May 29, 2018

Mr. Jamie R. Hyslop
U.S. Army Corps of Engineer
Alaska District CEPOA-RD-Hyslop
P.O. Box 6989
JBER, AK 99506-0898
Via E-mail: POA.donlingoldeis@usace.army.mil

Re: Donlin Gold Compensatory Mitigation Plan

Dear Mr. Hyslop,

Thank you for the opportunity to comment on the Donlin Gold proposed Compensatory Mitigation Plan. These comments are submitted on behalf of Earthworks, Earthjustice, Northern Alaska Environmental Center and Cook Inletkeeper.

Cook Inletkeeper is a community-based nonprofit organization formed in 1995 by concerned Alaskans to protect the Cook Inlet watershed and the life it sustains. Northern Alaska Environmental Center is an Alaska-based conservation organization dedicated to protecting the land, waters and wildlife of Interior and Arctic Alaska for current and future generations to use and enjoy. Earthworks is a national non-profit organization dedicated to protecting communities and the environment against the adverse effects of mining, while promoting sustainable solutions. Earthjustice is a non-profit environmental law firm wielding the power of law and the strength of partnership to preserve the wild, to fight for healthy communities and to advance clean energy for a health climate.

In general, we are concerned that the proposed Compensatory Mitigation Plan lacks sufficient information to determine whether wetland losses will be adequately compensated by the proposed mitigations. As a result, Donlin should be required to provide additional information, and apply for a new Section 404 permit. The CMP and final mitigation plans should be re-noticed, with a public comment period in accordance with the 2008 Mitigation Rule. Please see the attached technical comments for more detail.

Sincerely,

Bonnie Gestring
Northwest Program Director
Earthworks
bgestring@earthworksaction.org

Lachlan Gillespie
Clean Water and Mining Program Director
Northern Alaska Environmental Center
Lachlan@northern.org

Tom Waldo
Staff Attorney
Earthjustice
twaldo@earthjustice.org

Bob Shavelson
Inletkeeper and Advocacy Director
Cook Inletkeeper
bob@inletkeeper.org

Technical Report
A preliminary review of Donlin Gold LCC's Final Compensatory Mitigation Plan

The report has been done on behalf of Earthjustice, Earthworks, Northern Alaska Environmental Center and Cook Inletkeepers.

Prepared by Jessica Kayser Forster, MS. Sustainable Growth Solutions, Alaska

This report is a preliminary review of Donlin Gold LCC's Compensatory Mitigation Plan as it relates to specific elements of the 2008 regulation, Compensatory Mitigation For Losses of Aquatic Resources (33 CFR Part 332 and 40 CFR Part 230, subpart J).

Donlin Gold, in accordance with Clean Water Action Section 404 (b)(1) permit guidelines, submitted a compensatory mitigation plan as Appendix M, along with Department of Army Permit POA-1995-120 (Appendix J) as a part of the permittees Final Environmental Impact Statement to the Army Corps of Engineers, April 2018.

This report is specific only to the permittee's final compensatory mitigation plan as it relates to specific elements of the 2008 regulation. It does not offer insight nor opinion on any other aspect of Donlin Gold's EIS. Additionally, this report does not reflect the views of any of the ILF program and mitigation bank sponsors, agency personnel, and/or other Section 404 permittees with whom I have worked or currently work. The comments and considerations within are those of Sustainable Growth Solutions, Alaska.

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INTRODUCTION

As part of Donlin Gold LLC's final Environmental Impact Statement, Donlin Gold has submitted an application for the Department of the Army (DA) Permit for the Donlin Gold Project (POA-1995-120), pursuant to Section 404 of the Clean Water Act (Section 404) and Section 10 of the Rivers and Harbors Act of 1899 (Section 10) to the United States Army Corps of Engineers (USACE). The final permit application is Appendix J of the EIS document.

As part of the Section 404(b)(1) permit guidelines — when there are unavoidable impacts to aquatic resources of significant function, it is the responsibility of the applicant to identify and specify the desired mechanism to carry out the compensatory mitigation and to develop a final mitigation plan. In DA permit POA-1995-120 (Appendix J of the EIS), the applicant is proposing Permittee Responsible Mitigation using a Watershed Approach as the mechanism to carry out the compensatory mitigation and has submitted a final compensatory mitigation plan (CMP) (Appendix M of the EIS). Compensatory mitigation being carried out by Permittee Responsible Mitigation using a watershed approach is regulated under the 2008 regulation entitled Compensatory Mitigation For Losses of Aquatic Resources (The 2008 Mitigation Rule) (33 CFR Part 332 and 40 CFR Part 230, subpart J). The 2008 Mitigation Rule set standards that have to be met by the three different compensatory mitigation mechanisms (Mitigation Banks, In Lieu Fee Programs, and all forms of Permittee Responsible Mitigation (PRM) (PRM under a watershed approach, PRM through on-site and in-kind mitigation, and PRM through offsite and/or out-of-kind mitigation) in order to be approved by the US Army Corps of Engineers (USACE) to take on the mitigation liability and carry out the compensatory mitigation activities.

This report is a preliminary review of Donlin Gold LCC's Compensatory Mitigation Plan (CMP) and how certain sections relate to specific elements of the 2008 regulation, Compensatory Mitigation For Losses of Aquatic Resources (33 CFR Part 332 and 40 CFR Part 230, subpart J).

EXECUTIVE SUMMARY

During the 1980s and 1990s, researchers and on-the-ground implementers began to raise questions whether compensatory mitigation was being successfully implemented and whether it was effectively offsetting permitted impacts, especially for wetland impacts. In response to these concerns, the EPA asked the National Research Council (NRC) to conduct an in-depth, independent evaluation of wetland compensatory mitigation in the CWA Section 404 permit program. In 2001, NRC published its detailed findings and recommendations. The NRC's report highlighted the numerous challenges encountered in successfully implementing wetland compensatory mitigation projects (IWR. 2015).

Based on the findings in the NRC report and recognizing the need to strengthen rules governing wetland compensatory mitigation and the standards and requirements that apply to the various compensatory mitigation providers, Congress enacted Section 314 of the National Defense Authorization Act (NDAA) for fiscal year 2004 (Public Law 108-136). Section 314 of the NDAA required the Secretary of the Army, acting through the Chief of Engineers, to issue regulations to improve compensatory mitigation options. Congress directed that the regulations: maximize available credits and opportunities for compensation for wetland losses, provide flexibility for regional variations in wetland resources and their associated functions and services, and apply equivalent standards and criteria to all providers of mitigation (mitigation banks, in-lieu fee programs and permittee responsible mitigation plans) (IWR. 2015).

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In 2008, the USACE and the Environmental Protection Agency (EPA) published regulations entitled Compensatory Mitigation For Losses of Aquatic Resources (The 2008 Mitigation Rule) (33 CFR Part 332 and 40 CFR Part 230, subpart J).

The failures of compensatory mitigation projects undermine the public's trust and confidence in the mechanisms providing the mitigation and the permitting processes that authorize them. The 2008 Mitigation Rule was written to improve compensatory mitigation outcomes and ensure the regulated public that permitted unavoidable impacts to aquatic resources of significance will be offset and specific mechanisms are put in place to ensure that mitigation outcomes are achievable and successful.

Since 2015, the USACE, Alaska District (Alaska District) has taken considerable steps to bring the district's Compensatory Mitigation Program into compliance with the 2008 Mitigation Rule while also balancing the 1994 Alaska Wetland Initiative. Currently, Mitigation Banks and ILF programs operating throughout the state are ceasing credit sales and updating their program's legal Instruments in order to uphold the regulation. The Alaska District is requiring more substantiated information in order to gain approval of program Instruments and final mitigation plans. Additionally, the Alaska District has put effort into drafting a workable credit-debit method for the state of Alaska that supports the intent of the 2008 Mitigation Rule by incorporating important factors — including functional assessments, time lag, risk, and type of mitigation being proposed— into debit and credit determinations.

If approved, the Donlin Gold's final CMP sets a dangerously low standard for PRM using a watershed approach. As written, the CMP puts the District Engineer (DE) into the very difficult position of assuring the regulated public that enough information was required of the permittee in the development of the CMP and project specific mitigation plans to ensure the compensatory mitigation identified will offset unavoidable permitted impacts to the losses of significant aquatic resource functions documented in the EIS while also providing a level of information equivalent to that of what is being asked of third party mitigation providers operating in the Alaska District and/or working to seek approval to sell credits in Alaska (a key component of the 2008 Mitigation Rule).

Therefore the DA permit POA-1995-120 and accompanying final mitigation plans for the proposed PRM compensatory mitigation projects should not be approved in the record of decision for the project EIS until additional requirements are met. The applicant should address the efforts put forth by the Alaska District to ensure successful compensatory mitigation outcomes by updating the CMP to meet the 2008 Mitigation Rule standards and the standards that mitigation banks and ILF programs around the state are being required to uphold.

The following components of the 2008 Mitigation Rule call into question the completeness of Donlin Gold's PRM CMP (Appendix M), and the final mitigation plans for the Upper Crooked Creek (Attachment D of Appendix M) and Chuitna Preservation Area (Attachment E of Appendix M) projects:

- Mitigation hierarchy (33 CFR Part 332.3(b)/40 CFR Part 230.93(b)),
- Watershed approach (33 CFR 332.3(c)/40 CFR 230.93(c)),
- Fundamental elements of a mitigation plan (33 CFR 332.4(c)/40 CFR 230.94(c)),
- Congressional mandate and intent of the 2008 Mitigation Rule — establishment of equivalent standards for each type of compensatory mitigation: mitigation banks, in-lieu fee programs, and PRM.

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Based on my professional experience working with the Alaska District's Compensatory Mitigation Program over the past seven years and for reasons that will be stated within this report, once Donlin Gold has identified compensatory mitigation sites using a watershed approach that meet the mitigation hierarchy and has developed a final mitigation plan for each compensatory mitigation site, Donlin Gold should apply for a new Section 404 permit. The CMP and final mitigation plans should be public noticed with a public comment period in accordance with the 2008 Mitigation Rule.

REVIEW CONSIDERATIONS

Watershed approach (33 CFR 332.3(c)/40 CFR 230.93(c))

> *Watershed approach* means an analytical process for making compensatory mitigation decisions that support the sustainability or improvement of aquatic resources in a watershed. It involves consideration of watershed needs, and how locations and types of compensatory mitigation projects address those needs. A landscape perspective is used to identify the types and locations of compensatory mitigation projects that will benefit the watershed and offset losses of aquatic resource functions and services caused by activities authorized by [Department of the Army (DA)] permits. The watershed approach may involve consideration of landscape scale, historic and potential aquatic resource conditions, past and projected aquatic resource impacts in the watershed, and terrestrial connections between aquatic resources when determining compensatory mitigation requirements for DA permits (2008 Mitigation Rule definition).
>
> The goal of a watershed approach is to maintain and improve the quality and quantity of aquatic resources within watersheds through the strategic selection of compensatory mitigation sites. The level of information needed to support a watershed approach (33 CFR 332.3(c)) should be commensurate with the proposed impacts to aquatic resources (2008 Mitigation Rule).
>
> The watershed size selected should not be larger than is appropriate to ensure that the aquatic resources provided will effectively compensate for impacts resulting from activities authorized by DA permits. The DE should consider relevant environmental factors and appropriate locally developed standards and criteria when determining the appropriate watershed scale for compensation activities. file://localhost/(https/::www.epa.gov:sites:production:files:2015-07:documents:watershed_approach_handout.pdf).

The watershed approach requires the mitigation provider to determine a specific watershed size to conduct the watershed analysis. The watershed size selected by Donlin Gold in its PRM CMP is confusing and does not address the specific considerations written in the 2008 Mitigation Rule Based on the PRM final mitigation plan, Appendix B, section 6.0 Evaluation of Compensatory Mitigation Options, it seems the applicant selected to use a 10-digit HUC watershed size scale analysis to identify the Upper Crooked Creek (UCC) compensatory mitigation project. If this is the case, Donlin Gold should provide additional information to complete a full watershed approach analysis of the 10-digit HUC (See the end of this section for specific information to be included in the analysis). However, the applicant also states the compensatory mitigation is on-site and in-kind and therefore the sites have been picked accordingly. It is unclear to the reader if the UCC projects were chosen using a watershed approach or by implementing on-site and in-

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kind mitigation. The applicant should clarify and provide any necessary documentation to better explain the watershed approach used to determine the UCC project.

Section 6 goes on to read that once Donlin Gold exhausted options available in the 10 Digit HUC watershed, the permittee: "followed USACE guidelines in considering the proximity of specific opportunities to the impacted watershed, by first considering those within the middle Kuskokwim River watershed and then expanding out co-centrically, eventually extending to the entire Yukon-Kuskokwim (Y-K) region and then to other watersheds in Alaska (EIS. Appendix M)." This sentence implies to the reader that the watershed size boundary analyzed to identify other compensatory mitigation options and ultimately the Chuitna preservation area was extensive — and greater than a 10-digit HUC watershed approach.

The permit applicant goes on to list other types of off-site mitigation evaluated and reasons for not choosing specific options. Finally, the mitigation plan reads: "After conducting this extensive review, to supplement the reclamation and restoration of placer mined areas in Upper Crooked Creek, Donlin Gold proposes to preserve lands within the Chuitna watershed as compensatory mitigation for the Project. The PRM Plan for the Chuitna Preservation Area is provided in Attachment E."

When reviewing this section, the reader is left uncertain as to the watershed scale size selected by Donlin Gold when it picked the Chuitna Preservation Area. As this section reads now it could be inferred that this area was chosen from a watershed size boundary that spanned two 8-digit HUCs. It seems — because of the lack of background information on the watershed approach taken—that this mitigation opportunity was chosen because it is an existing opportunity with willing landowners in the greater vicinity of impacts, not because Donlin Gold conducted a watershed approach analysis and determined based on best available information that the aquatic resource functions in this area as the best to preserve based on the watershed needs identified.

The 2008 Mitigation Rule provides information that should be considered when conducting the watershed approach. Multiple Army Corps districts have developed specific guidance to ensure third party mitigation providers and PRM are successful in implementing a watershed approach when identifying compensatory mitigation options. The applicant should look to these resources to come into compliance with the 2008 Mitigation Rule's - watershed approach.

Below is information taken from the Environmental Protection Agency's informational PDF on the "watershed approach" as carried out under the 2008 Mitigation Rule. This is one resource of many that points to the types of information that need to be documented in order to inform a watershed approach analysis. For final approval, Donlin Gold's PRM CMP could include an in-depth watershed approach analysis that discusses the following information:

> A watershed approach to mitigation considers the importance of landscape position and resource type of mitigation projects for the sustainability of aquatic resource functions within the watershed. It considers how the types and locations of compensatory mitigation projects will provide the desired aquatic resource functions, and function over time in a changing landscape. Considerations include: • Habitat requirements of important species • Habitat loss or conversion trends • Sources of watershed impairment • Current development trends • Requirements of other regulatory and non-regulatory programs that affect the watershed, such as storm water management or habitat conservation programs.

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> A watershed approach to mitigation should include, to the extent practicable: • Inventories of historic and existing aquatic resources, including identification of degraded aquatic resources. • Identification of immediate and long-term aquatic resource needs within watersheds that can be met through permittee responsible mitigation, mitigation banks, or in-lieu fee programs. • Identification and prioritization of aquatic resource restoration, establishment, and enhancement activities, and preservation of existing aquatic resources that are important for maintaining or improving ecological functions of the watershed. • Identification and prioritization of resource needs should be as specific as possible, to facilitate determination of mitigation requirements.
>
> Without an appropriate watershed plan, the DE will use a watershed approach based on analysis of information regarding watershed conditions and needs, including potential sites for aquatic resource restoration activities and priorities for aquatic resource conservation. Such information includes: • Current trends in habitat loss or conversion • Cumulative impacts of past development activities • Current development trends • The presence and needs of sensitive species • Site conditions that favor or hinder the success of mitigation projects • Chronic environmental problems such as flooding or poor water quality. Information sources can include: wetland maps; soil surveys; U.S. Geological Survey topographic and hydrologic maps; aerial photographs; information on rare, endangered and threatened species and critical habitat; local ecological reports or studies; and other sources that could be used to identify locations for suitable compensatory mitigation projects in the watershed. The level of information and analysis needed must be commensurate with the scope and scale of the proposed impacts requiring a DA permit, as well as the functions lost as a result of those impacts. https://www.epa.gov/sites/production/files/2015-07/documents/watershed_approach_handout.pdf).

The final mitigation plan for Donlin Gold's PRM compensatory mitigation should include more information on the watershed size boundary and watershed approach analysis. The permittee must clarify the level at which it is conducting the watershed approach analysis before the public and the USACE can determine if the watershed approach as stated in the 2008 Mitigation Rule is being followed in this permit decision.

Mitigation hierarchy (33 CFR Part 332.3(b)/40 CFR Part 230.93(b))

The 2008 Mitigation Rule requires the DA to follow a hierarchy for choosing compensatory mitigation options to offset permitted impacts. The hierarchy is based upon the likelihood of compensatory mitigation plans being both successful and sustainable:

- Mitigation Bank Credits
- In Lieu Fee (ILF) program credits
- PRM under a watershed approach
- PRM though on-site and in-kind mitigation
- PRM through off-site and/or out of kind mitigation

In Donlin Gold's PRM CMP, the permittee states it is choosing to carry out PRM under a watershed approach because of the lack of available mitigation bank and ILF program credits. While it is true that there are no third party mitigation providers with available credits near the impact site, the watershed boundary from which the permittee is conducting the "watershed approach" to identify compensatory mitigation projects has not been clearly described in the final CMP (See Watershed Approach section above).

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In reading the CMP, it is impossible to determine if the compensatory mitigation is in fact PRM under a watershed approach and or PRM through on-site and in-kind mitigation and/or off-site and or out-of-kind. Because of this, it is difficult to determine if there are in fact bank or ILF credits available. Until Donlin Gold and the DE determine the watershed size boundary for the watershed approach analysis to be conducted, it is inconclusive as to whether or not the ILF credits available in the Matanuska Susitna area will be inside or outside of this boundary and therefore an option for the permittee. Though these credits would not satisfy the total compensatory mitigation needs for this permit, they could satisfy a part of the total amount. In cases like Donlin Gold, even if there were mitigation banks and ILF programs operating in the vicinity of the impacts, it would be difficult to imagine these sponsors having enough credits to meet the compensatory mitigation needs of an applicant with permitted impacts to thousands of acres of wetland and miles of streams. In these situations, the PRM applicant should fulfill its mitigation requirements using the suite of third party mitigation options available in the watershed boundary established before being allowed to opt for PRM.

In many areas in Alaska, often the only demands for ILF and mitigation bank credits are large industrial scale projects with extensive impacts. By requiring permittees to purchase third party mitigation credits first, and only then allowing them to obtain the remaining mitigation requirements as PRM, the Alaska District will be able to uphold the intent of the 2008 Mitigation Rule mitigation hierarchy and ensure enough business to mitigation banks and ILF programs in order to keep their mitigation programs operating.

A model for Donlin Gold and other permittees with sizable impacts and proposing to do PRM is the Alaska Department of Transportation, Southeast Alaska program, Angoon Airport Project, 2018. To fulfill its compensatory mitigation needs for impacts vastly smaller than Donlin Gold but still substantial (estimated 300 wetland acres), the Alaska District and IRT have encouraged the applicant to purchase any credits available from banks and ILF programs before offsetting the remaining mitigation liability using PRM.

In conclusion, the permittee must clarify the level at which it is conducting the watershed approach analysis before the public and the USACE can determine if the compensatory mitigation hierarchy as stated in the 2008 Mitigation Rule is being followed in this permit decision.

Fundamental elements of a mitigation plan (33 CFR 332.4(c)/40 CFR 230.94(c))

The 2008 Mitigation Rule establishes 12 fundamental elements that all mitigation plans must address and provides guidance on how to address them. There is no specific guidance for PRM in Alaska. However, around the country there are several Army Corps districts that have developed formative documents that support permittees in completing PRM mitigation plans. Based on the level of content in the mitigation plans for each compensatory mitigation project identified as well as the size and scope of both the permitted impacts and mitigation sites, requesting additional information from the permittee for each of the 12 elements of the mitigation plans for the UCC PRM project and the Chuitna PRM project is warranted.

> A mitigation plan is required for all forms of compensatory mitigation. A compensatory mitigation plan that consists of purchasing the appropriate number and type of mitigation credits from an approved mitigation bank or in-lieu fee program is presumed to be environmentally preferable, and requires less effort than developing and implementing a PRM plan. When a permittee secures mitigation credits from an approved mitigation bank or in-lieu fee program, the responsibility for conducting the

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necessary compensatory mitigation activities is transferred from the permittee to the mitigation bank or in-lieu fee program sponsor. file://localhost/(http/::www.sac.usace.army.mil:Portals:43:docs:regulatory:Guidelines_for_Preparing_a_Compensatory_Mitigation_Planf.pdf).

In order to be authorized as a mitigation bank or ILF, the program sponsor has to invest hundreds of thousands of dollars, demonstrate competence in the different types of compensatory mitigation, and facilitate a multi-year approval process with the Army Corps of Engineers and an interagency review team (IRT). The effort results in a program Instrument signed by the Army Corps. The program Instrument is the legal document that states how the compensatory mitigation sites will be identified, managed, maintained and mechanisms put in place to ensure compensatory mitigation projects are successful and monitored over the long term. PRM does not include a legal Instrument describing how this liability is managed and enforced. Therefore, the only document guiding the implementation, monitoring, enforcement and long-term management and protection of PRM compensatory mitigation project sites is the mitigation plan and accompanying documents. The process to seek approval of a PRM mitigation plans is generally time consuming and requires considerable effort by the permittee to develop a conceptual plan and final plan that puts in place mechanisms to ensure successful implementation, management and enforcement of PRM compensatory mitigation sites. The DE will request information commensurate with the size and scope of the impacts. The regulation mandates that the USACE require the same level of information from PRM mitigation plans as it does from third-party mitigation providers (2008 Mitigation Rule).

Within Donlin Gold's final CMP, Donlin Gold is proposing two PRMs under a watershed approach projects, in two different geographic regions. The permittee has developed a mitigation plan (33 CFR 332.4(c)/40 CFR 230.94(c)) for each project (Attachment, D and E of Appendix M).

Based on the information provided in the CMP, it remains unclear to the reader what watershed size boundary Donlin Gold chose to conduct the watershed analysis that identified these two sites. Therefor the reviewer remains uncertain if the two compensatory mitigation projects identified will meet the needs of the watershed chosen. As stated above, collecting the information for each of the elements of a final mitigation takes a considerable effort, especially for the size and scope of the compensatory mitigation projects Donlin Gold is purposing to carry out under PRM. Before moving forward with developing final mitigation plans for the UCC project and the Chuitna project the permittee should strengthen its watershed approach analysis in order to demonstrate to the DE and to the regulated public that these are the best projects to offset unavoidable losses to permitted impacts, that the aquatic resource functions restored and protected at these sites do in fact meet the aquatic resources needs of the watershed being assessed, and that there are no other bank or ILF credits available.

Once the watershed approach has been effectively carried out, the appropriate compensatory mitigation sites will be identified to offset the permitted impacts. At this point Donlin Gold will be required to develop information for the 12 elements of a mitigation plan as required by the 2008 Mitigation Rule.

Listed below are the 12 elements of a final mitigation plan. Under each element specific concepts outlined in the 2008 regulations are documented in *italic print*. Under the *italic print*, considerations specific to the Upper Crooked Creek (UCC) project and Chuitna Preserve Area (Chuitna) project have been described. These considerations are based on guidance from the 2008 Mitigation Rule and standards that ILF programs and mitigation bankers are meeting in order to

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sell wetland and stream restoration and preservation credits in Alaska. If an element does not have anything specified or if there are only a few points to consider, the lack of comment is not implying that no other information should be required. In fact, this is quite contrary. Based on this preliminary review, if these two projects are found to meet the watershed approach analysis required by the 2008 Mitigation Rule, then, as stated above, additional information for all 12 elements of the final mitigation plan should be required.

The two PRM compensatory mitigation projects as outlined in Donlin Gold's CMP are being proposed to compensate for 2053 permitted wetland impacts and 29.7 miles of permitted stream impacts:

Upper Crooked Creek Watershed Project (UCC project).
Restore and preserve approximately 101.7-acres of wetlands and riparian areas with 8,501-Linear feet (1.61-miles) of stream, and establish another 71.0-acres of riparian preservation buffers, in historical placer mining areas in the Upper Crooked Creek watershed (Donlin Gold. 2018) (Donlin Gold. 2018).

Chuitna Watershed Project (Chuitna project)
Preserve a total of 5,888-acres, of which it is estimated 2,558-acres are wetlands and ponds, with an additional 3,330-acres of upland riparian areas, stream area, and buffers, and 228,325-linear feet (43.24-miles) of streams in the Chuitna watershed (Donlin Gold. 2018).

Overview
On page 4 of Appendix M, under section Memorandum, Donlin Gold list six steps it plans to take to add to the final CMP. Once the information and data for all six of the actions listed on page 4 of the plan are generated and added to the document and additional information is developed for each of the 12 elements of the mitigation plans for the two proposed compensatory mitigation projects, the CMP will be more in compliance with the standards of the 2008 Mitigation Rule.

In the UCC project, the permittee is purposing to restore approximately 101.7 acres of wetlands and riparian areas and 1.61 miles of stream. In Appendix M, Attachment D, the permittee has listed mitigation work categories. These mitigation work categories list the type of restoration projects that will be carried out to offset permitted impacts. The PRM should be required to list each restoration project that is being grouped under the UCC project mitigation work categories and provide specific information for several of the 12 elements of a mitigation plan for each project identified. The DE and regulated public should ensure each restoration activity has: adequate baseline information, a determination of the credits generated at the specific restoration site and how they contribute to the overall number of credits generated throughout the entire UCC project area, a project work plan, a project maintenance plan, performance standards, monitoring plan, long term management plan, adaptive management plan and financial assurances in order to ensure the long term success of each of the different restoration projects being carried throughout the UCC project area.

For the Chuitna project, the permittee does not provide enough information for the following elements of the mitigation plan: the mitigation work plan, performance standards, monitoring requirements for performance standards, a long term management plan, adaptive management plan and financial assurances. The applicant claims that because the Chuitna project is preservation only compensatory mitigation it does not need to provide any or additional detail for these elements. This is not the same standard that the Alaska District is holding preservation-only ILF program and mitigation banker sites too when developing mitigation plans and does not meet

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the standards of the 2008 Mitigation Rule. The DE should require more information for each of the elements before approving the final mitigation plan.

12 Elements

1. Objectives: *A description of the resource type(s) and amount(s) that will be provided, the method of compensation (restoration, establishment, enhancement and/or preservation etc.), and the manner in which the resource functions of the compensatory mitigation project will address the needs of the watershed, ecoregion, physiographic province, or other geographic area of interest.*

Mitigation plans should specify the types and amounts of aquatic resources with as much precision as possible. In both mitigation plans Donlin Gold has provided estimates for the types and amounts. Functional assessments should be used in order to explain which aquatic resource functions at the compensatory mitigation sites will address the needs of the watershed identified. The mitigation plans should discuss the information and data collected from these various wetland and stream functional assessments and how it was used to document function lost at the impact site and functions gained at the mitigation site. If functional assessments are not conducted on aquatic resources being used, the permittee should give a detailed explanation as to why functions were not assessed and specify what approach was used to determine how the compensatory mitigation project meets the needs identified in the watershed approach.

2. Site selection:
A description of the factors considered during the site selection process. This should include consideration of watershed needs, onsite alternatives where applicable, and practicability of accomplishing ecologically self-sustaining aquatic resource restoration, establishment, enhancement, and/or preservation at the mitigation project site.

In this element for the Chuitna project, the permittee should be required to discuss the five criteria (33 CFR 332.3) required of preservation only compensatory mitigation sites. The applicant states, "The Chuitna project contains wetland aquatic resources that are unique to the area and provide valuable ecosystem functions at the watershed level." However, very little information is provided in this element or other elements to substantiate either of these statements.

3. Site protection instrument:
A description of the legal arrangements and instrument including site ownership that will be used to ensure the long-term protection of the mitigation project site.

As written, this element in both the UCC mitigation plan and the Chuitna mitigation plan need additional information in order to assure the regulated public that the aquatic resources will be protected, monitored, managed and financed accordingly over the long-term. In addition, a discussion should be added to both mitigation plans as to what the time frame is for the site protection instruments and why the time frame, if not in perpetuity, was chosen.

In its final form, this element in the UCC mitigation plan should specify what type of protection instrument will be used and a template with specific terms and conditions should be included. The permittee should identify cost categories associated with managing the protection easement and property as well as an explanation of how these funds will be transferred from the permittee to the land manager. If a conservation easement is not going to be required, identifying a third party to enforce the terms of the protection instrument should be considered.

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As written, this element of the Chuitna mitigation plan needs extensive consideration considering the permittee is proposing two deed restrictions and is providing the language intended to be included. Considering the size and scope of the impacts as well as the fact that the two land owners identified to hold the deed restrictions manage their resource assets for profit a discussion as to why a conservation easement held by a third party is not being considered. The permittee should identify costs categories associated with managing the deed restriction and property as well as an explanation of how these funds will be transferred from the permittee to the land manager. If a conservation easement is not going to be required, identifying a third party to enforce the terms of the protection instrument should be considered.

Both properties identified for compensatory mitigation have subsurface right considerations. The topic of subsurface rights is a serious consideration for all compensatory mitigation providers in Alaska. In certain circumstances mitigation bankers and ILF programs have to forego identified projects because subsurface rights have not been secured and/or cannot be secured. A discussion as to whether or not it is possible to get access to the subsurface minerals below the surface of the property boundary being protected for compensatory mitigation by means outside of the site boundary should be documented.

4. Baseline information:
A description of the ecological characteristics of the proposed compensatory mitigation project site and, in the case of an application for a DA permit, the impact site. This may include descriptions of historic and existing plant communities, historic and existing hydrology, soil conditions, a map showing the locations of the impact and mitigation site(s) or the geographic coordinates for those site(s), and other site characteristics appropriate to the type of resource proposed as compensation. The baseline information should also include a delineation of waters of the United States on the proposed compensatory mitigation project site. A prospective permittee planning to secure credits from an approved mitigation bank or in-lieu fee program only needs to provide baseline information about the impact site, not the mitigation bank or in-lieu fee project site.

5. Determination of credits:
A description of the number of credits to be provided, including a brief explanation of the rationale for this determination. (See § 332.3(f).)

> *(i) For permittee-responsible mitigation, this should include an explanation of how the compensatory mitigation project will provide the required compensation for unavoidable impacts to aquatic resources resulting from the permitted activity.*
>
> *(ii) For permittees intending to secure credits from an approved mitigation bank or in-lieu fee program, it should include the number and resource type of credits to be secured and how these were determined.*

For both the UCC mitigation plan and the Chuitna mitigation plan, the method used to determine the number of credits being provided by each compensatory mitigation site is confusing. Based on the mitigation plans for the proposed sites, the compensatory mitigation will provide wetland restoration credits, stream restoration credits and wetland and stream preservation credits. It seems these credits are based on acre and linear foot value. In that, one acre of wetlands restored equals 1 wetland credit and 1 linear feet of stream restored equals 1 stream credit. The Chuitna Project is not proposing any restoration credits only preservation credits. It seems, additional credits are not given for mitigating aquatic resources with significant functions nor are credits deducted for mitigating aquatic resource with little function. In fact there is no discussion of

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function and/or condition as it relates to determining credits. If these assumptions are true, this section of the mitigation plan needs to explicitly state this information.

The sum of the wetland acres and stream linear stream feet impacted does not equal the sum of the wetland acres and stream acres restored and protected under compensatory mitigation. In this scenario, the applicant seems to be purposing a mitigation ratio- where the amounts of permitted impacts is less than the amount of compensatory mitigation being proposed. The PRM should explicitly state how the amount of compensation has been chosen and why the specified amount adequately offsets the impacts. Also, it seems that compensatory mitigation for riparian areas and buffers receive the same amount of credit as wetlands and streams. If this is the case, the permittee should be required to explain why the non-aquatic resources areas generate the same number of credits as the aquatic resources areas.

In the case of both restoration and preservation compensatory mitigation: if the permittee is not going to use a functional or conditional assessment to determine credits, then, at the very least, the permittee should perform the same functional or conditional assessments on the aquatic resources within the impact and mitigation site project boundaries and discuss findings under this element. The final mitigation plans should state the aquatic resource type that is being mitigated and the specific functions and/or conditions that the resource is providing for the watershed should be identified.

In determining how many credits a compensatory mitigation site produces the 2008 Mitigation Rules addresses the following components: time lag, risk, and the five criteria that need to be met for preservation-only compensatory mitigation. In 2016, the Alaska District developed the Alaska District: Credit Debit Methodology, Version 1 (http://www.poa.usace.army.mil/Portals/34/docs/regulatory/specialpns/2016/_Alaska%20District%20Credit%20Debit%20Methodology%20Version%201.pdf?ver=2016-09-21-132006-233).

This document provides detailed information as to what time lag, risk and the preservation criteria are and how third party mitigation providers and PRM can address these components. In the final mitigation plan for the UCC and Chuitna projects Donlin Gold should address time lag, risk and the preservation criteria when determining the number of credits.

6. Mitigation work plan: *Detailed written specifications and work descriptions for the compensatory mitigation project, including, but not limited to, the geographic boundaries of the project; construction methods, timing, and sequence; source(s) of water, including connections to existing waters and uplands; methods for establishing the desired plant community; plans to control invasive plant species; the proposed grading plan, including elevations and slopes of the substrate; soil management; and erosion control measures. For stream compensatory mitigation projects, the mitigation work plan may also include other relevant information, such as planform geometry, channel form (e.g., typical channel cross-sections), watershed size, design discharge, and riparian area plantings.*

The level of information in the mitigation work plan for the UCC project fails to inform the DE and/or the regulated public about the specific restoration activities that will be carried out. Considering Donlin Gold is in the mining business and not the aquatic resource restoration business, the PRM should be required to provide substantial information, including potential third-party entities that will be contracted to ensure restoration activities are performed and monitored adequately.

7. Maintenance plan: *A description and schedule of maintenance requirements to ensure the continued viability of the resource once initial construction is completed.*

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For the UCC project, a maintenance plan for each restoration activity should be developed for the final mitigation plan

For the Chuitna project, a maintenance plan should be developed for the final mitigation plan.

8. Performance standards: *Ecologically-based standards that will be used to determine whether the compensatory mitigation project is achieving its objectives.*

For the UCC project, the permittee should look to USACE guidance on the development of performance standards. Performance standards are instrumental in determining the successful trajectory of restoration projects and to inform the DE if mitigation activities are resulting in functional and conditional lift. Each restoration site should have detailed performance standards, as well as a schedule as to when the standards will be met.

The permittee does not provide any performance standards for the Chuitna project. There are performance standards for preservation-only compensatory mitigation sites. The permittee should develop performance standards in the final mitigation plan for the Chuitna project.

9. Monitoring requirements: *A description of parameters to be monitored in order to determine if the compensatory mitigation project is on track to meet performance standards and if adaptive management is needed. A schedule for monitoring and reporting on monitoring results to the district engineer must be included.*

It is unclear who will be responsible for monitoring the projects carried out under the UCC project Based on the information provided in the long term management plan, site protection instrument, and the information listed under this element. A list of the information required in the monitoring reports should be included, as well as a schedule. Also, it reads under this element for the UCC project that monitoring reports for this area will be produced annually until the area meet performance standards. The mitigation plan does not provide a schedule for performance standards, therefore it is impossible to know when the monitoring period for the projects will end. The time frame required for monitoring should be described.

Additional monitoring requirements for the Chuitna project should be considered.

10. **Long-term management plan:** *A description of how the compensatory mitigation project will be managed after performance standards have been achieved to ensure the long-term sustainability of the resource, including long-term financing mechanisms and the party responsible for long-term management.*

Example template of the long-term management plan should be submitted with the final mitigation plans for the UCC and Chuitna projects. The plan should include who the responsible party is for stewarding the site over the long term. Financial assurances should be listed. A description of how the financial assurances to carry out long-term management are to be distributed and to whom they will be paid should be included.

11. Adaptive management plan: *A management strategy to address unforeseen changes in site conditions or other components of the compensatory mitigation project, including the party or parties responsible for implementing adaptive management measures. The adaptive management plan will guide decisions for revising compensatory mitigation plans and implementing measures to address both foreseeable and unforeseen circumstances that adversely affect compensatory mitigation success. (See § 332.7(c).)*

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12. Financial assurances. *A description of financial assurances that will be provided and how they are sufficient to ensure a high level of confidence that the compensatory mitigation project will be successfully completed, in accordance with its performance standards (see § 332.3(n)).*

In accordance with the 2008 Mitigation Rule, the Alaska District is requiring specific information in regards to financial assurance from third-party providers, including type, amount and how they will be used by and distributed to third parties when needed. There is an abundance of information and resources available to mitigation providers on financial assurance for compensatory mitigation projects. The USACE, Nashville and Memphis Districts developed a draft permittee-responsible mitigation guidance document in May 2016. These districts provide the following information to support PRM develop descriptions of financial assurances in the PRM mitigation plans:

> Financial assurance. For construction phase, maintenance, monitoring, remedial measures, and project success, identify: party responsible to establish and manage the financial assurance, the specific type of financial instrument (e.g., performance bonds, irrevocable trusts, escrow accounts, casualty insurance, letters of credit, etc.), the method used to estimate assurance amount, the date of establishment, and the release and forfeiture conditions. In order to ensure the financial assurances are adequate, an itemized spreadsheet listing costs associated with construction, planting, and maintenance of the mitigation site through the monitoring period (including potential adaptive management measures) should be prepared and included with the mitigation plan.
>
> Identify the schedule by which financial assurances will be reviewed and adjusted to reflect current economic factors. file://localhost/(http/::www.lrn.usace.army.mil:Portals:49:docs:Regulatory:Permittee-Responsible Mitigation Guidance.pdf%3Fver=2017-06-05-175549-910)

The Alaska District does not explicitly require the above information. However, it provides an example of the types of information Donlin Gold could include in both the UCC project and Chuitna project mitigation plans.

Considering the permittee is proposing to carry out over 100 acres of wetland restoration under the UCC project, the PRM final mitigation plan for a compensatory mitigation in the form of restoration and the financial assurance should document considerably more information to ensure the DA and the regulated public that there are financial resources set aside to ensure the success of these compensatory mitigation activities.

Conclusion

Based on my professional experience working with the Alaska District's Compensatory Mitigation Program over the past seven years and for the reasons stated within this report it would be concerning if the DE granted Donlin Gold a Section 404 permit and approved the final CMP with the mitigation plans, as written, for the UCC compensatory mitigation project (Attachment D, of Appendix M) and the Chuitna compensatory mitigation project (Attachment E of Appendix M).

The DE should require Donlin Gold to generate additional information in order to ensure: the watershed approach was implemented, the mitigation hierarchy was followed based on the watershed approach analysis, and the fundamental elements of a mitigation plan are complete for each PRM compensatory mitigation site identified. Once Donlin Gold has developed a final mitigation plan for each compensatory mitigation site a new Section 404 permit should be

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submitted with the updated CMP and final mitigation plans. The CMP and final mitigation plans should be public noticed with a public comment period in accordance with the 2008 Mitigation Rule. The public notice will provide the regulated public and in particular aquatic resource restoration practitioners and land protection agencies (in particular) a chance to review the final mitigation plans to ensure the level of information described for all 12 elements of the plan meet the 2008 Mitigation Rule and are commensurate with the size and scope of the impacts.

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Wrangell joins other Southeast communities, tribes in calling for transboundary mine reforms (https://www.ktoo.org/2021/10/31/wrangell-joins-other-southeast-communities-tribes-in-calling-for-transboundary-mine-reforms/)

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Wrangell's assembly has unanimously called on Canadian regulators to immediately pause permitting, development and expansion of mines upstream from Southeast Alaska's waterways. It's also asking the provincial government of British Columbia to permanently ban the practice of storing liquid mine waste behind earthen dams.

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By Morgan Krakow
Updated: June 14, 2022
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Morgan Krakow

Morgan Krakow is a general assignment reporter for the Anchorage Daily News. She is a 2019 graduate of the University of Oregon and spent the summer of 2019 as a reporting intern on the general assignment desk of The Washington Post. Contact her at mkrakow@adn.com.

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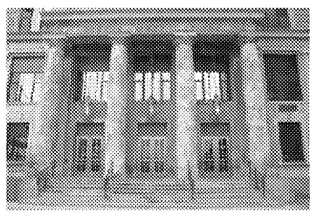

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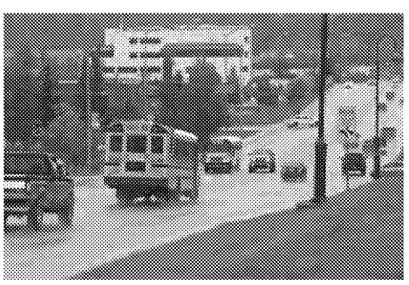

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KUSKOKWIM RIVER

Salmon Situation Report

SEPTEMBER 2021

KUSKOKWIM RIVER
INTER-TRIBAL FISH COMMISSION

Prepared by the Kuskokwim River Inter-Tribal Fish Commission
P.O. Box 190, Bethel, Alaska 99559
(907) 545-6206
info@kritfc.org

This situation report documents the current Chinook and chum salmon disasters on the Kuskokwim River and its impacts on the 33 subsistence-dependent communities in its watershed. The aim of the Kuskokwim River Inter-Tribal Fish Commission (KRITFC) in this report is to communicate the magnitude of our subsistence salmon declines and articulate the critical need for new conservation-based and ecosystem-based management regimes, particularly in their marine environment. These catastrophic Chinook and chum salmon declines, threatening food, cultural, spiritual, and economic security in the Kuskokwim drainage, demand attention and immediate action by the North Pacific Fishery Management Council.

While this report focuses on the impacts of these salmon stock collapses in the Kuskokwim drainage, we are acutely aware that other parts of western and interior Alaska are experiencing the same declines. Recent record-low Chinook and chum salmon returns to the Yukon River have had a devasting impact on subsistence-dependent communities throughout its entire international drainage, and salmon returns to rivers in the Norton Sound region have been in steep decline for nearly two decades.

This situation report is not meant to be a complaint or to dismiss our gratitude for the fish we are able to harvest along the Kuskokwim. Rather, it is meant to be an honest documentation of the experiences of our communities during Chinook and chum salmon shortages so we can effectively and equitably act to maintain our fishing ways of life for future generations.

About the Kuskokwim River Inter-Tribal Fish Commission

KRITFC represents the interests of the 33 federally recognized Tribal governments in the Kuskokwim River (Figure 1) in fisheries assessment and sustainable fisheries management. Its 33 Tribally appointed Fish Commissioners, 7 Executive Council members, and 4 In-Season Managers combine Traditional Knowledge and western science to conservatively manage Kuskokwim fisheries according to Yupik and Athabascan Dené values, subsistence harvest needs, and escapement targets aimed at rebuilding depleted salmon populations.

The values at the core of KRITFC's work are social and environmental justice, equitable and sustainable salmon harvests throughout the watershed, and unity as one fishing people along the Kuskokwim River.

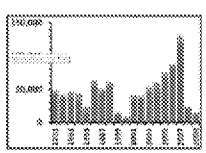
"The decline of chum and kings, they're really hurting us, but we're told to keep going through it with much effort, even [when] we're feeling bad about it. They told us we'll be reaching it, and do not complain too much. Do not complain too much about that. And it's hard not to complain, but we go through it."

ADOLPH LUPIE | TUNTUTULIAK

Kuskokwim River Chinook and Chum Salmon: TIMELINE OF A SUBSISTENCE SALMON CATASTROPHE

2007

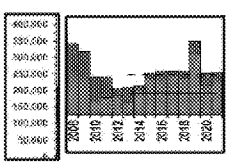
Chinook salmon bycatch in the Bering Sea pollock fishery peaks at 120,000.



(See Figure 7.)

2010-13

Lowest Chinook salmon runs on record. Escapement averages 47,000 fish.



(See Figure 3.)

2014

Chinook salmon crash requires assumption of management by USFWS under ANILCA.

2016

Subsistence-dependent communities sacrifice harvest to successfully meet critical Chinook salmon escapement goals and help rebuild populations.

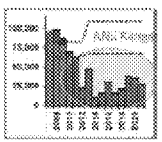
2019

First year of Kuskokwim River chum salmon crash. Stocks declined by over 80% compared to long-term averages. (See Figure 5.)

2021

Chum salmon stocks collapse on both the Kuskokwim & Yukon Rivers by **over 90%** compared to long-term averages. (See Figure 5.)

(See Figure 4.)



Subsistence-dependent communities meet less than half of their Chinook salmon needs for the eighth year in a row.

2021

Salmon bycatch in the Bering Sea pollock fishery continues unabated. As of September 2021:
2021 Bycatch = 13,000 Chinook salmon
2021 Bycatch = 528,000 chum salmon

Multi-Species Salmon Collapse Threatens Food Security and the Foundation of the Subsistence Economy in Kuskokwim River Communities

The Kuskokwim River has historically supported the largest subsistence salmon fishery in the state of Alaska, based on both the number of residents in the 33 villages (Figure 1) who participate in the fishery and the number of salmon harvested (Fall et al. 2011). With some of the lowest per capita monetary incomes in the state, this region is characterized by a high production of wild foods for local use (Wolfe and Walker 1987).

Over the past thirty years, village residents in the Kuskokwim region have annually harvested over 360 pounds of wild foods per person for human consumption, with fish comprising up to 85% of the total poundage of subsistence harvests, and salmon contributing up to 53% of subsistence harvests (Simon et al. 2007; Wolfe et al. 2011). Residents harvest all five species of Pacific salmon: Chinook, chum, coho, pink, and sockeye. One out of every two Chinook salmon caught for subsistence in the state is harvested by Kuskokwim River communities. In other words, salmon-dependent communities in the Kuskokwim watershed utilize half of all Chinook salmon harvested for subsistence state-wide (Figure 2).

Figure 1: KRITFC represents the interests of 33 Tribal communities heavily dependent on salmon for food security and cultural vitality along the Kuskokwim River.

The importance of salmon, particularly Chinook salmon, to residents extends well beyond nutrition and economic values to include socio-cultural identities and a way of life (Ikuta et al. 2013).

Since at least 2009, subsistence-dependent communities in the Kuskokwim drainage have noticed and suffered because of significant and sudden drops in salmon populations, beginning with Chinook salmon and now including chum salmon. The Kuskokwim River is experiencing a catastrophic multi-species salmon decline not seen in living memory. This situation report continues with detailed impacts of this decline on Kuskokwim communities.

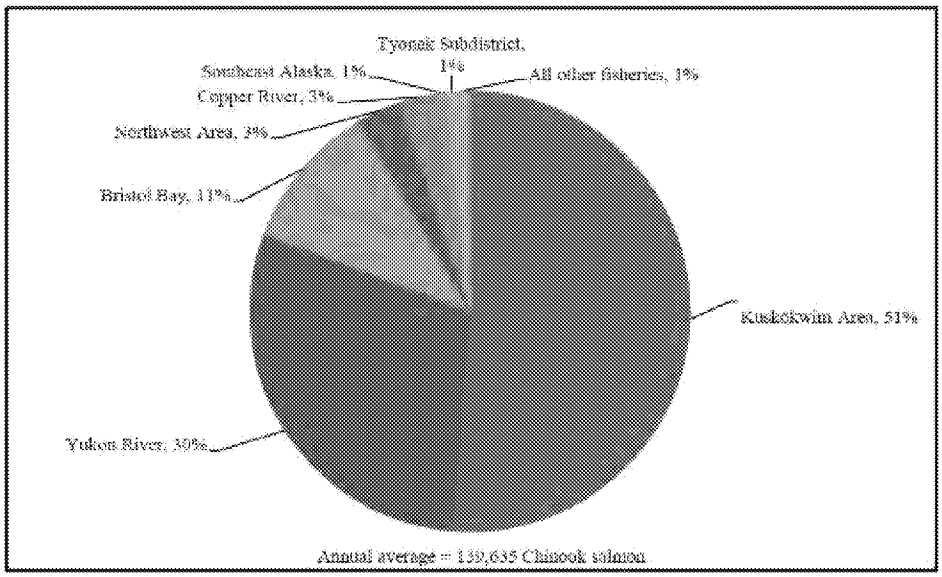


Figure 2: Percentage of average annual subsistence harvest of Chinook salmon by management area, 1994–2018. ADF&G 2020.

Impacts of the Prolonged Chinook Salmon Crash

Since 2009, the Chinook salmon (king salmon, *kiagtaq*, *taryaqvak*, *Oncorhynchus tshawytscha*) populations in the Kuskokwim River have crashed catastrophically and remain severely depressed through the 2021 season.

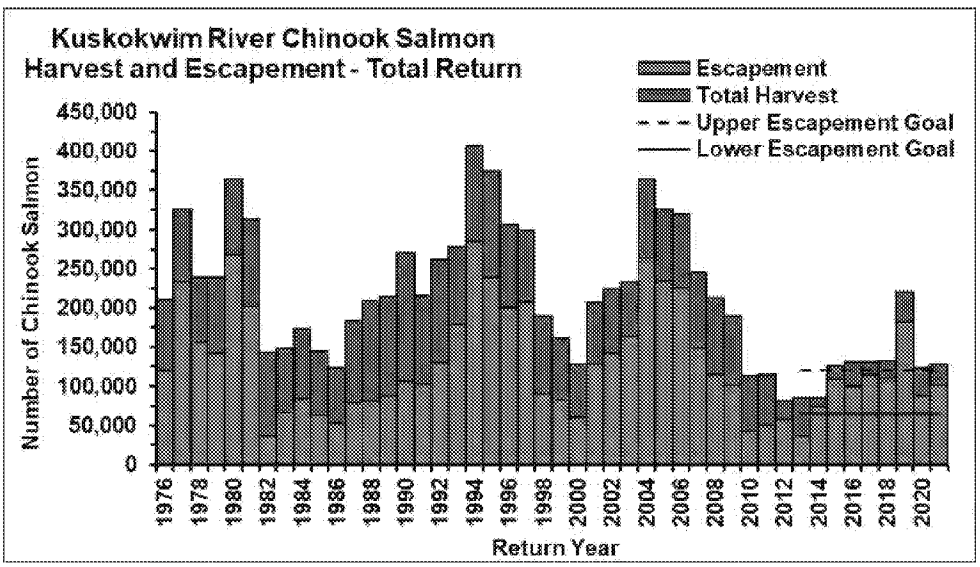


Figure 3: Kuskokwim River Chinook salmon escapement and total harvest by all user groups during 1976—2020. Source: Alaska Department of Fish & Game AYK Database. Note: The 2021 estimate of harvest and escapement is preliminary.

The 2021 Chinook salmon run was 47% below the long-term average (Figure 3). During the run, communities on the river were heavily regulated with very few limited harvest opportunities per week and net size and gear restrictions to try to meet the critical escapement goals. Consequently, in 2021, residents of the Kuskokwim River met less than one-third of their long-term Chinook salmon

"The numbers say two things: lower quality and lower quantity. The kings, as we are experiencing all over the Delta, are not as big and not as many. The same can be said for here in Quinhagak. Not as many females were captured, but that's fine because we don't want to take the females. I'm hoping this means the big females are going up to spawn."

JACQUELINE CLEVELAND | QUINHAGAK

harvest needs. Moreover, as the average size of Chinook salmon returning to the Kuskokwim has decreased from around 33 pounds per fish to 11 pounds per fish, subsistence fishers are not only harvesting fewer numbers of fish but fewer total pounds of fish. This compounds the food security crisis already unfolding with declined Chinook salmon stocks and restricted harvest opportunities.

Due to the steep declines and management actions required to meet critical escapement needs, only a fraction of the amount reasonably necessary for subsistence uses (ANS) (67,200-109,800 fish) was available for harvest for the past decade. Residents have not met their long-term harvest levels since 2010 (Figure 4). In the past decade, chum (dog) salmon, sockeye (red) salmon, and coho (silver) salmon have provided a critical supplement and source of food security during Chinook salmon declines; yet, recently, chum salmon returns have also crashed.

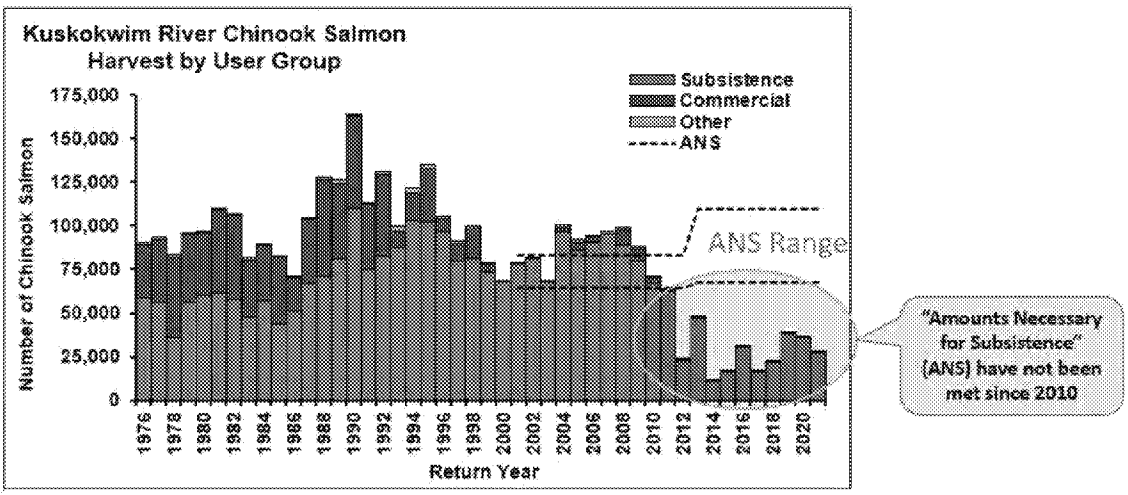


Figure 4: Kuskokwim River Chinook salmon harvest by user groups during 1976—2020, showing that long-term subsistence harvest needs in the watershed have not been meet since 2010. Subsistence harvest needs are based on ANS as determined by the Alaska Board of Fish in 2013. Source: Kuskokwim River Salmon Management Working Group November 18, 2020, meeting packet, ADF&G.

Unprecedented Recent Chum Salmon Crash

Chum salmon (dog salmon, *aluyak, iqalluk, neqepik, O. keta*) are especially critical for food security during years of poor Chinook salmon returns. They also provide unique traditional foods that cannot be prepared with other salmon species. While chum salmon harvests have declined in recent decades resulting from changes in customary and traditional use patterns (e.g., fewer dog teams), they are highly sought for preparing traditional delicacies like *eggamarrlluk* (half-dried, half-smoked salmon) and for feeding Elders and other family members who cannot consume the high fat content of other salmon species.

However, in 2020 and 2021, Kuskokwim chum salmon returns crashed unexpectedly (Figure 5). The 2021 chum run is clearly the lowest on record with fewer chum than Chinook salmon counted in the lower river sonar, during a period of continually poor Chinook returns. Because 2021 in-season run assessment data

"With one fish, you can feed about 3 families, and maybe more. For a small family, like a person that is just starting out, if you have maybe 1 or 2 children, 20 kings will probably feed you all winter. That's the way it used to be. That's how it was; but not anymore. We're lucky we put away about 10 to 15 kings in the past 10 years now. And the size of the kings is smaller."

SAM BERLIN | KASIGLUK

showed a poor chum salmon return, restricted management of chum management took place for the first time. Conservation closures, previously instituted to protect Chinook salmon and typically removed by the end of June as the Chinook salmon run wanes, continued through the end of July to protect depleted chum salmon.

As a result of this crash and the restriction of harvest to meet escapement needs, subsistence harvests of chum salmon in the Kuskokwim River in 2020 and 2021 have been well below the ANS range of 41,200-116,400 fish designated by the Alaska Board of Fisheries, representing some of the poorest harvests on record.

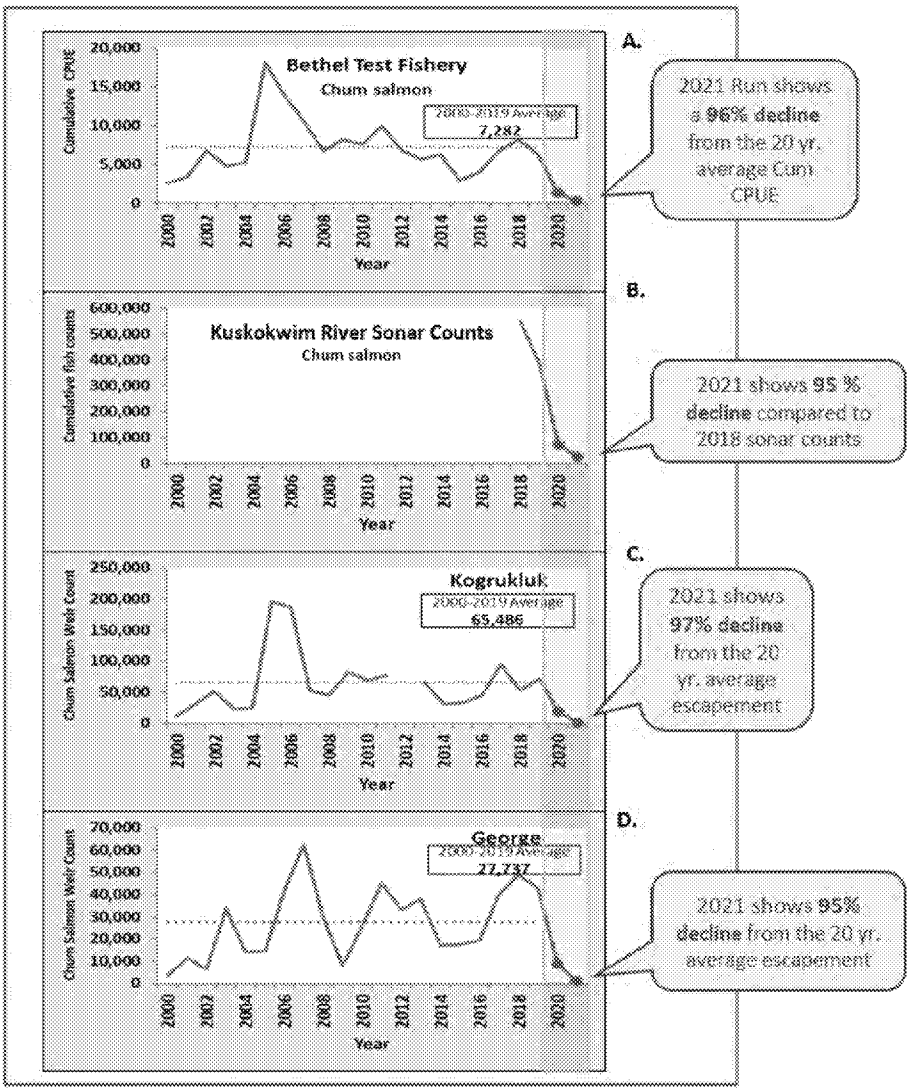


Figure 5: Evidence of catastrophically low 2020 and 2021 Kuskokwim River chum salmon abundance: A. Cumulative end-of-season CPUE of chum salmon caught in the Bethel Test Fishery, 2000–2021. B. Cumulative annual counts of chum salmon from the Kuskokwim River sonar project, 2018–2021. C. Kogrukluk river weir, 2000–2021. D. George River weir, 2000–2021. Source: ADF&G (Alaska Department of Fish and Game), AYK Database Management System.

"I honestly have no idea what's up with the chum. It was such a rapid decline. They were coming in the hundreds of thousands, millions, to the river to almost nothing. I don't really know what happened to them."

JONATHAN SAMUELSON | GEORGETOWN

Furthermore, the Chinook and chum salmon run failures have the potential to place increased harvest pressure on other limited fish stocks which could threaten the sustainability of those species. These failures and their associated in-river restrictions also limited subsistence-dependent communities from practicing their ways of life and passing on generations-old Traditional Knowledge to youth, especially the specialized food processing and preparation methods of cultural delicacies that are otherwise at risk of being lost. The collapse of both Chinook and chum salmon threatens the food and economic security and spiritual and cultural vitality of subsistence fishing communities on the Kuskokwim River.

"[In terms of chums,] there were none this year. That was different. I like to get chums for dryfish and for my half-dried. There just weren't any. I was having to harvest a lot more reds than I normally would for all of that other stuff...I think a lot more people were just getting a lot more reds. So, then that makes me concerned about the red numbers. If we have to keep doing this and hitting them hard, then maybe, is that going to negatively impact what's spawning, what comes back...? And that was the talk, too, a couple of years ago. I remember as we were having to harvest more chum, people were like, 'Well, you guys are going to have to start watching the chum numbers.' Same with whitefish, people were bringing that up. If we're having to harvest more whitefish, we're going to have to start thinking about watching those species. I guess it all has a ripple effect."

MEGAN LEARY | NAPAIMUTE

"I'm one of the fish campers...but I don't go to fish camp because of the fish closures. There's only maybe 5 in Tunt [who use their] fish camp right now. No, that's not that many."

ADOLPH LUPIE | TUNTUTULIAK

"We only had 2 chums in my fish rack all summer. That's unreal. I usually put up 2,000 chums for dogs...We put up a lot of reds, a healthy run of reds. I hope that all of us are hoping and praying that we would have enough returns on the kings, and that's unlikely."

MIKE WILLIAMS SR. | AKIAK

"I have not seen a dog salmon in long time. Even when I had nets out before, about a couple years ago, I didn't catch no dog salmon...Usually they're a pain in the butt, all over in your net. But no more. I guess not."

HELEN EVAN | MCGRATH

"There used to be [a lot of people from Eek who would commercially fish in Kuskokwim Bay], before all the restrictions and before the fish declined. It used to be almost the whole community going down, or most of the men from the community would go down and commercial fish in Quinhagak and Goodnews [Bay]. Now, it's just 3 or 4 boats that go down. Subsistence has been so slow that it's cutting into commercial fishing time. A lot of the guys are just focusing on subsistence fishing now."

JAMES HEAKIN | EEK

Bering Sea Chinook & Chum Salmon Bycatch Negatively Impacting Western Alaska Rivers

There are many potential factors affecting western Alaska salmon that cumulatively have caused declines in these populations (Figure 6). Though not the entire source of current poor salmon returns to the Kuskokwim, Yukon, and Norton Sound Rivers, it is undeniable that salmon bycatch in Bering Sea commercial fisheries is one such factor that has a negative impact on Chinook and chum salmon stocks in this region of the state. Humans can influence salmon bycatch levels and the effects of large-scale groundfish harvests through a variety of management actions, all of which are crucial during present-day collapses in subsistence salmon fisheries.

Moreover, the 33 Tribes of the Kuskokwim River all share Tribal rules associated with conservation of non-human relatives, namely taking only what one needs and can process and preserve properly without resulting in waste. Waste by humans offends these non-human relatives, resulting in resource collapses. As a result, Tribal ways of knowing clearly identify the wasteful harvest of prohibited salmon species as violating these Tribal rules and hold the North Pacific Fisheries Management Council culpable.

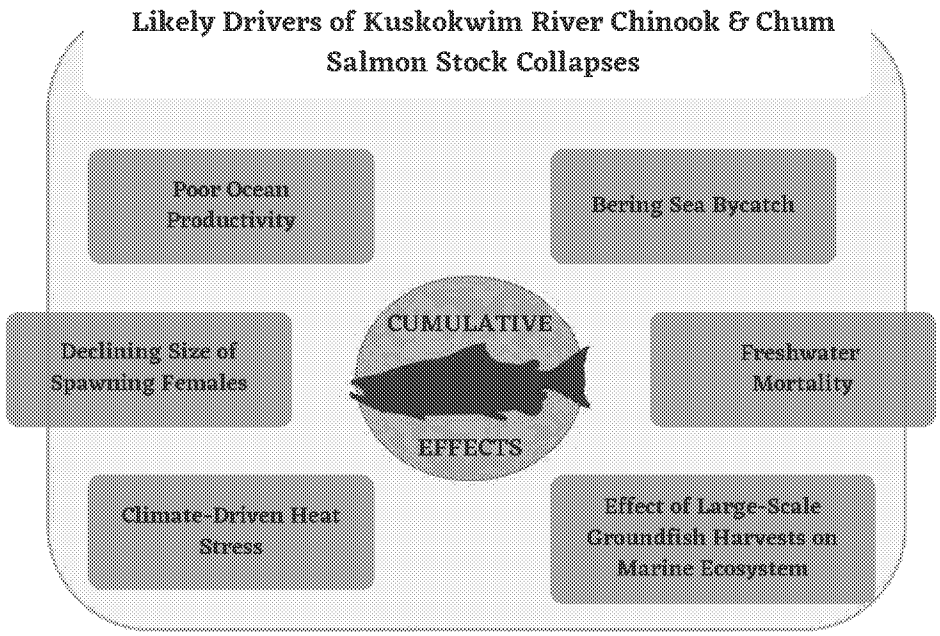


Figure 6: Potential factors that cumulatively work to cause salmon declines in the Kuskowkim River and other western Alaska rivers.

Overview of Bering Sea Salmon Bycatch

Kuskokwim River Chinook and chum salmon are caught as bycatch in the Bering Sea pollock fishery. Salmon are not the target species for the pollock fishery, and in fact are prohibited species. Chinook and chum salmon caught by the pollock fishery cannot be sold (so as not to create an incentive to catch them) and must either be discarded or donated. In the Bering Sea Aleutian Islands management area, the pollock trawl fishery is responsible for most chum salmon and Chinook salmon bycatch and accounted for

99% and 92% of 2020 chum and Chinook salmon bycatch, respectively (NMFS 2021). The pollock fishery is divided into two seasons: the A-season running January 20 extending into April, and the B-season running June 10 to November 1 annually.

Chinook Salmon Bycatch

Coastal Western Alaska Chinook stocks comprise the largest portion of Chinook salmon bycatch in the Bering Sea pollock fishery most years, especially during A-season. From 2008-2014, Coastal Western Alaska comprised over 40% of the estimated Chinook salmon bycatch (and greater than 60% of bycatch in many years). In 2019, Coastal Western Alaska and north Alaska Peninsula stocks accounted for approximately 40% and 15% of Chinook salmon bycatch, respectively (Figure 7).

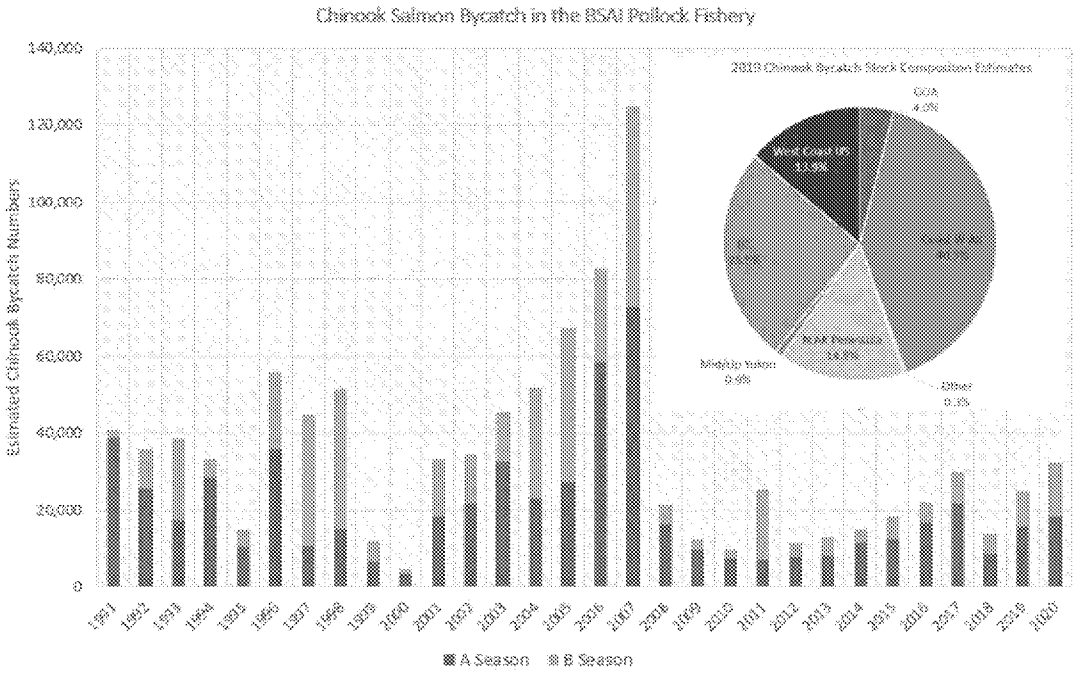


Figure 7: Chinook salmon bycatch in the BSAI pollock trawl fishery, 1991-2020 (NMFS 2021) and estimated Chinook stock composition for the 2019 pollock fishery (Guthrie et al. 2021).

Overall, 103,662 Chinook salmon from northern and western Alaskan rivers were caught as bycatch in the BSAI pollock trawl fishery between 2011 and 2019 (annual average 11,518 salmon). Estimates of Chinook salmon bycatch (numbers) have increased moderately in the Coastal Western Alaska and north Alaska Peninsula regions from 2012 to 2019 (Figure 8). While directed salmon fisheries are closed and subsistence use is exceedingly limited in western Alaska rivers, Chinook salmon bycatch continues with dire impacts to regional communities, including the 33 subsistence-dependent communities of the Kuskokwim River watershed.

"I don't like people that take advantage of something that we have eaten [for] subsistence all our lives."

SAM BERLIN | KASIGLUK

"If we are put on restrictions, how come the commercial fisheries and the deep sea trawlers are not bearing the burden like us[?]. The Kuskokwim, Yukon, and Norton Sound areas have less fish every year."

ANDREW MARTIN | BETHEL

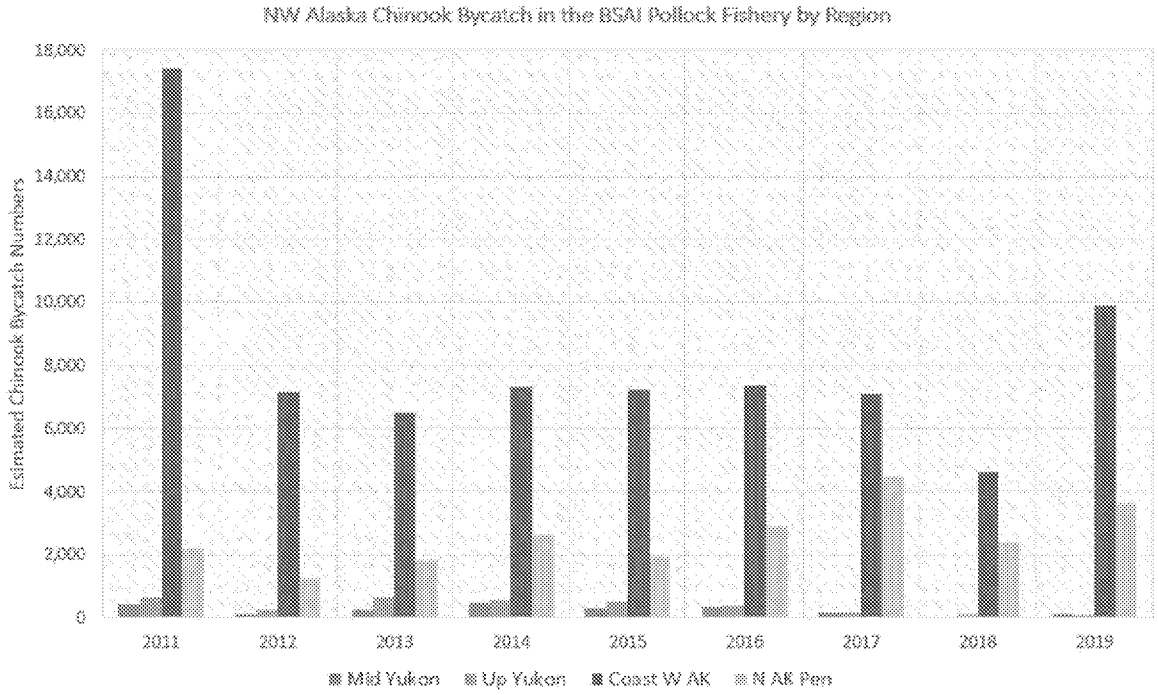


Figure 8: Estimated Chinook salmon bycatch numbers in the BSAI pollock fishery 2011-2019 by northwest Alaska region (Guthrie et al. 2021).

Chum Salmon Bycatch

Chum salmon bycatch in the Bering Sea increased dramatically from 2012-2021 (Figure 9). Chum salmon bycatch primarily occurs in the B-season BSAI pollock fishery. Western Alaskan rivers accounted for approximately 16% of chum incidentally caught in the 2019 BSAI B-season pollock fishery, and a total of 334,516 chum salmon (annual average 66,903 salmon) from Western Alaska and the Upper/Middle Yukon were caught as bycatch from 2014-2019 (Figure 10).

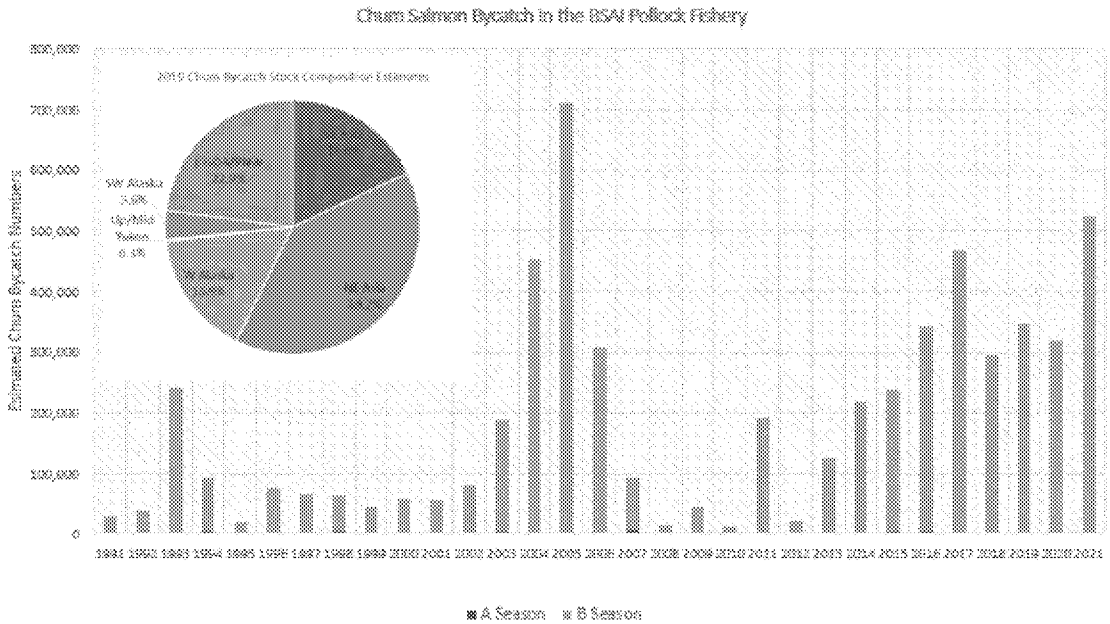


Figure 9: Chum salmon bycatch in the BSAI pollock trawl fishery, 1991-2021 (NMFS 2021) and estimated chum stock composition for the 2019 pollock fishery (Kondzela et al. 2021). Note: The 2021 values extend only through September.

Genetic analyses from recent years confirm that Western Alaska, Upper/Middle Yukon, and Southwest Alaska chum salmon stocks are heavily impacted by pollock trawl bycatch. A very low proportion of Upper/Middle Yukon chum were caught in BSAI B-season pollock bycatch in 2019, which may have been an early indicator that the Upper/Middle Yukon chum salmon are experiencing a decline in stock status.

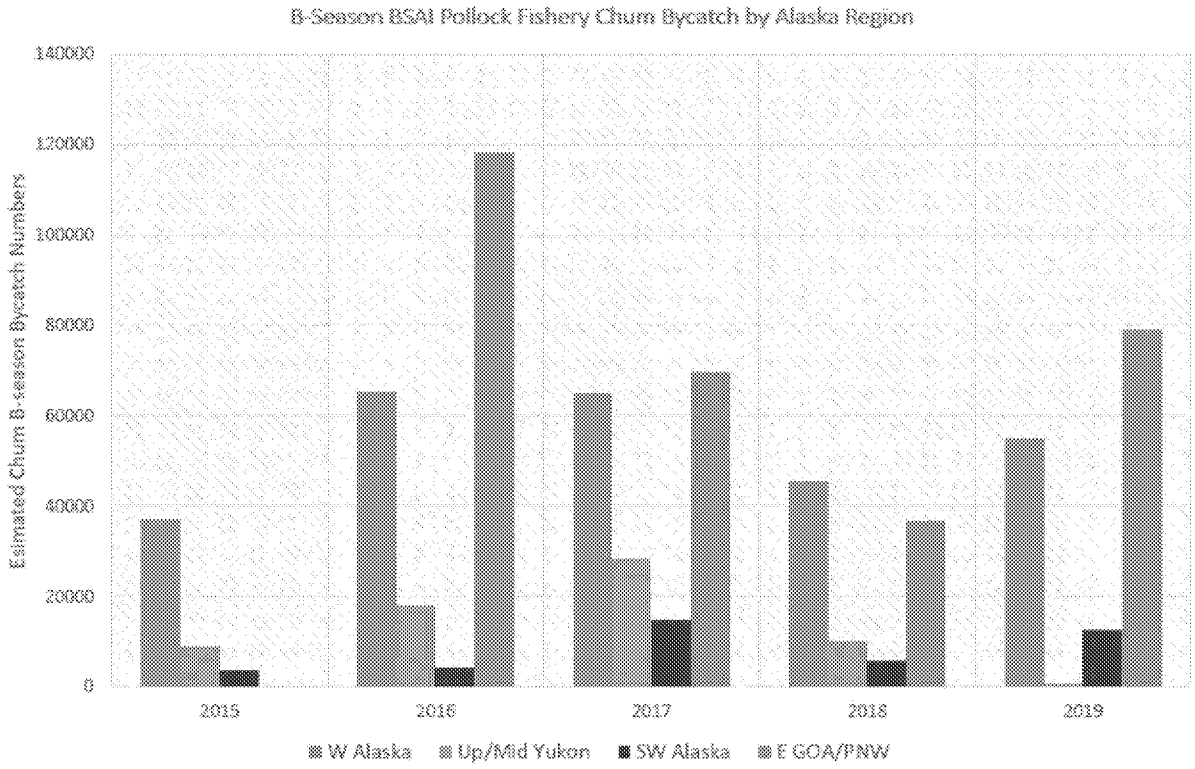


Figure 10: Estimated chum salmon bycatch numbers in the BSAI pollock fishery 2015-2019 by Alaska region (Kondzela et al. 2021).

Salmon Bycatch Management

Chum and Chinook salmon are managed as Prohibited Species Catch (PSC) in Alaska. In response to record-high chum and Chinook salmon bycatch levels in 2003-2007, the North Pacific Fishery Management Council (Council) implemented Amendment 91 in 2011, which established two Chinook salmon PSC limits for the pollock fishery: a 60,000 overall limit (fleetwide hard cap) and a 47,591-performance standard (sector specific performance target each year) for Chinook salmon. In 2016, the Council also implemented Amendment 110 in response to multiple years of historically low Chinook salmon abundance. Amendment 110 has two primary provisions: existing Incentive Plan Agreements (IPAs) were extended to include chum salmon, and a 3-System Index for western Alaska was developed based on the post-season in-river Chinook salmon run size for the Kuskokwim, Unalakleet, and Upper Yukon rivers. When this index is less than or equal to 250,000 Chinook salmon, NMFS applies a lower performance standard and low PSC limit for the following year (NPFMC 2021).

There is currently no cap or limit on the amount of chum salmon that can be caught as bycatch.

Asks of the North Pacific Fishery Management Council

While bycatch is one of numerous cumulative stressors linked with significant Chinook and chum declines in Western Alaska rivers (Figure 6), salmon bycatch is a known source of mortality over which we have control. Every Chinook and chum salmon matters to western Alaska subsistence fishing families that are unable to meet their food, cultural, spiritual, and economic security needs due to these declines. It is critical now more than ever that the Council institutes adaptive, inclusive, and ecosystem-wide sustainable management practices into the Bering Sea Aleutian Islands management area to protect these salmon stocks.

The Kuskokwim River Inter-Tribal Fish Commission has four priority asks of the North Pacific Fisheries Management Council:

(1) The Council should take emergency action to limit Chinook and chum salmon bycatch to zero in 2022 in the Bering Sea pollock fishery.

- We are amid a multi-species salmon collapse within the Kuskokwim River watershed.
- Chinook and chum salmon runs throughout the Artic-Yukon-Kuskokwim region were disastrous in 2020 and 2021. Chinook and chum salmon fisheries were completely shut down or severely limited.
- People on the Kuskokwim have lost a critical source of food and a key component of their culture. Every possible action must be taken to protect salmon stocks and ensure a collapse does not happen again.
- Given the current state of Chinook and chum salmon, and the lack of information about why this is happening, sustainable fishery management requires that the Council limit salmon bycatch in the Bering Sea pollock fishery to ensure that NO salmon are taken as bycatch in the Bering Sea pollock fishery in 2022.

(2) Ensure Alaska Native Tribes have a seat at the decision-making table.

- Support the amendment to the Magnuson-Stevens Act to add 2 Tribal seats to the NPFMC table.
- Ensure Alaska Native Tribal representation on all Council bodies, including the Advisory Panel (AP), Scientific and Statistical Committee (SSC), and plan teams.

(3) Send a letter to NMFS supporting funding for disaster declarations and research, observation and monitoring by Tribal organizations and co-management organizations.

(4) Support and encourage NOAA to initiate Tribal Consultation on the issue of salmon bycatch so that both NOAA and the Council have the best available information.

"In Yup'ik, the general word for food is neqa, which is also the word for fish. So if neqa is not how you view fish – if food is not the first thing you think of – then we come from different worlds. For us, we wouldn't exist without salmon. On the river, we coexist, salmon and people. And it's always been that way. We have this deep spiritual relationship that we have the obligation, but also the privilege, to maintain between fish and people."

JONATHAN SAMUELSON | GEORGETOWN

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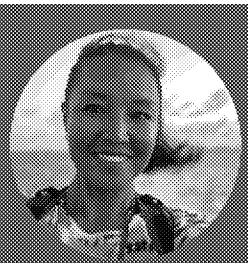

"Without my subsistence life, I don't know how I'd get through it. It's my therapy, being outdoors on the land and on the water. I'd hate to lose that, but we could possibly lose the fishery part, which is the most important part, if we're not proactive about this."

JACQUELINE CLEVELAND | QUINHAGAK

4 Yukon-Kuskokwim villages on lockdown in response to COVID-19 cases

By **Anna Rose MacArthur, KYUK - Bethel** - August 25, 2020

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Anna Rose MacArthur, KYUK - Bethel

Anna Rose MacArthur is a reporter at KYUK in Bethel.

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For the first time ever, state to close Kuskokwim and most tributaries to coho fishing

August 16, 2022 by Anna Rose MacArthur, KYUK - Bethel [https://www.ktoo.org/author/kyuk-bethel/]

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For the first time, live invasive green crabs have been found in Alaska (https://www.ktoo.org/2022/07/28/live-invasive-european-green-crabs-found-in-alaska/)

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Metlakatla Mayor Albert Smith says he's concerned about what this means for the community's traditional food sources.

(https://www.ktoo.org/2022/07/27/sitka-tribe-researchers-are-studying-how-far-herring-eggs-travel-when-they-get-shared/)

Sitka Tribe researchers are studying how far herring eggs travel when they get shared (https://www.ktoo.org/2022/07/27/sitka-tribe-researchers-are-studying-how-far-herring-eggs-travel-when-they-get-shared/)

July 27, 2022

An estimated 87% of eggs harvested out of Sitka are given away.

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OFFICE OF THE REGIONAL ADMINISTRATOR

JUN 27 2016

USACE RECEIVED JUL 05 2016 AK REGULATORY

Colonel Michael Brooks
Alaska District Engineer
U.S. Army Corps of Engineers
P.O. Box 6898
JBER, Alaska 99506-0898

Dear Colonel Brooks:

This letter is in further reference to Public Notice POA-1995-120 and the Draft Environmental Impact Statement prepared by the Alaska District. The PN and DEIS describe Donlin Gold, LLC's proposal to produce gold from ore reserves owned by Calista Corporation ten miles north of the Kuskokwim River village of Crooked Creek, Alaska.

The PN and DEIS indicate that the proposed project would discharge over 984 million cubic yards of fill material into approximately 9,758 acres of jurisdictional waters of the United States, including into 56 linear miles of streams. An additional 1,096 acres of jurisdictional waters would be impacted by land clearing, and over 5,000 acres would experience secondary impacts due to groundwater drawdown and fugitive dust from the proposed mine components.

