TECHNICAL MEMORANDUM

DATE 9 January 2017 **REFERENCE No.** 1410944-012-TM-Rev1-2016

TO Ms. Carrie Gillis
Faro Mine Remediation Project

FROM Ryan Preston and Al Chance **EMAIL** Ryan_Preston@golder.com; Al_Chance@golder.com

PIT SLOPE PHOTOGRAMMETRY MONITORING NETWORK TRAINING MANUAL

1.0 INTRODUCTION

A Pit Slope Photogrammetry Monitoring Network was established by Golder Associates Ltd. (Golder) in collaboration with Parsons from 7 to 9 September 2016. This memorandum presents instructions for operating the installed equipment and should be used in conjunction with the Pit Slope Monitoring Plan (PSMP) (Golder 2016) to conduct Pit Slope Stability Assessments.

2.0 ABOUT THE NETWORK

The network consists of fifteen monitoring locations, five at each of the Faro, Grum, and Vangorda pits, which are designed to allow for consistent photo records to be collected of the monitored slopes. The photos can be used for visual comparison, as well as generation of 3D models which can be used to measure slope deformations with sufficient accuracy to observe crest regression and large scale slope instability. With the exception of the first monitoring station at the Faro pit, all monitoring stations consist of an aluminum survey tripod which has been cemented into the ground such that the top of the tripod is approximately 1.2 m above the ground surface. A specialized tripod head and camera can be mounted to each monitoring station allowing for repeatable capture of photos from the same viewpoint each time.

Pit slope monitoring is best conducted in a systematic way where key data is collected and recorded during each review. Golder recommends that Parsons staff keep a monitoring log book where the following data are noted for future reference and comparison:

- tripod heights
- weather including precipitation, temperature, and visibility
- slope condition observations both from photo comparison and crest surveys
- other general comments pertaining to the survey or slope performance

Golder Associates Ltd.
Suite 200 - 2920 Virtual Way, Vancouver, BC, V5M 0C4
Tel: +1 (604) 296 4200 Fax: +1 (604) 298 5253 www.golder.com

Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America

3.0 STEP BY STEP USAGE

Pit slope monitoring is most critical during the spring thaw and summer/fall rain storms. As such, it is recommended that photogrammetry data be collected from each monitoring station in each pit, on a monthly basis between April and October. Concurrent to photo data collection, the crests should be inspected from a safe distance to check for ponding water and new or expanded tension cracks. To ensure worker safety, personnel should not pass beyond the first observed tension crack and should always maintain a safe clearance from the pit crest as dictated by relevant local regulations and company policy.

Photogrammetry monitoring should ideally be conducted on evenly spaced intervals, i.e., the first day of the month. However, the schedule should be adjusted so that photos can be collected during times of good visibility. Photogrammetry data should not be collected during heavy rain, snow, fog or other weather which may obscure the view of the slope.

In addition to the monitoring detailed above, in the event of an earthquake which is felt on site, regardless of magnitude etc., or a 30 mm rainfall event within a 24 hour period as reported by one or more nearby weather stations, a crest inspection and photo comparison should be conducted as soon as possible following the event.

After each photo collection, the photos should be visually assessed for signs of instability by Parsons staff and, after the June and October collections, all photos should be sent to Golder for 3D model generation and interpretation. Complete the following steps each time monitoring is required in order to collect and process the required data:

1) Assess weather and lighting conditions. If possible, collect photos at a time of day with dispersed lighting from high clouds or direct lighting without shadows. Photogrammetry monitoring should ideally be conducted on evenly spaced intervals, i.e., the first day of the month. However, the schedule should be adjusted so that photos can be collected during times of good visibility. Photogrammetry data should not be collected during heavy rain, snow, fog or other weather which may obscure the view of the slope.

