0.005	0.29	<0.005	<0.005	0.0090	<0.005	0.0090	0.50	<0.005	<0.005	6.43	<0.005	0.0060	0.0060	0.50	1.02	5.60
Hg	*0.002*	<0.0002	<0.0002	0.00030	<0.0002	<0.0002	0.00050	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
NO_3	*10*	0.08	0.14	0.13	0.02	0.06	0.14	0.04	0.02	<0.02	0.14	2.56	0.04	0.08	0.10	0.07	0.03	0.05	0.46	0.08	0.17
Se	*0.01*	0.00090	0.00010	0.016	<0.0001	0.0094	0.0037	0.0018	0.00060	0.00010	0.00070	0.0089	0.00030	0.00010	0.044	0.011	<0.0001	0.0091	0.036	0.034	0.012
Ag	*0.01*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.050	<0.01
Zn	*5*	0.010	0.010	<0.01	0.020	0.040	<0.01	0.010	0.020	<0.01	0.060	0.19	0.010	<0.01	12.5	<0.01	0.020	0.010	0.070	24.5	0.55

Concentration exceeds Oregon Groundwater Quality Guidelines(OAR 340-40-020)

Analytical limit of detection exceeds Oregon Water Quality Standard

Source: Grassy Mountain Static Test Database Rev14

6 Kinetic Test Results

Kinetic testing has been completed on nine samples of waste rock and one sample of tailings material as summarized in Table 6-1. The samples selected for kinetic testing are summarized in Table 4-8 along with the corresponding static test data. Time series plots of elemental release are presented in Appendix D along with a tabulation of the humidity cell test results.

Eight of the 10 humidity cells developed acidic conditions throughout the duration of the test and initial neutralization potential was consumed in all cells. The two cells that did not develop acidic conditions were HC-8 and HC-9, both of which are sinter. Sulfate and metals concentrations from these cells were generally lower compared to the other HCTs, related to the lower sulfide associated with this material type. HC-3 (mudstone) developed the most acidic conditions with pH values as low as 1.67 s.u. and had the highest leaching rates of parameters mobilized under acidic conditions (e.g., aluminum, copper, iron and nickel).

Humidity cell leachate concentrations were compared to OGWQG (Table 6-2). As shown in Table 6-2, HC-3 (mudstone) had the greatest number of parameters that exceeded the guidelines and HC-8 and HC-9 (sinter) had the least. The majority of cells that developed acidic conditions leached copper, iron, manganese, arsenic and sulfate at concentrations greater than the guidelines, indicating these elements are mobile under acidic pH conditions. Other constituents that were leached above OGWQG during the first few weeks of the test include cadmium, chromium, copper, fluoride, lead, selenium, silver and zinc. The tailings cell leached metals in the range of that observed for the waste rock cells. Mercury concentrations were below the OGWQG for all samples with the exception of the first few weeks for HC-2 (Sandstone).

The results of the HCT program are described below for each material type.

Table 6-1: Summary of HCT Status

Material Type	Primary Lithology	Cell ID	Sample ID	Status
Waste Rock	Sandstone	HC-1	CAL-002 (86-95)	Terminated week 87
		HC-2	CAL-004 (860-875)	Terminated week 87
	Mudstone	HC-3	CAL-003 (675-685)	Terminated week 87
		HC-4	GMC-012 (832-851)	Terminated week 87
		HC-5	CAL-004 (295-315)	Terminated week 87
	Siltstone	HC-6	CAL-001 (750-762)	Terminated week 87
		HC-7	GMC-014 (176-184)	Terminated week 87
	Sinter	HC-8	CAL-001 (380-400)	Terminated week 87
		HC-9	CAL-002 (177-187)	Terminated week 87
Tailings	--	HC-10	Calico Leached Res after CN destruct	Terminated week 87

6.1 HCT Results Summarized by Material Type

6.1.1 Sandstone (HC-1 and HC-2)

The two sandstone cells were initially characterized by neutral pH conditions. However, effluent pH rapidly declined and acidic conditions (pH<5) developed in the cells by week 3 (HC-1) and week 21 (HC-2). This is partly a function of the rapid consumption of the limited neutralizing potential (NP) in the cells, with the available NP having been completely consumed by week 6. Effluent pH for both cells was stable at ~pH 3 to 3.5 from week 40 onwards.

A number of constituents are mobilized under the acidic conditions, with iron, manganese and arsenic frequently being elevated above Oregon Groundwater Quality Guidelines. Chromium and fluoride are also sporadically elevated and an initial flush of mercury above the guidelines was observed for HC-2. Effluent pH for HC-1 was consistently below the minimum guideline of pH 6.5 for the duration of the test and for HC-2 was below the guideline from week 18 onwards.

6.1.2 Mudstone (HC-3 and HC-4)

The two mudstone samples produced acidic leachates throughout the humidity cell test, with effluent pH between 1.7 and 3.6. These acidic conditions reflect the initial sulfide content (1.4% and 0.5% for HC-3 and HC-4, respectively) and lack of neutralizing potential in these samples. Both cells show elevated sulfate and iron release (up to 4000 mg/kg/week and 660 mg/kg/week, respectively) indicating that active sulfide oxidation occurred in the cells.

Several constituents were mobilized under the acidic conditions, with iron, manganese, sulfate and TDS being consistently elevated above their respective guidelines. Arsenic was consistently elevated in HC-3 and HC-4 throughout the test. Effluent pH was consistently below the minimum guideline for both cells. There was also an initial flush in several constituents (including cadmium, chromium, copper, lead and zinc), however these constituents were typically depleted within the first few leach cycles. In general, constituent release from HC-3 was higher than HC-4, which reflects the higher initial sulfide content of this sample.

A rapid depletion of sulfur minerals occurred within the first few weeks of the test for both cells and the flushing of sulfide oxidation products declined over time.

6.1.3 Mud/Clay (HC-5)

The sample of mud/clay material produced acidic leachates (pH 2.8 to 4.2) throughout the humidity cell test, which reflects the lack of initial neutralizing capacity in this sample. Effluent pH is consistently below the Oregon minimum pH guideline.

Several constituents are mobilized under the acidic conditions, with iron and manganese being consistently elevated above their respective Oregon Groundwater Quality Guidelines. Arsenic and fluoride were sporadically elevated and selenium was elevated between weeks zero and four. Sulfate and TDS were also elevated in the initial flush from the cell (week zero).

6.1.4 Siltstone (HC-6 and HC-7)

The two siltstone samples exhibited different geochemical behavior during the humidity cell test. HC-7 was acidic from the beginning of the test, with effluent pH consistently between pH 2 and 3.

This likely reflects the lack of initial acid buffering minerals in this sample. A comparison of leachate chemistry for HC-7 to OGWQG indicates arsenic, iron and manganese were consistently elevated above their respective guidelines, sulfate and TDS were frequently elevated, and cadmium, chromium, copper, selenium, silver and zinc were elevated in the initial flush from the cell (weeks zero to two). A rapid depletion of sulfur minerals occurred within the first few weeks of the test and the flushing of sulfide oxidation products declined over time. At the end of the test, less than 20% of the initial sulfur minerals were remaining.

HC-6 initially exhibited neutral (pH 6 to 7) chemistry, reflecting buffering of solution pH by neutralizing minerals. However, the consumption of available NP by week 20 resulted in a decline in effluent pH from week 22 onwards, stabilizing at around pH 4.5 from week 40 onwards. Several constituents were mobilized from HC-6 at concentrations above OGWQG including pH that has been consistently below the minimum guideline, selenium that was elevated between weeks 0 and 12, and iron that was elevated from week 36 onwards. In general, constituent release was lower from HC-6 in comparison to HC-7, which likely reflects the lower sulfide content of this sample.

6.1.5 Sinter (HC-8 and HC-9)

The two sinter samples produced circum-neutral leachates (pH 6 to 8) for the first 20 weeks of the humidity cell test. For HC-8, these circum-neutral conditions were maintained throughout the test duration. However, HC-9 showed a slight decline towards more acidic conditions from week 20 onwards, with effluent pH currently around pH 5. Both sinter samples showed generally low levels of constituent release, with many parameters being at or below analytical detection limits, including beryllium, bismuth, boron, cadmium, cobalt, copper, mercury, molybdenum, silver, uranium and zinc. All parameters were below Oregon Groundwater Quality Guidelines. The only exception is pH for HC-9, which was below the minimum pH guideline of 6.5 from week 4 onward.

6.1.6 Tailings (HC-10)

The tailings sample produced acidic leachates throughout the humidity cell test, with pH declining from 4.3 initially to pH~3 by week 40. The effluent iron concentrations (up to 24.1 mg/L) indicate that active sulfide oxidation occurred in this sample. Several constituents were mobile under these acidic conditions, with iron and manganese being consistently elevated above Oregon Groundwater Quality Guidelines. Selenium, sulfate and TDS were elevated in the initial flush (week zero) and copper was elevated above the guideline between weeks zero and 24.

The tailings cell showed an initial flush in several constituents, including sulfate, iron, aluminum, cadmium, copper, fluoride, manganese, nickel and zinc which likely reflects the removal of soluble oxidation products from the material surfaces. These were typically flushed during the first couple of leach cycles. In addition, the tailings cell had detectable concentrations of total cyanide until week 16 in the range of 0.005 to 0.011 mg/L. WAD cyanide was detected in the first two weeks of testing at 0.011 mg/L and was measured at below the detection limit of 0.003 mg/L every other week.

Table 6-2: Summary of HCT Leachate Compared to Oregon Groundwater Quality Guidelines

Parameter	Oregon Groundwater Quality Guidelines	HC-1	HC-2	HC-3	HC-4	HC-5	HC-6	HC-7	HC-8	HC-9	HC-10
		Sandstone	Sandstone	Mudstone	Mudstone	Mud/Clay	Siltstone	Siltstone	Sinter	Sinter	Tailings
pH	6.5-8.5	X	X	X	X	X	X	X	O	X	X
As	0.01	X	O	X	O	O		X			
Ag	0.05										
Ba	1										
Cd	0.01			O	O			O			
Cu	1			O	O						O
Cl	250										
F	4	O	O	X	O	O	O	O	O	O	O
Fe	0.3	X	X	X	X	X	X	X			X
Pb	0.05					O		O			
Hg	0.002		O								
Mn	0.05	O	O	X	O	X		O			X
NO_3	10										
Se	0.01		O	O	O	O	O	O			
SO4	250			X	O			O			
TDS	500			X	O			O			
Zn	5			O	O			O			

Source: Grassy Mountain HCT Database Rev02

Notes:
X indicates greater than 50% of measurements exceeded the Oregon Groundwater Quality Guidelines.
O indicates less than 50% of measurements exceeded the Oregon Groundwater Quality Guidelines.
Blank cells Indicate measurements are all below the Oregon Groundwater Quality Guidelines.
All samples appeared to exceed as silver detection limit was higher than the standard.

6.2 Comparison of Static Test Results to HCT Results

A comparison of the static test results to the corresponding HCT results provides an indication of the effectiveness of the static tests in predicting longer term behavior (Table 6-3). Humidity cells with effluent pH values at or above 5 s.u. are considered non-acid generating since the pH of the extraction fluid (i.e., deionized water) is also around 5 s.u.

As shown in Table 6-3, samples with NNP values greater than -20 but less than 20 kg $CaCO_3$ eq/ton (i.e., uncertain) generated acid in the HCT. This suggests that using the NNP value to define acid generation potential, tends to under predict acid generation. A slightly better correlation between predicted acid generation and observed acid generation is seen for the NPR values; however, for one cell (e.g., HC-9) the NPR value over predicts acid generation potential. The best correlation is seen for the NAG results that are generally consistent with the HCT program, with samples with the highest NAG values resulting in the lowest HCT pH values.

Table 6-3: Comparison of Humidity Cell Test and Static Tests Results

Cell	Sample ID	Lithology	Sulfide Sulfur (wt%)	NNP (kg $CaCO_3$ eq/t)	NPR	NAG pH (s.u.)	Total NAG (kg H_2SO_4 eq/t)	Final HCT pH	HCT Prediction
1	CAL-002 (86-95)	Sandstone	0.246	-7.7	0.04	2.37	11.7	3.37	Acidic
2	CAL-004 (860-875)	Sandstone	0.083	2.6	0.12	3.14	14.7	3.82	Acidic
3	CAL-003 (675-685)	Mudstone	1.36	-42.5	0.01	2.33	47.2	2.29	Acidic
4	GMC-012 (832-851)	Mudstone	0.526	-16.4	0.02	2.56	18	3.18	Acidic
5	CAL-004 (295-315)	Mud/clay	0.073	-2.3	0.13	3.2	9.2	3.41	Acidic
6	CAL-001 (750-762)	Siltstone	0.065	-2.0	0.15	3.7	14.5	3.71	Acidic
7	GMC-014 (176-184)	Siltstone	0.488	-15.3	0.02	2.7	29.7	2.59	Acidic
8	CAL-001 (380-400)	Sinter	0.014	0.1	1.25	5.54	0	6.88	Non-acidic
9	CAL-002 (177-187)	Sinter	0.044	-1.4	0.21	3.96	15.6	5.03	Non-acidic
10	Calico Leach Res. After CN Destruct.	Tailings	0.089	-2.8	0.11	3.21	4.6	3.57	Acidic

Criteria for AP Predictions:

ABA Criteria	PAG	NNP<-20 or NPR<1
	Low PAG	NP between -20 and +20 or NPR between 1 and 3
	Non-PAG	NNP>20 or NPR >3
NAG Criteria	PAG	NAG>20
	Low to Moderate PAG	NAG between 1 and 20
	Non-PAG	NAG<1
HCT Criteria	Acidic	HCT pH < 5
	Non-acidic	HCT pH > 5

Source: Grassy Mountain HCT Database Rev02

PAG = Potentially Acid Generating, Low PAG = Uncertain Potential/Lower Capacity, Non-PAG = Non-Acid Generating

6.3 HCT Termination Test Results

To determine the level of reactivity in the cells during the humidity cell test, a series of termination tests were completed on the HCT residue material to measure changes in mineralogy, mass of key elements, and acid generation potential. Upon completion of the HCT, the columns were dismantled and the test residues were homogenized and split into sub-samples. These HCT residue samples were submitted for multi-element analysis, ABA and NAG testing. The methods used were the same as those used for the pre-leach (i.e., feed) material as described above. Mineralogy on the test residues is not considered necessary since the results of the HCT program are conclusive and indicate the majority of the waste rock and ore material will generate acid and leach metals. Termination test results for the humidity cells are provided in Appendix E and are summarized below.

6.3.1 Acid Base Accounting

The pre- and post-leach ABA results for the Grassy Mountain HCT samples are summarized in Table 6-1. Paste pH decreased in all samples except HC-4. As shown in Table 6-4, the post-leach sulfide sulfur concentrations are significantly lower than the initial concentrations, indicating the sulfur minerals were effectively oxidized during the test. These results are consistent with the sulfate and metals release observed during the HCT with greatest reduction in sulfur content seen for those cells that demonstrated the highest metal and sulfate release. The exceptions to this are two samples (HC-6 and HC-7) that contain post-leach sulfide sulfur greater than initial sulfide sulfur content.

For HC-6, a review of the total sulfur data from the ABA test indicates that total sulfur concentrations also increase for the post-leach sample, but are still within a reasonable range due to the inherent heterogeneity of geologic material (i.e., a Relative Percent Difference, RPD, of 20-35% is not uncommon for soil/sediment duplicate samples). The total sulfur results from multi-element analysis are comparable to the total sulfur from ABA and suggest the pre-leach sulfide sulfur results for HC-6 are a laboratory error. For HC-7, the RPD between the pre-leach and post-leach sulfide sulfur content is about 28 percent, likely reflects the heterogeneity of geologic material since this sample generated acid and leach metals during the HCT and a reduction in sulfide sulfur is expected under these conditions.

Table 6-1: Pre- and Post-HCT Sulfide Sulfur and Total Sulfur Results

HCT ID	Lithology	Acid Base Accounting Sulfide Sulfur (wt%)			Acid Base Accounting Total Sulfur (wt%)			Multi-element Analysis Total Sulfur (wt%)		
		Initial assay	Residue assay	% Loss	Initial assay	Residue assay	% Loss	Initial assay	Residue assay	% Loss
1	Sandstone	0.25	0.05	80%	0.471	0.15	68%	0.44	0.16	64%
2	Sandstone	0.083	0.02	76%	0.251	0.09	64%	0.23	0.11	52%
3	Mudstone	1.4	0.43	68%	1.86	0.87	53%	1.77	0.88	50%
4	Mudstone	0.53	0.48	9%	0.883	0.67	24%	0.85	0.65	24%
5	Mud/clay	0.073	0.01	86%	0.181	0.02	89%	0.18	0.03	83%
6	Siltstone	0.065	0.31	-380%	0.38	0.48	-26%	0.35	0.49	-40%
7	Siltstone	0.49	0.65	-33%	1.11	0.76	32%	1.06	0.75	29%
8	Sinter	0.014	0.01	29%	0.025	0.03	-20%	0.03	0.04	-33%
9	Sinter	0.044	0.02	55%	0.084	0.05	40%	0.07	0.06	14%
10	Tailings	0.089	0.03	66%	0.346	0.19	45%	0.34	0.2	41%

Source: Grassy Mountain HCT Database Rev02

6.3.2 Net Acid Generation Testing

Table 6-2 presents the NAG test results for the post-leach HCT residues. These results indicate that the NAG pH values for the residue samples are acidic to moderately acidic with slightly lower values than the initial analysis. The exception to this is Cell HC-8 that showed a greater decrease in NAG pH, likely due to the consumption of neutralization capacity during the test.

Total NAG values were generally higher in the residue analysis indicating sulfides are more available for reaction during the NAG test as a result of being exposed to oxidizing conditions. The exception to this is HC-3 and HC-7 that have a lower NAG value in the residue compared to the initial sample. As with the sulfur data, this likely reflects the heterogeneity of geologic material.

Table 6-2: Pre- and Post-leach NAG Test Results

Cell ID	Material type	NAG pH (s.u.)		NAG Value (kg H_2SO_4 eq/t)	
		Initial	Residue	Initial	Residue
HC-1	Sandstone	2.37	2.35	11.7	26
HC-2	Sandstone	3.14	3.99	14.7	35.1
HC-3	Mudstone	2.33	2.41	47.2	25.1
HC-4	Mudstone	2.56	2.32	18	32.5
HC-5	Mud/Clay	3.2	3.22	9.2	36.7
HC-6	Siltstone	3.7	2.32	14.5	15.9
HC-7	Siltstone	2.7	2.43	29.7	25.3
HC-8	Sinter	5.54	4.17	0.2	33.7
HC-9	Sinter	3.96	3.56	15.6	35.9
HC-10	Tailings	3.21	3.0	4.6	33.4

Source: Grassy Mountain HCT Database Rev02

6.3.3 Multi-Element Analysis

The pre- and post-leach multi-element results for key parameters are summarized in Table 6-3 through Table 6-8 which show the number of key parameters relating to ARD/ML leaching during the HCT. For most parameters, typically less than five percent and often much less than one percent of the original (head) assay was leached/mobilized during the 87 weeks of testing. The primary exceptions to this include cadmium, cobalt, copper, nickel and zinc that showed a range of mobilization ranging from less than 1% to as much as 80% presumably from the leaching of sulfides. Manganese and uranium demonstrated moderate mobilization with 1 to 15% of the original (head) assay being leached during the test.

The most significant decreases in elemental concentrations between the initial (i.e., pre-leach) and residual (i.e., post-leach) material were generally observed for HC-7 (siltstone) that also has the lowest pH values. The lowest constituent release was observed for the samples of sinter that did not generate acid during the test.

Table 6-3: Pre- and Post-leach Multi-Element Assay Results (Aluminum, Arsenic, Cadmium)

Cell ID	Material type	Aluminium				Arsenic				Cadmium			
		Head Assay* (mg/kg)	Residue Assay (mg/kg)	Cumulative Metal Release during HCT	% Mobilized during HCT	Head Assay* (mg/kg)	Residue Assay (mg/kg)	Cumulative Metal Release during HCT	% Mobilized during HCT	Head Assay* (mg/kg)	Residue Assay (mg/kg)	Cumulative Metal Release during HCT	% Mobilized during HCT
HC-1	Sandstone	29000	29000	13	0.047%	160	160	0.63	0.40%	0.087	0.08	0.0068	7.8%
HC-2	Sandstone	45000	45000	13	0.028%	110	110	0.32	0.28%	0.058	0.05	0.0085	14%
HC-3	Mudstone	82000	82000	480	0.59%	240	210	31	13%	0.12	0.02	0.097	83%
HC-4	Mudstone	78000	78000	320	0.41%	110	100	2.6	2.5%	0.053	0.02	0.033	62%
HC-5	Mud/Clay	25000	25000	12	0.046%	240	240	0.25	0.11%	0.038	0.03	0.008	21%
HC-6	Siltstone	53000	53000	0.85	0.0016%	66	66	0.033	0.05%	0.021	0.02	0.001	4.9%
HC-7	Siltstone	85000	84000	1400	1.6%	430	400	37	8.5%	0.14	0.02	0.12	86%
HC-8	Sinter	6500	6500	0.35	0.0053%	32	32	0.18	0.56%	0.031	0.03	0.001	3.3%
HC-9	Sinter	13000	13000	0.33	0.0025%	47	47	0.038	0.081%	0.031	0.03	0.0011	3.4%
HC-10	Tailings	39000	39000	31	0.08%	170	170	0.027	0.015%	0.041	0.03	0.011	27%

Table 6-4: Pre- and Post-leach Multi-Element Assay Results (Cobalt, Copper, Chromium)

Cell ID	Material type	Cobalt				Copper				Chromium			
		Head Assay* (mg/kg)	Residue Assay (mg/kg)	Cumulative Metal Release during HCT	% Mobilized during HCT	Head Assay* (mg/kg)	Residue Assay (mg/kg)	Cumulative Metal Release during HCT	% Mobilized during HCT	Head Assay* (mg/kg)	Residue Assay (mg/kg)	Cumulative Metal Release during HCT	% Mobilized during HCT
HC-1	Sandstone	2.1	1.3	0.76	37%	7	6.5	0.45	6.5%	180	180	0.27	0.15%
HC-2	Sandstone	5.5	4.3	1.2	22%	15	14	1.2	7.8%	83	83	0.2	0.24%
HC-3	Mudstone	11	0.7	10	93%	12	2.6	9.2	78%	14	14	0.28	2.0%
HC-4	Mudstone	3.5	0.6	2.9	83%	16	4.1	12	75%	58	57	0.6	1.0%
HC-5	Mud/Clay	1.3	1	0.31	24%	9.1	8.3	0.84	9.2%	140	140	0.12	0.085%
HC-6	Siltstone	1	0.9	0.11	11%	25	22	2.2	9.0%	67	67	0.1	0.15%
HC-7	Siltstone	9.1	0.9	8.2	90%	22	6.5	16	71%	30	29	0.56	1.90%
HC-8	Sinter	0.8	0.7	0.1	13%	6.7	6.6	0.1	1.5%	280	280	0.1	0.036%
HC-9	Sinter	1.3	1.2	0.11	8.1%	5.9	5.8	0.11	1.8%	170	170	0.11	0.063%
HC-10	Tailings	1.3	0.9	0.42	32%	49	17	31	65%	49	49	0.15	0.30%

SUMMARY OF THE TAILINGS STORAGE FACILITY (TSF) AT THE PROPOSED GRASSY MOUNTAIN GOLD MINE

The following is excerpted from the Prefeasibility Design Tailings Storage Facility Report completed by Golder Inc for Calico Resources USA Corp (Golder, 2018, *Pre-Feasibility Design Tailings Storage Facility, Grassy Mountain Project*, submitted to Calico Resources USA Corp June 29, 2018). This report has been submitted to the TRT and been reviewed by the ODEQ and the Consultant to DOGAMI, Cardno (Subcontracted to Tetra Tech). Calico is still completing testwork that will be included in a final report, which will be submitted with the Consolidated Permit Application.

The excerpt below is meant to briefly summarize the main aspects of the Tailings Storage Facility (TSF), addressing design, containment, monitoring and closure. All tailings put into the TSF will be treated with lime to address AMD issues and detoxified to bring the cyanide levels below the level required by Oregon regulation. The TSF has been designed as a closed facility with all contact water draining to the reclaim pond at the north toe of the embankment. Fresh water from precipitation will be re-routed around the TSF. All contact water will be recycled into for use in the processing facility.

This summary is not a complete final report. Interested parties should review the full report that has been submitted to DOGAMI and is part of the public record. The full document (including appendices) is 551 pages.

INTRODUCTION:

The proposed TSF will be located in the broad valley immediately west of the Grassy Mountain mine portal and process facilities. The TSF will fill the native valley and require embankments on the north and west sides. The embankments will be constructed in stages using downstream construction. At an average deposition rate of 680 tons per day (tpd) and total capacity of 3.2 million tons, the facility will have an approximate design life of 12.9 years.

The TSF will be a 100% geomembrane-lined facility with continuous primary and secondary containment as discussed in Section 3.5. Process solution will be managed with two independent underdrain and supernatant pool decant return water systems as discussed in Section 3.6. Anticipated maximum flow rates for each system have been estimated using a monthly time-step water balance discussed in Section 3.8. The supernatant pool will be maintained away from the embankment on the eastern side of the facility as shown on Drawing C1.

The TSF has been designed as a zero-discharge facility capable of storing the 500-year, 24-hour storm and an allowance for wave action. Permanent and temporary stormwater diversions will collect and divert a majority of the stormwater runoff around the facility to a natural drainage on the north side of the TSF.

Golder Associates Inc. is responsible for the design of the TSF. The following sections present the design criteria and brief discussions on the major components of the design.

DESIGN CRITERIA; REGULATIONS:

The design criteria presented below are based on Oregon Administrative Rules (OAR), requirements of the Project as defined by Calico, and Golder's experience designing and constructing TSFs and waste rock dumps (WRDs) in similar environments. The following OAR Divisions have been used to develop minimum acceptable design levels:

- Water Resources Department, Dam Safety Regulations, OAR 690, Division 20.
- Department of Geology and Minerals Industries (DOGAMI), Chemical Process Mine Regulations, OAR 632, Division 37
- Department of Fish and Wildlife (ODFW), Chemical Process Mining Consolidated Application and Permit Review Standards, OAR 635, Division 420
- Department of Environmental Quality (DEQ), Chemical Mining, OAR Chapter 340, Division 43

The following tables present the minimum design criteria proposed for the Grassy Mountain TSF.

Table 1: General TSF Design Criteria

Parameter	**Value**	**Reference or Regulation**
Capacity	3.2 million dry tons	Calico
Life of Mine	13 years	Calico
Average Tailings Deposition Rate	248,346 tons/year (680 tons/day)	Ausenco
Tailings Slurry Concentration	~43.75% solids (by weight)	Ausenco
Settled Tailings Density	70 lb/ft³	Golder
Slope of Tailings Surface	1.0%	Golder
Dam Construction Method	Staged Downstream Construction	Golder
Dam Construction Material	Heterogeneous rock fill and/or soil fill	Golder
Tailings Deposition System	Subaerial discharge spigots	Golder
Reclaim Water System	Decant pumping and gravity underflow reclaim pond	Golder
Supernatant Pool Location	East side hill, not in contact with dam	Golder

Table 2: Division 20- Dam Safety Minimum Design Criteria

Parameter	Value	Reference or Regulation
Embankment Geometry		
Upstream Slope Angle	Overall 3 horizontal to 1 vertical (3H:1V), local slopes 2.5H:1V	OAR 690-020-0038
Downstream Slope Angle	2.5H:1V	OAR 690-020-0038
Geotechnical Criteria		
Hazard Classification	Low	OAR 690-020-0100, Golder recommended
Design Earthquake, Operational	475 year return period	Exceeds OAR 690-020-0038 for Low Hazard Dams
Design Earthquake, Closure	2,475 year return period	Exceeds OAR 690-020-0038 for Low Hazard Dams
Peak Ground Acceleration, PGA	0.12g	Golder
Horizontal PGA Factor, k, for pseudo-static stability analyses	½ of the PGA	Haynes-Griffin, Franklin (1984) and Seed (1982)
Static Stability, Factor of Safety	1.5 (minimum)	Golder[1]
Seismic Stability (pseudo-static), Factor of Safety	1.05 (minimum)	Golder[1]
Impoundment Storage Requirement[2]		
Watershed and Hydrologic Inflows	Precipitation on TSF, small area of run-on into impoundment	Golder
Freeboard Above Supernatant Pool	3 feet above maximum operating water surface elevation for peak design storm event and wave action	Golder and Partial OAR 690-020-0042
Freeboard Above Tailings Beach	2 feet against dam embankment	Golder
Peak Design Storm Event	100 year, 24 hour plus wave run-up above maximum supernatant pool operating depth	OAR 690-020-0037 and OAR 340-043-0090
Water Conveyance		
Tailings Underflow Collection System	Perforated and solid CPE and HDPE piping network	OAR 690-020-0038

1. Golder has assigned these minimum factor of safety values for geotechnical stability of the embankment dams. Minimum factors of safety were not found in Division 20. Therefore, Golder requests the Oregon Water Resources Department can provide additional guidance for acceptable minimum factors of safety.
2. Structures, but for non-water impounding structure similar to a TSF embankment, a spillway is not industry for the Grassy Mountain project's climactic conditions.

Table 3: Chemical Mining Minimum Containment Design Criteria

Parameter	Value	Reference or Regulation
Containment and Leak Detection		
Facility Discharge	Zero discharge facility	Calico, Golder, and OAR 340-043-0000
TSF Basin Containment System (top to bottom)	Continuous 80-mil HDPE geomembrane, geosynthetic clay liner (GCL), prepared subgrade	Golder and OAR 340-043-0130
TSF Reclaim Pond Containment System (top to bottom)	Continuous 80-mil HDPE geomembrane, geonet leak collection and recovery system (LCRS), 60-mil HDPE geomembrane	Golder
Overall TSF Leak Detection System	Up gradient and down gradient groundwater monitoring wells	OAR 340-043-0050
Underdrain Channel Leak Detection System	Geomembrane lined channel will provide secondary containment, leak detection will be visual	Golder
Reclaim Pond Leak Detection System	LCRS between two geomembranes, and evacuation port	Golder
Process Water Management		
Tailings Underflow Collection System	– Perforated and solid CPE and HDPE gravity piping network in 18 inch thick drainage layer – 6 inch thick filter layer – Gravity flow to reclaim pond	Golder and OAR 340-043-0050
Supernatant Water	Decant pumping system	Golder
Surface Water Management		
Perimeter Diversion Channels	100 year, 24 hour storm event	OAR 340-043-0090

DESIGN SUMMARY

This section briefly summarizes the various components of the design focusing on how the design meets the requirements of the design criteria.

Site Layout:

The proposed TSF will be located in the broad valley immediately east of the Grassy Mountain mine portal and process facilities. Native slopes within the valley range from 4 to 20%. Embankments will be required on the north and west sides to impound the tailings. The main north embankment will span the width of the valley while the smaller west embankments will be used to bridge saddles along the western ridge. The TSF will cover an approximate area of 110 acres and has been designed to accommodate 3.2 million tons (mtons) of tailings. An overall layout of the site is presented on Drawing C1.

Hazard Classification

The PFS level design has been completed under the assumption that the Grassy Mountain TSF will have a hazard rating of "Low". It appears that OAR 690-020-0022 (22) supports the use of a low hazard classification by stating that, "*if the dam were to fail, loss of life would be unlikely and damage to property would not be extensive*". A dam breach analysis has not been completed for the PFS level design.

Embankments

A shown on Drawing C1, embankments will be constructed to impound the tailings on the north and west sides. The main embankment will cross the natural drainage to the north, and small secondary embankments will be constructed across saddles along the western ridge. The embankments with have a maximum overall upstream slope of 3H:1V with a downstream slope of 2.5H:1V. The north and west embankments will have a maximum height of 80-feet and 44-feet, respectively (Drawing C8). The crest width of the north embankment will be 50-feet, with 30-feet wide crests for the smaller west embankments. The upstream slope of the embankments will be geomembrane-lined to maintain the continuous lining within the facility. A discussion on the lining system is presented in Section 3.5. The TSF will be constructed in a maximum four stages. Stages 1 through 3 will each provide between approximately 0.72 and 1.0 million dry tons (mtons) of tailings storage for between 2.8 and 4.0 years of operating capacity per stage, with a smaller fourth stage adding an additional 0.6 mtons of capacity equaling an additional 2.5 years of operating capacity.

Lining System

The TSF impoundment area and upstream slopes of each embankment will be continuously-lined with both primary and secondary lining systems to provide continuous containment of process solution. The overall lining system will vary depending on the location within the facility. The proposed lined areas are presented on Drawing D1. An evaluation was performed to compare an alternative lining system to the one prescribed in OAR 340-043-0130 (3). The OAR guidelines for secondary containment are "*an engineered, stable, soil/clay bottom liner (maximum coefficient of permeability of* 10^{-7} *cm/sec) have a minimum thickness of 36 inches*". The evaluation compared the OAR requirement with both a standard geosynthetic clay liner (GCL) and an enhanced GCL. Both GCL's consist of a sodium bentonite layer between two geotextiles that are needle-punched together. The only difference is that the enhanced GCL is then laminated to a thin flexible membrane barrier to offer an increased level of hydraulic performance (decreased hydraulic conductivity). To perform the comparison, the potential fluid travel time through each of the lining systems was evaluated for the following scenarios: 1.Comparison of secondary containment alternatives alone (Soil/clay liner vs GCL), 2. Comparison of a 60 mil primary containment geomembrane liner with the secondary containment, 3. Comparison of an 80 mil primary containment geomembrane liner with the secondary containment. The enhanced GCL exceeded the performance based on fluid travel time for all three scenarios. Golder has proposed using an enhanced GCL in place of the soil/clay liner.

Within the impoundment, the lining system will consist of (from bottom to top) a 6 to 12-inch thick native prepared subgrade, a 300-mil thick enhanced GCL, 80-mil high density polyethylene (HDPE) geomembrane liner, an 18 inch thick drainage layer, and a 6 inch thick filter layer. Perforated piping will be located within the drainage layer to promote drainage of the tailings. The same lining system has been proposed for the waste rock dump (WRD).

Underdrain Collection System

As deposition continues, the tailings will consolidate due to increased vertical pressure as the tailings surface elevation increases. In addition to water bleeding upward into the tailings surface, water will also be released from the tailings downward. To capture the water released downward, an underdrain collection piping system will be installed above the geomembrane liner within the drainage layer in the TSF basin as shown in Drawing C2. The intent of the underdrain collection system is to reduce the hydraulic head on the geomembrane liner and promote drainage of process solution from the deposited tailings. This network of perforated pipes will capture and convey underflow via gravity to the reclaim pond located downstream of the main embankment as shown on Drawing C2. The underdrain collection system will consist of variable diameter and pipe types depending on their location and vertical pressure. The primary collection pipes will penetrate through the geomembrane liner at the upstream toe of the north embankment and pass under the dam via solid wall HDPE gravity conveyance pipelines to the reclaim pond. The perforated CPE collection pipes will transition to solid wall HDPE outlet pipes prior to exiting the lined portion of the TSF. For redundancy, the primary collection pipes will tie into two interconnected outlet pipes within the TSF basin and flow to the reclaim pond. Where they pass beneath the embankment, the HDPE outlet pipes will be encased in reinforced concrete to protect against deformation and maintain the integrity of the pipes.