Based on the U.S. Environmental Protection Agency's review of the available information, and pursuant to Part IV, paragraph 3(a) of the 1992 Clean Water Act Section 404(q) Memorandum of Agreement between the EPA and Department of the Army, the EPA notified the District by letter dated May 31, 2016, that the proposed discharges may result in substantial and unacceptable impacts to aquatic resources of national importance (3(a) letter).

On May 31, 2016, the EPA also provided the District with extensive comments specific to the DEIS via an independent letter and attached comment matrix. That letter was submitted pursuant to our responsibilities under the National Environmental Policy Act and Section 309 of the Clean Air Act. Section 309 specifically directs the EPA to review and comment in writing on the environmental impacts associated with all major federal agency actions to which NEPA applies.

The detailed discussions in our 3(a) and Section 309 letters are incorporated by reference and will not be repeated here.

Our 3(a) letter identified both the Kuskokwim River and Crooked Creek, along with its adjacent wetlands, and its tributaries American and Anaconda creeks, as aquatic resources of national importance. The EPA has received no new information regarding the issues we raised in our 3(a) letter. Pursuant to Part IV, paragraph (3)(b) of the MOA, the EPA hereby notifies the District that in the EPA's opinion the discharges associated with the proposed project will have a substantial and unacceptable impact on aquatic resources of national importance.

Per the MOA, the attached enclosure identifies the specific impacts as well as the need to modify, condition, or deny the Section 404 permit to protect the aquatic resources. The information about potential impacts and measures that could serve to reduce their severity is taken directly from the PN and DEIS.

The MOA requires the EPA's 3(a) and 3(b) letters to be submitted in response to the Section 404 PN. As described in our (3)(a) and Section 309 letters, however, the Section 404 PN and the DEIS lack required information about the extent and nature of the project's potential impacts on aquatic resources. The EPA considers it unfortunate that the District chose to issue the PN concurrent with the DEIS prior to completing its analysis of project impacts and compliance with the Section 404(b)(1) Guidelines.

Because the EPA's opinions are based on the incomplete information and analyses in the PN and DEIS, they are preliminary and subject to change in accord with future information. We strongly urge the District to complete and share its analyses of project impacts and 404(b)(1) compliance with the EPA as soon as possible so that we may resolve these issues in a timely fashion.

I appreciate the attention that you and your staff have provided to this project, and Region 10 looks forward to discussing our concerns. Should you choose to issue the proposed permit, please provide notice to the EPA in accordance with Part IV, paragraph (3)(c) of the MOA. Should you have any questions about this letter and the attached enclosure, please do not hesitate to contact me or have your staff contact Matthew LaCroix in our Alaska Operations Office at (907) 271-1480, or by email at lacroix.matthew@epa.gov.

Sincerely,

Dennis J. McLerran
Regional Administrator

Enclosure

cc: Karen Clark, Acting Regional Director, USFWS
Sheila Newman, Project Manager, USACE

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Enclosure to EPA's 3(b) Letter on Public Notice POA-1995-120

The proposed discharges will result in substantial and unacceptable adverse impacts to the Kuskokwim River.

Proposed fill discharges for project components would occur in multiple watersheds, with some of the more substantial direct and secondary impacts occurring along the lower and middle Kuskokwim River.

The Kuskokwim River is the second largest river in Alaska, measured both by length (702 miles) and discharge. The River's discharge of 67,000 cubic feet per second is approximately the same as that of the Missouri River in the continental United States. The numerous Alaska native communities located along the River rely on it for domestic water, subsistence fishing and cultural uses, recreation, and transportation. The Kuskokwim River provides essential fish habitat for all five species of Pacific salmon. The River supports one of the largest subsistence fisheries in Alaska as well as a substantial commercial salmon fishery.

The DEIS indicates the project has the potential to interfere with commercial and local navigation along the River, including for subsistence activities. In particular, the increase in diesel and cargo barge traffic during the mine life would result in additional boat wakes, induced shoreline erosion and bed scour, impacts to fish habitat, and the potential for barge groundings and accidental spills.

Detailed hydrologic modeling to predict the geomorphic effects of project-related barge traffic has not been done, but the DEIS does provide information about some of the related impacts. For example, Section 3.21-166 states that: "*Barging could potentially affect subsistence fishing by generating propeller wash and wakes that could interfere with fish nets, fish cutting rafts or fish wheels, and processing rafts, or erode river banks so that people either have to abandon or move fish camps.*"

Many of the potential impacts of barge traffic to fish habitat in the Kuskokwim River are poorly understood. Information about the specific micro habitats used by some fish species during different life stages such as spawning, rearing, and overwintering is limited. In addition, the processes that establish and maintain specific habitats are influenced by complex relationships between river stage and sediment transport. In contrast, the potential impacts to rainbow smelt are better understood.

Rainbow smelt are an important subsistence resource for residents along the Kuskokwim River. Baseline data collected for the DEIS indicate that the smelt are essentially a single population that spawns within a very limited area of the River. The DEIS indicates that prop wash scour from the increased barge traffic could alter the riverbed substrates and fish spawning gravel itself. The greater threat is that the prop wash could directly impact smelt eggs incubating in the gravel.

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The potential loss of rainbow smelt production due to the prop wash from barges is not quantified, but Section 3.13 indicates that a high level of injury or mortality to incubating rainbow smelt eggs from prop wash would be unavoidable unless barge traffic were prohibited during smelt spawning and incubation. Table 3.13-30 identifies the Geographic Extent of prop wash scour of riverbed substrates and fish spawning gravel in the Kuskokwim River as "Local." Although the impacts to the riverbed would in fact be "local," impacts to smelt spawning locations would have population-level implications that would be felt at least regionally.

Much of the project-related barge traffic would be associated with the transport of diesel fuel to the mine site. Natural gas would provide the power for the mine itself, but diesel would power the large 300-ton trucks that would transport waste rock and ore from the open pit. The DEIS indicates that the large trucks account for 75 percent of the total annual diesel consumption for the project. Two mechanisms for reducing the impacts of barge traffic are evaluated in the DEIS. The first of these is to reduce the *use* of diesel by mine trucks, and the second is to reduce the *barging* of diesel on the Kuskokwim River.

Alternative 3A would reduce the *use* of diesel by using LNG-powered haul trucks. This would, in turn, reduce the amount of diesel transported throughout the supply chain, and ultimately, on the Kuskokwim River to the mine site. Constructing an LNG facility at the mine site and using LNG to power the haul trucks would reduce peak annual diesel consumption by 69 percent, and reduce total peak barge traffic by 67 percent (from 58 round trips to 19) during mine operations. Tanker truck traffic from the Jungjuk Port to the mine site would also be reduced by 75 percent during operations.

The number of joint cargo/fuel barge trips would also be reduced by 32 percent, from 122 round trips to 83. Ocean barging of diesel fuel from the Pacific Northwest to Dutch Harbor would be reduced from seven round trips per year to two. Fuel barge trips from Dutch Harbor to Bethel would be reduced from fourteen to five, and the proposed additional diesel fuel storage in Bethel could be reduced or eliminated.

If LNG and/or natural gas were used for other mine vehicles in addition to the haul trucks, that would further reduce the need for diesel as vehicle fuel. LNG powered haul trucks of the size proposed for the mine are not currently available, but they might be available by the time a mine is developed.

Alternative 3B would eliminate diesel *barging* and the associated impacts to the Kuskokwim River by transporting diesel to the mine site via pipeline rather than barge. Barge traffic on the River would be exclusive to cargo; and barge trips would be reduced by 48 percent during operations, from 122 round trips per year to 64 round trips.

Diesel fuel would be delivered to the Tyonek North Foreland Facility on the west side of Cook Inlet. The existing dock would be extended by 1,500 feet to accommodate larger delivery

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vessels. This facility is nineteen miles from the start of the proposed pipeline route at Beluga. A diesel pipeline spur would span this distance.

The DEIS evaluates construction of a diesel pipeline as an alternative to the proposed natural gas pipeline. Diesel fuel would be used for vehicle fuel and to generate electricity for the mine. As evaluated, this alternative would eliminate natural gas use and triple diesel use. The potential to construct parallel natural gas and diesel pipelines should be evaluated.

The proposed discharges will result in substantial and unacceptable adverse impacts to Crooked Creek, its wetlands, and tributaries.

Crooked Creek is a tributary of the Kuskokwim River, and a majority of the project's direct and secondary impacts would occur in the Creek's watershed. Development of the mine would result in the permanent loss of over five thousand acres of wetlands and over 13 miles of streams, including the Crooked Creek tributaries of American and Anaconda creeks. The 2,240-acre waste rock facility (WRF) and 2,351-acre tailings storage facility (TSF) would bury the upper reaches of American and Anaconda creeks, respectively, while the 1,462-acre mine pit would eliminate the lower reach of American Creek. Both American and Anaconda creeks are anadromous and support coho salmon in their lower reaches.

Crooked Creek itself supports all five species of Pacific salmon, with a staggered distribution. The range of coho salmon extends upstream of the proposed mine site. Chinook salmon are found up to the confluence of American Creek; while pink, sockeye, and chum salmon are found downstream of the proposed mine site.

Development of the mine pit, WRF, and TSF would permanently alter the contours of the landscape. Dewatering of the mine pit would alter groundwater flow to the Creek. These changes, coupled with the loss of wetland acreage and surfaces streams, would permanently alter the surface and groundwater flow paths from the watershed to Crooked Creek. The consequences would be permanent modification of the hydrology, chemistry, and aquatic habitat of Crooked Creek.

Mine operations would use virtually all of the surface and groundwater from the vicinity of the mine that currently makes its way to Crooked Creek. The DEIS states that even in years of average precipitation, the capture of surface runoff and pit dewatering *"would not be able to meet process plant water requirements."* [DEIS 2-27] The necessary additional process water would be obtained from the proposed Snow Gulch reservoir.

The DEIS indicates that modeled reductions in Crooked Creek flow are as high as 100 percent. Section 3.13-109 states that *"Should the underlying geology of Crooked Creek reflect a high level of hydraulic conductivity, flow reductions in Crooked Creek between American Creek and Crevice Creek could be as high as 85 to 100 percent during Year 20 of operations. Farther downstream in Crooked Creek, flow reductions of 40 to 31 percent could occur near Getmuna and Bell creeks, respectively (BGC 2015c). In this case, predicted streamflow reductions of such*

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a high intensity would result in major impacts to salmon production in the middle and lower reaches of Crooked Creek."

The winter flow reductions could result in more than two miles of the Creek channel going completely dry, with impacts to incubating fish eggs in the gravel, as well as rearing, migration, and spawning habitat. The DEIS states that *"Under these conditions, flow reductions in the vicinity of the mine site during winter months could result in Crooked Creek freezing to the bottom between American Creek and Omega Gulch, with much of the flow restored below Crevice Creek (28 to 40 percent reductions) due to tributary inflows. Potential impacts to fish and aquatic habitat resulting from reduced flow during winter conditions are described in Section 3.13, Fish and Aquatic Resources."*[DEIS 3.5-83]

The DEIS states that flow reductions at this scale would cause major impacts. Table 3.13-30 identifies major impacts to: overall aquatic habitat; mainstem and off-channel aquatic habitat; salmon spawning habitat; and to salmon production in Crooked Creek. The potential loss of production of non-salmonids does not appear to have been evaluated.

Although the impacts to aquatic habitat are characterized as major, the DEIS evaluates potential impacts to salmon production in the context of total production for the Kuskokwim River drainage. *"Therefore, while impacts to Crooked Creek salmon production resulting from predicted flow reductions would range from moderate to major (depending on whether a High K scenario is considered), the context of such impacts relative to total salmon production in the overall Kuskokwim River drainage would be considered minor."* (Section 3.13-109)

It may be appropriate to consider the loss of salmon production from the mine in the context of *"...total salmon production in the overall Kuskokwim River drainage..."*, but that is not the <u>only</u> context in which to evaluate this loss.

The loss of salmon production may be minor to the agencies responsible for managing "total salmon production" in the drainage, but local residents do not have access to the entire Kuskokwim River drainage or to the total salmon production. The loss of local fish translates into the loss of local opportunities. Residents will need to travel farther to access non-local fish, increasing fuel and time expenditures. The additional travel will increase risk, including the risk of increased spoilage, and will leave less time for other activities. It will increase competition for other fish stocks and with other users. We believe the geographic extent of the impact from the loss of salmon production in Crooked Creek would be more than "Local."

Under more optimistic model assumptions, flow reductions are predicted to be 15-20 percent. Reductions of this scale would still substantially alter the hydrograph of Crooked Creek. This would change the water chemistry and temperature, alter sediment transport processes and the amount and availability of instream habitat, and interfere with fish passage. Reduced flow in the reach adjacent to the mine could result in bed aggradation and debris stranding. Over time, the channel could shift from single-thread to braided, with the potential for channel avulsions.

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The range of stream flows would be shifted downward, with fewer high flow and overbank events. This would affect the riparian disturbance regime and floodplain connectivity. Section 3.13-96 states:

> *"Reduced flows also could affect the frequency with which off-channel habitat maintains connection with the main channel. This is an important consideration because although off-channel habitats would likely re-connect to the main channel at some point during the year when the water stage increases, connections may no longer occur during very low flow periods in summer and winter resulting in temporary isolation of off-channel habitats from the main channel. This could affect rearing or spawning life phases of fish due to fish stranding and potential mortalities. Furthermore, a reduction in off-channel (or in-channel) winter habitat may adversely affect the survival of overwintering fish or incubating eggs if flows are reduced to the point where the water column becomes too shallow or freezes completely."*

A stream's flow regime, including the daily, seasonal, annual, and flood fluctuations, is key to its functioning. Numerous case studies in the literature indicate that altering a stream's hydrograph by more than 10 percent causes measurable changes in ecosystem structure. Streamflow alteration greater than 20 percent causes moderate to major changes in ecosystem structure and function, with impacts becoming more significant as alteration increases beyond 20 percent.

In a 2011 article titled *A Presumptive Standard for Environmental Flow Protection*, Richter *et al.* indicated that protecting a minimum of 80% of daily flows is necessary to maintain ecological integrity in most rivers.

Many of the potential impacts to Crooked Creek, its adjacent wetlands, and its tributaries American and Anaconda creeks would be unavoidable if the mine is developed. The DEIS does, however, identify how impacts to wetlands along Anaconda Creek can be reduced. The potential for direct and secondary impacts associated with construction of the TSF and its 464-foot high dam can be substantially reduced through the adoption of Alternative 5A.

Under Alternative 5A, mine tailings would be managed as a dry stack. The DEIS indicates that up to 80 percent of the moisture from the mine tailings could be removed to create dry pastes. Removing the majority of water from the tailings increases their stability, and minimizes the potential contamination of downgradient surface and groundwater from mine tailings in the event of a breach in the storage facility dam and/or a rupture of the liner.

Dry stack tailings reduce the risk of some tailings dam failure modes, such as piping and cracking through the embankment, and foundation failure. They are also much less mobile than saturated tailings, which reduces the risk of a catastrophic tailings release in the event of a minor problem with the dam.

The DEIS includes modeling of a minor tailings dam breach where 0.5 percent of the total tailings volume was released. The model was of saturated tailings with 50 percent water and 50 percent solids. The results indicate that 2.6 million cubic yards of tailings would reach the

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Kuskokwim River and up to ten feet of tailings would be deposited at the confluence of Anaconda Creek and Crooked Creek.

Removing water from the tailings consolidates their volume by about 40 percent, so the area needed for a dry-stack TSF is substantially less than for saturated tailings. Water removed from the tailings would report to an operating pond, and be pumped back to the process plant for reuse. This would increase the efficiency of process water use and minimize the need for make-up water from the Snow Gulch reservoir.

At mine closure, the operating pond water would be pumped to the pit and the footprint of the operating pond reclaimed. Reclamation of the operating pond is projected to take five years. Reestablishing wetlands within this footprint post mining, and the increased efficiency in water use during operations would reduce impacts to Crooked Creek relative to the proposed saturated tailings.

Whether designed to manage saturated or dry stack tailings, the TSF is a waste treatment system. This affects how impacts associated with the discharge of tailings to the TSF are evaluated. EPA requests that the District coordinate with us regarding evaluation of the TSF impacts.

The DEIS does not identify the least environmentally damaging practicable alternative (LEDPA). The 404(b)(1) Guidelines prohibit any alternative other than the LEDPA. The information presented in the PN and DEIS indicate that the LEDPA would include a combination of project components from Alternative 2, Alternative 3A, Alternative 3B, and Alternative 5A.

The potential of the proposed discharges to cause or contribute to significant degradation should be evaluated in the EIS.

We have highlighted a number of project alternatives evaluated in the DEIS, which would serve to avoid and minimize impacts to the Kuskokwim River and Crooked Creek. As referenced above, however, some of the potential impacts to Crooked Creek, its adjacent wetlands, and American and Anaconda creeks would be unavoidable. The DEIS characterizes many of these impacts as major. The compensatory mitigation projects identified by Donlin would do little to reduce the severity of the impacts. For example, they would not directly offset the Crooked Creek flow reductions.

The severity of individual impacts identified in the DEIS, and the cumulative impact of multiple less-severe impacts suggest that the project has the potential to cause significant degradation. Pursuant to 40 CFR § 230.10(c),

> *"...no discharge of dredged or fill material shall be permitted which will cause or contribute to significant degradation of the waters of the United States. Findings of significant degradation related to the proposed discharge shall be based upon appropriate factual determinations, evaluations, and tests required by subparts B and G, after consideration of subparts C through F, with special emphasis on the persistence and permanence of the effects outlined in those subparts."*

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The referenced subparts of the Guidelines identify impacts such as: the alteration of normal water fluctuations; modification of habitat, including spawning areas; restricting the movement of aquatic life; and interfering with the reproductive success of commercially important species [§ 230.24(b), 230.51(b)] as potentially causing or contributing to significant degradation.

The evaluation of the potential for significant degradation is necessary to demonstrate compliance with the Section 404(b)(1) Guidelines; and 40 CFR § 230.11 requires the factual determinations to be in writing. We believe the evaluation of potential short- and long-term effects of proposed discharges are precisely the type of analyses that should be included in the EIS. We once again call upon the District to include the "*...appropriate factual determinations, evaluations, and tests...*" in the EIS.

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A Guide to the

Management of Tailings Facilities

VERSION 3.2

The Mining Association of Canada

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A Guide to the

Management of Tailings Facilities

VERSION 3.2

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Version date: March 2021

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The electronic version of this document has enhanced features to improve the usability of the document:

- hyperlinks to external websites and documents;
- hyperlinks to other sections of the document; and
- pop-up boxes with definitions of key terms that appear when the cursor passes over them.

Please note that the pop-up boxes are not functional in the current (2021) Adobe Reader apps for iPad and iPhone, so they will not appear. Additionally, if the document is previewed as an email attachment using the Apple Mail app, the pop-ups will be visible at all times, blocking portions of the text. If using an Apple mobile device, we recommend opening the document in the Adobe Reader app, or using the Apple-friendly version available at "*http://www.mining.ca/tailings-guide*".

The Mining Association of Canada

CHANGES IN VERSION 3.1

Version 3.1 is an update to the third edition of *A Guide to the Management of Tailings Facilities* (the Tailings Guide), released in November 2017, to reflect the second edition of MAC's *Developing an Operation, Maintenance, and Surveillance Manual for Tailings and Water Management Facilities* (the OMS Guide), released at the same time as Version 3.1 of the Tailings Guide.

The most significant change is a re-write of *Section 5.2* Emergency Preparedness. This section now provides more detailed guidance for the preparation of emergency response plans and emergency preparedness plans.

Other changes include:

- alignment of terminology and definitions with the second edition of the OMS Guide;
- clarifying the definition of an Accountable Executive Officer;
- affirming that the scope of both Performance Evaluation (*Section 6*) and Management Review for Continual Improvement (*Section 7*) includes the site-specific tailings management system, emergency response plan, emergency preparedness plan, and the OMS manual;
- addition of guidance on post-incident analyses in *Section 6* Performance Evaluation;
- addition of text to clarify the difference between the checklist tool described in Section 5.3, and the *Table of Conformance* developed by MAC as a tool to assess performance against the Indicators described in the *TSM® Tailings Management Protocol*; and
- minor editorial corrections.

CHANGES IN VERSION 3.2

Version 3.2 is an update to the third edition of *A Guide to the Management of Tailings Facilities* (the Tailings Guide). Updates were undertaken following the 2020 release of the *Global Industry Standard on Tailings Management* (the Standard) to improve alignment between the tailings management component of MAC's *Towards Sustainable Mining® (TSM®)* program and the Standard.

The most significant changes are:

- Expanding on aspects to be considered in developing a corporate policy and/or commitment.
- Increasing the level of detail of descriptions of the roles and responsibilities of the Accountable Executive Officer and Responsible Person.
- Expanding on aspects to be addressed in a management review for continual improvement.
- Adding new text and a supporting appendix on information requirements related to:
  - Site characterization
  - Design information
  - Documentation on construction and as-built conditions
  - Closure plan
- Replacing the checklist tool with the *Table of Conformance* as a tool for gap analysis.

In addition, text on control of documented information was moved from the OMS Guide to the Tailings Guide, and some text from the OMS Guide on communications was moved to the Tailings Guide to consolidate discussion on this topic.

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Foreword

It is with pleasure that I present, on behalf of the Mining Association of Canada (MAC), the third edition of the *Guide to the Management of Tailings Facilities* (the Tailings Guide).

The first edition of MAC's Tailings Guide was released in 1998. At the time, it was one of the industry's first and most comprehensive management guides specific to tailings. Use beyond Canada led to this Guide being made available in Spanish and Portuguese, in addition to French and English.

MAC subsequently launched the *Towards Sustainable Mining® (TSM®)* initiative in 2004, and the Tailings Guide was integrated with the *TSM Tailings Management Protocol*, which includes performance indicators for tailings management. An updated second edition of the Tailings Guide was released in 2011. The Tailings Guide is also accompanied by MAC's *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities* (the OMS Guide), first released in 2003 and then revised in 2011.

Application of *TSM* is mandatory for MAC members for their operations in Canada. However, the Tailings Guide and the OMS Guide are designed to be stand-alone documents that can be applied by MAC members and non-MAC members alike, anywhere in the world. Exporting our expertise in sustainable and responsible mining practices, including for tailings management, is one important way that MAC and its members are contributing to improving mining performance globally.

Following the 2014 tailings failure at the Mount Polley Mine in British Columbia, MAC launched comprehensive external and internal reviews of the *TSM Tailings Management Protocol*, Tailings Guide, and OMS Guide. The external review was conducted by an Independent Task Force, and MAC's Tailings Working Group led the internal review. The Independent Task Force issued its report containing 29 recommendations in November 2015, which informed the work of the Tailings Working Group.

These reviews confirmed the strength and benefit of the management systems approach in the Tailings Guide, and made recommendations for further improvements. The recommendations of these reviews were highly convergent and complementary, and provided the basis for updating and strengthening the Tailings Guide.

The third edition of the Tailings Guide is another step in the continual improvement process for tailings management, moving towards the goal of minimizing harm: zero catastrophic failures of tailings facilities, and no significant adverse effects on the environment and human health.

We owe a debt of gratitude to the members of the Independent Task Force and MAC's Tailings Working Group who, together, have brought tremendous skill, dedication and enthusiasm to their important work. I trust that MAC members and others will find these improvements a useful contribution to strengthening tailings management in Canada and abroad.

Pierre Gratton

President & CEO

The Mining Association of Canada

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Preface

First Edition of the Tailings Guide

The first edition of MAC's *Guide to the Management of Tailings Facilities*, released in 1998, was developed in response to a series of international **tailings**-related incidents that occurred in the 1990s. The purpose of the first edition was threefold:

- to provide information on the safe and environmentally responsible management of **tailings facilities**;
- to help companies develop tailings management systems that include environmental and safety criteria; and
- to improve the consistency of application of sound engineering and management principles to tailings facilities.

The first edition reflected sound management practices already in place at that time. It adopted principles and approaches from sources that included mining company manuals, proceedings of two MAC workshops, the MAC *Environmental Policy and Environmental Management Framework*, the ISO 14000 standards related to environmental management, the Canadian Dam Association's draft *Dam Safety Guidelines* (1997), and international guidelines and standards.

Building on the implementation of the Tailings Guide and lessons learned, MAC introduced a companion document in 2003: *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities* (the OMS Guide). This guide focuses on the need for a site-specific operation, maintenance and surveillance (OMS) manual as an integral component of an overall tailings management system. Such a document can help companies comply with legal requirements and corporate policy, demonstrate voluntary self-regulation and due diligence, practice continual improvement, and protect employees, the environment and the public.

Introduction of MAC's *Towards Sustainable Mining®* Initiative

In 2004, MAC established the *Towards Sustainable Mining® (TSM®)* initiative. The objective of *TSM* is to enable mining companies to meet society's needs for minerals, metals and energy products in the most socially, economically and environmentally responsible way.

TSM is an award-winning performance system that helps mining companies evaluate and manage their environmental and social responsibilities. It is a set of tools and indicators to drive performance and ensure that key mining **risks** are managed effectively by mining operations. Mining companies that participate in the *TSM* initiative demonstrate their strong commitment to responsible mining. Adhering to the *TSM Guiding Principles*, mining companies exhibit leadership by:

- engaging with communities;
- driving world-leading environmental practices; and
- committing to the safety and health of employees and surrounding communities.

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The key strengths of *TSM* are that:

- performance is measured primarily at the facility-level, and results are externally verified and publicly reported;
- implementation of the program is monitored by an external Community of Interest Advisory Panel; and
- the program encourages continual performance improvement.

Tailings management is a core component of *TSM*. Performance indicators for tailings management are described in the *TSM Tailings Management Protocol*. The Protocol refers to, and is supported by, the Tailings Guide and the OMS Guide. The tailings management component of *TSM* provides a strong and consistent message to tailings facility owners, operators and contractors: the key to safe and environmentally responsible management of tailings is the consistent application of sound engineering capability within an effective management system and throughout the full **life cycle** of a facility.

Second Edition of the Tailings Guide

In 2011, the second edition of the Tailings Guide was released. This edition reflected information and experience gained through the course of developing and implementing the tailings management component of *TSM*, and working with tailings management systems around the world.

The second edition provided alignment with *TSM* principles and terminology, as well as with the OMS Guide. The scope of application was broadened slightly compared to the first edition, and the second edition expanded on some concepts described in the first edition, and introduced some new concepts. The second edition retained a strong focus on a management systems approach, and reduced the level of technical detail compared to the first edition.

Third Edition of the Tailings Guide

In August 2014, a tailings dam foundation failure occurred at the Mount Polley Mine in British Columbia. Soon after this incident, the MAC Board of Directors initiated a review of the tailings management component of *TSM*. The key question was whether there were any improvements to the tailings management component of *TSM* that could be made to prevent such an event from happening again.

This review, formally launched in March 2015, consisted of two parts:

- an external review by an Independent Tailings Review Task Force established by the MAC Board of Directors; and
- internal analysis by the MAC Tailings Working Group, which had developed the previous editions of the Tailings Guide as well as the OMS Guide.

The Task Force was broad-based, and its seven members represented a variety of expertise and interests:

- specialists in engineering and geotechnical issues;
- First Nations representatives;
- environmental specialists; and
- individuals with experience in executive management.

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The Independent Task Force's review focused primarily on the *TSM Tailings Management Protocol*, but also considered the Tailings Guide and the OMS Guide. The *Report of the Towards Sustainable Mining Tailings Review Task Force* was presented to the MAC Board of Directors in November 2015 and included 29 recommendations. Of these recommendations, five related to the Tailings Guide:

- Amend the Tailings Guide to require an independent review of site investigation and selection, design, construction, operation, closure, and post-closure of tailings facilities;
- Evaluate how best to include in the Tailings Guide assessment and selection of both Best Available Technology (BAT) and Best Applicable Practices (BAP) for tailings management;
- Develop and include definitions and/or guidance related to managing a change of Engineer-of-Record and a change of ownership in the change management section;
- Include a risk-based ranking classification system for non-conformances and have corresponding consequences. Guidance on risk assessment methodology should be included; and
- Include more specific technical guidance related to site selection and design, including how to select objectives and set design criteria.

Upon receiving the Task Force's report, the MAC Board of Directors committed to expeditiously identify how to best integrate the recommendations into *TSM* for implementation. The Board Chair stated that "it is imperative that the industry continuously improves how it works to ensure the safe operation of its tailings facilities."

The Tailings Working Group, consisting of MAC members and associate members, and representing a wide range of expertise related to tailings management, developed a suite of recommendations that were highly convergent with and complementary to those of the Task Force.

Once both internal and external reviews were complete, the Tailings Working Group began revising the Tailings Guide, leading to the third edition of the Guide. The *TSM Tailings Management Protocol* was also updated and revised to respond to the Task Force's recommendations.

The third edition of the Tailings Guide retains the second edition's strong emphasis on management systems. However, it has an increased emphasis on technical aspects, especially those critical to the physical and chemical stability of tailings facilities. The third edition also strengthens key concepts that were described in previous editions, and introduces others, including:

Risk-Based Approach: managing tailings facilities in a manner commensurate with the physical and chemical risks they may pose. Managing risk includes:

- regular, rigorous risk assessment;
- application of most appropriate technology to manage risks on a site-specific basis (**BAT**);
- application of industry best practices to manage risk and achieve performance objective (**BAP**); and
- use of rigorous, transparent decision-making tools to select most appropriate site-specific combination of BAT and location for a tailings facility.

Critical Controls: a risk control that is crucial to preventing a high-consequence event or mitigating the consequences of such an event. The absence or failure of a critical control would significantly increase the risk despite the existence of other controls.

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Engineer-of-Record: The **Owner**, in assuring that a tailings facility is safe, has the responsibility to identify and retain an EoR, who provides technical direction on behalf of the Owner. The EoR verifies whether the tailings facility (or components thereof) has been:

- Designed in accordance with performance objectives and indicators, applicable guidelines, standards and legal requirements; and
- Constructed, and is performing, throughout the life cycle, in accordance with the design intent, performance objectives and indicators, applicable guidelines, standards and legal requirements.

Independent Review: independent evaluation of all aspects of the planning, design, construction, operation, maintenance of a tailings facility by competent, objective, third-party reviewer on behalf of the Owner.

The third edition also updates the tailings management framework presented in the Tailings Guide as a key tool to help in the implementation of site-specific tailings management systems. Descriptions of the elements of the framework have been strengthened and clarified, and the framework is more aligned with the *ISO 14001 Environmental Management System* standard.

In addition to strengthened technical guidance throughout the body of the Tailings Guide, the third edition provides further guidance in appendices on:

- Risk management framework and approach;
- Integration of BAT and BAP;
- Assessment of alternatives;
- Integration of Independent Review;
- Considerations for managing throughout the life cycle of a tailings facility;
- Technical considerations;
  - Tailings transportation and placement plans;
  - Water management plans; and
  - Closure plans.

The third edition of the Tailings Guide is another step in the continual improvement process for tailings management, moving towards the goal of minimizing harm: zero catastrophic failures of tailings facilities, and no significant adverse effects on the environment or human health. The Tailings Guide; however, is but a roadmap on this journey – to succeed, it is incumbent on MAC members and the mining industry as a whole to achieve effective implementation of the principles embodied in the Tailings Guide.

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1 Introduction

This Tailings Guide provides guidance on best practices for the safe, and environmentally and socially responsible management of tailings facilities. Its purpose is threefold:

- to provide a framework for the management of tailings facilities;
- to help Owners of tailings facilities develop tailings management systems that include environmental and safety criteria; and
- to improve the consistency of application of reasonable and prudent engineering and management principles to tailings facilities.

Reference to a tailings management system does not imply the need for separate documentation specific to a management system for tailings. The tailings management system can be incorporated into broader site management systems. It is up to the Owner to decide how best to organize and integrate relevant information.

Tailings are a byproduct of mining, consisting of the processed rock or soil left over from the separation of the commodities of value from the rock or soil within which they occur.

Tailings and any associated water must be responsibly managed. Responsible management includes the prevention of impacts to human health and safety, the environment, and infrastructure. Tailings are managed in engineered facilities that are planned, designed, constructed, operated, closed and maintained in the long-term post-closure period (i.e., throughout the facility **life cycle**) in a manner consistent with the need for responsible management. Responsible management is defined by comprehensive assessments of the **risks** associated with a tailings facility, both physical and chemical, that evaluate the potential health, safety, environmental, societal, business, economic and regulatory impacts, and the implementation of appropriate controls to effectively manage those risks.

Tailings facility: The collective engineered structures, components and equipment involved in the management of tailings solids, other mine waste managed with tailings (e.g., waste rock, water treatment residues), and any water managed in tailings facilities, including pore fluid, any pond(s), and surface water and runoff. This may include structures, components and equipment for:

- classification of tailings through water content management (e.g., cyclones, thickeners, filter presses);
- transporting tailings to the tailings facility (e.g., pipelines, flumes, conveyors, trucks);
- containment of tailings and associated water (e.g., dams, dykes, stacks, liner systems, cover systems);
- management of seepage (e.g., underdrains, collection ponds, pumping wells);
- water reclaim systems (e.g., pumping to the ore processing facility);
- management of surface water releases from the tailings facility (e.g., diversions, decant structures, spillways, outlets, flumes, water treatment);
- structures, components and equipment for the surveillance and maintenance of tailings facilities; and
- mechanical and electrical controls, and power supply associated with the above.

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Owner is the company, partnership, or individual who has legal possession or is the legal holder of a tailings facility under law in the applicable jurisdiction where the facility is located. For example, the company, partnership or individual that owns the mine or ore processing facility from which tailings and water are generated is the owner of those tailings and can be considered the Owner of the tailings facility.

Each tailings facility is unique, reflecting site-specific environmental and physical characteristics that contribute to shaping the most appropriate approach to performance and risk management for that facility. The mining industry has the technology, experience and resources to locate, plan, design, construct, operate, decommission and close tailings facilities in a safe and environmentally responsible manner, and there remain opportunities to continually review and improve all aspects of tailings management.

The mining industry is accountable and responsible for managing tailings. This responsibility requires the development and implementation of a management system for effective decision making to integrate technical, legal, societal, and business requirements. An essential component of effective tailings management is the implementation of a tailings management system – one that embodies the elements of responsible tailings management. This Tailings Guide details a tailings management framework which provides the basis for Owners to implement a site-specific tailings management system. Elements of this framework are:

- Policy and commitment;
- Planning;
- Implementing the tailings management framework;
- Performance evaluation; and
- Management review for continual improvement.

A management system describes the set of procedures an organization needs to follow in order to meet its objectives. (International Standards Organization)

The intent of this Tailings Guide is to facilitate the development and implementation of facility-specific tailings management systems that address the specific needs of individual Owners and tailings facilities. Development and implementation of the tailings management system takes into account legal requirements and community expectations. The tailings management framework provides a foundation for managing tailings in a safe, and environmentally and socially responsible manner throughout the full life cycle of a tailings facility.

This third edition of the Tailings Guide is the result of a review of the current state of science regarding tailings management, incorporating current international best practice. The review has led to the strengthening of key concepts that were described in the previous editions, and introduces others, including:

Risk-Based Approach: an integral component of a tailings management system, with the goal of managing tailings facilities in a manner commensurate with the presence and magnitude of the physical and chemical risks that they may pose across the entire life cycle, including **closure**, and **post-closure**. Managing and mitigating risk includes:

- identification of potential risks at the **project conception and planning** phase of the life cycle, and rigorous risk assessment early in the life cycle, and updated periodically throughout the life cycle;

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- the application of the most appropriate technology to manage risks on a site-specific basis (**Best Available Technology – BAT**);
- the application of industry best practices to manage risk and achieve performance objectives in a technically and economically efficient manner (**Best Available/Applicable Practices – BAP**); and
- the use of rigorous, transparent decision-making tools to select a site-specific combination of BAT and location for a tailings facility.

Critical Controls: a risk control that is crucial to preventing a high-consequence event or mitigating the consequences of such an event. The absence or failure of a critical control would significantly increase the risk despite the existence of other controls.

Engineer-of-Record: The Owner, in assuring that a tailings facility is safe, has the responsibility to identify and retain an EoR, who provides technical direction on behalf of the Owner. The EoR verifies whether the tailings facility (or components thereof) has been:

- designed in accordance with performance objectives and indicators, applicable guidelines, standards and legal requirements; and
- constructed, and is performing, throughout the life cycle, in accordance with the design intent, performance objectives and indicators, applicable guidelines, standards and legal requirements.

Independent Review: systematic evaluation of all technical, management and governance aspects of a tailings facility across the life cycle by competent, objective, third-party reviewer(s). Provides assurance that the tailings facility's management system is effective across the life cycle.

Potential **consequences** of unwanted events associated with tailings facilities may include impacts on the environment, human health and safety, infrastructure, financial and legal implications, and reputational impacts. Thus, the scope of potential consequences to be managed is broader than those typically defined in consequence classification systems, such as that of the *Canadian Dam Association's Dam Safety Guidelines (2013 edition)*.

Continual improvement is the process of implementing incremental improvements and standardization to achieve better environmental and management system performance.

Mining companies and their associated projects and operations typically have management systems and frameworks in place. Integrating tailings management into these systems is part of the continual review and improvement of the system. The relevant procedures, activities and controls for managing tailings facilities should be appropriately assigned across personnel, departments, and business units and be scalable, depending on the nature of both the facility and its Owner. Periodic review of the efficiency and effectiveness of management systems will assist in meeting the objectives of responsible planning, design, construction, operation and eventual closure of tailings facilities.

From the initial phases of project conception and planning through to post-closure, a tailings management system should be in place to address and integrate risk management, legal requirements, technical, management, and governance aspects of tailings facilities. The integration of the technical and management components associated with tailings facilities is core to responsible management of tailings facilities and maintaining social acceptance in the mining industry. Owners of tailings facilities may adapt and implement the tailings management framework to meet their site-specific needs. Implementation of a tailings management system using this framework is intended to help Owners integrate environmental and safety considerations in a manner that is consistent with continual improvement in their tailings management and, in doing so, meet societal expectations.

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Also important to effective implementation of a site-specific tailings management system is engagement with Communities of Interest (COI). Such engagement is two-way, providing the COI with opportunity to ask questions about tailings management, provide information, and express their concerns. It is also an opportunity for the Owner to respond to proactively provide information, and address concerns and questions as they arise.

The Tailings Guide should be used in concert with MAC's *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities* (the OMS Guide). Developing and implementing a site-specific OMS manual is essential to implementing a tailings management system. The tailings management system provides an overall framework, but OMS activities need to be developed and implemented to make that framework function on a day-to-day basis.

Implementing the Tailings Guide and the OMS Guide will help Owners of tailings facilities achieve and demonstrate:

- a commitment to develop, implement, review and maintain a tailings policy;
- objective setting for planning and strategic activities related to performance and risk management of tailings facilities;
- continual improvement of a tailings management system;
- that internal controls and procedures are in place, maintained, implemented, and verified for the preparation, proper analysis, consideration and disclosure of technical, scientific, environmental and social information;
- that effective, transparent and appropriate level of authority and competency for decision-making is in place to evaluate, recommend and approve technical, management, environmental, social and economic aspects related to tailings and water management; and
- that verifiable, clearly defined and updated critical controls and procedures are in place to manage risks.

The objective of the Tailings Guide, together with the OMS Guide, is to continually work towards minimizing harm through the application of BAT and BAP in design, engineering, operation, maintenance, and surveillance of tailings facilities, and associated training. This is achieved through the application of risk assessment and management practices, and through the application of "continual improvement" principles. There are complementary guidance documents available and these should be integrated as appropriate provided they embody the principles described in this Tailings Guide.

Minimizing harm encompasses both physical and chemical performance and risks associated with tailings facilities, including:

- zero catastrophic failures of tailings facilities; and
- no significant adverse effects on the environment or human health.

MAC developed the *TSM Tailings Management Protocol* as a tool to measure progress in implementing this Tailings Guide and the OMS Guide. This Protocol contains a series of measurable indicators related to tailings management to complement these two Guides.

In 2016, the *International Council on Mining and Metals* (ICMM) released its *Position statement on preventing catastrophic failure of tailings storage facilities*, which describes a tailings governance framework. This Tailings Guide is aligned with and complementary to the ICMM position statement.

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Tailings and water facilities are complex engineered facilities that must be managed appropriately over long periods of time, some in perpetuity. Detailed technical guidance should be sought elsewhere as a complement to this Tailings Guide. Particularly for mines in Canada, implementation of the Tailings Guide is complemented by guidelines published by the *Canadian Dam Association (CDA)*:

- CDA Dam Safety Guidelines 2007 (2013 Edition); and
- Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (2014).

Other organizations that have produced high-quality, applicable technical guidance, including guidance on risk assessment and management, include, but are not limited to:

- *International Commission on Large Dams* (ICOLD);
- *Australian National Committee on Large Dams* (ANCOLD);
- *International Standards Organization* (ISO);
  - *ISO 9000 – Quality Management*;
  - *ISO 14000 – Environmental Management*; and
  - *ISO 31000 – Risk Management*;
- *International Code for Cyanide Management*;
- *Environment and Climate Change Canada*;
- *Western Australia Department of Mines and Petroleum*;
- *Australian Government Leading Practice Sustainable Development Program for the Mining Industry*;
- South African National Standards SANS 10286 1998;
- US Bureau of Reclamation;
- US Army Corps of Engineers;
- *US Federal Emergency Management Agency*;
- United Nations Environment Programme; and
- *European Union directive* and *Best Available Techniques (BAT) Reference Document for the Management of Waste from Extractive Industries* on mine waste management.

The Tailings Guide does not replace professional expertise or legal requirements. Owners of tailings facilities should obtain qualified professional advice, including legal, to be sure that each facility's specific conditions are understood and addressed.

It is important to note that this Tailings Guide discusses a wide range of information that should be documented as part of the development and implementation of a tailings management system. It is up to the Owner's discretion to decide how best to organize this information.

The Tailings Guide and the OMS Guide are not specific to Canadian conditions, and these Guides can be effectively applied to tailings management anywhere in the world. In addition, while written for tailings and associated water management facilities, many aspects of the Tailings Guide and the OMS Guide are equally applicable to the responsible management of other types of facilities, such as waste rock disposal areas, and heap leach facilities.

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2 Tailings Management Framework

2.1 Overview

This chapter presents the key elements of the framework to manage **tailings facilities** in a safe, sustainable, and environmentally responsible manner.

Figure 1 provides an overview of the essential elements of the tailings management framework as applied through all phases of the life cycle of a tailings facility: project conception and planning, design, initial construction, operations and ongoing construction, temporary or permanent closure, post-closure, and reopening of closed tailings facilities. The elements of the tailings management framework are:

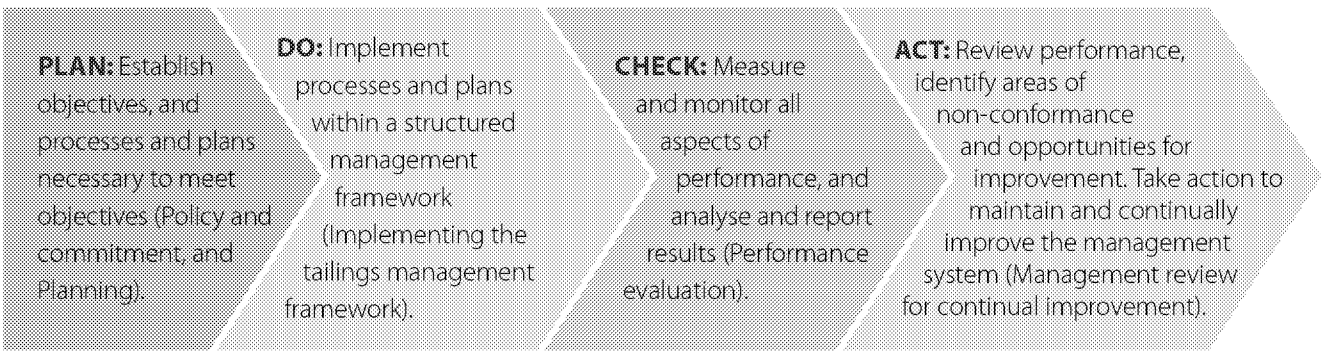
- Policy and commitment (*see Section 3*);
- Planning (*see Section 4*);
- Implementing the tailings management framework (*see Section 5*);
- Performance evaluation (*see Section 6*); and
- Management review for continual improvement (*see Section 7*).

Also integral to the development and implementation of an effective tailings management system is oversight provided through an assurance program. Assurance, which cross-cuts all elements of the **tailings** management framework, is further discussed in *Section 8*.

Environmental Management System (EMS): The part of an overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy and reducing environmental impacts (adapted from ISO 14001)

The tailings management framework is based on the *ISO 14001* definition of an environmental management system which includes: an organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining policies.

Consistent with other models for environmental management systems, the tailings management framework follows a cycle of Plan-Do-Check-Act; a management model for control and continual improvement.



The cycle is then repeated, with objectives re-visited and revised as appropriate, and processes and plans adjusted (see Figure 2). This helps to drive continual improvement, leading to improved environmental protection and reduced risk.

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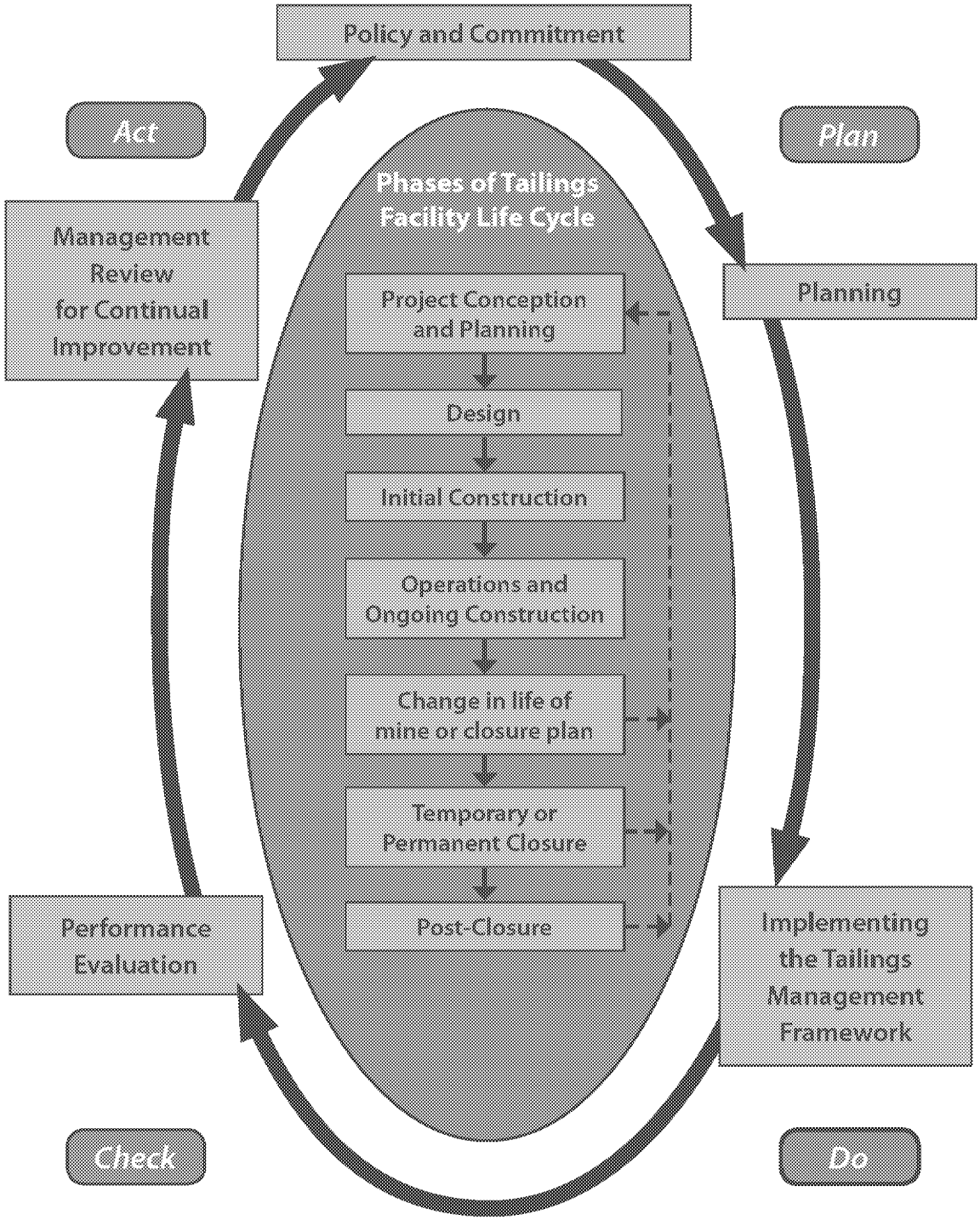
Figure 1: Elements of the Tailings Management Framework



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Phases of the Life Cycle of a Tailings Facility:

Project Conception and Planning: begins at the outset of planning of a proposed mine, and is integrated with conception and planning for the overall site, including the mine plan and plans for ore processing. The phase includes the use of rigorous decision-making tools to support selection of the location for the tailings facility, and the BAT to be used for tailings management.

Design: begins once the location and BAT for the tailings facility have been selected, and occurs in concert with detailed planning of all aspects of the proposed mine. Detailed engineering designs are prepared for all aspects of the tailings facility and associated infrastructure.

Initial Construction: construction of structures and infrastructure that need to be in place before tailings placement commences. This includes, for example, removal of vegetation and organic soils, and construction of starter dams, tailings pipelines, access roads, and associated water management infrastructure.

Operations and Ongoing Construction: tailings are transported to, and placed in, the tailings facility. Tailings dams may be raised, or new tailings cells added as per the design. The operations and ongoing construction phase of a tailings facility typically coincides with the period of commercial operations of the mine.

Standby Care and Maintenance: the mine has ceased commercial operations and the placement of tailings into the facility is not occurring. The Owner expects to resume commercial operations at some point in the future, so surveillance and monitoring of the tailings facility continue, but the facility and associated infrastructure are not decommissioned and the closure plan is not implemented.

Closure: begins when placement of tailings into the facility ceases permanently. The facility and associated infrastructure are decommissioned, and the closure plan is implemented, including:

- transitioning for operations to permanent closure;
- removal of infrastructure such as pipelines;
- changes to water management or treatment; and
- recontouring or revegetation of tailings and any containment structures or other structural elements.

Post-closure: begins when decommissioning work is complete, the closure plan has been implemented, and the tailings facility has transitioned to long-term maintenance and surveillance. During post-closure, responsibility for a tailings facility could transfer from the Owner to jurisdictional control.

NOTE: particularly with respect to closure and post-closure, there are various legal definitions in different jurisdictions. These definitions are intended strictly as function definitions, characterizing key activities that differentiate these phases.

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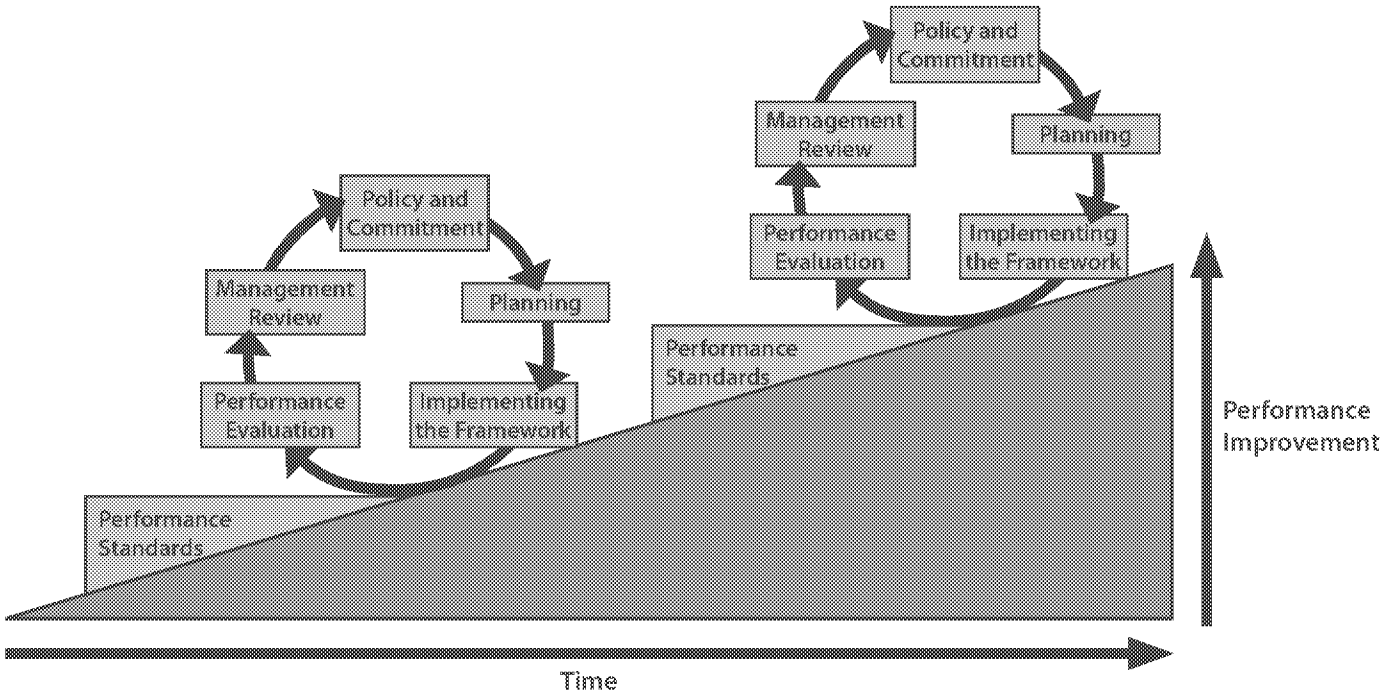
Figure 2: Continual Improvement through Implementation of the Tailings Management Framework



2.2 Overarching Principles

2.2.1 Risk Assessment and Management

The assessment and management of risk is essential to the effective management of tailings facilities, and is integral across all elements of the tailings management framework, and across the entire life cycle. Potential risks associated with tailings facilities, including the physical and chemical, as well as operational, organizational, financial and management risks, should be identified. Facilities should be conceived, designed, constructed, operated and closed in a manner that effectively manages risks to achieve the objective of minimizing harm.

Risks should be re-assessed throughout the life cycle, and as part of any material changes in the tailings facility, such as a mine life extension or a temporary suspension of operations. As the risk profile of the facility changes, the risk management measures should be updated accordingly.

Risk denotes a potential negative impact, detrimental to operations, the environment, public health or safety that may arise from some present process or future event. The potential severity or consequence of the impact and its probability or likelihood of occurrence are both considered when evaluating risk.

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For new and existing facilities, risk assessment should consider potential impacts of climate change, including extreme weather events (extended drought or high precipitation events), and potential impacts on permafrost in areas of high latitude or altitude. Risk management should include measures to ensure tailings facilities are resilient enough that risks continue to be appropriately managed under changing climate conditions, particularly in the long-term, through closure, and post-closure. Climate change adaptation is addressed in detail in MAC's *Guide on Climate Change Adaptation for the Mining Sector*.

Additional guidance on risk assessment and management is provided in *Appendix 1*.

One aspect of risk management is the identification, development, and implementation of critical controls, which are risk controls related to tailings facility management that should be implemented effectively to either prevent a high-consequence event from occurring, or to mitigate the consequences of such an event. The key steps in the identification, development, and implementation of critical controls are to implement a tailings management system, and to identify and evaluate:

- potential high-consequence events and plausible failure modes;
- critical controls for each plausible failure mode;
- performance indicators associated with these controls;
- actions to implement the controls; and
- pre-defined actions to be taken if performance is outside the specified range.

The implementation of appropriate corporate governance, including the implementation of a tailings management system, is a form of critical control. However, most other critical controls are more specific to the risks associated with a given tailings facility. Thus, some critical controls can be implemented and monitored at a corporate level, while others are implemented and monitored at the site-specific level. Critical controls are further discussed in *Section 4.1*.

2.2.2 BAT and BAP for Tailings Management

The identification and implementation of tailings management technology, including the application of site-appropriate BAT, together with the application of BAP, are the cornerstones of achieving performance objectives and managing risk. Selection of BAT requires consideration of a range of potential technologies, to select the most appropriate technology to manage risks on a site-specific basis. There are many factors to consider when choosing BAT for a tailings facility, examples of which include:

- Are the likelihood or consequences of a failure of a tailings facility reduced?
- Is material separation required to manage a potential geochemical concern?
- How much water will be retained in the tailings during their transport and placement?
- Is there potential to place any tailings in mined-out areas?
- Is the post-mining land use best served by a given technology?

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BAP are accepted practices across the full spectrum of tailings management to manage risk and achieve the best outcome in a technically sound and economically efficient manner. Elements of BAP can be applied widely, including:

- confirming geochemical and physical design parameters during operations, closure, and post-closure, and adjusting;
- structural monitoring of tailings facilities to detect movement or change;
- implementing a tailings management system;
- monitoring to assess performance against water balance requirements; and
- conducting Independent Review.

Best Available Technology (BAT) is the site-specific combination of technologies and techniques that is economically achievable and that most effectively reduces the physical, geochemical, ecological, social, financial, and reputational risks associated with tailings management to an acceptable level during all phases of the life cycle, and supports an environmentally and economically viable mining operation.

Best Available/Applicable Practice (BAP) encompasses management systems, operational procedures, techniques and methodologies that, through experience and demonstrated application, have proven to reliably manage risk and achieve performance objectives in a technically sound and economically efficient manner. BAP is an operating philosophy that embraces continual improvement and operational excellence, and which is applied consistently throughout the life of a facility, including the post-closure period.

For new facilities, and for facilities undergoing mine life extensions, performance objectives and the management of potential risks are key drivers at the conceptual planning and design phases. The selection of the most appropriate tailings management technology and facility location, using rigorous decision-making tools to assess alternatives, provides the foundation for future risk management and achieving performance objectives. At the design phase, consideration should also be given to BAP that could be applied throughout the life cycle of the facility.

For existing facilities, it may not be technically or financially possible to fundamentally change the technology used for tailings management. However, other aspects of technology associated with tailings management should be re-evaluated based on the results of updated risk assessments and evolving technology that could be applied to further reduce current and future risk. BAP should be re-evaluated throughout the life cycle, with the goal of continual improvement in tailings management. Management measures also need to be re-evaluated throughout the life cycle to ensure that they remain appropriate as the risk profile, or environmental or operating conditions of the tailings facility change.

Additional guidance on the integration of BAT and BAP is provided in *Appendix 2*. Assessment of alternatives for the selection of the tailings facility location and BAT is further discussed in *Appendix 3*.

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2.2.3 Independent Review

Regular, systematic Independent Review is recognized as a BAP for responsible tailings facility management.

Independent Review provides **Owners** with independent, objective, expert commentary, advice, and, potentially, recommendations to assist in identifying, understanding, and managing risks associated with tailings facilities. The primary purpose of Independent Review is to provide an opinion to the Owner's **Accountable Executive Officer** (*see Section 4.3.2*) regarding:

- completeness/appropriateness of the risk assessment and understanding;
- effectiveness of tailings governance and the tailings management system;
- whether the tailings facility is being effectively managed based on sound engineering practices;
- whether the risk assessment and the acceptable level of risk should be reviewed and updated;
- whether concepts and design criteria for the facility are consistent with legal requirements, industry guidelines and best practices, and current theory, methodologies and experience; and
- areas for improvement in the management of the tailings facility.

The objectives are to:

- facilitate informed management decisions regarding a tailings facility so that tailings-related risks are managed responsibly and in accordance with an acceptable standard of care; and
- ensure that the Accountable Executive Officer has a third-party opinion regarding the risks and the state of the tailings facility and the implementation of the tailings management system, independent of the teams (employees, consultants, and contractors) responsible for planning, designing, constructing, operating, and maintaining the facility.

As an overarching principle of the tailings management framework, Independent Review is applicable across all elements of the framework. It is also applicable across the entire life cycle of a tailings facility. The input of Independent Review should be sought from the initial conceptual planning and design phases, through to reviewing post-closure performance. However, over the life cycle of a tailings facility, and as the risk profile of a facility changes, the scope and focus of Independent Review should be re-adjusted to ensure it remains relevant and effective.

Independent Review is conducted by one or more appropriately qualified and experienced individuals, who have not been directly involved with the design or operation of the particular tailings facility. Qualifications and experience of reviewers should be aligned with the tailings facility's complexity and risk profile.

Additional guidance on Independent Review is provided in *Appendix 4*.

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2.2.4 Designing and Operating for Closure

Some of the potential impacts and risks posed by mining remain long after mining operations cease. In particular, tailings facilities may pose physical and chemical risks in perpetuity. Thus, tailings facilities may represent a long-term risk and liability that must be responsibly managed for many decades after mining operations cease. Designing and operating for closure is a BAP for mitigating these long-term risks and reducing liability.

A **closed tailings facility** is one that is no longer being used for the deposition of tailings, with the expectation that the facility will not be used for deposition of tailings in the future. The mine or ore processing facility with which the tailings facility is associated may or may not also be closed.

Designing and operating for closure requires a long-term view. Tailings facilities are seldom for temporary storage. While some may eventually be re-mined to recover additional commodities of value, they should be conceived, designed, constructed, operated and closed on the assumption that they will be permanent facilities. Tailings facilities, designed for closure, are true future engineered landforms, intended to remain physically and chemically stable for the long-term. It is important to ensure that short-term financial or operational priorities do not prevail over better design and operational practices that would have lower long-term impacts, complexity or risks.[1]

Designing and operating for closure is holistic, and takes all aspects of the mine into account, not just the tailings facility itself. For example, design and operational decisions related to mining and ore processing can impact both the quantity, and physical and chemical characteristics of tailings and associated water, and can have long-term implications for the management of tailings: management of tailings begins upstream in the operation – in the mine planning and in the ore processing plant.

The earlier that tailings hazards and associated unknowns are reduced, the greater the potential for meeting long-term closure objectives. Thus, planning and designing for closure should be initiated at the project conception and planning phase of the life cycle. Figure 3 illustrates the importance of planning for closure, and the application of BAT and BAP throughout the life cycle. For example, selecting the most appropriate combination of technology and the tailings facility location for a given site at the very outset will reduce risks and minimize closure liability.

1. The Australian Government (2016: *Leading Practice Sustainable Development Program for the Mining Industry: Tailings Management*) states that: "Conventional economic analysis can lead to minimising initial capital expenditure and deferring rehabilitation costs. Net present value analysis discounts the current cost of future expenditures on closure, rehabilitation and post-closure management. Therefore, if this short-term economic perspective is taken, without taking into account the longer term social and environmental costs, there is little motivation to invest more substantially at the development phase to avoid or reduce expenditures at the closure phase. There are a number of reasons, however, for applying leading practice at the earliest stage of development and for designing and operating the TSF to achieve optimal closure outcomes."

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Figure 3: Risk Management Practice over the Life of the Mine[2]

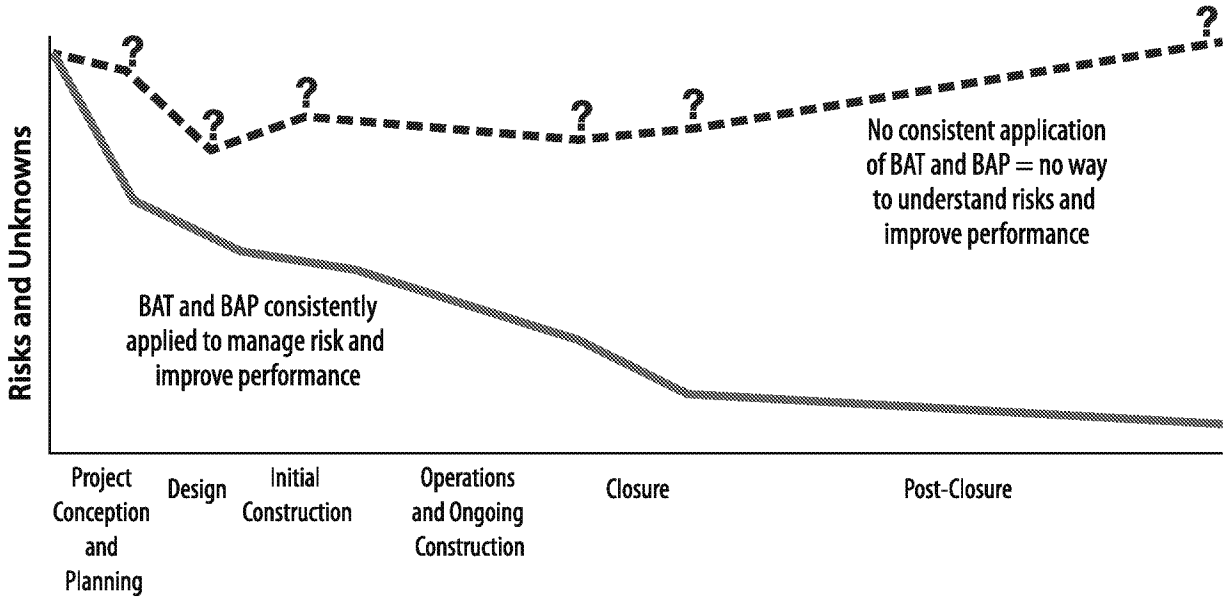

Figure 3 captures the importance of good decisions early in the life cycle of a tailings facility, but does not consider the financial accounting practices used in mine planning, particularly the application of discount rates to longer-term costs. Use of such practices can minimize, from a financial planning perspective, the importance of upfront investment in longer-term management of impacts and risks. At the same time, if every potential project became so risk adverse that financial considerations had no role in management practices, the benefits of mining to society would not be realized. Balance is required and a transparent decision process with input through Independent Review will assist in achieving, demonstrating, and communicating this balance.

After key design decisions are made about the selection of tailings management technology and a location for a tailings management facility, closure plans should continue to evolve and be refined in greater detail, considering changes in the mine plan, legal requirements, the risk profile of the tailings facility, status of progressive reclamation activities, and changes in **COI's** expectations.

Tailings facilities not originally designed with closure objectives in mind, such as facilities that have already been in operation for several decades, may be able to adjust their tailings management practices or adopt newer technologies (e.g., segregation if tailings with high potential for impacting water quality) to reduce risk and better position the tailings facility for closure. Regular review of such opportunities is central to continual improvement.

2. Figure adapted from International Council of Mining and Metals (2008): *Planning for Integrated Mine Closure: Toolkit*

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2.3 Managing Throughout the Life Cycle of a Tailings Facility

Mining companies face the challenge of effectively and efficiently managing tailings facilities throughout their life cycle, from project conception and planning, to design[3], through initial construction, operations and ongoing construction, to eventual closure, and post-closure[4] (Figure 1).

Tailings facilities continue to change and evolve over their life, and the life cycle of a tailings facility is rarely a simple linear progression from one phase to the next. For example, while construction is a discrete life cycle phase for most aspects of a mine, construction activities at a typical tailings facility continue throughout the operating life of the mine as dams or other containment structures are raised, or as facilities are enlarged to accommodate increasing volumes of tailings. This is unlike other types of containment structures, such as hydroelectricity dams or water resource management dams, which are typically built to final configuration at the outset. In addition, within the operational phase there can be changes that were not anticipated at the beginning of mine life, such as enlargements of the footprint of tailings facilities, care and maintenance suspensions (and subsequent re-starts), process and technology changes, and so forth, reinforcing the criticality of effective risk management and change management.

The life cycle timescale can extend for many decades to reach the end of the operations and ongoing construction phase, and centuries beyond for closure and post-closure. In some cases, tailings might be re-processed in the future as technology improves and commodity prices increase. Thus, many aspects of tailings management are not predictable at the mine's conception.

Change itself is a key source of risk for tailings facilities, and needs to be effectively managed. Systematic, risk-based management approaches provide a means of navigating these aspects of the mining life cycle.

At each phase in the tailings facility's life cycle, implementation of a tailings management system requires that actions be planned and implemented within the context of policies and commitments, with performance measurement and reporting mechanisms in place.

Typically, responsibility for the management of a tailings facility will come under different roles during different phases of its life cycle. For example, one team may lead the design, another the initial construction, another during the operations and ongoing construction phase, and another team for the closure phase. During post-closure, the facility may transition from active care and management to a more passive mode, but some level of surveillance and maintenance may still be required. Transfer of ownership of the facility may occur, but continuity of some degree of ongoing surveillance and maintenance may be necessary to ensure risks continue to be appropriately managed.

Consequently, having an established management system that ensures that design fundamentals/elements, operating principles and constraints, the risk assessment and risk management processes, and the associated critical controls are consistently carried forward to the subsequent management teams is essential to ensuring that risks are effectively managed and that new, unknown risks are not introduced by losing the original design data and intent.

Additional information on managing through the life cycle of a tailings facility is provided in *Appendix 5*.

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3. The project conception and planning, and the design phases encompass key steps in the mine planning process: Pre-Scoping Study, Scoping Study, Pre-Feasibility Study, and Feasibility. Thus, just as conceptual mine planning begins at the pre-scoping and scoping steps, planning for tailings management should also begin at these steps.

4. The closure and post-closure phases correspond to the overall closure phase, as described in the Canadian Dam Association's (CDA) *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (2014)*. The closure phase, as defined in this Tailings Guide, corresponds to the transition phase as defined by the CDA. The post-closure phase, as defined in this Tailings Guide, corresponds to the active and passive closure phases as defined by the CDA.

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3 Policy and Commitment

Every Owner of a tailings facility should establish a tailings management policy and/or commitments that meet the specific requirements applicable to their portfolio of **tailings facilities**. Each **Owner** should develop their commitments in the manner that best meets their needs and corporate management approach while addressing their commitments to regulators and their **COI**.

Each Owner should demonstrate commitment to:

- protection of public health and safety;
- responsible management of tailings with the objective of minimizing harm;
- allocation of appropriate resources to support tailings management activities;
- implementing a tailings management system through the actions of its employees, contractors, and consultants;
- establishing an organizational culture that promotes learning, communication, and early problem recognition; and
- emergency response and post-incident recovery participation in collaboration with appropriate regulatory authorities and COI.

On a facility-specific basis, the Owner should also make more specific commitments. These additional commitments will likely take the form of the following:

- plan, design, construct and operate tailings facilities in a manner that reduces long-term impacts, **risks** and liability;
- ensure tailings management complies with legal requirements, and conforms with reasonable and prudent engineering practice, set design criteria, company standards/guidelines, and the Owner's tailings management system;
- engage with COI, taking into account their considerations in relation to the design (including location), operation, and management of the tailings facility;
- manage tailings facilities commensurate with the risks they pose through implementation of BAT and BAP, with the objective of minimizing harm, and meeting performance, corporate governance, environmental and social requirements;
- manage all solids and water within designated areas;
- establish an ongoing program of review, including Independent Review, and continual improvement of health, safety and environmental performance through the management of risks associated with each tailings facility; and
- implement the level of accountability, authority and competency for decision making appropriate to the level of risk that the decision entails.

The policy and/or commitments should be:

- reviewed and endorsed by the Board of Directors or **Governance Level** (*see Section 4.3.1*);
- communicated to employees;

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- understood to a degree appropriate to their roles and responsibilities by employees and contractors whose activities may affect tailings management either directly or indirectly;
- communicated to COI; and
- implemented with budget allocation.

A tailings management policy does not need to be a stand-alone document, and can be part of an overarching company operation, environmental or sustainable development policy, if that policy contains specific reference to tailings management, and includes the policies and commitments as outlined here.

Some owners may have multiple policies to address different needs.

The key is that all necessary information be documented. It is up to the Owner to decide how best to organize that documentation.

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4 Planning

Planning is the first step in the Plan-Do-Check-Act cycle of the tailings management system. It lays the foundation for implementing a tailings management system. It consists of establishing the tailings management system itself, and development of all plans, processes, and systems, including engineering studies, to be integrated into and implemented within the tailings management system.

In subsequent cycles of the Plan-Do-Check-Act cycle of the tailings management system, Management System Planning includes updates, as appropriate, to those plans, processes, and systems as well as any updates to the management system itself. The tailings management system and all associated plans, processes, and systems should be aligned with the **Owner's** policy or commitment (*Section 3*). As such, the tailings management system serves as the primary vehicle to meet that policy or commitment on a site-specific basis.

Owners of existing tailings facilities that are developing a tailings management system for the first time may already have some of these plans, processes, and systems in place. A gap analysis should be conducted that identifies missing plans, processes, and systems and also assesses the current degree of alignment and integration of plans, processes, and systems, and identifies any deficiencies. This should include consideration of the adequacy and potential need for updates to the risk assessment and risk management plan. In conducting this gap analysis, it is important to recognize that a tailings management system is intended to be tailored in a site-specific manner, reflecting the site and tailings facility characteristics, the Owner's policy and commitments, legal requirements, and commitments to **COI**.

As part of Management System Planning an action plan should be developed and implemented to address identified gaps, and existing plans, processes, and systems, including engineering studies, should be revised as appropriate to improve/ensure their alignment and address any deficiencies. Development and implementation of an action plan should be informed by prioritizing the outcomes of the gap analysis and focusing first on:

- Gaps or deficiencies that pose the highest risks.
- Missing or inadequate information that is needed (e.g., site characterization information) to address the gaps or deficiencies identified.

MAC's Table of Conformance may be used to help conduct this gap analysis.

4.1 Risk Management

The identification and mitigation of **risk** are fundamental tenets of good management, and this applies to the management of tailings (*Section 2.2.1*). Risk assessments should be completed as frequently as required to meet the tailings management objectives established for any given facility. The acceptable level of risk should be defined in the context of the facility and for its specific **life** phase, taking into account the likelihood and consequence of catastrophic failure, and perspectives of the Owner, regulators and COI.

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Risk assessment and management should take into account:

- physical and chemicals risk of the **tailings facility**;
- environmental hazards such as earthquakes, landslides or avalanches, which could impact the facility; and
- other risks external to the Owner and the facility, including legal and permitting risks (e.g., not obtaining permits in a timely manner, or permits that are not aligned with the design intent of the tailings facility).

A risk management plan should be prepared and documented so that it describes the outcomes of the risk assessment, and mitigation measures to be implemented to:

- eliminate or avoid risk to the extent practicable;
- reduce risk by minimizing the likelihood or potential consequence of an unwanted event or condition that poses a risk; and
- detect, respond to, and minimize the consequences if an unwanted event or condition occurs that poses a risk.

Development of a conceptual risk management plan should begin at the **project conception and planning phase** of the life cycle for new facilities and expansions of existing facilities, and be refined and developed in greater detail during the **design phase**.

For all operations, the risk assessment and the risk management plan should be reviewed and updated regularly as appropriate through the life cycle of the tailings facility. The plan should also be reviewed and updated in the event of changes that were not anticipated at the beginning of mine life, such as mine life extensions, care and maintenance suspensions (and subsequent re-starts), changes in the ore being processed, process and technology changes, etc.

Critical Controls

Risk controls are described in the risk management plan, and are site-specific or governance-level measures put in place to either:

- prevent or reduce the likelihood of the occurrence of an unwanted event; or
- minimize or mitigate the negative consequences if the unwanted event does occur.

Critical controls are site-specific and governance-level risk controls that are crucial to preventing a high-consequence event or mitigating the consequences of such an event. The absence or failure of a critical control would significantly increase the risk despite the existence of other controls. Critical controls may be technical, operational, or governance-based.

Development and implementation of a framework for critical controls management is an important risk management tool that provides a high level of assurance against the occurrence of high-consequence events, as defined by the Owner and its EoR, with input from Independent Review, regulators, and COI.

The designation of critical controls is an Owner and tailings facility-specific exercise. Risk controls are typically designated as critical controls if one or more of the following conditions are met:

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- implementation of the control would significantly reduce the likelihood or consequence of an unwanted event or condition that poses unacceptable risk (see also *Appendix 1*);
- conversely, removal or failure of the control would significantly increase the likelihood or consequences of an unwanted event or condition that poses an unacceptable risk, despite the presence of other controls;
- the control would prevent more than one failure mode or would mitigate more than one consequence; or
- other controls are dependent upon the control in question.

Processes for management of critical controls should be implemented, key elements of which are as follows:

- identify potential failure modes and causes using risk assessment techniques (see *Appendix 1*);
- identify risk controls associated with potential failure modes and causes;
- identify those risk controls deemed to be critical on an Owner or facility-specific basis;
- appoint a "risk owner" and "critical control owner" for that risk;
- define the critical controls and their performance criteria, measurable performance indicators, and surveillance requirements;
- identify pre-defined actions to be executed if control is lost;
- verify execution of critical controls by the critical control owner or designate, at a frequency commensurate with the frequency of control execution;
- report deficiencies in critical controls to the Responsible Person(s) and, where appropriate, the Accountable Executive Officer, and identify actions and a schedule to address those deficiencies;
- track implementation of actions to address critical control deficiencies, and report to the Responsible Person(s) and, where appropriate, the Accountable Executive Officer; and
- periodically review and update risk controls and critical controls, based on updated risk assessments, risk management plans, and past performance.

In incorporating concepts such as critical controls into a tailings management system and corresponding OMS activities, it is important that such concepts be effectively implemented. However, there are other closely aligned concepts that use different terminology. For example, some Owners develop and implement Trigger Response Action Plans (TARPs). It is the concept that is essential, and not the terminology used to describe it.

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4.2 Performance Objectives

Establish and document performance objectives, indicators, and associated performance measures for the tailings facility based on:

- environmental requirements;
- risk assessment and the level of acceptable impact and risk; and
- risk management plan.

Performance objectives and indicators should be aligned with the Owner's tailings management system and policy and/or commitments, standards/guidelines, legal requirements, commitments to COI, and sound engineering and environmental practices.

Performance objectives and indicators should be developed for the entire life cycle of the tailings facility, including planning for both potential temporary and eventual permanent closure, and should address:

- protection of employee and public health and safety;
- design objectives and criteria, including geotechnical, geochemical, operational, community, and environmental performance objectives that the tailings facility is expected to achieve;
- mitigation of negative environmental impacts by ensuring continued physical and chemical stability of all components/structures; and
- acceptable post-closure use within a feasible technical and economic framework.

Performance objectives are overall goals, arising from the Owner's policy and commitment, which are quantified where practicable.

Performance indicators are detailed performance requirements that arise from the performance objectives and that need to be set and met in order to achieve those objectives. Performance indicators must be measurable and quantifiable.

(Both definitions adapted from *ISO 14001*)

For new facilities or facilities undergoing expansion, performance objectives should be established early in the conceptual planning and design phases. Assessments of alternatives for facility location and tailings management technology should take these performance objectives into account.

4.3 Accountability and Responsibility

A wide range of employees, contractors, and consultants are typically engaged to implement a tailings management system and apply a duty of care in ensuring that tailings facilities are managed in a responsible manner. Given the number of people involved, and the range of roles related to tailings management, it is important that accountability, responsibility, and authority be clearly defined and in place for all decisions related to tailings management. Decisions should be made by persons who have clear accountability or responsibility, the authority to make those decisions, and who are appropriately qualified and experienced.

It is essential that persons with accountability, responsibility, and authority for tailings management have an understanding—appropriate to their accountability, responsibility, and authority level—of how the tailings facility is planned, designed, constructed, and operated. This includes the risks posed by the facility, the risk management process, critical controls management, and operational constraints.

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The circumstances of each Owner and tailings facility vary and, therefore, governance and organizational structure should be appropriately tailored to the needs of each Owner and facility. At a minimum; however, accountabilities, responsibilities, authority, and roles should be clearly defined and documented for:

- Owner's Board of Directors or Governance Level;
- Accountable Executive Officer;
- Responsible Person(s);
- Engineer-of-Record (EoR); and
- Independent Reviewer(s).

The Owner should establish clear lines of communications between these positions.

It is also essential that the Owner understand the roles and mandate of all relevant regulatory agencies, and have a clear understanding of the legal framework within which the tailings facility is planned, designed, constructed, operated, and closed.

4.3.1 Board of Directors or Governance Level

Ultimately, the accountability for decisions related to tailings management rests with the Owner's Board of Directors or Governance Level. This will depend on the size and structure of the Owner company. This includes endorsing the corporate policy or commitment related to tailings management (*Section 3*).

The Owner should determine the respective roles and accountabilities of the Board of Directors or Governance Level and the Accountable Executive Officer.

Governance Level: The company Board of Directors (or a sub-committee of the Board of Directors) is considered the governance level of a company, the level at which the highest-level corporate decisions are made, particularly regarding organizational and financial resources. For companies headquartered outside of the country in which the tailings facility is located that do not have a Board of Directors based in that country, the governance level would be equivalent to the highest-level committee or board that provides oversight and review of tailings management activities within that country.

4.3.2 Accountable Executive Officer

An executive-level person (e.g., CEO, COO, Vice President) designated by the Board of Directors or Governance Level who is accountable for tailings management, and the development and implementation of the systems and associated training needed for responsible tailings management. This accountability cannot be delegated, but the Accountable Executive Officer may delegate responsibilities. This Officer has a direct reporting relationship to the Board, a Board committee, or the Governance level and:

- needs to be aware of key outcomes of tailings facility risk assessments and how these risks are being managed;
- has accountability and responsibility for putting in place an appropriate management structure and is accountable for ensuring development and implementation of site-specific tailings management systems and development of any required plans for emergency preparedness;

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- delegates responsibility and authority for tailings management and defines the personnel responsibilities, authority, and reporting relationships to implement the systems needed for responsible tailings management through all phases of the tailings facility life cycle;
- demonstrates to the Board of Directors/Governance Level whether tailings are managed responsibly;
- is accountable for establishing processes to ensure the approval (on the recommendation of the Responsible Person(s) and Engineer of Record, and subject to Independent Review) of:
  - the design and design intent of the tailings facility, including design associated with any material changes; and
  - risk management plan for tailings management;
- is accountable for ensuring that the Responsible Person, EoR, and Independent Reviewers have the appropriate competencies and experience commensurate with risk level and characteristics of the facility; and
- is accountable for ensuring that a process is in place for personnel to be able to report concerns related to tailings management, and for following-up on those concerns.

4.3.3 Responsible Person(s)

As a minimum, the Owner should designate one Responsible Person for each tailings facility. During initial construction, and operations and ongoing construction, there should be a Responsible Person immediately available at all times. The Responsible Person(s) has clearly defined, delegated responsibility for tailings management and appropriate qualifications. The Owner should describe the competencies required. There may also be a designated Responsible Person at the corporate level. The Responsible Person(s) identifies the scope of work and budget requirements (subject to final approval) for all aspects of tailings management, including the EoR, and will delegate specific tasks and responsibilities for aspects of tailings management to qualified personnel.

The Responsible Person(s) should be familiar with the design, construction, operation, and performance of the tailings facility and is integral to the development and implementation of the tailings management system.

The Responsible Person(s) is responsible for the management of the tailings facility, including:

- ensuring that a site-specific organizational structure is in place, with documented roles and responsibilities;
- establishing and maintaining a relationship and ongoing communications with the EoR;
- developing (where one does not currently exist) and implementing a site-specific tailings management system, including ensuring that:
  - the management system and associated plans, processes, systems are developed and implemented, commensurate with the risk profile, characteristics, and life cycle phase of the tailings facility (*Sections 4 and 5*);
  - tailings management performance is evaluated (*Section 6*);
  - management reviews for continual improvement are conducted at the frequency prescribed by the Owner (*Section 7*); and

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  - recommendations and action plans arising from management reviews are implemented, including reviewing/revising plans, processes, and systems (e.g., risk management plan, OMS manual) (*Section 7*);
- overseeing planning, design, and sequencing of construction, where applicable; and
- ensuring that:
  - risk assessment is conducted and reviewed at an appropriate frequency, and a risk management plan is developed, implemented, and updated accordingly (*Sections 2.2.1 and 4.1*); and
  - an assurance program is developed and implemented, including Independent Review, and that results are documented and considered (*Section 8*).

The Responsible Person(s) should maintain regular communication with the EoR and should also liaise with internal teams with direct and indirect responsibilities related to tailings management such as operations, planning, regulatory affairs, environment, and COI engagement.

4.3.4 Engineer-of-Record

The Owner, in assuring that a tailings facility is safe, has the responsibility to identify and retain an EoR, who provides technical direction on behalf of the Owner. The EoR verifies whether the tailings facility (or components thereof) has been:

- designed in accordance with performance objectives and indicators, applicable guidelines, standards, and legal requirements; and
- constructed, and is performing, throughout the life cycle, in accordance with the design intent, performance objectives and indicators, applicable guidelines, standards and legal requirements.

For tailings facilities that include retention structures/dams, the EoR is responsible for Dam Safety Inspections and associated reports. The EoR should also participate in the facility's risk assessments and be accessible to Independent Reviewers, and, for facilities with retention structures, dam safety reviews. The EoR provides these activities as part of the Owner's broader assurance process, as described in *Section 8*.