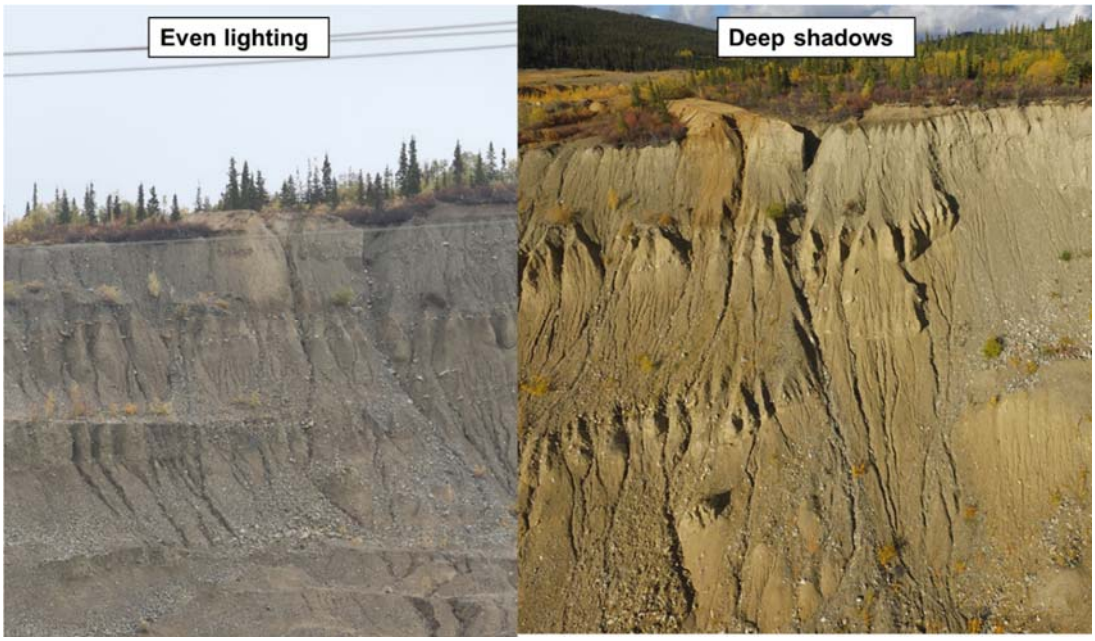

Figure 1: Example Photos Showing Dispersed Lighting (Desirable) and Deep Shadows (Avoid)

2) Assemble equipment – Camera (Canon 5D Mark III), lenses (200 mm and 85 mm), tribrach, tribrach adapter, and tripod head. Check camera for dust and smudges on lens and clean as necessary with soft, lint free cloth.

Figure 2: Camera and Tripod Assembly

3) Check the height of the tripod relative to the left leg and correct any errors resulting from loosening of the leg lock bolts over time. Note the height for future reference. It is expected that, over time, the tripod head will droop. By measuring the height relative to the left leg, a consistent elevation can be maintained for photos. The goal of this is to maintain the tripod height as close to the installed height as possible.

4) Attach tribrach to monitoring station and level.

5) Attach tribrach adapter and tripod head (Figure 2).

6) Assemble camera and check settings. Table 1 lists the important camera settings which should be used during photo collection and Figures 3, 4, and 5 show how to setup the tripod head, adjust camera settings and change the camera's lens, respectively:

   a) The 200 mm lens should be used for Faro and Grum pit photos.

   b) The 85 mm lens should be used for Vangorda Pit photos.

Figure 3: Tripod Head Setup

Camera Parts

1. Switch from Autofocus (AF) to Manual focus (MF)
2. Leave on Av (Aperture priority)
3. Press half way to focus during AF
4. Adjust Aperture (Leave at 8.0)
5. Shows Aperture value
6. Shows ISO (Leave on auto)
7. Leave on L
8. Press "INFO" until this screen appears, press Q and use joystick to select value to adjust, adjust with scroll wheel and button
9. Review photos
10. Delete photos
11. Use LCD screen as viewfinder
12. Zoom in and out of reviewed photos

Figure 4: Camera Settings and User Guide

Figure 5: Changing Lenses

7) Adjust tilt on tripod head so entire pit slope is visible and pan camera to far left extent of zone of interest (see Figures 5 to 7 for zones of interest for each pit).

Figure 6: Area of Interest – Faro Pit

Figure 7: Area of Interest – Grum Pit

Figure 8: Area of Interest – Vangorda Pit

8) Focus camera on pit wall by half pressing shutter, then switch camera to manual focus.

9) Collect photos of entire area of interest, panning camera such that consecutive photos overlap by ~50%, adjust tilt as necessary to retain entire pit slope within field of view. Review photos occasionally during collection for coverage, focus and lighting.

10) Remove camera and tripod head assembly, cover tripod with tarp and, move to next monitoring station

11) Repeat Steps 2 to 10 for each monitoring station in each pit.

12) Make relevant notes in the slope monitoring log book.

13) During cold weather keep the camera in the bag when moving between indoors and outdoors to help prevent fogging. When moving between stations and pits, if it is not possible for personnel to securely hold the camera, i.e., when driving, the camera should be placed in a protective case.

14) Store all camera equipment in a sealed case whenever it is not in use.

