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2018 ANNUAL PERFORMANCE REPORT FOR TAILINGS BACK DAM, RED DOG MINE, ALASKA

Mr. Sangha:

Golder Associates Inc. (Golder) is pleased to submit to Teck Alaska Incorporated (Teck) the 2018 Annual Performance Report for the Tailings Back Dam (TBD) at Red Dog Mine in northwest Alaska. The TBD has been assigned National Inventory of Dams (NID) identification number AK00303. The Annual Performance Report (APR) was supported by a site visit to inspect the dam from June 22-28, 2018 and a review of monitoring data provided by Teck. The work was done in accordance with our proposal dated February 8, 2018. The conclusion of this APR is that the TBD is being maintained in satisfactory condition and continues to perform as designed.

1.0 INTRODUCTION AND BACKGROUND

The Red Dog Mine and tailings impoundment are located about 90 miles north of Kotzebue, Alaska. The TBD forms the southern barrier of the tailings impoundment (tailings pond) and is located adjacent to the northern side of the Overburden Stockpile, as depicted in Figures 1 and 2. The Overburden Stockpile lies across the divide between the south fork of Red Dog Creek and Bons Creek drainages and is composed of unconsolidated material stripped off from over the mine pit area. The purpose of the TBD is to reduce seepage from the tailings impoundment into the Bons Creek drainage.

The TBD is a gravel fill and rockfill embankment dam utilizing a centralized plastic concrete cut-off wall (COW) as the primary seepage reduction feature. An insulated fill section is installed over the COW to protect it from freeze-thaw degradation. The central sector of the dam embankment was constructed with compacted, generally well-graded, sand and gravel fill materials (select fill) processed from un-mineralized crushed rock. This select fill section was constructed over native soil and bedrock following the removal of native ice-rich and organic materials to reduce thaw settlement potential. At the current Stage III crest elevation of 986 feet, the select fill is about 20 to 30 feet wide and has maximum 1.0 horizontal to 3.0 vertical (1H:3V) side slopes. The outside sectors of the dam embankment are constructed of compacted rockfill and is about 25 to 35 feet wide at the crest on either side of the central select fill section. This rockfill, which has 2.5H:1V side slopes, was placed against the Overburden Stockpile on the downstream side and against a rockfill cofferdam on the upstream side. The native

ice-rich and organic materials were not removed below the rockfill materials, so the rockfill is anticipated to deform as the frozen subgrade soils thaw and consolidate.

The performance of the TBD is monitored through the instruments shown in Figures 2 through 4. These instruments include three ShapeAccelArray movement monitoring arrays (SAAs), ten vibrating wire piezometers (VWPs), nine ground temperature monitoring arrays, eleven survey monuments, and a flowmeter at the sump pump.

The TBD has been constructed according to the following timeline:

- Stage I – Crest elevation 970 feet: Constructed 2007 through 2010
- Stage II – Crest elevation 976 feet: Constructed 2013
- Stage III – Crest elevation 986 feet: Constructed 2014 through 2016
- Stage IV – Crest elevation 996 feet: In progress, construction started in 2018, slated to finish in 2020
- Stage V – Crest elevation 1,006 feet: This final raise is slated to commence in about 2025

Stage IV construction activities had not been initiated at the time of Golder's field inspection; however, the following activities are scheduled to be completed during the 2018 construction season and will be done such that they do not interfere with operation of the TBD. Planned/ongoing construction activities are discussed herein in this context, but a complete summary of construction is not provided. The following activities are planned for the 2018 construction season:

- Preparation and verification of additional subgrade associated with the expanded Stage V TBD footprint
- Removal of plastic concrete spoils from the downstream face of the TBD
- Removal of uncontrolled mine waste placed within Stage V TBD footprint in 2016 and replacement with compacted rockfill
- Placement and compaction of rockfill upstream and downstream of the current TBD (centerline raise) to elevation 986 feet
- Preparation of monitoring instrumentation array for embankment raise to elevation 996 feet in 2019

The current *Certificate of Approval to Operate a Dam* (Certificate No. FY2018-14-AK00303) issued by the Alaska Department of Natural Resources Dam Safety and Construction Unit (ADNR Dam Safety) on February 12, 2018 stipulates that the holder of the certificate shall submit an APR by an engineer qualified in accordance with 11 AAC 93.193(b) by October 31 of each year during active mine operations. This submittal meets the above requirement.

2.0 FIELD INSPECTION

The field inspection for the TBD was performed by Golder employees Steven L. Anderson, PE, the designated Engineer of Record of the TBD, and Matt Ryans, PE. The field inspection was conducted from June 25 to 26, 2018. The weather during our week on site was partly to mostly cloudy with no precipitation. Select photographs taken during the site visit are included in Appendix A.

Highlights from the field inspection are summarized below.

- The tailings impoundment elevation during the site visit was approximately 974 feet.
- Except for the anticipated longitudinal cracking that is not a stability concern (see bullet below), the downstream and upstream dam embankment slopes appeared in satisfactory condition with no other indications of instability, such as slumping, depressions, etc. Plastic concrete spoils deposited along the downstream embankment face during the Stage III COW raise were observed and will be removed as part of Stage IV construction.
- Similar to past inspections, longitudinal surface cracking was observed on the downstream and upstream side of the dam. Figure 5 presents the surveyed locations of the cracking and some photos taken during the inspection. Golder probed along the length of the cracks, noting a maximum crack width of about 1.0 foot and maximum depth of 6.0 feet.
    - Longitudinal cracking was observed from about Station 20+30 to 26+70 on the downstream side and from about Station 22+10 to 24+05 on the upstream side near the outside board insulation limits. The location of the cracking was about 15 to 17 feet from the alignment centerline, which corresponds approximately with the interface between rockfill and select fill. The deeper cracks and larger crack widths were measured on the downstream side between about Station 24+00 and Station 26+00. Per design, this cracking is understood to be related to deformations from thaw consolidation of the previously frozen foundation materials below the rockfill and is not a stability concern.
    - Longitudinal cracking was also observed from about Station 16+00 to 16+90 where some larger plastic cement spoil piles were placed along the downstream rockfill crest. Cracking at this downstream area is believed to be related to movement of the spoil piles, likely due to seasonal saturation and freeze/thaw actions, and not movement of the rockfill slope itself. Therefore, the cracking in this area is not a stability concern.
- Similar to previous inspections, longitudinal cracking was observed along the downstream slope crest east of the haul road (See Photos 17 and 18, Appendix B). This cracking was initially observed during the 2014 periodic safety inspection[1] (PSI). The length and width of the cracking appeared to be similar to what has been previously observed. As described in previous reports, this cracking is not a stability concern and poses no risk to the COW.
- The insulation layer appeared to be in good condition, with the exception of four penetrations of HDPE pipes through the insulation layer (above the foamboard). Two of these pipes are conduits to pass the instrumentation cables across the dam crest and over the top of the COW (See Photo 11, Appendix B). These pipes could increase the frost depth at the locations due to convective transfer of cold air. The two additional pipes are pipelines to pass water across the dam crest from the sump and Overburden Stockpile pumpback system (See Photo 5, Appendix B). These two pipelines are less likely to increase the frost depth,

[1] Golder Associates Inc. (Golder). 2014. Periodic Safety Inspection Report No. 1 – Tailings Back Dam, Alaska Jurisdictional Dam No. AK00303, Red Dog Mine, Alaska, report prepared for Teck Alaska Incorporated, dated December 15. (Project Number 1400862). Anchorage, AK. Golder.

particularly because the pipe from the Overburden Stockpile pumpback system is insulated and both have water flowing through them year-round.

- A bench feature was observed on the upstream embankment slopes between about Station 20+00 and 24+00 (See Photos 13 and 14, Appendix B). Upon further review of historic construction and inspection photos, this feature is believed to be due to grading between constructed lifts where the upper lift was not filled out far enough. This feature will be remedied during the Stage IV construction during the key in of new fill lifts into the existing embankment.
- Similar to previous inspections, water was observed in a topographic low spot downstream of the TBD, near Station 7+00, and west of the Overburden Stockpile (see Photo 7, Appendix B). No other ponded water was observed at the ground surface near the downstream toe of the dam embankment during the inspection.

  During the Stage IV embankment raise, Golder construction quality assurance staff observed the dewatering of the topographic low spot in preparation for fill placement (July 12, 2018). Once the low spot was dewatered, water was observed to be flowing in from a discrete seep on the dam embankment side of the low spot. The elevation of the seep was recorded as 966 feet before the low spot was backfilled.
- The instrumentation installed in 2015 was observed along the embankment crest. Cables from the piezometers and SAAs were observed to be laying unprotected over the fill surface and connected into data loggers near the sump pump. The data logger for the SAAs was inside the sump pump insulated igloo and the data logger for the piezometers was connected to a metal communication tower.

3.0 REVIEW OF MONITORING INSTRUMENTION DATA

Monitoring instrumentation data related to the TBD and reviewed by Golder included data from the ShapeAccelArray (SAA) inclinometers, survey monuments, a site weather station, the sump pump flowmeter, VWPs, a tailings impoundment lake level survey, and temperature monitoring arrays. Monitoring data collected during the last year is summarized in the following subsections.

3.1 SAA Inclinometers

Three SAAs installed are installed in the Slope Indicator inclinometer casings located at approximately TBD Stations 14+00, 25+00, and 35+00 in 2015. The SAAs are located about 5 feet upstream of the COW centerline. These instruments monitor horizontal movement of the dam embankment, temperature, and are currently read weekly. Teck is in the process of integrating the SAAs into their NavStar data collection system (Geoexplorer) for real-time access to instrument readings. The SAAs record horizontal displacement of each vertical instrument segment with respect to the baseline survey taken immediately after installation of the instrument. As specified in the Operations and Maintenance Manual, Revision 3[2] (O&M Manual), the SAA data review does not incorporate the historical movements associated with the 10 to 11 preceding conventional inclinometer readings collected between October 2012 and July 2015 prior to the installation of the SAAs.

SAA data is presented in Figures 6 through 8 for instrument locations at 14+00, 25+00, and 35+00, respectively. These summary figures present data developed from raw SAA readings according to the procedure described in

[2] Golder Associates Inc. (Golder). 2016. Operations and Maintenance Manual Revision 3, Tailings Back Dam, Red Dog Mine, Alaska, report prepared for Teck Alaska Incorporated, dated October 16. (Project Number 1545935). Anchorage, AK. Golder.

the O&M manual. They include the cumulative magnitude of displacement with depth, cumulative magnitude of displacement over time presented at the elevation in which the greatest displacement has occurred, and direction of movement with respect to the COW centerline. As discussed in the O&M Manual, trigger thresholds for the SAA Inclinometers are 1 inch of cumulative movement or a movement rate of 0.2 inches per month. A summary of the SAA data presented in the figures follows:

- **Station 14+00:** As shown in Figure 6, the SAA at Station 14+00 has recorded a maximum of approximately 0.2 inches of total displacement (elevation 956.6 feet) since its initial survey in November 2015. Since 2015, the annual incremental movement rate recorded has been approximately 0.1 inch per year. Both the total displacement and incremental movement rates are within the acceptable limits prescribed by the O&M manual. The cumulative direction of movement is to the northwest, parallel to the COW.
- **Station 25+00:** As shown in Figure 7, the SAA at Station 25+00 has recorded a maximum of approximately 0.4 inches of total displacement (elevation 986.5 feet) since its initial survey in November 2015. Since 2015, the annual incremental movement rate recorded has been approximately 0.2 inches per year. Both the total displacement and incremental movement rates are within the acceptable limits prescribed by the O&M manual. The cumulative direction of movement is to the southwest, in a downstream direction.
- **Station 35+00:** As shown in Figure 8, the SAA at Station 35+00 has recorded a maximum of approximately 0.3 inches of total displacement (elevation 983.8 feet) since its initial survey in November 2015. Since 2015, the annual incremental movement rate recorded has been approximately 0.2 inches per year. Both the total displacement and incremental movement rates are within the acceptable limits prescribed by the O&M manual. The cumulative direction of movement is to the southeast, in a downstream direction.

3.2 Survey Monuments

Eleven survey monuments are established along the crest of the TBD and are surveyed using Global Positioning System (GPS) and Real Time Kinematic (RTK) survey techniques. The survey monuments are founded within the select fill prism of the TBD and are utilized to monitor vertical strain and horizontal movement of the dam embankment. The 11 survey monuments have been surveyed a total of 15 times since the initial baseline survey taken on August 15, 2016. The survey readings are shown on Figure 9 and a summary follows below:

- With the exception of Mon-15-05, the cumulative horizontal movements of the survey monuments have remained below the trigger level of 3.0 inches, and generally less than 1.0 inch (Mon-15-07 is the exception and has fluctuated up to about 1.4 inches from the baseline). Mon-15-05 has recorded relatively continuous movement since the baseline reading, crossing the trigger threshold of 3.0 inches on April 1, 2018. The movement coincides with the nearby cracking observed at the select fill/rockfill interface and is understood to be an effect of consolidation of soft and thawed materials underneath the downstream rockfill sector of the embankment.
- The maximum cumulative vertical movements have ranged from about 1.8 inches downward to 2.6 inches upward. However, we infer that much of the variability observed since September 2017 is related to inconsistent equipment or survey vertical control, resulting in data which is impossible to relate back to the baseline reading. Teck has taken measures to improve the reliability of their surveys by controlling the equipment used for the surveys and correctly recording survey rod height.

3.3 Air Temperature, Precipitation, Tailings Pond Elevation, and Sump Pump Data

Teck monitors the daily sump pump flow volumes at a flowmeter located near the TBD sump (Figures 2 and 4). The data is connected to Teck's "PI" system and is accessible in real time from the mine offices. Flow rates from the sump on the downstream side of the TBD are considered as part of the evaluation of COW and TBD performance. However, the sump pump flow rate is not a direct representation of seepage across the COW, and other influences such as air temperature and precipitation that impact groundwater recharge from downstream catchments need to be considered. Golder understands that the sump pump is typically operated on a float, with pumping initiated at elevation 935.4 feet. However, over the 2017/2018 winter, the pump float system froze and became inoperable, necessitating that the sump pump be set to cycle on a timer. Teck has since repaired the system and has planned improvements to the sump pumphouse to prevent the float system from freezing again.

There are gaps in the sump flow data associated with times when the pump was frozen or down for maintenance. Spikes in the sump pump data (particularly following a data gap) are typically observed following a period of inactivity or a significant precipitation event. Based on discussions with TAK personnel, sump pump rates lower than about 25 gpm (90,000 gallons per day) may not reflect a full day of operation.

Figure 10 shows the daily precipitation, sump pump volume, air temperatures, and tailings pond elevation over time since 2015. Figure 11 compares the sump pump rates and tailings pond elevation over the Julian year since 2015, and includes a chart comparing the cumulative sump pump volume and precipitation over the Julian year since 2015. Total precipitation in 2017 was greater than in 2016 and 2015, and the total precipitation through May 2018 was less than in 2015, 2016, and 2017. On average, winter air temperatures during the 2017/2018 season were warmer than the previous two winter seasons. As shown in both charts on Figure 10, sump pumping rates decrease during the winter season when average air temperatures fall below freezing and groundwater recharge from precipitation declines. The lowest sump pumping rates generally occur during January through May, and pumping rates increase during the spring freshet when average air temperatures rise above 32 degrees Fahrenheit. Once the snowpack and frozen water accumulated during the winter months melts and the sump pump rates decrease from the spike, sump pump rates correlate well with rainfall events, indicating that much of the water that reaches the sump is related to precipitation within the catchment area downstream of the COW.

As shown in the annual daily sump pumping volumes and tailings pond elevation chart in Figure 11, the sump pump flow before the spring freshet in 2018 was less than what has been recorded in the previous two years.

3.4 Vibrating Wire Piezometers

There are ten monitored VWPs installed within the TBD embankment between Stations 7+00 and 42+00. These instruments are connected to Teck's Navstar system and data can be viewed in real time from the mine offices. There is another VWP installed in the Overburden Stockpile (P-12-109). Data from P-12-109 is collected in a battery-operated data logger and is downloaded annually by Teck personnel. VWP locations at the TBD and Overburden Stockpile are presented in Figure 2.

The groundwater monitoring data collected from the 10 VWPs along the TBD, the tailings pond elevation, trigger elevations identified in the O&M manual, and the data collected from P-12-109 in the Overburden Stockpile are presented on Figure 12 and summarized below:

- Data from the two piezometers located upstream of the COW (P-15-137 and -142) correlates very well to the tailings pond elevation, indicating high permeability and free flow of water through the rockfill and select fill materials.
- The eight downstream TBD piezometers are influenced by the sump pump flow rate and therefore seasonal variations in precipitation and air temperature. Of the downstream piezometers, the two consistently highest piezometric surfaces are at Station 7+00 and 42+00 near the abutments and furthest away from the sump. The lowest piezometric surfaces occur near the sump (Station 26+50), reflecting groundwater flow toward the sump. Data gaps exist where the communication system went down resulting in no information being recorded.
- The O&M manual identifies two trigger levels related to the VWP monitoring array: exceedance of a groundwater elevation of 945 feet by P-15-138 or -139, and exceedance of a groundwater elevation of 981 feet (permitted freeboard) by P-15-137 or -142.
    - P-15-138 briefly exceeded the trigger level elevation during the start of the spring freshet, but the groundwater level was quickly dropped to an acceptable level as the sump pump was repaired.
    - Neither P-15-137 or -142 has exceeded the permitted freeboard elevation of 981 feet.
- Data from piezometer P-12-109 indicates that the groundwater level remained above elevation 945 feet, indicating flow towards the TBD sump. The battery has been replaced in the datalogger (died in February 2018) and data is currently being collected.
- Figure 12 also presents the downstream piezometric surface within the TBD superimposed on the COW profile. Data indicate that the groundwater flow gradient is towards the TBD sump.

3.5 Ground Temperature Monitoring

Subsurface temperatures are collected at 11 ground temperature monitoring arrays (manufactured by Beaded Stream [7], Geokon [1], and Measurand [3]). Appendix C presents the ground temperature monitoring data at each of the arrays and includes data from 7 additional ground temperature monitoring arrays located in the Overburden Stockpile.

Figure 13 shows the interpolated permafrost table at each of the ground temperature monitoring arrays within the TBD along the COW profile. This profile view shows that the highest permafrost table elevation occurs downstream near Station 37+00 and is within the native overburden materials. On the upstream side of the COW, only one of the three SAAs (Station 35+00) indicates permafrost within the extent of the casing. Below the depth of seasonal frost penetration, the SAAs at Station 14+00 and 25+00 have not recorded any temperatures below 32 degrees Fahrenheit. The seasonal frost penetration at SAAs 14+00, 25+00, and 35+00 were noted to reach elevations of approximately 6 to 8 feet below the top of the COW (elevation 986 feet). However, the temperatures recorded in the SAAs are not representative of the COW, since they are subject to thermal disturbance through the SAA casing, which is uninsulated and penetrates the insulation layer.

4.0 REVIEW OF INSPECTIONS AND INSTRUMENTATION ASSESSMENTS

As required by the O&M manual, Teck completes daily, weekly, and quarterly field inspections and monthly monitoring data reviews of the TBD. Teck additionally provides monthly reports to Golder that include the weekly

and quarterly field inspections as well as the monthly data reviews. Golder reviewed the inspection forms and monitoring reports listed above as part of the Annual Performance Review of the TBD.

4.1 Daily, Weekly, and Quarterly Inspections

The inspection reports provided for review included 70 Visual Tailings Back Dam Inspection reports (weekly and quarterly inspections) from January 7, 2017 to May 29, 2018. The visual inspection reports provide a means to monitor and record, among other things, the weather conditions, snow cover, wave action, ponded water condition, and apparent stability of the embankment, including signs of cracks, slumps, and seepage.

Based on our review, the weekly and quarterly visual inspections have been performed as required by the O&M manual for the TBD. Daily inspections were not reviewed.

4.2 Instrumentation Assessments

Starting in 2018, Teck has implemented a Periodic Instrumentation Assessment program where monitoring data is reviewed according to the procedures prescribed in the O&M manual. The reviews occur monthly, in line with the monitoring frequencies in the O&M manual and include weekly and quarterly inspection sheet scans. Teck submits these reports to Golder immediately after they are compiled, usually within a week of the month end. These reports have been very useful in initiating conversation between Teck and Golder related to monitoring data in exceedance of trigger levels or observations made by Teck. The following bullets present the Instrumentation Assessments provided to Golder and the date they were received.

- February 2018 Periodic Monitoring Assessment – Dated March 5, 2018
- March 2018 Periodic Monitoring Assessment – Dated April 2, 2018
- April 2018 Periodic Monitoring Assessment – Dated April 30, 2018
- May 2018 Periodic Monitoring Assessment – Dated June 6, 2018
- June 2018 Periodic Monitoring Assessment – Dated July 11, 2018

5.0 CONCLUSIONS

Based on our observations during the site visit and a review of the monitoring data, the following conclusions can be made concerning the safety of the dam and its performance:

- During the field inspection, the TBD and its appurtenant components appeared to be in satisfactory condition with no indications of unanticipated instability. Stage IV construction is ongoing, and Teck should continue to pay close attention to monitoring data and changing conditions.
- The longitudinal cracking between Stations 20+00 and 27+00 is occurring near the interface of the select fill and rockfill materials. This behavior has been observed after each stage of construction and is not considered to be a concern for the performance of the COW or the stability of the embankment as the majority of related movements are occurring within the rockfill. As described in previous inspection reports, these cracks are believed to be related to thawing and consolidation of permafrost soils and were considered during the initial design. As might be anticipated considering the thicker zone of ice-rich materials, movement monitoring data in this area suggests that movement is occurring more rapidly than at other regions of the TBD.

- Recent SAA readings indicate a maximum resultant magnitude of movement ranging from 0.2 to 0.4 inches. None of the three SAAs have shown an increased rate of movement since their installation in 2015 and all have an annual incremental movement rate of less than 0.2 inches, indicating the dam is performing as designed with respect to movement of the select fill core and COW.
- The survey monument at Station 21+10 downstream of the COW continues to record significantly more horizontal displacement than the other monuments, recently reaching a maximum of 3.2 inches. This is in excess of the trigger level threshold of 3.0 inches set in the O&M manual. Although this instrument is founded in the select fill prism, it was installed across the select fill/rockfill boundary so it registers movement that is occurring at this interface. No dominant direction of movement appears for any monument with respect to the vertical direction, with movement varying from -0.9 inches up to 1.4 inches before the November 13, 2017 survey. However, from the November 13, 2017 survey to April 1, 2018, vertical movement varied from 2.6 inches to -1.8 inches. It is suspected that the survey equipment or survey rod height varied for these surveys, resulting in inconsistent data.
- Golder recently completed a numerical modeling effort[3] evaluating the response of the TBD, including the COW, to the thawing of massive ice underneath the rockfill and adjacent to the select fill core. The modeling effort predicted a maximum of about 1.0 feet of displacement at the COW (modeled at Station 35+00). Similar to what has been observed in the field, the thawing ice and subsequent settlement within the model primarily affected the downstream rockfill zone of the embankment, with less movement translating to the select fill core. The modeling effort was based on simplifying assumptions related to the thickness of the thawing ice layer at the sections analyzed, and should not be viewed as a precise estimate of how much settlement can occur, or will translate to the COW. However, the modeling results do provide confirmation of how we understand the TBD will respond to thaw settlements, and an approximation of the magnitude of deformations that could occur.