The Owner should develop a terms of reference for the EoR that describe the roles and responsibilities of the position, reporting relationships, lines of communications, and required competencies.

The EoR must have experience and knowledge commensurate with the risk management requirements for the facility. The EoR must have the appropriate qualifications, which includes professional certifications relevant to the jurisdiction in which the tailings facility is located (e.g., Professional Engineer registration in the appropriate province or territory in Canada).

4.3.5 Independent Reviewer(s)

The Independent Reviewer(s) provides Owner with independent, objective, expert commentary, advice, and potentially recommendations, to assist in identifying, understanding, and managing risks associated with tailings facilities, as well as the implementation of the Owner's tailings management system. The Independent Reviewer(s) does not have decision-making authority. Accountability and responsibility for decisions rests with the Owner.

Independent Reviewers are third-parties who are not, and have not been directly involved with the design or operation of the particular tailings facility.

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4.4 Conformance Management

The Owner should document and implement conformance management processes to ensure that:

- applicable legal requirements and commitments (including commitments/conditions coming from environmental assessment and permitting) are identified, documented, understood and effectively communicated;
- owner's policies, guidelines, standards, practices are identified, documented, implemented, and reviewed;
- those accountable and responsible for conformance understand the conformance management plan and have the necessary training and competence; and,
- procedures to assess state of conformance have been established, implemented, documented and communicated as required for responsible management of the facility.

In cases of non-conformance, the Owner should:

- report the non-conformance, internally and externally, as appropriate;
- determine the causes of the non-conformance, and identify and implement corrective measures;
- address consequences of the non-conformance, including mitigating environmental impacts;
- review the effectiveness of measures to correct the non-conformance; and
- make necessary changes to the tailings management system to prevent future non-conformance.

The nature of non-conformance events should be documented, together with corrective actions taken, and the results of the corrective actions.

4.5 Managing Change

The Owner should document and implement processes to manage change to maintain the integrity of the tailings facility and the management system, including changes to:

- approved designs and plans, including temporary changes, and expansions to tailings facilities;
- facility ownership;
- persons involved, or roles of, employees, contractors, and consultants with key duties related to tailings management, including the Accountable Executive Officer, Responsible Person(s), EoR, and Independent Reviewer(s);
- conditions that may impact tailings management, including temporary suspension of mining operations;
- the closure plan;
- legal requirements; and
- any other changes that are potentially material to the risks associated with tailings management (i.e., any change that has the potential to change the performance or risk profile of the tailings facility or its component parts).

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Processes to manage change should include succession planning for key roles related to tailings management, including the Responsible Person(s), EoR, and Independent Reviewer(s). For roles such as the EoR and Independent Reviewer(s), this could include having documented terms of reference, descriptions of required qualifications, and a documented process for filling roles in the event of change. For the EoR, the succession plan should address the transfer of necessary information to the new EoR, including the procedures and timelines for transfer.

Changes that could impact the risk profile of a tailings facility should be reviewed and potential impacts should be evaluated. Changes should be approved by the relevant persons (e.g., EoR, Responsible Person(s), personnel involved in tailings management and related activities, and the Accountable Executive Officer, as appropriate). In particular, if changes are proposed to the original or current design of the tailings facility (e.g., changes in dam construction specifications), these proposed changes should be carefully documented and risks of the change in the current and future phases of the life cycle should be evaluated. Depending on the nature of the change and the potential impact, Independent Review of the proposed change is recommended (see also *Appendix 4*). Before implementing, the proposed change should be approved at a level commensurate with the potential impact of the change.

If other changes are proposed, such as changes to plans and procedures, the potential impacts of these changes should also be evaluated, and changes should be approved at the appropriate level prior to implementation. Changes should be documented.

4.6 Managing Information

Access to and use of, up-to-date, accurate information, and the retention of relevant information, is critical to responsible tailings management. The Owner should ensure that key information related to the tailings facility is documented, and reviewed and updated as appropriate throughout the life cycle. How this documentation is organized is at the discretion of the Owner.

4.6.1 Information to be Documented

There is a wide range of information that should be documented, as described in detail in *Appendix 6*. Information that should be documented and updated throughout the life cycle includes:

- relevant information about the mine, the tailings facility and its location, local and regional environmental, social, and socio-economic conditions, as well as other factors such as natural hazards and climate conditions (*Appendix 6*);
- information about the design of the tailings facility, including the initial design, updates through the operations and ongoing construction phase, and design for closure (*Appendix 6*);
- documentation of construction and as-built conditions of the tailings facility, including information to demonstrate whether the design intent is being met (*Appendix 6*);
- deviations from the design or operational plans, including assessing the cumulative impacts to risk of changes to the tailings facility, and recommendations to managed risks as appropriate; and
- closure plan (*Appendix 8*).

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4.6.2 Control of Documented Information

Information necessary for effective tailings management should be controlled. Owners need to establish and implement a process to ensure that documented information is created, maintained, retained, and archived. There are two aspects to control of documented information:

- access to, and use of, current and accurate documented information; and
- identification and retention of records that are potentially useful to the future management of the tailings facility.

Key documents related to tailings management should be managed as controlled documents, including:

- defining the process for reviewing and updating the documents, including both major and minor updates;
- identifying persons with authority to revise the documents and the scope of their authority (e.g., some may only have the authority to amend certain sections);
- describing mechanisms for approval of revisions; and
- for electronic documents, implementing measures to prevent unintended changes, or to prevent any changes by personnel without the appropriate authority.

In addition, there needs to be defined procedures for:

- providing personnel with access to the documents;
- informing personnel of changes to documents relevant to their roles and responsibilities;
- control of reference information used to develop and update documents;
- restricting access to out-of-date versions and clearly labelling those versions as out-of-date;
- identifying out-of-date materials that need to be retained; and
- archiving or disposing of out-of-date materials, as appropriate.

Archiving of relevant out-of-date materials is important to ensure that valuable records are not lost. Owners should develop and implement a process to identify records that are potentially useful to the future management of the tailings facility. These records should be retained and not destroyed. These records could include records related to planning, design, construction, operation and closure of tailings facilities, including surveillance and monitoring records.

Access to information may be interrupted (e.g., loss of paper copies due to fire, temporary loss of access to electronic copies due to loss of power). The potential loss of access needs to be evaluated, particularly in the case of OMS manuals or ERPs that are accessed electronically. There may be components of these documents that need to be accessible in paper copy in the event that electronic versions are not accessible. Indeed, a loss of power may be linked to certain critical controls (e.g., loss of ability to operate pumps), and having access to these documents during such periods may be necessary for the effective response to the situation.

Specific risks and vulnerabilities associated with potential loss of access need to be identified and contingency plans and information technology security plans need to be developed, including:

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- procedures for backup and recovery of paper and electronic copies;
- plans to prevent unauthorized access, including access to documentation, as well as access to instruments and other technologies that may be connected to mobile networks or wireless internet; and
- retention of paper copies of critical components of the OMS manual and ERP that can be used in the event of a loss of access to electronic documents.

Another consideration for control of documented information is the management of legacy electronic formats. A plan needs to be developed, with input from information technology and management experts, to address the management of legacy electronic formats to ensure that records potentially useful to tailings management are not lost or made impossible to access in the future as a result of obsolescence of software, electronic file formats, or data storage medium.

4.7 Quality Management

There are two key components to quality management: quality assurance (QA) and quality control (QC). These two components are closely related, but they are different.

To illustrate, a QA plan for the construction of a tailings dam or other containment structure would prescribe the specifications (determined at the design phase) for all aspects of construction, such as the specifications for materials to be used in the construction of the dam. A QC plan would describe procedures to ensure that these specifications are met, and procedures to address cases where specifications are not met. The overall goal is to ensure that the dam is constructed in a manner that is consistent with the design principles, and to eliminate risks associated with sub-standard construction of the dam.

QA and QC plans can be separate, or combined in a quality management plan, but it is important that both components be described and documented.

Quality, quality assurance and quality control are defined in the ISO 9000 Quality Management Standard as follows:

Quality: The degree to which a set of inherent characteristics fulfils requirement.

Quality assurance (QA): All those planned and systematic activities implemented to provide adequate confidence that the entity will fulfill requirements for quality.

Quality control (QC): The operational techniques and activities that are used to fulfill requirements for quality.

QA ensures that you are doing the right things, the right way. QC ensures that your results are what you expected.

Quality management should address a wide range of aspects related to the tailings facility, including:

- initial and ongoing construction, including specifications for materials and construction procedures (e.g., material compaction);
- OMS activities, such as calibration of surveillance instruments; and
- QA and QC related to closure plan implementation.

These aspects of quality management do not all have to be described in a single document. For example, information related to construction should be described in design documentation (*Appendix 6*), and information related to OMS should be described in the OMS manual.

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4.8 Operation, Maintenance, and Surveillance Manuals

An operation, maintenance, and surveillance (OMS) manual should be prepared for each tailings facility and should describe requirements for the OMS activities necessary to the effective management of the facility, based on the site-specific design intent, performance objectives, risk management plan, and critical controls. An OMS manual documents and clearly communicates requirements to implement OMS activities to employees, contractors, and consultants involved in tailings management.

The *OMS Guide* provides detailed guidance on the development and implementation of OMS manuals.

OMS activities are necessary to the effective management of risk controls and critical controls. An OMS manual documents these controls and describes pre-defined management actions necessary to retain or regain control.

Surveillance is key to the management of risk controls and critical controls – without surveillance there is no control. An OMS manual describes the performance indicators and criteria for risk controls and critical controls, and the ranges of performance linked to specific pre-defined management actions. An OMS manual also describes the procedures to collect, analyze, and report surveillance results in a manner consistent with the risk controls and critical controls and that supports effective, timely decision-making.

Operation: Includes activities related to the transport, placement and permanent storage of tailings and, where applicable, process water, effluents and residues, and the recycling of process water. It also includes reclamation and related activities.

Maintenance: Includes preventative, predictive and corrective activities carried out to provide continued proper operation of all infrastructure (e.g., civil, mechanical, electrical, instrumentation, etc.), or to adjust infrastructure to ensure operation in conformance with performance objectives.

Surveillance: Includes the inspection and monitoring (i.e., collection of qualitative and quantitative observations and data) of activities and infrastructure related to tailings management. Surveillance also includes the timely documentation, analysis and communication of surveillance results, to inform decision making and verify whether performance objectives and risk management objectives, including critical controls, are being met.

The link between OMS activities and critical controls management underscores the fact that it is essential that OMS manuals be developed to reflect site-specific conditions and circumstances. An OMS manual cannot be purchased "off-the-shelf". To be effective, it must be tailored to the site.

To be effective, an OMS manual also needs to:

- provide the necessary information to implement OMS activities on a daily basis; and
- be easily accessible to all relevant personnel.

An OMS manual includes or refers to other plans specific to various aspects of tailings management. These plans also need to be developed and documented (see also *Appendix 8*):

- tailings transport and placement plan;
- water management plan; and
- closure plan.

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4.9 Resources

For effective and efficient implementation of a tailings management system, including eventual decommissioning and closure, and sustained post-closure management, the Owner should identify, secure and regularly review adequacy of:

- human resources and external contractors and consultants;
- condition, function and suitability of equipment;
- financial resources; and
- schedules of activities that integrate the required resources related to tailings management. Examples of activities to be scheduled include timing of construction, access to construction material, reviews, inspections, and any other item critical to successfully implementing the tailings management system.

Measures should also be in place for financial control, control of documented information, training and competence, and communications, as further described below.

Financial Control

Establish and document a budget for tailings management, considering both short-term and long-term needs for responsible and effective tailings management throughout the life cycle.

Establish and document associated financial controls, obtain budget approval, and track capital and operating costs against the budget. In addition, at a frequency documented and appropriate to the facility and its life cycle phase, re-evaluate the decommissioning and reclamation provision for each facility commensurate with all applicable legal requirements and commitments.

4.10 Training and Competence

Training

Tailings management requires the Owner and personnel involved in the tailings facility to have a level of competence consistent with the requirements of the facility and its risks. Key elements of developing and maintaining competence are qualifications, training, and experience.

Providing appropriate training to those who are involved with the tailings facility, including contractors, consultants, and suppliers, will require different training at different levels. For example, senior management should receive higher level, conceptual training about the risks of tailings management, while mine managers and others working directly on specific aspects of tailings facilities, including their design, construction, and operations, should receive detailed and relevant training that corresponds to their work.

Typical aspects to be covered in training:

- tailings management system;
- tailings facility management plans, permits, approvals, and commitments;
- individual duties, responsibilities, and reporting relationships;
- the importance of conformance to design, operational controls, financial controls, and change management procedures;
- risk assessment;
- risk management and critical controls;
- significance of change, and change management process;
- emergency response plans;
- operation, maintenance and surveillance plans and processes described in the OMS manual; and
- importance of communications and document management.

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A training program should be developed and implemented. Records related to training for employees, contractors, and consultants, which was funded by or provided by the Owner, should be maintained.

Training addresses both:

- general aspects, such as the Owner's policy and commitments related to tailings management, and the overall goals of responsible tailings management; and
- specific aspects (e.g., technical, communications, management) related to the roles and responsibilities of individual personnel.

Training may be carried out using in-house resources but there may be a need to involve external parties such as the designer or EoR in development of the training materials. Owners may consider some form of evaluation of personnel on their knowledge of the content of the OMS manual to demonstrate competency. A tracking mechanism needs to be in place (e.g., training needs matrix) to ensure that all relevant personnel receive appropriate training.

4.11 Communications

The Owner should clearly describe lines and expectations for communications, and establish and implement communications processes for personnel with direct and indirect roles related to tailings management, including reporting of significant information (e.g., results of Performance Evaluation) and decisions to senior management, the EoR, regulators, and COI, as appropriate.

Communications processes, associated training, and the overall corporate culture should strive to foster an environment in which personnel are encouraged to report problems/concerns or identify opportunities for improving tailings management. The timely communication of potential problems can be essential to achieving the goal of minimizing harm. Two key mechanisms to establishing such a corporate culture are:

- establishment of a confidential process to receive, investigate and promptly address potential problems/concerns identified by personnel regarding possible violations of legal requirements or related public safety, tailings facility integrity or the environment; and
- development and implementation of mechanisms for whistleblower protection to ensure that there is no retaliation, discrimination against, or otherwise negative consequences to whistleblowers who, in good faith, have reported possible violations of legal requirements or potential problems/concerns related public safety, tailings facility integrity or the environment.

It is important to emphasize that these mechanisms do not need to be specific to tailings management, and in most cases, they are not likely to be. Existing, corporate or site-level processes can be used, or new processes could be developed, provided that it is clear that their scope includes tailings management.

There are limits to what can be achieved through establishment of communications processes. Effective communication is a skill that must be developed, and:

- effective communications need to be addressed as part of training activities;
- breakdowns in communications need to be investigated to learn and improve communications; and
- the effectiveness of communications needs to be assessed regularly, with the aim of identifying deficiencies and opportunities for improvement.

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Overarching all challenges around communications is complacency, the sense that "it won't happen to us." Complacency increases risk. A tailings management system, effectively implemented with clear communications, clear roles and responsibilities, and a decision-making framework (see OMS Guide Section 2.3), can help counter the tendency to be complacent by bringing greater rigour to all aspects of tailings management.

Further information on effective communications in relation to tailings management is presented in *Appendix 7.*

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5 Implementing the Tailings Management Framework

When fully implemented at a specific site, a tailings management system based on this framework will encourage continual improvement in the safe and environmentally responsible management of **tailings facilities**.

As described in *Section 2*, the tailings management framework has been designed for application through the full **life cycle** of a tailings facility, beginning at any phase. **Owners** of tailings facilities should implement the framework at the earliest practicable opportunity.

Implementing the tailings management framework requires the full implementation of all plans described in *Section 4*. In addition, there are two essential components to implementing the tailings management framework:

- implementing an OMS manual; and
- emergency preparedness.

5.1 Operation, Maintenance, and Surveillance Manual

Implementing a facility-specific OMS manual, developed as described in *Section 4.8* and the *OMS Guide*, is essential to implementing the tailings management framework. A tailings management system provides an overall framework, but an OMS is needed to make that framework function on a day-to-day basis. Developing and implementing an OMS manual is a critical component of meeting performance objectives and managing current and future risks associated with any tailings facility.

An OMS manual is a "living" document that needs to be regularly reviewed and revised as appropriate throughout the **operations and ongoing construction** phase of the tailings facility's life cycle, as well as beyond. An out-of-date OMS manual poses **risks** – it is essential that manuals be up-to-date.

5.2 Emergency Preparedness

There is a wide range of potential emergencies that may occur associated with tailings facilities, including structural failure of a facility, rising water levels within a facility, cracking of a dam, a sudden loss of environmental containment of a facility, or other events linked to the loss of one or more **critical controls**. There are also other types of emergencies that may affect a mine site more generally, including a tailings facility, such as a loss of power, an earthquake, or extreme conditions such as wildfire, landslide, or avalanche.

It is essential to be prepared to effectively respond to an emergency, should one occur. Being prepared for an emergency includes:

- assessing the range of potential emergency scenarios that could occur, and potential impacts;
- maintaining the necessary capacity (e.g., personnel, equipment, supplies) to respond;
- maintaining a state of readiness to respond, in collaboration with external parties (e.g., local first responders) that would be involved in responding to an emergency;
- developing plans for emergency preparedness; and
- conducting training and exercises/tests of the plans for emergency preparedness.

Owners of tailings facilities should undertake emergency preparedness and response planning for each mine site as a whole. Emergency preparedness for a tailings facility is a component of that broader planning.

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There are two components to emergency preparedness: emergency response plans (ERPs) and emergency preparedness plans (EPPs). ERPs and EPPs need to be developed for all tailings facilities, taking into consideration the risk profile, risk management plan, and critical controls for that facility.

In addition to the details provided below, the CDA's *Dam Safety Guidelines (Section 4) (2013 edition)* also provide information on emergency preparedness.

Emergency: A situation that poses an impending or immediate risk to health, life, property, and/or the environment and which requires urgent intervention to prevent or limit the expected adverse outcomes.

5.2.1 Emergency Response Plans

An ERP describes measures the Owner and, in some cases, external parties will take to prepare for an emergency, and to respond if an emergency occurs. Although some aspects of an ERP may involve external parties, it is intended to be an internal document. Elements of an ERP that would be implemented by external parties should be developed cooperatively and be provided to them. An ERP describes the following. While some of the items below duplicate those listed below for EPPs, it is expected that some of the information provided in the ERP would be more detailed.

- potential emergencies that may occur and the conditions that would trigger implementation of the ERP, including, where applicable, potential effects of inundation (see *Section 5.2.3*);
- resources (people, equipment, materials) required to respond to an emergency, including identifying resources that need to be retained on-site (e.g., equipment, stockpiles of rip-rap or other materials);
- roles and responsibilities of the Owner's employees, contractors, and consultants, and relevant external parties (e.g., local first responders, regulatory agencies) and the overall command structure in the event of an emergency;
- any mutual aid agreements with external parties, such as local first responders, other industrial facilities (e.g., nearby mines), or contractors (e.g., heavy machinery);
- site access, including primary and secondary means to access the mine site and tailings facility, and means of reaching the site of a potential emergency under various conditions (e.g., foot, boat, helicopter, all-terrain vehicle, etc.);
- communications systems, equipment and materials;
- procedures to activate the ERP, including internal and external notification and communications plans for emergency response, including up-to-date contact information (e.g., phone numbers and email addresses) for relevant personnel, both internal and external;
- training requirements and plans for relevant personnel, including external parties such as local first responders;
- procedures or actions to be taken to:
  - prevent an upset or unusual condition from becoming an emergency;
  - mitigate on and off-site environmental and safety impacts associated with emergency situations; and

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  - mitigate consequences if an emergency occurs, including:
    - evacuation plans; and
    - rescue plans;
- mechanisms to alert potentially affected parties of an imminent or developing emergency situation (e.g., alarms to notify downstream communities in the event of a tailings dam failure);
- linkages with the crisis management and communications plan (see *Section 5.2.4*);
- surveillance requirements;
- procedures and frequencies to test the ERP; and
- procedures for the administration and update of the ERP.

An ERP for a tailings facility in the **closure** or **post-closure** phase of the life cycle will need to be adapted to those phases, when there are fewer personnel and less equipment on-site. ERPs may need to involve local contractors who could provide heavy equipment and operators, as well as measures to ensure that equipment, fuel, and personnel can be transported to the site. Contingency plans may be needed for power generation on site, and communications infrastructure.

The *OMS Guide* addresses the relationship between OMS activities and ERP. An OMS manual describes OMS activities conducted under normal and upset or unusual conditions, while the ERP functions when there is an emergency. The OMS manual and ERP for a given tailings facility must be aligned, such that there are no functional gaps between normal operations and emergency response, and that procedures are in place to transition from normal conditions to an emergency situation that may arise.

5.2.2 Emergency Preparedness Plans

For emergencies that could result in downstream impacts on the environment, infrastructure, or safety, an EPP is developed for external use with input from **COI**, including local authorities (e.g., first responders, municipal governments), and regulatory authorities. An EPP includes:

- a description of the tailings facility, the potential emergencies that could occur, and the potential effects of those emergencies, including, where applicable, potential effects of inundation (see section 5.2.3);
- roles and responsibilities of the Owner and external parties (e.g., local first responders, regulatory agencies) and the overall command structure in the event of an emergency;
- notification procedures to be followed if an emergency occurs or is imminent, including up-to-date contact information (e.g., phone numbers and email addresses) for relevant personnel;
- mechanisms to alert potentially affected parties of an imminent or developing emergency situation (e.g., alarms to notify downstream communities in the event of a tailings dam failure);
- procedures and frequencies to test the EPP; and
- procedures for the administration and update of the EPP.

Information provided in the EPP may be used by potentially affected COI, including local authorities, to assist in the development of their ERPs. Copies of EPPs need to be provided to potentially affected COI with roles or responsibilities related to emergency response.

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5.2.3 Other Considerations for ERPs and EPPs

Risk-Based Approach

The level of detail and aspects addressed in ERPs and EPPs need to be commensurate with the potential consequences if an emergency occurs. For tailings facilities with high-consequence material risks, such as large tailings facilities with impounded water, ERPs and EPPs must be comprehensive and detailed, with active engagement of potentially affected COI. However, for facilities which pose only lower consequence material risks (e.g., stacked facilities with little or no risk of off-site movement of tailings), ERPs and EPPs may be more limited in scope, with a lower level of detail appropriate to the risk profile of that tailings facility. In such cases, COI should still be aware of the potential risks and consequences, but there may be less need for active COI engagement in emergency preparedness.

Integration with Site-Level ERPs and EPPs, and Linkages with other Documents

An ERP and an EPP need to be developed and documented for each tailings facility and integrated with the overall site-level ERP and EPP. Emergencies that may affect a mine site more generally (e.g., wildfire) need to be addressed in the site-level ERP and EPP, while the ERP and EPP for a tailings facility addresses the specific considerations for that facility if such an emergency occurs (e.g., emergency procedures for water management in the event of an extended loss of power).

Depending on the needs of the site and COI, an ERP and EPP can be combined, or they may be separate.

As with other documents related to tailings management, it is up to Owner to decide how best to organize necessary documentation. However, ERPs and EPPs are very important documents. While they may be incorporated into other documents, such as an OMS manual, it may in many cases be best practice to maintain them as separate documents, to ensure that they are:

- readily accessible in the event that an emergency occurs;
- administered and prepared by the appropriate personnel/groups;
- directed towards the appropriate audience; and
- more easily updated, based on the outcomes of reviewing and testing the plans.

Addressing Inundation Risks

For tailings facilities that pose a risk of inundation of downstream areas in the event of a failure, the ERP and the EPP need to take into account inundation mapping. The area that could be inundated needs to be clearly defined, describing the maximum extent of flooding, flood depths, and time to maximum depth. Maps of potentially inundated areas need to be developed and included in the ERP and the EPP, identifying any downstream mine site infrastructure, communities, residences, farms, recreational facilities, roads, railways, bridges, powerlines, other infrastructure, or other features (e.g., wildlife habitat) that could be impacted in the event that an emergency occurs. The scope of an EPP encompasses all COI and local authorities that could be potentially impacted by an inundation event.

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Inundation studies identify:

- predicted consequences associated with failure modes for a tailings facility;
- downstream areas that could be directly impacted by the release of tailings solids and water;
- timing and size of overall area of impact following a loss of containment; and
- potential impacts of a failure on: human health and safety, the environment, cultural and archeological resources, and infrastructure.

Inundation studies inform the analysis of potential consequences of a failure, including costs.

In accordance with the *CDA's Dam Safety Guidelines* (Section 2.5) (2013 edition), such analyses should be conducted for two scenarios:

Flood-induced event: Impoundment breach from a natural flood of a magnitude that is greater than what the tailings facility can safely pass.

Sunny-day event: This is a sudden event that occurs during normal operations. It may be caused by various factors, including internal erosion, piping, earthquakes, and operational events or errors leading to overtopping, or similar events.

Additional guidance is also available from the Association of Professional Engineers and Geoscientists of British Columbia, which released *"Flood Mapping in BC - APEGBC Professional Practice Guidelines"*

Review and Testing

Procedures need to be established and implemented for regularly scheduled review and testing of ERPs and EPPs to ensure that the plans are up-to-date and adequate, and that all relevant personnel, including external parties, are familiar with the plans and their roles and responsibilities if an emergency occurs. Review and testing of EPPs need to involve potentially affected COI such as local first responders and relevant government agencies. Portions of ERPs that would require action by external parties if an emergency occurs also need to be tested in this manner. Tests can range from a tabletop exercise to a full-scale simulation of an emergency and can include multiple failures. The results of tests need to be evaluated to identify any deficiencies or opportunities for improving the ERP or EPP, and the plans updated accordingly.

5.2.4 Integration with Crisis Management and Communications Planning

Emergency preparedness needs to be augmented with crisis management and communications planning. A crisis as an event or set of circumstances that could significantly affect an Owner's ability to carry out their business, damage an Owner's reputation and/or threaten the environment, the health and safety and well-being of its employees, neighbouring communities or the public at large. Any tailings-related emergency that constitutes a crisis must be managed as such.

If a crisis occurs, the Owner's first priorities must be to protect the safety and well-being of its employees, impacted communities and environments, and to remediate any negative impacts on nearby communities and the environment. However, there are a number of obstacles that can impede the quick resolution of a crisis.

Effective crisis management and communications, including proactive communication of how the Owner is managing and resolving the situation, can help facilitate the physical response to an emergency and help prevent or lessen impacts on the Owner and COI. Whereas ERPs are intended to guide the initial physical response to the emergency, the crisis management and communications plan is intended to guide communications internally and externally.

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Crisis management and communications are addressed in detail in MAC's *Crisis Management and Communications Planning Protocol*, which requires both head offices and facilities to develop crisis management plans, as well as establish crisis communications teams to support the execution of these plans. Facilities must be able to demonstrate, among other requirements, that they have crisis communications programs in place to effectively alert employees and the public of a crisis, its development and resolution. They must also be able to demonstrate that their crisis management plan is regularly tested and updated.

Further information on crisis planning is available, for example:

- MAC's *Crisis Management and Communications Planning Reference Guide*
- United Nations Environment Programme *Awareness and Preparedness for Emergencies at Local Level* (2nd Edition, 2015)

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6 Performance Evaluation

Performance evaluation is essential to:

- assess whether performance objectives are being met;
- assess the effectiveness of risk management measures, including **critical controls**;
- inform updates to the **risk** management process for the **tailings facility**; and
- inform the Management Review for Continual Improvement.

Performance evaluation builds upon the results of surveillance conducted in accordance with the requirements contained in the OMS manual by analyzing and interpreting the results to evaluate performance. The evaluation includes results of surveillance and reviews, both internal and independent, to evaluate:

- operating performance against performance objectives and indicators, and critical controls;
- compliance with legal requirements, and conformance with plans and commitments;
- the risk management process, including the need to update the risk assessment;
- the need for changes or updates to the OMS manual or other site-specific **tailings** management system-related documents. This includes evaluating the effectiveness of surveillance activities and the utility of the information being collected, and identifying any gaps in information collection; and
- the need for changes or updates to the ERP and EPP.

Performance evaluation should include the identification of gaps, deficiencies or areas of non-conformance with the tailings management system, including performance objectives and plans to address those objectives. Action plans to make necessary changes or updates should be documented, approved and implemented, and implementation of action plans should be documented and tracked to completion. Deviations from the approved corrective actions should be documented to describe if and why action different from those originally approved were undertaken. The status of action plans should be communicated internally and to **COI**, as appropriate.

Performance evaluation occurs at various timescales, from hourly or daily, to annual or more, depending on the aspect of performance being evaluated. For example, evaluation of conformance for some parameters related to tailings deposition or water management may require daily oversight, while broader, more comprehensive performance evaluation, such as evaluating the need for changes to the OMS manual, may be done on a less frequent basis.

Incidents can and do occur, both at tailings facilities within the **Owners**' portfolio, and at other facilities. It is essential that such incidents be analyzed and learnings from those incidents be identified and applied to improve performance and prevent similar incidents from occurring in the future.

As part of performance evaluation, the Owner should establish a mechanism to conduct post-incident analyses for any incidents related to tailings management that may occur, such as cases of non-conformance, un-anticipated upset conditions, or an emergency. Such analyses are important to learn from what happened to help prevent a similar incident from occurring in the future, and could consider a range of questions such as:

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- How can a similar event be prevented from happening in the future?
- Were any mistakes made that led to the incident, or in responding to the incident? If so, how can those mistakes be avoided in the future?
- What can be done to improve response if a similar incident occurs in the future?
- Are there any recommendations for changes to the tailings management system, ERP, EPP, or OMS manual as an outcome of the post-incident analysis?

If an incident occurs, a post-incident analysis should be conducted as soon as possible afterwards, while the memories of all personnel involved remain fresh. Results of the analysis should be documented and reported to the **Responsible Person(s)**, **Accountable Executive Officer**, and Board of Directors or **Governance Level**, as appropriate. Owners are also encouraged to share their analyses and outcomes with the industry more broadly, so that others may learn and improve their tailings management practices.

Results and recommendations arising from performance evaluations should be documented and reported. Frequency of reporting depends on the nature of the performance evaluation and the results.

It is necessary to report the results and recommendations of performance evaluations to the Responsible Person(s), the Accountable Executive Officer and, as appropriate, the Board of Directors or Governance Level, at a frequency and level of detail documented in the Owner's policies and procedures.

Assurance is a critical component of performance evaluation. *Section 8* provides the essential elements of an assurance program.

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7 Management Review for Continual Improvement

Management should perform regular reviews to ensure continual improvement, based on Performance Evaluation and Assurance. The management review process should evaluate the:

- status of actions from the previous management review;
- suitability, adequacy, effectiveness, and the need for changes to:
  - the **tailings** management system;
  - the ERP and the EPP; and
  - the OMS manual;
- performance of the **tailings facility**;
- effectiveness of **risk** management;
- adequacy of resources committed to tailings management; and
- integration of tailings management activities with site-wide systems, such as, where applicable, a site-wide environmental and social management system.

The management review process should also identify opportunities for improvement and describe associated action plans.

The frequency of management reviews varies, but is typically annual during the **initial construction**, and **operations and ongoing construction** phases, and the **closure phase**.

The management review for continual improvement is reported to the **Accountable Executive Officer** to ensure that the **Owner** is satisfied that the tailings management system is effective and continues to meet the needs of the facility. The management review for continual improvement goes beyond technical performance to address all aspects of the management of the tailings facility.

The management review process also provides an opportunity for the **Responsible Person(s)**, the **EoR** and other employees and contractors involved in tailings management to: reconfirm alignment between design requirements and OMS activities; discuss realized or anticipated changes and their implications/ management; and identify opportunities for improvement.

The management review should describe current conditions related to the tailings facility, including a summary of construction activities since the last management review and significant changes since the last management review. This should include:

- an assessment of whether the tailings facility is continuing to meet the design intent; and
- a summary of any deviations from the design or expected conditions since the last management review, including an assessment of the cumulative impacts of those deviations.

The management review should identify and evaluate the potential significance of changes since the previous management review that are relevant to the tailings management system, including:

- changes to legal requirements, standards and guidance, industry best practice, and commitments to **COI**;
- changes in mine operating conditions (e.g., production rate) or site environmental conditions;
- changes outside the mine property that may influence the nature and significance of potential impacts resulting from the tailings facility on the external environment or vice versa;

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- changes in the risk profile of the tailings facility; and
- relevant new or emerging technologies, practices or knowledge related to tailings management that may potentially be considered in continual improvement.

The management review should also provide a summary of significant issues related to the overall performance of the tailings facility and tailings management system, updated since the previous management review, including:

- compliance with legal requirements, conformance with standards, policies and commitments, and status of corrective actions;
- tailings facility maintenance;
- tailings facility surveillance; and
- inspections, internal or external audits, evaluations of effectiveness, and Independent Review.

The management review outcomes should be documented and reported to the Accountable Executive Officer, including:

- conclusions regarding the performance of the tailings facility, the tailings management system, the ERP and the EPP, and the OMS manual;
- if needed, action plans to:
  - ensure that performance objectives are met;
  - address non-conformance with requirements, standards, policy, or commitments; and
  - implement recommendations for continual improvement.
- any recommendations for modifications to the tailings management system, the ERP, the EPP, or the OMS manual; and
- any recommendations for additional resources for tailings management.

Progress towards implementing action plans should be tracked and reported at least annually to the Accountable Executive Officer.

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8 Assurance

Assurance is an oversight process to provide an outside perspective on whether tailings are being managed effectively and responsibly. It is distinct from the Performance Evaluation component of a tailings management system, and cross-cuts all other aspects of tailings management.

Effective assurance is a valuable feedback mechanism to those directly involved in tailings management. Depending on the assurance mechanism used, assurance potentially provides perspectives on current performance, deficiencies, opportunities for improvement, future plans, and other aspects of tailings management. It can also provide a challenge function to those directly involved in tailings management, from a perspective that sees the forest as well as the trees, and depending in the assurance mechanism used, may pose provocative questions such as:

- Why do you do it this way?
- Could there be a better way?
- Have you thought about this?
- Why did you make that assumption?

Outcomes of assurance can be used to help demonstrate the current state of tailings management to the **Owner** (including the **Responsible Person(s)**, **Accountable Executive Officer** and the Board of Directors or **Governance Level**), regulators, and **COI**.

Those providing assurance can be internal to the company (e.g., employees at the corporate level or from other facilities) or external. Assurance providers need to have appropriate qualifications relevant to their assurance activities to ensure that assurance is effective.

Several different mechanisms to be used to provide assurance are described below. These should not be treated as "either/or" options – all should be used, as they serve different purposes.

Audits (both internal and external): The formal, systematic and documented examination of a **tailings facility's** conformance with explicit, agreed, prescribed criteria, often requirements stipulated in law or regulation, or in the Owner's tailings management system. Audits evaluate and report on the degree of conformance with stipulated criteria, based on the systematic collection and documentation of relevant evidence. Audits involve some degree of judgment but are not designed to determine root cause of deficiencies, or to evaluate management system effectiveness.

Internal audits are conducted by employees with appropriate knowledge and competencies who are independent, impartial, and objective with respect to the management of the tailings facility being audited. For example, they could work at other tailings facilities in the Owner's portfolio or that could work at the corporate level.

External audits are conducted by auditors who are external to the company being audited. Auditors maintain an objective viewpoint throughout the audit process to ensure that findings and conclusions are based only on the evidence (Adapted from *ISO 19011*).

Evaluation of Effectiveness: An evaluation of effectiveness goes beyond determining whether a condition has been met and includes an assessment of whether tailings management is achieving the intended results. It considers both the extent to which planned activities have been realized, and the extent to which performance objectives have been achieved.

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Criteria to be examined will depend on the scope of the evaluation. Typical sources of information that should be considered when evaluating tailings management system effectiveness include changes in internal or external conditions that could affect the system and achievement of performance objectives.

Performance results and trends that should be evaluated to determine the effectiveness of tailings management include:

- the extent to which performance objectives and indicators are being achieved;
- the extent to which planned activities have been implemented as intended;
- fulfilment of conformance obligations;
- non-conformities and corrective actions;
- surveillance results;
- adequacy of resources to support achievement of performance objectives;
- feedback from practitioners and end users; and
- any additional relevant information or feedback from COI.

Independent Review: one of the overarching principles of the framework, Independent Review is described in *Section 2.2.3* and further discussed in *Appendix 4*.

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Glossary

Acceptable risk: The level of risk deemed acceptable to an Owner, considering legal requirements, internal policy, business factors and societal acceptance.

Accountability: The answerability of an individual for their own performance and that of any personnel they direct, and for the completion of specified deliverables or tasks in accordance with defined expectations. An accountable person may delegate responsibility for completion of the deliverable or task, but not the accountability.

Accountable Executive Officer: An executive-level person (e.g., CEO, COO, Vice President) designated by the Board of Directors or Governance Level, who is accountable for tailings management, and the development and implementation of the systems needed for responsible tailings management. This accountability cannot be delegated. This Officer has a direct reporting relationship to the Board, a Board committee, or the Governance level and:

- needs to be aware of key outcomes of tailings facility risk assessments and how these risks are being managed;
- has accountability and responsibility for putting in place an appropriate management structure;
- delegates responsibility and authority for tailings management and defines the personnel responsibilities, authority, and reporting relationships to implement the systems needed for responsible tailings management through all phases in the facility life cycle; and
- demonstrates to the Board of Directors/Governance level whether tailings are managed responsibly.

Authority: The power to make decisions, assign responsibilities, or delegate some or all authority, as appropriate. The ability to act on behalf of the Owner.

Best Available/Applicable Practice (BAP): Management systems, operational procedures, techniques and methodologies that, through experience and demonstrated application, have proven to reliably manage risk and achieve performance objectives in a technically sound and economically efficient manner. BAP is an operating philosophy that embraces continual improvement and operational excellence, and which is applied consistently throughout the life of a facility, including the post-closure period.

Best Available Technology (BAT): The site-specific combination of technologies and techniques that is economically achievable and that most effectively reduces the physical, geochemical, ecological, social, financial, and reputational risks associated with tailings management to an acceptable level during all phases of the life cycle, and supports an environmentally and economically viable mining operation.

Communities of Interest (COI): COI include all individuals and groups who have an interest in, or believe they may be affected by, decisions respecting the management of operations. Facility COI may include, but are not restricted to:

- indigenous peoples;
- community members;
- under-represented groups;
- employees;
- contractors/suppliers;

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- neighbours;
- local environmental organizations and other non-governmental organizations (NGO); and
- local governments and institutions.

Other COI may include:

- suppliers;
- customers;
- regional or national environmental organizations and other non-governmental organizations (NGO);
- governments;
- the financial community; and
- shareholders.

Continual improvement: The process of implementing incremental improvements and standardization to achieve better environmental and management system performance.

Critical controls: A risk control that is crucial to preventing a high-consequence event or mitigating the consequences of such an event. The absence or failure of a critical control would significantly increase the risk despite the existence of other controls. Critical controls may be technical, operational, or governance-based. Critical control management is a governance approach to managing high-consequence risks relating to an operation or business.

Documented information: Information of importance that is required to be controlled and maintained by the organization. Documented information can refer to the tailings management system and its processes, documentation, and records.

Emergency: A situation that poses an impending or immediate risk to health, life, property, and/or the environment, and which requires urgent intervention to prevent or limit the expected adverse outcomes.

Engineer-of-Record: The Owner, in assuring that a tailings facility is safe, has the responsibility to identify and retain an EoR, who provides technical direction on behalf of the Owner. The EoR verifies whether the tailings facility (or components thereof) has been:

- designed in accordance with performance objectives and indicators, applicable guidelines, standards and legal requirements; and
- constructed, and is performing, throughout the life cycle, in accordance with the design intent, performance objectives and indicators, applicable guidelines, standards and legal requirements.

For tailings facilities that include retention structures/dams, the EoR is responsible for Dam Safety Inspections and associated reports. The EoR should also participate in the facility's risk assessments and be accessible to Independent Reviewers, and, for facilities with retention structures, dam safety reviews. The EoR provides these activities as part of the Owner's broader assurance process.

Governance Level: The company Board of Directors (or a sub-committee of the Board of Directors) is considered the governance level of a company, the level at which the highest-level corporate decisions are made, particularly regarding organizational and financial resources. For companies headquartered outside of the country in which the tailings facility is located that do not have a Board of Directors based in that country, the governance level would be equivalent to the highest-level committee or board that provides oversight and review of tailings management activities within that country.

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Independent Review: Independent, objective, expert commentary, advice, and, potentially, recommendations to assist in identifying, understanding, and managing risks associated with tailings facilities. This information is provided to the Owner to:

- facilitate informed management decisions regarding a tailings facility so that tailings-related risks are managed responsibly and in accordance with an acceptable standard of care; and
- ensure that the Accountable Executive Officer has a third-party opinion regarding the risks and the state of the tailings facility and the implementation of the tailings management system, independent of the teams (employees, consultants, and contractors) responsible for planning, designing, constructing, operating, and maintaining the facility.

Legal Requirement: any law, statute, ordinance, decree, requirement, order, judgment, rule, or regulation of, and the terms of any license or permit issued by, any governmental authority.

Life cycle: The succession of phases in the life of a tailings facility, consisting of: project conception and planning, design, initial construction, operation and ongoing construction, closure, and post-closure. At some sites, the life cycle may also include temporary closure. In the case of tailings facilities, the life cycle, including the closure, and post-closure phases, can extend to decades or centuries, unless the facility is removed at some point in the future if tailings are reprocessed or relocated.

Project Conception and Planning: Begins at the outset of planning of a proposed mine, and is integrated with conception and planning for the overall site, including the mine plan and plans for ore processing. The phase includes the use of rigorous decision-making tools to support selection of the location for the tailings facility, and the BAT to be used for tailings management.

Design: Begins once the location and BAT for the tailings facility have been selected, and occurs in concert with detailed planning of all aspects of the proposed mine. Detailed engineering designs are prepared for all aspects of the tailings facility and associated infrastructure.

Initial Construction: Construction of structures and infrastructure that need to be in place before tailings placement commences. This includes, for example, removal of vegetation and organic soils, and construction of starter dams, tailings pipelines, access roads, and associated water management infrastructure.

Operations and Ongoing Construction: Tailings are transported to and placed in, the tailings facility. Tailings dams may be raised, or new tailings cells added as per the design. The operations and ongoing construction phase of a tailings facility typically coincides with the period of commercial operations of the mine.

Standby Care and Maintenance: The mine has ceased commercial operations and the placement of tailings into the facility is not occurring. The Owner expects to resume commercial operations at some point in the future, so surveillance and monitoring of the tailings facility continue, but the facility and associated infrastructure are not decommissioned and the closure plan is not implemented.

Closure: Begins when placement of tailings into the facility ceases permanently. The facility and associated infrastructure are decommissioned, and the closure plan is implemented, including:

- transitioning for operations to permanent closure;
- removal of infrastructure such as pipelines;
- changes to water management or treatment; and
- recontouring or revegetation of tailings and any containment structures or other structural elements.

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Post-closure: Begins when decommissioning work is complete, the closure plan has been implemented, and the tailings facility has transitioned to long-term maintenance and surveillance. During post-closure, responsibility for a tailings facility could transfer from the Owner to jurisdictional control.

Maintenance: Includes preventative, predictive, and corrective activities carried out to provide continued proper operation of all infrastructure (e.g., civil, mechanical, electrical, instrumentation, etc.), or to adjust infrastructure to ensure operation in conformance with performance objectives.

Management system: Processes and procedures that collectively provide a systematic framework for ensuring that tasks are performed correctly, consistently and effectively to achieve a specified outcome and to drive continual improvement in performance. A systems approach to management requires an assessment of what needs to be done, planning to achieve the objective, implementation of the plan, and review of performance in meeting the set objective. A management system also considers necessary personnel, resources and documentation requirements. Other definitions associated with management systems are:

Policy: The expression of management's commitment to a particular issue area that presents the stance of the company to interested external parties.

Practice: Documented approaches to carrying out a task.

Procedure: A documented description of how a task is to be carried out.

Operation: Includes activities related to the transport, placement and permanent storage of tailings and, where applicable, process water, effluents and residues, and the recycling of process water. The term "operation" applies throughout all phases of the life cycle of a tailings facility and is not limited to the operations and ongoing construction phase of the life cycle when tailings are being actively placed in the facility. As a result, operation also includes reclamation and related activities.

Owner: The company, partnership, or individual who has legal possession or is the legal holder of a tailings facility under law in the applicable jurisdiction where the facility is located. For example, the company, partnership or individual that owns the mine from which the tailings and wastewater are generated is the owner of those tailings and can be considered the Owner of the tailings facility.

In the case of joint ventures or similar projects, they may be more than one company involved in Ownership. In such cases, the Owner would comprise all companies that are represented on the Board of Directors and are involved in decision-making.

Quality: The degree to which a set of inherent characteristics fulfils requirement.

Quality assurance (QA): All those planned and systematic activities implemented to provide adequate confidence that the entity will fulfill requirements for quality.

Quality control (QC): The operational techniques and activities that are used to fulfill requirements for quality.

Responsibility: The duty or obligation of an individual or organization to perform an assigned duty or task in accordance with defined expectations, and which has a consequence if expectations are not met. An individual or organization with responsibility is accountable to the person that delegated that responsibility to them.

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Responsible Person: Identifies the scope of work and budget requirements (subject to final approval) for all aspects of tailings management, including the Engineer-of-Record, and will delegate specific tasks and responsibilities for aspects of tailings management to qualified personnel. The Responsible Person(s) has clearly defined, delegated responsibility for tailings management and appropriate qualifications.

As a minimum, the Owner needs to designate one Responsible Person for each tailings facility. There may also be a designated Responsible Person at the corporate level.

Risk: A potential negative impact, detrimental to operations, a facility, the environment, public health or safety, that may arise from some present process or future event. When evaluating risk, both the potential severity and consequence of the impact and its probability of occurrence are considered.

Risk controls: Measures put in place to either:

- prevent or reduce the likelihood of the occurrence of an unwanted event; or
- minimize or mitigate the negative consequences if the unwanted event does occur.

Risks need to be managed via controls, and risk controls should have designated owners and defined accountabilities. Some risk controls are designated as critical controls.

Surveillance: Includes the inspection and monitoring (i.e., collection of qualitative and quantitative observations and data) of activities and infrastructure related to tailings management. Surveillance also includes the timely documentation, analysis and communication of surveillance results, to inform decision making and verify whether performance objectives and risk management objectives, including critical controls, are being met.

Tailings: A byproduct of mining, consisting of the processed rock or soil left over from the separation of the commodities of value from the rock or soil within which they occur.

Tailings facility: The collective engineered structures, components and equipment involved in the management of tailings solids, other mine waste managed with tailings (e.g., waste rock, water treatment residues), and any water managed in tailings facilities, including pore fluid, any pond(s), and surface water and runoff. This may include structures, components and equipment for:

- classification of tailings through water content management (e.g., cyclones, thickeners, filter presses);
- transporting tailings to the tailings facility (e.g., pipelines, flumes, conveyors, trucks);
- containment of tailings and associated water (e.g., dams, dykes, stacks, liner systems, cover systems);
- management of seepage (e.g., underdrains, collection ponds, pumping wells);
- water reclaim systems (e.g., pumping to the ore processing facility);
- management of surface water releases from the tailings facility (e.g., diversions, decant structures, spillways, outlets, flumes, water treatment);
- structures, components and equipment for the surveillance and maintenance of tailings facilities; and
- mechanical and electrical controls, and power supply associated with the above.

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Appendix 1: Risk Management Framework and Approach

The mining industry operates within a risk management culture aimed at responsible management of risks. A risk management framework should be embedded within each organization's overall strategic and operational policies and practices. In general, risk management entails identification, assessment, and treatment of risks. In the tailings management context, a risk management approach facilitates continual review and improvement of risk management strategies across the life cycle of a tailings facility. It should, therefore, be flexible, iterative and responsive to change. In addition, effective and transparent management of risks requires an appropriate level of competency for decision-making to evaluate, recommend and approve technical, management, environmental, social and economic risks related to tailings management.

Implementation of a risk-based approach requires an Owner of a tailings facility to first define their facility's risk profile, taking into consideration the internal and external operating environment, and quantitative and qualitative factors. Once this context has been established, a risk assessment for the tailings facility can be performed.

As part of this, Owners should consider the "business risk" in the context of a tailings facility breach or other significant unwanted event. Most major mining companies employ comprehensive risk management systems that could be used to characterize potential business impacts such as those to workforce health and safety, lost production, corporate reputation, and market capitalization. In fact, an Owner's business risk may potentially be of more consequence and warrant more stringent design, construction and operating requirements than would otherwise be determined on the basis of other industry standards and/or legal requirements.

There are two basic approaches to risk assessment:

- identify the potential risks and determine the likelihood of a range of potential consequences of those risks; and
- determine credible failure modes and assess what potential conditions (hazards), and their likelihood, could result in those failure modes.

Applying both of these approaches provides for a robust assessment of risks.

Generally, a risk assessment attempts to answer the following fundamental questions:

1) What can happen (unwanted event) and how (failure mode)?
2) If it does happen, what are the consequences?
3) What is the likelihood (probability) that such an unwanted event will happen?
4) Can the risk be practically eliminated?
5) What can be done to reduce the likelihood?
6) What can be done to reduce the consequences?
7) Is the level of risk tolerable or acceptable and does it require further treatment?

Relationship between failure modes and hazards: a single failure mode (e.g., overtopping of a dam) could be triggered by multiple hazards (e.g., landslide, extreme precipitation, etc.); conversely, one hazard (e.g., downstream inundation) could be triggered by more than one failure mode (e.g., overtopping, foundation failure, piping of water through a dam, etc.).

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Risk management strategies typically involve developing and implementing risk controls aimed to control or mitigate risks identified during risk assessment. Through application of risk management strategies, organizations take the necessary steps to reduce identified risks within acceptable levels that are As Low As Reasonably Practicable (ALARP). These strategies mitigate and control risks by one or a combination of the following:

- eliminating or avoiding specific risks to minimize overall risk to the extent practicable;
- minimizing the likelihood that the risk will occur by early identification and implementation of appropriate controls; and
- developing contingency and mitigation plans for the potential consequences of the identified risks.

As Low As Reasonably Practical (ALARP): The point at which the cost (in time, money and effort) of further risk reduction is significantly disproportionate to the risk reduction achieved.

There may be some risks which, even when reduced to ALARP, remain unacceptable and hence require a re-evaluation of alternatives.

Additional guidance and information is available in the public domain on the topic of risk and its management with respect to tailings facilities and other similar infrastructure, including documents prepared by the:

- *Canadian Dam Association (CDA)*;
- US Bureau of Reclamation;
- *Australian Leading Practice Sustainable Development Program (LPSDP)*;
- *Australian National Committee on Large Dams (ANCOLD)*; and
- *International Commission on Large Dams (ICOLD)*.

Also, refer to *International Organization for Standardization (ISO)* standards or its country equivalents such as the Australian/New Zealand Standards and the *Canadian Standards Association* for more guidance on risk management and risk assessment concepts and tools. Readers may also refer to a paper entitled *Geotechnical Risk, Regulation, and Public Policy*, written by Dr. Norbert Morgenstern and published in August 2018 in Soils and Rock, volume 41(2).

Application of risk assessment tools:

According to ICOLD Bulletin 139, hazard rating is defined as "the consequential damage from a tailings dam failure (is) generally assessed in terms of its potential effect on the four categories of:

1) Loss of life
2) Environmental damage
3) Cost of physical damage
4) Social impact including public perception"

These four categories could be used as the basis to perform a risk assessment at any phase of the life cycle of a tailings facility. While trying to keep these categories as generic as possible, the above listed four categories could be expanded as follows:

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1) Health and safety (including potential injury, health degradation of people, and loss of life);
2) Environmental (including potential environmental damage and/or environmental degradation);
3) Financial (including increased costs to the operation/corporation and/or cost of potential physical damage);
4) Social (including potential cultural degradation and/or public perception);
5) Legal (including non-compliance and insufficient permits);
6) Operational management and control (including inadequate management tools, qualified resources, and/or funding); and
7) Reputation for the Owner, including market capitalization and share loss.

Note: Consequence and risk assessments can be performed with or without the Owner's financial considerations. Either method may be appropriate depending upon context and should be clearly declared.

Risks that are encountered during the different phases of the mine, or during extreme events affecting the tailings facility, can be evaluated against the categories listed above using a failure mode and effects analysis (FMEA) model and a typical likelihood–consequences matrix similar to the one shown in Figure A.1.1. Risks may be identified as extreme, high, moderate or low. As a starting point, all management concepts presented in *Appendix 2* should be assessed following such a risk-based approach and considering all life cycle phases of the tailings facility.

In addition to FMEA, there are several other risk assessment techniques that can assist in the evaluation of the likelihood of occurrence of an undesired event and its consequences to the operation, society, and the environment. Some other commonly-used techniques include preliminary hazard analysis, Monte Carlo simulation, cause and consequence analysis, and decision/event trees analyses. Some of these other techniques can be used in conjunction with a likelihood-consequences matrix. For example, the bow-tie method (see Figure A.1.2) could be used to gain a better understanding of the extent and effectiveness of risk controls, including critical controls, which are in place or could be implemented for the management of high or extreme consequence events, as identified in a likelihood-consequences matrix model. Refer to the Australian Government's *LPSDP document on Risk Management* for further details on the application of bow-tie analysis.

The Independent Reviewer(s) should be provided risk assessments and management plans for the tailings facility in question, and include the results of those assessments and plans in the scope of the IR. Summary results of risk assessments should be reported to the Accountable Executive Officer.

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Figure A.1.1. Sample of a typical qualitative risk assessment matrix. The likelihood, consequence and overall risk level descriptors (e.g., possible, major, high risk, etc.) are for illustrative purposes only, and many other descriptors are acceptable provided they are defined, understood, and used consistently.

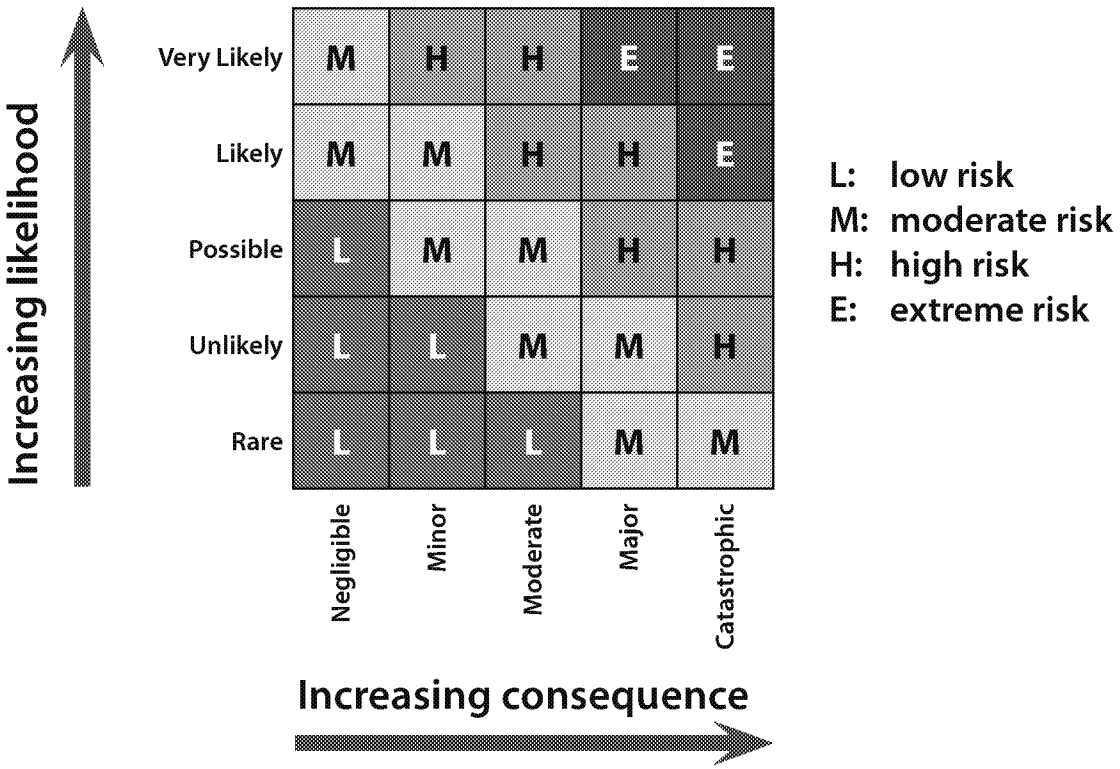

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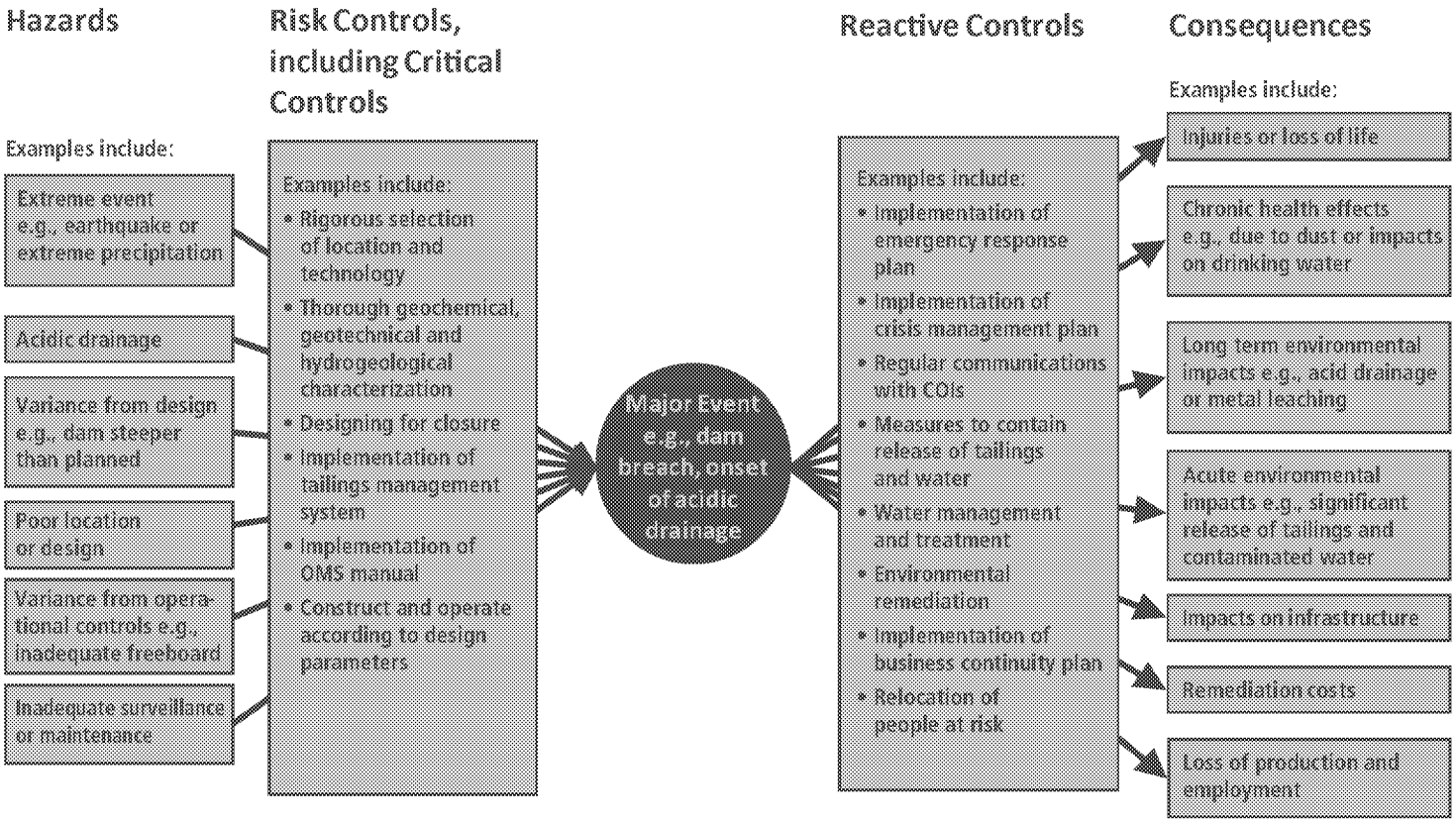
Figure A.1.2: Illustration of a typical bow-tie analysis, providing examples of possible hazards and risk controls to reduce the likelihood or consequence of a major event, and reactive controls and potential consequences if a major event occurs.



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Appendix 2: Best Available Technology and Best Available/ Applicable Practice

Best Available Technology, or BAT, is the site-specific combination of technologies and techniques that is economically achievable and that most effectively reduces the physical, geochemical, ecological, social, financial and reputational risks associated with tailings management to an acceptable level during all phases of the life cycle, and supports an environmentally and economically viable mining operation.

Best Available/Applicable Practice, or BAP, encompasses management systems, operational procedures, techniques and methodologies that, through experience and demonstrated application, have proven to reliably manage risk and achieve performance objectives in a technically sound and economically efficient manner. BAP is an operating philosophy that embraces continual improvement and operational excellence, and which is applied consistently throughout the life of a facility, including the post-closure period.

BAT

The incorporation of BAT into tailings management is designed to ensure that the selected tailings technology or methodology effectively achieves performances objectives, manages the identified risks, and is technically and economically feasible. When considering BAT for tailings management, it is important to understand that no single technology or technique, or combination thereof will be the best risk management alternative for every tailings facility. The variability of topography, climate, seismicity, ecosystem, mineralogical and chemical composition of soil and bedrock, project economics, and other site-specific considerations dictates that the BAT should be determined for each tailings facility on an individual basis.

The full spectrum of tailings management alternatives should be assessed for each potential facility location at the project conception and planning phase of the life cycle (see also *Appendix 3*). This rigorous, transparent process for assessing alternatives provides a methodology to identify the optimum combination of tailings management alternatives and facility location, considering the site-specific risk profile and conditions, and taking closure and post-closure risks and liabilities into account. Typically, the criteria to use when selecting BAT are summarized in *Appendix 3.1* and include:

- tailings facility risks;
- closure plan and end land use;
- tailings characteristics (physical and chemical);
- water balance and management;
- COI expectations;
- legal requirements and considerations; and
- project economics.

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The goal of applying BAT as part of the tailings management strategy for a site is to determine the tailings management methodology, which will provide a safe, stable facility with an acceptable level of impact and risk for the full life cycle of the facility.

BAT should be reassessed at discrete times throughout the life of the facility when operating data, new technology or other reasons to contemplate a significant change to the facility life cycle plan arise.

BAP

A commitment to using BAP is a commitment to using relevant knowledge and technology to help ensure success. In fact, implementing this Tailings Guide is an example of employing BAP.

For tailings management, BAP encompasses the management systems and operational procedures developed and implemented, in consideration of current engineering and governance practices, so that tailings facilities are designed, constructed, operated, maintained, monitored and closed to achieve performance objectives.

There are several key concepts that help define BAP:

- Tailings management practice is constantly evolving and improving as the collective knowledge base expands. As a result, the management system should include specific processes to ensure that practices stay current, effectively manage facility impacts and risks, and incorporate continual improvement;
- The management practices and processes need to be auditable and verifiable; and
- Successful implementation requires effective, timely communication inside and outside the company.

BAP is used to assess, monitor, verify and continually improve the Owner's management systems and practices. BAP is also used to help ensure that mechanisms are in place to:

- confirm that controls are effective at managing the evolving risks associated with tailings facilities;
- stay current with changes in technology, practice, and industry knowledge, including triggering re-assessments of BAT when warranted; and
- evaluate and incorporate applicable changes into the Owner's tailings management system and operating practices.

Relationship between BAT and BAP

Since technologies and practices evolve over time, it is important to recognize the interplay of BAT and BAP. Selection of BAT does not include the ongoing management, governance, and continual improvement processes throughout the life of the tailings facility – these, however, are components of BAP. Managing a facility with BAP principles may generate the need to reassess BAT if facility performance or available and applicable technology changes, or if some other factor is identified through the continual improvement process that potentially warrants a change to the facility design. The assessment of BAT facilitates a thorough and transparent identification and understanding of the potential impacts, risks, and costs associated with a tailings technology selection and provides a sound framework to manage these risks and costs through BAP.

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Appendix 3: Assessment of Alternatives

Overview

A process to assess alternatives for the location of a potential tailings facility, and the site-specific BAT for tailings management, should be implemented at the project conception and planning phase of the life cycle. Selection of BAT and facility location lay the foundation for all subsequent decisions and activities related to the tailings facility, including risk management. Decisions at this phase of the life cycle have profound and often irreversible implications throughout the life cycle.

Alternatives for closure and long-term closure objectives and post-closure land use are essential considerations in the initial selection of location and technology, and may also need to be reassessed at other phases throughout the life cycle. Alternatives may also need to be assessed at other phases throughout the life cycle in the event of a mine-life extension and the need for a new or expanded tailings facility.

Alternatives assessment is typically conducted as a multi-step process:

1) Identify performance objectives, describing how the tailings facility is expected to perform throughout the entire life cycle, including the long-term closure objectives and post-closure land use.
2) Identify possible (i.e., reasonable, conceivable, and realistic) alternatives, avoiding *a priori* judgments about the alternatives.
3) Pre-screen possible alternatives to eliminate from further consideration any that would not meet the performance objectives or otherwise have characteristics that would be "show-stoppers". This step is also referred to as fatal-flaw analysis.
4) Assess remaining alternatives using multiple accounts analysis or a similar decision-making tool.
5) Conduct a sensitivity analysis to test the robustness and validity of the outcomes of the detailed assessment of alternatives against various biases and assumptions. Despite efforts to make the assessment of alternatives as objective as possible, there will be biases and perceived biases in the process. For example, the assessment could be re-done without consideration of project costs, to see the impact of removing consideration of costs on the final outcome.
6) Document the results in a comprehensive technical report.

There are a number of aspects that are important for an effective alternatives assessment:

- The alternatives assessment should consider a wide range of factors, and be conducted by a multi-disciplinary team consistent with the unique conditions for the proposed facility. This team typically includes geotechnical engineers and geologists, fisheries biologists, hydrologists, archaeologists, specialists in community and Indigenous relations, specialists in traditional ecological knowledge, social scientists, and economists.
- Team members should be open minded, both to each other, and to the outcome of the process. Having a pre-conceived notion of the "right" answer can bias results. The team members need to respect the alternatives assessment process.
- Team members should collect and consider a broad range of information, examples of which are provided in *Appendix 3.1*.

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- External input is required through the steps described above. Input of COI, including regulators, informs the process, and Independent Reviewers should also be engaged.
- Alternatives should be assessed and documented using a rigorous, transparent decision-making tool, such as multiple accounts analysis, further described below.
- Given the need to select both a location and BAT, the process may require more than one iteration.

Figure A.3.1 illustrates an overall framework for the planning and design of tailings facilities, and the role of alternatives assessment within that framework.

Multiple Accounts Analysis

Multiple accounts analysis (MAA) is a tool that is used to support decision-making, including for tailings management. There are a number of good, structured decision-making tools available to assist the tailings planning and design process. Since the federal regulator in Canada mandates the use of MAA, it is given additional focus here. This approach was described in *A Multiple Accounts Analysis for Tailings Site Selection*.[5] It was expanded upon by Environment and Climate Change Canada in its *Guidelines for the Assessment of Alternatives for Mine Waste Disposal* (2011). This discussion is based on the approach as described in these documents.

MAA and similar tools are effective methods to help make complex decisions, and to help communicate to others how those decisions were made and what factors were considered. These tools are widely applicable to a range of potential decisions. In the context of decisions about tailings management, they are applicable regardless of tailings characteristics, geography, environmental and societal context of a site, and other factors that may influence such decisions.

MAA is part of a broader toolbox of methods referred to as multiple criteria decision analysis. The strength of such tools is that they provide a method of integrated assessment of different characteristics of alternatives, for example, for comparing potential impacts on wildlife with capital costs. In effect, these tools provide a rigorous, semi-quantitative means of comparing apples and oranges. The methodology also provides a means to make inherent subjectivity and biases more transparent, and then testable using sensitivity analysis.

MAA is a two-stage process. The first stage consists of the development of a multiple accounts ledger: a list of accounts and various sub-accounts that describe the alternative and its potential impacts. For example, an account for "Environment" could include a wide range of sub-accounts, from impacts on aquatic and terrestrial wildlife, to post-closure land use. Measurable indicators are described for each sub-account. For example, a sub-account describing the surface area of the facility would provide an indicator measured in square kilometres.

The second stage is referred to as a Value-Based Decision Process. It involves "ranking, scaling and weighting the indicator values in the sub-accounts in a systematic, transparent manner such that the value basis for the combination or accumulation of effects is readily apparent" (Robertson and Shaw, 1999).

5. Robertson, A.MacG., Shaw, S.C. (1999): Multiple Account Analysis for Tailings Site Selection. In Sudbury 99 conference proceedings, Mining and the Environment II, vol. 3, pp. 883-891.

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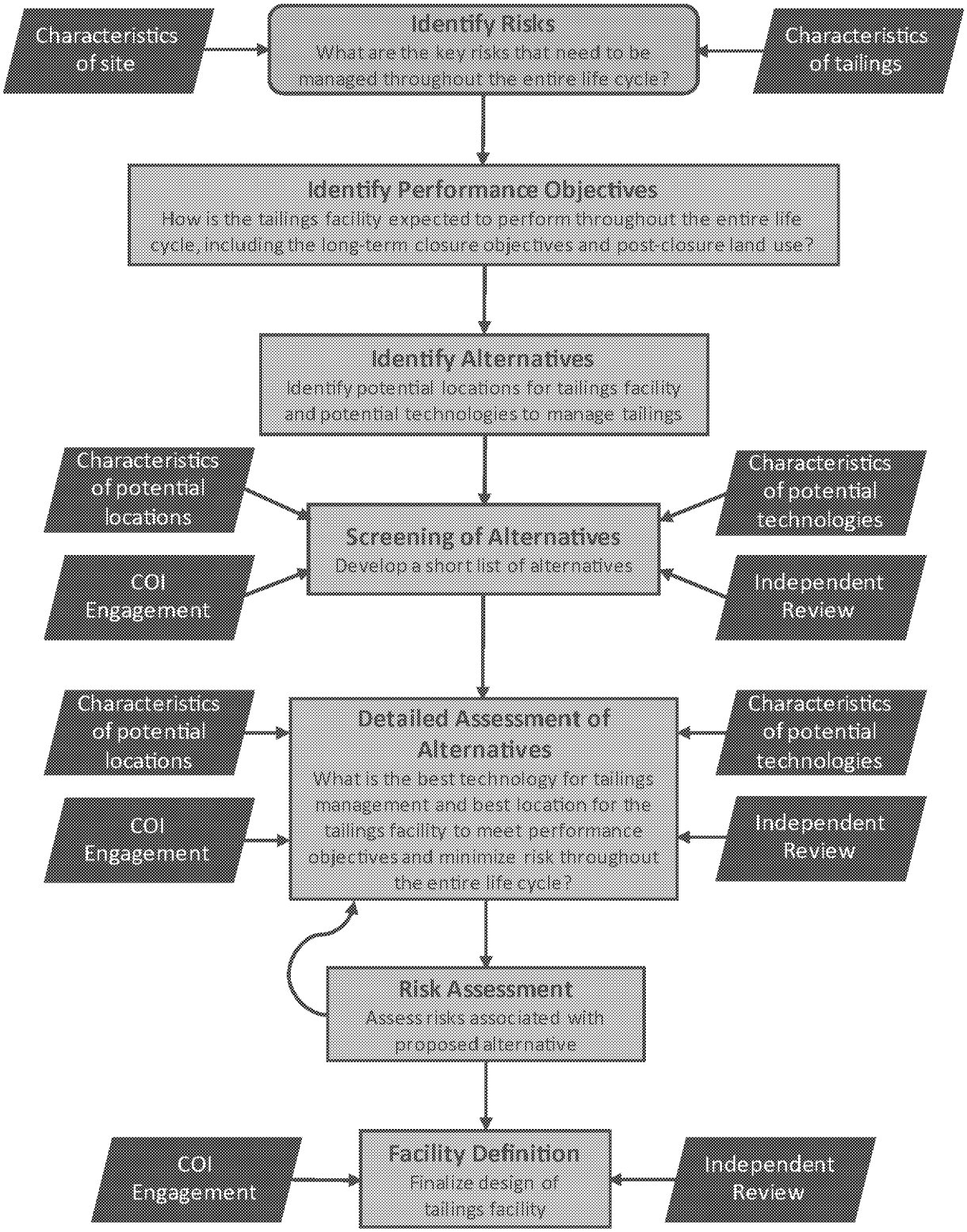
Figure A.3.1: Framework for Planning and Design of Tailings Facilities



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Appendix 3.1: Typical Information Considered for Assessment of Alternatives and Tailings Facility Design

Examples of the types of information typically considered for assessment of alternatives and designing of a tailings facility are provided below. This information listing is not exhaustive, and is intended to be illustrative rather than prescriptive. Information listed below may not be applicable in all cases, and additional types of information or detail may be needed on a site-specific basis.

1) Basic Characteristics

Characteristics of the Proposed Mine

Ore and host rock:

- Reserves and projected mine life
- Mineralogy
- Chemical composition
- Oxidation processes, including acid-generating potential
- Potential for leaching of metals and other contaminants

Mine plan and mine openings:

- Potential for sequential mine development and use of mined out openings for tailings management
- Potential for use of tailings as backfill during operations

Ore processing parameters related to tailings:

- Process and reagents to be used
- Treatment processes (e.g., cyanide destruction)

Characteristics of Tailings and other Materials

Tailings — characteristics independent of tailings management technology selected:

- Daily/annual throughput
- Total quantity of tailings and other materials to be managed in the tailings facility
- Mineralogy
- Size distribution
- Chemical composition
- Oxidation potential, including acid-generating potential
- Suitability for separating sulphides if potentially acid-generating
- Potential for leaching of metals and other contaminants
- Variability in all of the above

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Tailings — characteristics dependent on tailings management technology selected - should be evaluated for each technology alternative assessed:

- Rheology
- Consolidation properties
- Solids content
- Plasticity
- Liquid phase chemistry
- Hydraulic conductivity and anisotropy of fresh and compacted tailings
- Variability in all of the above

Materials to be co-managed with tailings (e.g., waste rock, treatment sludge):

- Daily/annual amount placed and total quantity to be managed in the tailings facility
- Timeframe for placement (could be after the end of operations in the case of treatment sludge)
- Chemical composition
- Oxidation potential, including acid-generating potential
- Potential for leaching of metals and other contaminants
- Stability considerations

Availability and Characteristics of Impoundment Construction Materials (if applicable)

Waste rock and tailings:

- Quantities suitable for construction
- Availability at appropriate time for construction
- Chemical composition
- Oxidation potential, including acid-generating potential
- Potential for leaching of metals and other contaminants
- Physical and engineering properties (e.g., strength, gradation, slaking potential)
- Hydraulic conductivity in the dam structure

Glacial till and other earthfill/rockfill materials:

- Availability and transport distances
- Quantity available
- Environmental impacts of excavating borrow material
- Environmental impacts of quarry development and operation
- Size distribution
- Suitability for low permeability applications
- Chemical composition

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- Oxidation potential, including acid-generating potential
- Potential for leaching of metals and other contaminants
- Durability and integrity
- Internal erosion potential
- Freeze/thaw resistance

Air and Water Management

Site climate (seasonal variations, means and extremes):

- Temperature
- Prevailing wind direction and speed, including dust generation potential
- Precipitation, including 1/100-year flood, 1/1000-year flood and Probable Maximum Flood
- Seasonal precipitation patterns, including snowfall, rainy season, etc.
- Evaporation
- Climate change projections (e.g., temperature, precipitation and extreme events)

Overall site water balance — independent of tailings management technology selected:

- Water use in ore processing
- Mine water production
- Evaporation
- Other water flows to be managed on site
- Clean water interceptors and diversions
- Availability of make-up water
- Water discharge to the environment

2) Additional Characteristics – Screening Level Assessment

These characteristics should be considered for each potential alternative included in the initial step of screening alternatives to develop a short list of alternatives for more detailed assessment. The objective at this stage is to identify "fatal flaws" in potential alternatives, to eliminate those alternatives from further consideration.

Basic information about each potential location:

- Distance from ore processing facility – transport of tailings
- Distance from mine – transport of waste rock for construction
- Topography, based on regional and detailed topographic maps, aerial photos or satellite images
- Surface area of potential tailings facility
- Potential locations of dams, and estimated dam heights, if applicable
- Estimated total capacity of potential tailings facility
- Identification of any sensitive downstream areas (e.g., communities) that could be impacted in the event of a failure of the facility

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Existing and planned infrastructure:

- Mine-related infrastructure, including roads, buildings, open pits and waste rock facilities
- Non-mine related infrastructure, including roads, utility corridors, proximity to communities or other land owners

Flora and fauna that could preclude a tailings facility at that location:

- Presence of fish-frequented water bodies within the footprint of the possible tailings facility that would have permitting implications
- Presence of endangered or threatened species, migratory species
- Other ecological values (e.g., calving or rutting grounds)

Hazards or other features that could preclude a tailings facility at that location:

- Risk of landslides or avalanche
- Geologic faults or other features
- Geotechnical conditions
- Hydrologic conditions

Social or cultural features that could preclude a tailings facility at that location:

- Significant archeological features, such as burial grounds
- Areas of spiritual significance
- Areas used for traditional harvesting for food, medicinal or spiritual purposes

Closure considerations:

- Ease of closure and related factors that could preclude a tailings facility at that location

Cost:

- Rough but defensible estimate of costs of a tailings facility at each location, across the entire life cycle, from planning and design, through closure and post-closure

3) Additional Characteristics – Detailed Assessment

These characteristics should be considered in a sufficient level of detail to be able to rigorously assess each potential alternative on the short list of alternatives for more detailed assessment. Level of detail is less than that required for detailed engineering design and construction, but should be detailed enough to understand the key factors that influence the selection of the location, and how a tailings facility at that location would be designed, constructed, operated and closed.

Tailings management plan (see also *Appendices 6 and 8*):

- Potential tailings technology (e.g., conventional, cycloned, thickened, paste or filtered)
- Management of acid-generating potential (e.g., wet cover, elevated water table, dry cover, segregation of sulphides)
- Management of neutral pH leaching of metals, metalloids and non-metals
- Surface area of potential facility, locations and heights of any dams or other containment structures

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- Capacity of facility as designed
- Design of any dams or other containment structures (e.g., permeable vs. water retaining, centreline or downstream, keyed to bedrock vs. constructed on surficial materials)
- Construction materials for any dams or other containment structures (e.g., glacial till core, waste rock, cycloned tailings, other materials)
- Any materials to be co-managed with tailings, and method of co-management

Closure plan (see also *Appendices 6 and 8*):

- Planned post-closure land-use
- Closure strategy for tailings facility
- Overview of long-term maintenance and monitoring
- Progressive reclamation plan

Basic information about each potential location:

- Detailed topography, based on LIDAR (Light Detection and Ranging) or other sources

Bedrock and hydrogeology:

- Rock units present in footprint of possible tailings facility and adjacent areas
- Presence of faults, aquifers, aquitards or other features that influence the direction and rate of groundwater flow
- Estimated hydraulic conductivity of relevant rock units, based on geological characteristics

Surficial geology and hydrogeology:

- Depth to bedrock in footprint of possible tailings facility
- Stratigraphy of surficial units
- Presence and extent of clay deposits and their potential to cause stability concerns if a tailings facility is constructed on top of the clay
- Presence and extent of other factors that influence stability and foundation conditions, such as organic material, high water table, loose sands, old tailings/filled ground, fractured bedrock, etc.
- Estimated hydraulic conductivity of surficial units, based on geological characteristics
- Presence and extent of high or low permeability units (e.g., sand or clay)

Hydrology within the footprint of the possible tailings facility, and in upstream and downstream areas:

- Watershed delineation and flow patterns
- Size and flow of streams
- Presence of wetland areas
- Runoff
- Return period of floods and potential severity
- Bathymetry of any lakes or ponds

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Water management:

- Inflows and outflows to possible tailings facility
- Design parameters for extreme weather events
- Seepage management measures (e.g., control and collection measures)
- Estimated rate of seepage from possible tailings facility
- Estimated quality of seepage groundwater
- Clean water interceptors and diversions

Natural hazards within the footprint of the possible tailings facility, and in adjacent areas that could impact the facility:

- Risk of landslides or debris flows
- Risk of avalanche
- Seismic risk

Terrestrial environment within the footprint of the possible tailings facility, and in adjacent areas that could be impacted by the facility:

- Key animal and plant species present
- Habitat features such as denning areas or natural pastures
- Presence of species of commercial, recreational or Indigenous significance, such as species that are trapped, hunted or gathered for food, sale, medicine or traditional/spiritual use

Aquatic environment within the footprint of the possible tailings facility, and in upstream and downstream areas that could be impacted by the facility:

- Water and sediment quality
- Any upstream or close downstream sources of impacts on water quality or disturbance to the aquatic environment
- Fish species present, including any endangered and threatened species
- Presence of species of commercial, recreational or Indigenous significance

Archeology within the footprint of the possible tailings facility and in immediately adjacent areas:

- Presence of archeological sites of Indigenous or non-Indigenous significance such as burial sites, camp sites, historic sites, etc.

Indigenous considerations associated within the footprint of the possible tailings facility, and in adjacent areas:

- Status of land claims
- Traditional use of the area for hunting or gathering
- Sites of spiritual significance
- Agreements with Indigenous communities

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Other considerations:

- Presence of permafrost
- Presence of areas impacted by past mining or other industrial or commercial activity

Socio-economic considerations – may be the same for all alternatives considered, but should be assessed on a location-by-location basis:

- Other current and historical land or water use, including recreation, parks, drinking water sources
- Other commercial uses in the area, such as mining, logging or farming

Cost:

- Estimate of costs of a tailings facility at each location, across the entire life cycle, from planning and design, through closure and post-closure

4) Additional Characteristics – Detailed Design

Bedrock and hydrogeology:

- As above under item (3), but more detailed as appropriate
- Measured hydraulic conductivity of relevant rock units

Surficial geology and hydrogeology[6]

- Detailed information on depth to bedrock in footprint of planned tailings facility
- Detailed stratigraphy of surficial units
- Detailed information on presence and extent of clay deposits and other factors that may influence stability and foundation conditions
- Measured hydraulic conductivity of surficial units
- Relevant physical characteristics of surficial units, particularly in areas of planned dam foundations

Hydrology within the footprint of the planned tailings facility, and in upstream and downstream areas:

- As above under item (3), but more detailed as appropriate

Natural hazards within the footprint of the planned tailings facility, and in adjacent areas that could impact the facility:

- As above under item (3), but more detailed as appropriate
- Description of mitigation measures
- Other characteristics listed under item (3), but more detailed as appropriate

Cost:

- Sufficiently detailed estimate of costs of the selected tailings facility, across the remaining life cycle of the facility.

6. See for example: Association of Professional Engineers and Geoscientists of BC (2016): *Site Characterization for Dam Foundations in BC*

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Appendix 4: Independent Review

Introduction

Tailings facilities are complex structures, and all aspects of their management are subject to human error. Tailings governance structures that support effective risk management decisions are critical for maintaining and increasing the resilience of tailings facilities throughout their life. A key aspect of effective Owner governance is regular Independent Review of tailings facilities and their governance, which is recognized as an essential BAP for responsible tailings facility management, and is required in some jurisdictions. In addition, many financial institutions require Independent Review processes to demonstrate responsible risk management. Insurance companies may offer premium reductions if Independent Review is part of a facility's risk management program.

There is no specific method or formula for conducting effective Independent Review. This appendix describes principles and elements that would be common to any effective Independent Review process; however, how these principles and elements are applied for a given facility will be as unique as that facility's characteristics. The following material and examples are intended to provide guidance, and are not intended to be prescriptive.

Owners of tailings facilities employing BAP typically use Independent Review to provide, in a systematic, ongoing manner, an independent, qualified opinion about:

- the risks and the state of the tailings facility;
- whether the tailings facility is being managed based on sound engineering practices; and
- whether concepts and design criteria are consistent with legal requirements, industry standards, and current theory, methodologies and experience.

Independent Review may also provide recommendations to improve tailings facility management, although Independent Review processes do not confer decision-making authority on the reviewers. Accountability and responsibility for decisions whether to implement recommendations rests solely with the Owner.

The objective of Independent Review is to allow those accountable and responsible for tailings facility management to make more informed decisions regarding a tailings facility so that tailings-related risks are managed responsibly and in accordance with acceptable standards of care.

Independent Review is not a substitute for appropriate design, or the role of the EoR, and it is essential that an Owner employ an appropriately qualified and experienced team and/or retains consultants to provide the necessary specialized services throughout the life cycle of the facility. It is important that an Owner designate a person responsible for coordinating Independent Review efforts with designers, operations staff and senior management.

