Memorandum

Date: February 10, 2017

To: Merle Keefe, Sabina Gold & Silver Corp.

From: Kerry Marchinko, ERM (PhD, R.P. Bio.)

Cc: Deborah Muggli, ERM (PhD, R.P. Bio.)

Subject: **Winter Ice Road Water Withdrawal Supplemental Information**

1. INTRODUCTION

In response to the terms and conditions set out for the Back River Project, Sabina has committed to supplying DFO with information required to satisfy DFO-3:

> *The Proponent will provide Fisheries and Oceans Canada (DFO) with the bathymetry, depth and location of proposed water withdrawal sites, volumes to be extracted, anticipated water level decreases, and fish habitat features within each waterbody proposed to be used for winter water withdrawal in support of the construction of the winter ice roads. This will be provided primarily during the regulatory phase however in certain cases waterbodies may be added in the future. If additional waterbodies are required the Proponent commits to provide all required information on the additional proposed lakes, to DFO for review prior to use of these waterbodies.*

Sabina's strategy is to provide the following detail for lakes serving as potential water withdrawal sources for the Winter Road:

- Generate bathymetric maps of all potential water withdrawal source lakes along the Winter Road Alignment using methods based on satellite imagery;
- DFO's protocol for winter water withdrawal will be applied, where no more than 10% of the under ice volume for lakes deeper than 3.5 m will be extracted;
- Provide locations of proposed water withdrawal sites, calculate the depth, volume, maximum withdrawal limits and maximum reduction in depth for each lake;
- Identify any potential for changes in overwintering capacity for fish; and
- Identify any potential for changes to spawning shoal habitat for fall spawning fish species.

1.1 Bathymetry

Bathymetric maps will be generated for all potential water withdrawal source lakes along the winter ice road alignment using stereophotogrammetry of satellite imagery. Satellite imagery has been used to generate highly detailed bathymetric maps in northern regions using DigitalGlobe's Worldview-2 satellite with the Coastal Blue, Blue and Green colour bands (Legleiter et al. 2014; Dörnhöfer and Oppelt 2016; Appendix A). These colour bands allow the identification of detailed lake bottom topography to a depth of 30 m and will provide more precise identification of bottom features than traditional bathymetry collected using one longitudinal and two (minimum) perpendicular transects, as indicated in Fisheries and Oceans Canada's (DFO) operational statement for winter water withdrawal (DFO 2010). The Coastal Blue colour, along with Blue and Green colour bands enable maximum water penetration, and the collection of large amounts of high-resolution stereo imagery at the ideal angle for water penetration. The advantage of this approach is that multiple images can be registered using tie points that are visible on land and in the water, and the resulting stereo composite can be used to calculate water depth. This level of topographic detail will be useful for identifying fish habitat features, such as shoals, and assessing fish habitat for fall spawning species (Lake Trout, Arctic Char, whitefish and ciscoes) during the application for a *Fisheries Act* (1985) Authorization, if required.

Briefly, the method proposed will use stereophotogrammetry interpretation methods to collect a three dimensional Digital Elevation Model (DEM) of each lake bottom. Source materials include newly acquired stereo satellite imagery (from DigitalGlobe's Worldview-2) and ephemeris (geographic position) data to establish image orientations. Trained photogrammetrists from an Aeroquest Mapcon (external to ERM) will use the surrounding terrain characteristics to interpret slopes entering into the lake at the shorelines. These slopes will be extrapolated out into the water body to connect with the lake bottom topography visualized through the Coastal Blue, Blue and Green bands. Photogrammetrists commonly use similar techniques, and available visual cues, to interpret ground underneath dense tree canopy where the ground is obscured. Any additional information about a lake, such as known depths, will be taken into account if available. A shoreline break line will also be captured and used to generate an estimated lake volume, when used in combination with the collected bathymetry elevation data. Recent studies (Ehses and Rooney 2015; Mohamed et al. 2016) indicate that an accuracy of approximately 0.2 m can be achieved using high quality satellite imagery (e.g., LiDAR) and similar sterophotogrammetry interpretation methods.

Upon acquiring the imagery data, it is anticipated that data analysis could take up to approximately 4 weeks. ERM will then conduct quality assurance/quality control (QA/QC) test of the data analysis of up to 2 weeks in duration. This QA/QC will involve comparing satellite generated bathymetric contours with the existing bathymetry previously assessed along the winter road alignment using Ground Penetrating Radar and hydroacoustic methods.

