TECHNICAL MEMORANDUM

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TO Ryan Fequet, Executive Director
Wek'èezhìı Land and Water Board

FROM Denise Lockett, Nighthawk Gold Corp. **EMAIL dlockett@nighthawkgold.com**

OPTIONS ANALYSIS TO ADDRESS ACIDITY CONCERNS AT DAMOTI LAKE (SNP 5-10)

1.0 INTRODUCTION

The Damoti Lake Site (Damoti) is located 200 km north of Yellowknife in the Northwest Territories (NT), within the Wek'èezhìı co-management land boundaries. Nighthawk Gold Corp. (Nighthawk) currently holds the leases to Damoti. Surveillance Network Program (SNP) monitoring is required under Type B Water Licence W2018L2-0003 (WLWB 2019). The pH at SNP stations around the waste rock area is monitored to detect changes in acidity over time because mobilization of heavy metals (e.g., iron, copper, and nickel) can be influenced by the local pH and reducing conditions. Over the past three sampling events (September 2020, June 2021, and September 2021), pH at SNP 5-10 ranged from 3.7 to 5.1 and was consistently below the range specified in the Water Licence of 6.0 to 9.5 (Golder 2020). The location and description of this station is provided in Table 1.

Further investigation of SNP 5-10 was conducted during the September 2019 and August 2021 sampling events to determine if the location of the station on the eastern edge of the rock piles may contribute to the distinct water quality observed in this area (Golder 2019, 2022). SNP 5-10 is surrounded by consolidated waste rock and is the only SNP station around the waste rock piles that is hydrologically isolated from the main drainage pathway (Golder 2021). The station is also located adjacent to a bog that has characteristically low pH; 4.5 to 5.2 in September 2019 and August 2021 (Golder 2019, 2022). Based on the results of this investigation, low pH at this station appears to be related to inputs from the bog and also lack of dilution from surface runoff through the main rock pile drainage.

At the direction of the Water Licence Inspector, treatment was performed at SNP 5-10 from May to October 2021 (GNWT-ENR 2021). The treatment procedure involved mixing sodium carbonate (i.e., soda ash) into the pond at SNP 5-10. The treatment resulted in short-term increases in pH but 14 site visits were required to try to maintain pH within the required Water Licence range.

This Information Request (IR) response provides an options analysis for SNP 5-10 as requested in IR#1 and provides a recommended process for implementing the selected option.

Table 1: Location and description of SNP station 5-10

Descriptor	Values
Description	Pool of standing water between waste rock/ore stockpiles
Easting	591929
Northing	7113986
Estimated surface area	125 m^2
Estimated average depth	0.4 m^2
Estimated volume	50 m^3

2.0 OPTIONS

Potential options identified for SNP 5-10 are outlined in Table 2. These options were identified to mitigate the acidity observed in the pond and are not identified as closure actions for the Site. The four main options for SNP 5-10 are summarized as follows:

1) Update the SNP compliance location in the new Type A Water Licence to be SNP 5-6 at the downgradient edge of the rock piles. This station would be the point of discharge to the receiving environment (Golder 2021), and the Water Licence limits and required pH range would therefore only apply at this station. Other stations would continue to be monitored under the SNP but would not be subject to the Water Licence limits. This option was developed based on the results of the drainage assessment (Golder 2021) that showed that SNP 5-10 is typically hydrologically isolated, but during high water levels, surface water may flow from SNP 5-10 into the main drainage pathway. Any changes in water chemistry resulting from inputs from SNP 5-10 would therefore be reflected in results at SNP 5-6. This approach would be accompanied by three new proposed SNP stations in the bog area to the east and northeast of SNP 5-10, as described in the response to IR#4.

2) Lime or soda ash application to neutralize pH will require ongoing (long-term) active treatment, and further consideration of the time intervals between treatment to maintain pH within the required Water Licence range.

3) Grading of the rock pile will be a long-term permanent solution, as it will result in removal of the standing pool of water at SNP 5-10. Each of the sub-options carries a higher initial capital cost than Option 1 or 2.

4) Installation of a liner in the pond at SNP 5-10 to limit the interaction of the ponded water with the waste rock piles.

Table 2: SNP 5-10 Options

Option No.	Option Description	Approximate Cost $ (Order of Magnitude)	Duration
1	Update the SNP compliance location in the new Type A Water Licence to be SNP 5-6 through regulatory consultation. Add three SNP stations east and northeast of SNP 5-10.	$20,000	Permanent
2	Lime/soda ash application at SNP 5-10 to neutralise pH in ponded water.	$50,000	<1 year
3a	Grading with (low PAG) waste rock from existing sources at site to remove pond at SNP 5-10.	$100,000	Permanent
3b	Grading with material from existing roads/trails (not waste rock) to remove pond at SNP 5-10.	$100,000	Permanent
3c	Grading with off site fill material (flown in from YK) to remove pond at SNP 5-10.	$150,000	Permanent
4	Lining the pond at SNP 5-10.	$35,000	5-10 year

3.0 OPTIONS ANALYSIS METHOD

A Multiple Accounts Analysis (MAA) selection method was used to compare the options in a transparent manner. This approach evaluates the options across several accounts, each weighted according to priority or relative importance.