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Benefits

Independent Review pools the experience and knowledge of experts in tailings facility design and management to respond to the technical challenges that an Owner is likely to encounter or may be currently facing.

Independent Review is most effective if it begins at the project conception and planning phase of the life cycle, and continues through design, construction, operation, closure, and post-closure. As such, the intent of Independent Review is to identify and address potential deficiencies before they occur and is fundamentally a preventative risk control measure. The preventative focus of Independent Review fosters continual improvement and mitigates complacency.

The Independent Review process requires that the Owner provides comprehensive, high-quality information to Independent Reviewers. Compiling such information helps strengthen documentation of the Owner's institutional memory and can reduce reliance on the memory of individuals involved in tailings management.

Independent Review may be used to support Performance Evaluation and Management Reviews for Continual Improvement.

Spirit of "Independent"

The intention, or spirit, of "independent" is that the reviewer(s) should not be directly involved with the design or operation of the particular tailings facility. Where potential conflict of interest exists, such conflicts should be identified and declared so the Owner understands when 'independence' is theoretically compromised and agrees. For example, it is acceptable to have an Independent Reviewer who is employed by the same company as the EoR for the tailings facility, provided the intent of 'independent' is met. This is further reinforced by maintaining a clear understanding between the Owner and their consultant(s) (e.g., designer, EoR) that an Independent Reviewer may need to abstain from a discussion or withhold an opinion when a conflict of interest may apply. This flexibility allows the Independent Review process to maximize the use of appropriately qualified reviewers; understanding that there may be a limited pool of such qualified individuals available.

Guidance for Independent Review

Guidance provided is for Independent Review intended for internal purposes, to inform the facility Owner. It is not intended to address other types of Independent Review, such as that required by some regulators.

Detail Level of Independent Review

The level and detail of Independent Review should be established clearly and prior to any review proceeding. An example of the level and detail required is consistent with that described for "Review Level" by Robertson and Shaw (2003)[7], as follows:

> *At this level the reviewer generally reviews all key documents and does at least "reasonableness of results" checks on key analyses, design values, and conclusions. Design, construction and operational procedures are reviewed at a level sufficient to develop an independent opinion of the adequacy and efficiency of the designs, construction and operations. The reviewer generally relies on the representations made to the reviewer by key project personnel, provided the results and representations appear reasonable and consistent with what the reviewer would expect. A review report is produced which documents the reviewer's observations as to the adequacy of the design, construction and operations and indicates any recommendations that flow from these.*

7. Robertson, Andy and Shaw, Shannon (2003): *Risk Management for Major Geotechnical Structures on Mines*

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Risk-Based Approach

Independent Review is a component of an effective risk management system. As such, the degree of Independent Review involvement over the life cycle of the facility should be risk-based, with particular emphasis on the potential impacts of a significant tailings facility event on the business overall, to worker and community health and safety and to the environment.

While some sites conduct Independent Review on an annual basis, the frequency of Independent Review should be determined on a facility-specific basis, depending on the risk profile and life cycle phase of the facility. In some instances, additional, special one-off type Independent Review sessions may be warranted; for example, where existing facilities are being upgraded to comply with current design criteria and standards or facilities that are in design, commissioning and initial operation. In these conditions, frequency of Independent Review should be determined in consultation with the Independent Review body, Owner and EoR. As a site approaches a "steady state" of operation, frequency of Independent Review may be reduced. The frequency of Independent Review during closure may vary according to risk.

An Independent Review body may comprise a single reviewer or several individuals. The Independent Review body composition and experience level should be commensurate with the tailings facility's complexity and risk profile. Accordingly, an Independent Reviewer could vary from a competent person employed by a separate Owner, to an internationally-recognized subject-matter expert. At high-risk facilities, (where a breach could plausibly result in inundation of residence(s) and loss of life) a panel of three or four subject-matter experts with different but complementary areas of expertise and experience may be required to cover the various disciplines associated with management of the facility (e.g., geotechnology, hydrology, hydrogeology, and geochemistry). In other instances, temporary Independent Review involvement for niche disciplines (e.g., paleo seismology, seismic hazard assessment) outside the expertise of the core Independent Review body may be required. Redundancy of technical disciplines within the Independent Review body should be considered in accordance with a facility's risk profile.

Independent Review Program

The terms of reference for Independent Review should be carefully considered in accordance with the facility risk profile. Recommended terms of reference are provided in Appendix 4.1. Effective Independent Review requires that Owners maintain reliable archives of relevant documents. This becomes particularly important in the event of changes in employees, contractors, or consultants (e.g., EoR) involved in tailings management, or if a significant event or change should occur.

The Independent Review process should involve both site-personnel (e.g., Responsible Person), the EoR, and key consultants to be most effective. The Independent Review process requires a wide range of information, which typically includes:

- facility description, including design and as-built information;
- risk assessment and risk management plans;
- OMS manual, with a summary of key operational, maintenance and surveillance practices and procedures;
- results of Performance Evaluation and Management Review for Continual Improvement;
- for new facilities, assessment of alternatives for selection of tailings facility location and BAT;
- any changes since the last Independent Review (if Independent Review has been done previously);

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- other relevant studies and assessments;
- summary of previous recommendations from Independent Review and status of implementation; and
- pertinent information on medium to long-range planning for the facility.

The Independent Review should be documented to describe: the review's scope and process; details of the technical issues evaluated; and, as appropriate, recommendations, including opportunities for improvement.

For Independent Review to best function as an effective risk management tool, the process should be confidential. A lack of confidentiality could undermine the process, because it relies on open discussions of the risks and issues related to a tailings facility, including scenarios about possible future site changes (e.g., information about potential mine life extensions that could influence current or potential shareholders or investors) that cannot legally be disclosed. In this regard, confidentiality is necessary for compliance with securities laws as the Independent Review typically considers future mining plans and "forward-looking information". If required, the Independent Review process and findings can be summarized for disclosure.

In response to any recommendations from Independent Review, an action plan should be developed. Progress of implementing the action plan should be tracked and, as appropriate, shared with the Independent Reviewer(s). The Owner should also identify any recommendations that will not be implemented, and document a rationale.

Suggested Reading

For facilities considering an Independent Review program, a process summary is appended to this document. The following publications are recommended resources to provide further context and examples of Independent Review:

Hoek, E. 2001. Geotechnical Review Boards in Mining. Geotechnical News. March 2001.

Matich, M.A.J. 1986. Design and Review Boards. Alberta Dam Safety Seminar. Edmonton. September 1986.

McKenna, G. 2001. Celebrating 25 Years – Syncrude's Geotechnical Review Board. Geotechnical News. September 1998.

Robertson, A. Shaw, S. 2003. Risk Management for Major Geotechnical Structures on Mines. http://www.infomine.com/library/publications/search.asp?action=16384&search_text=audit+review&search_dt_all=true&Search=Search

Appendix 4.1: Recommended Terms of Reference for Independent Review

Independent Review Mandate: To provide Independent Review of a tailings facility's design, construction, and management to allow the Owner to make more informed decisions regarding the facility so that tailings-related risks are managed responsibly and in accordance with an acceptable standard of care. The Reviewer(s) should comment on matters that:

- affect the physical or chemical integrity of the facility;
- may impact human health and safety, the environment and, potentially affected communities;

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- are beyond industry norms of current practice or evolving practice; and
- affect the future conditions of the site.

The Reviewer(s) should also consider the effectiveness of the site's tailings management system.

The Reviewer(s) are managed by an appropriate representative of the Owner. Independent Review findings are made known to the Accountable Executive Officer, either directly or through the Owner's representative. The Reviewer(s) does not have decision-making authority and does not replace the role of the EoR or an experienced independent dam safety reviewer for assessing dam safety. Other than acts of gross negligence, wilful misconduct or fraud, the Reviewer(s) should have no exposure to professional liability and should be indemnified by the Owner to direct and third-party claims.

In circumstances where imminent risk to public health or safety are apparent, the Reviewer(s) is responsible to disclose such risks on an "as soon as possible basis" to the Accountable Executive Officer, and confirms whether those risks are appropriately managed.

Requirements for "independent": The Reviewer(s) must be independent and not be directly involved with the design or operation of the tailings facility. Where there may be some conflict of interest, for part of the review being performed, this conflict should be declared such that the Owner understands when 'independence' is theoretically compromised and agrees or takes other action.

Level of Review: The level and detail intended for Independent Review should be consistent with that described for "Review Level" by Robertson and Shaw (2003).

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Appendix 5: Considerations for Managing Throughout the Life Cycle of a Tailings Facility

Considerations for tailings management for all phases of the life cycle are described below. It is important to note that different jurisdictions may have requirements that differ from what is described below, particularly with respect to the closure, and post-closure phases. In such cases, this Tailings Guide should not supersede those legal requirements.

Project Conception and Planning Phase

- For new facilities, or for operating facilities undergoing expansion, this phase is carried out by a multidisciplinary team of specialists such as engineers and geologists, and environmental and social scientists, all with relevant experience in the assessment of appropriate tailings management technologies, site selection, design of the tailings facility components, and construction and operation of tailings facilities. It is preferable to have the EoR engaged in this phase as part of the team. The team reports to the overall project development team assigned by the Owner to develop the mine.
- Designer-of-record should be assigned, which may be the same as the EoR.
- A long-term view is critical (including closure and post-closure), so that short-term financial priorities do not prevail over a more appropriate design that would have lower long-term impacts, complexity, and risks (including the long-term financial risks in the event of a failure).
- During the project conception and planning phase, select site and tailings management technology(ies) (see also Appendices 1, 2 and 3), and develop a conceptual design and closure plan for the tailings facility.

Design Phase

- The design team needs to have competent professional staff experienced in the disciplines required to appropriately design the tailings facility. The team will typically be managed by the project development team assigned by the Owner to develop the mine.
- The facility design needs to consider and address anticipated operating realities to design a robustly operable facility. As such, persons with operational expertise should be involved in the design process.
- During the design phase, develop the detailed facility design, construction methodology, operational controls and procedures, and a more detailed closure plan. Aspects of the tailings facility construction and operation should be planned and designed in compliance with legal requirements and in conformance with the approved plans, appropriate engineering and environmental practices, risk management, commitments to COIs and the Owner's tailings management system.
- Although many critical aspects of design should be completed before initial construction begins, aspects of design continue throughout the life cycle, particularly during the operations and ongoing construction phase.

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Initial Construction Phase

- Facility construction up to the commissioning of a facility is usually managed by a mine project development and construction management team.
- Implementation of a quality assurance plan and quality control plan is required to ensure that construction is in accordance with design specifications.
- The EoR provides assurance that design standards are being met.
- Conformance management plan and change management plan should be implemented.

Operations and Ongoing Construction Phase

- Facility operations and continuing construction during the operating phase are usually managed by site operators who are assigned responsibility at the beginning of the commissioning of the mine development.
- This change in the personnel responsible for the tailings facility, from the initial construction phase to ongoing construction during operations, can be problematic from a continuity perspective and, therefore, needs to be appropriately planned for and managed in the tailings management system.
- A facility that was initially designed and constructed in a project environment can be compromised by decisions of the facility operations team during or following commissioning of the facility.
- The facility operations team may not fully appreciate the potential significance and risks of decisions made during the operating phase. Consequently, it is important that the tailings management system plan for and incorporate measures to mitigate such risks.
- The EoR needs to closely support the facility operations team to ensure continuity with the original design requirements, and that an appropriate engineering assessment is carried out if the original design specifications or operating parameters/constraints are to be modified.

Closure and Post-Closure Phases

- A specific project team often takes the lead in preparing for decommissioning and closure. In many cases, this team will manage the decommissioning and closure of the tailings facility.
- At this phase, it is critical that the tailings management system accommodate planning for both the shorter-term, more finite period of decommissioning and closure, as well as addressing the long-term post-closure period, particularly long-term maintenance and surveillance to ensure that tailings landforms remain physically and chemically stable.
- The Owner should provide the financial and physical resources necessary to implement the closure plan and ensure long-term maintenance and monitoring.

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Appendix 6: Information to be Documented to Support Responsible Tailings Management

Site Characterization

Site characterization involves the collection and compilation of a wide range of information about a tailings facility and the environment in which it is or may be located. It should be initiated during the Planning phase, and site characterization information should be reviewed and updated throughout the life cycle to help ensure that decisions are based on accurate, up-to-date knowledge of the site. Site characterization information is used to inform:

- Setting performance objectives, indicators, and criteria.
- Risk assessment and the development of the risk management plan, as well as subsequent reviews and updates.
- Assessment of alternatives.
- All aspects of design of the tailings facility, from initial concept to construction-ready design and any subsequent material changes.
- Validation of tailings facility performance against the design and underlying assumptions.
- Development of the closure plan.

Information documented as part of site characterization may include:

- Characteristics of the mine, including production rate, life-of-mine, ore processing methods, locations of the tailings facility relative to the ore processing facility, water rock piles, water management infrastructure, and other relevant infrastructure.
- Physical and chemical characteristics of tailings and other wastes to be managed in tailings facility, and, where applicable, materials to be used in the construction of the tailings facility, including:
  - Moisture content, gradation, mineralogy, geochemistry, shear strength, compressibility, permeability and index tests.
- Characteristics of embankments (where applicable), including type of embankment, method of construction, and consequence classification.
- Physical and chemical characteristics of the tailiings facility foundation and any abutments, including:
  - Test hole logs and locations
  - Results from drill holes, penetration holes, core holes, auger holes, geophysical tests, test pits, etc.
- Potential natural hazards, such as landslides, avalanches and debris torrents, earthquakes, floods, frost heave, permafrost degradation, waves, wind, or ice movement or jamming.
- Characteristics of the potential/proposed/actual tailings facility (e.g., location, topography, surface area, containment structures)

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- Bedrock and surficial geology, including:
  - Surficial deposits and bedrock characteristics (moisture content, gradation, mineralogy, geochemistry, shear strength, compressibility, permeability and index tests), stratigraphy, geomorphology, mineral or petroleum resources, background elemental content.
- Local and regional hydrology:
  - Regional creeks, streams, rivers, ponds and lakes, marine conditions, catchment area, downstream areas that may be affected, water flow and volume, and water chemistry/quality.
- Local and regional hydrogeology:
  - Aquifers, aquitards, hydraulic conductivity within the tailings facility and underlying surficial and bedrock materials, direction of groundwater flow, volume of volume, and groundwater chemistry/quality
- Climate characteristics and meteorological conditions:
  - Temperature, wind, precipitation, evaporation, seasonal and extreme events, precipitation and runoff, and air quality
- Projections of future climate conditions, including projected changes in extreme events and projection changes in seasonal and annual "normal" conditions and, where applicable, potential for permafrost degradation.
- Terrestrial environment within the footprint of the tailings facility (for proposed new tailings facilities) and in areas that could be impacted by chronic or catastrophic events, including key species present, presence of any at risk species, and significant habitat features.
- Aquatic environment within the footprint of the tailings facility (for proposed new tailings facilities) and in areas that could be impacted by chronic or catastrophic events, including key fish, amphibian, crustacean, and bird species present, and aquatic environment types.
- Characteristics of any communities that could be impacted by chronic or catastrophic events, including community size, economic activities, etc.
- Status of Indigenous rights and title.
- Traditional use of the area, including sites of spiritual significance, traditional harvesting activities (including species of plants and animals harvested).
- Other commercial activities in the area that could be impacted by chronic or catastrophic events, such as agriculture, forestry, or commercial fishing.
- Recreational activities in the area that could be impacted by chronic or catastrophic events, such as sport fishing, camping, boating, hiking, and tourism
- Archaeological resources
- Existing and planned infrastructure off site that could be impacted by chronic or catastrophic events, such as bridges and other stream crossings, roads or railways.
- Legal requirements

Owners should develop a plan for collecting and compiling site characterization information, ensuring that it is updated throughout the life cycle, and ensuring the relevant information is retained. For existing facilities, Owners should conduct a gap analysis of site characterization information and develop a plan to address gaps, to the extent feasible.

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Information about the Design of the Tailings Facility

Detailed aspects of tailings facility design principles and concepts are outside the scope of this Guide. However, documentation of information related to the design of a tailings facility is critical to responsible tailings management.

Design applies to:

- Initial construction of new tailings facilities.
- Planned ongoing construction (e.g., raising embankments to increase tailings facility capacity) throughout the operations and ongoing construction phase.
- Any changes/deviations from the design through initial construction and operations and ongoing construction, including any changes to improve the design and enhance performance or reduce risk.
- Any proposed changes that could impact the risk profile or performance of the tailings facility.
- Design related to components of the closure plan (e.g., design of cover systems).

There are wide range of factors that form the basis for the design of a tailings facility. These should be carefully considered in the design process and should be documented. These factors include:

- Relevant site characterization information including:
  - Physical and chemical characteristics of tailings, construction materials, and the foundation.
  - Hydrology and hydrogeology
  - Climate conditions
  - Mine plan and mine site layout
  - Natural hazards
- Operating requirements, including:
  - Life of mine and production rate
  - Ore processing method
  - Tailings characteristics
  - Water management a water balance
- Other relevant constraints on the design, such as the presence of downstream communities, protected areas, or other factors.

Selection and application of appropriate design criteria are a key step in the design process. This Guide does not provide recommendations for design criteria, but through the planning and design process, it is essential that engineering standards and criteria for tailings embankments and other components be carefully considered.

It is important to emphasize that the application of engineering standards needs to be done on site-specific basis. Each location and tailings facility is unique, and care needs to be taken to ensure that engineering standards and criteria are selected and applied in a manner that is appropriate to the facility. In addition, it is important to select appropriate parameters for analysis and to understand and document both the underlying assumptions and aspects of uncertainty (e.g., knowledge of foundation conditions).

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The selection of appropriate, site-specific design criteria should consider:

- Maximum height and slopes of the tailings facility and embankments
- Construction materials and methods
- Seismic hazard
- Potential extreme flood and precipitation events.
- Potential for liquefaction and compaction
- Potential for brittle failure.
- Seepage management and the potential for piping
- Factor of safety for perimeter slopes for operation and closure
- Potential consequences of chronic or catastrophic failure
- Level of acceptable risk
- Legal requirements

Taking into account the design basis and design criteria, the tailings facility, including any embankments and other components, should be designed in a manner that is appropriate to meeting the corporate policy or commitment and site-specific performance objectives, and is informed by site characterization and the risk assessment, including credible failure modes.

Design related information should be documented (sometimes referred to as a design report or design basis report), including:

- Design assumptions and criteria, including operational constraints that provide the basis for the design, construction, operation, and closure of the tailings facility.
- Relevant aspects of site characterization, water balance modelling and water management, design analyses and evaluation of their results.
- Design of all stages of the facility including construction requirements and specifications, and construction drawings.

For existing facilities, Owners should conduct a gap analysis of design-related information and developing a plan to address gaps, to the extent feasible.

Information about Tailings Facility Construction

Tailings facilities are unique in that construction is an ongoing activity that includes:

- Initial construction of new tailings facilities.
- Planned ongoing construction throughout the operations and ongoing construction phase.
- Construction associated with:
  - Implementing any changes that could impacts that risk profile or performance of the facility.
  - Implementing the closure plan.

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For all construction activities, construction and as-built conditions should be documented, including:

- Deviations from the design or approvals process followed, and an assessment of the cumulative impacts to risk of changes to the tailings facility design.
- Information to demonstrate whether the design intent is being met, including in the case of any deviations from the design to deviations from expected conditions.
  - This should include documenting any discrepancies between the field conditions and the design assumptions.
- Dates of construction.
- General description of the construction, including a summary of the key elements that were constructed.
- Who was responsible for the construction: Responsible Person, EoR, designer, and construction contractor.
- As-built conditions, including survey drawings of the tailings facility showing the positions and configuration of features including (where applicable):
  - Embankments, including cross-sectional drawings
  - See page management and collection
  - Borrow material sources
  - Conveyance infrastructure for tailings and water management
  - Electrical supply for pumps, surveillance instruments, etc.
  - Access roads
  - Water management infrastructure
  - Surveillance instrumentation including installation details
- Results of field and/or laboratory testing of construction materials and foundation materials (e.g., borrow material, surficial geological units underlying the tailings facility), including documentation of variances between specifications for materials and actual conditions.
- Schedule and sequencing of construction activities completed.
- Procedures and equipment used for construction.
- Quality control and quality assurance data.
- Results of surveillance conducted during construction.
- Photographs, videos, and satellite imagery taken throughout construction.
- Description of any problems or unexpected conditions that arose during construction including natural (ground conditions, weather, etc.) or human-made (changes from approved design, construction methods differing from standard, etc.), and steps take to address these problems, include any mitigation measures implemented or changes made.
- Other relevant documentation.

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For existing tailings facilities, Owners should begin documenting current and future construction activities as per the points above. In addition, Owner's should strive to have as detailed an understanding of the current state of as-built conditions of the tailings facility as is feasible. With this goal in mind, Owners should:

- Describe original as-built conditions and construction history to the extent feasible.
- Identify gaps in understanding of the construction and construction history.
- Document the current configuration and state of as-built conditions of the tailings facility.
- Assess the need to conduct studies to better understand the current as-built conditions of the tailings facility. A key consideration in this regard is gaps in understanding that increase uncertainty in:
  - The risk assessment and effectiveness of risk management measures.
  - Design of any future proposed material changes.
  - Closure plan development and implementation.
- If there is a need to better understand current conditions, identify methodologies that may be used to collect information to address gaps (e.g., geotechnical drilling in the facility and/or foundation, ground penetrating radar), and develop a plan to collect this information.
- Use this information to:
  - Update documentation of the current configuration and state of as-built conditions.
  - Inform reviews and updates to the risk assessment and risk management plan.
  - Inform development of potential material changes to enhance performance and reduce risk.

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Appendix 7: Factors in Effective Communications, Governance, and the "Human Element" of Tailings Management

Below is a summary of lessons learned about governance and communications that are applicable to tailings management and dam safety, based on *Pearl Harbor: Lessons for the Dam Safety Community*.[1]

1. Personnel delegated the responsibility for a certain activity must have the authority to carry it out. When delegating authority or issuing specific instructions, follow-up to ensure that the delegated authority is being appropriately carried out, or that the instructions have been understood and correctly implemented. Do not assume that all is going according to plan.
2. Communications must be clear and unambiguous. Ensure that the meaning and intent of information communicated is fully understood. Avoid paraphrasing or condensing messages when relaying information, so that the actual meaning or intent is not lost.
3. Keep other personnel adequately informed regarding aspects of tailings management relevant to their responsibility and authority. Communications are two-way, and effective decision-making requires complete information, not a partial presentation of the facts.
4. Do not take anything for granted in communicating with other personnel involved either directly or indirectly in tailings management and either higher or lower in the "chain of command". Do not assume they fully understand the meaning or relevance of information provided. Similarly, do not withhold information from other personnel involved in activities on site. For example, a minor change in tailings characteristics, deemed unimportant by personnel responsible for ore processing because it does not affect recovery rates or reagent use could have significant implications for tailings management.
5. Be open to input from other personnel and those involved in other activities on site. All personnel should be encouraged to raise concerns or suggestions. Observations of personnel lacking in specific training or expertise related to tailings management (e.g., security personnel) should not be ignored or discounted.
6. Corporate personnel should provide all relevant information to the Responsible Person(s) on site and to other site personnel as appropriate. This includes new policies developed at the corporate level, potential legal changes that corporate personnel are aware of, and information on lessons learned from tailings management at other sites or other companies.
7. Never ignore, delay or "water down" an official instruction. If you are unclear, or if you question the validity of the instruction, raise those concerns promptly. But do not unilaterally decide not to carry out the activity as instructed.
8. Personal friendship must not interfere with clear communications on professional matters. Do not assume, because two people are friends, that they clearly communicate in their professional relationship. The reverse may be true, as they may make assumptions about what the other knows, and those around them may assume they are clearly communicating in their professional relationship because they are friends.

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9. Effective and timely surveillance is essential to tailings management. The Owner must allocate appropriate resources and ensure that there are competent personnel in place with responsibility for surveillance, and clear lines of communications regarding surveillance program design, implementation, and outputs.
10. Do not interpret surveillance results only through the lens of potential unwanted events or occurrences that were identified in the risk assessment. Consider the possibility that the results are pointing to a risk not previously anticipated.
11. A failure can occur at any time, sometimes without warning. Avoid becoming complacent or deferring actions out of a sense that "all is well". Be alert and ready to respond at all times, even to events with an extremely low probability of occurring, and no matter how good past performance has been. Better to have a false alarm than to ignore the warning signs of an impending loss of control.
12. Be ready to respond to a failure by preparing for any eventuality. Ensure that emergency response plans (ERPs) are developed and tested. ERPs need to be adaptable in case an event occurs that had not been anticipated and planned for.
13. The Owner must have a corporate culture that prioritizes responsible tailings management and avoids competition for resources between business units that could comprise tailings management. Giving secondary importance to tailings management can result in lead to choices with adverse long-term financial or other impacts.
14. The Accountable Executive Officer and Responsible Person(s) need to be familiar with their organization and understand the tailings facilities for which they are responsible, the risks the facilities pose, and the manner in which risk is being managed, including any failures, deficiencies, or opportunities for improvement. They must be informed by annual management reviews, input/results of assurance activities including Independent Review, and be apprised of any material developments in between these activities. If they do not have the competencies and knowledge needed, or if they rely on the assurances of their staff without being themselves fully informed, then they should pass that responsibility and accountability to others with the capacity to be fully engaged. The Accountable Executive Officer and Responsible Person(s) do not need to be involved in all details of tailings management, but they MUST understand the big picture of the facilities and risks for which they are accountable.

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Appendix 8: Technical Considerations

The management of tailings facilities involves a wide range of technical disciplines that are applied in a coordinated and timely manner throughout the life cycle of each individual facility. There are numerous sources of technical guidance for Owners, operators, designers, regulators, and others that are readily available. References to some of the available guidance are provided in this Tailing Guide and each of those references will, in turn, point to other relevant materials. As this technical guidance is readily available, this Guide has not been developed to be exhaustive or comprehensive in terms of the technical guidance provided. However, there are three technical aspects essential to any tailings facility that are described in this Appendix, and which form the basis of the technical considerations for this Guide.

Tailings Transportation and Placement Plan

The tailings transportation and placement plan demonstrates both the capacity and flexibility of the tailings facility to meet the demands of the mining plan as it evolves throughout its life cycle, and is crucial to successfully operating the facility from construction to closure. BAP includes having the transportation and placement plan integrated into the OMS manual and executed during the operations and ongoing construction phase. Temporary suspension and closure conditions typically rely on an interim or final tailings surface topography to facilitate the closure strategy and post-closure land use, for example, a water cover, or a "dry" surface with appropriate drainage patterns. Typically updated annually during the operations and ongoing construction phase of the life cycle, the tailings transportation and placement plan is prepared and implemented with eventual closure design and reclamation requirements as an objective.

The tailings transportation and placement plan is predicated upon the tailings management technology used and the site-specific conditions of the tailings facility, and should address:

- Whether the tailings will be managed as slurry, or whether they will be dewatered to some degree and managed as thickened, paste or filtered tailings. Planned moisture content and physical characteristics of the tailings are essential to the transportation and placement plan.
- What types of containment structures, if any, will be constructed, the construction method, materials to be used, and the method of raising those containment structures during the operating phase.
- Methods, if any, to control seepage from the tailings facility, such as the use of liners, water retaining dams, or underdrains.
- Whether there will be a single type of tailings, or whether there will be different types. For example, will there be separate "clean" tailings and potentially acid-generating tailings, which would be managed differently? If separate, how will these different types of tailings be managed?
- Whether any other materials, such as waste rock or treatment sludge, will be managed with the tailings. For example, will potentially acid-generating waste rock be managed with the tailings to prevent or control acidic drainage? What quantities of these materials will be placed in the tailings facility, compared to the quantity of tailings?
- How will the tailings be transported from the ore processing facility to the tailings facility? Options include a pipeline in the cases of slurry, thickened or paste tailings, and truck or conveyor belt in the case of filtered tailings.

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- Methods to prevent the release of tailings to the environment during transportation to the tailings facility.
- How will the tailings and any other materials be placed or deposited within the tailings facility?
- How much water will be retained in the tailings facility? What measures are in place to deal with excess water, such as due to high intensity precipitation, extreme snow-pack/melt, extended periods of wet weather, extended periods of water retention, etc?

In developing the tailings transportation and placement plan, a range of information about the physical and chemical characteristics of the tailings should be considered, including those listed in *Appendices 3.1 and 6*. These characteristics should be validated and updated on a periodic basis throughout the life of mine. If characteristics to not meet design specifications or intent, then the potential impacts and risks of these deviations should be assessed, and appropriate actions taken to address them.

Depending on how water will be managed, and whether water will be stored in the tailings facility, the tailings transportation and placement plan should be integrated with the water management plan.

Placement plans typically allow for expansion of the tailings facility over the life of the mine to accommodate increasing amounts of tailings solids. This could include staged lifts to increase the height of containment structures to accommodate additional tailings, or planned lateral expansions into new cells of the tailings facility. Depending on the water content of the tailings, and the relationship between tailings management and water management, such expansions may also increase the capacity to store water and increase the retention time of water within the tailings facility.

The tailings transportation and placement plan should be linked to the closure plan such that the tailings facility is in the configuration required for closure. The plan should be reviewed on an annual basis, with any changes to the plan subjected to the site's risk management and change management systems. Any changes should be documented.

Water Management Plan

An appropriate water management plan for any tailings facility will be unique to that facility. However, the following elements are essential to any water management plan.

Hydrology/Hydrogeology: Surface hydrology and hydrogeological data, including the delineation of tailings site catchment area(s) and all potential water sources, both natural and process, are used in the development of a water/contaminant balance and design of tailings facility components. Establish and document design parameters, then monitor actual experience to identify variances, validate projections, and anticipate potential problems.

Design Flood: The appropriate Environmental Design Flood and Inflow Design Flood need to be identified, with reference to current design standards and in consultation with regulatory agencies. Design flood considerations should be consistently applied throughout all phases of the life cycle, taking into account evolving BAP and any changes to legal requirements. Storage requirements, operating freeboard and spillway design are based on the hydrology of the watershed.

Water Balance: Complete a water balance study. Specify requirements for ongoing data collection for the ore processing facility and for tailings facility water balance calibration purposes. Water calculation to estimate fresh water needs and maximum pond storage requirements should be conducted and then updated at a frequency appropriate to the facility-specific conditions. Operational water balance should also be calculated and updated as appropriate.

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Surface Water Management Plan: Complete a water management plan detailing appropriate designs and strategies, where required, for: clean water interceptors and diversions; seepage collection; reclaim/pump-back systems; treatment/discharge systems, including all water conveyance systems; and water retention and discharge strategy, including operating parameters. Revise the surface water management plan at a frequency appropriate to facility-specific conditions to consider potential design or operational changes to the facility. Updates to the surface water management plan should take into consideration the life cycle phase, and further requirements and expected conditions through the life cycle, including changes to the surface water management plan for the closure, and post-closure phases, as well as potential care and maintenance.

Contaminant Balance and Release: The contaminant balance provides estimates of contaminant release to surface and groundwater. Develop, where required, a plan to control contaminant release within acceptable levels. Monitor and plan for long-term conformance.

Effluent Criteria: Establish criteria for the quality and quantity of any effluent to be released to the environment, taking into account legal requirements. The intent is to set performance criteria which are below legal requirements, to provide increased assurance of compliance with legal requirements. With respect to effluent quality, this may include criteria for dissolved and suspended solids, metals and metalloids, non-metals, thiosalts, cyanide, ammonia and other nitrogen compounds, and toxicity, and any other parameters that are subject to legal requirements, or of relevance to the Owner. With respect to effluent quantity, this may include criteria for maximum and base flow of effluent, as well as seasonal considerations for effluent release.

Closure Plan

Development of closure plans and performance objectives for closure and post-closure should begin at the project conception and planning phase. A conceptual closure plan, developed with a low level of detail at the project conception and planning phase, should become more detailed and elaborated at the design phase. The conceptual close plan should then be refined, elaborated, verified, and updated periodically during the initial construction and operating phases of the life cycle of the tailings facility, and in preparation for decommissioning, closure, and post-closure. The closure plan and objectives should be considered in the assessment of alternatives to select the tailings facility location and BAT, and should be a key consideration in the design of the facility. The closure plan and objectives should also be aligned with the OMS manual, so that activities during the operating phase are consistent with and support the closure plan and objectives.

A key aspect of closure that needs to be determined as early as possible in the life cycle, and at the project conception and planning phase for new facilities, is the closure strategy for the tailings facility, and the closure technology to be used. The selection of the strategy and closure technology should be driven by the objectives and performance objectives for closure and post-closure, and the planned post-closure land use. The potential physical and chemical impacts and risks of the tailings facility are key considerations. For example, if the tailings are predicted to be susceptible to oxidation or are potentially acid generating, then the facility needs to be designed to prevent or control oxidation to prevent acidic drainage throughout the life cycle. This implies designing and operating the facility, and implementing a closure strategy that will prevent exposure of the tailings to either water or oxygen. Options in such cases include a dry cover, a wet cover, or an elevated water table.

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Flexibility is needed in closure planning, in the event that the operating phase is longer or shorter than originally anticipated.

A wide range of information should be considered in the development, updating and, ultimately, implementation of closure plans, including:

- risk assessment and risk management plan;
- design of the facility, including any deviations from the as-designed plans throughout the operations and ongoing construction phase;
- legal requirements, industry standards and guidance, corporate policy and objectives, and COI expectations;
- existing infrastructure, and infrastructure to be retained during closure and post-closure;
- tailings transportation and placement plan;
- water management plan;
- OMS manual;
- physical and chemical characteristics of the tailings;
- topography;
- climate, including long-term climate change projections;
- hydrology;
- hydrogeology of surficial and bedrock units;
- soil conditions and geotechnical considerations;
- potential for revegetation, including access to seeds for native species; and
- availability of materials for reclamation.

Closure plans should address a wide range of topics related to the decommissioning of tailings-related infrastructure, measures to ensure the long-term physical and chemical stability of tailings facilities, and maintenance and surveillance plans for the long-term post-closure period, including:

- Progressive reclamation plan to address reclamation activities to be undertaken during the operations and ongoing construction phase of the life cycle;
- Decommissioning plan to address activities to be undertaken during the closure phase, including:
  - removal of infrastructure (e.g., tailings pipelines);
  - changes to water management, including construction of spillways;
  - changes to water treatment; and
  - recontouring of facilities;
- Reclamation and revegetation plan, including:
  - plan for stockpiling of overburden material for use in reclamation; and
  - revegetation requirements for tailings facility, including species to be used, and collection of plant or seed material;

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- Long-term maintenance and surveillance plan, including:
  - assign accountability and responsibility;
  - commit resources (infrastructure, staff, budget) needed to implement the plan;
  - documented requirements for maintenance, including frequency of various activities;
  - detailed surveillance plan, including types of surveillance to be conducted, frequency of surveillance activities, and timeframe for continuance of surveillance (how many years/ decades), and identification of types of surveillance that may be discontinued, with conditions to be met to discontinue;
  - conformance management plan, including action plans in cases of non-compliance or non-conformance with performance objectives, Owner's commitments, and legal requirements;
  - reporting (internal and external); and
  - COI engagement;
- Emergency response plan and emergency preparedness plan for the closure, and post-closure phases; and
- Plan to ensure continuity of control of documented information.

Closure plans require a thorough re-assessment of facility and dam stability under closure and post-closure conditions. All aspects of the facility and dam stability must be reviewed. The actual performance of the dams in service, including deformation, seepage, foundation and sidewalls, should be checked against design projections as well as against projected post-closure conditions. Design loads might be different after decommissioning and closure.

A goal for closure often includes measures to lower the risk profile of a tailings facility and confining dams that will be required to function in perpetuity.

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The Mining Association of Canada

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MEMORANDUM

To: Enric Fernandez – Senior Environmental Coordinator
Donlin Gold LLC

From: William Morris – Senior Aquatic Scientist
Owl Ridge Natural Resource Consultants, Inc.

Date: July 7, 2016

Subject: 2016 Rainbow Smelt Spawning Migration Observations Summary – Kuskokwim River, Alaska

INTRODUCTION

Owl Ridge Natural Resource Consultants, Inc. (Owl Ridge) conducted surveys of the rainbow smelt spawning migration and spawning habitat on the Kuskokwim River in 2014 and 2015 in support of the Donlin Gold Project. Results from this two-year survey (Owl Ridge, 2015) were used to describe characteristics of the annual spawning migration including: ice-out (breakup) conditions, water flow, water temperature, timing of rainbow smelt arrival in Bethel, upstream migration rates, spawning reaches, subsistence harvest timing, and spawning habitat.

In spring 2016, locations of smelt occurrence and water temperature data were reported to Owl Ridge by local scientists and fishers. The 2016 observations were compared to those collected in 2014 and 2015 surveys and this memorandum summarizes the results of the comparison.

ACKNOWLEDGEMENTS

Observations reported in 2016 provide valuable information that were only possible with support from the network of village observers that provided daily updates on the location of rainbow smelt during the 2016 migration. Thanks to:

Colleen Lauraux in Bethel for daily updates during the early days of the migration and for providing detailed information from the lower river.

Mark Leary with the Native Village of Napaimute, and Dave Cannon with the Kuskokwim River Watershed Council, who provided reports from villages throughout the migration. Dave provided daily water temperature data from Aniak throughout the migration.

Dan Ausdhal Jr. provided detailed observations and reports during the latter part of the migration, once smelt had reached the Kalskag region.

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Dan provided the detail needed to determine the end of spawning as well as the reach of the Kuskokwim River used by smelt for spawning in 2016.

SUMMARY OF COMPARISON

Ice, Water Flow, and Water Temperature

Ice Conditions

Kuskokwim River rainbow smelt begin their annual spawning migration shortly after ice has cleared from the river and after peak breakup flows begin to recede. In 2016, breakup along the Kuskokwim River occurred in late April and reports from village observers indicate that the river was ice-free between Crooked Creek and Bethel by April 28. The U.S. Geological Survey (USGS) gage on the Kuskokwim River at Crooked Creek was no longer reporting the presence of ice by April 21. In contrast, in 2014 and 2015, the USGS gage did not begin recording river discharge until May 5, presumably near the time of ice-out in the Kuskokwim River at Crooked Creek.

Water Flow

In all three years, smelt initiated upstream migration on a receding hydrograph (Figure 1). Similarly, spawning was on the receding leg of the hydrograph in 2014 and 2015 – post breakup, but prior to rising flows in June. However, in 2016 smelt spawned on an ascending hydrograph. The timing of smelt migration and spawning does not appear to have been directly related to absolute discharge in 2014, 2015, or 2016, as flows at spawning have varied: 46,000 cubic feet per second (cfs) (2014); 65,000 cfs (2015); and 76,000 cfs (2016).

Water Temperature

Water temperature data were collected around the smelt spawning areas near Kalskag in 2014 and 2015, and near Aniak in 2016 (Figure 2). Warming water temperature, in combination with receding flows after breakup, likely trigger the upstream spawning migration of rainbow smelt. Water temperature appeared to influence the spawning migrations in 2015 and 2016. Post breakup water temperatures near Kalskag in May 2015 remained persistently cool, around 8°C, for several days after rainbow smelt were first detected in the river below Bethel. Smelt held in the lower river during that period and did not initiate their upstream migration until water temperature began to steadily rise. In 2016, smelt began their migration, passing Bethel, when water temperatures (as measured at Aniak) were still around 6°C; however, water temperature was steadily rising. Rainbow smelt appeared to hold briefly in reaches of the river downstream from Kalskag before making a final movement to spawning grounds, after water temperatures in Aniak exceeded 10°C.

In 2016, spawning began on the first day that water temperature exceeded 10°C; while in 2014 and 2015 spawning occurred at warmer water temperatures, between 11°C and 12°C (Figure 2). Just prior to the 2016 spawning, strong hail and rain persisted for much

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of the day and by the end of the day the water had cooled to below 10°C. However, by the following morning smelt were no longer observed or harvested, indicating that spawning occurred during the afternoon and overnight on the day water first exceeded 10°C (Figure 2, Table 1).

Spawning Migration

Timing and Rate of Migration

The starting date of the spawning migration (loosely defined here as the passing of smelt by Bethel) has varied by two weeks over the period 2014-2016. The 2016 rainbow smelt spawning migration occurred between May 10 and 17, the earliest observed between 2014 and 2016. Historical knowledge of the fishery indicates that smelt usually spawn around the end of May, so spawning on May 16 was clearly very early. 2016 rainbow smelt movements were tracked beginning May 10, when fish were first reported in the lower river at Napakiak (21 river kilometers [rkm] downstream of Bethel), until May 17, when fish were no longer being reported in the river near spawning areas around Upper Kalskag (Figure 3).

By the morning of May 10, 2016, rainbow smelt harvesting had begun in Napakiak (Enoch 2016). By mid-day, smelt had arrived at Bethel and by evening, high harvest rates were reported. On May 11 and 12, smelt were moving between 21 and 34 rkm per day passing Kwethluk and Akiak. The migration rate increased May 13 and 14, with movements of 59 and 57 rkm per day, respectively. Similar to 2014 and 2015, within four days of their arrival at Bethel, smelt were being harvested within 25 rkm downstream of Upper Kalskag. However, once arriving in an 8-rkm reach of the river downstream from the Old River mouth (about 7 rkm downstream from Upper Kalskag), the migration slowed and smelt remained in the area for two days until they moved upstream of Lower and Upper Kalskag on May 16, presumably for spawning. Reports of smelt being harvested below Kalskag from an area between the Old River mouth to about 8 rkm downstream from the Old River mouth began on May 14 and persisted through the morning of May 16. Movement rates had dropped to around 10 to 13 rkm per day. Smelt first arrived at Lower Kalskag on May 16 at 13:00 hours, and by 20:00 hours harvests were being reported between Lower Kalskag and upstream of Upper Kalskag around river kilometer (RKM) 298 (measured upstream from the mouth of the Kuskokwim River), near two islands. Reports indicate that female smelt harvested between Lower Kalskag and RKM 298 were ripe females, with eggs spilling when handled. By morning on May 17, rainbow smelt were no longer being harvested or observed, and no gulls were present. 2016 rainbow smelt spawning was complete by the morning of May 17. Table 1 comprises a summary of 2016 rainbow smelt observations and approximate daily movement rates for the spawning migration.

In 2016, smelt moved an average of 28 rkm per day (rkm/day), considerably slower than the 48 rkm/day rate observed in 2014, but nearly identical to the 27 rkm/day rate observed in 2015, when smelt held in the lower river for two days prior to initiating their upstream migration. In 2016, the migration seemed to pause near the end, as rainbow smelt

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approached spawning areas, rather than at the onset of the migration. Figure 3 depicts the rainbow smelt migration for 2014, 2015, and 2016.

Rainbow Smelt Spawning Location

In 2016, rainbow smelt spawned in the same reaches as observed in 2014 – at Kalskag and just upstream. This area is indicated by local fishers as the usual spawning reach (Figure 4). Because substrate samples were not obtained in 2016 to define the extent of spawning, we have conservatively estimated the potential spawning reach as a 13 rkm area between the mouth of the Old River at RKM 285 and the islands immediately upstream from Upper Kalskag near RKM 298. However, the rapid upstream movement of fish into the area between Lower Kalskag and RKM 298 observed on May 16, and the immediate departure of fish by the morning of May 17, indicates that rainbow smelt likely spawned in nearly the same area used in 2014 (Figure 4). Despite the different breakup and river conditions during the spawning migrations in 2014, 2015, and 2016, rainbow smelt spawned within the same 35 rkm reach of the Kuskokwim River. In 2014 and 2016, the two years with the most disparate environmental conditions, smelt most likely spawned in the same 7 rkm reach beginning at and extending just upstream from Kalskag.

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FIGURES

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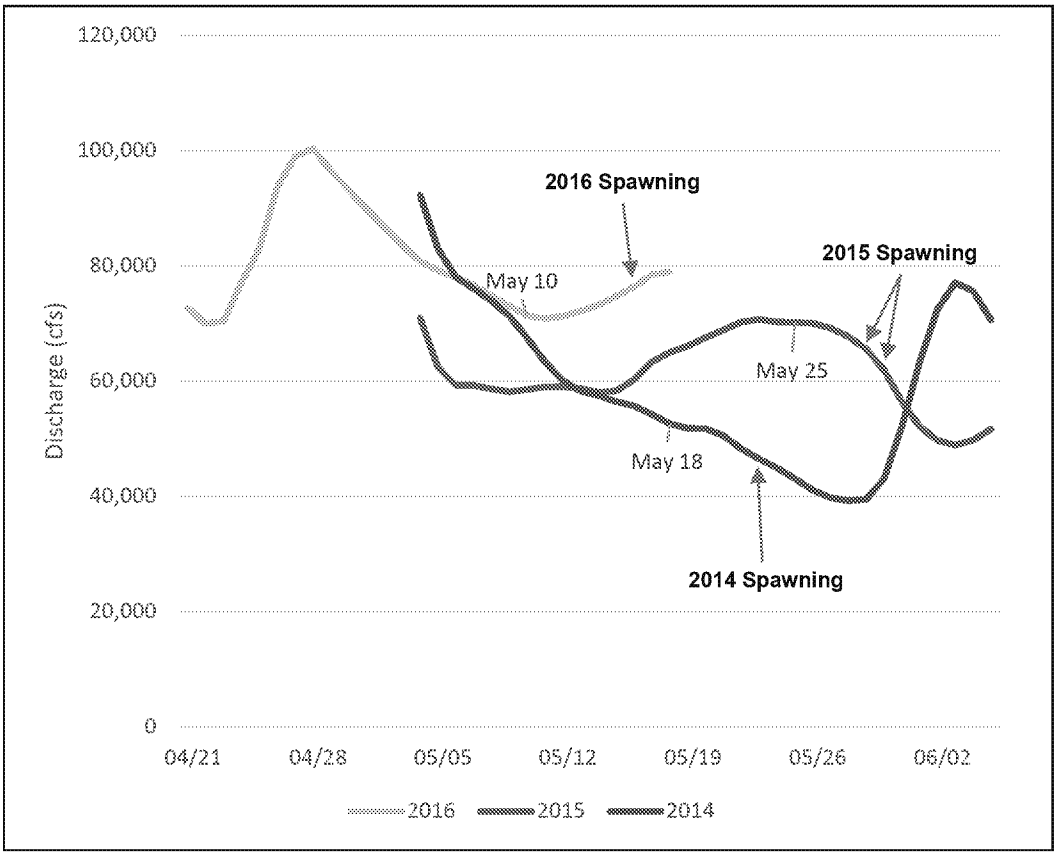

Note: Dates noted on the hydrographs indicate the date smelt first arrived in Bethel, AK

Figure 1. Kuskokwim River Discharge during April and May 2014, 2015, and 2016 – Depicting the Variability in River Flow Conditions during the Rainbow Smelt Migration

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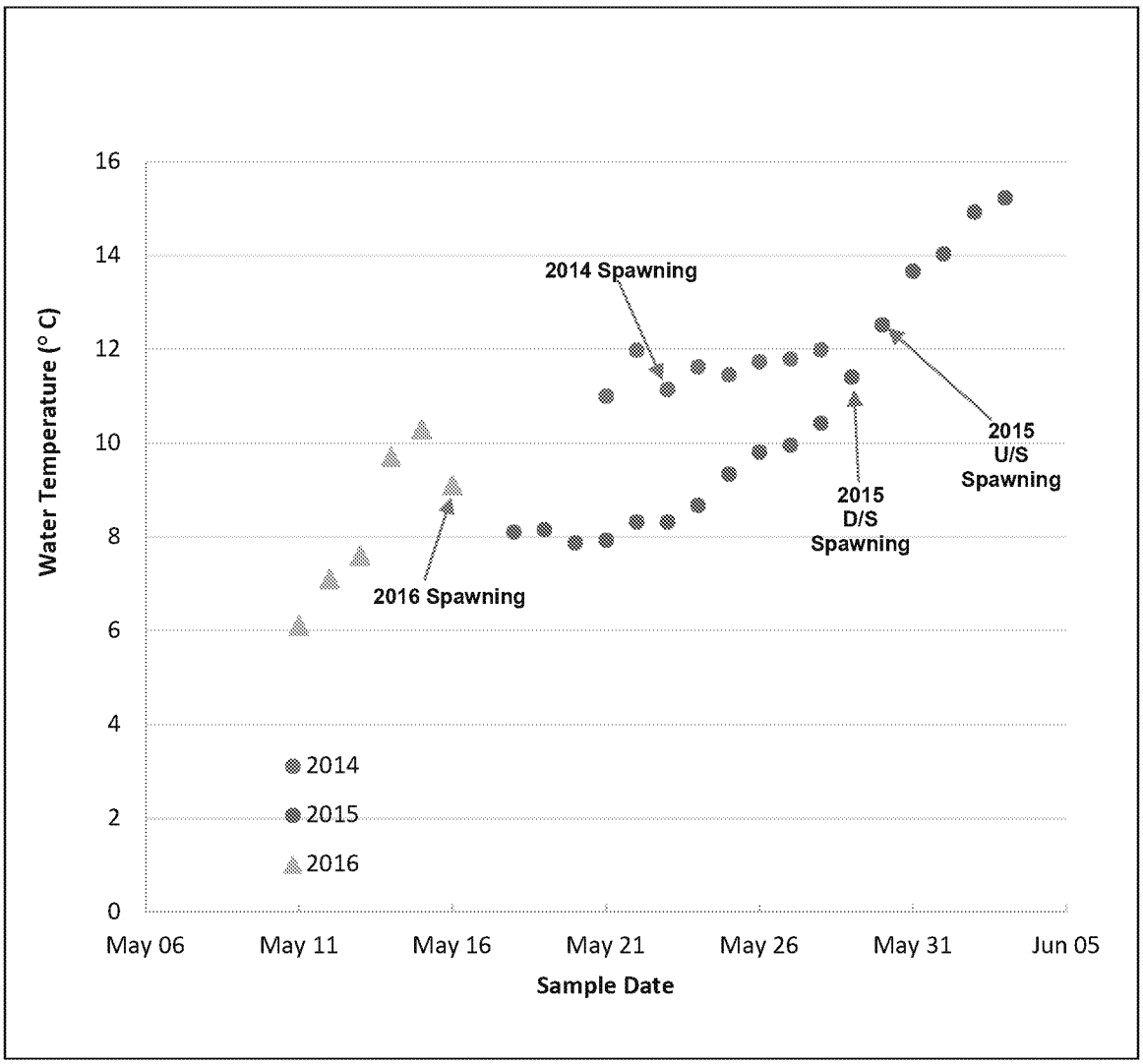

D/S = downstream; U/S = upstream

Note: 2014 and 2015 water temperature readings were recorded at Kalskag; 2016 water temperature readings were reported at Aniak by D. Cannon, Kuskokwim River Watershed Council.

Figure 2: Kuskokwim River Water Temperature near Kalskag during the Rainbow Smelt Migration (2014, 2015, 2016)

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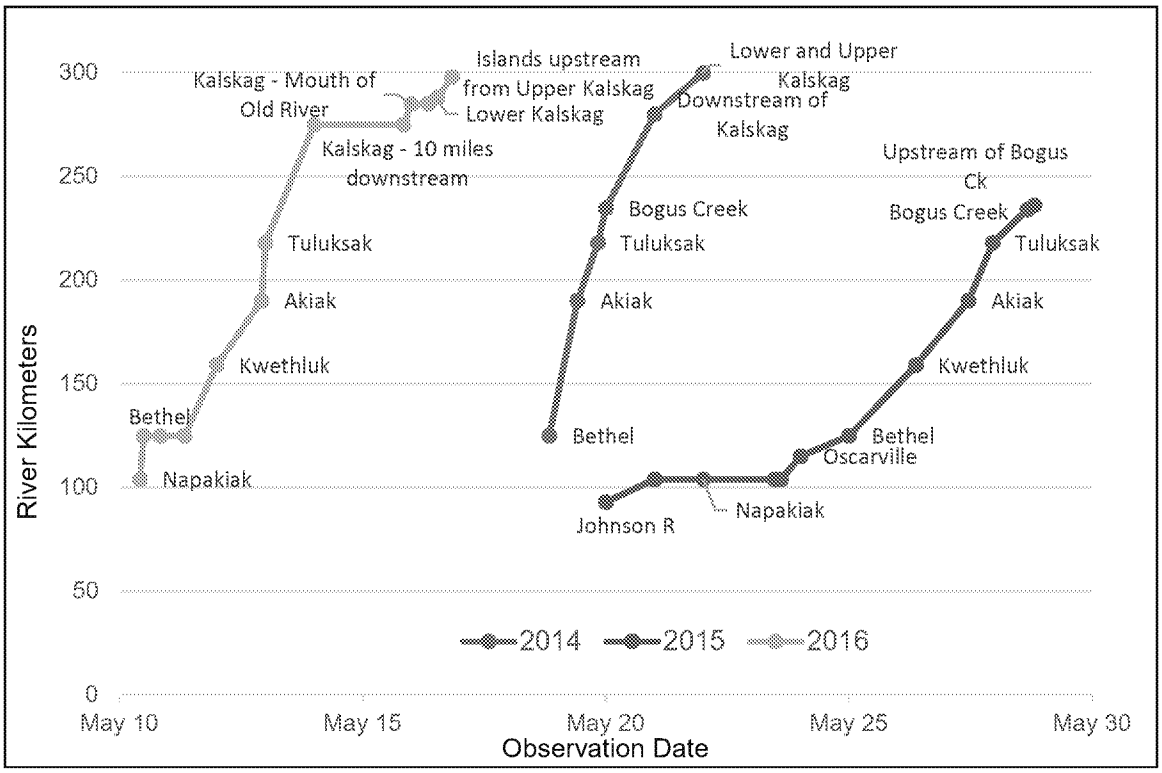

Note: River kilometers are measured from the mouth of the Kuskokwim River.

Figure 3: Spawning Migration of Rainbow Smelt in the Kuskokwim River as Reported by Village Observers (2014, 2015, 2016)

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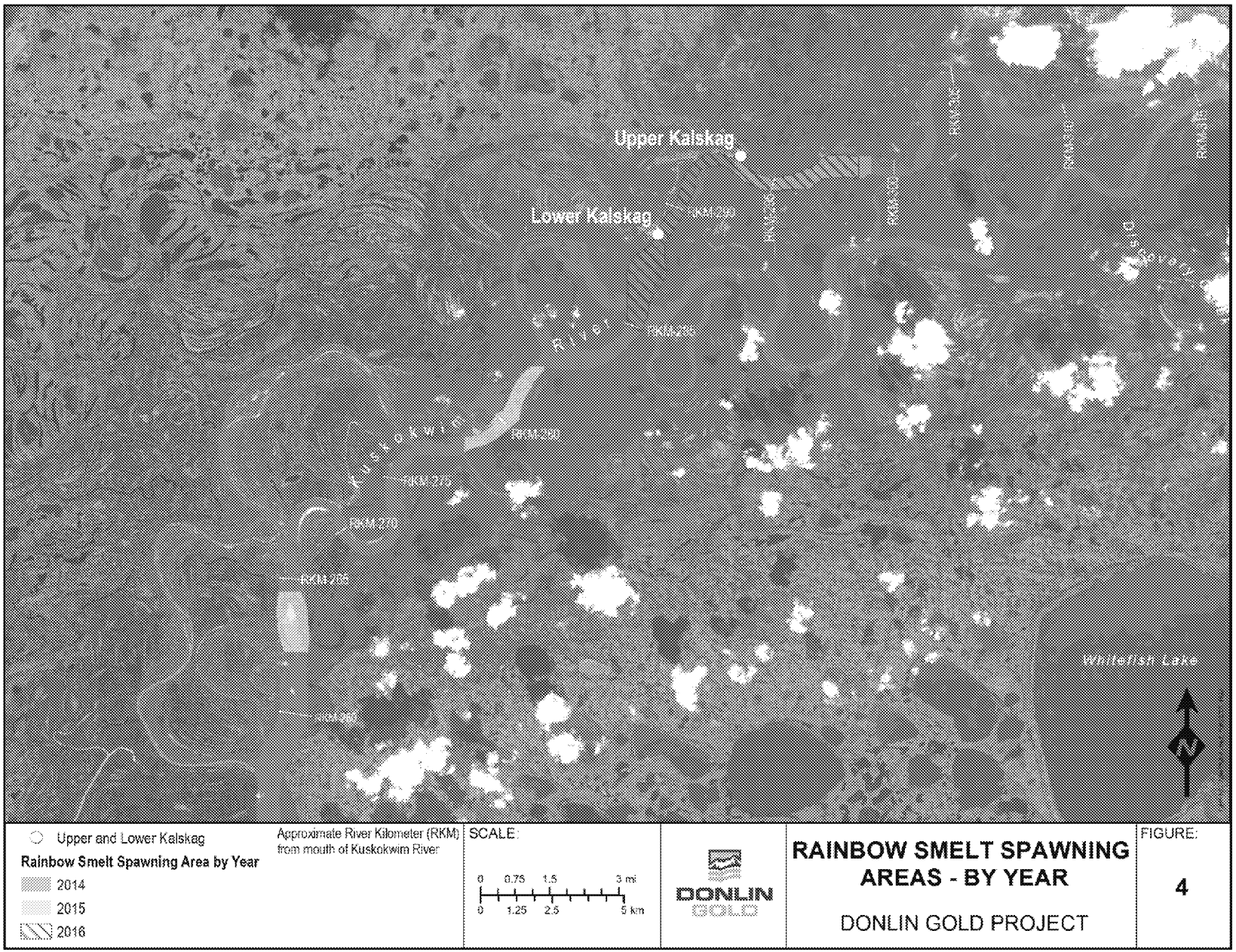

Figure 4: Rainbow Smelt Spawning Areas (2014, 2015, 2016)

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2016 TABLE

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Table 1: 2016 Upstream Movement of Rainbow Smelt in the Kuskokwim River as Reported by Village Observers

Date	Approx. Time	Location	Observation	River Kilometers	River Miles	Approx. rkm/day	Approx. miles/day
5/10/2016	AM	Napakiak	Fishing good - mostly 1/2 nets full	104	65	0	0
5/10/2016	mid-day	Bethel	Smelt being harvested but fishing slow	125	78		
5/10/2016	PM	Bethel	Hitting hard in evening	125	78		
5/11/2016	AM	Bethel	Smelt still being harvested along seawall	125	78	21	13
5/12/2016	....	Kwethluk	Smelt passed Kwethluk	159	98	34	20
5/12/2016	PM	Akiak	Smelt passed Akiak	190	116		
5/13/2016		Tuluksak	Smelt passed Tuluksak	218	135	59	37
5/14/2016		Kalskag - downstream	Smelt being harvested below bluffs downstream from Kalskag	275	171	57	36
5/15/2016	PM	Kalskag - 10 miles downstream	Smelt being harvested about 10 miles downstream from Kalskag	275	171		
5/15/2016		Kalskag	Smelt reported at mouth of Old River area	285	177	10	6
5/16/2016	AM	Kalskag	Smelt reported at mouth of Old River area	285	177	0	0
5/16/2016	13:00	Lower Kalskag	Smelt observed 13:00 hours; fish jumping and splashing	288	179		
5/16/2016	20:00	Lower Kalskag to upstream of Upper Kalskag	Smelt being harvested from Lower Kalskag to 2nd island upstream from Upper Kalskag, Females with eggs spilling being harvested, No smelt being harvested above islands, No gulls above islands	298	185	13	8
5/17/2016	AM	Kalskag	Fish no longer observed at islands above upper Kalskag or at town	298	185		
			Total Upstream Migration:			194	120
			Average Daily Movement Rate:			28	17

Sources:
D. Ausdhal, Upper Kalskag, 2016
D. Cannon, Kuskokwim River Watershed Council, 2016
C. Lauraux, Donlin Gold, Bethel, 2016
M. Leary, Native Village of Napaimute, 2016

ED_013708_00000178-00181

Save the Date: Infrastructure Grant Symposium September 7th, 2022

01.21.22

Delegation Announces Disaster Declarations for Alaska Fisheries

Commerce Determinations Clear the Way for Alaska Fisheries to Receive Relief Funds

U.S. Senators Lisa Murkowski and Dan Sullivan and Congressman Don Young, all R-Alaska, today welcomed determinations from the Department of Commerce that fishery disasters have occurred in numerous Alaska fisheries, allowing them to receive critical relief funding from the National Oceanic and Atmospheric Administration (NOAA). The funding can be distributed to fishermen and their crews, seafood processors, and research initiatives in the impacted regions.

"Alaska's fisheries are economic and subsistence lifelines for individuals and communities across our state, and they also produce more than $15 billion in national value each year. Their strength and vibrancy is one of my top priorities, and the reason I have been pushing the administration to make disaster declarations to help overcome a number of remarkably challenging seasons," **Senator Murkowski said**. "These determinations, and the funding they will allow, are a welcome relief for all who have been impacted. I thank the Department of Commerce and NOAA for supporting Alaskans, and Secretary Raimondo for her commitment to work with us to create a more efficient process moving forward."

"Our state has suffered extraordinary economic hardship over the last few years with the impacts of the pandemic layered on top of an unprecedented number of fishery disasters," **Senator Sullivan said**. "Our great fisheries resources provide a pillar within Alaska's economy and culture. Now that a fishery disaster has been declared, we can work to secure appropriations to fund these fishery disaster declarations. I want to thank Secretary Raimondo, who I recently hosted in a meeting with several members of United Fishermen of Alaska, for working so closely with the Alaska Congressional Delegation on these important determinations that will allow for much needed fishery disaster relief to reach Alaskans who are reliant on this resource."

"Our state's fisheries are a central part of our economy and way of life, particularly for Alaska Natives who have harvested fish from our waters for millennia. The past couple of years have been tough for Alaska's fisheries, causing immense pain for our hardworking fishing communities," **said Congressman Young.** "Today's news from the Department of Commerce is a bright spot for our fishermen, processors, and others who rely on a strong and vibrant

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seafood sector. I want to thank Secretary Raimondo for declaring a fisheries disaster and working with the Alaska Delegation to invest this critical relief in our state. In Congress, I will continue standing up for commercial, subsistence, and recreational fishing across Alaska."

Secretary Raimondo today issued determinations that fisheries disasters occurred in:

- 2018 Upper Cook Inlet East Side Set Net
- 2018 Copper River Chinook and sockeye salmon
- 2019 Eastern Bering Sea Tanner crab
- 2020 Prince William Sound salmon fisheries
- 2020 Copper River Chinook, sockeye, and chum salmon fisheries
- 2020 Eastern Bering Sea Tanner crab
- 2020 Pacific cod in the Gulf of Alaska
- 2020 Alaska Norton Sound salmon
- 2020 Yukon River salmon
- 2020 Chignik salmon
- 2020 Kuskokwim River salmon
- 2020 Southeast Alaska salmon fisheries
- 2020 Upper Cook Inlet salmon fisheries
- 2021 Yukon River salmon fishery

Background:

- In April 2021, the Alaska Delegation **sent a letter** to Secretary of Commerce Secretary Gina Raimondo in support of the State of Alaska's 2020 fisheries disaster declarations.
- In September 2021, the Alaska Delegation **sent a letter** to Secretary Raimondo in support of Governor Dunleavy's 2020 and 2021 fisheries disaster declarations.

Related Issues: Alaska's Fisheries

ED_013708_00000178-00183

TECHNICAL MEMORANDUM
REVIEW OF THE DRAFT SUPPLEMENT ENVIRONMENTAL IMPACT STATEMENT FOR THE DONLIN GOLD PROJECT

May 11, 2016

Prepared for: Northern Alaska Environmental Center

Prepared by: Tom Myers, PhD, Hydrologic Consultant, Reno NV

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1.0 INTRODUCTION

Donlin Gold, LLC (Donlin) has proposed to construct the Dolin Gold Project in the Kuskokwim watershed in southwest Alaska. The U.S. Army Corps of Engineers (Corps) is the lead agency for the preparation of the draft environmental impact statement (DEIS). The proposed project includes a large open pit mine with transportation facilities to a port at Bethel Alaska, and a natural gas pipeline from Cook Inlet.

This technical memorandum reviews the DEIS and supporting documents with an emphasis on hydrogeology at the mine sites. The emphasis is on the effects of mine dewatering, pit lake development, treatment of contact water (rainfall or snowmelt that has contacted lands disturbed by mining), and seepage from tailings and waste rock facilities reaching the streams. Dewatering effects include the effects on stream baseflow. This review does not include transportation facilities, port development, or the natural gas pipeline.

My background includes a PhD and MS in hydrology/hydrogeology from the University of Nevada, Reno and a BS in civil engineering from the University of Colorado. I have 35 years of employment experience in consulting, academics and government, with about 20 years specific to mining and energy development hydrogeology. My specialties include numerical modeling and contaminant transport. I have published 17 peer-reviewed journal articles with five articles since 2009 concerning groundwater modeling, contaminant transport, and aquifer water balance. My CV is attached to this review.

2.0 SUMMARY OF MAJOR IMPACTS OF THE PROPOSED PROJECT AND ERRORS WITH THE DEIS ANALYSIS

Development of the proposed mining project would affect the hydrogeology in the mine site area in the following ways.

Mine dewatering will substantially lower the groundwater table near the pit and in surrounding bedrock. Although errors in the conceptual flow model and numerical groundwater model cause the DEIS to under-predict the dewatering impacts, dewatering to keep the pit dry would intercept groundwater flowing toward a stream where it would be become baseflow. Dewatering will reduce streamflows by up to 10 and 30 % during summer and winter, respectively, according to the DEIS. Various uncertainties acknowledged in the DEIS could increase the flow loss from the creek.

Mine construction affects surface runoff in many ways, including the pit intercepting surface runoff in American Creek, thereby preventing it from reaching the stream and the tailings impoundment covering 70% of the Anaconda Creek drainage which prevents a large proportion

of that streams' flow from discharging to Crooked Creek. Ancillary mine facilities such as freshwater reservoirs divert or use surface water runoff which can affect both high and low streamflow rates. Together these effects could lower flows in the creek even more than just by dewatering, with some estimates being as high as 100 percent loss during winter baseflow periods.

The mine would require approximately 17,438 gpm for processing which would be discharged to the tailings impoundment during operations. Water for the process plant comes from various places, including freshwater reservoirs, contact water reservoirs, and dewatering wells. Excess water would be discharged to Crooked Creek with treatment, so failures in the collection and treatment system would discharge contaminants to and degrade Crooked Creek. During operations, expected discharge from the water treatment plant is 1268 gpm with 786 gpm from mine dewatering and the remainder from underdrains and contact water reservoirs. All sources are subject to much uncertainty meaning that periodic high flows could overwhelm the treatment system. For example, if the bedrock has a significantly higher conductivity, the dewatering rates could be much higher because it would pull water from further away and allow recharge to enter the bedrock from the shallow aquifer faster. Heterogeneity in the bedrock including with the faults could cause periodic high dewatering amounts. The DEIS does not plan for the probability that the treatment facilities will be periodically exceeded by dewatering water or other contact water requiring treatment before discharge.

The pit lake would recover during mine closure to a point where it would overflow its rim, if allowed, into Crooked Creek. The pit lake water quality would be very poor, according to pit lake modeling, due to waste rock seepage into the pit and acid generating rock around the pit and backfilled into the pit. Donlin would start pumping pit lake water when it reaches 33 feet below the rim to treat and discharge into Crooked Creek. At this point, most of the flow losses from Crooked Creek would cease. However, there are uncertainties not considered in the DEIS that could cause the pit lake to fill and overwhelm the pump and treat system. A spill could devastate Crooked Creek. Climate change could increase precipitation by up to 25% on average but there would also be more frequent very large events, which is not considered in the DEIS. This pump and treat system would be required forever so all possible combinations of weather will eventually occur.

The DEIS relies on the mine dewatering system and the pit lake to draw groundwater including seepage from the waste rock dump and prevent it contaminating downgradient groundwater or discharging to Crooked Creek. However, there is a significant probability that a perched aquifer will form in the shallow aquifer as dewatering lowers the groundwater table. This will short-circuit seepage from the waste rock dump to Crooked Creek. I describe the details in the next few paragraphs concerning the numerical groundwater model. Drawdown occurs under the

tailings impoundment but it will not draw groundwater to the pit because drawdown does not eliminate the ridge in the groundwater table between the tailings and the pit. Seepage escaping the underdrain will flow through the colluvium under Anaconda Creek and either discharge into Anaconda Creek or into the alluvium around and ultimately into Crooked Creek.

The DEIS does not consider the impacts of catastrophic failure, such as would occur with a tailings dam failure. The analysis should consider the probable maximum flood occurring in the watershed because the facility will be there forever. The DEIS should present hydraulic routing of a reasonable portion of the half million tons of tailings down Anaconda Creek and Crooked Creek to show the potential damages.

Most of the DEIS predictions are from a numerical groundwater model. Two aspects of the numerical groundwater model severely bias the predicted impacts of dewatering. The bias is that simulated dewatering does not spread far from the mine pit and affects stream flows much less than it probably will.

- The conceptualization of the bedrock away from the mine pit has very low conductivity, lower than measured in most pump tests and lower than would be expected by considering the scale effects of small-scale test and regional scale models. It is treated as undifferentiated bedrock, meaning treated as one single mass, with a conductivity an order of magnitude less than most of the bedrock simulated within the pit area. This low conductivity prevents the spread of drawdown from the pit into the bedrock, thereby limiting how far the effects can spread. The low conductivity is not justified by observed pump test values or by scale effects which would cause the conductivity to be higher than determined from small-scale pump tests. This prevents the simulated drawdown from affecting overlying streams and wetlands.
- The alluvium around Crooked Creek is simulated with a very high conductivity and very low storativity. Low conductivity bedrock and colluvium surrounds the alluvium. This effectively isolates the alluvium and Crooked Creek from impacts of dewatering. The low storage coefficient allows the alluvium to release very little water for a change in water levels in the alluvium while the very high conductivity limits the change in head. This explains why dewatering drawdown effectively hits a wall at the creek.

The numerical modeling also fails to consider that a perched aquifer could develop in the shallow aquifer. This is partly due to the large difference between bedrock and shallow aquifer conductivity. As simulated drawdown lowers the water table from the shallow groundwater into the bedrock, it is likely that an unsaturated zone would form between a saturated zone in the shallow aquifer and bedrock. Seepage from the waste rock facility would discharge to Crooked Creek rather than be drawn to the pit lake, as relied upon in the DEIS. Drawdown

would occur in the bedrock and pull contaminants toward the pit lake, but perched zones in the shallow aquifer would provide a saturated pathway for contaminants to reach Crooked Creek. The numerical model fails to simulate this because the model cannot simulate such as system. The only potential mitigation would be a liner beneath the waste rock with a leak capture system.

The option for the tailings facility that best prevents seepage from degrading Crooked Creek is dry stack tailing with both a liner and impervious cover to minimize potential seepage with time after closure. This is necessary because the tailings are outside of the pit capture zone and seepage would drain to the streams. The TSF should have a 100-mil liner rather than a 60-mil liner to make leaks would be less likely. The TSF should have an impervious cover to prevent percolation through the tailings from mounding on the liner, which would increase head on the liner and the leak rates and potentially cause instability problems.

Donlin should consider removing the Snow Gulch Reservoir from the plan to avoid impacts to that tributary watershed. They should also leave a buffer between the pit and the Crooked Creek alluvium to decrease the connection with the alluvium and decrease the amount of water potentially drawn from the creek.

3.0 DEIS ALTERNATIVES

The DEIS describes five alternatives, including no action (alternative 1), the proposed action (alternative 2,) (mine layout shown in Figure 1), two alternatives that alter the pipeline and transportation routes but leave the mine plan basically as proposed under alternative 2 (alternatives 3 and 4), and an alternative that would alter the mine plan to use dry stack tailings rather (alternative 5) than a slurry system. Dry stack tailings alternative 5 has two options. Option 1 would not be lined but there would be an underdrain to remove seepage. Option 2 would have a liner. There would be eight freshwater wells for domestic and sanitary uses, and up to 35 pit perimeter wells and 80 in-pit dewatering wells (DEIS, p 2-9).

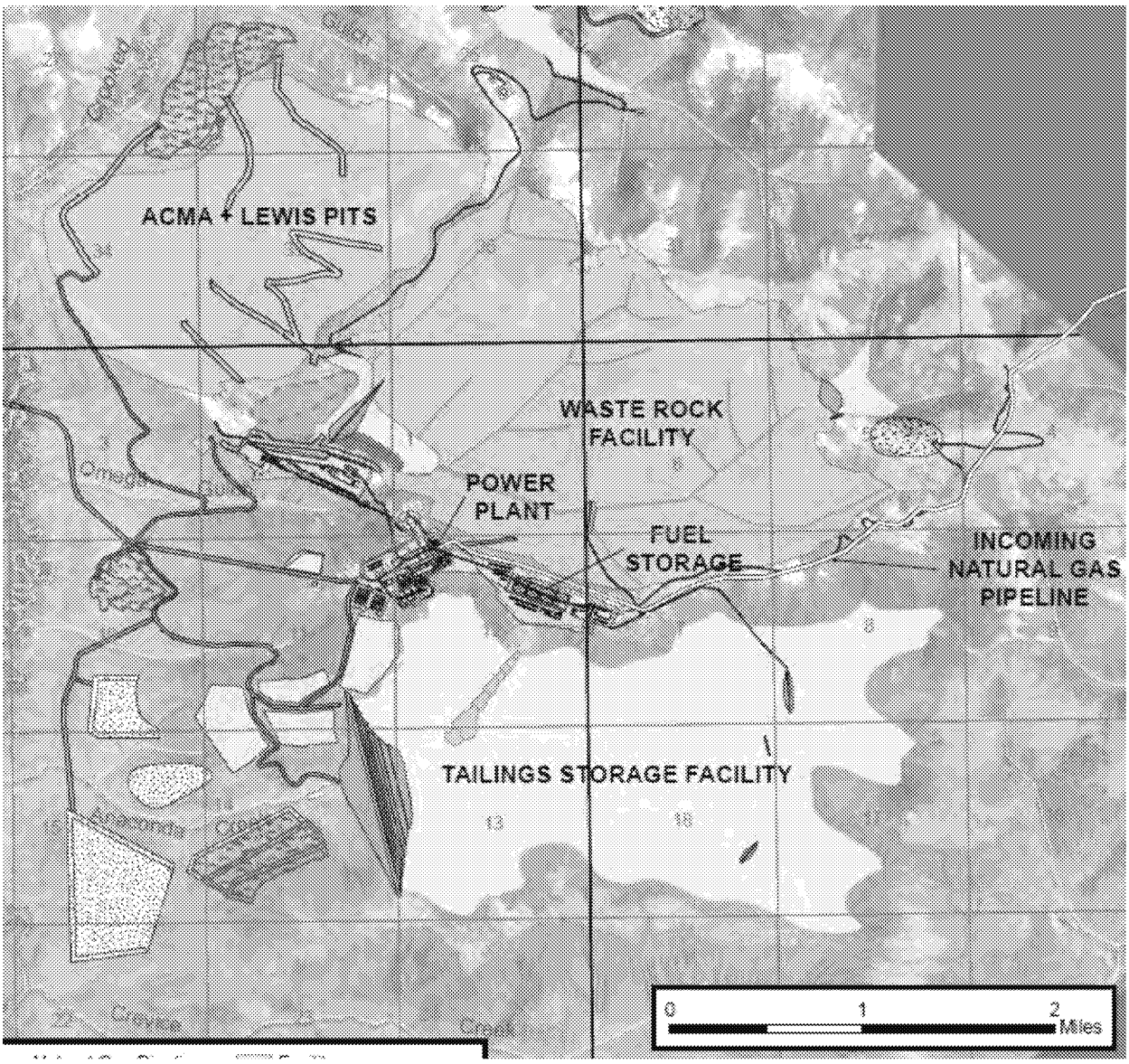


Figure 1: Alternative 2 general mine layout - DEIS Figure 2.3-1

3.1 Recommended Additional Alternative

A primary impact of this proposed mine is the impacts mine dewatering and pit lake formation could have on stream flows. As will be discussed in section 9.0, the properties of the bedrock separating the proposed pit from the alluvium under Crooked Creek have some control over the amount of surface water drawn from the stream into the groundwater. Several amendments should be made to Alternative 2 or should be added to an existing alternative and considered as a new alternative.

- The DEIS should include a setback alternative which requires the pit excavation not intersect the Crooked Creek alluvium. There should be a minimum setback from the creek of several hundred feet to protect stream flows. The exact distance could be determined based on additional understanding of the bedrock properties.
- The waste rock facility (WRF) that would be constructed over the American Creek should have a drain through it to allow streamflow to pass without being captured in an upper contact water pond. Below the WRF, there should be a channel created to allow it to pass the proposed pit
- Snow Gulch Reservoir should be removed if not really needed. See section 7.3 below.

3.2 Adaptive Management and Monitoring

The Corps calls for adaptive management activities pertaining to groundwater hydrology. Donlin should assess monitoring data especially with respect to drawdown to assess whether the groundwater monitoring regime is adequate. Donlin should assess whether drawdown has extended beyond the monitoring system.

- If drawdown at the most distant wells from the mine has become significant, new monitoring wells should be installed. This should be assessed at least every three years during operations.

The groundwater model would be reexamined after three years of pit dewatering to "minimize uncertainty about dewatering effects" (DEIS, p 3.6-44; DEIS, Table 5.7-1). This should include verification of the original model to assess the accuracy of the DEIS predictions.

- If they differ substantially, then new modeling and new NEPA analysis should be completed based on new predictions. A substantial difference is difficult to establish in advance, but would probably include the dewatering pumping rate being off by 100% (pumping twice the expected amount), having drawdown at a monitoring well twice that predicted, or having Crooked Creek lose flow along an unexpected rate or more than expected.
- New modeling should include new ideas of the conceptual flow model in the area. Two obvious considerations are the modeling of the bedrock as a porous media without considering fractures and the distribution of recharge throughout the area.

The Corps indicates that climate change should be considered in future modeling (DEIS, p 3.6-45, DEIS Table 5.7-1 #3). Long-term climatic observations at the site should be compared with climate model predictions to assess the accuracy of the predictions with respect to Donlin.

- Climate change effects on the project should be included with each model update and use the most current precipitation forecasts from global climate models. If the simulations predict substantially different potential future conditions, the Corps should complete supplementary NEPA analysis to disclose to the public the potential changes and to allow the public to provide additional comment.

4.0 MINE DEWATERING

Mine dewatering is the process of removing groundwater for the purpose of lowering the water table, or causing drawdown, to keep the mine pit dry. At Donlin, the company would use pit perimeter wells, in-pit wells, and horizontal drains in the pit wall. The water table would be drawn down near the Donlin pit as much as 1400 feet.

The lateral extent that drawdown expands to depends on recharge because recharge replaces groundwater as it is removed. Dewatering removes water out to the extent of an influence zone where the dewatering pumpage equals the sum of recharge that is captured and streamflow induced to recharge. Drawdown will expand until it has captured an amount of recharge and streamflow equal to the pumping rate needed to lower the water table at the mine. At the point where dewatering pumpage equals recharge, the groundwater pumping will approach steady state. Dewatering affects larger areas in dry regions because the recharge is low and smaller areas in wet regions because of the much higher recharge.

The bedrock hydrogeology controls the dewatering rate and affects how rapidly the drawdown expands. This effectively means conductivity (K), the ease with which groundwater flows through a porous media. All else being equal, more water will be pulled more quickly from further away with a high K value. This means the drawdown cone would approach its maximum extent more quickly with a high K.

4.1 Recharge

Groundwater recharge equals 5.5 in/y or 28 percent of average annual precipitation (DEIS, p 3.6-11). The DEIS does not provide a reference for this estimate, but the numerical model report (BGC 2014c) references BGC (2011b) as the source of the recharge estimate. That document mentions recharge only in an appendix which is a memorandum regarding "Potable Water Supply Assessment"; it states: "[a]verage annual recharge in the mine area was assumed to be 139 mm/y, based on the feasibility calibration of the numerical groundwater flow model (BGC 2007c)". The reference section does not have a BGC 2007c, but BGC 2007g is "Numerical Hydrogeologic Model Results ad Pit Dewatering Design, Final Report".

Recharge is usually estimated in a conceptual model report, but the most recent conceptual model report for Donlin, BGC (2014g), does not derive recharge. The amount used for this project, 5.5 in/y, is not unreasonable, based on my experience, although it is higher as a proportion of annual precipitation than most areas. Because snowmelt is a slow process the estimate is not unreasonable.

- It is important for the DEIS to have an accurate description of recharge, one of the most important hydrogeologic parameters, and how it was determined.

Recharge equals groundwater discharge from a basin which is at steady state (Myers 2016, Cherkauer 2004). Usually, groundwater discharge is stream baseflow. For the Crooked Creek watershed, recharge would equal baseflow at the mouth of the basin expressed as a depth, in inches, over the watershed. It could be estimated for smaller tributary basins if such detail is desirable but the accuracy may decrease if groundwater tributary areas do not exactly match topographic boundaries. In the Crooked Creek watershed, there could be two forms of baseflow because discharge from alluvial/colluvial aquifers should differ from discharge from bedrock aquifers. Shallow aquifers could effectively drain more quickly than the bedrock aquifers which should provide the late-winter baseflow. If the actual amount of recharge reaching bedrock is small, the drawdown in bedrock should expand more than it appears to and have a much larger effect on winter than on late summer flows (DEIS, Figure 3.6-8).

Recharge affects the DEIS predictions by its effects on groundwater model simulations, as reviewed below in section 9.3. In general, higher recharge means higher discharge and calibrating a model using higher groundwater flux rates would lead to higher estimated K values. Together, high recharge and high K could lead to higher dewatering estimates.

The modeled bedrock K is very low and that of the shallow aquifer, either colluvium or alluvium is much higher, as I describe below, so some of the recharge probably moves through the surficial aquifer to the nearest stream under natural conditions. Depending on the connection between the shallow and bedrock aquifer, dewatering of the bedrock might not pull all of the groundwater from the shallow aquifer into the bedrock which means that the shallow aquifer might remain saturated and continue discharging to the streams. While this might limit the effect of dewatering it also would affect the transport of contaminants from the TSF and WRF to the streams. Isotope data indicates that the age of groundwater varies from 21 to 56 years and that deeper water is older which generally follows the groundwater recharge path.

The DEIS notes that prediction of the impacts due to dewatering are very uncertain. "Sensitivity analysis simulations (see discussion below in this section) suggest that prediction of the amount of streamflow depletion is difficult." (DEIS, p 3.6-25) This refers to sensitivity of

the model predictions to both recharge and bedrock properties. I review model sensitivity in section 9.7.

4.2 Bedrock Hydrogeology

Most pit excavation will be in bedrock, so bedrock will control groundwater flow to the pit and, through connections with streams, control how dewatering affects groundwater baseflow. The DEIS (Table 3.6-2) reports bedrock K varies over about four orders of magnitude at each depth level for three different levels, upper (<330 ft), middle (330 – 660 feet depth), and lower (>660 ft depth). The K ranges are 0.006-14, 0.0009-0.9, and 0.0003-0.2 ft/d, respectively.

The gap analysis for hydrogeologic data acknowledges that scale could affect the hydrogeologic properties in the modeling (BGC 2013b). In general, the K of a formation increases with the scale of the volume being considered. This generally means that a single-well pump test or slug test yields a lower K estimate than a several day pump test with monitoring wells, with lab tests and groundwater modeling K estimates also considered on a similar scale relationship. The gap analysis suggests that BGC complete larger scale pump tests. As noted below in section 9.0, the numerical model did not account for scale effects.

The conceptual model report identifies up to 18 faults crossing the open pit zone (BGC 2014g). Little is known about the faults from a hydrogeologic perspective and they are not even mapped outside of the pit area. The bedrock hydrogeology treats the bedrock as a porous media meaning that the faults are not considered individually, either as flow barriers or conduits. Drawing 2 (BGC 2014g) shows mapped thrust faults mostly crossing the pit in a general east-west direction, but the mapping does not extend much beyond the pit. There is no indication of whether the fault layout in the pit is representative of faults beyond the pit. BGC (2014g, p 19) suggests that there is no indication of a trend of K with respect to the proximity to faults, but Drawing 26 does not show sufficient tests in the area with faults to support this claim. Thrust faults can have high permeability damage zones. Therefore, if faults intersected by the pit have long-scale high permeability damage zones, dewatering effects could extend for a long distance beyond the pit and the predicted drawdown cone.

- The DEIS does not adequately disclose the properties of the faults that intersect the pit. The DEIS also does not propose monitoring or adaptive management for dealing with a fault system that extends drawdown far from the pit or causes much higher dewatering than expected. Model sensitivity analysis without actually simulating the faults is insufficient planning for the faults.