15) Download photos and sort into folders according to pit and date.

16) Review photos as per PSMP and Section 3.1 below, and/or transfer to Golder:

    a) Panoramas can be generated using the freely available software package Microsoft ICE (Image Composite Editor) for ease of review, but may pose a problem for computers with limited memory. Microsoft ICE uses a wizard based approach whereby the desired photos to be stitched are dropped into the application window and the wizard is followed until the desired panorama is produced. Operating instructions can be provided by Golder if required.

    b) Photos can be sent to Golder via our Secure File Transfer system, which was successfully used by site staff to transfer photos to Golder after the September 2016 site visit. It is best if they are compressed into zipped files by pit. Secure File Transfer system invites will be sent by Golder as requested.

Table 1: Camera Settings

Setting	Value
Aperture	F8.0
ISO	Auto
Image Quality	JPEG L
Drive Mode	2 Second Timer

3.1 Trigger Action Response Plan

It is recommended that monthly inspections, photogrammetry and review be conducted by Parsons from April to October. Within a day following photo data collection, site staff should compare the current photos between previous months and years to detect changes such as sloughing, bulging, and changes in seepage patterns. Figures 9 to 15 present examples of changes in slope condition which should be noted.

3.1.1 Low Alarm

In the event of any of the following conditions, Golder and the Yukon Government should be notified as soon as possible:

- Any crest regression in the critical area of the Faro Pit crest observed from photo comparison or crest tours (Figure 9).

Figure 9: Critical Crest Regression Area in Faro Pit

- Any regression or sloughing affecting an area of 5×5 m or greater in any of the pits (Figures 10 to 13). The 3D PDF models provided in Golder's site visit report (Golder 2016b) can be used to measure affected areas (Figure 14).