Reclaim Pond

The reclaim pond will be a double-lined pond north of the main embankment that will capture TSF underdrain flows as shown on Drawing C2. The lining system for the reclaim pond will consist of (from bottom to top): a native prepared subgrade, 60-mil HDPE secondary geomembrane liner, HDPE geonet, and 80-mil HDPE geomembrane primary liner. The geonet located between the two geomembranes will serve as the leakage collection and recovery system (LCRS). The reclaim pond has a total capacity of 100,900 gallons while maintaining 2-feet of freeboard beneath the pond crest. Pond sizing calculations are presented at the back of the water balance in Appendix F. The reclaim pond was sized to contain, at a minimum, the total volume of water generated during the following: 1. 100-year, 24-hour design storm event falling on the surface of the pond, 2. Gravity underdrain flow from the TSF for the duration of a 48-hour power outage, 3. Volume of water within the entire length of the reclaim water pipe between the reclaim pond and the mill. Water from the reclaim pond will be pumped back to the mill for reuse in the process circuit. At all times, process fluid pipelines will be located above secondary containment that consists of either geomembrane liners or concrete containment structures.

Tailings Distribution System

Tailings will be delivered to the TSF from the mill via the 6-inch diameter DR17 HDPE tailings delivery pipe. The tailings delivery pipe will be located within a HDPE-lined containment channel in the alignment shown on Drawing C2. The tailings delivery pipe will route along the TSF perimeter access road where tailings will be deposited via discharge points called spigots. Spigots are 1-inch diameter drop pipes with manual control valves and are spaced at regular intervals to allow for tailings deposition as needed to maintain the appropriate supernatant pool configuration and location. As the tailings are deposited and the solids settle out of the slurry, free water will accumulate at the low point on the tailings surface. This is referred to as the supernatant pool. The supernatant pool will be maintained on the eastern side of the facility away from the main embankments as shown on Drawing C1. Water from the supernatant pool will be extracted via pumping and delivered back to the mill for reuse through a return water pipe. The supernatant pool is designed to fluctuate seasonally depending on climatological conditions.

Water Balance

A deterministic spreadsheet-based monthly time step water balance was developed for each stage based on the current proposed tailings deposition rate of 680 dry short tons per day. The inflows to the system include precipitation above lined areas, surface water run-on from up-gradient catchment areas below the permanent and temporary stormwater diversions, and water being deposited within the tailings slurry at a rate of 36.2 gpm. Outflows/losses include evaporation from the tailings beach area, evaporation from the supernatant pool area, interstitial water permanently stored within the tailings mass, and estimated reclaim flow rates to the mill. Results from this water balance estimate reclaim water flow rates from the TSF to the mill in order to effectively manage water in the supernatant pool.

Development of Climate Data

There is no weather station located at the Grassy Mountain project site, so climate data for the site was developed using nearby weather station data, regression analyses, and elevation of the proposed TSF. Daily recorded data from two Remote Automated Weather Stations (RAWS) and one Cooperative Observer Network (COOP) station were used as the base climate data sets. Golder used regression analyses to develop a factor based on measured annual average precipitation and station elevation for each of the three data sets in relation to the project site. That factor was used to predict the average monthly precipitation for the project site used for hydrologic analyses. Based on available data and unknown properties of the future supernatant pool, evapotranspiration data was used to predict average monthly evaporation used for the water balance.

Estimated Reclaim Flow Rates

The total reclaim flow rate was estimated using the results of the tailings testing. The total reclaim flow rate includes the sum of the estimated flow rate from the surface of the supernatant pool and estimated flow rate from the reclaim pond based on water removed from the underdrains. During the initial deposition during Stage 1, a majority of the flow will be recovered by the underdrain collection system leading to a larger flow rate from the reclaim pond back to the mill. As tailings are deposited throughout the life of the facility the amount of water reporting to the underdrains is anticipated to decrease, increasing the amount of water that will be recovered from the supernatant pool on the surface of the tailings.

Freeboard

For tailings storage facilities, freeboard is generally defined separately for the area with free water in the supernatant pool and dry tailings beach areas. The minimum freeboard definition presented in OAR 690-020-0042 is generally intended for water storage reservoirs where water is in contact with the embankments. However, for tailings storage facilities in arid climates, tailings deposition and reclaim water can be managed to prevent free water from contacting the embankment, similar to the proposed Grassy Mountain TSF, as shown on Drawing C1.

The proposed TSF is designed to provide a minimum freeboard depth of three feet above the maximum operating supernatant pool water surface where it is impounded against the geomembrane-lined southern hillside. This freeboard will provide suitable dam storage height above the maximum water surface elevation to contain wave action above the 100-year, 24-hour storm event falling on the TSF impoundment and the up-gradient catchment areas below the permanent and temporary diversion channels.

In addition to the above freeboard dimensions, the TSF is designed such that the lowest tailings surface and pool elevation is away from the perimeter embankments. This results in the overall tailings surface sloping away from the perimeter embankments southeast toward the Supernatant Pool. With appropriate fluid management of the TSF, overtopping or freeboard encroachment is not expected. Therefore, an emergency spillway has not been included in the design.

Stormwater Control

Permanent and temporary stormwater diversion channels have been included in the design to convey surface water run-off from up gradient catchment areas around the TSF to decrease the amount of run-on water that needs to be managed within the TSF. The stormwater channels are sized to contain the peak discharge from the 100-year, 24-hour storm event of 2.28 inches, and will be lined with riprap in areas where erosion protection is required. To prevent overtopping, all channels have been designed with a minimum freeboard of 9 inches.

The initial upstream portions of each permanent diversion channel will have a V-ditch shape with 2.5H:1V side slopes with channel grades along the flowline no steeper than one percent. The depth of the V-ditch channels will range between 1.75 and 2.5 feet. Once the flows generated by the large tributary areas upstream of the Grassy Mountain TSF join the permanent diversions, the channel section will transition to a 10-foot wide trapezoidal channel with 2.5H:1V side slopes. The trapezoidal channel will have slopes ranging between one and five percent, with channel depths ranging between 1.75 and 4 feet.

GEOTECHNICAL CONSIDERATIONS

The following sections present the general subsurface soil and groundwater conditions at the site along a summary of the stability and settlement analyses performed for the north TSF embankment. Slope stability analysis was conducted to evaluate performance of the north TSF embankment for long-term, post-closure conditions based on design criteria of the facility. Settlement analysis was conducted to evaluate potential impacts of settlement within native and engineered materials on performance of the underdrain collection piping beneath the embankment.

General Subsurface Soil and Groundwater Conditions

Subsurface soil and water conditions described herein are based on the field exploration and laboratory testing performed for the project to-date.

In general, site soils consisted of surficial alluvial and colluvial deposits across the site with thicknesses ranging from about 2 to 25 feet below the existing ground surface (bgs). These deposits were generally comprised of a mixture of stiff to hard clay and medium dense to very dense sand and gravel. The surficial soils were underlain by lacustrine deposits classified as very stiff to hard, lean to fat clay with varying fine to medium sand content. This horizon was encountered up to depths of 100 feet bgs (maximum depth of exploration) within the footprint of the TSF and may extend deeper. Site soils were observed to be moist.

Relatively shallow (less than 15 feet) weathered arkosic sandstone was observed within the north-central portion of the TSF and west portion of the mine process facilities. The sandstone is similar to a silty- to poorly-graded sand. In general, the west portion of the mine process facilities consisted of Quaternary deposits underlain by weathered arkosic sandstone, and the east portion of the mine process facilities area consisted of Quaternary deposits overlying fat clay lacustrine deposits.

The laboratory testing program focused on providing information for the more critical aspects of the design. These included the north TSF embankment and potential borrow areas, with a majority of the laboratory tests performed on the lacustrine clay deposits within the footprint of the north embankment. Based on results of the laboratory testing program, shear strengths of the lacustrine deposits varied and also indicated the presence of some low strength clays within the embankment footprint. These weak clay layers can greatly affect geotechnical stability of the TSF embankment, and ultimately, the embankment design; therefore, additional index and strength testing during detailed design may be required to assess the extents and effects of the low strength clays below the embankment foundation. No subsurface water or springs were observed within the footprint of the TSF or the process facilities during the field exploration.

Seismic Hazard Analysis

Golder completed a seismic hazard analysis (SHA) for the Grassy Mountain project site. The purpose of the SHA was to identify faults that have the potential for surface rupture and to estimate earthquake ground motions for the operational and closure design earthquakes at the site for input into stability modelling. The Grassy Mountain site is located in the Columbia Plateau, a region of relatively low historical earthquake activity. A probabilistic analysis using the USGS 2014 National Seismic Hazard Model indicates that the design earthquakes for the 475-year and 2,475-year return periods have mean peak ground accelerations (PGAs) of 0.05 g and 0.12 g, respectively. The complete SHA has been included in Appendix C.

A seismic coefficient (k) of 0.06g (one half the peak acceleration) was utilized for the pseudo-static slope stability analysis to model the earthquake loading of the embankment. This reduction in PGA is in line with the commonly accepted state-of-practice by Hynes-Griffin and Franklin (1984).

Embankment Slope Stability

Slope stability of the north TSF embankment was analyzed along a cross section that was considered to be the critical section of the embankment based on anticipated geotechnical conditions in the embankment foundation and the current design configuration (e.g. embankment height, slope angles, and existing topography).

Downstream critical failure surfaces were analyzed at the ultimate Stage 4 height of the 3.2 mton capacity TSF. The analysis considered both circular and block-type failures. Circular failures included both global failures through the embankment and foundation soils and shallow 'sloughing' failures of the downstream slope. Block-type failures were assumed to occur at the interface between the embankment fill and the underlying foundation material. All calculated factors of safety (FS) values were found to be above the minimum criterion (FS≥1.50 for static, FS≥1.05 for pseudo-static).

Settlement

Settlement analysis was performed to evaluate impacts to the integrity and performance of the underdrain collection piping due to settlement of engineered fills and native foundation materials below the facility. Material properties for settlement calculations were estimated from Golder's geotechnical field and laboratory testing programs presented in Appendix D. Subsurface soils generally consist of alluvium and colluvium Quaternary deposits of varying thickness (approximately 2 to 25 feet) overlying over-consolidated, lean to fat clays with varying sand content. Clays below the embankment were generally hard and settlement in both the engineered fills and native materials was evaluated using elastic theory. Post-settlement grades along the underdrain collection piping must remain adequately steep for positive solution flow. To maintain this flow, underdrain collection pipes were designed to have a minimum post-settlement slope of one percent. Results of the settlement analysis indicate that beneath the upstream and main portions of the north embankment, the underdrain piping is to be installed at a minimum 1.5 percent slope, and beneath the downstream portion of the main embankment, the underdrain piping must be installed at a minimum of 2.5 percent slope.

Borrow Material

Borrow material will be needed for construction of the TSF embankments and potential fill below planned structures. Several areas were explored during the PFS-level design to determine potential borrow source areas within the project boundary. Embankment fill material should consist of native granular soils such as sand, gravel, clayey to silty sand, and clayey to silty gravel. In general, embankment fill may be generated from the areas north of the TSF and mine process facilities and the basalt flows east of the TSF. Basalt flows encountered on the hillsides east of the project area are being permitted for use as embankment fil.

CLOSURE

The conceptual closure design of the TSF is intended to meet the OAR requirements. In accordance with the OAR 340-043-0140 (5) requirement, the tailings surface will be covered with a composite cover designed to prevent water and air infiltration. The closure cover will consist of (from bottom to top) the regraded tailings surface, operation layer of mine waste or on-site borrow (as needed for equipment access), a geomembrane liner, 18 to 24 inches of growth medium, and seed mix to revegetate the growth medium with native species. The typical closure cover system detail is presented in Drawing C10.

The following design components have been considered during the PFS design and will help facilitate closure once mining has ceased:

- During the staged construction of the TSF, the growth medium beneath the embankments and within the TSF basin will be removed prior to embankment construction and stockpiled for use during closure.
- At the end of milling, water will pumped out of the supernatant pool. The surface of the TSF will then be allowed to dry for one to two years.
- Once the surficial tailings have sufficiently dried out, the TSF surface will be graded to maintain positive surface flow to the northeast to prevent ponding water. Surface water run-off developing on the surface of the impoundment will be directed off the impoundment through an open channel that will tie into the permanent diversion channel on the east side of the TSF as shown on Drawing C10.
- There are no back-dams that will permanently impound the natural tributary drainages upstream of the TSF below the permanent diversion channels. During the reclamation period, the perimeter access road and any temporary stormwater diversion channels can be backfilled and reclaimed to facilitate surface flows and prevent ponding.
- The downstream embankments have been designed with 2.5H:1V downstream slopes that exceed the OAR 632-037-0130 (9) requirement for closure.
- The underdrain collection system installed above the geomembrane liner will help speed consolidation, settlement and draindown of the tailings during the closure period.

- Monitoring and management of TSF draindown will be required for a period of time after the completion of mining. During this time, monitoring and measurement of draindown flow rates and quality will be performed to assist with refinement of long-term closure plans.
- Draindown water may be managed with spray evaporators until flow rates decrease to the point that the reclaim pond can be retrofitted into an evaporation cell.

WASTE ROCK DUMP FACILITY

The WRD will be used as a temporary stockpile area for low grade ore and waste generated through the mining operations. The proposed layout of the WRD has been designed for an estimated capacity of 200,000 cubic yards. A detailed design of the WRD including stability analyses has not been completed at this time; however, it is likely that, due to the slopes of the native topography and the need for a lining system beneath the WRD, a pad will need to be constructed to flatten the ground surface beneath the WRD prior to liner placement to provide positive stability. Using the current layout, it is estimated that up to 26,000 cubic yards tons of fill material may be needed to create a stable pad for stacking. The proposed location for the WRD is presented on Drawing C1 An underdrain collection system will also be installed above the geomembrane liner for the WRD. The system will capture and convey any stormwater that comes into contact with the material stockpiled above the geomembrane liner. Similar to the TSF, the collection system will consist of a series of perforated pipes installed within the drainage layer above the geomembrane liner. Prior to exiting the WRD, the perforated CPE collection pipe will transition to solid-wall HDPE pipe. The solid-wall HDPE pipe will penetrate through the lined perimeter berm and travel in the lined WRD underdrain containment channel between the WRD and the edge of the TSF. The WRD underdrain outlet detail and location of the WRD underdrain containment channel are shown on Drawing C2. At the edge of the TSF, the solid wall HDPE pipe will be installed above the geomembrane liner within the TSF basin drainage layer where it will continue on beneath the north embankment to the reclaim pond on the north side of the TSF.

Design Criteria for the Waste Rock Dump (WRD)

The WRD has been designed using the criteria summarized in Table 4.

Table 4: WRD Design Criteria

Parameter	**Value**	**Reference or Regulation**
Capacity	200,000 tons	Ausenco/MDA
WRD Containment System (top to bottom)	Continuous 80-mil HDPE geomembrane, geosynthetic clay liner (GCL), prepared subgrade	Golder

During Feasibility-level design the WRD will be analyzed for the same operational geotechnical stability criteria listed in Table 2.

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Haynes, M.E., Franklin, F.G. (1984). *Rationalizing the Seismic Coefficient Method*. U.S. Army Corps of Engineers Waterways Experiment Station, Miscellaneous Paper GL-84-13, Vicksburg, MS.

Hynes-Griffin, M.E. and Franklin, A.G. 1984. "Rationalizing the seismic coefficient method. *Miscellaneous Paper GL-84-13, Geotechnical Laboratory, U.S. Army Engineering Waterways Experiment Station, Vicksburg, Mississippi.*

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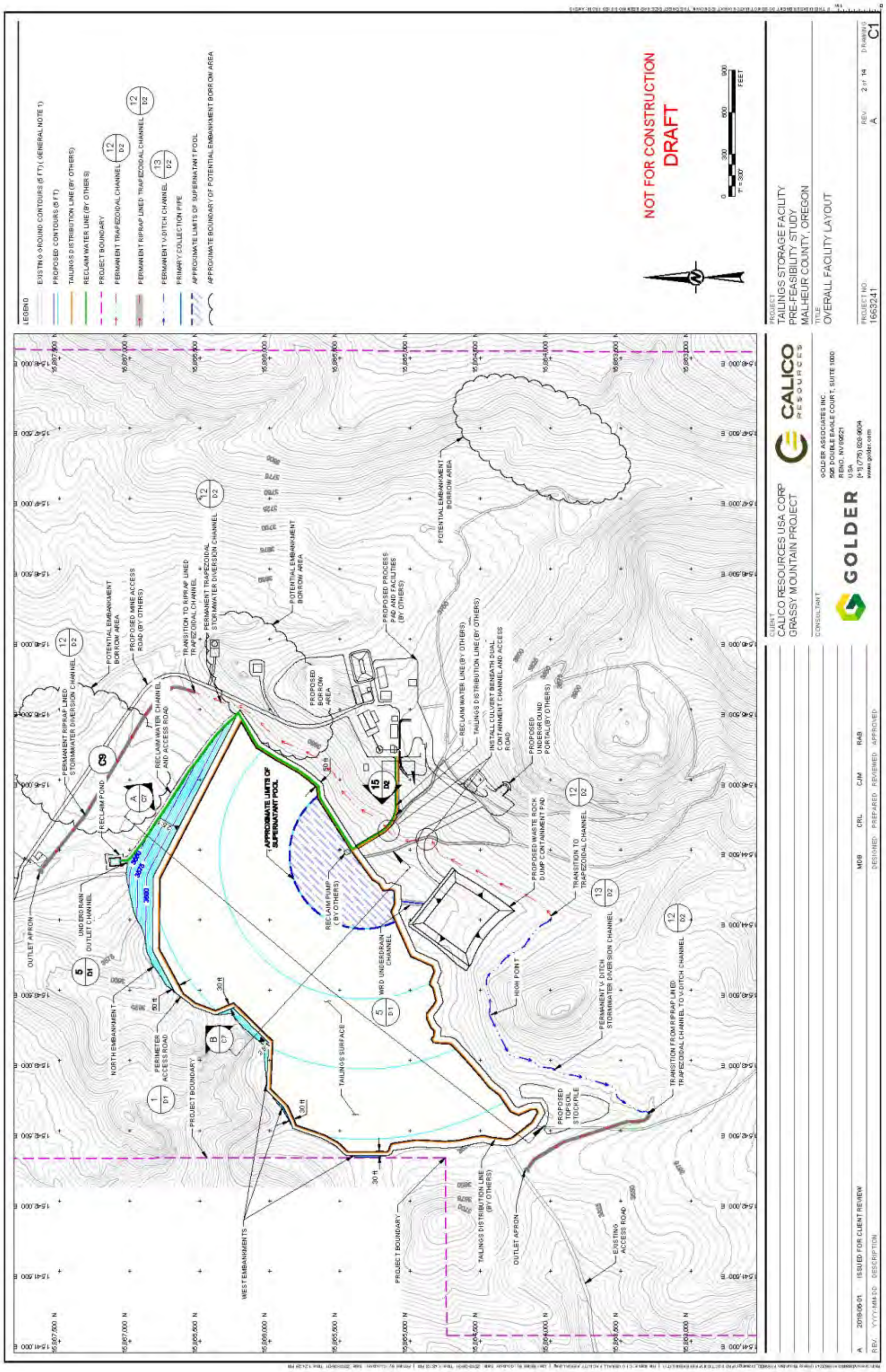
CALICO RESOURCES

Drawing C1



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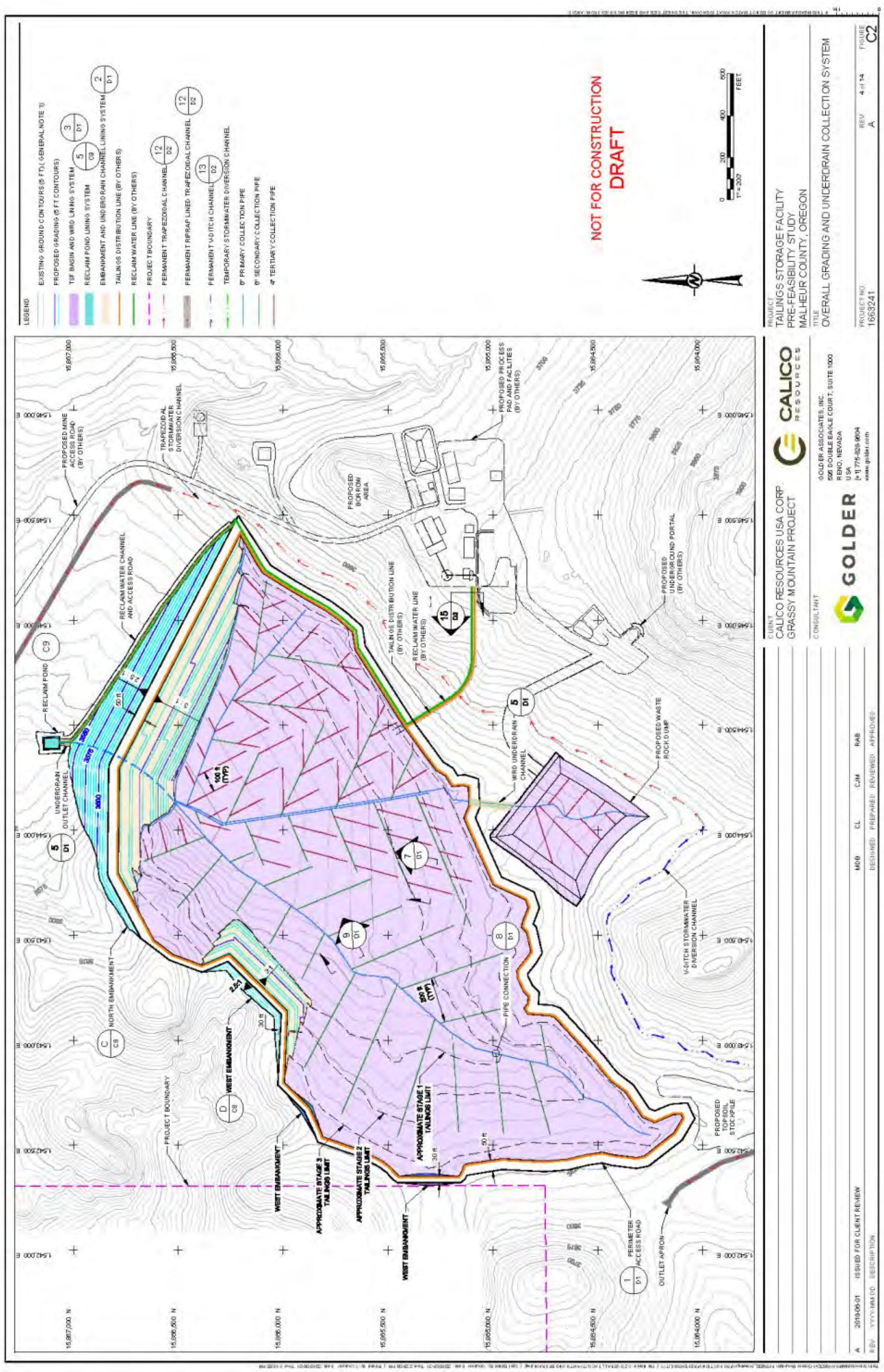

NOT FOR CONSTRUCTION
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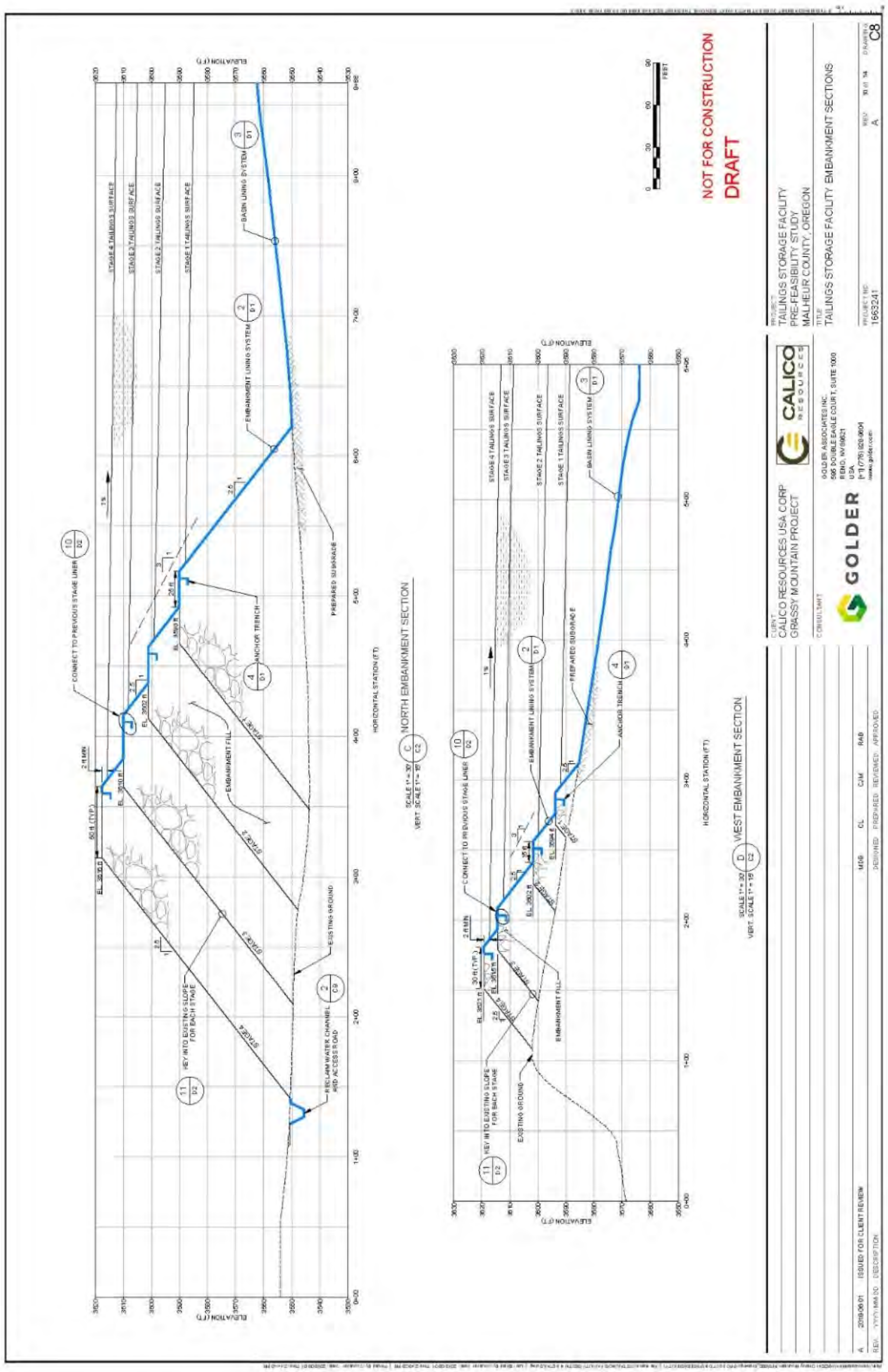
TAILINGS STORAGE FACILITY
PRE-FEASIBILITY STUDY
MALHEUR COUNTY, OREGON
OVERALL GRADING AND UNDERDRAIN COLLECTION SYSTEM
CALICO RESOURCES USA CORP
GRASSY MOUNTAIN PROJECT
GOLDER
CALICO RESOURCES
663241
C2

Drawing C8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DRAFT
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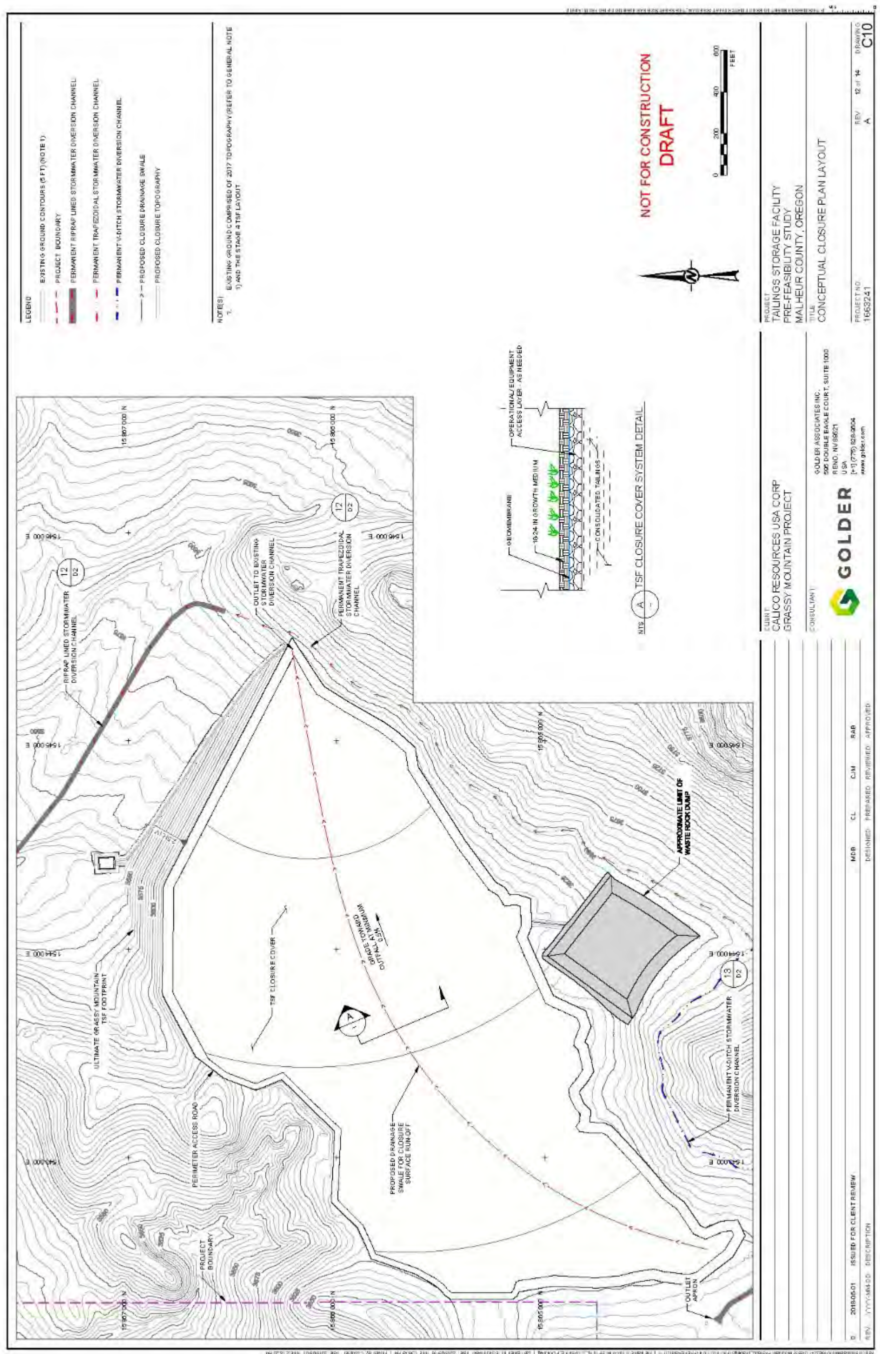
WEST EMBANKMENT SECTION
CALICO RESOURCES USA CORP
GRASSY MOUNTAIN PROJECT
TAILINGS STORAGE FACILITY
PRE-FEASIBILITY STUDY
MALHEUR COUNTY, OREGON
TAILINGS STORAGE FACILITY EMBANKMENT SECTIONS
GOLDER
1663241
C8

Drawing C10



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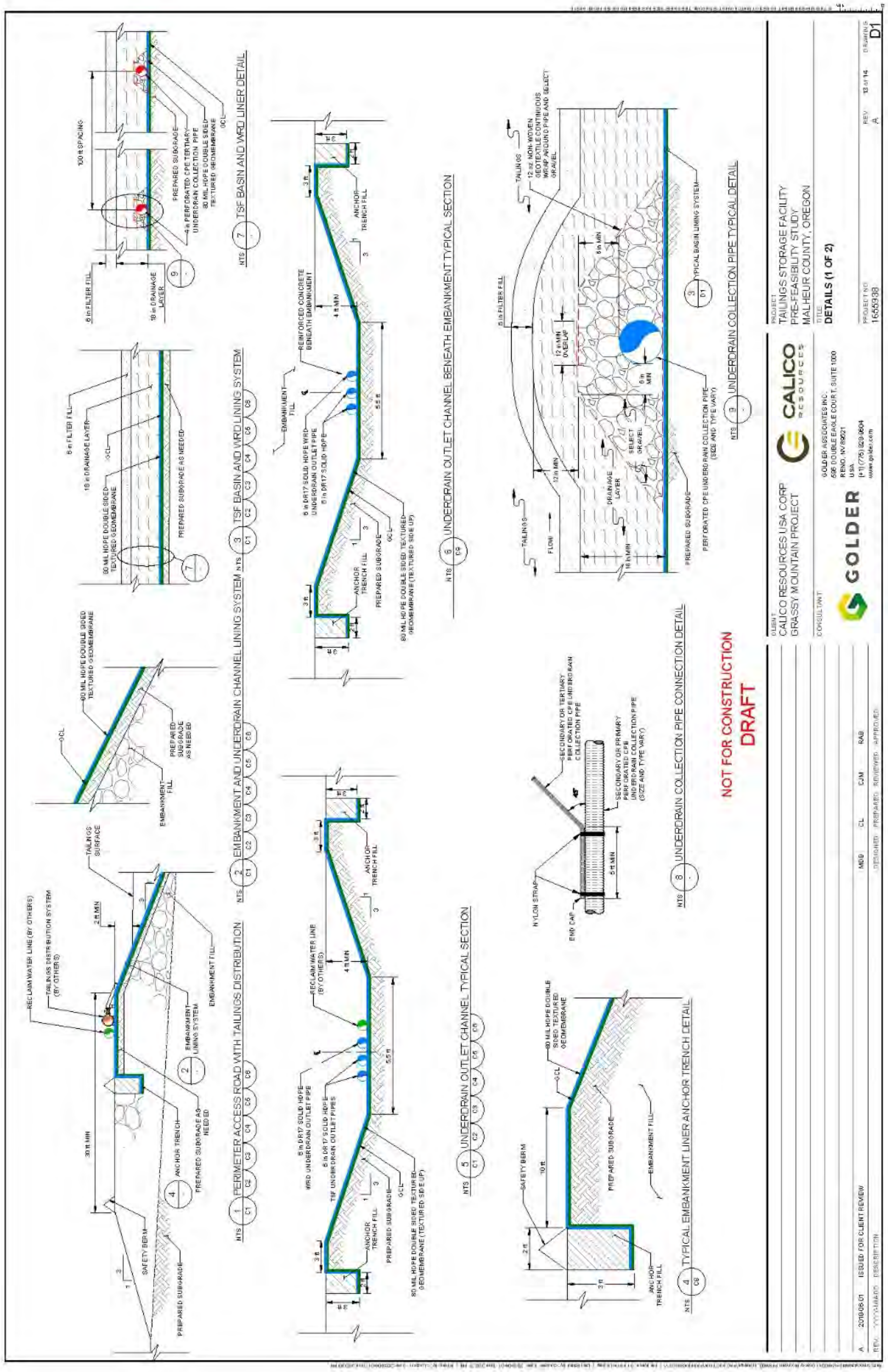
PERIMETER ACCESS ROAD WITH TAILINGS DISTRIBUTION
EMBANKMENT AND UNDERDRAIN CHANNEL LINING SYSTEM
TSF BASIN AND WRD LINING SYSTEM
TSF BASIN AND WRD LINER DETAIL
UNDERDRAIN OUTLET CHANNEL TYPICAL SECTION
UNDERDRAIN OUTLET CHANNEL BENEATH EMBANKMENT TYPICAL SECTION
TYPICAL EMBANKMENT LINER ANCHOR TRENCH DETAIL
UNDERDRAIN COLLECTION PIPE CONNECTION DETAIL
UNDERDRAIN COLLECTION PIPE TYPICAL DETAIL
NOT FOR CONSTRUCTION
DRAFT
CALICO RESOURCES USA CORP
GRASSY MOUNTAIN PROJECT
GOLDER
TAILINGS STORAGE FACILITY
PRE-FEASIBILITY STUDY
MALHEUR COUNTY, OREGON
DETAILS (1 OF 2)
D1

DRAFT REPORT

Pre-Feasibility Design Tailings Storage Facility

Grassy Mountain Project

Submitted to:

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June 6, 2018

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APPENDICES

1.0 INTRODUCTION

Golder Associates Inc. (Golder) has prepared this report to present the pre-feasibility (PFS) level design of the proposed tailings storage facility (TSF) for Calico Resources Corp.'s (Calico's) Grassy Mountain Project (Project) located in Malheur County in southeastern Oregon. General descriptions of the overall Grassy Mountain site have been presented elsewhere in the NI43-101 Technical Report. Discussions in this section will focus on the proposed location for the Grassy Mountain TSF and ancillary facilities.