1.2 Lake Parameters

Once bathymetric maps have been modeled, the maximum depth and total storage volume of the lake will be calculated from the generated contours. Maximum withdrawal limits will be derived by assuming that 10% of the volume of water available under ice will be withdrawn. For lakes above the treeline, the maximum ice thickness is assumed to be 2 m (DFO 2010). The maximum reduction in water depth (in meters under ice) will also be calculated assuming 10% of the water volume will be extracted.

1.3 Overwintering Capacity

The overwintering capacity of each lake will be assessed as a measurement of area (m^2) using bathymetric contours. Overwintering habitat will be classified into two categories: Fair Overwintering Habitat (between 2.5 m and 4 m depth) and Good Overwintering Habitat (> 4 m depth). In general, lake morphometry (i.e., lake size, depth, and shape) and productivity are important determinants of the overall oxygen inventory in a lake (Lampert and Sommer 2007). Shallow lakes that have a large sediment surface area to water volume ratio tend to lose much of their DO budget to sediment decomposition processes (Lampert and Sommer 2007). In Arctic lakes, DO inputs to a lake can be very low during the ice-covered season (lasting eight or nine months of the year) because ice and snow form a barrier to atmospheric exchange and light penetration needed for photosynthetic oxygen production. The DO inventory of a lake at the onset of ice formation will be depleted over the course of the ice-covered season, as respiratory rates exceed rates of DO replenishment (White et al. 2008). In shallow lakes that have a relatively small DO budget at the start of winter and a high sediment oxygen demand relative to the lake volume, winter DO depletion is of particular concern (White et al. 2008). Published data pertaining to overwintering Lake Trout dissolved oxygen requirements in Arctic lakes are currently unavailable.

Calculations of the area within each habitat class will be completed for baseline conditions (i.e. no water withdrawal) and post-withdrawal (i.e. after 10% of the under ice water volume is withdrawn). The maximum difference between baseline and post-withdrawal will be reported as an area and also as a percentage of baseline habitat for each lake. In addition, the overall reduction in overwintering habitat across all potential water withdrawal lakes along the length of the road alignment will be reported as a percentage of baseline habitat.

1.4 Spawning Shoal Habitat

Fall-spawning fish in the Arctic (Lake Trout, Arctic Char, whitefish and ciscoes) spawn prior to, or during the early stages of ice formation, but they must spawn below the maximum depth where ice and natural drawdown penetrate at a later date to guarantee that their eggs do not freeze or desiccate. Water withdrawal associated with winter ice road construction that causes under-ice drawdowns to stay within the lake's natural range are unlikely to affect spawning beds as these local populations of fish would be adapted to avoid these high-risk areas. However, drawdown that exceeds the natural range could be detrimental to egg survival, particularly if fish spawn immediately below where lake ice commonly extends.

Spawning habitat for fall spawning species will be examined using a risk level framework, conducted after collection of bathymetric data on each potential water withdrawal lake along the winter ice road alignment. Prior to determining the risk level, data from the bathymetric survey will be used to calculate the change in under ice water level due to water withdrawal during winter ice road construction. First, the elevation of under ice water level will be calculated for baseline conditions (i.e. no water withdrawal) assuming 2.0 m ice thickness. Second, post-withdrawal under ice water elevation will be calculated assuming that a maximum of 10% of the under ice water volume is withdrawn. The maximum difference between baseline and post-withdrawal under ice water elevation will be reported in meters for each lake. Once the change in under ice water level has been calculated, the risk level framework will be applied to examine the potential for alteration of spawning habitat availability.

Risk level framework: The risk of loss to spawning habitat and incubating eggs occurs when under ice water levels drop below that normally experienced by fall spawning species. Baseline data collected at eight sites within the Back River Project area over the years 2011, 2012, and 2013 indicate that average difference in ice thickness within a lake over the sampling period averaged

0.21 m (1 standard deviation [SD] = 0.19 m). The maximum difference was up to 0.65 m at Reference Lake B. Thus, fall spawning species would normally experience a 0.21 m change in ice thickness and any reduction of water level due to ice road construction less than 0.21 m would be considered of negligible risk to incubating eggs and represent no potential loss in spawning habitat. A drop beyond 0.21 m in would present progressively greater risk to incubating eggs and spawning habitat loss (Table 1).