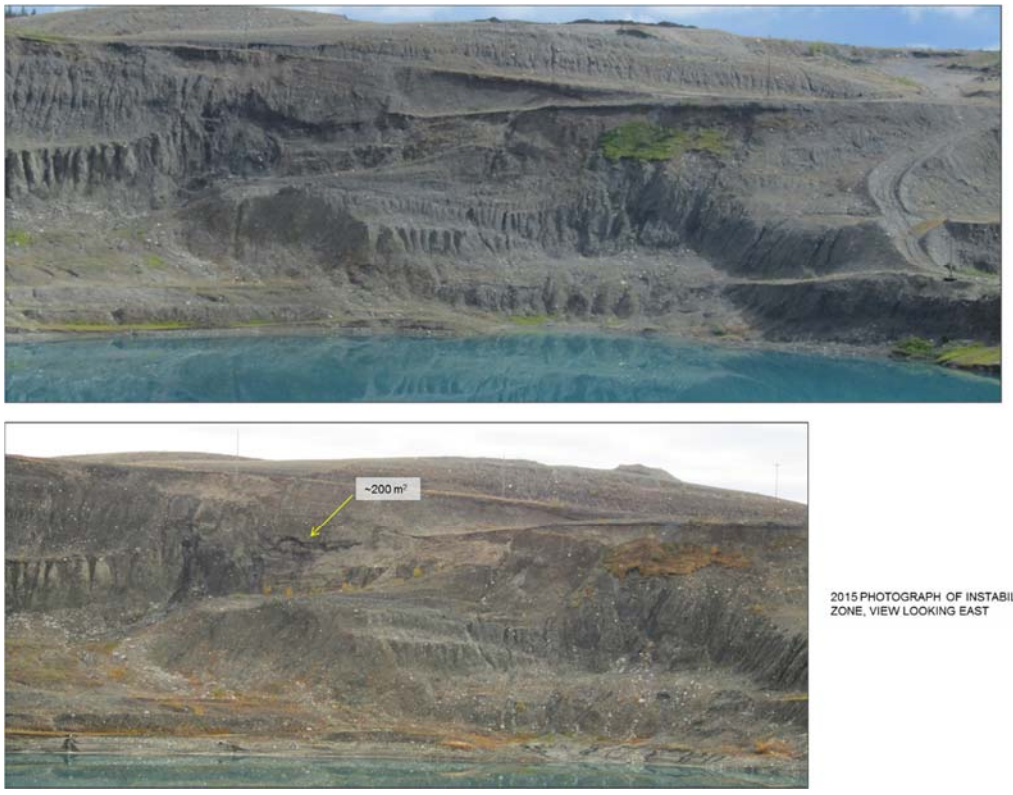

Figure 10: Example of Sloughing – Grum Pit

Figure 11: Example of Slumping – Grum Pit

Figure 12: Seepage Induced Sloughing in Upper Part of Vangorda West Wall

Figure 13: Cracks and Sloughing in Upper Part of Vangorda West Wall – North Side

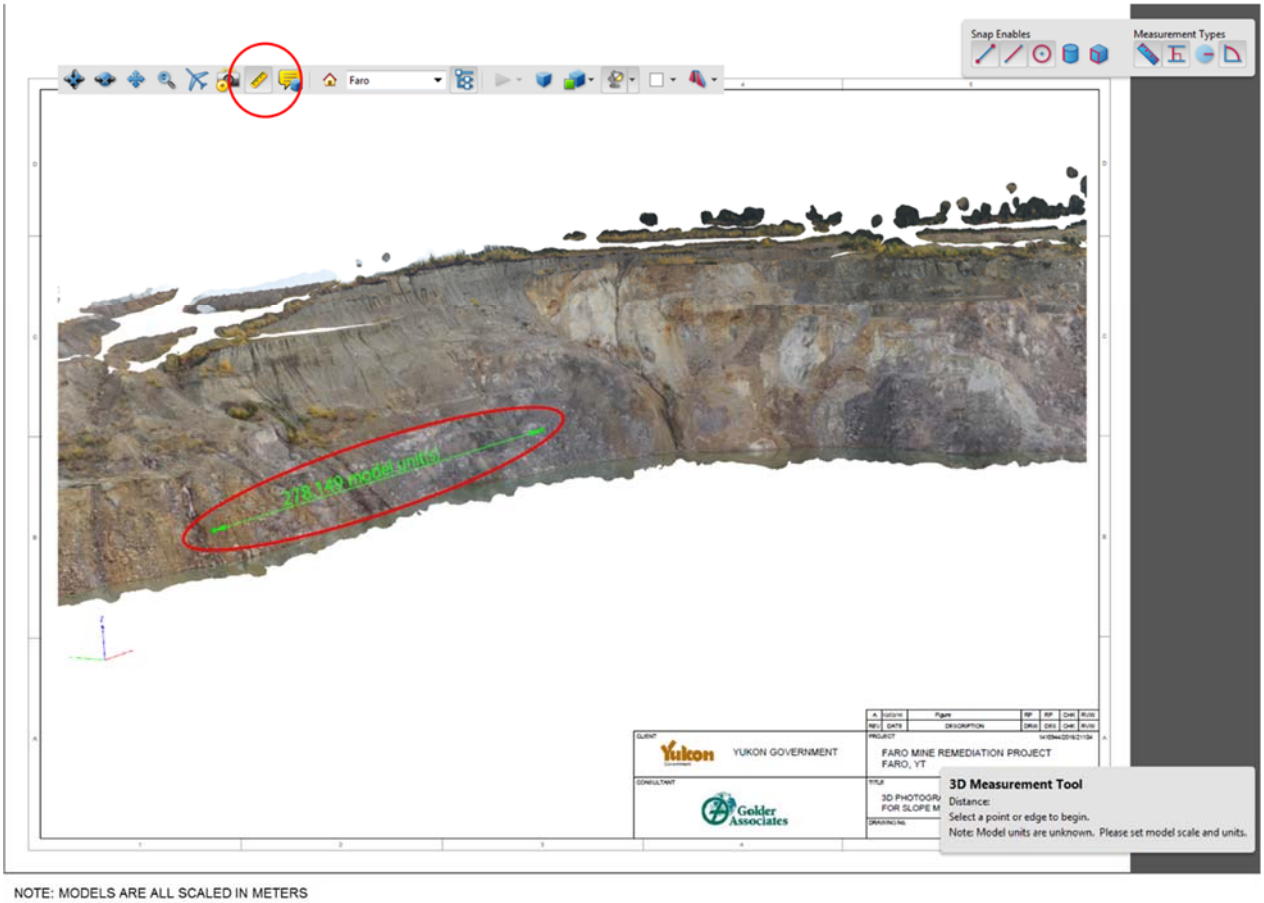

Figure 14: Measuring Dimensions from 3D PDF of Models

- Increases in pit wall seepage above those normally experienced for the time of year (Figure 13). Photo data from the preceding year and site personnel experience can be utilized to determine if observed seepage is unseasonal.
- New or growing cracks are observed in the pit crest (Figure 15).

Figure 15: Cracks behind Crest of East Wall – Grum Pit

- If BGC report displacements observed in the Faro Pit inclinometer data.