The proposed TSF will be located in the broad valley immediately west of the Grassy Mountain mine portal and process facilities. The TSF will fill the native valley and require embankments on the north and west sides. The embankments will be constructed in stages using downstream construction. At an average deposition rate of 680 tons per day (tpd) and total capacity of 3.2 million tons, the facility will have an approximate design life of 12.9 years.

The TSF will be a 100% geomembrane-lined facility with continuous primary and secondary containment as discussed in Section 3.5. Process solution will be managed with two independent underdrain and supernatant pool decant return water systems as discussed in Section 3.6. Anticipated maximum flow rates for each system have been estimated using a monthly time-step water balance discussed in Section 3.8. The supernatant pool will be maintained away from the embankment on the eastern side of the facility as shown on Drawing C1.

The TSF has been designed as a zero-discharge facility capable of storing the 500-year, 24-hour storm and an allowance for wave action. Permanent and temporary stormwater diversions will collect and divert a majority of the stormwater runoff around the facility to a natural drainage on the north side of the TSF.

The following sections present the design criteria and brief discussions on the major components of the design.

1.1 Design Team

A brief summary of the design team and their respective responsibilities for the Grassy Mountain Project has been presented below:

- Mine Development Associates is responsible for project resources, portions of the mine infrastructure design, economic analyses, and compiling and preparing the 43-101F1 Technical Report.
- Golder Associates Inc. is responsible for the design of the tailings storage facility.
- Ausenco Vancouver is responsible for the design of the project metallurgy, the design of the mineral process facility, development of process operating and capital costs, and a significant portion of the surface site development and infrastructure design.
- Ausenco Chile is responsible for the final geotechnical report, underground mine design, mining schedule, reserve development and the development of the underground operating and capital costs.
- SRK Consulting is responsible for the geochemical testing on samples of tailings and waste rock material.
- SPF Water Engineering is responsible for the hydrogeology and groundwater studies.
- EM Strategies is responsible for permitting the Grassy Mountain project.
- Calico Resources Corp. is the Owner and a wholly owned subsidiary of Paramount Gold Nevada.

1.2 Battery Limits

Golder is responsible for the design of the: TSF and the containment systems for the tailings storage facility, reclaim pond, waste rock dump, tailings distribution system, and reclaim water system. The design of the pumping and piping facilities for the tailings distribution system and reclaim water system are outside of Golder's scope. The battery limits for the containment systems for the tailings distribution and reclaim water line start at the edge of the process facility site. The containment systems are continuous to provide secondary containment of all process solution or mine impacted water.

2.0 DESIGN CRITERIA

The design criteria presented below are based on Oregon Administrative Rules (OAR), requirements of the Project as defined by Calico, and Golder's experience designing and constructing TSFs and waste rock dumps (WRDs) in similar environments. The following OAR Divisions have been used to develop minimum acceptable design levels:

- Water Resources Department, Dam Safety Regulations, OAR 690, Division 20.
- Department of Geology and Minerals Industries (DOGAMI), Chemical Process Mine Regulations, OAR 632, Division 37
- Department of Fish and Wildlife (ODFW), Chemical Process Mining Consolidated Application and Permit Review Standards, OAR 635, Division 420
- Department of Environmental Quality (DEQ), Chemical Mining, OAR Chapter 340, Division 43

The following tables present the minimum design criteria proposed for the Grassy Mountain TSF.

Table 1: General TSF Design Criteria

Parameter	Value	Reference or Regulation
Capacity	3.2 million dry tons	Calico
Life of Mine	13 years	Calico
Average Tailings Deposition Rate	248,346 tons/year (680 tons/day)	Ausenco
Tailings Slurry Concentration	~43.75% solids (by weight)	Ausenco
Settled Tailings Density	70 lb/ft^3	Golder
Slope of Tailings Surface	1.0%	Golder
Dam Construction Method	Staged Downstream Construction	Golder
Dam Construction Material	Heterogeneous rock fill and/or soil fill	Golder
Tailings Deposition System	Subaerial discharge spigots	Golder
Reclaim Water System	Decant pumping and gravity underflow reclaim pond	Golder
Supernatant Pool Location	East side hill, not in contact with dam	Golder

Table 2: Division 20- Dam Safety Minimum Design Criteria

Parameter	Value	Reference or Regulation
Embankment Geometry		
Upstream Slope Angle	Overall 3 horizontal to 1 vertical (3H:1V), local slopes 2.5H:1V	OAR 690-020-0038
Downstream Slope Angle	2.5H:1V	OAR 690-020-0038
Geotechnical Criteria		
Hazard Classification	Low	OAR 690-020-0100, Golder recommended
Design Earthquake, Operational	475 year return period	Exceeds OAR 690-020-0038 for Low Hazard Dams
Design Earthquake, Closure	2,475 year return period	Exceeds OAR 690-020-0038 for Low Hazard Dams
Peak Ground Acceleration, PGA	0.12g	Golder
Horizontal PGA Factor, k, for pseudo-static stability analyses	½ of the PGA	Haynes-Griffin, Franklin (1984) and Seed (1982)
Static Stability, Factor of Safety	1.5 (minimum)	Golder[1]
Seismic Stability (pseudo-static), Factor of Safety	1.05 (minimum)	Golder[1]
Impoundment Storage Requirement[2]		
Watershed and Hydrologic Inflows	Precipitation on TSF, small area of run-on into impoundment	Golder
Freeboard Above Supernatant Pool	3 feet above maximum operating water surface elevation for peak design storm event and wave action	Golder and Partial OAR 690-020-0042
Freeboard Above Tailings Beach	2 feet against dam embankment	Golder
Peak Design Storm Event	100 year, 24 hour plus wave run-up above maximum supernatant pool operating depth	OAR 690-020-0037 and OAR 340-043-0090
Water Conveyance		
Tailings Underflow Collection System	Perforated and solid CPE and HDPE piping network	OAR 690-020-0038

1. Golder has assigned these minimum factor of safety values for geotechnical stability of the embankment dams. Minimum factors of safety were not found in Division 20. Therefore, Golder requests the Oregon Water Resources Department can provide additional guidance for acceptable minimum factors of safety.

2. Structures, but for non-water impounding structure similar to a TSF embankment, a spillway is not industry for the Grassy Mountain project's climactic conditions.

Table 3: Chemical Mining Minimum Containment Design Criteria

Parameter	Value	Reference or Regulation
Containment and Leak Detection		
Facility Discharge	Zero discharge facility	Calico, Golder, and OAR 340-043-0000
TSF Basin Containment System (top to bottom)	Continuous 80-mil HDPE geomembrane, geosynthetic clay liner (GCL), prepared subgrade	Golder and OAR 340-043-0130
TSF Reclaim Pond Containment System (top to bottom)	Continuous 80-mil HDPE geomembrane, geonet leak collection and recovery system (LCRS), 60-mil HDPE geomembrane	Golder
Overall TSF Leak Detection System	Up gradient and down gradient groundwater monitoring wells	OAR 340-043-0050
Underdrain Channel Leak Detection System	Geomembrane lined channel will provide secondary containment, leak detection will be visual	Golder
Reclaim Pond Leak Detection System	LCRS between two geomembranes, and evacuation port	Golder
Process Water Management		
Tailings Underflow Collection System	– Perforated and solid CPE and HDPE gravity piping network in 18 inch thick drainage layer – 6 inch thick filter layer – Gravity flow to reclaim pond	Golder and OAR 340-043-0050
Supernatant Water	Decant pumping system	Golder
Surface Water Management		
Perimeter Diversion Channels	100 year, 24 hour storm event	OAR 340-043-0090

2.1 Design Criteria for the Waste Rock Dump (WRD)

The WRD has been designed using the criteria summarized in Table 4.

Table 4: WRD Design Criteria

Parameter	Value	Reference or Regulation
Capacity	200,000 tons	Ausenco/MDA

WRD Containment System (top to bottom)	Continuous 80-mil HDPE geomembrane, geosynthetic clay liner (GCL), prepared subgrade	Golder

During Feasibility-level design the WRD will be analyzed for the same operational geotechnical stability criteria listed in Table 2.

3.0 DESIGN SUMMARY

This section briefly summarizes the various components of the design focusing on how the design meets the requirements of the design criteria.

3.1 Site Layout

The proposed TSF will be located in the broad valley immediately east of the Grassy Mountain mine portal and process facilities. Native slopes within the valley range between approximately four and 20 percent. Embankments will be required on the north and west sides to impound the tailings. The main north embankment will span the width of the valley while the smaller west embankments will be used to bridge saddles along the western ridge. The TSF will cover an approximate area of 110 acres and has been designed to accommodate 3.2 million tons (mtons) of tailings. An overall layout of the site is presented on Drawing C1 in Appendix A.

3.2 Hazard Classification

The PFS level design has been completed under the assumption that the Grassy Mountain TSF will have a hazard rating of “Low”. It appears that OAR 690-020-0022 (22) supports the use of a low hazard classification by stating that, “*if the dam were to fail, loss of life would be unlikely and damage to property would not be extensive*”. A dam breach analysis has not been completed for the PFS level design. The use of a Low Hazard designation is based on the knowledge that there are no structures or dwellings downgradient of the TSF that would be at risk of inundation or damage in the unlikely event of dam failure. The stability analyses completed for the project and discussed in Appendix B2 indicate that for the design criteria listed in Section 2.0, the PFS level design for the TSF meets the design factor-of-safety requirements for stability.

3.3 Embankments

A shown on Drawing C1, embankments will be constructed to impound the tailings on the north and west sides. The main embankment will cross the natural drainage to the north, and small secondary embankments will be constructed across saddles along the western ridge. The embankments with have a maximum overall upstream slope of 3H:1V with a downstream slope of 2.5H:1V. The north and west embankments will have a maximum height of 80-feet and 44-feet, respectively. The crest width of the north embankment will be 50-feet, with 30-feet wide crests for the smaller west embankments. The upstream slope of the embankments will be geomembrane-lined to maintain the continuous lining within the facility. A discussion on the lining system is presented in Section 3.5.

The TSF will be constructed in a maximum four stages utilizing downstream construction techniques as shown on Drawing C7. Embankment fill construction materials will be soil or rock fill sourced from on-site borrow areas as discussed in Section 5.6. Temporary embankments constructed of local alluvium are proposed for the southern and eastern (up gradient) boundaries of each stage. These embankments will be used to manage stormwater and to fulfill freeboard requirements, and will be subsequently inundated with tailings material during the operation of each subsequent stage.

Stages 1 through 3 will each provide between approximately 0.72 and 1.0 million dry tons (mtons) of tailings storage for between 2.8 and 4.0 years of operating capacity per stage, with a smaller fourth stage adding an additional 0.6 mtons of capacity equaling an additional 2.5 years of operating capacity. The stage-capacity relationship is based on an average tailings deposition rate of 680 dry short tons per day. The storage volume of the TSF has been calculated assuming a dry unit weight of 70 pounds per cubic foot (pcf). The development of that value is discussed in the following section. A summary of the height-area-volume relationship for the proposed TSF is presented in Table 5 below.

Table 5: Stage Capacity Relationship Summary

Stage	Main Embankment Crest Elevation (ft)	Maximum Tailings Surface Elevation (ft)	Maximum Tailings Surface Area (acres)	Stage Storage Capacity (tons)	Cumulative Storage Capacity (tons)
1	Varies (Min. 3592)	3590	36.8	867,000	867,000
2	Varies (Min. 3605)	3603	55.8	723,000	1,590,000
3	Varies (Min. 3617)	3615	75.2	996,000	2,586,000
4	Varies (Min. 3622)	3620	85.8	616,000	3,202,000

3.4 Tailings Testing

Golder completed PFS-level laboratory testing and consolidation modelling on one pilot mill tailings sample delivered to Golder's geotechnical laboratory on August 14, 2017. Detailed discussions on the laboratory classification, consolidation properties and results of the consolidation modelling are included in Appendix D.

The tailings sample tested in the laboratory had 51.29 percent solids, a specific gravity of 2.65, P80 of 113 microns and fines content (percent of material passing the #200 sieve) of 63 percent. This information, along with the estimated consolidation properties presented in Appendix D, was used in the consolidation modelling to estimate the dry settled density of the deposited tailings with time. The consolidation modelling was completed using a tailings deposition rate of 750 tpd. This will be revised during the completion of additional tailings testing and consolidation testing performed in support of the detailed design. This revision is not anticipated to significantly affect the recommendations.

The one-dimensional consolidation analysis demonstrated that dry density values of the tailings sample ranged between 92 and 94 pcf, while recommending that this value should be decreased by 10 to 20 percent to account for tailings segregation that occurs during deposition. For conservatism during the PFS-level design, the tailings storage volume has been estimated using a dry unit weight of 70 pounds per cubic foot (pcf).

3.5 Lining System

The TSF impoundment area and upstream slopes of each embankment will be continuously-lined with both primary and secondary lining systems to provide continuous containment of process solution. The overall lining system will vary depending on the location within the facility. The proposed lined areas are presented on the staged layouts on Drawings C3 through C6 with the lining system details presented on Drawing D1.

Golder performed an evaluation to compare an alternative lining system to the one prescribed in OAR 340-043-0130 (3). The OAR guidelines for secondary containment are "*an engineered, stable, soil/clay bottom liner (maximum coefficient of permeability of* 10^{-7} *cm/sec) have a minimum thickness of 36 inches*". The evaluation compared the OAR requirement with both a standard geosynthetic clay liner (GCL) and an enhanced GCL. Both GCL's consist of a sodium bentonite layer between two geotextiles that are needle-punched together. The only difference is that the enhanced GCL is then laminated to a thin flexible membrane barrier to offer an increased level of hydraulic performance (decreased hydraulic conductivity). To perform the comparison, the potential fluid travel time through each of the lining systems was evaluated for the following scenarios:

- Comparison of secondary containment alternatives alone (Soil/clay liner vs GCL)
- Comparison of a 60 mil primary containment geomembrane liner with the secondary containment
- Comparison of an 80 mil primary containment geomembrane liner with the secondary containment

Using the comparison of fluid travel times, the standard GCL did not meet the same performance standard as the soil/clay liner (OAR requirement), however the enhanced GCL exceeded the performance based on fluid travel time for all three scenarios. Golder has proposed using an enhanced GCL in place of the soil/clay liner. The calculations are presented in Appendix E.

Within the impoundment, the lining system will consist of (from bottom to top) a 6 to 12-inch thick native prepared subgrade, a 300-mil thick enhanced GCL, 80-mil high density polyethylene (HDPE) geomembrane liner, an 18 inch thick drainage layer, and a 6 inch thick filter layer. Perforated piping will be located within the drainage layer to promote drainage of the tailings. The same lining system has been proposed for the waste rock dump (WRD).

On the upstream embankment slopes, the lining system will be the same, but without the overlying piping, drainage layer, and filter layer. Placement of a drainage layer above the geomembrane on the upstream embankment slopes will be impractical due to the relatively steep side slopes and erosion potential of a cover from tailings deposition. Additionally, the TSF underdrain channel, WRD underdrain channel, and tailings delivery channel from the process area will utilize the same lining system as the TSF embankment slopes.

3.6 Underdrain Collection System

As deposition continues, the tailings will consolidate due to increased vertical pressure as the tailings surface elevation increases. In addition to water bleeding upward into the tailings surface, water will also be released from the tailings downward. To capture the water released downward, an underdrain collection piping system will be installed above the geomembrane liner within the drainage layer in the TSF basin as shown in Drawing C2. The intent of the underdrain collection system is to reduce the hydraulic head on the geomembrane liner and promote drainage of process solution from the deposited tailings.

This network of perforated pipes will capture and convey underflow via gravity to the reclaim pond located downstream of the main embankment as shown on Drawing C2. The underdrain collection system will consist of variable diameter and pipe types depending on their location and vertical pressure. In general, primary collection pipes will be perforated 6-inch diameter double-wall corrugated polyethylene (CPE), secondary collection pipes will be perforated 6-inch diameter double-wall CPE, and tertiary collections pipes will be 4-inch diameter double-wall CPE. Tertiary collection pipes will be installed with greater density adjacent to the north embankment and beneath the supernatant pool.

The primary collection pipes will penetrate through the geomembrane liner at the upstream toe of the north embankment and pass under the dam via solid wall HDPE gravity conveyance pipelines to the reclaim pond. The perforated CPE collection pipes will transition to solid wall HDPE outlet pipes prior to exiting the lined portion of the TSF. For redundancy, the primary collection pipes will tie into two interconnected outlet pipes within the TSF basin and flow to the reclaim pond.

Where they pass beneath the embankment, the HDPE outlet pipes will be encased in reinforced concrete to protect against deformation and maintain the integrity of the pipes. Beyond the toe of the proposed Stage 4 embankment the reinforced concrete encasement will terminate and the outlet pipes will continue on to the reclaim pond within the geomembrane lined underdrain channel. Prior to discharging into the reclaim pond, each underdrain pipe will be equipped with flumes to measure and monitor underdrain flow and valves that can be used to restrict flow or be closed in case of emergency.

3.6.1 Reclaim Pond

The reclaim pond will be a double-lined pond north of the main embankment that will capture TSF underdrain flows as shown on Drawing C2. The lining system for the reclaim pond will consist of (from bottom to top): a native prepared subgrade, 60-mil HDPE secondary geomembrane liner, HDPE geonet, and 80-mil HDPE geomembrane primary liner. The geonet located between the two geomembranes will serve as the leakage collection and recovery system (LCRS).

The reclaim pond has a total capacity of 100,900 gallons while maintaining 2-feet of freeboard beneath the pond crest. Pond sizing calculations are presented at the back of the water balance in Appendix F. The reclaim pond was sized to contain, at a minimum, the total volume of water generated during the following:

- 100-year, 24-hour design storm event falling on the surface of the pond,
- Gravity underdrain flow from the TSF for the duration of a 48-hour power outage,
- Volume of water within the entire length of the reclaim water pipe between the reclaim pond and the mill.

Water from the reclaim pond will be pumped back to the mill for reuse in the process circuit. The reclaim water pipe will be installed in an HDPE geomembrane lined channel constructed beyond the toe of the Stage 4 embankment as shown on Drawings C3 through C6. The channel will extend up the eastern slope near the northeast corner of the TSF and will be extended further up the slope with each staged expansion. Near the crest of the TSF for each stage, the HDPE reclaim water pipe will transition from the lined channel to the perimeter access road where it will be installed above the existing TSF basin geomembrane liner and run adjacent to the tailings distribution line. The reclaim pipe will then transition into the geomembrane-lined tailings delivery channel where it will travel back to the mill.

At all times, process fluid pipelines will be located above secondary containment that consists of either geomembrane liners or concrete containment structures.

3.6.2 Waste Rock Dump

An underdrain collection system will also be installed above the geomembrane liner for the WRD. The system will capture and convey any stormwater that comes into contact with the material stockpiled above the geomembrane liner. Similar to the TSF, the collection system will consist of a series of perforated pipes installed within the drainage layer above the geomembrane liner.

Prior to exiting the WRD, the perforated CPE collection pipe will transition to solid-wall HDPE pipe. The solid-wall HDPE pipe will penetrate through the lined perimeter berm and travel in the lined WRD underdrain containment channel between the WRD and the edge of the TSF. The WRD underdrain outlet detail and location of the WRD underdrain containment channel are shown on Drawings D2 and C2, respectively. At the edge of the TSF, the solid wall HDPE pipe will be installed above the geomembrane liner within the TSF basin drainage layer where it will continue on beneath the north embankment to the reclaim pond on the north side of the TSF. The proposed underdrain collection system is presented on Drawing C2.

3.7 Tailings Distribution System

Tailings will be delivered to the TSF from the mill via the 6-inch diameter DR17 HDPE tailings delivery pipe. The tailings delivery pipe will be located within a HDPE-lined containment channel in the alignment shown on Drawing C2. The tailings delivery pipe will route along the TSF perimeter access road where tailings will be deposited via discharge points called spigots. Spigots are 1-inch diameter drop pipes with manual control valves and are spaced at regular intervals to allow for tailings deposition as needed to maintain the appropriate supernatant pool configuration and location. Design of the tailings delivery pipe and discharge spigots is being performed by other parties and is not included in this design.

As the tailings are deposited and the solids settle out of the slurry, free water will accumulate at the low point on the tailings surface. This is referred to as the supernatant pool. The supernatant pool will be maintained on the eastern side of the facility away from the main embankments as shown on Drawing C1. Water from the supernatant pool will be extracted via pumping and delivered back to the mill for reuse through a return water pipe. The supernatant pool is designed to fluctuate seasonally depending on climatological conditions. The supernatant pool will have an average operating depth of 5-feet that is controlled by the pumping system and is adequately deep enough to prevent drawing tailings solids from the pool bottom. The return water pipe will combine the flows from the supernatant pool and the reclaim pond. The combined flows will be pumped in a single pipe installed parallel the tailings delivery pipe located in the HDPE-lined channel and deliver the evacuated return water directly to the mill for reuse.

3.8 Water Balance

A deterministic spreadsheet-based monthly time step water balance was developed for each stage based on the current proposed tailings deposition rate of 680 dry short tons per day. The inflows to the system include precipitation above lined areas, surface water run-on from up-gradient catchment areas below the permanent and temporary stormwater diversions, and water being deposited within the tailings slurry at a rate of 36.2 gpm. Outflows/losses include evaporation from the tailings beach area, evaporation from the supernatant pool area, interstitial water permanently stored within the tailings mass, and estimated reclaim flow rates to the mill. Results from this water balance estimate reclaim water flow rates from the TSF to the mill in order to effectively manage water in the supernatant pool. The average reclaim rate from the supernatant pool is 48 gpm for Stages 1 through 4 and varies between 1.5 gpm during summer months (July and August) to 91 gpm during winter months (December and January). Make-up water required was defined as the rate of evaporation from the tailings beach and supernatant pool (outflow) plus interstitial water loss (outflow) minus precipitation (inflow). The make-up water rate is less than or equal to the rate that water is reporting to the TSF in the tailings slurry.

The water balance spreadsheet and supporting discussions are presented in Appendix F.

3.8.1 Development of Climate Data

There is no weather station located at the Grassy Mountain project site, so climate data for the site was developed using nearby weather station data, regression analyses, and elevation of the proposed TSF. Daily recorded data from two Remote Automated Weather Stations (RAWS) and one Cooperative Observer Network (COOP) station were used as the base climate data sets. Golder used regression analyses to develop a factor based on measured annual average precipitation and station elevation for each of the three data sets in relation to the project site. That factor was used to predict the average monthly precipitation for the project site used for hydrologic analyses. Based on available data and unknown properties of the future supernatant pool, evapotranspiration data was used to predict average monthly evaporation used for the water balance. Supporting calculations and discussions about the predicted climate data are presented in Appendix F.

3.8.2 Estimated Reclaim Flow Rates

The total reclaim flow rate was estimated using the results of the tailings testing previously discussed in Section 3.4. The total reclaim flow rate includes the sum of the estimated flow rate from the surface of the supernatant pool and estimated flow rate from the reclaim pond based on water removed from the underdrains. During the initial deposition during Stage 1, a majority of the flow will be recovered by the underdrain collection system leading to a larger flow rate from the reclaim pond back to the mill. As tailings are deposited throughout the life of the facility the amount of water reporting to the underdrains is anticipated to decrease, increasing the amount of water that will be recovered from the supernatant pool on the surface of the tailings. Supporting calculations for the estimated reclaim flow rate are presented in Appendix F.

3.8.3 Freeboard

For tailings storage facilities, freeboard is generally defined separately for the area with free water in the supernatant pool and dry tailings beach areas. The minimum freeboard definition presented in OAR 690-020-0042 is generally intended for water storage reservoirs where water is in contact with the embankments. However, for tailings storage facilities in arid climates, tailings deposition and reclaim water can be managed to prevent free water from contacting the embankment, similar to the proposed Grassy Mountain TSF, as shown on Drawing C1.

The proposed TSF is designed to provide a minimum freeboard depth of three feet above the maximum operating supernatant pool water surface where it is impounded against the geomembrane-lined southern hillside. This freeboard will provide suitable dam storage height above the maximum water surface elevation to contain wave action above the 100-year, 24-hour storm event falling on the TSF impoundment and the up-gradient catchment areas below the permanent and temporary diversion channels. Wave run-up calculations were developed assuming the TSF had experienced a 100-year, 24-hour storm with waves generated from sustained wind loading using the average wind speed in the prevailing wind direction. Wave run-up calculations have been included in Appendix F.

Tailings beach areas are defined as areas where the impoundment surface is free of pooled water and only comprised of tailings. The TSF is designed so that only tailings will impound against the embankments. In the tailings beach areas, a minimum freeboard of two feet will be provided from the highest beach elevation to the lowest dam crest elevation.

In addition to the above freeboard dimensions, the TSF is designed such that the lowest tailings surface and pool elevation is away from the perimeter embankments. This results in the overall tailings surface sloping away from the perimeter embankments southeast toward the Supernatant Pool. With appropriate fluid management of the

TSF, overtopping or freeboard encroachment is not expected. Therefore, an emergency spillway has not been included in the design.

3.9 Stormwater Control

Permanent and temporary stormwater diversion channels have been included in the design to convey surface water run-off from up gradient catchment areas around the TSF to decrease the amount of run-on water that needs to be managed within the TSF. The stormwater channels are sized to contain the peak discharge from the 100-year, 24-hour storm event of 2.28 inches, and will be lined with riprap in areas where erosion protection is required. To prevent overtopping, all channels have been designed with a minimum freeboard of 9 inches. A detailed summary of the hydraulic calculations is presented in Appendix G.

The initial upstream portions of each permanent diversion channel will have a V-ditch shape with 2.5H:1V side slopes with channel grades along the flowline no steeper than one percent. The depth of the V-ditch channels will range between 1.75 and 2.5 feet. Once the flows generated by the large tributary areas upstream of the Grassy Mountain TSF join the permanent diversions, the channel section will transition to a 10-foot wide trapezoidal channel with 2.5H:1V side slopes. The trapezoidal channel will have slopes ranging between one and five percent, with channel depths ranging between 1.75 and 4 feet. Typical channel cross sections are presented on Drawing D2.

4.0 WASTE ROCK DUMP FACILITY

The proposed location for the WRD is presented on Drawing C1. The WRD will be used as a temporary stockpile area for low grade ore and waste generated through the mining operations. The proposed layout of the WRD has been designed for an estimated capacity of 200,000 cubic yards. A detailed design of the WRD including stability analyses has not been completed at this time; however, it is likely that, due to the slopes of the native topography and the need for a lining system beneath the WRD, a pad will need to be constructed to flatten the ground surface beneath the WRD prior to liner placement to provide positive stability. Using the current layout, it is estimated that up to 26,000 cubic yards tons of fill material may be needed to create a stable pad for stacking.

5.0 GEOTECHNICAL CONSIDERATIONS

The following sections present the general subsurface soil and groundwater conditions at the site along a summary of the stability and settlement analyses performed for the north TSF embankment. Slope stability analysis was conducted to evaluate performance of the north TSF embankment for long-term, post-closure conditions based on design criteria of the facility. Settlement analysis was conducted to evaluate potential impacts of settlement within native and engineered materials on performance of the underdrain collection piping beneath the embankment. A more detailed description of stability and settlement calculations and methodologies are presented in Appendices B2 and B3, respectively.

5.1 General Subsurface Soil and Groundwater Conditions

Subsurface soil and water conditions described herein are based on the field exploration and laboratory testing performed for the project to-date. The geotechnical investigation and geotechnical laboratory testing program are discussed in detail in Appendix B.

In general, site soils consisted of surficial alluvial and colluvial deposits across the site with thicknesses ranging from about 2 to 25 feet below the existing ground surface (bgs). These deposits were generally comprised of a mixture of stiff to hard clay and medium dense to very dense sand and gravel. The surficial soils were underlain by lacustrine deposits classified as very stiff to hard, lean to fat clay with varying fine to medium sand content. This horizon was encountered up to depths of 100 feet bgs (maximum depth of exploration) within the footprint of the TSF and may extend deeper. Site soils were observed to be moist.

Relatively shallow (less than 15 feet) weathered arkosic sandstone was observed within the north-central portion of the TSF and west portion of the mine process facilities. The sandstone is similar to a silty- to poorly-graded sand. In general, the west portion of the mine process facilities consisted of Quaternary deposits underlain by weathered arkosic sandstone, and the east portion of the mine process facilities area consisted of Quaternary deposits overlying fat clay lacustrine deposits.

The laboratory testing program focused on providing information for the more critical aspects of the design. These included the north TSF embankment and potential borrow areas, with a majority of the laboratory tests performed on the lacustrine clay deposits within the footprint of the north embankment. Based on results of the laboratory testing program, shear strengths of the lacustrine deposits varied and also indicated the presence of some low strength clays within the embankment footprint. These weak clay layers can greatly affect geotechnical stability of the TSF embankment, and ultimately, the embankment design; therefore, additional index and strength testing during detailed design may be required to assess the extents and effects of the low strength clays below the embankment foundation.

No subsurface water or springs were observed within the footprint of the TSF or the process facilities during the field exploration. However, seasonal fluctuations in precipitation may occur that could affect surface water conditions at the sites or development of springs. It is recommended that during detailed design, a surface spring survey be performed after winter to identify any potential areas where seasonal springs may appear.

5.2 Seismic Hazard Analysis

Golder completed a seismic hazard analysis (SHA) for the Grassy Mountain project site. The purpose of the SHA was to identify faults that have the potential for surface rupture and to estimate earthquake ground motions for the operational and closure design earthquakes at the site for input into stability modelling. The Grassy Mountain site is located in the Columbia Plateau, a region of relatively low historical earthquake activity. A probabilistic analysis using the USGS 2014 National Seismic Hazard Model indicates that the design earthquakes for the 475-year and 2,475-year return periods have mean peak ground accelerations (PGAs) of 0.05 g and 0.12 g, respectively. The complete SHA has been included in Appendix C.

A seismic coefficient (k) of 0.06g (one half the peak acceleration) was utilized for the pseudo-static slope stability analysis to model the earthquake loading of the embankment. This reduction in PGA is in line with the commonly accepted state-of-practice by Hynes-Griffin and Franklin (1984).

5.3 Embankment Slope Stability

Slope stability of the north TSF embankment was analyzed along a cross section that was considered to be the critical section of the embankment based on anticipated geotechnical conditions in the embankment foundation and the current design configuration (e.g. embankment height, slope angles, and existing topography).

Downstream critical failure surfaces were analyzed at the ultimate Stage 4 height of the 3.2 mton capacity TSF. The analysis considered both circular and block-type failures. Circular failures included both global failures through the embankment and foundation soils and shallow ‘sloughing’ failures of the downstream slope. Block-type failures were assumed to occur at the interface between the embankment fill and the underlying foundation material.

All calculated factors of safety (FS) values were found to be above the minimum criterion (FS≥1.50 for static, FS≥1.05 for pseudo-static) as summarized in Table 6. Although stability results satisfy FS criteria developed for the project, material strengths of foundation soils below the embankment are based on currently available data. Due to the variability in strength and the presence of low strength clays, Golder recommends that additional index and laboratory strength tests be performed during detailed design on native soils in the embankment footprint to refine strength parameters used in analysis and assess how variations and discontinuities of the subsurface clay properties affect performance of the embankment.

Table 6: Summary of Critical Stability Analysis Results

Failure Condition	Static FOS		Pseudo-static FOS (k = 0.06 g)	
	Critical	Required Minimum	Critical	Required Minimum
Global Circular	1.93	1.5	1.65	1.05
Shallow Circular	1.69	1.5	1.44	1.05
Block-Type	1.88	1.5	1.60	1.05

5.4 Settlement

Settlement analysis was performed to evaluate impacts to the integrity and performance of the underdrain collection piping due to settlement of engineered fills and native foundation materials below the facility. Material properties for settlement calculations were estimated from Golder's geotechnical field and laboratory testing programs presented in Appendix D. Subsurface soils generally consist of alluvium and colluvium Quaternary deposits of varying thickness (approximately 2 to 25 feet) overlying over-consolidated, lean to fat clays with varying sand content. Clays below the embankment were generally hard and settlement in both the engineered fills and native materials was evaluated using elastic theory.

Post-settlement grades along the underdrain collection piping must remain adequately steep for positive solution flow. To maintain this flow, underdrain collection pipes were designed to have a minimum post-settlement slope of one percent. Results of the settlement analysis indicate that beneath the upstream and main portions of the north embankment, the underdrain piping is to be installed at a minimum 1.5 percent slope, and beneath the downstream portion of the main embankment, the underdrain piping must be installed at a minimum of 2.5 percent slope. Figure S1 in Appendix B3 presents a schematic of the recommended minimum underdrain collection pipe slopes along Section A.

5.5 General Foundation Recommendations for Mine Process Facilities

Mine process and support facilities are situated directly north of the proposed mine portal as shown on Drawing C1. It is our understanding these facilities will include office buildings, truck maintenance facilities, crushers, mill, and additional structures. Based on the subsurface exploration, the subsurface beneath the proposed location for the mine facilities can generally be separated into two areas as summarized below:

- **East portion:** Approximately 5 to 20 feet of Quaternary deposits comprising lean to fat clay soils and clayey sands overlying lacustrine clays.

- **West portion:** About 3 to 10 feet of Quaternary deposits comprising lean to fat clays and poorly graded gravel to silty sand overlying sandstone bedrock encountered at depths ranging from 3½ to 10 feet bgs.

In general, planned structures may be founded on conventional shallow foundations. Foundations may be supported by undisturbed medium dense to very dense granular, native alluvium/colluvium or weathered sandstone, or properly placed engineered fill. Lacustrine and overburden clay soils are not suitable to support foundations.

Topsoil, soil supporting plant growth, or loose soils are not considered suitable for the support of floor slabs, footings, or mat foundations, and should be removed from the site prior to grading.

Due to the presence of clay with a high potential for swelling, a minimum 4 feet of separation between the bottom of foundations and the clay soils is recommended. If clay soils are located within 4 feet of the base of foundations and slabs-on-grade, the clays are to be over-excavated and replaced with properly-placed granular engineered fill. The extent of over-excavation will depend on final grades established for the area. Maintaining positive site drainage away from foundations will be imperative to reduce the potential for swelling of the clays that may affect performance of the foundations. This is particularly important for the truck wash and other areas where water is likely to be present with an increased risk of ponding.