  Comparison of the numerical modeling results with the field and monitoring observations, the TBD is responding as anticipated to thaw settlements occurring downstream of the embankment between approximately 20+00 and 27+00. The SAA at Station 25+00 is recording deformations but remains below the trigger level of 1.0 inches set in the O&M manual. Exceedance of the trigger level could potentially occur without critically damaging the COW or TBD, as up to 1.0 feet of deformation was predicted in the numerical modeling effort.
- Groundwater monitoring data from the array of VWPs show that the two upstream piezometers at Station 12+00 and 32+00 follow the tailings pond elevation very closely. The eight downstream piezometers are hydrologically disconnected from the tailings pond by the COW, but show some similar behaviors, including a rapid water level rise during the spring freshet. Groundwater levels are highest near the abutments at Station 7+00 and 42+00, and lowest at Station 27+00 closest to the sump pump. The lowest head drop across the COW between February 28, 2017 and May 31, 2018 was 0.9 feet at Station 7+00 near the right abutment, while the highest is 38.8 feet at Station 27+00. The gradient across the embankment piezometers shows flow toward the sump pump over the entire data range. P-12-109, located downstream of the TBD in the Overburden Stockpile, also indicates a flow gradient from the Overburden Stockpile towards the sump

[3] Golder Associates Incorporated. (Golder). 2018. Static and Seismic Deformation Analysis of the Tailings Back Dam, report prepared for Teck Alaska Incorporated, dated March 28. (Project Number 1664603). Anchorage, AK. Golder.

pump; therefore, the data suggests total containment of TBD seepage within the drainage basin immediately downstream of the TBD.

- The ponded water at a topographic low spot (now filled in) observed during this and previous field inspections near Station 7+00 (downstream of TBD) is inferred to be infilling in part from a seep originating near the Stage III TBD embankment. The estimated seep elevation of 966 feet is lower than the typical elevation of P-15-144 (located in the TBD embankment), which indicates a gradient from the TBD to the topographic low spot. Based on our understanding of the groundwater downstream of the TBD, this water reports to the sump pump and is eventually pumped to the tailings pond.
- The minimum sump pump flow rate before the spring freshet was observed to be lower than what was observed in 2017 and 2016. The minimum flow rate is typically used to evaluate the performance of the COW and TBD system; however, due to operational difficulties (sump pump on timer in 2018), the lower observed flow rate in 2018 does not necessarily reflect a reduced flow volume through the COW.

  While the sump pump was on a timer, the water levels in piezometers P-15-139 and -138, which are located nearest to the sump pump along the TBD, were noted to register a consistent increase in water level. This means that the rate of pumping was not set high enough to match the inflows occurring to the sump, and that excess water was accumulating within the pore space of the TBD embankment. However, because a cross-wall gradient similar to previous years was maintained through the pre-spring freshet time period by pumping a similar volume of water through the sump pump, we infer that the COW and TBD are performing as designed and as observed in previous years.
- Based on the temperature monitoring data collected at the TBD, there is no clear permafrost degradation or subsurface thermal disturbance occurring. Except for seasonal active layer, the TBD embankment fill materials remain unfrozen.
- Based on review of the weekly, quarterly inspection reports, and monthly monitoring data assessments, Teck is performing inspections in accordance with the O&M manual.

6.0 RECOMMENDATIONS

The following recommendations were developed during preparation of this APR including the field inspection and our review of monitoring data. Recommendations that were also provided by Klohn Crippen Berger (KCB 2018) are designated with the appropriate KCB number (PSI-R-XX).

- Continue to conduct timely monitoring data review in accordance with the monitoring frequencies prescribed in the O&M manual. The Periodic Monitoring Assessments provide useful dialog between Teck and Golder and ensure that any potential issues or data collection errors are quickly addressed.
- Continue to monitor cracking along the dam crest and watch for correlations with monitoring data collected in nearby SAAs and survey monuments.
- Install the cables that extend from the SAAs and VWPs to the data loggers within a protective casing to protect them from being damaged from foot traffic or equipment and reduce their potential as a tripping hazard.

- Inspect the seal between the protective casings and board insulation within the insulation layer and make repairs with spray foam insulation to improve the seal, if necessary. Add insulation to the outside of the protective casing and the cap above the board insulation. (PSI-R-07)
- Route the HDPE pipelines used to hold the SAA and VWP instrument cables so they travel over the entire insulation layer surface, and cover the pipes with gravel to allow passage of vehicular traffic. As an alternative, replace the HDPE pipes with insulated HDPE pipes through the insulation layer. Plug the open ends of the insulated HDPE pipes with 4 inches of board insulation to prevent cold air from passing through. (PSI-R-07)
- Upgrade the sump pumphouse to prevent freezing of the sump pump / pumpback system.
- Install two additional SAA inclinometers, one upstream and one downstream of the COW, where cracks have been observed in the TBD crest (such as near survey monument Mon-15-05) to better characterize movements and compare with the numerical model. (PSI-R-04, -10)
- Evaluate the permeability of COW materials following degradation due to freeze-thaw cycling. This testing will guide the design of the insulation layer at closure. (PSI-R-17)

The conclusion of this APR is that the TBD is being maintained in a satisfactory condition and is performing as designed.

7.0 CLOSING

The work program followed the standard of care expected of professionals undertaking similar work in the State of Alaska under similar conditions. No warranty expressed or implied is made. Please contact us if you have any questions or comments regarding this report.

Sincerely,

Golder Associates Inc.

Samuel P. Saunders, PE
Senior Project Engineer

Steven L. Anderson, PE
Associate and Senior Consultant

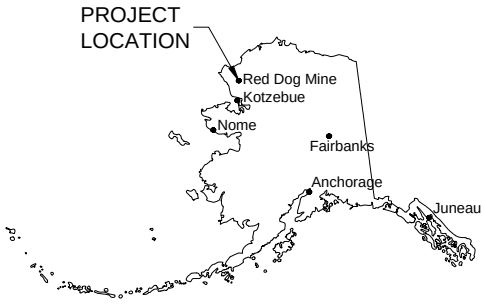
SPS/SLA/sps

Attachments: Figure 1 – Project Location
Figure 2 – Plan View of Tailings Back Dam
Figure 3 – Cut-off Wall Profile – Station 0+00 to 26+00
Figure 4 – Cut-off Wall Profile – Station 26+00 to 49+52
Figure 5 – Tension Cracks Along Back Dam Crest
Figure 6 – Horizontal Movement Monitoring at Station 14+00
Figure 7 – Horizontal Movement Monitoring at Station 25+00
Figure 8 – Horizontal Movement Monitoring at Station 35+00
Figure 9 – Movement Monitoring at Survey Monuments
Figure 10 – Air Temperature, Precipitation, Tailings Pond Elevation, and Sump Pump Data with Time (2015-2018)
Figure 11 – Sump Pump and Tailings Pond Elevation Data
Figure 12 – Groundwater Monitoring – Piezometric Surface
Figure 13 – Ground Temperature Monitoring – Top of Permafrost

Appendix A – ADNR Inspection Form
Appendix B – 2018 Site Inspection Photographs
Appendix C – Ground Temperature Monitoring Data

https://golderassociates.sharepoint.com/sites/23601g/deliverables/001 2018 back dam inspection/rev 0/1895461-001-l-rev0-red dog 2018 tailings back dam apr-20181001.docx

Figures



NOT TO SCALE

REFERENCE

AERIAL IMAGERY ACQUIRED BY KODIAK MAPPING ON JULY 13, 2017; FILENAME *REDDOG.MINE2FTLOCAL.TIF*

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

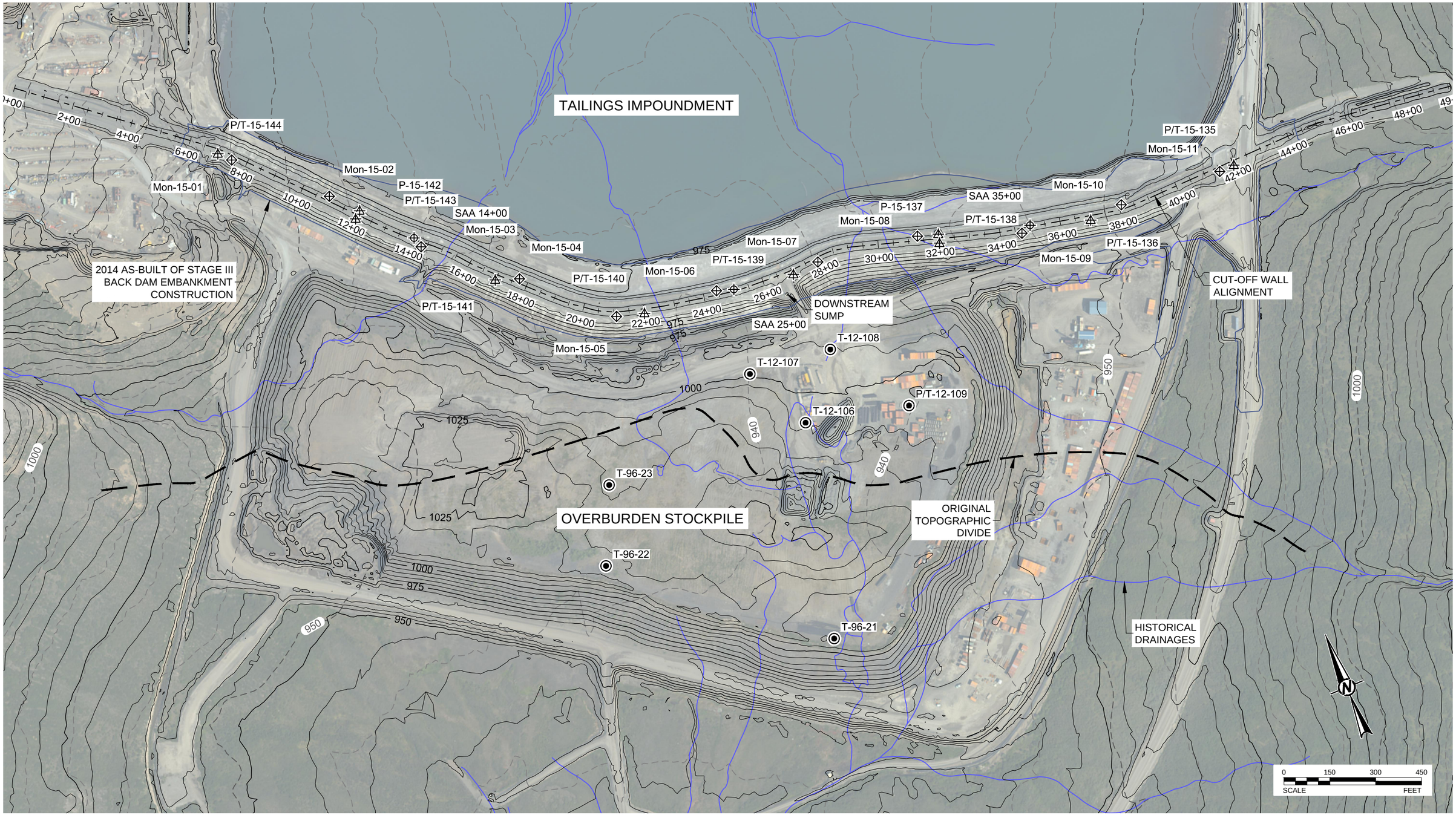
CONSULTANT
GOLDER

YYYY-MM-DD	2018-10-01
PREPARED	GC
DESIGN	N/A
REVIEW	SPS
APPROVED	SLA

PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

TITLE
PROJECT LOCATION

PROJECT No.	Rev.	FIGURE
1895461	0	1



LEGEND

1000	2017 TOPOGRAPHY (5 AND 25 FOOT CONTOURS)
1000	ORIGINAL TOPOGRAPHY (10 AND 50 F00T CONTOURS)
Mon-15-01	SETTLEMENT MONUMENT
T-96-22	TAC AND/OR PIEZOMETER LOCATION AT OVERBURDEN STOCKPILE
SAA 14+00	SAA INCLINOMETER
P/T-15-135	PIEZOMETER (P) AND/OR TEMPERATURE ACQUISITION CABLE [TAC] (T) AT TAILINGS BACK DAM

REFERENCES

1. TOPOGRAPHY FROM LiDAR SURVEY COMPLETED KODIAK MAPPING IN 2017 FILENAME: *Red Dog 2017_MS_LOCAL_CAD13*.dwg
2. ORIGINAL TOPOGRAPHY AND HISTORICAL DRAINAGES SHOWN FROM 1984 TOPOGRAPHIC CONTOURS PROVIDED BY TAK FILENAME: *All-84Topo*.dwg
3. AERIAL IMAGERY ACQUIRED BY KODIAK MAPPING IN 2017 FILENAME: *RedDog Mine 2FTLocal.tif*

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

CONSULTANT
GOLDER

YYYY-MM-DD	2018-10-01
DESIGNED	N/A
PREPARED	GC
REVIEWED	SPS
APPROVED	SLA

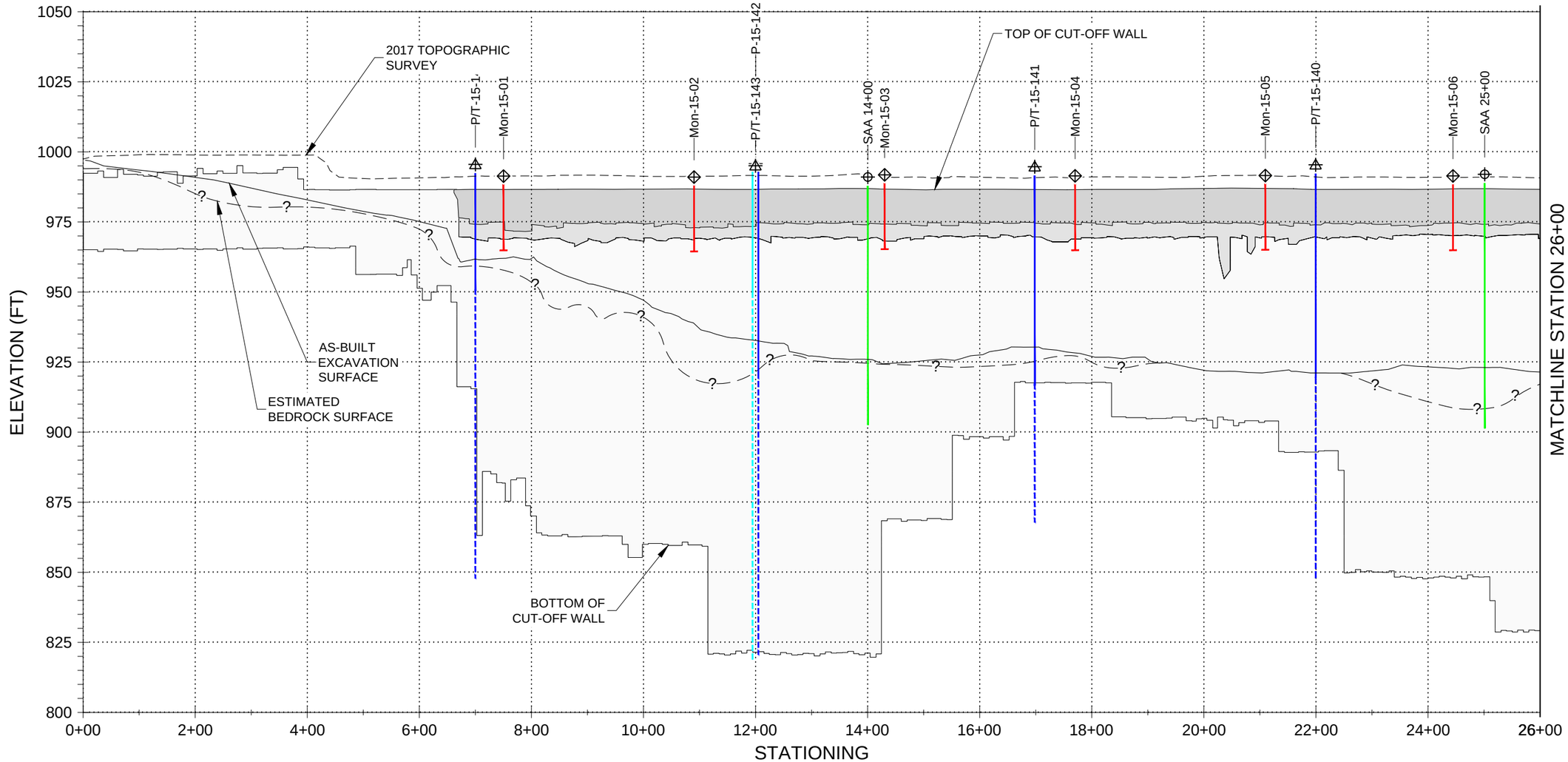
PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

TITLE
PLAN VIEW OF TAILINGS BACK DAM

PROJECT NO.	REV.	FIGURE
1895461	0	2

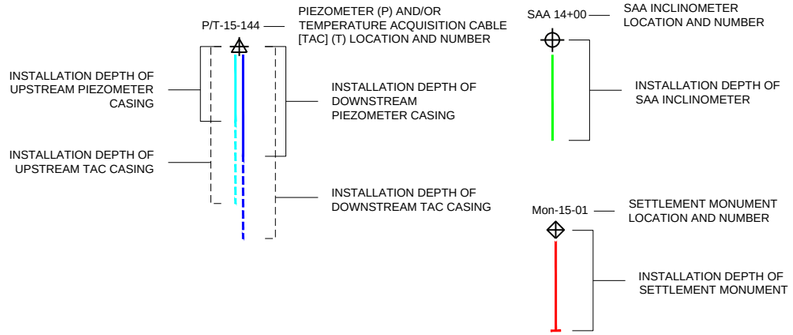
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

Path: \\anchorage\Publ\G\Geomatics\Teck\Red Dog\99_PROJECTS\1895461 TAK 2018 RD Annual Dam Insp\ex\02_PRODUCTION\DWG\ | File Name: RD BD ADI 2018 PAP.dwg



LEGEND

- STAGE I CUT-OFF WALL (CONSTRUCTED 2007-2010)
- STAGE II CUT-OFF WALL RAISE (CONSTRUCTED 2013)
- STAGE III CUT-OFF WALL RAISE (CONSTRUCTED 2015)
- AS-BUILT EXCAVATION SURFACE
- ESTIMATED BEDROCK SURFACE
- 2017 TOPOGRAPHIC SURVEY



0 100 200 300
HORIZONTAL SCALE FEET

0 20 40 60
VERTICAL SCALE FEET

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

CONSULTANT
GOLDER

YYYY-MM-DD	2018-10-01
DESIGNED	N/A
PREPARED	GC
REVIEWED	SPS
APPROVED	SLA

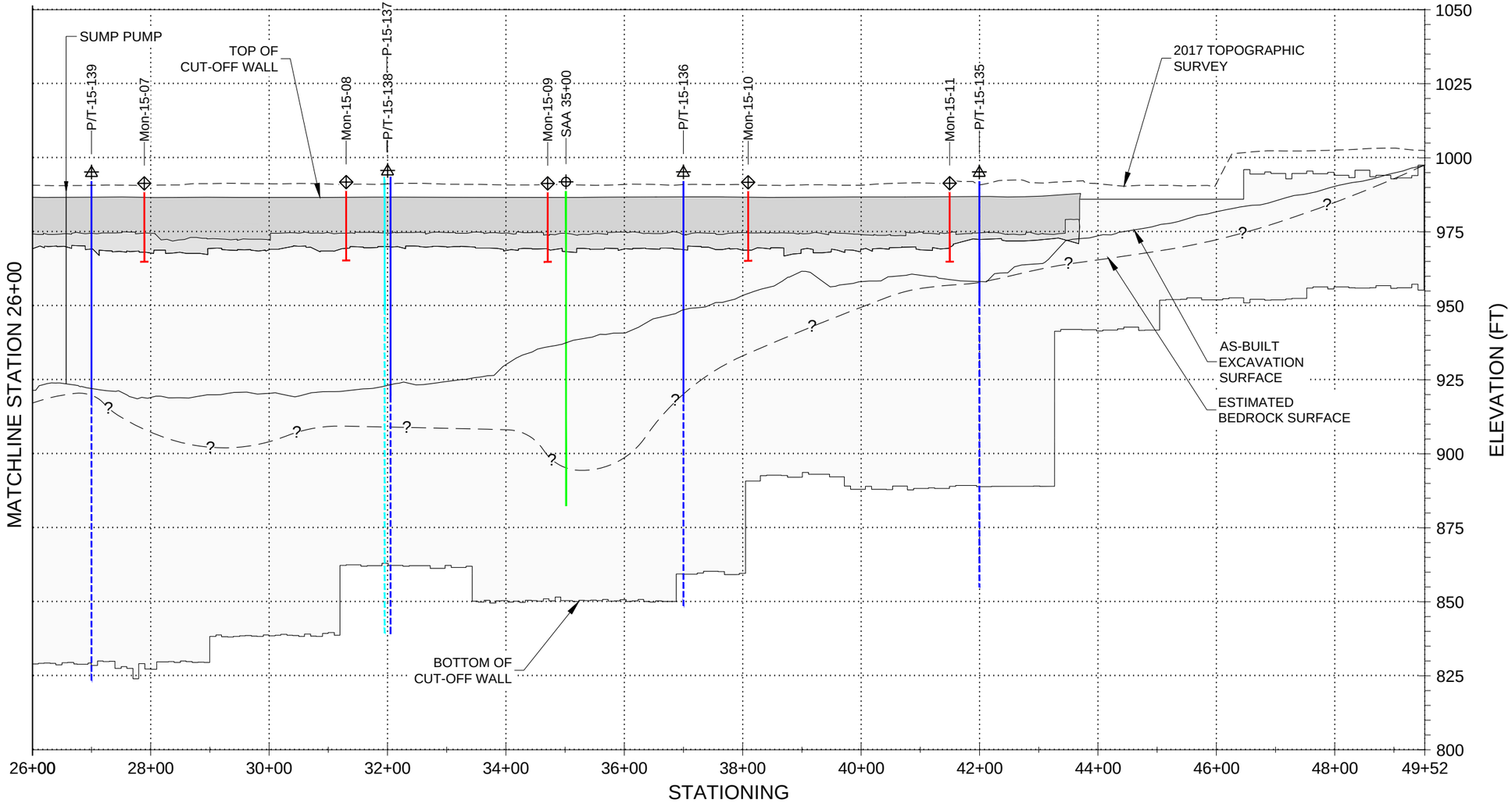
PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