- If there is sufficient data, the DEIS should provide a plot of K versus distance from a faults to estimate whether there is a trend. There should also be more pump testing completed in the pit area among the faults to collect sufficient data for analysis.

5.0 PIT LAKE FORMATION

After mining ceases, mine dewatering would stop and groundwater would begin to flow into the mine. The open pit would fill in 50 to 55 years with groundwater inflow, surface runoff, and water from the TSF (DEIS, p 2-40), although other reports have estimated other times up to 60 years (Lorax 2012). TSF water would be pumped to the pit lake whenever it does not meet standards (DEIS, p 2-40); at the beginning of closure, about 30,000 acre-feet (af) of tailings water would be pumped into the pit so simulations of pit lake development start with an initial volume. The pit initially would be a hydrologic sink for regional groundwater but would eventually fill to a point where it would discharge into Crooked Creek, except that when the water level is 33 feet below the crest, the mine would begin pumping and discharging the water. This would be required in perpetuity to prevent the pit lake from overtopping its banks (Id.). Treatment sludge would be dumped into the pit lake (Id.).

Inflow to the pit lake is groundwater and runoff from various sources. The pit lake essentially would exist forever so the planning must account for all potential inflows and climate change. BGC (2015l) considers some of the extreme conditions the pit would experience in future, specifically "the ability of the pit lake to handle storm events during the post-closure period" (BGC 2015l, p 1). The average discharge to Crooked Creek, if not treated would average 2812 gallons per minute (gpm) and the treatment plant would be able to treat at rates up to 7486 gpm (Id.) with an operating period of six months per year. More inflow would require a longer annual operating period. To provide freeboard (not designed for any specific return interval), treatment of the pit lake would begin when the pit lake is 33 feet below its crest (Id.). There would be a spillway in the southwest corner of the pit near Crooked Creek designed to accommodate the probable maximum flood of 11,301 cfs (with flood routing through the pit lake, the actual discharge rate would be less). At water level elevation 328 (33 feet below the crest), the pit lake volume would be 376,170 af and at the crest of 359 feet above mean sea level (amsl) the volume would be 405,360 af (BGC 2015l, p 2). The watershed area above the outlet would be 5122 acres (Id.), although much of that would be the pit lake, and the estimated average annual runoff is 4700 af/y (Id.). At this rate it would require six years to fill the pit over the upper 33 feet, or 29,190 af (Id.). Presumably the difference would be made up by groundwater inflow.

5.1 Pit Lake Water Quality

The DEIS discloses that the pit lake "water quality ... will not meet applicable water quality criteria without treatment" (DEIS, p 3.6-35). The DEIS and supporting documents complete substantial modeling of the pit lake water quality and show that it would be very poor. Details of that modeling are not reviewed here because there are huge uncertainties that lead to the precise predictions being inaccurate (Maest et al. 2005). The models are accurate enough to provide general trends of pit lake quality. DEIS Table 3.7-36 shows that the water quality of the surface layers of the pit lake would exceed standards for aluminum, antimony, arsenic, cadmium, copper, iron, lead, manganese, molybdenum, selenium, and mercury with pH being lower than standard (DEIS, p 3.7-129). Seepage inflows to the pit lake from PAG waste rock and from the tailings impoundment are extremely poor with sulfate inflow being as high as 180,000 mg/l (compare to a standard of 250 mg/l) (DEIS, Table 3.7-37). The modeling does depend on the pit lake remaining stratified because the pit lake quality at depth is extremely poor.

The predictions are accurate enough to plan around two aspects of the pit lake. Groundwater outflow from the pit lake would contaminate surrounding groundwater and discharges from the pit lake to surface water would contaminate Crooked Creek, in violation of standards and discharge permits.

5.2 Pit Lake Discharge Control

The plan is to use lake level management, basically pumping, to maintain the lake level at 10 to 30 feet below the level of Crooked Creek (Id.). The pumped water would be treated and discharged to Crooked Creek (Id.). The long-term treatment of water pumped from the pit lake, to prevent it overflowing, would be at 2911 gpm (BGC 2014b, Figure 5-4). This is pumping and treating in perpetuity. After closure and complete pit lake development[1], the groundwater inflow rate will probably not vary as much as it could during dewatering. However, the higher bedrock K scenario leads to substantially more groundwater inflow into the long term. The long-term pump and treat requirement could be much higher than specified here as a long-term average due to higher groundwater inflows. Runoff and precipitation entering the pit lake would cause short term variability.

BGC estimates the volume of the probable maximum precipitation over the watershed is 5030 af in 24 hours, which is about one sixth of the freeboard (Id.). Treatment capacity in six months

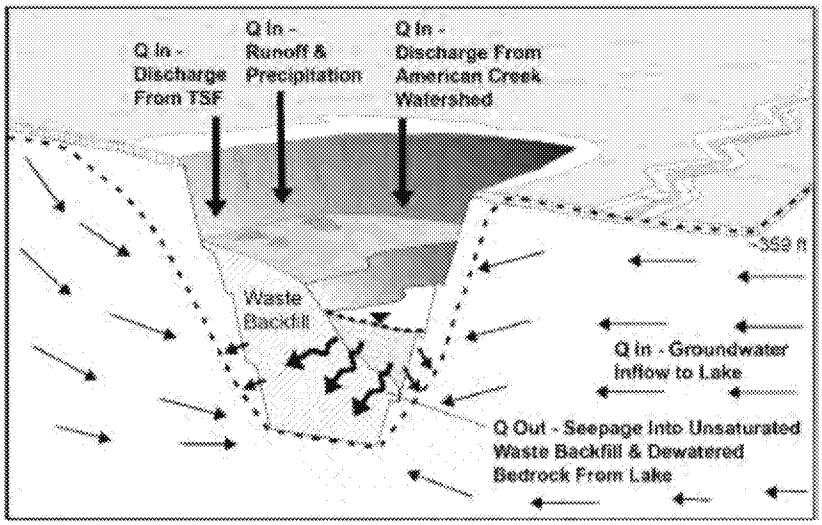
[1] Many pit lakes only approach full development if evaporation exceeds inflow, mostly of groundwater. These terminal pit lakes usually have only evaporation as an outflow. The Donlin pit lake will reach full conditions because it will fill to its rim if pumping did not establish an outflow. The pit lake as a whole would therefore not be subject to significant evapoconcentration as a pit lake with evaporation as its exclusive outflow.

is 5920 af (Id.). BGC's conclusion is that the pit lake would have no difficulty holding large volumes of runoff for treatment in the future.

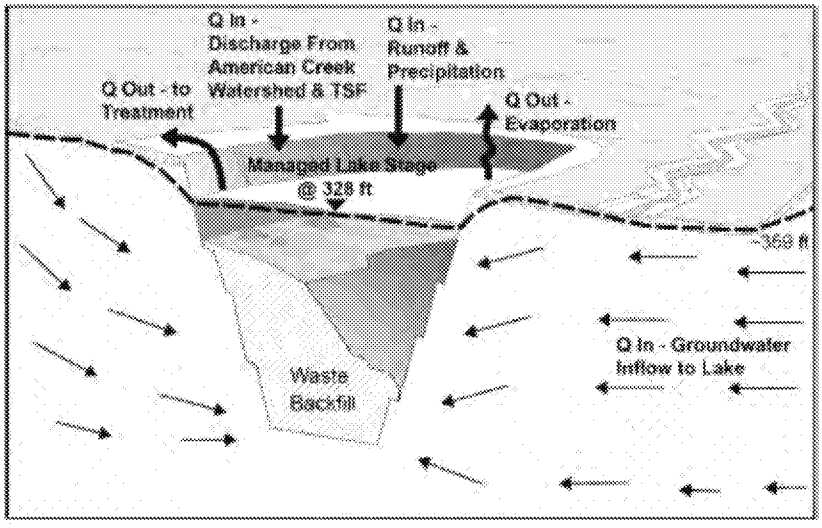
This is essentially a treatment in perpetuity plan. The calibrated groundwater model predicted the pit lake would fill in 52 years while two sensitivity analyses predicted 26 and 39 years for a wet climate and more conductive bedrock scenario, respectively. The wet climate scenario had increased recharge and streamflow rates by a factor of two and the more conductive bedrock scenario has increased bedrock K by a factor of five. Both scenarios filled the lake faster because they provided more water more quickly than the calibrated model scenario. After the pit is full, groundwater presumably continues to flow toward it from all directions (Id.).

5.3 Groundwater Flows

The DEIS discloses that pit lake water would discharge to surrounding groundwater both initially and in the long term (DEIS, p 3.6-35), as described in Figure 2. This is partly due to the placement of unsaturated backfill in the pit and to the fact that as the pit lake fills water from the pit lake will resaturate the surrounding bedrock. This differs from many pit lake systems which fill primarily by groundwater inflow, but at Donlin the bedrock K is low and does not recover immediately. Figure 3 shows simulated groundwater inflow and outflow at Donlin.



Early Pit Lake Filling Period



After Pit Lake is Full

Figure 2: Snapshot of a portion of DEIS Figure 3.6-9 showing the model of pit lake inflow and outflow.

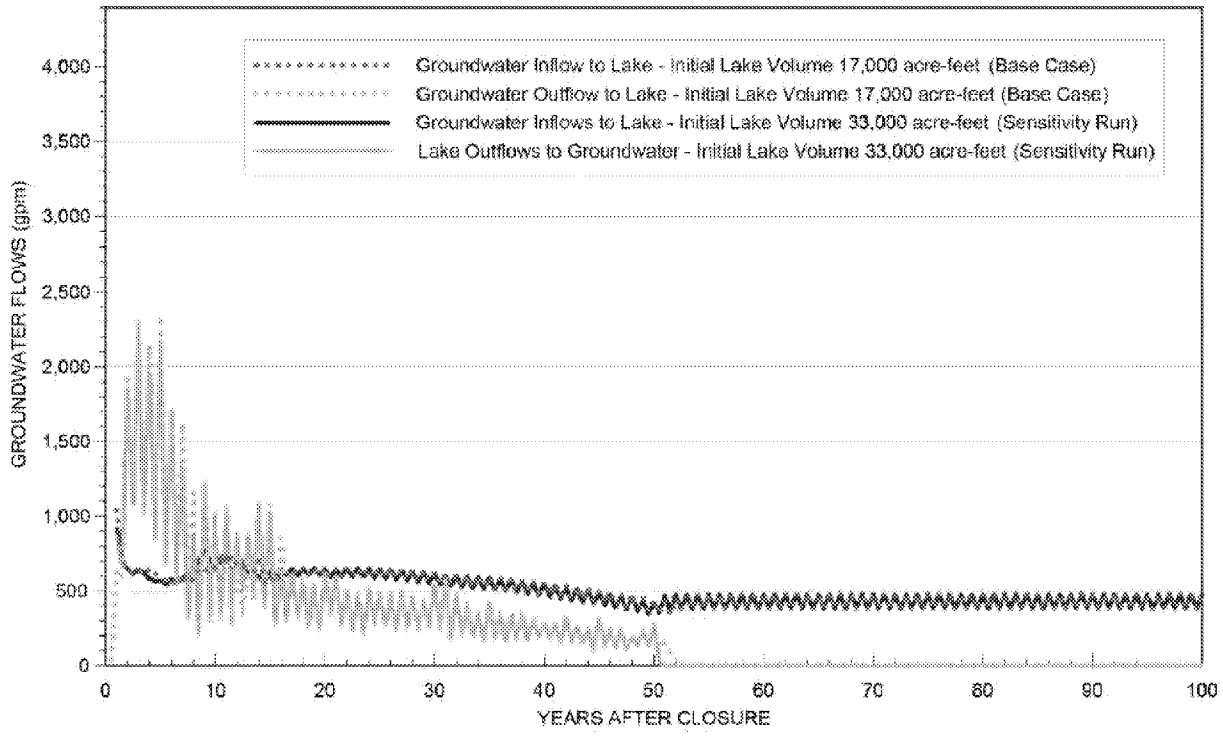


Figure 3: Snapshot of a portion of DEIS Figure 3.6-10 showing simulated groundwater inflow to and outflow from the pit lake as the pit fills with water.

Partially backfilling the pit causes an interesting system of groundwater inflow/outflow at the pit lake. The backfill would be unsaturated at the beginning of pit lake formation and therefore has to be wetted as part of the pit lake formation by groundwater outflow from the pit lake to the backfill (DEIS, p 3.6-35) (Figure 2). BGC (2014c) describes the groundwater/pit lake relationship:

> Results of the post-closure simulation show that the pit lake is predicted to fill to its managed maximum stage (i.e., 331 ft amsl or 101 m amsl) approximately 60 years after closure (Drawing 48). During the first 8 years after closure, pit lake water is predicted to seep out of the lake into the dewatered bedrock and into the pore space of the waste rock placed as backfill within the pit (see Figure 4-4). Predicted lake outflow during this period declines from approximately 2,860 gpm to 1,100 gpm (15,600 m3/d to 6,000 m3/d; Drawing 49). From Year 8 to 60 after closure, lake seepage or outflow is simulated to decline from 1,100 gpm to 0 gpm (6,000 m3/d to 0 m3/d) as groundwater elevations rise toward stable levels. Once the pit lake fills and groundwater elevations stabilize around the pit lake, seepage from the lake is predicted to cease. Thereafter, groundwater fluctuations are in response to seasonal changes and seasonal management of the lake stage. The managed lake stage results in a slight hydraulic gradient oriented toward the open pit, making the pit a groundwater sink. (BGC 2014c, p 45)

It is difficult to visualize how so much water leaves the pit lake and enters the surrounding groundwater (Figure 3), considering how the water table is hundreds of feet higher than the pit lake level (Figure 4). However, the modeling shows a significant outflow that is controlled partly by seasonal pit lake level changes. The net groundwater flow to the pit lake is very small (Figure 3) and the fact that discharge from the pit lake continues until the pit lake is almost full suggests pathways exist for flow to leave the pit lake and not return. This could occur at various depths depending on the details of the potentiometric surface.

The groundwater contours at the end of mining suggest one possible pathway for contaminants to leave the pit and possibly enter surface water (Figure 4). Southwest of the pit the groundwater contours are much lower than northeast of the pit due to the general slope of groundwater in the area. If the pit lake fills faster than the surrounding groundwater table, as indicated by Figures 2 and 3, it is possible that the pit lake creates pressure in deeper bedrock that causes an upward gradient to the creek away from the pit. Pit lake water could flow through deeper bedrock layers then upward toward the surface due to higher pressure conditions in deep bedrock.

- The DEIS or BGC (2014c) should present a detailed analysis of the potentiometric surface at depth near the pit lake to estimate where groundwater discharging from the pit lake would go. (The particle tracking diagrams in BGC (2014c) are not useful because they are apparently for single model layers whereas actual contaminants would change layers.)
- The DEIS or BCG (2014c) should present potentiometric surface maps for each model layer to assess whether outflow is possible from some depths in the pit lake.

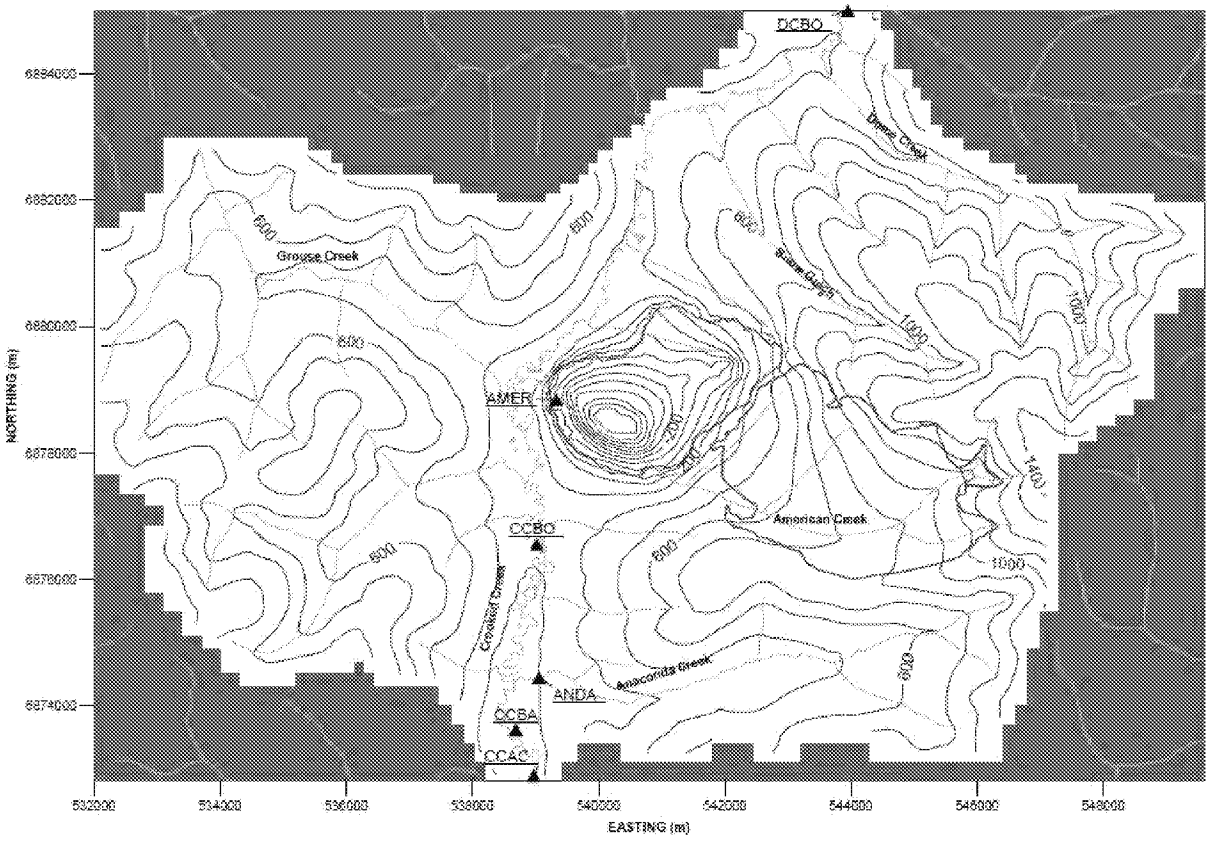


Figure 4: Snapshot of Drawing 39 (BGC 2014c) showing simulated groundwater contours at the end of mining.

5.4 Climate Change Impact on Pit Lake Planning

The DEIS must plan for significant climate change into the future, as it appears to acknowledge (DEIS, p 3.26-2), due to the necessity of pumping and treating the pit lake water in perpetuity. Increased precipitation in this part of the Alaska must be considered because it could vastly increase the inflows to the pit. If they occur over a short-term period, it would seem likely that the potential for spills from the pit would increase.

However, the modeling does not include climate change. The design water balance is based on a deterministic data set of precipitation running from 1940 to 2010. Climate change will increase precipitation up to 25% over the next 80 years (DEIS, section 3.23), but as discussed above, the increase would be highly variable. It is critical to consider the potential inflow to the pit lake with not just an increased average flow but with a much increased variance to account for large inflow events occurring during a wet period.

- Pit lake water balance simulations should include stochastically simulated precipitation events to account for the increased frequency of what are currently low frequency events.
- Pit lake simulations with climate change should also include simulations with higher groundwater inflow that could result from higher bedrock K or high-K faults and fractures.

Combined with the fact that groundwater inflow could be much higher (see section 9.0), the freeboard analyzed in BGC (2015l) is not as sufficient as suggested.

- The DEIS should disclose whether the closure treatment plant would be able to operate up to 12 months a year in all kinds of weather.
- The DEIS should plan for treatment on future conditions with climate change rather than being just based on the current climate statistics.

6.0 IMPACTS ON STREAM FLOWS

6.1 Pit Construction

Pit construction affects streamflow in two ways. First, dewatering to keep the pit dry would intercept groundwater flowing toward a stream where it would be become baseflow. Dewatering will reduce streamflows by up to 10 and 30 % during summer and winter, respectively (BGC 2014c, Drawing 44). Figure 5 shows reductions in groundwater discharges to various Crooked Creek tributaries caused by dewatering (BGC 2014c, p 40). The impact of dewatering decreases with distance from the stream.

Second, mine construction affects surface runoff in many ways, many having to do with mine water management described in Section 7.0. The pit would intercept surface runoff in American Creek, thereby preventing it from reaching the stream (BGC 2015h). The tailings impoundment would cover about 70% of the Anaconda Creek drainage (DEIS, p 3.5-77) which removes a large proportion of that streams' flow from discharging to Crooked Creek; much of that flow is diverted to mine water management as tailings water or as captured by the tailings underdrain. Ancillary mine facilities also divert or use surface water runoff which can affect both high and low streamflow rates.

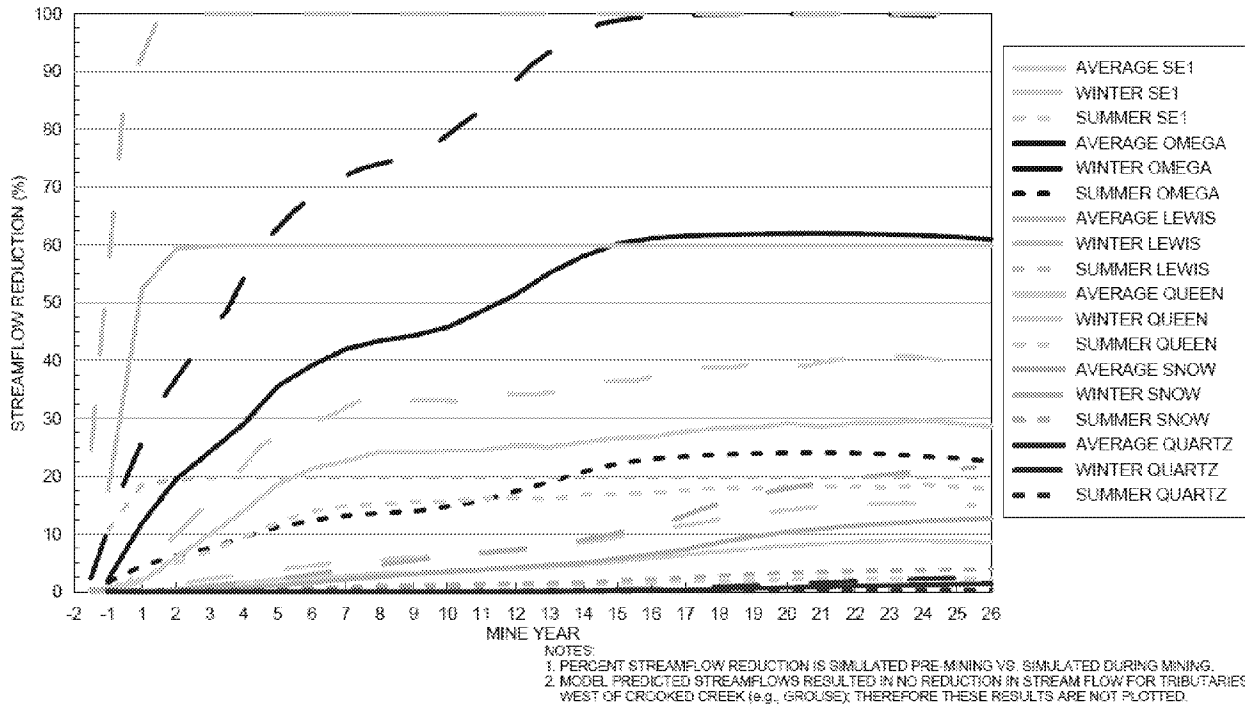


Figure 5: Snapshot of Drawing 45 (BGC 2014c) showing reductions in flow from various Crooked Creek tributaries due to mine dewatering.

Together, dewatering and mine water management cause very substantial changes in streamflows in Crooked Creek and its tributaries. The DEIS separates the discussion of impacts which can be very confusing. For example, the description of flow losses to Anaconda Creek (DEIS, p 3.5-76 - -77) does not address a loss to mine dewatering, but the summary of loss in DEIS Table 3.5-26 does include dewatering (as shown by the variation in losses for the high-K scenario which is a mine dewatering scenario in the groundwater model (BGC 2014c)). The DEIS apparently considers all impacts to Crooked Creek including cumulative impacts from the tributaries, which includes dewatering impacts (Figure 5). The failure to assign flow losses to specific activities increases the difficulty of considering mitigation.

- The DEIS should tabulate all of the predicted streamflow losses in the same table so that their magnitude can be compared

There is a lot of uncertainty around the predicted losses to Crooked Creek and other features.

Effects on Crooked Creek flow could vary widely depending on season, precipitation conditions, bedrock hydraulic K, phase of mine operations, and distance from the mine. For example, Crooked Creek flow below the mine site near Crevice Creek would be

reduced by 20 percent in winter under average precipitation and K conditions, and by 26 percent in dry conditions, during late operations (year 20 onward). The greatest flow reduction experienced near the mouth of Crooked Creek (at Bell Creek about 8 miles downstream of the mine) is projected to be 4 to 10 percent under the above conditions. In the event that K is higher than expected, 45 to 100 percent of Crooked Creek flow could be reduced in winter near the mine site under average to dry precipitation conditions, with much of the flow restored below Crevice Creek (16 to 40 percent reductions) due to tributary inflows. (DEIS, p 3.5-2)

Year 20 may be the year of maximum impact on Crooked Creek stream flows because the pit footprint would be at its maximum extent which would make for the greatest capture of runoff by the pit and because pit dewatering captures its maximum rate in year 20 (DEIS, p 3.5-82). Flow losses from Crooked Creek are as high as 100% (during year 20 at the confluence with American Creek for the high bedrock K, low precipitation scenario, DEIS Table 3.5-26), but are substantial all along the reach to Bell Creek.

- The DEIS should implement as mitigation for these flow losses a plan to discharge treated waste water in locations that would mitigate these losses.

6.2 Pit Lake Formation

Pit lake formation creates a permanent loss of water from Crooked Creek in two ways. First, the groundwater flow that pre-mine had been toward the creek will be reversed with the permanent drawdown to the pit reversing the gradient at the creek so that water flows into the groundwater. The Corps relies on this reversal of gradient to prevent highly contaminated pit lake water from reaching groundwater or downstream surface water. The streamflow loss to the pit lake would apply along the creek in the pit lake capture zone (the continuing drawdown cone near the pit lake). The second is that the pit would capture surface flows from American Creek, thereby preventing both high and low flows from reaching Crooked Creek.

- The overall effect of the pit depends on the timing of groundwater diversion from the creek, the hydrograph of captured water from American Creek, and the discharge of pit lake water into Crooked Creek.

Effects on surface drainages (Figure 3-5.1) appear mostly constrained to three drainages. If there are facilities that slope over drainage divides, the Corps should make efforts to avoid doing so.

7.0 MINE WATER MANAGEMENT

Mine water management is the plan for how the mine would handle water requirements throughout its operation. It is both a plan for obtaining necessary production water and for discarding water that hinders production. For example, approximately 17,438 gpm would be used for processing and discharged to the tailings impoundment during operations (DEIS, 3.5-21). Water for the process plant comes from various places, including freshwater reservoirs, contact water reservoirs, and dewatering wells. Stormwater management and mine dewatering are the two activities for which the mine attempts to discard excess water. Efficient management of the two can decrease the impacts the mine has on the environment, but the Donlin water management could be improved as described here.

7.1 Discharge to Crooked Creek

Excess water would be discharged to Crooked Creek with treatment, so failures in the collection and treatment system would degrade Crooked Creek. During operations, expected discharge is 1268 gpm with 786 gpm from mine dewatering (DEIS, Figure 3.5-21). The remainder is from underdrains and contact water reservoirs, with all estimates being highly uncertain. There is a lot of uncertainty in the dewatering estimates, but during operations, most of the dewatering water (547 + 694 = 1241 gpm), whether through perimeter or in-pit dewatering wells, would be treated and discharged (783 gpm) to Crooked Creek (BGC 2014b, Figure 4-2). However, as discussed below, the high K modeling scenario would result in dewatering as much as 3.3 times higher than the predicted scenario. With time, the mine would have to increase its treatment capacity to accommodate this much extra flow. However, the actual geology is highly heterogeneous so it is probable that actual dewatering rates would be variable and could periodically far exceed the 3.3 times, especially if there are high K faults combined with the high K bedrock. The high precipitation scenario which estimates treatment at 859 gpm (BGC 2014b, Figure 4-3) does not encompass the potential for higher treatment rates due to heterogeneous bedrock.

- The DEIS should better plan for treating higher flow rates of dewatering water (and contaminated water from other sources.
- The DEIS should better plan to use dewatering water in operations rather than capturing freshwater flows. For example see section 7.3 regarding the need for Snow Gulch Reservoir.

7.2 Climate Change

The Corps considered a climate change scenario for the mine site by using an estimate from a group at the University of Alaska Fairbanks, Scenarios Network for Alaska + Arctic Planning (SNAP). It was based on global climate models (GCMs). The SNAP data shows that precipitation during winter months "is projected to increase from current conditions over these decades" (DEIS, p 3.26-10), referring to the time from now to the end of the 21st century. By the 2060-2099 time frame, the SNAP data suggests that precipitation at the mine could increase by from 17 to 25 percent. DEIS Table 3.26-3 shows the increase by month for several future time periods. The table implies a systematic increase by month, but this does not disclose how those changes may occur. It is not likely that each storm system simply has increased precipitation. It is far more likely that a few large events will cause much of the increased precipitation. This could have significant impacts on aspects of the project affected by runoff, which would be much higher during these events. This perhaps could be most important with respect to treatment of runoff from various facilities.

- Treatment facilities must be designed to accommodate larger inflows that occur both as storm events and as long-term climate cycles.

7.3 Snow Gulch Reservoir

A reservoir would be constructed on Snow Gulch, north of the minesite, to provide a contingency source of water for the project (DEIS, p 2-27). "In years with average or below-average precipitation, the CWDs and pit dewatering system would not be able to meet process plant water requirements, in which case additional water would be obtained from the Snow Gulch reservoir" (Id.). However, the water balance modeling shows it provides only a small amount of water to the mine plan and that much more water would be discharged to Crooked Creek than obtained from Snow Gulch (BGC 2014b). During average conditions Snow Gulch would provide 136 gpm of water to the process plant (BGC 2014b, Figure 4-2) and BGC (2014b) Figure 4-1 shows the reservoir would hold about 3000 af most of the time. The process plant uses a large amount of water, with 17,484 gpm being discharged to the tailings; sources include contact water from the Lower and Upper Contact Water Dams (waste rock runoff and seepage), recycled water from the tailings, and dewatering water. Considering the treatment plant discharges 783 gpm to Crooked Creek, and that it is mostly dewatering water during operations, there does not seem to be a need for Snow Gulch water.

- The DEIS should provide better justification for constructing a reservoir in Snow Gulch. It should consider whether the water otherwise obtained from Snow Gulch could be obtained by dewatering at higher rates temporarily.

8.0 WATER QUALITY

Donlin Mine could affect water quality in many ways although they can be summarized into three possibilities. First, meteoric waters could seep through waste facilities (waste rock or tailings) to reach groundwater or streams. Second, there would be discharge of waters collected from various sources to surface water after treatment. The sources include collected seepage from waste facilities, excess tailings water, contact water from contact water reservoirs, and excess dewatering water (DEIS, Figure 3.5-21). If the collection and treatment facilities work as planned, treated water should not degrade water quality. A third source is the long-term discharge of pit lake water to groundwater or surface water, as discussed above in section 7.1.

8.1 Seepage from Waste Facilities

A significant issue is the potential for seepage from the WRF or TSF to reach streams thereby causing degradation. There will be over 3,000,000 tons of waste rock, which the DEIS claims would be about 91% NAG and the rest being PAG over varying time periods (DEIS, p ES-12). Most PAG-6 rock would be mined early and placed in isolated cells in the waste rock facility (WRF) (Id.). PAG-7 and some PAG-6 rock would be backfilled into the ACMA pit (Id.). In section 2.3, the DEIS identifies 2.99 billion tons waste rock, with 2.46 bil tons going into the WRF and the remainder backfilled into the ACMA pit (DEIS, p 2-7). Conventional tailings at 568 million tons will be held in a slurry tailings impoundment (DEIS, p 2-8).

DEIS Table 3.7-47 notes seepage from the WRF and TSF will exceed standards for various constituents. The Corps assumes that the seepage would either be captured by underdrains and treated or discharged to the pit lake (DEIS, Table 3.7-47, p 3.7-207). The modeling predicts that seepage from the waste rock dump would be diverted to the pit, both while dewatering and as a long-term pit lake. The DEIS relies on this mechanism to prevent stream degradation. The pit will likely be a sink for the bedrock aquifer, but there is much uncertainty regarding the shallow aquifer and whether it would drain towards the pit. The DEIS and supporting studies treat the shallow and bedrock groundwater system as being connected through the mining period, but there is no evidence supporting the assumption.

During pre-mining conditions, overall the aquifer would be unconfined with the pressure head in bedrock being similar to the water table in the shallow aquifer. As the groundwater simulation lowers the pressure below the top of the bedrock, it simulates the shallow aquifer becoming desaturated so that the bedrock aquifer becomes an unconfined aquifer. The reality may be that as pressure in the bedrock drops below the top of the bedrock, an unsaturated zone develops in the bedrock while the shallow aquifer remains saturated and functions as a

perched aquifer. The groundwater modeling code used to simulate dewatering, MODFLOW, is not capable of simulating the development of such an unsaturated zone, so the model results are not evidence against this idea.

Seepage from waste facilities would be into a rather thin surficial layer of alluvium, near the streams, or colluvium, over the mountains. The conceptual model report shows overburden thickness maps that indicate the colluvial thickness is rarely more than 30 feet in the American Creek drainage and mostly less than five feet in the Anaconda Creek drainage, except directly under the creek where it is more than six feet thick (BGC 2014g, Drawings 3 and 4). The groundwater model simulated the shallow aquifer as being 16 feet thick.

The shallow aquifer could have K substantially higher than the bedrock, at least in areas. As noted, the model cannot simulate the hydraulic disconnect that could occur during dewatering. Rather, the groundwater model simply draws groundwater from the surficial layer into the bedrock; the MODFLOW code can do nothing else because it simulates all layers as a saturated porous media with connections among all layers. It cannot simulate an unsaturated zone developing between the surficial layer and the bedrock in the upper part of the bedrock. Simulated drawdown in bedrock would lower the potentiometric surface below the bottom of the surficial aquifer after which MODFLOW simulations would simply desaturate the surficial aquifer.

Because the bedrock K is low, the surficial aquifer could remain saturated, and due to dewatering become perched at least in areas away from fractures. If hydraulic separation occurs and a perched aquifer develops, seepage from the waste facilities may not enter the bedrock and flow to the pit. Rather, the seepage could flow laterally through the surficial aquifer to the streams, thereby bypassing the pit. Seepage from the waste rock and tailings facilities could degrade surface water, primarily in Crooked Creek but also in its tributaries. All assumptions in the DEIS regarding contaminants reaching the pit and not the streams would be incorrect.

Mitigation would be very difficult. Pumpback wells, or converting monitoring wells to pumping wells, would not be effective unless they are very closely spaced[2]. This is because the surficial aquifer is thin and there is a limit to any capture zone that can be created. A capture zone is the portion of the aquifer that would be drawn to the pumping well. If the saturated zone within the aquifer is just a few feet or tens of feet thick, drawdown at the well would be limited

[2] Four monitoring wells would be installed downgradient of the TSF, two on each side of Anaconda Creek. On each side, one would be deep and one would be shallow. Each would be capable of pumping up to 90 gpm if necessary to capture TSF seepage downgradient of the tailings impoundment (DEIS, p 3.6-32). This would be grossly insufficient to capture seepage from the TSF.

to the interface with the bedrock; attempting to draw it lower could just create another bedrock/surficial aquifer disconnect. While theoretically, it is possible to intercept the flow through the surficial aquifer, the required well spacing could be as low as a hundred feet or even less.

- The only effective mitigation would be to avoid the seepage by having a liner under the waste rock. A liner would cause most seepage to collect in the underdrains.
- There is too little information concerning the connection between the surficial aquifer and the bedrock. Pump tests that show pumping in bedrock drawing from the stream are not actually testing what occurs if the potentiometric surface draws below the top of the bedrock; pump tests do not stress the system sufficiently to estimate the potential for a hydraulic disconnect.

8.2 Tailings Facility

The tailings impoundment would be lined with 60-mil liner. This is the same thickness as was used at the TSF at the Stillwater Mine in Montana. At Stillwater, the TSF has been shown to be leaky and the company will shift during future stages to 100-mil liner due to the failure of the 60-mil liner.

- The Donlin Mine should have a 100-mil liner rather than a 60-mil liner to make leaks would be less likely It would also reduce the amount of seepage captured in the underdrain and recirculated which could allow the TSF to be decommissioned more quickly.

The tailings facility is not within the pit capture zone, as shown in Figure 6. The tailings facility would lie over the Anaconda Creek drainage at the bottom of the figure. Although most of the watershed has drawdown due to the tailings impoundment capturing recharge (BGC 2014c, Drawing 40), the groundwater contours show that most of the Anaconda Creek watershed would drain to the low point beneath Anaconda Creek. The creek would lose substantial water due to a loss of recharge due to the tailings. Seepage however would report to the colluvium beneath Anaconda Creek and then to Crooked Creek.

- The best alternative from the perspective of avoiding contamination from the tailings facility is to use dry stack tailings with both a liner beneath them and then an impervious cover as part of reclamation. The DEIS predicts that seepage would be very low after 200 years. If leaks were limited, this option would minimize degradation to Crooked Creek. The impervious cover would help to prevent percolating water from mounding on the liner as well.

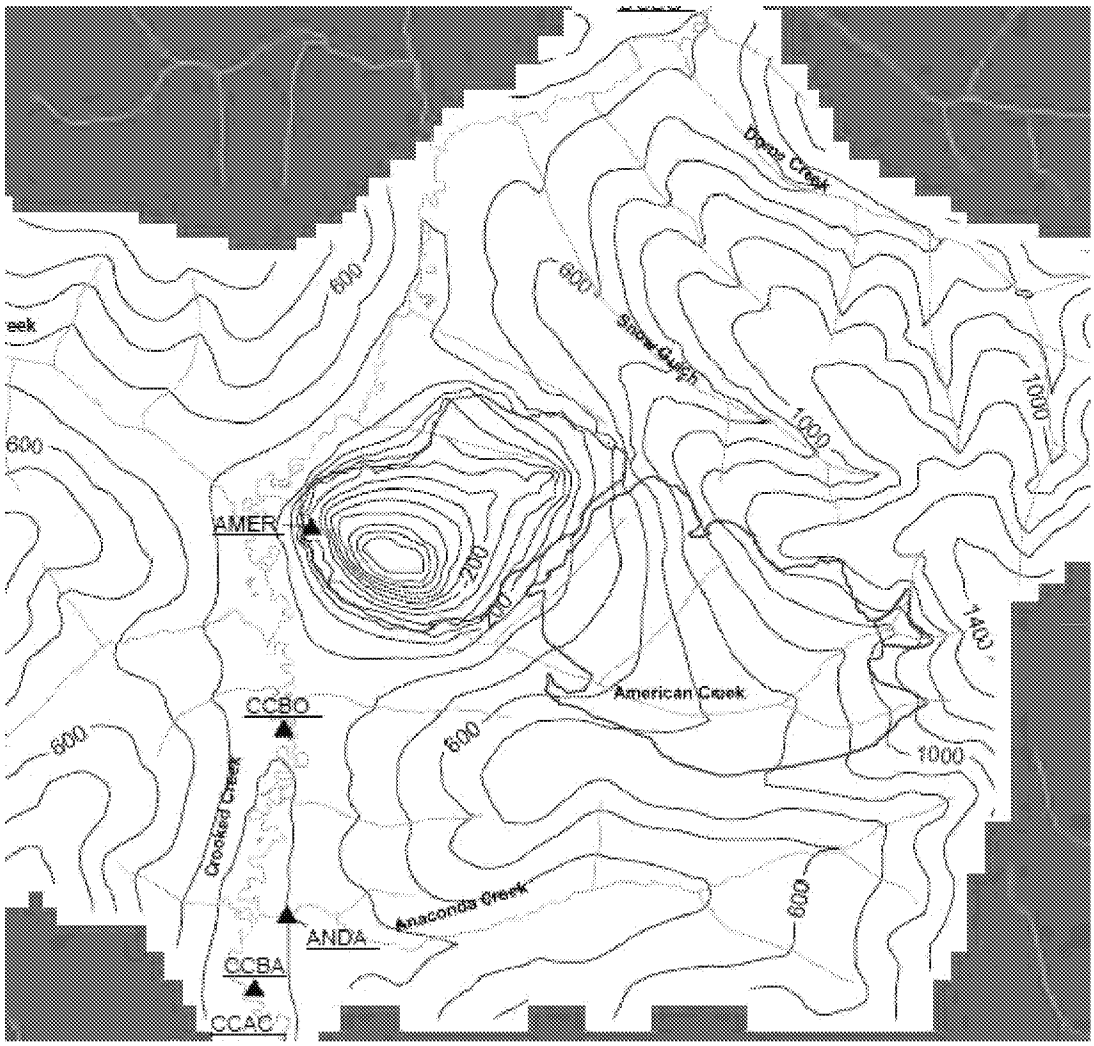


Figure 6: Snapshot of a portion of Drawing 39 (BGC 2014c) showing the bedrock potentiometric surface at the end of mine operations.

Some facilities are not within the predicted pit drawdown cone and the DEIS acknowledges a potential for contaminants to leach to Crooked Creek (DEIS, p 3.6-34). Mitigating measures include liners or other hydraulic containment and doing "further studies such as fate and transport groundwater modeling during final design" (Id.). These suggestions indicate the DEIS was issued prematurely since planning for the mine has not progressed far enough to even have completed all necessary studies or planned adequate mitigation.

- A supplemental DEIS is necessary to disclose important plans such as mitigation for seepage and to complete fate and transport modeling of contaminants leaching from mine facilities.

In closure, the pit lake would remain a hydraulic sink, but it would pull groundwater from much less of a distance during operations or early closure.

8.3 Failure Analysis

The Exec Summary notes that tailings are a "hazardous substance of concern" and that "focus is on high consequence, low probability occurrences [including] ... partial tailings dam failure" (DEIS, p ES-44). The DEIS should complete a detailed flow routing of slurried tailings. Under the actual discussion of "Estimated Likelihood and Characteristics of a Spill", there is no discussion of tailings failure, either significant leaks or catastrophic dam breaches.

- The DEIS should analyze the risks associated with tailings dam failure. The analysis should consider the PMF occurring in the watershed because the facility will be there forever. The DEIS should present hydraulic routing of a reasonable portion of the half million tons of tailings down Anaconda Creek and Crooked Creek to show the potential damages.

The DEIS notes that "complete failure of the TSF SRS could lead to release of untreated water in a matter of weeks" (DEIS, p ES – 34). This is another example of a potential systems failure that could lead to substantial degradation in a short time period.

9.0 REVIEW OF GROUNDWATER MODEL DETAILS

Most of the numerical predictions of mine dewatering and impacts on stream flow rely on groundwater modeling. The details of groundwater modeling were presented in BGC (2014c) which is reviewed in this section. BGC (2014c) used the MODFLOW SURFACT code which is based on the MODFLOW code but has a proprietary numerical solver and a routine for simulating unsaturated seepage of recharge to the water table.

9.1 Model Structure

Layer 1 represents alluvium or colluvium up to 200 m amsl and is 5 to 10 m thick (BGC 2014c, p 22). Above 200 m amsl, layer 1 is bedrock, presumably representing an outcrop. Layers 2 through 9 are bedrock with layer 4 being about 70 m thick and layers 5 through 9 increasing from 100 m to 240 m thick (Id.). Layers are thickest in the uplands.

9.2 Parameter Zones

The geologic formations in an aquifer are delineated into zones for simulation. Each model cell is assigned a zone according to its geology. The properties include horizontal and vertical K,

storage coefficients, and porosity. The values are initially set based on tests or literature values, and then adjusted during model calibration.

9.21 Conductivity

Within the pit area, the bedrock was delineated into 8 different sedimentary rock formations along with intrusives (BGC 2014c, p 24). Outside of the pit area, the bedrock was considered undifferentiated bedrock of the Kuskokwim group (Id.). Presumably this was done because the bedrock near the pit is better known than away from the pit. The figures showing parameter zones by layer show a complex square section near the pit that abuts against single parameters extending to the boundary; the single parameters are Kuskokwim – Valley and Kuskokwim – Ridge. There could be abrupt transitions among various parameter zones within a layer. This could have large effects on the flow patterns if the changes are substantial.

Basal Greywacke and Upper Greywacke have the same calibrated K values for the same layers (BGC 2014c, Table 7). For layers 1-4, 5, and 6-9 the K values are 0.1, 0.06, and 0.01 ft/d. These formations abut the Kuskokwim formation, which for layers 5, 6-7, and 8-9 have K equal to 0.03, 0,006, and 0.001 ft/d; above layer 5 the Kuskokwim (Ridge) K is 0.03 ft/d and the Kuskokwim (Valley) K varies from 0.1 to 0.3 ft/d (Id.). For layers 5 and lower the surrounding bedrock, undifferentiated Kuskokwim, has K about an order of magnitude lower than near the pit. The low calibrated K values away from the pit are not supported by the observed K values for bedrock near the pit area. The intrusive and shale formations within the pit area are also low K, but above layer 5 these will be removed within the pit. The detailed modeling occurs within the pit area and primarily is important during calibration because it would not be part of the simulation of either dewatering or pit lake development.

- The low K values away from the pit may prevent the expansion of drawdown away from the pit.

Zonation includes a trend of decreasing K with depth. Although they are extensive across the pit area (section 4.2), faults were not modeled except in the sensitivity analysis (Id.).

Calibrated horizontal and vertical K in the alluvium under Crooked Creek is 300 and 70 ft/d. These values are substantially higher than the colluvium which are respectively 0.2 and 0.06 ft/d. These K estimates for alluvium are about three times higher than the observed values. The colluvium estimates are close to the observed values but the tests in colluvium are small scale. Colluvium K may be substantially underestimated because the thinness of the aquifer would bias the estimate of K through pump test or slug tests to be low.

BGC (2014c, p 8) describes the colluvium as "well-graded materials ranging from cobbles and gravel to sand, silt and clay". Unless the fine materials, silt and clay, fill most of the pores in the cobbles and gravel, K should be much higher. Low simulated K values in the colluvium could limit the amount of water that enters the bedrock due during recharge and could limit the amount drawn into the bedrock during dewatering as long as the colluvium remains hydraulically connected to the bedrock. The contrast between higher K in the colluvium and low K in the bedrock could cause the seepage from waste facilities to move laterally through the shallow groundwater rather than enter deeper bedrock. As discussed in section 7.0, the dewatering simulation could cause a hydraulic disconnect between the bedrock and shallow groundwater allowing a perched zone to form in the shallow groundwater.

Model layer 1 has a sharp transition from alluvium along Crooked Creek to colluvium surrounding the alluvium (Figure 7). Conductivity changes from 300 to 0.6 ft/d along a long reach of the stream. Such large changes in K between adjacent cells often leads to water balance errors in the model solutions. BGC should address the potential for local errors which can lead to large inappropriate head changes. Conductivity of the valley Kuskokwim formation, which underlies the alluvium (Figure 8), ranges from 0.1 to 0.3 ft/d (BGC 2014c, Table 7). Effectively, the model simulates the high K alluvium as being surrounded by very low K bedrock or colluvium which essentially disconnects the alluvium from the rest of model domain; the model conceptualization as simulated here effectively isolates the alluvium. Using more appropriate K values to simulate the alluvium and surrounding formation would provide a more accurate simulation of flow across the formation boundaries and of the surface/groundwater interchange at Crooked Creek.

- The model simulates the alluvium with a very high K surrounded by low K bedrock and colluvium. This effectively isolates the alluvium and minimizes the effects of dewatering on the stream.

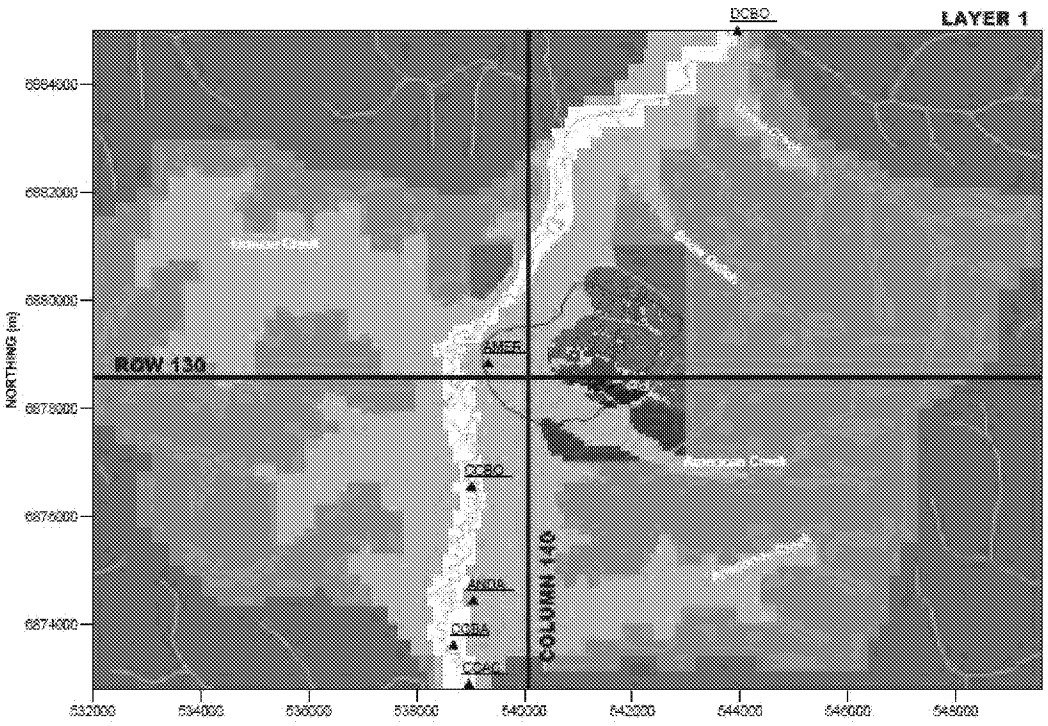


Figure 7: Snapshot of a portion of BGC (2014c) Drawing 17 showing parameter zones in model layer 1. See Figure 9 for a legend.

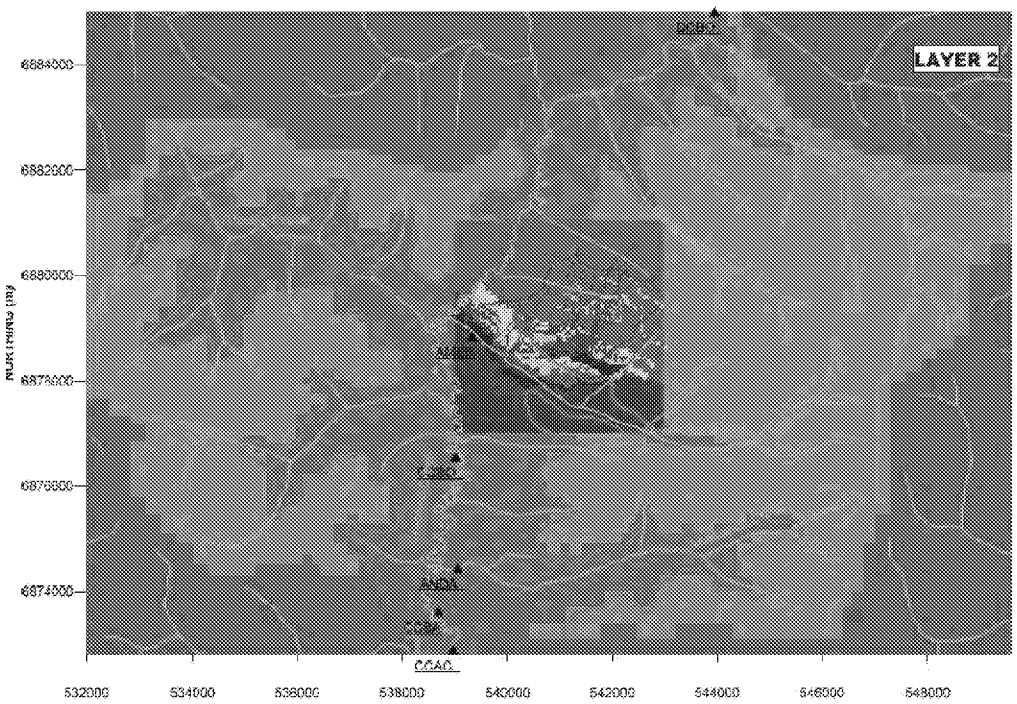


Figure 8: Snapshot of a portion of BGC (2014c) Drawing 18 showing parameter zones in model layer 2. See Figure 9 for a legend.

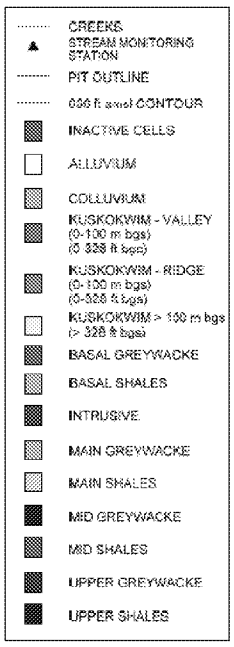


Figure 9: Snapshot of the legend from BGC (2014c) Drawing 18 describing parameter zones used for all of the model drawings. This applies to Figure 7 and 8.

The K estimates represent very small sections of their respective aquifers, but in setting the formation properties, the authors ignore important scale factors. In general, the representative volume of a pump test is the amount of water pumped, divided by the effective porosity (Schulz-Makuch et al. 1999); this effectively means a sample volume, including all pore spaces affected by the pumping. Short-term tests represent properties only over a very small volume. Figure 10 shows an example from the literature of variability for a fracture-flow media, the type of media that controls the flow near the pit. Hydraulic conductivity varies over seven orders of magnitude in the example (Figure 10), depending upon the volume of the aquifer represented in a given test. Setting K for the undifferentiated bedrock as a single value less than most of the tests violates these concepts of scale.

From the perspective of flow and transport prediction (as needed near the pit and waste rock dumps), small-scale properties control local flow while the larger-scale measurements control regional flow, which can be estimated without understanding localized details. A mine that intersects and excavates significant portions of a formation affects flow at a regional level, and therefore needs property measurements at that scale. The short-term tests in the crystalline bedrock presented by INTERA are not relevant at a regional scale.

- Most of the hydrogeologic properties estimated for the DEIS are for a small-scale and yield conductivity values that are much too low for regional flow analysis. This causes the DEIS to predict impacts limited to the areas closer to the Mine.

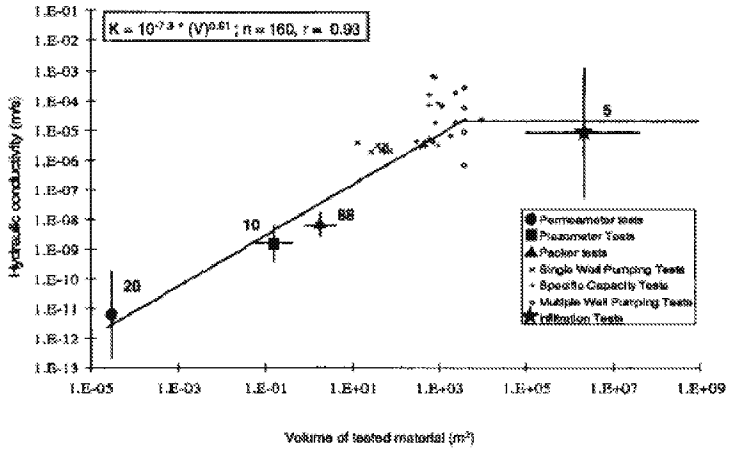


Figure 6. Relationship of hydraulic conductivity to scale of measurement in the Racine Formation of the carbonate aquifer of southeastern Wisconsin. Permeameter, piezometer, packer, and passive infiltration tests were plotted as geometric means with 95% confidence intervals; pumping tests and specific capacity data as single values. Number of observations are given adjacent to means. Passive infiltration tests are derived from the infiltration of Lake Michigan water into the Racine Formation due to the construction of a sewage tunnel. The regression line is derived from all individual values (n = 160) below the infiltration scale. The 95% confidence interval about the slope is 0.91 ± 0.06, and r is the correlation coefficient.

Figure 10: Figure 6 from Schulz-Makuch et al. (1999) showing the variation of hydraulic conductivity with volume of material used for testing. The Racine Formation is a fracture-flow formation and is used here only as an example of the variability.

9.22 Storage Coefficients

Specific yield (Sy) for the alluvium is extremely low, being set at 0.01 (BGC 2014c, Table 7). Sy is the amount of water that is released from storage for a unit drop in the water table; for Sy=0.01, a head drop of one foot would release just 0.01 foot of water from storage. Usually, Sy is much higher. Table 3.5 in Anderson and Woessner (1992) shows a range of 0.01 to 0.46 for categories from fine sand through coarse gravel, the particle sizes found in the alluvium along Crooked Creek. The published range of Sy technically includes the value used in this model for alluvium, but Sy = 0.01 is for fine sand (Id.). Crooked Creek alluvium includes a mixture of particle sizes and the estimates for fine sand have a mean of 0.33 (Id.). Without a substantial detailed pump test estimate of Sy for the alluvium, the value used for the Donlin groundwater model is suspect. Also, the very high K and low Sy in the alluvium are incongruous because Sy is often a surrogate for porosity, and having porosity equal 0.01 is inconsistent with K being 300 ft/d.

- A low Sy for the alluvium will cause the model to underestimate the amount of water drawn into the bedrock during dewatering.

Together the high K and low Sy in the alluvium would serve to minimize the simulated flux from the alluvium into the bedrock. The Sy value affects the simulated interchange of water between the stream and the alluvium and then between the alluvium and the bedrock beneath it. The amount of water drawn into the bedrock from the alluvium due to dewatering could be grossly underestimated. The very high K would allow the alluvium to provide water to the bedrock very easily, meaning without substantial change in head. The gradient at the stream boundary would change very little due to the high K. The streambed K was set equal to the alluvium K so the stream allowed water to pass easily, meaning it provided the necessary water with very little change in gradient. The simulated drawdown would be very low.

9.3 Recharge

The model assumes that recharge enters the model domain at a 28% of annual precipitation per year rate, with all 5.5 in/y applied all in the summer period. If the water surface is above the ground surface, the model does not accept the recharge and it becomes surface runoff to the stream network (BGC 2014c, p 25).

Three conceptual problems with this recharge simulation are obvious. The method does not account for recharge variability due to precipitation amount, slope, or geology. Studies from around the western US have shown variable rates of recharge as a proportion of precipitation, although none of the studies were based in Alaska.

Because recharge must first percolate through a soil zone it is likely that a higher proportion will do so for a higher precipitation because the amount of evapotranspiration is unlikely to increase linearly along with precipitation and because higher precipitation would more often have moister antecedent conditions leading to less precipitation being taken up to make up a soil water deficit.

Slope and geology controls the rate at which precipitation can enter the aquifers and unsaturated zone between the soils and aquifer. Fractured bedrock accepts more percolation than intact bedrock and the ground slope controls the rate at which the meteoric water may runoff or flow downslope as interflow, if a soil layer is available. Differences in conductivity and slope would lead to differences in the rate of recharge at a given point.

Combined, precipitation amount, slope and geology controls the amount of recharge at a location, with the remainder becoming runoff. Drainages would likely be sources of large amounts of water and recharge beneath the streams.

Very little recharge as simulated reaches deeply into the bedrock because the low simulated permeability of the deep bedrock significantly limits the deeper circulation of recharge. BGC (2014c) does not present the simulated amount of groundwater that percolates into the bedrock, the deep groundwater system, but it should. This would reflect the contrast in conductivity between shallow and deep aquifer systems, with lower conductivity at depth preventing deep percolation. The water that remains in the shallow system discharges to surface water quickly. This critical point controls the most important results of the model simulation as well. If the deep bedrock is a little more permeable and allows more recharge to circulate deeply, the required mine dewatering could be doubled without changing the discharge to the stream very significantly.

The comparison of premining baseflows shown in DSEIS Table 4-7 is not meaningful since presumably each model used similar recharge and if the inflow to each model domain is the same, so must be the outflow.

9.4 Calibration

There were about 182 observed groundwater elevations used for calibration. For a model of this size, this is a reasonable number, however, there was a definite bias in their distribution. As shown on BGC (2014c) Drawing 7, the majority of sites were in drainages and only a few were on the ridges. Groundwater converges into the drainages so there is likely an upward gradient in most of the areas that are most represented in the calibration.

Initial calibration for most models is by a steady state simulation wherein average fluxes are simulated and average head values are matched. BGC apparently skipped this step, opting instead for calibrating based on a seasonal transient model (BGC 2014c, p 27). This is reasonable if the model best fit was compared to an observed time series of groundwater observations (and stream flows). However, the "primary calibration target at each location" was the average value of multiple observations, if there were multiple observations (BGC 2014c, p 28). Average groundwater levels may not represent any given seasonal time period, so at best this calibration technique is difficult to evaluate.

BGC (2014c) does not provide necessary details for understanding the calibration simulation:

- BGC should describe the initial conditions used for the calibration scenario.
- BGC should specify how long the calibration scenario was run.
- BGC should specify the head value used for comparison to the average observed head. Is it the value for a given time period or an average for a multitude of simulated observations?

Given that the calibration scenario description is not very useful, the graph of simulated and observed head values (BGC 2014c, Drawing 24) shows some significant bias in the calibration. About 20 of the observations plot below the -25 m envelope line on the graph and just two plot above the +25 m line. At least eight of the observations below the -25m line are wells in the Upper Greywacke formation, layers 1 through 3. The Upper Greywacke may be seen south of and on the south side of the pit underlying much of the American Creek drainage. Simulated heads are about 50 m lower than observed in this area. The gradient driving flow to the American Creek is likely simulated lower than observed. This could lead to a higher K estimate which would lead to drawdown affecting the creek less than it actually would do.

A second calibration scenario was the simulation of the MW07-11 pump test (BGC 2014c, p 29). Other than stating that the grid size was changed for the simulation (Id.), BGC provides almost no details of the test, as follows: "Model stress period lengths or time steps were not specified. It is common to define a stress period based on pumping at specific rates, but the report does not specify how or whether this was done." (Id.)

The report does not explain how calibration was competed. In short term pump test simulations, it is common to adjust storage coefficients because short-term head changes are more sensitive to storage coefficients. The report does not specify whether test statistics were determined for the pump test simulations, so it is difficult to objectively evaluate these transient calibrations.

The graphs that compare simulated water levels with observed show a very poor match (BGC 2014c, Drawings 26-29). There is no apparent consistency or bias, with some simulated levels exceeding observed and vice versa (Id.). BGC (2014c, p 29) suggests that "bedrock hydraulic conductivity is heterogeneous at the scale of the pumping test". This means that the model may not be accurate with respect to the details of the simulation. However, BGC also suggests that having simulated values "within a factor of two to three of measured drawdowns at the observations wells" (Id.) suggest the K values are reasonable for the scale of the modeling. There is no logic behind this statement because missing the target by a factor of three implies the K should have been set substantially different. It indicates there is substantial room for improvement.

The second transient calibration was of the pump test run to test properties between Crooked Creek and the proposed pit. The drawdown graphs for both alluvial and bedrock wells (BGC 2014c, Drawings 30-32), including both pumped and monitoring wells, show very little agreement between simulated an observed hydrographs. However, these tests were used to set the high alluvial K and low Sy values described above. The lousy match between the

observed and simulate groundwater levels does not provide justification for the alluvial parameters, the effects of which were described above.

Based on the overall calibration summary (BGC 2014c, p 32), the following bullet points suggest problems with the calibration.

- Modeled K of the alluvium is generally higher than observed and that of the colluvium is low for the model scale used here (Id.).
- Modeled bedrock K tended to be lower than the observed range, especially at distance from the pit.
- There is no evidence that storage parameters were even calibrated since they do not vary among formations and because the model fit during pump tests was so poor.
- Any agreement between simulated and observed flows (Drawing 25) is spurious due to the large difference in flow rates.
- It is not appropriate to claim there was a good seasonal match. Graphs for wells MW03-02, -03, -04, -05, -06, -07, -09, -12, -13, and -15, (BGC 2014c, Appendix A) show almost no simulated seasonal effect while the observed seasonal variation exceeds a meter. Some wells, such as MW07-05, and -06, show an observed trend with time that substantially masks the seasonal trend.

9.5 Simulating Mine Dewatering and Pit Development

BGC (2014c) chapter 7 describes the methods used to simulate mine dewatering and pit development. The modeling has three objectives that are of interest here:

- Estimate the dewatering extraction rate
- Evaluate the impacts on mine dewatering and pit development on local surface water
- Estimate the rate of pit lake formation and the recovery in groundwater levels and flow conditions after dewatering

Also of interest is how development of the tailings impoundment affects flows. Other objectives specified by BGC (2014c) are for design purposes.

BGC simulated dewatering using MODFLOW drain boundaries, and possibly also used the well package in advance of reaching a given pit level to remove some initial water. ET was appropriately set to zero within the enlarging pit. However, recharge should have continued to have been simulated because precipitation falls within the pit and if it does not runoff, it will percolate and become recharge. Runoff from within the pit may be captured and managed, but by definition recharge is precipitation that does not runoff. If not pumped it will flow into the

pit at lower levels; there is really no way to "manage" precipitation to prevent recharge (BCG 2014c, p 34).

Captured streams were appropriately turned off during the simulation. During operations, there would be some backfill in the pit. The simulation included simply turning off the drain boundary to the level of the backfill and allowing the groundwater level to recover.

The bedrock properties were not altered during the operations portion of the simulation (BGC 2014c, p 35). This was justified due to the relatively short time period simulated. However, not changing the bedrock properties was an error due to the large difference in storage properties between backfill (Sy = 0.33 for closure simulations) and in-situ bedrock (Sy = 0.003, BGC (2014c), Table 7). The amount of water necessary to fill the unsaturated bedrock with Sy=0.003 is miniscule, by two orders of magnitude, compared to that necessary to fill the backfill with Sy=0.33. During the five years of operations, groundwater levels would fill in the backfill while removing very little water from the model. Presumably this would be the initial conditions for simulations of the operations period. Recovery would have occurred with too little water being removed. This would decrease the simulated losses to the streams and basically cause the model to underestimate flow losses to the streams. If it allows the backfill to become saturated prematurely, the initial conditions for the closure simulation will be too high and cause the model to simulate too little water removed from the model to be stored in the backfill; this would also reduce the simulated impacts to the streams.

The modeling predicted that total groundwater extraction rate from all wells and drains would initially equal 1700 gpm, increase to 2600 gpm by year 12 and average 1600 gpm over the mine life. The simulated rate decreases to about 1500 gpm after year 20 and some groundwater recovery into the backfill begins to occur (BGC 2014c, Drawing 36). Various factors, some already discussed, could make the dewatering rate higher than simulated:

- Bedrock K away from the pit has been underestimated. This slows the flow of groundwater to the pit and minimizes the simulated dewatering.
- Failure to simulate recharge within the pit boundary simply ignores a source of water that will be removed as dewatering water.

Dewatering dries much of layer 1 as can be seen by the 30 foot drawdown contour encircling much of the area (Figure 11). The model cells within that area would be dry. As noted in the text (BGC 2014c, p 39), drawdown in the alluvium along Crooked Creek is less than two feet. The lack of drawdown corresponds to the high K and encirclement by low K bedrock and colluvium as described above. The alluvium is effectively isolated from the effects of dewatering (Figure 11) by the model design.

The model also simulates substantial reductions to streamflow in Crooked Creek and tributaries, which would have a large effect on the flows in those streams. However, the reductions have been underestimated for reasons as described herein. Primarily, all dewatering water is prevented from discharging to a groundwater sink which in this model would be a stream. For all of the reasons that dewatering rates have been underestimated, the reductions in streamflow has also been underestimated. Additionally, dewatering effects on Crooked Creek have been underestimated due to the simulation of K and storage properties, therefore Crooked Creek flows would be decreased much more than disclosed in the DEIS.

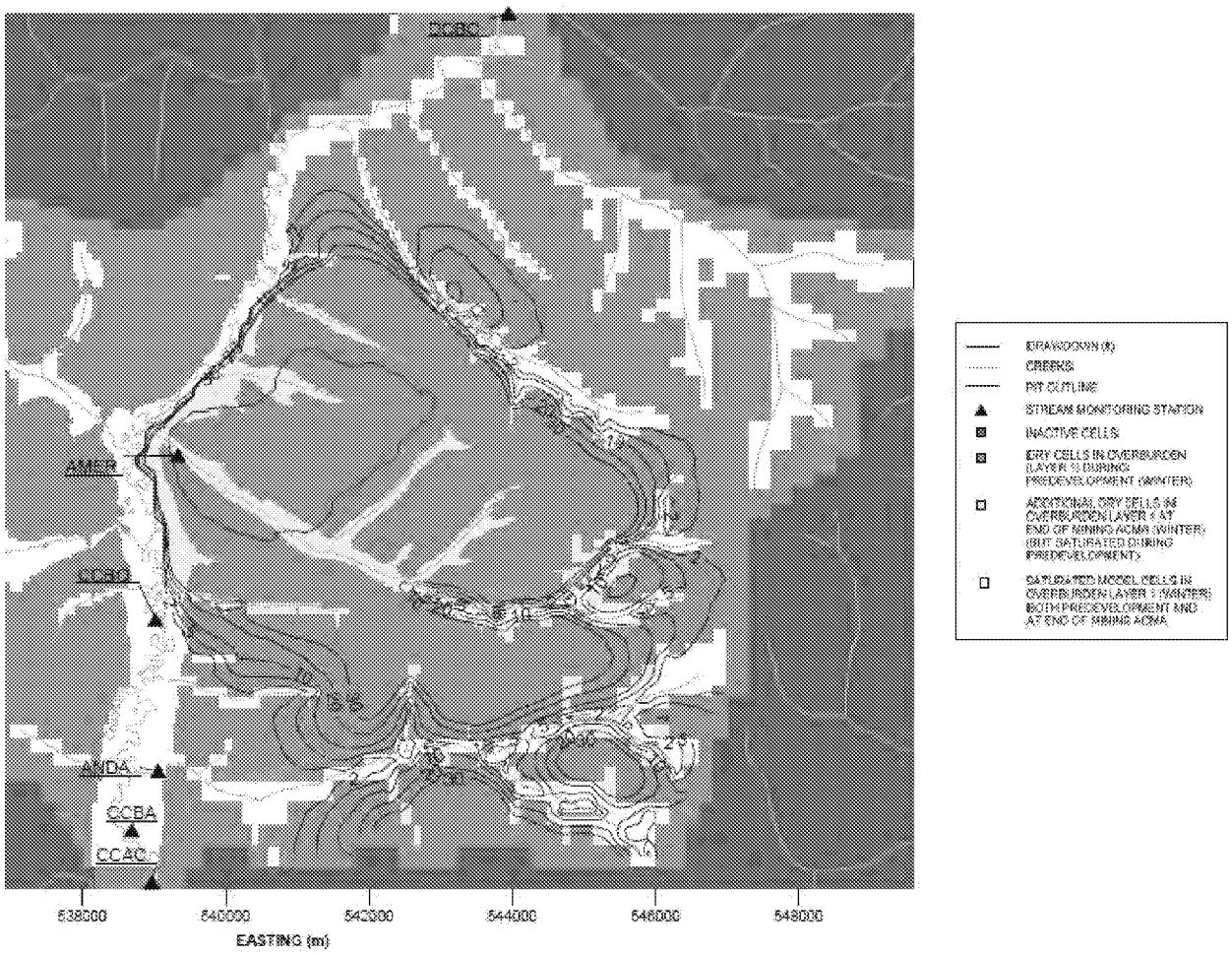


Figure 11: Snapshot of a portion of BGC (2014c) Drawing 37 showing drawdown in model layer 1, the surficial aquifer.

9.6 Simulating Pit Lake Formation

BGC (2014c) used a special pit lake package to simulate the forming lake. In addition to groundwater flowing into the pit lake, there is inflow from precipitation, runoff, American

Creek flows, waste rock underdrain, contact pond water, and tailings impoundment discharge. The pit lake fills until it is just below its crest after which water would be pumped, treated, and discharged. It initially receives almost 33,000 af of excess tailings water (Lorax 2012, p 3-7), which is generally of poor quality (Lorax 2012, Table 3-3). Water from the tails and waste rock would be discharged to the bottom of the pit void "to encourage the more contaminated (i.e. denser) water to remain at depth within the pit lake and to foster chemically stratified or meromictic conditions within the pit lake" (Lorax 2012, p 3-7)). If this works as planned and the lake does not turn over, water at the bottom of the pit lake would be highly contaminated.

Groundwater inflow to the pit lake will generally be of good quality compared to the inflows of waste or tailings seepage (Lorax 2012, Table 3-3). However, Lorax (2012) has not simulated different groundwater quality for groundwater entering from different levels or formations. Background groundwater quality is not homogeneous through the entire mass of rock surrounding the pit (BGC, 2011l) and inflows should not be simulated as if it is. This could affect the predicted pit lake water chemistry.

The pit lake would be almost full after 60 years. Although the pit is a sink, meaning the regional groundwater flows toward it from all directions, there is a significant groundwater outflow (BGC 2014c, Drawing 49). This outflow is to fill the backfilled waste rock and dewatered bedrock near the pit, presumably as the lake fills faster than the groundwater levels recover. The particle tracking (BGC 2014c, Drawings 50-53) does not suggest that any water would escape the pit and flow away into the groundwater, but BGC should verify this because escaping pit lake water would degrade surrounding groundwater.

The managed lake elevations is intended to provide adequate freeboard and maintain water levels that the groundwater would continue to discharge to the pit lake rather than creating a flow-through pit lake (BGC 2015g). The gradient is "slight" (BGC 2015g, p 2), however, which suggests that it could reverse so that pit lake water would discharge from the lake occasionally.

- The groundwater model should consider groundwater/pit lake relations when the pit fills to its crest as it could do during extreme wet conditions, as reviewed herein at section 5.2.

9.7 Sensitivity Analysis

A numerical model sensitivity analysis is designed to test the effects of changing various model parameters on the results of simulation. BGC (2014c) chapter 9 describes the sensitivity analysis completed for the Donlin numerical model. BGC's method is to simply make large adjustments to various factors and compare the change in the calibration and to show how it

changes the simulation of future conditions. I review only the sensitivity results that reveal important aspects of the model with respect to the environmental impacts of the proposed mine.

The model was not sensitive to raising and lowering the hydraulic K of the alluvium because the alluvium was essentially isolated from the rest of the system so that stream levels controlled the heads, as discussed above. Calibration statistics improved for three changes, decreasing bedrock K, increasing recharge and streamflow, and simulating faults as low hydraulic K faults (BGC 2014c, p 51). That these wholescale changes improved the calibrations shows the model is not unique but also suggests that the calibration as presented in BGC (2014c) is not as accurate as it could be. I argued above that bedrock K was underestimated so the improvement in calibration statistics for using even lower K suggests that some other aspect of the model is more important for matching head values. Recharge and streamflow were estimated external to the model so changing them would be inappropriate.

Including low K faults improved the calibration (BGC 2014c, p 51). This conceptualization suggests the groundwater system could be segmented. Details of the analysis are sparse, but the faults were only mapped in the pit area so it is likely that faults were only added in that area. This sensitivity analysis illustrates the importance of better understanding the faults and how they affect the groundwater flow.

- Faults could segment bedrock into higher or lower K zones better than formation maps.
- Faults could segment bedrock in ways that would allow dewatering to affect areas farther from the pit, especially if the segmentation includes areas with higher K.
- If the higher K segments extent under creeks, they could create zones in the streams that are much more affected by dewatering.

The model, and DEIS, requires much more information about the faults to be accurate.

Mine dewatering rates were sensitive to bedrock properties (BGC 2014c, p 52). Increasing bedrock K by a factor of 5 increased mine dewatering rates by 3.3 times; increasing bedrock storage coefficients by ten times increased mine dewatering rates by 1.5 (Id.). High K faults could increase the mine dewatering rates up to 3.3 times depending on their location and the extent of connection with Crooked Creek (BGC 2014c, p 53). This could probably also result from the low-K faults segmenting high-K bedrock under the streams.

Changing bedrock K substantially affected stream flows. Reducing bedrock K reduced streamflows relative to the base case. If the model has bedrock K that is too low, as I argued above, impacts on the streams would be underestimated. Increasing bedrock K by a factor of 5

reduced winter streamflow by 86% and simulating high K faults decreased streamflows by 83% (BGC 2014c, p 54). Increasing bedrock K by a factor of 20 caused Crooked Creek to go dry by the pit (Id.). Increasing storage coefficient also reduced streamflows. The sensitivity of the model predictions to bedrock properties further indicates that the model could have grossly underestimated impacts to streamflow.

The sensitivity results regarding bedrock K verifies the points above about how low K estimates could have caused the model to underestimate dewatering, the extent of the drawdown, and impacts on streamflow.

Low K faults decreased the impacts that dewatering had on streamflow (BGC 2014c, p 54). This is probably due to the segmentation caused by the faults.

Changing alluvial K had little effect on the impacts dewatering had on streamflow (BGC 2014, p 54). This further reflects the comments above about how the alluvium under Crooked Creek is isolated from the bedrock. The isolated alluvium acts as a tub in which water is easily exchanged with the stream.

Pit lake refill time was also sensitive to bedrock K (BGC 2014c, p 55). The increased bedrock K causes the pit lake to fill from 14 to 30 years faster, reflecting the higher flow to the pit (Id.). Decreased K increased the fill time by about 12 years (Id.).

9.8 TSF underdrain predictions

The groundwater model (BGC 2014c) estimated discharge to the tailings impoundment underdrain (Figure 12). The only description of how the TSF was simulated was to note that ET and recharge was set equal to zero (BGC 2014c, p 16, 34).

> The TSF will be a fully-lined impoundment. Therefore, groundwater recharge to the underlying aquifer will cease within the footprint of the facility. In addition, the TSF underdrain will be installed beneath the **liner to capture groundwater discharge from the catchment and deliver it to the SRS downstream of the TSF dam**. Any seepage through the liner would also report to the SRS. SRS water will be used either as make-up water in the process or potentially treated and discharged to Crooked Creek. (BGC 2014c, p 16, emphasis added)

The DEIS describes it as follows: "The TSF would be designed with a rock underdrain that would serve two purposes: 1) capture and direct any TSF leakage to a Seepage Recovery System (SRS) located immediately downgradient of the TSF dam; and 2) collect groundwater from areas upgradient of the TSF and direct it to the SRS as TSF underflow" (DEIS, p3.6-31). The mine would obtain a water right for the diversion of groundwater by the TSF drain (DEIS, p 3.6-32).

The report does not describe the boundary used to simulate the drains, although if the underdrain is beneath the liner to capture groundwater discharge, the underdrain must be simulated as a drain in layer 1. An underdrain would allow groundwater discharging upward due to artesian pressure from undermining the TSF.

Decreased bedrock K in the sensitivity analysis increased flows to the tailings underdrain system (BGC 2014c, p 54, 55). This is because low bedrock K causes more groundwater to remain in the shallow groundwater.

> The reduction in recharge is predicted to lead to a progressive decrease in groundwater flow reporting to the foundation underdrain, from approximately 730 gpm (4,000m3/d) in Year -2 to approximately 440 gpm (2,400m3/d) at the end of mining" (BGS 2014c, p xiv). "Predicted groundwater discharge to the TSF underdrain for the post closure analysis fluctuates on a seasonal basis, and averages 370 gpm (2,000 m3/d) during the winter season, and 440 gpm (2,400 m3/d) during the summer season (BGC 2014c, p xv).

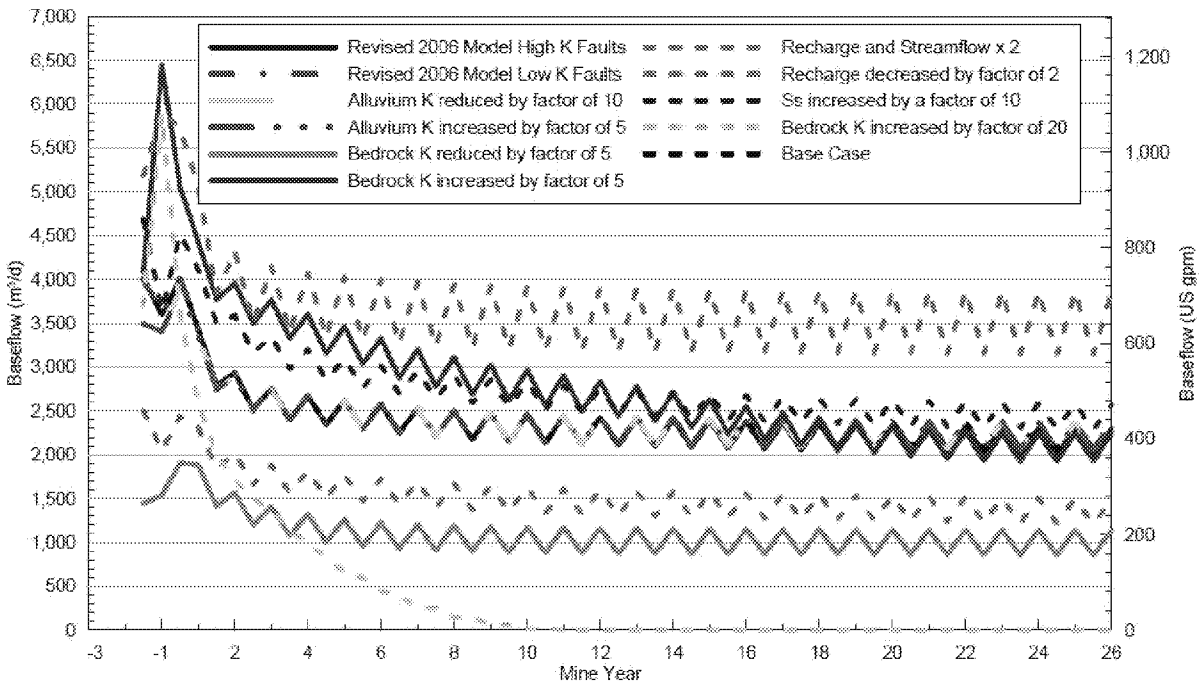


Figure 12: Snapshot of BGC (2014c) Drawing G22 showing the discharge to the tailings impoundment underdrain for the base case and various sensitivity analysis simulations.

10.0 MISCELLANEOUS

The potentiometric surface map (DEIS Figure 3.6-2) does not distinguish among aquifers which means there is an assumption that the groundwater pressure in the bedrock equals the water table in the overlying colluvial aquifer. It argues that "vertical gradients within the groundwater system are not large compared to the scale of the map and the overall relief of the potentiometric surface" (DEIS, p 3.6-8). A reference is to BGC 2011d. This can be an important assumption, driving recharge and discharge locations. What is meant by gradients "not large compared to the scale of the map"?

Groundwater discharge occurs only in creeks and gulches, not to wetlands away from the creeks and gulches (BGC 2014g, p 6). Permafrost is intermittent and generally limited to soils but does extend into bedrock up to 33 feet with an average of 14 feet (BGC 2014g, p 6-8). The only trends apparent in the permafrost mapping show that permafrost is more common in the drainages of American and Anaconda Creek.

11.0 REFERENCES

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Attachment 1

Tom Myers CV

Tom Myers, Ph.D.
Consultant, Hydrology and Water Resources
Ex. 6 Personal Privacy (PP)
Reno, NV 89523
Ex. 6 Personal Privacy (PP)

Curriculum Vitae

Objective: To provide diverse research and consulting services to nonprofit, government, legal and industry clients focusing on hydrogeology specializing in mine dewatering, contaminant transport, natural gas development, groundwater modeling, NEPA analysis, federal and state regulatory review, and fluvial morphology.

Education

Years	Degree	University
Ex. 6 Personal Privacy (PP)	Ph.D. Hydrology/Hydrogeology	University of Nevada, Reno Dissertation: Stochastic Structure of Rangeland Streams
		University of Arizona, Tucson AZ Classes in pursuit of Ph.D. in Hydrology.
	M.S. Hydrology/Hydrogeology	University of Nevada, Reno Thesis: Stream Morphology, Stability and Habitat in Northern Nevada
		University of Colorado, Denver, CO Graduate level water resources engineering classes.
	B.S., Civil Engineering	University of Colorado, Boulder, CO

Professional Experience

Years	Position	Duties
1993-Pr.	Hydrologic Consultant	Completion of hydrogeology studies and testimony focusing on mine dewatering, groundwater modeling, natural gas development, contaminant transport, NEPA review, and water rights for nonprofit groups and government agencies.
1999-2004	Great Basin Mine Watch, Exec Director	Responsible for reviewing and commenting on mining projects with a focus on groundwater and surface water resources, preparing appeals and litigation, organizational development and personnel management.
1992-1997	Univ of NV, Reno, Res. Assoc.	Research on riparian area and watershed management including stream morphology, aquatic habitat, cattle grazing and low-flow and flood hydrology.
1990-1992	U of AZ, Res. and Teach. Assistant	Research on rainfall/runoff processes and climate models. Taught lab sections for sophomore level "Principles of Hydrology". Received 1992 Outstanding Graduate Teaching Assistant Award in the College of Engineering
1988-1990	U of NV, Reno Res. Asst	Research on aquatic habitat, stream morphology and livestock management.
1983-1988	US Bureau of Reclamation Hydraulic Eng.	Performed hydrology planning studies on topics including floodplains, water supply, flood control, salt balance, irrigation efficiencies, sediment transport, rainfall-runoff modeling and groundwater balances.