5.6 Borrow Material

Borrow material will be needed for construction of the TSF embankments and potential fill below planned structures. Several areas were explored during the PFS-level design to determine potential borrow source areas within the project boundary. Embankment fill material should consist of native granular soils such as sand, gravel, clayey to silty sand, and clayey to silty gravel. In general, embankment fill may be generated from the areas north of the TSF and mine process facilities and the basalt flows east of the TSF (Appendix B1).

Basalt flows encountered on the hillsides east of the project area may also be suitable for use as embankment fill; however, use of the basalt flows will likely require ripping and/or blasting. Weathered arkosic sandstone is considered to be unsuitable for embankment as the material is generally brittle and erosive. If material meeting the requirements for embankment fill is used as fill beneath planned structures, screening may be required to remove over-sized material.

6.0 CLOSURE

The conceptual closure design of the TSF is intended to meet the OAR requirements. In accordance with the OAR 340-043-0140 (5) requirement, the tailings surface will be covered with a composite cover designed to prevent water and air infiltration. The closure cover will consist of (from bottom to top) the regraded tailings surface, operation layer of mine waste or on-site borrow (as needed for equipment access), a geomembrane liner, 18 to 24 inches of growth medium, and seed mix to revegetate the growth medium with native species. The typical closure cover system detail is presented in Drawing C10.

The following design components have been considered during the PFS design and will help facilitate closure once mining has ceased:

- During the staged construction of the TSF, the growth medium beneath the embankments and within the TSF basin will be removed prior to embankment construction and stockpiled for use during closure.

- At the end of milling, water will pumped out of the supernatant pool. The surface of the TSF will then be allowed to dry for one to two years.
- Once the surficial tailings have sufficiently dried out, the TSF surface will be graded to maintain positive surface flow to the northeast to prevent ponding water. Surface water run-off developing on the surface of the impoundment will be directed off the impoundment through an open channel that will tie into the permanent diversion channel on the east side of the TSF as shown on Drawing C10.
- There are no back-dams that will permanently impound the natural tributary drainages upstream of the TSF below the permanent diversion channels. During the reclamation period, the perimeter access road and any temporary stormwater diversion channels can be backfilled and reclaimed to facilitate surface flows and prevent ponding.
- The downstream embankments have been designed with 2.5H:1V downstream slopes that exceed the OAR 632-037-0130 (9) requirement for closure.
- The underdrain collection system installed above the geomembrane liner will help speed consolidation, settlement and draindown of the tailings during the closure period.
- Monitoring and management of TSF draindown will be required for a period of time after the completion of mining. During this time, monitoring and measurement of draindown flow rates and quality will be performed to assist with refinement of long-term closure plans.
- Draindown water may be managed with spray evaporators until flow rates decrease to the point that the reclaim pond can be retrofitted into an evaporation cell.

7.0 RECOMMENDATIONS FOR ADVANCING THE DESIGN

The PFS-level design presented in this document contains suitable and industry-accepted PFS-level engineering analyses to support that the proposed designs meet the requirements and guidelines of the OAR for Chemical Mining and Dam Safety. Golder recommends the following as the design advances to the Feasibility stage:

- Golder utilized an assumed settled tailings dry density of 70 pcf to develop the staged layouts presented in this PFS level design. Based on past experience with gold tailings, this density is suitable for PFS-level design. Additional tailings testing will be completed in support of the detailed design to evaluate the tailings segregation potential.
- Due to the variability of subsurface materials and presence of low strength materials, Golder recommends that additional geotechnical investigation, laboratory index testing, and strength testing be performed on native soils below the embankment to refine strength parameters used in support of this PFS-level design. This program will assist in refining the understanding of how variations and discontinuities in the subsurface clay properties may affect stability of the embankment. If low-strength materials are determined to be more prevalent than assumed in this design, a buttress may be required along the downstream toe of the embankments to satisfy the stability requirements.
- The seismic hazard assessment should be updated with the data obtained from future geotechnical investigations to verify the assumptions used in the analysis. It may be necessary to re-evaluate the earthquake ground motions if design site soils conditions vary by more than 20% from those assumed in the analysis.

- If the facility locations deviate from what has been presented in the PFS, the geotechnical recommendations should be re-evaluated due to the potential for swelling of subsurface clays.
- The proposed borrow areas should be further refined to better characterize both the quantity and quality of potential construction material.
- The embankment sections should be optimized with zoning to utilize the available on-site borrow material.

8.0 CLOSING

Golder is pleased to present this PFS-level design for the proposed TSF for the Grassy Mountain Project. If you have any questions or comments regarding the information presented herein, please contact the undersigned at (775) 828-9604.

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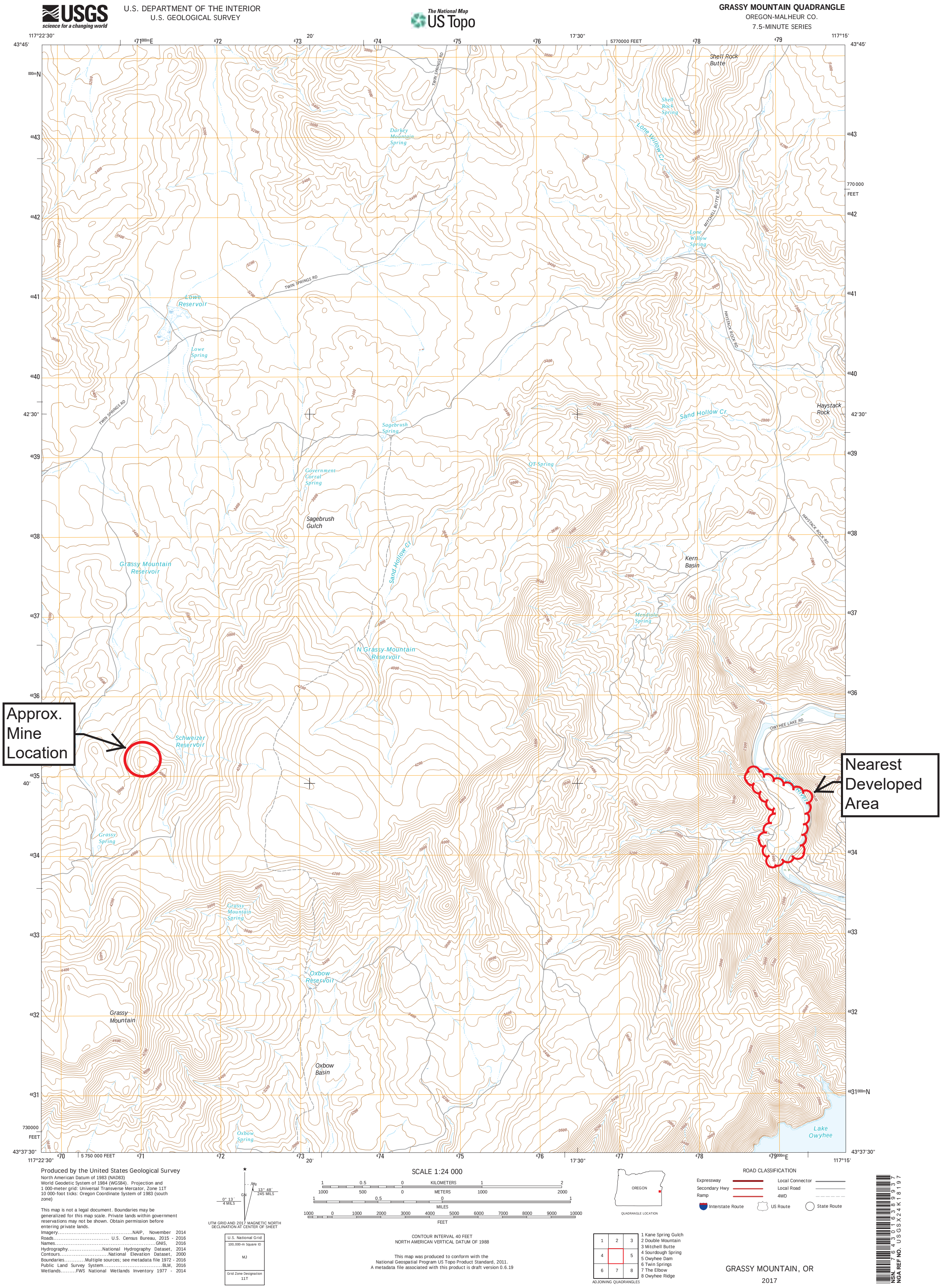


Exhibit 11
Page 1 of 1

WORLD GOLD COUNCIL

MAXWELL STAMP PLC

The social and economic impacts of gold mining

Exhibit 12
Page 1 of 40

The social and economic impacts of gold mining.

A research study by Maxwell Stamp commissioned by the World Gold Council.

About the World Gold Council

The World Gold Council is the market development organisation for the gold industry. Working within the investment, jewellery and technology sectors, as well as engaging with governments and central banks, our purpose is to provide industry leadership, whilst stimulating and sustaining demand for gold.

We develop gold-backed solutions, services and markets based on true market insight. As a result we create structural shifts in demand for gold across key market sectors.

We provide insights into international gold markets, helping people to better understand the wealth preservation qualities of gold and its role in meeting the social and environmental needs of society.

Based in the UK, with operations in India, the Far East, and the US, the World Gold Council is an association whose members comprise the world's leading gold mining companies.

About Maxwell Stamp

Maxwell Stamp is one of the world's leading international economics consultancies. Established in 1959, they have over 50 years of experience in over 165 countries and territories, with a strong track record in developing and transitional countries and expertise across a wide range of competencies and policy areas: from international trade to rural livelihoods, from privatisation to financial reform, from gender to industrial strategy. Through the services delivered for clients, Maxwell Stamp is committed to working towards the eradication of poverty and increased social well-being.

Acknowledgments

MAXWELL STAMP PLC

This research study was undertaken for the World Gold Council by Maxwell Stamp PLC. The lead author was Andrew Britton, working closely with Ross Lakhdari. Additional contributions were provided by Jack Harvey and Simon Forster.

For the World Gold Council, the project was led by John Mulligan.

For more information

Please contact economicimpact@gold.org

Contents

Cover image courtesy of AngloGold Ashanti and This is Gold.

Executive summary

Despite the industry's scale, the socio-economic impacts of the gold mining industry are not well understood.

Gold mining companies are a major source of income and economic growth, with an important role in supporting sustainable socio-economic development. During 2013, gold mining companies contributed over US$171.6bn to the global economy through their production activities and expenditure on goods and services. This is more than the combined gross domestic product of Ecuador, Ghana and Tanzania, or close to half of the gross domestic product of countries such as South Africa or Denmark.

Whilst the potential for negative social and environmental impacts from gold mining activities is well known, the nature and distribution of the socio-economic impacts of gold mining at an industry level on host nations and communities is relatively poorly understood. Focusing on the impacts of large-scale commercial gold mining,[i] this report builds on previous studies commissioned by the World Gold Council to provide an understanding of the socio-economic impacts of the gold mining industry at a global, national and host community level. In doing so, this report seeks to facilitate more effective dialogue between companies, governments, citizens and civil society and contribute towards the development of policies and engagement activities that deliver shared value for all stakeholders.

The value created by the gold mining industry is becoming increasingly important for the socio-economic development of nations and communities

Responsibly undertaken, gold mining has the potential to make a significant, positive impact on the economies of the countries in which gold mining takes place and on the lives of the citizens of those countries. Amongst the top 30 gold producing countries, over 60% are low or lower-middle income countries with substantial socio-economic development needs. In eight of the top 30 gold producing countries, the production and procurement activities of gold mining companies generate over 10% of each country's gross domestic product. For two of these countries, this figure rises to over 25% of gross domestic product.

Many of the countries that are significant gold producers are also impoverished countries that are long term recipients of development assistance (aid) from foreign government donors. Given that reliance on foreign aid is an inherently vulnerable position for any impoverished country, it is notable that the economic value directly and indirectly created by the gold mining industry globally has exceeded the global total value of development assistance every year since 2010.

i It is recognised that in several gold producing countries the socio-economic impacts of artisanal and small-scale gold mining are significant, particularly for local communities. However the need for data transparency and consistency has dictated that this report focuses solely on larger-scale, corporate gold mining activities, primarily undertaken by listed companies. These gold mining activities represent the majority of gold extraction globally.

Perhaps more importantly, given cuts to aid budgets in many donor countries, the longer term trend for the economic value created by the gold mining industry is that of significant growth. The direct economic contribution of the gold mining industry to the global economy, as defined by 'gross value added' (GVA), has increased almost seven-fold in the period from 2000 to 2013. The world regions that have benefited most from the growth in the value created by gold mining are Asia and Africa, which account for the largest shares of gold mining GVA. Amongst several of the lower income gold producing countries, such as Ghana and Mali, growth of the gold mining industry means that gold mining companies now create substantially more value in the economy than is received from development assistance programmes. For Ghana and Mali this was not the case as recently as 2008.

The economies of gold producing countries gain far more value from the productive activities of gold mining companies than they do from royalties on land use

Naturally, governments of gold producing countries want to maximise the value that they receive from the mining companies that develop their resources. Much of the literature on this topic suggests that royalty rates on mineral extraction are the principal economic benefit for governments. However, an analysis of gold mining company expenditures reveals that far more value is distributed to host governments and the wider economy through other means.

By far the most significant means by which value flows from gold mining companies to the economies of host countries is through payments to suppliers and contractors and wages for employees. Together these two areas, usually taxed by governments, account for 70% of total expenditures by gold mining companies. In terms of direct taxation, almost 60% of the payments that gold mining companies make to host governments are for income and corporate taxes. Royalty rates, by contrast, account for around 15% on average of direct taxation. Other taxes that can be almost as significant as royalty payments include import or fuel duties – for some mining companies fuel costs may account for up to 40% of total operating expenses, so such duties can be significant.

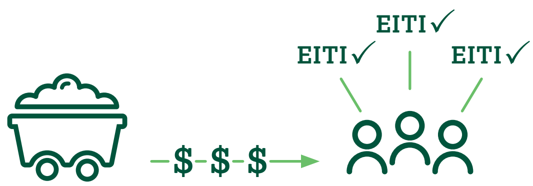
Societal benefit from the revenues created by gold mining depends upon responsible host governments – and there is evidence that revenue management in gold-producing developing countries is improving

Arguably the most well documented challenge facing resource-rich developing countries is the management of revenues from the extractive industries. Governments, especially in poorer countries, are not always open about the revenues they receive from extractive industries which has an impact on the ability of their citizens to hold them to account. A key initiative designed to help improve the accountability of governments is the Extractive Industries Transparency Initiative (EITI), which provides a mechanism for host governments to publicly disclose the revenues raised and received from extractives companies. The gold mining industry is an active supporter of the EITI as are many gold producing countries: 70% of the developing countries within the top 30 gold producing countries have implemented the EITI and over 20 international gold mining companies support the administration of the initiative.

One of the objectives of transparency initiatives such as the EITI is to reduce corruption risk, a significant factor in the misuse of revenues from extractive industries. In gold producing countries, this appears to be working. An analysis of eight gold producing countries that have implemented the EITI shows a positive correlation between growth in the economic contribution of large-scale commercial gold mining and a reduction in corruption. Clearly there are other factors beyond EITI implementation that drive reductions in corruption. Nonetheless, this trend illustrates how responsible gold mining companies, working in partnership with governments, civil society and other stakeholders, can contribute towards improvements in host country governance.

70% of total expenditures by gold mining companies

are on payments to suppliers, contractors and employees.



One of the objectives of transparency initiatives such as the EITI is to reduce corruption risk, a significant factor in the misuse of revenues from extractive industries. In gold producing countries, this appears to be working.

Globally, gold mining companies directly employed over one million people in 2013, with over three million more people employed as a result of the industry's procurement activities.

Responsible gold mining companies can be important job creators for host communities and employment stimuli for local economies

Managing the expectations of host communities on the numbers of people that a mining operation will employ can be a significant challenge for companies, given the capital intensive nature of gold mining. Globally, gold mining companies directly employed over one million people in 2013, with over three million more people employed as a result of the industry's procurement activities.[ii] Nonetheless, the gold mining industry simply does not employ the same number of workers as other sectors, such as manufacturing. What it does do, however, is provide high value employment.

Gold mine employees consistently earn more than the local average and in less developed economies considerably more. This is an important trend because in less developed economies each worker will usually support a higher number of dependants than in more developed economies. In Mali a study found that each gold mine worker supported six dependants. In addition to receiving relatively high salaries, employees also benefit from the investments that companies make in skills development and training of their workforces.

Moreover, gold mining companies are relatively successful at employing local people in their operations: in most regions over 90% of the employees at gold mining operations are local workers. For comparison, in the oil and gas sector on average around 70% of the workforce are local workers.

In common with other segments of the extractive industries, gender diversity remains a challenge in the gold mining industry with companies reporting an average of around 10% of their workforce at mining operations being women. However, there is some evidence that, despite their low numbers, on average women employed at gold mining operations are earning more than men as a result of occupying higher skilled positions.

Gold mining companies can catalyse development projects for local communities

Securing the social licence to operate is a critical issue for the gold mining industry. The value of a company's assets below ground can only be realised if the social and political environment above ground enables production. In addition to being 'the right thing to do', the need to secure the social licence to operate means that gold mining companies, in common with other extractives industries, often invest heavily in improving the socio-economic conditions of host communities. In many cases, gold mining companies make targeted investments that focus on the same social or economic challenges that aid donors and national governments are also seeking to address.

Gold mining companies are relatively successful at employing local people in their operations:

in most regions over 90% of the employees at gold mining operations are local workers.

ii Employment figures are calculated utilising published industry data. It is recognised that the numbers of people employed in artisanal and small-scale gold mining can also be significant in some countries. However, as previously noted, the impacts of artisanal and small-scale mining are outside of the scope of this report.

For example, many gold mining companies focus significant resources in improving healthcare in local communities. Beyond the benefits such investments bring in terms of the social licence, investments in community healthcare can often help minimise absenteeism and reductions in productivity due to workforce illness. Health issues that are often prioritised by gold mining companies include HIV/AIDS, tuberculosis and malaria. In a significant number of gold producing countries, the growth of the gold mining industry over a ten-year period coincides with a reduction in the prevalence of these diseases. Whilst these improvements in disease control cannot be solely attributed to the gold mining industry, the industry investments in community healthcare will have made an important contribution.

Moreover, a key benefit that gold mining companies can bring to investments in community healthcare is the ability to finance healthcare interventions that may be beyond the resources of most aid programmes due to cost or technical investment requirements. The existence of a business case for addressing a community health issue can provide an entirely different perspective on how a programme is funded compared to the approaches that aid agencies must take.

For the development potential of the gold mining industry to be realised, stakeholders will need to work together in partnership

Whilst many communities are benefiting from responsible gold mining, there are others where there are disputes and even conflict between mining companies and other stakeholders. Undoubtedly, gold mining companies bear a burden of responsibility to ensure that their presence in a community and country results in socio-economic benefits.

During this year, 2015, the global community of the United Nations is developing a new set of Sustainable Development Goals (SDGs) that include an unprecedented focus on the role of business. It is, therefore, timely to focus on the role that the gold mining industry can play as a development partner.

This report shows that responsible gold mining companies can create many benefits for host communities and governments in gold producing countries. However, there remain very significant challenges that the gold mining industry cannot address alone. Partnerships are key. Considering gold mining companies as development partners for gold producing countries would represent a major shift from the conventional, more transactional type of relationship that currently exists between many industry, government and community stakeholders, and a major milestone in the journey towards sustainable socio-economic development.

Finally, this research found some deficiencies in the data available on the socio-economic impacts of gold mining. Addressing these deficiencies would be of significant benefit to all stakeholders working on understanding, improving or making the most of the socio-economic impacts of the gold mining industry.

Introduction

In recent years there has been increasing recognition of the role that the extractive industries can play in supporting sustainable socio-economic development. Multilateral institutions such as the World Bank, donor agencies such as the United States Agency for International Development (USAID) and the UK's Department for International Development, civil society organisations such as CARE International and Building Markets, and policy think-tanks such as the Africa Progress Panel all recognise the significant contributions that the sector can make to improving peoples' lives, often in some of the world's poorest regions. As one of the key segments of the broader extractives sector, the gold mining industry has the potential to make a significant, positive impact on the economies of the countries in which gold mining takes place and on the lives of the citizens of those countries.

There are challenges, however. The potential for negative social and environmental impacts from the extractive industries is well known. At the same time, the nature and distribution of the socio-economic contributions that mining can make to host nations and communities is relatively poorly understood. This creates a challenge that hinders effective dialogue between companies, governments, citizens and civil society and impedes the development of policies and engagement activities that create shared value for all stakeholders.

The World Gold Council has been working to address this gap and has commissioned a number of reports analysing the socio-economic impacts of gold mining. Two reports have been produced analysing the impacts of gold mining on the economy of one important gold-producing country, Peru. The *Responsible mining and value distribution* series of reports provides valuable data on the socio-economic contributions of World Gold Council member companies. The 2013 report *The direct economic impact of gold* by PwC provided baseline figures indicating the economic impacts of the gold supply chain on the world's major gold producing and consuming countries.

The nature and distribution of the socio-economic contributions that mining can make to host nations and communities is poorly understood.

This report builds on these previous studies by examining the socio-economic impacts of the commercial gold mining industry at both a global, national and host community level. As such, this report aims to help improve the understanding of all stakeholders on the overall socio-economic impact of the gold mining industry on the global economy, on the contributions it makes to the economies of gold producing countries – particularly those that have developing economies – and on the contributions it makes to the lives of people in host communities. In doing so, this report seeks to facilitate better understanding and more effective dialogue between all stakeholders.

Report structure

The impacts of the gold mining industry are explored in this report through four themes:

- **Supporting global economic growth:** Analyses the global scale of the gold mining industry and its patterns of growth.
- **Supporting host nations:** Analyses the economic contributions of the industry in gold producing countries, including how value is distributed from the industry and its role in supporting effective governance of mineral revenues.
- **Investing in people:** Analyses the nature and extent of job creation by the gold mining industry, discusses some key challenges and how the industry is responding.
- **Supporting communities:** Discusses why companies need to invest in ensuring that communities share in the value created by the gold mining industry and analyses how the industry is doing this.

The scope of this report is limited to the impacts of larger scale gold mining. Artisanal and small-scale (ASM) gold miners can play a significant role in many local economies and communities, but reliable data on the socio-economic impacts of artisanal gold production is not currently available.

Scope and approach

The scope of this report is limited to the impacts of larger scale, corporate gold mining activities, primarily undertaken by listed companies. The reason for this is twofold. Firstly, such activities represent the majority of physical gold extraction. Secondly, the analysis for this study required access to reliable and comparable data sources, much of which has been derived from the reports that corporate gold mining companies are obliged to provide to investors, regulators and other stakeholders.

It is recognised that, in several developing countries, artisanal and small-scale (ASM) gold miners can play a significant role in local economies and communities. However, reliable and comparable data on the socio-economic impacts of artisanal gold production across different gold producing countries is not currently available. The nature of the socio-economic impacts of ASM is also quite different to that of larger-scale commercial operations which further hinders attempts at comparison.

Throughout this report, all references to the gold mining industry or to gold mining companies refer solely to larger scale, corporate and publicly listed companies.

No primary research has been undertaken for this report, which relies on secondary data sources. Key data sources included:

- Industry data providers, such as GFMS, Thomson Reuters and SNL Metals and Mining.
- Studies by mining industry bodies and associations, such as the World Gold Council, This is Gold, the International Council on Mining and Metals and national mining chambers.
- Multilateral organisations including the World Bank, the Organisation for Economic Co-operation and Development (OECD) and various bodies of the United Nations.
- Initiatives such as the Extractive Industries Transparency Initiative (EITI) and the Corruption Perceptions Index.
- Research studies from academia and advocacy organisations.
- Reports from companies, such as their corporate sustainability reports and annual reports.

The availability, quality and consistency of data vary significantly between sources, topics and geographies, with social data proving a particular challenge. Therefore, whilst best efforts have been used to obtain and utilise the most accurate and up-to-date data, readers should be mindful that the purpose of this report is to identify and analyse relevant industry-wide trends and themes rather than precisely quantify specific impacts.

Further details of the research methodology are provided in the Appendix.

Section 1: Supporting global economic growth

"Growth is not an end in itself. But it makes it possible to achieve other important objectives of individuals and societies. It can spare people en masse from poverty and drudgery. Nothing else ever has."

The Commission on Growth and Development

- Globally, the gold mining industry directly contributed around US$ 83.1bn to the global economy in 2013 – equivalent to the combined gross domestic product of Ghana and Tanzania.
- Once the indirect economic impact of the industry's expenditure on goods and services in its supply chain is taken into account, this figure rises to US$ 171.6bn – equivalent to almost half of the gross domestic product of South Africa.
- Gold mining is a growth industry – its direct economic contribution to the economy has increased almost seven-fold from 2000 to 2013.
- The growth in the economic impact of the gold mining industry has been most significant in Asia and Africa.
- The pattern of growth in the gold mining industry is mirrored by improvements in the income status of gold producing countries.

As a mineral, gold has always epitomised prosperity, and gold mining is amongst the world's oldest forms of economic activity. Societal awareness and interest in gold as a metal is high yet, despite this, the role of the gold mining industry in supporting growth within the global economy is seldom discussed. Commentators tend to focus on the impact of mining industry as a whole, grouping gold production with other minerals such as iron ore or copper. However, whilst the absolute volumes of gold produced from mining operations is dwarfed by those of other minerals, the value of gold means that the gold mining industry can make substantial contributions to the growth and prosperity of national and regional economies.

The scale of the industry's economic contribution can be assessed by calculating the 'gross value added' (GVA) by gold mining. GVA is a calculation that estimates the contribution of industrial activity to a nation's gross domestic product (GDP). It is important to note two points in relation to GVA:

- GVA is not the same as production; production statistics describe the physical volume of gold produced whereas GVA statistics (as used throughout this report) describe the economic value of gold output.
- GVA is not the same as profit; a company can generate substantial GVA within an economy and still be unprofitable.

Direct GVA estimates the economic value of the gold mining industry's production to an economy. Indirect GVA estimates the value of economic production in associated sectors as a result of gold mining companies' expenditures on raw materials, goods and services (the supply chain). Details of the study methodology, including GVA calculations, are provided in the Appendix.

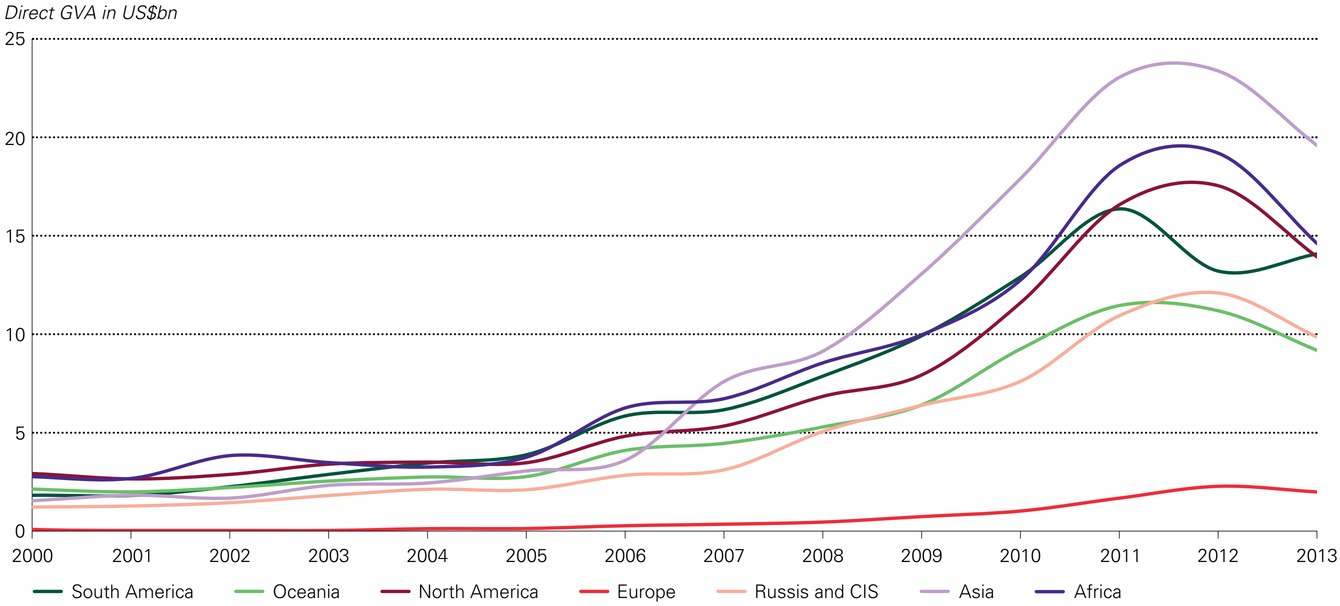
Globally, the gold mining industry directly contributed around US$83.1bn to the global economy in 2013; once the indirect economic impact is taken into account, this figure rises to

Chart 1 illustrates the global direct GVA contribution of the gold mining industry between 2000 and 2013, categorised by region. One of the most striking features of this graph is the rate of growth that the gold mining industry has experienced over this period, particularly following the post-2005 commodity boom. Between 2005 and 2012 the industry grew by over 400%, fuelled by both demand for gold and the rising gold price. From 2012 onwards most regions experienced a decline in the economic contribution of gold mining as a result of a decline of over 15% in the average annual gold price. In 2013 the industry contributed around 16% less to the global economy than it did in 2012, though still almost 14% more than in 2010. With an almost seven-fold increase in gold mining direct GVA from 2000 to 2013 the longer-term trend remains that of industry growth, despite the gold price movements of recent years.

Prior to 2005, differences between the GVA generated by gold mining in world regions was minimal. Following the onset of the commodities boom in 2005, the economies of Asia, followed by Africa and South America, were the largest beneficiaries of GVA from gold mining. North American GVA closely followed these regions.

South America experienced a notable drop in GVA in 2011; this illustrates the impact of Venezuela nationalising its gold industry in 2011. The nationalisation of the industry contributed to around a five-fold increase in industry operating costs between 2011 and 2012 and a corresponding impact on the value of that country's gold output and its contribution to the GVA for the region as a whole.

Chart 1: Direct GVA (US$bn) of the global gold mining industry from 2000 to 2013



Source: Maxwell Stamp analysis based on GFMS, Thomson Reuters *Gold survey*; GFMS, Thomson Reuters *Gold mine economic service*; The London Gold Market Fixing Limited (TLGMFL)

With an almost seven-fold increase in gold mining direct GVA from 2000 to 2013 the longer-term trend remains that of industry growth, despite the gold price movements of recent years.

Following the onset of the commodities boom in 2005, the economies of Asia and Africa, followed by South America, were the largest beneficiaries of GVA from gold mining.

The economic impact of the industry more than doubles when both the direct and indirect GVA contributions of the gold mining industry are taken into account.

The global economic impact of the industry more than doubles when both the direct and indirect GVA contributions of the gold mining industry are taken into account. This is illustrated by **Table 1**, which also illustrates how the price of gold affects the contribution that the gold mining industry makes to the economies of host countries; changes to the price of gold have clearly been central to the growth in the gold mining industry's economic contribution, though the increase in GVA exceeds the rise in the price of gold.

The economic contribution of the industry to the global economy has been growing fast over the last decade, and is now significant on a global scale. At around US$171.6bn, the total economic contribution resulting from the gold mining industry and its supply chain to the global economy in 2013 was equivalent to over half the national output of South Africa, and just under 10% of the national output of Canada.

In addition to its growth, an important macro trend that can be observed is the shift in the geographical location of the gold mining industry's value creation activities from advanced to less developed economies. This is also true of the mining industry more broadly. Several centuries ago the locus of the world's mining industry was Europe. With the growth of the US economy in the 19th century the focus of mining activities moved across the Atlantic. In the latter part of the 20th century most mining took place south of the equator where Africa and South America host large amounts of untapped mineral reserves.[1]

Gold mining has followed a similar trend. Whilst North America remains a significant region for gold mining activity, the majority of gold production is from regions with less advanced economies. This has important implications for economic development, as in smaller and less advanced economies the contributions of the gold mining industry will have a greater proportionate impact on national economies and therefore, potentially, also on the economic development of host nations.

Gold mining can be an important catalyst for development, but as other industry sectors develop the relative importance of gold mining declines as the economy diversifies. In China's case it is clear from the industry's significance in the domestic economy (illustrated by **Table 3**, page 13) that gold mining is not solely responsible for the country's emergence as a global economic power. Nonetheless, the role that China's gold mining industry has played in supporting development and driving high levels of economic growth should not be underestimated. The industry's contribution to national GDP has grown by 269% since 2007 and was estimated to be US$11.98bn in 2013, more than double the size of Suriname's entire economy.

Table 1: Total global direct and indirect GVA of the global gold mining industry and annual average gold price

Year	Direct GVA (US$bn)	Direct and indirect GVA (US$bn)	Global annual average price (US$ per ounce)
2000	12.2	25.2	279.1
2005	19.0	39.0	444.5
2010	73.1	150.3	1,224.5
2012	98.7	205.6	1,669.0
2013	83.1	171.6	1,411.2

Source: Maxwell Stamp analysis based on GFMS, Thomson Reuters *Gold survey*; GFMS, Thomson Reuters *Gold mine economic service*; The London Gold Market Fixing Limited (TLGMFL)

An important macro trend that can be observed is the shift in the geographical location of the gold mining industry's value creation activities from advanced to less developed economies.

The role that gold mining plays in supporting economic development is illustrated by **Chart 2**. Focusing on a group of 47 countries that account for over 90% of global gold production, the chart shows how direct GVA from gold mining was distributed across economies of different income levels in 2003 and 2013. It can be seen that in 2003, 33 of these countries were classed as low or lower-middle income economies by the World Bank. 14 countries were classed as upper-middle or high income economies. By 2013, amongst that same group of countries, 26 were now classed as upper-middle or high income economies, and the number of low income economies had dropped from 16 in 2003 to five in 2013.