TITLE
CUT-OFF WALL PROFILE
STATION 0+00 TO 26+00

PROJECT NO. 1895461 | REV. 0 | FIGURE 3

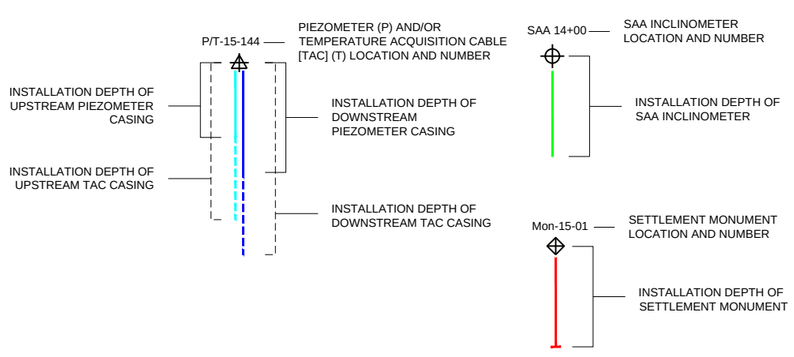
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Path: \\Anchorage\Public\Geomatics\Teck\Red Dog\09_PROJECTS\1895461 TAK 2018 RD Annual Dam Inspect\02_PRODUCTION\DWGs | File Name: RD BD ADI 2018 P&P.dwg



LEGEND

- STAGE I CUT-OFF WALL (CONSTRUCTED 2007-2010)
- STAGE II CUT-OFF WALL RAISE (CONSTRUCTED 2013)
- STAGE III CUT-OFF WALL RAISE (CONSTRUCTED 2015)
- AS-BUILT EXCAVATION SURFACE
- ESTIMATED BEDROCK SURFACE
- 2017 TOPOGRAPHIC SURVEY



0 100 200 300
HORIZONTAL SCALE FEET

0 20 40 60
VERTICAL SCALE FEET

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

CONSULTANT
GOLDER

YYYY-MM-DD	2018-10-01
DESIGNED	N/A
PREPARED	GC
REVIEWED	SPS
APPROVED	SLA

PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

TITLE
CUT-OFF WALL PROFILE
STATION 26+00 TO 49+52

PROJECT NO. 1895461 | REV. 0 | FIGURE 4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

1 in
0

Path: \\Anchorage\Public\Geomatics\Teck\Red Dog\99_PROJECTS\1895461 TAK 2018 RD Annual Dam Inspect\02_PRODUCTION\DWG\ | File Name: RD BD ADI 2018 P&P.dwg

SAA INCLINOMETERS

SURVEY MONUMENTS

HISTORIC 2015 DEPRESSION AREA

CUT-OFF WALL CENTERLINE ALIGNMENT

DOWNSTREAM SUMP

14+00

STA 14+30

15+00

16+00

17+00

STA 17+70

18+00

19+00

20+00

21+00

STA 21+10

22+00

23+00

24+00

STA 24+50

25+00

25+00

26+00

27+00

STA 27+90

28+00

29+00

30

0 150 300 450

SCALE FEET

LEGEND

- CRACK SURVEYED IN 2018
- CRACK SURVEYED IN 2015
- CRACK SURVEYED IN 2013

REFERENCES

1. AERIAL IMAGERY BY KODIAK MAPPING INC. DATED 07-26-14
2. PHOTOGRAPHS TAKEN DURING BACK DAM FIELD INSPECTION, JUNE 25-26, 2018

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

CONSULTANT

Golder Associates

YYYY-MM-DD	2018-10-01
DESIGNED	N/A
PREPARED	GC
REVIEWED	SPS
APPROVED	SLA

PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

TITLE
TENSION CRACKS ALONG BACK DAM CREST

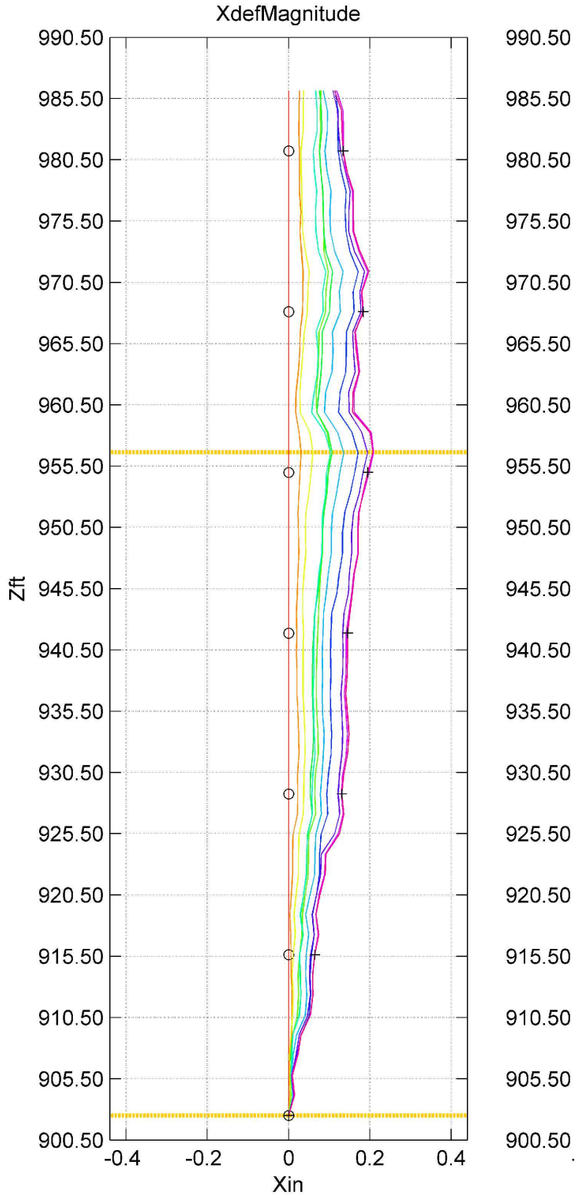
PROJECT NO. 1895461
REV. 0
FIGURE 5

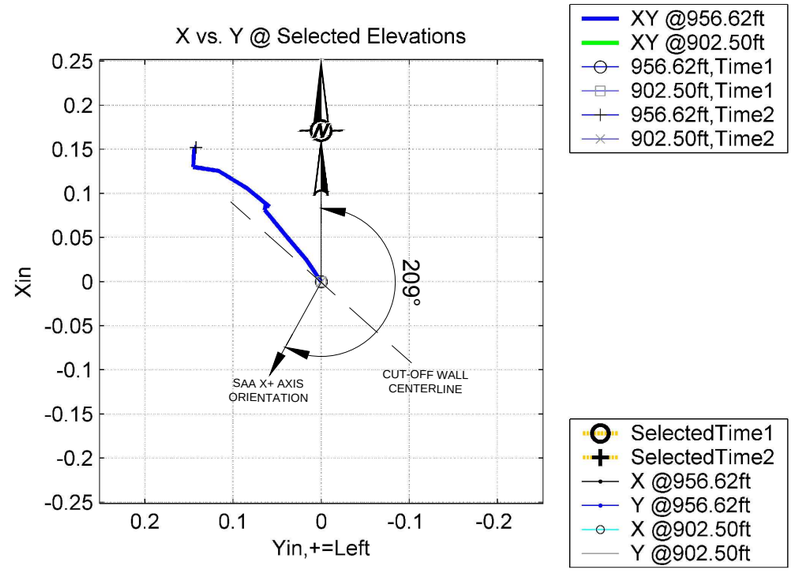
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

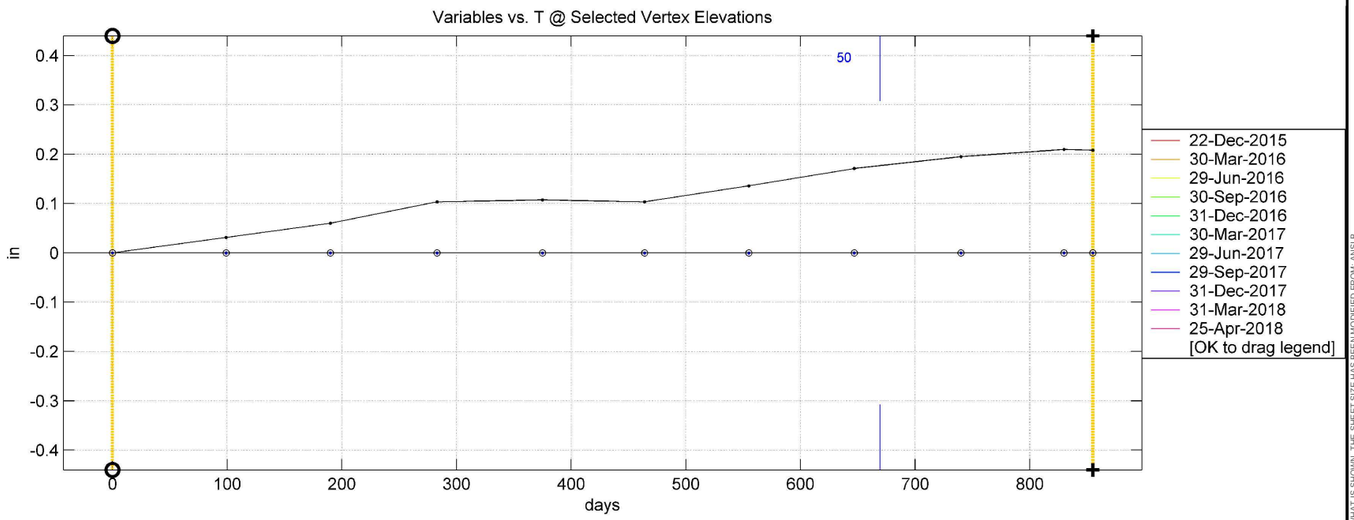
1 in

0

Path: \\Anchorage\Public\Geomatics\TTeck\Red Dog\09_PROJECTS\1895461 TAK 2018 RD Annual Dam Inspect\02_PRODUCTION\DWG\ | File Name: RD 2018 Crack Survey.dwg | Last Edited By: sanderson Date: 2018-10-01 Time:9:57:20 AM | Printed By: SSaunders Date: 2018-10-01 Time:10:09:58 AM







CUMULATIVE SAA INCLINOMETER DATA COLLECTED FROM NOVEMBER 2015 BASELINE

NOTES

1. DISPLACEMENT PLOTTED VERSUS TIME AT LOCATION OF MAXIMUM DISPLACEMENT WITHIN VERTICAL ARRAY.

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

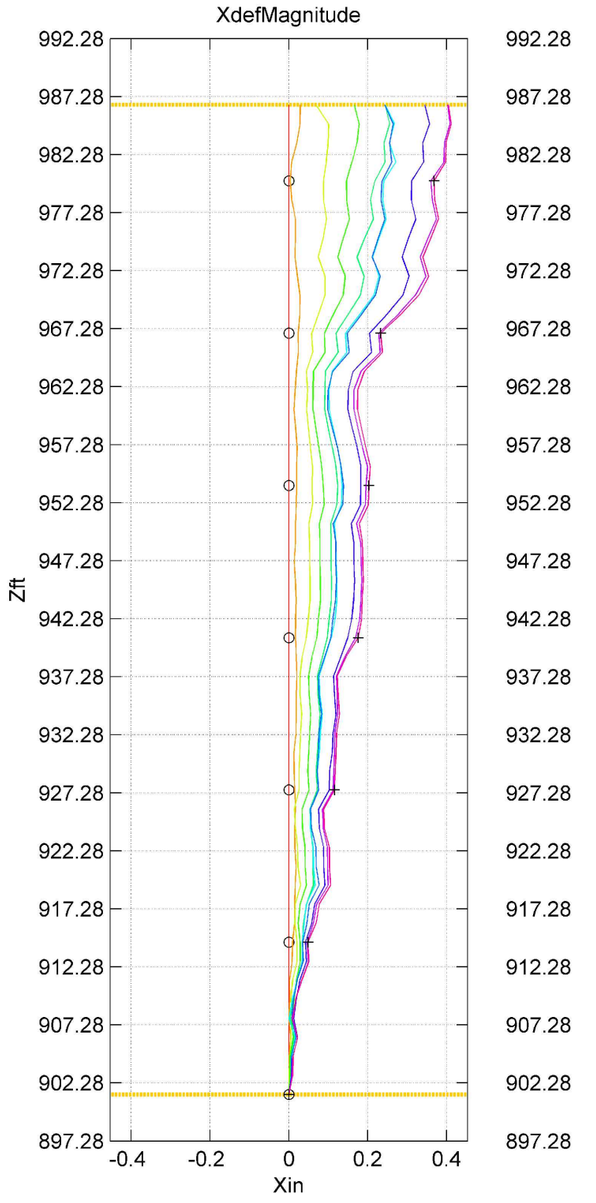
CONSULTANT
GOLDER

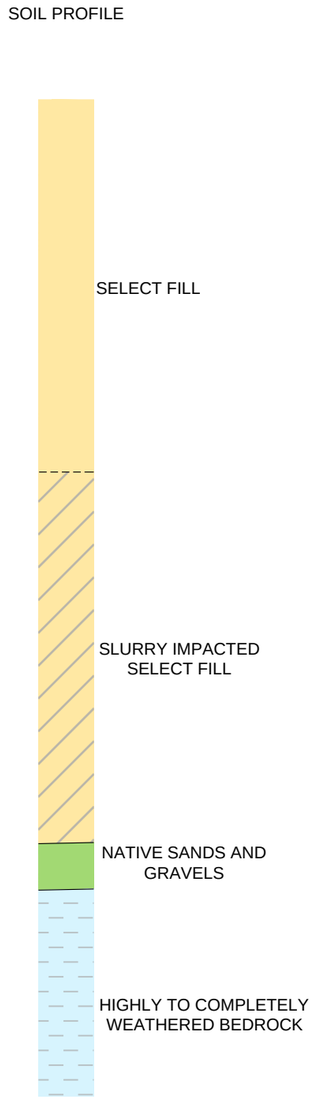
YYYY-MM-DD	2018-10-01
PREPARED	GC
DESIGN	N/A
REVIEW	SPS
APPROVED	SLA

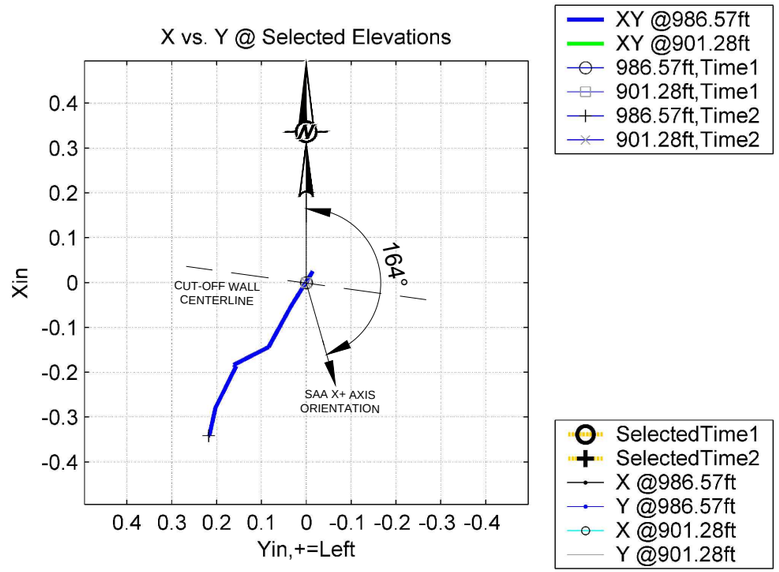
PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

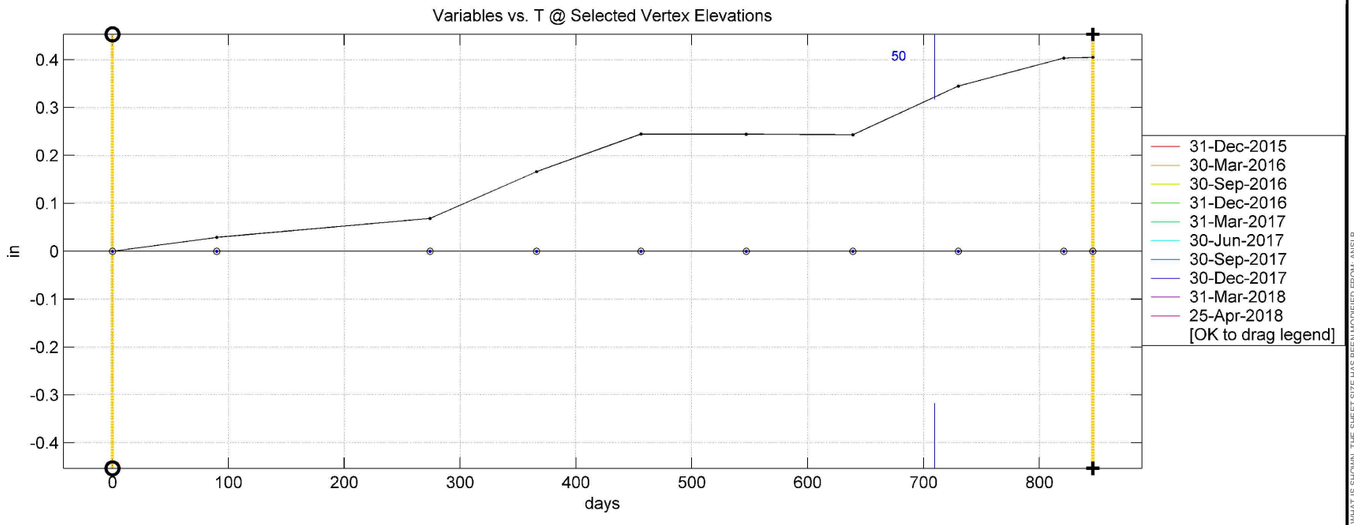
TITLE
HORIZONTAL MOVEMENT MONITORING AT STATION 14+00

PROJECT No.	Rev.	FIGURE
1895461	0	6









CUMULATIVE SAA INCLINOMETER DATA COLLECTED FROM NOVEMBER 2015 BASELINE

NOTES

1. DISPLACEMENT PLOTTED VERSUS TIME AT LOCATION OF MAXIMUM DISPLACEMENT WITHIN VERTICAL ARRAY.

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

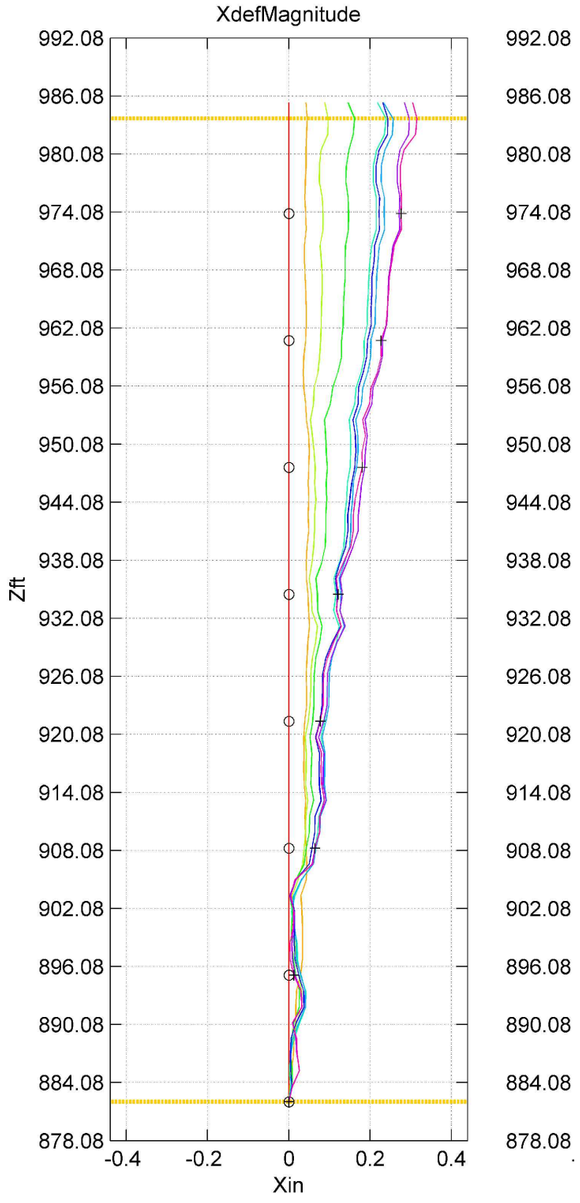
CONSULTANT
GOLDER

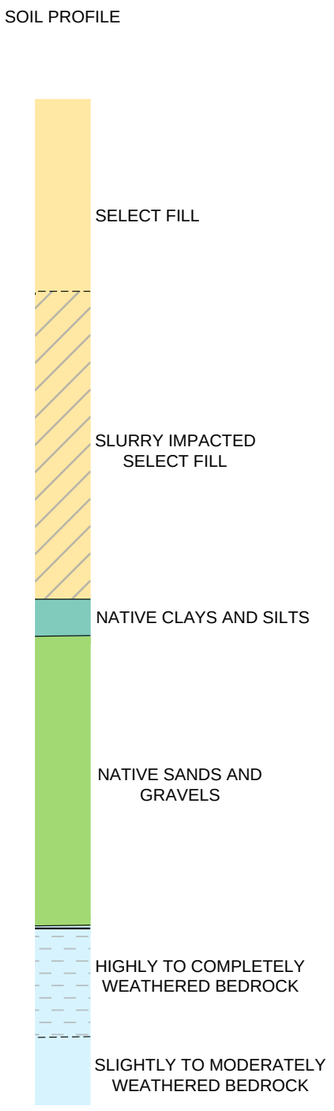
YYYY-MM-DD	2018-10-01
PREPARED	GC
DESIGN	N/A
REVIEW	SPS
APPROVED	SLA

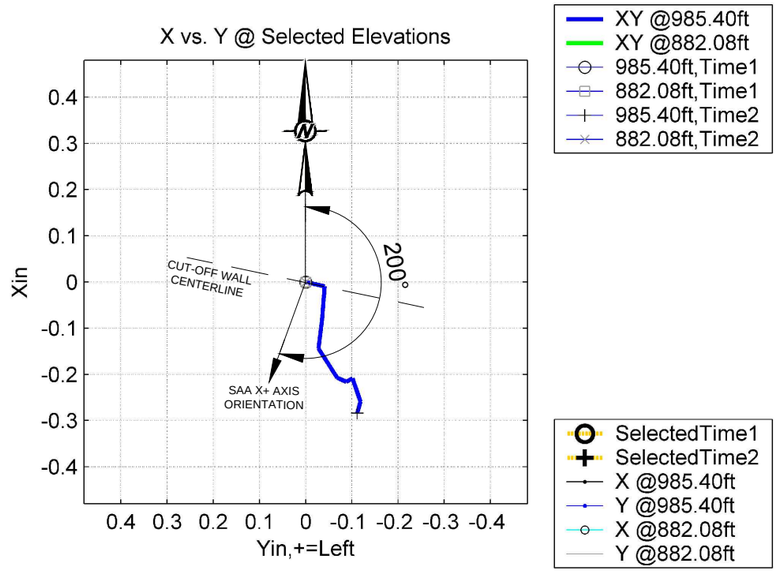
PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