The MAA assessment involved relative evaluation of the options in four general categories or accounts: environmental, technical, economic, and acceptance/approvals. For each account, evaluation criteria, called subaccounts, were developed. Each option was scored against the evaluation criteria in a systematic and transparent manner. The scores and weightings were combined to calculate weighted scores for each alternative to allow for relative ranking of the options and determination of the preferred option. All of the evaluation criteria, weightings, and scoring criteria were compiled into a table.

The options were evaluated against each account using a five-point scoring scale, with 1 being least preferred and 5 being most preferred. Each option was evaluated relative to the other options for each indicator and scores were assigned using the scoring descriptions. Quantitative methods were used to assign relative scores where possible; however, some indicators required the use of qualitative judgement.

The MAA accounts, sub-accounts, weightings, and scoring descriptions used are summarized in Table 3. Section 3.1 outlines the calculations used to combine scores and weightings to calculate rankings for individual options.

Table 3: SNP 5-10 Options Assessment – Accounts, Sub-accounts, and Weightings

Account	Account Weighting	Sub-account	Weight within Account	Indicator	Scoring Criteria		
					1	3	5
Environmental	25%	Aquatic life protection	33%	Water quality is safe for aquatic life in Lardass Lake	Water quality predictions indicate that aquatic life benchmarks may not consistently be met	Water quality predictions indicate that aquatic life benchmarks will be met with a reasonable level of confidence/certainty.	Water quality predictions that meet or are significantly better than aquatic life benchmarks with a high level of confidence/certainty.
		Terrestrial life protection	33%	Water quality is safe for terrestrial life at SNP 5-10	Water quality predictions indicate that wildlife benchmarks may not consistently be met.	Water quality predictions indicate that wildlife benchmarks will be met with a reasonable level of confidence/certainty.	Water quality predictions that meet or are significantly better than wildlife benchmarks with a high level of confidence/certainty.
		GHG emissions	33%	GHG emissions from the project	GHG emissions are high relative to other options	GHG emissions are reasonable and in line with other options	GHG emissions are minimized
Technical	25%	Option complexity	50%	Effort and complexity for procurement, logistics and execution	Significant equipment and materials to construct must be sourced offsite and mobilized via winter road, requiring significant lead times and logistical planning. Complex construction required.	Requirement to mobilize additional equipment/materials via helicopter, but no significant logistical challenges. Procurement and lead times are a non-issue provided proper planning is completed. Option is limited in complexity.	Minimal equipment and materials are required to execute. Minimal or no logistical planning required. Execution method is simplistic.
		Confidence in Performance	50%	Proven reliability in technology	Option has no/limited previous full-scale implementation or precedence.	Option is well understood but may have limited deployment/precedence in this environment (climate, regulatory expectations, closure criteria).	Option is well understood with multiple examples/case studies of successful implementation in this environment.
Economic	25%	Capital Expenditure (CAPEX)	100%	CAPEX	>$200,000,000 CAD	>$50,000 CAD but <$200,000 CAD	Options <$50,000
Affected Parties	25%	Community Acceptance	33%	Overall community response	Community partners likely to vehemently oppose option.	Option likely to be acceptable by community partners, although not always preferred and with some opposition.	Option is likely to be generally accepted or preferred by community partners with limited or no opposition.
		Nighthawk Acceptance	33%	Risk mitigation at reasonable CAPEX	Option does not mitigate risk or does so at very high cost.	Option mitigates risk at a reasonable cost.	Option that significantly reduces risk at low cost.
		Regulatory Approval	33%	Regulatory confidence in option	Option that is likely to be viewed as higher risk by the Mines Inspector. Option will require significant effort/rationale to justify. Carries risk that it will not be approved.	Option has been approved or there is precedent for approval.	Option is likely to be preferred by Mines Inspector. Viewed by Regulator as an improvement to the current conditions.

GHG= greenhouse gas

3.1 Multiple Accounts Analysis Option Ranking Calculations

Scores and weights were combined to calculate weighted scores for each option to allow for relative ranking of the options and determination of the preferred option. The calculations involved taking individual scores and weightings for each sub-account within the four accounts and converting them to a single score for each option. This involved several steps that are described below:

5) Account merit ratings were calculated using the following steps:

   a) Calculate sub-account merit scores (S_{MS}) by multiplying the sub-account merit ratings (Rs) by the sub-account weightings (W_S), using the following equation:

$$S_{MS} = Rs \times W_s$$

   b) Calculate account merit ratings (R_A) by summing sub-account merit scores, using the following equation:

$$R_A = \sum S_{MS} \ (within\ account)$$

6) Closure option merit ratings were then calculated as follows:

   a) Assign account weightings (W_A). Equal account weightings were assigned to the four accounts (W_A = 25%).

   b) Calculate account merit score (S_A) by multiplying the account merit rating (W_A) by the account weightings, using the following equation:

$$S_A = R_A \times W_A$$

   c) Calculate option merit rating (R_o) by summing the account merit scores for each option, using the following equation:

$$R_O = \sum S_A \ (for\ each\ option)$$

The resulting option merit score is a value between 1 and 5 and provides a means to evaluate the relative ranking of the various options considered. The highest option score represents the preferred option.