Whilst it would be misleading to claim that this improvement in national economies is a direct result of the growth of the gold mining industry, there is little doubt that the value created by the industry will have made an important contribution. For example, in 2007 China was classed as a lower-middle income economy and was the fourth-largest gold producing country, behind South Africa, the United States and Australia. In 2008, China became the world's largest gold producer, a position it maintains to this day. China reached upper-middle income status in 2010. Peru, the world's fifth-largest gold producer in 2013 was a lower-middle income country until 2008. Prior to 1995, Peru was not amongst the world's top 10 gold producing countries.[2]

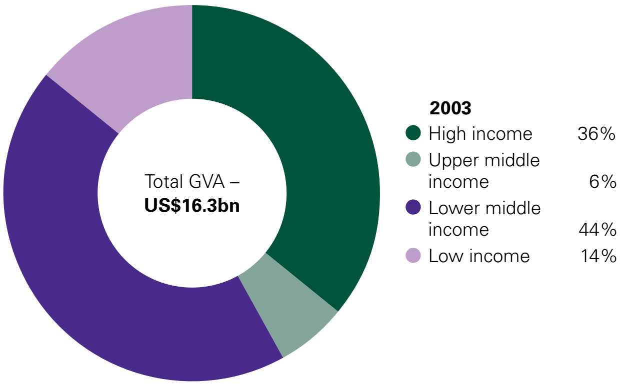
Table 2 illustrates the distribution of direct and indirect GVA from gold mining across different world regions. It can be seen that in 2013 the economies in Asia were the greatest recipients of the value generated by gold mining, with just over US$39bn being generated by the industry and its suppliers. Africa was the second-largest regional recipient, with almost US$35bn flowing into African economies from gold mining activities. The table also illustrates how the 'multiplier effect' can impact the total amount of value created in a region; the direct GVA from gold mining in Africa was only fractionally higher than in South America, however the total economic contribution once indirect contributions are taken into account is substantially higher in Africa than in South America. This is likely to be because of the benefits indirectly derived from gold mining in a more developed and diversified economy will be proportionally smaller than in a less developed economy. For example, a new mine opening in Tanzania is likely to have a greater impact in terms of stimulating the creation of business services that didn't previously exist, than the same sized mine opening in USA where most of the businesses that would service the mine probably already exist. However caution is needed in drawing too firm a conclusion due to the limited numbers of studies that have evaluated regional economic multipliers.[iii]

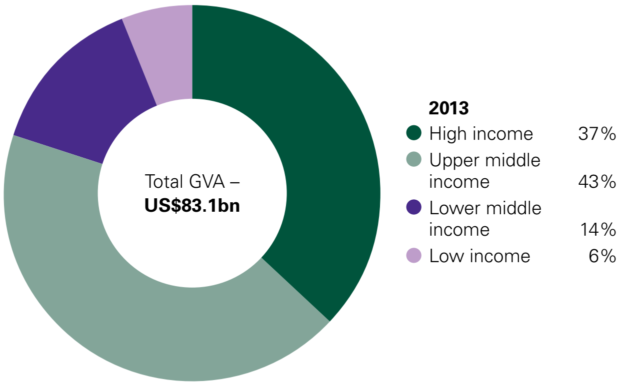
Table 2: Regional distribution of direct and indirect GVA from gold mining in 2013

Total direct and indirect GVA (US$bn)	Direct	Indirect	Total
Asia	19.6	19.6	39.1
Africa	14.6	20.3	34.9
North America	13.9	15.3	29.2
South America	14.1	11.3	25.3
Russia and CIS	9.8	9.9	19.7
Oceania	9.2	10.1	19.2
Europe	2.0	2.2	4.1
Global	**83.1**	**88.6**	**171.6**

Source: Maxwell Stamp analysis based on GFMS, Thomson Reuters *Gold survey*; GFMS, Thomson Reuters *Gold mine economic service*; The London Gold Market Fixing Limited (TLGMFL)

Chart 2: Changes in income status between 2003 and 2013 amongst the same group of gold producing countries





Source: Maxwell Stamp analysis based on GFMS, Thomson Reuters *Gold survey*; GFMS, Thomson Reuters *Gold mine economic service*; The London Gold Market Fixing Limited (TLGMFL). Income classifications are from the World Bank. Total direct GVA figures illustrated are for global production

iii Details of the multipliers used in this analysis are provided in the Appendix.

Section 2: Supporting host nations

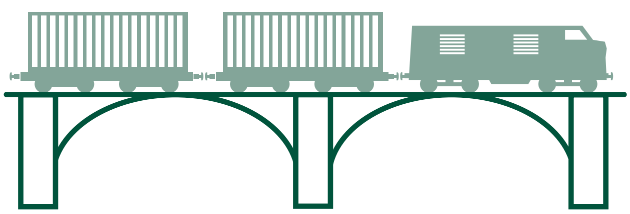
“Defying the predictions of those who believe that Africa is gripped by a ‘resource curse’, many resource-rich countries have sustained high growth and improved their citizens’ daily lives.”

Kofi Annan, former UN Secretary-General (1997-2006)

- The largest gold producing countries are those with more advanced economies, but industry growth is increasingly focused on developing countries where the gold mining industry is proportionately more influential in national economies.
- Amongst the top 30 gold producing countries, over 60% are low or lower-middle income countries with substantial socio-economic development needs.
- Many of the gold producing countries with the least developed economies are significant recipients of foreign aid – in some of these countries the value of the economic contribution of the gold mining industry has now overtaken the value of foreign aid received; in all countries industry growth far exceeds growth in the value of foreign aid.
- Payments to suppliers and employees account for 70% of the value that gold mining companies distribute within an economy – and host government treasuries collect far more revenue from income and employment taxation than they do from royalties.
- There is a positive correlation between the growth of commercial gold mining in countries that have implemented the Extractive Industries Transparency Initiative and reductions in corruption.

2.1 Industry contributions to national economies

Soaring demand for resources is a potential windfall for all resource-driven countries, but particularly for low- and lower-middle income economies. Mines have a long operating life; typically around 30 to 40 years. Revenues from mining can enable investments in food security, healthcare, education, infrastructure and economic diversification, thus ensuring that the development of finite mineral resources provides enduring benefits to host nations. Utilising mining revenues for such investments is primarily the responsibility of host governments. However companies also make significant investments, for example in infrastructure, which can have wider benefits for local communities beyond the life of the mine itself. In many cases significant investments in areas such as infrastructure are made by companies as part of the mine development process, prior to operations commencing.

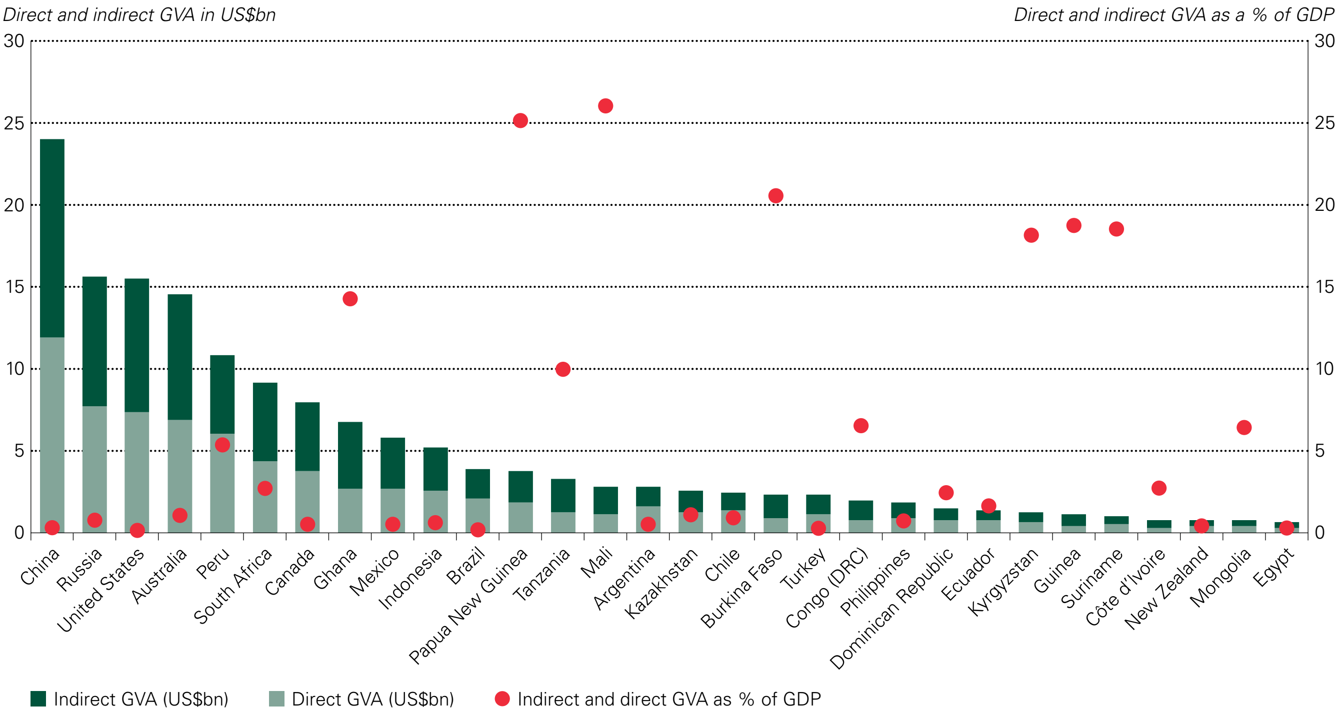


Companies also make significant investments, for example in infrastructure, which can have wider benefits for local communities beyond the life of the mine itself.

Whilst gold is seldom the only natural resource in a resource-driven country, it can nonetheless be significant. **Chart 3** shows the economic contribution that gold mining made to the economies of the top 30 gold producing countries in 2013,[iv] providing both the value of the direct GVA from gold mining in each country, together with the proportion of GVA in each country's total GDP. Of these 30 countries, 23 are classed as having resource-driven economies.[v]

It can be seen that China is the world's largest gold producing country, followed by Russia, the USA and Australia. In all of these countries, despite the value of the gold produced, the gold mining industry contributes considerably less than 1% to each country's national economy. In the economy of the next largest gold producer, Peru, a country synonymous with gold mining since the time of the Incas, gold mining is more significant in the national economy but nevertheless remains the source of only 3% of the country's gross domestic product (GDP). This figures rises to over 5% once indirect impacts are taken into account. Amongst the top four gold producing nations in 2013, who between them accounted for over 40% of global gold production, gold mining directly contributes on average 0.25% of the national GDP; a figure that remains below 1% once indirect impacts are included.

Chart 3: Direct and indirect GVA from gold mining for the top 30 gold-producing countries in 2013, compared against the contribution of direct and indirect GVA to each country's national GDP



Source: Maxwell Stamp analysis based on GFMS, Thomson Reuters *Gold survey*; GFMS, Thomson Reuters *Gold mine economic service*; The London Gold Market Fixing Limited (TLGMFL) and World Bank[vi]

iv The top 30 gold producing countries are categorised and ranked according to total direct and indirect GVA.

v Maxwell Stamp analysis based on a classification developed by McKinsey (2013). Note that the definition of resource-driven encompasses all minerals as well as oil and gas. None of the top 30 gold producing countries are defined as having resource-driven economies solely on the basis of gold mining.

vi The World Bank's GDP data is periodically updated. World Bank data used in this study was sourced in October 2014.

Amongst some of the smaller producers, however, the gold mining industry is more significant in the national economy, particularly once the indirect impact of gold mining companies' procurement is taken into account. In eight of the top 30 gold producing countries, the direct and indirect economic contributions of commercial gold mining companies generate over 10% of each country's gross domestic product. For two of these countries, this figure rises to over 25% of GDP.

In order to gain a clearer perspective of the industry's significance to national economies, **Table 3** compares the percentage of GVA in GDP produced directly from gold mining to other sectors in 10 of the top 30 gold-producing countries. In the table all value generated from mining activities, including gold production, is aggregated with other sub-sectors, namely construction, utilities and manufacturing, to constitute the industrial sector. Gold mining is also shown on its own as a sub-component so that its contribution relative to other sectors of the countries' economies can be seen.

As **Table 3** shows, despite being the largest gold producer China's gold mining activities form only a small proportion of the country's economy, contributing 0.2% to gross national production. The value created by gold mining accounts for 0.4% of the country's industrial production and is dwarfed by the value created in the agriculture and services sectors. However, amongst other top gold producers, such as Australia, South Africa and Peru, it can be seen that even though the value from gold mining is relatively modest when compared to the wider economy it is comparable to other sectors. For instance, South Africa's gold industry contributed 1.5% of GDP in 2012 but is around two-thirds the size of the nation's agriculture sector. Notably, the GVA produced by gold mining in Burkina Faso and Suriname constitute around 44% of the industrial sector in each country. In Mali it is around 76%. In Suriname's case the gold mining industry is one third the size of the domestic service sector and almost double its agricultural sector in terms of the value generated in 2012.

With the exception of Peru, every country where gold mining accounts for more than 1.5% of national GDP is a low or lower-middle income economy. All of these low or lower-middle income countries are also resource-driven economies. Globally, resource-driven economies are home to a disproportionately high number of the poor in the world; a recent study estimated that 69% of people in extreme poverty live in resource-driven economies.[3] When considering the role of the gold mining industry in supporting development, it is useful therefore to draw comparisons with value of Official Development Assistance (ODA) programmes in these countries.

Table 3: Comparison of the direct GVA from gold mining with other sectors of the economy within key gold producing countries[vii]

	Sectoral Value Added – 2012 (% of national GDP)			
Country	**Agriculture**	**Services**[1]	**Industry**[2]	**Gold mining**[3]
Mali	38%	32%	21%	16.0%
Suriname	8%	47%	35%	15.3%
Burkina Faso	33%	36%	25%	10.9%
Ghana	22%	47%	28%	8.3%
Kyrgyzstan	17%	48%	22%	6.0%
Peru	7%	51%	34%	4.0%
South Africa	2%	62%	26%	1.5%
Australia	2%	65%	26%	0.6%
Mexico	3%	58%	35%	0.3%
China	10%	45%	45%	0.2%

1 Including government, wholesale and retail trade, transport, financial and professional services.
2 Including mining, manufacturing, utilities and construction.
3 Gold mining is shown on its own as a sub-component of industry.

Source: Maxwell Stamp analysis based on GFMS, Thomson Reuters *Gold survey*; GFMS, Thomson Reuters *Gold mine economic service*; The London Gold Market Fixing Limited (TLGMFL) and World Bank[viii]

Amongst some of the smaller producing nations, the gold mining industry is very significant for the national economy, particularly once the indirect impact of gold mining companies' procurement is taken into account.

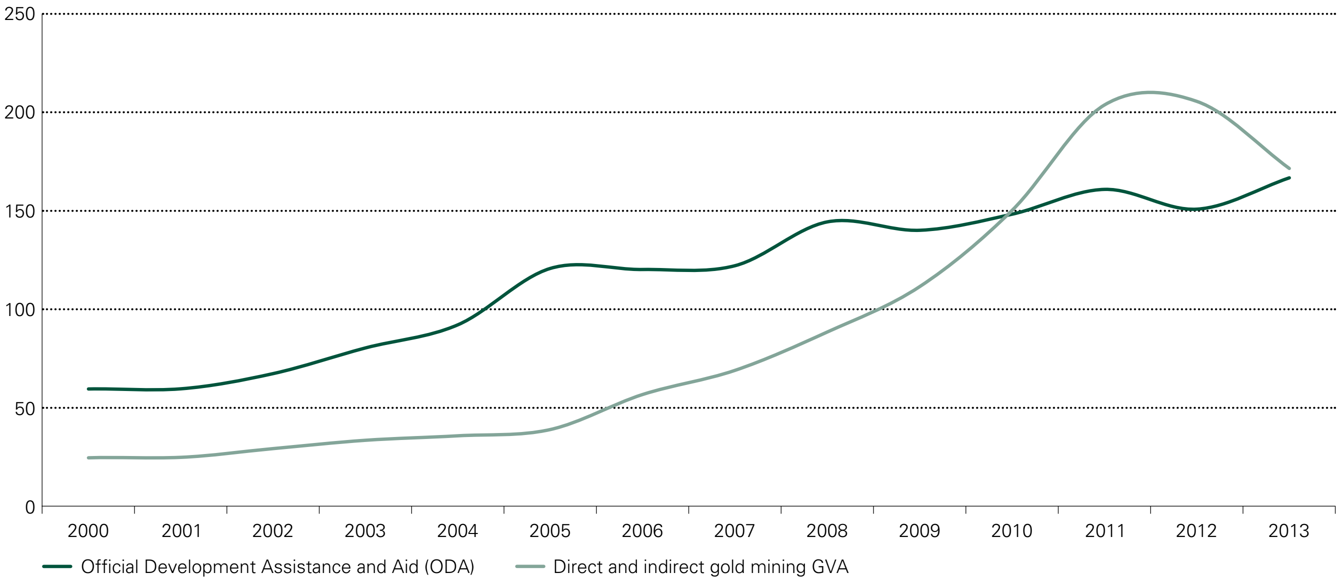
vii Note: Gold mining GVA is contained within the 'industry' GDP. For example, in Mali 21% of GDP is from industry. Gold mining GVA accounts for around 16% of GDP, so industry sectors other than gold mining account for only 5% of Mali's GDP. Gold mining therefore accounts for the majority of industry activity in Mali.

viii World Bank's GDP data is periodically updated. World Bank data used in this study was sourced in October 2014.

Chart 4 and **Table 4** illustrate the relative significance the gold mining industry plays in supporting the development of resource-rich countries. **Chart 4** compares the value of direct and indirect GVA generated by the global gold mining industry against the total value of ODA provided by developed countries to less developed countries from 2000 to 2013.

Whilst the amount of ODA has increased significantly since the turn of the century the rate of growth is relatively modest when compared to the rate of growth in the value generated by the gold mining industry. In 2000 the value directly and indirect generated by the gold mining industry was equivalent to around 40% of total ODA. However, from 2010 onwards the value generated by the gold mining industry has exceeded the total value of ODA every year.

Chart 4: Comparison of growth in global indirect and direct GVA from gold mining and Official Development Assistance (ODA) between 2000 and 2013



Source: Maxwell Stamp analysis based on GFMS, Thomson Reuters *Gold survey*; GFMS, Thomson Reuters *Gold mine economic service*; The London Gold Market Fixing Limited (TLGMFL) and OECD

Table 4: Comparison of Official Development Assistance and direct GVA in selected resource-rich developing countries between 2000 and 2012

	Official Development Assistance (US$mn)			Direct GVA (US$mn)		
Country	**2000**	**2012**	**Growth Rate (%)**	**2000**	**2012**	**Growth Rate (%)**
Ghana	598.2	1,807.9	202%	273.0	3,476.4	1174%
Mali	288.0	1,001.3	248%	192.7	1,689.0	777%
Côte d'Ivoire*	160.5	2,635.6	1542%	17.0	464.0	2635%
Papua New Guinea	275.2	664.8	142%	371.5	2,252.2	506%
Tanzania	1,063.9	2,831.9	166%	87.6	1,690.9	1830%
Suriname*	23.9	39.6	66%	139.9	766.9	448%
Peru	396.8	393.8	-1%	942.2	7,800.7	728%
South Africa	486.4	106.7	-78%	1,837.5	5,562.1	203%
Indonesia	1,653.0	67.8	-96%	756.9	2,852.4	277%
Kyrgyzstan	214.7	472.9	120%	100.5	382.1	280%

*Figures relate to the period 2004 to 2012.

Source: Maxwell Stamp analysis based on GFMS, Thomson Reuters *Gold survey*; GFMS, Thomson Reuters *Gold mine economic service*; The London Gold Market Fixing Limited (TLGMFL) and World Bank

Recently some governments have started to see extractives companies as potential partners in development.

Many impoverished resource-rich countries have long had a significant reliance upon foreign aid, which is an inherently vulnerable position. The only solution to dependency on foreign aid is economic growth. **Table 4**, on page 14 provides a closer examination of the amount of ODA received by selected countries and the value added by their gold mining industries. Apart from a handful of countries which experienced negative growth, the amount of ODA has more than doubled for most countries, with the exception of Suriname, from 2000 to 2012. The fact that ODA has grown in seven out of the ten countries is a good indicator of enduring human development challenges in these countries. The rate of ODA growth is dwarfed, however, by the rate of growth in the economic value of gold mining in each country. For example in Ghana, ODA grew by over 200% over 13 years, whereas the value of gold mining GVA grew by over 1,170%. Notably, the value of gold mining GVA in 2012 was significantly higher than the value of ODA for the majority of countries shown in **Table 4**. In Papua New Guinea, the economic contribution from gold mining in 2012 was around US$ 2.3bn, whereas the value of ODA was close to US$ 0.7bn. Clearly, the gold mining industry has the potential to play a very significant role in supporting socio-economic development in impoverished countries.

2.2 Supporting better governance

If governments in low and low-middle income countries use their endowments from resource industries such as gold mining wisely, they have the potential to transform their economies and the lives of their citizens. Similarly, gold mining companies operating in these countries have the potential to catalyse transformative improvements in the lives of host communities.

In practice, however, the record of the extractives industries (both mining and oil and gas) is mixed. A study on the impact of the extractives industries in Africa found that whilst Tanzania reduced extreme poverty from 84% to 67% between 2000 and 2007 and Ghana reduced extreme poverty by one third between the end of the 1990s and 2005, in Mali growth had no discernible effect.[4] The International Council of Mining and Metals (ICMM)[ix] has noted that at a local community level, mining projects have not always led to marked improvements in human and social development in the regions and countries in which they have operated, and are often associated with negative social, economic and environmental impacts. In the absence of appropriate governance or adequate attention to the management of project impacts, the negative effects of mining may undermine any positive development outcomes, or such positive opportunities may remain unrealised.[5]

The primary responsibility for ensuring that mining developments create positive socio-economic benefits for host nations rests with national governments. This, however, does not dilute the responsibilities of companies to work as responsible and proactive partners of national governments.

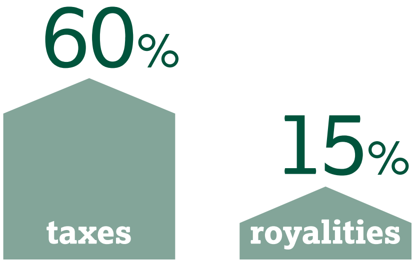
Governments and the extractive industries have often found themselves in antagonistic relationships as both have tried to defend their interests. Recently, however, some governments have started to see extractives companies as potential partners in development. A good example of this is the African Mining Vision which highlights the central role that mining can and should play in unleashing the development potential of host nations.[6]

Sources of value distribution from gold mining

One of the most important roles for mining companies as partners in development is that of value creator: generating the financial resources that governments can invest in developing their countries. Naturally, governments want to maximise the value they receive from mining companies investing in their countries. Much of the literature on the economic contributions of mining to host countries focuses on the royalty rates that governments levy on mineral extraction as the primary economic benefit. However, an analysis of gold mining company expenditures reveals that far more value is distributed through other means.

One of the most important roles for mining companies as partners in development is that of value creator: generating the financial resources that governments can invest in developing their countries.

ix The International Council on Mining and Metals (ICMM) is membership organisation of 21 mining and metals companies as well as 35 national and regional mining associations and global commodity associations that works to address sustainable development issues for the sector: www.icmm.com



Income and other corporate taxes account for almost 60% of direct payments to governments, compared to 15% from royalties and land use payments.

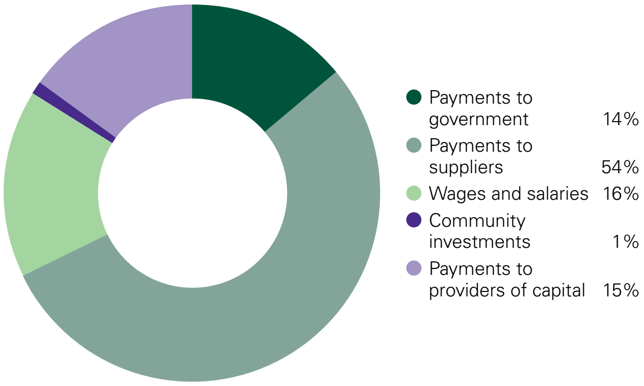
Chart 5 provides a breakdown of the 2013 in-country expenditures of the top 22 global mining companies. The operations for which this data has been reported together account for around 30% of global gold production in 2013. It can be seen that by far the most significant area of value distribution is in payments that mining companies make to their suppliers, followed by payments to their employees. Together, these two areas account for almost 70% of the total economic value distributed by gold mining companies. By contrast direct payments to governments, which includes both taxation and royalties, account for 14% of total expenditures. This is similar to the payments that are made to providers of capital.

Focusing specifically on payments to governments, **Chart 6** further illustrates the diversity of mechanisms by which host governments receive direct payments from gold mining companies. It can be seen that income and other corporate taxes account for over almost 60% of companies' payments to governments, compared to 15% from royalties and land use payments.

As **Chart 6** illustrates, there is also a significant category of 'other' payments made to government that are not royalties or direct taxation. Included within this category are taxes such as import or fuel duties, as well as certain categories of dividend payments to governments. For example, fuel costs are one of the largest single contributors to the operating costs of a mine, accounting for up to 40% of total operating expenses in some instances,[7] so taxes on fuel can form a significant element of the payments that mining companies make to governments in certain jurisdictions. In addition to the direct payments that companies make to governments, it is worth noting that in most instances governments will be raising revenues indirectly through companies' payments to suppliers and employees, for example through Value Added Tax and employee income tax.

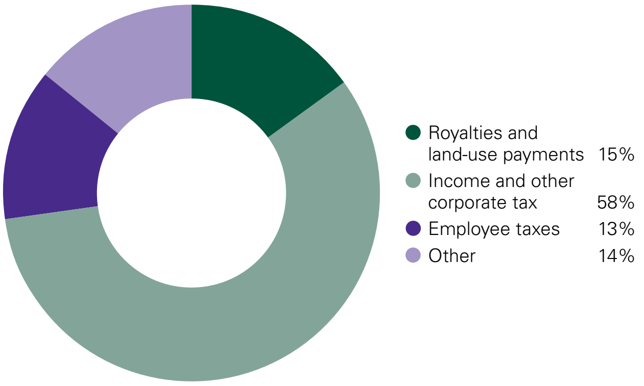
For regulators who are working to maximise the benefits host governments gain from mining activities, this highlights the importance of considering all of the different mechanisms by which value can be captured when, for example, modifications to taxation regimes are being considered.

Chart 5: In-country recipients of value distributed by the top 22 gold mining companies in 2013



Source: Maxwell Stamp analysis based on World Gold Council *Responsible gold mining and value distribution survey,* This is Gold survey, and company financial accounts

Chart 6: Average composition of the direct payments made to host governments by the top 21[x] gold mining companies in 2013



Source: Maxwell Stamp analysis based on World Gold Council *Responsible gold mining and value distribution survey,* This is Gold survey, and company financial accounts. Data was available for the majority, but not 100%,of the selected companies' operations

x Due to variances in company reporting it was not possible to obtain the data presented in Chart 6 for one of the top 22 gold mining companies included within the analysis presented in Chart 5.

The challenge of revenue management

Arguably the most well documented challenge facing resource-rich developing countries is the management of revenues from the extractive industries. The often intertwined issues of how royalty rates and taxations rules are established and implemented, and the prevalence in many poor countries of endemic corruption, mean that governments have frequently been opaque about the revenues that are collected from the extractive industries. This impacts the ability of the citizens of resource-rich countries to understand what benefits their countries gain from the extractive industries and to hold their governments to account on how those revenues are spent. For example, as Paul Collier, Co-Director of the Centre for the Study of African Economies at Oxford University has pointed out, the Democratic Republic of Congo (DRC) reported that it received only US$86,000 in mineral royalties in 2006.[8]

A key initiative designed to tackle this challenge is the Extractive Industries Transparency Initiative (EITI). Further details are provided in **Box 1**. Whilst this initiative is not exclusive to the gold mining industry, many gold mining companies are active supporters of this initiative which provides a mechanism for citizens of a resource-rich country, and any other interested stakeholders, to understand what revenues extractive industry companies have paid to national governments and what national governments have received.

The EITI was established to provide a mechanism that would provide a 'level playing field' for the disclosure of the revenues that are paid to governments by extractive industries, and is part of a movement towards revenue transparency in the extractive industries involving governments, companies and campaigners. The origins of the push for revenue transparency are in the late 1990s, when campaigning non-governmental organisations (NGOs) such as Global Witness began raising awareness on how the lack of transparency over financial payments made by extractive companies to governments in host countries aided and abetted the mismanagement and embezzlement of these revenues by in-country elite groups.

There is strong evidence that this initiative is having a positive impact on revenue reporting in resource-rich countries, with the DRC providing a good case in point. The DRC began implementing the EITI in 2008. The DRC's most recent EITI report, which is for 2011, reports that the DRC government received US$1.4bn in payments from extractives companies.

Box 1: Extractive Industries Transparency Initiative

The Extractives Industries Transparency Initiative (EITI) is a multi-stakeholder initiative involving governments, companies and civil society organisations that works to enhance openness and accountability with regards to the revenues that governments receive from natural resources. Implementation of the EITI requires that both payments made by companies to a country's government and the revenues received by that government are regularly reconciled by an independent, credible administrator and published in an accessible and comprehensive report.

Despite some criticisms, since its launch in 2003 the EITI has evolved into a global rules-based standard with 44 implementing countries, 26 of whom have reached 'compliant' status. A number of EITI countries have enshrined the reporting requirements into law.

Whilst the EITI is implemented by national governments, it is publicly endorsed and supported financially and technically by over 90 extractives companies, 21 of whom are gold mining companies, and over 80 global investment institutions.

Gold-producing countries that have implemented the EITI are Burkina Faso, Côte d'Ivoire, Democratic Republic of Congo, Ghana, Guinea, Kyrgyzstan, Mali, Mongolia, Peru and Tanzania.

Source: Extractives Industry Transparency Initiative: https://eiti.org/

There is strong evidence that the Extractives Industries Transparency Initiative is having a positive impact on revenue reporting in resource-rich countries.

Key mining industry groups, notably the ICMM, have long supported revenue transparency as an important aspect of broader governance improvements in resource-rich countries. It is recognised by many companies, campaigners and governments that transparency over revenues that governments receive from extractive companies plays an important role in strengthening government macro-economic management, reducing corruption, empowering local communities and building trust. Transparent reporting also plays an important role in enhancing companies' accountability to their stakeholders, not least investors. ICMM released its first 'position statement' on revenue transparency in 2003 and a commitment towards revenue transparency and the EITI forms a key element of the requirements that mining company members of ICMM must publicly commit to and report against.[9]

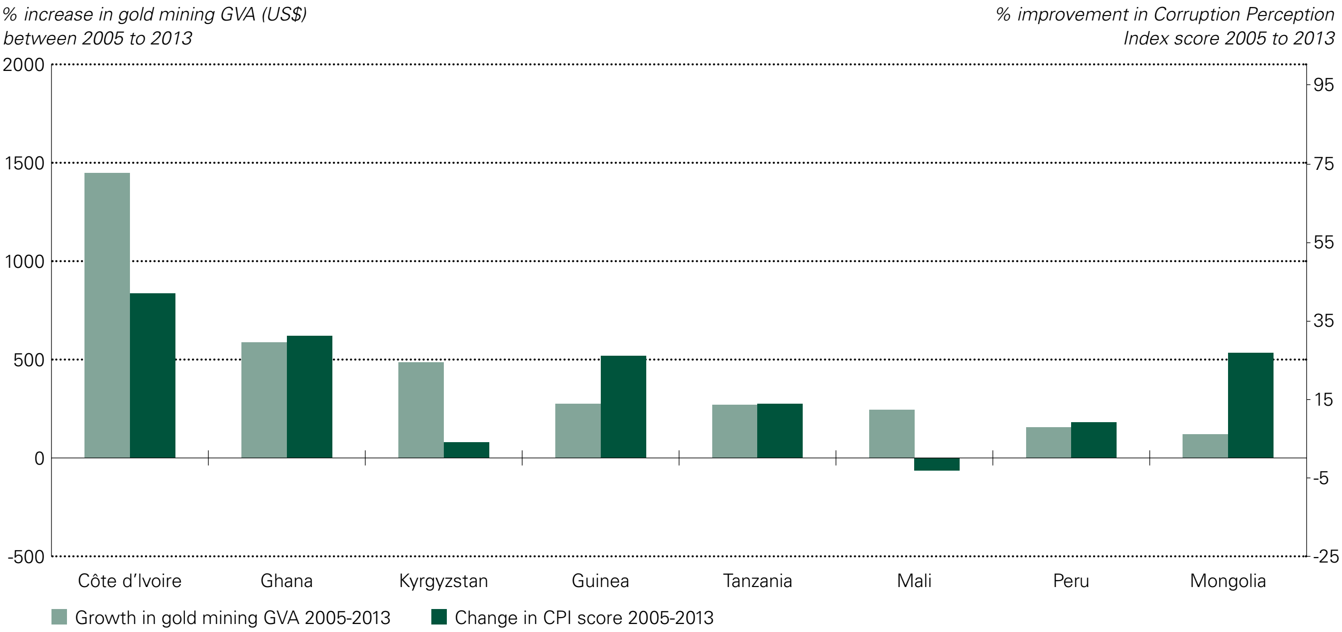
Increasingly, revenue transparency is becoming a regulatory requirement for publicly listed extractives companies. In the United States, Canada and the European Union, regulations are either in place or going through the legislative process that require extractives companies to include, within their regulatory reporting, details of the payments that have been made to host governments. A key objective of these regulations is to ensure that transparency on payments made to governments is the norm, and not just dependent upon host governments committing to initiatives such as the EITI or companies voluntarily reporting this information to their stakeholders.

One of the primary objectives of the EITI is to provide a mechanism that helps address corruption. **Chart 7** provides an illustration of its impact. The chart shows eight of the 10 gold producing countries that have implemented the EITI and for which data on gold mining GVA is available from 2005. It can be seen that all of these countries have experienced substantial growth in the economic contribution made by gold mining in their economies since 2005. Even in Mongolia, which has experienced the lowest rate of gold mining growth of these countries, the GVA from gold mining in 2013 was 115% higher than in 2005. The economic contribution that Côte d'Ivoire receives from gold mining has grown almost 15 times over in this eight year period which, in a country that still suffers from weak governance and a high level of corruption (Côte d'Ivoire was ranked 136 in the 2013 Corruption Perception Index), might be expected to 'add fuel to the fire' and make corruption worse. However, Côte d'Ivoire has improved its Corruption Perception Index score by 42% during the last eight years. Whilst clearly corruption remains a significant problem in Côte d'Ivoire, this data would suggest that at least as far as gold mining revenues are concerned, the EITI is having a positive impact, not least because the majority of other countries shown in **Chart 7** have experienced the same trend.

The only country shown by **Chart 7** where the CPI score has decreased is Mali. This is likely due to the long-running conflict between the government and Tuareg rebels in that country which has escalated over the time period covered by the chart.

Clearly there are other factors beyond EITI implementation that drive reductions in corruption. Nonetheless, the trends illustrated by **Chart 7** highlight the contribution that responsible gold mining companies, working in partnership with governments, civil society and other stakeholders, can make towards improvements in host country governance.

Chart 7: Direct GVA growth from gold mining between eight EITI implementing states and the relationship between this growth and the countries' scores on the Corruption Perception Index



Source: Maxwell Stamp analysis based on GFMS and Transparency International

Section 3: Investing in people

"People, wherever they are, want the opportunity to be financially independent, and to have the dignity of being able to provide for themselves and their family."

The Rt Hon Justine Greening MP, UK Department for International Development

- Globally, gold mining directly employed over one million people in 2013, with over three million employed as a result of gold mining procurement activities.
- Gold mining jobs may not be as numerous as jobs in other industries, but they are high value – the apparel sector in India employs four times as many people as gold mining does globally, but generates less than 10% of the value generated by gold mining.
- Gold mining jobs consistently pay above-average wages – significantly above-average in less developed countries where each worker typically supports a high number of dependants.
- In most regions, over 90% of the employees at gold mining operations are local workers.
- Gold mining companies are working on improving gender equality of their workforces, though there remains considerable scope for improvement in this area.