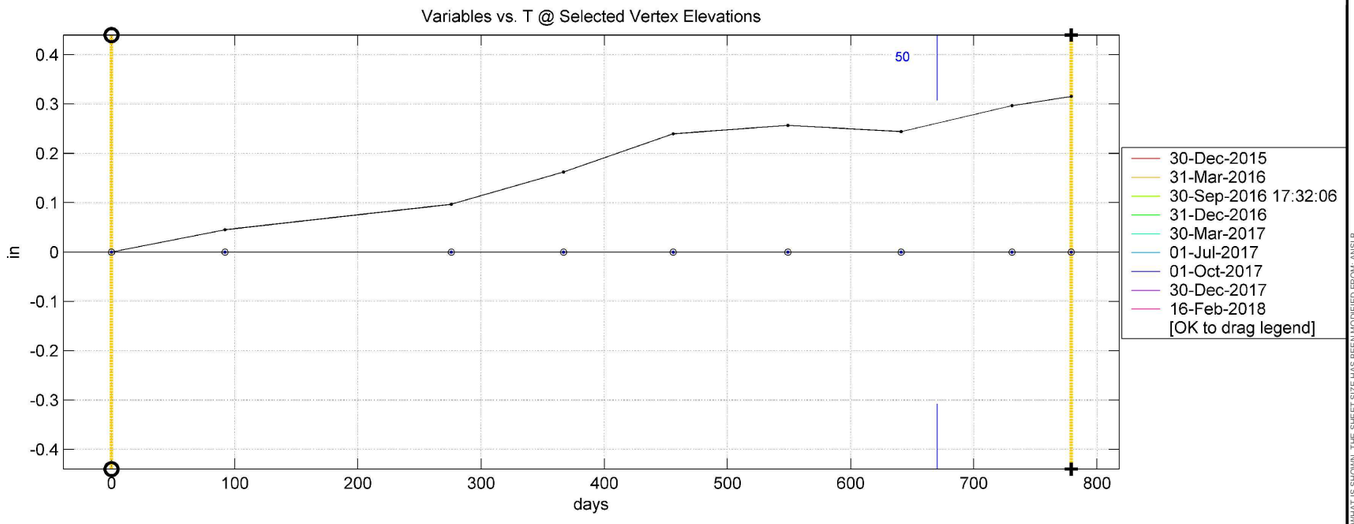
TITLE
HORIZONTAL MOVEMENT MONITORING AT STATION 25+00

PROJECT No. 1895461 | Rev. 0 | FIGURE 7









CUMULATIVE SAA INCLINOMETER DATA COLLECTED FROM NOVEMBER 2015 BASELINE

NOTES

1. DISPLACEMENT PLOTTED VERSUS TIME AT LOCATION OF MAXIMUM DISPLACEMENT WITHIN VERTICAL ARRAY.

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

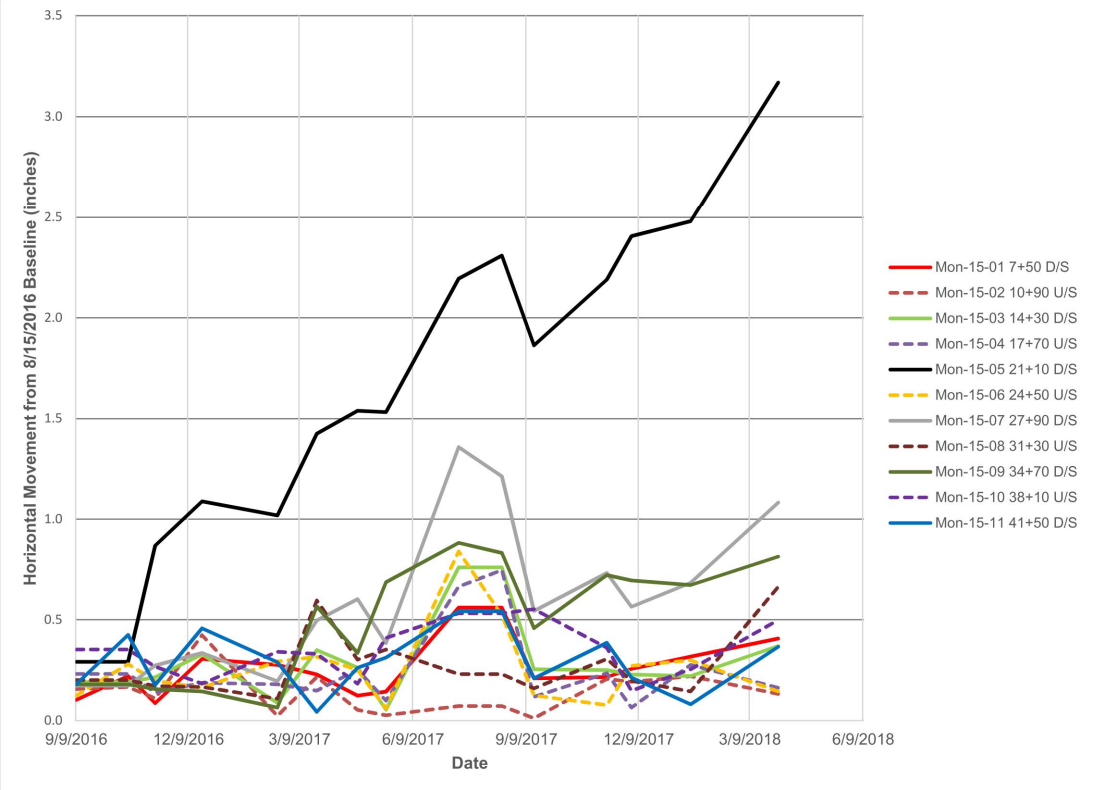
CONSULTANT
GOLDER

YYYY-MM-DD	2018-10-01
PREPARED	GC
DESIGN	N/A
REVIEW	SPS
APPROVED	SLA

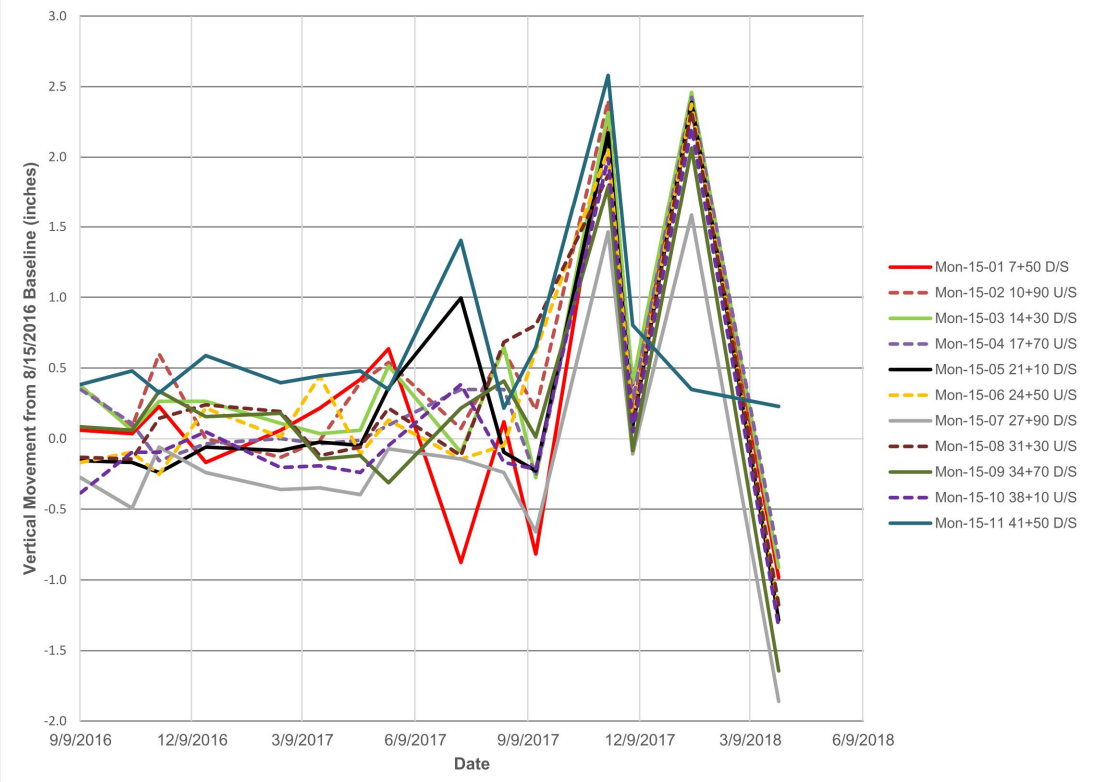
PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

TITLE
HORIZONTAL MOVEMENT MONITORING AT STATION 35+00

PROJECT No.	Rev.	FIGURE
1895461	0	8



SUMMARY OF HORIZONTAL MOVEMENTS



SUMMARY OF VERTICAL MOVEMENTS

NOTES

1. BASELINE SURVEY READINGS TAKEN ON AUGUST 15, 2016.

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

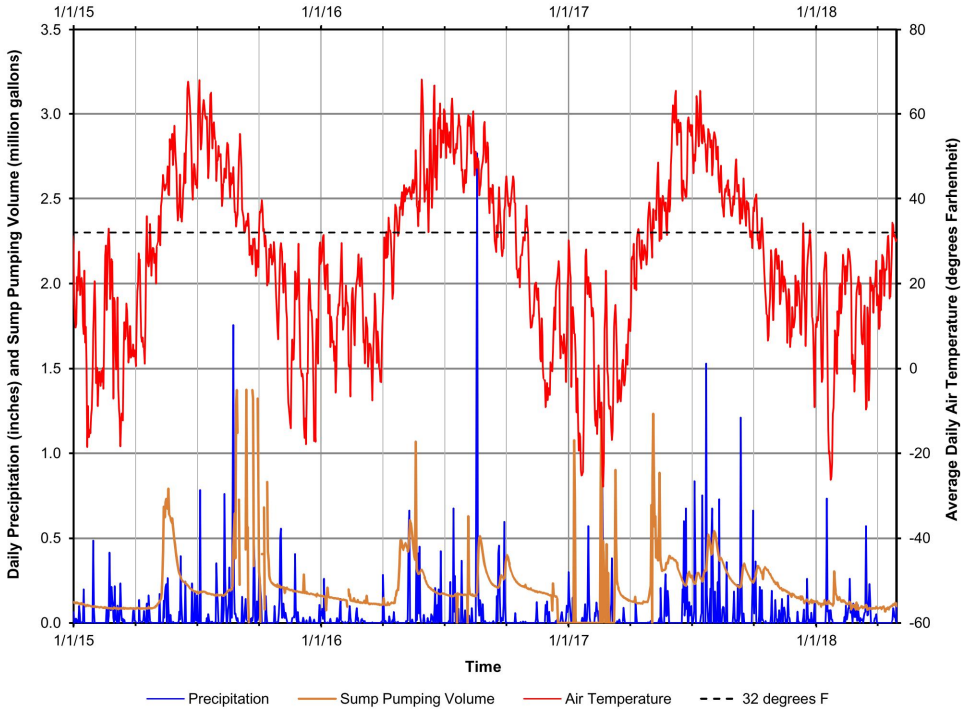
CONSULTANT
GOLDER

YYYY-MM-DD	2018-10-01
PREPARED	GC
DESIGN	N/A
REVIEW	SPS
APPROVED	SLA

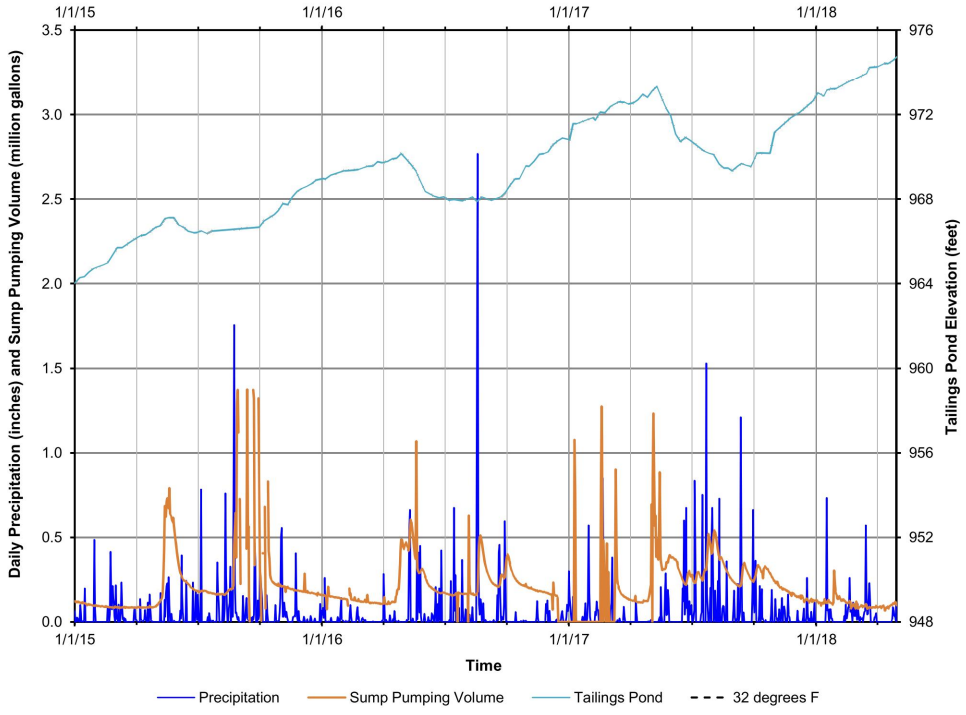
PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

TITLE
MOVEMENT MONITORING AT SURVEY MONUMENTS

PROJECT No.	Rev.	FIGURE
1895461	0	9



PRECIPITATION, SUMP PUMP, AND AIR TEMPERATURE DATA



PRECIPITATION, SUMP PUMP, AND TAILINGS POND ELEVATION DATA

NOTES

1. SUMP PUMP DATA THAT IS MISSING IS LIKELY RELATED TO PERIODS WHEN SUMP PUMP WAS FROZEN OR DOWN FOR MAINTENANCE.

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

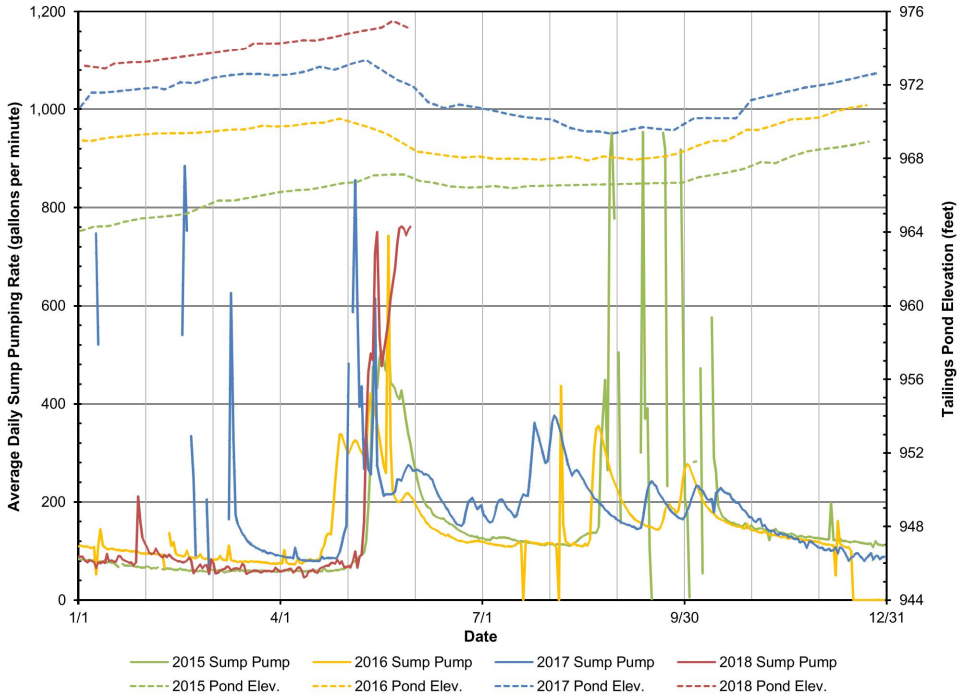
CONSULTANT
GOLDER

YYYY-MM-DD	2018-10-01
PREPARED	GC
DESIGN	N/A
REVIEW	SPS
APPROVED	SLA

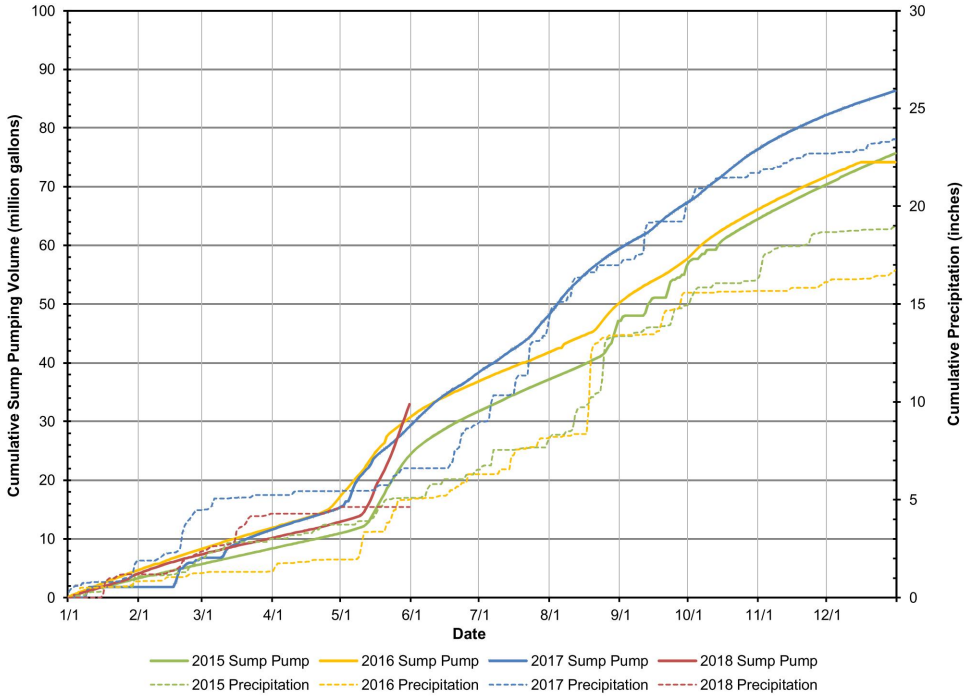
PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

TITLE
AIR TEMPERATURE, PRECIPITATION, TAILINGS POND ELEVATION, AND SUMP PUMP DATA WITH TIME (2015-2018)

PROJECT No. 1895461 | Rev. 0 | FIGURE 10



DAILY SUMP PUMPING RATES AND TAILINGS POND ELEVATION



CUMULATIVE SUMP PUMPING VOLUMES AND PRECIPITATION

NOTES

1. SUMP PUMP DATA THAT IS MISSING IS LIKELY RELATED TO PERIODS WHEN SUMP PUMP WAS FROZEN OR DOWN FOR MAINTENANCE.

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

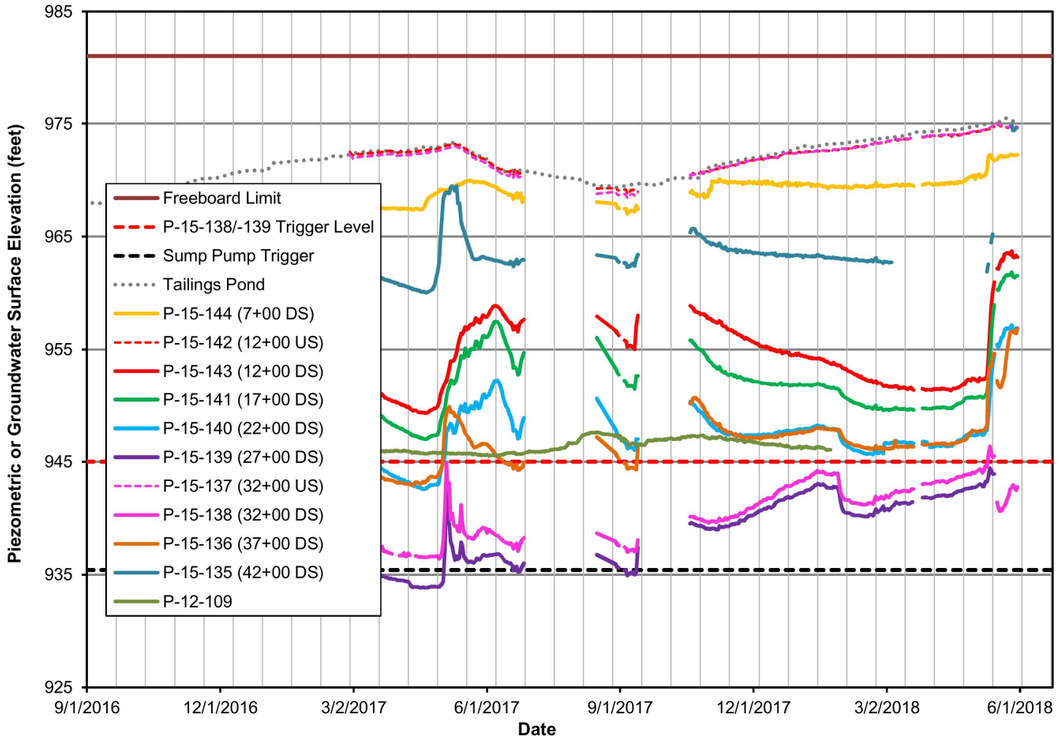
CONSULTANT
GOLDER

YYYY-MM-DD	2018-10-01
PREPARED	GC
DESIGN	N/A
REVIEW	SPS
APPROVED	SLA

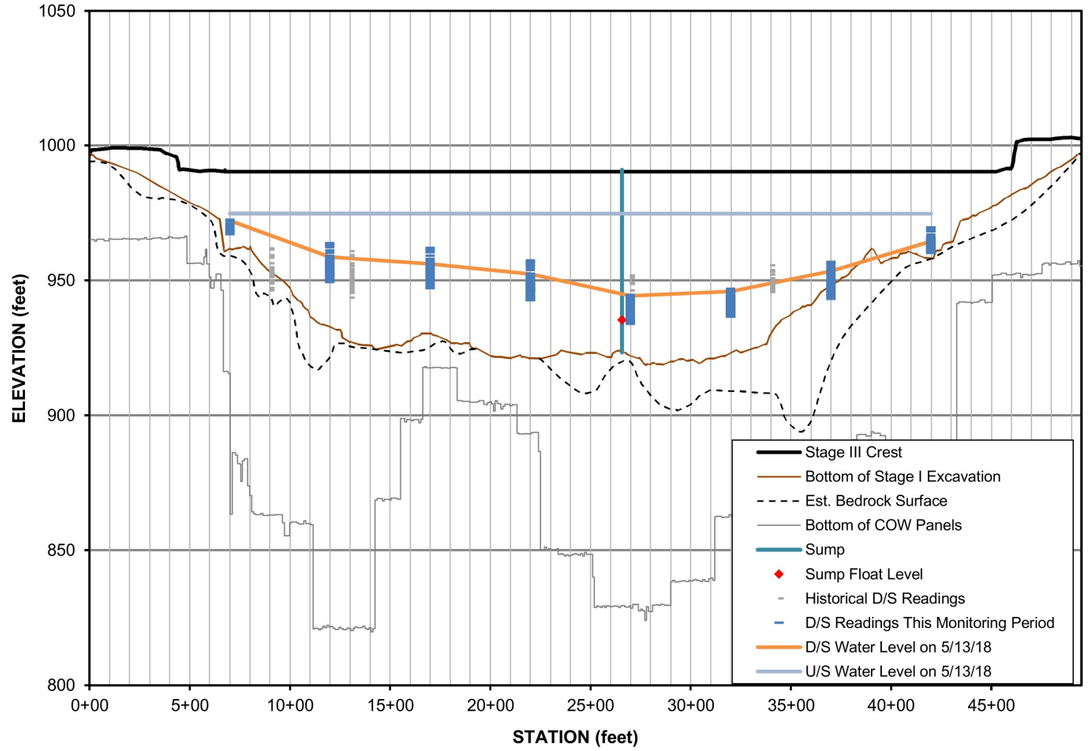
PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

TITLE
SUMP PUMP AND TAILINGS POND ELEVATION DATA

PROJECT No. 1895461 | Rev. 0 | FIGURE 11



RECENT PIEZOMETRIC DATA - NOTE 1



PROFILE VIEW - PIEZOMETRIC SURFACE (HISTORICAL AND RECENT DATA)

NOTES

1. P-12-109 IS LOCATED AT THE OVERBURDEN STOCKPILE, AS ON FIGURE 2. WATER LEVEL DATA IS CALIBRATED BASED ON A WATER TAPE READING FROM OCTOBER 29, 2017.