Peer-Reviewed Publications

Myers, T., 2016. A modeling approach to siting mine facilities in northern Minnesota USA. *J Hydrology* 533: 277-290. Doi: 10.1016/j.jhydrol.2015.12.020

Myers, T., 2013. Remediation scenarios for selenium contamination, Blackfoot Watershed, southeast Idaho, USA. *Hydrogeology J.* DOI 10.1007/s10040-013-0953-8

Myers, T., 2013. Reservoir loss rates from Lake Powell and their impact on management of the Colorado River. *Journal of the American Water Resources Association.* DOI: 10.1111/jawr.12081.

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Myers, T.J. and S. Swanson, 1996. Temporal and geomorphic variations of stream stability and morphology: Mahogany Creek, NV. *Water Resources Bulletin* 32:253-265.

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Myers, T.J. and S. Swanson, 1995. Impact of deferred rotation grazing on stream characteristics in Central Nevada: A case study. *North American Journal of Fisheries Management* 15:428-439.

Myers, T.J. and S. Swanson, 1992. Variation of stream stability with stream type and livestock bank damage in northern Nevada. *Water Resources Bulletin* 28:743-754.

Myers, T.J. and S. Swanson, 1992. Aquatic habitat condition index, stream type, and livestock bank damage in northern Nevada. *Water Resources Bulletin* 27:667-677.

Zonge, K.L., S. Swanson, and T. Myers, 1996. Drought year changes in streambank profiles on incised streams in the Sierra Nevada Mountains. *Geomorphology* 15:47-56.

Representative Reports and Projects

Myers, T., 2015. Conceptual Flow and Transport Model, Uranium Plume near the Homestake Millsite, Milan, NM. Prepared for Bluewater Valley Downstream Alliance. Marcy 16, 2015.

Myers, T., 2015. Hydrogeology of the Humboldt River Basin, Impacts of Open-pit Mine Dewatering and Pit Lake Formation. Prepared for the Progressive Leadership Alliance of Nevada and Great Basin Resource Watch, Revised June 2015.

Myers, T., 2015. Letter Report: Comments on the Draft Supplemental Environmental Impact Review for the Panoche Valley Solar Project. Prepared for Adams Broadwell Joseph and Cardozo, San Francisco CA

Myers, T., 2015. Technical Memorandum – Review of Assessment of the Potential Impacts of Hydraulic Fracturing for Oil and Gas on Drinking Water Resources. Prepared for Delaware Riverkeeper Network. August 24, 2015.

Myers, T., 2015. Technical Memorandum – Review of Finger Lakes LPG Storage, LLC, Proposed LPG Storage Facility. Prepared for Earthjustice, New York. January 13, 2015

Myers, T., 2015. Technical Memorandum – Review of Pennsylvania Governor's Executive Order Concerning Hydraulic Fracturing in Pennsylvania State Parks and Forest. Prepared for Delaware River Keeper, January 9, 2015.

Myers, T., 2015. Technical Memorandum – Review of Water Supply Assessment, Village at Squaw Valley. Prepared for Sierra Watch, July 13, 2015.

Myers, T., 2014. Expert Report: In the Matter of California Department of Parks and Recreation v. Newmont Mining Corporation, et al. Prepared for the California Department of Justice, February 2014.

Myers, T., 2014. Groundwater Flow and Transport Modeling, NorthMet Mine and Plant Site. Prepared for the Minnesota Center for Environmental Advocacy.

Myers, T., 2014. Letter Report: Comments on the Environmental Assessment for the Proposed Photovoltaic Array Proposed for Ft Irwin CA. Prepared for Adams Broadwell Joseph and Cardozo, San Francisco CA, October 13, 2014

Myers, T., 2014. Review of the Water Quality Modeling, NorthMet Mine and Plant Site, Minnesota. Prepared for Minnesota Center for Environmental Advocacy.

Myers, T. 2014. Technical Memorandum: Review of Performance Standards, Center for Sustainable Shale Development. Prepared for Delaware River Keeper. May 8, 2014.

Myers, T. 2014. Technical Memorandum: Review of the Hydrogeologic Aspects of the Draft Environmental Impact Statement, Haile Gold Mine, Lancaster County, South Carolina. Prepared for Southern Environmental Law Center, May 8 2014.

Myers, T., 2014. Technical Memorandum: Review of the Supplemental Draft Environmental Impact Statement, NorthMet Mining Project and Land Exchange. Prepared for Minnesota Center for Environmental Advocacy. March 10, 2014

Myers, T. 2014. Technical Memorandum: Twin Metals and the Boundary Waters Canoe Area Wilderness, Risk Assessment for Underground Metals Mining. Prepared for Northeastern Minnesotans for Wilderness. August 8 2014

Myers, T. 2012-3. Participation in EPA Potential Impacts of Hydraulic Fracturing on Drinking Water Resources Study. US Environmental Protection Agency, Washington DC.

Myers, T., 2013. DRAFT: Chapter 5.1: Water Quality. Initiative for Responsible Mining.

Myers, T., 2013. DRAFT: Chapter 5.2: Water Quantity. Initiative for Responsible Mining.

Myers, T., 2013. Technical Memorandum: Comments on Encana Oil and Gas Inc.'s Application for the Madison Aquifer to be Exempt Wyoming Oil and Gas Conservation Commission Docket No. 3-2013. Prepared for Natural Resources Defense Council, Powder River Basin Council. June 12, 2013.

Myers, T. 2013. Technical Memorandum: Impact Analysis: Wishbone Hill Water Right Application. Prepared for Trustees for Alaska

Myers, T, 2013. Technical Memorandum: Review of Montanore Mine Dewatering Instream Flow Methodology. Prepared for Save our Cabinets, Earthworks. March 26, 2013

Myers, T. 2012. Technical Memorandum: Chuitna Coal Mine Project, Review of Arcadis DRAFT Hydrogeologic Conceptual Site Model Update and Associated Documents. Prepared for Cook Inletkeeper. May 11, 2012.

Myers, T., 2012. Technical Memorandum, Review of DRAFT: Investigation of Ground Water Contamination near Pavillion Wyoming Prepared by the Environmental Protection Agency, Ada OK. April 19, 2012.

Myers, T., 2012. Participation in: Keystone Center Independent Science Panel, Pebble Mine. Anchorage AK, October 1-5, 2012.

Myers, T., 2012. Technical Memorandum, Review and Analysis, Revised Draft, Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program, Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs. Prepared for Natural Resources Defense Council.

Myers, T., 2012. Technical Memorandum, Review of the Special Use Permit PP2011-035-Camilletti 21-10, Groundwater Monitoring Requirements. Prepared for Routt County Board of Commissioners and the Routt County Planning Department. June 19, 2012.

Myers, T., 2012. Testimony at Aquifer Protection Permit Appeal Hearing, Rosemont Mine. Phoenix AZ, August and September, 2012.

Myers, T., 2012. Drawdown at U.S. Forest Service Selected Monitoring Points, Myers Rosemont Groundwater Model Report. Prepared for Pima County, AZ. March 22, 2012.

Myers, T. 2011. Baseflow Conditions in the Chuitna River and Watersheds 2002, 2003, and 2004 and the Suitability of the Area for Surface Coal Mining. January 14, 2011.

Myers, T., 2011. Hydrogeology of Cave, Dry Lake and Delamar Valleys, Impacts of pumping underground water right applications #53987 through 53092. Presented to the Office of the Nevada State Engineer On behalf of Great Basin Water Network.

Myers, T., 2011. Hydrogeology of Spring Valley and Surrounding Areas, Part A: Conceptual Flow Model. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Confederated Tribes of the Goshute Reservation.

Myers, T., 2011. Hydrogeology of Spring Valley and Surrounding Areas, Part B: Groundwater Model of Snake Valley and Surrounding Area. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Confederated Tribes of the Goshute Reservation.

Myers, T., 2011. Hydrogeology of Spring Valley and Surrounding Areas, PART C: IMPACTS OF PUMPING UNDERGROUND WATER RIGHT APPLICATIONS #54003 THROUGH 54021. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Confederated Tribes of the Goshute Reservation.

Myers, T., 2011. Rebuttal Report: Part 2, Review of Groundwater Model Submitted by Southern Nevada Authority and Comparison with the Myers Model. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Confederated Tribes of the Goshute Reservation.

Myers, T. 2011. Rebuttal Report: Part 3, Prediction of Impacts Caused by Southern Nevada Water Authority Pumping Groundwater From Distributed Pumping Options for Spring Valley, Cave Valley, Dry Lake Valley, and Delamar Valley. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Confederated Tribes of the Goshute Reservation.

Myers, T., 2011. Baseflow Selenium Transport from Phosphate Mines in the Blackfoot River Watershed Through the Wells Formation to the Blackfoot River, Prepared for the Greater Yellowstone Coalition.

Myers, T., 2011. Blackfoot River Watershed, Groundwater Selenium Loading and Remediation. Prepared for the Greater Yellowstone Coalition.

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Myers, T., 2010. Planning the Colorado River in a Changing Climate, Colorado River Simulation System (CRSS) Reservoir Loss Rates in Lakes Powell and Mead and their Use in CRSS. Prepared for Glen Canyon Institute.

Myers, T., 2010. Technical Memorandum, Updated Groundwater Modeling Report, Proposed Rosemont Open Pit Mining Project. Prepared for Pima County and Pima County Regional Flood Control District

Myers, T., 2009. Monitoring Groundwater Quality Near Unconventional Methane Gas Development Projects, A Primer for Residents Concerned about Their Water. Prepared for Natural Resources Defense Council. New York, New York.

Myers, T., 2009. Technical Memorandum, Review and Analysis of the Hydrology and Groundwater and Contaminant Transport Modeling of the Draft Environmental Impact Statement Blackfoot Bridge Mine, July 2009. Prepared for Greater Yellowstone Coalition, Idaho Falls, Idaho.

Myers, T., 2008. Hydrogeology of the Carbonate Aquifer System, Nevada and Utah With Emphasize on Regional Springs and Impacts of Water Rights Development. Prepared for: Defenders of Wildlife, Washington, D.C.. June 1, 2008.

Myers, T., 2008. Hydrogeology of the Muddy River Springs Area, Impacts of Water Rights Development. Prepared for: Defenders of Wildlife, Washington, D.C. May 1, 2008

Myers, T., 2008. Hydrogeology of the Santa Rita Rosemont Project Site, Numerical Groundwater Modeling of the Conceptual Flow Model and Effects of the Construction of the Proposed Open Pit, April 2008. Prepared for: Pima County Regional Flood Control District, Tucson AZ.

Myers, T., 2008. Technical Memorandum, Review, Record of Decision, Environmental Impact Statement Smoky Canyon Mine, Panels F&G, U.S. Department of the Interior, Bureau of Land Management. Prepared for Natural Resources Defense Council, San Francisco, CA and Greater Yellowstone Coalition, Idaho Falls, ID. Reno NV.

Myers, T., 2007. Groundwater Flow and Contaminant Transport at the Smoky Canyon Mine, Proposed Panels F and G. Prepared for Natural Resources Defense Council, San Francisco, CA and Greater Yellowstone Coalition, Idaho Falls, ID. Reno NV. December 11, 2007.

Myers, T., 2007. Hydrogeology, Groundwater Flow and Contaminant Transport at the Smoky Canyon Mine, Documentation of a Groundwater Flow and Contaminant Transport Model. Prepared for Natural Resources Defense Council, San Francisco, CA and Greater Yellowstone Coalition, Idaho Falls, ID. Reno NV, December 7, 2007.

Myers, T., 2007. Review of Hydrogeology and Water Resources for the Final Environmental Impact Statement, Smoky Canyon Mine, Panels F and G and Supporting Documents. Prepared for Natural Resources Defense Council, San Francisco, CA and Greater Yellowstone Coalition, Idaho Falls, ID. Reno, NV. December 12, 2007.

Myers, T., 2007. Hydrogeology of the Powder River Basin of Southeast Montana Development of a Three-Dimensional Groundwater Flow Model. Prepared for Northern Plains Resource Council. February 12 2007.

Myers, T., 2007. Hydrogeology of the Santa Rita Rosemont Project Site, Conceptual Flow Model and Water Balance, Prepared for: Pima County Flood Control District, Tucson AZ

Myers, T., 2006. Review of Mine Dewatering on the Carlin Trend, Predictions and Reality. Prepared for Great Basin Mine Watch, Reno, NV

Myers, T., 2006. Hydrogeology of Spring Valley and Effects of Groundwater Development Proposed by the Southern Nevada Water Authority, White Pine and Lincoln County, Nevada. Prepared for Western Environmental Law Center for Water Rights Protest Hearing.

Myers, T., 2006. Potential Effects of Coal Bed Methane Development on Water Levels, Wells and Springs of the Pinnacle Gas Resource, Dietz Project In the Powder River Basin of Southeast Montana. Affidavit prepared for Northern Plains Resource Council, April 4 2006.

Myers, T., 2006. Review of Hydrogeology and Water Resources for the Draft Environmental Impact Statement, Smoky Canyon Mine, Panels F and G, Technical Report 2006-01-Smoky Canyon. Prepared for Natural Resources Defense Council.

Myers, T., 2006. Review of Nestle Waters North America Inc. Water Bottling Project Draft Environmental Impact Report / Environmental Assessment. Prepared for McCloud Watershed Council, McCloud CA.

Myers, T., 2005. Hydrology Report Regarding Potential Effects of Southern Nevada Water Authority's Proposed Change in the Point of Diversion of Water Rights from Tikapoo Valley South and Three Lakes Valley North to Three Lakes Valley South. Prepared for Western Environmental Law Center for Water Rights Protest Hearing

Myers, T., 2005. Review of Draft Supplemental Environmental Impact Statement, Ruby Hill Mine Expansion: East Archimedes Project NV063-EIS04-34, Technical Report 2005-05-GBMW. Prepared for Great Basin Mine Watch.

Myers, T., 2005. Hydrogeology of the Powder River Basin of Southeast Montana, Development of a Three-Dimensional Groundwater Flow Model. Prepared for Northern Plains Resource Council, Billings, MT in support of pending litigation.

Myers, T., 2005. Nevada State Environmental Commission Appeal Hearing, Water Pollution Control Permit Renewal NEV0087001, Big Springs Mine. Prepared for Great Basin Mine Watch, Reno NV.

Myers, T., 2005. Potential Effects of Coal Bed Methane Development on Water Levels, Wells and Springs In the Powder River Basin of Southeast Montana. Prepared for Northern Plains Resource Council, Billings, MT.

Myers, T., 2004. An Assessment of Contaminant Transport, Sunset Hills Subdivision and the Anaconda Yerington Copper Mine, Technical Report 2004-01-GBMW. Prepared for Great Basin Mine Watch.

Myers, T., 2004. Technical Memorandum: Pipeline Infiltration Project Groundwater Contamination. Prepared for Great Basin Mine Watch.

Myers, T., 2004. Technical Report Seepage From Waste Rock Dump to Surface Water The Jerritt Canyon Mine, Technical Report 2004-03-GBMW. Prepared for Great Basin Mine Watch.

Myers, T., 2001. An Assessment of Diversions and Water Rights: Smith and Mason Valleys, NV. Prepared for the Bureau of Land Management, Carson City, NV.

Myers, T., 2001. Hydrogeology of the Basin Fill Aquifer in Mason Valley, Nevada: Effects of Water Rights Transfers. Prepared for the Bureau of Land Management, Carson City, NV.

Myers, T., 2001. Hydrology and Water Balance, Smith Valley, NV: Impacts of Water Rights Transfers. Prepared for the Bureau of Land Management, Carson City, NV

Myers, T., 2000. Alternative Modeling of the Gold Quarry Mine, Documentation of the Model, Comparison of Mitigation Scenarios, and Analysis of Assumptions. Prepared for Great Basin Mine Watch. Center for Science in Public Participation, Bozeman MT.

Myers, T., 2000. Environmental and Economic Impacts of Mining in Eureka County. Prepared for the Dept. Of Applied Statistics and Economics, University of Nevada, Reno.

Myers, T., 1999. Water Balance of Lake Powell, An Assessment of Groundwater Seepage and Evaporation. Prepared for the Glen Canyon Institute, Salt Lake City, UT.

Myers, T., 1998. Hydrogeology of the Humboldt River: Impacts of Open-pit Mine Dewatering and Pit Lake Formation. Prepared for Great Basin Mine Watch, Reno, NV.

Selected Abstracts, Magazine and Proceedings Articles

Myers, T., 2014. Reservoir Loss Rates, Lakes Mead and Powell and Fill Mead First. INVITED PRESENTATION at 2014 Future of the Colorado Plateau Forum – Drought and the Colorado River. http://musnaz.org/educational-programs/public-programs/future-of-the-colorado-plateau-forums/

Myers, T., 2013. Three-dimensional Groundwater and Contaminant Flow around Marcellus Gas Development. INVITED PRESENTATION at 2013 Associated Engineering Geologists Conference, Seattle WA.

Myers, T., 2012. Mine Dewatering: Humboldt River Update. INVITED PRESENTATION at 2012 Nevada Water Resources Association Annual Conference.

Myers, T., 2012. Reservoir loss rates from Lake Powell, and long-term management of the Colorado River system. 2012 Nevada Water Resources Association Annual Conference

Myers, T., 2011. Reservoir loss rates from Lake Powell, and long-term management of the Colorado River system. 2011 Fall Conference, American Geophysical Union.

Myers, T., 2006. Modeling Coal Bed Methane Well Pumpage with a MODFLOW DRAIN Boundary. In MODFLOW and More 2006 Managing Ground Water Systems, Proceedings. International Groundwater Modeling Center, Golden CO. May 21-24, 2006.

Myers, T., 2006. Proceed Carefully: Much Remains Unknown, *Southwest Hydrology 5(3)*, May/June 2006, pages 14-16.

Myers, T., 2004. Monitoring Well Screening and the Determination of Groundwater Degradation, Annual Meeting of the Nevada Water Resources Association, Mesquite, NV. February 27-28, 2004.

Myers, T., 2001. Impacts of the conceptual model of mine dewatering pumpage on predicted fluxes and drawdown. In MODFLOW 2001 and Other Modeling Odysseys, Proceedings, Volume 1. September 11-14, 2001. International Ground Water Modeling Center, Golden, Colorado.

Myers, T., 1997. Groundwater management implications of open-pit mine dewatering in northern Nevada. In Kendall, D.R. (ed.), Conjunctive Use of Water Resources: Aquifer Storage and Recovery. AWRA Symposium, Long Beach California. October 19-23, 1997

Myers, T., 1997. Groundwater management implications of open-pit mine dewatering in northern Nevada. In Life in a Closed Basin, Nevada Water Resources Association, October 8-10, 1997, Elko, NV.

Myers, T., 1997. Uncertainties in the hydrologic modeling of pit lake refill. American Chemical Society Annual Meeting, Las Vegas, NV, Sept. 8-12, 1997.

Myers, T., 1997. Use of groundwater modeling and geographic information systems in water marketing. In Warwick, J.J. (ed.), Water Resources Education, Training, and Practice: Opportunities for the Next Century. AWRA Symposium, Keystone, Colo. June 29-July 3, 1997.

Myers, T., 1995. Decreased surface water flows due to alluvial pumping in the Walker River valley. Annual Meeting of the Nevada Water Resources Association, Reno, NV, March 14-15, 1995.

Special Coursework

Years	Course	Sponsor
2011	Hydraulic Fracturing of the Marcellus Shale	National Groundwater Association
2008	Fractured Rock Analysis	MidWest Geoscience
2005	Groundwater Sampling Field Course	Nielson Environmental Field School
2004	Environmental Forensics	National Groundwater Association
2004 and -5	Groundwater and Environmental Law	National Groundwater Association

ALASKA

Temperatures in Alaska have increased by about 3°F since 1925 but with large multidecadal variations. Most of the warming has occurred in the winter and spring. Under a higher emissions pathway, historically unprecedented warming is projected during this century.

Annual average precipitation is projected to increase by 10% or more across all of Alaska by the middle of this century under a higher emissions pathway.

Late-summer arctic sea ice extent and thickness have decreased substantially over the last several decades. Climate models project that before 2050 arctic waters will be virtually ice-free by late summer.

Alaska's vast expanse and geographical variation lead to a variety of climate types. Four main factors influence the state's climate: its northerly latitude crossing the Arctic Circle; its large elevation range, from sea level to the highest peak in the United States; regional variations in proximity to the ocean; and the seasonal distribution of sea ice along its western and northern boundaries. Annual average (1991–2020 normals) temperatures range from the mid-40s (°F) in the south, where moderating maritime influences are strong, to about 13° to 20°F in the Arctic region north of the Brooks Range (Figure 2); the coldest long-term reporting stations are along and near the Arctic Ocean north of 70°N latitude, with an annual average temperature of less than 15°F. The greatest seasonal changes in temperature occur in the state's Interior region, where summer average maximum temperatures are in the upper 60s (F°) and winter average minimums are 15° to 25°F below zero. The highest temperature ever recorded in Alaska was 100°F at Fort Yukon, in the Interior (June 27, 1915), and the coldest was −80°F at Prospect Creek, also in the Interior (January 23, 1971).

Alaska's temperature climate is highly variable. It was moderately warm from the 1920s into the 1940s, much cooler from the late 1940s into the 1970s, and warmer thereafter. **Since 1925 (the beginning of reliable records), temperatures in Alaska have increased by about 3°F** (Figure 1), **compared to about**

Observed and Projected Temperature Change

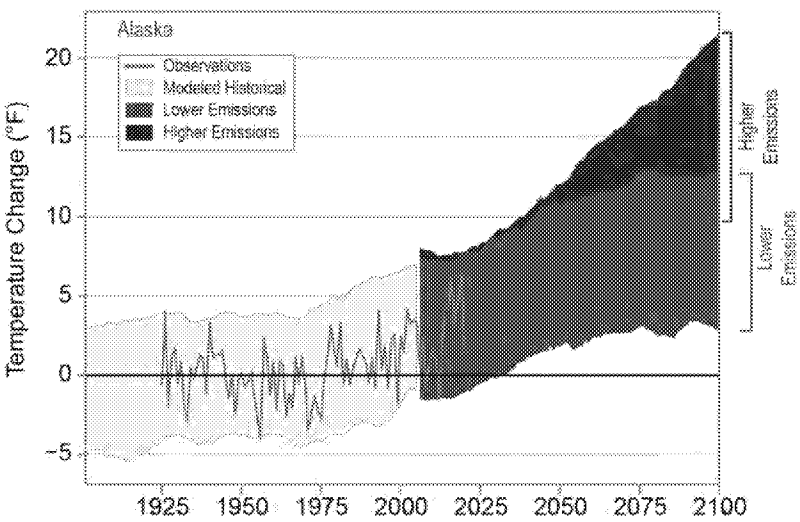

Figure 1: Observed and projected changes (compared to the 1925–1960 average) in near surface air temperature for Alaska. Observed data are for 1925–2020, while model simulations of the historical period are shown for 1901–2005. Projected changes for 2006–2100 are from global climate models for two possible futures: one in which greenhouse gas emissions continue to increase (higher emissions) and another in which greenhouse gas emissions increase at a slower rate (lower emissions). Temperatures in Alaska (orange line) have increased by about 3°F since 1925 but with large multidecadal variations. Shading indicates the range of annual temperatures from the set of models. Observed temperatures are generally within the envelope of the modeled historical simulations (gray shading). Historically unprecedented warming is projected during this century. Less warming is expected under a lower emissions future (the coldest end-of-century projections being about 2°F warmer than the historical average; green shading) and more warming under a higher emissions future (the hottest years being about 15°F warmer than the hottest year in the historical record; red shading). Sources: CISESS and NOAA NCEI.

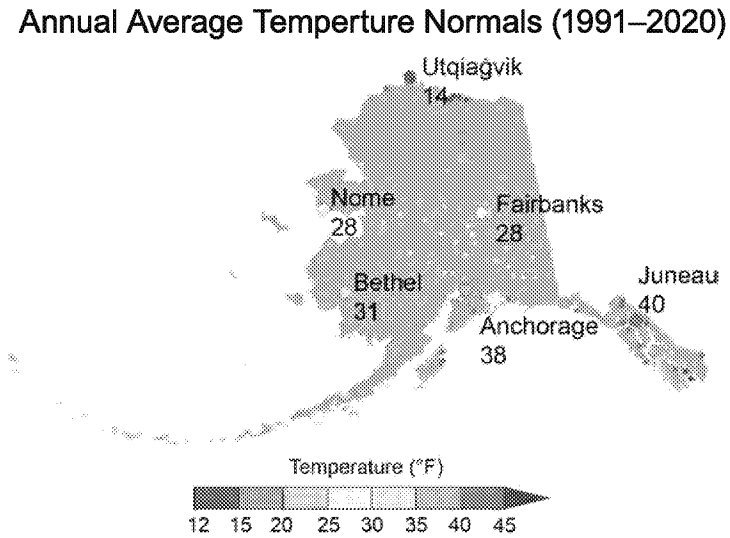

Figure 2. Annual average temperature normals (1991–2020) for long-term reporting stations in Alaska. Normals vary from less than 15°F in the far north to greater than 45°F at a few locations along the southeast coast. Sources: CISESS and NCEI. Data: NOAA NCEI U.S. Climate Normals.

1.8°F since 1900 for the contiguous United States. There is considerable regional variability in the warming, with the greatest warming occurring in the North Slope (about 4°F) and the least warming (less than 2°F) occurring in the Panhandle and the Aleutians. Most of the warming has occurred in the winter and spring and the least amount in the summer and fall. Summer temperatures have been above average since the late 1980s (Figure 3b), and winter temperatures have been mostly above average since 2001 (Figure 3a). The increase in summer temperatures is primarily due to a large increase in summer minimum temperatures (Figure 3c). The large decadal variability is caused in part by changes in hemispheric climate patterns. For example, a substantial increase in annual average temperature occurred around 1976, followed by gradual additional warming through 2020. Specifically, annual average temperature increased by about 1.5°F from the 1970s to the 1980s and then by about 2°F from the 1980s to the 2010s, with much higher values locally. At Utqiaġvik, annual temperature has increased by more than 12°F since 1976. This warming coincided with a shift in a climate pattern known as the Pacific Decadal Oscillation (PDO). In the past, during the warm phase of the PDO, increased atmospheric flow from the south brought warm air into Alaska during the winter. Accelerated warming has occurred since mid-2013: 2016 and 2019 were the second-warmest and warmest years on record, respectively. The shift to warmer temperatures in the 1970s can be seen in the number of extremely cold nights (Figure 4), which has generally been below the long-term (1930–2020) average since 1980, with the lowest multiyear averages occurring in the 2000–2004 and 2015–2020 periods. The number of warm days was high during the early 1990s, early 2000s, and late 2010s; 2019 experienced the second-highest number of warm days, after 2004 (Figure 5). Over the past 100 years, the length of the growing season in Fairbanks has increased by 45%, and the number of snow-free days has increased by 10%.

Total annual precipitation amounts vary greatly across Alaska. Coastal mountain ranges in the southeastern Panhandle receive more than 200 inches per year, while totals drop to 60 inches south of the Alaska Range, 12 inches in the Interior, and less than 6 inches in the North Slope. The highest 24-hour rainfall total was 15.05 inches in October 1986 at Seward, in Southcentral Alaska. The highest 24-hour snowfall total was 78 inches on February 9, 1963, at Mile 47 Camp along Highway 4 in the southeastern portion of the state. The driest multiyear periods were in the 1950s, late 1960s, and early 1970s, and the wettest were in the late 1920s (Figure 6a). The driest consecutive 5-year interval was 1968–1972, and the wettest was 1928–1932. Since the late 1980s, total annual precipitation in Alaska has been near to above average, except for a dry period in the late 1990s. There is considerable regional variability, however, as portions of Interior and Arctic Alaska have observed a long-term

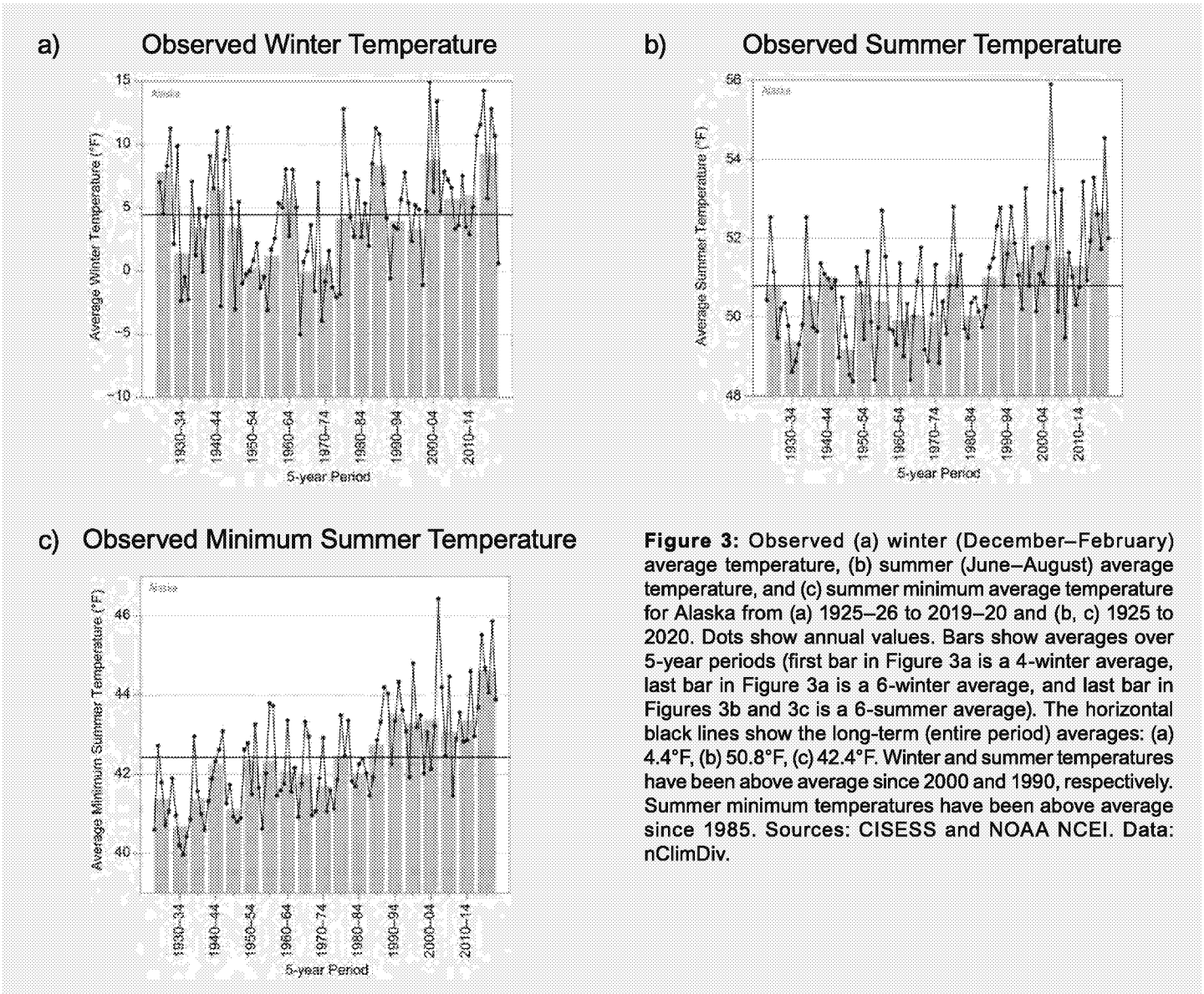

Figure 3: Observed (a) winter (December–February) average temperature, (b) summer (June–August) average temperature, and (c) summer minimum average temperature for Alaska from (a) 1925–26 to 2019–20 and (b, c) 1925 to 2020. Dots show annual values. Bars show averages over 5-year periods (first bar in Figure 3a is a 4-winter average, last bar in Figure 3a is a 6-winter average, and last bar in Figures 3b and 3c is a 6-summer average). The horizontal black lines show the long-term (entire period) averages: (a) 4.4°F, (b) 50.8°F, (c) 42.4°F. Winter and summer temperatures have been above average since 2000 and 1990, respectively. Summer minimum temperatures have been above average since 1985. Sources: CISESS and NOAA NCEI. Data: nClimDiv.

decrease in precipitation. Also, for the summer season, the 2010–2014 period was the wettest on record (Figure 6b). As with average precipitation, the occurrence of extreme precipitation events is highly variable and is both regionally and seasonally dependent. Most of Alaska has seen an increase in the heaviest 1% of 3-day precipitation totals since the mid-20th century; however, the number of daily precipitation events of 1-inch or more has been near to below average since 1990, and the highest values occurred in the 1930s (Figure 6c).

Late-summer arctic sea ice extent and thickness have decreased substantially over the last several decades, and the ice extent is approximately one-half of that observed at the beginning of satellite monitoring in 1979. The lowest minimum arctic sea ice extent occurred in 2012 (Figure 7). Arctic sea ice plays a vital role in the climate of Alaska, the lives of its inhabitants, and the functionality of its ecosystems. Warming linked to ice loss influences atmospheric circulation and precipitation patterns both within and beyond the Arctic region. Alaskans rely on sea ice for hunting and fishing and as a protective barrier against severe coastal storms. With the late-summer ice edge located farther north than it used to be, storms produce larger waves and cause more coastal erosion. A significant increase in the number of coastal erosion events has been observed, as the protective sea ice embankment is no longer present during the fall months. In response to the increased erosion, several coastal communities are seeking to relocate.

Much of the Alaska Interior (between the Brooks and Alaska Ranges) is a zone of discontinuous

permafrost, and the area north of the Brooks Range is a zone of continuous permafrost. **Increasing temperatures result in permafrost thawing, which causes substantial repercussions for the ecology and infrastructure (e.g., damage to buildings, pipelines, roads, airports, and water supply and sewage systems from ground subsidence [sinking]), as well as an increase in greenhouse gas emissions**. As the climate continues to warm, snow in Alaska melts earlier each spring, lengthening the snow-free summer season.

Wildfires are also a particular concern for the state, especially in recent years. Drying of wetlands, increased frequency of warm, dry summers, and associated thunderstorms have led to a greater number of large fires during the 2000s than in any previous decade since record keeping began in the 1940s. From 2000 to 2020, the frequency of large (more than 2,000 square miles burned) wildfire seasons (35%) more than doubled compared to the 1955–1999 period (15%). The largest wildfire seasons (since 1955) were 2004 (10,500 square miles) and 2015 (8,000 square miles). **The area burned by wildfires may increase further under a warming climate**.

Under a higher emissions pathway, historically unprecedented warming is projected during this century (Figure 1). Even under a lower emissions pathway, annual average temperatures are projected to most likely exceed historical record levels by the middle of the century. However, a large range of temperature increases is projected under both pathways, and under the lower pathway, a few projections are only slightly warmer than historical records.

While historical precipitation trends are mixed, average precipitation is projected to increase in all seasons during this century, with the greatest increases expected in winter and spring. By the middle of the century, annual precipitation increases are projected to exceed 10% over the majority of the state (Figure 8).

Since 1900, global average sea level has risen by about 7–8 inches. However, in Alaska, sea level is actually falling along much of the southern coast

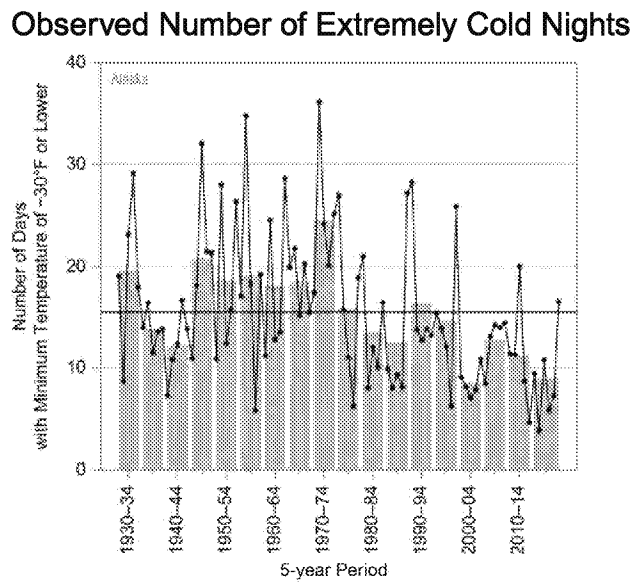

Figure 4: Observed annual number of extremely cold nights (minimum temperature of –30°F or lower) for Alaska from 1930 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 16 nights (note that the average for individual stations varies greatly because of the state's large elevation range). These values are averages from 10 of 14 long-term reporting stations. Four long-term stations located near the western and southern coasts have been excluded from the averaging because the moderating effects of the oceans prevent the occurrence of such low temperatures. Since 2000, all 10 stations have experienced numbers lower than the long-term average. The lowest multiyear averages occurred in the early 2000s and late 2010s. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily.

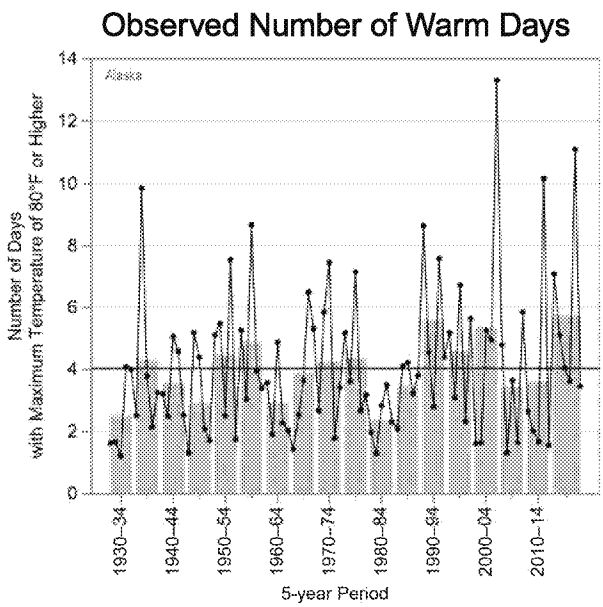

Figure 5: Observed (a) annual number of warm days (maximum temperature of 80°F or higher) for Alaska from 1930 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar is a 6-year average). The horizontal black line shows the long-term (entire period) average of 4.0 days (note that the average for individual stations varies greatly because of the state's large elevation range). The highest number of warm days occurred during the early 1990s, early 2000s, and late 2010s. Sources: CISESS and NOAA NCEI. Data: GHCN-Daily from 14 long-term stations.

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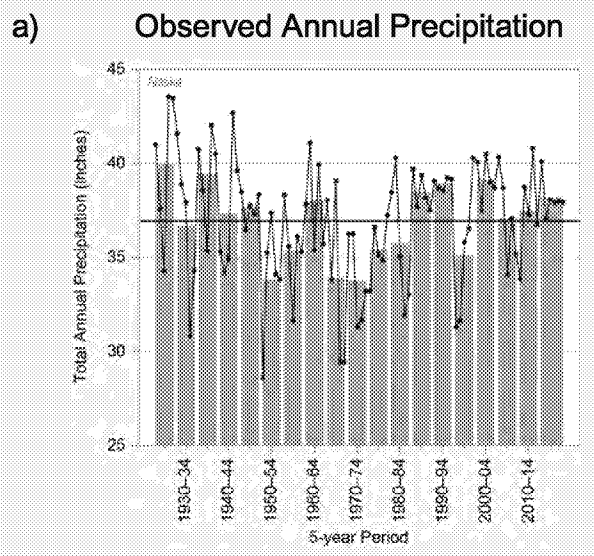
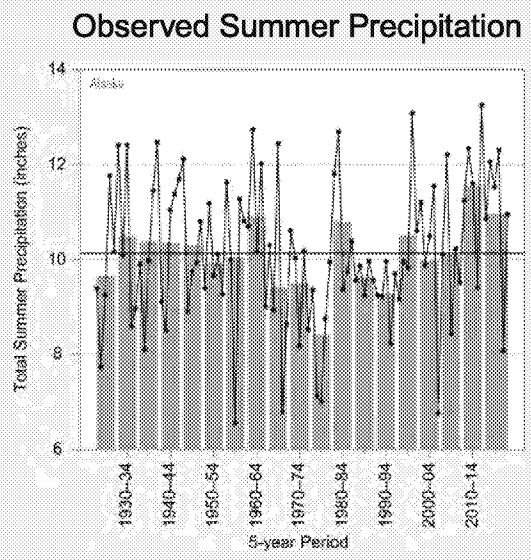
due to isostatic rebound (rising ground) from ice mass loss. In other parts of the coast, tectonic activity results in subsidence, exacerbating the effect of sea level rise. Although global sea level is projected to likely rise another 1 to 4 feet by 2100 as a result of both past and future emissions from human activities (Figure 9), the changes in coastal erosion due to the combined effects of sea ice loss and permafrost thaw are likely to cause larger impacts well before the inundation associated with sea level rise. **Climate models project that Alaska's northern waters in late summer could be virtually ice-free before 2050**.





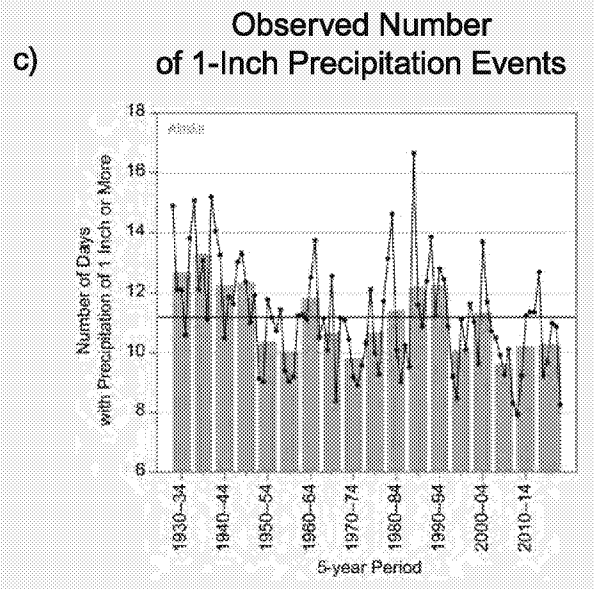


Figure 6: Observed (a) total annual precipitation, (b) total summer (June–August) precipitation, and (c) annual number of 1-inch extreme precipitation events (days with precipitation of 1 inch or more) for Alaska from (a, b) 1925 to 2020 and (c) 1930 to 2020. Dots show annual values. Bars show averages over 5-year periods (last bar in Figures 6a and 6c is a 6-year average, last bar in Figure 6b is a 6-summer average). The horizontal black lines show the long-term (entire period) averages: (a) 37.0 inches, (b) 10.1 inches, (c) 11 days. Annual precipitation has been variable with no long-term trend. For summer precipitation, the 2010–2014 period was the wettest on record.The number of 1-inch extreme precipitation events has been near or below average since the late 1990s. A typical reporting station experiences about 11 events per year, but in the diverse climate of Alaska, this number is highly variable from station to station. Sources: CISESS and NOAA NCEI. Data: (a, b) nClimDiv; (c) GHCN-Daily from 14 long-term stations.

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March and September Arctic Sea Ice Extent

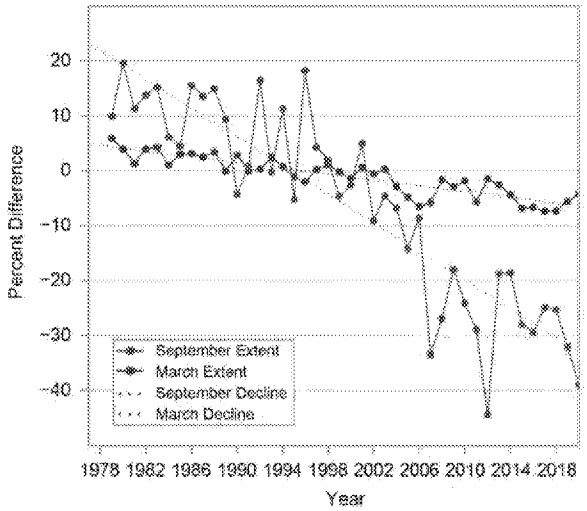


Figure 7: Time series of arctic sea ice extent anomalies in March (the month of maximum ice extent) and September (the month of minimum ice extent) from 1979 to 2020. The anomaly value for each year is the difference (%) in ice extent relative to the average values for the period 1981–2010. The red and blue dashed lines indicate ice losses of −2.6% and −13.4% per decade in March and September, respectively. Both trends are significant at the 99% confidence level. Sources: CISESS and NOAA NCEI. Data: NSIDC.

Projected Change in Annual Precipitation

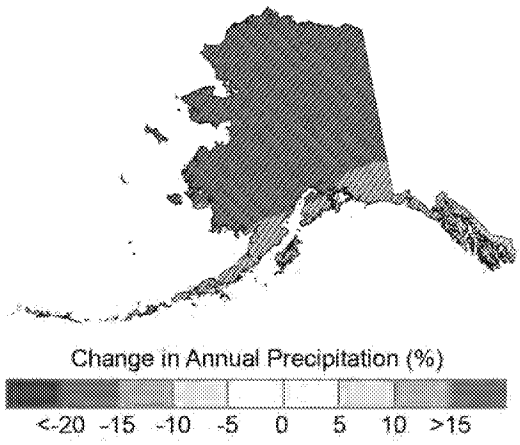


Figure 8: Projected changes in total annual precipitation (%) for the middle of the 21st century compared to the late 20th century under a higher emissions pathway. Hatching represents areas where the majority of climate models indicate a statistically significant change. Projected increases in Alaska's annual precipitation are consistent with a large pattern of projected increases at high latitudes Sources: CISESS and NEMAC. Data: CMIP5.

Observed and Projected Change in Global Sea Level

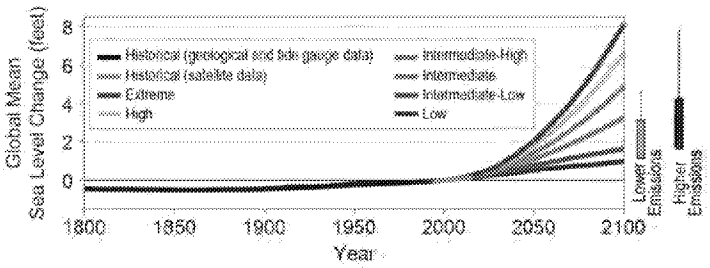
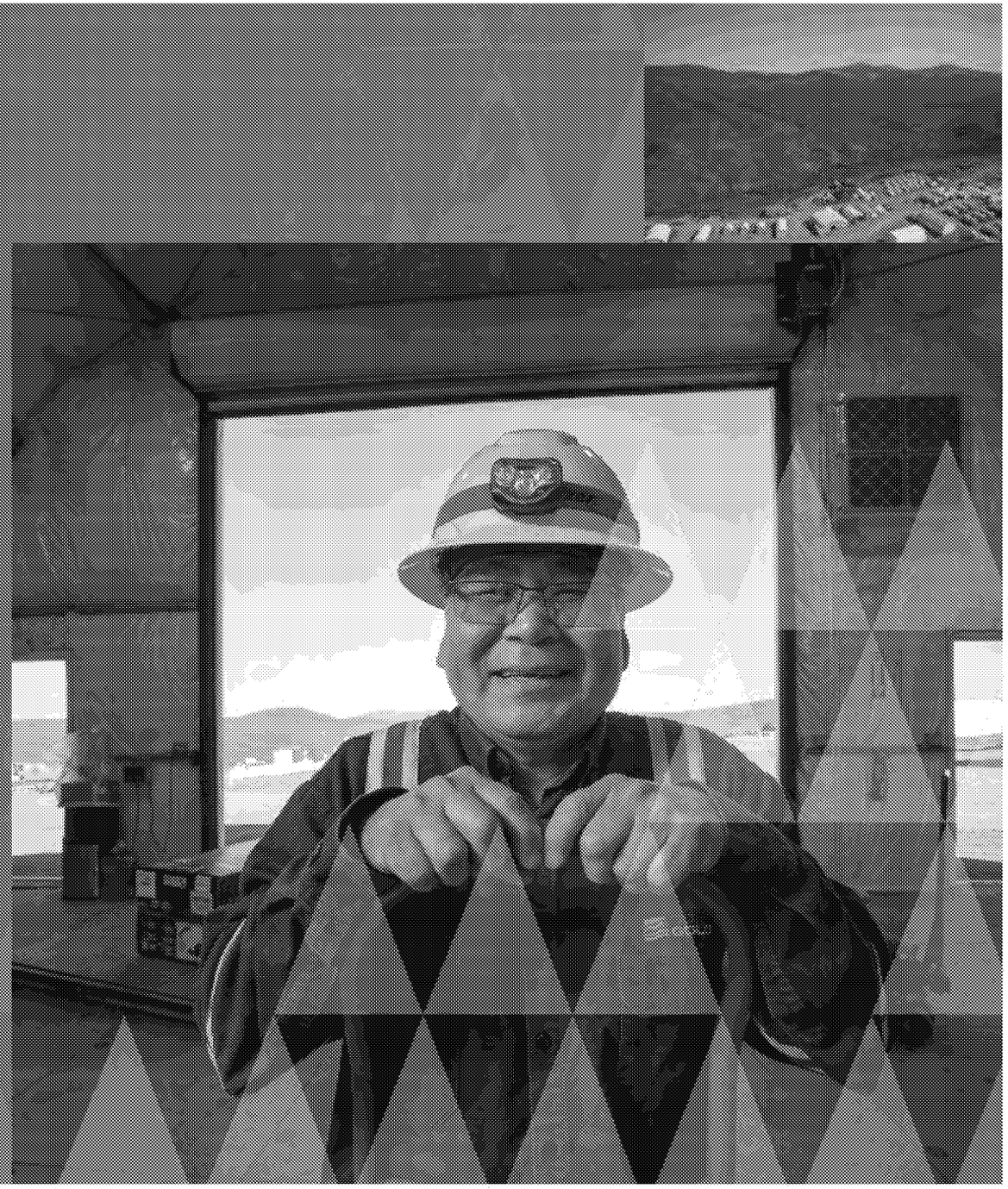


Figure 9: Global mean sea level (GMSL) change from 1800 to 2100. Projections include the six U.S. Interagency Sea Level Rise Task Force GMSL scenarios (Low, navy blue; Intermediate-Low, royal blue; Intermediate, cyan; Intermediate-High, green; High, orange; and Extreme, red curves) relative to historical geological, tide gauge, and satellite altimeter GMSL reconstructions from 1800–2015 (black and magenta lines) and the very likely ranges in 2100 under both lower and higher emissions futures (teal and dark red boxes). Global sea level rise projections range from 1 to 8 feet by 2100, with a likely range of 1 to 4 feet. Source: adapted from Sweet et al. 2017.

Technical details on observations and projections are available online at https://statesummaries.ncics.org/technicaldetails.

NOVAGOLD

2022 Corporate Presentation – May/June



TSX, NYSE American: NG novagold.com

Cautionary statements

REGARDING FORWARD-LOOKING STATEMENTS

This presentation includes certain "forward-looking information" and "forward-looking statements" (collectively "forward-looking statements") within the meaning of applicable securities legislation, including the United States Private Securities Litigation Reform Act of 1995. All statements, other than statements of historical fact, included herein, including, without limitation, statements regarding the permitting, potential development, exploration, construction and operation of Donlin Gold and statements relating to NOVAGOLD's future operating and financial performance and production estimates are forward-looking statements. Forward-looking statements are frequently, but not always, identified by words such as "expects", "anticipates", "believes", "intends", "estimates", "potential", "possible", "poised", and similar expressions, or statements that events, conditions, or results "will", "may", "could", "would" or "should" occur or be achieved. These forward-looking statements may also include statements regarding the exploration potential of Donlin Gold; NOVAGOLD's sustainability commitments; anticipated Donlin Gold mine life; perceived merit of properties; anticipated permitting timeframes; the 2022 forecasted spending; the 2022 outlook; exploration and drilling results and budgets; mineral reserve and resource estimates; work programs; capital expenditures; timelines; strategic plans; benefits of the project; market prices for precious metals, including the potential performance of the price of gold; the potential of gold equities to outperform broader equities during current inflationary environment; whether the final $75 million promissory note from the sale of Galore Creek will mature and be payable; potential shareholder returns; statements regarding the work program for the 2022 field seasons; anticipated benefits from the 2022 drill programs; or other statements that are not statements of fact. Forward-looking statements involve various risks and uncertainties. There can be no assurance that such statements will prove to be accurate, and actual results and future events could differ materially from those anticipated in such statements. Important factors that could cause actual results to differ materially from NOVAGOLD's expectations include the uncertainties involving unexpected cost increases, which could include significant increases in estimated capital and operating costs; the need for additional financing to explore and develop properties and availability of financing in the debt and capital markets; risks related to the coronavirus global pandemic (COVID-19); uncertainties involved in the interpretation of drilling results and geological tests and the estimation of reserves and resources; the need for continued cooperation with Barrick Gold Corporation for the continued exploration and development of the Donlin Gold property; the need for cooperation of government agencies and native groups in the development and operation of properties; risks of construction and mining projects such as accidents, equipment breakdowns, bad weather, non-compliance with environmental and permit requirements; unanticipated variation in geological structures, ore grades or recovery rates; the need to obtain permits and governmental approvals; fluctuations in metal prices and currency exchange rates; whether a positive construction decision will be made regarding Donlin Gold or Galore Creek; the timing and outcome of any decisions to reconsider any permit under appeal; and other risks and uncertainties disclosed in NOVAGOLD's annual report filed on Form 10-K for the year-ended November 30, 2021, and subsequently in NOVAGOLD's quarterly reports filed on Form 10-Q, with the United States Securities and Exchange Commission (SEC), Canadian securities regulators, and in other NOVAGOLD reports and documents filed with applicable securities regulatory authorities from time to time. Copies of these filings may be obtained at no charge by visiting our Investor Relations website at www.novagold.com or the SEC's website at www.sec.gov or at www.sedar.com. NOVAGOLD's forward-looking statements reflect the beliefs, opinions and projections of management on the date the statements are made. NOVAGOLD assumes no obligation to update the forward-looking statements of beliefs, opinions, projections, or other factors, should they change, except as required by law.

ALL DOLLAR AMOUNTS QUOTED IN THIS REPORT ARE IN U.S. CURRENCY UNLESS OTHERWISE NOTED.

Forward-looking statements are based on a number of material assumptions, including but not limited to the following, which could prove to be significantly incorrect: our ability to achieve production at any of our mineral exploration and development properties; estimated capital costs, operating costs, production and economic returns; estimated metal pricing, metallurgy, mineability, marketability and operating and capital costs, together with other assumptions underlying our resource and reserve estimates; our expected ability to develop adequate infrastructure and that the cost of doing so will be reasonable; assumptions that all necessary permits and governmental approvals will be obtained and the timing of such approvals; assumptions made in the interpretation of drill results, the geology, grade and continuity of our mineral deposits; our expectations regarding demand for equipment, skilled labor and services needed for exploration and development of mineral properties; and that our activities will not be adversely disrupted or impeded by development, operating or regulatory risks.

CAUTIONARY NOTE CONCERNING RESERVE & RESOURCE ESTIMATES

This presentation uses the terms "mineral resources", "measured mineral resources", "indicated mineral resources" and "inferred mineral resources". Mineral resources that are not mineral reserves do not have demonstrated economic viability. You should not assume that all or any part of measured or indicated mineral resources will ever be converted into mineral reserves. Further, inferred mineral resources have a great amount of uncertainty as to their existence and as to whether they can be mined legally or economically. On October 31, 2018, the SEC adopted new mining disclosure rules ("S-K 1300") that are more closely aligned with current industry and global regulatory practices and standards, including National Instrument 43-101 – Standards of Disclosure for Mineral Projects ("NI 43-101"). NOVAGOLD has elected to comply with S-K 1300 for its fiscal year ended November 30, 2021.

While S-K 1300 is more closely aligned with NI 43-101 than the prior SEC mining disclosure rules, there are some differences. Notably, unlike NI 43-101, S-K 1300 requires that resources be disclosed exclusive of mineral reserves, and that mineral resources and reserves be disclosed on the basis of our interest in them. NI 43-101 is a rule developed by the Canadian Securities Administrators, which established standards for all public disclosure an issuer makes of scientific and technical information concerning mineral projects. Unless otherwise indicated, all resource estimates contained in this presentation have been prepared in accordance with NI 43-101 and the CIM Definition Standards, as well as S-K 1300.

Project	Qualified Person(s)	Most Recent Disclosure
Donlin Gold	Kirk Hanson, MBA, P.E. Michael Woloschuk, P.Eng. Henry Kim, P.Geo. Wood Canada Limited	"NI 43-101 Technical Report on the Donlin Gold Project, Alaska, USA" ("2021 Technical Report") prepared by Wood Canada Limited ("Wood"), effective June 1, 2021. "S-K 1300 Technical Report Summary on the Donlin Gold project, Alaska USA" ("S-K 1300 Technical Report") prepared by Wood, dated November 30, 2021.

Paul Chilson, P.E., who is the Manager, Mine Engineering for NOVAGOLD and a "qualified person" under NI 43-101 and S-K 1300, has approved the scientific and technical information contained in this presentation.

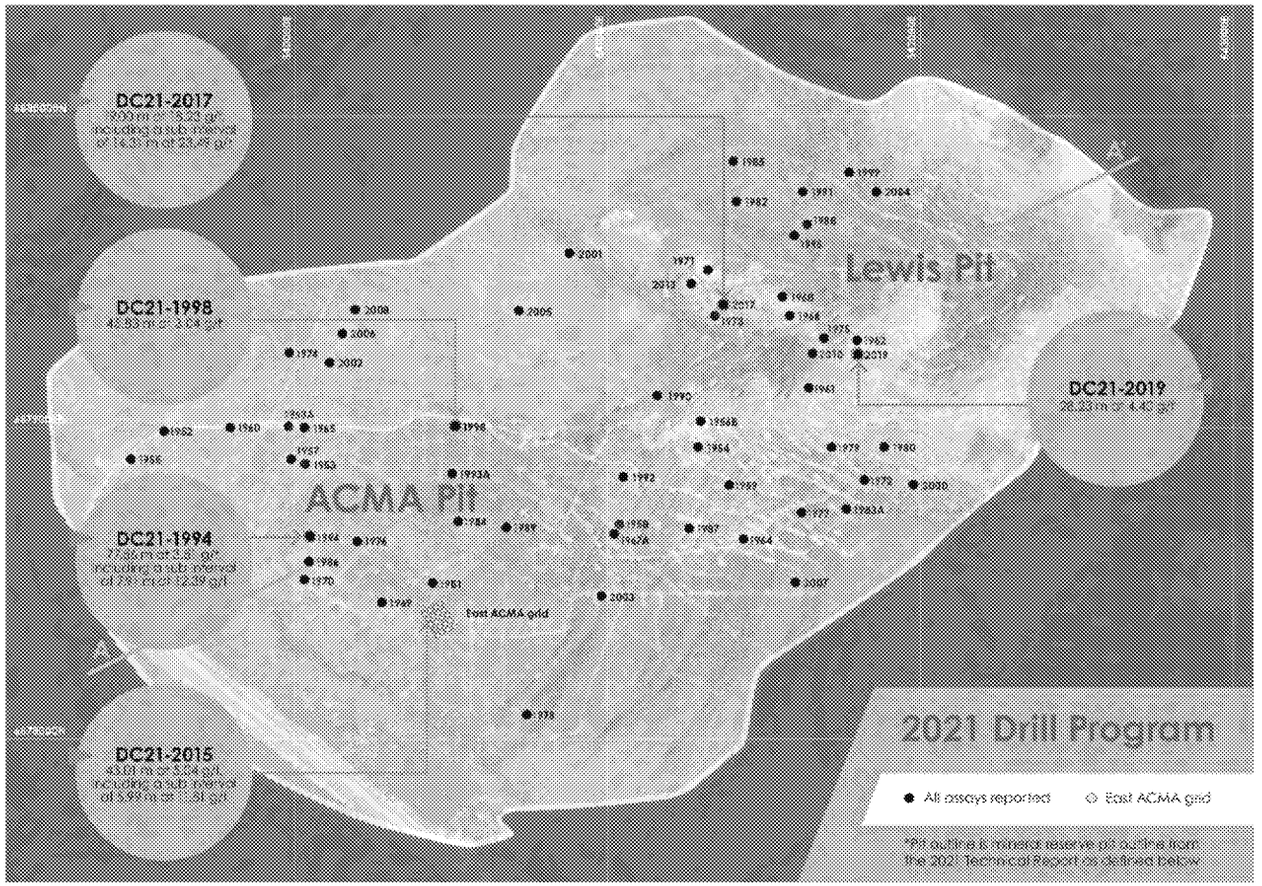
2021 drill program delivers outstanding gold intercepts

Bringing Donlin Gold up the value chain

Top ten intervals based on drilled grade-thickness[1]

	Hole Id	Date Reported	From	To	Drilled Thickness (m)	Grade (g/t Au)	Grade-Thickness (m x g/t Au)
1.	DC21-1970	9/2/2021	69.7	161.7	92.0	7.8	713.3
2.	DC21-1963A	9/2/2021	114.3	155.3	41.0	10.5	431.8
3.	DC21-1969	9/2/2021	400.5	448.3	47.8	9.0	430.1
4.	DC21-1976	12/1/2021	270.4	327.6	57.3	6.9	393.4
5.	DC21-1959	9/2/2021	378.9	403.3	24.4	14.7	357.9
6.	DC21-2017	2/28/2022	144.5	163.5	19.0	18.2	346.4
7.	DC21-1994	2/28/2022	262.6	340.1	77.6	3.5	272.6
8.	DC21-1961	9/2/2021	275.5	281.3	5.7	42.2	242.4
9.	DC21-1970	12/1/2021	173.2	192.3	19.2	12.6	240.8
10.	DC21-1964	9/2/2021	255.6	304.7	49.1	4.9	239.5

- 2021 drill program completed: 79 holes (24,264 meters[2]) drilled in ACMA and Lewis pit areas
- Program plan was expanded by 13 holes and approx. 4,000 meters added
- Final results disclosed during the first quarter with highlights including numerous high-grade gold intercepts coupled with important grade continuity



See endnotes for this slide in Appendix

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BARRICK

Strong partnership alignment

50:50 joint venture partnership

"Our orebody knowledge of Donlin in Alaska continues to grow. **The 2021 drill campaign finished strongly with high-grade intercepts and some of the best drill results for an open pit gold project industry wide.** We began 2022 under the largest project budget for Donlin in over a decade, designed to update geologic modelling and interpretation work for an updated resource model, including engineering activities for use in a potential updated feasibility study."

- Barrick's Annual Report 2021, Page 24.

See endnotes for this slide in Appendix

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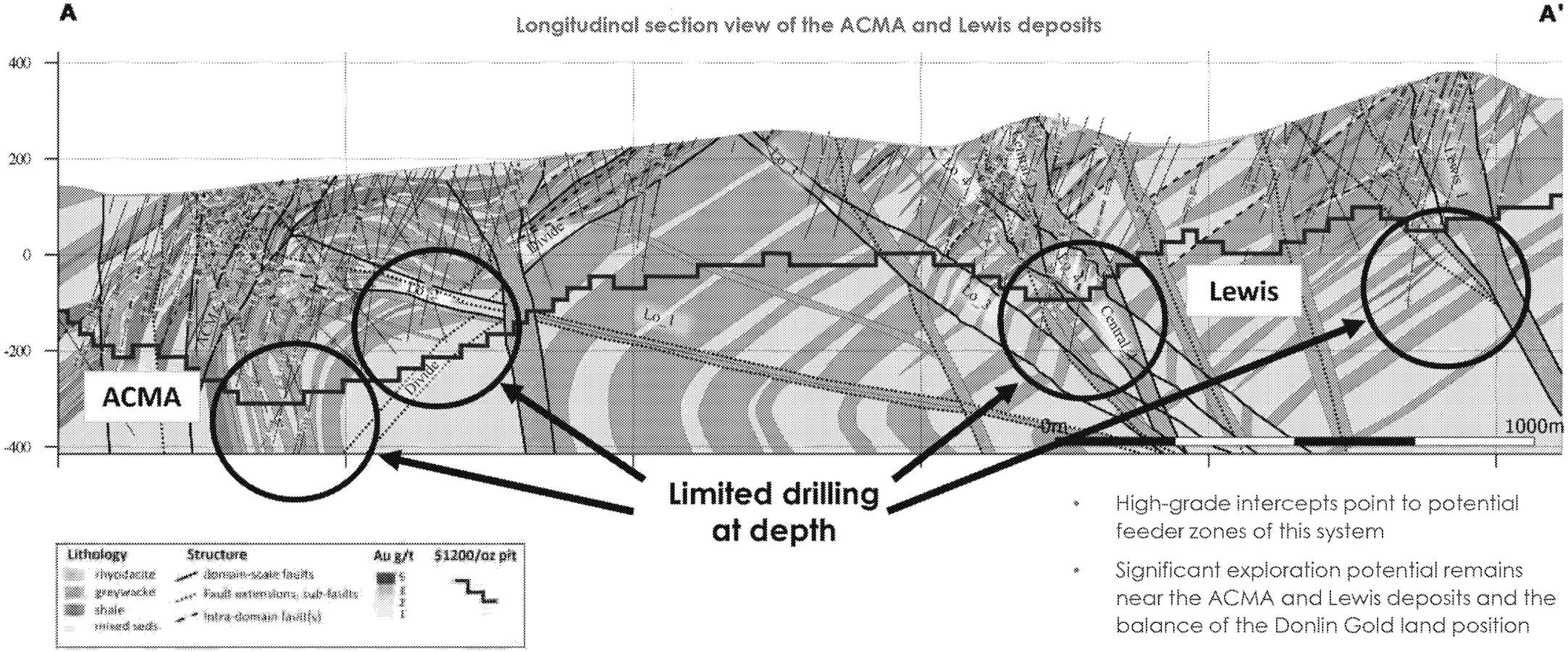
2022 drill program

ACMA and Lewis deposits open at depth



- High-grade intercepts point to potential feeder zones of this system
- Significant exploration potential remains near the ACMA and Lewis deposits and the balance of the Donlin Gold land position

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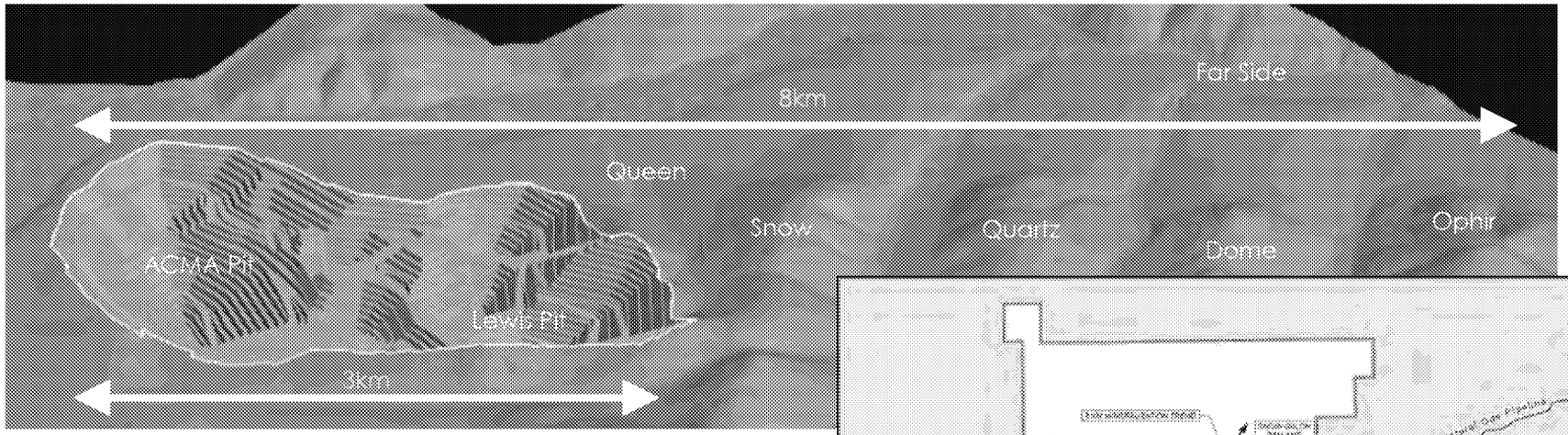
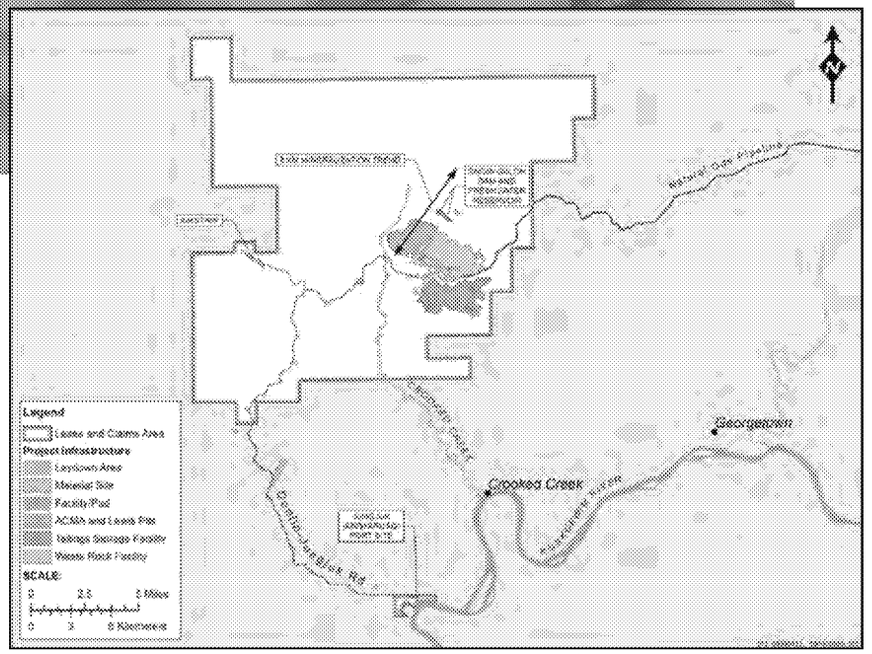
The next big gold discovery could be at Donlin Gold

Significant potential to expand current resource along strike

- From 2006 to 2011, M&I resources increased 135% (16.6Moz[1] to 39.0Moz[2])
- Gold resource defined with approximately 1,400 drillholes totaling more than 339,000 meters
- Inferred mineral resource: 6Moz of gold (92M tonnes grading 2.02 g/t Au) mainly inside the reserve pit[3]





Mineral Reserves and Mineral Resources are contained in the ACMA and Lewis pits occupying only 3km of an 8km mineralized belt, which itself is located on less than 5% of Donlin Gold's total mineral land package

See endnotes for this slide in Appendix

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2022 drill program: largest budget in more than a decade

2022 drill program (approx. 34,000 meters of core drilling) **$34M**

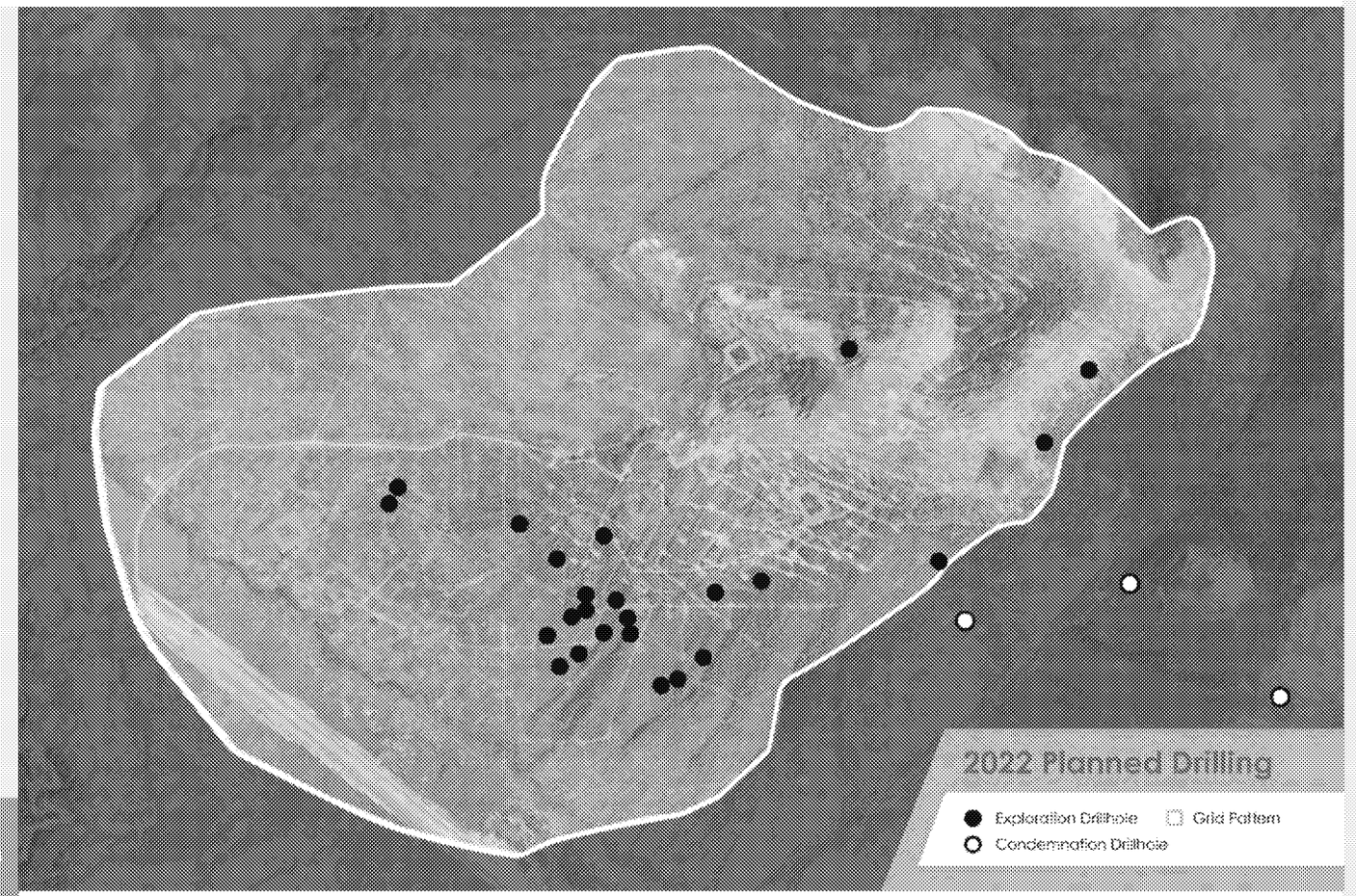
- Grid drilling (mineralization continuity and geologic structural controls in three areas of the deposit)
- In-pit and below pit exploration
- Waste Rock Facility condemnation drilling
- Platform mapping to confirm mineralization continuity and key geological controls in representative areas of the deposit

External affairs, permitting, environmental, land and legal activities **$18M**

Project planning and fieldwork **$8M**

- Geologic modelling and interpretation work for an updated resource model and engineering activities for use in an updated project feasibility study
- Dam and water structures permitting
- Metallurgical testing
- Hydrogeology and geochemistry
- Infrastructure planning

TOTAL BUDGET: $60M
NOVAGOLD: $30M | Barrick: $30M



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Permitting update

Key federal permits for the project received and state permitting is well-advanced

Federal permitting completed	
✓	Final Environmental Impact Statement (EIS)
✓	Joint Record of Decision (ROD) by the Army Corps of Engineers and Bureau of Land Management
✓	Section 10/404 (wetlands) permit and BLM Offer to Lease for pipeline
✓	Pipeline and Hazardous Materials Safety Administration special permit

State permitting pending
Dam safety certifications (multi-year commitment)

State permitting completed	
✓	Air quality
✓	Alaska Discharge Pollutant Elimination System
✓	Clean Water Act section 401 Certification*
✓	Reclamation Plan approval
✓	Title 16 fish habitat permits
✓	Waste management permit
✓	Pipeline Right-of-Way lease*
✓	Land leases, easements, and land use permits issued (non-pipeline)
✓	Water Rights permits*

*Under appeal

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Maintaining a strong treasury

Largest planned spending for Donlin Gold in over a decade

See endnotes for this slide in Appendix

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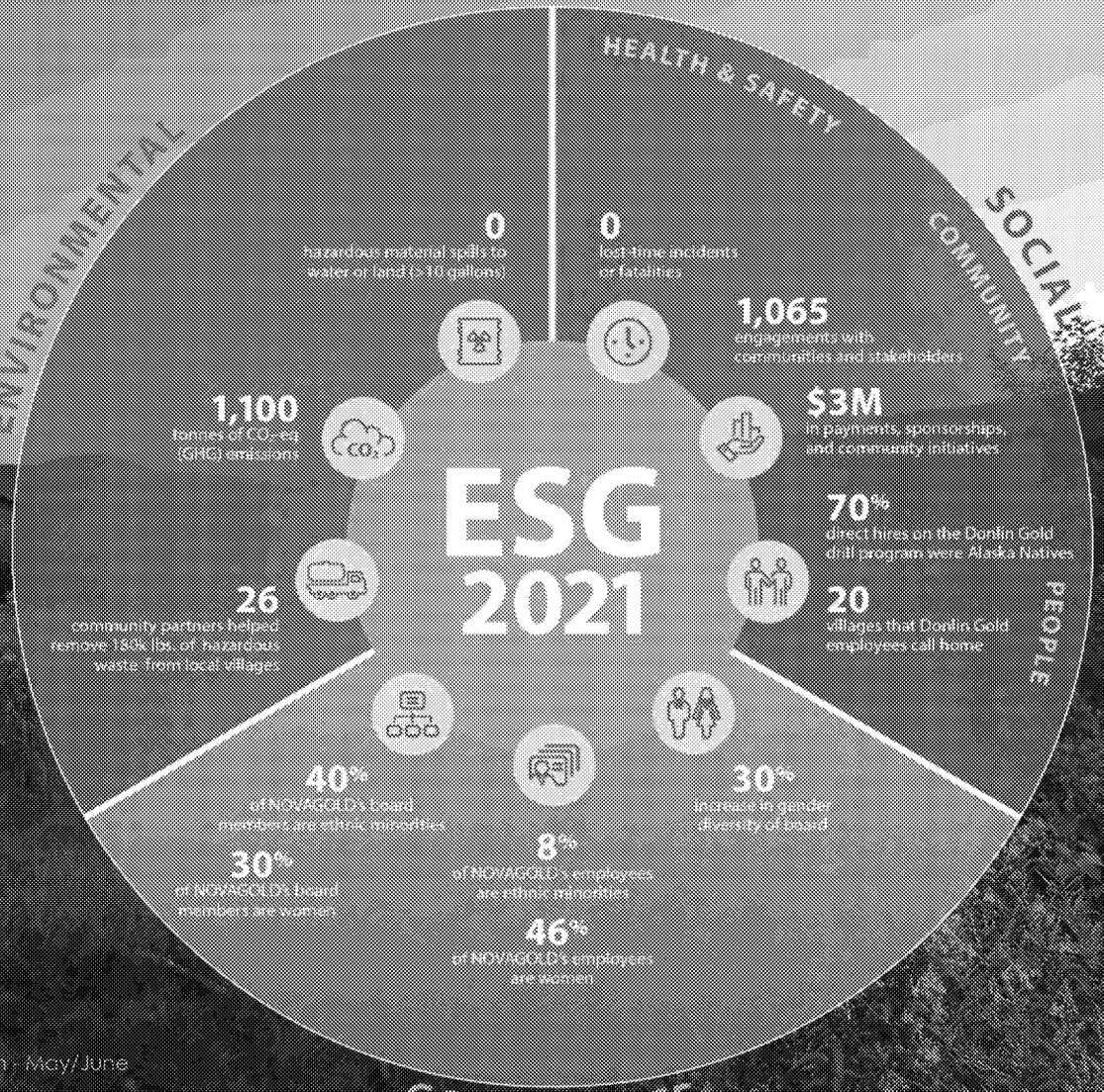
Sustainability performance



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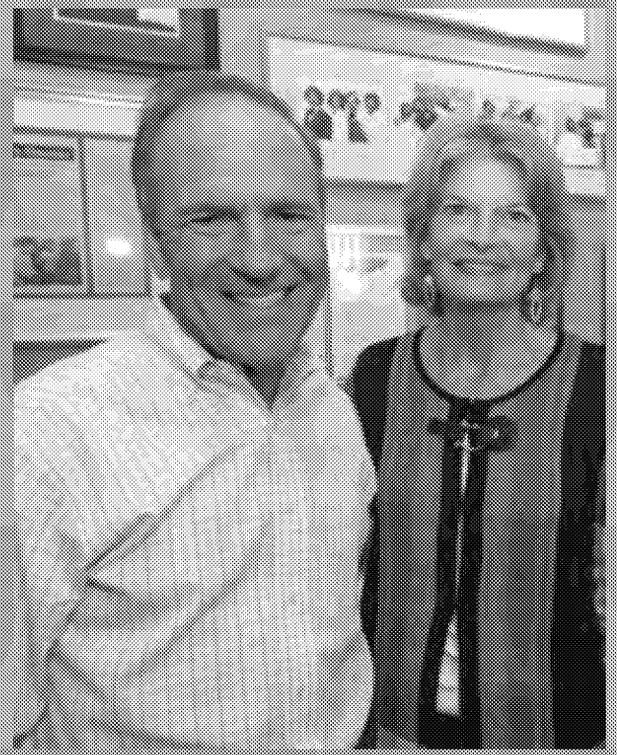
Decades of government engagement

Working together since 2001 to take the Donlin Gold project up the value chain

- The Donlin Gold project land and mineral rights are under private ownership of our Alaska Native Corporation partners, Calista Corporation and The Kuskokwim Corporation (TKC), whose mandate is to provide economic and social benefits for their shareholders, many of whom live in the Yukon-Kuskokwim region
- During the first quarter, Calista and Donlin Gold continued their proactive bipartisan outreach in Alaska and Washington DC to highlight the thoroughness of the project's environmental review and permitting processes as well as the benefits the project would deliver to Native Alaskans.
- Alaska's U.S. Senators recently reaffirmed their long-standing support of the Donlin Gold project in discussions with Donlin Gold, Barrick, and NOVAGOLD leadership
- Donlin Gold continues to work with our Native Corporation partners in all aspects of outreach and feedback in the communities of the Y-K region



Alaska Senator Lisa Murkowski and NOVAGOLD's President & CEO, Gregory F. Anderson, September 2021

NOVAGOLD

Donlin Gold: a tier-one asset[1] in a tier-one jurisdiction[2]

Generational asset with strong, investor-friendly attributes

SIZE

39 million gold ounces contained in measured and indicated mineral resources[3]

GRADE

2.24 g/t[4] Au more than double the world average grade[5]

EXPLORATION POTENTIAL

Only 5% of 489 sq km land package explored

PREMIER JURISDICTION

Alaska is a **top mining jurisdiction**[6] which respects socially and environmentally responsible mine development

PARTNERSHIPS

Successful track record of building long-term relationships with Native Corporations and Barrick