3.1 Job creation

Investments in the health, knowledge, and skills of the people in a country – human capital – are as important as investments in the more visible, physical capital of the country.[10] This is also an area in which citizens of resource-rich countries are becoming increasingly vociferous: they want jobs. Governments are responding, often incorporating legal requirements on 'local content' – the proportion of the workforce that should be made up of nationals – into mining licences.[xi] A recent study found that more than 90% of resource-driven economies have some form of local content regulation in place.[11]

It is also a challenging issue for companies to respond to, as gold mining is highly capital intensive and, compared to other sectors such as manufacturing, does not require particularly large workforces in comparison to the capital value of a project. According to the United Nations Economic Commission for Africa, the manufacturing sector is 17.5 times more labour-intensive than the mining sector.[12] Expectations of mining job creation, both in terms of the numbers of jobs that will be created by a mining investment and the ability of those jobs to be fulfilled by nationals, can be at odds with the practical realities. For example, the Democratic Republic of Congo requires 96% of roles in the mining sector – and 98% of management positions – to be filled by nationals, but the requisite number of people with the necessary technical and managerial skills and experience are simply not available.[13]

Nonetheless, gold mining can still be a significant employer, particularly once the indirect impacts of job creation by suppliers to mining operations are considered. In addition to their core workforce, all mining operations will have significant requirements for suppliers to provide goods and services, for example construction, logistics, raw materials, catering, maintenance, accountancy and legal services.

xi Note: There is no standard definition of 'local content'. The term is frequently applied to mean the procurement of goods and services locally, as well as the employment of locals within the workforce.

Table 5 estimates the total number of people employed by the gold mining industry in 2013, illustrating both the number of direct jobs (working directly for mining companies) and indirect jobs (working for suppliers to mining companies). The distribution of these jobs by region is also shown.[xii]

Globally, commercial gold mining companies directly employed over one million people in 2013. When indirect employment created by mining companies' suppliers is included, the total number of jobs that result from commercial gold mining rises to around 4.2 million globally.

Perhaps unsurprisingly, the regional distribution of gold mining job creation mirrors regional production trends, with the greatest number of jobs being created in Asia, followed by Africa and South America. Whilst the number of studies of industry multiplier effects is limited (see the Appendix), the research that is available suggests that the multiplier impacts of job creation from gold mining are more pronounced in developing economies compared to advanced economies. In other words, for each job created by a gold mining company in Asia or Africa, there is a greater number of corresponding jobs indirectly created in the supply chain than there are for each job created by a gold mining company in North America. This is not particularly surprising, given that in Asia and Africa a supplier of, for example, construction services, is likely to utilise a higher proportion of manual labour than a construction services supplier in North America. But it is an important point to note when considering the job creation contributions of the gold mining industry, particularly in light of the industry's increasing focus on growth in developing countries. The multiplier impacts also highlight the role that mining can play in supporting the diversification of an economy in less developed countries.

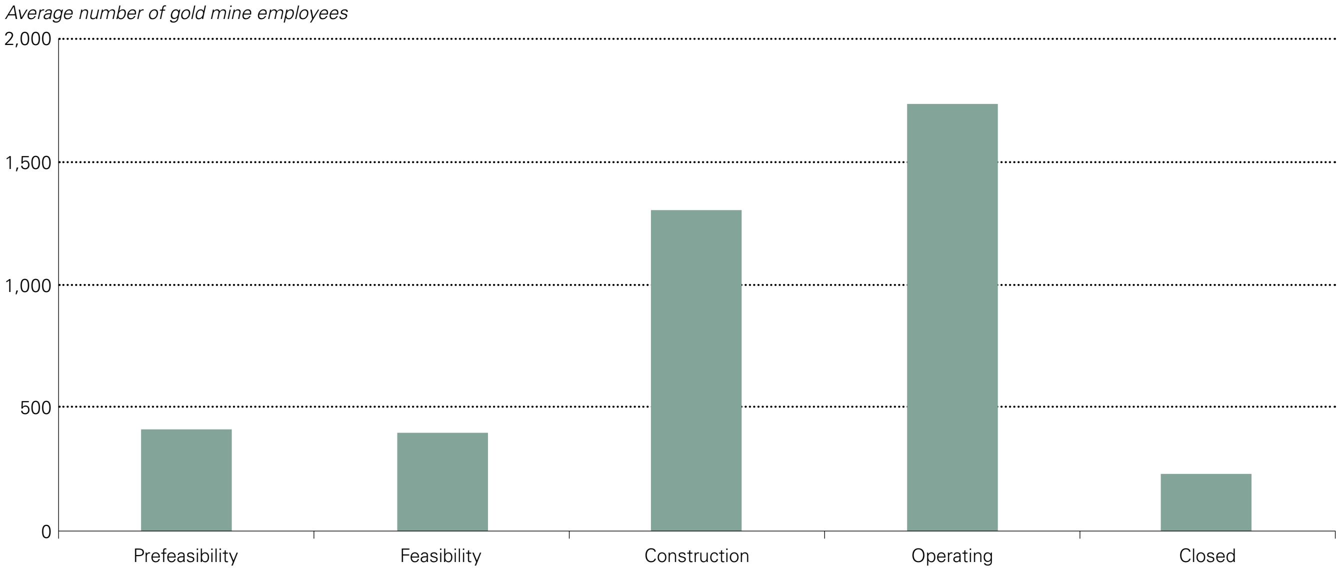
Table 5: Direct and indirect employment in the gold mining industry in 2013

Region	Direct employment	Indirect employment
South America	140,000	398,000
Oceania	39,000	76,000
North America	66,000	127,000
Europe	8,000	15,000
Russia and CIS	67,000	183,000
Asia	414,000	1,132,000
Africa	308,000	1,241,000
Global total	**1,042,000**	**3,172,000**

Source: Maxwell Stamp analysis based on GFMS, Thomson Reuters *Gold survey*; World Gold Council *Responsible gold mining and value distribution survey;* This is Gold survey, and company reports. (Data is rounded down to the nearest thousand)

The number of jobs created by gold mining varies at the different stages in a mine's life cycle. The average number of jobs created by an operating gold mine at these different stages is illustrated by **Chart 8**. It should be noted that there is considerable variation in the numbers of jobs created at different mines, driven by a wide variety of factors including the size and grade of the ore body and whether the mine is an underground or open pit mine. Nonetheless the overall trends hold true on a global basis. It can be seen that the most significant phase in terms of job creation is operation. It has been estimated that 75-90% of total mining expenditure is during the production phase. Development and construction, by comparison, accounts for around 10-25% of total expenditure.[14]

Chart 8: Average direct employment by an operating gold mine during key mine life-cycle phases



Source: Maxwell Stamp analysis based on GFMS, Thomson Reuters *Gold survey*

xii Note: At the time of writing employment data on China's gold mining industry was very limited. Consequently the employment numbers in Table 4 for Asia are likely to be a significant underestimate.

3.2 Employment income

The absolute numbers of jobs created by the development of the gold mining industry in a country is not insignificant, but compared to other less capital-intensive industries gold mining doesn't employ particularly large numbers of people compared to the value of its output. For comparison, the apparel sector in India employs around six million people, though it should also be noted that the economic value of the industry creating these six million jobs is less than 10% of the value of the gold mining industry with its 4.2 million jobs.[15]

The high economic value of the gold mining industry is reflected in the income that gold mining employees earn. **Chart 9** illustrates the average wage ratio between the lowest paid employees at companies' gold mining operations and local minimum wages (or typical wages, if there is no minimum wage defined by the government). It can be seen that, on average, gold mining companies pay significantly more than typical local wages, and that this differential increases in less developed economies. For example, in lower-middle income gold producing countries such as Côte d'Ivoire or Mongolia, the lowest paid mine worker will on average earn 3.5 times more than the typical local wage, and may earn almost seven times more. This is an important trend because in low income countries, each wage-earning worker usually supports a higher number of dependants than in higher income countries. For example, a study of the gold mining industry in Mali found that on average, each mine worker supported six dependants.[16]

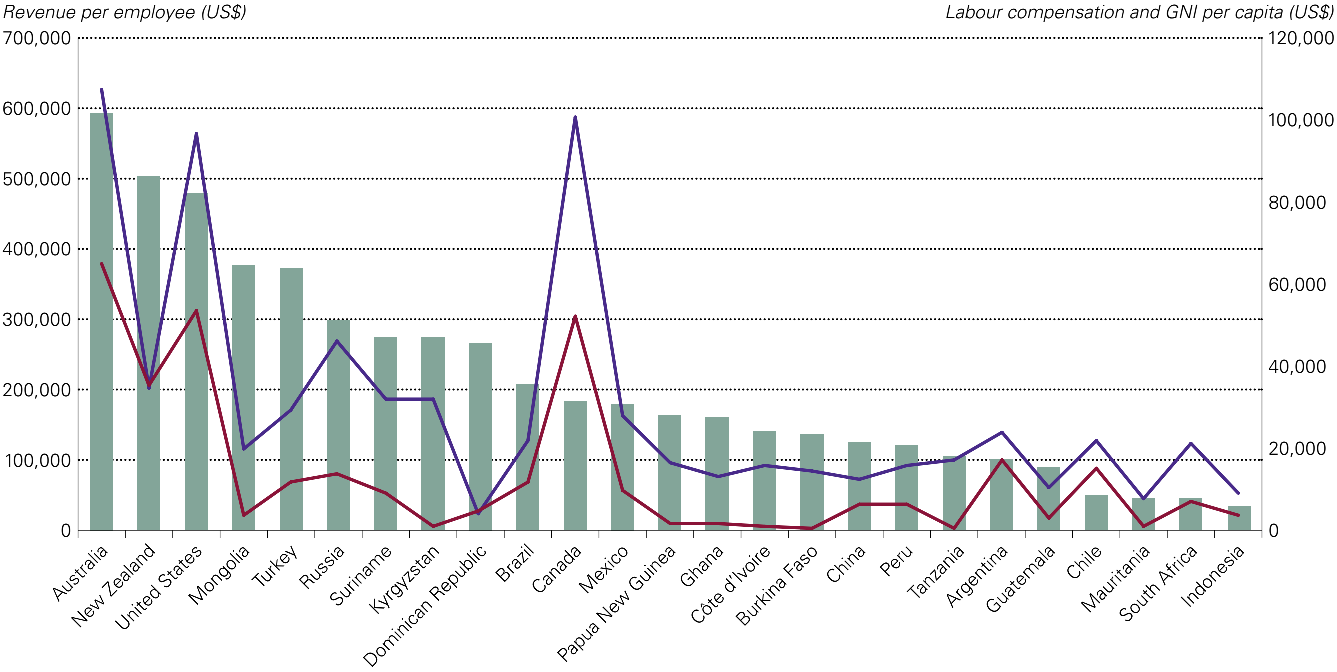
Chart 9: Comparison of wage ratios between entry-level roles in gold mining companies and local typical or minimum wages

Source: Maxwell Stamp analysis based on company sustainability reports (Note: there was insufficient data to provide a highest and lowest ratio range for mines in low income countries)

In low income countries, each wage-earning worker usually supports a higher number of dependants than in higher income countries.

The wage differential is further illustrated by **Chart 10** which shows the average gold mine employee wage compared to the average national wage for the top 25 gold producing countries in 2013. The chart also shows the average company revenue per employee in each country. It can be seen that average mine worker salaries are consistently higher than the national average and also that, with one or two exceptions, the salaries paid to mine workers is relative to the average revenue per employee that the mining company receives.

Chart 10: Comparison of the average gold mine employee wage compared to the national average wage (gross national income per capita) for the key gold producing countries in 2013, together with average company revenue per employee



Source: Maxwell Stamp analysis based on World Gold Council *Responsible gold mining and value distribution survey*, This is Gold survey, World Bank and company reports

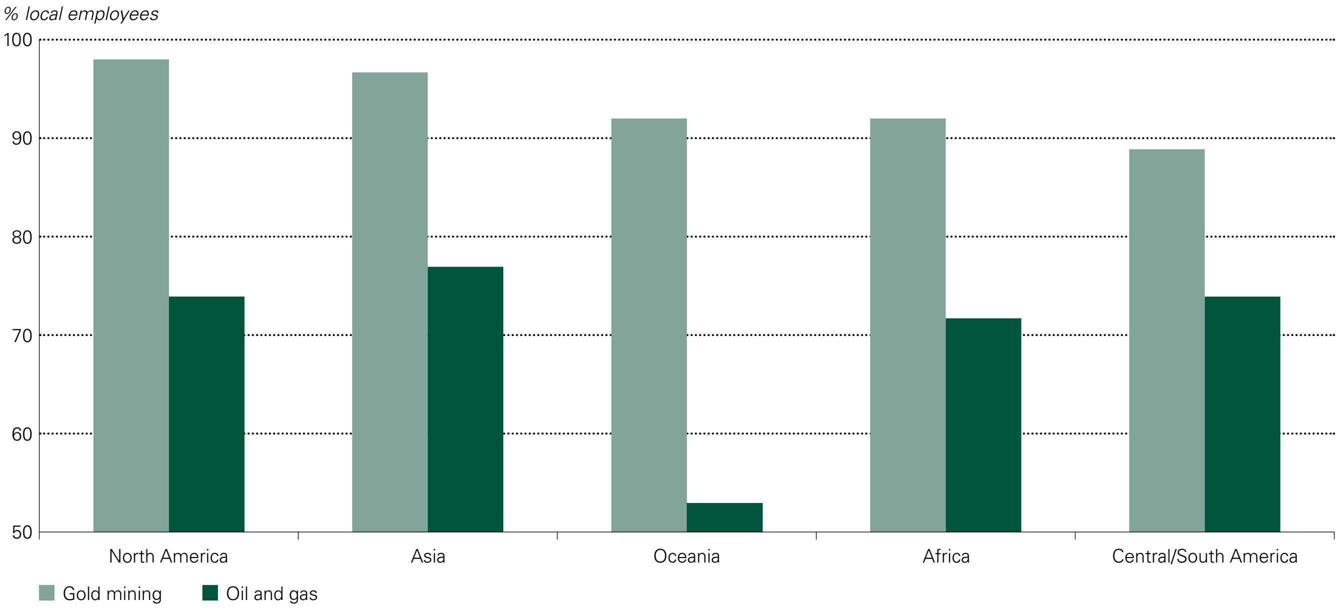
Average mine worker salaries are consistently higher than the national average.

3.3 Local employment

Of course, the potential socio-economic benefits of the relatively high incomes that mine workers earn would be of little benefit to host nations and communities if all the workers were expatriates. As noted above there is significant pressure on the gold mining industry (and other extractive industries) to demonstrate that local people are the beneficiaries of mining job creation. Data from companies' annual reports suggests that the gold mining industry is being quite successful in this area. **Chart 11** shows the average percentages of companies' workforces that are made up of local workers, with data on the oil and gas sector also provided as a comparison.

It can be seen that in most regions, over 90% of the employees at gold mining sites are local workers. Whilst there are some limitations and uncertainties with this data, such as no consistent industry definition for 'local' workers, the data nonetheless suggests that the citizens of gold producing countries are the main beneficiaries (at least in terms of employment numbers) of the above-average-wage-paying job creation impacts of gold mining. By comparison, in the oil and gas sector operations tend to employ a higher proportion of expatriate workers than in the gold mining industry. Clearly this differential is affected by differences between the two sectors in terms of both the skillsets required and the overall labour requirements; the oil and gas industry is no less focused on local content than the gold mining industry. Nonetheless **Chart 11** illustrates that there can be significant differences in the local employment opportunities created by different extractive industries.

Chart 11: Average percentage of gold mining operations workforces that are made up of local employees compared to the oil and gas sector



Source: Maxwell Stamp analysis based on company sustainability reports[xiii] and *Hays/oil and gas job search*[17]

xiii Local employment data at an operational level was obtained from the 2013 sustainability reports of Acacia (formerly African Barrick Gold), Agnico Eagle Mines, Centerra Gold, Goldcorp, IAMGOLD, Kinross Gold Corporation, Newcrest Mining and Primero Mining Corporation.

Ensuring that local communities directly benefit from job creation opportunities is, and will remain, a critical issue for the gold mining industry. This issue is particularly pertinent as the industry increasingly seeks growth opportunities in remote, rural locations in low income countries, where local communities may lack the skills and expertise the gold mining companies need from their workforce and supply chain.

A related issue is that of inequality; both in terms of which individuals benefit from employment and who within a community benefits from mine workers' spending. In most instances the demand for employment within poor communities will exceed the number of jobs that are available. Similarly, research undertaken for the World Bank has found that the economic benefits created from mine workers' salaries are more likely to be captured by individuals within a community who are already relatively well-off within that community and have the capacity to respond to these new economic opportunities.[18] This can be a source of resentment in communities affected by mining operations and in some instances can lead to conflict.

Issues of inequality can be challenging for companies to respond to, though there are steps that can be taken. Companies can build linkages within a local economy by seeking to maximise the procurement of goods and services from local suppliers through transparent and equitable purchasing procedures. Alongside this, companies can use their social investment activities to build capacity amongst local businesses that may need to develop in order to access the market opportunities created by a mining operation or the spending of its workforce. Social investment activities can also be used to ensure that members of a community who may not be able to access economic benefits are able to gain other benefits from a mine's presence in their community, such as improvements in healthcare, infrastructure or environmental rehabilitation.

As an aside, the implications of population size should also be factored into considerations of the potential economic and human development benefits of gold mining job creation. The creation of 1,000 gold mining jobs in Mongolia (population c.three million) will make a greater proportional contribution towards national and human development than the same number of jobs in Indonesia (population c.250 million) as the benefits of this employment are shared amongst a far smaller group of people.

3.4 Gender equality

Perhaps even more of a challenge for gold mining companies than local employment is gender equality. Research studies by the World Bank and the International Finance Corporation have found that across the mining sector, women often miss out on the potential benefits the industry can bring and bear an unequal share of its burdens. Employment and income are largely captured by men, with formal unemployment rates for women in mining communities as high as 90%. Simultaneously, the environmental and social risks of mining tend to fall upon women through the loss of productive agricultural land, marginalisation and an increase in health risks, including HIV/AIDS.[19]

Box 2: Local employment in developed economies

Expectations of employment creation that benefits local communities are not restricted to gold mining operations in developing countries. For example, in Australia local content regulations have been in place since 2011, requiring mining companies to publish details of their procurement requirements and to report on their progress in using local suppliers.[20]

Gold mining companies operating in developed countries such as Canada and Australia face strong pressure to demonstrate that local indigenous communities gain socio-economic benefits from the development of gold mining operations on their land.

One approach that has been deployed by a number of mining companies is to establish a separate 'arm's length' organisation, led by members of the local community, to lead on community investment activities. For example, as part of Barrick Gold's mining lease negotiations at Lake Cowal in New South Wales, Australia with the Wiradjuri Native Title Party, the Wiradjuri Condobolin Corporation was established to be an independent organisation focused on safeguarding indigenous heritage and maximising the socio-economic benefits that the Wiradjuri Condobolin people gain from the mine. Key programmes have included establishing a Business Hub to support local entrepreneurs, an education centre and a cultural heritage programme.[21]

Ensuring that local communities directly benefit from job creation opportunities is, and will remain, a critical issue for the gold mining industry.

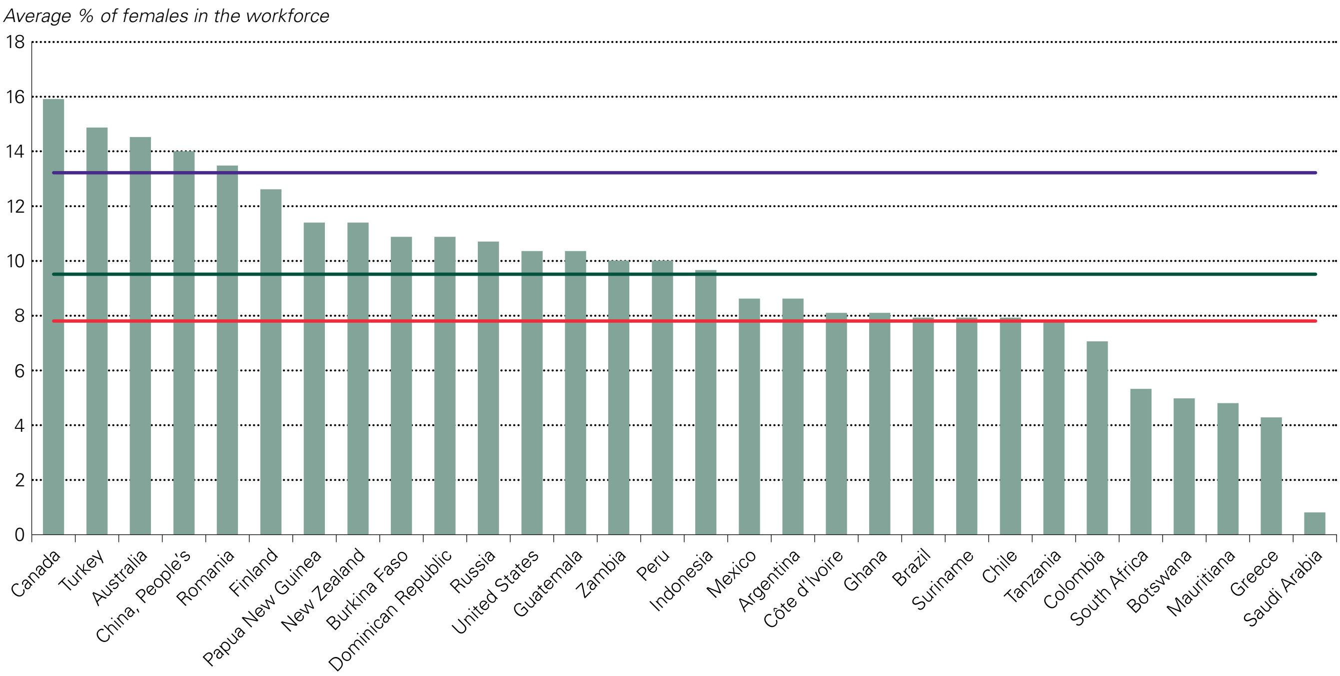
The social development benefits that can be gained when women have the same access to employment opportunities as men are well understood. Where women have access to employment, evidence shows that women are more likely to invest in education, health, and nutrition for their families.

As a sector, the mining workforce remains male-dominated and the gold mining industry is no different. However, in recent years gender equality has rapidly risen up the agenda and become a strategic priority for most mining companies. Aside from societal expectation and, increasingly, legislative requirements, the business benefits of employing women in operational and managerial roles in the mining industry are now well understood. Companies have found that employing women can create a more predictable business environment with fewer production disruptions. Women are often more dependable, they follow rules, obey health and safety regulations, and can be more reliable employees.[22] For example, the gold and silver mining company, Fresnillo, has actively targeted the recruitment of women as haul truck drivers as it found that women drivers drove more efficiently than their male counterparts, saving on fuel costs.[23] Companies have found that women haul truck drivers can extend the life of the truck tyres; an important means of reducing operating costs when each tyre can cost in the region of US$100,000.[24] More broadly, the mining industry as a whole is facing a future skills shortage. It has been estimated that the Canadian mining industry may need as many as 100,000 new workers in the next decade, a need that is unlikely to be met without the proactive recruitment of women.[25]

Progress is being made across the extractive industries, though there is still some way to go. In 2013 it was estimated that women accounted for just over 13% of total employment in the mining sector.[26] By comparison, in the oil and gas sector women constitute around 8% of the total workforce.[27] **Chart 12** shows the average percentage of gold mining companies workforces occupied by women across different countries. It can be seen that the global average for women in gold mining company workforces is around 10%.

Whilst not diminishing the need for continued focus on gender equality, it is noteworthy that one study of a gold mine in west Africa found that although women only occupied just over 11% of jobs, on average female employees' salaries were 14% higher than the male average salary, reflecting that women tended to occupy higher skilled positions.[28]

Chart 12: Percentage of women in the workforce of gold mining operations in different countries



Source: Maxwell Stamp analysis based on This is Gold and company sustainability reports.[xiv] Oil and gas and mining sector estimates based on *Hays global salary guide.* Country selection based on data availability

xiv Gender diversity data at an operational level was obtained from the 2013 sustainability reports of Acacia (formerly African Barrick Gold), Agnico Eagle Mines, Alamos Gold, Barrick Gold, China Gold International Resources, Eldorado Gold, Goldcorp, Golden Star Resources, IAMGOLD, Kinross Gold Corporation, Newcrest Mining, Newmont Mining Corporation, Primero Mining Corporation and Yamana Gold.

3.5 Building human capital

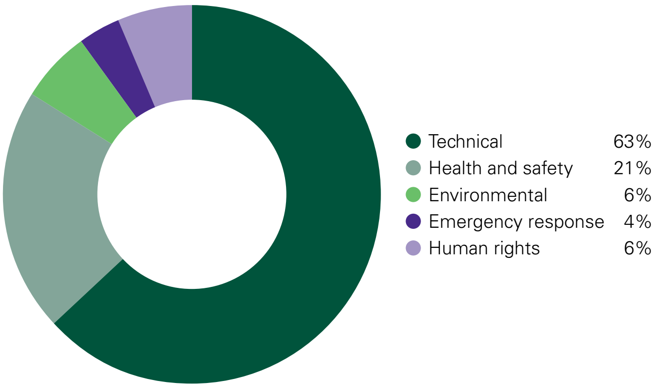
One important mechanism by which countries gain lasting benefits from the development of finite natural resources is through investments in human capital: the skills and expertise of people. Investments that companies make in training their workforce bring benefits to host nations by increasing productivity which in turn increases the value created for the economy. Broader benefits can also be obtained when training provides skills that are transferable beyond the mine and enable workers to obtain employment in other industries should employment at the mine no longer be available. For example, at Goldcorp's Marlin mine in Guatemala the company has developed a literacy programme in association with Guatemala's Ministry of Education which provides training in reading and writing to employees from local communities.[29]

Chart 13 shows the breakdown of the different types of training that gold mining companies provide to their employees and illustrates the average number of hours of training on each topic that each employee receives in a year. The majority of employee training is technical job-related training, with the average gold mining employee receiving 30 hours of technical training each year. It is perhaps unsurprising that the majority of the workforce training effort is focused on technical skills development as this is directly related to the business needs; however, from a national development perspective this is noteworthy as it is highly likely many of the skills that mine employees learn may be transferable to other industries. Skills development also facilitates career progression, which in turn increases income. As workers advance in career development entry-level positions become available which may provide opportunities for new, low or unskilled local employees to join the workforce. In such a way, investments in training and skills development play a central role in bringing socio-economic benefits to local populations.

Broader benefits can also be obtained when training provides skills that are transferable beyond the mine.

Training and workforce development is an important issue for gold mining companies wherever they operate. As a focus area for companies this is not limited to operations in developing countries. For example, according to the Minerals Council of Australia, Australian gold companies spend around 4% of their payroll costs on training, with the majority of gold mining companies providing both structured and unstructured training, and providing apprenticeship and trainee schemes to support new entrants to the workforce.[30] This is marginally higher than the averages seen in other industries. For example, a cross-sectoral survey of 475 US-based organisations found that firms typically dedicate 3.6% of payroll costs towards learning and development.[31]

Chart 13: Average training hours per subject per employee per year



Source: Maxwell Stamp analysis based on company sustainability reports[xv]

xv Data providing a breakdown of training hours and subjects was obtained from the 2013 sustainability reports of Acacia (formerly African Barrick Gold), Barrick Gold, Centerra Gold, China Gold International Resources, Eldorado Gold, Golden Star Resources, IAMGOLD, Kinross Gold Corporation, Newcrest Mining, Newmont Mining Corporation and Yamana Gold.

Section 4: Supporting communities

"Do your little bit of good where you are; it's those little bits of good put together that overwhelm the world."

Archbishop Desmond Tutu

- Maintaining the social licence to operate is a critical business issue and community investment activities have an important role to play in developing and maintaining this.
- Gold mining companies can catalyse development projects that improve the socio-economic conditions of host communities – often aimed at tackling similar issues to those that aid agencies seek to address.
- Community investment projects can often be supported by a sound financial business case which can enable companies to mobilise significant resources to address social issues in a way that traditional aid donors often cannot.
- Healthcare is a significant focus area for gold mining companies, particularly HIV/AIDS, tuberculosis and malaria – in a significant number of gold producing countries, the growth of the gold mining industry over a ten-year period coincides with a reduction in the prevalence of these diseases.

More so than many other industries, mining has a direct impact on the environment of the communities within the vicinity of a mine site. Whilst local communities may not often have formal regulatory control over mining companies, building and maintaining good relationships with local communities that enable operations to proceed with their 'permission' – often referred to as the social licence to operate – is a critical business issue for mining companies. The mining industry has been focused on this area for many years, with many of the community engagement strategies and methodologies developed by the sector, such as ICMM's Community Engagement Toolkit, becoming recognised beyond the mining sector as good practice standards. Nevertheless, community relations remain a critical area for the mining sector; the social licence to operate was the third highest risk on EY's 2014 business risks survey for mining and metals.[32] The value of a mining company's assets below ground can only be realised if the social and political environment above ground enables production.

The value of a mining company's assets below ground can only be realised if the social and political environment above ground enables production.

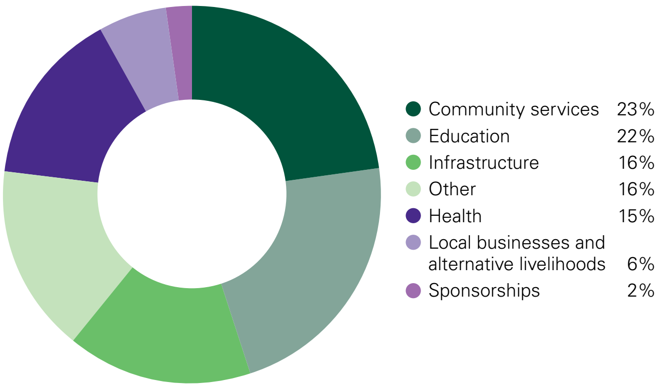
There is good reason for community relations to be considered a critical business issue. Academic studies on conflicts between communities and mining companies have identified several instances where project delays as a result of conflicts with local communities cost the projects around US$20m per week as a result of delays to production.[33] A study of 26 gold mines owned by 19 publicly traded companies between 1993 and 2008 found that around two thirds of the estimated value of the gold controlled by these companies was related to the companies' management of external relationships with host communities and governments.[34] Conflicts between mining companies and local communities can result in operations being disrupted by protests, employees being intimidated, damage to property and even violence; all of which can be further complicated by local politics. Modern communications technology and social media mean that groups with grievances against companies can leverage support and gain profile very quickly and far more effectively than in the past.

Of course the need to build and maintain good community relations is just one of many factors driving the need for careful management of the socio-economic and environmental impacts of mining operations. In response, companies have evolved relatively sophisticated and broad corporate responsibility programmes, covering issues such as governance and ethics, employment, occupational health and safety, community and environment. Multiple mining-specific and cross-sectoral industry forums and voluntary performance standards have developed, such as the Mining, Minerals and Sustainable Development Project (which led to the creation of ICMM), the EITI, the World Economic Forum's Responsible Mineral Development Initiative, the Natural Resource Charter, the United Nations Guiding Principles on Business and Human Rights, the Voluntary Principles on Security and Human Rights, the OECD Guidelines for Multinational Enterprises and the World Gold Council's Conflict-Free Gold Standard, amongst others.

4.1 Distribution of community investments

As previously discussed in this report, the biggest in-country expenditures for gold mining companies are on suppliers and employee wages; expenditures that will in themselves have positive impacts for local communities. Over and above this, gold mining companies also spend significant amounts on community investment activities; on average around 0.9% of revenue from gold sales.[xvi] It is worth noting that these investments continue to be made even when many companies are sustaining losses. **Chart 14** provides an illustration of the different types of areas in which gold mining companies make community investments. Due to the lack of comparability in how companies report different categories of community investment this chart relies on a small sample, nonetheless it is useful as an indication of community investment activity in the sector. It can be seen that 'community services' – investments in community facilities such as sports venues – and education are the largest categories, with infrastructure and healthcare also significant areas of investment.

Chart 14: Illustrative breakdown of gold mining community investment expenditures across different focus areas



Source: Maxwell Stamp analysis based on company sustainability reports[xvii]

xvi Maxwell Stamp analysis based on 2013 reported data from 10 leading gold mining companies: Acacia (formerly African Barrick Gold), Barrick Gold, Centerra Gold, Eldorado Gold, Goldcorp, Golden Star Resources, IAMGOLD, Kinross Gold Corporation, Newmont Mining Corporation, Newcrest Mining.

xvii Data providing a breakdown of focus areas for community investment was obtained from the 2013 sustainability reports of Acacia (formerly African Barrick Gold), Goldcorp, Kinross Gold Corporation and Primero Mining Corporation.

One of the challenges for the industry in managing community relations is that there can sometimes be a misalignment between the focus of corporate activities and the expectations of external stakeholders. In Ghana, for example, the work conditions and health and safety of mine workers (which most mining companies publicly state as their highest priority) are almost completely absent from the lively public discussions and NGO campaigning activities, which are largely directed at environmental, community and human rights concerns.[35] This is not to suggest that health and safety should have a lower priority; rather it highlights the importance for companies of active engagement and communication with communities and wider stakeholders if they are to be seen as partners in the development of communities and nations.

It is increasingly recognised, both by the gold mining industry and by external stakeholders, that building linkages from the mine to the broader economy is central to supporting wider development of the local economy. An example of an initiative designed to achieve this is the Ahafo Linkages project in Ghana, which was initially implemented by Newmont Mining with support of the International Finance Corporation and has been further developed by the Ghana Chamber of Mines. This project provides technical support and capacity building for small and medium-sized businesses and supports businesses that are, or could become, suppliers to the mine as well as other businesses within the wider community. One of the specific objectives of the project was to support economic diversification beyond mine-related procurement.[36] Part of the project's success has been due to the work undertaken to strengthen local business associations and service providers to local businesses, together with the encouragement of other businesses such as Ecobank, the pan-African commercial bank, to provide support to the project.[37]

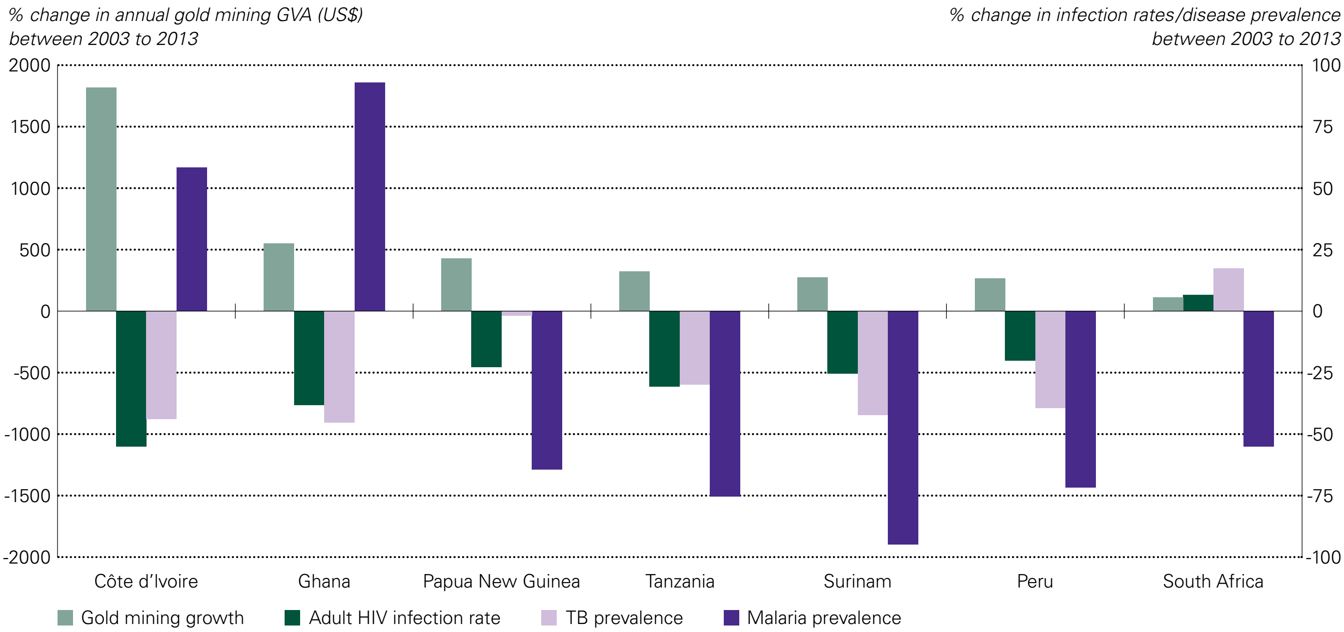
It is increasingly recognised, both by the gold mining industry and by external stakeholders, that building linkages from the mine to the broader economy is central to supporting wider development of the local economy.