4.0 OPTIONS ANALYSIS RESULTS AND CONCLUSIONS

The scores for each option are presented for each indicator in Table 4 along with a description of information that was used to assign the scores.

Table 4: SNP 5-10 Options Assessment – Accounts, Sub-accounts, and Weightings

Account	Account Weighting	Sub-account	Weight within Account	Indicator	Scores					
					Option 1	Option 2	Option 3a	Option 3b	Option 3c	Option 4
					Update SNP	Lime/soda ash application	Grade with waste rock	Grade with material from roads/trails	Grade with off-site fill material	Line pond at SNP 5-10
Environmental	25%	Aquatic life protection	33%	Water quality is safe for aquatic life in Lardass Lake	4	4	2	4	4	4
		Terrestrial life protection	33%	Water quality is safe for terrestrial life at SNP 5-10	3	3	4	5	5	3
		GHG emissions	33%	GHG emissions from the project	5	1	3	3	2	4
Technical	25%	Option complexity	50%	Effort and complexity for procurement, logistics and execution	5	4	3	3	2	4
		Confidence in Performance	50%	Proven reliability in technology	5	3	1	2	2	2
Economic	25%	CAPEX	100%	CAPEX	5	3	3	3	3	5
Affected Parties	25%	Community Acceptance	33%	Overall community response	3	4	2	4	4	4
		Nighthawk Acceptance	33%	Risk mitigation at reasonable CAPEX	3	2	3	4	4	3
		Regulatory Approval	33%	Regulatory confidence in option	5	5	2	3	3	3

CAPEX = capital cost; GHG = greenhouse gas

Table 5 summarizes the account and option merit scores for each option and also presents the overall ranking of the options. From this analysis it is apparent that Option 1, which involves updating the SNP to remove station 5-10 is the preferred option. The option of lining the pond at SNP 5-10 to reduce interaction of the rock piles with standing water has the next highest ranking.

Table 5: Summary of SNP 5-10 Options Analysis

Account	Max Account Merit Score	Account Merit Scores					
		Option 1	Option 2	Option 3a	Option 3b	Option 3c	Option 4
		Update SNP	Lime/ soda ash application	Grade with waste rock	Grade with material from roads/trails	Grade with off-site fill material	Line pond at SNP 5-10
Environmental	1.25	1.00	0.67	0.75	1.08	1.00	0.92
Technical	1.25	1.25	0.88	0.50	0.63	0.50	0.75
Economic	1.25	1.25	0.75	0.75	0.75	0.75	1.25
Acceptance and Approvals	1.25	0.25	0.33	0.17	0.33	0.33	0.33
Option Merit Score	5.0	1.00	0.58	0.75	1.08	1.00	0.92
Option Rank	**-**	**1**	**4**	**6**	**3**	**5**	**2**

Note: Shading indicates highest merit score for each account.

5.0 OPTION DEVELOPMENT

If Option 1 is selected (i.e., set the compliance point for Site discharge at SNP 5-6), approval would be required in the new Type A federal and territorial Water Licences. In this case, it is anticipated that interim treatment may be required in 2022 to maintain compliance with the existing Type B Water Licence until issuance of the new licence.

Option 2 was developed as a short-term (1 year) option and would require equipment to be shipped to site for the open water season, including a water quality meter, lime of soda ash, sample bottles, and other consumables. For this option, a sampling plan will be developed in advance in consultation with the Water Licence Inspector.

Option 3a and 3b would require the mobilization of heavy equipment, such as an excavator to Site. This would require a winter road. Option 3c could be completed without heavy equipment onsite, but would require many flights to ship fill, such as sand to Site and grading the area manually.

If Nighthawk and the WLWB decide to proceed with Option 4 procurement of a panel of geomembrane liner would be required and sand bags should be shipped to Site during the winter road season. While this option would limit the interaction of standing water with the waste rock piles, the liner may require periodic maintenance and adjustments to maintain its effectiveness.

6.0 CLOSURE

We trust the information contained in this memorandum is sufficient for your present needs. Should you have any questions or require further information, please do not hesitate to contact the undersigned.

Nighthawk Gold Corp.

Denise Lockett
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https://golderassociates.sharepoint.com/sites/146693/project files/5 technical work/9_ir responses/08_options analysis (ir1)/technical memorandum.docx

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