See endnotes for this slide in Appendix

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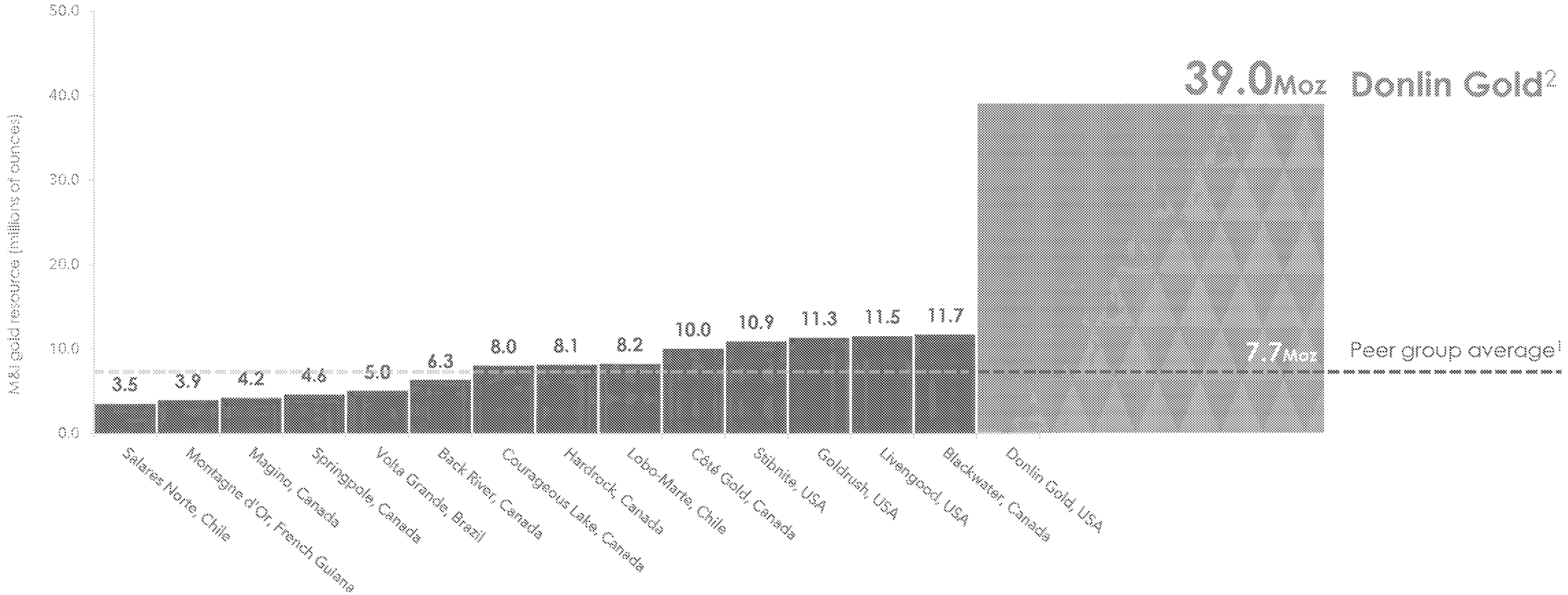
Largest gold development project in its category[1]

A resource more than five times the size of the peer group average



See endnotes for this slide in Appendix

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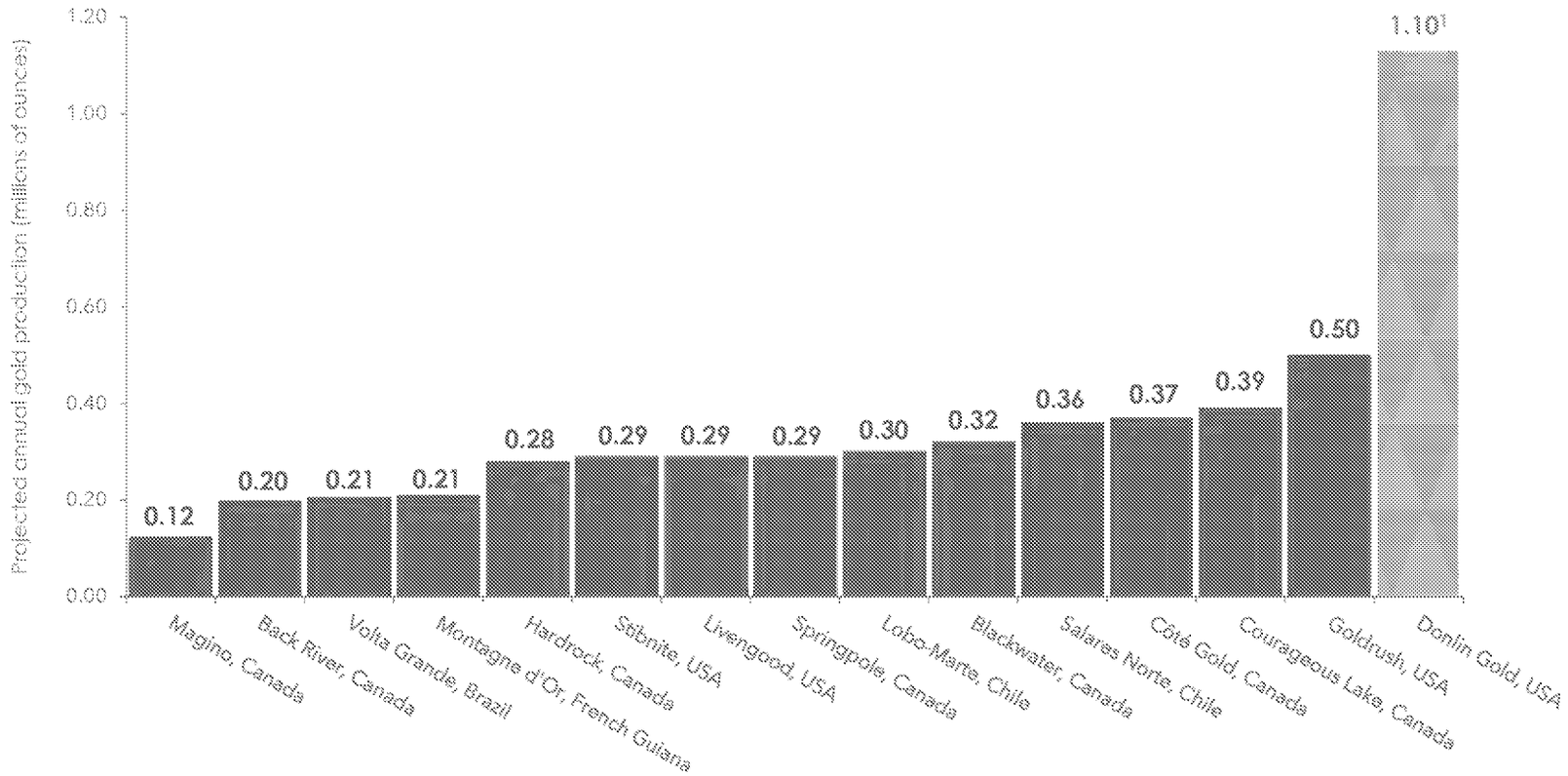
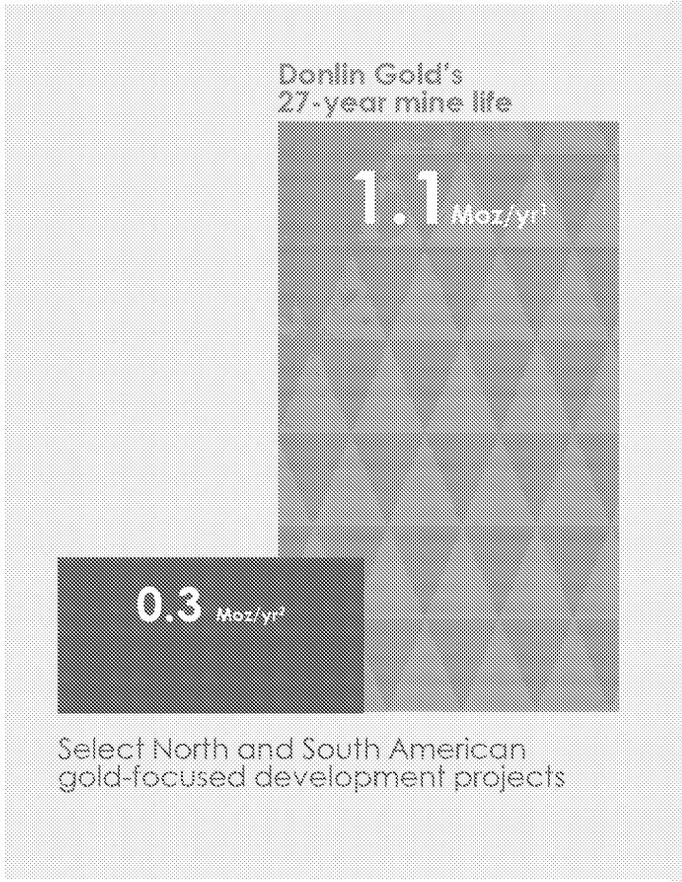
Positioned to become a million-ounce gold producer[1]

Anticipated to be one of the highest gold producers in the industry





See endnotes for this slide in Appendix

NOVAGOLD

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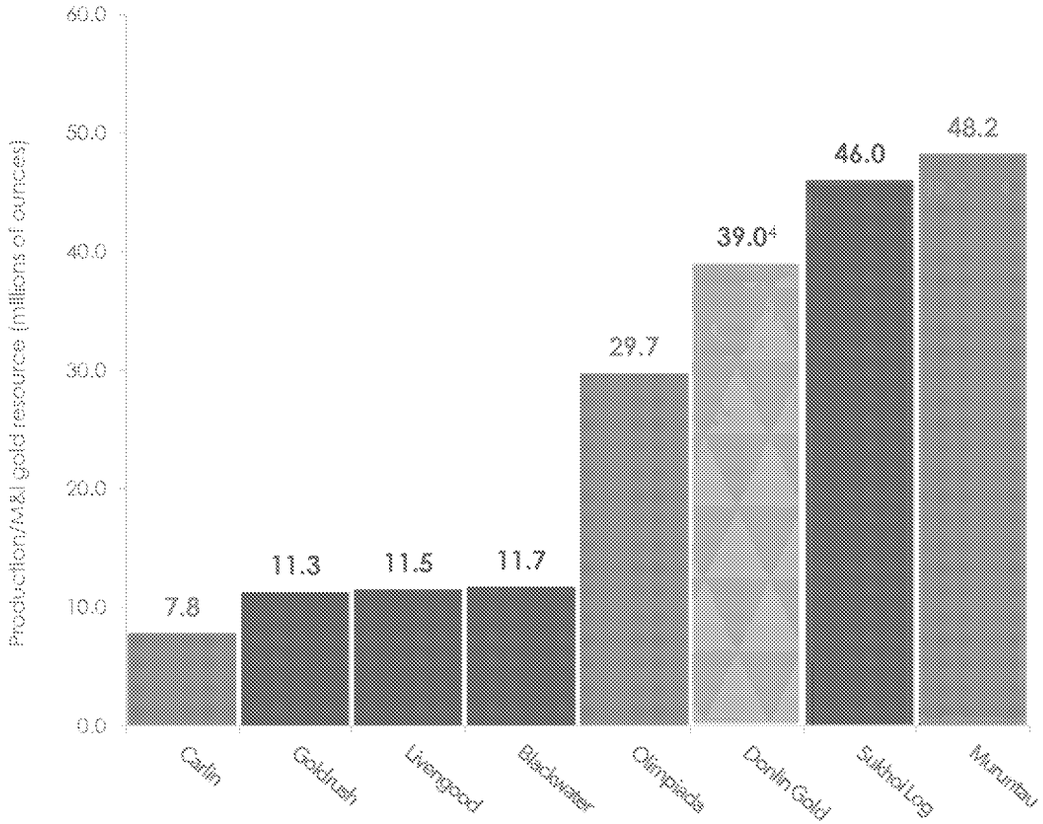
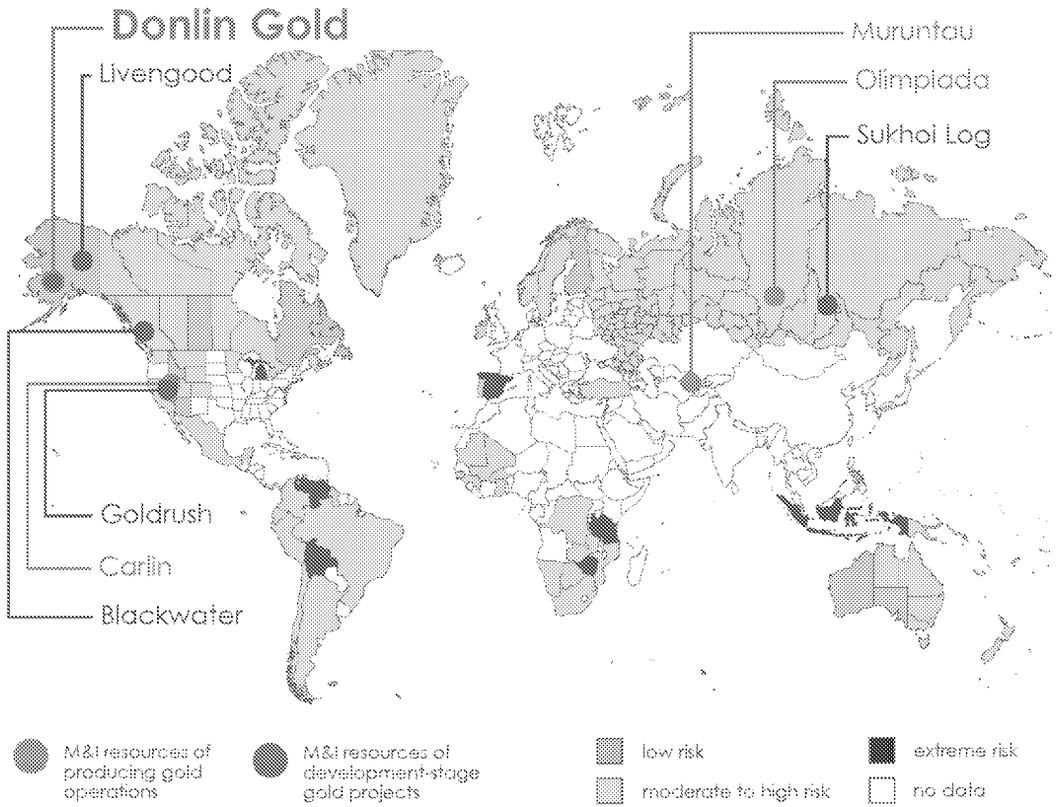
A substantial gold project in a safe jurisdiction[1]

Comparing the top three gold producing operations[2] and the five largest development-stage gold projects[3]





See endnotes for this slide in Appendix

NOVAGOLD

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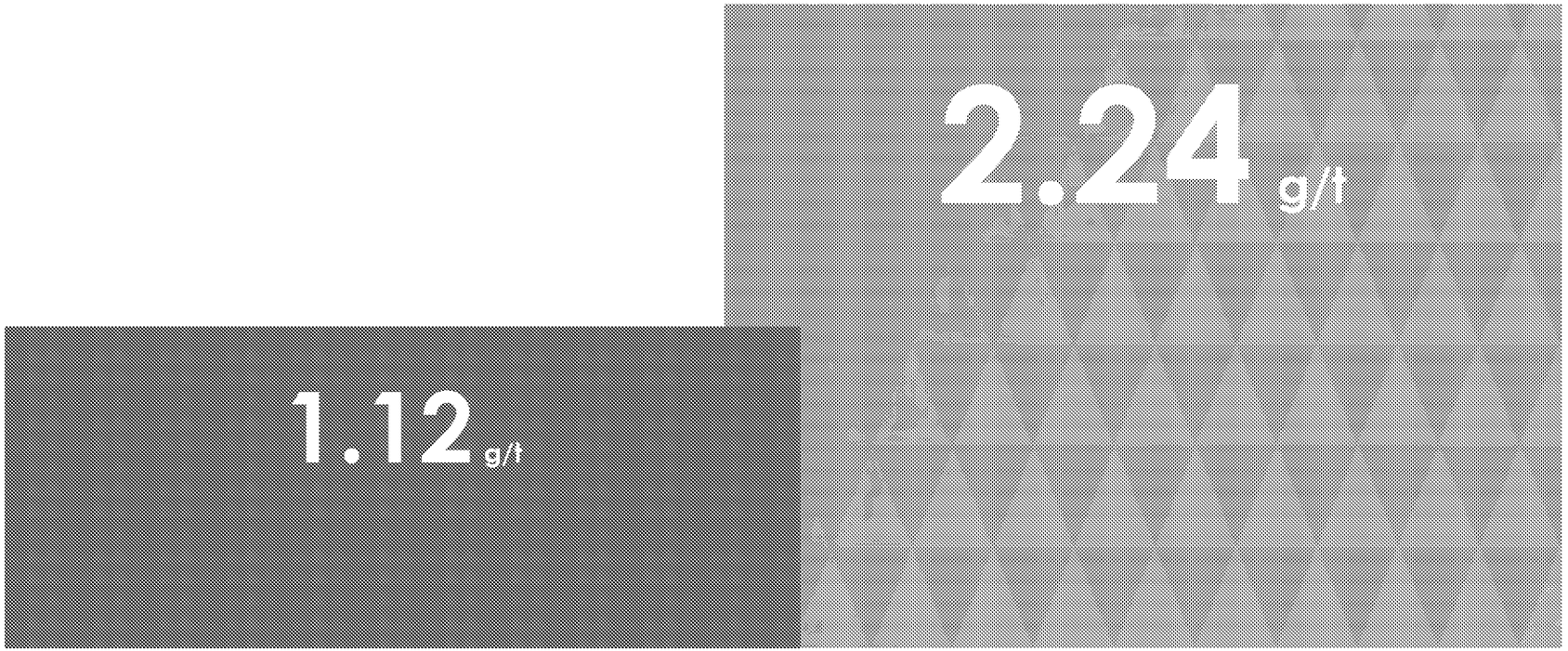
Double the global average gold grade[1]

Among the world's highest-grade known open-pit gold deposits



Global average grade[1]

Donlin Gold average grade[2]

While global average gold grades are declining, **Donlin Gold's grade provides resilience** through commodity price cycles

See endnotes for this slide in Appendix

NOVAGOLD

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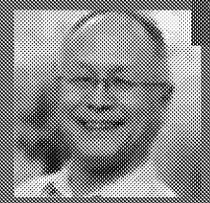
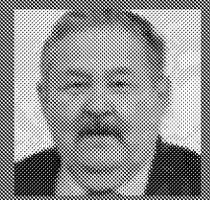
Alaska Native Corporation partnerships elevate the project

Donlin Gold has life-of-mine agreements with Alaska Native Corporations Calista and TKC

Land valuable for resource potential was selected by regional Alaska Native Corporations, and resource development companies were invited by the Native Corporations to explore. As landowners, Calista and TKC are committed to developing a mining operation consistent with the Elders' vision of responsible development that creates jobs and economic benefits while safeguarding the environment and culture.



Andrew Guy,
President & CEO



Robert Beans,
Board Chair

Calista Corporation

Calista has been involved with the proposed Donlin Gold project site for over 45 years. Calista and leaders from the region have worked toward and supported the effort to mine gold from the area. Our early leaders successfully fought for the right to select the land because of its rich mineral deposit. Collaboration and planning are vital when discussing opportunities within the industry. Our families and especially our children deserve the best when making decisions that affect their lives now and well into the future."

Andrea Gusty,
President & CEO

The Kuskokwim Corporation (TKC)

The Kuskokwim Corporation, TKC, has been involved every step of the way, in not only inviting Donlin Gold onto our land, but also in writing the permits, in environmental oversight, and really ensuring that this is the best possible project on our land to provide those opportunities for our shareholders, and so we have been very focused on this partnership between Donlin Gold and its partners, Barrick and NOVAGOLD. Calista Corporation and the Kuskokwim Corporation, we're all working very closely hand-in-hand."

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Promises kept, excellent partnerships

Track record of converting company goals into shareholder value

Successful strategic repositioning as a pure gold play

- 2012: Spin-out of 100%-owned Ambler project to form NovaCopper (now Trilogy Metals[1] – C$165M[2] market cap)
- 2018: Monetization of Galore Creek with 2018 sale of 50%-interest to Newmont Corp. for up to $275M[3]

Aligned on project strategy and timeline with Barrick Gold

- 14-year history of building value with an unwavering focus on stakeholder wealth creation; technical excellence; environmental stewardship; and social responsibility
- Constructive and positive relationship with Barrick, respect for Barrick's corporate objectives, including renewed focus on geology

Steady advancement of Donlin Gold up the value chain

2021
Technical report

2018
Receipt of Record of Decision and major Federal permits

2017-2021
Receipt of key state permits

2017-2021
Successful drill campaigns advance Donlin Gold up the value chain

2012
Permitting commences

2011
Technical report

Our focus: maximizing shareholder value

- No financing since early 2012
- Ensuring that Donlin Gold advances with limited impact to shareholder value

Culture of mutual respect between NOVAGOLD, Donlin Gold and local stakeholders

Well-established partnership with Native Corporations

- Resource development for future benefit of all stakeholders
- Employment, scholarships, workforce development and environmental programs in the region

See endnotes on the right: Appendix

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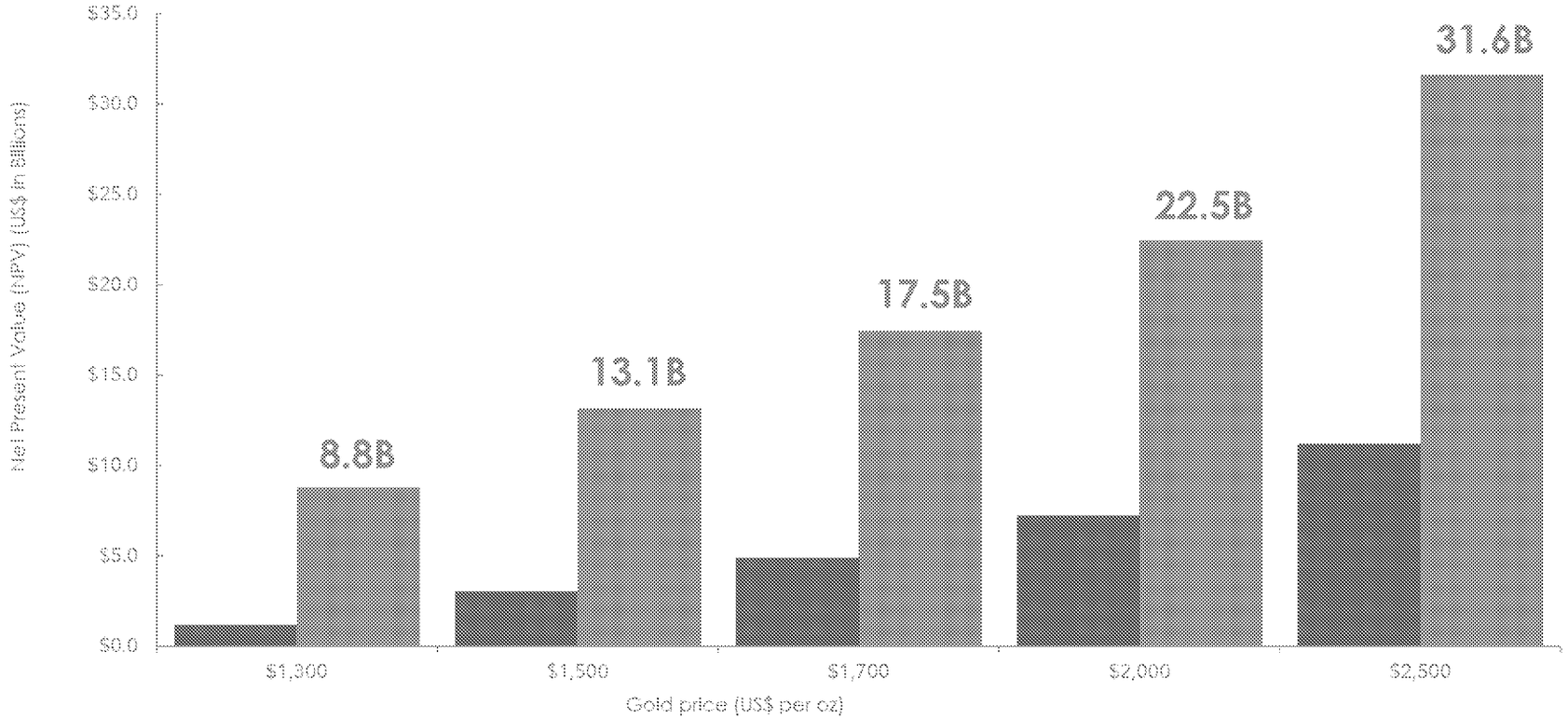
Significant value upside with higher gold prices



- Project return increases substantially with higher gold prices[1]
- Good payback at a broad range of gold prices
- Long mine life offers high likelihood of enjoying one or more cyclical bull markets

NPV at 5% NPV at 0%

Operating and capital costs per technical report not adjusted for inflation

See endnotes for this slide in Appendix

NOVAGOLD

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Strong institutional shareholder and management support

The 10 largest shareholders represent 64.4% of shares issued and outstanding[1] Executive Officers' ownership has increased to ~2.8 million shares[2] since joining the company

35.2%
all other shareholders

Common shares issued & outstanding[4]: 333,192,571[3]

Options[4]: 9,672,751

PSUs[4]: 1,293,200

DSUs[4]: 323,939

Warrants: None

64.8%
top 10 shareholders

25.4% Electrum Strategic Resources LP & affiliates

7.2% Fidelity Management & Research Company
6.7% Paulson & Co. Inc.
6.0% BlackRock Institutional Trust & affiliates
4.8% Saudi Public Investment Fund
3.8% EXOR Investments (UK) LLP
3.5% First Eagle Investment Management
3.4% Van Eck Associates Corporation
2.7% The Vanguard Group, Inc.
1.3% Kopernik Global Investors LLC

See endnotes for this slide in Appendix

NOVAGOLD

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Donlin Gold: a tier-one asset[1] in a tier-one jurisdiction[2]

Generational asset with strong, investor-friendly attributes

SIZE

39 million gold ounces contained in measured and indicated mineral resources[3]

GRADE

2.24 g/t[4] Au more than double the world average grade[5]

EXPLORATION POTENTIAL

Only 5% of 489 sq km land package explored

PREMIER JURISDICTION

Alaska is a **top mining jurisdiction**[6] which respects socially and environmentally responsible mine development

PARTNERSHIPS

Successful track record of building long-term relationships with Native Corporations and Barrick

See endnotes for this slide in Appendix

NOVAGOLD

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Appendix

NOVAGOLD

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Mineral reserves

Donlin Gold	Tonnage	Grade	Metal Content	Attributable to NOVGAOLD
GOLD	kt	g/t Au	koz Au	koz Au
Reserves[1]				
Proven	7,683	2.32	573	287
Probable	497,128	2.08	33,276	16,638
P&P	504,811	2.09	33,849	16,925

a) These Mineral Reserve estimates have been prepared in accordance with NI 43-101 and the 2014 CIM Definition Standard and S-K 1300, unless otherwise noted.
b) Rounding as required by reporting guidelines may result in apparent summation differences between tonnes, grade, and contained metal content.
c) Tonnage and grade measurements are in metric units. Contained gold is reported as troy ounces. Currency is reported as U.S. dollars.

*Mineral reserves and mineral resources are reported on a 100% basis and on a 50% basis. NOVAGOLD and Barrick each own 50% of the Donlin Gold project.

Donlin Gold approximate cut-off grades (see Mineral Resources and Reserves Footnotes):
Reserves[1] : 0.57 g/t gold
Resources[2] : 0.47 g/t gold

t = metric tonne
g/t = grams/tonne
oz = troy ounce
k = thousand
M = million

See endnotes for this slide in Appendix

NOVAGOLD

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Mineral resources

Donlin Gold	Tonnage	Grade	Metal content	Attributable to NOVGAOLD
GOLD	kt	g/t Au	koz Au	koz Au
Resources[2], exclusive of Reserves				
Measured	869	2.23	62	31
Indicated	69,402	2.44	5,435	2,718
M&I	70,271	2.43	5,497	2,749
Inferred	92,216	2.02	5,993	2,997
Resources[2], inclusive of Reserves				
Measured	7,731	2.52	626	313
Indicated	533,607	2.24	38,380	19,190
M&I	541,337	2.24	39,007	19,503
Inferred	92,216	2.02	5,993	2,997

*Mineral reserves and mineral resources are reported on a 100% basis and on a 50% basis. NOVAGOLD and Barrick each own 50% of the Donlin Gold project.

Donlin Gold approximate cut-off grades (see Mineral Resources and Reserves Footnotes):
Reserves[1] : 0.57 g/t gold
Resources[2] : 0.47 g/t gold

t = metric tonne
g/t = grams/tonne
oz = troy ounce
k = thousand
M = million

a) These Mineral Resource estimates have been prepared in accordance with NI 43-101 and the 2014 CIM Definition Standard and S-K 1300, unless otherwise noted.
b) See endnotes on resource information.
c) Rounding as required by reporting guidelines may result in apparent summation differences between tonnes, grade, and contained metal content.
d) Tonnage and grade measurements are in metric units. Contained gold is reported as troy ounces. Currency is reported as U.S. dollars.

See endnotes for this slide in Appendix

NOVAGOLD

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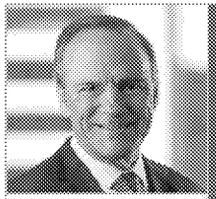
Management



Gregory Lang
President and CEO

- Former President of Barrick Gold North America
- 35+ years experience building & operating major open-pit and underground mines (Goldstrike, Cortez, Turquoise Ridge, Bald Mountain, Porgera)
- In-depth knowledge of Donlin Gold

David Ottewell
VP and Chief Financial Officer

- Former VP and Corporate Controller of Newmont Mining Corporation
- 25+ years of mining industry experience
- Diverse experience in all facets of financial management, from mine operations to executive corporate financial management of premier gold producers

Mélanie Hennessey
VP, Corporate Communications

- Held a variety of executive and senior IR & corporate communications positions with Goldcorp, New Gold, and Hecla Mining Company
- Leading NOVAGOLD's internal and external communications functions

Ron Rimelman
VP, Environment, Health, Safety and Sustainability

- 35+ years of environmental experience, managing environmental impact assessments and permitting activities world-wide
- Leadership role on mine permitting and NEPA evaluations for mine projects in Alaska since 1993
- President of the American Exploration and Mining Association, 2022

Richard Williams
VP, Engineering and Development

- Led the design and construction of the Pueblo Viejo project in the Dominican Republic
- 30+ years of experience developing and operating major mines (Goldstrike and Mercur)
- Highly knowledgeable and experienced leader in autoclave technology
- Member of the American Institute of Mining, Metallurgical, and Petroleum Engineers; CIM

Board of directors

Dr. Thomas Kaplan Chairman	• Chairman and CEO of The Electrum Group LLC, a privately held natural resources investment management company that controls a diversified portfolio of precious and base metals assets
Dr. Elaine Dorward-King	• Former Executive VP of Sustainability and External Relations at Newmont Corporation • Serves as a director of Sibanye-Stillwater, Kenmare Resources plc, and Great Lakes Dredge and Dock Company, LLC
Sharon Dowdall	• Former Chief Legal Officer and Corporate Secretary with Franco-Nevada, transforming an industry pioneer into one of the most successful precious metals enterprises in the world • Serves as director of Olivut Resources
Dr. Diane Garrett	• President, CEO and director of Hycroft Mining Holding Corporation • Former President and CEO of Nickel Creek Platinum and Romarco Minerals; and former director of OceanaGold and Revival Gold
Greg Lang President and CEO	• Former President of Barrick Gold North America, with intimate knowledge of Donlin Gold • Serves as director of Trilogy Metals
Igor Levental	• President of The Electrum Group LLC • Former VP of Homestake Mining and International Corona Corp.
Kalidas Madhavpeddi	• Chairman of Glencore plc, and director of Trilogy Metals and Dundee Precious Metals Inc. • Former CEO of China Moly Corp and former Executive with Phelps Dodge
Clynton Nauman	• CEO and director of Alexco Resources • Formerly with Viceroy Gold and Kennecott Minerals
Ethan Schutt	• Executive VP and General Counsel of Bristol Bay Native Corporation; and Board Trustee of the Alaska Permanent Fund Corporation • Former CEO of Alaska Native Resource Development LLC, an Alaska Native Tribal Health Consortium company (ANTHC) and Chief of Staff to ANTHC and Senior Vice President, Land and Energy Development for Cook Inlet Region Inc. (CIRI)
Anthony Walsh	• Former President and CEO of Miramar Mining Corporation, sold to Newmont Mining Corporation in 2007 • Serves as director of Dundee Precious Metals and Sabina Gold & Silver Corporation

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Endnotes

SLIDE 3 - 2021 drill program delivers outstanding gold intercepts

1. Significant intervals represent drilled intervals and not necessarily true thickness of mineralization. Mineralized intervals meet or exceed 3 meters in length above 1 g/t. A maximum of 4 meters of continuous dilution (< 1 g/t) is permitted.
2. See media release from February 28, 2022 titled "Donlin Gold Announces Final Assay Results for 2021 Drill Program; Highlights Include Numerous High-Grade Gold Intercepts Coupled With Important Grade Continuity; 2022 Project Budget Is Largest In Over a Decade."

SLIDES 4 – Strong partnership alignment

1. As per Barrick's Annual Report 2021 entitled "Building our future", released March 18, 2022, excerpt from page 24: https://bit.ly/3KcxG8C

SLIDE 6 - The next big gold discovery could be at Donlin Gold

1. Represents measured and indicated mineral resources previously reported by NOVAGOLD and supported by a past technical report, "Preliminary Assessment, Donlin Creek Gold Project, Alaska, USA", effective September 20, 2006. Represents 100% of measured and indicated mineral resources reported, of which NOVAGOLD's share was 70% in September 2006. Measured resources totaled 20 million tonnes grading 2.56 grams per tonne, and indicated resources totaled 196 million tonnes grading 2.39 grams per tonne. These estimates were not prepared in accordance with S-K 1300. This estimate has been superseded by the estimate contained in the 2021 Technical Report. For current mineral reserves and resources, refer to "Cautionary Note Concerning Reserve & Resource Estimates" and "Mineral Reserves & Mineral Resources" table on slides 2, 23 & 24.
2. Represents 100% of M&I resources, inclusive of mineral reserves, of which 50% is NOVAGOLD's share. Donlin Gold is not in production and a construction decision has not been made. For more information see "Cautionary Note Concerning Reserve and Resource Estimates" and "Mineral Reserves & Mineral Resources" table on slides 2, 23 & 24.
3. Represents 100% of inferred mineral resources, of which NOVAGOLD's share is 50%. See "Cautionary Note Concerning Reserve and Resource Estimates" and "Mineral Reserves & Mineral Resources" table on slides 3, 34 & 35. Inferred resources have a great amount of uncertainty as to their existence and as to whether they can be mined legally or economically.

SLIDE 9 - Maintaining a strong treasury

1. NOVAGOLD sold its 50% ownership of the Galore Creek project to Newmont in 2018. Deferred compensation on the sale of Galore Creek includes $25 million on earlier of Feasibility Study or July 27, 2023. An additional $75 million is due upon construction approval.
1. Forecast includes $30 million to Donlin Gold, $13 million to NOVAGOLD G&A and $3 million for withholding taxes on PSUs and other working capital. This presentation may also contain future-oriented financial information ("FOFI") and information which could be considered to be a "financial outlook". Such FOFI or financial outlook was approved by NOVAGOLD's management as of the date of this presentation for the purpose of providing management's reasonable estimate based on the assumptions set forth in such estimates and the information may not be appropriate for other purposes. Management cautions that such FOFI or financial outlook reflects NOVAGOLD's current beliefs and are based on information currently available to NOVAGOLD and on assumptions NOVAGOLD believes are reasonable. Actual results and developments may differ materially from results and developments discussed in the FOFI or financial outlook as they are subject to a number of significant risks and uncertainties. Certain of these risks and uncertainties are beyond the NOVAGOLD's control. Consequently, all of the FOFI or financial outlook are qualified by these cautionary statements.

SLIDES 12 & 21 - A tier-one asset in a tier-one jurisdiction

1. NOVAGOLD defines a Tier-One gold development project as one with a projected production life of at least 10 years, annual projected production of at least 500,000 ounces of gold, and average projected operating costs over the production life that are in the lower half of the industry cost curve.
2. NOVAGOLD considers Tier-One jurisdictions to be any in the top 10 rank by the Investment Attractiveness Index in the Fraser Institute Annual Survey of Mining Companies, 2021. Alaska is ranked number 4.
3. Represents 100% of M&I resources, inclusive of mineral reserves, of which 50% is NOVAGOLD's share. Donlin Gold is not in production and a construction decision has not been made. For more information see "Cautionary Note Concerning Reserve and Resource Estimates" and "Mineral Reserves & Mineral Resources" table on slides 2, 23 & 24.
4. Represents average grade of measured and indicated mineral resources, inclusive of mineral reserves. See "Cautionary Note Concerning Reserve and Resource Estimates" and "Mineral Reserves & Mineral Resources" table on slides 2, 23 & 24.
5. 2021 average grade of open-pit and underground deposits with gold as primary commodity and over 1Moz in measured and indicated resources, sourced from S&P Global Market Intelligence.
6. Alaska ranks number 4 globally in the Fraser Institute Annual Survey of Mining Companies 2021, Investment Attractiveness Index.
7. Map Source: Alaska Miners Association, "The Economic Benefits of Alaska's Mining Industry" February 2021.

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Endnotes

SLIDE 13 - Largest gold development project in its category

1. Peer group data based on company documents, public filings and websites as of February 2022. Comparison group of 14 projects based on large (2Moz Proven and Probable cut off), North/South American gold-focused development projects with >75% projected revenues from gold.
2. Represents 100% of M&I resources, inclusive of mineral reserves, of which 50% is NOVAGOLD's share. Donlin Gold is not in production and a construction decision has not been made. For more information see "Cautionary Note Concerning Reserve and Resource Estimates" and "Mineral Reserves & Mineral Resources" table on slides 2, 23 & 24.

SLIDE 14 - Positioned to become a million-ounce gold producer

1. Anticipated annual gold production during full life of mine if put into production as contemplated in the 2021 Technical Report and the S-K 1300 Technical Report Summary. See "Cautionary note concerning Reserve & Resource Estimates" and "Mineral Reserves & Mineral Resources" table on slides 2, 23 & 24.
2. Average of comparison group data of 14 projects based on large (2Moz P&P cut off), North/South American gold-focused development projects with >75% projected revenues from gold, as per latest company documents, public filings and websites as of February 2022.

SLIDE 15 – A substantial gold project in a safe jurisdiction

1. The jurisdictional risk map is derived from the top 10 (lower risk) and bottom 10 (extreme risk) of 77 jurisdictions reviewed in the Fraser Institute Annual Survey of Mining Companies 2020.
2. Only three mines produced greater than 1 million ounces in 2020: Muruntau (2,652koz), Carlin (1,665koz), and Olimpiada (1,229koz), as per SNL Metals & Mining, an offering of S&P Global Market Intelligence.
3. Gold development stage projects defined as the top 5 globally by contained gold in measured and indicated resources, >75% projected revenues from gold, and with stated proven and probable reserves, as per latest company documents, public filings and websites as of February 2022.
4. Represents 100% of M&I resources, inclusive of mineral reserves, of which 50% is NOVAGOLD's share. Donlin Gold is not in production and a construction decision has not been made. For more information see "Cautionary Note Concerning Reserve and Resource Estimates" and "Mineral Reserves & Mineral Resources" table on slides 2, 23 & 24.

SLIDE 16 - Double the global average gold grade

1. 2020 average grade of open-pit and underground deposits with gold as primary commodity and over 1Moz in measured and indicated resources, sourced from S&P Global Market Intelligence.
2. Represents average grade of measured and indicated mineral resources, inclusive of mineral reserves. See "Cautionary Note Concerning Reserve and Resource Estimates" and "Mineral Reserves & Mineral Resources" table on slides 2, 23 & 24.

SLIDE 18 - Promises kept, excellent partnerships

1. As per the media release titled "NovaGold Shareholders Overwhelmingly Approve the NovaCopper Spin-Out", dated March 29, 2012.
2. As of February 24, 2022.
3. As per the media release titled "NOVAGOLD Enters Agreement to Sell Its 50% Stake in Galore Creek to Newmont for up to $275 Million", dated July 26, 2018.

SLIDE 19 - Significant value upside with higher gold prices

1. Donlin Gold estimates as per the 2021 Technical Report and the S-K 1300 Technical Report Summary. All dollar figures are in USD, represent 100% of the project of which NOVAGOLD's share is 50%, and reflect after-tax net present value (at 0% and 5% discount rates) of the Donlin Gold project using the reference date of start of Year -06 as the first year of discounting. Estimated owner's initial capital project development costs of approximately $348M to be spent prior to the reference date are treated as sunk costs. At a 5% discount rate, the net present value is: $1,161M @ $1,300 gold; $3,040M @ $1,500 gold; $4,887M @ $1,700 gold; $7,229M @ $2,000 gold; and $11,199M @ $2,500 gold. The project requires a gold price of approximately $930 per ounce to break even on an undiscounted cash flow basis and a gold price of approximately $1,180 per ounce to break even on a 5% discounted basis.

SLIDE 20 - Strong institutional shareholder and management support

1. Shareholder positions are based on the latest 13-D, 13-F or 13-G filings as of March 31, 2022.
2. Per SEC Form 4 filings as of April 15, 2022 for NOVAGOLD's CEO and CFO under the NOVAGOLD Resources Inc. profile at https://www.sec.gov/edgar/search/ and https://www.novagold.com/investors/financials/.
3. Market Capitalization based on 333.2 million shares issued and outstanding and stock options outstanding as of March 29, 2022. NOVAGOLD share price of $6.38 as of May 4, 2022.
4. Common shares issued and outstanding, options, PSUs, and DSUs effective March 29, 2022. See SEC Form 10-Q filing dated April 5, 2022 for additional information.

SLIDE 28 - Global decline in reserves, discoveries, grade, and sharp underinvestment in exploration

1. Data on this slide from S&P Global Intelligence Metals and Mining Exploration Trends (PDAC special edition), published April 2022. Not all companies are considered in all categories.
2. S&P Global Market Intelligence, "Gold price increase drives surge of smaller discoveries", June 29, 2021. Gold contained in reserves, resources and past production, as calculated by S&P Global Market Intelligence. Grade refers to combined Reserves and Resources.

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Endnotes

SLIDES 23 & 24 - Mineral reserves and Mineral resources

1. Mineral Reserves are reported within the pre-feasibility pit designs, and supported by a mine schedule, featuring variable throughput rates, stockpiling and cut-off optimization. The pit designs are contained within an optimized pit shell based on the following economic and technical parameters: Metal price for gold of $1,200/oz; reference mining cost of $2.16/t incremented $0.0033/t/m with depth from the 220 m elevation (equates to an average mining cost of $2.64/t), fixed processing cost $13.78/t processed; sustaining capital of $1.54/t processed; general and administrative cost of $3.66/t processed; stockpile rehandle costs of $0.24/t processed assuming that 45% of mill feed is rehandled; variable metallurgical recoveries by rock type, ranging from 86.7% in shale to 94.2% in intrusive rocks in the Akivik domain; refining and freight charges of $1.21/oz gold; royalty considerations of 4.5% NSR and $0.50/t processed; and variable pit slope angles, ranging from 23° to 43°. Mineral Reserves are reported using an optimized block value (BV) based on the following equation: BV = Au grade * Recovery * $1,200/oz – royalties & refining costs – process operating costs – G&A cost reported in $/t. Assuming an average gold recovery of 89.5% the marginal gold cut-off grade would be approximately 0.57 g/t, or the gold grade that would equate to a $0.001 BV cut-off at these same values. The life-of-mine (LOM) strip ratio is 5.48:1. The assumed LOM throughput rate is 53,500 t/d.

2. Except as noted, Mineral Resources are inclusive of Mineral Reserves. Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability. Inferred Resources are in addition to Measured and Indicated Resources. Inferred Resources have great uncertainty as to their existence and whether they can be mined legally or economically. The cut-off date for the sample database used in the Mineral Resource estimate is 1 November 2009. However, more recent drilling data were used to validate the resource model as remaining current. Mineral Resources are constrained within a conceptual Measured, Indicated and Inferred optimized pit shell using the following assumptions: gold price of $1,200/oz; variable process cost based on 2.1874 * (sulphur grade) + 10.6485; administration cost of $2.29/t; refining, freight & marketing (selling costs) of $1.85/oz recovered; stockpile rehandle costs of $0.20/t processed assuming that 45% of mill feed is rehandled; variable royalty rate, based on royalty of 4.5% * (Au price – selling cost); and a variable metallurgical recovery depending on the host rock type ranging from 86 to 94%. Assuming an average recovery of 89.5% and average S% grade of 1.07, the marginal gold cut-off grade is 0.47 g/t. These technical and economic parameters are those that were used in the Donlin Creek Gold Project Alaska, USA, NI 43-101 Technical Report on Second Updated Feasibility Study, effective November 18, 2011 (as amended January 20, 2012) to establish reasonable prospects of eventual economic extraction. Based on the QP's review of the estimate, there would be no material change to the Mineral Resources if the gold price were updated to $1,500/oz and other economic parameters were updated to the 2020 parameters used in the Mineral Reserve estimate. As a result, the Mineral Reserve and Mineral Resource estimates shown above remain unchanged from the 2011 estimates contained in the prior technical report. See "Cautionary Note Concerning Reserve & Resource Estimates" on slide 2.

Technical Reports and Qualified Persons

The documents referenced below provide supporting technical information for the Donlin Gold project.

Project	Qualified Person(s)	Most Recent Disclosure
Donlin Gold	Kirk Hanson, MBA, P.E. Michael Woloschuk, P.Eng. Henry Kim, P.Geo. Wood Canada Limited	"NI 43-101 Technical Report on the Donlin Gold Project, Alaska, USA" prepared by Wood Canada Limited, effective June 1, 2021. "S-K 1300 Technical Report Summary on the Donlin Gold project, Alaska USA" dated November 30, 2021.

Paul Chilson, P.E., who is the Manager, Mine Engineering for NOVAGOLD and a "qualified person" under NI 43-101 and S-K 1300, has approved the scientific and technical information contained in this presentation.

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TSX, NYSE American: NG | novagold.com

NOVAGOLD RESOURCES INC.
Suite 1860 – 400 Burrard Street
Vancouver BC Canada V6C 3A6
T: 604 669 6227
TF: 1 866 669 6227
F: 604 669 6272
E: info@novagold.com

Mélanie Hennessey
VP, Corporate Communications
melanie.hennessey@novagold.com

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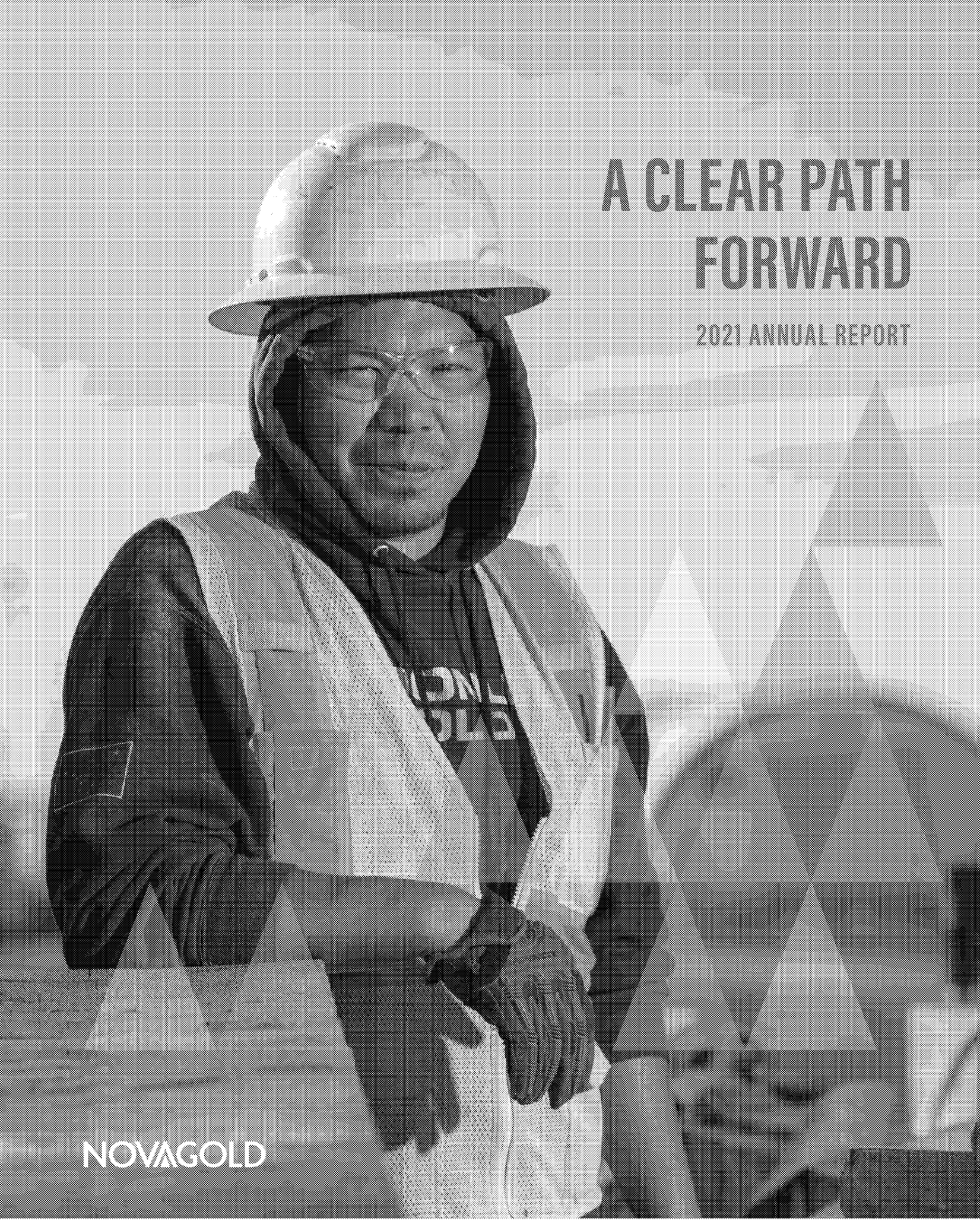
A CLEAR PATH FORWARD

2021 ANNUAL REPORT



NOVAGOLD

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COVER PHOTO: Donlin Gold employee and Stony River resident Christopher Gregory.

PAGE ONE: One of the drill rigs from Donlin Gold's 2021 drill program.

Our employees and neighbors take pride in the work and activities depicted in the photographs throughout this report, most of which were taken at the Donlin Gold site or in the surrounding communities.

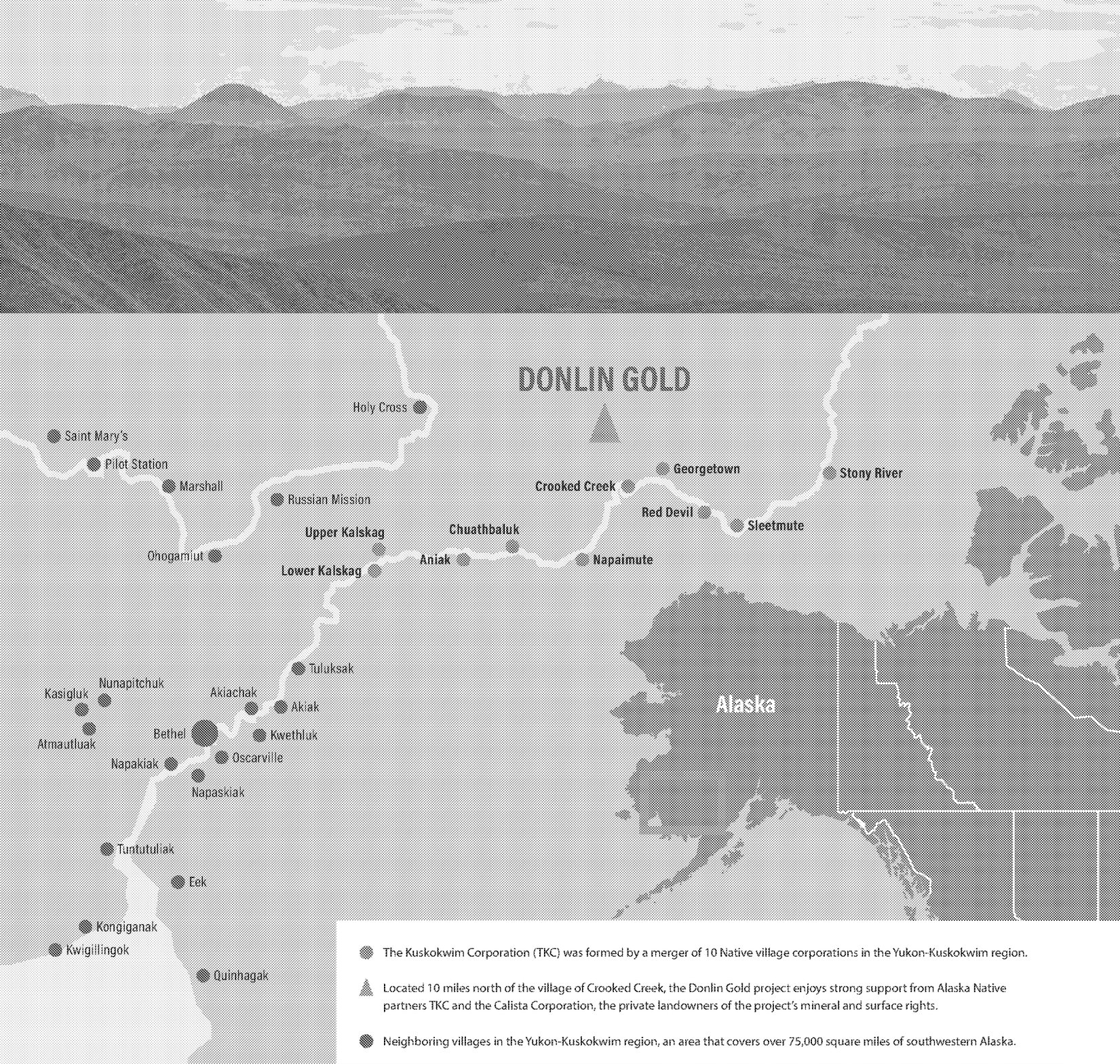
All scientific and technical information in the body of this annual report is qualified by – and is to be read in conjunction with – the Mineral Reserves & Mineral Resources table and associated notes found on page 35.

All dollar amounts quoted in this report are in U.S. currency unless otherwise noted.

This annual report contains forward-looking statements or information concerning anticipated results and developments in our operations in future periods, planned exploration activities, the adequacy of our financial resources, and other events or conditions that may occur in the future. It may include statements regarding perceived merit of properties, exploration results and budgets, mineral reserves and resource estimates, work programs, capital expenditures, operating costs, cash flow estimates, production estimates and similar statements relating to the economic viability of a project, timelines, strategic plans, including our plans and expectations relating to the Donlin Gold project, market prices for precious metals, or other statements that are not statements of fact. These statements relate to analyses and other information that are based on forecasts of future results, estimates of amounts not yet determinable, and the beliefs, expectations, and opinions of management as of the date of this report. We do not assume any obligation to update forward-looking statements if circumstances or management's beliefs, expectations, or opinions should change, except as required by law. Investors should therefore not place undue reliance on forward-looking statements. See complete disclaimer on page 35.

THIS IS AN EXCITING TIME FOR NOVAGOLD, ITS PARTNERS, AND ITS STAKEHOLDERS.

Key Donlin Gold permits received. Continued stakeholder support. Some of the best drill results in the gold mining industry. A progression plan in place — with more resources than ever committed to advancing the unrivaled Donlin Gold project further up the value chain.



The Kuskokwim Corporation (TKC) was formed by a merger of 10 Native village corporations in the Yukon-Kuskokwim region.

Located 10 miles north of the village of Crooked Creek, the Donlin Gold project enjoys strong support from Alaska Native partners TKC and the Calista Corporation, the private landowners of the project's mineral and surface rights.

Neighboring villages in the Yukon-Kuskokwim region, an area that covers over 75,000 square miles of southwestern Alaska.

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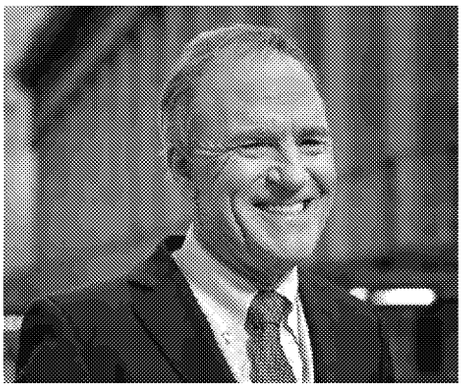

PRESIDENT & CEO'S MESSAGE

Gregory A. Lang

As we enter 2022, it is important to reflect on many milestones that were reached in 2021, a year in which we advanced our Donlin Gold project up the value chain against the backdrop of the global COVID-19 pandemic. And while the pandemic continues to affect us all, NOVAGOLD remains laser-focused on its top priority of ensuring the safety and well-being of employees, contractors, and the diverse community of stakeholders in its 50 percent-owned Donlin Gold project in Alaska. Our unwavering commitment to responsible mine development in the Yukon-Kuskokwim (Y-K) region remains strong.

HEALTH & SAFETY

NOVAGOLD is committed to the health, safety, and well-being of its personnel, visitors, and members of the multiple communities in which the company operates. We are proud of the fact that we have created a corporate culture that encourages safe practices for our workforce. Our safety achievement awards and performance recognition, both in the workplace and in our local communities, are highly sought after and hard-earned.

Since the start of the pandemic, the majority of NOVAGOLD employees have been working remotely. Despite less in-person engagement, we have managed to stay more connected than ever before. We continued to hold regular internal

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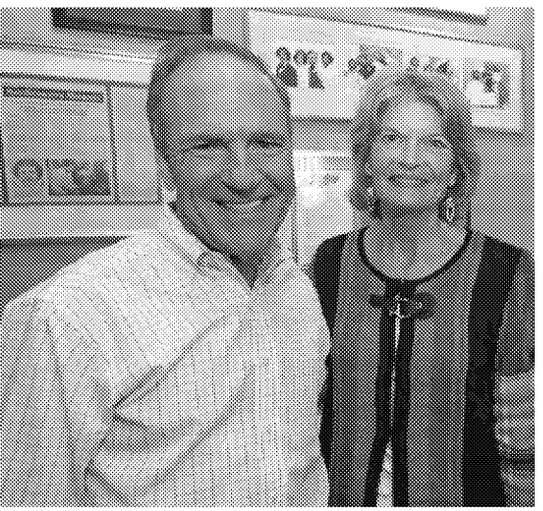
meetings and conferences, mainly in a virtual environment, and we maintained regular communications with our key stakeholders, shareholders, and investors. As we enter the third year of the pandemic, we reflect on the challenges that have affected our families, our communities, and our organizations.



I am proud of the accomplishments of the teams at NOVAGOLD, our partner Barrick Gold, and Donlin Gold, who executed the 2021 work program with minimal COVID-19 cases at the project site and no Lost-Time Incidents. During our 2021 field season, out of approximately 171,310 hours worked, we recorded four cases of COVID-19 at the Donlin Gold project site. The affected individuals fully recovered and ultimately returned to work.

Our operating protocols call for individuals to undergo mandatory COVID-19 testing prior to traveling to the Donlin Gold project camp and again before leaving the site to return home. Our procedures were especially important at the time when cases began to rise in Alaska throughout the summer. Our enhanced COVID-19 Community and Workforce Protection Plan was particularly effective in making sure that safe operations could continue and the workforce would remain safe and healthy. Careful collaboration with our Native Corporation partners Calista Corporation and The Kuskokwim Corporation (TKC), as well as with other Tribal groups in the Y-K region, remain key to our success.

In the third quarter, Donlin Gold put further restrictions on its Anchorage office following two positive COVID-19 cases there. All Donlin Gold employees in Anchorage who may have been exposed were tested and quarantined while continuing to work remotely in accordance with the protocols.

SUSTAINABILITY REPORT

NOVAGOLD developed a methodical process of reporting information related to environmental, social, and governance (ESG) matters for fiscal year 2020. We launched our inaugural Sustainability Summary in the Integrated Annual Report, which is now available on NOVAGOLD's website. For 2021, NOVAGOLD will be issuing a stand-alone Sustainability Summary Report to offer more information and detail regarding our ESG initiatives. These initiatives have always been an important part of our business, and we are excited to be building upon our track record of sharing our comprehensive ESG framework with our stakeholders. We are invested in achieving the highest possible standards through our workforce development, performance, actions, and conduct as we continue to make improvements to this increasingly important sphere of our operations while advancing Donlin Gold up the value chain. NOVAGOLD is committed to responsible mining, stewardship of the environment, and community support in the areas where we operate.

If you haven't already done so, please subscribe to NOVAGOLD's email list and follow us on social media to ensure you don't miss our Sustainability Summary Report.

COMMUNITY PARTNERSHIPS & COMMITMENTS

Donlin Gold is fortunate to have long-term partnerships with Calista and TKC, owners of the project's mineral and surface rights, respectively. These partnerships date back decades. The project's location on private land specially designated for mining activities, enshrined through the 1971 Alaska Native Claims Settlement Act (ANCSA), distinguishes it from many other mining projects in Alaska. In fact. 2021 marked the 50th anniversary of this landmark act, which has served as a pillar of support for the well-being of the Indigenous people of Alaska. We are proud to share that in September 2021, the board of directors of the ANCSA Regional Association of the 12 regional Native Corporations unanimously passed a resolution in support of the Donlin Gold project. As representatives of key

▲ NOVAGOLD president & CEO Gregory Lang with U.S. Senator Lisa Murkowski at a Donlin Gold dinner in Anchorage in September 2021.

▶ Donlin Gold's 2021 "In It for the Long Haul" backhaul project removed and consolidated approximately 180,000 pounds of hazardous and electronic waste from 26 villages throughout the Y-K region, including Bethel, where these photos were taken.

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stakeholders in the state, the support of the ANCSA Regional Association is greatly appreciated.

As landowners, Calista and TKC are committed to developing a mining operation consistent with the Elders' vision of responsible development that creates jobs and economic benefits for the community while protecting the environment and local culture. This commitment is at the core of both Barrick's and NOVAGOLD's philosophy on how the project should be developed. During the 2021 field season, 70 percent of Donlin Gold direct hires were Alaska Natives from 20 Y-K communities. In a region marked by high unemployment and fewer job options than in urban areas, the work experience and skills gained at Donlin Gold are particularly valuable to the local community members.

Donlin Gold is committed to supporting the needs of its community partners. As part of Donlin Gold's ongoing community engagement efforts, we continue to make progress in formalizing these relationships and finding common ground with Shared Value Statements that build upon the long-term agreements with Calista and TKC that are already in place. At the end of 2021, Donlin Gold had entered into Shared Value Statements with eight villages from the Y-K region (Akiak, Sleetmute, Napaimute, Crooked Creek, Napaskiak, Nikolai, Tuluksak, and Upper Kalskag). These agreements include educational, environmental, and social initiatives which help provide support for these villages.

In the first quarter of 2021, Donlin Gold, in partnership with TKC, the village of Crooked Creek, and the Napaimute Tribe, was the lead sponsor of a program to construct and maintain the upper portions of the ice road on the Kuskokwim River. The ice road greatly improved safety and access to nearby communities for residents in remote locations. At its completion in February 2021, the Kuskokwim ice road was approximately 200 miles long.

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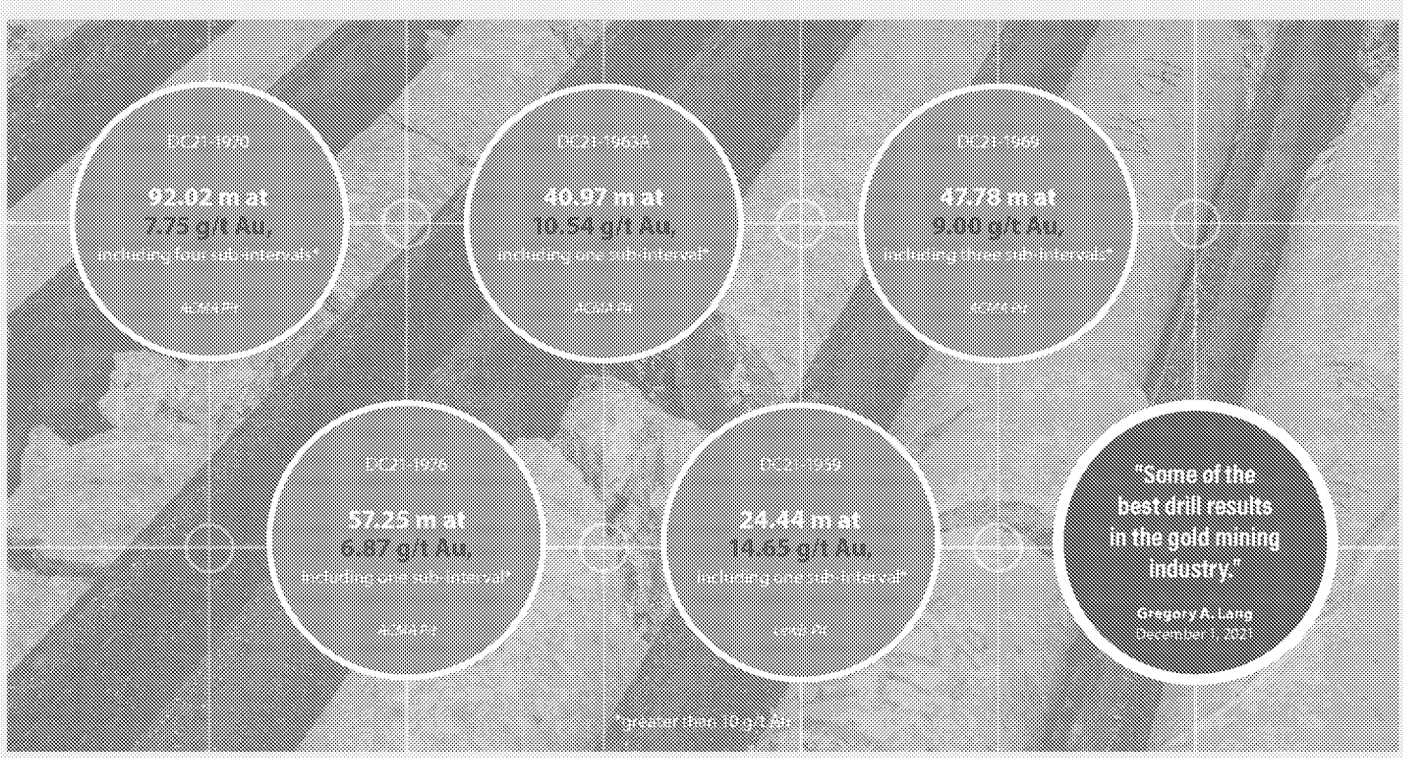
In mid-January 2021, the water supply plant in the Middle Kuskokwim village of Tuluksak (population 370) was destroyed by fire, creating a health and safety crisis for the entire community. Donlin Gold worked with the Tuluksak Tribal administrator and Tribal council to assess how they could best help coordinate support for immediate needs and sustainable long-term solutions. In the days following, Donlin Gold, together with several other community organizations, companies, and individuals, stepped in to provide drinking water, buckets for carrying and storing water, sanitary wipes, diapers, and other health supplies. Team members traveled to Tuluksak via the ice road and delivered 100 five-gallon reusable containers of water to be distributed to each household in the community. Shortly after the fire, Donlin Gold worked with Alaska Commercial Company and Fox Air in Bethel to deliver 120 cases of water, along with basic needs items like paper towels, baby wipes, hand sanitizer, and bar soap to the village as quickly as possible. Donlin Gold also arranged for Desert Air to donate a DC-3 flight directly from Anchorage to Tuluksak to bring a second delivery of water tanks, containers, pumps (including hose assemblies), totes for washing and bathing, scrub brushes for cleaning, 50 more cases of water, and other supplies.

In March 2021, following the Tuluksak fire, the Thomas Lodge in Crooked Creek – the only lodging facility in the village that is closest to the project site – also suffered substantial fire damage. Donlin Gold aided with labor and materials to get the building back in order and operating by May, prior to the busy summer season.

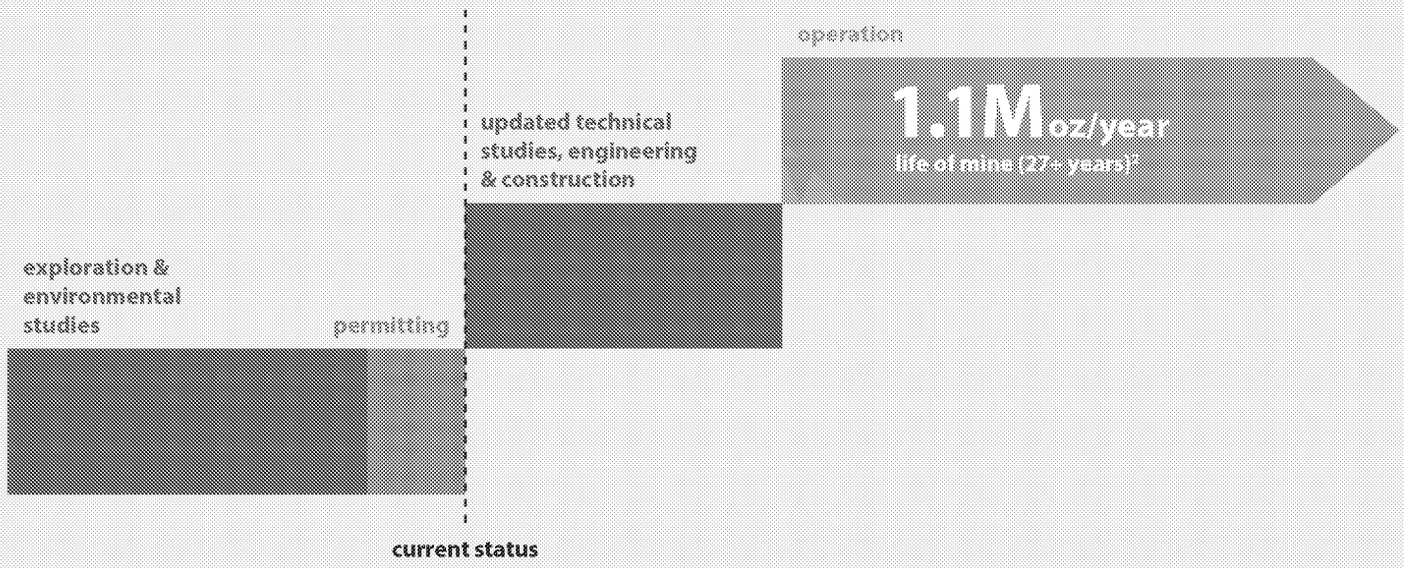
In August, Donlin Gold held the fourth annual "In It for the Long Haul" backhaul project, removing and consolidating approximately 180,000 pounds of hazardous and electronic waste from 26 villages throughout the Y-K region. The waste was then packed into containers and shipped to Anchorage and Seattle for recycling and safe, proper disposal. In terms of scale and reach, this was the most successful backhaul yet. Over the past five years this program has removed almost 400,000 pounds of hazardous and electronic waste from Y-K villages.

Access to training and education are two important areas in which we collaborate with our Native Corporation partners. The Lower Kuskokwim School District's annual college and career fair was held virtually in April, with a record number

SIGNIFICANT HIGH-GRADE INTERCEPTS FROM THE 2021 DRILL PROGRAM[1]



PROJECTED LIFE CYCLE



of vendors and high student participation. Donlin Gold also sponsored the annual Best in the West competition at the Kuskokwim campus of the University of Alaska to encourage and support the leaders of tomorrow.

In January 2022, NOVAGOLD established the Mining and Geological Engineering Scholarship at the University of Alaska (Fairbanks & Anchorage) to help support students seeking bachelor's degrees in mining or geological engineering, with a focus on underrepresented students as a commitment to foster diversity in the industry.

Along with supporting initiatives in Alaska, NOVAGOLD recognizes the importance of sponsoring events in the areas where we operate. In May of 2021, we sponsored and participated in the Mining for Miracles Pie Throw, a fundraising event in support of the BC Children's Hospital in Vancouver. Each year, senior leaders from across the industry are paired up in a friendly fundraising competition, with the one raising the most money earning the right to toss a pie at the other. I was happy to participate in this event and help raise funds for the Cellular and Regenerative Medicine Centre. In a healthy competition with Red Conger from Teck, I was on the receiving end of the pie.

These various community partnerships, activities, and programs form just one dimension of NOVAGOLD's multi-dimensional commitment to sustainable and responsible development.

2021 DRILL PROGRAM – CONTINUING & CONSISTENT SUCCESS

Following completion of a strong 2020 drill program, our plan for 2021 was to complete the work necessary to validate mineralization continuity and structural control, as well as test extensions of high-grade zones within different rock types. This information was important to increase confidence in geologic modeling concepts ahead of an updated feasibility study.

We re-opened the Donlin Gold camp in May 2021 with numerous improvements completed ahead of the ambitious field season. Specifically, heavy equipment was purchased, kitchen facilities expanded, a new recreation area furnished, sleeper capacity expanded, camp facilities remodeled, a large new warehouse added, core logging, and cutting facilities upgraded. With the crews operating efficiently – and without increasing the budget – the drill program was expanded to include 13 additional holes to gather more closely spaced data to assess the dominant controls and orientations of gold mineralization. I am delighted to report that the 2021 drill program was completed in September, on time and on budget, with 79 holes drilled for a total of 24,264 meters. The program yielded some of what I view as the best results in the gold mining industry for an open-pit project, and we are grateful to our local and Alaska partners who have worked with us to reach these important milestones.

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Greater attention was paid to the eastern side of the ACMA pit area that transitions into the Lewis pit area and has had less drilling than the main areas of the deposit.

As with the 2020 drill results, we have gained a better understanding of the definition of controls on mineralization in the deposits. The last core was logged in mid-October with final samples sent offsite to laboratories for further processing. The core logging and assay laboratory results data will be incorporated into a geologic model update, with the subsequent shift to feasibility study update work, subject to a formal decision by the Donlin Gold LLC Board.

As the 2021 drilling was coming to a close, Barrick and NOVAGOLD held senior executive management workshops and a site visit aimed at jointly assessing results and mapping out future plans. Barrick CEO Mark Bristow and I met with local stakeholders as well as with senior Alaska federal and state representatives who expressed their continued support for the project. Following these meetings, the Donlin Gold LLC board approved an additional $3 million expenditure for 2021 to advance studies and increase staffing in preparation for an updated feasibility study.

Final results from the 2021 drill program are expected to be released in early 2022. The camp was closed at the end of October 2021 and re-opened in January 2022 for a winter drill program that will continue into the summer and fall of 2022. Part of the objective of the 2022 exploration and drill program will be to confirm mineralization continuity and key geologic controls in other representative areas of the deposit.

The owners of this large, multi-generational, high-grade project, located on private land specially designated for mining activities in a Tier-One[3] jurisdiction, have a unique opportunity to generate wealth in the area. The fact that it is being advanced in partnership with Alaska Native Corporations – who are committed to developing a mining operation consistent with the Elders' vision of responsible development that creates social and economic benefits while safeguarding the environment and culture – makes Donlin Gold unique.

Barrick Gold president & CEO Mark Bristow and NOVAGOLD president & CEO Gregory Lang at the Donlin Gold site in September 2021.

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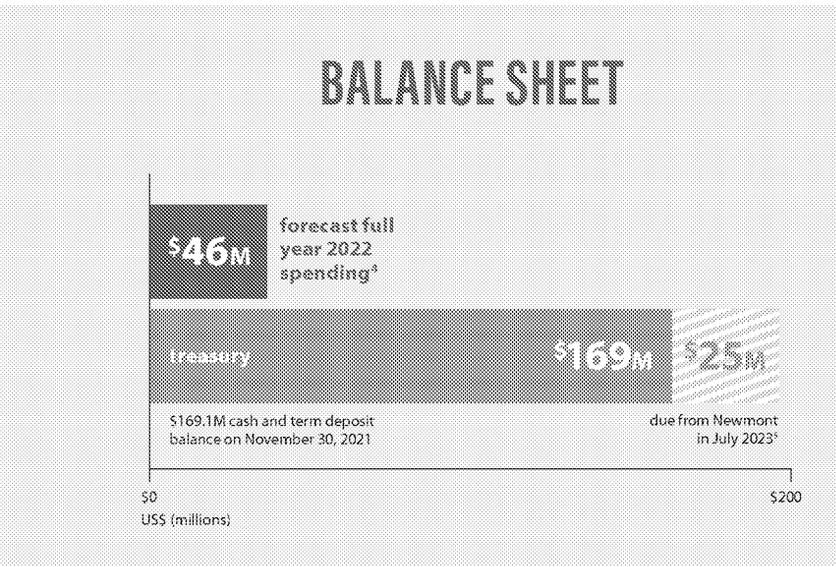

PERMITTING

With federal permitting complete, Donlin Gold, together with Calista and TKC, continued to focus its 2021 permitting efforts on advancing the remaining Alaska permits and approvals for the project. A lot of effort went into supporting the Alaska agencies with various permit applications.

In late 2021, the Donlin Gold project was issued a third extension of the air quality permit by the State of Alaska. This is a rare achievement and speaks to the dedicated effort by all on the permitting team, including our native partners and Alaska agencies. Three permits held by Donlin Gold came under appeal in 2021, specifically the Clean Water Act Section 401 certification, the 12 water rights permits, and the Right-of-Way (ROW) agreement for the buried natural gas pipeline. The permits remain in effect while these appeals are pending.

Unfortunately, litigation led by environmental non-governmental organizations (ENGOs) that oppose resource development of any kind has become a regular part of business in the U.S. and, as such, is something that must be anticipated in the planning process from the start of permitting. We are not surprised by these legal challenges. As a consequence, we have built and sustained, in partnership with the Alaska Native landowners and our partner Barrick Gold, a comprehensive, science-based record that we believe will withstand any legal challenge to our permits.

The most significant outstanding Alaska permits are the dam safety certifications. Securing these permits requires a multi-year effort to gather geotechnical data and prepare various engineering studies. It is anticipated that the 2022 work plan will incorporate important milestones to advance the work in this area.

BALANCE SHEET

NOVAGOLD's strong balance sheet allows us to continue taking the company up the value chain without the need for raising more capital and, by extension, diluting shareholder value. We now have approximately $169 million in cash and term deposits as of November 30, 2021, which we believe is sufficient to advance Donlin Gold to a point when a construction decision would be made. Our treasury includes a payment of $75 million the company received from Newmont Corporation in July 2021 related to the sale of NOVAGOLD's 50 percent interest in the Galore Creek project in British Columbia[6]. Another payment of $25 million from Newmont comes due in July 2023. There's an additional payment of $75 million contingent upon a Galore Creek construction approval.

2022 GOALS & BUDGET

By all measures, Donlin Gold is an exceptional project. With approximately 39 million ounces[7] of gold in measured and indicated mineral resources, it is one of the largest in the world. Its grade of 2.24[8] grams per tonne is approximately twice the industry average[9]. The 2021 drill program has been very successful in reinforcing the robust integrity of this massive endowment.

Donlin Gold is in the rare position of having a sufficient foundation to advance toward construction once the owners make that decision. As currently envisioned, the project would produce an average of about 1.1 million ounces per year over its 27-year mine life[10], a very important factor given a frequently held view that global gold production is expected to decline in the absence of major new discoveries. Furthermore, the fact that it is located in Alaska, where there is long-standing support

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for socially and environmentally responsible mine development and respect for the rule of law, gives Donlin Gold a special status among the very few of the world's development projects, particularly in light of the fact that the project already has all the major federal and most key Alaska permits.

Any discussion about Donlin Gold would not be complete without reference to its exploration potential. The project's current resources and reserves are contained within only three kilometers of an eight-kilometer mineralized belt which, in itself, represents only five percent of the total mineral land package. It is not surprising that the consistency of grade and high-grade intercepts from the current and past drill programs are further reinforcing its exploration potential.

Looking ahead to 2022, NOVAGOLD and Barrick expect to finalize geologic modeling and interpretation work with results from the 2021 drill program for an updated resource model, which would then lead into an updated feasibility study. We are particularly intrigued by the 2022 work plan, which includes some exploration drilling under the ACMA and Lewis pit areas that are open along strike and at depth.

NOVAGOLD anticipates spending approximately $46 million in 2022. About $30 million will be allocated to fund our share of expenditures at the Donlin Gold project, representing the largest project budget in more than a decade. It includes $17 million for the 2022 drill program; $9 million for external affairs, permitting, environmental, land, and legal activities; and $4 million for project planning and fieldwork. A total of $13 million is allocated for NOVAGOLD general corporate and administrative costs and an additional $3 million for withholding taxes on share-based compensation and other working capital.

CONCLUSION

I wish to thank the experienced team of professionals at NOVAGOLD, Donlin Gold, and Barrick, along with our drill crews and contractors at the project site, for their expert navigation of the project. Our success would not have been possible without their dedication and hard work. There's tremendous commitment by each of these groups to maintain the highest standards of safety and environmental protection. My gratitude also extends to the various State of Alaska agencies for their thorough and professional work in advancing permitting for the project. A big thank-you also goes to Calista and TKC, our Native Corporation partners who have been strong supporters in ensuring that Donlin Gold is developed to the highest standards of environmental stewardship and social responsibility. I would also like to express my sincere thanks to the entire NOVAGOLD board and team for their commitment and devotion to the company. I enjoy working alongside each and every one of you.

Lastly, I'd like to thank our shareholders for your unwavering support, engagement, knowledge, and encouragement. Each of these strong relationships has been strengthened over the past two years during the pandemic, and I look forward to continuing our engagement and sharing many more achievements in 2022.

Gregory A. Lang
President and CEO
February 28, 2022

Donlin Gold employees from the Y-K region (left to right): Daryl Petruska, Christopher Gregory, Scott Fitka, Jordan Shriner.

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THE UNRIVALED DONLIN GOLD

39Moz

There are 39 million gold ounces[7] contained in Donlin Gold's measured and indicated resources – five times the peer group average.

5%

Only five percent of Donlin Gold's total land package has been explored.

TOP 5

According to the Fraser Institute[10], Alaska is ranked fifth in the world for investment attractiveness.

2.24g/t

Donlin Gold's grade – 2.24 grams of gold per tonne[8] – is more than double the world's average among known open-pit deposits.

$169M

NOVAGOLD has a strong balance sheet, including $169.1 million in cash and term deposits as of November 30, 2021, plus $25 million in notes receivable in 2023.

2+2

A true partnership between NOVAGOLD and Barrick, project owners, and Calista and TKC, mineral and surface rights owners.

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The Donlin Gold 2021 drill program was completed with 79 holes drilled for a total of 24,264 meters.

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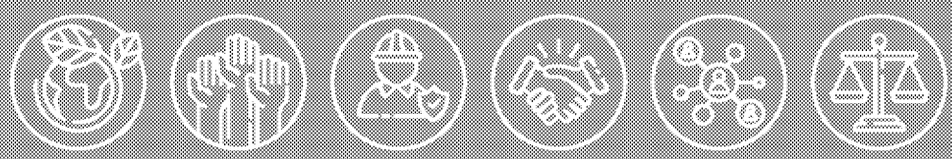
S U S T A I N



NOVAGOLD is committed to delivering long-term value to all our stakeholders through responsible mining. Our sustainability approach involves setting and meeting high standards in environmental, social, and governance matters in all that we do – while contributing to the social and economic development of the communities in the regions where we operate. We believe that mines can be responsibly developed in partnership with our local stakeholders who have the knowledge to help us manage and minimize environmental impacts. NOVAGOLD is committed to building trust and transparency, continuous improvement, and stage-appropriate enhancements to its sustainability initiatives and policies.

The 2021 Sustainability Summary is our first stand-alone report that integrates sustainability data and gives stakeholders a tangible overview of our non-financial performance in fiscal year 2021. This report demonstrates how policy and practice are bringing about real and positive benefits at the Donlin Gold project and for the Yukon-Kuskokwim region, both today and in the years to come.

The ACMA and Lewis deposits at the Donlin Gold project site in the Yukon-Kuskokwim region in Alaska.

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CHAIRMAN'S INTERVIEW

John Hathaway (left) and Dr. Thomas S. Kaplan (right)

On Friday, December 3, 2021, John Hathaway, CFA — portfolio manager of Sprott Hathaway Special Situations Strategy and co-portfolio manager of the Sprott Gold Equity Fund — sat down with Dr. Thomas S. Kaplan, chairman of the board of directors at NOVAGOLD and chairman and CEO of The Electrum Group. The two discussed gold's market trajectory, jurisdictional safety, and cryptocurrencies — and why Tom thinks NOVAGOLD has the potential to significantly outperform its peer group. The interview has been edited both for length and for clarity; to watch a video of the conversation, please visit novagold.com/media-gallery.

This interview should be read in conjunction with the cautionary statements and the "Mineral Reserves & Mineral Resources" information on page 35.
All figures are in USD unless otherwise stated.

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John Hathaway: Tom, it's so nice to see you. Thank you for inviting me.

Dr. Thomas S. Kaplan: The pleasure is mine. And so is the honor.

I've known you forever, it seems.

You have.

Through many iterations. What led you to NOVAGOLD after Apex, African Platinum – or, as then known, South African Resources – and a few other things along the way, not to mention your other interests that are not remotely gold-oriented? But maybe they all fit together.