During low alarms, care and maintenance operations within and around the pit areas may continue. Golder will endeavour to provide guidance within the next business day of receiving notice. A spotter must be used whenever personnel are working within the affected pit or along the affected pit crest during Low Alarm periods. The spotter's purpose is to scan the pit walls and crest, especially in areas of previously observed deformation or slope instability activity, for signs of rapidly changing ground conditions. The intent of the spotters is to provide advance warning to staff working within the pit of rapidly changing conditions that warrant a rapid evacuation of the pit, that may not be observed by the staff within the pit.

3.1.2 High Alarm

In the event that slopes are observed to be undergoing daily change, such as continual slumping, growth of seepage areas or a slump of 10×10 m or greater area, operations in the pit and along the pit crest should cease until the pit wall stability is reviewed by Golder.

3.2 Communications with Golder

Unless any of the triggers discussed in Section 3.1 are observed, data should be sent to Golder twice per year, after the June data collection and again after the October data collection.

From discussion with Karen Furlong, it is Golder's understanding that slope inclinometers have been installed at the pit crest by BGC Engineering (BGC), with the data being reviewed by BGC on a regular basis. The inclinometer data should also be sent to Golder, so that Golder can also review these data to assist in the assessment of the Faro pit east wall overall slope stability.

Twice yearly, after receipt of April to June data and again after receipt of July to October data, Golder will review the photo data, generate 3D photogrammetry models and compare them to the September 2016 and subsequent models to analyse for potential large scale slope stability. The results of this review will be summarized in a technical memorandum with 3D pit models provided as 3D PDFs for site personnel's reference. It should be noted that budget for this work is not provided under work plan #001, and a new scope of work, budget and authorization to carry out the work will be required.

3.3 Care and Maintenance

3.3.1 Camera Equipment

Clean the lenses with a soft, lint free cloth if they become smudged. Keep the camera dry and free of dust and avoid changing lenses in a dusty environment. Store all camera equipment in a sealed case whenever it is not in use. Most issues should be addressed by sending the camera to a certified repair location.

3.3.2 Tripods

Tripods should be covered with tarps between surveys to protect them from precipitation. Check the tightness of the leg adjustment screws after each use to ensure the tripod maintains the installed height. Tarps were not provided during network installation and training and should be purchased by Parsons.

4.0 CLOSURE

The reader is referred to the Study Limitations, which follows the text and forms an integral part of this memorandum.

We trust this memorandum addresses your needs for operating instructions for the Pit Slope Photogrammetry Monitoring Network at the Faro Mine Remediation Project. Please do not hesitate to contact us if you have any questions or comments.

GOLDER ASSOCIATES LTD.

Ryan Preston, MSc, PEng (BC)
Geological Engineer

Al Chance, PEng
Principal, Mining Geotechnical Engineer

RP/AVC/it/cmm/rs

Attachment: Study Limitations

o:\final\2014\dynamics numbers - mining division\1410944\1410944-012-tm-rev1-2016\1410944-012-tm-rev1-2016-pit slope photogrammetry training comments 09jan_17.docx

REFERENCE

Golder Associates Ltd. 2016. Faro Mine Remediation Pit Slope Monitoring Plan. Submitted to Faro Mine Remediation Project, Whitehorse, YT, Canada. Golder Doc. No. 1410944-013-TM-RevB-2016. 7 October 2016.

STUDY LIMITATIONS

Golder Associates Ltd. (Golder) has prepared this document in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this document. No warranty, express or implied, is made.

This document, including all text, data, tables, plans, figures, drawings and other documents contained herein, has been prepared by Golder for the sole benefit of the Government of Yukon. It represents Golder's professional judgement based on the knowledge and information available at the time of completion. Golder is not responsible for any unauthorized use or modification of this document. All third parties relying on this document do so at their own risk.

The factual data, interpretations, suggestions, recommendations and opinions expressed in this document pertain to the specific project, site conditions, design objective, development and purpose described to Golder by Government of Yukon, and are not applicable to any other project or site location. In order to properly understand the factual data, interpretations, suggestions, recommendations and opinions expressed in this document, reference must be made to the entire document.

This document, including all text, data, tables, plans, figures, drawings and other documents contained herein, as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder. Government of Yukon may make copies of the document in such quantities as are reasonably necessary for those parties conducting business specifically related to the subject of this document or in support of or in response to regulatory inquiries and proceedings. Electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore no party can rely solely on the electronic media versions of this document.