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

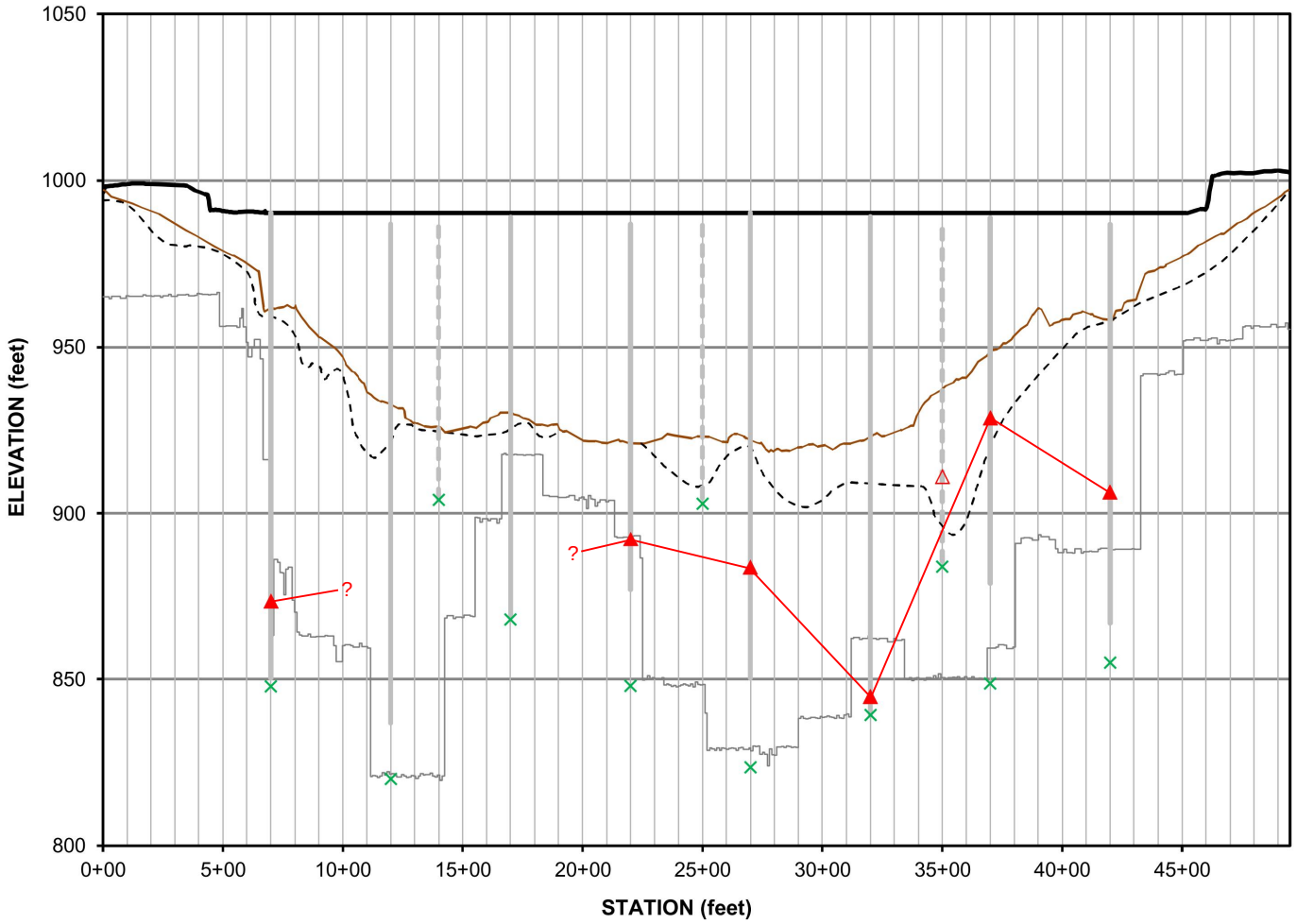
CONSULTANT
GOLDER

YYYY-MM-DD	2018-10-01
PREPARED	GC
DESIGN	N/A
REVIEW	SPS
APPROVED	SLA

PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

TITLE
GROUNDWATER MONITORING

PROJECT No.	Rev.	FIGURE
1895461	0	12



LEGEND

- Stage III Embankment Crest
- Est. Bedrock Surface
- Bottom of COW Panels
- Bottom of Stage I Excavation
- Downstream Temperature Monitoring Array
- Upstream Temperature Monitoring Array
- Bottom of TAC Casings
- Top of D/S Permafrost (4/20/18)
- Top of U/S Permafrost (2/21/18)

PROFILE VIEW - PERMAFROST SURFACE (HISTORIC AND RECENT DATA)

NOTES

1. ESTIMATED PERMAFROST ELEVATION (32 DEGREES FAHRENHEIT) DETERMINED THROUGH REVIEW OF THERMISTOR DATA AND INTERPOLATION BETWEEN READINGS.

CLIENT
TECK ALASKA INCORPORATED
3105 LAKESHORE DRIVE, BUILDING A, SUITE 101
ANCHORAGE, ALASKA, 99517

CONSULTANT
GOLDER

YYYY-MM-DD	2018-10-01
PREPARED	GC
DESIGN	N/A
REVIEW	SPS
APPROVED	SLA

PROJECT
2018 TAILINGS BACK DAM ANNUAL INSPECTION
RED DOG MINE, ALASKA

TITLE
GROUND TEMPERATURE MONITORING

PROJECT No.	Rev.	FIGURE
1895461	0	13

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0

APPENDIX A

ADNR Inspection Form

ALASKA DAM SAFETY PROGRAM
VISUAL INSPECTION CHECKLIST

GENERAL INFORMATION

NAME OF DAM: Tailings Back Dam	POOL ELEVATION: ~975 feet
NATIONAL INVENTORY OF DAMS ID#: AK00303	TAILWATER ELEVATION: n/a
OWNER: Teck Alaska Incorporated	CURRENT WEATHER: Partly Cloudy
HAZARD CLASSIFICATION: II	PREVIOUS WEATHER: Partly Cloudy
SIZE CLASSIFICATION: N/A	INSPECTED BY: Steven L. Anderson, PE and Matthew W. Ryans, PE
PURPOSE OF DAM: Tailings Storage Facility	
O & M MANUAL REVIEWED: Yes	INSPECTION FIRM: Golder Associates Inc.
EMERGENCY ACTION PLAN REVIEWED: Yes	DATE OF INSPECTION: June 25-26, 2018

ITEM	YES	NO	REMARKS
RESERVOIR			
1. Any upstream development?		X	
2. Any upstream impoundments?		X	
3. Shoreline slide potential?		X	
4. Significant sedimentation?	X		Stored tailings
5. Any trash boom?		X	
6. Any ice boom?		X	
7. Operating procedure changes?	X		Stage IV Dam Construction Planned
DOWNSTREAM CHANNEL			
1. Channel			Overburden Stockpile
a. Eroding or Backcutting		X	
b. Sloughing?		X	
c. Obstructions?		X	
2. Downstream Floodplain			
a. Occupied housing?	X		Emulsion Plant
b. Roads or bridges?	X		
c. Businesses, mining, utilities?	X		Mine Water Supply
d. Recreation Area?		X	
e. Rural land?	X		
f. New development?		X	
EMERGENCY ACTION PLAN			
1. Class I or Class II Dam?	X		Class II Dam
2. Emergency Action Plan Available?	X		In Operations and Maintenance manual
3. Emergency Action Plan current?	X		
4. Has EAP been tested in last year?		X	
INSTRUMENTATION			
1. Are there			
a. Piezometers?	X		
b. Weirs?		X	
c. Observation wells?	X		Seepage Pumpback Sump
d. Settlement Monuments?	X		
e. Horizontal Alignment Monuments?	X		SAA Inclinometers
f. Thermistors?	X		
2. Are readings			
a. Available?	X		
b. Plotted?	X		
c. Taken periodically?	X		In accordance with O&M Manual

ALASKA DAM SAFETY PROGRAM
VISUAL INSPECTION CHECKLIST

SAFETY

ITEM	YES	NO	REMARKS
SAFETY			
1. ACCESS			Type: Gravel Road
a. Road access?	X		
b. Trail access?		X	
c. Boat access?		X	
d. Air access?		X	
e. Access safe?	X		
f. Security gates and fences?		X	Remote secured site
g. Restricted access signs?	X		
2. PERSONNEL SAFETY			
a. Safe access to maintenance and operation areas?	X		
b. Necessary handrails and ladders available?			n/a
c. All ladders and handrails in safe condition?			n/a
d. Life rings or poles available?	X		Available at Mine offices
e. Limited access and warning signs in place?	X		
f. Safe walking surfaces?	X		
3. DAM EMERGENCY WARNING DEVICES			
a. Emergency Action Plan required?	X		
b. Emergency warning devices required by EAP?	X		Types: monitoring instrumentation
c. Emergency warning devices available?	X		
d. Emergency warning devices operable?	X		
e. Emergency warning devices tested?	X		
f. Emergency warning devices tested by owner?	X		When: monthly during instrumentation review
g. Emergency procedures available at dam?	X		Mine offices
h. Dam operating staff familiar with EAP?	X		
4. OPERATION AND MAINTENANCE MANUAL			
a. O & M Manual reviewed?	X		
b. O & M Manual current?	X		Rev 3, October 21, 2016
c. Contains routine inspection schedule?	X		
c. Contains routine inspection checklist?	X		

ALASKA DAM SAFETY PROGRAM
VISUAL INSPECTION CHECKLIST

EMBANKMENT DAMS

ITEM	YES	NO	REMARKS
EMBANKMENT DAMS			Type: Gravel and Rockfill centerline plastic concrete cut-off wall
1. CREST			
a. Any settlement?		X	
b. Any misalignment?		X	
c. Any cracking?	X		Along select fill / rockfill interface
d. Adequate freeboard?	X		
2. UPSTREAM SLOPE			
a. Adequate slope protection?	X		
b. Any erosion or beaching?		X	
c. Trees or brush growing on slope?		X	
d. Deteriorating slope protection?		X	
e. Visual settlement?		X	
f. Any sinkholes?		X	
3. DOWNSTREAM SLOPE			Type: Rockfill
a. Adequate slope protection?	X		
b. Any erosion?		X	
c. Trees or brush growing on slope?		X	
d. Animal burrows?		X	
e. Sinkholes?		X	
f. Visual settlement?		X	
g. Surface seepage?		X	
h. Toe drains dry?			n/a
i. Relief wells flowing?			n/a
j. Slides or slumps?		X	
4. ABUTMENT CONTACTS			
a. Any erosion?		X	
b. Seepage present?		X	
c. Boils or springs downstream?		X	
5. FOUNDATION			Type: Overburden, stripped of ice-rich materials during construction
a. If dam is founded on permafrost			
(1) Is fill frozen?		X	N/A
(2) Are internal temperatures monitored?	X		
b. If dam is founded on bedrock			Type: cherts and shales
(1) Is bedrock adversely bedded?		X	
(2) Does rock contain gypsum?		X	
(3) Weak strength beds?		X	
c. If dam founded on overburden			Type: N/A
(1) Pipeable?		X	
(2) Compressive?		X	
(3) Low shear strength?		X	

ALASKA DAM SAFETY PROGRAM
VISUAL INSPECTION CHECKLIST

SPILLWAYS

ITEM	YES	NO	REMARKS
SPILLWAYS			Type: none
1. CREST			Type:
a. Any settlement?			
b. Any misalignment?			
c. Any cracking?			
d. Any deterioration?			
e: Exposed reinforcement?			
f. Erosion?			
g. Silt deposits upstream?			
2. CONTROL STRUCTURES			
3. CHUTE			
a. Any cracking?			
b. Any deterioration?			
c. Erosion?			
d. Seepage at lines or joints?			
4. ENERGY DISSIPATERS			
a. Any deterioration?			
b. Erosion?			
c. Exposed reinforcement?			
5. METAL APPURTENANCES			
a. Corrosion?			
b. Breakage?			
c. Secure anchorages?			
6. EMERGENCY SPILLWAY			
a. Adequate grass cover?			
b. Clear approach channel?			
c. Erodible downstream channel?			
d. Erodible fuse plug?			
e. Stable side slopes?			
f. Beaver dams present?			

ALASKA DAM SAFETY PROGRAM
VISUAL INSPECTION CHECKLIST

INTAKES

ITEM	YES	NO	REMARKS
INTAKES			
1. EQUIPMENT			
a. Trash racks			
b. Trash rake?			
c. Mechanical equipment operable?			
d. Intake gates?			
e. Are racks and gates operable?			
f. Are gate operators operable?			
2. CONCRETE SURFACES			
a. Any cracking?			
b. Any deterioration?			
c. Erosion?			
d. Exposed reinforcement?			
e. Are joints displaced?			
f. Are joints leaking?			
3. CONCRETE CONDUITS			
a. Any cracking?			
b. Any deterioration?			
c. Erosion?			
d. Exposed reinforcement?			
e. Are joints displaced?			
f. Are joints leaking?			
4. METAL CONDUITS			
a. Is metal corroded?			
b. Is conduit damaged?			
c. Are joints displaced?			
d. Are joints leaking?			
5. METAL APPURTENANCES			
a. Corrosion?			
b. Breakage?			
c. Secure anchorages?			
6. PENSTOCKS			
a. Material deterioration?			
b. Joints leaking?			
c. Supports adequate?			
d. Anchor blocks stable?			

APPENDIX B

2018 Site Inspection Photographs

Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 1 WEST (RIGHT) ABUTMENT NEAR STATION 0+00	
PHOTO 2 DOWNSTREAM EMBANKMENT NEAR STATION 5+00	

Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 3 UPSTREAM EMBANKMENT AND TAILINGS POND NEAR STATION 7+00	
PHOTO 4 INSULATION LAYER AND INSTRUMENTATION CABLES NEAR STATION 15+00	

Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 5

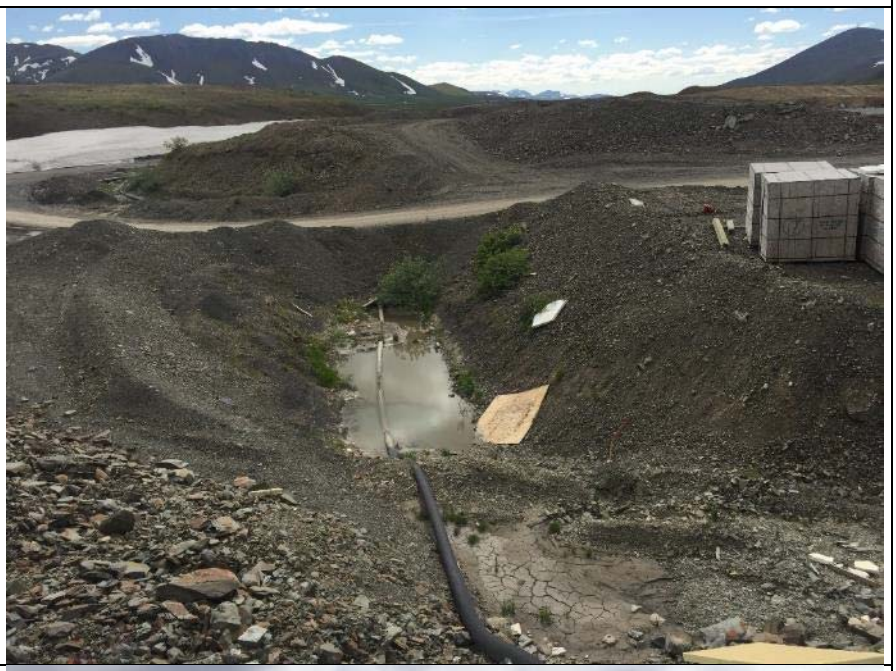
PIPE CROSSING THROUGH INSULATION LAYER NEAR STATION 10+00

PHOTO 6

CUT-OFF WALL SPOILS PILE ON DOWNSTREAM EMBANKMENT NEAR STATION 8+00

Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 7 PONDED WATER IN LOW SPOT NEAR STATION 7+00	
PHOTO 8 CUT-OFF WALL SPOILS ON DOWNSTREAM EMBANKMENT SLOPE NEAR STATION 8+00	

Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 9

DOWNSTREAM EMBANKMENT SLOPE AND OVERBURDEN STOCKPILE NEAR STATION 19+00

PHOTO 10

CUT-OFF WALL SPOILS AND PLASTIC CONCRETE TRUCK WASH DEPOSITS ON DOWNSTREAM EMBANKMENT SLOPE NEAR STATION 25+00

Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 11 CRACKING AT SELECT FILL/ROCKFILL INTERFACE, DOWNSTREAM CREST NEAR STATION 26+00	
PHOTO 12 CRACKING AT SELECT FILL/ROCKFILL INTERFACE, DOWNSTREAM CREST NEAR STATION 24+00	

Appendix B: Photographs

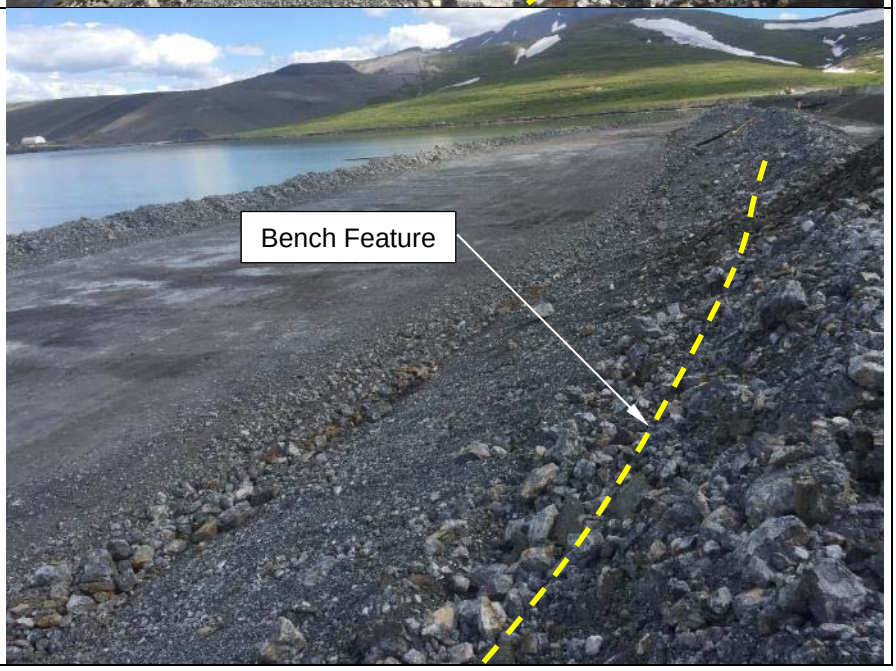
All photographs taken June 25-26, 2018

PHOTO 13

COFFERDAM ROAD AND UPSTREAM EMBANKMENT SLOPE NEAR STATION 20+00

PHOTO 14

COFFERDAM ROAD AND UPSTREAM EMBANKMENT SLOPE NEAR STATION 24+00



Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 15 CRACKING AT SELECT FILL/ROCKFILL INTERFACE, UPSTREAM CREST NEAR STATION 23+50	
PHOTO 16 CUT-OFF WALL SPOILS SPREAD OVER DOWNSTREAM EMBANKMENT SLOPE NEAR STATION 39+50	

Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 17 CRACKING AT DOWNSTREAM EMBANKMENT CREST NEAR STATION 49+00	
PHOTO 18 CRACKING AT DOWNSTREAM EMBANKMENT CREST NEAR STATION 47+00	

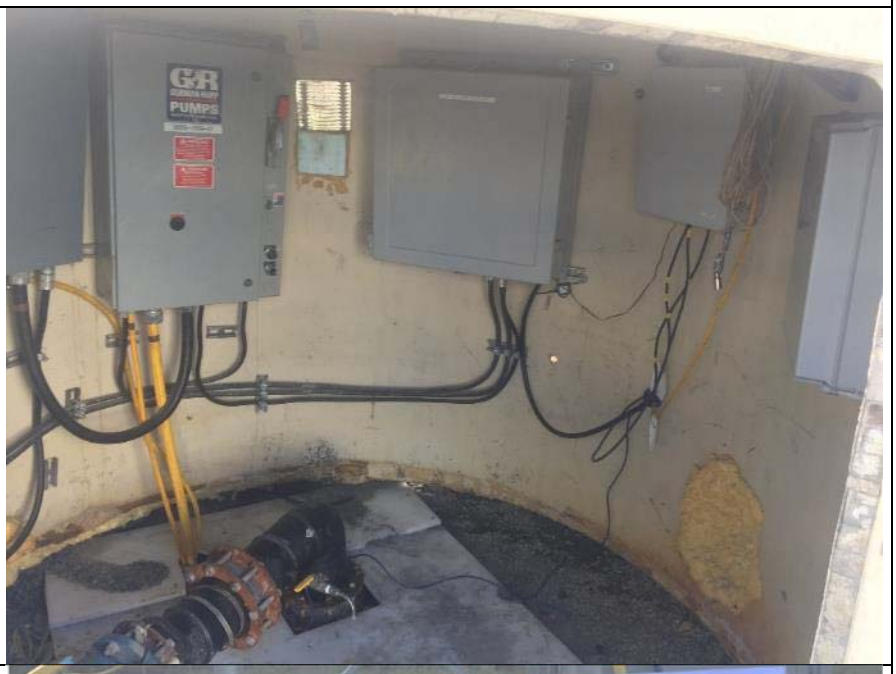
Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 19 CREST AT EAST (LEFT) ABUTMENT	
PHOTO 20 SUMP PUMP HOUSE AND COMMUNICATIONS TOWER NEAR STATION 25+50	

Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 21 INTERIOR OF SUMP PUMPHOUSE	
PHOTO 22 INTERIOR OF MONITORING BOX AT COMMUNICATION TOWER	

Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 23 SUMP PUMP DISCHARGE PIPE AT UPSTREAM SIDE	
PHOTO 24 SAA 35+00	

Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 25 SAA 14+00	
PHOTO 26 TYPICAL PIEZMETER/TAC CONFIGURATION AT SURFACE	