4.2 Focus on healthcare

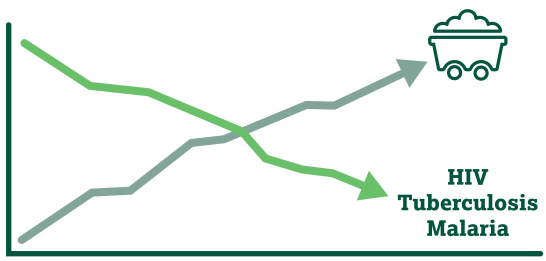
Healthcare is a priority area for many companies' community investment programmes. Beyond the benefits in terms of the social licence to operate, there are often commercial drivers for mining companies to invest in healthcare improvements for the communities surrounding their mines; investment in community healthcare can help minimise absenteeism and reductions in productivity due to workforce illness. Ensuring the provision of clean water and sanitation in areas which are the sources of labour are primary considerations, as is the management of more serious conditions that plague the gold mining industry such as malaria, tuberculosis and HIV/AIDS.

Chart 15 shows how the prevalence of HIV, tuberculosis and malaria has changed over a ten-year period in seven resource-dependent gold producing countries. The rate of growth of the gold mining industry over the same time period, as measured by direct GVA, is also shown. It can be seen that in most cases, as the gold mining industry has grown, the prevalence of these diseases has reduced. Whilst the improvements in disease control cannot be solely attributed to the gold industry, efforts by gold mining companies will have made a contribution. For example, Barrick Gold is working in partnership with the Asian Development Bank to operate a health clinic that provides voluntary HIV/AIDS testing for the local communities near its Porgera and Kainantu mines in Papua New Guinea.[38] **Box 3** provides an example of a company-led initiative to control malaria.

Chart 15: Trends in HIV, tuberculosis and malaria prevalence between 2003 and 2013 in seven gold producing countries compared against the rate of gold mining industry growth in each country



Source: Maxwell Stamp analysis based on GFMS, Thomson Reuters *Gold survey* and UNDP



Whilst not solely attributable to the gold industry, in several gold producing countries as the industry has grown the prevalence of a number of serious diseases has reduced.

There are exceptions, however, to the general trend in improvements to controlling HIV, tuberculosis and malaria in gold-producing countries. According to the World Health Organisation, deaths from malaria have decreased by 47% between 2000 and 2013 worldwide,[39] yet in Côte d'Ivoire and Ghana the prevalence of malaria has got worse, not better. This highlights the importance of gold mining companies continuing to play their part in assisting with control of this disease through initiatives such as the Obuasi model described in **Box 3**.

Similarly, whilst tuberculosis has generally reduced in most gold-producing countries, South Africa is experiencing a tuberculosis epidemic. In 2013 there 760,000 new cases of tuberculosis reported in sub-Saharan Africa that were connected with the mining industry and in South Africa it is estimated that nine out of ten gold miners are latently infected with tuberculosis.[40] Gold mining companies have a central role to play in tackling this disease by identifying and treating workers who are infected with tuberculosis as well as developing and implementing initiatives such as silica dust control measures.

Box 3: AngloGold Ashanti – investing in malaria control

AngloGold Ashanti is a global gold mining company with operations throughout Africa, the Americas and Australia. One of AngloGold Ashanti's major mining operations in Ghana is located in Obuasi, a mining town in the southern part of the Ashante region, which has long been synonymous with gold mining in the country.

In 2004 the company identified that malaria had become a serious business issue. In 2005, the town's hospital, which is operated by the company, was treating on average 6,800 malaria cases each month, of whom 2,500 were mine employees. This represented over 30% of the mine's workforce, with almost 7,000 work days lost each month.

Working in collaboration with Ghana's ministry of health, AngloGold Ashanti developed a comprehensive malaria prevention and treatment programme that encompassed education, malaria prevention and treatment, and featured indoor residual spraying as the main form of prevention. The programme was rolled out in 2006, with the indoor residual spraying encompassing all structures (private and mine-owned buildings, and surrounding villages) in Obuasi municipal district.

The indoor spraying programme is a key feature that distinguishes the 'Obuasi model' from many other malaria treatment programmes. The spraying benefits the entire community as, quite simply, there are fewer mosquitos that can spread malaria. Despite the World Health Organisation recommending indoor spraying with residual insecticide as a "powerful way to rapidly reduce malaria transmission," indoor spraying is used comparatively little compared to mass distribution of bed nets as the spraying needs to be carried out comprehensively in a particular area in order to be effective. This can be both technically demanding and comparatively expensive; consequently many aid organisations therefore don't undertake such spraying programmes.

However for AngloGold Ashanti, in addition to the community relations benefits of the Obuasi programme there are clear commercial benefits through substantially improved workforce productivity that more than offset the costs of the programme. In Obuasi district there has been a 79% reduction in malaria cases reported since 2006, and a 94% reduction in the working time lost by mine employees to malaria.

Following the success of the Obuasi model, AngloGold Ashanti set up a separate company which is managing a national malaria treatment programme funded by a five-year US£154mn grant from Global Fund to Fight AIDS, Tuberculosis and Malaria. The national programme began operations in 2011. AngloGold Ashanti is also deploying the Obuasi model at its other mine sites in Africa.[41 42 43]

Conclusions

Without economic development there can be no sustainable poverty reduction. For some countries there is no path to development that does not involve leveraging the contributions of extractive industries such as gold mining. This report has shown that gold mining industry has a key role to play in helping to develop nations and provide opportunities to enhance public well-being. It has also shown that these benefits extend far beyond those that many stakeholders traditionally focus on, such as the mineral royalties received by governments. Any discussion of how to maximise the contributions of gold mining to host economies needs to consider the broader context, including the indirect impacts of the industry supply chain and also the broader investments that companies make in people and in host communities.

There are many benefits for host communities and governments in gold producing countries. However, there remain very significant challenges. Whilst many communities are benefiting from responsible gold mining, there are others where there are disputes and even conflict between mining companies and other stakeholders. Undoubtedly, gold mining companies bear a burden of responsibility to ensure that their presence in a community and country results in socio-economic benefits.

However, this cannot be the responsibility of companies alone. Partnerships are key. Furthermore, for gold mining companies to be active development partners, host country governments need to ensure that there is a viable commercial operating environment in place. Nonetheless, considering gold mining companies as development partners for gold producing countries would represent a major shift from the conventional, more transactional type of relationship that currently exists between many industry, government and community stakeholders, and a major milestone in the journey towards sustainable socio-economic development. By shedding some light on the broader socio-economic effects of the gold mining industry, it is hoped that this report at least marks a contribution towards that journey.

This research has found notable gaps in the available data on the social and economic impacts of gold mining – addressing this would be of significant benefit to all stakeholders.

Improving socio-economic development reporting

In undertaking this research there were a number of notable deficiencies in the available data; addressing these would be of significant benefit to all stakeholders working on understanding, improving or making the most of the socio-economic impacts of gold mining. Key areas for improvement include:

- **Defining local:** Despite local content being a high business issue both within and beyond the gold mining industry, it remains an area that suffers from a lack of consistent definitions and terminology. This hinders effective dialogue between stakeholders as well as limiting the ability for companies to report on their performance and for stakeholders to evaluate performance. The gold mining industry could develop and agree to report against consistent definitions and utilise standard metrics.
- **Socio-economic baselines:** A common challenge in development (that is not unique to the gold mining industry) is a lack of baseline social and economic data against which the effectiveness of socio-economic development initiatives can be measured. Whilst the gold mining industry cannot take responsibility for national-level data deficiencies in host nations, they could work in partnership with local stakeholders to support the systematic collection, analysis and utilisation of relevant data from communities impacted by mining operations. Where appropriate, companies could support appropriate research institutions in building or updating datasets that would be useful not just for analysing the company's own impacts but also more broadly by other development actors.
- **Community investment data:** Few companies provide a breakdown of precisely how community investment funds are spent, and where information is provided definitions often vary between companies. This is not covered by the Global Reporting Initiative indicators against which many companies report, but would be useful at a local or national level for quantifying certain aspects of companies' contribution to development and thereby informing subsequent analyses of effectiveness (i.e. are community investments achieving the desired outcomes?). Whilst care would be needed on how such information is disclosed in order to avoid potential risks such as inter-community rivalry, such data could usefully support companies in understanding and improving the development effectiveness of their community investment activities. The gold mining industry could agree to report this information against consistent categories and definitions.

Appendix: Study methodology

This appendix describes the mechanisms and data sources employed in this study to calculate the economic contributions of the gold mining industry. Primarily, it provides an explanation of the techniques applied in calculating direct and indirect Gross Value Added (GVA) in both a national and regional context. A description of the techniques used to estimate direct and indirect employment is also included.

A1. Gross Value Added

Calculating GVA is a widely recognised approach for estimating the economic contribution of a particular company or industry to the economy of a country or region.[44] GVA is closely linked to Gross Domestic Product (GDP), the primary means by which national economies are measured, and forms part of its calculation.[xviii] Similar to GDP, estimates of GVA can be compiled using three approaches:

- Total value of output less intermediate consumption (production).
- Total earnings derived from production (income).
- Total expenditure on goods and services (expenditure).

In theory, all three approaches (income, expenditure or production) will produce the same results.

A1.1 National GVA

This report uses the income approach to calculate the value added in each nation's gold mining industry. This approach calculates the total income directly earned by companies and their employees from the production of goods or services and was selected as the key data inputs to the GVA calculation, described below, are widely available in reports published by listed gold mining companies and by industry data providers.

A number of data sources were utilised in our estimation of GVA. The average annual gold price supplied by The London Gold Market Fixing Limited (TLGMFL), the annual gold output figures recorded by GFMS, Thomson Reuters *Gold survey* and industry production costs provided by GFMS, Thomson Reuters *Gold mine economics service* were used to forecast total corporate earnings in the industry before tax, depreciation and amortisation. Data on labour costs, sourced from GFMS, Thomson Reuters *Gold mine economics service,* acted as a proxy for labour compensation and are added to the estimate of corporate earnings to produce a measure of direct GVA for each country *i* at time *t* as illustrated in the following equation:

$$Revenues_i^t = Price^t \times gold\ output_i^t$$
$$Direct\ GVA_i^t = Revenues_i^t - Operating\ costs_i^t + Labour\ compensation_i^t$$

A1.2 Regional GVA

National GVA estimations formed the basis of the regional analysis. Amongst the regional groupings, the value added by each gold producing country was totalled to give an estimate of the value created in each region, as illustrated in the following equation:

$$Direct\ GVA_{South\ America}^t = GVA_{Peru}^t + GVA_{Brazil}^t + GVA_{Argentina}^t \ldots + GVA_{Other}^t$$

In some cases a proportion of the regional gold output reported by the GFMS, Thomson Reuters *Gold survey* was attributed to 'other countries' within a region rather than being assigned to specific named countries. A credible estimation of the GVA produced in these unclassified countries was achieved by calculating the average earnings and compensation per ounce of gold within each region before multiplying these figures by the recorded volume of gold produced by the unclassified countries within the region. Regional GVA is therefore equivalent to the sum of the value added by all classified and unclassified countries in that region.

xviii Gross Domestic Product (GDP) is equal to the GVA associated to a particular firm, nation or region plus taxes and minus any subsidies on goods or services.

A2. Indirect gross value added

Within this report, indirect GVA refers to the rise in demand and economic output created in other industries as a result of gold mining activities. In order to calculate indirect GVA it is necessary to identify appropriate multipliers; the ratio by which the direct contribution can be multiplied by to provide an estimate of the indirect impact within an economy.

For this study a comprehensive review of the published literature on economic multipliers in the mining industries was undertaken. A wide selection of multipliers were identified which depict the ratio between the total, indirect and direct effects. As it would be misleading to assume the magnitudes of the indirect impacts are equivalent for each region, the multipliers are categorised based on the dynamics and characteristics of the respective gold industries in each region (**Table A1.1**). The median multiplier value across each sample was calculated before applying this to the estimates of direct GVA. Given the limited number of published studies on industries in Asia, Russia and CIS, a multiplier based on the full sample was used to estimate the indirect impact in these regions.

Table A1.1: Value added multiplier analysis

Industry	Location	Direct impact	Indirect impact	Direct and indirect impact	Source: Author (date)
Africa (not including South Africa)					
Gold mining	Ghana	1.0	1.80	2.80	Kapstein et al. (2011)[27]
Gold mining	Tanzania	1.0	1.52	2.52	Ernst & Young (2013)[45]
Cooper mining	Zambia	1.0	1.20	2.20	ICMM (2014)[46]
Median value			***1.52***	***2.52***	
South America					
Mining sector	Peru	1.0	0.90	1.90	World Gold Council (2011)[47]
Metals mining	Chile	1.0	0.80	1.80	McCurdy, K., Keresztes, T. (2012)[48]
Copper mining	Chile	1.0	0.28	1.28	Aroca, P. (2000)[49]
Median value			***0.80***	***1.80***	
North America, Oceania, Europe and South Africa					
Gold mining	South Africa	1.0	1.20	2.20	Virtual Metals Research & Consulting Limited (2006)[50]
Gold mining	South Africa	1.0	1.73	2.73	Genesis Analytics (2008)[51]
Gold mining	South Africa	1.0	0.70	1.70	Holland, N. (2014)[52]
Gold mining	Canada	1.0	0.61	1.61	Dungan, P., Murphy, S. (2014)[53]
Gold mining	Canada	1.0	0.54	1.54	Dungan, P., Murphy, S. (2014)[52]
Metals mining	Finland	1.0	1.47	2.47	McCurdy, K., Keresztes, T. (2012)[46]
Metals mining	UK	1.0	0.77	1.77	McCurdy, K., Keresztes, T. (2012)[46]
Metals mining	Spain	1.0	1.33	2.33	McCurdy, K., Keresztes, T. (2012)[46]
Gold mining	New Zealand	1.0	1.29	2.29	Brent, W. (2003)[54]
Gold mining	Romania	1.0	2.0	3.0	Oxford Policy Management (2009)[55]
Mining	USA	1.0	0.6	1.6	Barnett, C.(1999)[56]
Mining	South Australia	1.0	1.0	2.0	Barnett, C.(1999)[55]
Median value			***1.10***	***2.10***	
Asia, Russia and CIS					
Silver, gold and copper mine	Mongolia	1.0	0.97	1.97	Stokes, E. (2005)[57]
Median value			***0.97***	***1.97***	
Full sample median value			*1.00*	*2.00*	

A3. Employment

The number of people directly employed within each region's gold industry was estimated using an analysis based on the recorded level of output. First, a regional average output per employee was estimated from the information provided in company accounts, the World Gold Council *Responsible gold mining and value distribution survey,* and This is Gold survey. As illustrated in the formula below, the average output per employee in a region was then compared against the total gold output recorded by GFMS, Thomson Reuters *Gold survey* for the same region to give an extrapolated estimate of the number of workers directly employed in each region j as shown in the following equation:

$$\text{Direct employment}_j = \frac{\text{Gold output}_j}{\text{Average output per employee}_j}$$

A3.1 Indirect employment

Estimates of the direct employment were combined with the findings from our multiplier analysis to obtain a measure of the number of jobs indirectly created through the gold mining industry. The table below lists the data sources, regional groupings and estimated median values which were applied to the direct employment figures in order to estimate indirect employment.

Table A1.2: Employment multiplier analysis

Industry	Location	Direct impact	Indirect impact	Direct and indirect impact	Source
Africa (not including South Africa)					
Mining	Tanzania	1.0	7.6	8.6	ICMM (2007)[58]
Gold mining	Tanzania	1.0	6.87	7.87	Ernst & Young (2013)[44]
Cooper mining	Zambia	1.0	2.61	3.61	ICMM (2014)[45]
Gold mining	Tanzania	1.0	3.0	4.0	World Gold Council (2009)[59]
Gold mining	Mali	1.0	6.0	7.0	United Nations Conference on Trade and Development (2007)[60]
Median value			***6.0***	***7.0***	
North America, Oceania, Europe and South Africa					
Gold mining	Canada	1.0	1.92	2.92	Dungan, P., Murphy, S. (2014)[52]
Gold mining	Canada	1.0	1.44	2.44	Dungan, P., Murphy, S. (2014)[52]
Gold mining	Australia	1.0	2.13	3.13	Minerals Council of Australia (2013)[61]
Gold mine	New Zealand	1.0	1.19	2.19	Brent Wheeler (2003)[53]
Gold mining	Romania	1.0	3.25	4.25	Oxford Policy Management (2009)[54]
Mining	USA	1.0	1.8	2.8	Barnett, C (1999)[55]
Mining	South Australia	1.0	3.0	4.0	Barnett, C (1999)[55]
Median value			***1.92***	***2.92***	
South America					
Mining sector	Peru	1.0	4.0	5.0	Mining Institute of Engineers of Peru (2010)[62]
Mining sector	Peru	1.0	1.9	2.9	World Gold Council (2011)[46]
Metals mining	Chile	1.0	4.41	5.41	McCurdy, K., Keresztes, T. (2012)[46]
Large copper and gold mines	South America	1.0	2.84	3.84	Ernst & Young (2013)[44]
Medium gold mines	South America	1.0	2.28	3.28	Ernst & Young (2013)[44]
Median value			***2.84***	***3.84***	
Asia, Russia and CIS					
Silver, gold and copper mine	Mongolia	1.0	2.05	3.05	Stokes, E. (2005)[56]
Median value			***2.05***	***3.05***	
Full sample median value			*2.73*	*3.73*	

Exhibit 12
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ODFW Sage-Grouse Core Areas

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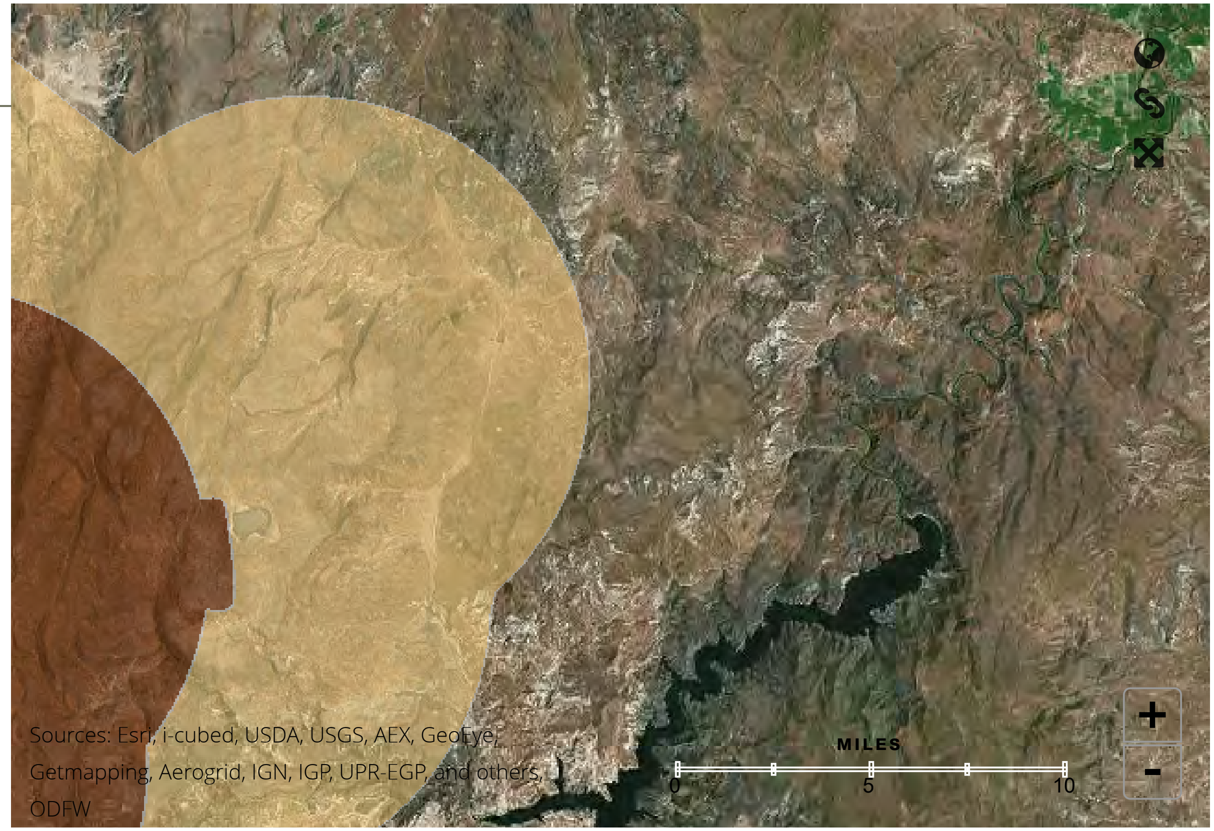

Tutorial

Exhibit 13
Page 1 of 1

SUMMARY OF PROCESSING, CHEMICAL MANAGEMENT AND CYANIDE DETOXIFICATION AT THE PROPOSED GRASSY MOUNTAIN GOLD MINE

The following discussion is excerpted from the Preliminary Feasibility Study Report (Mine Development Associates, 2018, *Preliminary Feasibility Study and Technical Report for the Grassy Mountain Gold and Silver Project, Malheur County, Oregon, USA*, July 9,2018) (PFS). The processing description begins on page 92 of the PFS.

The purpose of this brief summary is to describe processing, chemicals use/management and cyanide detoxification at the proposed Grassy Mountain Mine. Additional work is in progress, which will be included in the DOGAMI Consolidated Permit Application.

The full report is public information that can be downloaded from the Paramount Gold Nevada Corp website: http://www.paramountnevada.com/wp-content/uploads/2018/07/NI43-101_GrassyMtn_PFS_v09.pdf

This report is not meant to be a full discussion of the project or the processing. Calico recommends that interested parties refer to the full report at the link above.

Milling and Refining

The Grassy Mountain process flowsheet involves crushing and grinding the ore, gravity separation, and a CIL cyanide circuit, electrowinning recovery, and cyanide detoxification.

The Grassy Mountain gold-silver mineralization is considered to be amenable to the proposed recovery process that will involve a combination of gravity concentration and cyanide leaching. A nominal process plant treatment rate of 750 short tons per day has been designed to recover and concentrate gold and silver. The plant will be of the conventional CIL type and is designed to operate with two shifts per day, 365 days per year, with an overall plant availability of 91.3 percent. The process plant will produce gold doré bars to be sold to gold refiners.

The plant feed will be hauled from the underground mine to a mobile crushing facility that includes a jaw crusher as the primary stage and cone crushers for secondary and tertiary size reduction. The crushed ore will be ground by a ball mill in a closed circuit with hydro-cyclones. A centrifugal gravity concentrator will collect gravity-recoverable gold (GRG) from the cyclone underflow and discharge it to an intensive-leach reactor (ILR) for recovery. The hydro-cyclone overflow with P80 of 100 mesh will flow to a CIL recovery circuit via a pre-aeration reactor.

Gold and silver leached in the CIL circuit will be recovered on carbon and eluted in a pressurized Zadra-style elution circuit and then precipitated by electrowinning in the gold room. The gold-silver precipitate will then be mixed with fluxes and smelted in a refining furnace to pour doré bars. Carbon will be re-activated in a carbon regeneration kiln before being returned to the CIL circuit.

Leached tailings will be detoxified in a Sulfur Dioxide (SO2)/air cyanide destruction circuit. Detoxified tails will be pumped to a TSF for final deposition and recovery of decant water. Process water recovered from the decant water will be re-used for grinding and plant utility water.

Flowsheet Development

The process flowsheet was developed based on the historical comminution data and 2017 SGS laboratory test work results. The flowsheet considers that the process plant will consist of the following unit operations:

- Crushing and stockpile;
- Grinding and classification;
- Gravity concentration with concentrate intensive leaching;
- CIL leaching;
- Carbon management;
- Gold room; and
- Detoxification and tails deposition.

The Grassy Mountain Process Flow Sheet is below (Figure 28).

Process Flow Sheet - Grassy Mountain

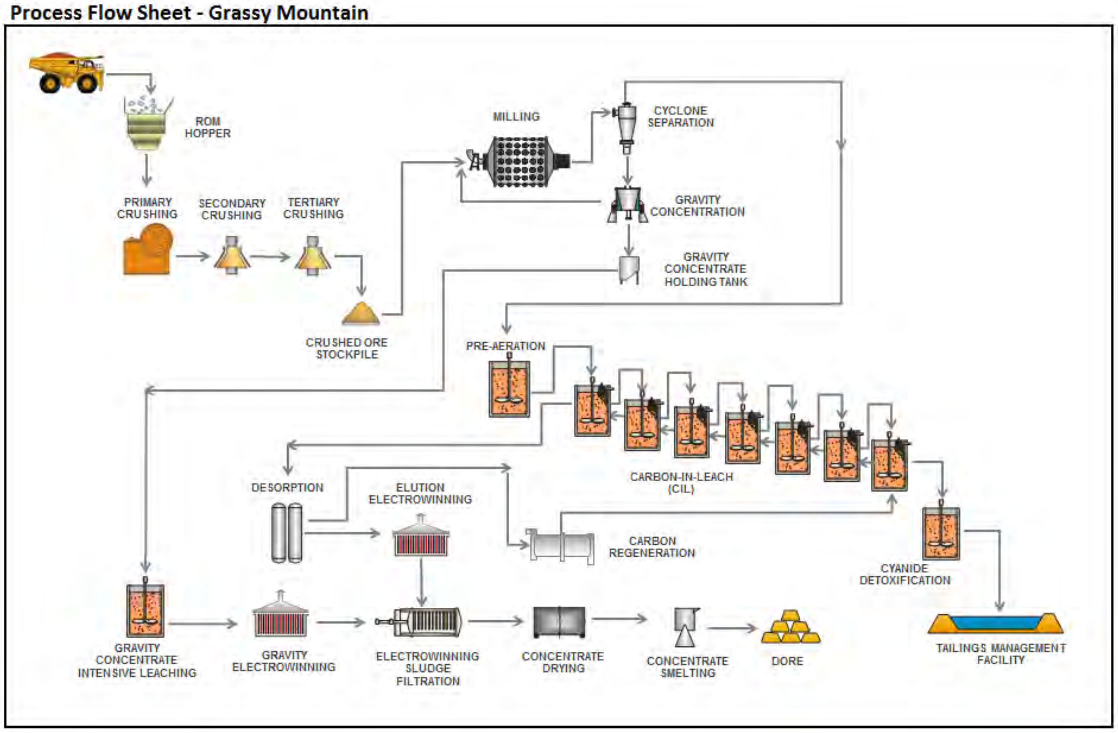

Figure 28. Grassy Mountain Process Flow Sheet (Note that the term "tailings management facility" in Grassy Mountain Process Flow Sheet figure below is equivalent to the term "TSF" that is used elsewhere in this report)

Major Process Design Criteria

The principal process-design criteria for the Project are outlined in the Grassy Mountain Process Design Criteria Summary below.

Table 1. Grassy Mountain Process Design Criteria Summary

Description	Units	Value
Ore Throughput	tons/y	273,750
Design Grade - Au	oz/ton	0.24
Design Grade - Ag	oz/ton	0.34
Operating Schedule		
Crusher Availability	%	70
Plant Availability	%	91.3
Throughput, Daily - average	tons/day	750
Plant capacity, Hourly	tons/hour	31
Crushing (Three Stage)		
Primary Crusher	type	Single Toggle Jaw Crusher
Secondary/Tertiary Crusher	type	Cone Crusher
Fine Ore Stockpile Residence Time - Live	day	5
Grinding		
Circuit Type		3-Stage Crush, Ball mill
Bond Ball Mill Work Index	kWh/ton	19.0
Ball Mill Power	hp	1,072
Feed Particle Size, F_{80}	inch	0.394
Product Particle Size, P_{80}	U.S. mesh	100
Gravity Concentration		
Overall Gravity Gold Recovery	%	10
Carbon-In-Leach		
Total Leach Time	hour	24
Number of Tanks	#	1 pre-aeration + 7 leach / adsorption

Description	Units	Value
Cyanide Addition	lb/ton	0.82
Lime Addition	lb/ ton	2
Carbon Concentration	lb/ft^3	1.56
Carbon Loading (Au + Ag)	oz/ton	175
Desorption/Electrowinning/Refining		
Elution method	-	Pressure Zadra
Carbon batch size	ton	3.3
Elution CIL strips per week	#	7
Gravity leach solution electrowinning batches per week	#	7
Cyanide Destruction		
Method	-	SO_2 Air
Residence time	hour	2
CN_{WAD} target	ppm	<0.1
Sodium Metabisulphite Addition	lb/ton	4

Process Plant Description

See the Proposed Process Plant Layout figure (Figure 29) below.

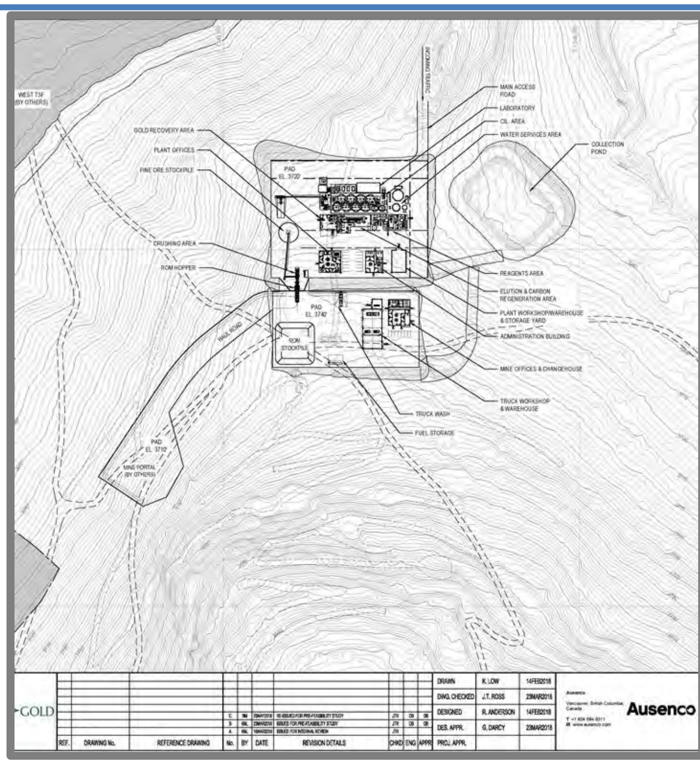

Figure 29. Proposed Process Plant Layout

Crushing and Stockpile

The crushing facility will be mobile and have a two-stage crushing circuit that will process the underground ore at a nominal processing rate of 42 tons per hour. The major equipment and facilities at the ore-receiving and crushing areas include:

- Ore-surge bin;
- Stationary ore-bin grizzly;
- Vibrating grizzly feeder;
- Primary jaw crusher (35-inch by 26-inch);
- Double-deck vibrating screen (five-foot by 14-foot);
- Secondary cone crusher (120-horsepower [hp]);
- Covered fine-ore stockpile; and
- Stockpile-reclaim hopper and belt feeder.

The ore will be trucked from the underground and dumped directly into the ore-surge bin, or it will be stockpiled on the stockpile storage pad which can be reclaimed by a front-end loader for continuous feed. Particles larger than the stationary ore-bin grizzly can be removed by the front-end loader for individual breakage using a mobile rock breaker.

Grinding and Classification

The primary grinding circuit will consist of a ball mill in a closed circuit with classifying cyclones. The circuit will be equipped with a single centrifugal gravity concentrator to recover GRG. Approximately 33 percent by weight of the cyclone underflow will be fed to the gravity concentrator. The proposed grinding circulation load for the closed-circuit ball mill is 350 percent of new feed.

The primary grinding circuit is designed for a product size P80 of 100 mesh. The major equipment in the primary grinding circuit will include:

- One 11-foot diameter (inside shell) by 17-foot effective grinding length (EGL) single-pinion ball mill driven by a single 1,072 hp fixed-speed wound-rotor drive motor; and
- One cyclone cluster, consisting of two 15-inch diameter cyclones (one operating, one standby).

As required, steel balls will be added into the ball mill using a ball bucket and kibble system to maintain grinding efficiency.

Ore addition to the ball mill is to be supplemented with process water to achieve a slurry density of approximately 72 percent solids (by weight). The ball-mill discharge will flow through a trommel screen, which will remove any trash or broken mill balls and discharge them into a tote. The cyclone overflow will flow via gravity to the trash screen, which diverts trash or fibrous materials into a trash bin. The trash screen underflow then will flow via gravity to the pre-aeration tank.

Gravity Concentration and Intensive Leaching

The grinding circuit will be equipped with a centrifugal gravity concentrator to recover coarse gold before it goes to the leach circuit. A gravity recovery circuit has been included due to the presence of free gold in the ore. If left in the leach feed, coarse gold particles with a low surface area to volume ratio, may not dissolve completely before leaving the leach circuit, causing reduced gold recovery.

Flushing water will rinse the gravity concentrate to a gravity concentrate hopper located beneath the concentrator. Water will be continually decanted as the GRG concentrate accumulates in the hopper. Access to the gravity concentrator hopper storage area will be restricted to authorized personnel only. Once per day the concentrate accumulated in the gravity concentrate hopper will be pumped to the ILR where it is dosed with sodium hydroxide and high levels of Sodium Cyanide (NaCN). The ILR then will process the batch for about 20 hours to ensure all gold particles have been dissolved. It then decants the pregnant leach solution from the solids, aided by flocculant, and pumps it to the gravity electrolyte tank near the gold room.

Leaching

A pre-aeration tank was included ahead of the leach circuit, as testwork showed this reduced consumption of cyanide and lime in leaching by passivating the sulfides in the ore. The high level of dissolved oxygen (DO2) in the tank oxidizes the surface of sulfides in the ore, preventing them from reacting with cyanide and lime in the leach circuit and thereby reducing consumption of those reagents.

A CIL circuit was selected due to the small throughput required. Laboratory-scale leach kinetics modeling indicated that a carbon-in-pulp (CIP) process produced marginally better performance than CIL, but significantly higher carbon-processing requirements more than doubled the size of the carbon elution and regeneration circuit. Testwork determined that the gold is leached to completion with a residence time of 24 hours. Carbon-management modeling determined that seven leach stages are required, the optimum carbon concentration is 1.56 lb/ft3, and the advance rate to minimize solution losses is 3.3 tons per day.

The pre-aeration tank will mix the cyclone overflow with lime; low-pressure air will be pumped in, raising the DO2 to about ten parts per million (ppm). Passivated slurry will overflow the pre-aeration tank to the first CIL tank, where it will be adjusted with lime to about pH ten and cyanide will be added.

Leached gold and silver will be adsorbed onto granular carbon, which is present in all tanks in a CIL-type leach circuit. Barren carbon will be added to the last CIL tank and will travel up through the circuit in the opposite direction from the slurry flow. Carbon will advance once per day with carbon transfer pumps, which pump carbon-laden slurry to the next tank in the train. Carbon will be retained in the tanks after the transfer with inter-stage screens, which have mesh baskets sized to allow slurry to pass through but not the loaded carbon.