Table 1. Risk Level Framework for Fall Spawning Habitat

Risk of Spawning Habitat Loss	Change in Water Elevation under Ice (m)	Reasoning
Negligible	< 0.21	The reduction in water level lies within the average change in ice thickness (i. e. within normal variation).
Low	0.22 - 0.41	The reduction in water level remains within 1 SD of the average
Medium	0.42 - 0.8	The reduction in water level remains between 1 and 2 SD of the average
High	> 0.8	The reduction in water level is beyond 2 SD of average and there is less than a 5% chance for this occurring naturally.

After each potential water withdrawal lake has been assessed within this framework, the list of potential lakes can be refined in order to avoid, mitigate or offset any potential harm to incubating eggs and spawning habitat. This refinement process, along with the location of each lake and a full assessment of the potential effects of water withdrawal due to winter road construction on fish habitat, will be made during the application for an authorization under Paragraph 35(2)(b) of the *Fisheries Act* (1985).

2. SUMMARY

Sabina commits to providing DFO with the information collected along the winter ice road alignment to satisfy term and commitment # DFO-3. Specifically, Sabina will submit the bathymetric maps, estimates of volume, depth and the maximum limits to their reduction, and estimates of potential losses to overwintering and spawning habitat for fish. Although it is not anticipated that winter ice road construction will require an authorization under the *Fisheries Act* (1985), the description of potential effects and the appropriate avoidance and mitigation measures will be included in the application for a *Fisheries Act* Authorization for the Project.

Prepared by:

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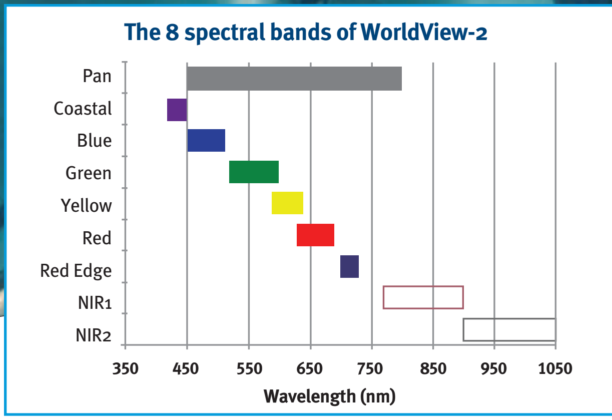
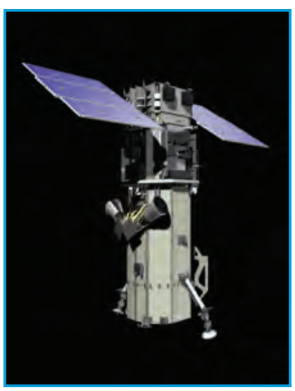
— Appendix A —

DigitalGlobe Bathymetry Datasheet



Bathymetry

Launching in Sept/Oct 2009, WorldView-2 will be the first high resolution satellite to provide half-meter panchromatic resolution and 1.8 meter multispectral resolution across 8 spectral bands. With unprecedented agility and a collection capacity of 975,000 km² per day, WorldView-2 will double the DigitalGlobe collection capacity and provide worldwide intra-day revisit capabilities.



WorldView-2 is the first high-resolution multispectral satellite to provide a Coastal Blue detector (400-450nm) enabling it to see further into the water and support bathymetric studies around the globe. With unsurpassed accuracy, agility and collection capacity, WorldView-2 is delivering comprehensive new solutions for the marine community.

Remote sensing of the shallow ocean floor will now become much clearer, thanks to the addition of the Coastal Blue band. Analysts will be able to discriminate features more accurately and increase the scope of remote sensing applications. And, thanks to WorldView-2's ability to collect large volumes of stereo imagery, new photogrammetric techniques for calculating ocean depth are finally possible. Current, accurate depth measurements will provide increased navigational security, and support detailed mapping and modeling applications.

Applications

Updating navigational hazards
Current and accurate nautical charts are critical to the safety of marine navigation. With global coverage and continuous collections, the opportunity to create and update charts rapidly is a dramatic improvement over current capabilities.

Coastal modeling
Predicting the effects of storm surge and tsunamis requires a detailed understanding of the near-shore environment. With photogrammetric techniques, the entire coastline can be mapped simultaneously above and below the water, providing unprecedented continuity and critical insights.

Marine habitat monitoring
Government agencies monitor coastal areas to document changes to protected habitats. The ability to map large under water areas, and classify marine habitats with great detail enables more efficient responses and a better understanding of the environment.