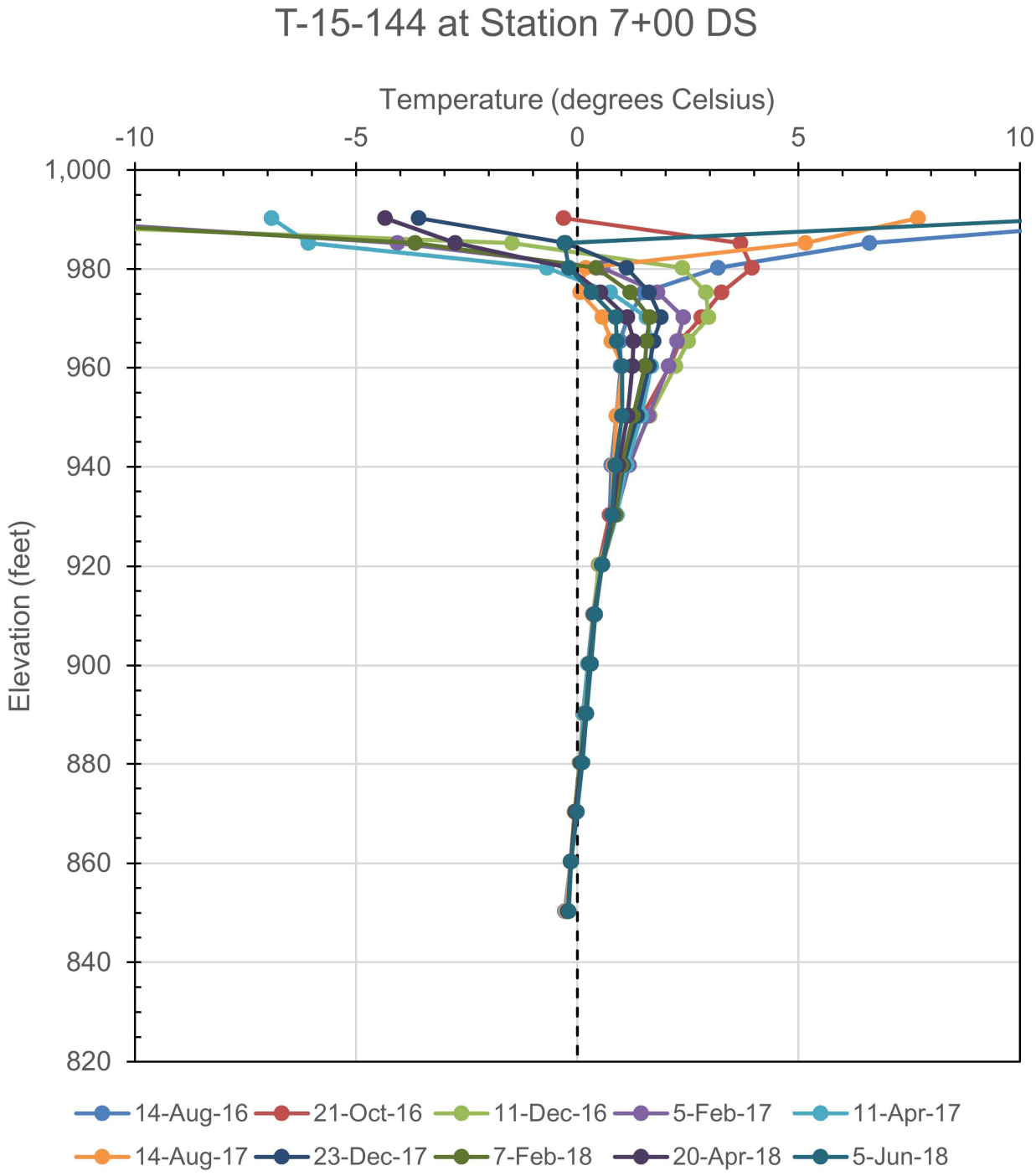
Appendix B: Photographs

All photographs taken June 25-26, 2018

PHOTO 27 TYPICAL PIEZOMETER/TAC CONFIGURATION	
PHOTO 28 TYPICAL SETTLMENT MONUMENT AT SURFACE	

APPENDIX C

Ground Temperature Monitoring Data

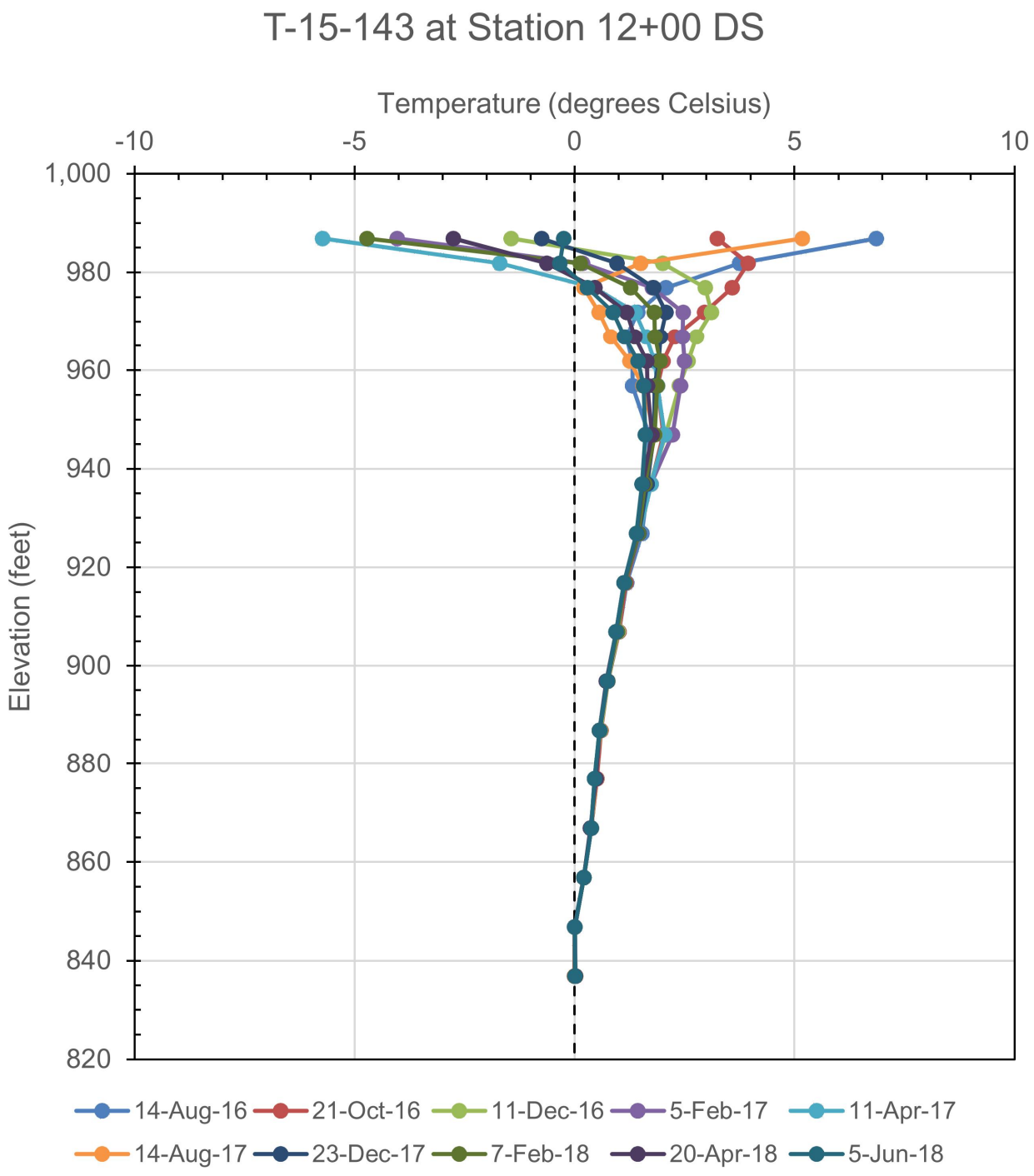


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT STATION 7+00 DS

FIGURE C-1

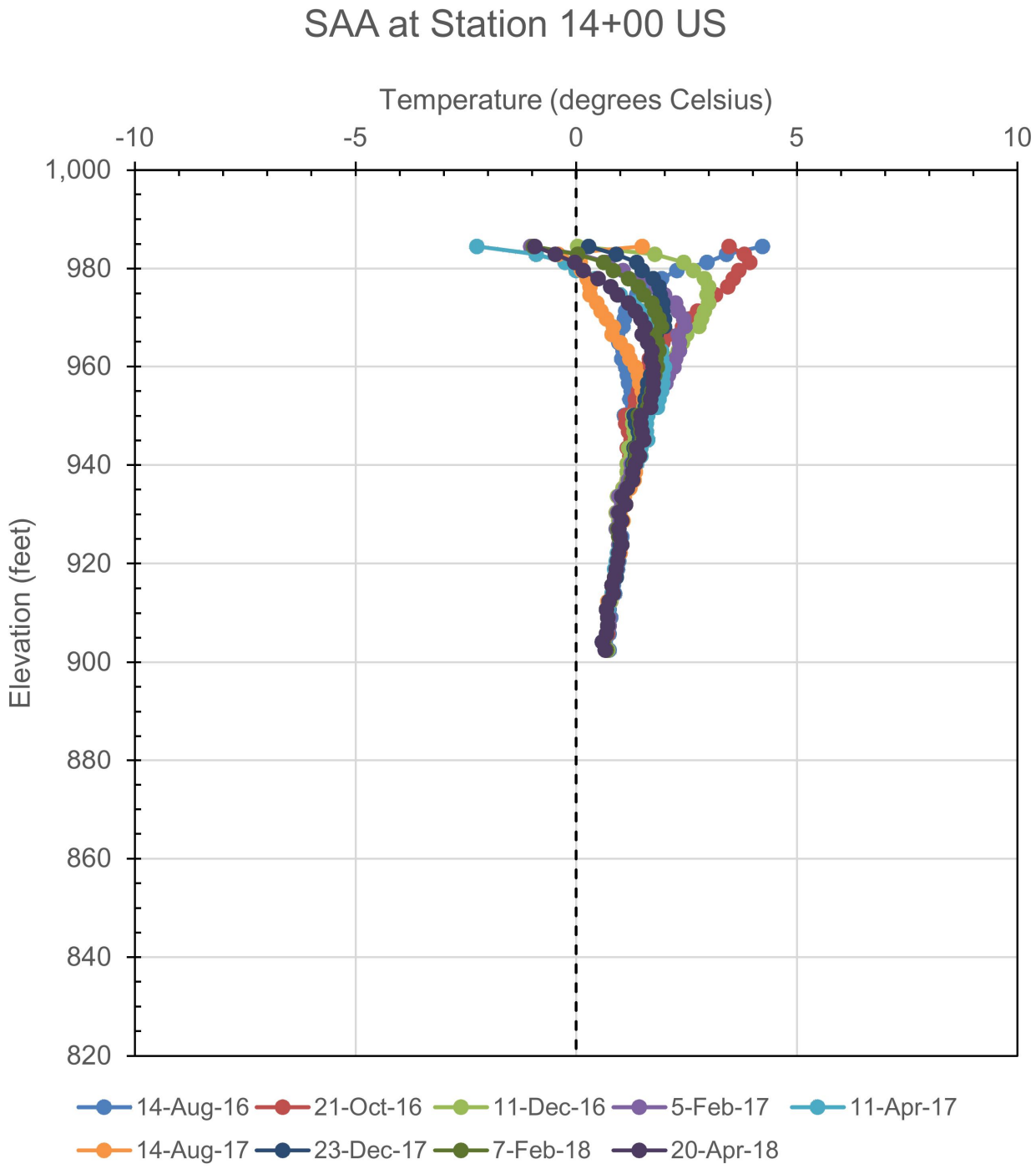


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT STATION 12+00 DS

FIGURE C-2

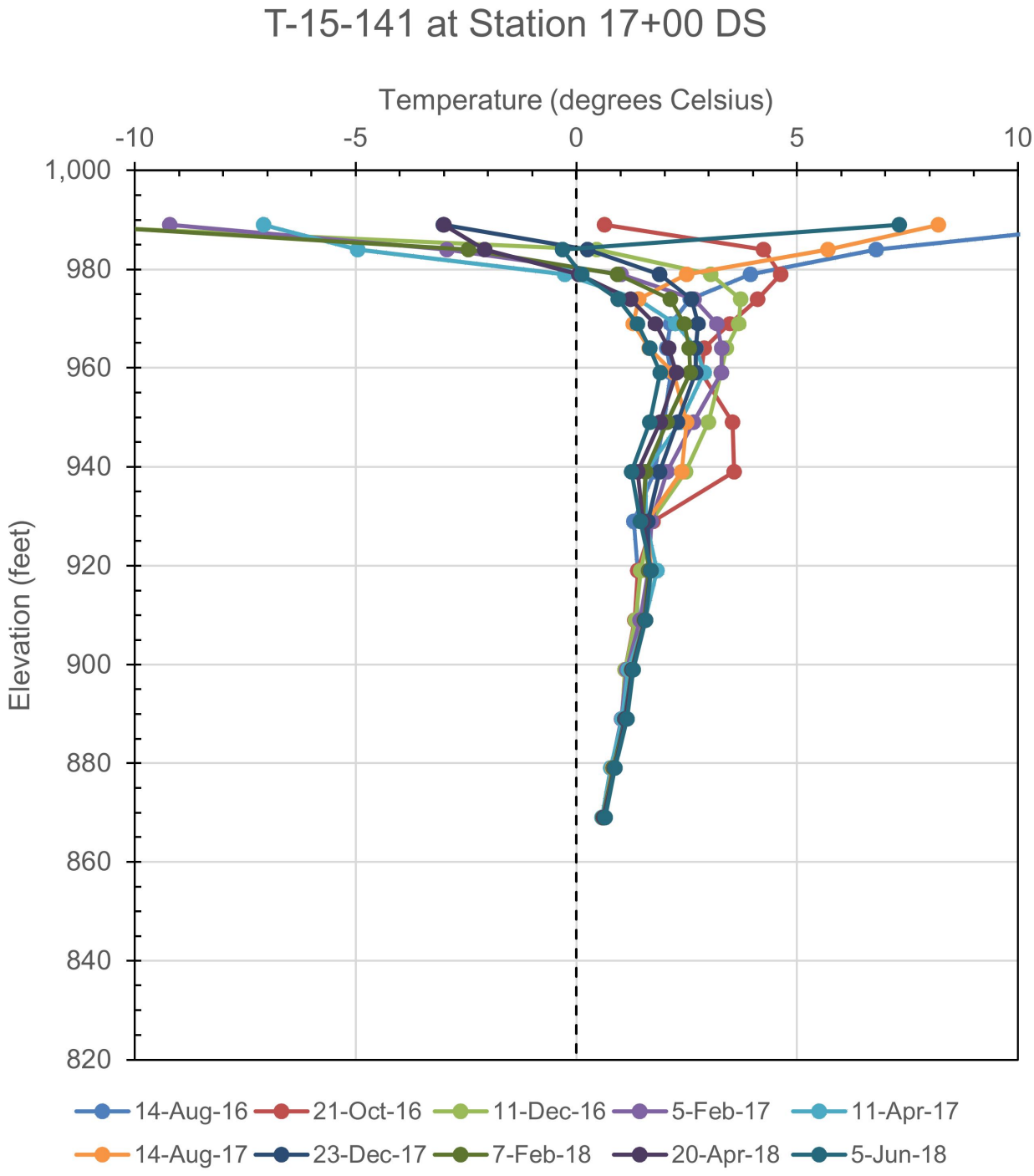


RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT STATION 14+00 US

FIGURE C-3

GOLDER

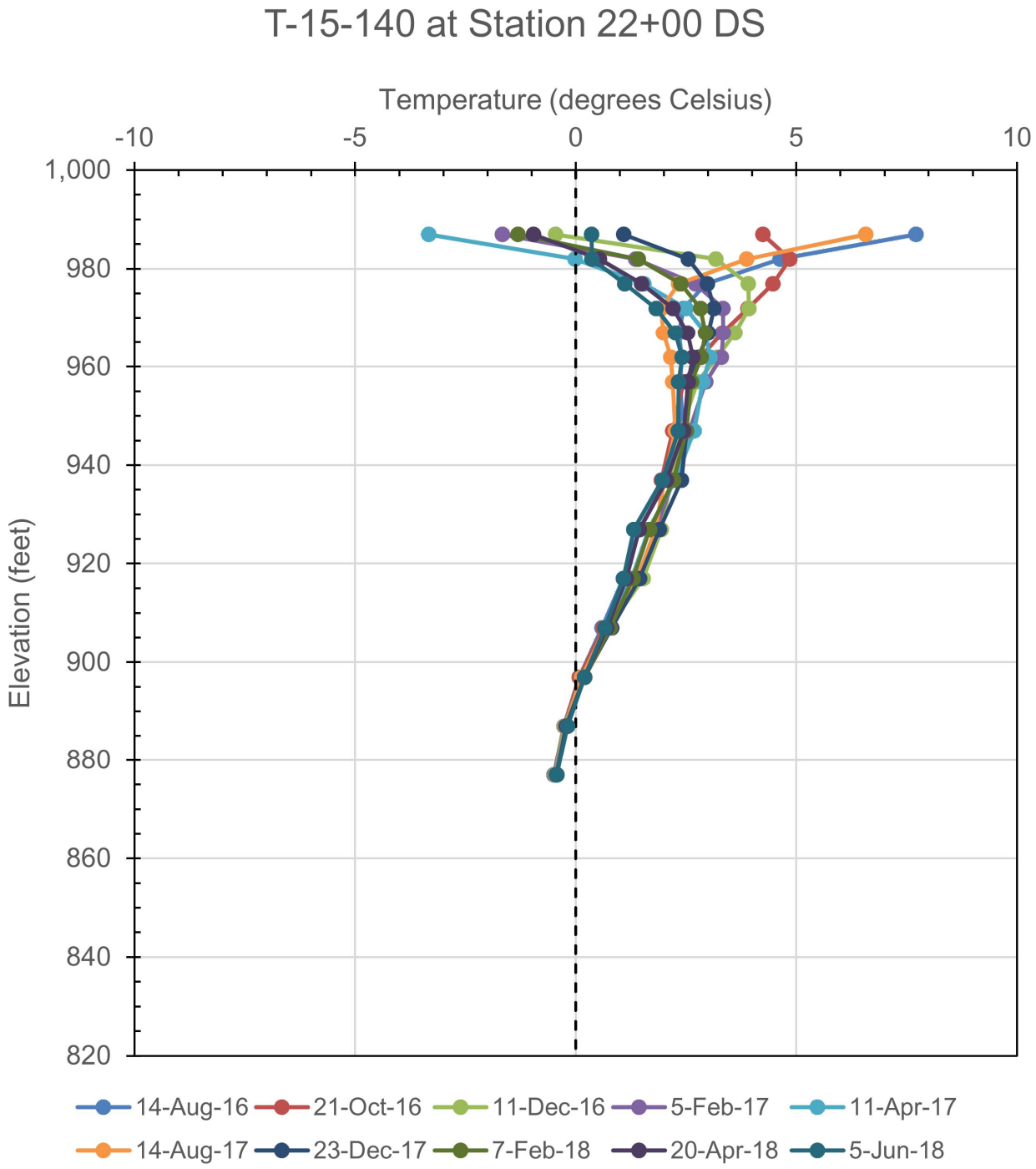


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT STATION 17+00 DS

FIGURE C-4

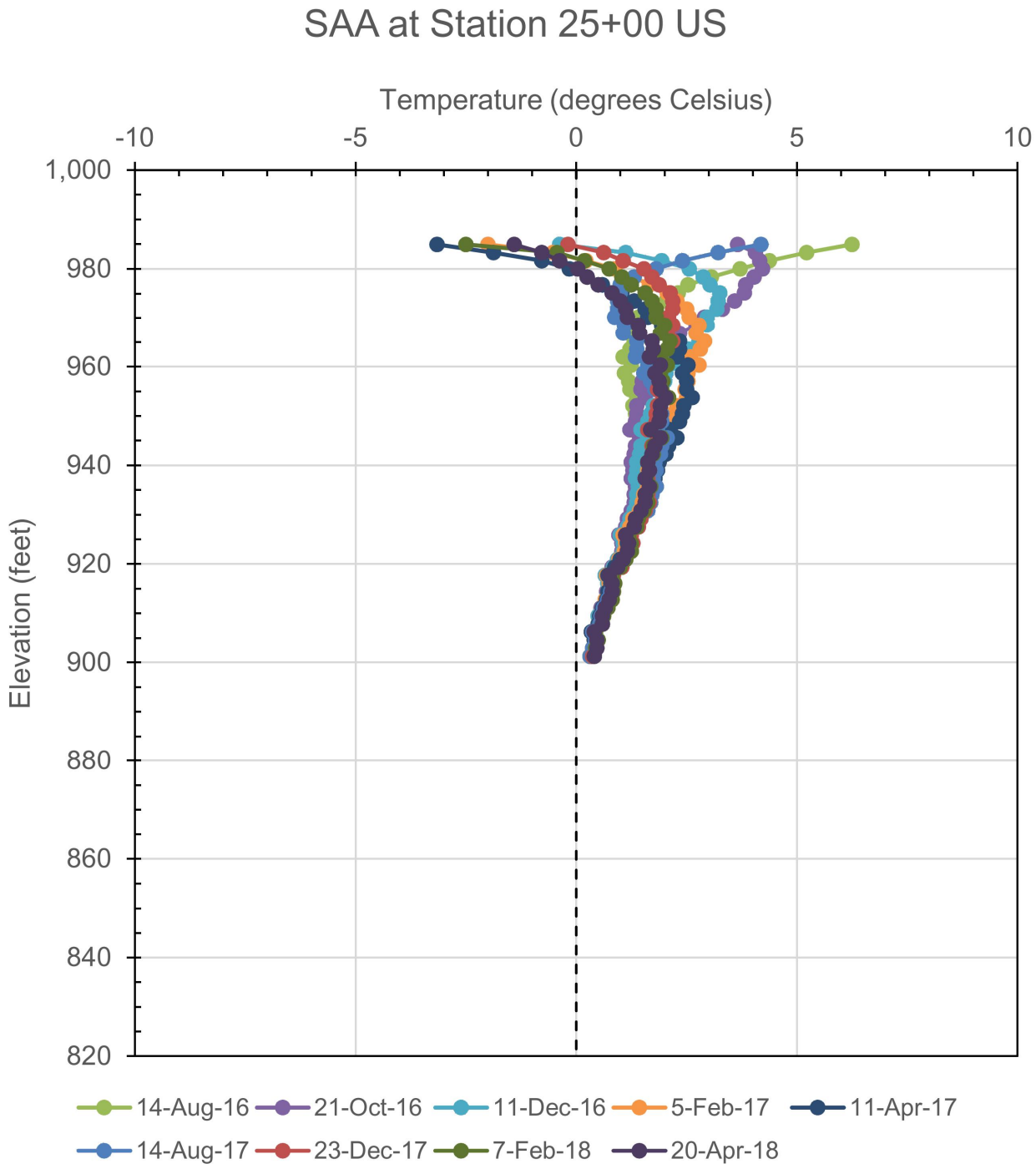


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT STATION 22+00 DS