Leached tails will overflow the last tank and are to be pumped to the carbon safety screen, which collects carbon that would otherwise be lost to the tailings in the event of a hole in one of the inter-stage screens. Loaded carbon is to be pumped from the first leach tank to the elution circuit via a loaded-carbon screen, which will separate the carbon from slurry and send the slurry back to the leach circuit.

Carbon Management

Acid Wash: Loaded carbon from the leach circuit is to be loaded into an acid-wash column, where it will be submerged in a three percent hydrochloric-acid solution in order to dissolve lime scale that would otherwise interfere with the elution process. After soaking for 30 minutes, the acid will be drained, and several bed volumes of raw water are to be circulated through the column to rinse and neutralize the acid from the carbon. After rinsing, the carbon will be pumped to the elution column via carbon-transfer water.

Carbon Elution: A pressure Zadra circuit was selected for elution of gold and silver from carbon due to the small carbon processing requirements of the CIL circuit and unknown water quality from the raw water wells. A pressure Zadra circuit is less complicated than comparable alternatives, and is less sensitive to poor water quality, which makes it a better choice in this instance.

Strip solution (eluate) will be made up in the strip-solution tank using raw water dosed with two percent sodium hydroxide and 0.2 percent cyanide to form an electrolyte for the electrowinning process. This solution will be circulated through the elution column via an eluate heater, which heats the solution, the carbon, and the column to 275° Fahrenheit (F). The elution system will be pressurized to keep the solution from flashing to steam in the heater or elution column.

A recovery heat exchanger will transfer heat from the hot pregnant solution exiting the column to the incoming solution before passing through the solution heater. Once system temperature is reached, the hot pregnant eluate solution will be directed to the electrowinning cell, where the metals will be plated onto the cathodes. Solution continues to circulate through the elution column and electrowinning cell until all metals are eluted from the carbon and deposited in the electrowinning cell.

Carbon Regeneration: Once the elution cycle is complete, the barren carbon will be transferred to the regeneration-kiln feed hopper where it is metered into the regeneration kiln. The kiln will heat the carbon to 1,380°F, which regenerates it by burning off foulants that would otherwise reduce the carbon's ability to adsorb metals in the leach circuit.

Carbon leaving the kiln will fall into a water-filled quench tank, which will keep it from continuing to burn. The quench tank will also serve as a holding tank for carbon that is ready for use in the leach circuit. Regenerated barren carbon will be pumped from the quench tank to the first leach tank via a barren-carbon sizing screen, which will remove the fines and dewater the carbon.

Carbon Pre-Attrition: Bags of new carbon are to be processed in a pre-attrition tank before being sent to the leach circuit. This process will break off the corners of the angular, coconut-shell-based carbon particles and separates them so they do not end up in the leach circuit. The new carbon is to be charged to the pre-attrition tank via a bag breaker where water is to be added to produce an effective solids density of about 50 percent carbon. A high-intensity agitator will stir the carbon slurry vigorously to break off the sharp corners, reducing the angular particles to a more spherical shape. Once complete, the new carbon will be pumped to the regeneration-kiln-quench hopper where it will be held to be added to the leach circuit via the carbon-sizing screen, which will separate the fines from the coarse carbon.

Carbon Transport Water: All carbon movements in the elution and regeneration circuits are to be accomplished using carbon-transport water. A transport-water tank and pump are planned to supply transport water to carbon movement demands as needed. As the carbon arrives at the elution column, strainers in the column-discharge ports allow the transport water to exit while the column retains the carbon. Transport water will pick up fines when moving carbon from one place to another due to both the previous process and the attrition associated with the carbon movement itself. Once the movement is complete, strained or decanted transport water will report to a small carbon-fines clarifier where flocculant will settle the fines and the overflow water recharges the transport-water tank. Process water can be added as necessary to maintain the level in this tank to account for leaks and spillage. The carbon fines are to be removed from the clarifier underflow periodically and shipped to the refinery to recover contained precious metals.

Gold Room

The gold room will house the electrowinning cells, smelting furnace, and associated support equipment within a security envelope that will limit access to authorized gold-room personnel only. Access in and out is to be controlled by security personnel at both a man door and a vehicle-access roll-up door for the armoured car. The armoured-car door is to be enclosed by a fence with an automated gate controlled by security personnel. The exception to this will be an emergency exit door which will set off alarms when opened from the inside. Once per week, both the CIL and gravity-electrowinning cells will be opened, and the sludge cleaned out manually with a high-pressure spray gun. Sludge from the clean-up will flow by gravity to the electrowinning-sludge-filter feed tank and into manually operated pressure canister filters to be dewatered. Dewatered sludge is to be collected in trays and placed in the drying oven overnight. No evidence was found of mercury-bearing minerals, so no mercury retort has been included in the design.

Dried sludge will be removed from the oven the next day and combined with fluxes in a flux mixer before being charged into the smelting furnace. The dried sludge and flux mixture must be completely dry to avoid explosions when adding it to the furnace on top of an already melted charge. Once all the mixture has been added to the furnace, and sufficient time is allowed for the melt to become fully liquid, the slag will be poured off into a conical slag pot. The liquid metal can then be poured into a mold cascade to allow multiple bars to be poured at once. Cooled doré bars will be cleaned and stamped, and the bars will then be placed in the gold-room safe to await shipment to the refinery via armoured car.

Dust collection will be provided in the gold room for flux mixing. Mist scrubbers are planned for the electrowinning cells and smelting-furnace off gasses and extraction fans.

Cyanide Detoxification and Tailings Deposition

A cyanide-destruction circuit has been included in the design to comply with the tailings-discharge permit requirements. Testwork shows that SO2/air process was the most effective detoxification method and the only one to reduce weak acid dissociable (WAD) cyanide levels to 0.1 ppm.

The CIL tailings will be pumped to the 2-stage agitated cyanide-detoxification tanks, where lime will be added to buffer pH, copper sulfate will be added as a reaction catalyst, and sodium meta-bisulfite (SMBS) will be added as a source of SO2. The tanks are sized to provide two hours of residence time for the reaction to proceed to completion. Detoxified slurry will overflow the second detoxification tank to the final tailings pump box where it will be pumped to the TSF by the final tailings pumps. At the TSF, the tailings will be deposited using spigotting manifolds positioned along the rim of the impoundment to create low-angle deposition beaches. The position of the spigotting manifolds will be moved periodically to produce an even beach head and push decant water towards the decant-water pool. A pontoon-mounted decant-return water pump will be provided to pump decant water back to the process-water tank for re-use in the plant.

Reagents

The reagents will be prepared and stored in separate self-contained areas within the process plant and delivered by individual metering pumps or centrifugal pumps to the required addition points. Acidic and basic reagents are to be stored and mixed in physically separated areas to ensure no exposure of cyanide to acidic chemicals, which would generate hydrogen-cyanide gas.

Estimated reagent consumptions are estimated as follows:

Sodium cyanide - 0.93 lb per ton processed
Lime - Eight lb per ton processed
Sodium metabisulphite - 3.92 lb per ton processed
Hydrated Lime: Preparation of the hydrated lime will require:
A bulk-storage silo;
A mixing tank;
Dosing pumps feeding a ring main; and
Automatically-controlled dosing points from the ring main.

Hydrated lime will be used in leaching and detoxification for pH control. The hydrated lime will be delivered to site by bulk tanker and blown into a bulk-storage silo. Process water will be added at the same time to maintain the mixture strength of 20 percent, forming a milk-of-lime suspension. Milk-of-lime will be distributed to the various dosing points using a ring main that provides constant flow to various destinations. Dosing will be accomplished with drop lines off the ring main with automated on-off valves that open when pH is low and close when the operator specified target is reached.

Sodium Cyanide: Preparation of NaCN will require:

A bulk handling system;
Mixing and holding tanks; and
Dosing pumps.

NaCN will be used in leaching as a lixiviant and in elution as a carbon-stripping aid. Cyanide will be delivered to site in one-ton bulk bags contained within wooden boxes and stored in a separate area of the plant from the other chemicals. The NaCN will be dosed from the cyanide-storage tank to dosing points via dedicated positive-displacement metering pumps. The discharge piping is to be arranged such that the low-use pumps can be used as back-up spares for the leach-dosing pump. When the cyanide-storage tank level is low, a cyanide-mix batch is started by removing a cyanide bulk bag from its box and dropping it onto a bag breaker, which discharges cyanide into the mix tank. The mix tank will have been previously filled with sufficient raw water, and buffered with sodium hydroxide to pH 12, to produce a cyanide-mixture strength of 28 percent. Once mixing is complete and there is sufficient room in the holding tank, the mixed cyanide solution will be pumped to the cyanide-storage tank by a NaCN transfer pump.

Sodium Hydroxide: Preparation of sodium hydroxide will require dosing pumps. Sodium hydroxide is to be delivered to site in 275-gallon totes at about 50 percent solution strength. It will be dosed to its various demands at full strength using dedicated positive-displacement metering pumps. Sodium hydroxide will be used for pH control in cyanide mixing and in the ILR. It will also be used as an electrolyte in carbon elution/electrowinning.

Sodium Meta-bisulfite (SMBS): Preparation of SMBS will require:

A bulk-handling system;
Mixing and holding tanks; and
Dosing pumps.

SMBS will be used as a source of SO_2 for cyanide destruction with the SO_2/air process. It will be delivered to site in one-ton bulk bags and will be stored in the reagents-storage building. The SMBS will be held in the SMBS storage tank after it is mixed. When the storage-tank level is low, a SMBS mix will be started by dropping a bulk bag of SMBS onto a bag breaker, which discharges SMBS into the mix tank. The mix tank will have been previously filled with sufficient process water to produce a mixture strength of 20 percent. Once mixing is complete, and if there is sufficient room in the holding tank, the mixed SMBS solution will be pumped to the SMBS holding tank by a SMBS-transfer pump. From the storage tank, SMBS will be dosed to the detoxification circuit via dedicated positive-displacement metering pumps for each stage. A third pump is provided as an installed spare for the detoxification-dosing pumps.

Copper Sulphate: Preparation of copper sulfate will require:

A bulk-handling system;
A combined mixing/storage tank; and
Dosing pumps.

Copper sulfate will be used as a catalyst in cyanide destruction by the SO_2/air process. It will be delivered to site in one-ton bulk bags and will be stored in the reagents storage and handling building. Copper sulfate will be mixed and stored in a combined mixing/storage tank laid out such that the mixing tank will be directly above the storage tank and mixed solution will flow by gravity into the storage tank. When the storage-tank level is low, copper sulfate will be added to the mixing tank by dropping a bulk bag onto a bag breaker, which discharges copper sulfate into the mix tank. The mix tank will have been previously filled with sufficient process water to produce a mixture strength of 15 percent. Once mixing is complete, and there is sufficient room in the holding tank, the mixed copper-sulfate solution will be transferred by gravity to the holding tank. From there, copper sulfate will be dosed from the storage tank to the detoxification circuit via duty/standby positive-displacement metering pumps.

Hydrochloric Acid: Preparation of hydrochloric acid will require a mixing tank and dosing pumps. Hydrochloric acid will be used to remove lime scale from loaded carbon in the acid-wash column of the elution circuit. It will be delivered to site in 275-gallon totes at about 32 percent solution strength and will be stored in the reagents storage and handling building. Hydrochloric acid will be mixed with raw water in a dilute-acid mixing tank to three percent strength and pumped to the acid-wash column with a dedicated dilute-acid transfer pump.

Process Plant Air Services

Low-Pressure Air: Three low-pressure air blowers will supply air to the pre-aeration, leach, and detoxification tanks. The installed blowers will be multiple-stage, centrifugal-type blowers and will be used with a "blow-off" arrangement to adapt to fluctuations in air demand.

Plant & Instrument Air: Two rotary-screw plant air compressors will provide high-pressure compressed air, operating in lead-lag mode, to meet the demand for plant and instrument-air requirements. Wet plant air will be stored in the plant-air receivers to account for variations in demand prior to being distributed throughout the plant. Instrument air will be dried in the instrument-air dryer before distribution throughout the plant.

Process Water Services

Raw Water: Raw water will be pumped from borehole wells to a 200,000-gallon raw-water storage tank located in the water-services area for feed to the plant. Raw water is to be supplied to the plant by two raw-water pumps in a duty/standby configuration. Raw water in the raw-water storage tank will be used to supply the process-water tank, gland water, reagent mixing, and fire-protection requirements.

Potable Water: Potable water will be sourced from the raw-water tank and treated in the potable-water treatment skid. The treated water will be stored in the potable-water storage tank for use by two potable-water pumps in a duty/standby configuration.

Gland Water: Gland water will be supplied from the raw-water tank and distributed to the plant by two gland-seal water pumps in a duty/standby configuration.

Process Water: Process water will be comprised mainly of TSF reclaim water. Process water is to be stored in the process-water storage tank and distributed by the two process-water pumps, in a duty/standby configuration.

Quality Control Assay and Metallurgical Laboratory

The Grassy Mountain process plant will be equipped with automatic samplers to collect shift and routine samples for aqua-regia digestion, atomic-absorption analyses, and fire assays. The samples to be analyzed will include head, intermediate products, tailings, and doré. The data obtained will be used for product quality control and routine process optimization.

The metallurgical laboratory will perform metallurgical tests for quality control and process-flowsheet optimization. The laboratory will include equipment such as laboratory crushers, ball mill, sieve screens, bottle rollers, leach reactors, balances, DO2 meters, and pH meters.

Projected Energy Requirements

Process-related power consumption is estimated to be 53.3-kilowatt hour (kWh) per ton processed.

Chemical Storage and Use

The volume and shipment frequency of fuels and reagents used in process is shown in the Fuels and Reagents Volumes and Shipments table below. Acid solutions, caustic soda, and concentrated cyanide solutions will be delivered to the site in liquid form. Containment of process solutions is based on 110 percent of the largest containment volume for each reagent.

Acid will be stored in the absorption, desorption, and refining (ADR) building and limited to individual totes or barrels that are used in the acid area and will not exceed 1,300 gallons. The volume of acid stored in the building will be less than the largest acid tank, which will be the acid wash vessel having a volume of 2,320 gallons.

Cyanide solution will be delivered to the Project in concentrated liquid form. Cyanide solution will be discharged from a liquid tank truck to a 10,000-gallon storage tank. The cyanide solution will then be metered to various points throughout the plant. The transfer of the cyanide solution from the delivery truck to the cyanide tank will be done on a contained concrete slab that drains to the cyanide containment sump.

Delivery and storage of caustic soda solution will be the same as for cyanide. Caustic soda solution will be received in a 10,000-gallon tank, diluted, and then distributed to the plant. Liquid caustic soda will be delivered to the mine site at 50 percent concentration and diluted to 20 percent concentration for use on site. Transfer of caustic soda solution will occur on the same concrete slab used for cyanide solution.

Hydrocarbon products, including lubricants, oils, antifreeze, and used oil will be stored at the truck workshop. Reagents will be transported, stored, and used in accordance with federal, state, and local regulations. Diesel fuel and hydrocarbon products will be stored in primary (tanks, tote bins, barrels) and secondary containment to prevent release to the environment. Used oil and used containers will be disposed or recycled according to federal, state, and local regulations.

Petroleum Contaminated Soil Management

Calico will submit a Petroleum Contaminated Soil Management Plan to the Oregon DOGAMI and BLM describing how all petroleum contaminated soils will be transported to an off-site facility.

The following is a brief summary of the detoxification process that will be used at the proposed Grassy Mountain Mine.

Cyanide Detoxification—Grassy Mountain Project:

Overview:

Tailings from the CIL circuit that no longer contains gold will flow to the carbon safety screen prior to reaching the cyanide detoxification stage. The slurry contains cyanide species that are not suitable for release from the process plant, as such a detoxification process is completed. After being screened the slurry is sent to the cyanide detoxification circuit. In this circuit reagents are added to facilitate the breakdown of cyanide species to acceptable levels before reporting to the tailings pumpbox and being sent to the tailings management facility.

Process Background

The cyanide detoxification stage of a gold processing operation is the location where the process slurry reports prior to tailings management to reduce the level of Weak Acid Dissociable (WAD) cyanide and in turn the total cyanide released from the plant.

WAD cyanides are described as weak metal complexes that form during the leaching stage of the operation. Typical metals seen in these complexes include copper, zinc and nickel. The concern with these complexes are that they dissociate in solution to produce an environmentally significant concentration of free cyanide that could pose a risk to the environment and wildlife, or persist on a longer term basis due to a resistance to natural degradation.

The detoxification circuit receives all of the slurry from the upstream processes with the addition of acid rinse solution from the elution circuit and sump slurry on an intermittent basis from several areas within the plant. During the detoxification process the reaction will convert the free cyanide in solution to the less toxic cyanate ion. This is achieved through the SO_2/Air reaction utilizing a copper catalyst, the reaction is seen below.

$$CN^- + SO_2 + O_2 + H_2O \rightarrow OCN^- + H_2SO_4$$

The free cyanide and WAD cyanide are oxidized during the reaction to form the cyanate and sulphuric acid. The reaction typically operates in the pH range of 8 to 9 therefore requires the addition of lime to counteract the production of acid.

The reaction requires a soluble copper catalyst to achieve the cyanide reduction. The copper is typically administered in the form of a soluble copper sulphate pentahydrate solution. In some cases, copper may already be in solution as a result of it being native to the ore being mined. In these instances, the copper sulphate addition may not be necessary.

Iron cyanide removal is initiated by the reduction of iron from the ferric to the ferrous state. Following this step the reaction will then react with a soluble metal cation to produce a precipitate. The same will be the case for trace metals that will be precipitated as their hydroxides. The remaining thiocyanate and cyanate are reduced by means of oxidation and hydrolysis respectively.

Through this process the key cyanide species of interest are converted into chemical species acceptable for discharge to the tailings management facility.

Once in the tailings management facility processes such as photodegradation by UV light and biodegradation will also contribute to the minimization of cyanide species in a lined Tailings Management Area where precautions are implemented to minimize the impact to the impact to wildlife.

Carbon Safety Screen

Tailings from the CIL circuit flows by gravity to the Carbon Safety Screen. The safety screen retains any carbon that has reported with the slurry due to a leak in inter-stage screen mesh or seals in the CIL circuit. Water sprays on the vibrating screen deck to wash off process slurry from the carbon particles before reporting to a tote box. Screen underflow flows to the Cyanide Detoxification Tanks.

Cyanide Detoxification Tanks

The cyanide detoxification circuit provides sufficient residence time for the detoxification reaction. In addition to this, acid wash effluent from the acid wash column of loaded activated carbon and the area sump pump discharge are also added to the Cyanide Detoxification Tank on an intermittent basis.

The cyanide detoxification circuit reduces weak acid dissociable cyanide (CN_{WAD}) to a target value. Air supply for the detoxification reaction is supplied to each cyanide destruction tank via a dispersion cone mounted to the bottom of each tank to maintain a high redox potential to maximise oxidation of the cyanide. The tanks utilize dual-impeller high shear agitators to enhance air dispersion and dissolution in the slurry to meet the oxygen demand of the cyanide destruction process. A sodium metabisulphite solution (a source of SO_2) is added to the slurry in the tanks. Copper sulphate solution, when needed, is dosed as catalyst for the cyanide detoxification process while lime slurry is added from a ring main into each tank to maintain the desired pH of 7.0 to 9.0.

The slurry will be reduced from a CN WAD concentration of 100 ppm from the CIL circuit to the target concentration before the slurry is discharged to the Tailings Pumpbox and pumped to the Tailings Management Facility.

CYANIDE DETOXIFICATION:
INCO SULFUR DIOXIDE/AIR PROCESS

DRAFT

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DISCLAIMER AND ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

As a National policy, the Environmental Protection Agency (EPA) is integrating the concept of pollution prevention and waste minimization in many of its activities. Both the Resource Conservation and Recovery Act (RCRA) and the Pollution Prevention Act of 1990 (PPA), encourage the reduction in volume, quantity and toxicity of waste. While RCRA focuses primarily on the reduction in volume and/or toxicity of hazardous waste, the PPA encourages maximum possible elimination of all waste through source reduction.

EPA believes that there are pollution prevention/waste minimization practices currently being implemented by the mining industry. Many of these practices may, in addition to their environmental benefit, realize significant cost savings. It is EPA's intent to identify these practices and foster technology and information transfer throughout the mining industry.

Recognizing that unique issues are associated with the mining industry, such as large volumes of raw material used and waste generated, EPA has conducted research to identify the potential for pollution prevention/waste minimization in the mining industry. This report highlights the INCO Sulfur Dioxide/Air Process which was patented in 1984 to remove cyanide and base metal complexes from industrial wastestreams. Information used to prepare this report was either provided by INCO Exploration and Technical Services Inc. or collected from publicly available documents.

2.0 INCO'S CYANIDE TREATMENT TECHNOLOGY

2.1 INCO Treatment of Tailings Pulps or Slurries

The precious metals mining industry's use of cyanide to extract precious metals from low grade ores is widespread. Cyanidation is the predominant method for precious metals beneficiation and is used on heap leaches or in tank operations to liberate precious metal values from remaining gangue in the ore. Several cyanide detoxification technologies have been developed to treat cyanidation wastes. The International Nickel Company's (INCO) sulfur dioxide/air process is one of two patented sulfur dioxide processes (Devuyst et al., 1992). The other process is patented by Noranda Inc. Both processes are similar with some limited differences in operating procedures. (McGill and Comba 1990)

The INCO process has been commissioned at more than 36 sites in North America. Ten sites are located in the U.S. and are listed in Table 1. Six of these 10 sites, use the INCO process to treat tailings prior to disposal. After treatment, tailings are typically disposed of in a tailings impoundment subject to zero discharge requirements under the Clean Water Act. In addition to Federal Clean Water Act standards, many states have solid waste-related discharge standards for the tailings prior to discharge to the tailings impoundment and the INCO treatment process is used to meet these State requirements.

Table 1. Sites Using INCO Process in the U.S.

Operation	Commissioning Date	Location	Tonnage (MT/D)/CN in Feed	Effluent Type/ CN in Effluent
Colosseum	1987	California	3,600/350	CIP Tails/1
Mineral Hill	1989	Montana	500/150 to 500	Barren/ < 1
Snow Caps	1990	California	Heap	Rinse Water
McCoy/Cove	1990	Nevada	7,500/500-1,000	Thickener U/F / < 10
Kettle River	1990	Washington	1,500/250	CIP Tails/ < 10
Citigold (Ryan Lode)	1991	Alaska	Heap	Pond
Barrick Mercur	1992	Utah	5,000/50	CIP Tails/ < 1
Grant	1992 (Process complete)	Alaska	- - -	Unused cyanide pellets were treated in tanks.
Hayden Hill	1992	California	- - -	Tails
San Luis	1992	Colorado	- - -	Tails

2.2 Treatment Chemistry

In the INCO process, free cyanide and weakly or moderately bound metal-cyanide complexes present in the wastestream are oxidized to cyanate (CNO^-) by the addition of sulfur dioxide and oxygen according to the following stoichiometric reaction:

$$CN^-_{WAD}(1lb) + SO_2(2.64lb) + O_2(1.23lb) + H_2O \text{ yields } OCN^-(1.88lb) + H_2SO_4(3.77lb)$$

(Cyanide + Sulfur Dioxide + Oxygen + Water **yields** Cyanate + Sulfuric Acid)

The reaction usually takes place in a well-mixed and aerated reactor. The aeration provides mixing and oxygen. Sulfur dioxide may be supplied to the reactor in a gas or liquid state, or by the application of sodium sulfite or sodium metabisulfite. INCO has reported actual SO_2 dosages to be 3 - 5 g/g CN_T for barren solutions and 4 - 7 g/g CN_T for tailing slurries. Theoretical reagent consumption for sulphur dioxide was 2.5 mg SO_2/mg WAD cyanide and for lime, 2.2 mg CaO/mg

WAD cyanide. (Smith and Mudder, 1991). Higher dosages are reportedly required to treat low concentrations of weak acid dissociable (WAD) forms of cyanide (Vergunst et al., 1991). The reaction is pH dependent: the optimal pH range is 8 - 10. Incomplete oxidation may occur at pH levels > 11. At pH levels below 8, there is a reported reduction in the reaction rates. Since the oxidation reaction results in the formation of sulfuric acid, lime or caustic is added to maintain the optimal reaction pH. The presence of a copper catalyst at an approximate concentration of 50 mg/L is also necessary for the reaction to take place. If the copper concentration naturally present in the wastestream is too low, then supplemental copper may be provided by the addition of copper sulfate solution to the reactor contents.

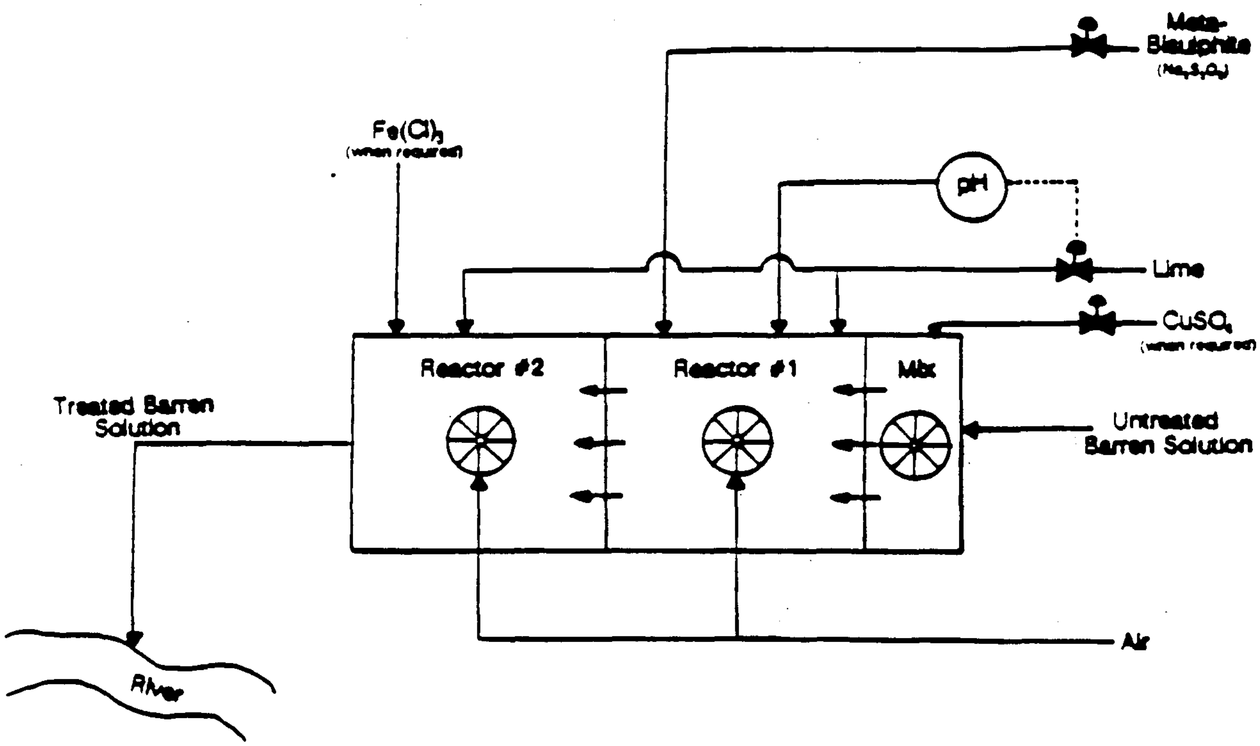
Although oxygen is also added to the reactor, the literature is not specific as to recommended dissolved oxygen operating levels. This is probably dependent on site specific conditions. The oxidation reaction has also been reported to be temperature dependent. At 25°C, the reaction is rapid and results in a residual cyanide concentration of 0.2 mg/L whereas at 5°C the reaction is slow and results in a residual cyanide concentration of 2.0 mg/L (McGill and Comba, 1990).

In addition to the oxidation of cyanide, metals are also removed from solution by precipitation as metal hydroxides. Unlike the alkaline chlorination oxidation process, the INCO process is capable of removing stable iron-cyanide complexes from solution. Ferricyanides are reduced to insoluble ferricyanide salts and precipitated from solution. The presence of iron-cyanide complexes is undesirable given their ability to decompose in the presence of sunlight, releasing free cyanide. Under typical operating conditions, only 10-20% of thiocyanate is removed. This reportedly results in lower chemical requirements for the SO_2 compared to other oxidation processes and also ensures removal of the more toxic forms of cyanide. Additional removal of thiocyanate is possible by continuing the application of SO_2 following the complete oxidation of the free and complexed forms of cyanide.

The typical INCO treatment system components consist of a single reactor (sometimes two parallel units), SO_2 storage and feed system, lime or caustic chemical feed system, copper sulfate chemical feed system (if needed), and an aeration system. For certain situations where the wastewater contains high nickel concentrations or when arsenic removal is required, multiple stage reactors have been used. (See Figure 1) Since the typical INCO system does not remove significant levels of thiocyanate, cyanate, or ammonia, additional treatment units may be necessary to meet more stringent permit limits for those parameters. Maintaining control of the pH may be difficult due to the formation of a dense slurry in the process of neutralizing the strong acid produced during the process. (Smith and Mudder, 1991)

Figure 1. A Typical Two-Stage Inco Process for Cyanide and Metals Removal

(Source: Smith and Mudder, 1991)



All three parameters, thiocyanate, cyanate, and ammonia, have the potential to contaminate ground water and are toxic to fish. Ammonia may result in increased nitrate levels in ground water assuming nitrification takes place in the upper soil layers. Additional ammonia may be produced by the hydrolysis of cyanate in waters retained in tailings ponds. The retention of precipitated metal hydroxide sludges in tailings ponds may also have undesirable environmental effects. The tailings remaining from the INCO oxidation process may have a considerable heavy metal content. If the sludge is stored for extended periods in unlined (or improperly lined) ponds, there is potential for the metals to migrate into the groundwater.

2.3 Costs

Costs for the installation and operation of INCO's SO_2/Air cyanide destruction facility varies according to the size of the operation, and desired effluent targets. It was not determined how INCO compared to the alkaline chlorination or hydrogen peroxide treatments in similar cases.

Capital Costs

Main equipment components of the INCO process include a reaction tank, a mixer with motor and support, an air compressor or blower with associated piping, an SO_2 reagent system with associated instrumentation and piping, a copper sulfate delivery system (when required) and a lime delivery system. Use of sulfur dioxide roaster gas rather than powdered sodium sulphite or sodium meta-bisulphite, or burning of pure sulfur, is the least expensive source of sulfur dioxide for this process, and will keep costs down (Smith and Mudder, 1991).

INCO has found that equipment costs for a large installation, a site producing 3300 stpd or more, (requiring 5 to 10 stpd of SO_2), and treating their pulp tailings, may reach approximately $500,000 (Canadian dollars), or about $1.2 million (Canadian dollars) installed. (Devuyst and Robbins, undated)

Operating Costs

Operating costs include cost of reagents, labor, electric power, maintenance, and licensing fees, and may very between $0.09 to $1.58 (Canadian dollars) per standard ton of ore. Average costs for a plant treating CIP tailings using liquid SO_2 is $1.18 (Canadian dollars) per standard ton of ore. Lower operating costs may be realized in pond water treatment, where natural degradation plays a large role in detoxification. Reagent costs tend to be somewhat low, a distinct advantage of the INCO process, compared to the alkaline chlorination and hydrogen peroxide forms of cyanide detoxification.

INCO's process is patented and requires a license to operate. The associated licensing fee is determined on a site specific basis. INCO also offers services to determine process specifications and equipment needs, and provide training and all other assistance to get the process up and running. Services are also negotiable within the framework of the license.

2.4 Benefits

The INCO treatment process treats cyanide (including ferricyanide) contaminated wastes and may be effective to concentrations less than 1.0 mg/L. According to INCO representatives, the process is relatively rapid and can be used to treat both slurries and clear solutions. The process has a flexible design, which permits possible incorporation into existing treatment or production facilities and can be used for either batch or continuous treatment.

According to INCO representatives, the process has one benefit over alkaline-chlorination in that it does not produce cyanogen chloride, as a toxic intermediate reaction by-product. However, other by-products, such as ammonia, cyanate, and thiocyanate may be generated during INCO treatment. Capital and operating costs are comparable with other chemical treatment processes.

2.5 Limitations

Although the INCO process may be effective in treating cyanide concentrations, the process has poor removal efficiency for ammonia, cyanate, and thiocyanate. Tailings treated with INCO may continue to contain ammonia, cyanate, thiocyanate, and metals and additional treatment units may be necessary to meet discharge permit limits for these constituents. Treatment may also result in increased total dissolved solids.

Strict pH control with frequent monitoring is necessary to ensure adequate oxidation of cyanide and metals precipitation. Relatively high reagent consumption (SO_2, lime and copper sulphate) can be expensive.

2.6 Case Study: Echo Bay's Cove-McCoy Mine

INCO completed installation of their largest tailings pulp treatment operation at Echo Bay's Cove-McCoy mine near Battle Mountain in Nevada on September 12, 1990. The INCO sulfur dioxide/air cyanide destruction facility was installed in response to numerous failed and costly efforts to prevent migratory fowl deaths in their 145 hectare tailings pond. (Devuyst, et al. 1992) Installation of the INCO treatment plant detoxified cyanide in the tailings, significantly reducing the numbers of mortalities. (Smith and Mudder, 1991)

The system was designed to treat tailings pulp from CCD underflow at 40 percent solids by weight for a 8,500 short tons per day mill throughput. Tailings pulp containing 268 kg CN_{WAD}/hr at 40% solids is treated with both reactors, (or 134 kg CN_{WAD}/hr per reactor), to a target residual cyanide level of 10 mg/l CN_{WAD}. The SO_2 additions are programmed and controlled by a feed-forward control loop, based on continuous measurement of wt % solids and slurry flow rate, as well as periodical CN_{WAD} analysis. The ratio of SO_2 to CN_{WAD} load is maintained by a feed-back loop in which continuous readings of the treated effluent for pH and cyanide electrode mV's, and periodic readings of residual CN_{WAD} are performed. The ore usually supplies sufficient copper catalyst so that the addition of copper sulfate is rarely needed.

Laboratory data showed that a dosage of 3.7g SO_2/g CN_{WAD} and 60 minutes retention time, yielded an effluent containing less than 5 mg/l CN_{WAD}. During McCoy-Cove's commissioning, a higher SO_2 to cyanide dosage ratio was used to ensure low residual cyanide in the treated tailings. As effluent levels of CN_{WAD} were reduced to 10 mg/L, SO_2 addition levels were reduced to less than 3 g/g CN_{WAD}. According to facility personnel, the current ratio ranges from 2.6 to 4 SO_2/g CN_{WAD}.

As of October 1990, McCoy-Cove increased the cyanide concentration in their leach circuit to increase their gold recovery rate from 82 percent to 90 percent. During the week of November 17, 1990, the cyanide load was at 150 percent of the design load. Currently the facility has cut cyanide consumption and need for treatment by re-using cyanide.

According to facility personnel, tailings are disposed of in the tailings impoundment where WAD cyanide levels are monitored daily and currently range from 4 to 7 ppm WAD cyanide. According to facility personnel, the INCO system is working well with the major concern being the managment and measurement of SO_2.

3.0 CONTACTS

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5.0 COMMENTS AND RESPONSE

Echo Bay Minerals Company submitted comments to EPA and requested that a number of minor edits to the draft be made. EPA has corrected the text to accommodate the requested changes.