Benefits

- Provide navigational charts for remote places that do not have accurate surveys
- Frequently update dynamic areas, such as river deltas and barrier islands
- Locate debris deposited by storms, to efficiently direct cleanup operations

- Map properties and infrastructure that are at risk due to coastal inundation
- Model the effects of storm surge to create better emergency response plans
- Rapidly conduct change analyses, in order to test and refine existing models

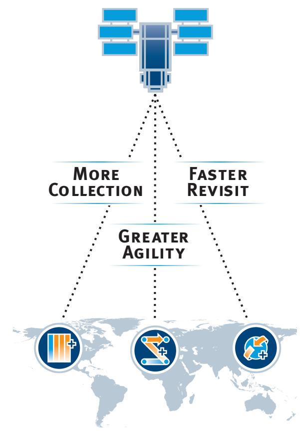
- Rapidly identify changes that can indicate the early effects of pollution
- Develop accurate models of reef recovery with bathymetric studies after catastrophic events
- Monitor the impact from coastal development such as offshore wind farms and shallow water oil platforms

We expect to see WorldView-2 derived bathymetric measurements to propagate quickly around the globe, improving the safety of marine navigation, and providing much needed insight into the ever-changing marine environment.

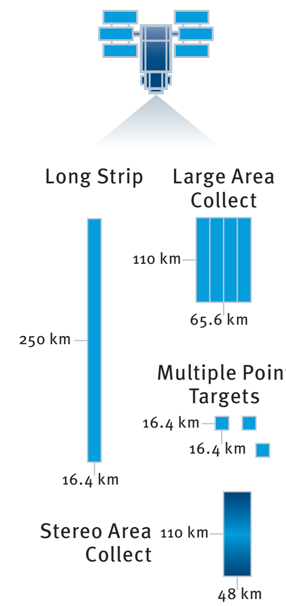
Bathymetry

Design and Specifications

Launch Information	Date: Anticipated Sep/Oct 2009 Launch Vehicle: Delta 7920 (9 strap-ons) Launch Site: Vandenberg Air Force Base
Orbit	Altitude: 770 kilometers Type: Sun synchronous, 10:30 am descending node Period: 100 minutes
Mission Life	7.25 years, including all consumables and degradables (e.g. propellant)
Spacecraft Size, Mass and Power	4.3 meters (14 feet) tall x 2.5 meters (8 feet) across 7.1 meters (23 feet) across the deployed solar arrays 2800 kilograms (6200 pounds) 3.2 kW solar array, 100 Ahr battery
Sensor Bands	Panchromatic + 8 Multispectral: 4 standard colors: red, blue, green, near-IR 4 new colors: red edge, coastal, yellow and near-IR2
Sensor Resolution	Panchromatic: 0.46 meters GSD at nadir, 0.52 meters GSD at 20° off-nadir Multispectral: 1.84 meters GSD at nadir, 2.08 meters GSD at 20° off-nadir
Dynamic Range	11-bits per pixel
Swath Width	16.4 kilometers at nadir
Attitude Determination and Control	3-axis Stabilized Actuators: Control Moment Gyros (CMGs) Sensors: Star trackers, solid state IRU, GPS
Pointing Accuracy and Knowledge	Accuracy: <500 meters at image start and stop Knowledge: Supports geolocation accuracy below
Retargeting Agility	Acceleration: 1.5 deg/s/s Rate: 3.5 deg/s Time to Slew 300 kilometers: 9 seconds
Onboard Storage	2199 gigabits solid state with EDAC
Communications	Image and Ancillary Data: 800 Mbps X-band Housekeeping: 4, 16 or 32 kbps real-time, 524 kbps stored, X-band Command: 2 or 64 kbps S-band
Max Viewing Angle / Accessible Ground Swath	Nominally +/-45° off-nadir = 1355 km wide swath Higher angles selectively available
Per Orbit Collection	524 gigabits
Max Contiguous Area Collected in a Single Pass	96 x 110 km mono 48 x 110 km stereo
Revisit Frequency	1.1 days at 1 meter GSD or less 3.7 days at 20° off-nadir or less (0.52 meter GSD)
Geolocation Accuracy (CE90%)	Specification of 6.5m CE90, with predicted performance in the range of 4.6 to 10.7 meters (15 to 35 feet) CE90, excluding terrain and off-nadir effects With registration to GCPs in image: 2.0 meters (6.6 feet)



Collection Scenarios



Sensor Bands

- Panchromatic
- Multispectral
- 4 Additional Bands

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