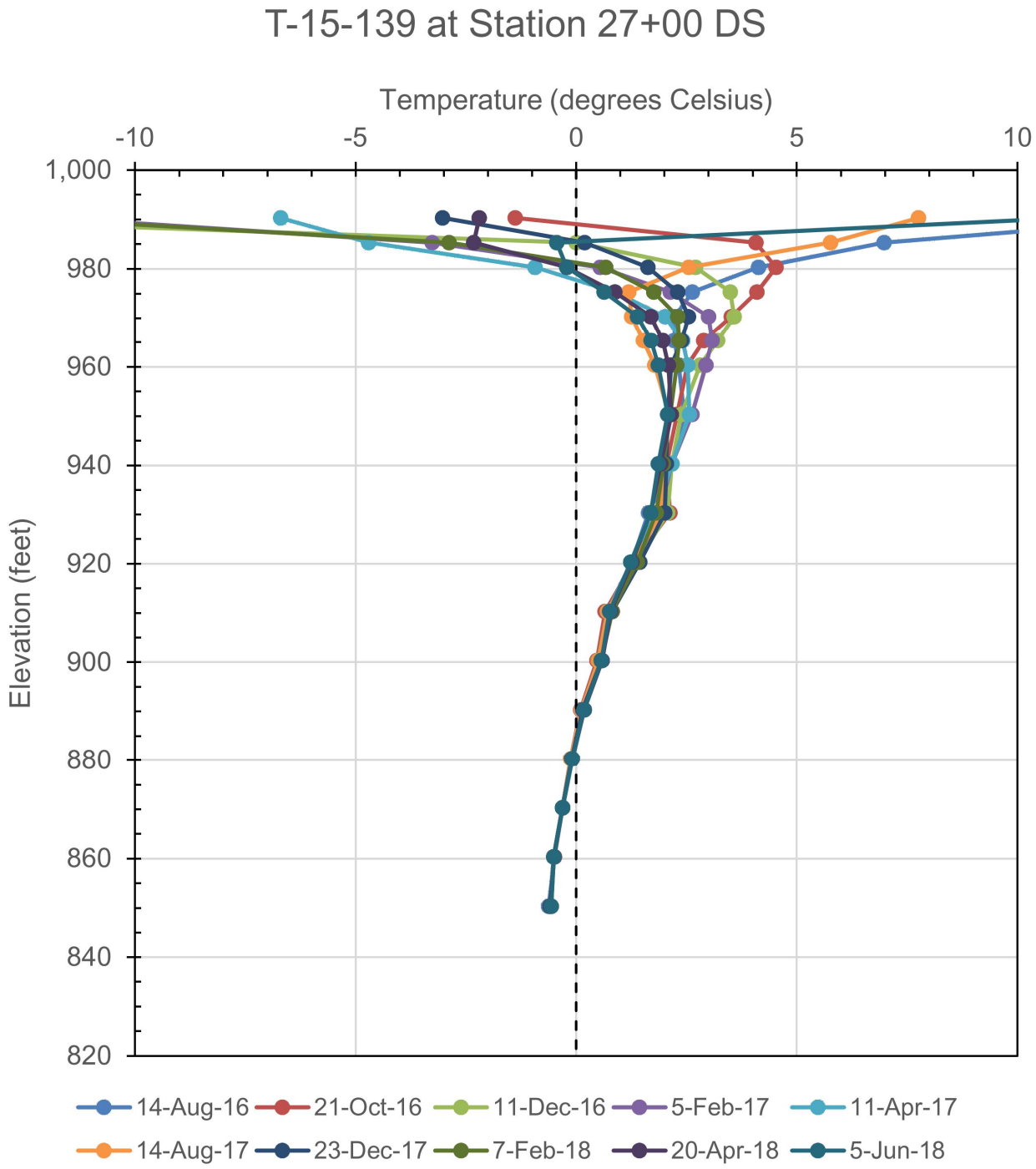
FIGURE C-5



RED DOG 2018 ANNUAL INSPECTION
GROUND TEMPERATURE DATA AT STATION 25+00 US

GOLDER

FIGURE C-6

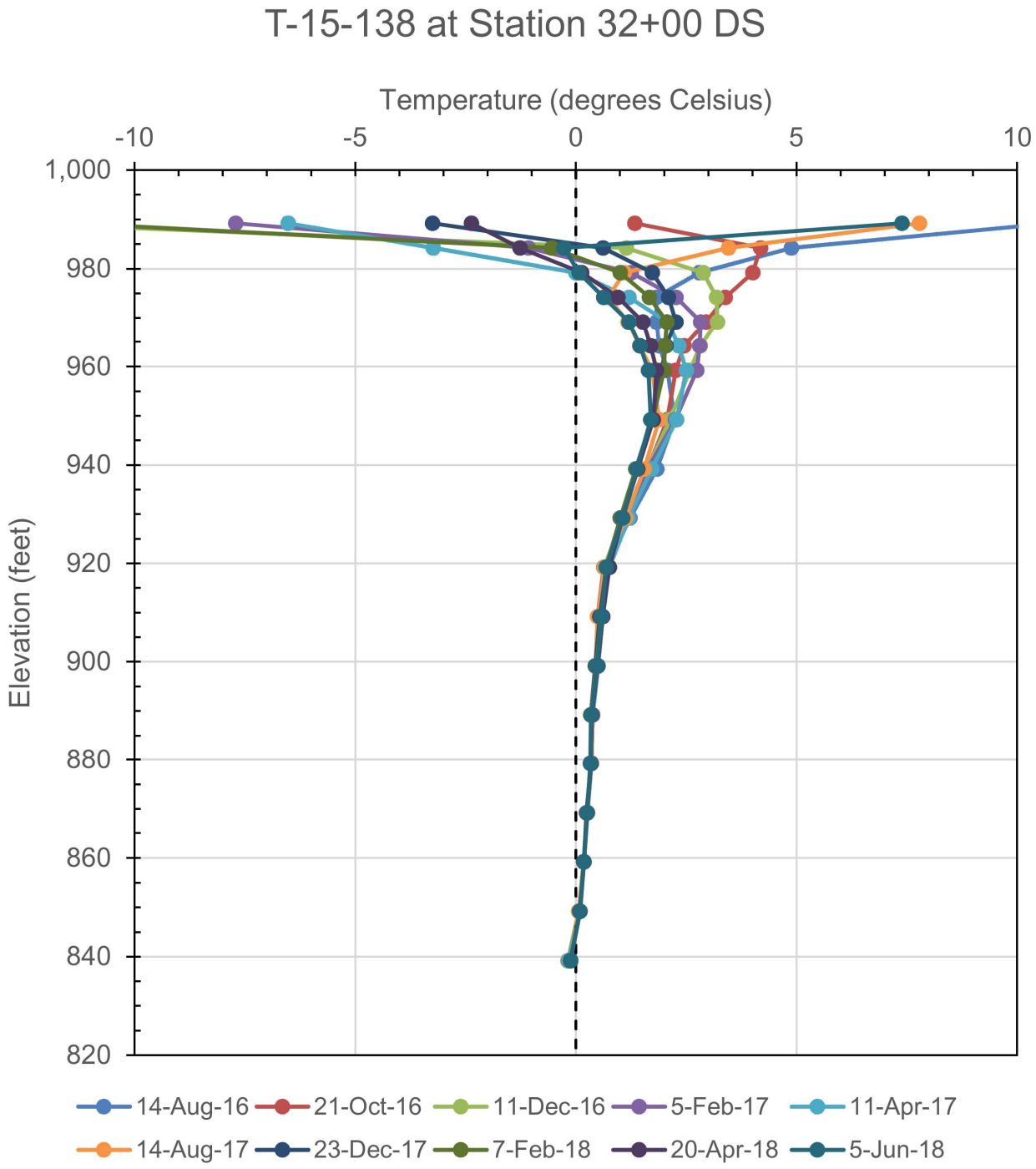


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT STATION 27+00 DS

FIGURE C-7

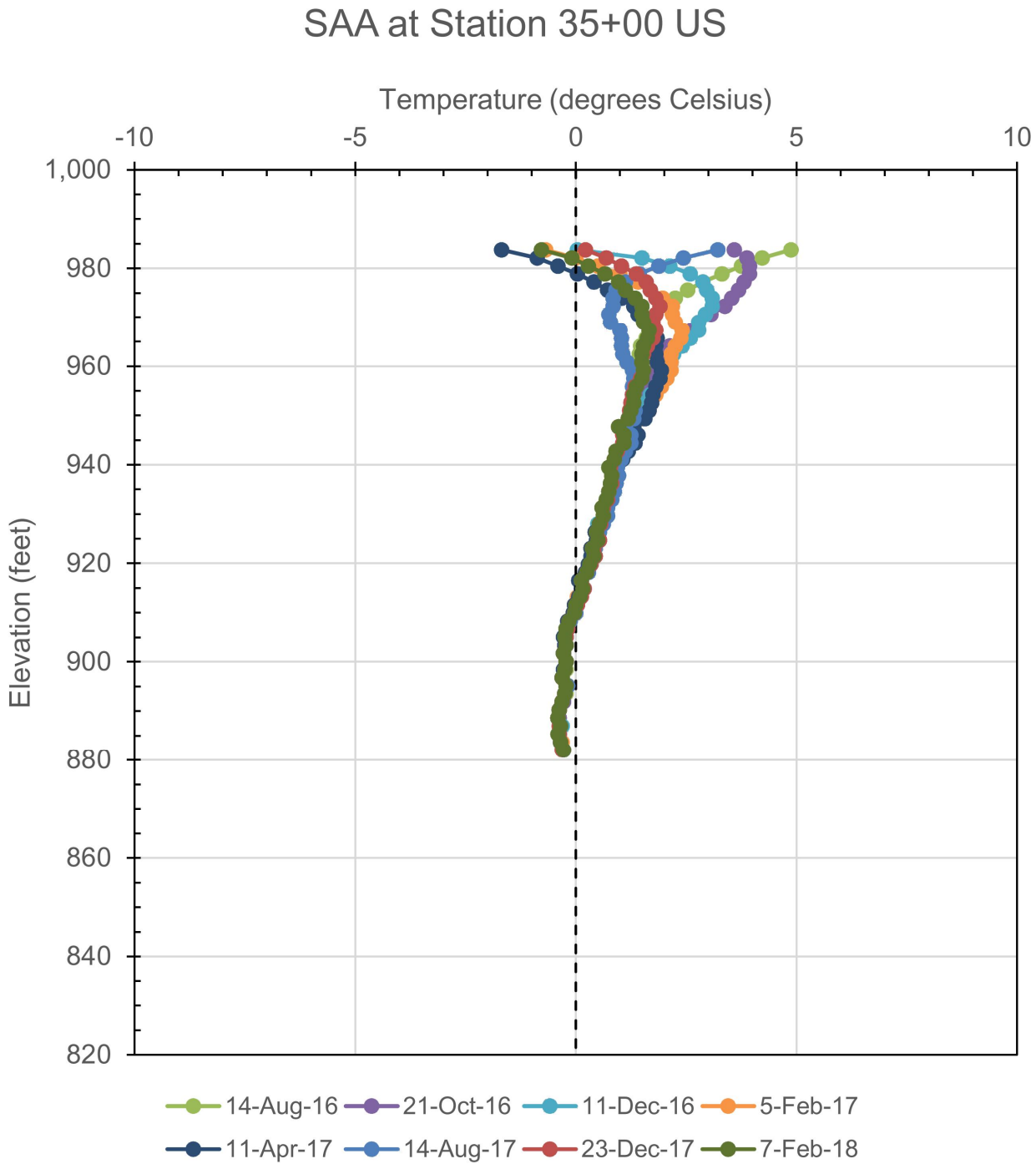


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT STATION 32+00 DS

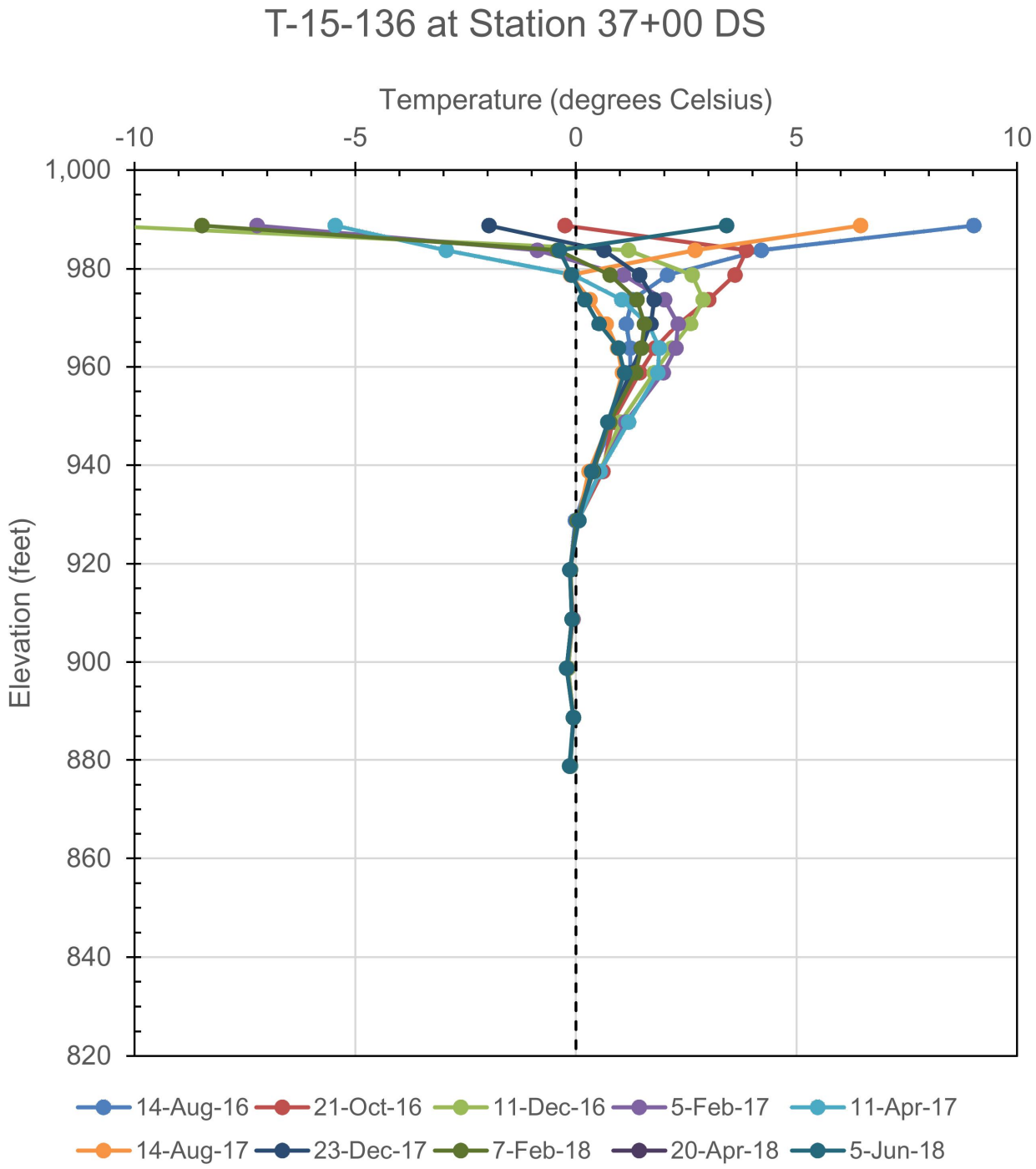
FIGURE C-8



RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT STATION 35+00 US

FIGURE C-9

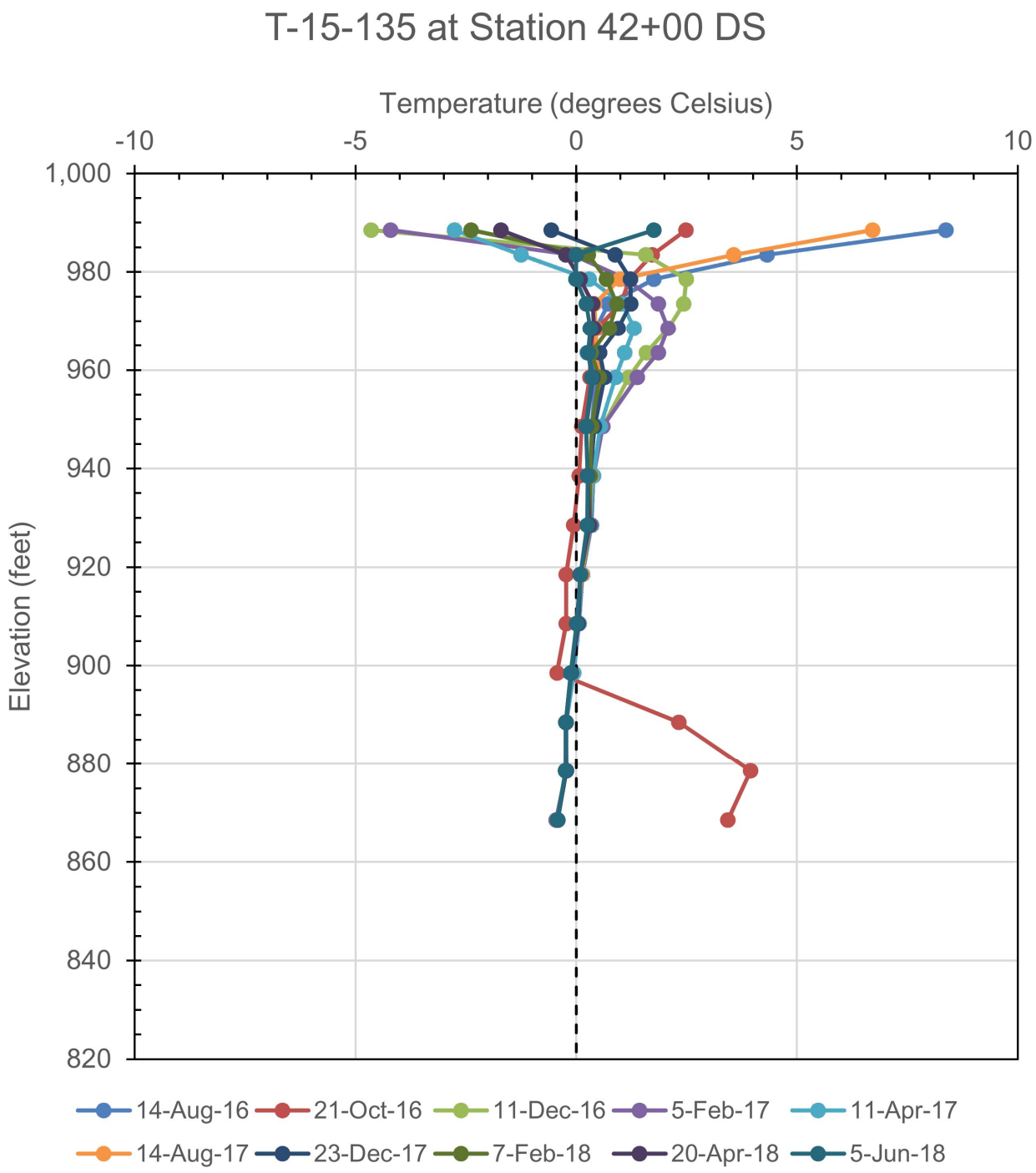


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT STATION 37+00 DS

FIGURE C-10

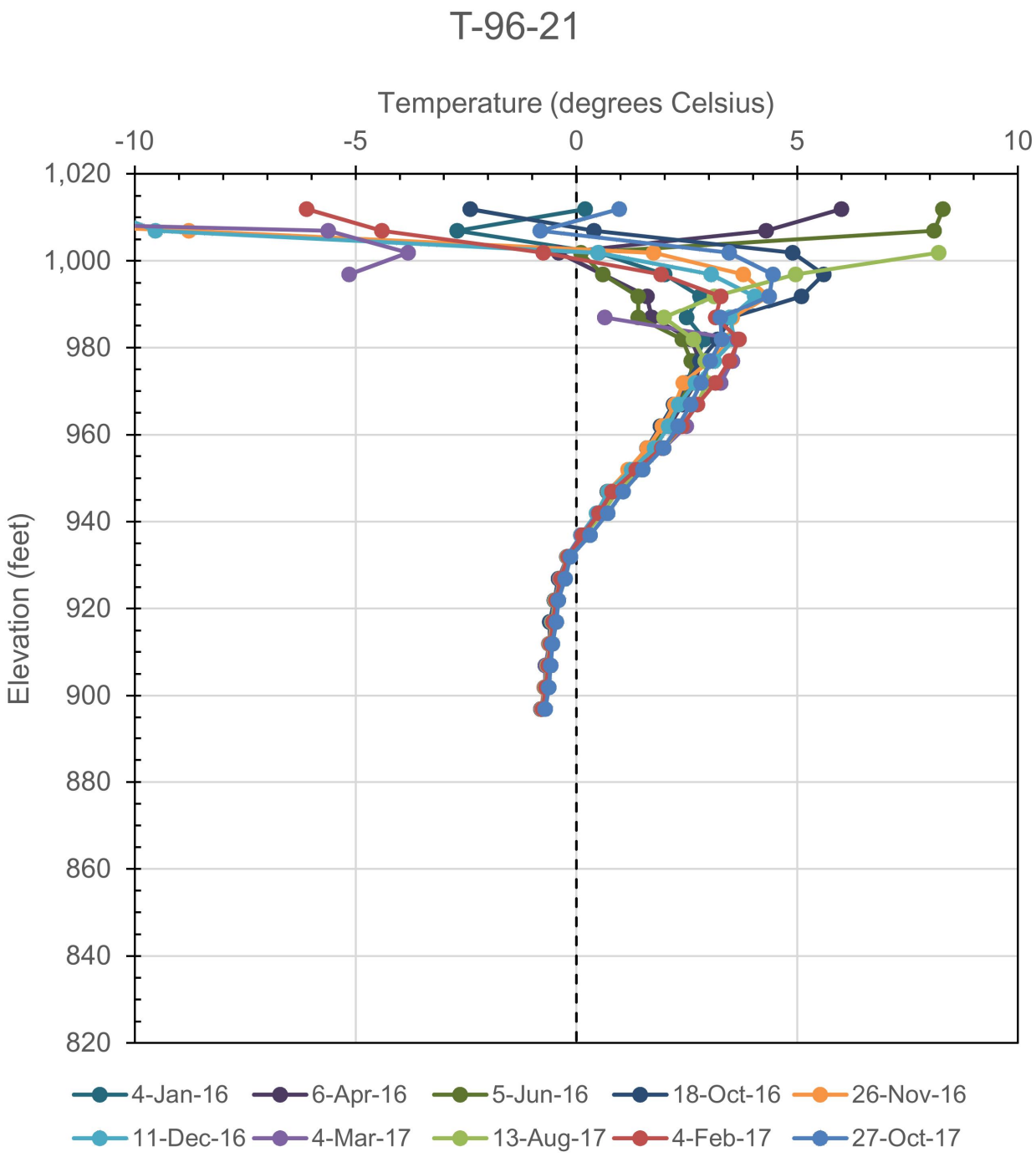


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT STATION 42+00 DS

FIGURE C-11

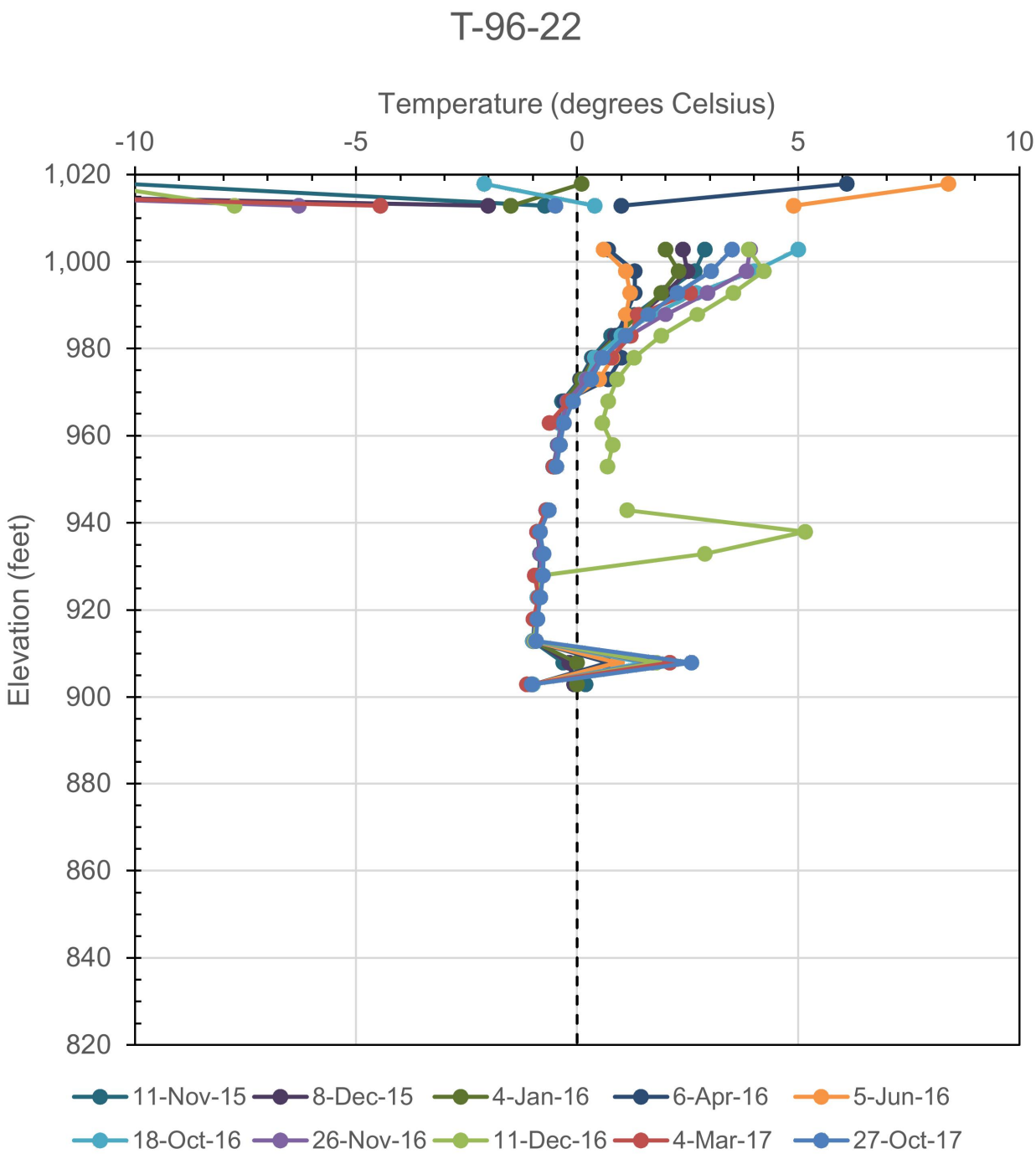