It may simply be because I'm shallow and superficial, but I am clearly drawn to the iconic. I'm drawn to beauty. I'm drawn to great assets – those things which really give me a sense of joy when I'm engaged with them. And that runs the gamut. So, in my business career, I've had the great luck of being able to either discover – in the case of silver, platinum, natural gas – or to take control of assets that are really category-killers in their space, and which have almost always ended up being in the portfolios of much larger companies who needed these kinds of assets to move the needle in their own reserves or production.

There is something of a correlation when you look at my other interests too. In art, for example, I'm drawn to Rembrandt. There isn't any list of the greatest painters of all time which doesn't include Rembrandt and several other artists that I love. It's that combination of intensity and beauty – similarly with a passion that, for me, is even something that burns brighter than art: wildlife conservation. I've always been drawn to the big cats – actually all cats, big and small. There's something about the grace and the beauty and the power of cats that has a certain charisma. They are iconic, they're at the top of the food chain, and they're the umbrella species under which if you save them, you've also saved all the flora and fauna in these critical ecosystems. So, whether it's assets or whether it's other beautiful subjects, there is that commonality of the iconic nature.

NOVAGOLD, in many respects, embodies my arc in the mining world. When I began my career in the nineties with Apex Silver and through our own engagement in African Platinum, which was taken over by Impala – and indeed in NOVAGOLD itself – what my career has shown is two very distinct features. The first has been the constant in my career: this gravitational pull toward category-killer assets. Assets which any larger company would want to own at a price if given the opportunity. I've come to believe that no matter how sophisticated a piece of paper is when you're doing a transaction and making an investment, at the end of the day it's all about the assets.

If you don't have a high-quality asset, but you've got the best kind of piece of paper, you're still going to lose money and it's only going to be heartache. It's all about the assets. And if you superimpose onto those assets great management teams, then you can deliver outstanding returns. In silver we had a 200X return and that got me started. And then we went into platinum, in which we had a 100X return, and hydrocarbons a 100X return. We then sold everything in 2007 in order to pivot into gold and silver. It was the only thing that I really believed in. And I was lucky. We were able to make exits in hydrocarbons to Encana, in platinum to Impala. And so when we entered the financial crisis, I had capital and conviction, and whenever I have capital and conviction in something, it proves to be a lethal combination.

You say that's dangerous.

It is, it really is. Now, I had coveted NOVAGOLD for years, and I had watched it go from a 60 cent stock to $14, $15 when Barrick made a hostile takeover attempt in 2006. I didn't own it. So I'm not taking any credit for having owned it. I fell into that trap that investors sometimes face and thought I missed it instead of realizing you do not make money looking in the rear-view mirror. I watched the company and shareholders reject the Barrick bid and the stock went to $19.74 CAD. Again, I didn't own it, but I did watch as it made a round trip and at different intervals, I would look and say, maybe now is the time to strike.

What was it that attracted me to NOVAGOLD? Donlin Gold. I really felt that Donlin Gold was the ultimate category-killer. I had that sense that the Donlin Gold trend could be something

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akin to the Carlin trend – not necessarily the same kind of system, but in terms of how the next big discovery at Carlin would lead to another discovery. And when we realized that the 30, 40 million ounces that we could see in 2008 were on a small percentage of the entire land package – concentrated on a three-kilometer area that had been heavily drilled, as well as being open at depth – I sent my chief geologist to assess it. This geologist, Dr. Larry Buchanan, is one of the great exploration geologists in the world. The Buchanan model is a textbook analysis of epithermal deposits that's still unrivaled to this day.

And I sent Larry out and I said, "What do you think?" (This was after we'd already made the deal, which gave us effective control.) I asked, "Are the 40 million ounces there?" And he said, "Oh no." For a moment my heart sank. We're already in it. And he said, "I think there's at least double, maybe more. In fact, I think that the next Donlin Gold is *at* Donlin Gold." If you're in the mining industry, you know, it's an old adage: If you're going out in search of elephants, go to elephant country. And what he was basically saying was in terms of the geological potential at Donlin Gold, we were perhaps just scratching the surface. Now this got me extremely excited despite the fact that everything that I know about mining development and operations would fit very generously into a thimble.

So when I got this conviction that NOVAGOLD was going to give me all the leverage I could possibly want to the underlying gold thesis, I realized we had a tiger by the tail. Now, up until that time – when we came into NOVAGOLD in 2008 – Electrum had perhaps the most widespread and diversified exploration portfolio in the world. I was the largest holder of mineral rights in mining, so I was told, in the Islamic world from Mauritania all the way through to Pakistan, and it was one of the things that got me to open up doors and ultimately become partners with sovereign wealth funds from the Arabian Gulf. But around the time that we made the investment in NOVAGOLD, I'd come to believe that the era of "Go where the gold is" mentality was coming to an end. And that ultimately investors such as myself would gravitate toward jurisdictions where the rule of law wasn't a novelty, where when you go to sleep at night you feel completely confident that when you wake up in the morning, what you thought you own the evening before, you still own. Therefore, I changed my mantra. So the mantra went from being "seek out great assets that give you extraordinary leverage to an underlying theme," to "seek out great assets that give you extraordinary leverage to an underlying theme in a jurisdiction that will allow you to keep the fruits of that leverage when the time comes to ring the cash register."

Ultimately, we have in the picture a big partner who owns 50 percent. So some of it would be the dynamics between the two partners. Do you think that can be monetized? A lot of this is unknown at this stage, but we know that you have a scarce asset. Gold is in itself scarce. Maybe you could just talk about the various things that would come into play in advancing NOVAGOLD. Why, in your opinion, will this particular asset outperform its peer group?

NOVAGOLD is the flagship asset of The Electrum Group. We have interests in multiple gold and silver assets – hence the name Electrum, which is a naturally occurring alloy of gold and silver – in North America as well as some exposure to Australia. For us, Donlin Gold is the holy grail. And the reason I say that is because we believe that Donlin Gold, as a vehicle for investors to be able to get true octane in the development space in gold, is unique. What does it mean to be unique? What it means is that when you look at Donlin Gold's attributes…Its size: There's never been a gold mine that began production with 40 million ounces plus. The scale: We're talking about something that could be a million-ounce-a-year producer. The mine life: It is projected to start with 27 years of production. The cost structure: Because it is projected to be a high-grade mine for a

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JURISDICTIONAL SAFETY[11]

large-scale open pit, between two and three grams, it could be one of the lowest-cost producers in the world.

Then you have to take into account the fact that it's in the safest part of the world, for which a premium should be attached. Before we entered into the "Go where the gold is" mentality in the early 1990s, particularly led by Newmont's move into Yanacocha with Buenaventura, gold assets were pretty much valued as follows: U.S. assets were valued using a 0 percent discount rate because they were considered to be the safe jurisdictions. And if you had exploration potential, all the better. These were arbitraged against the risky jurisdictions: Australia, Canada, and South Africa. That just shows you how far we came because once Newmont went into Peru and then into Uzbekistan – and you had Barrick following suit into Chile and ultimately looking for gold in Russia and Freeport into Irian Jaya – everything changed. And at a certain point, it came around to the assets in North America being valued lower than in these other jurisdictions because it was assumed that the constraints on permitting and environmental considerations would mean longer lead times.

So you were getting higher valuations for assets in Africa than you were in North America. When we pivoted away from the developing world into what we called the safe jurisdictions – now what would be known as the Tier-One jurisdictions – at least in my case people couldn't say, "Well Tom, you're talking your own book. You've taken a stake in NOVAGOLD." It's not exactly true. I'd become the largest holder of Moto Goldmines at the same time. And we engineered the sale of Moto to Mark Bristow and Randgold and AngloGold. So we were still willing to take opportunistic bets in the developing world, but we viewed that as being a warrant, as opposed to being a stock. The true stocks were U.S., Canada, Mexico, and Australia. Now, when you look at NOVAGOLD, what you see is this combination of Donlin Gold's size, grade, exploration potential, production profile, and cost structure. And superimposed upon all that is jurisdictional safety. Alaska is a state that welcomes mining.

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It is already the second largest gold-producing state after Nevada. We are very blessed to have our Native Corporation partners at the local level, the Calista Corporation and The Kuskokwim Corporation, and to have as our strategic partner Barrick Gold. As a consequence, the level of professionalism that came from the NOVAGOLD team and the support that we had at the local level and at the government level in Alaska and, ultimately, the federal government allowed us to be able to do something that a lot of people thought would be too hard to do. We got a Record of Decision. In fact, it was the first time that the Bureau of Land Management and the U.S. Army

> "We have, like the tortoise and the hare, taken [Donlin Gold] up the value chain while other projects that people thought would go into production have, like the hare, fallen by the wayside. Donlin Gold is on the path. I believe that Donlin Gold will be a producer for decades to come."

Corps of Engineers combined to provide a joint Record of Decision – something that so moved them to have their own ceremony to celebrate the occasion. One of the great things about Donlin Gold is that anyone who goes to Alaska – and Mark Bristow has now been there a couple of times and seen it firsthand – realizes the depth of support that we have from Calista and TKC, the owners of the mineral and surface rights, but all the way through to the governors and to the senators themselves. Donlin Gold is now viewed as the flagship for gold development in Alaska.

When you combine all of these factors, what you have is a situation where I'm often asked, "Why do you say that Donlin Gold is unique?" The reasons are when you look at the combination of attributes of this asset, you realize that there is no other in the world like it. No mining project has ever begun production with over 40 million ounces. NOVAGOLD's resources are only on three kilometers of a mineral belt that is eight kilometers. And those eight kilometers represent only 5 percent of the total land package. We're just simply following an old adage that if you're going to look for elephants, go to elephant country. There are only a few mines in the world that can have that kind of production because the grade is already double if not triple what's coming online in the gold industry.

Now you take all of that *and* the fact that it's located in a jurisdiction that is already the second largest gold-producing state in the union – on land that is private and already designated by law for mining – what you see is an asset that, if we are right, could be the next Nevada. And *already* is poised to be the greatest gold story in the development space. The only other asset that compares to it is Sukhoi Log in Russia, and we wish them the best of success. But we would argue, I think, that we're on the right side of the Bering Strait.

Your partner has, to my way of thinking, been tone-deaf on the issue of jurisdictional safety. You can observe that simply by where their assets are located. I don't have to go through the litany of where they are. So I guess maybe something changed recently with your joint announcement with Barrick in terms of their way of viewing the world and their evaluation of political safety as being relevant in terms of where they spend their capital.

I think it's fair to say that Mark Bristow is without a doubt one of the greatest CEOs of his generation in the gold mining industry. Mark's experience is primarily in Africa. I also have African experience in gold. I sold him the Kibali mine as well as a platinum asset in Zimbabwe. So, I'm not Pollyanna when it comes to my experiences in Africa. I also got my first lucky break in Bolivia. So I do have an understanding of the opportunities that are present in the developing world.

Mark's focus has always been Tier-One assets that will make a certain kind of return; that are of a significant production profile and all of the other attributes which Barrick

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discusses. I also believe in Tier-One assets. In fact, I'm even more stringent, certainly when it comes to what I'm looking for in an asset that can really move the needle in terms of production and reserves for a company. An asset like Donlin Gold, for example. In fact, our mantra over the last 30 years has been great assets. Now it's great assets in safe jurisdictions. Mark's attitude, I believe, is that it's all about the assets. Even if those jurisdictions are challenging, he has the skillset to be able to navigate those challenges. And if anyone can do it, I think it's Mark. So when we look at Donlin Gold, I'm not sure that that indicates that he sees it from a jurisdictional standpoint. I think what I can say is that he understands this can easily evolve into a Tier-One producer.

I would say that being a Tier-One producer is absolutely critical in terms of being able to explain to investors why the long-term prospects of Donlin Gold, and hence NOVAGOLD, are so good. But I would say that for me as an investor, and I think I speak for our shareholder base, we want not only Tier-One assets, we want Tier-One assets in Tier-One jurisdictions. We want to be able to sleep well at night, knowing that when we wake up in the morning, whatever we thought we owned the night before, we still own.

I think that what we're seeing with Barrick, as evidenced by the joint press release that we issued in December, is a recognition that Donlin Gold is now very much part of their project pipeline profile in a way that it wasn't before. They are getting comfortable with it. Mark is a geologist. He is absolutely punctilious when it comes to geology. There was never a doubt that the gold is there, but Mark wants to be able to quantify how every ounce is going to come out over a 10-year period. And I'm the last person to gainsay such a dedication to one's craft, but for me, this press release, I think, was a game-changer. And I think that in the not-too-distant future, when gold reaffirms its bull market trajectory, we will be the go-to stock in the development space. NOVAGOLD's got all the attributes that investors will be looking for and they will want octane in their portfolio. We've seen M&A in the gold space take out name after name after name.

There's a shortage of names that are in safe jurisdictions. And it's hard to imagine capital is going to flow to Sukhoi Log before it flows to Donlin Gold.

I would agree with you. We've seen analysts attach valuations of 10 billion to 15 billion dollars on Sukhoi Log. Now that Barrick is starting to talk about Donlin Gold, I think that the bell is going to start ringing. Remember, for 12 years we've been in the story, and we have framed the narrative on Donlin Gold and we have, like the tortoise and the hare, taken this thing up the value chain while other projects that people thought would go into production have, like the hare, fallen by the wayside. Donlin Gold is on the path. I believe that Donlin Gold will be a producer for decades to come and that it will pay dividends.

I'm not sure how patient I am on that sort of thing.

Look, we are now at the point where we have something that is pretty much permitted in a safe jurisdiction with great partners. We're in great shape. Mark sees this – and Barrick knows even from experience in North America that a Record of Decision is a big deal. Barrick knows that being able to have a property that is on private land designated for mining, in an era when people are starting to talk about royalties on government land, is a big asset on top of what is demonstrably a very, very big asset. So my belief is that what we will see over the coming year is quite a bit of very positive news. The more we drill, the more we find. We say that Donlin Gold is a gift that keeps on giving.

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We've had some astonishing results – some of the most promising in the gold mining industry – but there's also another factor here. For investors in NOVAGOLD stock and those who have relied upon me, Greg Lang, Mélanie Hennessey, Igor Levental, and other members of the NOVAGOLD management team to tell that story, we're going to see a sea change. Because as exuberant and passionate as we are about Donlin Gold, anyone who knows Mark Bristow knows that when he loves, he loves very deeply. And I believe that he will be falling in love with Donlin Gold. He's already said that he's catching up with the Kaplan narrative. Now, I think after anyone that's been listening to me, that must be a terrifying prospect because the fact that two of us will be doing that simultaneously is very good.

So here's what I think will happen, which I believe is so wonderful for NOVAGOLD shareholders: Number one, anyone from the sell side who follows the gold industry follows Barrick. They're now going to *have* to look more deeply into Donlin Gold. Some of them will be doing so in the context of following Barrick, which I really hope they will. This is great news for Barrick shareholders because I don't believe that the value of Donlin Gold is reflected at all in the Barrick share price. And analysts following Donlin Gold already will start to follow NOVAGOLD as a pure play on this emerging gold district. So we'll have more analytical coverage. I feel pretty confident about that. It's almost the law of averages.

> "When you look at NOVAGOLD, what you see is this combination of Donlin Gold's size, grade, exploration potential, production profile, and cost structure. And superimposed upon all that is jurisdictional safety."

You're going from almost none to potentially...

Right now, we have two analysts following us. God bless them, we love them dearly. But even they, I would imagine, would love to see six or eight analysts following us. Now, just look at the psychology of it. If you are already following Donlin Gold because you have to follow Barrick, because it's the 800-pound gorilla, then why not look at having a pure play on a great asset in a great jurisdiction? Why not? Some won't bother. Others will jump all over it. Now, that's number one, but number two is that as the Donlin Gold story gets rippled through the market because of Barrick, some of that offtake is going to spill out onto us. And we're a stock with very, very loyal shareholders who've been in it for a long time – some of them almost as long as I have, and I've been in it for 12 years. I am more passionate about the story than ever before. They are watching this unfold.

In fact we've had multiple calls from people saying congratulations with regard to the December joint press release because they understand that as Donlin Gold gets some more coverage, more investors will be looking for a pure play on the story. And you start to get a few shareholders taking positions like the Public Investment Fund of Saudi Arabia did over the last year or so, and it's a game-changer. My agenda and Greg's agenda is that we are aiming to be the go-to stock in the gold development space. I believe that we're already there. But more than that, we want to be viewed as being the premier value and growth story in a sector in which the defining attribute is scarcity.

Where do you think – because this is an unusual, unique situation – NOVAGOLD should trade? I understand that more analysts following it will certainly help, but theoretically, hypothetically, we have a long-dated call on the gold price. That's how I see it anyway. How in your mind, and I'm strictly asking this from an academic point of view, because I know you and I think the stock should trade higher, but how would one analytically get to a higher price, when I guess production will not occur until six, seven, eight years down the road? What are your thoughts on that?

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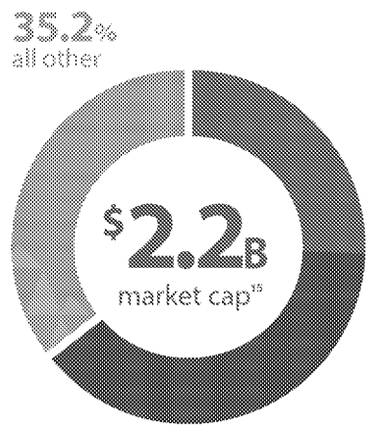
I've always been a believer that at the end of the day, the money is made on having great assets. I've never believed that production in and of itself should be the metric on taking a position to the contrary.

That's radical in the world of sell-side research.

Completely. But you know, that's how I've made my living. If everybody adhered to the same opinion, I would've had far more competition in the space. So if you've got someone whose foremost credential to be in the mining industry is a PhD in counterinsurgency, then there must be something else going for him. In my case I am probably the luckiest person I've ever met – personally and professionally. I've been blessed with surrounding myself with the best in breed: geologists like Larry Buchanan, specialists like Igor Levental and Ken Rye. And then being able to create an ecosystem in which we have this coterie of superior managements. For example, Greg Lang. Before he joined NOVAGOLD, Greg was the president of Barrick North America for eight years. He was producing more gold than Goldcorp, but he was also someone who had been with Barrick and its predecessor companies for nearly 30 years. Why did he leave Barrick to join NOVAGOLD? The reason was because, as he said, "I wanted to go into the company that had access to being a pure play on what I felt was the greatest development story in the gold industry." And he knew it. Donlin Gold came under his purview at Barrick. He was part of the team that made the takeover attempt in 2006. So he was an educated consumer – which of course as we know is the best customer. When he came in, he said, "I will join as CEO if you join as chairman." And that's how I took the position. I very rarely join the boards of companies even if I own 70 or 80 percent of them. My shareholders, those who follow us, know that I follow these stories extremely carefully. As they say at Fidelity, the owner lives above the store. I don't have to be on the board of NOVAGOLD, but I do it because I enjoy it. I do it because I am a huge believer in Donlin Gold. I nearly named my third child, our youngest son, Donlin Gold. So that's got to be indicative of the passion which we have for this story.

I do it because it's one of the most enjoyable gigs in the gold mining industry. I get to work with Greg Lang. I get to work with Mélanie Hennessey. I get to work with Richard

TOP 10 SHAREHOLDERS



64.8% top 10

- **25.4%** Electrum Strategic Resources LP & affiliates
- **7.5%** Fidelity Management & Research Company
- **6.7%** Paulson & Co. Inc.
- **6.0%** BlackRock Institutional Trust & affiliates
- **4.9%** Saudi Public Investment Fund
- **3.6%** EXOR Investments (UK) LLP
- **3.5%** First Eagle Investment Management
- **3.2%** Van Eck Associates Corporation
- **2.6%** The Vanguard Group, Inc.
- **1.4%** Kopernik Global Investors LLC

Williams and Ron Rimelman and Dave Ottewell. A great cast of people, all of whom have this huge company experience but have come together to help build out what they all believe to be the greatest gold story in the space. When Richard Williams joined from Barrick, he had just taken into production Pueblo Viejo. That was the biggest gold investment Barrick had ever made. And when Victor Flores, who came to visit Donlin Gold for John Paulson, asked him why he made that move, Richard conveyed that he wanted to be part of the greatest gold story in the world. That's a statement. And that is part of our DNA. We've all been together as a team for many, many years, and I enjoy it. I enjoy their company. Otherwise, I simply wouldn't do it. I wouldn't need to do it, that's for sure.

You certainly don't need to. One of the questions I think that crosses investors' minds, and certainly my mind from time to time, is this is a large capital commitment. The last count was I think seven billion. I know it can be staged and maybe wouldn't be that large, but, from NOVAGOLD's point of view, whatever is decided would still be a major financial commitment. So I would be interested in your thoughts on how you will negotiate that particular issue. And I know there are many different ways to do it, but I kind of think it would be interesting to hear your thoughts on that.

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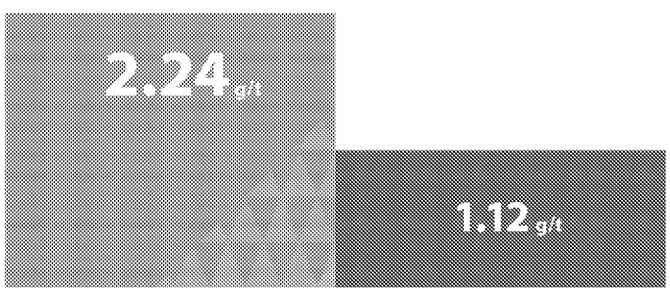
Well, I can tell you that, when the time is right to go into production, I think this will be the easiest gold mine to finance. In Alaska, with Barrick as a partner, it will be something where I think it can be done in several phone calls. Now, let's break this down. I'm only using hypotheticals here. These are purely forward-looking statements; disavow all of them. I'm just using round numbers. Let's assume that phase one of the project is four billion dollars, split two ways. That's two billion each. Obviously for Barrick, not difficult – but not difficult for us either. Electrum financed a very prosperous silver project in Mexico, which we operate ourselves (not with the benefit of a major like Barrick), and we got 70 percent financing.

AVERAGE GRADE



Donlin Gold average grade[16] global average grade[17]

Let's say that happens for us. What are we really talking about? $600 million, $700 million, $800 million? Now let's do something that investors very rarely do, but they should, which is to take themselves out of where they are today and their present mindset and understand what will be the conditions that will pertain when we're talking about going into production. I believe that gold will have embarked on the next leg of its bull market. I think that it will take us well beyond $2,000. I think ultimately it'd be $3,000 to $5,000, but once you see that gold has embarked upon that next wave, I think Barrick will be extremely excited to go into production. And I've always said that when Barrick is ready, we'll be ready. We have three sovereign wealth funds as our partners in Electrum, and we're very, very close to them and we've always had a number of major players in the financial space in mining who've always said when you're ready, just let us know. For me as the largest shareholder, what I want to see is that when gold prices are where they should be, when the mine is ready to be built, our share price I believe will be multiples where it is today.

One of the rationales for investing in NOVAGOLD is a belief in a substantially higher gold price, which is hard to come by these days outside of this room. Of the few believers in gold, my friends are well chosen. You did toss out $3,000 to $5,000 earlier; what are some of the things that come to mind as to how we'll get there?

Now, $2,000 gold – if you're a bull on gold – isn't really a number. It's nothing. And when I pivoted from energy to gold in 2007, oil was heading to $120-140 per barrel. We sold our energy company when oil was $120. Gold had a 600 handle, and I gave all the reasons why I felt that one should be in a currency that can't be produced at will. And I think that gold and silver provided me with exactly the kind of exposure that I needed. When we sold our energy company, we didn't go back in because I told people I could no longer really comfort myself with conviction as to whether oil was worth $20 or $120. Little did I know that last year it would be worth briefly minus $20. But the one thing that I did know is that gold would multiply, and my long-term target for gold in 2007 was between $3,000 and $5,000 when it was at $600. So we're on our way. I mean we've tripled since then. And something that I really want to mention because you've brought this out in your own writings. The idea that you need to be a dollar bear to be a gold bull; it's not true. The idea that you need to be a bull on oil to be a gold bull; it's not true. You've pointed these out, and here's the proof: In 2007, we got a wire transfer for $2.55 billion from Encana for the sale of our stake in Leor Energy…

You remember the date?

Oh yeah, and if for no other reason than that I have no idea what would have become of us if we had made that sale six months later. One thing I did was I looked around at where we were going to park the money. Well, dollar-euro was 1.47. Today it's 1.13. Gold was $600-ish and it's three times higher with the dollar having strengthened by 30 percent. The concept that you have to be a dollar bear is not true. Oil was $120 with gold at $600-ish. Oil is now half – and was even much lower – and gold is a multiple of that, which tells you this: First of

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all, gold has been the best performing currency in the world, and second, as a commodity, which is the way some people look at it, it's also outperformed. So when I look at gold, I see something that is an accident waiting to happen. And I love being long on accidents.

Seems to be asymmetric in terms of risk/reward.

Completely. So when I look at the gold space, I see no reason to adjust my $3,000 to $5,000 target. And by the way, I think that there will be days when gold trades peak to trough the absolute price that it's trading today. It would not surprise me to see $1,700-$1,800 days where gold will trade up and down. I think that we're going to see that kind of volatility by definition. That means that gold is a great buy here, if I can say that with that level of conviction. I did that once before when I made that forecast in silver, which was trading at around $6 per ounce at the time and people thought that I was nuts and you had much greater intraday volatility a couple of years later – the implication being that silver was much, much higher. So for gold bulls, I would say what we're seeing now is a correction within a long-term bull market, but $2,000 won't be the number. And if $2,000 per ounce gives me a $10 billion NPV for Donlin Gold without adding any reserves, you know what? That's a very good investment.

This is probably a good time to bring up crypto, because I think crypto has sucked the oxygen out of the room for gold in many ways. It's been a headwind, and certainly has a generational aspect to it in that guys at my stage of the game believe in gold. What are your thoughts on the competitive aspects of gold and crypto?

It reminds me of that famous exchange between Henry Kissinger and Premier Zhou Enlai when Kissinger was secretly negotiating Nixon's visit to China and the U.S.'s recognition of the People's Republic. Kissinger, being a historian, asked Zhou Enlai what he thought the long-term implications were of the French revolution of 1789. Zhou Enlai famously responded, "It's too soon to tell." Now I don't think that we need to be that long-term in our thinking to understand that crypto is a phenomenon. Crypto currencies are here to stay, just as automobiles were a phenomenon, just as airplanes were a phenomenon. Railroads were a phenomenon. Most of those that were early movers ended up going broke.

We don't yet know who the winner is. I personally think that it's likely to have a Chinese name attached to it. They're a larger trading partner with more countries than the United States. They have of course phenomenal opportunity just domestically to be able to develop that market. And through the Belt and Road Initiative, they have a lot of other countries who may very well be open to that idea. What that means for things like Bitcoin or Ethereum, I don't really know.

I am, I suppose, a true conservative. There was a professor at The London School of Economics named Michael Oakeshott who once defined a true conservative as one who prefers present happiness to future utopia. There are many different forms of crypto. I don't know which of them will emerge victorious, whether we even know its name yet. I do know that there's only one gold, there's only one silver. They have their chemical definitions. They're called AU and AG, and that's it. So, what we've seen in the crypto market to me is extremely bullish. In the same way that I view the scarcity value of Donlin Gold to be one of its greatest attributes, I view the scarcity value of precious metals to be amongst those greatest attributes.

Let's understand what the crypto phenomenon really means in its essence. It means that your narrative, the John Hathaway narrative, the Tom Kaplan narrative, has won. That is, we have seen gold – and the reasons why people buy

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gold – be adopted by the crypto crowd, to the extent that in order to be able to induce people to look at crypto in the first place, people refer to it as gold 2.0. Now for some people, that may be enough to be able to have exposure to crypto as being a currency that has limited ability to be reproduced. But there will always be enough people who are interested in gold, and I think personally that the acceptance of that "gold 2.0" narrative is going to create a lot of arbitrage between gold 2.0 and gold 1.0. You know the Chinese, the Indians, many countries around the world are still buying a lot of gold. Central banks are buying a lot of gold. Singapore, which is a bellwether central bank, bought gold for the first time in decades. That was made public in December. Now to me, central banks are like insiders. They know the value of the assets that they hold.

> "If you don't have great relationships with the communities, if you don't have great relationships at the provincial level so that people...see that what you are doing is going to have a direct impact on their lives and, most important, the prospects for their children, then you're going to go nowhere fast – or even worse, you're going to build something and find that you have challenges. We don't have those issues."

Most of which are dollars.

Most of which are dollars, are now subpar financial assets that they've had to hoover up in order to sustain the global economy since 2008, 2009. So when they're buying gold, it's like when a museum buys a work of art. They're voting with their feet to be able to have some exposure to it.

Now, I don't need people to have as much exposure to gold as to crypto. If we even had a fraction of the market cap of Bitcoin, going into gold, gold would be at $20,000 per ounce. But do I think that there's going to be some spillover effect onto gold, as people say? Well, maybe gold is undervalued.

Relative to...

Yeah, we've bought the argument for gold, but maybe it is actually undervalued. And it does cost something to produce – that we can quantify – so we just need some of that to rub off on a scarce asset and gold will be like a bat out of hell. And one of the things that we've seen is that in today's world, when something's going up, that's when people really want it the most. So, if gold goes through $2,000, it can also go to $2,100, $2,200, $2,500.... People will start saying I'll buy it on a pullback and then it will pull back and then they'll be afraid to buy it because they don't want to be the sucker who bought it at all-time highs. And then it can go to $3,000, $4,000, $5,000. We see that, by the way, in cryptocurrencies. We see that in assets when they're in a bull market and they have momentum, and especially now where there's so much capital. So, I think when you do see that $2,000 breakthrough, it's going to be enduring and the uptrend will be violent, which is just wonderful for us and it's especially wonderful if you've got assets with great leverage to that in places that are not going to nationalize you because now you're viewed as a strategic asset that should be in their portfolio. You want to be in a place where private property is enshrined constitutionally – and there aren't that many.

Right. It's a short list.

And getting shorter by the day. You know, they say that they don't ring a bell, but as we were discussing earlier, the "Go where the gold is" mentality really began in the early 1990s when Newmont went to Yanacocha. I think that they rang the bell when Newmont and its partner Buenaventura weren't able to continue with Mina Conga in Peru. There was almost an unfortunate but poetic symmetry to the entire arc of the scramble for gold, regardless of jurisdictional risk. But we see it now across the board. In fact, in Peru, you know, they just devastated a silver miner stock on the London stock exchange.

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True.

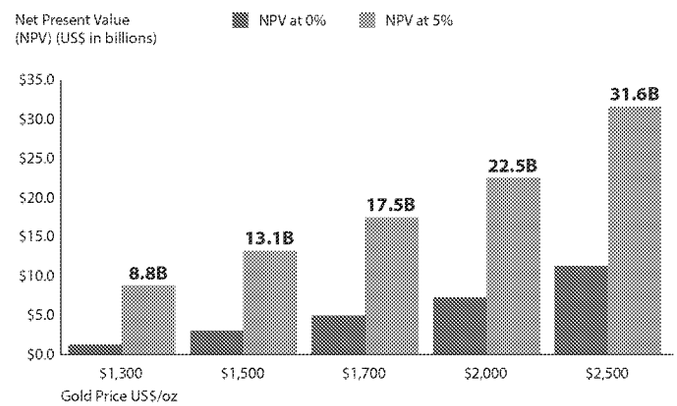
This is happening now all over. And who needs it?

And it's kind of monkey see, monkey do. I mean, if one country decides to get more of the economics, they're all going to follow in.

If your neighbor has just changed the rules, whether it's windfall profit taxes or local ownership or outright nationalization, and you're on the other side of the fence, you have to follow suit, politically. It's suicide not to. If you're a dictatorship, people will be saying, "He must be on the take of the mining company." If you're a democracy, your constituents aren't going to allow your national endowment to be plundered by foreigners. When on the other side, they've shown you can get away with getting more. So politically, regardless of your form of government, it's unsustainable for other governments not to join in. I often say it's like popcorn: Nobody ever eats one piece of popcorn. I think that that's already begun. So if I'm right about that from an investor standpoint, it means that the premium multiples are going to be seen in those assets in safe places, which are immune from that kind of confiscatory trend.

Well, Tom, one of the things that we spent a lot of time obsessing about are costs. In fact, we've interviewed many different managements and one of the first questions is, What do you expect your all-in sustaining costs to be and where are the cost pressures coming from? And we're finding that in many cases we're talking about 6-7 percent. Of course, there's no inflation. Of course, it's transitory. But in my mind, it's not. And, obviously that's one of the arguments for gold as inflation has become embedded and there's no way out, but when it comes to NOVAGOLD, we're a long way away from producing. How do you think investors will look at the profile of costs and the structure of the costs in Donlin Gold when it starts producing?

UPSIDE VALUE[18]



First of all, as you said, we have the luxury of time, and it really is a luxury. My own experience in the space shows how being developers can give you such a long runway to have opportunities to make money. But we are quite a while away from being in a situation where cost pressures today are going to have an impact on our valuation. The most important aspect that goes into determining what your cost of production is going to be is grade. So therefore, all things being equal, *ceteris paribus*, if you have a company that is extracting one gram of gold per tonne, rather than two grams – or in our case, two-plus grams per tonne – their cost of production is going to be double what Donlin Gold's would be. The grade profile of Donlin Gold as a large-scale open-pit mine gives us tremendous advantages. It will place us at the low end of the cost curve. But let's again enter into the exercise of what does it mean if we have five or six percent cost inflation in gold mining by the time we're in production? What does that mean for the price of gold? Do you really think that gold will be at $1,700 or $1,800? One of the challenges that investors have – you don't suffer from this issue – is that they make the

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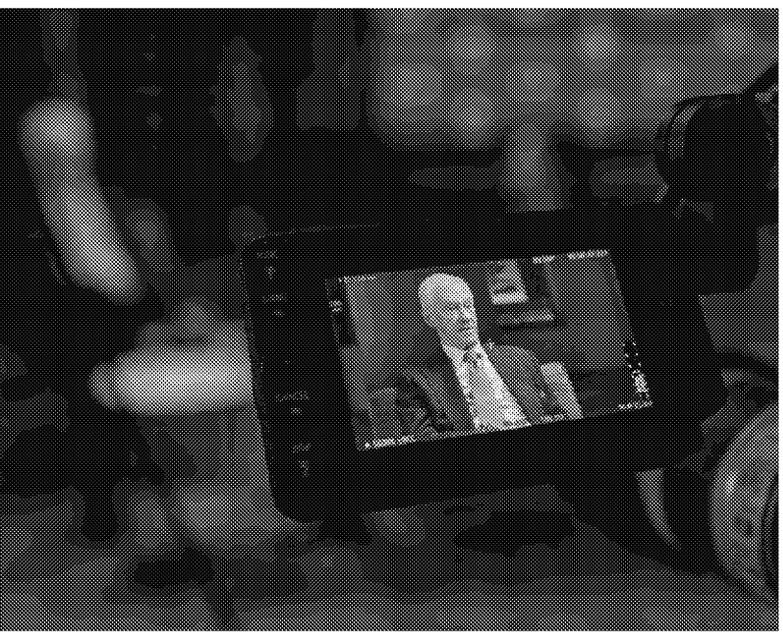
assumption in valuing something that the conditions upon exit are going to be the same as they are today. In other words, they don't game things out. What we always try to do is we say to ourselves, okay, hopefully we're buying when you have, as John Templeton put it, maximum pessimism. That was certainly the case when we came into NOVAGOLD. It was on the verge of bankruptcy, and we hadn't owned one share when we came in as a white knight and saved the company. And because of the exigent circumstances, we were able to go to 40 percent rather than having to take a takeover bid. I wanted to buy the whole company, but fortunately, I have around me people whose job in life....



Calmer heads prevail.

It's not just calmer heads, it's wiser heads. So, in this instance, comrade Igor Levental was whispering into my ears as he was supposed to: "Thou art mortal, Caesar." So, whereas I sold my energy company and was flush with cash and brimming with conviction on gold, particularly on the holy grail, in my mind, which was Donlin Gold, then hence NOVAGOLD, he was saying, "You know, you might think twice or three times about making a bid for the entire company because everyone may be asleep," as it was December 31st, 2008 when the deal was signed. But one of the most important things is that he said, "Look, you're in a position to buy the company for $2 a share. You have the cash. Barrick tried to buy it at $16 a share. You don't think that they're going to walk you up dollar for dollar until they get to where they want?" And it turns out that Barrick wasn't the only company that was hoping to buy NOVAGOLD on the cheap. There were others, including Newmont and even the Russians. And so we realized we have an opportunity to take control of one of the greatest gold stories in the development space: NOVAGOLD. But we would have to settle for less than a hundred percent. And we ended up going 40 percent fully diluted. That was the right move.

The attributes of Donlin Gold are that we are in a situation where the grade gives us plenty of leeway. Grades have collapsed over the decade-plus that I've been in the NOVAGOLD story. We're now approaching one gram per tonne for projects and going sub-one gram per tonne. At a certain point, particularly if you're not in stable jurisdictions, this is a real challenge.

When we look at Donlin Gold, which has multiples more than those projects, we know that we have a cushion. And if anything, the results of the drill programs over the last couple of years have given us, with great input from Mark Bristow as a geologist – and the Barrick team – a much greater definition on the controls on the mineralization. The Bristow of Barrick, or the Barrick of Bristow, is absolutely committed to wanting to know every single ounce that will come out over a 10-year period. And I think that's a great discipline. I think you, as an investor – I, as an investor – in the space have come to understand that when people cut corners, the back end can be pretty brutal. The more work you do on the front end, the more the back will take care of itself.

Now we know that once Donlin Gold is built, it will have been pretty well-engineered. Costs will be known. Cash flow year X will be pretty much known other than the gold price.

Look, we have an A team: You have the Barrick side, of course, led by Mark; you have the NOVAGOLD side led by Greg. Richard Williams built Pueblo Viejo for Barrick and at the time Goldcorp, now Newmont, and is one of the world leaders

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in autoclave technology. So, when we look at Donlin Gold, the amount of work that's gone into it, combined with the robustness of the asset and the grade, we're very comfortable in where the cost structure will be. But once again, people tell me, "Well, you know, you could have significant cost inflation years down the road." And I say, like General David Petraeus said as Commander in Iraq, "Tell me, where does this end?" If you say that, then please tell me, where do you think gold is? "Oh no, we make the assumption gold is the same." Really? Then why are we even talking?

Yeah, the average expectation on the sell side is $1,600 gold per ounce. It's a flat price deck.

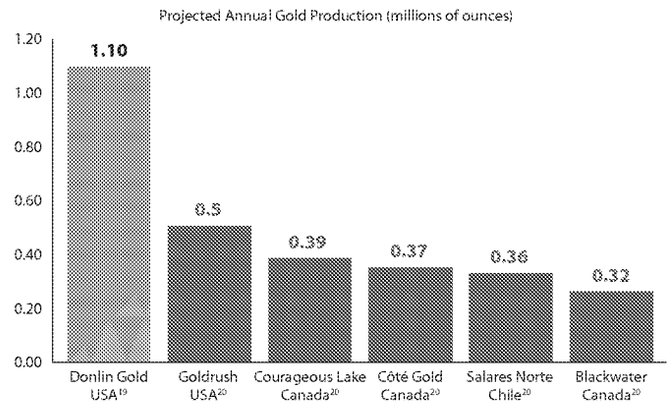
Well, you know, we are bullish on gold and we want to be able to provide the premier vehicle for those who want it, on a risk-adjusted basis, the most octane and the lowest risk in the development space for a Tier-One asset in a Tier-One jurisdiction. That's our mantra. We are gold bulls. And for those who aren't gold bulls…

Go somewhere else.

One thing I've learned over the last 30 years is bears don't buy shares. And I will spend time talking to someone if they have a thousand shares or they have 10 million shares. I enjoy it, clearly, and it's not because I have to do it. It's because I like to do it. Being associated with Donlin Gold to me is like being associated with Rembrandt or being associated with tigers. You're literally talking the best in breed in their space. That's not a hardship, that's a privilege.

Maybe this would be a good time to talk about sustainability. It's something that we frankly have become more and more involved in, and, of course, it has become one of the screens by which large capital will invest in the mining space. So I'd be interested in hearing how you look at that and what you're doing – and what you still need to do in terms of the ESG side of the equation.

PRODUCTION



Well, fortunately, we haven't had to make any philosophical adjustments in the company for the last decade. Greg Lang, the entire management team of NOVAGOLD, and I have always been extremely committed to ESG on every level. And even before ESG became a popular initialism, my own affinity, indeed passion, for wildlife conservation and particularly for species which require entire landscapes in which to be able to thrive, like big cats, means that for me, the environment is not just second nature, it's actually first nature. So the first thing that my kids will associate with me is passion for wildlife. And I've managed to inculcate that in all of them. So I would never ever be around anything that countenanced cutting any corners when it comes to the environment or sustainability.

Social license, the environmental license, is existential in the mining industry. If you don't have great relationships with the communities, if you don't have great relationships at the provincial level so that people buy in so that they see that what you are doing is going to have a direct impact on their lives and, most important, the prospects for their children, then you're going to go nowhere fast – or even worse, you're going

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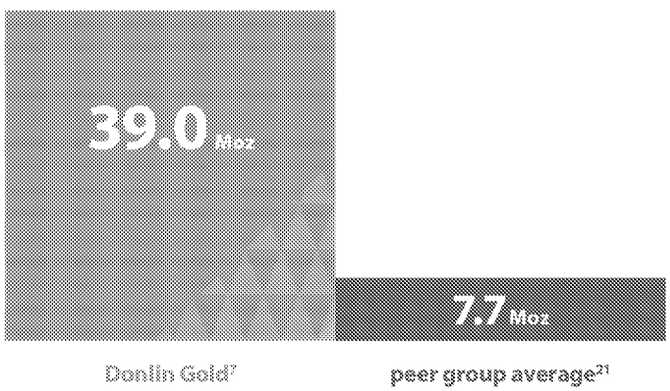
to build something and find that you have challenges. We don't have those issues. We've been very blessed in that our local partners, Calista and TKC, are our most vocal supporters. And of course the Native Corporations will all share in the benefits of Donlin Gold. All of the Native Corporations in Alaska – that's the way the system works. So, a certain percentage goes to those who are most immediately related to the project, and the rest is spread around the state. We have that kind of buy-in.

As far as governance is concerned, we are a paradigm of an independent board. I've always believed that shareholders should have a significant say even at the board level. I think

RESOURCE SIZE



that the transparency with which NOVAGOLD has conveyed its message in the media, in our annual reports, to our shareholders, is at least as good if not actually the best of any company that I've encountered. I remember in my first mining story, when we went public, I waived rights to be able to have more board seats because I felt having more independent directors means that you're going to get more independent points of view.

The more independent points of view you get, especially if you're just coming into the space and you're in your thirties, the less likelihood you have of problems. That certainly pertains to the NOVAGOLD board, but more than that, we have gone out of our way strenuously to leave no room in terms of explaining to our shareholders what our strategy is. And I'm very proud of the fact that since the 10 years that Greg Lang and I have been functioning as CEO and chairman, respectively, every promise that we've made to shareholders, we've kept. Soon after we came on board, we did a capital raise at the beginning of 2012. We raised over $330 million dollars because of the enthusiasm of the combination of both of us and our relative skillsets. What endeared the investors to us was that we laid out very specifically what our plans were.

We were going to spin off the company's copper assets. We did. The company is now called Trilogy Metals. It's a very successful developer in partnership with South 32 in Alaska. We would sell our share of Galore Creek, not for the $40 or $50 million that people assumed, but for $200-275 million. We would therefore position Donlin Gold as a pure play on the next Nevada through our vehicle, NOVAGOLD.

So we felt we didn't have headwinds. And in fact we moved right through permitting all the way through to a Record of Decision. So, essentially what you have is a company that articulates its strategy. It's not trying to be all things to all people. We've never gone out of our way to say when we're going to go into production, for the simple reason that we've always said that the whole idea is to make money and that required higher gold prices because our job is not to be producing high-grade, open-pit gold to subsidize Chinese and Indian consumption. When share prices are higher, we minimize dilution. And to our mind, certainly now, the shares are more valuable than the metal itself. So, for all of these reasons, I think that we have an exceptionally educated shareholder base, which is one of the reasons why they've been very loyal to us. Obviously, as they say in Russia, a fish rots from the head down. So they at least see that in our case, the owners live above the store and are completely investor-friendly because we're in fact the largest shareholders. We've got skin in the game.

Now that you're positioned, you've sold Galore, you've spun out Trilogy, you're permitted, and you've got the Record of Decision, what would you say are the next key events from an investor's point of view in 2022 – and maybe beyond?

Well, I think that we just had a press release, which was issued in December, that lays out the joint strategy by Barrick and NOVAGOLD for taking Donlin Gold up the value chain. We have a drill program coming up. It's very exciting for us, especially for me, because my fortunes have been made through the drill bit and I've always been a very strong believer

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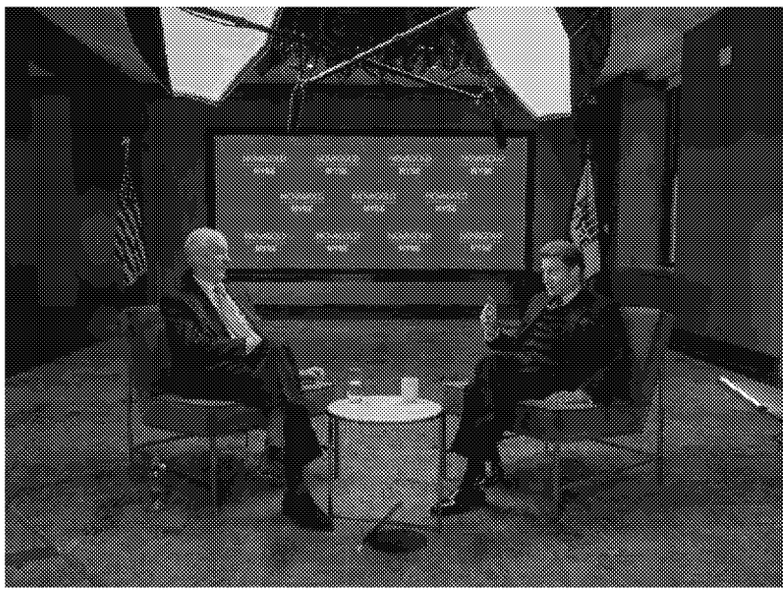
in the exploration potential at Donlin Gold. And in a bull market in gold, when you deliver exploration results that are positive, it's a very, very wonderful thing. So, I'm looking forward to that and I believe that the next step will therefore be a review of the feasibility study, which was last done nearly a decade ago. Sure, a lot has changed, not the least of which is the potential strategy itself of developing Donlin Gold in stages. Ultimately that will be determined jointly by the board of Donlin Gold, which is 50 percent Barrick, 50 percent NOVAGOLD.

One of the things that I really have to stress – because it's one of our most attractive attributes – is that Donlin Gold, the joint venture, is a true 50/50, which means that no partner has one iota greater rights than the other. In practical terms, we've never had any dissonance between the shareholders, certainly not since the time that I've been involved in the story. We get along extremely well with Barrick and the relationship between the management teams of Barrick and NOVAGOLD has never been better. And Mark Bristow and I have a relationship that goes back over 20 years and has been marked by successes in African Platinum, where he was a director and I was the largest shareholder.

I was the largest shareholder of Moto Gold and was able to deliver that to him when he decided that he wanted the Kibali project in Congo, and we've enjoyed really great relations. But very importantly, what you also see is that we're in sync on the work plan which has been laid out, something that is using very much Randgold kind of influences. In terms of news flow, we're hopeful about the next drill program and we believe that it should lead to a decision by Donlin Gold to proceed with a review of the feasibility study. When we talk about the Donlin Gold joint venture, investors have to understand that the way that it was constructed was brilliant. It had nothing to do with me so I'm not claiming any credit for it, but before we came into the NOVAGOLD story, they had devised two 50/50 joint ventures on Donlin Gold Creek, as it was then called, and Galore Creek. These are genuine 50/50s, which is why when Newmont came into Galore Creek, they were able to join Teck Resources as a completely equal partner. In this business, unlike in hydrocarbons, for example, that extra 0.1 of a percent and operatorship makes a big difference. Because we don't have any deficiency in that respect with regard to Barrick, should one day NOVAGOLD be the object of a takeover attempt, one of the most attractive attributes for an acquirer is that when they enter into the story, they are not subordinate to the existing partner. It's a true 50/50. They will both jointly be the operator. That is a huge selling point in this industry.



Not that you're for sale...

Not that we're for sale, but our job is to ensure that under any eventuality we get the premium valuation for our asset. And if that means being the beneficiary of things that took place before we came onto the scene, great. I think everything that we have done on our watch has positioned the company so that we are in a position to take this project, with our partner Barrick, up the value chain; to be able to finance the project, our aim being with minimal equity dilution; and if someone else is going to pay shareholders for the future – in a way that is accretive and attractive – our job is to maximize that value and hence to maximize the valuation. I think that everything that we've done – but most importantly, everything about the Donlin Gold asset – has given us the attributes that, whether we take this into production or someone else does, it's going to prove to be one of the industry's really, really great and epic successes.

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Delivery of supplies for the 2021 Porfiin Gold drill program.

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NOTES

1) See media releases titled "Donlin Gold Initial 2021 Drill Program Results Continue to Deliver for Project Advancement", September 2, 2021 and "Barrick and NOVAGOLD Agree on Next Steps Toward Advancement of Donlin Gold; Drill Assay Results Continue to Yield High Grade Intercepts and Demonstrate Important Grade Continuity, with Clear Improvement in Definition of Controls of Mineralization, that Project is Advancing Towards Feasibility Study Update", December 2021.

2) Anticipated annual gold production during full life of mine if put into production as per the NI 43-101 Technical Report on the Donlin Gold Project, Alaska, USA with an effective date of June 1, 2021 (the "2021 Technical Report") and the S-K 1300 Technical Report Summary on the Donlin Gold Project, Alaska, USA, November 30, 2021 (the "S-K 1300 Technical Report Summary"). See "Cautionary Note Concerning Reserve & Resource Estimates" and "Mineral Reserves & Mineral Resources" table on page 35.

3) NOVAGOLD defines a Tier-One gold development project as one with a projected production life of at least 10 years, annual projected production of at least 500,000 ounces of gold, and average projected cash costs over the production life that are in the lower half of the industry cost curve.

4) Forecast includes $30 million to Donlin Gold, $13 million to NOVAGOLD G&A and $3 million for withholding taxes on PSUs and other working capital. This report may also contain future-oriented financial information ("FOFI") and information which could be considered to be in the nature of a "financial outlook". Such FOFI or financial outlook was approved by NOVAGOLD's management as of the date of this report for the purpose of providing management's reasonable estimate based on the assumptions set forth in such estimates and the information may not be appropriate for other purposes. Management cautions that such FOFI or financial outlook reflects NOVAGOLD's current beliefs and are based on information currently available to NOVAGOLD and on assumptions NOVAGOLD believes are reasonable. Actual results and developments may differ materially from results and developments discussed in the FOFI or financial outlook as they are subject to a number of significant risks and uncertainties. Certain of these risks and uncertainties are beyond NOVAGOLD's control. Consequently, all of the FOFI or financial outlook are qualified by these cautionary statements, and there can be no assurances.

5) NOVAGOLD sold its 50% ownership of the Galore Creek project to Newmont in 2018. Deferred compensation on the sale of Galore Creek includes $25M on the earlier of completion of a Feasibility Study or July 27, 2023. An additional $75M is due upon construction approval. For additional detail, see the media release dated July 28, 2021: "NOVAGOLD Receives $75 Million from Newmont Corporation".

6) See July 26, 2018 media release titled "NOVAGOLD Enters Agreement to Sell its 50% Stake in Galore Creek to Newmont for up to $275 Million."

7) Donlin Gold data as per the 2021 Technical Report and the S-K 1300 Technical Report Summary (as defined herein). Donlin Gold proven and probable reserves of approximately 16.925Moz grading 2.09 g/t attributable to NOVAGOLD (33.849Moz on 100% basis) and measured and indicated resources, exclusive of reserves, of approximately 2.749Moz grading 2.43 g/t attributable to NOVAGOLD (5.497 Moz on 100% basis). 39Moz refers to mineral resources inclusive of reserves on a 100% basis.

8) Donlin Gold data as per the 2021 Technical Report and the S-K 1300 Technical Report Summary (as defined herein). Donlin Gold measured resources of approximately 8 Mt grading 2.52 g/t and indicated resources of approximately 534Mt grading 2.24 g/t, each on a 100% basis and inclusive of mineral reserves, of which 50% are attributable to NOVAGOLD through their 50% ownership interest in Donlin Gold LLC. Exclusive of mineral reserves, Donlin Gold possesses measured resources of approximately 1Mt grading 2.23 g/t and indicated resources of approximately 69Mt grading 2.44 g/t, each of which 50% are attributable to NOVAGOLD. Mineral resources have been estimated in accordance with NI 43-101 and S-K 1300.

9) 2020 average grade of open-pit and underground deposits with gold as primary commodity and over 1Moz in measured and indicated resources is 1.12 g/t, sourced from S&P Global Market Intelligence.

10) *Annual Survey of Mining Companies*, 2020

11) The jurisdictional risk map is derived from the top 10 (lower risk) and bottom 10 (extreme risk) of 77 jurisdictions reviewed in the Fraser Institute *Annual Survey of Mining Companies*, 2020.

12) Represents 100% of M&I resources, inclusive of mineral reserves, of which 50% is NOVAGOLD's share. Donlin Gold is not in production and a construction decision has not been made. See "Cautionary Note Concerning Reserve and Resource Estimates" and "Mineral Reserves & Mineral Resources" table on page 35.

13) Gold development stage projects defined as the top 5 globally by contained gold in measured and indicated resources, >75% projected revenues from gold, and with stated proven and probable reserves, as per latest company documents, public filings and websites as of November 2021.

14) Only three mines produced greater than 1 million ounces in 2020: Muruntau (2,652koz), Carlin (1,665koz), and Olimpiada (1,229koz), as per SNL Metals & Mining, an offering of S&P Global Market Intelligence.

15) Market Capitalization based on 332.9 million shares issued and outstanding and NOVAGOLD share price of $6.82 as of January 25, 2022. Stock options outstanding as of January 19, 2022.

16) Represents average grade of measured and indicated mineral resources, inclusive of mineral reserves. See "Cautionary Note Concerning Reserve and Resource Estimates" and "Mineral Reserves & Mineral Resources" table on page 35.

17) 2020 average grade of open-pit and underground deposits with gold as primary commodity and over 1Moz in measured and indicated resources, sourced from S&P Global Market Intelligence.

18) Donlin Gold data as per the 2021 Technical Report and the S-K 1300 Technical Report Summary (as defined herein). All dollar figures are in USD, represent 100% of the project of which NOVAGOLD's share is 50%, and reflect after-tax net present value (at 0% and 5% discount rates) of the Donlin Gold project using the reference date of start of Year -06 as the first year of discounting. Estimated owner's initial capital project development costs of approximately $348M to be spent prior to the reference date are treated as sunk costs. At a 5% discount rate, the net present value is: $1,161M at $1,300 gold; $3,040M at $1,500 gold; $4,887M at $1,700 gold; $7,229M at $2,000 gold; and $11,199M at $2,500 gold. The project requires a gold price of approximately $930 per ounce to break even on an undiscounted cash flow basis and a gold price of approximately $1,180 per ounce to break even on a 5% discounted basis.

19) Anticipated annual gold production during full life of mine if put into production as contemplated in the 2021 Technical Report and the S-K 1300 Technical Report Summary (as defined herein). See "Cautionary Note Concerning Reserve & Resource Estimates" and "Mineral Reserves & Mineral Resources" table on page 35.

20) Peer group data based on company documents, public filings and websites as of November 2021. Comparison group of 14 projects based on large (2Moz P&P cut off), North/South American gold-focused development projects with >75% projected revenues from gold.

21) Average of comparison group data of 14 projects based on large (2Moz P&P cut off), North/South American gold-focused development projects with >75% projected revenues from gold, as per latest company documents, public filings, and websites as of November 2021.

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MINERAL RESERVES & MINERAL RESOURCES

Donlin Gold	Tonnage	Grade	Metal content 100% basis	Attributable to NOVAGOLD 50%
GOLD	kt	g/t Au	koz Au	koz Au
Reserves[1]				
Proven	7,683	2.32	573	287
Probable	497,128	2.08	33,276	16,638
P&P	504,811	2.09	33,849	16,925
Resources,[2] exclusive of Reserves				
Measured	869	2.23	62	31
Indicated	69,402	2.44	5,435	2,718
M&I	70,271	2.43	5,497	2,749
Inferred	92,216	2.02	5,993	2,997
Resources,[2] inclusive of Reserves				
Measured	7,731	2.52	626	313
Indicated	533,607	2.24	38,380	19,190
M&I	541,337	2.24	39,007	19,503
Inferred	92,216	2.02	5,993	2,997

Donlin Gold approximate cut-off grades (see Mineral Resources and Reserves Footnotes):
Reserves:[1] 0.57 g/t gold
Resources:[2] 0.47 g/t gold

Notes:

a) Mineral Reserves & Mineral Resources are reported on a 100% basis and on a 50% ownership basis, and are current as of November 30, 2021. The 50% basis is attributable to NOVAGOLD through its 50% ownership interest in Donlin Gold LLC which owns the Donlin Gold project.
b) These Mineral Reserve and Resource estimates have been prepared in accordance with NI 43-101, the 2014 CIM Definition Standard, and S-K 1300.
c) Rounding may result in apparent summation differences between tonnes, grade and contained metal content
d) Tonnage and grade measurements are in metric units. Contained gold is reported as troy ounces. Currency is reported as U.S. dollars.

t = metric tonne g/t = grams/tonne oz = troy ounce k = thousand M = million

Mineral Resources and Reserves Footnotes:

1) Mineral Reserves are reported within the pre-feasibility pit designs, and supported by a mine schedule, featuring variable throughput rates, stockpiling and cut-off optimization. The point of reference for Mineral Reserves estimates is where the reserves are delivered to the mill. The pit designs are contained within an optimized pit shell based on the following economic and technical parameters: Metal price for gold of $1,200/oz; reference mining cost of $2.16/t incremented $0.0033/t/m with depth from the 220 m elevation (equates to an average mining cost of $2.64/t), fixed processing cost $13.78/t processed; sustaining capital of $1.54/t processed; general and administrative cost of S$3.66/t processed; stockpile rehandle costs of $0.24/t processed assuming that 45% of mill feed is rehandled; variable metallurgical recoveries by rock type, ranging from 86.7% in shale to 94.2% in intrusive rocks in the Akivik domain; refining and freight charges of $1.21/oz gold; royalty considerations of 4.5% NSR and $0.50/t processed; and variable pit slope angles, ranging from 23° to 43°. Mineral Reserves are reported using an optimized block value (BV) based on the following equation: BV = Au grade * Recovery * $1,200/oz – royalties & refining costs – process operating costs – G&A cost reported in $/t. Assuming an average gold recovery of 89.5% the marginal gold cut-off grade would be approximately 0.57 g/t, or the gold grade that would equate to a $0.001 BV cut-off at these same values. The life-of-mine (LOM) strip ratio is 5.48:1. The assumed LOM throughput rate is 53,500 t/d.
2) Mineral Resources that are not Mineral Reserves do not have demonstrated economic viability. Inferred Resources are in addition to Measured and Indicated Resources. Inferred Resources have great uncertainty as to their existence and whether they can be mined legally or economically. The cut-off date for the sample database used in the Mineral Resource estimate is 1 November 2009. However, more recent drilling data were used to validate the resource model as remaining current. Mineral resources are reported in-place (point of reference) and contained within a conceptual measured, indicated and inferred optimized pit shell using the following assumptions: gold price of $1,200/oz; variable process cost based on 2.1874 * (sulphur grade) + 10.6485; administration cost of $2.29/t; refining, freight & marketing (selling costs) of $1.85/oz recovered; stockpile rehandle costs of $0.20/t processed assuming that 45% of mill feed is rehandled; variable royalty rate, based on royalty of 4.5% * (Au price – selling cost); and a variable metallurgical recovery depending on the host rock type ranging from 86 to 94%. Assuming an average recovery of 89.5% and average S% grade of 1.07, the marginal gold cut-off grade is 0.47 g/t. These technical and economic parameters are those that were used in the Donlin 2011 Technical Report to establish reasonable prospects of eventual economic extraction (effective 11 July 2011). Based on the QP review of the estimate, there would be no material change to the Mineral Resources if the gold price were updated to $1,500/oz and other economic parameters were updated to the 2020 parameters used in the Mineral Reserve estimate. As a result, the Mineral Reserve and Mineral Resource estimates shown above remain unchanged from the 2011 estimates contained in the prior technical report. S-K 1300 requires that Mineral Resources be reported exclusive of Mineral Reserves. We have supplementally reported Mineral Resources inclusive of Mineral Reserves.

Regarding Forward-Looking Statements

This report includes certain "forward-looking information" and "forward-looking statements" (collectively "forward-looking statements") within the meaning of applicable securities legislation, including the United States Private Securities Litigation Reform Act of 1995. All statements, other than statements of historical fact, included herein, including, without limitation, statements regarding the permitting, potential development, exploration, construction and operation of Donlin Gold and statements relating to NOVAGOLD's future operating and financial performance and production estimates are forward-looking statements. Forward-looking statements are frequently, but not always, identified by words such as "expects", "anticipates", "believes", "intends", "estimates", "potential", "possible", "poised", and similar expressions, or statements that events, conditions, or results "will", "may", "could", "would" or "should" occur or be achieved. These forward-looking statements may also include statements regarding the exploration potential of Donlin Gold; anticipated mine life; perceived merit of properties; anticipated permitting timeframes; exploration and drilling results and budgets; mineral reserve and resource estimates; work programs; capital expenditures; timelines; market prices for precious metals, including the potential performance of the price of gold or other statements that are not statements of fact. Forward-looking statements involve various risks and uncertainties. There can be no assurance that such statements will prove to be accurate, and actual results and future events could differ materially from those anticipated in such statements. Important factors that could cause actual results to differ materially from NOVAGOLD's expectations include the uncertainties involving unexpected cost increases, which could include significant increases in estimated capital and operating costs; the need for additional financing to explore and develop properties and availability of financing in the debt and capital markets; risks related to the outbreak of the coronavirus global pandemic (COVID-19); uncertainties involved in the interpretation of drilling results and geological tests and the estimation of reserves and resources; the need for continued cooperation with Barrick Gold Corporation for the continued exploration and development of the Donlin Gold property; the need for cooperation of government agencies and native groups in the development and operation of properties; risks of construction and mining projects such as accidents, equipment breakdowns, bad weather, non-compliance with environmental and permit requirements; unanticipated variation in geological structures, ore grades or recovery rates; the need to obtain permits and governmental approvals; fluctuations in metal prices and currency exchange rates; whether a positive construction decision will be made regarding Donlin Gold and other risks and uncertainties disclosed in NOVAGOLD's annual report filed on Form 10-K for the year-ended November 30, 2021, and subsequently in NOVAGOLD's quarterly reports filed on Form 10-Q, with the United States Securities and Exchange Commission (SEC), Canadian securities regulators, and in other NOVAGOLD reports and documents filed with applicable securities regulatory authorities from time to time. Copies of these filings may be obtained at no charge by visiting our Investor Relations website at [illegible] or the SEC's website at [illegible] or at [illegible]. NOVAGOLD's forward-looking statements reflect the beliefs, opinions and projections of management on the date the statements are made. NOVAGOLD assumes no obligation to update the forward-looking statements of beliefs, opinions, projections, or other factors, should they change, except as required by law.

Forward-looking statements are based on a number of material assumptions, including but not limited to the following, which could prove to be significantly incorrect: our ability to achieve production at any of our mineral exploration and development properties; estimated capital costs, operating costs, production and economic returns; estimated metal pricing, metallurgy, mineability, marketability and operating and capital costs, together with other assumptions underlying our resource and reserve estimates, our expected ability to develop adequate infrastructure and that the cost of doing so will be reasonable, assumptions that all necessary permits and governmental approvals will be obtained and the timing of such approvals; assumptions made in the interpretation of drill results, the geology, grade and continuity of our mineral deposits; our expectations regarding demand for equipment, skilled labor and services needed for exploration and development of mineral properties; and that our activities will not be adversely disrupted or impeded by development, operating or regulatory risks.

Cautionary Note Concerning Reserve & Resource Estimates

This report uses the terms "mineral resources", "measured mineral resources", "indicated mineral resources" and "inferred mineral resources". Mineral resources that are not mineral reserves do not have demonstrated economic viability. You should not assume that all or any part of measured or indicated mineral resources will ever be converted into mineral reserves. Further, inferred mineral resources have a great amount of uncertainty as to their existence and as to whether they can be mined legally or economically. On October 31, 2018, the SEC adopted new mining disclosure rules ("S-K 1300") that are more closely aligned with current industry and global regulatory practices and standards, including National Instrument 43-101 – Standards of Disclosure for Mineral Projects ("NI 43-101"). NOVAGOLD has elected to comply with S-K 1300 for its fiscal year ended November 30, 2021.

While S-K 1300 is more closely aligned with NI 43-101 than the prior SEC mining disclosure rules, there are some differences. Notably, unlike NI 43-101, S-K 1300 requires that resources be disclosed exclusive of mineral reserves, and that mineral resources and reserves be disclosed on the basis of our interest in them. NI 43-101 is a rule developed by the Canadian Securities Administrators, which established standards for all public disclosure an issuer makes of scientific and technical information concerning mineral projects. All reserve and resource estimates contained in the tables about have been prepared in accordance with NI 43-101 and the CIM Definition Standards, as well as S-K 1300.

Technical Reports and Qualified Persons

The documents referenced below provide supporting technical information for the Donlin Gold project.

Project	Qualified Person(s)	Most Recent Disclosures
Donlin Gold	Kirk Hanson, MBA, PE. Michael Woloschuk, P.Eng. Henry Kim, P.Geo. Wood Canada Limited	"NI 43-101 Technical Report on the Donlin Gold Project, Alaska, USA" prepared by Wood Canada Limited ("Wood"), effective June 1, 2021. "S-K 1300 Technical Report Summary on the Donlin Gold Project, Alaska, USA" prepared by Wood Canada Limited ("Wood"), November 30, 2021.

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CORPORATE INFORMATION

MANAGEMENT TEAM

GREGORY LANG . . . . . President & Chief Executive Officer
DAVID OTTEWELL . . . . . Vice President & Chief Financial Officer
MÉLANIE HENNESSEY . . . . . Vice President, Corporate Communications
RON RIMELMAN . . . . . Vice President, Environment, Health, Safety, & Sustainability
RICHARD WILLIAMS . . . Vice President, Engineering & Development

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SHARON DOWDALL [2, 4] . . . . . Corporate Director
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GREGORY LANG [1, 5] . . . . . President & CEO, NOVAGOLD RESOURCES INC.
IGOR LEVENTAL [4, 5] . . . . . President, The Electrum Group
KALIDAS MADHAVPEDDI [2, 3] . . . . . Corporate Director
CLYNTON NAUMAN [1, 3] . . . . . CEO, Alexco Resource Corp., & CEO, Asset Liability Management Group ULC
ETHAN SCHUTT [1, 4, 5] . . . . . Executive Vice President & General Counsel, Bristol Bay Native Corporation
ANTHONY WALSH [1, 2] . . . . . Corporate Director Independent Lead Director, NOVAGOLD RESOURCES INC.

Member of:
1. Audit Committee
2. Compensation Committee
3. Environment, Health, Safety, Sustainability, and Technical Committee
4. Corporate Governance and Nominations Committee
5. Corporate Communications Committee

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AUDITORS

PRICEWATERHOUSECOOPERS LLP

SHARE LISTINGS

TSX, NYSE AMERICAN: NG
ISSUED AND OUTSTANDING AT JANUARY 19, 2022, 332.9 MILLION

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2021 FINANCIAL REPORT

From NOVAGOLD's Annual Report on Form 10-K for the fiscal year ended November 30, 2021
For full Annual Report on Form 10-K, please visit www.novagold.com, www.sec.gov, or www.sedar.com
Or call Investor Relations at 1.866.669.6227

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ANNUAL MEETING OF SHAREHOLDERS

Wednesday, May 18, 2022 – 1pm PT
Live Webcast at:
virtualshareholdermeeting.com/NG2022

INVESTOR INQUIRIES

T: 604.669.6227
Toll free: 1.866.669.6227
info@novagold.com
novagold.com
linkedin.com/company/novagold
twitter.com/novagold
facebook.com/novagold

CORPORATE OFFICE

400 Burrard Street, Suite 1860
Vancouver, BC, Canada V6C 3A6
T: 604.669.6227
Toll free: 1.866.669.6227
F: 604.669.6272
info@novagold.com

SALT LAKE CITY EXECUTIVE OFFICE

201 South Main Street, Suite 400
Salt Lake City, UT, USA 84111
T: 801.639.0511
F: 801.649.0509

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Q&A →

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GALORE CREEK TRANSACTION

Q&A

MOST COMMON QUESTIONS

What are the key milestones and goals for 2022?

What is the Company doing to respond to the COVID-19 pandemic?

Why should I be interested in NOVAGOLD today?

What makes the Donlin Gold project so unique among other large undeveloped projects?
It all comes down to geology, potential, economics, location, partnerships, and management.

Geology –With approximately 39 million ounces of gold in the measured and indicated resource categories (541 million tonnes of gold at an average grade of 2.2 grams per tonne)[1] , and an additional approximately six million ounces (92 million tonnes at an average grade of 2.0 grams per tonne) in inferred resources, Donlin Gold is one of the world's largest known undeveloped gold deposits. These are excellent numbers, placing Donlin Gold well within the top one percent of known global gold deposits in terms of size. It's also blessed with high grades when compared with other open pit mines and projects. As we've seen in the recent downdraft in the mining industry, this kind of quality counts. Its grade is where the average grade of the industry was ten years ago and is more than double the average grade of gold mines and projects globally[2].

Potential – The NI 43-101 Technical Report on the Donlin Gold Project, Alaska, USA filed in 2021 and the S-K 1300 Technical Report Summary on the Donlin Gold Project, Alaska, USA, November 30, 2021[3] demonstrated that, as envisioned, Donlin Gold could become one of the largest single gold-producing mines in the world, averaging approximately 1,500,000 ounces of gold production in the first five years of operation and approximately 1,100,000 ounces per year over its 27-year life. And that's assuming no more higher-grade ore is found – or any additional ore at all, for that matter. In addition to its already large mineral endowment, Donlin Gold has excellent exploration potential,

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with the opportunity to expand the current open-pit resource both along strike and at depth. Considering that the current pit occupies only part of a three-kilometer area that is itself only a portion of an eight-kilometer mineralized belt, in NOVAGOLD's view it is likely that Donlin Gold's mine life, already measured in decades, or ultimate production profile – or both – is likely to be greater than anticipated.

Economics – During the first five years of operations, Donlin Gold's operating costs are estimated to be $3.5 billion or $477 per ounce of gold sold. Over the life of mine, the operating costs are estimated to be $19.3 billion or $635 per ounce of gold sold. This is very favorable in today's worl and a function of the project's high grade. The after-tax Net Present Value (NPV), using a gold pric of $1,500 per ounce at a 5 percent discount rate, was estimated at $3.0 billion, per the NI 43-101 Technical Report on the Donlin Gold Project, Alaska, USA. The NPV at 5% increases to $4.9 billion a gold price of $1,700 per ounce and $7.2 billion at a gold price of $2,000 per ounce.

Jurisdiction – Unstable and changing geopolitics, including but not limited to economic and political instability, have altered how the market views investment opportunities on the frontier. In our view, it's not an overstatement to say that jurisdictional risk represents the single greatest threat to the mining industry. Many companies and assets in the developing world have been victims of sovereign risk with unanticipated tax increases, royalties, civil unrest, permitting delays, corruption and resource nationalism. Market analysts, commentators, and investors are taking note of the actions by a number of governments to impose higher taxes and royalties on gold and other metal mines in their assessment of project value. We believe that the fact that Donlin Gold is in Alaska, America's second largest gold producing state, on private land already designated for mining and owned by Alaska Native corporations, distinguishes the project from other undeveloped open pit gold deposits. In summary, as a corollary to this heightened awareness, we believe that when sentiment returns to the space, Donlin Gold's location in the United States will give NOVAGOLD a tremendous competitive advantage during a time when heightened resource nationalism and jurisdictional uncertainty is second only to investor sentiment as the most significant factor negatively affecting shareholder value among natural resource companies.

Partnerships – Donlin Gold enjoys broad support, including from our Alaska Native corporation stakeholders, Calista and TKC, who own the mineral and surface rights to Donlin Gold. Our well-established track record of social engagement and environmental stewardship in the community is a huge plus. The government of Alaska cites Donlin Gold as a model project for responsible development, a reputation that was reinforced in 2014 by a unique strategic alliance with the National Fish and Wildlife Foundation. That's not something you see every day, and we're proud of it.

Management – NOVAGOLD's operating management team is among the most solid in their credentials and pedigree as any you'll find in the industry. Greg Lang, president and CEO, has been fortunate to work with some of the most experienced individuals in the gold sector and on some of its greatest assets. He ran Barrick's top assets – their North American operations – as president for eight years before joining NOVAGOLD. During the majority of his 30-year career, Greg rose through the ranks with Barrick and the companies it had acquired, Homestake Mining and International Corona. Greg leads a team of experienced industry veterans. Dave Ottewell joined NOVAGOLD from Newmont; Mélanie Hennessey joined from Hecla; Ron Rimelman joined from Tetra Tech; and Richard Williams joined NOVAGOLD from Barrick right after bringing into production the mammoth Pueblo Viejo project. Each of these individuals left senior positions at these senior companies because they too see in Donlin Gold a truly unique and attractive gold asset in an era defined by quality asset scarcity.

In summary, Donlin Gold has size and extraordinary grade, industry-leading projected output, a low-cost structure, a company-making mine life, excellent exploration upside, strong local partnerships, and jurisdictional safety. Donlin Gold is a truly unique and attractive gold asset in an era defined by

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asset scarcity with leverage to rising gold prices in a strong gold environment. Finally, Donlin Gold is well-advanced in the permitting process; positioned to be ready to construct when market sentiment will support construction of a major new gold mine.

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[1] Donlin Gold data as per the NI 43-101 Technical Report on the Donlin Gold Project, Alaska, USA, effective June 1, 2021 and the S-K 1300 Technical Report Summary on the Donlin Gold Project, Alaska, USA, November 30, 2021. 39Moz refers to mineral resources inclusive of reserves on a 100% basis. Donlin Gold proven and probable reserves of approximately 16.925 Moz grading 2.09 g/t attributable to NOVAGOLD (33.849 Moz on 100% basis) and measured and indicated resources, exclusive of reserves, of approximately 2.749 Moz grading 2.43 g/t attributable to NOVAGOLD (5.497 Moz on 100% basis).
[2] 2020 average grade of open pit and underground deposits with gold as primary commodity and over 1Moz in measured and indicated resources, sourced from S&P Global Market Intelligence.
[3] See full technical reports here: https://www.novagold.com/properties/donlin_gold/technical_report/

What is the latest status of the Donlin Gold project?

What state permits remain outstanding for the Donlin Gold project?

What is your anticipated spending for Donlin Gold in 2022?

How much risk do you see of environmental litigation delaying the project?

DONLIN GOLD

Do you have all the surface rights and exploration licenses in place to mine at the Donlin Gold project for as long as there is potential?

How would you describe the Donlin Gold ore body?

Is there potential for a smaller scale project requiring lower initial capital and providing better economics in this gold price environment? Or does the large infrastructure requirement make a smaller scale project difficult economically?

Can you briefly describe the social stakeholders in the Donlin Gold project and how are you managing your community relations and obligations?

FUNDING AND VALUATION

How does NOVAGOLD expect to finance its share of the capital cost of putting Donlin Gold into production?

Does NOVAGOLD participate in the Direct Registration of Shares (DRS)?

STILL HAVE A QUESTION?

Please email info@novagold.com. While we may not be able to post all questions on the website, we will respond promptly to everyone.

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NovaGold Resources' (NG) CEO Greg Lang on Q1 2016 Results - Earnings Call Transcript

Apr. 05, 2016 1:48 PM ET | **NovaGold Resources Inc. (NG), NG:CA**

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NovaGold Resources, Inc. (NYSE:NG) Q1 2016 Earnings Conference Call April 5, 2016 11:00 AM ET

Executives

Melanie Hennessey - VP, Corporate Communications

Greg Lang - President and CEO

David Ottewell - Vice President and CFO

Analysts

John Bridges - JPMorgan

Operator

Good day, ladies and gentlemen and welcome to the NOVAGOLD First Quarter 2016 Conference Call and Webcast. At this time, all participants are in a listen-only mode. Later, we will conduct a question-and-answer session and instructions will follow at that time. [Operator Instructions].

I would now like to turn the conference over to your host, Melanie Hennessey, you may begin.

Melanie Hennessey

Thank you, Melissa [ph] and good morning everyone. Thanks for joining us to get an update on NOVAGOLD's first quarter results and also to hear about the Donlin Gold and Galore Creek project update. Today on the call we have Mr. Lang, NOVAGOLD's President and CEO; and David Ottewell, NOVAGOLD's Vice President and CFO.

At the end of the presentation, we will have time for Q&A by phone and by e-mail, but before we get started, we would like to remind all of you that some of the statements may contain forward-looking information for which the risks are detailed in our various EDGAR and SEDAR filings, and also in our forward disclaimers that are included in this presentation.

With that, I have the pleasure of introducing Mr. Lang, NOVAGOLD's President and CEO. Greg?

Greg Lang

Thank you, Melanie and good morning everyone. For those who are less familiar, NOVAGOLD is a development stage company with two great assets in North America. Our flagship Donlin Gold project, which we co-own with Barrick, is well into permitting and poised to become one of the largest producers in the industry. Galore Creek, which is held in 50% partnership with Teck is expected to be one of the largest and lowest cost copper mines in Canada.

In the first quarter, meetings were held with the Corps of Engineers across the Y-K region as part of the Donlin Gold draft EIS public comment period. This is no small feat considering that the Y-K region is comparable in size to the State of Utah. At each meeting, the Corps presented an overview of the draft EIS, which evaluates the potential environmental, social, and economic impacts of the proposed projects, and the Corps encourages local residents to communicate what the project means to them and their families.

The meetings are expected to conclude in the second quarter, and all the comments will be reviewed and responded to by the Corp in the final EIS, which is anticipated to be published in 2017. While actively participating in the EIS, Donlin Gold has also advanced other major permits, applications, and approvals.

At Galore Creek, we continue to work with Teck on technical studies, mine planning, and design. Phase 1 of the tunnelling practise study is also underway to evaluate alternatives for this undertaking. Through our investments in Donlin Gold and Galore Creek, NOVAGOLD remains an active member of the local communities where we operate. For the sixth consecutive year, Donlin was the principal sponsor of the Iditarod Sled Dog Race completed in Nome, Alaska.

We'd like to take this opportunity to recognize Pete Kaiser, a resident of the Y-K region that we sponsor, who placed fifth in the race this year. This race is truly a test of endurance and determination. Additionally, Donlin Gold continued as the premier sponsor of the Iron Dog 2016, a 2000 mile long snow mobile race.

In Northern British Columbia, Galore Creek continues to sponsor and participate in a number of Tahltan community activities. At this stage, I'll turn it over to Dave to cover our financials.

David Ottewell

Thank you Greg and good morning everyone. Turning to slide six, our share of Donlin Gold and Galore Creek funding totaled $2.0 million [ph] for the quarter as we expected. For the full year, we continue to expect to expand approximately $10 million to fund Donlin Gold and Galore Creek.

Slide seven highlights our first quarter operating performance. For the quarter, we reported a $1.8 million decrease in operating loss, approximately 16% lower than the prior year quarter. General and administrative expense was lower, primarily due to lower corporate communication and share based compensation costs and the stronger U.S. dollar in relation to the Canadian dollar.

Also, our share of expenses at Donlin Gold and Galore Creek was $400,000 lower than in the prior year quarter.

NOVAGOLD's cash flow highlights are outlined on slide eight. During the first quarter, our cash and term deposits decreased by $9.8 million as planned and similar to the prior year quarter. Cash spending is higher in the first quarter each year to settle our year end accounts including professional fees and annual employee incentive programs.

We ended the quarter with cash and term deposits totaling $117 million and continue to expect to end the year with over $100 million. Greg, back to you.

Greg Lang

Thank you, Dave. Our Donlin Gold project has all the key attributes that are required of the modern cost effective mine. Starting with size, Donlin is one of the largest undeveloped Gold deposits in the industry, and our shareholders look at this thing as an unexpiring warrant on an ounce of gold. Its size and scale are without equal in the gold industry.

When you compare Donlin to the other undeveloped gold deposits, it's far and away the largest, and many of the other development stage projects are located in some very challenging jurisdictions. At a million and a half ounces a year, its production profile would make it the largest gold mine in the industry if it was built today.

The other attribute that really separates Donlin from other undeveloped deposits is its grade. At two and a quarter grams, Donlin is one of the highest large scale open pit deposits in the industry. It's this quality that really distinguishes Donlin from other recently developed gold mines.

Yes, it's a big deposit but it's still got a lot of room to grow. You know looking at this illustration, we've only extensively explored less than half of the gold bearing system. When the time is right, we'll resume exploration and have the potential to significantly add to our reserves and resources.

Donlin also brings the project and our shareholders tremendous leverage to rising gold prices. You know the project has modest marginal returns of today's prices that go up substantially in a rising price environment, and we think that that rising price environment is just resuming its upward path.

You know we've got great partners on Donlin. We've been working hand in hand with Barrick as we've advanced the permitting of this asset and conducting ongoing technical studies to enhance the value of the asset. Neither of us had to build it at any price mentality. When the time when the markets are right, we'll make a construction decision.

Slide 15 provides an overview of the development schedule as well as outlining our key permitting milestones. You were about past the halfway point in the public comment period and when you look at the investment in time it takes to get a project of this stage, we think the four years in permitting is just a minor part of the timeline.

Permitting in the United States is a very public process. We welcome the input from local stakeholders. We're out there actively in the villages, encouraging people to participate in the process. This project will be a core economic force in the Y-K regions, and it will fulfil the promise of the Alaska native's claims settlement act to provide economic prosperity for Alaska natives through responsible development of their land. Their voice is an essential factor in determining the future of this project.

Our other grade asset, Galore Creek on slide 17, I mean it's a tremendous copper, gold, silver deposit, it's somewhat lost in the shadow of Donlin, but it's a great asset. We are working on advancing this at a fairly measured pace with our partner and when the time is right, we'll monetize this asset to further strengthen our balance sheet.

On slide 18, NOVAGOLD it's an institutional quality gold stock. Over half of our outstanding shares are with our major shareholders, many of them whom have been in the company for a long time. Yes, so why would you look at this company now?

We are in great shape financially. We've got top tier assets in safe jurisdictions, and we'll be a significant gold producer in a few years time. Thank you. We'll now open the line for questions.

Question-and-Answer Session

Operator

Thank you. [Operator Instructions] Our first question comes from the line of John Bridges, JPMorgan. Your line is open.

John Bridges

Good morning, Greg everybody. Just wondered what sort of topics were coming up in the meetings and how those meetings were going in general?

Greg Lang

John, the topics that have come up in the public meetings were near largely as we expected. Barging remains a significant issue as people are concerned about the potential impacts on the substinence [ph] fishing on the river, and you know we've worked with the Corps of Engineers to address those issues. But I think that other issues that have come up are pretty typical of large scale industrial activity like this that people want to know about mercury controls and other means that the project will take to protect the environment, but nothing really surprising, John.

John Bridges

There are no surprises is good, right. And just wondered also your partner has been talking about the sort of Phase I scale of operations. I know you are working on it, I just wonder if there is any new development there that you could talk about?

Greg Lang

John, now we are working actively with Barrick on different development scenarios, nothing that we're really ready to bring out and do the full light of day yet, but it's very co-operative spirit with Barrick and I think you know stage development is really nothing new. I mean, when people look back at other large scale operations, Goldstrike among them, you know that was built in a series of phases over many years and you know the staged approach on Donlin may make sense, you know a year and a half from now. A lot of it of course will depend on gold prices and market conditions. But it's -- we're focussed on getting our big projects approved and when we've got that behind us we'll look at what makes the most sense to take forward.

John Bridges

Okay. Interesting. Best of luck, Greg everybody, and I'll get out of the way. Thank you.

Greg Lang

Thank you, John. Appreciate you participating in the call today.

John Bridges

You're welcome.

Operator

[Operator Instructions]

Greg Lang

All right everyone. Thank you for participating in our call this morning. There being no further questions, we'll close the lines

Operator

Ladies and gentlemen, thank you for participating in today's conference. This concludes today's program. You may all disconnect. Everyone have a great day.

Comments

Sort by Newest