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT OVERBURDEN STOCKPILE T-96-21

FIGURE C-12

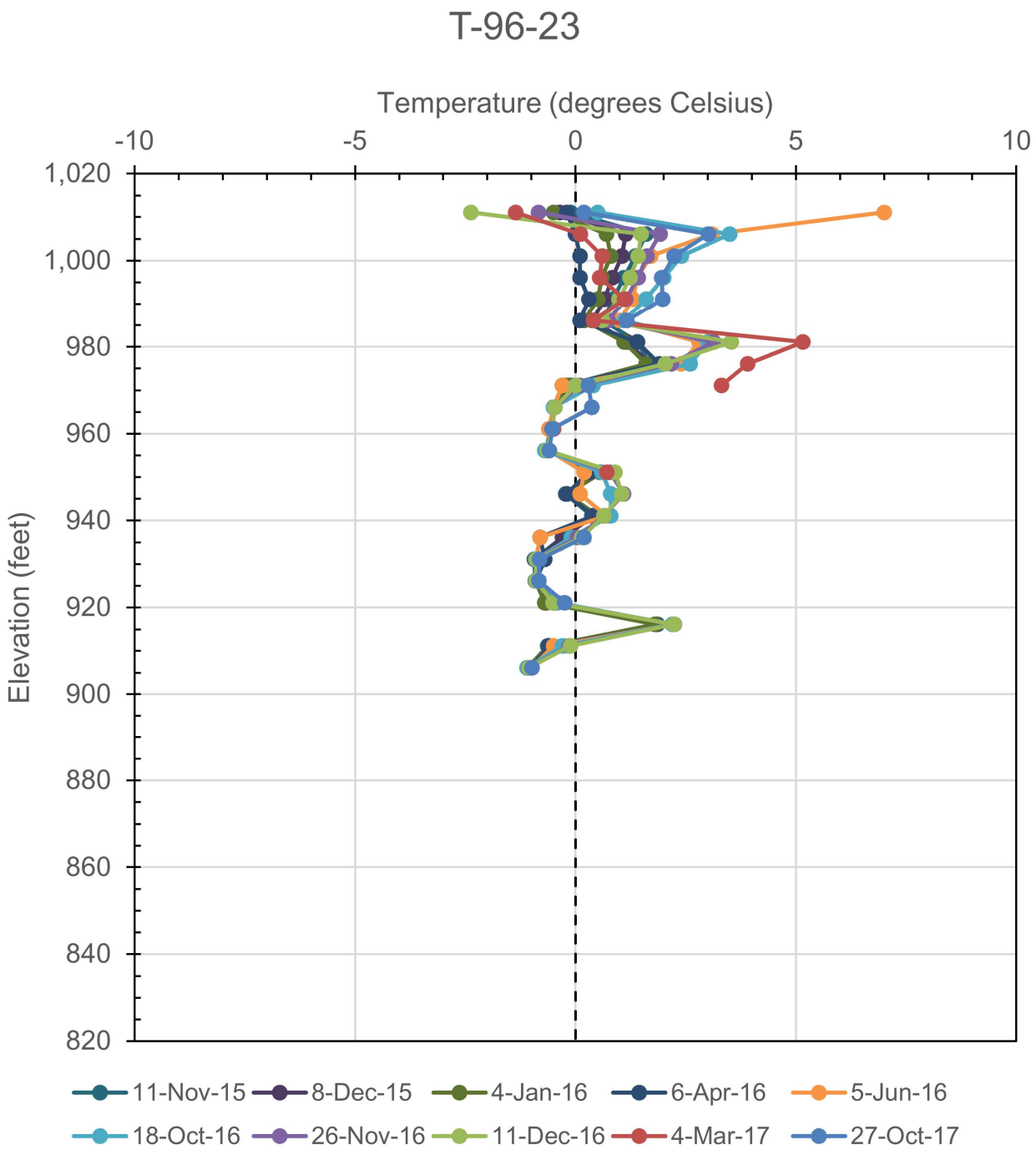


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT OVERBURDEN STOCKPILE T-96-22

FIGURE C-13

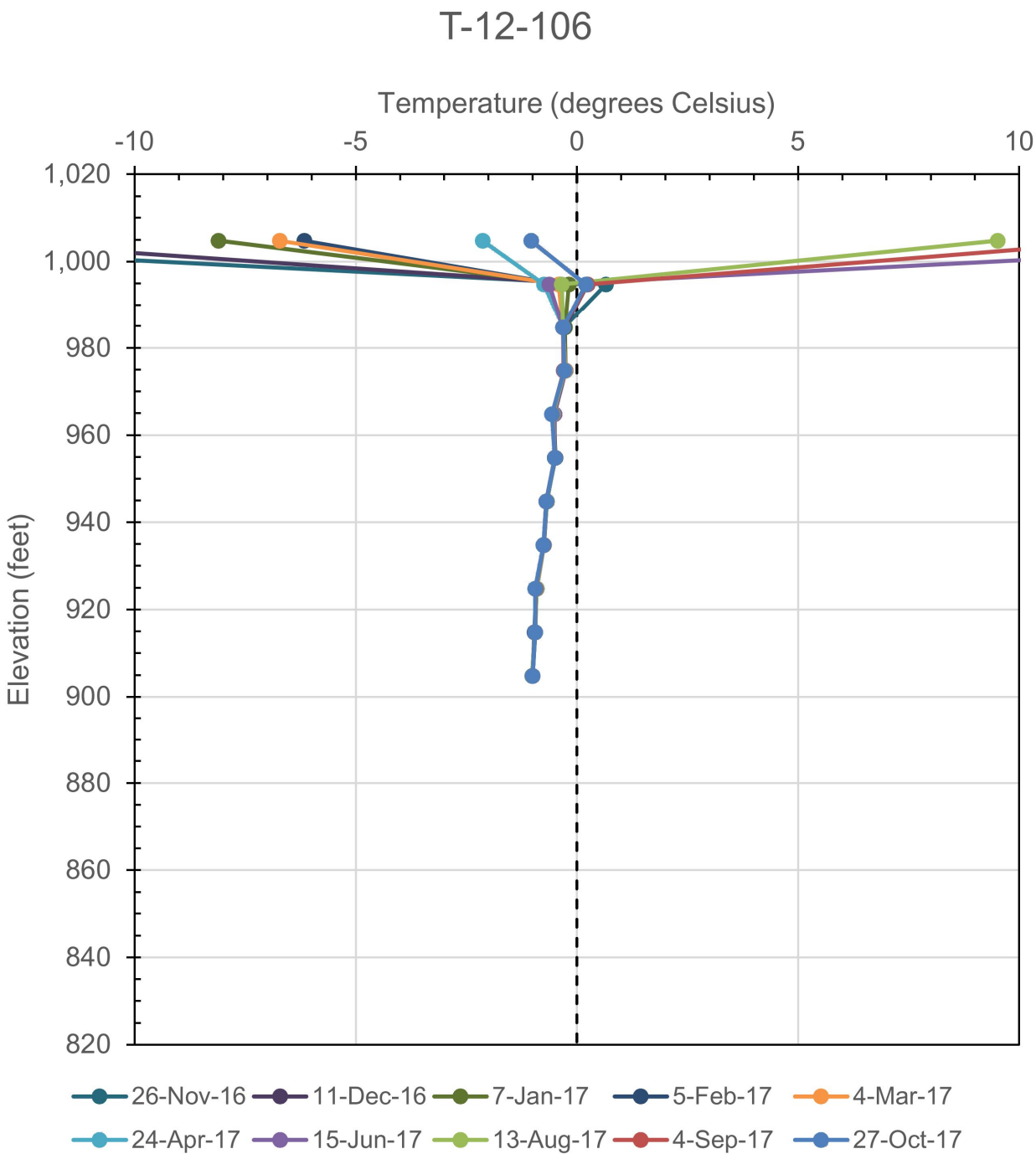


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT OVERBURDEN STOCKPILE T-96-23

FIGURE C-14

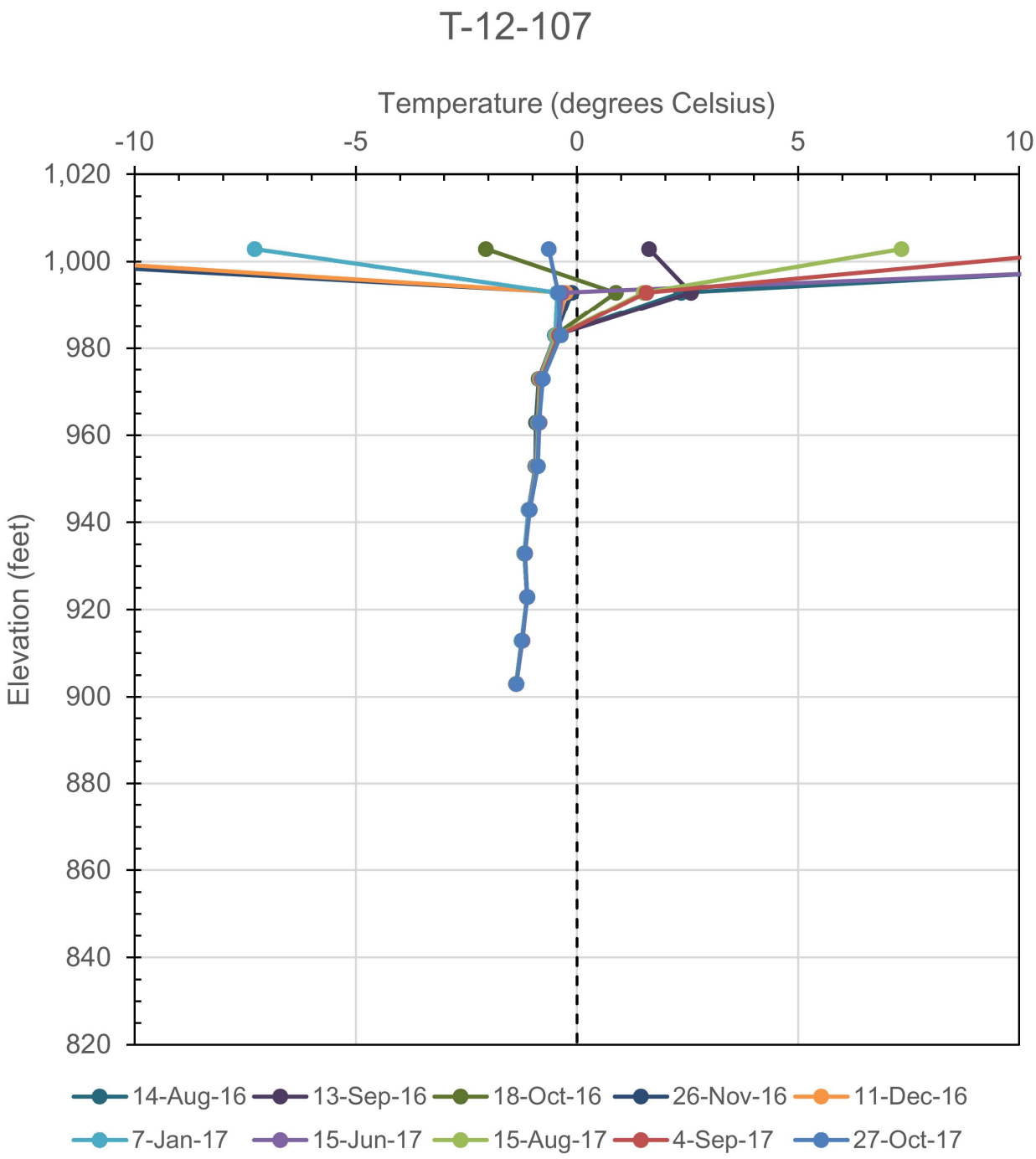


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT OVERBURDEN STOCKPILE T–12–106

FIGURE C-15

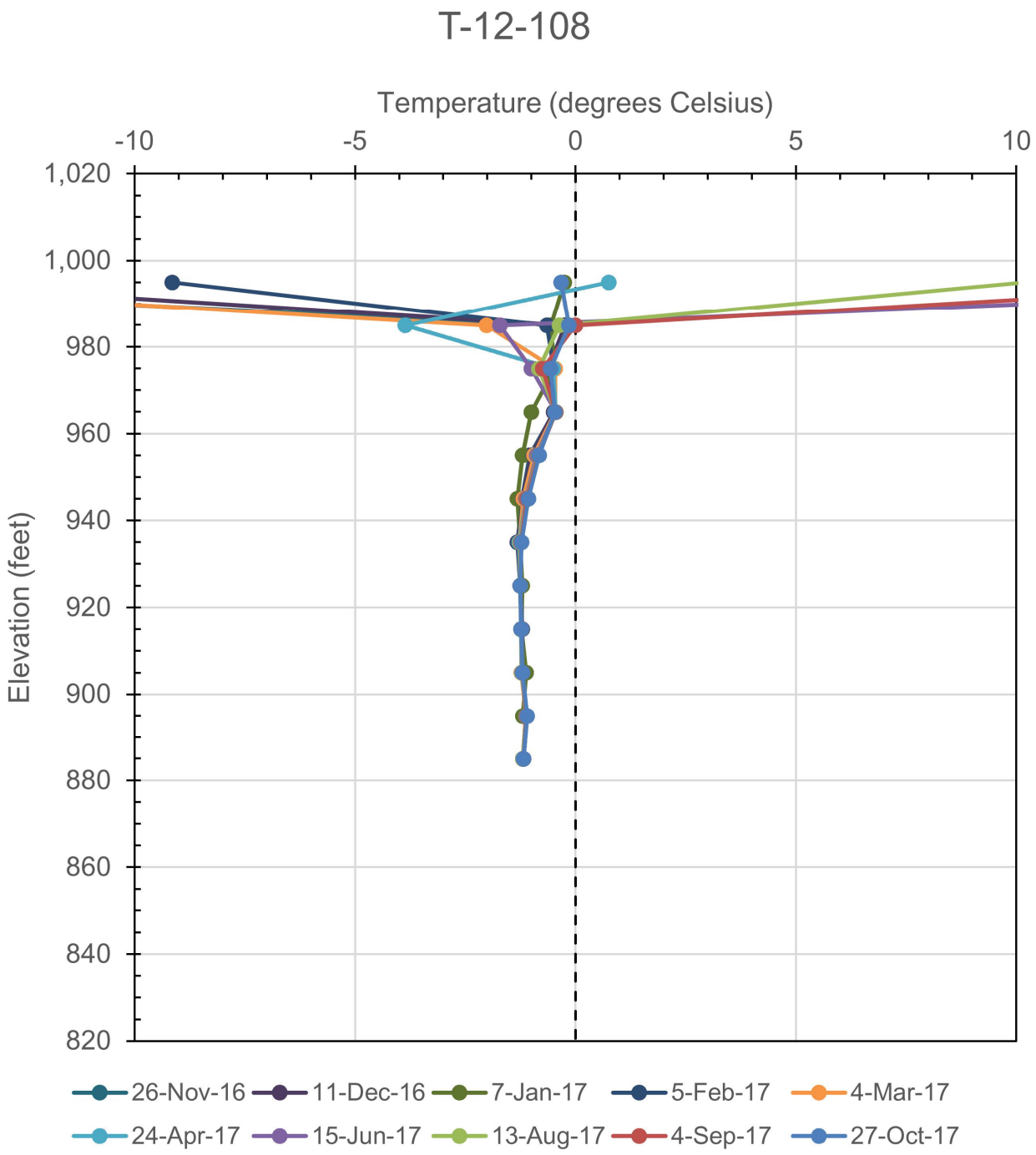


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT OVERBURDEN STOCKPILE T-12-107

FIGURE C-16

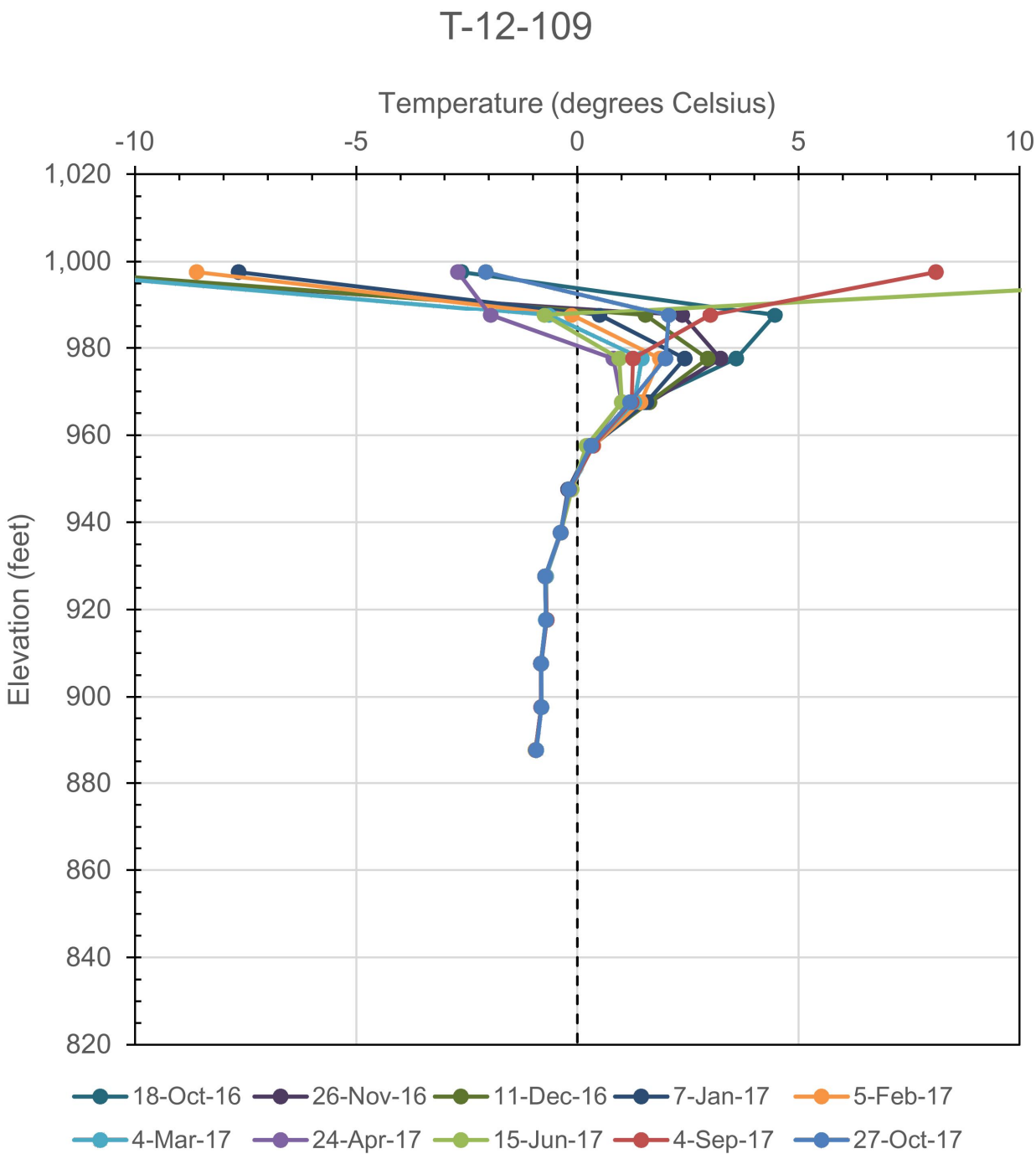


GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT OVERBURDEN STOCKPILE T–12–108

FIGURE C-17



GOLDER

RED DOG 2018 ANNUAL INSPECTION

GROUND TEMPERATURE DATA AT OVERBURDEN STOCKPILE T–12–109

FIGURE C-18